AMOS global meteor network

AMOS
All-sky Meteor Orbit System

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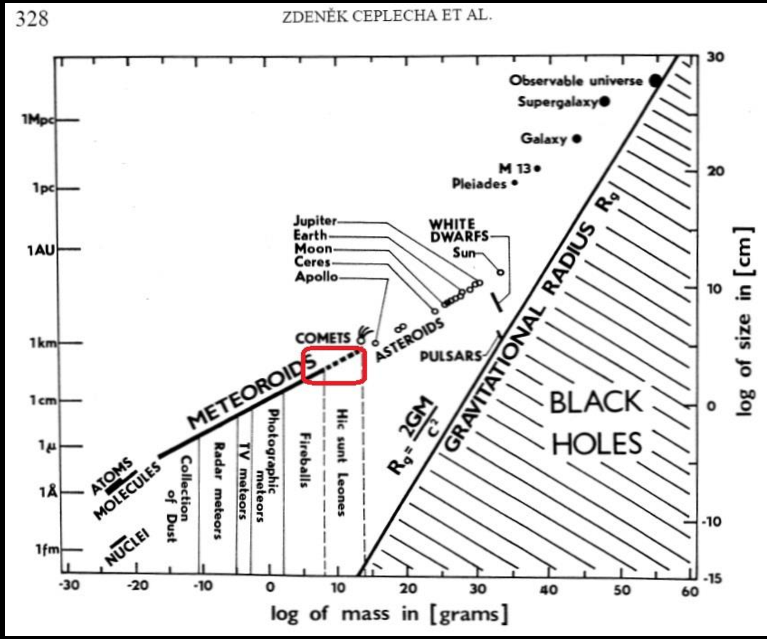
Outline of the talk:

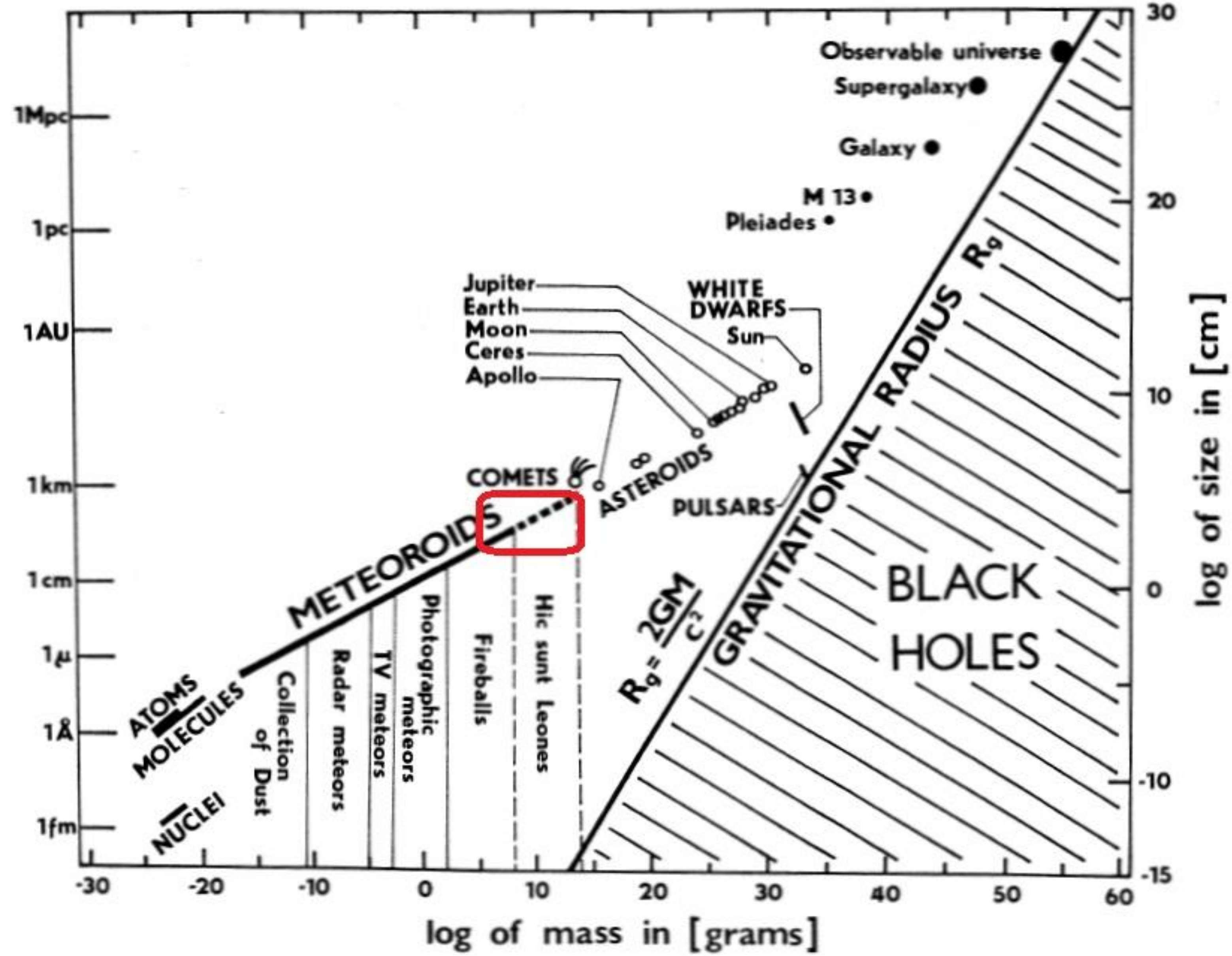
- Introduction to meteroroid’s world
- Motivation for the AMOS system and the network
- AMOS system description
- Network
- Some results

What is a meteoroid?

- IAU definition of meteoroid: natural object 30μm – 1m

- mostly fragments of comets and asteroids
- few samples returned from space (Stardust, Hayabusa)
- natural delivery of planetary material daily/nightly
- Detection: eye, photo, video, CCD, radar, infrasound
- We learn: dynamical, chemical and physical properties by optical systems
- Dynamics -> parent bodies

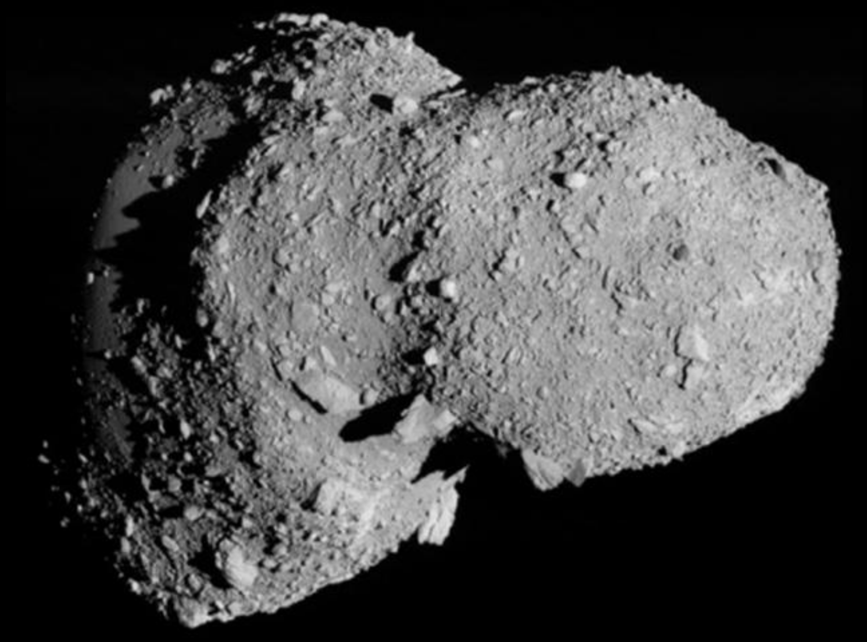



Observable universe
Supergalaxy
Galaxy
M 13
Pleiades
1Mpc
1pc
1AU
1km
1cm
1μ
1Å
1fm
Jupiter
Earth
Moon
Ceres
Apollo
WHITE DWARFS
Sun
COMETS
ASTEROIDS
PULSARS
METEOROIDS
ATOMS
MOLECULES
NUCLEI
Collection of Dust
Radar meteors
TV meteors
Photographic meteors
Fireballs
Hic sunt Leones
$R_g = \frac{2GM}{c^2}$
GRAVITATIONAL RADIUS R_g
BLACK HOLES
log of mass in [grams]
log of size in [cm]
-30
-20
-10
0
10
20
30
40
50
60
30
20
10
0
-10
-15

From comets & asteroids to meteoroids

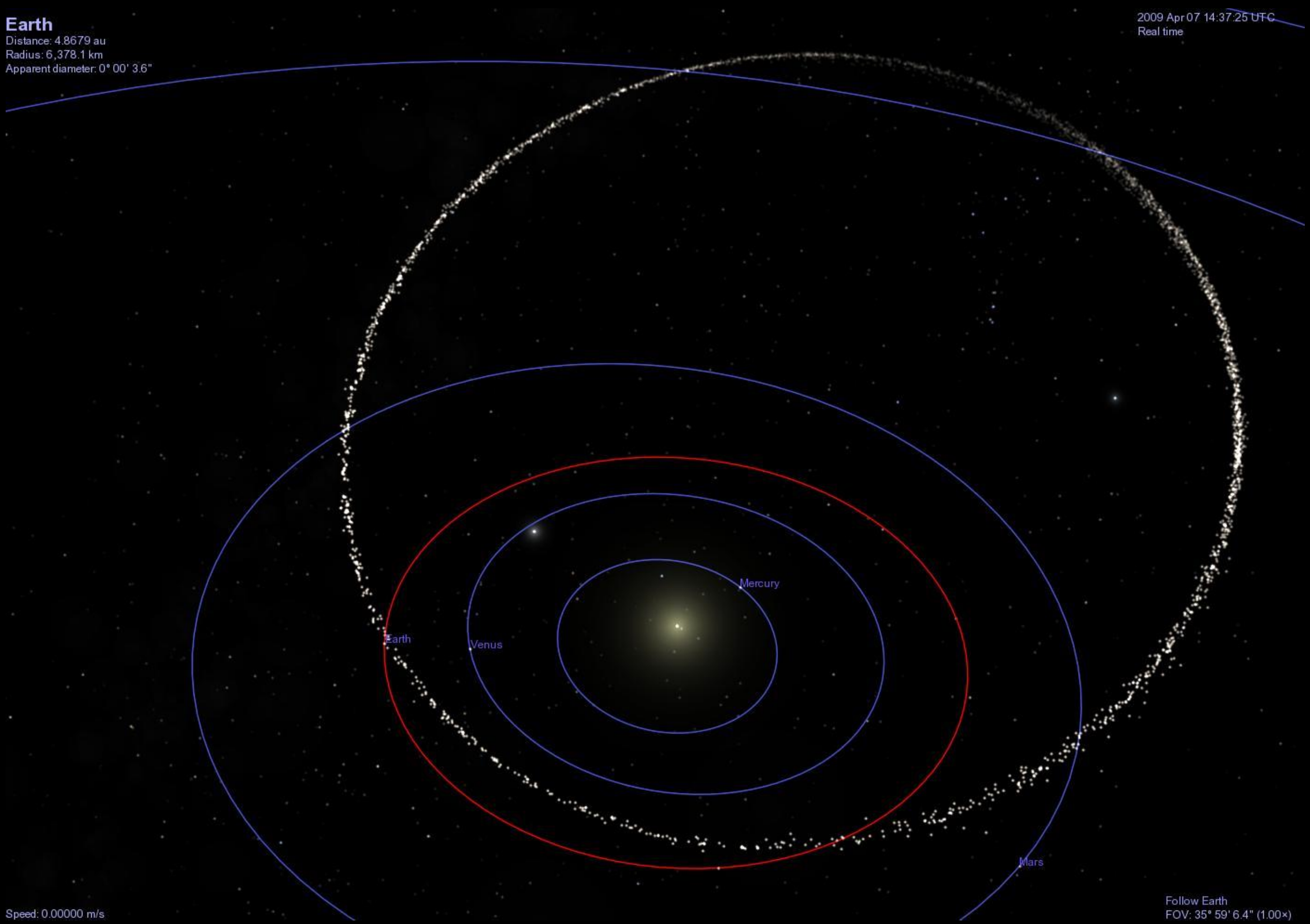
- Gas drag, impacts, tidal break-ups, …

67/P, ESA



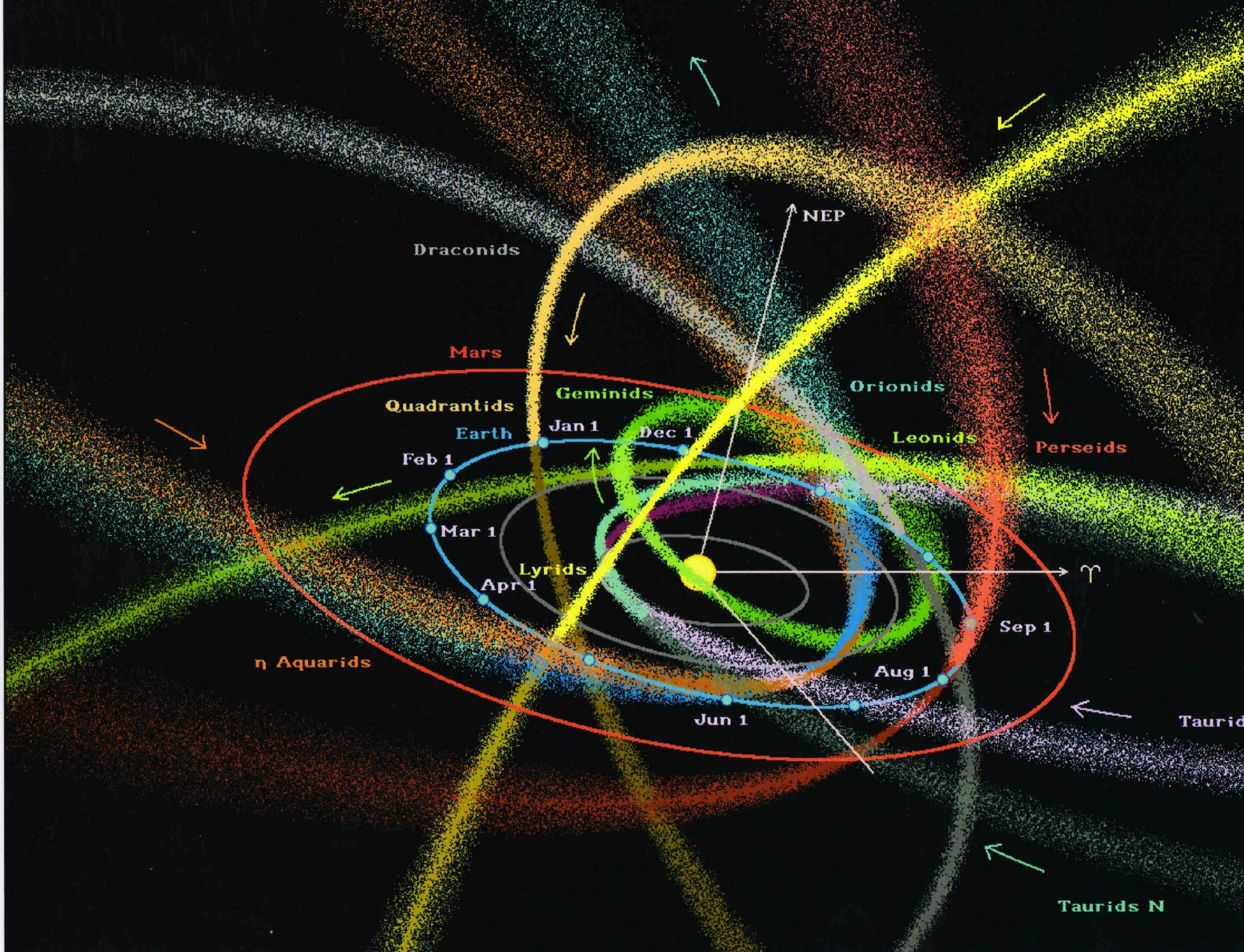
Asteroid Itokawa, JAXA

Meteoroid stream …



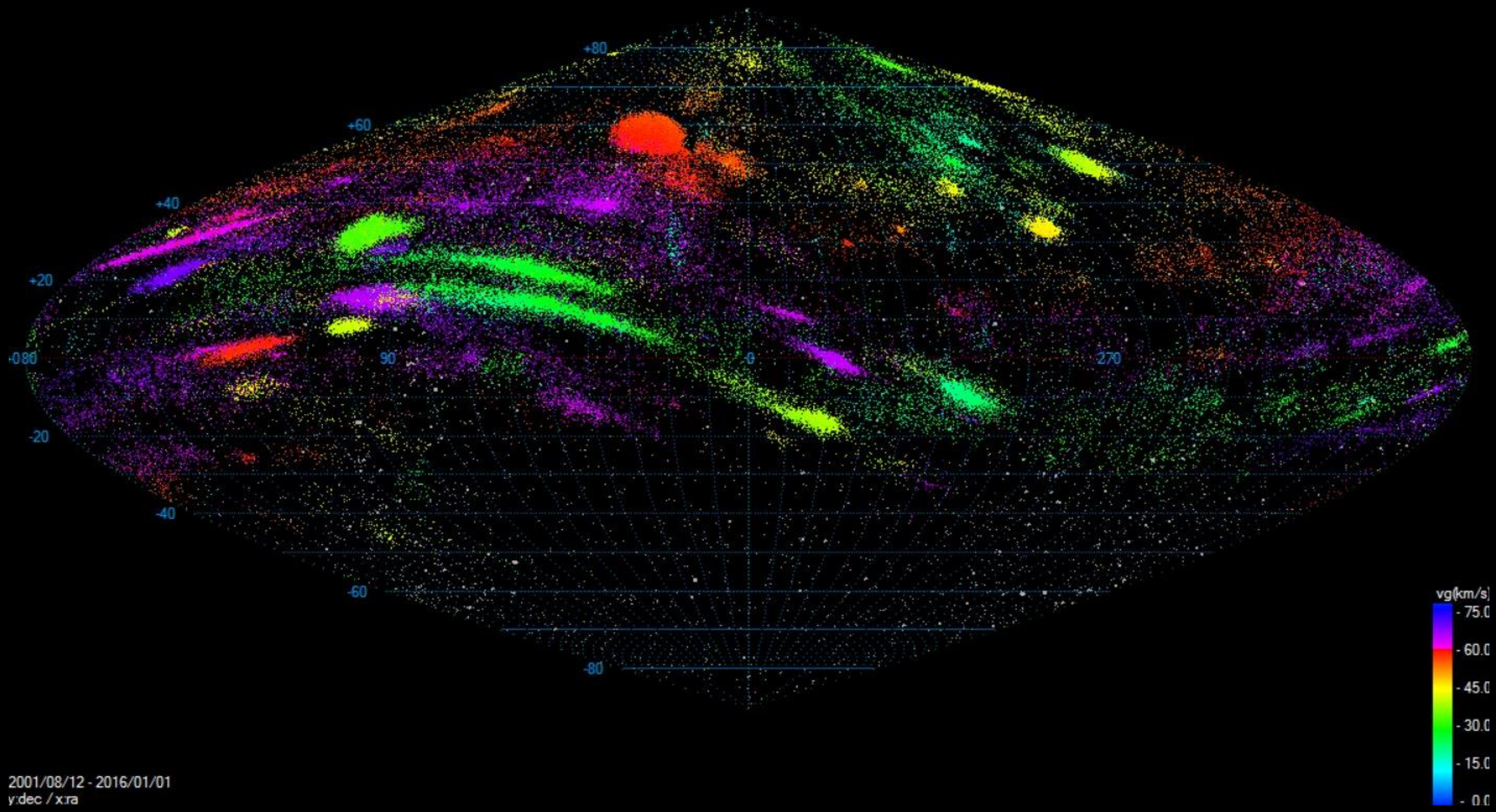
Tóth, Vereš, Kornoš, MNRAS, 2011
Celestia software

See inside front cover



Meteoroids meet the Earth: meteor shower

- 112 established, 820 on the working list of m. showers (IAU MDC)

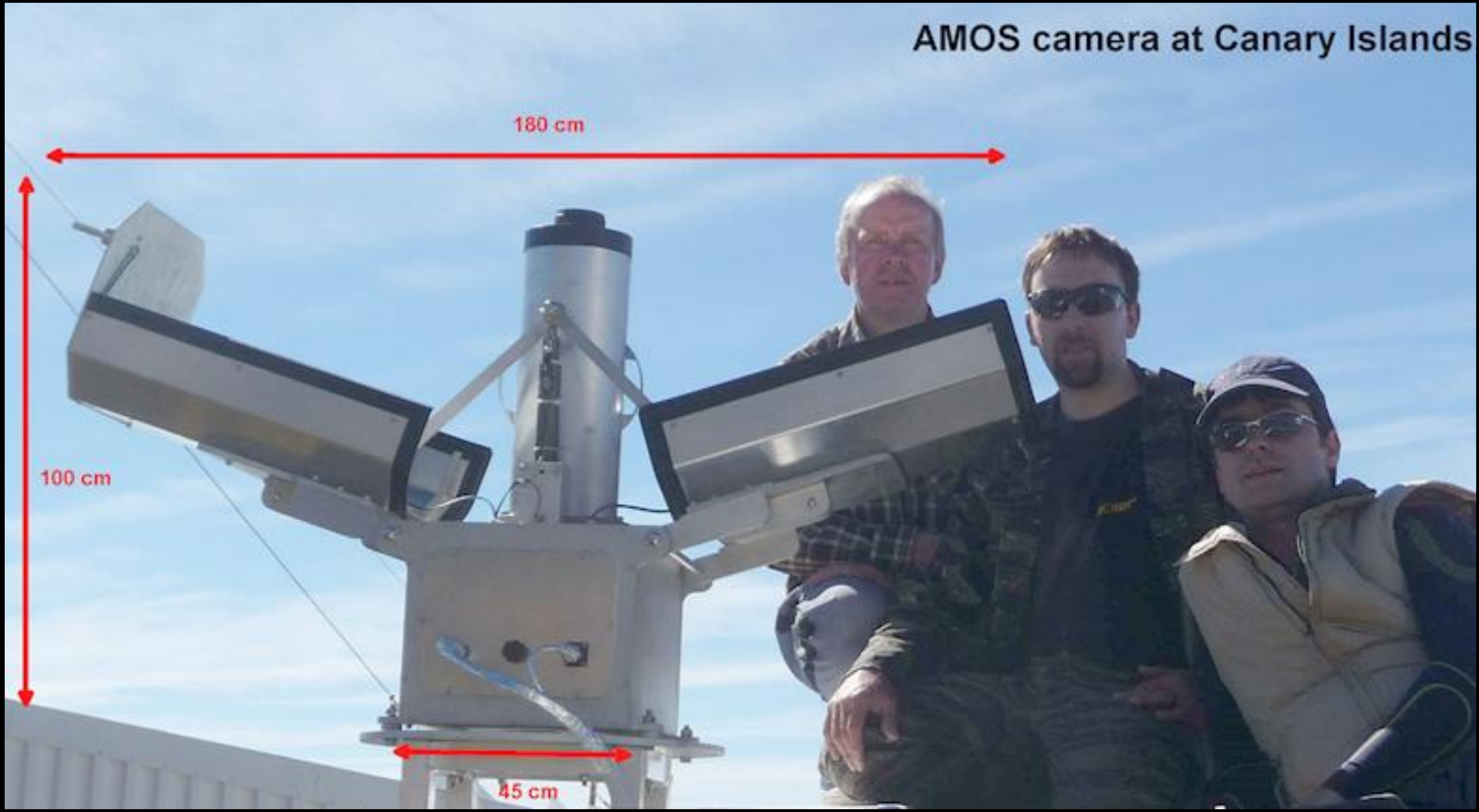


AMOS (All-Sky Meteor Orbit System)

- our own developed and patented system

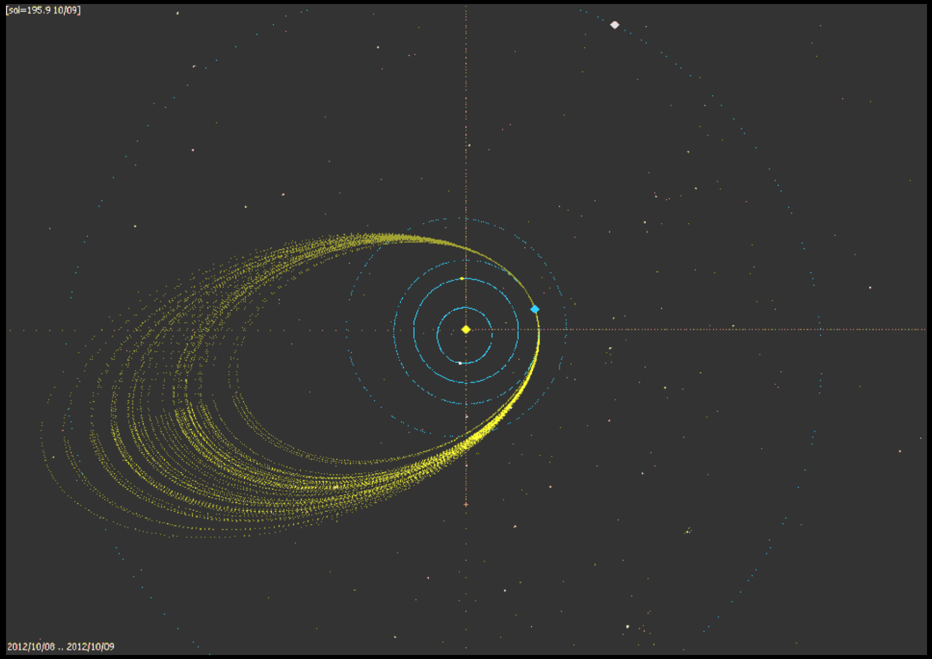
AMOS instrumentation:

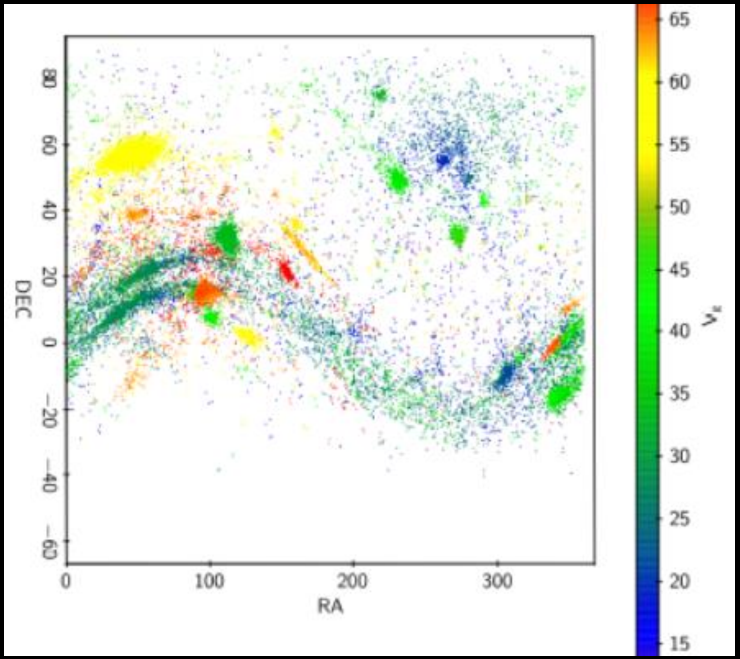
- Autonomous intensified optical video system
- Field of view 180 x 140 deg
- Resolution 1600 x 1200, 20 fps
- Stellar limiting magnitude + 5.0



AMOS (All-Sky Meteor Orbit System)

- dynamics of meteoroids, streams vs. parent comets/asteroids
- meteoroid flux variations
- spectral study of meteors in the atmosphere
  - orbital distribution of primitive and evolved meteoroids
- meteorites recoveries – e.g. Košice meteorite
  (15th case with the known orbit)



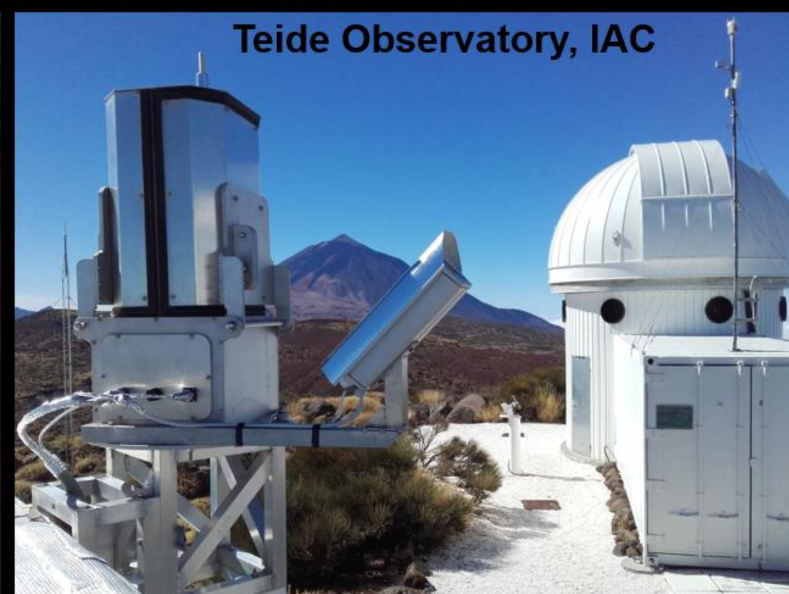


AMOS composite image from Chile

One thousand Geminids above Tenerife
Dec.13/14, 2017

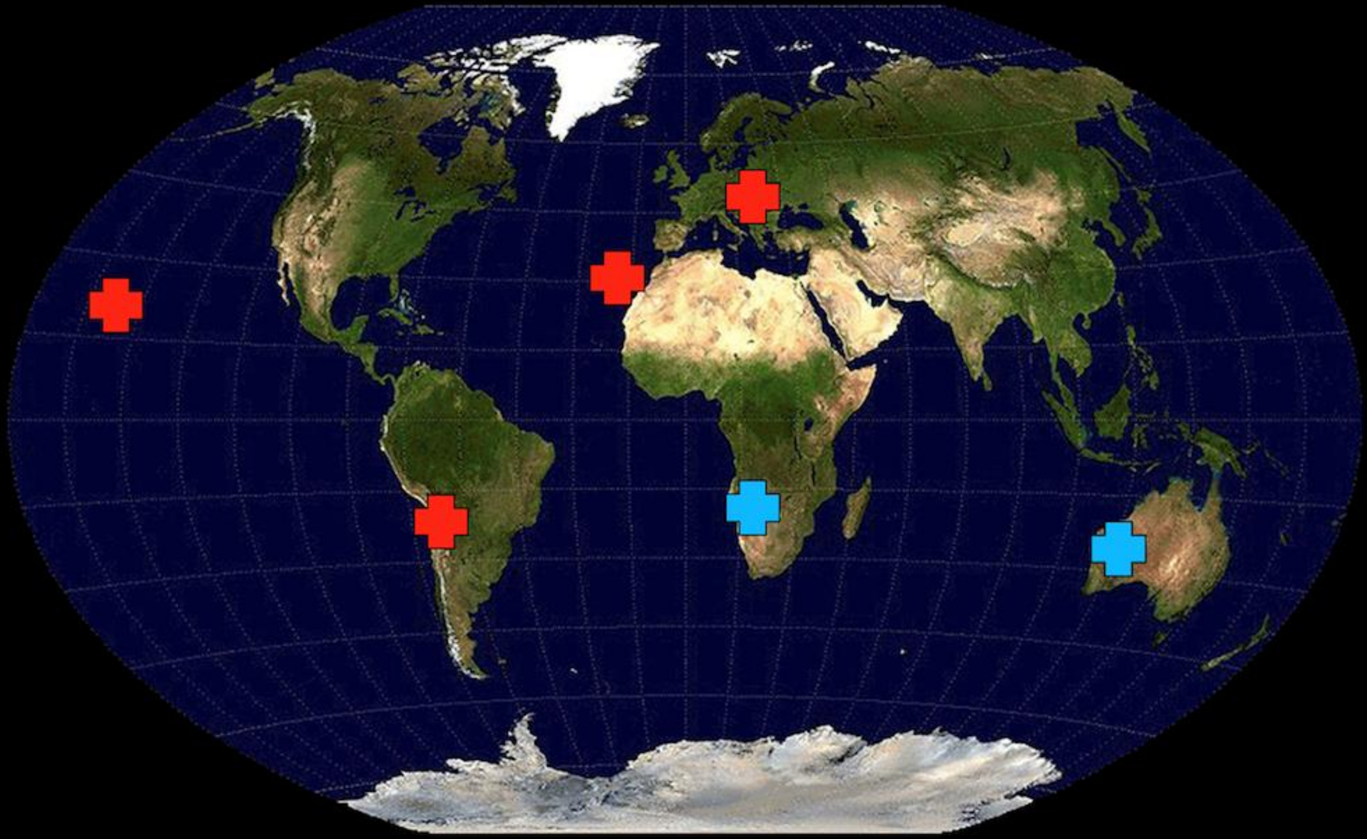
AMOS, Teide, IAC
Tóth et al., 2017

AMOS (All-Sky Meteor Orbit System) network



AMOS global network – 10 stations on 4 locations

- Slovak Video Meteor Network 2009
- Canary Islands 2015
- Chile, Atacama 2016
- Hawaii, 2018



… just installed on Haleakala

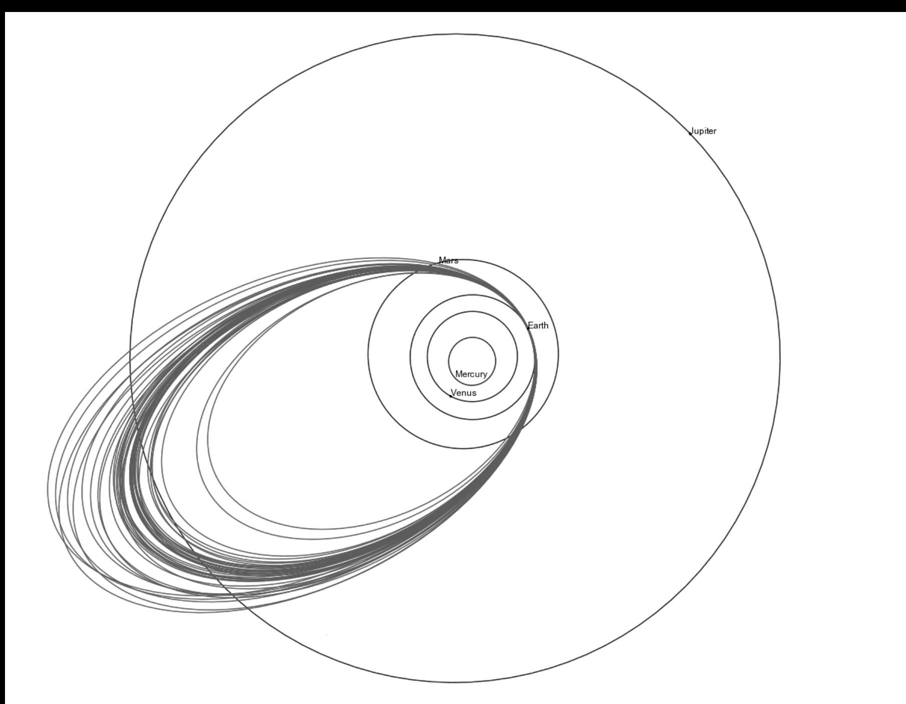
The first European meteor observation airborne campaign

J. Vaubaillon (IMCCE, PI)
J. McAulliffe (INSA/ESA)
D. Mautet (USU)

P. Koten (Ondrejov obs, PI)
J. Zender (ESA)
J. Toth (Univ. Bratislava)

Draconid meteor airborne campaign

- Main scientific results:
- Orbital parameters in agreement with the modeling
- Activity, flux profile as an input for the meteoroid ejection model and confirmation of activity of parent comet 21P/G-C prior its discovery



Three Peaks of 2011 Draconid Activity Including that Connected with Pre-1900 Material

Pavel Koten · Jeremie Vaubaillon · Juraj Tóth · Anastasios Margonis · František Ďuriš

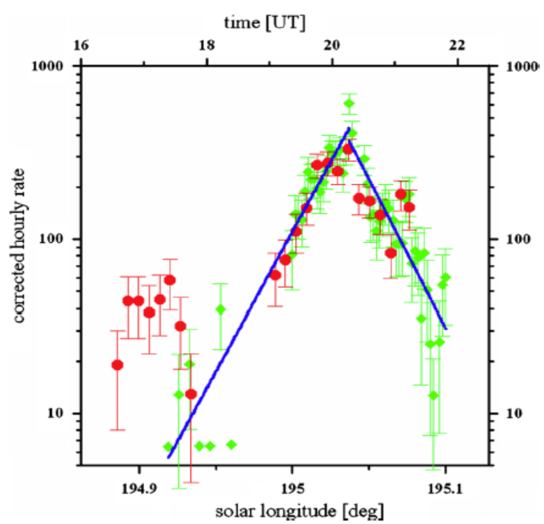
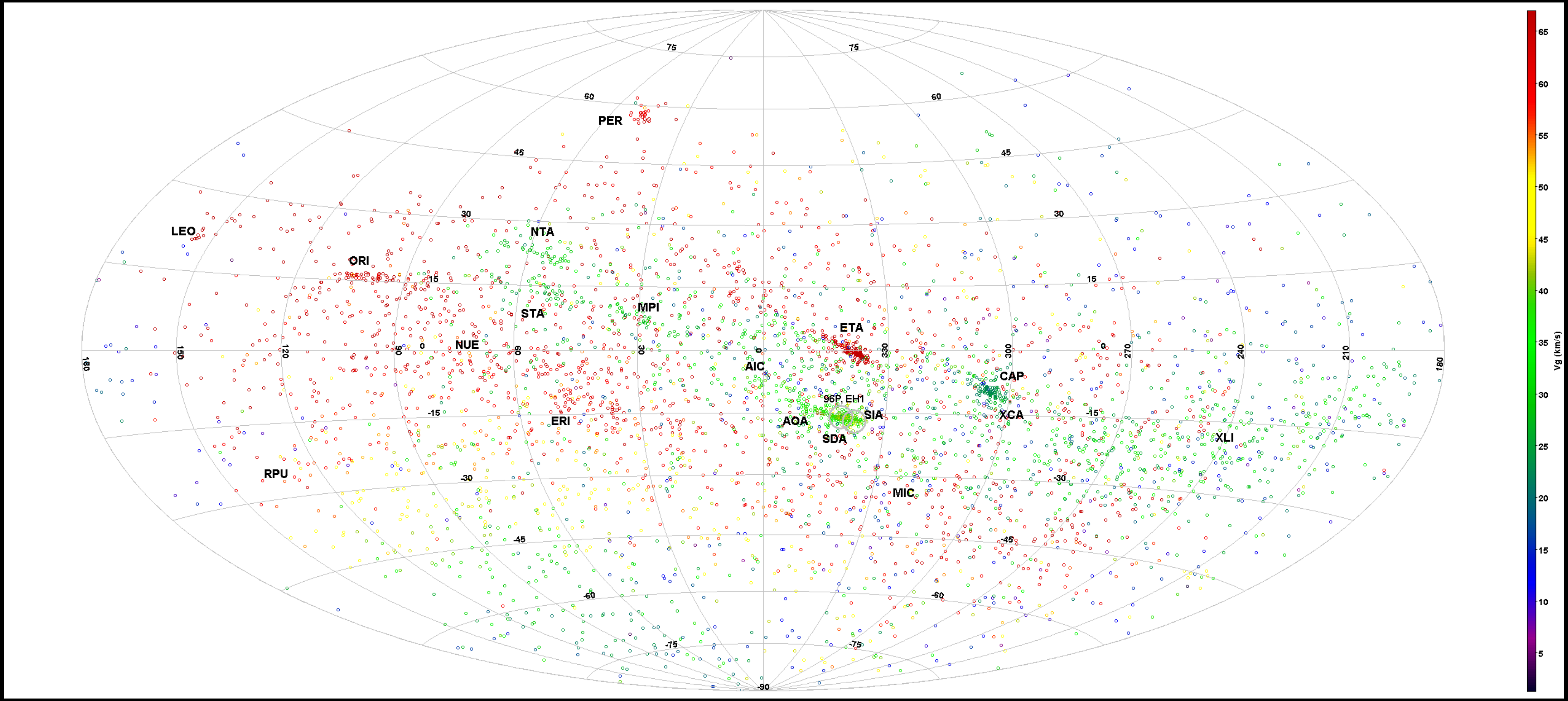


Fig. 4 Profile of Draconid outburst activity in logarithm scale based on all the data recorded by the all-sky and SPOSH cameras. *Blue lines* show exponential fits on the all-sky camera data for ascending and descending branches. The figure shows that the profile is more symmetrical when the ground based data are included. *Red circles* represent data recorded by SPOSH camera. The first peak of activity around 17:20 UT is clearly visible

AMOS in Chile, Atacama desert

- Radiant distribution of 4463 meteors, 03/2016 – 11/2016
- 68 meteor streams confirmed
- Agreement with the 96P/Machholz and 2003 EH_1 modelling and observed filaments



Fireball May 1, 2016 by AMOS, Chile, $M_V=-9^{mag.}$

Fireball May 1, 2016 by AMOS, Chile, M_V=-9$^{mag.}$

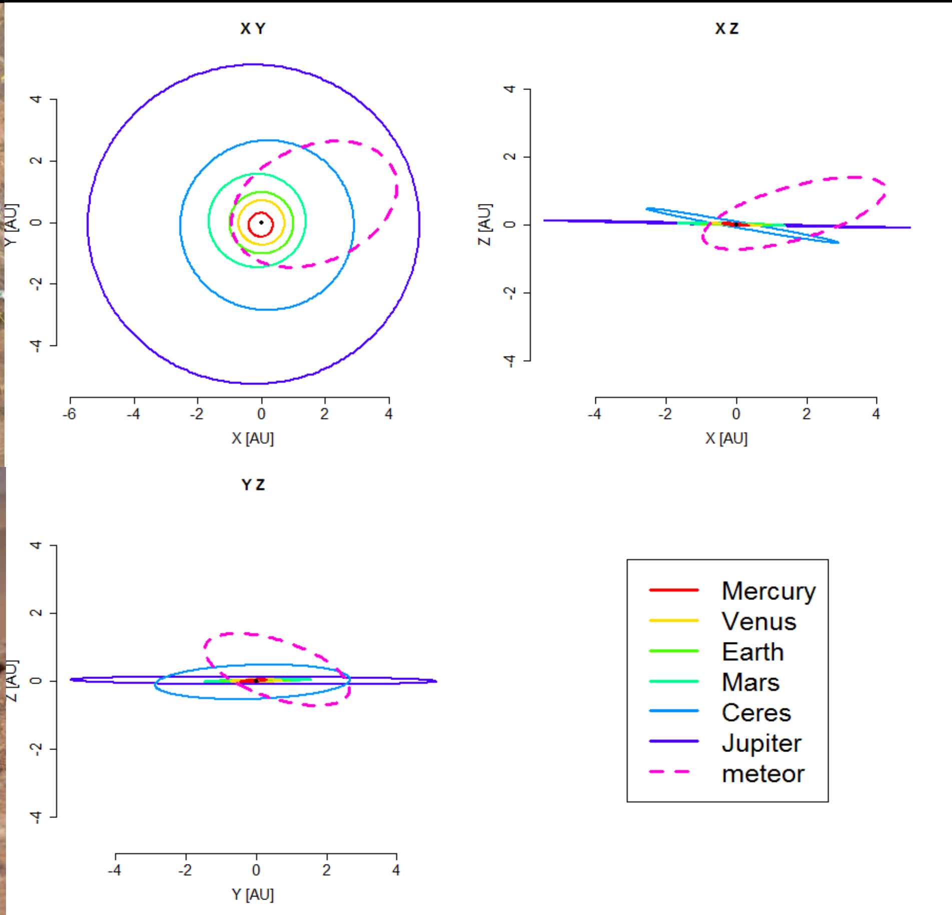
Fireball May 1, 2016 by AMOS, Chile, M_V=-9$^{mag.}$

Trajectory

H_B = 90km, H_E = 43km

Orbit

a=2.85 AU, e=0.66, i=28.7°



AMOS Spectral Instrumentation

AMOS-Spec

Camera:	1600x1200, 12 fps
Grating:	1000 grooves/mm
Resolution:	1.5 nm/px
FOV:	100 deg circular
Lim. mag.:	-2.0

AGO Modra (Slovakia) - since 11/2013

Supplemented by 4 AMOS stations (Slovak Video Meteor Network)

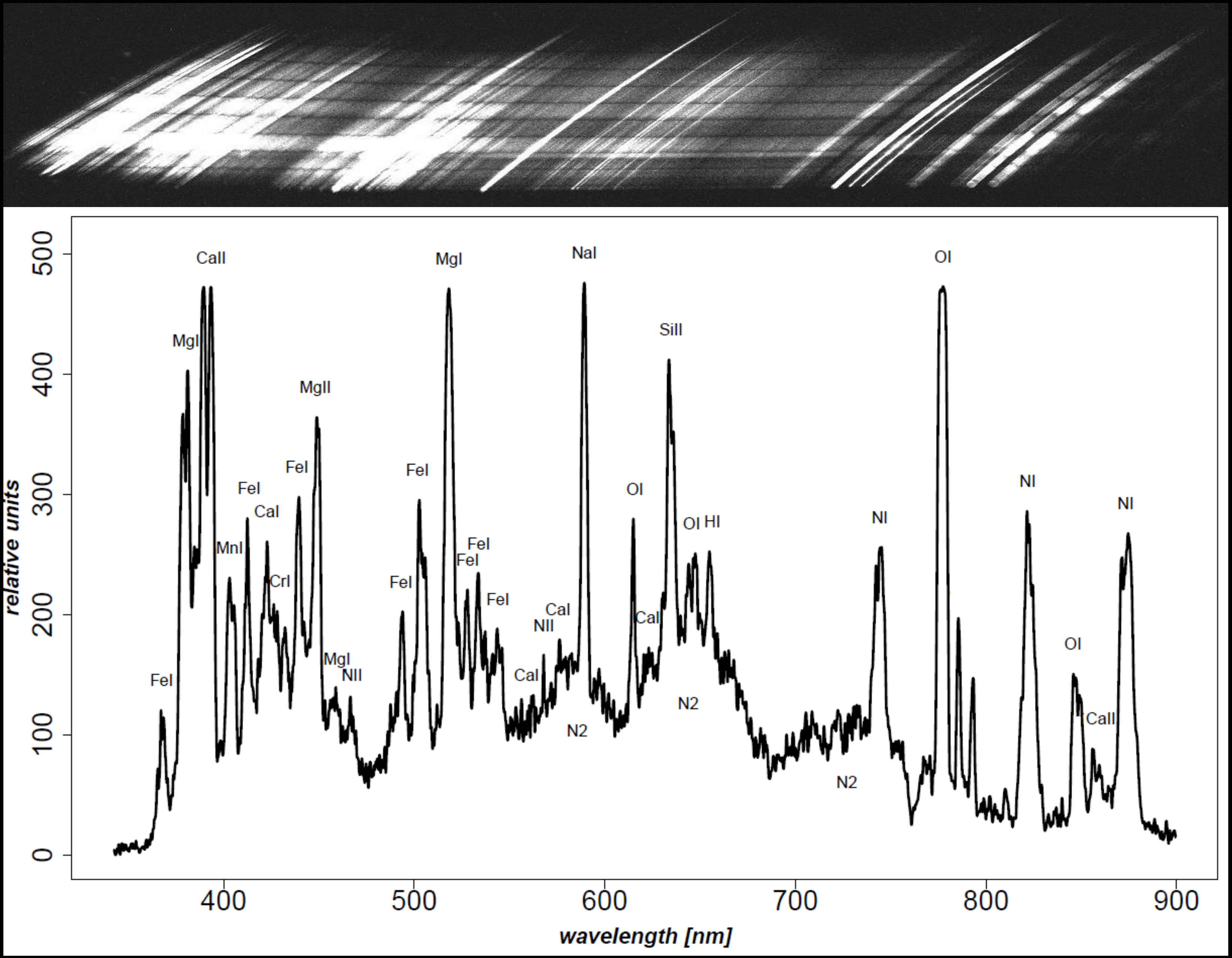
AMOS-HS

Camera:	2048x1536, 15 fps
Grating:	1000 grooves/mm
Resolution:	0.5 nm/px
FOV:	60 x 45 deg
Lim. mag.:	-1.5

Canary Islands and Chile - since 12/2016

Supplemented by 2 AMOS stations on Canary Islands, Chile and Hawaii

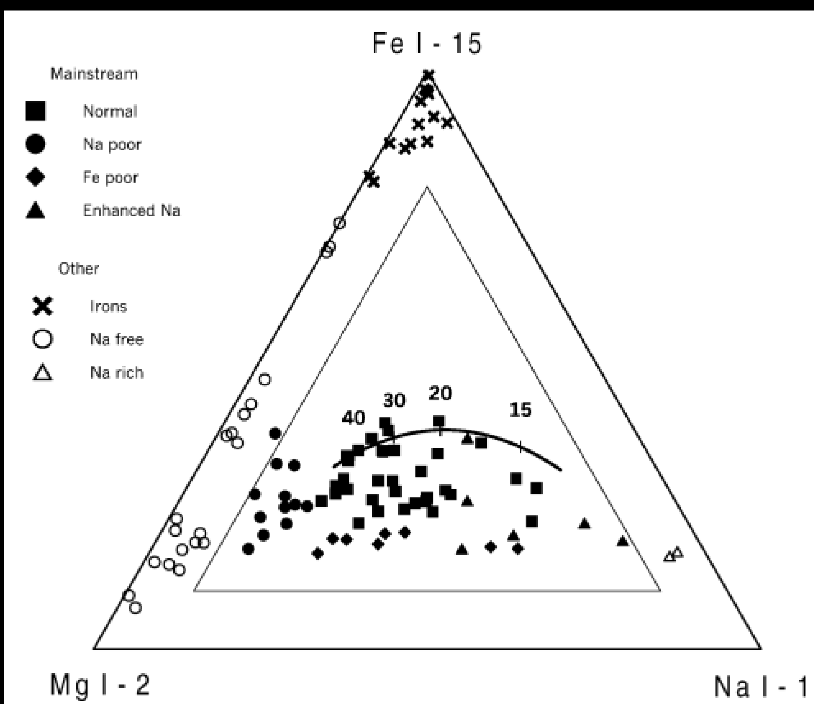
AMOS – spectral observations



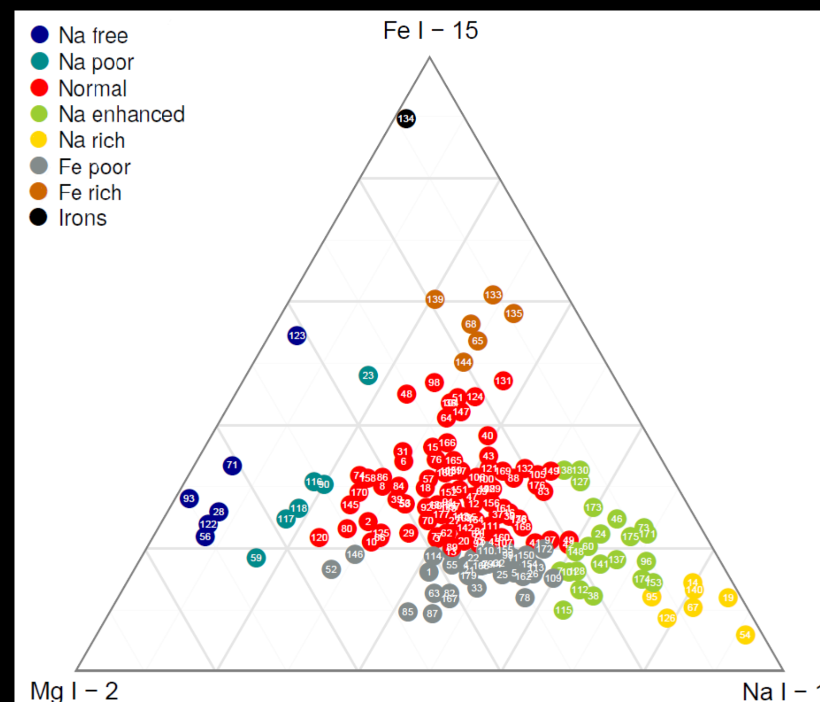
… spectral hardware including PhD. student

AMOS – spectral observations, open issues

- higher Na/Mg ratio for larger meteoroids
- low number of pure iron meteoroids for cm – dm sizes
- new population of Fe rich meteoroids
- higher amount of Na rich meteoroids on Apollo orbits



(Borovička et al., 2005)



(Matlovič et al., 2018, in preparation)

Na-rich meteoroids: observations

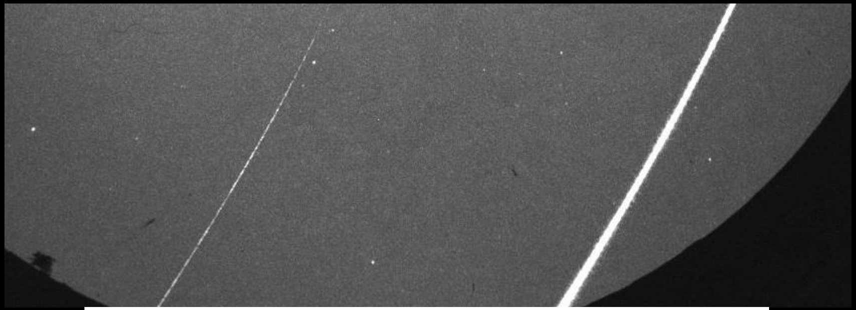
Slow, long-trail meteors with dominant Na I - 1 (589.2 nm) line

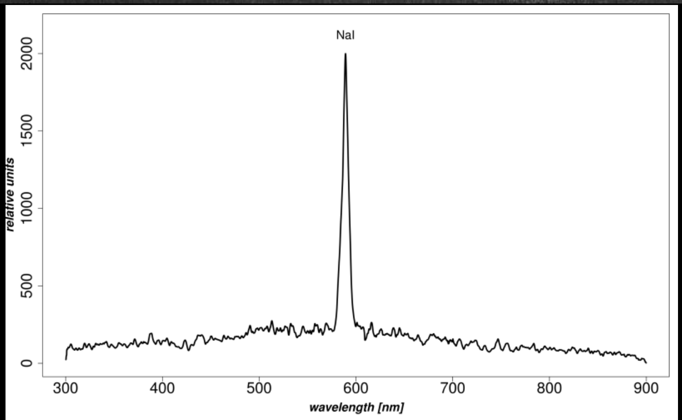
Na/Mg ratio larger than expected for given speed or eqvivalent

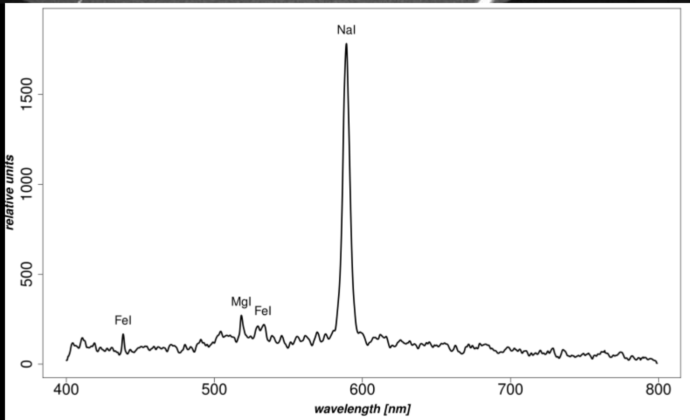
Asteroidal orbits ($T_J > 3$), larger perihelion distances ($q > 0.8$), Apollo type orbits

High material strengths: usually P_E type I, K_B type A

Fragmentation pressures up to 0.5 MPa (~ 0.15 MPa sample average)







Results: Taurid meteoroids

2015 Taurid outburst - ejected by the 7:2 resonance with Jupiter (Asher, 1991, Spurný et al., 2017)

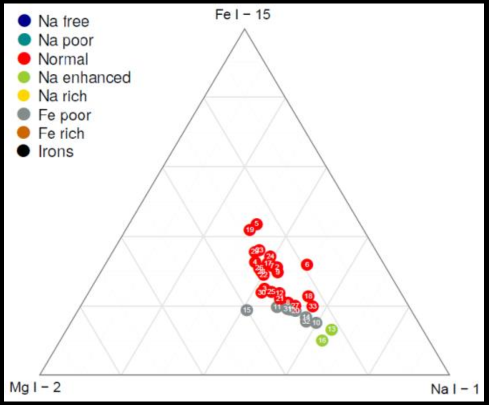
“Spectra and physical properties of Taurid meteoroids” (Matlovič et al., 2017)

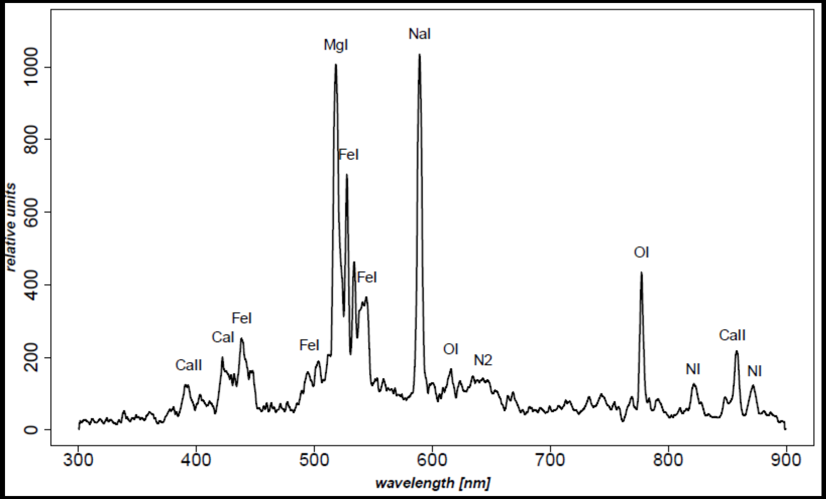
Confirmed orbital associations with several NEOs (2015 TX24, 2003 UV11, 2007 UL12)

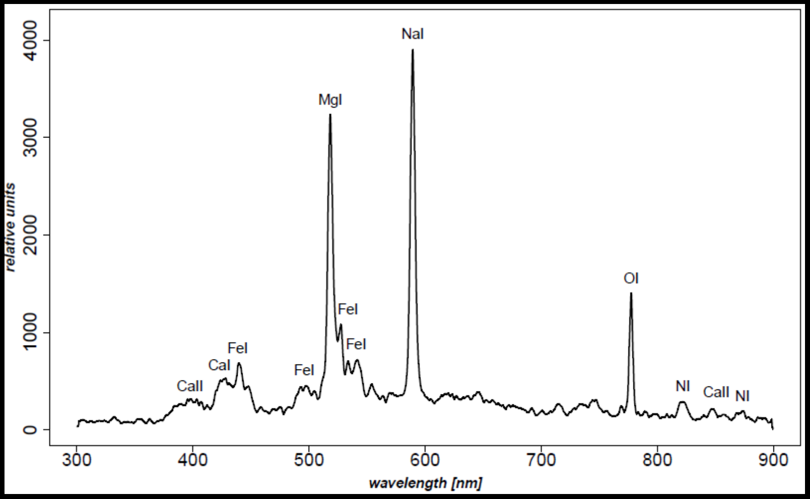
Large variations of iron content

Enhancement of Na/Mg in all meteoroids

Heterogeneous content of Na - aging effect

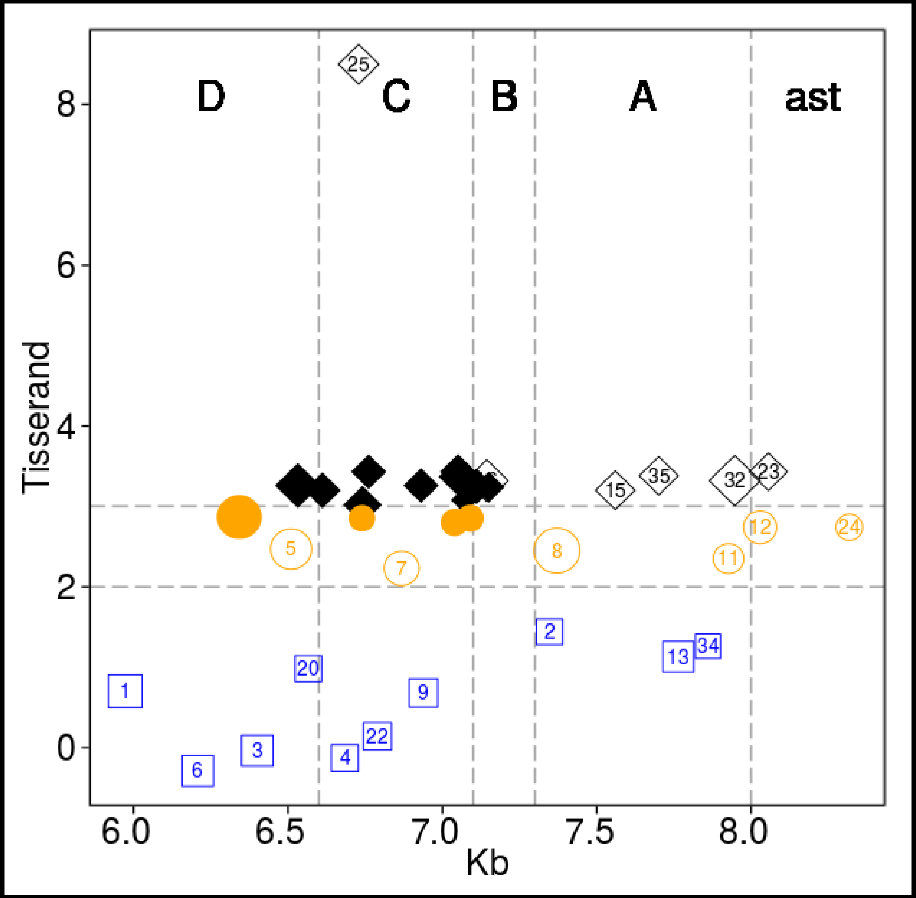


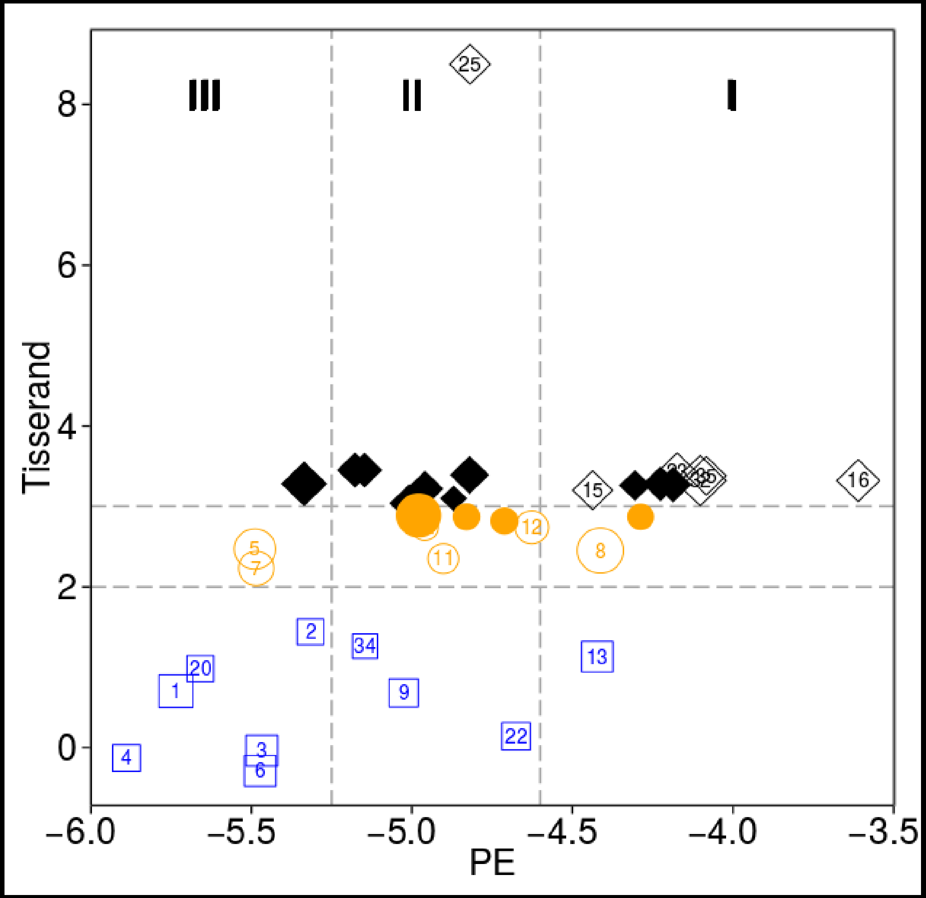




Material strength vs. Tisserand parameter

Taurids 2015 results





Mineralogical density of meteoroids

• Grain/mineralogical density of substance can differ from bulk density in presence of voids, volatile inclusion, and porous structure (Bronshten, 1981)

• From heat conductivity equation

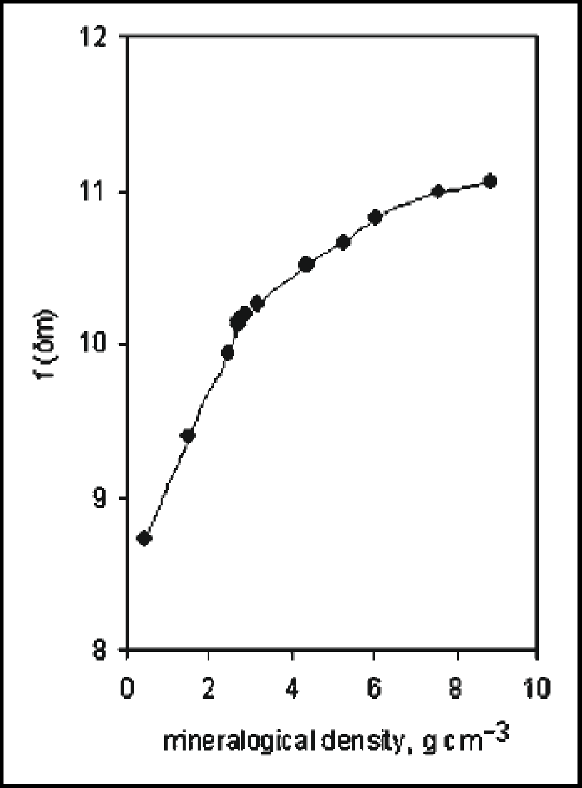
$$\frac{2T_B(\lambda\delta_m c)^{1/2}}{\Lambda} = \frac{V_0^{5/2}\rho}{(b\cos Z_R)^{1/2}}$$

• Left side

- Levin (1956): Λ = 0.75 - stone particles
  Λ = 1 - iron particles
  T_B = 1600 K - friable stones
  T_B = 2400 K - dense stones
  T_B = 2800 K - irons

- Laboratory data of various rocks, minerals, and metals from Berch et al. (1949): λ, δ_m, c

• Right side terms directly measurable from meteor observations



Meteorites material laboratory tests ...


Any questions?