

Tracker Alignment in FASER experiment

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ForwArd Search ExpeRiment (FASER)



Standard Model explained most of physics
 However, there are questions still remain such as the identity of **dark matter** which is not found experimentally yet

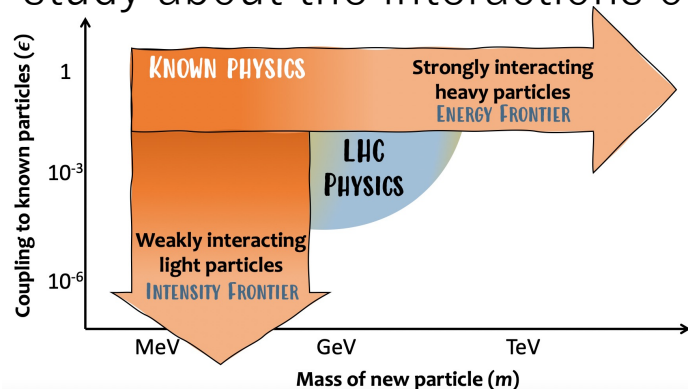
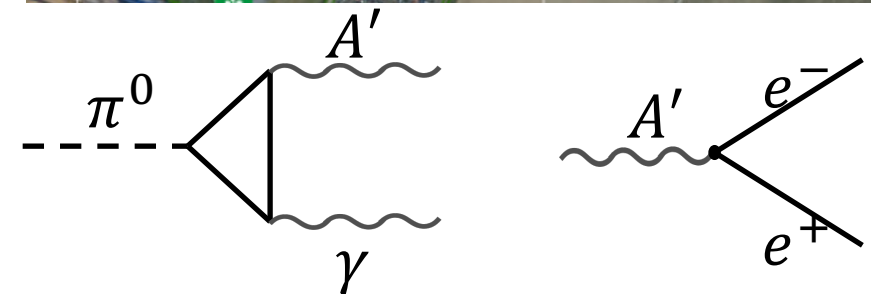
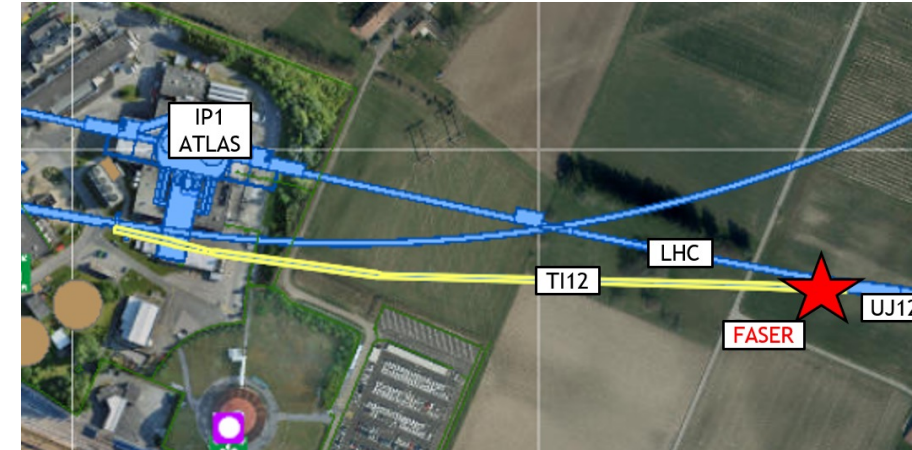
Some experiments (e.g. ATLAS, CMS) searched in **Energy Frontier** region

On the other hand, **Intensity Frontier** is also needed to search

FASER experiment is designed to search for

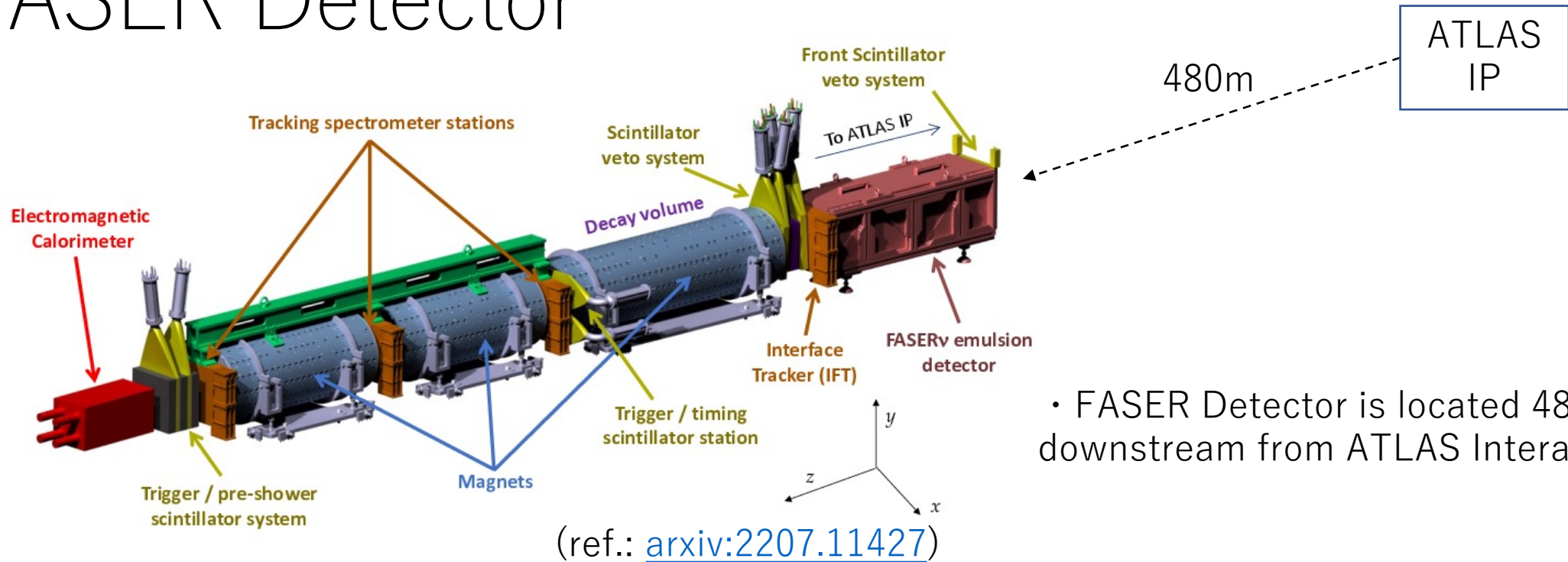
- new, light and weakly-interacting particles (e.g. dark photon, axion)

in the Intensity Frontier region and study about the interactions of high-energy neutrinos



(ref.: [Looking Forward to New Physics with FASER](#), [arXiv:1901.04468](#), [arxiv:2207.11427](#))

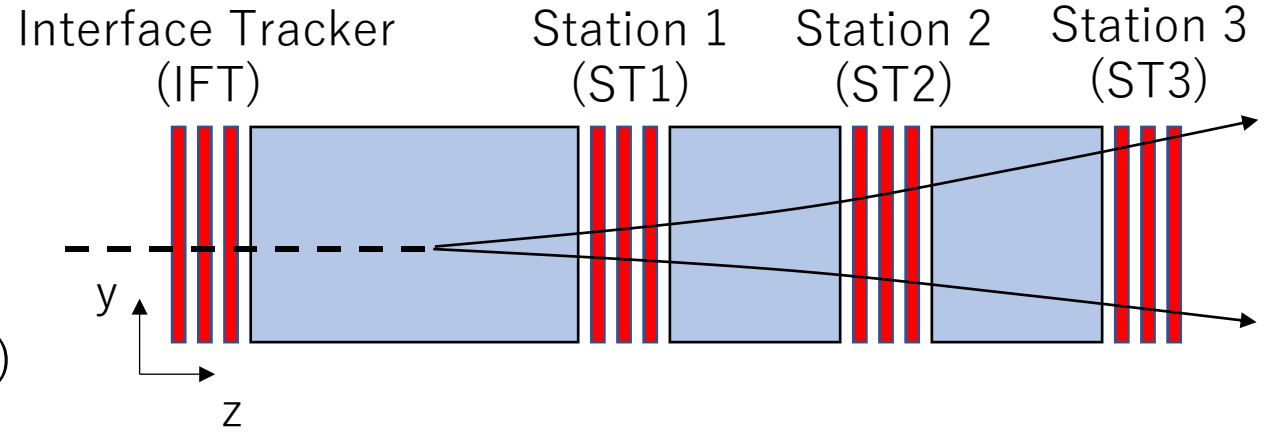
FASER Detector



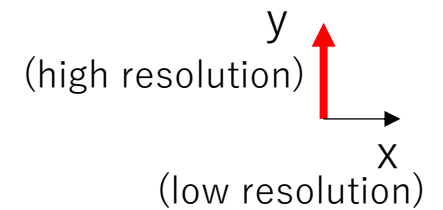
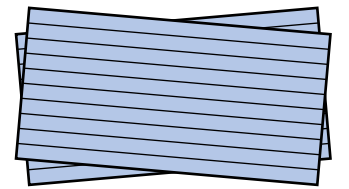
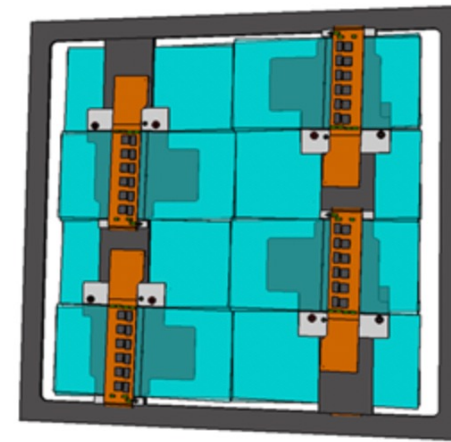
FASER Detector consists of

- Scintillators... for timing, trigger and veto charged particles from ATLAS IP
- Magnets... to separate pairs of oppositely charged particle
- Trackers... to detect two high-energy, oppositely charged tracks
- Calorimeter... to measure an electromagnetic shower via interaction with a matter
- FASER ν Emulsion Detector... to identify a flavor of neutrino

Tracker in FASER



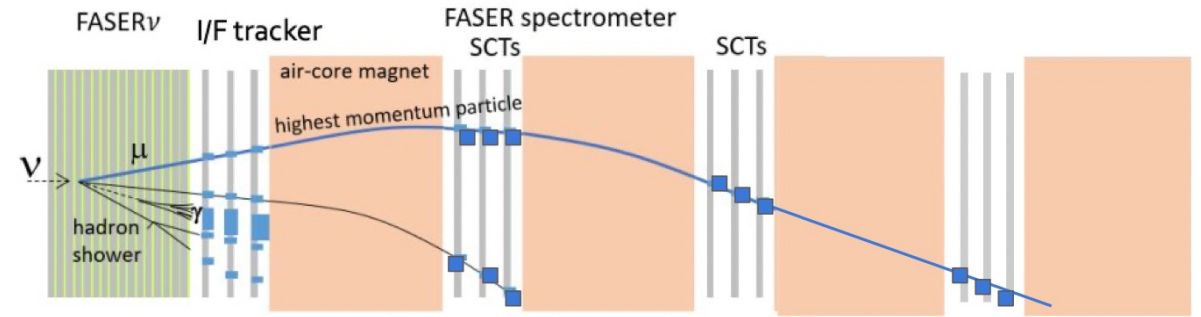
- There are 4 stations (Interface Tracker (IFT) + Station (ST) 1, 2, 3)
- Each station has 3 layers
- Each layer contains 8 modules
- Each module has 2 sides to get a sensitivity to both of x and y direction



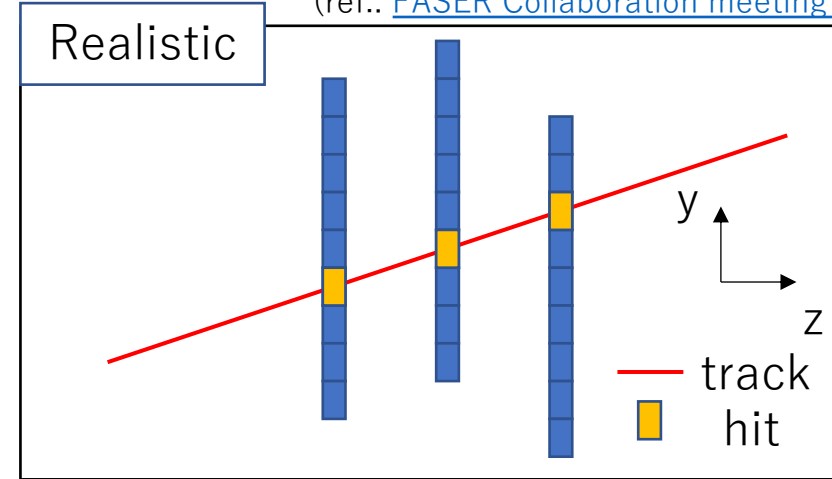
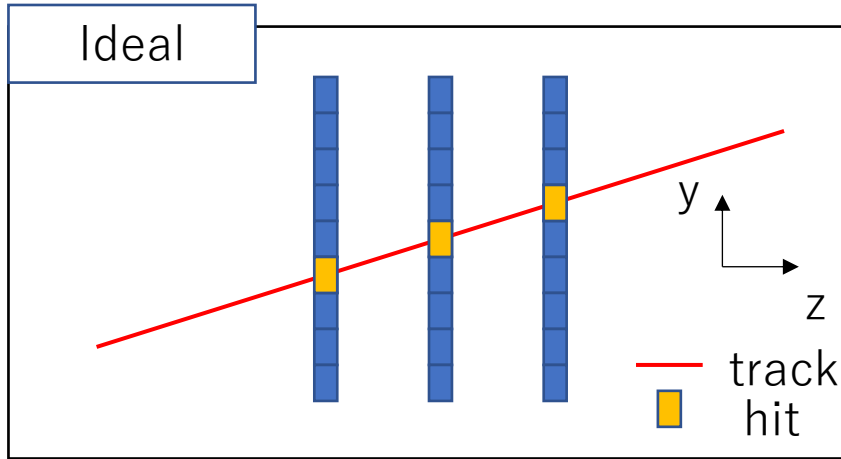
- Each side has 768 strips at a constant pitch of $80 \mu\text{m}$
- 40 mrad angle between the front and back sides
- Tracker has high resolution for y direction

(ref.: [FASER Tracker](#))

Tracker Alignment



(ref.: [FASER Collaboration meeting #5-Emulsion/I/F matching](#))

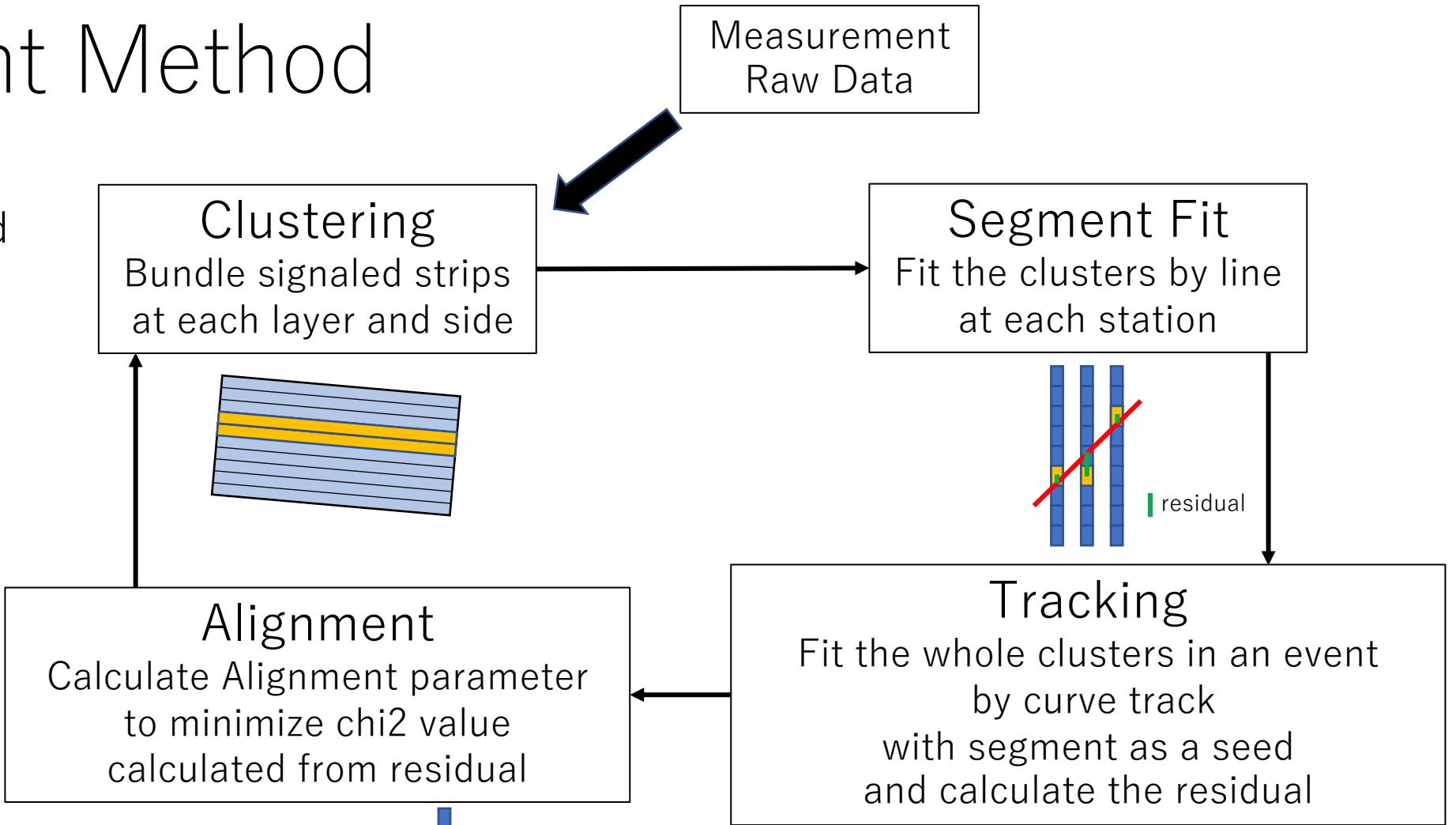


If the geometry is perfect, layers are completely parallel and only z -coordinates differ
However, the position of detectors can shift, so, we have to calibrate position to derive exact information of particles from measurement
Alignment is important to connect the track with the track in emulsion detector

The alignment parameters has 576 (x, y, z , and rotation- x, y, z for 96 modules) degrees of freedom, so, we determine these parameters by using multiple tracks

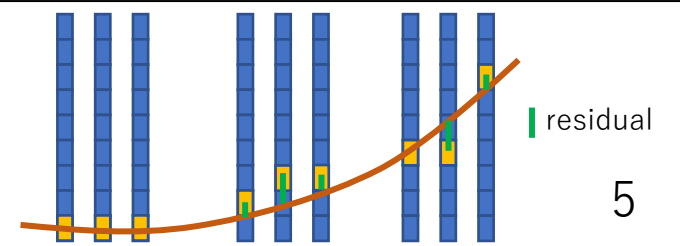
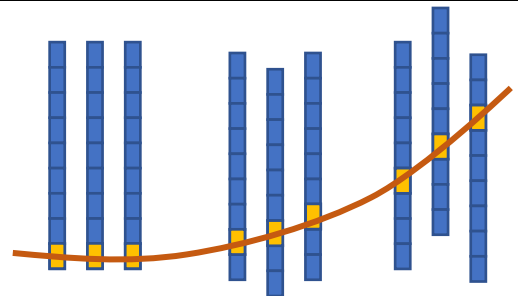
Alignment Method

Alignment is performed in the steps shown on the right figure



Alignment shift influences the construction of the segment and track

So, we have to iterate these steps to get best parameters

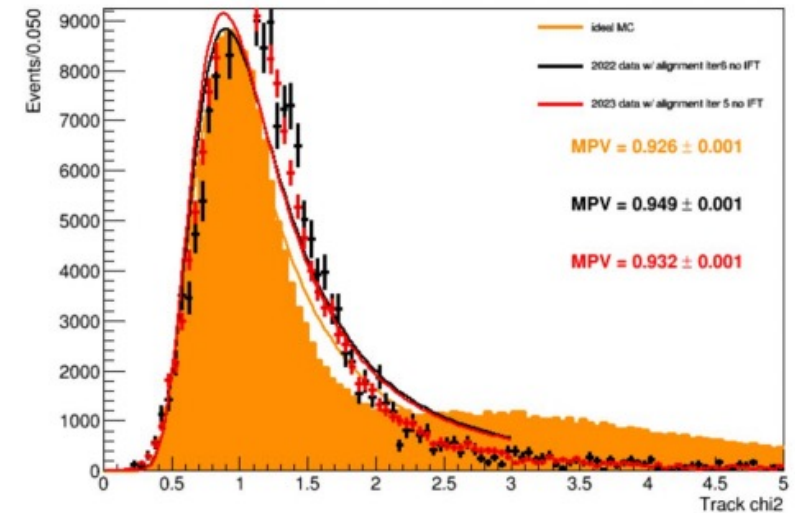


Status of Alignment

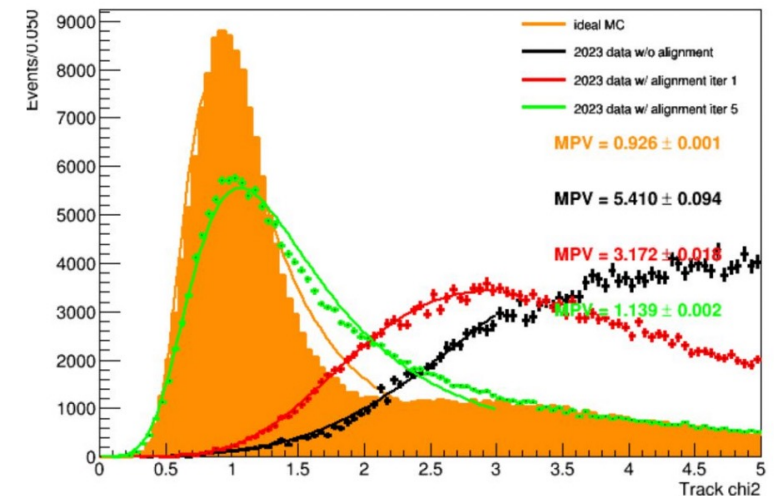
So far, we succeeded in alignment with the clusters in 3 Tracker station (without IFT)

However, we have not succeeded in alignment with the clusters in all 4 stations yet
So, I studied about an improvement of the method of alignment in this program

Chi2 distributions of 2022 and 2023 data without IFT



Chi2 distributions of 2023 data with IFT



My study

Until now, I tried to check the track and to find the difference between IFT and other trackers

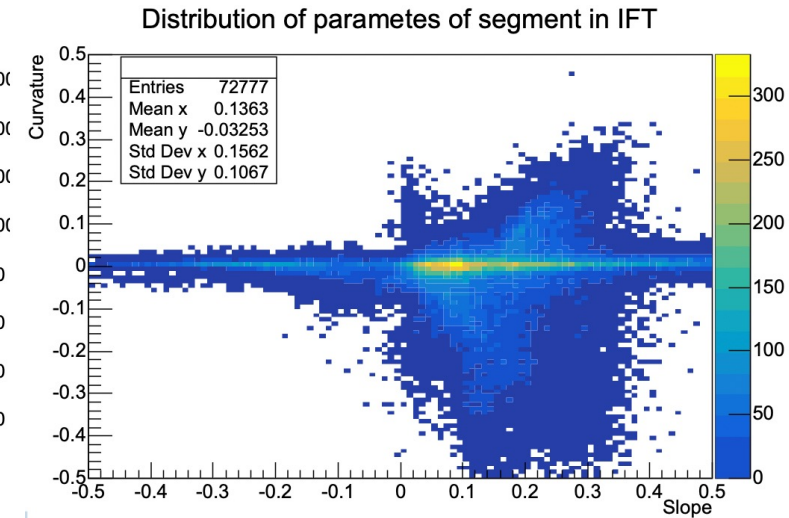
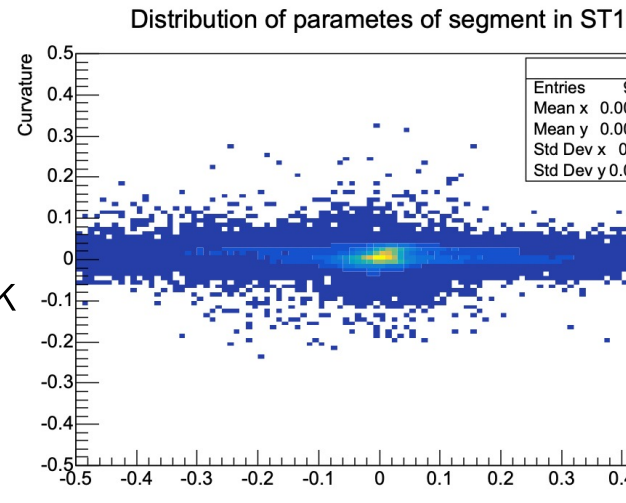
I found

- curious distribution of feature of tracks in IFT
- some strange tracks which seems not to be used in alignment

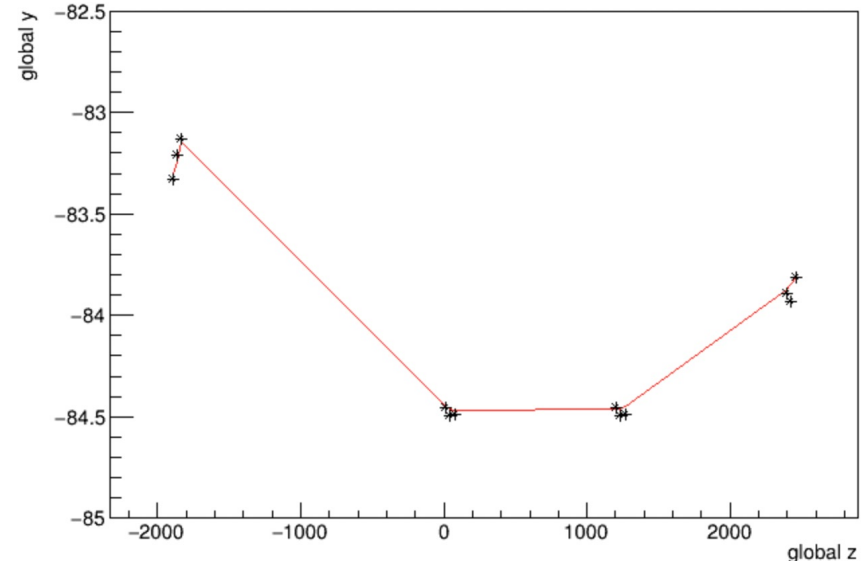
Currently, strange tracks are also used for the alignment optimization

However, it should not be included

I plan to eliminate those tracks by optimizing cuts



an Example of Strange Track



Curvature:
Positive when
the track is
concave up and
Negative when
concave down
in the station

Summary

The target of FASER experiment is new, light and weakly-interacting particles

FASER detectors have 4 trackers and the alignment of trackers is needed

So far, the alignment using 3 stations (without IFT) was succeeded, however, some problems were occurred when combine it with measurement in IFT

Now I am trying to determine the cause and make some additional cut to select good track to using for alignment

