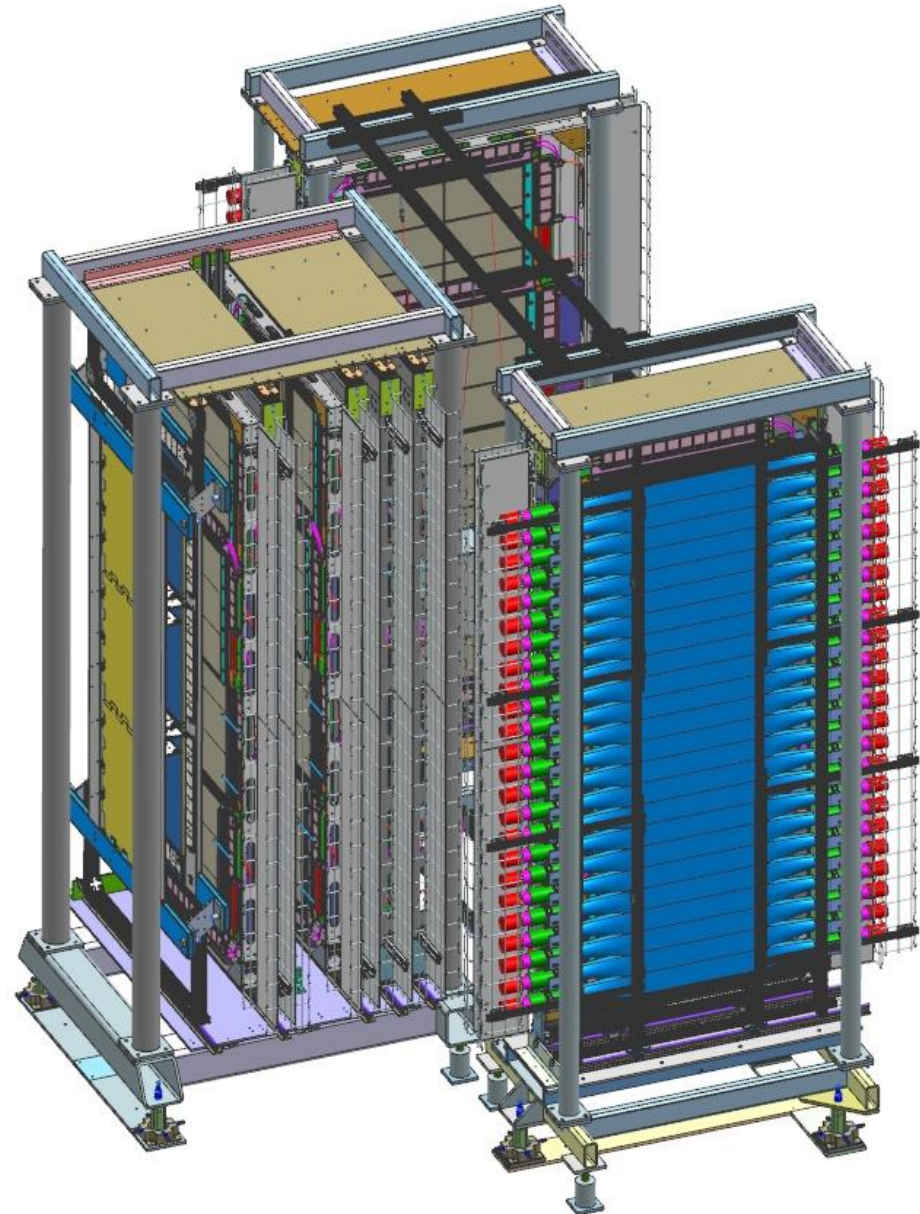


SBS GEMs for GEn-RP

Kondo Gnanvo

SBS Collaboration Meeting

02/17/2021



Outline

1. Status of GEM Layers for GEn-RP

- Purpose, Performances specifications
- Status of UVa GEM layers for GEn-RP
- Status of the U/V strip GEM productions

2. Detector equipment listing

- Table of readout electronics / DAQ and other hardware

3. Plan for installation of GEn-RP GEM layers in Hall A

- Timetable for installation of the layers in GEn-RP detector frames in ESB
- Timetable for installation in Hall A

4. Commissioning and Calibration plans with beam

- What software to be used for (who is in charge?)
- Online Monitoring and event display (who is in charge?)
- Timetable for completion

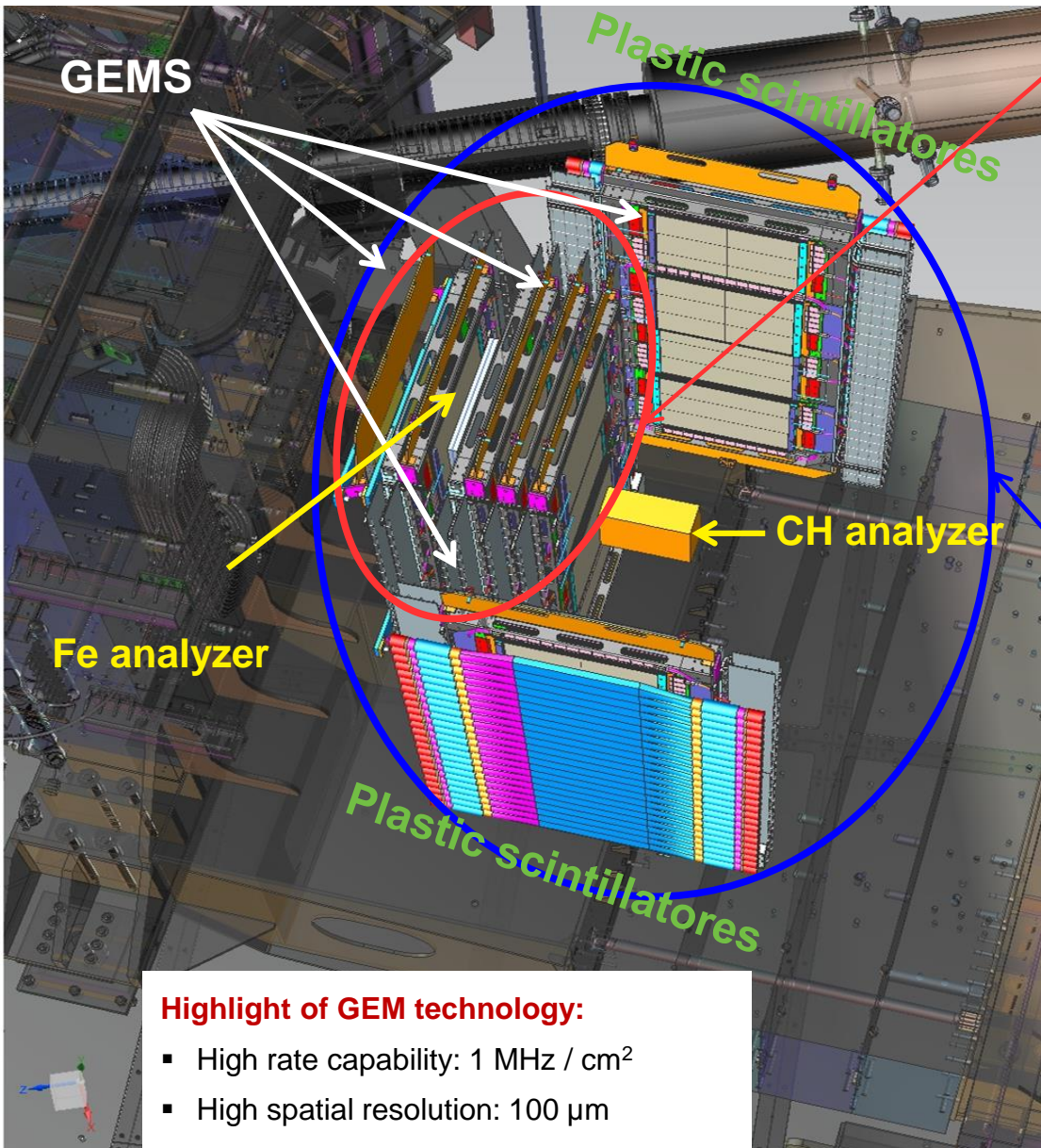
5. Accounting of manpower

- List of staff and users
- List of responsible personnel

6. Documentation status

- Operation manuals
- How-tos for shift worker

SBS GEM for GEn-RP: Purpose



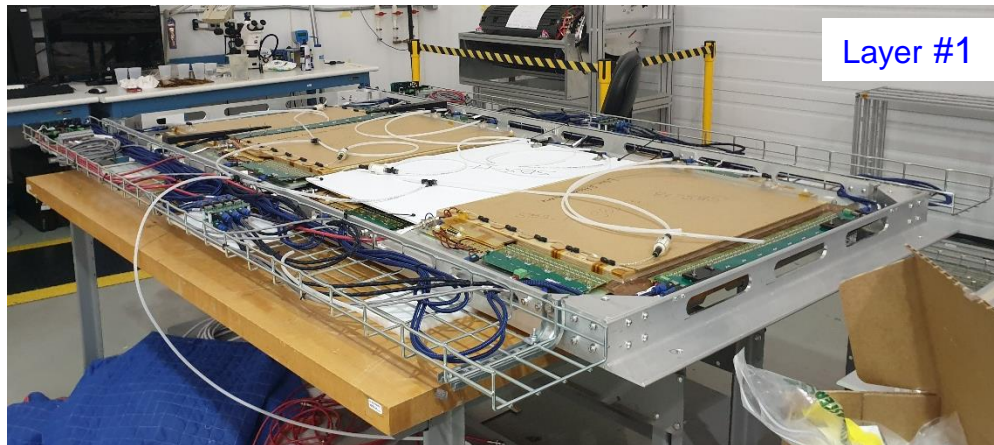
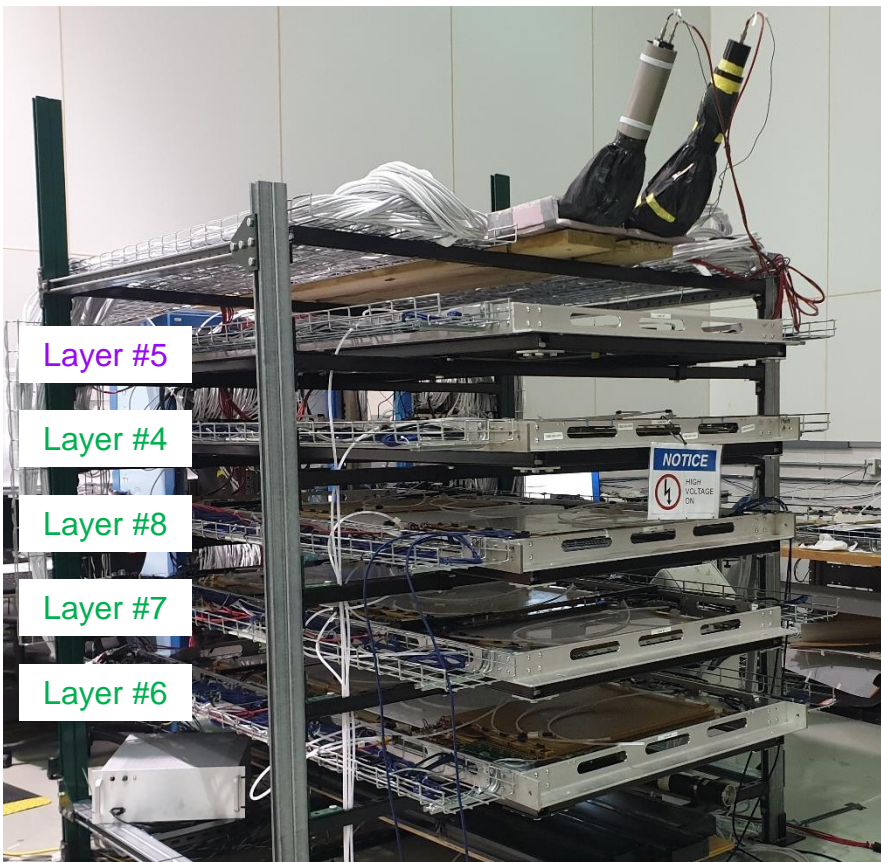
- **Charge Exchange (CE) Polarimeter**
High-momentum forward protons (towards HCAL) after CE $np \rightarrow p$
- 2 INFN GEM planes
- 6 UVa GEM planes
- 1 Steel analyser
- **Proton Recoil (PR) Polarimeter**
Low-momentum large-angle recoiling protons after $np \rightarrow np$ and also signal in HCAL (nn sct)
- Active CH analyser
- 2 sections, one each side of CE Polarimeter
- Each section has 2 UVa GEM planes and 1 plastic scintillator plane

Highlight of GEM technology:

- High rate capability: 1 MHz / cm²
- High spatial resolution: 100 μm
- Large area capabilities: 150 cm x 55 cm
- Low cost technology

Status of GEM Layers for GEn-RP

GEN-RP GEM layers: Assembly of UVa X/Y GEMs



- Ready for installation in GEN-RP frames
- Assembly completed, Need cosmic test validation
- Layer #5: HV issue with 2 modules, still with old divider → will be fixed later
- Ongoing layer assembly



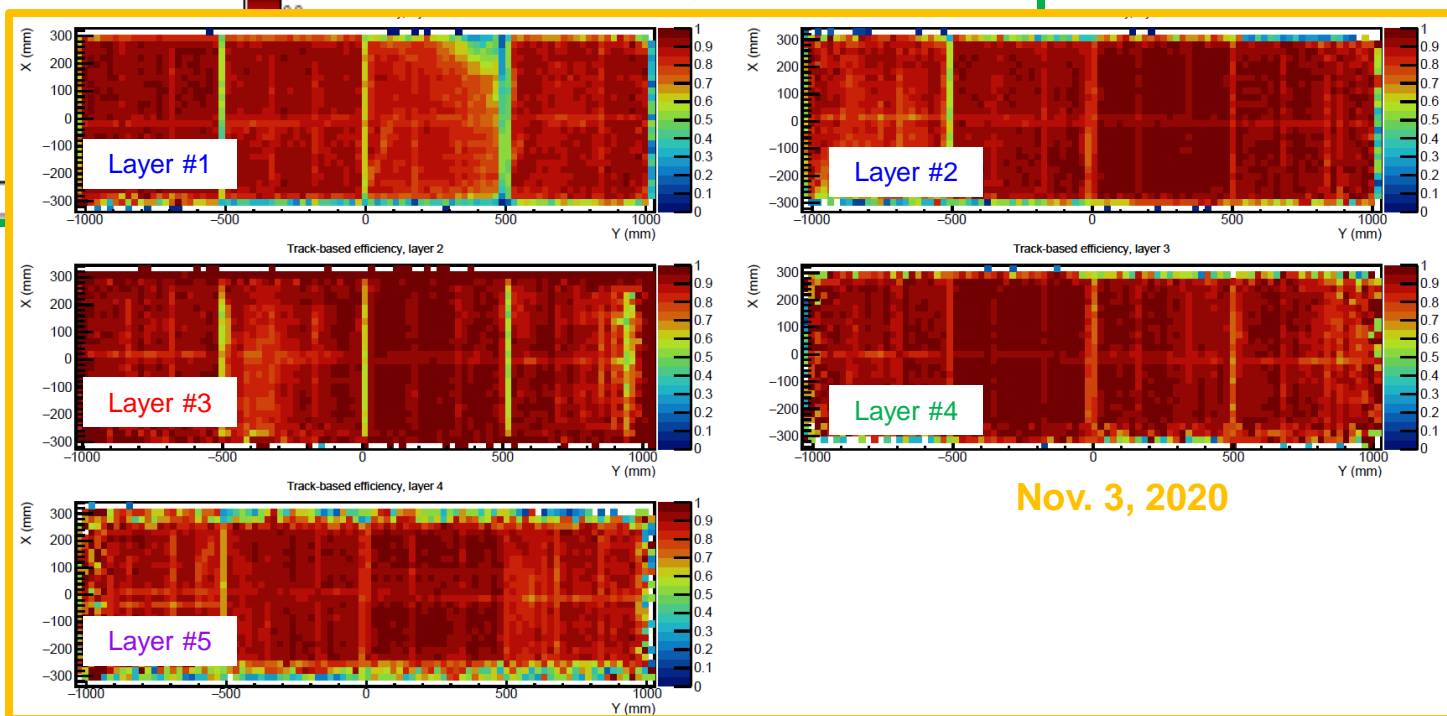
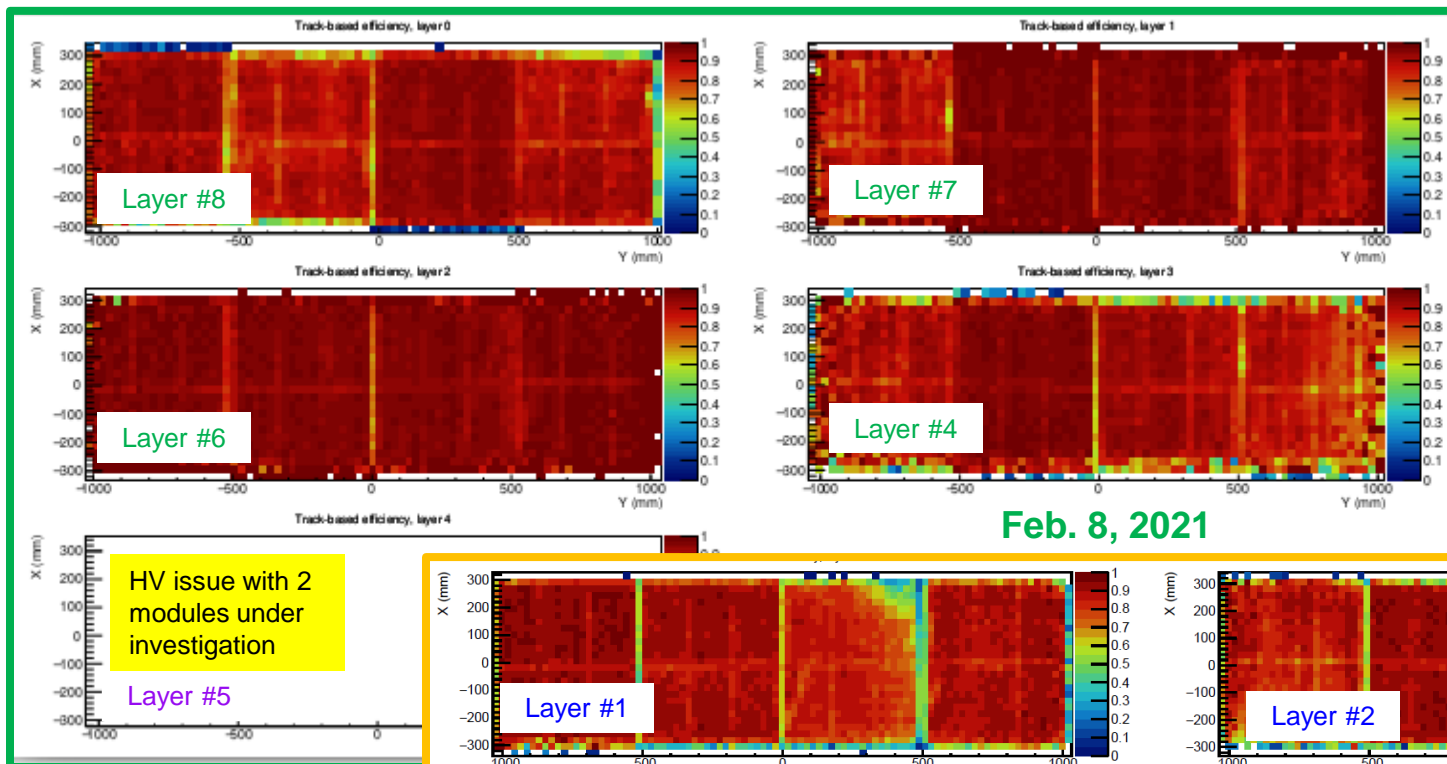
Performances of UVa X/Y GEMs: Efficiency Map

Tracking software for
SBS GEMs by
Andrew Puckett

Efficiency ~ 90% in all
32 modules of the 8
layers tested so far

HV scan to identify the
optimal operating HV for
each individual module

Feb. 8, 2021



Nov. 3, 2020

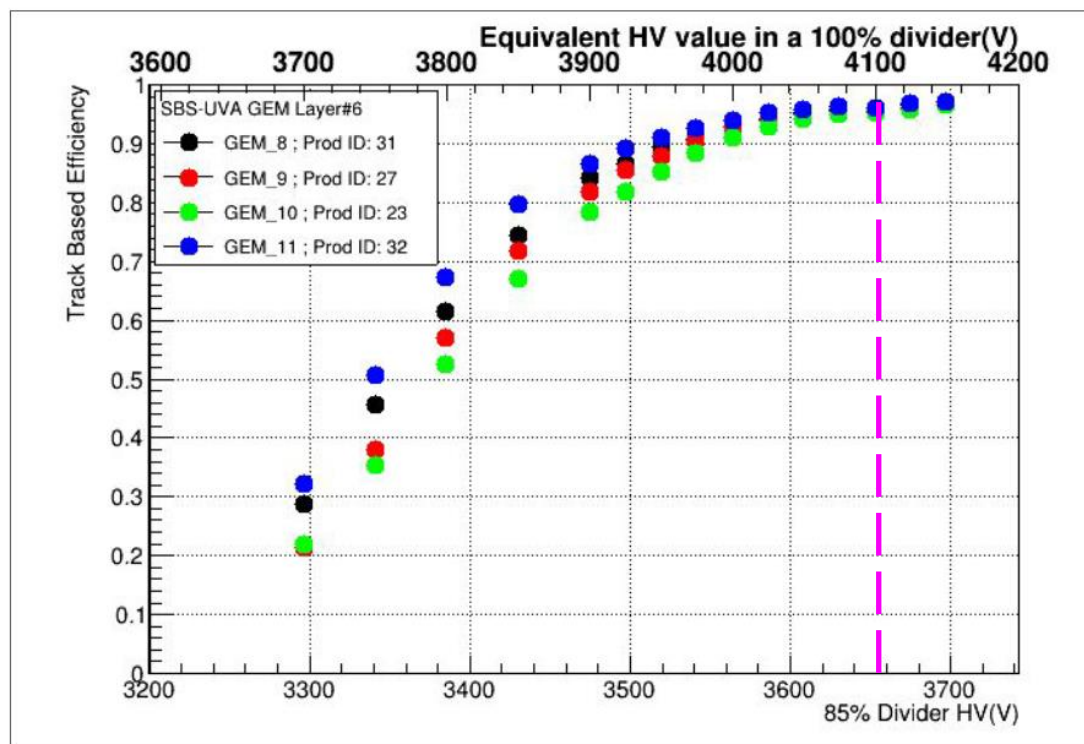
Layer #1 & #2: back on
assembly tables

Layer #3: installed in BB
frame in TEDF

Layer #5: HV issue with 2
modules, still with old divider
⇒ will be fixed later

All other layers other than #5
with new HV divider scheme

- HV scan performed for each individual GEM module to determine the optimum operating voltage
- On the right plots, results is show for all 4 modules for layer #6
- Efficiency plateau starts for all for @ around 3600 V (with new divider) or 4050 V equivalent with the old divider
- This plots to be produced for the modules for all 10 layers and adequately documented for future reference

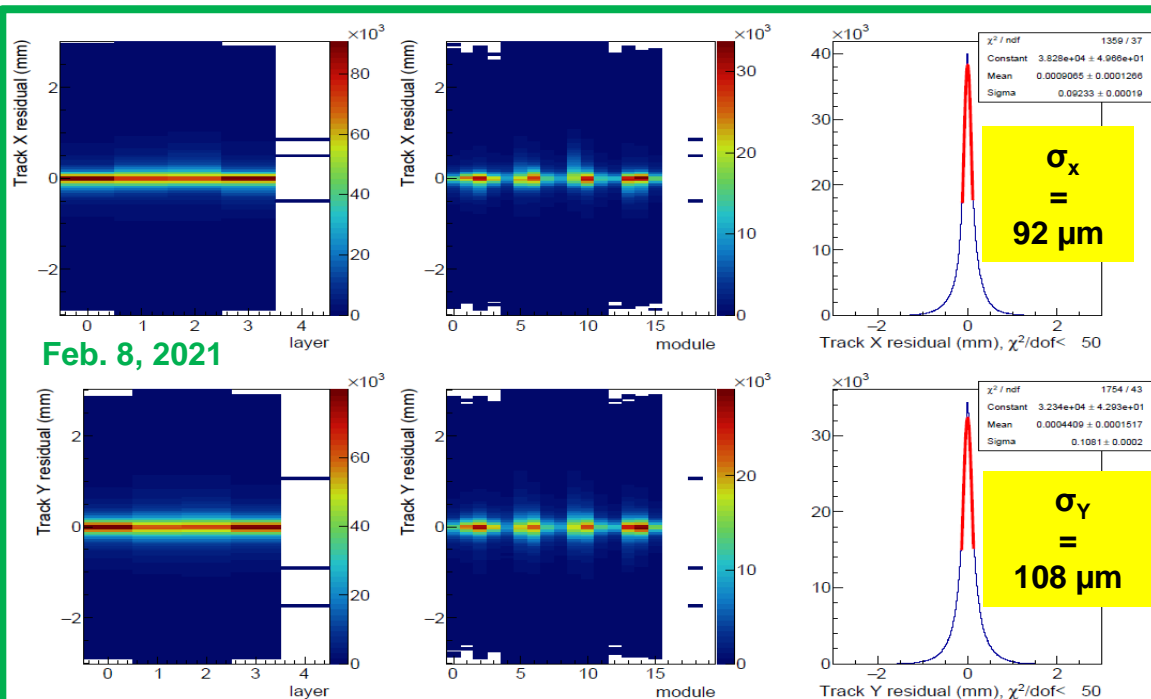


Performances of UVa X/Y GEMs: Spatial Resolution

Tracking software for
SBS GEMs by
Andrew Puckett

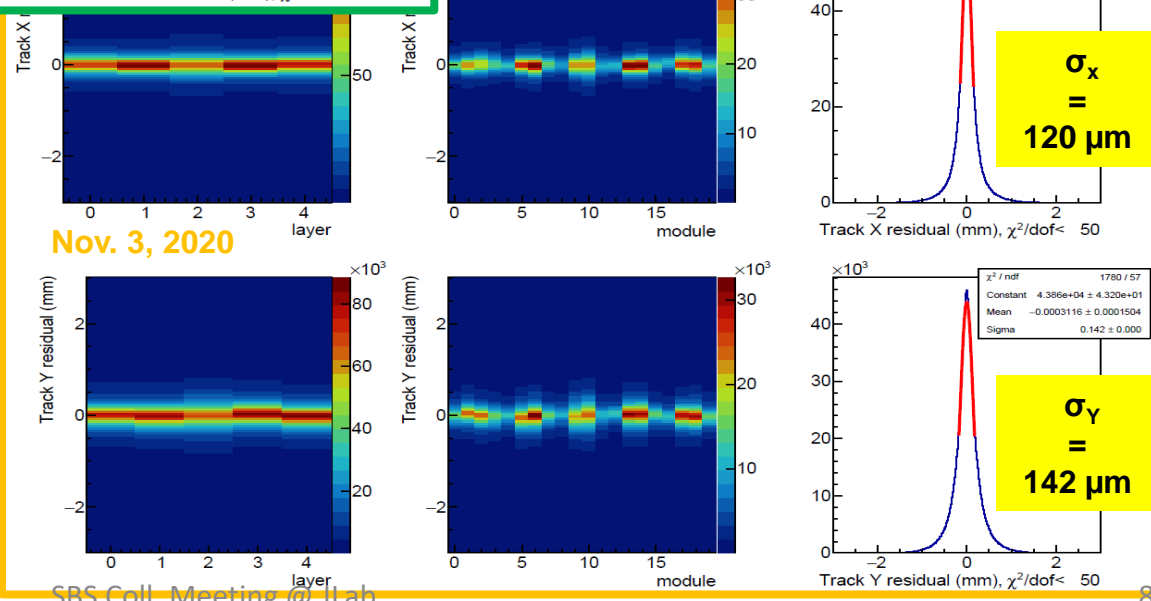
- Better resolution performance for Feb. 8 2021 data probably because of better alignment
- Resolution in x always better than in y because tracks in y has a larger angular distribution because of the size

Feb. 8, 2021



Feb 08, 2021 data from
layers #4, #6, #7 & #8:
new HV divider scheme

Nov. 3, 2020 data from
layers #1, #2, #3, #4 & #5:
old HV divider scheme



UVa U/V GEM layers: Status of assembly

Motivation:

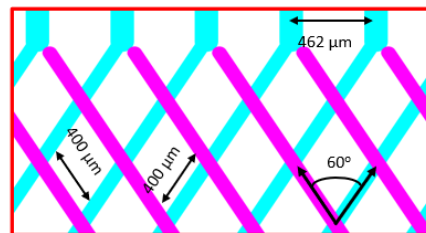
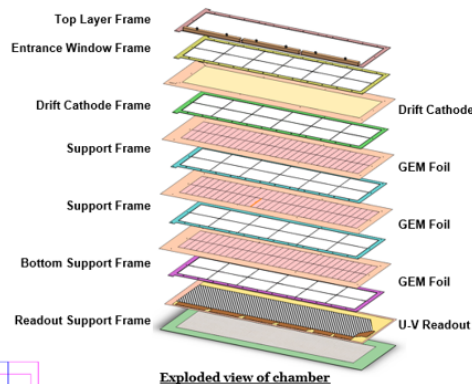
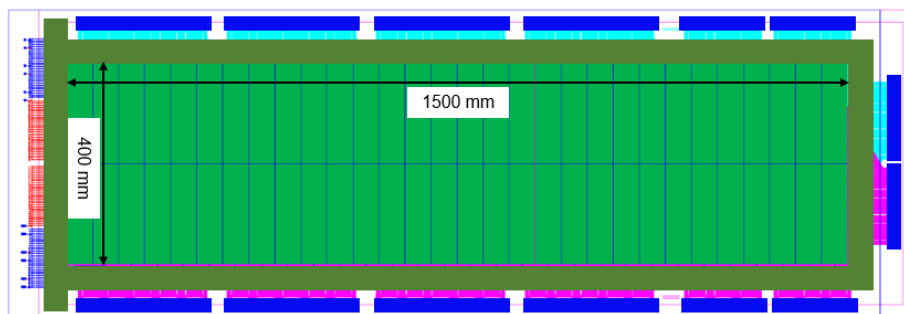
- ⇒ The U-V GEM: to complement the INFN GEM Layers which use COMPASS 2D straight strip.
- ⇒ The addition of U-V geometry enhances and complements the X-Y strips and will help with tracking in the high rate environment.

Key Features: active area: $150 \times 40 \text{ cm}^2$, U-V strips readout (60°) stereo angle

- ⇒ New GEM foil production allows for the FT U-V GEM layer to be **one single large module**
- ⇒ **No dead area** from support frames or electronics (Other than for spacers and HV sector)
- ⇒ The INFN-built MPD readouts for these GEMs will be the same as for all SBS GEMs

Our Experience: UVa has a successful track record with large area GEMs and U-V readout

- ⇒ Large GEM with PRad Experiment (June 2016 in Hall B), similar size
- ⇒ U-V strip readouts with large U-V GEM for the EIC Forward GEM Trackers Detector R&D



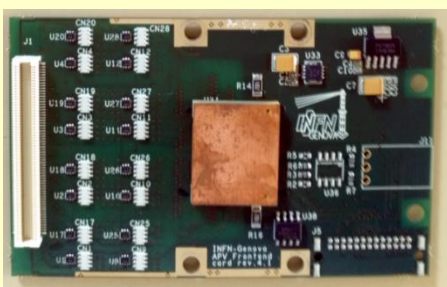
SBS-UV-01 & SBS-UV-02: Assembly completed

- Unexpected problem with gas flow for both chambers ⇒ Drift cathode foils received from CERN (which contribute to our gas flow system) did not satisfy the specifications ⇒ We believe we have a solution to modify the gas flow system but need to be tested
- Because of this issue, we will perform cosmic test with these 2 modules at UVa after the fix is applied
- **if everything goes well, the two modules will be ready for installation in BB by end of March 2021**

SBS-UV-03 & SBS-UV-04: Assembly of 2 remaining chambers to start in about two weeks from now (01 March 2021)

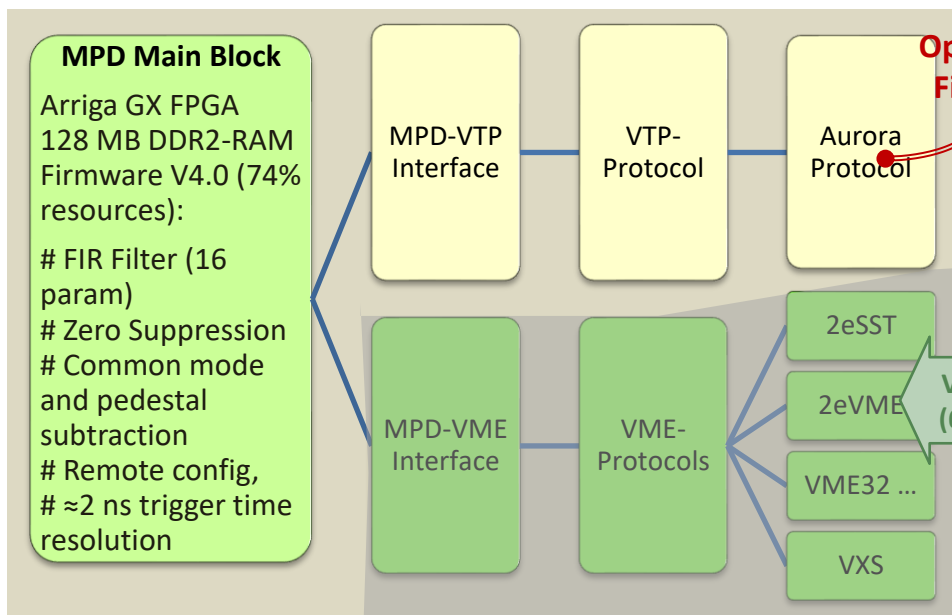
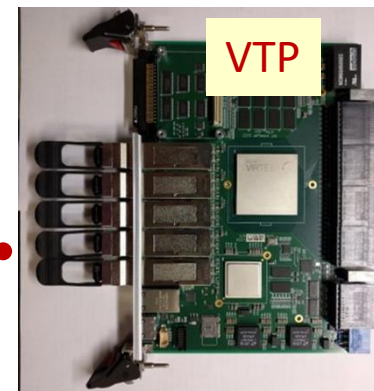
- Last batch of GEM foils shipment expected to be delivered next week
- CERN promise to ship two new cathodes foil with the correct specifications by end of Feb 2021
- The two chambers can be ready (assembled and tested in cosmic @ UVa) by the end of May 2021
- **will be selected for installation in BB frame before May 15 if the gas distribution fix of SBS-UV-01 & SBS-UV-02 does not work as expected**
- If fix for SBS-UV-01 & SBS-UV-02 work as expected, SBS-UV-03 & SBS-UV-04 could be reserved for GEn-RP

GEN-RP GEM Equipment: MPD Readout & DAQ



- 128 analog ch / APV25 ASIC
- 3.4 μ s trigger latency (analog pipeline)
- Capable of sampling signal at 40 MHz
- Multiplexed analog output (100 kHz readout rate)

	Channels	APV25	MPDs
UVa GEMs	113000	880	70
INFN GEMs	14000	108	8

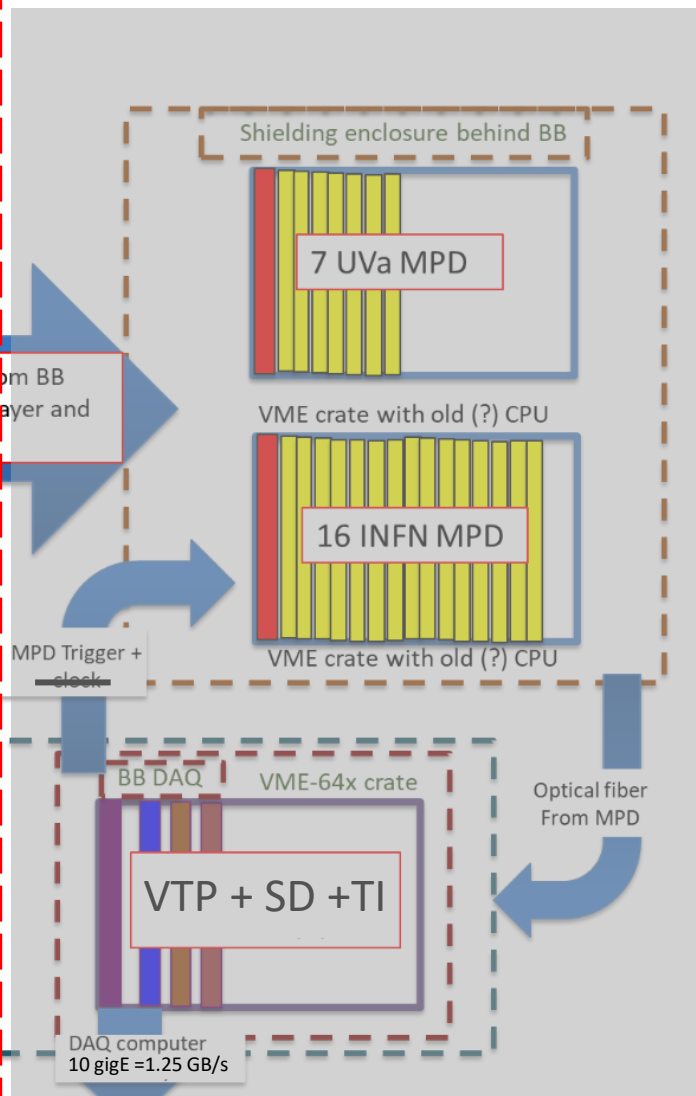
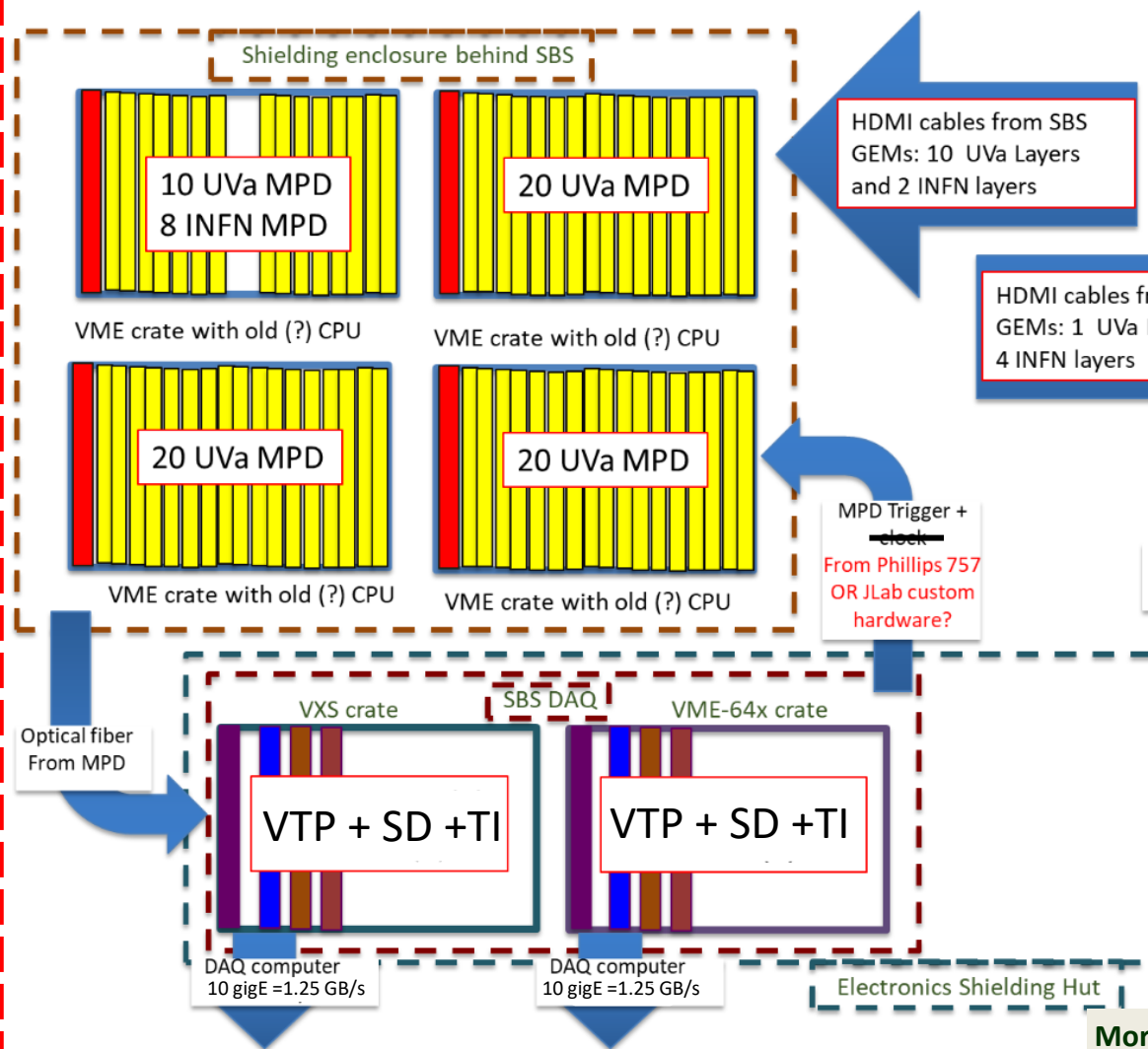


More detailed talks on:

- ☐ high rate MPD readout by B. Raydo (5:50 pm today)
- ☐ DAQ talk by A. Camsonne (4:50pm today)

GEN-RP GEM Equipment: GEM readout layout

SBS GEMs Electronic Hut



More detailed talks on:

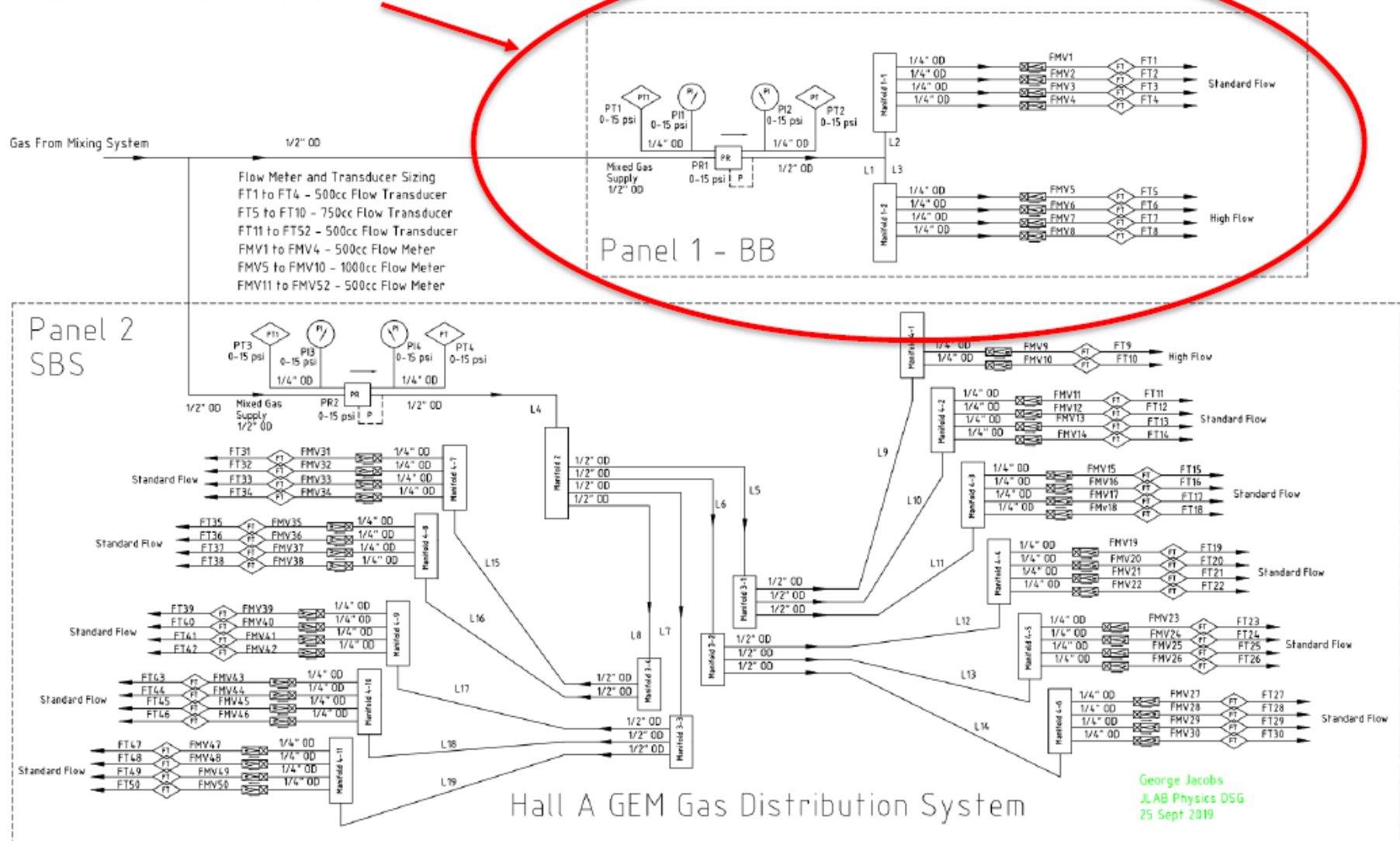
- ❑ high rate MPD readout by B. Raydo (5:50 pm today)
- ❑ DAQ talk by A. Camsonne (4:50pm today)

GEN-RP GEM: SBS GEM Gas System in Hall A

by DSG group at Jlab
Marc McMullen

Layout of the gas distribution In Hall A for Bigbite and SBS GEM layers

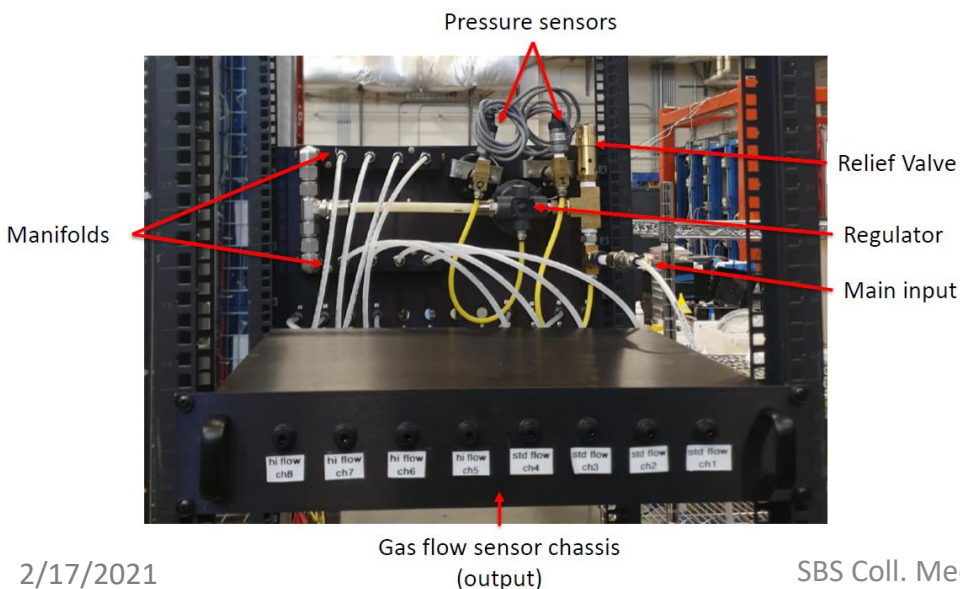
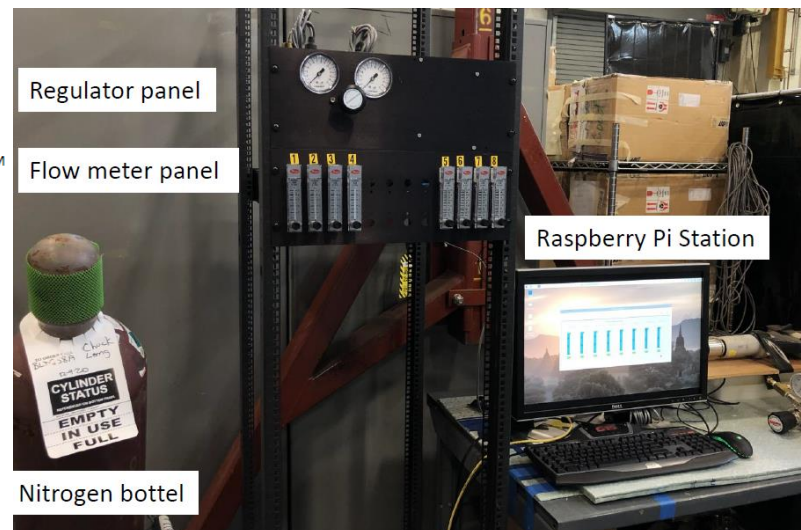
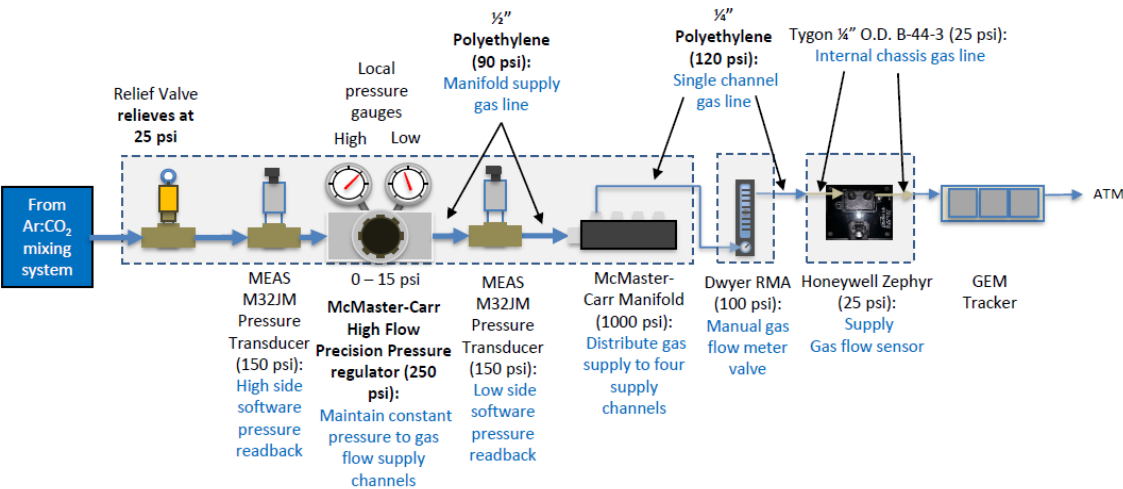
BigBite (BB) supply arm



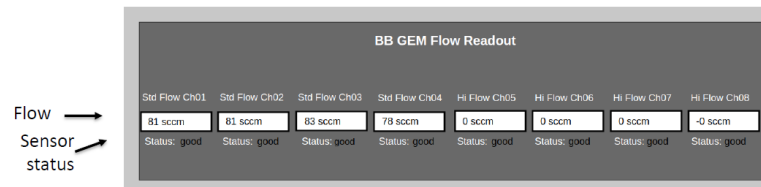
GEN-RP GEM: SBS GEM Gas System in Hall A

Prototype under test with UVa GEM layer in Bigbite frame in TEDF

by DSG group at Jlab
Marc McMullen



- DSG has developed WEDM web-based monitoring



- DSG is developing regulator input and output pressure signals to the remote monitoring capabilities of the system
- DSG has developed prototypes for the exhaust flow system for the GEM detectors

Equipment listing

GEN-RP GEMs: Tentative timeline for installation

Layer	Assembled	HV tested	Cosmic tested	Ready for installation as of 02/17/2021	Comments
UVa #1	Yes	Yes	Yes and No	No	Was re-assembled layer ⇒ require another round of cosmic test
UVa #2	Yes	Yes	Yes and No	No	Was re-assembled layer ⇒ require another round of cosmic test
UVa #4	Yes	Yes	Yes	Yes	
UVa #5	Yes	Yes?	Yes?	No	HV stability issues with 2 modules: need to replace divider
UVa #6	Yes	Yes	Yes	Yes	
UVa #7	Yes	Yes	Yes	Yes	
UVa #8	Yes	Yes	Yes	Yes	
UVa #9	Ongoing	No	No	No	
UVa #10	March 2021	No	No	No	
UVa #11	March 2021	No	No	No	
INFN - J1	Yes	Yes	Yes	No	require another round of cosmic test after J0 and J2 are installed in BB
INFN - J3	Yes	Yes	Ongoing	No	Some issue with data (readout electronics) but should not be a concern for the layer

GEN-RP GEMs: Equipment listing

Items	Need	In hand	Order in pipeline?	Other sources / comments
MPDs (UVa GEMs)	70	65 (incl. order from Glasgow & JLab)	3 (UVa) ?	Look like we are still missing 5 units
APV25 FE Cards (UVa GEMs)	880	831	Yes as more cards also needed for U/V GEMs	M. Kohl to provide about 100 additional cards if needed
12-slots backplane (UVa GEMs)	44	47		
5-slots backplane (UVa GEMs)	88	92 (incl. recently purchased by JLab)		
MPD (INFN GEMs) BB & SBS	24	24 (+ spares...?)		
APV25 FE Cards (INFN GEMs) BB & SBS	324	all in hand		
Backplanes (INFN GEMs) BB & SBS		all in hand		
4-slots backplanes (U/V GEMs) BB & SBS	48	52 (recently purchased by JLab)		
3-slots backplanes (U/V GEMs) BB & SBS	16	18 (recently purchased by JLab)		
HDMI (1m, 2m, 3m & 10m)		All in hands (look like we are missing a few 1m-cables)		Cheap and easily available on amazon. Not an issue
Low voltage regulators		All in hand (incl. recently purchased by JLab)		
Low voltage PS		All in hand		JLab Electronics group (C. Cuevas)

GEN-RP GEMs: Equipment listing

Item	In Hand	Status
3 VTP modules (together with BB GEM readout)	To be ordered	(can use 2 HCAL ones at worse and 1 SoLID)
3 TI – Trigger supervisor	3 TI and 1 TS On hand	
3 SD cards	1	2 ordered by INFN
Master VME (for SSP and TI)	3	
Trigger / clock fan-out (78 channels)	2	4
3 VXS crate (for SSP, TI ...) (together with BB GEM readout)	3	
4 VME crate (no master) for MPDs	3 ?	Need more ? (could use VME64X crate)
50 Optical fiber MPD – SSP connection	30 on hand need 20	
78 (+ 1) NIM cables trigger distribution		To be identified / procured (1 from SBS GEM hut to electronic hut)
78 NIM cables (10 cm) for clock distribution		To be identified
46 x HV cables	Yes	
6 x LV cables pairs (15 m?)	Yes	To be identified / procured
HV power supplies for 46 channels (40 UVa GEMs + 6 INFN GEMs)	1 Wiener crate & 6 HV modules (8 ch. each) => 42 channels	UVa has 1 spare crate + at least one more HV module
LV power supplies (2xTTI-Eth., UVa system)	Yes: by JLab Electronic group (C. Cuevas)	Currently used in cosmic (+spare)
SBS GEMs Electronic Hut		JLab Engineering - (Jack Segal, Chandan Gosh)

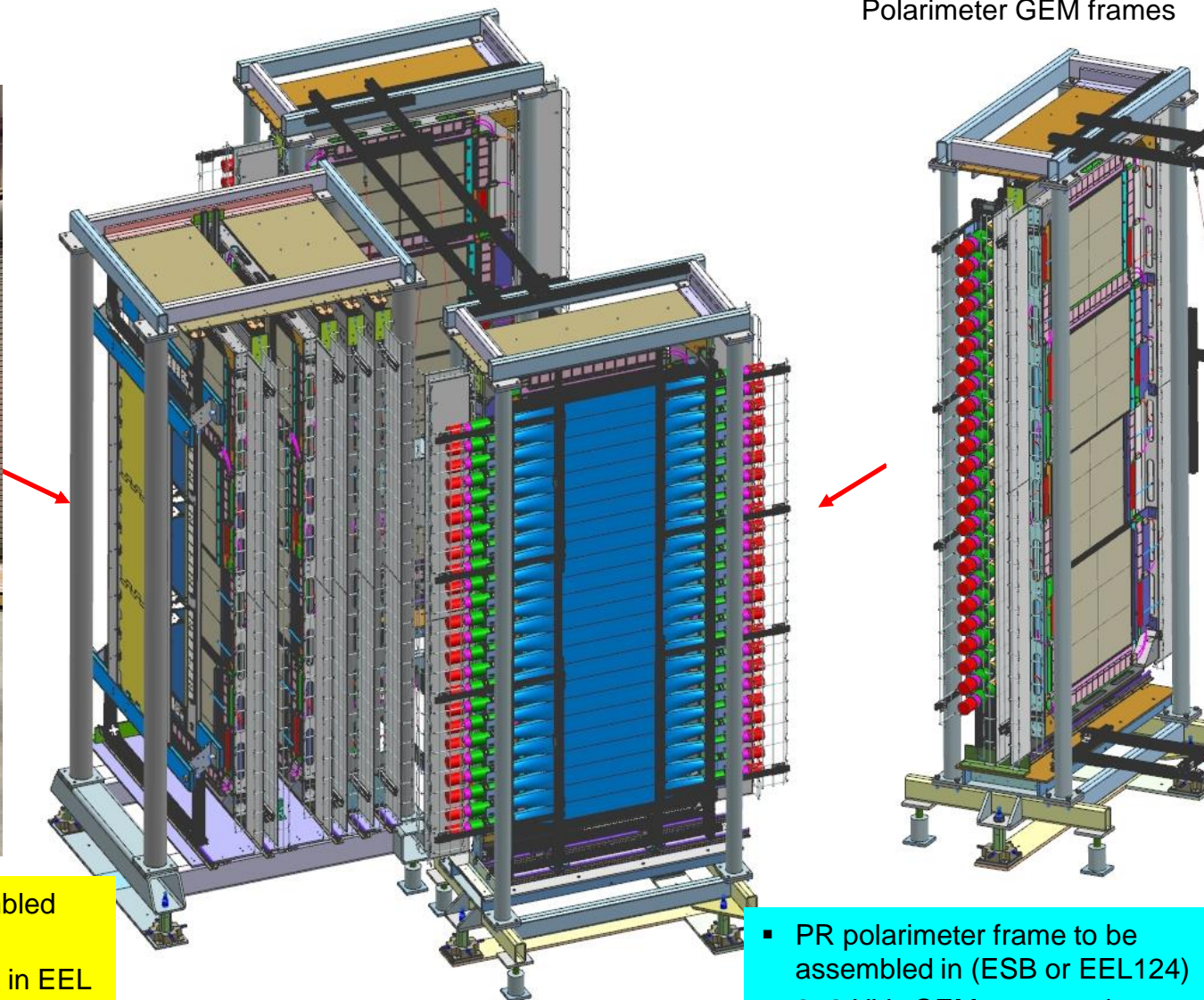
Installation Plans

GEN-RP GEMs: Detector frames

Charge Exchange (CE)
Polarimeter GEM frame



Proton Recoil (PR)
Polarimeter GEM frames



- CE polarimeter frame to be assembled and moved to EEL124
- UVa GEMs mounted in the frames in EEL
- INFN GEMs will be added later
- The frames will move to Hall A

- PR polarimeter frame to be assembled in (ESB or EEL124)
- 2×2 UVa GEMs mounted
- The frames will move to Hall A

GEN-RP GEMs: Tentative timeline for installation

- ⇒ **Installation of 6 UVa GEM layers in Charge Exchange (CE) Polarimeter frame**
 - ⇒ **End Feb 2021***: Frame will be assembled near EEL124 then move to EEL 124 for mounting of UVa GEM layers
 - ⇒ **March 2021****: 6 UVa GEM layers will be mounted ⇒ use EEL124 crane for the installation
 - ⇒ 4 layers ready for installation & 2 other ready to be tested on the cosmic stand before installation in the frame
- ⇒ **Installation of 2 × 2 UVa GEM layers in Proton Recoil (PR) Polarimeter frame**
 - ⇒ **Feb to March 2021***: 2 frames will be assembled in ESB and hodoscope will be mounted
 - ⇒ **End April 2021****: Complete the assembly and cosmic test of the first three UVa U/V GEM layers
 - ⇒ **End May 2021****: Complete the assembly and cosmic test of the forth UVa U/V GEM layer
- ⇒ **No need to repeat cosmic test for layers on GEN-RP frames ⇒ Just HV test to check stability on N2 gas**
- ⇒ **Installation of 2 Front tracker GEM layers (INFN J1 & J3) in Charge Exchange (CE) Polarimeter frame**
 - ⇒ **May 2021*****: INFN GEMs will be ready to be installed in EEL 124 after the step above
 - ⇒ **May 08, 2021**: The best UVa U/V GEM layers will be installed in **BB frame** and the remaining 2 will be reserved for **GEN-RP**
 - ⇒ U/V GEMs for GEN-RP will also depend on availability of APV25 with Panasonic connectors
- ⇒ **All 3 frames will be moved to the Hall A after May 15 2021**
 - ⇒ Final cabling (HDMI cables, gas, HV and LV) ...
 - ⇒ HV test and the checking the readout electronics / DAQ with pedestal

* Schedule defined by crew helping at JLab ⇒ **(Kondo & Brad)**

** Schedule define by flow of activities in EEL124 as well as JLab technical support availability **(Kondo & Brad)**

*** Schedule for the U/V GEMs defined by how things are going at UVa **(Nilanga)** and with cosmic tests for INFN GEMs **(Evaristo)**

GEN-RP GEM layers: Project progress / status

A: Amount of work needed for completion of GEN-RP GEM layers before May 15

- Assembly of the last 3 UVa X/Y GEM layers (layers #9, #10 and #11)
- HV test and performance evaluation on cosmic stand of layers #1, #2, #9, #10, #11
- Fix HV test issues of layer #5 \Rightarrow we believe it is just a matter of implementing the new divider 85%]
- Continue the evaluation of other minor issues such as dividers, the data and associated r/o and DAQ performance
- **Installation of layers into the 3 GEN-RP detector frames**
 - ✓ By end March – early April 2021: Installation of 6 UVa X/Y GEM layers in inline CE detector frame in EEL124
 - ✓ By end April – early May 2021: Installation of 4 UVa X/Y GEM layers in the 2 side PR detector frames in EEL124 (or maybe ESB)
 - ✓ By mid May 2021: Installation of 2 INFN layers and / or UVa U/V GEM layers in the inline CE detector frame in EEL124
 - ✓ HV test of all layers in all 3 frames and look at the pedestal data to ensure the R/O connection is ok
- **Complete the assembly and cosmic test of all 4 UVa U/V GEM layers \Rightarrow May 2021**
 - ✓ By May 08, 2021: The best two layers would have been installed in BB frame and the remaining 2 will be reserved for GEN-RP

B: Amount of work accomplished over last 1.5 month (start from January 2021)

- Assembly of two layers (layers #1 and #2) and start assembly of layer #9
- HV test and performance evaluation on cosmic stand of 3 new layers #6, #7 and #8, together with layer #4 and #5
- A lot of troubleshooting of HV instabilities with a few modules \Rightarrow fortunately seems like divider problem and not from modules
- Complete the installation and beginning cosmic data commissioning of UVa X/Y layer #3 in BB detector frame
 - ✓ Implement the gas system develop by DSG as prototype test for layer #3
 - ✓ Complete the r/o connection and preliminary test of the R/O and DAQ for this layer in BB

Let assign some A/B ratio:

- Assembly and HV test and performance evaluation on cosmic stand of UVa X/Y layers: $A = 3$, $B = 2 \Rightarrow$ **ratio $A / B = 1.5$**
- Assembly and HV test and performance evaluation on cosmic stand of UVa U/V layers: $A = 4$, $B = 2 \Rightarrow$ **ratio $A / B = 2$**
- Installation of GEM layers in the 3 GEN-RP frames: $A = 5$ (for 10 layers), $B = 1$ (based on layer #3 in BB) \Rightarrow **ratio $A / B = 5$ (does not mean that the task require $5 \times$ more time rather that it is $\sim 5 \times$ more complicated / more demanding of manpower time)**

GEN-RP GEMs: Commissioning and Calibration in Hall A

- ⇒ Target date to start moving the detectors in Hall A will be May 15
- ⇒ Commissioning with cosmic before the beam on
 - ⇒ Setup trigger scintillators for cosmic test of all GEN-RP GEM detectors when beam is off
 - ⇒ We might want to keep the external scintillator setup in place for systematic cosmic data for any extended period of beam down
- ⇒ Calibration runs with beam on
 - ⇒ Low luminosity runs with magnet off (straight tracks, low rate)
 - ⇒ Low luminosity runs with magnet on (nominal tracks, low rate)

Manpower & Documentation list

UVa GEMs:	FTE	Current roles
Kondo (UVa)		Leading
Nilanga (UVa)		Supporting
Huong Nguyen		Leading All GEM production and testing at UVa
Michael Kohl (HU)		Supporting
Thir Gautham (HU) (*)	Postdoc (0.5)	DAQ, monitoring, analysis, commissioning
Xinzhan Bai (UVa)	Postdoc (0.5)	DAQ, monitoring, analysis, commissioning
Salina Ali (UVa)	Postdoc (0.5)	U/V layer production, testing, and commissioning
John Boyd (UVa)	Student (0.5)	U/V layer production, testing, and commissioning
Sean Jeffas (UVa)	Student (0.5)	U/V layer production, DAQ, monitoring, analysis, commissioning
Anuruddha Rathnayake (UVa)	Student (0.5)	DAQ, monitoring, analysis, commissioning
Malinga Rathnayake (HU) (*)	Student (0.5)	DAQ, monitoring, analysis, commissioning
Manjukrishna Suresh (HU) (*)	Student (0.5)	DAQ, monitoring, analysis, commissioning
Vimukthi Gamage (UVa)	Student (0.5)	Start in June 2021
Bhashitha Dharmasena (UVa)	Student (0.5)	Start in June 2021



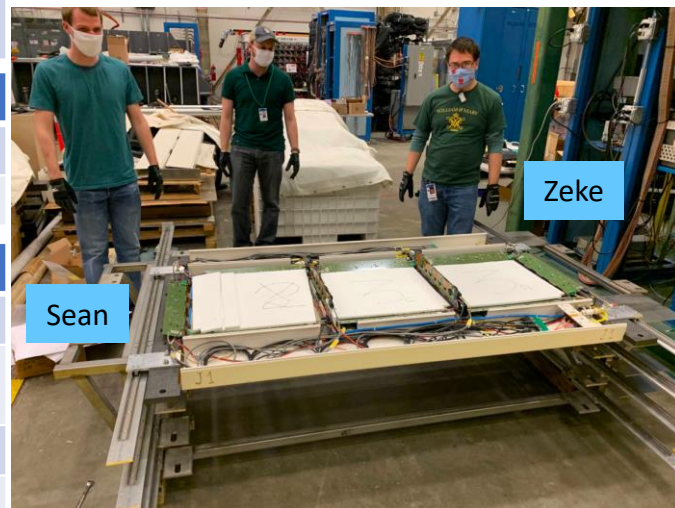
(*) available until October, could be extended further

(*) will graduate this summer or maybe in the fall

(*) PhD research on GENRP, and it would make every sense to get him trained and involved as soon as possible.

INFN GEMs, Tracking Software, GEM readout and DAQ

INFN GEMs:	FTE	Roles
Roberto		Leading and supporting
Evaristo		Leading and supporting
Ezekiel Wertz	student (1)	Analysis, tracking, hardware, and commissioning
Tracking and software:	FTE	Roles
Andrew Puckett	user (0.3)	tracking
Sean Jeffas	student	online monitoring, event displays
GEM readout and DAQ:	FTE	Roles
Alexandre	staff (0.3)	Leading all DAQ
Paolo Musico		Leading design and developer, MPD support
Holly	staff	Leading GEM DAQ
Ben Raydo	staff (0.3)	High rate, VTP
Bryan Moffit	staff (0.25)	High rate, DAQ
Xinzhan Bai	postdoc	DAQ, data quality
Sean Jeffas	student	DAQ, data quality



❑ GEM operation manuals:

⇒ INFN GEMs: <https://pandora.infn.it/public/3b9827>

⇒ UVa GEMs (in progress): <https://www.overleaf.com/project/60280700719b746c97e92524>

⇒ GEn-RP GEMs ERR wiki: https://hallaweb.jlab.org/wiki/index.php/E12-17-004-ERR-29May2019#Responses_to_the_Committee_Recommendations

❑ THA and OSP for GEMs (submitted):

⇒ https://misportal.jlab.org/mis/apps/mis_forms/operational_safety_procedure_form.cfm?entry_id=113037

❑ Still under development:

⇒ Established benchmarks for beam commissioning

⇒ How-to for shift workers

Summary

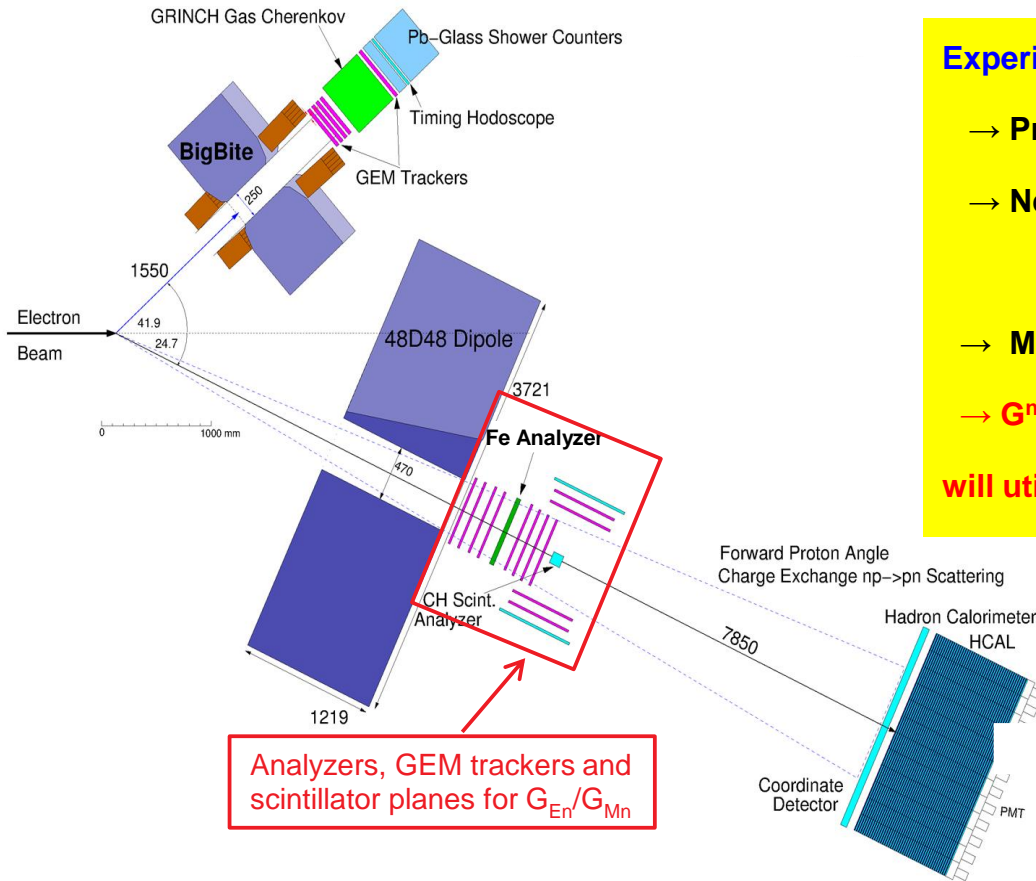
- ❑ Assembly of UVa X/Y layers on good tracks
 - ❑ 8 / 11 layers assembled and tested, 3 remaining could be completed in on month
 - ❑ Troubleshooting issues with DAQ and GEM divider boards
- ❑ Production of the 4 UVa U/V GEMs ongoing
 - ❑ 2 of these layers could be made available for GEn-RP by end May 2021
- ❑ GEM MPD readout and DAQ status in good shape
- ❑ SBS GEM gas system developed by the DSG
 - ❑ Prototype of the system is under test with UVa layer in BB
- ❑ Installation of all 10 UVa + 2 INFN layers in GEn-RP detector frames by early May 2021
- ❑ GEn-RP GEMs move into the Hall mid May
 - ❑ Commissioning with cosmic will be set up in the hall before beam run

Backup

SBS GEM: Purpose

- SBS is a 2.5 T*m dipole magnet with vertical bend, and a flexible configuration detectors
- A large solid angle, high luminosity (up to $10^{39} \text{ cm}^{-2} \text{ s}^{-1}$) with large momentum bite

Schematic view of 4.5 (GeV/c)² kinematic setting



Experiments being prepared with SBS:

→ Proton FFs: E12-07-109 (G_E^p up to $Q^2 = 12 \text{ GeV}^2$)

→ Neutron FFs: E12-09-016 (G_E^n up to $Q^2 = 13.5 \text{ GeV}^2$)

E12-09-019 (G_M^n up to $Q^2 = 13.5 \text{ GeV}^2$)

→ Measurement of TPE to e-n elastic scatt. at $Q^2 = 4.5 \text{ GeV}^2$

→ G_E^n - RP: E12-17-004 at $Q^2 = 4.5 \text{ GeV}^2$

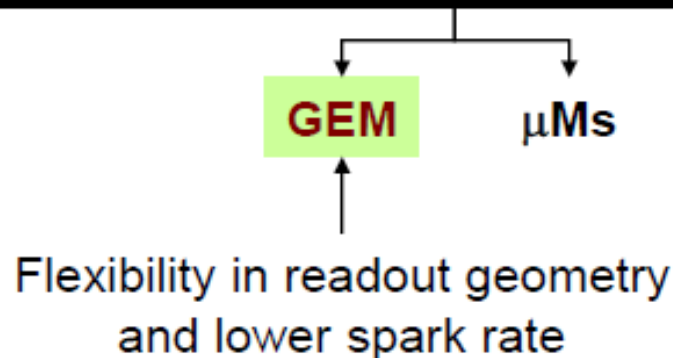
will utilize recoil neutron polarimetry at high momentum

Reference to the proposal E12-17-004: [J.R.M. Annand et al.](#)

SBS GEM for GEn-RP: Requirements

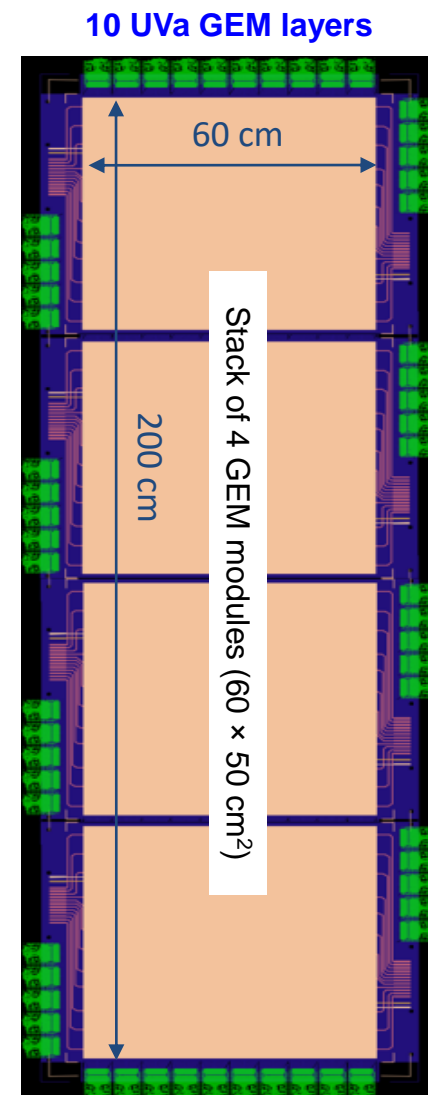
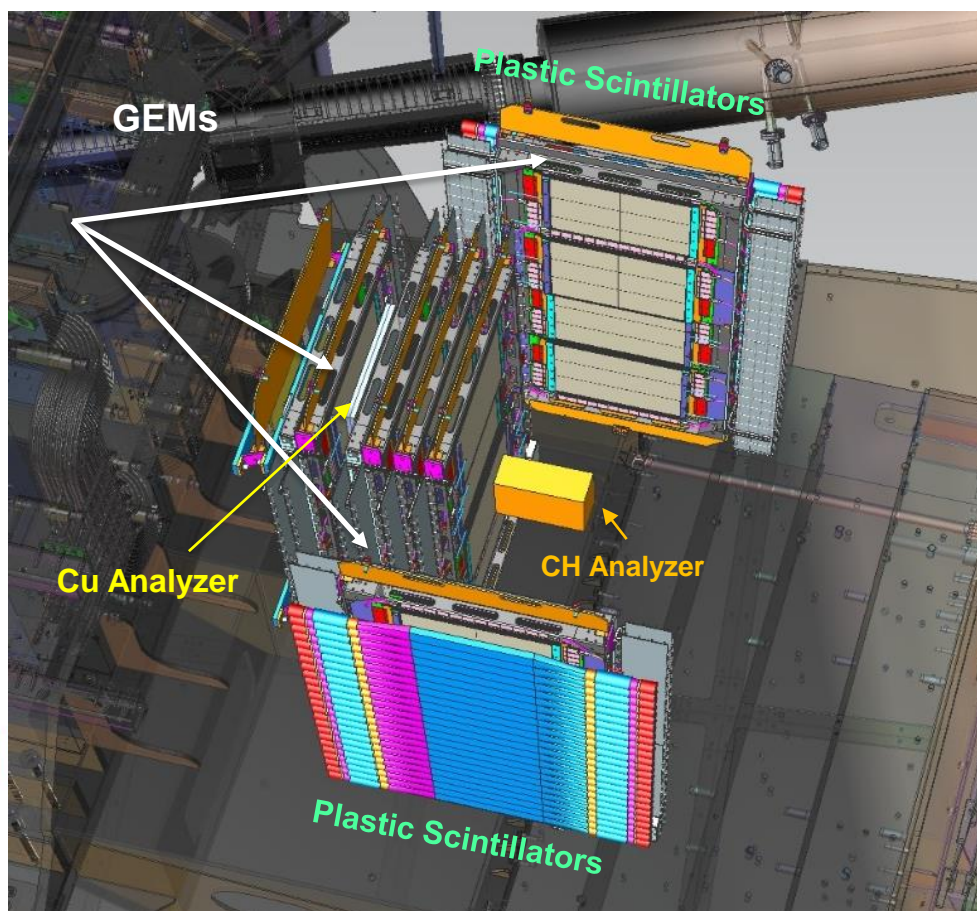
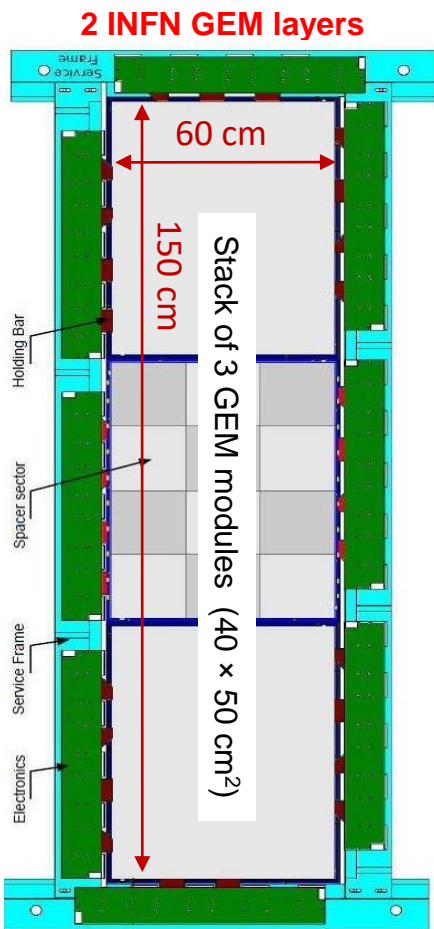
System Requirements	Tracking Technology		
	Drift	MPGD	Silicon
High Background Rate (up to): (low energy γ and e) 1 MHz/cm²	NO	MHz/mm²	MHz/mm²
High Resolution (down to): 70 μm	Achievable	50 μm	30 μm
Large Area: from 40×150 to 80×300 cm ²	YES	Doable	Very Expensive

... and modular: reuse in different geometrical configuration



GEN-RP GEM Trackers

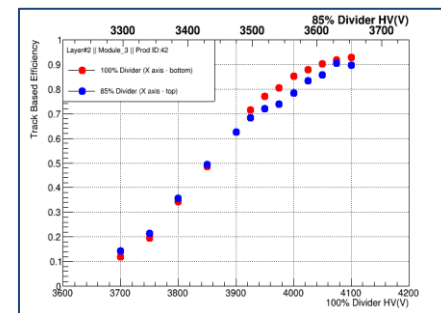
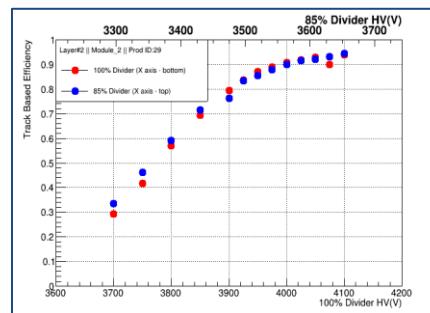
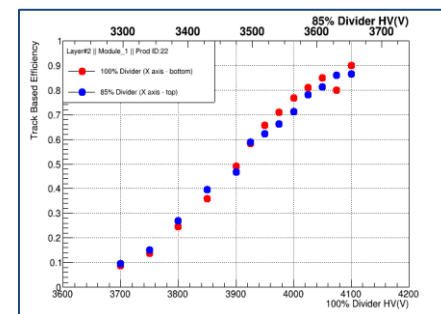
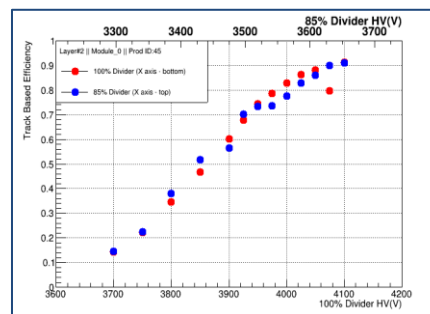
- The Charge-Exchange (CE) Polarimeter:
 - ⇒ 2 INFN + 2 UVa layers, in front of Cu analyzer.
 - ⇒ 4 UVa layers behind the Cu analyzer.
- The Proton-Recoil (PR) Polarimeter:
 - ⇒ 2 Identical arms, 2 UVa GEM layers in each arm



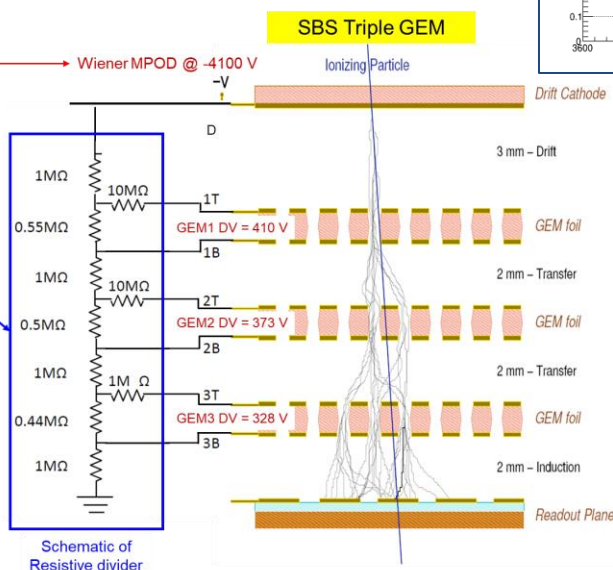
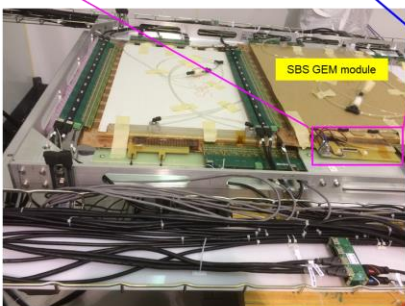
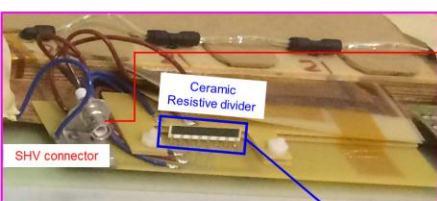
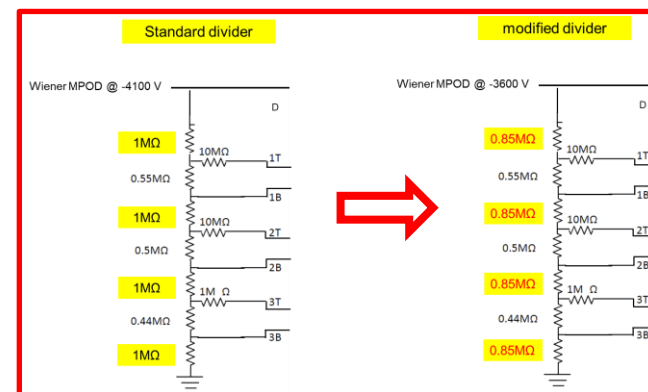
Performances of UVa GEMs: Divider Modification

- ⇒ Few modules show some stabilities issues with the HV, that we think are linked some vibrations between GEM foils cause the chamber to discharge
- ⇒ The problem disappear at lower voltage and / or if we reduce the gas flow rate from 5 Vol changes / hour to ~ 4 Vol changes / hour
- ⇒ Mitigate the problem by reducing the E-field between GEM foils while maintain the GEM amplification ⇒ **Similar GEM gain = same performance**
- ⇒ Modification was implemented on the 4 modules of layer #3 for first test
 - ⇒ **Red dots:** old divider 100% & **Blue dots:** modified divider 85%
 - ⇒ Modification is now implemented in all assembled layers except #5
 - ⇒ Layer #5 on top of cosmic stand not accessible for the modification

HV scan: 4 modules of Layer#3



modification



Performances of UVa GEMs: HV scan

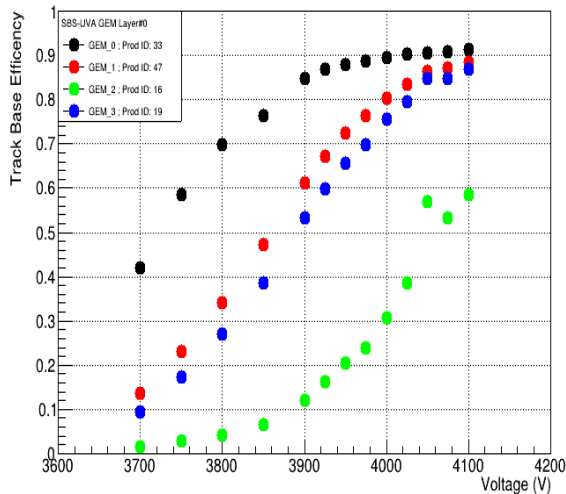
Layer #1 & #2: back on assembly tables

Layer #3: now in BB frame in TEDF

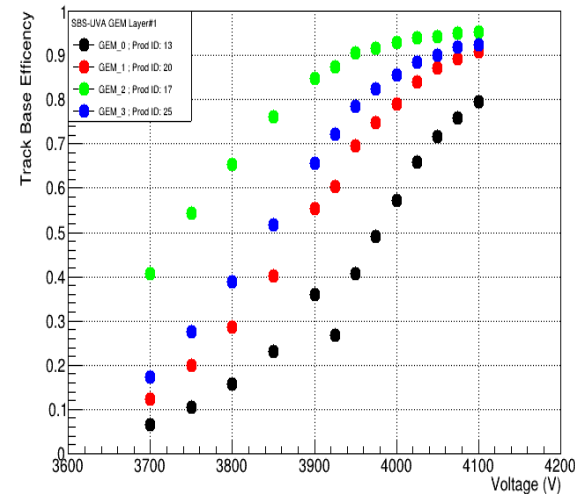
Layer #5: HV issue with 2 modules, still with old divider \Rightarrow will be fixed later

Layer #6, #7 & #8 with new HV divider scheme

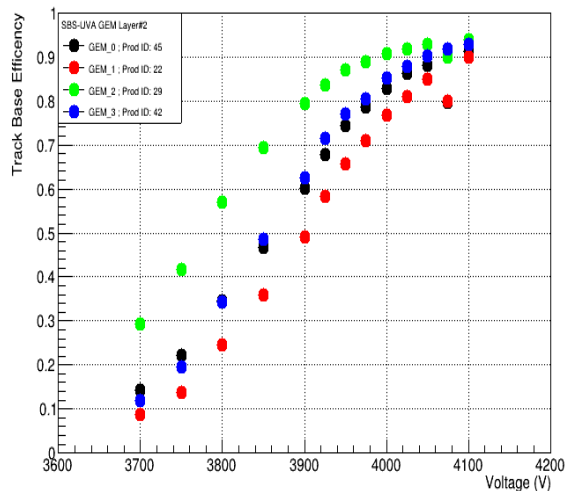
GEM Layer#0



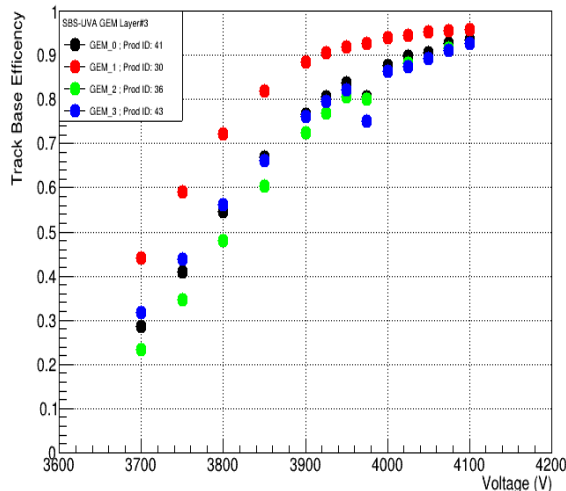
GEM Layer#1



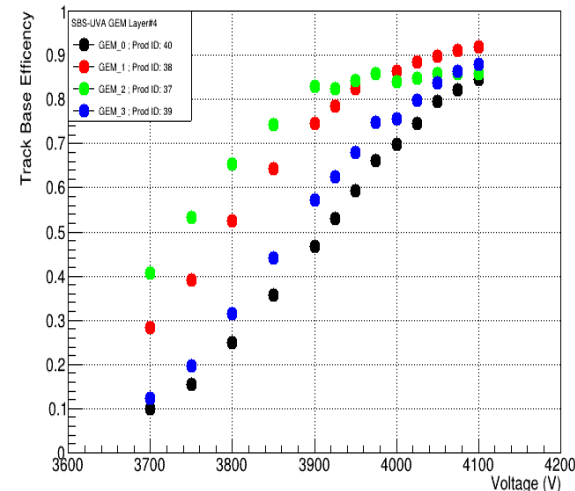
GEM Layer #4



GEM Layer #4



GEM Layer #5



GEN-RP GEM Equipment List

Procurement by JLab (Bogdan ...)

Needed to complete the 11 large GEM layers:

Item	Number	Estimated cost
5-slot back planes	8	\$1000
Analog patch panels	15	\$500
Digital patch panels	15	\$500
Low voltage regulators	4	\$ 150
Total		\$ 2,150

Needed for the 4 UV layers

Item	Number	Estimated cost
4-slot back planes	52	\$ 5500
3-slot back planes	18	\$ 1600
Digital patch panels	20	\$ 675
Low voltage regulators	28	\$ 975
Total		\$ 8,750

Status of the procurement

Patch panels:

- PCBs (analog and digital) delivered (done)
- **Next:** HDMI connectors assembly (couple of weeks)

Voltage regulators:

- PCBs delivered (done)
- voltage regulators chips delivered (done)
- **Next: Mounting of the voltage regulators**

Back planes:

- Order was issued to EES (Italy) on Feb. 2 ⇨ Expected delivery Feb. 26