

APV25 Electronics for GEMs at UVa and for the 12 GeV  
Upgrade Program in HallA at JLab  
*RD51 Electronic School, February 3-5, 2014*

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# Outline

- GEM Trackers for Hall A 12 GeV Upgrade at JLab
  - Super Bigbite Spectrometer (SBS)
- APV25 Electronics for SBS GEMs
  - MPD Electronics
  - SRS-ATCA electronics ?
- Current status of SRS Electronics at UVa
  - Test of large SRS system with the SRU
  - SRS Electronics in Test beam at Fermilab



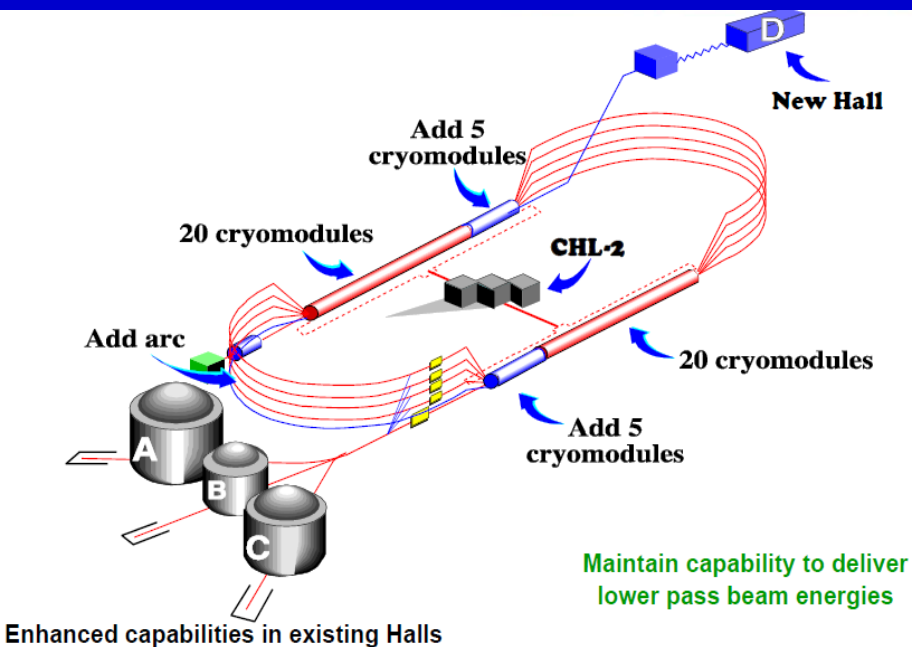
# 12 GeV Upgrade of CEBAF @Jefferson Lab in Newport News VA, USA

## CEBAF 6 GeV (before 2013)

- Max. current: 200  $\mu\text{A}$
- Max. Energy: 5.7 GeV
- Longitudinal pol.: 75 to 85 %

## CEBAF 12 GeV (2014)

- Max. current: 90  $\mu\text{A}$
- Max. Energy: 11 GeV (Hall A, B, C), 12 GeV (Hall D)
- Longitudinal pol.: 75 to 85 %



## Newport News, VA



# Super BigBite Spectrometer (SBS) in Hall A @ JLab

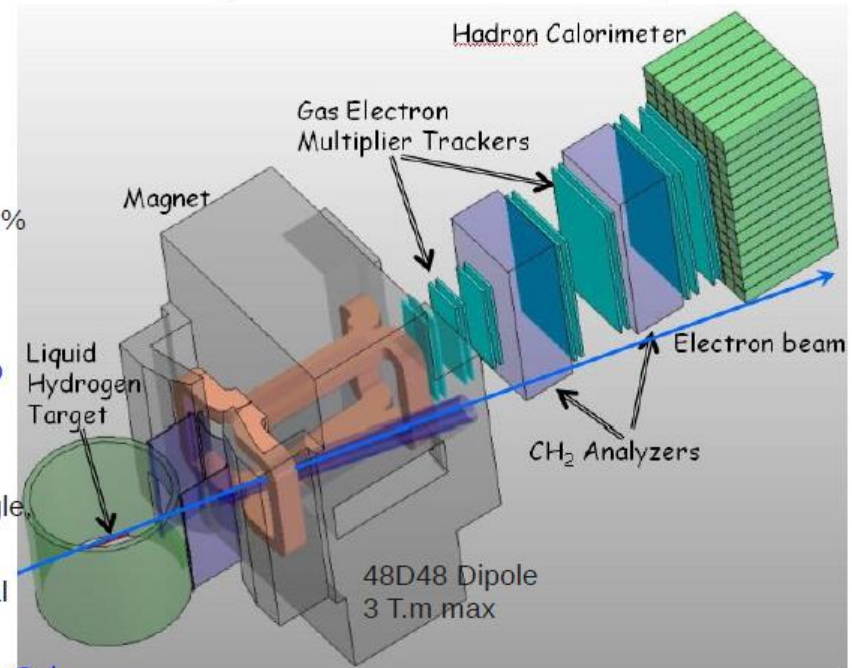
- SBS is the first apparatus in Hall A for the CEBAF 12 GeV upgrade at JLab
- Set of instrument for flexible spectrometer configuration

- Dipole Magnet
  - GEM for Tracking
  - Calorimeters
  - CH<sub>2</sub> Analyzer for Proton
  - Polarimeter for GEp (5)
  - Dual-radiator RICH for SIDIS
- Program

## SBS Configured for Recoil-Proton Polarimetry

- High Luminosity:  $8 \times 10^{38} \text{ cm}^{-2}\text{s}^{-1}$
- Support high background:  $500 \text{ kHz/cm}^2$  (low energy photons mainly)
- Forward angle
- Large acceptance
- Good angular (0.2 mr) and reasonable momentum (0.5% @ 4-8 GeV/c) resolution
- Flexibility: use the same detectors in different experimental setup
- 2 tracker geometries, same base module
- 1<sup>st</sup> front, momentum, angle, vertex
- 2<sup>nd</sup> polarimeter, azimuthal scattering
- Also GEM in BigBite and BigCal

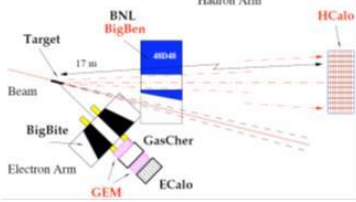
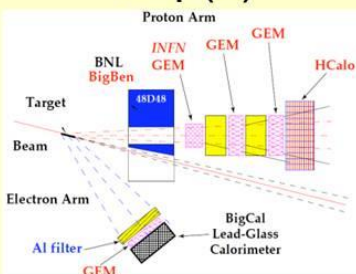
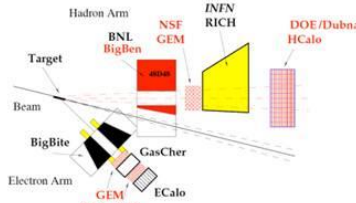
SBS Configured for Recoil-Proton Polarimetry



J.R.M. Annand, JointGEM Meeting, Helsinki, July 2010

# Super BigBite Spectrometer (SBS) in Hall A @ JLab

## Some challenging experiments in Hall A

| Experiments   | Luminosity<br>( $\text{s}\cdot\text{cm}^2$ ) <sup>-1</sup> | Tracking Area<br>( $\text{cm}^2$ ) | Resolution        |                |                 |
|---|--|------------------------------------|-------------------|----------------|-----------------|
|   |  |                                    | Angular<br>(mrad) | Vertex<br>(mm) | Momentum<br>(%) |
| <b>GMn - GEn</b><br> | up to $7\cdot 10^{37}$                                     | 40x150<br>and 50x200               | < 1               | <2             | 0.5%            |
| <b>GEP(5)</b><br>   | <b>up to</b><br><b><math>8\cdot 10^{38}</math></b>         | 40x120,<br>50x200 and<br>80x300    | <0.7<br>~1.5      | ~ 1            | 0.5%            |
| <b>SIDIS</b><br>   | up to $2\cdot 10^{37}$                                     | 40x120,<br>40x150 and<br>50x200    | ~ 0.5             | ~1             | <1%             |

**Most demanding**

**High Rates**

**Large Area**

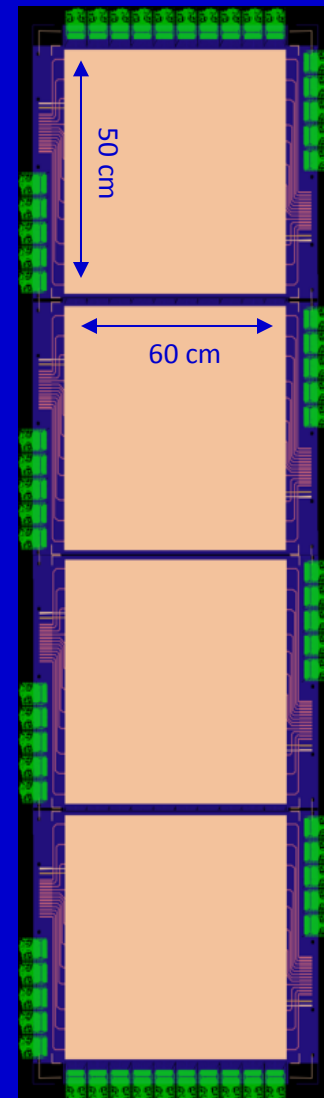
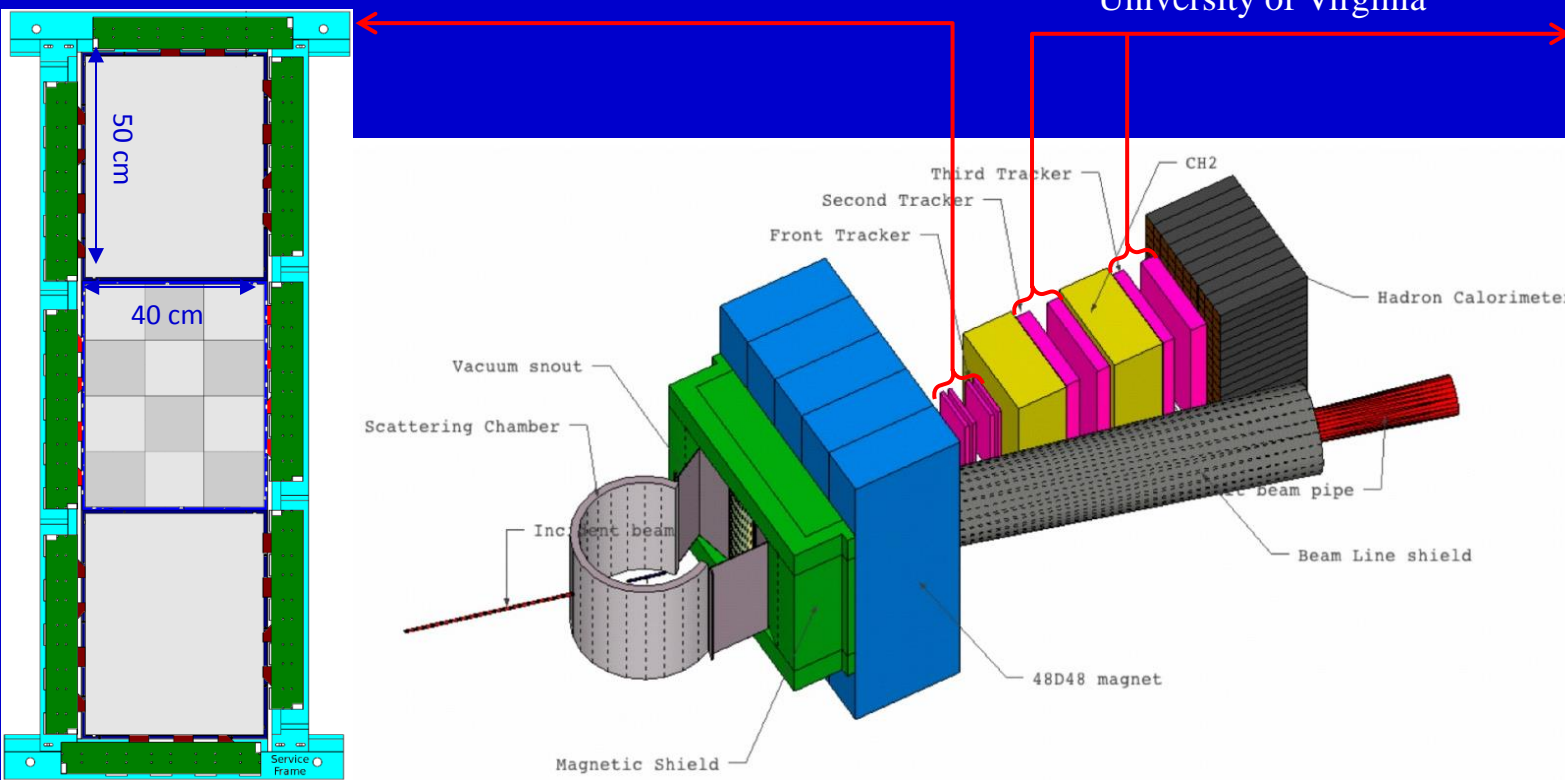
**70  $\mu\text{m}$  spatial resolution**



# GEM Trackers for SBS

- **Front Tracker:**
- 6 GEM Layers ( $150 \times 40 \text{ cm}^2$ )
- Each layer = 3 GEM modules ( $50 \times 40 \text{ cm}^2$ )
- R&D and Production by INFN Roma, Catania

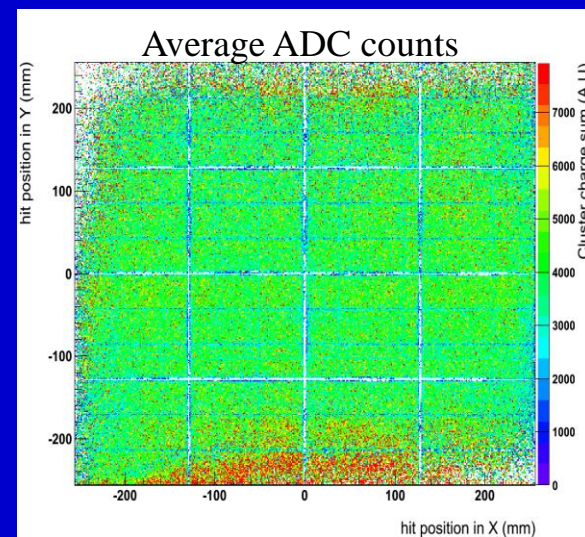
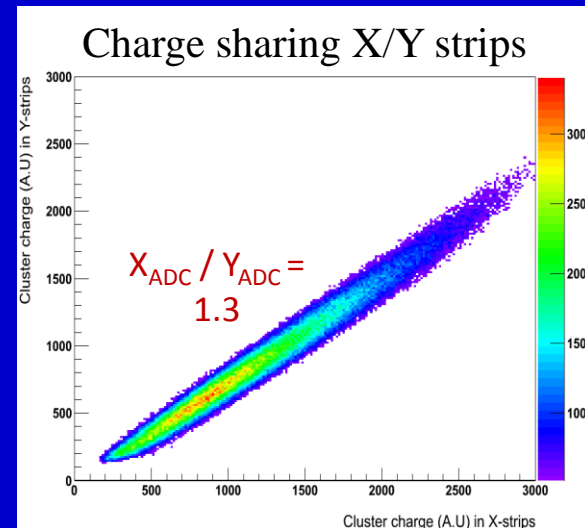
- **Back Tracker**
- 8 GEM Layers ( $200 \times 50 \text{ cm}^2$ )
- Each Layer = 4 GEM modules ( $50 \times 60 \text{ cm}^2$ )
- R&D and Production @ University of Virginia



Proton arm layout for GEp (5) experiment

# SBS Back Tracker GEM Module

- 50 × 50 cm<sup>2</sup> prototype @ UVa with APV25 electronics (SRS FE cards)
- Final design size is going to be 60 × 50 cm<sup>2</sup> production just started





# Two APV25 Readout Systems for SBS GEM Trackers

## Front Tracker: Multi Purposed Digitizer (MPD)

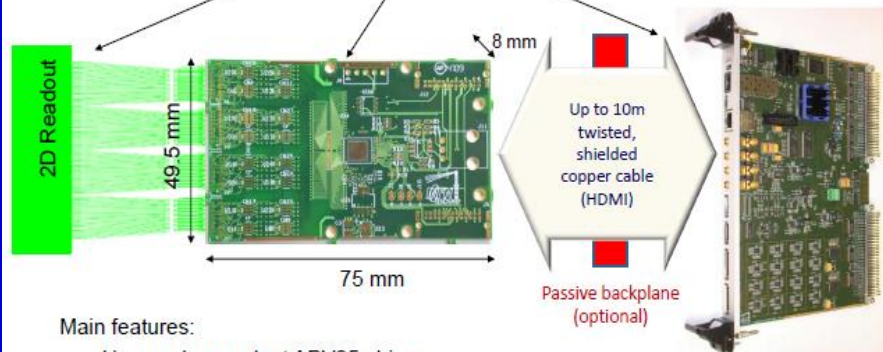
- *By Paolo Musico (INFN Genoa)*
- VME 64x crate
- Two active components: apv25 FE cards and MPD VME module
- Backplane interface between FE cards and MPPD

## Back Tracker: SRS-ATCA + SRU

- Hans Muller (RD51) & eicSys (Germany)
- ATCA crate
- High density channels at limited cost/channel
- High rate for experiment like SBS

### Electronics Components

GEM ⇒ FEC ⇒ MPD ⇒ DAQ



#### Main features:

- Use analog readout APV25 chips
- 2 "active" components: Front-End card and VME64x custom module
- Copper cables between front-end and VME
- Optional backplane (user designed) acting as signal bus, electrical shielding, GND distributor and mechanical support

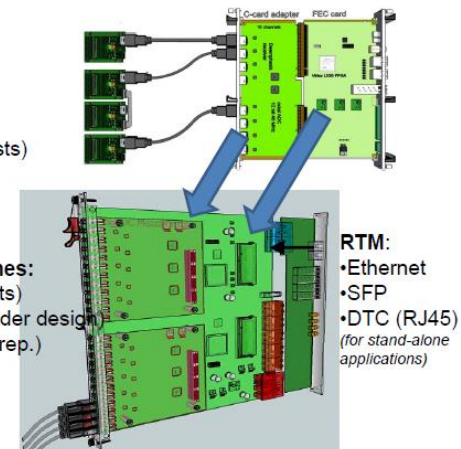
MPPD001 - 29 August 2011 - Kobe  
E. Caluso et al. - GEM Tracker @ LBNL Hall A

### SRS\_ATCA\*



**ATCA-FEC blade:**  
• dual FEC blade (exists)

**SRS-ATCA Mezzanines:**  
• 12 x HDMI ADC (exists)  
• 12 x HDMI Digital (under design)  
• 8 x SFP Optical (in prep.)



- 1.) higher channel integration => reduce cost/channel for large systems
- 2.) certified crate standard
- 3.) replace DTCC cables by ATCA backplane
- 4.) start with 2-slot ATCA crate that can be read out via DTCC cables to SRU

• Commercial production for NEXT, EMCaL, ATLAS NSW, IFIN-HH by EicSys GmbH

# Status of MPD

- Hardware modifications:
- Used HDMI-A connectors for analog and digital signals
- Adopted larger FPGA (+20%)
- Replaced DDR with DDR2 (128 MB)
- 110 MHz system clock
- Removed USB support
- Moved from Flash to SD-Card
- Added front panel coax clock
- All spare signals go to PMC compliant connectors
- Improved ADC power distribution
- Added optional termination on ADC inputs



# Status of MPD

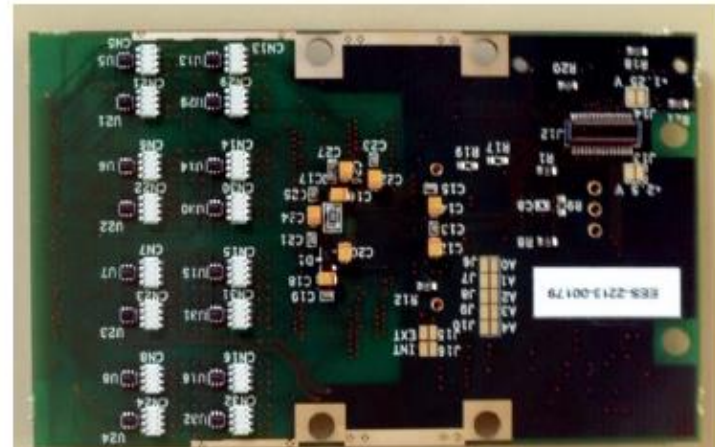
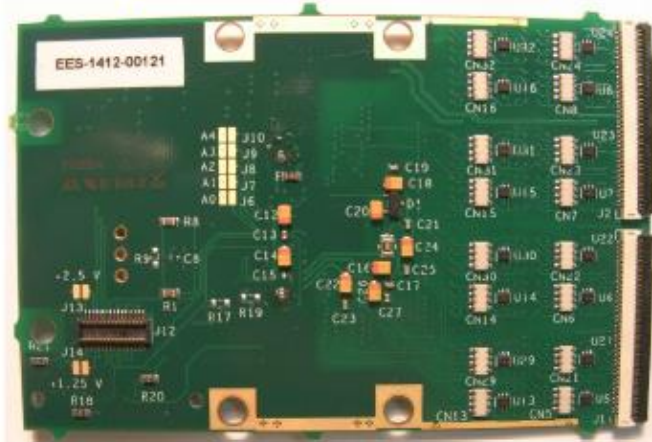
## New APV Card with Panasonic 133pins connector

We now have two versions of the APV cards:

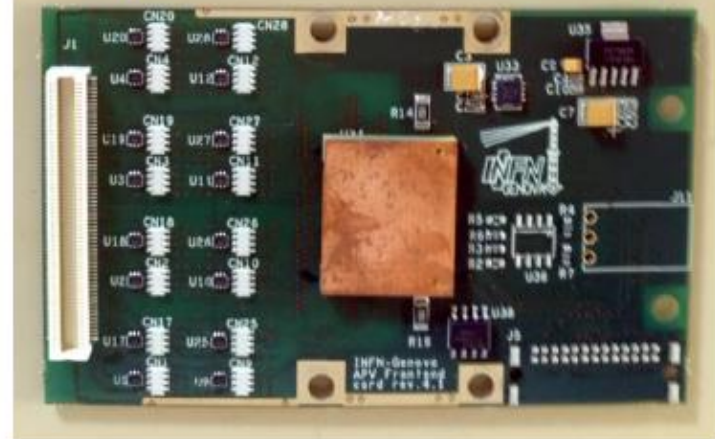
- 2xZIF connectors
- Panasonic 133 pins «CERN Standard connector (few mm longer)

All other components identical  
Both versions will be maintained

ZIF Connector version



«Standard» Panasonic. NEW!



28/Aug/2013

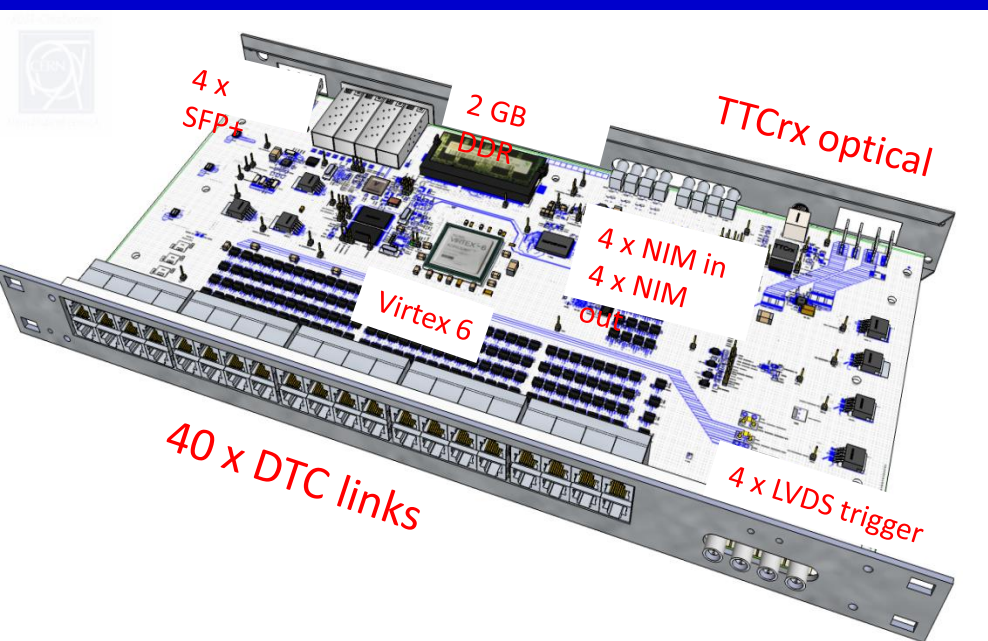
SBS Weekly Meeting - FT Status

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# SRS-ATCA For SBS GEM Back Trackers

- Requirement for SBS Back Trackers GEMs
  - 91 K electronics channels at an acquisition rate up to 5kHz
- SRS-ATCA: Certified crate standard: ADC/FEC combo replaced by ATCA blades
  - Higher channel integration => reduce cost/channel for large systems
  - Replace DTCC cables by ATCA backplane
- The Standard CERN Scalable Readout Unit (SRU)
  - Event builder: collect events from up to 40 FECs and send to the DAQ PC via a 10 Gb optical link
  - SRU distribute the trigger and clock signals via DTCC links to APV25 and the ATCA blades ad ADCs ,

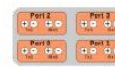


## ATCA -14 slot crate

Ad interim: SRU-3 connected via rear RTMs (SRU-4 to become slot 1 card)

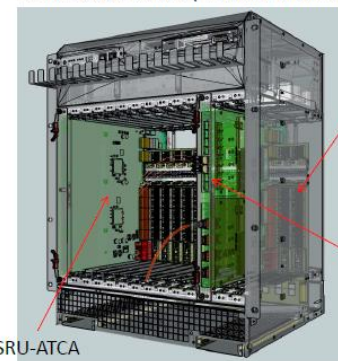


Full-mesh backplane: 4x 6 Gbit duplex links embedded in each backplane slot



each Blade can talk to each other:  
→ new possibilities to explore

12 SRS-ATCA blades ( 72k APV channels )



ATCA full mesh backplane

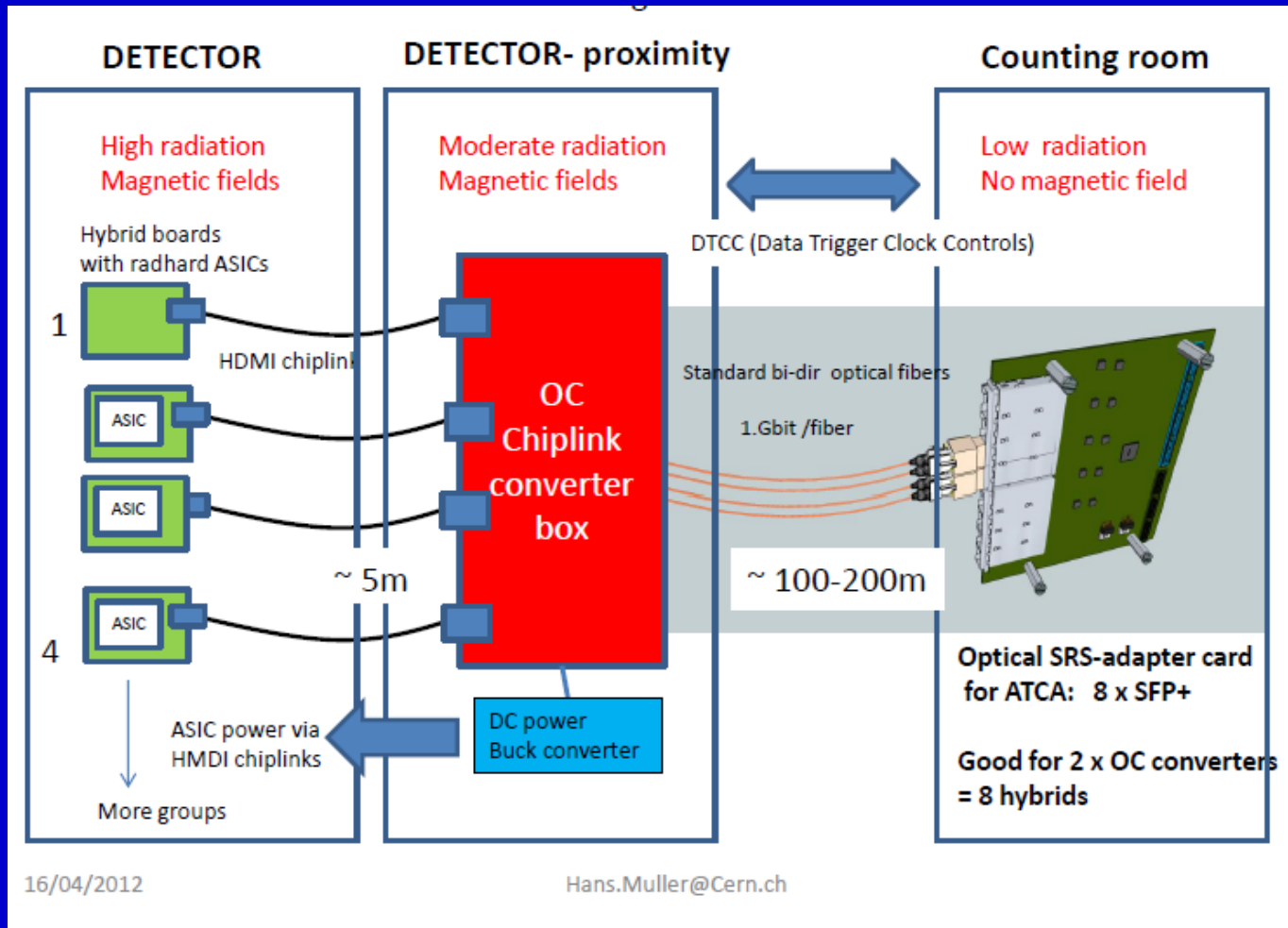
SRS-ATCA card

Hans.Muller@cern.ch

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# SRS-ATCA: OC Chiplink Converter Box

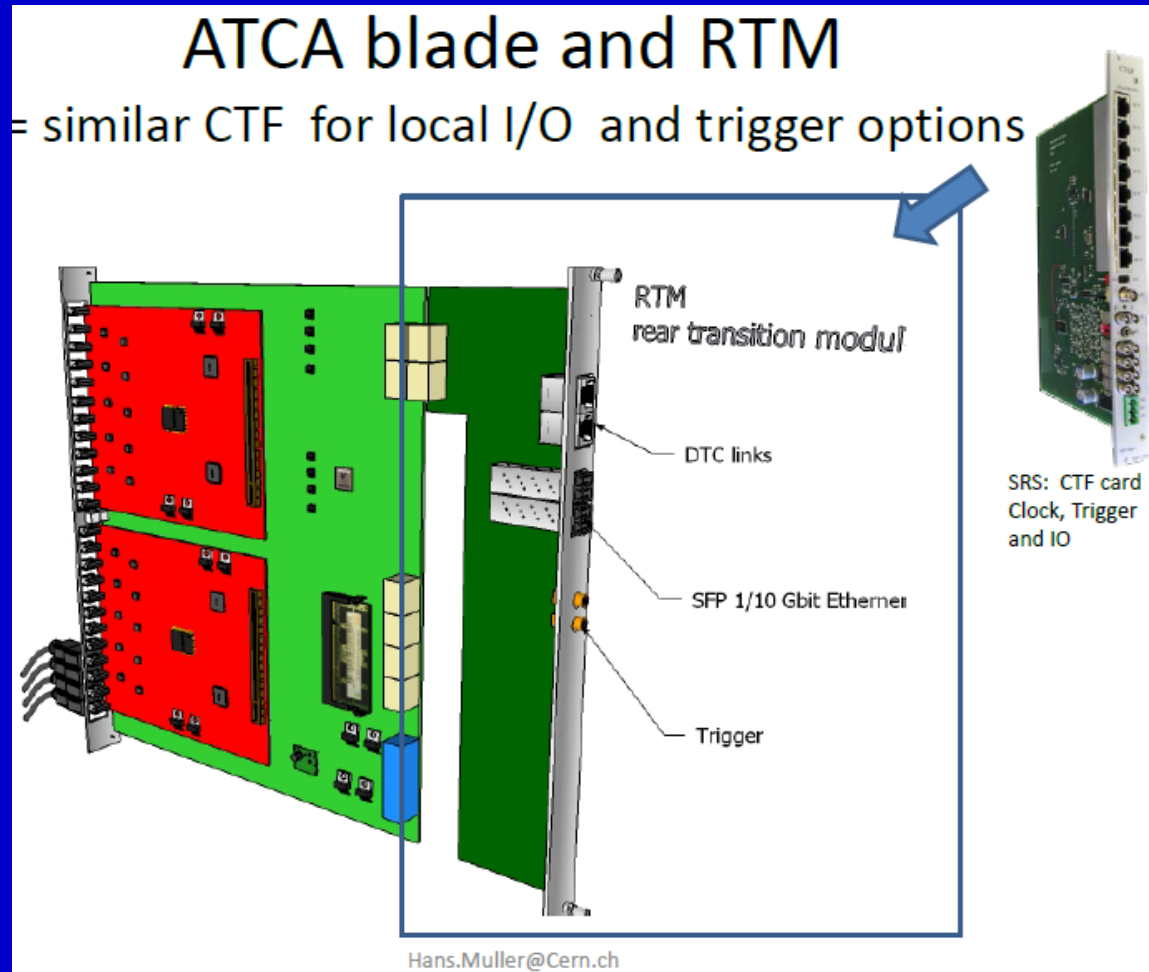
- SRS crates far away from the detectors with optical fibers
- ASIC power via HDMI → address our concern with no rad hard LDOs on APVs Hybrids
- We are really interested in this development and would like to contribute to the effort





# SRS-ATCA: What is the current status of the RTM?

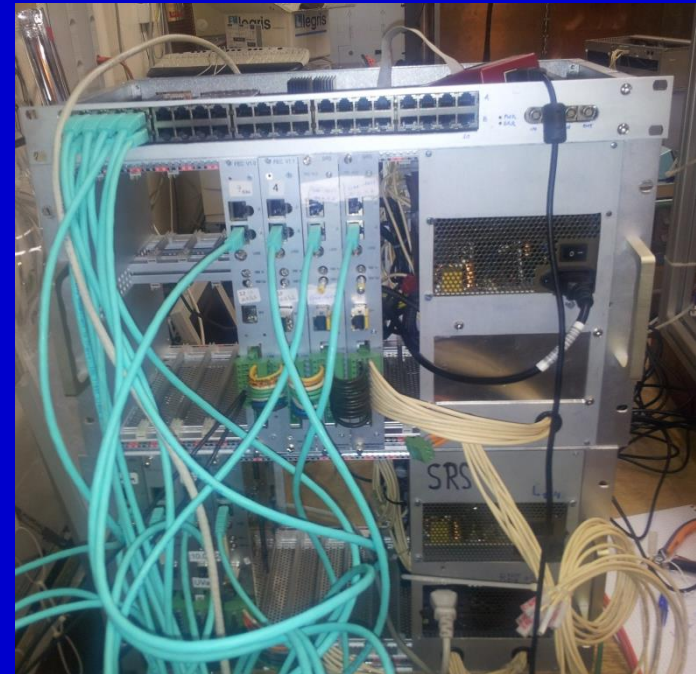
- Can we have 4 DTCC links for each RTM (with at least 3 for the data to the SRU?)
- What are the other options available?





# Test of the SRU with Multiple FECs

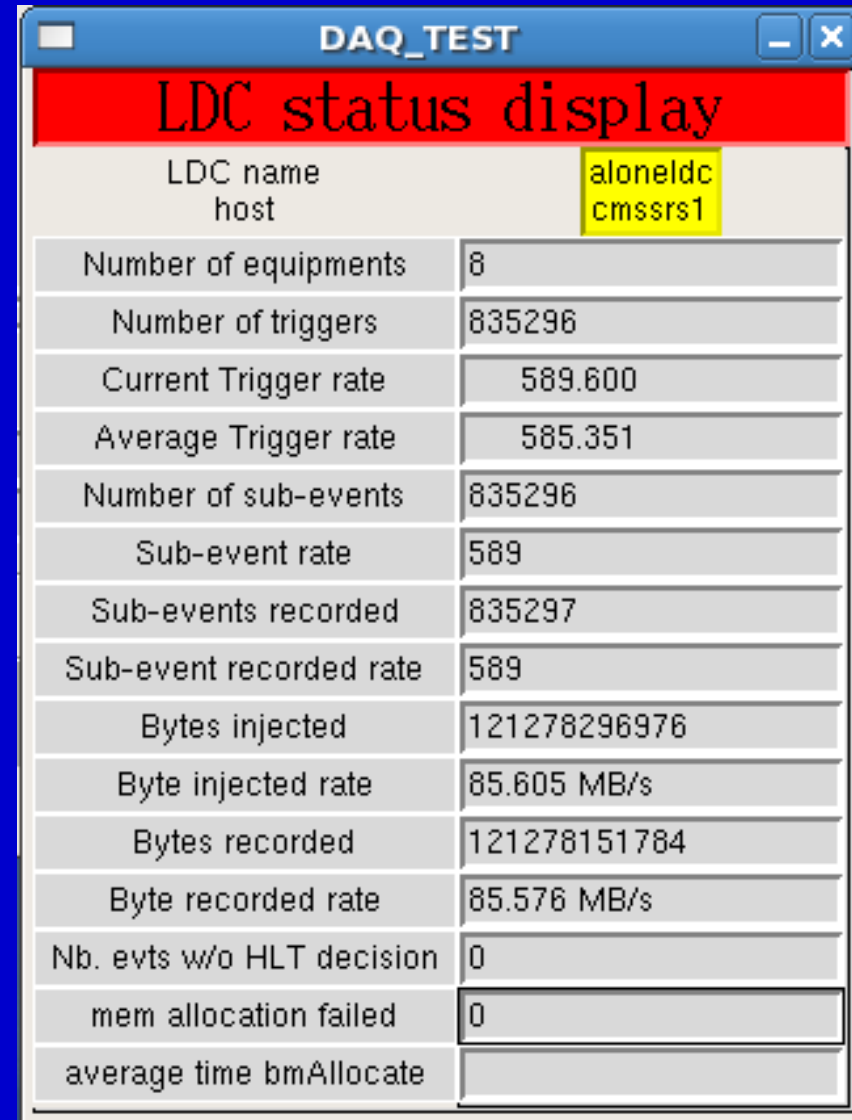
- Test performed at CERN August, 15<sup>th</sup> – 30<sup>th</sup> 2013
- First time SRU was been tested with more than one FEC card
- Many groups interested and involved in the test:
  - UVa (Kondo Gnanvo)
  - RD51 Electronics WG5 (Hans Muller & Alfonso Tarazona)
  - RD51 GDD lab at CERN (Eraldo Oliveri)
  - ATLAS MAMMA Group (Andre Zibel, Michele Bianco)
- SRS Material used for the test:
  - **UVa:** SRU + FP Euro crate + 1 FEC card + 4 ADCs cards + 40 apv25 hybrids
  - **Florida Tech:** 2 FEC/ADC combos
  - **MAMMA Group at CERN:** 2 FEC/ADC combos + Micromegas Tracker Telescope
  - **RD51 GDD:** 2 FEC/ADC combos + x-ray box and DATE PC



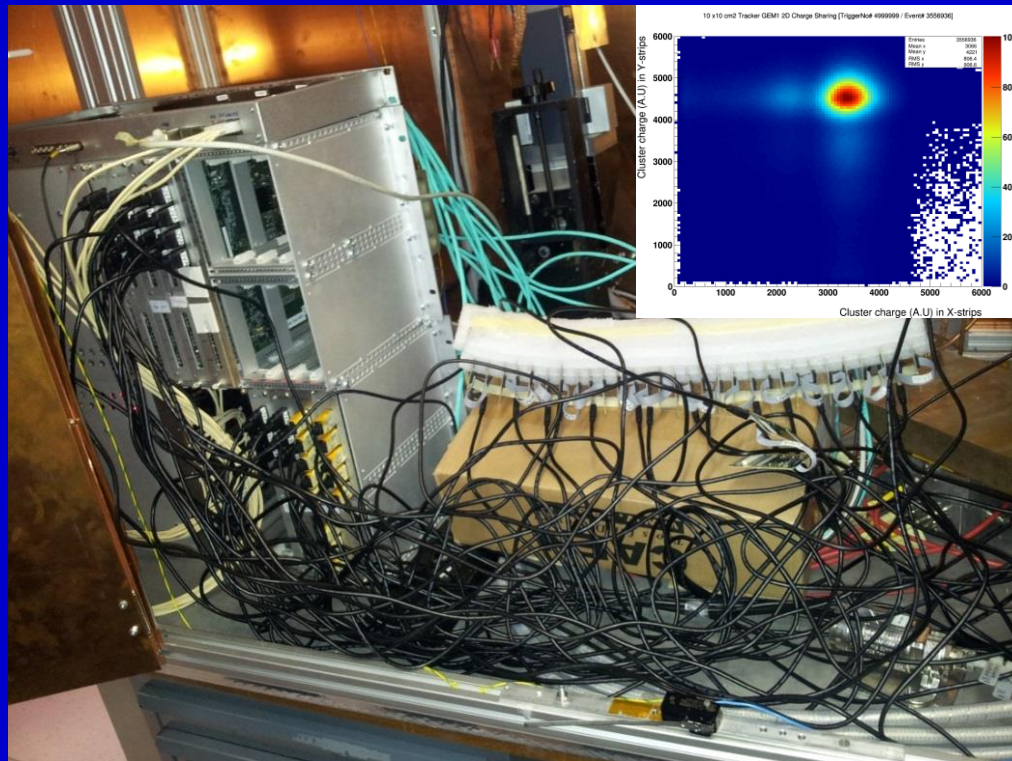
# Test of the SRU with Multiple FECs at CERN

- SRS-SRU tested in RD51-GDD X-ray box
- 8 FECs card connected to the SRU
- 70 APV25 Hybrids, 4 APV25 connected to a small 10 x 10 GEM chamber
- High rate capability of the system

## DATE Run Control Display



| LDC name                  |              | alonedlc |
|---------------------------|--------------|----------|
| host                      |              | cmssrs1  |
| Number of equipments      | 8            |          |
| Number of triggers        | 835296       |          |
| Current Trigger rate      | 589.600      |          |
| Average Trigger rate      | 585.351      |          |
| Number of sub-events      | 835296       |          |
| Sub-event rate            | 589          |          |
| Sub-events recorded       | 835297       |          |
| Sub-event recorded rate   | 589          |          |
| Bytes injected            | 121278296976 |          |
| Byte injected rate        | 85.605 MB/s  |          |
| Bytes recorded            | 121278151784 |          |
| Byte recorded rate        | 85.576 MB/s  |          |
| Nb. evts w/o HLT decision | 0            |          |
| mem allocation failed     | 0            |          |
| average time bmAllocate   |              |          |

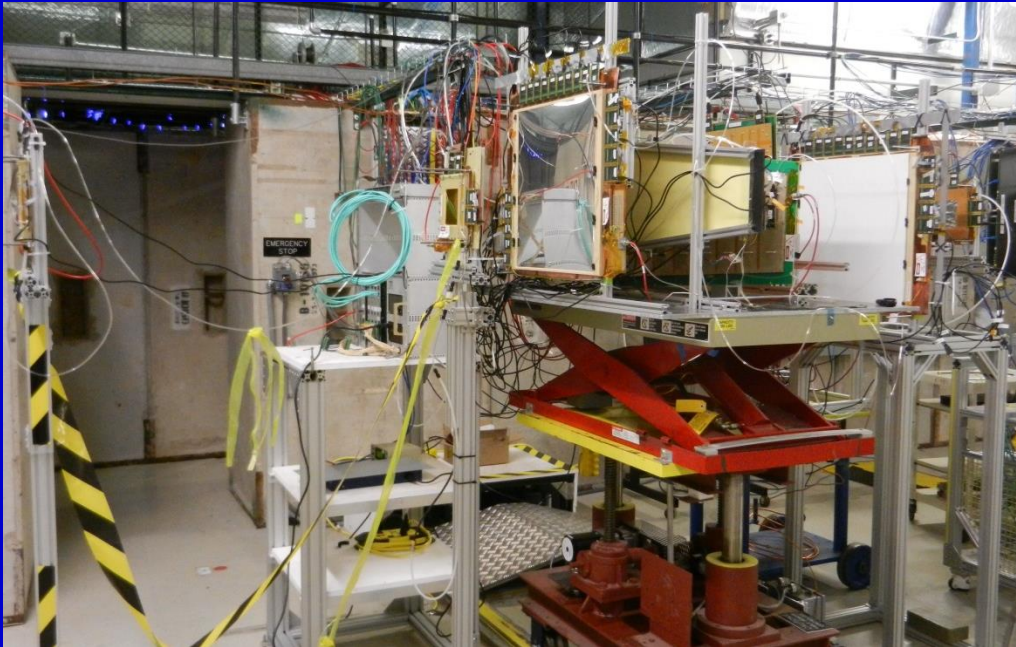




# Test Beam T-1037 @ Fermilab: GEMs for EIC Tracking and PID Detectors

*UVa & Florida tech: Large Size GEM for forward tracking*

*Yale Univ: 3D-Coordinate GEM setup*

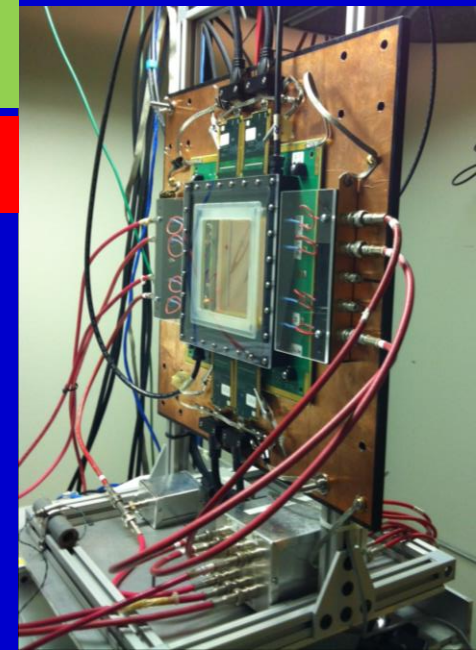


T-1037 is funded by  
Site-neutral R&D  
Program administered @  
BNL

*BNL: Mini drift GEM*

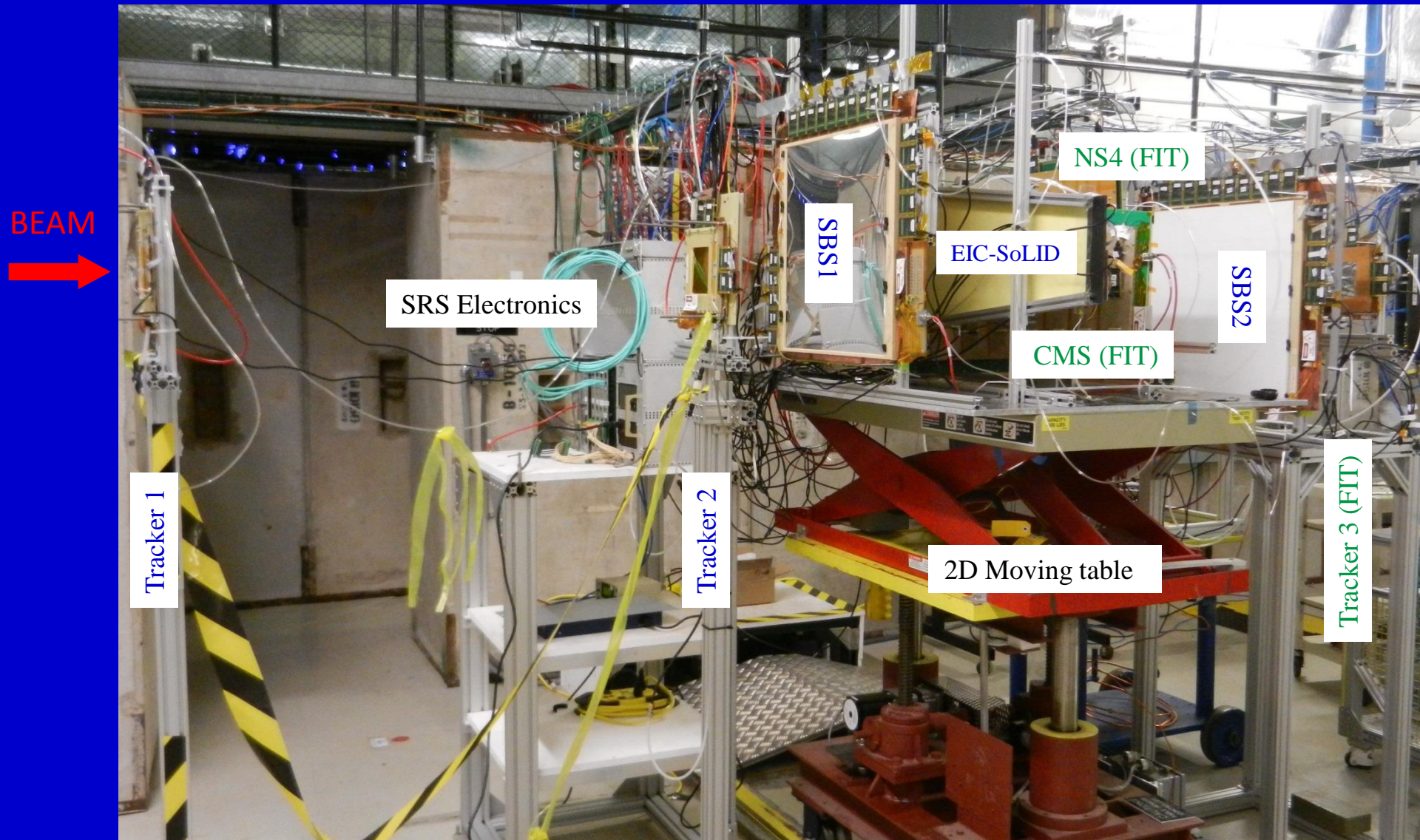
*Stony Brook Univ: GEM-RICH setup*

APV25-SRS for all the  
20 GEMs of the 4 setups





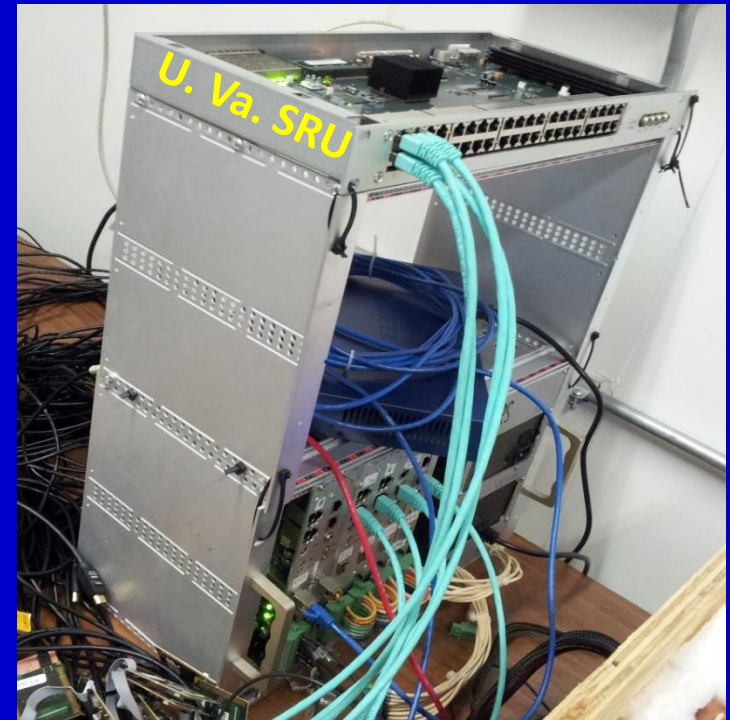
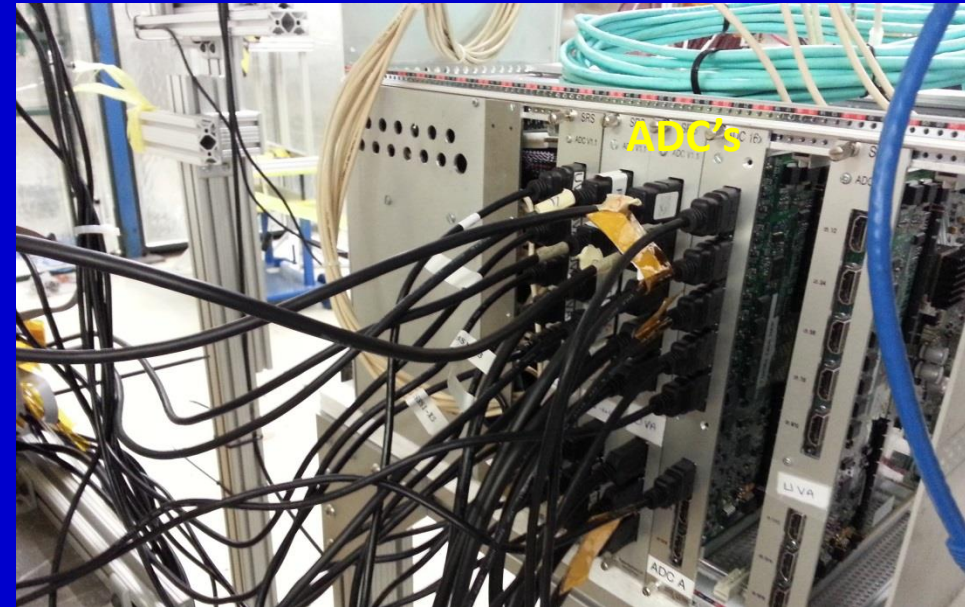
# Large Size GEMs in MT6-2B @ FTBF (Fermilab) (UVa and Florida Tech joint effort)





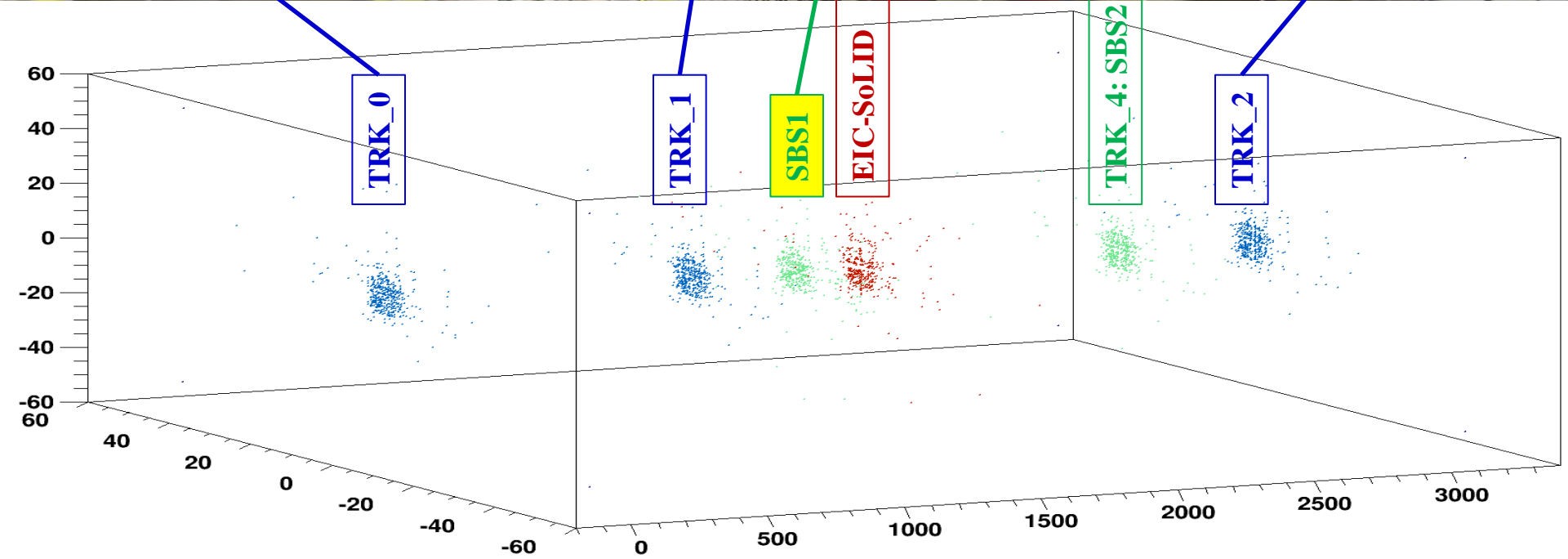
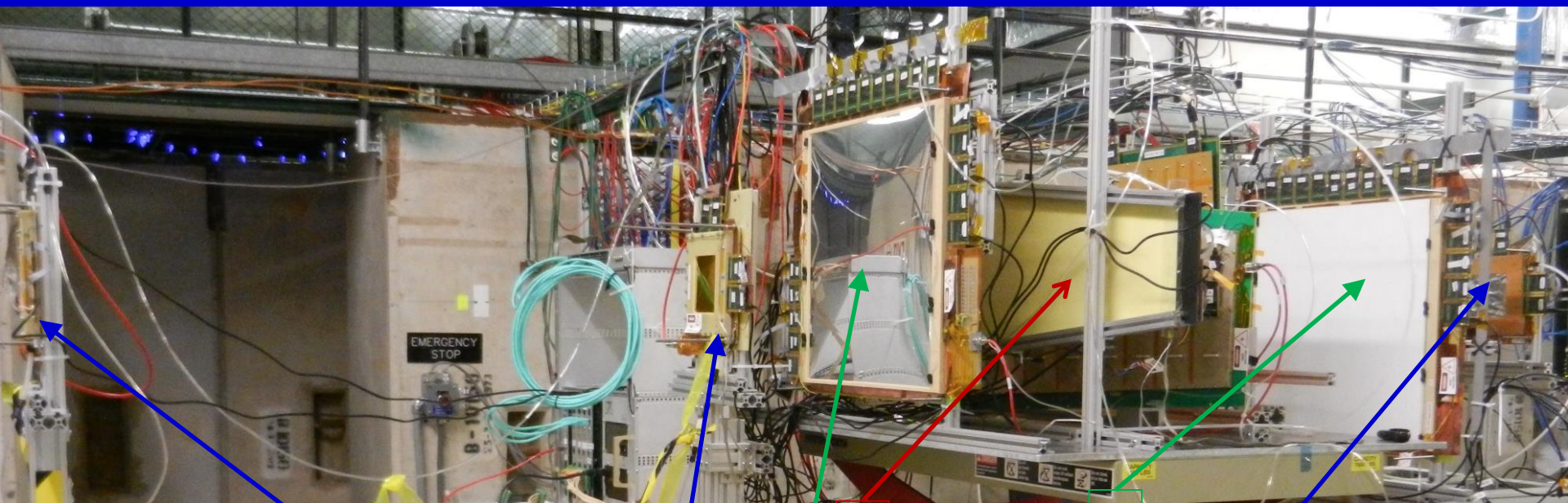
# SRS Readout With DATE @ FTBFL (FNAL)

- Beam structure: 1min cycle, 4s spills 10k to 35k particles/spill
- 64 APV25 with SRS+SRU+ 4FEC/ADC combos
- DAQ rate is up to 400 Hz (average over 4s spill)
- Using 3,6 and 9 time slices (25ns) for digitization
- Trigger: coincidence of 3 scintillators



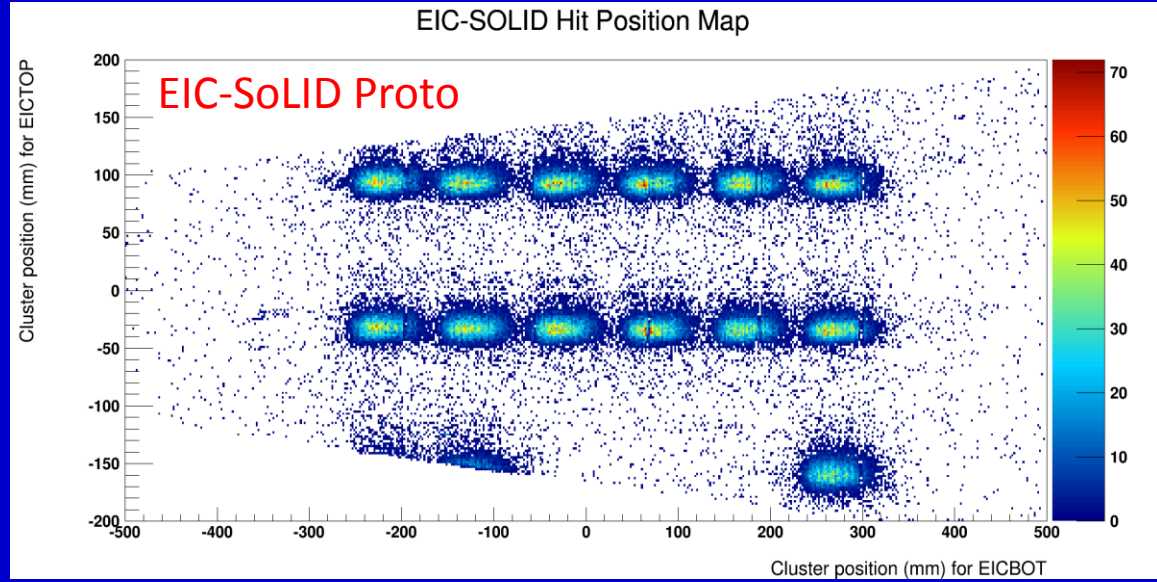
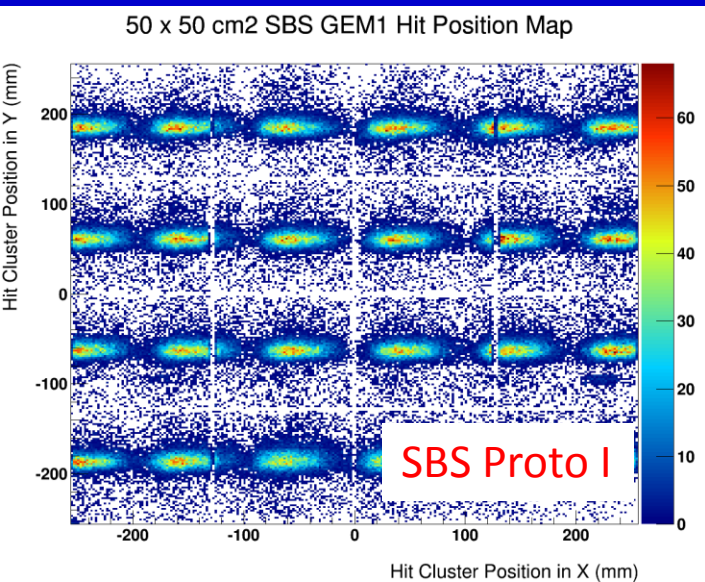


# SRS Readout With DATE @ FTBF

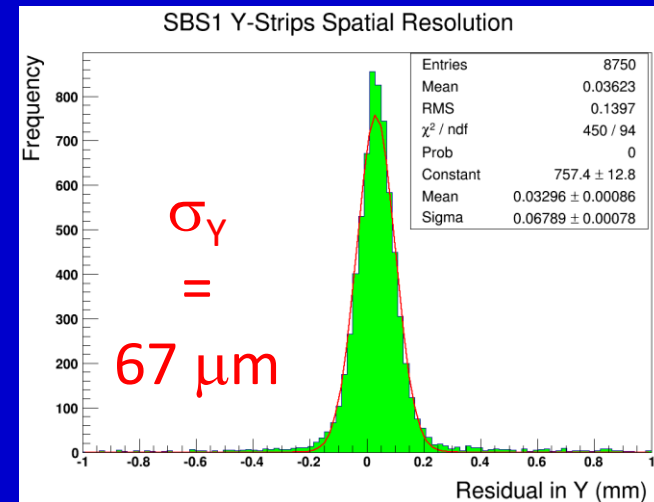
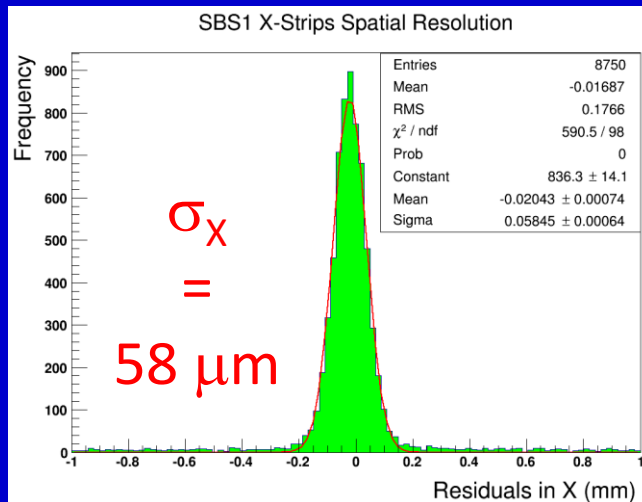
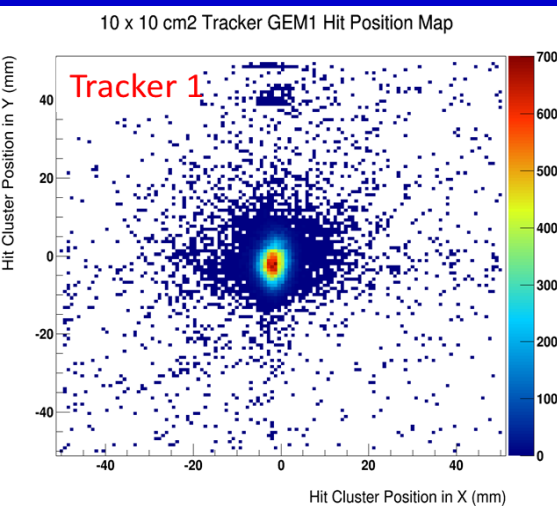


# Preliminary Results with Fermilab Test Beam

## 20 GeV Hadron Beam: Position Scan of SBS1 and EIC Chambers



## 120 GeV Proton Beam: Position Resolution of SBS1 Chambers



# Summary

- GEM Trackers for SuperBigBite in Hall A 12 GeV Upgrade at JLab on very good track
  - Ongoing production for the GEMs for the Front (INFN Roma, Catania) and Back Trackers (at UVa)
- Two APV25 based Electronics for SBS GEMs
  - MPD Electronics for the Front Tracker GEMs
  - SRS-ATCA electronics candidate for the Back Tracker GEMs
  - Some important development needed for SRS-ATCA to satisfy the requirement for the SRS
  - Discussion with RD51 Electronics Group (Hans Muller) on the implementation of these upgrades
- Current status of SRS Electronics at UVa
  - Test of “large” SRS system with the SRU at CERN and in Test Beam Fermilab
  - Early promising results w.r.t the requirements needed for the SBS challenging environment