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Magnitude −5 Taurid fireball photographed by Ralf Koschack in Weißwasser, Germany, on November 11, 1991, at $0^h00^m01^s$ UT. The photograph was exposed from $23^h16^m35^s$ till $00^h02^m43^s$. An ISO 400/27° film was used in combination with an $f/3.5$, f = 30-mm lens.

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Useful Information

The August Issue *(WGN 20:4)*

The *August issue* is expected to be mailed during the last week of July 1992. Therefore, contributions are due *July 3*. They should be sent to *Marc Gyssens.*

WGN Subscription/IMO Membership 1992

The subscription rate for volume 20 (1992) is 25 DEM for six issues. Additional gifts are of course welcome. It is anticipated that volume 20 will contain over 240 pages.

Administrative Correspondence

Ordering *IMO* publications is done in the same way as paying subscription/membership fees. Complaints about not receiving *WGN* or changes of address should be sent to *Paul Roggemans.*

All addresses can be found on the inside of the back cover.

From the Editor-in-Chief

Marc Gyssens

For the third time in a row, WGN *publishes a thick issue of its magazine. There are several reasons for this unusual decision.*

First of all, the influx of articles remains high. This confirms that WGN *is indeed* the *international forum where meteor amateurs—as well as professionals—exchange their experiences. Even in this time of year, traditionally a period in which meteor amateurs are not very active, articles keep coming in at an impressive frequency. Please continue these efforts! With the northern hemisphere summer holidays being almost there, I am looking forward to the results of your observations.*

Second, there is the annual International Meteor Conference *to be held in Smolenice, Slovakia, from July 2 to 5. This meeting is bound to become the most truly international event the* IMO *has organized thus far. At such an occasion, the* IMO *must present the activity of its members in the best possible way: that is another reason for which we have chosen to prepare a thick issue.*

Finally, we needed some extra space to implement a new initiative. At the previous IMC *in Potsdam, there was a general demand for more proof-reading and for some form of refereeing of our journal. Especially the latter request was not so easy to meet. As* WGN *is primarily a forum for the international meteor community, we must take care that our standards are not that high that beginning observers are virtually excluded from this forum. On the other hand, however, the IMO does valuable work (recall last year's Perseids outburst), which does not always receive the credit it deserves. After an extensive exchange of ideas between both amateur and professional meteor workers, we think we found a solution meeting both concerns raised above.*

From now on, global analyses of observational results, articles on observing techniques and methods to reduce the observations thus obtained, articles about observations with professional equipment, and theoretical papers will be submitted to a refereeing process in which at least one professional and one experienced and knowledgeable amateur will be involved. The refereed articles will appear in a new section of this magazine, called "Progress in Meteor Science."

When a paper is received, the editor will decide whether or not the paper qualifies for refereeing based on the criteria outlined above. Hence it does not make sense to submit your paper to the refereed section; if, however, you do not *want a paper that might qualify for the refereed section to be reviewed (e.g., because you attach more importance to timely publication), you can specify so. What I want to emphasize is that the publication procedure will not change for all the other articles, which constitute the large majority of the material submitted to* WGN.

This issue features the premiere of the section "Progress in Meteor Science," *just in time for the* IMC. *It contains the results of the* IMO *Aquarid Project. While not every remaining issue of this volume of* WGN *will contain the new section, it will become a regular item starting next year. Meanwhile, of course, we welcome all comments on this initiative!*

Letters for WGN

compiled by Marc Gyssens

The strong meteor display of November 5, 1991

In WGN *20:1, February 1992, pp. 28-31, a strong meteor display over Hawaii on November 5, 1991, was reported, which may have been associated to the defunct Comet P/Biela (see* WGN *20:2, April 1992, pp. 55-57). In the previous issue on p. 55, Gotfred Kristensen suggests that he may have picked up some of the November 5 activity with his radio equipment. The following is a reaction to my editorial comment on his letter.*

I do not quite understand the editor's comment on the meteor display of November 5, 1991 in *WGN* 20:2, April 1992. He points out that the outburst must have occurred during the European daytime hours. I think my radio observations confirm a higher activity during these hours. The two graphs in Figure 1 could be helpful in confirming this.

The graph on all radio meteors shows peaks around 4^{h} UT, which could easily be caused by the Taurids. This however cannot be the case for the weaker peak around 12^{h}, as the radiant is under the horizon around that time.

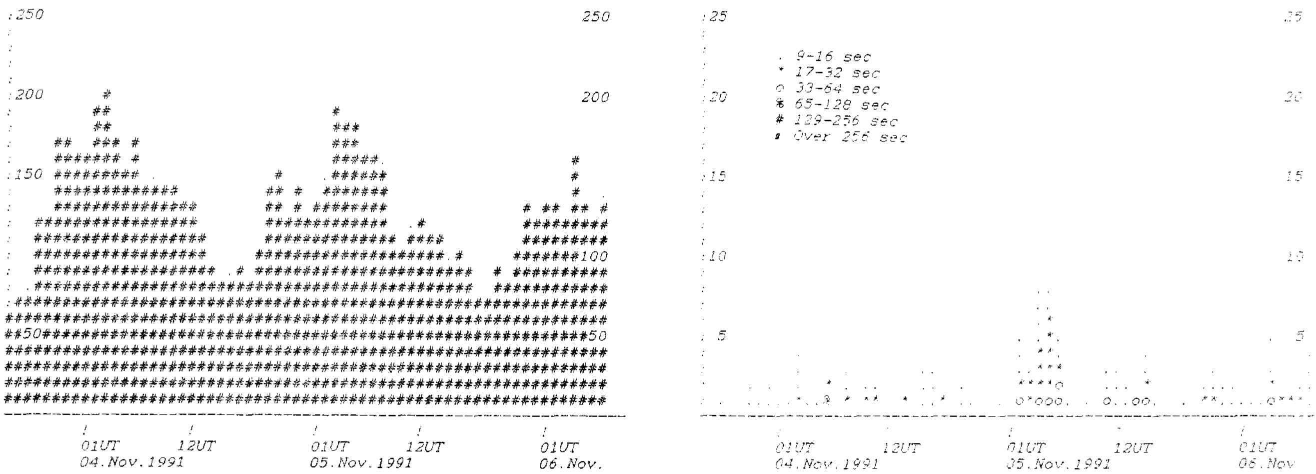

Figure 1 – Radio meteor activity around November 5: all signals *(left)* and bright signals *(right)*.

The graph on the bright radio meteors shows an increase in very bright meteors twice on November 5: the first increase is between 1^h and 6^h UT (presumably Taurids), and the second between 11^h and 15^h UT. Eight of the signals concerned have the characteristics of a fireball reflection, and 13 others those of very bright meteors. This is rather unusual within only 24 hours.

If there was an outburst on November 5, I think around-the-clock radio observations by pen recorder *must* reveil this outburst. And I think this is exactly what has happened.

Gotfred Møbjerg Kristensen, April 25, 1992

Reply by the Editor: The aim of my comments to Gotfred Kristensen's previous letter was merely to prevent readers to think that the November 5 outburst could have been connected to activity around 22^h *UT.*

Precision of telescopic meteor recordings

In WGN *20:2, April 1992, pp. 70–83, Pravec and Boček reported experiences of Czechoslovakian observers regarding the precision of telescopic meteor recordings. Below, Telescopic Commission Director Malcolm Currie comments.*

In recent years I have championed telescopic observing in this journal. One of my main arguments has been the accuracy of plotting afforded by this technique, and all that it offers to investigate radiant properties. The conclusions of an investigation by Petr Pravec and Jaroslav Boček [1] contradicts this stand-point, since their nominal error in position angle is 11°. Therefore, I should like to comment.

I should like to make it clear at the outset that I welcome programs that determine the errors of observation, such as the Czechoslovakian team's, for the reasons given in their paper. Here I want to address possible reasons for the discrepancy between the *BAA* findings upon which I made my case, and these results.

In telescopic analysis the orientation error is far more important than *(i)* the transverse or shift error because of the magnification, and *(ii)* the "sliding" error since these are highly subjective. Therefore I shall concentrate on position-angle errors.

Dealing with the analysis of the errors first, I should have like to have seen a differential histogram in addition to Figure 5 (like Figure 7 of [2]) to judge whether the analysis suffers from outliers swamping. Figure 5 suggests that it might. The fact that there are no significant correlations between plotting accuracy and the following parameters: position of the meteor within the field, the path length, the experience of the observer, angular velocity, quality of the plots is indicative of a much larger error swamping these more subtle effects. [3]

Now to the actual observing method. The Czechoslovakian team used ultra-wide angle binoculars with 74° apparent field, whereas the *BAA* size was more typically 50°. As the size of the field increases the probability that a meteor will not be well seen, i.e., near the center of vision, grows, and hence the plotting accuracy decreases. There is less tendency for sudden eye movement as the meteor flashes across the field. There was a Czechoslovakian (?) paper around the mid-1960s that is not my possession, hence I cannot give a reference, which had quantitative evidence of this, the scale of improvements I outlined in [4]. (If anybody knows the paper I should be delighted to have the reference.) Judging by the numbers from this paper a factor of two to three in positional error can be accounted.

Another difference in methods is that the *BAA* style extracts the salient features of a telescopic meteor: its path, brightness, and approximate speed. A fourth parameter, the type, is derived from the path. The Czechoslovakian method includes "several other parameters." In the late 1960s visual observers were recording many parameters of dubious worth let alone reliability. A study [5,6] showed that most could be dropped without compromising the program of the *BAA Meteor Section*; quite the contrary was found. The accuracy of the fundamental parameters—magnitude and shower association—improved. Telescopic observation is not easy and trying to remember or estimate too many properties only serves to degrade the critical ones. As a telescopic observer of only a decade's experience I humbly suggest that the Czechoslovakian team should concentrate on the main parameters.

Another unresolved matter is how the meteor's path is determined. Visually, the norm seems to be 4° orientation error [3,7]. However, the *BAA*, or more precisely, Prentice's method was capable of attaining a phenomenal tilt error of $0\overset{\circ}{.}7$ [8] in the hands of experienced observers. Telescopically, I use the Prentice method except that I cannot hold up a ruler or stretched string to overlay the path.

Simulations can help to assess plotting errors. I tried using Jaroslav Gerbos's simulation software on a PC in a darkened room. For forty meteors observed during two hours my rms orientation error was $1\overset{\circ}{.}4$. The apparent field of view is only 36° though the user interface to define the path is clumsy and certainly places a strain on the memory as a rubber-band cursor is used. My feeling was that I could have done better on some meteors had I been plotting on charts. On the other hand it was performed in comfortable conditions. These findings are in agreement with the experiments of the *AVWM*. [9]. An rms of 2–3° looks plausible for 50–60° fields. It would be interesting to know what errors the Czechoslovakian observers obtain using the same software.

Telescopic data have shown compact radiants for minor showers, for example the discovery of the 11 Canis Minorids where 8 of the 9 meteors passed within $4'$ at the radiant. [10] Now these may have been due to chance because the errors conspired to generate an apparently smaller radiant, though given the number of compact radiants I have seen in the telescopic records I very much doubt it. Analysis of recent data with *Radiant* yields radiant diameters (2–5°) commensurate with the smaller errors I maintain. Of course, the formal error is larger, since the anomalous plots are so errant they add to the chaotic background. It does not look like there is a normal distribution with orientation errors of about 10°—some of the minor radiants would be smeared out into the noise. Rejecting the abnormal outliers gives errors of about 3°.

In conclusion I should be happy to participate in a further investigation of positional accuracy, and would like to hear from any telescopic and video observers who would like to join in. There is an onus on me to show convincingly that my error values for the *BAA* method are valid. Even if they are not as wonderful as I claim, the Czechoslovakian group should consider how they might reduce their errors to be similar to naked-eye plotting. I should also like to know of simulation software that uses X-windows or GKS graphics (preferably written in C or Fortran), so that I can perform simulations using a 20-inch monitor giving a field of view comparable to my telescope's 52°.

[1] P. Pravec, J. Boček, "Precision of Telescopic Meteor Recordings—Plotting Errors and Recording Probabilities", *WGN* 20:2, April 1992, pp. 70–83.

[2] R. Koschack, "Analysis of Visual Plotting Accuracy and Sporadic Pollution and Consequences for Shower Association", *WGN* 19:6, December 1991, pp. 225–241.

[3] P. Pravec, J. Boček, "Statistical Results About the Precision of Telescopic Records of Meteors", *Proceedings of the International Meteor Conference 1991*, 1992, pp. 48–53.

[4] M.J. Currie, "Telescopic Meteors—Surely You are Not Serious?", *WGN* 17:5, October 1989, pp. 175–183.

[5] K.B. Hindley, *J. Brit. Astr. Assoc.* 79, 1969, pp. 391–397.

[6] K.B. Hindley, *BAA Meteor Section Bulletin* 7, 1969.

[7] F. Watson, E.M. Cook, "The Accuracy of Observations by Inexperienced Meteor Observers", *Pop. Astr.* 44, 1936, pp. 258–261.

[8] J.G. Porter, "An Analysis of British Meteor Data", *Mon. Not. R. Astr. Soc.* 103, 1943, pp. 134–153.

[9] D. Koschny, R. Egger, "The Simulation of Meteor Position Determinations", *Proceedings of the International Meteor Conference 1991*, 1992, pp. 40–47.

[10] K.B. Hindley, "The 11 Canis Minorid Meteor Stream", *J. Brit. Astr. Assoc.* 79, 1969, pp. 138–142.

Malcolm J. Currie, May 21, 1992

The reappearance of P/Swift-Tuttle

Below, José Trigo gives his reasons for thinking that we are lately encountering new material from the Perseids' parent comet.

Several circumstances suggest that new material participated in the first maximum of the 1991 Perseids:

- The solar longitude of the time for this maximum shows that a recent ejection of this cloud of meteoroids from the nucleus of Comet P/Swift-Tuttle lies within the possibilities.
- The activity detected in Japan and the former USSR in 1991 at solar longitude $\lambda_\odot = 139\overset{\circ}{.}56$ (2000.0) is very high and of short duration. This is an argument in favor of the presence of a very new and dense cloud of material.
- The visual ZHRs during the nights around the maximum in 1991 were very high.

- It is strange that the double Perseid maximum was suddenly detected in 1988, while former years only showed minor activity around the time of the new peak.

Also, the Perseids show different visual characteristics lately. In particular, variations in the photometric curve and some peculiar phenomena of a very high percentage of Perseids were reported:

- During the night of maximum, approximately 50% of the Perseids had a very persistent train. The difference with other days is spectacular, since the normal rate of trained Perseids is 25%.
- During the night of maximum approximately 1.5% of the Perseids showed an explosion. The difference with data from other years is evident, since the normal number of meteor explosions is between 1 and 3 per 1000.
- The photographic data of *SOMYCE* show a peculiar change in the photometric curve of the 1991 Perseids. Our data are in favor of a "leaked" path in several cases [1]. This phenomenon is also clearly present in the persistent trains.

E.N. Kramer has a very interesting comment in [2]:

> "It is possible to forward the following hypothesis. Various meteoric bodies of cometary origin contain inclusions that can, under certain conditions, lead to the explosion and fragmentation of the meteoroid. Such a fragmentation can occur both in the Earth's atmosphere (as in the case of the meteor of 1965) and outside its limits (as in the cases of hyperbolic orbits). These phenomena show that the inclusions must be sufficiently volatile."

This comment is in favor of the possibility of an increase in more recent Perseid particles containing significantly more volatile elements. For older meteoroids, the interaction with the solar wind (particles of high energy) must result in the loss of these volatile components and in the meteor fragmentation in particles of smaller mass. As a consequence, these data are in favor of the presence of new material from Swift-Tuttle.

During the August 12-13, 1991, between 21^h30^m and 4^h00^m UT the author observed 43 "bundles.". This number is very high for an activity of ZHR = 100, possibly indicating recent periodic ejections from the nucleus of Swift-Tuttle. During other years, a number of 3 bundles per hour is normal, but in 1991 the number of bundles detected lies much higher.

For the parent body, the uncertainty in the orbital elements is very high. I propose studying our orbital photographical data in order to determine the possible orbital differences between the old and new Perseid meteoroids. For that, our group has the necessary equipment to analyze the photographs obtained in August 1991 with reliable software for the computation of orbits.

In 1992, observers in Europe should examine whether a great activity is displayed at the time of the first—and new—maximum.

The work of all *IMO* groups during the next few years is essential in the study of the meteor characteristics in relation with the age of the particles. I propose to create stations for long basis studies, take data on the percentage of trained and exploded meteors and on the grouped apparitions. Also, I propose the use of video and photographic techniques in several stations to determine the photometric curves of the possibly new Perseids.

[1] Grishchenyuk A.I., Martynenko V.V., "The 1991 Perseids in the USSR", *WGN* 20:1, February 1992, pp. 41–42.

[2] Kramer E.N., "On the structure and chemical composition of meteor bodies of cometary origin", in *Physics and Dynamics of Meteors*, Kresak and Millman (eds.), pp. 236-238.

José M. Trigo, April 5, 1992

Comment by the Editor: While I cannot but agree that all the evidence is in favor of the Earth meeting "new" filaments of the Perseid stream, it must be emphasized that these filaments are not as new as some might think. If indeed the reappearance of P/Swift-Tuttle is scheduled for the fall, then by physical and geometrical considerations, it is virtually impossible that the Earth could already have encountered new ejecta from the Comet!

Send in your observations in time!

Around the time that you receive this journal the Report on the 1991 visual and fireball observations will be ready. Although 1991 set a record in the history of the *IMO*, it is unfortunate that a lot of 1991 observations could not be included into it, simply because some observing groups keep failing to observe deadlines.

It is the *IMO*'s task to give feed-back to the observers within a reasonable time lapse. This however is only possible if all observers cooperate by sending in their observations in time.

In the last issue, we asked you to return your 1992 Quadrantid observations before the end of June. If you have not done so yet, send them without any further delay! Your cooperation in this matter is greatly appreciated, as it allows us to make an early analysis of this shower with all data available.

International Meteor Organization

VISUAL METEOR TRAIN OBSERVING FORM

Date : ______ (year) ___ (month) ___ (day). Begin : ___ ^{h} ___ ^{m}. End : ___ ^{h} ___ ^{m} (UT)

Location IMO Code : ______ , Country : ____________ . Observer IMO Code : ________

Net observed time T eff = ____ ^{m} = ____ ^{h}. Average Lm = ____ , spread = ____ - ____

magnitude / train duration table. Shower IMO Code : ________ , number : ____

magnitude	-6	-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5	+6	Tot
meteors														
train 0.5 s														
1 s														
2 s														
3 s														
4 s														
5 s														
>5 s														
Total														
%														

specify events brighter than -6^m and/or exceeding 5 seconds duration :

magnitude : ___ duration ___ ___ ___ ___ ___ ___ ___ ___ circle those events

___ ___ ___ ___ ___ ___ ___ ___ ___ that were drifting

___ ___ ___ ___ ___ ___ ___ ___ ___

___ ___ ___ ___ ___ ___ ___ ___ ___

Are any drawings of drifting trains included ? : Yes / No (circle appropriate).

Sporadics and minor showers : list in format n x n^m of n^s (number, mag, duration)

shower : ______ trains ________________________________

______ ________________________________

______ ________________________________

______ ________________________________

______ ________________________________

______ ________________________________

______ ________________________________

______ ________________________________

A Request for Observations of Meteor Trains

Mark Vints

Within the *IMO*, there seems to be a lack of interest in meteor trains: everybody sees trains, but very few observers make a record, let alone report them. Nevertheless, there are some good reasons for spending more attention to meteor trains. Train data are usable in the study of the following:

- the variation of train percentages throughout a stream or within an outburst;
- the relative influences of creation and decay of ionization;
- changing ionospheric conditions;
- wind pattern in the meteor region;
- meteor train spectra; and
- the influence of weather conditions or observer skills.

Those who find the list above too concise are invited to read the transcript of my talk at the 1991 *IMC* in Potsdam [1].

The present request for observations of meteor trains is aimed primarily at visual observers. They should consistently record trains and afterwards report them to me on the observing form on the previous page. The general idea is to supplement the magnitude distribution with a train duration distribution for each of the magnitudes. "Off-scale" events can be specified separately. For sporadic meteors or minor showers, few trains are expected, and the lines at the bottom of the form should suffice for reporting train activities.

Given enough observers participate in the project, a database will be set up to collect the data and facilitate any research into the matter.

It would very much interest me to see some observers do binocular observations of trains. Probably the method is to have low-power wide-field binoculars ready to aim when a (bright) meteor is seen. It is unclear yet to what degree the gain in magnitude is compensated by the time lost while aiming. Certainly there will be much more drifting trains: I have seen this from my own (limited) experience. I would also like to get photographic or video observers into the project, but at the time I cannot give them any practical suggestions since I am unfamiliar with these techniques.

I encourage everybody wanting to receive or communicate useful comments to write me. Also, I have a few dozens of papers from the Meteor Library on matters relating to meteor trains (mostly physics). Finally, I wish to thank Ralf Koschack, Paul Roggemans, and, especially, Alastair McBeath for their comments.

[1] Vints M., "Meteor Trains", in *Proceedings of the 1991 IMC*, J. Rendtel and R. Arlt, eds., *IMO*, 1992, pp. 56–58.

Visual Observers' Notes: July–August 1992

Jeff Wood

1. Introduction

The months of July and August are the most consistently rich period of the year meteor-wise. Apart from the major showers, the δ-Aquarids and the Perseids, a host of minor streams and a high sporadic rate ensure that overall rates exceed 20 meteors per hour on a regular basis during this time. When it is considered that for northern hemisphere observers July and August occur during the summer holiday season, the warm nights with good rates and no work commitments make for exciting viewing. Table 1 below lists some of the more important showers that occur during July and August. Table 2 as usual shows the observing conditions moon-wise.

2. July Phoenicids

The July Phoenicids are fairly fast faint meteors which probably accounts for them being first detected by radio meteor techniques. Since this stream can only be observed from the southern hemisphere where it is winter, it has not been very well monitored to date. As the July Phoenicids are well placed for viewing moon-wise in 1992, southern hemisphere observers are therefore encouraged to make this a special project.

Table 1 – A list of some of the meteor showers to be seen in July–August 1992

Shower	Activity	Maximum		Radiant			Drift		V_∞	r	ZHR
		Date	$\lambda_\odot$	α	δ	Diam.	$\Delta\alpha$	$\Delta\delta$			
Pegasids	Jul 07–Jul 11	Jul 10	107.°7	340°	+15°	5°	+0.°8	+0.°2	70	3.0	8
Phoenicids (Jul)	Jun 24–Jul 18	Jul 15	112.°7	21°	−43°	7°	+1.°0	+0.°2	47	3.0	
Piscis Austrinids	Jul 09–Aug 17	Jul 29	125.°7	341°	−30°	5°	+1.°0	+0.°2	35	3.2	8
δ-Aquarids S	Jul 08–Aug 19	Jul 29	125.°7	339°	−16°	5°	Table 3		41	3.2	20
α-Capricornids	Jul 03–Aug 25	Jul 30	126.°7	307°	−10°	8°	Table 3		23	2.5	8
ι-Aquarids S	Jul 15–Aug 25	Aug 04	131.°7	333°	−15°	5°	Table 3		34	2.9	3
δ-Aquarids N	Jul 15–Aug 25	Aug 12	139.°7	326°	−05°	5°	Table 3		42	3.4	5
Perseids	Jul 17–Aug 24	Aug 12	139.°9	46°	+58°	5°	Table 3		59	2.6	95
κ-Cygnids	Aug 03–Aug 31	Aug 18	145.°7	286°	+59°	6°			25	3.0	5
ι-Aquarids N	Aug 11–Sep 20	Aug 21	147.°7	327°	−06°	5°	Table 3		31	3.2	3
π-Eridanids	Aug 20–Sep 05	Aug 29	155.°7	52°	−15°	6°	+0.°8	+0.°2	59	2.8	
α-Aurigids	Aug 24–Sep 05	Sep 01	158.°6	84°	+42°	5°	+1.°1	0.°0	66	2.5	15
Piscids S	Aug 15–Oct 14	Sep 21	177.°7	8°	00°	8°	+0.°9	+0.°2	26	3.0	3

Table 2 – Moonlight and observing conditions in July–August 1992.

Date	k	Date	k
Friday July 03	0.09+	Friday August 07	0.66+
Friday July 10	0.79+	Friday August 14	1.00−
Friday July 17	0.96−	Friday August 21	0.55−
Friday July 24	0.39−	Friday August 28	0.00−
Friday July 31	0.02+	Friday September 04	0.51+

New Moon:	June 30, July 29, August 28
First Quarter:	July 7, August 5, September 3
Full Moon:	July 14, August 13, September 12
Last Quarter:	June 23, July 22, August 21

3. Perseids

This shower is active from July 17 to August 24 and reaches a maximum ZHR of about 95 on August 12. Due to the Full Moon on August 13 observing conditions are most unfavorable. Useful observations are possible from July 19–August 9 and August 18–24 only. Therefore, the *IMO* encourages meteor workers to spend their observing time concentrating on the other July–August showers that are not moon-affected in 1992.

Nevertheless, European observers must do an effort to monitor the activity during the maximum night, and preferably also the night before and the night after, to see if the outburst witnessed by the Japanese last year recurs. This new Perseid peak, first detected by the IMO in the 1988 observations, is expected to occur on August 12, around 22^{h} *UT. While the Full Moon will yield correction factors that are probably too high for observations to be useful quantitatively, it is vital that we will at least be able to say in a qualitative manner whether or not last year's phenomenon happened again this year.*

4. Aquarids/Capricornids

This rather complex group of showers were subject to intense scrutiny during 1989 to 1991. The results of the *IMO* Aquarid project can be found elsewhere in this issue. Nevertheless, more data on this still too poorly covered complex are still required. The visual observing program requires a good observational experience and an observing site south of 45° N. Looking at Table 3, it is obvious that the observer has to look at a point between the radiants of the δ-Aquarids N and the ι-Aquarids S in order to distinguish meteors of these southern showers. This will be quite impossible for observers situated north of 45° N. Observations of this program should start only if the radiants have a sufficient altitude. If possible, two observers should look into the same field simultaneously. This could allow estimates of the accuracy of the data. Only meteors possibly radiating from the Aquarius/Capricornus-region should be plotted. It is necessary to consider the direction, trail length and angular velocity. All other meteors are counted only. Any Aquarids or Capricornids appearing outside the map's field are also counted after careful association to the radiants given in Table 3.

Table 3 – Radiant drifts for the α-Capricornids, the δ-Aquarids South and North, the ι-Aquarids South and North, and the Perseids.

Date	α-Cap		δ-Aqr S		δ-Aqr N		ι-Aqr S		ι-Aqr N		Per	
	α	δ	α	δ	α	δ	α	δ	α	δ	α	δ
Jul 05	290°	−14°	321°	−21°								
15	296°	−13°	329°	−19°	311°	−11°	310°	−19°			12°	+43°
25	303°	−11°	337°	−17°	321°	−09°	321°	−17°			24°	+49°
Aug 05	312°	−09°	345°	−15°	332°	−06°	335°	−15°			37°	+55°
15	318°	−06°	353°	−13°	342°	−04°	346°	−13°	322°	−06°	50°	+59°
25	324°	−04°			352°	−02°	356°	−11°	332°	−06°	63°	+61°
Sep 05									343°	−04°		
15									353°	−02°		

In doing so, we are able to calculate ZHRs based on the tabulated radiant positions, and to analyze the radiant position using the plotted meteor trails only. We want to draw the attention to the relationship between the angular velocity of shower meteors, the altitude of their beginning point h_b and the distance D between their end point and their radiant. This criterion is as important as the alignment and the trail length and has to be used carefully in the case of countings. For your convenience, the relationship between this quantities is repeated in Table 4. Your reports must include the following for each date:

1. copies of your *Atlas Brno* maps with the meteors plotted on them (X and Y coordinates should be measured with respect to the frame of the map), and
2. a report using the *IMO* Visual Observing Forms.

The shower association should be done at the desk using all criteria, including path length, position w.r.t. the radiant and angular velocity. For more details, we refer to [1].

5. Piscis Austrinids

This southern hemisphere shower is active from July 9 to August 17 and reaches a maximum ZHR of 5 to 10 meteors per hour on July 29. With favorable moon conditions in 1992, southern observers are encouraged to observe this shower as part of the Aquarid/Capricornids project. Observers should plot all Piscis Austrinids occurring on the part of the sky covered by the map and count those appearing outside the map's field after careful consideration of path length and angular velocities.

6. π-Eridanids

The π-Eridanids radiate out from the "Loop of Eridanus" during the latter part of August and early September. They reach maximum on August 29. Observations to date indicate that activity varies from year to year. At best they produce ZHRs of around 10 and at worst they are almost non-existent. π-Eridanids are fast meteors and they frequently produce trains. Observers should watch for these meteors in the pre-dawn hours when the radiant is high in the sky. They are best seen in the southern hemisphere. All π-Eridanids should be plotted.

7. κ-Cygnids

This shower is active from August 3 through to August 31 and reaches a maximum ZHR of 5 on August 18. The radiant position of $\alpha = 286°$ and $\delta = +59°$ is virtually constant throughout the activity period due to its proximity to the North Ecliptic Pole. Its diameter is 8°. For the period August 18 to 31 observers north of latitude 45° N should concentrate on the κ-Cygnids. The κ-Cygnids are noted for their slow moving often bright meteors. All possible shower members should be plotted. Observers should ensure that the center of their observing field is located at a distance less than 40° from the radiant.

8. α-Aurigids

The α-Aurigids are active from August 24 to September 5. They reach maximum on September 1. The α-Aurigids produce variable activity from year to year and urgently require attention from meteor workers in the northern hemisphere where they are best seen. The α-Aurigids are fast moving meteors comparable to the Perseids in speed. Intending observers should take into account that the radiant reaches it greatest elevation during the latter part of the night. At the maximum, the Moon is at New Moon phase and so there will be dark skies. Unless the α-Aurigid maximum exceeds a ZHR of 10, all possible shower members should be plotted. Observing fields should be centered no further than 40° from the radiant.

Reference

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Table 4 – Angular velocity (°/s) as a function of the altitude of the meteor's beginning point h_b and the distance D between the end point and the radiant for various values of a stream's geocentric velocity V_∞. H_b is the altitude of the meteor's beginning point above the Earth's surface.

	$V_\infty = 20$ km/s, $H_b = 100$ km					$V_\infty = 25$ km/s, $H_b = 100$ km				
	$h_b = 10°$	20°	40°	60°	90°	10°	20°	40°	60°	90°
$D = 5°$	0.2	0.3	0.6	0.9	1.0	0.2	0.4	0.8	1.1	1.3
10°	0.3	0.7	1.3	1.7	2.0	0.4	0.9	1.6	2.2	2.5
20°	0.7	1.3	2.5	3.4	3.9	0.9	1.7	3.2	4.3	4.9
40°	1.3	2.5	4.7	6.3	7.3	1.6	3.2	5.9	8.0	9.3
60°	1.7	3.4	6.3	8.5	9.8	2.2	4.3	8.0	11	13
90°	2.0	3.9	7.3	9.8	11	2.5	4.9	9.3	13	14

	$V_\infty = 30$ km/s, $H_b = 100$ km					$V_\infty = 35$ km/s, $H_b = 100$ km				
	$h_b = 10°$	20°	40°	60°	90°	10°	20°	40°	60°	90°
$D = 5°$	0.3	0.5	1.0	1.4	1.6	0.3	0.6	1.1	1.5	1.7
10°	0.5	1.1	2.0	2.7	3.1	0.6	1.2	2.2	3.0	3.4
20°	1.1	2.1	4.0	5.3	6.2	1.2	2.3	4.3	5.8	6.7
40°	2.0	4.0	7.4	10	12	2.2	4.3	8.2	11	13
60°	2.7	5.3	10	14	16	3.0	5.8	11	15	17
90°	3.1	6.2	12	16	18	3.4	6.7	13	17	20

	$V_\infty = 40$ km/s, $H_b = 100$ km					$V_\infty = 50$ km/s, $H_b = 110$ km				
	$h_b = 10°$	20°	40°	60°	90°	10°	20°	40°	60°	90°
$D = 5°$	0.3	0.7	1.3	1.7	2.0	0.4	0.8	1.5	2.0	2.3
10°	0.7	1.4	2.6	3.5	4.0	0.8	1.6	2.9	3.9	4.6
20°	1.4	2.7	5.0	6.8	7.9	1.6	3.1	5.8	7.8	9.0
40°	2.6	5.0	9.5	13	15	2.9	5.8	11	15	17
60°	3.5	6.8	13	17	20	3.9	7.8	15	20	23
90°	4.0	7.9	15	20	23	4.6	9.0	17	23	26

	$V_\infty = 60$ km/s, $H_b = 115$ km					$V_\infty = 66$ km/s, $H_b = 115$ km				
	$h_b = 10°$	20°	40°	60°	90°	10°	20°	40°	60°	90°
$D = 5°$	0.5	0.9	1.7	2.3	2.6	0.5	1.0	1.9	2.5	2.9
10°	0.9	1.8	3.4	4.5	5.2	1.0	2.0	3.7	5.0	5.8
20°	1.8	3.5	6.7	9.0	10	2.0	3.9	7.3	10	11
40°	3.7	6.7	13	17	20	3.7	7.3	14	18	21
60°	4.6	9.0	17	23	26	5.0	10	18	25	29
90°	5.3	10	20	26	30	5.8	11	21	29	33

	$V_\infty = 70$ km/s, $H_b = 126$ km				
	$h_b = 10°$	20°	40°	60°	90°
$D = 5°$	0.5	0.9	1.8	2.4	2.8
10°	1.0	1.9	3.6	4.8	5.5
20°	1.9	3.7	7.0	9.4	11
40°	3.6	7.0	13	18	21
60°	4.8	9.4	18	24	28
90°	5.5	11	21	28	32

Surveillance Needed of Possible Corvid Shower in Late June

Duncan Steel, Anglo-Australian Observatory

The Corvid meteor shower has been observed once only, by Cuno Hoffmeister from southern Africa in the last week of June 1937: he determined the radiant to be near $\alpha = 192°$, $\delta = -19°$ with a very low geocentric velocity of about 11 km/sec [1–3]. The radiant was diffuse (diameter almost 15°) so that, with only a poor radiant and velocity determination, the orbit of the responsible stream cannot be accurately calculated; note that one of Hoffmeister's orbit assessments was in any case incorrect [2]. However, it is clear that the orbital period is short, of the order of 4–30 years at most. Activity was first noted two days after Full Moon, on June 25, with some meteors being observed through to July 2–3; the peak ZHR on June 26 was 13.

The fact that this shower has been observed in one year only, and yet the orbital period is short, points towards this stream being recently-formed since otherwise the meteoroids would be spread around the orbit with an annual shower being observed. It would be of great utility if a plausible parent asteroid or comet were known, but to date no known objects show a convincing fit.

Hartung has suggested a rather novel origin for the shower [4]. He has put forward the suggestion that in June 1178 A.D. a large impact on the Moon, forming the Giordano Bruno Crater, ejected a large quantity of material into heliocentric orbits which may intersect the Earth with low geocentric velocities. He also calculates that the apparent radiant for such ejecta fits with the Corvid radiant observed by Hoffmeister. In addition it is noteworthy that this impact has been linked to the Taurid Complex [5–8].[1]

Returning to the Corvid shower and Hartung's hypothesis that it is due to ejecta thrown from the lunar surface in 1178 A.D., Hartung himself suggests how this hypothesis may be tested [4]. The gap in time between 1178 and 1937 is 759 years. If the Corvid meteoroids are a single small concentration in the stream orbit (so that a shower is not seen every year, but only in those years when the concentration is at the correct longitude in late June to intercept the Earth) then 759 must be the product of two integers, one representing the Corvid orbital period, the other the number of showers which occurred between 1178 and 1937. Possible factors of 759 are as follows: 3, 11, 23, 33, 69, and 253. The mechanism whereby a shower occurs in certain years only can then be imagined as being similar to that which causes meteor storms, such as the October Draconids (Giacobinids) or Leonids to recur in certain years only [12–17].

It seems clear that the factor 3 can be excluded: Corvid showers are apparently not observed every 3 years. If 11 were the period then showers should have been seen in 1948, 1959, 1970 and 1981, and it would be worthwhile to search back through the records to find whether any enhanced activity from Corvus occurred in the last week of June in those years. The next year in this progression, and thus the motivation for the present article, is 1992: Hartung encourages observers to make a special effort in the last week of this June to see whether a detectable Corvid shower recurs (he expects not). Using 23 years as the orbital period, showers in 1960 and 1983 would have been expected, the next being in 2006 (as for a 69 year period); and for 33 years, showers in 1970 and 2003 (as for the 11 year period) would be anticipated. Again, searches through observation records are warranted.

The low geocentric velocity estimated by Hoffmeister for the Corvids argues against a long period for the shower, so that the 11-, 23-, or at most 33-year periods are favored; the 69- and 253-year periods seem improbable. Data collection by observers in the southern hemisphere, or at suitably-low northern latitudes, are to be encouraged in late June of this year: a null result, if obtained, would be of scientific interest since this would exclude the possible 11 year periodicity.

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Telescopic Observers' Notes, July–August 1992

Malcolm J. Currie

Few reports have been received during the first quarter of 1992. I myself was able to make a few post-midnight watches (19.5×127 mm, 2°6 field) during February's atypically clear nights. Rates were better than I expected—around 10 per hour—totaling 73 meteors. A cursory analysis indicated Virginid activity (0.2 sporadic) on February 28-29. Michael Nolle recently sent me his 1991 data. On March 12-13, 1991, in two watches either side of midnight, 5 out of 14 meteors were probably Virginids. These rates are typical of earlier years and somewhat higher than found visually by the Tenerife group [1]. On February 9-10, 1992, over a quarter of the meteors appeared to come from a diffuse area around $\alpha = 255°$, $\delta = +40°$ seen from three fields. It is far too premature to say there is a shower present; what was observed may merely be the concentration of sporadic background between the apex and the zenith. The charts have yet to be measured.

July marks the start of the traditional meteor-watching season in the north. The warm nights, vacations, and climbing sporadic rates coupled with activity from major and many minor showers should encourage the telescopic observer to brush off the cobwebs from his binoculars.

This year, moonlight interferes with the peak of the Perseids and the α-Lyrids, therefore during the period I should like telescopic watchers to direct their energy towards the *Capricornid-Aquarid* complex. Its constituent showers are rich in faint meteors. Already, we have positional data in recent years showing that the activity is indeed complex, and that more data are needed to make the conclusions statistically valid [2]. It will be fascinating to compare the distribution of radiants through the activity period, with that seen by visual watchers presented elsewhere in this issue. Careful plotting of the meteor paths is the only way to resolve the components. To be confident that a radiant exists and is not an artifact of the geometry, it is important that a radiant is "seen" in at least three field centers. Therefore, I shall not prescribe field centers, suffice to say that they should lie in the area $\alpha = 250°$–$10°$, $\delta = +05°$–$20°$, and be separated by 20°–30°. Observers in Australia and South America might prefer $\delta = -25° - -40°$. Try to observe from at least three centers during a night.

Whilest investigating the southern showers it is also possible to gather data on northern minor showers. Looking at 1989 [2], and Mark Vints's 1991 data with *Radiant*, it is evident that sporadic meteors dominate, and minor radiants barely protrude above this noise. A number of radiants were detected around August 3–5, but these do not tally with those reported by Znojil [3] from two decades earlier. Regular monitoring and statistical analyses should indicate the genuine showers. Observers are requested to record the apparent angular speed on a 1 (slowest) to 5 (fastest) scale, or in degrees per second. This information helps to discriminate between showers.

Although having a population index as low as 2.5, the *α-Aurigids* are evident at telescopic magnitudes from the end of August to early September. They are swift moving and therefore it is best to look in the direction of Perseus and Camelopardus to reduce the angular speed. The radiant is low in the north-east until after midnight, so watches to dawn are required. The aims are to find the radiant size and motion. The *π-Eridanids* are also a feature of the end of August to the naked eye, though they are somewhat erratic. However, I have no record of telescopic activity from this shower. So it is worth checking, especially for those in the southern hemisphere.

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Progress in Meteor Science

Articles in this section have been formally refereed by at least one professional and one experienced, knowledgeable amateur meteor worker, and deal with global analyses of meteor data, methods for meteor observing and data reduction, observations with professional equipment, or theoretical studies.

Results of the IMO Aquarid Project

Rainer Arlt, Ralf Koschack, and Jürgen Rendtel

The *IMO* Aquarid Project was set up in 1989 to find out to which extent visual observations could contribute to our knowledge of the radiant structure of the minor summer showers in Aquarius and Capricornus, and determine the ramifications of the results for the method by which complex showers are observed. During this three-year project, 4989 visual meteor plots were obtained, mainly from mid-northern latitudes.

First, the method used for radiant determination is presented and discussed. It is shown that the angular velocity is an essential criterion for radiant determination and separation of radiant-complex components. In particular, the radiant positions of the α-Capricornids, the Northern and Southern δ-Aquarids, and the Northern and Southern ι-Aquarids were investigated. Usable results have been obtained for the α-Capricornids and the Northern δ- and ι-Aquarids. The α-Capricornids show a distinct although diffuse radiant, while the various Aquarid radiants are detectable mainly around their activity maxima. Finally, the meteor activity towards the end of August from a radiant position that fits the Northern δ-Aquarids as well as the Southern Piscids must be associated with the latter when considering its prominence under the criteria developed and tested here.

1. Introduction

The problem of identifying genuine radiants has been a controversial issue ever since radiants were shown to be the terrestrial perspective of a meteor stream. In the introduction to his "General Catalogue" Denning [1] points out that "there are considerably more than 50 showers in play on any and every night of the year." This statement is, in its consequences, almost equivalent to the opposite—an isotropic distribution of meteor trails [2].

In 1989, observers were invited to participate in an observing project of the minor summer showers in Aquarius and Capricornus in order to shed more light on the actual radiant structure of this complex. More concretely, the aims of the Aquarid Project were as follows:

1. to find out whether visual observing is suitable for distinguishing the various Aquarid components;
2. if so, to determine the positions and the drifts of the individual radiants; and
3. to derive guidelines for observing meteor shower complexes and analyzing the observations.

So, rather than searching for unknown radiants, we had to verify meteor shower radiants with known parameters. Table 1 gives these parameters as they appear in the *IMO* working list (e.g., [3], p. 9–11).

Table 1 – The investigated showers according to the *IMO* 1992 Meteor Shower Calendar [3]. Activity period, radiant position at maximum, and entry velocity are given.

Shower	Activity period	Max.	α	δ	v_∞
α-Capricornids	Jul 03–Aug 25	Jul 30	307°	−10°	23 km/s
δ-Aquarids N	Jul 15–Aug 25	Aug 12	326°	−05°	42 km/s
δ-Aquarids S	Jul 08–Aug 19	Jul 29	339°	−16°	41 km/s
ι-Aquarids N	Aug 11–Sep 20	Aug 21	327°	−06°	31 km/s
ι-Aquarids S	Jul 15–Aug 25	Aug 04	333°	−15°	34 km/s

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WGN, the Journal of the International Meteor Organization, Vol. 20, No. 3, June 1992, pp. 114–135.

Three years after the start of the Project, the positional database of the *IMO* contains the coordinates of 4989 meteors recorded for this purpose in 1989, 1990, and 1991, covering the period July 14–August 28. The data were contributed by the following observers (for each observer, country—B = Belgium; BG = Bulgaria; D = Germany; E = Spain; USA = United States, *IMO* code, and number of plotted meteors are given):

> Petja Andonova (BG, ANDPE, 115), Rainer Arlt (D, ARLRA, 315), Luis R. Bellot (E, BELLU, 85), Ragnar Bödefeld (D, BODRA, 13), Koen Clement (B, CLEKO, 10), Sabine Clement (B, CLESA, 3), Albert de Clerck (B, DE AL, 12), Carl de Pooter (B, DE CA, 10), Victor Gonzalez (E, GONVI, 108), Michail Ivanov (BG, IVAMI, 169), Eva Ivanova (BG, IVAEV, 7), Mark Kidger (E, KIDMA, 74), André Knöfel (D, KNOAN, 21), Ralf Koschack (D, KOSRA, 1951), Petr Lozanov (BG, LOZPE, 105), Julian Markov (BG, MARJU, 19), Vladimir Petrov (BG, PETVL, 59), Dulce Plasencia (E, PLADU, 13), Ina Rendtel (D, RENIN, 644), Jürgen Rendtel (D, RENJU, 429), Petra Rendtel (D, BALPE, 46), Paul Roggemans (B, ROGPA, 407), Ulrich Sperberg (D, SPEUL, 20), Plamen Stefanov (BG, STEPL, 209), Richard Taibi (USA, TAIRI, 45), Pierre van Mechelen (B, VANPI, 2), Daniel Verde (E, VERDA, 9), Mark Vints (B, VINMA, 80), Jean-Marc Wislez (B, WISJE, 6).

In order to be able to efficiently determine radiants from these positional data, we developed the program *Radiant* [4]. Despite the automatization, it turned out that a correct interpretation of the displays generated by this program requires some experience on the part of the user.

This paper is organized as follows. In Section 2, we briefly describe the analyzing method and its chief tool, the program *Radiant*. In particular, we explain how this program takes into account radiant drift, plotting errors, and the meteors' angular velocities. The section concludes with a discussion of some of the problems that may arise when interpreting the displays generated by *Radiant*. In Section 3, the radiant structure and the radiant drift of the α-Capricornids are investigated. Section 4 discusses the activity of the Aquarid radiants up to roughly mid-August. Meaningful results were only obtained for the Northern δ-Aquarids. For the latter half of August, only data from 1990 were available. These data are studied in Section 5. In the first week of this period, the Northern ι-Aquarids are clearly active, while no sign of the Northern δ-Aquarids is present. It is argued that another radiant active around August 23–24 must be associated with early Southern Piscid activity. Finally, the Conclusions summarize the most important consequences of this study for similar analyses in the future.

2. Description and discussion of the analyzing method

There are several methods for radiant determination, the simplest of which were proposed during the last century.

In one such method, radiants are defined by backward prolongations of a few meteors that intersect each other within a small area in the sky. For this purpose, plots obtained during different nights were often put together. However, this method gave rise to giant lists of radiants, most of which turned out to be spurious.

Prentice tried to overcome this problem by using only meteors observed simultaneously from two sites [5]. Unfortunately, the sample becomes quite small due to this restriction, while the plotting errors remain the same. Therefore, Prentice's method led to uncertain radiant positions and sizes.

Hoffmeister [6] returned to single-station meteors and developed a statistical method for detecting a radiant. He called the number of backwards prolongations intersecting a field of 3° diameter its "degree of convergence." These degrees of convergence follow a certain distribution if meteors are distributed homogeneously. If there is a radiant, however, the number of convergences of a higher degree will increase while the number of convergences of a lower degree will decrease.

Essentially, the *Radiant* program is based on Hoffmeister's method. The program divides the relevant portion of the sky into fields of equal size, called *pixels*, and computes the backward prolongations of meteor trails relative to these fields. The computations result in a matrix of so-called *densities*, yielding the numbers of backward prolongations incident upon each field. As these densities can be regarded as weights in the process of radiant determination, we introduced in [4] the quantity

$$z = \frac{p-a}{\sigma},$$

where p is the peak density of a potential radiant (central area), a the average density of all pixels in the display, and σ the scatter of these values. The value z measures the distinctness of the radiant under consideration and will henceforth be called its *prominence*. Of course, the prominence criterion should be applied with great care, especially in the case of double or multiple radiants of different strengths being present in the same display. For these instances, the *Radiant* program allows the exclusion of the dominant radiant area, and the calculation of the prominence of the weaker radiant area relative to its surroundings. In our experience so far, a value of $z \geq 2$ is generally required for an interpretable radiant. Some exceptions to this rough rule will be discussed later.

In order to allow superposition of displays obtained from successive observations, we have to consider the radiant drift. As the radiant is nearly parallel to the ecliptic, we simply reduce the meteor's ecliptical longitude to a reference solar longitude λ_{ref} (cfr. [3]) by applying a longitudinal shift

$$\Delta\lambda = 1.01456 m_d(\lambda_{\mathrm{ref}} - \lambda_{\mathrm{met}}),$$

where m_d is the daily motion of the radiant in ecliptical longitude and λ_{met} is the solar longitude at the time of meteor's appearance. Conversely, the radiant coordinates in the displays need to be recalculated from their reference values to the actual solar longitudes. Only then will the radiant drift become obvious, for otherwise the radiant will remain at a fixed position if the assumed drift is correct. This last property also allows for determining the correct drift in those instances where there is a distinct center of radiation.

Rather than applying Hoffmeister's backward prolongation scheme naively, the program *Radiant* takes into account two important parameters: plotting errors and the meteors' angular velocities. Due to plotting errors, the radiant need not lie on the backward prolongation of the meteor trail *exactly*. Relative to the entry velocity of the shower under investigation, a meteor's angular velocity restricts the section of its backward prolongation on which the meteor's radiant can occur.

First, we consider plotting errors. Recent investigations [7] have shown that plotting errors are random and thus can be fitted well by a Gaussian distribution. Therefore, the plotting accuracy is taken into consideration by smearing out the backward prolongations using a Gaussian profile. Hence, each meteor causes a wedge-shaped area of more or less probable "radiants." Each cross-section through this area perpendicular to the meteor's prolongation is a Gaussian distribution with a standard deviation depending on the cross-section's distance to the starting point of the meteor. This relationship has also been investigated in [7].

Clearly, plotting errors are of minor importance in the case of short trails close to their common radiant as all relevant cross-sections have steep Gaussian profiles. Poorly distributed meteors, however, can cause undesired artifacts. A number of weakly diverging paths, for example, tend to drag the highest density toward their starting points, as the Gaussian distributions have higher maxima in this area. Fortunately, this effect can strongly be reduced by also considering the meteors' angular velocities.

Provided it is estimated in absolute figures (i.e., degrees per second), the angular velocity of a meteor allows the calculation of the position along the backward prolongation where the radiant is most likely to be relative to the entry velocity of the shower meteors into the Earth's atmosphere. The errors on the angular velocity estimates are taken into account by assuming a Gaussian distribution [7]. Rather than by giving absolute figures, some observers estimate angular velocities on a subjective, discrete scale. The analysis, however, proved the conversion of velocity steps to degrees per second impossible.

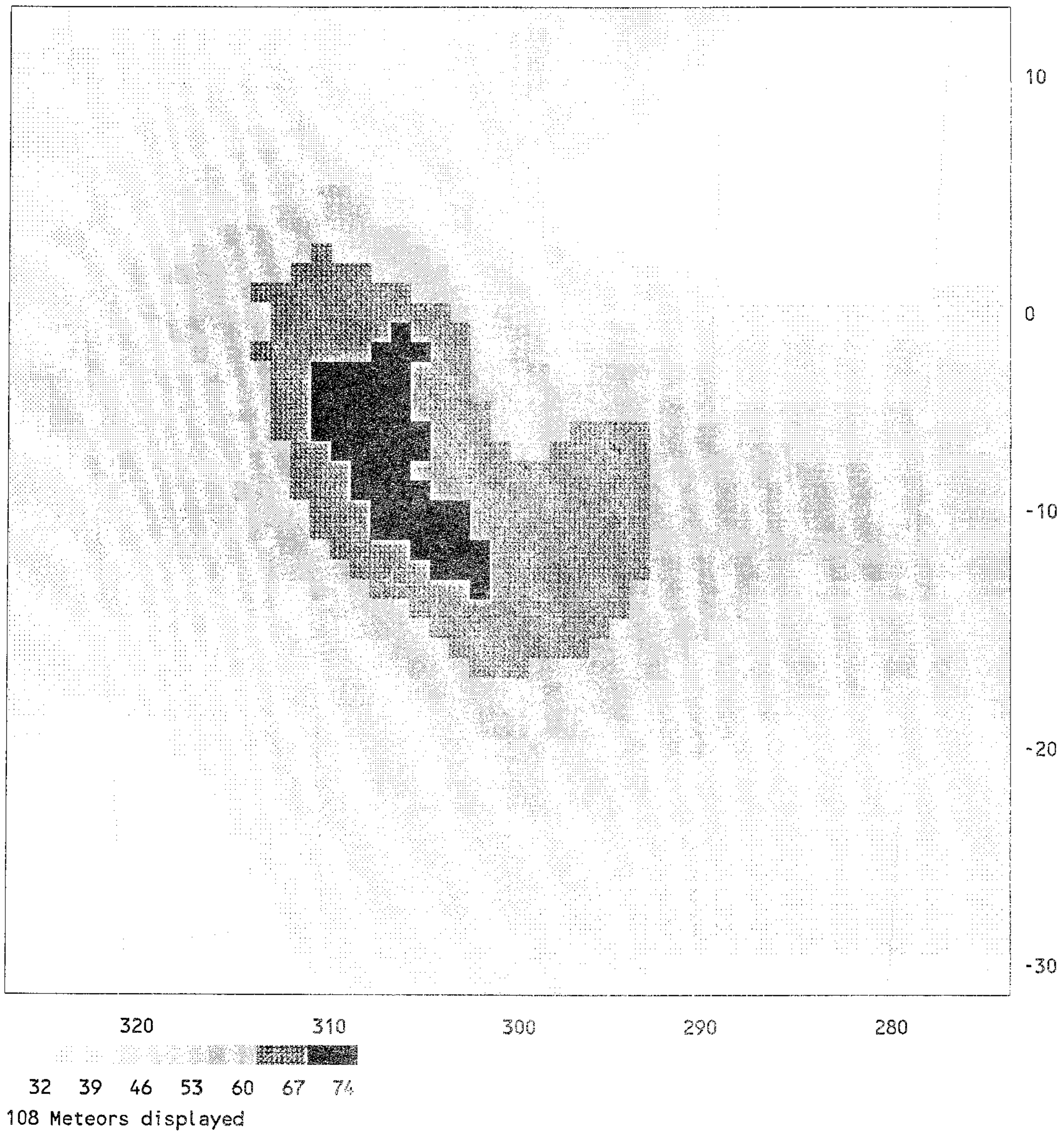

Figure 1 – Radiant area of the α-Capricornids obtained by taking into account the angular velocity criterion with $v_\infty = 23$ km/s. Period July 21–30, $\lambda_{\text{ref}} = 122°$. Mean radiant position referring to July 26 ($\lambda_\odot = 123°$): $\alpha = 303°$, $\delta = -09°$; $\lambda = 303°$, $\beta = +10°$; $z = 2.3$. The dotted grid shows equatorial coordinates.

The necessity of taking into account angular velocities becomes obvious in the case of the α-Capricornids, which have a low entry velocity of 23 km/s. If angular velocities are taken into account, a distinctive radiation area is found (Figure 1). If, on the other hand, the angular velocity criterion is not included, which comes down to naively tracing back the meteor trails, the α-Capricornid radiant has disappeared, while a new area of higher density has emerged at the left edge of the display (Figure 2). The large number of meteors in the part of the sky under investigation does indeed represent a whole mixture of angular velocities and path lengths, causing the artifact described above.

For a good understanding of the results of the analysis, it must be emphasized that meteors were *not* pre-selected using the observer's shower association, for an obvious reason: the pre-selection is bound to reproduce the pre-assumed radiant without providing any insight into the prominence of that radiant relative to its surroundings. Thus the displays generated in this analysis include the sporadic pollution, and suffer from the loss due to plotting errors. Consequently, a radiant cannot be expected to appear as a point-like feature. Rather, it will show up as an area with a certain width depending mainly on the number of meteors and the distribution of their trails.

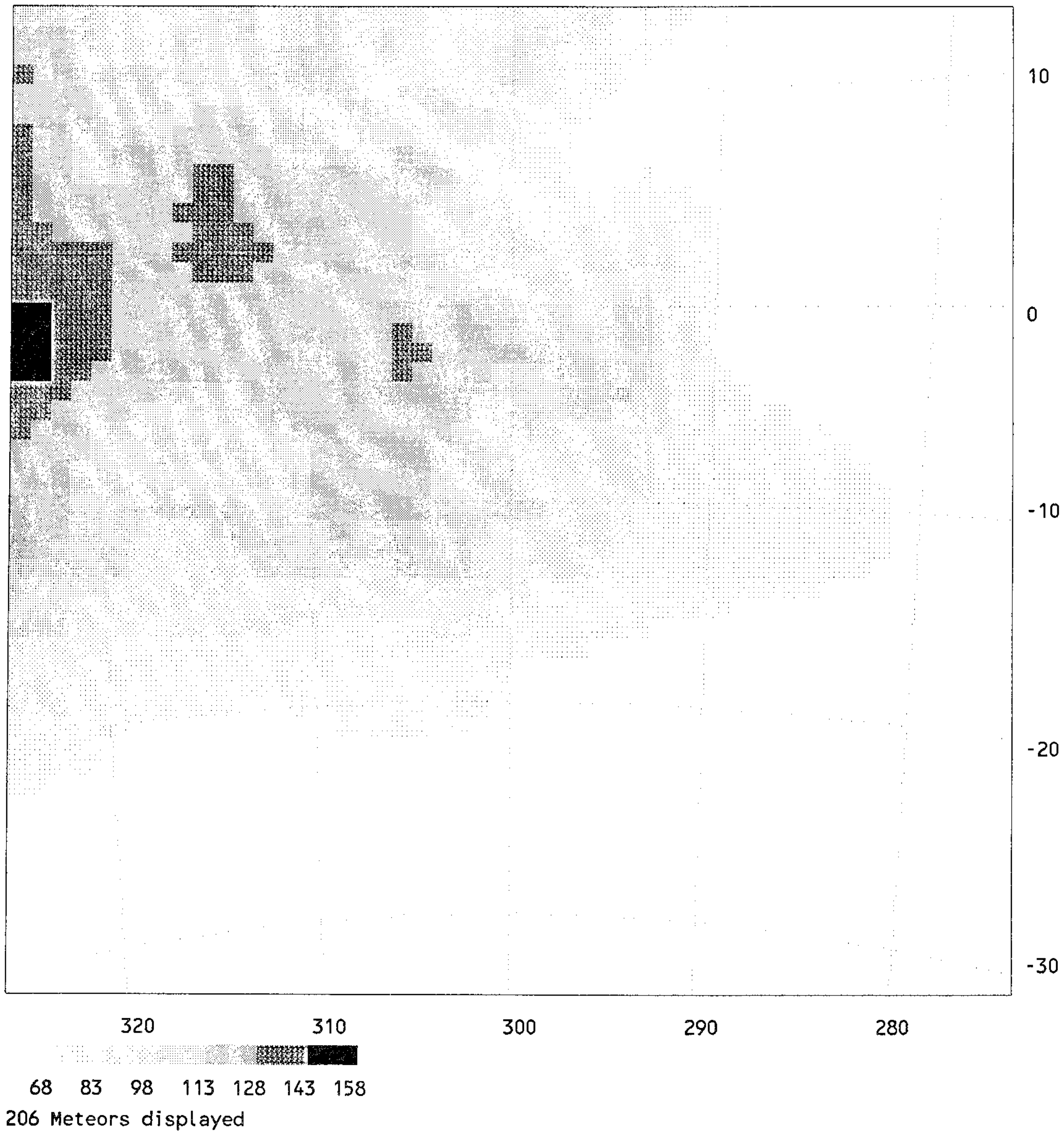

Figure 2 – The same display as in Figure 1, but without taking into account the angular velocity criterion (whence meteor plots without velocity estimates were used). The distinct α-Capricornid radiant of Figure 1 has vanished. The local peak corresponding the most to the radiant in Figure 1 has prominence $z = 1.8$ and cannot be interpreted as a radiant as it hardly stands out of the very "noisy" background. The peak near the edge of the display is an artifact caused by the backward prolongations of non-Capricornids passing east of the area.

For clarity's sake, the lowest densities (less than 20% of the peak values) are not shown in the print-outs, as the corresponding pixels do not contain any valuable information regarding radiants.

A nice example of a sharp, isolated, and undisturbed radiant is given by the Perseids (Figure 3). In this case the observers plotted all meteors that may have originated from an area of about 20°–25° around the Perseid radiant. Therefore, the sample certainly contains a lot of non-Perseids. The substantial number of Perseids in the sample and the high entry velocity of the Perseid meteors are responsible for a well-defined, circular radiant. It is interesting to note that, in accordance with photographic results, there is no indication whatsoever of sub-radiants or, for that matter, any other sub-structure within the Perseid radiant. The position of the radiant center is also in good agreement with the results of other observations [8].

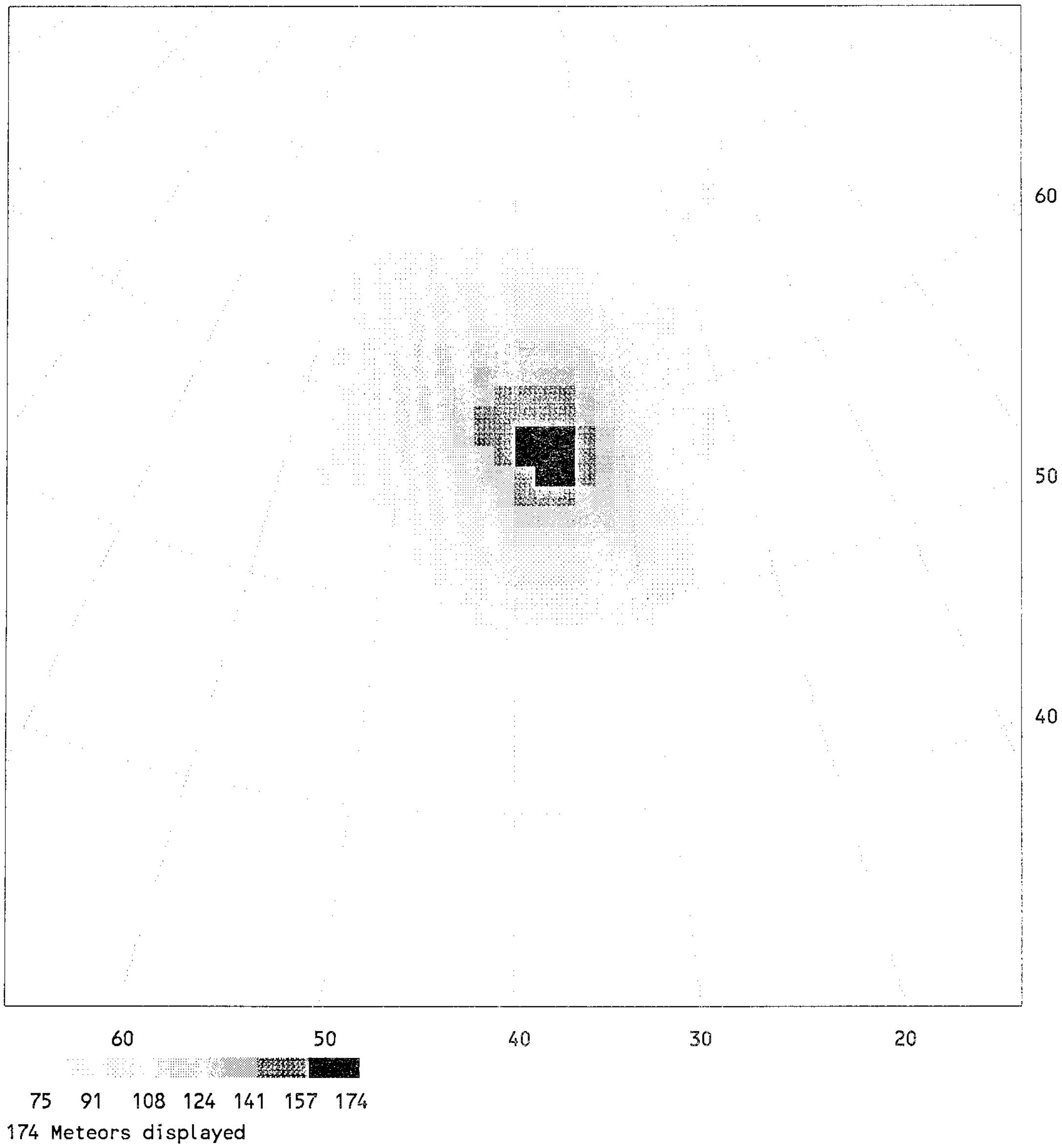

Figure 3 – The Perseids visually observed from Mount Rozhen (Bulgaria) between August 5 and 9, 1991 ($\lambda_{\text{ref}} = 134°$), yield a very distinct circular radiant without any structure. It is the result of a nearly point-like source which is smeared out by random plotting errors as shown in [7]. Radiant position referring to August 06 ($\lambda_{\odot} = 134°$): $\alpha = 38°$, $\delta = +57°$; $z = 4.9$.

The Aquarids, on the other hand, are not located in such an isolated position in the sky: several radiants are active at the same time. They have only slightly different entry velocities, but their activity varies during the period under study. Therefore, radiants are superimposed and sometimes difficult to separate, especially if the weaker radiant only appears as a shoulder of the stronger radiant (Figure 4, middle).

There are definitely some similarities between the separation of close components of double stars or the separation of superimposed spectral lines and the separation of multiple radiants as in Figure 4.

In the case of spectral lines, the so-called *Sparrow criterion* requires a dip in the intensity I along the spectrum, e.g., there is a point for which

$$\frac{\mathrm{d}I}{\mathrm{d}x} = 0, \quad \frac{\mathrm{d}^2 I}{\mathrm{d}x^2} > 0.$$

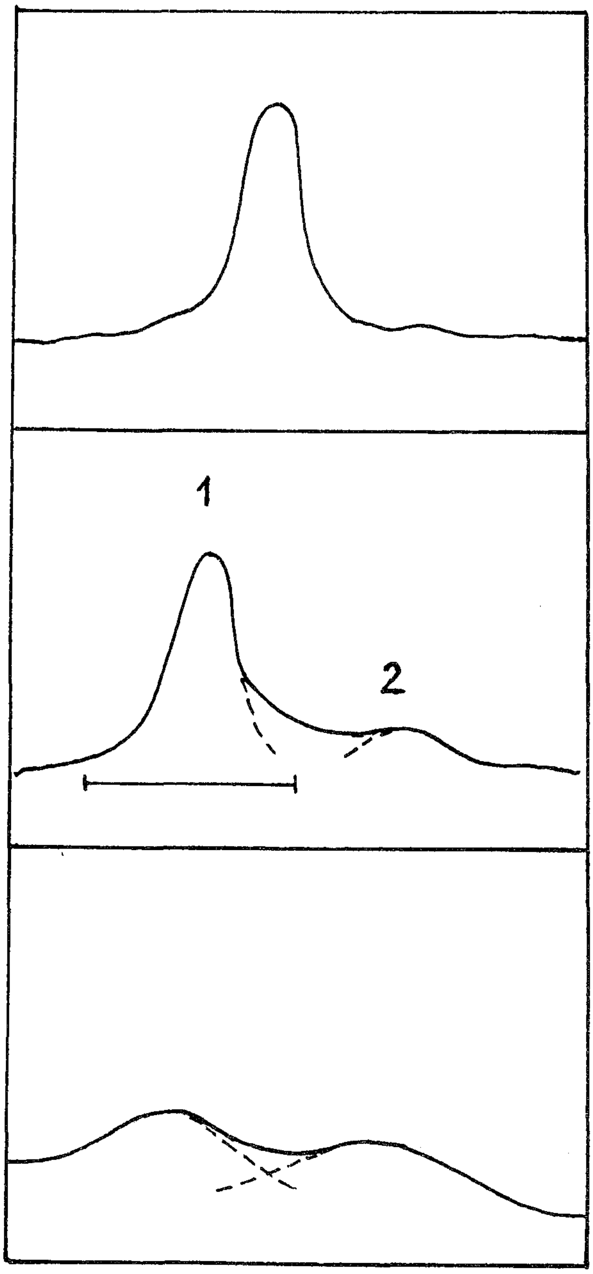

Figure 4 – When radiant areas are close together, the weaker ones may be hard to detect. This is especially the case if a radiant with low activity is located near a radiant with high activity and comparable entry velocity *(top)*. In all diagrams, the x-axis represents the position, and the y-axis the density. The *Radiant* program allows one to cut out a certain area (the bar in the *middle* diagram), and to determine the prominence against the remaining background. In the example, the "disturbing" peak no. 1 is eliminated, allowing the calculation of the prominence of the weaker radiant no. 2, nearly invisible in the top diagram. A more general solution for separating close radiants could be a fit of the profiles with Gaussians obtained from their outer sides *(bottom)*.

Applying this criterion to our two-dimensional display, we could consider pairs of expected centers and check whether there is a density dip in between. If the cross-section of a radiant may be considered as having a Gaussian profile, the outer sides of the superimposed profile might be fitted by a Gaussian profile the locations of their peaks being potential radiants. However, this is only a supposition, and it has to be checked whether additional error sources might prevent this procedure from being applicable. Any interpretation must be made very carefully bearing in mind all kinds of plotting errors involved.

Finally, in order to obtain good results, it is important that the sample contains meteor trails in all directions from the radiant. Unfortunately, this requirement is only partially fulfilled in our sample as the number of meteors observed south of 30° northern latitude is negligible. Some 90% of the data were obtained from sites located between 40° and 45° N. Therefore all statements regarding the prominence and detectability of radiants are valid for observations in this latitude range only (i.e., for certain maximum radiant elevations, and thus a decreasing number of shower meteors for more southern radiants and a smaller ratio to the non-shower meteors). Observers from more southern sites may easily gather a larger sample which should lead to different displays, presumably showing higher prominence of the southernmost radiants.

3. The α-Capricornids

We first consider the radiant structure. From July 21 onwards there are enough data available to allow one to perform a meaningful analysis. Nevertheless it was necessary to summarize the data of the period July 21–30 to obtain an interpretable display . Figure 1 shows the radiant for this period distinctly though rather diffuse, as is confirmed by the rather low prominence $z = 2.3$.

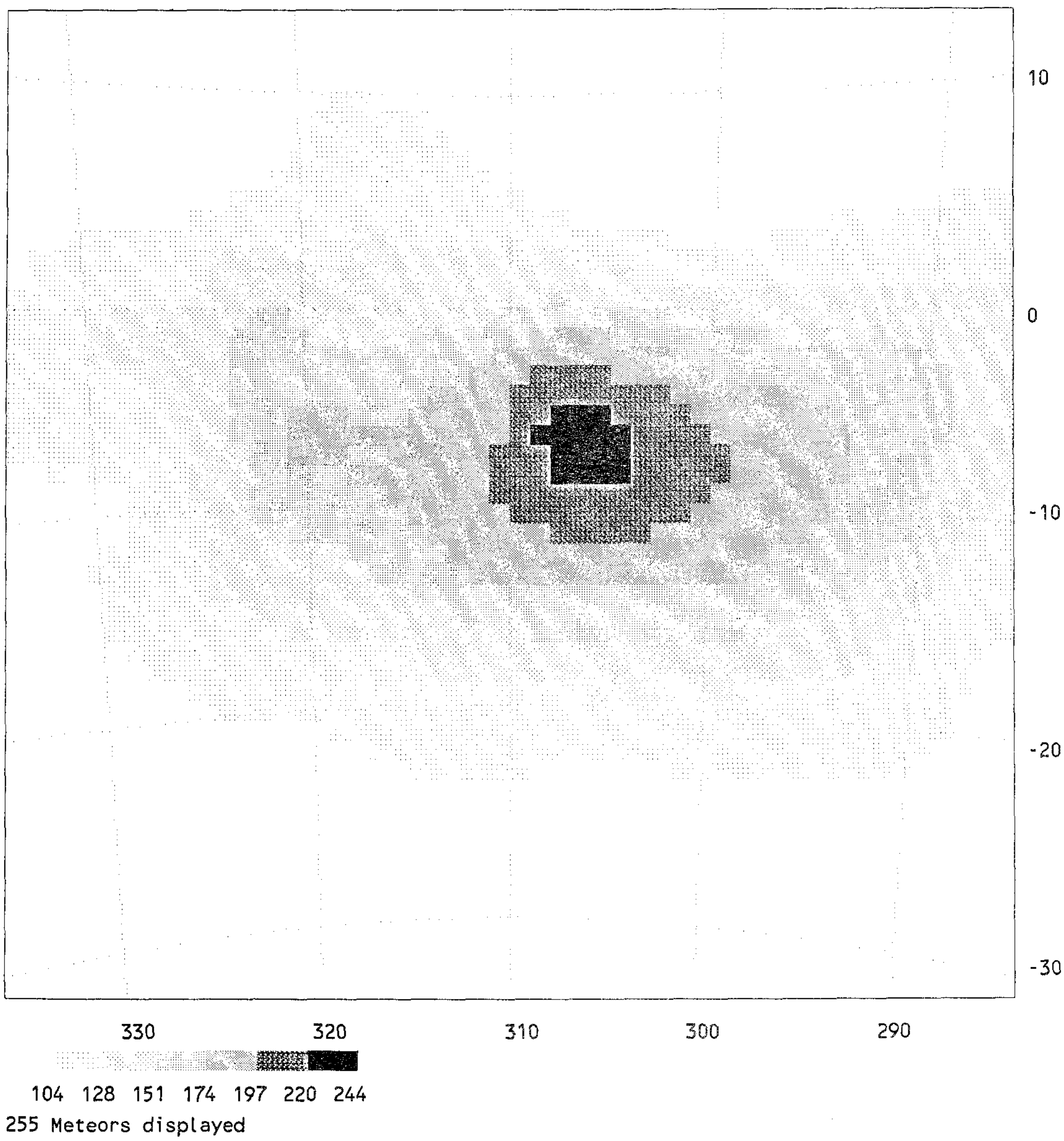

Figure 5 – Density distribution computed with $v_\infty = 23$ km/s. Period August 2–3, $\lambda_{\text{ref}} = 128°$. Radiant position of the α-Capricornids referring to August 3 ($\lambda_\odot = 130\overset{\circ}{.}5$): $\alpha = 308°$, $\delta = -07°$; $\lambda = 309°$, $\beta = +12°$; $z = 3.0$.

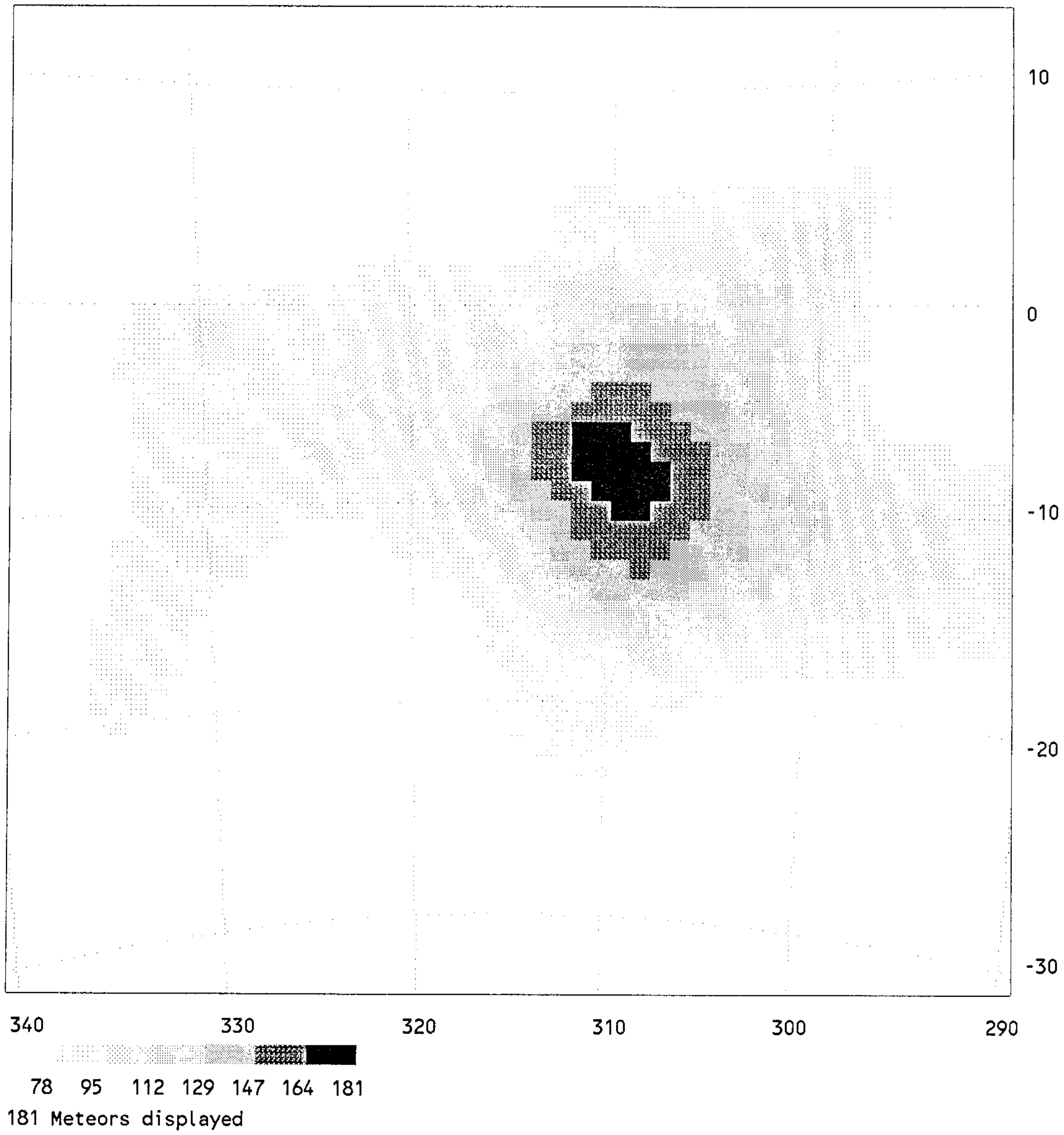

Figure 6 – Density distribution computed with $v_\infty = 23$ km/s Period August 6, $\lambda_{\text{ref}} = 133°$. Radiant position of the α-Capricornids referring to August 6 ($\lambda_\odot = 134°$): $\alpha = 308°$, $\delta = -09°$; $\lambda = 311°$, $\beta = +09\overset{\circ}{.}5$; $z = 3.6$.

As the α-Capricornid radiant is isolated, i.e., there are no disturbing radiants its vicinity, the shower meteors can be well-separated from other meteors.

Figures 5 and 6 were chosen from a larger number of similar displays to show the evolution of the radiant during the first week of August. It is still isolated and becomes more and more prominent. Cook's list [9] gives the radiant position for the visual maximum ($\lambda_\odot = 128°$) as $\alpha = 308°$, $\delta = -10°$. The differences with our results are negligible.

Table 2 – Evolution of the prominence z of the α-Capricornid radiant.

Period	z	Period	z
Jul 21–30	2.0	Aug 02–03	3.0
Jul 31–32	2.3	Aug 06	3.6
		Aug 08–10	2.5

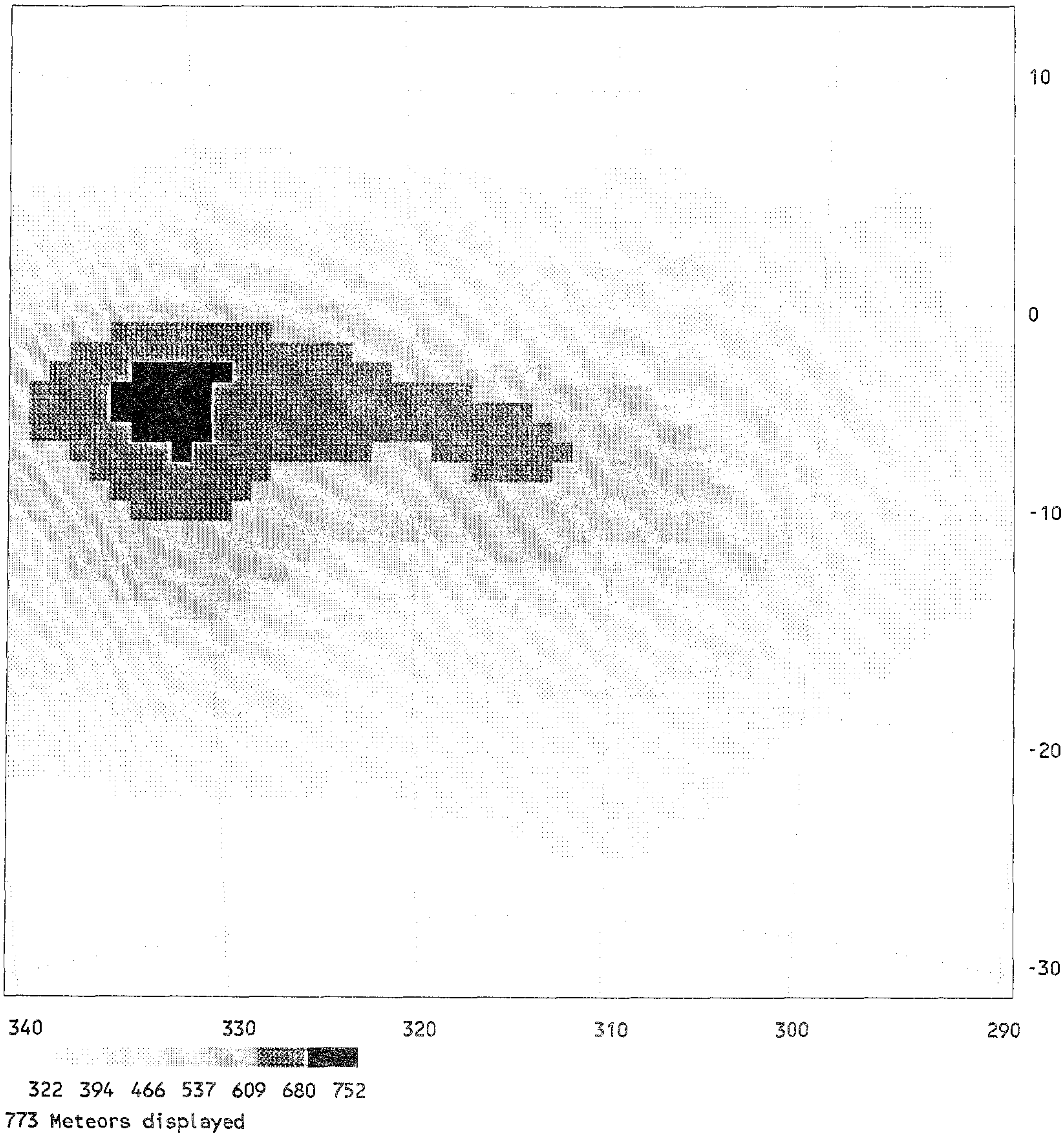

Figure 7 – Density distribution computed with $v_\infty = 23$ km/s. Period August 8–10, $\lambda_{ref} = 133°$. Radiant position of the α-Capricornids referring to August 9 ($\lambda_\odot = 137°$): $\alpha = 318°$, $\delta = -08°$; $\lambda = 320°$, $\beta = +10°$; $z = 2.5$ (excluding the area $\alpha \geq 322°$).

In the second week of August, the picture changes completely. During the period August 8–10, the area dominating the display (Figure 7) must probably be interpreted as the Northern δ-Aquarid radiant. Only its slight extension to the west might be identified with the weak α-Capricornid radiant.

In order to check this, we re-computed the display with a higher entry velocity ($v_\infty = 32$ km/s). While the extension to the west remained visible, it became less prominent. Hence, the weaker radiant is more likely to be caused by meteors with $v_\infty = 23$ km/s rather than by meteors with $v_\infty = 32$ km/s.

The profile of Figure 8 shows details not visible in the displays due to the limited number of grey-steps. In the profile for $v_\infty = 23$ km/s, there is some kind of plateau for $\alpha = 316°–321°$ followed by a weak dip at $\alpha = 322°$ and a strong increase towards the Northern δ-Aquarid-radiant. In the profile for $v_\infty = 32$ km/s, the increase towards the radiant of the Northern δ-Aquarids is rather steady. From this comparison we must conclude that the plateau in the first profile is to be identified as the α-Capricornid radiant. Moreover, it follows that this radiant can be distinguished from the Northern δ-Aquarids if the angular velocity is estimated *in absolute figures* (i.e., in degrees per second).

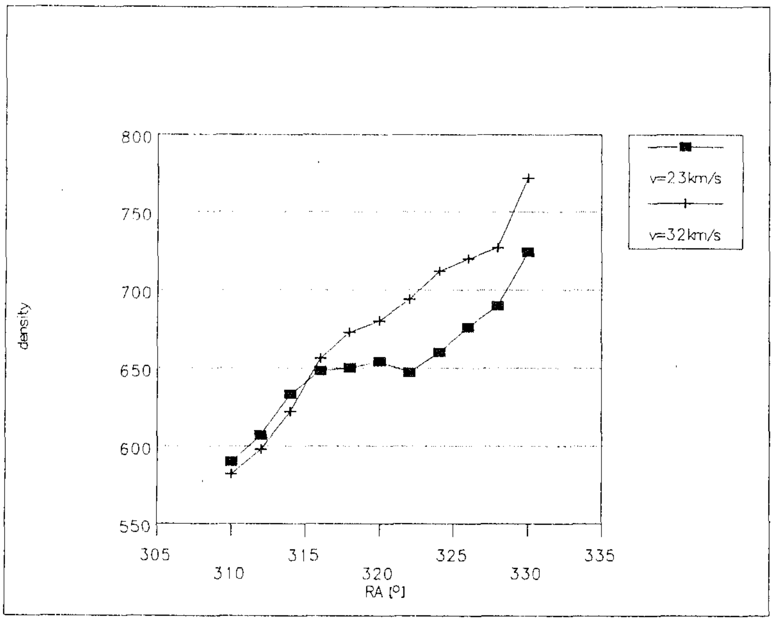

Figure 8 – Density distribution profiles of the *Radiant* displays along $\delta = -05\overset{\circ}{.}5$ for the period August 8–10, computed with $v_\infty = 23$ km/s and $v_\infty = 32$ km/s. Note that while α increases from right to left in the displays, it increases from left to right in this profile.

The strong, neighboring Northern δ-Aquarid radiant reduces the prominence of the α-Capricornid radiant greatly. In order to allow for a meaningful comparison with the z-values obtained when the radiant was still isolated, we had to eliminate the influence of the Northern δ-Aquarids.

Therefore, we excluded the region $\alpha > 322°$. The resulting prominence is $z = 2.5$, considerably smaller than a few days before. In the display for $v_\infty = 32$ km/s, the α-Capricornid radiant reached a prominence of only 1.8, supporting the genuine character of the radiant in the original display.

The neighborhood of a stronger radiant and the decreasing prominence z from August 8 onwards make it very difficult to separate α-Capricornids from other meteors, even if the angular velocity is very carefully taken into account. Without considering the angular velocity, the separation simply becomes impossible.

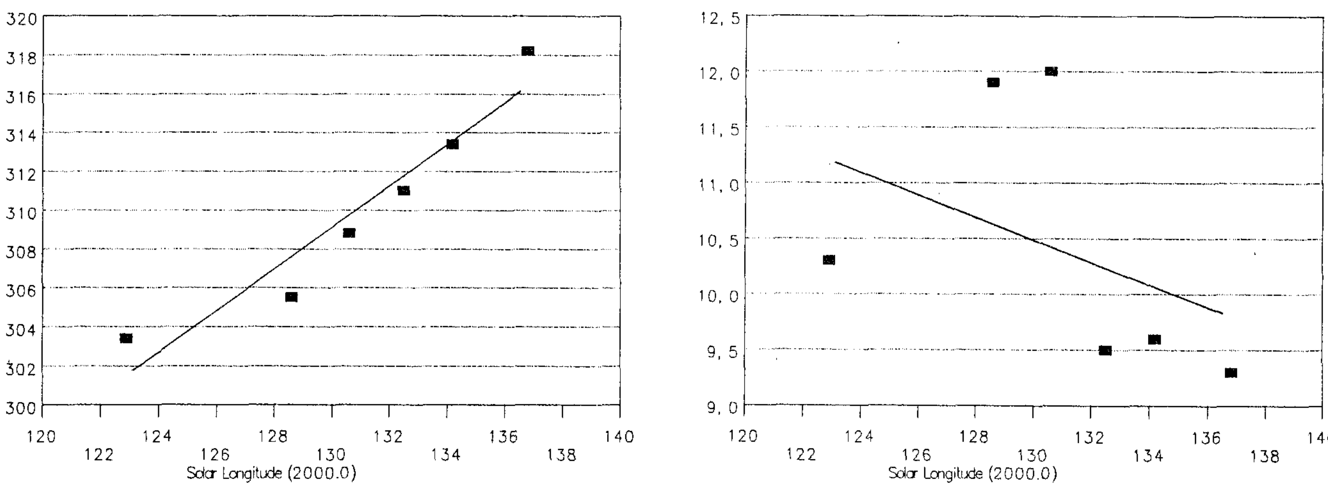

Figure 9 – Radiant drift of the α-Capricornids in ecliptical coordinates. The ecliptical longitude *(left)* and latitude *(right)* plotted as functions of solar longitude.

We now turn to the drift of the α-Capricornid radiant, which can be expressed in ecliptical coordinates by the following relationships obtained after linear regression (see also Figure 9):

$$\lambda = 309^\circ\!.1 + 1.06 \times (\lambda_\odot - 130^\circ)$$
$$\beta = +\ 10^\circ\!.5 - 0.1 \times (\lambda_\odot - 130^\circ).$$

While the correlation of the first regression is very good, the one for β is rather poor. This discrepancy may be due to the fact that the determination of the radiant positions in ecliptical latitude β is less accurate since the observers were situated at about 40° N, thus seeing most meteors north of the radiant. I any case, it is clear that the drift in ecliptical latitude is very small. In [8], a drift of $\Delta\alpha = +0^\circ\!.9$/d and $\Delta\delta = +0^\circ\!.3$/d is given, corresponding to $\Delta\lambda = +0^\circ\!.95$/d and $\Delta\beta = 0^\circ\!.0$/d. This drift agrees very well with the values derived above. Table 2 shows the variation of z over the period for which enough data are available. Remarkably, the radiant is most prominent about one week after the visual maximum given in the literature [3,8]. According to our first experiences with this quantity, the maximum prominence $z = 3.6$ is surprisingly high for a minor shower. During the first week of August, the high prominence and the isolated position of the radiant together with the low entry velocity make for an easy identification of shower members by the observers.

4. The Aquarid radiants

As is to be expected, the showers in Aquarius are the hardest to investigate by means of visual observations. It is interesting to see that the Northern δ-Aquarids are the dominant branch from July 20 to August 12. The other showers active in this period (Southern δ-Aquarids and Southern ι-Aquarids) do not yield meaningful results. Indeed, our density distributions represent only the ***observed*** meteors. At latitudes of about 50° N, the number of Northern Aquarids visible is about twice the number of Southern Aquarids visible. Moreover, the unfavorable distribution of the paths may further contribute to the lack of Southern Aquarids. Southern Aquarids appearing north of the radiant complex enhance the density peak of the northern branch too. Hence, even if there is some more or less distinct southern radiant, it is heavily overrun by the Northern δ-Aquarids.

If not disturbed by the artifacts discussed in the Introduction, the radiant positions for the Northern δ-Aquarids correlate to some extent with the solar longitude. A few mean positions are listed in Table 3.

Table 3 – Radiant positions of the Northern δ-Aquarids: n gives the number of displayed meteors, z the prominence of the radiant, and α_{list} and δ_{list} the radiant positions according to the *IMO* 1992 Meteor Shower Calendar [3].

Period	$\lambda_\odot$	n	z	α	δ	α_{list}	δ_{list}
Jul 21–30	122°	129	2.9	320°	−03°	321°	−09°
Jul 30–34	128°	534	3.0	320°	−05°	326°	−08°
Aug 03–05	133°	593	2.7	323°	−05°	332°	−06°
Aug 06–07	135°	327	3.2	332°	−02°	335°	−05°
Aug 08–09	137°	444	2.9	337°	−02°	337°	−05°
Aug 10–11	139°	430	2.8	337°	−02°	339°	−04°

All radiants are slightly shifted towards the equator, perhaps an effect caused by the predominance of paths north of the shower complex. The radiant motion can be estimated as $+0^\circ\!.9$ per day in right ascension or $+0^\circ\!.95$ per day in ecliptical longitude.

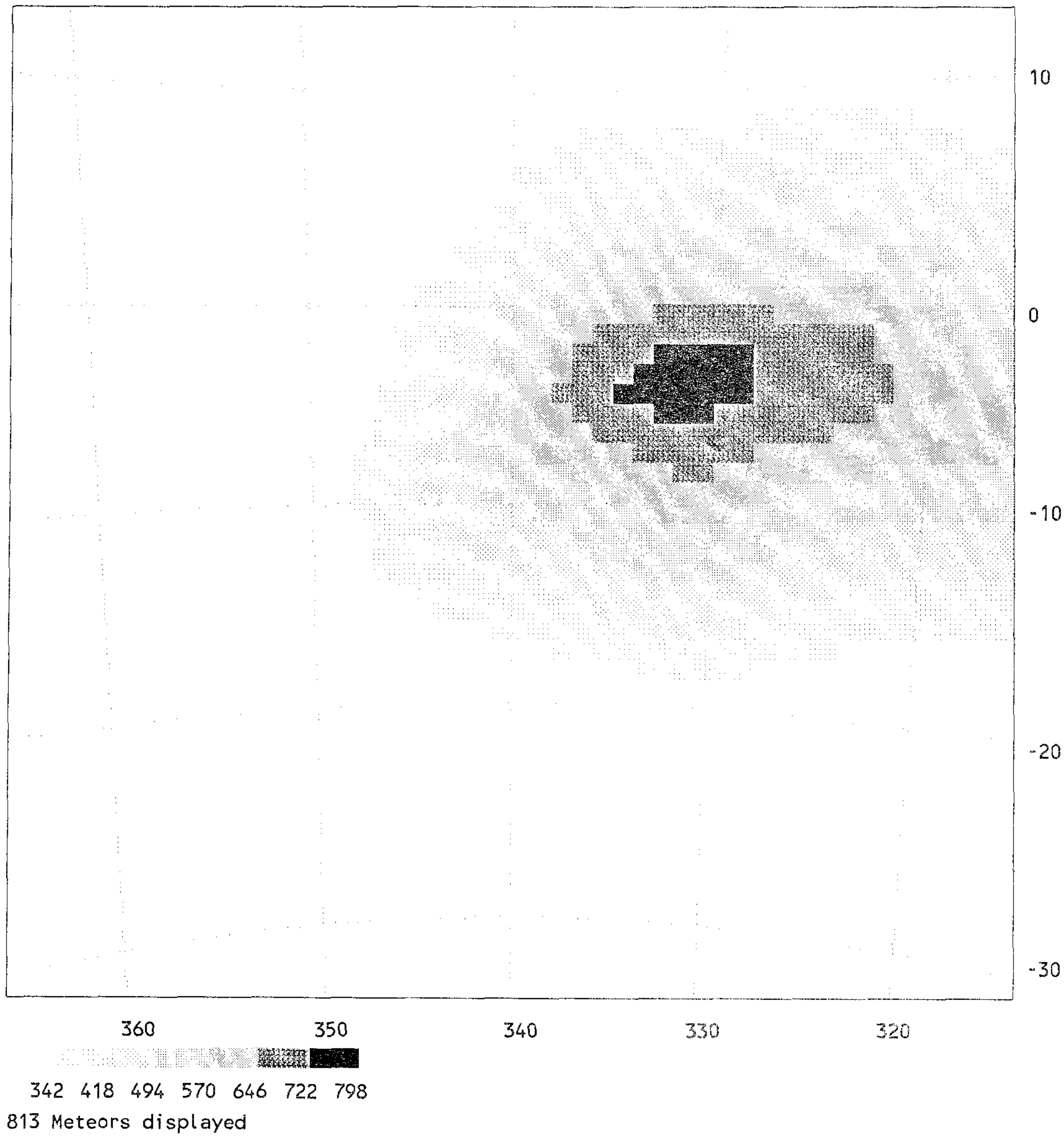

Figure 10 –This display is computed with $v_\infty = 41$ km/s. Period August 8–10, $\lambda_{\text{ref}} = 133°$. Radiant position of the Northern δ-Aquarids referring to August 5 ($\lambda_\odot = 133°$): $\alpha = 330°$, $\delta = -05°$; $\lambda = 331°$, $\beta = +07°$; $z = 2.8$. The Northern δ-Aquarid radiant is quite large.

In order to improve the distribution of the paths around the radiants, we re-calculated a display using only meteors with angular velocities less than or equal to 5°/s. These paths were expected to be close to the radiants, and hence well-distributed. The result was indeed a more prominent Northern δ-Aquarid radiant. The results without and with speed limitation are shown in Figures 10 and 11, respectively. As both displays are nearly identical, the above-mentioned effect of a poorly trail distribution does not influence the display greatly.

On a few occasions, the Southern δ-Aquarids appear at the limits of detectability. The most reliable position ($z = 2.7$) is that of the period July 31 to August 01, 1989. The equivalent display of 1991 does not show any radiant besides that of the Northern δ-Aquarids. Interestingly, the best display for the Southern δ-Aquarids is obtained near that shower's activity maximum on July 30. The position agrees well with the list value [3], though it is also shifted somewhat towards the north. The other displays with Southern δ-Aquarids show the radiant to be in good agreement with the position in the Meteor Shower Calendar as well; the meteor numbers, however, do not even exceed 100. Table 4 lists the radiant positions determined for the Southern δ-Aquarids. Their significance, however, does not go beyond confirming the data in the Calendar.

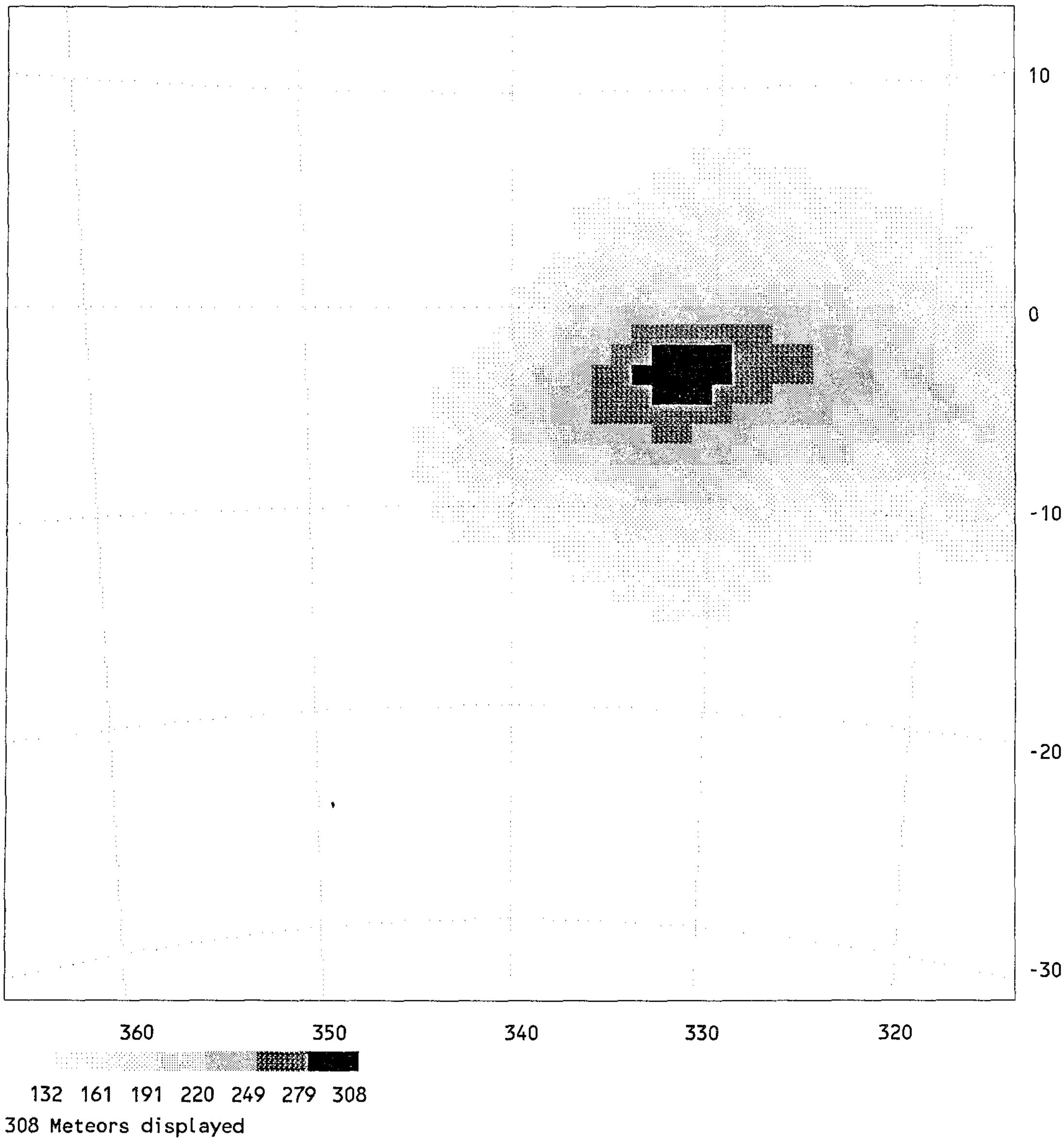

Figure 11 – The same display as in Figure 10, after excluding all meteors with angular velocities above 5°/s. It merely shows the radiant of the Northern δ-Aquarids more distinctly ($z = 3.5$).

Table 4 – Radiant positions determined for the Southern δ-Aquarids.

Date	α	δ	Date	α	δ
Jul 31	340°	−14°	Aug 06	344°	−14°
Aug 04	345°	−14°	Aug 07	344°	−12°

Figure 12 shows the radiant of the Southern δ-Aquarids being suppressed by the α-Capricornids at the right edge. Figure 13 is a magnification of the area around the Southern δ-Aquarid radiant in Figure 12. The radiant now becomes obvious.

The Southern ι-Aquarids radiant becomes noticeable one day after their activity maximum on the display of August 5, 1989, exactly at the position of the *IMO* meteor shower working list in [3]. A possible second appearance on August 7 is actually too weak to be significant.

The Northern ι-Aquarids become active only on August 11 (Table 1) and therefore do not show up in the period considered in this section. This shower is considered in the following section.

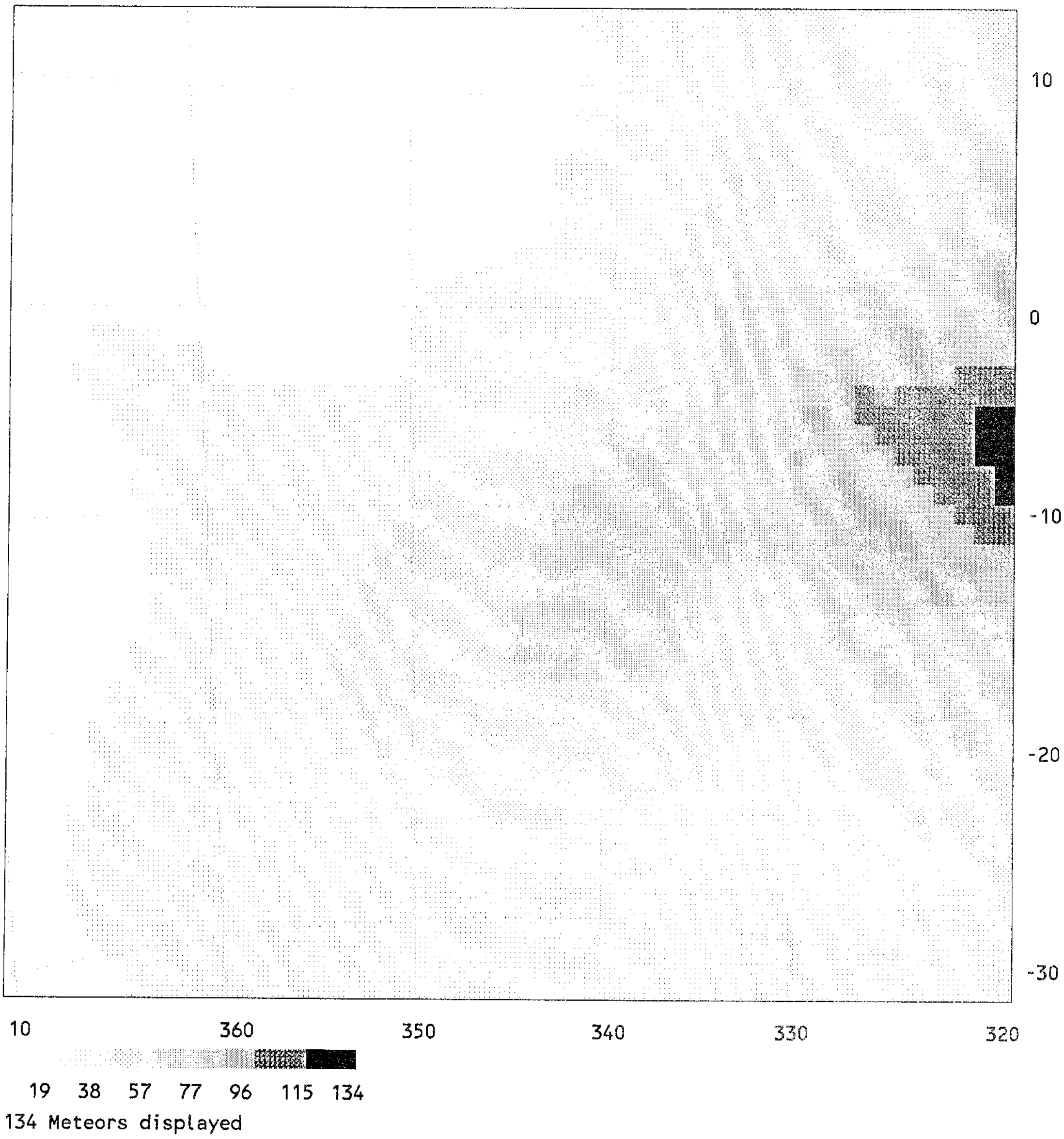

Figure 12 –The Southern δ-Aquarid radiant for the period July 31 to August 1 ($\lambda_{\text{ref}} = 128°$) is merely a shoulder of the strong α-Capricornid radiant at the right edge of the display. Radiant position of the Southern δ-Aquarids referring to July 31 ($\lambda_{\odot} = 128°$): $\alpha = 340°$, $\delta = -14°$; $\lambda = 336°$, $\beta = -05°$; $z = 2.7$.

5. The period August 19–28

For the period August 19–28, only the data of a German group observing in Lindenberg (52° N) in 1990 are available. According to the *IMO* working list of meteor showers in [3], the Northern and Southern ι-Aquarids and the Northern δ-Aquarids should be active in this period. Therefore the displays were computed using both $v_\infty = 32$ km/s and $v_\infty = 41$ km/s.

The radiant of the Northern ι-Aquarids stands out very prominent and isolated during the period August 19–22, 1990 (Figure 14). The display computed for the Northern δ-Aquarids in the same period does not show any sign of activity from the latter shower.

During the period August 23–24, 1990, the radiant of the Northern ι-Aquarids is still clearly visible with only slightly reduced prominence. In addition, there is a radiant at the position of Northern δ-Aquarids (Figure 15). Let us therefore have a look at the display computed with the δ-Aquarid velocity of 41 km/s (Figure 16). In this display, the unknown radiant is much less distinctive than in Figure 15. Hence, the secondary radiant cannot be attributed to the Northern δ-Aquarids.

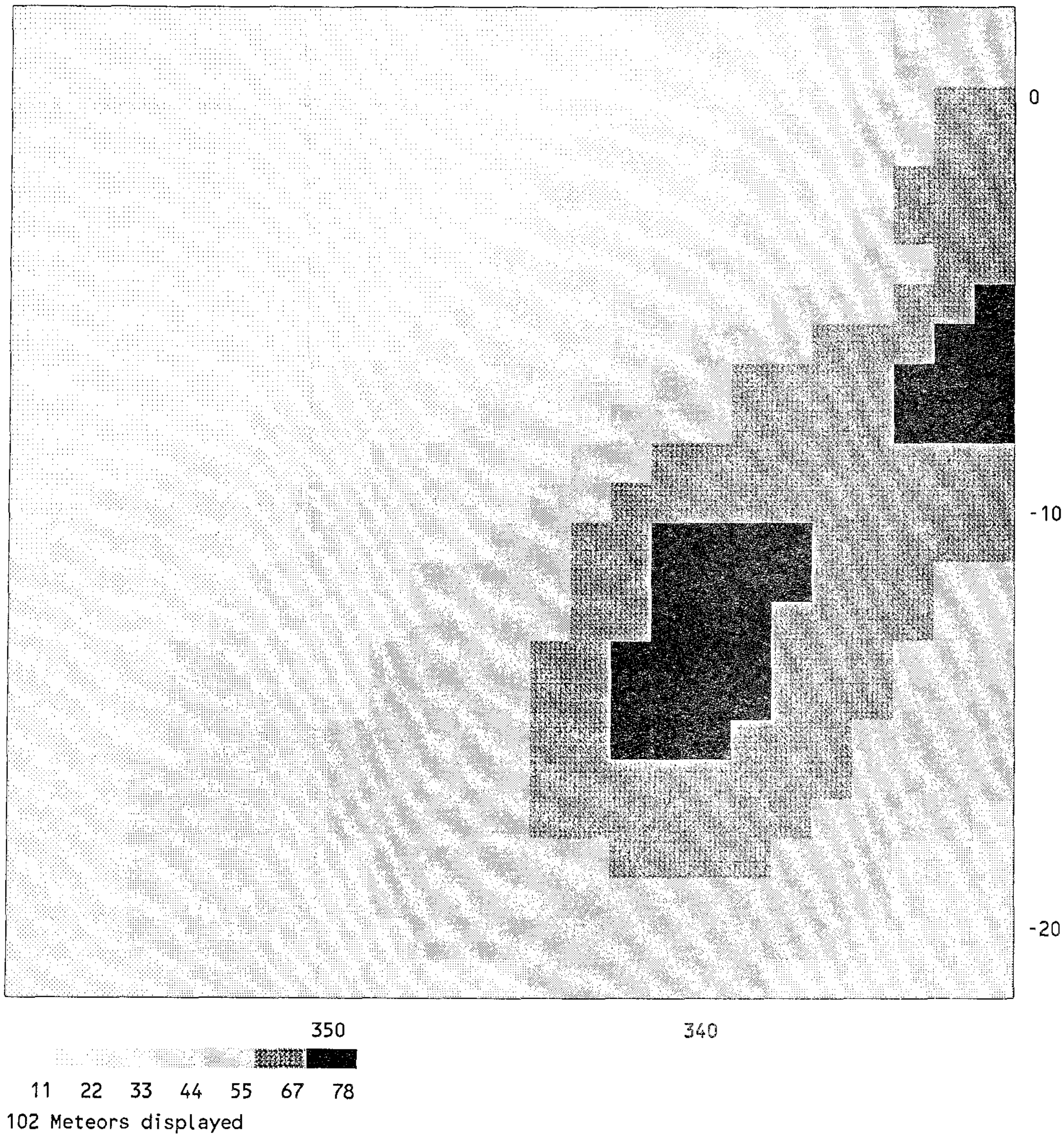

Figure 13 – Magnifying the relevant part of Figure 12 makes the Southern δ-Aquarid radiant obvious.

For the unknown radiant, two possibilities remain:

1. the Northern ι-Aquarids have a double radiant; or
2. the activity of the Southern Piscids ($v_\infty = 22$ km/s) starts earlier than is usually assumed (e.g., in [3]).

To resolve this dilemma, a display for $v_\infty = 22$ km/s has been computed (Figure 17). The z-value of the unknown radiant now exceeds that of the radiant of the Northern ι-Aquarids, reversing the situation in Figure 15 ($v_\infty = 32$ km/s). Consequently, the entry velocity of the unknown radiant must be considerably smaller than 32 km/s, a strong indication in favor of an association with the Southern Piscids.

The profiles in Figure 18 show details not visible in the displays due to the limited number of grey-steps. The change in prominence of the radiants as a function geocentric velocity used for the computation is obvious.

According to Cook's list [9] the radiant of the Southern Piscids is at $\alpha = 7°$ and $\delta =$ 00° on September 20 ($\lambda_\odot = 177°$). The radiant drift is unknown. Assuming a drift $\Delta\lambda = +0\overset{\circ}{.}9$/d and $\Delta\beta = 0\overset{\circ}{.}0$/d—which is an average of all known drifts—the radiant on August 24 ($\lambda_\odot = 151°$) should be at $\alpha = 345°$ and $\delta = -09°$, close to the position obtained from the display.

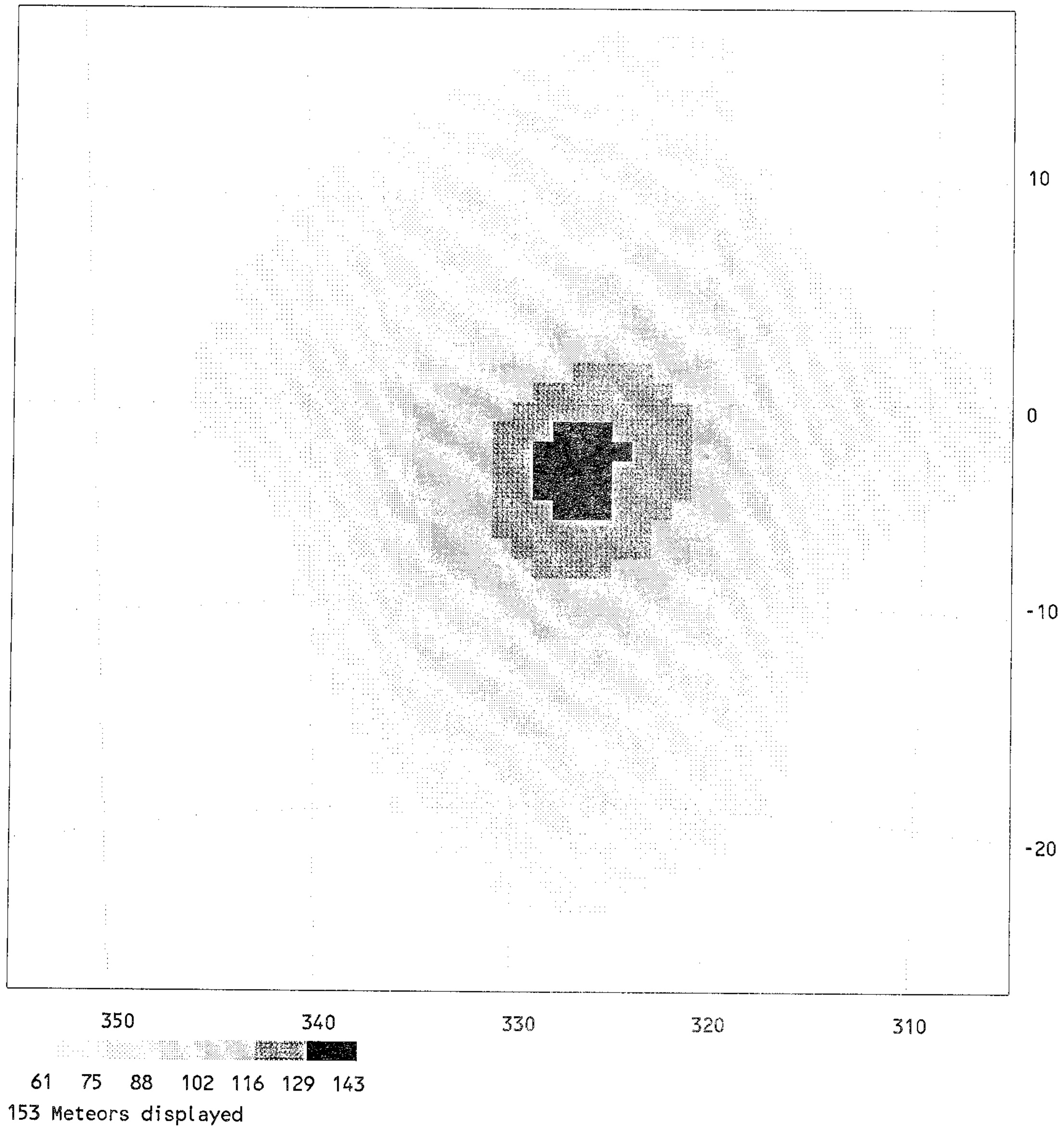

Figure 14 –Density distribution computed with $v_\infty = 32$ km/s. period August 19–22, $\lambda_{\text{ref}} = 152°$. Radiant position of the Northern ι-Aquarids referring to August 21 ($\lambda_\odot = 148°$): $\alpha = 323°$, $\delta = -05°$; $\lambda = 324°$, $\beta = +09°$; $z = 3.0$.

The radiant position of the Northern ι-Aquarids, on the other hand, is given as $\alpha = 328°$ and $\delta = -06°$ on August 20 ($\lambda_\odot = 147°$). With the drift of $\Delta\alpha = 1\overset{\circ}{.}03$/d and $\Delta\delta = 0\overset{\circ}{.}1$/d given in [8], corresponding to $\Delta\lambda = 1\overset{\circ}{.}0$/d and $\Delta\beta = -0\overset{\circ}{.}2$/d, the radiant positions should be $\alpha = 328°$, $\delta = -06°$ on August 21, and $\alpha = 331°$, $\delta = -05°$ on August 24. In this study, the radiant positions were determined as $\alpha = 323°$, $\delta = -05°$ and $\alpha = 327°$, $\delta = -03°$, respectively, which is about 5° west of the literature values.

During the period August 25–28, 1990, the Northern ι-, Southern ι-, and Northern δ-Aquarids were no longer detectable (Figure 19). In contrast, the Southern-Piscid radiant is isolated and very prominent, showing that the appearance of this radiant in the previous display was not a short-lived feature but the beginning of a stable activity period.

It is a pity that these most interesting results are based on data from a single year only (1990). To verify the findings of 1990, we need further observations. The possibility of obtaining unexpected results should also encourage observers to organize observing campaigns in periods where "nothing interesting is to be seen."

It is also interesting to see that detailed analyses of this kind allow for conclusions about the activity periods of certain showers that are not based on ZHR values.

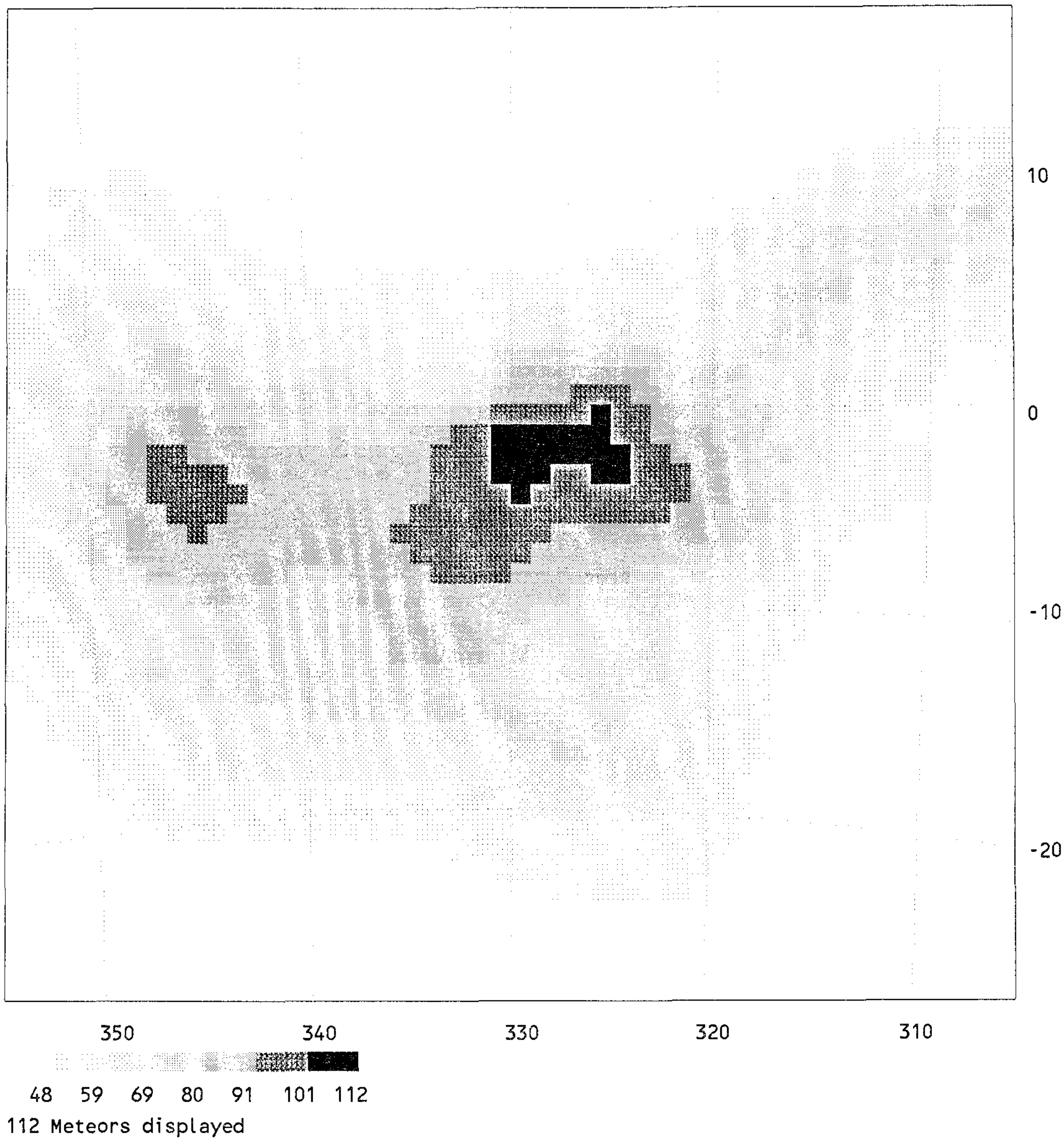

Figure 15 –Density distribution computed with $v_\infty = 32$ km/s. Period August 23–24, $\lambda_{\rm ref} = 152°$. Radiant position of the Northern ι-Aquarids referring to August 24 ($\lambda_\odot = 151°$): $\alpha = 327°$, $\delta = -03°$; $\lambda = 328°$, $\beta = +10°$; $z = 2.7$. Radiant position of the unknown radiant referring to the same date: $\alpha = 344°$, $\delta = -04°$; $\lambda = 344°$, $\beta = +02°$; $z = 2.0$.

6. Conclusions

The displays discussed here taking into account the previously-determined errors of experienced observers demonstrate the possibility to distinguish between neighboring radiants. The procedure allows an objective analysis, independent of the subjective shower association of the observer. In this connection, it should be noted that a relatively high ZHR does not necessarily indicate strong radiant activity, as the ZHR value may be based on a substantial portion of meteors with rather uncertain shower association.

What this study probably demonstrated the most clearly, is the importance that must be attached to the angular velocity criterion in calculating reliable radiants.

Discrete, subjective scales for estimating the angular velocity do not allow for an adequate conversion to absolute units; therefore, observers should try to apply the method described in [10].

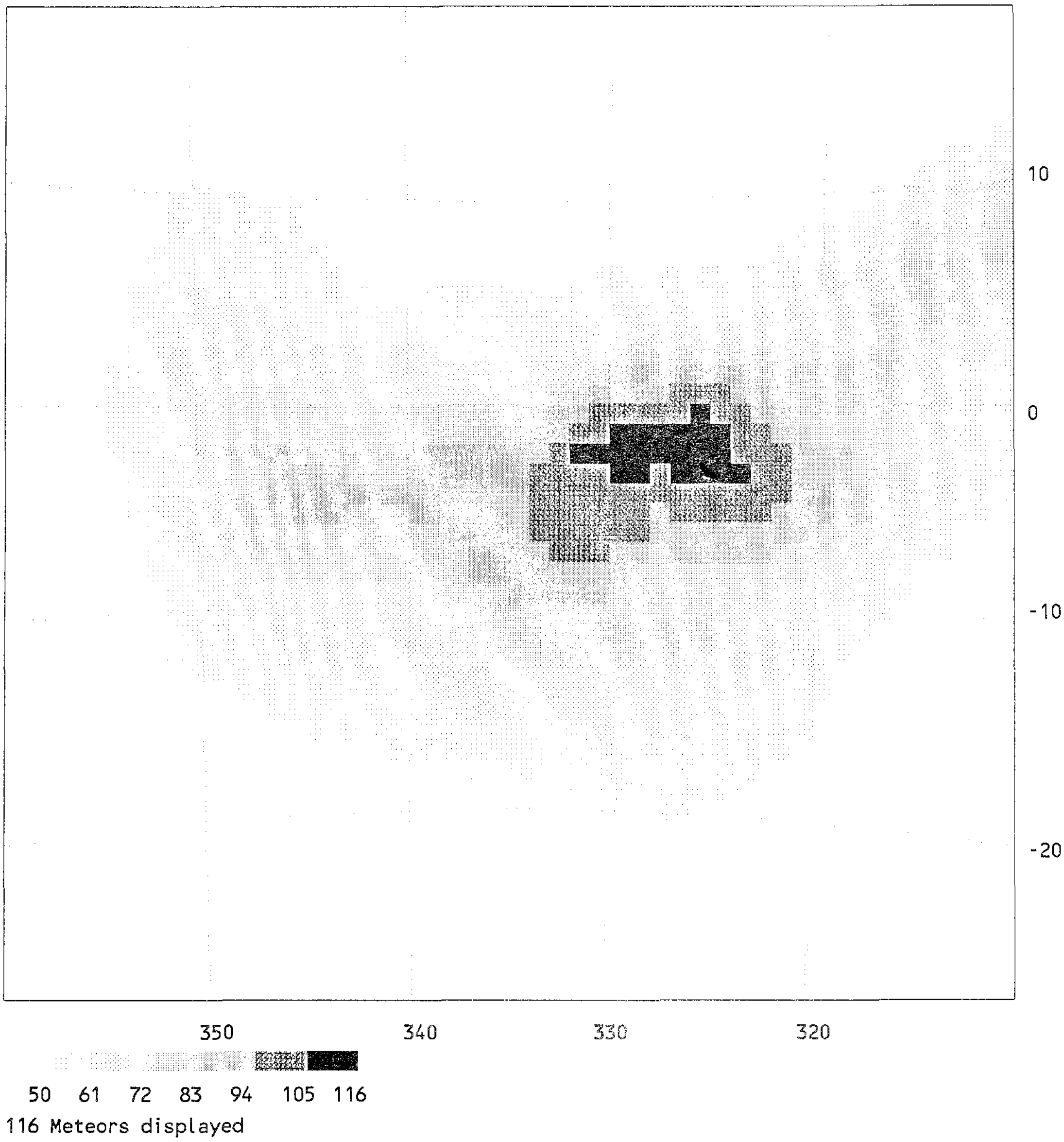

Figure 16 –The same display as in Figure 15, but computed with $v_\infty = 41$ km/s. The secondary radiant in Figure 15 becomes much less distinctive.

If angular velocities are obtained with reasonable accuracy, it is moreover possible to check which pre-atmospheric velocity is most probable for a detected radiant. As displays calculated with entry velocities differing by only 10 km/s can be strongly different, we expect that the determination of the entry velocity is possible with a reasonably high precision.

Another important aspect of this study is that each display heavily depends on the number of meteors available. In order to distinguish a radiant from its background, a substantial number of shower meteors is required. Therefore observers from the southern hemisphere may contribute greatly to the investigation of the southern components of the Aquarid Complex. The respective radiants are then expected to emerge more distinctively than on the displays obtained from observations north of 40° N.

Using the *Radiant* program, radiant displays are easily obtained. A caution is given to the idea that the search for radiants is now a simple task, since quite a lot of time is still needed for familiarization with the images and the interpretation of the features within the displays. The inspection and discussion of the displays used for the *IMO* Aquarid Project alone took the authors some ten hours. During this time, several attempts were made to separate neighboring radiants. Nevertheless, stronger radiants severely reduce the detectability of weaker radiants in their immediate vicinity.

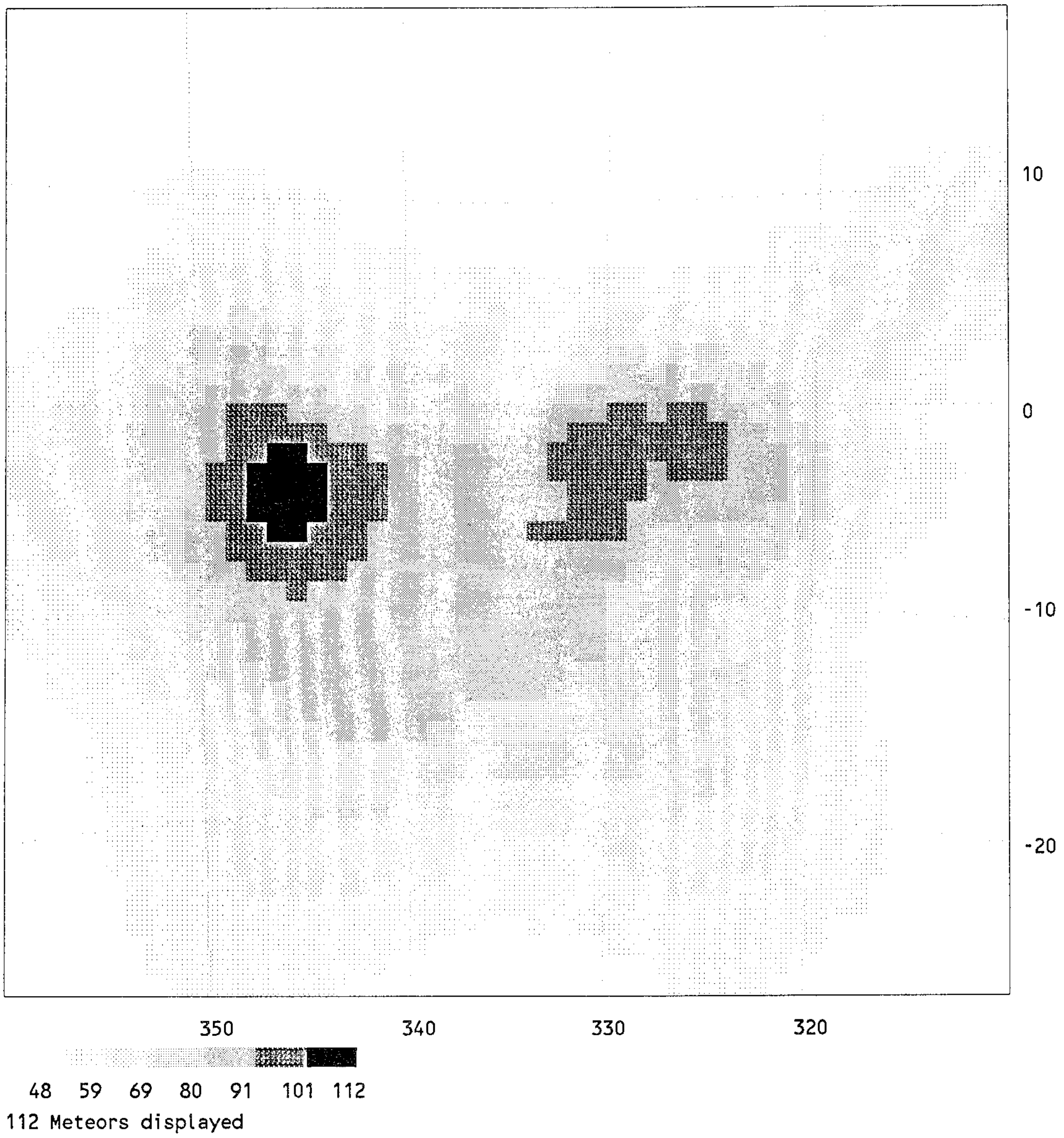

Figure 17 –The same display as in Figure 15, but computed with $v_\infty = 22$ km/s. The Southern Piscid radiant now yields $z = 2.6$; the Northern ι-Aquarid radiant only $z = 2.1$.

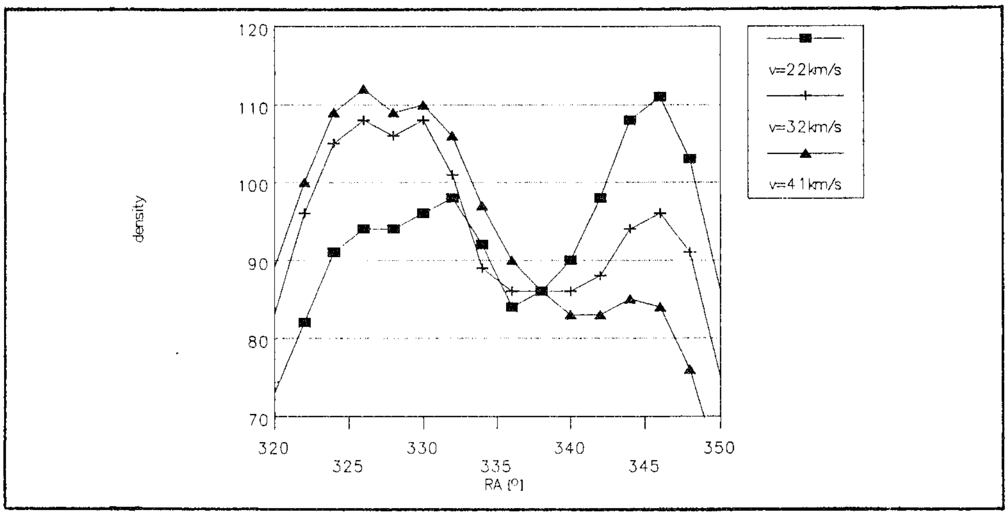

Figure 18 –Density distribution profiles of the *Radiant* displays along $\delta = -03^\circ\!.5$ for August 23–24, computed with $v_\infty = 22$ km/s, 32 km/s, and 41 km/s.

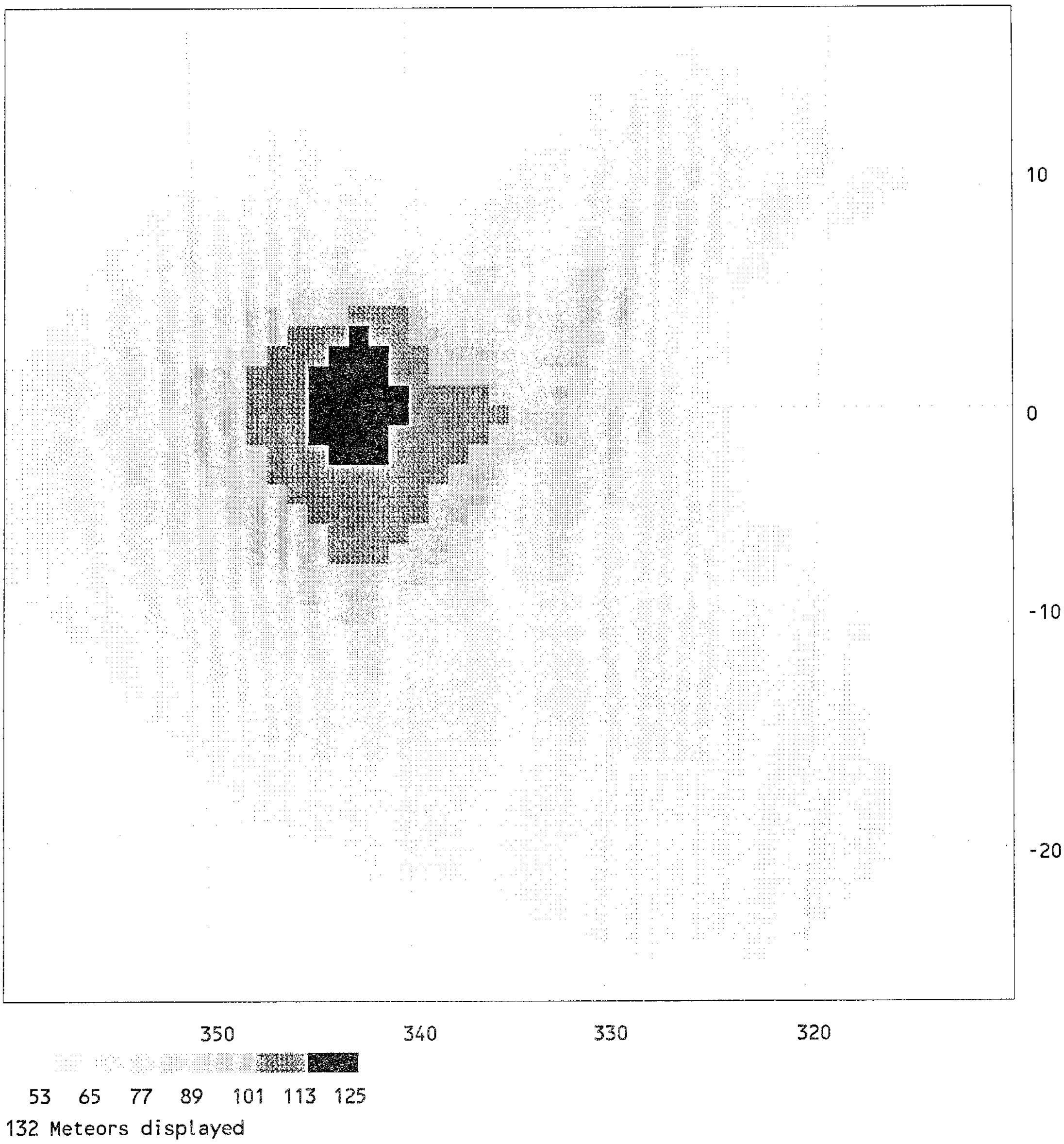

Figure 19 –Density distribution computed with $v_\infty = 22$ km/s. Period August 25–28, $\lambda_{\text{ref}} = 152°$. Radiant position of the Southern Piscids referring to August 27 ($\lambda_\odot = 153\overset{\circ}{.}5$): $\alpha = 343°$, $\delta = -01°$; $\lambda = 344°$, $\beta = +05°$; $z = 3.1$.

As this study only represents our first experiences with the *Radiant* program, more experience and simulations are needed to determine error margins for positions and prominence values. It has however become clear now that a sufficient quantity of visual data of good quality allows for a reliable analysis of radiant positions and sizes.

Acknowledgment

The authors are very much indebted to Ragnar Bödefeld for entering many positional data and for valuable discussions especially in the initial phase of this work.

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Ongoing Meteor Work

PosDat—The Positional Meteor Database of the IMO

Detlef Koschny

A short description of *PosDat* and a rationale for its creation is given.

1. The reason

It is not the first time that collecting positional data of meteors, i.e., the coordinates of begin and end points, was suggested; see, e.g., [1], or the discussion on meteor data standardization at the 1986 *International Meteor Weekend* in Hingene. Plotting was and still is a common technique when observing meteors.

However, the only practical way to derive useful information from observational data within a reasonable amount of time is using a computer system. Until a few years ago, there were just too many different systems around. Moreover, most of these systems had insufficient storage capacity. With the IBM standard having been adopted by most people and hard-disks with 120 Megabytes storage capacity being available for under 500 USD, the above-mentioned drawbacks do no longer exist. This evolution has allowed the *IMO* to set up a *Visual Meteor DataBase (VMDB)* and a *Photographic Meteor DataBase (PMDB)*, containing positional data from meteor photographs. In order to be able to store positional data from telescopic, video, and visual observations, a new database has now been implemented within the *IMO*.

The relevance of setting up a positional database, of course, heavily depends on the accuracy of the data to be stored in it. So, how accurate are these positions?

First studies about visually-determined positions indicate that average standard deviations for experienced observers are around 2°–4° [2,3] (if the average standard deviation were 2°, 65% of the observations would be more accurate than 2°, and 95% would be better than 4°; if the standard deviation were 4°, 65% would be more accurate than 4°, and 95% would be more accurate than 8°).

Telescopic observations are more accurate, of course. A magnification of 10× and the limited field of view result in standard deviations of about 0°1–0°3 [4]. (For comparison: an all-sky fish-eye camera recording a fireball on photographic film results in positions accurate to about 0°1 [5]). I do not have any figures on the accuracy of video data, but assuming a 20° field of view and a resolution of 512 pixels, we obtain 0°04 per pixel. It seems that telescopic and video observations have accuracies comparable to at least fish-eye photography; the visual data are less accurate, but still useful due to the larger quantity available.

Now, what can we do with these positional data? The telescopic and video data stored in *PosDat* will give us fairly accurate information about the position of meteor radiants. The less accurate visual observations will give at least preliminary radiant information, necessary for, e.g., the detection of minor meteor streams. The apparent (angular) velocities (or the velocities on a subjective scale[1]), which are stored too, combined with the distance of the meteor to the potential radiant, allow for a better determination of the stream to which an individual meteor belongs. Parallel telescopic observations, if available in sufficient quantity, may even allow for reasonable altitude determinations. More rationales, especially for the telescopic observations, can be found in [4]. Probably, many more useful applications will come up as we play with the data.

[1] *It should be noted here that the first experiences with the program* Radiant *revealed that angular velocities estimated on a subjective scale unfortunately have little value. In this connection, please read the preceding article in this issue. Observers are therefore encouraged to estimate angular velocities in absolute figures, i.e., degrees per second,* only. *(Ed.)*

I would like to stress at this point that the aim of *PosDat* is to store *positional data*, and *not* to store "as much as possible." Some groups also record color, persistent trains, etc. These data will *not* be entered in *PosDat*.

2. Structure of the system

Figure 1 gives an idea of the system's structure. There will be one person maintaining the database. Optimistically spoken, he or she receives the data from different observing groups as PC-compatible files, as ASCII files, or as dBase files, which can be appended to the master files. This will happen with a special "appender," a program checking for inconsistencies and applying necessary changes in the reference fields of the data (see next paragraph). Each of these files will have an extension unique to the respective observing group, e.g., the data of the "Astronomische Vereinigung West-München" would send their 1990 data to the coordinator in files with the names "PDdata90.a01," "PDhead90.a01," and "PDrema90.a01." The "a" in the extension denotes an ASCII file; for dBase files, it is replaced by a "d."

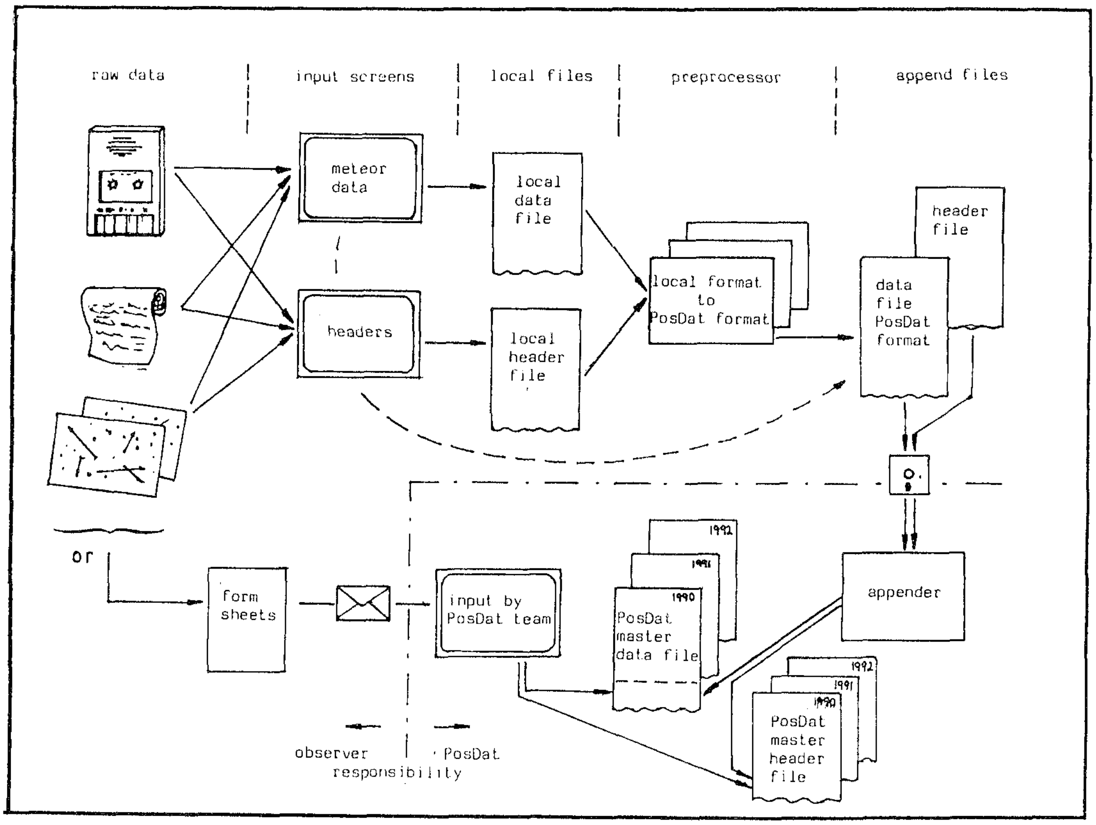

Figure 1 – The *PosDat* system and the relationship between the observer and the *PosDat* coordinator. Two possibilities are indicated: *(i)* The observer uses a computer to store his or her data. A special program then converts these data to the *PosDat* format. The observer sends these "append files" on floppy disks to the *PosDat* coordinator, who will append them to the master files; *(ii)* The observer writes down his or her data in the *PosDat* format, on paper. Data input is then performed by the *PosDat* team. This option is currently offered to telescopic observers only. The remarks file has been omitted in this diagram for the sake of clarity.

As can already be seen from this example, the PosDat system consists of a data file, a header file, and a remarks file, one each every year (Figure 2). The data file contains fields such as time, apparent velocity, and coordinates of begin and end point of each meteor. The header file lists observer name, limiting magnitude, etc., data which are common to several meteor records. Whenever one of these items changes, we need a new header entry. In the data file, each record contains a field called "`ID`," which refers to the corresponding header.

I do not want to go into too much detail on the file structure here. For more details, see [6] or the upcoming new edition of the Visual Handbook.

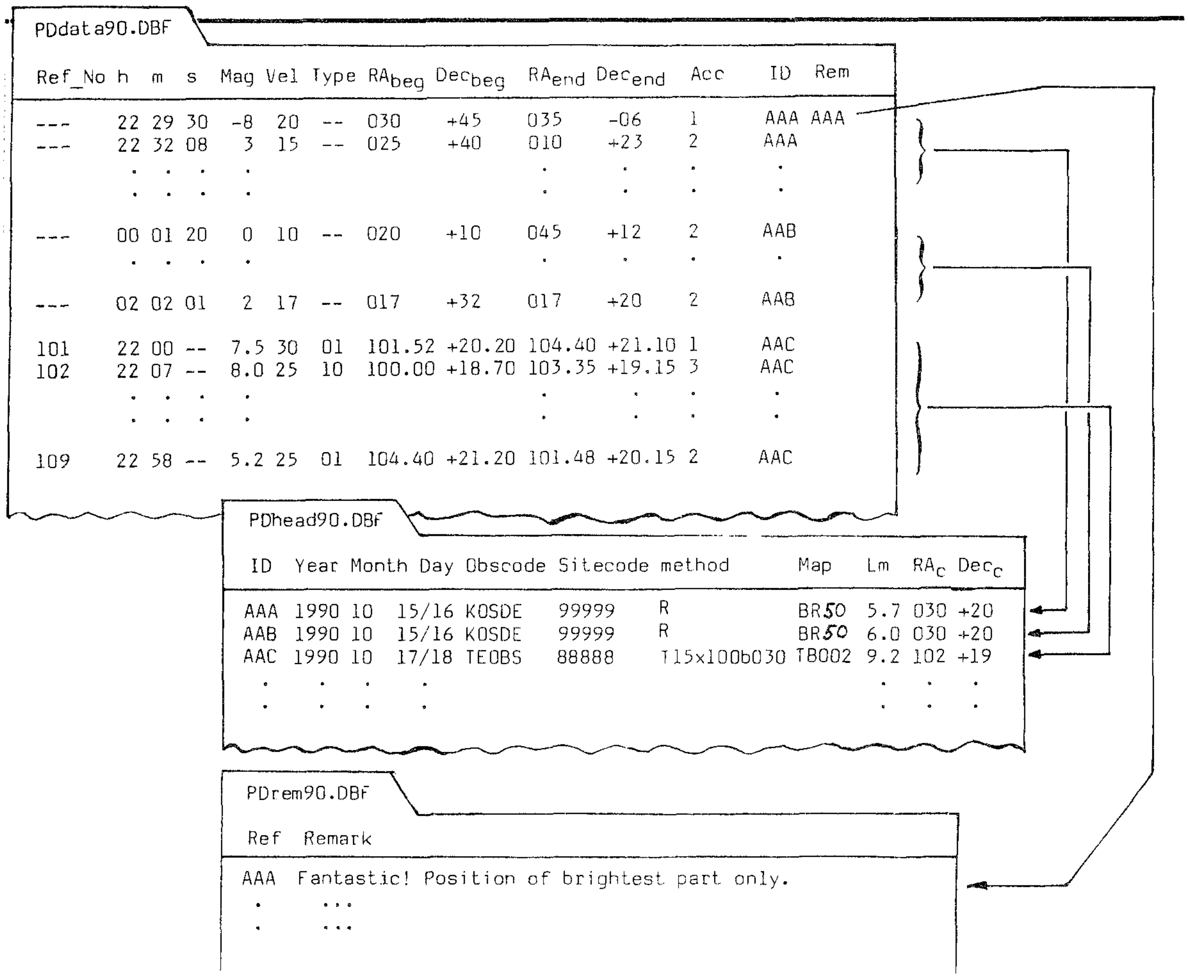

Figure 2 – The various files of *PosDat*. A detailed description of the record fields can be found in [6]. In the data file PDdataYY.DBF (YY = year) we have the following fields: **Ref_No**—a reference number used by telescopic observers; **h**, **m**, **s**—the time (UT) (only the hour is required); **Mag**—the magnitude; **Vel**—the true apparent velocity in °/s or on a subjective scale; **Type** (for telescopic observers only)—denotes whether the meteor started or ended outside or inside the field of view; **RAbeg**, **Decbeg**, **RAend**, **Decbeg**—the coordinates of begin and end point of the meteor; **Acc**—the accuracy of the observation, **ID**—refers to the header file; **Remark**—refers to the remark file. In the header file PDheadYY.DBF we have the following fields: **ID**—the reference number to the data records; **Year**, **Month**, **Day**—the date of the observation; **Obscode**, **Sitecode**—*IMO* abbreviations of the observer and the observing site; **Map**—abbreviation of the map used, if any (Atlas Brno, etc.); **Lm**—the limiting magnitude; **RAc**, **Decc**—the coordinates of the center of the field of view. The remarks file PDremaYY.DBF only contains the reference number (**Ref**) and some text (**Remark**).

Of course, many persons do not have access to a PC. Malcolm Currie offered to enter data of telescopic observers. Handwritten data from naked-eye observers, provided they are in the format of our files, might be accepted later, but currently we simply do not have the people willing to enter the data. So, please find a way to store your data on a floppy: at your school, at a friend's, ...

A dBase program for entering the data in the right format is available. Persons that do already store their data on computer in a different format will need a "preprocessor" converting the data into *PosDat* format. The preprocessor concept is very powerful: as an example, a special preprocessor may be written that accepts x, y-coordinates measured on gnomonic maps, and converts this information to right ascension and declination. Another preprocessor might be able to convert old data already stored to the *PosDat* format (that already happened with the data of our observing group).

3. Current status

In the team defining the structure of *PosDat* at the 1990 *IMC*, the following persons participated: Rainer Arlt, Malcolm Currie, Roland Egger, Ralf Koschack, Detlef Spötter, Bruno Wagner, and the author. That was done in September 1990, so, what has happened since?

First, a directory "PD" has been created on my hard-disk, so far containing only selected positional data of our observing group (the *Astronomical Association of West-Munich, AVWM*) and the *Arbeitskreis Meteore (AKM)*. Our data were extracted from ASCII files containing all our data (the "local data"). The data were entered with the Turbo-Pascal editor (our "input screen"). The extraction and conversion to the data files "PDdataYY.DBF" was performed by a program written in Turbo-Pascal. The header data were simply entered under dBase.

Also, a first version of the program "PDcheck" was finished. It browses over data and header files and checks them for correctness. Also, the appender program is working and waiting for data.

4. How can you contribute data?

Please send a DOS-formatted floppy (either 5.25" (maximum 1.2 Mbytes) or 3.5" (maximum 1.44 Mbytes) to the author (address on the inside back cover), as well as a hard-copy listing of some of your original data. I will then return the floppy to you with sample files (ASCII and dBase) that will help you to get the format right, a sample Pascal listing of the preprocessor for our data which you can adapt to your own needs, the newest version of "PDcheck," and a Pascal unit containing some procedures that might be useful in your own programs (this unit is currently still very small ...), plus a dBase PRG-file for entering data in dBase format.

Furthermore, I will send you a copy of [6], describing the file format in detail. Please read it carefully to make sure your format is correct.

You will also be assigned an extension for your files, which you may send to me either in ASCII or dBase format, whichever is more convenient for you.

5. Conclusions

PosDat will store telescopic, video, and visual meteor positional data, allowing evaluations not possible with the *VMDB*. Other meteor databases exist; however, *PosDat* will be the first one working on personal computers, thereby being available for a large number of people.

I ask everybody recording positions of meteors to contact me, and to contribute data to this valuable database.

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On the Presence of Trains in Meteor Showers

Luis Ramón Bellot Rubio

Different mechanisms for meteor train generation are reviewed. Train percentages for different showers are calculated and compared. An attempt is made to correlate numbers of trains with train duration. Finally, fireball trains are considered.

1. Introduction

It is well-known that different meteor streams produce different train rates. Although chemical composition is the mean reason for this behavior, velocity and mass also play an important role.

In this study, over 26 000 meteors and fireballs are analyzed to get train rates for streams. From our point of view, trains are important for two reasons: first of all, the knowledge of train rates can help us in associating a meteor with its radiant; furthermore, the study of train phenomena can be a first step in investigating the chemical composition of various streams and their parent bodies.

Finally, fireballs with trains lasting more than, say, 10 minutes provide interesting data about the upper atmosphere. Unfortunately, such long-lived trains are very rare events whence they still cannot be analyzed with statistical significance.

2. Physics of trains

As fireball spectra show, the light we observe when a meteor appears comes from most of the allowed transitions of Fe, Na, Mg, O, and Si from excited levels with an average energy of 5 eV above the ground state. This emission is due to impact processes between meteoritic atoms and atmospheric molecules, as well as between meteoritic atoms themselves, located at the gas cap or "coma" in front of the solid body (so-called second-order collisions).

Train formation, on the contrary, seems to follow other mechanisms, depending on the duration of the train. For short-lived trains [1], the fundamental process is the electric neutralization between positive meteoritic ions M^+ (M can be Fe, Mg, Si, Ca, Na, or K) and negative atmospheric ions (mainly O^- and O_2^-):

$$\mathrm{M}^+ + \mathrm{O}^-, \mathrm{O}_2^- \longrightarrow \mathrm{M}^* + \mathrm{O}^*, \mathrm{O}_2^*.$$

This reaction leaves the final products in excited states, which then decay to their ground levels by means of one or more transitions. It is estimated (Hawkins, Howard, 1959) that the resulting emission decreases by about 0.2 in stellar magnitude per second.

For long-lived trails, the most important mechanisms are recombination processes of atoms and molecules behind the meteor. Although the phenomenon itself is not yet well-known, some suggested reactions can produce the minimum linear emission necessary to make the train naked-eye detectable, which amounts to 10^{13} photons per second and per centimeter in the meteor trajectory, as Cook and Hawkins demonstrated in 1956.

The intensity I produced by the recombination of two chemical species x and y (molecules, atoms, or ions) can be expressed by means of the formula

$$I = k[x][y],$$

where k is the coefficient of photon emission in the process (in, e.g., $\mathrm{cm^3 s^{-1}}$) and $[x]$ ($[y]$) is the number density of the species x (y) (defined as the number of particles of x (y) per cubic centimeter).

The values of $[x]$ and $[y]$ strongly depend on the volume in which the recombination process takes place. This dependence however is complicated by the diffusion of the train in the atmosphere, a process that increases the volume. If r_0 is the initial radius of the train, and D the diffusion coefficient, then the radius r of the train at time t is given by

$$r^2 = 4Dt + r_0^2.$$

At meteor heights of around 90 km, D is about 10 m^2/s. Hence, the number densities $[x]$ and $[y]$ will decrease quickly and the train luminosity will diminish rapidly, unless there is an injection of new particles x and y.

One of the most important recombination processes is the Lewis-Rayleigh afterglow of nitrogen [2] This reaction can be written as

$$\mathrm{N} + \mathrm{N} \longrightarrow \mathrm{N}_2\,(B^3\Pi) + h\nu.$$

The origin of atomic nitrogen is the atmospheric molecule N_2, dissociated by first order collisions (i.e., impacts between atmospheric particles and the meteor body). Since our knowledge of impact processes in the atmosphere is incomplete, there exists a great uncertainty when computing [N] in the train column.

To obtain an upper limit for I, Baggaley assumes that half of all N_2 molecules within the train column have been dissociated by collisions with the solid body. In this way, we can put $[\mathrm{N}] \approx [\mathrm{N}_2]_0 = 5 \times 10^{13}\ \mathrm{cm}^{-3}$, where $[\mathrm{N}_2]_0$ is the number density of N_2 in the unperturbed atmosphere.

As $k = 10^{-18}\ \mathrm{cm}^3\mathrm{s}^{-1}$, the final intensity produced by the Lewis-Rayleigh afterglow is $I \approx 2.5 \times 10^9$ photons per cubic centimeter and per second, or, assuming a cylindrical train column with a radius r of 1 meter (Hawkins and Whipple, 1958), $I \approx 10^{14}$ photons per centimer and per second, which is one order of magnitude larger than the required minimum emission.

In this case, I depends on $[\mathrm{N}]^2$, and hence the intensity decreases quickly due to nitrogen diffusion. Assuming $r_0 = 1$ m, the emission rate decreases a hundredfold in 2.5 seconds [2].

Apart from recombination processes, other mechanisms have been suggested for long-duration trains. For example, the sodium catalytic cycle [3] can be written as

$$\begin{aligned}
\mathrm{Na} + \mathrm{O}_3 &\longrightarrow \mathrm{NaO} + \mathrm{O}_2 \\
\mathrm{NaO} + \mathrm{O} &\longrightarrow \mathrm{Na}\,(^2\mathrm{P}) + \mathrm{O}_2 \\
&\ \mathrm{Na}\,(^2\mathrm{S}) + \mathrm{O}_2 \\
\mathrm{Na}\,(^2\mathrm{P}) &\longrightarrow \mathrm{Na}\,(^2\mathrm{S}) + h\nu.
\end{aligned}$$

The radiation corresponds to the sodium doublet, and hence the train would be yellowish. This process can produce a train of even one hour in good conditions: a fireball of at least −10 and a laminar regime with a large eddy structure.

3. Observational results

This analysis deals with about 26 000 meteors observed by *SMS* members between 1987 and 1991. The sample is not homogeneous, since the majority of the meteors are Perseids and sporadics. Furthermore train percentages for any given stream should be based on at least 100 meteors to be statistically significant. The relevant data are shown in Table 1. The column "v_∞" shows the geocentric velocity as listed in [4].

Table 1 – Percentage of trained meteors for some showers.

Shower	Meteors	Trained	Percentage	v_∞
α-Bootids (ABO)	119	12	10%	20 km/s
α-Scorpids (ASC)	138	25	18%	35 km/s
α-Capricornids (CAP)	368	57	15%	23 km/s
η-Aquarids (ETA)	307	128	42%	66 km/s
Geminids (GEM)	1247	93	7%	35 km/s
κ-Cygnids (KCG)	184	8	4%	25 km/s
Leonids (LEO)	467	98	21%	71 km/s
Lyrids (LYR)	373	54	14%	49 km/s
δ-Aquarids N (NDA)	274	12	4%	42 km/s
Taurids N (NTA)	266	13	5%	29 km/s
Orionids (ORI)	364	106	29%	66 km/s
Piscis Austrinids (PAU)	157	20	13%	35 km/s
Perseids (PER)	10295	3290	32%	59 km/s
δ-Aquarids S (SDA)	554	39	7%	41 km/s
ι-Aquarids S (SIA)	208	12	6%	34 km/s
Taurids S (STA)	228	10	4%	27 km/s
Virginids (VIR)	181	12	7%	30 km/s
Sporadics (SPO)	9049	948	10%	
Complete sample	25845	5101	20%	
Id., without PER and SPO	6501	863	13%	

It is readily seen that there are not many showers with a high percentage of trains: only two of the showers listed have more than 30% of trained meteors. Both of them are major showers. This phenomenon could be explained by selection effects, because we still do not have enough data for many streams.

Among showers (without taking into account Perseids and sporadics), the average percentage of trained meteors is 13%, which is surprisingly similar to that of the sporadics. All in all (Perseids and sporadics included), we get a moderate percentage of 20%. Hence, although the train phenomenon is not one of the major features of meteors, it is quite common.

Most data with duration estimations came from the Canary Islands group of observers, and they allow us to seek for a relationship between the number of trains and their durations. This relationship is similar to that between the number of meteors and their magnitudes, whence we can speak of a "population index" τ for the train distribution. The computation is quite analogous to that of the traditional population index r, although it is necessary to include some variations. First, we choose a maximum duration to start the procedure. In our case, we choose 5 seconds, because there are too few trains with longer durations. Then, the cumulative number of trains must be calculated from longer to shorter durations, as the number of trains increases with decreasing durations. Finally, we expect a relation of the form

$$\Phi(T) = 10^{aT+b},$$

where $\Phi(T)$ is the cumulative number of trains of at least T seconds, and a and b are constants. Then, the population index τ is given by $\tau = 10^a$, The meaning of τ follows from

$$\frac{\Phi(T+1)}{\Phi(T)} = \tau,$$

i.e., on average, there are τ times as many trains with duration at least $T+1$ seconds than there are trains with duration at least T seconds. (Notice that τ must be smaller than 1.)

Calculations have been carried out for the Perseids, Orionids, and sporadics, and must be regarded as preliminary results. Table 2 shows the result obtained. One observational fact is confirmed: long-duration trains are rare events.

Table 2 – Train duration in seconds for the Perseids, Orionids, and sporadics.

Shower	≤ 1	2	3	4	5	Tot	τ	ρ
Perseids	932	210	57	30	14	1243	0.33 ± 0.02	0.997
Orionids	31	10	2	0	0	43	0.22 ± 0.03	0.995
Sporadics	161	44	18	4	4	231	0.36 ± 0.02	0.997

Finally, a correlation between the percentage of trains and the entry velocity v_∞ of the stream was attempted at. In general, the number of trained meteors grows with velocity. After elimination of outliers, a rather weak correlation

$$\text{Train percentage} = 0.42 v_\infty - 3.9$$

with $\rho = 0.77$. We must conclude that trains also depend on chemical composition and, very probably, also on mass, as we expect keeping in mind the physical meaning of trains.

4. Trains in fireball phenomena

In order to find out if there exists a different behavior between "normal" meteors and fireballs, an analysis of *FIDAC* data for the period 1988–1991 was carried out. In studying fireball trains, one must be very careful, as the observers often do not explicitly report the absence of a train. Because of this, only 472 *FIDAC* fireballs were useful for our purpose. Of these, 47 did not show a train. Again, it is impossible to give a percentage of trained meteors, as we cannot be sure that every train has been reported. However, the situation seems to be improving from 1990 onward; for these data, a preliminary figure of 81% was found. Nevertheless, this figure should be considered with great care.

As is the case for "normal" meteors, the sample is not homogeneous, since there are more reports than average in August, November, and December, mainly due to the Perseid, Leonid, and Geminid campaigns. Hence we must keep in mind that our data are "contaminated" by an excess of these showers.

Table 3 gives the train durations for 253 fireballs. As we can see, long-duration trains are extremely rare events: only four fireballs had a train lasting for more than 10 minutes. In our sample, there is one train of 10 minutes, two trains of 20 minutes, and one train of 37 minutes. From Table 3, it is obvious that if a train lasts for more than 10 seconds, the observer tends to round the duration (for example, to 15 or 20 seconds). Because of this rounding, long durations are often approximate.

Table 3 – Train durations for fireballs.

Duration (seconds)	Trains	Duration (seconds)	Trains	Duration (seconds)	Trains	Duration (seconds)	Trains
≤ 1	34.5	8	8	15	8	$[50, 60]$	3
2	33.5	9	3	16	1	90	3
3	29.5	10	18	17	2	120	2
4	25.5	11	1	20	8	180	3
5	21	12	6	$]20, 30]$	13	420	1
6	11	13	1	$]30, 40]$	3	≥ 600	4
7	9	14	1				

We calculated the population index for fireball train durations. Now the upper limit of time was set to 9 seconds. The logarithmic fit yielded $\tau = 0.67 \pm 0.01$ with correlation coefficient $\rho = 0.989$, for a sample of 172 fireballs. The interval for the fitting was 1 second to 8 seconds; the 9 second group was rejected as outlier.

Comparing this value with those of normal showers, it is clear that fireballs produce a higher percentage of long-duration trains (about a factor of 2.5).

Finally, Table 4 shows train colors for those fireballs with duration data. This color distribution does not need to be similar to that of meteor colors, since different mechanisms are involved. Although there are few data, yellow, red, and blue are the most common colors (as in [5], white is not considered). Surprisingly, green appears with a moderate percentage, much higher than in "normal" meteors [5]. Yellow trains can originate from both the human eye's efficiency and the radiation of the sodium catalytic cycle, as pointed out before. Green trains are probably due to oxygen transitions. More observations are needed, however, to draw such kinds of general conclusions.

Table 4 – Colors and durations in seconds of fireball trains.

Color	1	2	3	4	5	6	7	8	9	10	Total
Blue	1	2	1		1				1	2	8
Green	1	3	1							1	6
Yellow	3	1	1	2	2		1				10
Orange		1		1					1	1	4
Red	1	3	1	2						2	9
Grey		1		1	1						3
White	4	2	5		4	2					17

5. Suggestions for future work

It is necessary to collect more data about the presence of trains in meteors. Some observers include train percentages in their report forms, although this is not common practice. Maybe this item could be added to each report. Certainly it seems worthwhile to recommend observers seeing a fireball to report whether or not there is a train, and if so, to note down its duration. Only in this way, fireball data can serve many purposes.

Acknowledgment

The author is grateful to André Knöfel for sending *FIDAC* files and encouraging this study. The author is also grateful to Mark Kidger for very interesting comments and for providing Canarian data, and to all *SMS* members, who with their observations made possible this analysis.

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Radio-Meteor Detection: Hints for Changing from 75 MHz to 50 MHz

Dave Jarrell, Mike Morrow and Meteor Group Hawaii

Radio amateurs using radio-meteor detection schemes on 75 MHz are urged to switch to 50 MHz. Appropriate changes to the Hawaiian system described in an earlier article in this journal (June 1990) are discussed.

The *American Meteor Society* is no longer advocating radio-meteor detection schemes on 75 MHz. The reason for the suggested change in frequency is that 75-MHz Aeronautical Beacons have had their output power reduced world-wide with the result that meteor echoes of this frequency are no longer detectable with amateur radio equipment. The cause of the power reduction is another story in itself and will not be related here. It is enough to say that the situation prevails and other frequencies must be employed to maintain a radio watch on meteoric activity.

A previous article of the Meteor Group Hawaii appeared in the June 1990 issue of *WGN*, suggesting the use of the 75-MHz frequency.

Due to the change of frequency and the need to keep expenses to a minimum, we at first decided to convert the 75-MHz equipment to the new frequency. This decision was short-lived because newer technology is vastly superior to that which was available to us only a few years ago. Building a new converter was and is more practical than reworking old 75-MHz equipment.

We will have our own Beacon which has been authorized to operate on 50.07 MHz. The new converter will enable us to listen on 10.07 MHz, so that we do not need to obtain a 6-meter or 50-MHz receiver. This frequency is easily obtained on any good quality Amateur Radio Receiver or good quality Short Wave Radio. This also allows us to easily listen to WWVH/WWV. Not only is the new equipment simpler and more sensitive, it is physically smaller.

We present a schematic diagram for those inclined to convert or rebuild a 75-MHz system (Figure 1, next page). Component values are as shown.

The reader should remember that we are located on a remote set of islands and many things easily obtained by those living on the continents are not available to us. The large number of 50-MHz beacons in continental areas should make it easy for most to use an existing 6-meter receiver without the headache of constructing a converter and/or a beacon.

It is hoped that this short note will be of help to those contemplating listening to meteors on 50 MHz.

Erratum on Precision of Telescopic Meteor Recordings

Petr Pravec

I would like to correct an error in my article in *WGN* 20:2, pp. 70–83. Some confusion has arisen in the definitions of the types of errors analyzed (p. 78). The quantities `DevPA` and `TS` shown in Figure 4 both have *negative* signs. In case of any doubts about the definitions, please, refer to that figure.

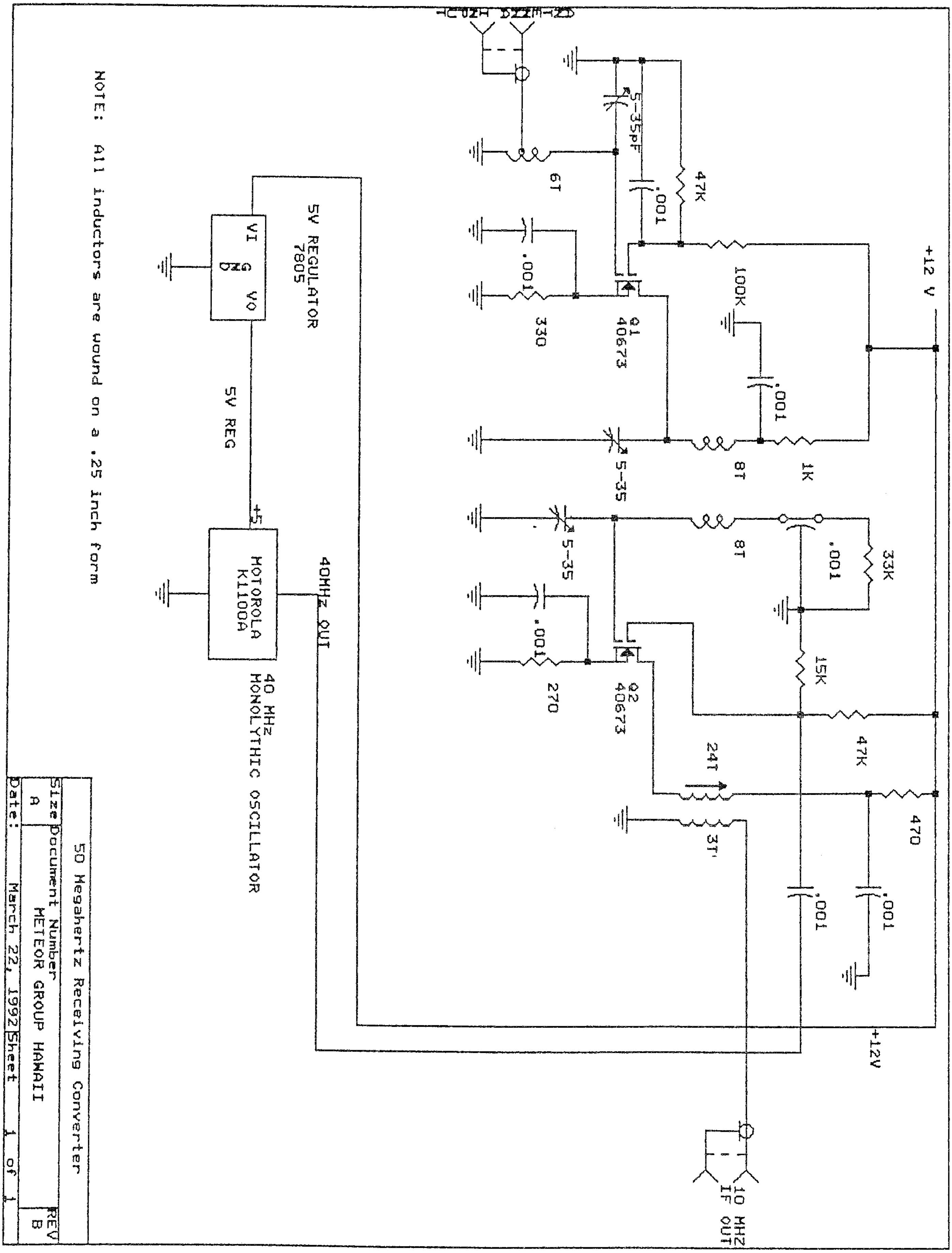

Figure 1 – The 50-MHz Receiving Converter.

Fireballs and Meteorites

Fireball

Austria, January 17, 1992, $21^h21^m20^s$ UT

Pavel Spurný and Zdenek Ceplecha, Ondřejov Observatory

In the evening of January 17, 1992, a fireball of approximately −15 maximum absolute magnitude was photographed over Austria.

Lately, we obtained one photographic record of this event from Dieter Heinlein taken at the German station of Gahberg (located in Austria, near Salzburg). This photograph is of a similar quality as our record as it was also taken in an almost cloudy night. Nevertheless, we were able to obtain practically complete results with a good accuracy. We were able to estimate the maximum absolute magnitude only from several independent visual observations and not from our photographic records. Its probable value was about −15. The fireball traveled an 88-km photographed luminous trajectory in 6 seconds and terminated its light at a height of 62 km. Its trajectory was almost horizontal: the slope to the horizon was only 17°, and the difference between the beginning and the terminal height was only 26 km. The initial mass was very probably of the order of hundred kilograms, but a meteorite fall is quite excluded, because the terminal point was extremely high.

Table 1 – Trajectory data.

	Beginning	Terminal
Velocity (km/s)	15.8	14.4
Height (km)	84.2	61.8
Latitude (° N)	47.370	48.074
Longitude (° E)	13.885	14.251
Z R (°)	72.5	72.8

Fireball type: very probably IIIA or IIIB

Table 2 – Radiant data.

Radiant (1950.0)	Observed	Geocentric	Heliocentric
α (°)	70.5	65.0	
δ (°)	−22.6	−35.9	
λ (°)			30.6
β (°)			−14.7
Initial velocity (km/s)	15.8	11.4	37.3

Table 3 – Orbital data.

Orbit (1950.0)	
a	2.14 AU
e	0.54
q	0.9768 AU
Q	3.3 AU
ω	11°5
Ω	116°4555
i	14°7

Fireball

Germany, March 4, 1992, $19^h34^m52^s$ UT

Pavel Spurný, Ondřejov Observatory

In the evening of March 4, 1992, a slow-moving −7 maximum absolute magnitude fireball was photographed over Germany.

A slow-moving fireball of −7 maximum absolute magnitude was photographed by three Czech stations of the European Network. The fireball traveled a 52-km luminous trajectory in 3.1 seconds and terminated its light at a height of 35 km.

The following results are based on all available records measured by J. Keclíková.

Table 1 – Trajectory data.

	Beginning	Maximum light	Terminal
Velocity (km/s)	18.951	18.04	8.76
Height (km)	74.62	53.7	36.58
Latitude (° N)	48.563	48.656	48.7334
Longitude (° E)	13.230	13.006	12.8204
Abs. magnitude	− 4.2	− 7.0	− 3.9
Photom. mass (kg)	1.9	1.3	none
Z R (°)	43.23		43.55

Fireball type: I

Ablation coefficient: 0.0210 s^2/km^2

Table 2 – Radiant data.

Radiant (1950.0)	Observed	Geocentric	Heliocentric
α (°)	147.2	148.7	
δ (°)	+ 17.70	+ 14.15	
λ (°)			95.81
β (°)			+ 0.55
Initial velocity (km/s)	18.967	15.133	37.40

Table 3 – Orbital data.

Orbit (1950.0)	
a	2.27 AU
e	0.642
q	0.8128 AU
Q	3.73 AU
ω	237°.5
Ω	343°.803
i	0°.59

Fireball

Austria, March 9, 1992, $4^h06^m00^s$ UT

P. Spurný, Ondřejov Observatory

In the morning of March 9, 1992, a slow-moving −10 maximum absolute magnitude fireball was photographed over Austria.

A slow-moving fireball of −10 maximum absolute magnitude was photographed by three Czech stations of the European Network. The fireball traveled a 80-km luminous trajectory in 5.0 seconds and terminated its light at a height of 22 km. The following preliminary results are based on three Czech records, but further records from the German part of the European Network are expected.

Table 1 – Trajectory data.

	Beginning	Maximum light	Terminal
Velocity (km/s)	18.57	16.71	5.5
Height (km)	83.2	37.1	21.7
Latitude (° N)	47.714	47.66	47.645
Longitude (° E)	16.379	15.88	15.705
Abs. magnitude	− 4.0	− 9.9	− 5.6
Photom. mass (kg)	33.0	23	(10)
Z R (°)	34.8		40.2

Fireball type: I

Ablation coefficient: 0.0043 s^2/km^2

Multiple meteorite falls of a total mass of about 10 kg are very probable. The predicted impact area is located at $\varphi = 47\overset{\circ}{.}638 \pm 0\overset{\circ}{.}009$ N and $\lambda = 15\overset{\circ}{.}595 \pm 0\overset{\circ}{.}011$ E.

Table 2 – Radiant data.

Radiant (1950.0)	Observed	Geocentric	Heliocentric
α (°)	299.3	303.6	
δ (°)	+ 39.0	+ 37.1	
λ (°)			61.5
β (°)			+23.7
Initial velocity (km/s)	18.57	14.61	29.7

Table 3 – Orbital data.

Orbit (1950.0)	
a	0.980 AU
e	0.265
q	0.720 AU
Q	1.240 AU
ω	72°
Ω	$348\overset{\circ}{.}2565$
i	$24\overset{\circ}{.}7$

A Southern Taurid Fireball over Japan

Yasuo Shiba and Katsuhito Ohtsuka

The result of orbital calculations of a fireball photographed over Japan on November 3, 1991, is presented. The fireball turned out to be a Southern Taurid.

A fireball (no. YS9101) with a terminal flare of magnitude −6 was photographed simultaneously by two stations in the *NMS* Fireball Network on November 3, 1991, at $13^h27^m40^s$ UT, using 35-mm fireball cameras with wide angle lenses.

The results of the trajectory and orbital elements are shown in Table 1. They indicate that YS9101 was a member of the Southern Taurid Meteor Shower, which is known to be associated with P/Encke.

Table 1 – Trajectory and orbital data of meteor YS901 (1950.0).

Time of appearance	1991 November 03.56088 UT
Solar longitude	$\lambda_\odot = 220\overset{\circ}{.}1$
Apparent radiant position	$\alpha = 52\overset{\circ}{.}5 \quad \delta = +14\overset{\circ}{.}5$
Corrected radiant position	$\alpha = 52\overset{\circ}{.}9 \quad \delta = +14\overset{\circ}{.}0$
Begin	$\lambda = 134°58\overset{'}{.}6$ E $\varphi = +33°52\overset{'}{.}6$ N $h = 81.5$ km
End	$\lambda = 134°51\overset{'}{.}3$ E $\varphi = +33°55\overset{'}{.}3$ N $h = 64.4$ km
Velocity	$v_\infty = 31.9$ km/s $v_{geo} = 29.7$ km/s $v_{hel} = 37.2$ km/s
Angular elements	$\omega = 118\overset{\circ}{.}4 \quad \Omega = 40\overset{\circ}{.}1 \quad i = 6\overset{\circ}{.}3$
Other elements	$e = 0.854 \quad q = 0.317$ AU $\quad a = 2.18$ AU

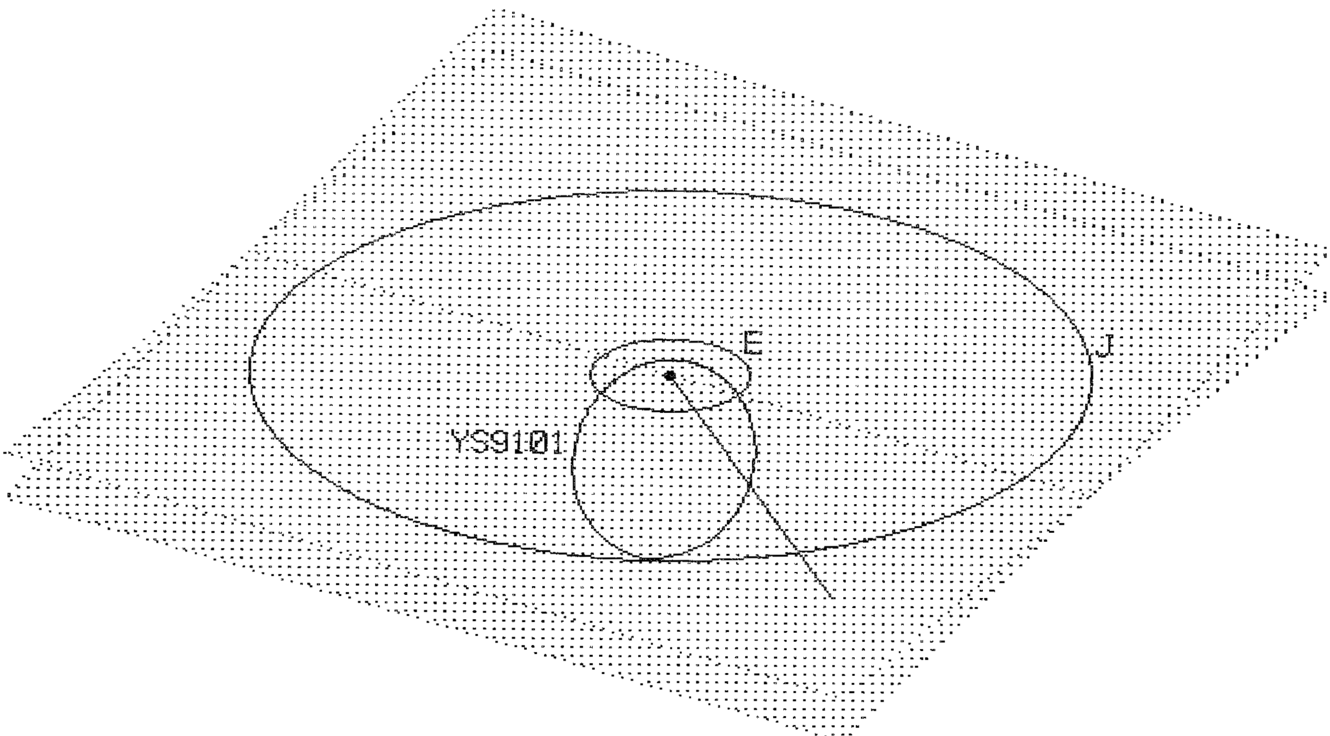

Figure 1 – The orbit of YS9101.

Meteorite Falls in Denmark

Gotfred Møbjerg Kristensen

A summary is given of four meteorites found in Denmark.

In Denmark, four meteorites have been found and recognized as such. Some information is contained in Table 1.

Table 1 – Meteorites found in Denmark.

Site	Date Found	Time of Fall	Mass	Type	Remarks
Mern, Sjælland	1878 Aug 29	13^h30^m UT	4 kg	stone	Immediately found
Århus, Jylland	1951 Oct 02	17^h13^m UT	720 kg	stone	Found shortly after fall
Jerslev, Sjælland	1977		40 kg	iron	very old and corroded
Felsted, Sjælland	1977		13.5 kg	iron	very old and corroded

Denmark has an area of 43 074 square kilometers. In addition to the items listed above, there are at least two suspected falls, but these have not been confirmed.

It would be interesting if *WGN* could publish more data on meteorite falls and discoveries, received from *IMO* members from countries all over the world. Therefore I would like to ask *IMO* members to send me a list of meteorite falls in their country. Depending on the quantity of data, such a list could be published in the *WGN* journal or a separate report. If, on the other hand, there already exists an up-to-date catalogue of meteorites from the entire globe, its existence should be made more widely known.

Visual Observational Results

The 1991 Perseids in Malta

Franco Gatt

Meteor observers were fortunate last year in that there was no moonlight to hamper observations of the Perseid stream—New Moon occurring on August 10, three days before maximum. As a result, Society members maintained excellent coverage of the shower over its full three weeks of activity.

Twenty-six observers contributed 412.4 man-hours of observation in the period July 30 to August 21, reporting 6164 meteors, of which 3649 were recorded as Perseids. The names of the observers were as follows:

> Stephen Abela, Joseph Agius, Neville Aquilina, Anna Baldacchino, Godfrey Baldacchino, Bernard Bonnici, Mark Borg, Stephen Brincat, Edwin Camilleri, Deborah Esposito, Erika Esposito, Klaus Farrugia, Adrian Galea, Martin Galea, Alex Gambin, Franco Gatt, Antoine Grima, Claudine Micallef, James Mizzi, Gordon Pace, Michael Schembri, Annabelle Sciculuna, Mark Sciculuna, Louise Suban, Christabelle Tabone, Frankie Tanti.

Observations were carried out from sites in Malta and Gozo where sky conditions were generally good (mean stellar limiting magnitude of +5.6).

Our data tends to show that in 1991 Perseid activity was higher than normal. The sporadic rates also showed an increase during the period under review. This was probably the consequence of observations being made in late evening in the first two weeks, in early morning in the last week, with coverage of entire nights close to the night of maximum. In fact, sporadic rates are seen to rise steadily during the night due to the changing relative velocities of the Earth and incoming meteoroids.

The Perseid shower is well-known for its relatively high number of bright meteors. In 1991 the fireball proportion was 6.3% for the Perseids, compared to 2.3% for the sporadic meteors. Of particular interest was a Perseid fireball of magnitude −8 observed on August 12 at 22^h53^m UT. This meteor produced a train which persisted for 15 seconds.

Fall 1991 Meteor Observations from the ALPO

Robert Lunsford

In 1991, *ALPO* observers managed to obtain data on 52 of the 92 days that occur during October, November and December.

The Orionids were well covered from October 6 to November 6 despite a bright Moon during the time of maximum. The Leonids were hampered by poor weather throughout North America. Only 59 shower members were seen on November 17 and 18.

The weather was even worse for the Geminid maximum. Only the western portion of North America enjoyed clear skies for the maximum. Many deserving observers in Hawaii and the eastern two-thirds of North America were denied their chance to see one of the better Geminid displays of recent years. I was fortunate enough to see rates as high as 123 per hour from my California location.

To summarize 1991, *ALPO* observers were active on 146 of the 365 days of the year. We currently have approximately 50 active observers in the United States, Canada and South Korea. We would like to expand our organization to include Mexico, Central and South America. First and foremost we must train our present roster to become competent meteor observers. We look forward to working closely in the future with the *IMO* to provide a clearer picture of the meteor activity that occurs in our longitudes and to reverse the present misconception that good meteor work is nonexistent in the United States.

The 1990 and 1991 Geminids in Rumania

Valentin Grigore

The author presents his observations of the 1990 and the 1991 Geminids from Tirgoviste, Rumania ($\lambda = 25°29\overset{\prime}{.}0$ E, $\varphi = 44°57\overset{\prime}{.}3$ N).

1. The 1990 Geminids

During two nights (December 12-13 and 13-14), the author saw 318 Geminids and about 180 sporadics in an effective observing time of $8\overset{h}{.}20$. The mean limiting magnitude was +5.7. Table 1 gives the magnitude distribution of the 1990 Geminids. About 3% of the meteors showed a train.

Table 1 – Magnitude distribution of the 1990 Geminids.

Magnitude	-4^-	-3	-2	-1	0	$+1$	$+2$	$+3$	$+4$	$+5$	$+6$	Tot
Number	1	1	4	31.5	117.5	78.5	48.5	29	5	2	0	318

The most remarkable meteor was a bluish fireball of magnitude -6 in the night of December 12-13 at 1^h50^m UT. A very bright purple circular hue preceded the fireball at a small distance. Its trail broke and was visible for four seconds.

2. The 1991 Geminids

During four nights (December 12-13, 14-15, 15-16 and 16-17) the author observed 191 Geminids, 9 σ-Hydrids, 6 Monocerotids, 3 χ-Orionids, 21 Coma Berenicids, and 137 sporadics, totaling an effective observing time of $9^h.15$. The worst mean limiting magnitude was $+6.0$. The most relevant magnitude distributions are shown in Table 2. About 9% of the Geminids, 15% of the Coma Berenicids, and 8% of the sporadics showed a train.

Table 2 – Magnitude distribution of the 1991 Geminids and Coma Berenicids, and of the sporadics seen during that period.

Shower	-4^-	-3	-2	-1	0	$+1$	$+2$	$+3$	$+4$	$+5$	$+6$	Tot
Geminids	3	6	5	15.5	39.5	52	35	18	9	7	1	191
Coma Berenicids	0	0	1	1	4.5	6	3	3	2	0.5	0	21
Sporadics	0	2	0.5	5	22.5	32	23	24	19.5	6.5	2	137

The most memorable Geminid was a bluish fireball of magnitude -6 at 3^h50^m UT on December 15-16. Its trail was broken and was visible for two seconds.

The 1992 Quadrantids in Bulgaria

Valentin Velkov

An overview is given of Bulgarian observations of the Quadrantids in the night of January 3-4, 1992. A very high activity was noticed. Some speculations are made regarding the possible existence of a subradiant as well as regarding the existence of a minor shower with radiant near δ CMa.

The Meteor Group of our Amateur Astroclub *Canopus* in Varna, Bulgaria, started its activity in 1975 with a Quadrantid watch. Since 1982, Quadrantid campaigns are held regularly. The 1992 Quadrantid observations were carried out in the village Avren, near Varna, by Julia Miteva, Valentin Velkov, Plamen Stefanov, and Stanimir Mechev. Three of us used the counting method to obtain ZHRs, while the fourth plotted meteors on the *Atlas Brno* maps to obtain radiant positions. We could only observe on January 3-4, but all that night, the sky conditions were comparatively good, with the limiting magnitude ranging between $+6.1$ and $+6.4$.

Two years ago, we decided to adopt the *IMO* method. Therefore, it is difficult to compare our present results with those of previous year, but we think a Quadrantid activity higher than that of 1992 has not yet been recorded in our Astroclub. According to the publications in *WGN* 20:1 and 20:2, observers from other countries have also seen very high hourly rates. What is puzzling is that not only our ZHRs but even the uncorrected hourly rates of the Quadrantids exceed the ZHRs calculated by other observers. Indeed, most of us saw about 180 Quadrantids per hour between 2^h and 4^h UT!

During the night, the shower activity kept increasing and so did the portion of the brighter Quadrantids, in agreement with the results obtained by British observers and cited by Malcolm Currie in *WGN* 17:5, p. 182.

As far as we know, there are long-standing suspicions that the Quadrantid radiant is complex. They are supported by some meteor observers in the former Soviet Union. Our latest observations as well as some observations conducted by members of our Club in the past also make us feel that this problem deserves further investigation.

Different sources give different information about the radiant position and the geocentric velocity of the Quadrantids, the latter varying between 35 and 46 km/s. Most frequently, the following data can be found [1–7]:

(i) $\alpha = 231°$, $\delta = +50°$, or similar; and

(ii) $\alpha = 230°$, $\delta = +55°$, or similar.

The first listing corresponds with the coordinates in the *IMO* list. The second listing corresponds to the coordinates of the possibly differentiated subradiant near the star ι Draconis ($\alpha = 226°$, $\delta = +56°$). From the 140 Quadrantids we plotted in the night of January 3-4, we associated about 10% with this subradiant. Indeed, the percentage is too small, and we agree completely with Ralf Koschack's notes in *WGN* 20:1, but we cannot but pay attention to similar results obtained by the Crimean observers [6] who were also able to distinguish such a subradiant.

Unfortunately, we have overlooked the Coma Berenicids specified at the end of the *IMO* list and mentioned in recent *WGN* publications. We recorded several δ-Cancrids and some δ-Canis Majorids—a shower which cannot be found in the *IMO* list. May be the same shower is known to the Spanish observers as ω-Canis Majorids (*WGN* 20:2). In the former Soviet Union, they are also called "Siriusids." The δ-Canis Majorids are described as beautiful, white meteors often leaving persistent trains. The orbital period of the stream is supposed to be 43 years. On January 2, 1873, a storm was observed with hourly rates above 1800. Significant activity was seen also in 1916 and 1959. An interesting appearance could therefore occur in 2002, too [2].

References

[1] Roggemans P., ed., "Handbook Visual Meteor Observations", 1987.

[2] Abalkin V.K., ed., "Astronomical Calendar - Invariable Part", Moscow, 1981 (in Russian).

[3] McKinley D.W.R., "Meteor Science and Engineering", Toronto, 1961 (Russian translation).

[4] Babadzanov P.B, "Meteors and Meteor Observations", Moscow, 1987 (in Russian).

[5] Astapovich I.S., "Meteor Phenomena in the Earth's Atmosphere", Moscow, 1958 (in Russian).

[6] Martynenko V.V., Levina A.S., "Meteor Activity in 1983–1984", *Earth and Universe* 3, 1985 (in Russian).

[7] Cesevich V.P., "What and How to Observe in the Sky", Moscow, 1979 (in Russian).

Comments from the editor

I am not going to repeat over and over again why great care should be taken in deciding whether or not certain minor showers—or, for that matter, subradiants of major showers—are actually real. I hope that the encouraging first results of the Radiant program discussed in the article about the Aquarid Project elsewhere in this issue are indeed just the first in a list of many, which might resolve some of the actual controversy. In this connection, I would like to point out that, as the Aquarid article shows, the 1991 Perseid radiant turned out to be completely unstructured, despite many claims of the contrary that were made over the past decades. In order to verify radiant structure or existence in other instances, it is vital that observers commit themselves to regular, high-quality and unprejudiced observing! It is indeed remarkable that the Bulgarian observing group noticed several minor showers one of which is not on the IMO list, while they missed the one that was most obvious, namely the Coma Berenicids!

Quadrantid Observations from Halifax, Nova Scotia

Paul Gray

An overview is given of 1992 Quadrantid observations from the east coast of Canada. Although group countings prevent reliable ZHR calculations, the observations confirm very high activity around 6^h30^m UT on November 4, 1992.

Three members of the Halifax Center of the *Royal Astronomical Society of Canada (RASC)* (Paul Gray, Pat Kelly and David Lane) observed the Quadrantid Meteor Shower from the east coast of Canada (the Beaverbank observing site, located just outside Halifax, Nova Scotia) on the night of January 3-4, 1992. Since the projected maximum of the 1992 Quadrantids occurred during night in North America, and since most of the continent was cloud-covered, these observations provide an important part of the picture of the 1992 shower (see articles in *WGN* 20:1, pp. 31–36).

Upon arrival at the observing site at 23^h20^m local time the sky was cloudy but thin enough to see the brightest stars which convinced us to wait. At 23^h50^m the sky had cleared well enough in the north-east sector such that observing could begin. The observations began at 4^h00^m UT and extended to 6^h30^m UT.

The skies were mainly clear for the session except from 4^h49^m UT to 5^h00^m UT, when some high haze blew over cutting the limiting magnitude to about +4.5. The limiting magnitude was found to be +5.8 during most of the observing session, corrected to +5.9 for the zenith according to information in the *RASC* Observers' Handbook. From 5^h00^m UT to 5^h14^m UT, large patches of cloud blew over and we thought that was it for the night. Fortunately, the sky cleared again, and after a brief break to rest our eyes and drink some coffee, we continued observations. From Halifax, the radiant is low in the sky, ranging from a zenith angle of 77° early in our observations to 62° at the end.

Unfortunately group totals, rather than independent observer counts, were kept, which makes strict ZHR calculations impossible. The three observers watched approximately the same area of the sky, and it is estimated that a factor of 0.85 should be applied in converting group totals to single observer counts. Assuming a population index of 2.1, the correction factor of 0.85 yields ZHRs ranging from about 130 at the beginning of the observations to about 205 at the end. These values are in general agreement with those reported in *WGN* from other parts of the world by more experienced meteor observers. Many sporadics were also observed, but only meteors from the Quadrantid radiant are indicated in this report.

As time wore on, we started to get cold and tired, so it was decided to stop at 6^h30^m UT. This may have been a bad decision as a bit longer observations might have identified the peak with more precision. Our best guess is that the peak was at 6^h30^m UT, only a half hour after predicted in the 1992 *RASC* Observers' Handbook. The other possibility was that the peak was much later and that we missed a spectacular show that few people would have observed.

The above was extracted (and slightly refined) by R.L. Hawkes from an article published in Nova Notes, Halifax RASC, Jan-Feb 1992, by Paul Gray.

The August issue

The August issue will appear a little bit earlier than usual, say in the last week of July rather than the first week of August. Therefore, make sure your contributions arrive in time! Also, the August issue will be a normal one, so do not be disappointed if your contribution cannot be accommodated right away. (Ed.)

Telescopic Observational Results

The 1992 Quadrantids in Czechoslovakia

Petr Pravec, Ondřejov Observatory

The Quadrantid Meteor Shower was observed telescopically by Czechoslovak observers during the nights of January 2-3 and 3-4, 1992. There were 227 telescopic records of meteors received from reliable observers before the end of February 1992; this number is expected to further increase. A preliminary look into the data showed that about 70 Quadrantids and about 20–25 apparent Coma Berenicids were recorded.

Very favorable conditions for observing the Quadrantids in January 1992, and a discussion about the possibility to organize a common observing program for several groups of telescopic meteor observers in Central and Western Europe at the 1991 *IMC* in Potsdam caused us to work up the 1992 Quadrantid Telescopic Program (1992 QTP) [1]. The main task of the program was to describe the activity and the structure of the radiant of Quadrantids of magnitudes +4 to +8, since observations of such faint Quadrantids were very rare till that time.

From January 1 to 6, 1992, Czechoslovakian observers were ready for implementing the 1992 QTP. Unfortunately, there were only two nights with rather favorable weather conditions (January 2-3 and 3-4); fortunately, the second one coincided with the Quadrantid maximum. Especially during the night of the maximum, very strong telescopic activity of the Quadrantid Meteor Shower was recorded. (By the way, the telescopic observations suffered from a tendency of some observers to turn away from telescopic observations for being able to observe such a strong shower of bright meteors visually!)

Up to the end of February, 1992, I received from 14 Czechoslovak observers a total of 227 telescopic meteor records obtained for the 1992 QTP. A preliminary look into the data revealed that about 70 Quadrantids were recorded. Due to the geometry of the observed fields with respect to the Quadrantid radiant, a good analysis of its position with a precision better than 1° will be possible. The observing fields were indeed selected in such a way that some necessary conditions for good telescopic observations of this shower were fulfilled (three fields were selected at a distance of about 19° in various directions from the radiant). With respect to the fact that the 1992 return of the Quadrantids was one of the strongest in the 20th century (see, e.g., [2]), the description of the radiant position (and structure) of this shower is of special interest.

A thorough analysis of the data will be performed in the near future. Performing a preliminary analysis of the data (227 records), I found a significant excess of fast, faint meteors in a rather wide range of the position angle around 50° (position angle of the projected meteor velocity with respect to the north, counterclockwise) in field no. 1 ($\alpha = 228\overset{\circ}{.}67$, $\delta = 67\overset{\circ}{.}35$) and around 45° in field no. 3 ($\alpha = 203\overset{\circ}{.}81$, $\delta = 44\overset{\circ}{.}20$) (all eq. 2000.0). This excess indicates a significant activity of some shower with a high population index from some (rather extensive) radiant area lying—unfortunately for a more accurate description by these observations—somewhere near the great circle connecting the centers of the fields no. 1 and no. 3 (more exactly, near the section of this great circle closer to field no. 3).

Angular velocities of the meteors contained in the excess were very high (4 or 5 in the relative 0–5 telescopic velocity scale), but somewhat lower in field no. 3. Such a high velocity is an indication for a high v_∞ of the shower and for a rather great distance between its radiant and the observed field. (E.g., the Perseids with $v_\infty = 59$ km/s have angular velocities of 2 or 3 at a distance of about 13° from the radiant; the Quadrantids with $v_\infty = 41$ km/s have similar angular velocities at 19° from the radiant.) A rough estimate of the number of meteors in this excess is 20–25 (out of 227).

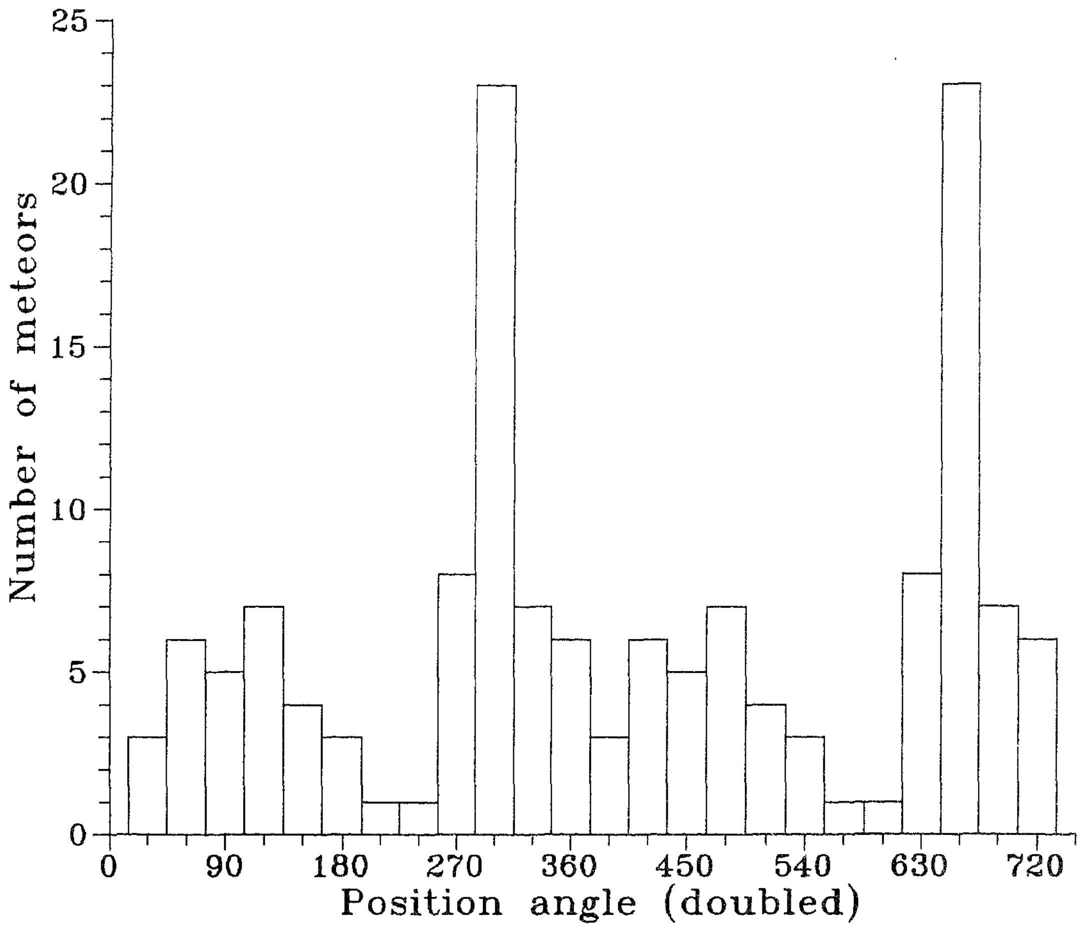

Figure 1 – Number of meteors versus position angle for a subset of medium-slow meteors (velocities 1 to 3) observed in field no. 2. The position angle axis has been doubled in order to make the make obvious the cyclic nature of that quantity. An excess at about $300° = 660°$ is due to the Quadrantids. Other meteors were sporadic. A very broad local excess between 30° and 180° is an indication of the excess of sporadic meteors radiating mainly from greater elevation, if a field is not close to the zenith. (You really see meteors falling into the atmosphere.) After selecting only "bright" meteors (say, brighter than +8.5), the number of sporadic meteors is greatly reduced, while the number of Quadrantids remains almost the same, due to the low population index.

The identity of this shower can be revealed by visual observations. Luis Bellot [3] and Trond Erik Hillestad [4] mentioned enhanced activity of the Coma Berenicids in the visual magnitude range on the night of January 3-4, 1992. According to [5], the radiant of the Coma Berenicids was at $\alpha = 188°$, $\delta = +22°$ in the night of January 3-4. Further data include $v_\infty = 65$ km/s, $r = 3$, and diameter of the radiative area equal to about 5°. Considering this radiant position, the position angle of Coma Berenicid meteors at the center of field no. 1, respectively no. 3, is 51°, respectively 36°, while the distances between the radiant center and the field centers are 52° and 26°, respectively. Almost all these figures agree well with our shower, with exception of the size of the radiant area, which seems to be much more extensive in our observations. This however may have been caused by larger plotting errors for meteors of magnitude about +9 and/or by sporadic pollution. It seems probable that the observers indeed saw the Coma Berenicid Shower, but more data and detailed analyses are needed to confirm this hypothesis.

I expect to receive further telescopic data about the 1992 Quadrantids from Czechoslovak observers. I would like to make a proposal to all telescopic observers over the world who observed the 1992 Quadrantids. If you care for thorough analysis of your Quadrantid telescopic data, please contact me. I would be very glad to analyze also your data together with the other data; the results would be more accurate and reliable. The nice 1992 Quadrantids are worthy of it!

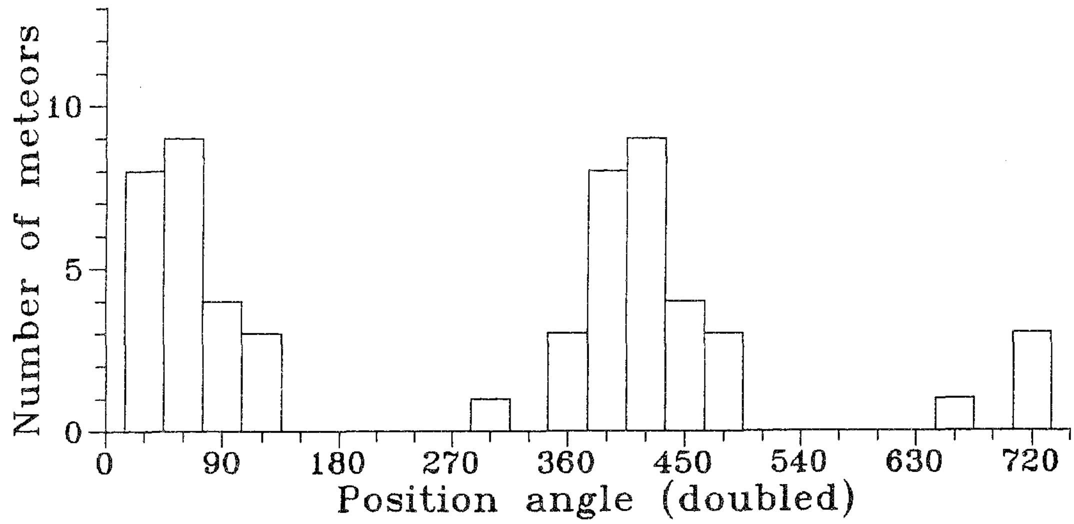

Figure 2 – Number of meteors versus position angle for a subset of fast meteors (velocities 4 to 5) observed in field no. 1. An excess around 50° = 410° is a sign of a shower, probably the Coma Berenicids, consisting mainly of faint meteors. Its width is rather great, due at least partially to the sporadic pollution (see the caption of Figure 1). Its excess is less pronounced in other fields, but obvious at least in field no. 3.

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[1] P. Pravec, V. Znojil, "The 1992 Quadrantid Telescopic Program", Department of Interplanetary Matter, Ondřejov Observatory, December 1991.

[2] R. Koschack, "Strong Return of the Quadrantids over Europe", *WGN* 20:1, 1992, p. 31.

[3] M. Gyssens, ed., "The 1992 Quadrantids in England and Spain", *WGN* 20:1, 1992, p. 33.

[4] T.E. Hillestad, "The 1992 Quadrantids in Norway", *WGN* 20:1, 1992, pp. 34–35.

[5] J. Wood, R. Koschack, D. Artoos, "Observers' Notes: January–February 1992", *WGN* 19:6, 1991, pp. 222–224.

Radio Observational Results

Hungarian Observations of the 1991 Leonids

István Tepliczky and Péter Spányi

Last year, the Full Moon prevented visual observations of the Leonids. That is why the maximum of the shower could be studied only by radio methods. The Meteor Section of the *Hungarian Astronomical Association* received reports on the 1991 Leonids from three places.

János Szűcs (SZUJA) in Makó (46°15′ N, 20°28′ E) counted meteor echoes in half-hour periods on nine consecutive mornings (from November 13 to 22, 1991) between 5^h00^m and 5^h30^m UT. (He used an amplified 9-elements Yagi antenna directed to 120° azimuth, 0° elevation. His receiver's sensitivity was 2 microvolts, its frequency was 88.3 MHz). His results are shown in Figure 1.

Károly Jónás (JONKA) and László Vámosi (VAMLA) in Budapest (47°24′ N, 19°07′ E) made several one-hour countings in the morning hours around the expected date of the maximum. (Technical parameters: 6-elements Yagi antenna directed to 90° azimuth, 0° elevation; sensitivity 2 microvolts, frequency 87.8 MHz). Their average hourly rates between 2^h and 5^h UT were 157, 138, and 142, on November 16, 17, and 18, respectively.

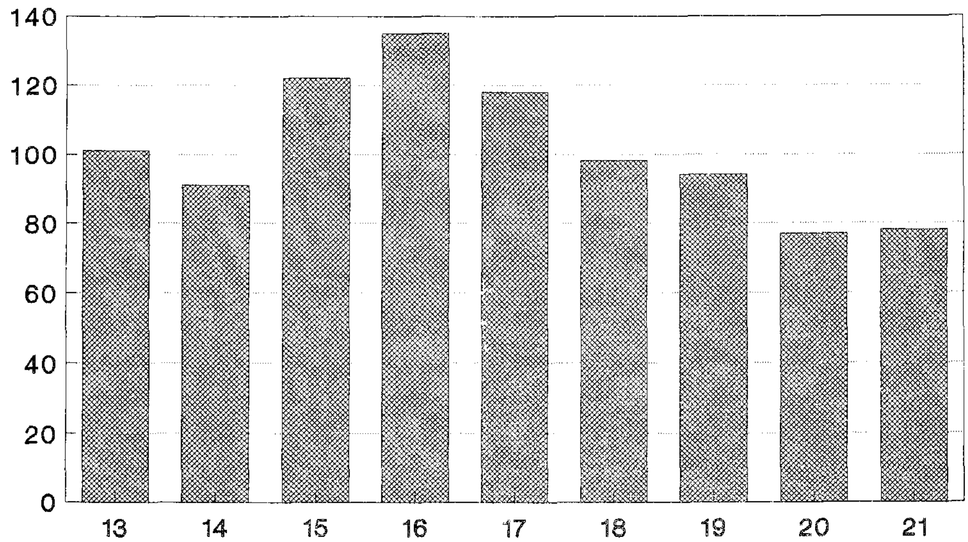

Figure 1 – Number of echoes in half-hour intervals obtained by János Szűcs in November 1991.

Both observations suggest that the activity was higher on November 16 than on November 18, which was the expected date of the maximum, although the difference is not essential.

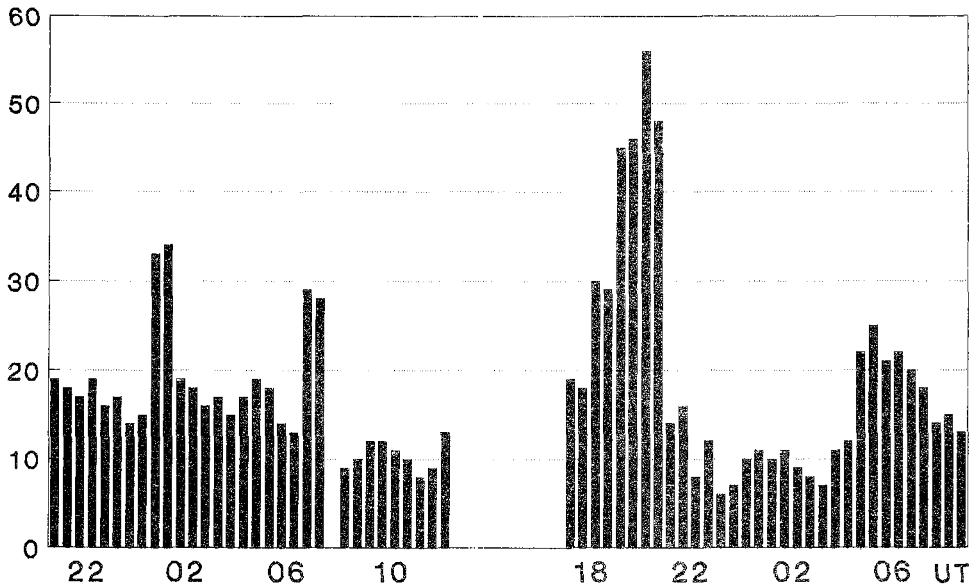

Figure 2 – Number of echoes in half-hour intervals obtained by the team in Rumania on November 15-16-17.

The following team of 13 observers made a 36-hour long, almost continuous, radio observation with rather simple instruments on 56.8 MHz in Odorhei-Secuisc, Rumania (46°17′ N, 25°17′ E):

Csaba Bálint, Enikó Csoma, Zsolt Csutak, Ágnes Mika, Zsófia Mika, Imola Nagy, Zsófia Székely, Csaba Thamó, Attila Tóth, Márta Vajda, Attila Vaszi, Melinda Vaszi and Attila Vétesi.

Their work was interrupted by a five-hour long power cut; that is why the value of their results is limited. Figure 2 shows the meteor rates in 30 minute periods. The increase of activity in the morning hours could be caused by the Leonids. The peaks on November 16 are higher than those on the following days, as in the two other observations mentioned above. There is no explanation, however, for the high activity in the evening of November 16. The Leonid radiant was below the horizon at that time, and the profile does not resemble a slow and continuous increase of the echo rate.

The HAA/MS is Founded

István Tepliczky and Péter Spányi

Hungarian meteor observations in the modern era date back to two decades. In the beginning, only very simple descriptive-style observations were made. Since the early 80s, a major change has taken place. Then, we started to apply more sophisticated, more "professional" methods and we redesigned our meteor plotting charts. Since then, the number of observers and the amount of observations has been increasing: more and more data are collected about meteor streams. We have more than 100 visual and a few radio and photographic observers.

We introduced our observing system in 1985. This is slightly different from that of the *IMO*, but we are working on an approach to adapt our method to the *IMO*'s system. Most of our data can be transformed, so they can be used "more or less" for global investigations.

Until the end of last year, the Hungarian meteor observers had been working in the *Hungarian Meteor and Fireball Observing Network (HMFON)*, an officially unregistered organization. This name was a heritage from the past 20 years. In 1989, the *Hungarian Astronomical Association (HAA)* was re-founded after a 40 year long pause. In the future, the Hungarian meteor observers would like to work as a section of the *HAA*. The foundation ceremony was held on December 15, 1991, during an observing camp organized to watch the Geminids. This stream greeted the event by a spectacular "firework." The new name and new organization, however, do not imply any change in the character of our observing work. Just as before, we continue to send visual, photographic, and radio data to the *IMO*.

Meeting of the Radio Commission

Ghent, Belgium, February 1, 1992

Jeroen Van Wassenhove

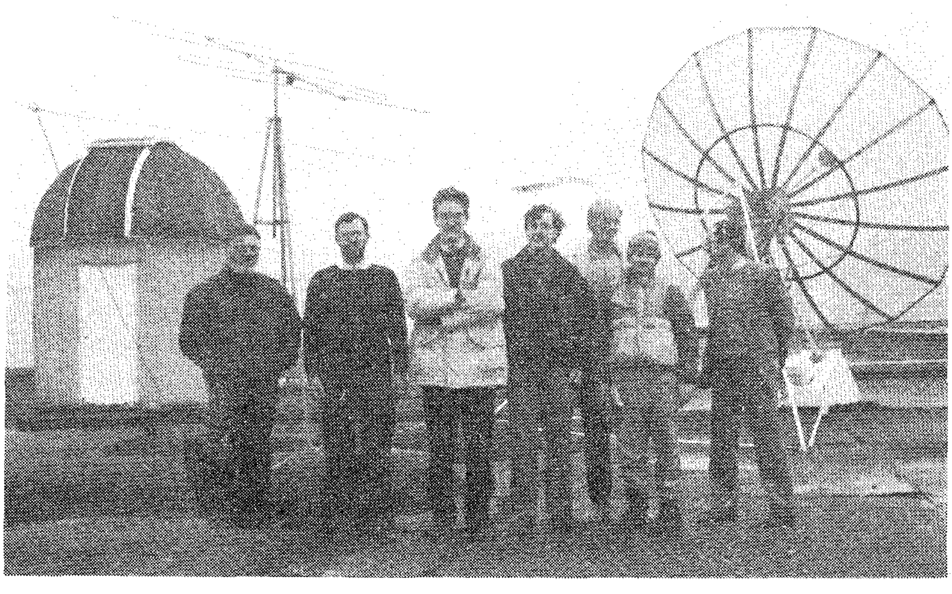

Figure 1 – Radio Commission meeting in Ghent, February 1, 1992 (see *WGN* 20:2, April 1992, p. 102). From left to right: Maurice De Meyere, Dirk Laurent, Paul Vauterin, Jeroen Van Wassenhove, Knud Bach Kristenson and his son, and Christian Steyaert.

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