GEM-based Polarimeter Detector Development at CAPP/IBS

Seongtae Park
CAPP/IBS

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

Seongtae Park/stpark@ibs.re.kr

CAPP/IBS

Outline

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

What we are working on

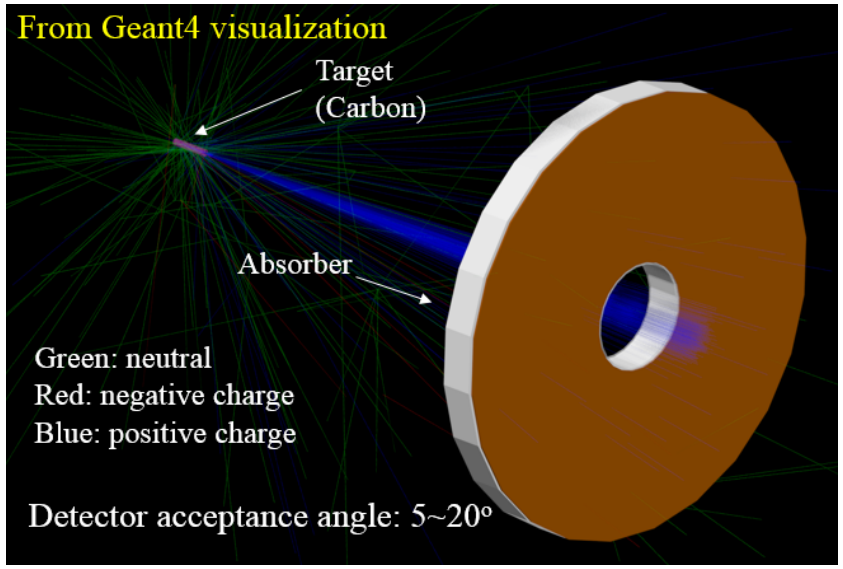
- **Prototype polarimeter detector development** for pEDM experiment
  - **Gas Electron Multiplier (GEM)** detector development for particle tracking
  - Scintillation detector development for asymmetry counters
- **Geant4 simulation for p-C scattering**
  - Understanding p-C interaction
  - Understanding 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

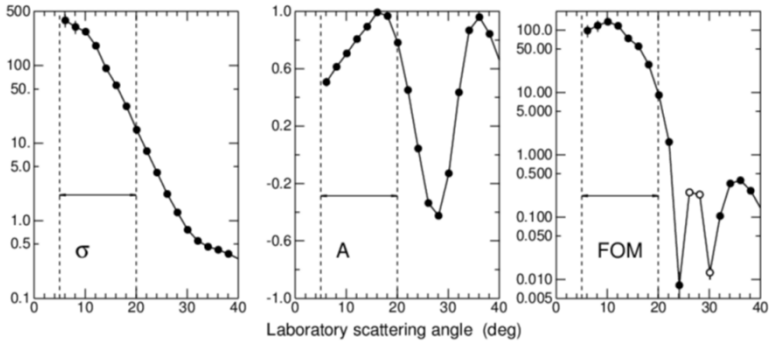
Geant4 simulation

Seongtae Park/stpark@ibs.re.kr

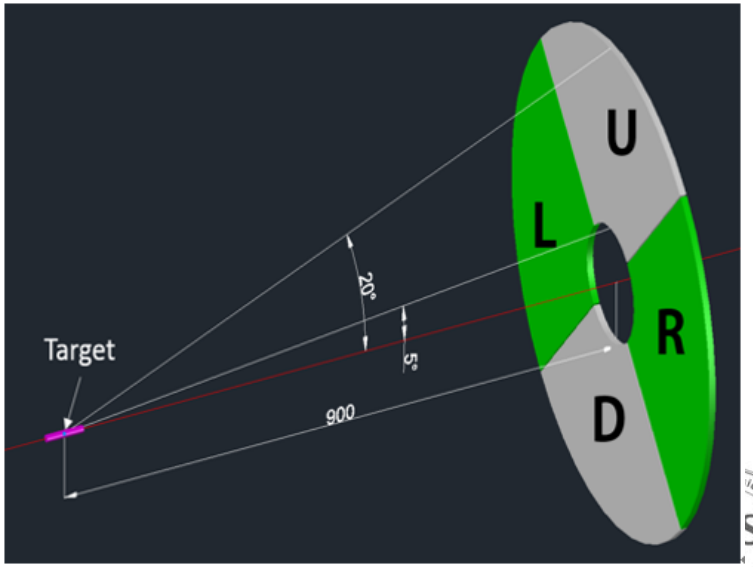
Understanding p-C interaction (Geant4 simulation)



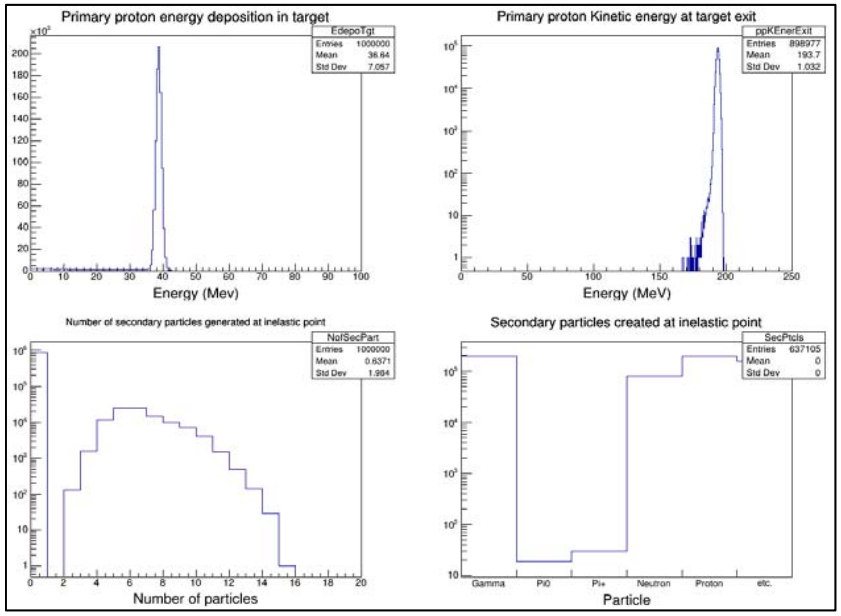
- Simulation tool: Geant4 v4.10.p02
- Physics list used for simulation: Shielding, QGSP_BERT
- Input particle: protons, 1,000,000 POTs
  - ✓ P=701 MeV/c, $\Delta p/p=4.6\times10^{-4}$, $\beta=0.6$, K=233 MeV
- Target length: varies (1~60mm)
- Target material: Graphite(C:N:O=99:0.7:0.3, 1.7~2.22 g/cm^3)
- Distance between target and detector: 900 mm

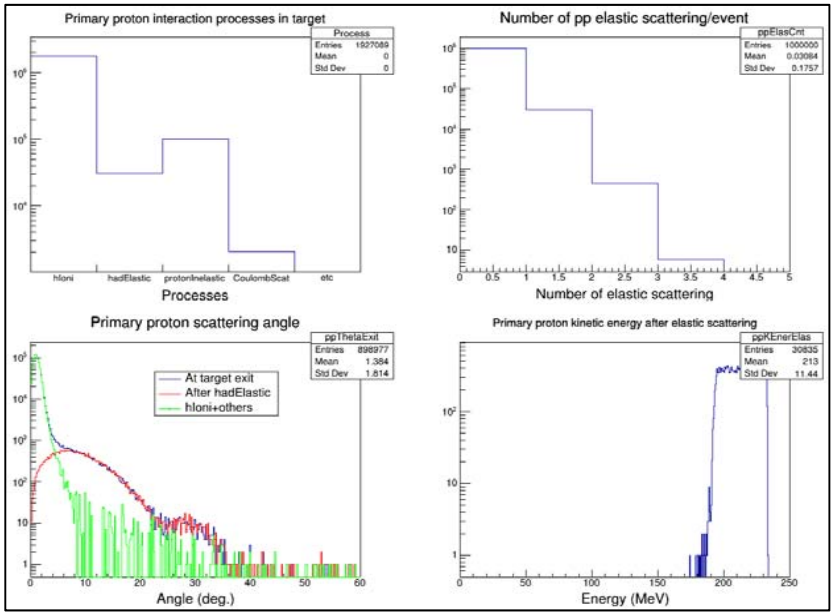


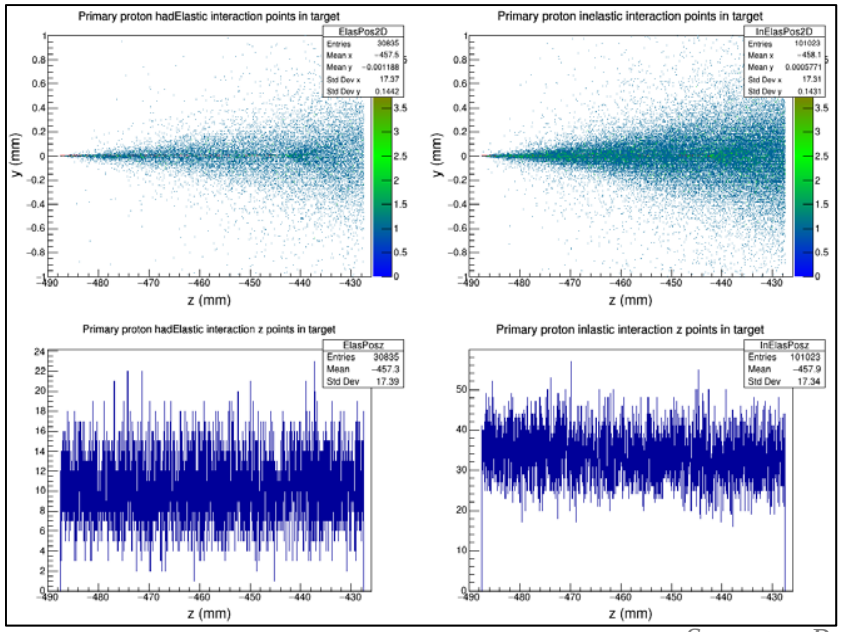
Best FOM is obtained in 5~20 deg.
Fig: from Proton EDM proposal

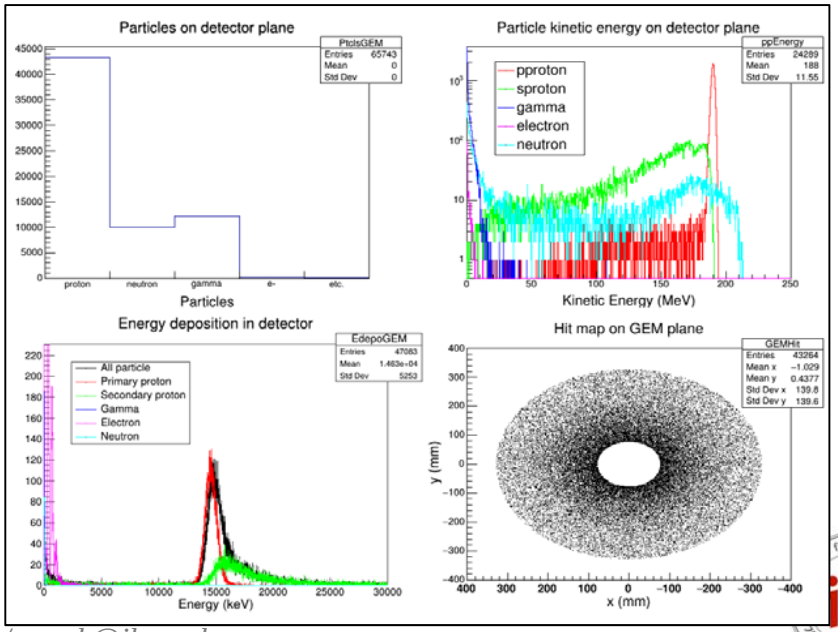


Geant4 simulation results on p-C scattering



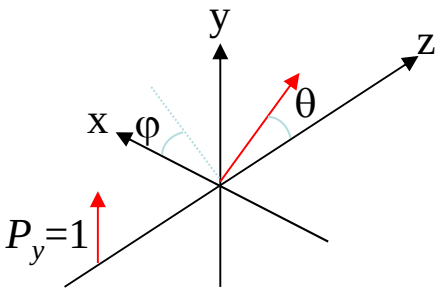






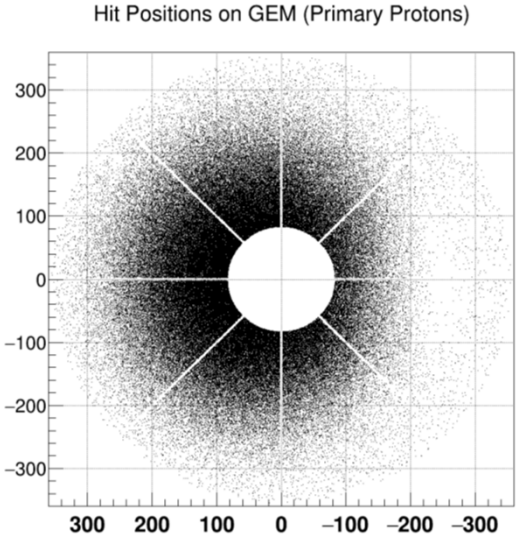
Asymmetry realization in Geant4

**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

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



Preliminary result
Simulation by Hoyong Jeong

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

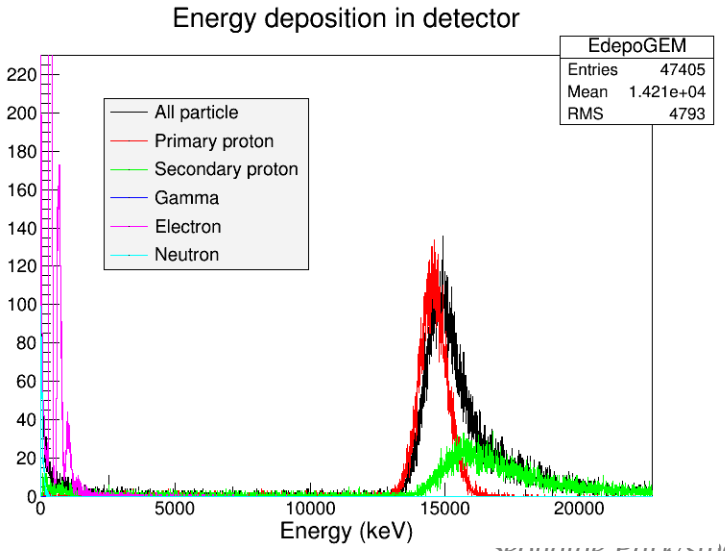
Seongtae Park/stpark@ibs.re.kr

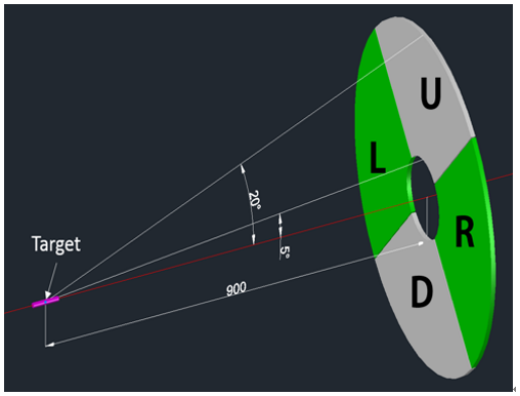
CAPP/IBS

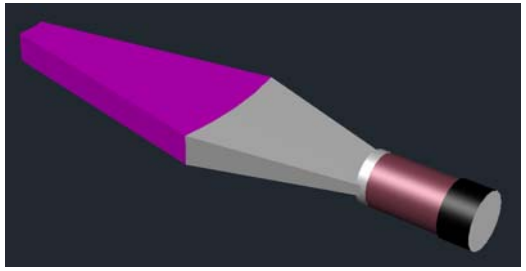
Detectors (hardware)

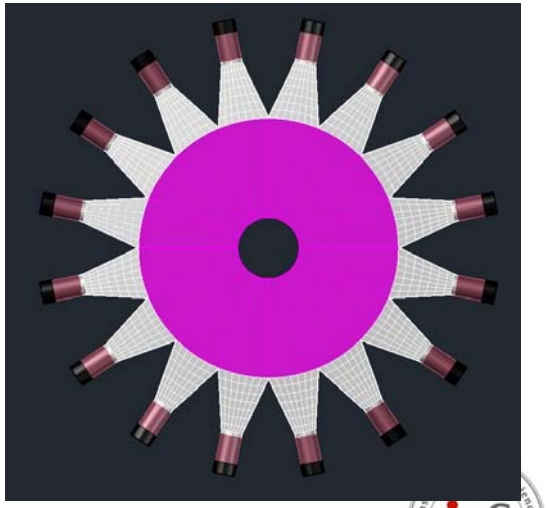
Counting rate and detectors

- $5x10^{10}$ protons/storage
- Beam extraction for 1000s
- Assuming full extraction at the constant extraction rate for the entire extraction: $5x10^{7}$ 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%
- $2.2x10^{6}$ hits on detector plane/s
- Use16 scintillation counters: ~$1.4x10^{5}$ hits/counter



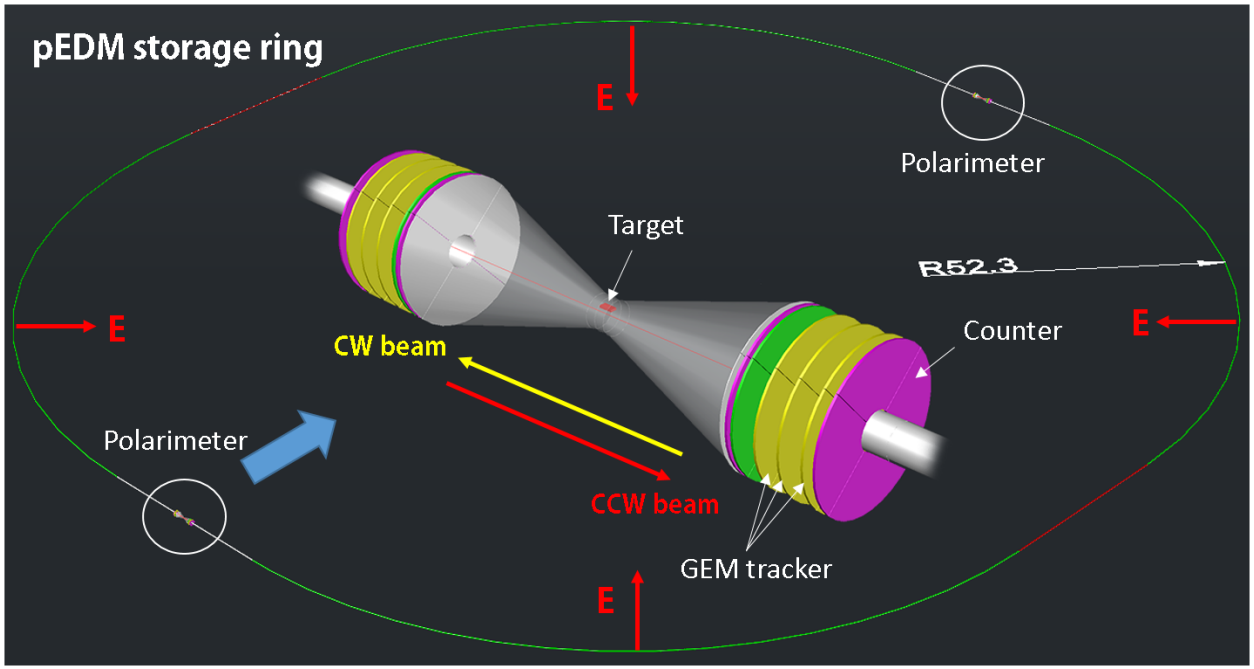


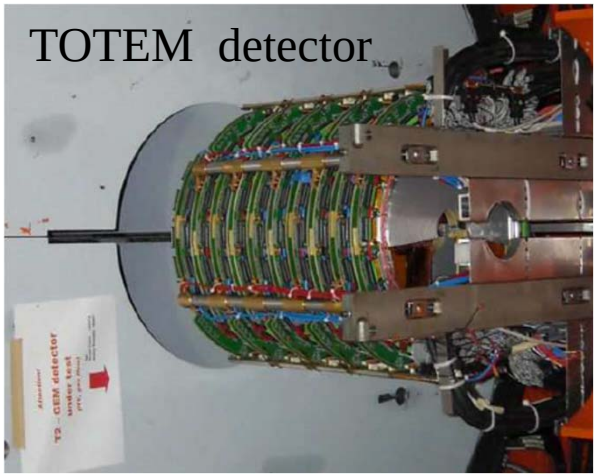




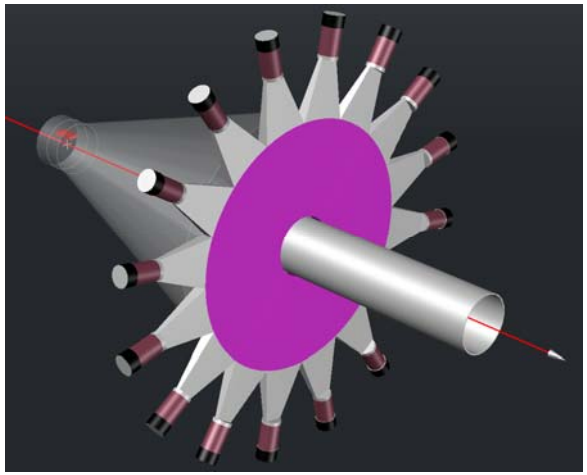
Seonghee Park/spark@ibs.re.kr

Prototype polarimeter detector concept





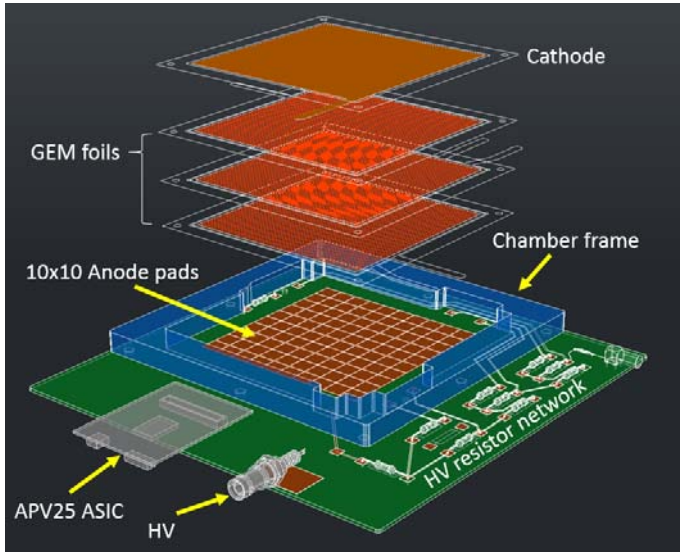
GEMs for tracker

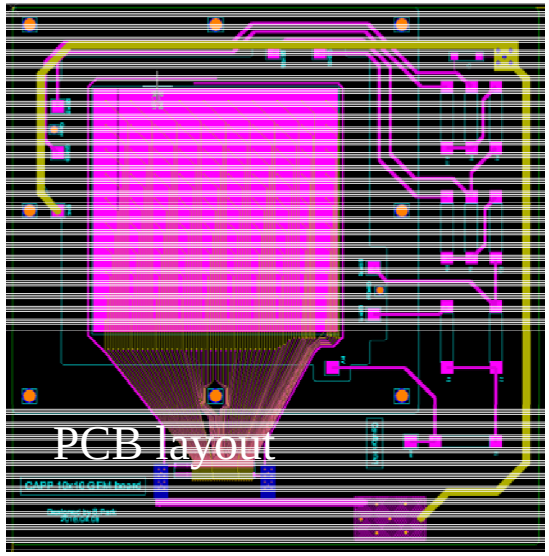


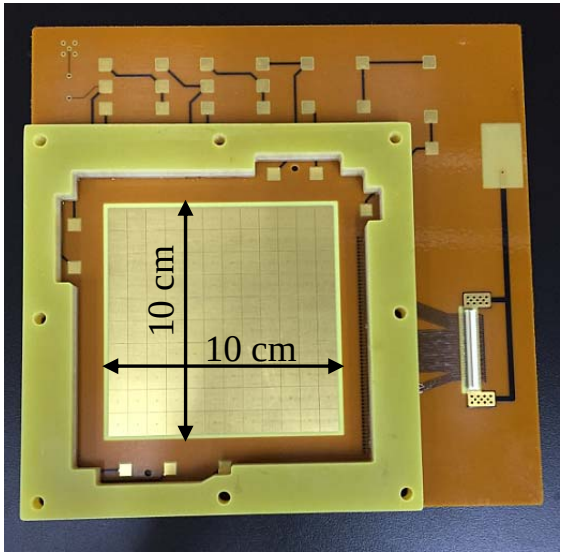
Scintillators for counters

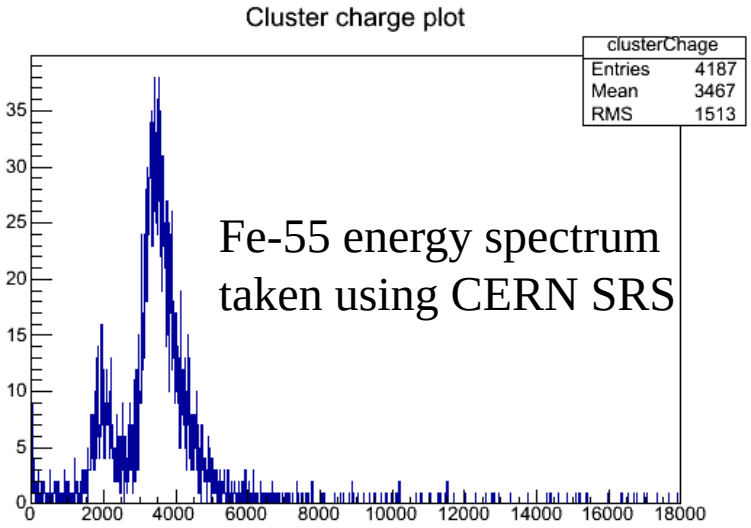
CAPP/IBS

10x10 cm^2 test GEM detector (10x10 pad board)

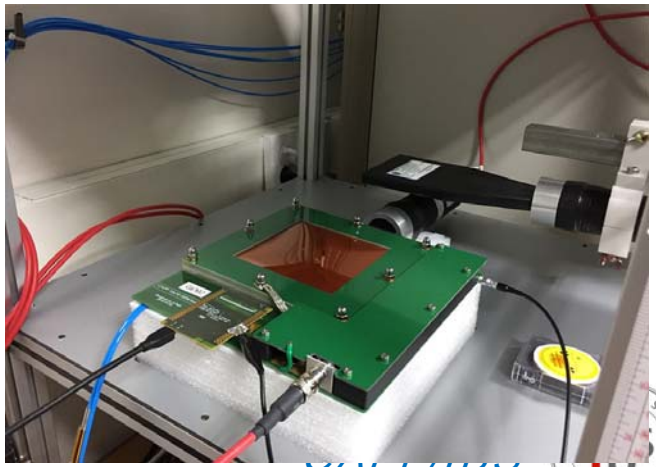






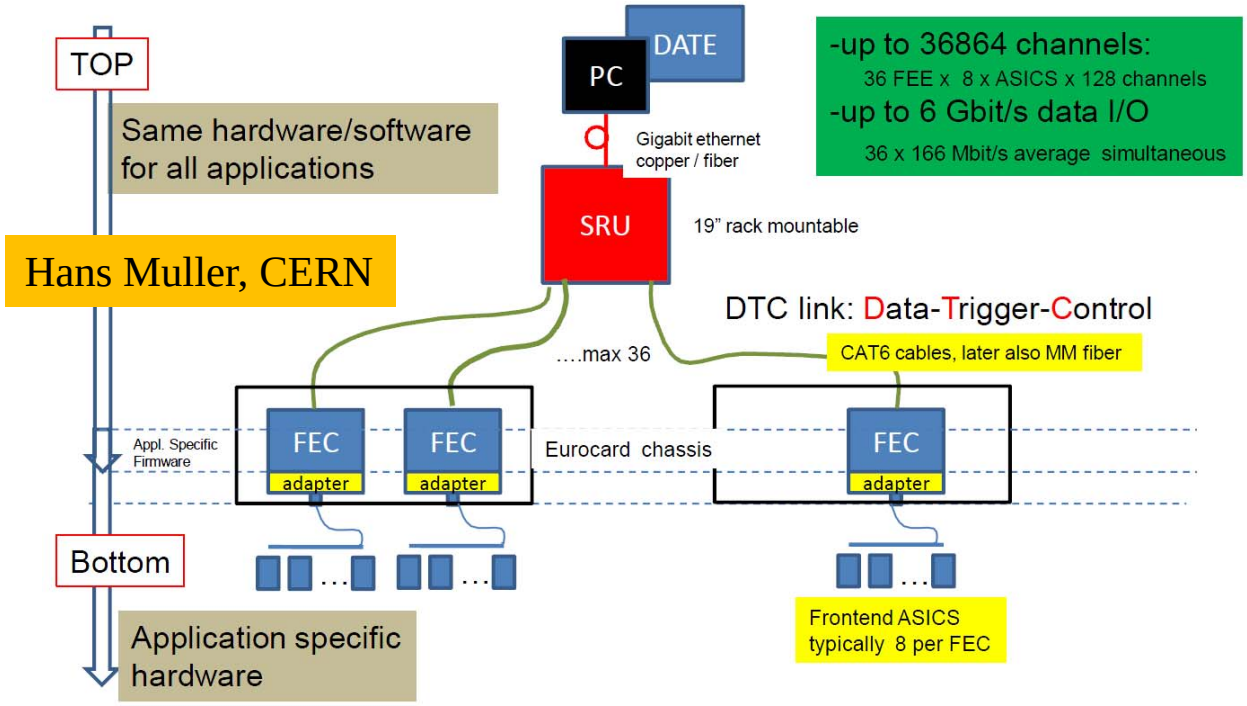


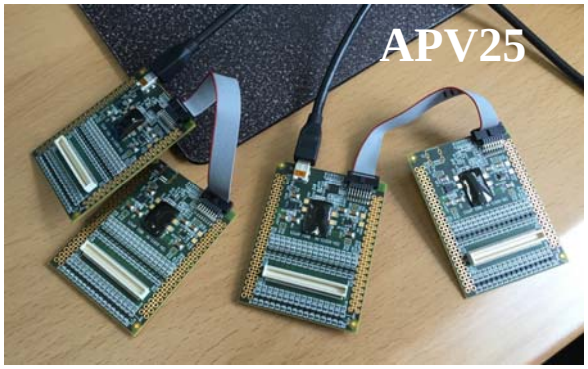
GEM detectors are built and being tested with CERN SRS(APV25).



Seongtae Park/stpark@ibs.re.kr

DAQ electronics for GEM test (SRS)

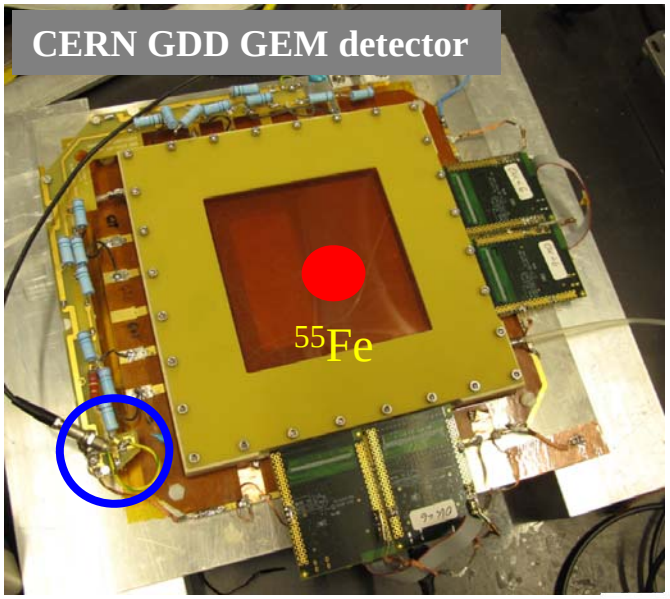




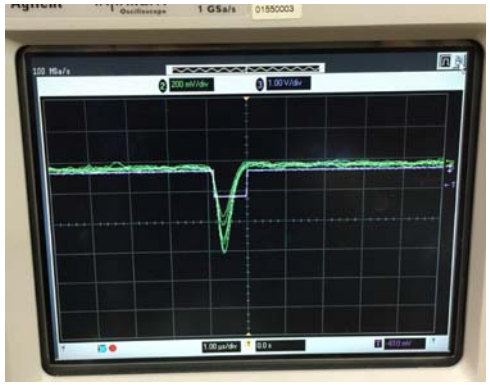
- ❖ SRS: Scalable Readout System
- ✓ Developed and distributed by the RD51 collaboration
- ✓ FE Hybrid+ adapter card+FEC+DAQ PC
  - Hybrid: **APV25**, **VMM**, GEMROC, Beetle, etc
  - APV: analog chip
  - VMM: digital chip with peak detection and time information

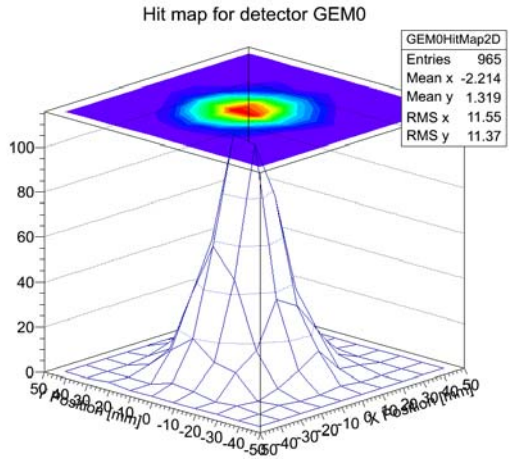
Test results/Source run(^{55}Fe, x-y strip board)

Test at CERN GDD lab.

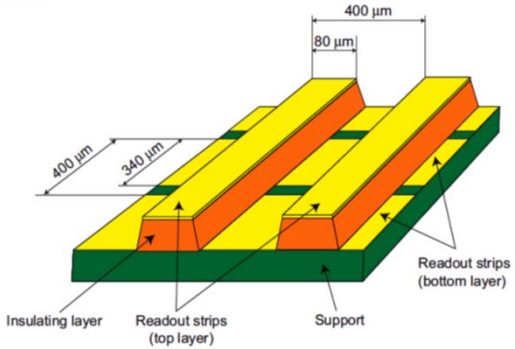


Trigger signal from the bottom electrode of the third GEM.
Rate=~280



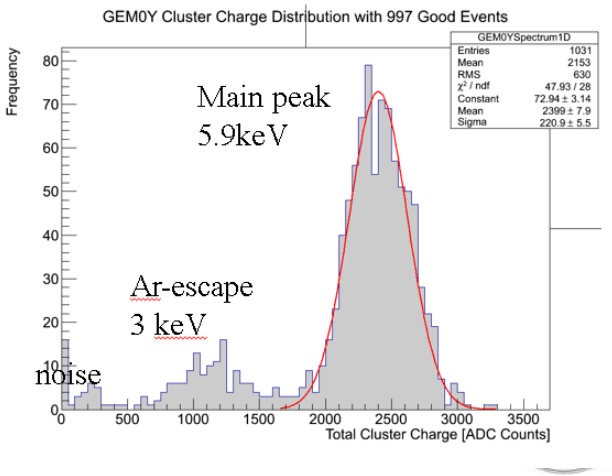


- 10x10 cm^2 GEM chamber
- Triple GEMs
- Ar:CO_2=70:30
- HV=3800V
- P=400μm strip→R~115μm



x-y strip board

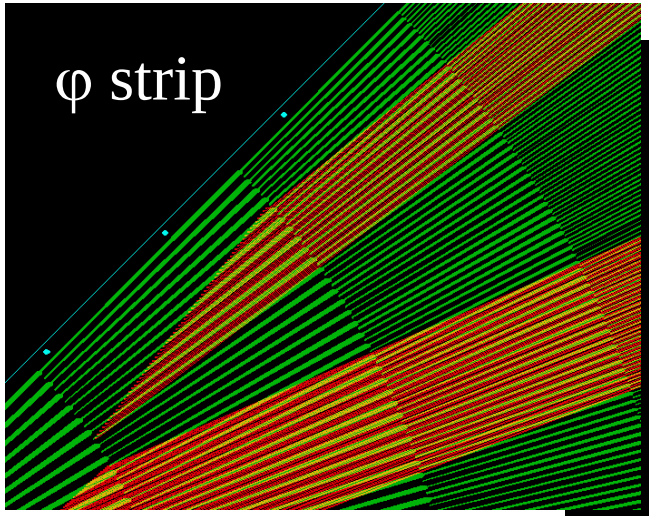
Fe55 energy spectrum

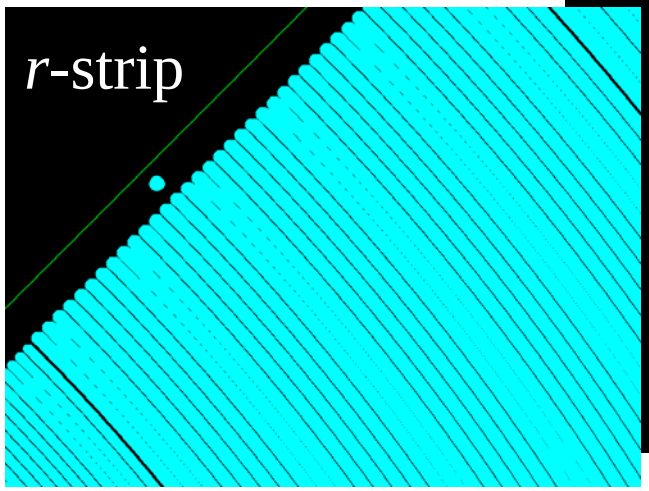


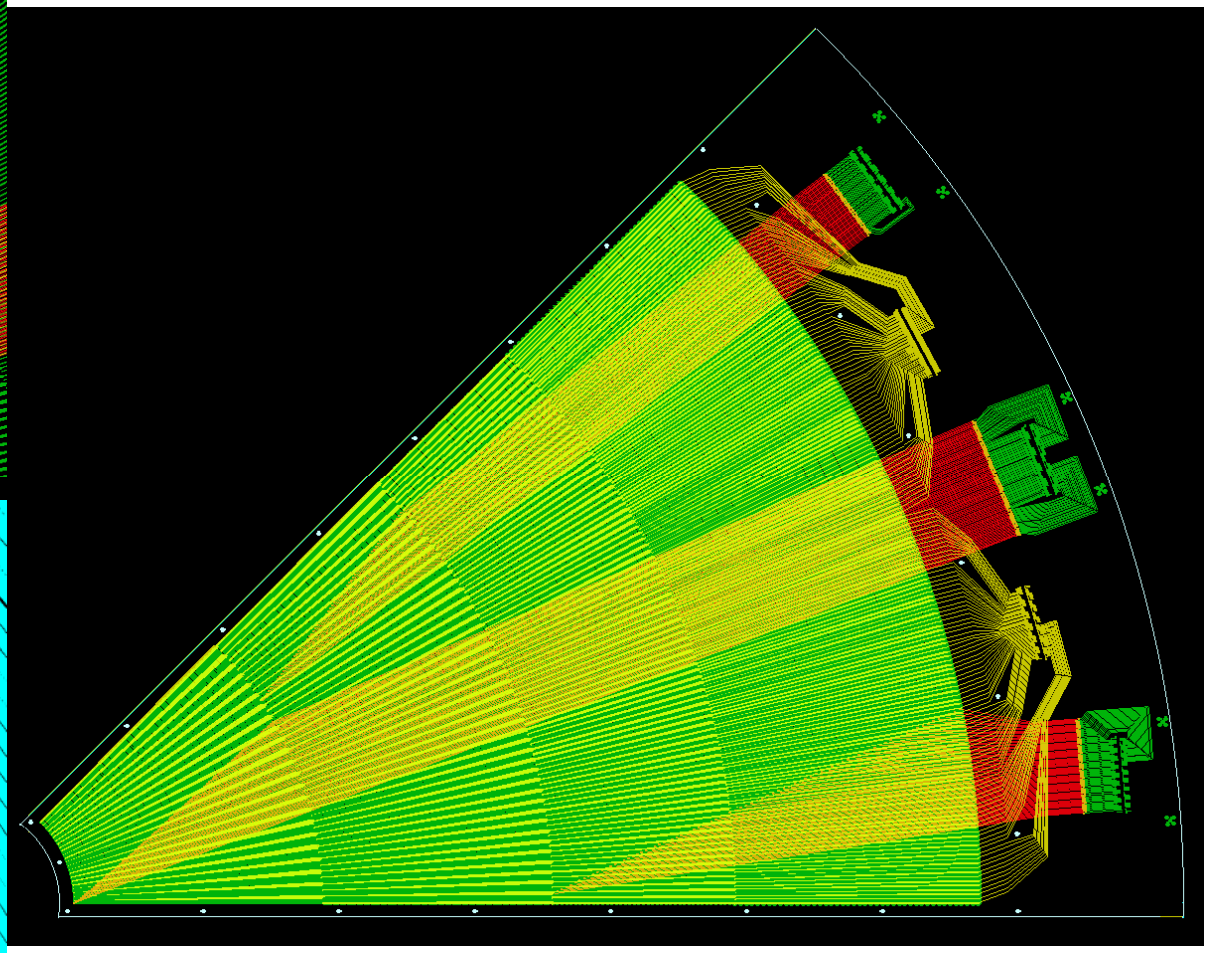
Seongtae Park/stpark@ibs.re.kr

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.

Seongtae Park/stpark@ibs.re.kr

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**

Seongtae Park/stpark@ibs.re.kr

2017 International Workshop on

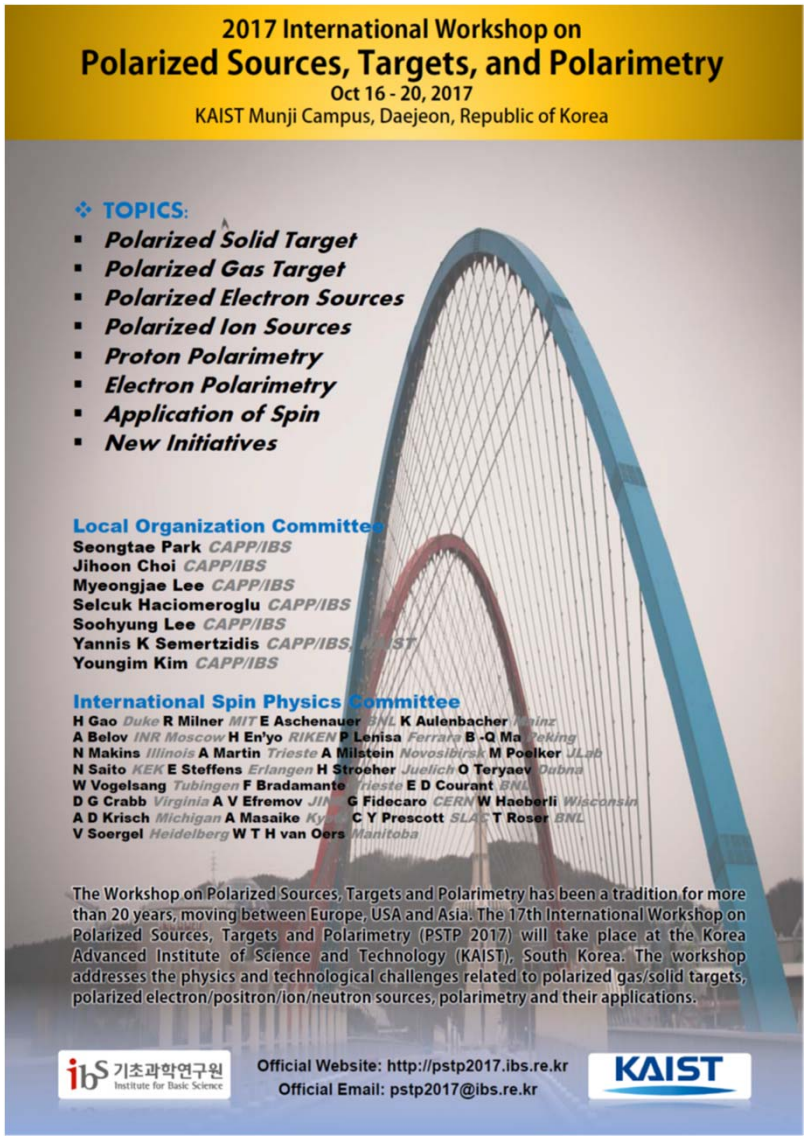
Polarized Sources, Targets, and Polarimetry

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!



Seongtae Park/stpark@ibs.re.kr

CAPP/IBS

Thank you!

Seongtae Park/stpark@ibs.re.kr

CAPP/IBS