

GEM-based Polarimeter Detector Development at CAPP/IBS

Seongtae Park
CAPP/IBS

EDM kick-off meeting
CERN, Mar 13~14, 2017

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Outline

- 1. What we are working on**
- 2. What have been done so far**
- 3. Plans and future works**

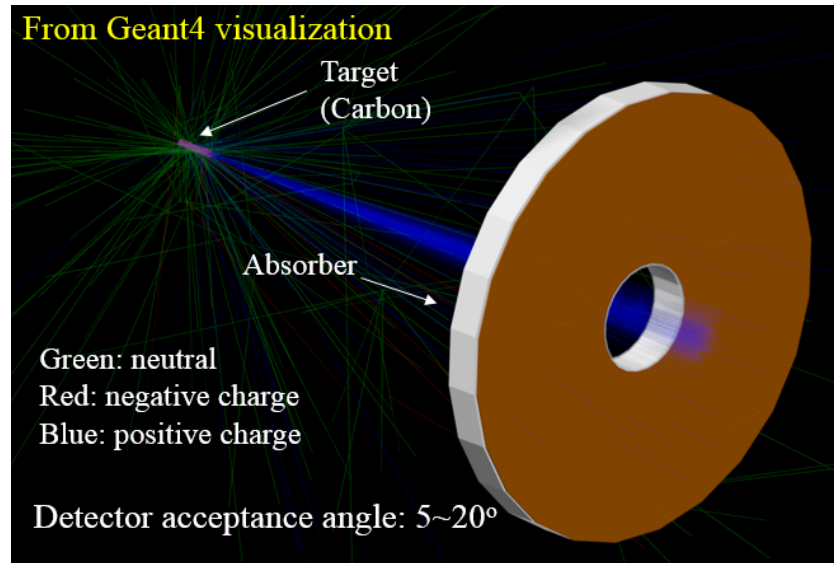
What we are working on

- ❖ **Prototype polarimeter detector development for pEDM experiment**
 - **Gas Electron Multiplier (GEM)** detector development for particle tracking
 - Scintillation detector development for asymmetry counters
- ❖ **Geant4 simulation for p-C scattering**
 - Understanding p-C interaction
 - Understanding particles on the detector plane
 - Asymmetry realization in Geant4 (with spin dependence)
- ❖ **Polarimeter concept development for electron EDM experiment (Compton back scattering polarimeter)**
 - Theoretical back ground study: x-section, AP calculation etc. (done)
 - Feasibility studies for electron EDM measurement

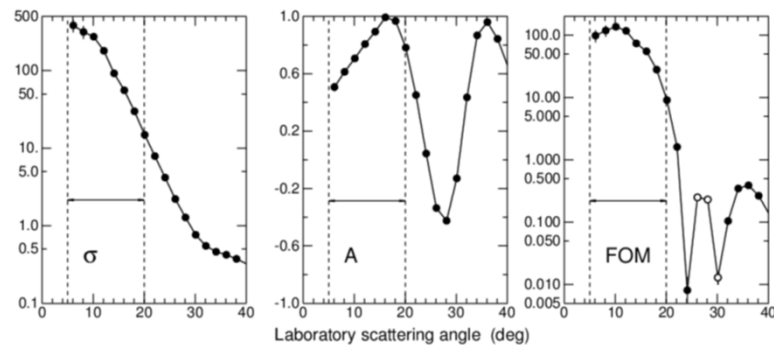
What have been done so far

Geant4 simulation

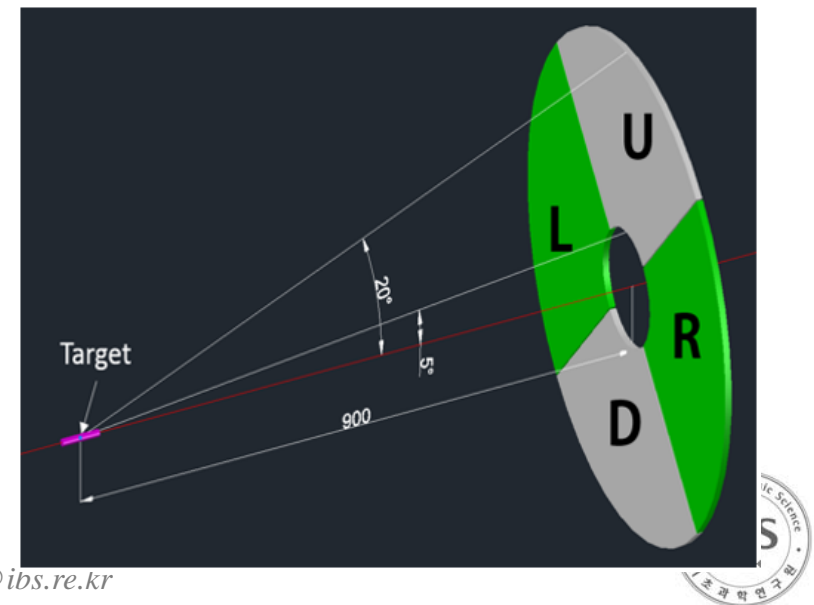
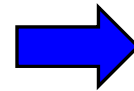
Understanding p-C interaction (Geant4 simulation)



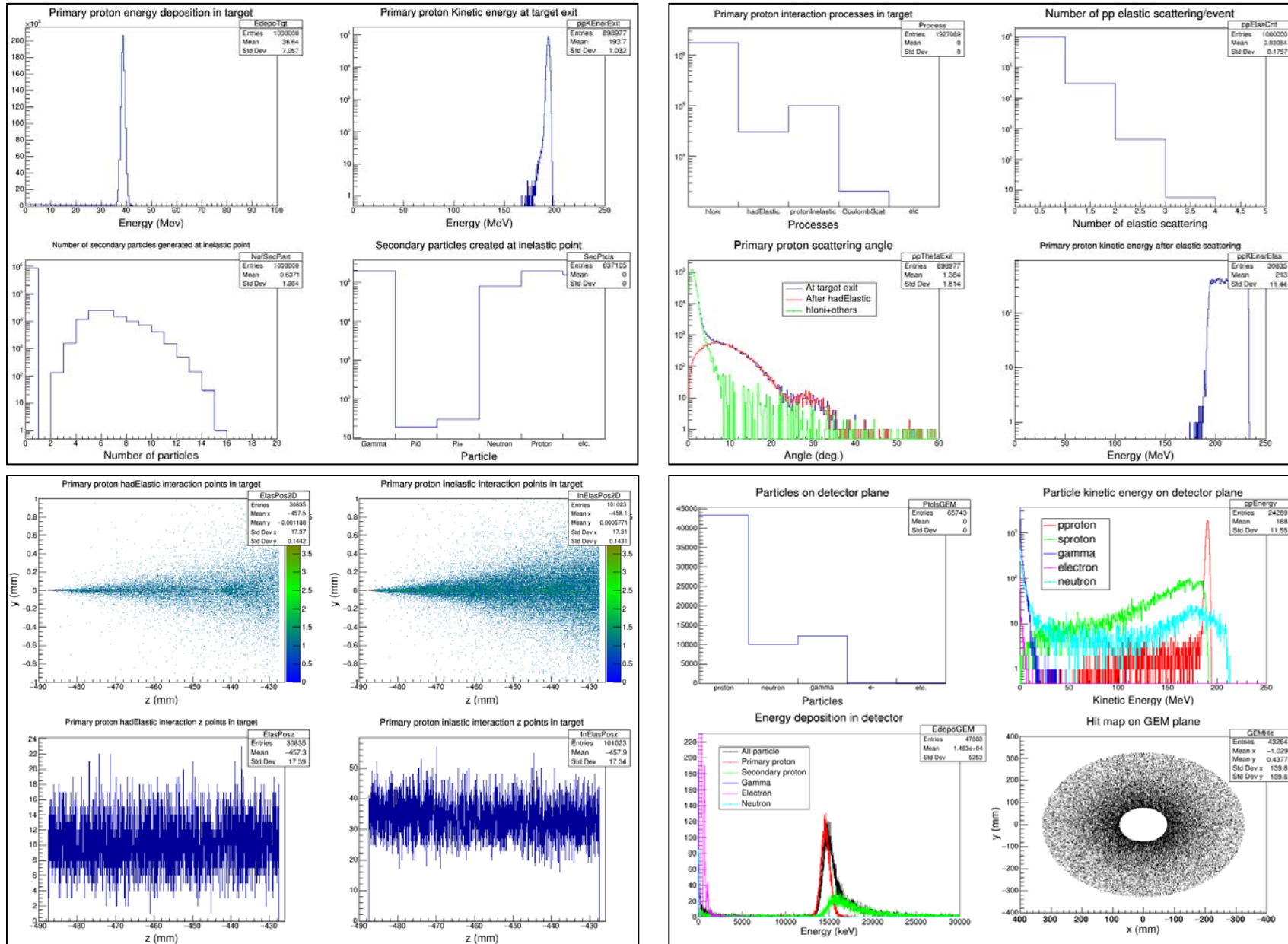
- Simulation tool: Geant4 v4.10.p02
- Physics list used for simulation: Shielding, QGSP_BERT
- Input particle: protons, 1,000,000 POTs
 - ✓ $P=701 \text{ MeV}/c$, $\Delta p/p=4.6 \times 10^{-4}$, $\beta=0.6$, $K=233 \text{ MeV}$
- Target length: varies (1~60mm)
- Target material: Graphite(C:N:O=99:0.7:0.3, 1.7~2.22 g/cm³)
- Distance between target and detector: 900 mm



Best FOM is obtained in 5~20 deg.
Fig: from Proton EDM proposal



Geant4 simulation results on p-C scattering⁶



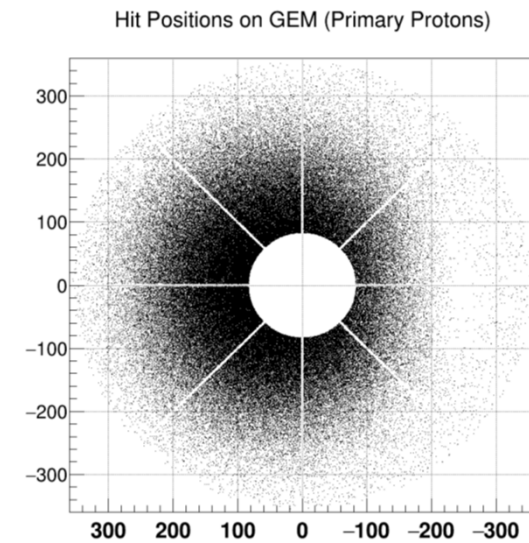
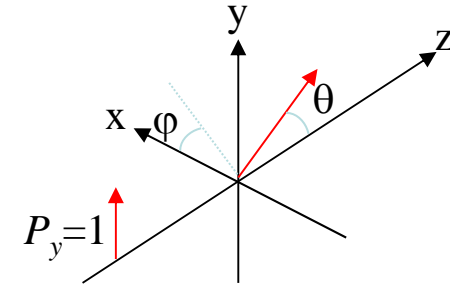
Asymmetry realization in Geant4

**with Dr. Edward Stephenson*

- ❖ No spin-orbit interaction (p-C) in the current version Geant4.
 - ✓ No spin dependent asymmetry in proton hits
- ❖ However, we know where the proton should go after the interaction (θ, φ) once we know the x-sections and analyzing powers of the protons on carbon target.
- ❖ Solve the following equation at every proton interaction point to get φ after the scattering

$$\varphi + A(\theta)\sin(\varphi) = 2\pi r$$

- To complete this, we need experiment **database for x-section and analyzing powers**.
- We plan to do the measurement either at COSY or RCNP

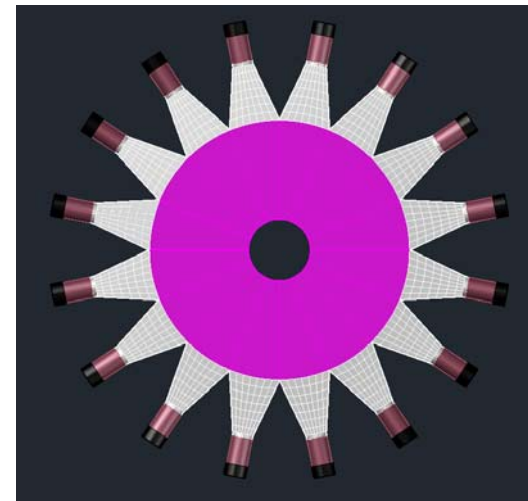
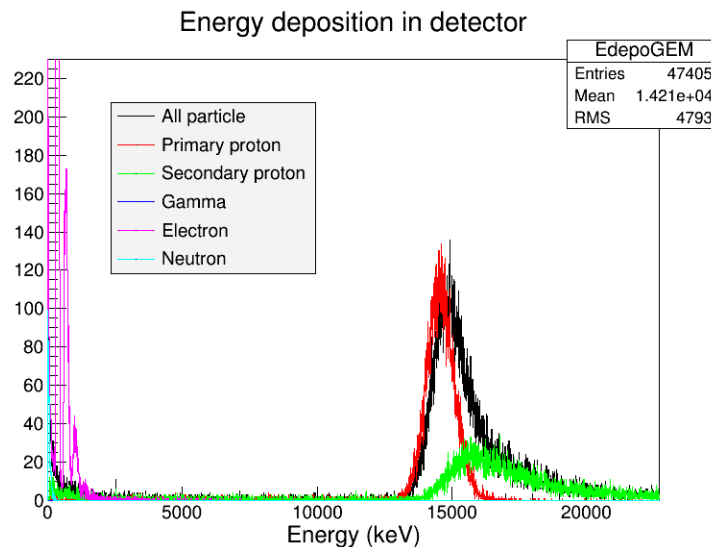
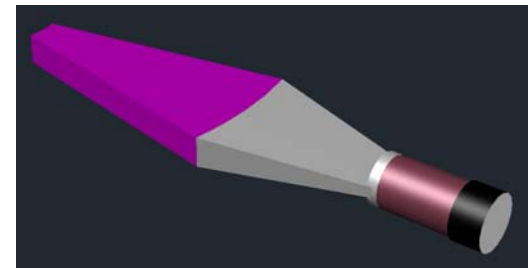
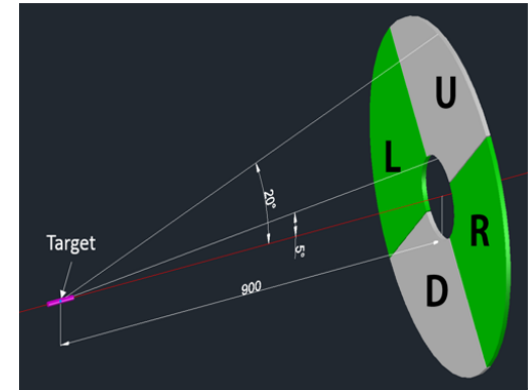


Preliminary result
Simulation by Hoyong Jeong

Detectors (hardware)

Counting rate and detectors

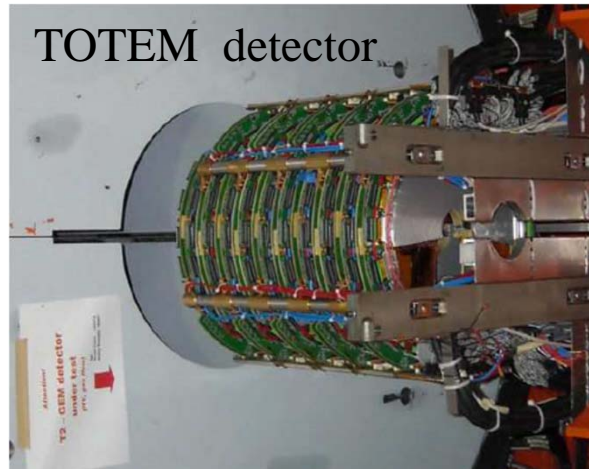
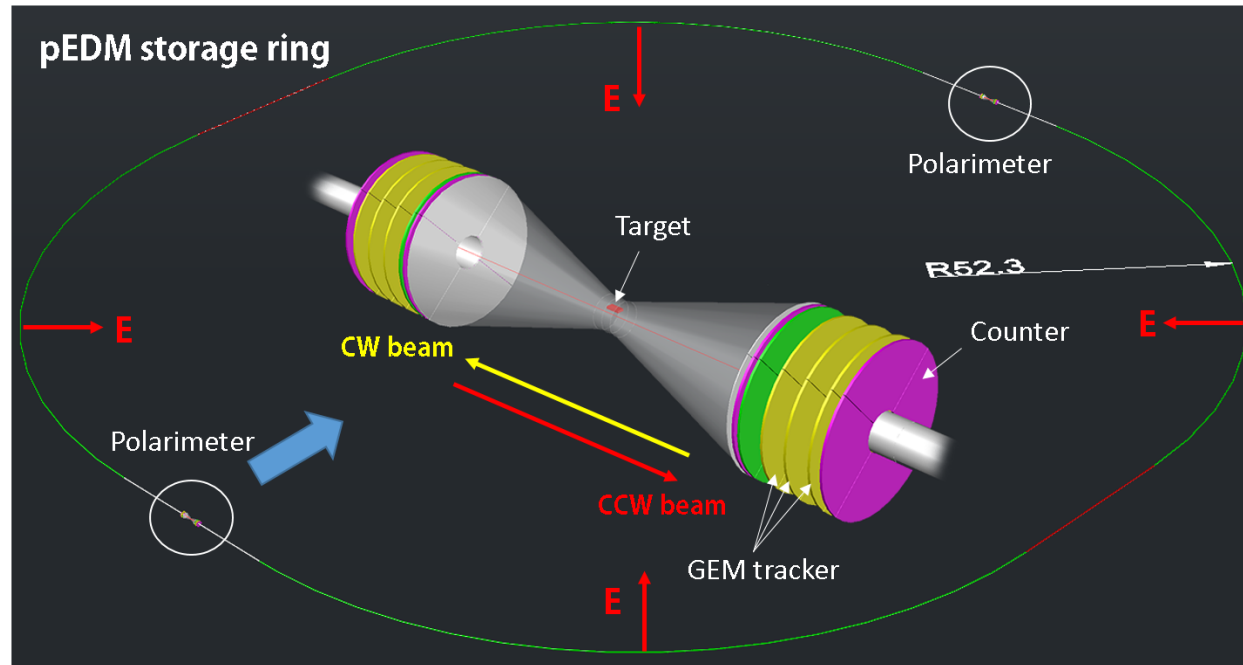
- 5×10^{10} protons/storage
- Beam extraction for 1000s
- Assuming full extraction at the constant extraction rate for the entire extraction: 5×10^7 interactions/s
- Assume 4.4 % of detector acceptance (Geant4 simulation with 6 cm target length, assume counting only protons)
 - ✓ Protons on detector plane: 4.4%
 - Primary proton: 2.4%
 - Secondary proton: 2%
- 2.2×10^6 hits on detector plane/s
- Use 16 scintillation counters: $\sim 1.4 \times 10^5$ hits/counter



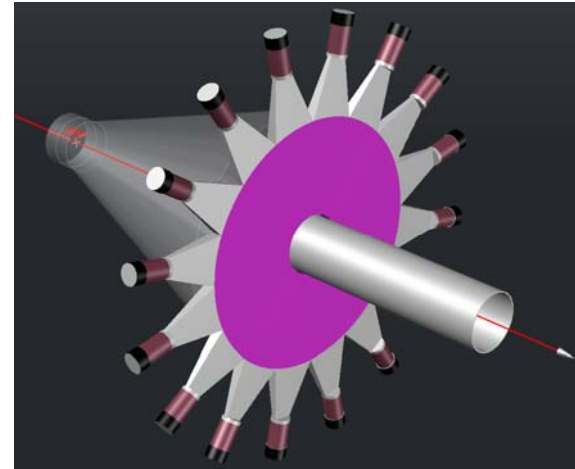
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Prototype polarimeter detector concept



TOTEM detector



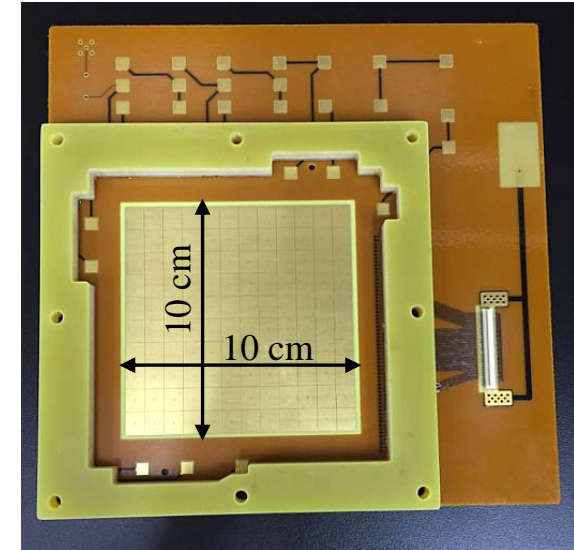
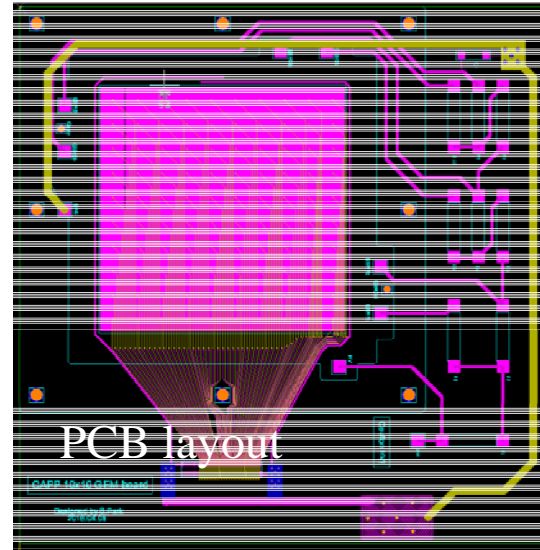
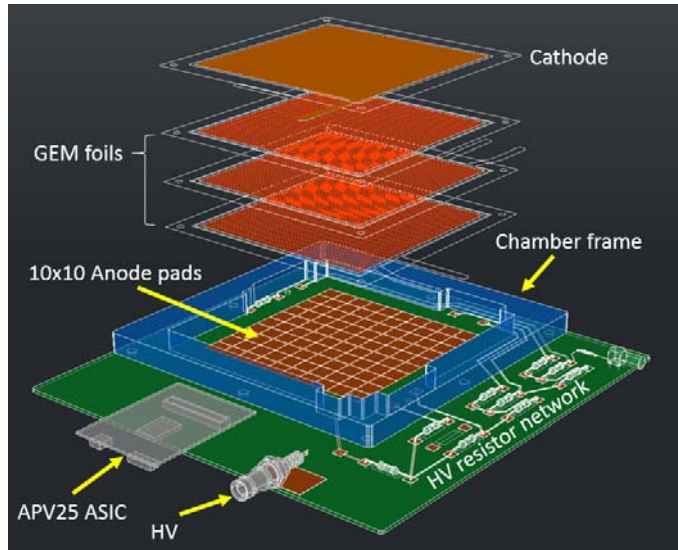
Scintillators for counters

GEMs for tracker

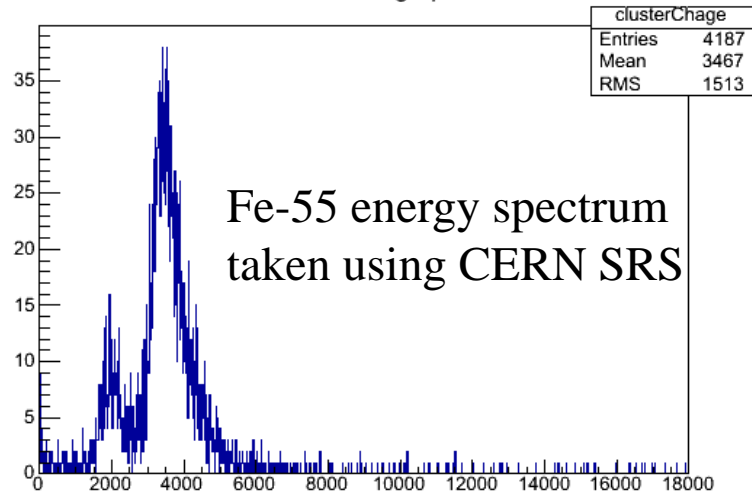
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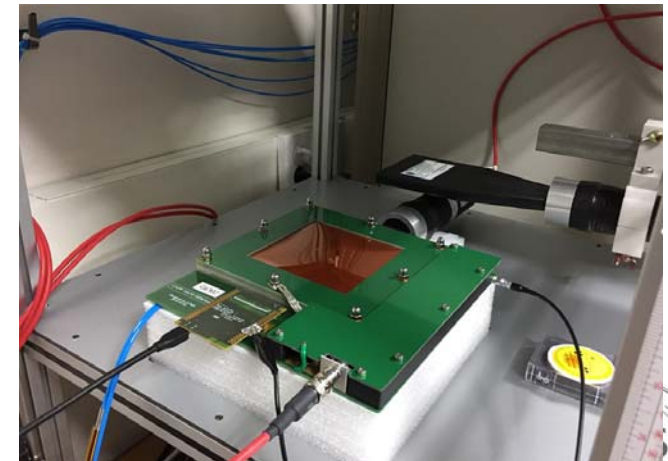
10x10 cm² test GEM detector (10x10 pad board)



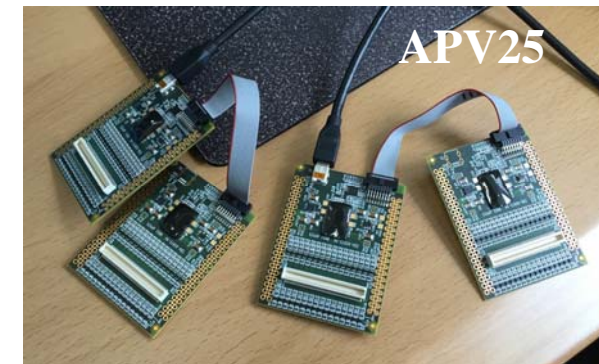
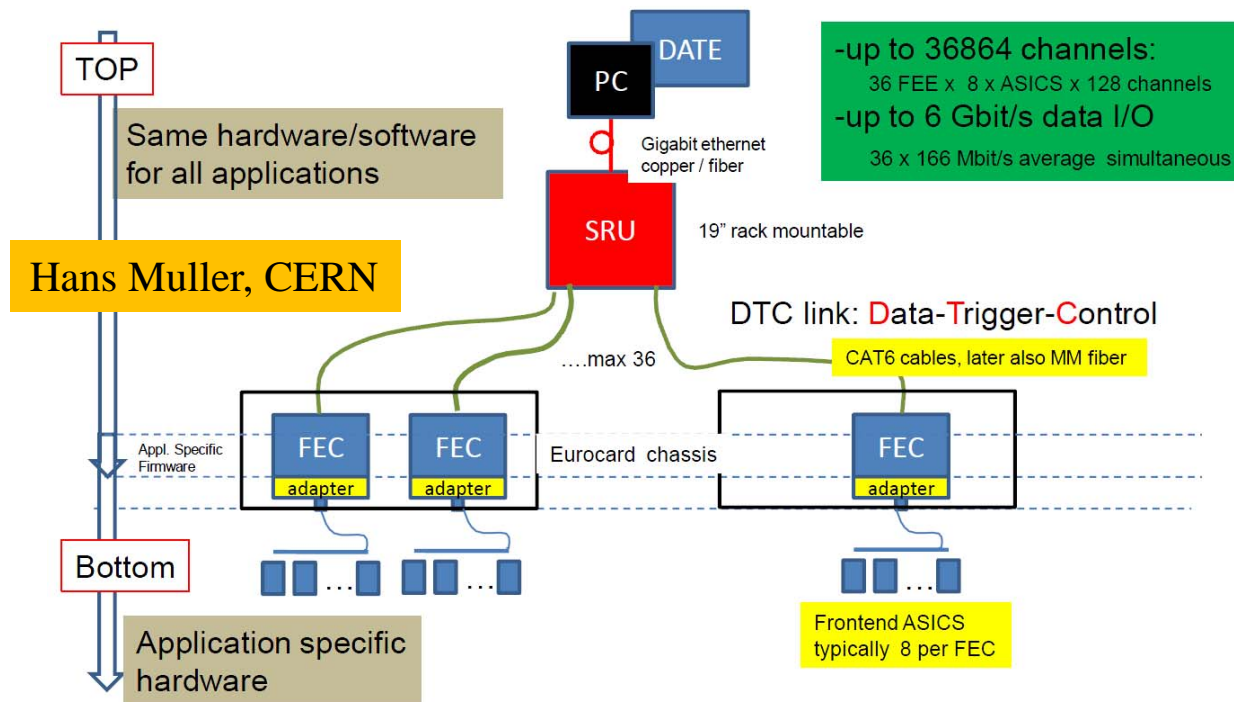
Cluster charge plot



GEM detectors are built and being tested with CERN SRS(APV25).



DAQ electronics for GEM test (SRS)

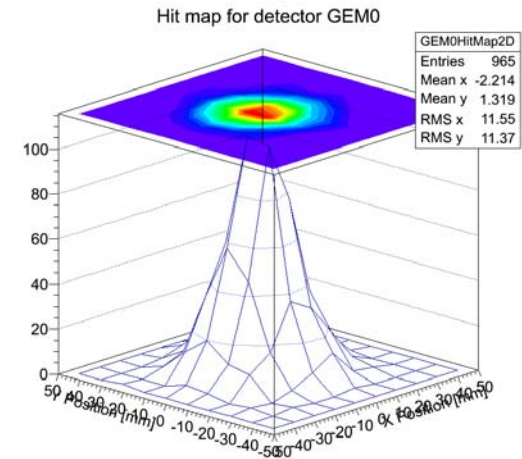
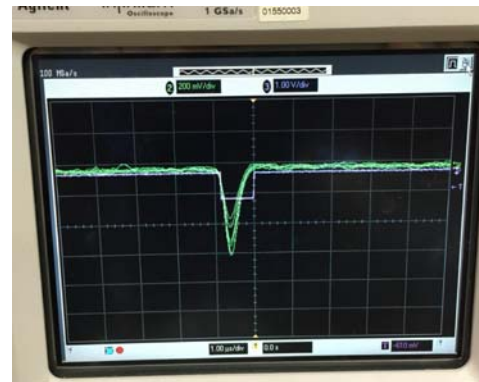
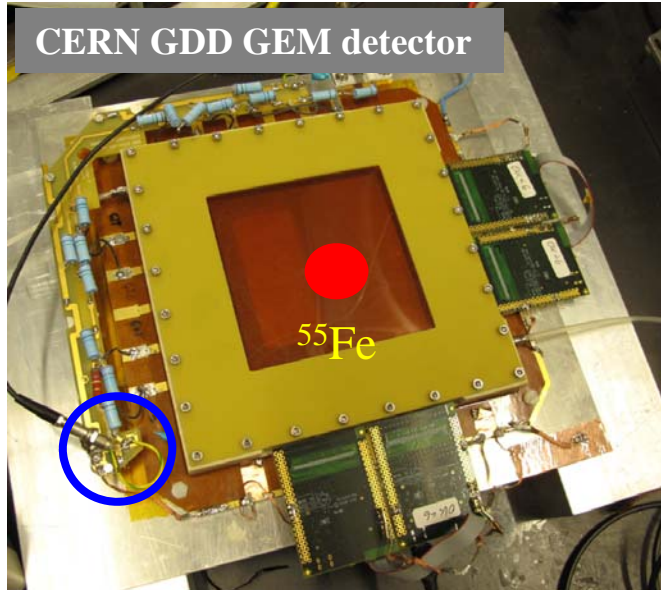


- ❖ SRS: Scalable Readout System
- ✓ Developed and distributed by the RD51 collaboration
- ✓ FE Hybrid+ adapter card+FEC+DAQ PC
 - Hybrid: **APV25**, **VMM**, GEMROC, Beetle, etc
 - APV: analog chip
 - VMM: digital chip with peak detection and time information

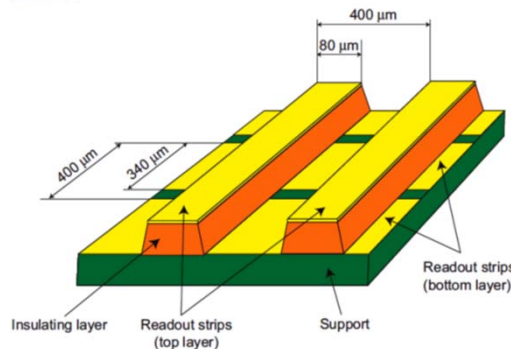
Test results/Source run(⁵⁵Fe, x-y strip board)

Test at CERN GDD lab.

Trigger signal from the bottom electrode of the third GEM.
Rate= \sim 280

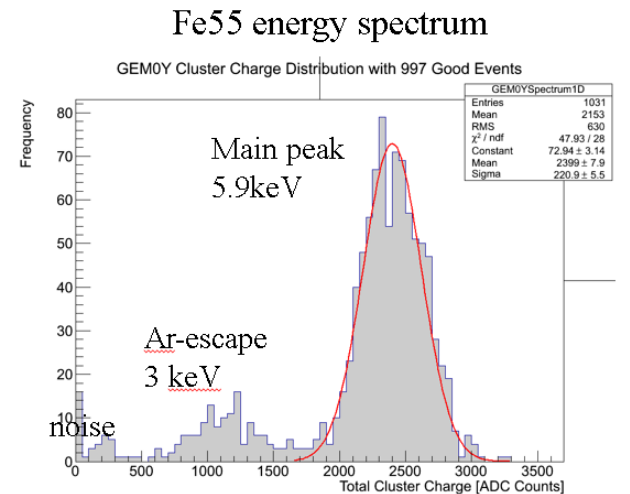


- ❖ 10x10 cm² GEM chamber
- ❖ Triple GEMs
- ❖ Ar:CO₂=70:30
- ❖ HV=3800V
- ❖ P=400 μ m strip \rightarrow R \sim 115 μ m



x-y strip board

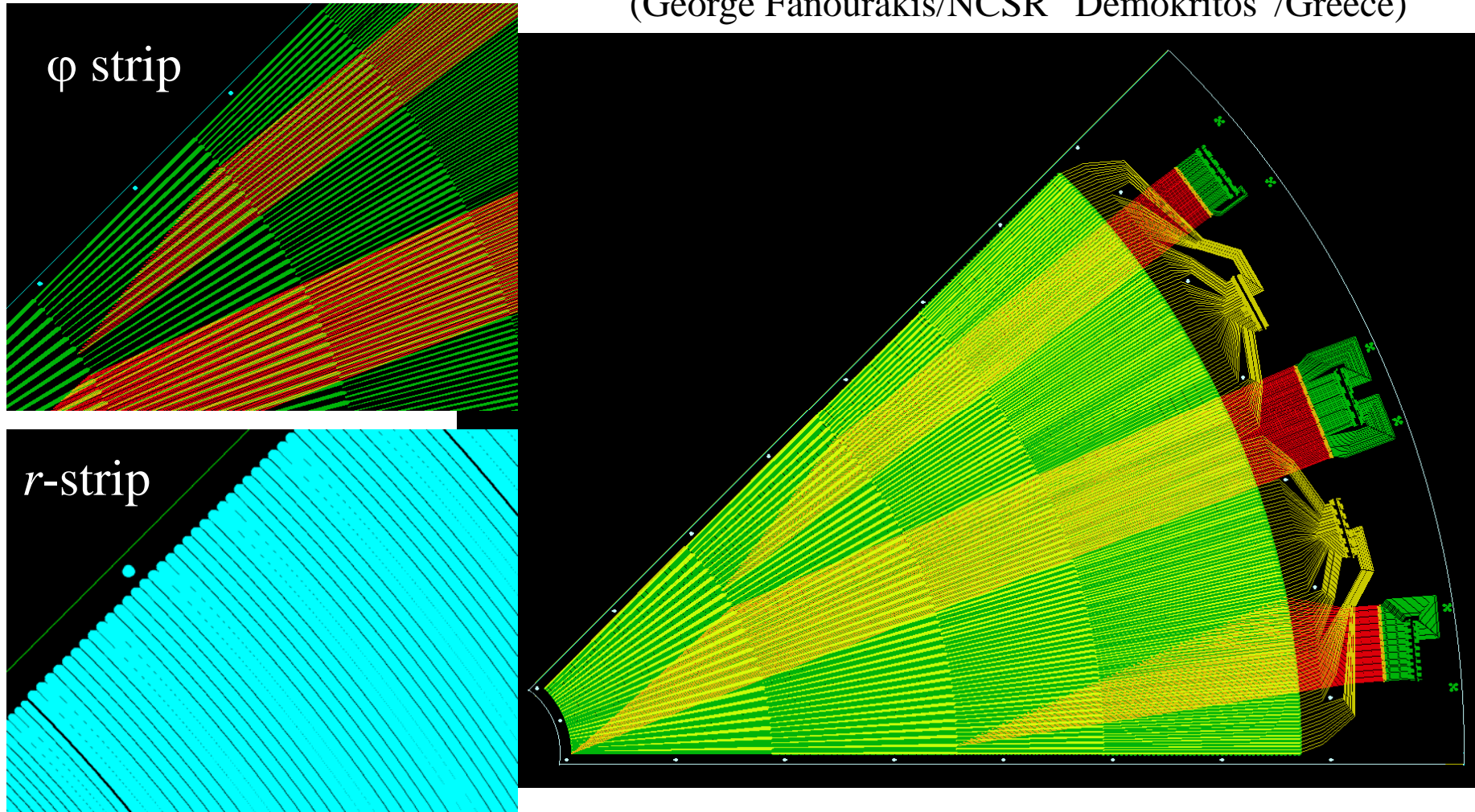
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Anode board for GEM-based tracker

CERN PCB workshop

(George Fanourakis/NCSR “Demokritos”/Greece)



r - ϕ anode board for tracking detector

Multiple layers of these detectors provide you track information.

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DAQ and analysis tools for GEM detectors

- **DAQ program: DATE(ALICE experiment)**
- **Online monitoring and analysis: AMORE(ALICE experiment)**

- We have learned how to use DATE and AMORE.
- However, the analysis tool (Amore) is detector readout configuration dependent.
- We need to develop our own Amore tools for our GEM detectors (r-φ strip board).
- We understood the Amore framework and currently working on it.

Plans and future work

- **GEM detector beam test (with protons, COSY/RCNP)**
- **Data base measurement for proton (x-sections, analyzing powers, COSY/RCNP)**
- **Construct/test prototype polarimeter detector with r - ϕ anode board**
- **Scintillation counter construction and test**
- **Continue MC simulation studies with Geant4**

2017 International Workshop on Polarized Sources, Targets, and Polarimetry

Oct 16 - 20, 2017

KAIST Munji Campus, Daejeon, Republic of Korea

Hosted by CAPP/IBS

We'd like to invite all of you to Korea in Oct!

**2017 International Workshop on
Polarized Sources, Targets, and Polarimetry**
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❖ TOPICS:

- *Polarized Solid Target*
- *Polarized Gas Target*
- *Polarized Electron Sources*
- *Polarized Ion Sources*
- *Proton Polarimetry*
- *Electron Polarimetry*
- *Application of Spin*
- *New Initiatives*

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The Workshop on Polarized Sources, Targets and Polarimetry has been a tradition for more than 20 years, moving between Europe, USA and Asia. The 17th International Workshop on Polarized Sources, Targets and Polarimetry (PSTP 2017) will take place at the Korea Advanced Institute of Science and Technology (KAIST), South Korea. The workshop addresses the physics and technological challenges related to polarized gas/solid targets, polarized electron/positron/ion/neutron sources, polarimetry and their applications.

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Thank you!