Status of UVA GEM setup in EEL clean room

SBS Weekly Meeting, December 19, 2019

Kondo Gnanvo

UVa: Nilanga, Kondo, Anuruddha, John, Danning

HU: Michael, Malinga, Thir

JLab: Bogdan, Chuck, Alex, Bryan, Ole, Brad

And many more ....

Weekly meeting for the commissioning of the GEMs every Wednesday at 10:00 am

Wiki: https://hallaweb.jlab.org/wiki/index.php/GMn_GEM_Commissioning_Meeting

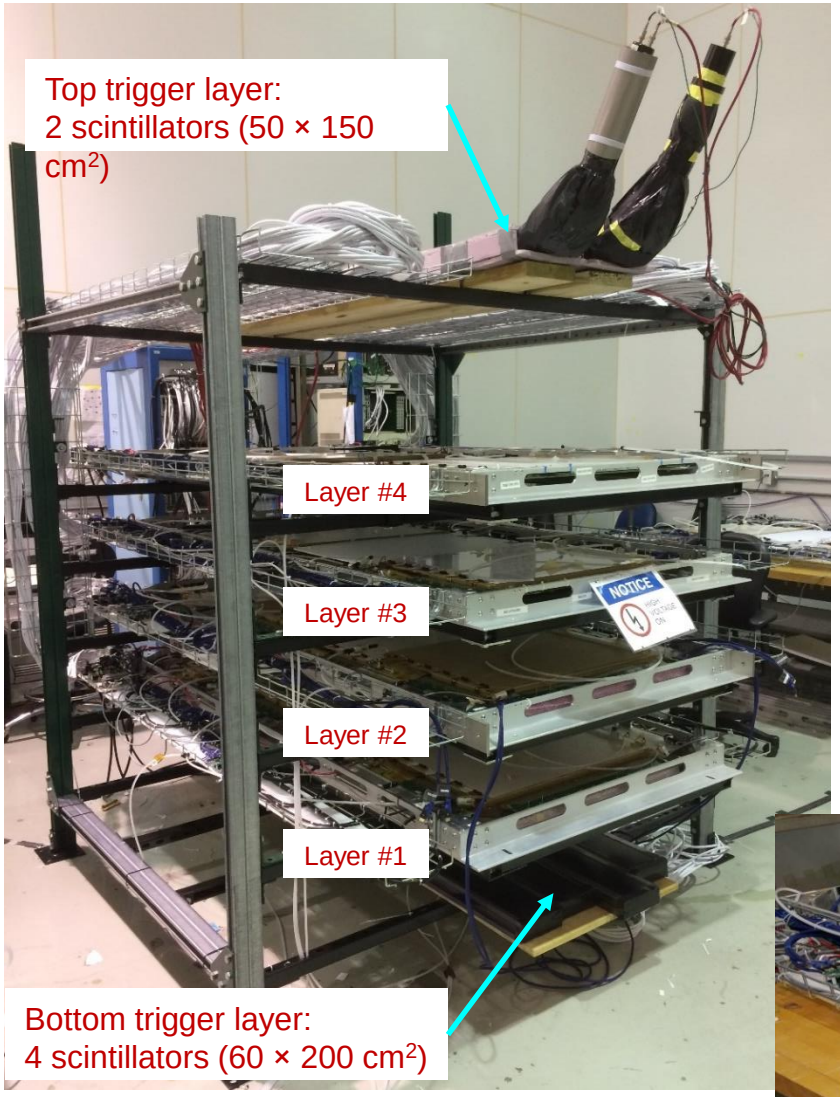
Outline

- Status of UVa GEM layers assembly in EEL124
- GEM Analysis Software Development
- Update on Front Trackers GEMs with U-V Strips Readout
- GEM Gas System in Hall A for the SBS Experiments

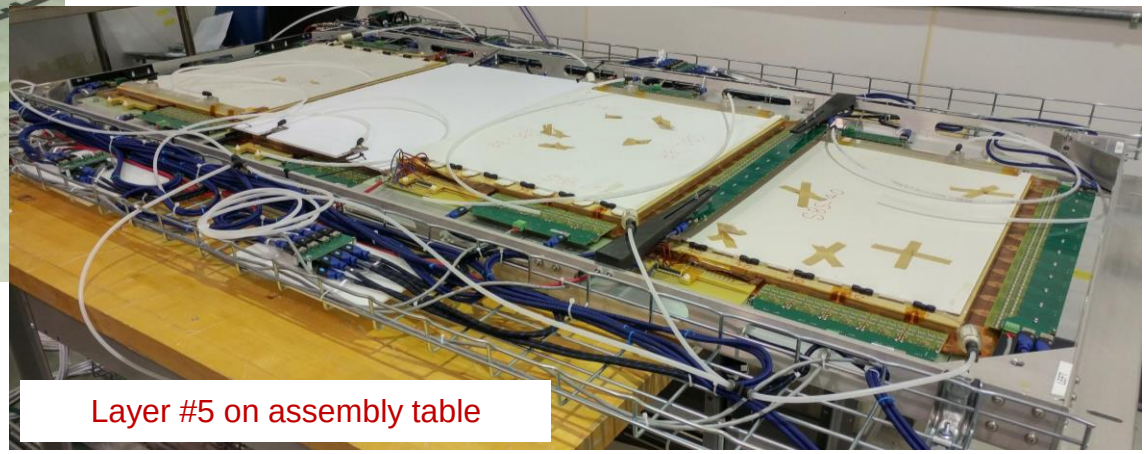
Status of UVa GEM layers assembly in EEL124

Andrew Puckett

Status of UVa GEM layers assembly in EEL124

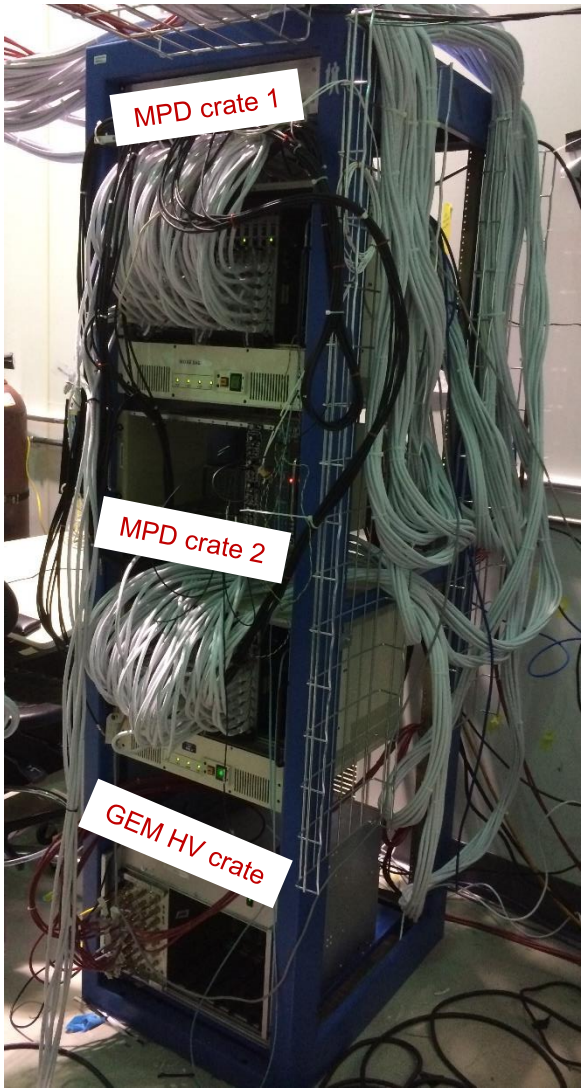


- ⇨ **5 of all 11 UVa GEM layers:** are assembled tested and validated.
- ⇨ **4 layers are on the cosmic stand:** They have been tested to be working perfectly. HV tests performed regularly (not problem so far with any of the 16 modules). We took some preliminary cosmic data
- ⇨ **layer #5 is completed:** sitting on the assembly table. It has passed the HV tests and readout electronics tests and ready to go to the cosmic stand when the "jacking system" is ready.
- ⇨ **Layer #3, #4, and #5 are assembly are final:** all equipped with the final low voltage power distribution for the APV25 electronics, mechanical support for the FE cards, final gas system, FE cards. All are ready for the experiment.
- ⇨ **Layer #1 and #2** are going to be taken out for some modifications.



DAQ and R/O Electronics, HV Power Supplies and Trigger Logic

MPD DAQ & GEM HV Power Supply

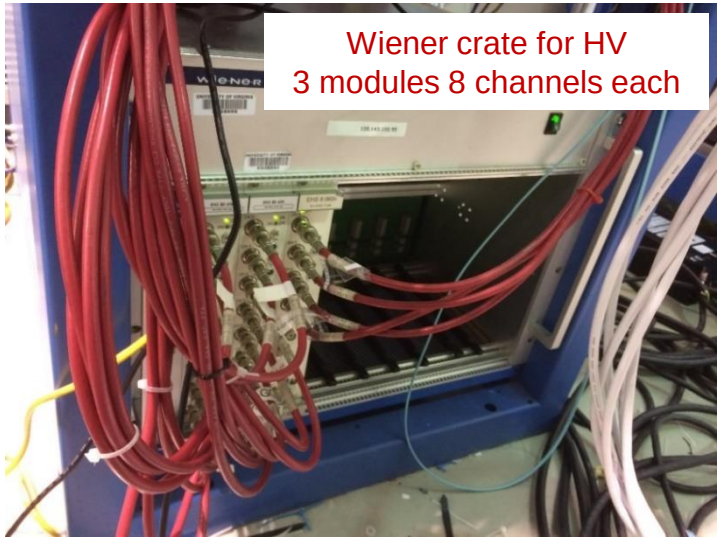


MPD DAQ & GEM HV PS

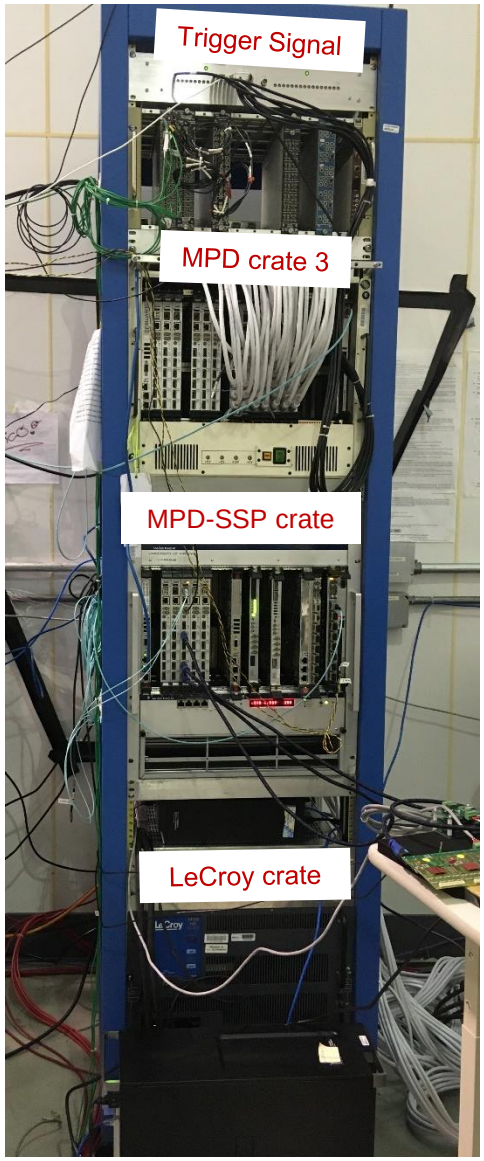
- ⇨ 2 standard VME crates for the MPD electronics
  - ⇨ 28 MPDs & 352 APV25 cards
  - ⇨ Configured to read out 4 layers in cosmic stand
- ⇨ Trigger signal distribution (JLab custom module)
- ⇨ Wiener HV power supply crates for the GEM
  - ⇨ 3 HV modules with 8 channels each for 5 layers in the cosmic stand + test of the layer on assembly table

MPD DAQ & Trigger Rack

- ⇨ 1 standard VME crates for MPD electronics
  - ⇨ read out 5th layer & and layer on assembly table
- ⇨ 1 VXS crate Test SSP readout mode (Danning, & Ben)
- ⇨ 1 LeCroy PS crate for the trigger scintillators
- ⇨ NIM crate for the trigger coincidence logic

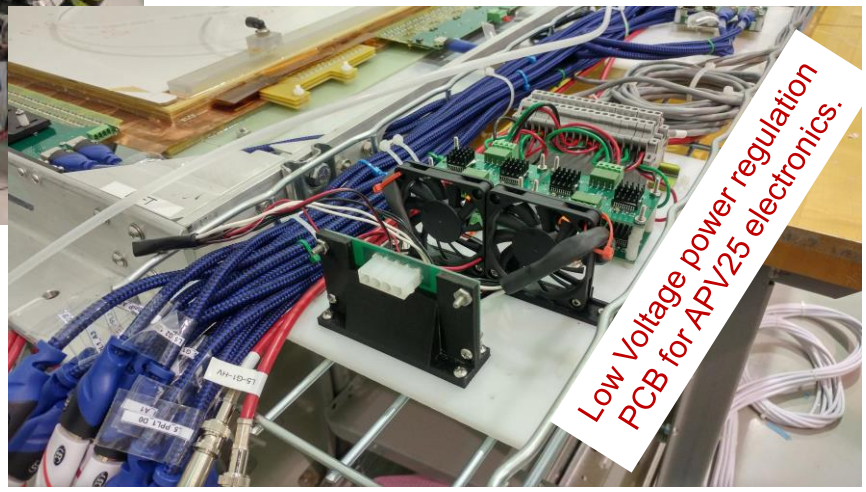


MPD DAQ & Trigger Rack



Recent development in EEL Clean Room

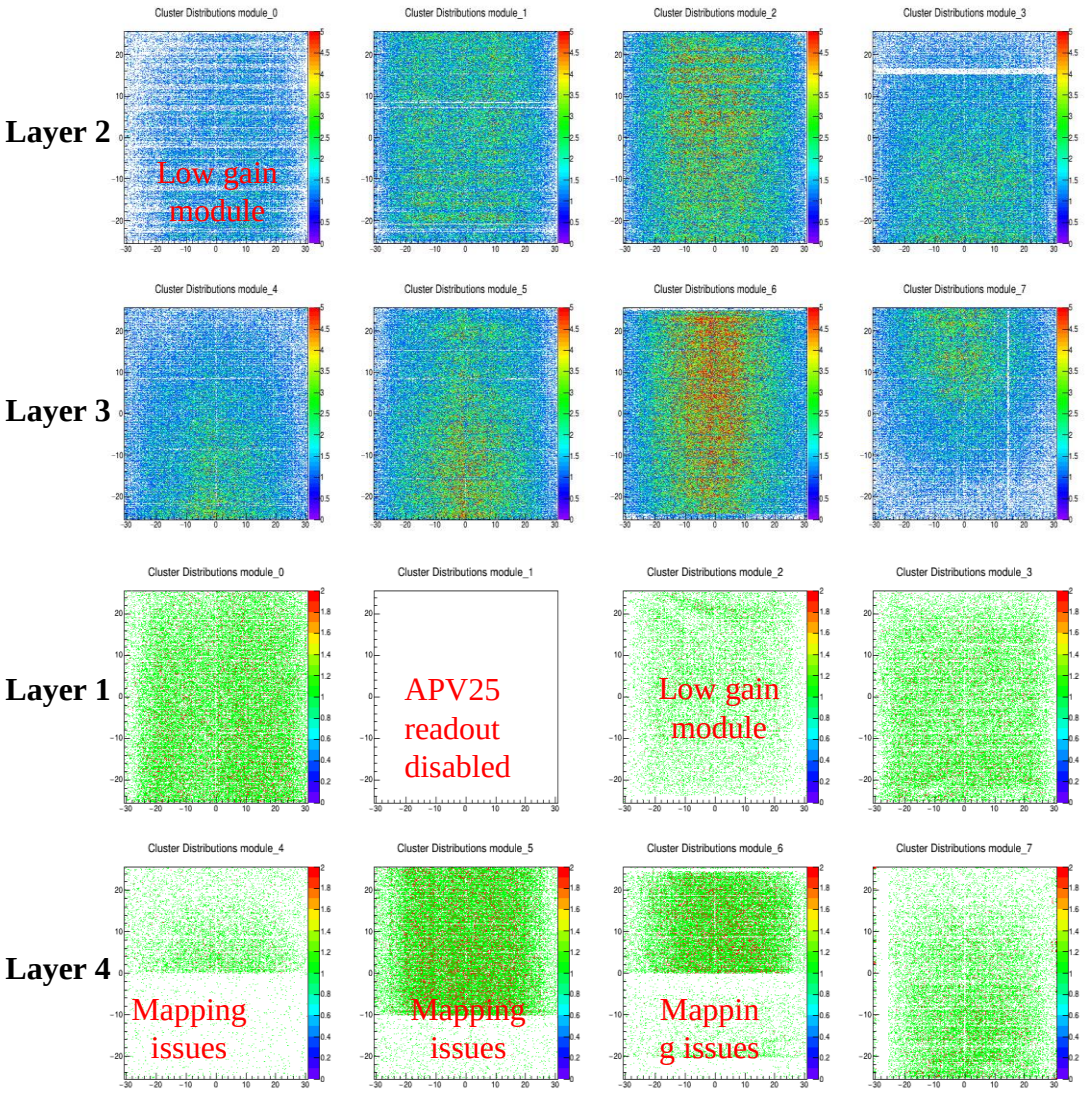
HDMI cable arrangement and support on the cosmic stand



Low Voltage power regulation PCB for APV25 electronics.

Rearrangement of the gas distribution panel

Preliminary cosmic data with all 4 layers in cosmic stand



- HV on all 4 layers @ 4050 V on Ar/CO2
- Preliminary round of cosmic (~1.5 M triggers event in 1.5 days)
- All 8 modules of layer #2 and #3 working very well, no dead sector
- All 8 modules of layer #1 and #4 working very well as well but with this run, we had some issues with the mapping for GEM #0, #1 and #2 of layer #4 (related to 3 5-slots back planes connected together to the same MPD) and we also disabled the APV25 for GEM #1 layer #1 because we were having some issues with the MPDs
- Low gain in GEM#0 layer#2, GEM#2 layer#1 and GEM0# layer#4 due to known issue with these chambers ⇨ need to operate at higher HV. A few of our GEM modules have similar issues due to GEM foil holes parameters we got from CERN ⇨ Not really an issue
- **All these problems are minor issues**

GEM Analysis Software Development

Andrew Puckett

Software development for GEM data Analysis

Andrew Puckett

Development of Standalone GEM data reconstruction and alignment macros:

- ⇨ Demonstration of the capabilities and performances with the existing INFN GEM cosmic data (see Andrew's presentation at the SBS Weekly Meeting Nov 07, 2019:

  https://hallaweb.jlab.org/12GeV/SuperBigBite/SBS-minutes/2019/PuckettGEM_COSMIC_ANALYSIS_11_13_update.pdf

  - ⇨ Macros currently exists : "as is" on the batch farm, in sbs work disk area at:
    - ⇨ **/work/halla/sbs/puckett/GEM_COSMIC_ANALYSIS/**
  - ⇨ In this folder, 2 subfolders: "GEM_align" (containing the code) and "GEMfixNov18 (containing the decoded "hit" root files)
  - ⇨ The relevant ROOT macros are: GEM_reconstruct.C and GEM_align.C which do exactly what they sound like they do.
- ⇨ Instruction to run the macros: Need a configuration file ("config.txt" is an example for the reconstruction, "configalign.txt" is an example for the alignment).

Works in progress and a lot more diagnostic plots could be added to the "Standard" list of plots,

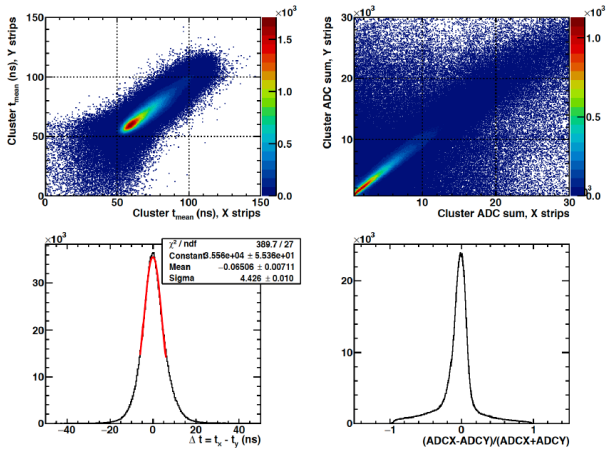
- ⇨ Not naturally set up to do yet is to chain multiple cosmic runs together for higher statistics and finer-grained efficiency analysis.
- ⇨ Due to changes in HV, gas flow, and possible slight differences in alignment, to analyze multiple runs together one would like to be able to load, e.g., different geometry parameters for different runs, a la the usual "database" used by the analyzer.
- ⇨ UVa GEMs EEL cosmic data, PREX GEMs data and Hall A UVa GEMs 2017 test beam data all expected to be analyzed with these macros soon to study **the performances of UVa GEMs and test the robustness of the codes with different setup**

In any case, all this will hopefully go directly in the analyzer soon.

Few Examples of INFN GEM Data Analysis

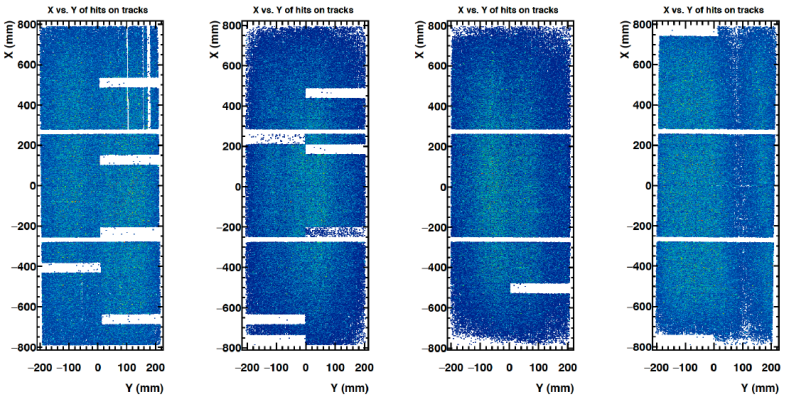
Andrew Puckett

ADC and Time correlations, I



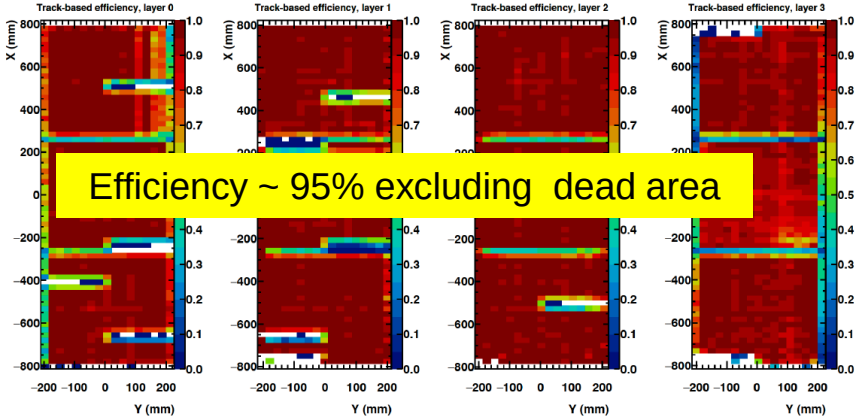
- These distributions are for all clusters on good tracks, without any explicit cuts applied.

Hit Maps, Run 3805



- Distribution within each layer of reconstructed hit coordinates, showing dead areas/shorted sectors/etc.
- "Stripe" at y = 100 mm in layer 3 is caused by trigger bias; gap between trigger scintillators above GEMs.

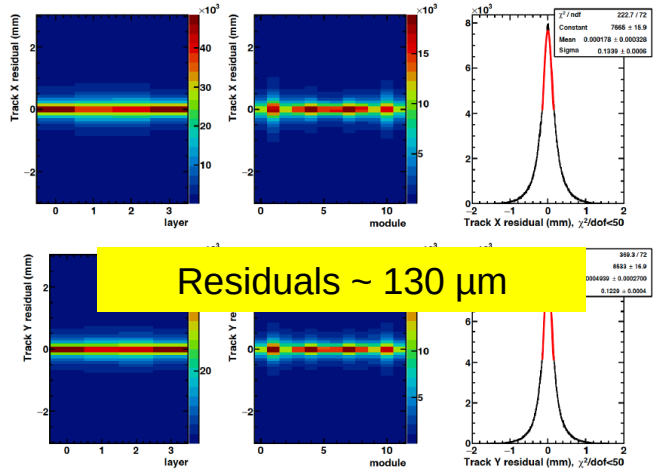
Track-Based Efficiency (INFN cosmic run 3805)



Efficiency ~ 95% excluding dead area

- Divide each layer into coarse XY binning so that we have on average ~few hundred events/bin
- Then for each track falling in that bin, ask if there was a hit on that track in that bin.
- Ratio of "Did hit"/"Should hit" gives local efficiency
- After bug fixes and improved alignment, "good" regions of GEM active area are >95% efficient, and "dead areas" between modules are more clearly visible.
- Fourth (top) layer shows clearly lower efficiency, could be related to gas flow issue during this run…

Tracking residuals



Residuals ~ 130 μm

- **After software alignment, Gaussian fit to FWHM of tracking residuals gives $(\sigma_x, \sigma_y) = (134\ \mu m, 123\ \mu m)$. Some additional improvement possible with more sophisticated hit position reconstruction (currently just simple ADC-weighted average strip position). Modest additional analysis needed to derive "intrinsic" spatial resolution from tracking residuals and details of detection geometry**

Summary of the current status in the EEL Clean Room

Layer assembly and cosmic tests (Anuruddha, Malinga, Thir)

- ⇨ 5 layers assembled and tested ⇨ Everything in place for the 6 remaining layers (all parts and fixes are under control)
- ⇨ Need to build the "jacking system to easily move and insert layers on the cosmic stand (January 2020)
- ⇨ **From the experience, assembly and tests of the remaining 6 layers can be done within 6 months with the same team**

Set up of the new DAQ PC & Online Monitoring Tool for GEM cosmic data (John Matter)

- ⇨ New powerful PC for the DAQ and online monitoring of the cosmic data. Setup by Ole, Brad and Bryan.
- ⇨ John Matter is responsible for the cosmic data management, and the upgrade of the GEM decoder software for the online monitoring and basic pre-analysis of the raw data to provide input for the analysis tool from Andrew
- ⇨ **Right now, we are stuck with decoding of data with more than one VME crates within CODA (Mark Jones is to help)**

Analysis of the cosmic data (Andrew Puckett)

- ⇨ Tremendous GEM analysis software development: perform track-based efficiency & spatial resolution analysis.
- ⇨ Demonstration with INFN GEM data ⇨ **~ 85% efficiency (including dead area) and 100 μm spatial resolution measured**
- ⇨ Will provide data to Andrew from UVa cosmic setup as soon as the decoding software issue is fixed, PREX GEM data as well as 2017 test beam in Hall A will be analyzed with Andrew's script ⇨ **a few order of magnitude higher rate than cosmic data**

Development of the MPD readout with SSP mode and online data reduction i.e zero suppression: (Danning Di)

- ⇨ The MPD4-SSP online reduction works for up to 4 MPDs per SSP Currently testing the MPD5-SSP setup where the SSP is expected to read up to at least 16 MPDs. There are some issue currently under investigation.
- ⇨ Final test of 14 MPDs, connected to 2 full UVa GEM tracking layers using cosmic to validate the development.
- ⇨ Test the rate limit of large scale MPD-SSP online reduction setup by turning on calibration channels on APV.
- ⇨ Test small scale system under X-ray. This is for double checking the accuracy (correctness) of the online reduction algorithm

Update on Front Trackers GEMs with U-V Strips Readout

Front Trackers GEMs with U-V readout: designs

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 × 40 cm^2, U-V strips readout (60º) stereo angle

⇨ New GEM foil production allows for the FT U-V GEM layer to be **one single large module**

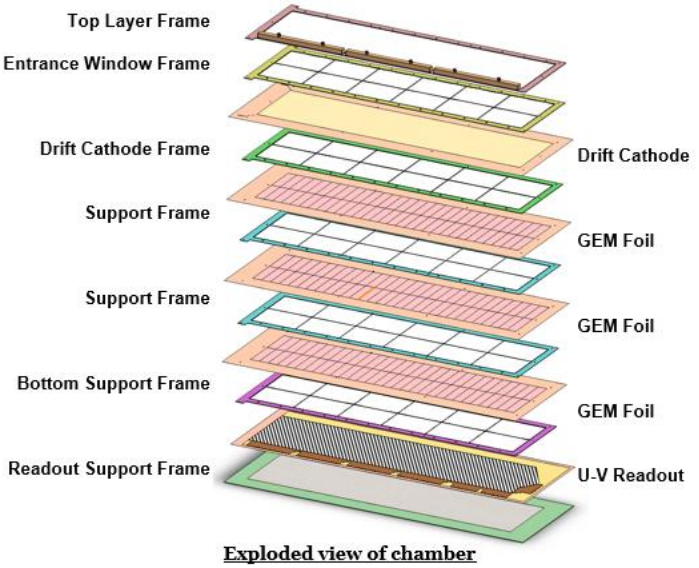
⇨ **No dead area** from support frames or electronics (Other than for spacers and HV sector)

⇨ The INFN-built MPD readouts for these GEMs will be the same as for all SBS GEMs

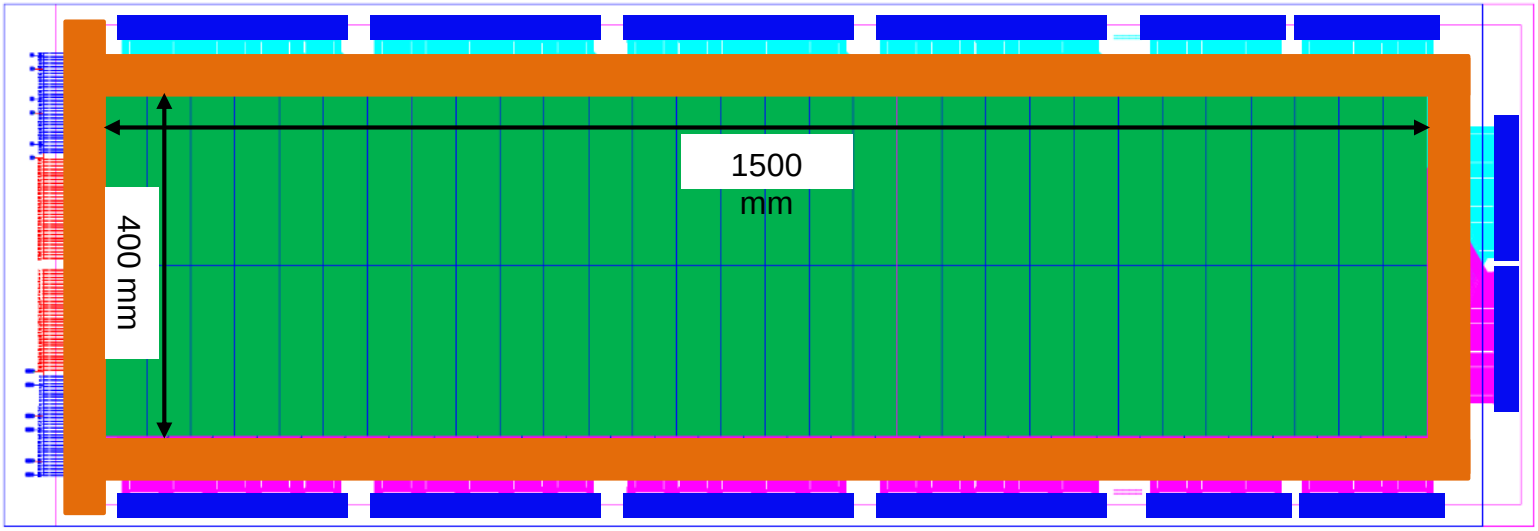
Our Experience: UVa has a successful track record with large area GEMs and U-V readout

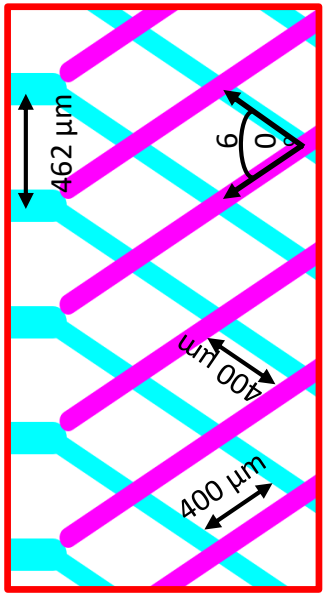
⇨ Large GEM with PRad Experiment (June 2016 in Hall B), similar size

⇨ U-V strip readouts with large U-V GEM for the EIC Forward GEM Trackers Detector R&D



Exploded view of chamber





Front Trackers GEMs with U-V readout: Contributing Institutes

- **⇨ 12 GEM foils (CERN) ⇨ cost of 1,800 CHF / each**
  - ⇨ 8 GEM foils by from North Carolina Central University (Branko Vlahovic),
  - ⇨ 3 GEM foils by JLab (Thia Keppel)
  - ⇨ 1 GEM foil by UVa (Nilanga Liyanage)

Expected delivery of first 6 foils by mid February 2020

- **⇨ 4 U-V readout foil (CERN) ⇨ cost of 5,100 CHF / each**
  - ⇨ 1 R/O by University of Connecticut (Andrew Pucket)
  - ⇨ 1 R/O by Glasgow University (David Hamilton)
  - ⇨ 1 R/O by JLab (Thia Keppel)
  - ⇨ 1 R/O by UVa (Nilanga Liyanage)

Expected delivery of first 2 R/O by mid February 2020

- **⇨ 4 Drift cathode foils (CERN) ⇨ total cost of CHF 700 CHF / each**
  - ⇨ UVa (Nilanga Liyanage)

Expected delivery of all 4 drifts foils by mid February 2020

- **⇨ 4 sets of Frames (RESARM) ⇨ Cost 7,044 Euros / set**
  - ⇨ 3 sets by INFN Rome and Catania (Evaristo Cisbani),
  - ⇨ 1 set by Glasgow University (David Hamilton)

Expected delivery of all 4 sets by February 2020

- **⇨ 4 Layout and Tooling (CERN) ⇨ total cost of CHF 4,400 CHF**
  - ⇨ Saint Mary's University (Adam Sarty)
- **⇨ Clean Room Equipment, Tooling and Manpower for fabrication**
  - ⇨ UVa (Nilanga Liyanage)

Work to start in January 2020

GEM Gas System in Hall A for the SBS Experiments

SBS & BB GEM Gas System (GEn-P configuration)

Gas volume need for GEn BigBite + GEn-RP: most demanding in term of GEM layers

⇨ 6 FT layers (18 INFN modules) and 11 UVa GEM layers (44 UVa GEM modules)

⇨ For 5 vol. change / h: UVa module 5 × 3.4 L = 17 L / h and INFN module 5 × 2.4L = 12 L / h

⇨ Total gas flow volume 964 L / hours for 5 volume change / hours (This is for GEp V)

⇨ **More likely 600 L / hours for GMn & GEn-RP**

⇨ Per month: ~600,000 STP liters of Argon + 150 000 STS liters of CO2

Gas Shed and Mixing System: (see following slides)

⇨ Need bigger gas shed outer enclosure ⇨ Requires 7 T-size Argon and 3 K-Size Argon

⇨ Jack Segal estimate that the space available for the existing gas shed is sufficient for the gas mixture

⇨ Jack Segal has completed the design for the gas mixing system and has a detail estimated at 30k$ detail

⇨ Jack responsible of the Gas mixing system and the main 1/2-inch gas line carrying the gas down to the pivot location in Hall A. These ½-inch lines already exist in place and will be re-purposed for this system

Gas Distribution System

⇨ Detector Support Group @ JLab ⇨ Marc McMullen (see next slides)

⇨ The collaboration (Nilanga, Evaristo) is responsible for gas distribution system from the pivot to the GEMs

SBS & BB GEM Gas System (GEn-P configuration)

Collaboration

DSG (M. McMullen's group)

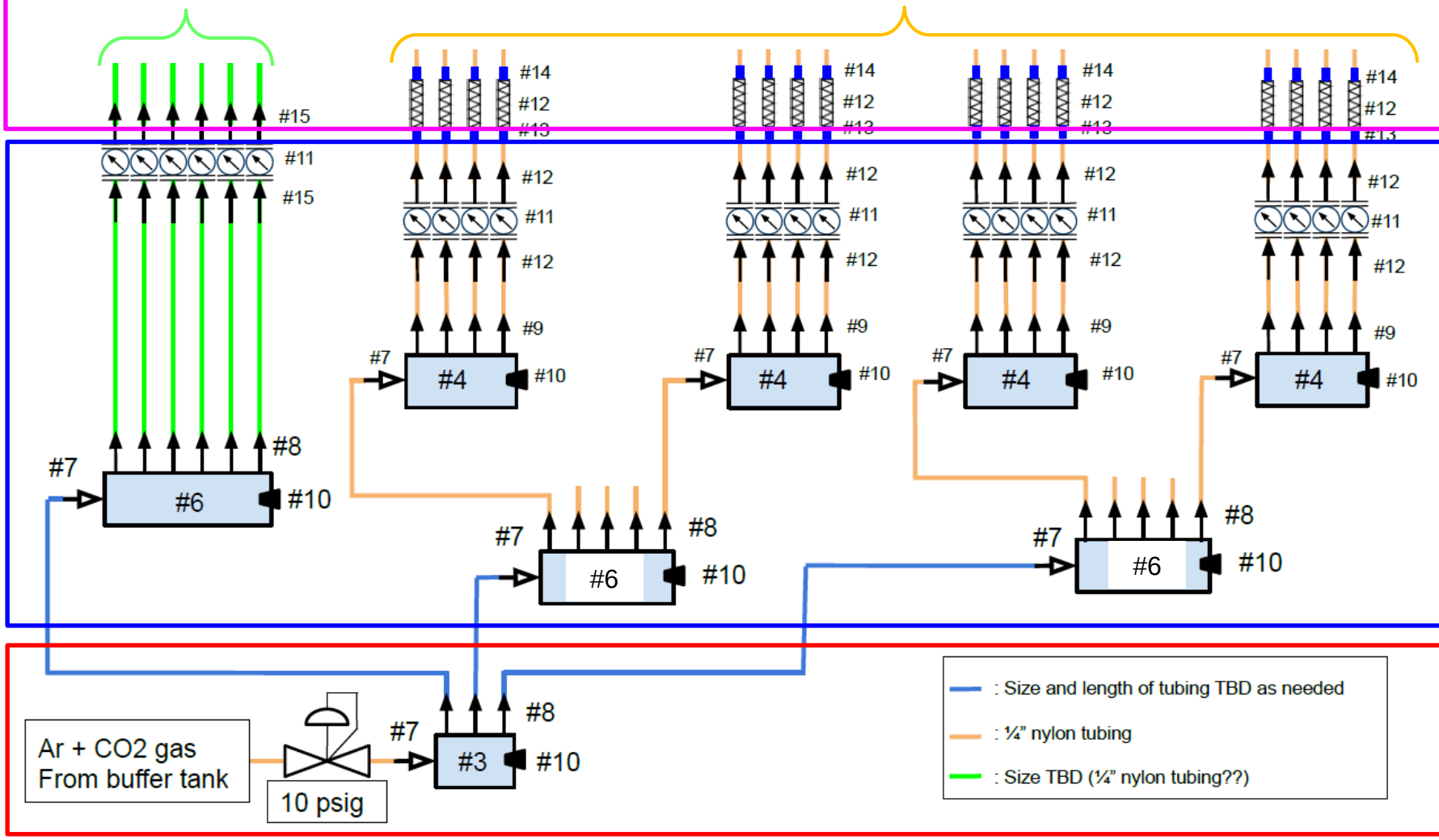
J. Segal

INFN GEM Modules: Total of 6 individual lines

- 4 lines to the BB spectrometer
- 2 lines in the SBS arm for Gen-RP

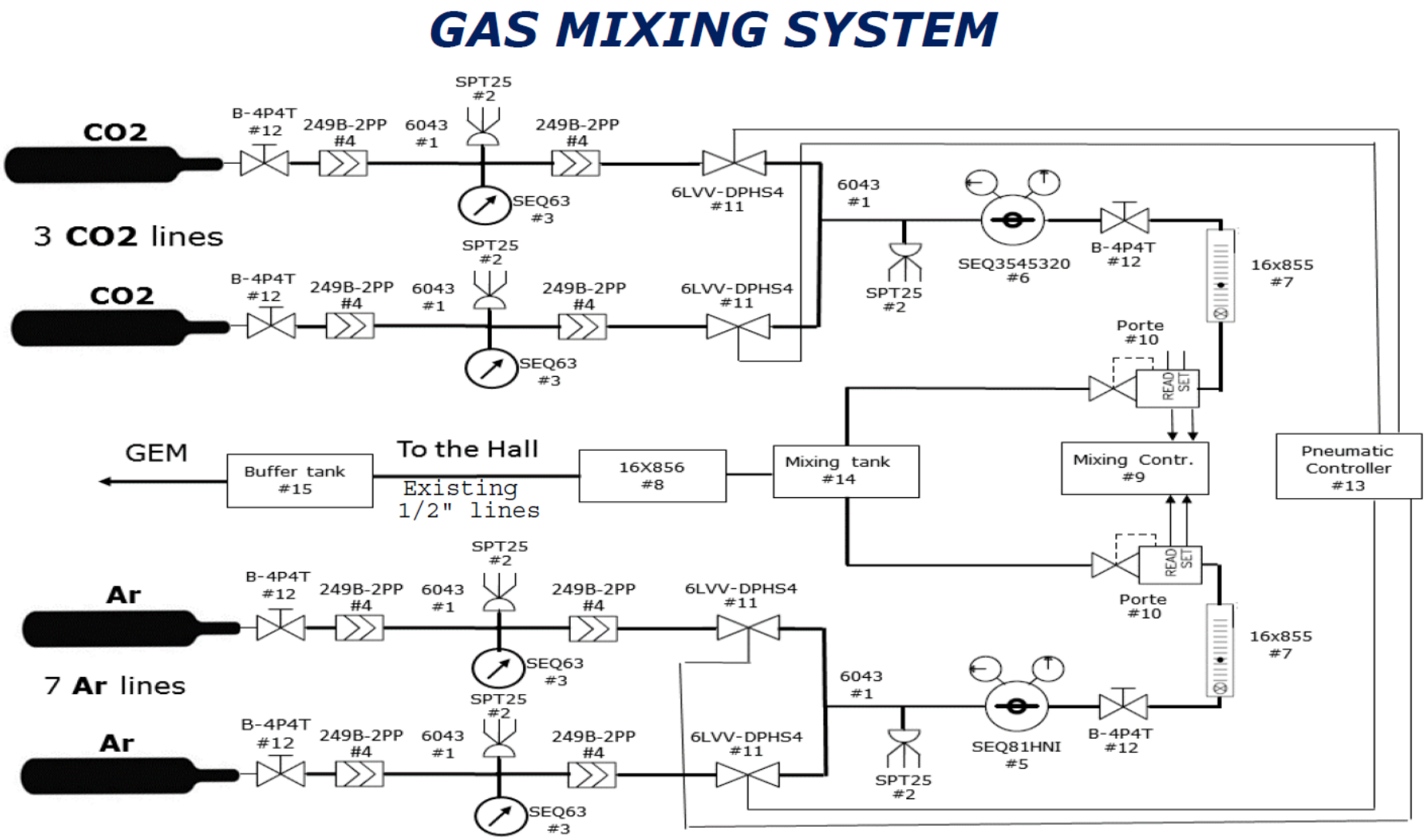
UVa GEM Modules: Total of 44 individual lines

- 4 lines to the BB spectrometer
- 40 lines in the SBS arm for Gen-RP



SBS & BB GEM Gas System (GEn-P configuration)

Jack Segal's team



SBS & BB GEM Gas System (GEn-P configuration)

Jack Segal's team

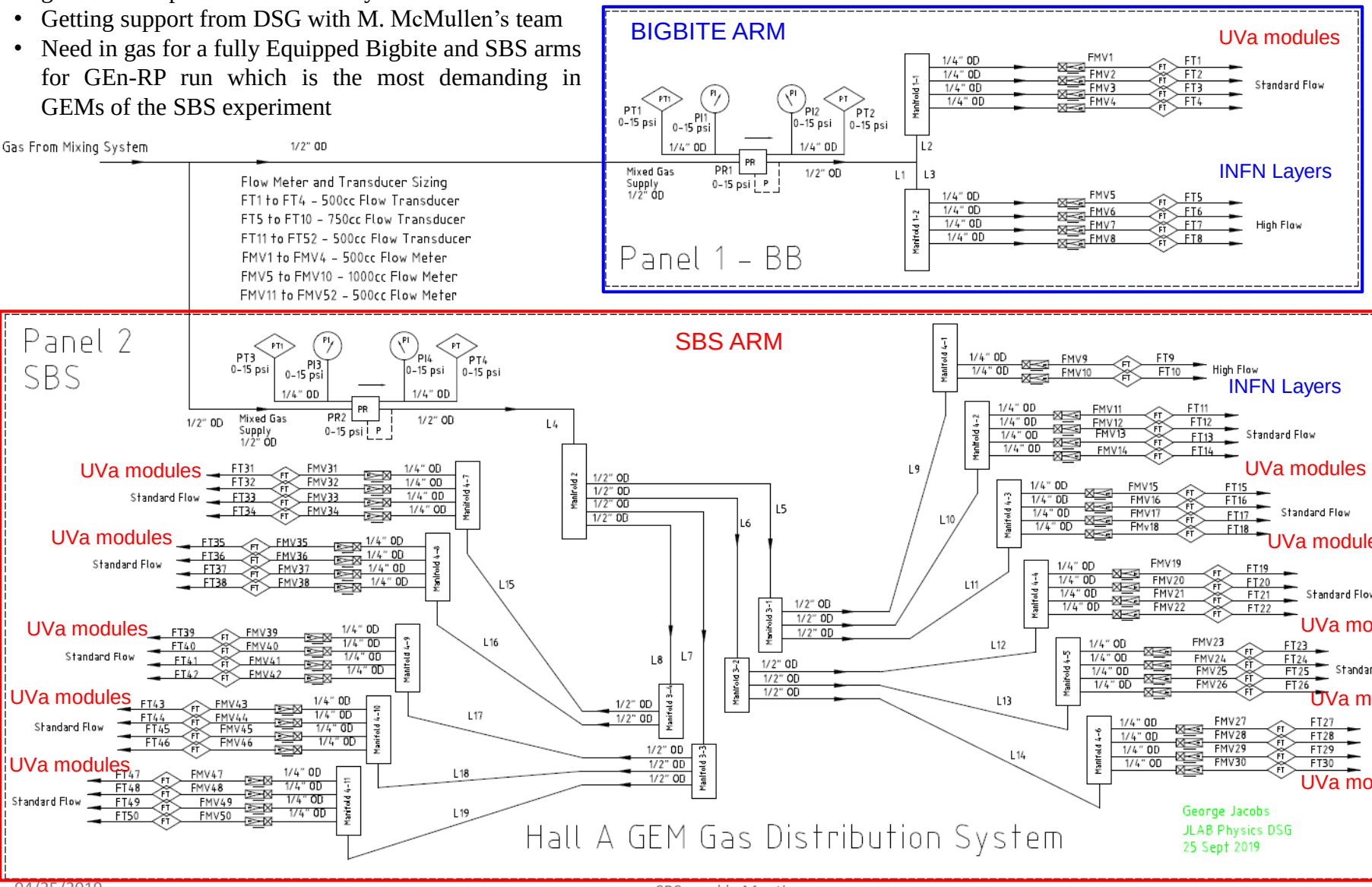
GAS MIXING SYSTEM PARTS

#	Part	Part number	Price/ Unit	Units	Price$
1	Flex Hose Assembly - Armored (3 Foot Long)	6043	187	12	2,244
2	Pressure sensor from Automation Direct	spt25-10-3000a	115	12	1,380
3	Small Pressure Gauge (Brass) (0-3000psig)	SEQ631133	24	12	288
4	200 Series Check Valves 0 to 3000 psig	249B-2PP	57	20	1,140
5	81 Series Dual-Stage General Purpose Regulator - Brass (no inlet fitting) (for the argon)	SEQ81HNI	295	1	295
6	3540 Series Heated Dual-Stage Regulator - Brass (for the CO2)	SEQ3545320	594	1	594
7	2 to 25 LPM Variable Area Flowmeter	Item# 16X855 2510A2A16SVVT	82	2	162
8	2 to 25 LPM Variable Area Flowmeter	Item# 16X856 2510A2A16BNBN	54	1	54
9	Mixing Controller (made by Jack)		3,500	1	3,500
10	Mass Flow Controller Porte(601AV,MFC,NCV,0-5V,1/4CP) + MFC T-Cable adapter(BHT,RS232,T-PAR)*	601AVQAAD22V + 7.03.366	1,775+110=1,885	4 or 3	7,500
11	316L VIM-VAR UHP High Pressure Diaphragm Sealed Valve, 1/4 in. Swagelok Tube Fitting, NC	6LVV-DPHS4-C	323	10	3,230
12	Brass Quarter-Turn Instrument Plug Valve, 1/4 in. Swagelok Tube Fitting, 1.6 Cv	B-4P4T	42	12	502
13	Pneumatic controller (made by Jack)		3,000	1	3,000
14	Mixing air tank (2 gal)	91022	63	1	70
15	Buffer air tank (5 gal)	91050	90	1	100
16	Fastenal Part No. (SKU): 0508510 48" x 44" x 29 White Poly 1200Lb-WLL Bulk Box **	0508510	363	1	363
17	49" x 45" x 3" White Poly Lid **	0508512	89	1	89
18	Fittings, papes				5,000
	Total			**30,000**	

SBS & BB GEM Gas System (GEn-P configuration)

Marc McMullen's team

- The collaboration in charge for the distribution of the gas from the pivot to the GEM layers.
- Getting support from DSG with M. McMullen's team
- Need in gas for a fully Equipped Bigbite and SBS arms for GEn-RP run which is the most demanding in GEMs of the SBS experiment



SBS GEM Gas System

Marc McMullen's team

List of parts to be procure upon validation of the gas distribution scheme

	A	B	C	D	E	F
1	Component	Part#	Description	# of units	Cost per unit	Total Cost
2	PR1 and PR2	McMaster 1888k1	0-15 psi low pressure regulator	2	$94.00	$188.00
3	PI1 to PI4	McMaster 3846k99	0-15 psi gauge	4	$18.13	$72.52
4	PT1 to PT4	626-07-GH-P1-E4-S1	0-15 psig transducer	4	$135.00	$540.00
5						
6	Manifold 1	McMaster 5975k19	1/2 NPT to 6 of 3/8 NPT out (1/2 tube)	1	$33.06	$33.06
7	Panel 1	GUESTIMATE	Holds manifold 1, PR1, PI1-2, PT1-2	1	$100.00	$100.00
8	Manifold 2	McMaster 5975k15	3/8 npt to 5 of 1/4 npt out (FWD)	2	$23.95	$47.90
9	Panel 2	GUESTIMATE	Holds manifold 2, FMV/FT, needle valves	1	$250.00	$250.00
10	Manifold 3	McMaster 5975k36	1/2 npt to 3 of 3/8 npt (2nd and 3rd)	4	$29.28	$117.12
11	Panel 3	GUESTIMATE	Holds manifold 3	1	$100.00	$100.00
12	Manifold 4	McMaster 5975k12	3/8 npt into 4 of 1/4 npt out	12	$21.20	$254.40
13	Panel 4	GUESTIMATE	Holds Manifold 4, FMV and FT	12	$150.00	$1,800.00
14						
15	FMV5 to 10	Dwyer RMA-13-ssv	For the larger volume GEMs	6	$48.00	$288.00
16	FMV1 to 4, FMV11 to 50	Dwyer RMA-12-ssv	GEMs	44	$48.00	$2,112.00
17	1/8 npt to 1/4" push loc	McMaster 5779k108	For FMV connections	120	$3.16	$379.20
18						
19	FT1 t0 4, FT11 to 50	Honeywell Zephyr	0-400 sccm flow transducer	44	$91.66	$4,033.04
20	FT5 to 10	Honeywell Zephyr	0-750 sccm flow transducer	6	$95.36	$572.16
21						$0.00
22	1/4" push lok, bulkhead	McMaster 5779k677	line to GEMs, 17/32" dia hole	58	$5.45	$316.10
23	1/4 npt to 1/2" comp	B-810-1-4	PR1 in and out	2	$13.00	$26.00
24	1/4 npt to 1/4 posh lok	Mcmaster 5779k108	For gauges and transducers	64	$3.16	$202.24
25	1/2" npt plug	McMaster 4464k564	1/2" npt plug	12	$2.70	$32.40
26	1/4 FNPT union	4464k352	gauge and transducer connections	4	$3.83	$15.32
27	1/4 fnpt tee	4464k48	gauge and transducer connections	2	$7.80	$15.60
28	1/4 push lok Tee	5779k34	gauge and transducer connections	2	$4.88	$9.76
29	3/8 npt to 1/2 push lok	McMaster 5779k121	for 1/2" tubing runs	36	$7.80	$280.80
30	3/8 npt plug	McMaster 4464k563	for unused 3/8 npt openings	16	$2.00	$32.00
31	1/4" push lok union	McMaster 5779k14	for flow transducer connections	120	$3.20	$384.00
32	1/2 npt to 1/2 push loc	McMaster 5779k122	1/2" npt to 1/2" push lock	12	$8.20	$98.40
33	1/4" push lok caps	McMaster 5779k473	push lok cap for tubing	24	$2.18	$52.32
34	1/4" push lok plugs	McMaster 5779k54	push lok plug for fitting	24	$1.18	$28.32
35	1/2" push lok 90 deg					
36	1/4" tubing		guestimate of 40 ft per line	2400	$0.48	$1,152.00
37	Tygon 1/4"	1/4" OD x 3/16 ID tygon	guestimate of 0.5 ft per line	25	$0.98	$24.50
38	1/2" tubing		guestimate of 40 ft per line	200	$1.61	$322.00
39	Panel supports			15	$50.00	$750.00
40	misc			1	$1,500.00	$1,500.00
41	labels			1	$450.00	$450.00
42	Readback cables and electronics					$5,000.00
43						
44			FMV System Estimate			$11,973.96
45						
46			FMV plus FT System Estimate			$21,579.16

Summary

UVa GEM assembly and Cosmic Setup in EEL 124 Clean Room

- ⇨ 5 layers assembled and tested ⇨ Everything in place for the 6 remaining layers (all parts and fixes are under control)
- ⇨ From the experience, assembly and tests of the remaining 6 layers can be done within 6 months with the same team
- ⇨ Right now, we are stuck with decoding of data with more than one VME crates within CODA (Mark Jones is to help)

GEM analysis Software Development

- ⇨ Tremendous GEM analysis software development: perform track-based efficiency & spatial resolution analysis.
- ⇨ Demonstration with INFN GEM data ⇨ ~ 85% efficiency (including dead area) and 100 µm spatial resolution measured
- ⇨ Will provide additional data to Andrew from UVa GEM layers for analysis and to test the macros

Update on Front Tracker GEMs with U-V Strip Readout

- ⇨ Design of all parts completed and production of GEMs, R/O and drift foils (CERN) and Frames (RESARM) are ongoing .
  - ⇨ Expect to start receiving the parts by mid February 2020 and start the assembly of the first layer by end of February 2020
- ⇨ Several institutes participated in the payment of the parts for 4 layers to be assembled at UVa
- ⇨ **We should be able to provide two fully tested Front tracker GEM with U-V strips to by July 2020**

GEM Gas System in Hall A for the SBS Experiments

- ⇨ A lot of progress in the designing of the gas distribution system in Hall A for the SBS GEM layers
- ⇨ Jack Segal Team in charge of Ar/CO2 70/30 gas mixture to the pivot in Hall A
- ⇨ DSG group in charge of the distribution of the gas from the pivot to the individuals layers
  - ⇨ Ready to start procurement as soon as they get final approval from the collaboration