International Meteor Conference, Porec, Croatia, September 24-27, 2009

10 Years IMO Video Meteor Network

Data Set and Analysis Procedure

Sirko Molau

Arbeitskreis Meteore e.V. (AKM), Germany

Agenda

- MetRec 5
- 2009 Data Set
- Analysis Procedure

MetRec 5 (I)

Latest Development

- All cameras in the IMO Network use the MetRec software, which so far supports only DOS
- In 2008, D. Koschny presented the work of ESA programmer H. Smith to port MetRec to Windows
- Starting from February 2009, Hans and me have cooperated intensively on this issue (~20 code iterations since then)
  - » The code base for DOS and Win has been combined, all OS specific functions were moved to specific modules
  - » Some core routines (frame handling, time determination) underwent a significant redesign and simplification
  - » A number of bugs that went unnoticed under DOS were identified and corrected
  - » New features requested by different observer were implemented on the new code base
- The new version will be MetRec 5

MetRec 5 (II)

New Features

- Grab/GrabSeq/GrabStrm: date & time stamp can be inserted
- MetRec: a background image may be saved after a predefined amount of time; DST correction;
- Ref2Txt & Txt2Kml: create KML files in a comfortable way
- RadFind & StrmFind: implementation of the new radiant and meteor shower search algorithm (observability function, Laplace distribution, recomputed meteor shower assignment, meteor altitude formula); shower identification based on the MDC working list with >300 showers
- RefStars: combined measurement of several reference images
- MetRec, PostProc & Co: extension of PosDat header IDs 000-ZZZ, the frame grabber device number can be chosen if more than one grabber is installed (not yet fully tested)

MetRec 5 (III)

Current Status

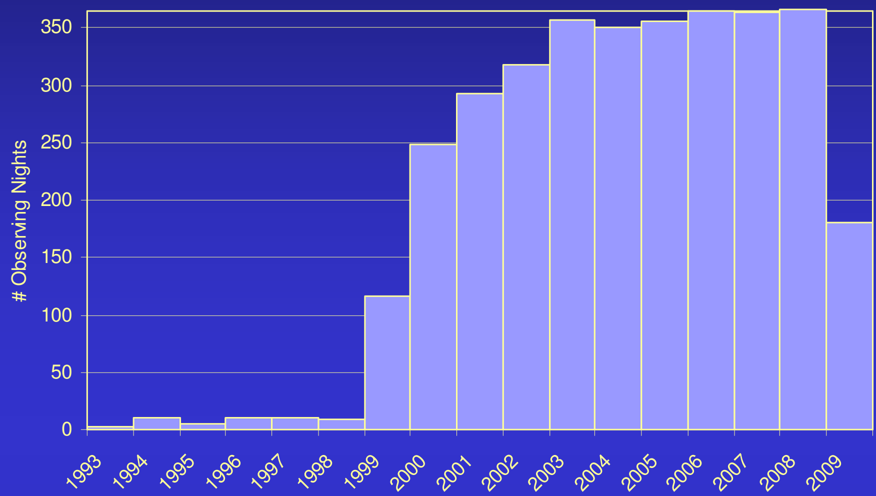
- Both OS versions can be compiled error-free from the same source code with two different compilers (Watcom and MS VC++)
- All keys combinations are working in both environments
- The code has been tested and is running on both platforms
- A few minor functions are not yet available under Windows (e.g. support of DCF clocks)
- D. Koschny has been using the Win version for almost a year now, the Polish observers have tested the program as well, but more field tests are still required → test users are welcome
- MetRec 5 will be released later in 2009

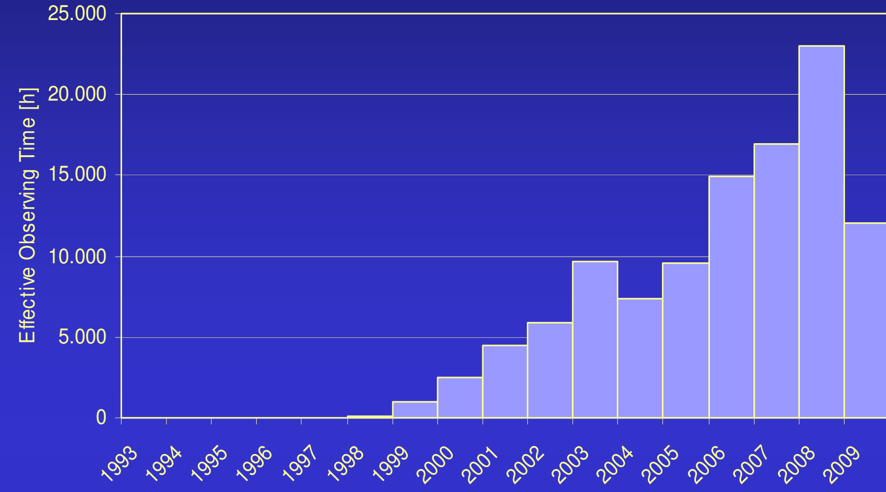
2009 Data Set (I)

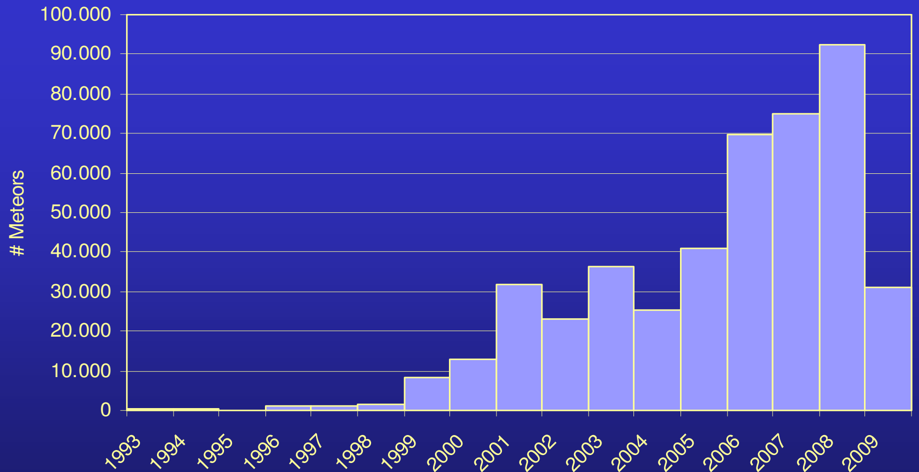
Motivation for a New Analyses

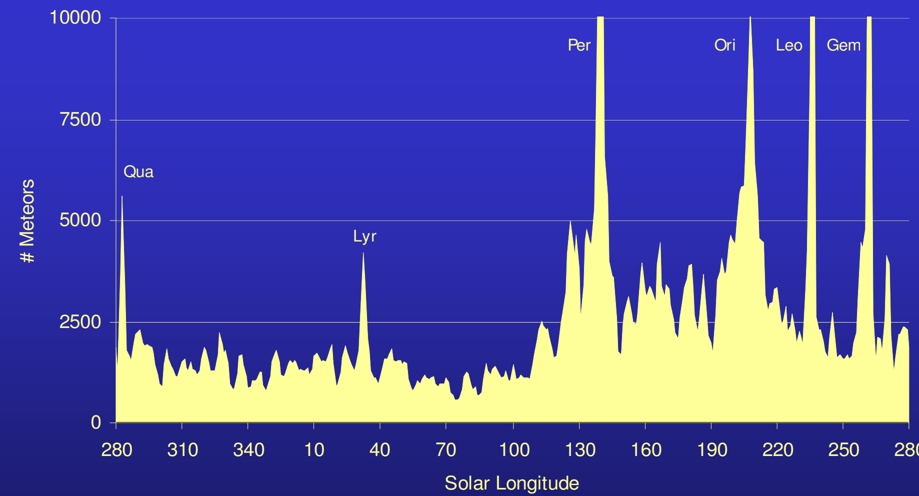
- The IMO Video Meteor Database has further grown since the last analyses: 188,000 met. (2006) → 360,000 met. (2008) → 450,000 met. (2009)
  → >680 meteors per solar longitude interval
- The meteor shower detection algorithm has stand the practice test → all showers newly found by the SonotaCo network could be confirmed with IMO data
- To the automated shower extraction was augmented with a manual refinement and plausibility check
- Provide input for the rework of the MDC meteor shower list in 2009
- Last but not least: 10th Anniversary of the IMO Video Meteor Network

2009 Data Set (II)









2009 Data Set (III)

Observer	Country	IMO Code	Nights	Teff	Meteors
Sirko Molau	DE	MOLSI	2.344	20.807,2	127.072
Jörg Strunk	DE	STRJO	1.696	12.709,4	42.009
Javor Kac	SL	KACJA	1.173	10.333,0	31.354
Ilkka Yrjölä	FI	YRJIL	942	5.419,2	18.596
Stane Slavec	SL	SLAST	871	4.318,9	11.262
Flavio Castellani	IT	CASFL	794	5.775,4	13.802
Orlando Benitez-Sanchez	ES	BENOR	733	4.088,3	10.473
Jürgen Rendtel	DE	RENJU	647	3.823,4	17.223
Bernd Brinkmann	DE	BRIBE	598	2.376,2	8.366
Detlef Koschny	NL	KOSDE	509	3.126,3	11.567
Mihaela Triglav	SL	TRIMI	505	2.585,9	8.474
Robert Lunsford	US	LUNRO	495	3.204,2	22.122
Enrico Stomeo	IT	STOEN	492	3.605,5	13.854
Stephen Evans	UK	EVAST	457	2.807,3	11.411
Wolfgang Hinz	DE	HINWO	455	2.689,5	13.690
Carl Hergenrother	US	HERCA	399	2.805,7	5.570
Steve Quirk	AU	QUIST	341	3.041,8	10.109
Rui Goncalves	PT	GONRU	320	2.850,6	9.931
Biondani Roberto	IT	ROBBI	229	1.261,6	4.082
Stefano Crivello	IT	CRIST	229	1.459,4	6.217
Mirko Nitschke	DE	NITMI	213	942,5	5.425
David Przewozny	DE	PRZDA	196	1.073,6	3.745
Stefan Ueberschaer	DE	UEBST	173	882,3	1.684
Ulrich Sperberg	IT	SPEUL	159	1.021,6	4.339
Maurizio Eltri	DE	ELTMA	169	1.210,4	5.886
Paolo Ochner	IT	OCHPA	134	733,2	1.763
Rosta Stork	CZ	STORO	98	1.052,8	14.732
Rob McNaught	AU	MCNRO	52	401,2	5.285
Andre Knöfel	DE	KNOAN	47	289,0	648
Klaas Jobse	NL	JOBKL	47	288,0	2.231
Milos Weber	SL	WEBMI	29	49,4	1.050
Mitja Govedic	HU	GOVMI	33	156,7	489
Antal Igaz	CZ	IGAAN	32	217,7	369
other	-	OTHER	25	186,8	6.452
Overall			***3.363***	***107.594,0***	***451.282***

- Data from Jan 1993 – Jun 2009
- >70 cameras
- >30 observers
- 12 countries (Australia, Czech Republic, Finland, Germany, Hungary, Italy, Portugal, Slovenia, Spain, the Netherlands, UK, USA)
- 12.3 years of continuous observations and 1.5 days of continuous meteors

Analysis Procedure (I)

Radiant Search

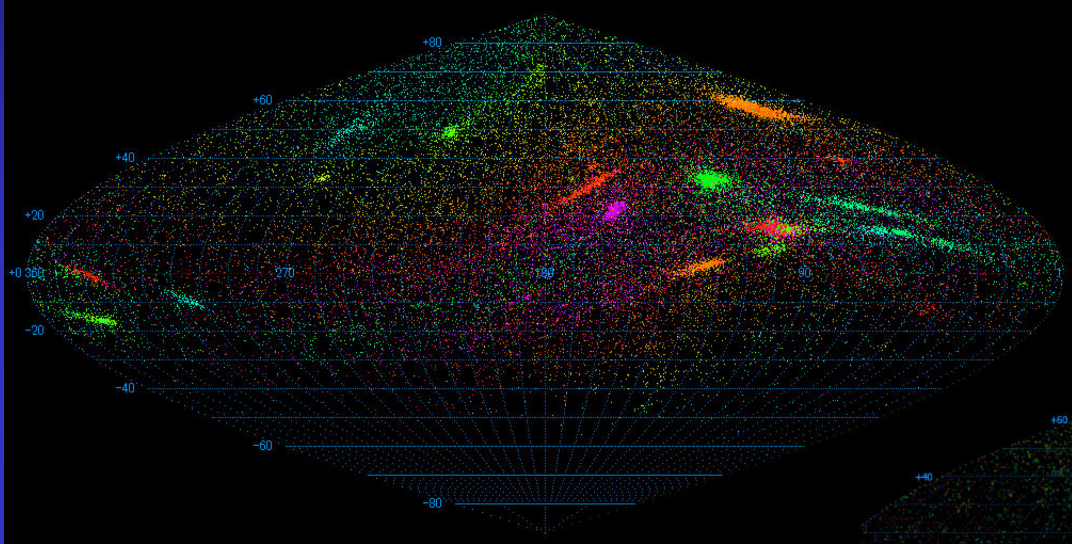
- Find the set of radiants R that maximizes the conditional probability P (M | R) given the set of meteors M:

$$P(M \mid R) = [\exp(-0.8\, D) * \exp(-V/(0.4+V/50))]$$

with: D ... Radiant miss distance [°]
V ... Velocity deviation [°/s]

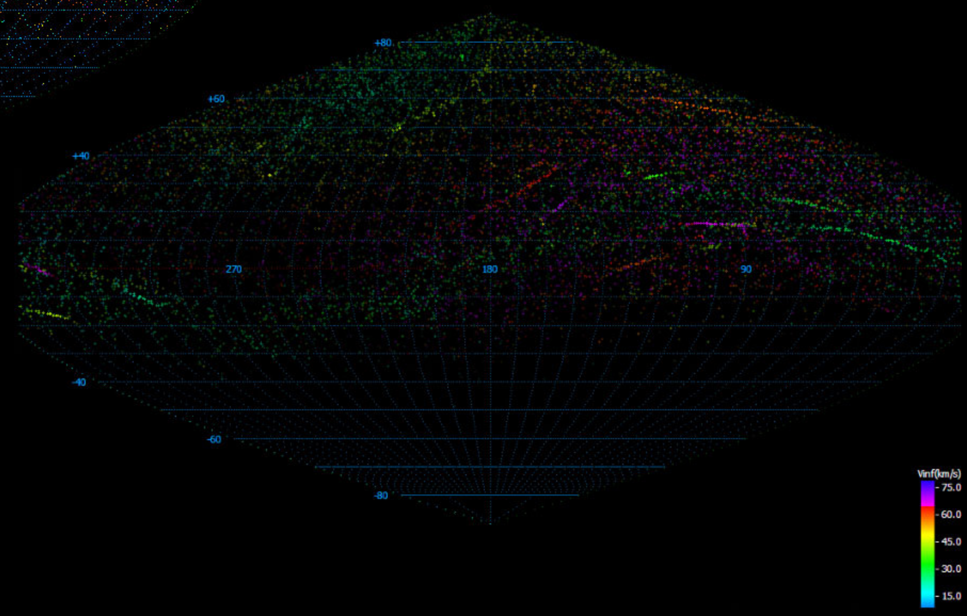
- Cut the observations into solar longitude slices of 2° length, 1° shift
- Step size ½° in position and 1 km/s in velocity
- Iterative radiant search:
  - → Start: Accumulate P (M | R) over all possible R
    - → Loop: Select the radiant R\` with largest probability P (M | R\`)
    - → Determine all meteors M\` belonging to R\`
    - → Accumulate P (M‘ | R) over all possible R and subtract it from the original distribution
  - → End: Reassign the meteors to the meteor showers and recompute the shower parameters

Analysis Procedure (II)



IMO Network

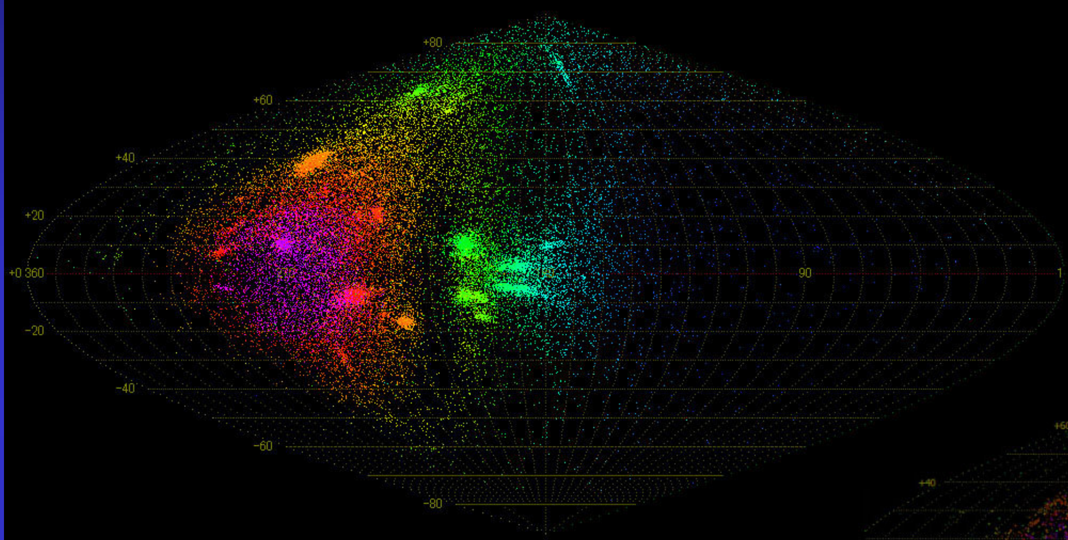
- Each dot one radiant
- 17.000 radiants with 10-10^3 met.
- Radiant velocity color coded
- Radiants strength intensity coded



SonotaCo Network

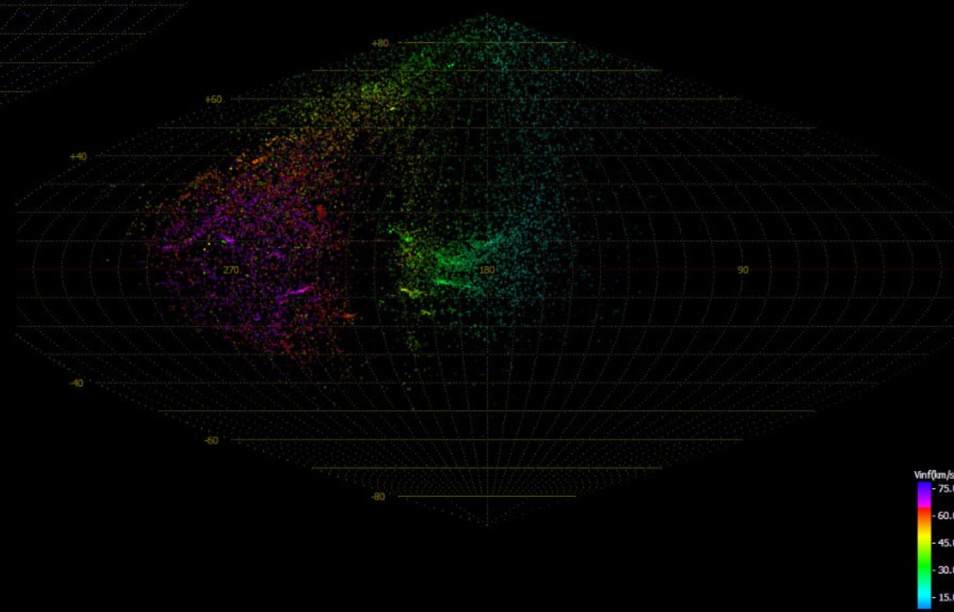
- Each dot one orbit
- 39.000 orbits
- Radiant velocity color coded

Analysis Procedure (III)



IMO Network

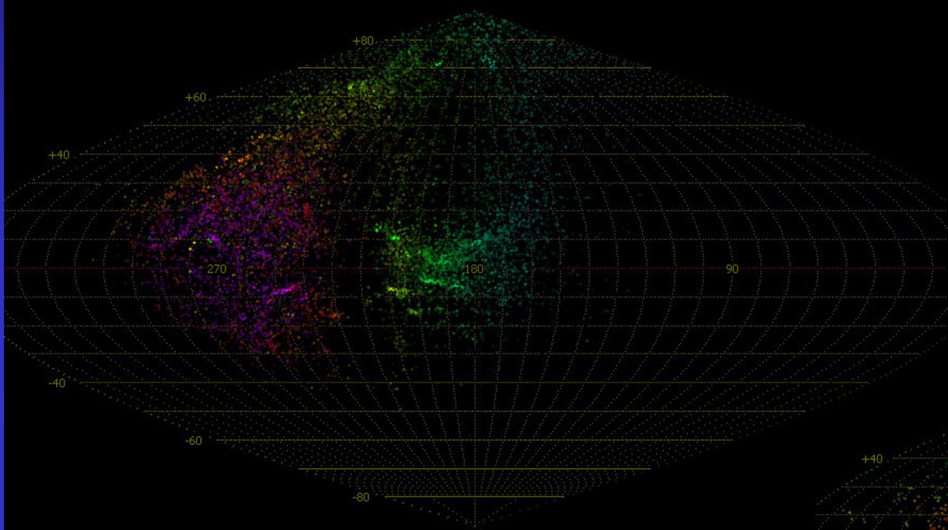
- Ecliptical minus solar longitude vs. ecliptical latitude of radiant



SonotaCo Network

- Ecliptical minus solar longitude vs. ecliptical latitude of radiant

Analysis Procedure (IV)

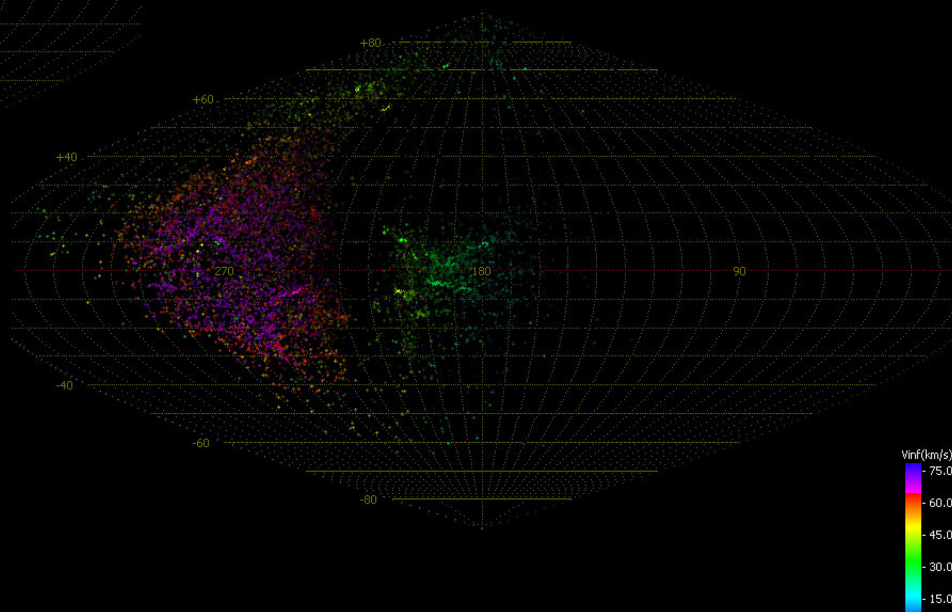


IMO Network

- Without observability correction

IMO Network

- With observability correction



Analysis Procedure (V)

Meteor Shower Search

- Connect radiants with similar position/velocity in consecutive solar longitude intervals
  - → Minimum shower duration: 5° solar longitude (in further steps reduced to 3°)
  - → Maximum shift in position: 7°
  - → Maximum shift in velocity: 7 km/s
- Compute shower parameters: Radiant position, drift, velocity
- Comparison against the MDC list and known sporadic sources for shower identification
- Compute the VR (video rate) profile
  - → Observability corrected shower counts
  - → Ratio of shower and sporadic meteors
  - → Correct for annual sporadic activity variation
  - → Scale to give ETA a VR_{max} of 50

Analysis Procedure (VI)

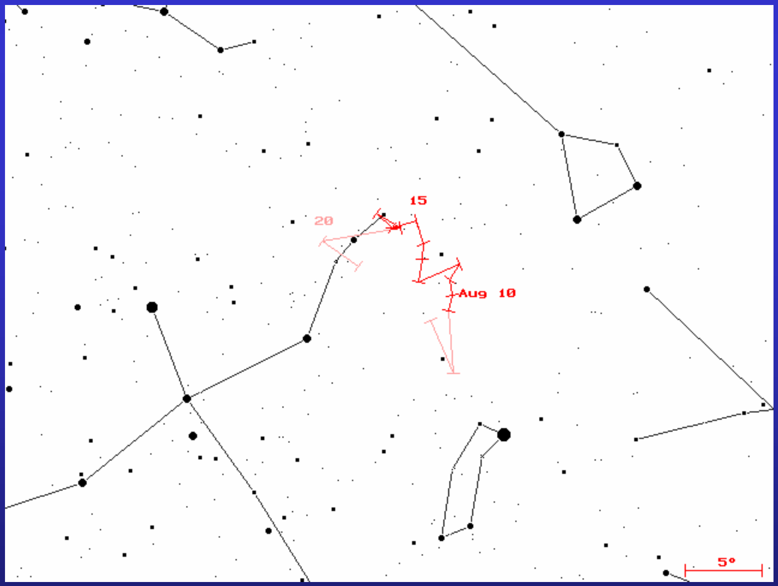
Manual Refinement

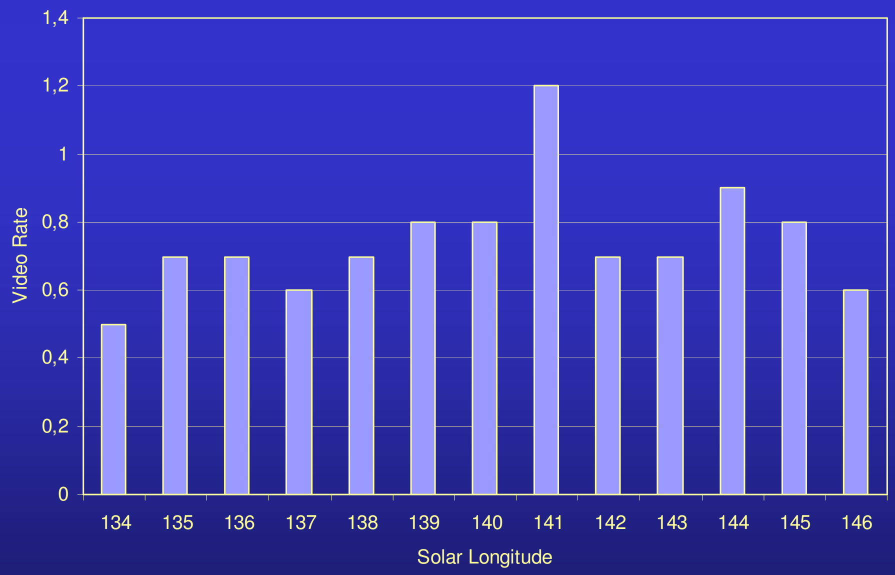
- Omit uncertain intervals at the begin or end of meteor shower activity where
  - → The radiant position does not yield a consistent drift
  - → The shower velocity is not consistent with the average value
  - → The video rate falls below a certain limit
- Omit showers that have no consistent drift, velocity or a sufficient VR at all
- Split merged and combine splitted meteor showers
- Recompute shower parameters by weighted linear regression from the reduced activity interval
  - → Shower maximum
  - → Average radiant position and drift
  - → Average shower velocity and possibly drift
- Resulting accuracy (estimated for VR>2):
  - → $<1°$ in position
  - → <1 km/s in velocity

Analysis Procedure (VII)

Example: kappa-Cygnids

- Boundaries obtained from the 2009 data set
  - → Maximum deviation in position between consecutive solar longitude intervals: 3°
  - → Minimum video rate: 0.7





The End

Thanks for your attention!

Questions?