Hardware Meeting

29.2.2024

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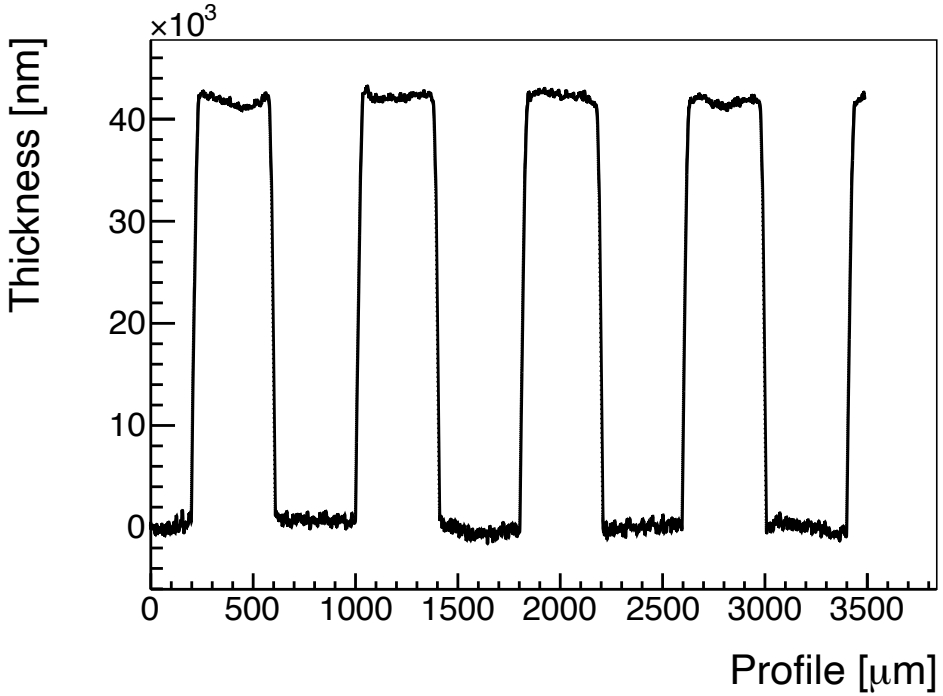
Converter Layers

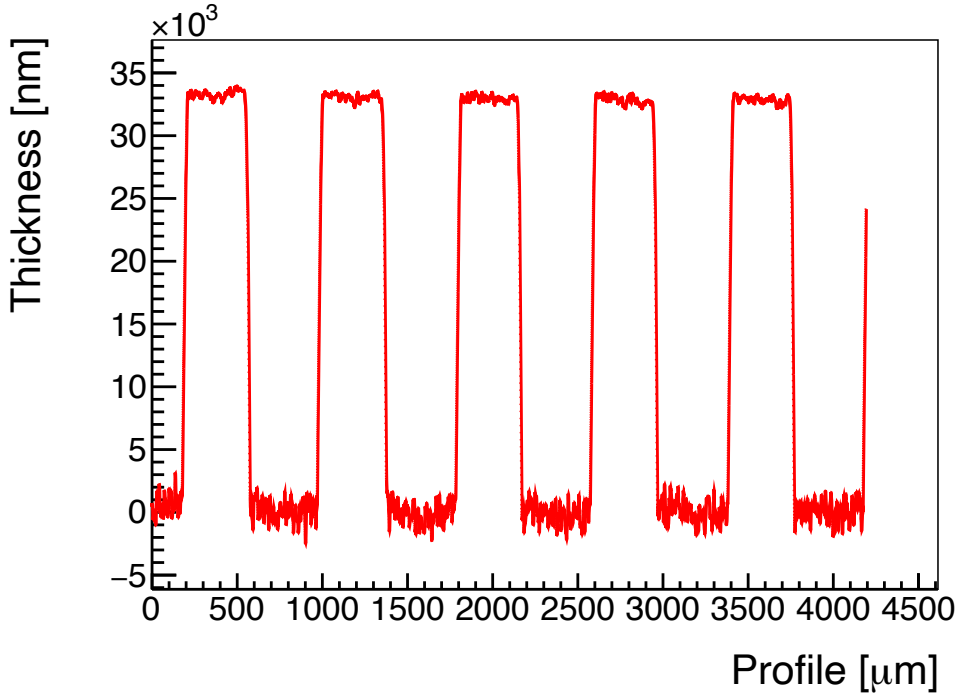
Converter Layers (bought)	Double-Sided Cu	Expected Thickness [mm]	Measured Thickness
1550 µm FR4 + 35 µm Cu	yes	1.620	1.59±0.01
300 µm FR4 + 35 µm Cu	yes	0.370	0.32
100 µm PI + 35 µm Cu	yes	0.170	0.17
100 µm PI + 18 µm Cu	yes	0.136	0.14
50 µm PI + 35 µm Cu	yes	0.120	0.12
50 µm PI + 18 µm Cu	yes	0.086	0.09

- PI: Polyimide
- thickness measurement with digital caliper
- for layers made of Kapton show agreement
- FR4 layers show differences in thickness → further investigation

FR4 Layers – Copper Thickness



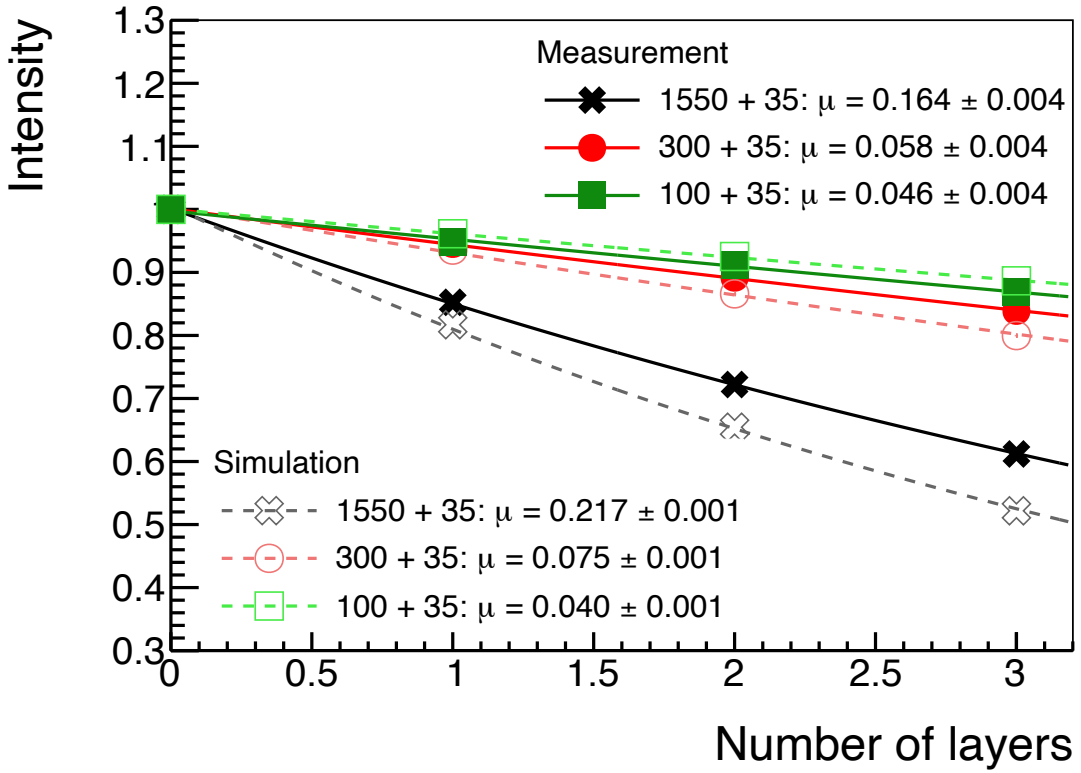
1550 FR4 + 35 Cu



300 FR4 + 35 Cu

- FR4 thicknesses (taking 35 µm of Cu on both sides):
  - 1520 µm FR4 instead of 1550 µm
  - 250 µm FR4 instead of 300 µm FR4
- for 1520 µm layer it is 42 µm strip thickness → is it Cu or glue? → currently use 35 µm Cu

Recap - Photon Absorption Measurement



- discrepancies between simulation and measurement for FR4

FR4 Layers

- product: ISOLA Duraver DE104

(https://www.multi-circuit-boards.eu/support/download/datenblaetter.html)

Construction	Resin Content%	Thickness (inch)	Thickness (mm)	Dielectric Constant (DK)/ Dissipation Factor (DF)				
				100 MHz	500 MHz	1 GHz	2 GHz	5 GHz
2 x 1652	42%	0.010	0.25	4.67 0.0140	4.64 0.0150	4.62 0.0170	4.60 0.0180	4.55 0.0180
8 x 7628	42%	0.060	1.52	4.67 0.0140	4.64 0.0150	4.62 0.0170	4.60 0.0180	4.55 0.0180

(https://www.isola-group.com/pcb-laminates-prepreg/de104-laminate-and-prepreg/)

- 42 % brominated Epoxy Resin, 58 % Fibrous Glass → composition?

FR4 Layers – Fibrous Glass Properties

	Property		E-Glass
	Advantage	Disadvantage	
SiO_2	Dk, Df	Drilability	52-56%
CaO		Dk	20-25%
Al_2O_3		Df	12-16%
B_2O_3	Dk, Dk		5-10%
MgO	Meltability	Dk	0-5%
Na_2O,K_2O		Dk, Df, Durability	0-1%
TiO_2,LiO_2	Meltability		0%

Used now:
54 % SiO2
14 % Al2O3
22 % CaO
7 % B2O3
2 % MgO
1 % Na2O

- https://www.isola-group.com/wp-content/uploads/Isola-Glass-Fabric-04_2022.pdf

FR4 Layers – Brominated Epoxy Resin

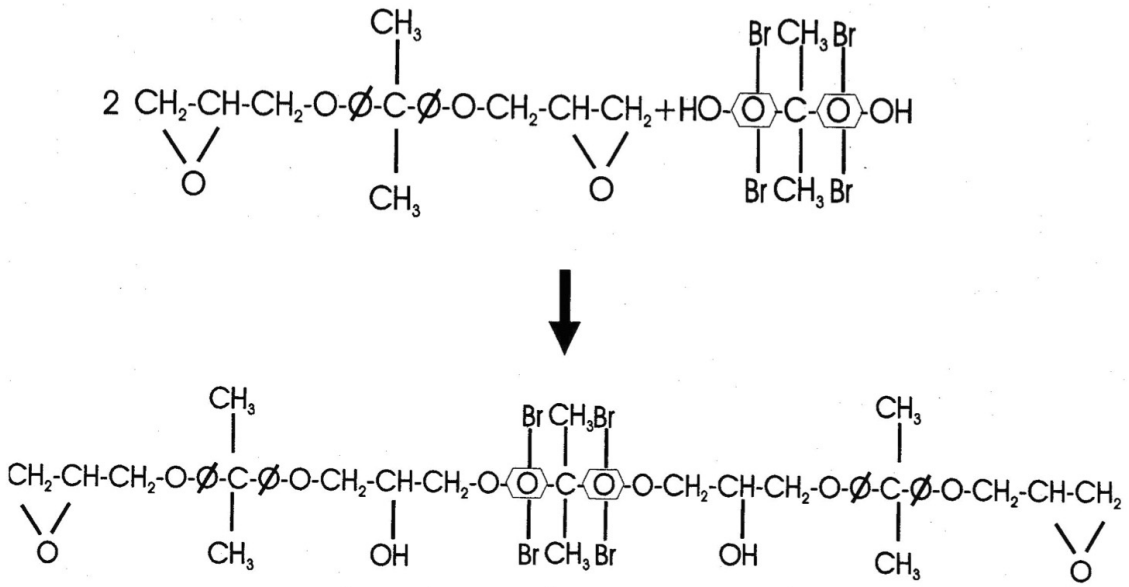


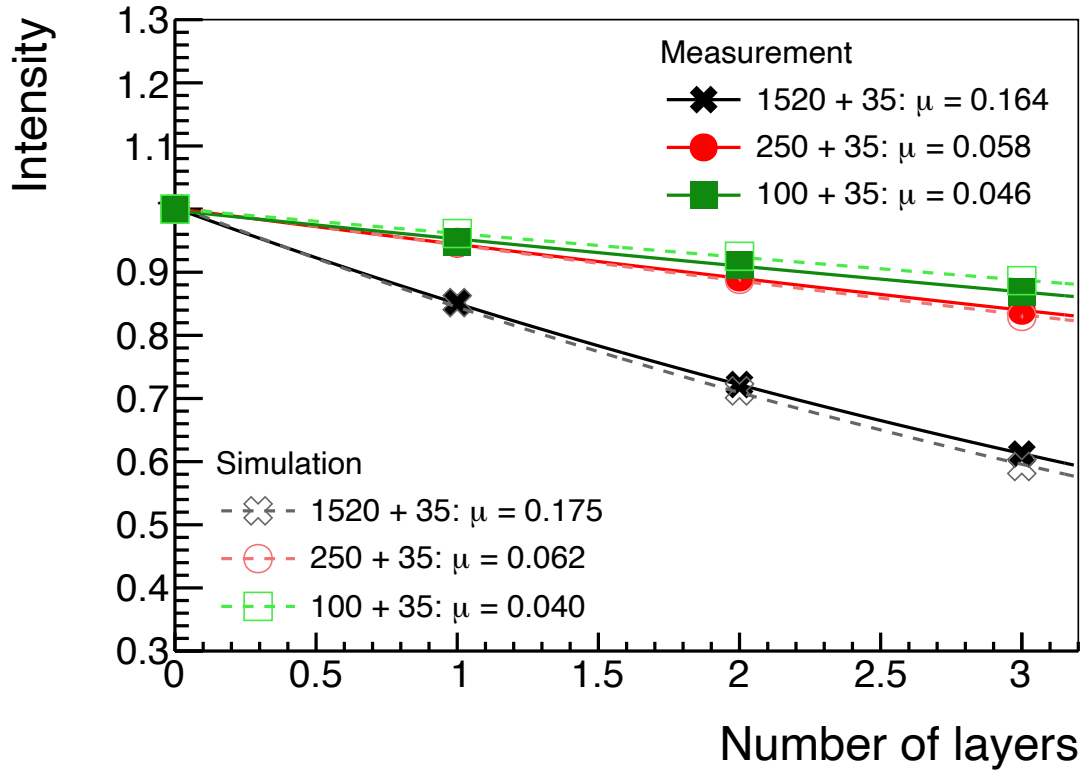
Figure 1 – Brominated Epoxy Resin

Used now:
$C_{57}H_{60}O_6Br_4$

- http://isola-group.com/wp-content/uploads/High-Tg-Bromine-free-Laminates-for-PWB-Applications.pdf

- new FR4 composition: 10.7 wt% Br (in this paper 7.4 wt%. Reported for similar material from ISOLA → DEBROMINATION OF DUROPLASTIC FLAME-RETARDED POLYMERS by Katrin Mackenzie and Frank-Dieter Kopinke)

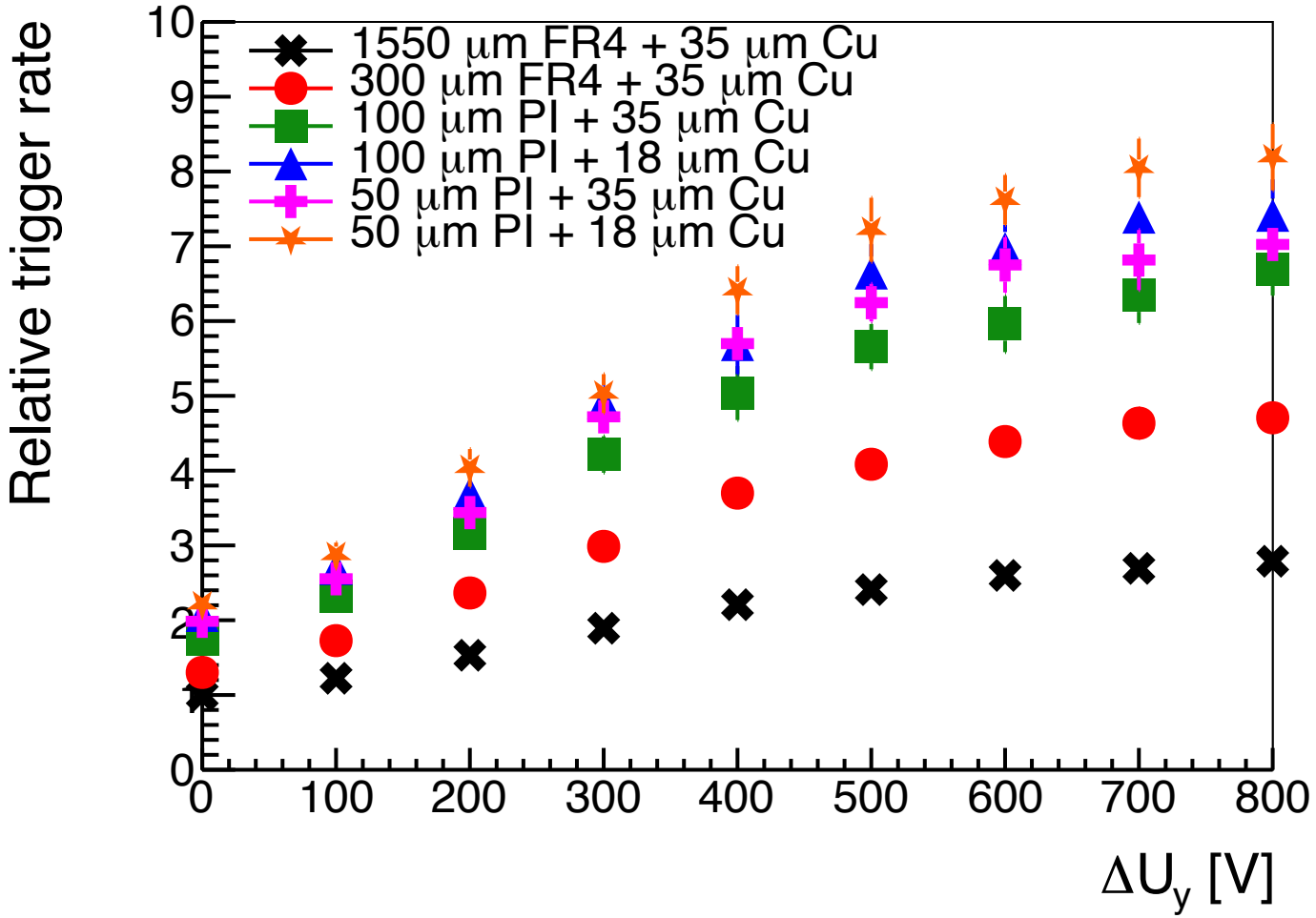
Photon Absorption Measurement – New Material



- Better agreement between simulation and measurement :)

Converter Layer Measurement

Measurement – Converter Layers



- still old labelling
- used climate cabinet and pressure system

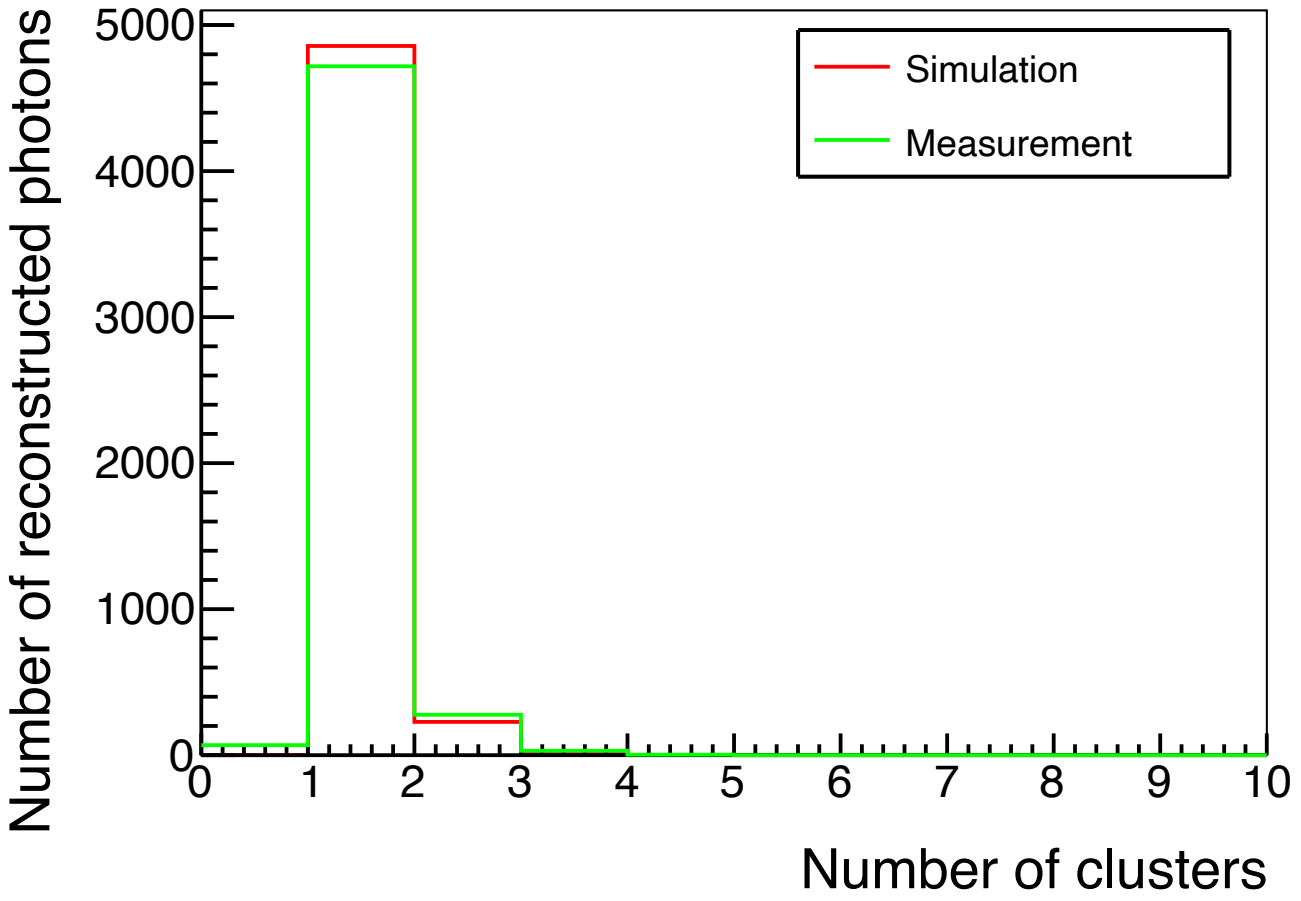
→ GEM voltage correction (maybe still adaption necessary)

- 50 µm PI + 18 µm Cu best performing layer up to now ☺
- Simulation doesn't show any agreement for different materials☹

Comparison Measurement and Simulation

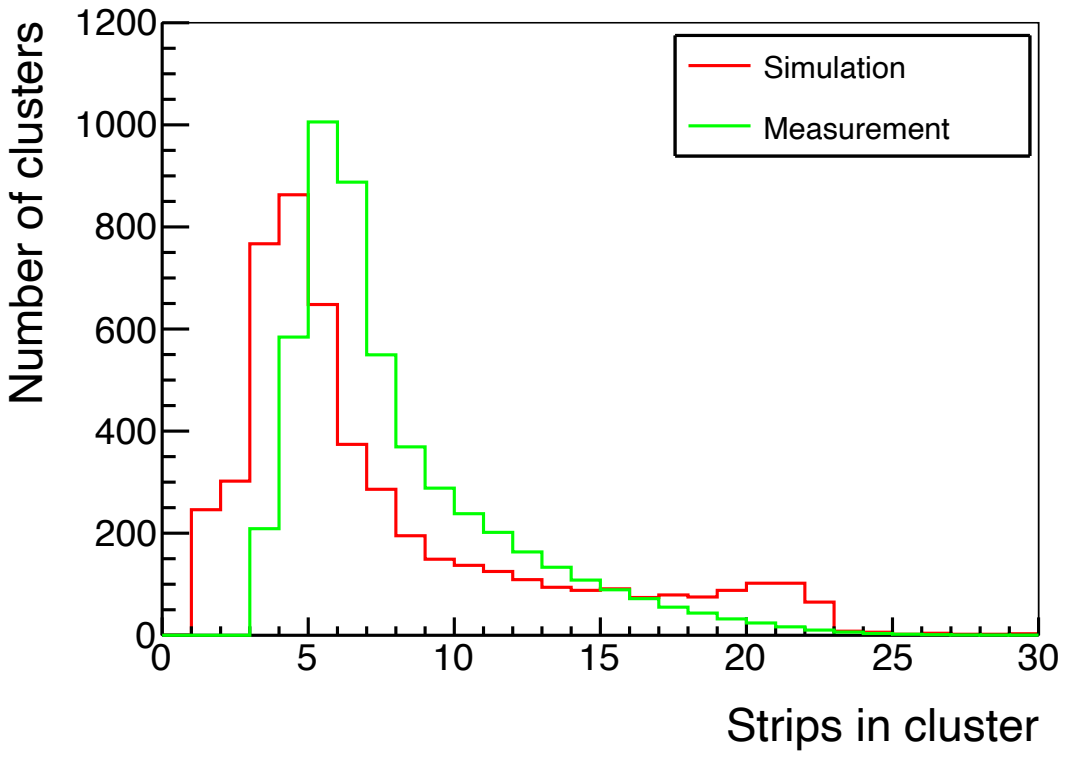
(Preliminary)

Cluster No

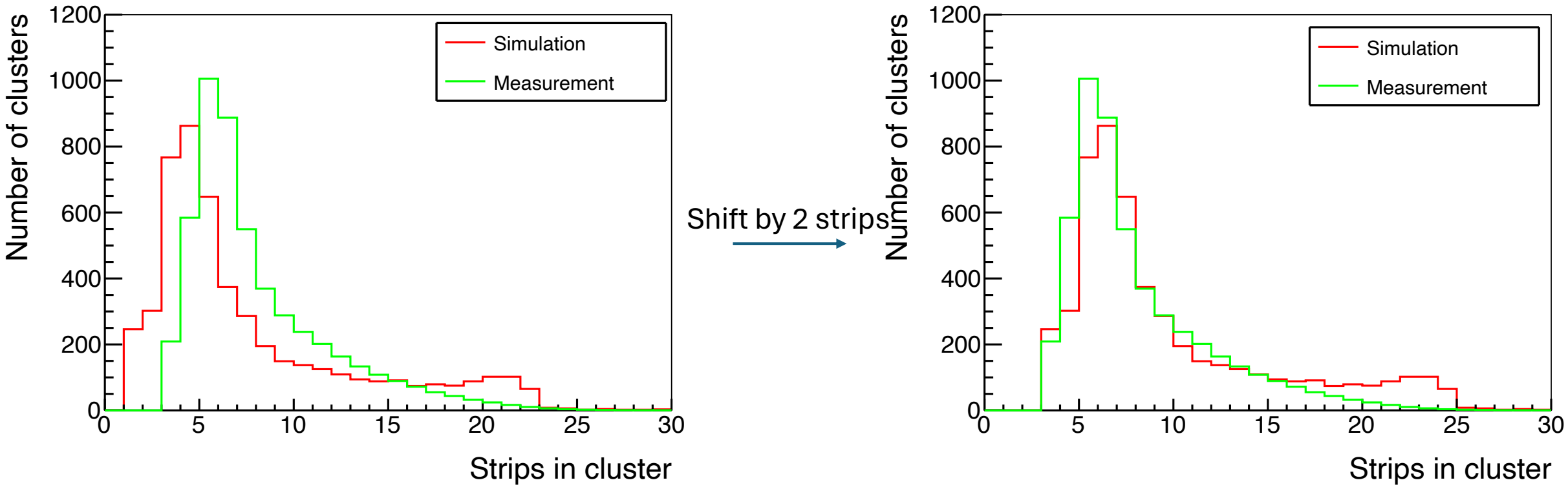


- For 1550 µm and 35 µm layers at dUy=600V und dUx=0V
- Show agreement

Strips per Cluster (x-direction)

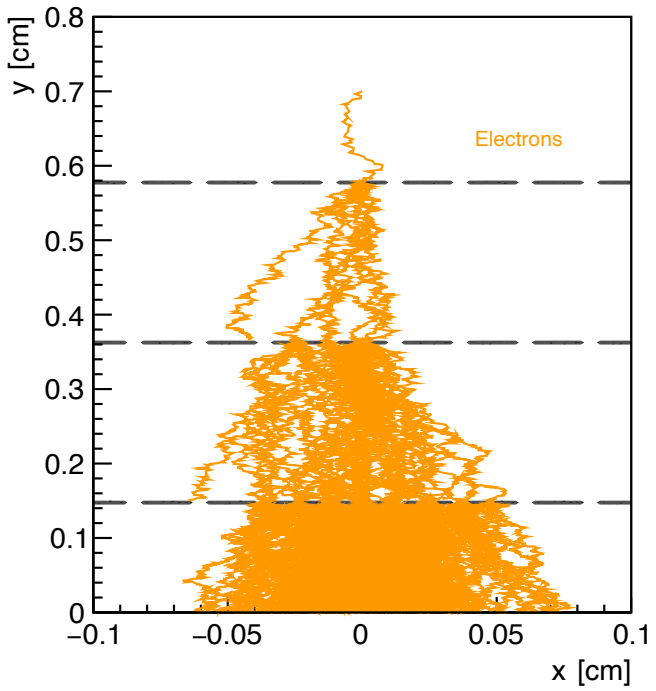


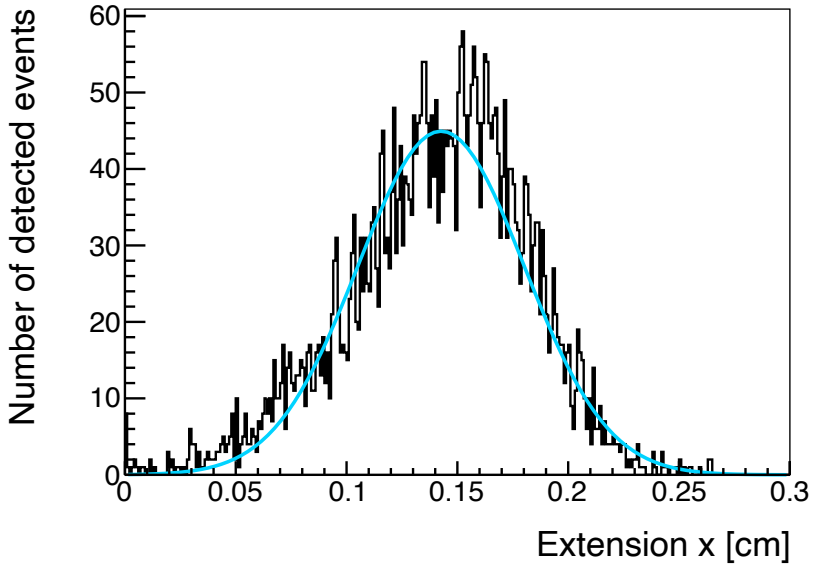
Strips per Cluster (x-direction)

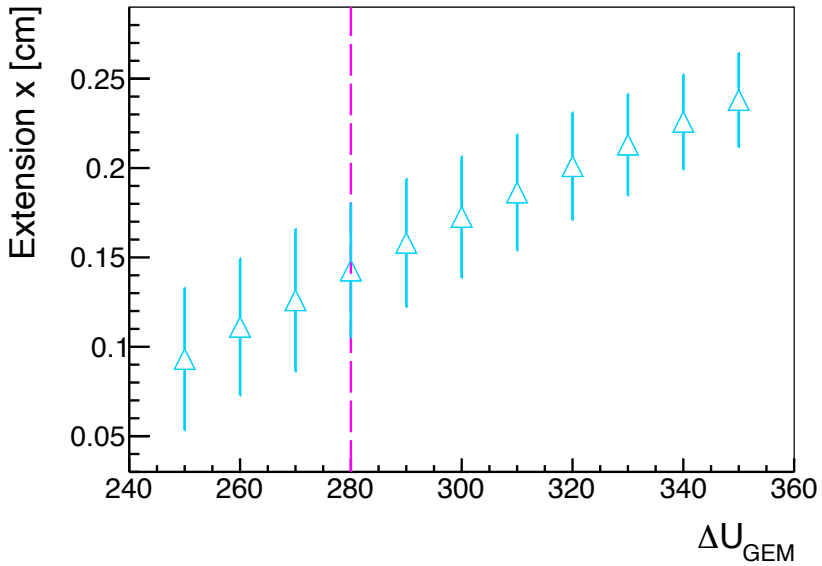


- with 2 strip offset correction same shape -> only tail differs
- Physical reason for this behaviour -> TO DO

Is this Shift valid? -> Garfield Simulation

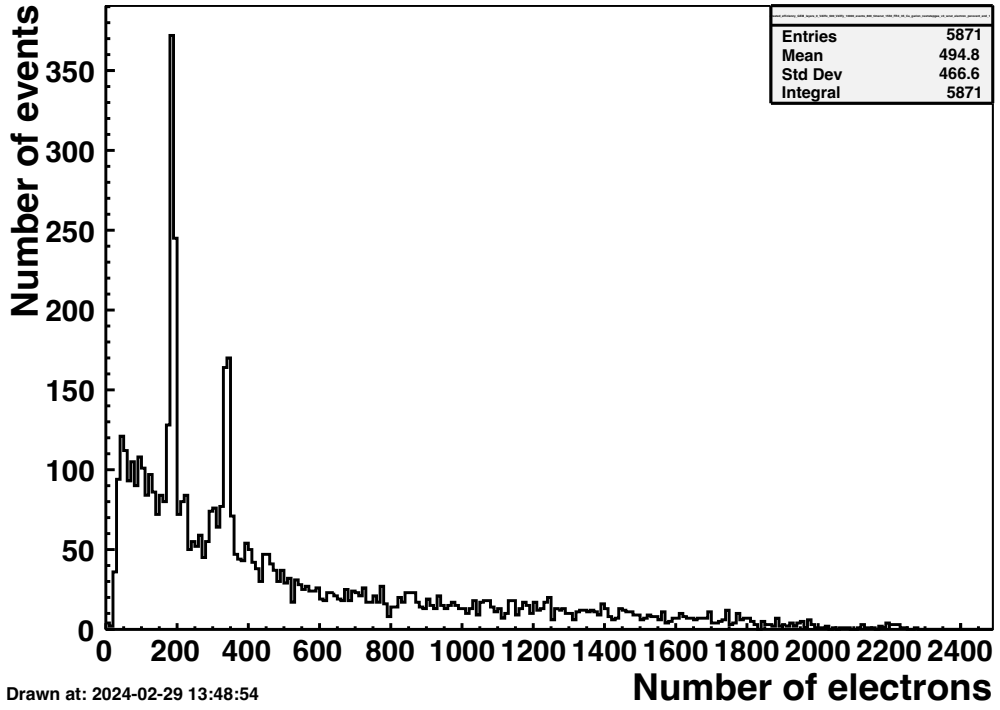






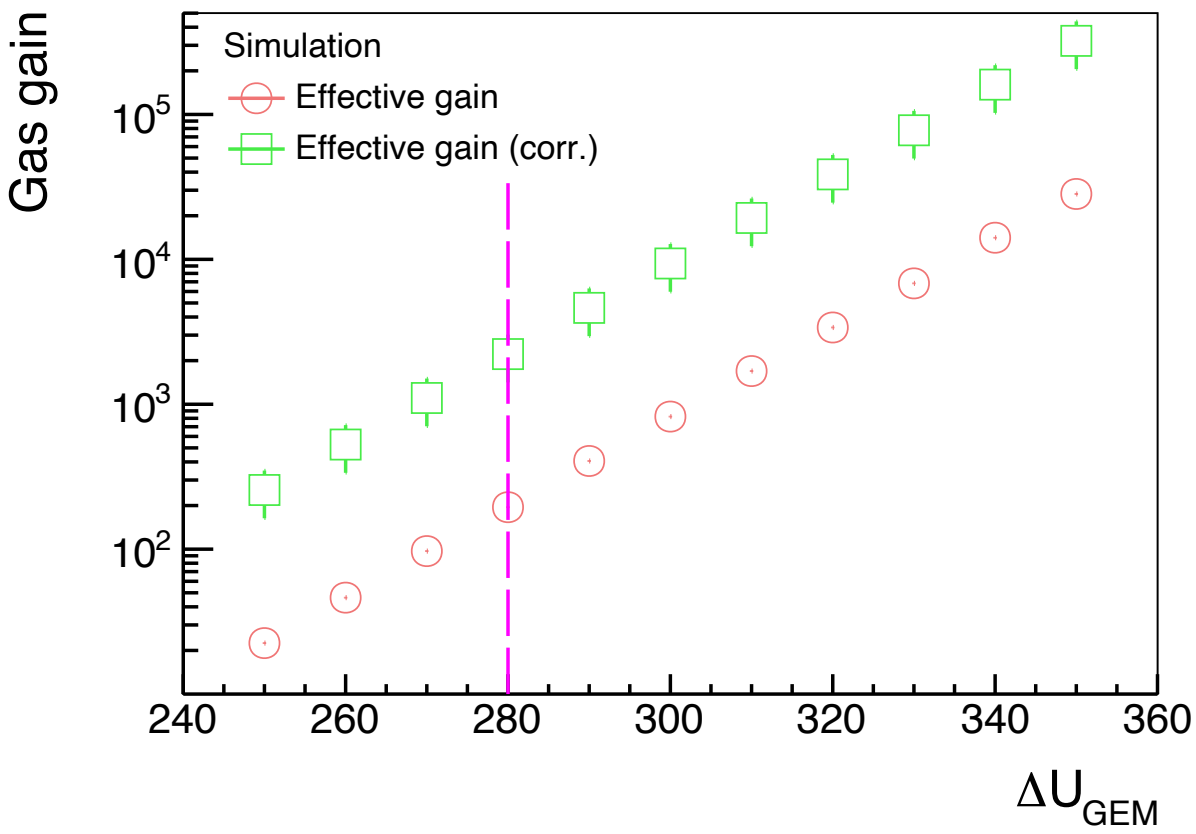
- Simulation suggests an offset of 3 strips for electron avalanche (currently under investigation)

Cluster Charge



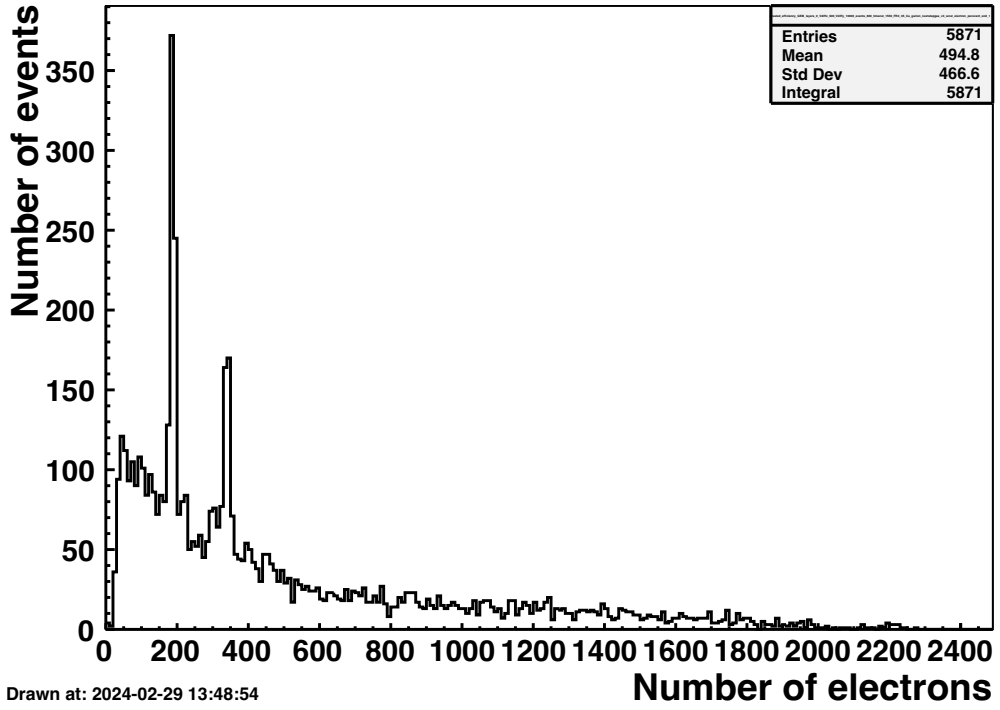
- Simulation: Peak at around 180 electrons after drift @ first GEM
- Reason for this peaks still under investigation

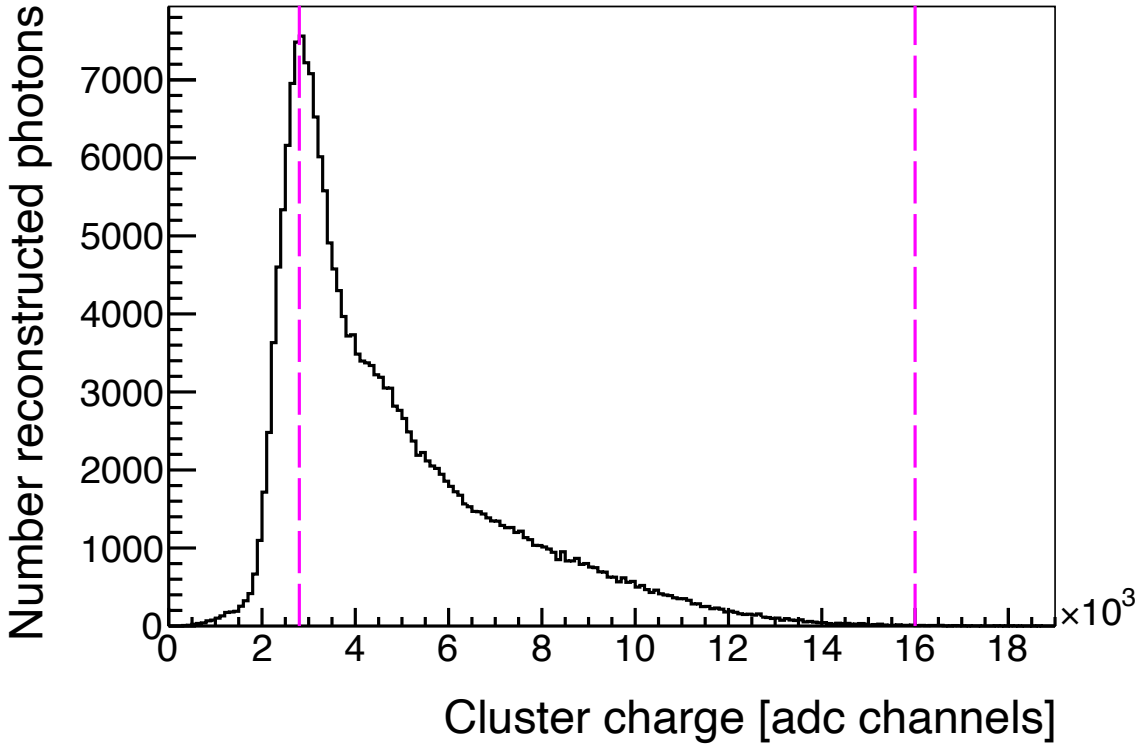
Garfield Simulation: Amplification



- Amplification between 1505 -3104
- Plot here: 2209

Cluster Charge





- Simulation: Peak at around 180 electrons after drift @ first GEM
- 1ADC count is 230 e- -> **Expected peak between 1177 and 2429 ADC counts**

-> Currently at about 2800 ADC counts for this measurement -> close to expected value -> check for pressure influence