GEn Polarimeter Overview and Run Plan

GMn Preparation Review

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for the E12-17-004 collaboration

30th October 2018

E12-17-004 GEn-Recoil

- E12-17-004 experiment proposed to:

  Measure G_{En}/G_{Mn} at $Q^2 = 4.5$ $(GeV/c)^2$ using Recoil Polarization technique

  Compare standard np→ np and charge-exchange np→ pn scattering
  as analyzers of the neutron polarization at several GeV neutron energy

- Approved for 5 days of beam

- "The PAC is excited at the prospect of neutron polarimetry via the charge exchange reaction as it opens the door to measurements of the neutron form factor ratio at high momentum transfer via recoil polarimetry. We are also glad to see that there has been close interaction with E12-11-009 as shown by the fact that some members of that experiment have joined the present proposal. The PAC is optimistic that the proposed experiment will make a significant contribution to the program with recoil polarimetry at JLab."

E12-17-004 GEn-Recoil

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- Approved for 5 days of beam

- Proposed to "piggy-back" the G_{En}/G_{Mn} measurement on the G_{Mn}/G_{Mp} experiment at the 4.5 $(GeV/c)^2$ kinematic point (identical kinematics)

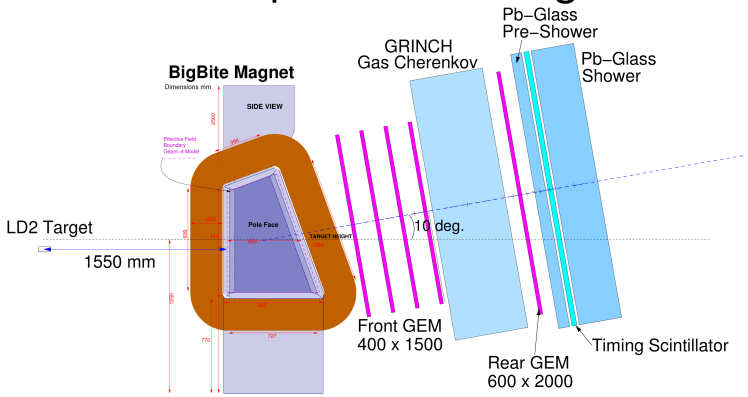
- Most of the apparatus is common to the two experiments

- Piggy-back operation results in major saving of G_{En}/G_{Mn} setup time but must not cause significant down time for G_{Mn}/G_{Mp}

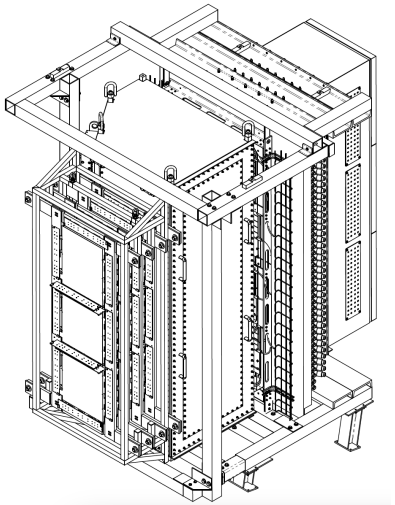
- Additional to the G_{Mn}/G_{Mp} apparatus (E12-09-019), G_{En}/G_{Mn} requires the neutron polarimeter: neutron-scattering analyzer blocks, proton trackers and the associated electronics, readout etc.

Experimental Apparatus

Electron Spectrometer BigBite

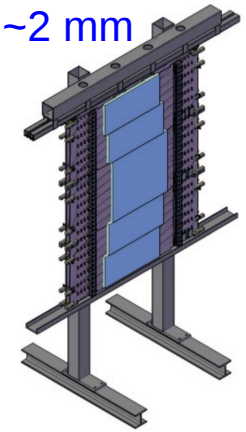


Ω ~ 55 msr
$\delta p/p$ ~ 0.5%
$\delta\theta$ ~ 1 mr
δz ~ 2 mm @ target
δt ~ 150 ps



Coordinate Detector CDet

δx, δy ~2 mm

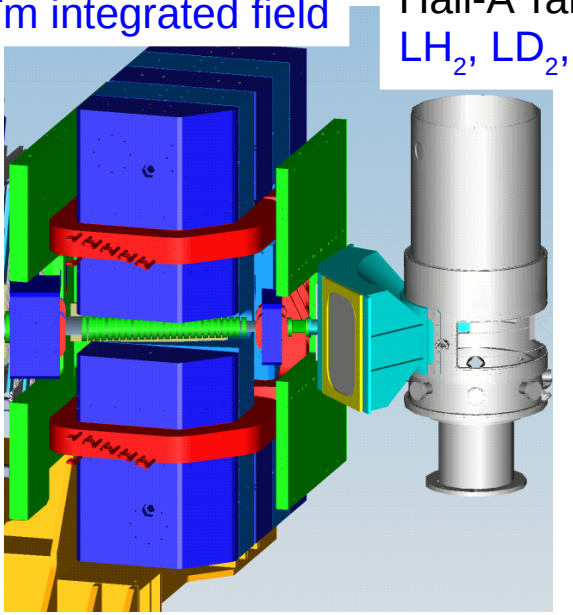


48D48 Dipole

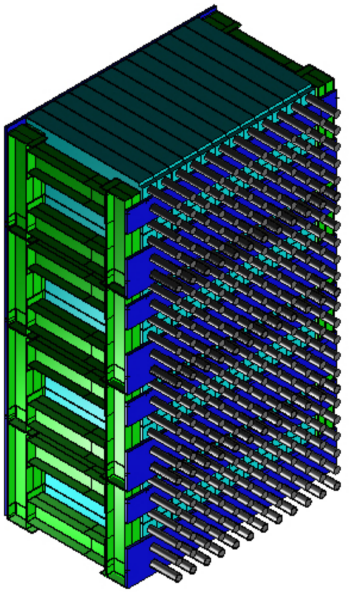
~2 Tm integrated field

Hall-A Target

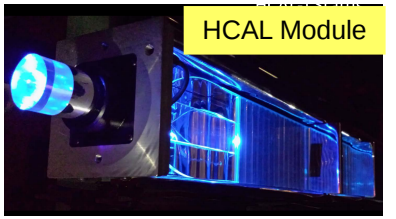
LH_2, LD_2, C-foil



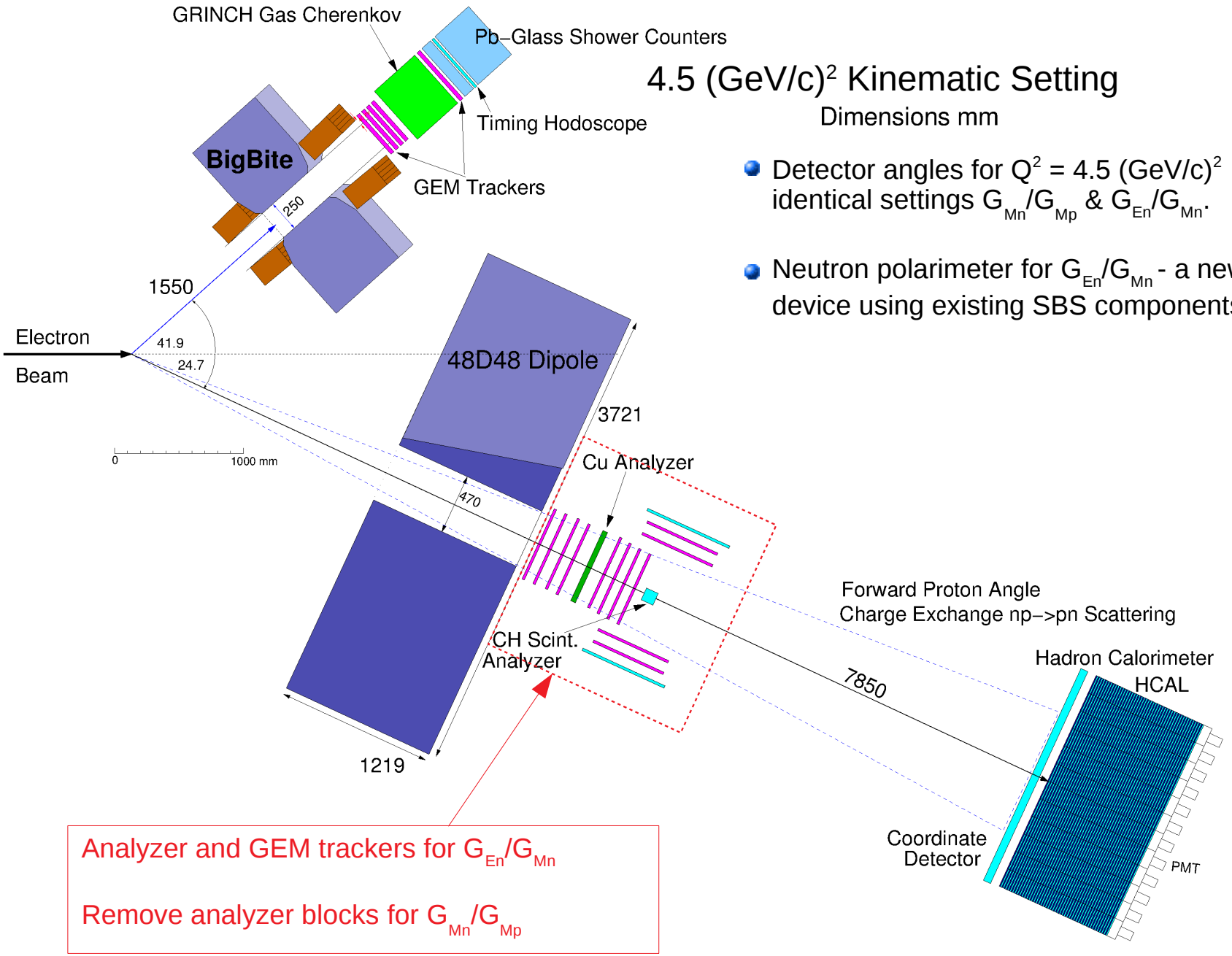
Hadron Calorimeter HCAL



80 – 90% efficiency multi-GeV p and n
Effective suppression of soft background
~0.5 ns timing resolution



Schematic Experiment Layout



4.5 $(GeV/c)^2$ Kinematic Setting

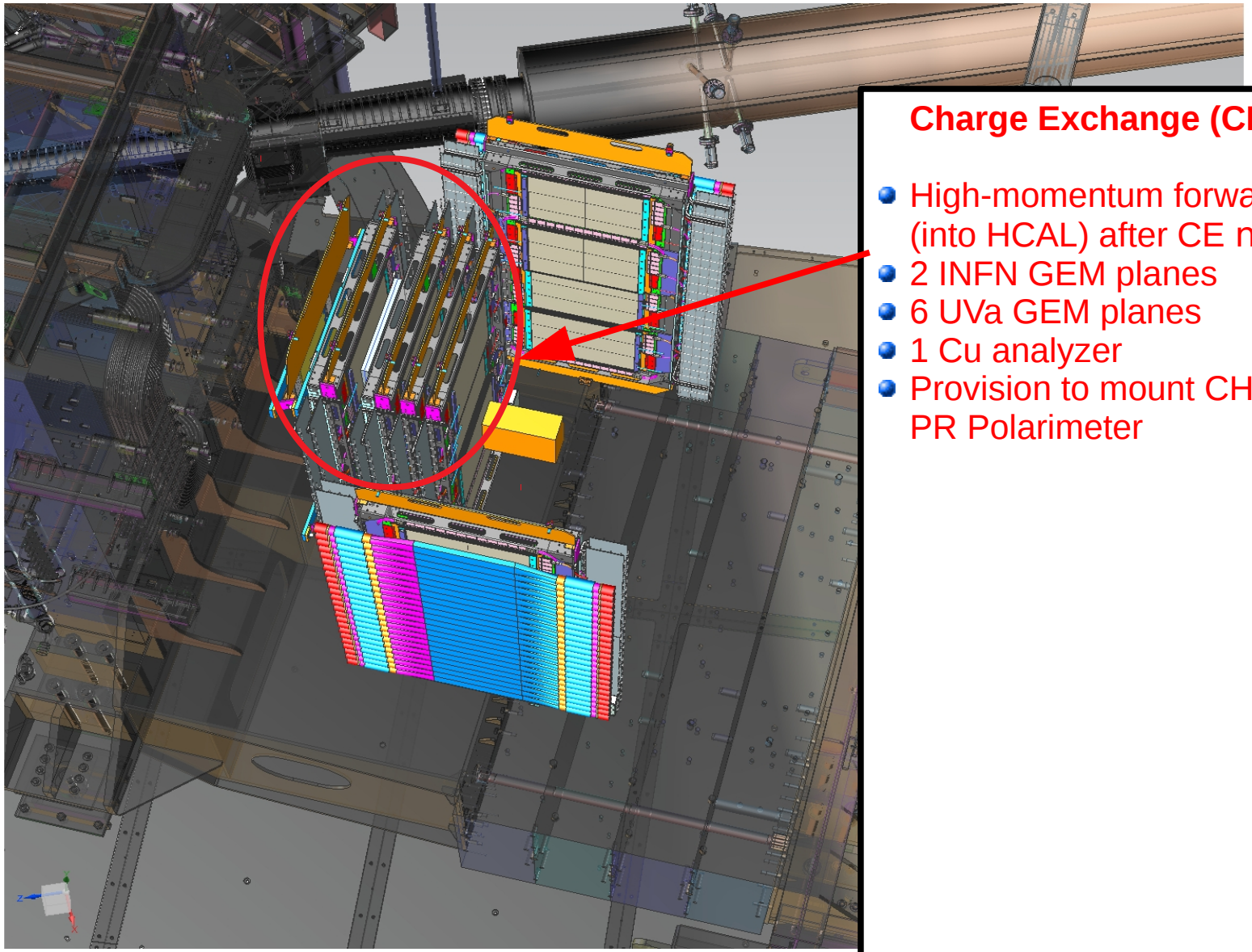
Dimensions mm

- Detector angles for Q^2 = 4.5 $(GeV/c)^2$ identical settings G_{Mn}/G_{Mp} & G_{En}/G_{Mn}.
- Neutron polarimeter for G_{En}/G_{Mn} - a new device using existing SBS components

Analyzer and GEM trackers for G_{En}/G_{Mn}

Remove analyzer blocks for G_{Mn}/G_{Mp}

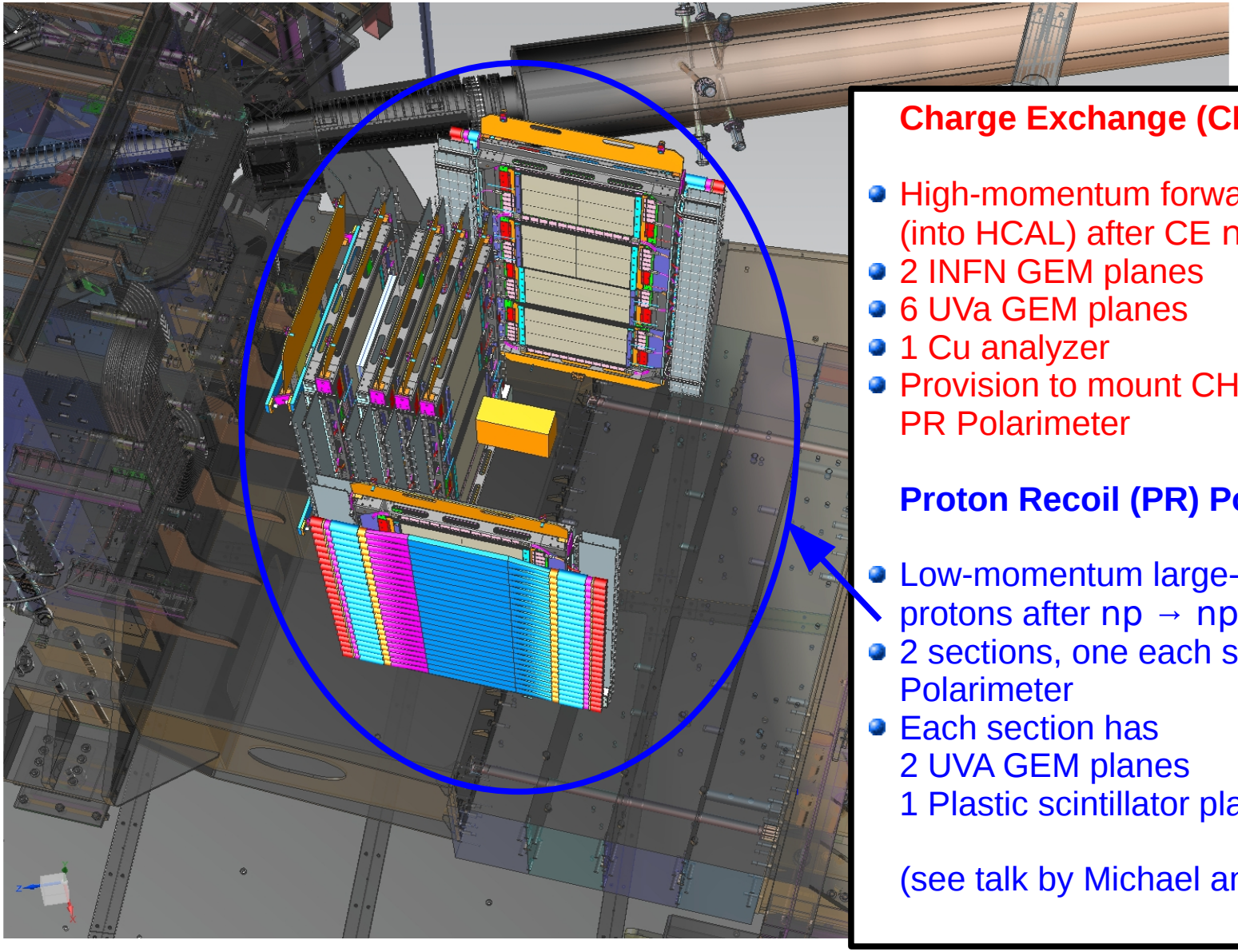
Two Neutron Polarimeters for GEn-Recoil



Charge Exchange (CE) Polarimeter

- High-momentum forward protons (into HCAL) after CE np → pn
- 2 INFN GEM planes
- 6 UVa GEM planes
- 1 Cu analyzer
- Provision to mount CH analyser for PR Polarimeter

Two Neutron Polarimeters for GEn-Recoil



Charge Exchange (CE) Polarimeter

- High-momentum forward protons (into HCAL) after CE np → pn
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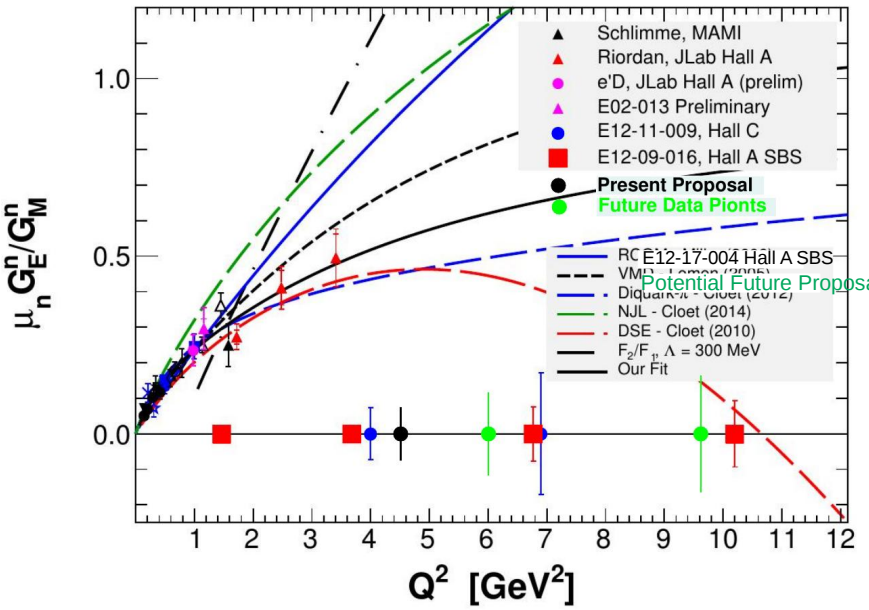
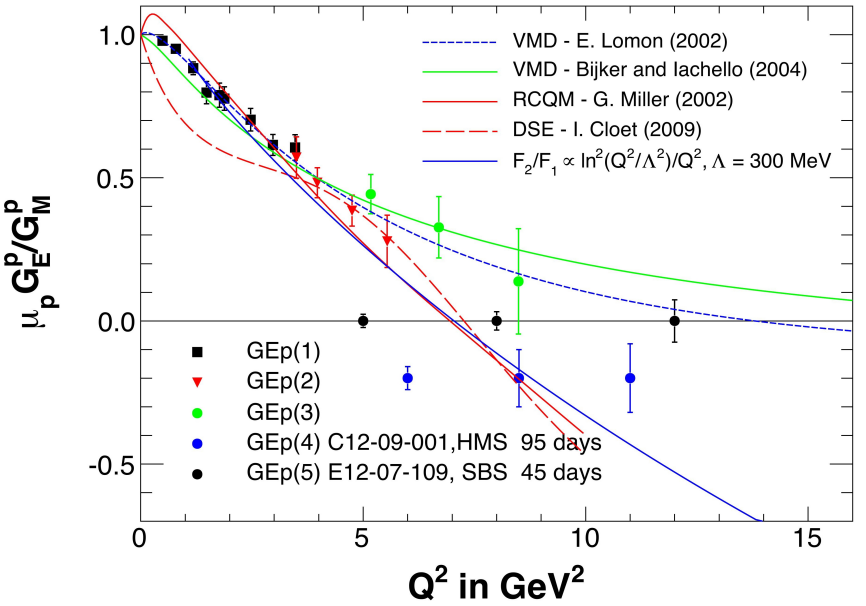
Proton Recoil (PR) Polarimeter

- Low-momentum large-angle recoiling protons after np → np
- 2 sections, one each side of CE Polarimeter
- Each section has
  2 UVA GEM planes
  1 Plastic scintillator plane

(see talk by Michael and Brad)

Run Plan





G_E^n/G_M^n 17004 Hydrogen/Deuterium

Experimental Points — 10cm Hydrogen/Deuterium

Q^2 [GeV^2]	θ_{BB} [deg]	d_{BB} [m]	θ_{48D48} [deg]	d_{48D48} [m]	d_{HCAL} [m]	Beam Line Configuration #
4.5	41.9	1.55	24.7	2.25	8.5	3

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

- G_{En}/G_{Mn} via charge exchange polarimetry;
- G_{En}/G_{Mn} via large angle recoil proton polarimetry;
- G_{Ep}/G_{Mp} via standard (forward) recoil polarimetry;
- G_{Ep}/G_{Mp} via charge exchange polarimetry.

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

Run Plan and GMn Compatibility

- GMn plans to run in the following order (Brian's July talk):

  Kinematic Setting 1 Q^2 = 3.5 GeV^2,
  Kinematic Setting 2 Q^2 = 4.5 GeV^2,
  Kinematic Setting 3 Q^2 = 5.7 GeV^2, ...

- We therefore propose to:

1. Install all CE and PR polarimeter components (except analyzer blocks) during GMn installation.
2. Take parasitic data with GEMs and scintillator hodoscopes at the first two GMn kinematic settings (same trigger), which will allow us to test and commission our detectors in-situ.
3. Install analyzer blocks (8 hours) after GMn data-taking for kinematic setting 2 is complete and begin production data-taking for positive 48D48 polarity for GEn-recoil (50 hours). Switch 48D48 polarity and take data for another 50 hours.
4. Decable and crane out the beamline-side PR detectors;
   Remove analyzer blocks;
   Decable the other PR and CE detectors? (12 hours in total)
5. Switch to GMn kinematic setting 3 (5.7 GeV^2) and resume GMn data-taking.

Extra Data Requirements

Kinematic Point	Time	Data Rate (worst-case estimates from Alex's July talk)
GMn 3.5 GeV^2	12	200 MB/s
GMn 3.5 GeV^2 (with polarimeter GEMs)	12	350 MB/s
GMn 4.5 GeV^2	12	100 MB/s
GMn 4.5 GeV^2 (with polarimeter GEMs)	12	200 MB/s
GEn-recoil 4.5 GeV^2	100	200 MB/s

- Running the polarimeter detectors during the first two GMn kinematic settings will increase the total GMn data taken by around 10 TB (total expected 216 TB).
- Total data for GEn-recoil expected to be 72 TB, assuming a factor of 3 reduction in GEM rate due to SSP deconvolution.
- Cost of tape (LTO 5) for this additional 100 TB around $6k.

University of Glasgow

Summary

- The Gen-recoil experiment will utilize two neutron polarimeters (CE and PR).
- Work is already ongoing:
  - Design of detector frames and electronics hut complete by spring 2019;
  - GEM planes and scintillator hodoscopes will be ready for installation late 2019;
  - Identifying suitable GEM readout electronics.
- The GEn-recoil experiment E12-17-004 will "piggy-back" on GMn SBS experiment.
- Causing the minimum possible disruption to GMn data taking is our top priority.
- We propose to take data with the polarimeter detectors for the first two GMn kinematic points, which will result in an increased but still manageable data rate and a modest increase in data storage requirements.
- Following 100 hours of data-taking for GEn-recoil, the small-angle PR polarimeter detectors will be craned out, analyzers removed and remaining detectors decabled.