# BigBite GEM's

E. Cisbani for the INFN & UVa GEMs groups

| Subsystems | Status |
|---|---|
| GEM chambers | Cosmic tests performed on Front Tracker since Sep/2018 – issue on 2 modules (out of 12) in June 2019<br>UVa layers preliminary test done, cosmic test underway |
| Electronics and DAQ | Operational on cosmic test |
| HV system | Operational on cosmic test |
| Low Voltage System | Operational on cosmic test |
| Gas Supply System | Under finalization with JLab group |
| BigBite Interface | Frame ready for loading, spacers designed, under approval |
| Analysis Software | All major libraries in use; porting to HallA analyzer in progress |

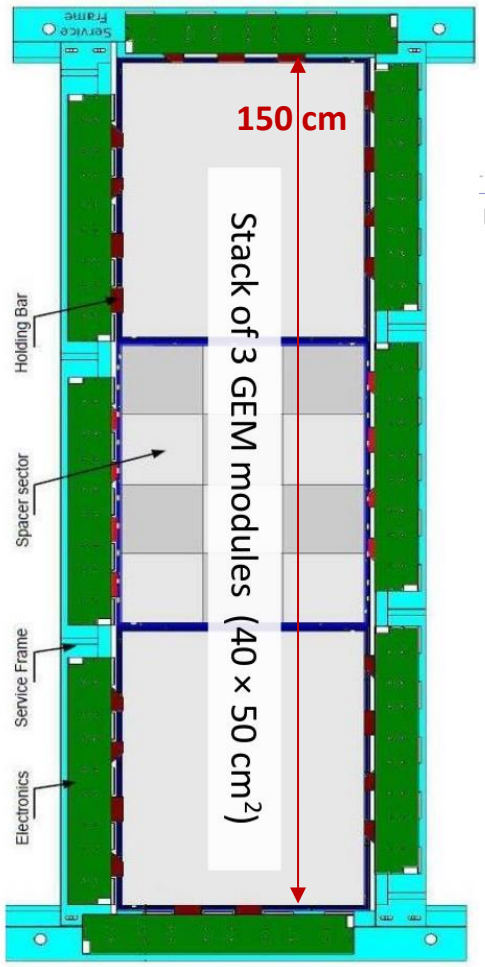
Alexandre talk

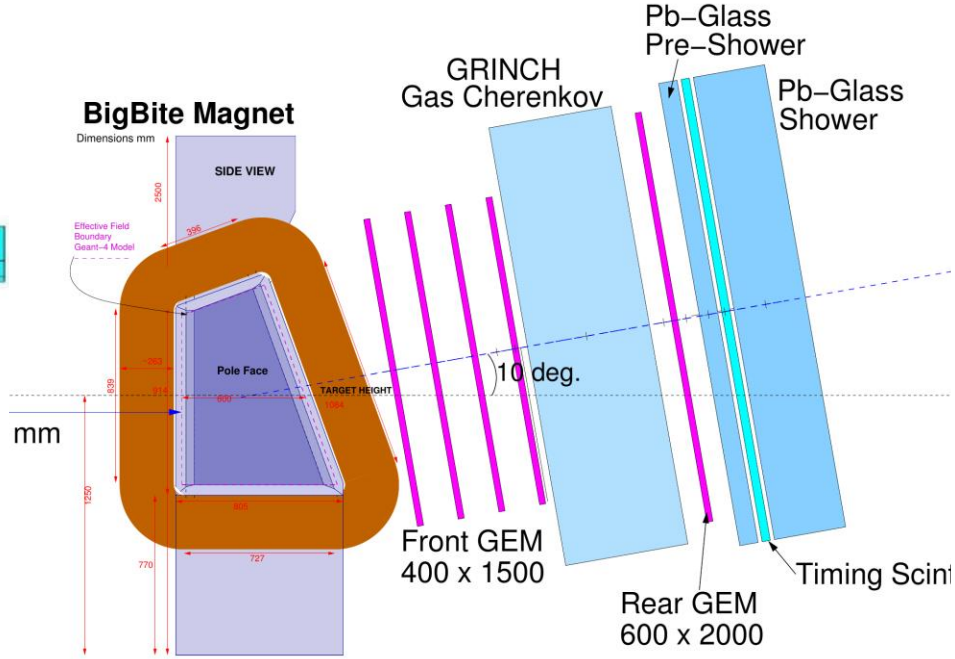
Kondo talk for details

Andrew talk

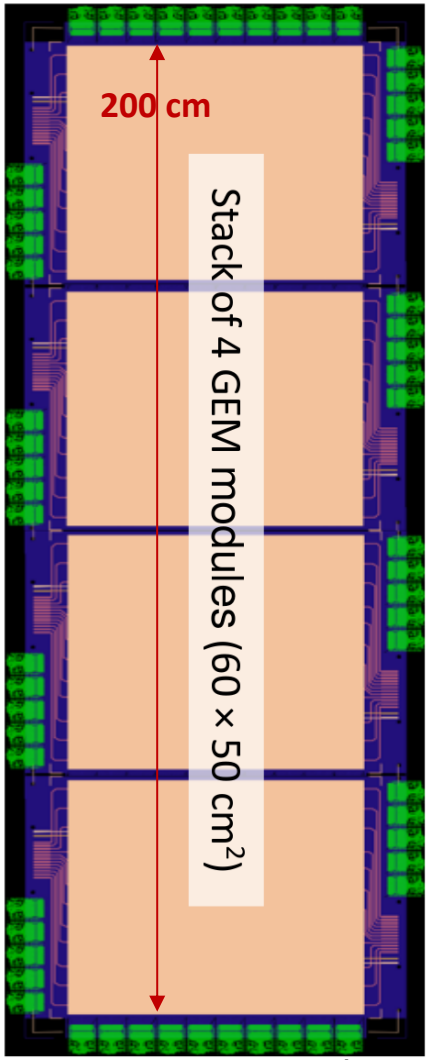
# GEMs tracker in BigBite

**4 x Front-GEM**




**1 x Rear-GEM**

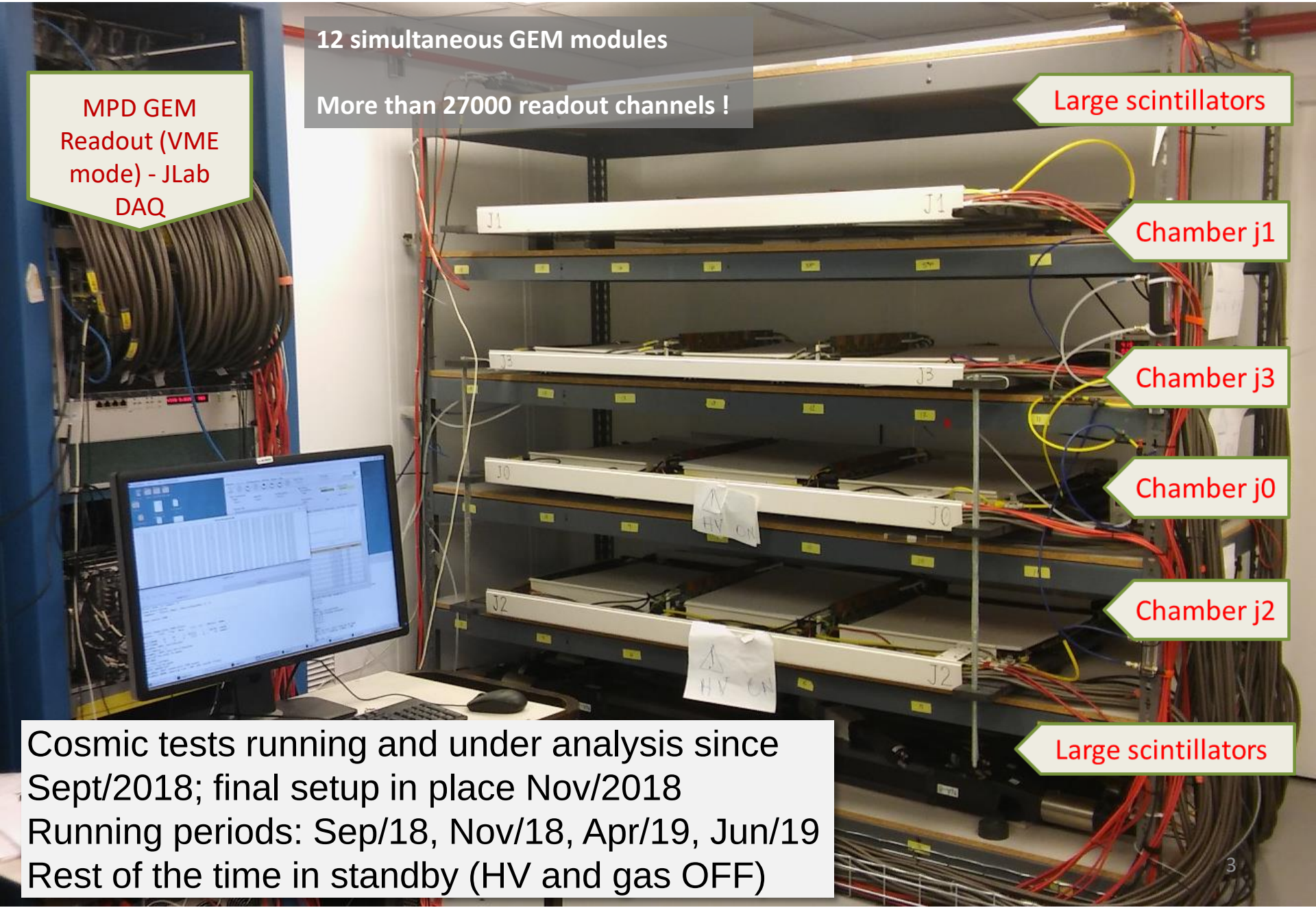



- **Similar design**
- **Almost identical electronics**
- **Same DAQ and analysis**
- **Same gas mixture**

**Expected Hit Spatial resolution < 100 um**

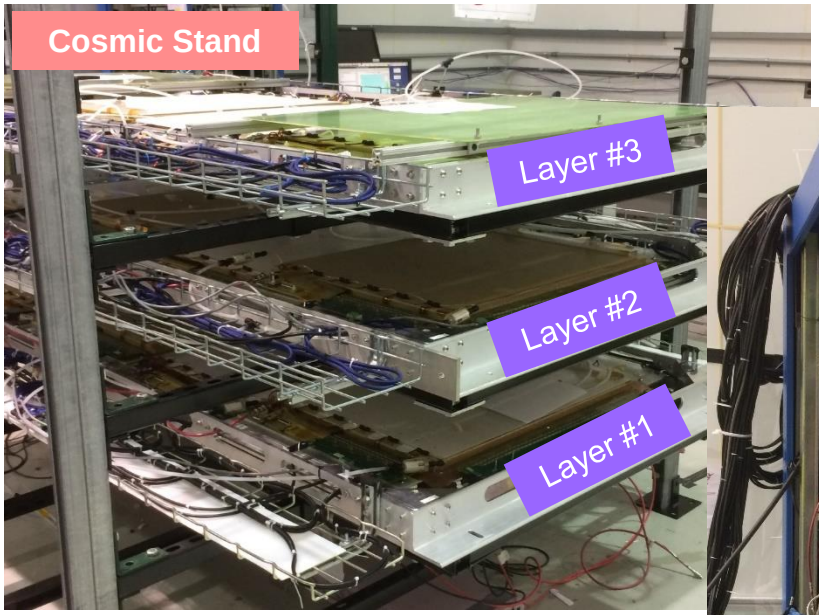
# GEM Front Tracker / Cosmic Setup

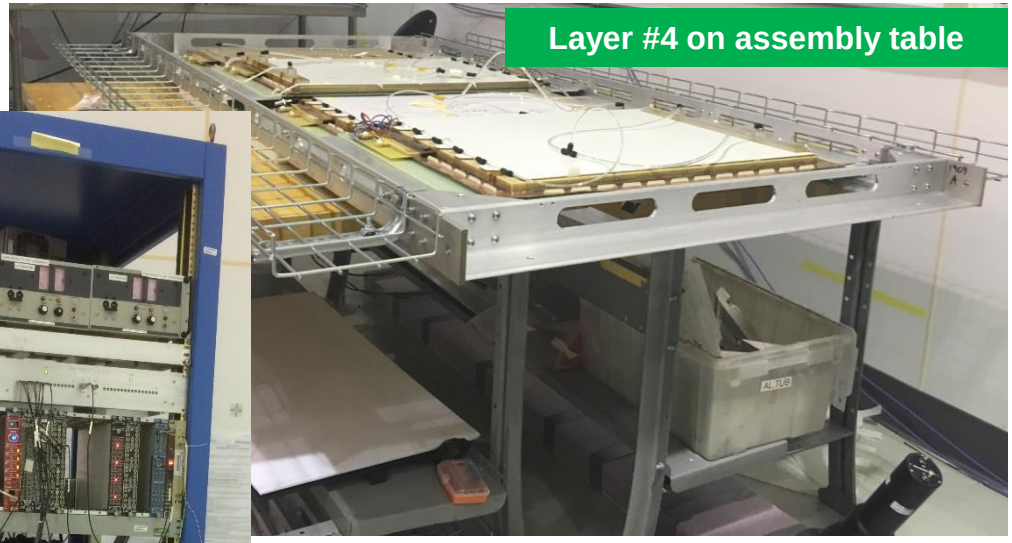
Nov/18 →




Cosmic tests running and under analysis since Sept/2018; final setup in place Nov/2018
Running periods: Sep/18, Nov/18, Apr/19, Jun/19
Rest of the time in standby (HV and gas OFF)

# Rear-GEM: JLab EEL Building Clean Room



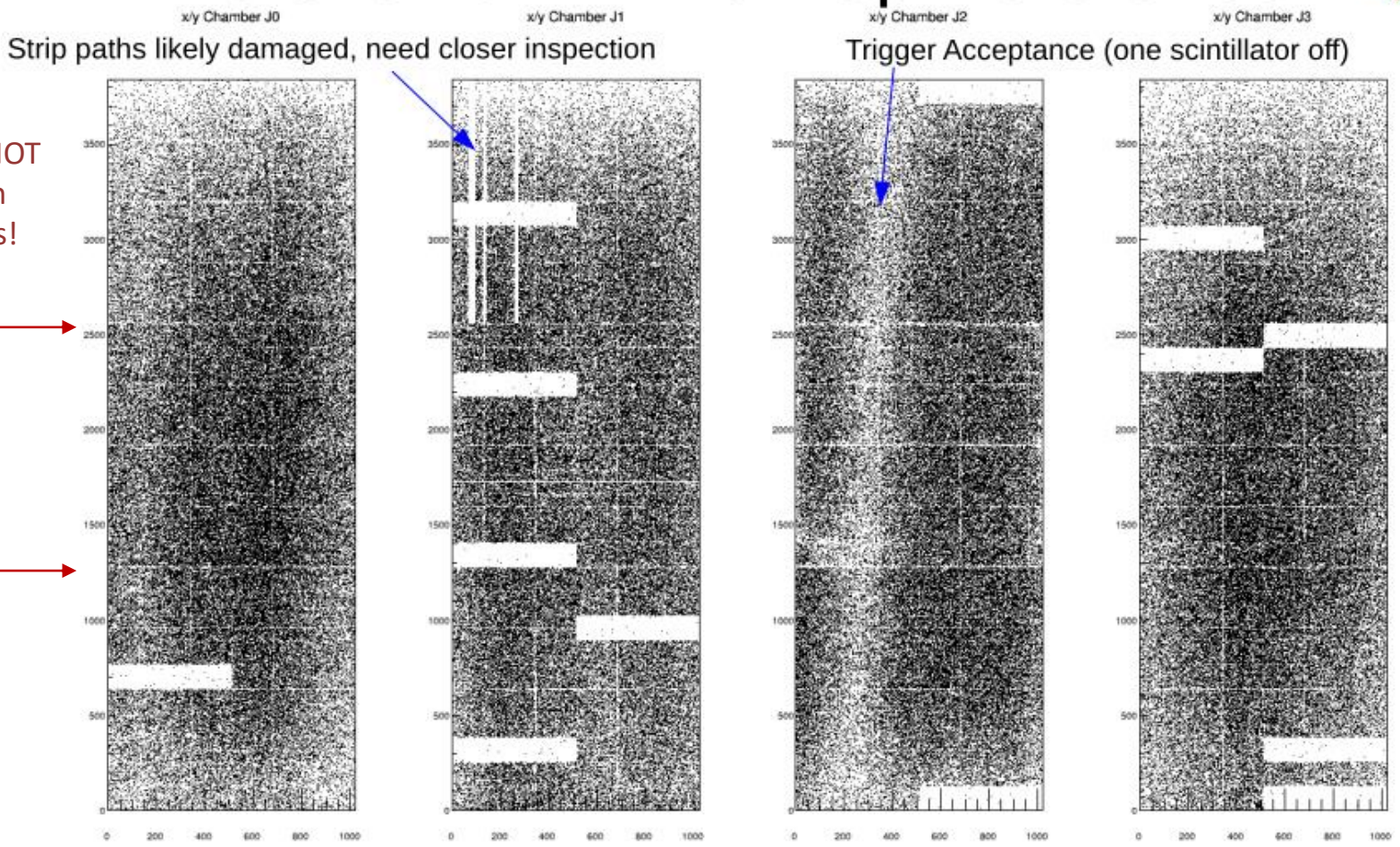






Front

# Nov/18: GEM Hit Map "reference"

4000 V




Gaps between modules NOT included in these plots!

**Clearly visible spacer between GEM foils and even HV sectors -> good hit reconstruction**

Same hit maps in Apr/19

# Front-GEM x-y Charge Sharing

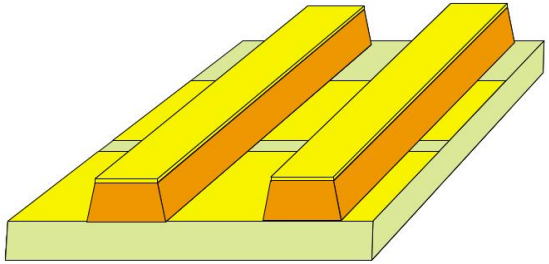


Fig. 6. Schematic view of the two-dimensional readout structure.

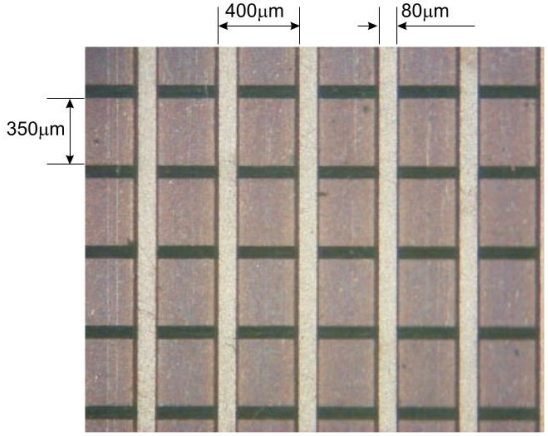
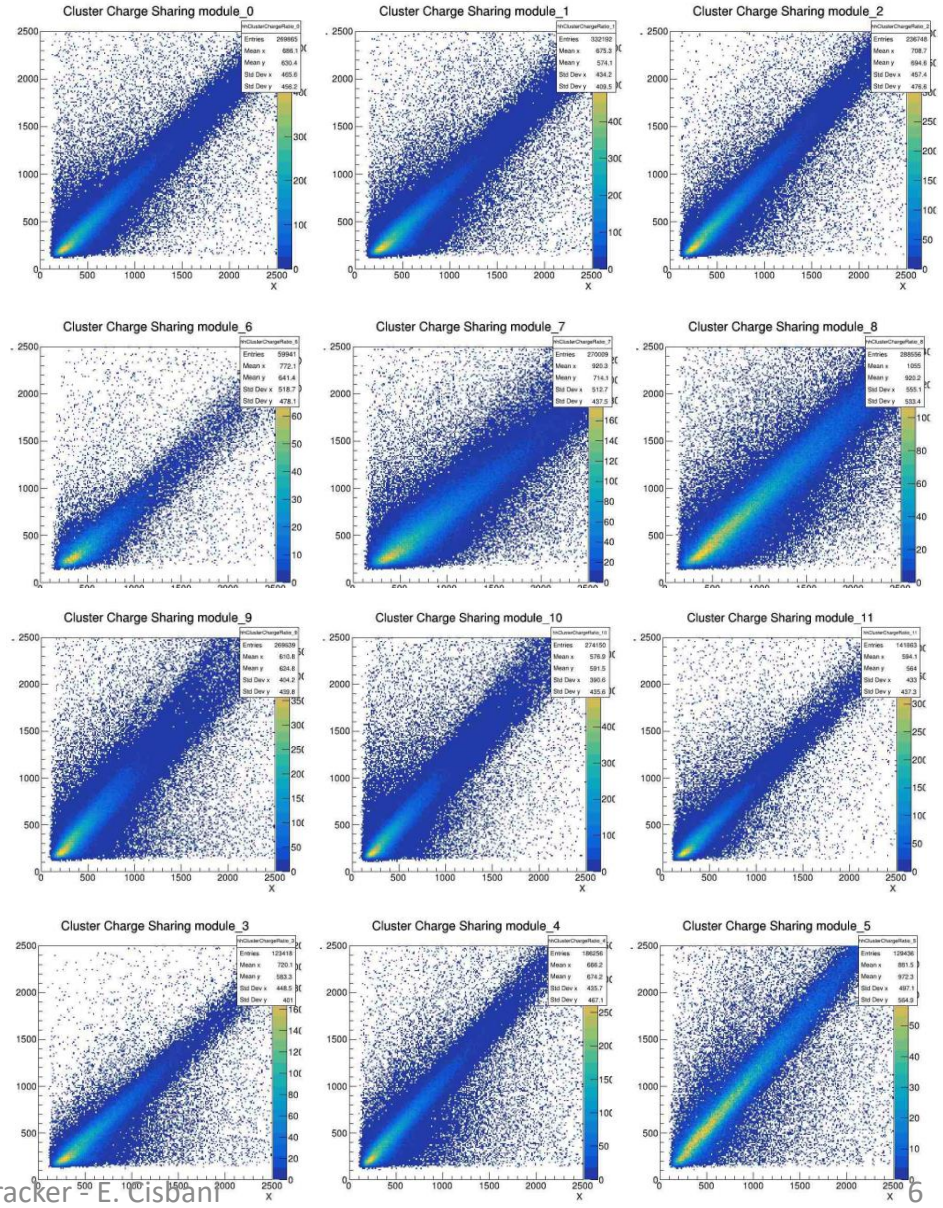



Fig. 7. Microscope photograph of the two-dimensional readout structure.




Charge sharing looks very reasonable: GEM modules do not seem to show major issues in electrostatic field

(from Siyu analysis)

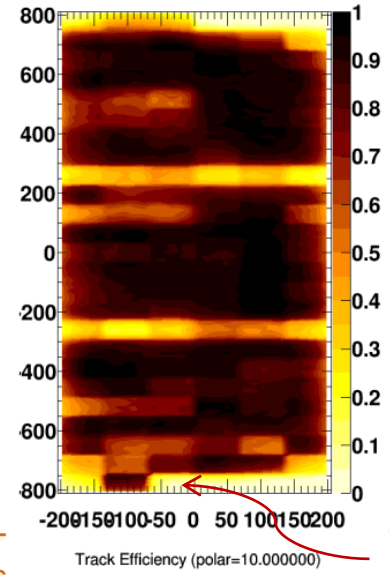
# Front-GEM estimated track efficiency

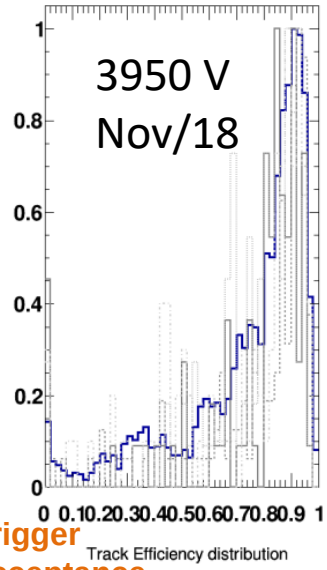
**Single Chamber Efficiency:**

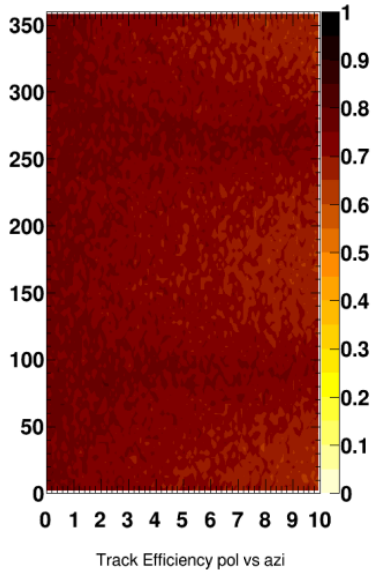
**use 3 chambers for tracking, estimate impact point on 4th chamber, accept if within given distance (50 mm) from measured hit; rough alignment only (we have the alignment code but need know tracks)**

**Track Efficiency:**

**at least 3 hits out of 4 chambers along the simulated track; hit occurrence based on estimated chamber efficiency.**

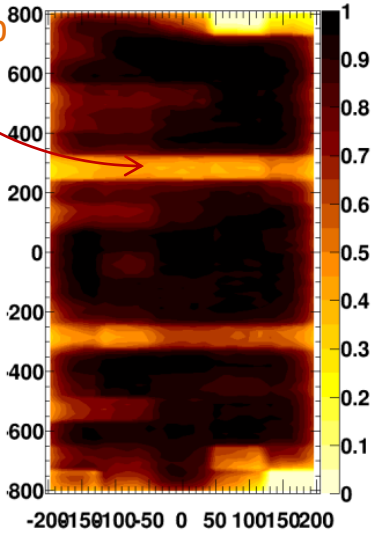


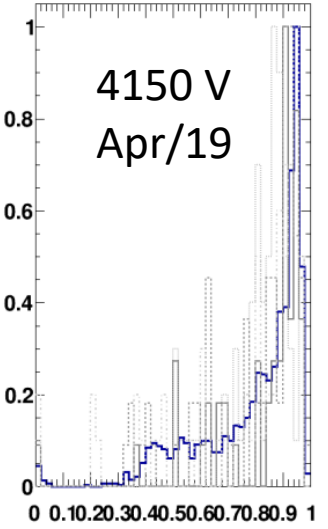



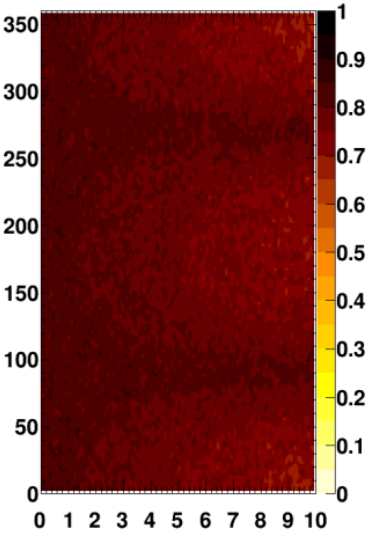




Inter-modules gap

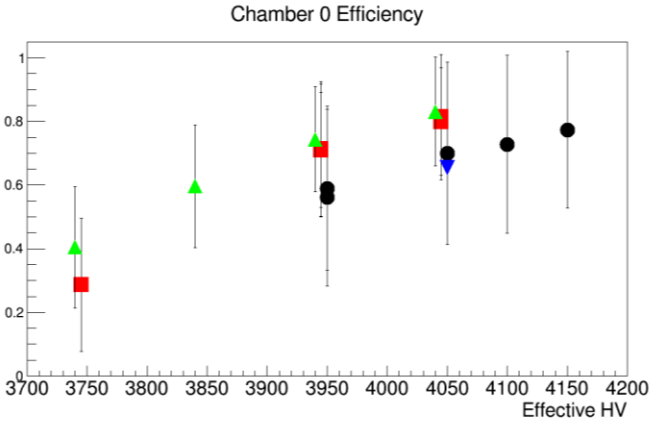
Trigger acceptance

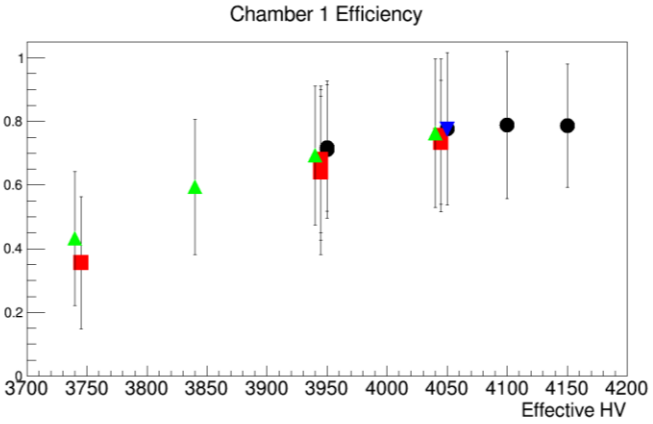


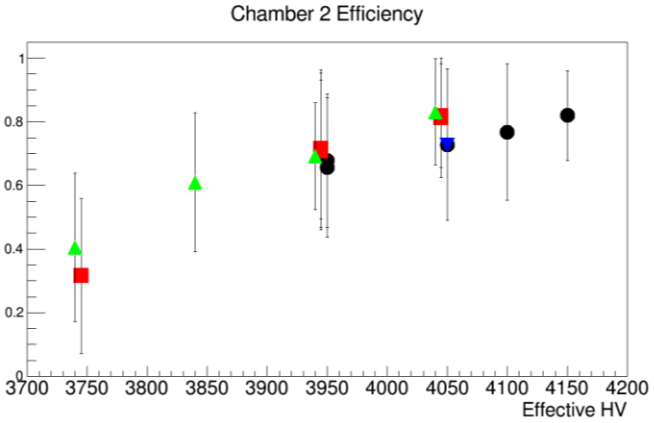


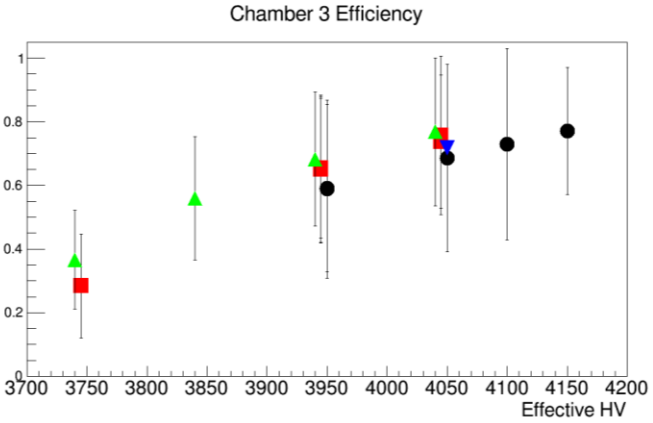



# GEM efficiency vs HV and gas flow




Black Circle: 9 l/h*
Red Square: 18 l/h
Green Triangle: 36 l/h
Blue Triangle: 18 l/h
no alignment

1 chamber volume
~ 12 liters

*) relatively short flushing period

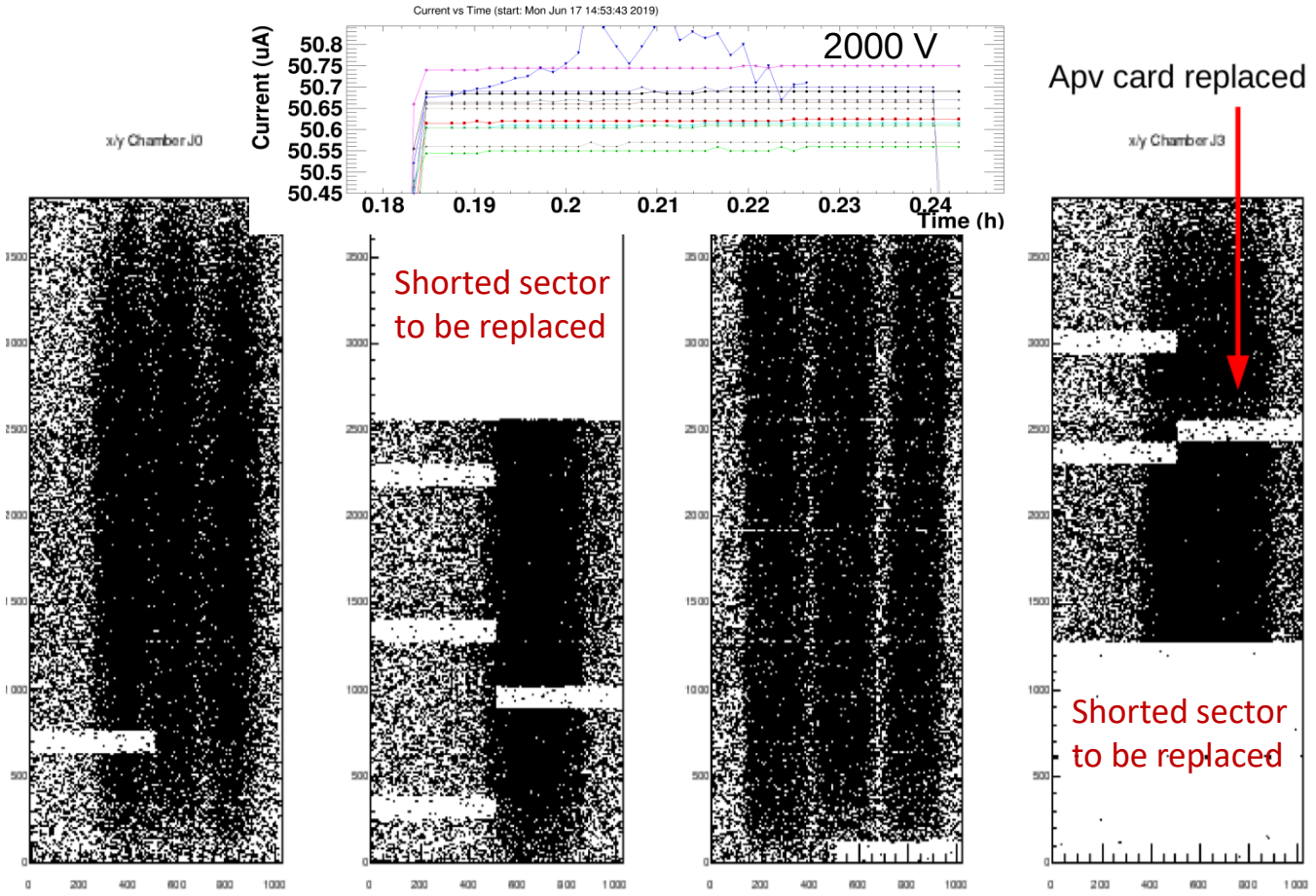
Nov/2018 and Apr/2019 cosmic data

NOTE: Chamber efficiencies include gaps between GEM modules (~5%)!

Effective HV plateau around **4050-4100 V**
Gas flow larger than **18 l/h** (per chamber) to avoid noticeable effects on efficiency

# Front Tracker - June Contingency

**Jun/19: Two sectors shorted few min. after HV start ramping up!**




Possible sources of failure:

- Work on the upper trigger scintillators
- Removed pressure gauge from gas cylinder (but each gas line has a 10 um inlet filter)
- Different humidity conditions (needing longer gas flushing)
- ??

!! During standby conditions, better to flush inert gas (N2) continuously !!

The 2 GEM modules will be replaced end of August/19 before installation in BigBite

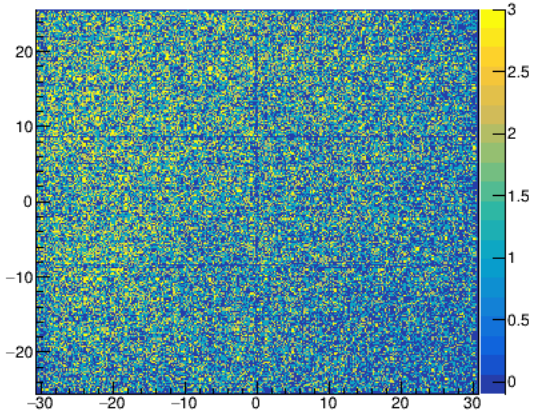
# Front Tracker GEM modules status

| | |
|---|---|
| #1 (0) | integrated in final chamber j2 |
| #2 (1) | at JLab, originally in final chamber j2, removed due to large dead area |
| #3 (2) | at JLab, rejected after further tests with 90Sr source at JLab |
| #4 (3) | at JLab, rejected after further tests with 90Sr source at JLab |
| #5 (4) | integrated in final chamber j2 |
| #6 (5) | at JLab, rejected after further tests with 90Sr source at JLab |
| #7 (8) | under fixing/test in Rome; 4 HV damaged paths have been fixed so far |
| #8 (9) | integrated in final chamber j0 |
| *#9 (10) | integrated in final chamber j1 – shorted in June/18 – to be replaced |
| #10 (12) | integrated in final chamber j0 |
| #11 (13) | integrated in final chamber j1 |
| #12 (14) | integrated in final chamber j1 |
| #13 (15) | integrated in final chamber j0 |
| *#14 (16) | integrated in final chamber j3 – shorted in June/18 – to be replaced |
| #15 (17) | integrated in final chamber j3 |
| #16 (18) | integrated in final chamber j2 (replace module #2). |
| #17 (19) | integrated in final chamber j3 |
| *#18 (20) | at JLab, ready for integration in chamber (j4) |
| *#19 (21) | at JLab, ready for integration in chamber (j4) |
| #20 (22) | rejected (in Rome); many shorted sectors |
| #21 (23) | tested in Rome; passed with new issue on strips (j4) |
| #22 (24) | under testing; gas and HV training successful (j5) |
| #23 (25) | under testing; gas training (j5) |
| #24 (26) | planned; need GEM foil fixing at CERN; (j5) |

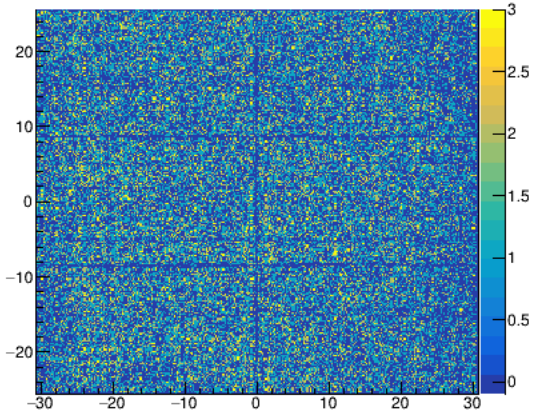
| | |
|---|---|
| **Operational/Jun19:** | **10** |
| **Available for inst.** | **3** |
| **Under Test:** | **2** |
| **Rejected:** | **8** |
| **Planned:** | **1** |

# Rear-GEM Layer Hit Map

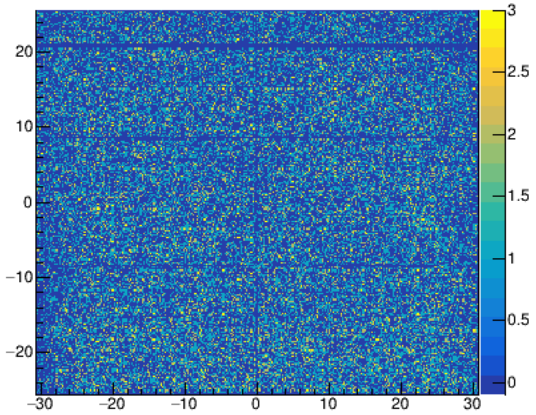
L1-M33-P0



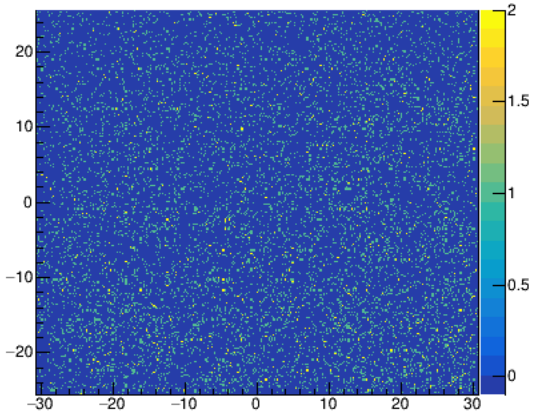
L1-M47-P1



L1-M21-P2



L1-M35-P3



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

**We don't have performance pots per say yet**

**We have not yet start cosmic data with several layers**

**Plan is to have the first data mid August**

**Also waiting for some preliminary plots of the performances of UVa GEM in PREX experiment**

Kondo Talk for additional details

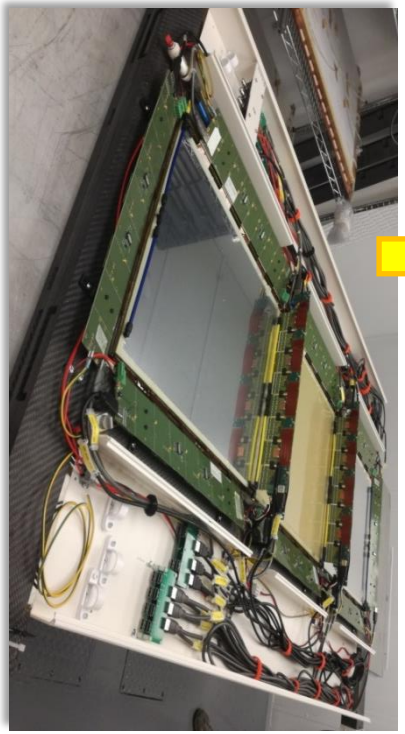
# GEM chambers BB Integration plan

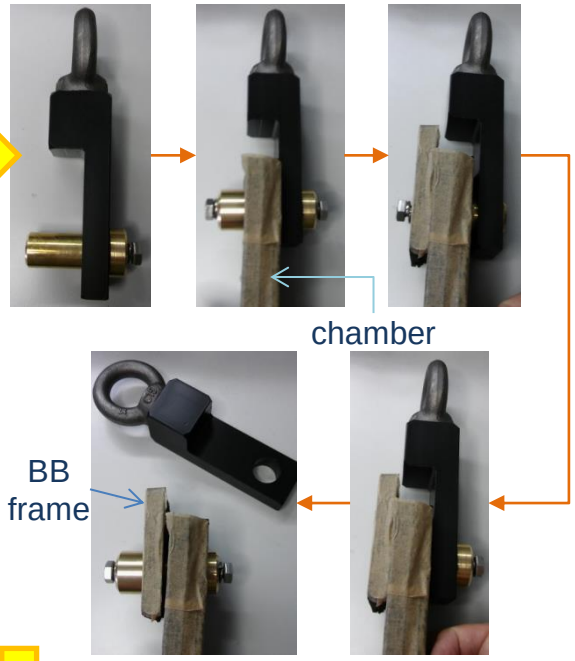
| | 2019 | | | | | 2020 | | | | | | | | | | | 2021 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | S | O | N | D | J | F | M | A | M | J | J | A | S | O | N | D | J | F | M | A |
| **-- Main SBS/BB Timeline --** | | | | | | | | | | | | | | | | | | | | | |
| 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. 2nd and 3rd 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 |

**KG:**

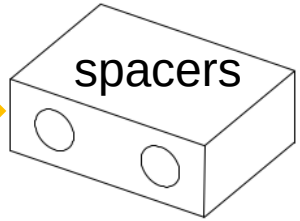
- Ideally UVa GEM for BB can be installed in Sept week #2 or #3 ⇨ Pretty straight forward,
- If well coordinated with Doug and Jessie …, one week is more than enough for the actual installation in BB

# Tracker integration in BigBite

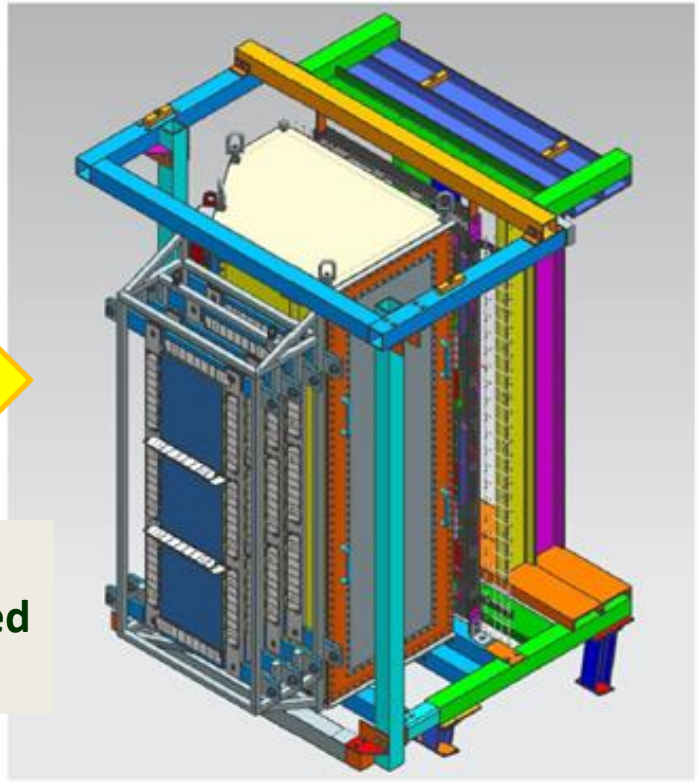





Use crane to lift the Front GEM chambers and load into BB frame.
Custom made hooks and axes to hold the chamber and fasten in the BB frame

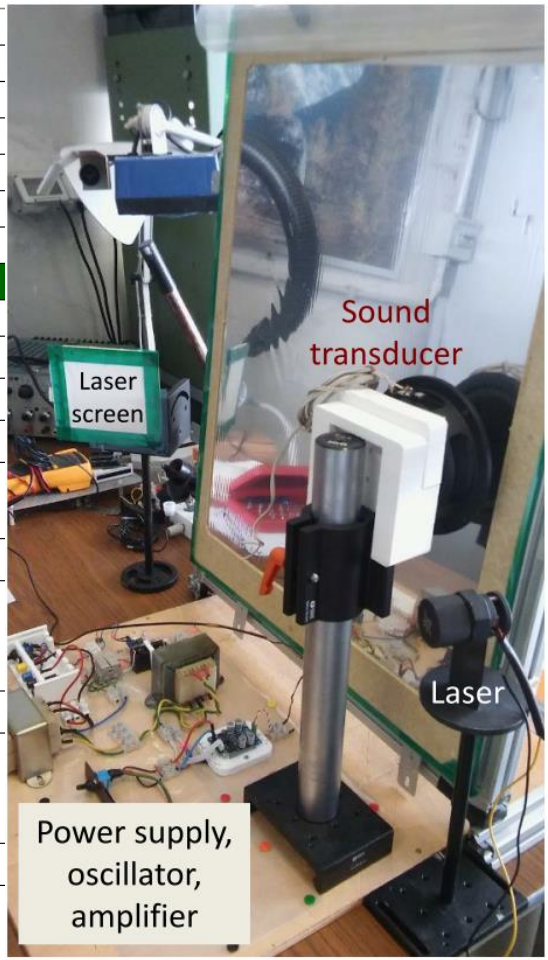




**No additional supports required for Rear GEM**



# GEM Modules working plan

| | 2019 | | | | | 2020 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | S | O | N | D | J | F | M | A | M | J | J | A | S | O |
| **-- 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 | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| **-- Complete SBS GEM chambers --** | | | | | | | | | | | | | | | |
| Start Integration and test of the 5th GEM chamber | | X | | | | | | | | | | | | | |
| Prepare for “cleaning” a multi sector shorted GEM module (in Rome) in ultrasound bath 40 kHz | | | X | | | | | | | | | | | | |
| Try cleaning GEM module | | | | X | | | | | | | | | | | |
| If negative try a different approach either by focusing antenna or direct vibration of the GEM foil with shorts | | | | | X | X | | | | | | | | | |
| Additional cleaning tests | | | | | | X | X | | | | | | | | |
| If positive procure material, setting up a cleaning system at JLab and proceed to clean potentially fixable modules | | | | | | | | X | X | X | | | | | |
| Integrate last GEM chamber(s) and test | | | | | | | | | | X | | X | X | | |




Main issue in INFN GEM are the shorted sectors: we are evaluating «cleaning» procedures based on (ultra)sounds up to 80 hKz

# GEM – Readout Electronics

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

| | Channels | APV25 | MPDs |
|---|---|---|---|
| Front Tracker | 28000 | 216 | 16 |
| Rear Tracker | 12000 | 100 | 7 |

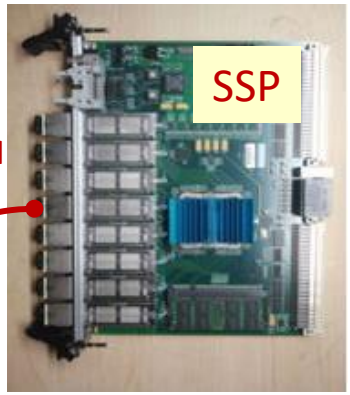

**MPD Main Block**

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

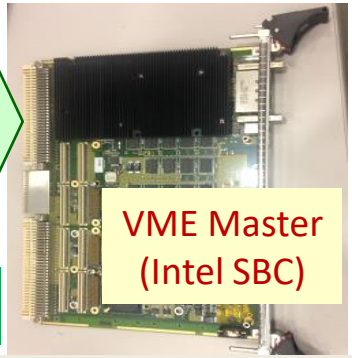
MPD-SSP Interface → SSP-Protocol → Aurora Protocol

MPD-VME Interface → VME-Protocols → 2eSST, 2eVME, VME32 …, VXS

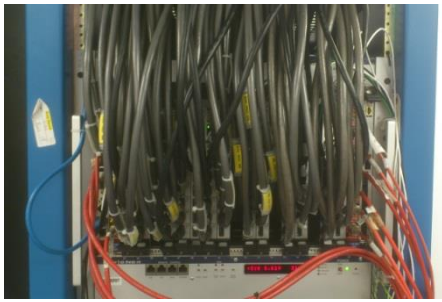
Optical Fiber




VME (64x)



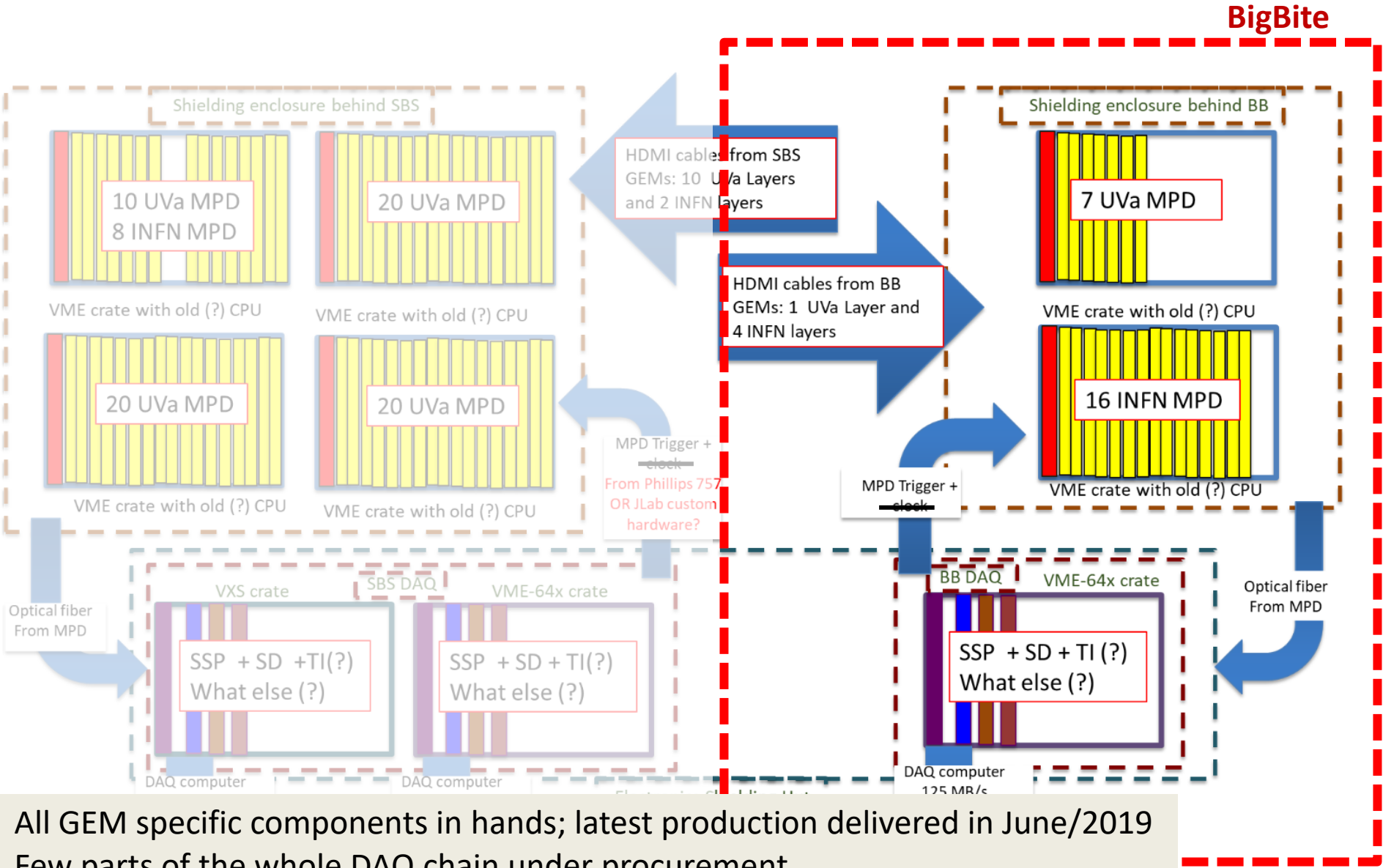

All major firmware issues fixed so far



**Electronics is up and running (or going to run) on:**

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

# SBS/BigBite Electronics setup




All GEM specific components in hands; latest production delivered in June/2019

Few parts of the whole DAQ chain under procurement

# BigBite GEM Electronics/DAQ

| *Item* | *Status* |
|---|---|
| 216 x Front End Boards, 58xBCKs, HDMI short cabling, patch panels | Currently used in cosmics (+spare) |
| 23 x MPDs | Currently used in cosmics (+spare) |
| 1 x SSP modules | in hand 2 tested by UVa, 1 back from Italy,(to be shared with GEn-RP) |
| TI – Trigger supervisor | Used in cosmics |
| Master VME (for SSP and TI) | To be identified |
| Trigger fan-out (23 channels) | JLab custom boards under test |
| 1 VME 64x (for SSP, TI …) | 3 in hand (to be shared with GEn-RP) |
| 2 VME crate (no master) for MPDs | Currently used in cosmic (or simpler ones) |
| 1 VME (mini)crate for slow control + Master | To be identified / procured / shared |
| 140 x HDMI cable (10/15 m long) | Currently used in cosmics (+spare) |
| 23 Optical fiber (BB hut – BB weld.) MPD–SSP | Under procurement by Alex |
| 23+1 NIM cables (~m) trigger distribution | To be identified / procured (1 from BB hut – BB weld.) |
| 21 NIM cables (10 cm) for clock distribution | To be identified |
| 16 x HV cables (10-25 m) | Cable on hand, to be finalized, length depend on location (hut or weld.) |
| 6 x LV cables pairs (10-25 m) | To be identified / procured, length depend on location (hut or weld.) |
| HV power supplies (2xCAEN-VME, UVa system) | Currently used in cosmic (+spare); location to be finalized |
| LV power supplies (2xTTI-Eth., UVa system), in BB hut | Currently used in cosmic (+spare); location to be finalized |

Kondo talk for general view

GEMs are under cosmic test; most of the components will be reused in final installation

# Manpower and Main Timeline

| People Involved | |
|---|---|
| AC | Alexandre Camsonne |
| BM | Bryan Moffit |
| CS | Concetta Sutera |
| DD | Danning Di |
| EC | Evaristo Cisbani |
| JLab | BB expert/resp., Electronics service, Mechanical workshop |
| JS | Jack Segal |
| KG | Kondo Gnanvo |
| LR | Leonard Re (till mid 2020) |
| MJ | Mark Jones |
| MK | Michael Kohl and his student(s) |
| NL | Nilanga Liyanage |
| PM | Paolo Musico |
| RP | Roberto Perrino |
| SJ | Siyu Jian |
| Tech (INFN) | Fausto Giuliani, Fabio Santavenere, Antonio Grimaldi, Domenico Sciliberto, Maurizio Salemi, Francesco Librizzi |
| VB | Vincenzo Bellini |
| AR | Anuruddha Rathnayake |
| AP | Andrew Puckett |

Currently INFN can guarantee

~4-6 man-month/year at JLab (T+R)

+ overseas work

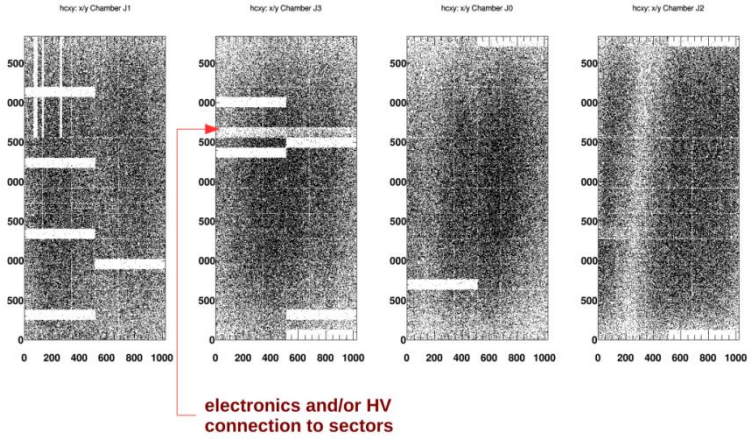
UVa: 1 R + 1PhD-S >1/2 time at JLab

| Item | Deadline |
|---|---|
| Complete Characterization | Aug 2019 |
| Front Tracker in BB | Sep 2019 |
| BB System Tests | Spring 2020 |
| Hall A installation | Summer 2020 |

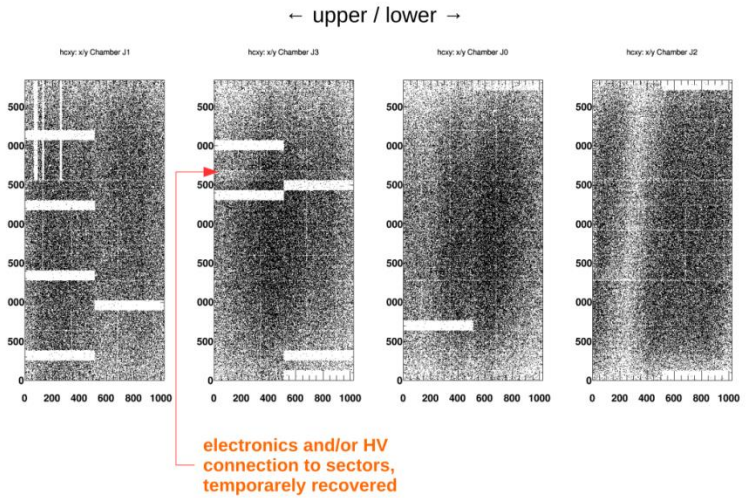
# Support Slides

# April/2019 - Cosmic Test (few days)

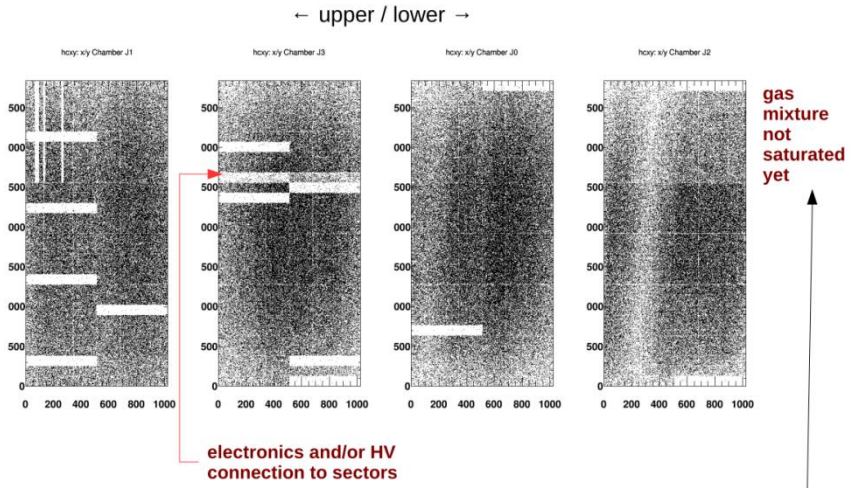
## Apr/19: 4100 V




## Apr/19: 4150 V

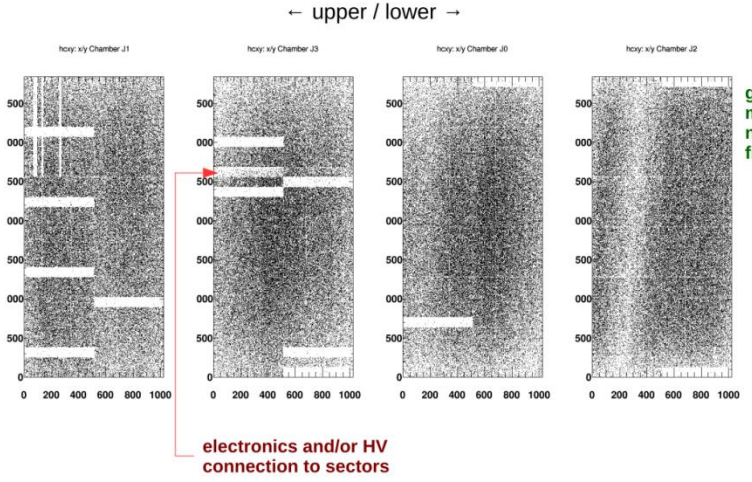



## Apr/19: 4200 V first ~150 kevents




NOTE: Gas bottle replaced at 9:30, Run started arount 10:30

## Apr/19: 4200 V last ~150 kevents




Stable results, matching Nov/18 maps