Geminids are made of compact carbonaceous material

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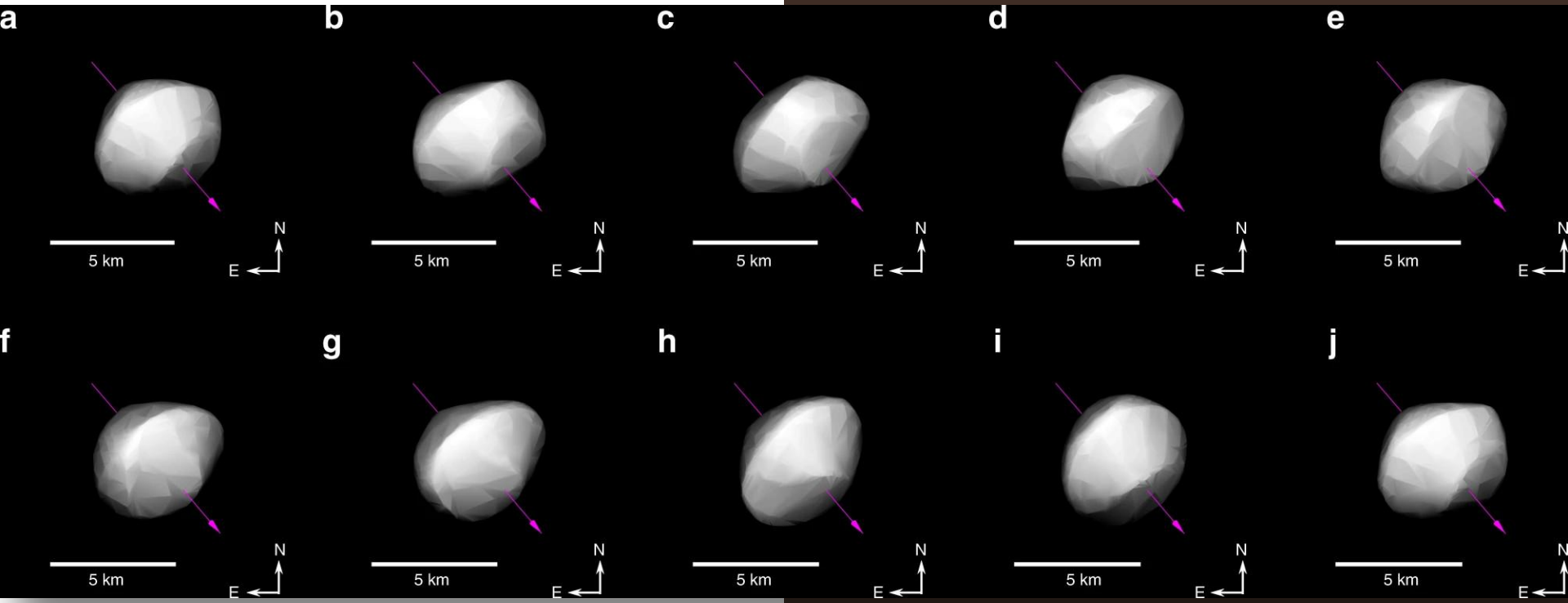
Motivation

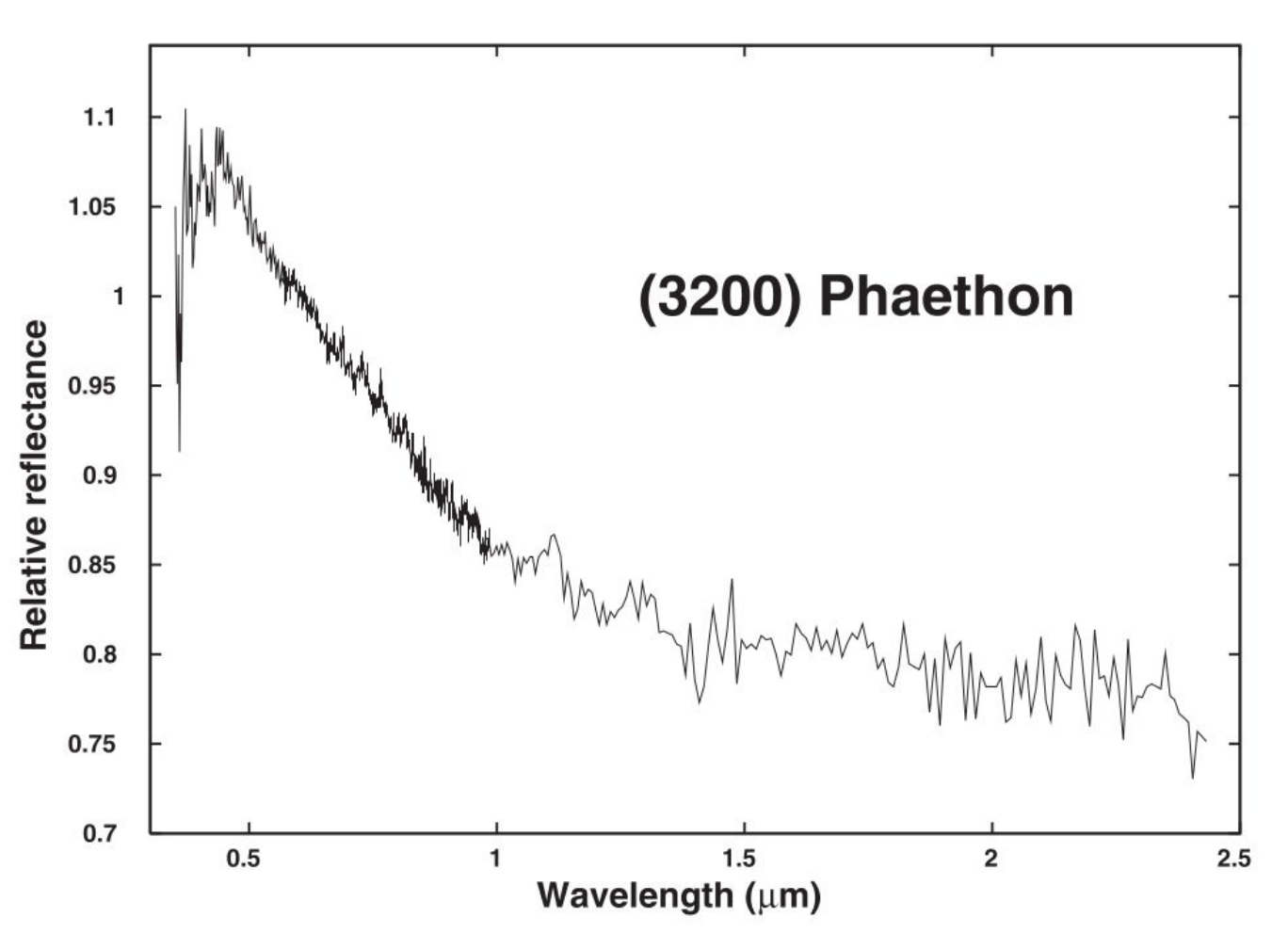
- most active annual meteor shower, maximum: December 14
- shower meteors/bolides with a known parent body carry information about a specific asteroid or comet
- detailed modeling of bright fireballs yields physical and mechanical properties of the meteoroid

Motivation

- parent body of Geminids is 3200 Phaethon
- active asteroid, q=0.14 AU
- regular perihelion brightening can be explained by sodium release
- to be visited by JAXA's DESTINY^{+} mission
- B type asteroid, C-complex, related to carbonaceous material



Takir et al. 2020,
Hanuš et al. 2018



Licandro et al. 2007

Geminids modeling

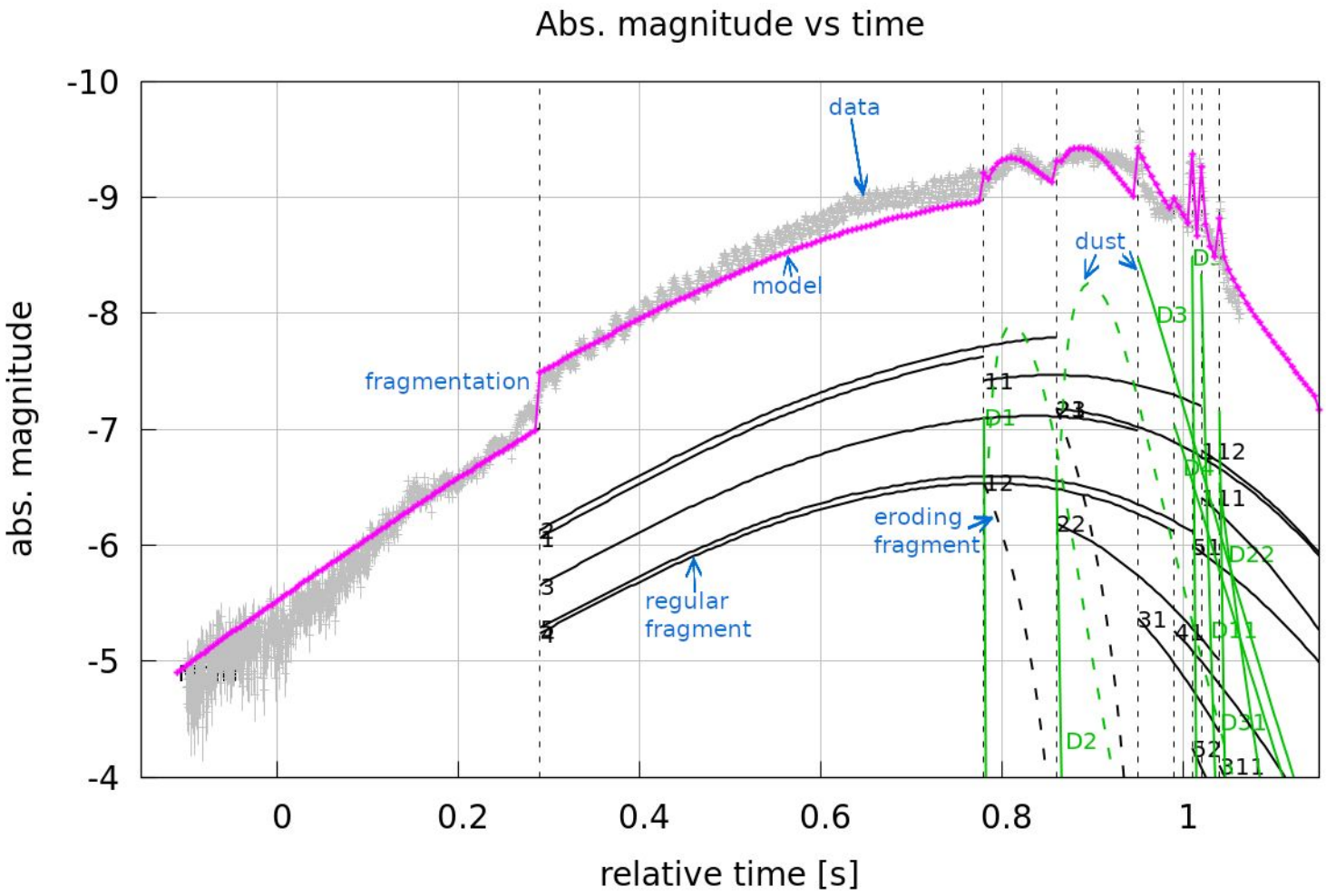
- fragmentation modeling of 9 Geminids and 8 asteroidal fireballs of comparable entry mass
- data from the European Fireball Network (we fitted radiometric and photometric light curves, foremost fragment dynamics)
- semi-empirical fragmentation model of Borovička et al. (2020) connected with a genetic algorithm optimizer (Henych et al. 2023)

Geminids modeling

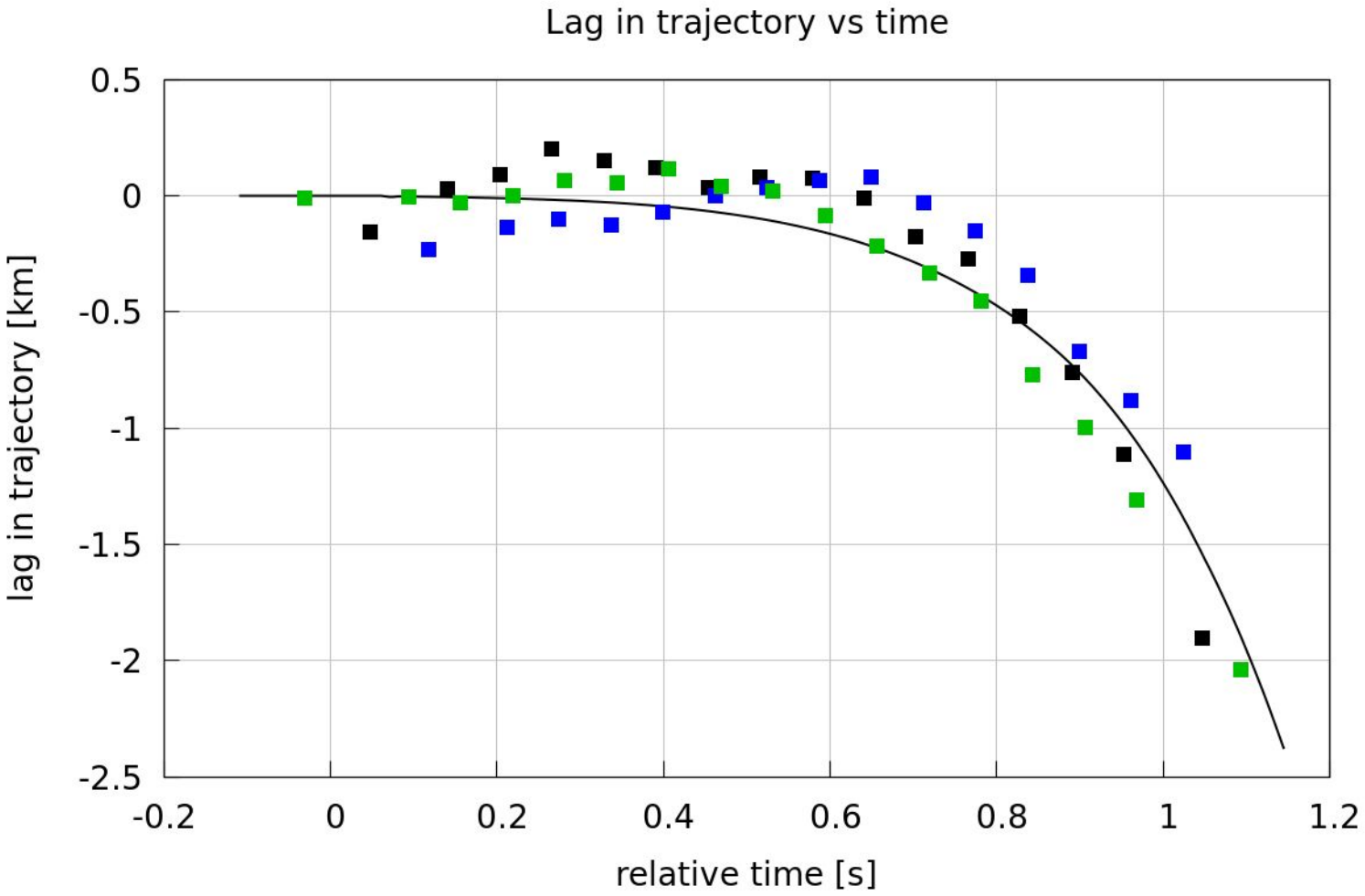
- we derived dynamic pressure exerted on the meteoroid and its fragments
- at fragmentation points it serves as a proxy for a tensile strength of the fragmenting meteoroid
- we compared Geminds to ast. fireballs, to Taurids (Borovička et al. 2020) and to the Winchcombe fireball (McMullan et al. 2023)

Rob Wilcock

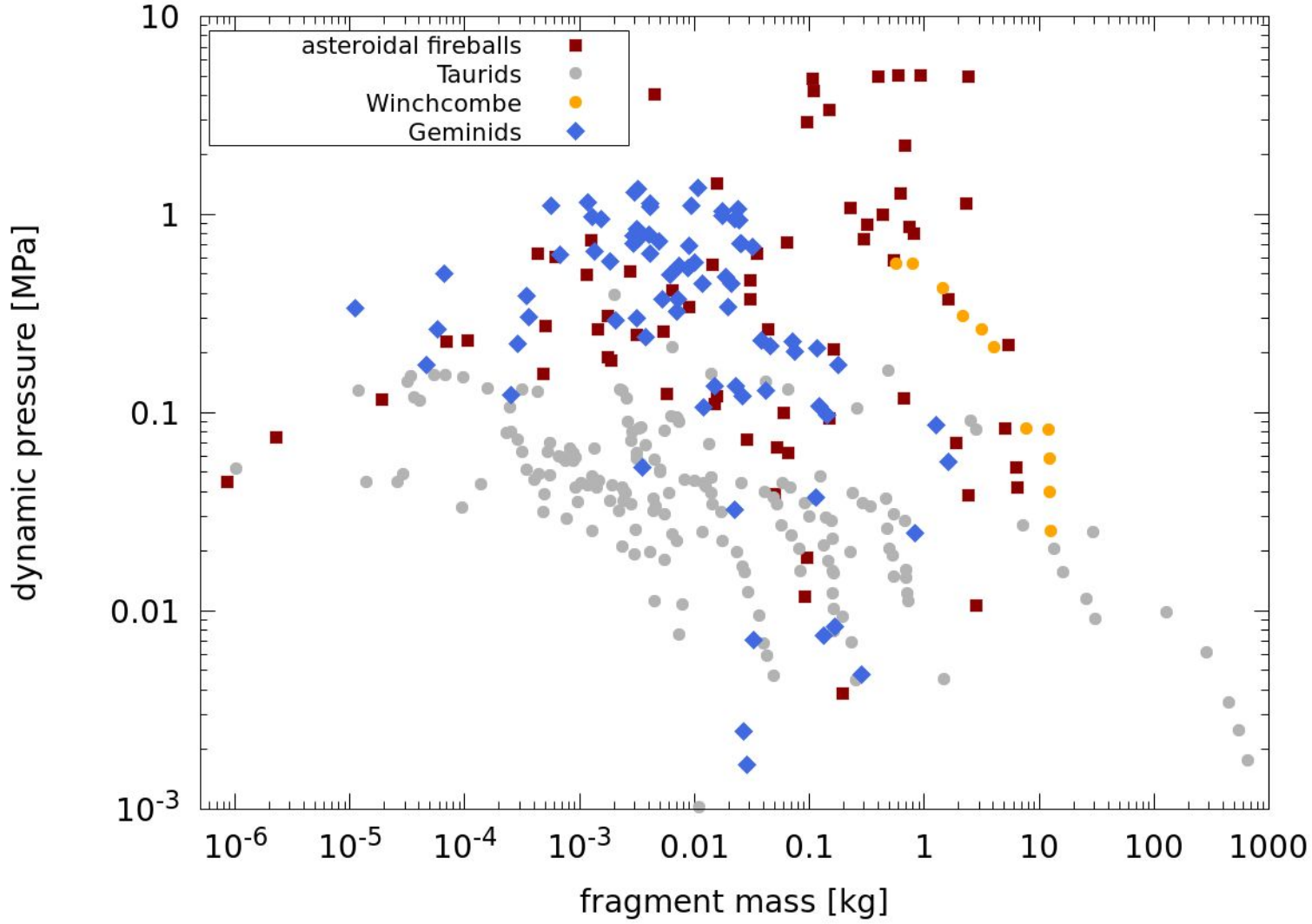
Radiometric curve



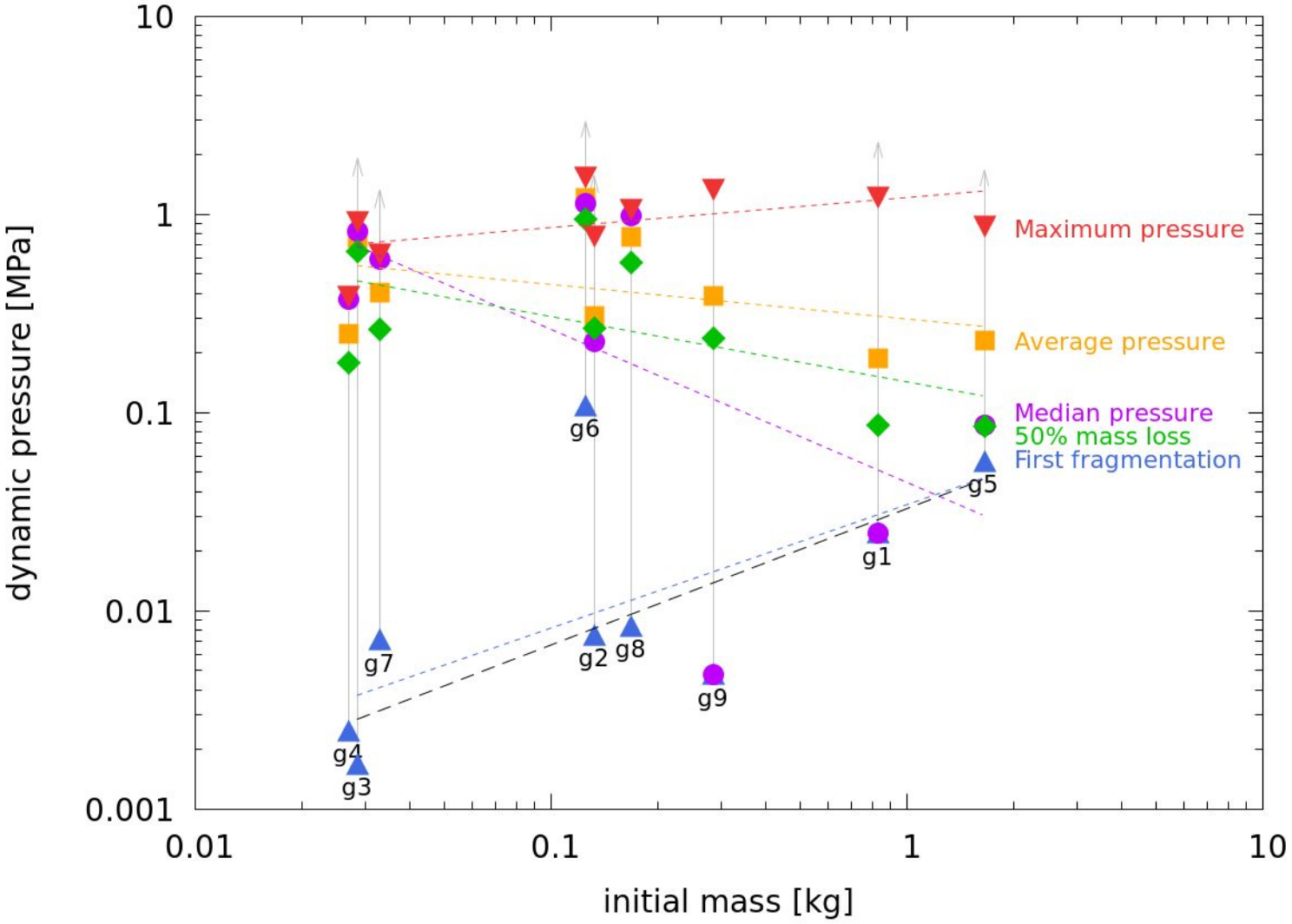
Dynamics


Lag in trajectory vs time
lag in trajectory [km]
relative time [s]
0.5
0
-0.5
-1
-1.5
-2
-2.5
-0.2
0
0.2
0.4
0.6
0.8
1
1.2

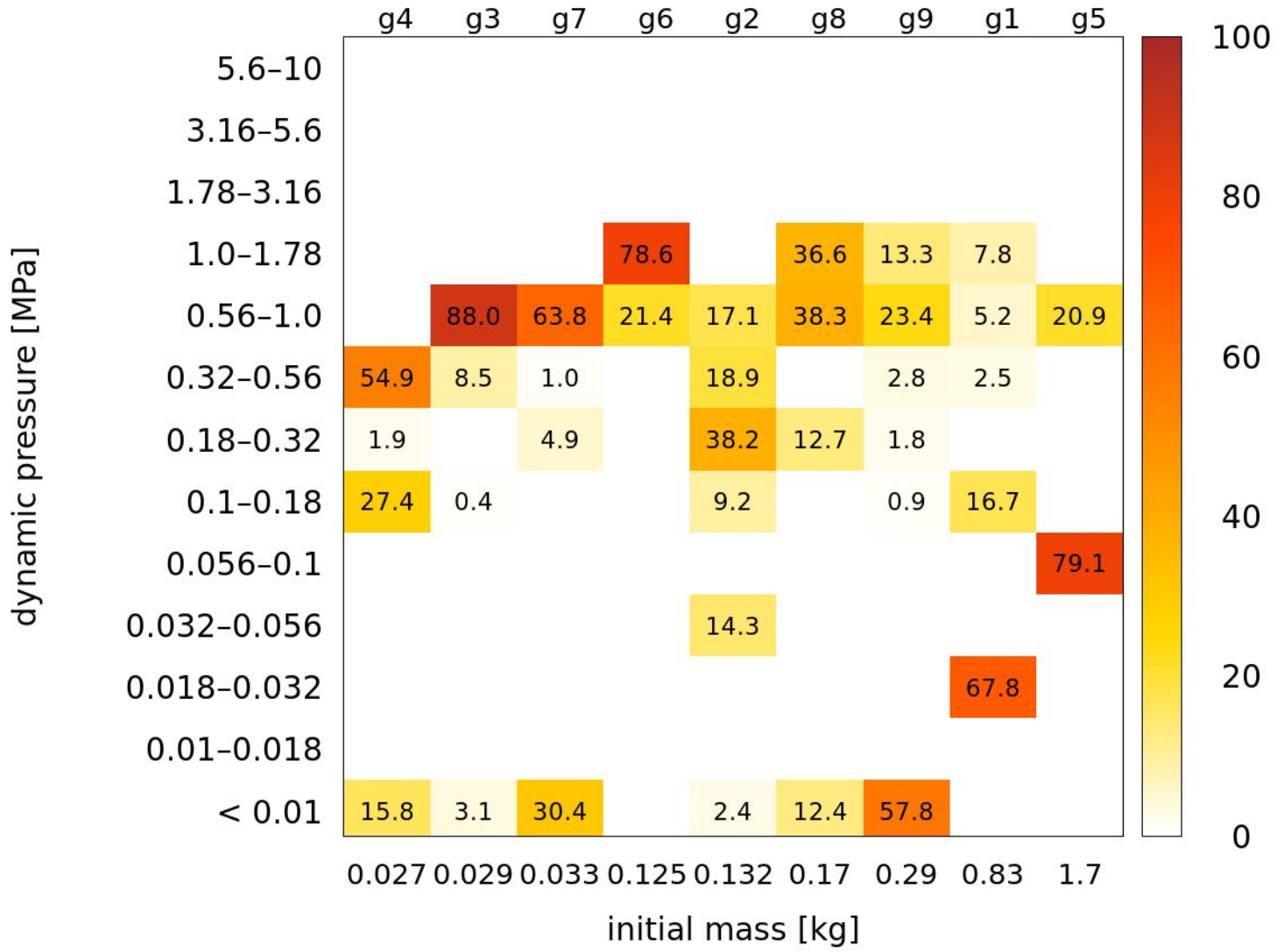
Dynamic pressure vs fragment mass

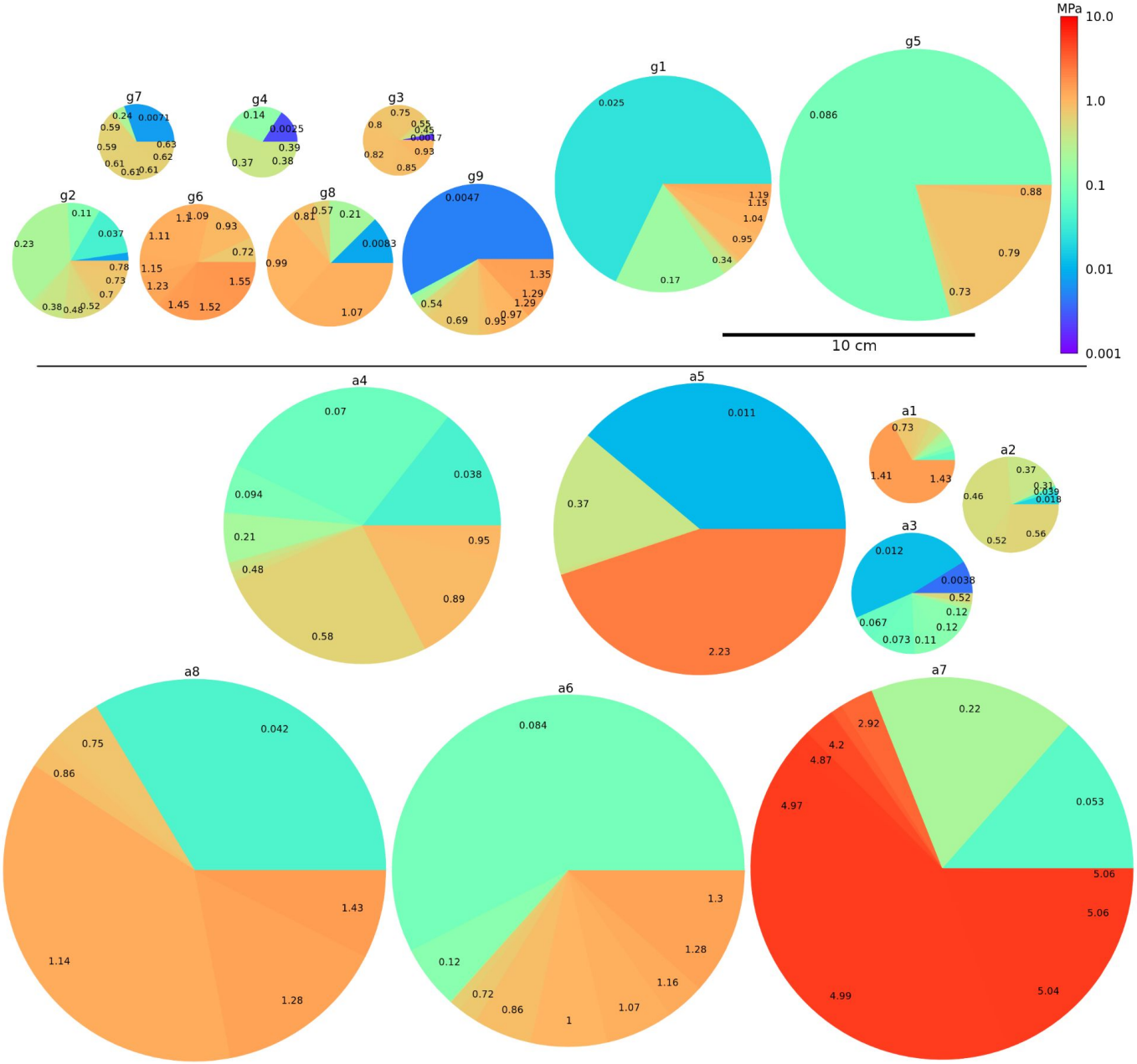


Pressure statistics in Geminids

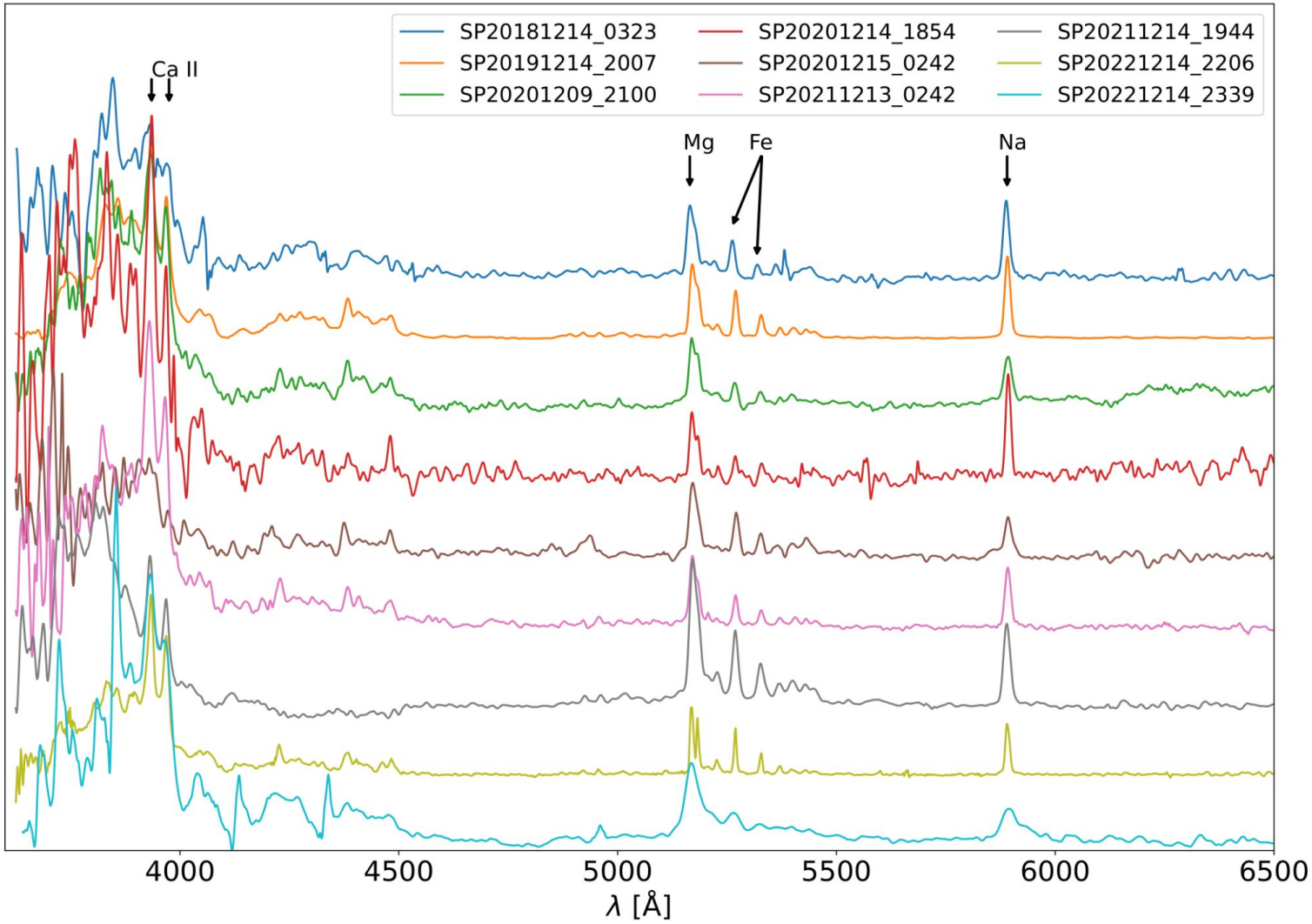


Strength proxy distribution

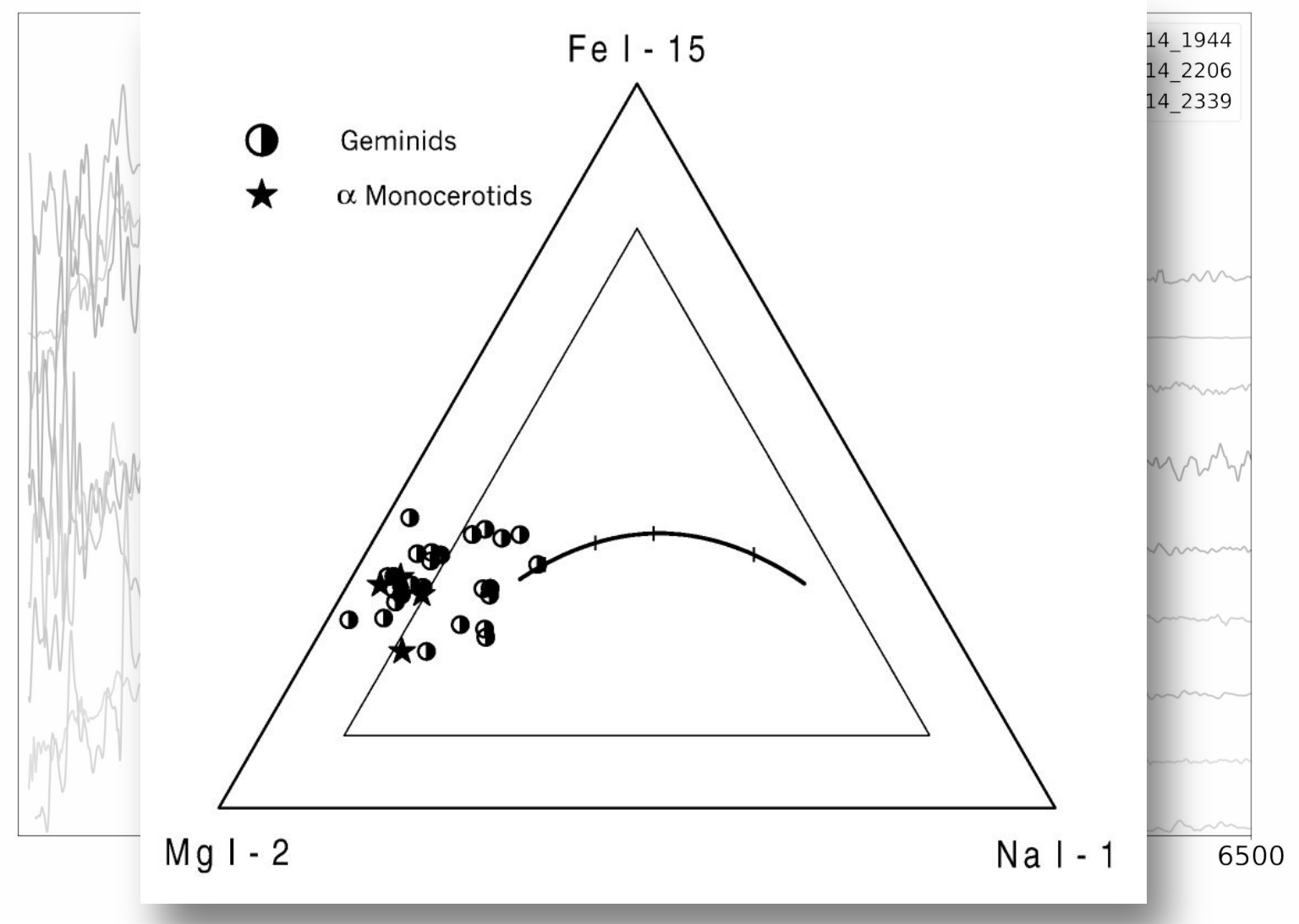



MPa
10.0
1.0
0.1
0.01
0.001
10 cm
g1
g2
g3
g4
g5
g6
g7
g8
g9
a1
a2
a3
a4
a5
a6
a7
a8

Spectra of Geminids



Spectra of Geminids



Borovička et al. 2005

Take away messages

- modeled Geminids 4x weaker than asteroidal fireballs and 2.5x stronger than the Winchcombe fireball (CM2 carbonaceous chondrite)
- probably formed by compact carbonaceous material
- smaller Geminids fragment at lower pressures than larger ones => thermal stresses destroy larger and weaker meteoroids (Čapek & Vokrouhlický 2012)
- large Na variation seen in mm-sized Geminids but not in cm-sized Geminids
- paper submitted to A&A