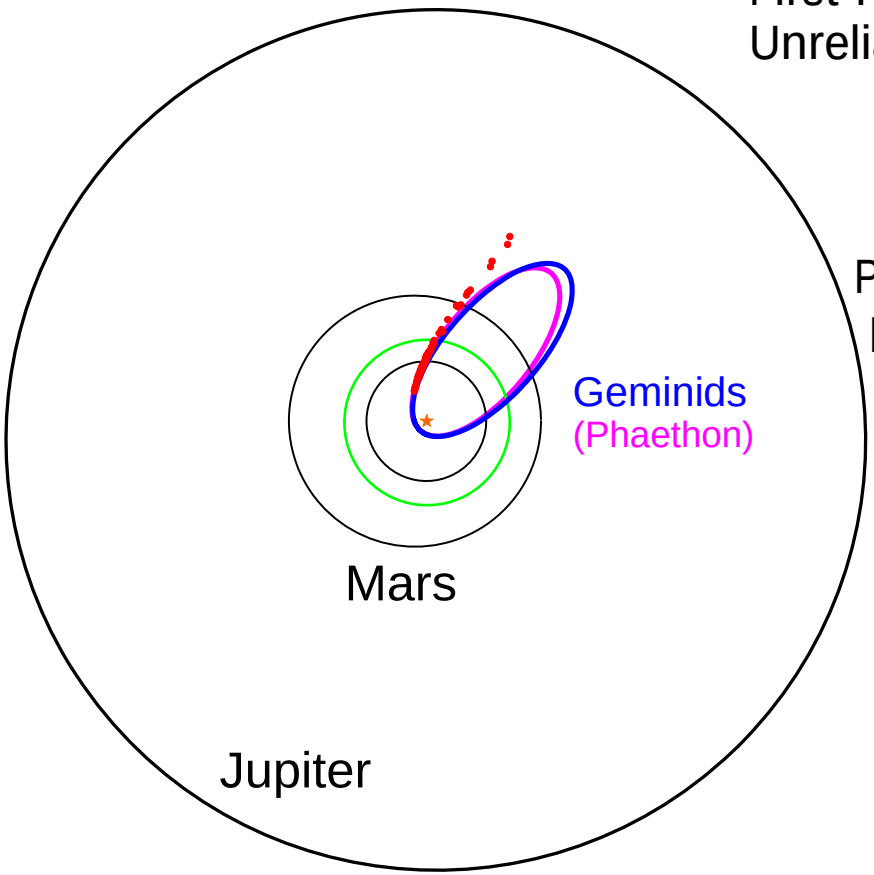
The Geminid stream modelling: lessons of history

Galina Ryabova

Tomsk State University

International Meteor Conference, Poznan, 22—25.08.2013

Geminid meteoroid stream



First reliable registration: 1862 (King, 1926)
Unreliable: bolides 381, 1038–1099, 1163
(Astapovich & Terenteva, 1968),
1077 (Hasegawa, 1999)

Parent: 3200 Phaethon,
but could be a complex (Ryabova, 2008)

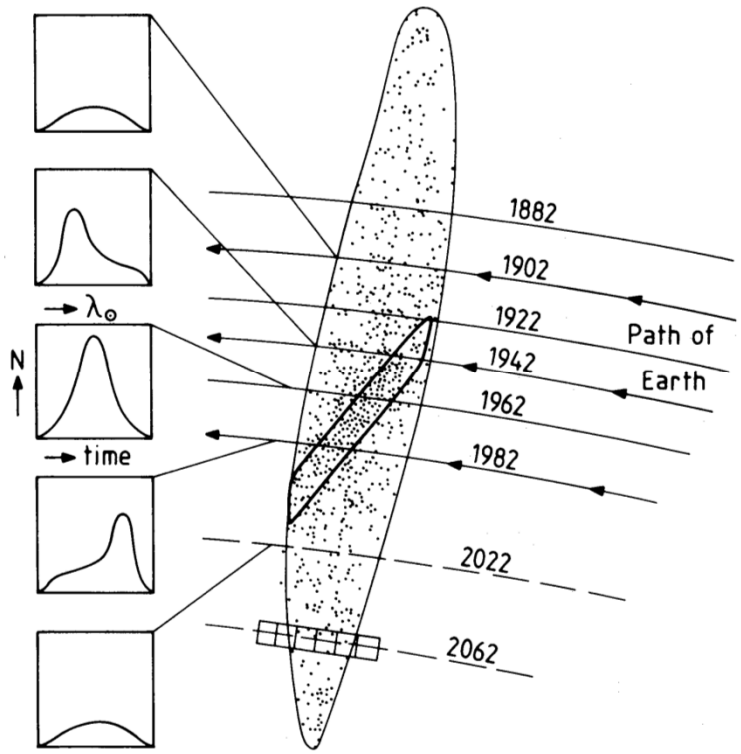
Orbit: a = 1.4 AU
q = 0.14 AU
e = 0.9
i = 23°

Activity:
Dec. 5 – 16
Nov.22 – Jan 2 (Brown et al., 2010)
Nov. 30 – Dec. 31 (Forti, 1968)

Plavec (Nature, 1950)

- Single orbit (Whipple, 1947)
- Secular perturbations (E+J, Gauss-Hill)
- Visibility period 1700 – 2100

Fox, Williams & Hughes (MNRAS, 1982, 1983)



1. Bundle of test-particles (500 000!)
2. Evolution calculated by polynomials
3. Profile change as a function of meteoroid mass
4. Profile change as a function of time

$$\Omega_T = \Omega_0 - 0.014750T + 6.6 \times 10^{-6}(T^2 - 1000T)$$

$$\omega_T = \omega_0 + 0.014867T - 4.1 \times 10^{-6}(T^2 - 1000T)$$

$$i_T = i_0 + 0.008048T + 2.1 \times 10^{-6}(T^2 - 1000T)$$

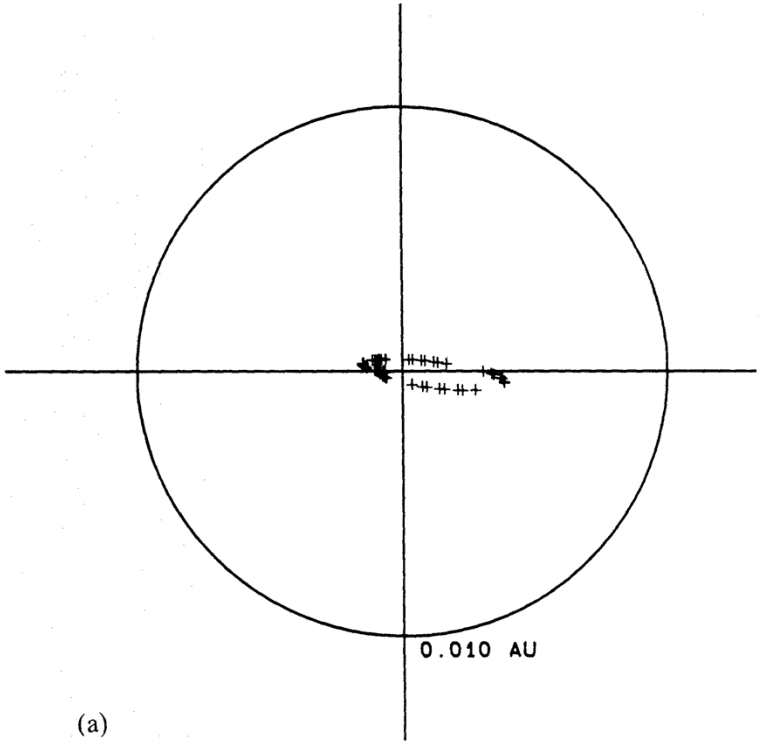
$$e_T = e_0 - 1.3 \times 10^{-5}T - 3.8 \times 10^{-9}(T^2 - 1000T)$$

$$a_T = a_0 - 2.1 \times 10^{-5}T - 9.9 \times 10^{-8}(T^2 - 1000T).$$

10 test-particles on a mean Geminid's orbit,
Gauss-Jackson, V+E+J,
Time-interval 300 years

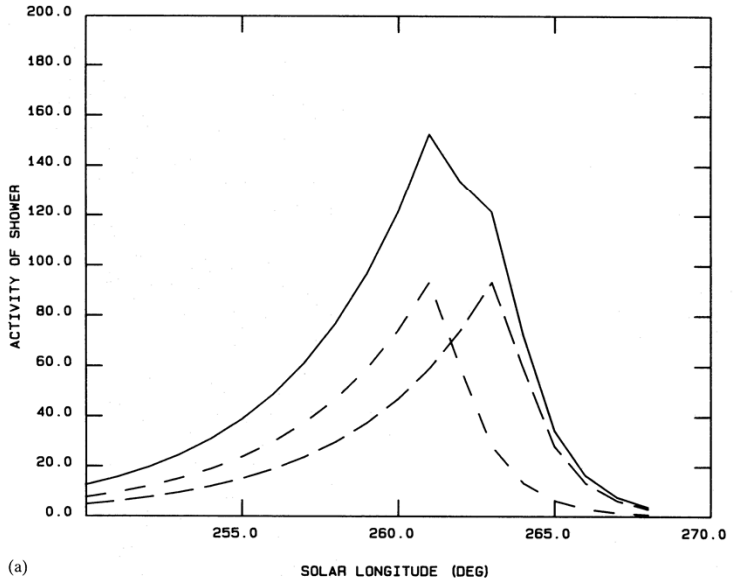
Jones (MNRAS, 1985)

Scatter of meteoroid orbits caused by gravitational perturbations.



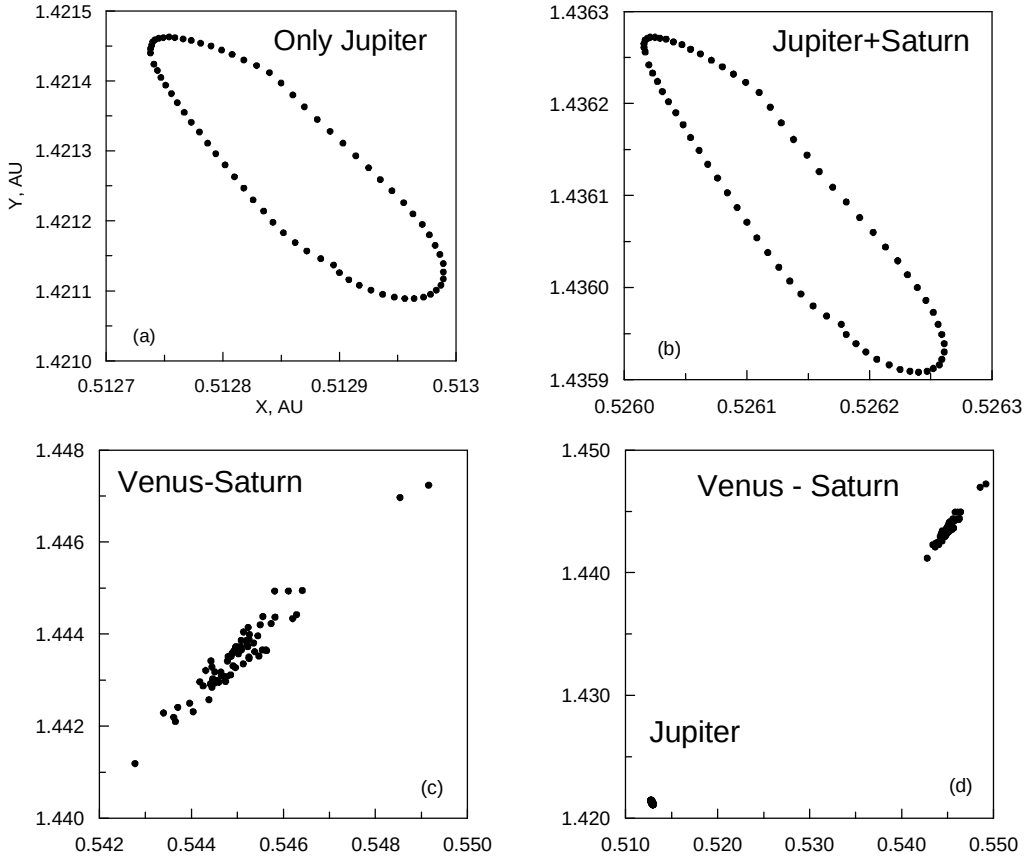
GEMINID STREAM CROSS-SECTION AFTER 1000 YEARS

71 test particles launched in the Geminid mean orbit, Runge-Kutta 4th, 5000 years, only Jupiter



Simulation of the effect of a double shower. Age = 16 000 yr

Jones' model, revision



71 test particles,

Everhart 19th,

1000 years

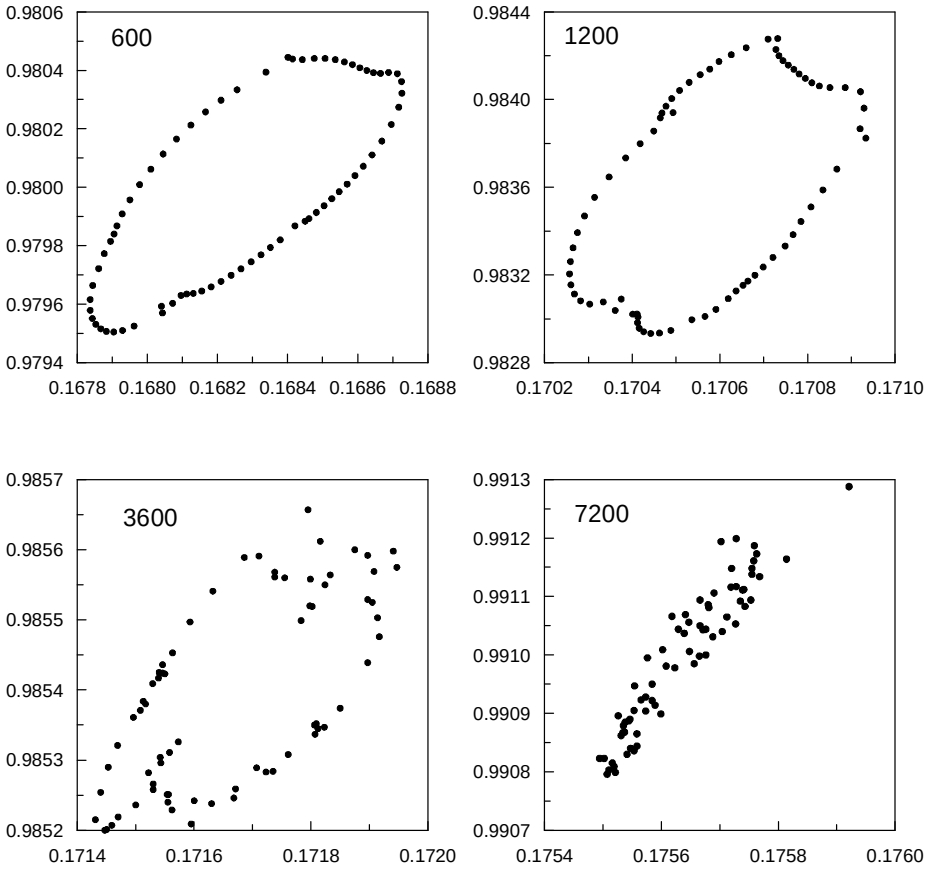
Jones' model, revision

5 planets (Venus-Saturn),

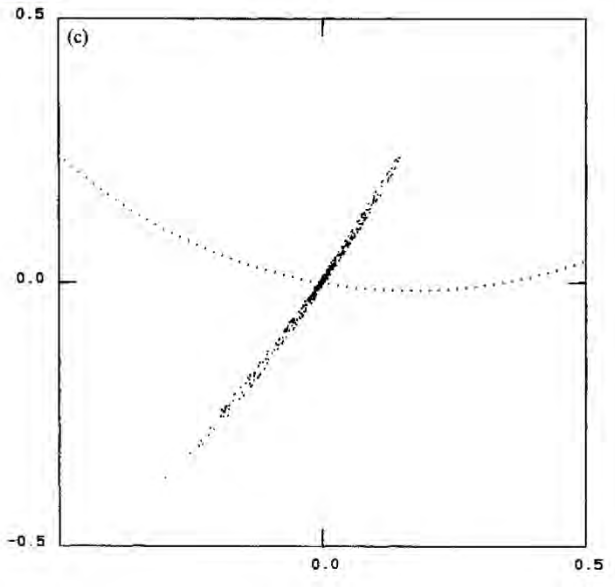
ecliptic plane,

600, 1200, 3600, 7200 days

of evolution



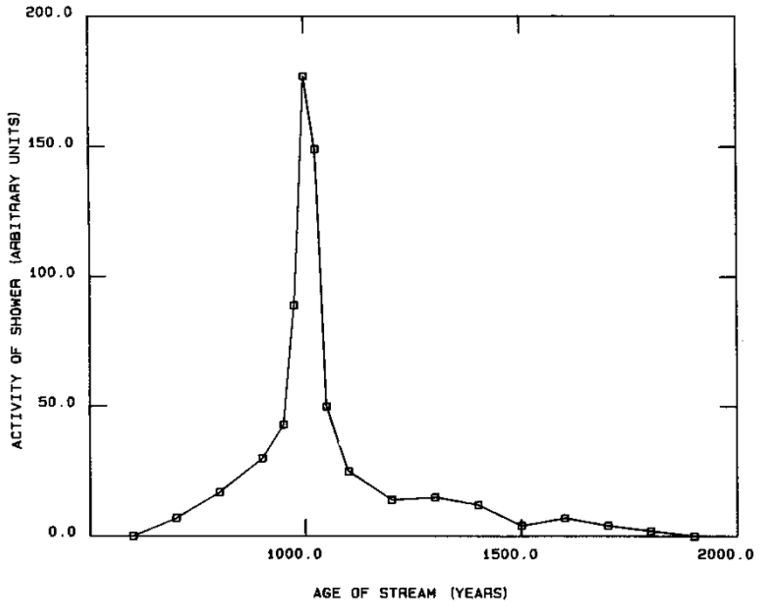
Jones & Hawkes (1986)



$$\langle di/dt \rangle = 0.65 + 0.90(a - 1.35) + 2.69(e - 0.896)$$

$$\langle d\omega/dt \rangle = 1.98 + 4.55(a - 1.35) + 8.44(e - 0.896)$$

$$\langle d\Omega/dt \rangle = -1.98 - 4.62(a - 1.35) - 9.42(e - 0.896)$$



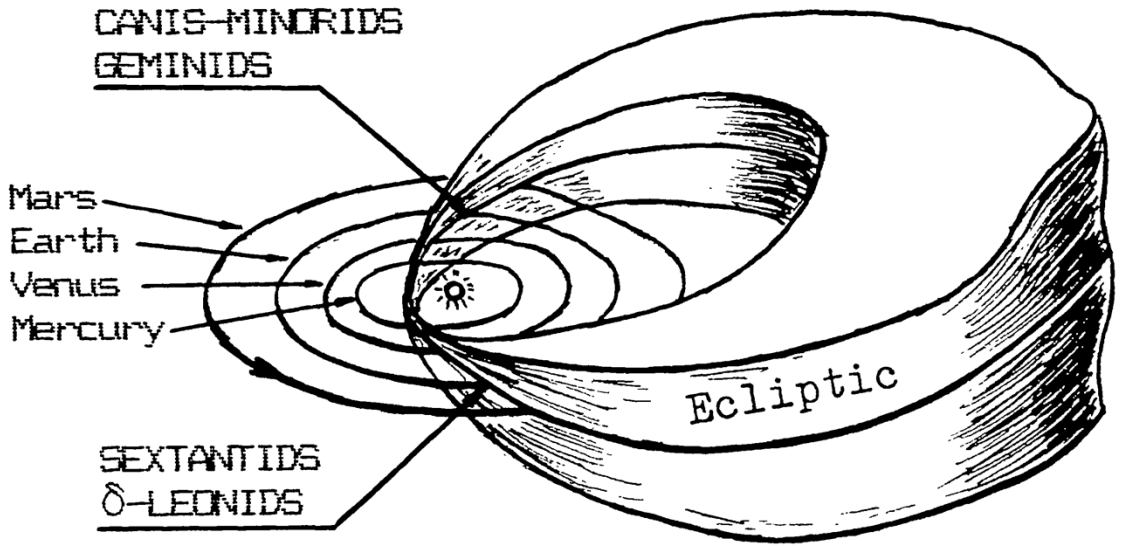
Whipple (1951) cometary model + gravitational (Jup) perturbations.

Result: activity, width of the shower, motion of the ascending node

Babadzhanov & Obrubov (1986)

Age = 20000 years

V_{ej} = 650 m/s

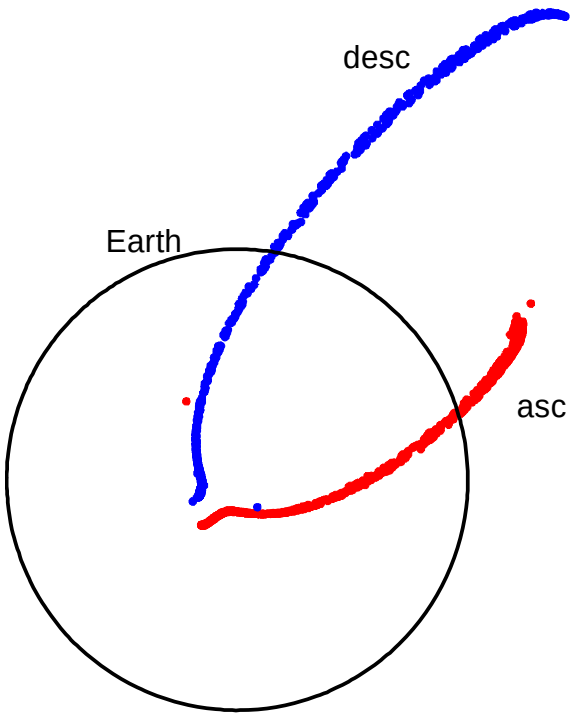


$(1 - e^2) \cos^2 i = \text{const},$

$e^2(2/5 - \sin^2 i \times \sin^2 \omega) = \text{const},$

$\Omega + \omega = \text{const}$

Babadzhanov & Obrubov, revision

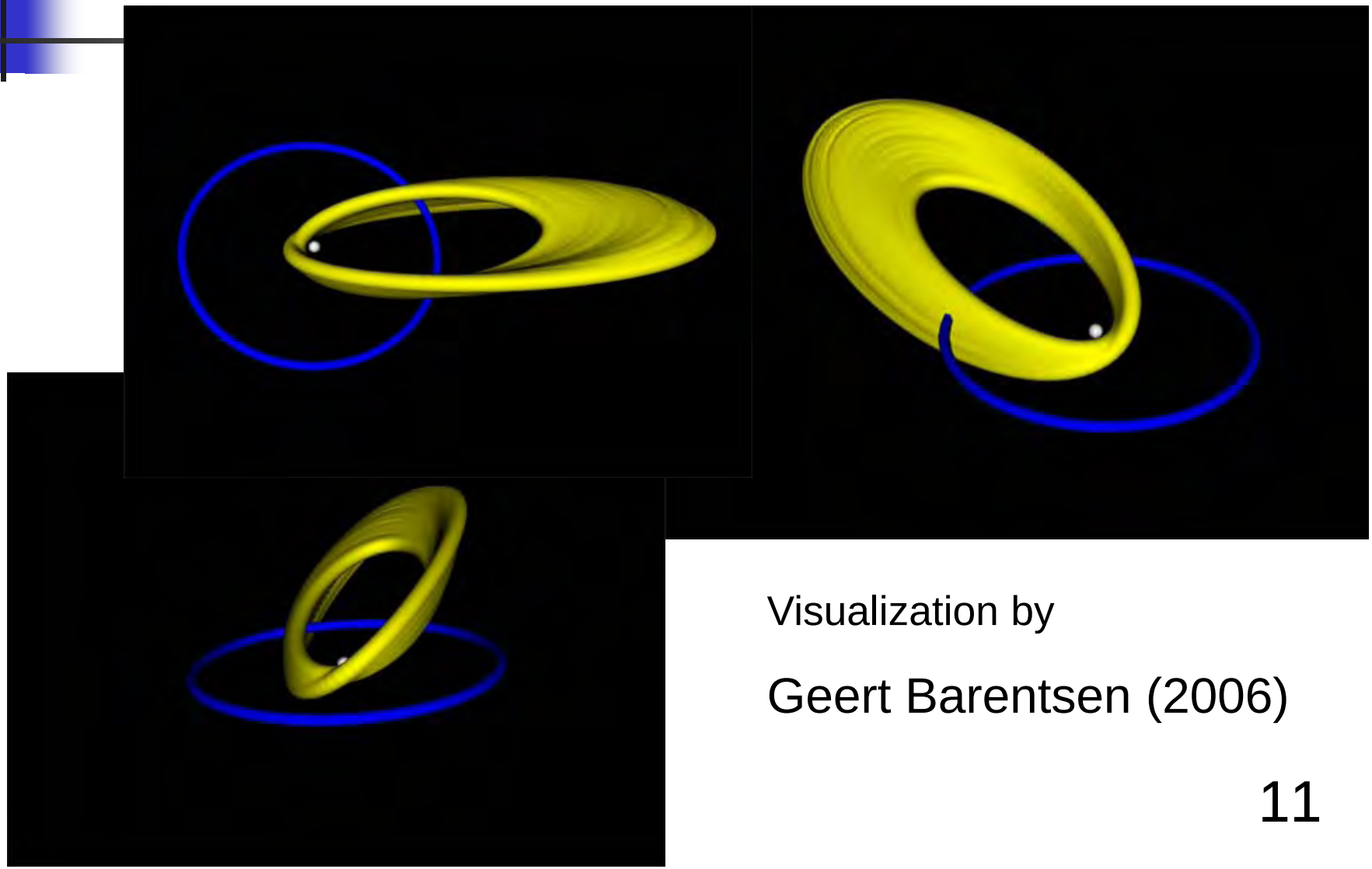


1000 meteoroids, 10^{-3} g
Gauss-Haplhen-Goryachev integrator.
20 000 years

Results:

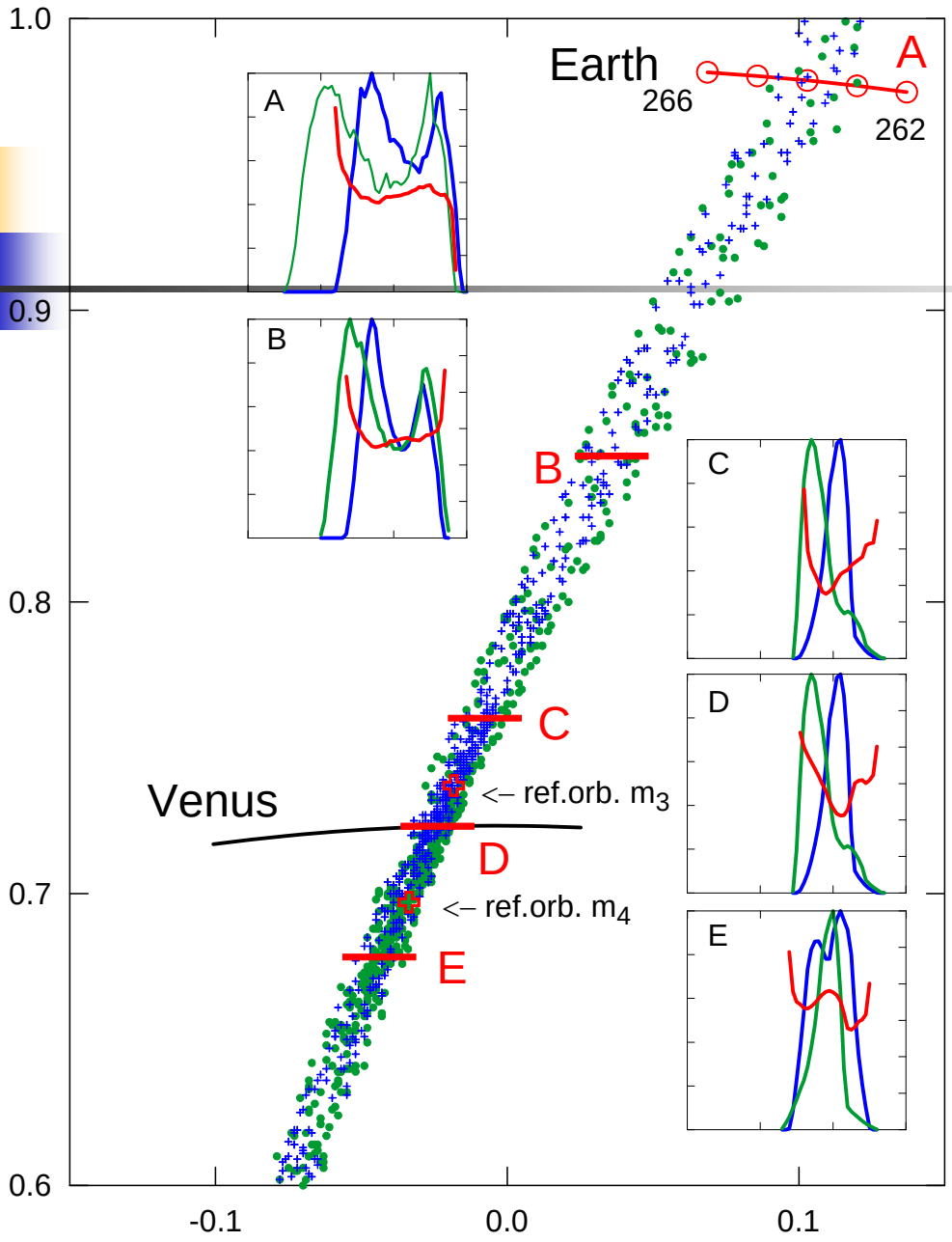
- The stream is less dispersed
- Only two showers
- **None of them is the Geminid shower**

Ryabova (2007)



Visualization by

Geert Barentsen (2006)

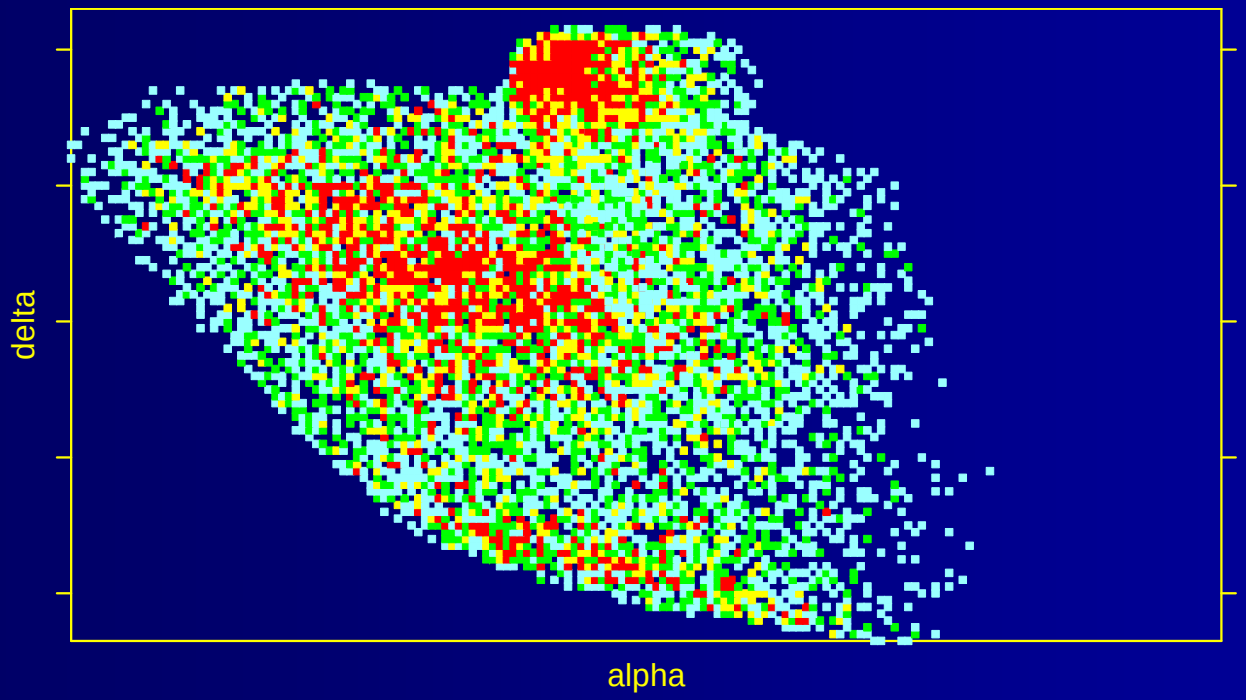


The main advantage is the fast computation of evolution:

$$b = b_0 + \sum_{j=1}^{n} \sum_{k=0}^{m} b_{jk} a_0^k t^j$$

$$b = a, e, i, \Omega, \omega$$

One night of observations



(Meteoroids 2007)

Ryabova (2007)

Highs

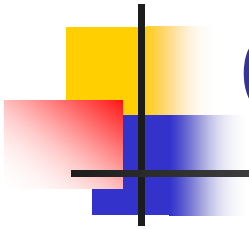
- Fast calculation of evolution
- Explained activity profile bimodality
- Explained “many” showers in radiant

Lows

- Not precise
- Width of the model shower is twice less then that of the observed one **= >** non-gravitational jet forces

Preliminary numerical model

- 90 000 particles of three masses (10^{-2}, 10^{-3} and 10^{-4} g)
- Everhart integrator, all planets (+ Moon, + Pluto), + PR
- Shower's width is the same as in (Ryabova, 2007), so dispersion of the stream due to encounters with planets is not high.



Conclusion

Be very careful with old models!

To make models reliable and to verify them...

Conclusion

we need more reliable data!