

Analysis of hadronic interaction in GRAINE experiment

Hiroaki Kawahara
and GRAINE collaboration

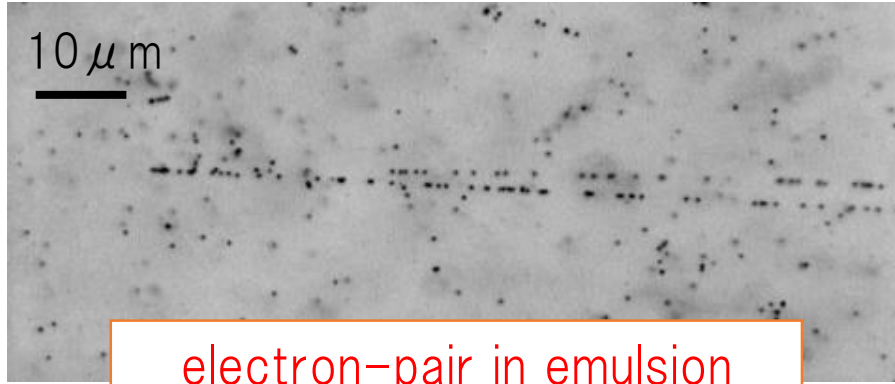
4th Oct. 2016

Workshop on Hadron Production Measurement



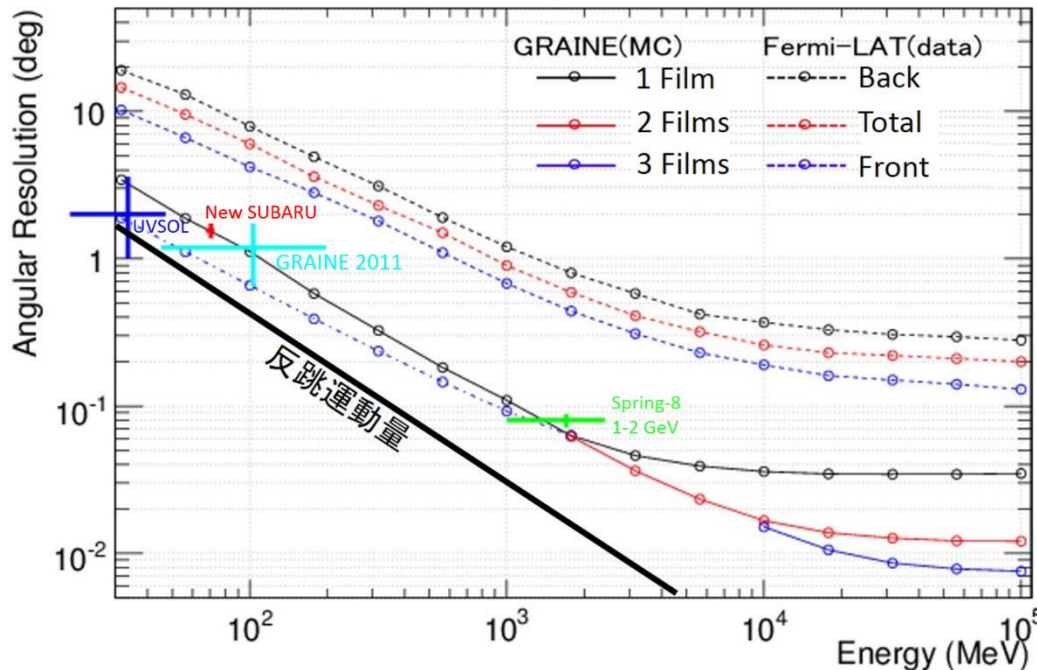
Nuclear emulsion

✓ sub-micron position resolution

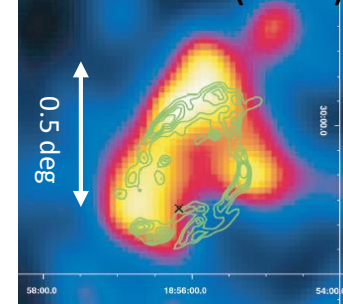


GRAINE

aiming precise measurement of cosmic gamma-rays



Fermi-LAT (data)



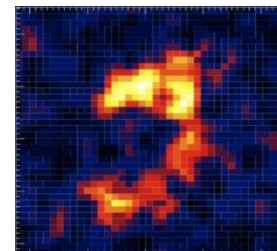
Energy
2–10 GeV

Observation
~ 6 month

SNR W44

A. A. Abdo. et al.
(2010) Science

GRAINE (MC)

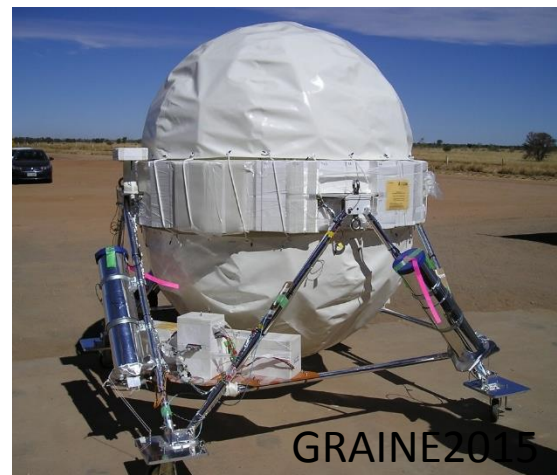
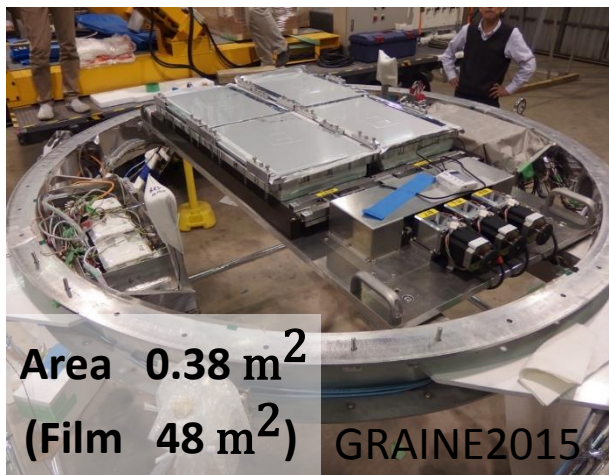
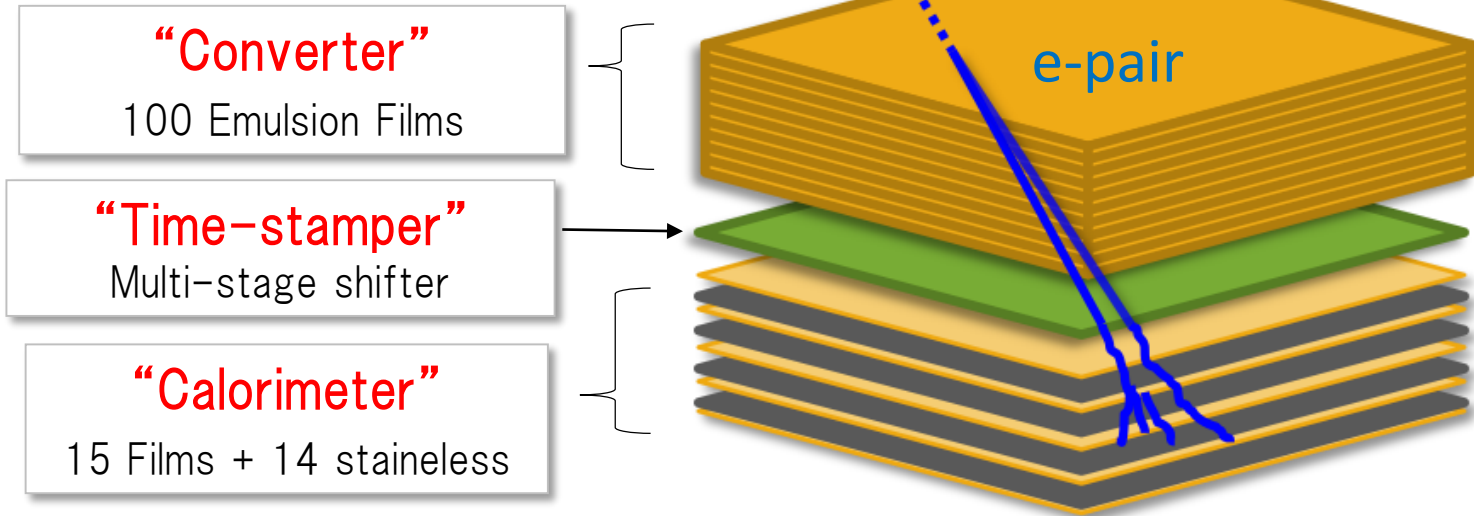


Energy
> 1 GeV

Observation
1000 m²·hour

GRAINE2015

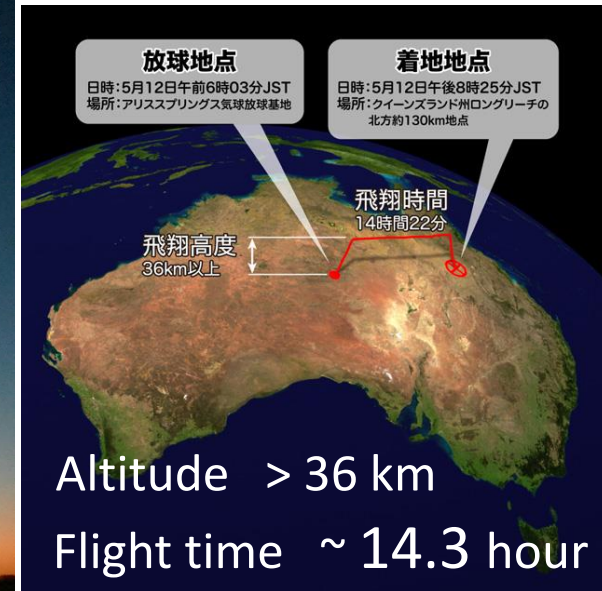
Target : Vela pulsar



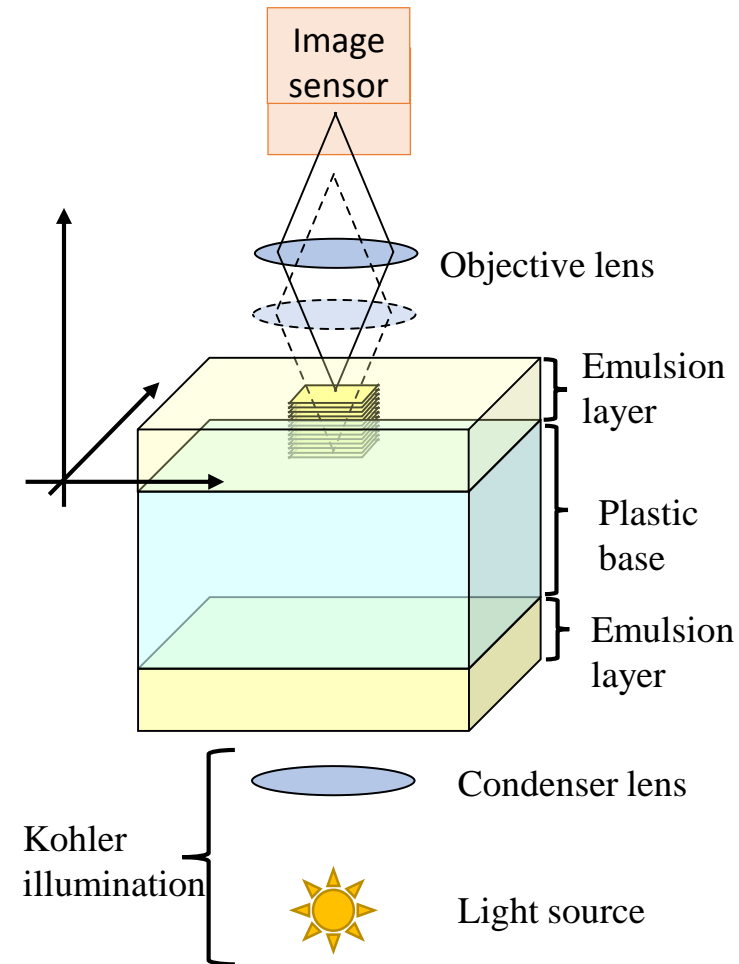
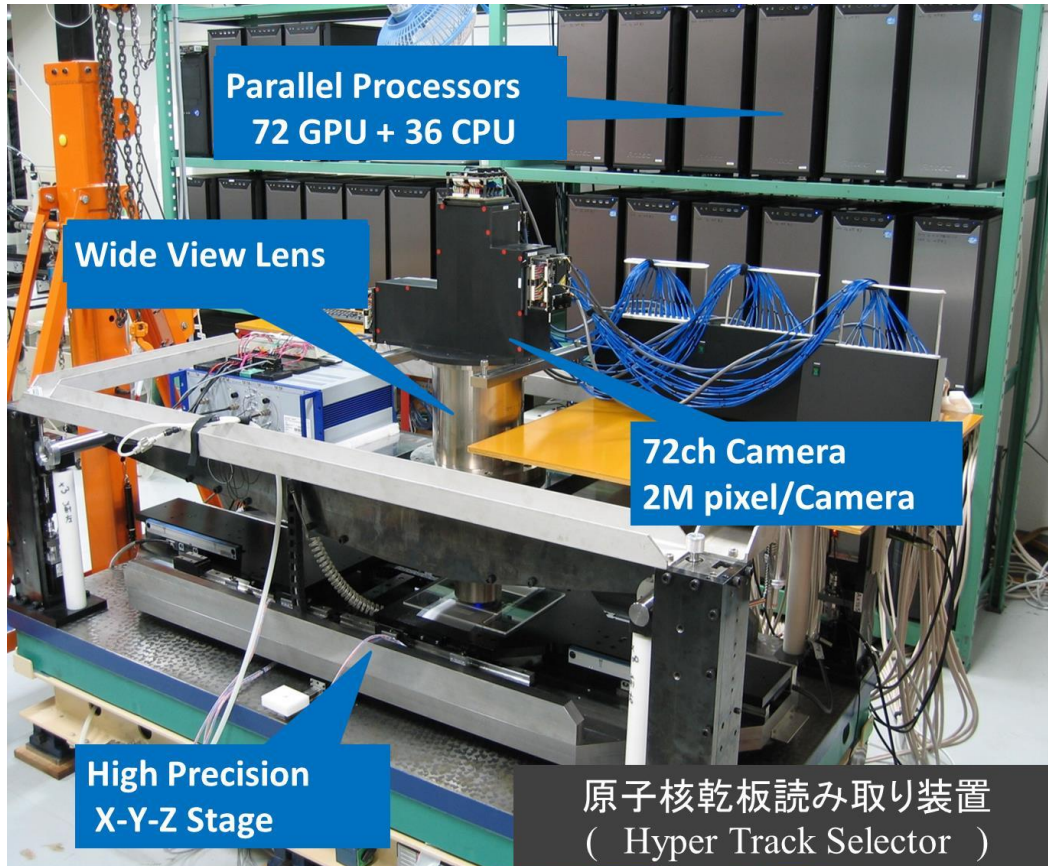
The Launch

Alice Springs in Australia

12th May

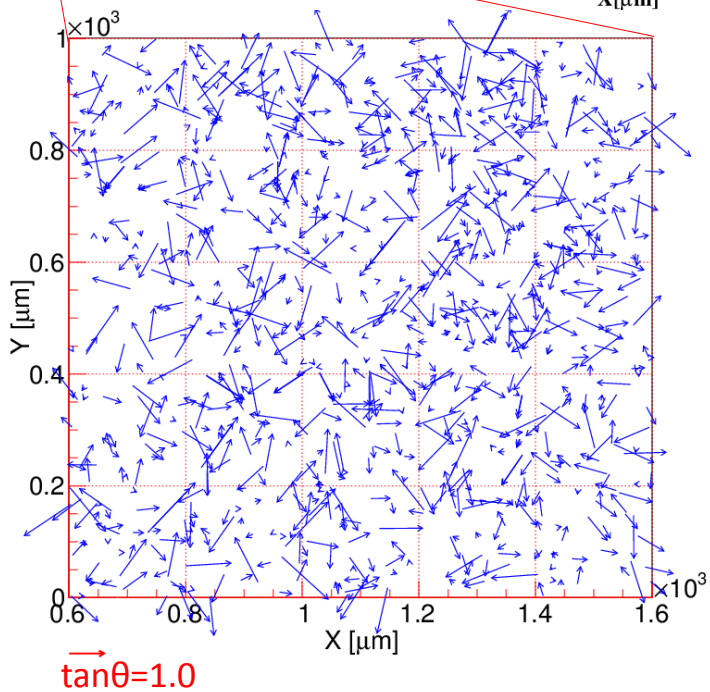
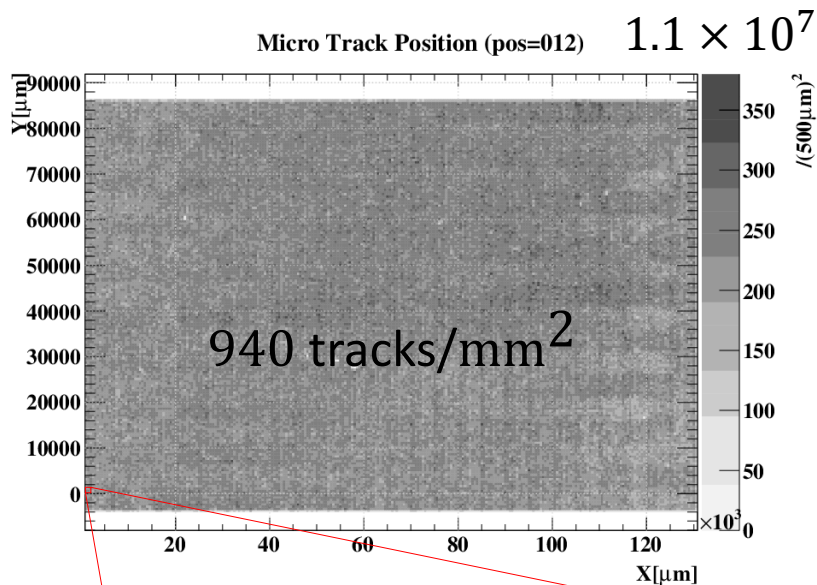


Hyper Tracks Selector @Nagoya

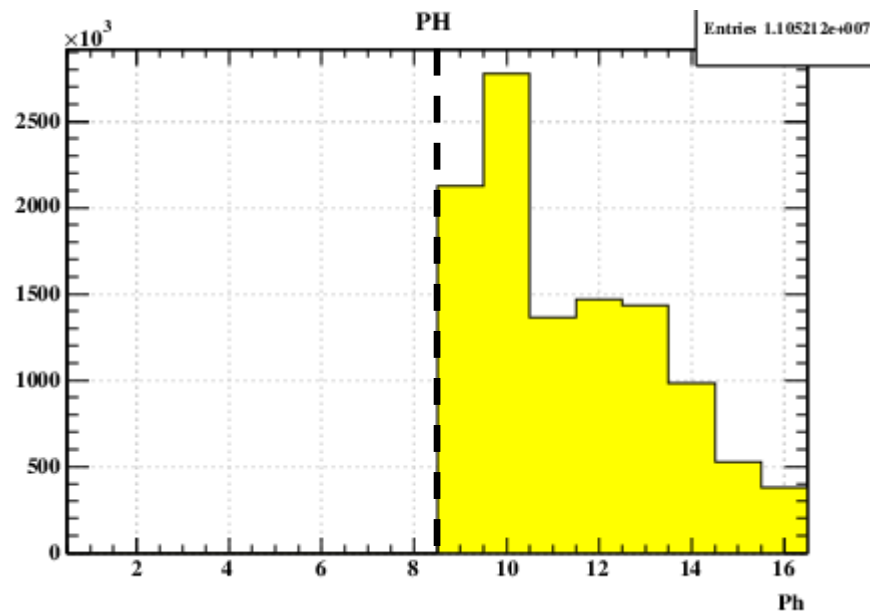


Basic data of tracks on a film

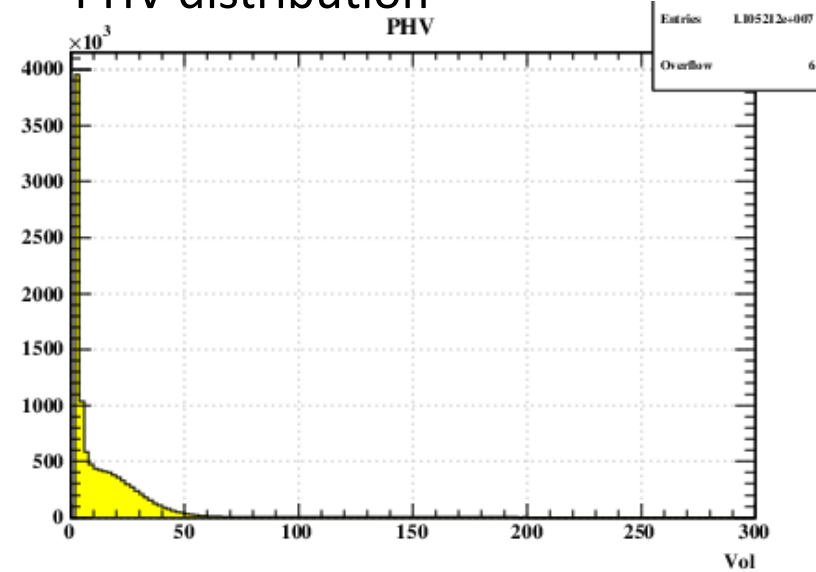
- *PH is the number of hit in 16 layers.
- **PHV have correlation to thickness of tracks.



PH distribution *



PHV distribution **

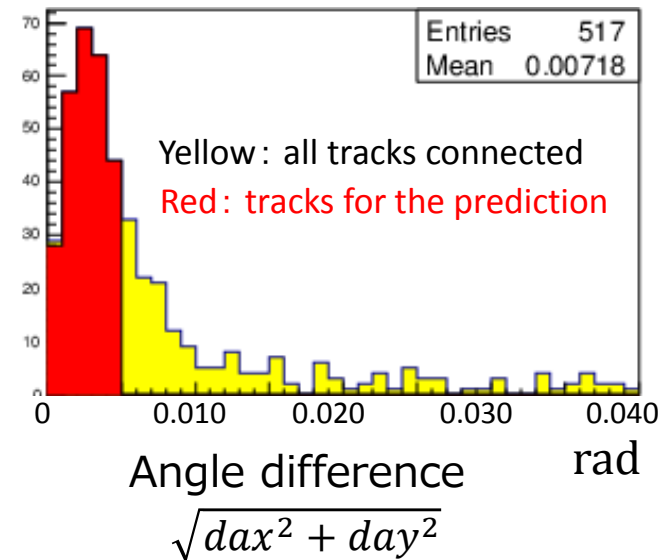
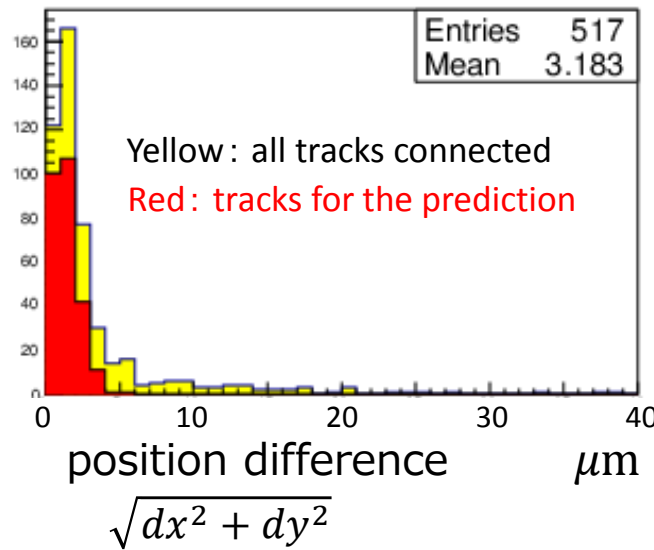


Quality check : Tracking efficiency



① Making prediction
using upper/down-stream films.

$$|\tan\theta| < 0.1$$

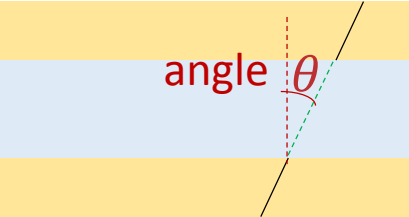
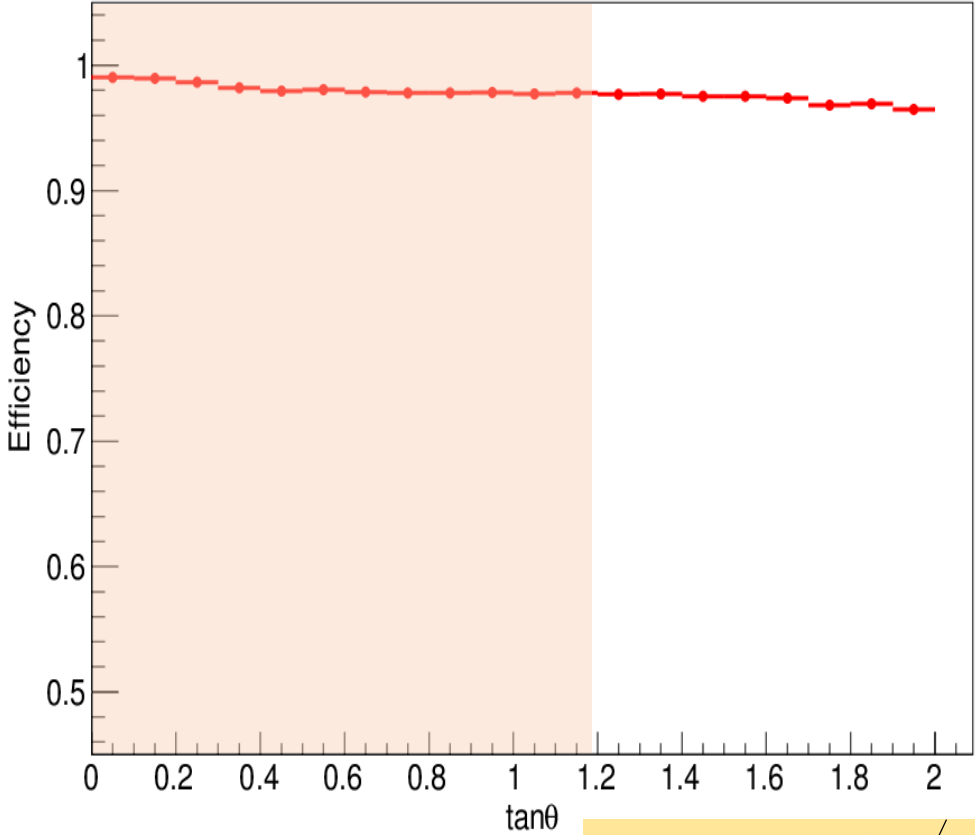


② Check existence of the predicted tracks.

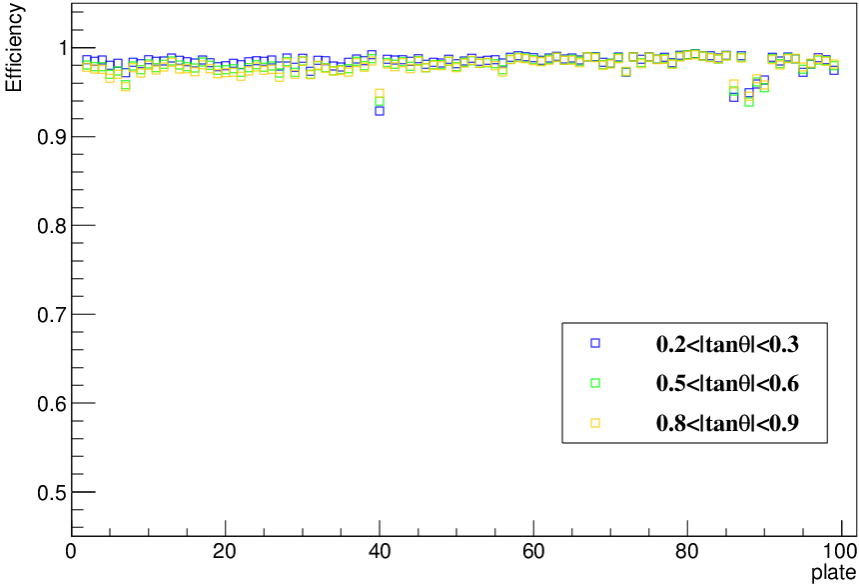
Quality check : Tracking efficiency

GRAINE2015

@Unit3-PL02 Area5

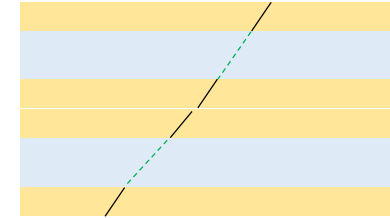


All films @Unit3 Area5



Quality check : Angle resolution

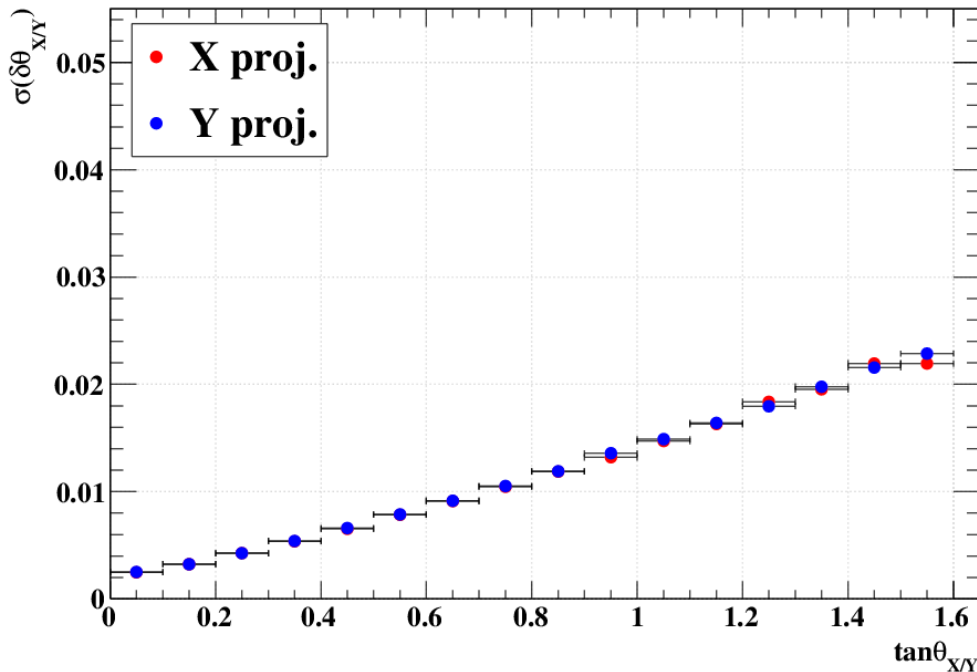
I evaluate the angle difference of tracks between films.



GRAINE2015

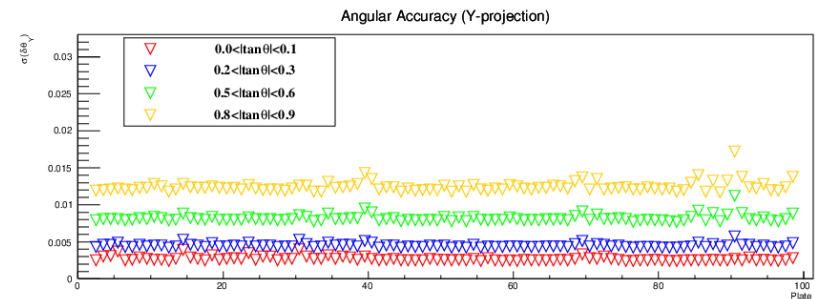
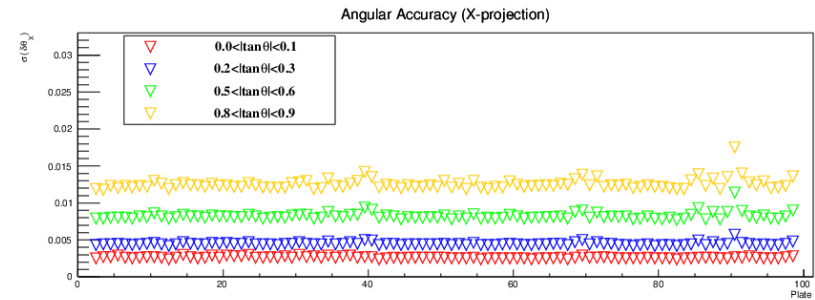
Unit3 PL02-PL03 Area5

Angle accuracy (PL02 PL03)



All films

Unit3 Area5

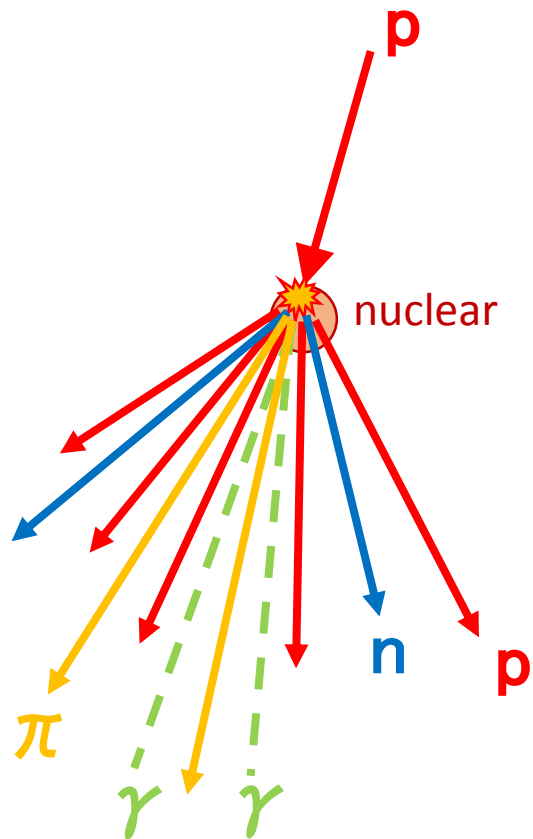


Hadronic interaction search

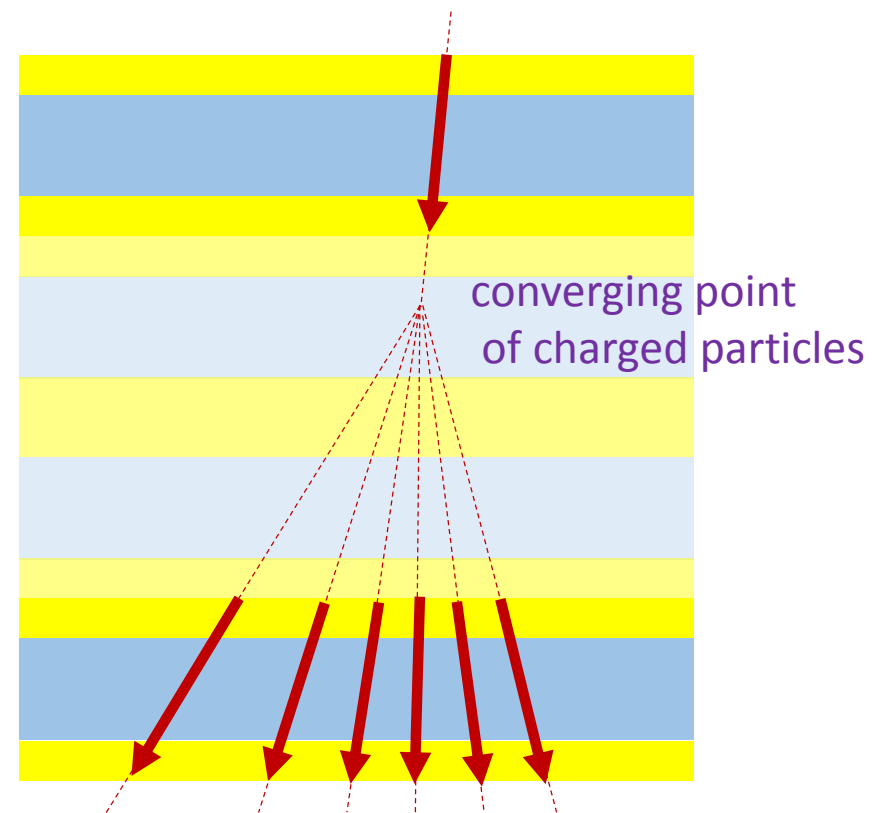
< Motivation for GRAINE >

Hadronic interactions produce gamma-rays. ($\pi^0 \rightarrow 2\gamma$)

They are useful as the calibration source for the telescope.

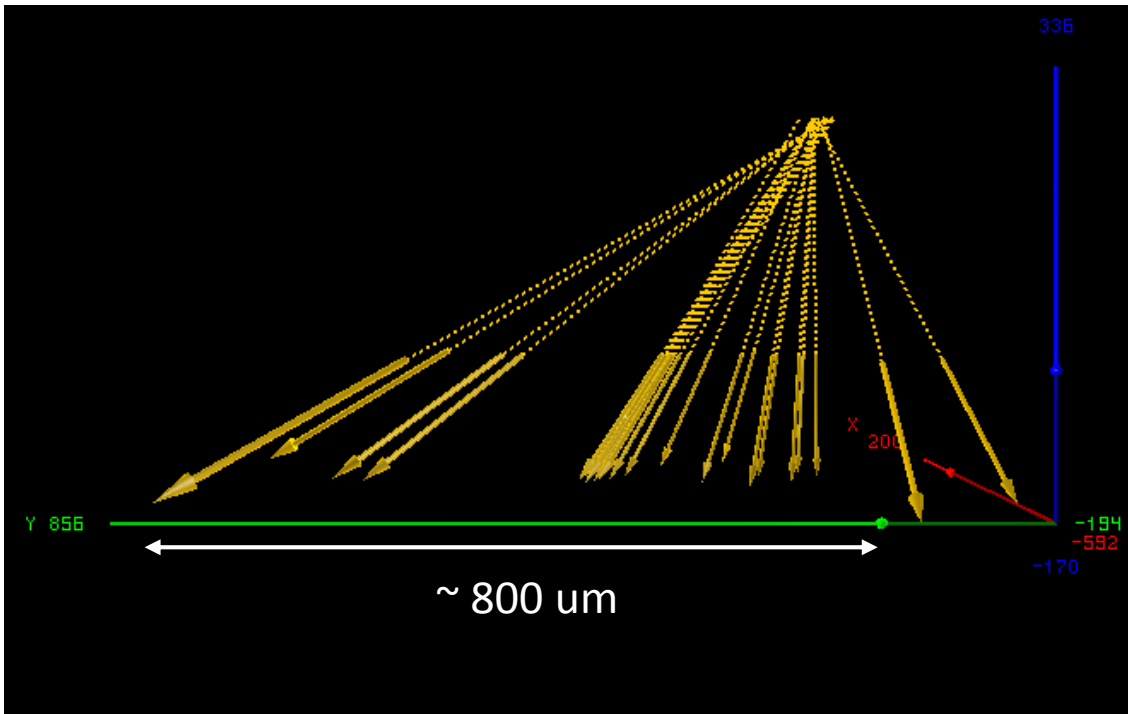


< Concept for the search >



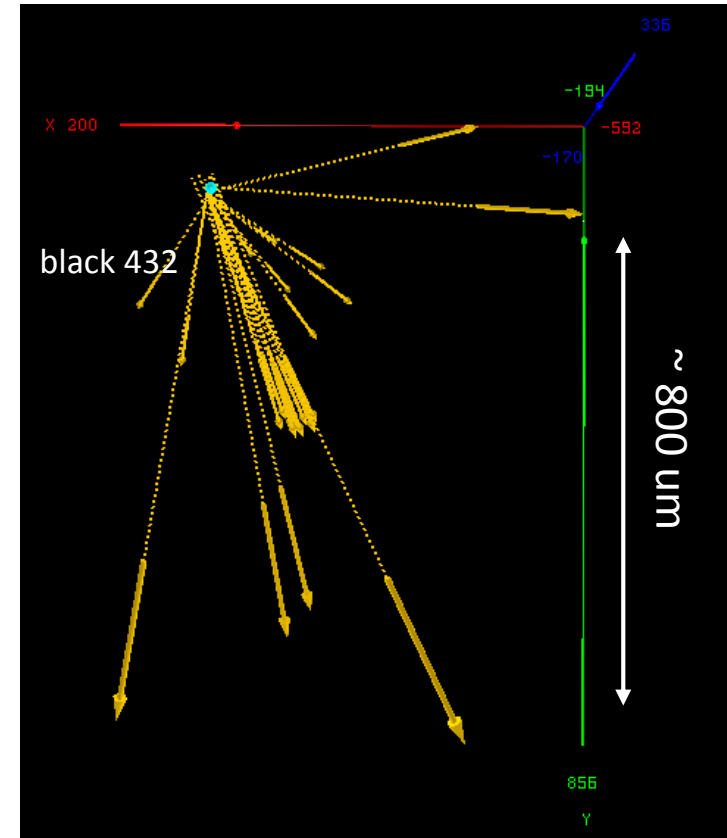
Detected events

Side view



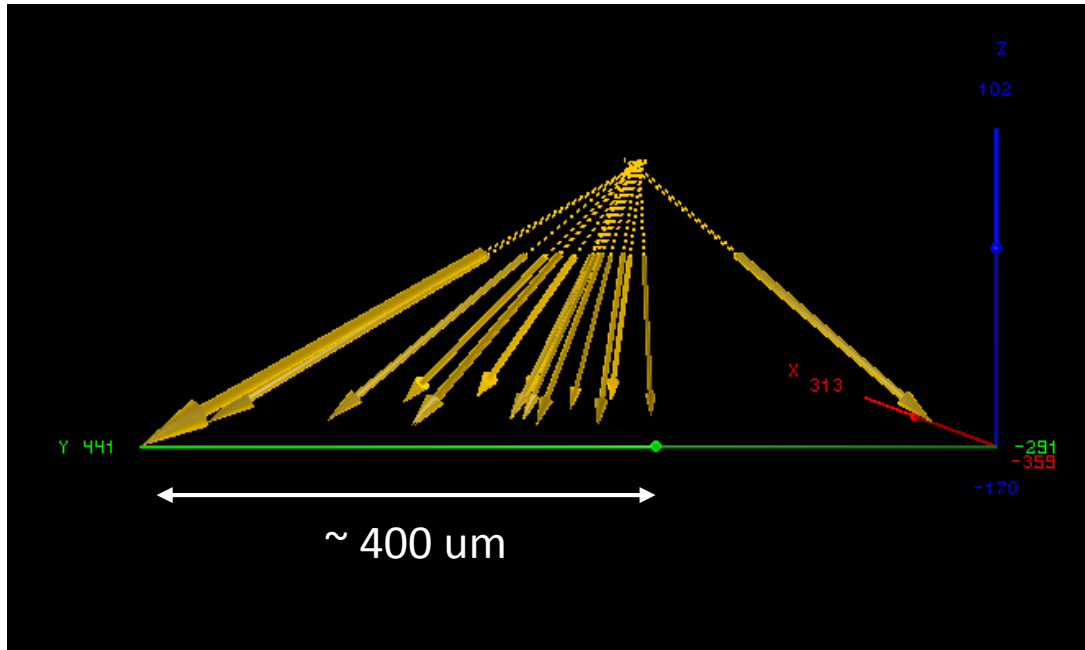
Top view

gray : PHVsum 150-299
black: PHVsum 300-



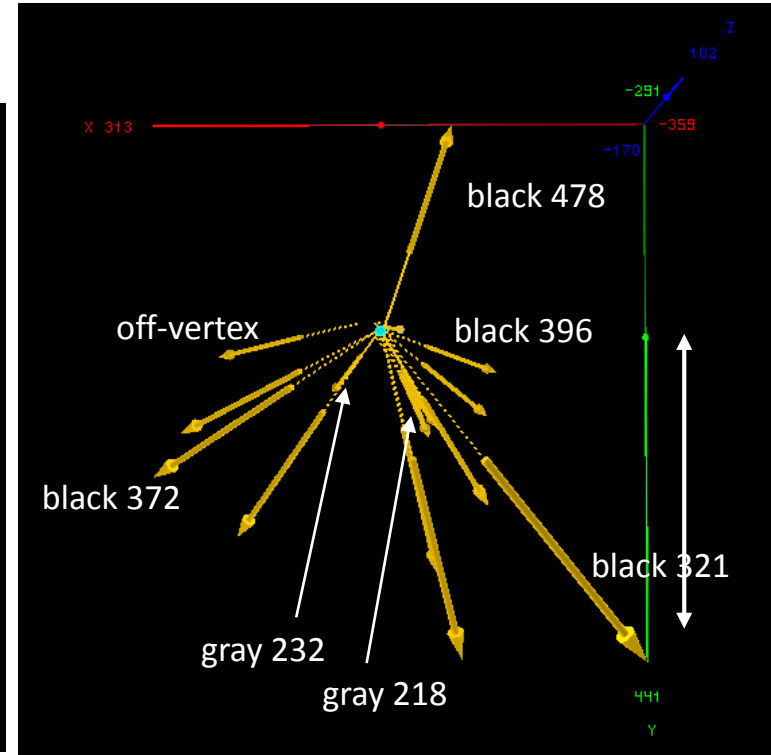
Detected events

Side view

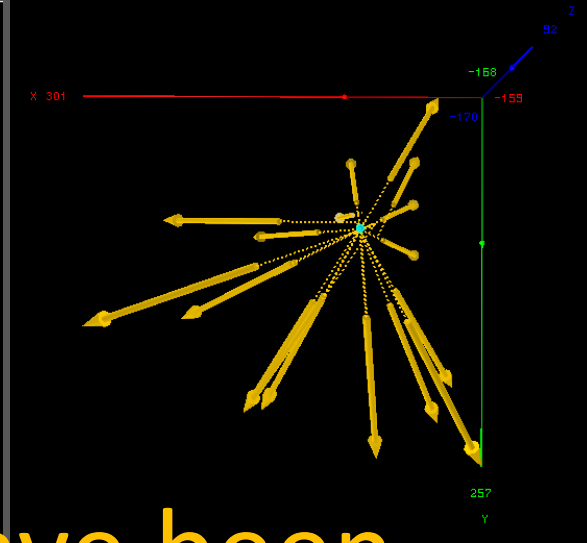
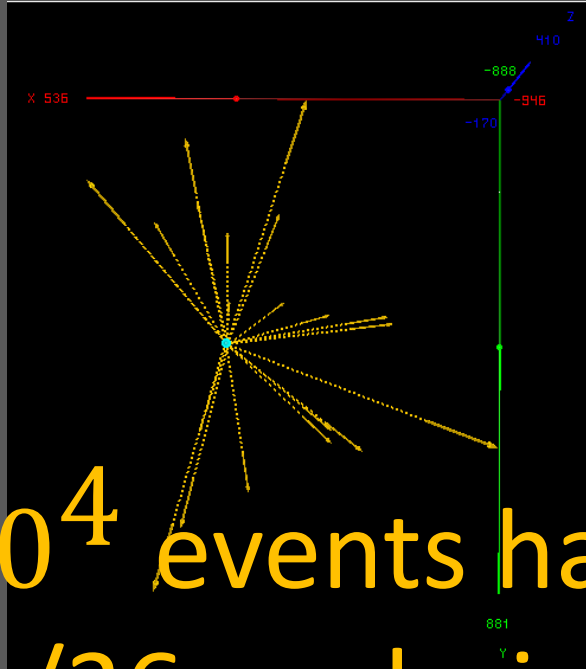
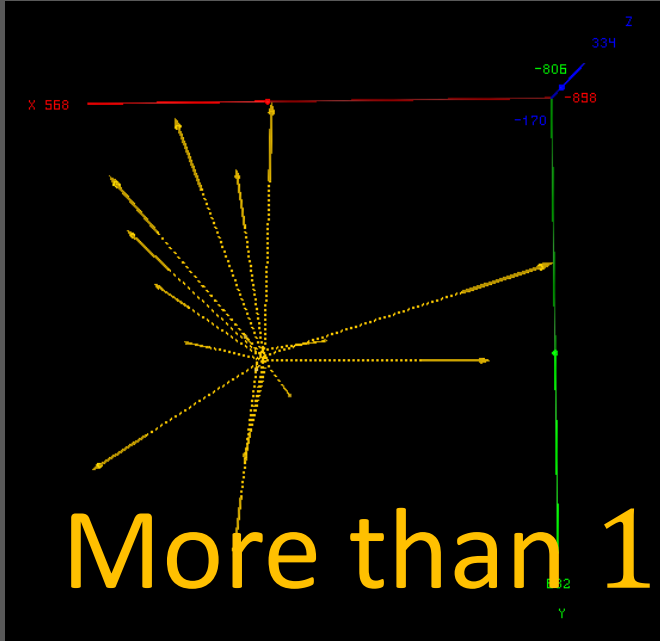


Top view

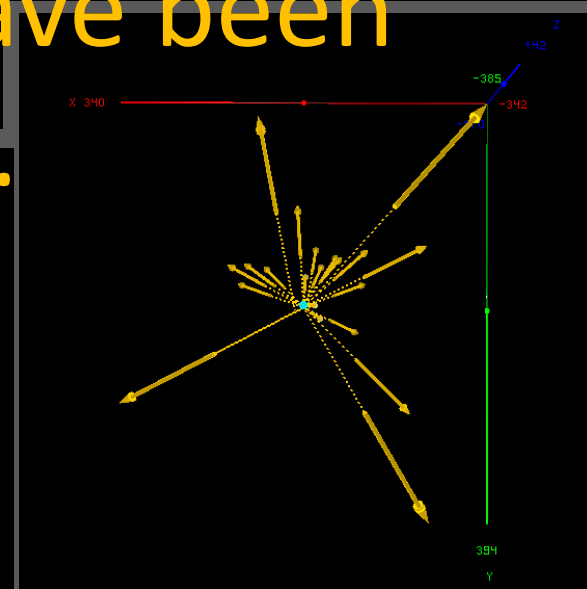
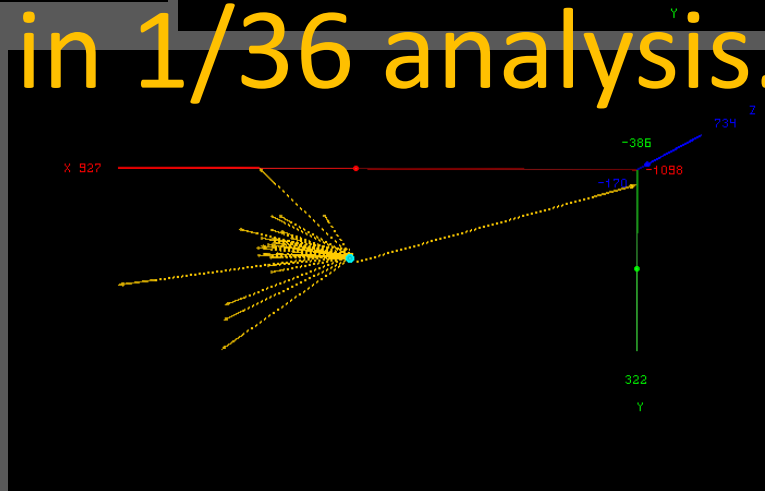
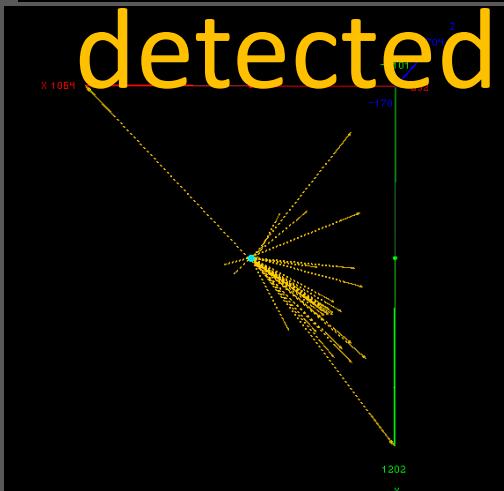
gray : PHVsum 150-299
black: PHVsum 300-



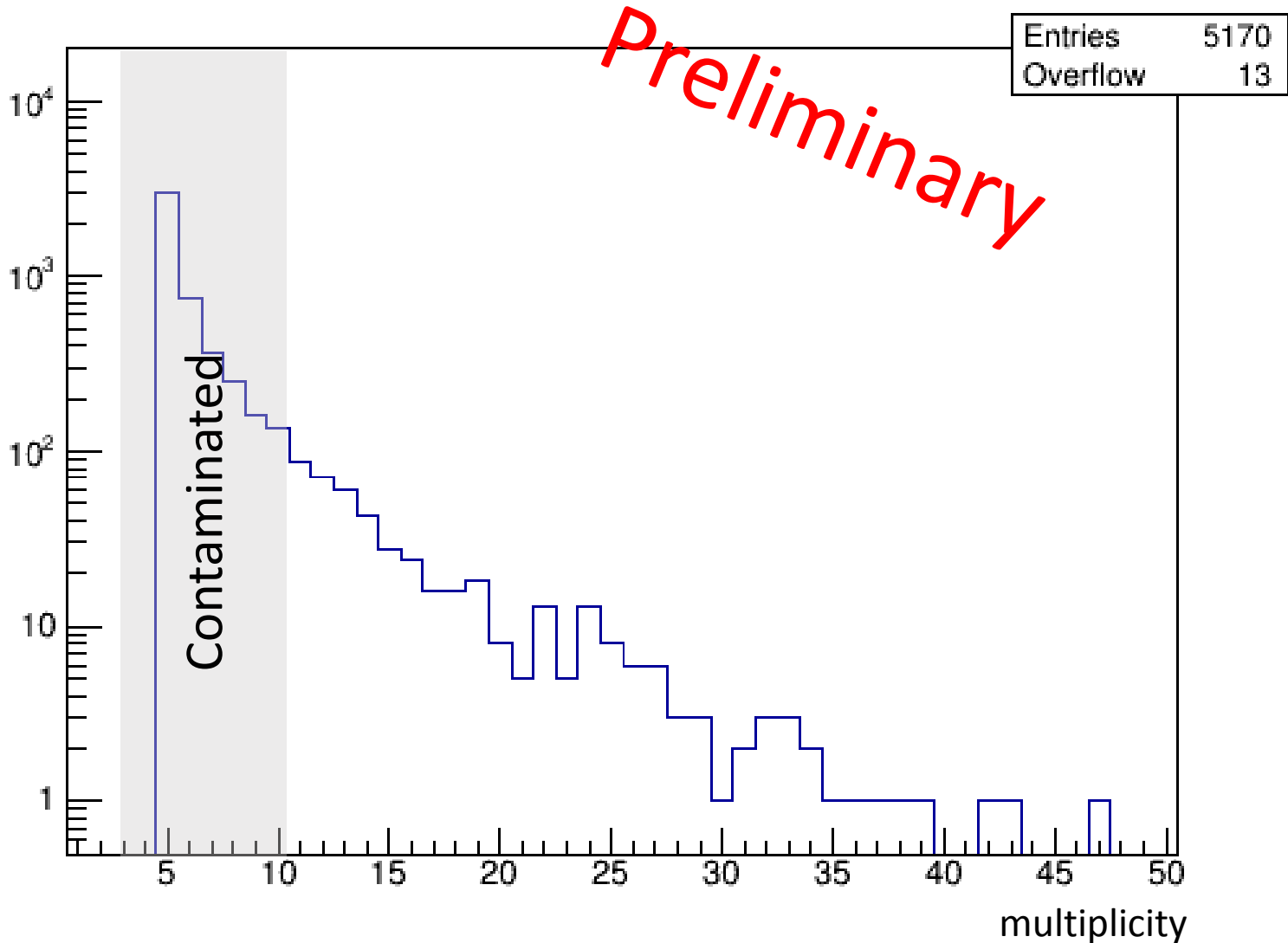
Detected events



More than 10^4 events have been detected in 1/36 analysis.



Multiplicity distribution



Secondary γ -ray detection

Event 1

γ -ray @PL08

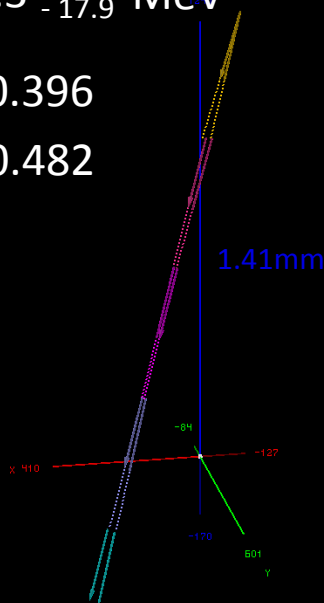
P_1 51.3 $^{+29.1}_{-11.2}$ MeV

P_2 55.0 $^{+48.2}_{-13.9}$ MeV

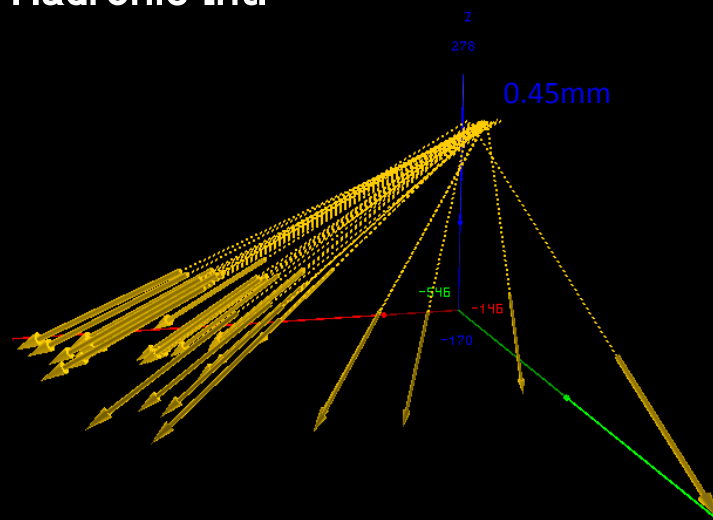
E_γ 106.3 $^{+56.3}_{-17.9}$ MeV

$\tan\theta_x$ 0.396

$\tan\theta_y$ 0.482



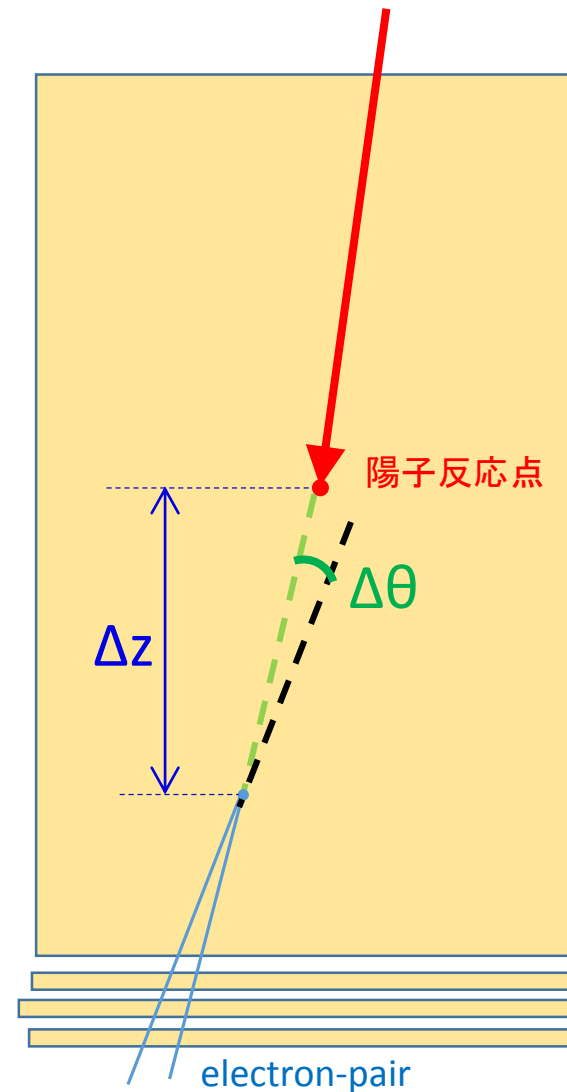
Hadronic Int.



detection @PL44

multiplicity 25

time 15:09 - 15:28 (ACST)



Δz 11.64 mm

$\Delta\theta$ 0.0161 rad

Secondary γ -ray detection

Event 2

γ -ray @PL08

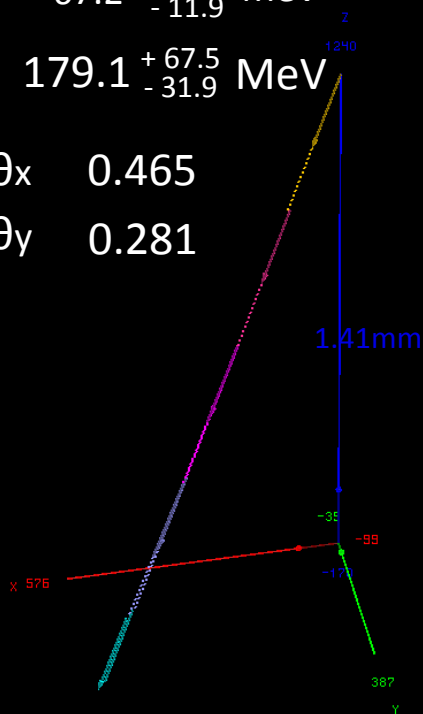
P_1 111.9 $^{+63.2}_{-29.6}$ MeV

P_2 67.2 $^{+23.7}_{-11.9}$ MeV

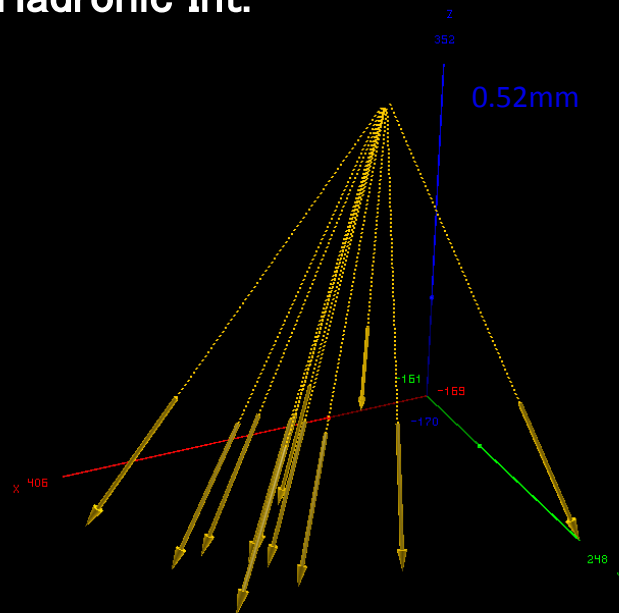
E_γ 179.1 $^{+67.5}_{-31.9}$ MeV

$\tan\theta_x$ 0.465

$\tan\theta_y$ 0.281



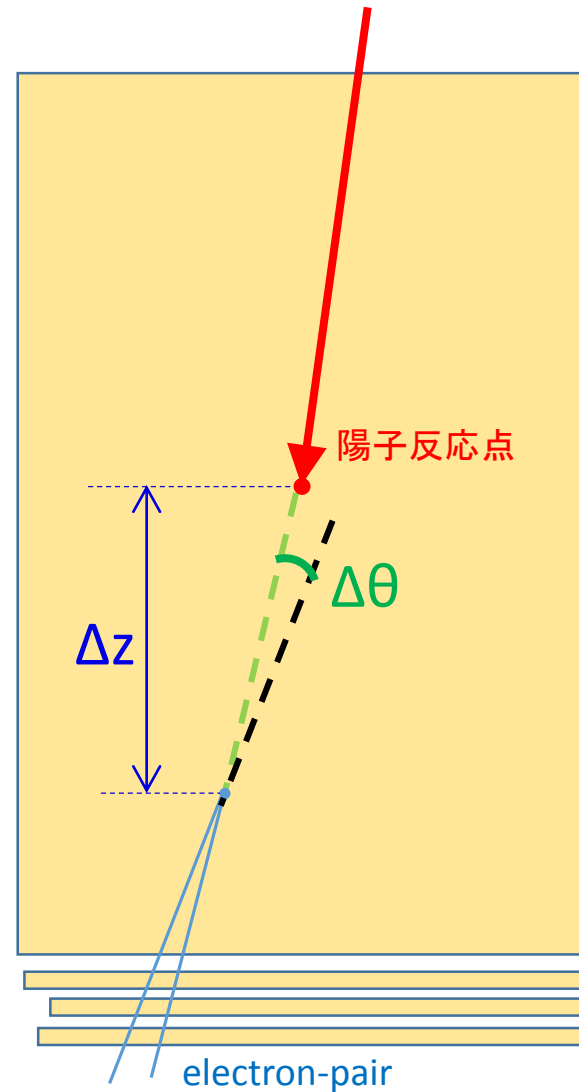
Hadronic Int.



detection @PL23

multiplicity 12

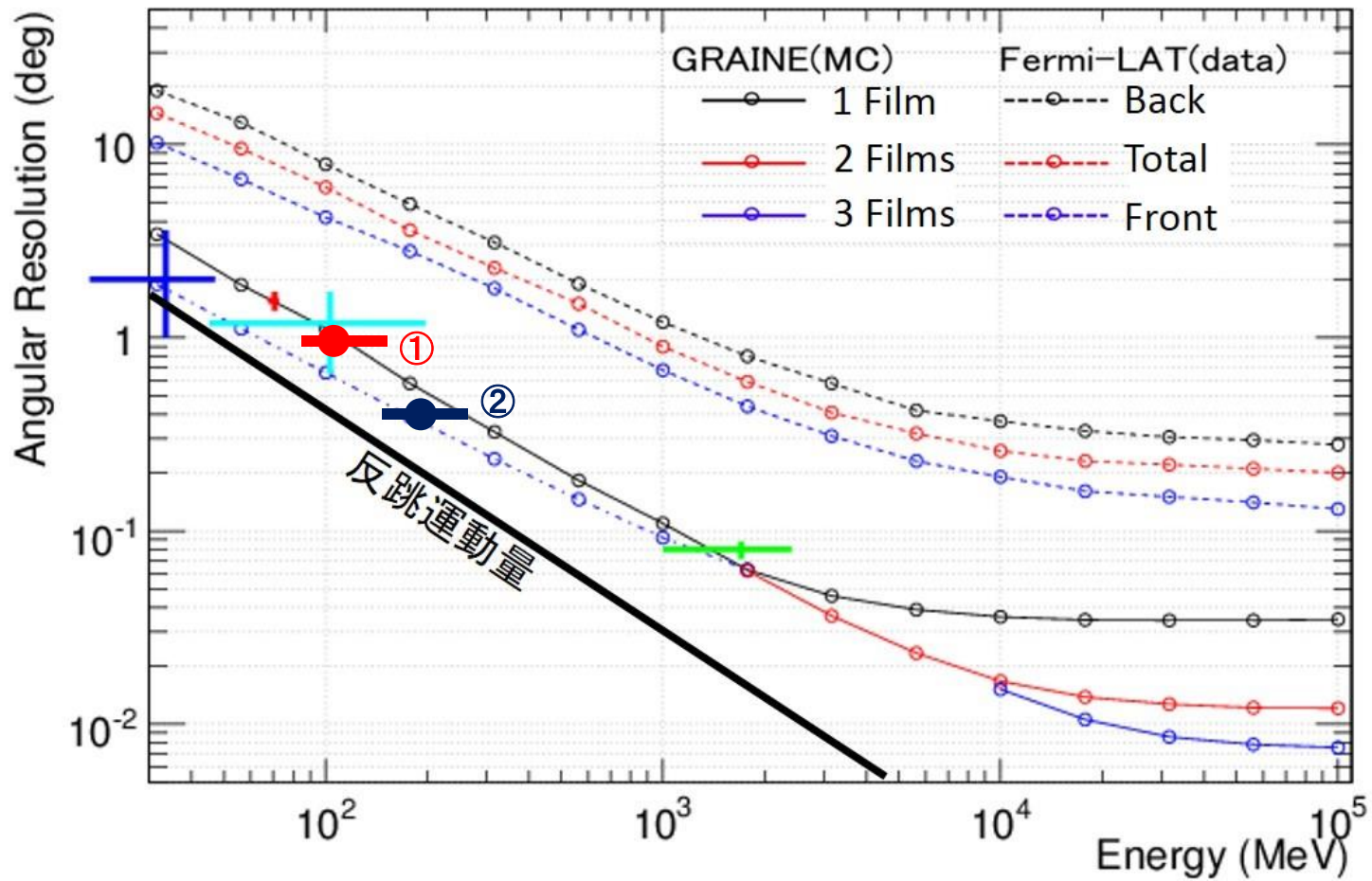
time 16:43 - 17:02 (ACST)



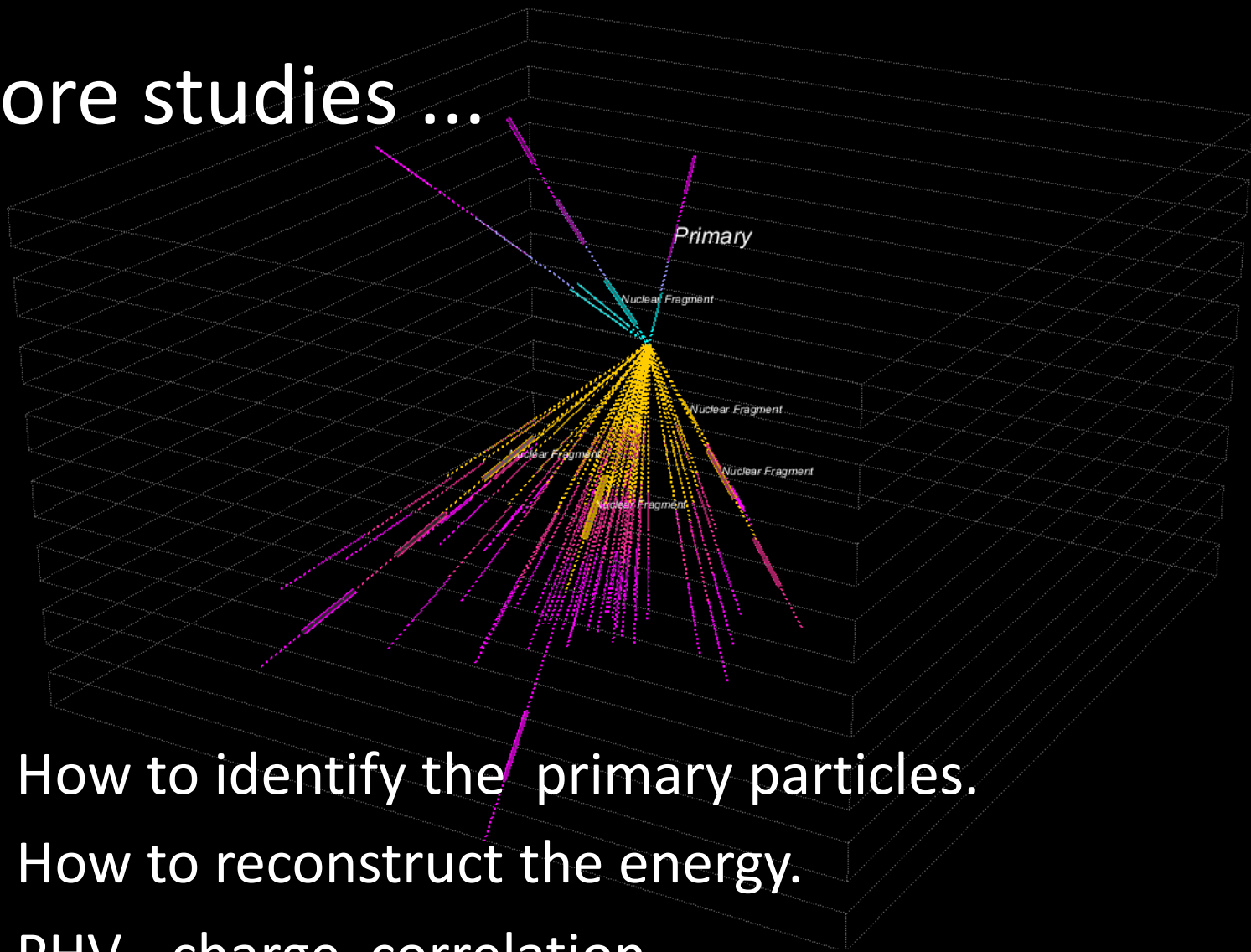
Δz 4.91 mm

$\Delta\theta$ 0.0068 rad

Plot $\Delta\theta$



More studies ...



- How to identify the primary particles.
- How to reconstruct the energy.
- PHV - charge correlation.
- Simulation study !!
- • •

- GRAINE performed balloon experiment in 2015.
Area 0.38 m^2 (Total film 48 m^2),
Flight time 14.3 hour
- $O(10^6)$ interactions are in the full data.
- Systematic detection/reconstruction method is under developing.

We will try ...

- Simulation study for detection / reconstruction.
- Proton beam test (ex. D_s -Tau).

Do you have any ideas for $O(10^6)$
cosmic-ray interaction ?