UConn Physics Research in Hall A at Jlab (Puckett group)

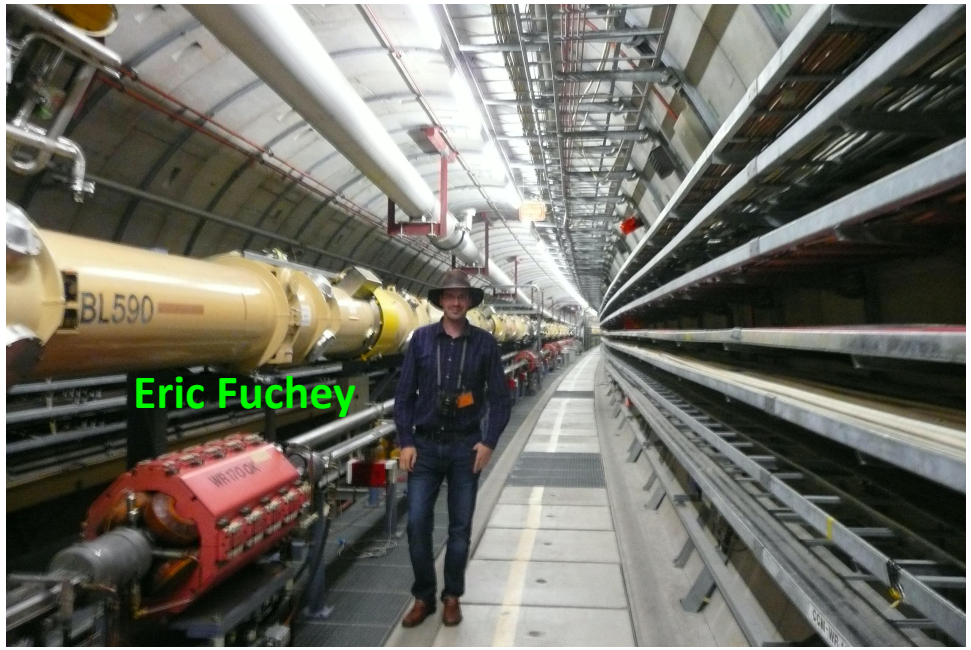
Andrew Puckett

UConn physics (virtual) graduate open house

March 12, 2021

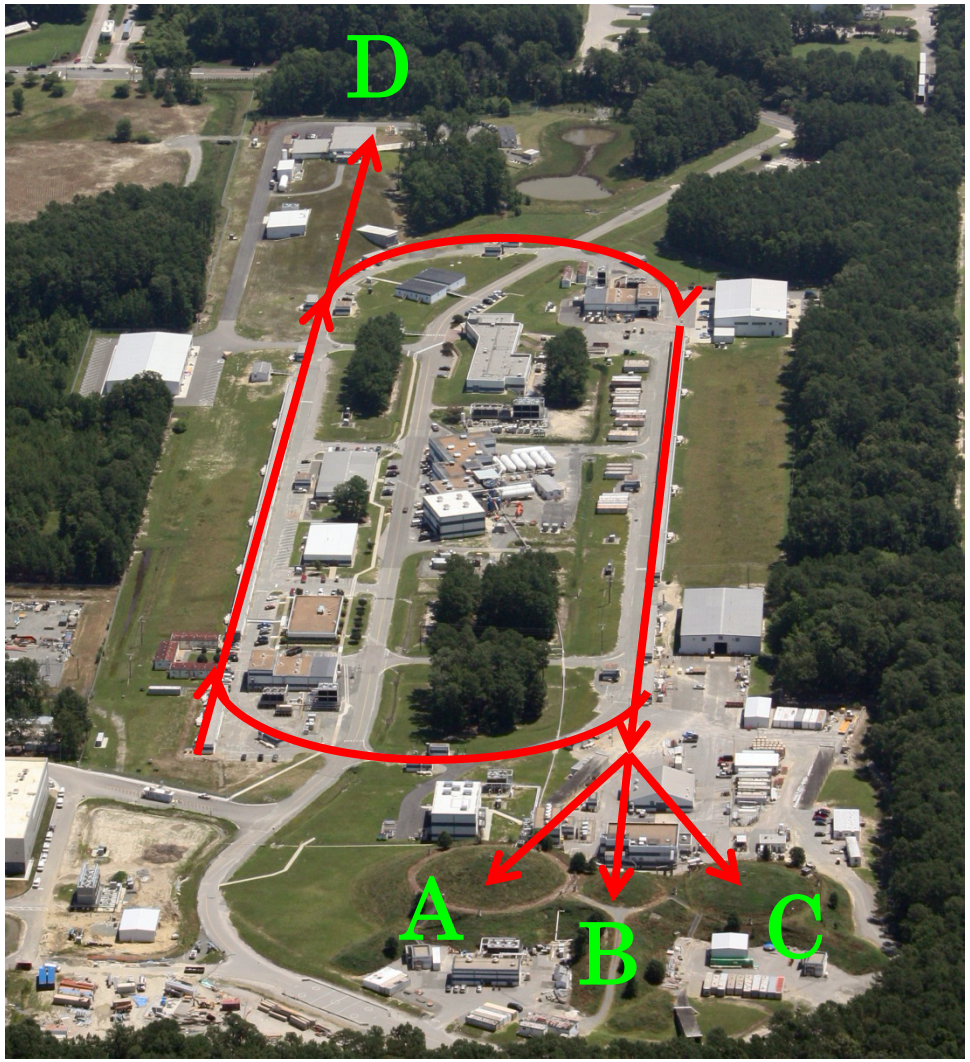
UCONN

Puckett Group Introduction

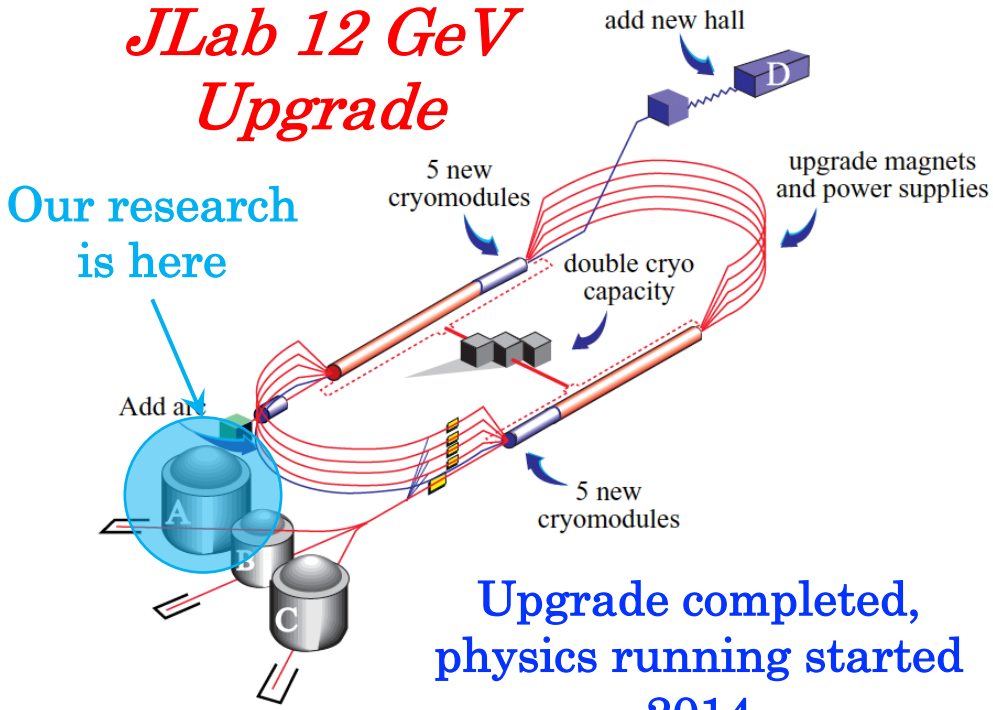


- Group homepage: https://puckett.physics.uconn.edu
- Andrew Puckett: Associate Professor, PI
  - DOE funding, DE-SC0021200
- Dr. Eric Fuchey: Postdoctoral Research Associate (August 2016-present)
  - Ph.D. Université Blaise Pascal in Clermont-Ferrand (2010).
- Ph.D students: Provakar Datta (2018-present), Sebastian Seeds (2018-present)

Jefferson Lab Overview



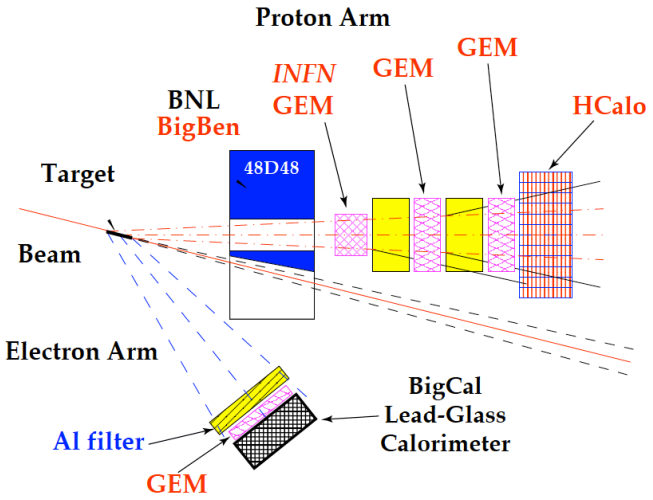
Site Aerial, June 2012



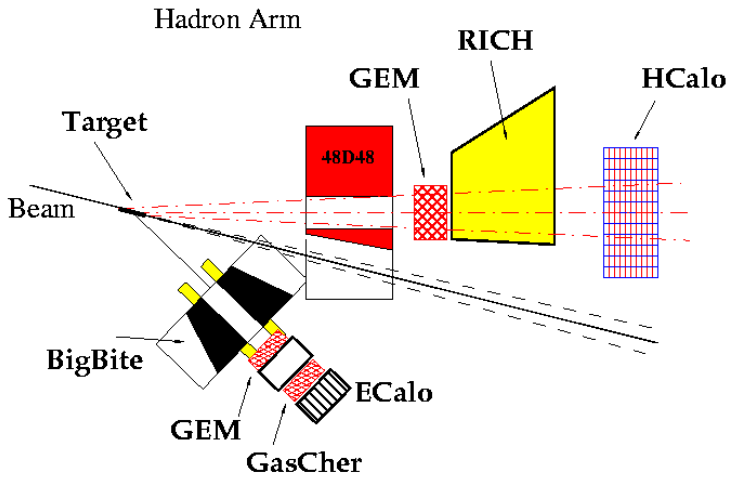
Seven-cell, High-Gradient Niobium SRF cavity for 12 GeV Upgrade

The Super BigBite Spectrometer in Hall A

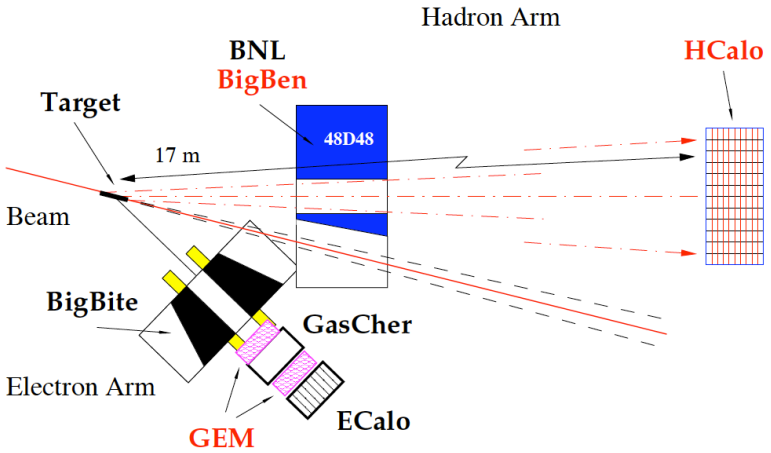
Proton form factors ratio, GEp(5) (E12-07-109)



SIDIS transverse single-spin asymmetry experiment: E12-09-018

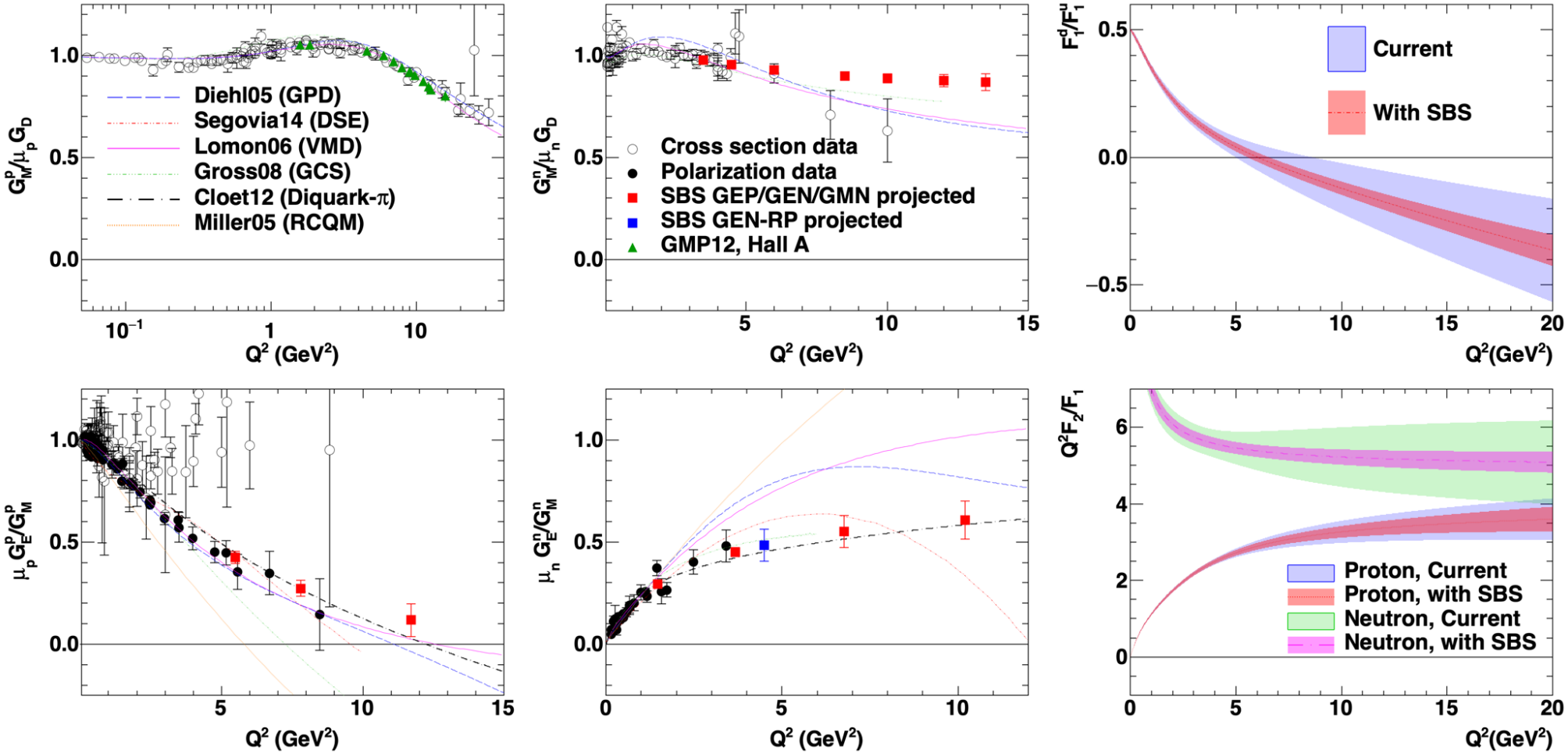


Neutron form factors, E12–09–016 and E12–09–019



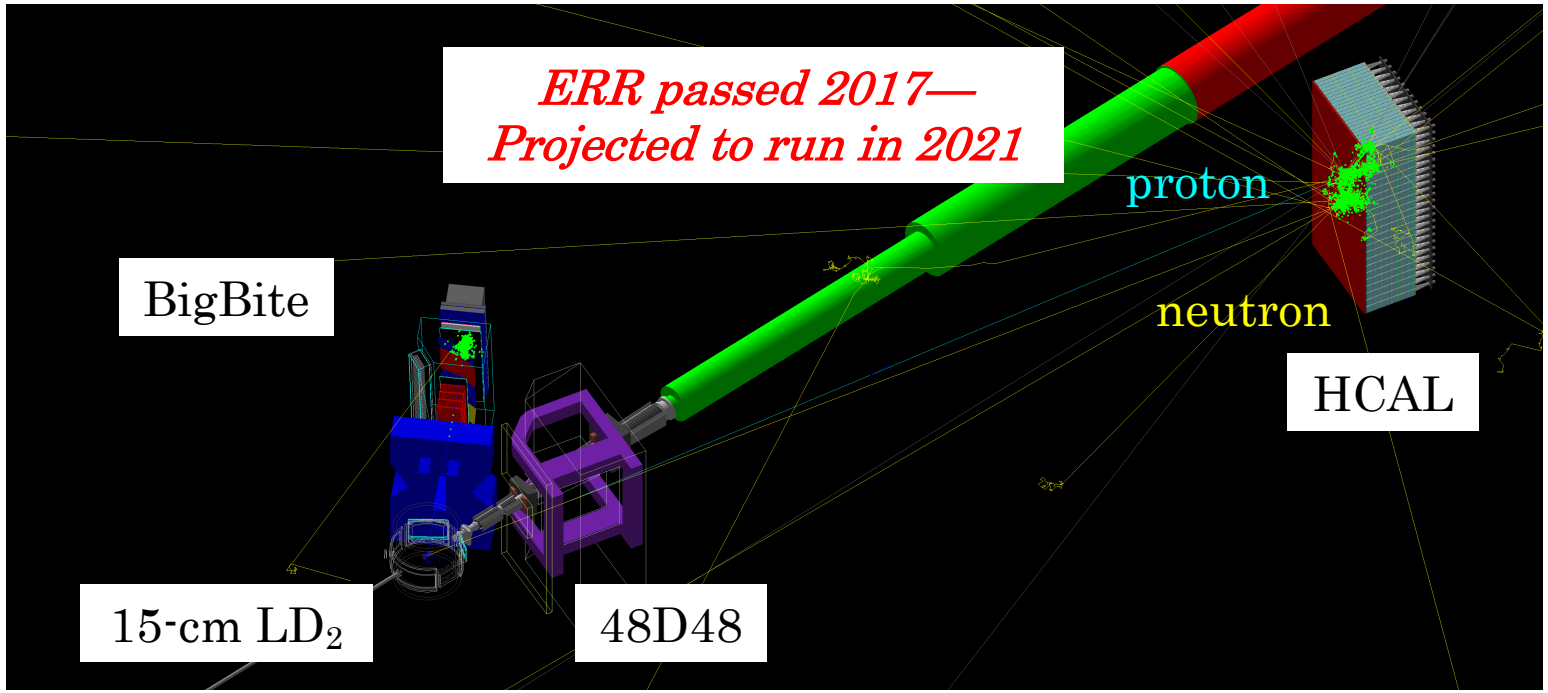
- What is SBS? → A collection of magnets and detectors designed to operate at forward scattering angles with large acceptance at high luminosity
- Five fully approved "large" experiments plus two fully approved "small" experiments, focused on high-Q^2 nucleon form factors, transverse SSAs in SIDIS
- Conditionally approved future program of "tagged DIS"
- ***Large solid-angle + high luminosity @ forward angles = most interesting physics!***

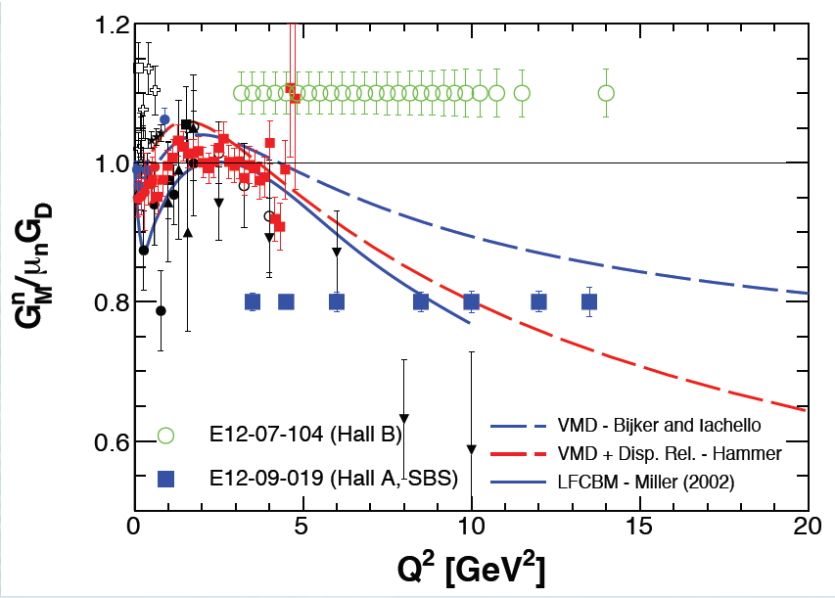
SBS FF Program Summary



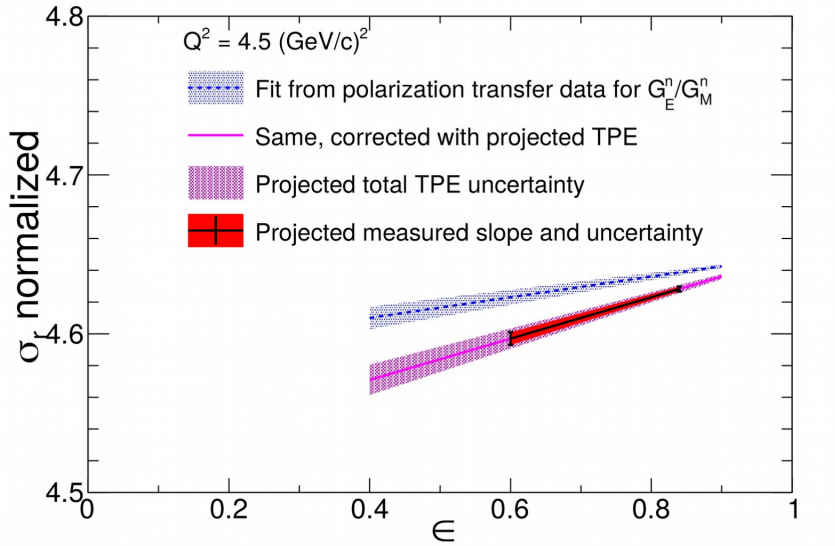
- Expected data from JLab 12 GeV for G_E^p, G_E^n, G_M^n to $Q^2 \geq 10$ GeV^2 allows full flavor decomposition of FFs, severe constraints to most sophisticated theoretical descriptions of the nucleon (and to GPD modeling)
- First "run group": GMN+GEN-RP+nTPE+WAPP starting summer 2021

E12-09-019: Neutron magnetic form factor G_M^n to $Q^2 = 13.5$ GeV^2

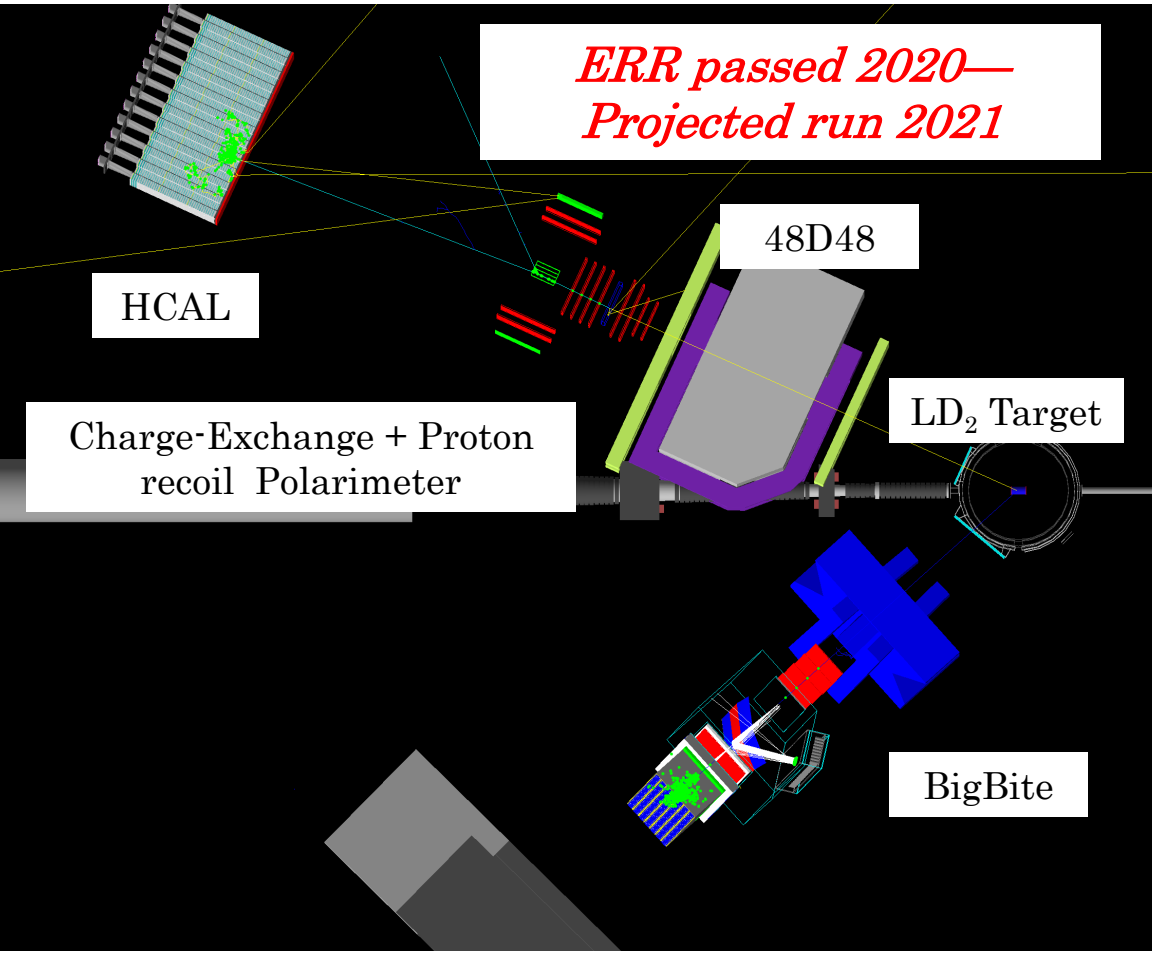


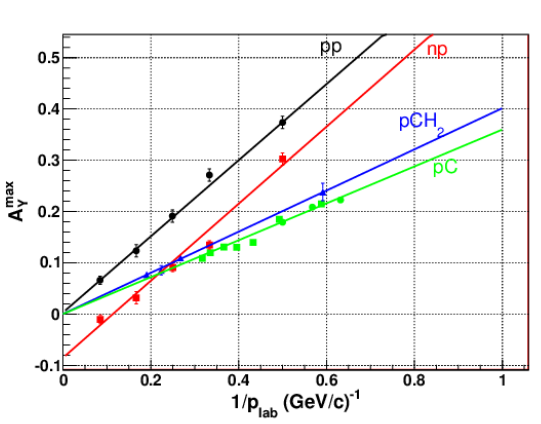


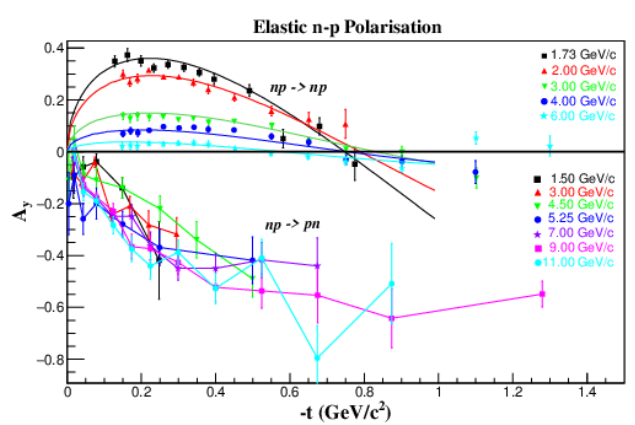
- E12-09-019 will measure neutron magnetic form factor G_M^n to 13.5 GeV^2 using the "ratio" method on deuterium. **FIRST SBS experiment!**
- E12-20-010, a recently approved "add-on" measurement, will determine the Rosenbluth slope in elastic *en* scattering for the first time at $Q^2 = 4.5\ GeV^2$
- Uses hadron calorimeter for efficient nucleon detection; magnetic deflection for charge ID
- BigBite detects electron, defines $\vec{q}$ vector, vertex for selection of quasi-elastic



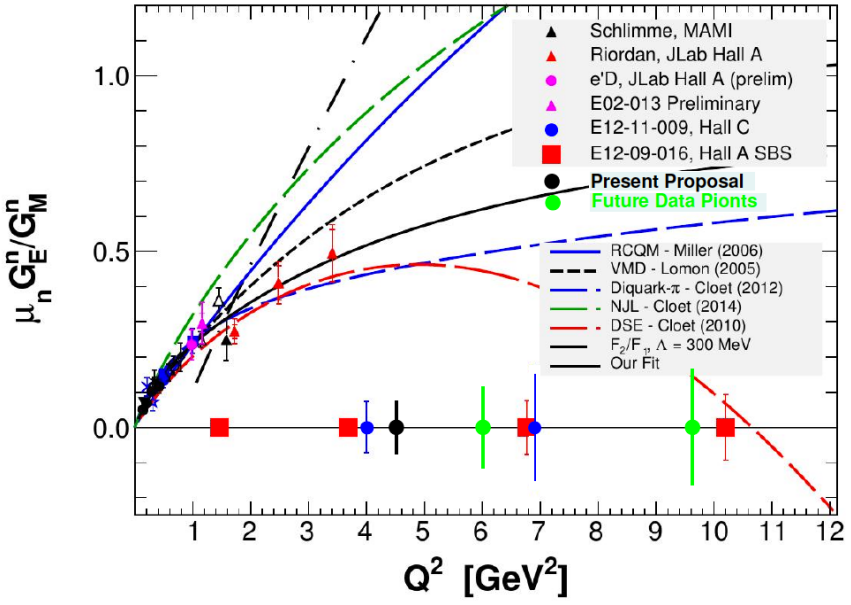
E12-17-004: G_E^n/G_M^n to 4.5 GeV² via charge-exchange recoil polarimetry





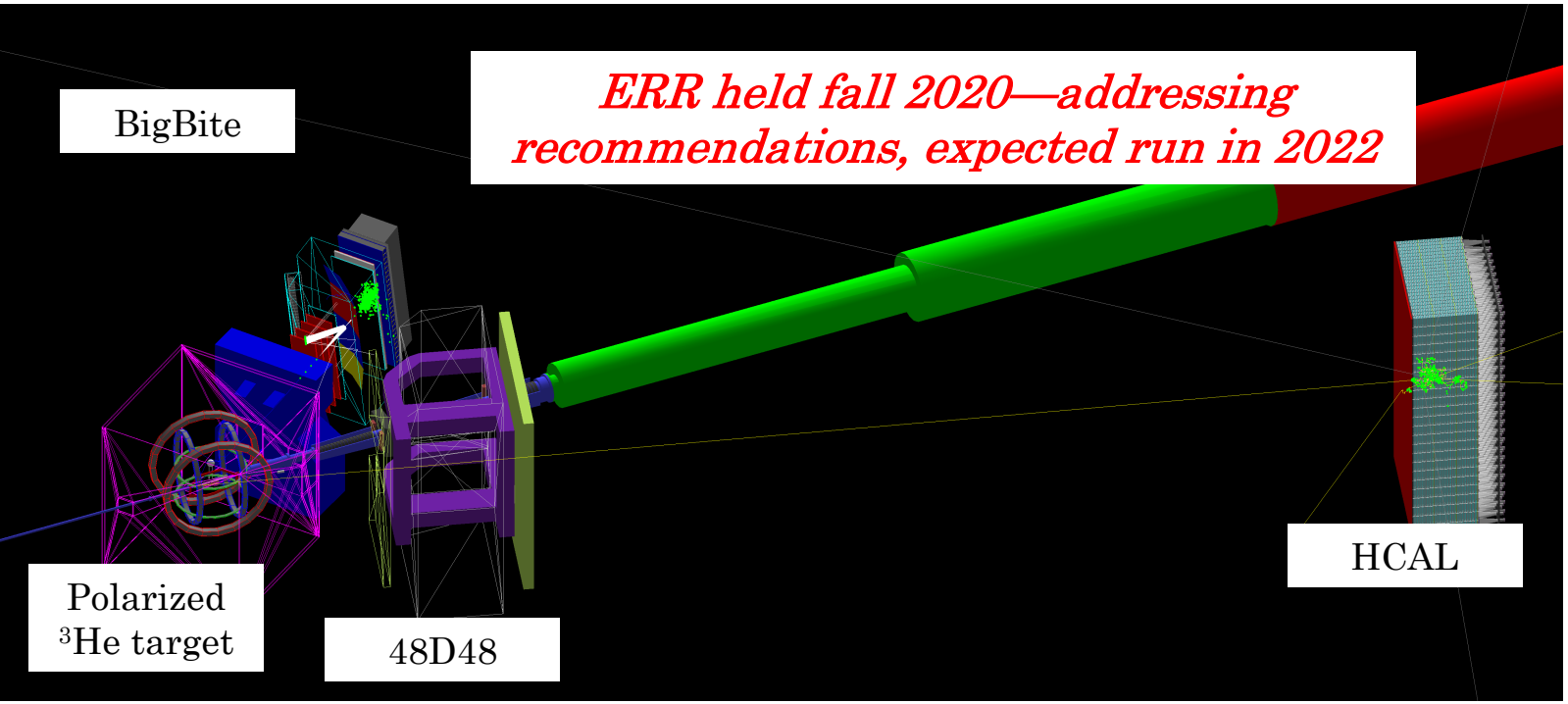


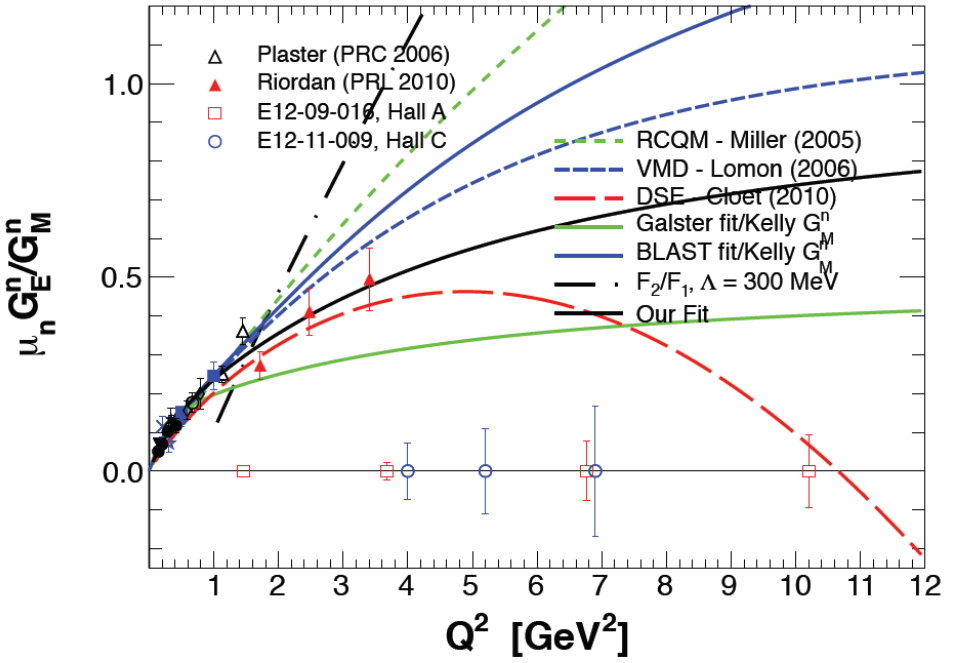
Analyzing powers for np, pp, pA scattering vs. initial momentum (left) and vs. transferred momentum (right)



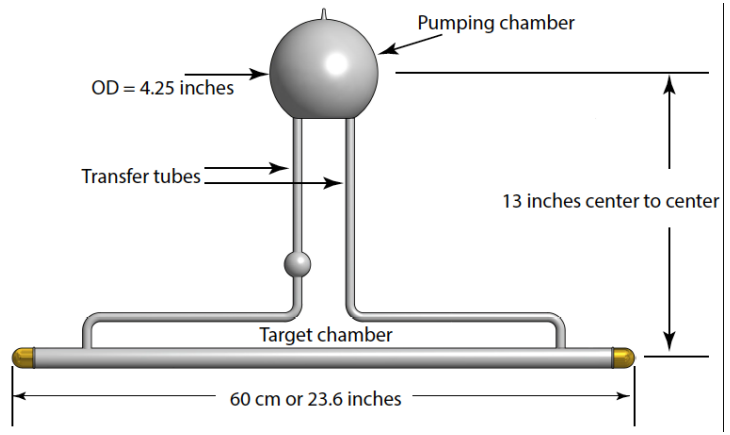
- E12-17-004 layout (above) and projected results (right):
  - First use of charge-exchange polarimetry in a FF experiment
- E12-20-008 approved as add-on to measure K_{LL} for $\gamma n \to \pi^- p$

E12-09-016: G_E^n/G_M^n to 10 GeV^2 using polarized ^{3}He(e,e'n)pp

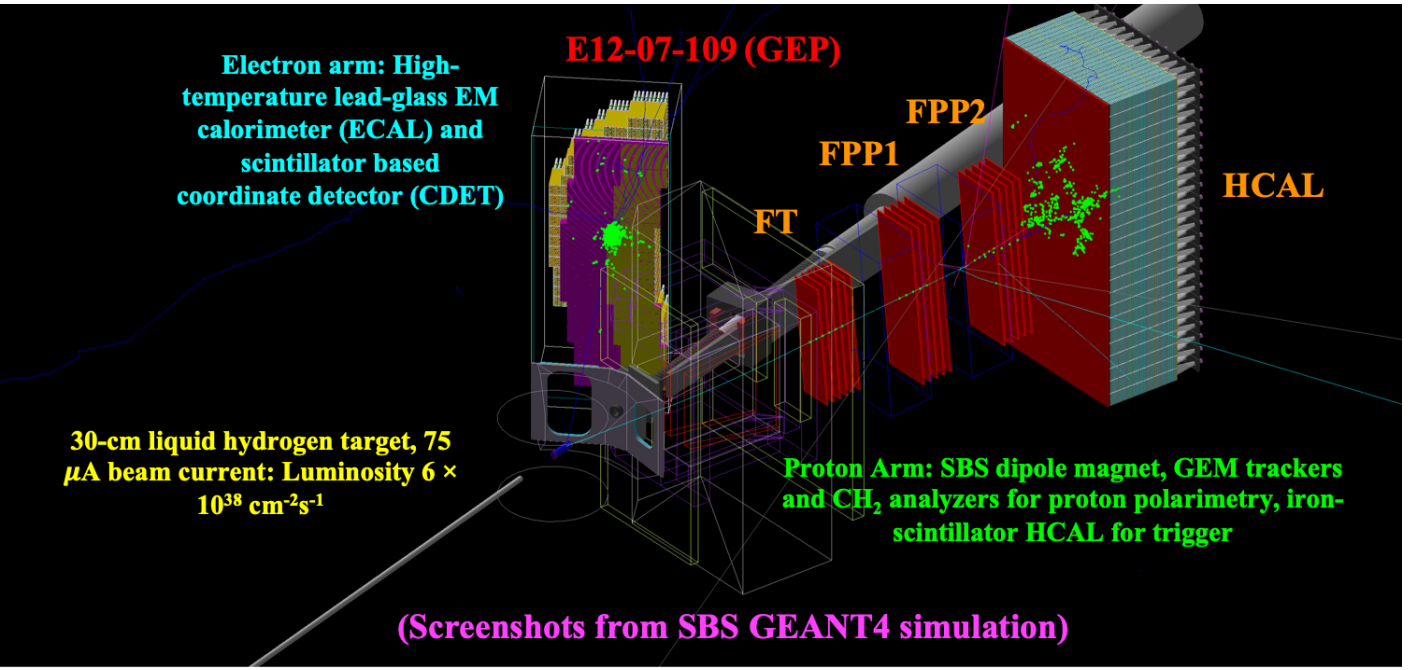




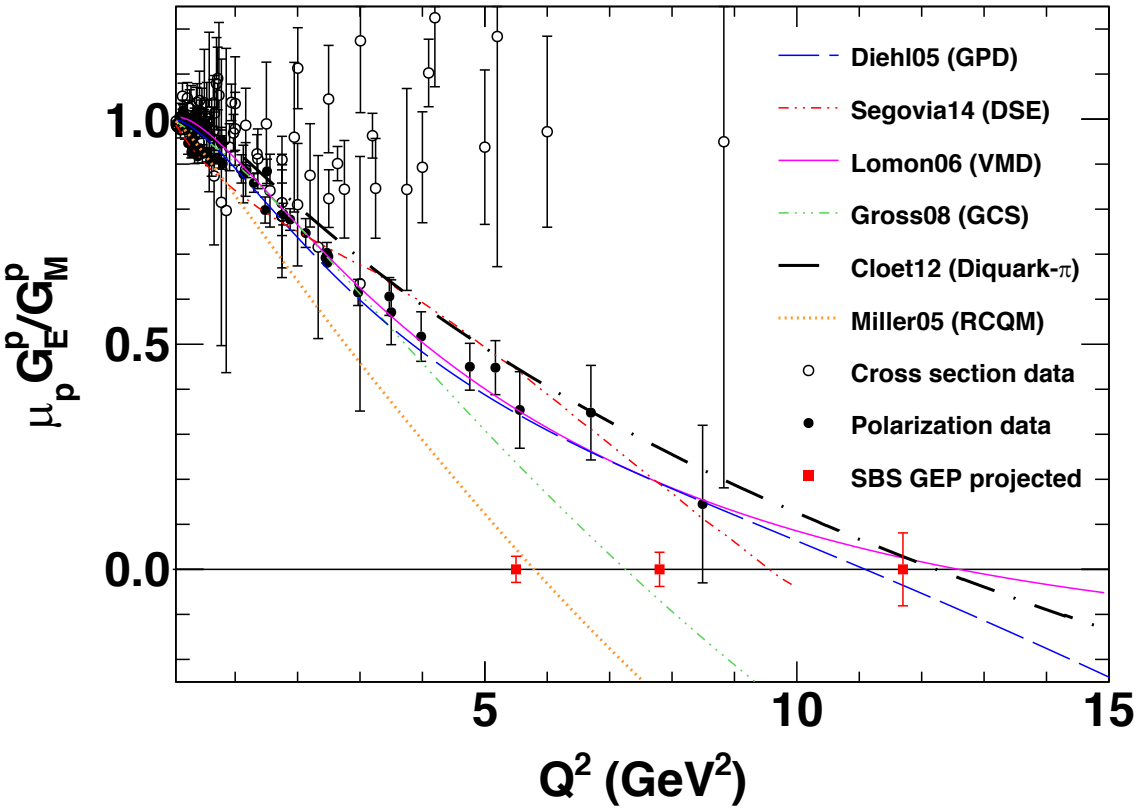
- E12-09-016 will measure the neutron electric form factor to 10 GeV^2 using the beam-target double-spin asymmetry method on polarized ^{3}He
- Same detector configuration as GMN (E12-09-019)
- High-luminosity polarized ^{3}He target with convection-driven circulation of polarized gas.
- Measurement to 10 GeV^2 has enormous discrimination power among theoretical models—will severely test DSE calculations, virtually alone in predicting a turnover and zero crossing of G_E^n



E12-07-109: G_E^p/G_M^p to 12 GeV² via polarization transfer

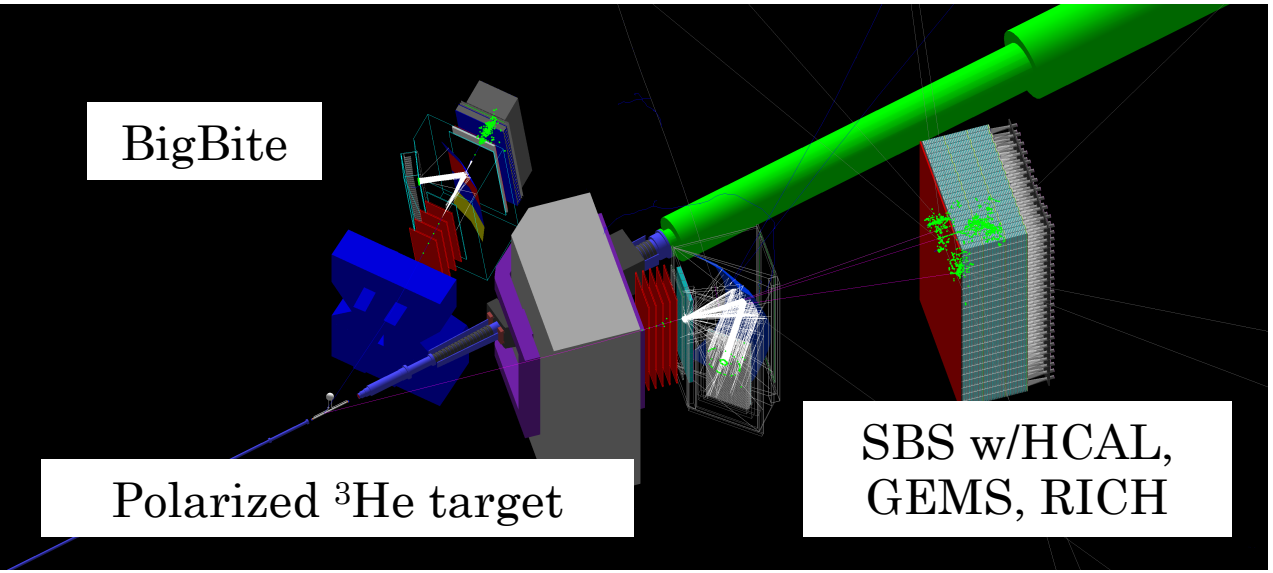


- Original motivation for SBS concept—first approved 2007
- Designated "High Impact Experiment" by JLab PAC41
- Jeopardy proposal reapproved by PAC47 in 2019
- Currently projected to run in ~2023
- Novel high-temperature lead-glass calorimeter detects scattered electron with scintillator-based coordinate detector—triggering, aid tracking in front GEMs, and rejection of inelastics
- GEM-based trackers with CH_2 analyzers for proton polarimetry
- HCAL for trigger and preferential section of nuclear scattering events with high analyzing power

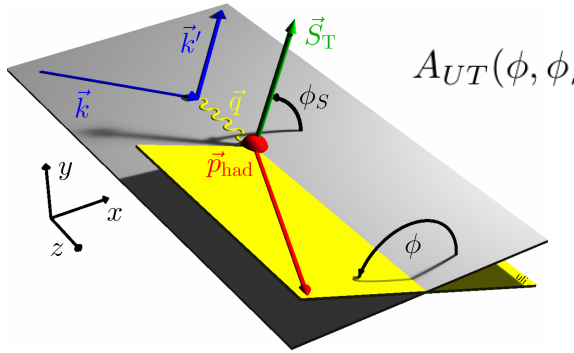


Projected SBS statistical precision for $\mu_p G_E^p/G_M^p$ compared to existing data and selected theoretical models

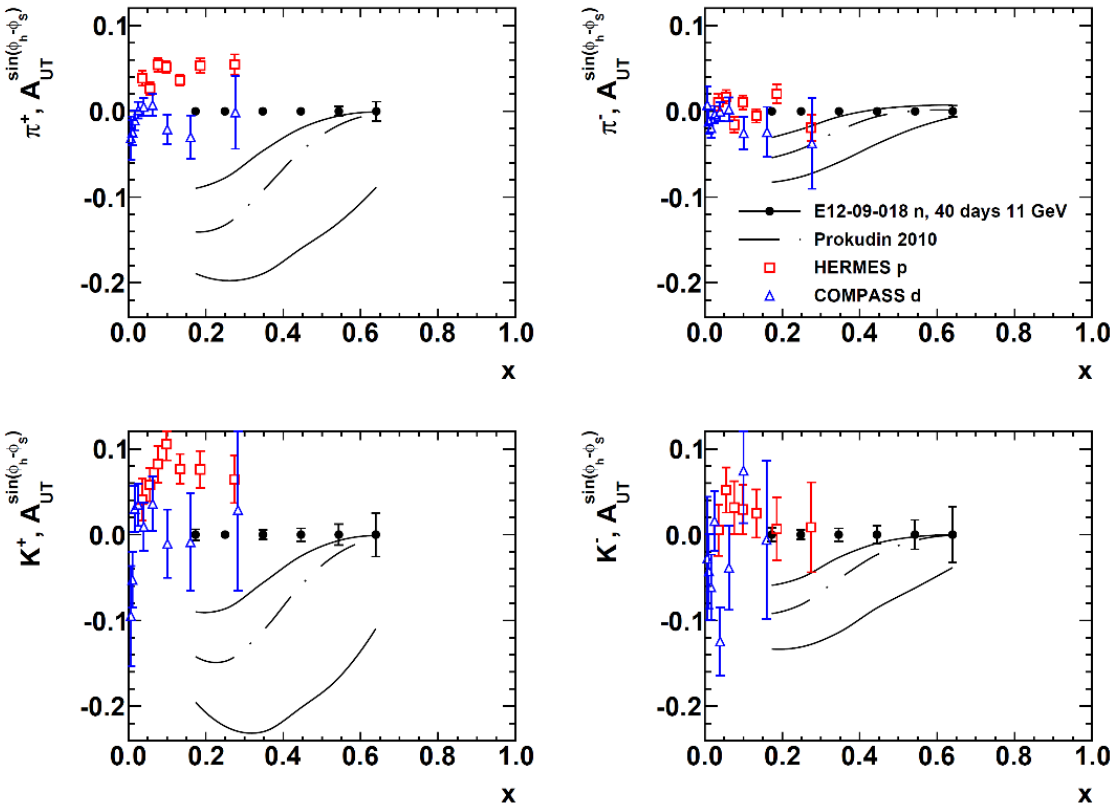
SBS SIDIS program: E12-09-018 (Transversity)



- **E12-09-018** in Hall A: 40 (20) days production at E = 11 (8.8) GeV—significant Q^2 range at fixed x
- Reach high x (up to ~0.7) and high statistical FOM (~1,000X Hall A E06-010 @6 GeV)

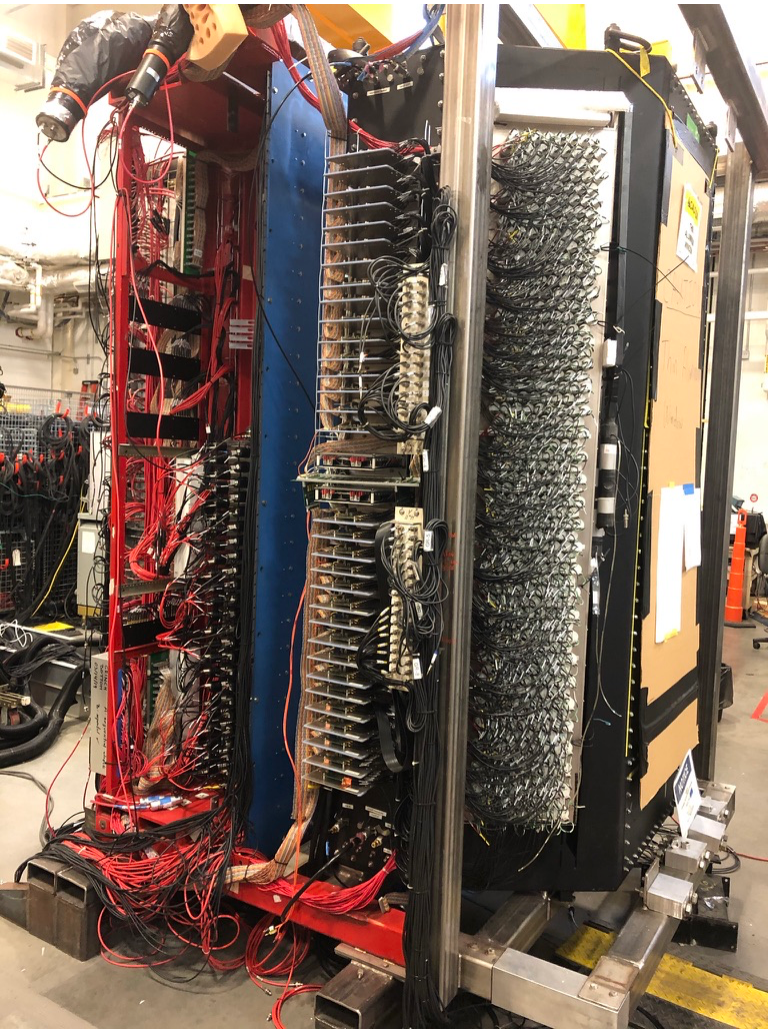


$$A_{UT}(\phi,\phi_S) = \frac{1}{P_T}\frac{d\sigma(\phi,\phi_S)-d\sigma(\phi,\phi_S+\pi)}{d\sigma(\phi,\phi_S)+d\sigma(\phi,\phi_S+\pi)}$$
$$= A_{UT}^{Collins}\sin(\phi+\phi_S)+ A_{UT}^{Sivers}\sin(\phi-\phi_S)+ A_{UT}^{Pretz}\sin(3\phi-\phi_S)$$



Example of projected E12-09-018 precision: neutron Sivers moments for charged pions and Kaons (11 GeV data only)

SBS PICS! (some outdated)



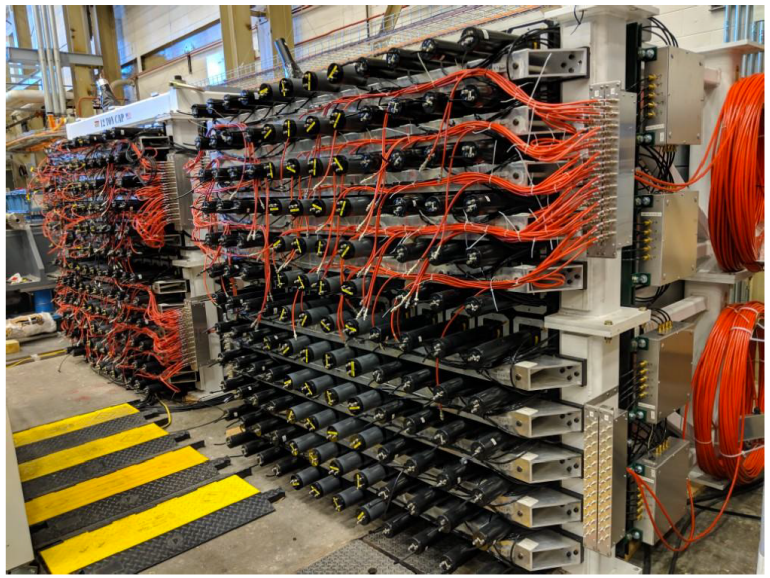
INFN – Front Tracker GEM

Activities are going on despite exceptional restrictions thanks to:

- Ezekiel Wertz working on-site since end of September; Chuck, Alexandre, Brian, Holly … help locally; Roberto and Evaristo support from remote; Ben + Paolo improving MPD-DAQ; Andrew helps on tracking analysis

- Taken cosmic data with CODA3
- Fixed different cabling and other electronics/DAQ tedious issues
- Chambers for BigBite under preparation including machinery on carbon frames
- … and more

Jan/2021 FT GE

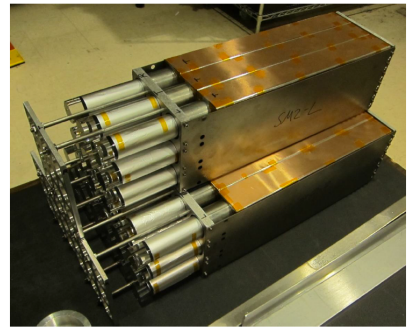


UVa GEMs: Cosmic Setup in EEL124

8/6/2019 SBS Coll. Meeting @ JLab 6

Work since Feb SBS meeting

- 126 of out 191 supermodules have been assembled
- JLab Detector Support Group is contributing manpower to assembling supermodules.



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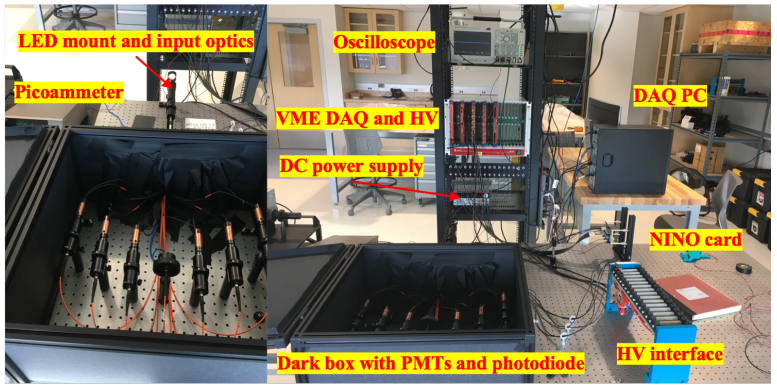
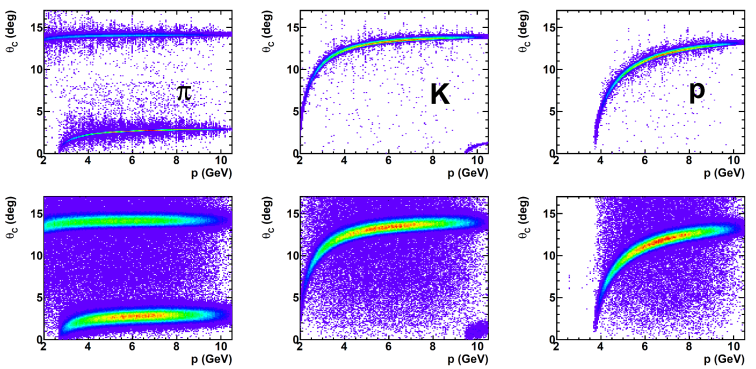
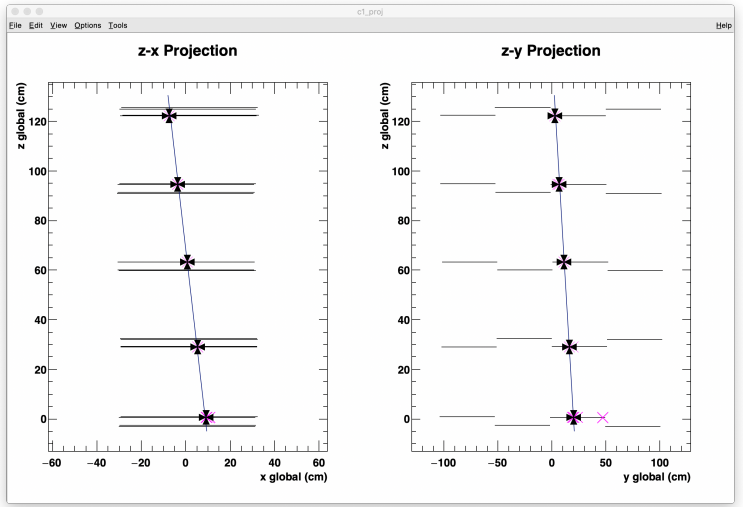
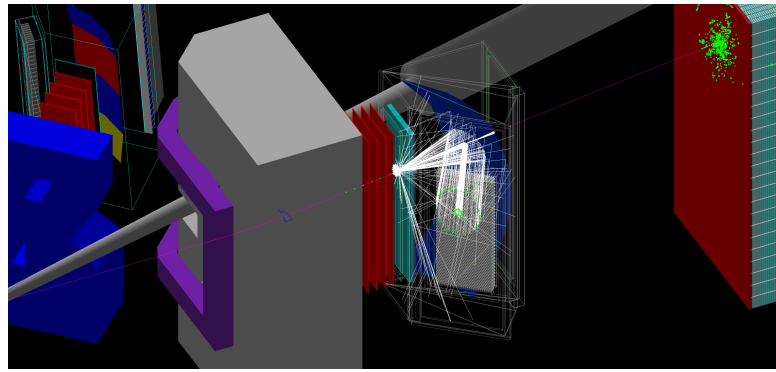
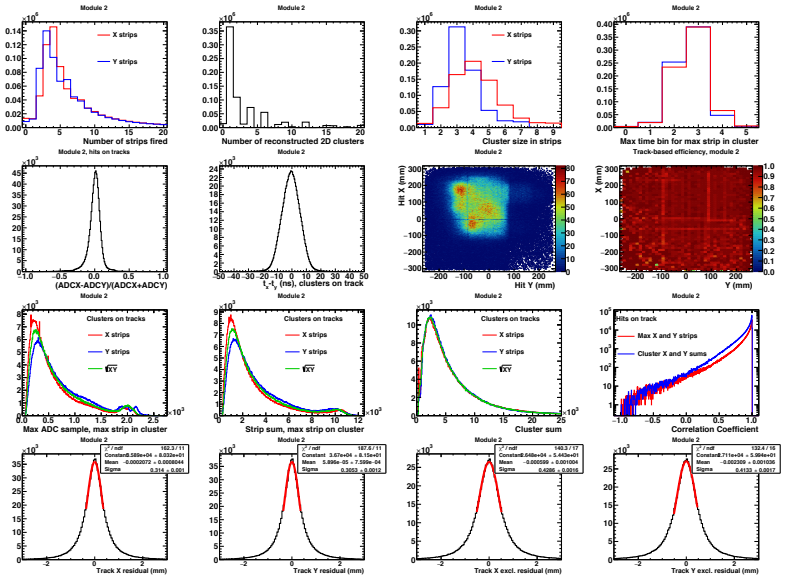
Puckett group role in SBS Collaboration











- Prof. Puckett is SBS Coordinating Committee chair and GEP experiment representative—spokesperson of 3 of the 7 fully approved SBS experiments
- We are leading the Monte Carlo simulations, event reconstruction and data analysis software development for SBS program
- We are in charge of preparing RICH detector for charged particle ID in SIDIS experiment

Ph.D. research opportunities in Puckett Group

- **We are seeking at least one more Ph.D. thesis student from Fall 2021 incoming class to work on the SBS program**
- Student joining the group in Fall 2021 would most likely conduct thesis research on the SIDIS (E12-09-018) or GEP (E12-07-109) experiment.
- Full research support after completing course and exam requirements→ expectation to relocate to JLab (at least during thesis experiment run)
- SBS program starting 2021—occupying Hall A for the next 3-5 years.
- High-impact, highly anticipated experiments that will generate high-profile publications and many Ph.D. dissertations!
- **Nucleon structure and strong interaction physics is the main motivation driving the construction of the US-based Electron-Ion Collider—this field of research has a bright long-term future**
- Our activity is part of broad UConn-led efforts at JLab, see also:
  - Prof. Kyungseon Joo—nucleon structure studies in Hall B with CLAS12
  - Prof. Richard Jones–GlueX program in Hall D

Backups

Overview of SBS Program—Actual and Potential

Fully Approved:

- E12-07-109 (GEP): 45 PAC days, A- rate, "High Impact"
- E12-09-019 (GMN): 25 PAC days, B+ rate
- E12-09-016 (GEN): 50 PAC days, A- rate
- E12-09-018 (SIDIS): 64 PAC days, A- rate
- E12-17-004 (GEN-RP): 5 PAC days, A- rate
- E12-20-010 (nTPE): 2 PAC days, A- rate
- E12-20-008 (WAPP): 2 PAC days, B+ rate

Conditionally Approved:

- C12-15-006 (TDIS): 27 PAC days, A- rate; "C1" approval status
  - "Run-group" add-on of kaon structure measurement also C1 approved

Potential future physics using SBS:

- A_1^n: formerly an approved BigBite experiment (2006), withdrawn at jeopardy (2019) due to imminent Hall C run, new proposal with BB+SBS likely (pending Hall C results)
- J/ψ photoproduction polarization observables/LHCb pentaquark physics: LOI submitted 2017
- e^+p elastic scattering polarization transfer—part of science program for positron beam at CEBAF in LOI and now white paper available in arxiv: https://arxiv.org/abs/2007.15081
- More DIS/SIDIS/TMD physics:
  - Longitudinally polarized SIDIS on ^{3}He and spin-flavor decomposition (deferred PR12-14-008)
  - Transversely polarized DIS/SIDIS on proton: g_2^p, Collins, Sivers, etc.
- Polarization observables and xsec in exclusive ϕ production
- Strange FFs at high Q^2 (not really an "SBS" proposal *per se*, but re-using some SBS components)
- Higher-Q^2 EMFFs/higher-x physics w/future CEBAF energy upgrade?