Yet another results of the spectral and fragmentation study of small meteoroids

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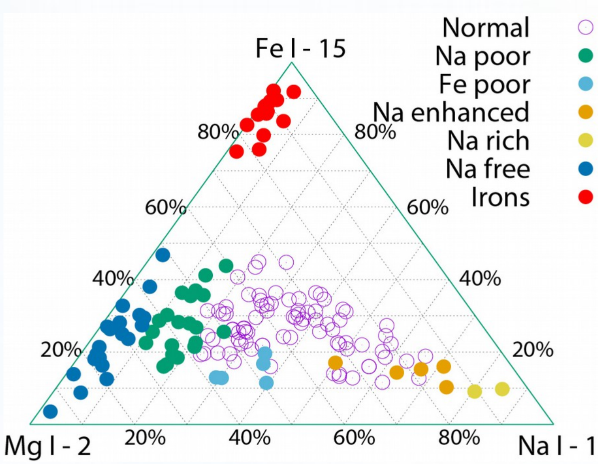
Video observation of meteors

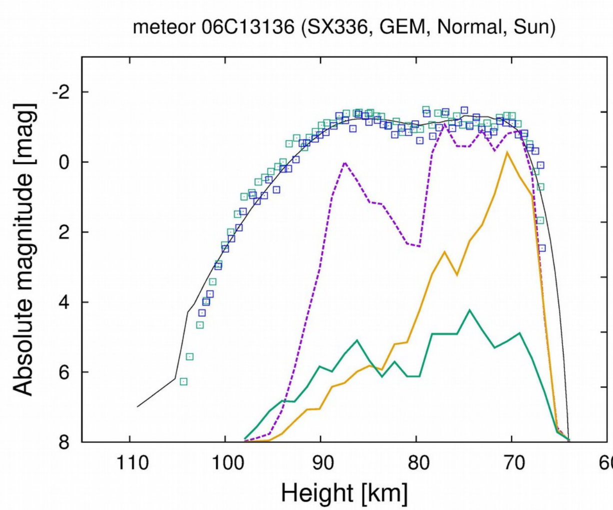
- In Ondřejov since 1990, database of faint meteors
- 2 stations, 2 direct cameras, 1 spectral camera

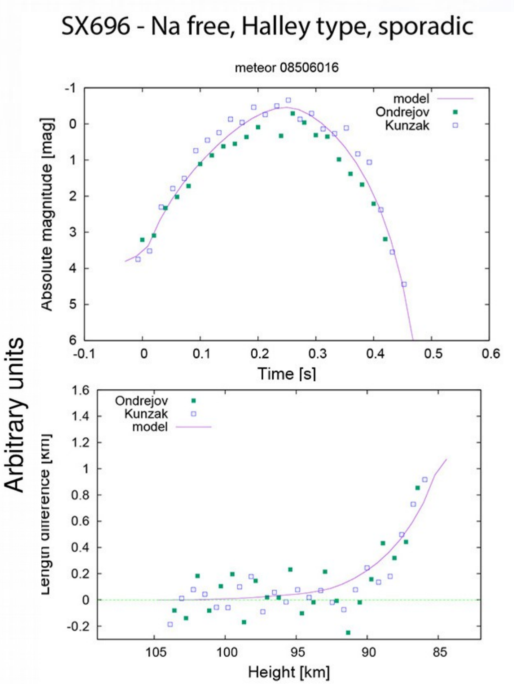
  This work: S-VHS cameras, Mullard image intensifiers, 2004 – 2014
- Orbits, spectra
- fragmentation model

Obtained data

- 152 meteors with orbits, trajectories, spectra
- Spectral classification (Borovička et al., 2005)
  - Mg I-2, Na I-1, Fe I-15
- Application of fragmentation model (Borovička et al., 2007)
- Monochromatic light curves

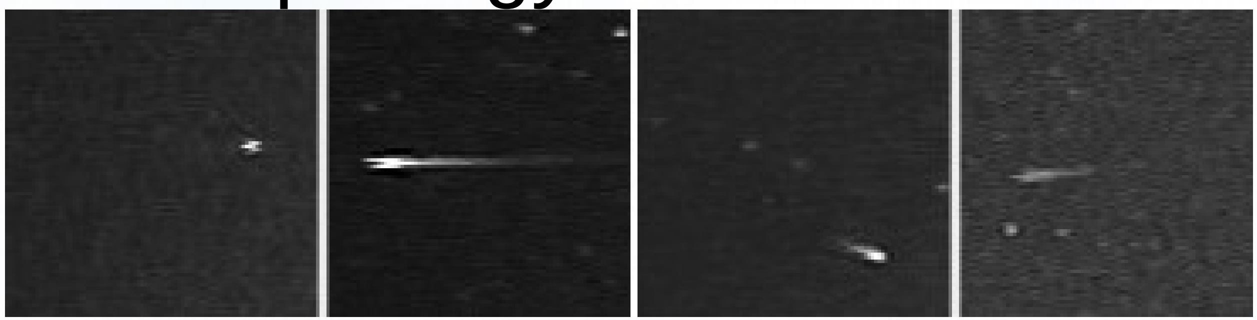






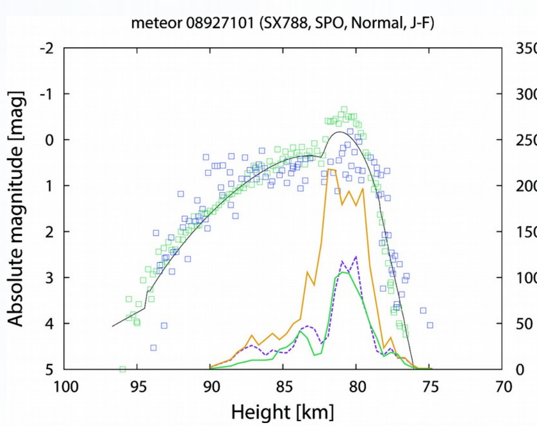
Yet another results...

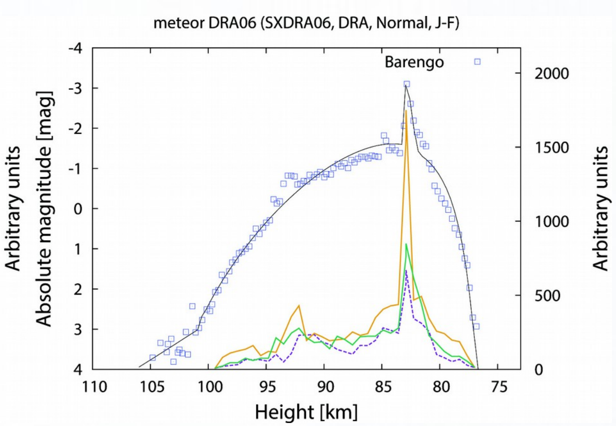
- Study of morphology of faint meteors



- Irons on cometary orbits

- Two phases of erosion of small meteoroids





The morphology

- Low resolution of cameras (200m/px), but still…
- Three categories:
  - No wake

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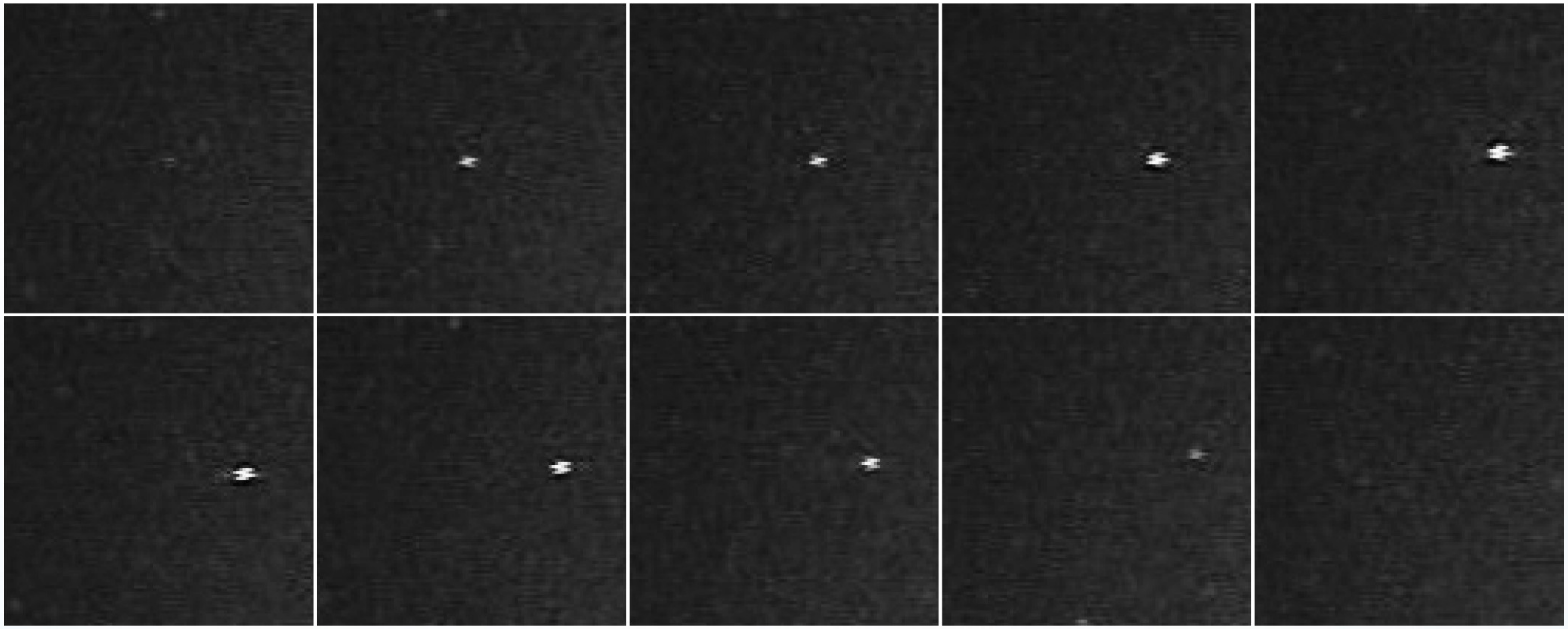
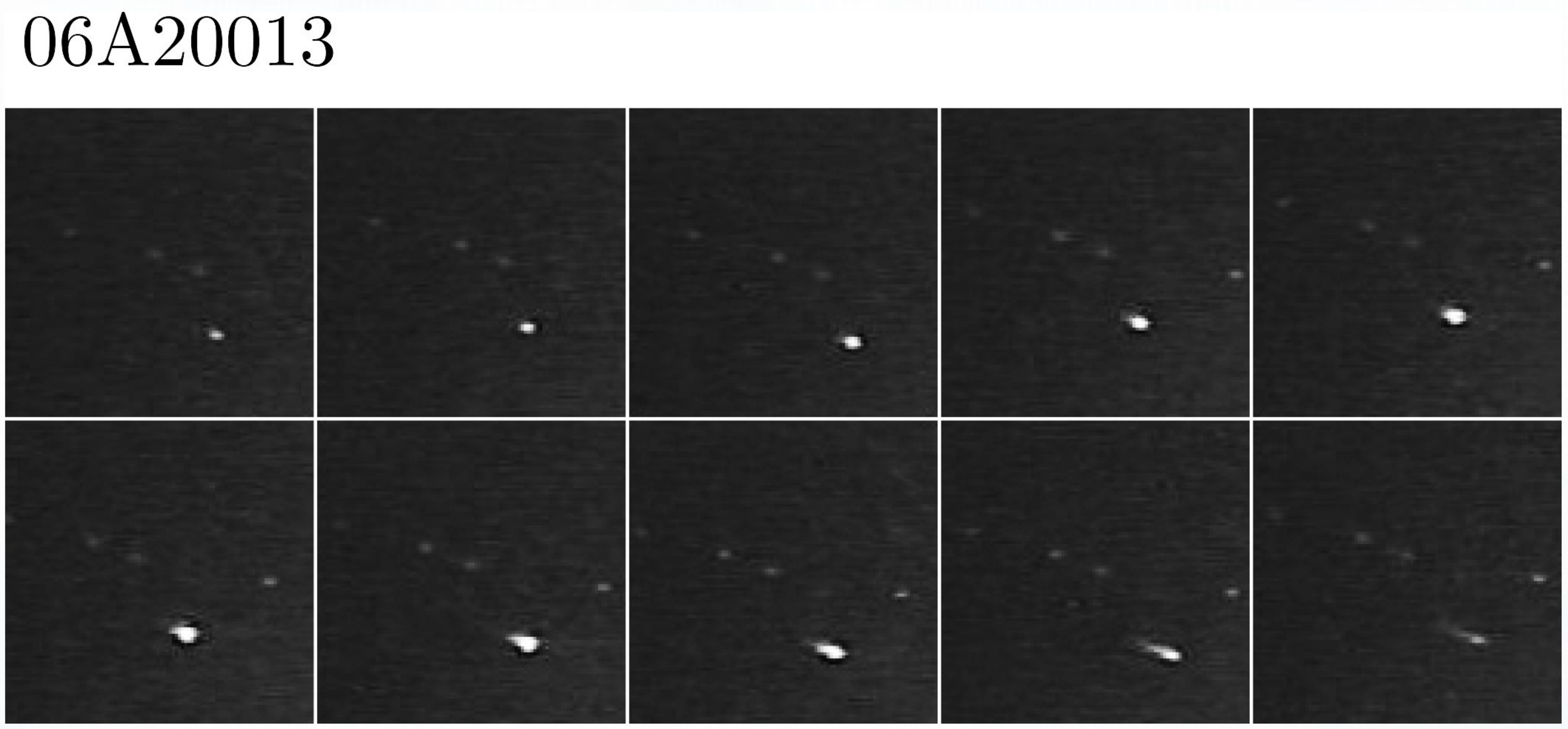


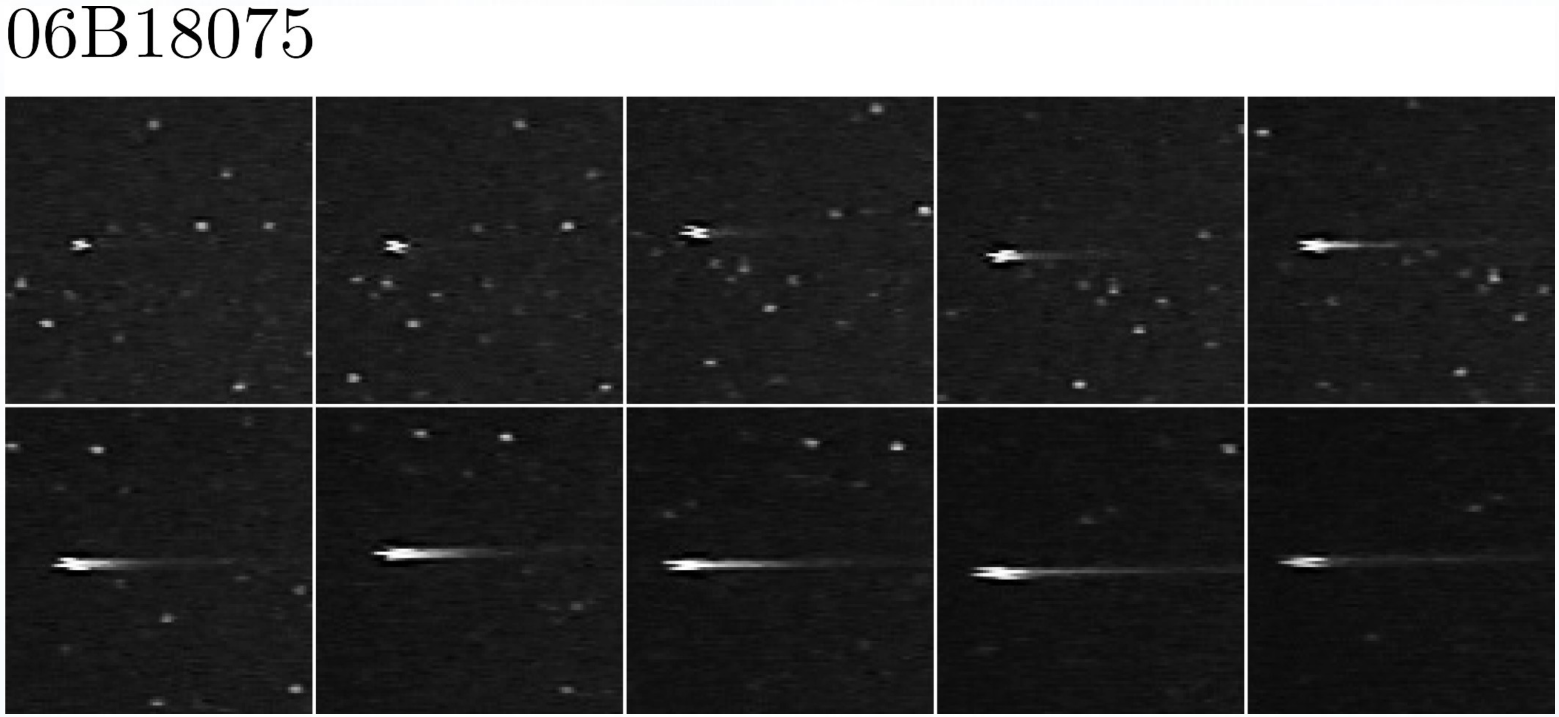
The morphology

- Low resolution of cameras (200m/px), but still…
- Three categories:
  - Short, faint wake (3 - 15px)



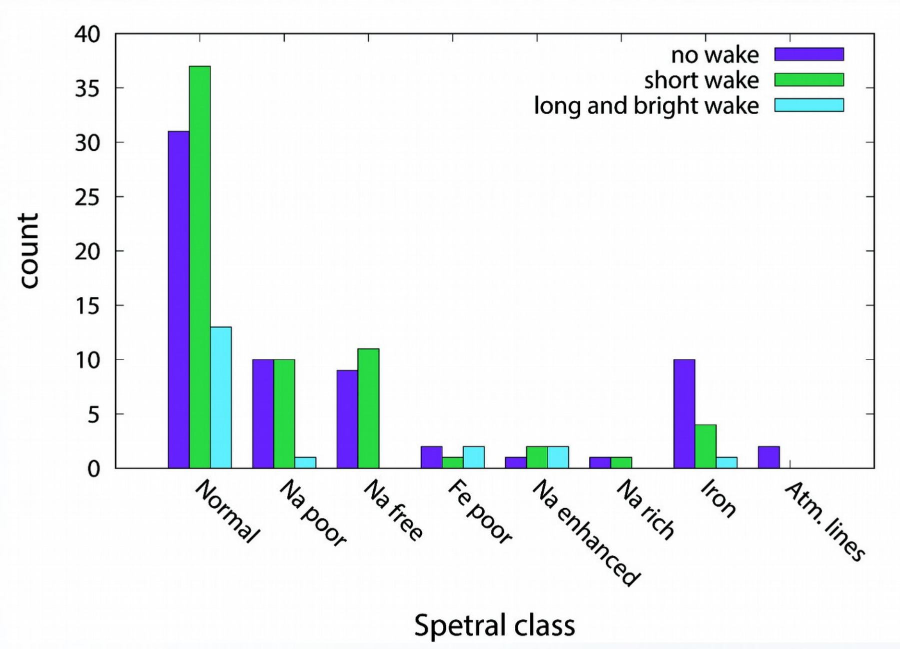
The morphology

- Low resolution of cameras (200m/px), but still…
- Three categories:
  - Long, bright wake (15 – 100px)



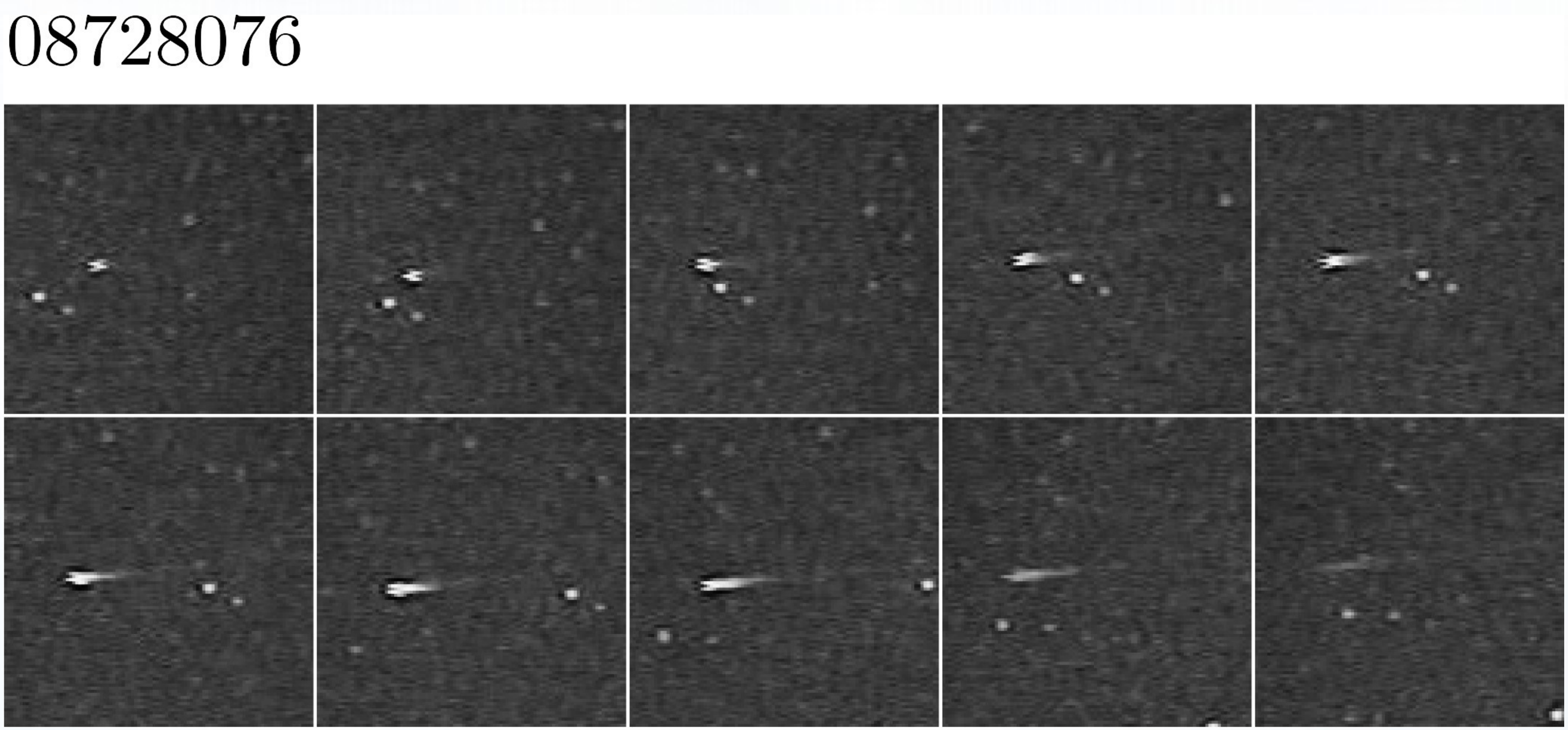
The morphology

- Wake formation?
  - Smaller grains declerated more than larger grains (Campbell-Brown et al. 2013)
- Na free, Na poor – short faint wakes, no wakes
  - No very small grains
- Irons – no wakes, short faint wakes
  - Small number of grains



The morphology

- Elongated endings
  - Draconids
  - Three sporadic meteors



The morphology

- Elongated endings
  - Draconids
  - Three sporadic meteors
- Some parameters similar to each other:
- Velocity 25 km/s
- Higher ablation coefficient
- Grain sizes 10^{-2} – 10^{-3} mm
- Es ~ 10^{6} J/m^{2}

Irons

- 15x irons, 4x modelled
- 10x asteroidal
- 1x Sun – approaching
- 2x Jupiter family
  - 81P/Wild 2: large range of Fe-Mg, Fe-Ni content (Zolensky et al., 2008)
- 2x Halley – inclination ~ 60°

Irons

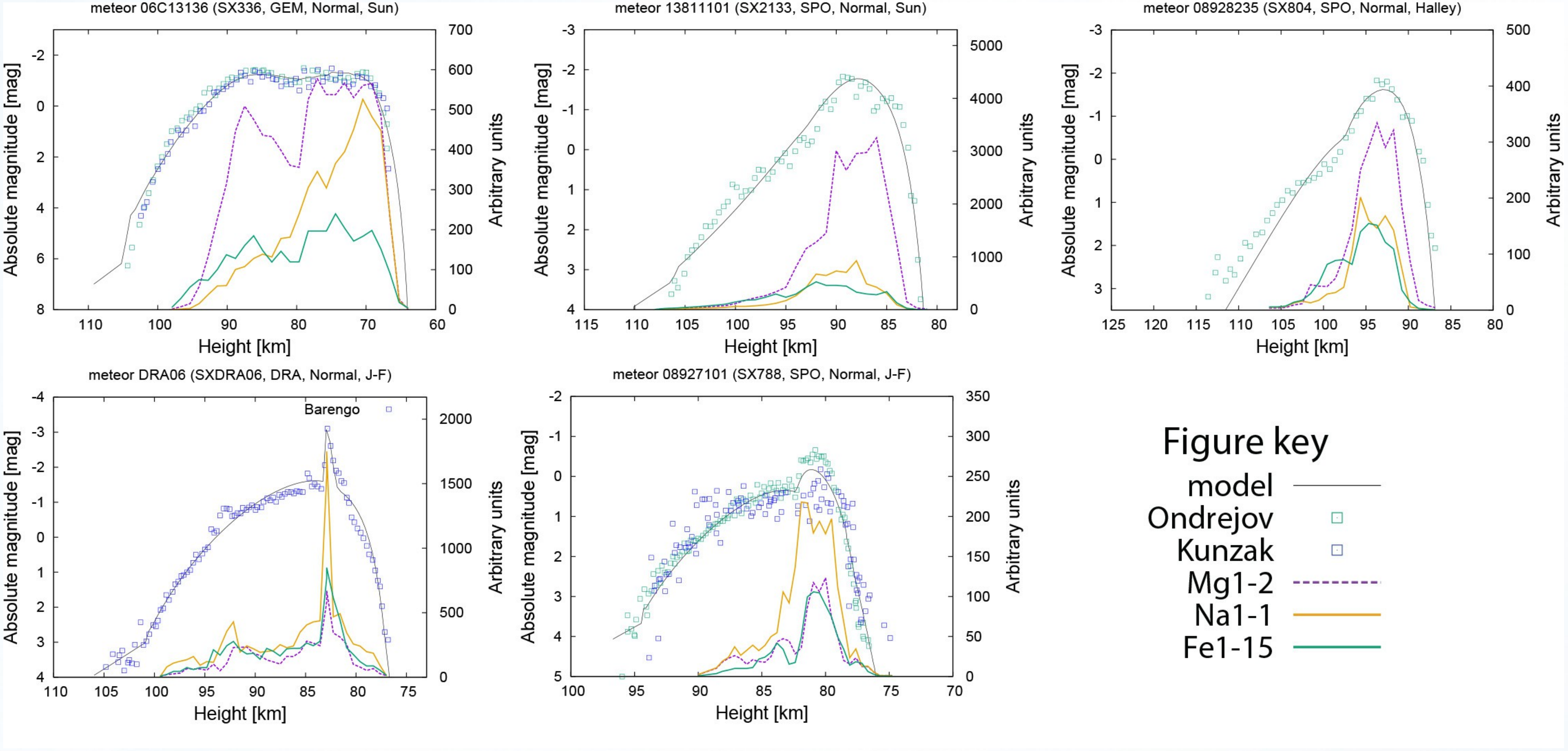
- 2x Halley – inclination ~ 60°
  - ??Grand Tack model (Walsh et al. 2011): migration of big planets – planetesimals in Oort cloud

Table 1: Orbital elements of meteoroids classified as Irons. Second row for each meteor contains corresponding errors.

	a (AU)	q (AU)	Q (AU)	i (°)	ω (°)	Ω (°)	v (km/s)	T_J	orbit
SZ2410	3.50	0.654	6.4	63.2	103.2	14.32	40.7	1.9	Halley
	0.09	0.001	0.2	0.2	0.3	-	0.1	0.1	
SX1938	3.6	0.486	7	63	277	143.30	43.4	1.7	Halley
	0.8	0.008	2	1	2	-	0.8	1.0	

Two stages of erosion

- 10% meteors with second brightening

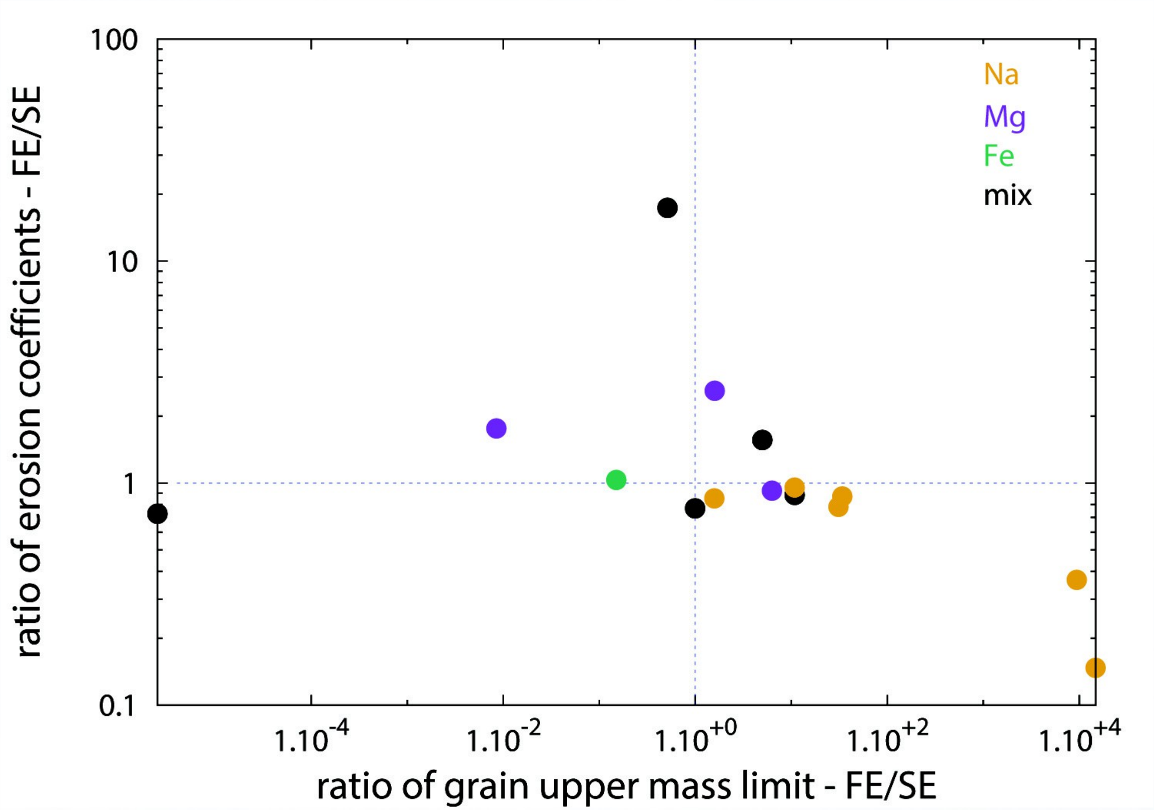


Two stages of erosion

- 10% meteors with second brightening
- Cometary, S-A & Normal, Na poor, Draconids
- Model:
  - Different grain sizes
    - 2nd stage larger grains, less grains
    - Draconids smaller, more grains
  - Ablation coefficient same
  - Erosion coefficient
    - Brightening by Mg = smaller
    - Brightening by Na = larger, same

Two stages of erosion

- Erosion coefficient
  - Brightening by Mg = smaller
  - Brightening by Na = larger, same



Two stages of erosion

- Only cometary and Sun-approaching?
  - Material differences more common
- GAIDA – Rosetta mission:
  - mix of compact and fluffy material (Fulle et al. 2015)
- Solar heating – change in material properties? (increased density – model Mukai & Fechtig 1983)

Conclusion

- Wake formation: highr probability for meteoroids with larger difference in grain sizes?
- Elongated ending typical for Draconid like meteoroids
- Irons on cometary orbits?
  - We can expect iron rich particles
  - Early solar system mixing of material?
- Two stages of erosion
  - Mix of material with different structure
  - Sometimes caused by brightening of individual lines