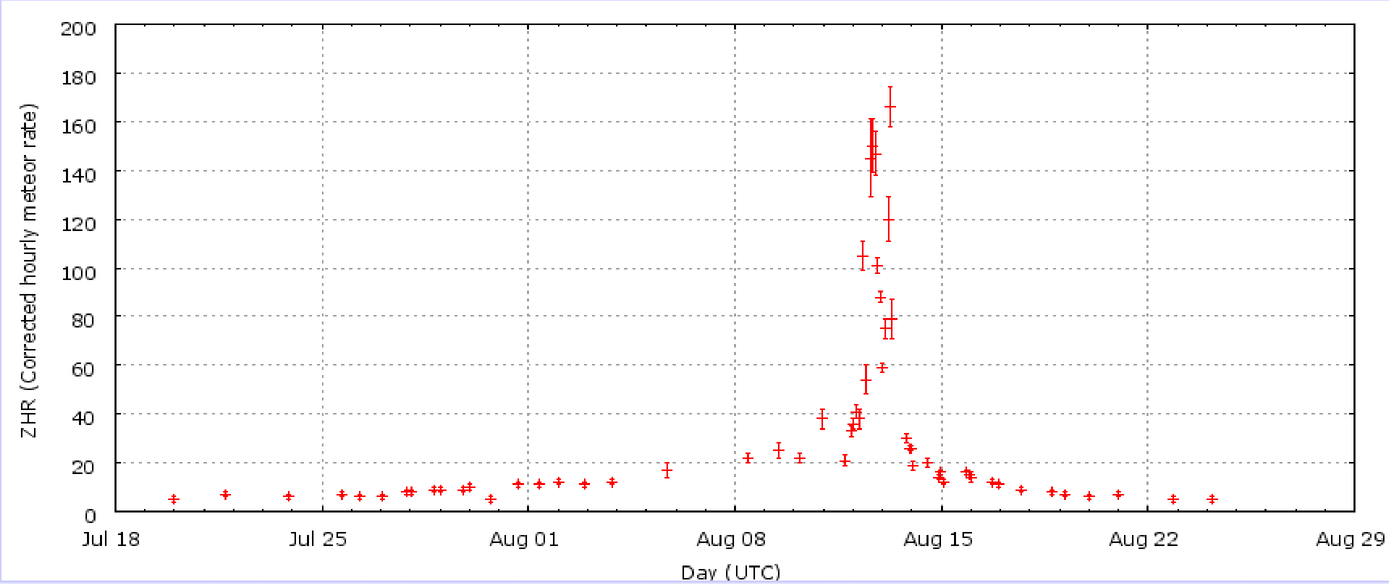
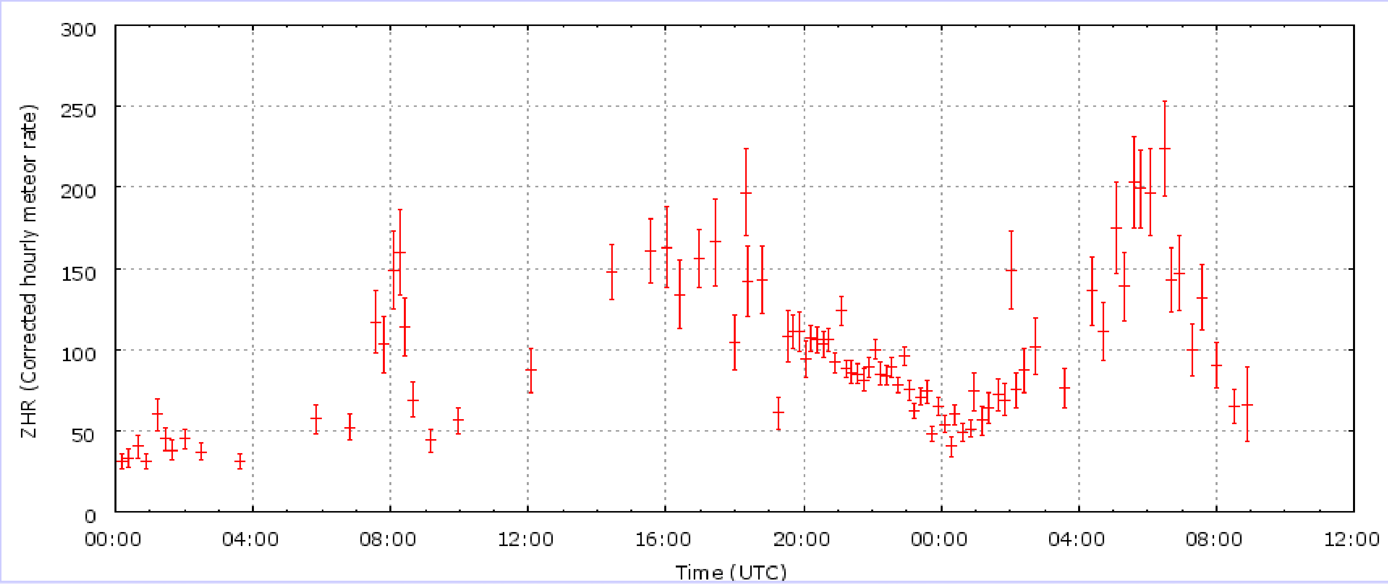
Where to go in meteor science?

Rainer Arlt

Visual observations

- Still the most powerful tool to obtain activity profiles
- Almost all meaningful results have been de rived from “counting”
- Big question:
  is there a reason to plot meteors?



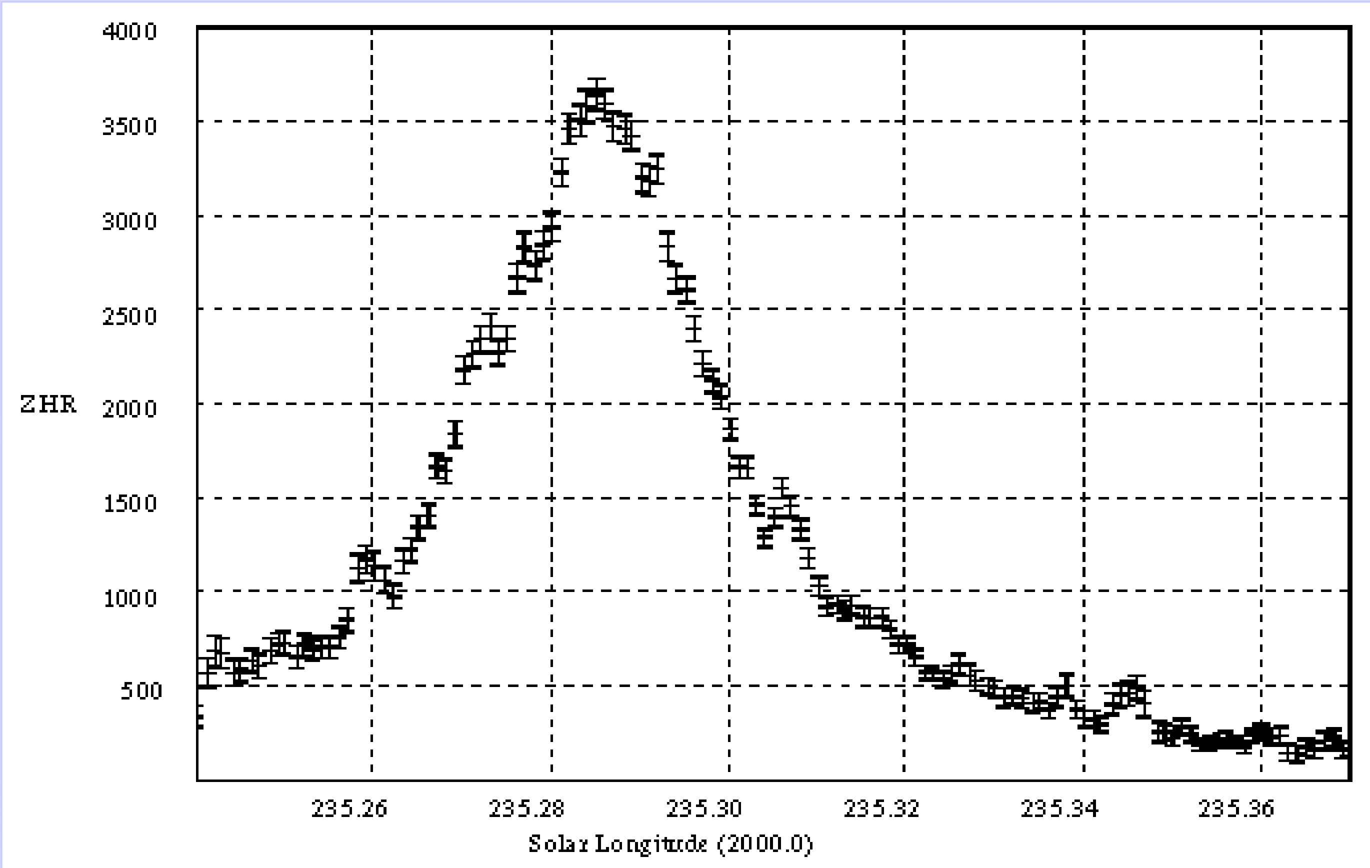


2009 Perseids
(Barentsen, IMO website)

Visual observations

- Extremely high resolution activity profiles possible
- Not achievable by any camera network because of Poissonian errors
- Requires excellent international coordination and motivation

1999 Leonids



Historical data?

- Analyses by Rendtel (Geminids, Orionids), Brown (Leonids), Arlt (June Bootids)
- No comprehensive set of data available
- Enormous amount of data, but be care ful when analazing

Hoffmeister 1914

Zur Erlangung befriedigender Übereinstimmung der Endpunkte muß die in Sonneberg beobachtete Bahn bis $\alpha = 31.°6$, $\delta = +71.°1$ verlängert werden. Der Ort des Aufleuchtens und die Bahnlänge wurden nach der Jenaer Beobachtung bestimmt, da sich die Sonneberger Bahn zu nahe beim Radianten befindet.

I.	$\lambda = 11° 54'$	$\varphi = +51° \; 4'.5$	$H = 99$ km
II.	$11 \; 37.5$	$+50 \; 54$	71.0 km

Radiant: $\alpha = 20.°4 \quad \delta = +61.°2$

$\lambda = 48.°1 \quad \beta = +47.°5 \quad E = 51.°9$

$a = 223.°6 \quad i = 46.°2 \quad l = 38.7$ km.

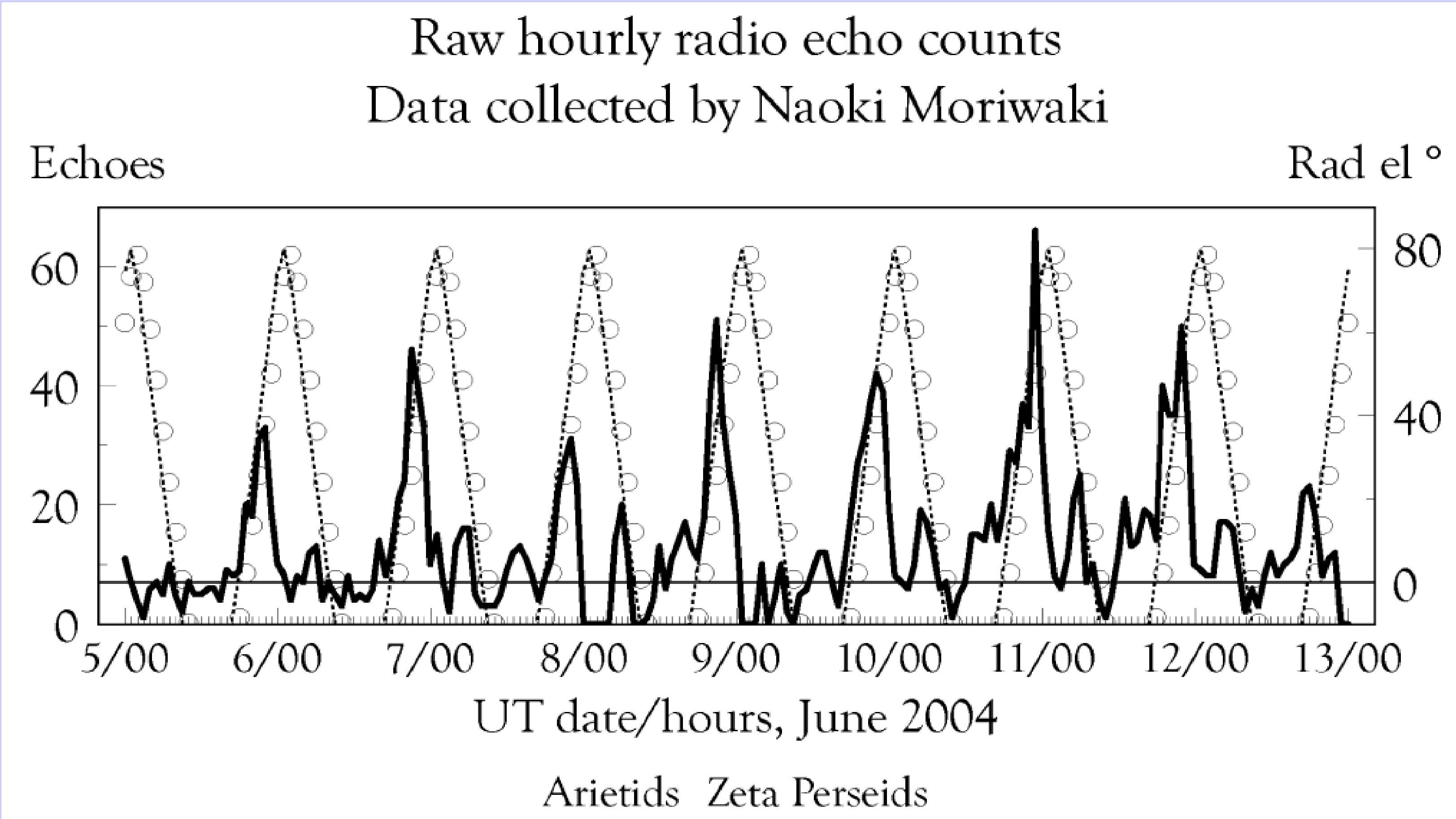
32) 1913 Juli 28. $10^h 42^m 11^s$; 2^m, gelb.

	α_1	δ_1	α_2	δ_2	W
Nordhausen	298.°5	+38.°0	298.°5	+19.°0	2
Sonneberg	218.0	+84.3	170.0	+80.7	3

Wegen eines Widerspruches, der wahrscheinlich durch die unsichere Auffassung der Sonneberger Bahn verursacht ist, sind alle Ergebnisse wenig sicher beim Radianten ins-

Forward-scatter observations

- Unattended observing possible, large numbers detectable
- Day-time showers:
  any chance of physical quantities of meteoroid streams?
- Alert-function for unexpected activity



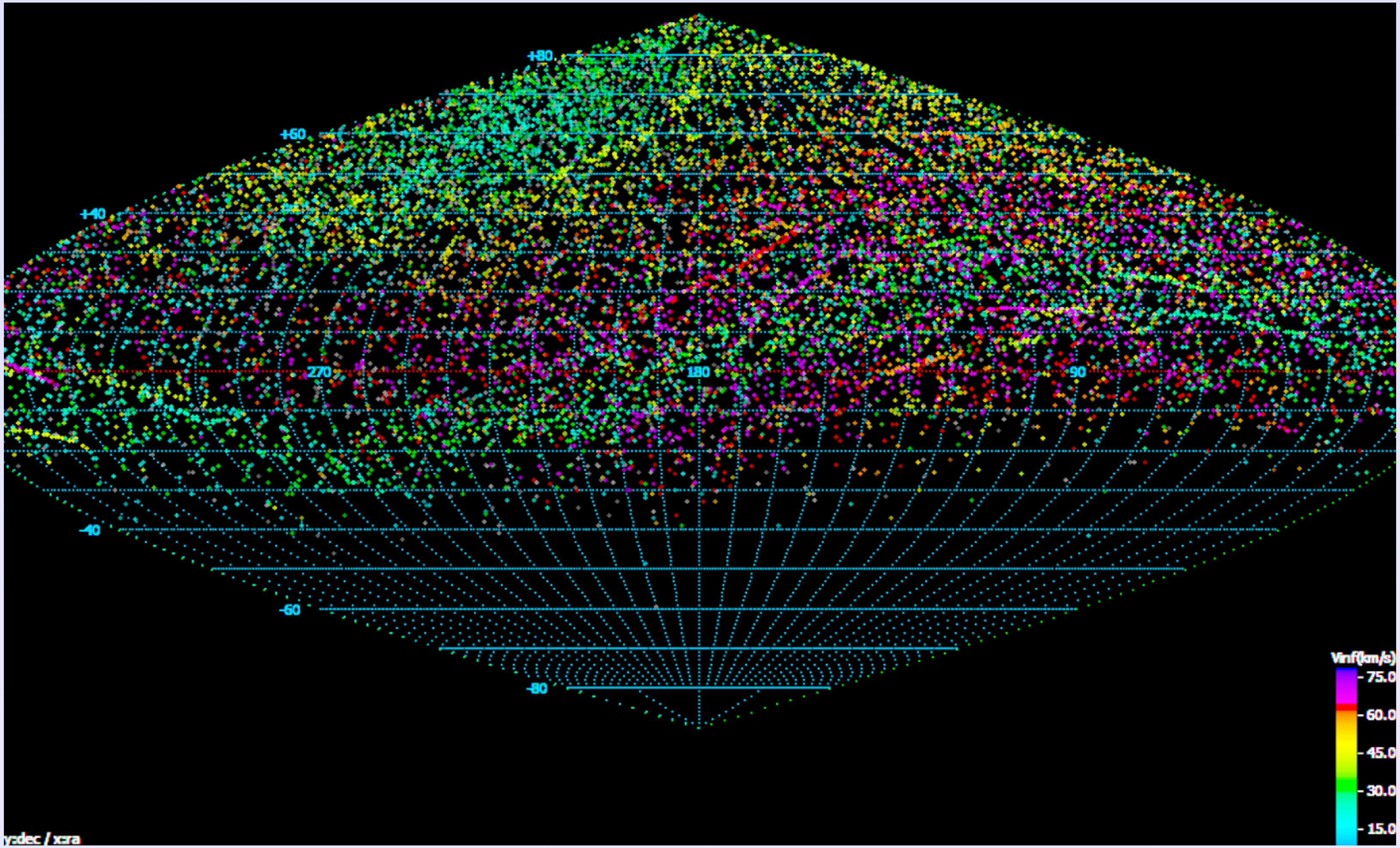
Where are the activity curves?

McBeath 2007

Radiant searches

- Why do you do radiant searches?
- What meaning has the activity period?

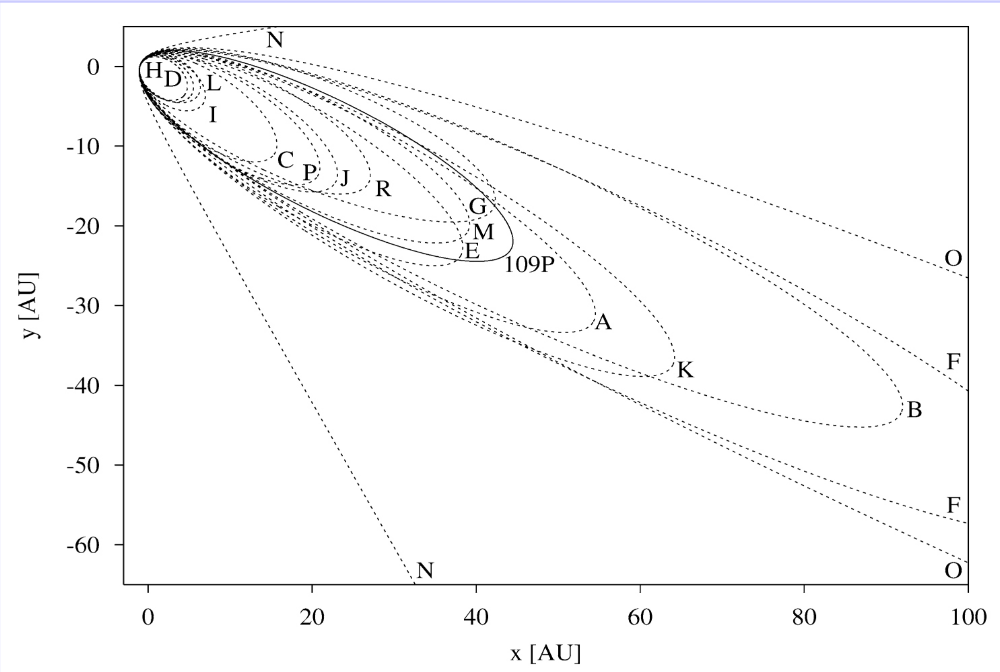
Molau and Rendtel 2009



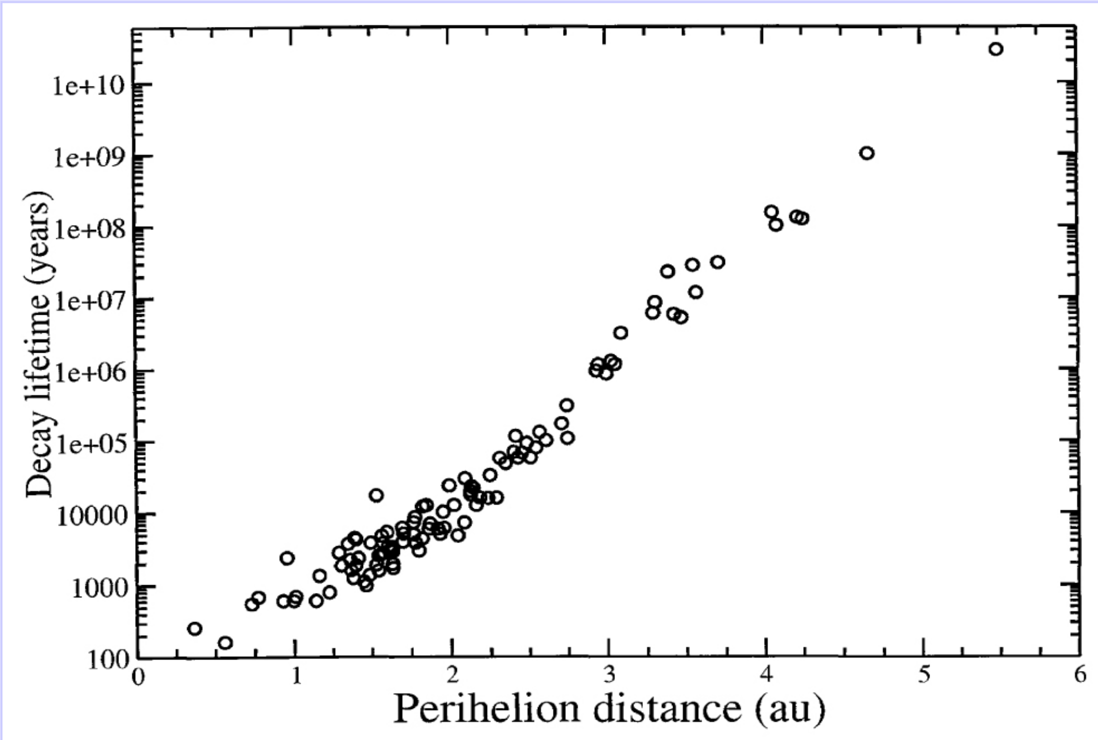
Stream searches

- Go even further: why do you do stream searches?

- D-criteria compare instants
- What we need is a measure for finding similar evolutions
- Evolutionary D-criterion → „E-criterion“



Svoren et al 2006



Comet decay – Hughes 2003

Stream evolution

Table 3. The theoretical (T) and observed (O) orbital elements, geocentric radiants and velocities (in km s^{-1}) of the meteor showers and fireballs associated with the NEO 2003EH1. D and N denote day- and night-time activity, respectively.

Meteor showers and fireballs	q (au)	e	i (°)	Ω (°)	Ω (°)	$L_\odot$ (°)	Date	α (°)	δ (°)	V_g	D_{S-H}	Type	Catalogue
T ‘A’	0.992	0.678	70.8	285.8	168.5	285.8	January 07	232.5	48.3	41.2		N	
O Quadrantids	0.976	0.683	72.5	283.4	170.0	283.4	January 05	230.5	48.3	41.5	0.05	N	C
O Quadrantids	0.974	0.682	70.3	284.0	168.1	284.0	January 05	232.7	49.2	40.5	0.06	N	S1
O Quadrantids	0.977	0.686	72.3	285.5	170.7	285.5	January 07	231.6	48.4	41.5	0.04	N	G
O 680107	0.966	0.720	76.0	286.7	171.8	286.7	January 08	229.4	46.7	43.7	0.12	N	PN
O 040192	0.960	0.700	72.8	283.1	174.7	283.1	January 04	228.3	50.0	41.8	0.08	N	EN
T ‘B’	0.990	0.681	71.2	109.1	345.2	289.1	January 10	160.0	−65.2	41.6		N	
O 9 meteors of Carinids	0.978 ±0.003	0.550 ±0.049	74.1 ±1.8	115.9 ±2.5	358.4 ±3.2	295.9	January 17	160.7 ±1.6	−62.4 ±1.7	42.4 ±0.7	0.24	N	MODC
T ‘C’	0.130	0.958	20.1	133.7	320.6	133.7	August 07	336.6	−1.7	38.8		N	
O N.δ Aquarids	0.065	0.970	18.0	128.7	334.0	128.7	August 01	337.6	5.3	40.5	0.16	N	K
O N.δ Aquarids	0.083	0.960	21.2	128.4	331.1	128.4	July 31	336.2	−3.2	38.9	0.11	N	L
O N.δ Aquarids	0.133	0.927	16.0	140.5	324.5	140.5	August 13	344.1	0.5	35.4	0.20	N	S1
T ‘D’	0.122	0.961	20.9	312.0	142.3	132.0	August 05	341.1	−16.1	39.1		N	
O S.δ Aquarids	0.069	0.976	27.2	305.7	152.8	125.7	July 29	333.8	−16.3	41.4	0.15	N	C
O S.δ Aquarids	0.082	0.960	28.0	307.7	151.0	127.7	July 31	341.7	−15.7	39.4	0.15	N	K
O S.δ Aquarids	0.064	0.970	22.9	307.3	153.7	127.3	July 30	341.1	−14.7	40.2	0.14	N	L
O S.δ Aquarids	0.099	0.969	26.5	313.8	147.3	133.8	August 06	345.1	−14.9	40.6	0.15	N	G
T ‘E’	0.122	0.961	21.0	56.5	37.8	56.5	May 18	27.1	19.3	39.1		D	
O As.49 (η Pscds)	0.065	0.960	23.0	56.7	26.0	56.7	May 17	21.7	15.3	38.4	0.21	D	K
O As.184 (β Arids)	0.158	0.900	23.7	59.6	38.5	59.6	May 20	27.4	22.8	34.3	0.11	D	L
T ‘F’	0.139	0.956	19.8	234.0	220.3	54.0	May 16	31.2	4.3	38.3		D	
O As.186 (α Pscds)	0.088	0.940	20.6	239.4	208.0	59.4	May 20	29.8	4.8	36.4	0.13	D	L
T ‘G’	0.986	0.684	65.8	259.0	195.3	259.0	December 12	210.4	65.6	38.7		D	
O As.784 (α Drads)	0.987	0.640	67.0	259.2	187.4	259.2	December 11	213.5	62.6	38.6	0.10	D	L
T ‘H’	0.985	0.686	69.5	78.7	15.6	258.7	December 12	127.4	[illegible]	40.6		[illegible]	
O Puppid–Velids	0.950	0.626	70.3	75.7	25.2	255.7	December 08	123.4	−45.2	40.0	0.12	D	C1

Babadzhanov et al 2008

Stream evolution

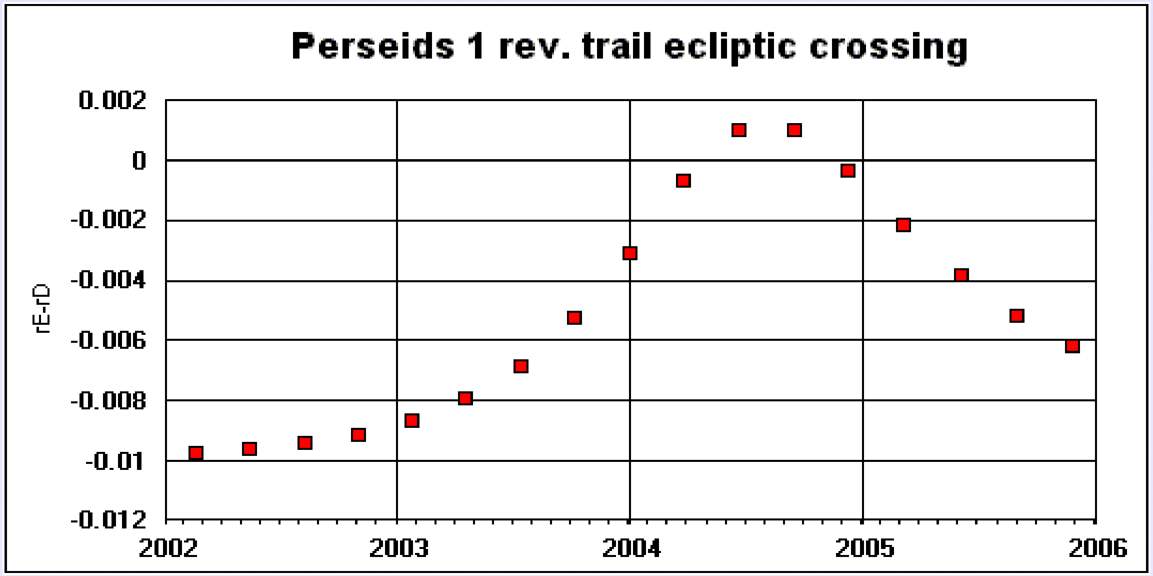
- Geminids, Quadrantids->multiple parents

- Rubble pile asteroids enter standard picture: nearly all near-Earth asteroids >200 m
- Disintegrate at $P_{rot} < 2$ h
- Disintegration of body may a frequent process

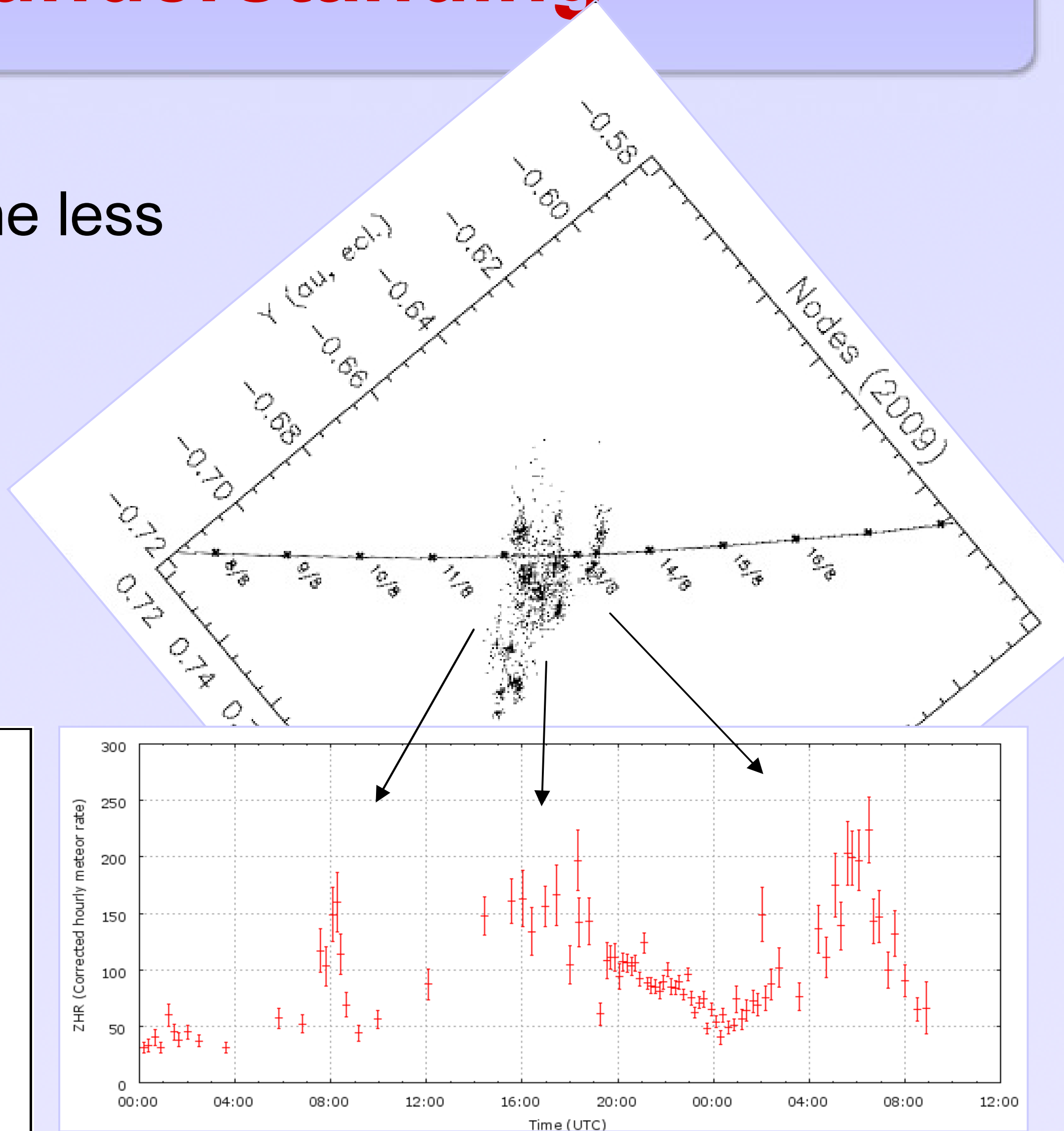
- Study stream evolution under the premise of parent-body disintegration

Predictions vs. understanding

- The more robust the predictions the less informative
- Predicting a system well does not necessarily mean understanding a system well.



Lyytinen 2004



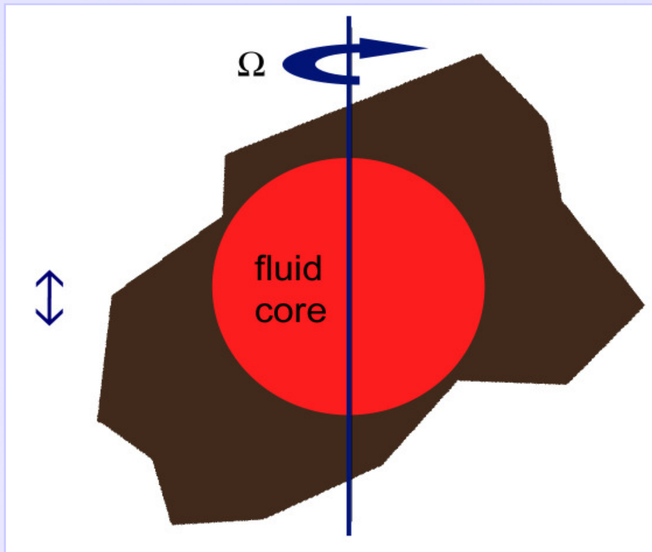
2009 Aug 12

Vaubaillon 2009, IMCCE website + IMO website live-graph

Meteorites

- contain unique information about the early solar sytem (Weiss et al. 2008, 2009)
- Hand magnets destroy the remanent magnetization!
- Fireball networks + searching for fresh falls is extremely important
- All efforts in running, combining, and analyzing fireball data is welcome
- See also efforts of Virtual Meteor Observatory

By courtesy of A.Knöfel



Where to go

- Visual: concentrate on high resolution graphs of major showers
- Video/Photo: concentrate on high precision orbits
  combine al efforts to get good statistics
- Forward scatter radio: go for real activity graphs!
- Simulations: compare in terms of particle densities (flux densities)
  get a handle on the physics at comets / asteroids
- Lunar impacts: explore the real limits of the method
  Can we use the Moon as an „observing location“?
- Fireball networks: meteorite droppers are very interesting.
  Connect to meteorite hunters, perserve magnetization