Rate, gain, and uniformity measurement for the CMS GE1/1-III GEM detector with X ray generator (Au anode)

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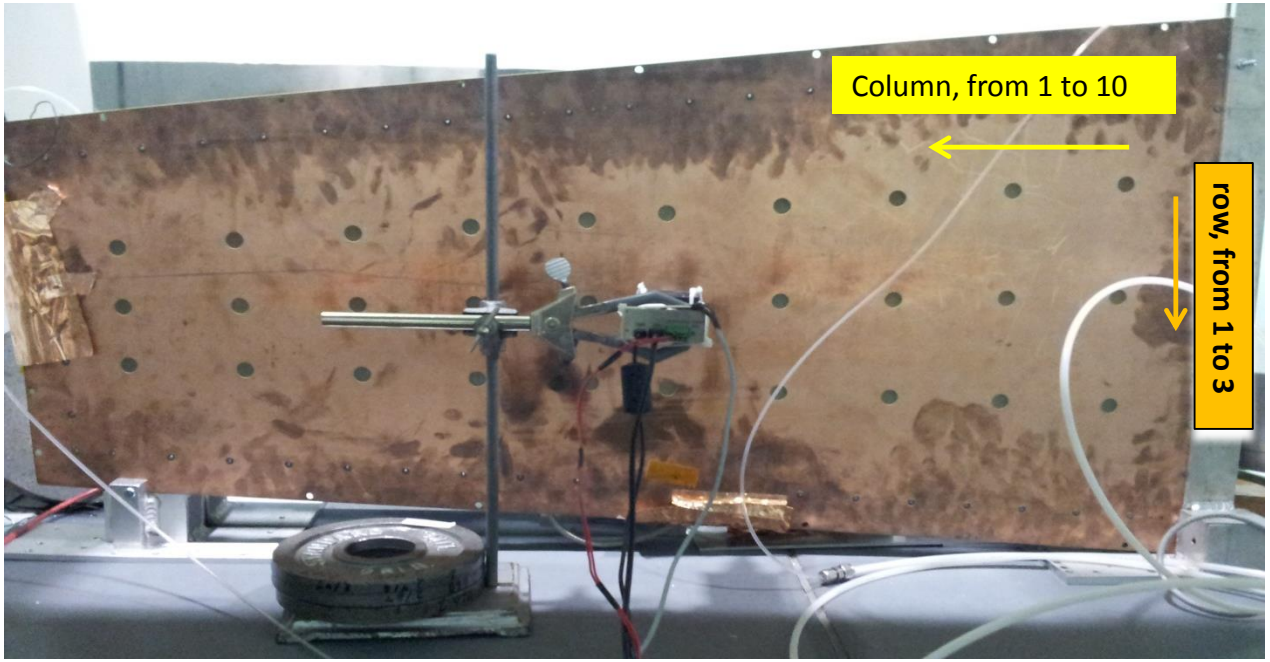
07/15/2015

GEM detector hardware meeting

Setup

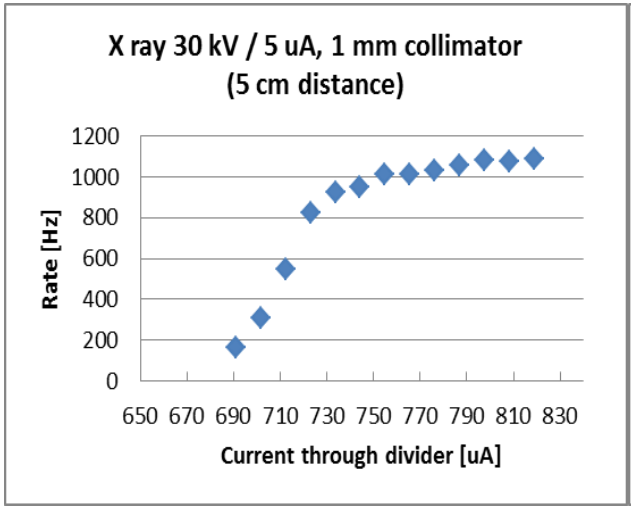


- This is a GE1/1-III GEM with straight strips r/o; gas gaps 3/1/2/1 mm; in Ar/CO2 (70:30);
- A HV filter is used (100 kOhm*3, 2.2 nF*2, same as Jeremie's) to reduce noise.
- Trigger signal is picked from bottom of 3rd GEM foil, through a 470 nF capacitor (to reduce capacitance that preamp sees and hence to reduce noise). This signal is then feed to preamp (Ortec 142PC) and linear amp. (TC 202BLR). Output from linear amp. are feed to (1) scope for monitoring; (2) MCA for spectrum; and (3) SCA for discrimination and counting.
- Pico-ameter (Keithley 6485) is used to measure current from strips with 1 Panasonic connector which connects 128 strips together, for gain measurement, we need to make sure beam spot is in the region where those 128 strips locate.
- X ray generator faces the drift board side.
- There are 10 column (in eta), 3 rows (in phi) of holes in the drift board. The naming strategy for them is shown on the figure above.
- The detector has ~60% gas leak.

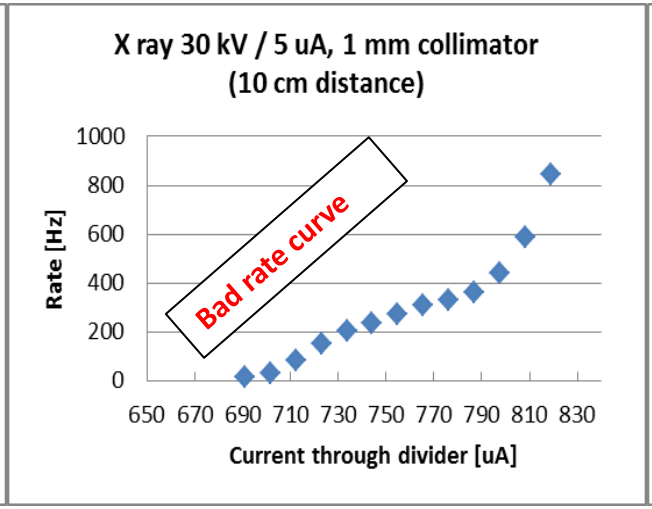
A remark for rate measurement

- In the process when measuring rate, a first observation is that when source is put far away from detector there is bad rate vs. HV curve (No plateau).
- Then the remark is: we found for those measurement we used only one Panasonic connector on the r/o board which is connected to the pico-ameter. This turns out that other strips are floating, and induction field for those regions is kind of wrong! When the source is far away from detector so that the beam spot is larger, then we can not measure correct counts in those regions without good induction field. So, we need to ground every single strip properly even we don't pick up signals from it.

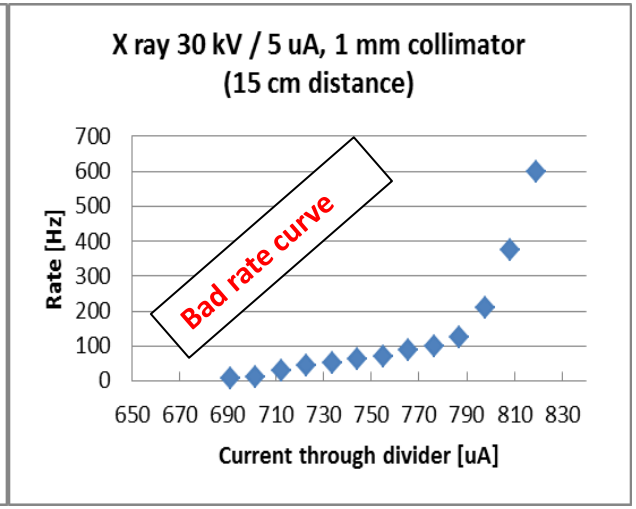
Beam spot: 6 mm



Beam spot: 11 mm



Beam spot: 16 mm



Source was pointing to drift hole 5-2;
discriminator threshold 60 mV

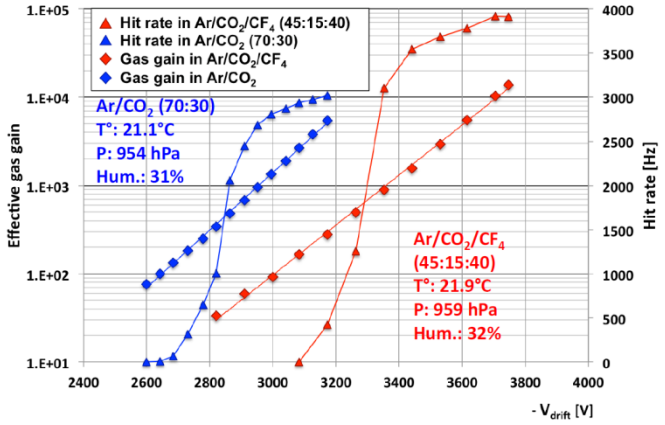
Rate and gain at different positions

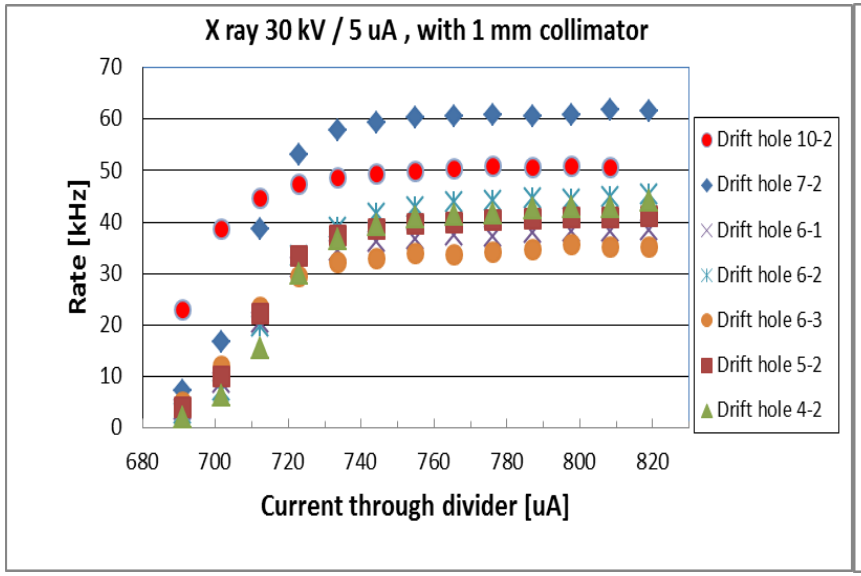
Highlights:

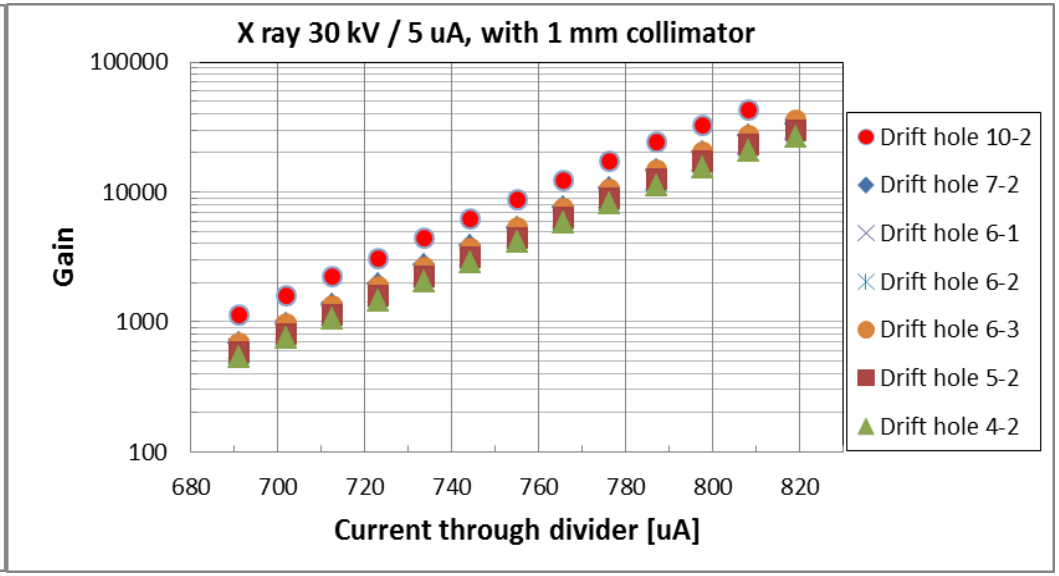
(1) good rate plateau can be measured at different positions;

(2) Gain is very similar at different positions, expect at 10th column where the gas inlet is located.

From the GEM TDR

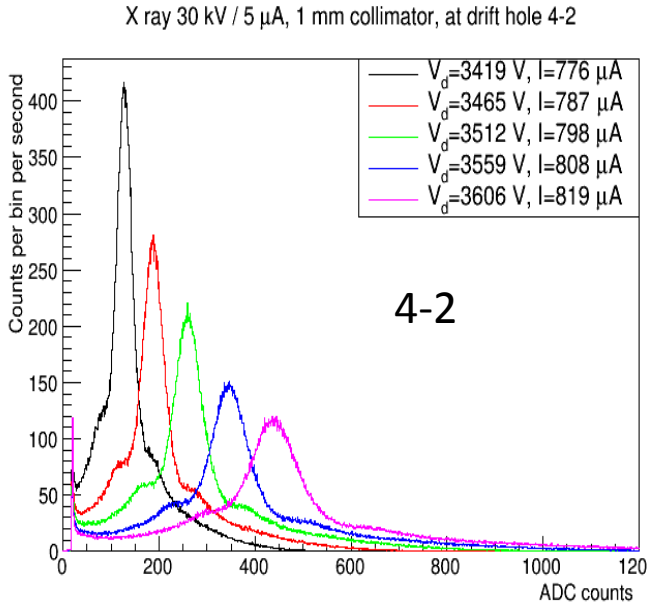


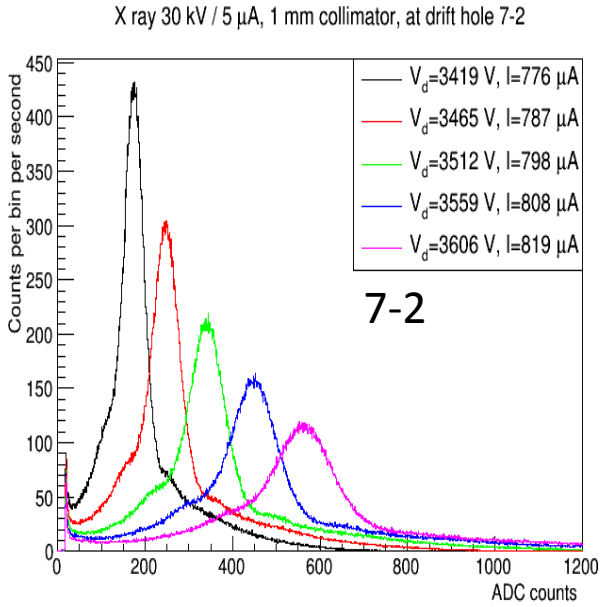


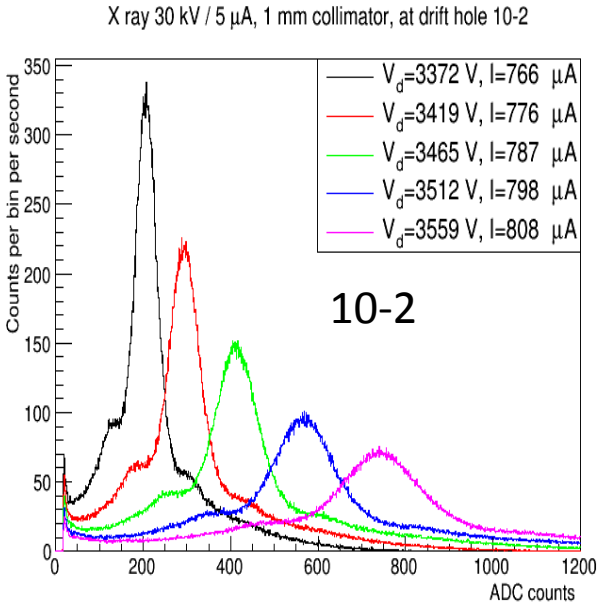


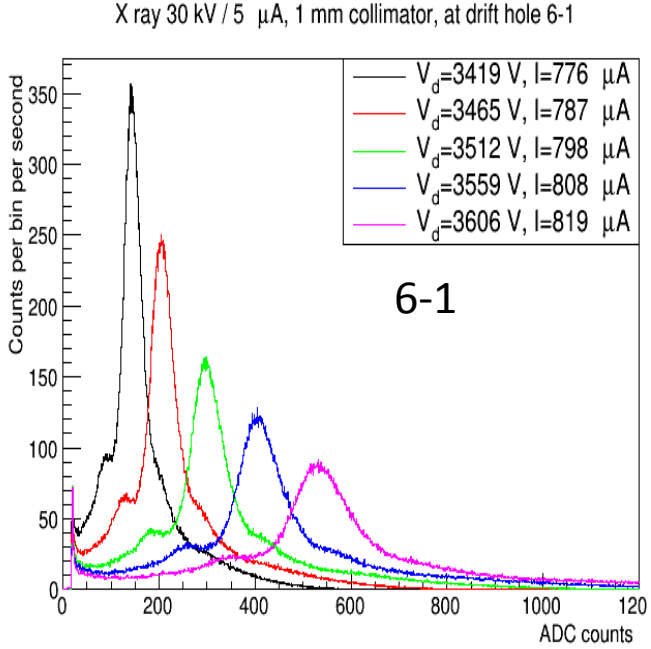
- For these measurements, X ray gun was very close (~0) to the drift holes.
- (Threshold for rate is 60 mV)

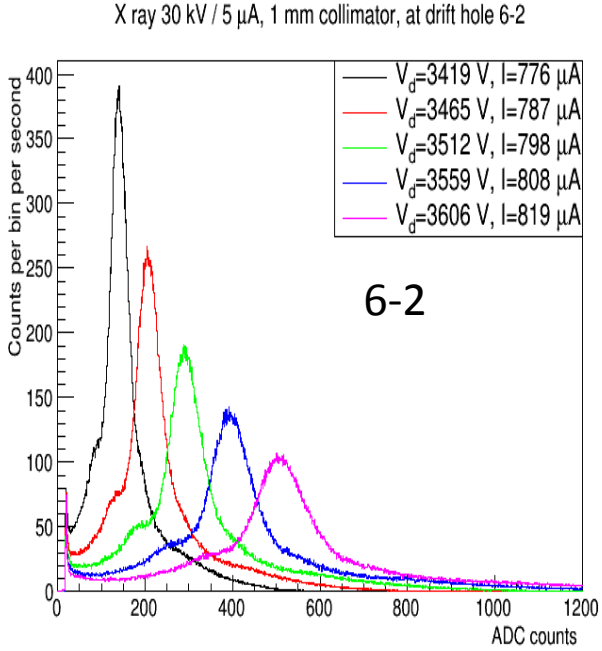
X ray spectra at different positions

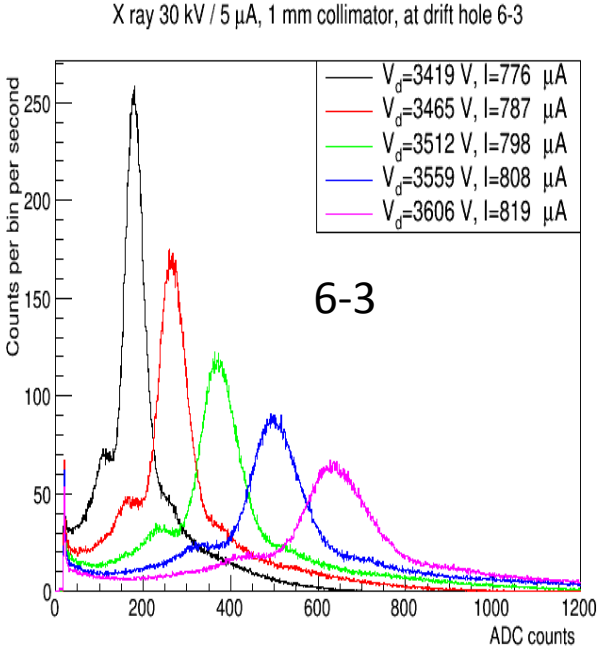




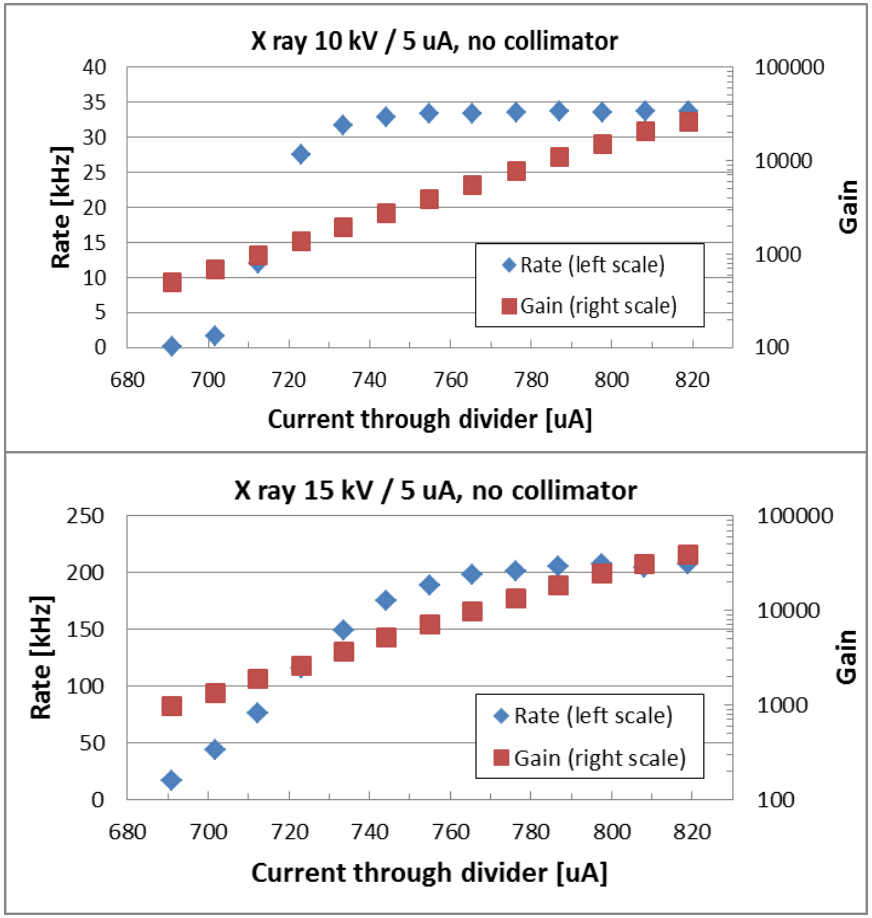


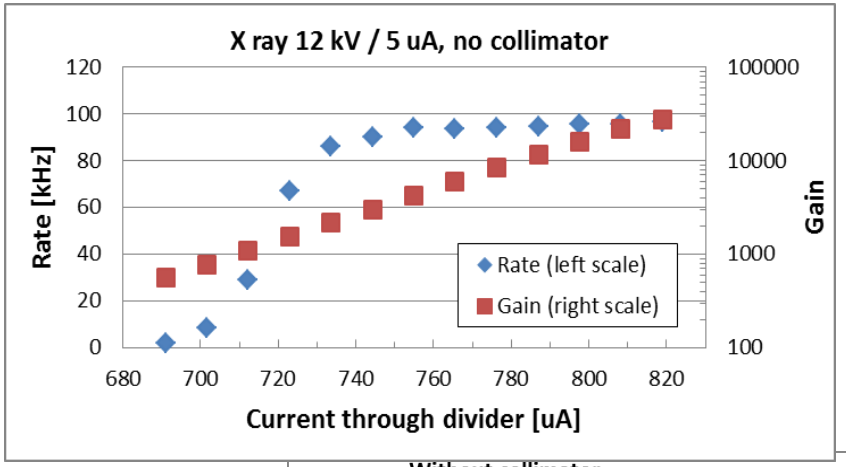


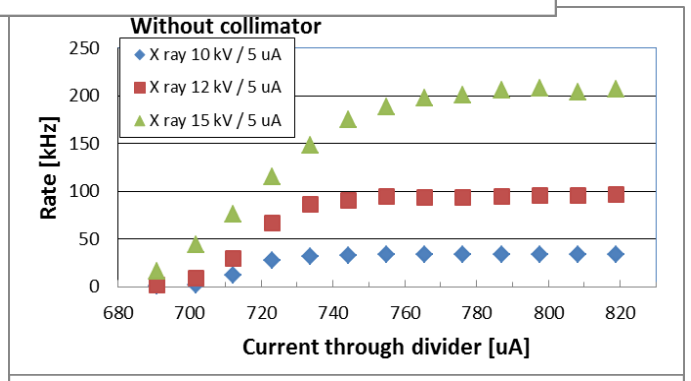


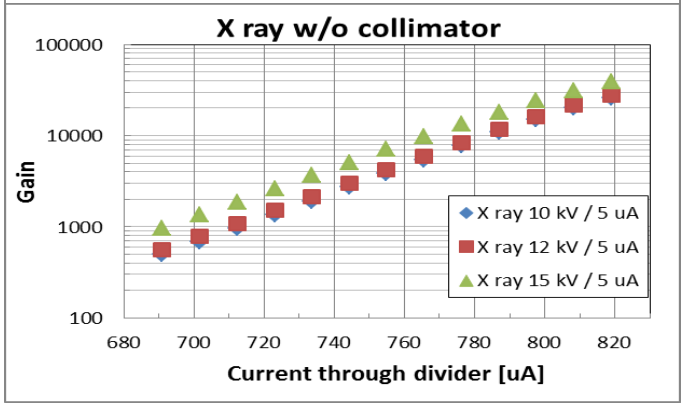


Gain and rate for the detector – at lower X ray energies and w/o collimator



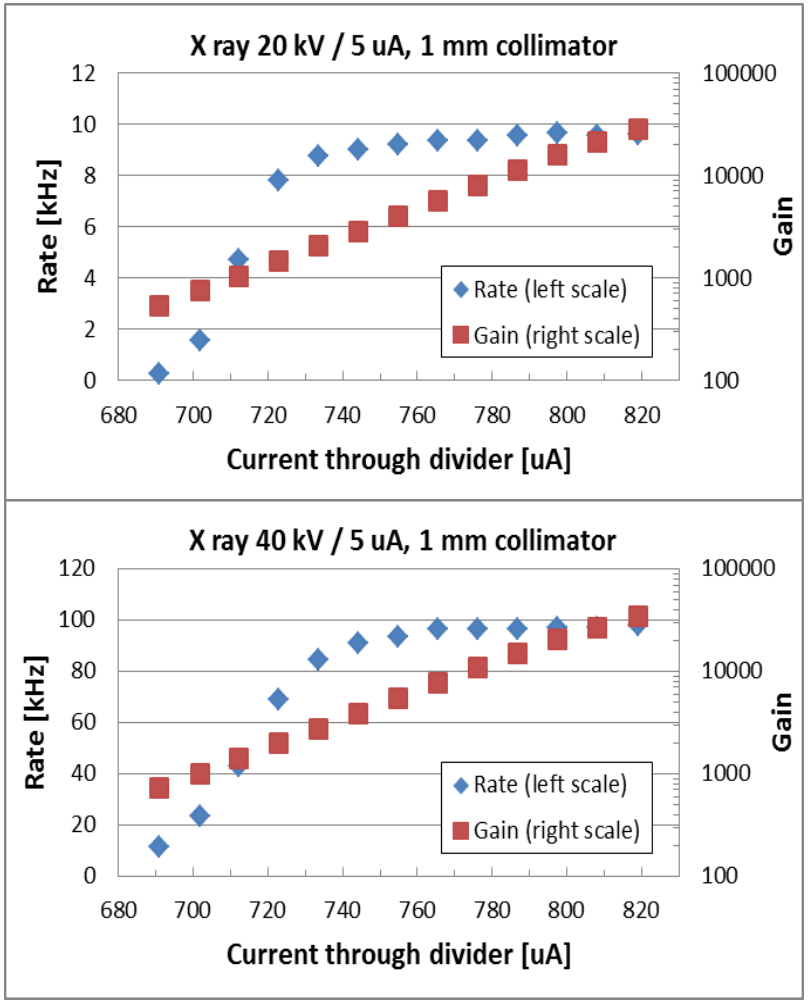


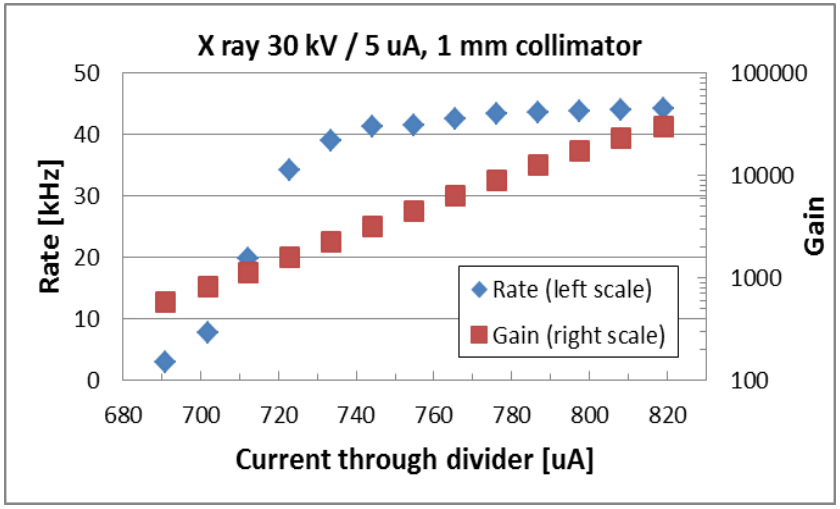


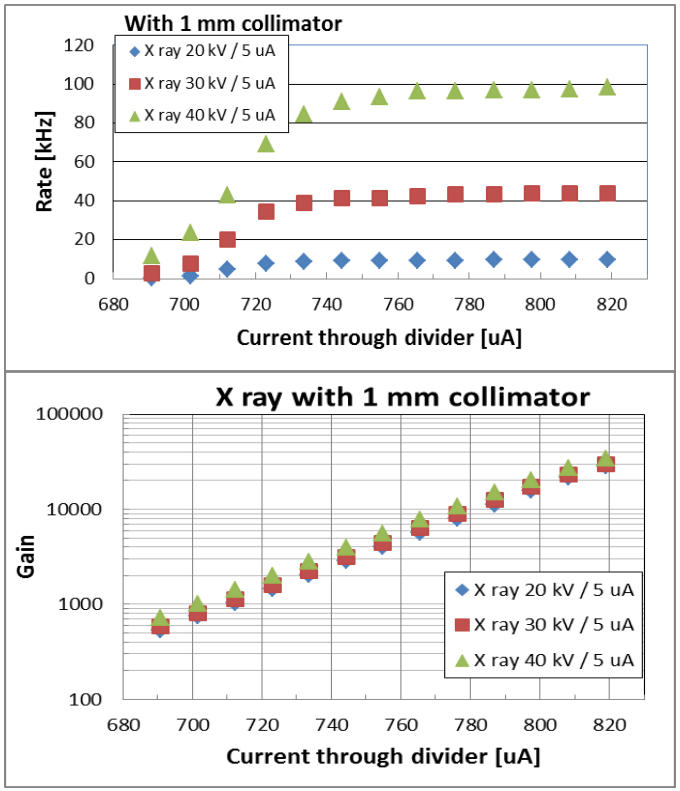


- Measured at drift hole 5-2, source distance to detector is roughly 0 cm.
- Current through strips are all stable (see examples in backup slides).
- Since can not see Fe-55 signals, energies of X ray is not calibrated. Using previous measurement on the 10 cm GEM detector, gain can be still calculated. (Energy has an impact on primary ionization numbers)
- For different X ray energies (at different voltage settings), a same primary ionization number is used. The difference on gain due to this aspect should be small. So, we can conclude that we measure almost same gain at different X ray energy settings.

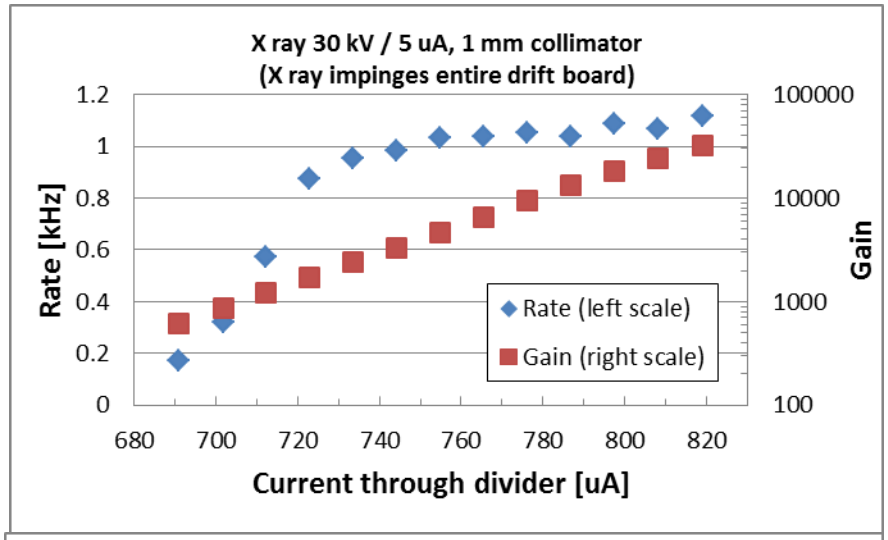
Gain and rate for the detector – at high X ray energies and with 1 mm collimator



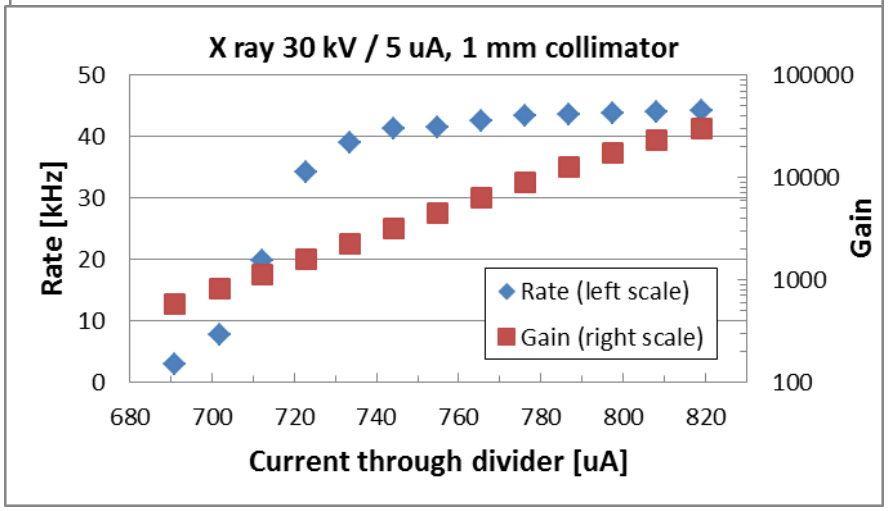




Gain and rate for the detector – impact of the drift board



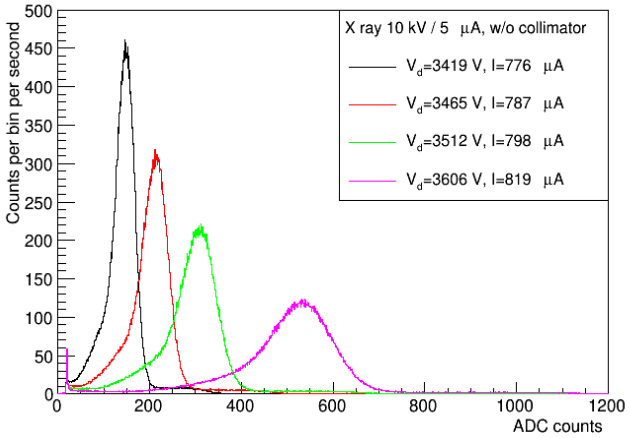
X ray impinges drift at a position ~5 mm to the right of the hole 5-2

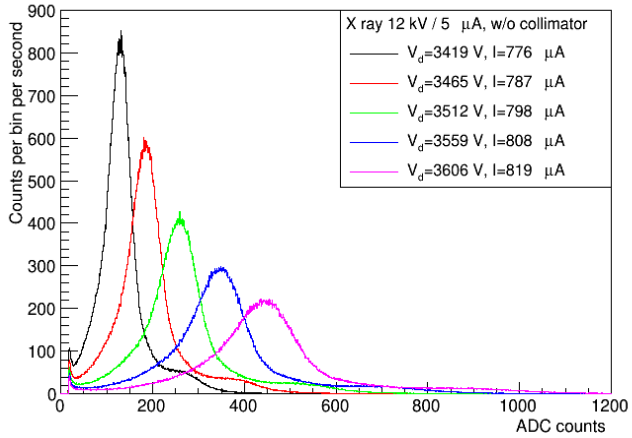


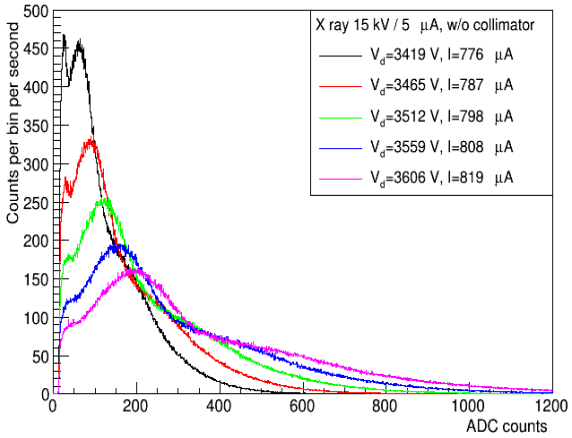
X ray impinges drift on the hole 5-2

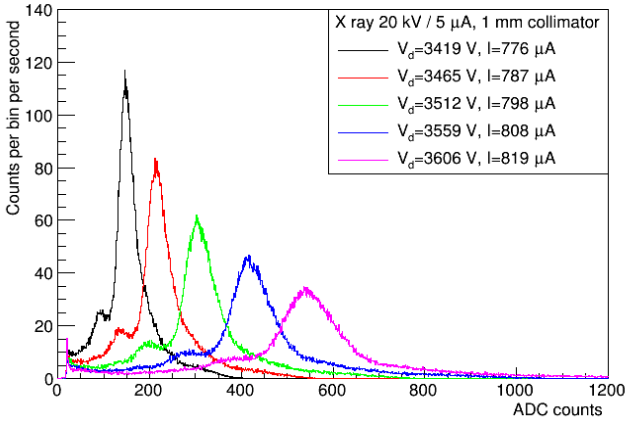
The impact of drift board to the rate and gain is small.

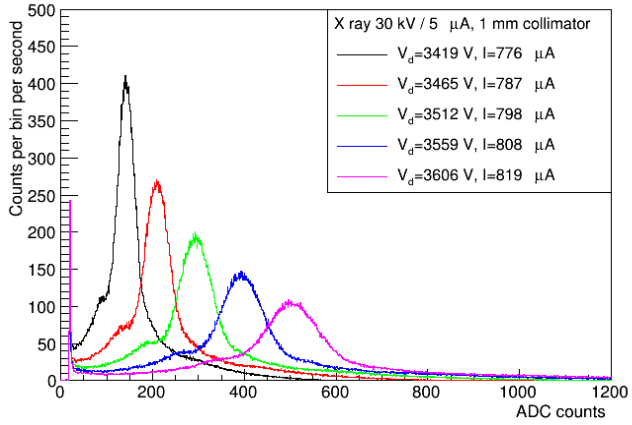
X ray spectra of the measurements (at drift hole 5-2)

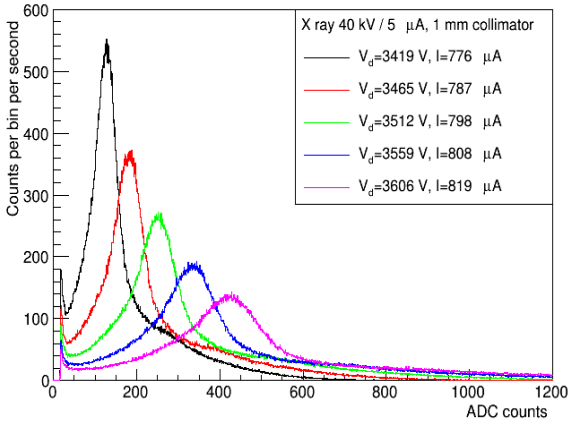




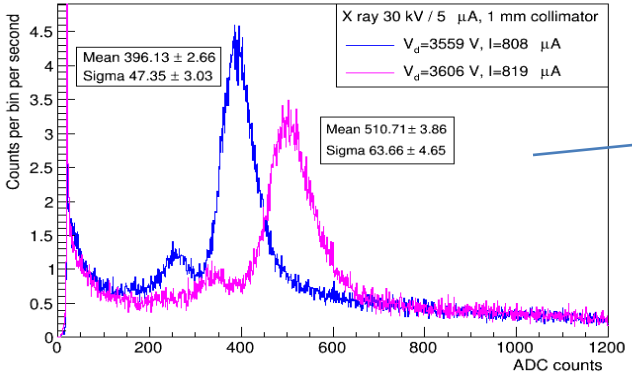








X ray impinges the whole drift (Not at a hole)

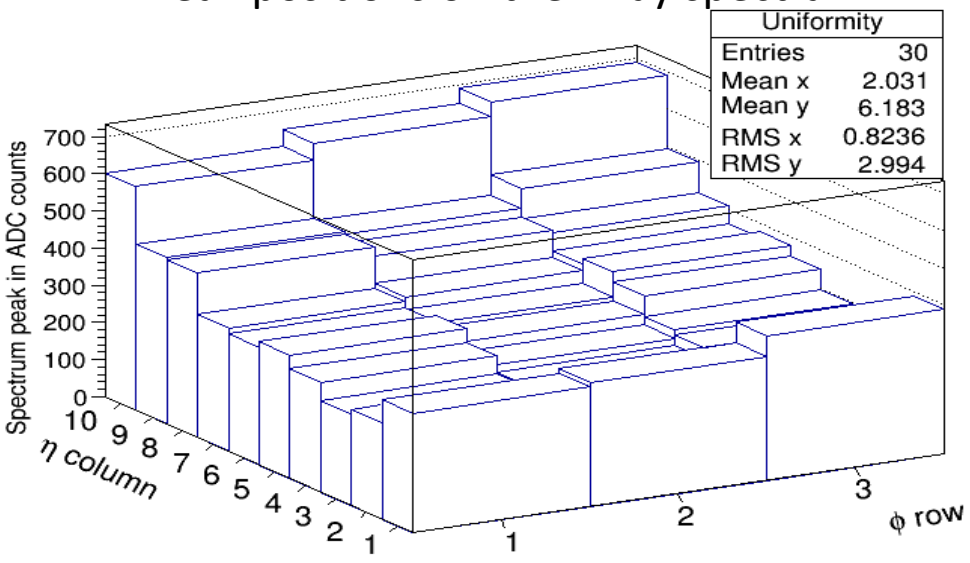


Energy resolution: ~ 12%

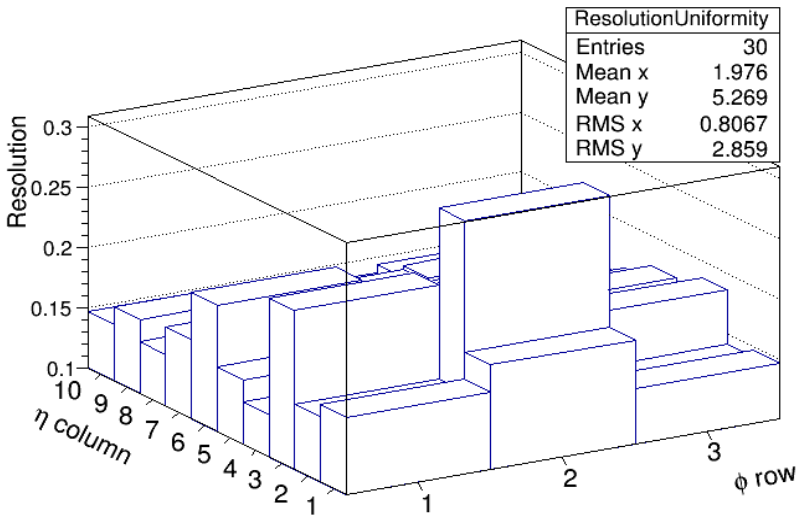
~5 mm off drift hole 5-2

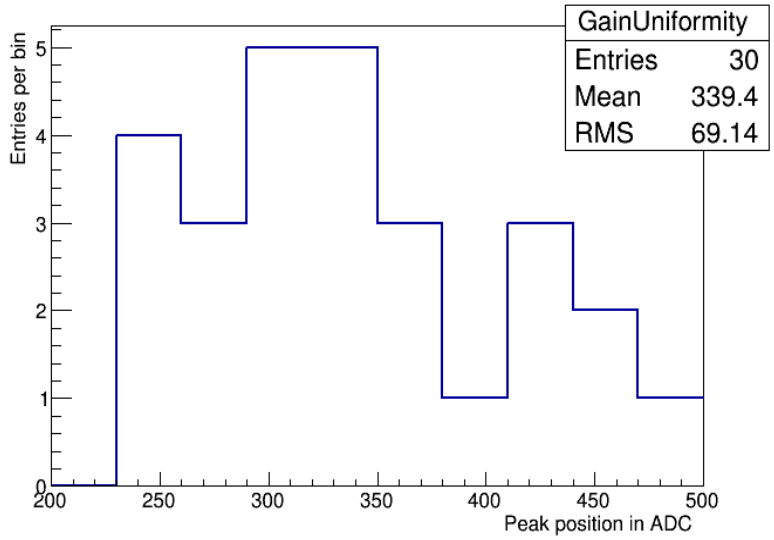
Uniformity measurements (X ray 30kV/5uA, 1 mm collimator, I=798uA,V_d=3512V)

Peak positions on the X ray spectra



Energy resolution (sigma/peak)



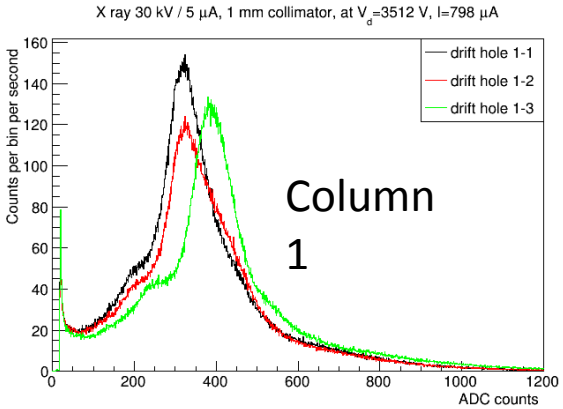


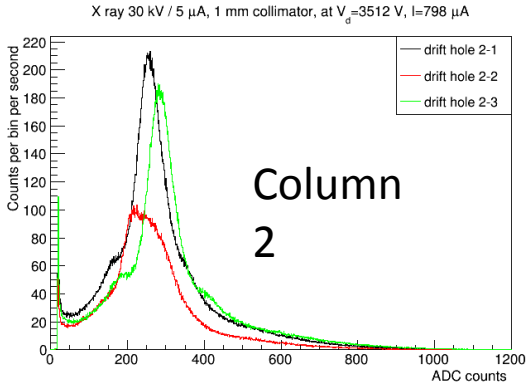
- A measure of the non-uniformity

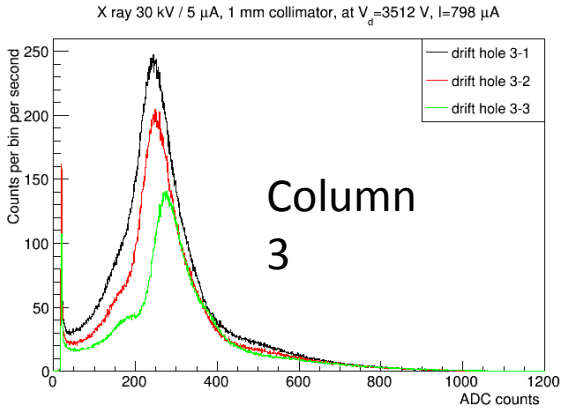
(column 1 data not included on the histogram): RMS/Mean=69.14/339.4=20.4%, in agreement with our beam test.

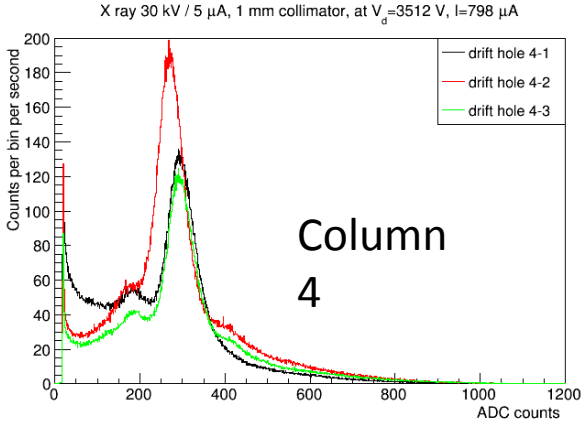
- We observe the gain decreases from column 10 to 1, especially at column 10 it is about 2 times higher. The reason could be: (1) we have gas leak at the outlet which is close to column 10, so at outlet positions O2 contamination reduces the gain; (2) gas flow rate at inlet is higher which potentially gives higher gain; (3) due to bending of drift, gas gap is smaller at column 10 region.

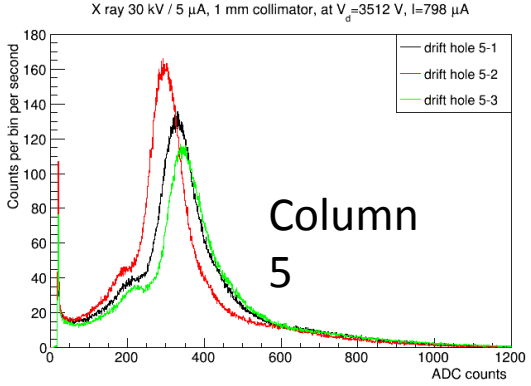
Spectra at different positions for uniformity measurement

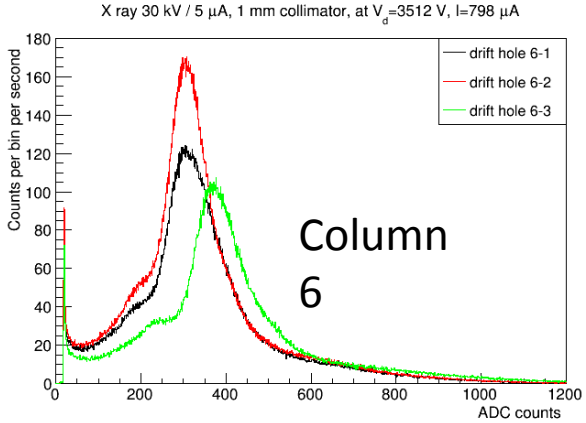


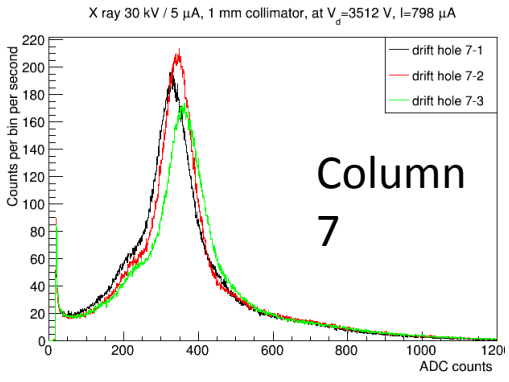


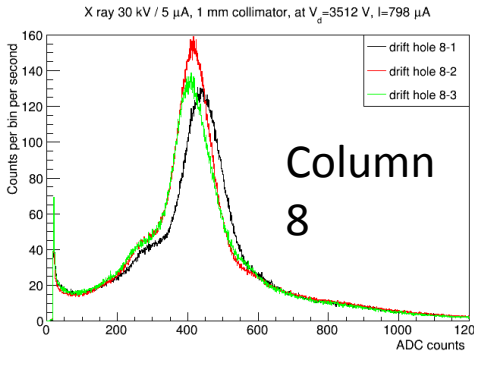


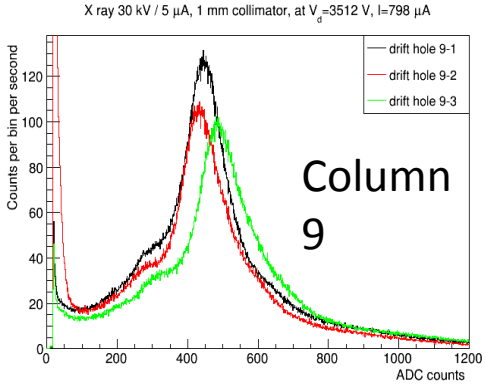


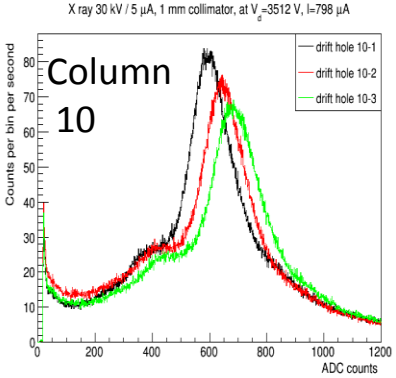




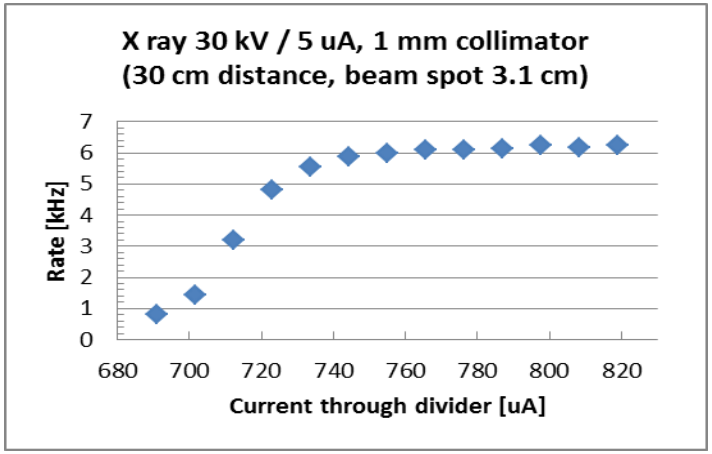


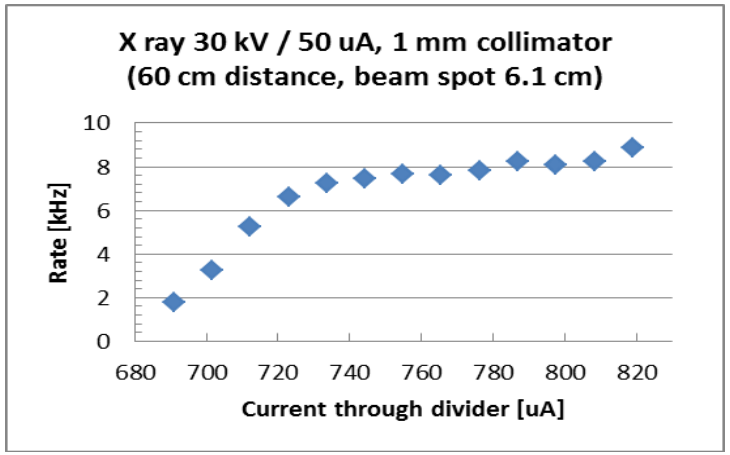




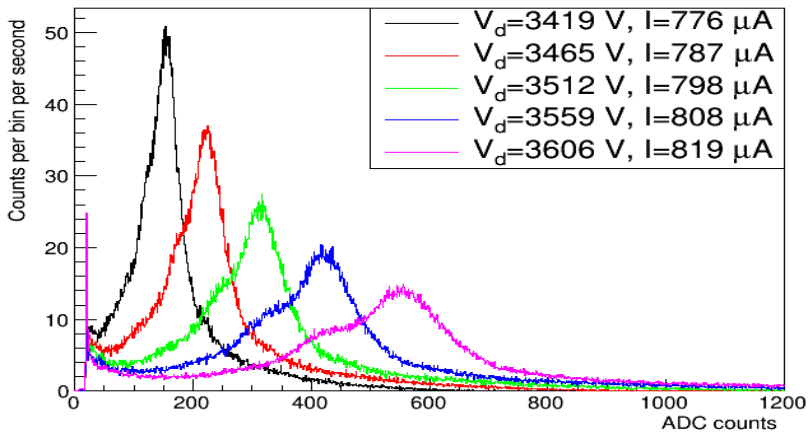


Rate measurement with higher beam spot (medium distance)

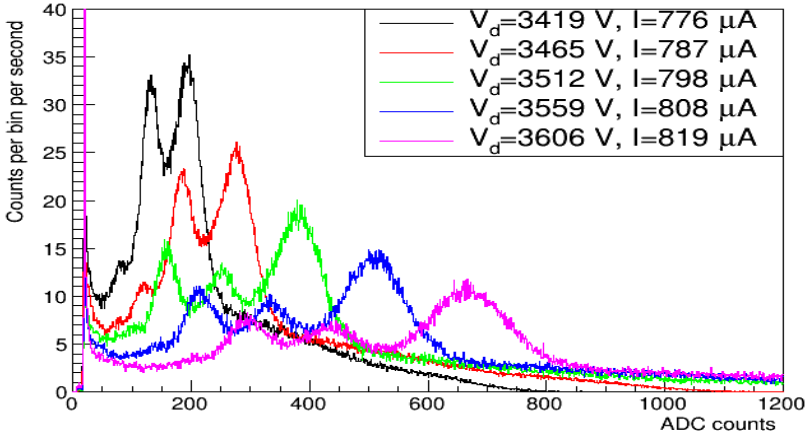




X ray 30 kV / 5 µA, 1 mm collimator, at 30 cm distance

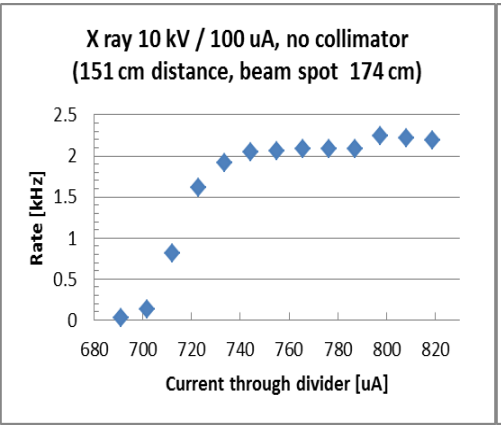


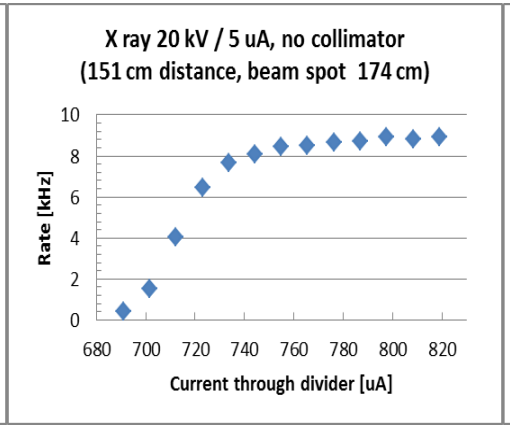
X ray 30 kV / 50 µA, 1 mm collimator, at 60 cm distance

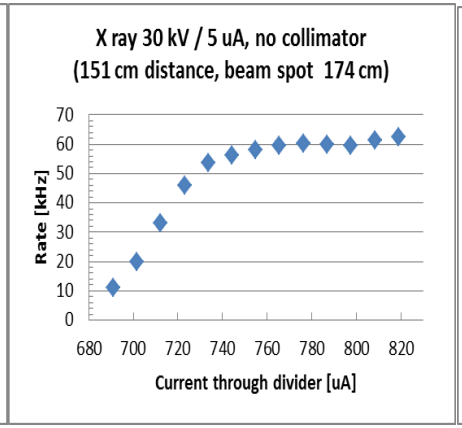


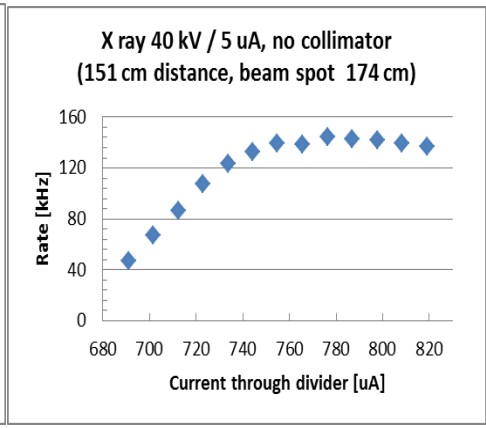
- Point the X ray source roughly at drift hole 6-2, vary the distance between source and detector and measure again the rates. In both cases there are good rate plateau. On the 2nd plot it is not very flat, this might be real gain impact due to ~6 cm beam spot.
- The spectra for the 2nd case (on the right) are also strange: they have 3 peaks…Gain variation should not be giving this big difference on peak positions.

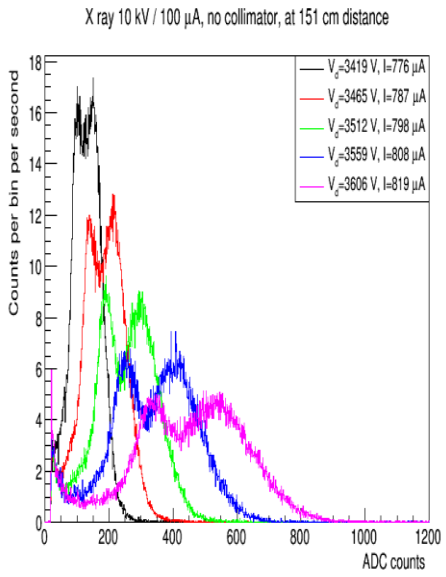
Rate measurement with larger beam spot (large distance)

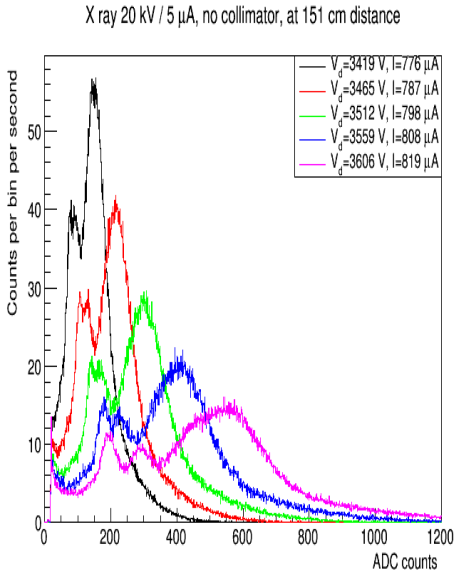


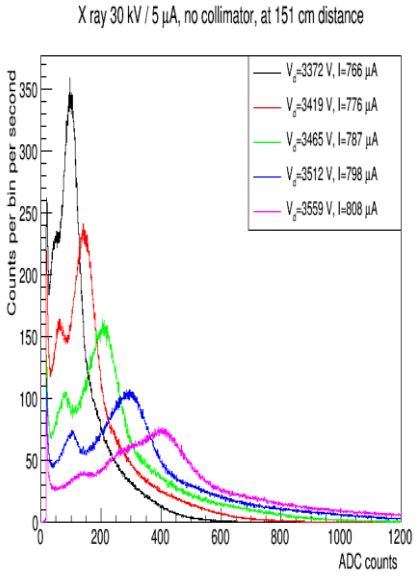


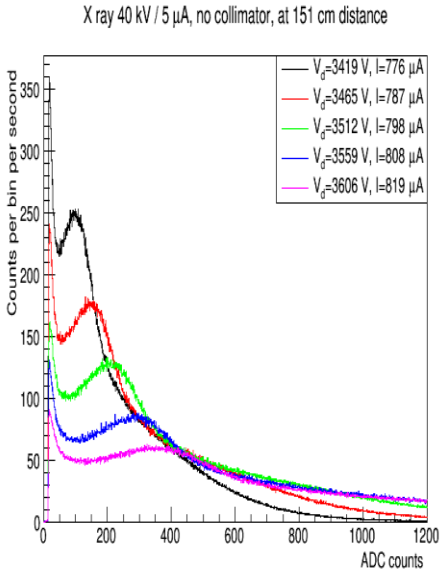












Connect all strips to the r/o ground,

Source is at ~**151 cm distance**, w/o collimator.

Good rate plateau can be still measured, for different X ray gun voltages.

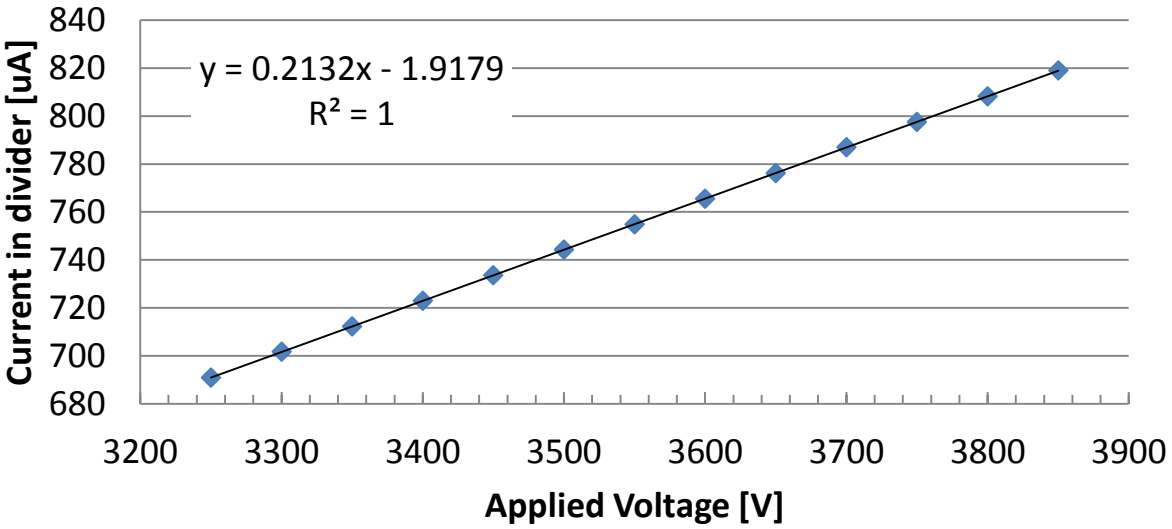
Summary

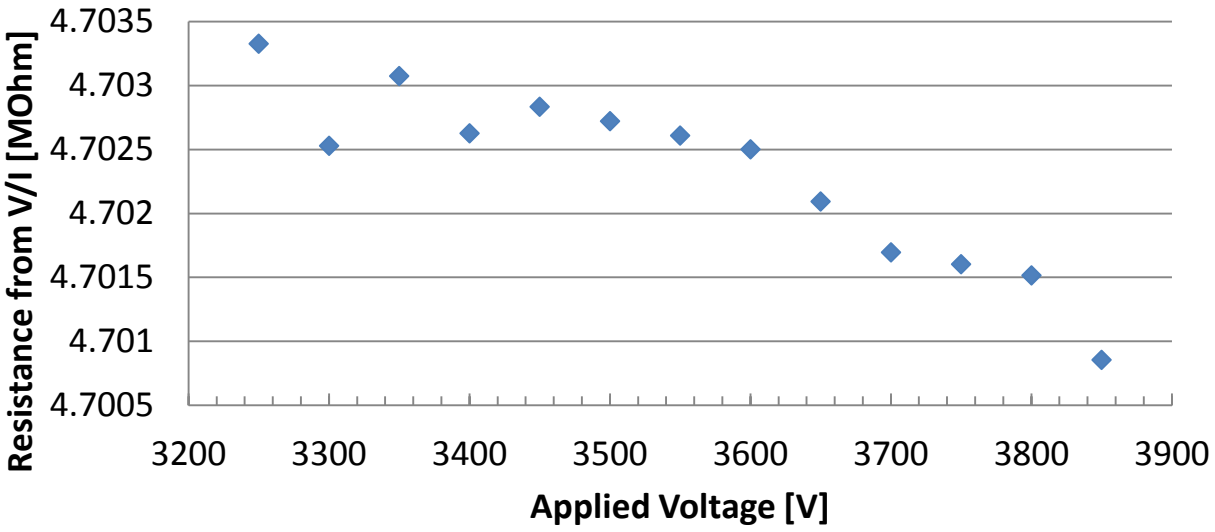
- Now we have much more understanding for the GE1/1-III GEM assembled at FIT, gas gain is measured to be reaching 30k; overall non-uniformity is ~20%.

- The next plans:

-> Mount the chamber with 80/20 Al extrusions , this way all other parts (preamp., cable, etc.) can be tied to the stands, so that a fully equipped chamber can be moved as a whole. The chamber can be swapped out with other prototypes easily, and even it allows mounting two chambers simultaneously.

-> Plug on APVs and test the chamber with SRS (SRU), this will be the main work at this moment.


y = 0.2132x - 1.9179
R² = 1
Current in divider [uA]
840
820
800
780
760
740
720
700
680
3200
3300
3400
3500
3600
3700
3800
3900
Applied Voltage [V]


Resistance from V/I [MOhm]
4.7035
4.703
4.7025
4.702
4.7015
4.701
4.7005
3200
3300
3400
3500
3600
3700
3800
3900
Applied Voltage [V]