部分軌跡を用いたMEG II実験陽電子スペクトロメータ検出器の性能評価の試み

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日本物理学会第75回年次会

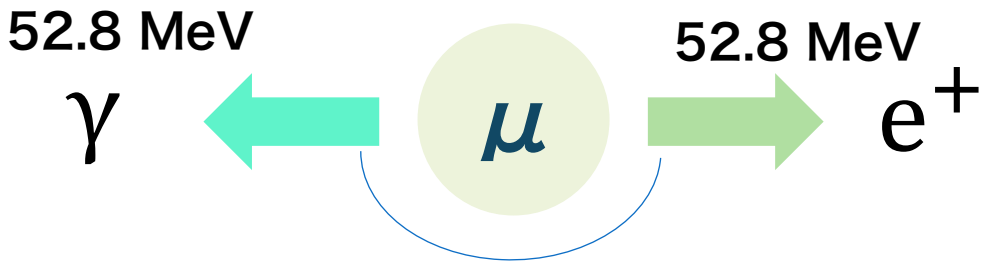
MEG II
Mu - E - Gamma collaboration
ICEPP
The University of Tokyo
Core-to-Core Program

Outline

- Introduction
  - $\mu \to e\gamma$ Decay
  - MEG II Experiment
  - Positron Spectrometer
- Detector Commissioning 2018-2019
- Commissioning Data Analysis
- Summary

$\mu \rightarrow e\gamma$ Decay

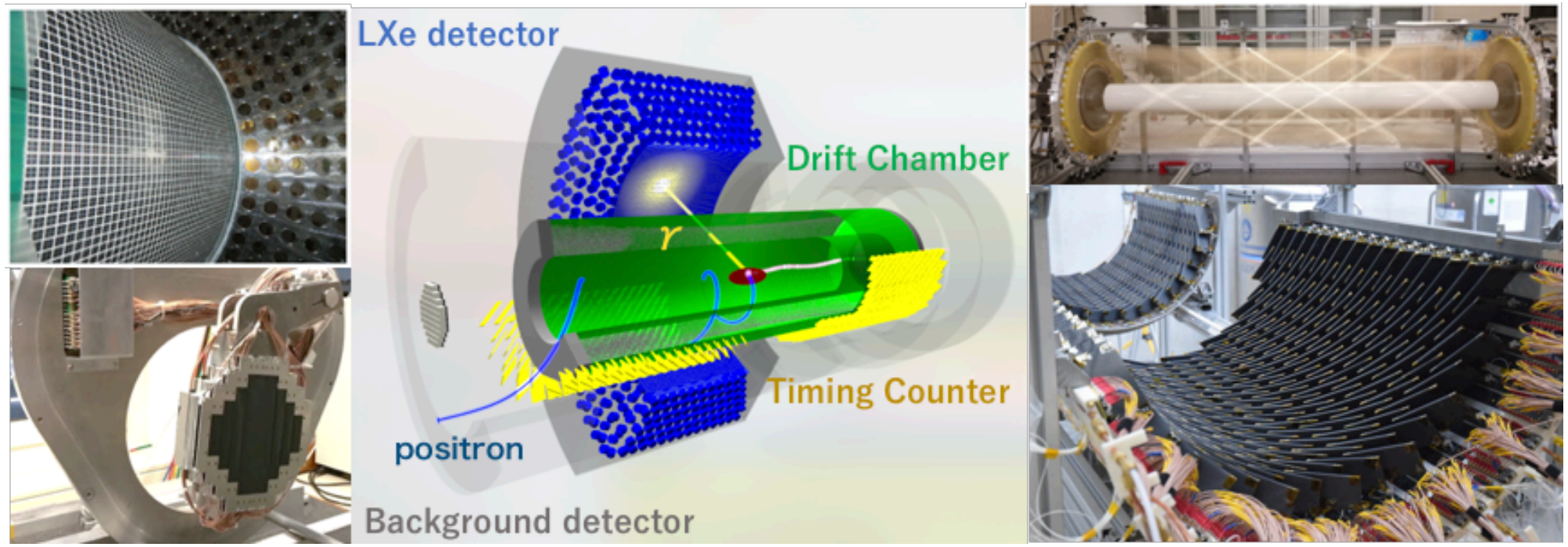
- $\mu \rightarrow e\gamma$: charged Lepton Flavor Violation (cLFV)
  - Prohibited in the standard model / Predicted in the beyond standard model within experimental reach
  - To discover $\mu \rightarrow e\gamma$ means to discover the new physics!!
- Signal kinematics of $\mathbf{e}$ and $\boldsymbol{\gamma}$: 2 body decay
  - Timing, position, and momentum is the key parameters



180° (back to back) at the same timing from the same position

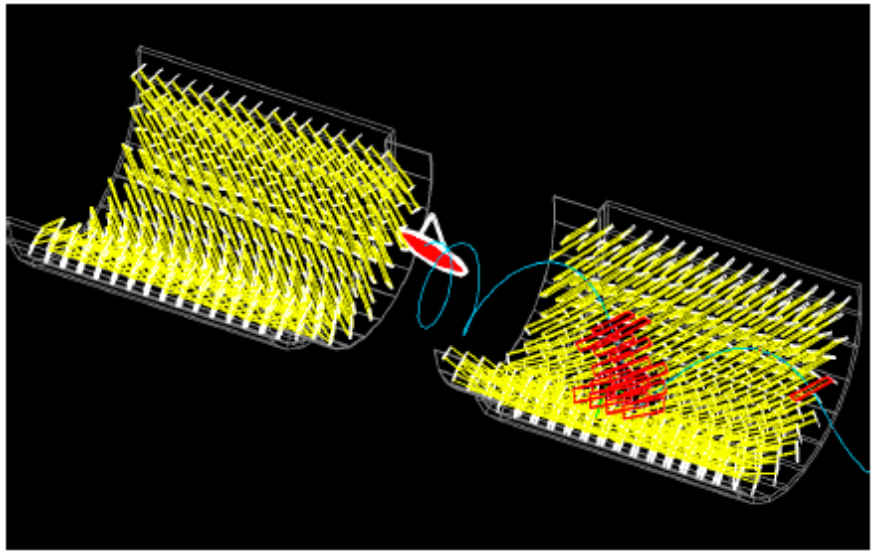
MEG II Experiment

- The most sensitive $\mu \to e\gamma$ search with the most intense muon beam ($7\times10^7\ \mu^+/s$) in Paul Scherrer Institut
- Precise background separation is the key to success – Innovative positron detectors were developed



pixelated Timing Counter (pTC)

× 512

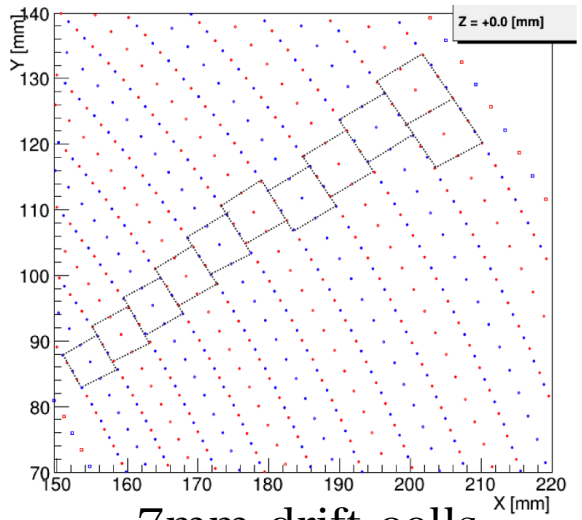


σ (Timing) ~ 80 ps with each counter

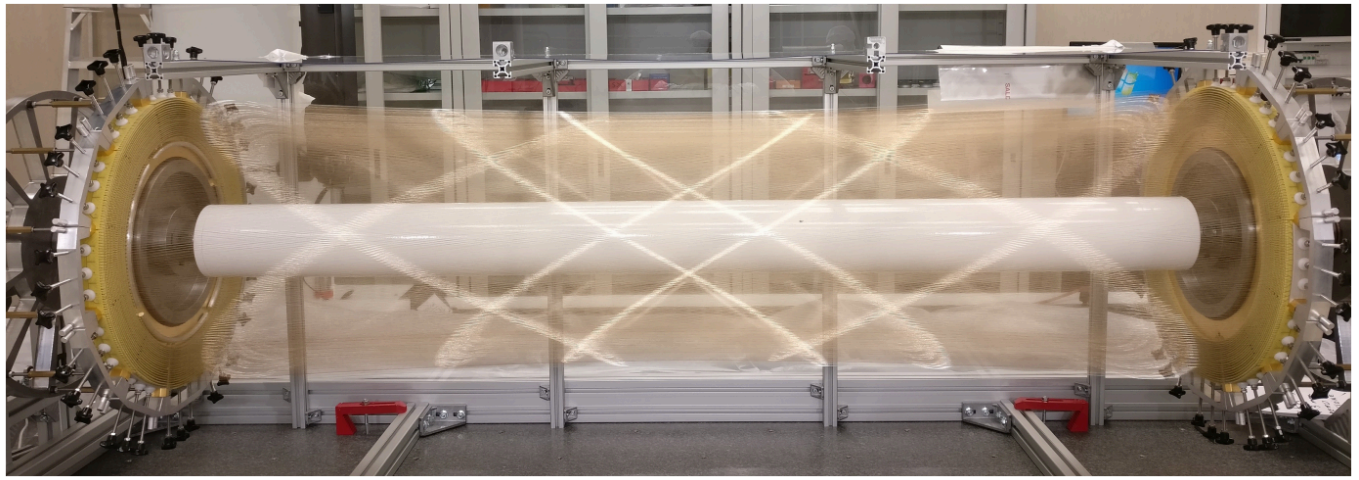
~ 8 hits/positron on average

- MEG II pTC measure the positron crossing timing with the precision of O(30 ps)
- 512 "pixelated" design enables the multi-hit information (~8 hits / positron on average)

Cylindrical Drift Chamber (CDCH)



~ 7mm drift cells



~2 m

- Ultra-low mass (90% helium based mixture and 10% isobutene) cylindrical stereo wire chamber to reconstruct the positron track with 2 times better efficiency (~70%) from MEG
- 192 drift cell (7-9mm square shape) x 9 layers

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  - First Look
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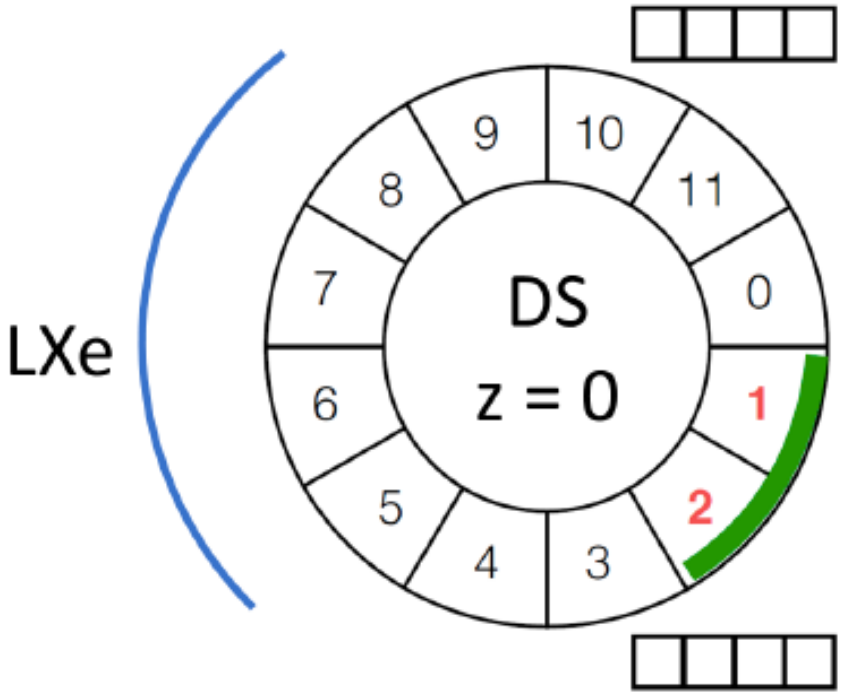
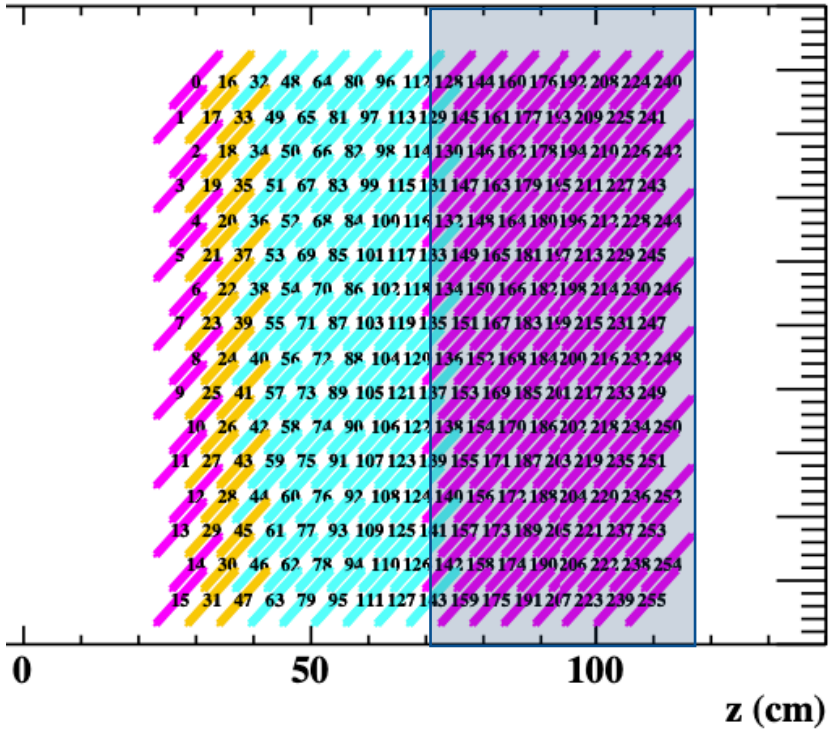
Situation & Configuration

- Readout electronics was strictly limited in both years: only ~6%(96/1728 cells) of CDCH and 25%(128/512) of pTC were available
  - In 2020?
- There are still many problems we are facing… anyway, we now have the data and have to start the analysis to understand the detector

Configuration in 2018

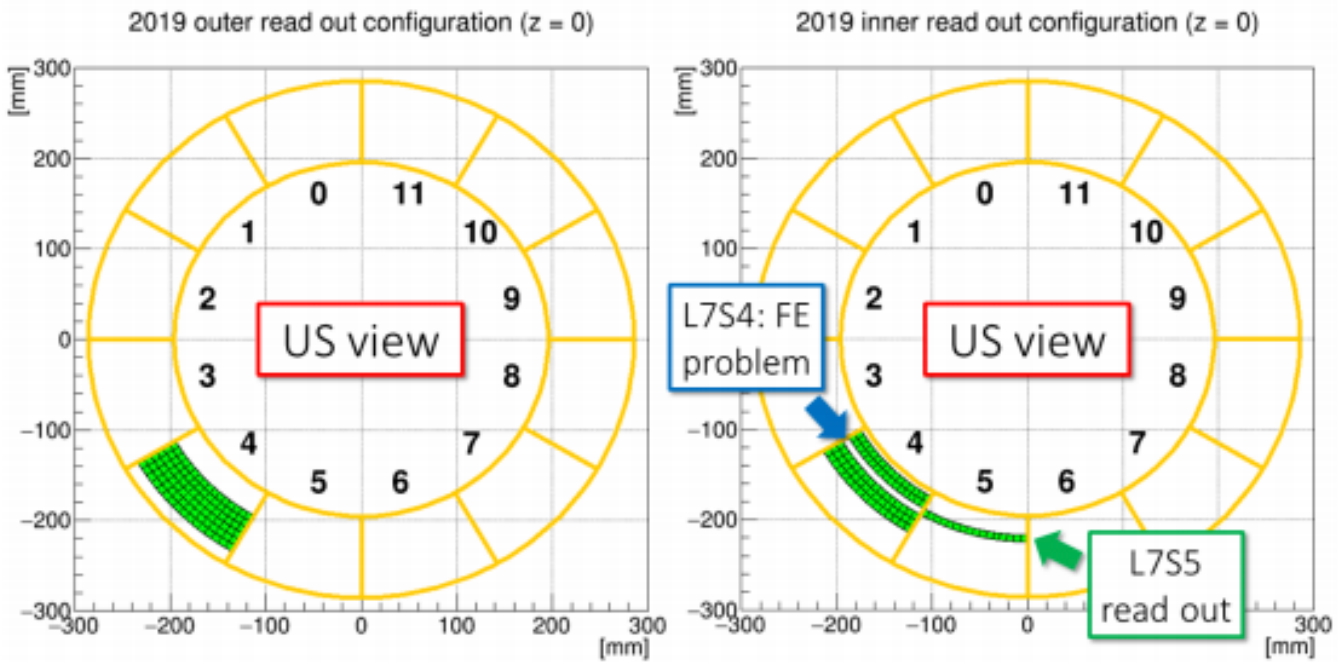


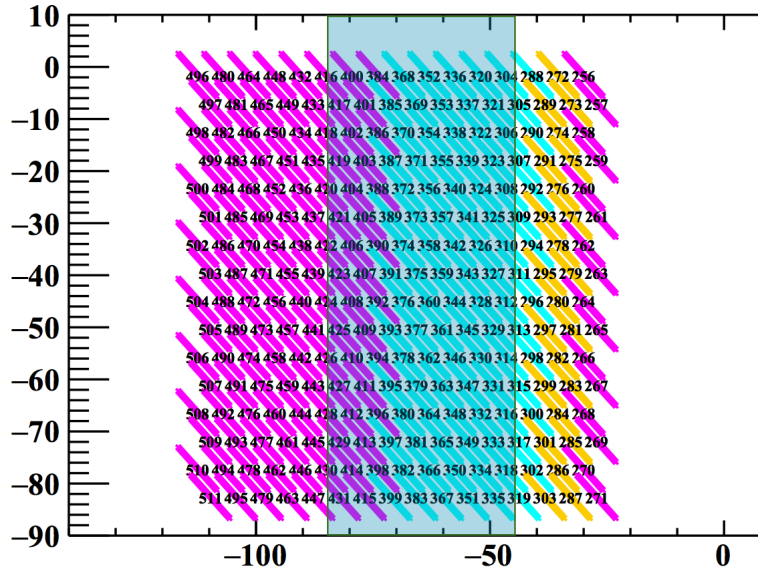


In 2018, pTC + CDCH were operated for the first time

- Current oscillation, inner layers could not reach the nominal vol.
- Wire tension (+3.8 mm) was not enough -> overstretching to +5.6mm, achieved the nominal high voltage in 2019
- Electronics synchronization problem – correction from software

Configuration in 2019





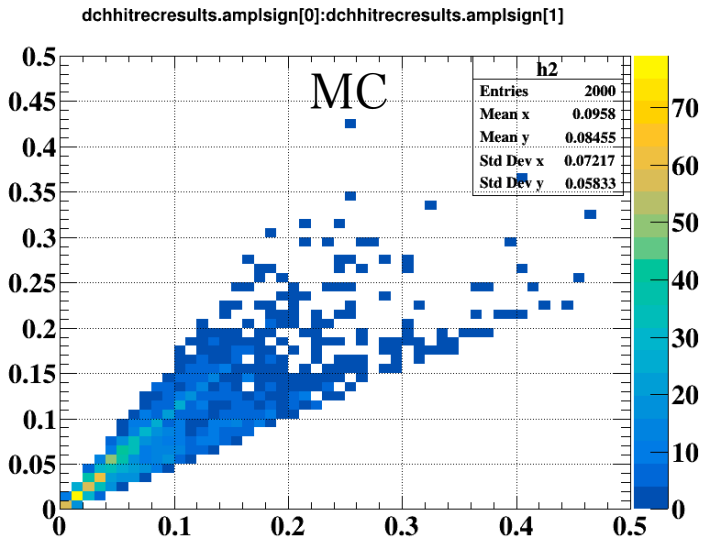
Available this year (304 - 431)
-> For SPX IndependentTracking, hit should be in 320 – 415

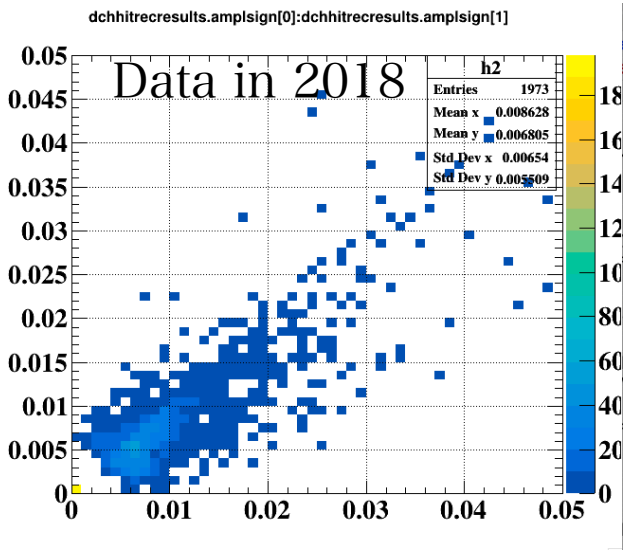
In 2019, we succeeded to apply nominal vol on inner / outer conf, but…

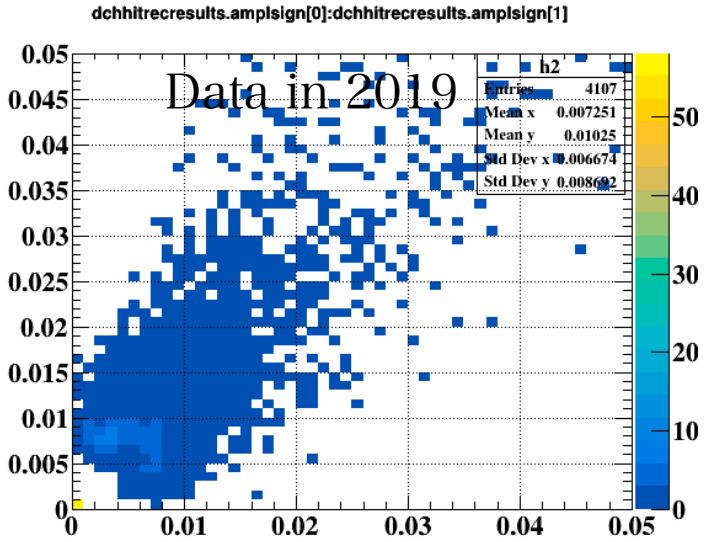
- Sync problem again – situation seems worse than 2018
- we found that L1, L3, L5 has less hits – no stereo information this year
- Anomalous current (10—480 μA) observed – we could not continue DAQ in Nov

First Look

ch0 amplitude vs ch1 amplitude on michel positron







- The pulse height is roughly ~ 1/10
  - ~1/5 from wrong electronics gain of CDCH
  - ~1/2 from many factors (unbalanced gains in 2018, the missing effects in MC, z-dependence of drift-cell size etc …

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  - Partial Track Reconstruction
  - Z evaluation
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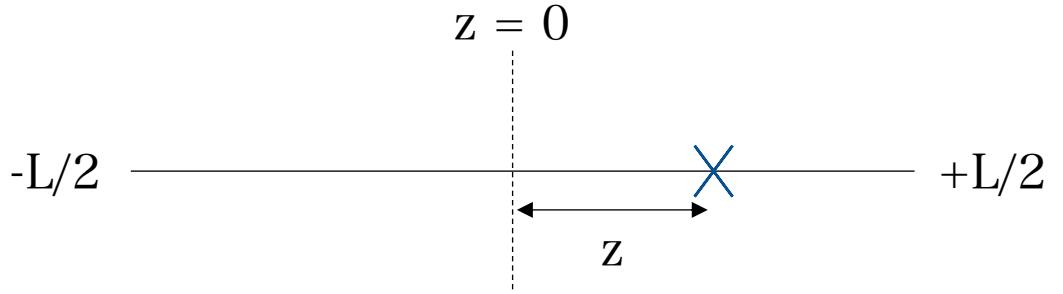
PRELIMINARY

Z Reconstruction in CDCH

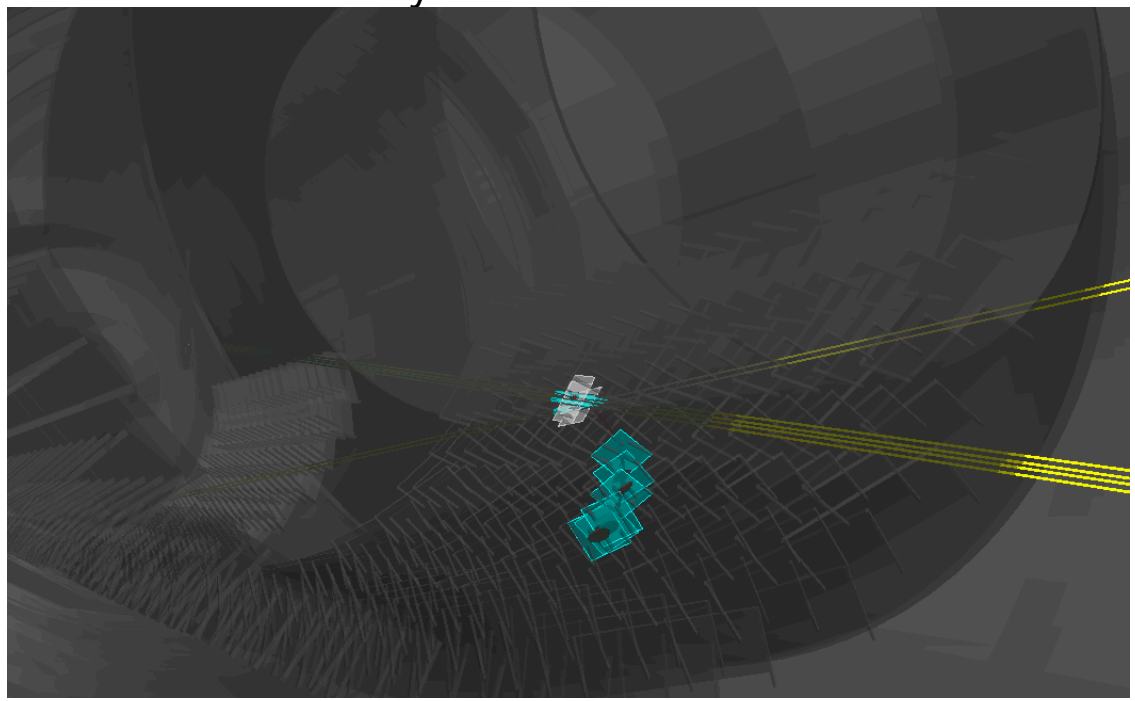
- Z calculation by 2 methods:
  - Time difference (σ~5 cm)
    - $z = \frac{T_{up} - T_{down}}{2} v$
    - Time calibration is needed
  - Charge division (σ~ < 1 cm ?)
    - $z = A\, L_{eff}$

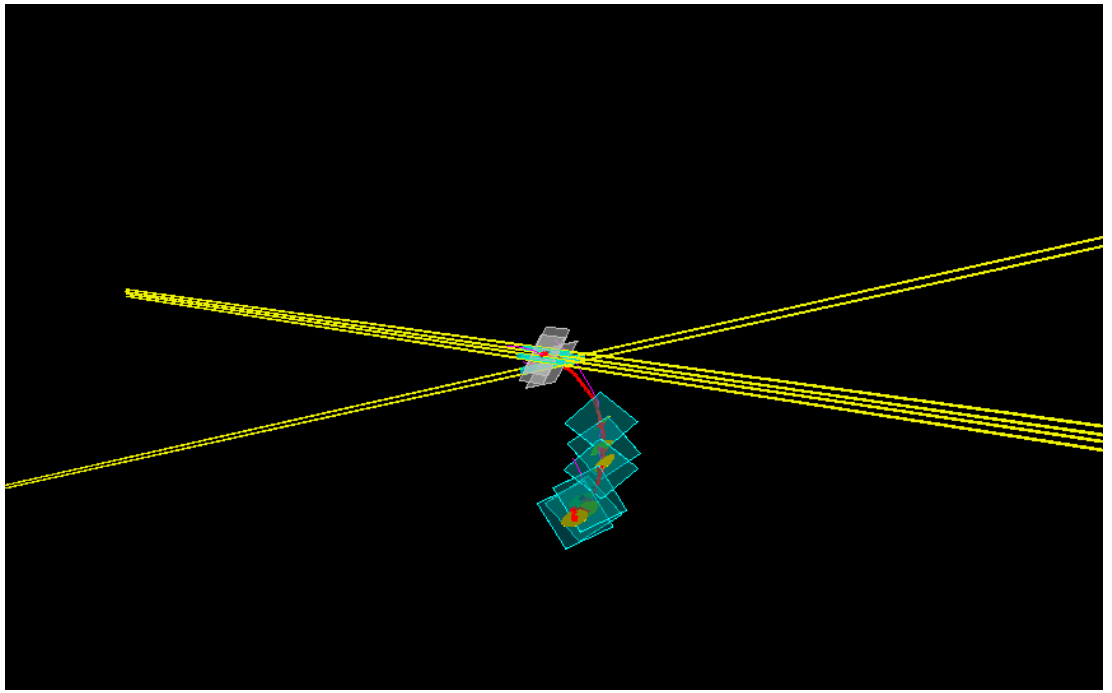
    where $A = \frac{Q_{up} - Q_{down}}{Q_{up} + Q_{down}}$ (charge asymmetry) and $L_{eff} = \frac{2R + \rho L}{2\rho}$ (effective wire length)
    - Gain/ Effective wire length calibration is needed
- For MC tracking study, assuming 10 cm uncertainty for Z
  - Z measurement information helps pattern recognition
- For hit finding from SPX, z position cut is effective
- Understanding the z resolution with commissioning data is necessary!



Partial Track Reconstruction

- SPX self-track + CDCH 3-layer hits
  - Starting from pTC track, search the CDCH hits and add them to the track
  - Fitting with Deterministic Annealing Filter (DAF) from GENFIT
  - Stereo information is used for the clustering -> 2019 data not available
    - Today I will focus on 2018 data

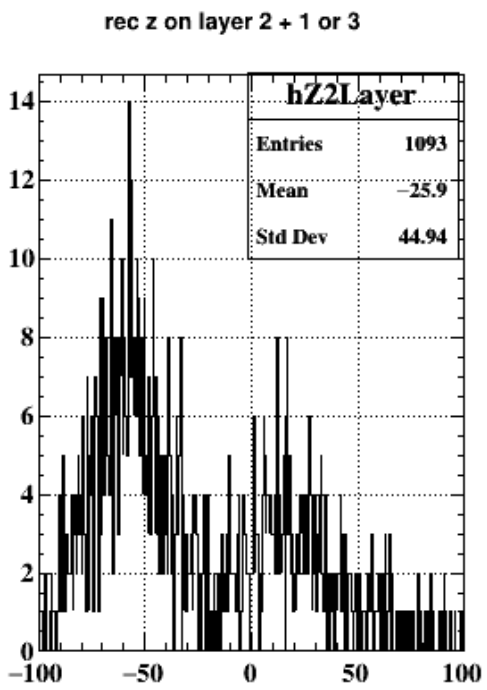




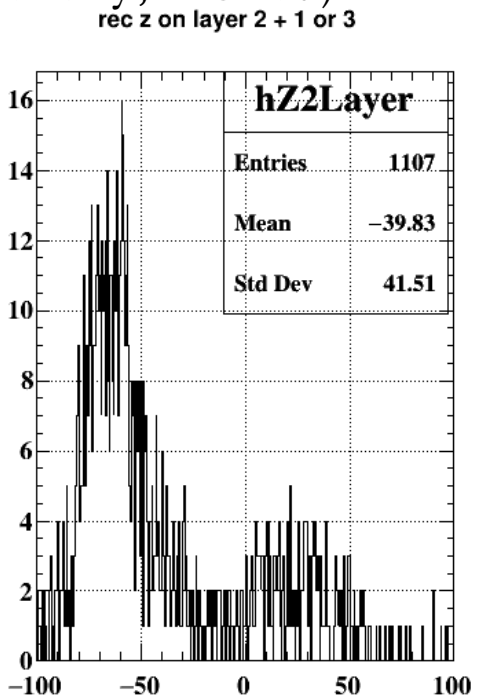
1.34e7 michel data

Z evaluation

2018 data (low-intensity, 1.34e7)

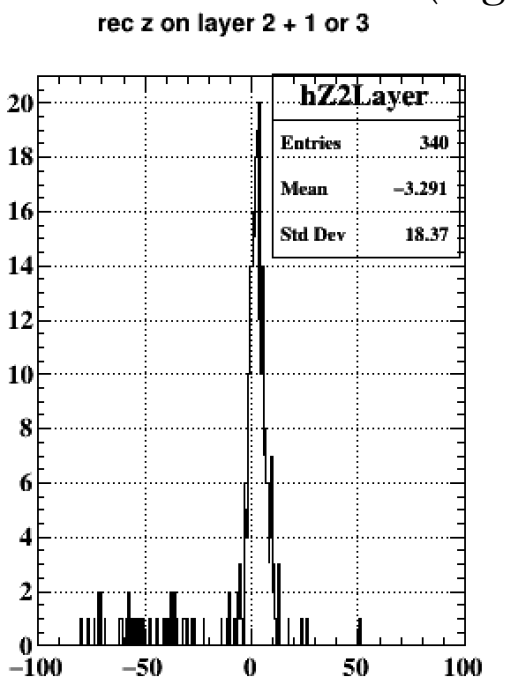


Charge

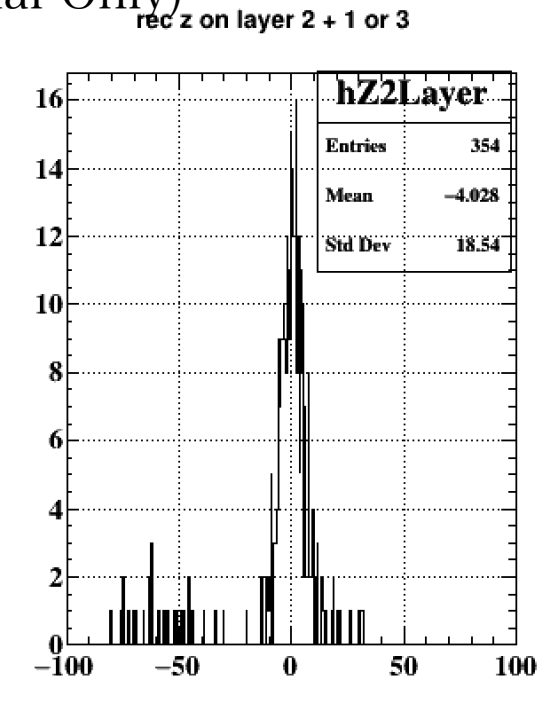


Time dif

MC (Signal Only)



Charge



Time diff

- $(z_{CDCH\ measured} - z_{SPX})$
  - Measured z in CDCH and pTC z does not match well in data
  - 2 peak can be seen : around z=0 (center, high rate) and z~100 (near SPX)

Summary

- Detector commissioning for positron detectors in 2019 has been completed
  - We succeeded on accumulating the positron spectrometer data, analysis ongoing – Today I showed the preliminary results
  - We also found some serious problems for detector operation / software analysis point of view - Must overcome
  - Partial track reconstruction algorithm was developed – We succeeded on positron track reconstruction from data for the first time