# E12-17-004 GEn-RP Update

SBS Collaboration Meeting
July 14–15, 2020

[E12-17-004 Wiki Page](#)

Brad Sawatzky

Jefferson Lab

JSA

GEN-RP Physics / Experimental Approach

- E12-17-004 will measure GEn/GMn using two recoil pol. techniques at $Q^2 = 4.5$ (GeV/c)^2
  - → "GMn" beam, beamline, target, BB
    - » Beam: 4.4 GeV/c, ~40 μA, P_b = ~80%
    - » Target: 15 cm LD2 (unpolarized)
  - → Scattered electron measured in BigBite
  - → Charge-Exchange np → pn channel (primary goal)
    - » Steel analyzer (passive)
    - » GEM tracking + HCAL measure forward protons
  - → Conventional np → np (secondary goal)
    - » Plastic analyzer (active)
    - » Large-angle recoil protons → Side detectors (GEM + hodoscope)
    - » Forward neutron → HCAL

- Detector components also used in:
  - → Wide-angle Charged Photoproduction (WAPP)
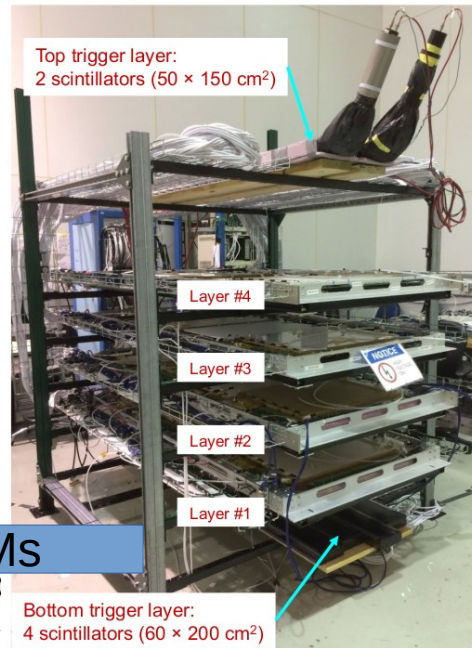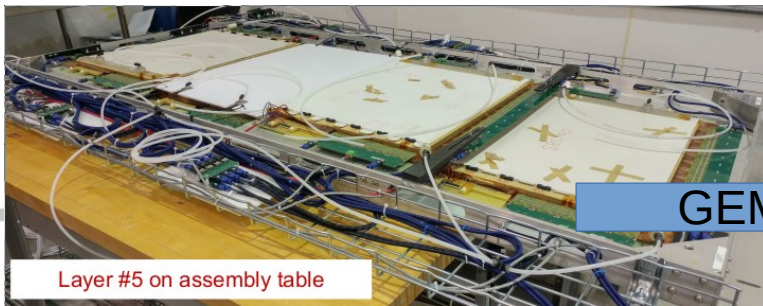   - » SBS Inline GEM stack + Steel analyzer
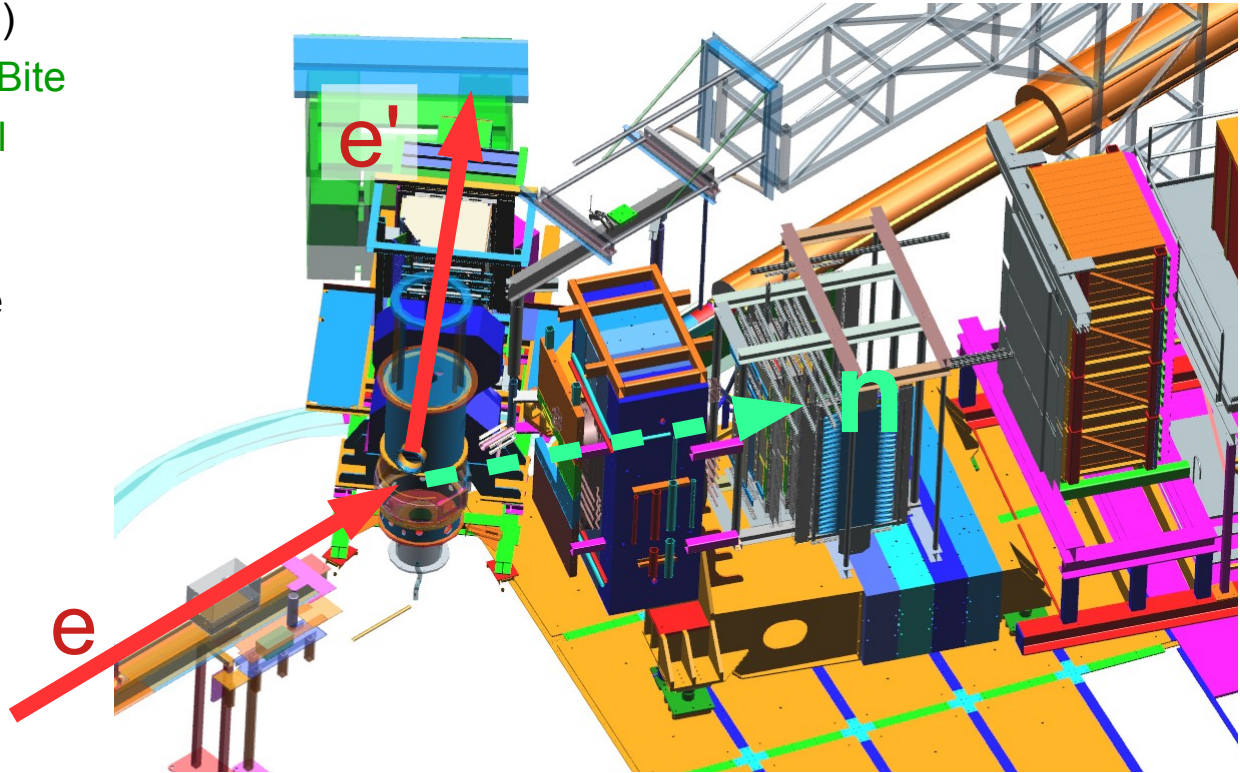
Addl. Hardware for GEn-RP / E12-17-004

- Active Analyzer (PR)
  - → segmented plastic scint. array
  - → np recoil vertex identification

- Recoil proton detectors (PR)
  - →2 packages total:
    - » One on SBS Left
    - » One on SBS Right
  - →Each package contains
    - » 1x Hodoscope array
      - – timing, coarse location
    - » 2x UVa GEM planes
      - – Tracking protons from CH analyzer

- Inline GEMs (PR + ChEx)
  - → 2x INFN + 6x UVa GEMs
  - → Charged particle veto (both)
  - → forward proton tracking (ChEx)
- Steel Analyzer (ChEx)
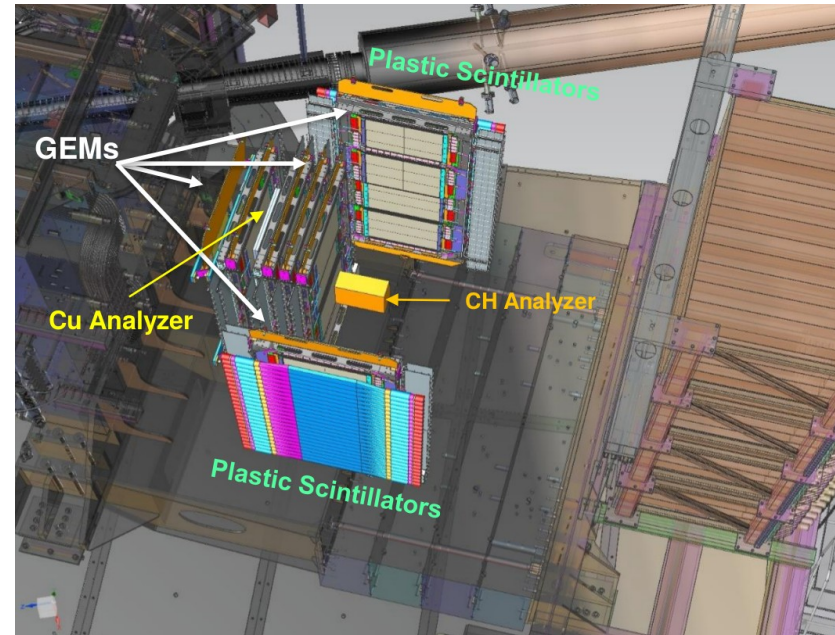
GEN-RP Status

- ERR process is ongoing...getting closer.
  - → Extensive response recently submitted
    - » Reflects major effort on the part of the GEM hardware and software groups.
    - » Significant benefit to entire SBS program.
  - → One 'Status Report' requirement left
- GEn-RP support frame designs completed
  - → Most(?) parts on-site now!

- Detector commissioning is ongoing
  - → UVa and INFN GEM groups continue to produce detectors (needed for GEn-RP, but also for future GEp-5 program)
  - → All GEn-RP scintillator hw is on-site and being commissioned

Layer #5 on assembly table

Top trigger layer: 2 scintillators (50 × 150 cm²)

Layer #4
Layer #3
Layer #2
Layer #1

GEMs

Bottom trigger layer: 4 scintillators (60 × 200 cm²)
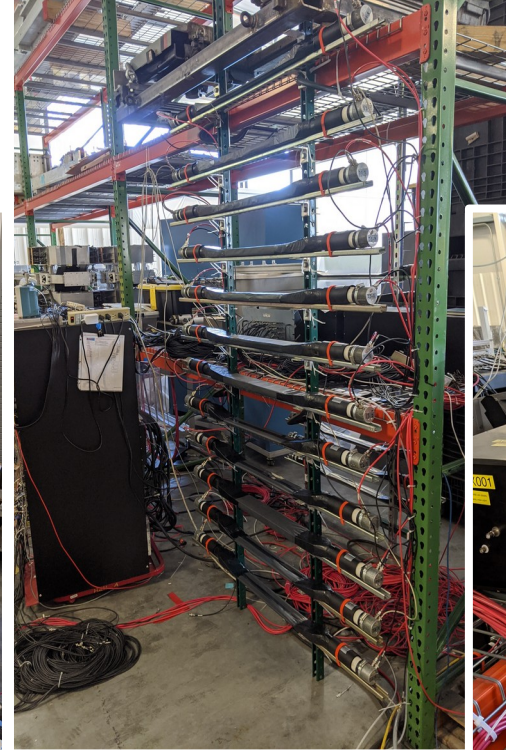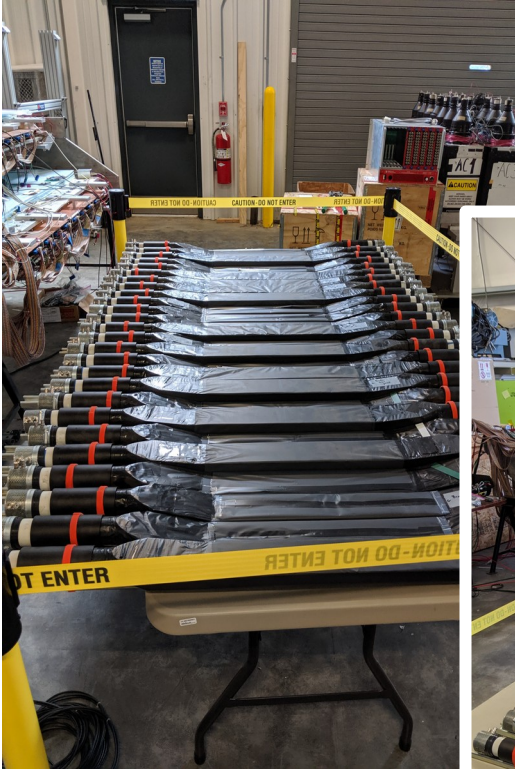
Active Analyzer

Hodoscopes

High Level Tasks / Todo List (Non-GEM)

- Near Term tasks w/ ESB DAQ testbed (ASAP: Summer/Fall)
  - → PR Hodoscope Bars (80% done)
    - » Finish regluing broken joints
    - » Complete checkout and gain matching
  - → Active Analyzer
    - » Recheck functionality
    - » Gain match w/ cosmics
  - → Sort and re-label cables

Local support: Brad, Holly
- Original CNU and Summer Student plans were squashed by COVID, but <u>great</u> student projects here!

- SBS fringe field test with PMTs (Fall?)
  - → Validate B-shielding options with actual PMTs using HH coil PMT test stand in TestLab

- Longer Term (Spring/Summer)
  - → Install/Mount hodoscopes in new stands (when available)
    - » Re-check all bars w/ cosmics
  - → Integrate UVa GEMs into PR sub-assemblies as soon as possible
  - → Software work (Analyzer)
    - » Add GEN-RP PMT arrays to PODD (easy)
   - » Add SBS GEM tracking to PODD (harder)

GEN-RP Paddle Work (ESB)

Carly Wever (CNU)
Tanner Hawk (CNU)

Active Analyzer Status and Timeline

- Assembled and tested in Glasgow some time ago
  - → 4 x 8 array of scint bars w/ PMTs
    - » 4cm x 4cm x 25cm each
    - » Assembly weighs ~ 30 kg

- Current Status
  - → Shipped to JLab and is in ESB
  - → Unpacked, looks to be in good shape, but not plugged in and checked out at JLab yet.
    - » Next in queue for checkout in ESB
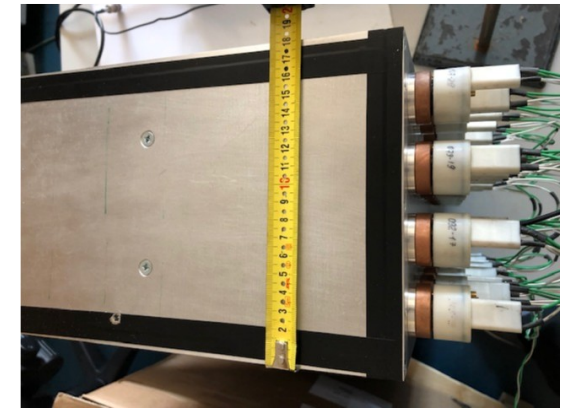
Software / Analyzer Notes

- The 4 UVa GEMs downstream of Steel Analyzer provide track for Charge-Exchange proton
  - → Supported by kin. constraints from e- in BB and HCAL cluster
  - → Assumption was that we would leverage existing GEM tracking infrastructure for BigBite in Podd
    - » Andrew et al. have made significant progress in the last 6 months
    - » See afternoon talks

- Upstream GEMs are a used as *charge-veto only* for GEN-RP (relatively low bar)
  - → Tracking required in this region for WAPP
    - » Significantly higher BGs
    - » Could be challenging

- Hodoscope / Active analyzer fairly easy to implement and monitor with existing Podd
  - → Kinematics and online "physics" monitoring modules/scripts need to be developed though

ERR Status

- See E12-17-004 ERR Wiki for details and reports.
  - → Short answer is that we're getting there... but it has incremental.

- Most challenging items to clear have been related to INFN and UVa GEM requirements and observed performance
  - → Last two reports/responses to the ERR Committee have been focused on these issues

- Committee Questions (abv.)
  - → List concrete performance metrics for GEMs assumed/ required for experiment
    - » MIP efficiency
    - » Noise/BG assumptions
    - » Track recon. eff., etc...
  - → Compare those values against demonstrated/ measured performance
  - → Details on GEN-RP "fallback plans" if only a subset of GEM planes are functional
    - » Will touch on these later...

ERR Status ... continued

- **GEN-RP and GEM group provided a 30 page response addressing those issues last month.**
  - → Reflects an *enormous* amount of work by the UVa GEM group and Andrew's software team in particular.

- **Interested parties for all SBS experiments should review that document as a baseline for expected performance in upcoming SBS/BB measurements**

Response to the ERR follow up questions on GEn RP GEMs

D. Di, K. Gnanvo, N. Liyanage, S. Jian,
H. Nguyen A. Puckett, A. Rathnayake, B. Sawatzky
(on behalf of the E12-17-004 Collaboration)

June 5, 2020

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ERR: GEN-RP "Fallback Options"

- **Issues driven by questions around current INFN GEM status**
  - → Cosmics hitmaps for 4 planes shown below (as of Fall 2019)
  - → 2 addl planes in progress
    - » 5th plane similar to J1 (left)
    - » 6th plane TBD
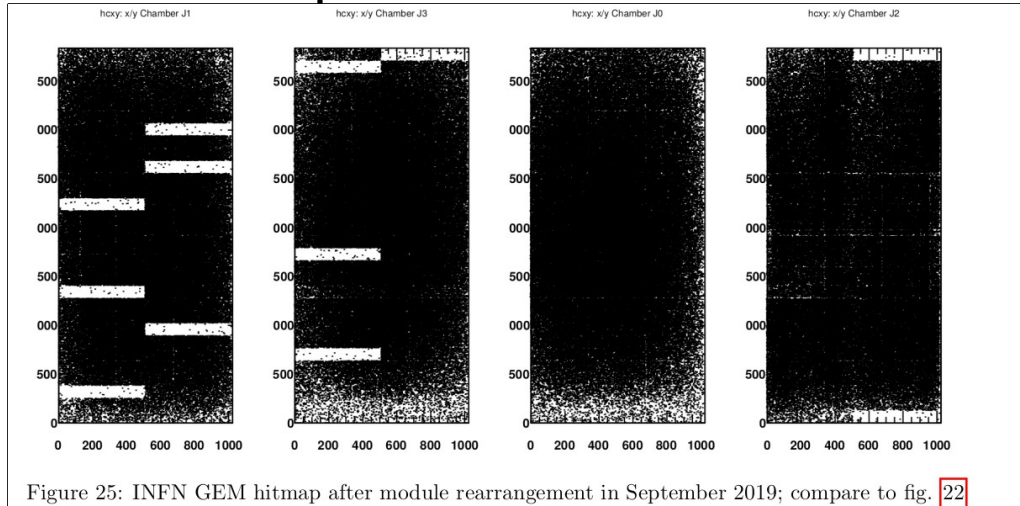
Figure 25: INFN GEM hitmap after module rearrangement in September 2019; compare to fig. 22

Jefferson Lab
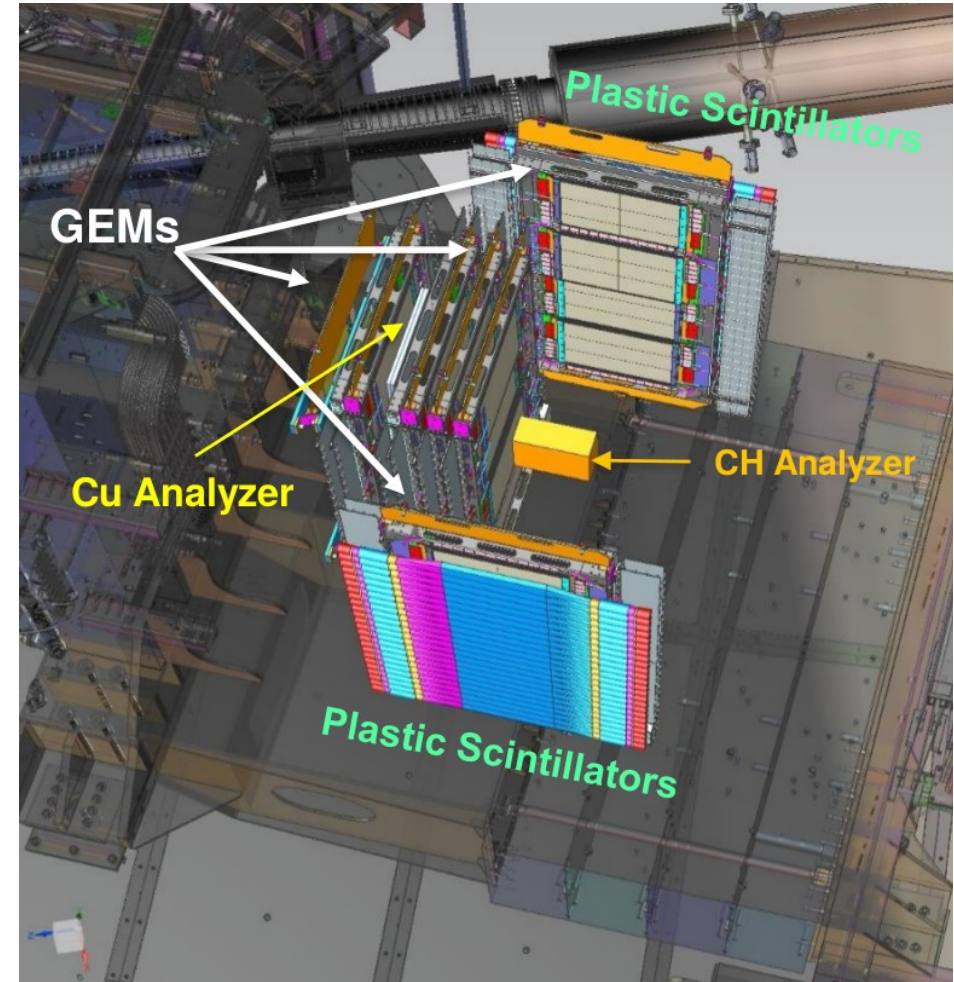
ERR: GEN-RP "Fallback Options"

- Always assume 4 best INFN GEMs must be in BigBite

- Original Plan
  - → All INFN and UVa planes have performance no worse than prior slide

- Fallback Plan "A"
  - → INFN planes 5, 6 are worse than J1
    - » Demonstrated RPGEN can tolerate significant plane inefficiencies in upstream (veto) GEMs
    - » Should be able to get by with 3 "effective" planes in GEM veto region with minimal impact on FoM
      - – *ex*: Can tolerate 1 dead sector if other planes in that solid angle are OK
  - → *This situation likely inadequate for tracking upstream of analyzer (WAPP)*
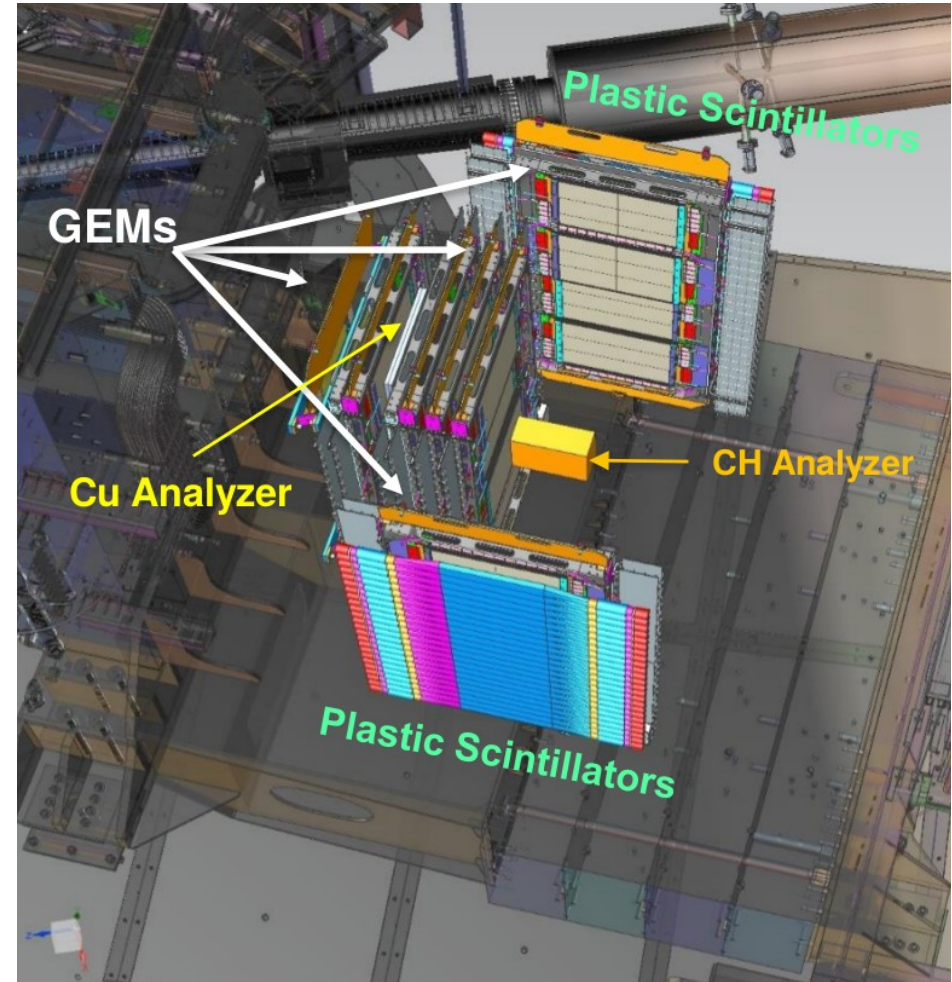
ERR: GEN-RP "Fallback Options"

- Always assume 4 best INFN GEMs must be in BigBite

- Deep Fallback Plan "B"
  - → 2–3 GEM layers (INFN + UVa) are effectively non-functional
    - » Earlier we know, the better...
  - → A few options evaluated
    - » All involve shuffling GEM layers from side detectors to fill gap(s) in Inline-GEM stack.
    - » Worst case is to drop an entire side-detector assembly
      - – lose 1/2 stats on RP meas.
      - – Loss of symmetry and assoc. systematic controls

- NOTE: UVa "U/V" GEMs increase our options (if available)
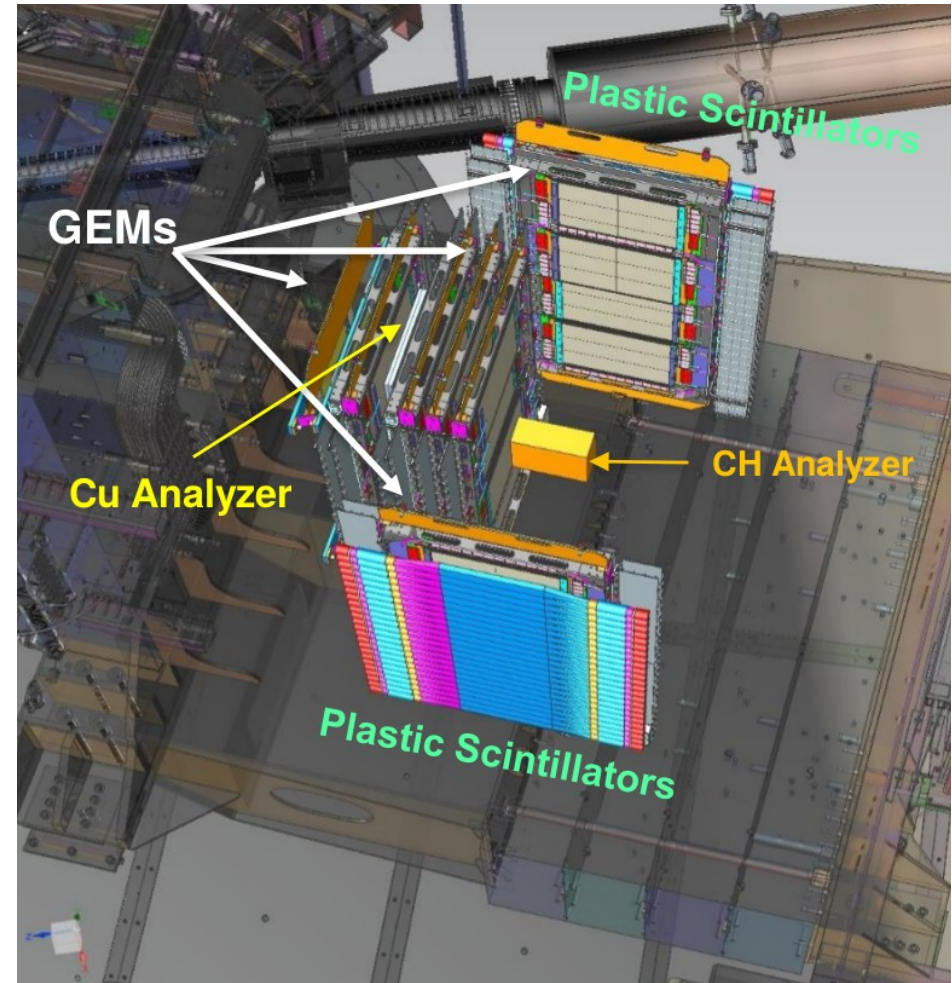
ERR: Pending Recommendations

- Provide the manufacturer/ model# of the HV supply you plan to use, along with a simple schematic of the HV connection method

- Provide by *October 15, 2020* an update on the detector status for both UVa and INFN GEM chambers that includes
  - → # of layers assembled
  - → # of layers tested w/ cosmics
  - → Characterization plots for the layers tested with cosmics as shown in latest report

→ Schedule for finishing the detector assembly and characterization that also includes

  - » time frame for modifications of detectors (grounding, HV dividers) if needed,
  - » and the personnel involved in these activities

- 2nd bullet (3 months away) is a critical milestone to allow GEN-RP to be formally placed on schedule.

Staging and Run-plan Integration

- GEn-RP detectors will be installed in SBS detector stack and checked out in-situ prior to start of beam
  - → This includes the all GEMs and side hodoscopes
  - → Active analyzer will be cabled and checked out in-situ w/ cosmics as well
  - → Jesse's schedule pencils in (with many caveats noted yesterday!)
    - » GEN-RP equipment moving into the Hall: June 2021   (with rest of SBS equipment)
    - » GEN-RP hookup and prebeam tests: July—Aug 2021   (with other BB/SBS checkout)
- GEn-RP will run adjacent to associated 4.5 $(GeV/c)^2$ GMn kinematic setting
  - → Current plan has us running 1st in the GMn program *before* the SBS is moved to small angle.
    - » BB, HCAL, GEM commissioning w/ must all be completed before production begins
    - » Current beam schedule has 3 weeks of dedicated SBS commissioning—good to see!
  - → Removal of GEn components prior to GMn 4.5 $(GeV/c)^2$ GMn data taking
    - » Side GEMs + hodoscope packages will be decabled and craned out as units
    - » (*) Steel analyzer craned out
    - » (*) Inline GEM package craned out as unit

(*) Remain if WAPP approved

- Intent is to schedule all transitions during opportunistic Accelerator downs
  - → Beam studies, RF recover, etc.

Local Personnel

- **GEM Systems**
  - → **UVa Group**
    - » Kondo, Nilanga, et al.
  - → **Hampton Group**
    - » Michael K. (Lead)
    - » Thir   (Postdoc)
    - » Malinga (MSc student)
    - » Manju   (new PhD st.)

- **If things return to normal'ish and travel options return:**
  - → **David H. group   (Glasgow)**
    - » Ralph Marinaro (PhD st.)
  - → **Will T. group   (NMU)**

- **PMT based detectors / DAQ (Hodoscopes, Active analyzer)**
  - → **JLab**
    - » Brad, Holly(?)
    - » I'll try not to lean on JLab post-docs too much—I think they are needed on the GMn systems(?)
  - → **Hampton**
    - » Might steal some time from Michael's team as COVID and GEM work allows.

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Thank you

GEn-RP (E12-17-004)

- GEn/GMn form factor measurement
  - → Models with diff. assumptions of quark dynamics diverge rapidly as Q^2 rises.
  - → Full program supports nuclear u and d quark decomposition
- E12-17-004 is a "Proof of Principle" measurement of GEn/GMn:
  - → Validate new neutron polarimetry technique exploiting Charge Exchange channel (promises much better FoM at high Q^2!)
  - → Cross checked using the "conventional" large angle np scattering polarimetry
- GEn-RP is allocated 5 PAC days to do single Q^2 point at 4.5 (GeV/c)^2
  - → Overlaps with GMn setting
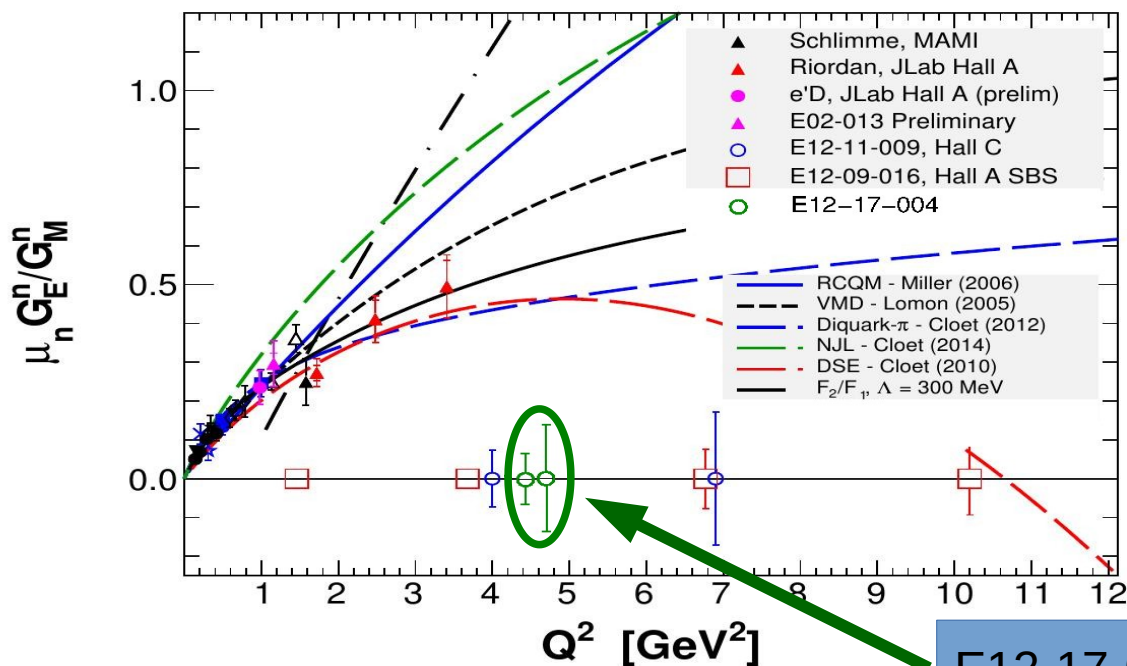 - → If all works, will return to PAC for full measurement
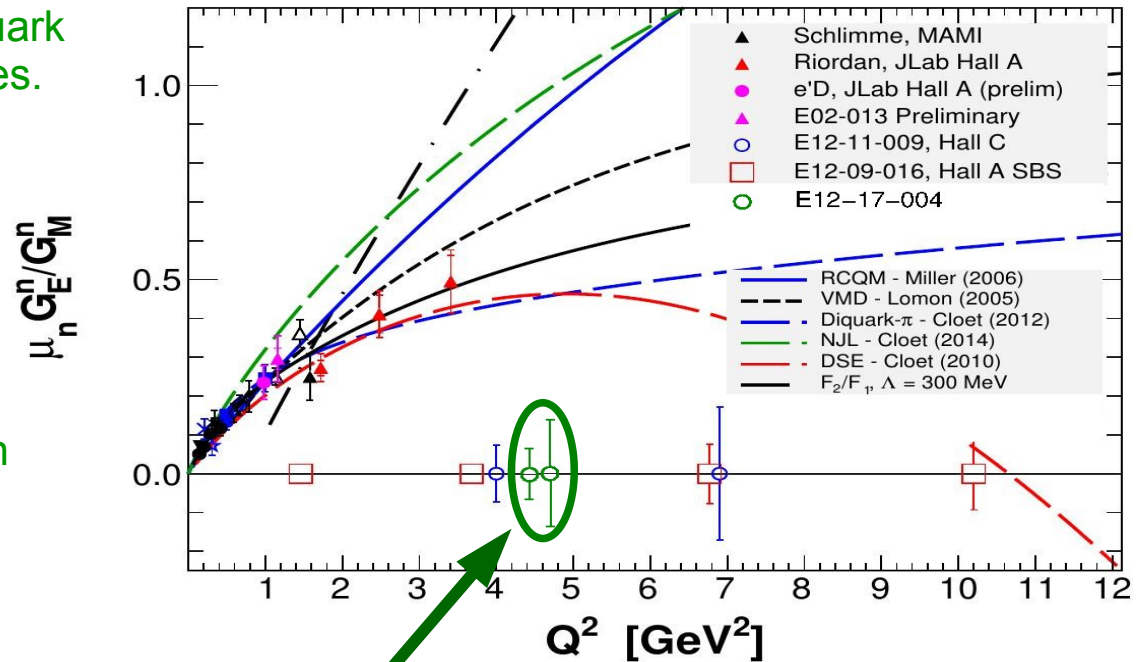
E12-17-004 (projected)

Precision on the Form Factor Ratio

$$\delta P = \sqrt{\frac{2}{N_{inc}\mathcal{F}^2}} \qquad R = \mu_n G_E^n / G_M^n \qquad \left(\frac{\delta R}{R}\right)^2 = \left(\frac{\delta P_x}{P_x}\right)^2 + \left(\frac{\delta P_z}{P_z}\right)^2$$

E_{beam} (GeV)	Q^2 (GeV/c)^2	p_n (GeV/c)	Rate (Hz)	Time (hours)	FOM $\times 10^{-4}$	dP (absolute)	dR (absolute)
4.4	4.5	3.15	48.8	120	2.6 (CE)	0.019	0.078
					0.8 (PR)	0.034	0.140
					3.4 (Total)	0.017	0.070

- Estimates from latest g4sbs agree very well with previous simulation studies (in proposal)

- *dR* based on Galster G_{En} and Kelly G_{Mn} parametrizations

- Expect overall systematic error to be ~3.0%

E12-17-004 (projected)