Co-funded by the European Union

MINISTRY OF EDUCATION, YOUTH AND SPORTS

Palacký University Olomouc

FAST

Fluorescence detector Array of Single-pixel Telescopes

FAST - interesting results

Petr Hamal

on behalf of FAST Collaboration*

* Jose Bellido, Fraser William Bradfield, Ladislav Chytka, John Farmer, Toshihiro Fujii, Petr Hamal, Pavel Horvath, Miroslav Hrabovsky, Hiromu Iwasaki, Vlastimil Jilek, Jiri Kvita, Max Malacari, Dusan Mandat, Massimo Mastrodicasa, John Matthews, Stanislav Michal, Hiromu Nagasawa, Hiroki Namba, Marcus Niechciol, Libor Nozka, Miroslav Palatka, Miroslav Pech, Paolo Privitera, Shunsuke Sakurai, Francesco Salamida, Petr Schovanek, Radomir Smida, Zuzana Svozilikova, Akimichi Taketa, Kenta Terauchi, Stan Thomas, Petr Travnicek, Martin Vacula

SLO and Prague astroparticle meeting, Olomouc, 14.10.2024

Supported by FORTE – CZ.02.01.01/00/22 008/0004632

FAST at TA

Black Rock Mesa site

Three telescopes in operation

Coverage 90° in azimuth,
~80% FoV of BRM TA FDs

External trigger from BRM FD

438 coincidences found in ~240h

ID	Event time	TA FD Mono (Prelim.)		FAST (Prelim.)	
		Energy (EeV)	$X_{max}(gcm^{-2})$	Energy (EeV)	$X_{max}(gcm^{-2})$
1	2019/10/25 04:23:52	6.31	793	3.67±0.19	728±27
2*	2020/01/28 08:20:44	3.02	865	1.7±0.3	816±49
3	2020/01/28 11:13:17	1.91	478	1.44±0.1	439±10
4	2022/11/25 09:24:16	1.66	646	1.54±0.13	384±13
5**	2022/11/26 04:42:03	8.13	771	6.6±0.9	509±26
6	2023/02/17 05:13:36	1.55	561	1.29±0.16	533±19
7*	2023/02/20 08:15:51	1.78	867	3.7±0.6	375±30

Table 1: Top-down reconstruction results for real events measured by FAST@TA.

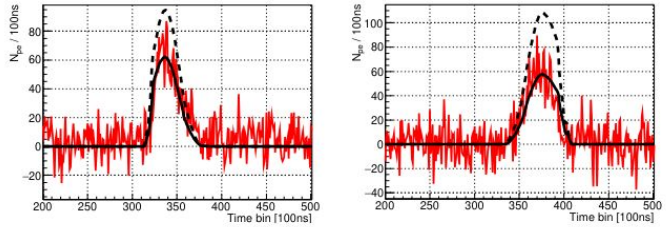
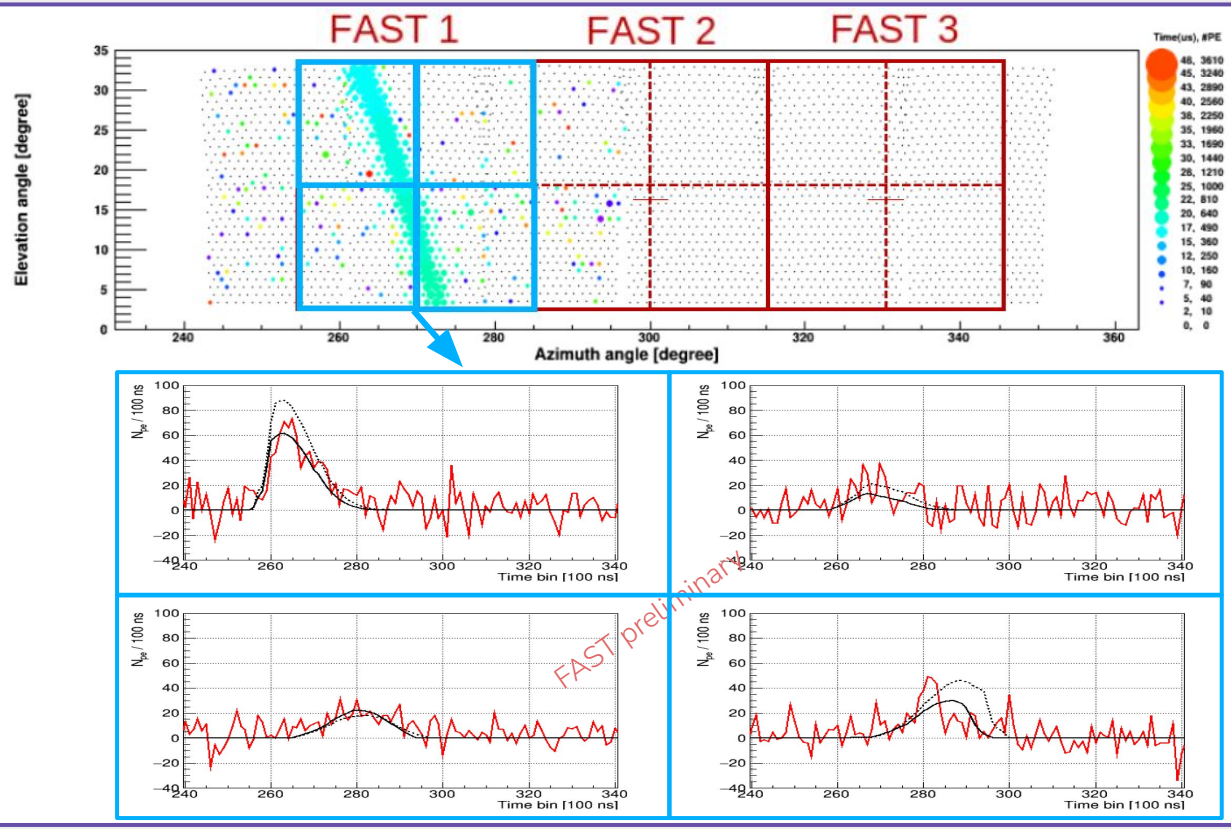


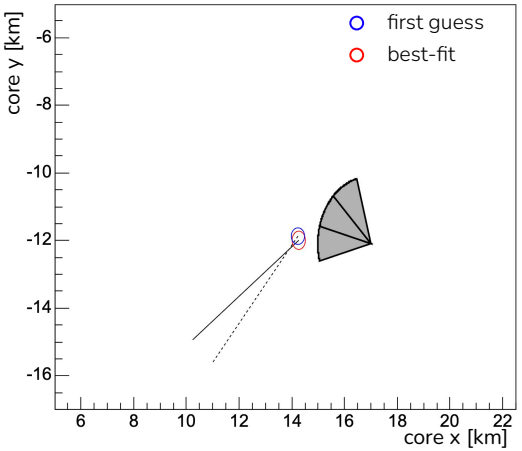
Figure 7: Top-down reconstruction fit to the significant PMT signals from event ID 2. The dashed line shows the simulated trace using the TA parameters as the first guess. The solid line shows the final result of the fitting procedure.

https://pos.sissa.it/444/303/pdf

FAST event examples - from Telescope Array

Reconstructed values from TA used as first guess for the FAST reconstruction





Preliminary result

Event: 2019/01/11 06:30:01

	TA-Mono	FAST
Energy [EeV]	0.93	0.56 ± 0.11
X_{max} [g/cm^2]	663	764 ± 124
Zenith [deg]	20.4	20.5 ± 0.2
Azimuth [deg]	-138.8	-126.4 ± 1.8
Core x [m]	14240	14266 ± 19
Core y [m]	11880	11984 ± 37

FAST at Auger

Los Leones site

One telescope in operation (two installed)

Coverage 30° in azimuth,
~17% FoV of Auger Los Leones FDs

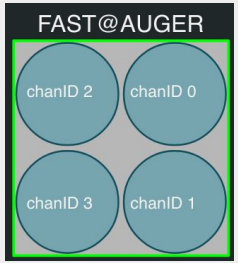
Internal trigger - from 2019 to 2020

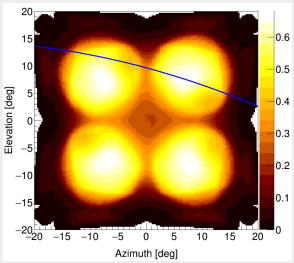
External trigger from LL bay4 FD
- since July 2022
- 236 coincidences found in ~122h

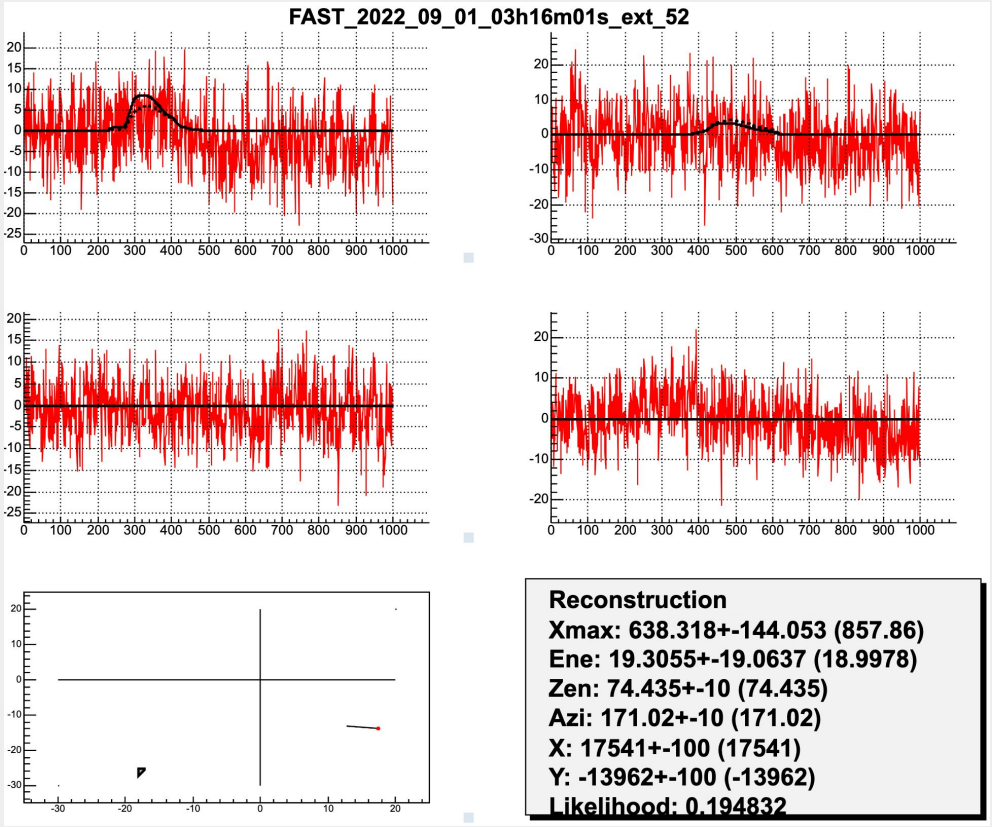
FAST at Auger - the event with Rp = 21 km, response in PMT2

External trigger, R_p ~ 21 km, response in PMT2

Found with the newly developed search algorithm







Simulating with Auger reconstructed values as first guess reproduces signal in PMT 2

Reconstructed parameters: X_{max} and E

Would be even better result when reconstructing all parameters

FAST - combined results

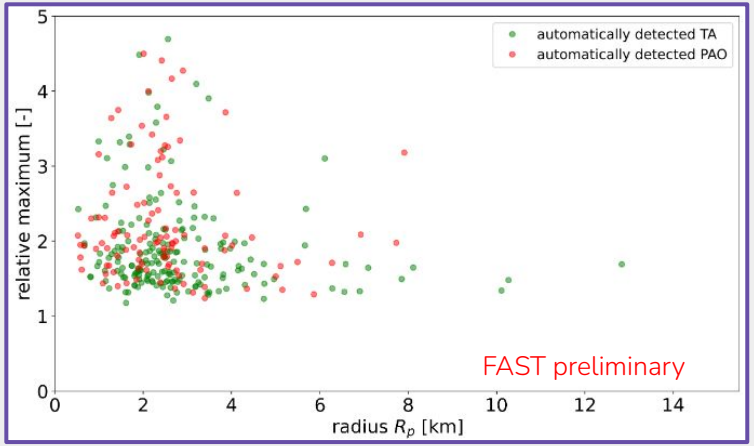
External signal triggering at both TA and Auger

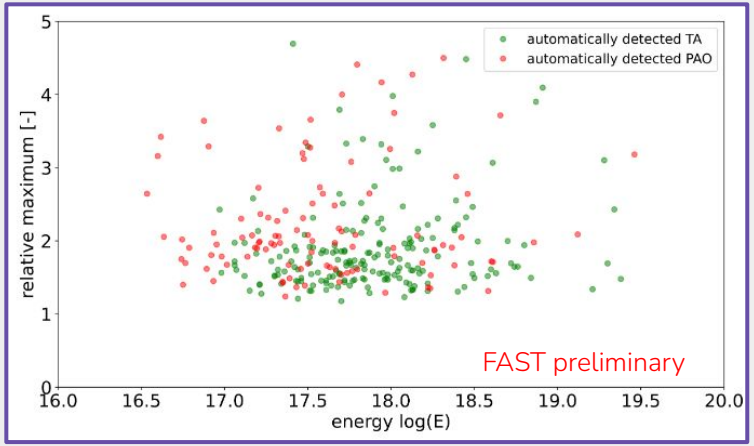
Relative maximum is defined as the size of the entire signal relative to the background

Illustrated in terms of the impact factor (R_p) and energy (E)

Good agreement in FAST telescope sensitivity across both hemispheres (~15%)

median values	$E < 10^{18}$ eV	$E \geq 10^{18}$ eV	R_p
FAST@TA	1.701	1.886	1.720
FAST@PAO	2.032	1.943	2.000





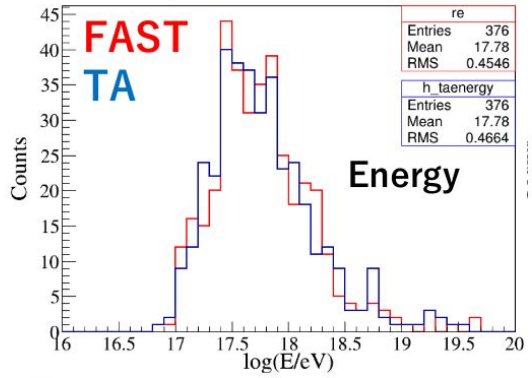
FAST - combined results

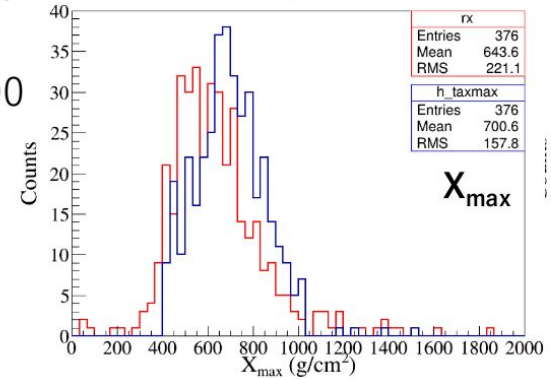
Reconstruction results: X_{max}/Energy

Reconstruction setup

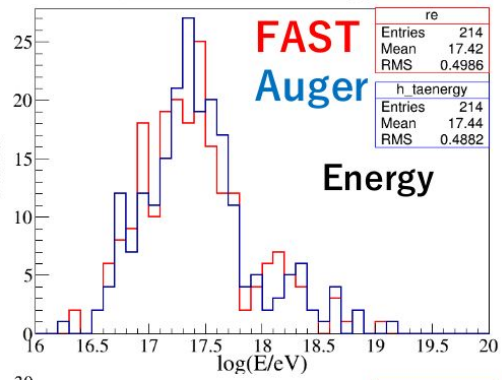
- Recon (E, X_{max}, θ, ϕ, x, y) + Abs. time offset
- Using TA/Auger recon values as first guess
- Cuts：
  - Successful minimization (from Minuit)
  - Time offset between 100 and 500
- **FAST reconstructed X_{max} lower than TA/Auger**

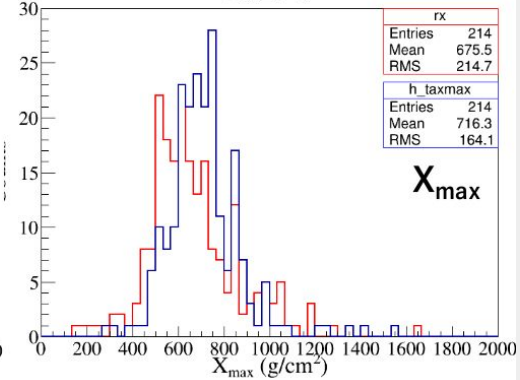
FAST@TA





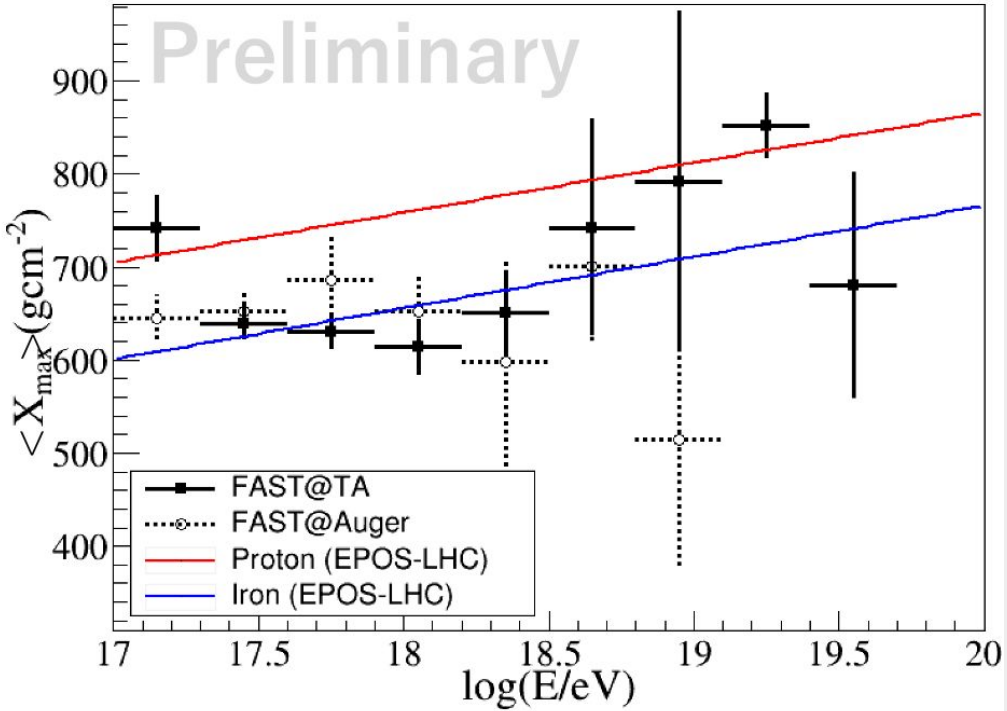
FAST@Auger





Reconstruction results：Elongation rate

- **Proton** and **iron** rails from FAST simulation
- $10^{17.5}$-$10^{18.5}$ eV range – towards iron composition
- FAST@TA and FAST@Auger results, within statistical error, largely agree

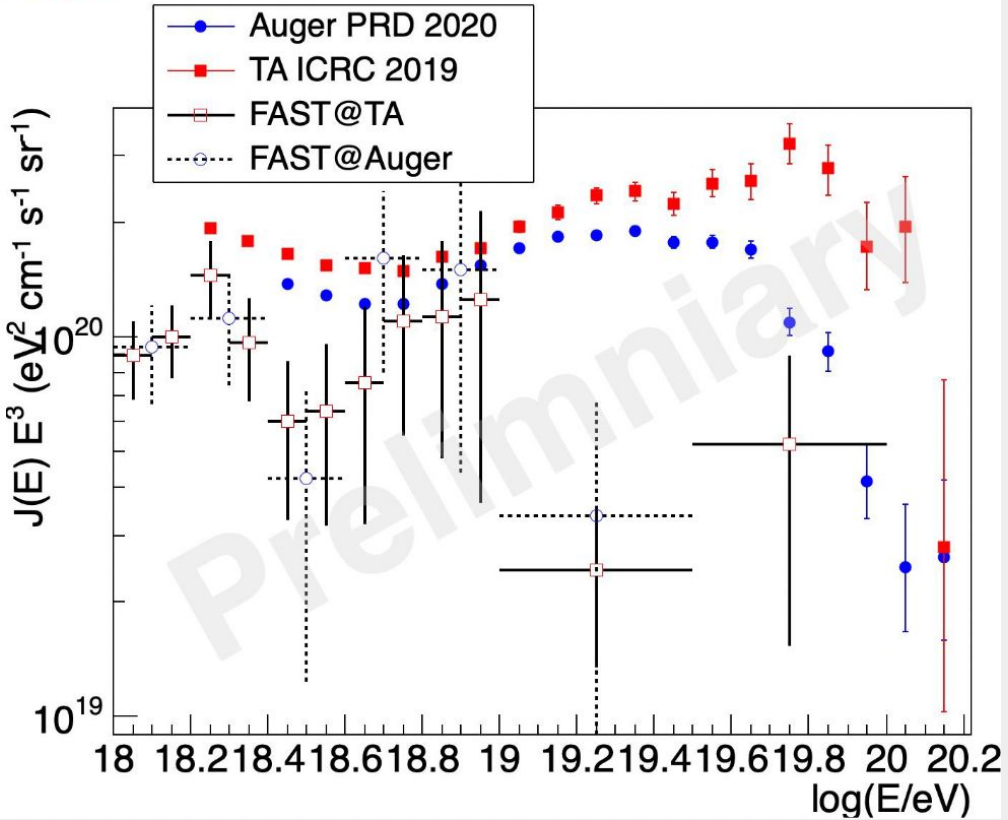


FAST - combined results

Energy spectrum

First spectrum from FAST

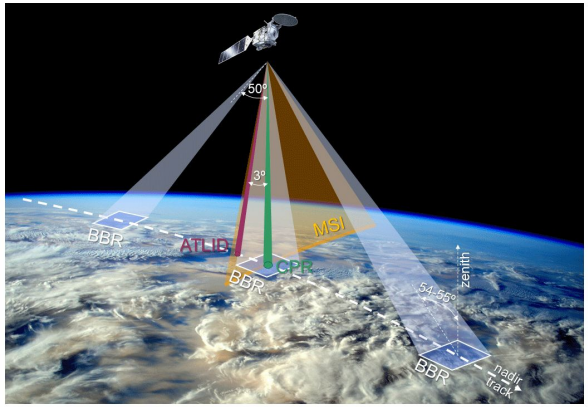
- Put together using exposure from before and FAST reconstructed energy
- Once again, FAST@TA and FAST@Auger results largely agree



FAST and EarthCARE (ATLID)?

ATLID main observation parameters (design requirements)

Sensor type	High Spectral Resolution Lidar (HSRL)
Developer	European Space Agency (ESA)
Center wavelength	355 nm
Measurement range	Ground to 40 km
Footprint (IFOV)	< 32 m
Horizontal sampling	Approx. 280 m (Target 140 m)
Vertical sampling	Approx. 100 m

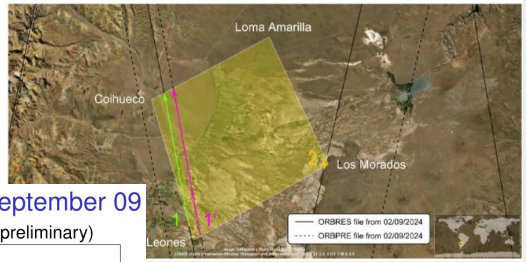


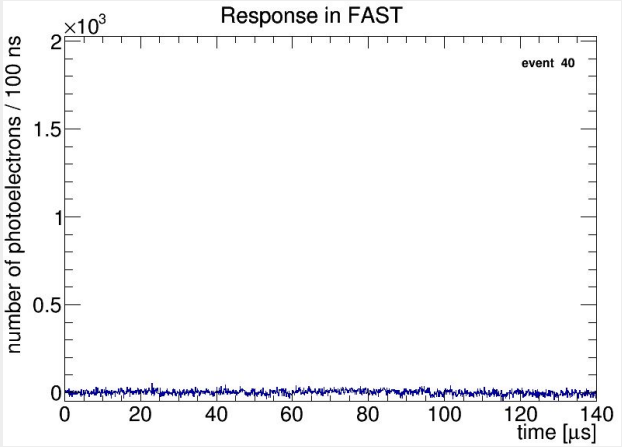
2024 orbit prediction Oliver Lux (DLR)

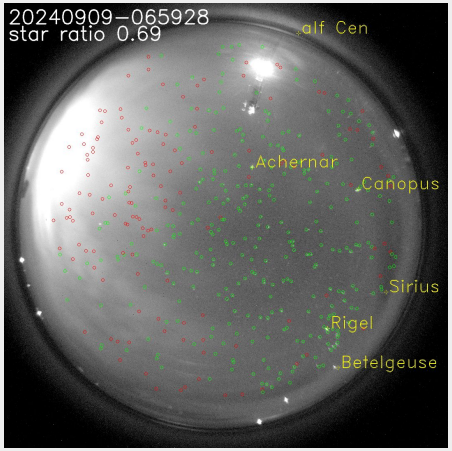
DLR

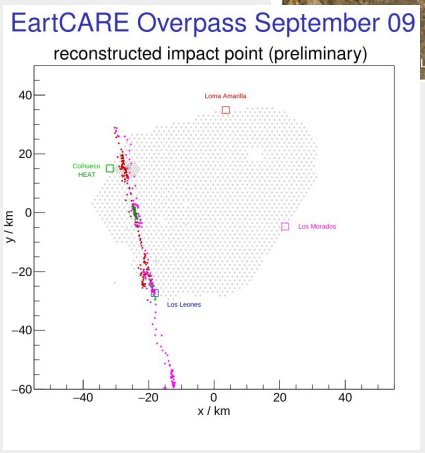
- EarthCARE orbit is still drifting in September 2024, therefore orbit files (ORBRES) are only valid for 3 days (current file valid until 05/09/2024)
- Alternatively, prediction files (ORBPRE) are produced based on forecasts of Earth-centric cartesian coordinates (current version valid from 02/09/2024 to 09/09/2024)
- Based on these files, one or two overpasses are found in CW37

Overpass #	Date	UTC time	Duration	Orbital node	Orbit file
1	09/09/2024	06:59:13	4.4 s	Ascending	ORBRES
1'	09/09/2024	06:58:59	6.3 s	Ascending	ORBPRE
2	15/09/2024	18:17:34	0.1 s	Descending	ORBRES









Thank you