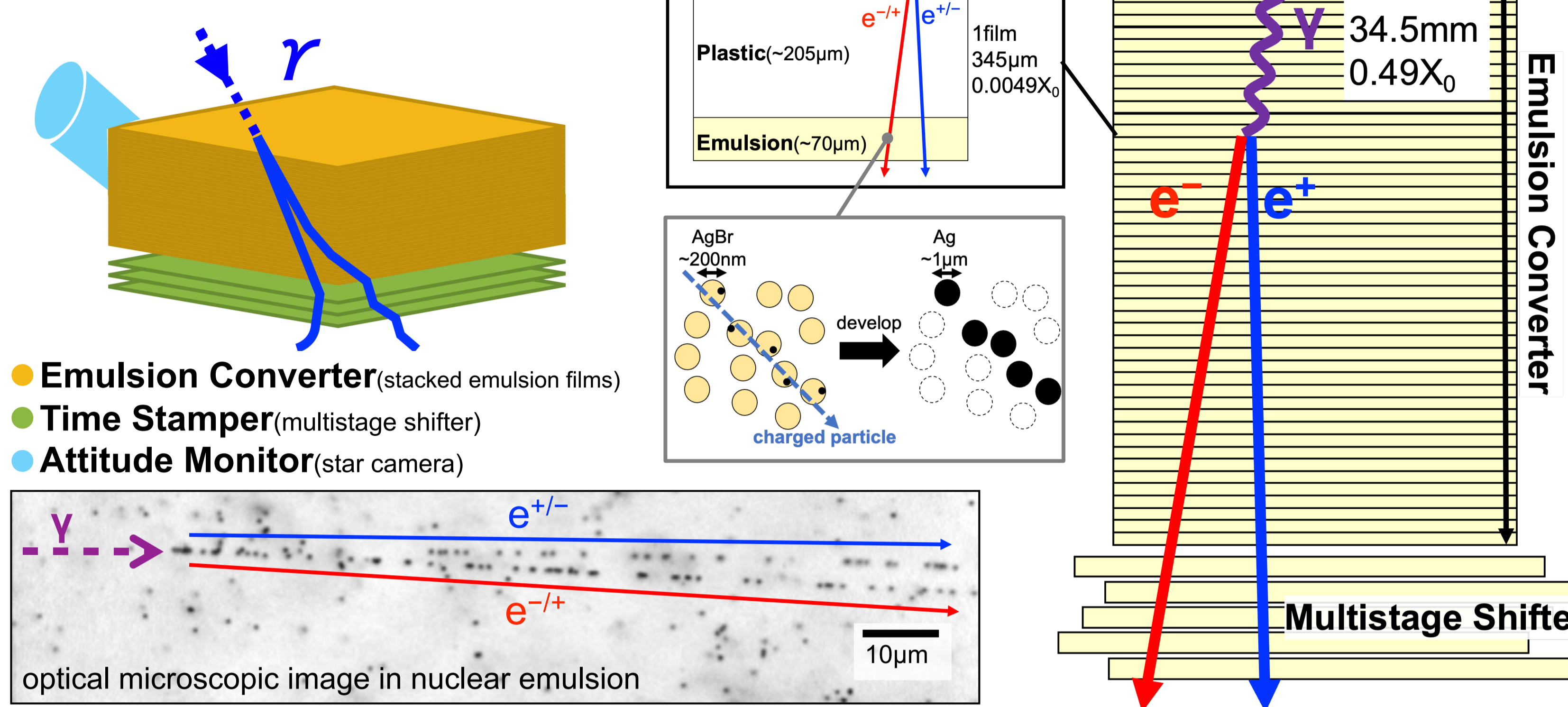


GRAINE project: Analysis Status of Nuclear Emulsion Converter for the 2023 balloon experiment

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I. GRAINE

Gamma-Ray Astro-Imager with Nuclear Emulsion



- Emulsion Converter (stacked emulsion films)
- Time Stamper (multistage shifter)
- Attitude Monitor (star camera)

GRAINE road map

Demonstration phase

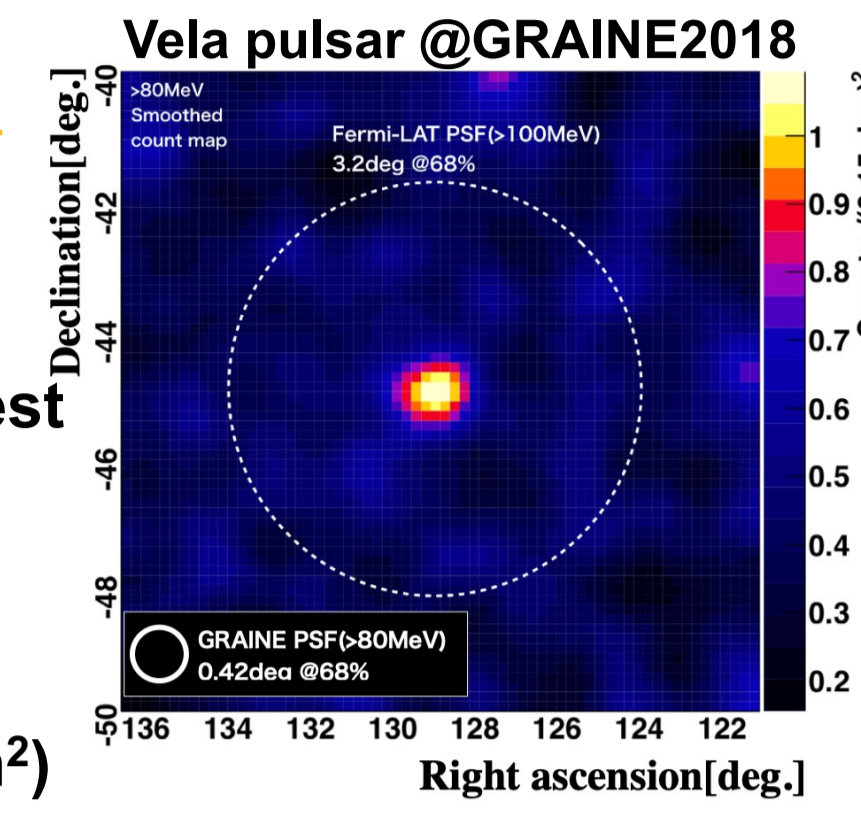
- 2011 at Hokkaido (0.0125 m²)
- 2015 at Alice Springs (0.38 m²)
- 2018 at Alice Springs (0.38 m²)
- Success in world's highest resolution imaging of Vela pulsar (>80 MeV)

Scientific phase

- 2023 at Alice Springs (2.5 m²)

Future Plan

- 10m² aperture area
- long duration flight (~1week)
- repeating flight

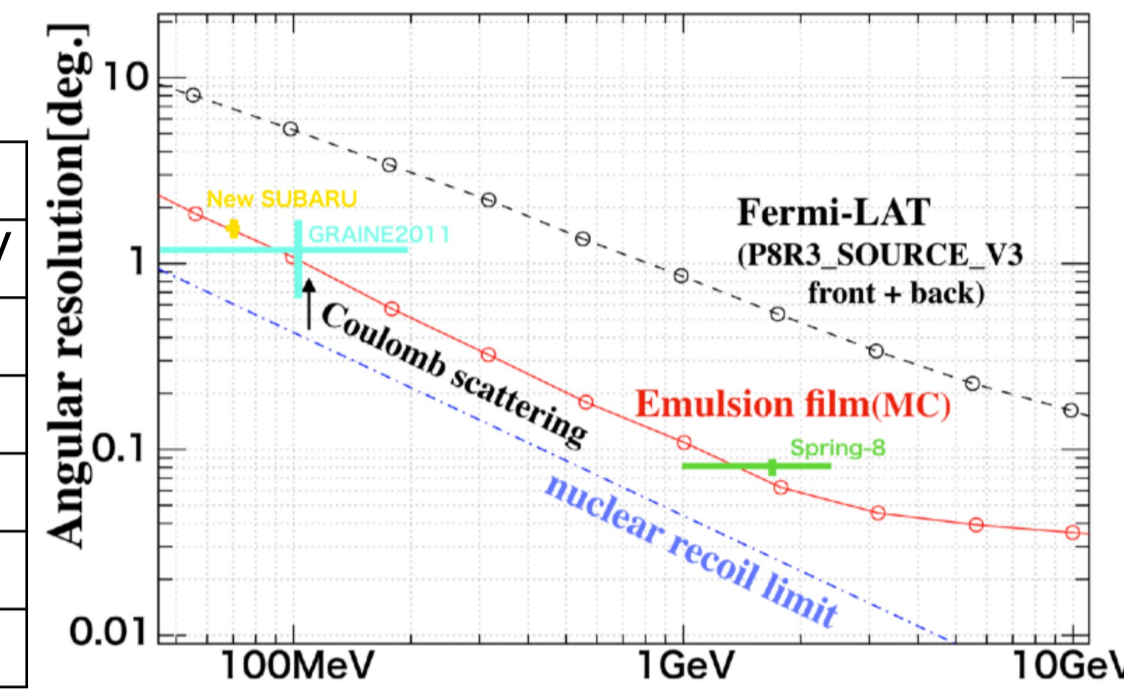


Scientific Target

- Precise observation of Galactic Center (Survey of GeV excess)
- Polarization measurement
- Observation of Transient sources

High angular resolution
 Large aperture area
 Polarization Sensitive

	Fermi-LAT	GRAINE (10m ²)
Energy range	20 MeV – 300 GeV	10 MeV – 100 GeV
Angular resolution (@ 100 MeV)	5.0°	1.0°
(@ 1 GeV)	0.9°	0.1°
Effective area (@ 100 MeV)	0.34 m ²	2.4 m ²
(@ 1 GeV)	0.82 m ²	3.0 m ²
Polarization sensitivity	No	Yes



II. GRAINE2023 balloon experiment

Converter : 25cm×50cm×90films
 total : 20Converters, 1800films

aluminum honeycomb plate with 2 Converter

time stamper film

2.5m² Emulsion Telescope

Jun. - Nov. 2022 Film production at Nagoya Univ.
 Nov. 2022 - Jan. 2023 Making converter
 Feb. 2023 - Final preparation in Australia

Apr. 30 – May 1 success in 27hours flight!
 24.3h level flight at 36km (~5hPa)

Observed region in GRAINE2023 balloon flight

Vela pulsar 15pm–21pm

Galactic Center 0am–6am

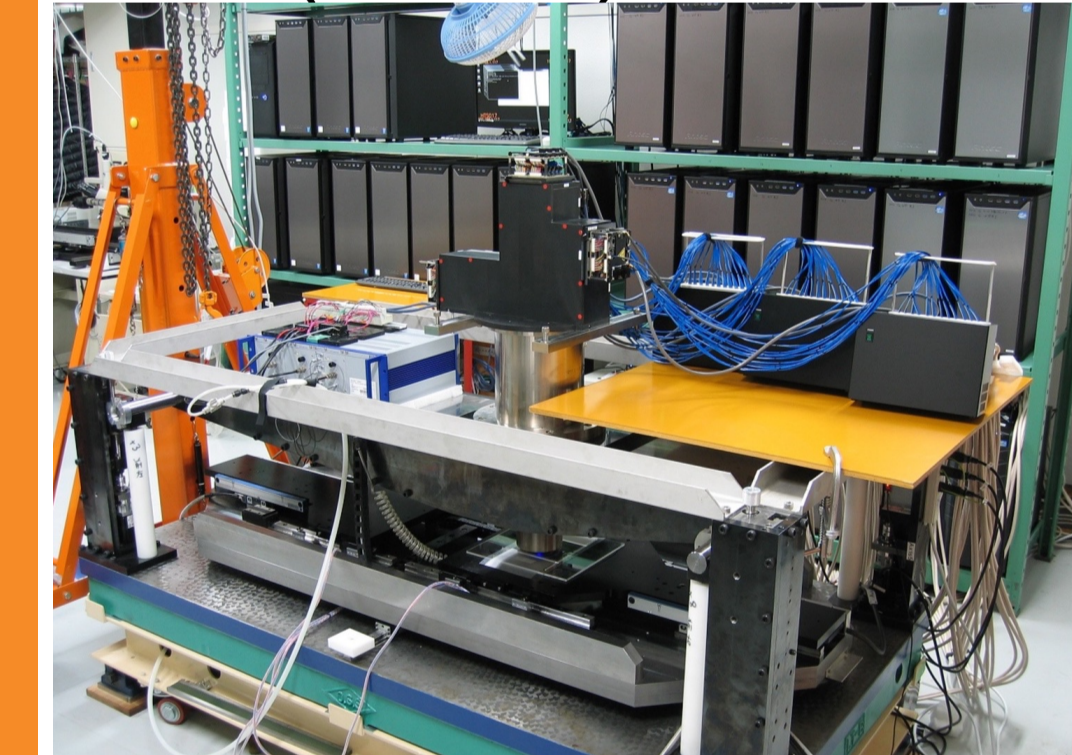
Development facility at Gifu Univ.

67.5films (8.4m²/day)
 90films×3days
 +preparation 1day

III. Analysis status of Converter films for GRAINE2023

Machine to readout tracks

HTS(2015-)

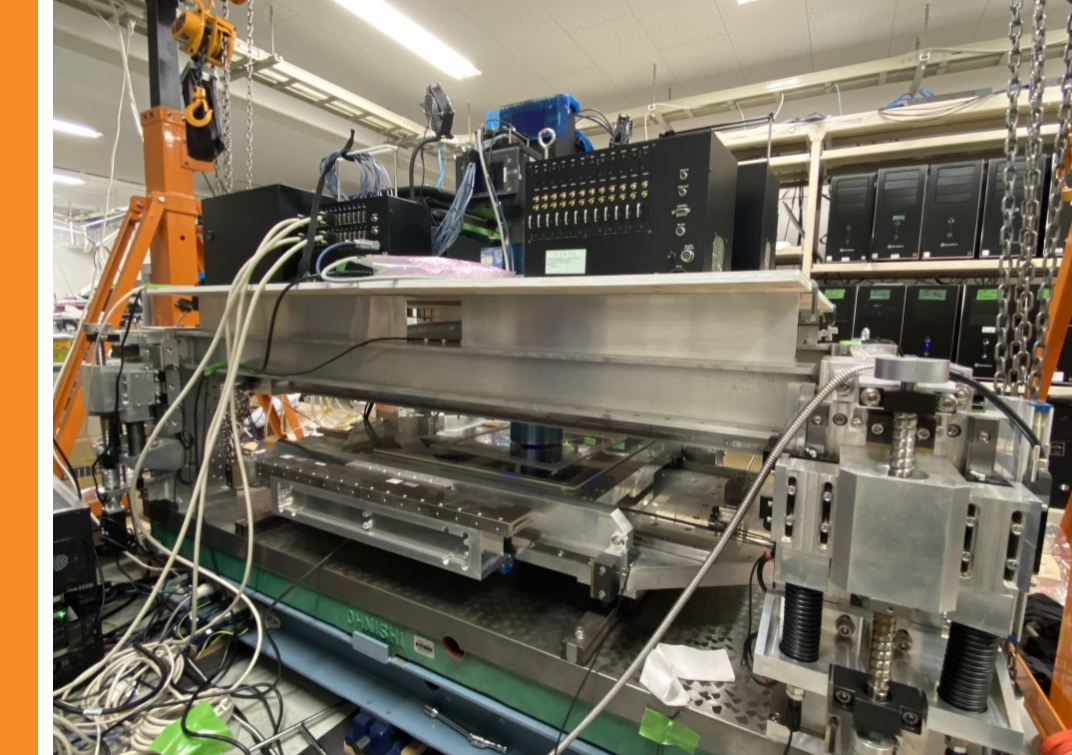


scanning speed :
 4700 cm²/h/layer

HTS is well-established
 but slow for GRAINE2023

If we use HTS for GRAINE2023,
 it would take 2 years to scan films.

HTS2(2023-)
 x5 faster

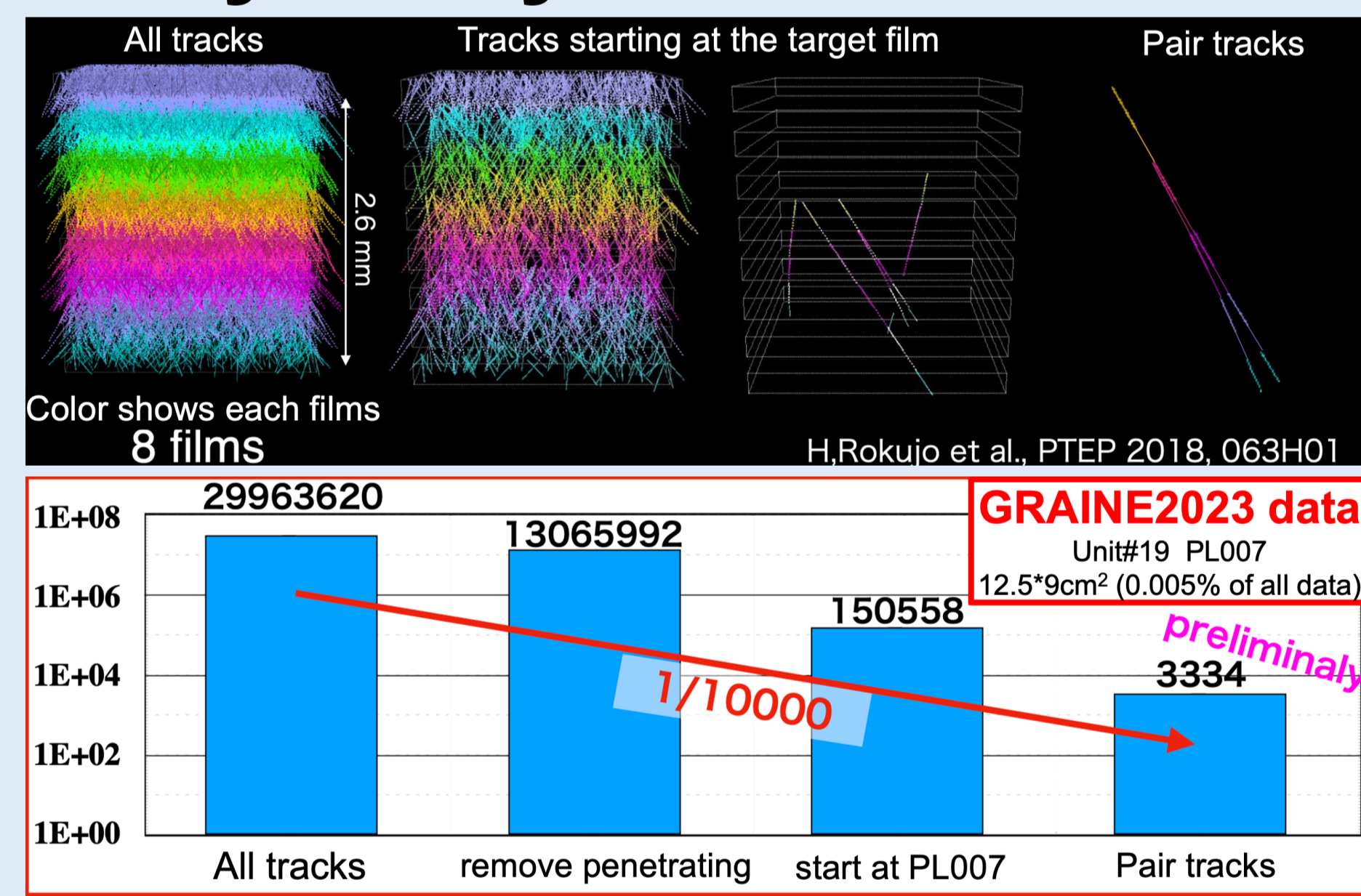


- 2 times larger FOV
- New image capturing method

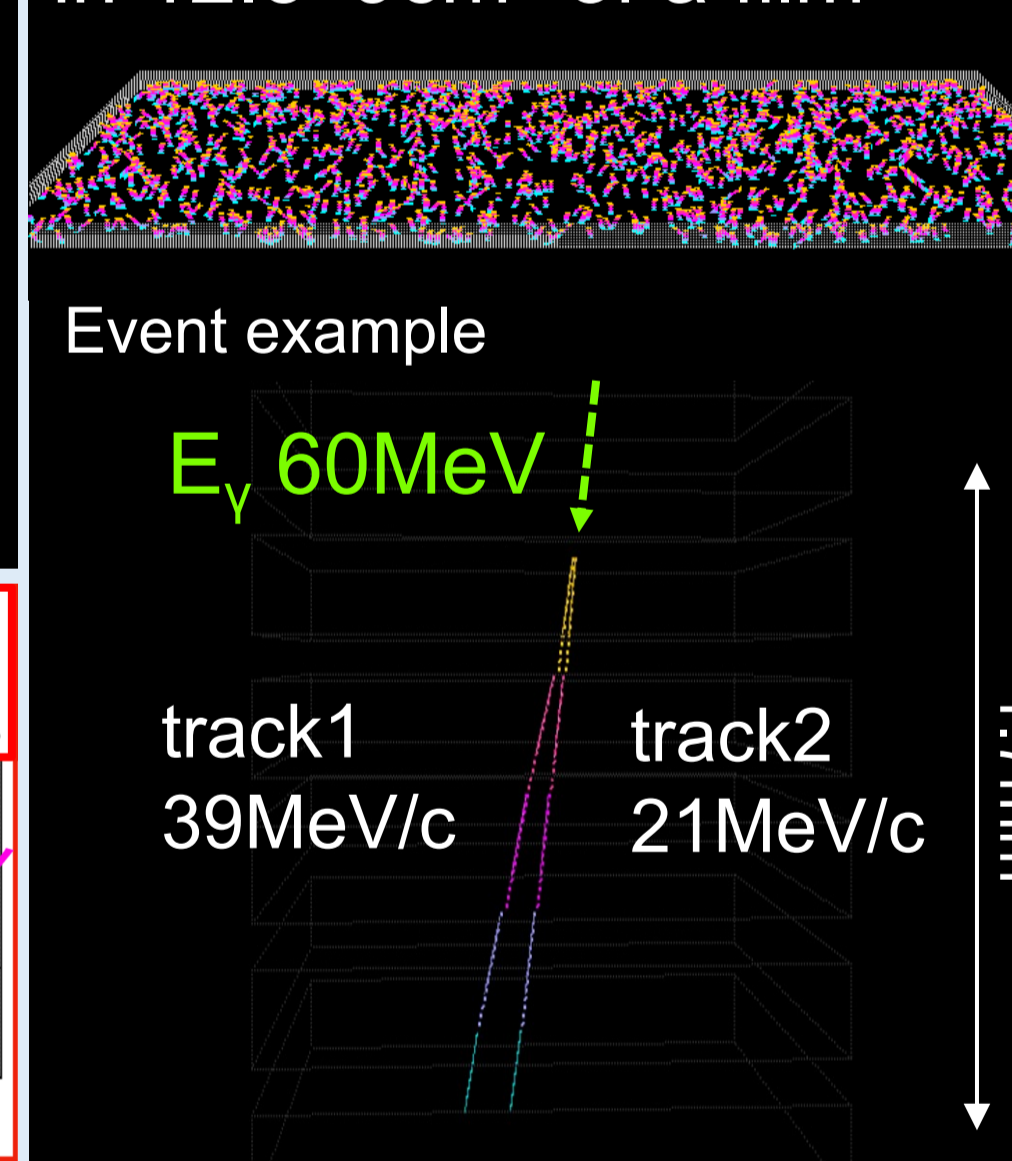
scanning speed :
 25000 cm²/h/layer (target)

GRAINE becomes the first
 experiment to use HTS2!

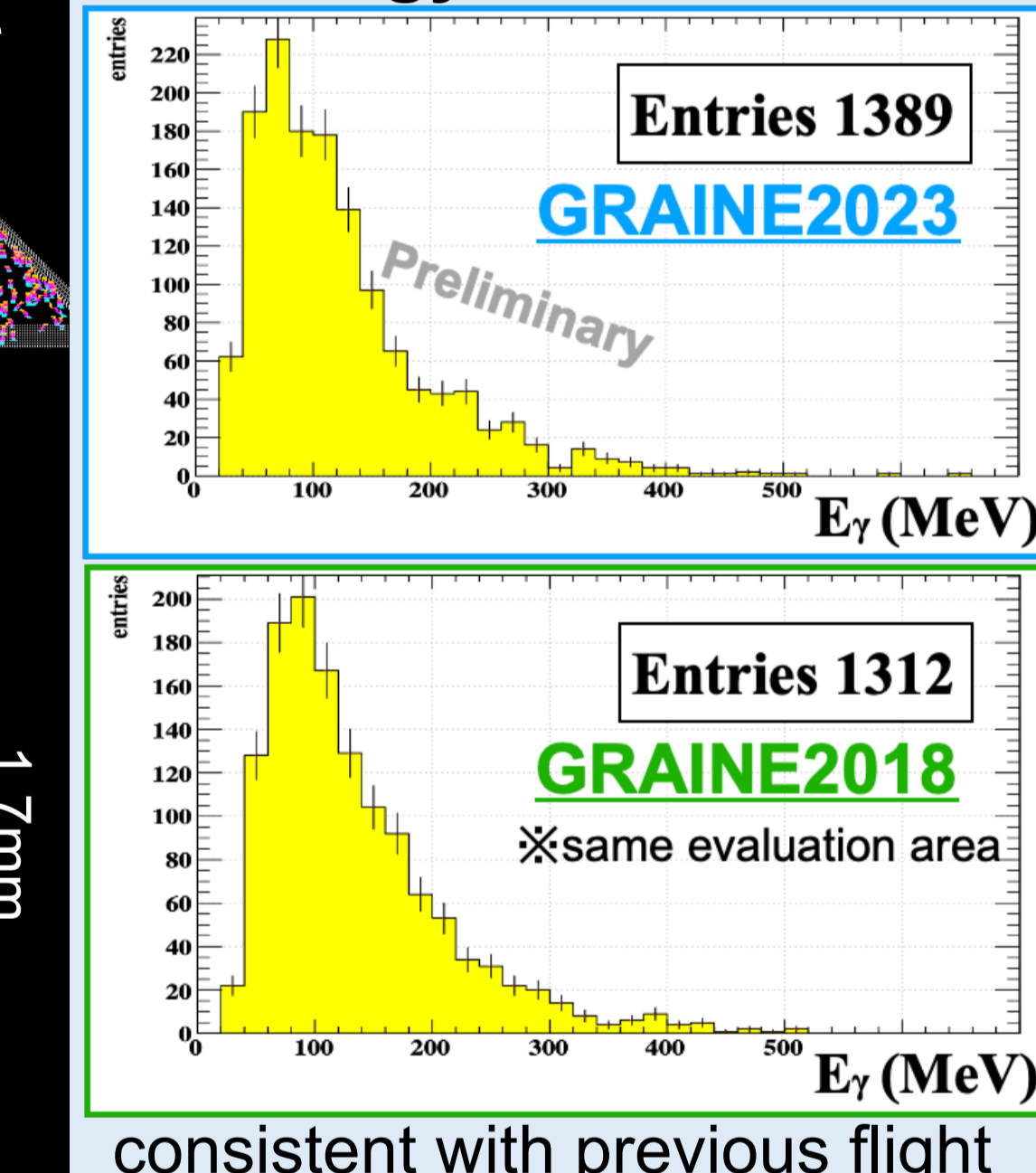
Early analysis with HTS



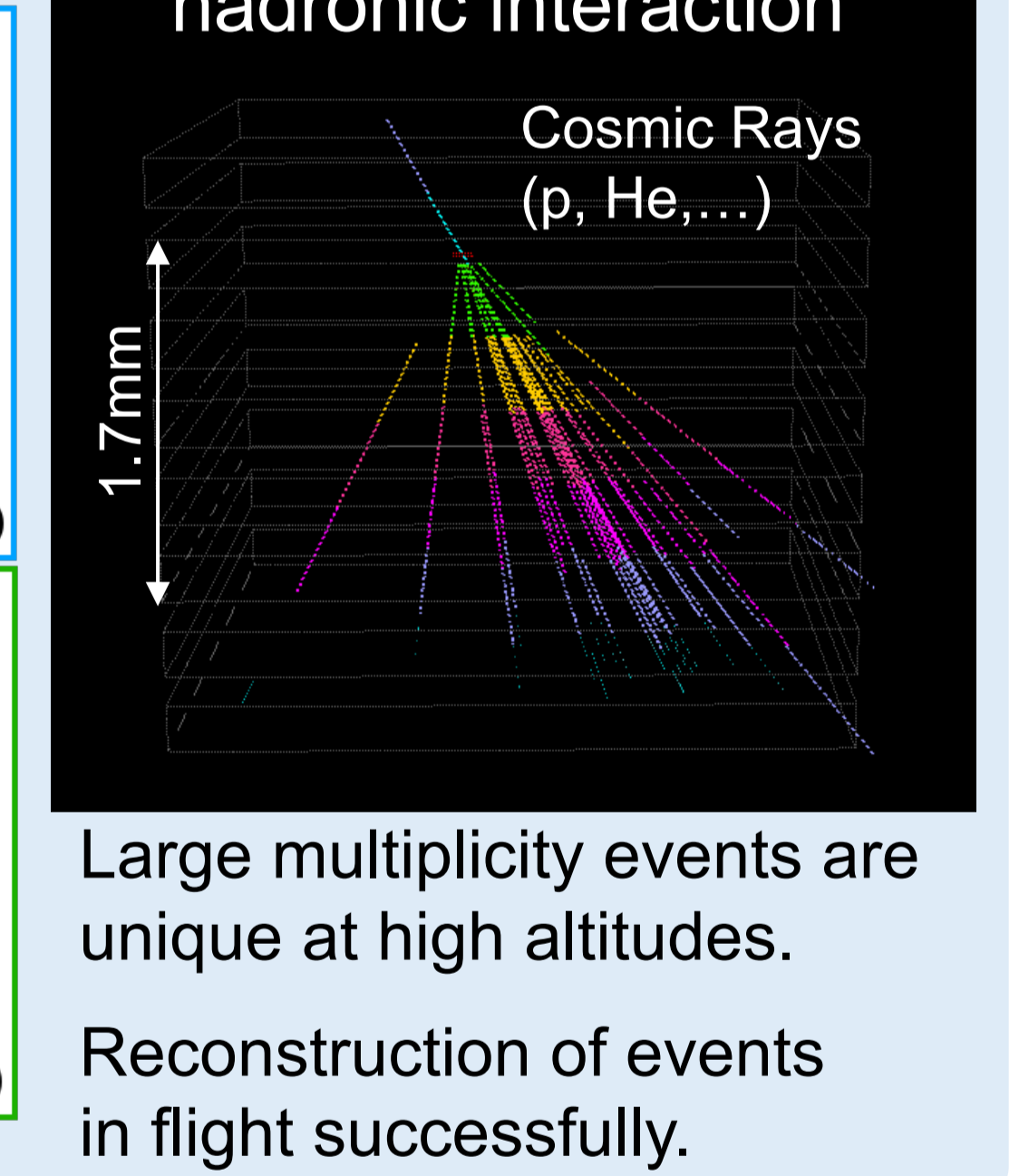
reconstructed γ -ray event
 in 12.5×9cm² of a film



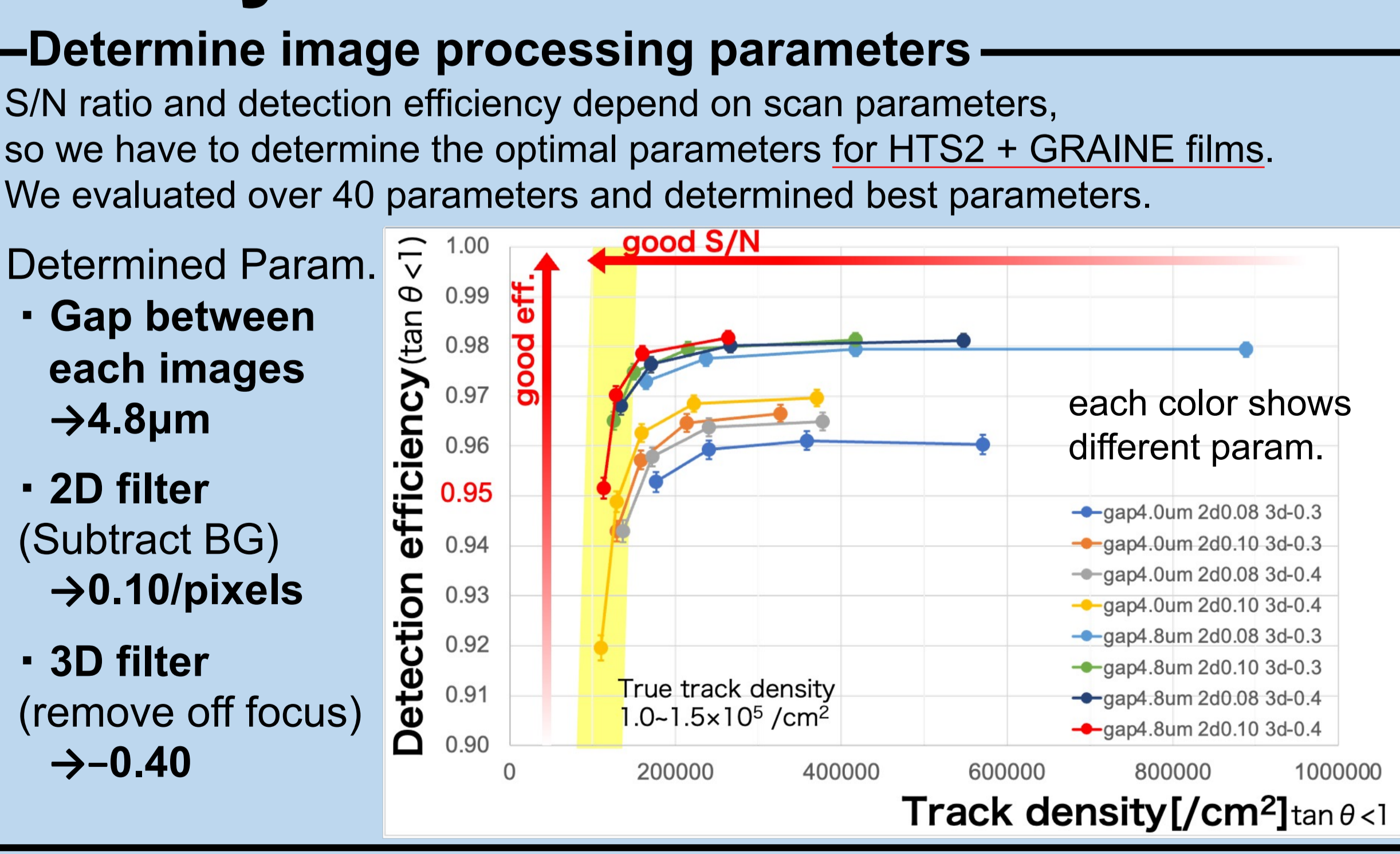
Energy distribution



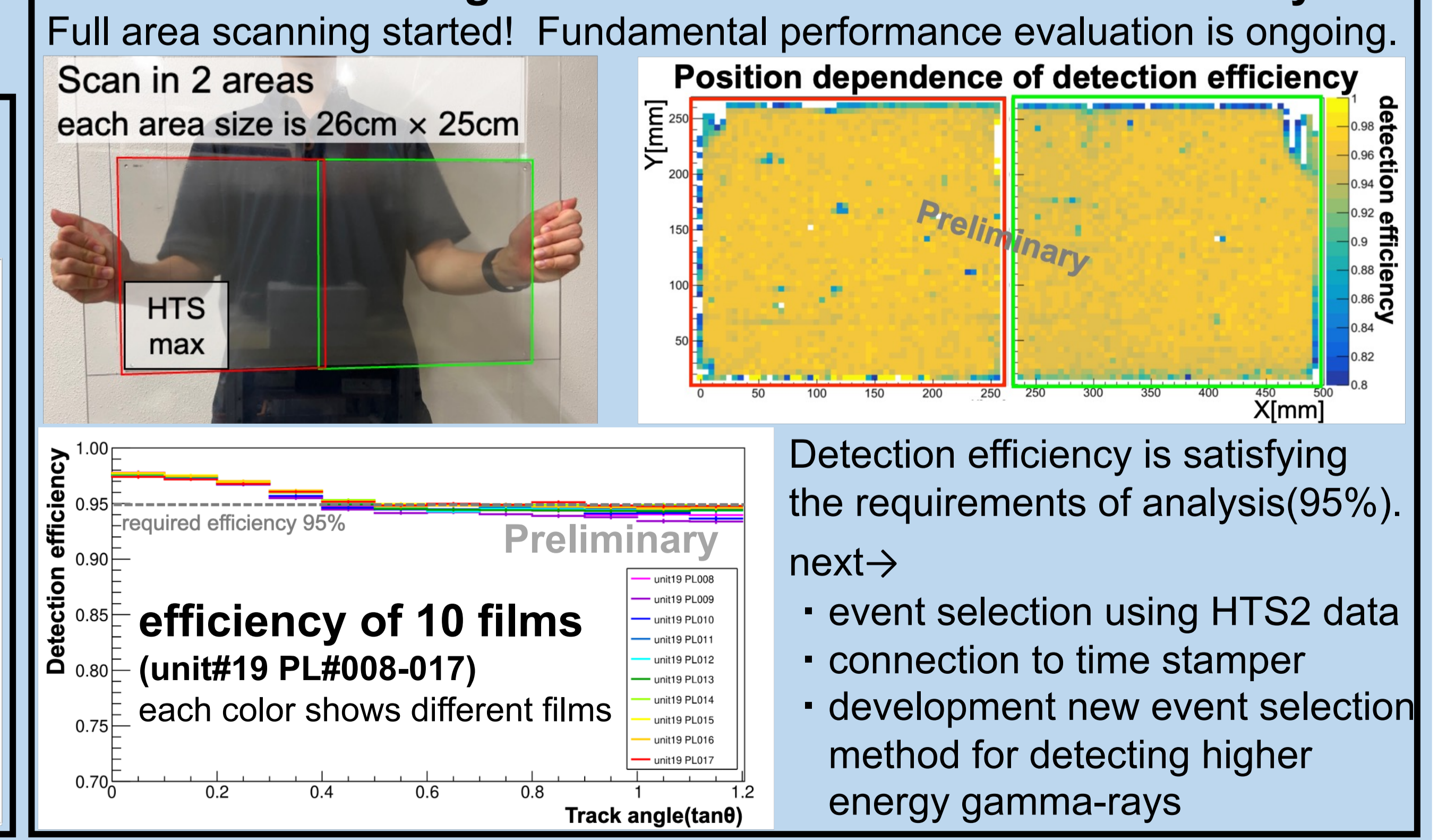
hadronic interaction



Analysis with HTS2



Full area scanning and Evaluation of detection efficiency



IV. Summary & Outlook

- GRAINE aims to observe sub-GeV/GeV gamma-ray precisely with emulsion telescope.
- We made 2.5m² emulsion telescope and launched by balloon and succeeded 27hours flight.
- All emulsion films were already developed in Japan. Flight film analysis is ongoing.
- Converter films are scanned by new generation scanning machine HTS2 with good performance.

• We are analyzing of each part aiming to have the initial results of imaging of Vela pulsar in the fall of 2024.

