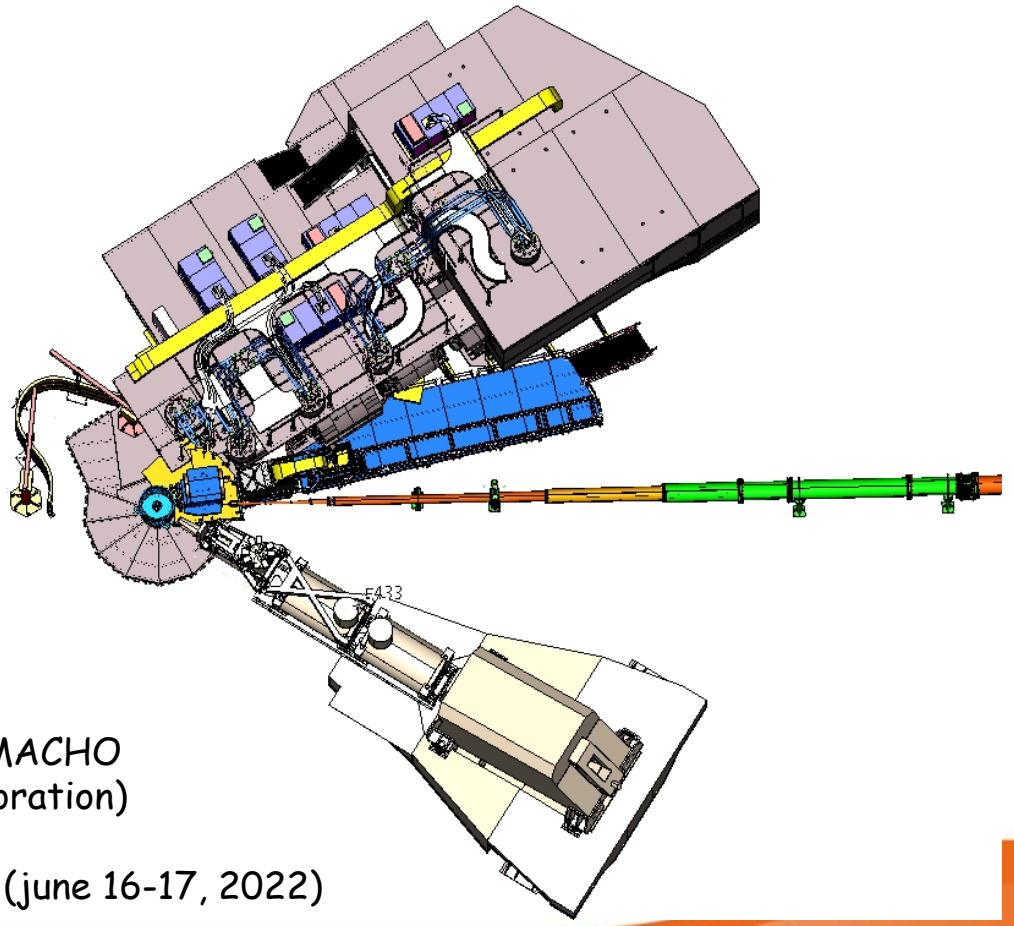
PR12-22-006:
Deeply Virtual Compton Scattering off the neutron with the Neutral Particle Spectrometer in Hall C

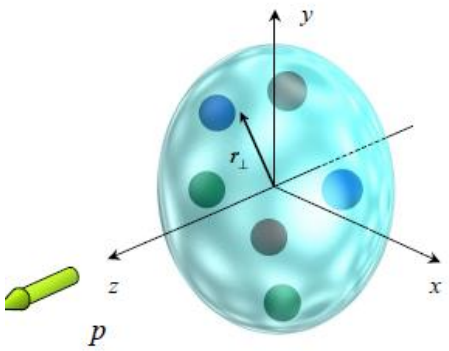


Carlos MUÑOZ CAMACHO
(for the NPS Collaboration)

Hall A/C Collaboration Meeting (june 16-17, 2022)

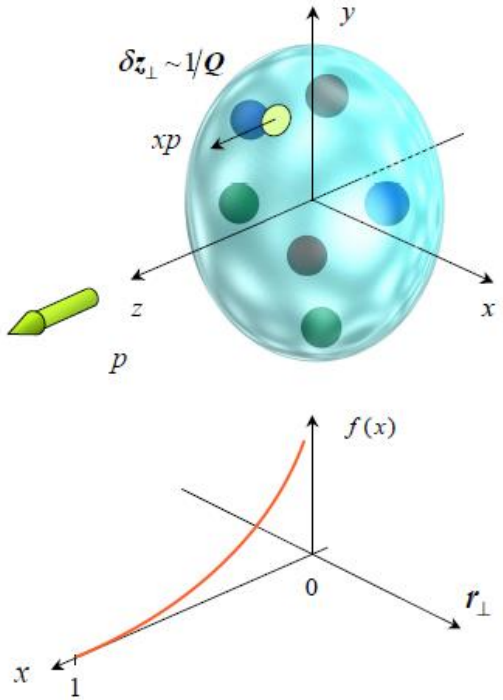
3D imaging of quarks and gluons

Elastic scattering



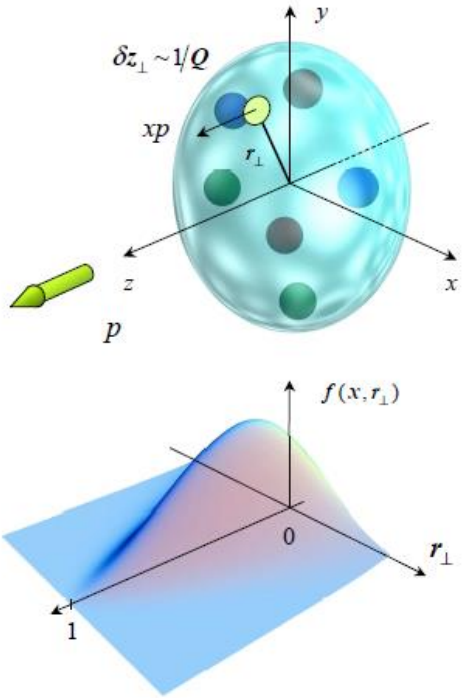
Form factors

Deeply Inelastic Scattering

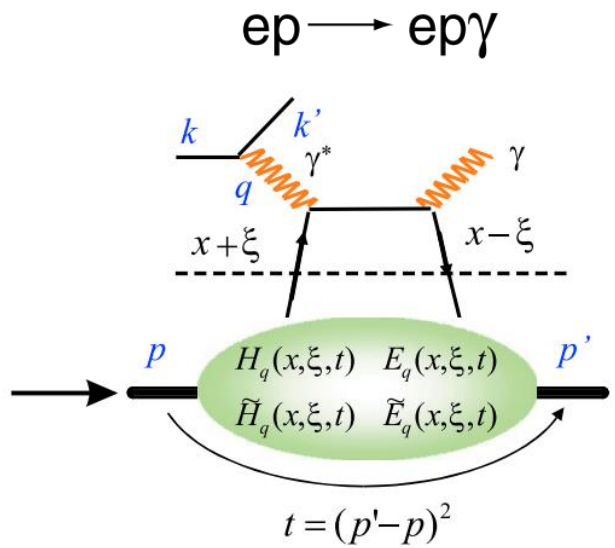


Parton distributions

Hard exclusive processes



Generalized Parton Distributions (GPDs)



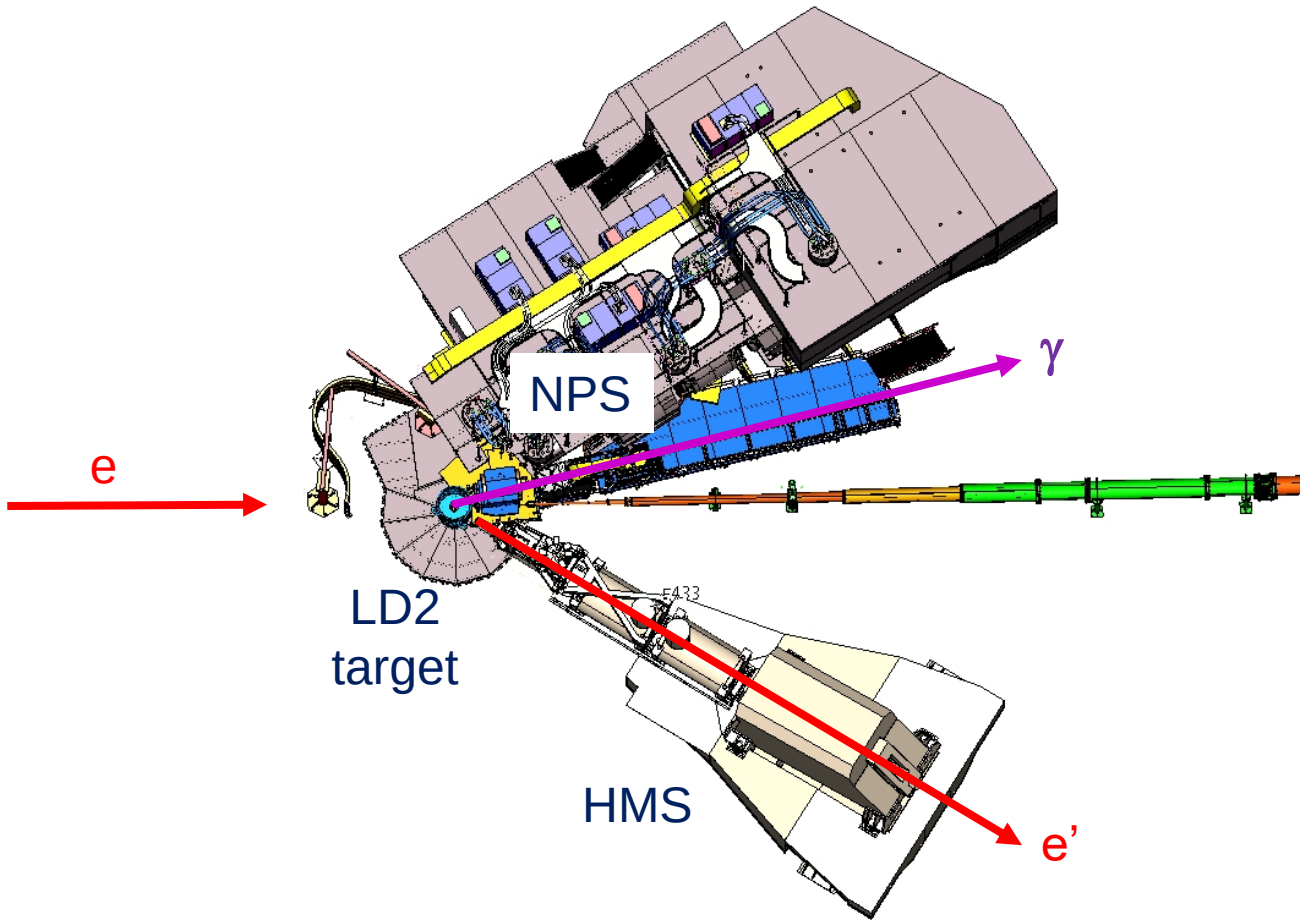
Motivation

- Neutron DVCS (nDVCS) is the best and necessary reaction to probe flavor dependence of GPDs
- Accurate cross section measurements are needed for high sensitivity results
- Extensive program of DVCS measurements on proton targets approved at JLab12
- No experiment yet proposed to measure the nDVCS cross section at JLab12

  (only 2 experiments for BSA in Hall B)
- 12 GeV kinematics and the high resolution NPS system offer several advantages over pioneer measurements at 6 GeV:
  - Better separation of nDVCS from coherent DVCS off deuteron, due to the larger values of momentum transfer *t*
  - Natural suppression of coherent DVCS off deuteron (sharp drop of *d* form factor)
  - Higher energy resolution of NPS wrt previous measurents using an PbF_2 calorimeter

Experimental setup

Measurement of the e N → e' γ X reaction (N=p,n,d) using an LD2 target in Hall C



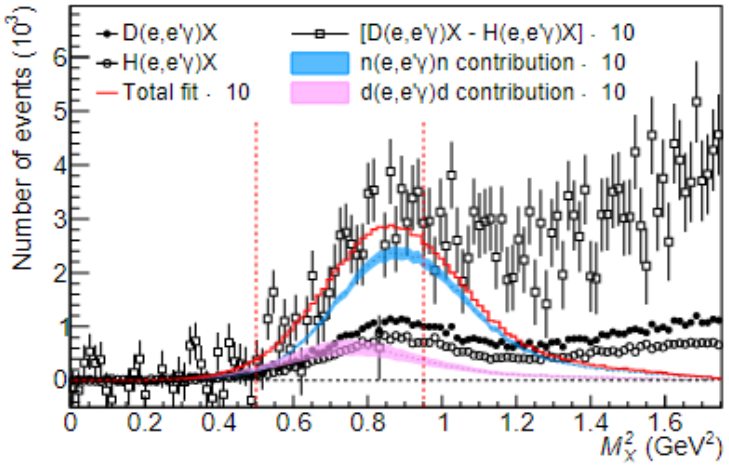
Analysis technique (impulse approximation):

$$D(e,e'\gamma)X = d(e,e'\gamma)d + n(e,e'\gamma)n + p(e,e'\gamma)p$$

Separated by missing mass

$$\left(\Delta M_X^2 = t(1 - M_N/M_d) \approx t/2\right)$$

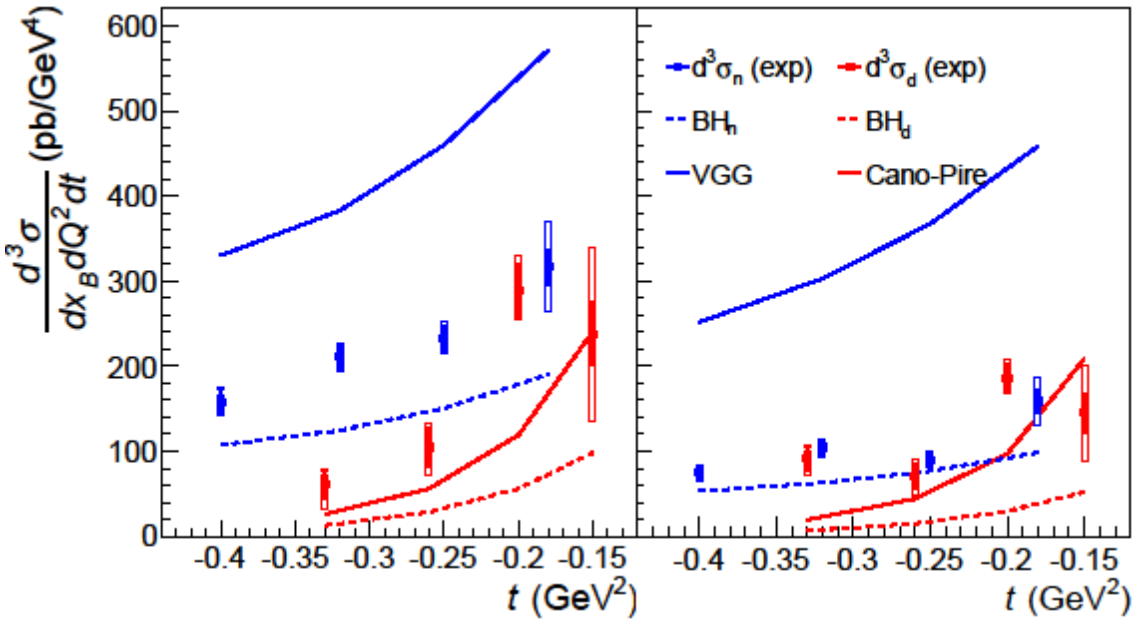
Subtracted using interleaved data on LH2 (approved experiment E12-13-010)



Results from 6 GeV experiment E08-025

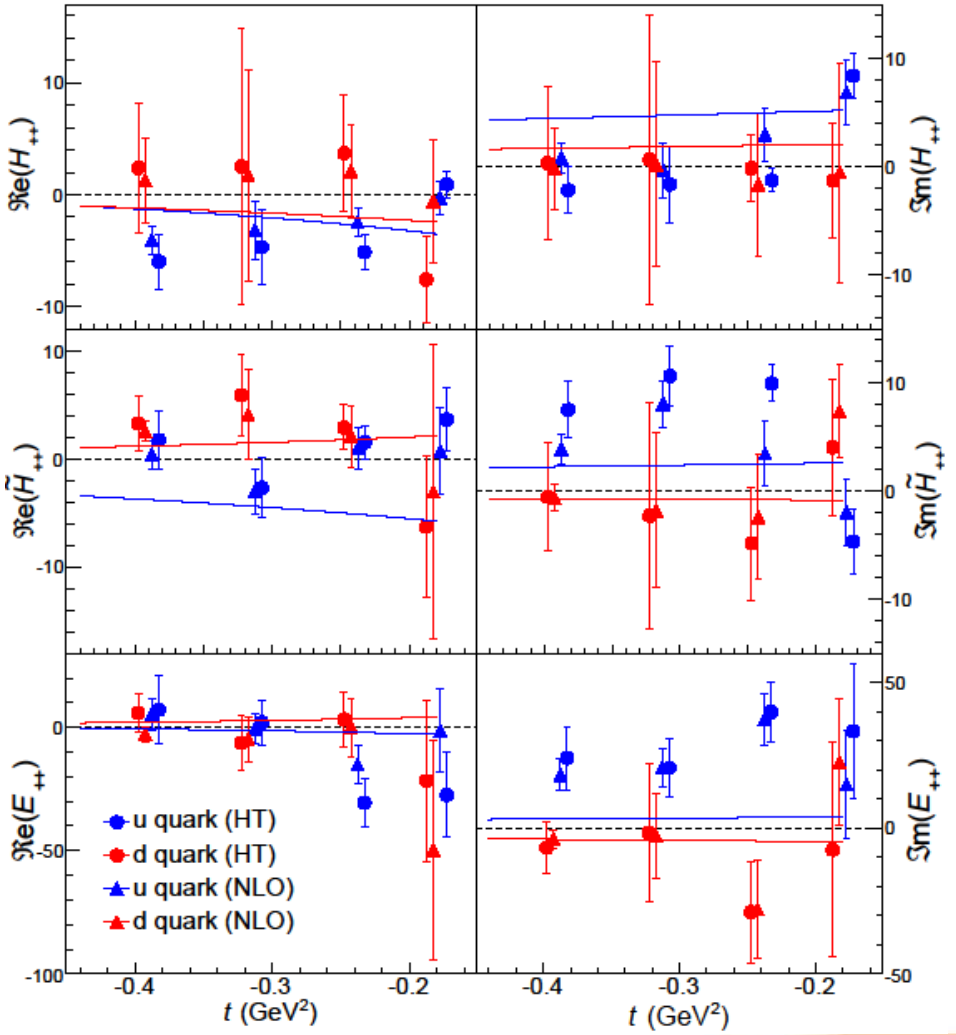
High impact measurements to flavor separate GPDs

Cross section measurements from E08-205



Benali et al, Nature Phys. 16, 191 (2020)

Flavor separation of Compton Form Factors



12 GeV DVCS kinematics

Approved proton DVCS E12-13-010

x_B	0.2					0.36					0.5				0.6			
Q^2 (GeV)^2	2.0			3.0		3.0		4.0		5.5	3.4		4.8		5.1			6.0
E_b (GeV)	6.6	8.8	11		6.6	8.8	11	8.8	11		8.8	11			6.6	8.8	11	
k' (GeV)	1.3	3.5	5.7	3.0	2.2	4.4	6.6	2.9	5.1	2.9	5.2	7.4	5.9		2.1	4.3	6.5	5.7
θ_{Calo} (deg)	6.3	9.2	10.6	6.3	11.7	14.7	16.2	10.3	12.4	7.9	20.2	21.7	16.6		13.8	17.8	19.8	17.2
D_{Calo} (m)	6	4		6		3		4	3	4	3							
I_{beam} (μA)	11	5	50	11		28		50	28	50	28							
$\sigma_{M_X^2}$ (GeV^2)	0.17			0.22	0.13		0.12	0.15		0.19	0.09		0.11		0.09			
$-t_{min}$ (GeV^2)	0.04					0.16		0.17			0.37		0.39		0.65			0.67
$-t_{min}/(2\sigma_{M_X^2})$	0.1					0.6		0.55		0.4	2		1.7		3.6			3.7
LH_2 Days	1	1	1	1	1	2	1	1	3	5	3	2	5		5	1	5	10
LD_2 Days					1	2	1	1	3	5	3	2	5		5	1	5	10
					This Proposal: 44 days on LD_2													

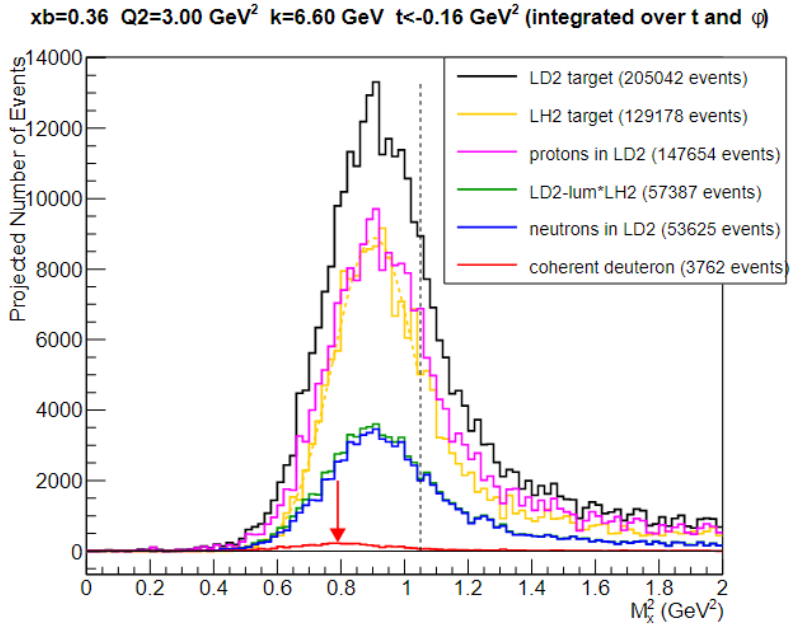
Typical 6 GeV kinematics

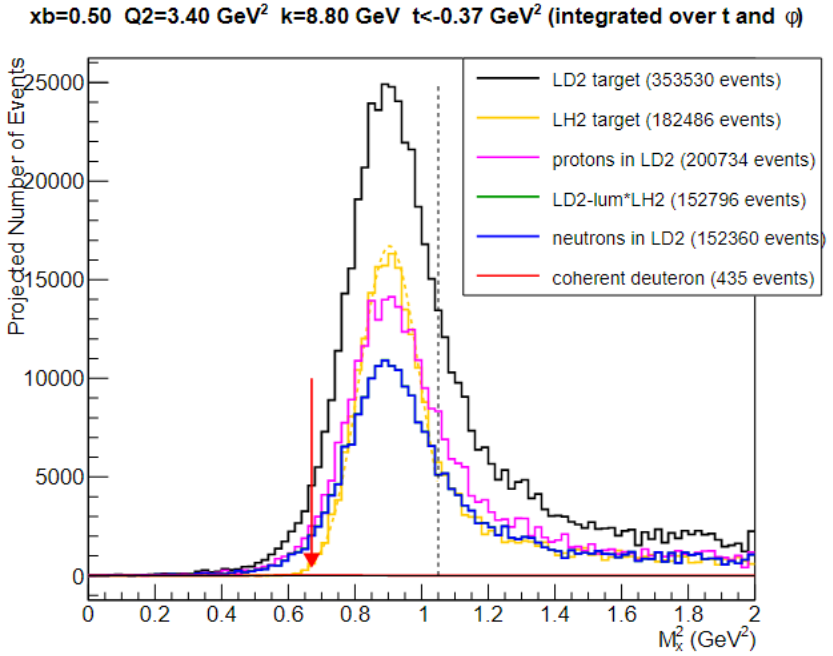
~ ×4 better nDVCS & dDVCS separation than previous 6 GeV experiment

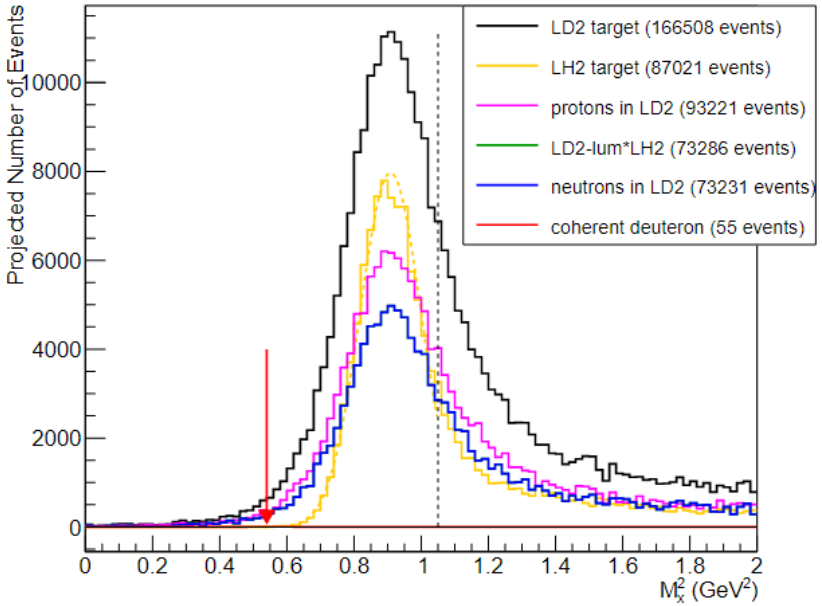
- 12 GeV → higher x_B → higher t_{min}
- NPS: higher energy resolution → smaller $\sigma_{M_X^2}$

Projections: missing mass distributions

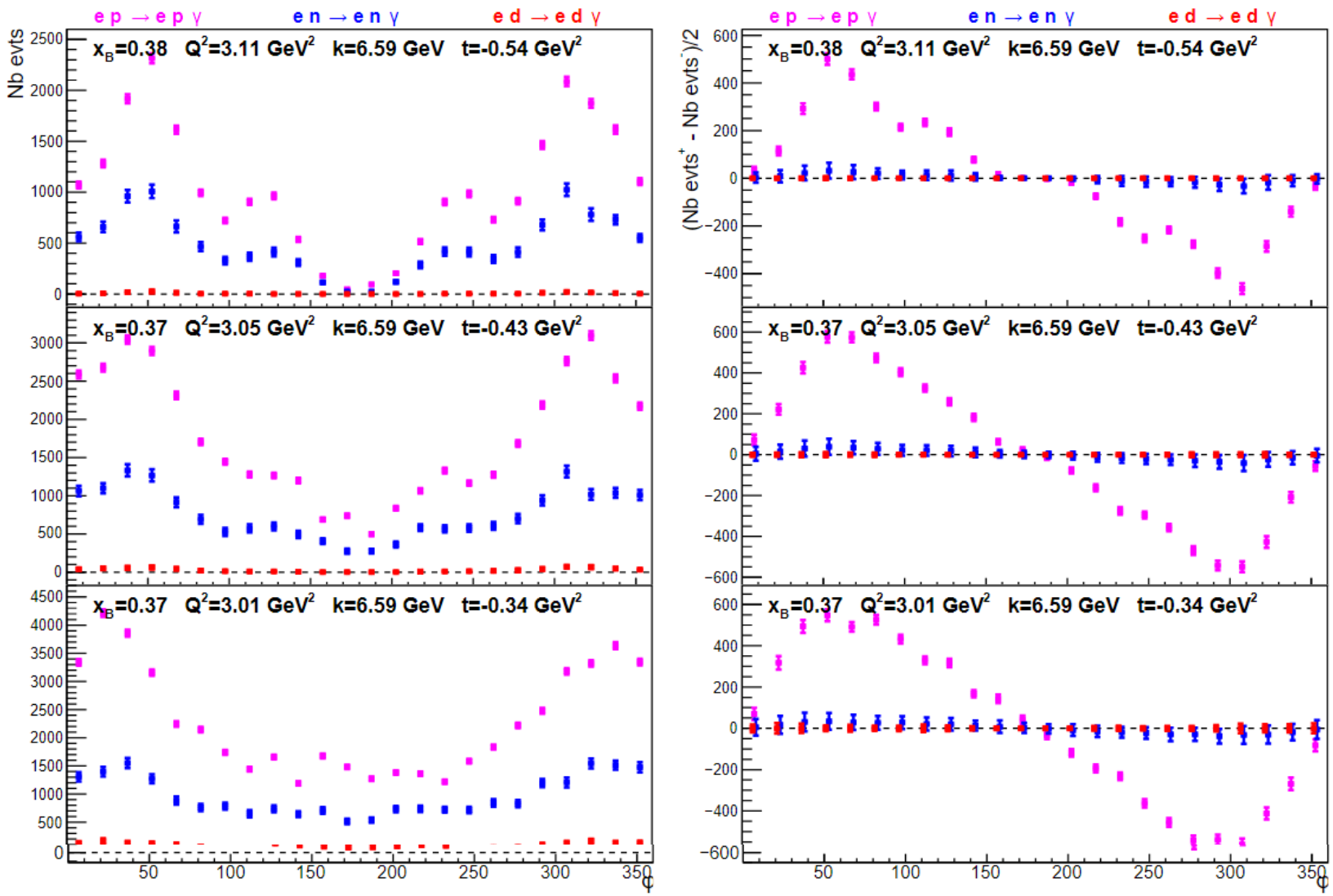
- Full Geant4 simulation of pDVCS, nDVCS and pDVCS through experimental setup
- pDVCS and nDVCS weighted by DVCS cross section model by G. Goldstein et al.
- dDVCS weighted by Bethe-Heitler



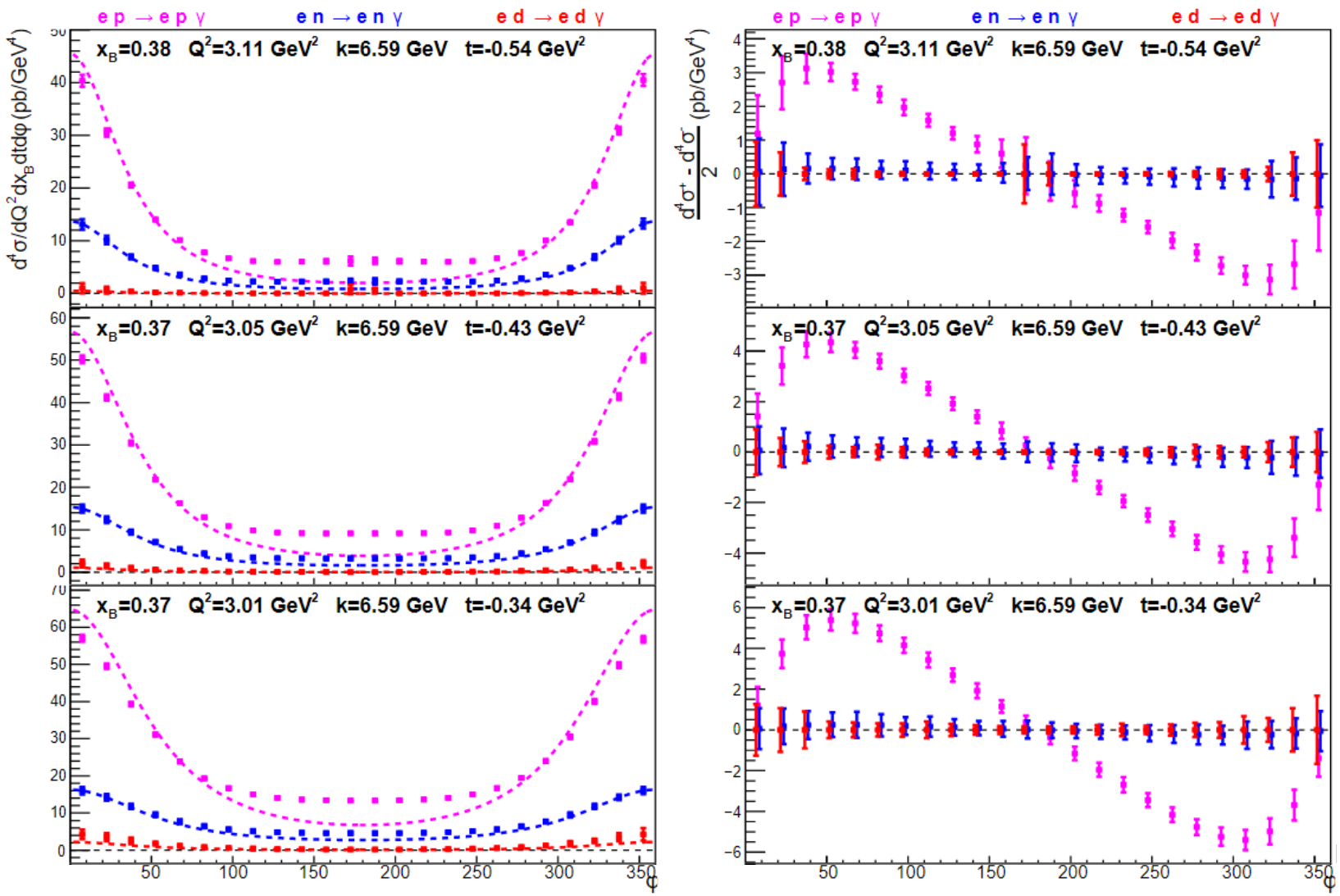




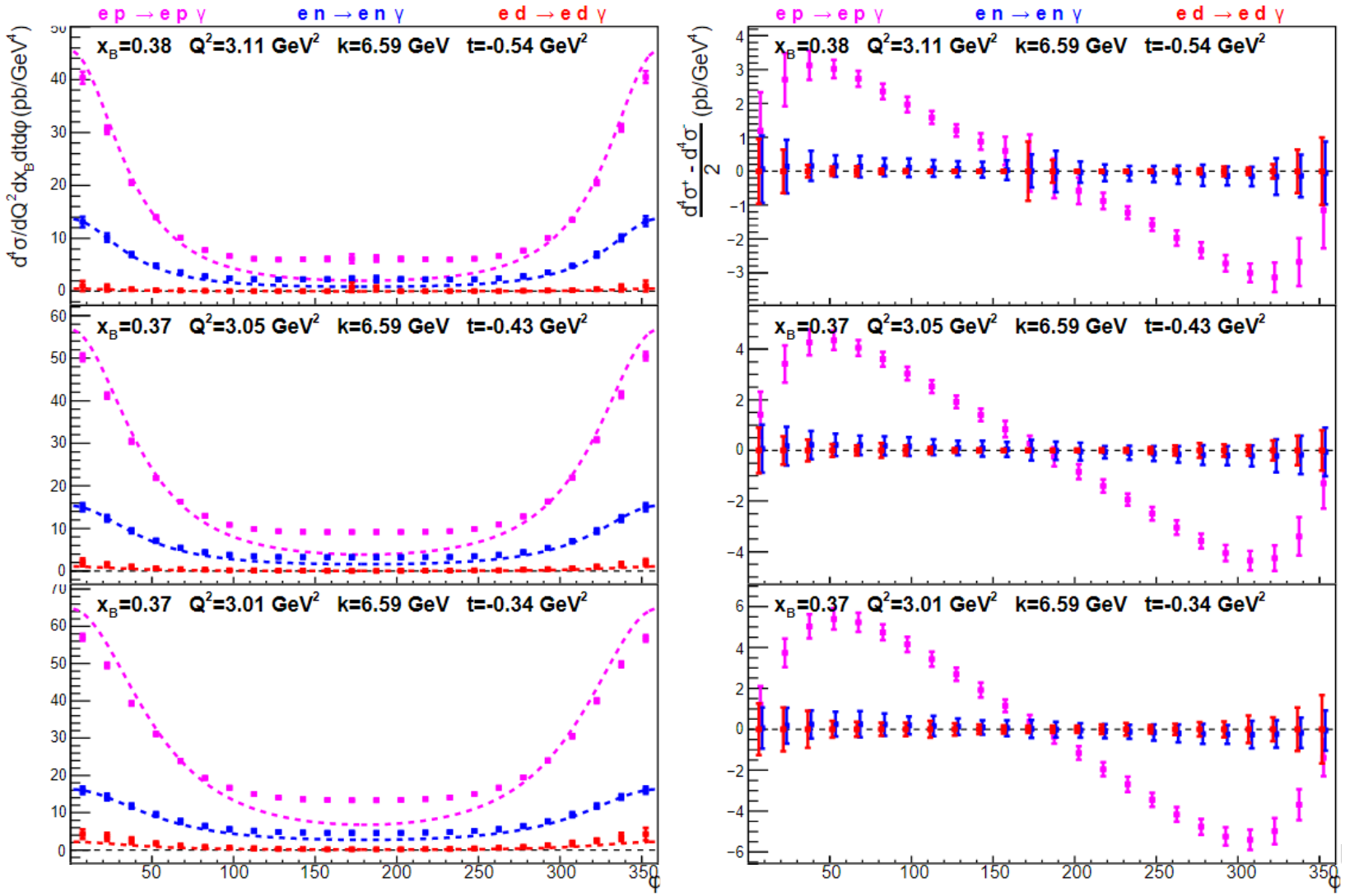
Projections: number of counts



Projections: cross section measurements



Projections: cross section measurements



Summary

- We propose to measure the DVCS cross section off quasi-free neutrons with an LD2 target & NPS in Hall C
- Accurate cross section measurements off neutron are a necessary complement to approved proton DVCS program at JLab12
- Essential measurements for probing the flavor separation of GPDs
- 12GeV kinematics and NPS will significantly improve initial results at 6 GeV
- *Interleaved measurements with approved LH2 experiment (E12-13-010) will reduce systematics uncertainties*
- Exclusive π^0 electroproduction cross section off the neutron will also be measured

Beam time request: 44 days

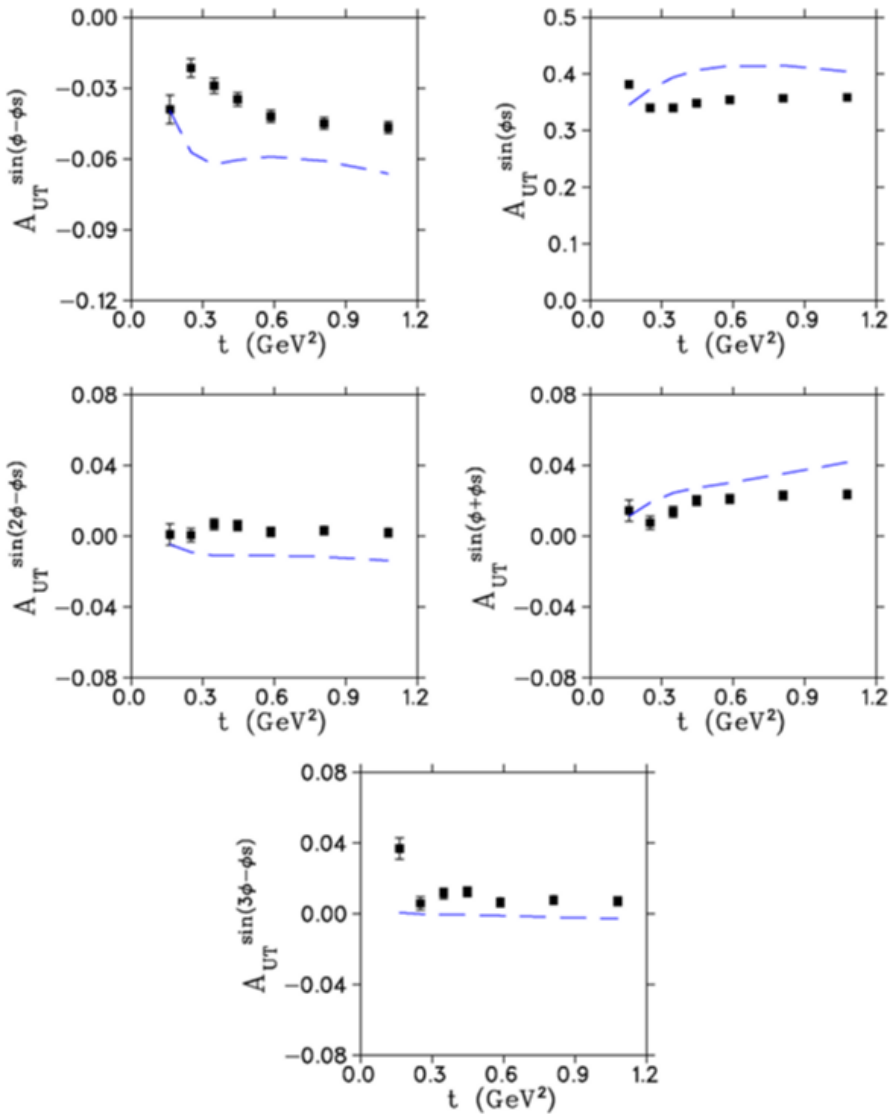
Back-up

DVCS in Hall A with SOLID

One rungroup experiment approved

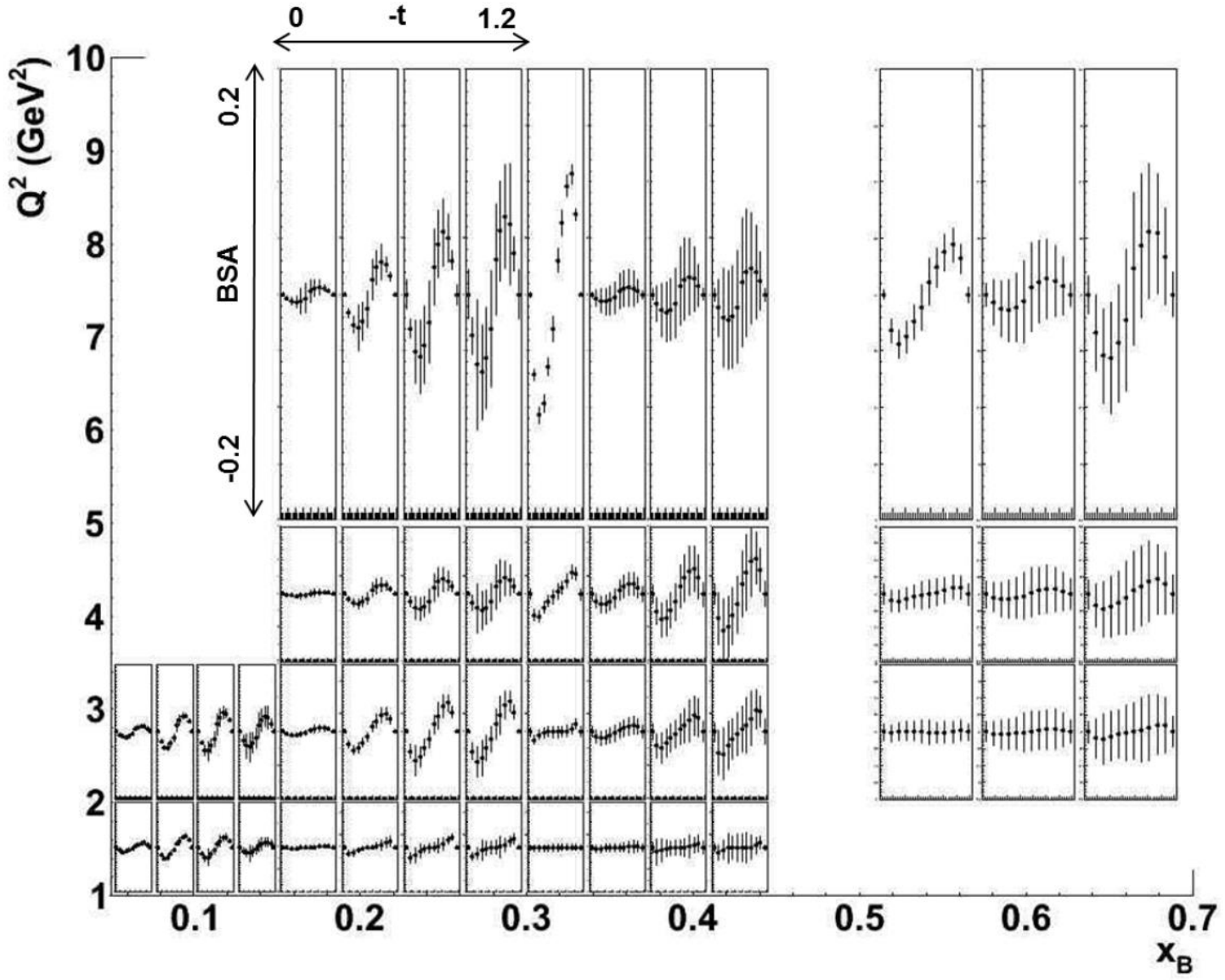
to measure DVCS with a polarized

^{3}He target



nDVCS in Hall B

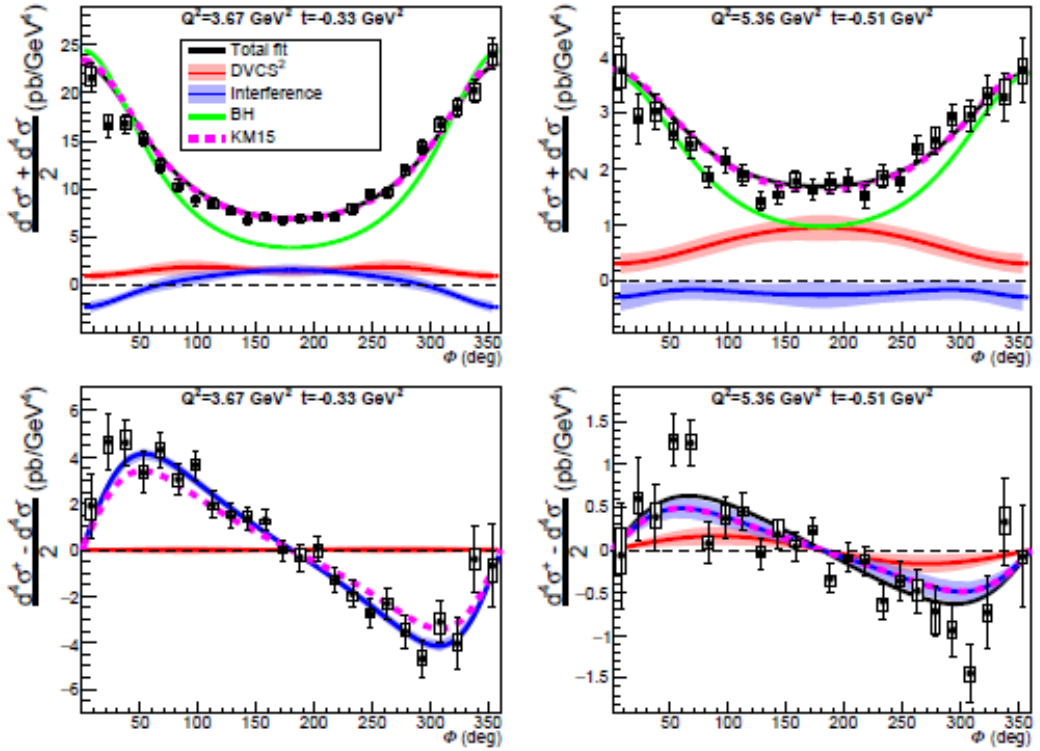
Beam spin asymmetries

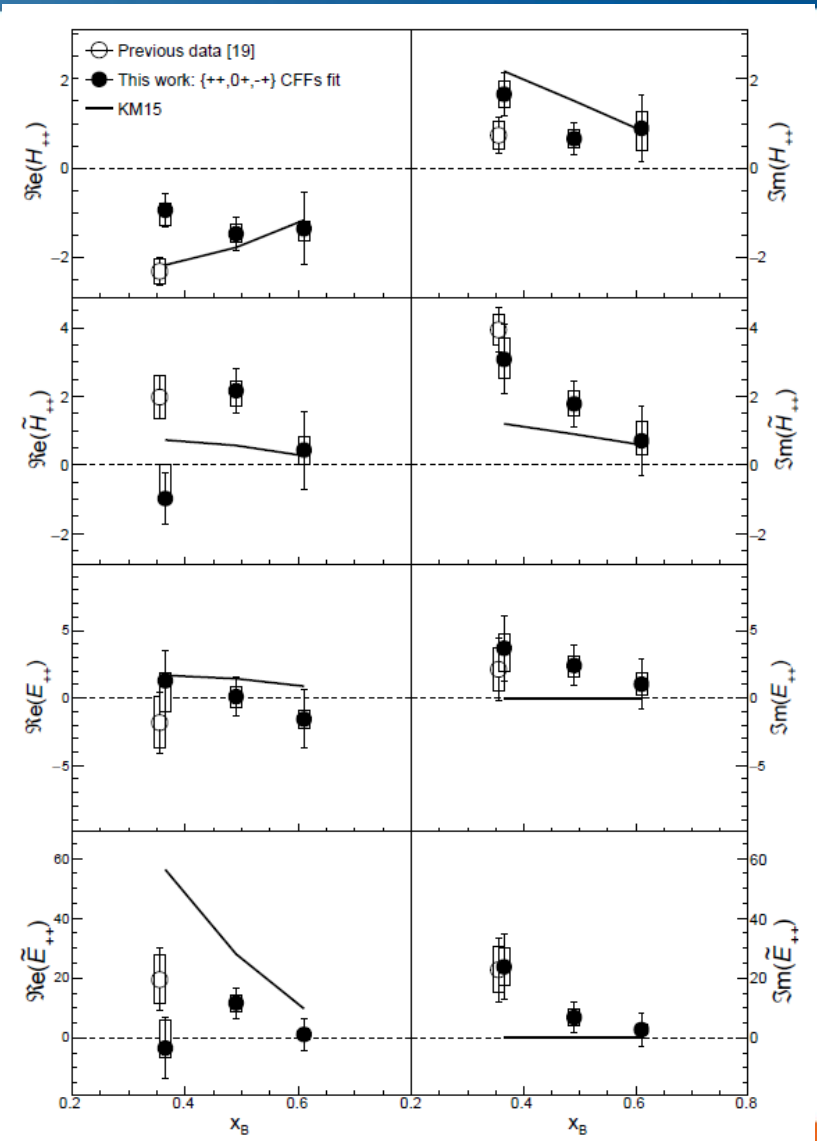


DVCS in Hall A

Constraints in all 4 CFFs (Re & Im parts)

High precision
helicity-dependent & helicity-independent cross sections

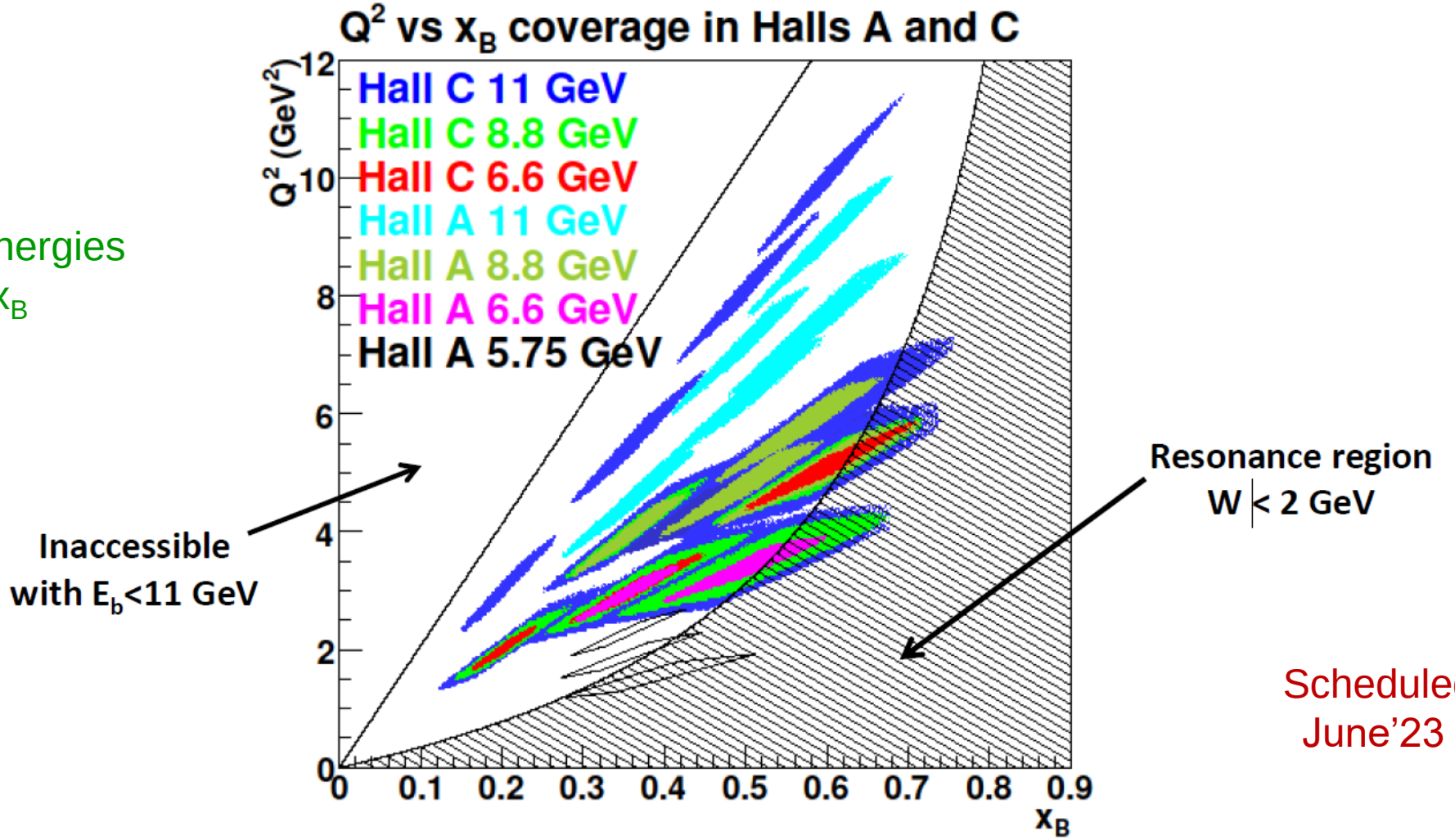




Phys. Rev. Lett. (in press)

DVCS in Hall C

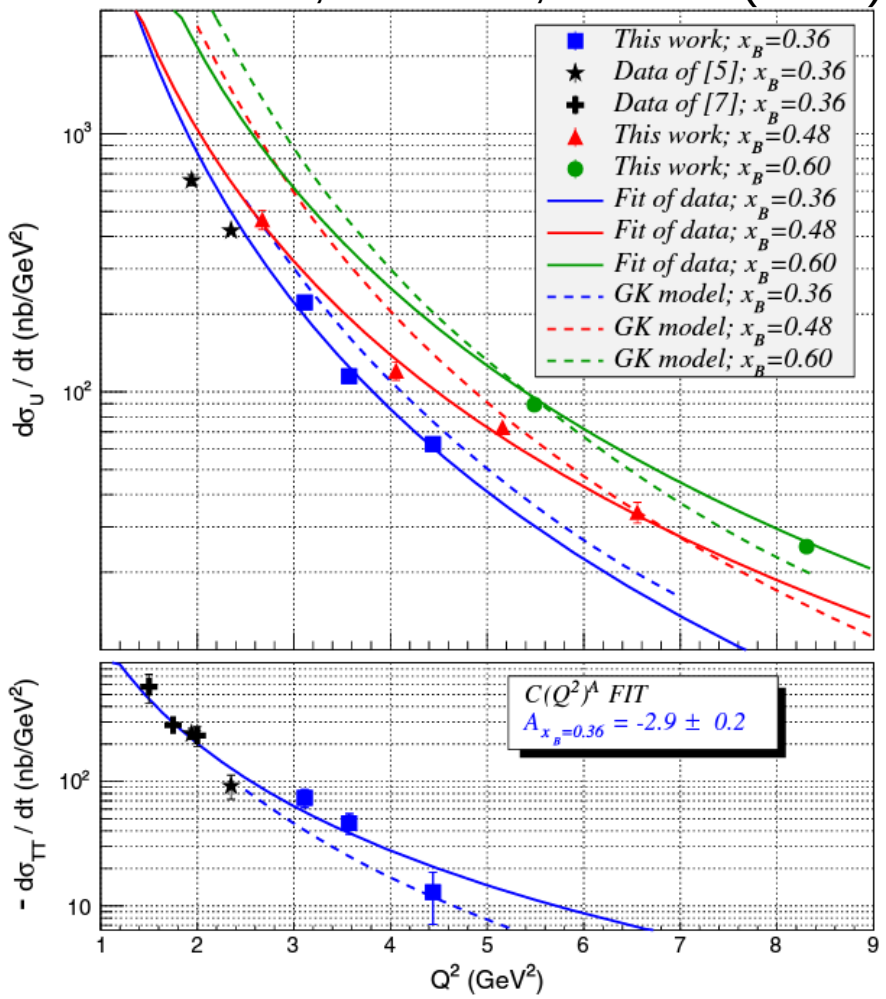
Different beam energies at fixed Q^2,x_B

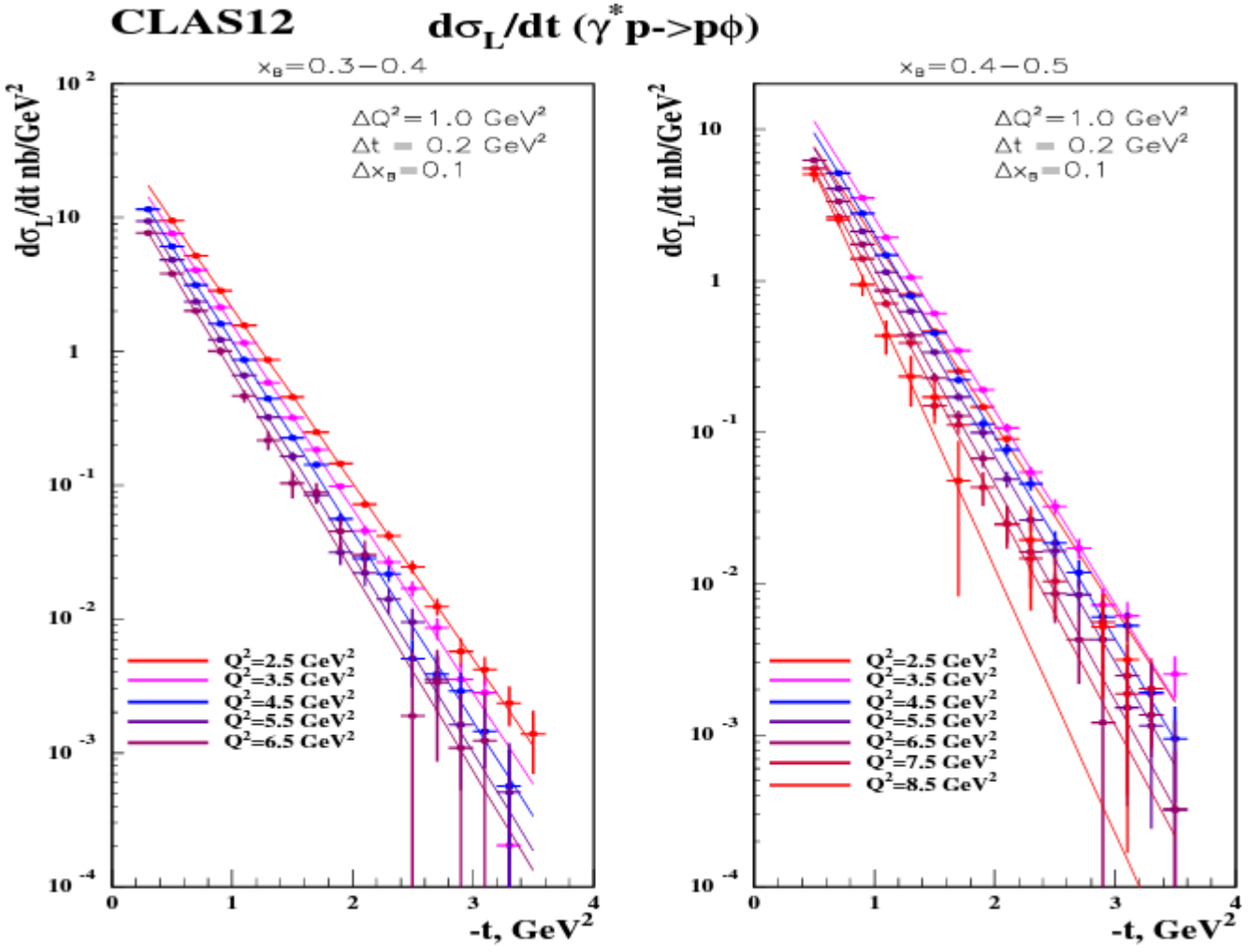


Scheduled to run in June'23 – Mar'24

Exclusive meson production

Hall A π^0, PRL 127, 152301 (2021)





Measurement	Hall	Ntes
DVCS	A,B,C	B includes long. & trans. target
nDVCS	B	Unp. & long. pol. target
DVCS w/ e+	B, C	
TCS	A (Solid), B, C	
Excl. π^0	A,B,C	
Excl. π^-	A (Solid), (B)	
Excl. ϕ, η	B	
L/T separation (K, π+)	C	
WACS (γ, π^0)	A, C	
Backwards π^0	C	