Status of pEDM polarimeter detector development at CAPP/IBS

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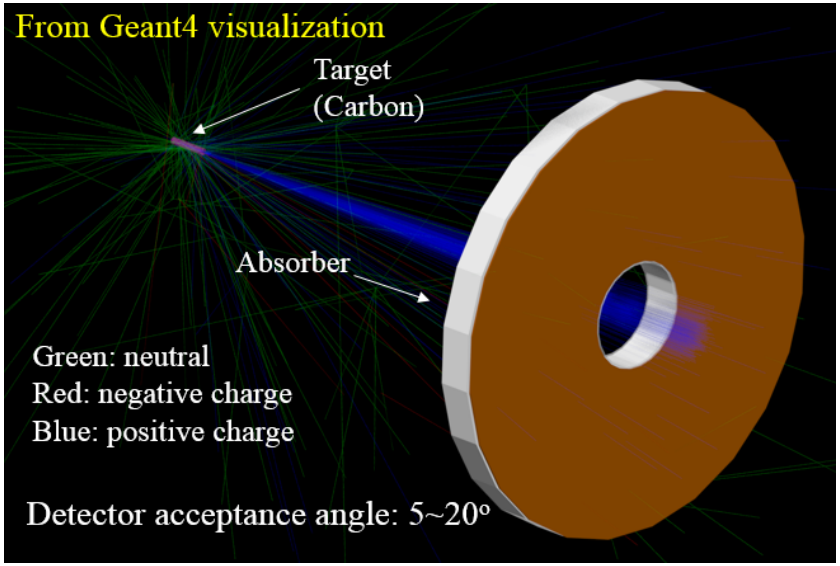
Outline

1. MC simulation on p-C scattering
2. GEM-based polarimeter detector
3. About DAQ (CERN SRS)
4. GEM detector construction and lab test results
5. COSY beam test plans
6. Summary and plans

Geant4 simulation on p-C scattering



- Simulation tool: Geant4 v4.10.p02
- Physics list used for simulation: 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: 60mm
- Target dia.: 10 mm
- Target material: Graphite(C:N:O=99:0.7:0.3, 1.7 g/cm^3)
- Distance between target and detector: 900 mm

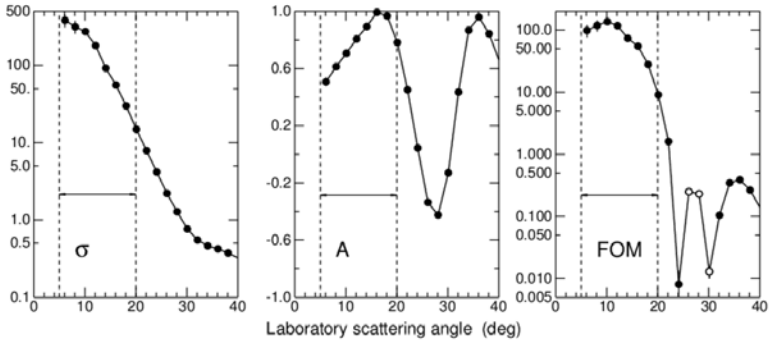
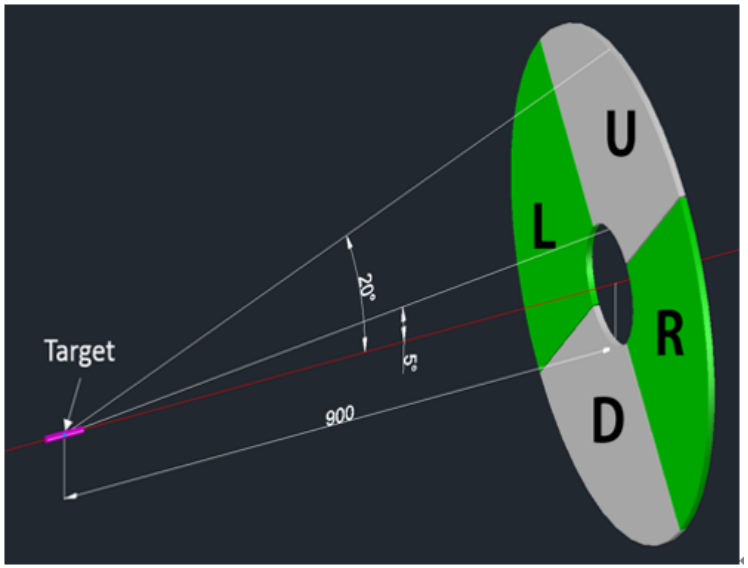
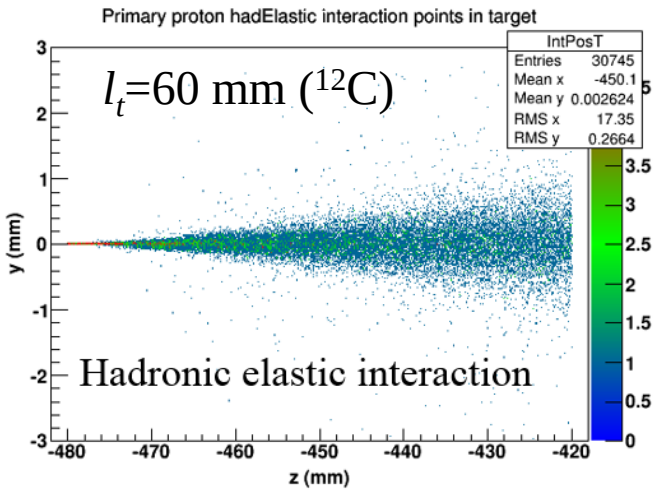
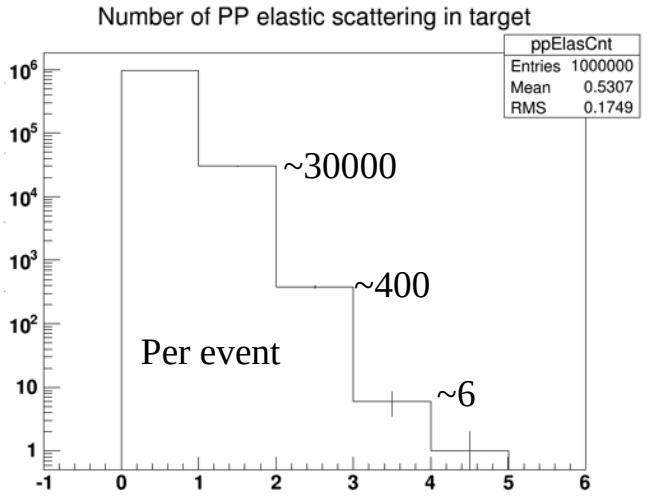


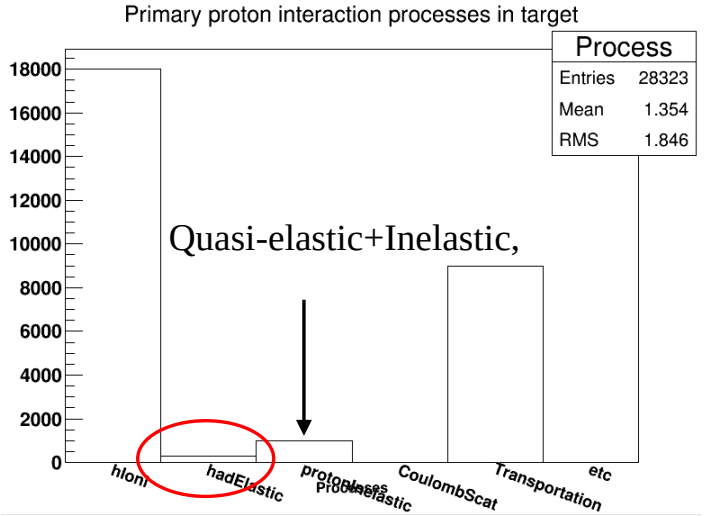
Fig: from Proton EDM proposal

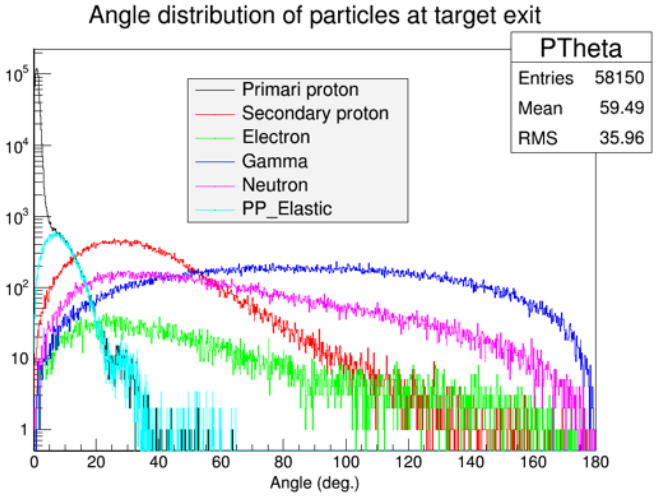


Proton interaction in Carbon target

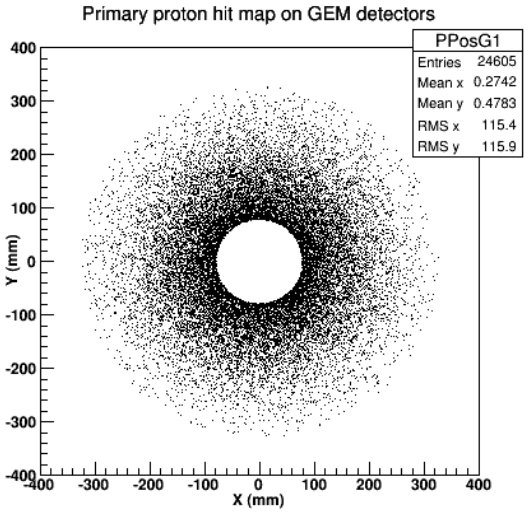


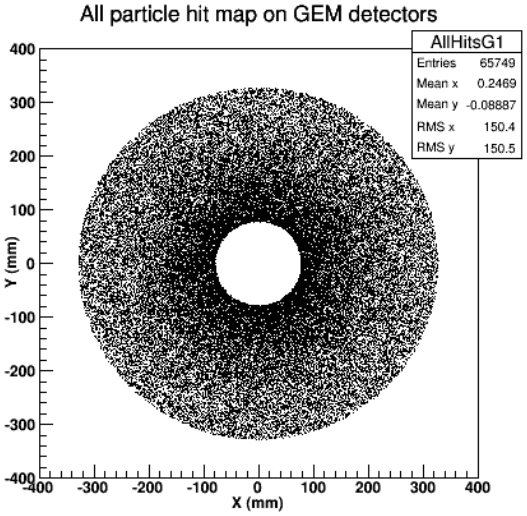


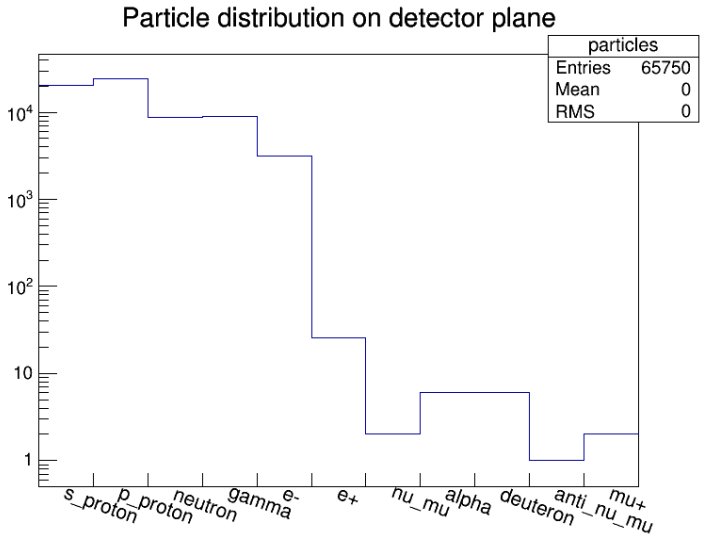




Particles on the detector plane/Detector acceptance







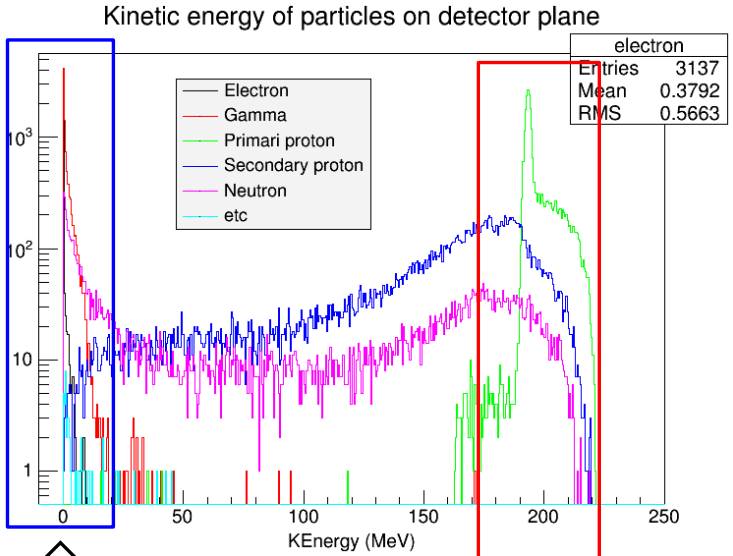
Hits by primary protons only

Detector acceptance : 2.5 %

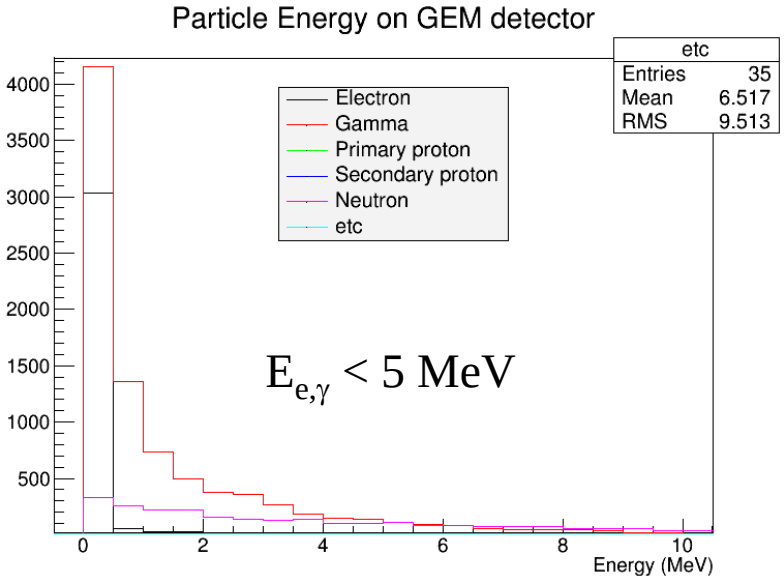
All hits including secondaries

Detector acceptance: 6.6 %

Particles on the detector plane

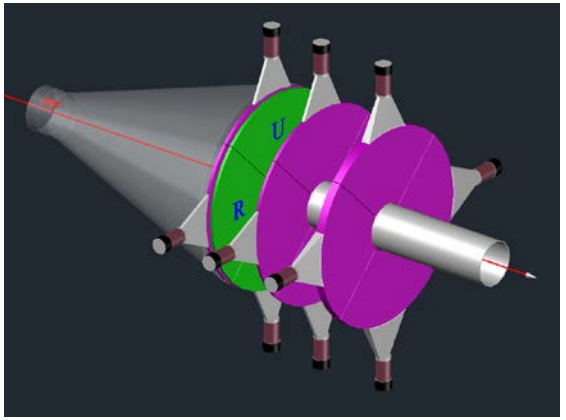


$E_{e,\gamma} < 5$ MeV



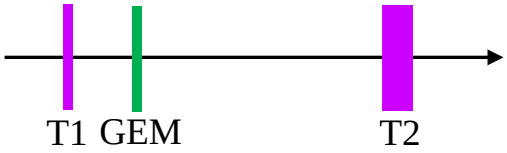
$E_{e,\gamma} < 5$ MeV

Signals overlap with background.
The major BG is secondary protons.



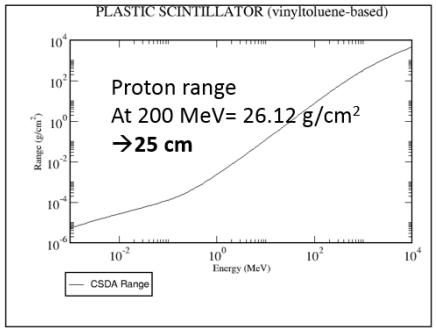
Trigger telescope

Coincidence triggers/improving signal to BG

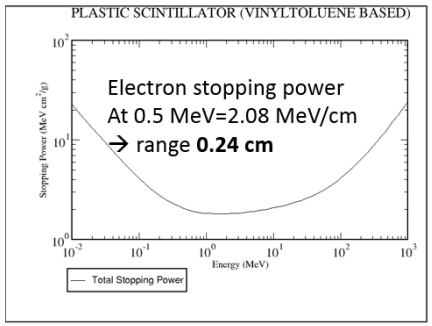


Plastic scintillator(polyvinyltoluene)

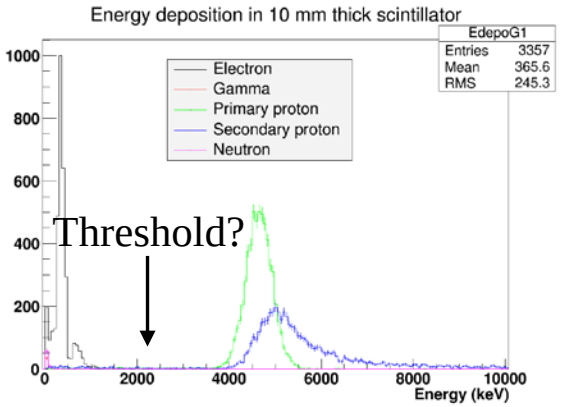
Excitation energy: 64.7 eV
Density =1.032 g/cm^3



Protons

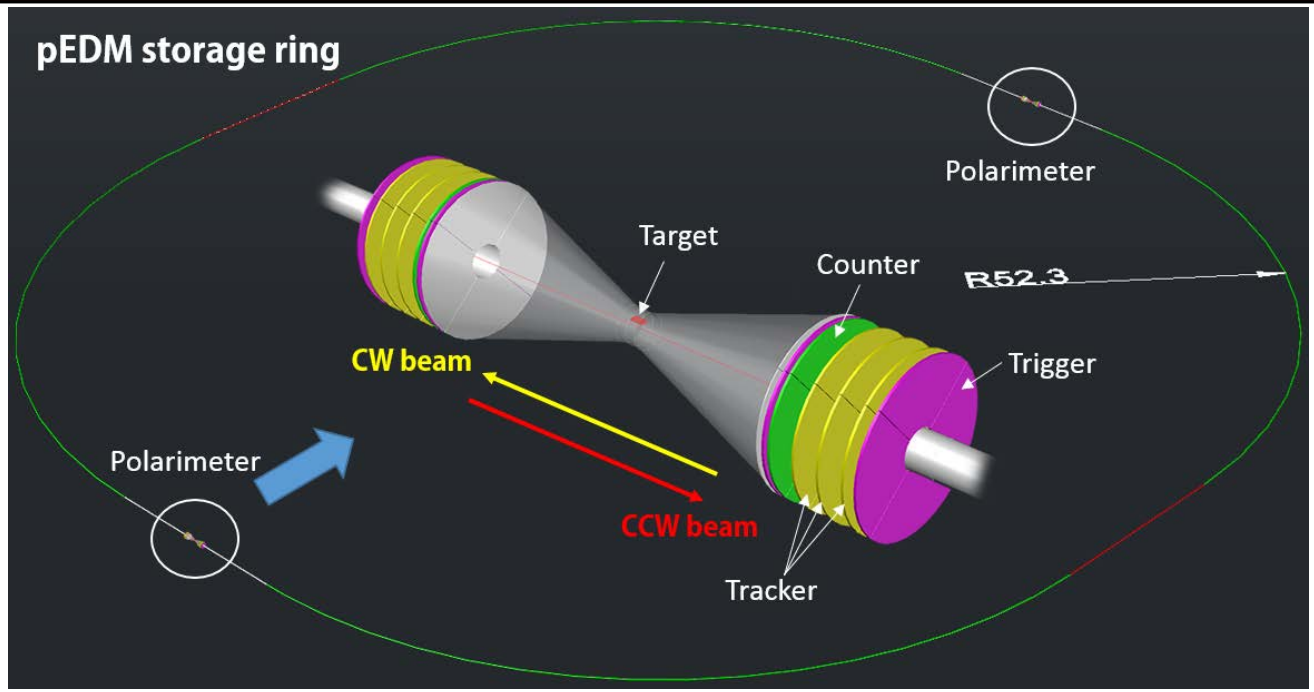


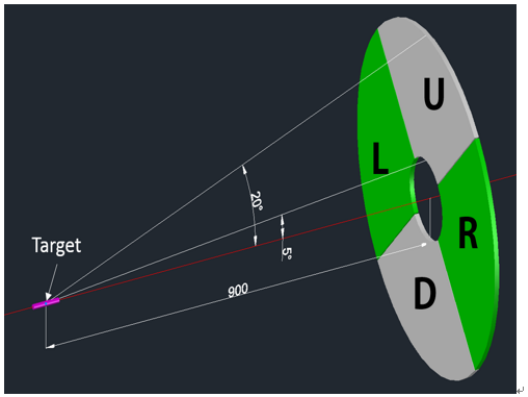
Electrons

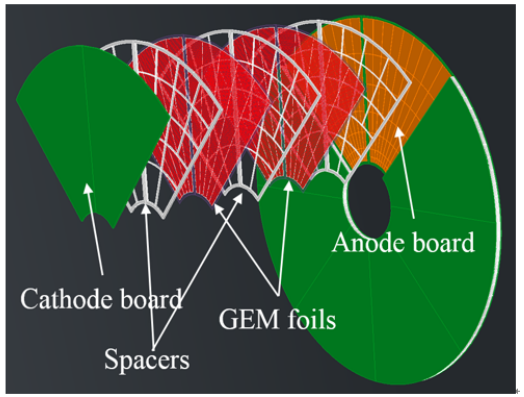


- Low energy electrons can be removed easily in the first scintillator T1(t=1 cm).
- Gamma still survive through T1 and reach the detector. Ex> 13 MeV γ: 60% absorption in 40 mm Iron.
- Low energy e,γ are well separated in **thick scintillation detectors** from the high energy protons as shown below.
- The final triggers are obtained from the two/three scintillation detectors.

GEM-based prototype polarimeter detector concept







GEM-based prototype polarimeter detector concept

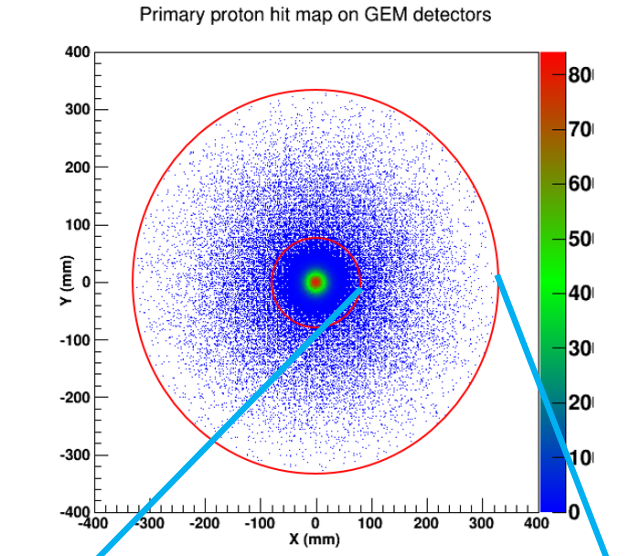
About detector counting rate

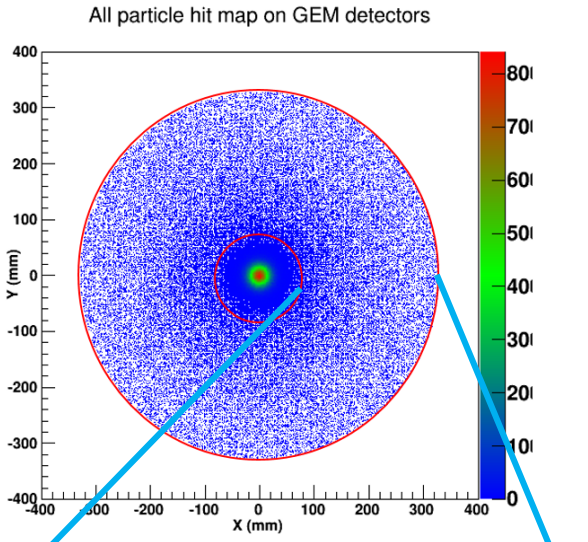
Beam parameters:

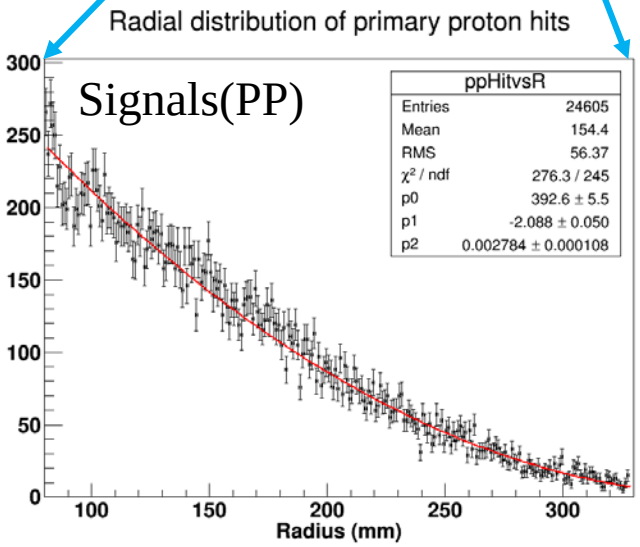
1. 701 MeV/c protons (E_k=233 MeV, β=0.6→v=1.8x10^8 m/s)
2. Ring circumference 500 m.
3. Revolution frequency is about 0.36 MHz.
4. About 100 bunches
   - ✓ 5 m between bunches
   - ✓ 28 ns bunch spacing
   - ✓ 0.36MHz x 100=3.6x10^7 bunches/s
5. **5x10^{10} particles/storage**
   - ✓ 5x10^8 particles/bunch
6. 4 polarimeters on the ring for CW/CCW beams

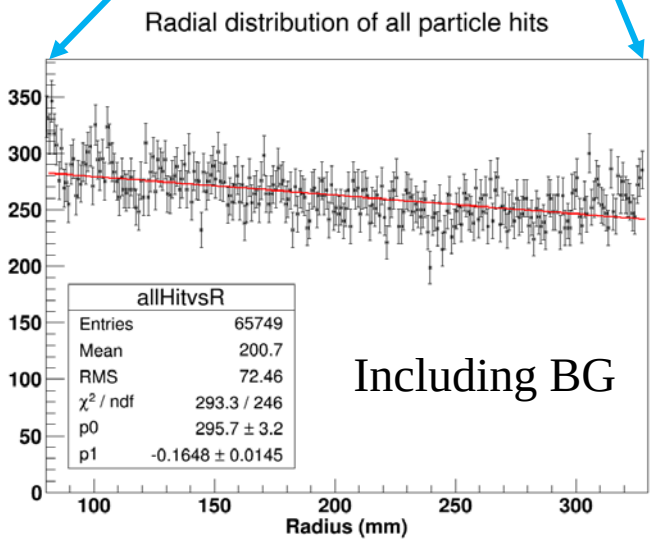
- ✓ **Beam extraction for 1000s**
- ✓ Assuming full extraction at the constant extraction rate for the entire extraction
  - **5x10^7 interactions/s**
- ✓ 5x10^7/3.6x10^7=1.4 interactions/bunch
- ✓ Assume 6.5 % of detector acceptance(including BG, from simulation)
  - **3.25x10^6 hits on detector/s**
  - 4 detectors(1024x4=4096 channels)
  - →**800 hits/ch/s (including BG)**
- ✓ For signal(2.4 % acceptance)
  - **1.2x10^6 hits on detector/s**
  - →**300 hits/ch/s (signal)**

Radial distribution of particle hits on the detector plane



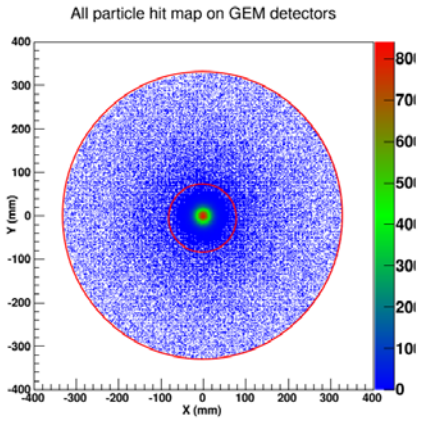


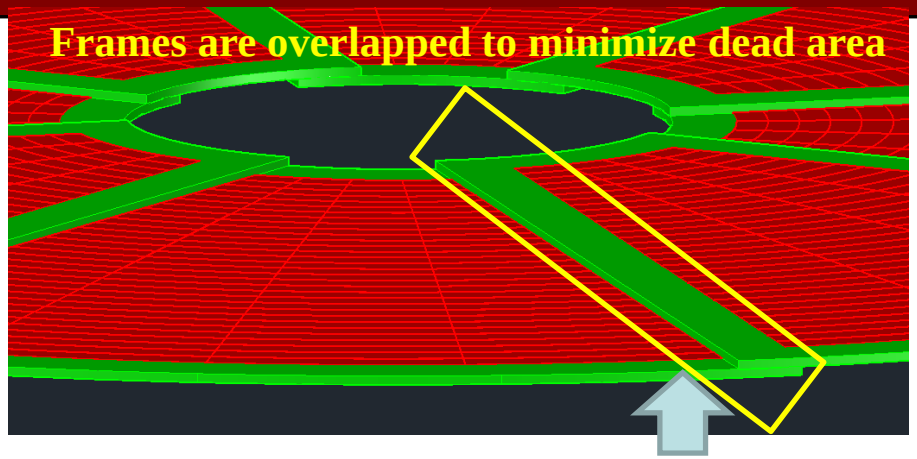




R=79~328 mm(5~20º)

Equal rate anode pad design for handling high rate

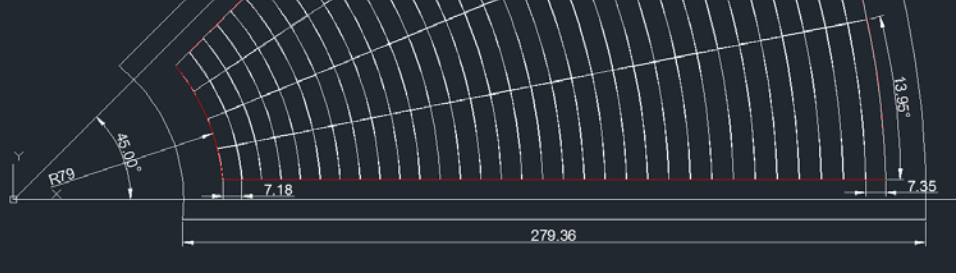


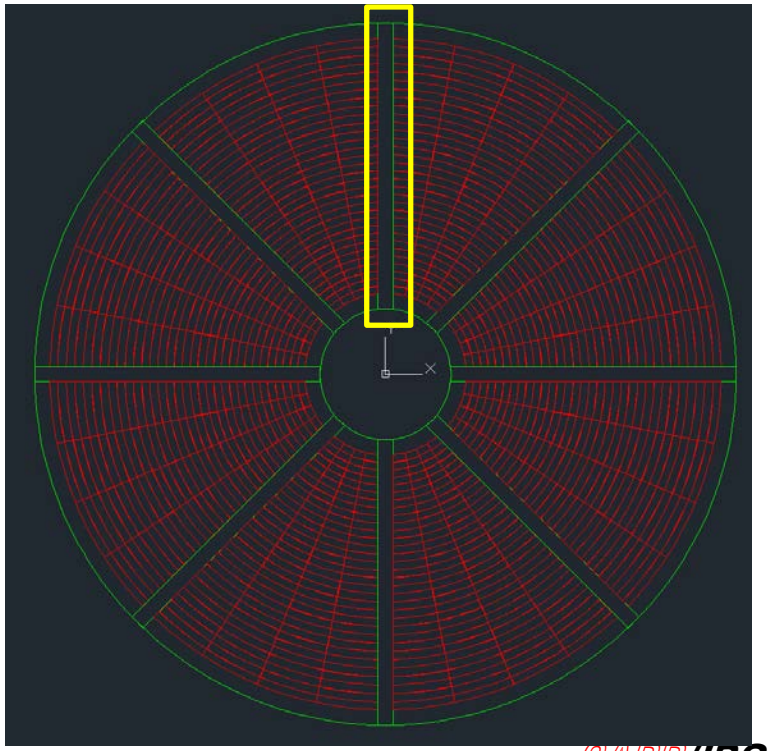


- **800 Hz/ch(with BG)**

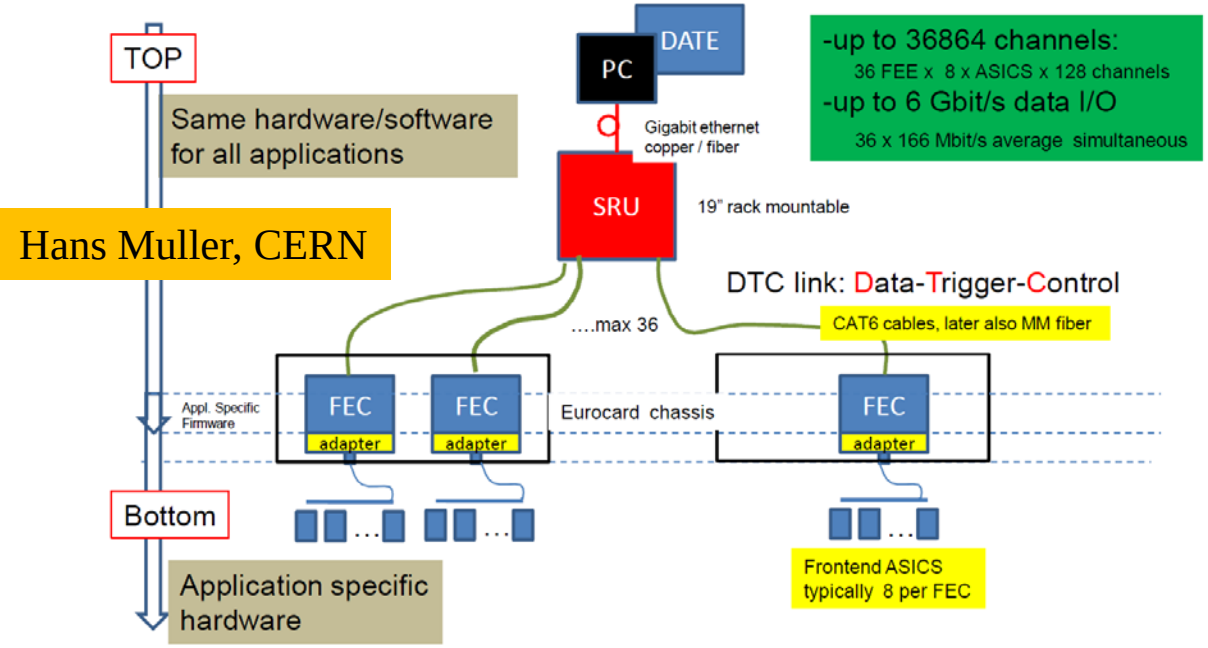
Inner most pad area=89 mm^2
Outer most pad area=440 mm^2

Counting rate on the inner most pad=899 Hz/cm^2
Counting rate on the outer most pad=182 Hz/cm^2

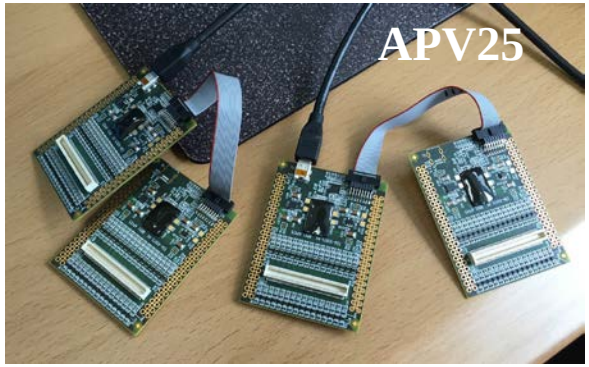




DAQ system for GEM test



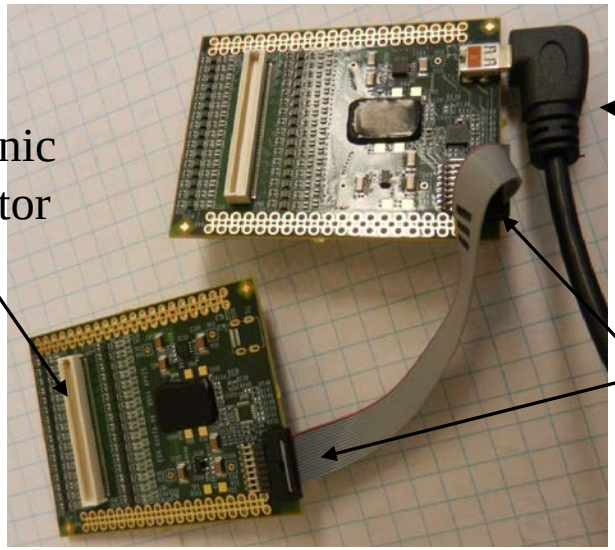
RD51 SRS

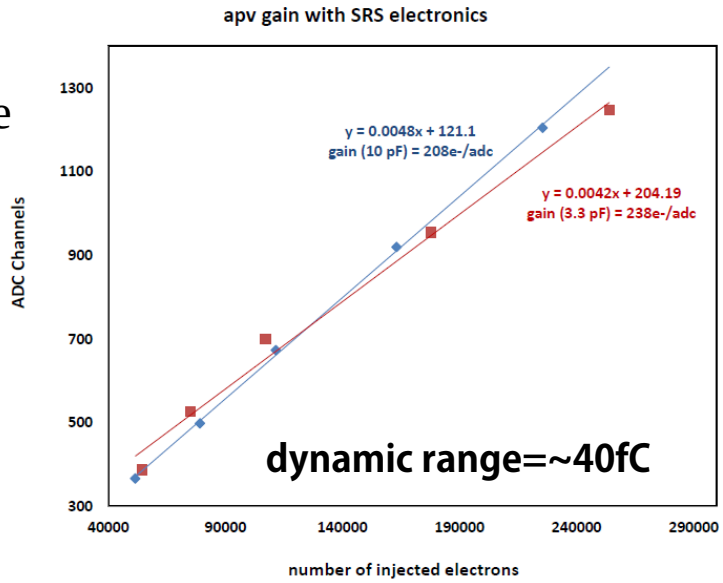


- ❖ SRS: Scalable Readout System
- ✓ Developed and distributed by the RD51 collaboration
- ✓ FE Hybrid+ adapter card+FEC+DAQ PC
  - Hybrid: **APV25**, **VMM**, GEMROC, Beetle, etc
  - APV: analog chip
  - VMM: digital chip with peak detection and time information

Hybrid chip/APV25

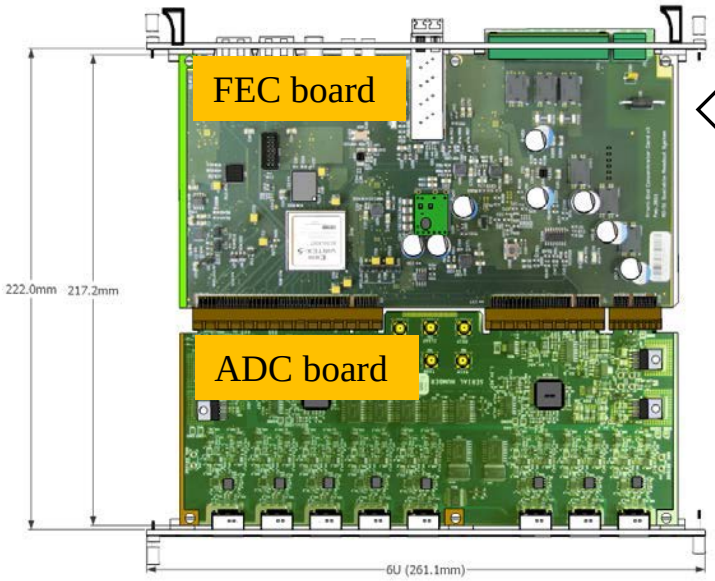
- The **APV25 is a 128 channel analogue pipeline chip** for readout of silicon microstrip detectors in the **CMS tracker at the LHC.**
- Each channel comprises a low noise amplifier, a **192 cell analogue pipeline** and a deconvolution readout circuit.
- Output data are transmitted on a single differential output via an **analogue multiplexer.**
- The chip is fabricated in a **0.25 micron CMOS process to take advantage of the radiation tolerance,** lower noise and power, and high circuit density which can be achieved.
- **Spark protection circuits** in the input channels

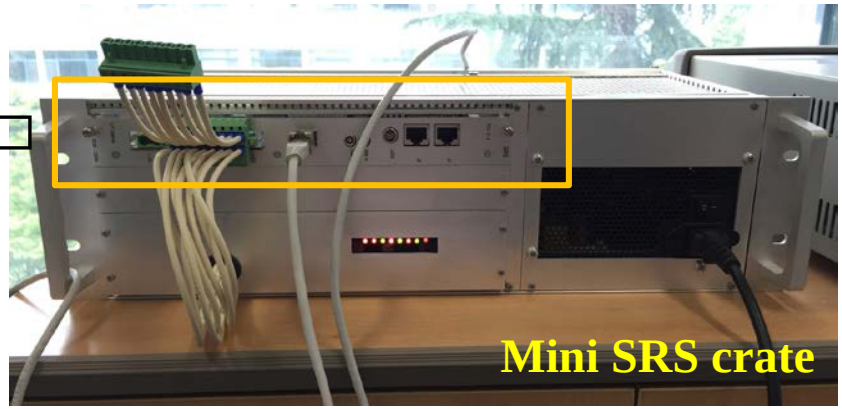




ADC/FEC card

- **ADC card.** The ADC card is the first C card adapter for analogue frontend chips like the APV25 and Beetle. It integrates 16 ADCs of 12 bit**, sampling at 40 MHz** (Texas Instruments ADS 5281).
- Digital data from the **ADC's get read out via 480 MHz high speed links to the FPGA on the FEC card**. The ADC Frontpanel provides 8 HDMI connector slots for A-type HDMI cables up to 25 meter. Two hybrids per HDMI cables can get powered via the ADC card.



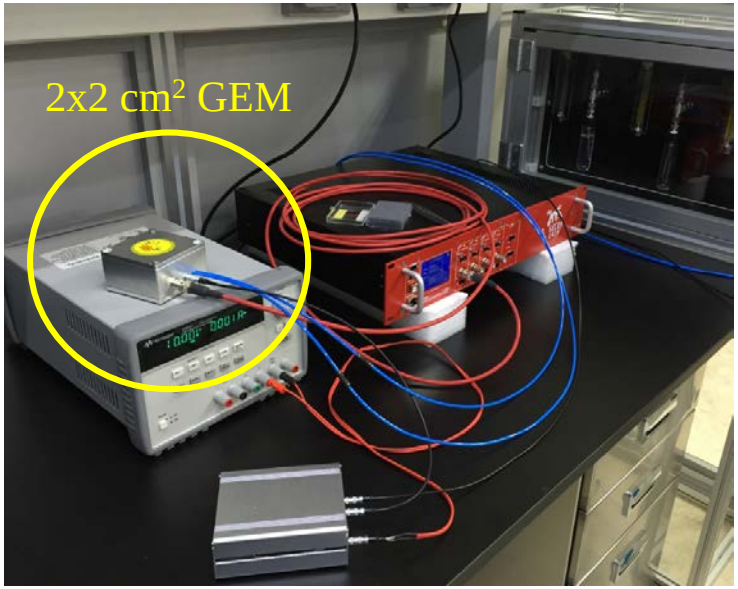


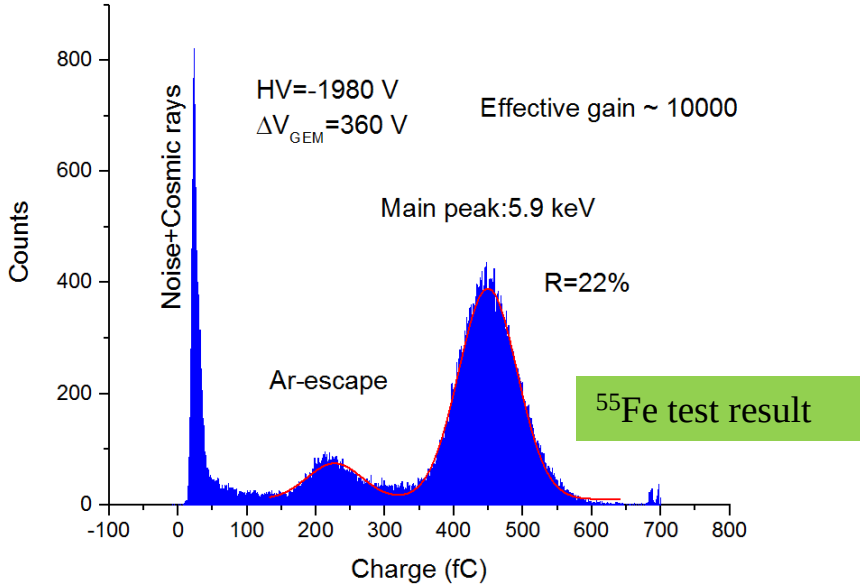
- HDMI channels with two APV25s/HDMI
- Minicrate: total 4k channels
- Eurocrate: up to 16k channels

SRS test environment

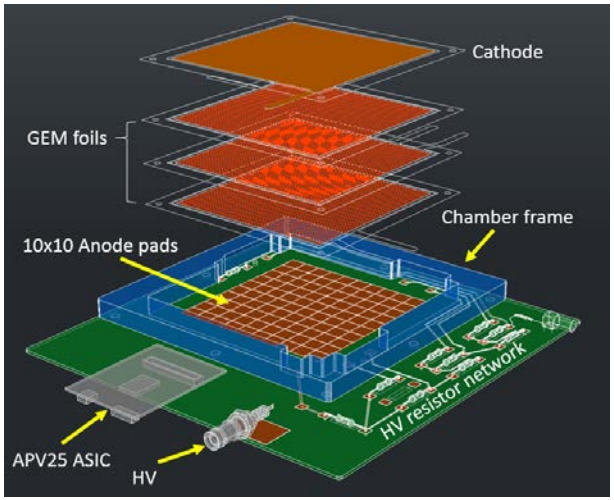
- OS: SL v5.8 on VirtualBox
  - ✓ Ethernet connection for data acquisition
    - Activate Intel virtual technology in bios setup
    - Enable jumbo frame in the network setup, 9KB MTU
- DAQ program: DATE(ALICE experiment)
- Online monitoring and analysis: AMORE(ALICE experiment)
- Asic: APV25(128ch/chip)
  - ✓ Two ASICs(256 ch) for calibration and pedestal test
    - Without detector
  - ✓ Four ASICs for GEM detector with Fe55 source
    - $10\times10cm^2$ GEM chamber
    - Triple GEM with $ArCO_2$=70:30
      - 3-2-2-2 gaps
    - With x-y strip anode board with 512ch
    - Strip pitch=400μm
    - Trigger signal from the bottom electrode of the last GEM
- Mini crate

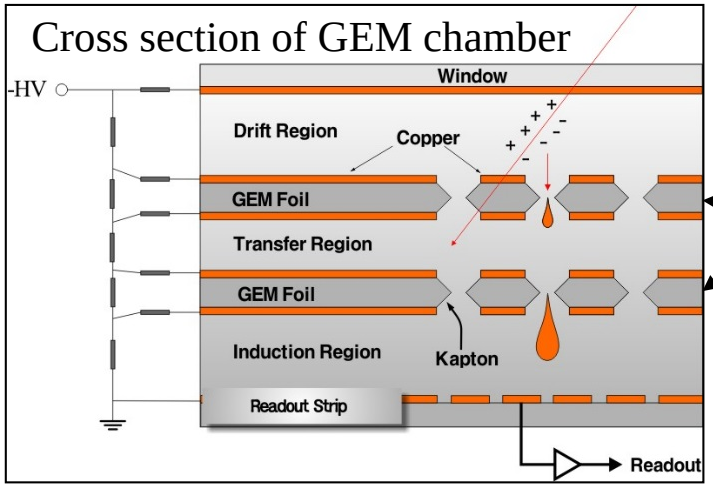
New polarimeter lab is ready





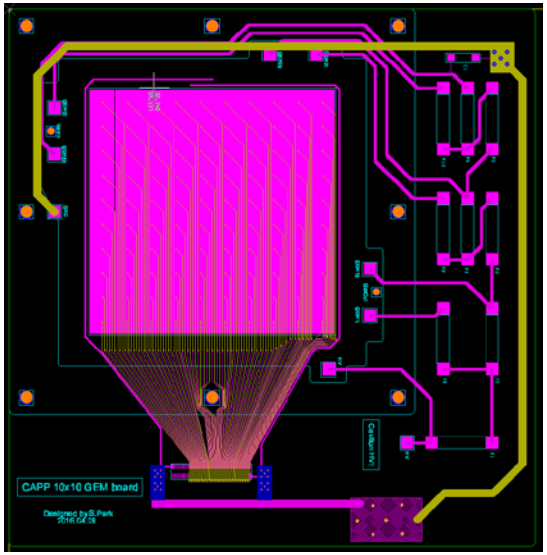
10x10 cm^2 test detector

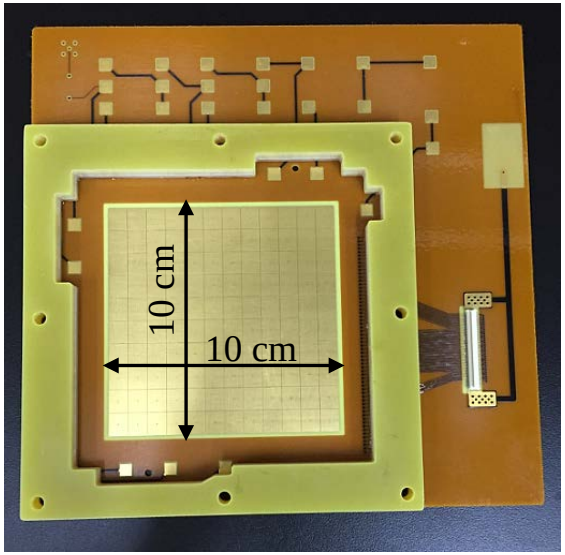




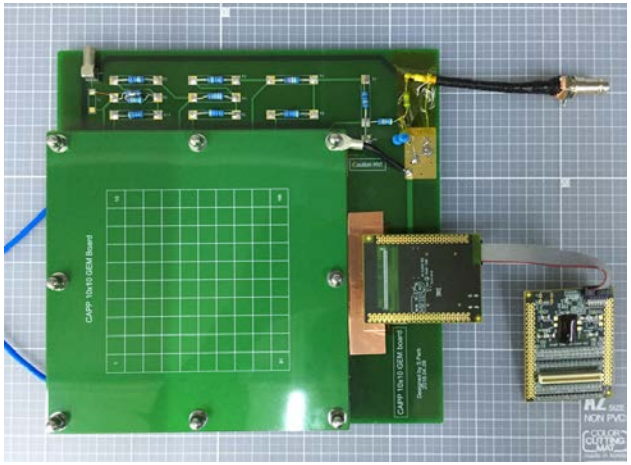
10x10 GEM foil

PCB layout



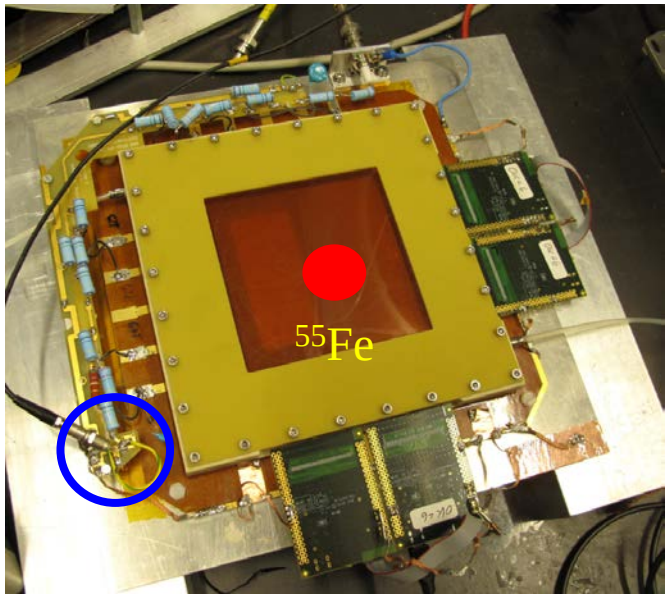


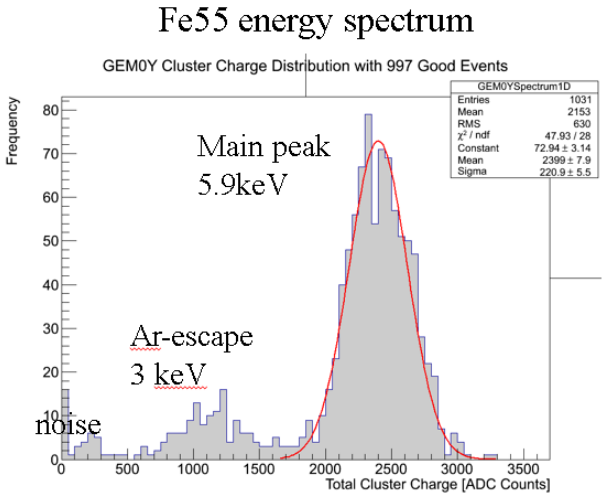
Under assembling.
Will be tested soon and go beam test with APV25.

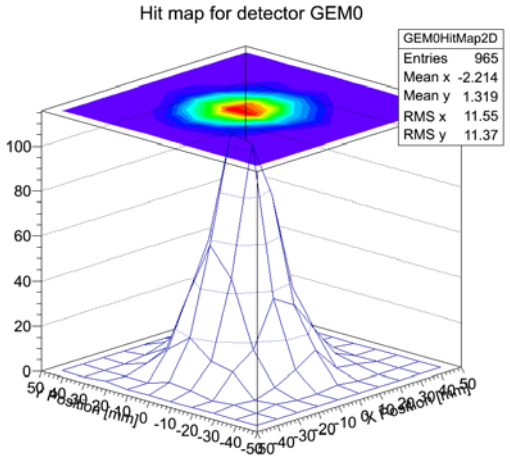


Test results/Source run(Fe55)

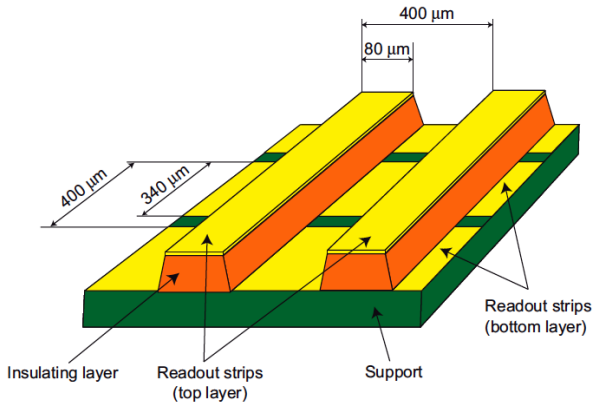
Test at CERN GDD lab.







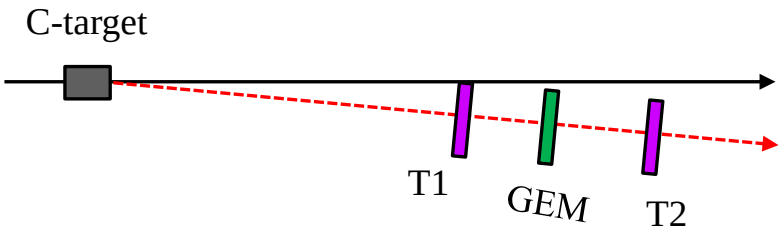
- 10x10 cm^2 GEM chamber
- Triple GEMs
- Ar:CO_2=70:30
- HV=3900,3800V
- P=400μm strip→R~115μm

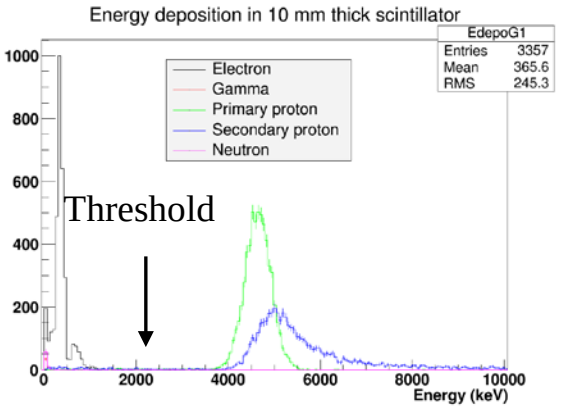


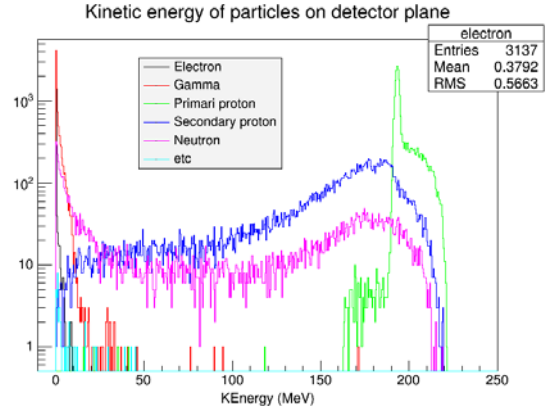
x-y strip anode board

Plan for the beam test at COSY

1. DAQ (CERN SRS) test with 10x10 GEM detector
2. Trigger study (plastic scintillation counter: 10x10 cm^2, t=1, 2, 3 cm)
   - ✓ Proton beams with E_k=230, 200, 170, 140, 110 MeV etc.
3. GEM detector efficiency measurement
4. Counting rate measurement at various scattering angles
   - ✓ Use 2x2cm^2 scintillation counters
   - ✓ 1 m away from the target
   - ✓ 5~20^o angle scan
5. Etc.







Summary

- Continuing Geant4 simulation for p-C scattering
  - ✓ Including asymmetry realization (Ed Stephenson)
- A new polarimeter detector lab is ready at CAPP
- Test GEM detectors are constructed and being tested with CERN SRS DAQ
  - ✓ Detector chacterization
  - ✓ Analysis tool development
- Plans for COSY beam test in 2017