# SBS-BigBite Front Tracker Status

E. Cisbani 15 July 2020 SBS Collaboration Meeting

#### People

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#### Involvment

BA+LE : Gas system / GEM Test, Analysis, Simulation

- CT : GEM QA, Assembly, Analysis, Simulation
- GE : Readout Electronics
- RM : GEM Test, Reconstruction, Simulation

All: JLab - Test, Integration and Commissioning

E=Engineer R=Researcher S=Student T=Technician

Main collaboration with: University of Virginia, JLab, Hampton University

SBS Front Tracker Status

### Upcoming GMn + Gen-RP (+ TPE + WAPP)



UVa-GEM





#### Main activities and events from 08/19 to 07/20

- 1. Independent and improved **analysis** of cosmic data with better software alignment (thanks to A. Puckett)
- Modules rearranged to maximize active areas of the first 4 chambers (layers)
- 3. New modules produced  $\rightarrow$  fifth chamber assembled (j4)
- 4. HV accident during maintainance near front-end electronics partially recovered
- 5. First test of GEM chamber installation in BB frame and detailed plan defined
- 6. Improved foils and GEM module drying (N<sub>2</sub> flushing) and started evaluation of cleaning procedures
- 7. GEM readout electronics fine tuning and minor bug fixing
- 8. Microscopic simulations and data transfer optimization

### Independent analysis of Nov/2018 Cosmics

(run 3805: ~500000 events, High Voltage of 4100 V, gas flow rate/single layer of ~400 ccpm)



# Previous Efficiency estimation confirmed $\rightarrow$ look pretty good (except know dead sectors)

July/2020

#### Spatial Resolution after better software aligment



#### Spatial resolution $\approx$ 110-130 um (for uniform distribution $\approx$ 115 um)

## First 4 GEM layers rearranged

Chamber

**JO**, **J2** 

13

11

**Geometrical Efficiency** 

100 %

95 %

 $90\% \rightarrow 93\%$ 

- 2 modules with shorted sectors replaced, chamber configuration improved
- Cosmic runs with different HV/gas settings
- Annoying DAQ MPD timeout partially fixed (apparently) re-plugging couple of LEMO trigger cables
- No issue with HV with continuous gas flowing



# Fifth GEM chamber integrated



July/2020

# Accident during maintainance





Sep/19: Accident during maintainance near frontend electronics of module M21 procured HV discharge in module M23!

Misconfigured the HV module and likely damaged one MPD

In Nov/19 fixed HV misconfiguration and verified good conditions of both M21 and M23 modules

DAQ/Electronics will be fixed at next visit (need careful check of MPD7 and MPD18; their replacement at worst)

# Cosmic runs with DAQ issues

Nov/19



#### Horizontal and vertical white stripes are artefact of faulty electronics (annoying but solvable issue) July/2020 SBS - Front Tracker GEM 10

#### First Chamber loaded for testing in BB frame/Sep 2019

- Implemented sliding system to load the chambers in the limited and critical space of the BigBite Frame
- Tested loading on the first chamber; likely solved all relevant issues, so far, but we get trouble with 3<sup>rd</sup> chamber





•Designed the patch panel for the cable ends, gas and power supply of the electronics for easy installation ... Bogdan yesterday talk Detailed installation procedures defined (version 1): https://pandora.infn.it/public/143c29

## GEM modules status

#1 (0)	integrated in chamber j2										
#2 (1)	at JLab, originally in chamber j2, rejected 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 chamber j2										
#6 (5)	at JLab, rejected after further tests with 90Sr source at Jlab – recons	idered as j5 candidate									
#7 (8)	in Rome; 4 HV damaged paths have been fixed so far										
#8 (9)	integrated in chamber j3										
#9 (10)	integrated in final chamber j1 – shorted June/19 – candidate for j5										
#10 (12)	integrated in chamber j0										
#11 (13)	integrated in chamber j1	Needed	18								
#12 (14)	integrated in chamber j1	Droducod	22								
#13 (15)	integrated in chamber j0	Produced:	23								
#14 (16)	integrated in chamber j3 – shorted June/19 – candidate for j5 (?)										
#15 (17)	integrated in chamber j3	Operational:	15								
#16 (18)	integrated in chamber j2 (replace module #2).										
#17 (19)	integrated in chamber j3	With issues but									
#18 (20)	integrated in chamber j1	usable	3								
#19 (21)	integrated in chamber j4										
#20 (22)	rejected (in Rome); many shorted sectors – cleaning study	Rejected	5								
#21 (23)	integrated in chamber j4	hejected.	5								
#22 (24)	integrated in chamber j0	Diamanda	4								
#23 (25)	integrated in chamber j4	Planned:	T								
#24 (26)	planned for integration; material available (j5)										

## X-ray test of the "acceptable" modules

Cluster Position (run=152 mod=4)

M0 is properly working, no Xray performed at that time M8 has broken HV paths (fixable?) Expect one more module in Sep/Oct-2020

July/2020



Cluster Position (run=152 mod=5) M5

Cluster Position (run=782 mod=8)

13

# Kapton weakness (underestimated)

- Polyimide film: H-C-N-O
  - polyimide materials tend to absorb moisture (faster than epoxies)
- Used as electrical wire insulator; responsible of tragic airplane accident (<u>https://hackaday.com/2018/04/04/kapton-miracle-material-with-a-tragic-history/</u>)
  - Kapton insulation is degraded by moisture
  - If "insulation is compromised, arcing can occur, which leads to charring of the Kapton"
- We expect carbonized area (from kapton burning) in (some of) the shorted sectors: attempt to clean them with focalized sound/ultrasound (M. Kalliokoski et al. / Physics Procedia 37 ( 2012 ) 464 – 471)

## Humidity, gas flushing and GEM cleaning

- Since Jun/2019 (after the almost simultanous shorts in two GEM modules) we finally succeeded to establish a continuous gas flushing to keep foils dry and GEM in pressure (prevent dust from outside)
  - no more shorts ... up to now
- Extend flushing from hours to days before GEM foil quality check:
  - two old GEM foils previously rejected have been rechecked succesfully; a third new foil also passed the check.
  - One foil with shorts cleaned by ultrasound (using half size bath not optimal) then checked: resistance increased by about 20% (encouraging); further studies needed (it is gas consuming and take time to dry the cleaned foil)

## Jan-Feb/2020 – GEM foils quality checks

latest lab activities before lockdown



July/2020

# 15/Jun/2020 – GEM foils quality checks first lab activity after lockdown

#### Foil 86 (never checked before)



#### N<sub>2</sub> flushing for days before high voltage on

# Attempt of GEM cleaning by sound

- We setup an high frequency acoustic waves (10-15 kHz) with available components to understand potential problems and possible approaches; tests on a rejected module was unsuccessfull
- Literature and CERN experts suggest to use ultrasound from 40-80 kHz for single foil.
- Identified ultrasound bath with adequate volume in FE/Uni (thanks to Luca Barion) – possible option
- Activity is recovering ...



#### SiD & GEM – Readout Electronics

			Channels	APV25	MPDs
• 128 analog ch / APV25 ASIC		Silicon µstrip	8300	64	5
• 3.4 µs trigger latency (analog pipeli	ne)	Front Tracker	41472	324	24
• Capable of sampling signal at 40 MI	Ηz	Rear Tracker	112640	880	62
• Multiplexed analog output (100 kHz <b>NPD Main Block</b> 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-VME Interface MPD-VME Interface	e readout rate)	Protocol 2eSST 2eVME VME32 VXS	tical ber ME (4x) Running cosn test/ Jlab (VN mode)	SSI SSI VME Ma (Intel SI	Ster BC)

#### Electronics Status – Short Summary

Latest MPD features implemented:

- Data out by default to fiber, can be switched to VME
- Deadlock in single MPD can be avoided
- Data can be readout without passing in the DDR SDRAM
- Only 15 channels implemented (for memory optimization)
- Latest bug solved the 14 Jan 2020 (thanks Ben!)
- Everything on GITHUB: https://github.com/musico964/Fpga\_4\_Fiber MPD Firmware: two images available in EPROM (User and Factory)
- daq@triton:/home/daq/paolo/ProgramEpcs.c
  - Loads the User Image in the Flash EPROM (Factory image from the programming cable)
  - It can also reload the Factory image: to be used carefully!
- daq@triton:/home/daq/paolo/RunUserFpga.c
  - switch between Factory and User FPGA images: NOT VERY RELIABLE yet: It works < 50% of times: additional check must be performed to be sure which release is running</li>

In case of new electronics production, we need to update the MPD obsolete (and hard to find) FPGA – worth if more than  $\approx 10$  new MPD needed

MPD Data Format:

- loop on
   channels/samples
   inverted for optimized
   SSP processing
- not yet optimized to save bandwidth

#### Microscopic GEM simulator

to better model the real behavior of the tracker and to prepare for the physics experiments

Geometric Model Definition Mesh Generation	GMSH (3.05 and 4.0.7) OpenCascade	ANSYS Multiphysics							
<b>Electrostatic Field Solution</b>	ELMER (2018)	(R17-19)							
Gas properties	Magboltz								
High Energy particle Photoabsorption ionization	HEED								
Microscopic Gas Simulator	Garfield++ (v3)								
Automate and parallelize multiple simulations	Bash scripts								
Analysis/Visualization	ROOT								
Simulation Platforms	Xeon/16 cores and i7/16 cores								

All steps are implemented programatically

*Full 3xGEM+Readout simulation by different modelling approaches* 

#### Different approaches comparison Gain Drift N<sub>Collected</sub> Secondaries/N 350 **High Energy** charged particle 300 track Block 0 250 GEM0 200 150 Block 1 GEM1 100<sup>L</sup> 1600 N<sub>Tracks</sub> Efficiency Block 2 GEM2 /N<sub>Tracks</sub> GMSH+ELMER Multistep N Collected Secondaries>Q<sub>THR</sub> GMSH+ELEMER 3xGEM Block 3 0.7 ANSYS 3xGEM 0.6 Readout 0.5 0.3 0.1<sup>[</sup> 200 400 600 800 1000 1200 1400 $\mathbf{Q}_{\mathsf{THP}}$

 $\rightarrow$  Discrepancy most likely related to the different meshes

#### APV Signal re-analysis for realtime noise suppression

- Goal: identify a robust signal/noise discriminating fuction that can be implemented in the DAQ FW

   E 400
   E 400
- Use AI/Brain Project tools [M.Russo] on pre-classified X-ray data based on
  - Spatial correlation (in/out)
  - Pulse amplitude and shape
  - Temporal correlation
- Need to prepare training/validation data
- Detailed new analysis of the off-line classification criteria





Working on test on un-classified data ongoing

## **COVID** impact

 Installation of GEM in BigBite (planned to start in early spring/20) postponed. Currently we do not know when we can plan our next visit at Jlab

#### Any local support (David Armstrong and/or others) is very welcome

- Assembling of the very last module in Italy/CT postponed (foil checks done); if situation in Italy does not get worse we expect to complete it by Sep/Oct
- GEM cleaning study slowly resuming

# 2020 INFN GEM Plan ... postponed

Ja	n	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec			
Prelimiary work in INFN Clean Room															
Replace plastic Cable Trays in GEM chambers						neec	l me	tallic	trays	from	JLab				
Do latest HV/cosmic test on GEM before moving to TED															
Preliminary work in TED															
Free space in TED for GEM installation															
Setup the gas system in the TED building															
Test Installation/Removal procedure on dummy chamber						need	l fina	alized	BB G	EM f	rame				
Finalize BB GEM frame															
Move the DAQ system from the Clean Room to TED BigBite area															
Install GEM chambers into BigBite GEM frame															
Move each single GEM chamber to TED and load in BB GEM frai	me						nee	d fina	lized	BB G	EM fr	rame a	nd gas s	ystem i	n TED
Cabling and Test Chamber + DAQ															
Install the loaded BB GEM frame into BigBite detector															
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BB Integration and test															
Move BigBite to the Hall A															
Install in Hall A															
Test and Commissioning															

# High-level remaining tasks for BigBite installation (specific of front tracker)

- Replace plastic cable trays and fix annoying DAQ/Electronics issues that prevent to take continuous cosmic data # INFN/4 man\*week
- Do some final cosmic tests # INFN/2 man\*week
- Finalize new GEM BigBite Frame # JLab
- Finalize procedure for insertion/removal of GEM from the BigBite Frame – probably some custom tools needed #JLab-INFN/~6 man\*week

Hall Installation non included

# High-level remaining tasks for PR detector installation (specific of the 2 INFN GEMS)

- Assemble the very last module in Italy and test it; (if successul we will have 4 candidate modules for last GEM layer) # INFN/12 man\*week
- Select modules and integrate the 6th GEM layer # INFN/4 man\*week
- Do some cosmic test (and/or by <sup>90</sup>Sr radioactive source) # INFN/2 man\*week
- Define installation procedure and test it # JLab-INFN/~6 man\*week

Hall Installation non included

#### Links to main GEM documentation

- GEM user manual (sort of):
   <u>https://docs.google.com/document/d/1QWbZPQZJ9sGWcWRk</u>
   <u>JDHIxRwA0eFIcie8kyNKTMDKzTs/edit?usp=sharing</u>
- Cosmic and installation test Run Log: <u>https://pandora.infn.it/public/cd5c37</u>
- Electronics MPD Firmware: https://github.com/musico964/Fpga\_4\_Fiber
- Also some entries in the SBS wiki: <u>https://hallaweb.jlab.org/dvcslog/SBS/</u>