Science Program with the Neutral Particle Spectrometer

Tanja Horn

For the NPS Collaboration

NPS Collaboration (since 2012)

Collaboration and meetings open to All!

The NPS collaboration consists of members active in the construction and commissioning of the instrument (listed below) and additional collaborators on the individual NPS experiments.

1. Ibrahim Albayrak (Akdeniz Univ/Turkey)
2. Salina Ali (UVA)
3. Tristan Anderson (VTech)
4. Moskov Amaryan (ODU)
5. Vladimir Berdnikov (JLab)
6. Peter Bosted (W&M)
7. William J. Briscoe (GWU)
8. John R.M. Annand (U Glasgow)
9. Arshak Asaturyan (JLab)
10. Vincenzo Bellini (INFN-Catania)
11. Kai Brinkmann (Giessen U.)
12. Marie Boer (VTech)
13. Alex Camsonne (JLab)
14. Marco Carmignotto
15. Josh Crafts (CUA)
16. Donal Day (UVa)
17. Maxime Defurne (CEA)
18. Bhesha Devkota (MSU)
19. Rolf Ent (JLab)
20. Yeran Ghandilyan (CUA)
21. Michel Guidal (IJCLab-Orsay)
22. Wassim Hamdi (U. of Monastir)
23. David J. Hamilton (U Glasgow)
24. Tanja Horn (CUA)
25. Zheng Huang (UIC)
26. Charles Hyde (Old Dominion University)
27. Oliver Jevons (U Glasgow)
28. Greg Kalicy (CUA)
29. Dustin Keller (UVa)
30. Cynthia Keppel (JLab)
31. Mitchell Kerver (ODU)
32. Paul King (Ohio University)
33. Edward Kinney (U. of Colorado)
34. Mark Mattison (Ohio University)
35. Malek Mazouz (U. of Monastir)
36. Arthur Mkrtchyan (AANL, YerPhI)
37. Hamlet Mkrtchyan (AANL, YerPhI)
38. Rachel Montgomery (U. Glasgow)
39. Carlos Munoz-Camacho (IJCLab-Orsay)
40. Jacob Murphy (Ohio University)
41. Pawel Nadel-Turonski (Stonybrook)
42. Gabriel Niculescu (James Madison U.)
43. Rainer Novotny (Giessen U.)
44. Rafayel Paremuzyan (JLab)
45. Ian Pegg (CUA)
46. Pierre Pichard (U. Nantes/Ohio University)
47. Christine Ploen (Old Dominion University)
48. Hashir Rashad (Old Dominion University)
49. Riley Reedy (Ohio University)
50. Julie Roche (Ohio University)
51. Oscar Rondon (UVa)
52. Simon Sirca (U Ljubljana)
53. Alex Somov (JLab)
54. Igor Strakovsky (GWU)
55. Vardan Tadevosyan (AANL, YerPhI)
56. Richard Trotta (CUA)
57. Hakob Voskanyan (AANL, YerPhI)
58. Erik Wrightson (MSU)
59. Bogdan Wojtsekhowski (JLab)
60. Steve Wood (JLab)
61. Zhenyu Ye (UIC)
62. Zhihong Ye (Tsinghua University, Beijing, China)
63. Carlos Yero (JLab)
64. Simon Zhamkochyan (AANL, YerPhI)
65. Yao Peng Zhang (Tsinghua University, Beijing, China)
66. Carl Zorn (JLab)
67. Jixie Zhang (UVa)

More info in the NPS Wiki: https://wiki.jlab.org/cuawiki/index.php/Main_Page

NPS Science Program

NPS Wiki

Run Group 1a (NPS at small angles and HMS - SHMS used as carriage for NPS):

- **E12-13-010** (Run status: complete): Exclusive Deeply Virtual Compton and Neutral Pion Cross-Section Measurements in Hall C Link
- **E12-13-007** (Run Status: complete): Measurement of Semi-Inclusive pi0 Production as Validation of Factorization Link
- **E12-22-006** (Run status: complete): Deeply Virtual Compton Scattering off the neutron with the Neutral Particle Spectrometer in Hall C Link
- **E12-23-014** (Run status: complete): Measurements of the Ratio R = sigmaL/sigmaT p/d ratios, Pt dependence, and azimuthal asymmetries in Semi-Inclusive DIS pi0 production form proton and deuteron targets using the NPS in Hall C Link

Run Group 1b (NPS at small angles and HMS - SHMS used as carriage for NPS):

- **E12-06-114** (35 days moved to Hall C): Measurements of the electron-helicity dependent cross-sections of deeply virtual Compton scattering

Run Group 2 (NPS at large angles and HMS - SHMS used as carriage for NPS):

- **E12-14-003**: Wide-angle Compton Scattering at 8 and 10 GeV Photon Energies Link
- **E12-14-005**: Wide Angle Exclusive Photoproduction of pi-zero Mesons Link

Run Group 3 (NPS+CPS - SHMS used as carriage for NPS)

- **E12-17-008**: Polarization Observables in Wide-Angle Compton Scattering at large s, t, and u Link

Run Group 4 (NPS reconfigured as part of an ECAL+HCAL system downstream from target)

- **E12-23-004** A Search for a Nonzero Strange Form Factor of the Proton at 2.5 (GeV/c)^2 Link

Run Group 5 (NPS+Positrons)

- **C12-20-012** (status C2): Deeply Virtual Compton Scattering using a positron beam in Hall C Link

LOIs and proposal being developed

- LOI12-23-003: GluToNY: Gluon tomography in nucleons by gamma-polarimetry
- LOI12-23-014: Recoil Nucleon Polarization in Deeply Virtual Compton Scattering and Neutral Pion Electroproduction in Hall C
- C12-18-005: Timelike Compton Scattering Off a Transversely Polarized Proton Link (requires NPS + CPS)

This talk

NPS RG1a complete – analysis starting (see talks by Casey, Christine, Mark, Josh/Avnish in this session)

RG1b (small angles) and **RG2 and RG3** (large angles) use the NPS as is. RG3 also needs the CPS

RG4 re-configures the NPS

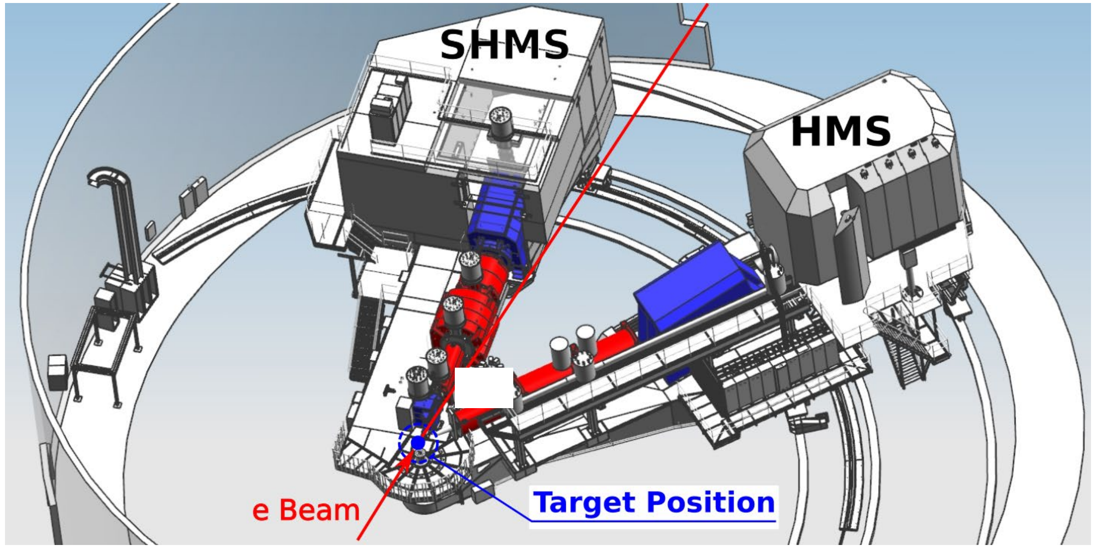
RG5 uses NPS as is – requires positron beam

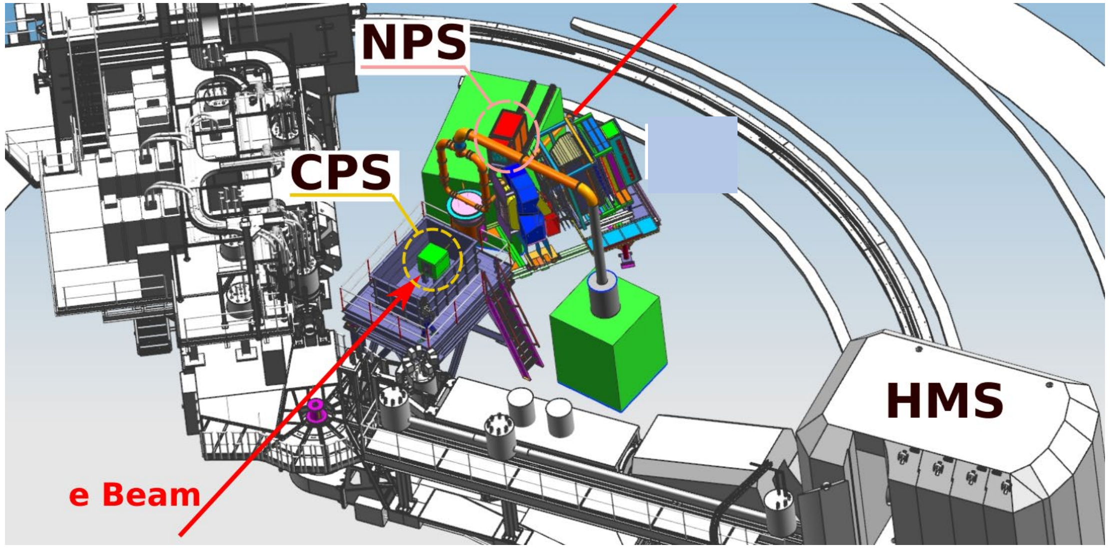
Many additional ideas

NPS in Hall C - Overview

Got ideas for experiments – join our meetings!

- ❑ Neutral Particle Spectrometer replaces one of the Hall C focusing spectrometers in the experiments
  - ➢ Angle reach between 5.5 and 60 degrees
  - ➢ allows for precision (coincidence) cross section measurements of neutral particles (γ and π^0).
- ❑ HMS (existing 6 GeV era)
  - ➢ Has been recommissioned for 12 GeV
- ❑ Beam line and beam line instrumentation
- ❑ Cryogenic liquid hydrogen and solid targets
- ❑ Data acquisition, counting house, computing

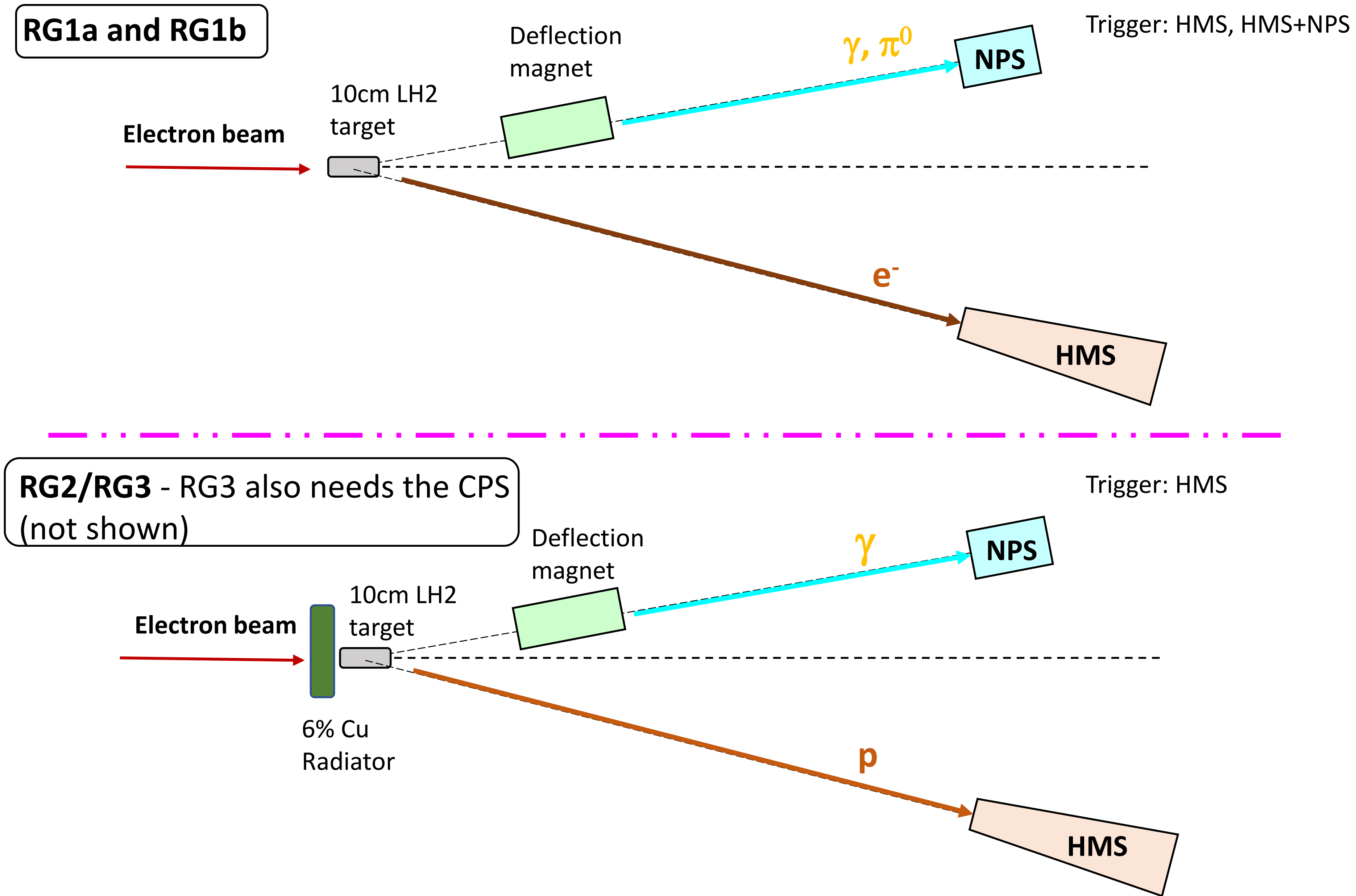




More in Jefferson Lab Hall C: Precision Physics at the Luminosity Frontier (Hall C White Paper); D. Mack et al. arXiv 2209.11838

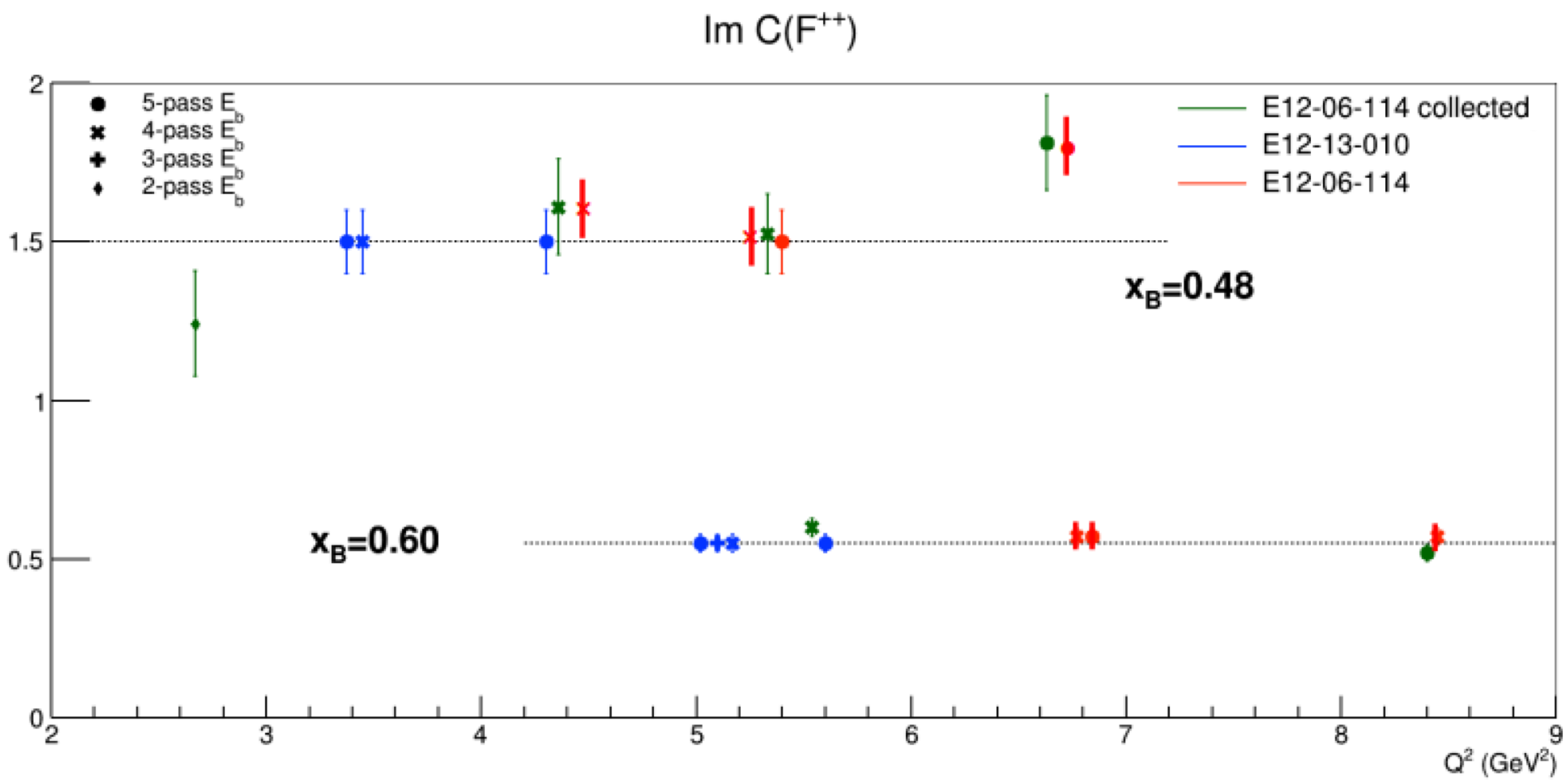
Experimental Techniques RG1 and RG2/RG3

The Neutral Particle Spectrometer (NPS) is a facility in Hall C, utilizing the well-understood HMS and the SHMS infrastructure, to allow for **precision (coincidence) cross section measurements of neutral particles (γ and π^0).**



RG1b: E12-06-114: DVCS precision cross section

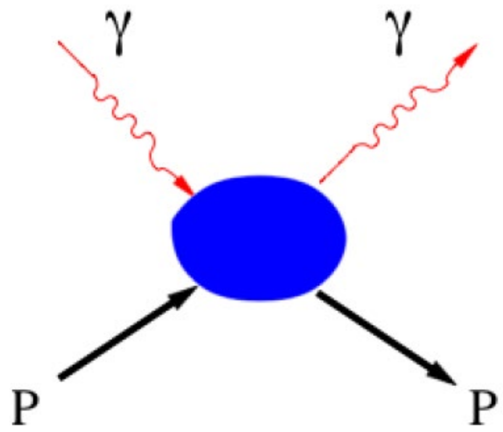
- ❑ Measure energy dependence
- ❑ 35 jeopardy days – moved from Hall A to Hall C
- ❑ x_B = 0.6: relax statistics slightly
- ❑ x_B = 0.48: full statistics @ full acceptance



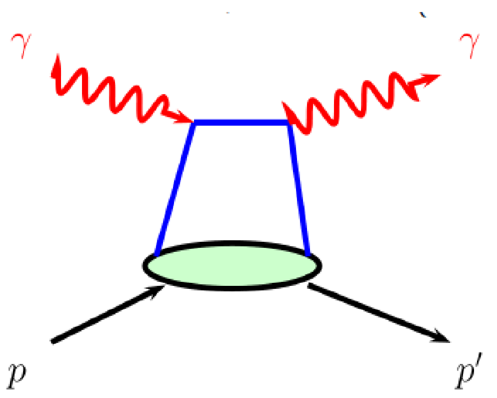
	x_B	Q^2 (GeV^2)	E_{Beam} (GeV)	Lumi (10^{37}/cm^2/s)	Days
48_2	0.48	4.365	8.52	7.5	3
48_3	0.48	5.334	8.52	7.5	3
48_J1	0.48	5.334	10.62	7.5	3
48_4	0.48	6.900	10.62	10	4
60_J1	0.60	6.822	8.52	7.5	7
60_J2	0.60	6.822	10.62	7.5	6
60_J3	0.60	8.400	8.52	13.	9
Total					35

- ❑ Uses the same NPS + HMS setup as RG1a
- ❑ Status: ready modulo refurbishments (see later slides)

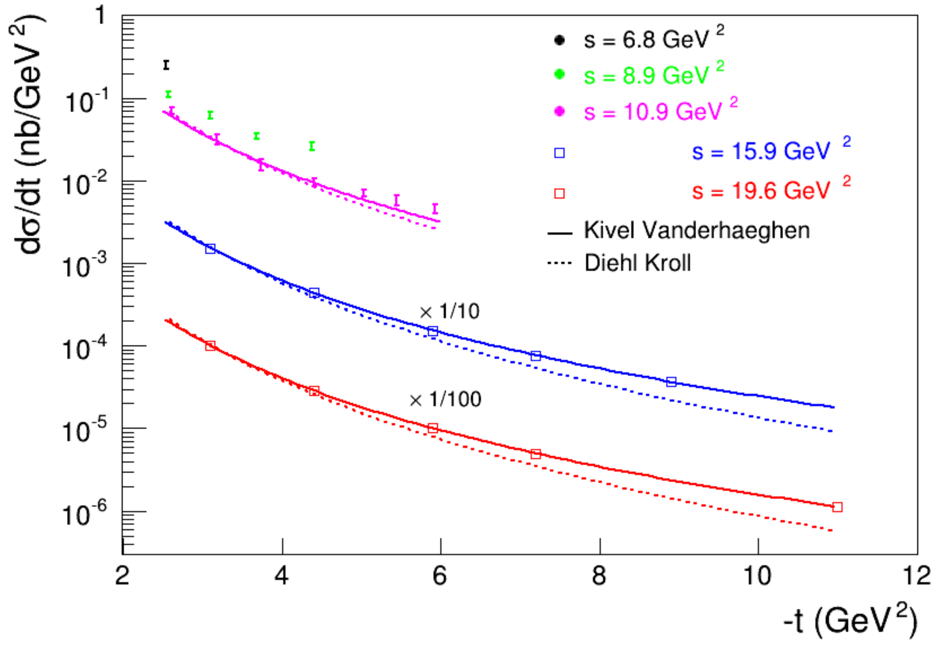
RG2: E12-14-003: Wide Angle Compton Scattering



- ❑ Arguably the least understood of the fundamental reactions in the several-GeV regime
- ❑ Wide-Angle Compton Scattering cross section behavior was a foundation leading to the GPD formalism
- ❑ Reaction mechanism intrinsically intertwined with basics of hard scattering process (handbag diagram), yet also sensitivity to transverse structure like high-Q^2 form factors

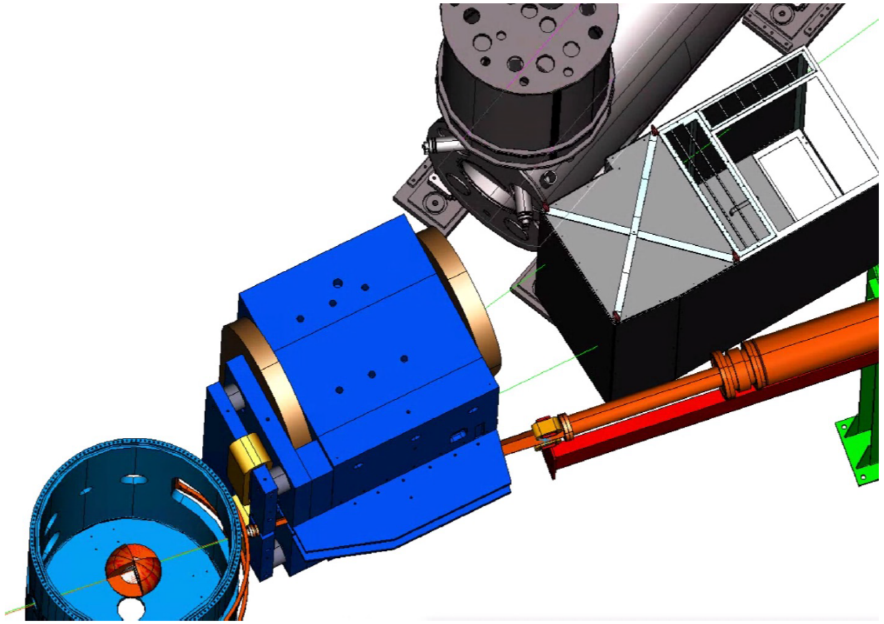


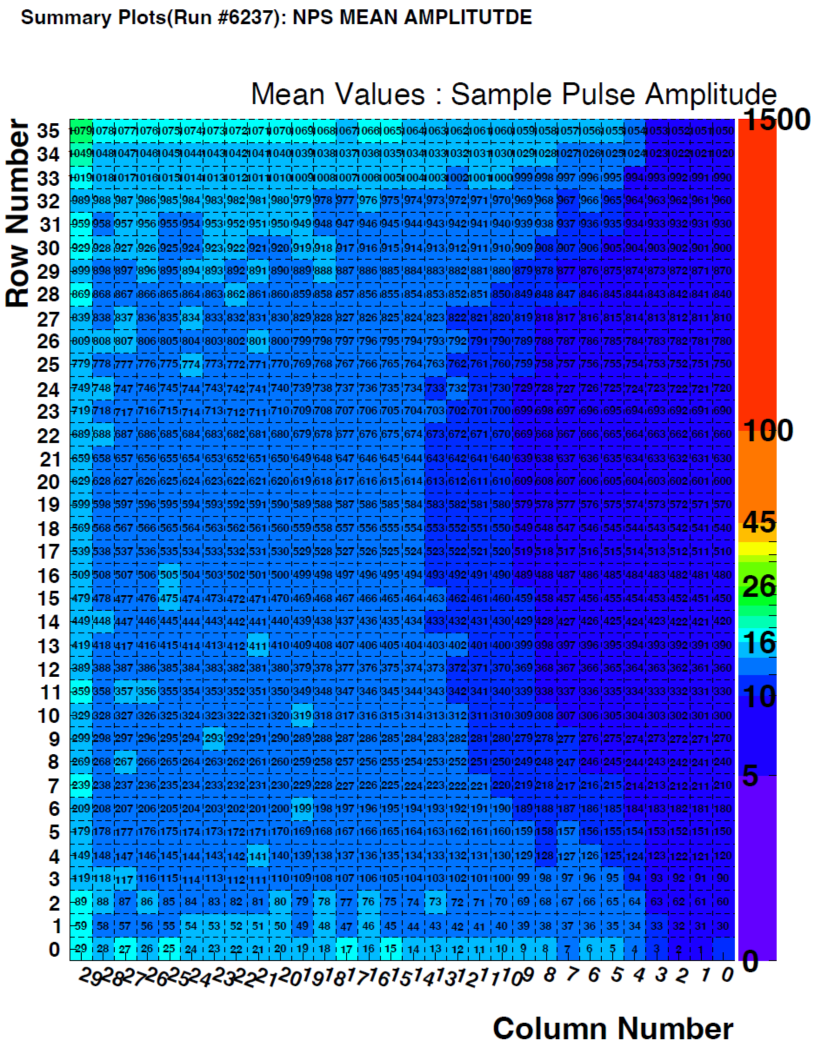
- ➢ Perhaps (6-GeV data) factorization valid for *s, -t, -u > 2.5 GeV²*
- ➢ 12-GeV data for *–u > 2.5* and *–t* up to *~ 10, s* up to *~ 20* GeV²



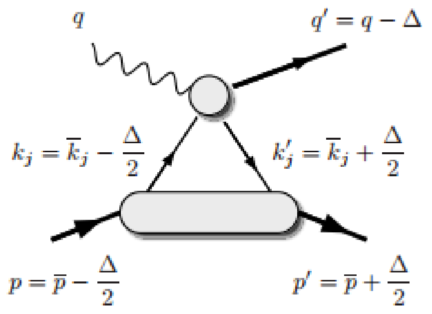
Wide Angle Compton Scattering at 8 and 10 GeV Photon Energies

Sweeper magnet deflects scattered electrons vertically





RG2: E12-14-005: Wide angle exclusive photo-production of π^0 mesons

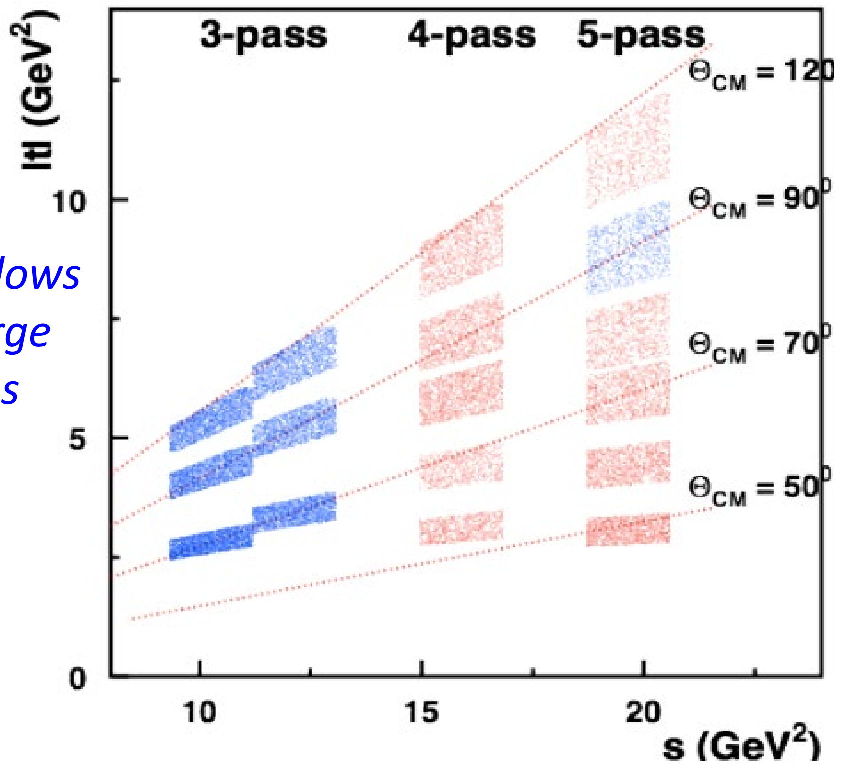


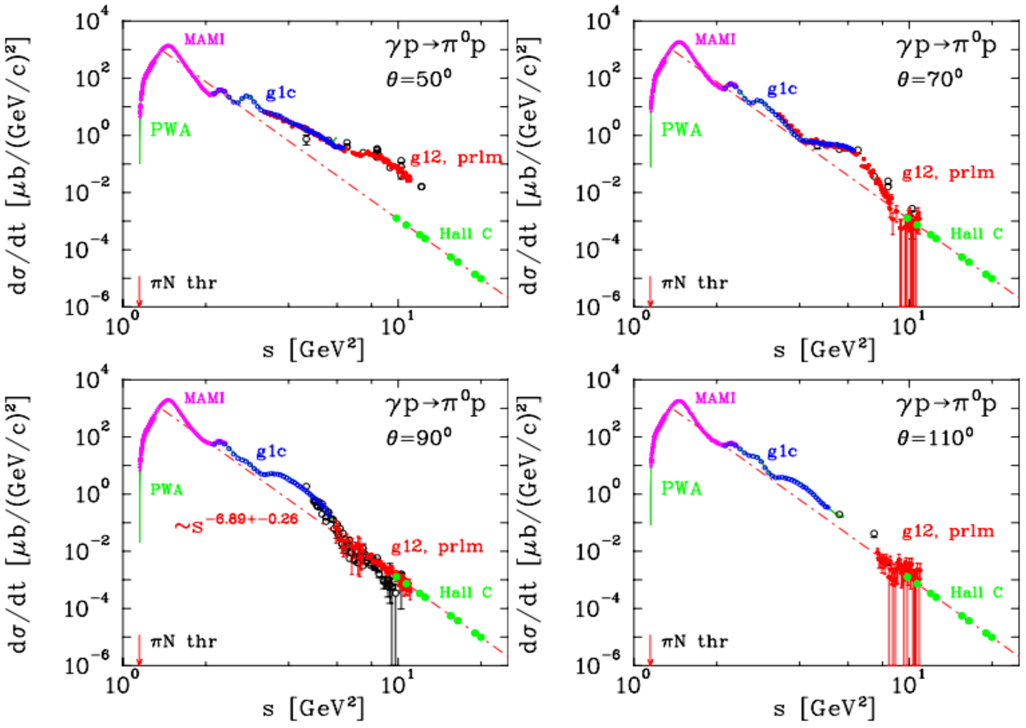
The next simplest reaction after Compton scattering.

But model prediction disagree with data by orders of magnitude!

E12-14-005 projections

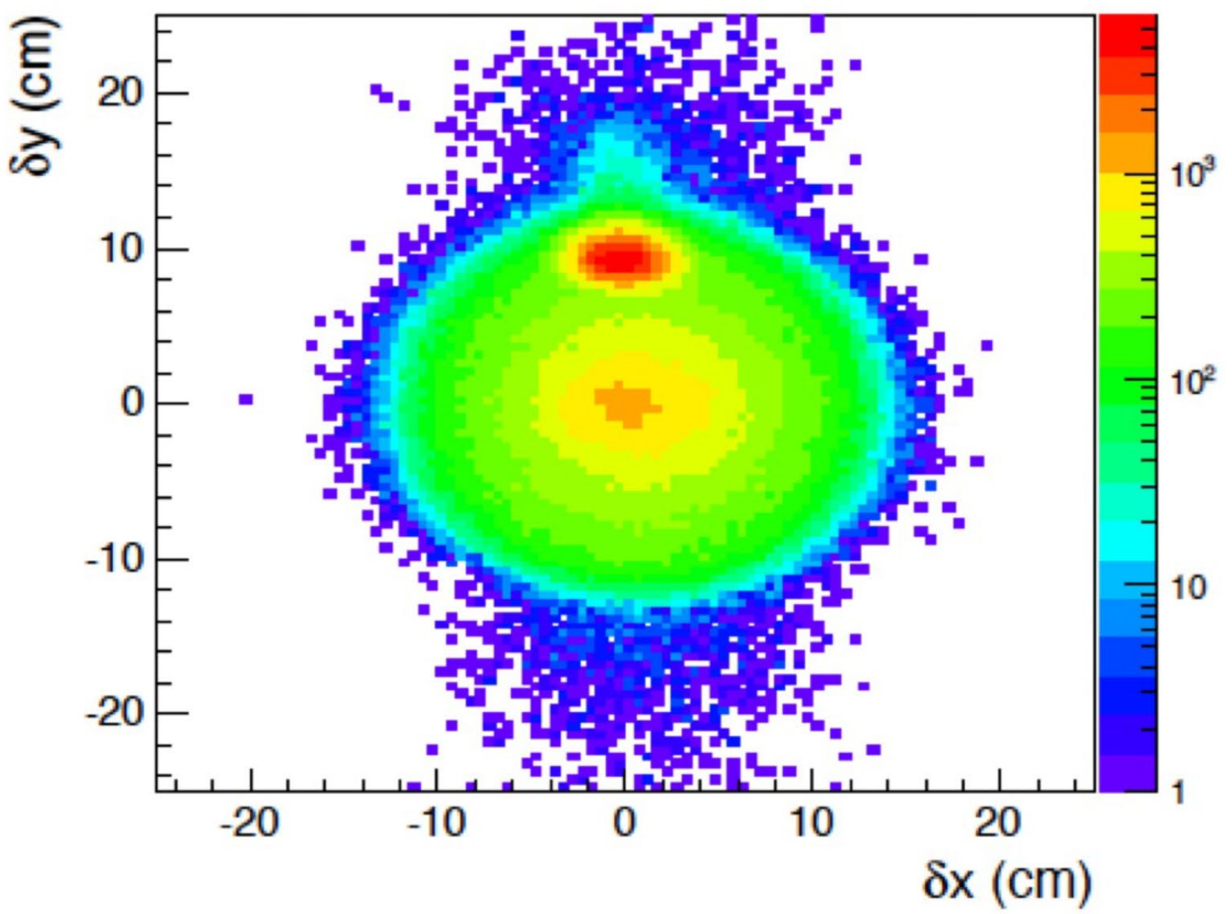
Using the NPS allows for covering a large range in |t| and s



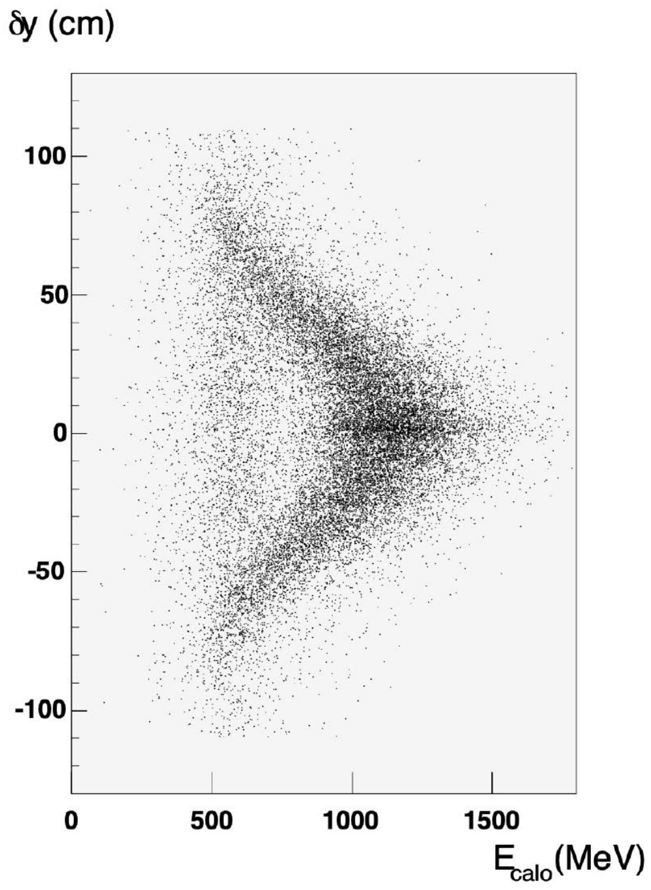


NPS data will help confirm scaling and provide wide angular coverage for testing models based on the dominance of handbag mechanism. Also help extract Regge trajectories.

Wide angle exclusive photo-production of π^0 mesons



single π^0 wings



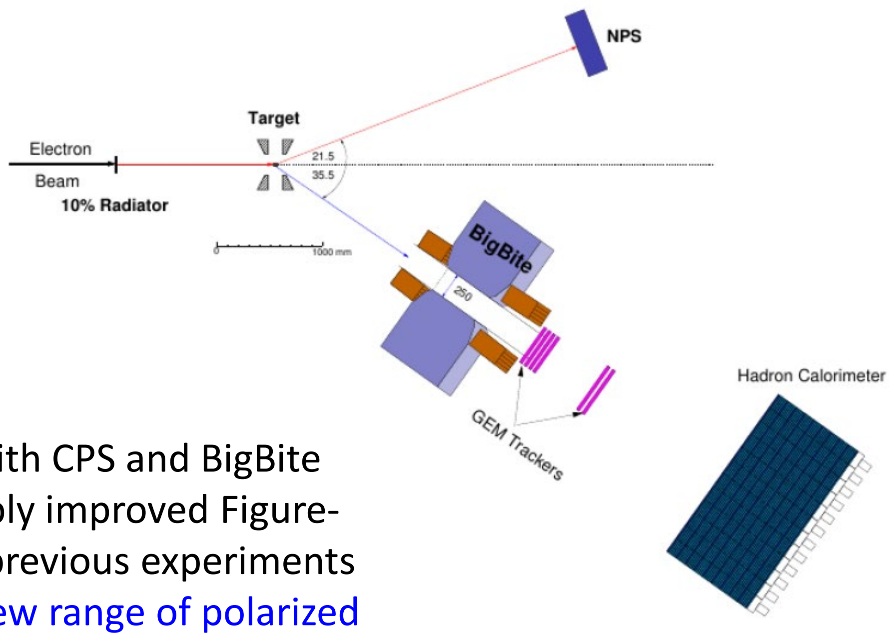
E99-114 experiment

RG2 Status

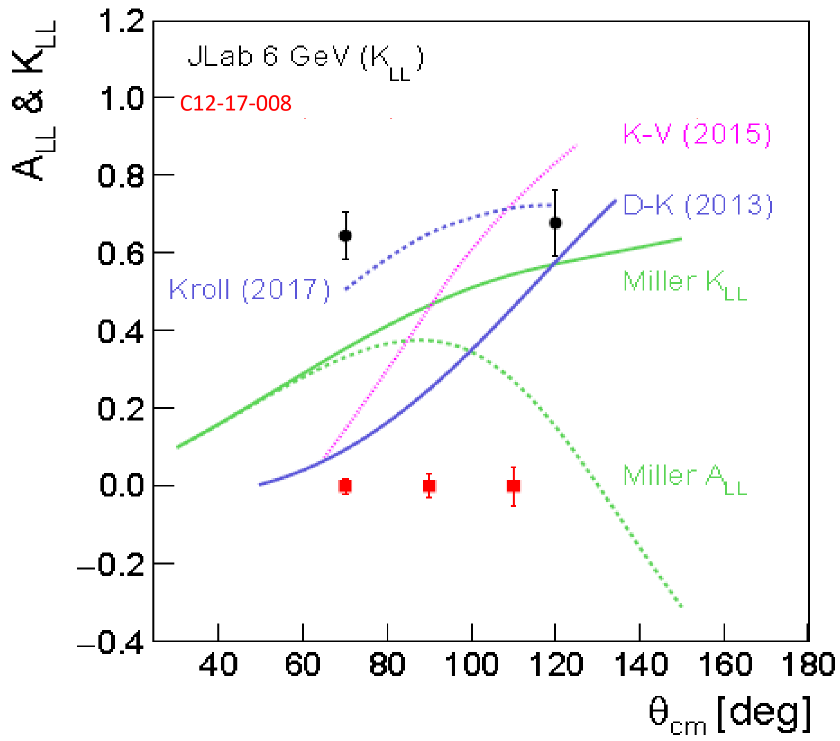
- ❑ Very close to being ready to run
- ❑ NPS needs some modest work
    - ➢ Replace temperature sensors - or rather the keysight card with the active components
    - ➢ Re-work resistor chain on dividers to work up to 1500V - currently limited in voltage to 850 V
    - ➢ Optimize PMTs - first few columns
        - o remove some from first few columns, test, and get spares
        - o check connection to crystal for dried optical connection
    - ➢ Optimize Cable management
    - ➢ Resolve issue with connectors on calorimeter side
        - o possibly have an intermediate patch panel
        - o replace connectors?
    - ➢ Optional: Shielding to shield strips on boards to reduce noise between boards
    - ➢ Optional: Bleach crystals

RG3: E12-17-008: Polarization Observables in WACS

Versatility – combine NPS with other equipment in Hall C



Combining NPS with CPS and BigBite gives a considerably improved Figure-of-Merit over all previous experiments and opens up a new range of polarized physics opportunities at Lab

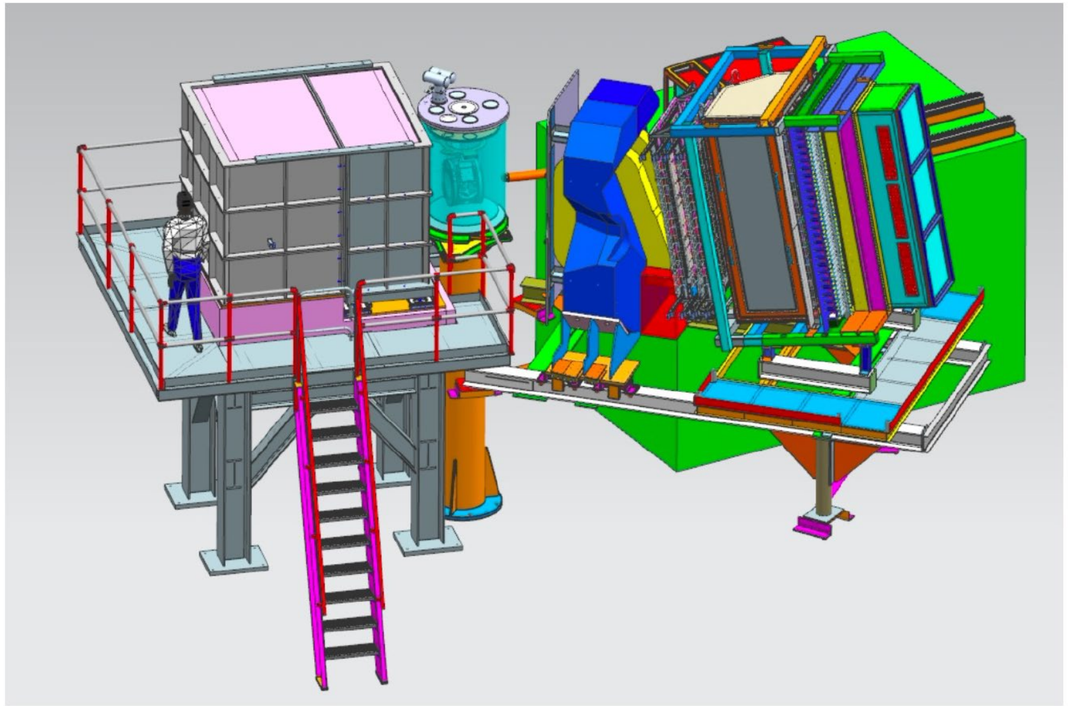


- ❑ Make an explicit, model-independent test of factorization by measuring the s-dependence of the polarization observables at fixed centre of mass angle, t, and verify that target mass corrections and higher twist effects are small
- ❑ Measurement of A_{LL} at large angles allowed for tests of relevant degrees of freedom in hard exclusive reactions
- ❑ Also extract the Axial and Pauli form factors - constrain GPDs $\widetilde{H}$ and E at high –t

More on CPS design: A Conceptual Design Study of a CPS for Jefferson Lab; D. Day et al., Nucl. Instrum. Meth. A 957 (2020) 163429

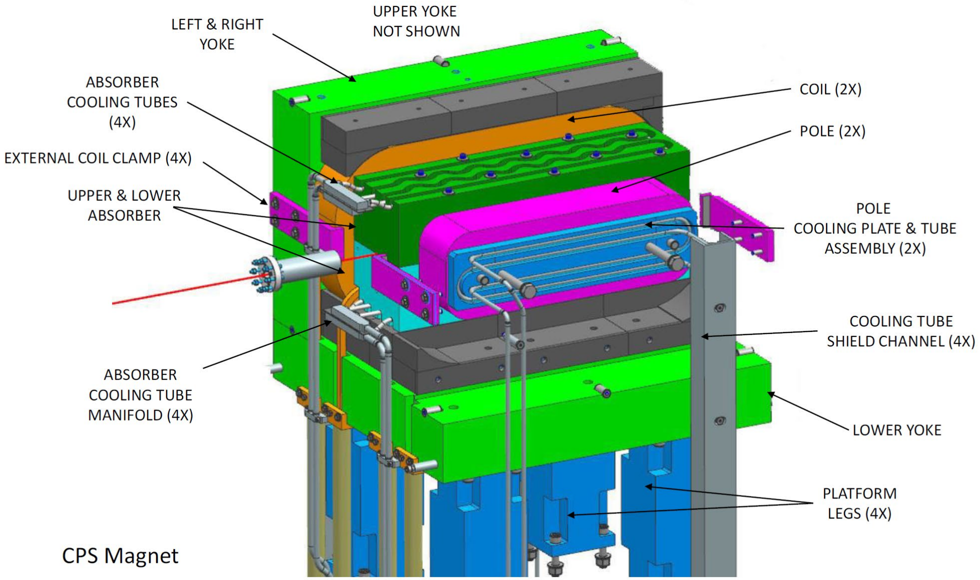
RG3: Setup with NPS+CPS

- A 2.5 uA polarized electron beam incident on a 10% radiator inside a new Compact Photon Source (CPS) produces a high-intensity untagged photon beam
- The proton target is the UVA/JLab solid polarized NH3 target
- The recoil proton Is detector with the BigBite spectrometer equipped with GEM trackers and trigger detectors
- The highly-segmented PWO NPS calorimeter is used to detect the scattered photon



CPS Status

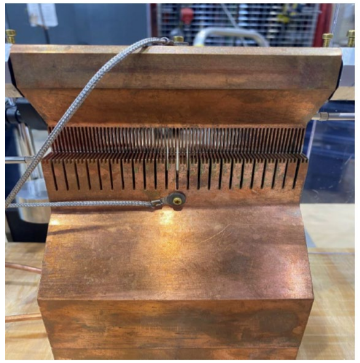
CAD drawings: CPS magnet and shielding

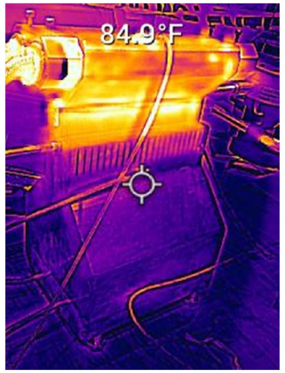


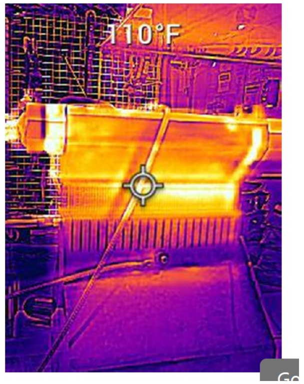
CPS Magnet

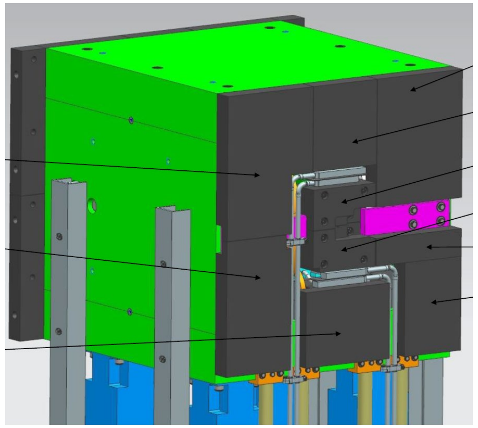
CPS magnet assembled at factory

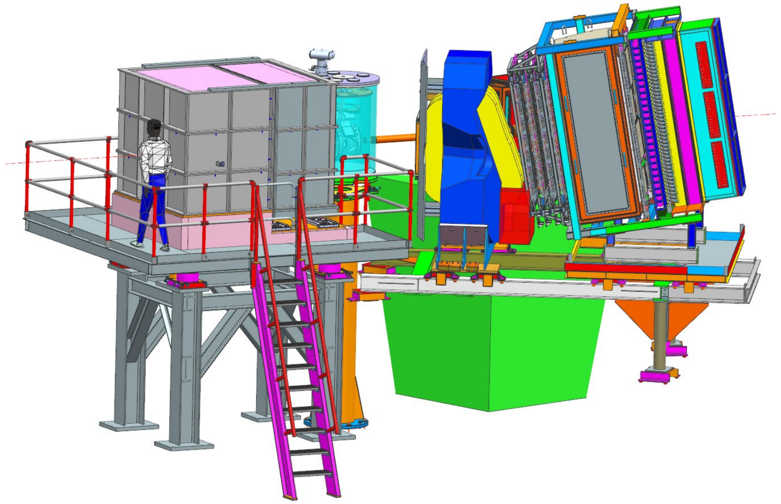
Cu absorber thermal testing











CPS Items Remaining

- ❑ Finish testing of Cu absorber prototype and finalize design
- ❑ Brazing of cooling plate water lines and final machining
- ❑ Cu absorber cooling plates (finish design, fabricate & test)
- ❑ Machining/brazing of Cu absorber halves
- ❑ Beam line finalize and procured
- ❑ Procurement of water chillers and containment chambers
- ❑ Support frames for CPS, target, NPS calorimeter, and BigBite
- ❑ Layout of PSU and cooling lines
- ❑ Assembly of magnet and field mapping

Spinning NH3 polarized target

Dustin Keller

3. **Uniform Illumination of the target cups**

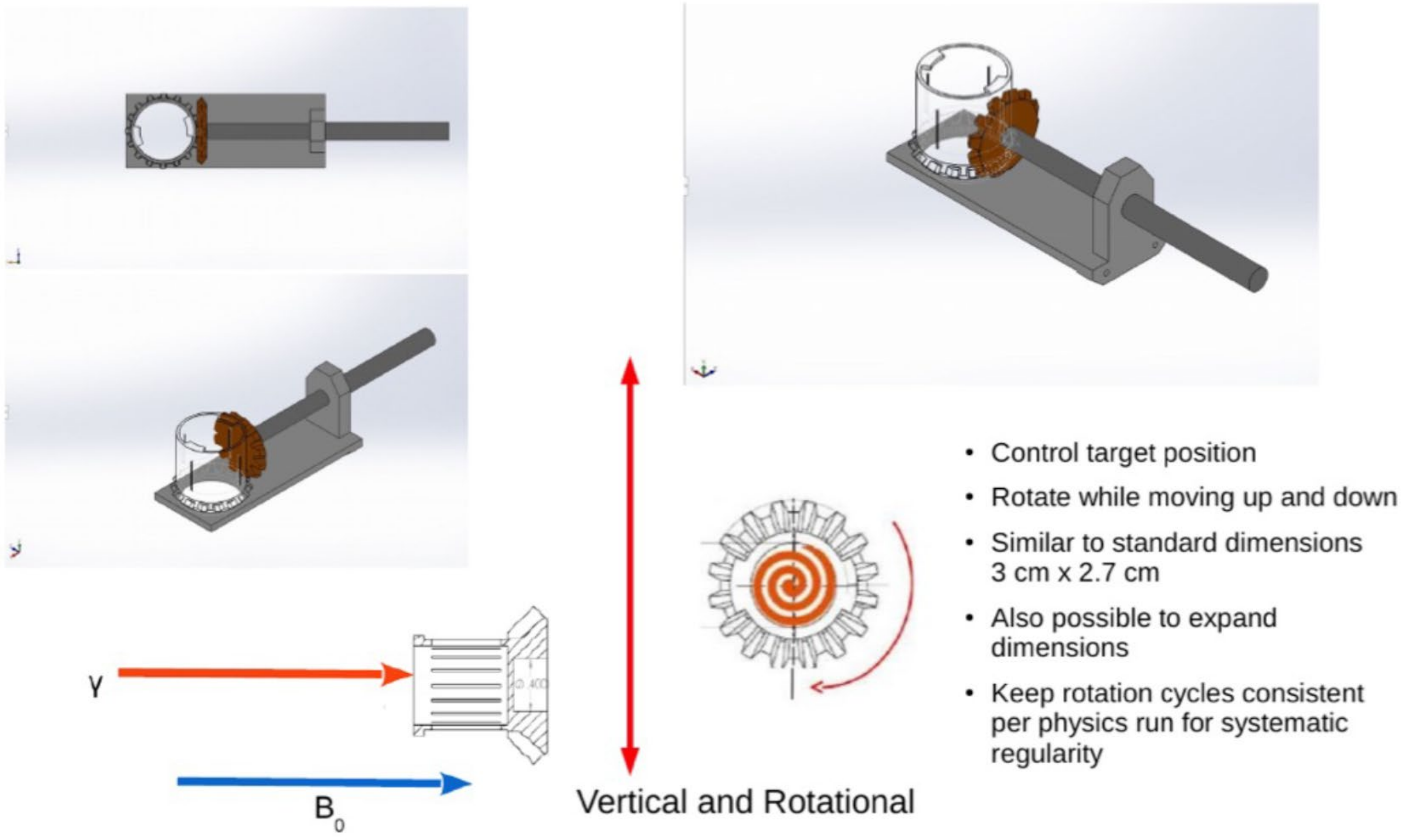
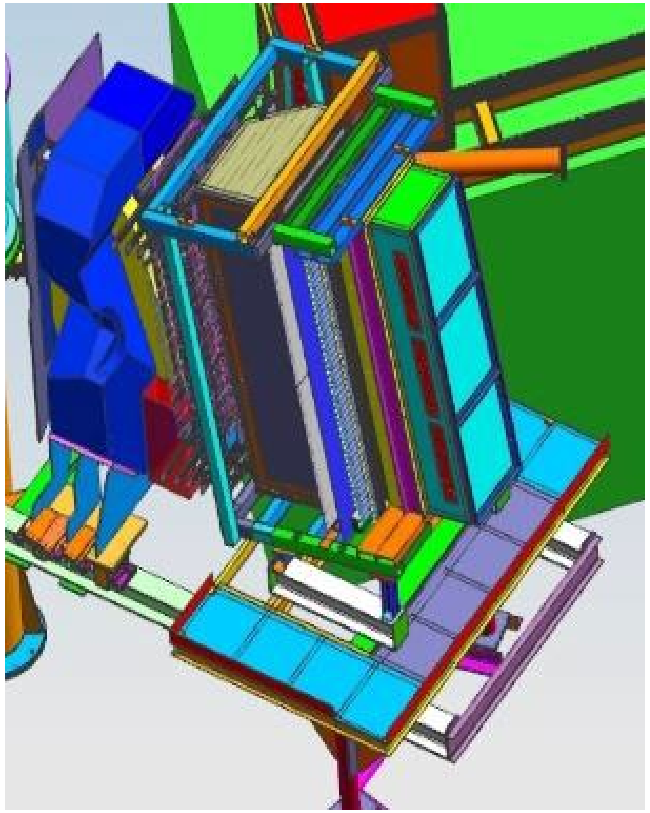


Figure 1: A simple geared cup example specialized so that the target cup does not interact with the beam. Vertical motion combined with rotation of cup will allow uniform coverage of target cell. The red dot represents the fixed position of the photon beam. The colored bead in the cup can be seen moving as the cup rotates counterclockwise and the target ladder is moved up.

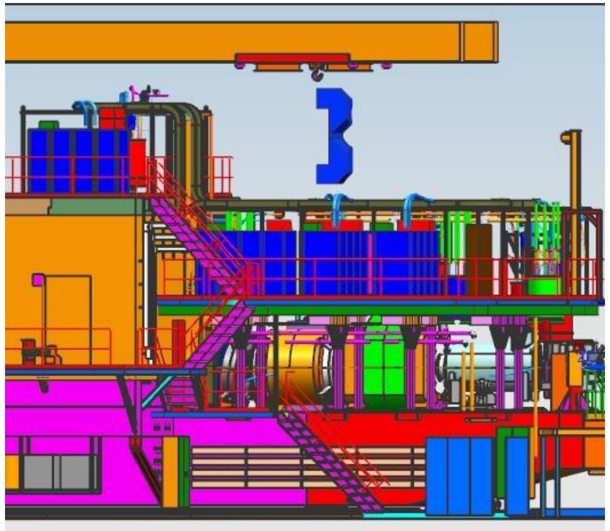
RG3 Status

- ❑ Based on CPS (close to ready)
- ❑ Experiment also needs significant design/construction work on BigBite + detector and NPS support structures



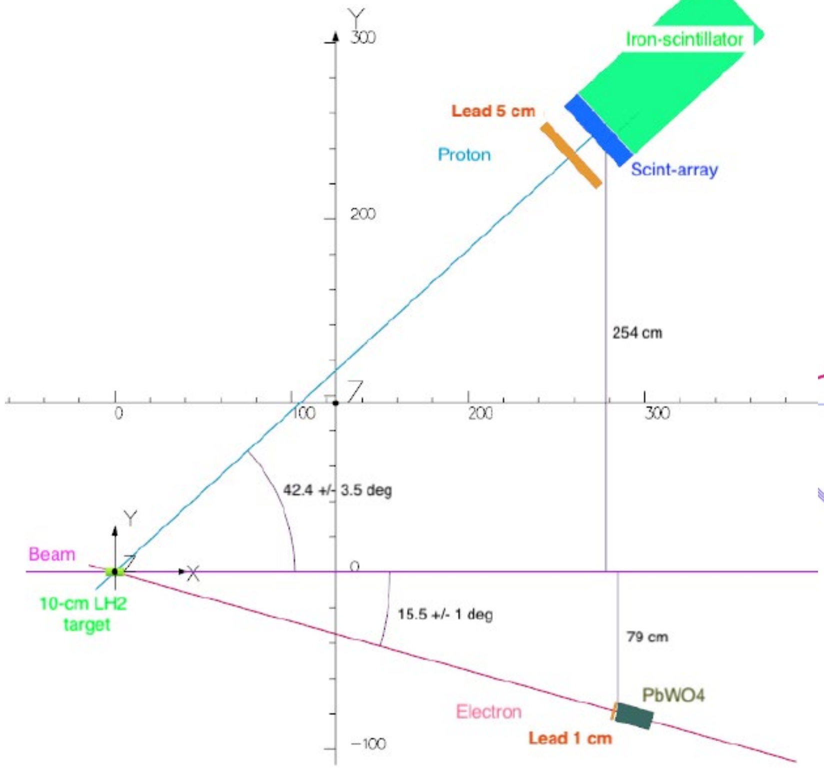
Getting BigBite magnet over SHMS

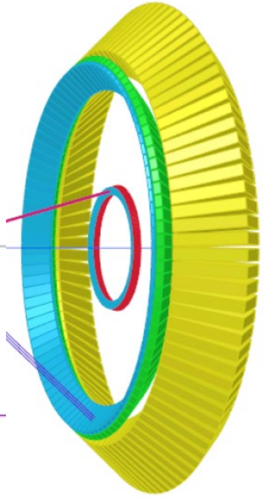
- Can be disassembled and lifted over the SHMS with Hall C standard crane
- If not disassembled BigBite magnet to be lifted with a mobile crane



RG4: E12-23-004 - Search for a Nonzero G_S at 2.5 GeV^2

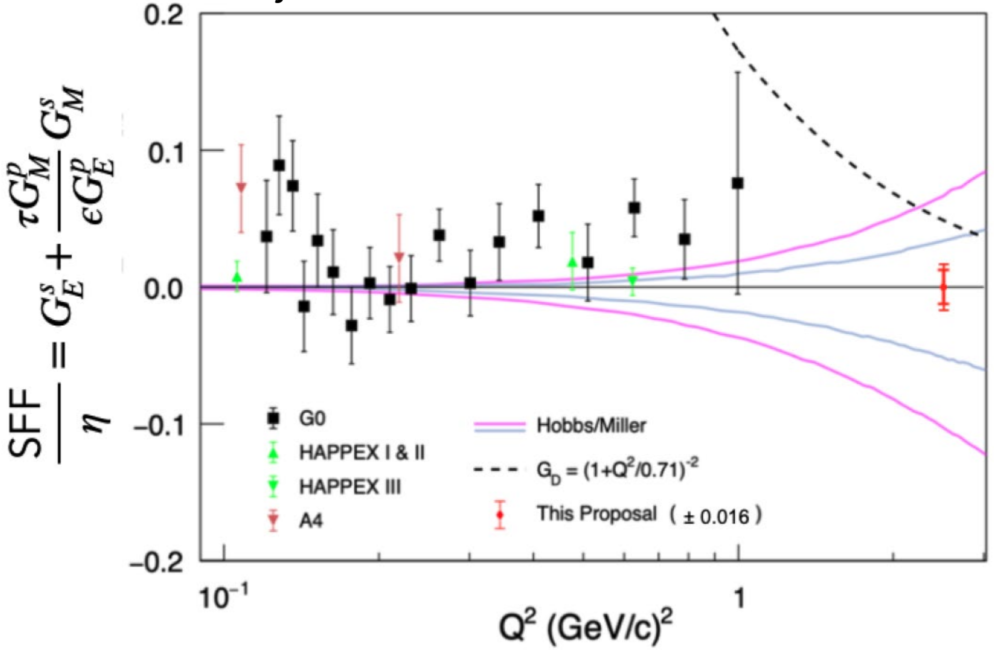
Versatility – NPS as precision EMCal – reconfigure and use with other equipment in Hall C





Measure the PVA for elastic e-p using a highly segmented NPS-type EMCal as electron arm and an iron-scintillator-based HCal as proton arm in coincidence mode

Projections



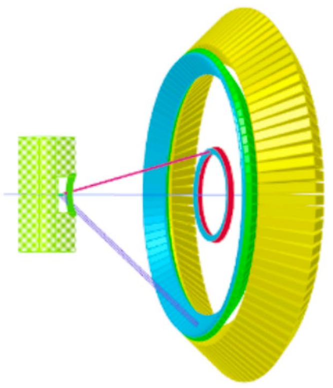
Approved at PAC51 (B. Wojtsekhowski, C. Palatchi, K. Paschke, et al.)

Science questions:

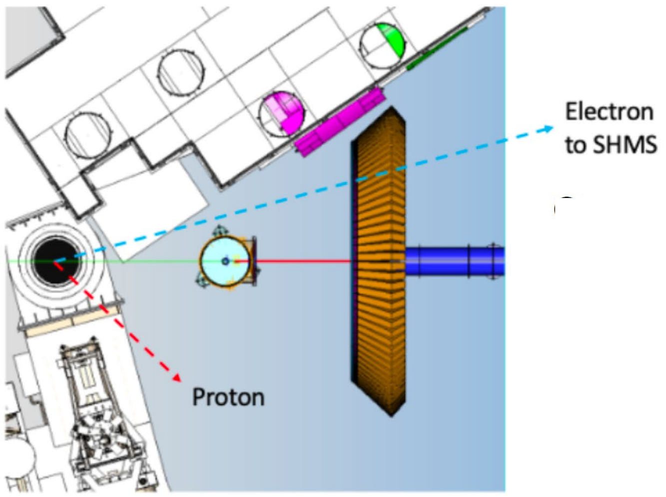
- How large is the contribution of $s\bar{s}$ quark pairs to the hadron current at x_B=1
- Is the lattice prediction of the almost zero values of G_S consistent with experiment

RG4: E12-23-004 – Status and next steps

Beam Test: position the SHMS to 15.5° to detect electrons, measured in coincidence with a prototype proton detector at 42.4°



electron angle 15.5°
proton angle 42.4°



Prototype Proton Detector

- ❑ Pixel array of 20 small scintillators with MA-PMT readout + 2 SBS HCAL blocks
- ❑ FADC readout in spectrometer DAQ
- ❑ 50uA on 15 cm hydrogen target at 6.6 GeV, about 2kHz rate into detector
- ❑ Test elastic identification and background rate and exclusion

Fraction of total by event type	Offline
Elastic scattering	0.989
Inelastic (pion electro-production)	0.002
Quasi-elastic scattering (target windows)	0.008
π^0 photo-production	0.001

Progress but significant work to be done towards beam test

- ❑ Scintillator array prototype construction
- ❑ Assemble and test HCAL prototype
- ❑ Simulation to select proton arm location
- ❑ Mechanical design of proton arm test stand
- ❑ Detailed DAQ configuration and prepare analysis

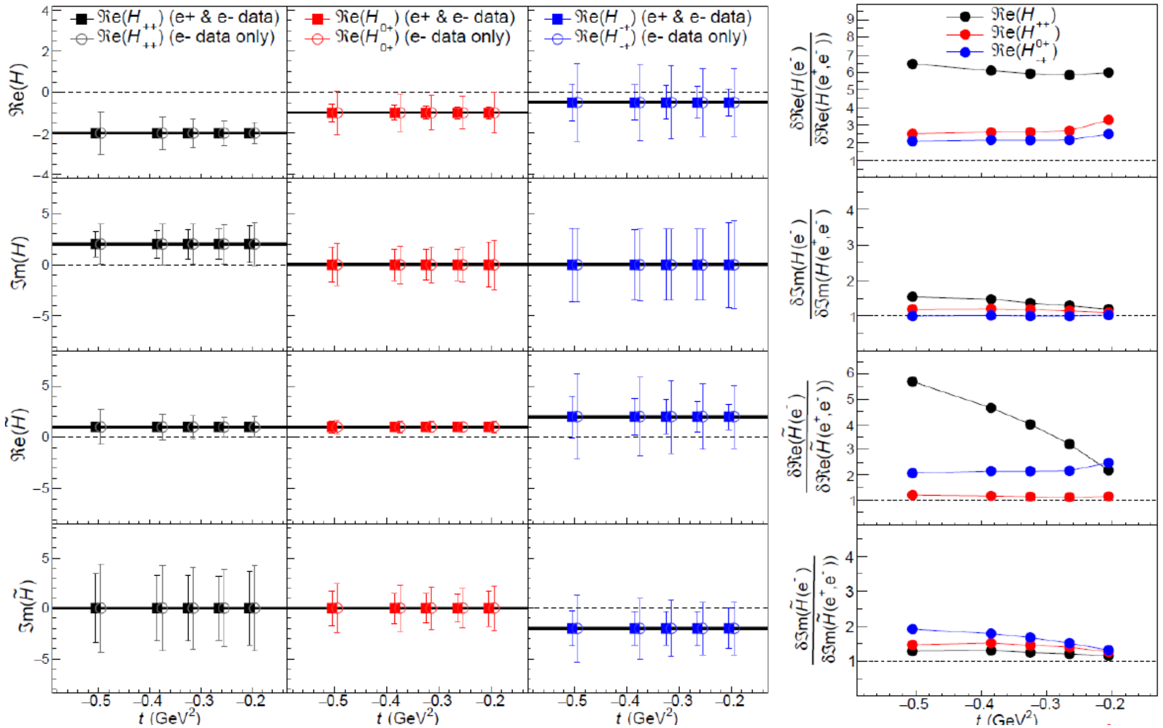
RG5: E12-20-012: DVCS using a positron beam in HC

Versatility – combine NPS and a positron beam in Hall C

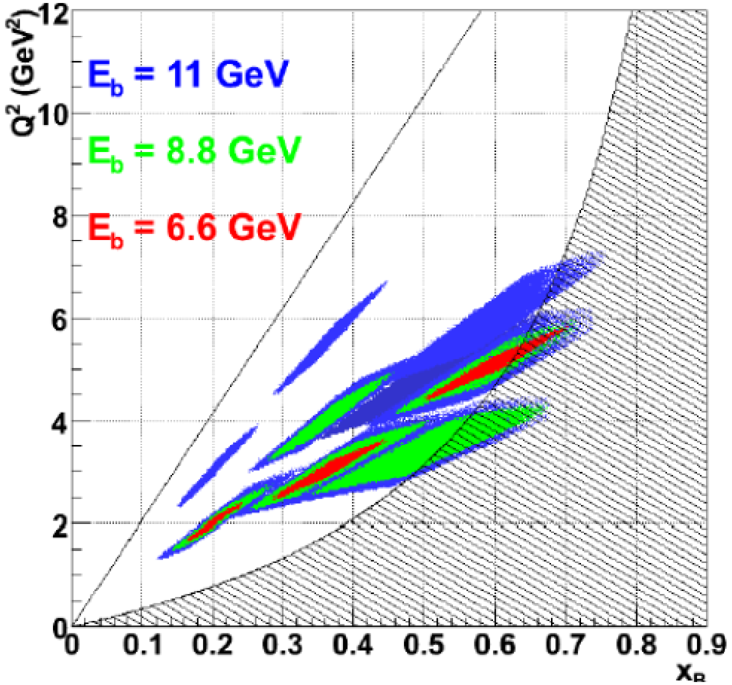
$$|\mathcal{T}(\pm ep \to \pm ep\gamma)|^2 = |\mathcal{T}^{BH}|^2 + |\mathcal{T}^{DVCS}|^2 \mp \mathcal{I}$$

Opposite sign for e- & e+

Impact on Compton Form Factors (CFFs) extraction



A factor of 4-6 improvement in the extraction of LO/LT CFFs Re(H) and Re($\widetilde{H}$), factor of ~2 for HT/NLO



Physics Goals and motivation:

- Precise determination of the absolute photon electroproduction cross section
- Clean model-independent separation of DVCS^2 and DVCS-BH interference
- More stringent constraints on CFFs by combining e^+/e^- data

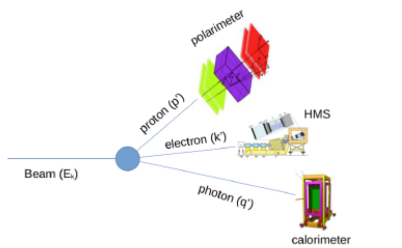
New Physics with NPS: New DVCS Observables

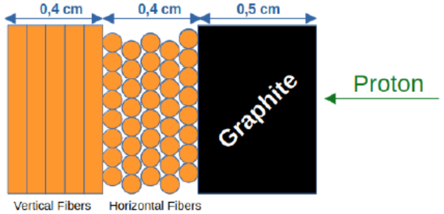
Versatility – NPS as precision EMCal – reconfigure and use with other equipment in Hall C

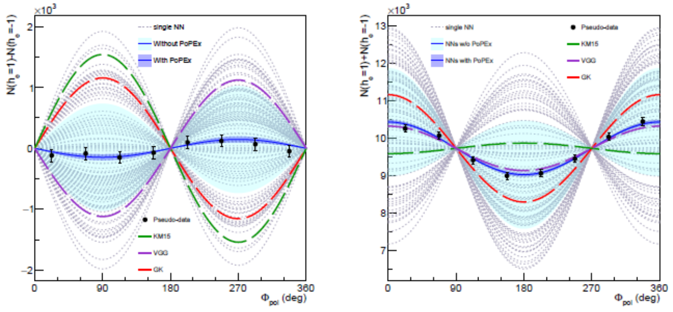
New DVCS observable: the recoil proton polarization

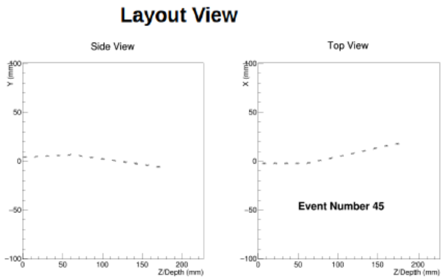
- Can only be done at JLab with NPS,
- Simultaneous access to E and $\widetilde{H}$ through the two transverse polarization of the recoil proton,
- Large polarimeter on the ground made of Scintillating Fibers.
- π^0-electroproduction done simultaneously.
- More details in LOI 12-23-014.

Bessidskaia Bylund *et al.*, Phys. Rev. D 107, 014020





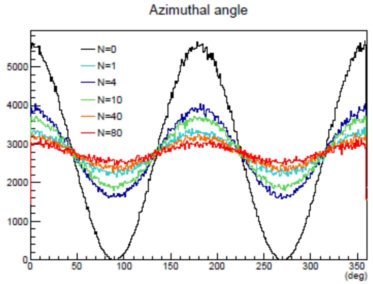


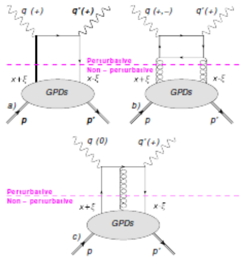


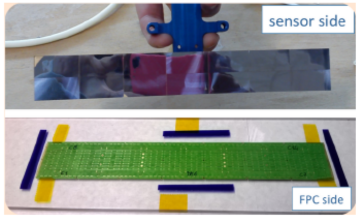
New DVCS observable: Linear polarization of DVCS photon

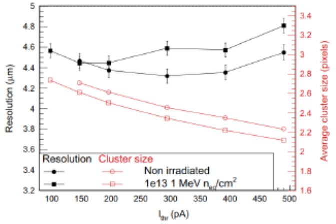
- Can only be done at JLab with NPS,
- Direct access to gluon transversity GPDs,
- Pair polarimeter composed of light MAPS planes.
- Figure-of-merit being optimized (anlyzing power vs efficiency).
- May need SBS as electron arm to increase acceptance.
- More details in LOI 12-23-003.

Below, reconstruction of azimuthal angle as lepton pair goes through layers of 0.05% of radiation length spaced by 0.5 mm.







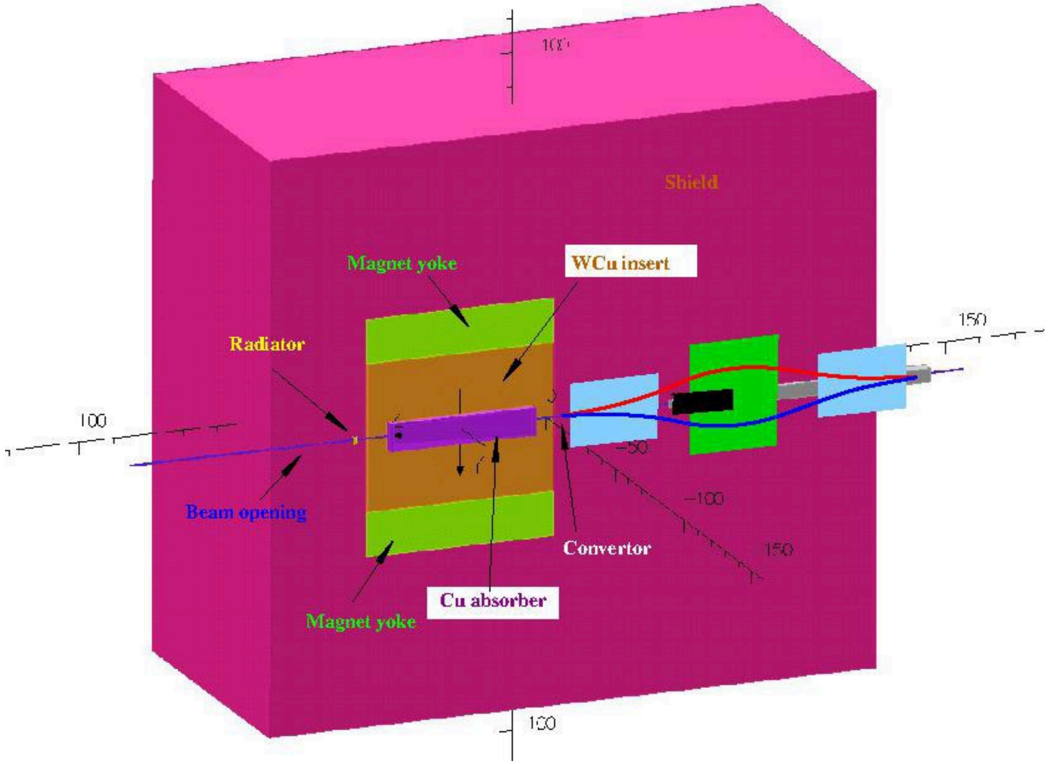


New LOIs to PAC51 (M. Defurne)

Other new physics ideas with NPS

CPS as a positron source

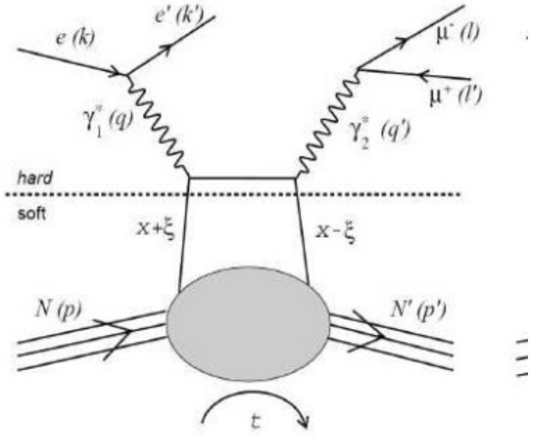
- TPE effects
- Dark photon search



More in Jefferson Lab Hall C: Precision Physics at the Luminosity Frontier (Hall C White Paper); D. Mack et al. arXiv 2209.11838

Beyond DVCS and TCS

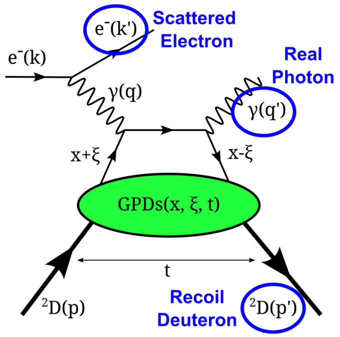
- DDVCS (access to ERBL region)
- J/Psi on transversely polarized target



DDVCS
Access GPDs
$Q'^2 \neq Q^2$ & greater than 1 GeV²
Depends on x, xi, t + evolution

Marie Boer et al. – 2022 NPS Collaboration Meeting

Tensor-polarized DVCS



A. J. Zec et al. – 2024 NPS Collaboration Meeting

Summary

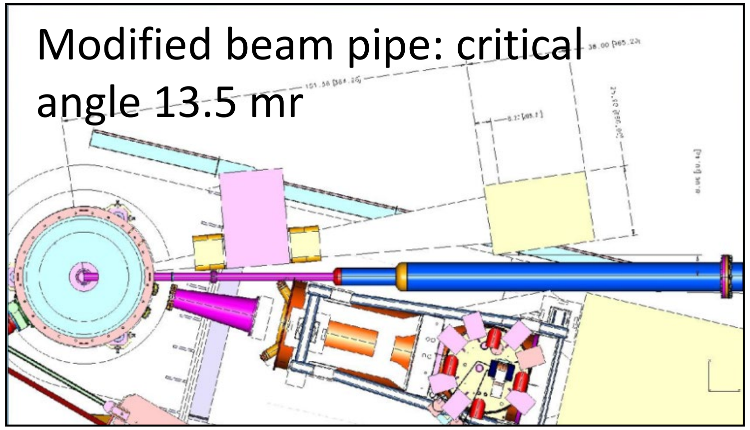
- ❑ NPS is a new facility in Hall C allowing for high-precision studies of cross sections and polarization observable involving neutral final states
- ❑ The currently approved NPS science program consists of eight approved experiments aiming at
  - Systematically study the reaction mechanism and factorization
  - Map out nucleon structure in new kinematic regimes
- ❑ Some exciting new physics ideas are under development combining NPS with positron beam and/or other equipment in Hall C (possibly 22 GeV JLab)
- ❑ NPS run group 1a (RG1a) ran in 2023/2024
- ❑ Anticipate to run RG1b and RG2 next

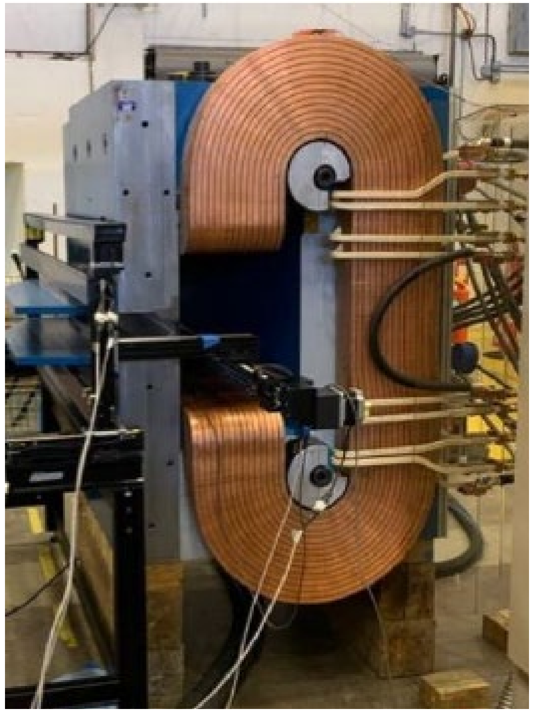
More info in the NPS Wiki: https://wiki.jlab.org/cuawiki/index.php/Main_Page
RG1a analysis: [Offline Analysis Meetings]()

NPS General Design Concept

NSF MRI PHY-1530874

- a ~25 msr neutral particle detector consisting of up to 1116 **$PbWO_4$ crystals** in a temperature-controlled frame including gain monitoring and curing systems
- HV distribution bases with built-in amplifiers for operation in a high-rate environment
- Essentially deadtime-less digitizing electronics to independently sample the entire pulse form for each crystal – JLab-developed Flash ADCs
- A new 0.3Tm sweeping magnet allowing for small-angle and large angle operation at 0.6 TM. The magnet is compatible with existing JLab power supplies.
- Cantelevered platforms off the SHMS carriage to allow for remote rotation (in the small angle range), and platforms to be on the SHMS carriage (in the large angle range)
- A beam pipe with as large critical angle as possible to reduce beamline-associated backgrounds



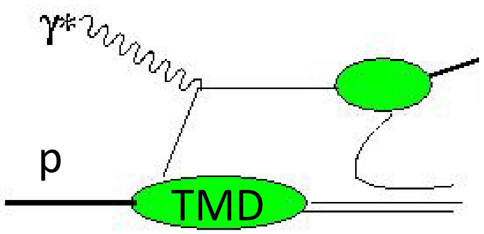


More on PWO crystal studies: Scintillating Crystals for the NPS in Hall C at JLab; T. Horn et al., Nucl. Instrum. Meth. A 956 (2020) 163375

RG1a: E12-13-007 – SIDIS basic $(e,e'\pi^0)$ cross sections

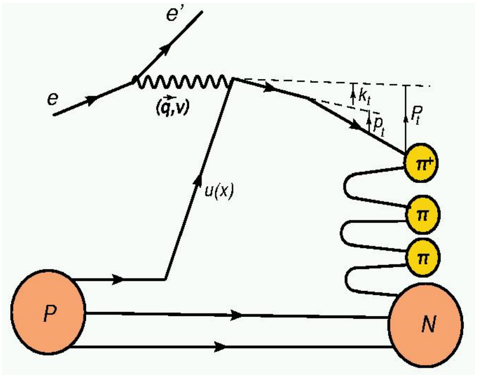
Linked to framework of *Transverse Momentum Dependent Parton Distributions*

- Validation of factorization theorem needed for most future SIDIS experiments and their interpretation
- Need to constrain TMD evolution w. precision data
- Questions on target-mass corrections and ln(1-z) re-summations require precision large-z data



$TMD^q(x,k_T)$

Transverse momentum widths of quarks with **different flavor (and polarization)** can be different



$P_T = p_t + z\, k_t + O(k_t^2/Q^2)$

E12-13-007 goal: Measure the basic SIDIS cross sections of π^o production off the proton, including a map of the P_T dependence ($P_T \sim \Lambda < 0.5$ GeV), to validate(*) flavor decomposition and the k_T dependence of (unpolarized) up and down quarks

(*) Can only be done using spectrometer setup capable of %-type measurements (an essential ingredient of the global SIDIS program!)

Requires new ~25 msr Neutral-Particle Spectrometer

<u>Advantages of $(e,e'\pi^o)$ beyond $(e,e'\pi^{+/-})$</u>

- ❑ Many experimental and theoretical advantages to validate understanding of SIDIS with neutral pions
- ❑ Can verify: $\sigma^{\pi^0}(x,z) = ½ (\sigma^{\pi^+}(x,z) + \sigma^{\pi^-}(x,z))$
- ❑ Confirms understanding of flavor decomposition/k_T dependence

PAC: "the **cross sections** are **such basic tests of the understanding of SIDIS** at 11 GeV kinematics that they will play a **critical role** in establishing the entire SIDIS program of studying the partonic structure of the nucleon."

RG1a: E12-13-010: precision DVCS/π^0 cross sections

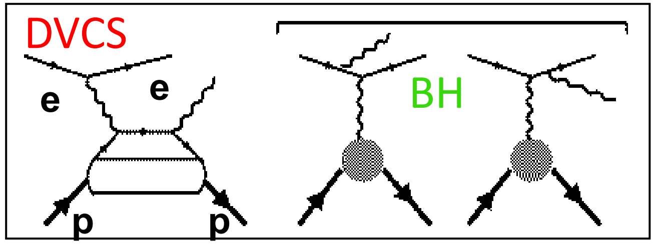
Simplest process: **$e + p \rightarrow e' + p + \gamma$ (DVCS)**

E12-13-010 DVCS measurements follow up on measurements in Hall A:

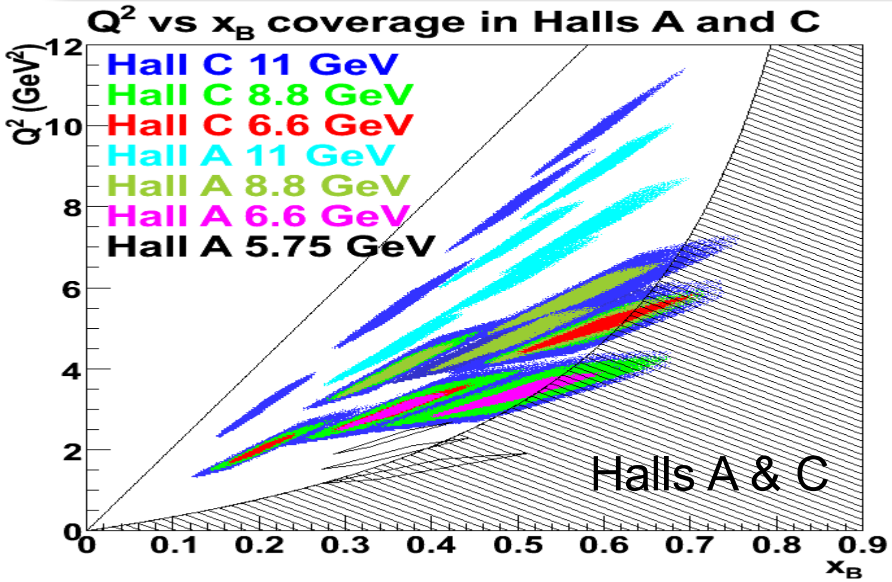
- Scaling of the Compton Form Factor
- Rosenbluth-like separation of DVCS:

$$\sigma = |BH|^2 + \mathrm{Re}\left[DVCS^{\perp}\ BH\right] + |DVCS|^2$$
$$\sim E_{beam}^2 \qquad\qquad \sim E_{beam}^3$$

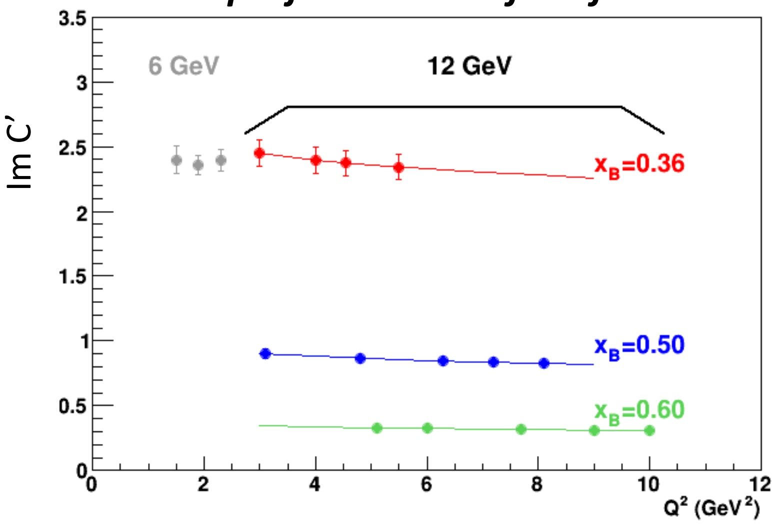
- L/T separation of π^0 production



Hall A data for Compton form factor (over *limited* Q^2 range) agree with hard-scattering



12 GeV projections: confirm formalism

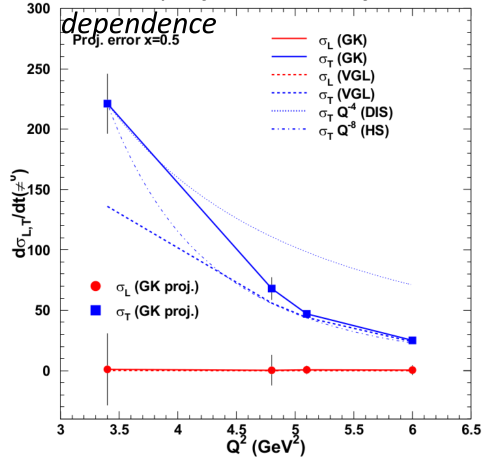


Extracting the real part of CFFs from DVCS requires measuring the cross section at multiple beam energies (DVCS²–Interference separation)

π^0 Exclusive Cross Sections

- Relative L/T contribution to π^0 cross section important in probing transversity
- Results from Hall A at 6 GeV Jlab suggest that the longitudinal cross section in π^0 production is non-zero up to Q^2=2 GeV^2

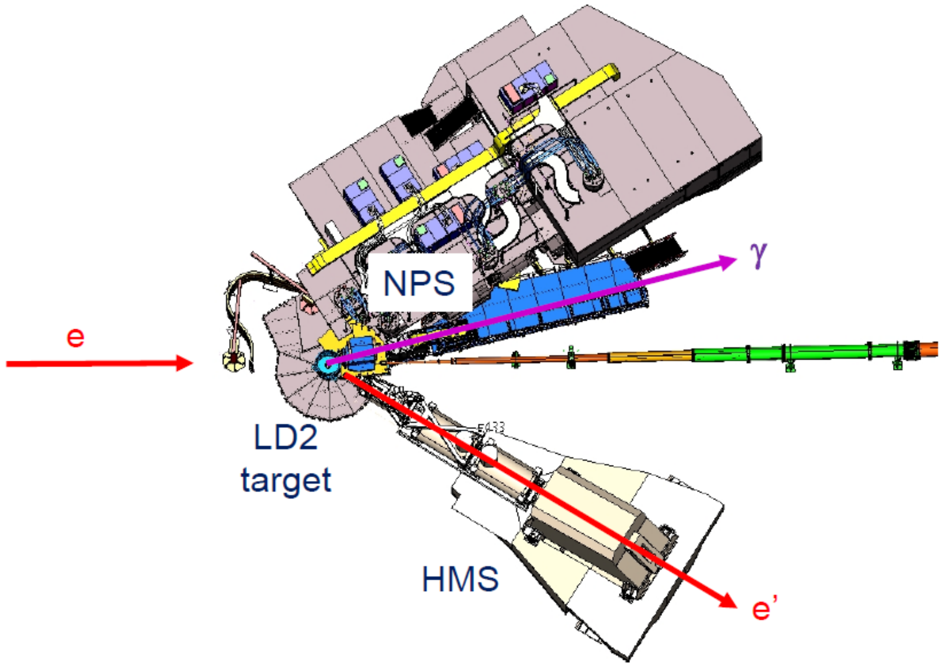
12 GeV projections: confirm Q^2/t dependence



E12-13-010 provides also data on σ_T and σ_L at higher Q^2 for reliable interpretation of 12 GeV GPD data

RG1a: E12-22-006: DVCS off the Neutron

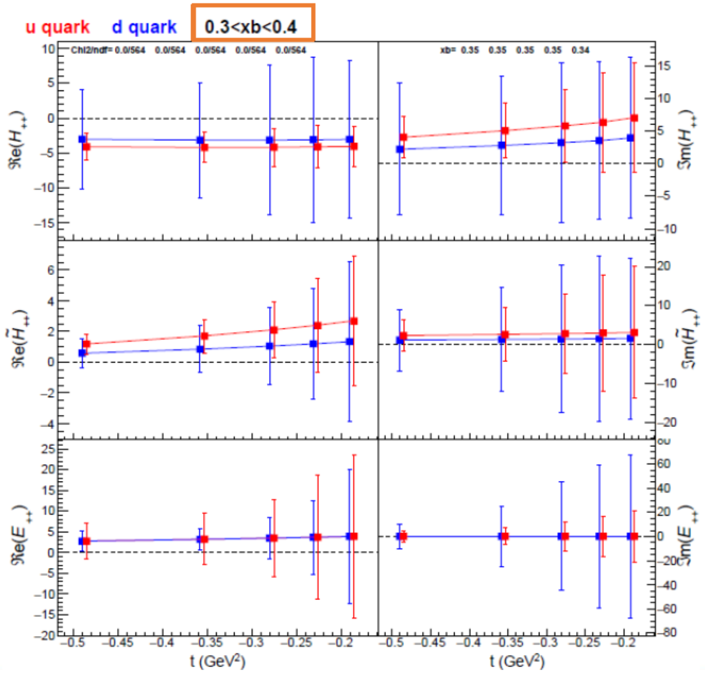
Probe flavor dependence of GPDs with precision nDVCS cross sections
Measurement of the $N \rightarrow e'\gamma X$ reaction (N=p, n, d) using an LD_2 target in Hall C

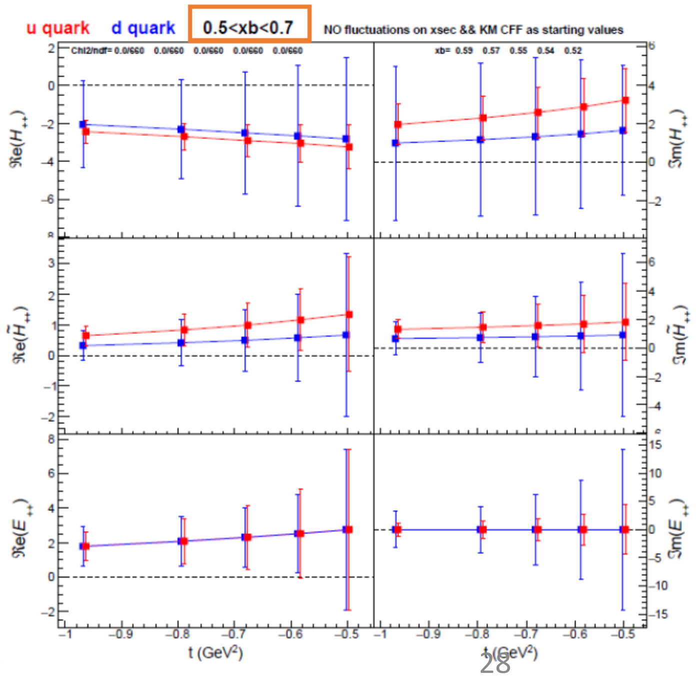


With NPS and HMS in Hall C reach ~x2-12 better nDVCS & dDVCS separation than previous 6 GeV experiment

Projected Impact on flavor dependence of CFFs

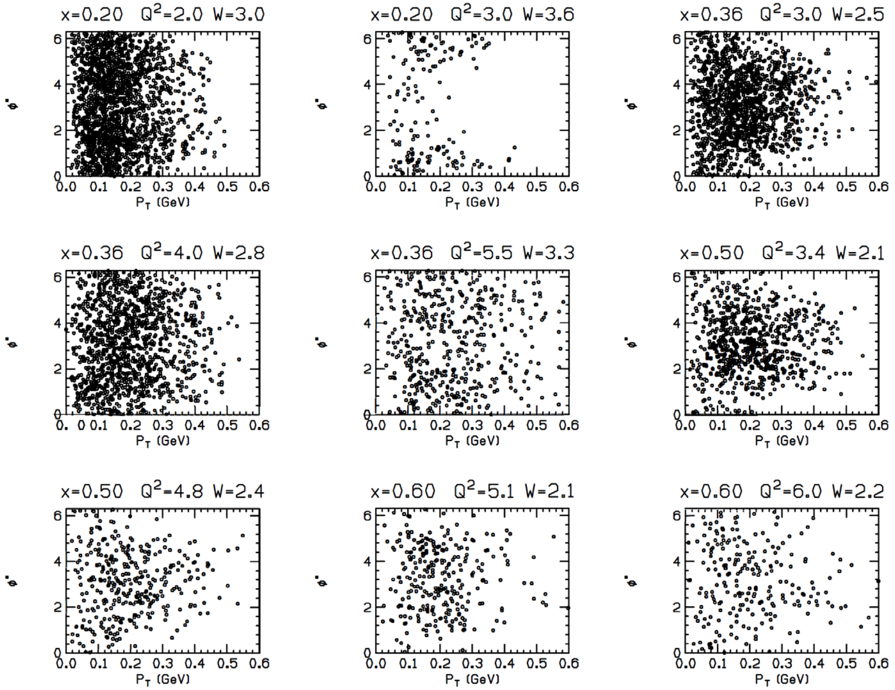
- *Simultaneous fit of E12-13-010 (p) and E12-22-006 (n)*
- *Real and imaginary parts of CFFs H and $\widetilde{H}$ and E (u & d) as free parameters (nDVCS not sensitive to $\tilde{E}$)*





RG1a: E12-23-014: SIDIS basic $(e,e'\pi^0)$ cross sections

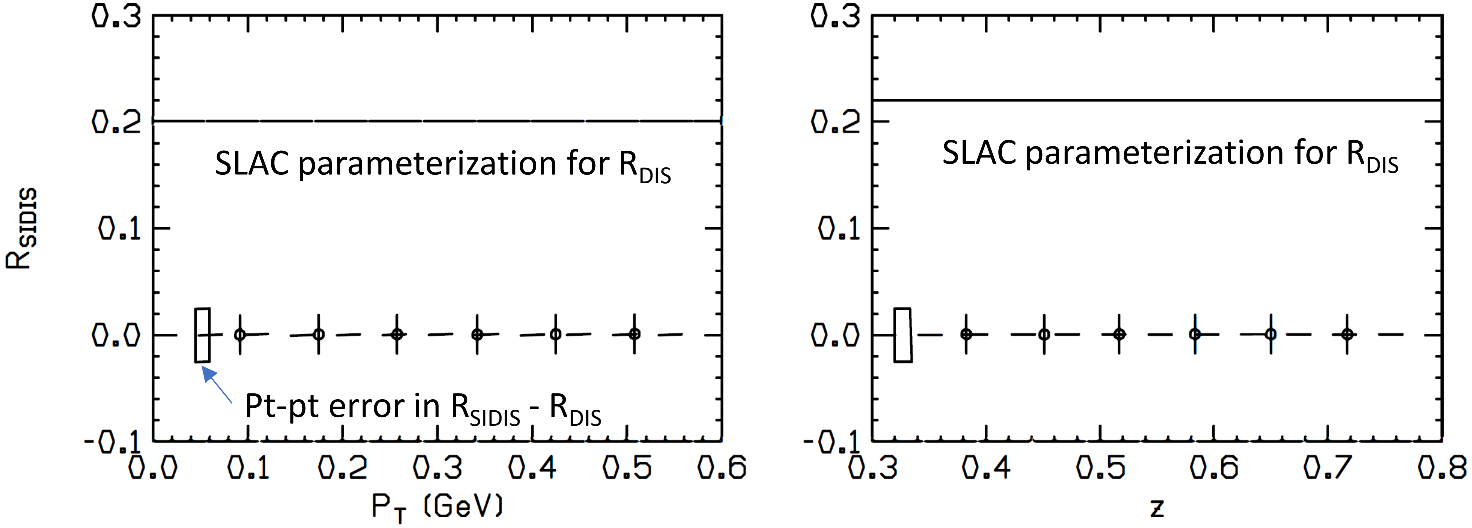
Angles for which NPS has good acceptance in (z,p_T)



Set	x	Q^2	W	E	ϵ	E'	θ_e	θ_π	d	I	D_p	D_d
		GeV^2	GeV	GeV		GeV	deg	deg	m	μA	day	day
Ib	0.20	2.0	3.0	8.5	0.64	3.17	15.7	8.9	4	50	0.1	0.1
IIIa	0.36	3.0	2.5	6.4	0.51	1.96	28.3	11.2	3	28	0.1	0.1
IVb	0.36	4.0	2.8	8.5	0.52	2.58	24.7	9.9	4	40	0.1	0.1
V	0.36	5.5	3.3	10.6	0.41	2.46	26.6	7.5	4	40	0.3	0.3
VIIIa	0.60	5.1	2.1	6.4	0.46	1.87	38.1	13.2	3	28	0.3	0.3
VIa	0.50	3.4	2.1	6.4	0.67	2.78	25.3	16.9	6	28	0.1	0.1

Measure $R_{LT}= \sigma_L/\sigma_T$, the ratios of d/u cross sections, the transverse momentum dependence of the cross section, and the spin-independent and beam-spin-dependant modulations of the cross section

Projections for R_{LT} SIDIS as function of p_T and z



Physics goals are driven by the need to more fully understand the production processes that enter SIDIS for better understanding of the 3D nucleon structure

- Dynamic and target higher twist, deep-exclusive processes, VM, CSV

NPS - activities