Characterizing the X ray gun (Au target) with 10 by 10 cm^2 GEM detector

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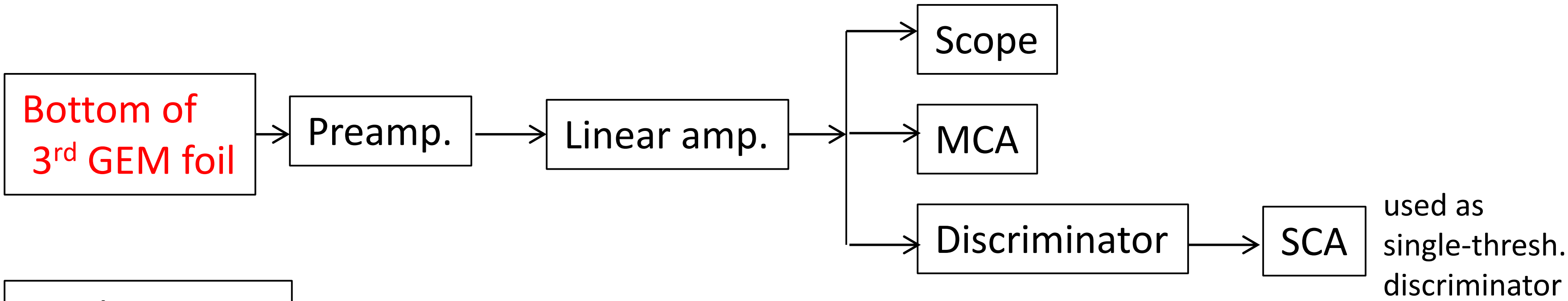
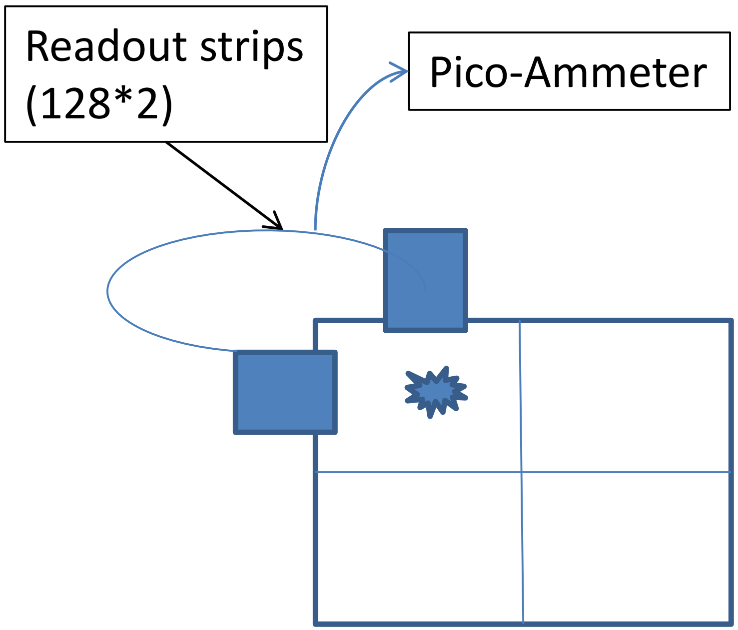
GEM detector hardware meeting

Results with std. Triple-GEM detector (10 cm × 10 cm)



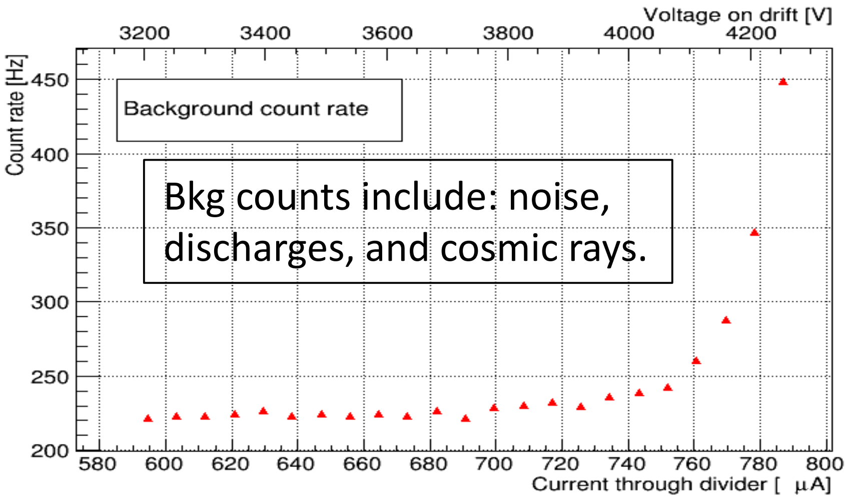


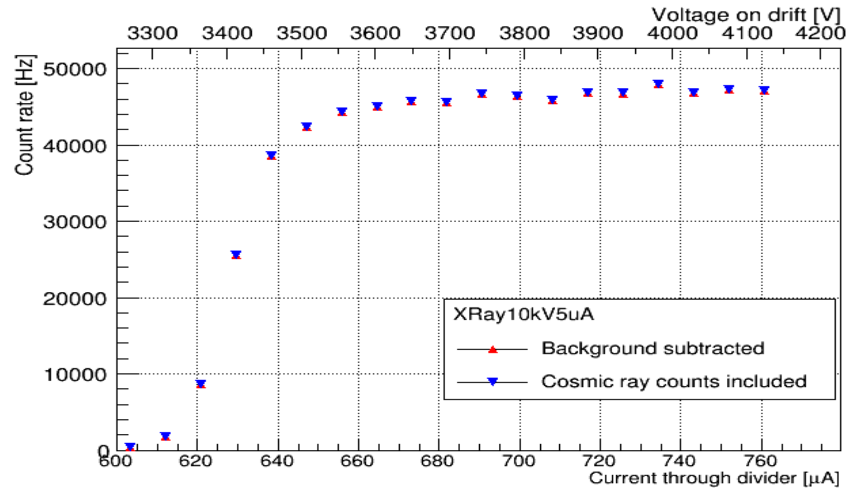
- The GEM gaps are 3/2/2/2 mm
- Ceramic HV divider is used.
- An HV filter is used: 2 100 kOhm resistors and 1 2.2 nF capacitor. This reduces noise a lot!
- A standard 2D readout board is used.
- In order to record good current, X ray gun is put over one quadrant of the chamber and two Panasonic connectors are combined to output the current to pico-ammeter.
- Noise level from linear amp is <20mV when HV is off. It increases (to a 100mV level) when HV is on. Threshold is set to 50 mV. Background counts are subtracted (though they are small as compare to X ray counts from the X ray gun) when measuring rate.

All data presented below are based on pulses picked up from the bottom of the 3rd GEM that faces the readout

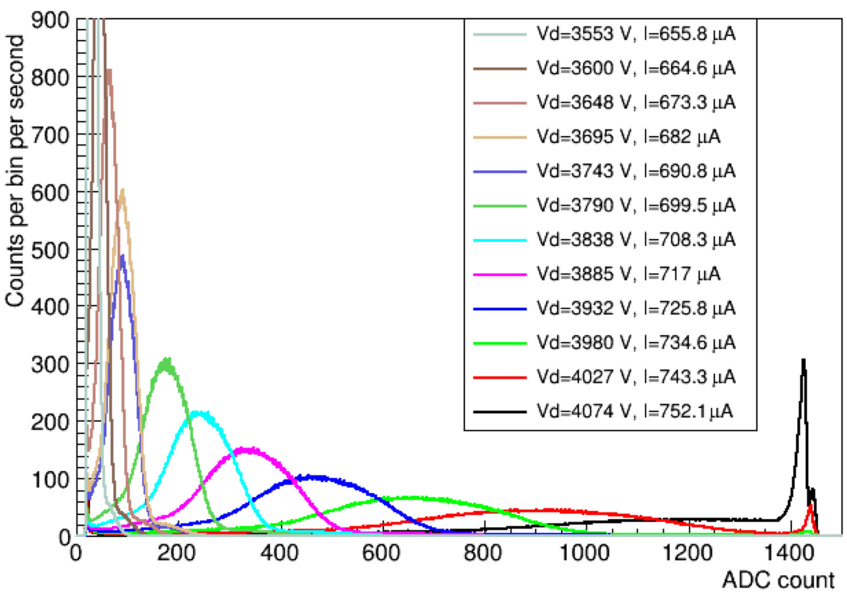
Rate curve and spectrum of X rays

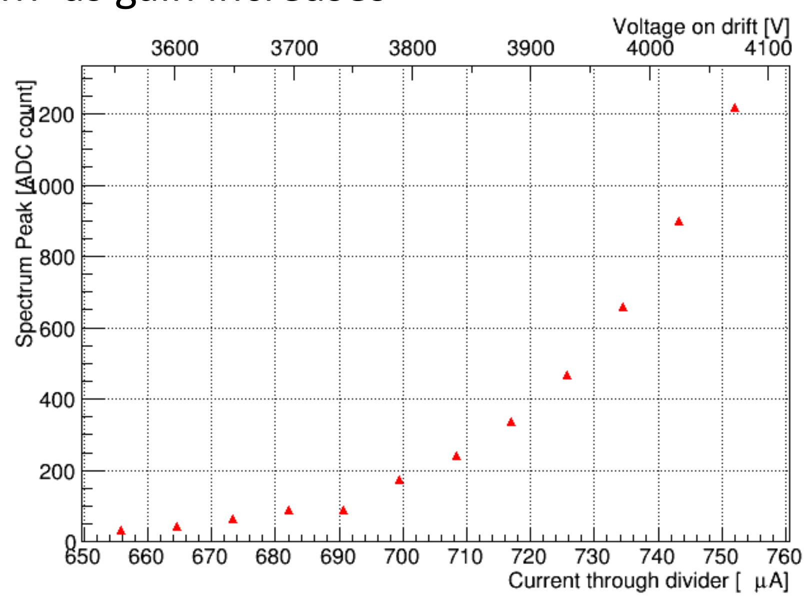
- X-ray at 10kV/5μA w/ 2 mm collimator, ~15 cm above the GEM.





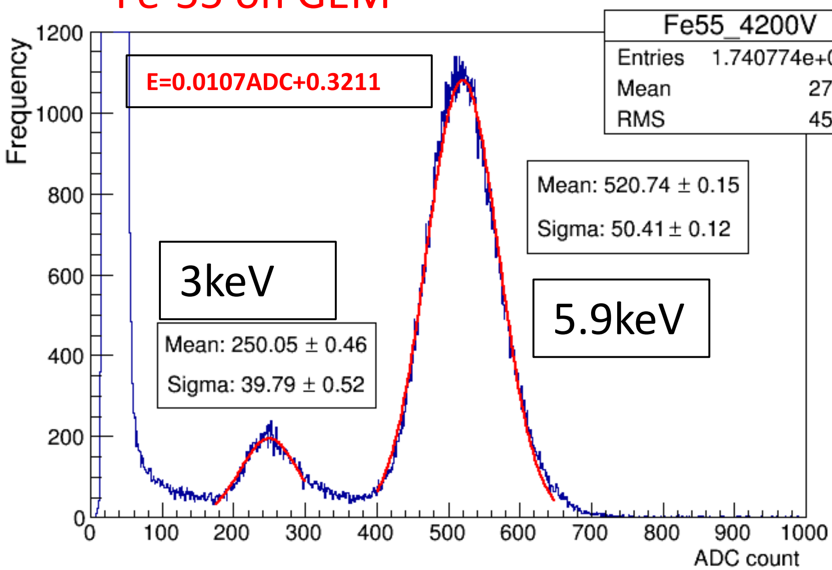
- Peak shifts to right when increasing HV on GEM as gain increases



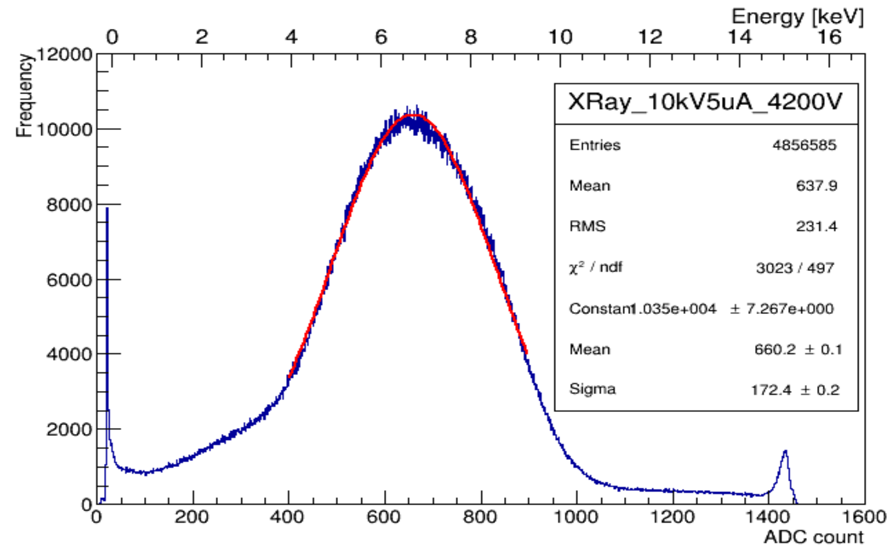


Calibration of X ray with Fe-55 source

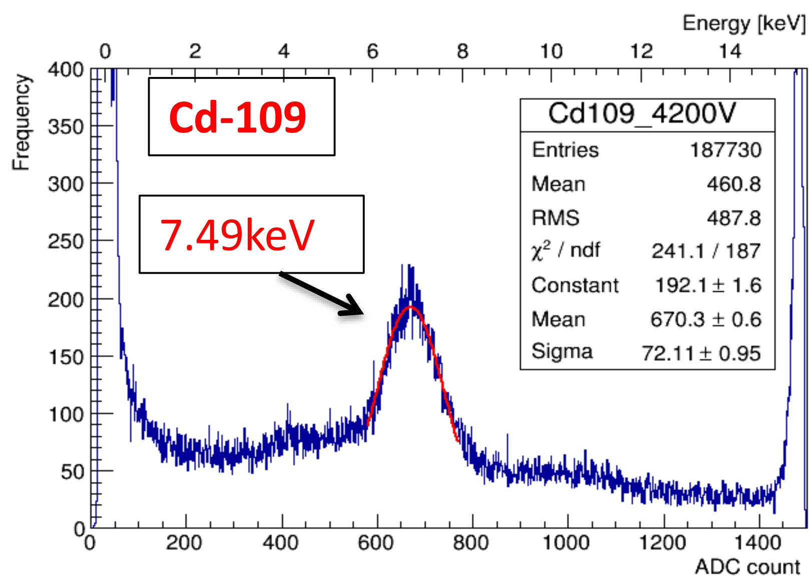
Fe-55 on GEM



X-ray gun on GEM (2 mm collimator, w/o filter)



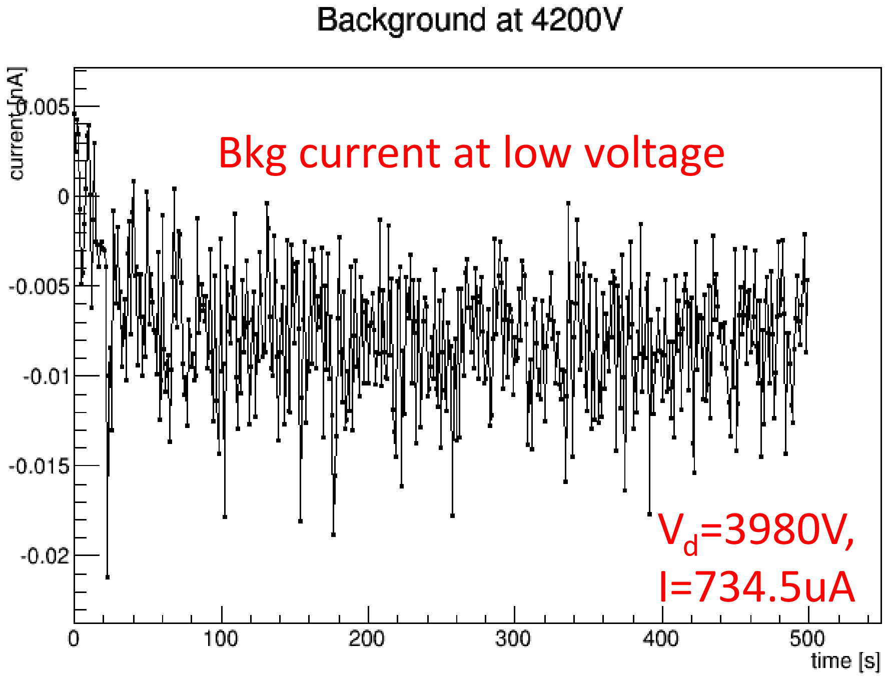
- Calibrated with Fe-55, X ray energy is <u>**7.39 keV**</u> @ 10kV/5uA settings.

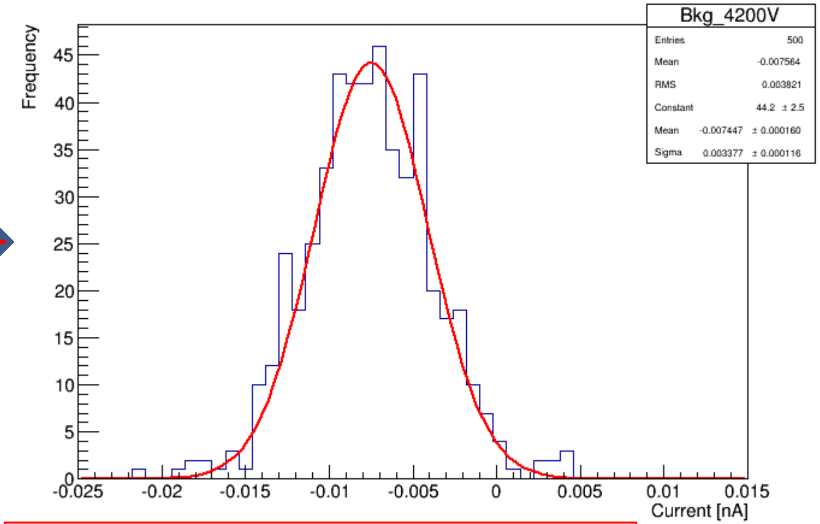


- Cadmium spectrum also indicates <u>**7.49 keV**</u> (peak).

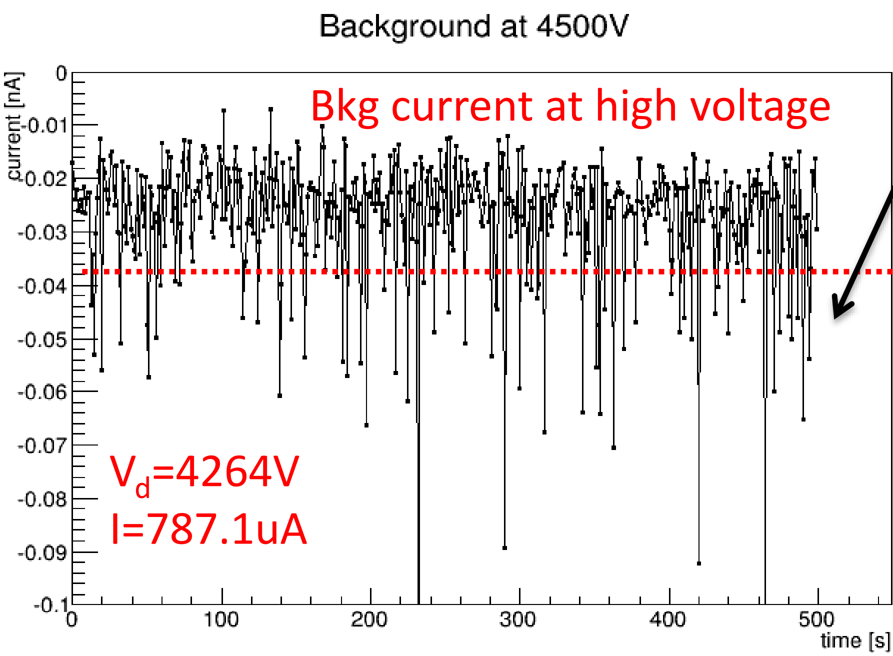
- One conclusion: This confirms that signals that are seen in GEM with the X-ray gun are from K lines (~8 keV) of copper due to x-ray fluorescence.

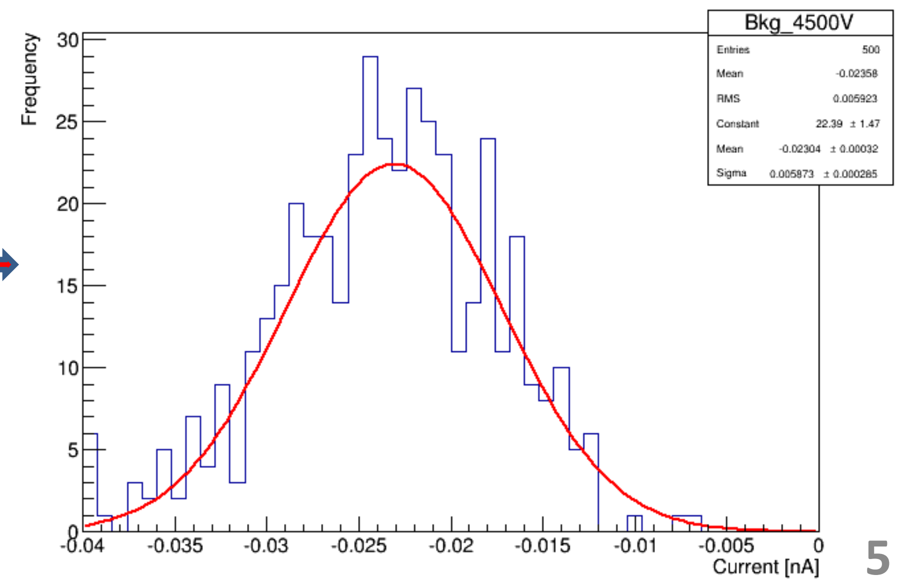
Current measured from readout strips (Bkg.)



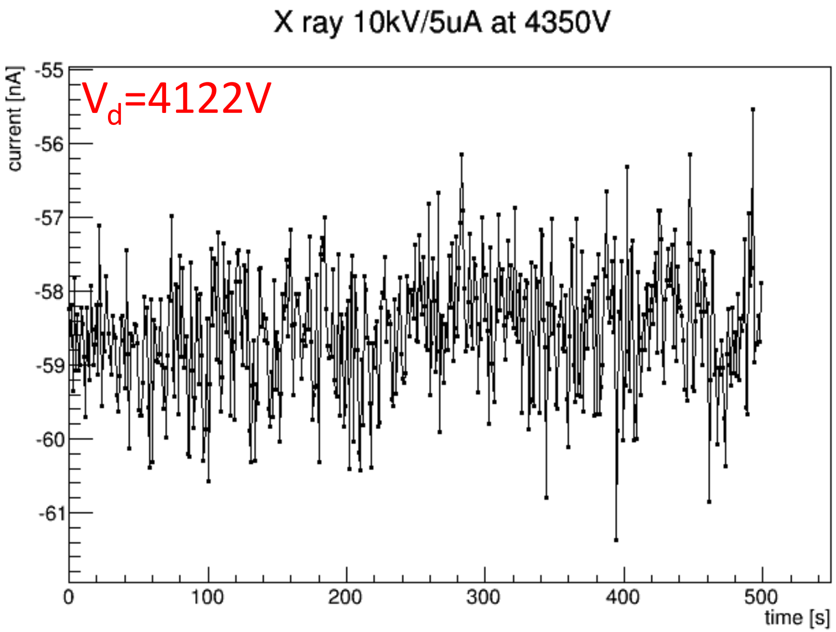


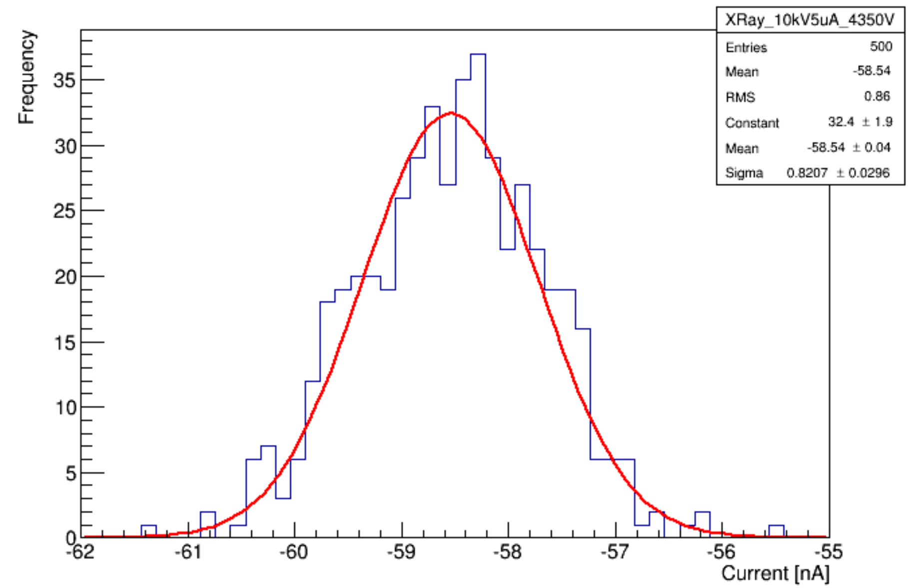
Cosmic signals show currents of > 0.04 nA



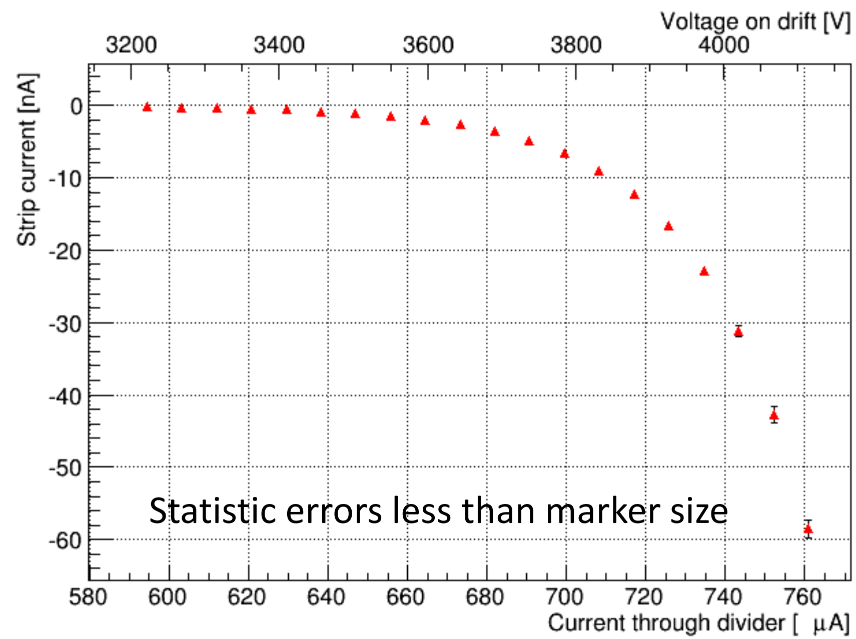


Current measured from readout strips (X-ray at 10kV/5μA)

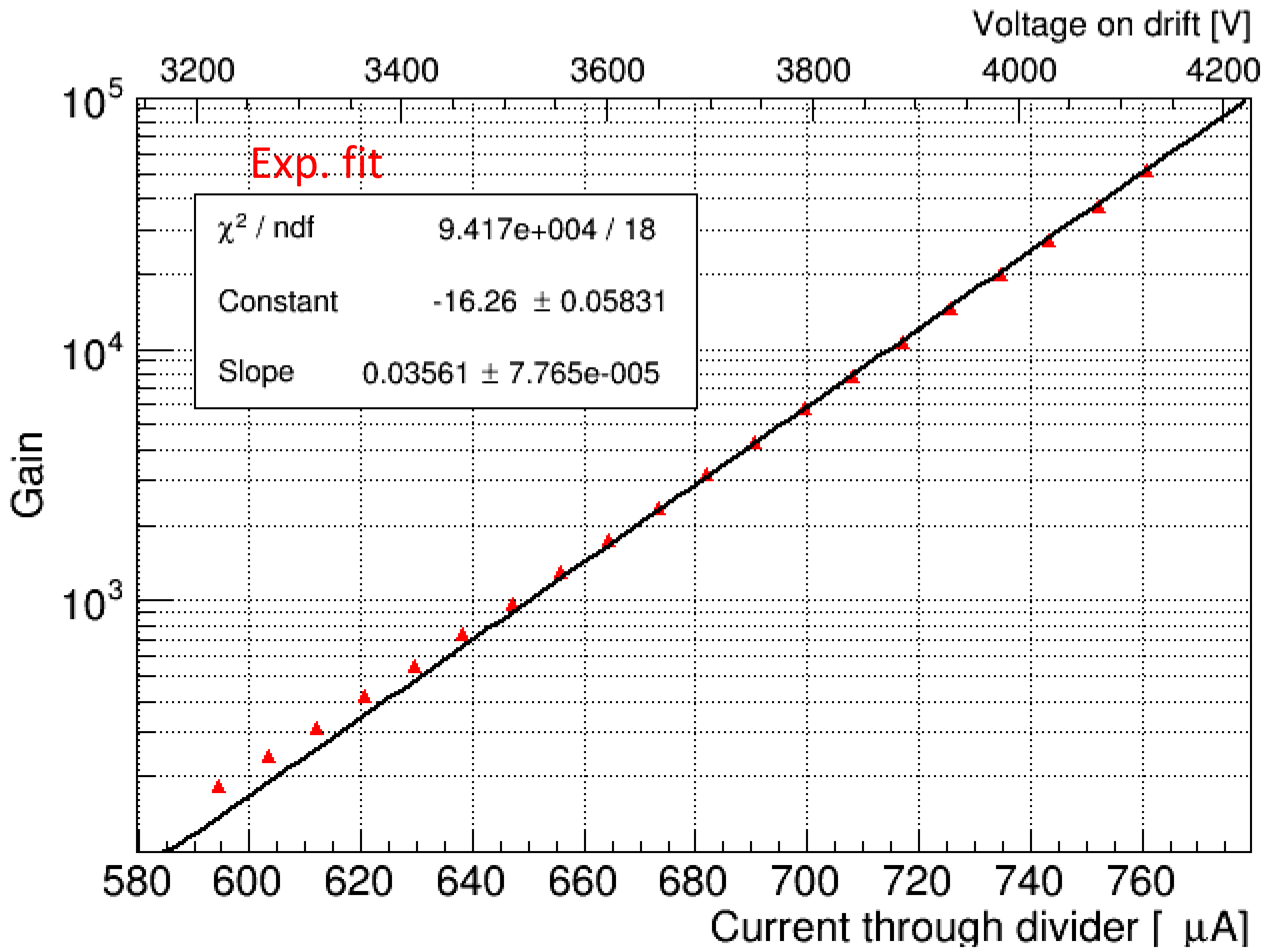




- At each tested voltage point, current is stable! The above two plots are for the highest tested point (V_d=4122V).
- Current on strip vs. current in divider is shown on the right.



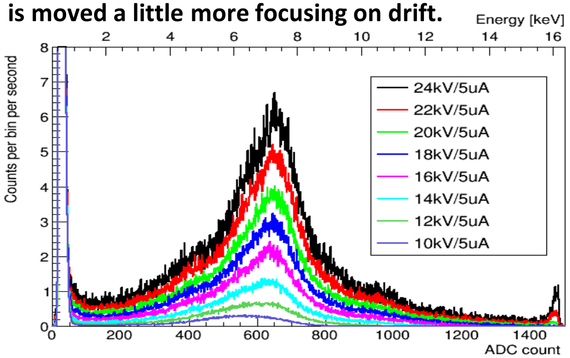
Gain curve


Voltage on drift [V]
3200
3400
3600
3800
4000
4200
Exp. fit
χ² / ndf 9.417e+004 / 18
Constant -16.26 ± 0.05831
Slope 0.03561 ± 7.765e-005
Gain
10⁵
10⁴
10³
580
600
620
640
660
680
700
720
740
760
Current through divider [μA]

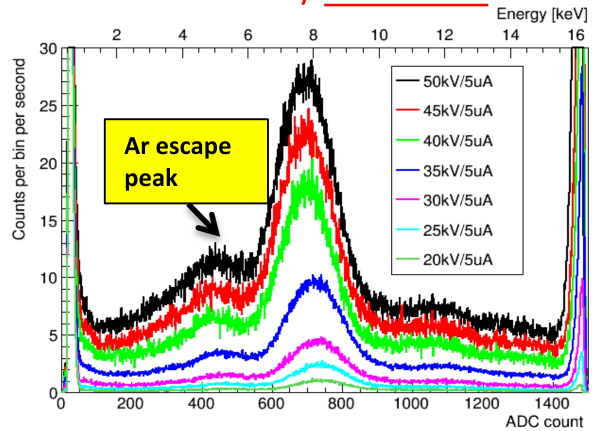
X ray spectrum at 5 μA, distance 45 cm, V_{drift} = 3980 V, I=734.5 uA, gain 2× 10^4

1 mm collimator / **No filter**

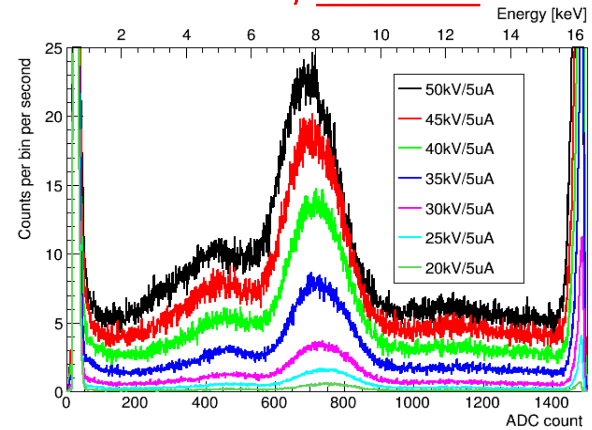
Rate is lower than others. Reason is the X ray hits mainly the honey-comb frame. For others the position is moved a little more focusing on drift.



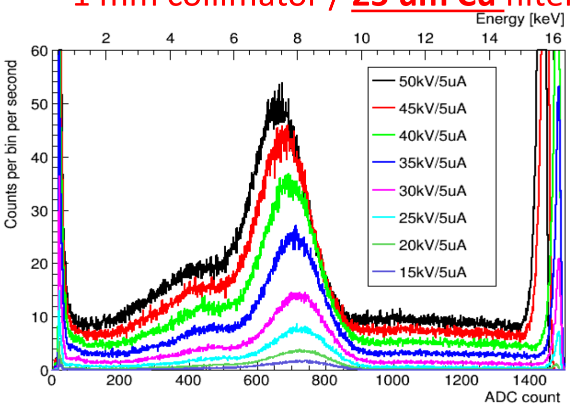
1 mm collimator / **250 um Al** filter



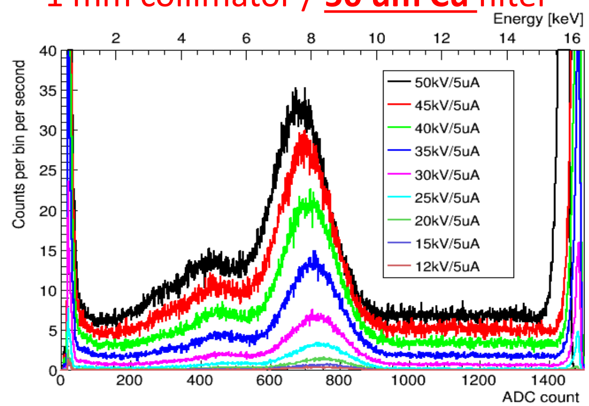
1 mm collimator / **500 um Al** filter



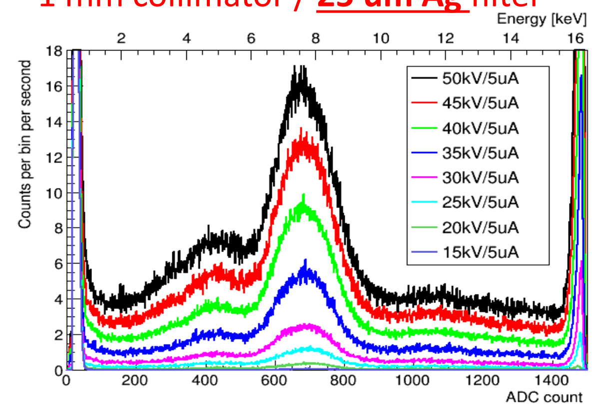
1 mm collimator / **25 um Cu** filter



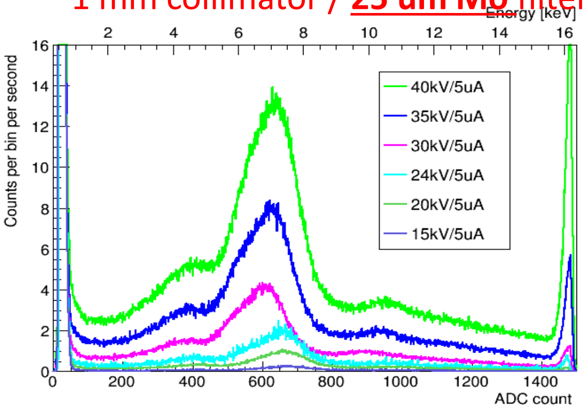
1 mm collimator / **50 um Cu** filter



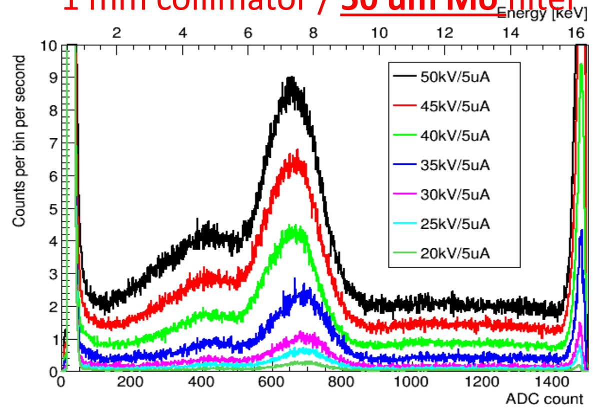
1 mm collimator / **25 um Ag** filter



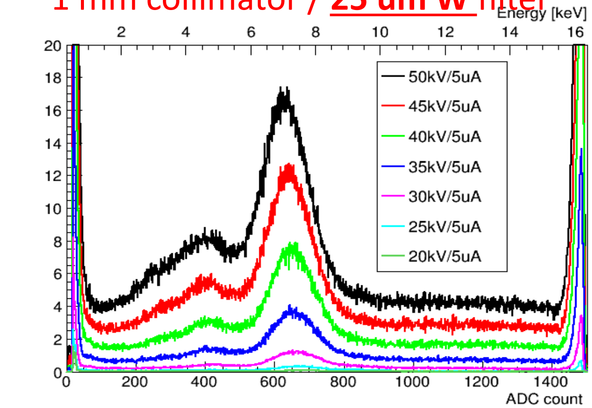
1 mm collimator / **25 um Mo** filter



1 mm collimator / **50 um Mo** filter

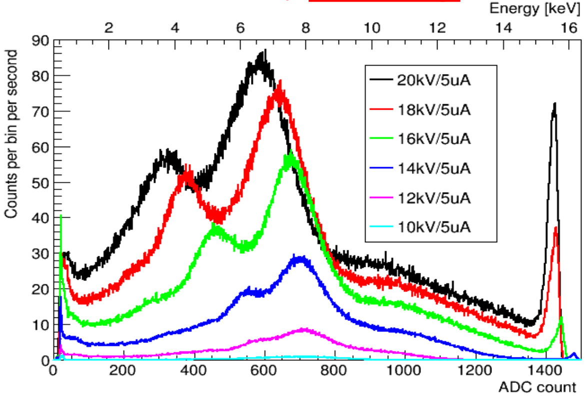


1 mm collimator / **25 um W** filter

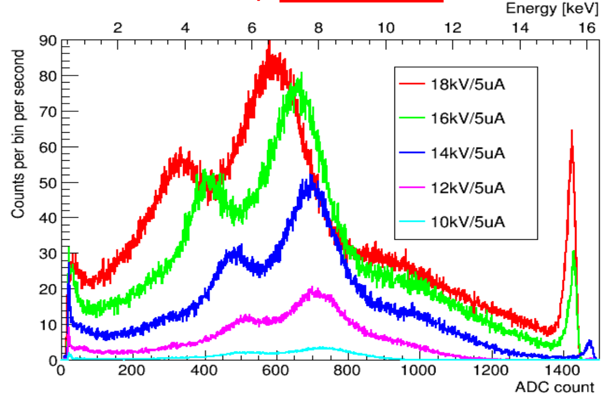


X ray spectrum at 5 uA, distance 45 cm, V_{drift} = 3980 V, I=734.5 uA, 2× 10^4

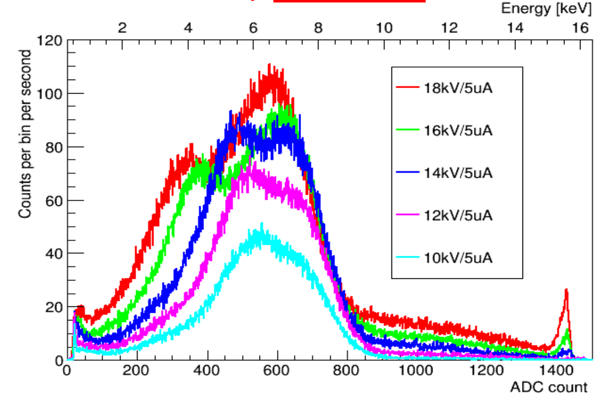
No collimator / 25 um Ag filter



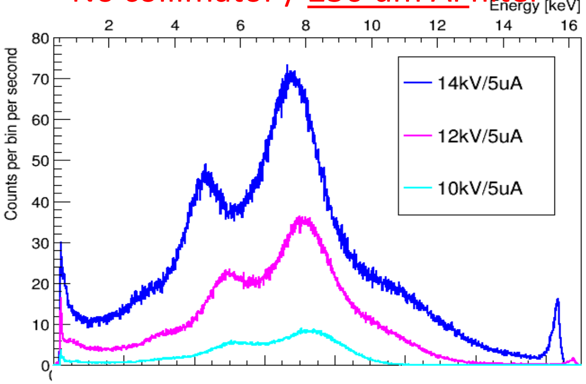
No collimator / 25 um Mo filter



No collimator / 25 um Cu filter

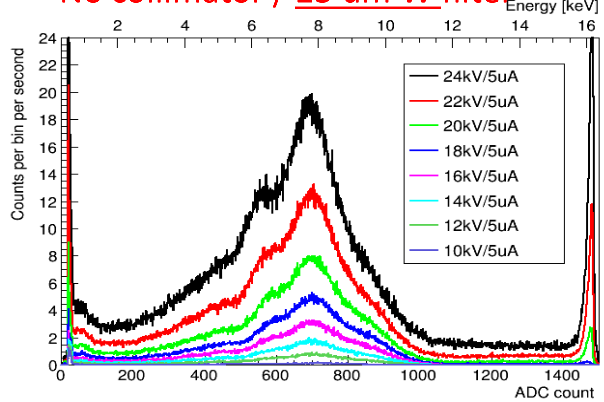


No collimator / 250 um Al filter



This looks like a useful filter!

No collimator / 25 um W filter



- Without collimator, there are many pile-up events at higher X ray voltage (high rate). So these data are taken at X-ray gun voltage not more than 24 kV.
- Pile-up pushes the peak on a spectrum to the left, i.e. to lower energy.

X-ray spectrum at 5 μA, distance 45 cm, V_{drift} = 3980 V, I=734.5 uA

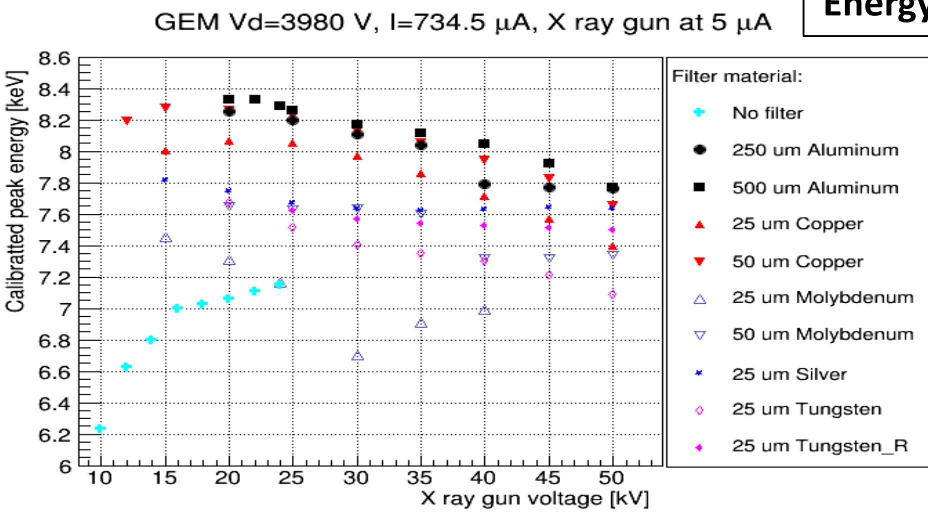
- Calibrated peak energy vs. X ray gun voltage.

Table of fluorescence X ray energies of material

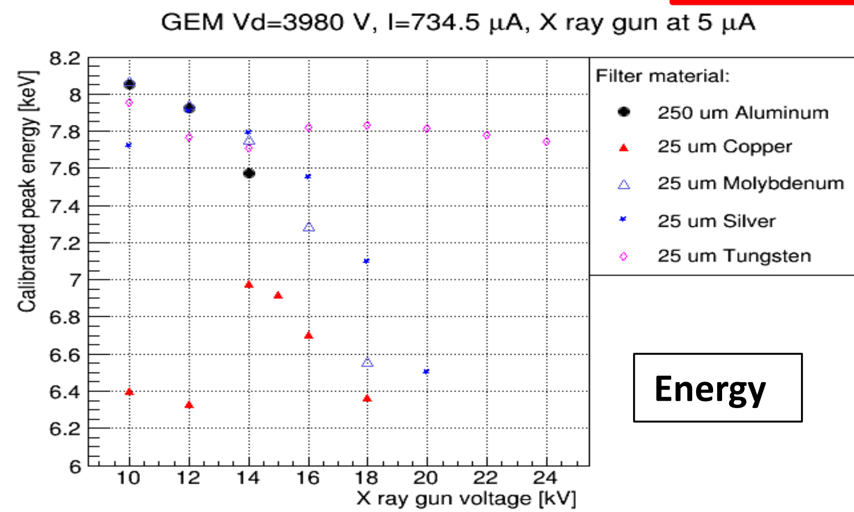
Material	K alpha [keV]
Cu	8
Al	1.5
Mo	17
Ag	22
W	58

X ray on GEM, with 1 mm collimator

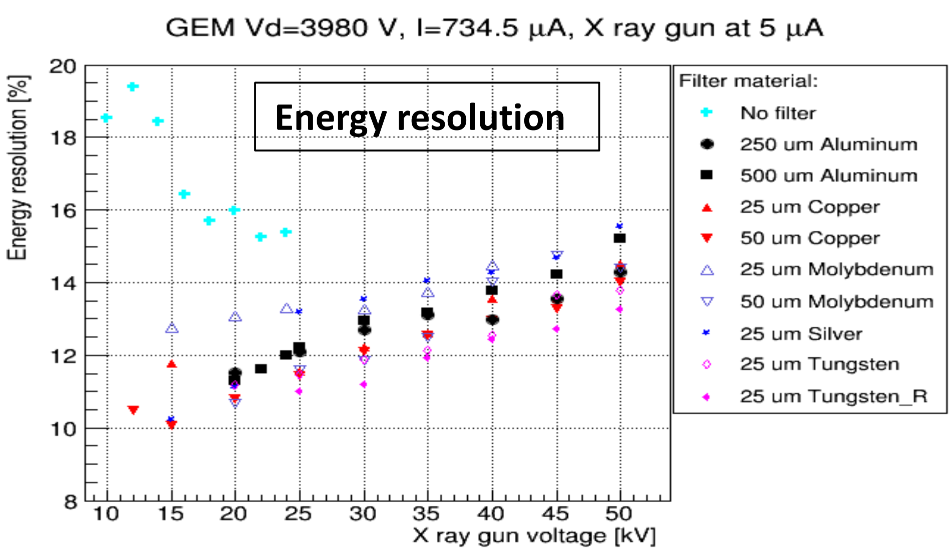
Energy

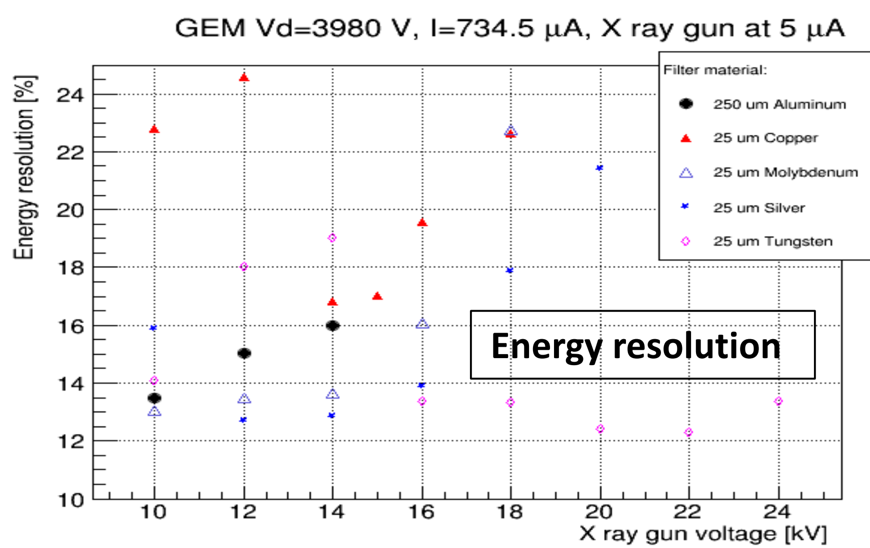


X ray on GEM, **NO** collimator



- **At lower X ray voltage, Al/Ag gives better energy resolution; at higher x-ray voltage, W filter gives better resolution.**





Summary

Tested the X-ray gun (Au target) with a commercial NaI(Tl) detector:

- Find out that the Cd-109 source in our lab is actually not pure, very likely it contains Ba-133 contamination.
- Scanned X ray voltage (energy) at fixed current (5 μA) and find that the measured X-ray peak energy is a square root function of the applied X-ray voltage.
- Also scanned X ray current at fixed voltage (15kV,30kV) , the energy peaks don't change at all; only rate changes. This confirms that the current does not change X ray energy.
- Some fluorescence X rays are recognized in the X ray gun voltage scan, such as: possibly M lines of Au (~3keV), K lines of Iodine (28-32keV), K lines of Ag (22keV), K lines of Mo (17keV).
- K lines of Cu (8 keV) are NOT measured (even with a Cu filter) due to a 0.5 mm Al window.
- The measurable flux of X ray from the gun reaches up to 8 kHz/cm^2 (rate ~200 kHz). This is limited by our slow electronics (~1 us shaping time, 3 us signal width, max. 0.33MHz w/o pileup).

Tested the X-ray gun (Au target) with a std. 10cm × 10cm Triple-GEM detector:

- Get good rate curve (plateau rate 44kHz) and gain measurement (5*10^4) with X ray gun.
- Confirmed that peaks in spectrum measured with the GEM are fluorescence X rays of copper.
- Tested different filter materials and scanned different X ray gun voltages. For future tests with GE1/1, we expect to run the X ray gun at lower voltage. In that case, Al or Ag filter can be used to get better energy resolution, i.e. sharper peaks (photopeak and Ar escape peak).

Next plan

- Fighting with noise on the large GEM detector (GE1/1) and repeat these measurement, in addition, we will do uniformity scan on the detector.

-> X ray properties of element:

http://xdb.lbl.gov/Section1/Periodic_Table/X-ray_Elements.html