

Phenomenological approach of the meteor phenomenon

J. Vaubaillon, A. Egal, M.K. Kwon, F. Colas, M. Birlan, M.
Mougeot - IMCCE
B. Zanda - MNHN
S. Bouley, C. Marmo, Y Audureau - GEOPS
P. Vernazza - LAM
J. Gattaccecca, PYTHEAS



Outline

- **Goal & needs**
- **Meteoroid Disintegration**
- **Fragmentation**
- **Chelyabinsk event**

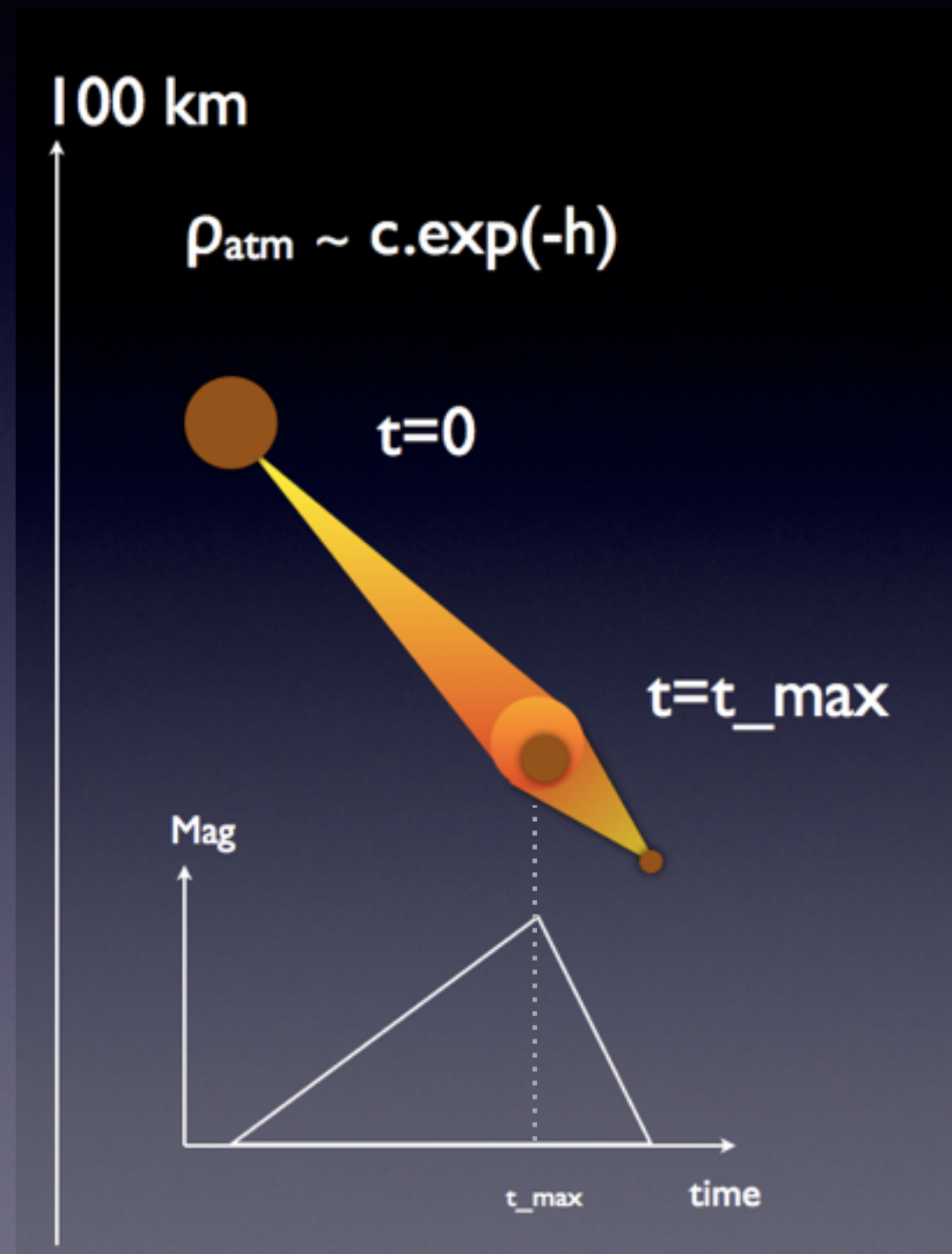
Goal & Needs

- FRIPON Goal (practical): find the meteorite
- NEEDS:
 - Know where to search and **WHAT** to search for
 - Understand the meteor phenomenon

Meteoroid disintegration



FRIPON



Towards reproducing the disintegration

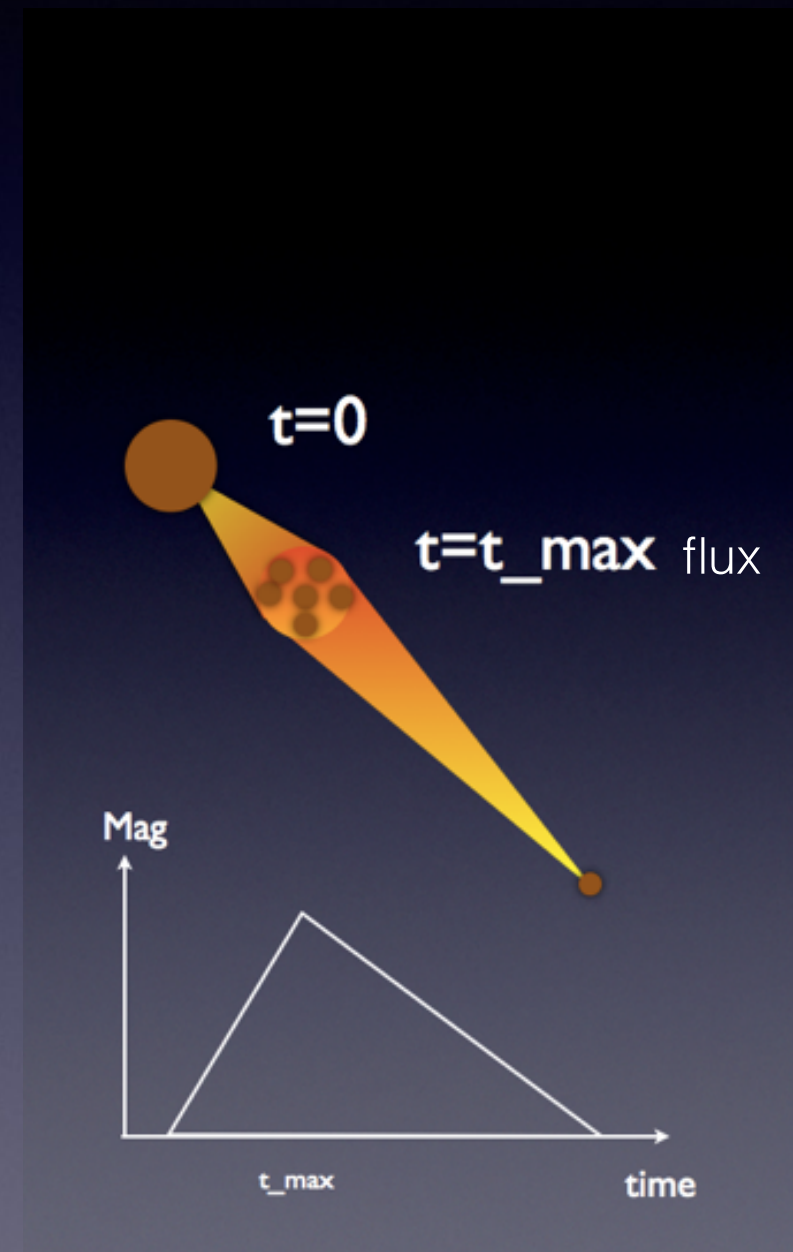
(after Borovicka et al. 2007)

mass loss $\propto \rho_{\text{atm}} r_{\text{met}}^2 V_{\text{met}}^3 / Q_{\text{heat}}$

velocity change $\propto V_{\text{met}}^2 / r_{\text{met}} \rho_{\text{met}} / \rho_{\text{atm}}$

radiant change $\propto -G_{\text{pla}} \sin(\theta_{\text{met}}) / V_{\text{met}}$

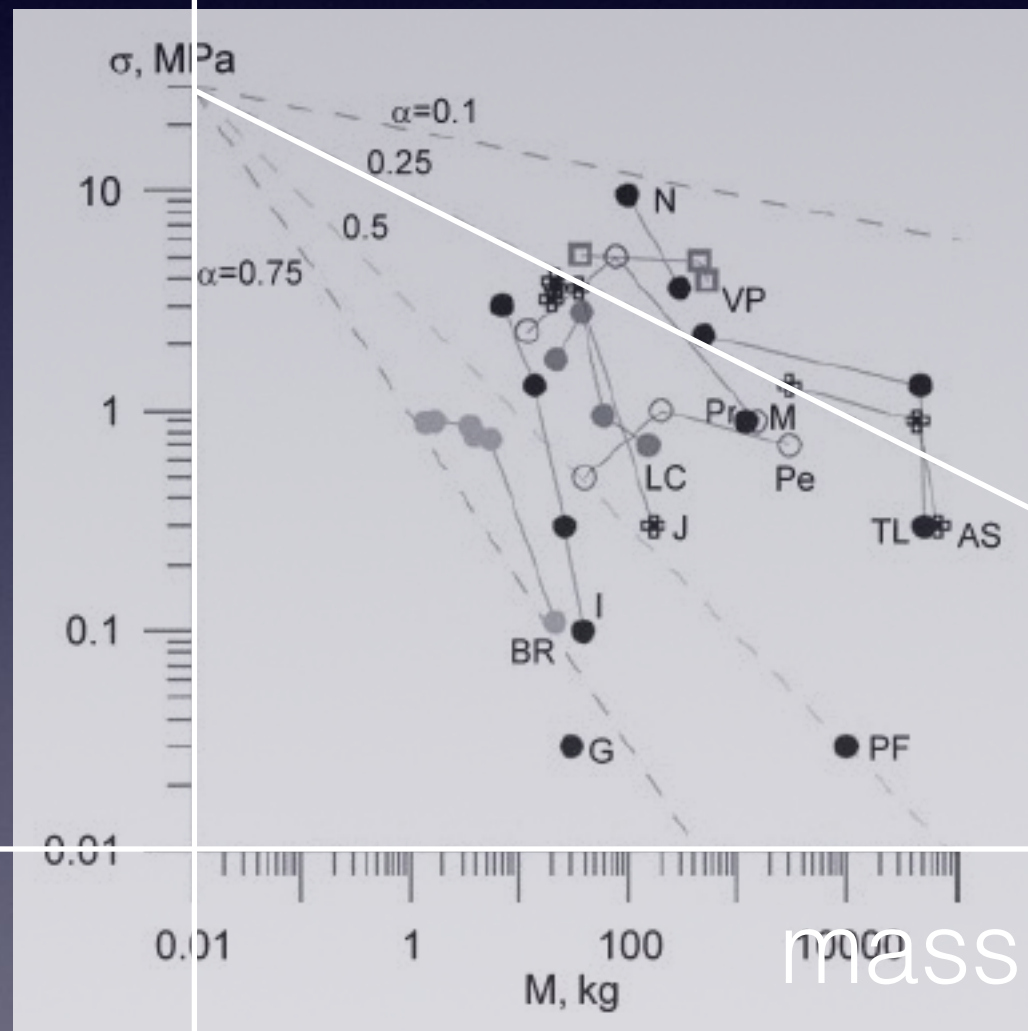
Meteoroid Fragmentation



Phenomenological approach of fragmentation

Strength
(MPa)

$$P \propto \rho_{\text{atm}} V_{\text{met}}^2 > \sigma_{\text{met}} \Rightarrow \text{fragmentation}$$



Bolide event	mass (kg)	diameter (cm)	Type
Příbram	1300 ^a	90	H5 ^w
Lost City	160 ^{b,k}	45	H5 ^w
Innisfree	40 ^{c,k}	28	L5 ^w
Peekskill	5000 ^a	140	H6 ^w
Tagish Lake	65,000 ^d	420	C2, C ^{m,n}
Morávka	1500 ^a	93	H5-6 ^l
Neuschwanstein	300 ^e	55	EL6 ^{e,s}
Park Forest	10,000 ^{f,j}	180	L5 ^f
Villalbeto	600 ⁱ	70	L6 ^g
de la Peña			
Bunburra	22 ⁿⁿ	24	Achondrite-anomalous ^{nn,w}
Rockhole			
Almahata Sitta	70,000 ⁱ	400 ^{jj}	Ureilite-an ^{jj}
Jesenice	170 ^{qq}	45 ^{qq}	L6 ^{qq}
Grimsby	30 ^{rr}	13 ^{rr}	H4-6 ^{rr}

From: Popova et al 2011 (MAPS)

Towards reproducing fragmentation

(following Gritsevitch et al 2014 - Kosice)

$$P \propto \rho_{\text{atm}} V_{\text{met}}^2 > \sigma_{\text{met}} \Rightarrow \text{fragmentation}$$

- σ_{met} : fit to reproduce the 1st fragmentation
- How many fragments?
- CPF: $F = 10^{-N/(c \cdot r)}$
- What mass per fragment?
- Grady CFD: $N = 1 - \exp(1 - M/\mu)$

Chelyabinsk: observations



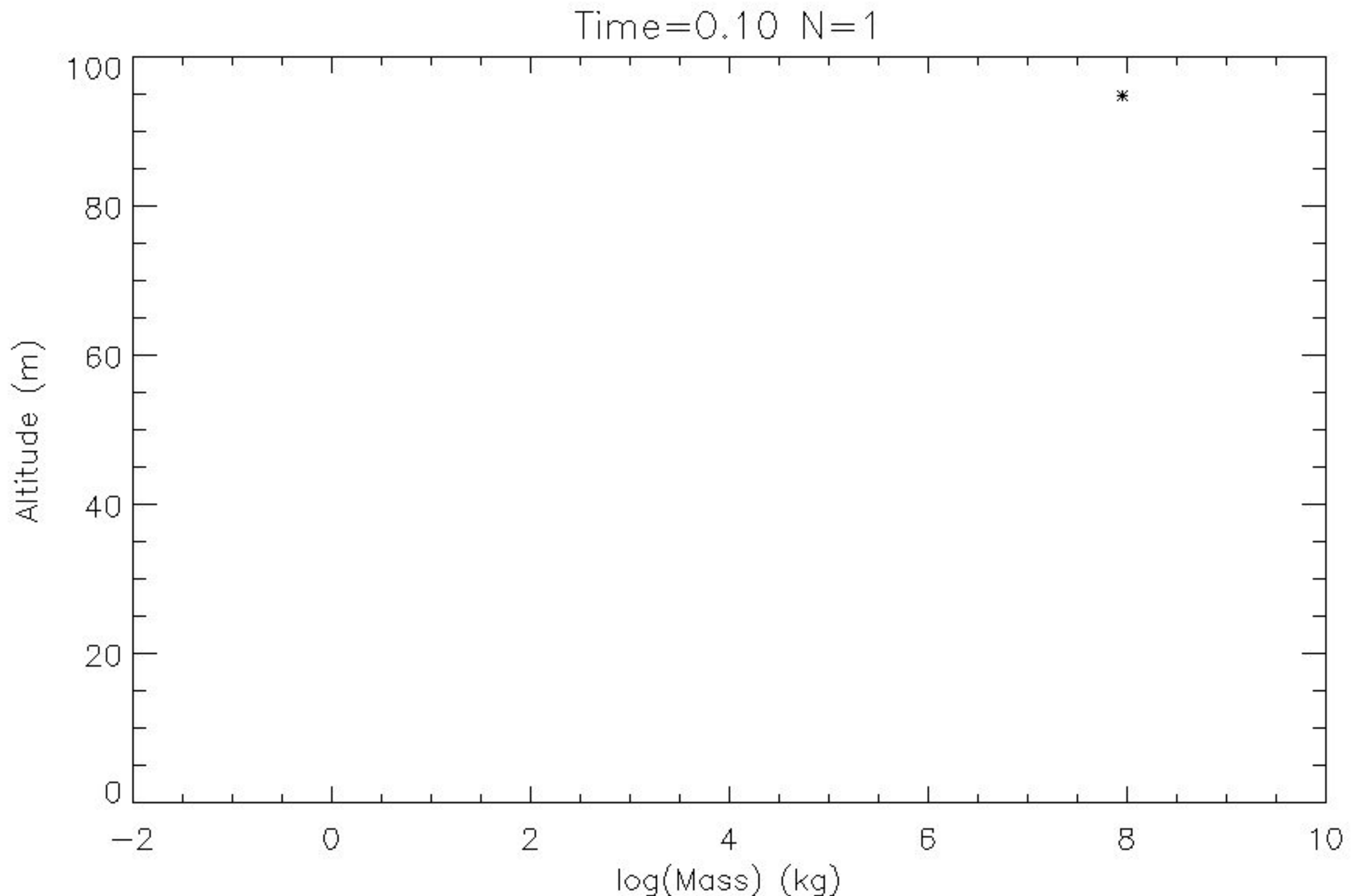
To be reproduced:

Altitude of breakup(s) < 40 km

Mass distribution of fragments on the ground

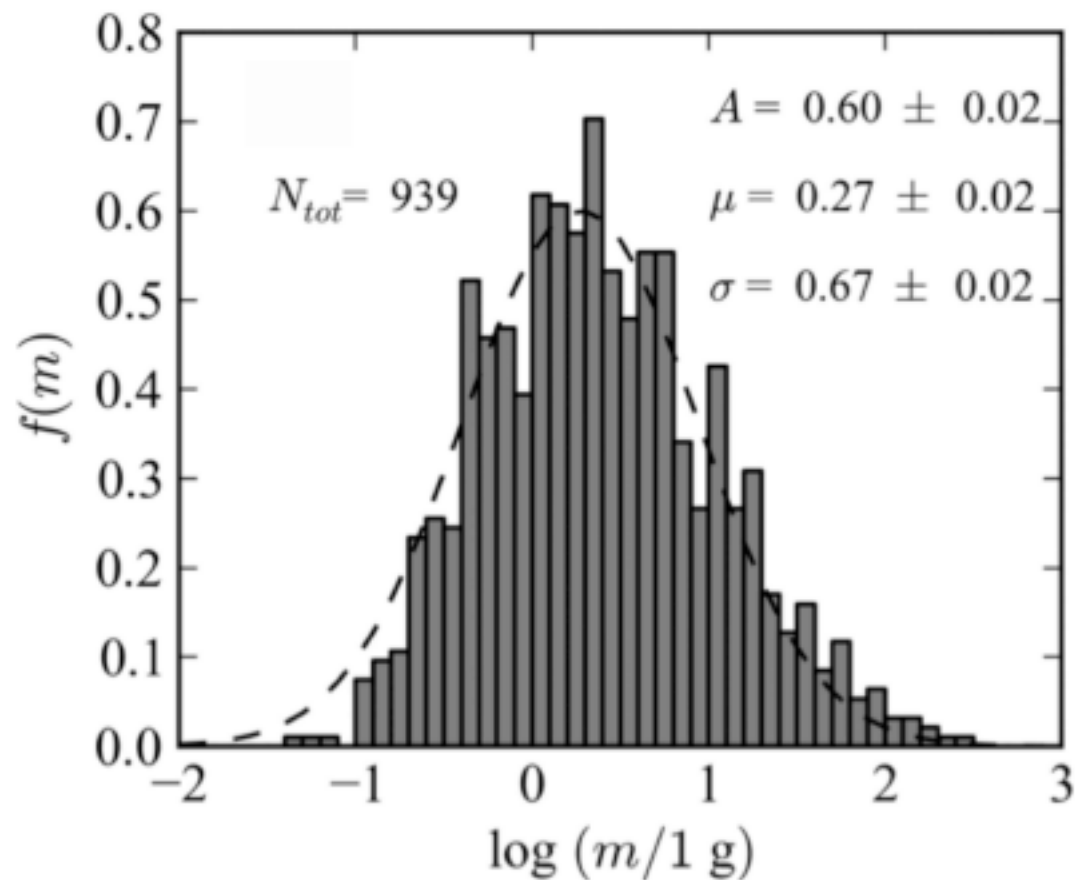
Chelyabinsk: Simulations

$\sigma_{\text{met}} \text{ index}=0.165$



Surviving fragment mass distribution

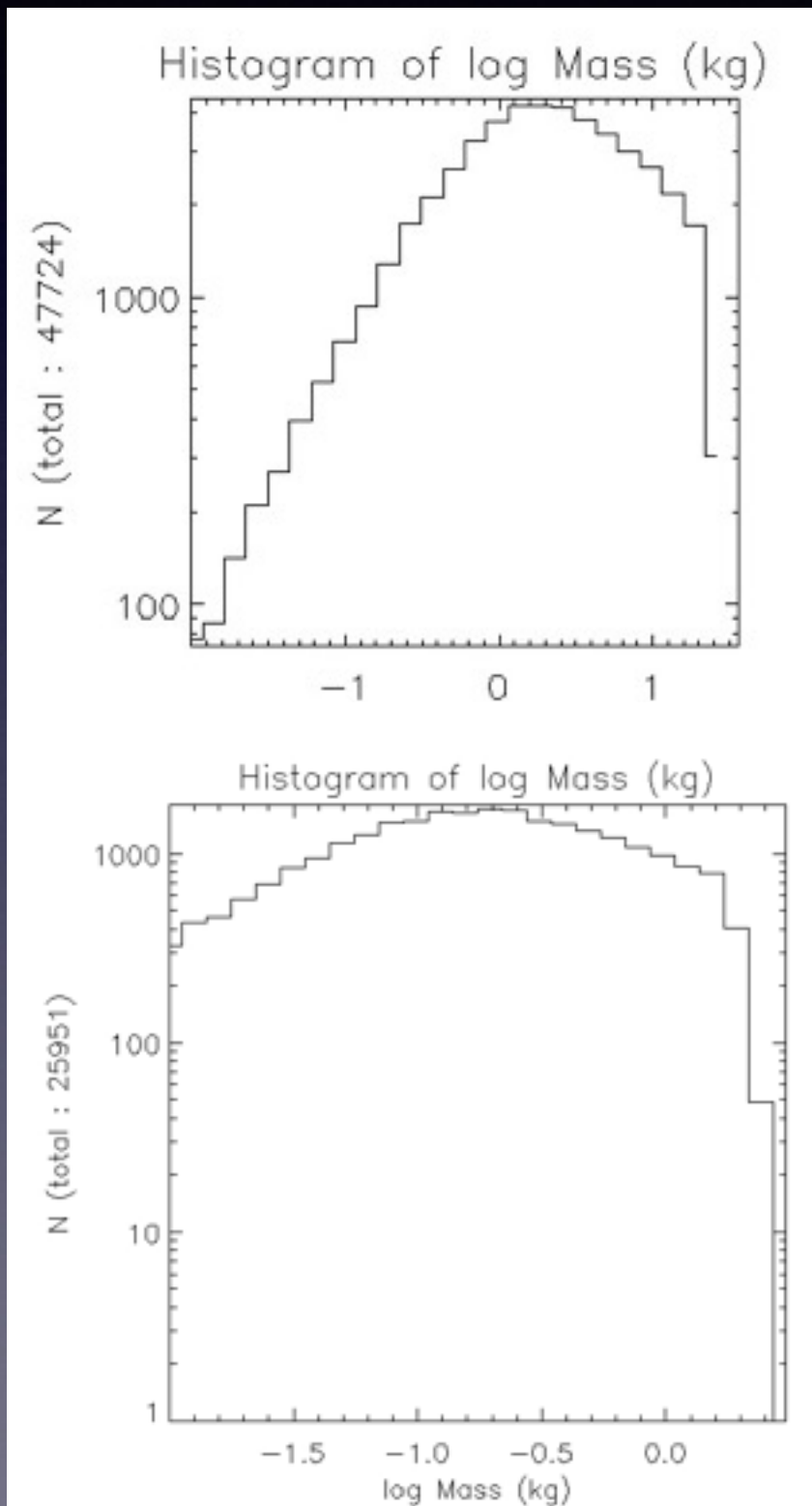
939 meteorites, 0.04-300 g



$$Q = 2E+07$$
$$c = 0.6$$

$$Q = 1E+07$$
$$c = 0.9$$

Popova et al 2013



Conclusion & Future works

- Phenomenological approach : little physics, ongoing work
- Reproduce the fragmentation of known meteorite falls

2016 Perseids

1079 -0.0019809 UT 12/ 8 4:56

1479 0.0075660 UT 11/ 8 23:29

1862 -0.0052961 UT 11/ 8 23:30

