E12-17-004 GEN-RP UPDATE

SBS SUMMER COLLABORATION MEETING

William Tireman for the E12-17-004 collaboration

Co-spokesperons: Bogdan Wojtsekhowski, Michael Kohl, David Hamilton

Outline

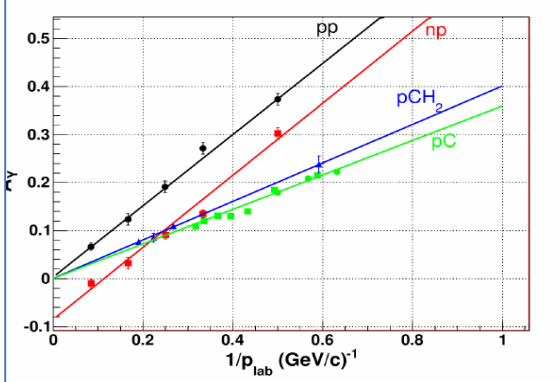
- Experimental overview
- GEn-RP Layout
- g4sbs study
- Design update
- Equipment status
- Personnel
- Summary

E12-17-004 GEn-RP Overview

- E12-17-004 goals:
  - Measure G_{En}/G_{Mn} at $Q^2 = 4.5$ $(GeV/c)^2$ using charge-exchange recoil neutron polarimetry
    - 4.4 GeV/c Energy, P_{beam} ~80%
    - 30μA on 15-cm LD_2
  - Compare FOM for charge-exchange np→ pn scattering and the more standard np→ np
  - Demonstrate the feasibility of detecting low-energy recoil protons from an active analyzer at large angles in an unshielded environment
- Originally proposed to “piggy-back” the GEn-RP measurement on the GMn experiment at the 4.5 $(GeV/c)^2$ kinematic setting.
- GEn-RP received final report from ERR Nov. 2020
- After many delays, GEn-RP now scheduled to run March 2024

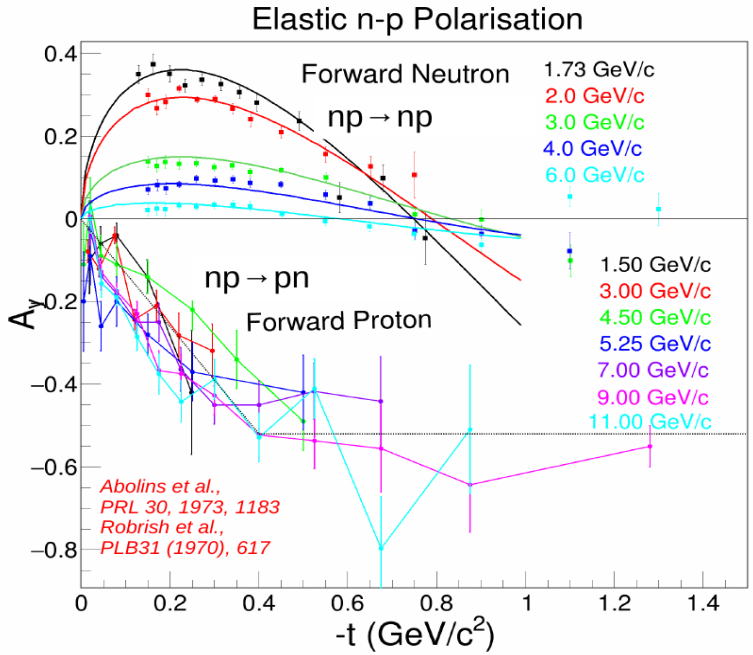
Analyzing Power for Recoil Neutrons

- Until recently no data on n+C→n+p+X at several GeV/c (nor any nucleus)



- A_y for np→np falling rapidly with increasing neutron momentum
- A_y for charge-exchange np→pn large at sufficiently large t (θ_p ~ few deg.)
- $\sigma_{np\to np}$ factor ~10 higher than $\sigma_{np\to pn}$

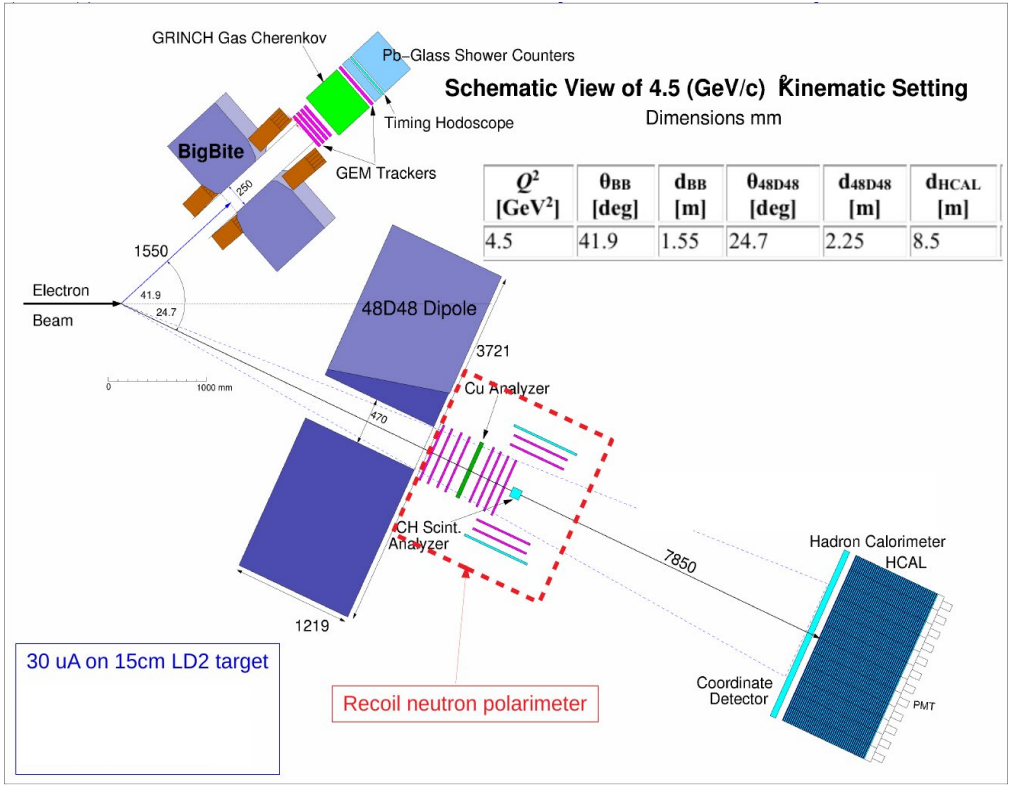
Diebold et al.,
PRL 35,(1975),632
Fits: Ladygin JINR
E13-99-123 (1999)



Abolins et al.,
PRL 30, 1973, 1183
Robrish et al.,
PLB31 (1970), 617

From David Hamilton (Glasgow)

Kinematics and Schematic Setup (Original Design)



Schematic View of 4.5 (GeV/c) Kinematic Setting

Dimensions mm

Q^2 [GeV^2]	θ_{BB} [deg]	d_{BB} [m]	θ_{48D48} [deg]	d_{48D48} [m]	d_{HCAL} [m]
4.5	41.9	1.55	24.7	2.25	8.5

GEn-RP Layout Placement (Original Design)

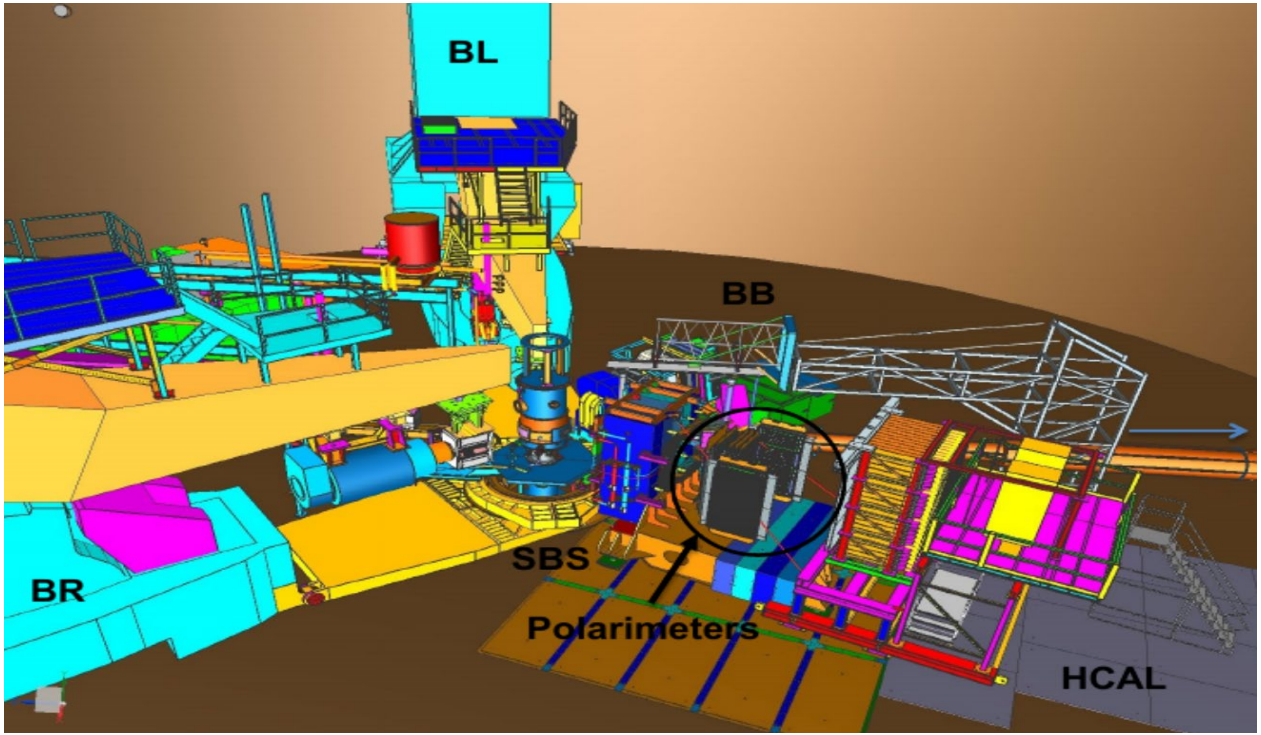
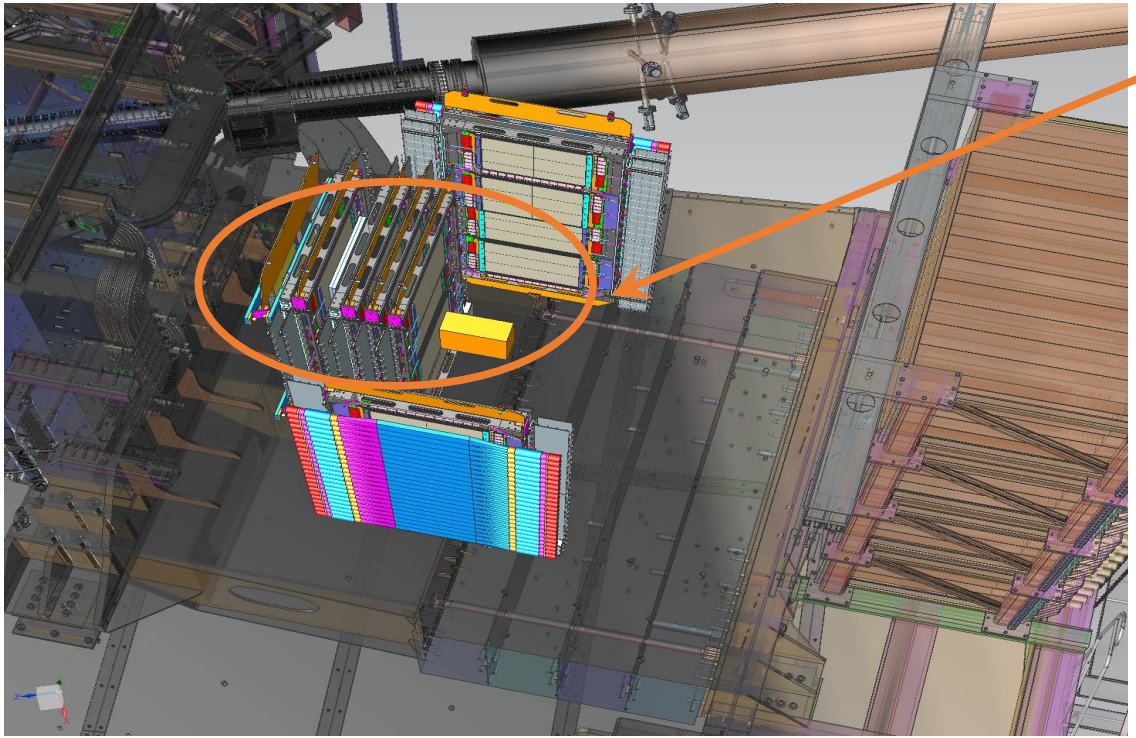


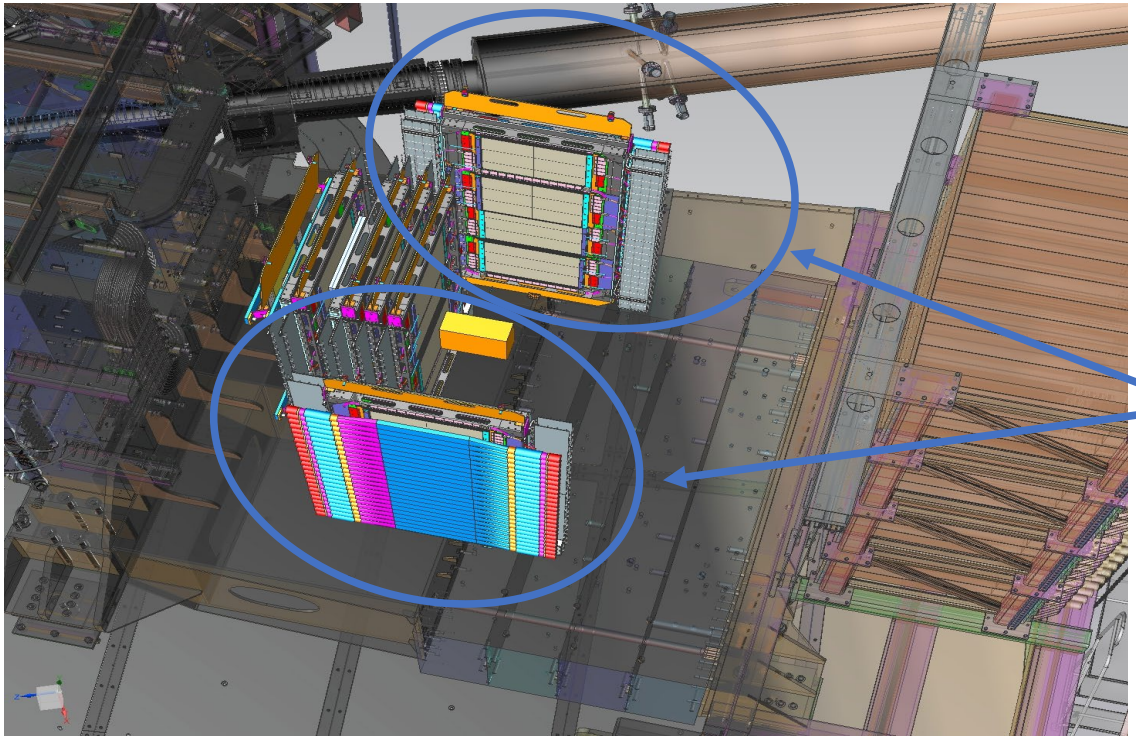
Figure from Robin Wines

Two Neutron Recoil Polarimeters (Original Design)



- **Charge Exchange (CE) Polarimeter**
- High-momentum forward protons (into HCAL) after CE np → pn
- 8 GEM planes
- 1 steel analyzer (change from Cu)
- Provision to mount active CH analyzer for np → np (detection of high-momentum forward neutrons in HCAL)
- **Proton Recoil (PR) Polarimeter**
- Low-momentum large-angle recoiling protons after np → np
- 2 sections, one each side of CE Polarimeter
- Each section has
- 2 GEM planes
- 1 Plastic scintillator plane

Two Neutron Recoil Polarimeters (Original Design)



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- High-momentum forward protons (into HCAL) after CE np → pn
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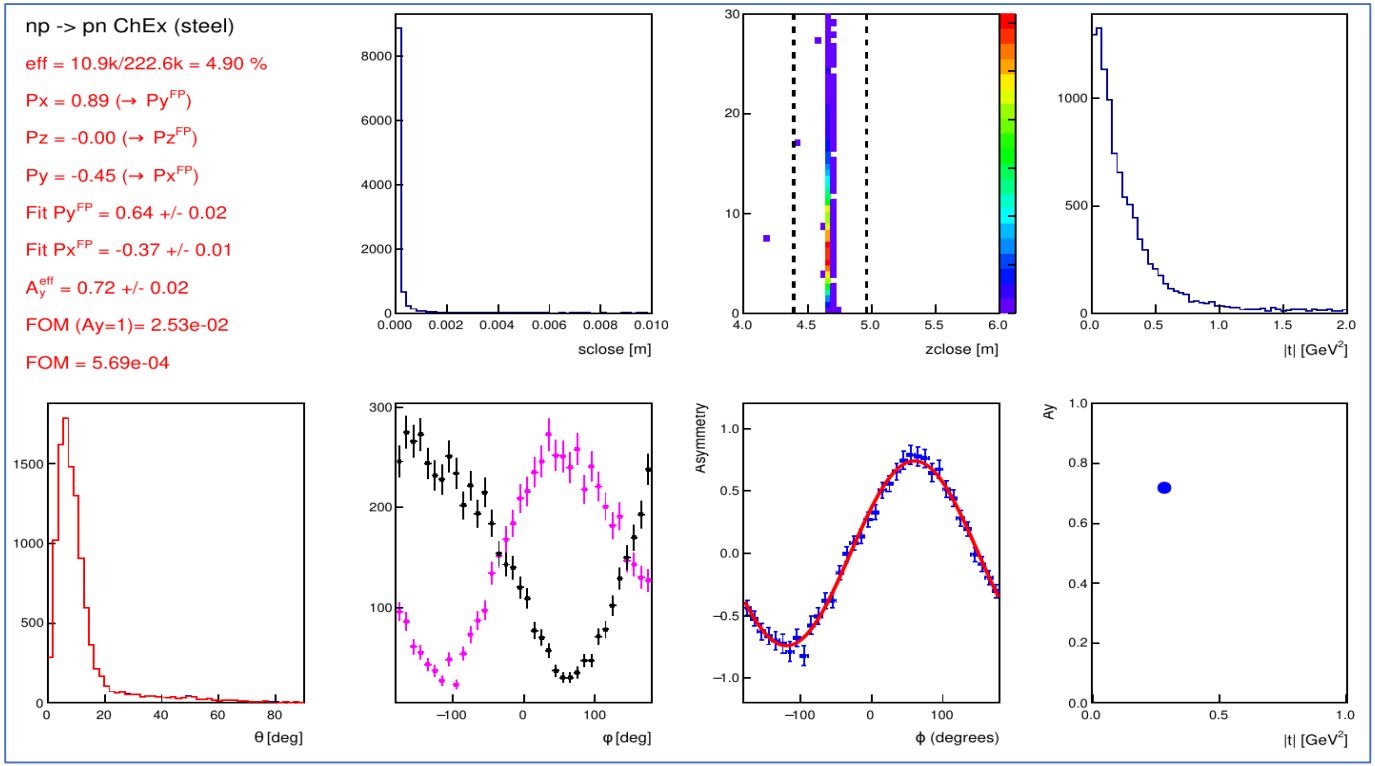
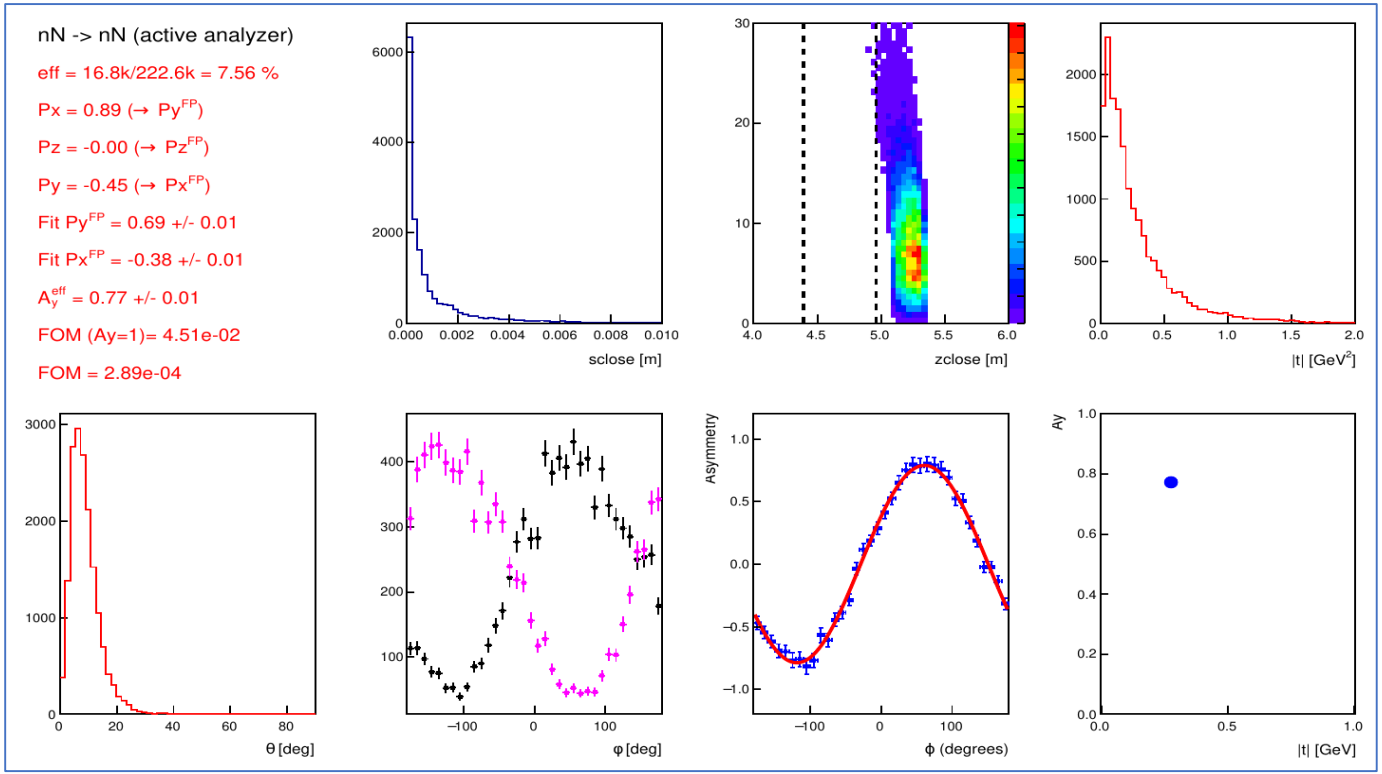
- **Proton Recoil (PR) Polarimeter**
- Low-momentum large-angle recoiling protons after np → np
- Original 2 side detector arrays reduced to 1
- 2 GEM planes
- 1 Plastic scintillator plane

Latest g4sbs studies (Charge Exchange)



From David Hamilton (Glasgow)

Latest g4sbs studies (Forward Neutron)

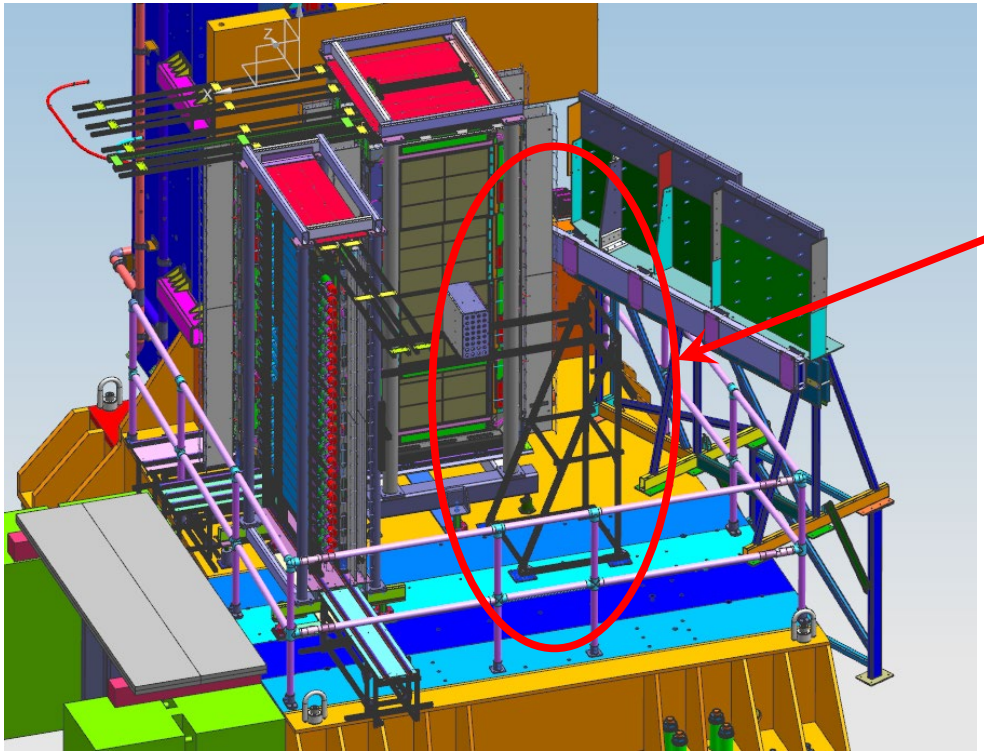


From David Hamilton (Glasgow)

Results from g4sbs studies

- The latest studies suggest the side PR polarimeters look much less encouraging:
  - Rates on the beamline-side detectors (>100 MHz) require lead shielding in the dipole cutout on the beam side
    - detrimental effect on charge-exchange polarimetry
  - Even with shielding, GEM occupancies on beamline-side will make identifying clusters and associating them with scintillator hits very challenging
  - Low-energy proton re-scattering and energy loss in the active analyzer causes a significant drop in efficiency
  - Background hits in the scintillator planes from electrons and pions cause significant dilution of the analysing power
  - Therefore the beamline-side detectors have been removed
  - This will mean two less GEM planes will be needed for the experiment

GEn-RP Support Structure Modifications (Final Design)



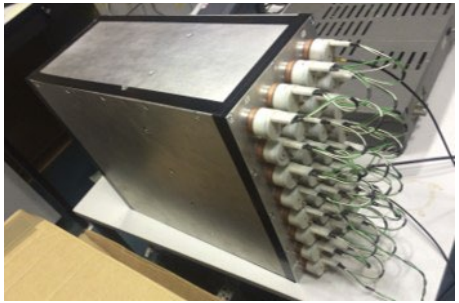
- Beam line side detector array removed
- Support structure for the active analyzer array redesigned
- Lead from beam side dipole cutout removed from design
  - Unseen from this angle

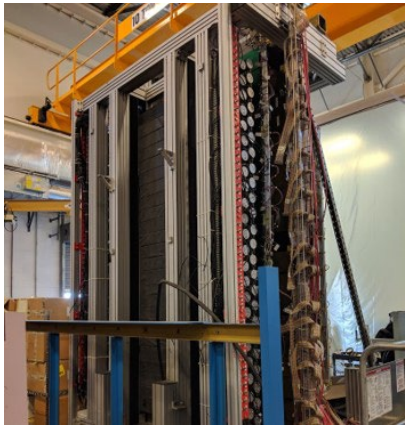
Equipment for Charge Exchange Polarimeter

- Passive steel analyzer on site
- HCal currently installed and operational
- GEM detectors are available
- Lead wall and support structure is on site
- Support and mounting frames are complete and on site
  - Exception is the modifications for the beam side change

Equipment for Large Angle Proton Recoil Detection

- Active analyzer on site (from Glasgow)
  - 4x8 array of scintillator bars w/ PMTs
  - 4-cm x 4-cm x 25-cm each
  - Weighs about 30 kg (in ESB)
- Proton detectors from old BigBite Hadron Stack
  - 24 detectors 3.0-cm x 8.5-cm x 50-cm
  - 2 PMTs each
  - All detectors checked 2019/20 (in ESB)





Electronics needed for scintillator detectors

- 48 channels negative HV
- 32 channels positive HV
- 1 Caen V1190 TDC (in Glasgow)
- 5 F250 FADCs
- 1 VXS crate (in Glasgow or ECAL) + SD + TI
- CAMAC crate and discriminators (in ESB)
- 80 180’ HV and RG-58 signal cables (at JLab)

Personnel

- From University of Glasgow
  - David Hamilton, Rachel Montgomery (faculty)
  - Oliver Jevons (Postdoc)
  - Possibly one PhD Student + help with shifts from Gary Penman
- From Hampton University (MK group)
  - Michael Kohl (faculty)
  - Saru Dhital (PhD Student)
  - One Postdoc (50%) pending funding and selection
  - Expect supporting help from MK group members for shifts
- From Northern Michigan University
  - Will Tireman (faculty)
- SBS Collaboration for Hcal, BB, and GEM support
- Jlab technical support

Summary

- The GEn-RP experiment will measure the G_n^E of the neutron in quasi-elastic scattering from a deuterium target via charge exchange neutron polarimetry
- The figure-of-merit for two different multi-GeV neutron polarimeter concepts will be directly compared: the latest g4sbs studies look promising
- The feasibility of detecting low-energy, large-angle recoil protons will be investigated
- Installation to begin after Gen-II is completed with run in March 2024
- Will be thinking about a run plan and coordinating with the pion K_{LL} spokespeople in the coming weeks
- Results from this experiment will be used for future proposals in Hall C

Thank you

Extra slides

Simulated Background Hodoscope Rates

Configuration	Beam Side Hodoscope average rate		Far Side Hodoscope average rate		Active Analyzer Average Rate	
Original GEn-RP geometry	7.6	MHz	0.887	MHz	0.908	MHz
Removed lead Wall	10.2	MHz	0.868	MHz	0.625	MHz
Removed lead Wall Removed Beam Side detectors	----	MHz	0.843	MHz	0.802	MHz

24 detectors x average rate ≈ 200 – 300 MHz on beamline side