GEEn-RP Status Update

William Tireman
Northern Michigan University

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Experimental Technique/Design

E12-17-004 will measure ratio of GEn/GMn using two recoil polarimetry techniques at 4.5 $(GeV/c)^2$ via the $^2H(\bar e, e'\bar n)p$ reaction

- “GMn” beam, beamline, target, BB
- Beam: $\sim$11 GeV/c, $\sim$40 $\mu$A, $P_{beam} = \sim$80%
- Target: 10cm LD$_2$ (unpolarized)

(A) Main goal: Charge-Exchange np $\rightarrow$ pn channel
- Steel analyzer (passive)
- GEM tracking + HCAL measure forward protons

(B) Secondary goal: Conventional np $\rightarrow$ np
- Plastic analyzer (active)
- Large-angle recoil protons $\rightarrow$ Side detectors
- (GEM + hodoscope)
- Forward neutron $\rightarrow$ HCAL

Approved for 120 PAC hours
- $\sim$ 10 Calendar days
Status of Polarimeter Preparations

• Active CH analyzer
  • On site from Glasgow
  • Existing 4x8 array of 40x40x250 mm EJ200
  • Will be checked out summer 2020

• Large angle recoil proton detectors
  • Hodoscope detectors
    • Check out proceeding (CNU students and Brad)
    • UVa GEM detectors under construction and testing

• CE Polarimeter
  • INFN and UVa GEM detectors under construction and testing
  • Steel analyzer in procurement

• With exception of lead wall, all design work done and procurement started (Chris S. and Robin W.)
  • Lead wall work to continue next week (Brad, Chris)
Status of Other Equipment  
(as reported at weekly SBS meetings)

• HCAL
  • Good progress is being made
  • Currently debugging cabling, completing PMT coupling grease work
  • Work on discriminator thresholds
  • Setting up cosmic triggers with larger scintillators

• BigBite Spectrometer
  • Work is ongoing
  • More details in Mark Jones talk later today

• Moller Polarimeter
  • Reported as ready to go
  • Will run a detailed simulation before experiment
  • Each run takes ~1 shift to complete
ERR Recommendation #1

1) Outline a plan and schedule to pursue realistic simulations of high-rate tracking performance in the presence of anticipated backgrounds, and to take advantage of any opportunities to validate the simulations using real data.

- Tracking algorithms being implemented
- Direct validation of simulations to experimental data in progress (PRad, UVa x-ray tests, etc.)
- Discussed existing simulations in more detail
  - G4SBS, Glasgow version G4SBS, and NMU GEn background sim

Link to GEn-RP ERR here ➔ E12-17-004 ERR Page
ERR Recommendation #2

2) Update simulation geometries to the latest CAD model of the final installation and include fringe magnetic fields.

- Geometry updates completed (cross checked with CAD model)
  - No major changes simulation geometry
  - No major changes in results
- Updates to magnetic field models
  - Looking into field clamp impacts (GEn-RP in particular)
  - Fringe field effects
  - Impact on scintillator PMTs being evaluated
ERR Recommendation #3

3) Obtain a written agreement with E12-09-019 which includes a high-level schedule showing how installation and deinstallation of all experiment hardware interleave with the run plans of the two experiments.

- Extensive document has been drafted between Brian Q., Brad S., and Bogdan W.
- Still a work in progress
- Will summarize GEn-RP portion here
GEn-RP Installation Summary (with GMn)

• GEn-RP specific hardware needs to be installed with sufficient time for cosmic checkout

• GEn-RP specific hardware will remain installed until after GEn-RP run is complete, with the exception of analyzers

• Installation of GEn-RP hardware prior to beam time
  • GEn-RP requires the use of the Moller Polarimeter
  • SBS rear field clamp
  • Recoil polarimeter detector assemblies (1 hodoscope array, 2 UVa GEM planes)
  • “Inline” SBS frame which supports GEMs, Steel analyzer, and CH analyzer
  • GEMs for inline assembly (2x INFN + 6x UVa GEMs)
  • Shield wall between SBS and beamline
  • Lead bricks inside dipole gap
  • Steel and CH analyzers will be test fitted then removed for beamline/BB/HCAL commissioning
• Front end VME-based readout hardware to be placed in bunker on large angle side of SBS

• DAQ software needs to be implemented for
  • GEn-RP GEM detectors (identical to GMn BB readout)
  • GEn-RP scintillator detectors (standard/existing FADC + v1190)

• GEn-RP physics modules for SBS analysis software
  • Gain settings, Timing checks, PID, Yields, Asymmetries
    • straight-forward implementation in PODD framework
  • Displays for PMT-based hodoscopes and analyzes
    • existing/standard online display GUI
  • GEM tracking support for SBS GEMs
    • clone (with minor config. changes) of GMn BB GEM software
GEn-RP Run Plan as Integrated with GMn

• GMn / GEn-RP will spend 5 days on equipment commissioning
  • Beamline, HCAL at 14-m, and BB
  • GEn-RP will take one shift to commission specific equipment
• HCAL will be moved to 8.5-m (~4 hours)
• GEn-RP will then take over with
  • Installation of analyzers, cabling
  • Additional shielding for GEn-RP not previously installed
  • Nominal 1 calendar shift
• GEn-RP production running (~108 hours)
  • Selected to match GMn running to minimize overhead
    • SBS at 24.7 degrees and 2.25-m from pivot
    • Beam energy 4.4 GeV
    • Beam Polarization assumed to be 80% (GMn doesn’t require polarization)
### GEn-RP Data Collection Run Plan

<table>
<thead>
<tr>
<th>Item</th>
<th>$Q^2$ (GeV/c)$^2$</th>
<th>Beam GeV/c</th>
<th>Target</th>
<th>Beam μA</th>
<th>Time hour</th>
<th>BB ang/dist deg./meter</th>
<th>SBS ang/dist deg./meter</th>
<th>SBS BdL T·m</th>
<th>HCAL dist. m</th>
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Table 5: The beam time and other parameters of the GEn-RP 4.5 GeV$^2$ run (Sect. 3.6). Total 108 hours of beam on target (out of 120 PAC hours). 8 of the remaining 12 PAC hours (nominal 2 calendar shifts) are used for backing-in and backing-out of the GEn configuration. One additional calendar shift is used for overhead during production running. Note that (existing) E12-09-019 BB optics and SBS momentum calibrations for the 4.5 GeV$^2$ kinematic setting will be used and will not be remeasured.
GEn-RP de-installation plan

• De-installation of GEn-RP components (nominal 1 shift)
  • Remove SBS rear field clamp
  • Remove CH and steel analyzers
  • Remove lead shielding on beamline side and dipole gap as needed
  • Remove shielding around SBS GEM crates
  • De-cable and remove beamline side Proton Recoil detector
  • Right-side Proton Recoil detector can be left in place or removed as desired
ERR Recommendation #4

4) Provide an evaluation of the expected INFN GEM performance or present a plan for using alternate detectors.

- Two fallback options have been identified
- (1) Evaluate veto efficiency of “as-is” 3 layer (INFN + INFN + UVa) upstream triplet
  - Do not need tracks, just a charged veto for GEn
- (2) Shuffle a single GEM plane from the paired GEM planes in the RP assemblies into upstream triplet
  - CH analyzer + hodoscope position/time information provides track
  - Tracking GEMs for CE process are unchanged
ERR Recommendation #5

5) Provide updated reports and expected performance evaluations for both UVa and INFN GEM detectors based on the most recent test results. Present a plan that assures the availability of detectors having suitable performance for the experiment.

- Following updates provided by Kondo Gnanvo
11 large GEM layers needed for GEn-RP: one going to Bigbite and 10 to SBS side polarimeter.

5 UVa GEM layers have been assembled, tested and validated: All modules hole HV and stable.

4 layers are on the cosmic stand 5th layer will be moved there in the next couple of weeks

DAQ is now ready for taking cosmic data with all assembled layers. Expect to start next week with 4 layers.

From now on assemble the remaining 6 layers @ ~ 1 layer per month.

Continue cosmic data taking, extract resolutions, efficiencies etc.

(Andrew Puckett)
GEMs with U-V readout to supplement front tracker

Motivation:

⇒ The U-V GEM: to complement the INFN GEM Layers which use COMPASS 2D straight strip.
⇒ The addition of U-V geometry enhances and complements the X-Y strips and will help with tracking in the high rate environment.

Key Features: active area: $150 \times 40 \text{ cm}^2$, U-V strips readout (60°) stereo angle

⇒ New GEM foil production allows for the FT U-V GEM layer to be one single large module
⇒ No dead area from support frames or electronics (Other than for spacers and HV sector)
⇒ The INFN-built MPD readouts for these GEMs will be the same as for all SBS GEMs
⇒ The design is finalized, GEM foil components under fabrication at CERN now, expect all parts at UVa by early March.
⇒ On track to complete fabrication of 2 UV GEMs by July, 3rd one to follow.
What is needed for GEMs on Bigbite side

VME VXS crates
Bandwidth ~ 110 MB/s

~80 MB/s

FPGA based online data reduction by a factor of 20~50 depending on occupancy from simulation

Evaluated at 4 kHz
GEM DAQ test and implementation plan

SBS side

C_1  C_2  C_3  C_4  
(Top view)  C_5  C_6  C_7  C_8

Analyzer

21-slots VME crates

MPDs x 15  Empty

MPDs x 21

MPDs x 21

MPDs x 21

21-slots VME crates

VME VXS crates

Bandwidth ~ 110 MB/s

Evaluated at 4 kHz

3.4 GB/s

4.3 GB/s

4.3 GB/s

~70 MB/s

~ 40 MB/s + 40 MB/s = 80 MB/s
Plan of GEM DAQ

• SSP based online data reduction has been implemented on small scale and tested with cosmic data.
• Currently working with DAQ group(Ben) on going to large scale --- by March 2020
  ▶ The large scale setup will be tested with 4 layers of UVa GEM chamber in EEL.
• High occupancy test with X-ray --- by May 2020
• Installation of final setup starts from this summer.
Summary

- GEn-RP specific detector frame/support designs complete and procurement started
- RP side detector hodoscopes refurbishment on track
- RP CH analyzer complete, on-site and ready for final checkout
- DAQ hardware, cabling, and software for PMT systems in-hand
- GEM system construction and checkout in progress
- Readout systems/software identical to that needed for GMn BigBite arm (GMn collaboration taking the lead on this)
- ERR was left in a ‘pending’ state, we must satisfy the committee regarding the tracking and GEM related issues they identified
- Plan to have ERR formally cleared by May at the latest
Backup slides ... land of the forgotten
Run Plan

\[ \frac{G_E^n}{G_M^n} \quad 17004 \quad \text{Hydrogen/Deuterium} \]

Experimental Points

<table>
<thead>
<tr>
<th>Q^2 [GeV^2]</th>
<th>( \theta_{BB} ) [deg]</th>
<th>d_{BB} [m]</th>
<th>( \theta_{45D45} ) [deg]</th>
<th>d_{45D45} [m]</th>
<th>d_{HCAL} [m]</th>
<th>Beam Line Configuration #</th>
</tr>
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<tbody>
<tr>
<td>4.5</td>
<td>41.9</td>
<td>1.55</td>
<td>24.7</td>
<td>2.25</td>
<td>8.5</td>
<td>3</td>
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</table>

With 5 days (120 hours) beamtime with a 4.4 GeV polarized electron beam on a deuterium target, E12-17-004 will measure:

- \( \frac{G_E^n}{G_M^n} \) via charge exchange polarimetry;
- \( \frac{G_E^n}{G_M^n} \) via large angle recoil proton polarimetry;
- \( \frac{G_E^n}{G_M^n} \) via standard (forward) recoil polarimetry;
- \( \frac{G_E^n}{G_M^n} \) via charge exchange polarimetry.

It is anticipated that these measurements will have a large impact on future Halls A and C recoil polarization experiments.