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

Andrew Puckett
UConn physics (virtual) graduate open house
March 12, 2021
Puckett Group Introduction

- Group homepage: [https://puckett.physics.uconn.edu](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

JLab 12 GeV Upgrade

Our research is here

Upgrade completed, physics running started 2014

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

3/12/21
• 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!
• 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

**ERR passed 2017—Projected to run in 2021**
E12-17-004: $G_E^n/G_M^n$ to 4.5 GeV$^2$ via charge-exchange recoil polarimetry

**ERR passed 2020—Projected run 2021**

- 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 $\gamma n \rightarrow \pi^- p$

Analyzing powers for np, pp, pA scattering vs. initial momentum (left) and vs. transferred momentum (right)
E12-09-016: $G_E^n / G_M^n$ to 10 GeV$^2$ using polarized $^3\text{He}(e,e'n)\text{pp}$

- E12-09-016 will measure the neutron electric form factor to 10 GeV$^2$ using the beam-target double-spin asymmetry method on polarized $^3\text{He}$
- Same detector configuration as GMN (E12-09-019)
- High-luminosity polarized $^3\text{He}$ 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 GeV$^2$ 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 SIDS 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)
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

Work since Feb SBS meeting
- 126 of out 191 supermodules have been assembled
- JLab Detector Support Group is contributing manpower to assembling supermodules.
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:
- E12-09-019 (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:
- $A_1^q$: 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)
- $J/\psi$ photoproduction polarization observables/LHCb pentaquark physics: LOI submitted 2017
- 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: $g_{2p}$, Collins, Sivers, etc.
  - Polarization observables and xsec in exclusive $\phi$ production
  - Strange FFs at high $Q^2$ (not really an “SBS” proposal per se, but reusing some SBS components)
  - Higher-$Q^2$ EMFFs/higher-$x$ physics w/future CEBAF energy upgrade?