

Division of Astronomy and Astrophysics  
Faculty of Mathematics, Physics, and Informatics  
Comenius University in Bratislava



**Bezovec 2023**

# Analysis of CZ-3B R/B re-entry event observed by all-sky camera system AMOS

**Mgr. Daniela Bartková**

**Supervisor:** doc. RNDr. Juraj Tóth, PhD.

**Consultant:** Mgr. Jiří Šilha, PhD.

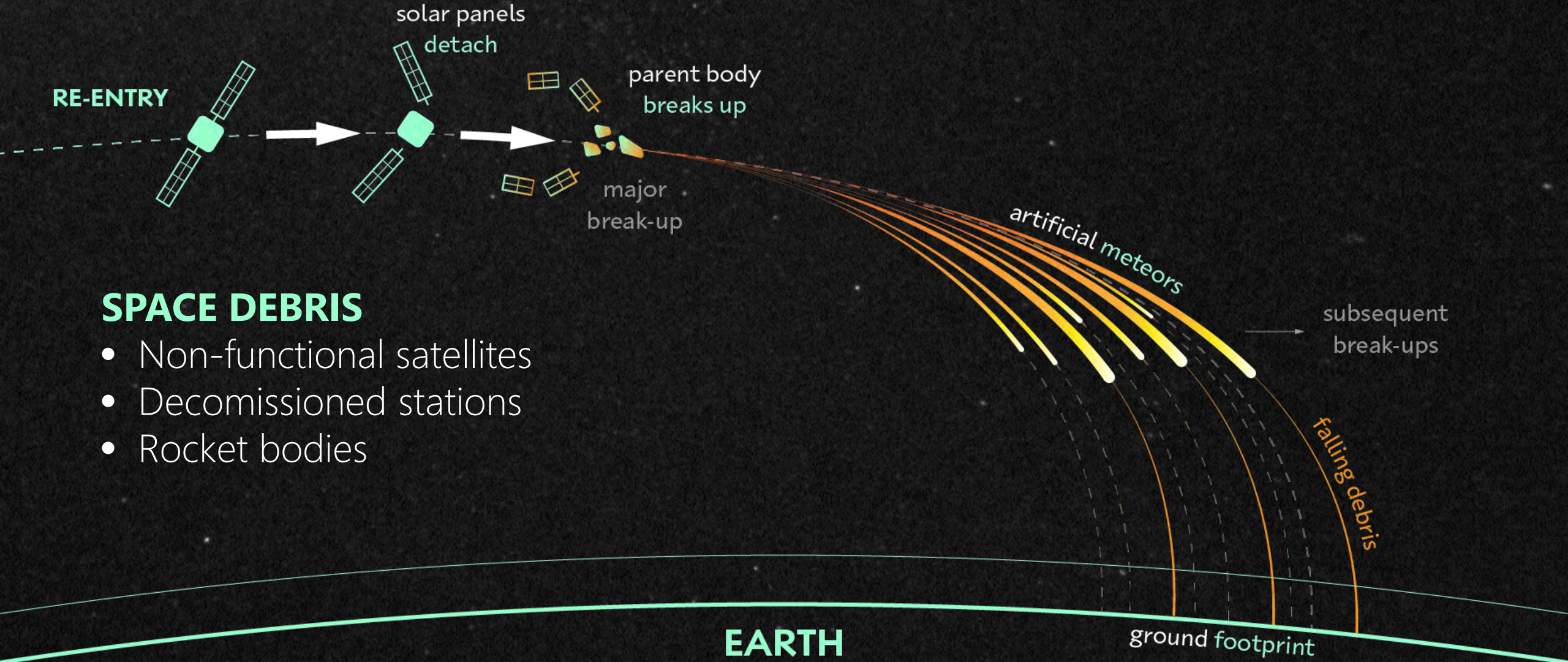




# OUTLINE

- Motivation (re-entry events)
- CZ-3B R/B re-entry event – ongoing analysis
  - Cluster of fragments – trajectories
  - Automatic Meteor Orbit System (AMOS) - DAFEM (FMPH CU)
- Trajectory reconstruction
- Preliminary results
- Next steps





## SPACE DEBRIS

- Non-functional satellites
- Decommissioned stations
- Rocket bodies

Figure: Re-entry event illustration



# 3<sup>RD</sup> STAGE OF LONG MARCH 3B RE-ENTRY EVENT

2020-10-25  
08:00:36.195 UTC

3<sup>rd</sup> stage →



CZ-3B

Figures: Composite images of CZ-3B re-entry recorded by AMOS all-sky cameras.

## AMOS-HK

Haleakala

2020-10-25 08:01:38.934 UTC

duration: 51 s

## AMOS-MK

Mauna Kea

2020-10-25 08:01:37.207 UTC

duration: 56 s





# ONGOING ANALYSIS

of CZ-3B R/B 3<sup>rd</sup> stage re-entry

- 1 Reduction**  
of data recorded during  
luminous phase  
→ reconstructed trajectory  
+ dynamics (velocity)  
→ light curves (absolute magnitudes)

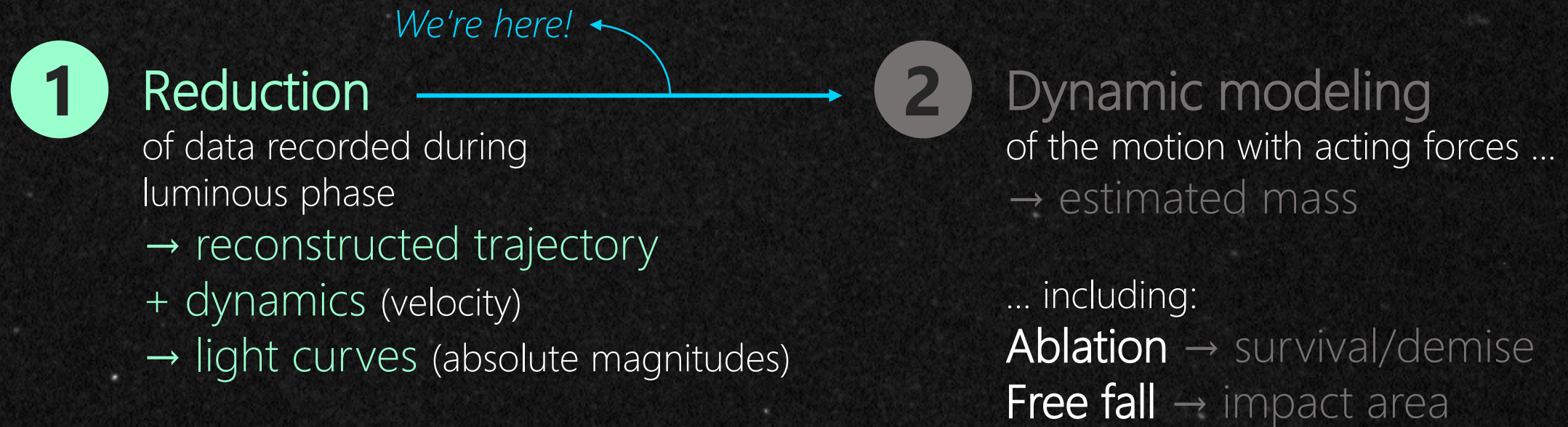
- 2 Dynamic modeling**  
of the motion with acting forces ...  
→ estimated mass  
  
... including:  
**Ablation** → survival/demise  
**Free fall** → impact area



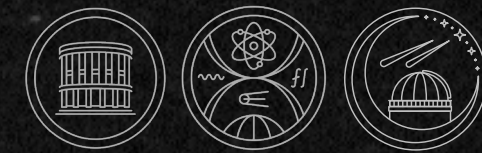


# ONGOING ANALYSIS

of CZ-3B R/B 3<sup>rd</sup> stage re-entry







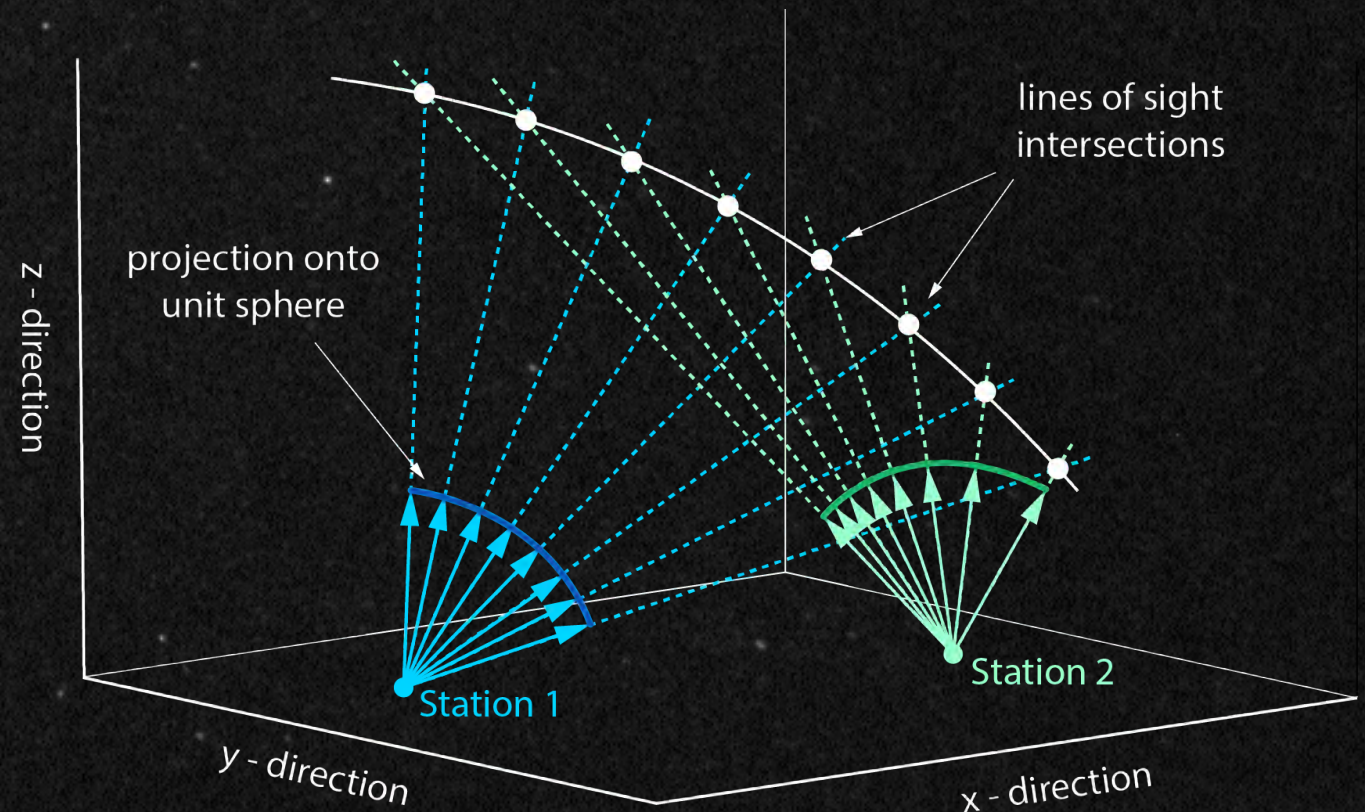
# TRAJECTORY RECONSTRUCTION

## Straight triangulation

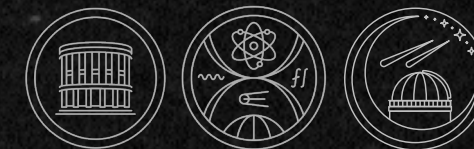
### TRIANGULATION

= method for measuring the distance of celestial objects

- Correct transformation of the coordinate system
  - position of the stations changes with time
- **Minimum distance** between two skew lines in 3D space
  - measurement errors
  - different time marks



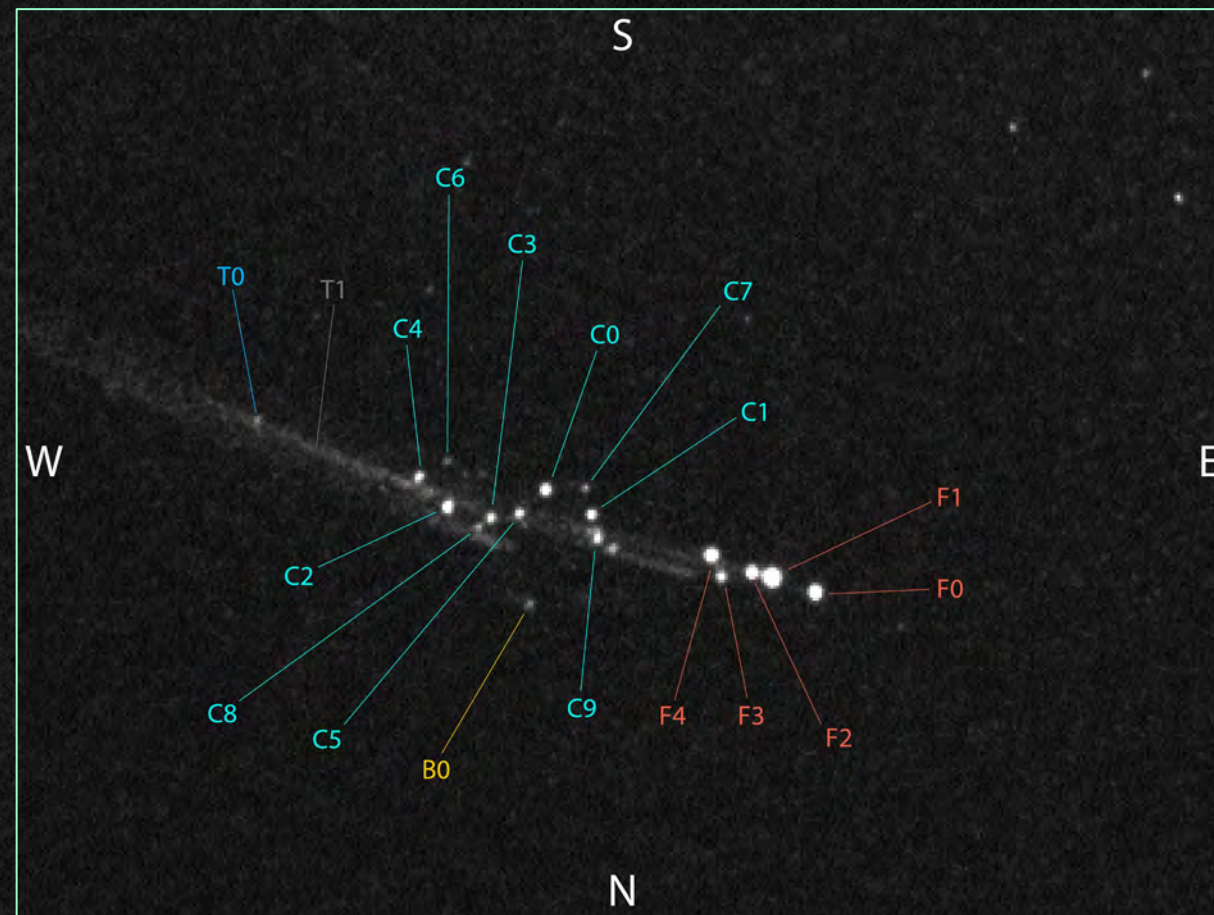
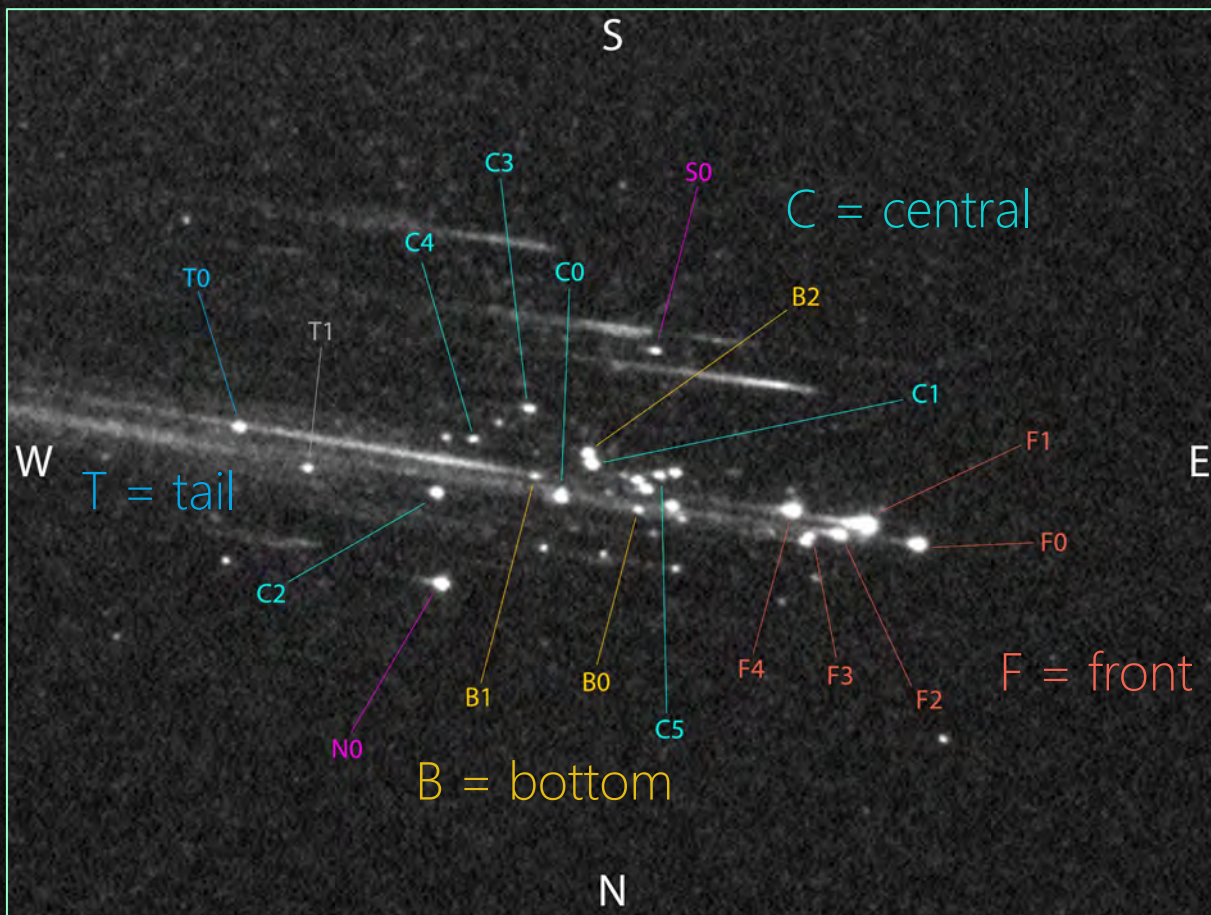




# MAPS OF FRAGMENTS

bottom view of the cluster

side view of the cluster



Figures: Maps of fragments of CZ-3B re-entry cluster.

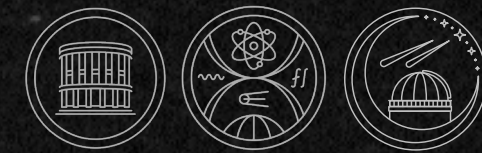
**AMOS-HK**



**AMOS-MK**

17 fragments



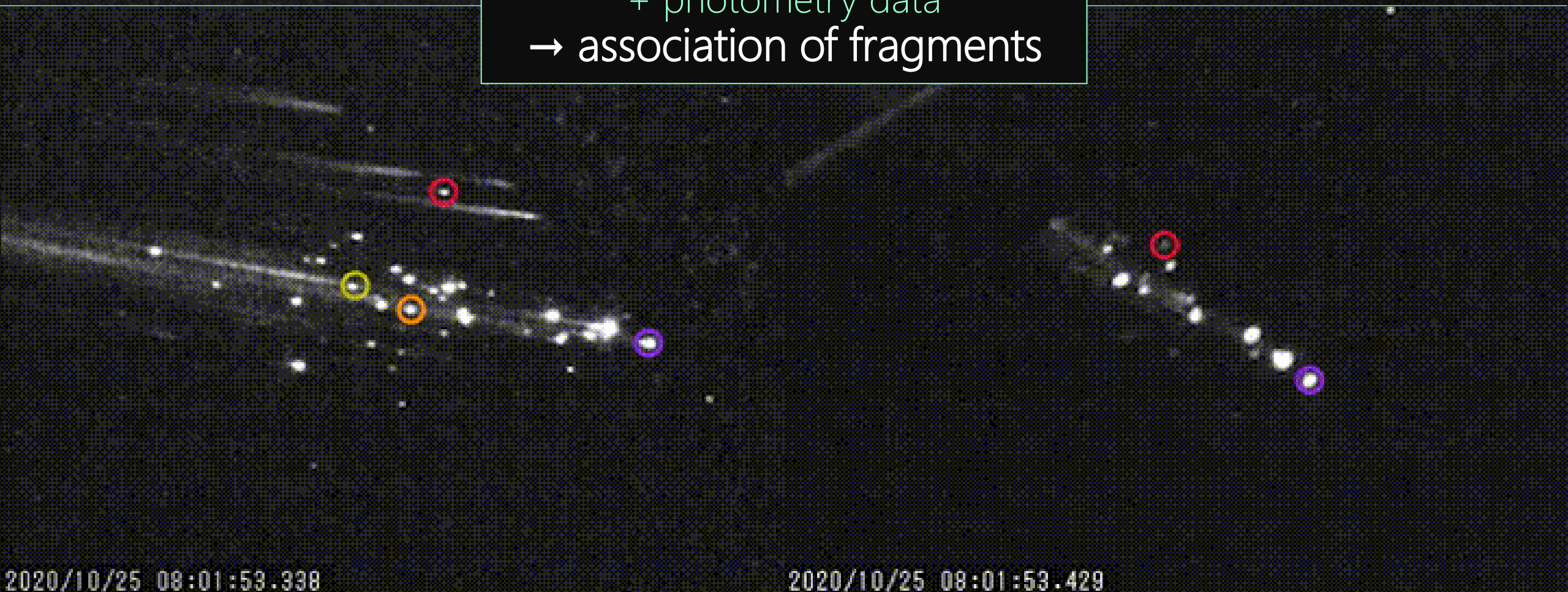


# SPATIAL DISTRIBUTION

bottom view of the cluster

side view of the cluster

+ photometry data  
→ association of fragments



2020/10/25 08:01:53.338

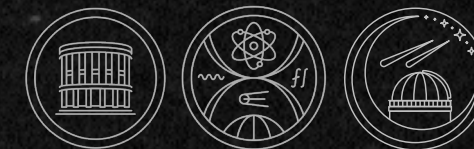
2020/10/25 08:01:53.429

**AMOS-HK**

**AMOS-MK**

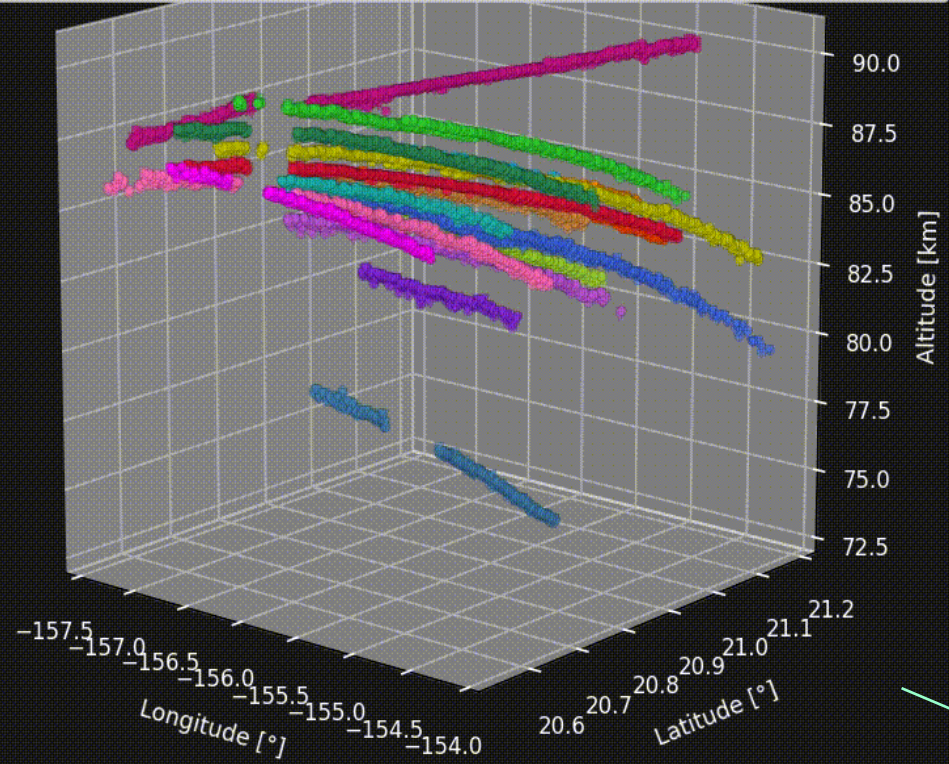
17 fragments



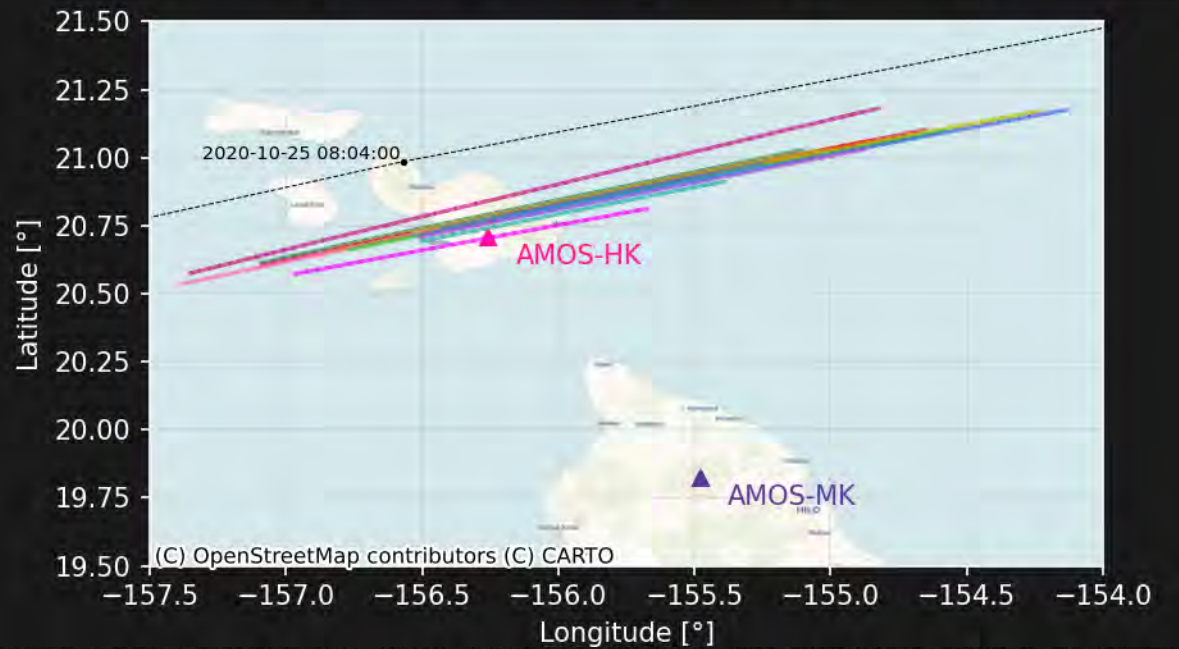


# PRELIMINARY RESULTS

● HK-F0	▼ MK-F2	● HK-C0	▼ MK-C4	● HK-C5	▼ MK-C8	● HK-S0
▼ MK-F0	● HK-F3	▼ MK-C3	● HK-C3	▼ MK-C9	● HK-B2	▼ MK-C7
● HK-F1	▼ MK-F3	● HK-C1	▼ MK-C10	● HK-B0	▼ MK-C5	● HK-T0
▼ MK-F1	● HK-F4	▼ MK-C0	● HK-C4	▼ MK-B0	● HK-N0	▼ MK-T0
● HK-F2	▼ MK-F4	● HK-C2	▼ MK-C6	● HK-B1	▼ MK-C2	



— HK-F0	— MK-F2	— HK-C0	— MK-C4	— HK-C5	— MK-C8	— HK-S0
— MK-F0	— HK-F3	— MK-C3	— HK-C3	— MK-C9	— HK-B2	— MK-C7
— HK-F1	— MK-F3	— HK-C1	— MK-C10	— HK-B0	— MK-C5	— HK-T0
— MK-F1	— HK-F4	— MK-C0	— HK-C4	— MK-B0	— HK-N0	— MK-T0
— HK-F2	— MK-F4	— HK-C2	— MK-C6	— HK-B1	— MK-C2	



Velocity: **6.0 – 8.0 km/s**

Figures: Reconstructed trajectories in geodetic coordinates.





# NEXT STEPS

- Dynamic modeling – **ablation**
  - re-entry debris found on land – **reports**: shape, size, weight
- Investigation of the **fragmentation**
  - Dynamic modeling backward in time
- Publishing dataset
  - **Verification** for re-entry simulators (ESA DRAMA)



Figure: Hydrazine tank from re-entry of CZ-3B.  
Source: universemagazine.com



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**THANK YOU FOR ATTENTION!**

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captured with all-sky camera system AMOS

**Daniela Bartková, Jiří Šilha, Juraj Tóth**  
daniela.bartkova@fmph.uniba.sk



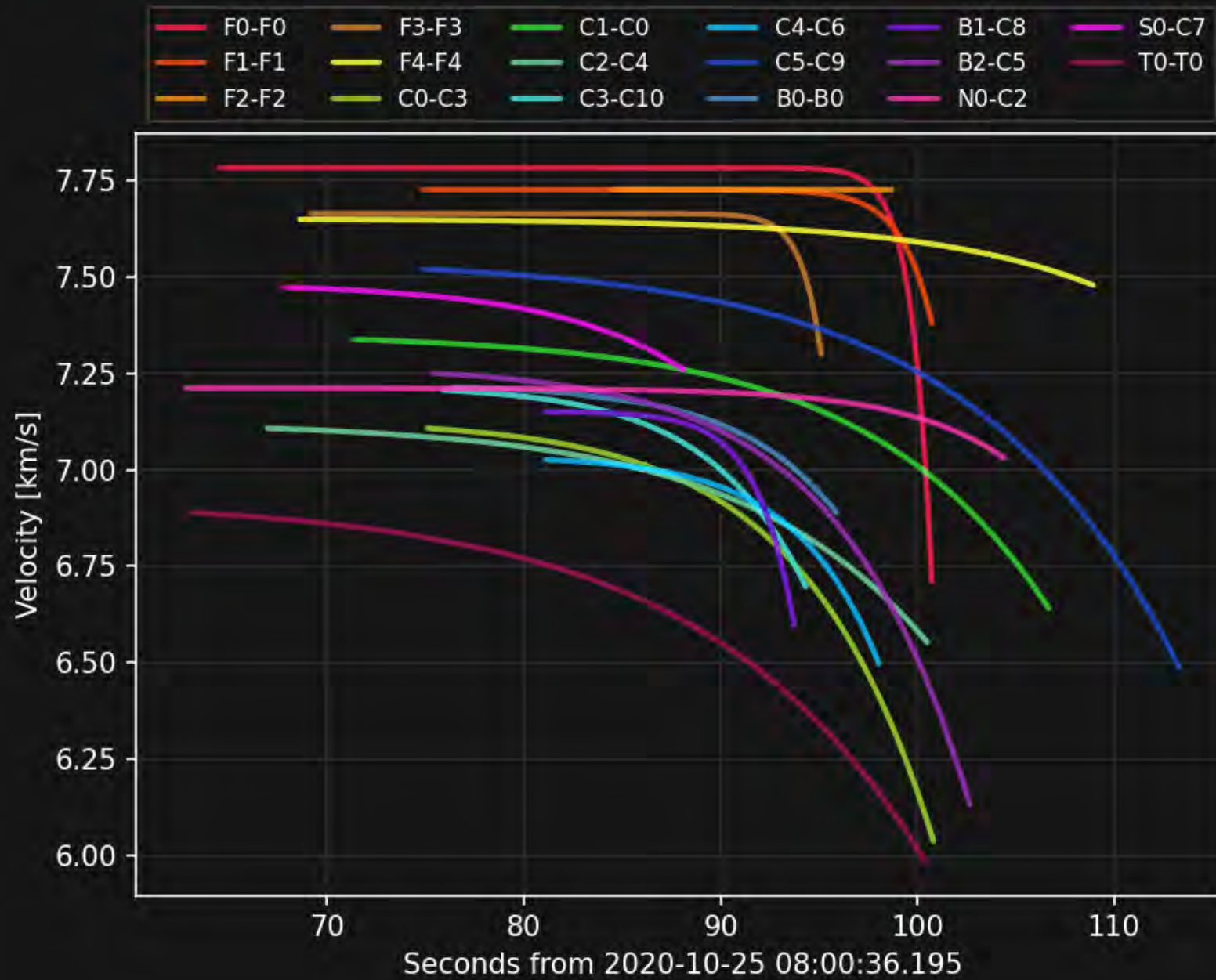


Figure: Jacchia velocity fit to traveled distances of fragments.