Optimizing GEM parameters for SoLID simulation

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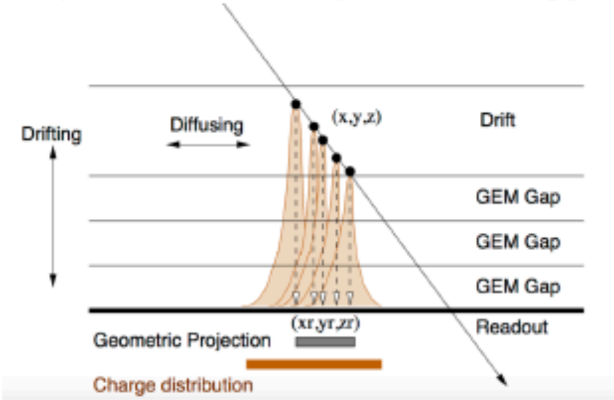
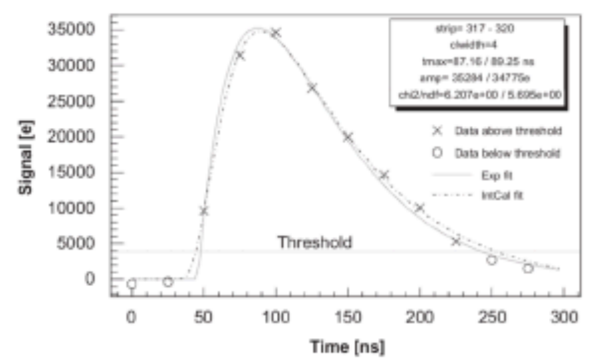
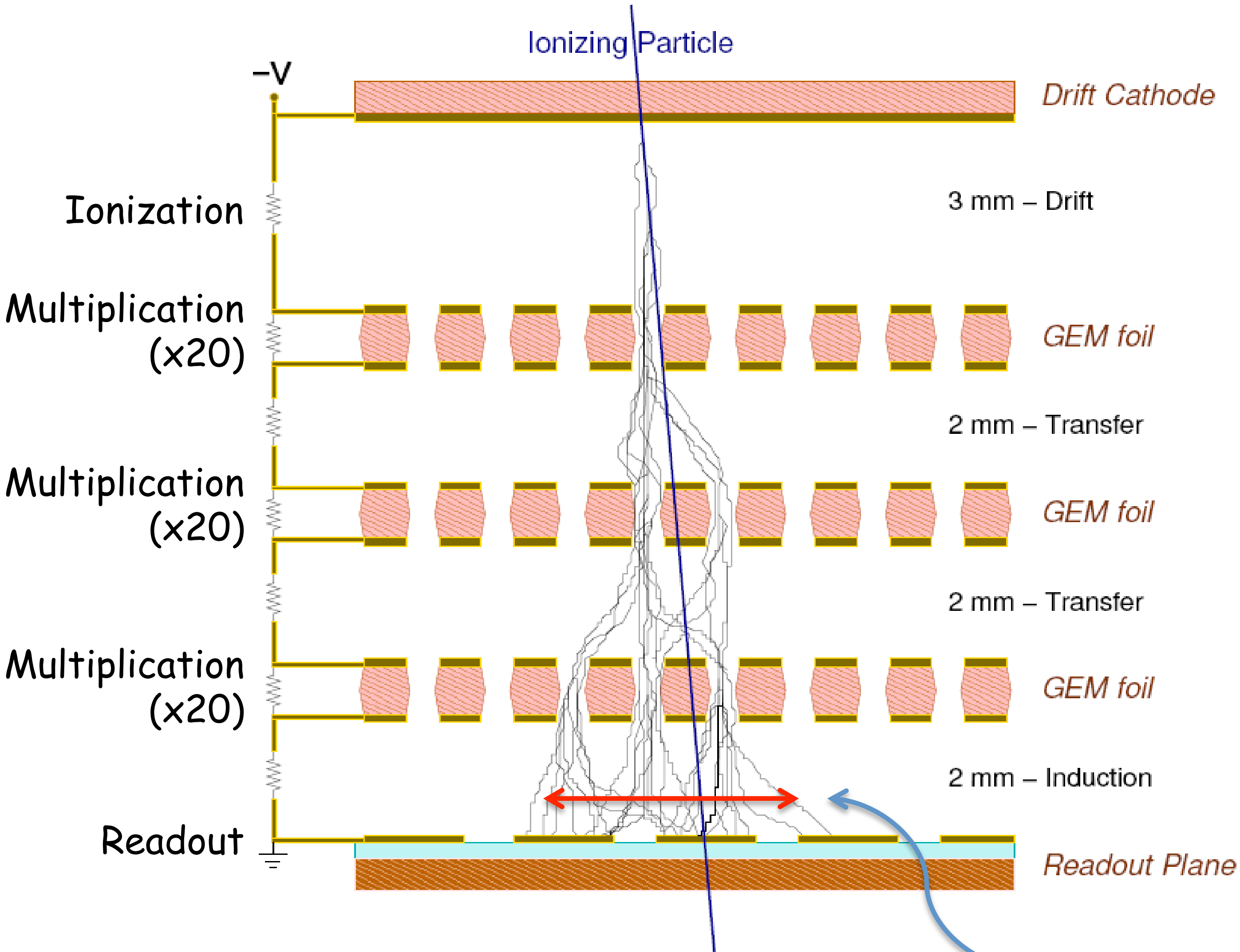
Digitization

- GEM digitization based on SBS work (E. Cisbani, R. Holmes) and Ole's work for SoLID.
- Input: GEMC hit position and energy deposition in the gas layer above the first GEM foil.
- Process:
  - Poisson-distributed number of ion pairs based on energy deposition
  - Uniform distribution for ionization probability along the path
  - Assume constant-velocity diffusion and drift
  - Gaussian distribution of charge deposition on strips
  - GEM response tuned to match COMPASS observation
  - Sample up to 10 time samples after trigger



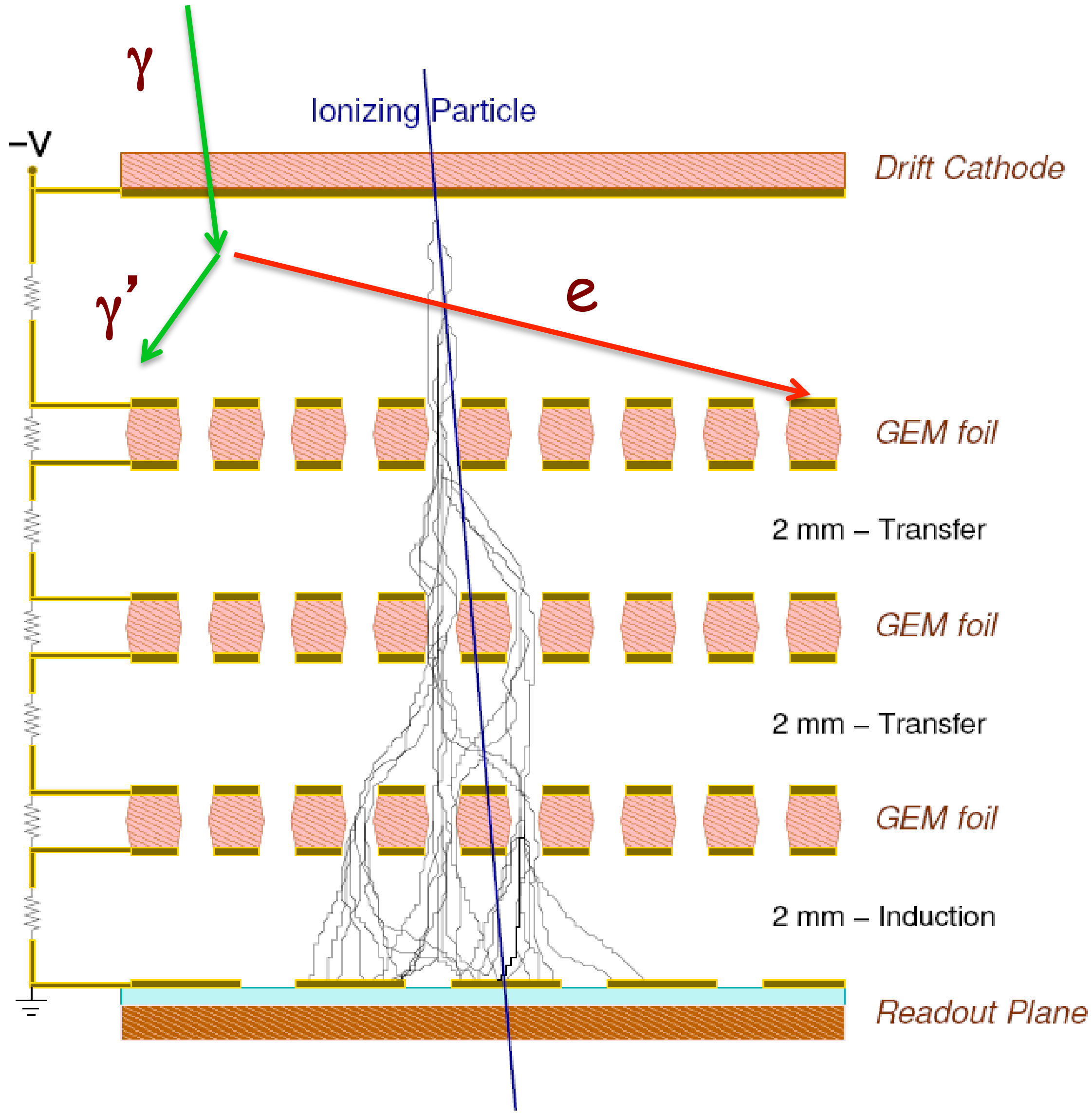


Optimizing simulation parameters



~ transverse diffusion coefficient

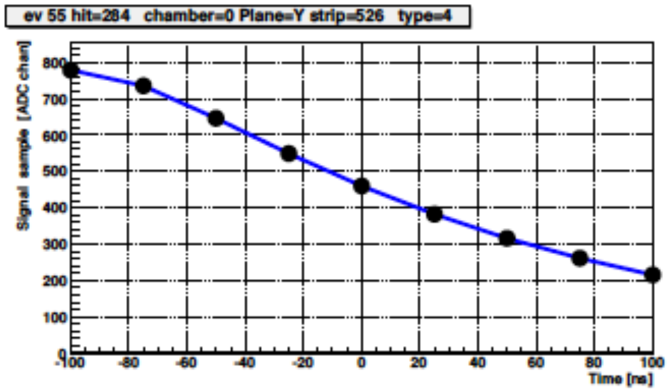
Optimizing simulation parameters

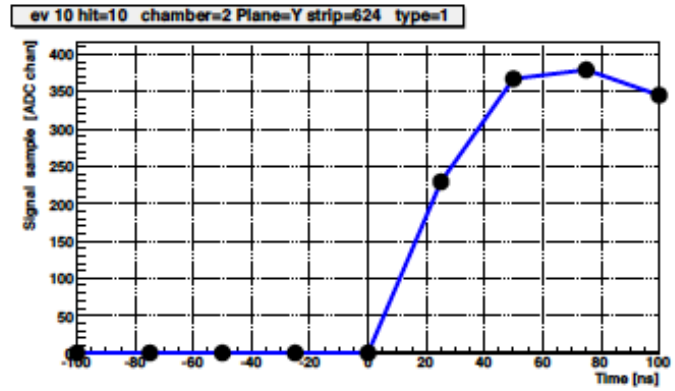


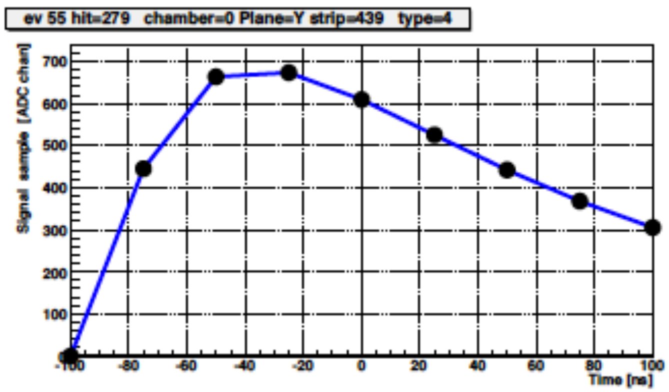
Variables to compare between simulation and data:

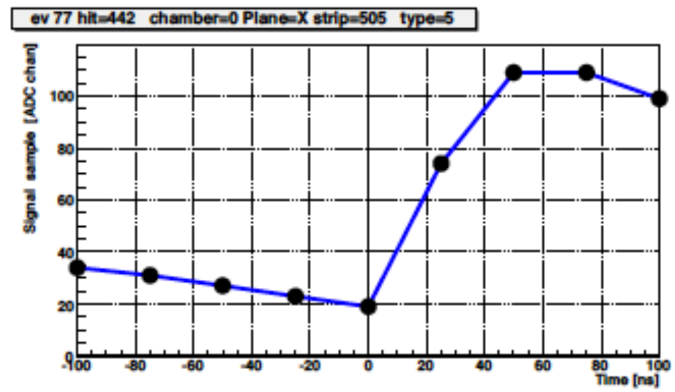
- Number of strips per cluster
- Number of strips
- Cluster ADC sum
- ADC-x vs. ADC-y
- Occupancy.

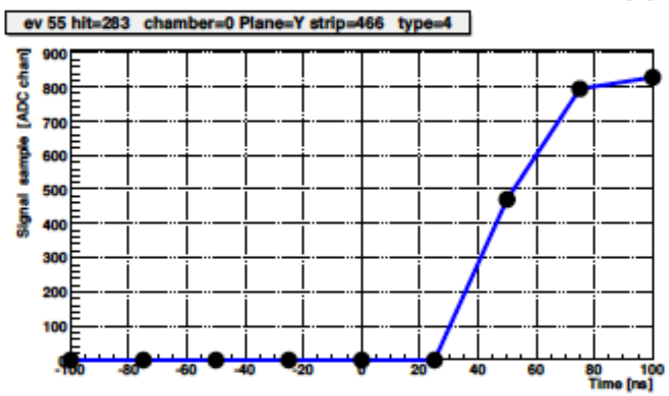
Pileup: minimum allowable time between signal and background

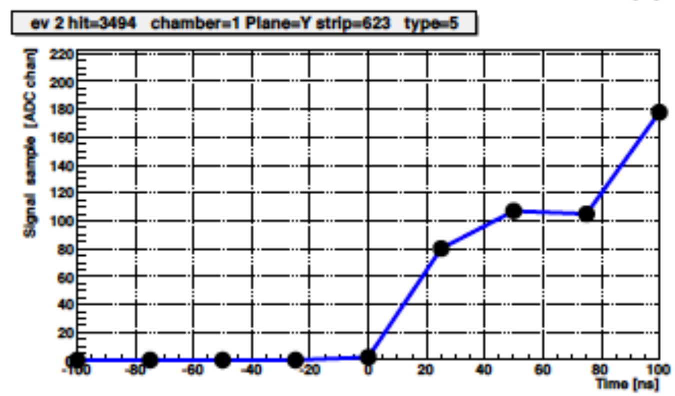






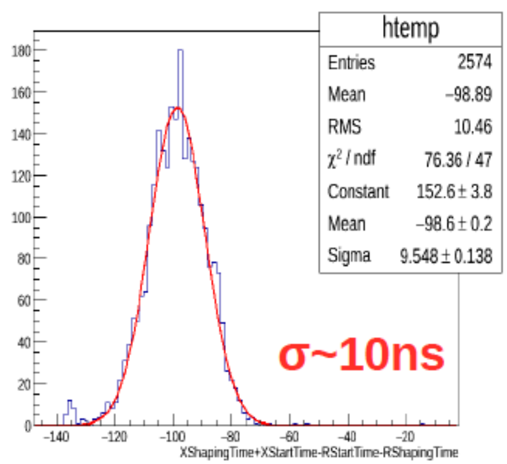




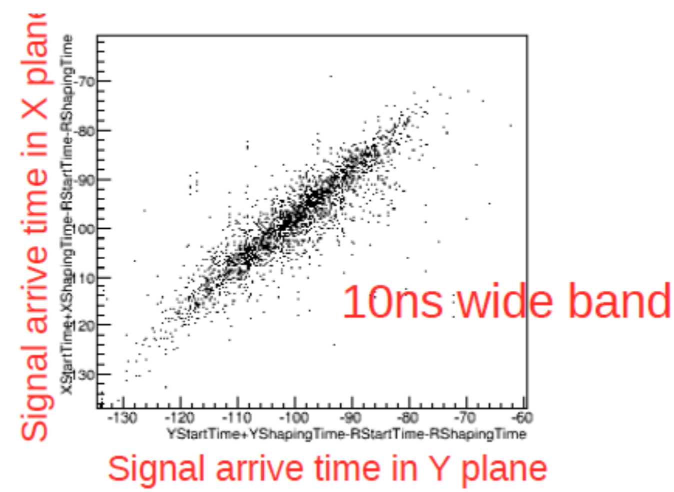


Two important effects due to high occupancy

- On a single strip:
  - If a background hit falls within the pileup time on a signal strip, the signal is lost: leads to strip inefficiency.
  - Given that we have 5 layers, we will be able to tolerate up to about 25% max.
- On a given module at tracking level
  - Many background hits on a given plane: leads to n^2 level ghost hits
  - Correlating the signal hit time to trigger allows to cut background.
  - Recent results show we can narrow this time window to ~ 30 ns.

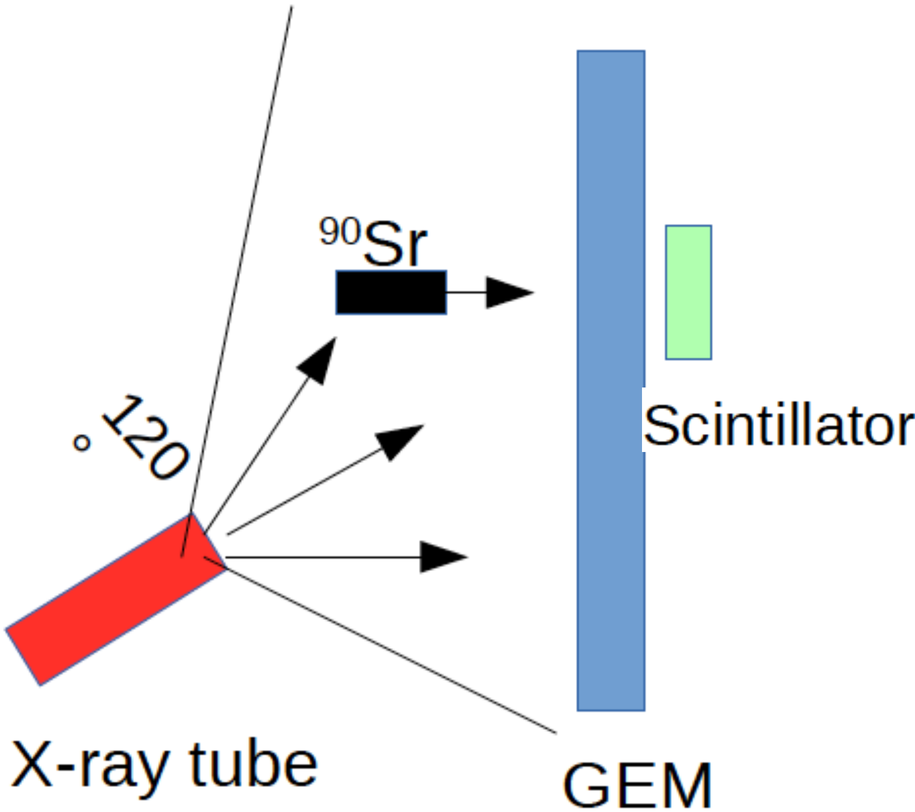


Time resolution(after DAQ clock phase correction, from fit)



Timing correlation between X and Y plane

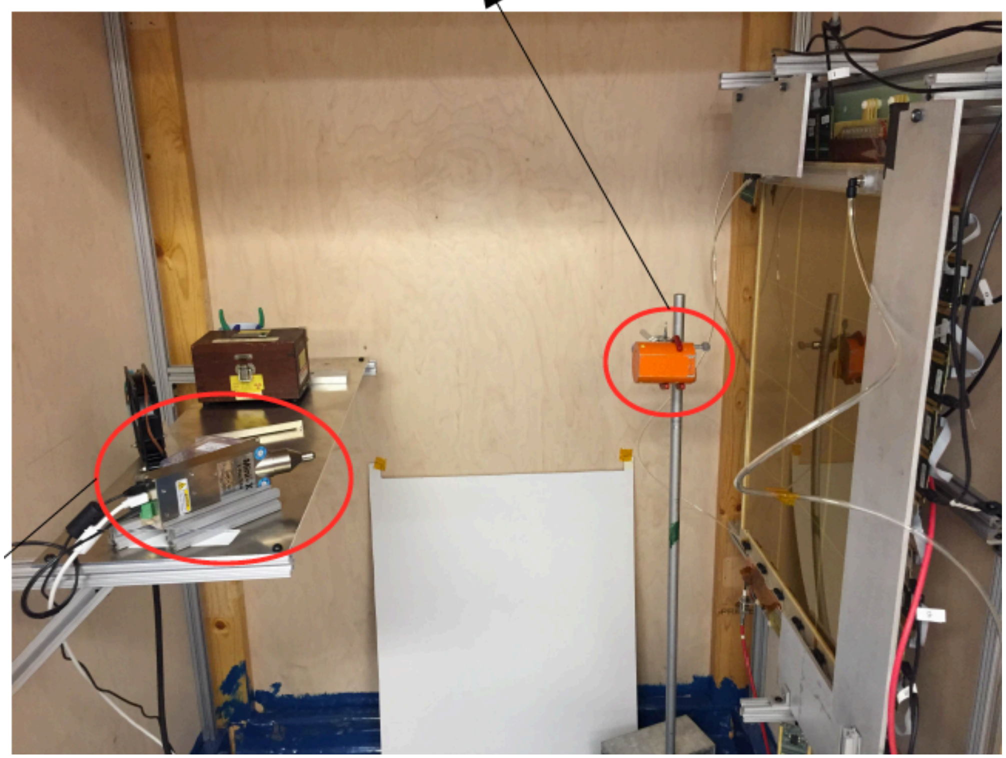
Testing the modules



X-ray generator specification:

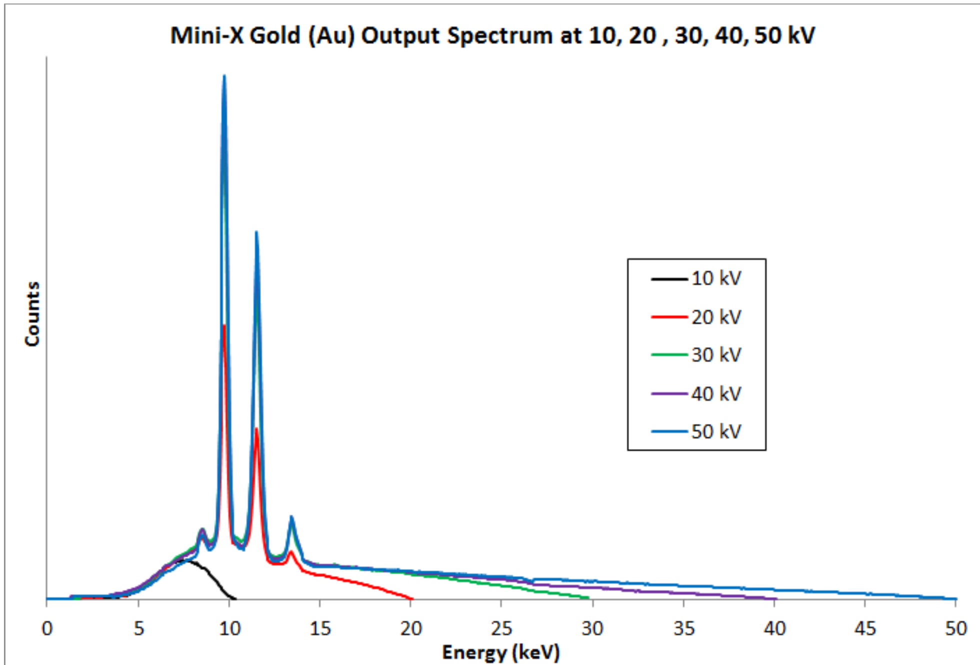
- Photon energy range: up to 50 keV
- Output flux: 100 MHz/cm^2 on the surface of GEM (conversion rate ~0.5% to electrons for ionization to happen)
- Angular distribution: uniform within 60°

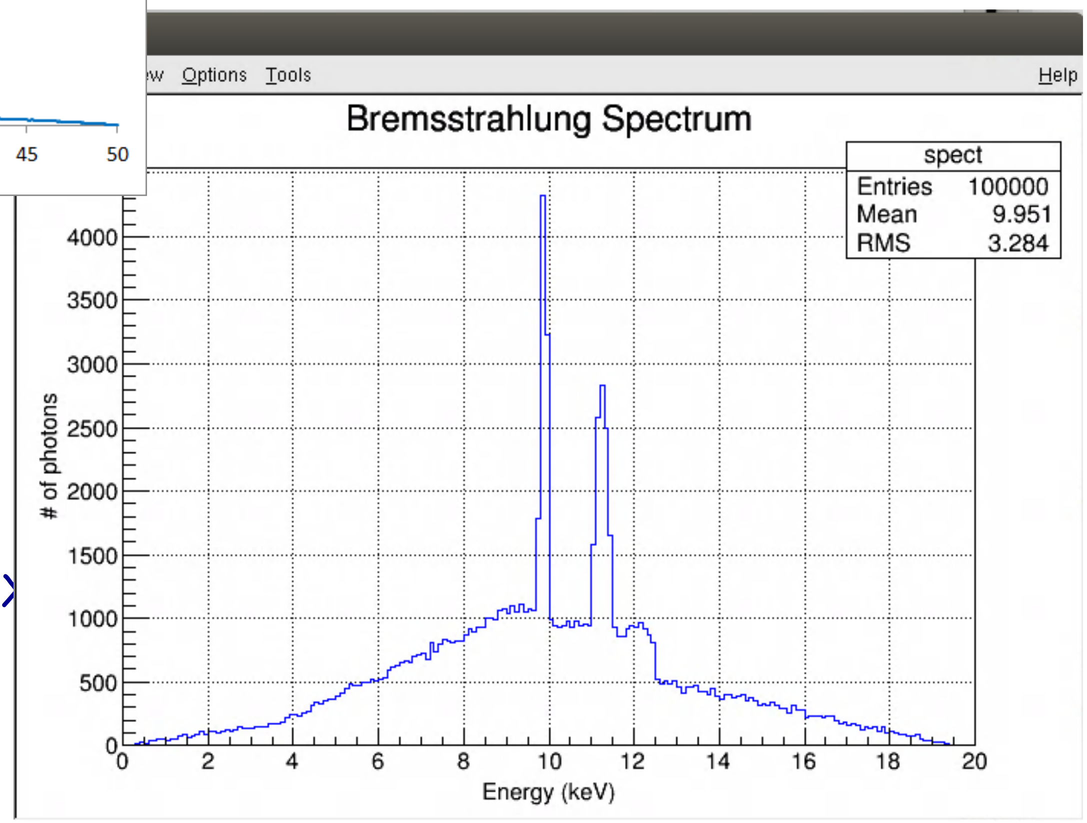
^{90}Sr source(simulating real hit)



This setup provides:

- Charge deposition in GEM: up to 3.4×10^{11} e$^-$/cm^2/s , equivalent to ~7MHz/cm^2 MIP.

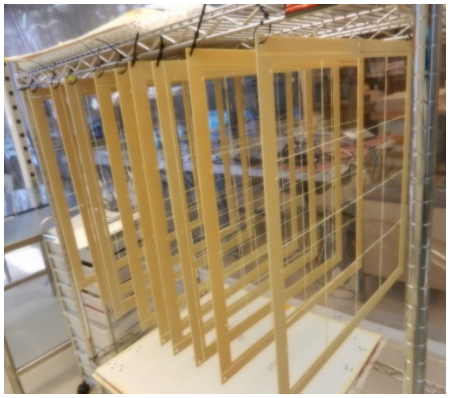

Mini-X Gold (Au) Output Spectrum at 10, 20 , 30, 40, 50 kV
Counts
10 kV
20 kV
30 kV
40 kV
50 kV
0
5
10
15
20
25
30
35
40
45
50
Energy (keV)

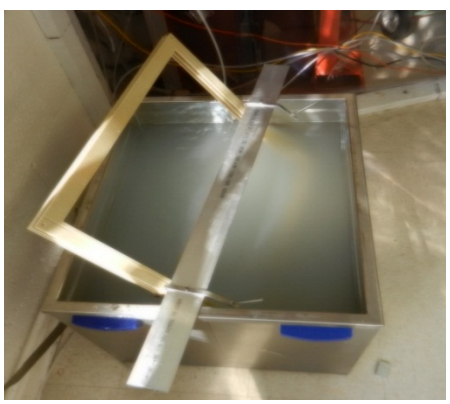

w Options Tools
Help
Bremsstrahlung Spectrum
spect
Entries 100000
Mean 9.951
RMS 3.284
# of photons
0
500
1000
1500
2000
2500
3000
3500
4000
0
2
4
6
8
10
12
14
16
18
20
Energy (keV)

Plan and Timeline

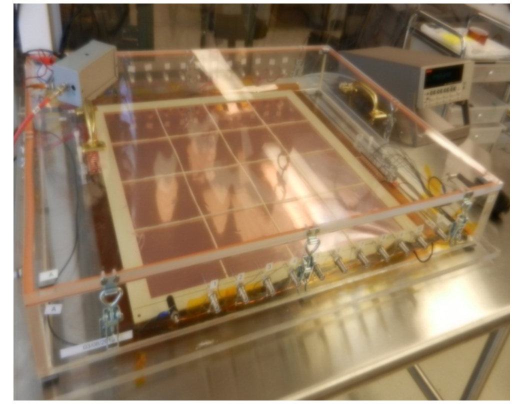
- Geant4 simulation of X-ray and ^{90}Sr into a SBS GEM: complete
- Digitization of X-ray and ^{90}Sr runs: complete
- Analyze simulated data using the same scripts used for UVa data: in progress
- Compare simulation versus data for x-ray/^{90}Sr setup and optimize parameters: ~ 2-3 weeks.
- Run high rate simulations to compare with high intensity x-ray runs to study pileup/rate limitations. ~ 1 month
- Check optimized simulations against pRad, test beam and cosmic data. ~ 1-2 months
- Work with Weizhi and Zhiwen to get occupancy rates for SoLID conditions. ~ 2 months
- Optimize strip geometry and segmentation if needed.

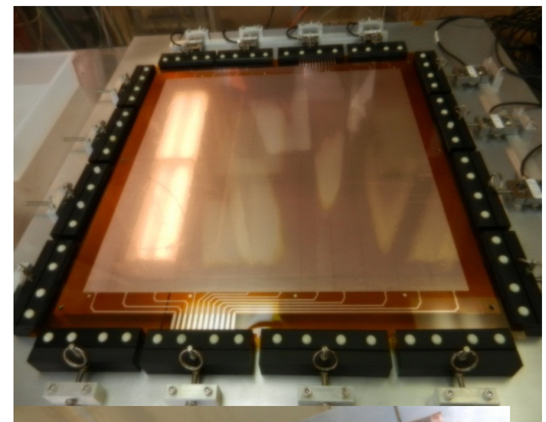
UVa GEM Lab

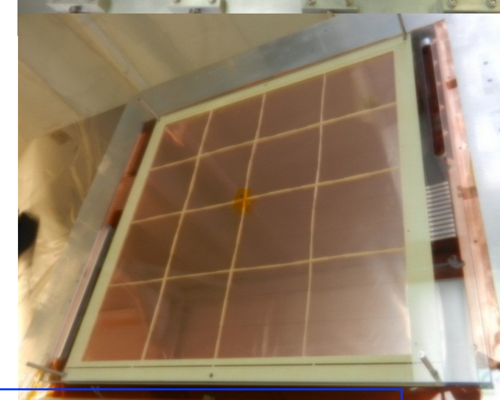




Large area (3×7 m^2) class 1000 Clean Room







Team members: NL, Dr. Kondo Gnanvo, Dr. Vladimir Nelyubin, Dr. Huong Nguyen, Xinzhan Bai, Danniung Di, Siyu Jian, Tim Tim McMullen

Micro-pattern detector R&D program

- Overview

  - R&D effort focuses on intermediate tracking system:
    - Barrel tracking system based on MicroMegas detectors (Dedicated barrel / curved MM EIC R&D program) manufactured as cylindrical shell elements and
    - Rear / Forward tracking system based on triple-GEM detectors manufactured as planar segments (Collaboration of FIT/ TU / UVA)

  - R&D effort - Main strategy:
    - Design and assembly of large cylindrical MicroMegas detector elements and large planar triple-GEM detectors
    - Test and characterization of MicroMegas and triple-GEM prototype detectors
    - Design and test of new, common chip readout system employing CLAS12 'DREAM' chip development, ideally suited for micro-pattern detectors
    - Utilization of light-weight materials
    - Development and commercial fabrication of various critical detector elements
    - European/US collaborative effort on EIC detector development (CEA Saclay, and Temple University)