MEG II実験におけるマルチピクセル陽電子時間検出器のための粒子飛跡を用いた位置較正手法の開発

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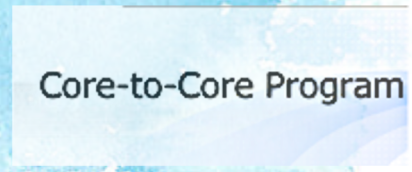

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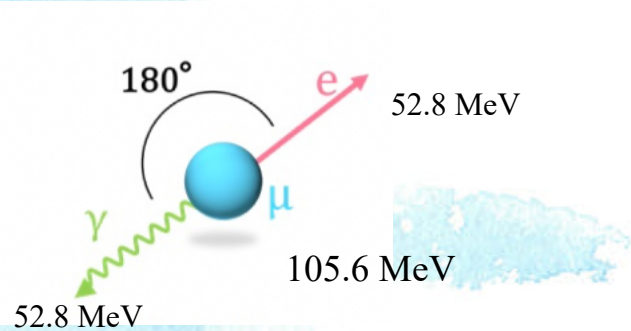
$\mu \rightarrow e + \gamma$



- One of charged lepton flavor violating (cLFV) decays, which is forbidden in the Standard Model.
- Many of the new physics beyond the Standard Model predict that the branching ratio is $\mathcal{O}$ (10^{-13}) – $\mathcal{O}(10^{-14})$ mediated by an undiscovered particle in $\mathcal{O}(10)$ TeV.
- Considering the high energy scale particle and the small branching ratio, high intensity muon beam is effective to search the decay.
- Upper limit on the branching ratio: $\mathcal{B}(\mu^+ \rightarrow e^+ + \gamma) < 4.2 \times 10^{-13}$ (90% C.L.)

  ↑ Final results of the MEG experiment

MEG II experiment

- Upgrade of the MEG experiment

- The search for $\mu^+ \rightarrow e^+ + \gamma$

  μ^+ : most intense beam at PSI (10^8 μ^+ /s)

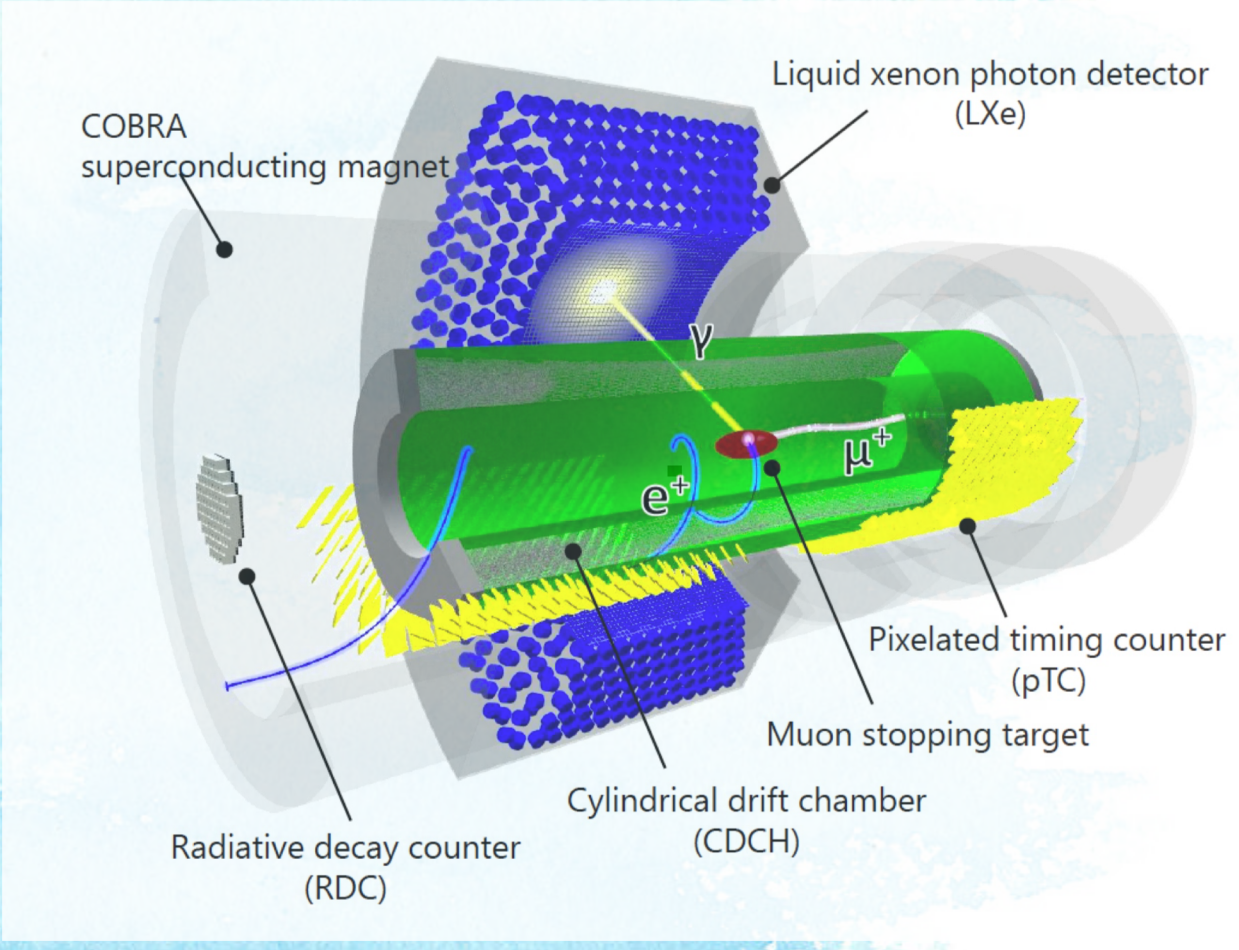
  γ : detected by LXe

  e^+ : bent by COBRA magnet,

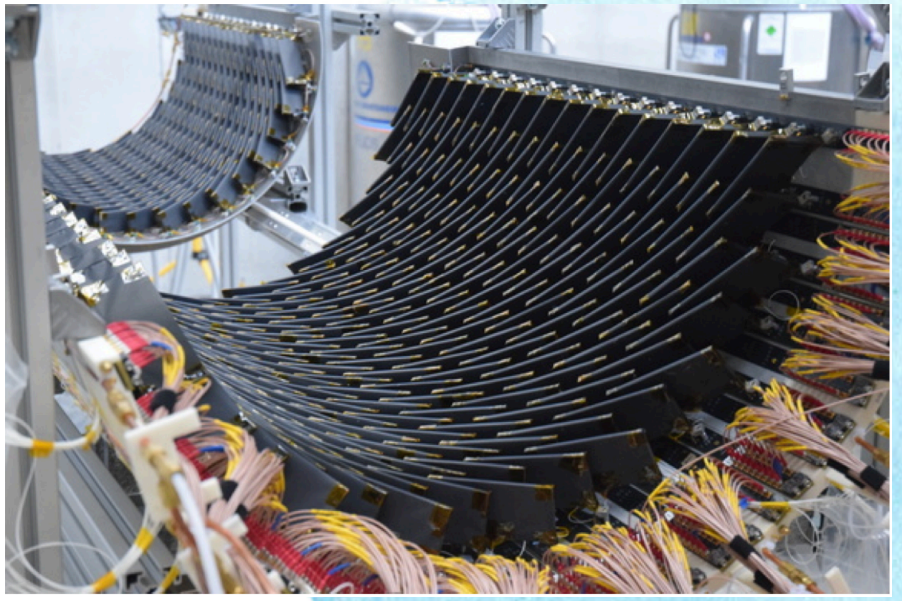
  detected by pTC & CDCH

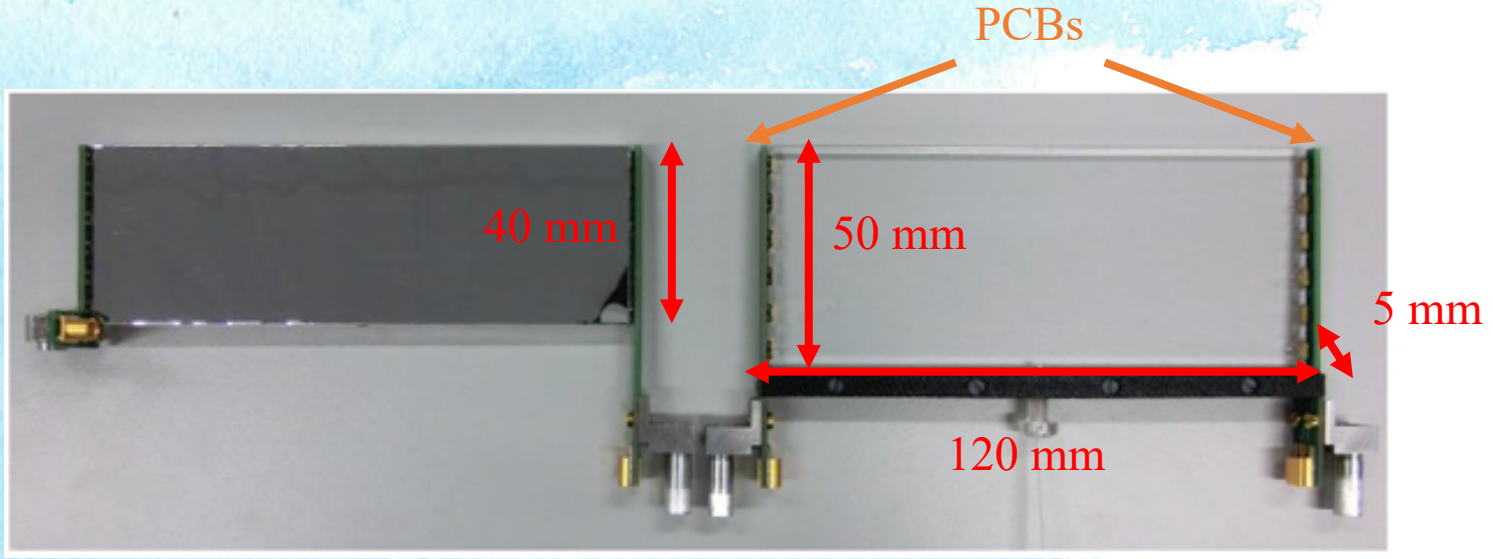
- expected sensitivity:

  $\mathcal{B}(\mu^+ \rightarrow e^+ + \gamma) \sim 6 \times 10^{-14}$



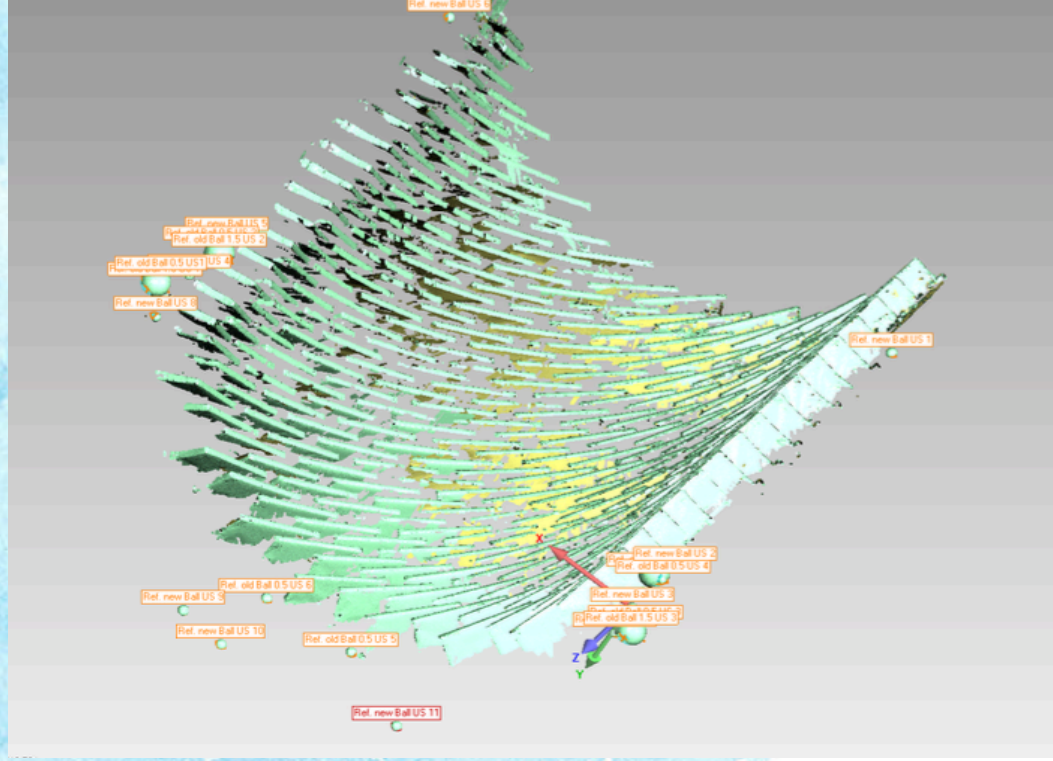
MEG II - Pixelated Timing Counter



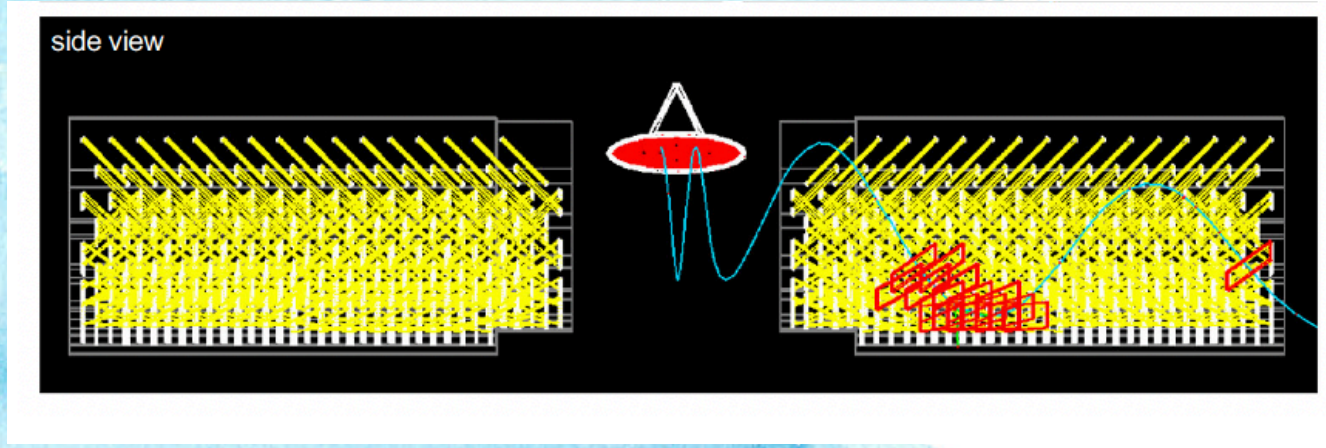


- a highly segmented (256 tiles ×2) scintillation detector on two semi-cylindrical super-modules.
- each counter consists of a 120mm × 40mm (50mm) × 5mm plastic scintillator.
- read by series connection of 6 SiPMs attached to both side of the scintillator.
- time resolution ~ 38 ps for 9 hits (average number of hits for signal e^+), whereas 90~100 ps for a single hit.

pTC alignment



- 3D survey ← JPS2019秋季大会、2020年次大会
- from e^+ track ← this talk



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Flowchart

- Generate MC events with some geometrical deviations added to each pixel.

Original deviation

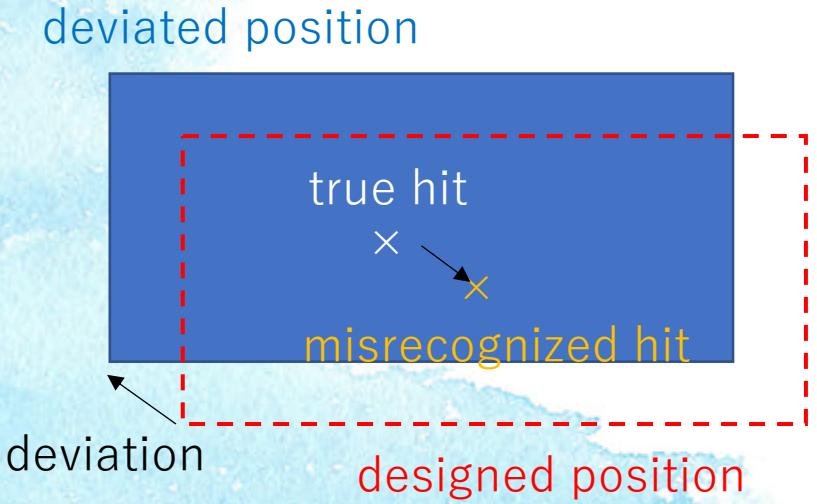
- Reconstruct position of hits on each counter which considered to be affected by geometrical deviations, and tracks which considered to have more precise position information.

Can be reflected?

- Compare hit positions reconstructed by each counter and by track.

Some bias?

Event generation & analysis



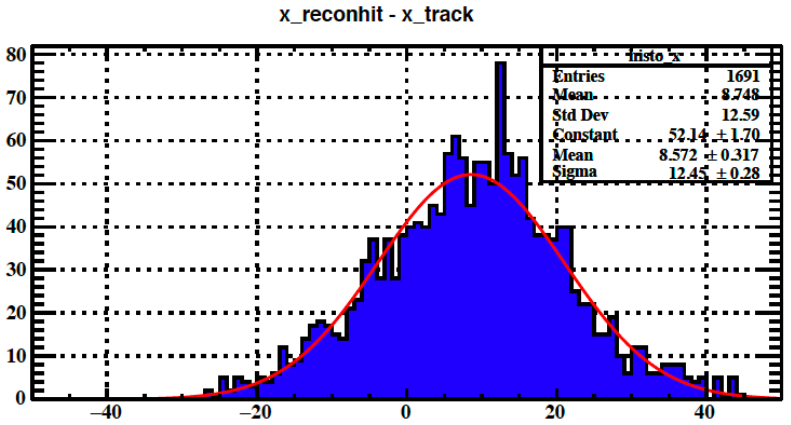
- The major mode of muon decay — Michel decay: $\mu \rightarrow e\nu_e\nu_\mu$
- Only 451st pixel is given a randomly generated deviation ($\Delta x,y,z < 5mm$)
- Compare reconstructed hits by misrecognized geometry and in track.

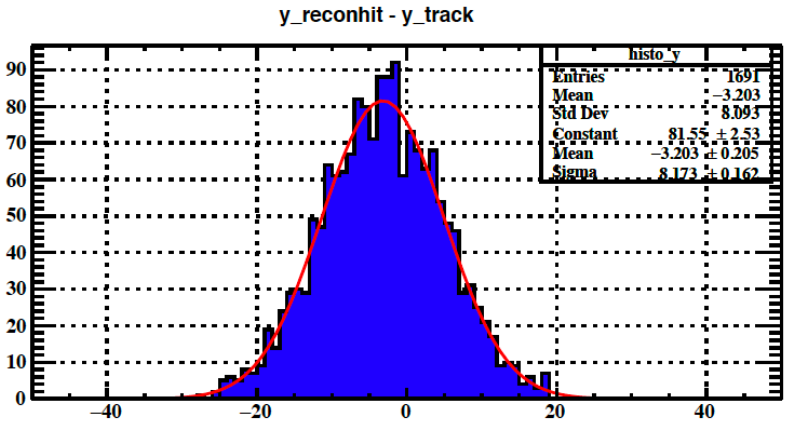
※ Because track reconstruction uses pTC hits information including their positions, tracks are naturally affected by the deviations.
(→Discussion)

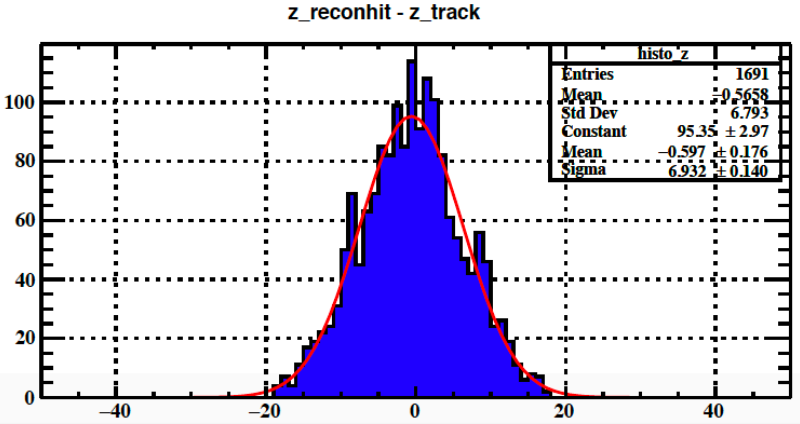
Results

- The deviation b/w hit position and position in track shows
  mean of Δx: 8.6 ± 0.3 mm
  mean of Δy: -3.2 ± 0.2 mm
  mean of Δz: -0.60 ± 0.2 mm

- The pixel has been given these deviations:
  x: -0.907781 mm
  y: +1.11799 mm
  z: +1.80194 mm







Discussion

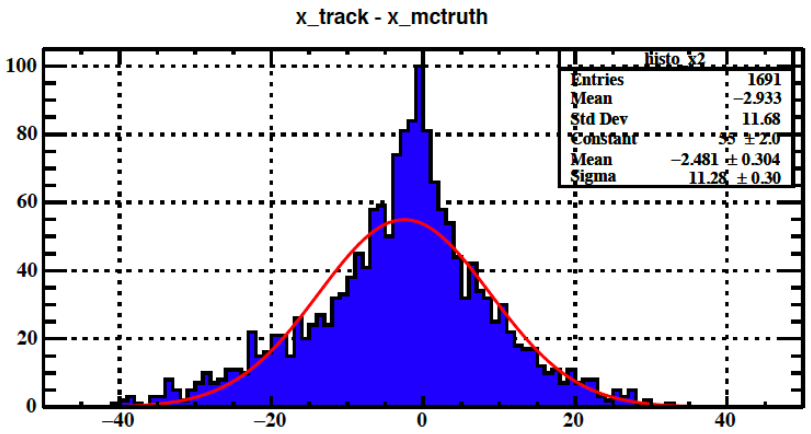
- Here are deviations b/w track and MC truth, as track reliability.

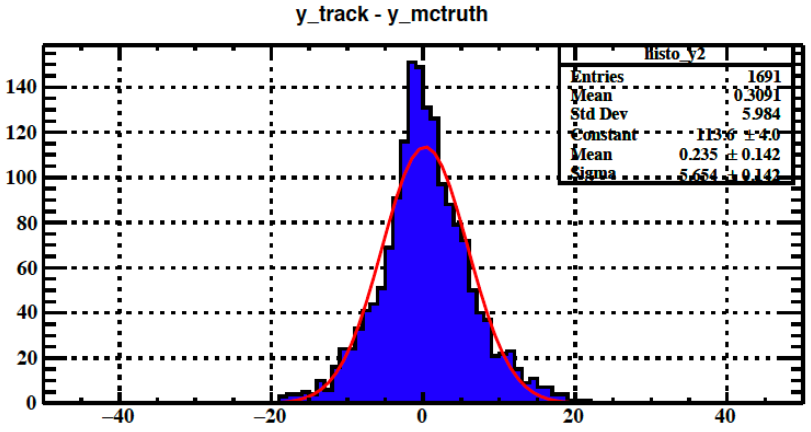
※MC Truth = average of entering/exiting the pixel

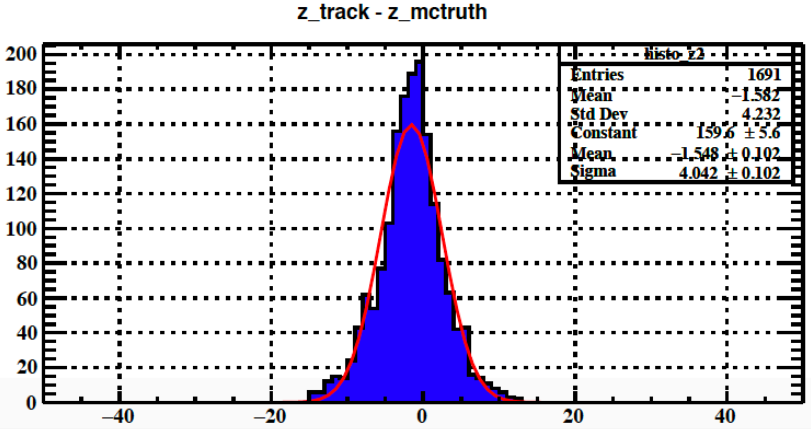
mean of Δx: -2.4 ± 0.3 mm
mean of Δy: 0.24 ± 0.1 mm
mean of Δz: -1.5 ± 0.1 mm

- x,z information in track is not compatible with *O*(1 mm)
- y information is likely to be accurate in *O*(1 mm), but the result does not match by ~2mm.

- Track alignment can no more than guessing the plus and minus of deviation, at least in the current condition.







Summary

- Develop a new alignment method for the positron timing counter (pTC) in the MEG II experiment, which can be completed only by analyzing the run data.
- The deviation of the position of each pixel should be reflected in the deviation of the hits reconstructed on the pixel and the hits on the particle track which is comprehensively reconstructed.
- From MC simulation, the position measurement seems not to be accurate enough to determine the deviation quantitatively.

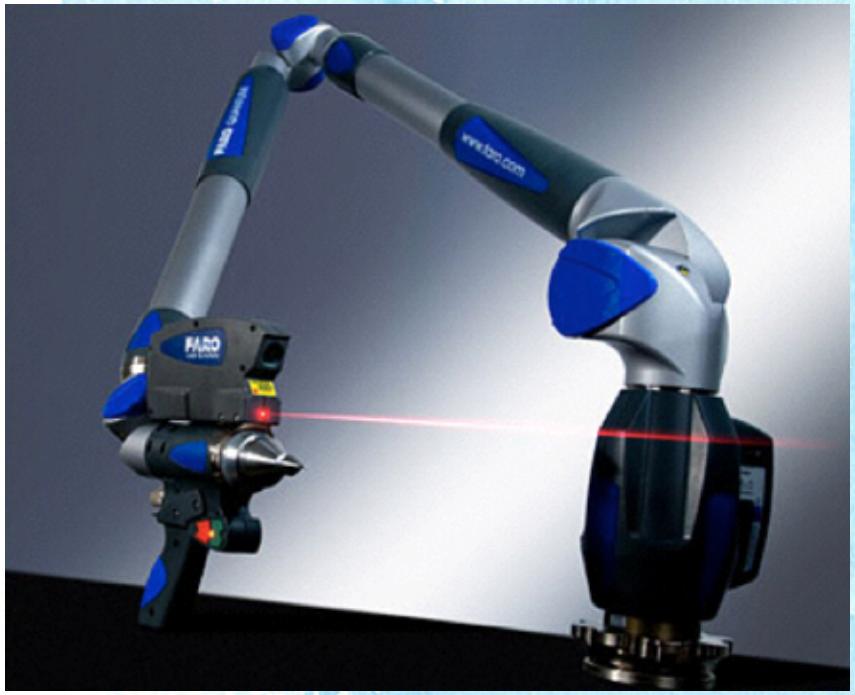
Prospect

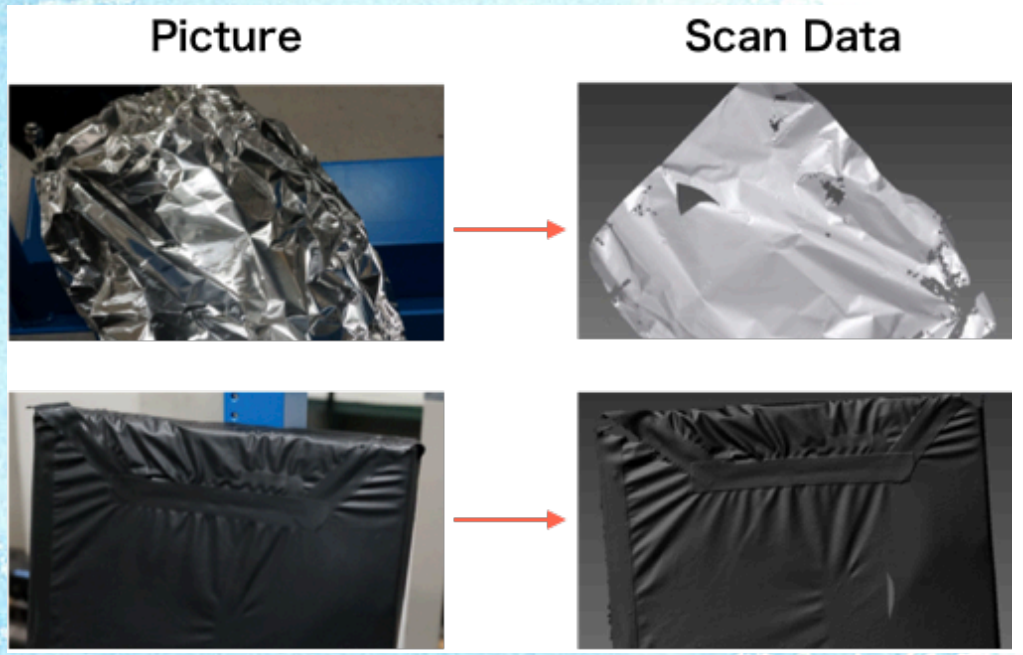
- Appearance of position deviation probably differ in each xyz direction, because a pixel only can accurately reconstruct hit position in its width direction.
- Investigate more pixels and xyz should be transformed to local coordinates of each pixel.
- Finally, apply this method to the actual run data and compare the results with the 3D scan method.

Back up

Instruments - 3D scanner

3D Scanner (FARO Edge ScanArm HD)





- Accuracy ± 25μm
- Scan rate : 560,000 points/sec
- Cited from https://www.faro.com/resource/faro-edge-scanarm-hd/