Spin Physics with 12-GeV CEBAF

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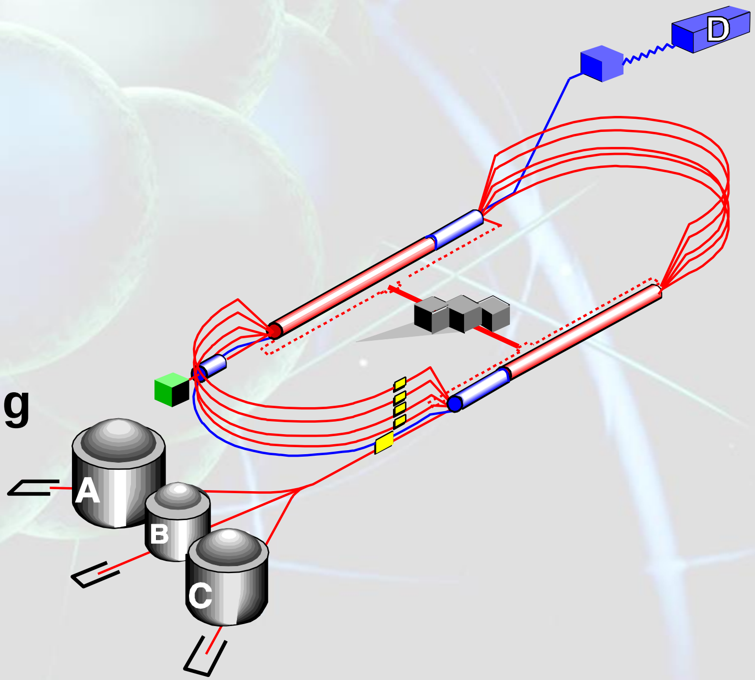
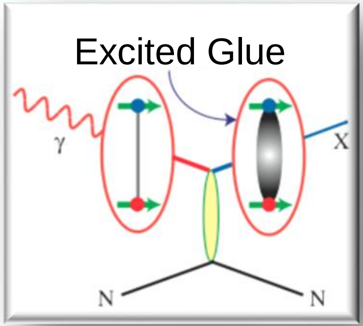
12 GeV Science Questions
12 GeV detectors and accelerator status
12 GeV Spin Physics – nucleon structure
- spectroscopy
- large x
- form factors
- **transverse spatial and momentum imaging**
- EMC with spin
- parity-violation at JLab

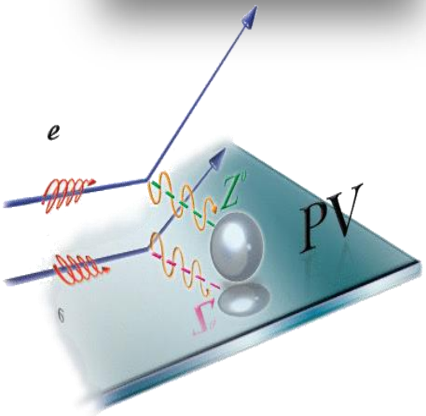
Backup: Early Hall Physics Plans



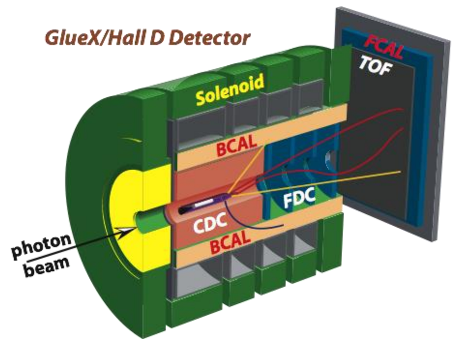
21st Century Science Questions

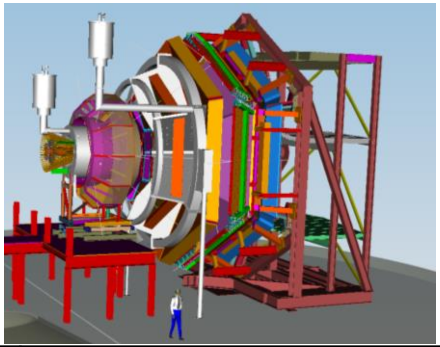
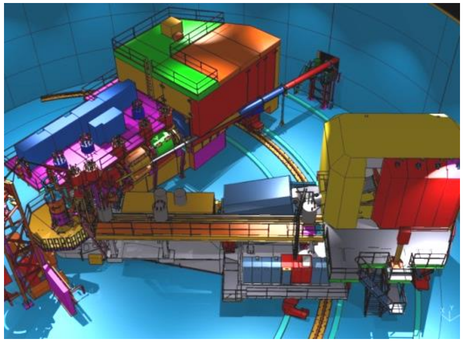
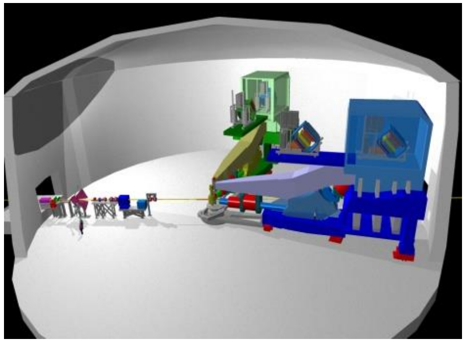
- **What is the role of gluonic excitations in the spectroscopy of light mesons?**
- **Where is the missing spin in the nucleon? What is the role of orbital angular momentum?**
- **Can we reveal a novel landscape of nucleon substructure through measurements of new multidimensional distribution functions?**
- **What is the relation of short-range nuclear structure and parton dynamics?**
- **Can we discover evidence for physics beyond the standard model of particle physics?**

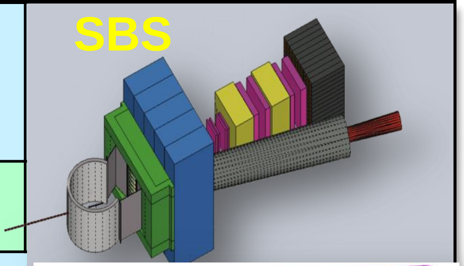


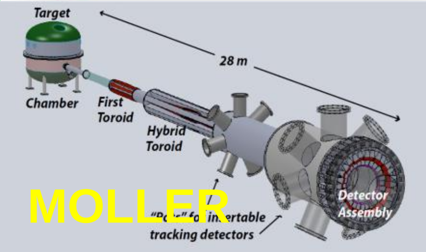


Detector Requirements: Complementarity



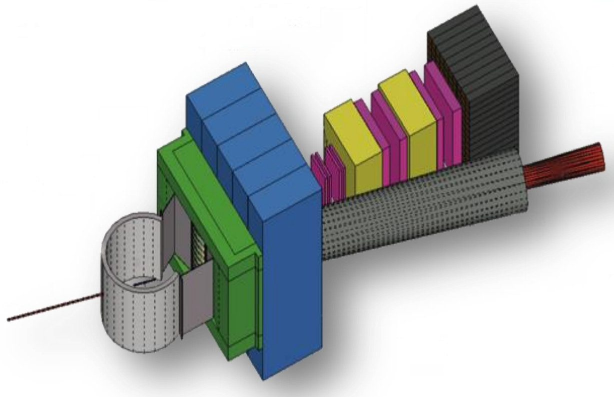




Hall D	Hall B	Hall C	Hall A
excellent hermeticity	luminosity 10^{35}	energy reach	
polarized photons	hermeticity	precision	
E_γ~8.5-9 GeV	11 GeV beamline		
10^8 photons/s	target flexibility		
good momentum/angle resolution		excellent moment	
high multiplicity reconstruction		luminosity u	
particle ID			

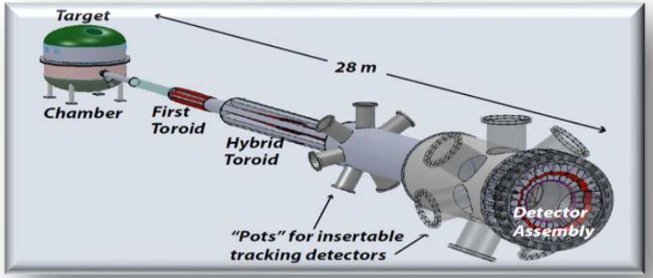


Hall A Large Installations Beyond 12 GeV Upgrade

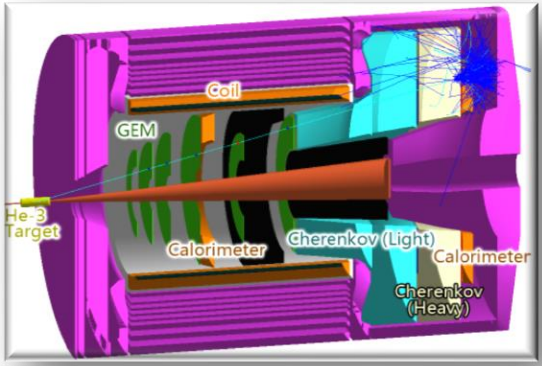
- Super BigBite Spectrometer
  (Approved for FY13-16 construction)
  - high Q^2 form factors & SIDIS
  - Project formally started October 1 2012
  - 1st Successful Annual Review November 2013
  - 2nd Annual Review Scheduled November 2014



- MOLLER experiment (MIE)
  - Standard Model Test
  - ~100 Collaborators, ~30 Institutions
  - Successful Science Review September 2014
  - Detector – quartz beam tests at Mainz
  - Magnet pre-engineering tasks with MIT/Bates

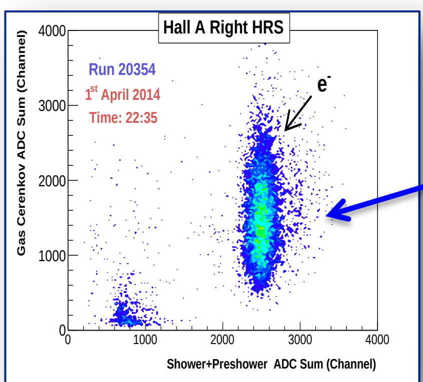


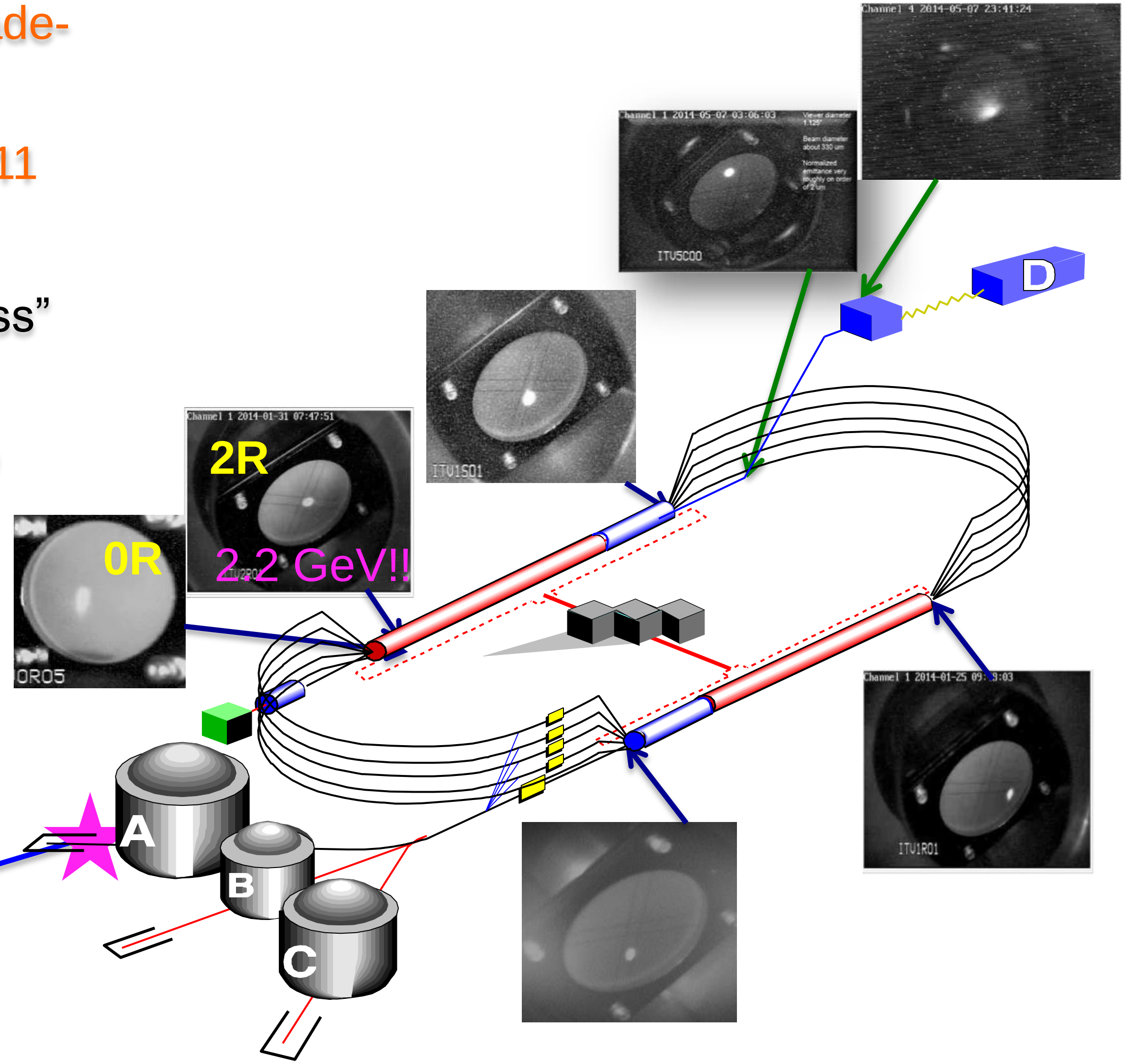
- SoLID – PVDIS, SIDIS, J/Ψ, …
  - 190+ Collaborators, 50+ institutions
  - Large Chinese collaboration
  - CLEO Solenoid – preparing for 2016 move
  - Draft Conceptual Design Report submitted for Director's Review to be scheduled



Accelerator Commissioning & First Beam to Halls

- Feb 5, 2014 achieved full upgrade-energy of 2.2 GeV in one pass.
- April 1, 2014 “3-pass” beam, 6.11 GeV electrons @ 2 nA in Hall A
- May 7, 2014 10.5 GeV (“5.5 pass” beam) to Hall-D Tagger dump
- November 2014 beam to Hall D (GlueX engineering run), Hall A (DVCS/G_M^P exp.), Hall B (non-CLAS12 exp.)



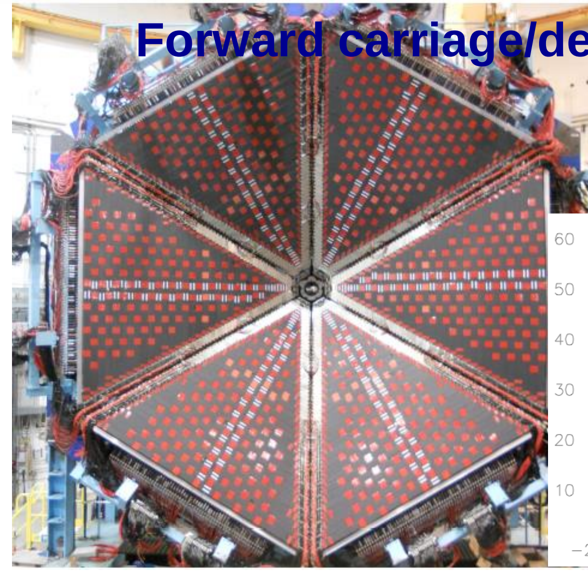


Beam on Carbon Target

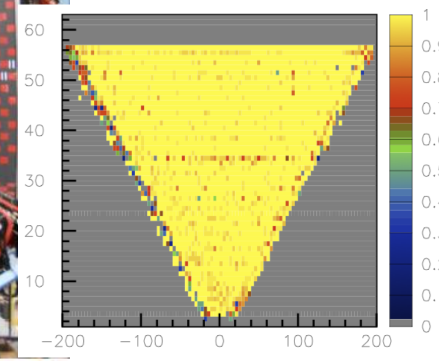
Detector completion: Hall D 100%, Halls B & C 74%

(to do: mainly Superconducting magnets)

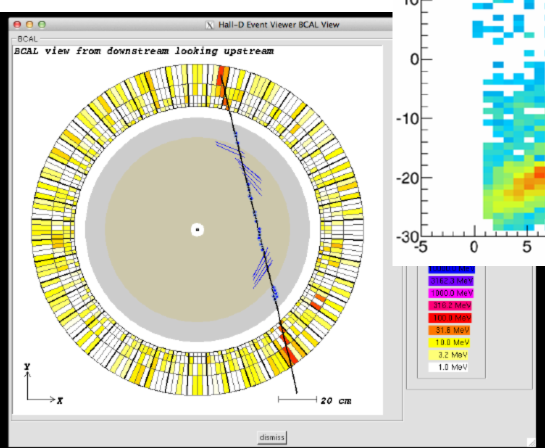
Forward carriage/detector installed

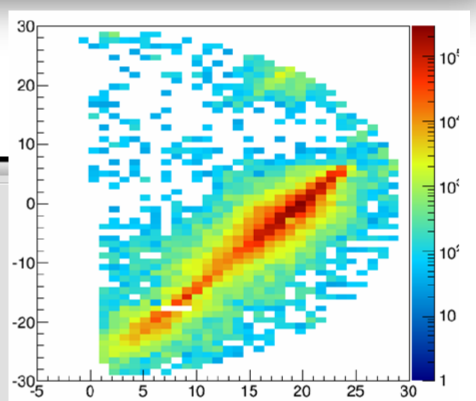


FTOF 1b/1a efficiency study



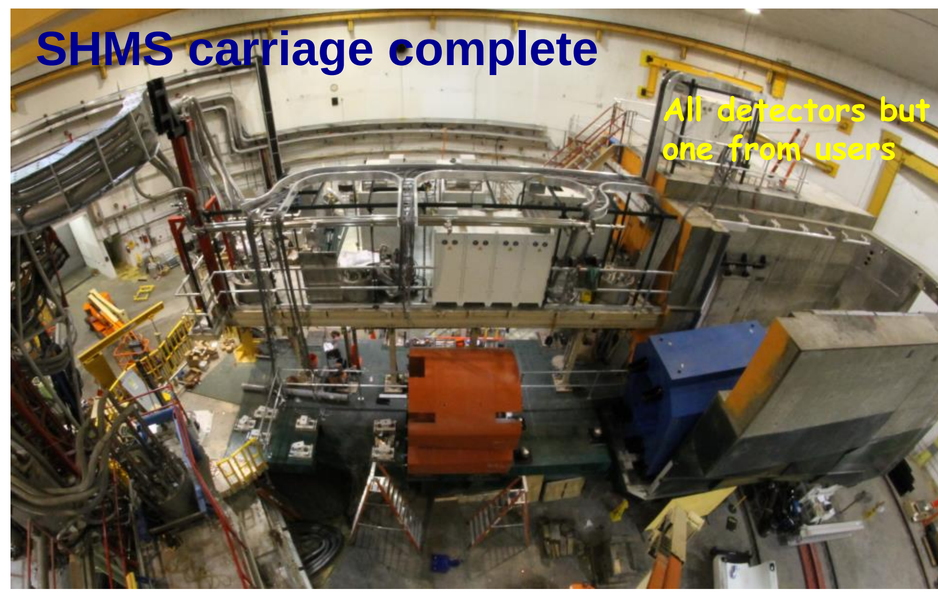
BCAL/CDC Cosmics



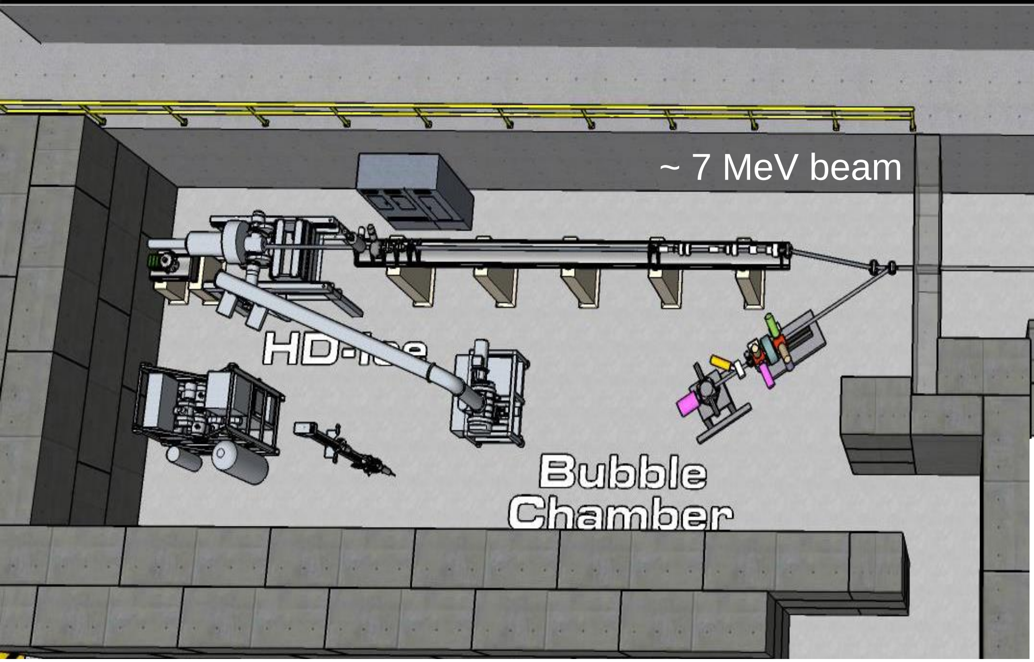


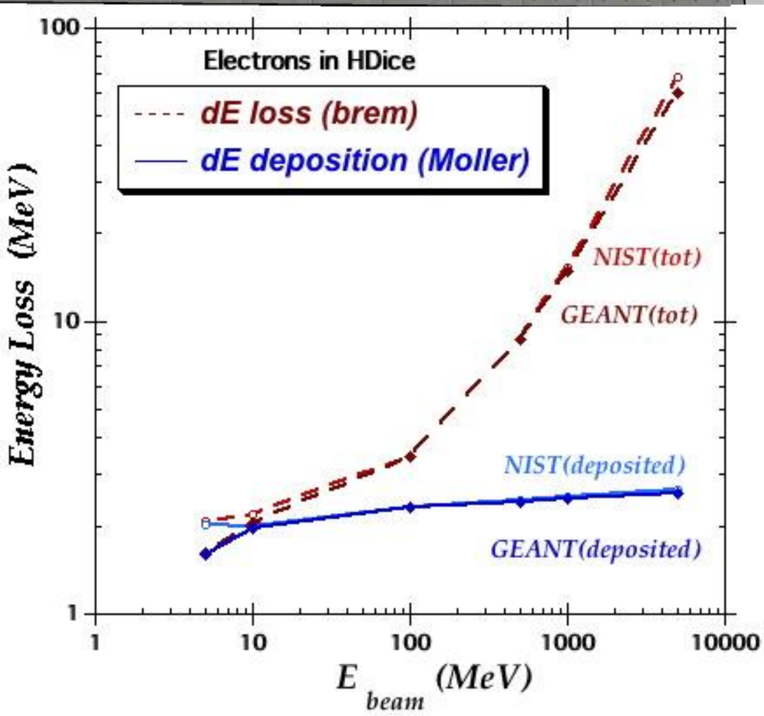
FCAL Cosmics

SHMS carriage complete



$\vec{\text{eHD}}$ Development at the ITF



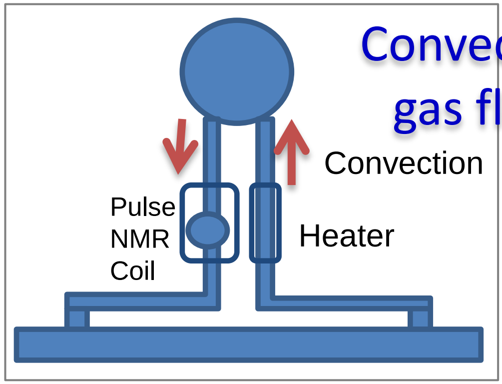


- Operating performance with electrons beams requires further beam tests (plan to use upgrade of the injector test facility: ITF)
- ionization & energy deposition ~ E independent an ITF @ 7 MeV ~ Hall B at 11 GeV
- ITF schedule: 1st beam ~ Jan 2016? (alternate uses: parity-quality beam for Moller, target irradiation facility, detector radiation tests)

Hall A & Hall C – ^{3}He Target

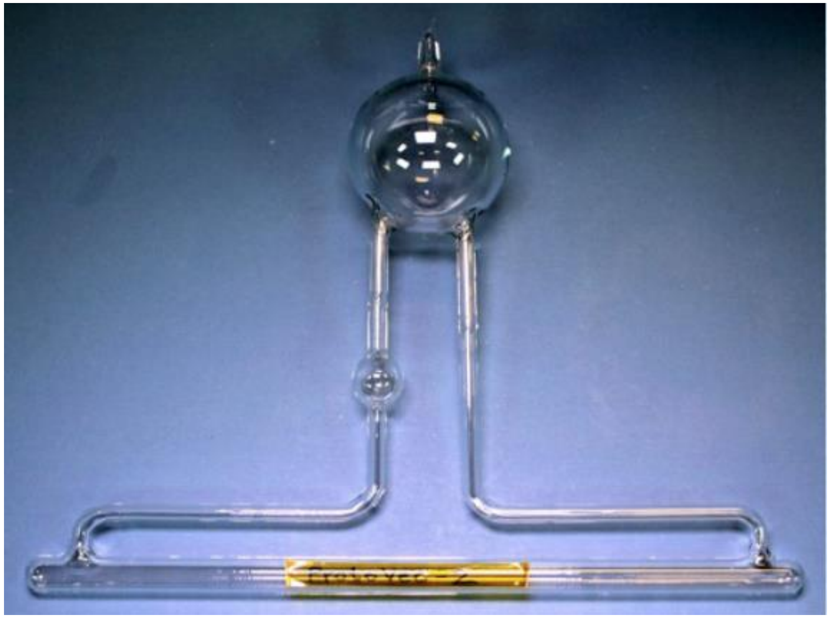
^{3}He target will become compatible with operation in both Halls A & C

Ongoing improvements include:
Lasers, optical fibers from laser house to Hall C, mechanical work to modify for a higher-FOM target, NMR for polarization measurements, etc.



- Two steps upgrade to increase FOM:
  - 1st step(COL): new convection-based target for operations in both Halls A and C
  - 2nd step (proposed): increase target length from 40 to 60 cm, and allowable beam current to 60 μA.

- Maximum polarization test on one new convection cell has been completed and the new convection cell reached polarization at near 60% with convection.

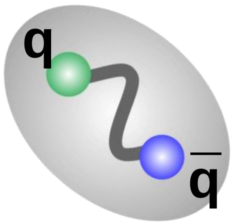


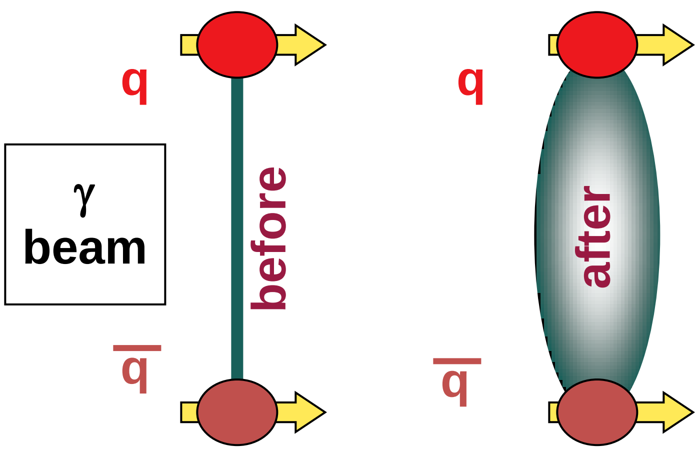
UVA R&D on convection gas flow

Gluonic Excitations and the mechanism for confinement

QCD predicts a rich spectrum of as yet to be discovered gluonic excitations - whose experimental verification is crucial for our understanding of QCD in the confinement regime.

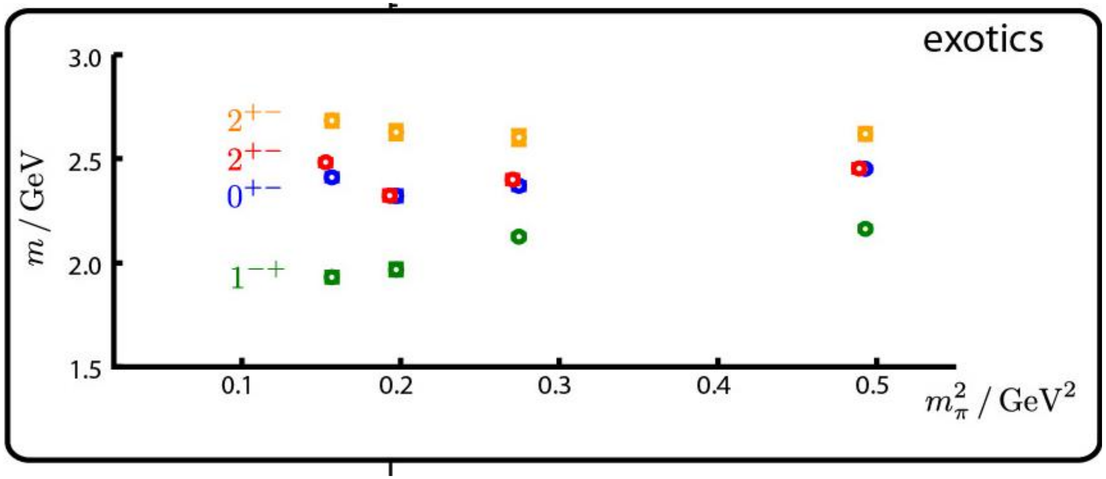
With the upgraded CEBAF, a linearly polarized photon beam, and the GlueX detector, Jefferson Lab will be <u>uniquely poised</u> to:
- discover these states,
- map out their spectrum, and
- measure their properties





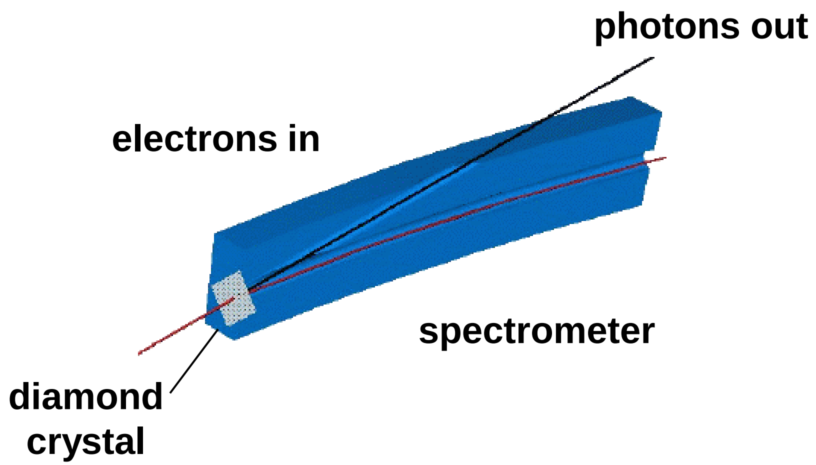
Dudek et al.

States with Exotic Quantum Numbers

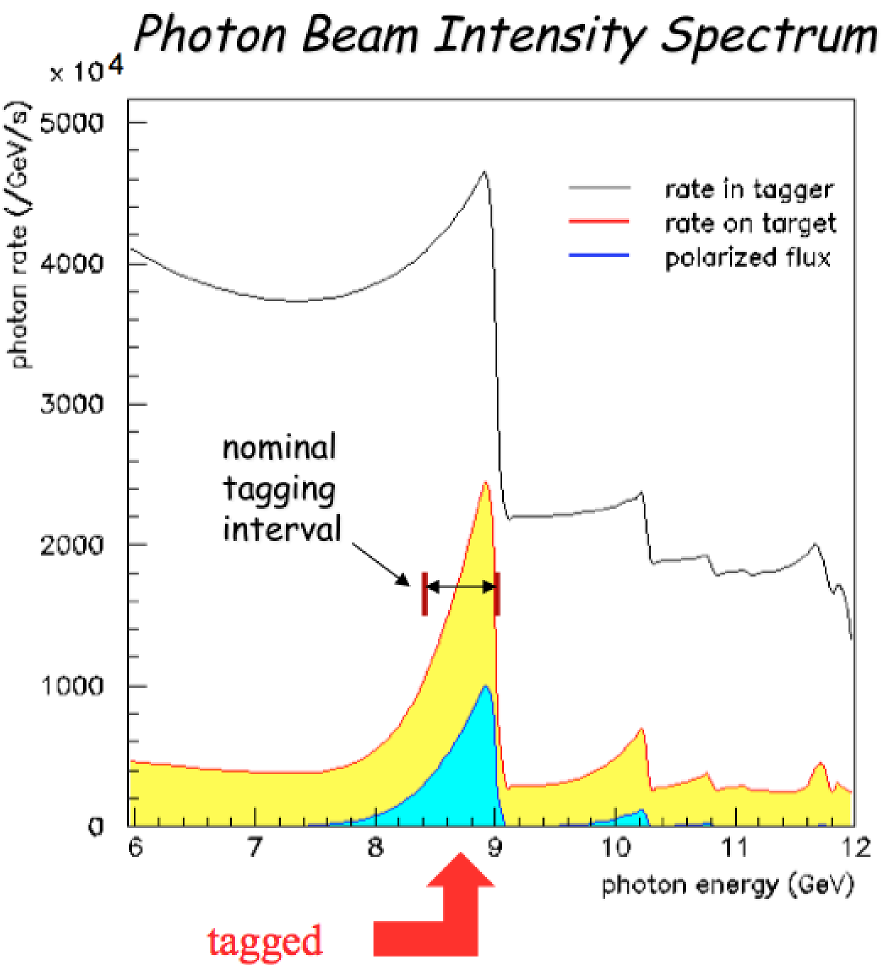


Hall D Strategy: Coherent Bremsstrahlung

- Use 8-9 GeV polarized photons (12 GeV electron beam)
- Use hermetic detector with large acceptance
- Perform amplitude analysis



This technique provides requisite energy, flux and polarization
(gain of 10,000 versus existing photo-production data)

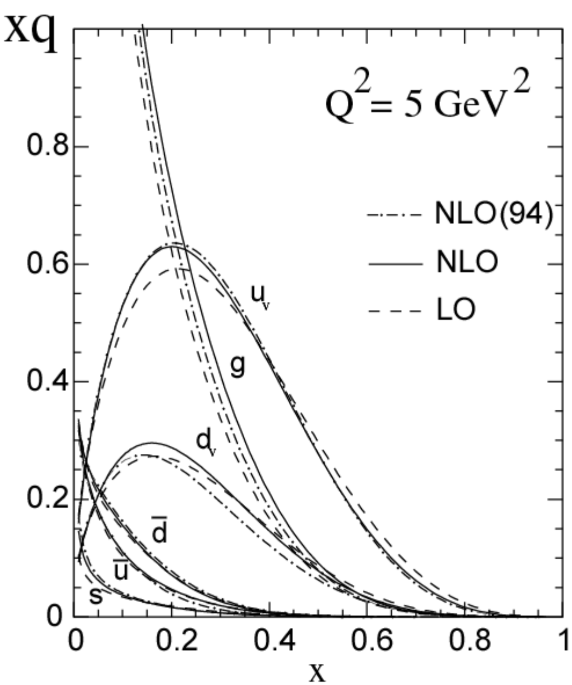


$\delta E/E = 0.1\%$ photon energy (GeV)
Pol = 40%

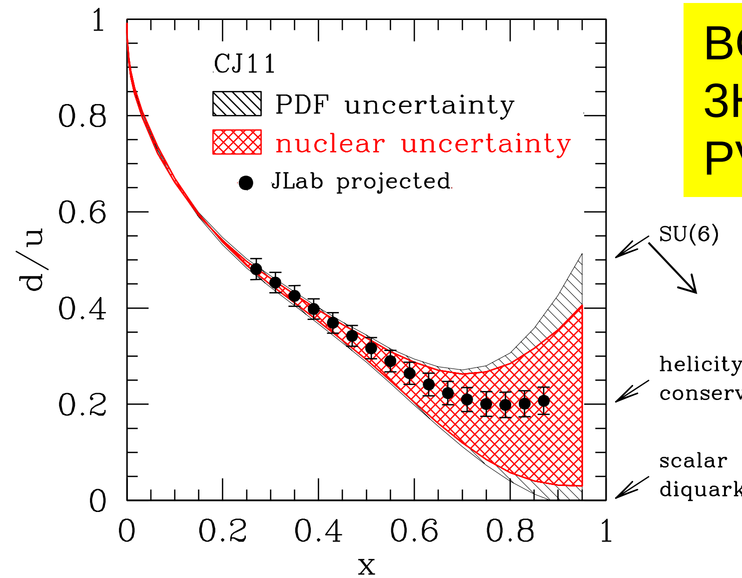
Measuring High-x Structure Functions

REQUIRES:

- High beam polarization
- High electron current
- High target polarization
- Large solid angle spectrometers



12 GeV will access the regime (x > 0.3), where valence quarks dominate



BONUS
3H/3He
PVDIS

x →1 predictions	**F_2^n/F_2^p**	**d/u**	**A_1^n**	**A_1^p**
SU(6)	**2/3**	**1/2**	**0**	**5/9**
Diquark Model/Feynman	**1/4**	**0**	**1**	**1**
Quark Model/Isgur	**1/4**	**0**	**1**	**1**
Perturbative QCD	**3/7**	**1/5**	**1**	**1**
QCD Counting Rules	**3/7**	**1/5**	**1**	**1**

Measuring High-x Structure Functions

REQUIRES:

- High beam polarization
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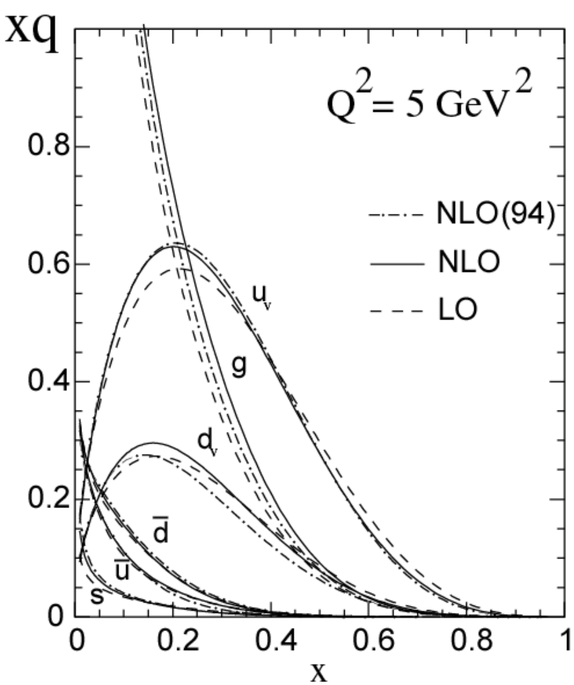
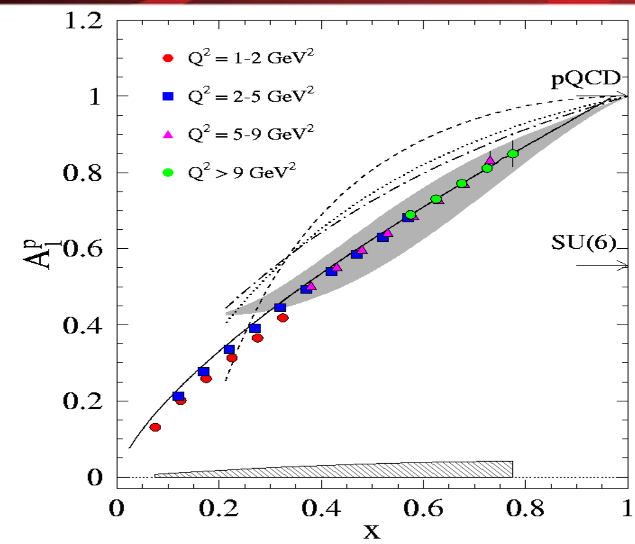
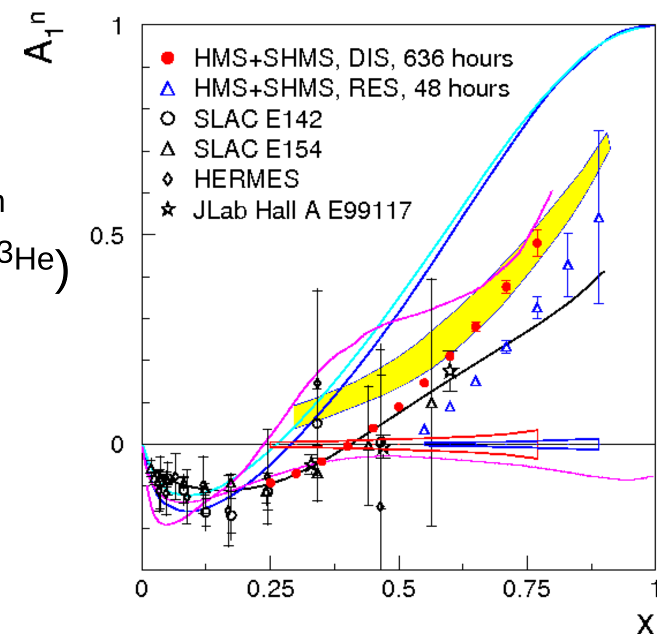


12 GeV will access the regime (x > 0.3), where valence quarks dominate

Hall B: A_1^p (and A_1^d)



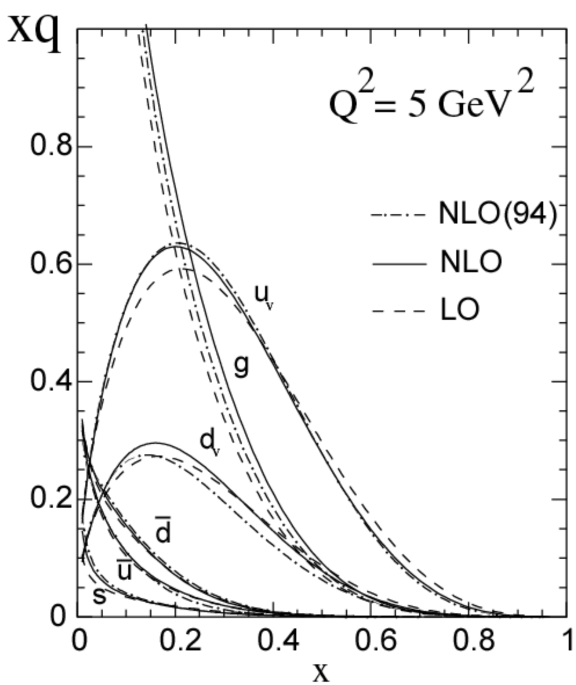
Hall C: A_1^n (from A_1^{3He})

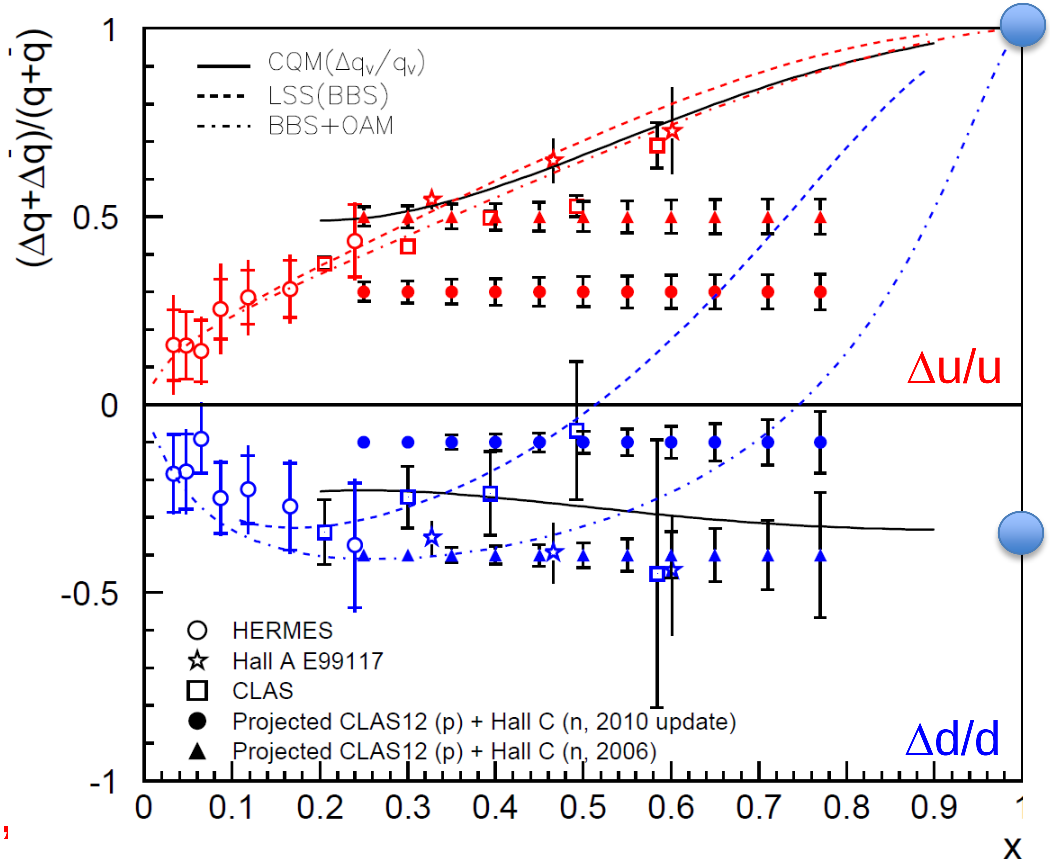


Measuring High-x Structure Functions

REQUIRES:
- High beam polarization
- High electron current
- High target polarization
- Large solid angle spectrometers

Combine Hall B A_1^p and Hall C A_1^n
→ extract Δu/u and Δd/d
(constrained by knowledge of A_1^n → requires polarized ^{3}He performance!)



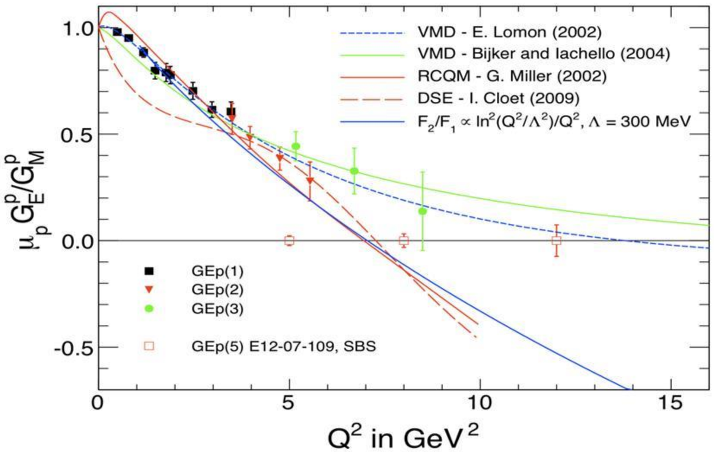


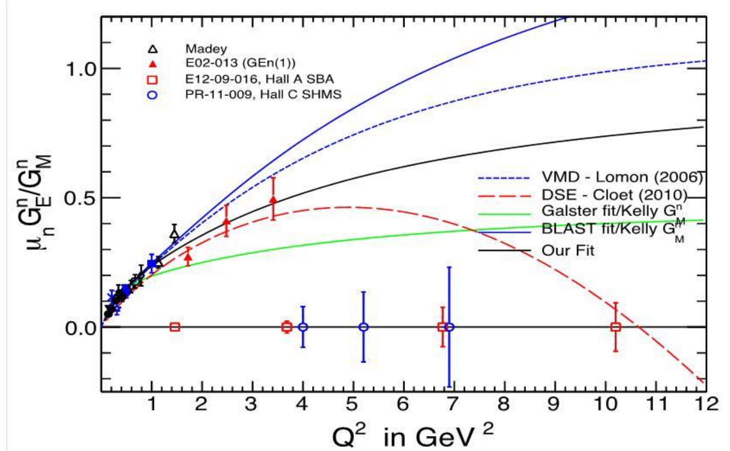
12 GeV will access the regime (x > 0.3), where valence quarks dominate

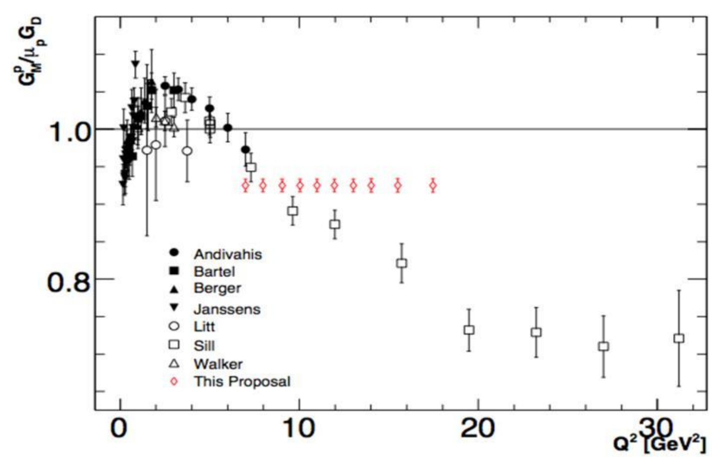
Measuring Elastic Form Factors – add SBS

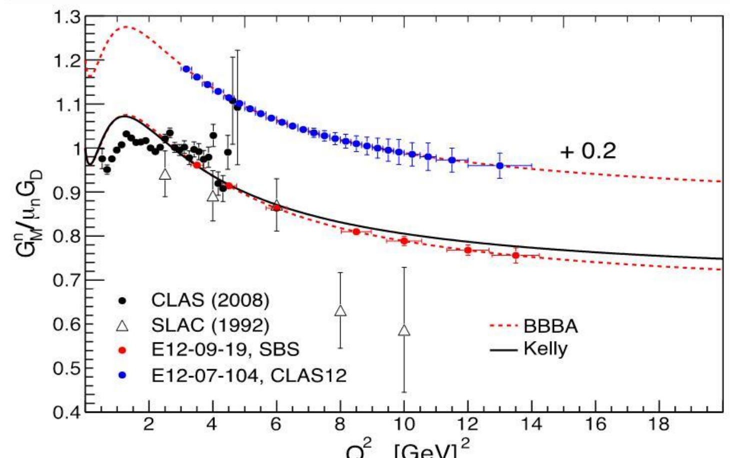
Physics Reach extended by Super BigBite Spectrometer (SBS) in Hall A:

- Use high luminosity + open geometry + GEM detectors









- Pushes G_E^p/G_M^p, G_E^n, G_M^n to high Q^2 (>10 GeV^2)
- Allows for flavor decomposition to distance scales deep inside the nucleon

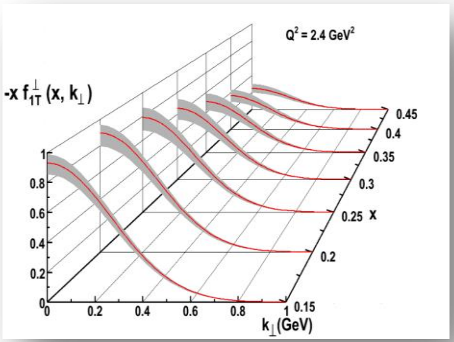
3D Mapping of the Nucleon

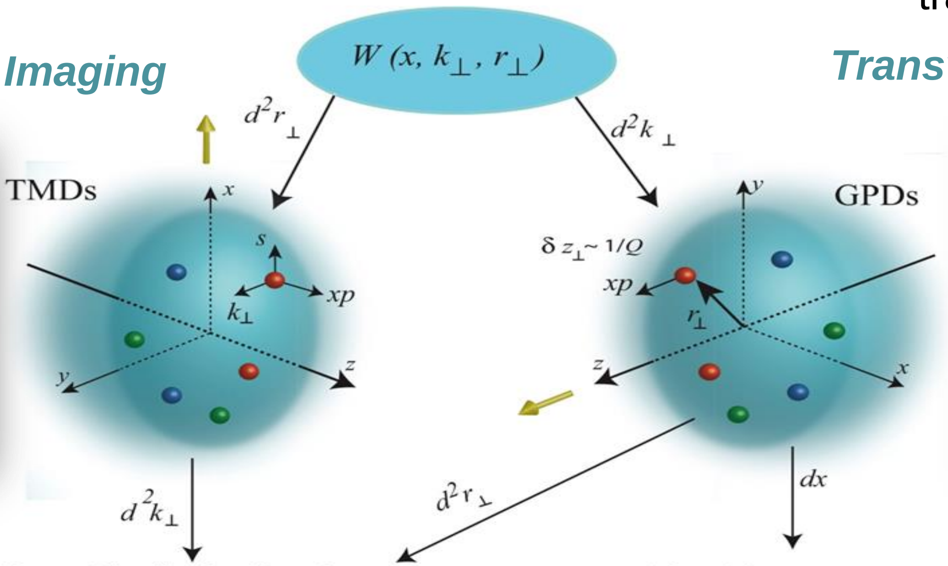
TMDs: Longitudinal momentum fraction x and transverse momentum k

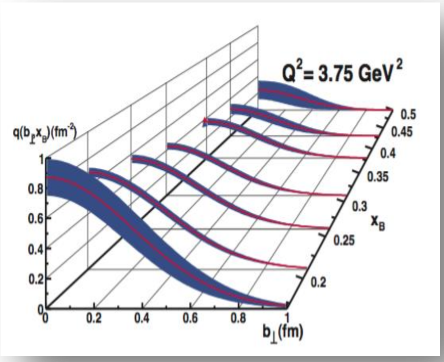
GPDs: Longitudinal momentum fraction x at transverse location b

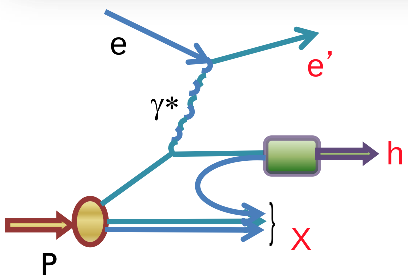
Transverse Momentum Imaging

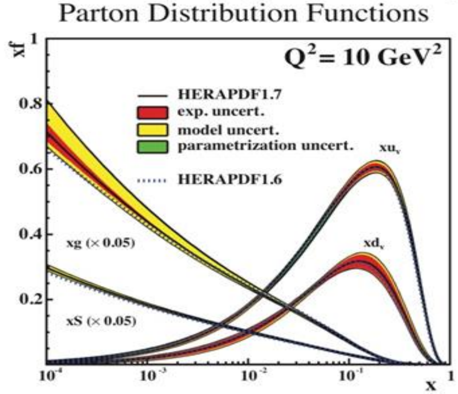
Transverse Spatial Imaging

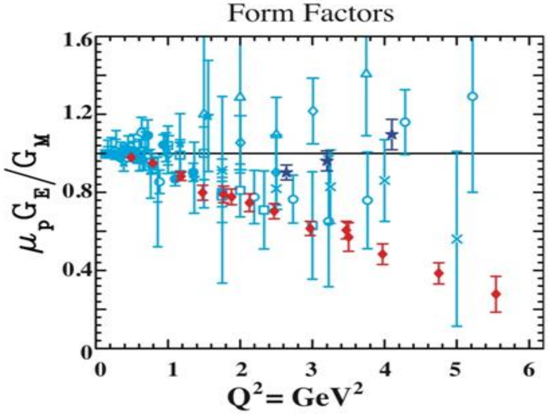


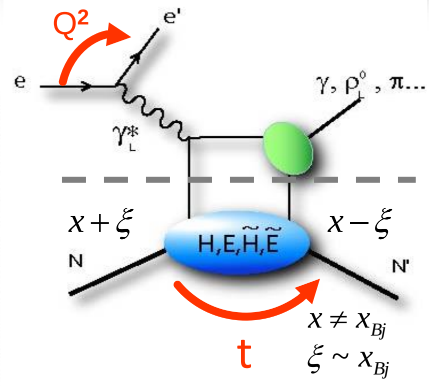








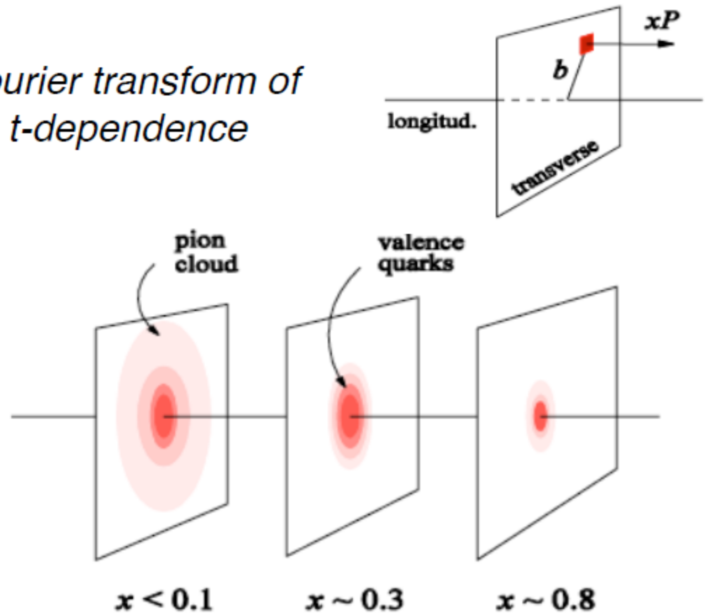




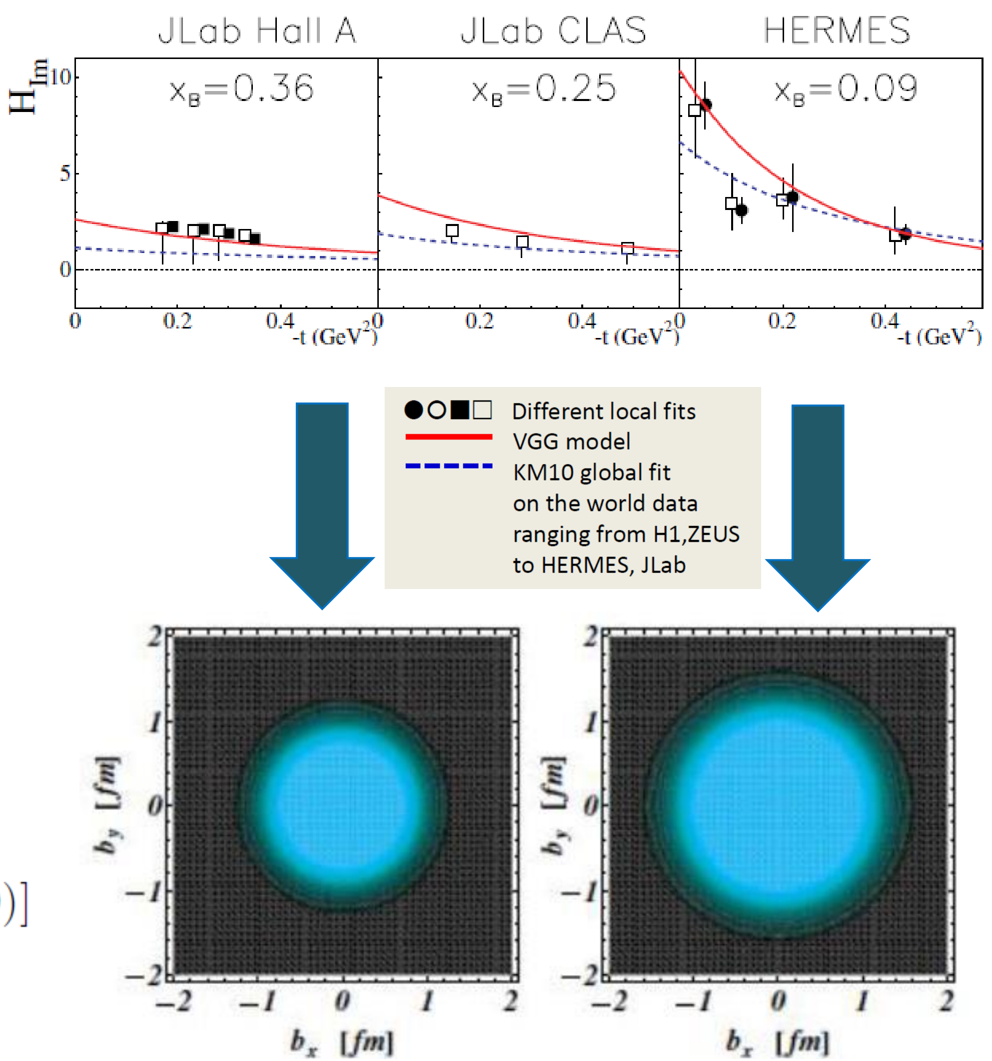
Hard Exclusive Processes → GPDs

Goal 1: Transverse Imaging of Nucleon

Fourier transform of t-dependence



The First Crude Images - **the GPD H in *Im* DVCS**



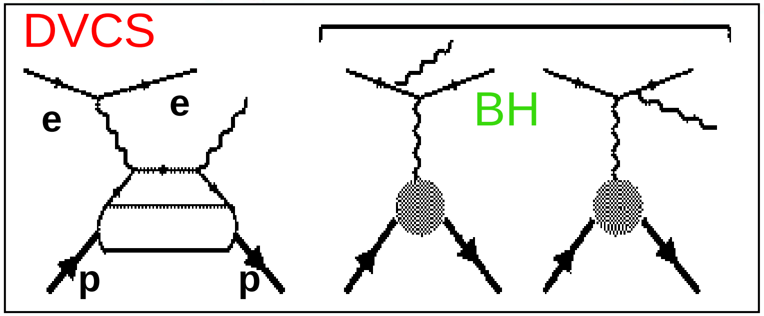
Goal 2: Orbital Angular Momentum

Ji's Sum Rule for $J^q = \frac{1}{2}\Delta\Sigma + L^q$

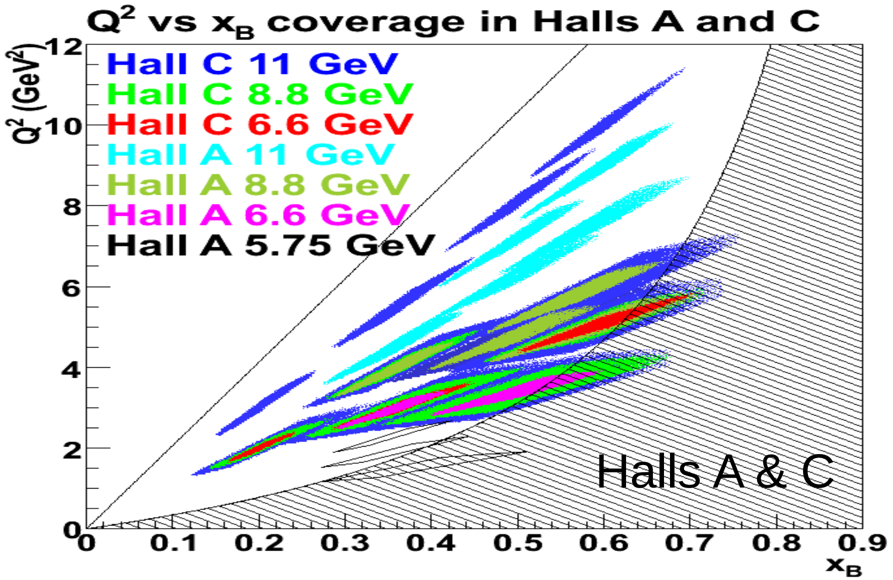
$$J^q = \frac{1}{2}\int_{-1}^{1} x\,dx\,[H^q(x,\xi,t=0) + E^q(x,\xi,t=0)]$$

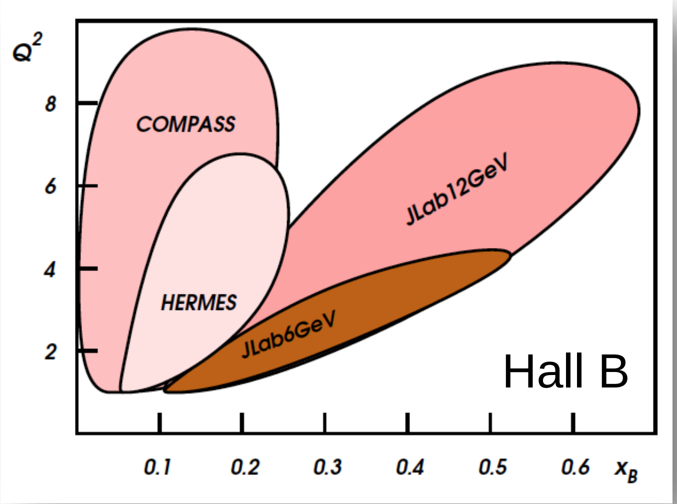
Towards the 3D Structure of the Proton

Simplest process: **e + p → e' + p + γ (DVCS)**



DVCS measurements are planned in all three Halls: A, B, C; meson production in B and C





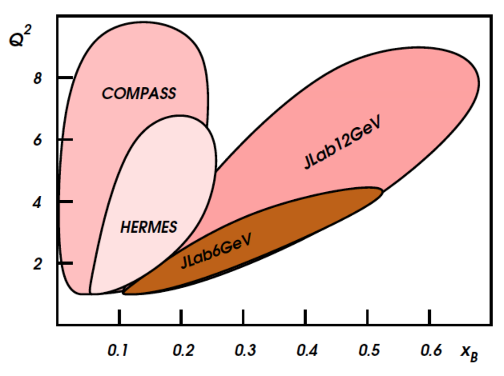
- Scaling of the Compton Form Factor
- Rosenbluth-like separation of DVCS:

$$\sigma = |BH|^2 + Re[DVCS^{\dagger}BH] + |DVCS|^2$$
$$\sim E^2_{Beam} \qquad \sim E^3_{Beam}$$

- L/T Separation of $\pi^{+/o/-}$ and K^+ production

- General survey DVCS program: all the DVCS observables accessible with a polarized beam, a longitudinally and a transversely polarized target.
- General survey meson production.

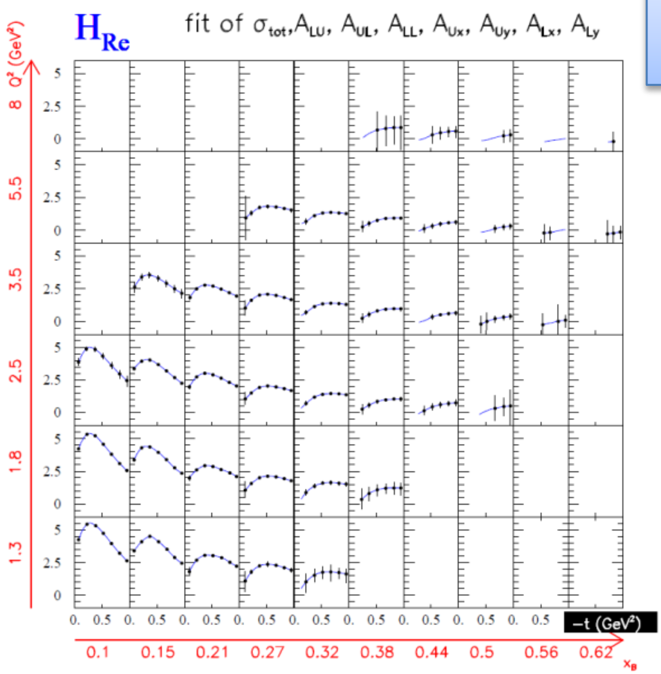
Towards the 3D Structure of the Proton

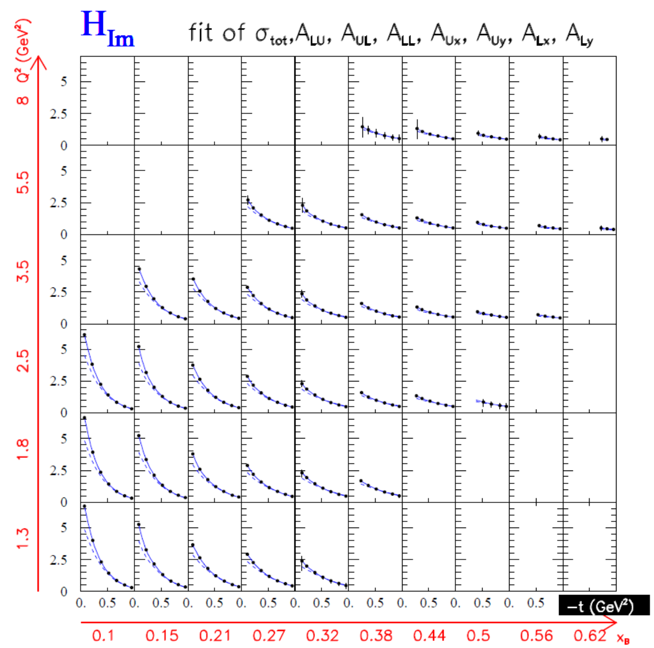


Hall B beam-spin asymmetry data show potential for imaging studies from analysis in x, Q^2 and t

- **CLAS12** **is expected to measure all the DVCS observables accessible with a polarized beam, a longitudinally and a transversely polarized target.**

Example: impact on $\mathcal{H}$





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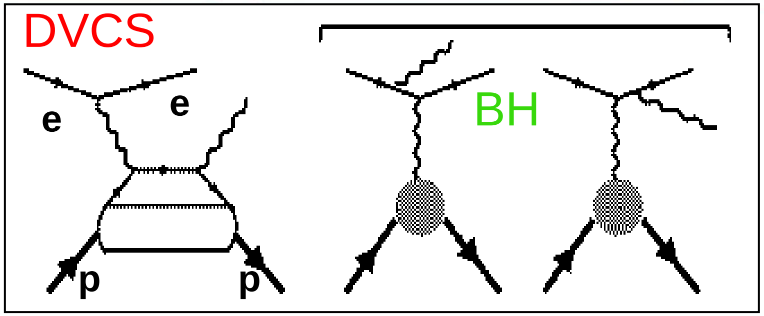
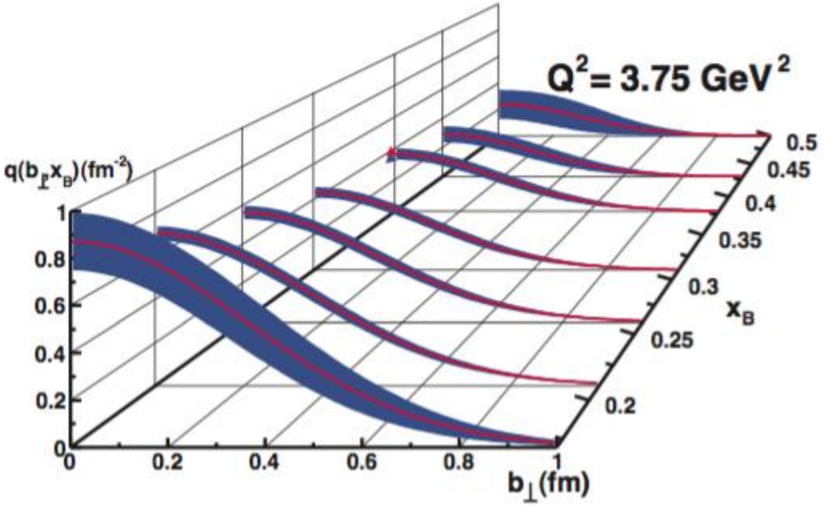


- Polarized beam, unpolarized target: ***H(ξ,t)***
- Unpolarized beam, long. polarized target: ***H̃(ξ,t)***
- Unpolarized beam, transv. polarized target: ***E(ξ,t)***

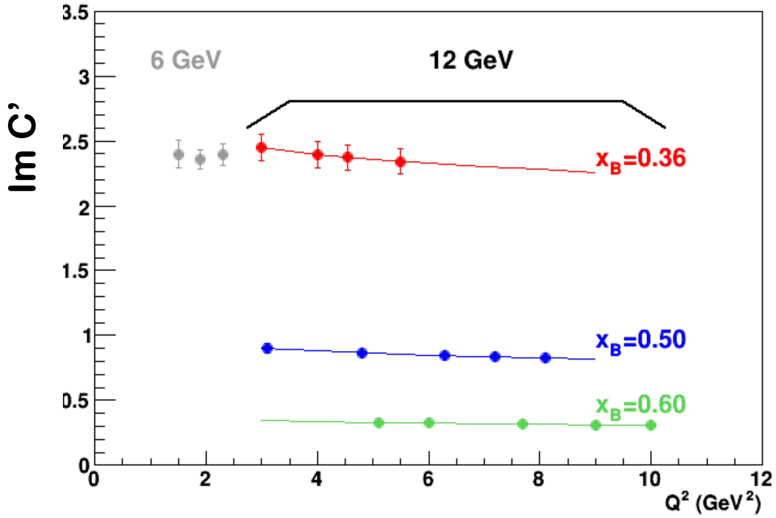
Hall B beam-spin asymmetry data show potential for imaging studies from analysis in x, Q^2 and t

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

12 GeV projections: transverse spatial maps

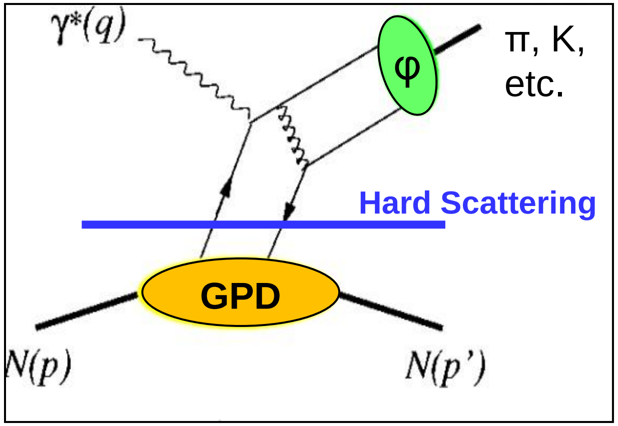


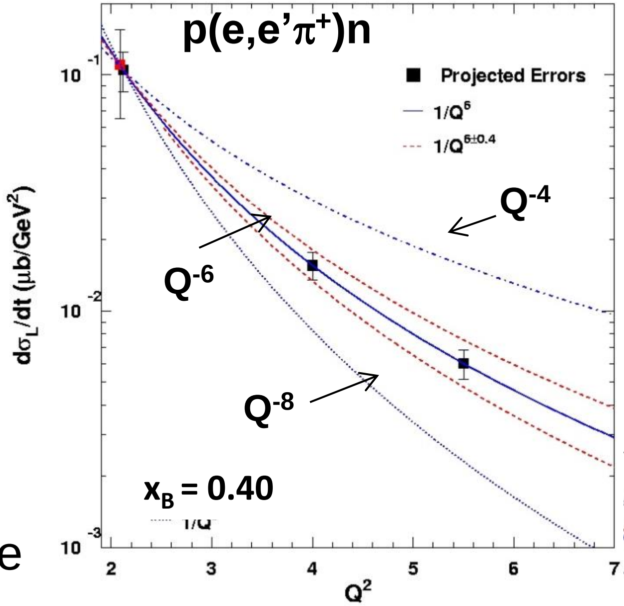
12 GeV projections: confirm formalism



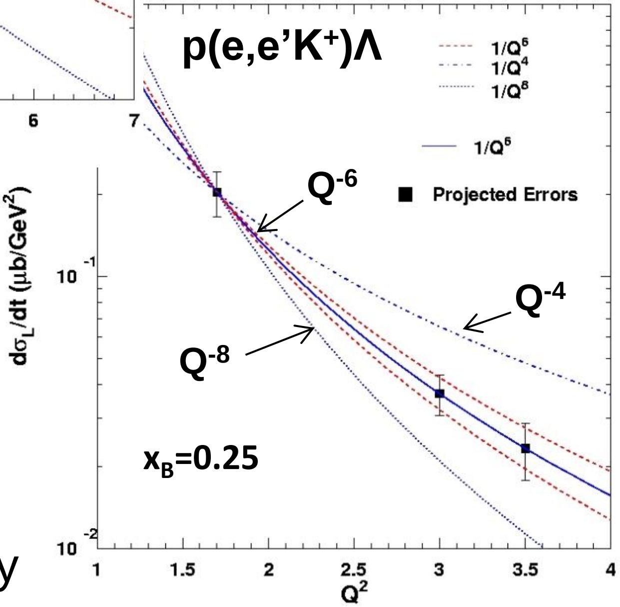
Hall C: Factorization in π^+ and K^+ Electroproduction

$$\sigma = \Gamma(\sigma_T + \varepsilon\sigma_L + \varepsilon \cos(2\phi)\sigma_{TT} + [\varepsilon(\varepsilon+1)/2]^{1/2}\cos(\phi)\sigma_{LT})$$





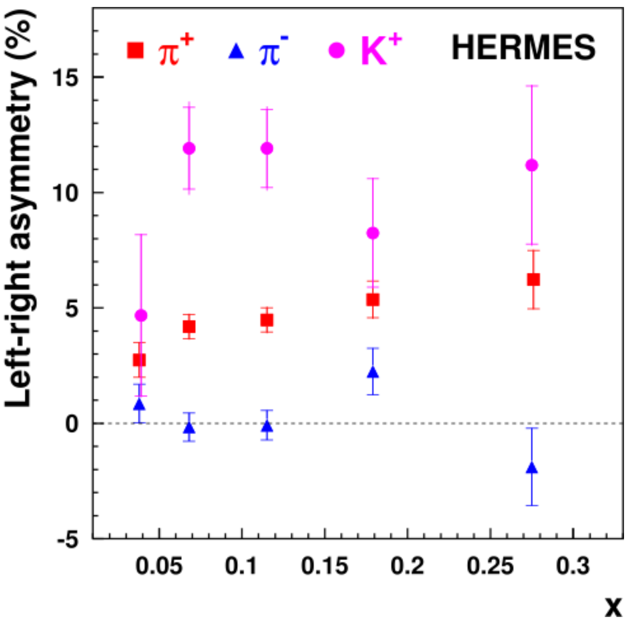
Fit: $1/Q^n$



- One of the most stringent tests of factorization is the Q^2 dependence of the π and K electroproduction cross section
  - σ_L scales to leading order as Q^{-6}
- Experimental validation of factorization essential for reliable interpretation of results from the JLab GPD program at 12 GeV for meson electroproduction
- K and π together provide quasi model-independent study

3D Parton Distributions: TMDs

A surprise of transverse-spin experiments



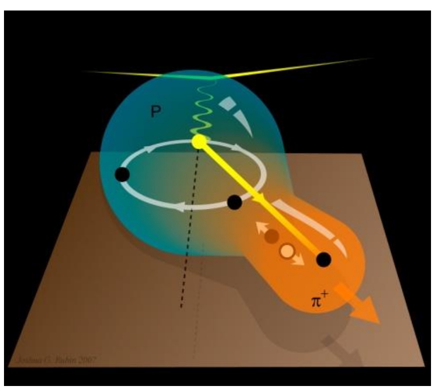
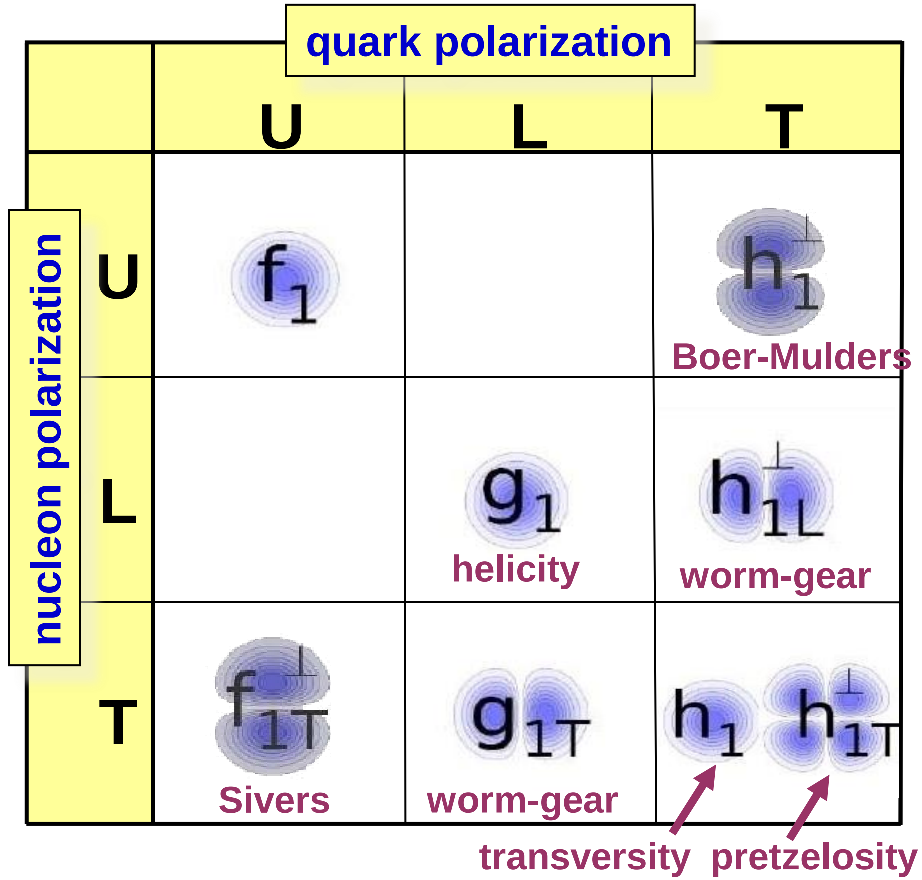


Illustration of the possible correlation between the internal motion of an up quark and the direction in which a positively-charged pion ($u\bar{d}$) flies off.

- **Access orbital motion of quarks**
  ➔ contribution to the proton's spin
- Observables: Azimuthal asymmetries due to correlations of spin q/n and transverse momentum of quarks



TMDs and SIDIS - Formalism

General formalism for (e,e'h) coincidence reaction w. polarized beam: [A. Bacchetta et al., JHEP 0702 (2007) 093]

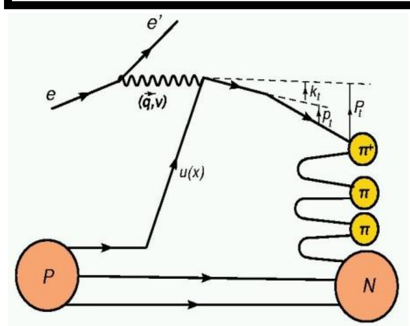
$$\frac{d\sigma}{dxdy\,d\psi dz d\phi_h dP_{h,t}^2} = \frac{\alpha^2}{xyQ^2}\frac{y^2}{2(1-\varepsilon)}\left(1+\frac{\gamma^2}{2x}\right)\Big\{F_{UU,T} + \varepsilon F_{UU,L} +$$

$$\sqrt{2\varepsilon(1+\varepsilon)}\cos\phi_h F_{UU}^{\cos\phi_h} + \varepsilon\cos(2\phi_h) F_{UU}^{\cos(2\phi_h)} + \lambda_e\sqrt{2\varepsilon(1+\varepsilon)}\sin\phi_h F_{LU}^{\sin\phi_h}\Big\}$$

(Ψ = azimuthal angle of e' around the electron beam axis w.r.t. an arbitrary fixed direction)

If beam is unpolarized, and the (e,e'h) measurements are fully integrated over ϕ, only the $F_{UU,T}$ and $F_{UU,L}$ responses, or the usual transverse (σ_T) and longitudinal (σ_L) cross section pieces, survive.

Unpolarized k_T-dependent SIDIS: $F_{UU}^{\cos(\phi)}$ and $F_{UU}^{\cos(2\phi)}$, in framework of Anselmino et al. described in terms of *convolution of quark distributions f and (one or more) fragmentation functions D*, each with own characteristic (Gaussian) width. Transverse momentum widths of quarks with **different flavor (and polarization)** can be different.

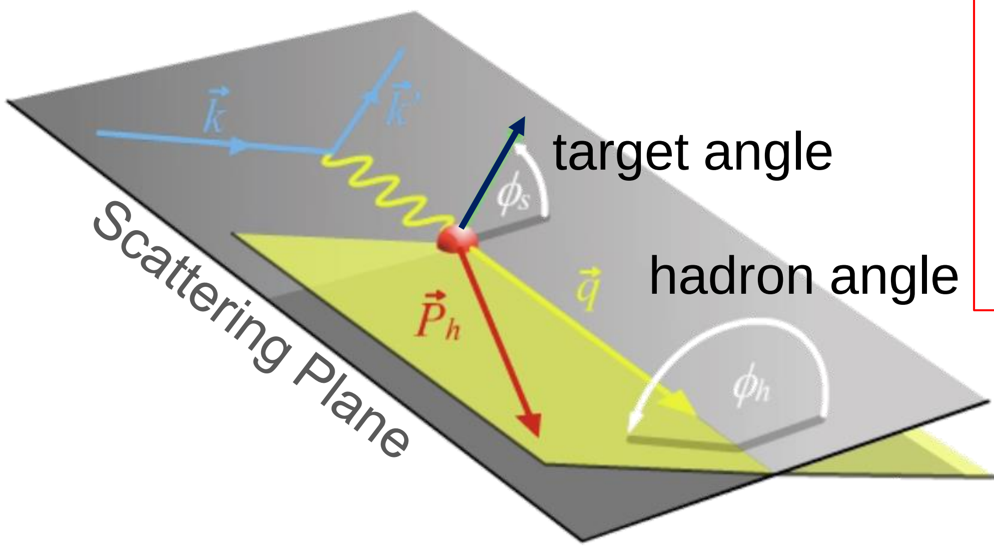


Final transverse momentum of the detected pion $\mathbf{P}_t$ arises from convolution of the struck quark transverse momentum $\mathbf{k}_t$ with the transverse momentum generated during the fragmentation $\mathbf{p}_t$.

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

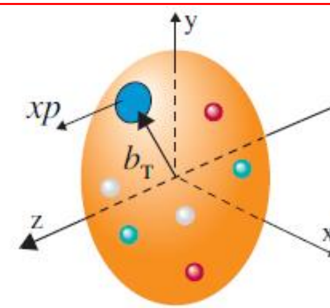
TMDs Accessible through Semi-Inclusive Physics

- Separate Sivers and Collins effects



Naturally, two scales:
- High Q: localized probe
  to "see" quarks and gluons
- Low P_T: sensitive to confining scale
  to "see" their confined motion

\+ Theory input: TMD QCD factorization
TMD QCD evolution

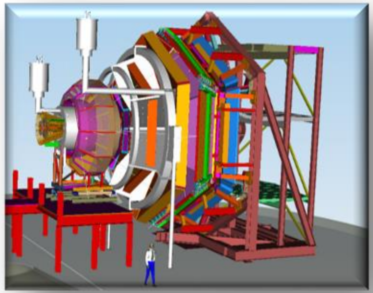


- **Sivers** angle, effect in distribution function: **(ϕ_h-ϕ_s)**
- **Collins** angle, effect in fragmentation function: **(ϕ_h+ϕ_s)**
- Or other combinations: Pretzelosity: **($3\phi_h$-ϕ_s)**

Together stronger: SIDIS Studies with 12 GeV

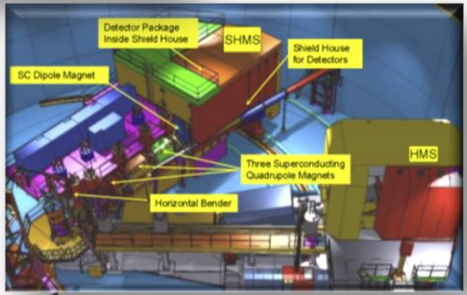
- **CLAS12 in Hall B**

  General survey, medium lumi



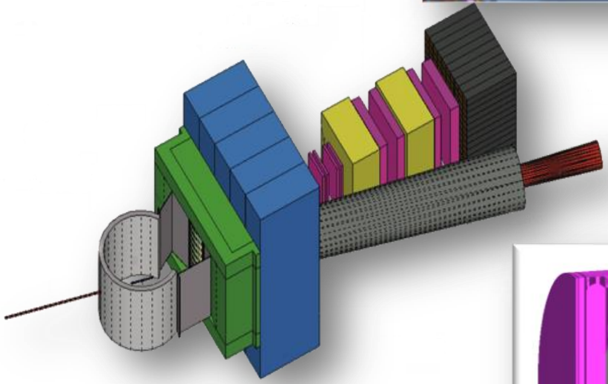
- **SHMS- HMS in Hall C**

  L-T studies, precise π^+/π^- ratios



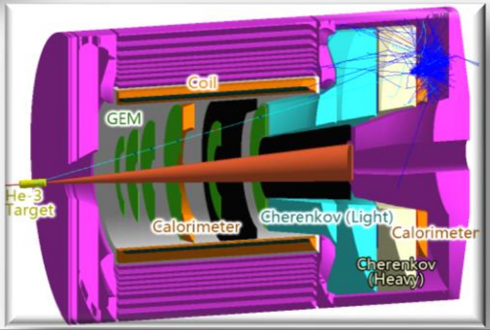
- **SBS in Hall A**

  High x, High Q^2, 2-3D



- **SOLID in Hall A**

  High Lumi and acceptance – 4D



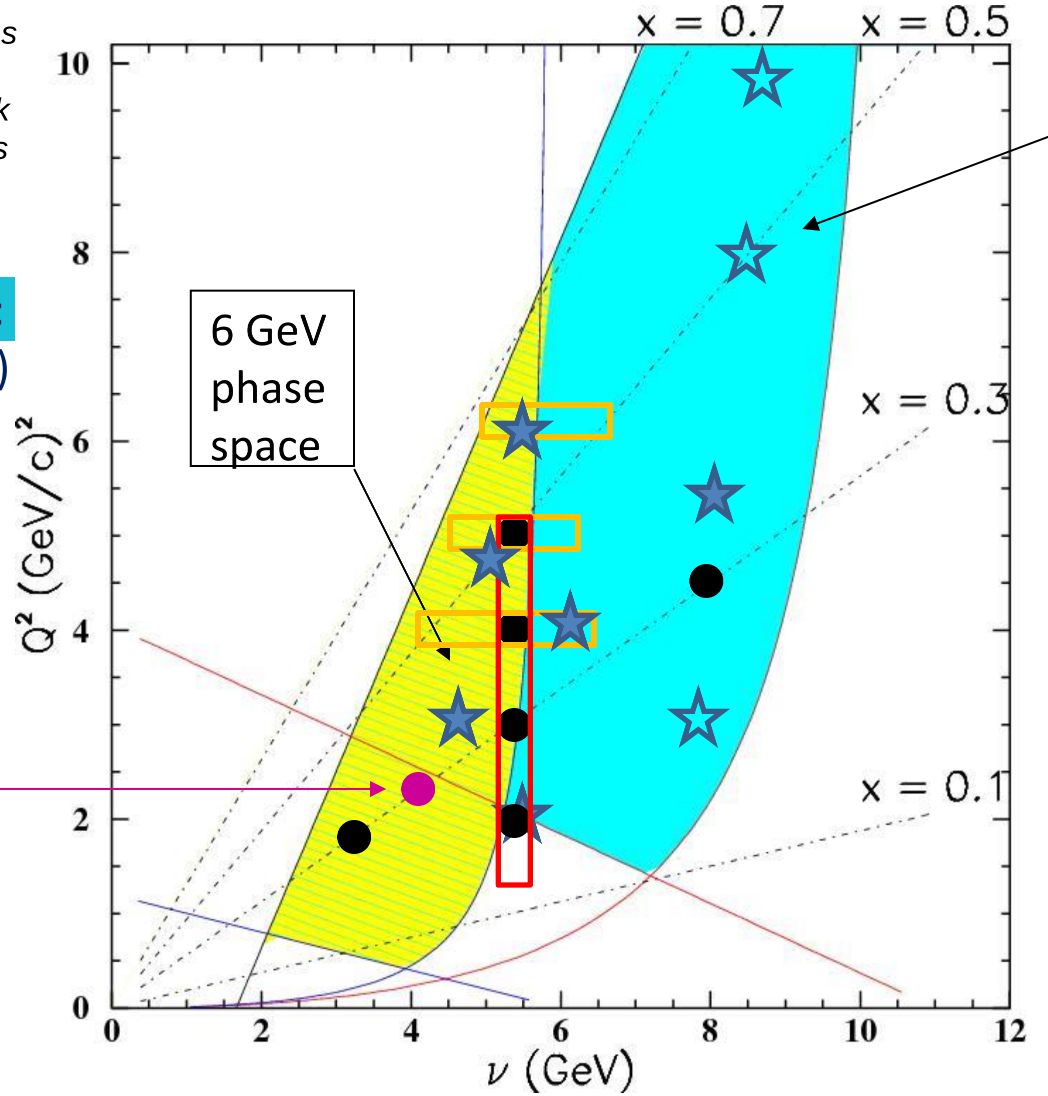
Hall C SIDIS Program (typ. x/Q^2 ~ constant)

HMS + SHMS (or NPS) Accessible Phase Space for SIDIS

Accurate cross sections for validation of SIDIS factorization framework and for L/T separations

E12-13-007
Neutral pions:
Scan in (x,z,P_T)
Overlap with E12-09-017 & E12-09-002

Parasitic with E12-13-010



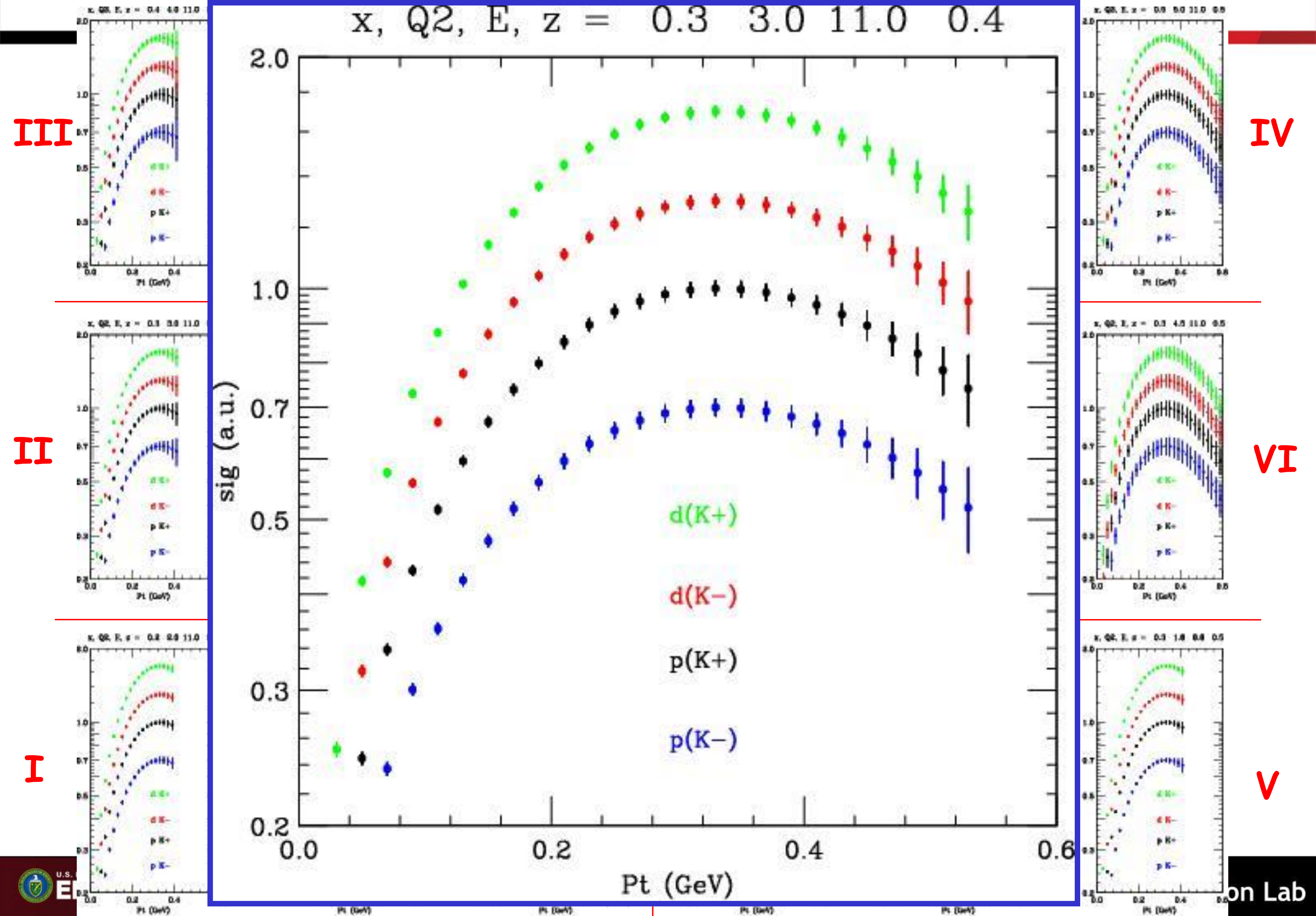
Charged pions:

E12-06-104
L/T scan in (z,P_T)
No scan in Q^2 at fixed x: $R_{DIS}(Q^2)$ known

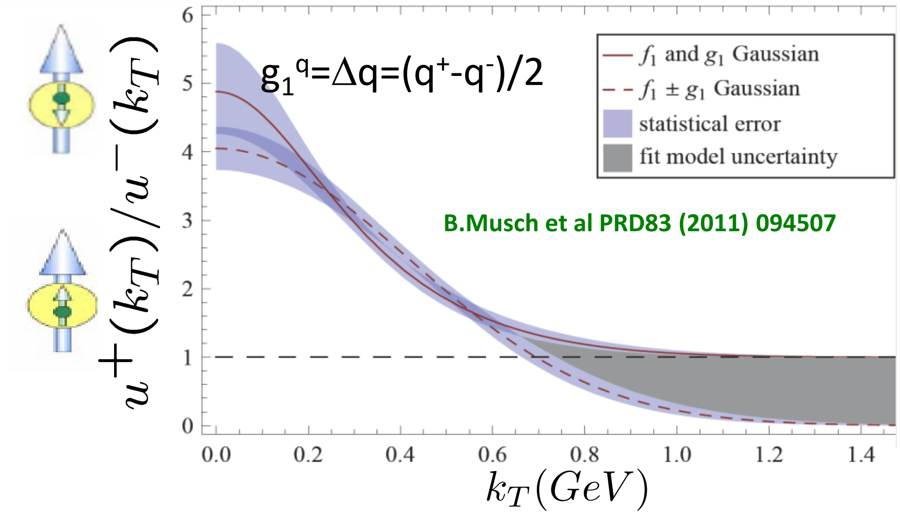
E12-09-017
Scan in (x,z,P_T)
+ scan in Q^2 at fixed x

E12-09-002
+ scans in z

Hall C Projected Results – Kaons



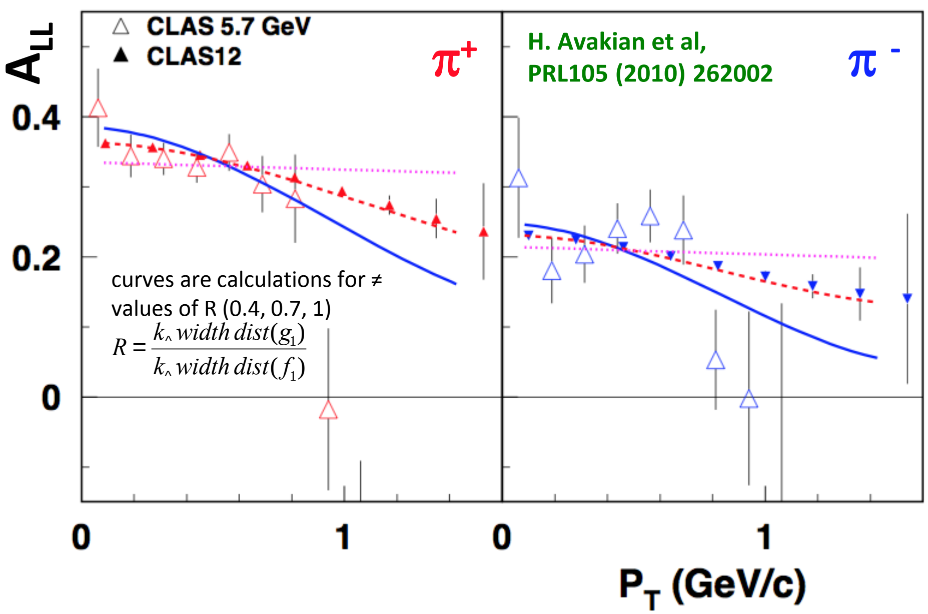
CLAS12: K_T Helicity Dependence



- Higher probability to find a quark anti-aligned with proton spin at **large k_T**
- Important to have q^+ and q^- **k_T** dependent distribution separately
- q^- sensitive to orbital motion:

$$q^-_{L=1} \sim (1-x)^5 log^2(1-x)$$

H. Avakian et al. PRL 99 (2007) 082001



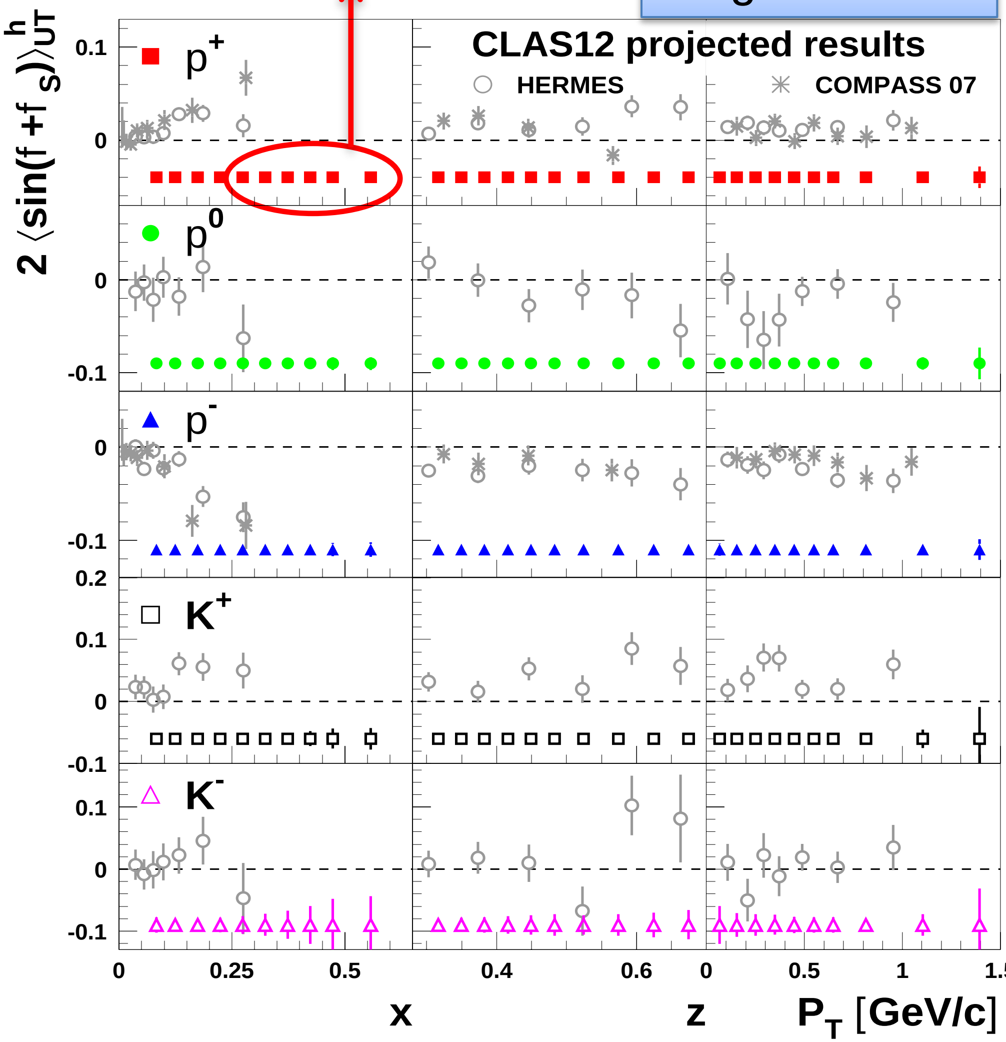
- Double spin asymmetries from CLAS@JLab consistent with wider **k_T** distributions for f_1 than for g_1
- **Wider range in P_T from CLAS12 is crucial !**

Measurements of the P_T-dependence of A_{LL} ($\propto g_1/f_1$) provide access to transverse momentum distributions of quarks anti-aligned with the proton spin.

Transversity with CLAS12

Large x important to constrain the tensor charge

Single Hadron

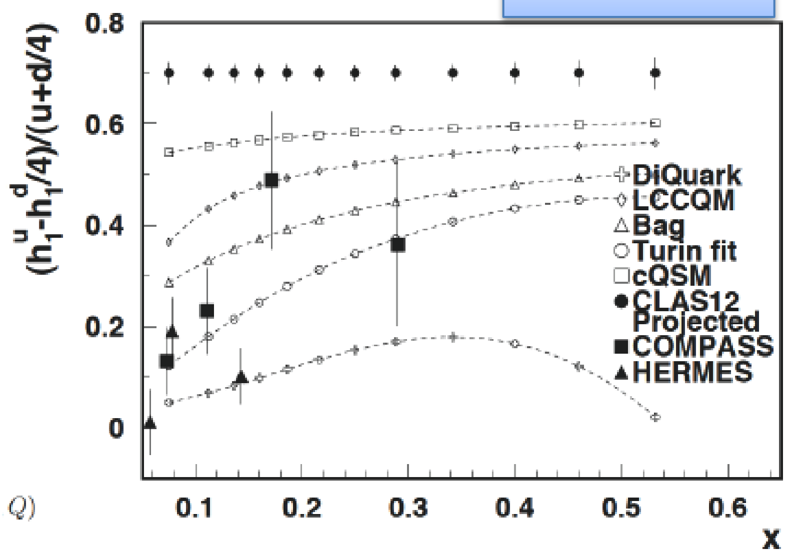


High Impact Exp. From PAC41 (C12-11-111 + C12-12-009)

N/q	U	L	T	
U	f_1		$h_1^\perp$	
L		g_1	$h_{1L}^\perp$	
T	$f_{1T}^\perp$	$g_{1T}^\perp$	h_1	$h_{1T}^\perp$

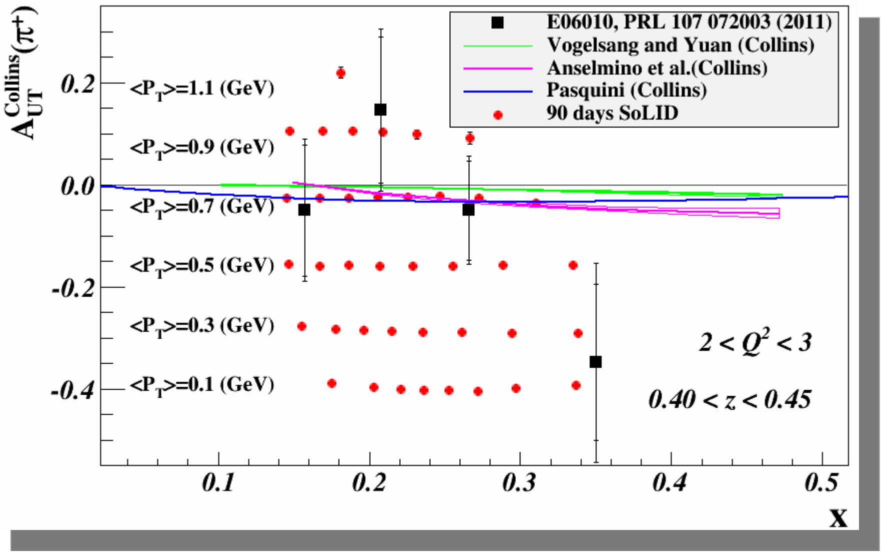
- HD-transversely polarized target and CLAS12

Di-hadron

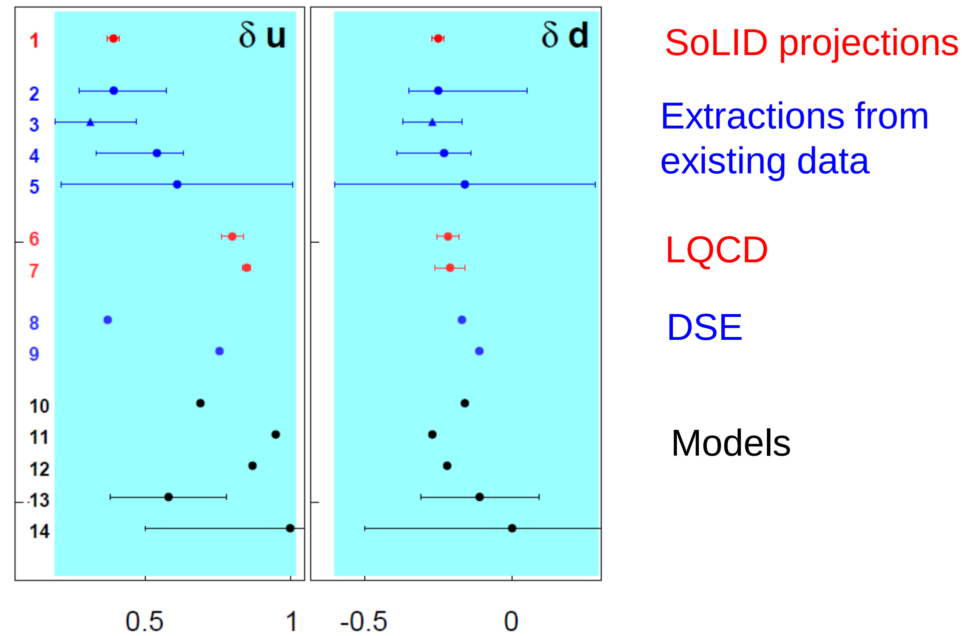


TMD Program in Hall A with SoLID & SBS

(match large acceptance devices at high luminosity to anticipated polarized 3He target performance)



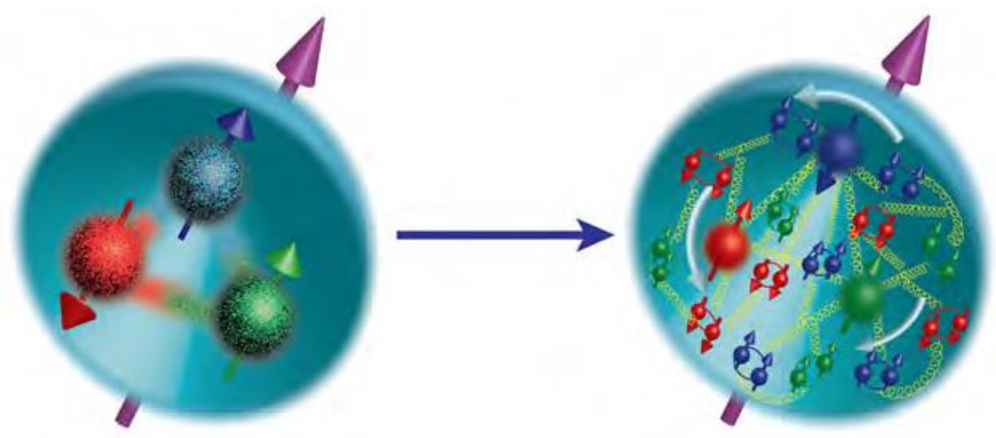
Tensor Charges



SoLID projection extraction by A. Prokudin using **only** statistical errors and based on:

- a set of data with a limited range of x values
- the assumption of a negligible contribution from sea quarks
- assumption on Q^2 evolution
- model dependent assumptions on the shape of underlying TMD distributions

The Incomplete Nucleon: Spin Puzzle



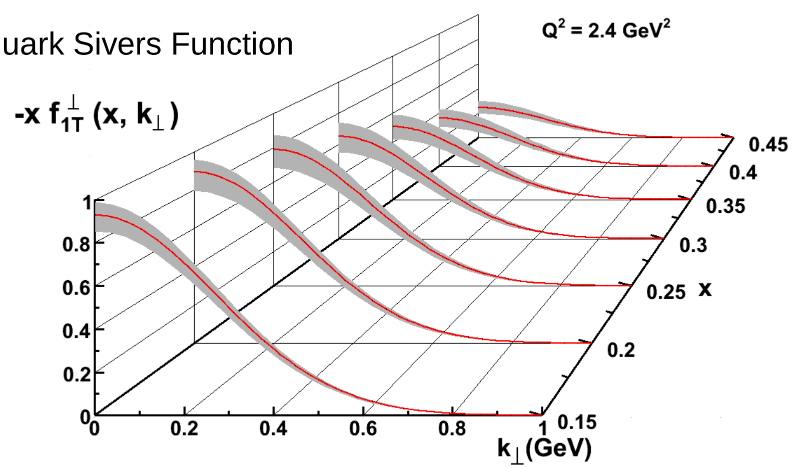
$$\frac{1}{2} = \frac{1}{2}\Delta\Sigma + L_q + J_g$$

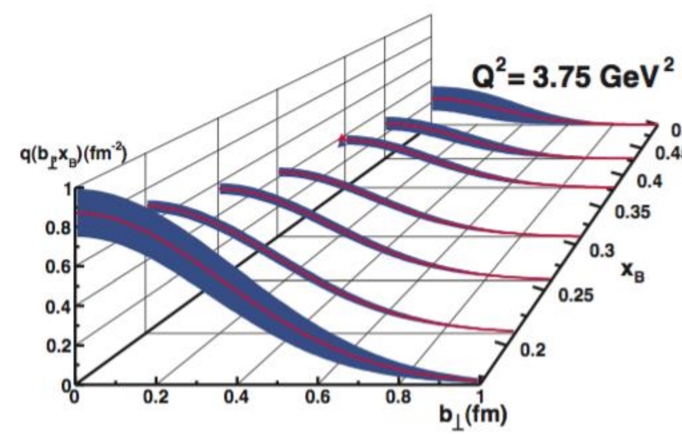
- $\Delta\Sigma \sim 0.25$ (world DIS)
- ΔG small (RHIC+DIS)
- L_q?

Longitudinal momentum fraction x and transverse momentum images

Longitudinal momentum fraction x and transverse spatial images

Up quark Sivers Function

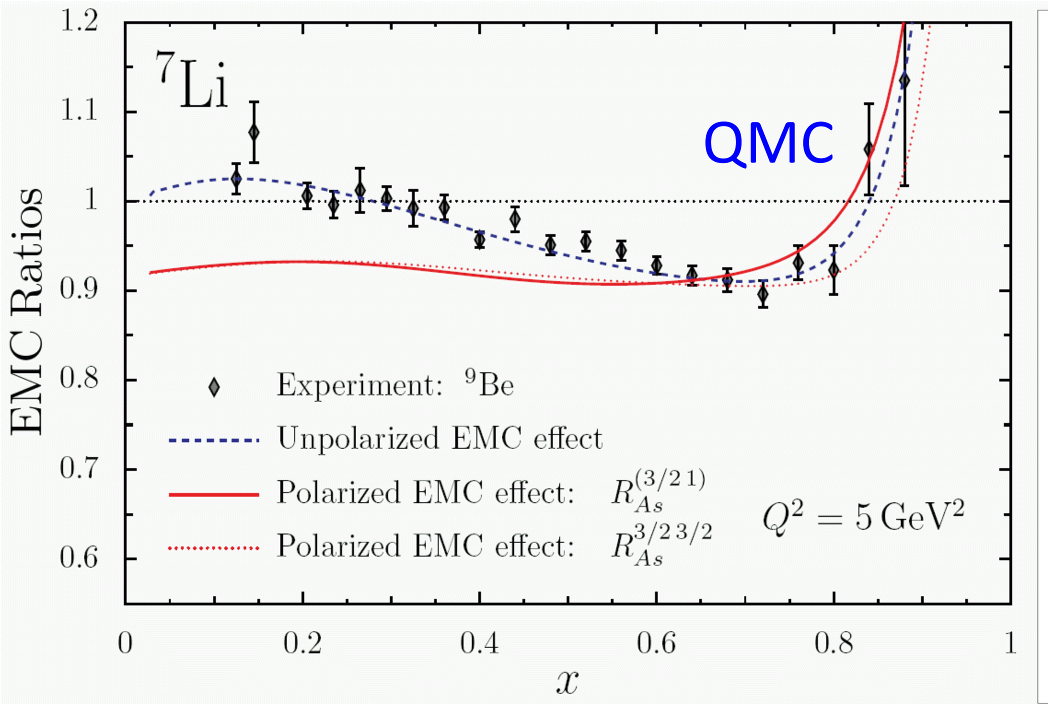


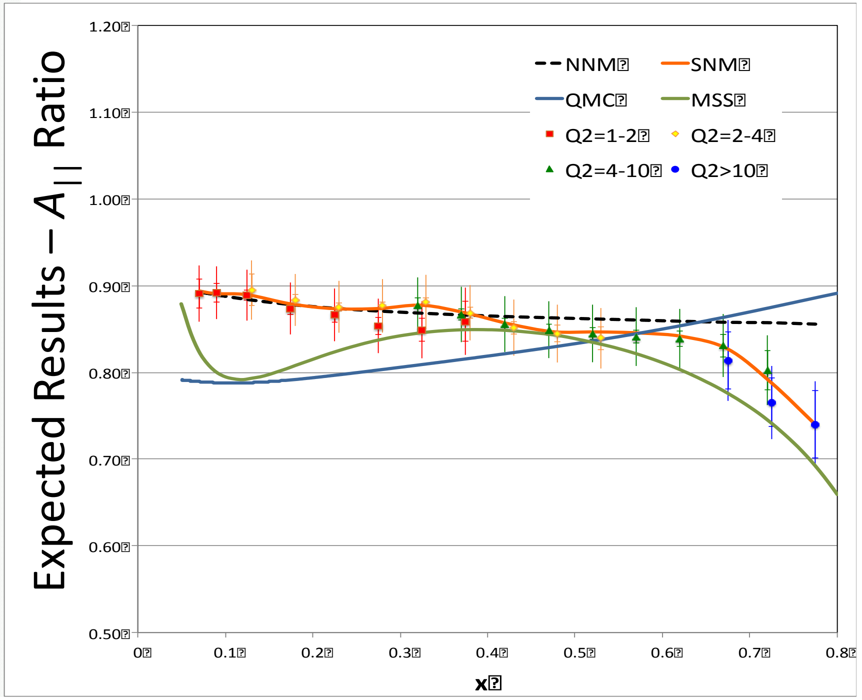


12 GeV projections: valence quarks well mapped

g_1(A) – "Polarized EMC Effect"

- Calculations indicate larger effect for polarized structure function ratio than for unpolarized: scalar field modifies lower components of Dirac wave function
- Spin-dependent parton distribution functions for nuclei nearly unknown

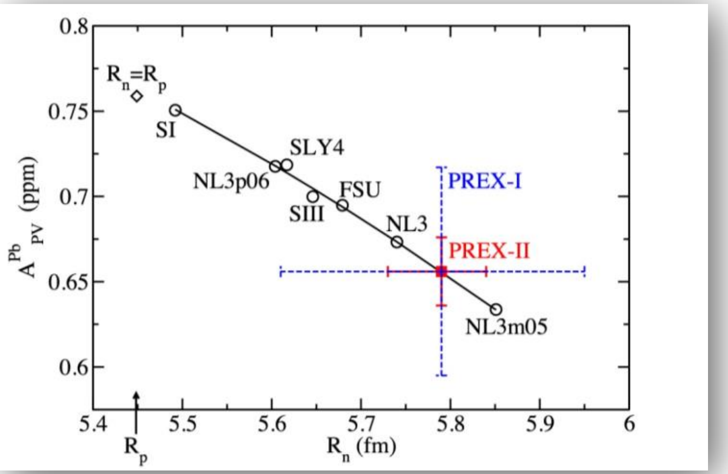


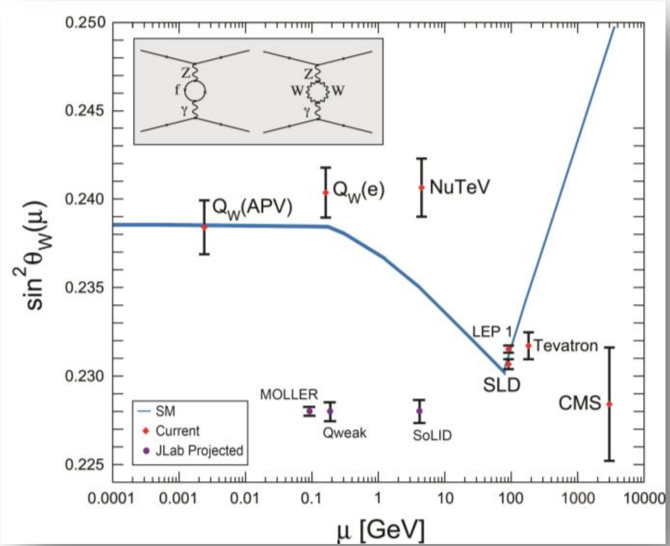


- After 30 years, still no universally accepted model of the EMC-effect
- Spin degrees of freedom access specific nuclear orbitals and dynamical mechanisms
- Part of four-pronged EMC effect attack at 12-GeV: precision (while varying n/p ratio), extraction of F_2^n, tagging, polarized

Parity Violation at JLab

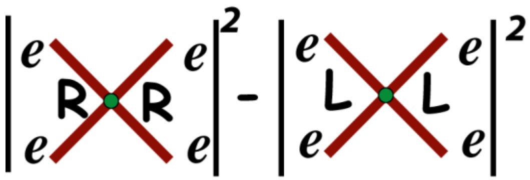
- Strangeness Form Factors (complete)
  HAPPEX (Hall A)
  G0 (Hall C)
- PREX neutron skin
  first experiment completed
  PREX-II and CREX preparation ongoing
- Qweak (under analysis)
  proton weak charge
- MOLLER
  electron weak charge
  purely leptonic interaction
- SoLID
  lepto-quark couplings
  d/u, higher-twist





Møller Parity-Violating Experiment: New Physics Reach

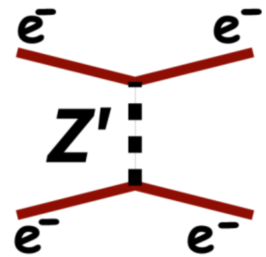
(example of large installation experiment with 11 GeV beam energy)

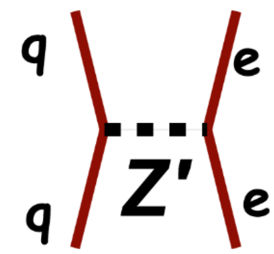


JLab Møller

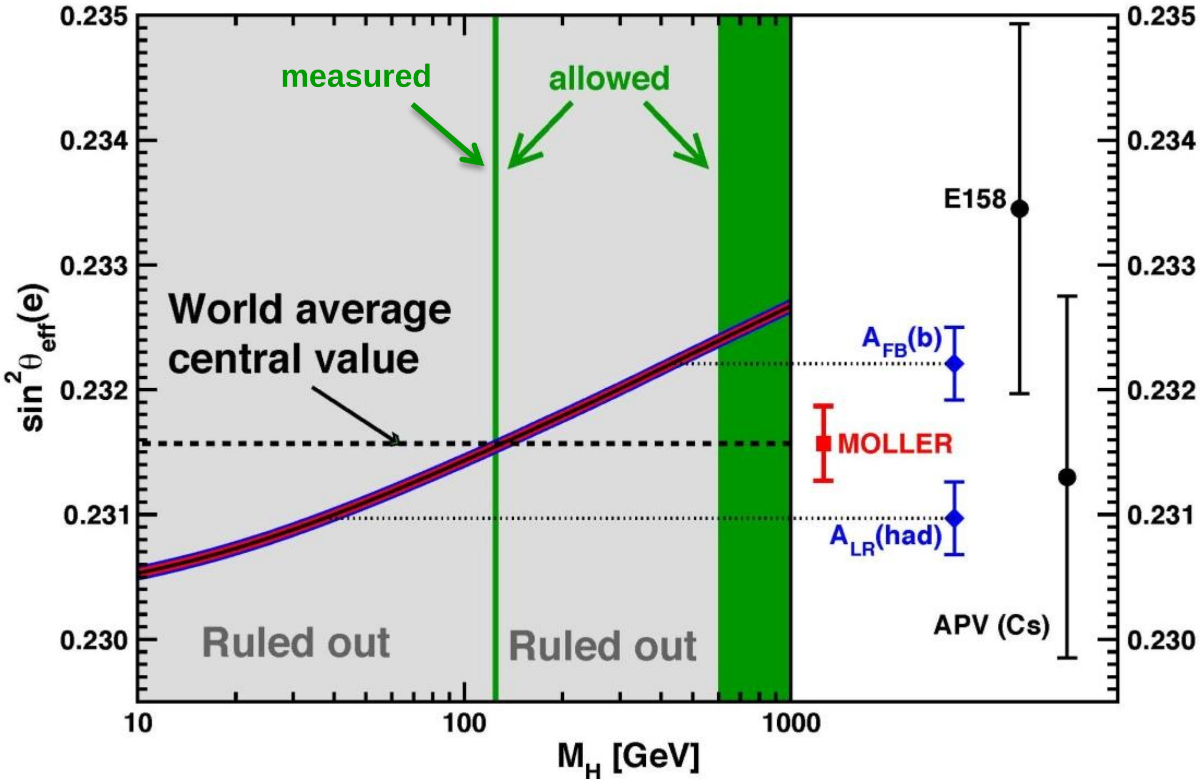
Λ_{ee} ~ 25 TeV

New Contact Interactions





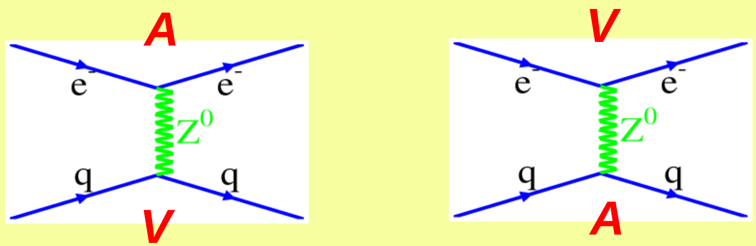
LHC



Known Higgs mass now fixes the SM curve → Not "just another measurement" of $\sin^2(\Theta_W)$

- $A_{FB}(b)$ measures the product of e- and b-Z couplings
- $A_{LR}(had)$ measures purely the e-Z couplings
- Proposed $A_{PV}(b)$ measures purely the e-Z couplings at a different energy scale

Use precision JLab data to unravel the C_{1q} & C_{2q} couplings



$C_{1i} \equiv 2 g_A^e g_V^i$ $\quad$ $C_{2i} \equiv 2 g_V^e g_A^i$

Vector quark couplings *Axial-vector quark couplings*

$$A_{LR} = A_{PV} = \frac{\sigma_\uparrow - \sigma_\downarrow}{\sigma_\uparrow + \sigma_\downarrow} \sim \frac{A_{weak}}{A_\gamma} \sim \frac{G_F Q^2}{4\pi\alpha}$$

$$\times\ (\alpha\ [2C_{1u} - C_{1d}] + \beta\ [2C_{2u} - C_{2d}])$$

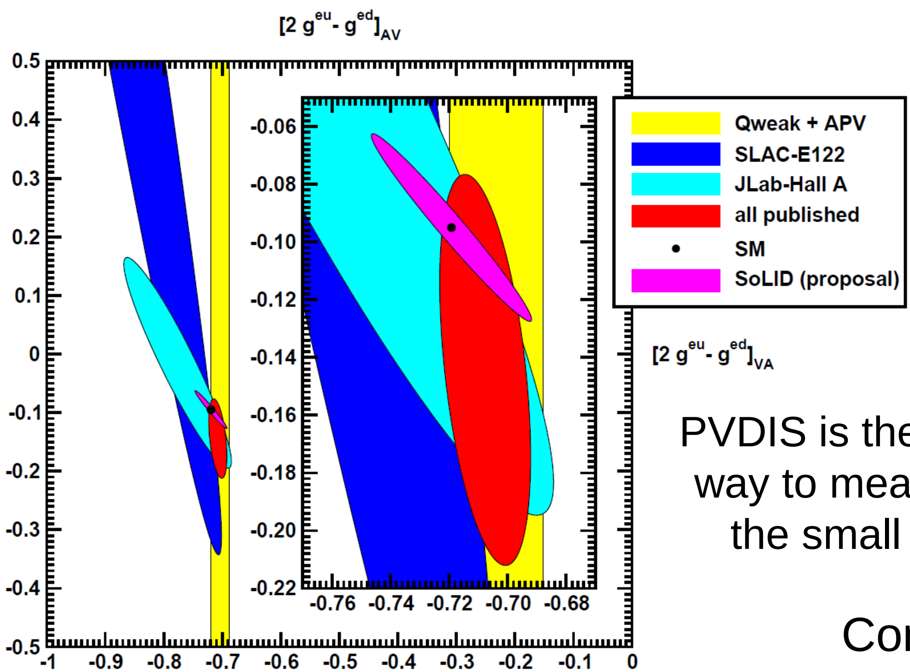
Nature 506, 67–70 (06 February 2014)

The Jefferson Lab PVDIS Collaboration

See also News & Views, *Nature* 506, 43–44 (06 February 2014)

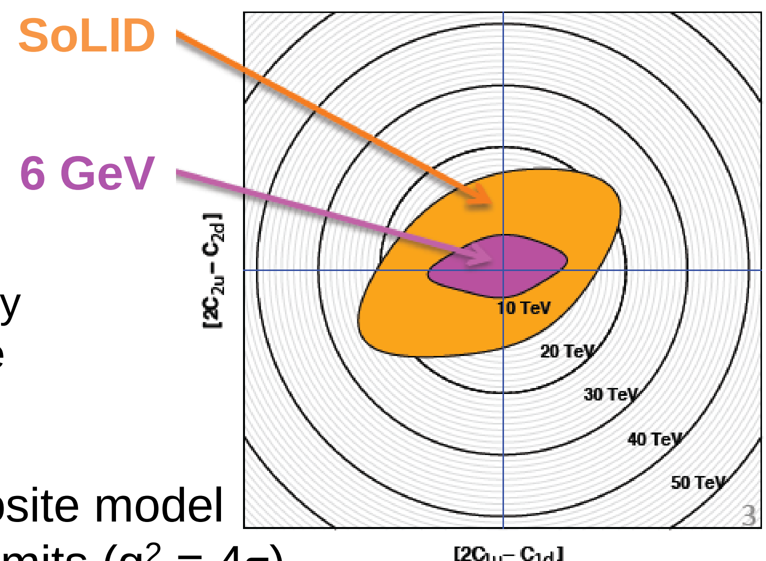
$2C_{2u} - C_{2d} = 0.145 \pm 0.068$

With SoLID: $\delta(2C_{2u}-C_{2d}) = 0.003$



6 GeV **(+ SoLID@12 GeV)**

PVDIS is the only way to measure the small C_2

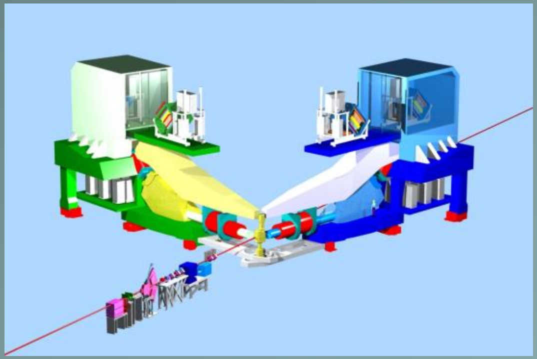


Composite model mass limits ($g^2 = 4\pi$)

Status of 12-GeV towards Spin Physics - Summary

We have made all the necessary preparations to have a chance for high-impact science already as early as FY15

1) 12-GeV Accelerator has been installed and has started commissioning
2) In Hall A, equipment is on the floor to execute together both a 3rd generation DVCS experiment to validate the formalism towards 3D spatial imaging in the simplest process, and a precision measurement of elastic e-p cross section - a necessary ingredient of the JLab form factor program.
3) In Hall D, all preparations have been made to possibly reap science benefit from the engineering run. With 30 days of engineering run exciting discovery science can come out if we are lucky…
4) In Hall B, we have potential to prepare for two high-impact experiments both in the upstream and downstream beam line alcove, if compatible with CLAS-12 installation, to do a Heavy Photon Search and measure the Proton Radius.
5) A tremendous outlook for a spin program in Hall C (precision), Hall B (general survey, all processes) and Hall A (future installations) is approaching!



Preliminary Plans for Early Beam in Hall A

- 3 A-rated experiments in first years of running
- DVCS (HRS-L + calo) and G_M^p (HRS-R) run is combined
- Some flexibility incorporated

16 mo. Shutdown

12 GeV Commissioning

Early Experiments

high impact

DVCS-I / G_M^p
Access to GPDs — EM Form Factor

high impact

$^3H/^3He$ d/u at High x

high impact

PREX Neutron skin

high impact

(A_1^n, APEX) Neutron spin structure

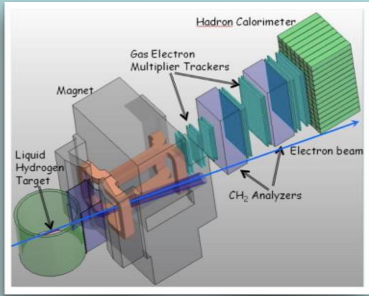
SBS Experiments

EM Form Factors at high Q^2

12 GeV Projects:
1. Moller polarimeter
2. Compton polarimeter
3. Energy Meas. upgrade

SBS Project

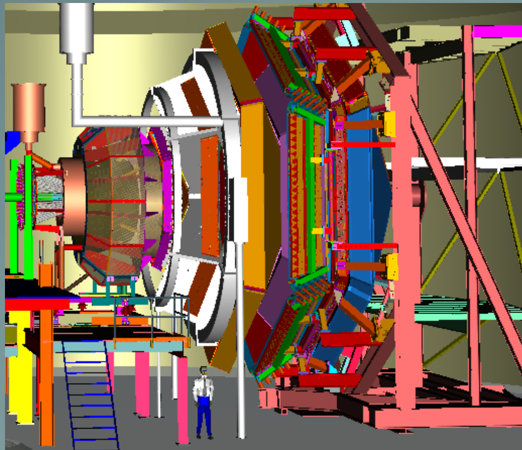
SuperBigbite Spectrometer



Beam 1st to Hall A

11 GeV

FY 2013	FY 2014	FY 2015	FY 2016	FY 2017



Preliminary Plans for First Years of Beam in Hall B

- 6 A rated experiments in first 3 years of running
- PCR, HPS, pDVCS, nDVCS, pSIDIS, g_1^p/g_1^n
- High discovery potential during first year

Pre-CLAS12

CLAS12

Construction

Installation

Early 11 GeV Experiments

< 6 GeV beam

Installation

Heavy Photon Search

Proton Charge Radius

high impact

1st beam to Hall B

First 11 GeV

pDVCS & GPDs pSIDIS & TMDs

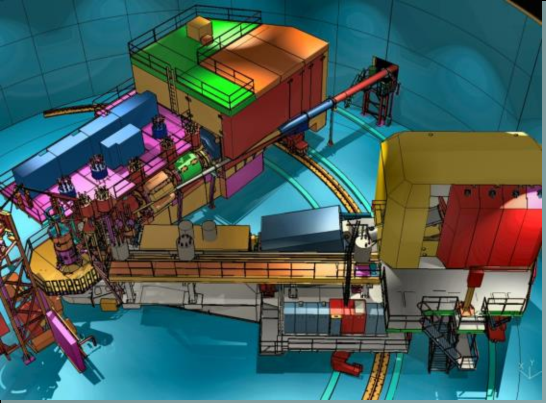
nDVCS & GPDs nSIDIS & TMDs

g_1^p , g_1^n large x spin str.

Proton TMDs Transverse spin structure

high impact

FY 2014 | FY 2015 | FY 2016 | FY 2017 | FY 2018



Preliminary plans for Early Beam in Hall C

- Straightforward "commissioning experiments"
- Basic SIDIS and easiest L/T separation
- Base equipment in early years

SHMS Installation

12 GeV Commissioning

Early Experiments

p, d,A(e,e'),
A(e,e'p), d(e,e'p)

High x nucleon structure
Short-range nuclear structure

high impact

A_1^n, d_2^n

Neutron Spin Structure

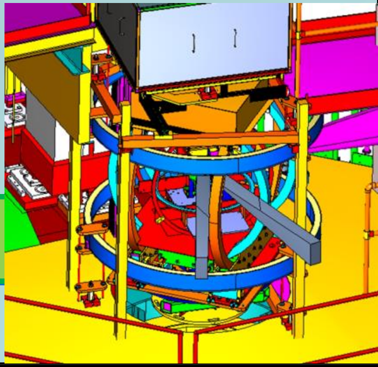
TMDs, CSV, (e,e'K)

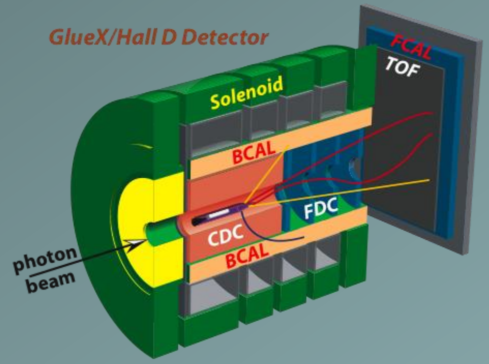
Basic SIDIS cross sections
Charge Symm. Violation
Deep Exclusive Kaon Prod.

Polarized ^{3}He Experiments

1st 11 GeV Beam

FY 2015	FY 2016	FY 2017	FY 2018





Preliminary Plans for First Beam in Hall D

- Search for Gluonic Excitations (GlueX)
- η, η' couplings, rare decays using Primakoff reaction

12 GeV Commissioning

GlueX

Primakoff
$\eta \rightarrow \gamma\gamma$

Hardware

Polarized Beam

$10^7 \gamma/s$

high impact

Light quark mass ratio
η and η' mixing angle

E = 12 GeV
polarized

E < 12 GeV
unpolarized

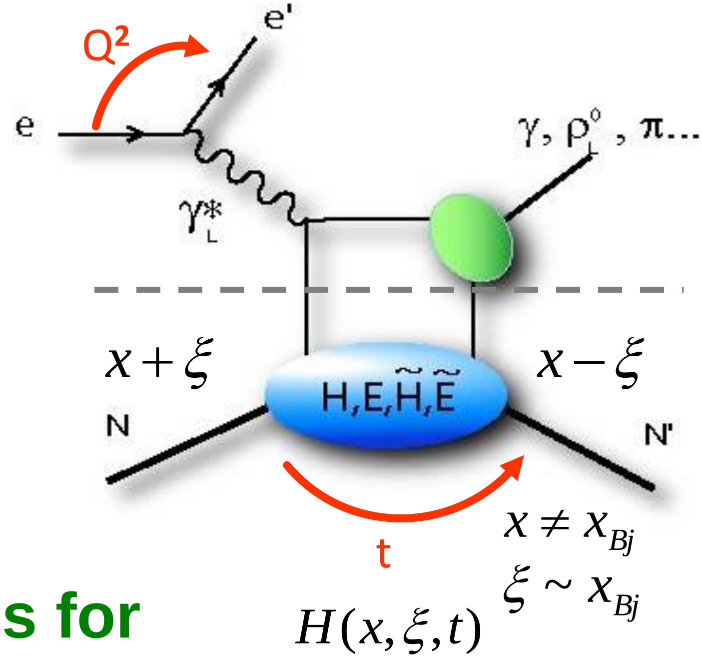
$10^8 \gamma/s$
preparations

FY 2014	FY 2015	FY 2016	FY 2017

3D Parton Distributions: GPD

- **Longitudinal** momentum fraction **x** at **transverse** location **b**

- At leading twist eight GPDs whose extraction is possible ony through **models/parameterizations ➔ needs data in a large kinematic domain of x_B, t, Q^2**



DVCS provides the cleanest process for accessing GPDs

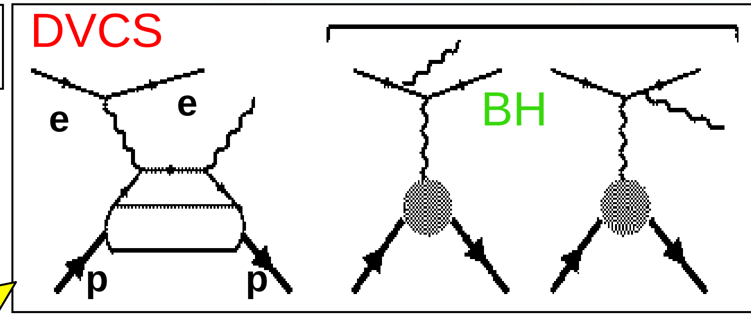
Polarized beam, unpolarized target: ➔ $H(\xi,t)$

Unpolarized beam, longitudinal polarized target: ➔ $\tilde{H}(\xi,t)$

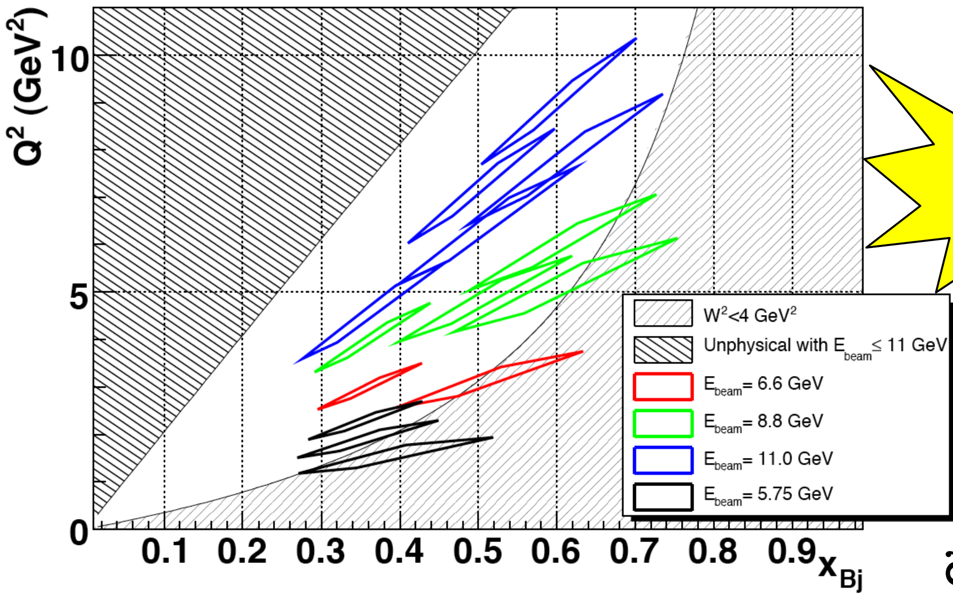
Unpolarized beam, transverse polarized target: ➔ $E(\xi,t)$

Towards the 3D Structure of the Proton: Hall A DVCS

Simplest process: **e + p → e' + p + γ (DVCS)**



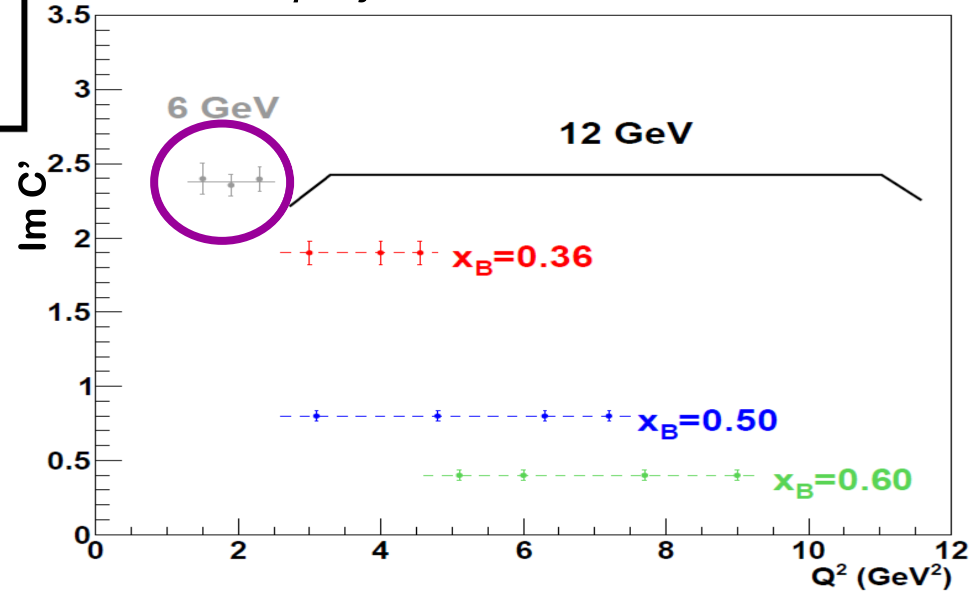
3rd Generation DVCS Experiment



high impact

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

12 GeV projections: confirm formalism



Goals for E12-06-114 (Hall A DVCS):

- To measure precise absolute cross-sections (3-5% stat and 4% sys uncertainties),
- To test the scaling of the DVCS amplitudes,
- To separate the *Re* and *Im* part of the DVCS Compton amplitudes.