How GEMs work
(and trying to predict performance)

Presentation is in progress and will be updated when we better understand how to extrapolate, but today I show what we understand as of now.

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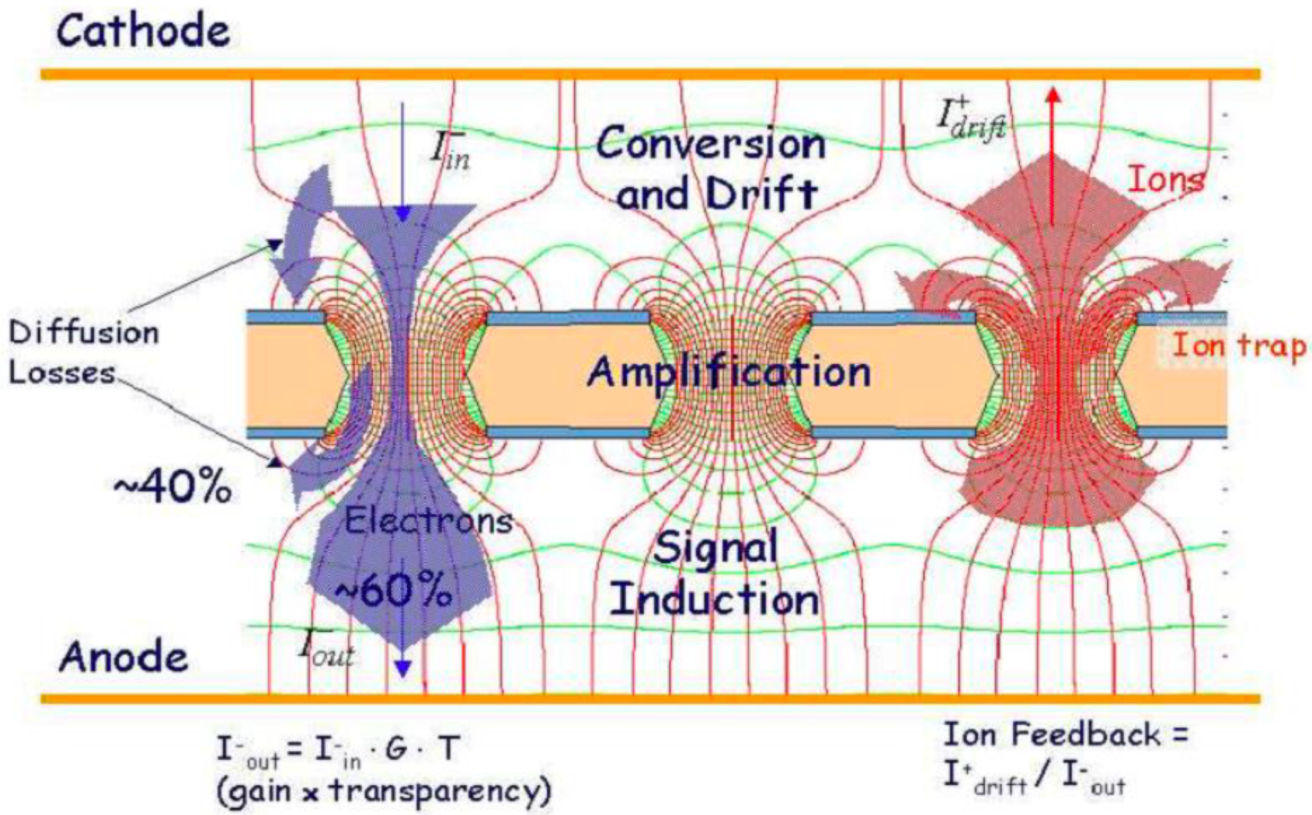
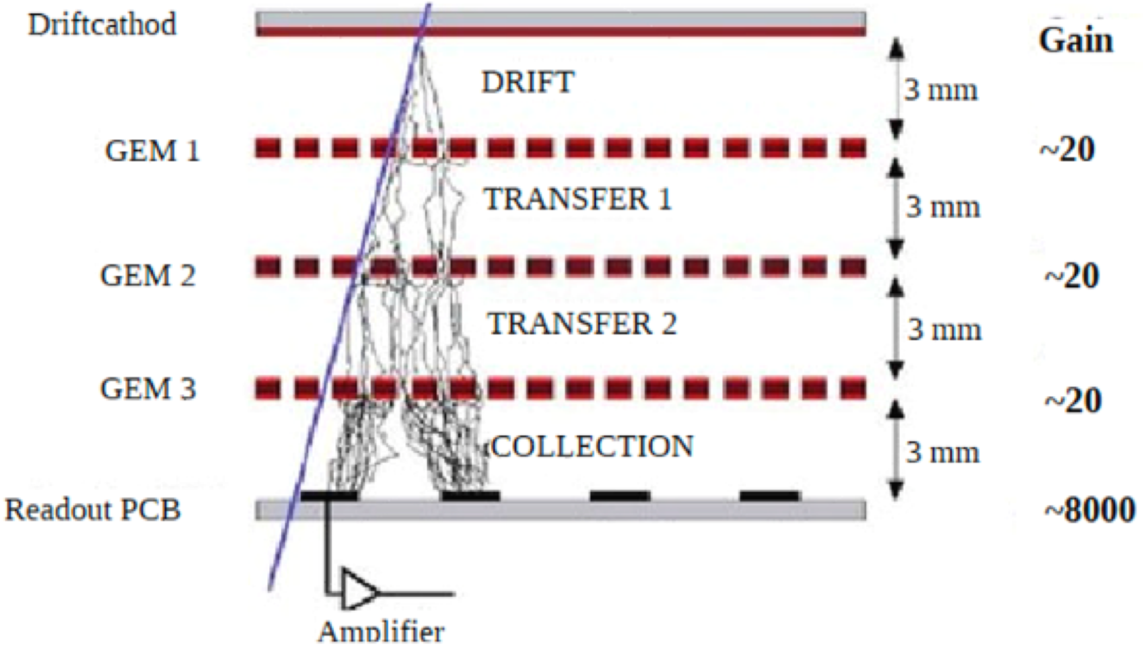
- In trying to predict the needs and rate implications for GEp, we had to go back to the basics to evaluate the GEM performance

- See basic GEM characteristics of ionization in a single foil:



- Note that the effective gain, G_{eff}, encompasses the diffusion losses, and is strictly interpreted to be the ratio of the detected / primary ionization charge

Triple foil increases overall gain and reduces the discharge probability



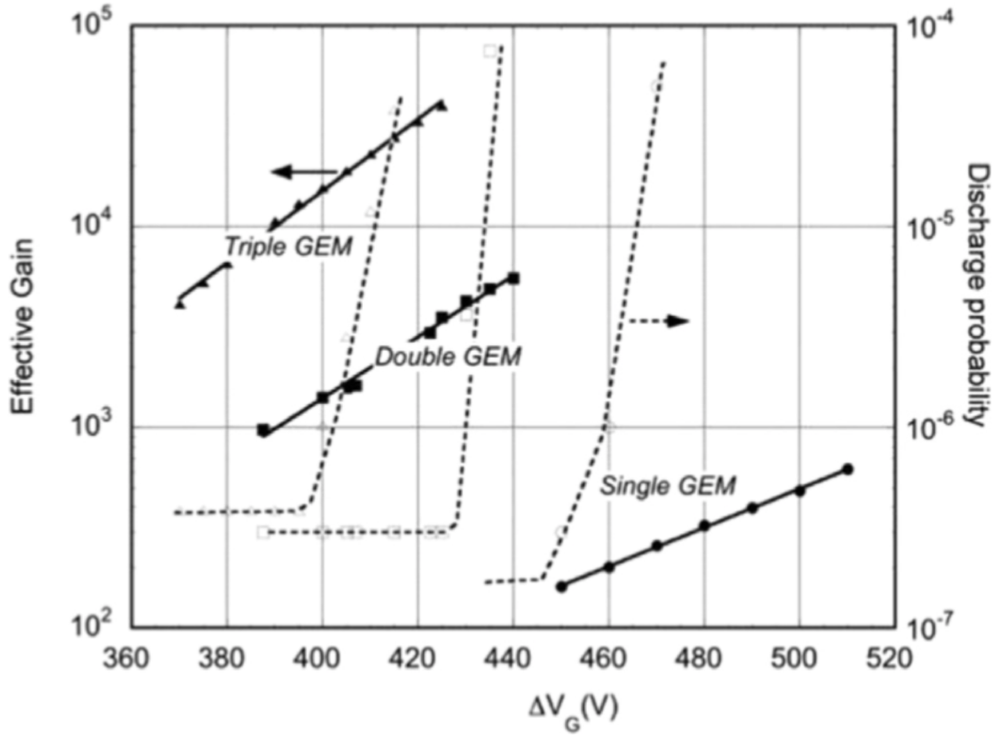


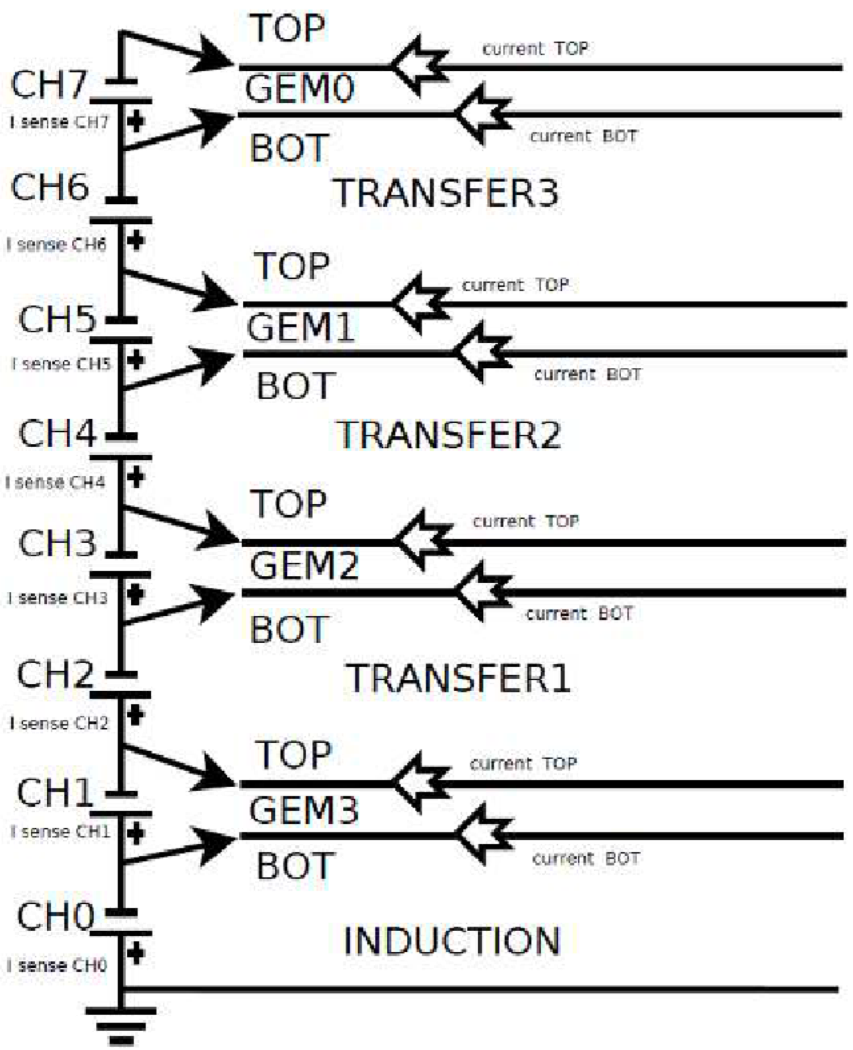
Fig. 11. Effective gain and discharge rates as a function of voltage in multi-GEM detectors.

$$g = C\, V^{\alpha}$$

$$\alpha = 15$$

(for Triple GEM)

Schematic of the individual power supply channels



Cathode

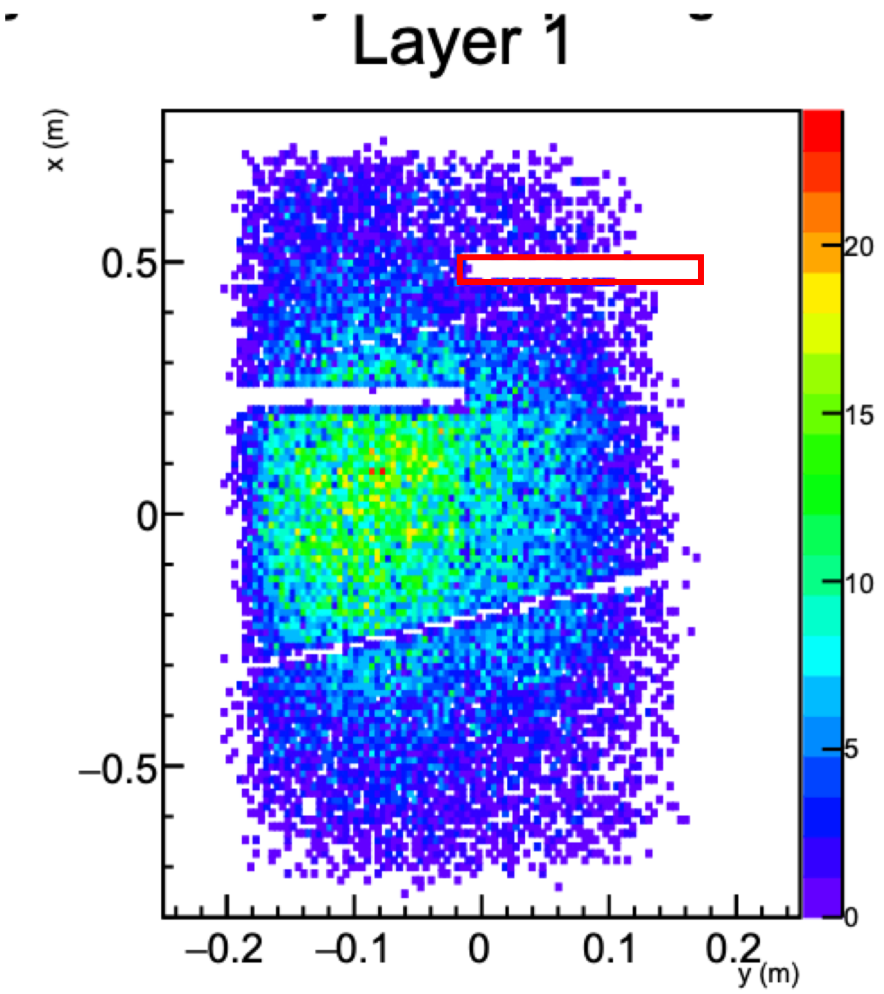
GEM 1

GEM 2

GEM3

Anode/Induction/Readout

Here’s how the UV layer is designed in reality:



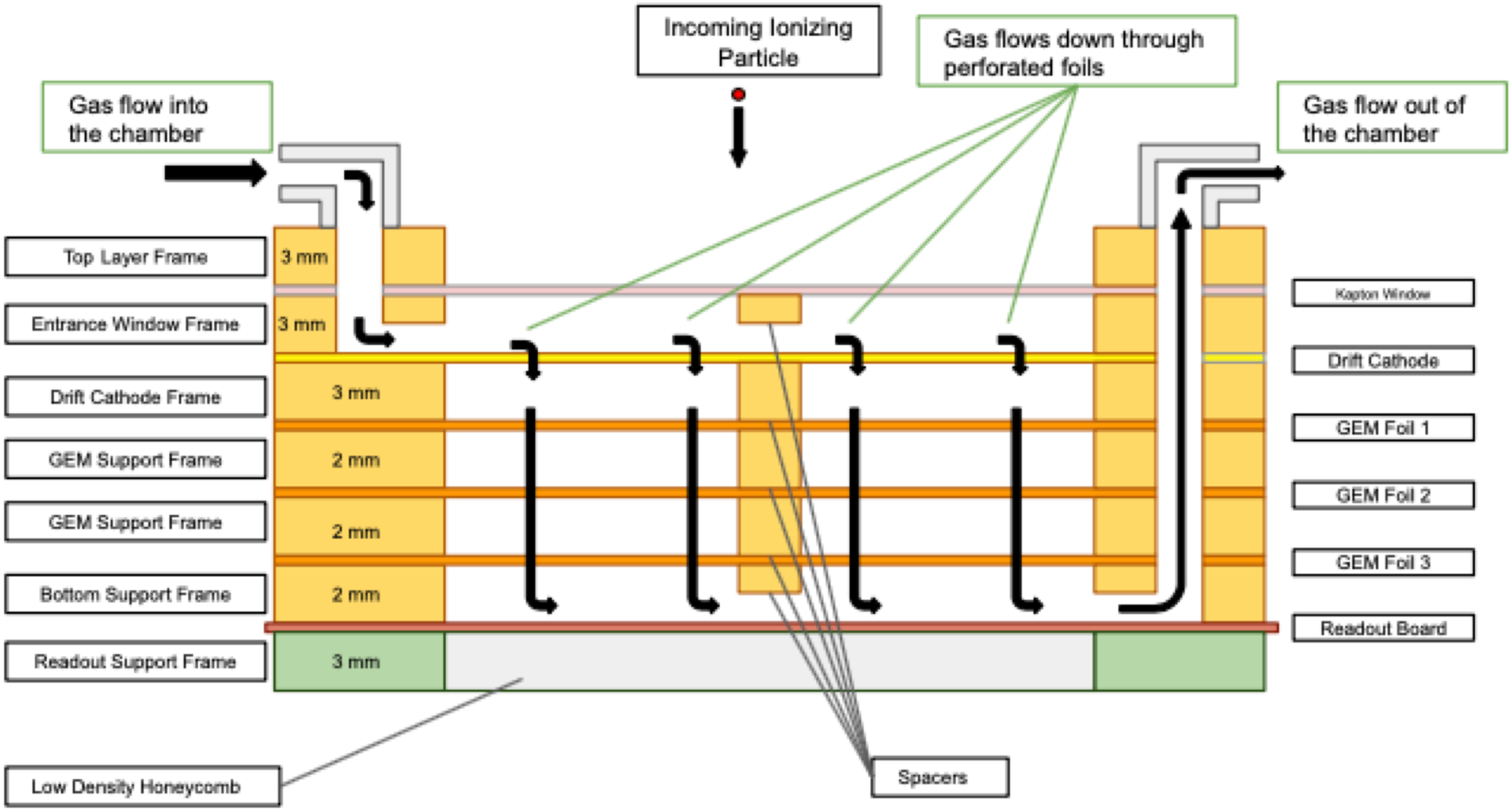
Each UV layer has 60 HV sectors

Each sector has protective resistors:

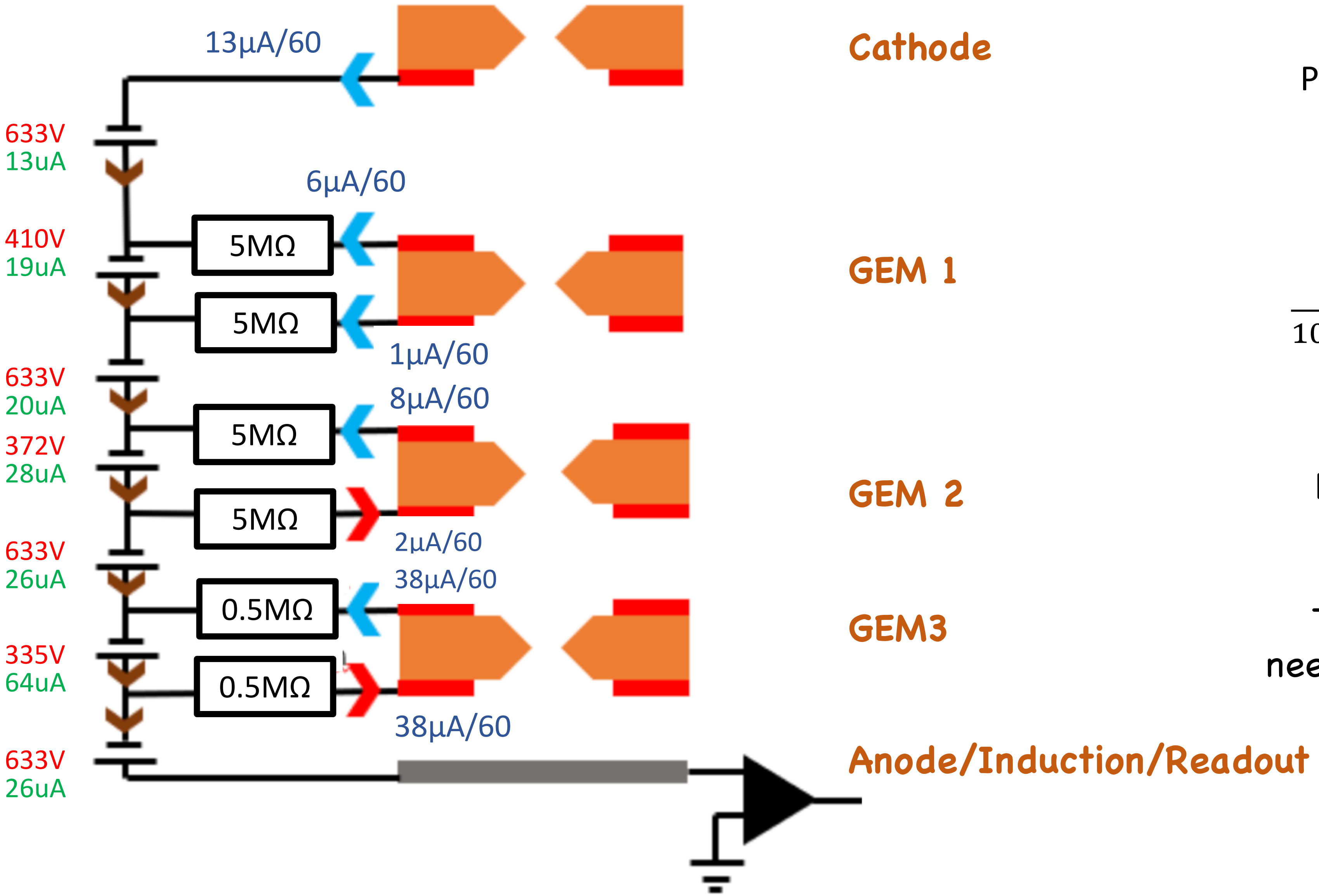
- 5 MΩ resistor for each top and bottom foil (GEMs 1 and 2)
- 0.5 MΩ resistor for each top and bottom foil (GEM 3)

This setup enables the remaining GEM to continue working when there is a short in a sector (white areas in left plot)

UV layer cross section, for reference:



- What is going on in our GEMs with beam?
- GEn kinematics at 36-deg, C multi-foil optics target (1.3%X0), 5uA beam (8E36 /cm2/s)



Putting some numbers to this…..

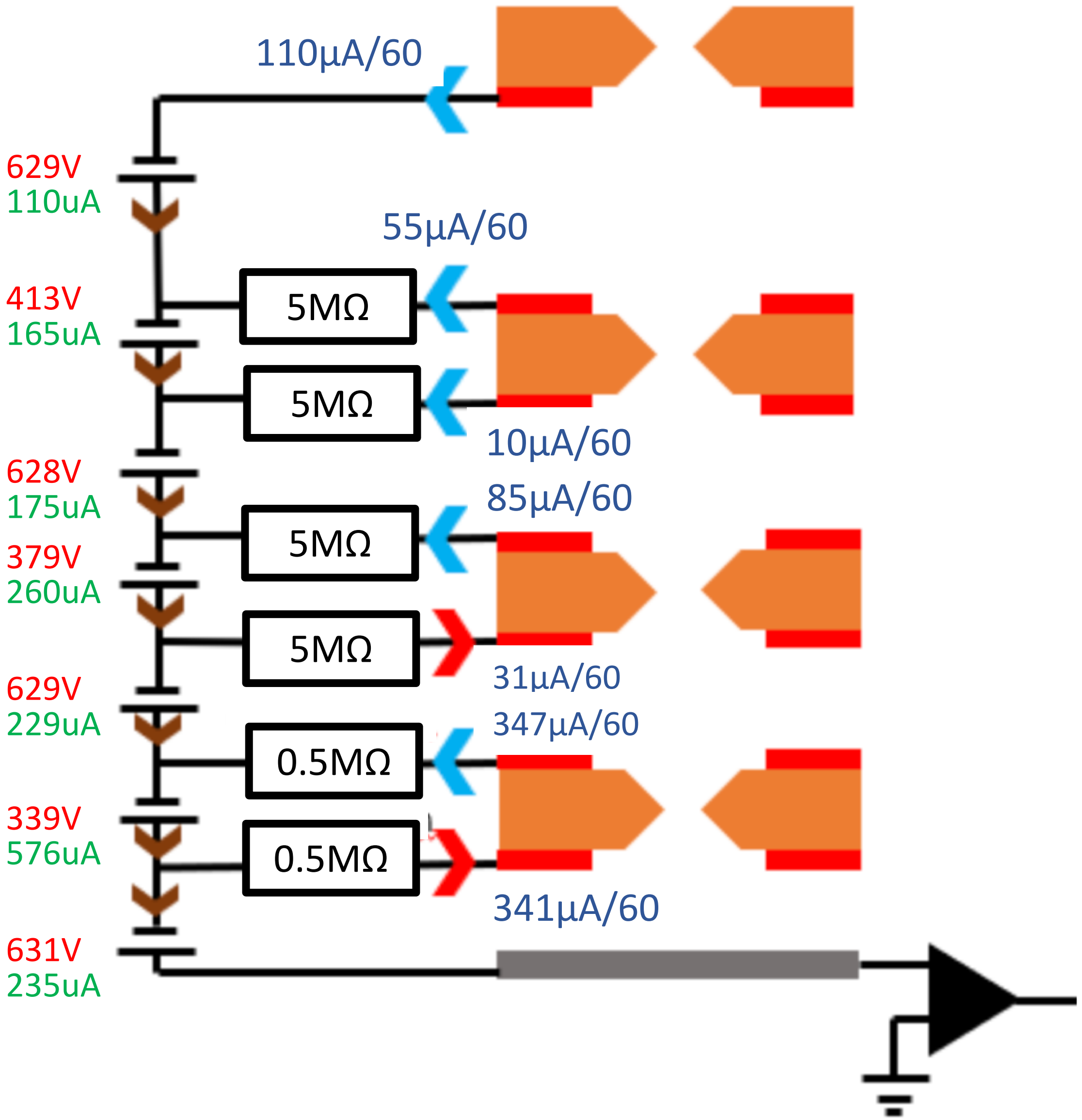
$$\frac{I_{ro}}{npe \times G_{eff} \times Area} =$$

$$\frac{26\mu A}{10^2 \times 10^4 \times (6\times10^3)} = 26\ \text{kHz/cm}^2$$

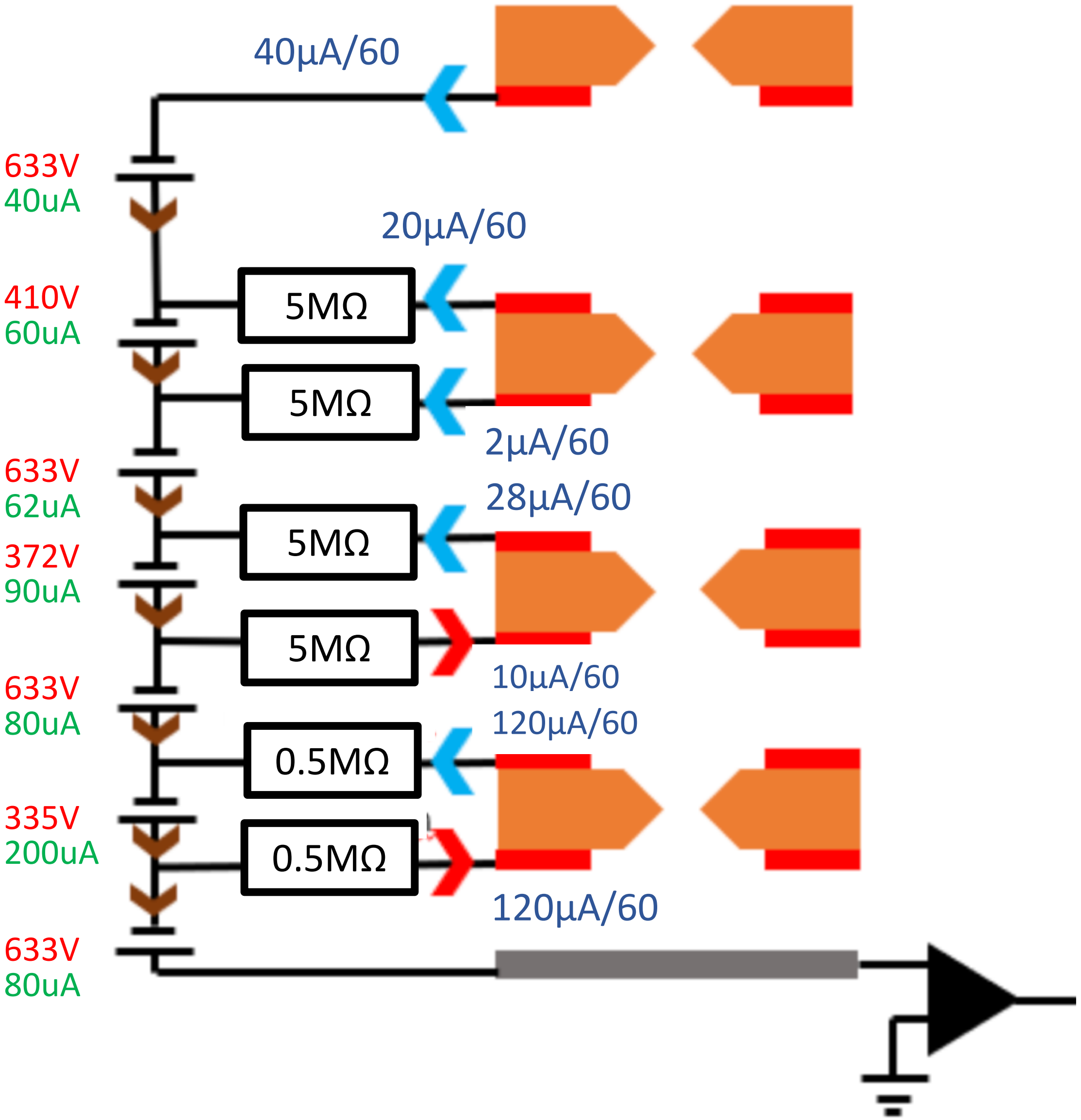
Note: G3 draws the highest current

This is all interesting, but it needs simulation to benchmark it!

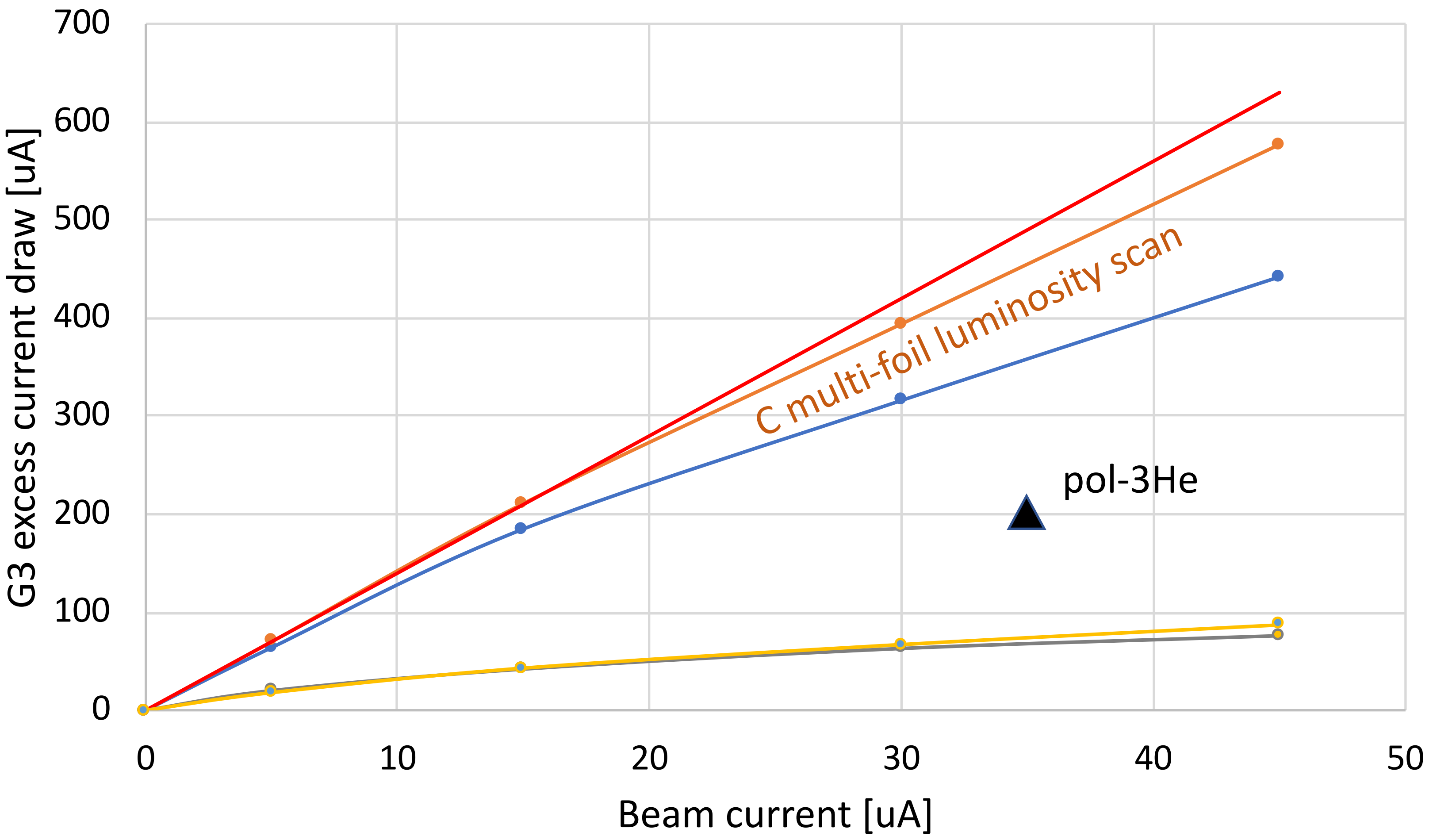
GEn kinematics at 36-deg, C multi-foil optics target (1.3%X0), 45uA beam (7E37 /cm2/s)
→ 242 kHz/cm²



GEn kinematics at 36-deg, polarized 3He (0.1%X0), 35uA beam
→ 82 kHz/cm²



How can we interpolate to GEp from what we know?



How should we scale from pol-3He to rates with C-multifoil?

Data would indicate a factor of 2.

What does simulation indicate?
→ Simulation at 36 deg on pol-3He at 45uA yields 50 kHz/cm^2. So approximately 39 kHz/cm^2 at 35uA of beam (note we extrapolated 82 kHz/cm^2 from readout current alone, see previous slide).

i.e. for C-multifoil, I_{G3} = 200uA at 17uA beam. For pol-3He, I_{G3}=200uA at 35uA beam.

GEp ERR findings:

- Configuration defined
- All modules will be used in prior experiments
- HV plan for individual channel power supplies
- **Comments**:
  - Power consumption per HV channel?
  - Power dissipation in detectors?
- **Recommendations**: None ☺

Path forward:

- Cross check a few more settings between data and simulation
- Evaluate our gain at readout, relationship between amplitude and charge in APV