Update on GEM R&D at UVa

Kondo GNANVO
University of Virginia
Outline

- Update on Construction of SBS GEM prototype
- New Design for the SBS GEM
- Toward the Large Area GEM for SoLID
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50 cm x 40 cm Modules are assembled to form larger chambers with different sizes

- Front tracker: Six 40 cm x 150 cm GEM layers
  - INFN Funding: to be built in Italy
- Polarimeter trackers: Eight 50 cm x 200 cm GEM layers
  - to be built in Virginia
HV Test of the GEM foils

- Nitrogen Box with 20 connectors for the HV sectors on the GEM foil

- Keithley Picoammeter 6487
  - Voltage Source 505 V
  - Ohmmeter

- Criteria for good HV sector on the foil
  - < 5 nA leakage current @ 500 V in Nitrogen
The Stretcher device for the SBS GEM foils

- UVa Stretcher device upgraded from Benciveni (LNF. Italy) and Cisbani (Roma, Italy)
- Improvement ➔ Easy to handle and fast ➔ a foil is stretched in less than 30 min
- 7 Load cells (max 23 kg over 13 cm, ➔ max 1.78kg/cm)
  - Test foils stretched at 0.25kg/cm, 0.35kg/cm, 0.75kg/cm
- Monitoring displays of the measured tension
Gluing GEM foil to its frame

- Stretched foil glue to the spacer frame
- Glue Epoxy: Araldite 103-1 + Hardener HY 991 (100:40 ratio in weight)
- Recommended by RD51 and used for COMPASS, TOTEM GEMs …
- Main deformation of the frame after gluing in vertical direction
  - agreement with simulations
- We are working to prevent this effect

Dry test on a mylar foil stretched at 0.34kg/cm and glued to a frame
Preparing the frame before gluing …

- **Step 1**: Polishing of the frame and the inner spacer
- **Step 2**: Cleaning in Ultra Sonic Bath (USB)
- **Step 3**: Drying the frame in a storage cabinet with Nitrogen flowing inside

Nitrogen Cabinet for drying and storage
Preparing the frame before gluing …

- **Step 4:** HV test of the dry frame at 4kV
- 12 frames tested ➔ 2 two of them spark ➔ not properly dry

HV Box for both the Frames and GEM foils
Preparing the frame before gluing …

- **Step 5:** Coating of the inner part of the frames
- **Varnish:** Nurovern LW + hardener
- **Supplier:** Walter Mader (Switzerland)
Next step: Full assembly of the SBS GEM

- The stretcher for the GEM foils produced and tested
- The full procedure for testing the GEM foil is in place and validated
- We went to all the steps to prepare the spacer frames for the gluing
- Next delicate step: Solder the protection resistors on the foil
- We are just waiting for the readout boards from CERN
  - (At last check it was supposed to be delivered end March …)
- As soon as we get them, we are ready to fully assemble the first SBS prototype
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Current frame design with the gas distribution

- In the current design, the gas flows laterally in each region of the chamber
- 3 gas inlets and 3 outlets on each frames to allow a uniform distribution (same design for all the frames)
- Aperture in the spacers on each frame to allow the lateral flow
- Concern about the uniform gas distribution in the GEM holes level at high rate
In the new design, the gas flows laterally in drift region and vertically in the GEM transfer regions through the GEM holes (5 different frame designs)

1 gas inlet in the window frame and 1 outlet in the readout frame at the opposite corner

Large aperture in the spacers only in the drift frame and the last GEM3 frame

We are also making modification to be able to mount the chambers on the external support frames
New design of the GEM foil

- Redesign the HV sectors ➔ No resistors soldered directly on the foils
  - Allow testing the GEM HV sector after frame is glued
  - Allow replacement or disabling of a bad HV sector after assembly
  - Avoid soldering in the clean room

- The new foil will have 20 electrodes strips for the HV sectors coming out of the frames on the smaller side of the chamber
- External PCB with the HV divider and the protection resistors
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Large Area GEM R&D at UVa

- We are involved in 3 R&D efforts for large area GEM chambers
  - CMS High Eta Muon Chamber Upgrade
  - EIC Forward Tracker
  - SoLID Large GEM Tracker

- All 3 chambers will have similar size GEM foil (~100 cm × 50 cm) and trapezoidal shape chambers

- The readout board is the only major difference between the 3 at this step of prototyping stage

- We expect to be able to build on such large prototype by the end of this
Common development for the 3 Chambers

- Build a larger stretcher for $1 \times 0.5 \, \text{m}^2$ This is an extension of the SBS stretcher
- Build for the HV test Nitrogen box
- Setup for gain uniformity measurement of large GEM foil
- Setup with IR lamp structure for heating and preparing large spacer frames ➔ replacement of the Nitogen Cabinet
Common development for the 3 Chambers

Large prototype GEM module for CMS: 99 cm x (22 - 45.5) cm
Specific Readout and Electronics for SoLID

- Readout board for SoLID
- Need to start the design of the readout
- Establish the contact with Tech Etch to study the single layer 2D readout
- Beyond APV25 electronics, looking at other SRS alternatives
- BNL chip VMM1 for ATLAS Muon Chamber Upgrade might be a good

### PVDIS GEM configuration

- Suggested readout scheme:
  - a 2D readout optimized to get high accuracy in the \( \phi \) coordinate, lower but sufficient resolution in the \( r \) coordinate.
  - each set of stripes parallel to one of the radial sides of the module: i.e. stripes at a 10-deg stereo angle to each other.
  - strip pitch is 0.6 mm for locations 7 and 8;
  - 0.4 mm for locations 4, 5 and 6.
- Issues:
  - A full tracking simulation needs to determine that this readout scheme gives the required tracking resolution.
  - How well will the 10-deg stereo angle separated strip layers work? - need to test with prototypes.
Personnel at UVa

- **Senior Research Scientist:**
  - Prof. Nilanga Liyanage
  - Vladimir Nelyubin

- **Research Scientist:**
  - Kondo Gnanvo

- **Graduate Students:**
  - Kiadtisak Saenboonruang (small GEM tracker, analysis)

- **Undergraduate Student**
  - Taylor Sholz (drawings for the stretcher and new GEM design)
  - Seth Saher (Test and assembly of SBS GEM)