

# GEMs Chambers for SBS

K. Gnanvo

SBS Collaboration Meeting

08/06/2019

**UVa:** K. Gnanvo, S.Jian, N. Liyanage, A. Rathnayake

**HU:** M. Kohl, M. Rathnayake, T. Gautam

**INFN:** E.Cisbani, P. Musico, R. Perrino, L. Re

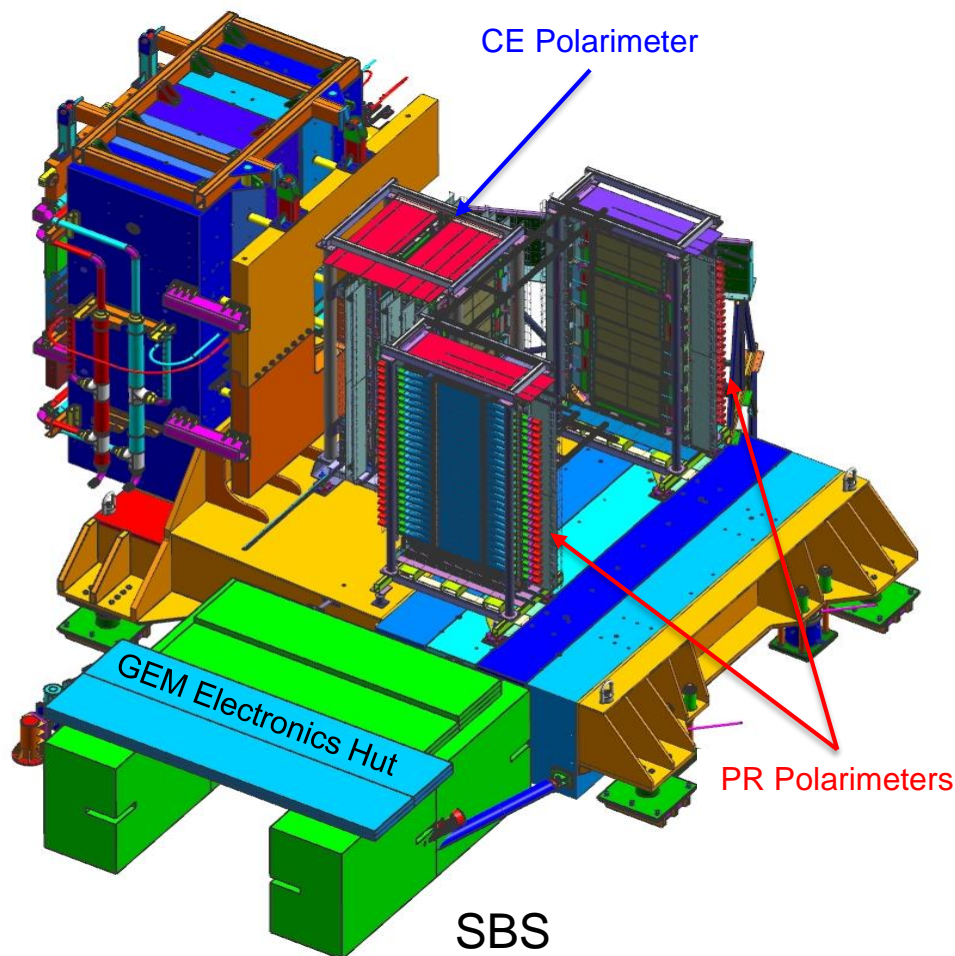
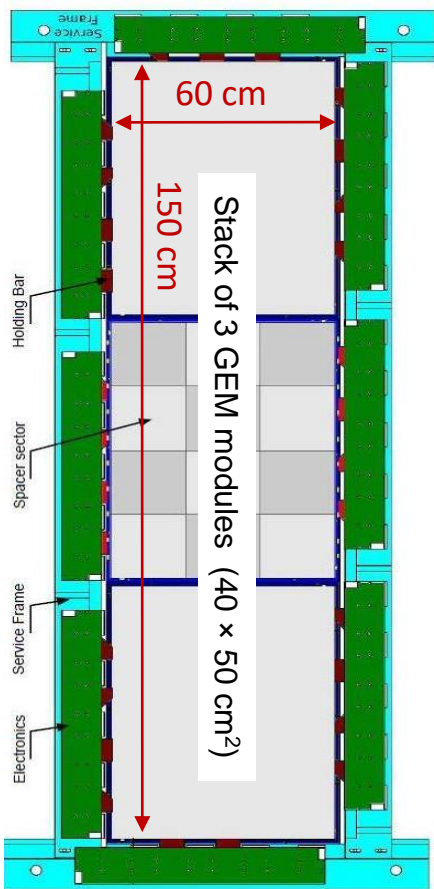
**And many more ....**

- Status of UVa GEMs
  - Production Status
  - Commissioning in EEL Clean Room 124
- Preparation for GMn / GEn-RP Experiments
  - Status of GEM Electronics & DAQ
  - Gas System
- U-V Front Tracker GEMs
  - Design and Procurement
  - Timeline for detector Construction

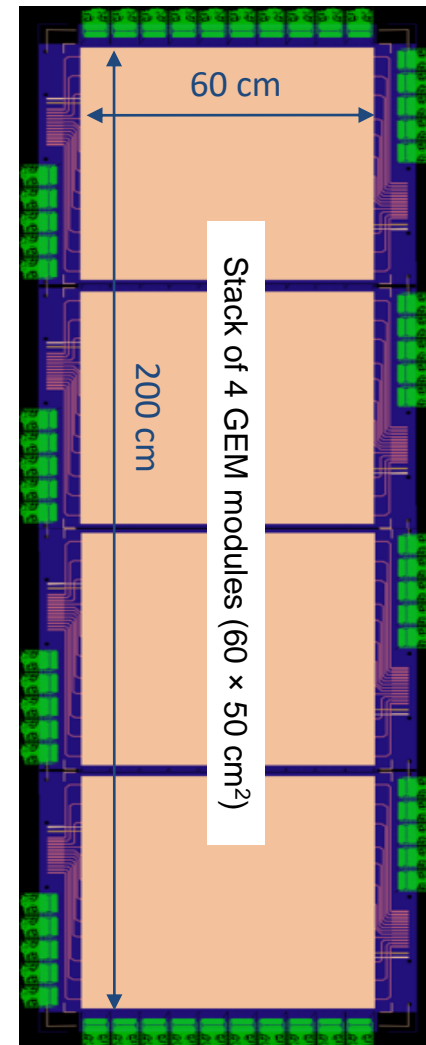
# GEN-RP GEM Trackers in SBS

- 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

## 2 INFN GEM layers



## 10 UVa GEM layers



# Status of UVa GEMs

# UVa GEMs: Summary of UVa GEM Modules

Module 01: ⇒ OK Where: UVa - shelfe Tested at: UVa, known fixes	Module 11: ⇒ OK Where: EEL-124 - shelfe Tested at: UVa, known fixes	Module 21: ⇒ OK Where: Hall A - PREX Tested at: UVa & JLab	Module 31: ⇒ OK Where: EEL-124 - shelfe Tested at: UVa	Module 41: ⇒ OK Where: EEL-124 - shelfe Tested at: UVa
Module 02: ⇒ OK, 1HV out Where: UVa - shelfe Tested at: UVa, known fixes	Module 12: ⇒ OK, 1HV out Where: Hall A - PREX Tested at: UVa & JLab	Module 22: ⇒ OK Where: EEL-124 – Layer#3 Tested at: UVa & JLab	Module 32: ⇒ OK Where: EEL-124 - shelfe Tested at: UVa	Module 42: ⇒ OK Where: EEL-124 – Layer#3 Tested at: UVa & JLab
Module 03: ⇒ OK Where: UVa - shelfe Tested at: UVa, known fixes	Module 13: ⇒ OK Where: EEL-124 – Layer#2 Tested at: UVa & JLab	Module 23: ⇒ OK Where: EEL-124 - shelfe Tested at: UVa	Module 33: ⇒ OK Where: EEL-124 – Layer#1 Tested at: UVa & JLab	Module 43: ⇒ OK Where: EEL-124 - shelfe Tested at: UVa
Module 04: ⇒ OK Where: UVa - shelfe Tested at: UVa, known fixes	Module 14: ⇒ OK Where: Hall A - PREX Tested at: UVa & JLab	Module 24: ⇒ OK Where: UVa - shelfe Tested at: UVa	Module 34: ⇒ Stretch issues Where: UVa - shelfe Tested at: UVa, require fixes	Module 44: ⇒ FAILED Where: UVa - shelfe Tested at: under Investigatio
Module 05: ⇒ Stretch issues Where: UVa - shelfe Tested at: UVa, require fixes	Module 15: ⇒ OK Where: EEL-124 - shelfe Tested at: UVa	Module 25: ⇒ OK Where: EEL-124 – Layer#2 Tested at: UVa & JLab	Module 35: ⇒ OK, 1HV out? Where: EEL-124 - shelfe Tested at: UVa & JLab	Module 45: ⇒ OK Where: EEL-124 – Layer#3 Tested at: UVa & JLab
Module 06: ⇒ Stretch issues Where: UVa - shelfe Tested at: UVa, require fixes	Module 16: ⇒ OK Where: EEL-124 – Layer#1 Tested at: UVa & JLab	Module 26: ⇒ OK Where: Hall A - PREX Tested at: UVa & JLab	Module 36: ⇒ OK Where: EEL-124 - shelfe Tested at: UVa	Module 46: ⇒ OK Where: UVa - shelfe Tested at: UVa
Module 07: ⇒ OK Where: EEL-124 - shelfe Tests: UVa, known fixes	Module 17: ⇒ OK Where: EEL-124 – Layer#2 Tested at: UVa & JLab	Module 27: ⇒ OK Where: EEL-124 - shelfe Tests: UVa	Module 37: ⇒ OK Where: EEL-124 - shelfe Tested at: UVa	Module 47: ⇒ OK Where: EEL-124 – Layer#1 Tested at: UVa & JLab
Module 08: ⇒ OK Where: EEL-124 - shelfe Tested at: UVa, known fixes	Module 18: ⇒ OK Where: Hall A - PREX Tested at: UVa & JLab	Module 28: ⇒ OK Where: Hall A - PREX Tested at: UVa & JLab	Module 38: ⇒ OK Where: EEL-124 - shelfe Tested at: UVa	Module 48: ⇒ OK Where: UVa - shelfe Tested at: UVa
Module 09: ⇒ OK Where: EEL-124 - shelfe Tested at: UVa, known fixes	Module 19: ⇒ OK Where: EEL-124 – Layer#1 Tested at: UVa & JLab	Module 29: ⇒ OK Where: EEL-124 – Layer#3 Tested at: UVa & JLab	Module 39: ⇒ OK Where: EEL-124 - shelfe Tested at: UVa	Module 49: ⇒ Under Test Where: UVa - shelfe Tested at: under test
Module 10: ⇒ OK Where: EEL-124 - shelfe Tested at: UVa, known fixes	Module 20: ⇒ OK Where: EEL-124 – Layer#2 Tested at: UVa & JLab	Module 30: ⇒ OK Where: EEL-124 - shelfe Tested at: UVa	Module 40: ⇒ OK Where: EEL-124 - shelfe Tested at: UVa	Module 50: ⇒ Under assbly Where: UVa – clean room Tested at: Not yet

**First modules:** Require straightforward fixes  
Under control

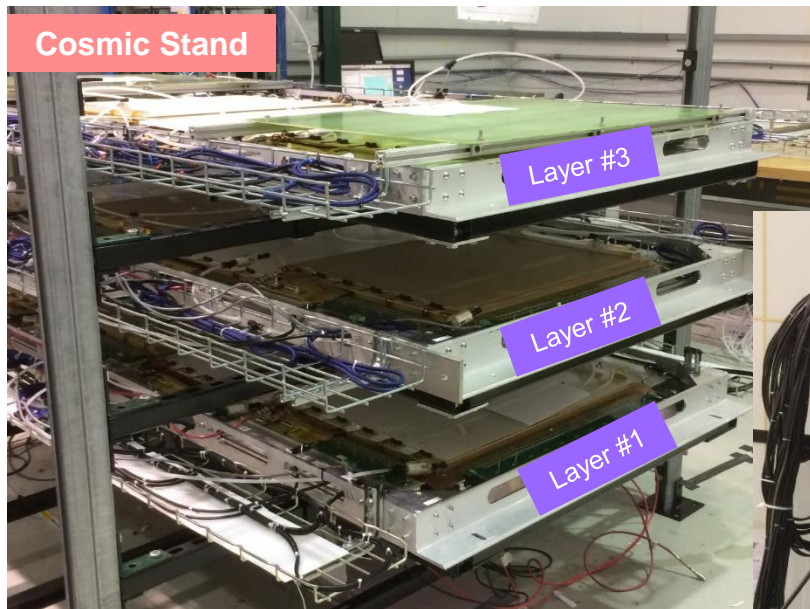
**4 modules:** stretching related HV issues  
Under investigation

**Modules 49 and 50:** Spare modules  
Under construction and tests

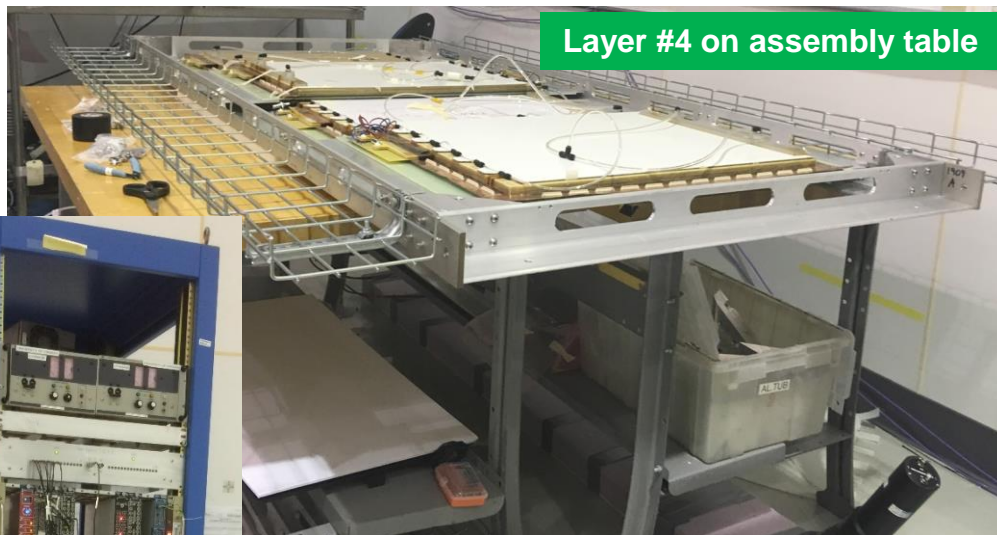


# UVa GEMs: Cosmic Setup in EEL124

Cosmic Stand



Layer #4 on assembly table



Setup for Individual modules test



DAQ and HV Rack



Storage Shelves

# UVa GEMs: Status of Cosmic Setup in EEL124

## ■ Status of the UVa GEM layers assembly

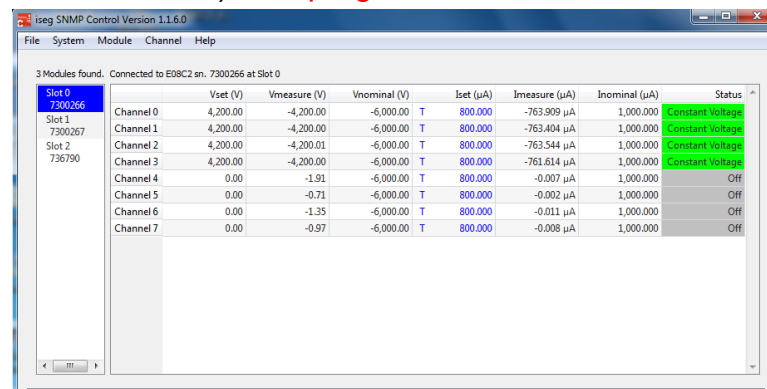
- 3 layers installed on the cosmic stand ⇒ **HV test Ok**
- All work on the 3 layers side (HV, HDMI, Gas tubing, APV25-backplane support) ⇒ **completed**
- Connection to the DAQ / readout system 10m-long HDMI from back planes to MPDs ⇒ **in progress**
- 4<sup>th</sup> layer is currently under assembly on the table ⇒ **Expected to be completed in two weeks**

## ■ Status of APV low voltage power supply

- Use available LV power supply modules (working with C. Cuevas' group)
- Same scheme is under test with UVa GEMs for PREX Trackers in Hall A
- Packaging and other small details (cooling of the voltage regulator, LV cables etc....) ⇒ **in progress**

## ■ Status of HV Power supply for the GEMs

- UVa Wiener crate + 3 HV Mpod modules moved to JLab
- Enough channels for 6 UVa GEM layers
- Already in operation ⇒ used for the test of GEM layer #3



Channel	Vset (V)	Vmeasure (V)	Vnominal (V)	Iset (µA)	Imeasure (µA)	Inominal (µA)	Status
Channel 0	4,200.00	-4,200.00	-6,000.00	T 800,000	-763.909 µA	1,000,000	Constant Voltage
Channel 1	4,200.00	-4,200.00	-6,000.00	T 800,000	-763.404 µA	1,000,000	Constant Voltage
Channel 2	4,200.00	-4,200.01	-6,000.00	T 800,000	-763.544 µA	1,000,000	Constant Voltage
Channel 3	4,200.00	-4,200.00	-6,000.00	T 800,000	-761.614 µA	1,000,000	Constant Voltage
Channel 4	0.00	-1.91	-6,000.00	T 800,000	-0.007 µA	1,000,000	Off
Channel 5	0.00	-0.71	-6,000.00	T 800,000	-0.002 µA	1,000,000	Off
Channel 6	0.00	-1.35	-6,000.00	T 800,000	-0.011 µA	1,000,000	Off
Channel 7	0.00	-0.97	-6,000.00	T 800,000	-0.008 µA	1,000,000	Off

## ■ Status of HDMI cables

- Short to Long compatibility tests ⇒ **Done**
- Procurement of HDMI cables (long and short) ⇒ **Done** (Need some place for storage of the cable boxes)
- Cabling of the 3 assembled layers with long HDMI ⇒ **Ongoing**

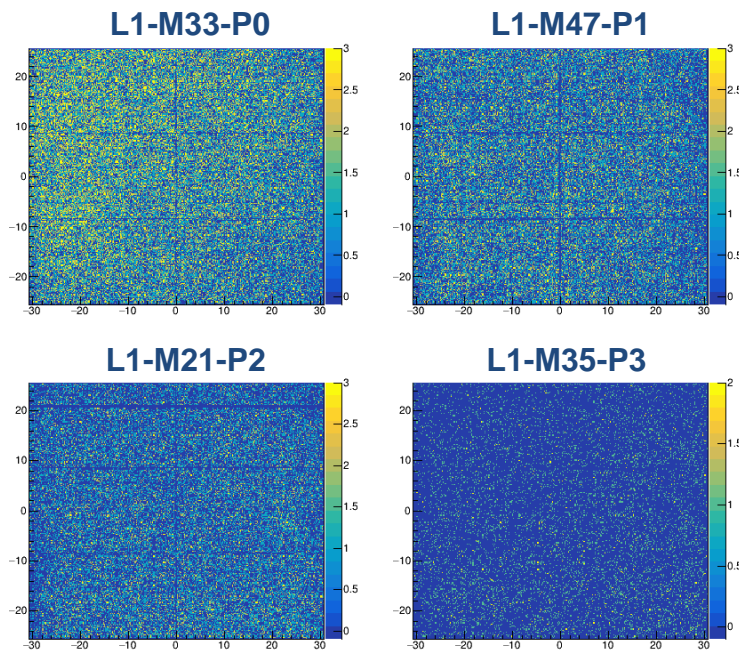
## ■ Trigger Counters

- Use 4 long (> 2.5 m) counters in store in ESB ⇒ thanks Bogdan
- Need help from Jessie to move them ⇒ **ideally next week**
- Bogdan offers to help fixing light guides and voltage dividers ⇒ **ideally in the next 2 weeks**



# UVa GEMs: MPD readout / DAQ setup in EEL124

- **77 MPD modules for all 11 UVa GEM layers in hand**
  - UVa: 58 “original” + 3 new, Glasgow U.: 11 new , JLab: 5 new
  - “Original” modules needed some I2C hardware fixes  $\Rightarrow$  39 already fixed and tested with latest firmware and libraries (Brian Moffit)
  - <https://docs.google.com/spreadsheets/d/1r4riWfe9C7jSSWQ1xkkCZngdpKBAs1grYjP15RH3Jm0/edit#gid=1565304014>
  - A few MPDs have some issues  $\Rightarrow$  Paolo will look at the issue in September
- **Status of the other MPD readout / and DAQ items:**
  - All APV25 needed for UVa GEMs in hand (900 from UVa and 100 from HU)
  - JLab MPD trigger and clock modules in use in Testlab and EEL setups
  - Will make full inventory of low cost items like back planes
- **Set up the DAQ for cosmic stand (Support from Bryan Moffit)**
  - Set up and configure the DAQ for 1 layer with Bryan  $\Rightarrow$  ideally start this week
  - Latest version of firmware, libraries, configuration tools etc.
  - Setup all 3 layers  $\Rightarrow$  Need a second VME crate, ideally by the following next two weeks (mid august)
  - **Plan: Start cosmic data with all 3 layers by mid August**

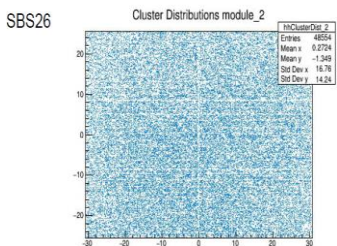
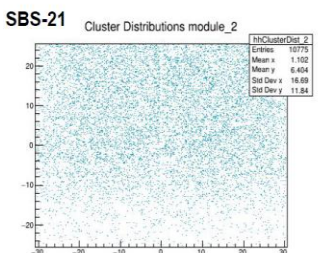
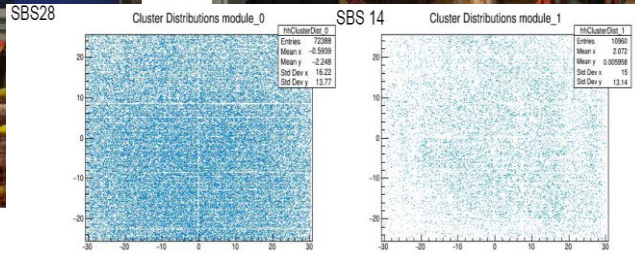
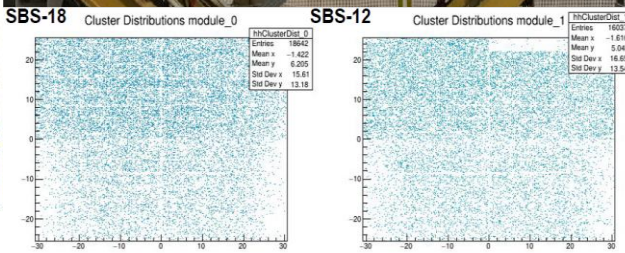
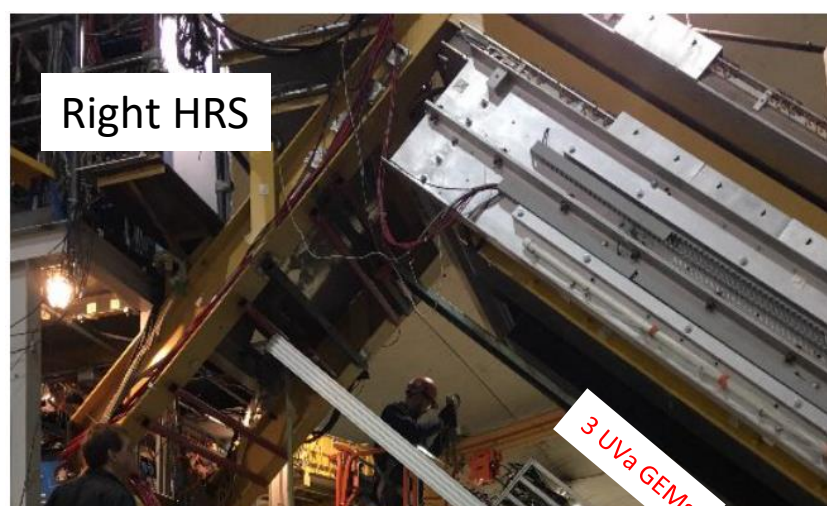


Hit map plot of the cosmic test of the 4 modules of layer#1



# UVa GEMs: In both HRS spectrometer for PREX

- Modules #12, 14, 18, 21, 26, 28
- First use of SBS GEM in an actual experiment at JLab: Excellent opportunity for commissioning and validation of the chambers
- The modules were all tested with cosmic before installation but Help us define the operation working point later for GEn-RP



Ar-CO2 : 75:25  
HV : 3900 and 3950

Cosmic tests

Cosmic tests

# Preparation for GMn / GEn-RP Experiments

# Integration of UVa GEM layer into BB (GMn)

	2019					2020										2021					
	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A
-- Main SBS/BB Timeline --																					
Full Cosmic Testing Underway, all components with final DAQ																					
Start preparation for movement of equipment in Hall A																					
Installation of SBS starts (pending CREX de-installation)																					
Detectors move to the Hall A																					
Detector commissioning in final location																					
First beam to the GMn experiment																					
-- GEM Front Tracker installation in BigBite --																					
Ship to JLab latest tested GEM modules (exp. 4)	X																				
Fix shorted sectors showed up in June/2019 (replace modules), and test new configuration	X																				
Load BigBite Frame with the 4 tested chambers		X																			
Install loaded BigBite Frame into the BB spectrometer, cable and pipe chambers		X																			
Install BB UVa Layers (Sep. 2 <sup>nd</sup> and 3 <sup>rd</sup> weeks)		X																			
Test overall setup of Front Tracker			X																		
Test BigBite DAQ (including GEM readout)			X	X																	
Participate in cosmic testing of all components					X	X	X														
Support moving BB to Hall A								X	X	X											
Support installation in Hall A									X	X	X										
Support commissioning in Hall A													X	X	X	X	X	X	X		
Support operation of experiment																				X	X

UVa layers

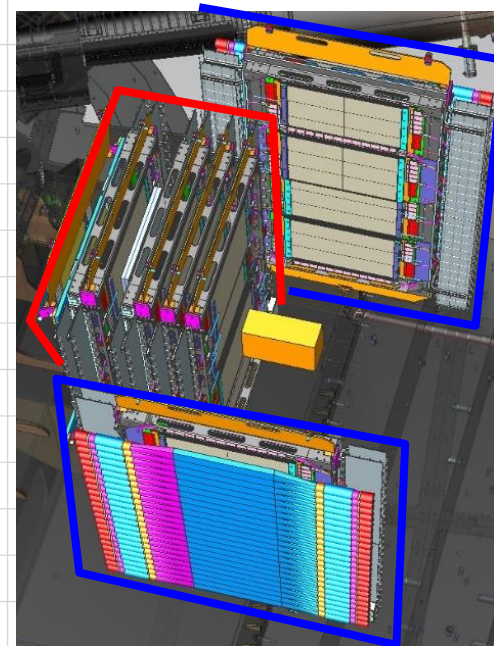
- Ideally UVa GEM for BB can be installed in Sept week #2 or #3 ⇒ Pretty straight forward,
- If well coordinated with Doug and Jessie's crew ..., one week is more than enough for the installation in BB



# Integration of UVa GEM layers into SBS (GEn-RP)

To Do List (next 12 Months)	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Manpower
layer #1, #2 and #3 on cosmic stand	Current status												
Layer #3: Assembly / Cosmic Tests	Assemble	Test											KG, AR, MR, TG (NL & MK)
Layer #4: Assembly / Cosmic Tests		Ass.	Test										KG, AR, MR, TG (NL & MK)
Layer #4 in BB			BB										KG, AR, MR, TG (NL & MK)
Layer #5: Assembly / Cosmic Tests			Ass.	Test									KG, AR, MR, TG (NL & MK)
Layer #3 & #5 in Gen-RP Ch. Ex Pol.					Ch. Ex.								KG, AR, MR, TG (NL & MK)
Layer #6: Assembly / Cosmic Tests				Ass.	Test								KG, AR, MR, TG (NL & MK)
Layer #7: Assembly / Cosmic Tests					Ass.	Test							KG, AR, MR, TG (NL & MK)
Layer #6 & #7 in Gen-RP Ch. Ex Pol.							Ch. Ex.						KG, AR, MR, TG (NL & MK)
Layer #8: Assembly / Cosmic Tests						Ass.	Test						KG, AR, MR, TG (NL & MK)
Layer #9: Assembly / Cosmic Tests							Ass.	Test					KG, AR, MR, TG (NL & MK)
Layer #8 & #9 in Gen-RP Ch. Ex Pol.									Ch. Ex.				KG, AR, MR, TG (NL & MK)
Layer #10: Assembly / Cosmic Tests								Ass.	Test				KG, AR, MR, TG (NL & MK)
Layer #11: Assembly / Cosmic Tests									Ass.	Test			KG, AR, MR, TG (NL & MK)
Layer #8 & #9 in Gen-RP Proton Pol.											PP		KG, AR, MR, TG (NL & MK)
Layer #1: Re-Assembly / Cosmic Tests										Ass.	Test		KG, AR, MR, TG (NL & MK)
Layer #2: Re-Assembly / Cosmic Tests											Ass.	Test	KG, AR, MR, TG (NL & MK)
Layer #8 & #9 in Gen-RP Proton Pol.												PP	KG, AR, MR, TG (NL & MK)

INFN layers



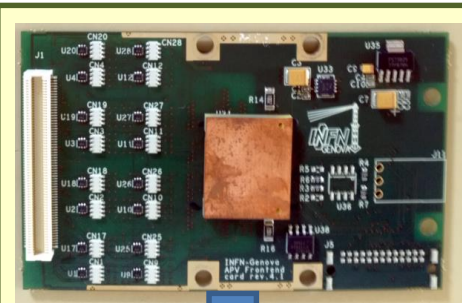
- INFN layers for in Ch. Ex frame (anytime between January and June 2020)
- Likely, first layer in February 2020
- Second INFN layer, if available for in Ch. Ex frame (after April 2020)



# Integration of UVa GEM layers into SBS (GEn-RP)

Items	People	Completion target
UVa GEM: Assembly of 10 layers	<u>Gnanvo</u> , <b>A. Rathnayake</b> , <b>M. Rathnayake</b> , (Liyanage, Kohl)	Spring 2020 (see slide 8)
UVa GEMs: Readout and DAQ for commissioning	Gnanvo, <b>T. Gautam (50%)</b> , (Liyanage, Kohl)	Spring 2020
UVa GEMs: Commissioning with cosmic	<u>Gnanvo</u> , <b>A. Rathnayake</b> , <b>M. Rathnayake</b> , <b>T. Gautam</b> , (Liyanage, Kohl)	Spring 2020 (see slide 8)
UVa GEMs: Installation of 6 GEMs in central frame (CE Polarimeter)	<u>Gnanvo</u> , <b>Kohl</b> , et al., & With support from Hall A Technicians	Feb 2020 (see slide 8)
UVa GEMs: Installation of GEMs in side frames (Recoil Proton Polarimeter)	<u>Gnanvo</u> , <b>Kohl</b> , et al., & With support from Hall A Technicians	May 2020 (see slide 8)
<b>INFN GEMs</b> : Assembly and Commissioning of 2 layers + electronics	<b>Cisbani</b> , et al., <u>Gnanvo</u> , (Liyanage, Kohl)	Fall / Winter 2019
<b>INFN GEMs</b> : Installation in in central frame (Charged Veto detectors)	<u>Gnanvo</u> , <b>M. Kohl</b> , et al., Cisbani, & With support from Hall A Technicians	Spring 2020

# SBS GEM Electronics for Gen-RP



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

	Channels	APV25	MPDs
Front Tracker	14000	108	8
Rear Tracker	110000	880	70

MPD  
(INFN)



## MPD Main

Arriga GX FPGA  
128 MB DDR2-RAM  
Firmware V4.0  
(74% resourcesBlock):  
# FIR Filter (16 param)  
# Zero Suppression  
# Common mode and pedestal subtraction  
# Remote config,  
#  $\approx 2$  ns trigger time resolution

MPD-SSP  
Interface

SSP-  
Protocol

Aurora  
Protocol

Optical  
Fiber

MPD-  
VME  
Interface

VME-  
Protocols

2eSST

2eVME

VME32 ...

VXS

VME (64x)



SSP

Electronics is up and running (or will be shortly) on

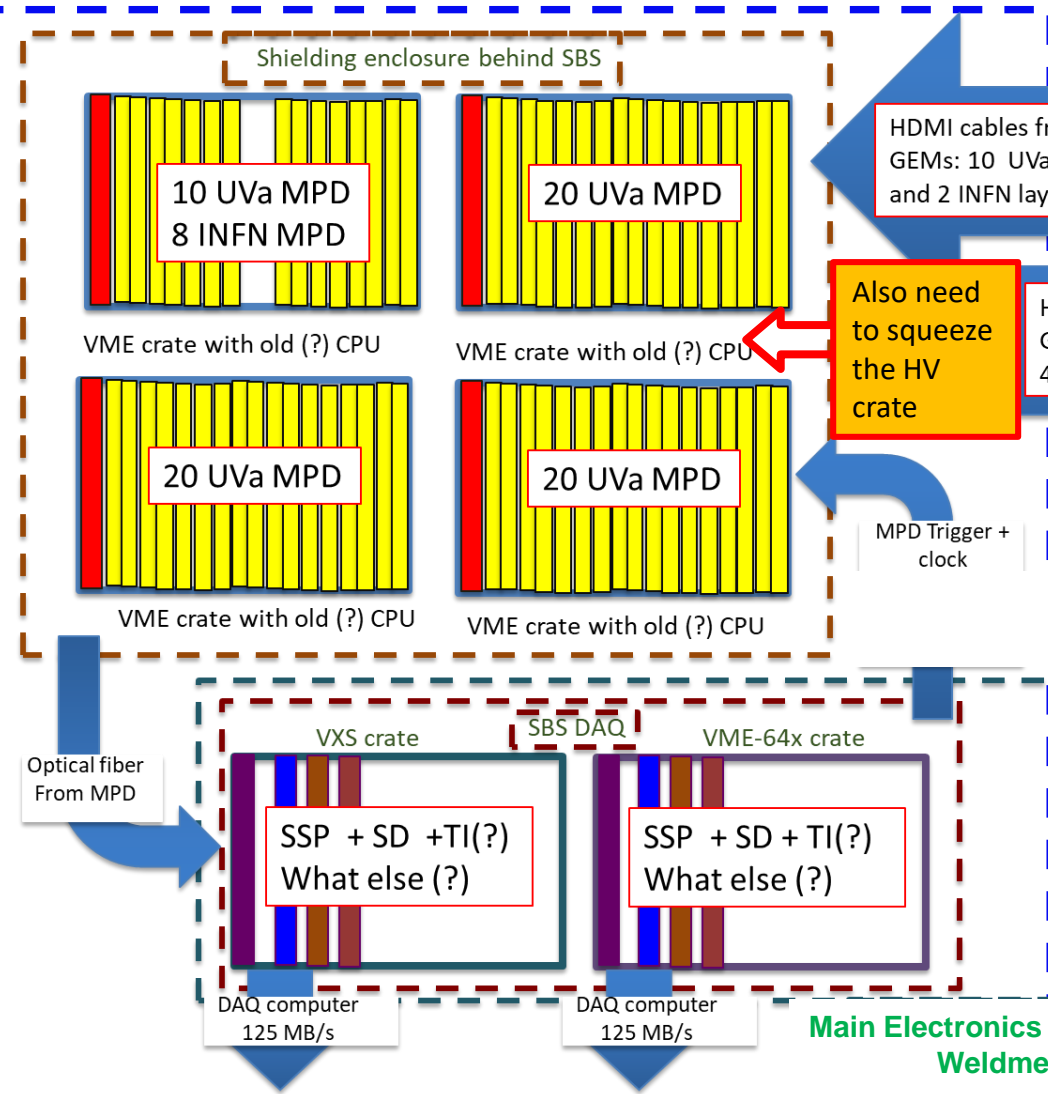
- Front-GEM cosmic test in VME mode
- **SSP mode in Rear GEM cosmic test**
- **PREX UVa GEM**



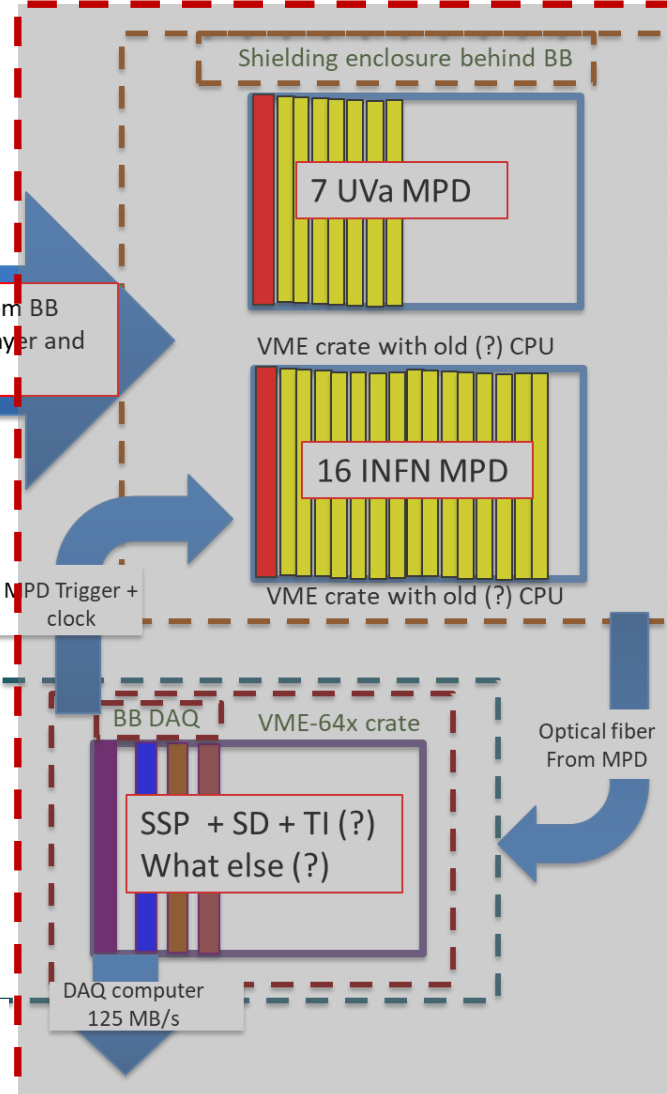
VME Master  
(Intel SBC)

# SBS GEM Electronics for Gen-RP

## GEM Electronics Hut in SBS Arm



## GEM Electronics Hut in BB Arm



## Main Electronics Hut in DAQ Weldment

- JLab custom device to distribute the clock & trigger to the MPD from the SSP instead of the Phillips 757 modules to save money
- Statements yesterday that these modules have 16 inputs, we would need 20 inputs according to this scheme

# Status of SBS GEM Electronics (for GEn-RP arm)

Items for	Need	In hand (total)	Spares
MPDs (UVa GEMs)	70	yes	~2
APV25 FE Cards (UVa GEMs)	880	yes	yes (A few)
12-slots backplane (UVa GEMs)	40	42	Not yet
5-slots backplane (UVa GEMs)	80	82	Not yet
MPDs (INFN GEMs)	8	yes	A few
APV25 FE Cards (INFN GEMs)	108	yes	yes
Backplanes (INFN GEMs)	Flex: 6 Rigid: 18	yes	yes



# SBS GEM Electronics - components

Item	Status
3 SSP modules	3 in hand: 2 with UVa, 1 with Paolo (Italy) 4th (for BB) identified to be in Ben's hand in Hall A
3 VME64x / VXS (for SSP, TI ...)	3 <b>VXS</b> crate ordered (Alex) – How about the 4th (for BB)?
4 VME crate (no master) for MPDs	6 in hand for SBS and BB (Alex) + 3 more in RHRS as spares
TI – Trigger supervisor	Available (Alex) + spares
Master VME (for SSP and TI)	12 ordered (Alex)
Trigger / clock fan-out (78 channels)	JLab custom boards (under test in EEL and Test lab)
1 VME minicrate for slow control + Master	Available (Alex) Do we use the same for BB?
Short HDMI cables (+ spares) : connected to the GEMs	In hand (in EEL 124)
Long HDMI cables (374 + 14 spares): to the MPDs	In hand (in EEL 125 ⇒ Could it be store in EEL 126?)
78 Optical fiber MPD – SSP connection and transceivers	30 optic fibers and 150 transceivers ordered (Alex)
2 × 78 (+ 1) NIM cables trigger and clock distribution	To be identified / procured (1 from SBS GEM hut to electronic hut)
46 x HV cables (15 m?, 55 m? ... )	To be produced / provided at JLab
6 x LV cables pairs (15 m?)	To be identified / procured
HV power supplies for 46 channels (40 UVa GEMs + 6 INFN GEMs)	In hand: 1 Wiener crate & 6 HV modules (8 ch. each) => 42 channels To be procured: 1 spare crate + at least one more HV module
LV power supply	Available at Jlab, Currently used / tested in cosmic (+spare)
SBS GEMs Electronic Hut	JLab Engineering - (R. Wines talk)

# Gas System for SBS & BB GEMs

**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  $5 \times 3.4 \text{ L} = 17 \text{ L / h}$  and INFN module  $5 \times 2.4 \text{ L} = 12 \text{ L / h}$
- ⇒ 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 CO<sub>2</sub>

**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 1/2-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

# Gas System SBS / BB GEMs

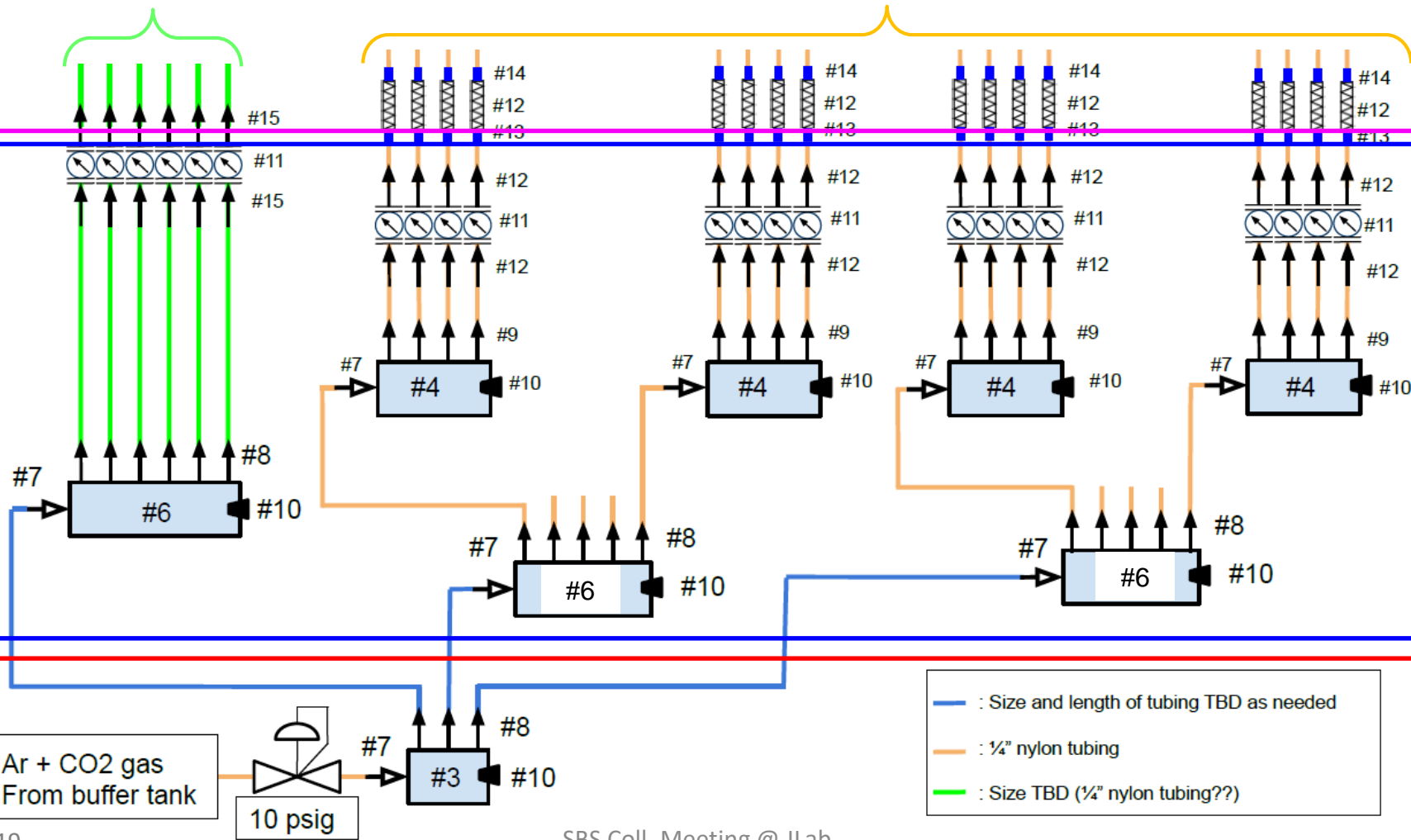
(John Boyd, UVa)

## 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

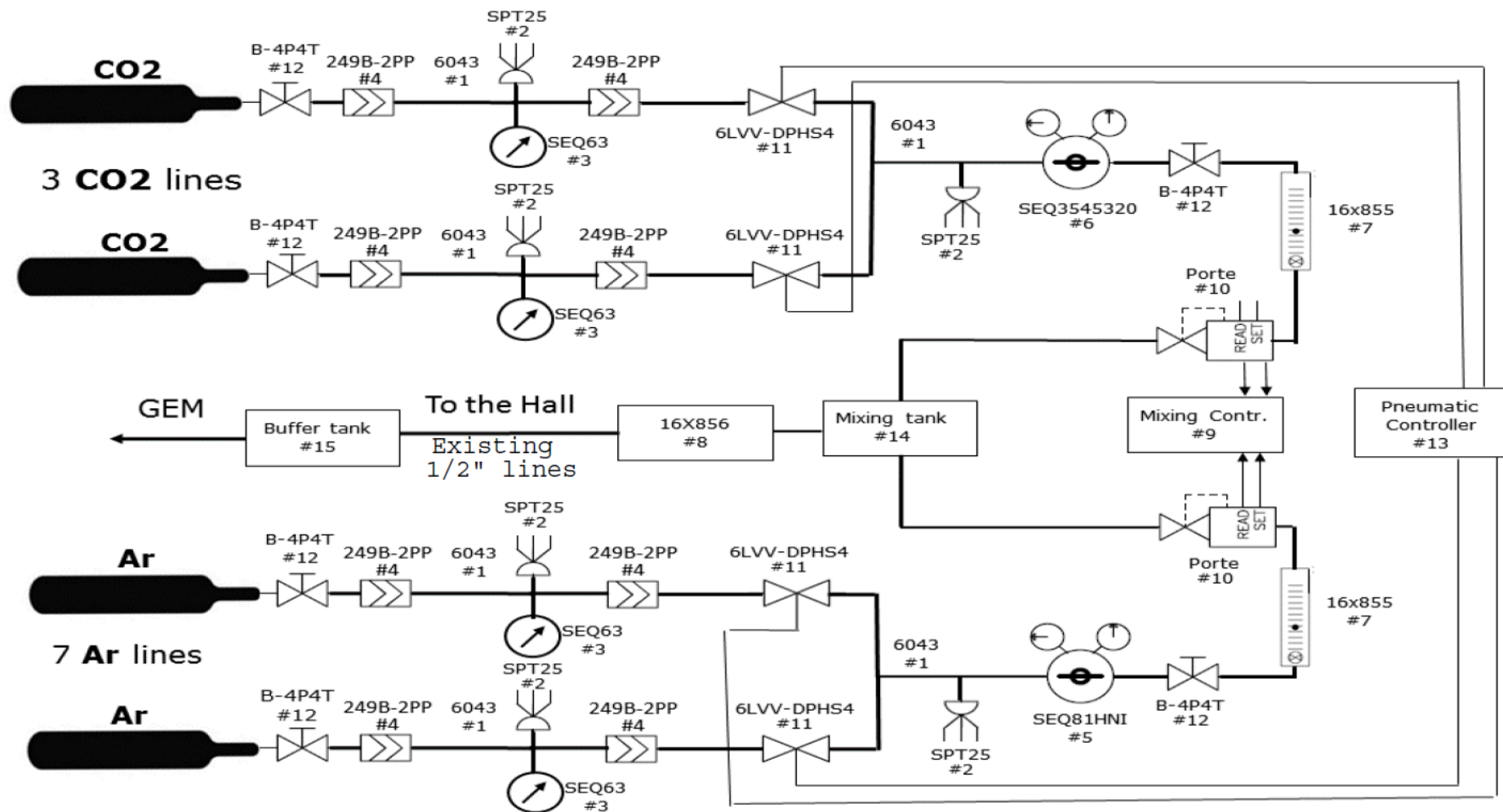
- 4 lines to the BB spectrometer
- 40 lines in the SBS arm for Gen-RP



# Hall A GEM Gas Mixing

(J. Segal)

## GAS MIXING SYSTEM





# Hall A GEM Gas Mixing Cost Estimate

(J. Segal)

## ***GAS MIXING SYSTEM PARTS***

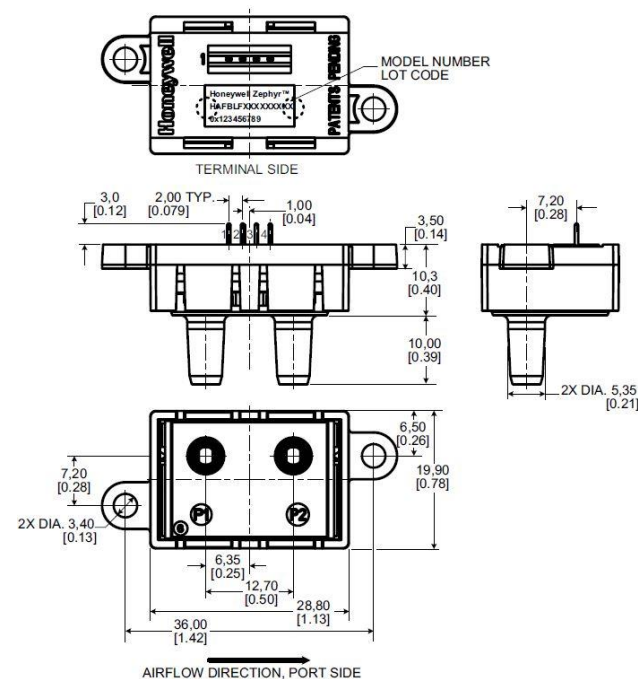
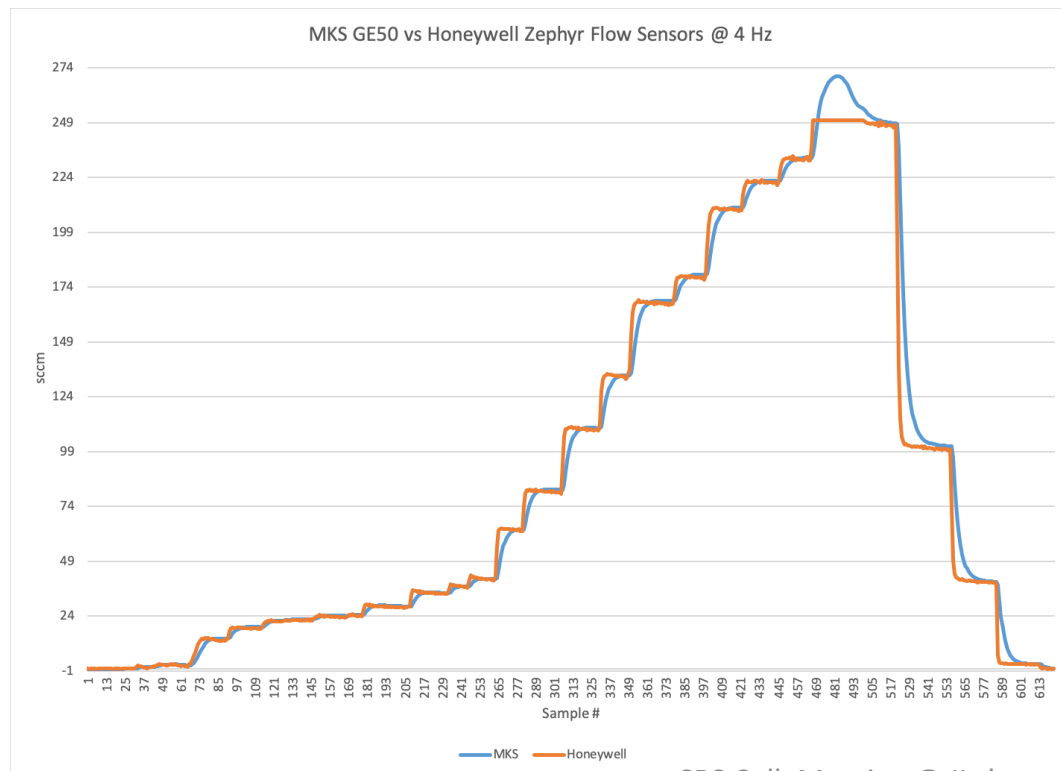
#	Part	Part number	Price/ Unit	Units	Price\$
1	Flex Hose Assembly - Armored (3 Foot Long)	6043	187	12	2,244
2	Pressure sensor from Automation Direct	spt25-10-3000a	115	12	1,380
3	Small Pressure Gauge (Brass) (0-3000psig)	SEQ631133	24	12	288
4	200 Series Check Valves 0 to 3000 psig	249B-2PP	57	20	1,140
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
	<b>Total</b>			<b>30,000</b>	



# Hall A GEM Gas: Flow Control and Monitoring

(Marc McMullen, DSG)

- Hall A requires monitored flow for all distribution circuits (48).
- DSG has identified a viable option on market to measure mass flow and provide an output signal that can be monitored and used in EPICS for alarms.
  - DSG design will include individual manual valves for each line.



# Hall A GEM Gas Cost Estimate

(Marc McMullen, DSG)

- DSG will design and build the Hall A gas distribution system
  - SBS/BB gas distribution has multiple configurations. Gas distribution system will need to be designed to support changes.
  - This will include flow control and remote monitoring for each GEM module.
- DSG is developing cost list for material and equipment.
- Flow sensors have arrived and are being tested.

Component	Part#	Description	# of units	Cost per unit	Total Cost
PR1	McMaster 1888k1	0-15 psi low pressure regulator	1	\$94.00	\$94.00
PI1	McMaster 3846k99	0-15 psi gauge on PR1 out	2	\$18.13	\$36.26
PT1	626-07-GH-P1-E4-S1	0-15 psig transducer	2	\$135.00	\$270.00
Manifold 1	McMaster 5975k19	1/2 NPT to 6 of 3/8 NPT out (1/2 tube)	1	\$33.06	\$33.06
Panel 1	GUESTIMATE	Holds manifold 1, PR1, PI1-2, PT1-2	1	\$100.00	\$100.00
Manifold 2	McMaster 5975k15	3/8 npt to 5 of 1/4 npt out (FWD)	2	\$23.95	\$47.90
Panel 2	GUESTIMATE	Holds manifold 2, FMV/FT, needle valves	1	\$250.00	\$250.00
Manifold 3	McMaster 5975k36	1/2 npt to 3 of 3/8 npt (2nd and 3rd)	4	\$29.28	\$117.12
Panel 3	GUESTIMATE	Holds manifold 3	1	\$100.00	\$100.00
Manifold 4	McMaster 5975k12	3/8 npt into 4 of 1/4 npt out	12	\$21.20	\$254.40
Panel 4	GUESTIMATE	Holds Manifold 4, FMV and FT	12	\$150.00	\$1,800.00
FMV1 to 10	Dwyer RMA-13-ssv	For the larger volume GEMs	10	\$48.00	\$480.00
FMV11 to 58	Dwyer RMA-12-ssv	GEMs	48	\$48.00	\$2,304.00
1/8 npt to 1/4" push loc	McMaster 5779k108	For FMV connections	120	\$3.16	\$379.20
FT11 to 58	Honeywell Zephyr	0-400 sccm flow transducer	48	\$91.66	\$4,399.68
FT1 to 10	Honeywell Zephyr	0-750 sccm flow transducer	10	\$95.36	\$953.60
1/4 npt to 1/2" comp	B-810-1-4	PR1 in and out	2	\$13.00	\$26.00
1/4 npt to 1/4 push lok	McMaster 5779k108	For gauges and transducers	64	\$3.16	\$202.24
1/2" npt plug	McMaster 4464k564	1/2" npt plug	12	\$2.70	\$32.40
1/4 FNPT union	5078k92	gauge and transducer connections	4	\$1.50	\$6.00
1/4 push lok Tee	5779k34	gauge and transducer connections	2	\$4.88	\$9.76
3/8 npt to 1/2 push lok	McMaster 5779k121	for 1/2" tubing runs	36	\$7.80	\$280.80
3/8 npt plug	McMaster 4464k563	for unused 3/8 npt openings	16	\$2.00	\$32.00
1/4" push lok union	McMaster 5779k14	for flow transducer connections	120	\$3.20	\$384.00
1/2 npt to 1/2 push loc	McMaster 5779k122	1/2" npt to 1/2" push lock	12	\$8.20	\$98.40
1/4" push lok caps	McMaster 5779k473	push lok cap for tubing	24	\$2.18	\$52.32
1/4" push lok plugs	McMaster 5779k54	push lok plug for fitting	24	\$1.18	\$28.32
1/4" tubing		guestimate of 40 ft per line	2400	\$0.48	\$1,152.00
Tygon 1/4"	1/4" OD x 3/16 ID tygon	guestimate of 0.5 ft per line	25	\$0.98	\$24.50
1/2" tubing		guestimate of 40 ft per line	200	\$1.61	\$322.00
Panel supports			15	\$50.00	\$750.00
misc			1	0	\$1,500.00
labels			1	\$450.00	\$450.00
Readback cables and electronics					\$5,000.00
		FMV System Estimate			\$11,616.68
		FMV plus FT System Estimate			\$21,969.96



# Front Tracker U-V GEMs

# Front Trackers GEM with U-V strips readout

## Motivation:

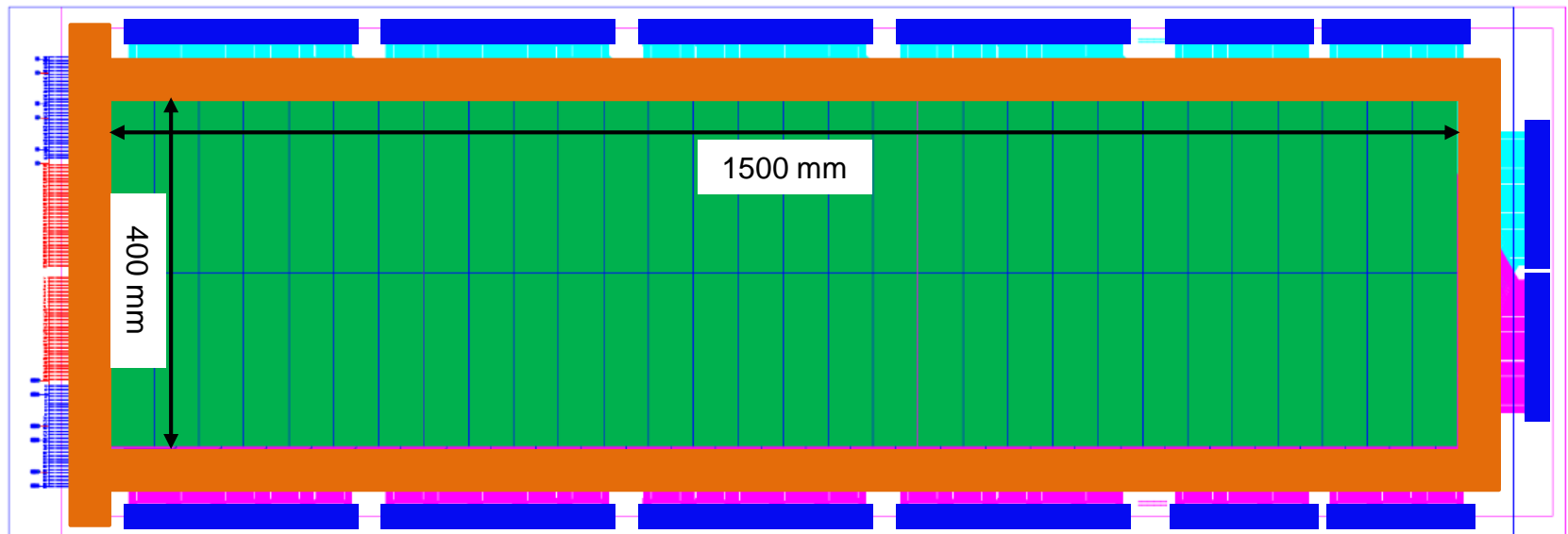
- ⇒ The U-V GEM modules to complement the INFN Front Tracker GEM Layers which use COMPASS 2D cartesian strip readouts.
- ⇒ The addition of U-V geometry enhances and complements the X-Y strips and will help with tracking in the high rate environment.

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

- ⇒ New GEM foil technology allows for this new FT U-V GEM layer to be **one single large module**
- ⇒ **No dead area** from support frames or electronics (Other than for the frame spacers and HV sector boundaries)
- ⇒ 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

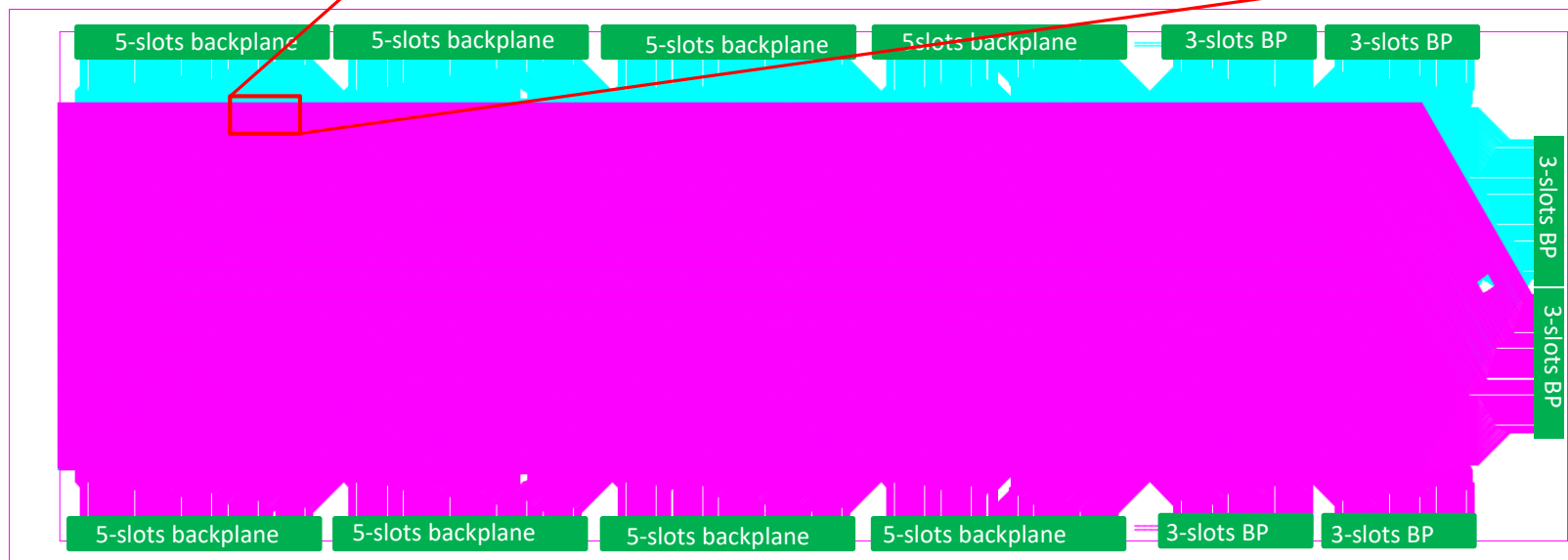
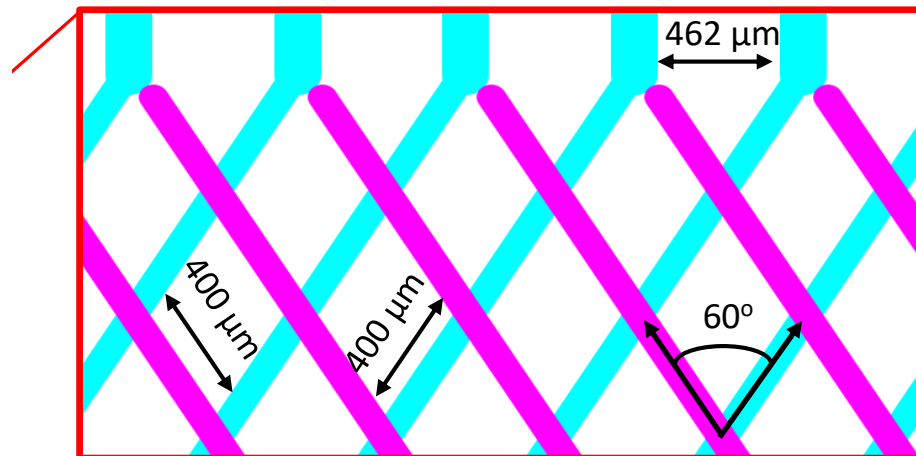
- ⇒ Large GEM with PRad Experiment (June 2016 in Hall B), similar size ⇒ but PRad **more far challenging** to build
- ⇒ U-V strip readouts with large U-V GEM prototypes for the EIC Forward GEM Trackers Detector R&D



# Front Tracker U-V GEMs: 2D readout with U-V strips

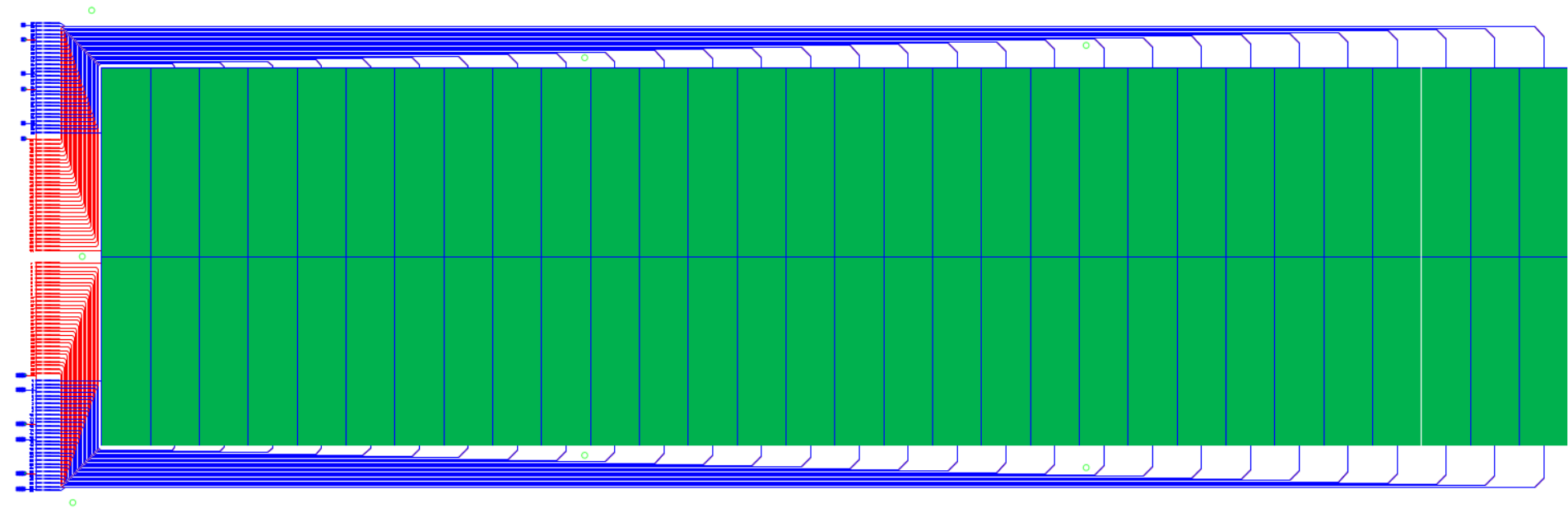
## U-V Strip readout design:

- ⇒ U and V pitch of **400  $\mu\text{m}$** , Vertical pitch: **462  $\mu\text{m}$**
- ⇒ top (U-) strip: **80  $\mu\text{m}$**
- ⇒ bottom strips: **350  $\mu\text{m}$**
- ⇒ About 7k e- channels per layer
- ❖ Will rearrange connectors on the detector to have 4-slots only
- ❖ Avoid HDMI 5<sup>th</sup> data lines & reduced number of HDMI cable



# Front Tracker U-V GEMs: GEM foil Design

- ⇒ GEM foil will have segmentation on both side unlike previous large GEM chambers where only top Cu-electrode were segmented
  - ⇒ A short sector during operation **would not make the whole layer inoperable** ⇒ but only dead sector
  - ⇒ Limited voltage drop in the divider at high particle rate



# Front Tracker U-V GEMs: GEM Support Frame

(John Boyd, UVa, see poster)

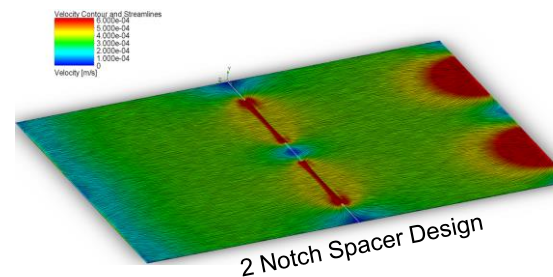
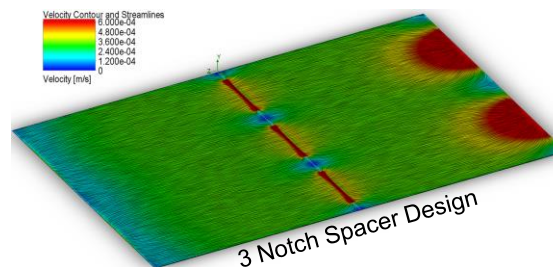
## Design:

- ⇒ 7 frames constructed of Permaglass high-pressure fiberglass laminate
- ⇒ 6 frames have spacers which are 500  $\mu\text{m}$  thick to provide uniform gap stability while also minimizing dead area.
- ⇒ Some spacers have notches in them to provide proper gas flow between different sectors.
- ⇒ Designed with a wide outer frame for added rigidity and support when fully assembled.

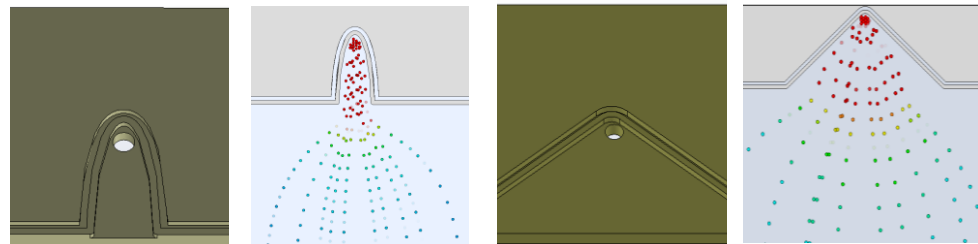
## Flow Simulation:

CFD simulations and calculations performed to determine the best design for optimal gas distribution through the chamber.

### Optimization of Gas inlet

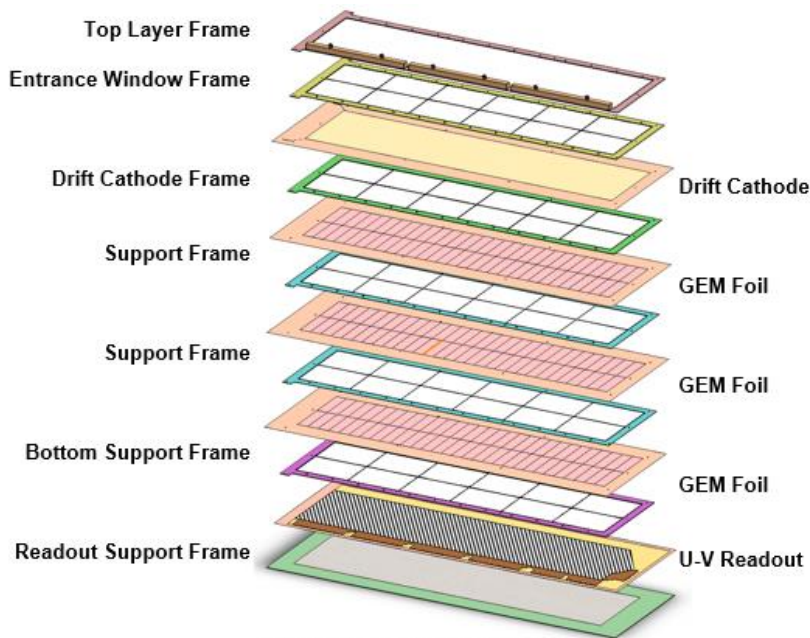


### Optimization of Spacer (notch) Design



Previous Gas Inlet design

New Gas Inlet design





# Front Tracker U-V GEMs: Production Timeline

## ⇒ GEM and Readout foils (CERN)

- Design of GEM foil and R/O almost completed
- To do: Finalize the design ⇒ few more details to hash out and check compatibility with support frames design
- Green light CERN for production (**min ~ 6 Months expected**)

## ⇒ GEM frames (RESARM Belgium)

- Communication with RESARM ⇒ No problem fabricating frame of this size
- To do: Finalize the frame design and check compatibility with GEM foils
- Green light CERN for production (**min ~ 3 Months expected**)

## ⇒ Timeline of the two U-V GEM chambers assembly at UVa

- Foil Stretcher (Tooling and Clean Room Equipment): (**12/2019**)
- Two chambers Fabrication: (**end 06/2020**)
- Testing & delivery to JLab: (**end 07/2020**)

# Front Tracker U-V GEMs: Contributing Institutes

⇒ **8 GEM foils (CERN)** ⇒ total cost of CHF 14,400

⇒ North Carolina Central University (Branko Vlahovic)

⇒ **2 U-V readout foil (CERN)** ⇒ total cost of CHF 5,100 each

⇒ One by University of Connecticut (Andrew Pucket)

⇒ One by Glasgow University (David Hamilton)

⇒ **Layout and Tooling (CERN)** ⇒ total cost of CHF 4,400

⇒ Saint Mary's University (Adam Sarty)

⇒ **Support Frames (RESARM, Belgium)** ⇒ Cost ? (waiting for a quote)

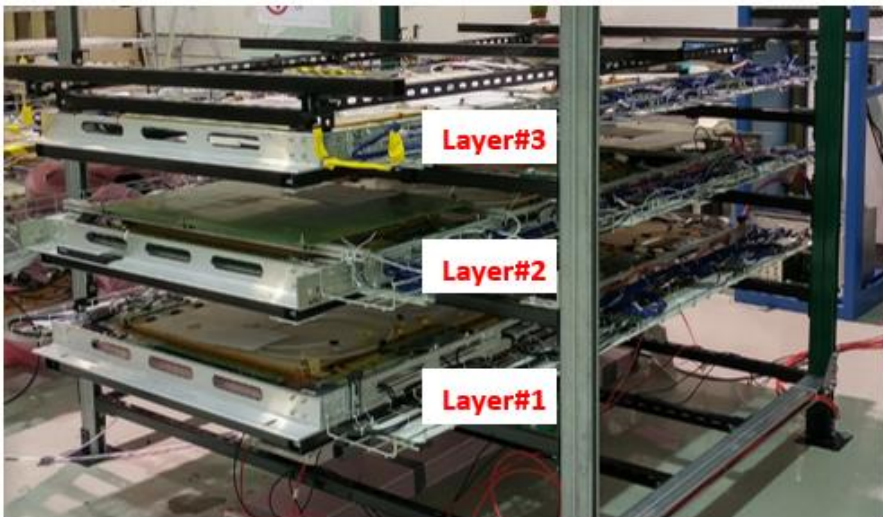
⇒ INFN Rome (Evaristo Cisbani), Glasgow University (David Hamilton)

⇒ **Clean Room Equipment, Tooling and Manpower for fabrication**

⇒ UVa (Nilanga Liyanage)

# Back up

# UVa GEMs: HV tests of UVa GEM layers



### UVa GEM layer#1

4CH HV PROGRAMMABLE POWER SUPPLY

**HV**

	USE1 [U]
AL	4200.0
LC	4200.0
CH	4200.0

Ch0  $\Rightarrow$  L1\_GEM0\_Module#33  
 Ch1  $\Rightarrow$  L1\_GEM1\_Module#47  
 Ch2  $\Rightarrow$  L1\_GEM2\_Module#16  
 Ch3  $\Rightarrow$  L1\_GEM3\_Module#19

**I (uA)**

	IMON [uA]
AL	0776.60
LC	0775.75
CH	0767.25
	0771.60

ENTER

### UVa GEM layer#2

4CH HV PROGRAMMABLE POWER SUPPLY

**HV**

	USE2 [U]
AL	4200.0
LC	4200.0
CH	4200.0

Ch0  $\Rightarrow$  L2\_GEM0\_Module#17  
 Ch1  $\Rightarrow$  L2\_GEM1\_Module#25  
 Ch2  $\Rightarrow$  L2\_GEM2\_Module#13  
 Ch3  $\Rightarrow$  L2\_GEM3\_Module#20

**I (uA)**

	IMON [uA]
AL	0775.35
LC	0776.20
CH	0767.40
	0772.45

ENTER

### UVa GEM layer#3

iseg SNMP Control Version 1.1.6.0

File System Module Channel Help

3 Modules found. Connected to E08C2 sn. 7300266 at Slot 0

Slot	Vset (V)	Vmeasure (V)	Vnominal (V)	Iset (uA)	Imeasure (uA)	Inominal (uA)	Status
Slot 0 7300266	4,200.00	-4,200.00	-6,000.00	800.000	-763.909 uA	1,000.000	Constant Voltage
Slot 1 7300267	4,200.00	-4,200.01	-6,000.00	800.000	-763.544 uA	1,000.000	Constant Voltage
Slot 2 736790	4,200.00	-4,200.00	-6,000.00	800.000	-761.614 uA	1,000.000	Constant Voltage
Channel 4	0.00	-1.91	-6,000.00	800.000	-0.007 uA	1,000.000	Off
Channel 5	0.00	-0.71	-6,000.00	800.000	-0.002 uA	1,000.000	Off
Channel 6	0.00	-1.35	-6,000.00	800.000	-0.011 uA	1,000.000	Off
Channel 7	0.00	-0.97	-6,000.00	800.000	-0.008 uA	1,000.000	Off

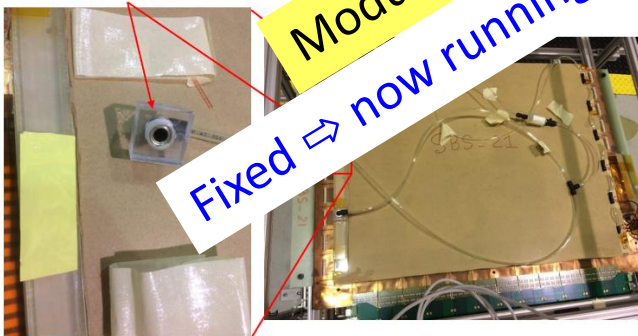
Ch0  $\Rightarrow$  L3\_GEM0\_Module#45  
 Ch1  $\Rightarrow$  L3\_GEM1\_Module#22  
 Ch2  $\Rightarrow$  L3\_GEM2\_Module#29  
 Ch3  $\Rightarrow$  L3\_GEM3\_Module#42

# UVa GEMs: Issues reported @ last sbs Coll. meeting

## UVa GEMs: Some issues with gas outlet plastic piece

- Glue epoxy used for the gas output plastic pieces does not polymerize well with the plastic
  - Some of the pieces get unglued and detached ⇒ Module M21 in layer L1 had this problem last week
  - Was removed from L1 to be fixed and replaced in the layer by another module M15
- Easy fix for this problem ⇒ We already identify a special glue (suitable for plastic) to be used
- For the most recent chambers that we built, we avoid this problem by properly preparing the surfaces to be glued before, in order to have a strong adherence of the glue

Detachment of the plastic piece for output gas

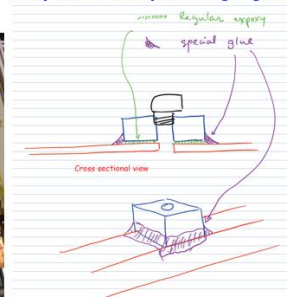


7/28/2019

SBS Coll. Meeting @ JLab

7

Easy fix ⇒ Identify a stronger glue



## UVa GEMs: Module 35 with high leakage current

- Module 35 has developed a higher than normal leakage current during cosmic data taking
  - Was Ok and tested with cosmic twice at JLab and also in EEL setup after the assembly
- This is very similar to an issue that happened in chamber a few months ago
  - We suspect a spark caused by particle dusts (probably from a bottle change)
- Not seem be a short circuit, is good chance to fix the sector in question
  - We will have to work on it later ⇒ Burn in at 600 V (600 V) on the sector
- the chamber was also removed from the setup and replaced by another module
- We will get high purity filter on the gas line to avoid the problem in the future
  - It will be in action just the input of each individual module
- Cosmic setup: It would be desirable to get N2 gas flushing continuously

Module 35

Need to isolate faulty sector

7/28/2019

SBS Coll. Meeting @ JLab

8



# SBS / Bigbite GEM Electronics - components

Items	Need (SBS + BB)	In hand (Total)	Spares
MPDs (UVa GEMs)	77	61 (UVa) 11 (Glasgow U) 5 (JLab)	so far 2 (HU)
APV25 FE Cards (UVa GEMs)	968	900 (UVa) 100 (HU)	A few dozens
12-slots backplane (UVa GEMs)	44	42	
5-slots backplane (UVa GEMs)	88	82	
MPD (INFN GEMs)	24	26 (INFN: 19 at JLab, 2 at UH, 5 in Italy)	2 (INFN, in Italy)
APV25 FE Cards (INFN GEMs)	324	350 (INFN, 311 at JLab)	5 + few to be tested
Backplanes (INFN GEMs)	Flex: 24 Rigid: 48	all in hands at JLab	Flex: 4 Rigid: 7 + some to be retested

# SBS GEM Electronics - components

Item	Status
4 SSP modules ( <b>3 for SBS</b> )	3 in hand: 2 with UVa, 1 with Paolo (Italy) <b>4th identified to be in Ben's hand in Hall A</b>
4 VME64x / VXS (for SSP, TI ...) ( <b>3 for SBS</b> )	3 <b>VXS</b> crate ordered (Alex) – <b>How about the 4th one?</b>
6 VME crate (no master) for MPDs ( <b>4 for SBS</b> )	At least 6 in hand (Alex) + 3 more crates in RHRS as spares
TI – Trigger supervisor	Available (Alex) + spares
Master VME (for SSP and TI)	12 ordered (Alex)
Trigger / clock fan-out (101 channels)	JLab custom boards (under test in EEL and Test lab)
1 VME minicrate for slow control + Master	Available (Alex)
Short HDMI cables (+ spares) : connected to the GEMs	In hand
Long HDMI cables (374 + 14 spares): to the MPDs	In hand
78 Optical fiber MPD – SSP connection and transceivers	30 optic fibers and 150 transceivers ordered (Alex)
2 × 78 (+ 1) NIM cables trigger and clock distribution	To be identified / procured (1 from SBS GEM hut to electronic hut)
46 x HV cables (15 m?, 55 m? ... )	To be produced / provided at JLab
6 x LV cables pairs (15 m?)	To be identified / procured
HV power supplies for 46 channels (40 UVa GEMs + 6 INFN GEMs)	In hand: 1 Wiener crate & <b>5 or 6 HV modules ? (8 ch. each)</b> => 42 channels To be procured: 1 spare crate + at least one more HV module
LV power supply	Available at Jlab, Currently used / tested in cosmic (+spare)
SBS GEMs Electronic Hut	JLab Engineering - Spring 2019 (R. Wines & D. Hamilton's talk)