GEM Trackers for upcoming SBS Experiments

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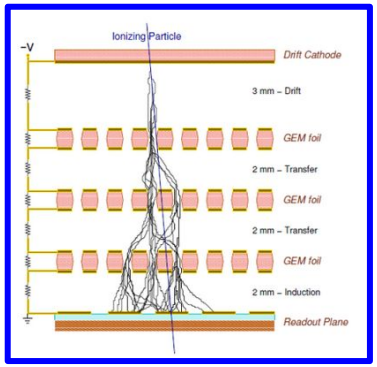
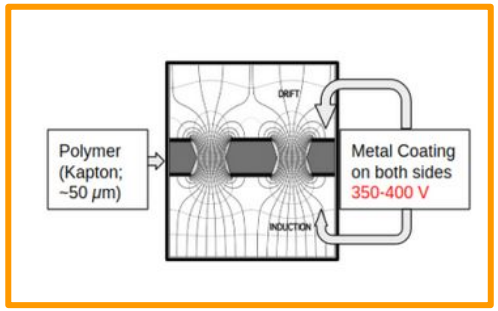
On behalf of the SBS GEM Group
Hall A Collaboration Meeting
January 17, 2024

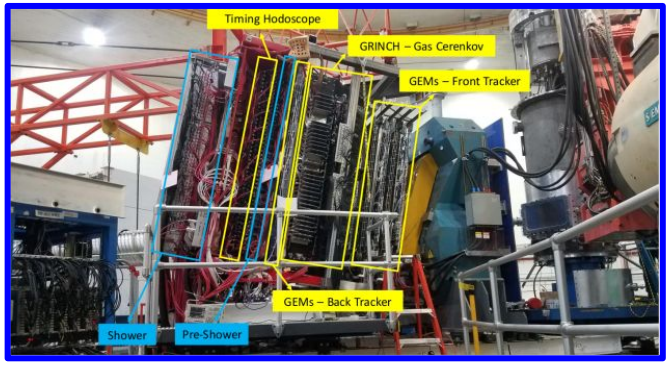
GEMs in SBS Experiments



Cross section of a triple GEM detector



Cross section of a GEM foil



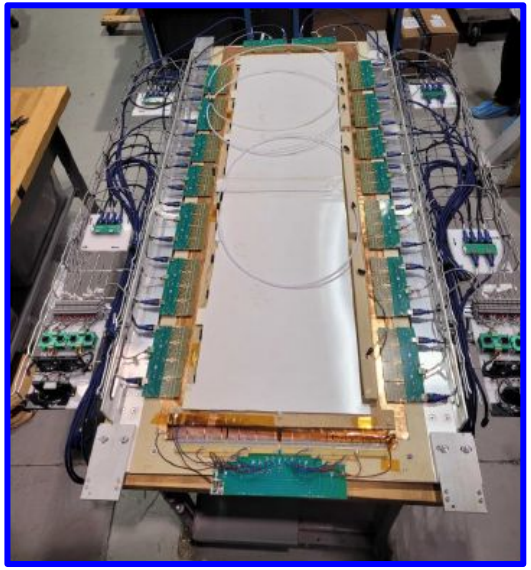
BigBite Spectrometer

- Using three GEM foils back to back increases the gain (roughly 20 per foil → 20 X 20 X 20 = 8000)
- Capabilities
  - High spatial resolution : 70 μm
  - Can handle high rates : over many MHz/sqcm of intrinsic rates
  - Tracking issues in large area trackers limit the rate to 0.5 MHz/sqcm

SBS Spectrometer

GEMs in SBS Experiments

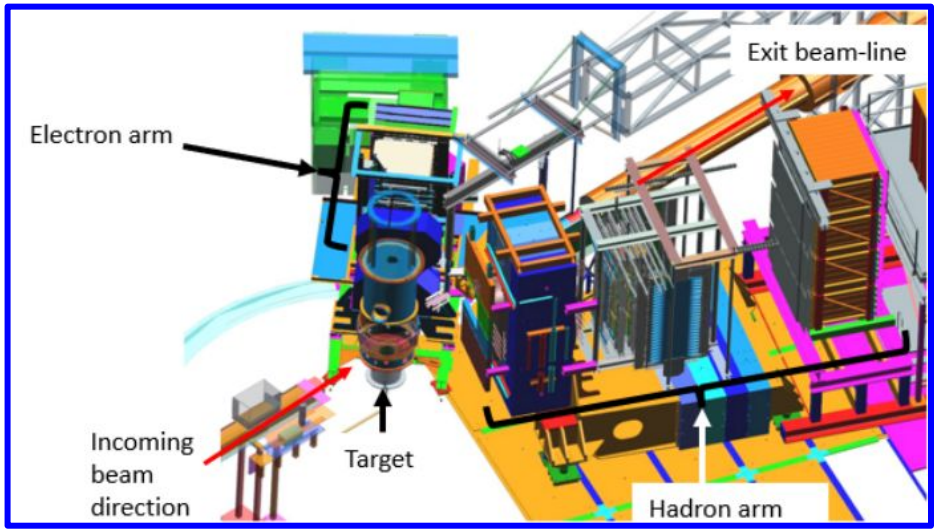
- 50cm x 60cm GEM Modules for SBS rear tracker (XY)
  - 48 total modules produced
  - 28 have been in beam
- 150cm x 40cm large GEM Modules for SBS front tracker
  - 4 have been in beam (UV)
  - 2 in production (XW)



UV Layer

XY Layer

Setup for GEn-RP and K_II Experiments



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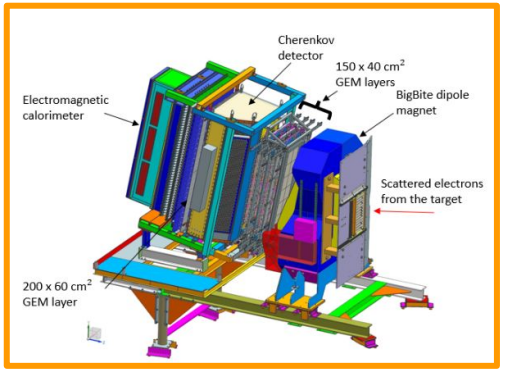
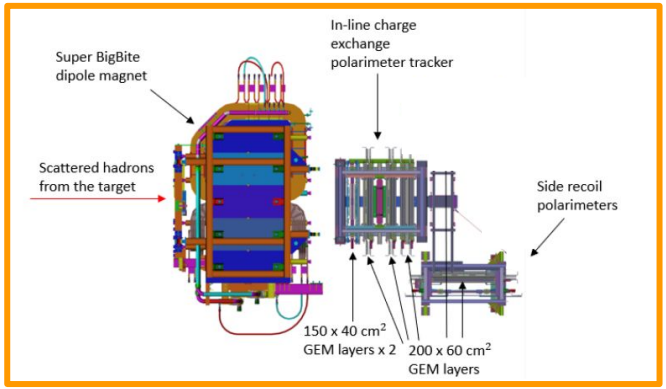


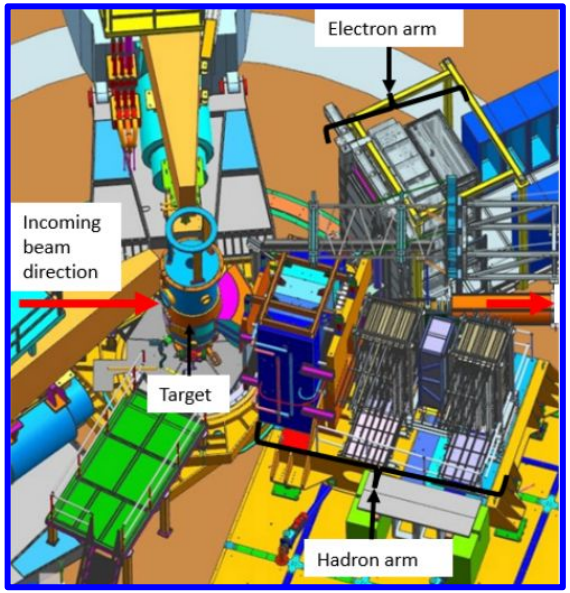
Electron Spectrometer

- BigBite
  - 4 layers of 150cm x 40cm UV GEMs (single module)
  - 1 layer of 200cm x 60cm XY GEMs (four modules put together)
- SBS
  - 2 layers of 150cm x 40cm XW GEMs (single module)
  - 8 layers of 200cm x 60cm XY GEMs (four modules put together)
- 2 XW + 6 XY in the inline stack and 2 XY in the side polarimeter

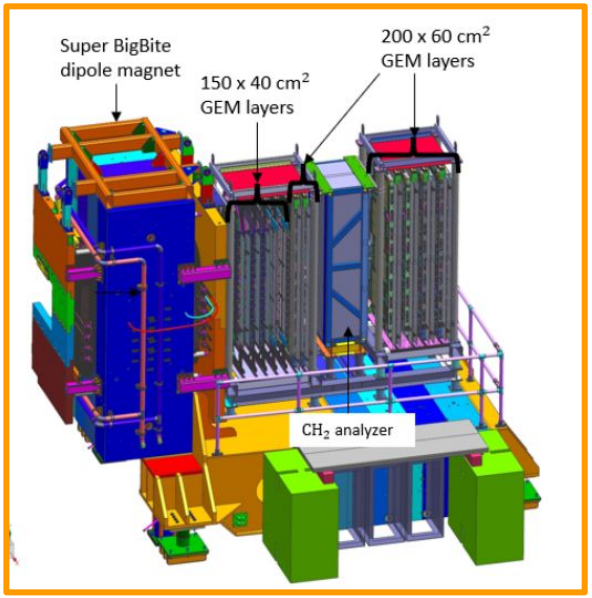


Hadron Spectrometer

Setup for GEp-V Experiment



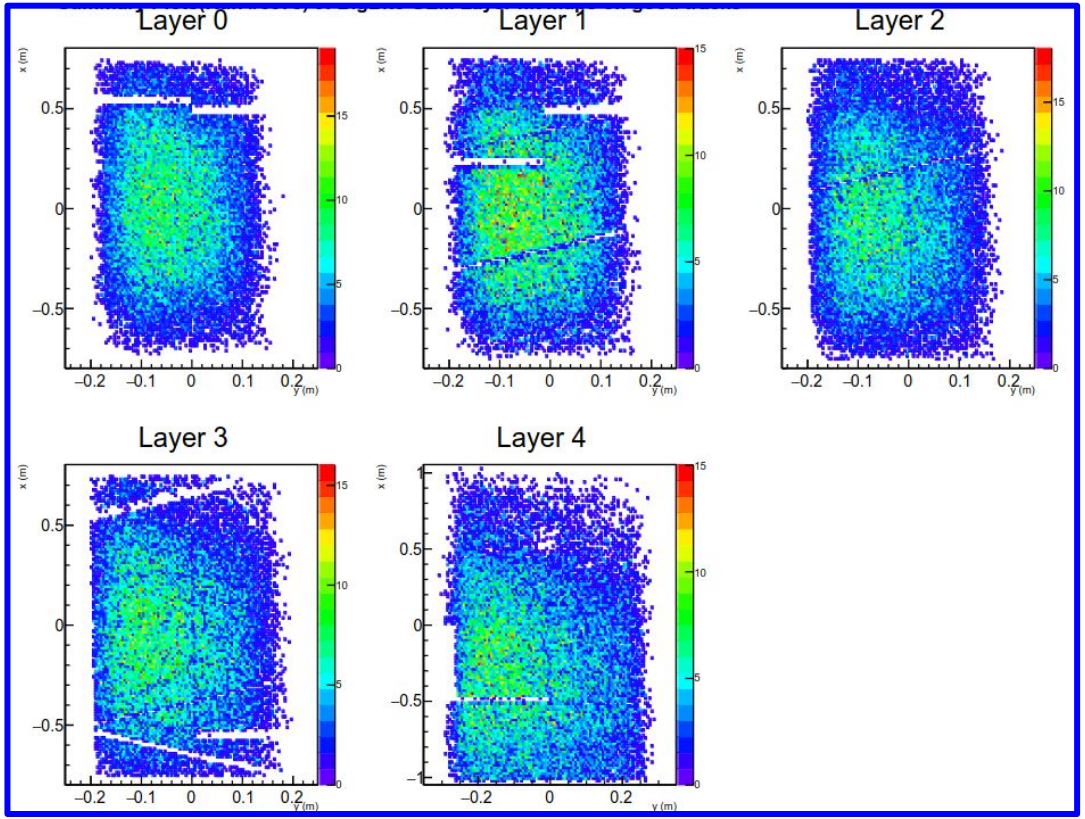
Setup for GEp-V Experiment

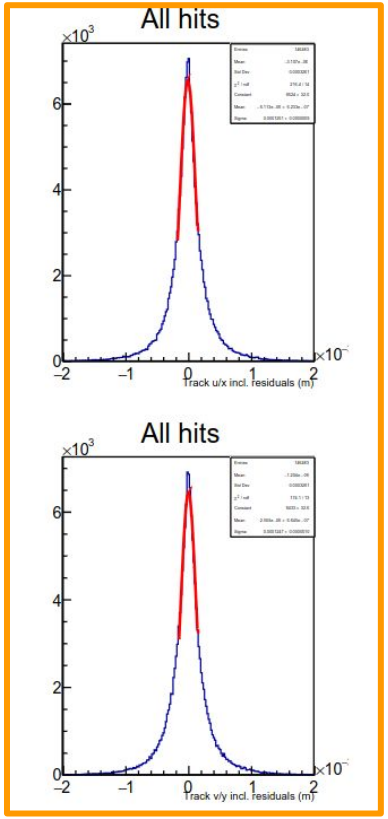


Hadron Spectrometer

- SBS front tracker
  - 6 layers of 150cm x 40cm GEMs (single module) - 2 XW + 4 UV
  - 2 layers of 200cm x 60cm XY GEMs (four modules put together)
- SBS back tracker
  - 8 layers of 200cm x 60cm XY GEMs (four modules put together)

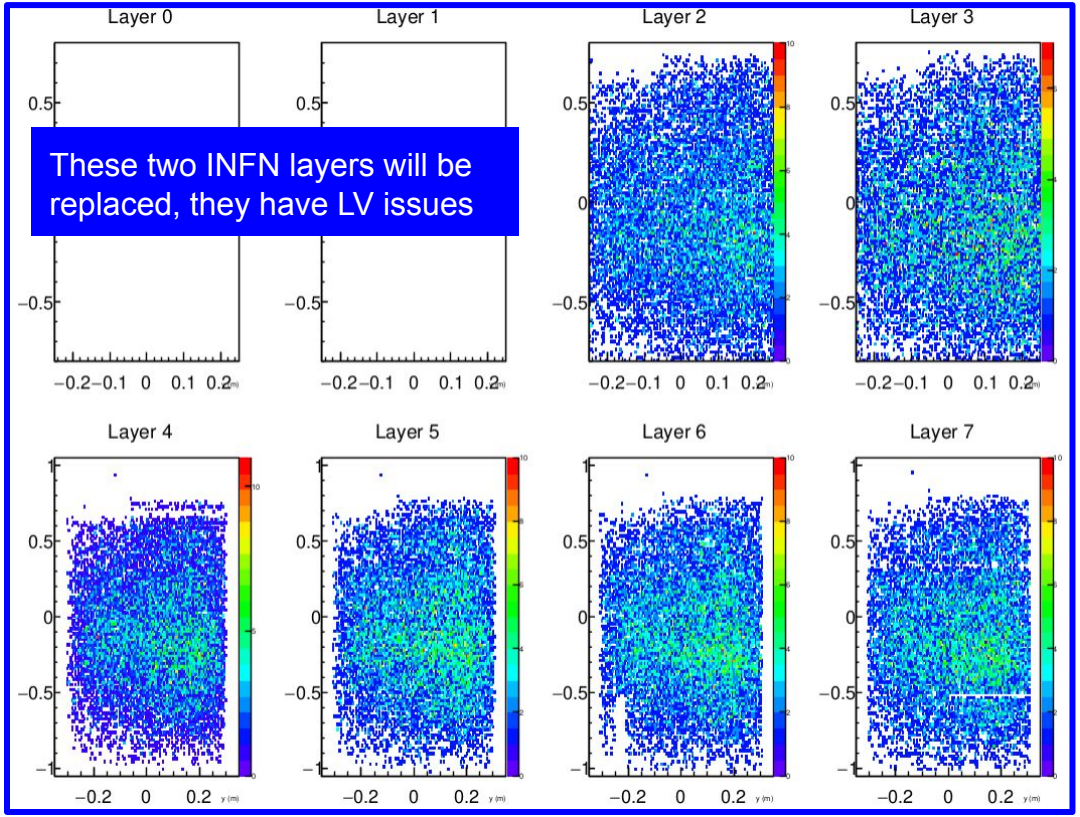
Performance of BigBite during GEn

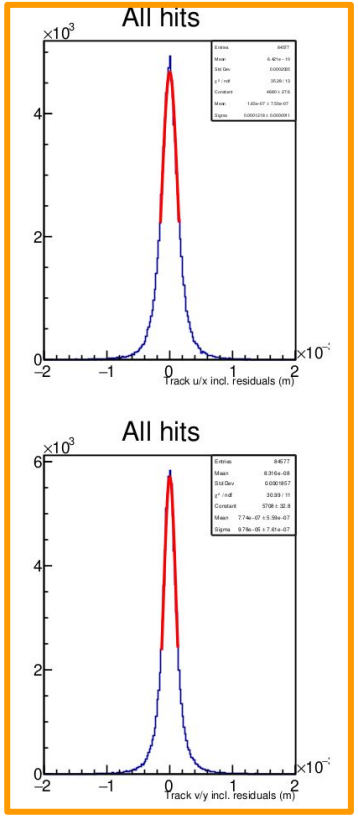




Tracking residuals sigma ~ 70-100um

Performance of SBS during GEn





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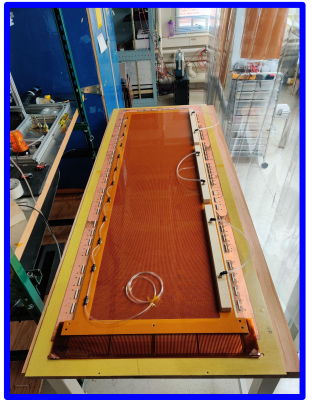
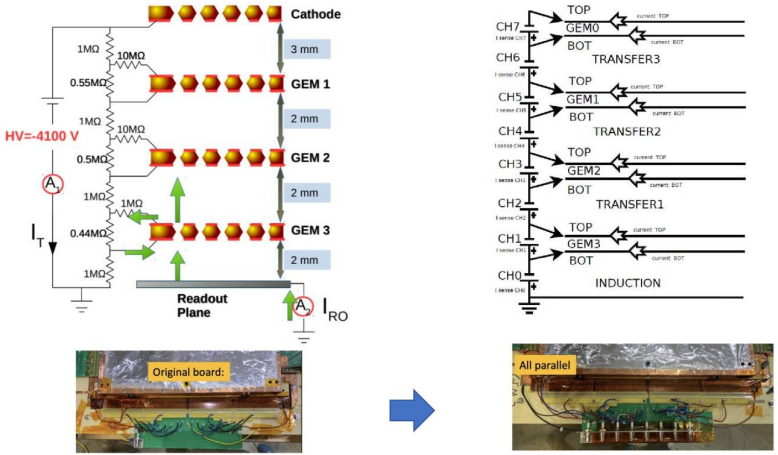
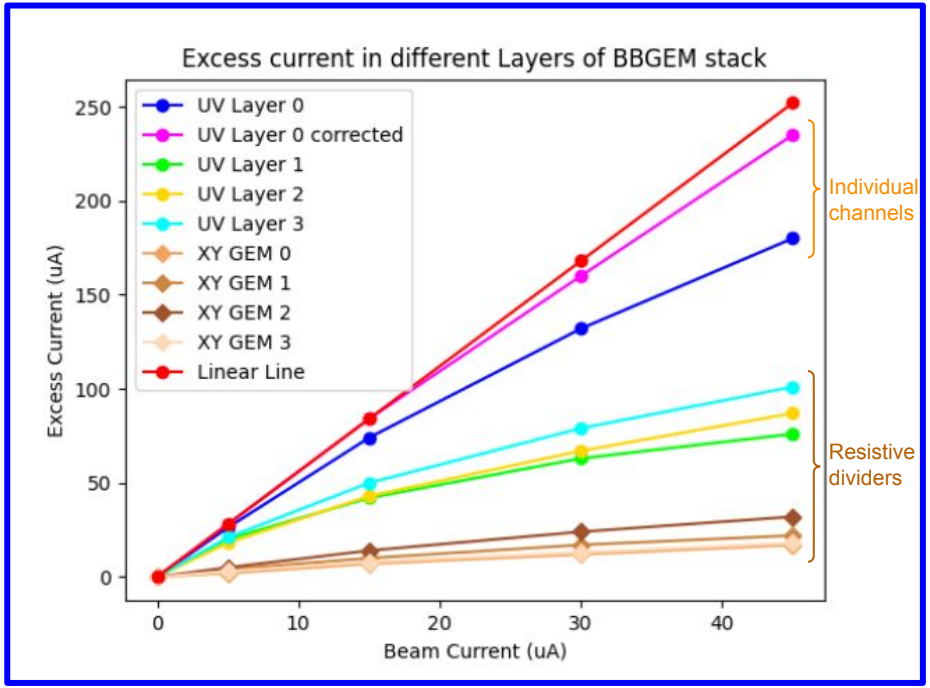


Replacement for INFN layers

High voltage supply issue and solution



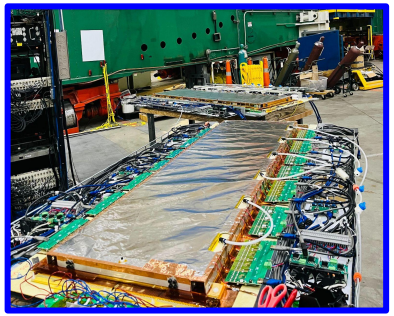
- Observed a loss of tracking efficiency correlated with the occupancy due to high voltage divider configuration
- Non linear increase in current draw with increased occupancy
- Solution : remove the resistive divider and use individual power channels
- Extensively tested at UVa using X-ray and at JLab during GEn-II running
- Slope of the graph is analogous to the gain of the detector



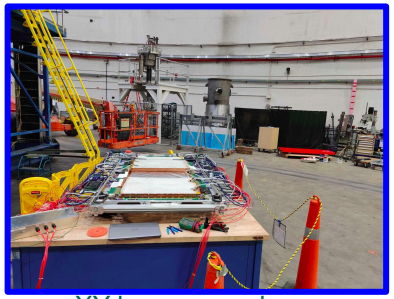
Data from luminosity studies during GEn-II (Sean Jeffas)

High Voltage Upgrades

- High Voltage upgrades will reduce the gain drop in GEMs in high luminosities
- High power modules which can go up to 3mA(1.5W) per channel are used power up front tracker
- Link to power supplies



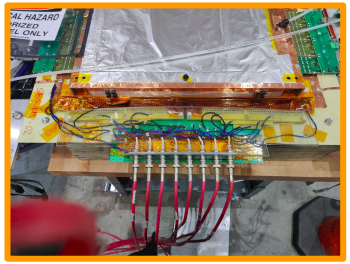
UV layer upgrades

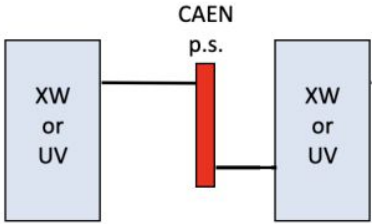


XY layer upgrades

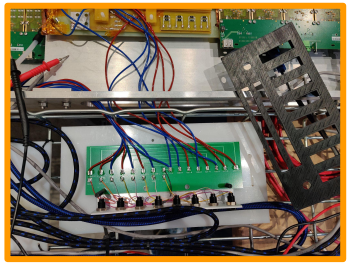
Configuration per GEM type:

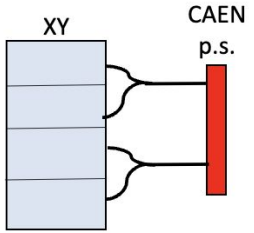
- UV or XW GEMs





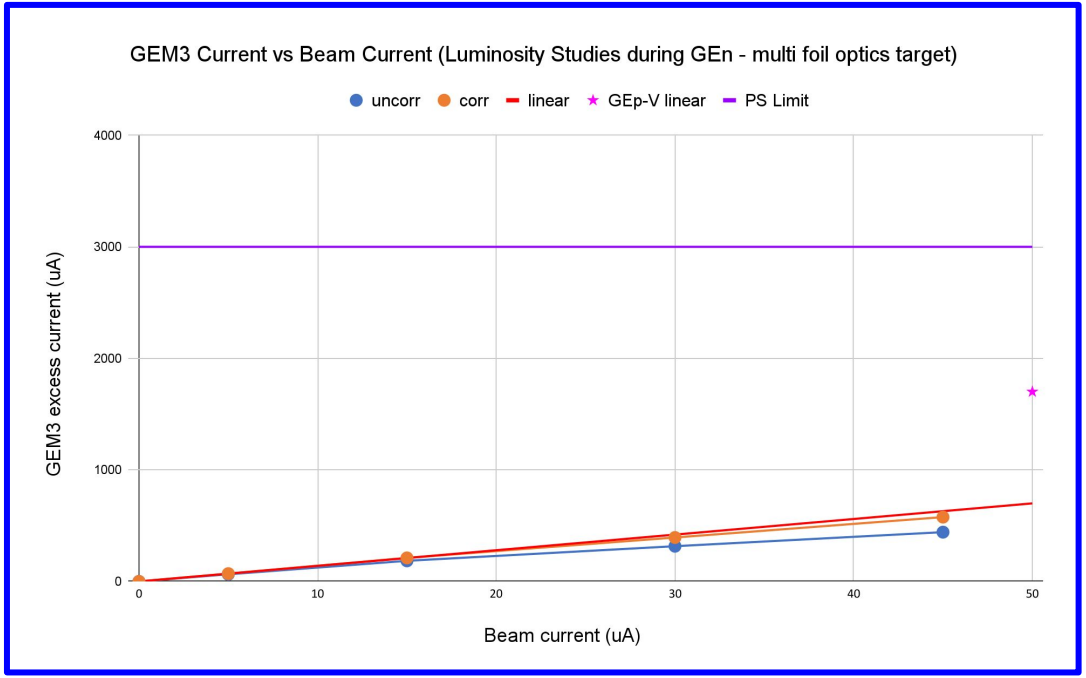
- XY GEMs





Current draw Projections for GEp-V at the Front Tracker

- Modifying the input voltages for drop across protective resistors gets us closer to the linear line, i.e linear gain (red and orange)
- GEp-V at 50uA of beam current will draw 2.7 times the current through GEM3 shown here at 45uA
- i.e 1700uA (★)which is <3000uA, power supply current limit



Low Voltage Upgrade

- SBS Low voltage has not been reliable over the course of GEn
- We suspect the high radiation makes the low voltage modules to go bad regularly requiring frequent replacements
- New power supply specifications :
  - TDK-Lambda Model GEN 10-330-LAN-3P480
  - 10 volt DC 330 amp output
  - 480VAC input
  - LXI Compliant LAN interface.
- Datasheet
- This will be placed in a low radiation area
- Joe Beaufait is helping us to setup the distribution

Tasks and Timeline

1. BB GEM work mostly completed in December. All UV layers have HV upgrades.
    - Need to finish setting up the power supply and write an interface to quickly load HV values - this week
2. Transported the recoil detector, active analyzer into hall
    - HV upgrades done
3. Remove the SBS GEM stack around Jan 25 for HV upgrades and APV repairs/swaps
    - Work on SBS GEM is 15 days until Feb 15
4. Build the SBS GEM bunker after the SBS and HCAL moved into position - late February, early march
5. XW Layers
    - Layer 1 - Production already completed at UVa Will arrive at JLab early March
    - Layer 2 - March 25
6. Joe B is working on LV power supply upgrade for SBS. We will continue to use the electronics/LV in place while we upgrade and troubleshoot

Experience gained from long term high exposure operation

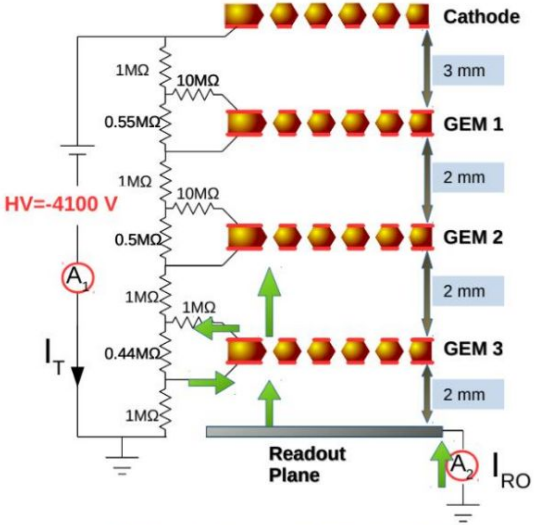
- UVa GEM tracking layers have been operating well during GMn, nTPE and GEn-II experiments
  - Stable operation
  - Robust under harsh conditions
  - No radiation damage
  - No detector aging effects observed
  - Noise levels sufficiently low
  - Good gain
  - Good spatial resolution
- Most important lesson : The current draw from the detector is too high under high rate conditions for resistive voltage dividers to feasible; causes efficiency loss
- New power supply scheme has been tested and operational over the GEn-II running
- Unstable SBS low voltage supplies are being replaced
- Many other upgrades were done during GEn-II to improve the up time
  - Gui to easily troubleshoot the gem daq crates - Holly and Sean

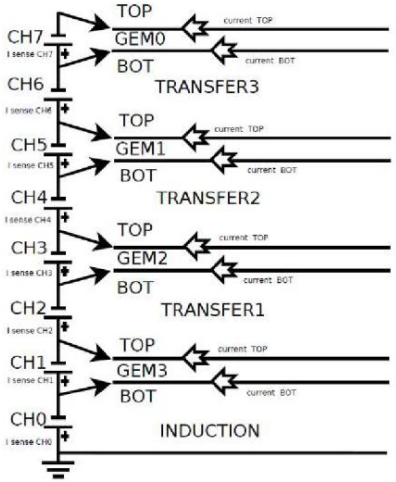
Back up

Individual Channel HV Supply

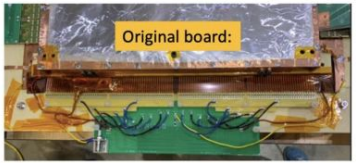
High voltage individual power supply

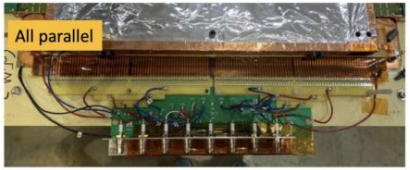
Current equivalent to Hit rate x Gain x primary electrons x electron charge





Note: protective resistors not shown here....see backup





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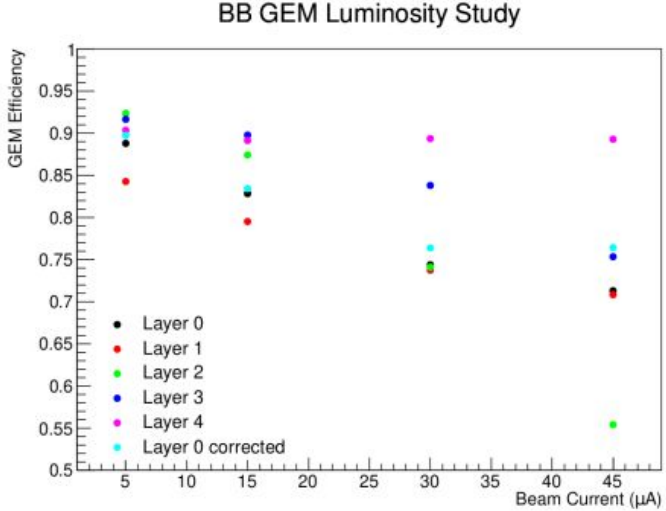
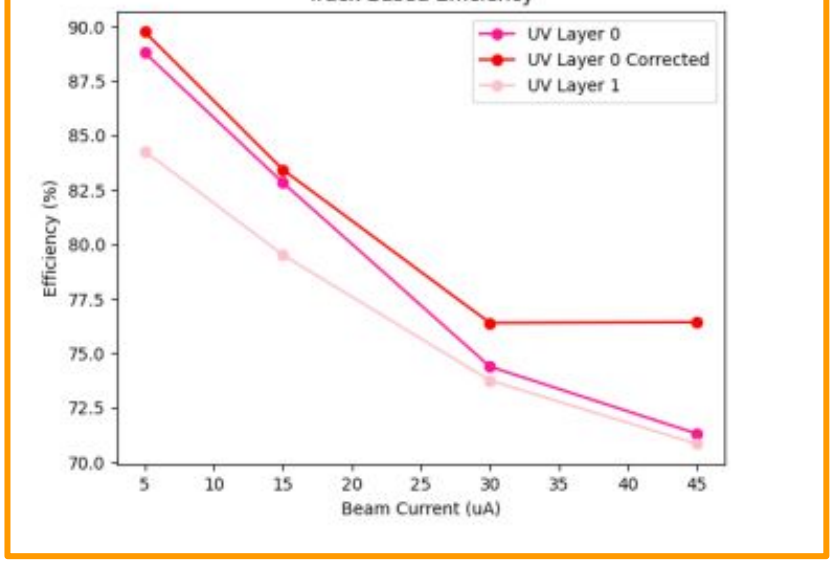
Luminosity Studies during GEn





Inventory

- HV

	GEp config										
	GEM Layer	RO Type	Modification	HV module	HV mod status	CAEN crate	SHV cx	SHV cables	HV Patch panel	LV cable	A996 connectors
Front Tracker	Layer 0	XW	Parallel Supply	A1515BTGHP-3mA	on hand-JLab	CNU, on hand	8	8	on hand		on hand
	Layer 1	XW	Parallel Supply				8	8			
	Layer 2	UV	Parallel Supply	A1515BTGHP-3mA	on hand-JLab		8	8			on hand
	Layer 3	UV	Parallel Supply				8	8			
	Layer 4	UV	Parallel Supply	A1515BTGHP-3mA	on hand-JLab		8	8			on hand
	Layer 5	UV	Parallel Supply				8	8			
	Layer 6	XY	Parallel Supply	A1515BTGHP-3mA	on hand-JLab		32	32	on hand		on hand
	Layer 7	XY	Parallel Supply	2xA1515BTGHP	on hand-JLab		32	32			on hand (x2)
Back Tracker	Layer 8	XY	Parallel Supply	A1515BTG	on hand-JLab	Glasgow-will order	32	32	need		JLab ordered
	Layer 9	XY	Parallel Supply	A1515BTG	on hand-JLab		32	32			JLab ordered
	Layer 10	XY	Parallel Supply	A1515BTG	on hand-JLab		32	32			on hand
	Layer 11	XY	Parallel Supply	A1515BTG	purchased-JLab		32	32	need		on hand
	Layer 12	XY	Parallel Supply	A1515BTG	on hand-UVa		32	32			on hand
	Layer 13	XY	Parallel Supply	A1515BTG	on hand-INFN		32	32			on hand
	Layer 14	XY	Parallel Supply	A1515BTG	on hand-INFN	Glasgow-will order	32	32	need		on hand
	Layer 15	XY	Parallel Supply	A1515BTG	on hand-INFN		32	32			on hand
(not in GEp)	Layer 16	XY	Parallel Supply								
								368			
			spare	A1515BTG	on hand-JLab			25760			
				A1515BTG	on hand-JLab						

- Electronics
  - APV25 - We should be fine for GEn-RP, New order will be placed for GEp-V
  - Backplanes and MPDs - good

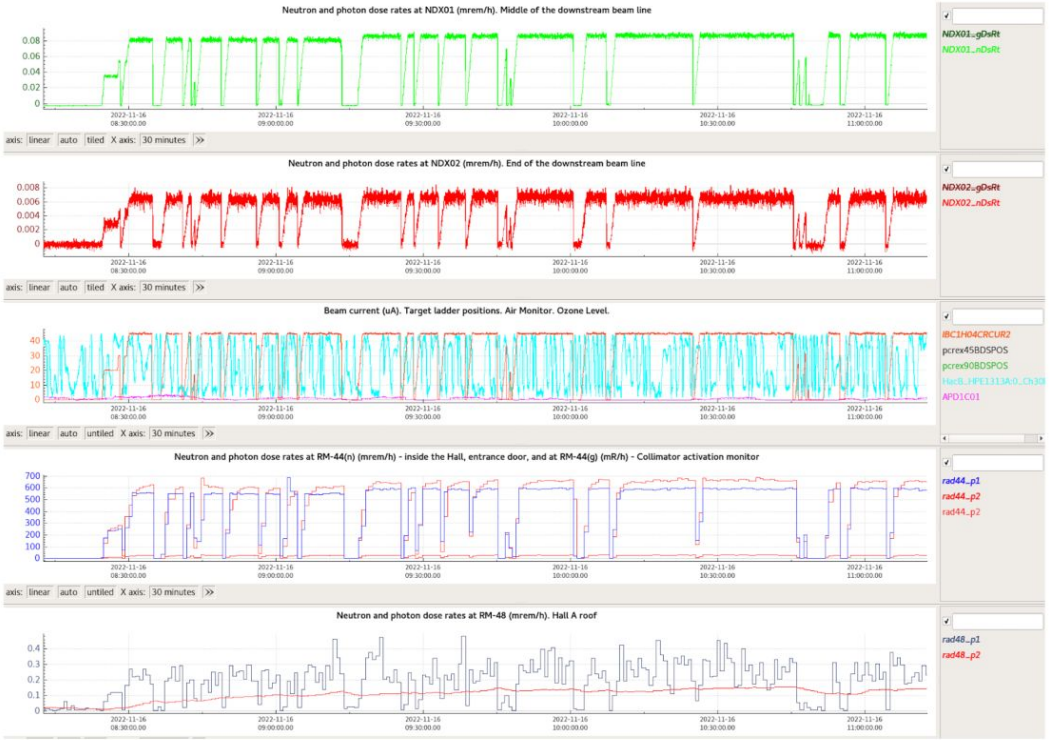
Radiation at SBS bunker

Radiation at the SBS bunker

80 mrem/hr at 40 uA beam
(100 mrem/hr at same current in BB bunker)

Maximum in GMn, sbs-14, 180 mrem/hr at 10 uA

250 mg/cm^2 material in beamline
-> x9 in GEp



Jefferson Lab