Meteorites Orbits Reconstruction by Optical Imaging - MOROI

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Definition

- **MOROI** is a mean, mythical creature of the romanian folklore. Akin to vampires, it manifests itself as a pillar of fire flying straight trough the air searching for people, cattle or houses to strike.

History

- The project started in 2016 after the installation of ROIF01, the most eastern camera of FRIPON network.
- The project was financed by the Romanian Academy and the Ministry of Research and Innovation and is operated by the Astronomical Institute.
- Plans to be included as one of the Romanian Space Situational Awareness infrastructures.
- The first three camera were deployed on western Transylvania in early 2017 for tests and system validation.
- Funding has been secured for hardware (20 cameras) and two years of operation.

The camera

The camera

The network of cameras

The architecture.

- First 3 nodes are INTEL NUC i5 running under an average load of 15%. For the rest of the nodes the minimum required configuration was "downgraded" to INTEL NUC i3 7th generation leading to a modest increase of the average load to 20%.
- Each node runs Ubuntu Linux 16.04 LTS. Local storage on M.2 128GB SSD for OS and a 5400 rpm 1TB HDD for the bulk of data (stacks, captures, events).
- Image acquisition & meteor detection software freeture https://github.com/fripon/freeture
- Openvpn gathers all nodes on the same local network 10.0.0.0/24.
- Ganglia Monitoring System http://ganglia.sourceforge.net/ for monitoring data storage and visualizations.
- Python scripts for .fits files handling (extraction, detection ftp uploading to central node)
- Ansible https://www.ansible.com/ for IT automation: mass updates on nodes, mass deployment of freeture configuration files for parameter tuning (regular captures, scheduled captures for bright satellites passes detections, etc.), OS configuration and tuning.
- Data volume per day: 6.7GB for all 1 min stacks plus 0.9GB for each detection. Lossy compression of .fits file might be an option to reduce storage/data transfer.
- Project website https://observer.astro.ro:8080 runs on Django.

The interface

observer.astro.ro:8080 90% Search

MOROI | Stations | Events | Network status | Network map | Partners | Examples | Actions | Welcome admin | Logout

M.O.R.O.I.

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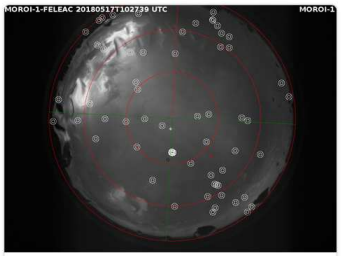
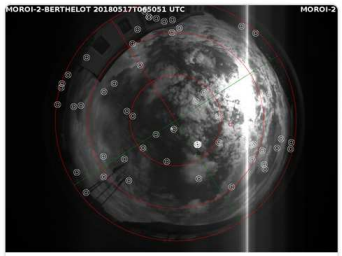
A project of the Astronomical Institute of the Romanian Academy

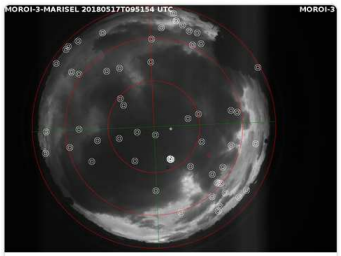
An all-sky network of 20 cameras to detect atmospheric entries of meteoroids and space-debris. Work in progress.



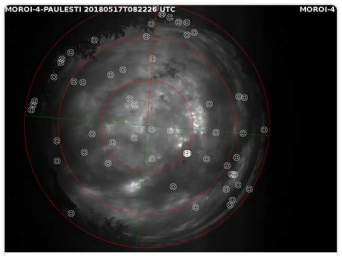
Feleac
Coordinates λ 23.5937148, φ 46.7102406
Feleac Observatory
Data from 0 minutes ago



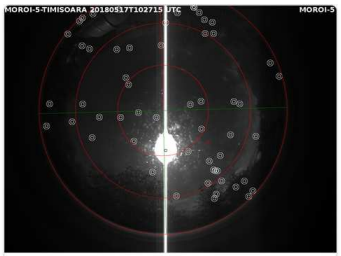
Berthelot
Coordinates λ 22.8850633, φ 45.6134068
General Berthelot
Data from 0 minutes ago



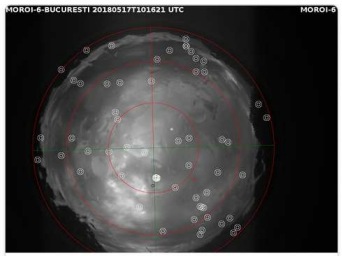
Marisel
Coordinates λ 23.0751838, φ 46.6609761
Mărișel Observatory
Data from 29 minutes ago



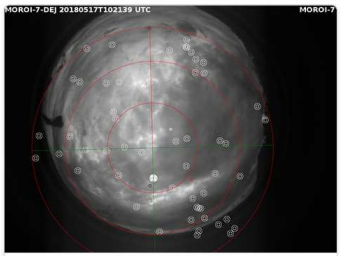
Paulesti
Coordinates λ 25.9625392, φ 45.0027304
Păulești Observatory
Data from 120 minutes ago!



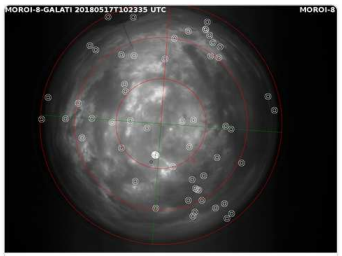
Timisoara
Coordinates λ 21.2307929, φ 45.7380603



Bucuresti
Coordinates λ 26.095081, φ 44.410581



Dej
Coordinates λ 23.8744526, φ 47.1556528



Galati
Coordinates λ 28.0319187, φ 45.4191328

The interface

observer.astro.ro:8080/status/ 90% Search

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M.O.R.O.I.

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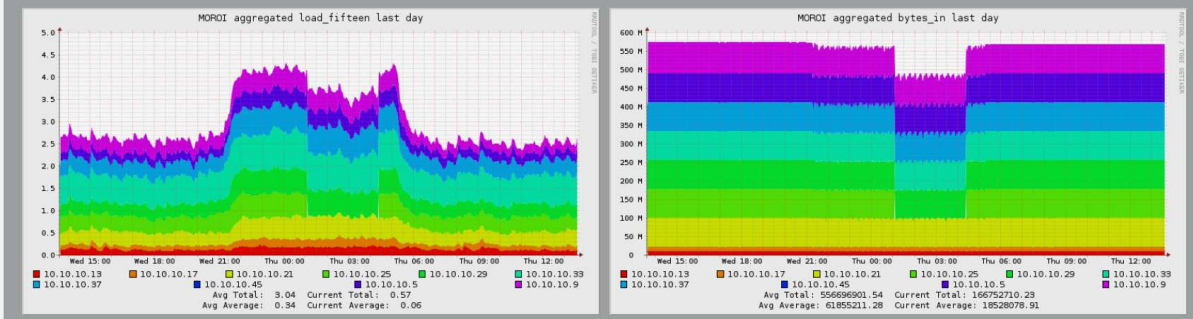
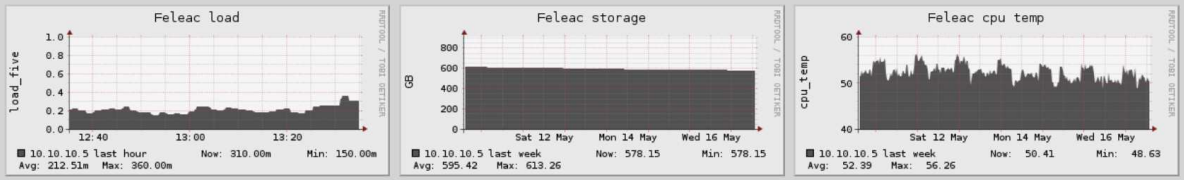
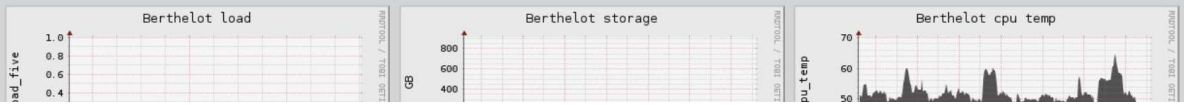
M.O.R.O.I. network status



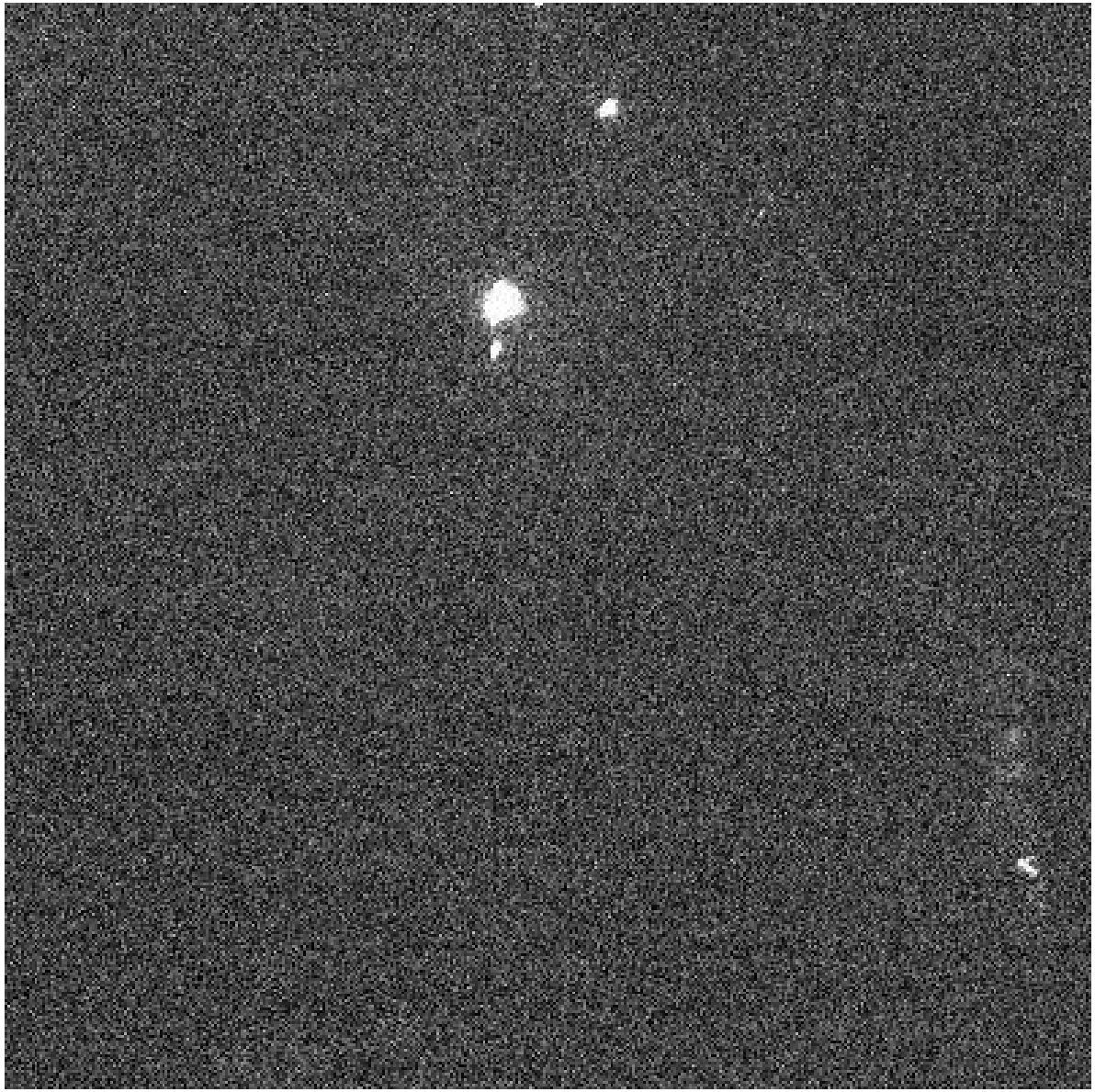
Feleac @ 10.10.10.5



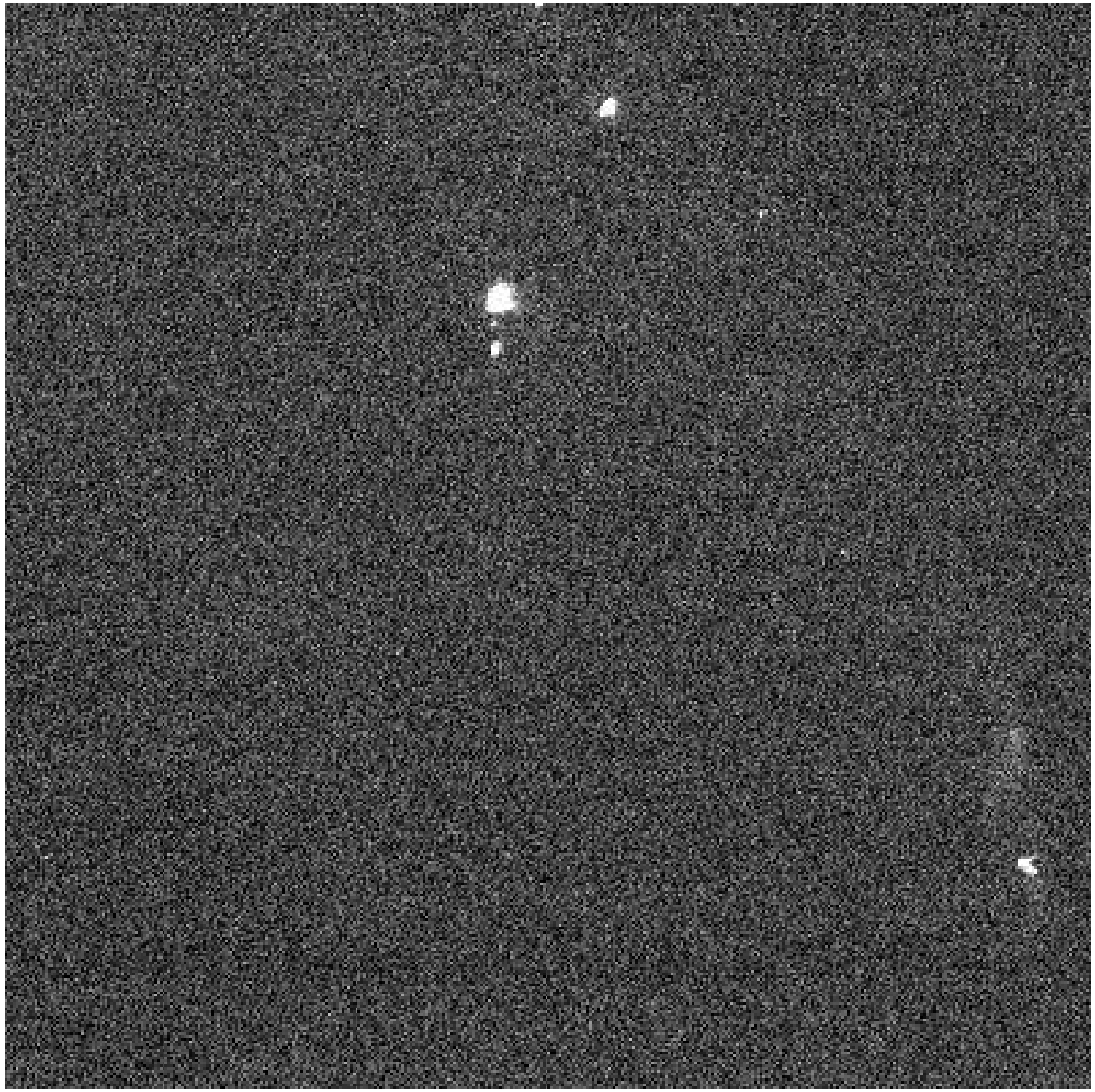
Berthelot @ 10.10.10.9



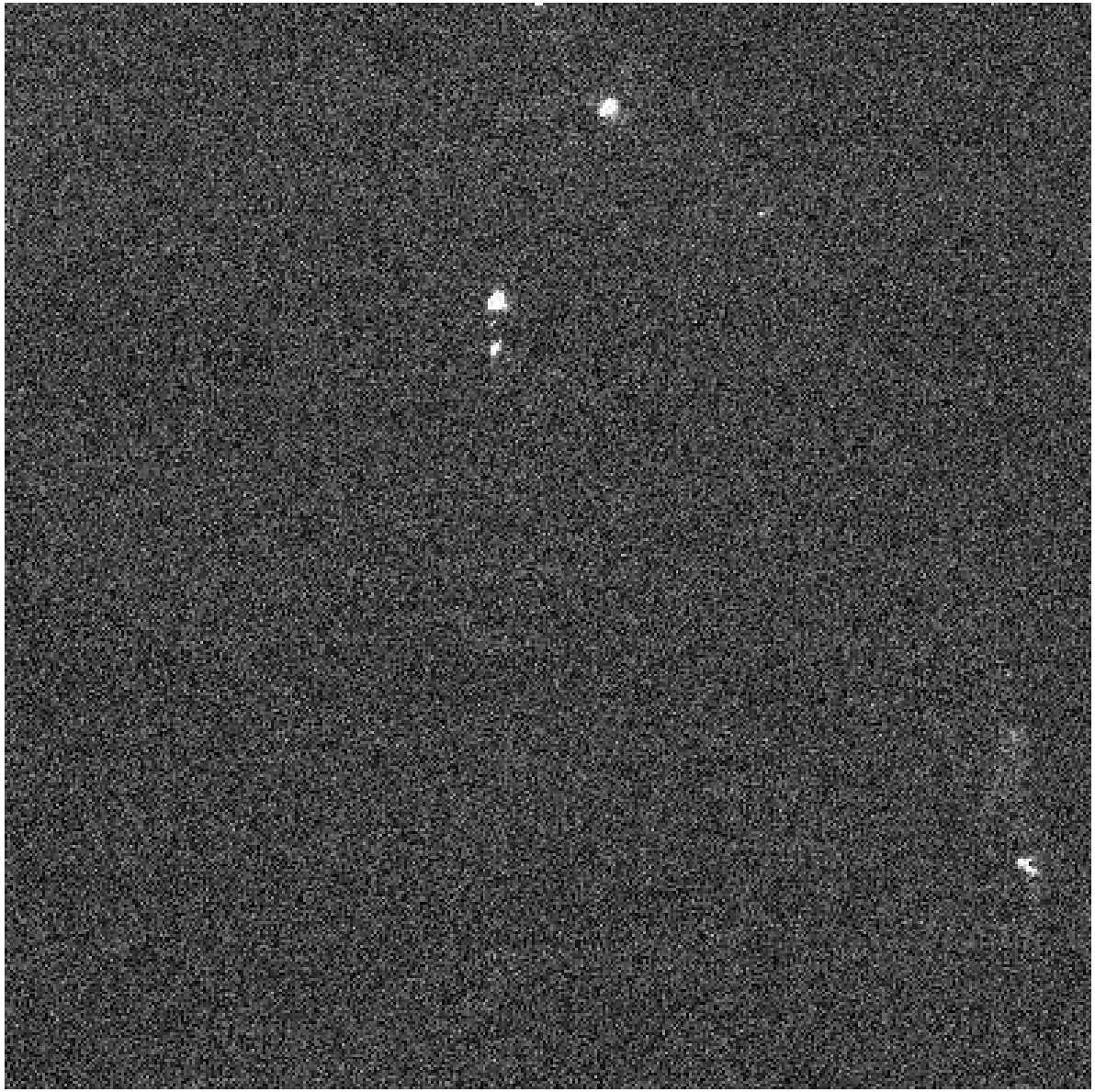
Data flow. 30fps detection



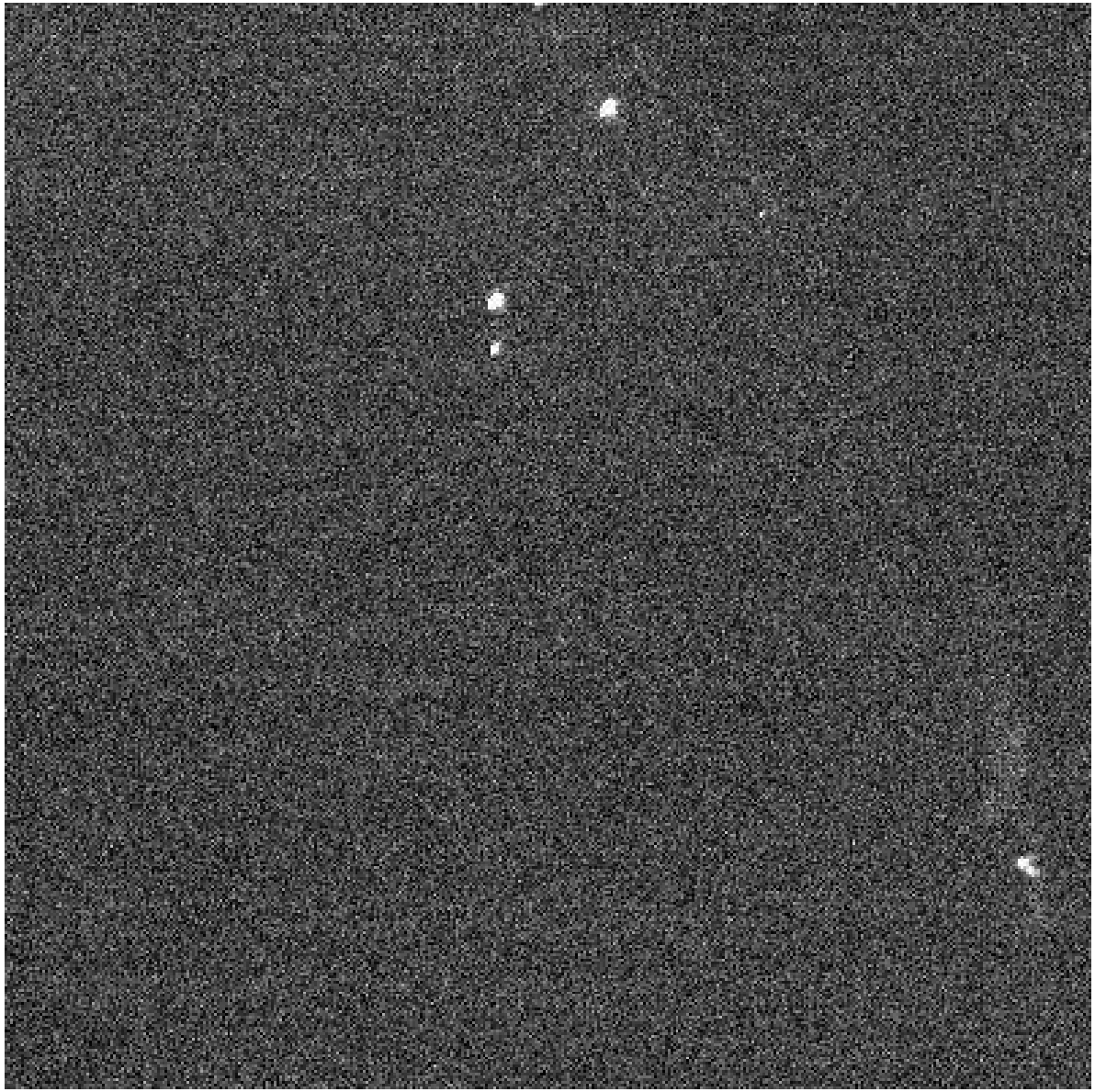
Data flow. 30fps detection



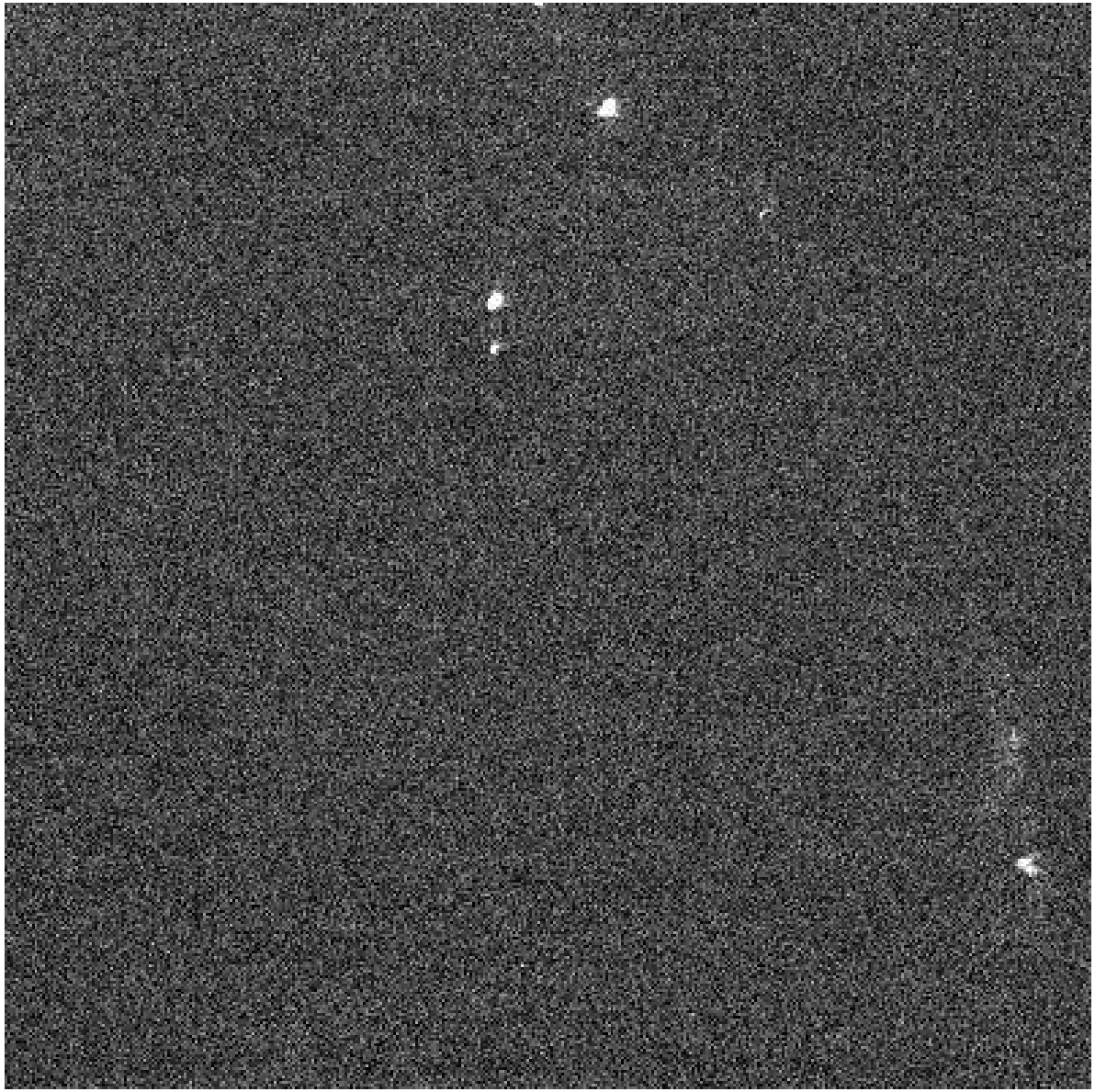
Data flow. 30fps detection



Data flow. 30fps detection



Data flow. 30fps detection



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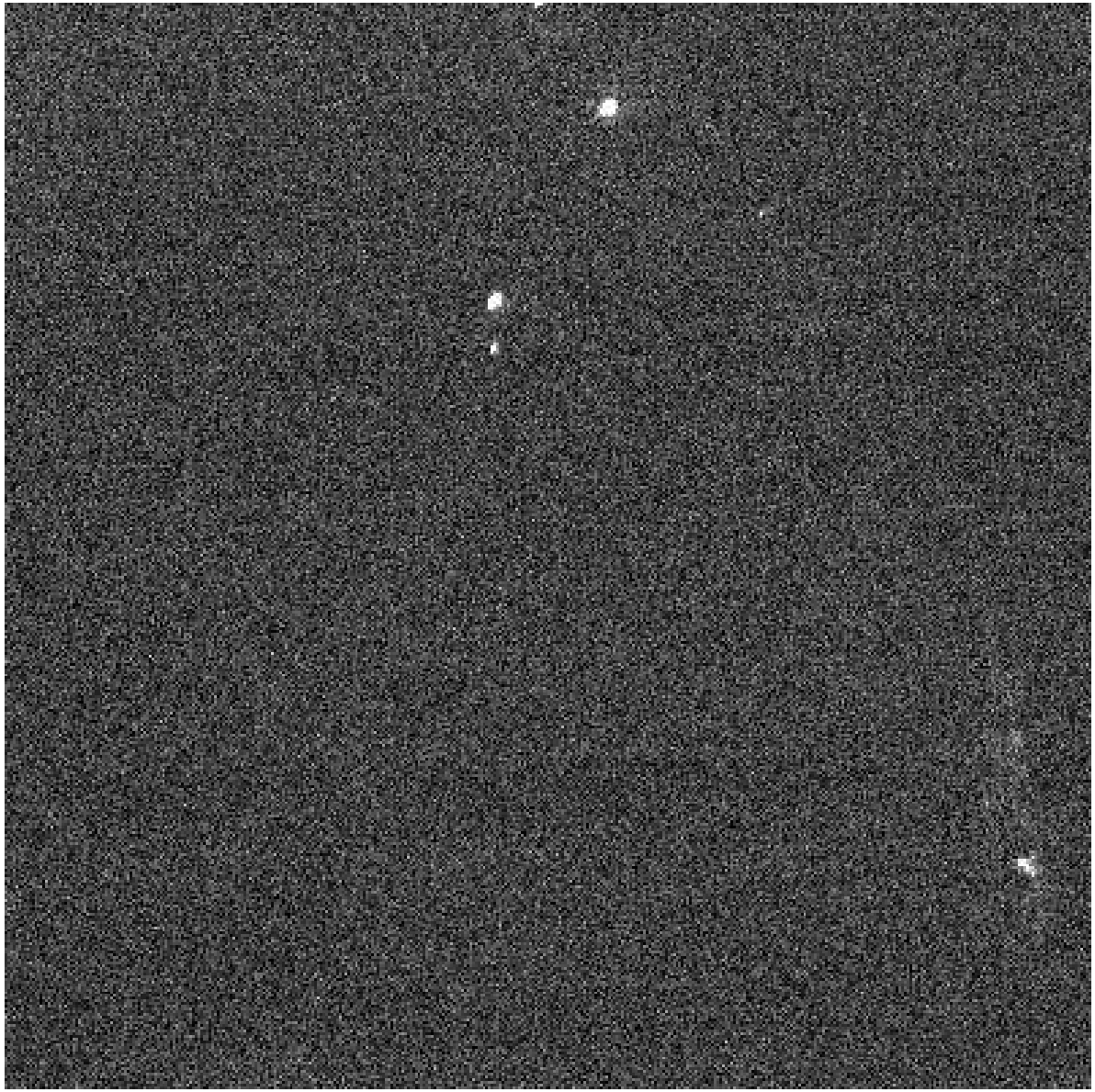

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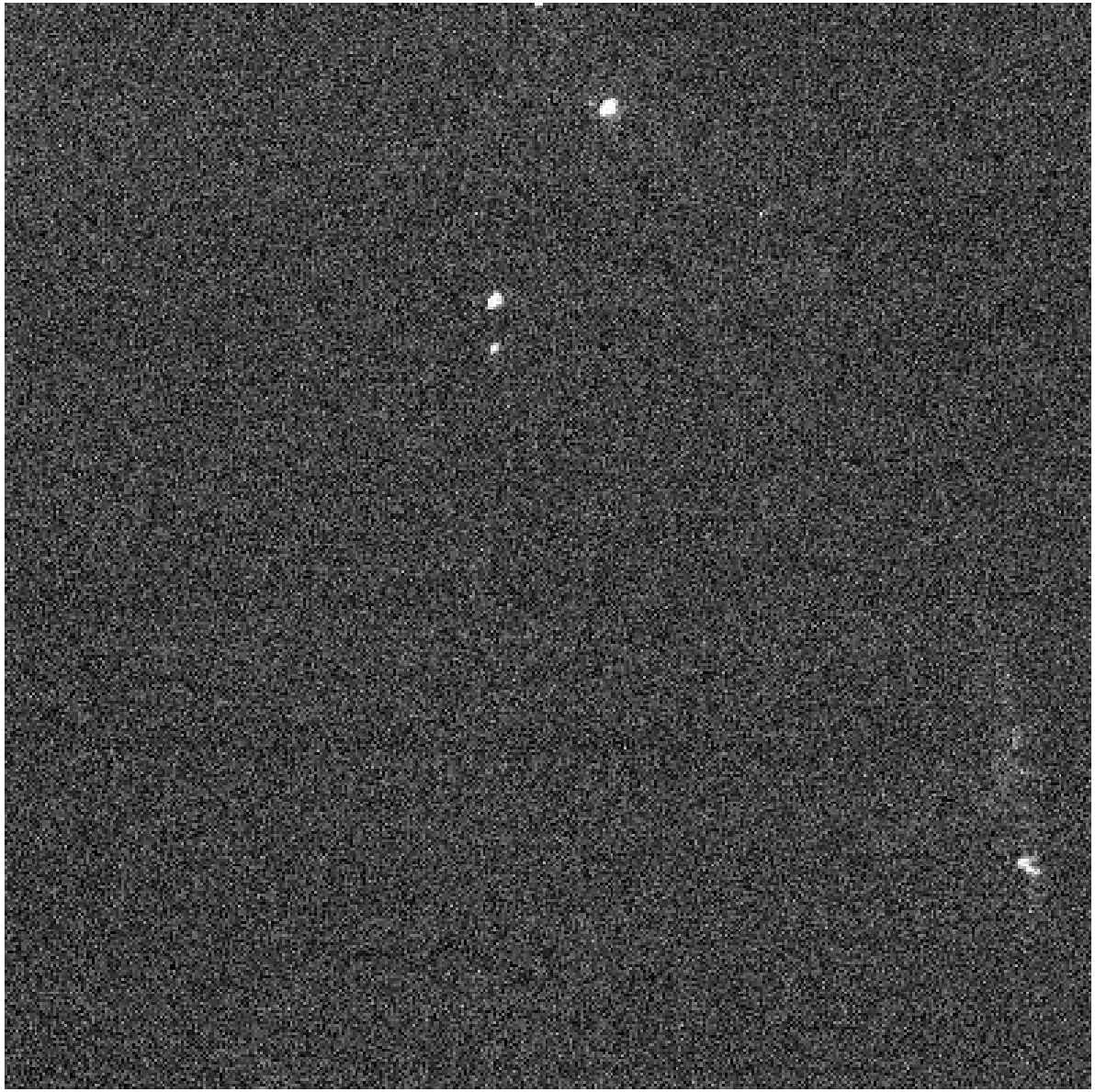

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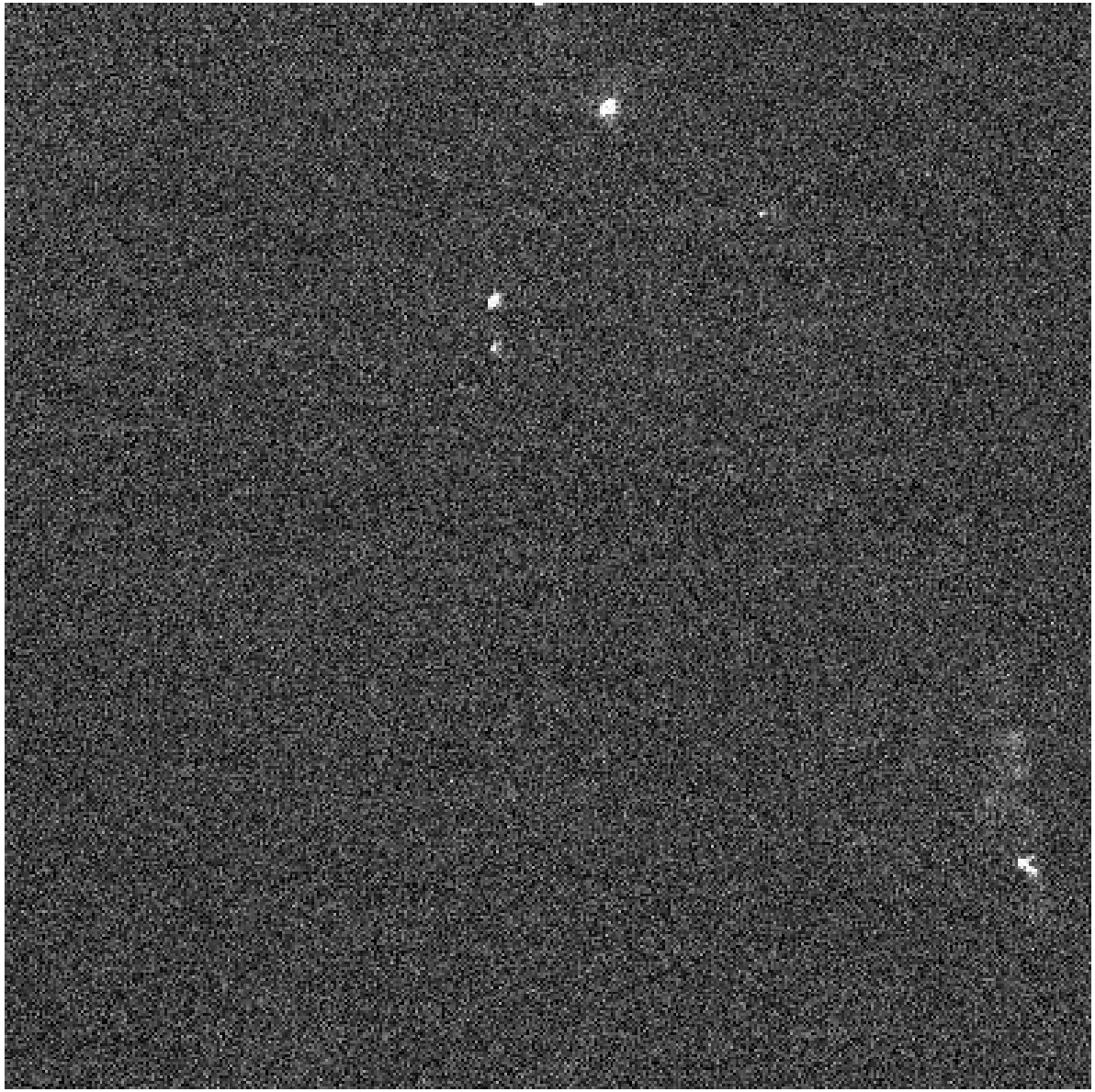
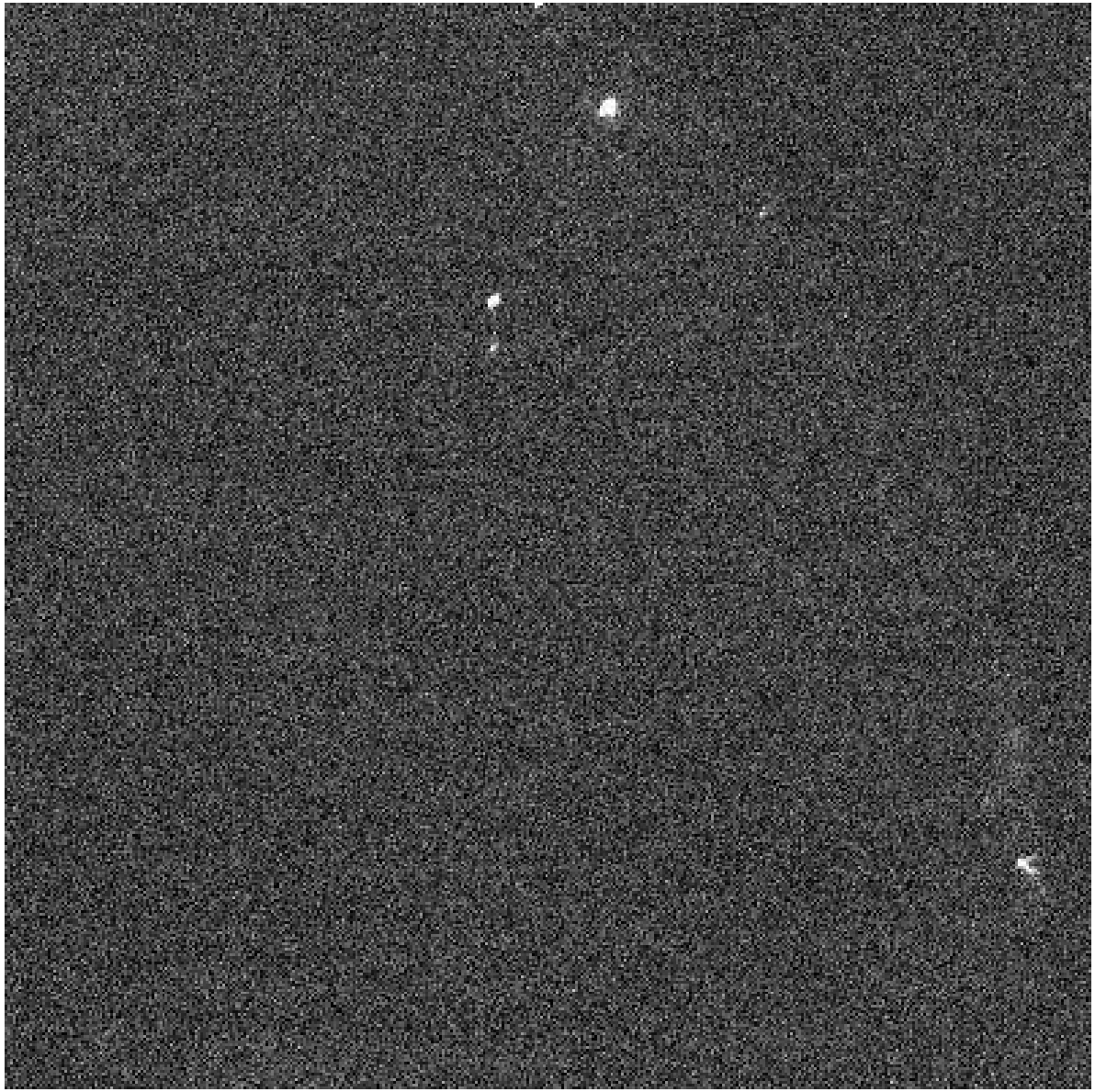
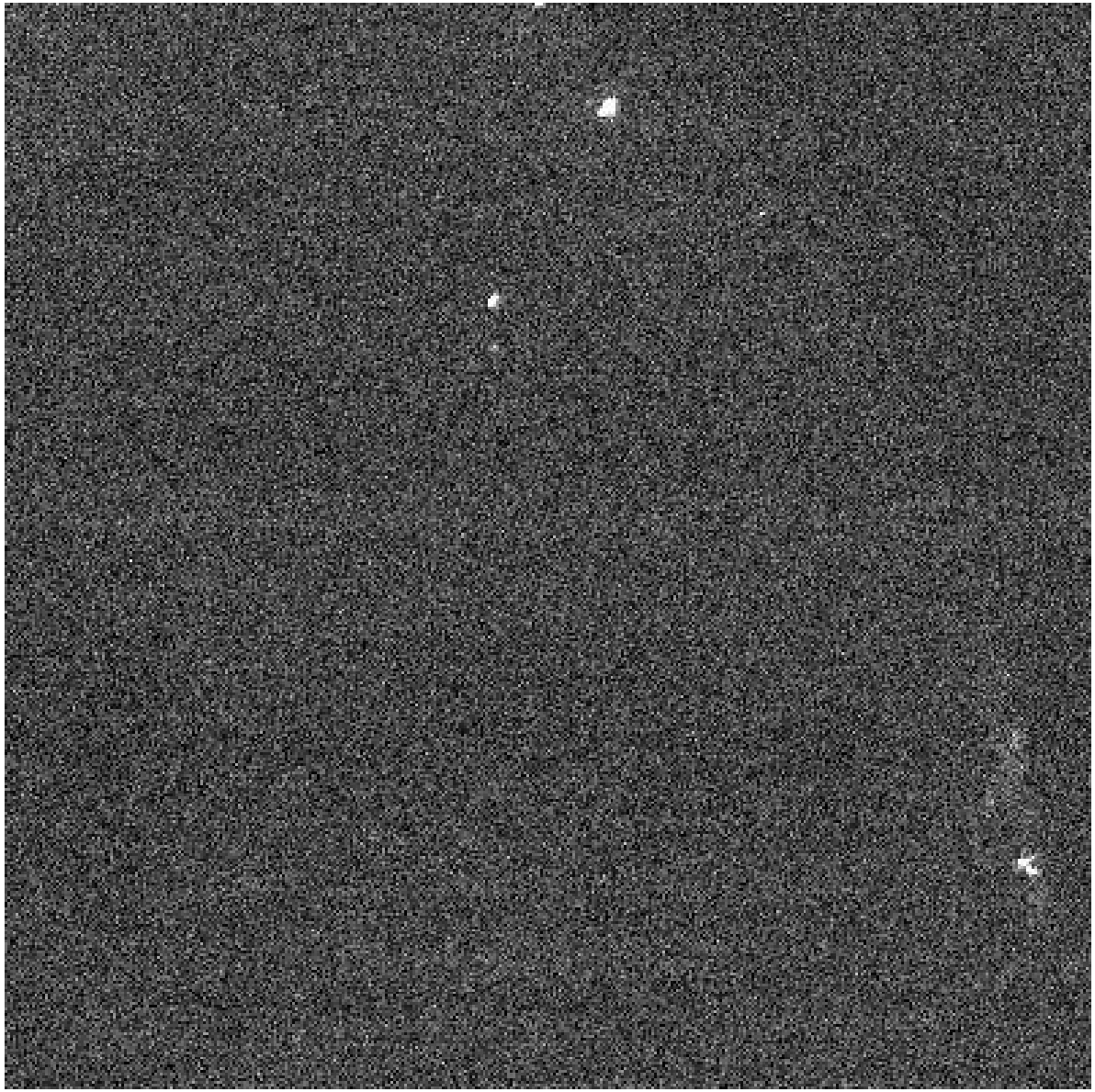


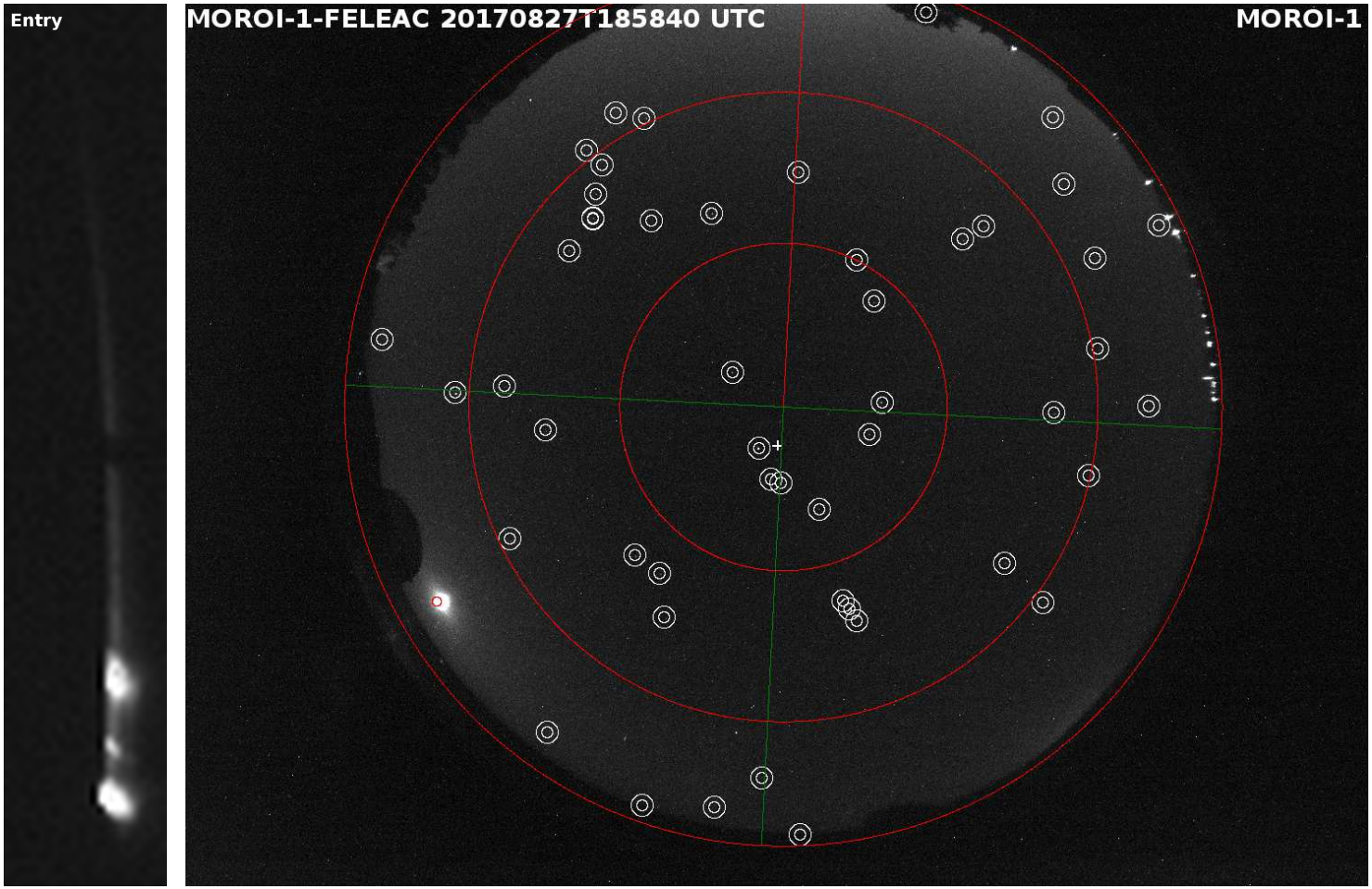
Data flow. 30fps detection



Data flow. 30fps detection



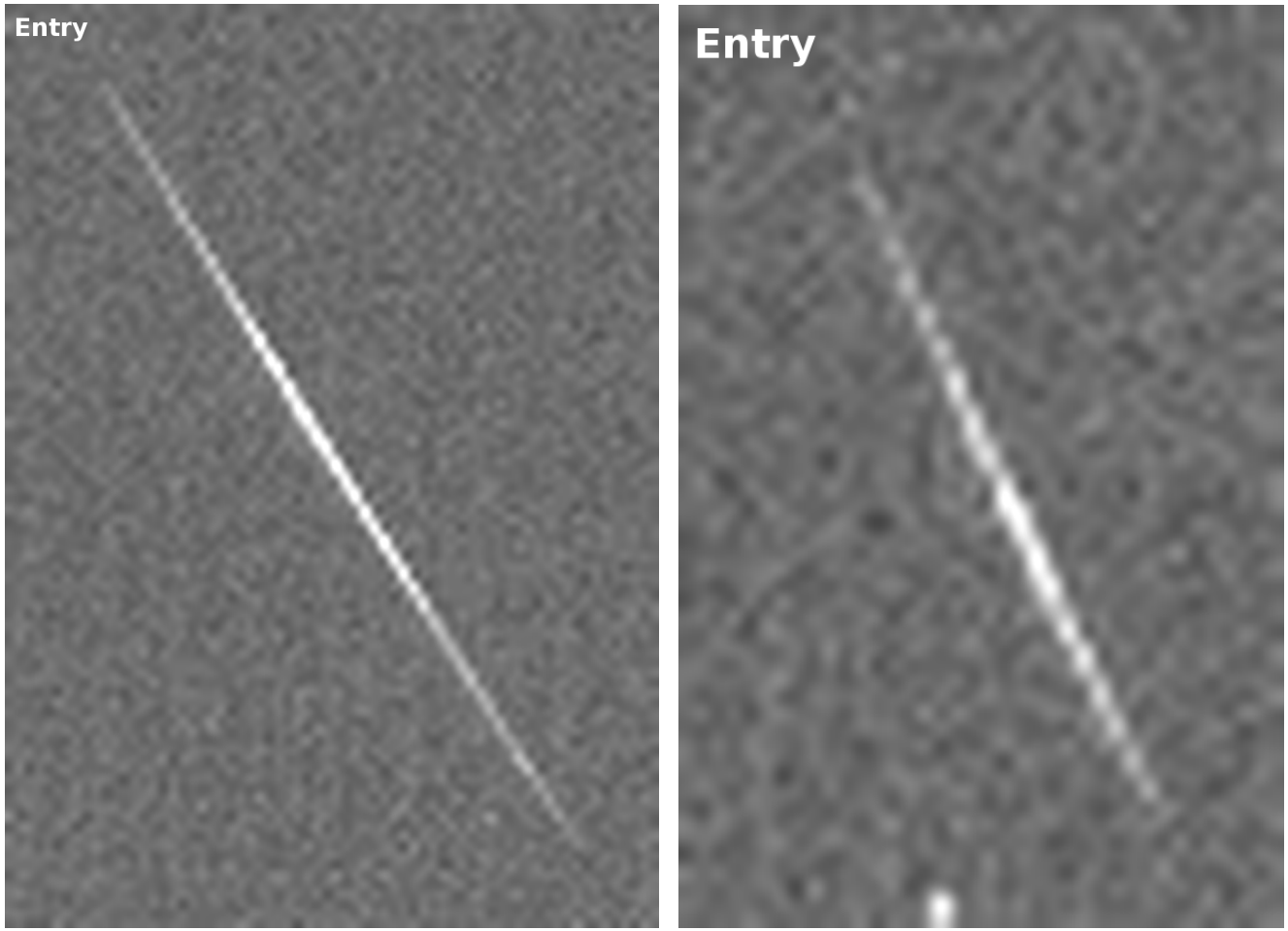
Data reduction



A 1st order solution for astrometric calibration obtained by fitting a model with radial distortion. RMS 0.5px, 0.1°.

Fit degrades for $h < 20^{\circ}$. Automated star detection within windows centered at estimated star positions and fitting using different functions is a work in progress. (Ceplecha 1987)

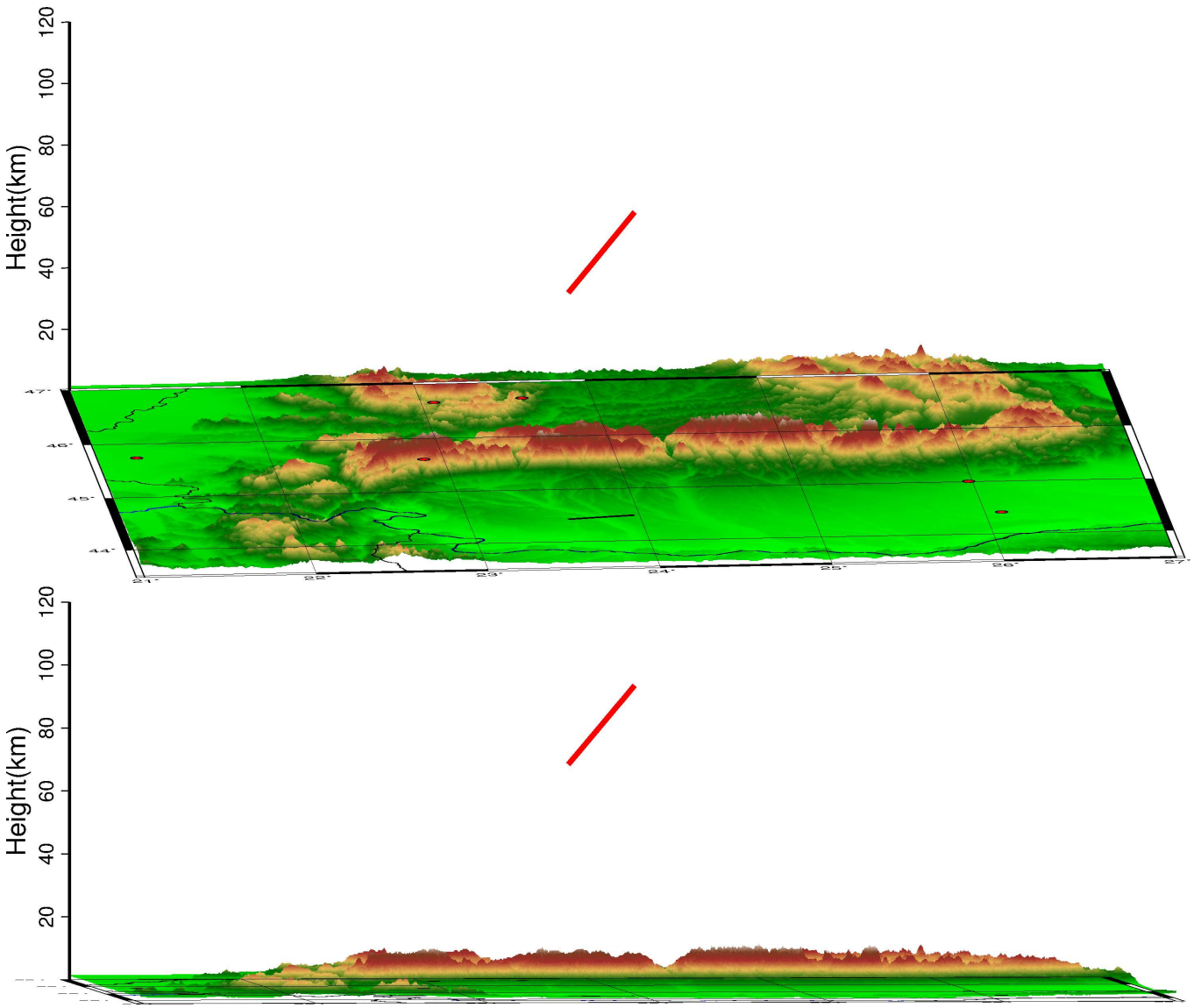
Multiple detection



Prototype service. Distributed to moroi-core@astro.ro

Simultaneous detection by Bucuresti(6) Paulesti(4) 2018-03-12 17:23:35.7 UTC. 1.8 sec Visible from 66 km to 46 km, Radiant (α, δ) = (51°, +58°), V 12.6km/s. slow, sporadic(?)

Luminous trajectory reconstruction



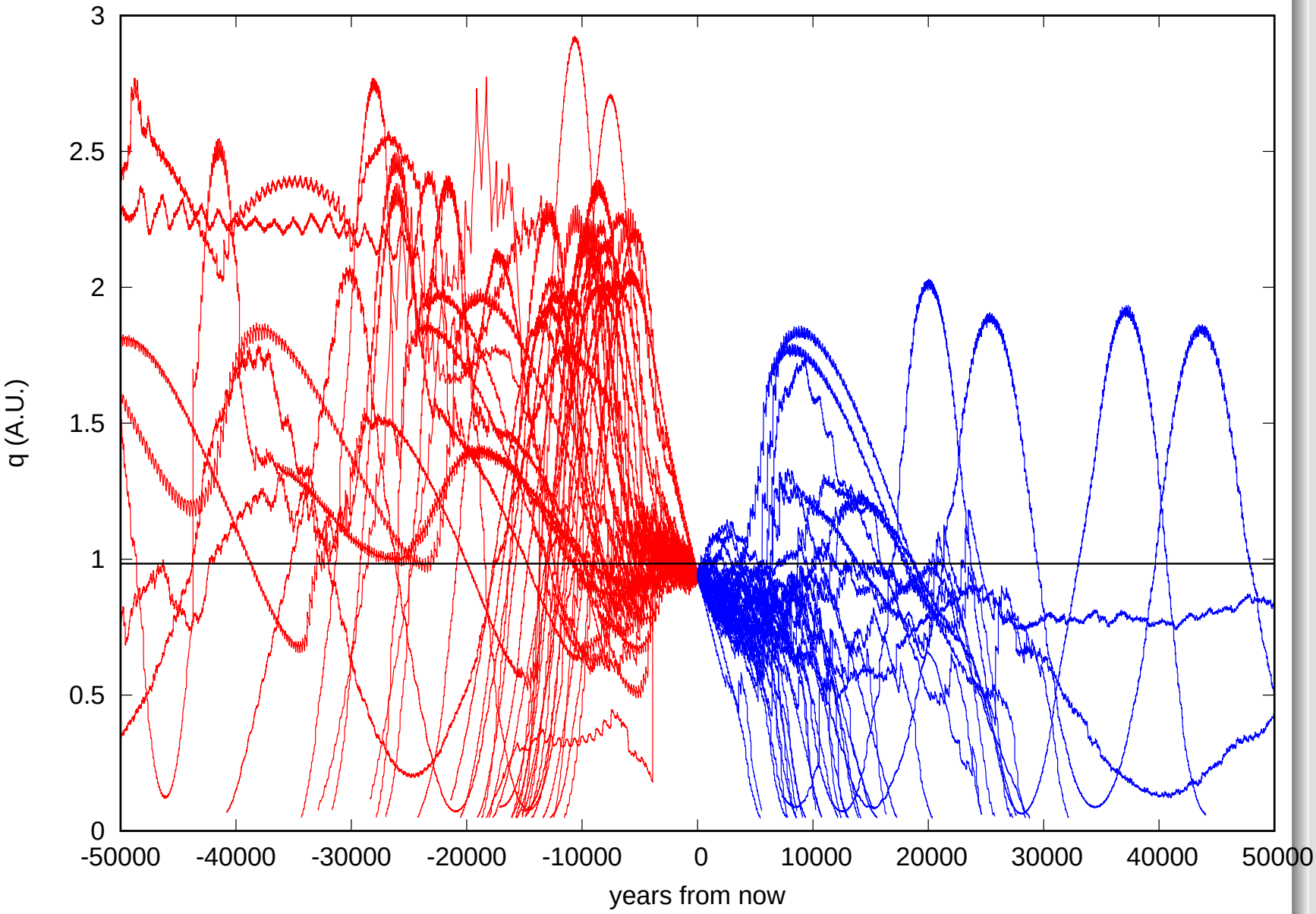
Two Lyrids from 2018 detected by MOROI

	2018/04/22/ 22:11:28	2018/04/21 23:32:12	C/1861 G1 (Thatcher)
Ω°	32.47	31.56	31.86
ω°	212.64	210.8	213.45
a A.U.	26.77	5.58	55.68
i°	82.78	81.44	79.77
e	0.965	0.831	0.983

The structure of Lyrids stream

The Lyrids are a low ZHR (10) meteor shower active in the period April 16 - 26, with a maximum around April 21 - 22. The stream is known to produced outburst of $>$ 100 ZHR with a period of 12 years (Jenniskens 1995). The stream has a finer structure with short and long period components from 2.3 to 32 A.U possibly caused by resonances with giant planets (Porubcan and Kornos, 2008) The two detected Lyrids have similar beginning and end heights (97 & 74 km) and a geocentric velocity of $\sim$ 48 km/s.

Numerical integration of short period stream components. q evolution



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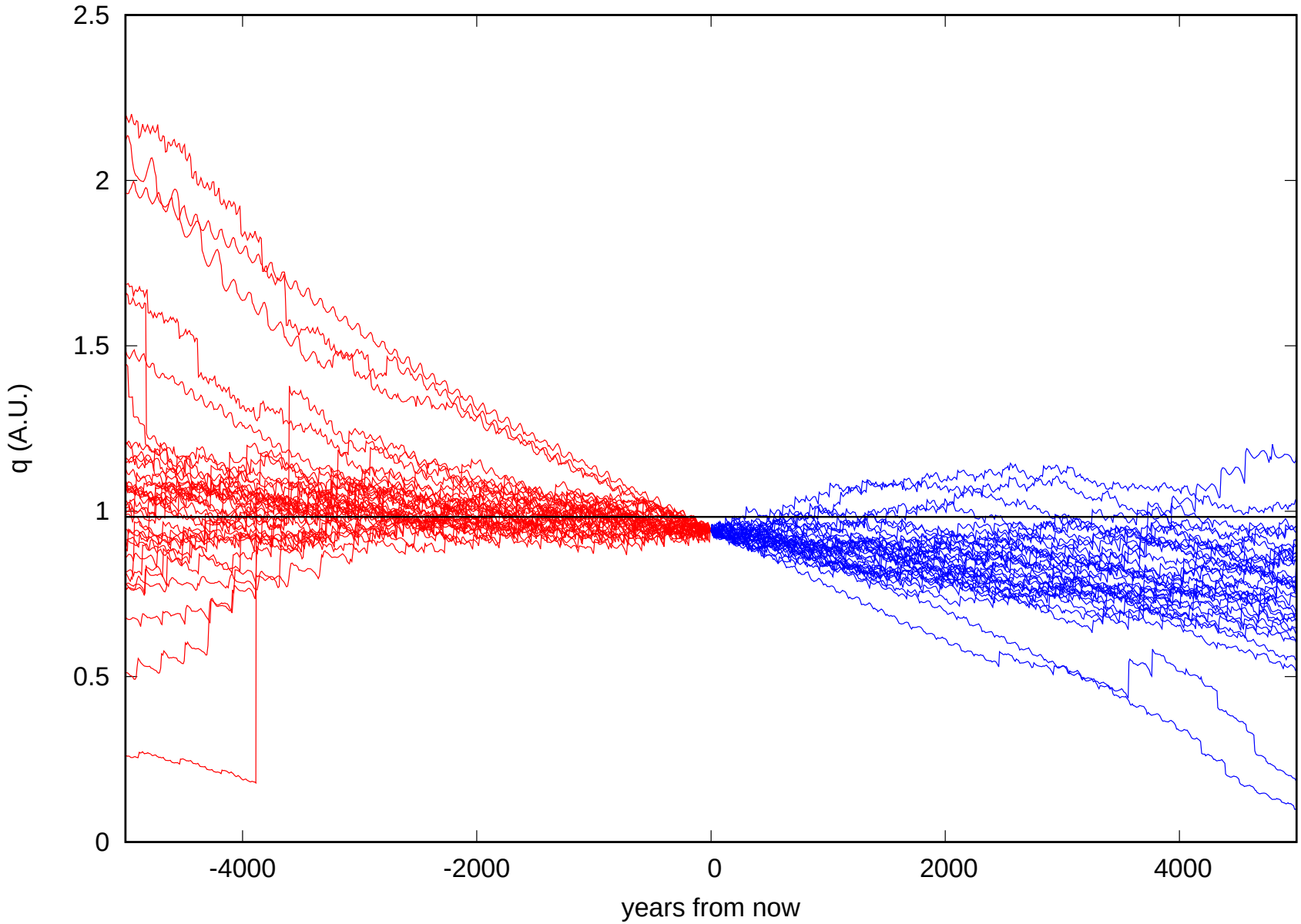
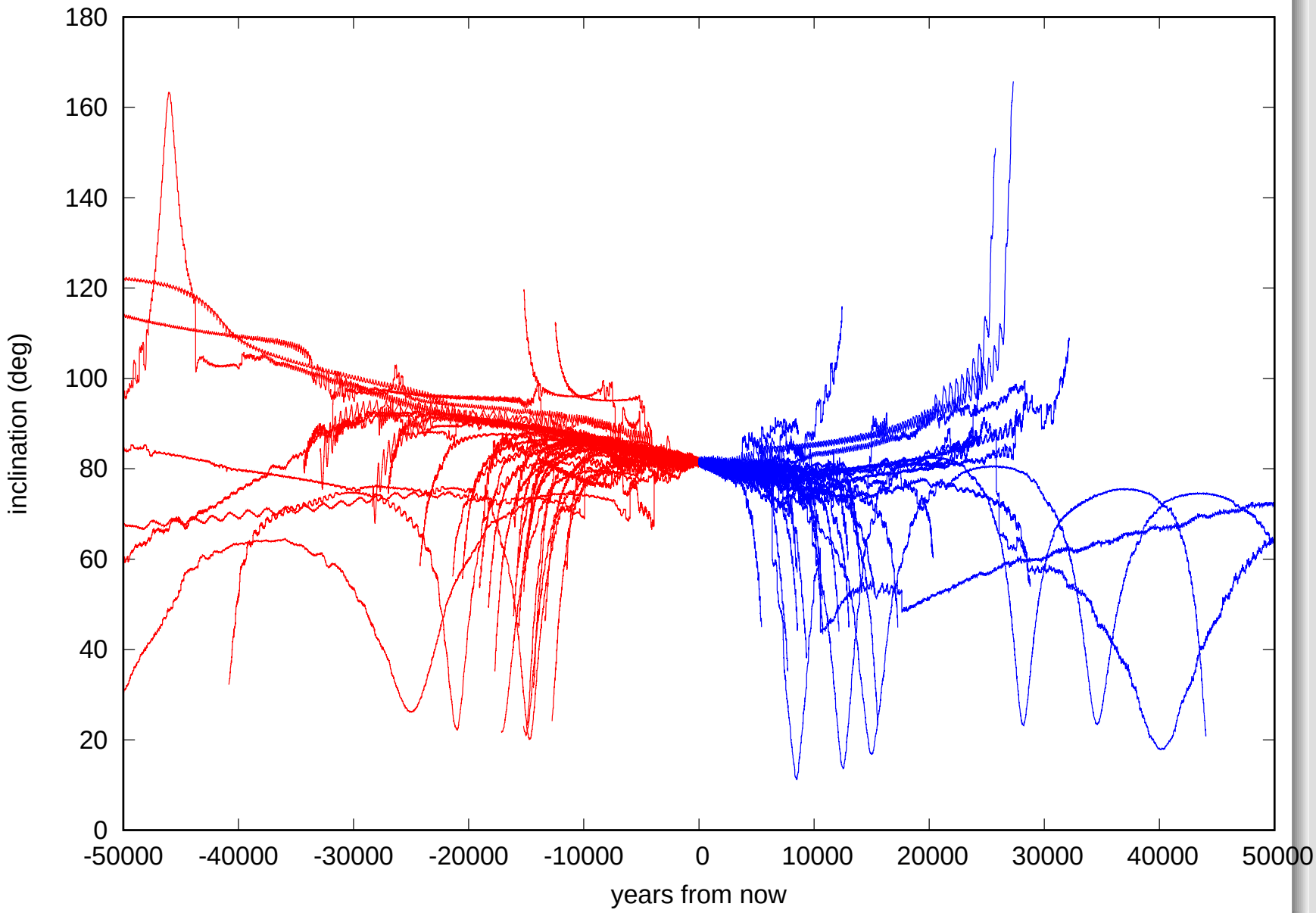
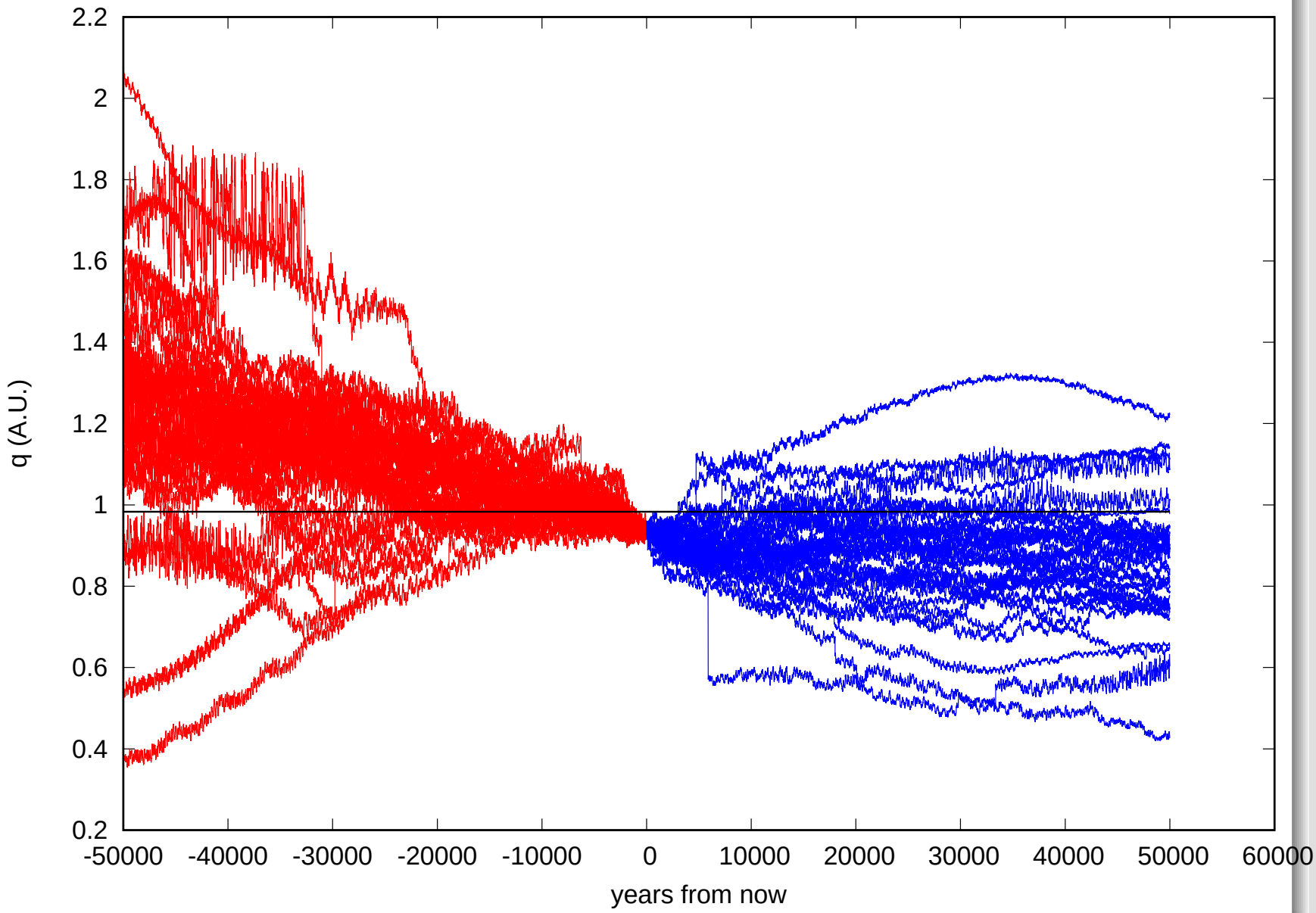


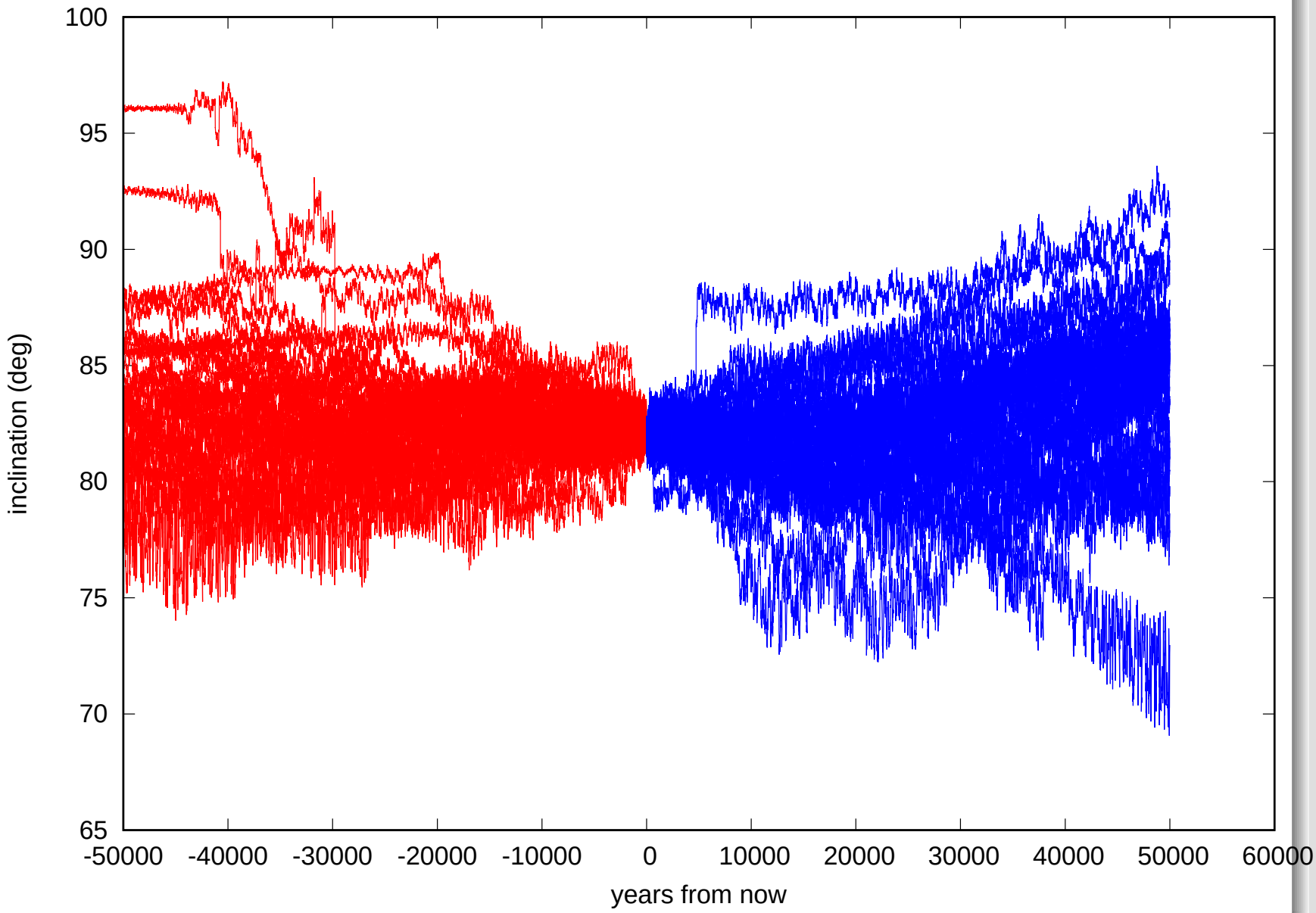
Numerical integration of short period stream components. i evolution



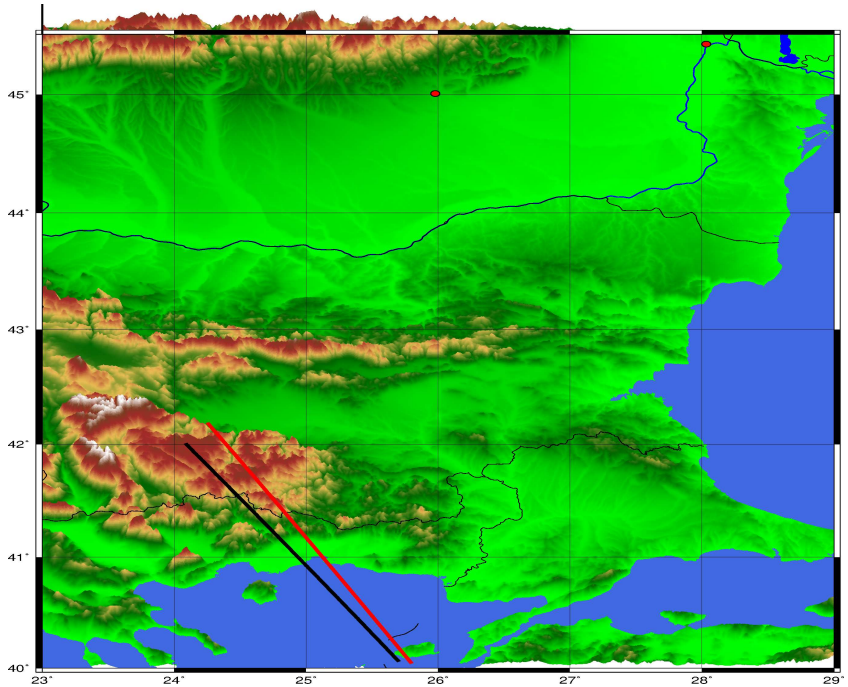
Numerical integration of long period stream components. q evolution



Numerical integration of long period stream components. i evolution



Space Surveillance and Tracking experiment



We ran an observing session of Atlas Centaur R/B, a rocket body, on 27/04/2018. Two of MOROI nodes, Paulesti and Galati were configured to obtain a sequence of 20 images centered at the moment of maximum brightness. The object was easily detected by each station at a SNR level > 20. For the 38.5 seconds of the tracking, the maximum total positional difference from the published TLE was of 25 km. The maximum departure on geocentric rectangular coordinates was [+17 km , -16 km, -15 km] on [x, y, z] respectively. In horizontal coordinates the maximum difference was [-0.44°, -0.19°] for (a, z), values entirely consistent with all-sky images astrometric calibration residuals. The sub-satellite trajectory provides a good visual representation of these differences.