Status of Polarimeter GEMs

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SBS Summer Collaboration Meeting

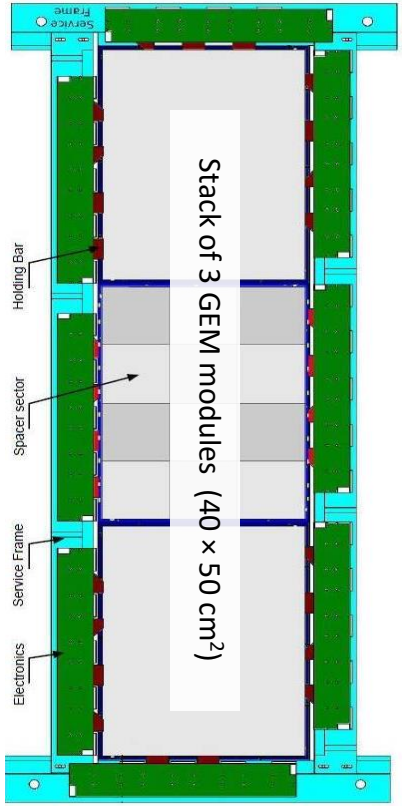
07/13/2017

Outline

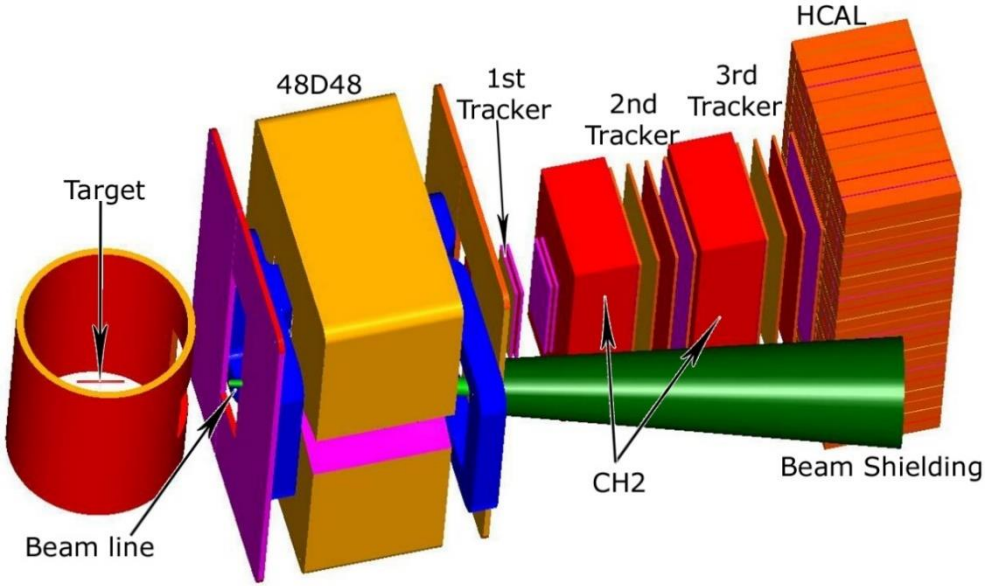
- Status of the Production
- Activities in the GEM “Clean” room space
- Preparation for GMn Experiment

Overview of SBS GEM Trackers modules

Front Tracker layer
INFN
(Rome, Catania)

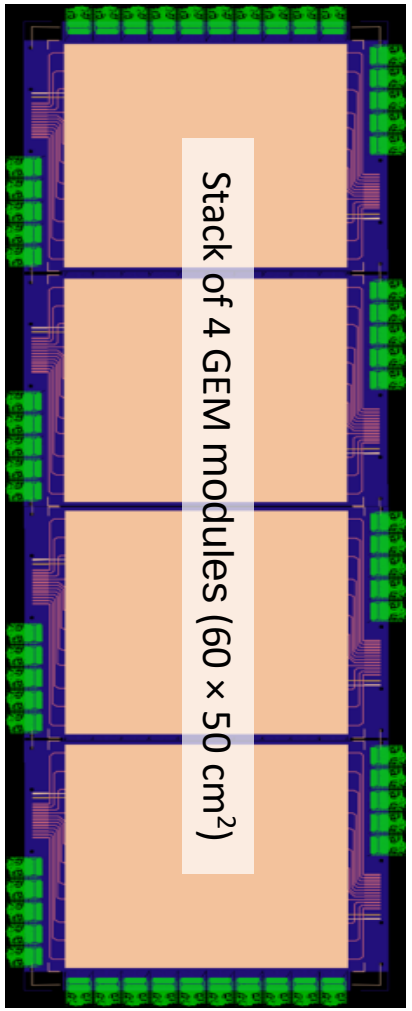


- **Front Tracker (FT): Track of the recoil protons**
  - ⇨ **1st tracker:** 6 GEM layers, active area of 150 × 40 cm²
  - ⇨ **Layer:** vertical stack of 3 GEM modules (50 × 40 cm²)
  - ⇨ **Production:** 18 modules (+3 spares)
- **Back Tracker (BT): Polarimetry of the recoil protons**
  - ⇨ **2nd & 3rd Trackers:** 2 × 5 layers, active area of 200 × 60 cm²
  - ⇨ **Layer**: vertical stack of 4 GEM modules (60 × 50 cm²)
  - ⇨ **Production:** 40 modules (+ 8 spares)



Hadron arm in GEp(5)

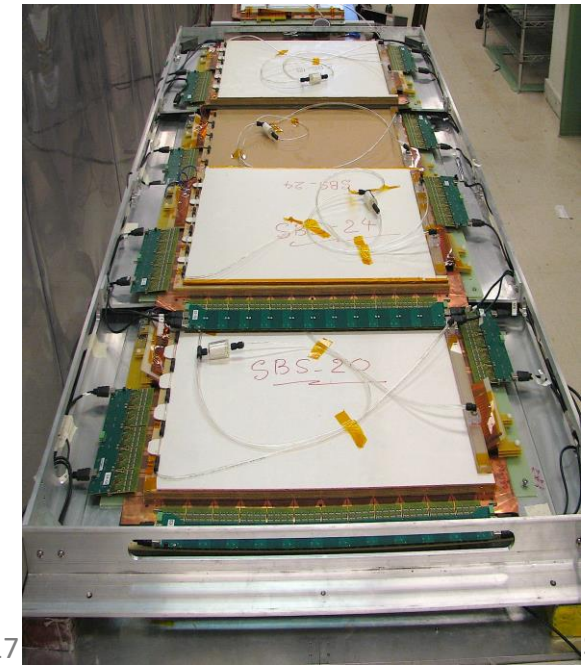
Back Tracker layer
(UVa)



Production of GEM modules @ UVa

- **43 modules built and tested**
  - ⇨ 41 modules: 100% operational,
  - ⇨ 2 modules: 97% OK (1 bad sector)
- **5 spare modules in the assembly queue**
  - ⇨ 2 almost completed, all expected by August 2017
- **9 modules already moved to JLab in test lab**
  - ⇨ 4 modules stored in GEM “clean” room, 5 modules on test beam stand
  - ⇨ Next shipment of 8 modules week July 17th
- **All 10 Al frames for Uva GEM layers in store in test lab**
  - ⇨ Frame prototype tested at UVa
  - ⇨ One frame will be fully instrumented with 4 modules and MPD electronics

Al Frame prototype with 4 UVa GEMs

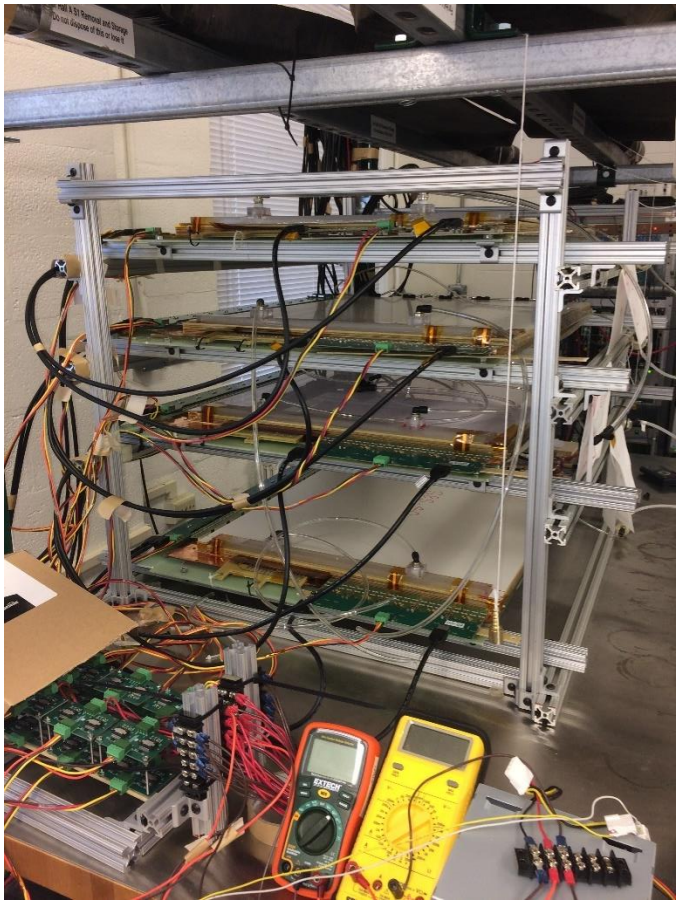


Back Tracker modules @ UVa

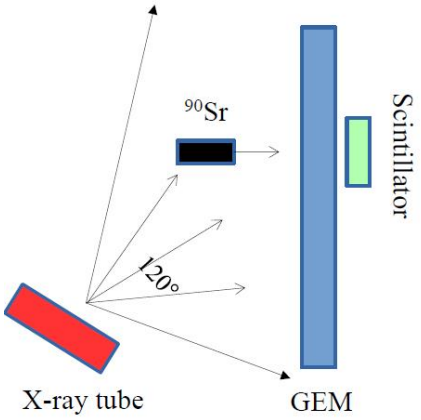
Test of GEM modules @ UVa

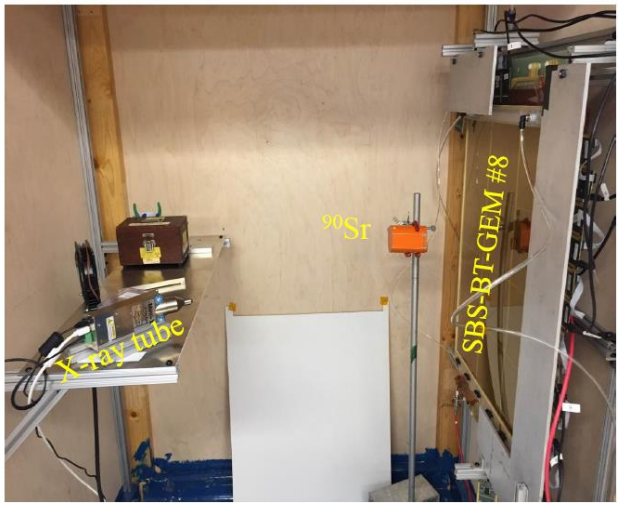
- **Cosmic stand setup**
  - ⇨ Test that the HV sectors are all operational
  - ⇨ Data with 4 modules fully instrumented MPD electronic
  - ⇨ Tracking efficiency studies
- **X-ray setup**
  - ⇨ Test the modules in high rate environment
  - ⇨ Test DAQ in high rate and high background
  - ⇨ Performance of x-ray background with Sr^{90} as source

Cosmic stand @ UVa



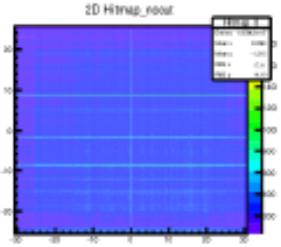
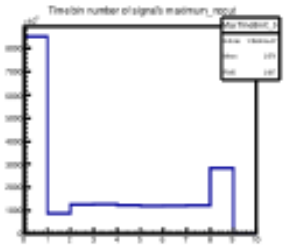
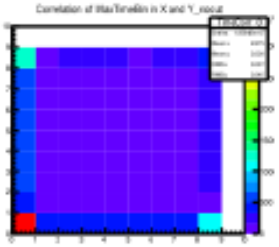
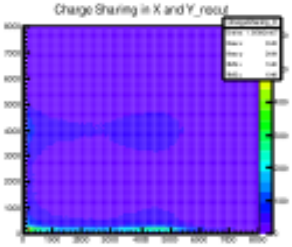
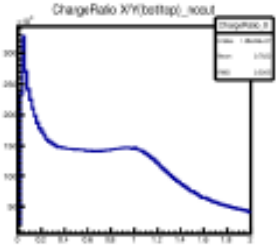
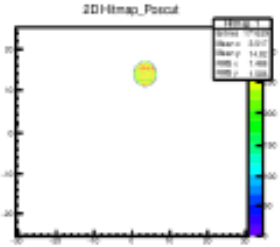
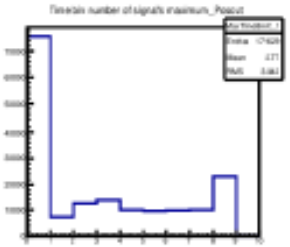
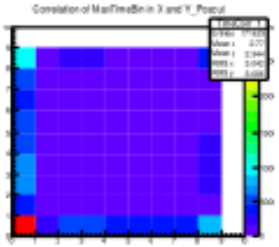
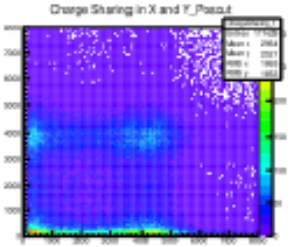
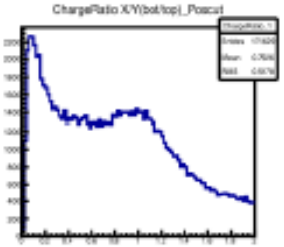
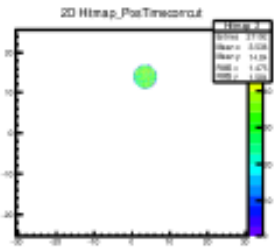
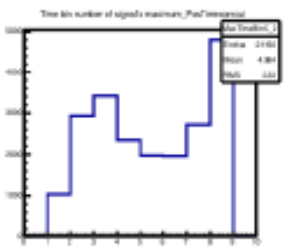
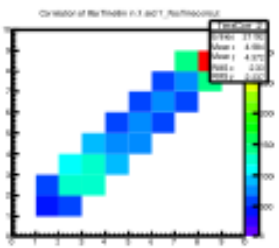
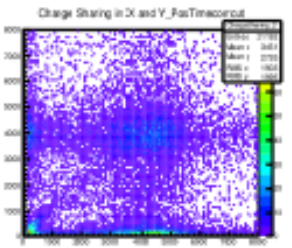
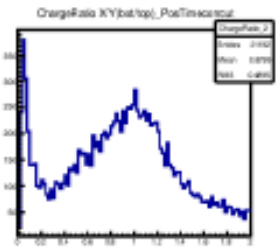
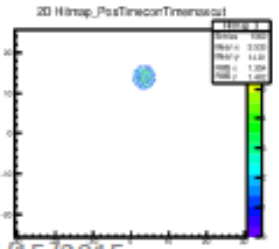
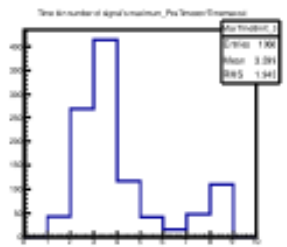
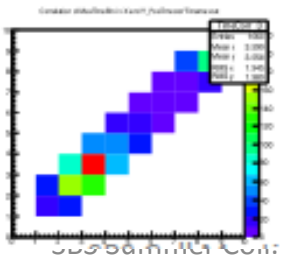
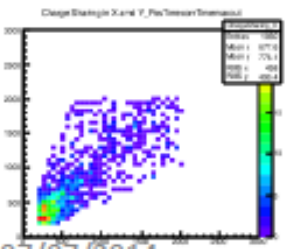
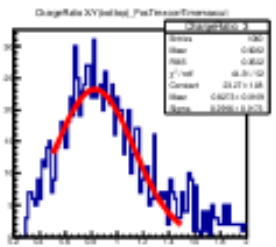
X-Ray setup @ UVa





High rate studies: Various cuts applied to background

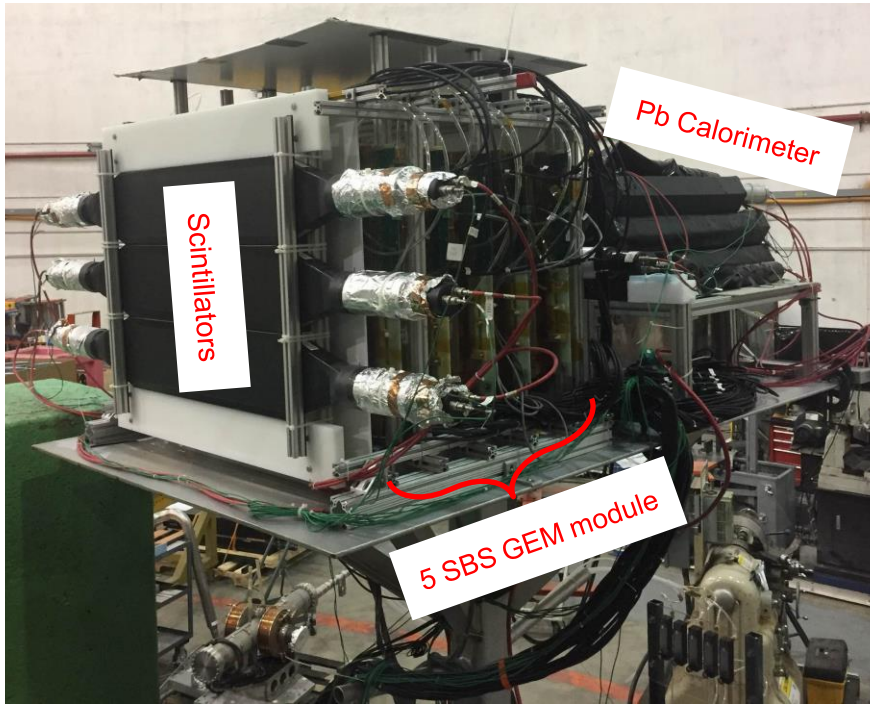
X-ray setting:11kV, 200uA. Hit rate: 25,000 Hz/cm^2, Charge deposition rate: equivalent to 0.44MHz MIPs

Hit Map	Time bin of APV25 peak	x/y time bin correlation	x/y correlation charge sharing	x/y charge sharing ratio	
					No cut
					Position Cut
					+ Timing correlation selection
					+ Cut on large ADC value

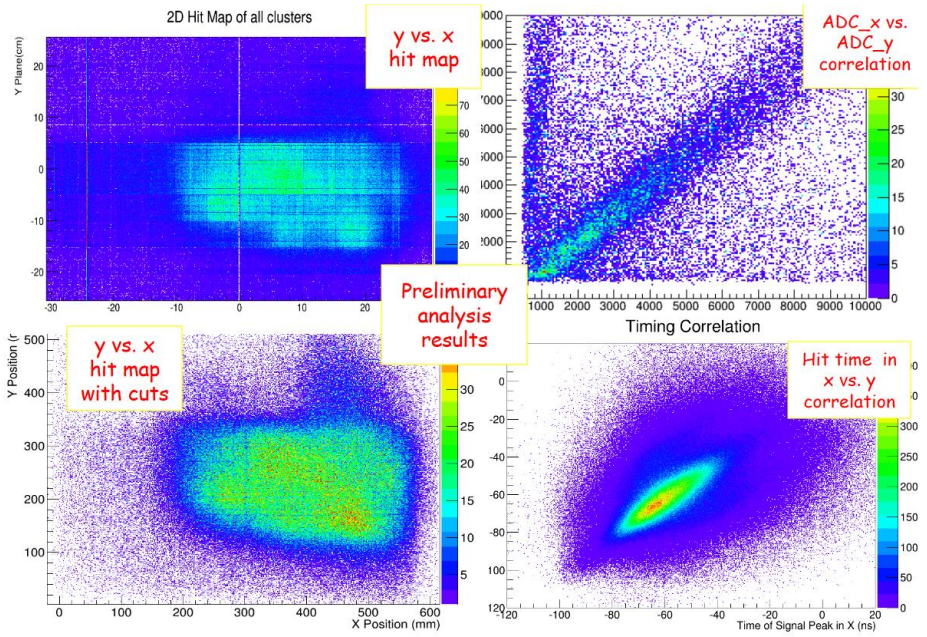
Polarimeter GEM modules in Beam Test in Hall A (Fall 2016)

Setup in Hall A @ JLab

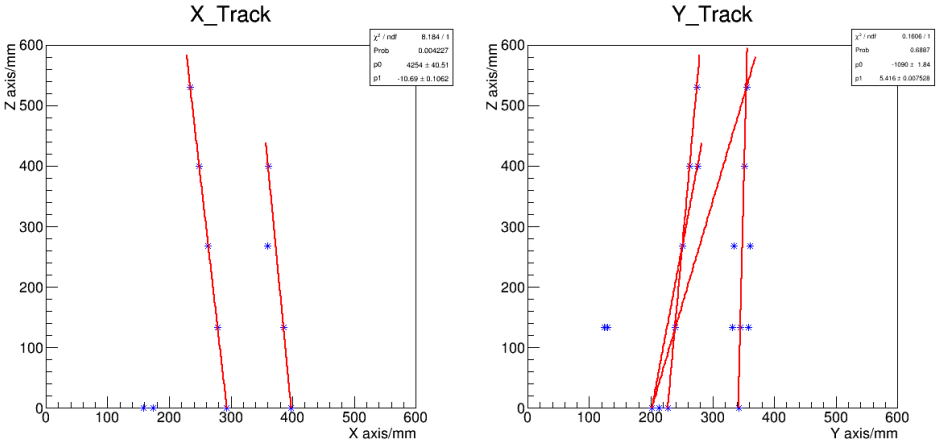
- 5 modules separated by 10 cm each: similar to a SBS tracker configuration.
- Triggered by a lead-glass matrix at center
- Goals: Identify good tracks in a high rate, background, effectiveness of timing and charge correlation cuts to suppress background
- Placed at 70º, occupancy is ~ 1%, similar to GMn



Preliminary background suppression analysis



Preliminary tracking analysis



Preparation for “Clean” Room space for SBS GEM modules

- **“Clean” room space for SBS GEM modules**
  - ⇨ Space allocated in the test lab for the storage of the GEMs modules
  - ⇨ Migration of UVa GEM modules is ongoing
  - ⇨ ⇨ First 4 modules arrive earlier this month
  - ⇨ next 8 modules next week
- **Setup of a cosmic stand for GMn GEM trackers**
  - ⇨ Goal: Have all 4 FT GEM layers (INFN) on the cosmic stand
  - ⇨ One polarimeter UVa GEM layer on a separate setup
  - ⇨ Cosmic data expected by 08/01/2017
- **Goal: Full characterisation of the GEM modules**
  - ⇨ Evaluate the dead area (disabled HV sector), study efficiency, define the working HV
  - ⇨ gas flow for each module, Full readout performance DAQ

4 UVa modules on storage shelves

Preparation for cosmic stand setup

Standalone setup for UVa GEM layer frame

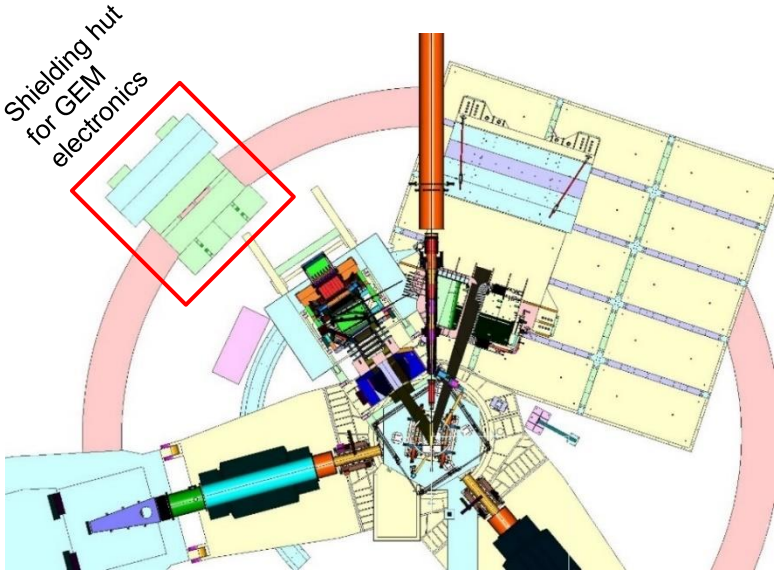
Preparation for GMn Experiment

GMn GEM Tracker: 4 layers

- Front Tracker layer: (150 cm x 40 cm) : 3 INFN modules
- 2 chambers already delivered @ Jlab, 2 on their way

One additional Back Tracker layer behind the GRINCH detector:

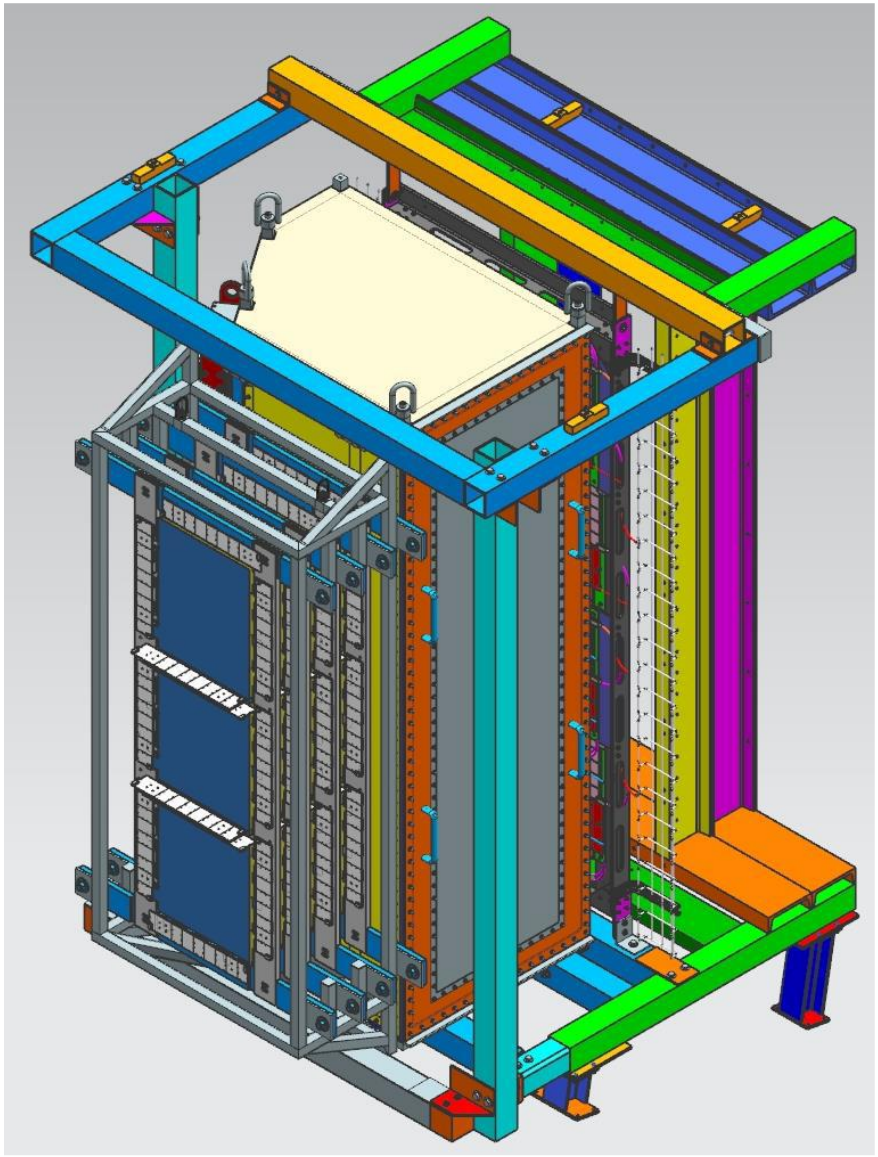
- Back chamber layer (200 cm x 50 cm) : 4 UVa modules



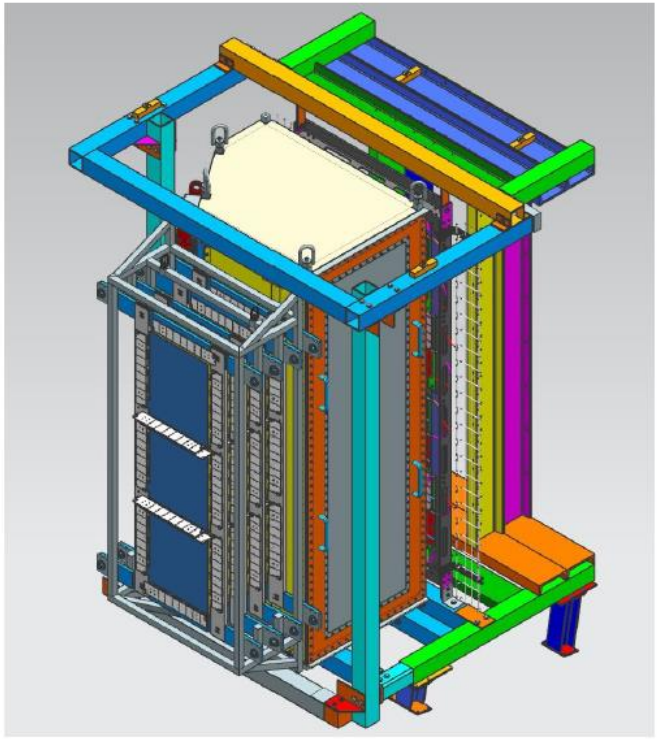
2 VME crates for all 4 + 1 GEM layers

Front Tracker crate	**Back Tracker crate**
16 MPDs (v4.0)	7 MPDs (v.40)
1 SSP	1 SSP
1 Trigger Supervisor	1 Trigger Supervisor
1 VME CPU or Controller	1 VME CPU or Controller
2 slots for HV PS	1 slots for HV PS (or not)

Bigbite Spectrometer for the GMn experiment



Preparation for GMn: GEM Gas System



Gas mixture: 70% Ag+30%CO2 (premixed gas)

Front tracker (INFN, Italy):
4 blocks * 3 chambers=12 chambers
0.5 l/block/min*60min=30 l/block/hour
30 l/block/hour*4 blocks=120 l/hour

Second tracker (UVa):
1 blocks * 4 chambers/block=4 chambers
10 l/hour/chamber*4chambers=40 l/hour

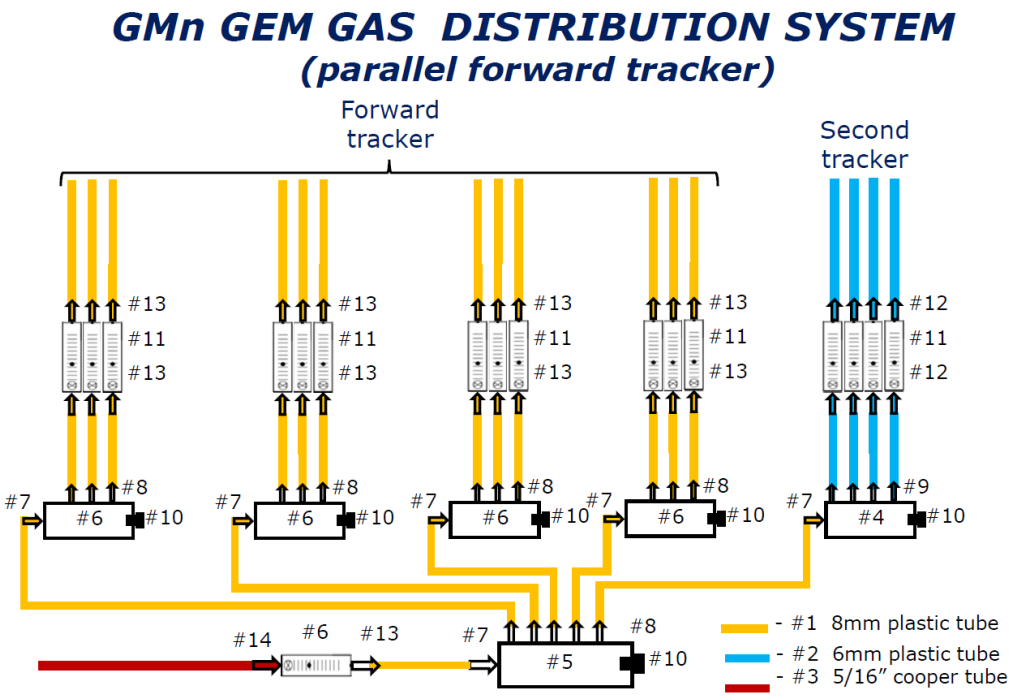
For GEM totally:
(120+40) l/hour ~ 160 l/hour
~ 3,900l/day ~ 120,000l/month

T-size gas cylinder consist of 335 ft^3=9.29 m^3~9,300 l of gas.
For 90% of gas from cylinder is used:
9,300*0.9~8,300 l/cyl.
120,000/8,300 ~ 15 T- cylinders of gas is required for GEM operation per a month.
$170/cyl *15~$2.5K/month

Preparation for GMn: GEM Gas System

An existing Hall A gas shed and gas delivery system can be used for GMn experiment.

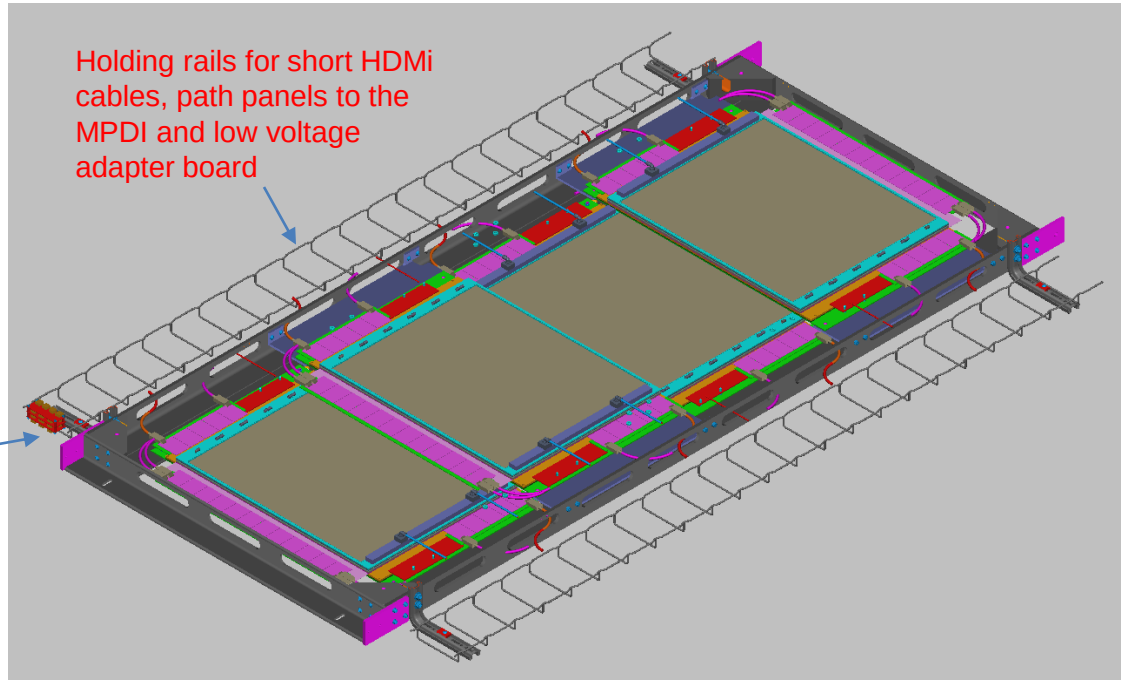
System was tested (50 l/hour) at DVCS running period



#	Cost, $
Premixing gas	2,5K/months
Gas distribution system	4.5K
Total	~7.0K

Consideration on HDM cables arangment for BT layer

- **Cabling to the MPD electronics**
  - ⇨ 4 layers of BT layer read out with 4 MPD modules
  - ⇨ Data and control signal through HDMI cables
- **Two sets of HDMI cables:**
  - ⇨ Short cables (0.5 m to 3 m) from the back planes (GEM modules) to patch panel / connectors
    - ⇨ **Need to decide if we use same length for all cables or adapt length to minimize cross talk, noise etc …**
    - ⇨ **Try out pros / cons of different length approach with the layer in "clean" room before final decision**
  - ⇨ Long cables (minimum 8 m) from the patch panel / connectors to the MPD in shielding box
  - ⇨ Connection between long and short cables through patch panel and HDMI to HDMI connector



Preparation for GMn: HDMI cable arrangement for the BT GEM layer

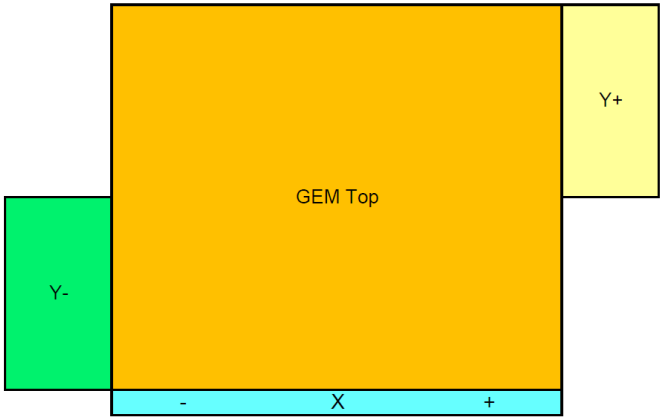
Analog (data) signal

CABLES AND PATCH PANELS FOR ANALOG SIGNALS

MPD	ADC ch	Analog Patch MPD	Analog Patch GEM	GEM	Plane	I2c
0	0–3	HDMI_0	HDMI_0	0	X	15–12
	4–7	HDMI_1	HDMI_1			11–8
	8–11	HDMI_2	HDMI_2			7–4
	12–15	Vacant				
1	0–3	HDMI_0	HDMI_0	1	X	15–12
	4–7	HDMI_1	HDMI_1			11–8
	8–11	HDMI_2	HDMI_2			7–4
	12–15	Vacant				
2	0–3	HDMI_0	HDMI_0	2	X	15–12
	4–7	HDMI_1	HDMI_1			11–8
	8–11	HDMI_2	HDMI_2			7–4
	12–15	Vacant				
3	0–3	HDMI_0	HDMI_0	3	X	15–12
	4–7	HDMI_1	HDMI_1			11–8
	8–11	HDMI_2	HDMI_2			7–4
	12–15	Vacant				

4	0–3	HDMI_0	HDMI_0	0	Y+	4–1
	4–7	HDMI_1	HDMI_1		Y-	0–12
	8–11	HDMI_2	HDMI_2	2	Y-	11–8
	12–15	HDMI_3	Vacant			7–4
5	0–3	HDMI_0	HDMI_0	1	Y-	4–1
	4–7	HDMI_1	HDMI_1		Y+	0–12
	8–11	HDMI_2	HDMI_2	2	Y+	11–8
	12–15	HDMI_3	Vacant			7–4
6	0–3	HDMI_0	HDMI_0	3	Y-	4–1
	4–7	HDMI_1	HDMI_1		Y+	0–12
	8–11	HDMI_2	VACANT			11–8

- Minimize number of patch panels / maximize the one to one HDMI to HDMI connection
- Color coded arrangement:
  - Magenta: direct HDMI to HDMI connection
  - Red: 3-to-4 patch panels (analog signals)
  - Blue: 4-to-2 patch panels (digital signals)
  - Cyan: 12-slots backplanes
  - Yellow and green: 5-slots backplanes
  - Brown: BT GEM module



Number of MPDs	**7 MPD** for 4 GEM modules. 4 MPD reads X plane. 3 reads Y plane
Long HDMI	**23 analog** (3 × 4 for X, [2 × 4] + [1 × 3] for Y), **10 digital (4 for X, 6 for Y),** **Total = 33**
Short HDMI	**20 analog** (3 × 4 for X, 2 × 4 for Y), **12 digital** (4 for X and 2 × 4 for Y), **Total = 32**
analog patch panel	**3 × 3-to-4 for Y** **Total = 3**
digital Patch panel	**1 × 4-to-2 for Y,** **Total = 1**
HDMI to HDMI	12 analog (3 × 4 for X), 8 digital (4 for X, 2×1 for Y, 2 for Y on GEM3), **Total = 20**

Preparation for GMn: HDMI cable arrangement for the BT GEM layer

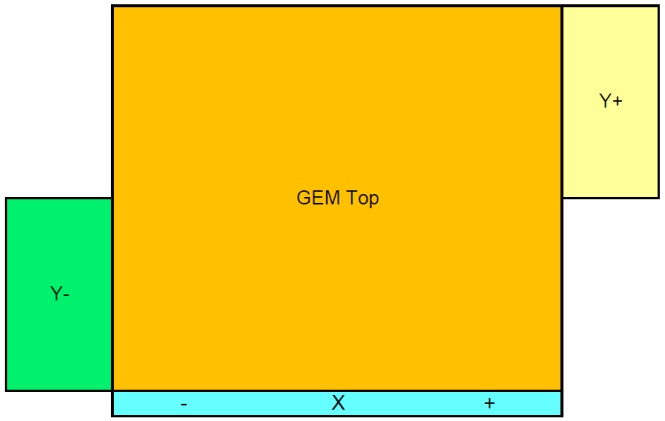
Digital (control) signal

CABLES AND PATCH PANELS FOR DIGITAL SIGNALS

MPD	ADC_ch	Digital_Patch_MPD	Analog_Patch	GEM	Plane	I2c
0	0–11	HDMI_0	HDMI_0	0	X	15–4
	12–15	Vacant				
1	0–11	HDMI_0	HDMI_0	1	X	15–4
	12–15	Vacant				
2	0–11	HDMI_0	HDMI_0	2	X	15–4
	12–15	Vacant				
3	0–11	HDMI_0	HDMI_0	3	X	15–4
	12–15	Vacant				

4	0–9	HDMI_0	HDMI_0	0	Y+	4–9
	10–15		HDMI_1		Y-	20–15
	0–11	HDMI1	HDMI_2	2	Y-	18–7
	12–15	Vacant				
5	0–9	HDMI_0	HDMI_0	1	Y-	4–9
	10–15		HDMI_1		Y+	20–15
	0–11	HDMI_1	HDMI_2	2	Y+	18–7
	12–15	Vacant				
6	0–11	HDMI_0	HDMI_0	3	Y-	4–10
	12–15	HDMI_1	HDMI_1		Y+	4–1

- Minimize number of patch panels / maximize the one to one HDMI to HDMI connection
- Color coded arrangement:
  - Magenta: direct HDMI to HDMI connection
  - Red: 3-to-4 patch panels (analog signals)
  - Blue: 4-to-2 patch panels (digital signals)
  - Cyan: 12-slots backplanes
  - Yellow and green: 5-slots backplanes
  - Brown: BT GEM module



Number of MPDs	7 MPD for 4 GEM modules. 4 MPD reads X plane. 3 reads Y plane
Long HDMI	**23 analog** (3 × 4 for X, [2 × 4] + [1 × 3] for Y), **10 digital (4 for X, 6 for Y),** **Total = 33**
Short HDMI	**20 analog** (3 × 4 for X, 2 × 4 for Y), **12 digital** (4 for X and 2 × 4 for Y), **Total = 32**
analog patch panel	3 × 3-to-4 for Y **Total = 3**
digital Patch panel	1 × 4-to-2 for Y, **Total = 1**
HDMI to HDMI	12 analog (3 × 4 for X), 8 digital (4 for X, 2×1 for Y, 2 for Y on GEM3), **Total = 20**

Summary

Production Status of Polarimeter GEM modules

- ⇨ 43 modules already built and fully tested
- ⇨ construction of the last 5 to be completed by august 2017
- ⇨ 9 modules already move to Jlab, remaining to be moved by set of 8 in the next few weeks

Preparation and commissioning of SBS GEMs for GMn expeiment

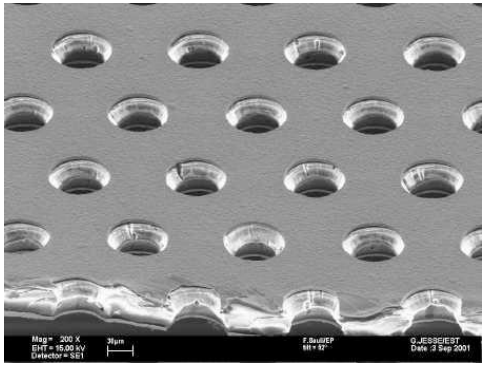
- ⇨ Acitivites in the clean room in full mode
- ⇨ Cosmic stand setup on going for the FT layers (4 INFN layers needed for GMn)
- ⇨ BT layer need for GMN in a standalone setup for test
- ⇨ Gas system need for the GMn GEMs has evaluated
- ⇨ GMn GEM electronic shielding box has been designed and scheme for optmal HDMI cabling is set
- ⇨ Cosmic test should be ready tp start in a few weeks

Backup

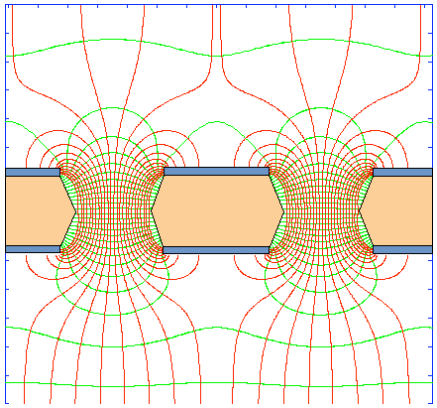
Why GEMs for Super Bigbite Spectrometer (SBS)?

- **SBS require high rate and good spatial resolution in trackers.**
- **Gas Electron Multiplier (GEM) detectors provide a cost effective solution for high resolution tracking under high rates over large areas**
  - ⇨ Rate capabilities higher than many MHz/cm^2, High position resolution (< 75 μm)
  - ⇨ Large areas (100s of m^2) at modest cost, low thickness (~ 0.5% radiation length)
  - ⇨ Used for many experiments around the world: COMPASS, Bonus, KLOE, TOTEM, STAR FGT, ALICE TPC, pRad etc.
  - ⇨ Future experiments with GEMs: CMS Muon Chambers upgrade, SoLID Trackers, Moller, P2 @ Mainz, tracking at the EIC …

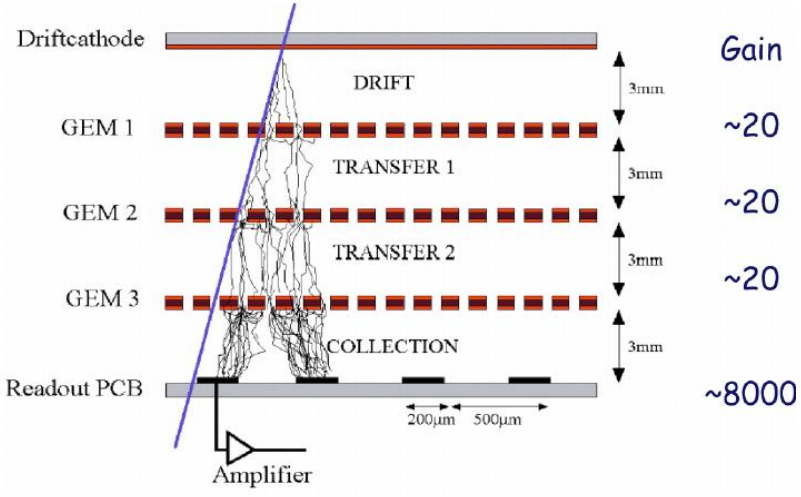
GEM foil: 50 μm Kapton + few μm copper on both sides with 70 μm holes, 140 μm pitch



Strong electrostatic field in the GEM holes, ~ 70kV/cm



Triple-GEM detector



2D readout strips board