SoLID Double Deeply Virtual Scattering in Hall A Jefferson Laboratory

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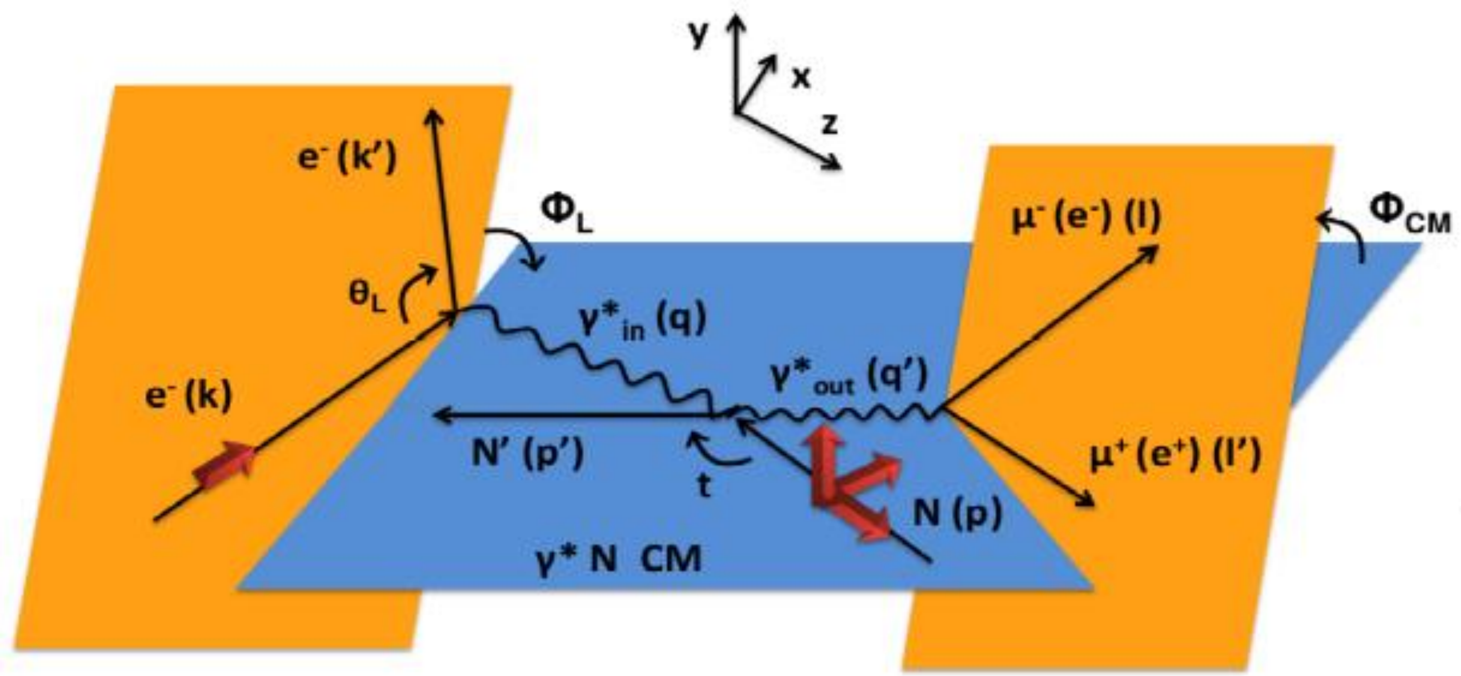
Outline

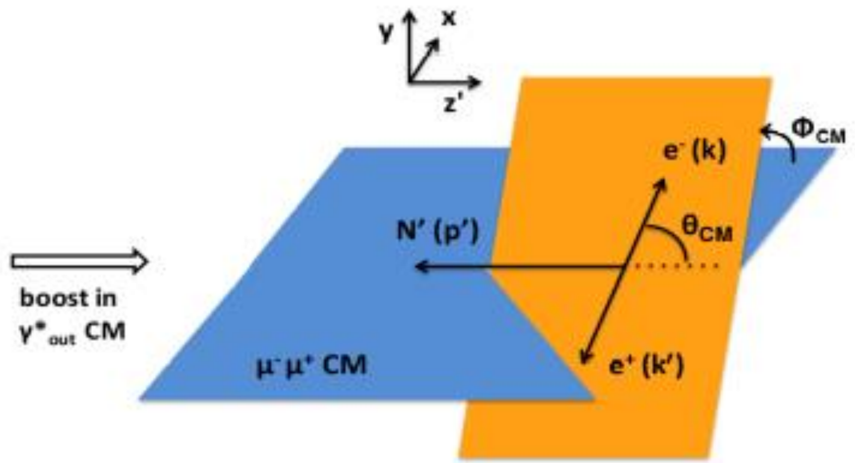
- Introduction Generalized Partons Distributions
- Double Deeply Virtual Compton Scattering
- Overview Jefferson Laboratory
- Overview SoLID Spectrometer
- Hall A DVCS results
- SoLID J/Psi setup
- SoLID DDVCS muon detector
- Kinematical coverage at 11 GeV
- Background to DDVCS
- Estimates at 11 GeV
- Coverage at 22 GeV
- Conclusion

Modern hadronic structure

- Elastic form factors : spatial charge distribution of nucleon
- Hadronic structure through Deep Inelastic Scattering (1950s) : gives density of longitudinal momentum quarks and gluons inside a nucleon but no spatial information
- Spin crisis : spin of nucleon not simply spin of valence quarks
- Nucleon is a dynamic system, raises many questions
  - Mass repartition
  - Motion of quarks and gluons inside nucleons : quark orbital momentum

Definition of the angles



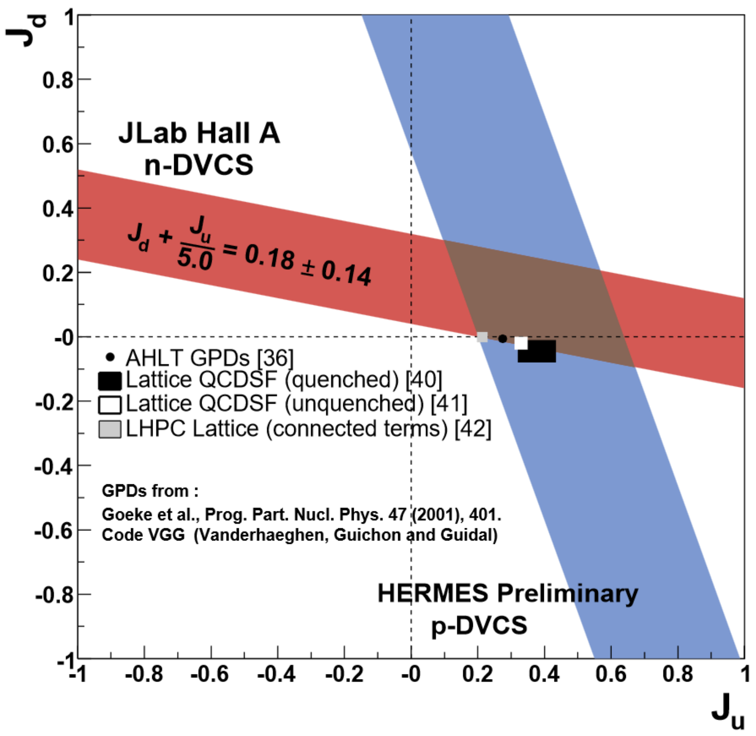


Informations from GPDs

- Orbital momentum of quarks Ji's sum rule

$$J^q = \frac{1}{2}\left[A^q(0) + B^q(0)\right] = \frac{1}{2}\Delta\Sigma^q + L^q$$

$$\int_{-1}^{1} x dx \left[H^q(x,\xi,t) + E^q(x,\xi,t)\right] = A_q(t) + B_q(t)$$

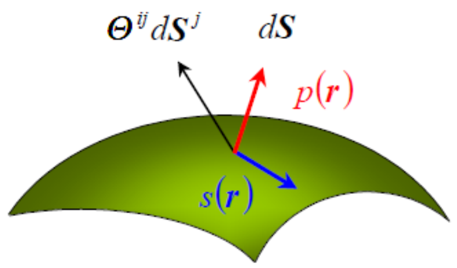


- Access to nucleon pressure

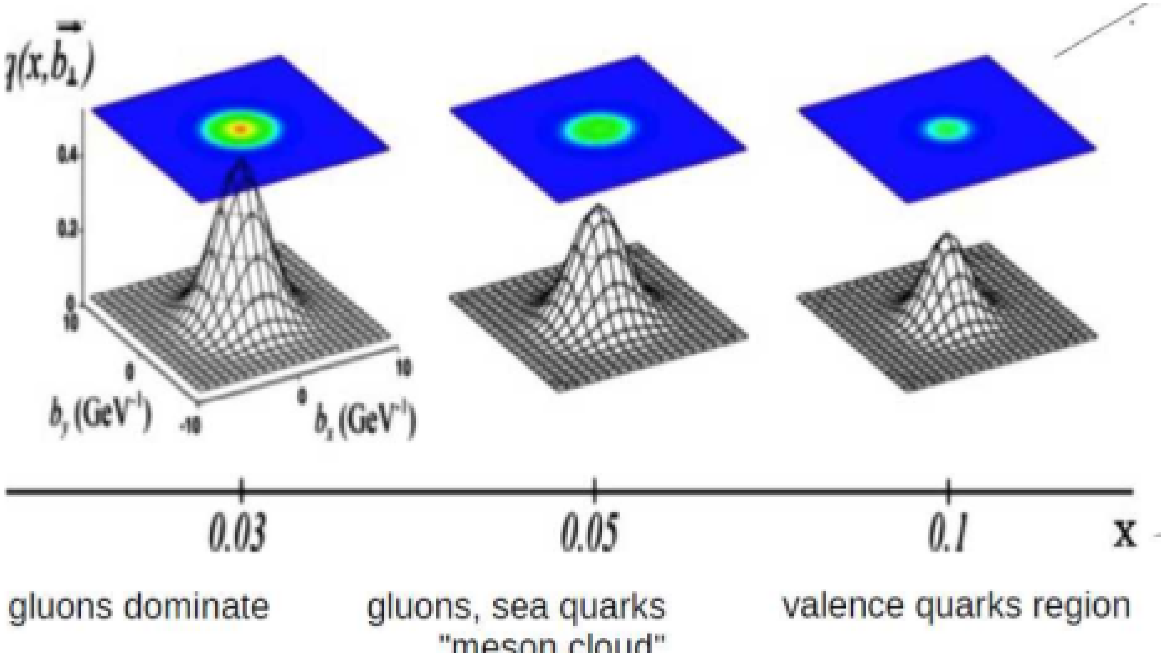
e-Print: [2104.02031] [nucl-ex] Girod, Burkert, Elouadrhiri

[hep-ph/0504030v3] Unraveling hadron structure with generalized parton distributions (arxiv.org) p64

$$\langle p_2|\Theta^{a,\mu\nu}|p_1\rangle = \frac{1}{2}\left(H^a(\Delta^2)p^{\{\mu}h^{\nu\}} + E^a(\Delta^2)p^{\{\mu}e^{\nu\}} + D^a(\Delta^2)\frac{\Delta^\mu\Delta^\nu - g^{\mu\nu}\Delta^2}{2M_N}b\right) \pm \widetilde{D}(\Delta^2)M_N g^{\mu\nu}b\,,$$



Tomographic interpretation of the Generalized Parton Distributions



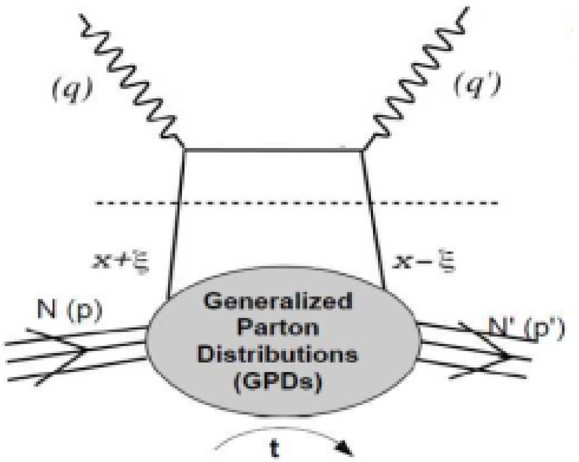
Momentum dependent Impact parameter distributions

GPDs depend on x (quark's momentum fraction), xi (skewness), t (Mandelstam) [+ evolution]

Momentum dependent Impact Parameter Distributions aka "tomographic views"
- Obtained from Fourier Transform of **GPDs at xi=0: need deconvolution of x and xi**

Not possible with other reactions such as DVCS… (why: next slides)

From Hard Exclusive Reactions to Generalized Parton Distributions



GPD: matrix element that connect N and N' and contain quark/gluons interactions

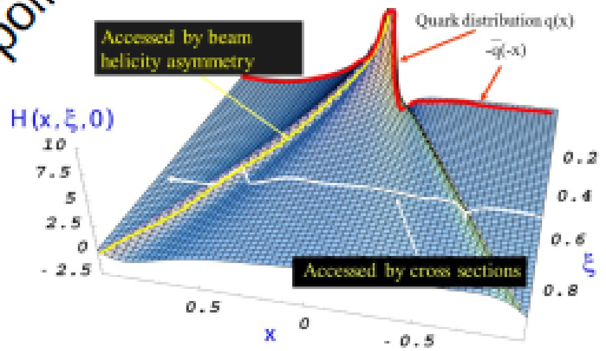
- Unpolarized GPDs: partonic distributions
- Polarized GPDs: related to spin partition
- Chiral-odd GPDs: spin flip; related to parton's mass
- Higher order / twist: extra gluons exchanges

1. Extracted at xi (// momentum) and t (momentum transfer [2]) from experimental data

"Compton Form Factors": Complex functions of amplitudes

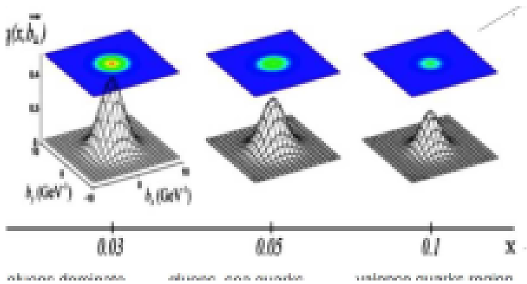
2. Extrapolation to physics points

GPD

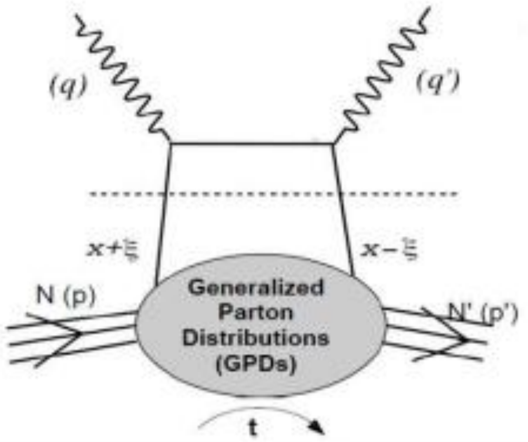


3. Fourier transform

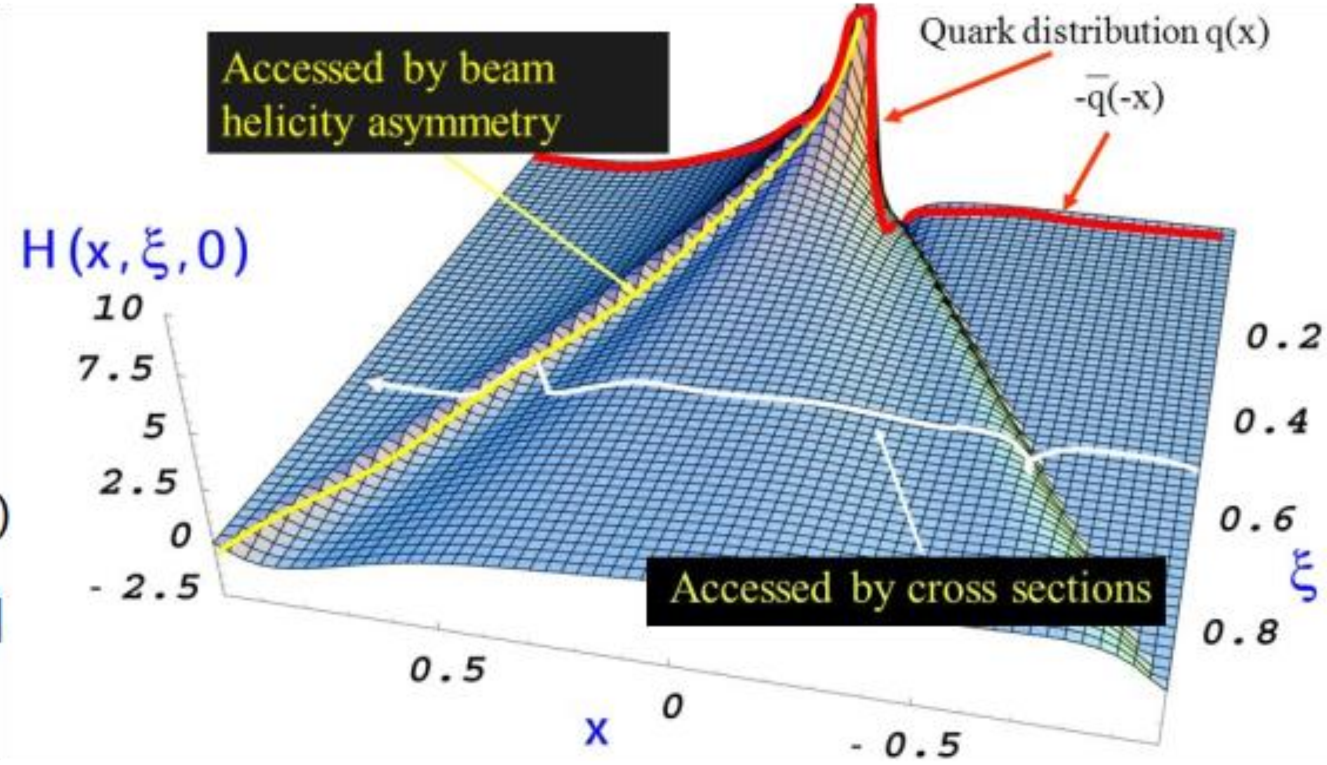
Momentum dependent Impact parameter functions



Generalized Parton Distributions from CFF fits (with DVCS or TCS)



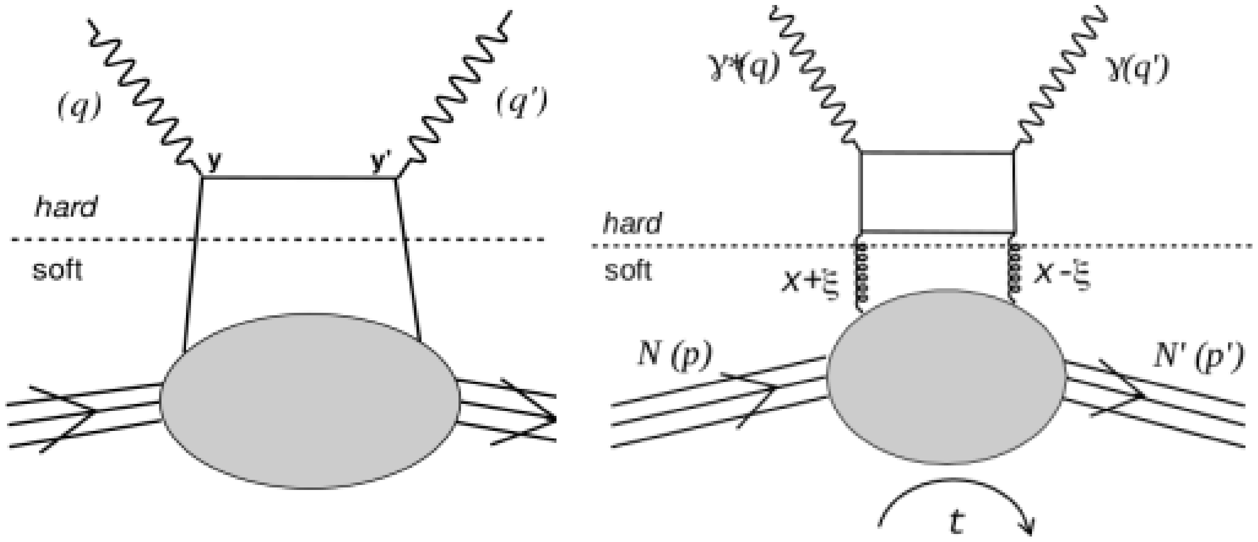
Extracted at ξ (skewness // momentum)
and t (momentum transfer [2])
from experimental data [can't access x]



$$T^{DVCS} \sim \int_{-1}^{+1} \frac{H(x,\xi,t)}{x \pm \xi + i\varepsilon} dx + \ldots \sim \underbrace{P\int_{-1}^{+1} \frac{H(x,\xi,t)}{x \pm \xi} dx}_{\mathrm{Re}(\mathcal{H})} \underbrace{- i\pi H(\pm\xi,\xi,t)}_{\mathrm{Im}(\mathcal{H})} + \ldots$$

Propagator: only access "diagonal" part |x|=xi

Hard Exclusive Compton-like reactions and Double Deeply Virtual Compton Scattering



Leading order / leading twist generic handbag diagram

DVCS: final photon is real, incoming is spacelike
(Spacelike Deeply Virtual Compton Scattering)

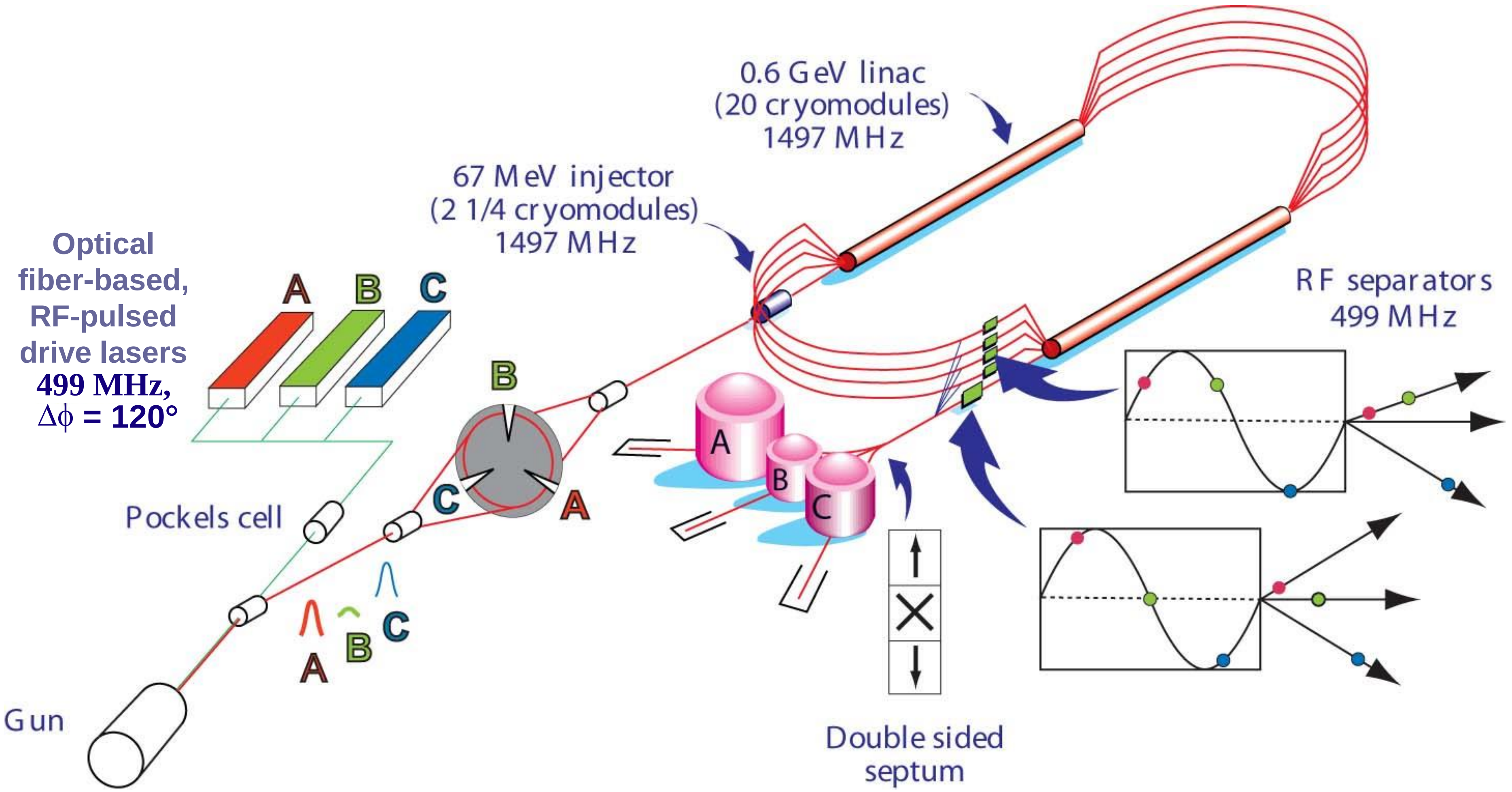
TCS: incoming is real, final is timelike
(Timelike Deeply Virtual Compton Scattering)

DDVCS: incoming is spacelike, outgoing is timelike
Double Deeply Virtual Compton Scattering

Other: multi-photons, photon+meson, ...

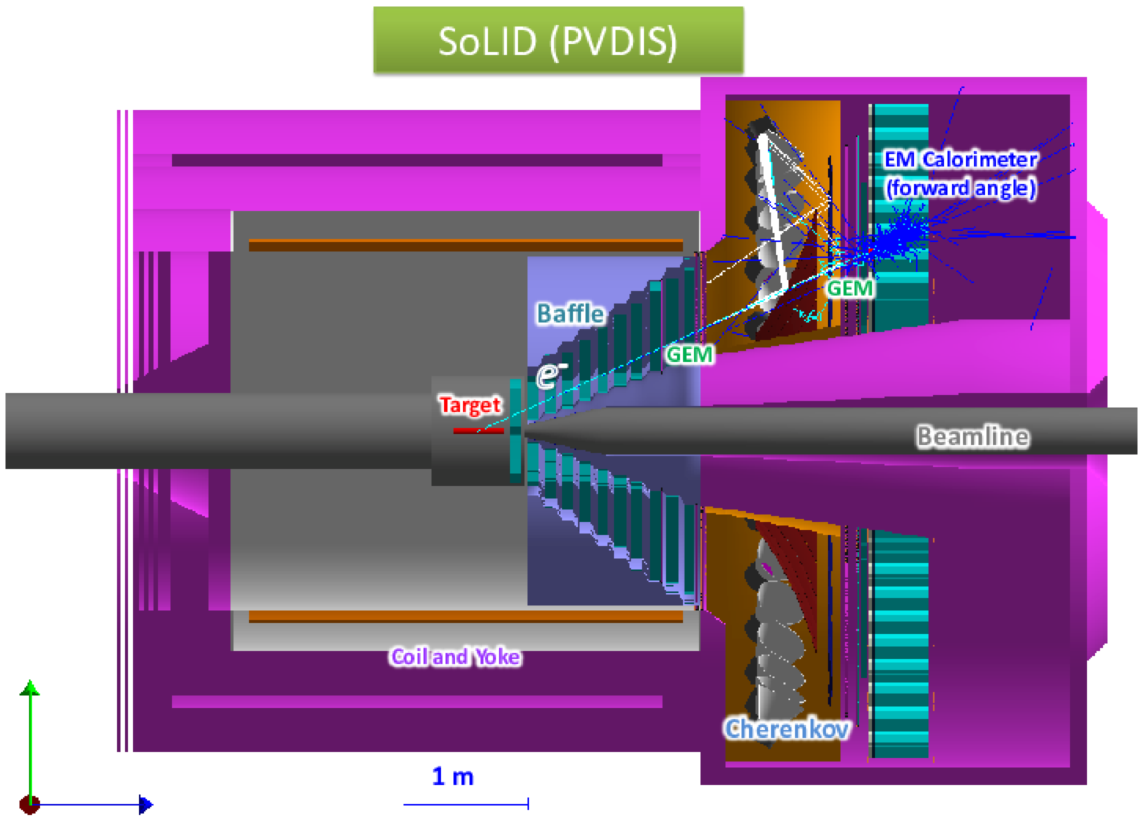
Guidal and Vanderhaegen : Double deeply virtual Compton scattering off the nucleon (arXiv:hep-ph/0208275v1 30 Aug 2002)
Phenomenology of double deeply virtual Compton scattering in the era of new experiments
Belitsky Radyushkin : Unraveling hadron structure with generalized parton distributions (arXiv:hep-ph/0504030v3 27 Jun 2005)
Phenomenology of double deeply virtual Compton scattering in the era of new experiments
K. Deja(NCBJ, Warsaw), V. Martinez-Fernandez(NCBJ, Warsaw), B. Pire(Ecole Polytechnique, CPHT), P. Sznajder(NCBJ, Warsaw), J. Wagner(NCBJ, Warsaw)
(Mar 23, 2023 e-Print: 2303.13668 [hep-ph])
Prospects for GPDs extraction with Double DVCS
K. Deja(NCBJ, Warsaw), V. Martinez-Fernandez(NCBJ, Warsaw), B. Pire(Ecole Polytechnique, CPHT), P. Sznajder(NCBJ, Warsaw), J. Wagner(NCBJ, Warsaw)
(Apr 7, 2023 e-Print: 2304.03704 [hep-ph])

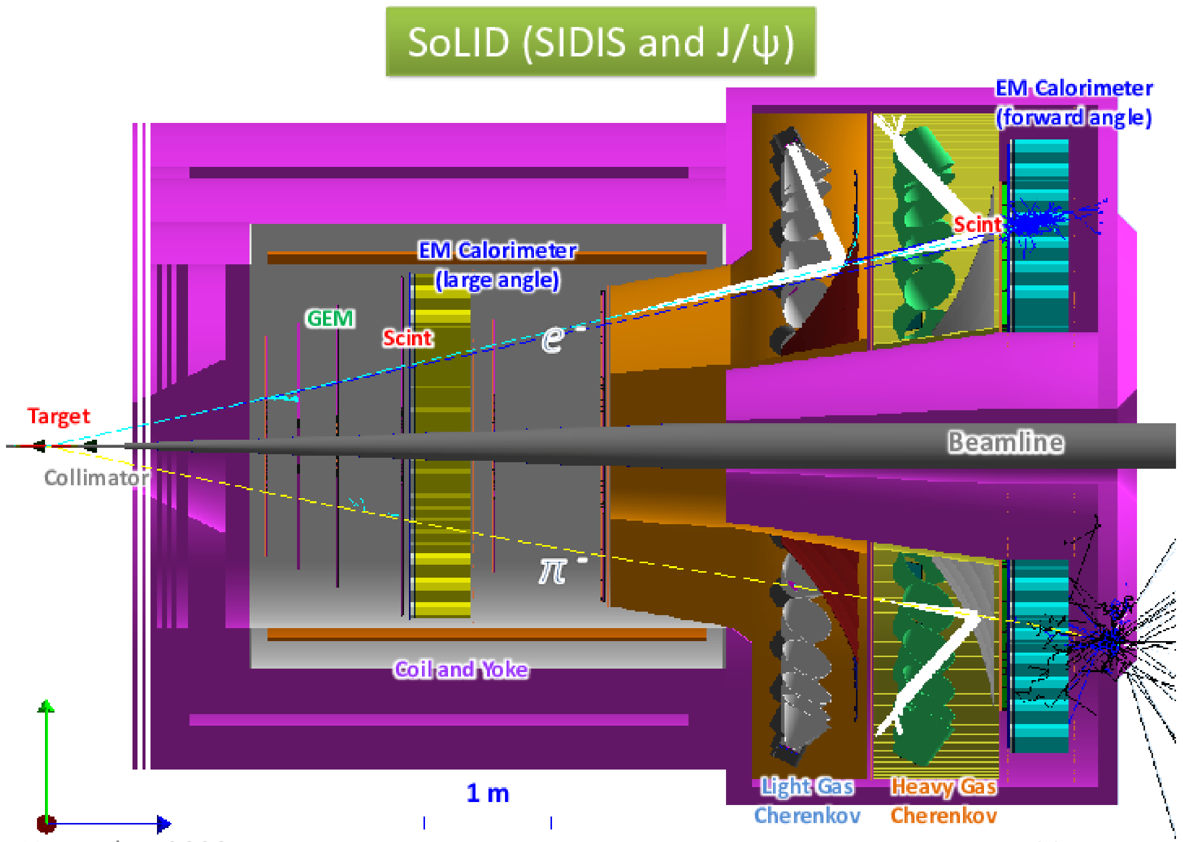
Continuous Electron Beam Accelerator Facility



SoLID setup and experiments

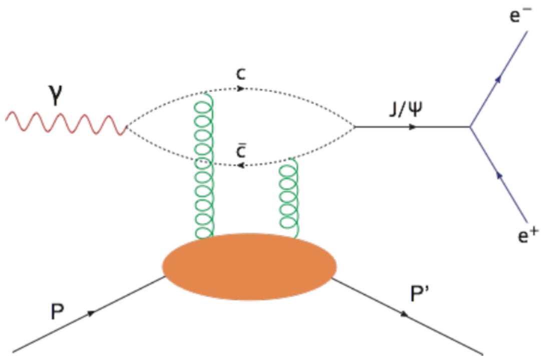
- SoLID detector : CLEO magnet + GEM trackers + Cerenkov + ECal
- 2 detector setup : PVDIS 60 uA, SIDIS 15 uA He3, J/Psi 3uA 15 cm LH2 target

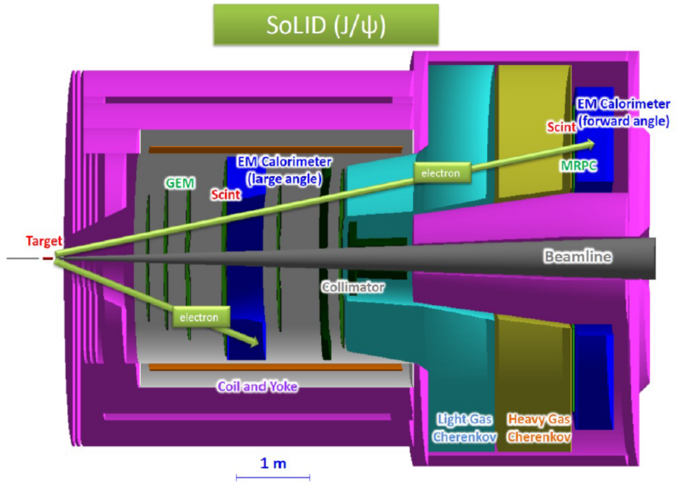


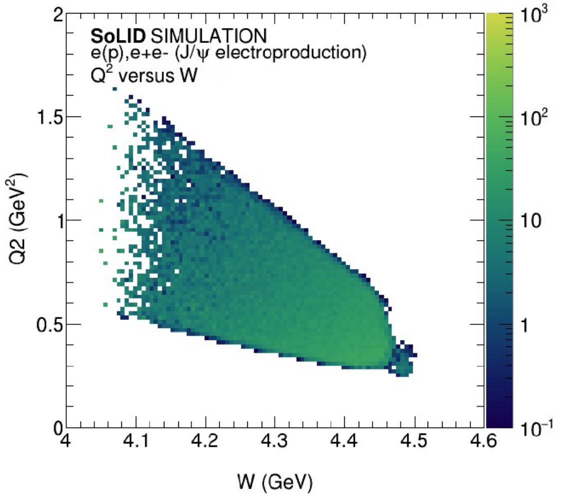


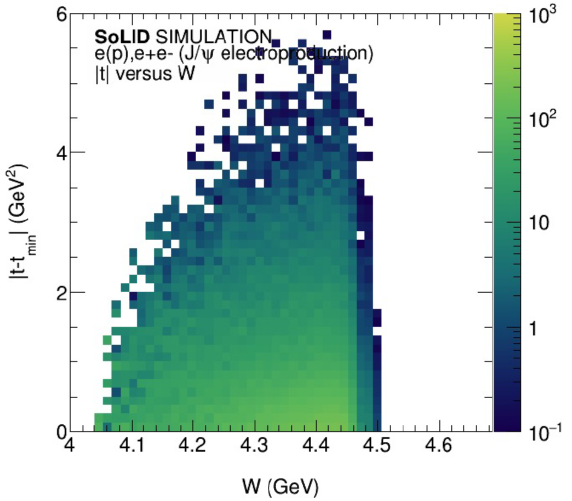
SoLID Experiment Overview

- 50 days of 3 μA beam on a 15 cm long LH_2 target at $1 \times 10^{37} cm^{-2} s^{-1}$
  - 10 more days include calibration/background run
- SoLID configuration overall compatible with SIDIS
  - **Electroproduction trigger**: 3-fold coincidence of e, $e^- e^+$
  - **Photoproduction trigger:** 3-fold coincidence of p, $e^- e^+$
  - **Additional trigger:** 4-fold coincidence of ep, $e^- e^+$
  - And (inclusive) 2-fold coincidence $e^+ e^-$







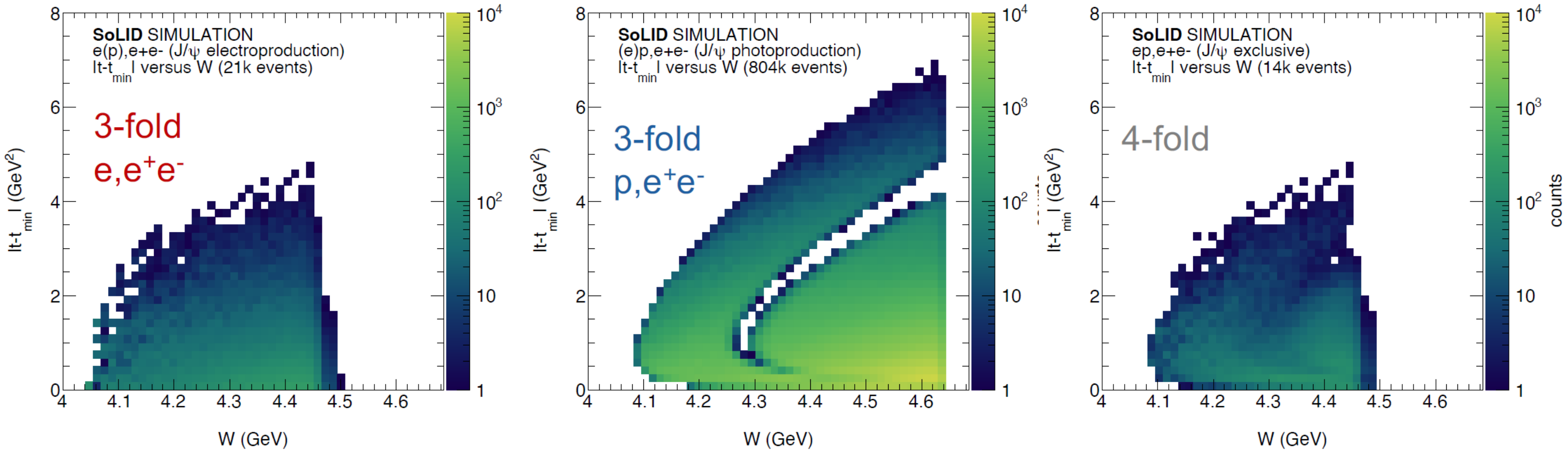


$$e^- + p \longrightarrow e^- + p + J/\psi\,(e^+ + e^-)$$

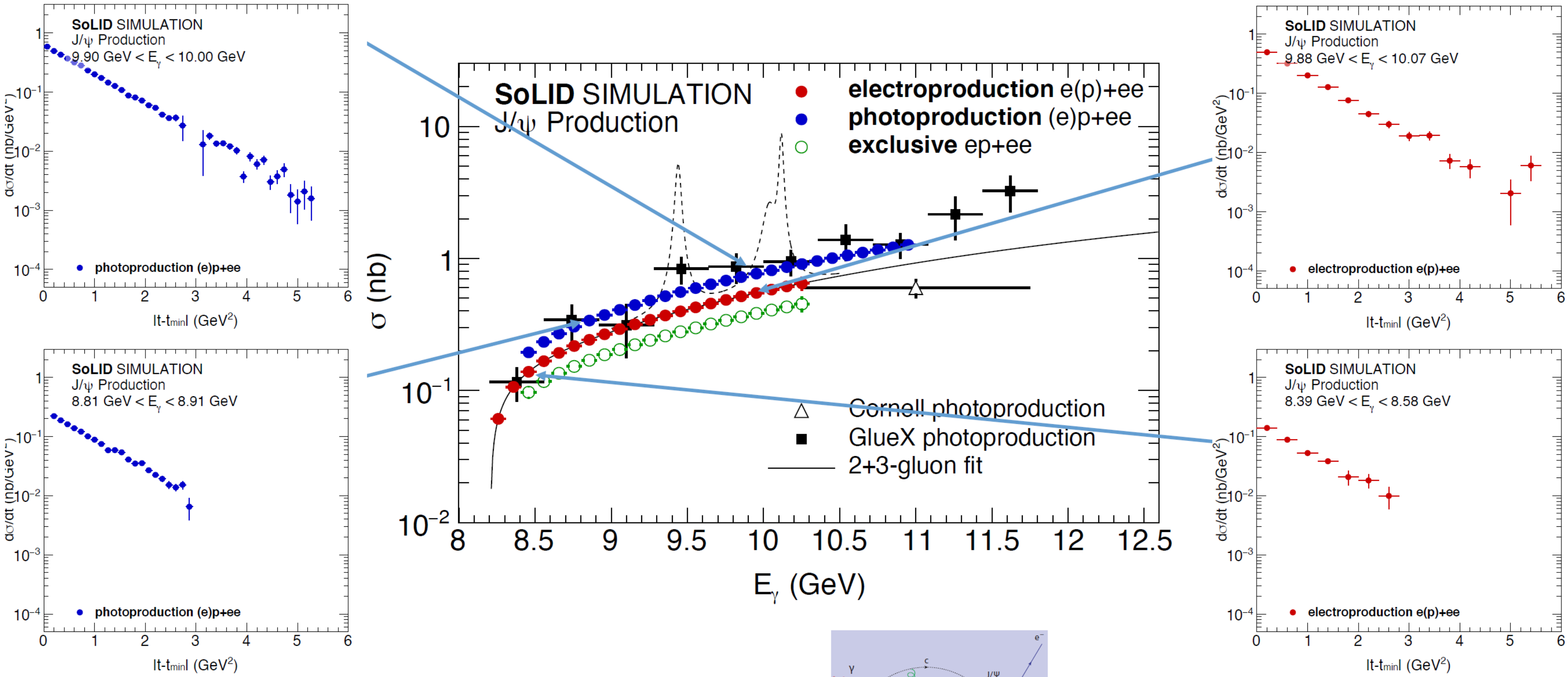
Event Counts @ 1×10^{37} in 50 days

- 4-fold coincidence: ep,e^+e^-
  - **280-400** events/day
- 3-fold (electroproduction): e,e^+e^-
  - **415-594** events/day
- 3-fold (photoproduction): p,e^+e^-
  - **16k-23k** events/day
- 2-fold (inclusive): e^+e^-
  - 26k-37k events/day

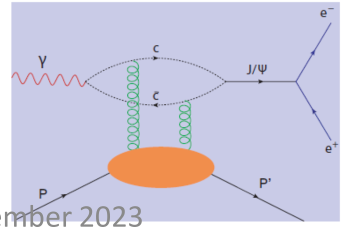
	Time (Hour)	Time (Day)
LH_2 at 11 GeV	**1200**	**50**
Dedicated Al dummy run	**72**	**3**
Optics and detector check out	**72**	**3**
Special low luminosity	**96**	**4**
Total	**1440**	**60**



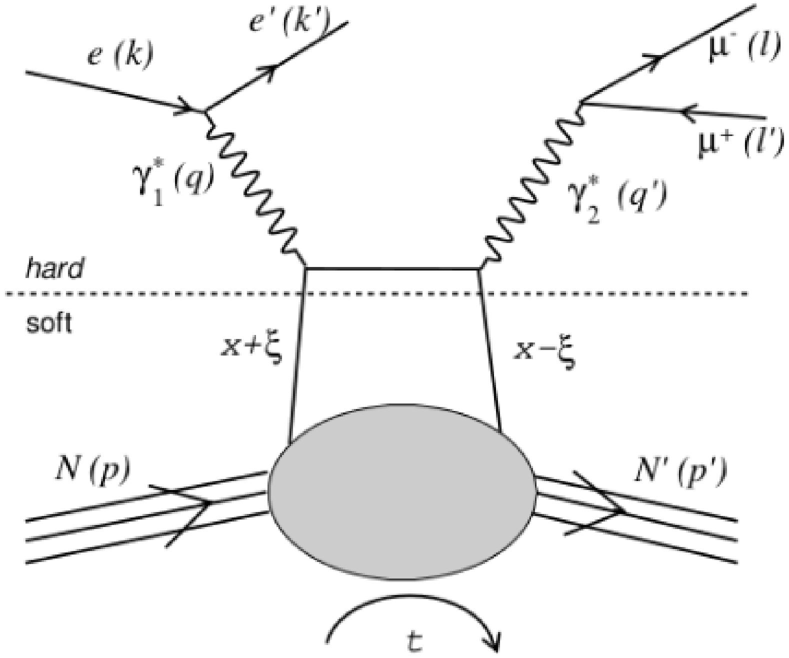
J/Psi Experiment E12-12-006 @ SoLID (C4)



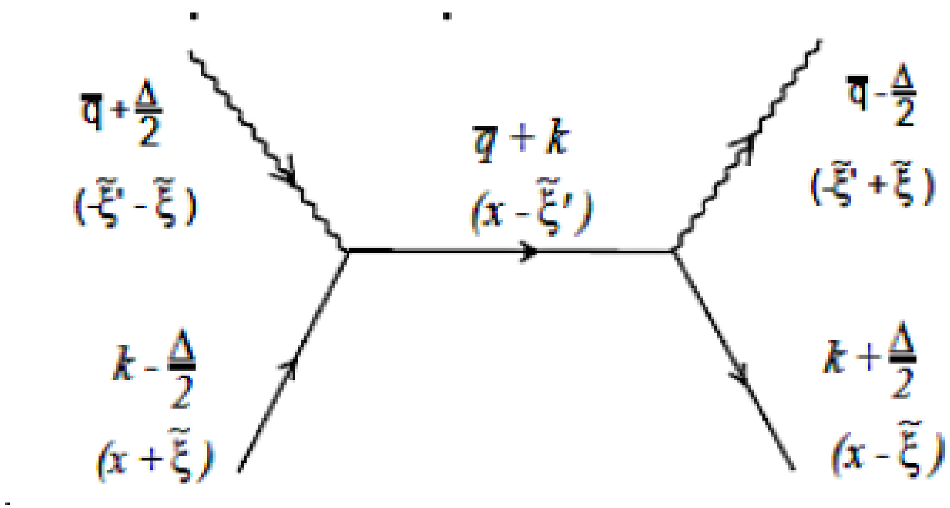
Sensitivity at threshold at about 10^{-3} nb!



Double Deeply Virtual Compton Scattering kinematical variables



e P → e' P' μ+ μ-



$$P = \frac{1}{2}(p + p'), \qquad P^\mu = \tilde{p}^\mu + \frac{\bar{m}^2}{2} n^\mu$$

$$\Delta = (p' - p) = (q' - q) \qquad \Delta^\mu = -2\tilde{\xi}\tilde{p}^\mu + \tilde{\xi}\bar{m}^2 n^\mu + \Delta^\mu_\perp$$

$$\bar{q} = \frac{1}{2}(q + q') \qquad \bar{q}^\mu = -\tilde{\xi}'\,\tilde{p}^\mu - \frac{\bar{q}^2}{2\tilde{\xi}'} n^\mu$$

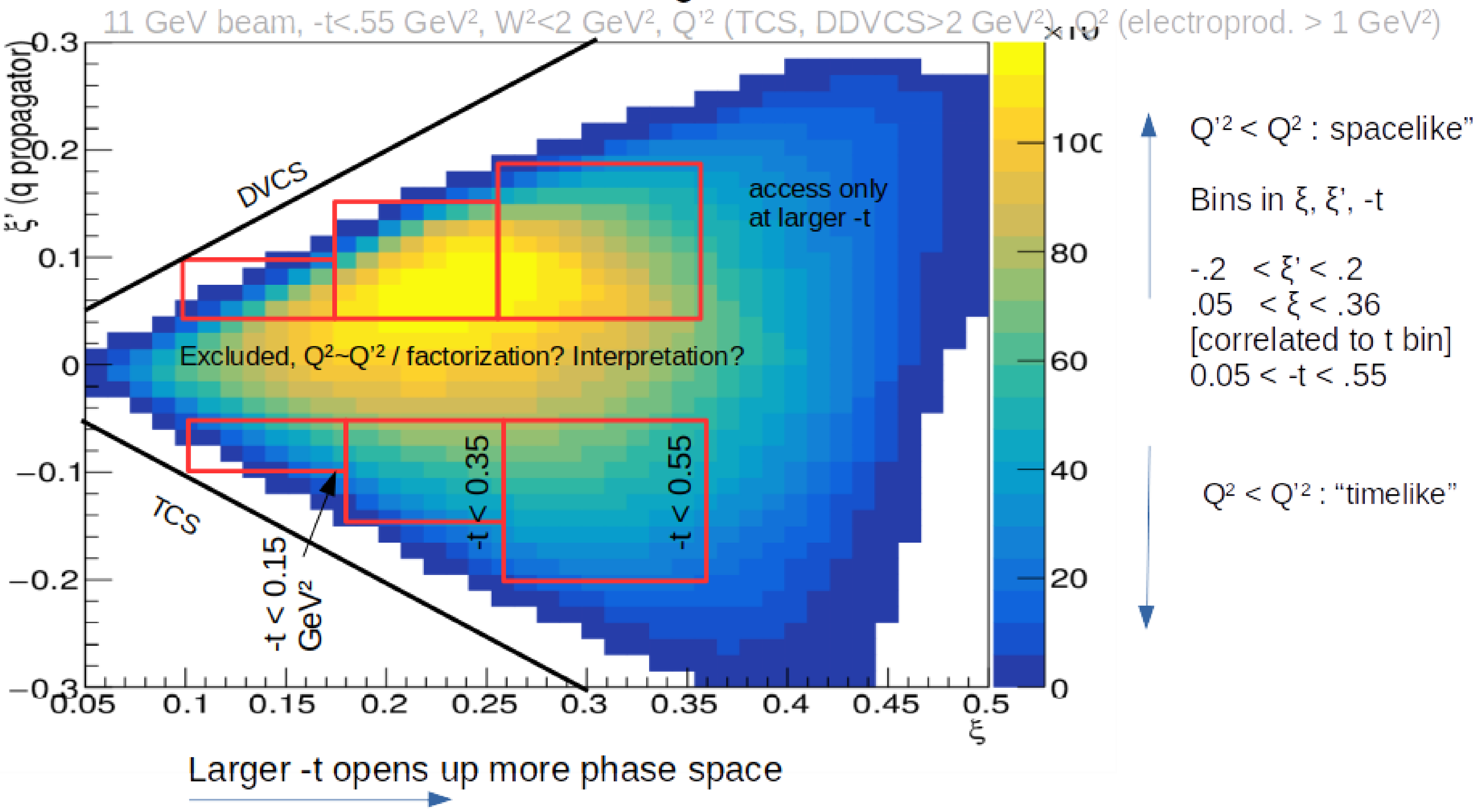
Need to measure a muon pair (antisymetrization, possibility to get the kinematics of 2 forward leptons)

7-independent variables for cross section.
Choice: E_e, ξ (or x_{bj}), t, Q^2, Q'^2, Φ_L, Φ_{CM}, θ_{CM}

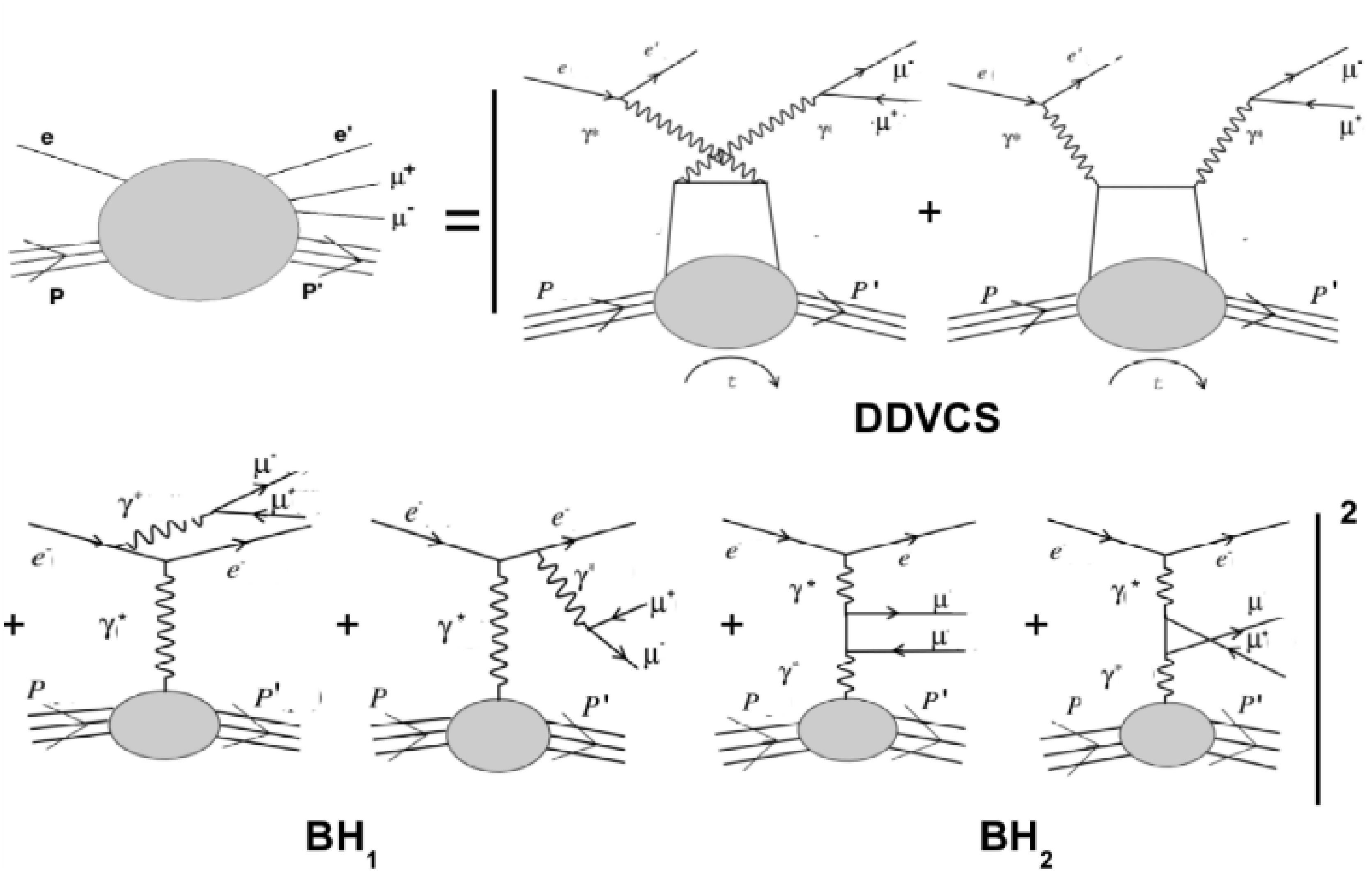
GPDs are function of a new variable skewness which is ration “transverse momentum over longitudinal “

$$\xi = \frac{\Delta.\bar{q}}{P.\bar{q}}$$

Off diagonal access



Interference with Bethe-Heitler

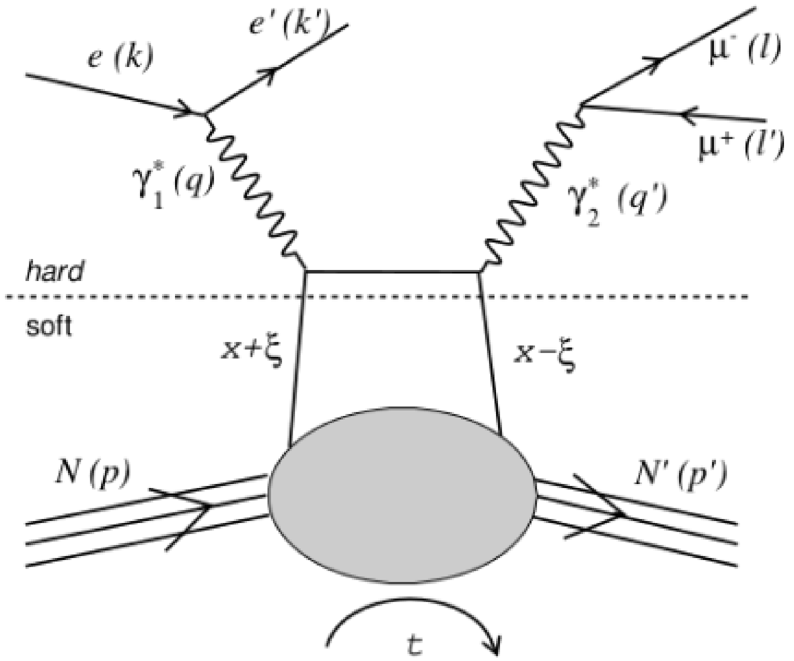


$d^5\vec{\sigma} - d^5\overleftarrow{\sigma} = Im(T^{BH}.T^{DDVCS})$

$d^5\vec{\sigma} + d^5\overleftarrow{\sigma} = |BH|^2 + Re(T^{BH}.T^{DDVCS})+ |DDVCS|^2$

BH1: understood from DVCS+BH ; BH2: understood from TCS+BH ("peaks" in thetaCM)

What do we want to measure?



e P → e' P' μ+ μ-

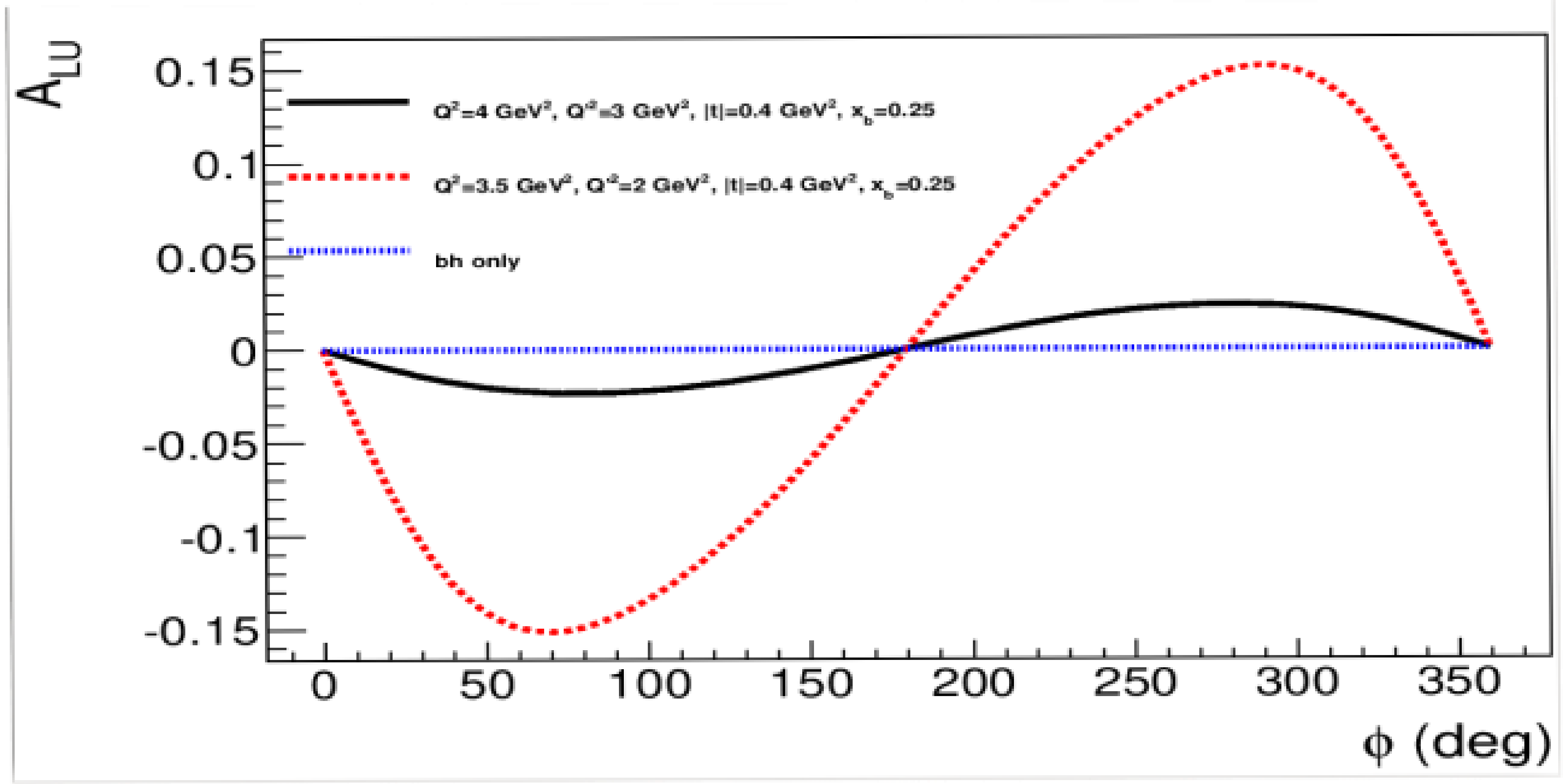
Need to measure a muon pair
(antisymetrization, possibility to get the kinematics of 2 forward leptons)

7-independent variables for cross section.
Choice: E_e, ξ (or x_{bj}), t, Q^2, Q'^2, Φ_L, Φ_{CM}, θ_{CM}

$$\left\{ \begin{matrix} A_{LU}^{\sin\phi} \\ A_{LU}^{\sin\varphi_\mu} \end{matrix} \right\} = \frac{1}{\mathcal{N}} \int_{\pi/4}^{3\pi/4} d\theta_\mu \int_0^{2\pi} d\varphi_\mu \int_0^{2\pi} d\phi \left\{ \begin{matrix} 2\sin\phi \\ 2\sin\varphi_\mu \end{matrix} \right\} \frac{d^7\overrightarrow{\sigma} - d^7\overleftarrow{\sigma}}{dx_B\, dy\, dt\, d\phi\, dQ'^2\, d\Omega_\mu} \propto \Im\mathrm{m}\left\{ F_1\mathcal{H} - \frac{t}{4M_N^2} F_2\mathcal{E} + \xi(F_1+F_2)\widetilde{\mathcal{H}} \right\},$$

Observables for DDVCS measurements at JLab

Beam Spin Asymmetry



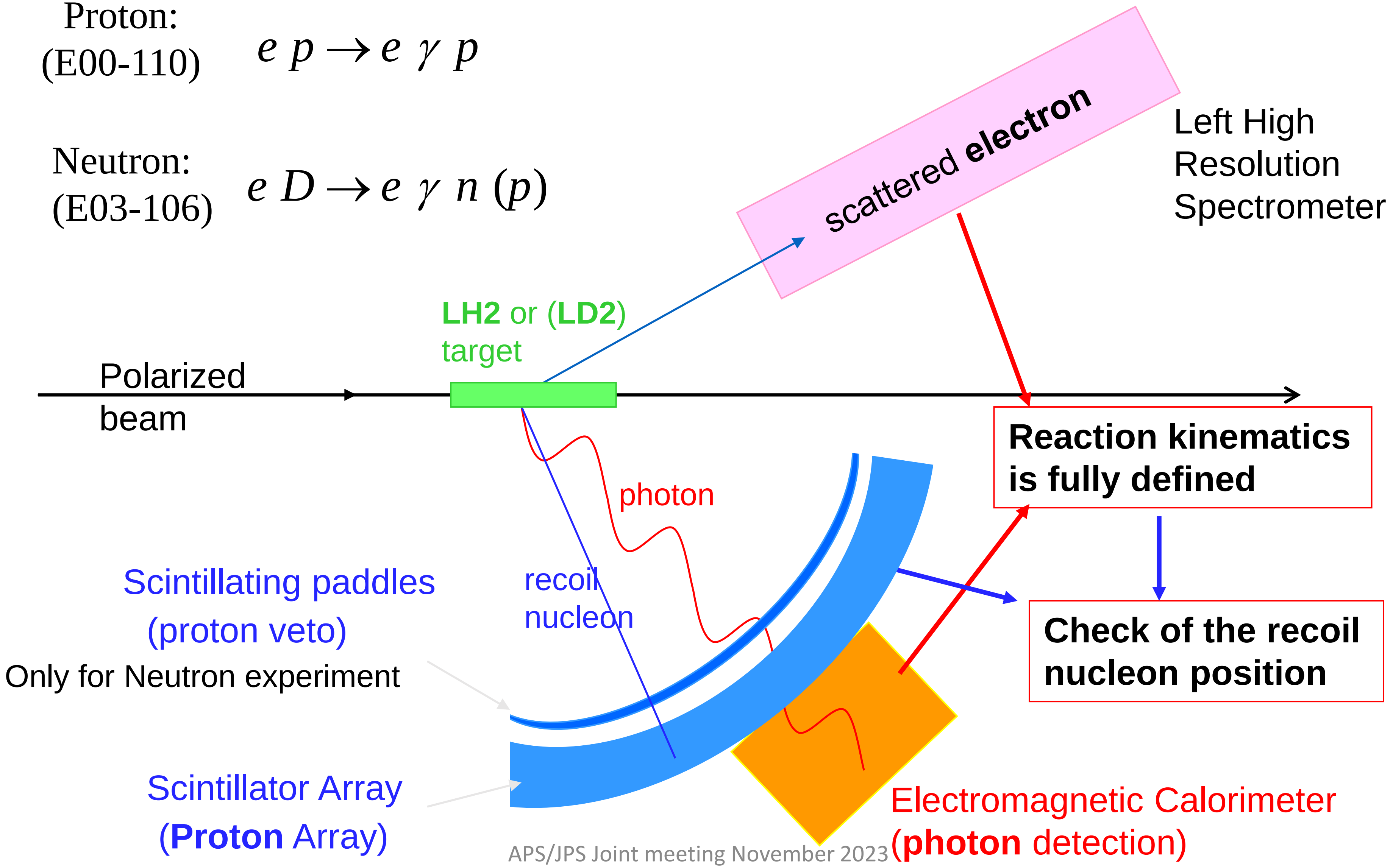
purely coming from interference between BH(1+2)*DDVCS asymmetries are sizeable.

Change of sign to be observed in different kinematic regions

Similar technique as DVCS in Hall A on neutron and proton

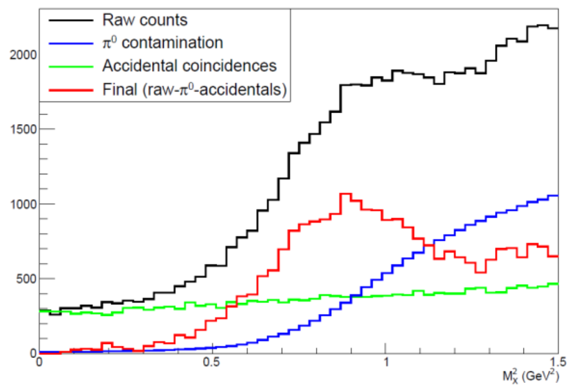
Proton:
(E00-110) $e\,p \to e\,\gamma\,p$

Neutron:
(E03-106) $e\,D \to e\,\gamma\,n\,(p)$



12 GeV DVCS on proton

- Jefferson Lab Hall A Collaboration•F. Georges(IJCLab, Orsay) et al. (Jan 10, 2022)
- e-Print: 2201.03714 [hep-ph]Deeply virtual Compton scattering cross section at high Bjorken x BxB



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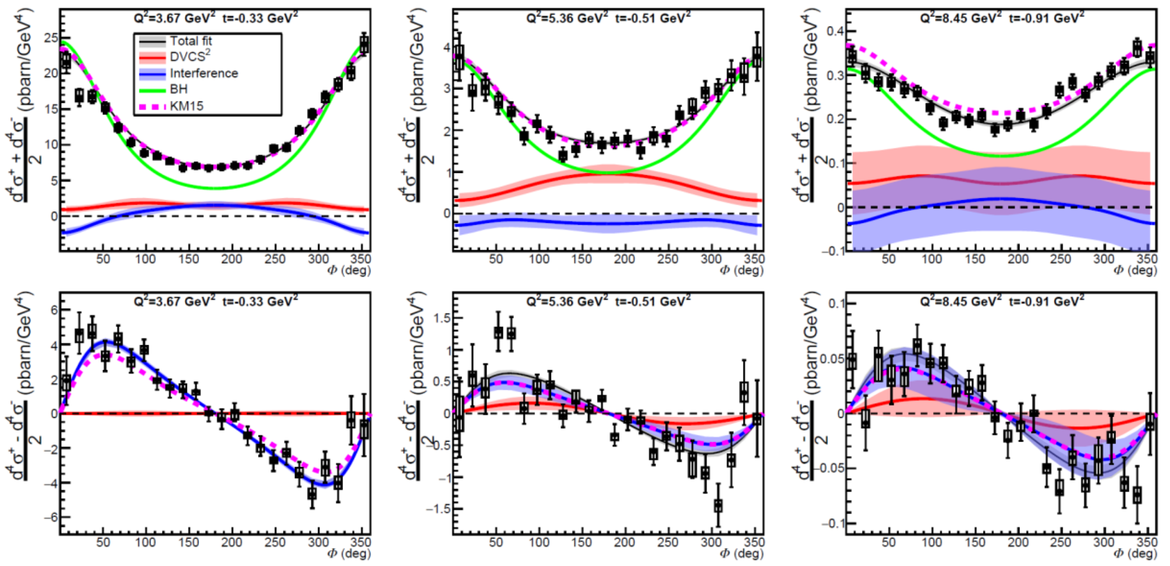
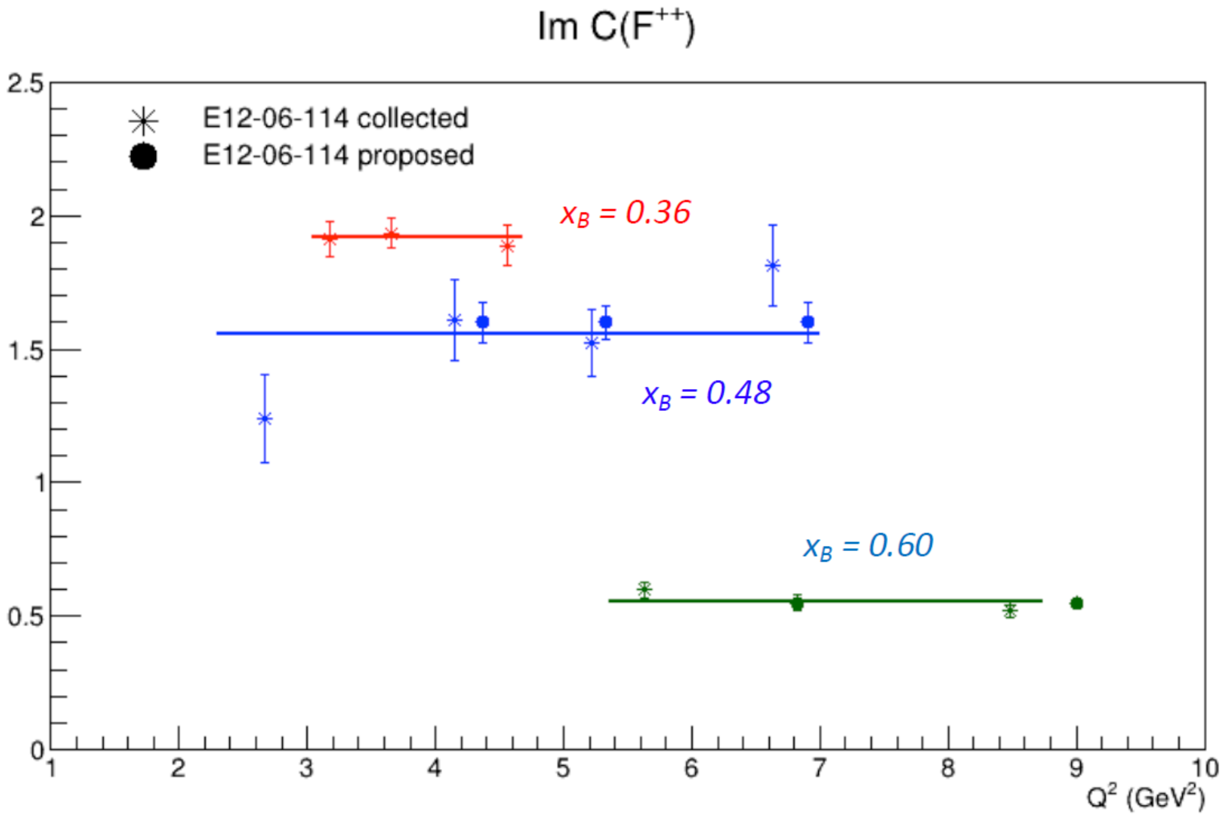
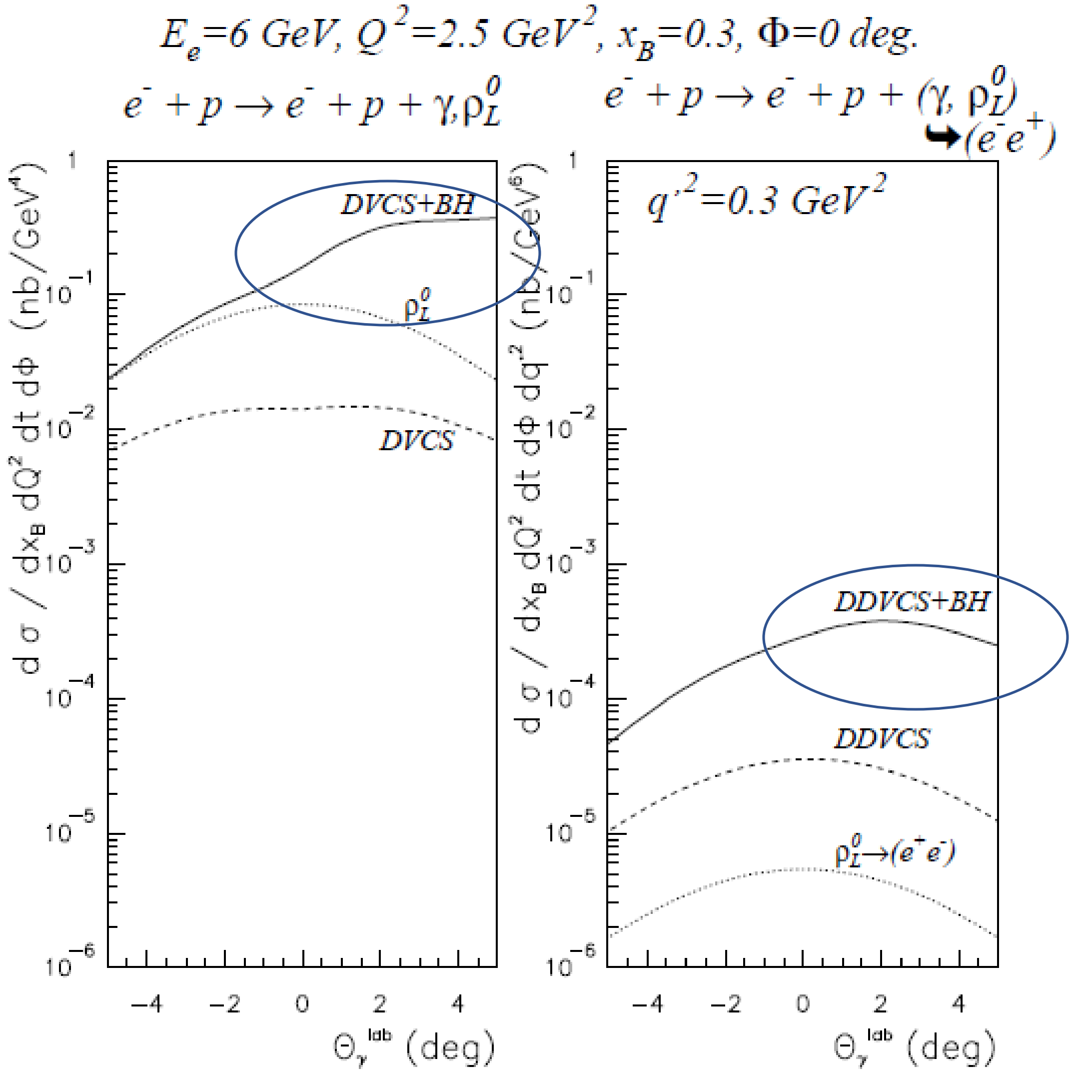


Hall A at 12 GeV: The DVCS experiment, E12-06-114

- Im[DVCS*BH]
  - “sinϕ”
- x = 0.48
  - Full statistics at full acceptance
- x=0.60
  - High statistics run at two additional Q^2 values



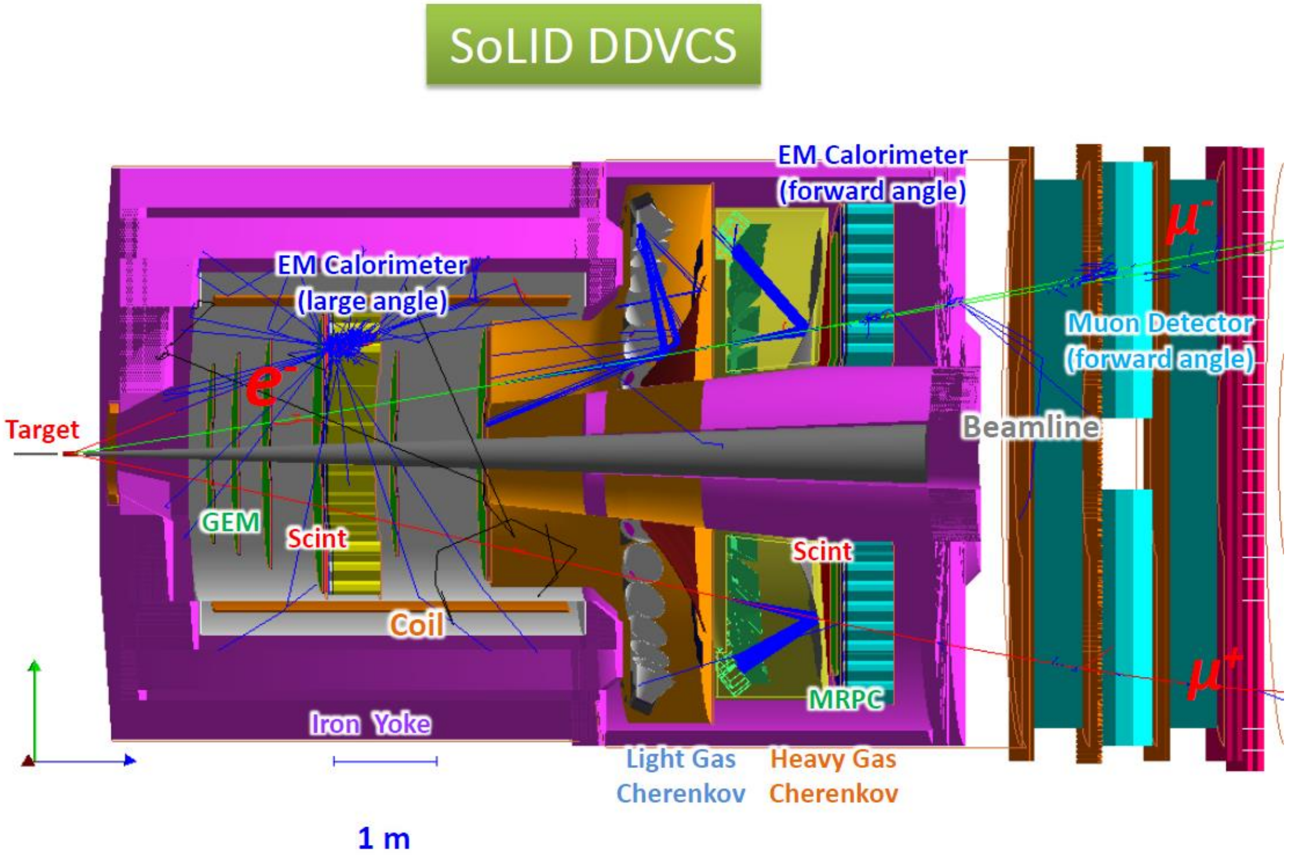
DDVCS cross section



- VGG model
- Order of ~0.1 pb = 10^{-36}cm^2
- About 100 to 1000 smaller than DVCS
- Virtual Beth and Heitler
- Interference term enhanced by BH
- Contributions from mesons small when far from meson mass

SoLID DDVCS Setup

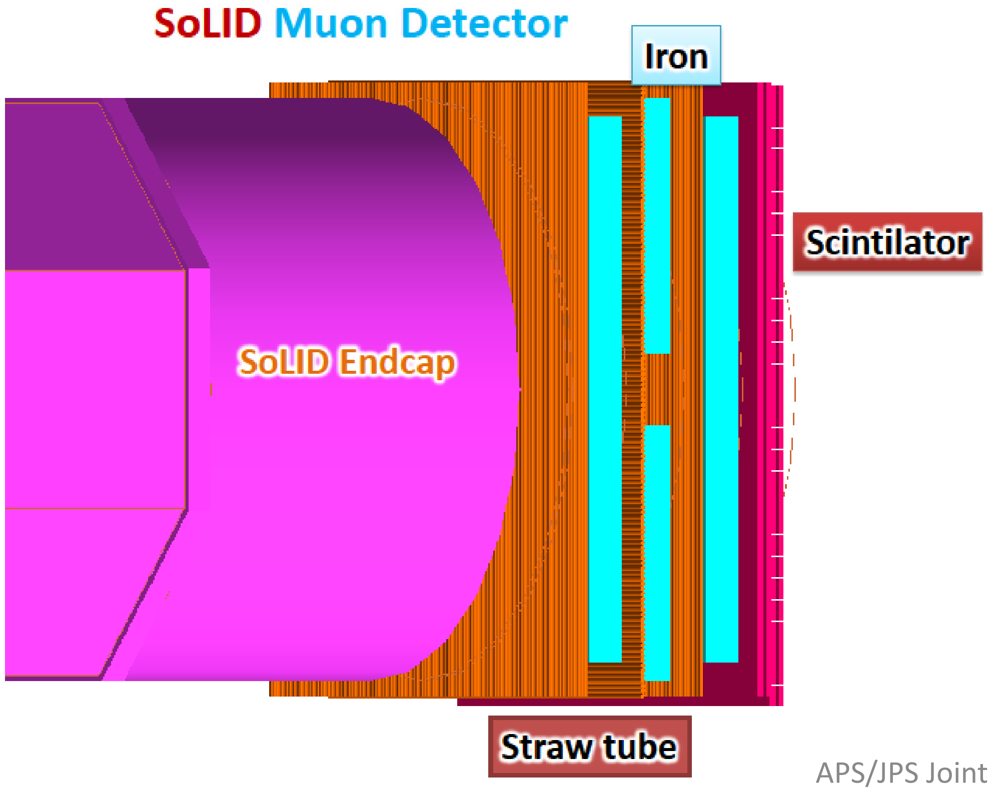
- Based on SoLID JPsi setup with forward muon detector added



- Muon detector outside from SoLID so lower background than e^+e^-
- Muons detection remove ambiguity with scattered electron compared to e^+e^- channel
- Main background behind calorimeter are pions
- Pions can be ranged out with iron plates while muon go through all layers

forward angle muon detector

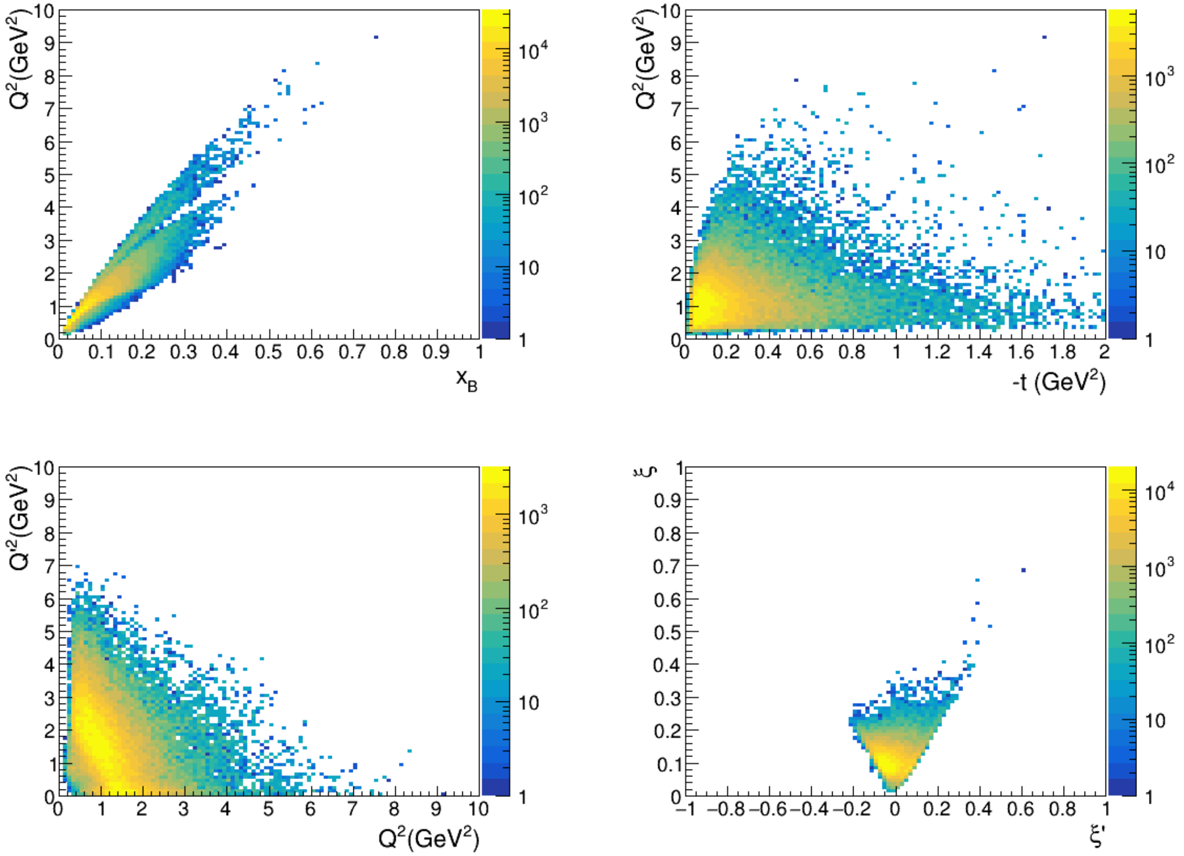
- 3 layers iron to block pion, 3 layers straw tube for tracking, 2 layer2 scintillator for trigger

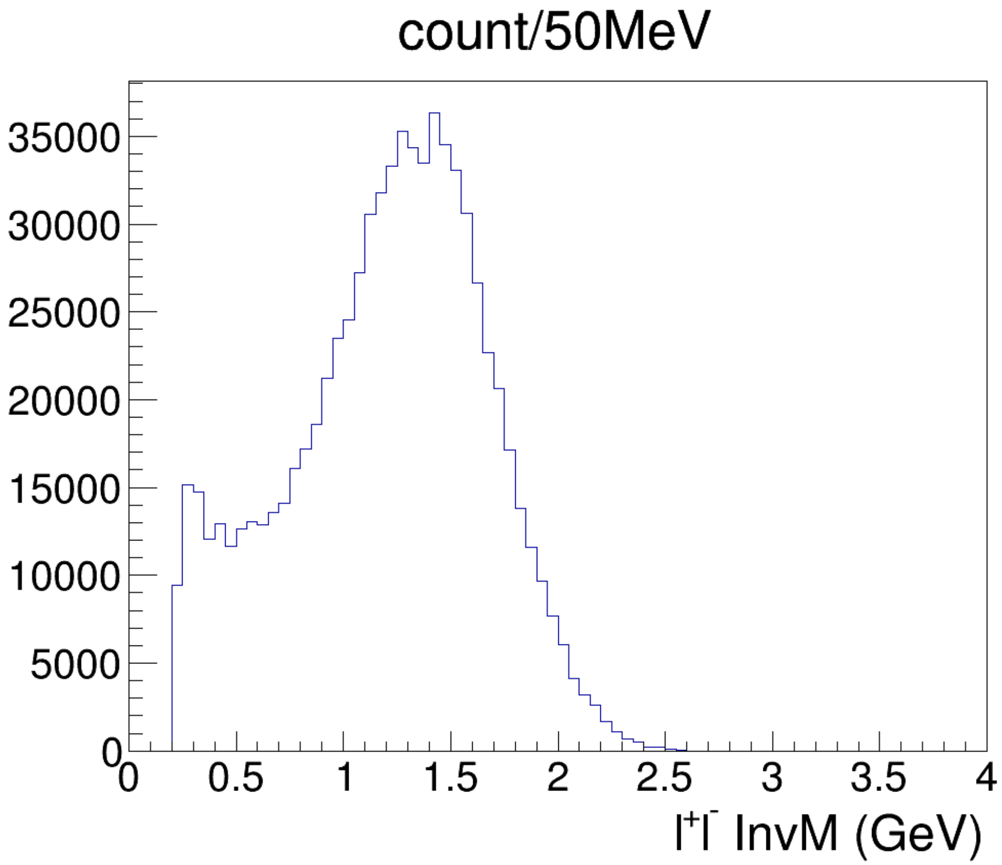


Example of straw tube chambers similar to Seaquest experiment

Bethe Heitler kinematics and counts (800k events)

- 30k events for 2GeV< InvM, 600k events for 1GeV<InvM
- Enough for ~500bins in 5D with 1000 events per bin





Single pion background at muon detector

- Start from “evgen_bggen” generator based on resonance fit and pythia
- go through full SoLID simulation for pion blocking and muon decay
- Including both primary and secondary particles
- pi-/pi+ rate 9khz, mu-/mu+ rate 26khz, total 70khz
- Two charge particle coincidence rate 70e3*70e3*100ns<1khz
- Main source of rate in the muon detector
- Straw chambers and scintillators were operated up to 1 MHz for Seaquest

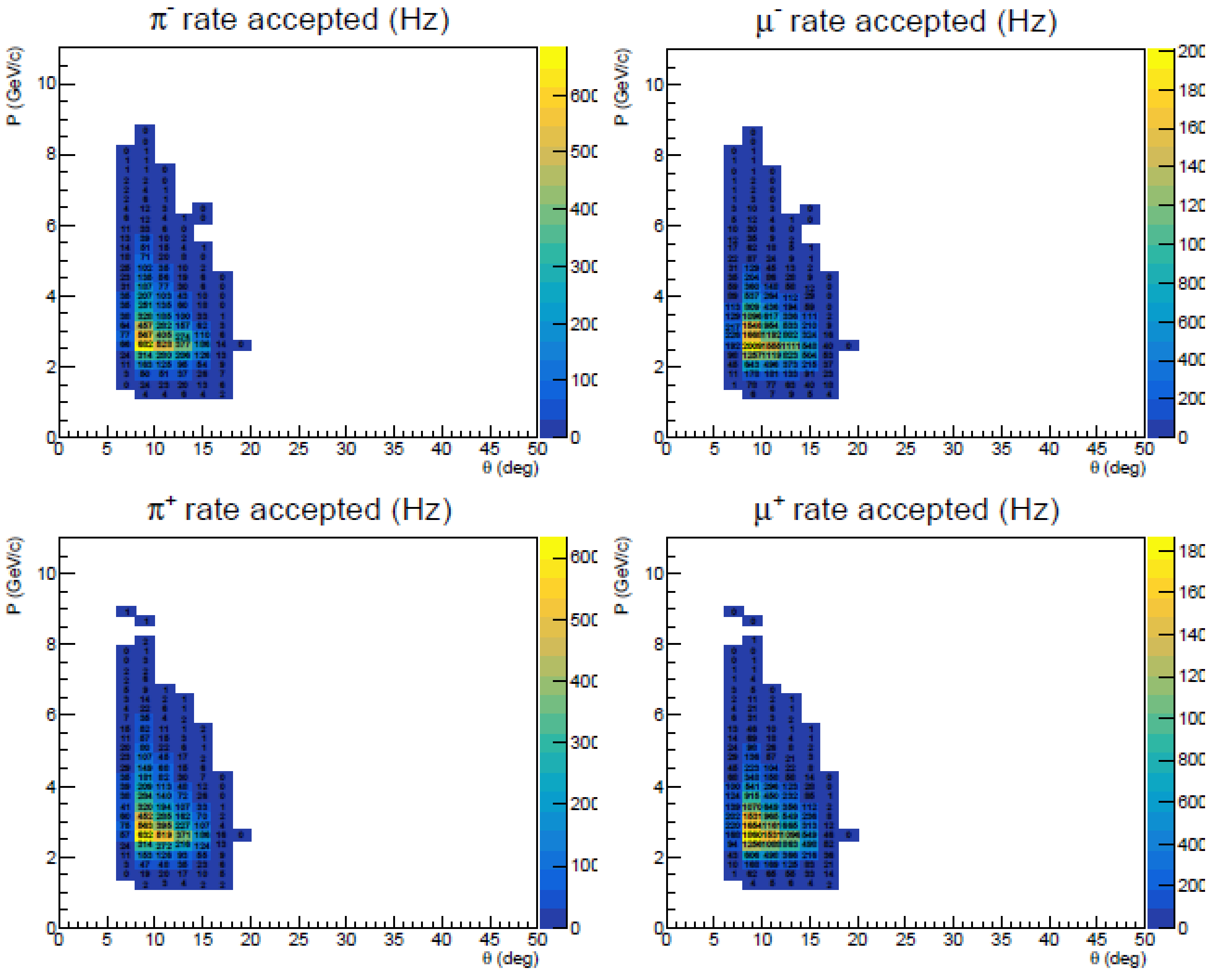
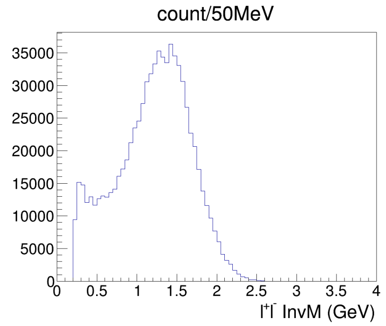


Figure 22: Single particles rate of pion and muon from pion decay at the back of forward angle muon detector. They include both pions directly from target and all secondaries and muons from their decay.



Two pion exclusive background

- Start from “twopeg” generator based on CLAS data fit and extrapolation to 11GeV beam kinematics
- go through full SoLID simulation for pion blocking and muon decay
- Including primary particles only
- 10% of BH counts, mainly from both decay into muons.
- Tracking with vertex cut could reduce it further

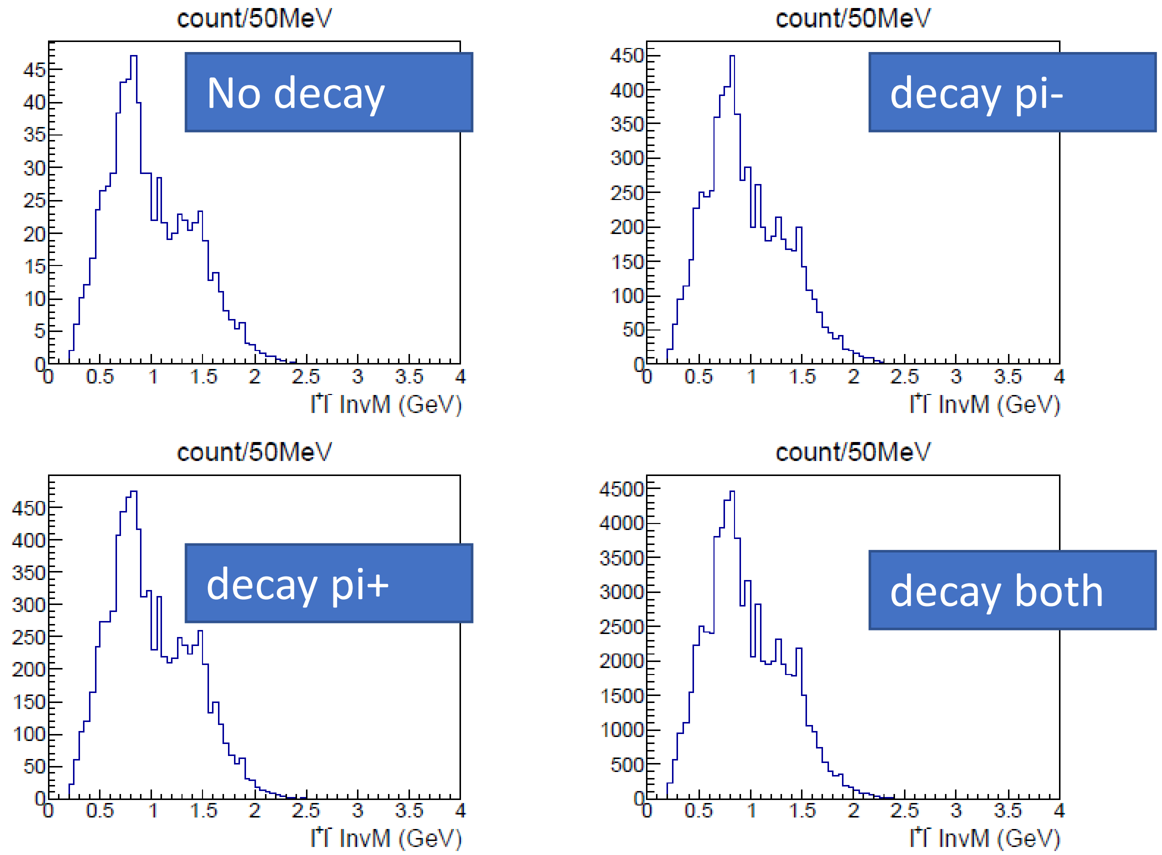
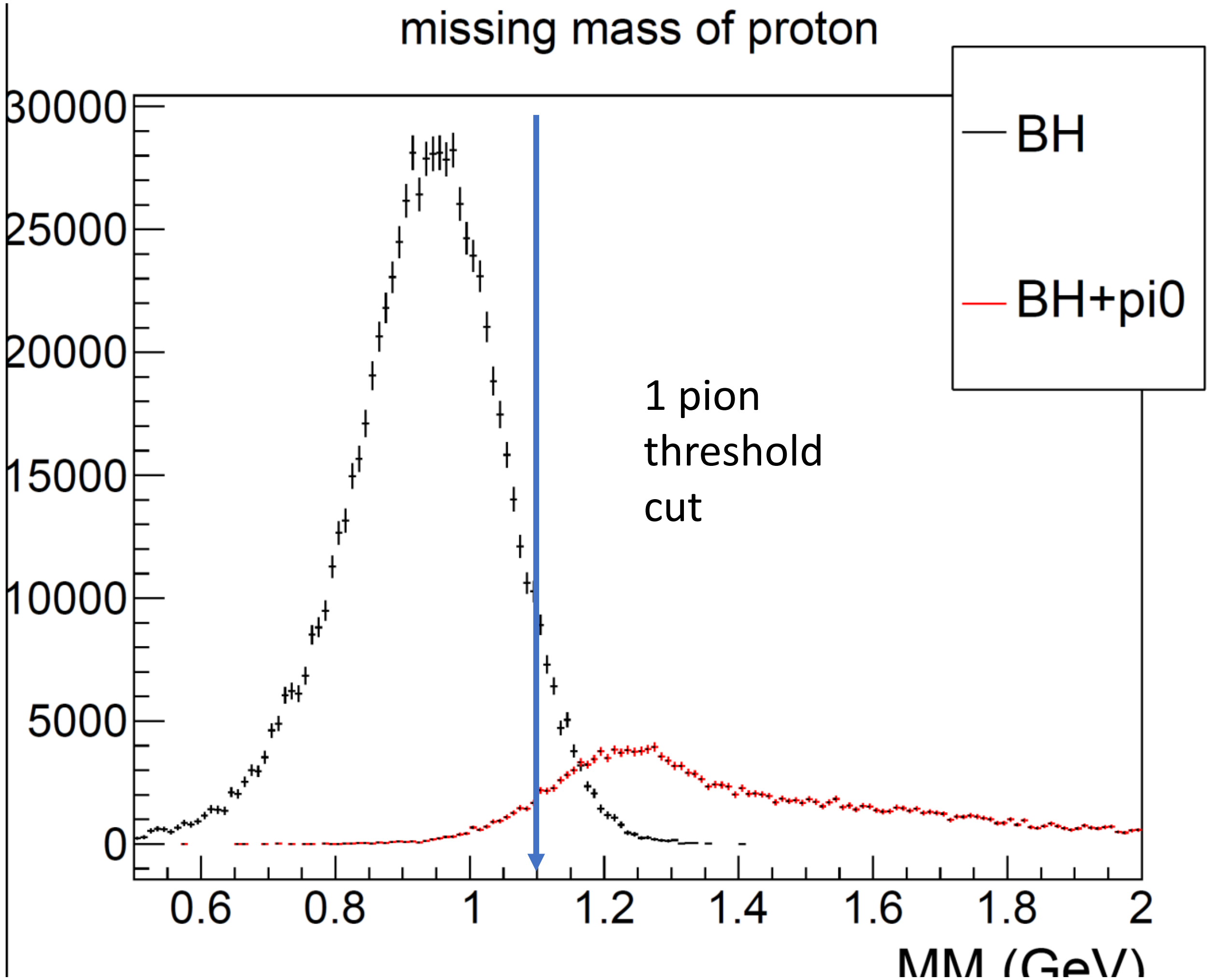


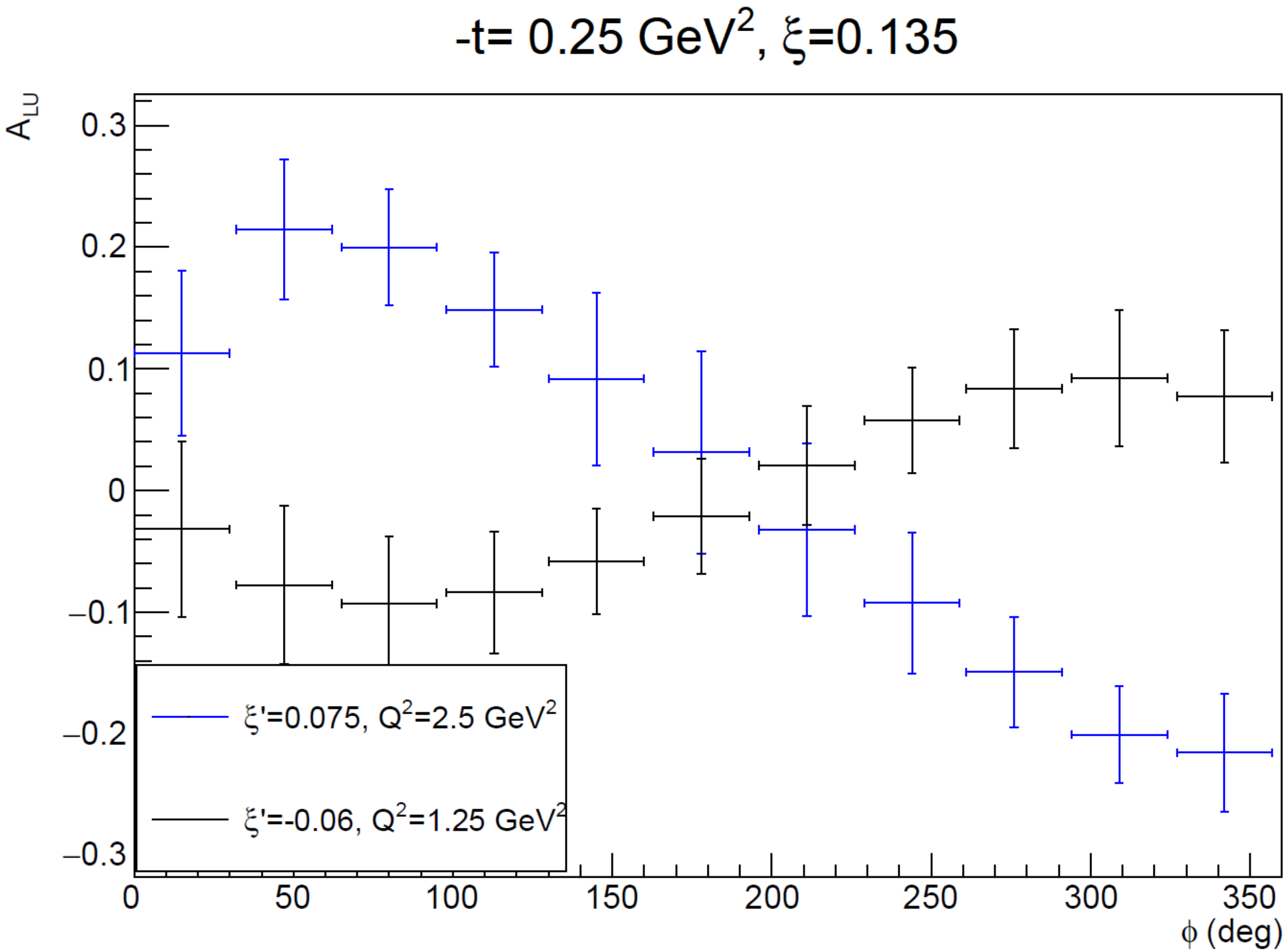
Figure 23: From left to right and top to bottom, the counts from the two pion exclusive channel contamination are shown in 4 cases, neither pion decay, negative pion decays into muon, positive pion decays into muon, and both pions decay.

Missing Mass $e\mu^+\mu^-X$



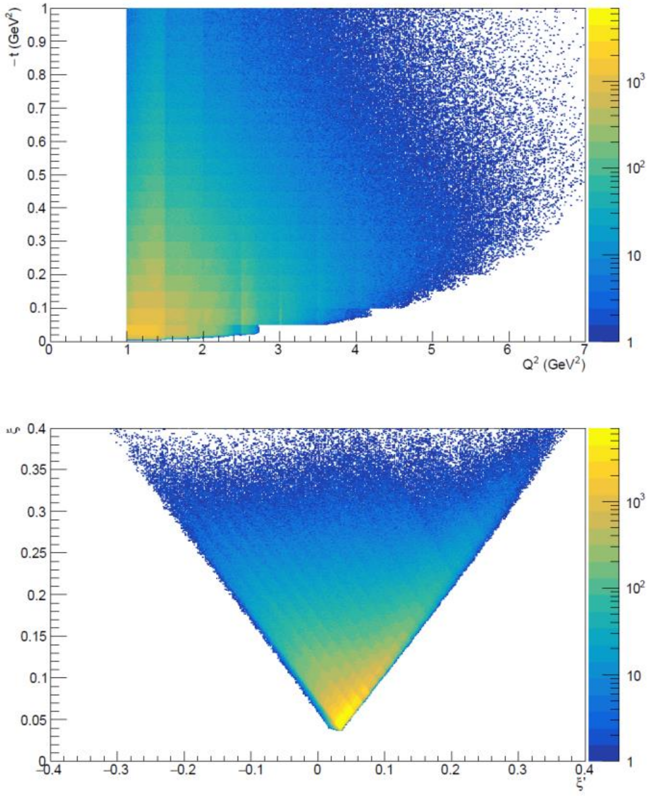
- Used proton resolution for J/Psi
- BH and inelastic from Grape normalized to J/Psi luminosity
- Missing mass resolution very good to separate exclusive events

Example one bin asymmetry with J/Psi luminosity

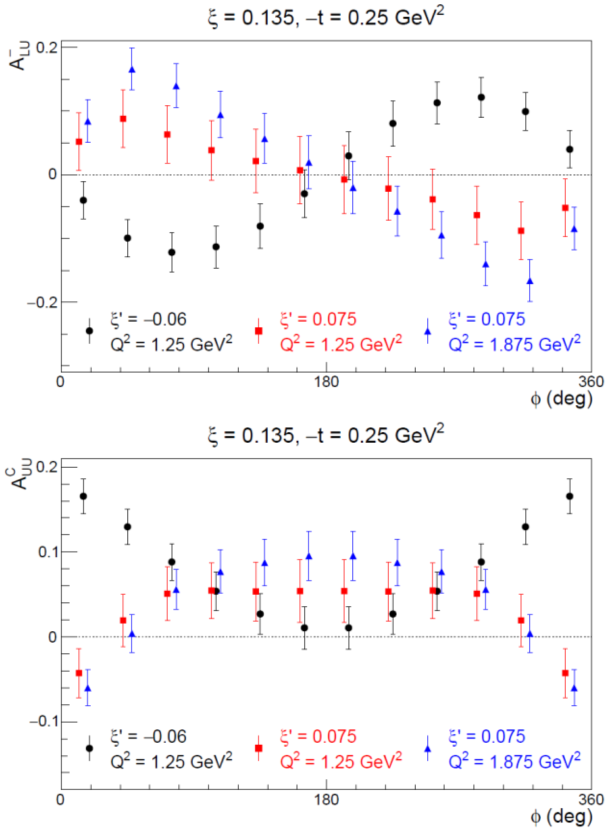


DDVCS with 11GeV positron beam

coverage



projection



$$\xi' = \frac{Q^2 - Q'^2 + t/2}{2Q^2/x_B - Q^2 - Q'^2 + t}$$

$$\xi = \frac{Q^2 + Q'^2}{2Q^2/x_B - Q^2 - Q'^2 + t}$$

50 days of electron BSA

plus 50 days of positron BCA

EPJA 57, 240 (2021)

$$A^{\pm}_{LU}(\phi) = \frac{1}{\lambda^{\pm}} \frac{d^5\sigma^{\pm}_{+} - d^5\sigma^{\pm}_{-}}{d^5\sigma^{\pm}_{+} + d^5\sigma^{\pm}_{-}} = \frac{d^5\widetilde{\sigma}_{DDVCS} \mp d^5\widetilde{\sigma}^{\mathrm{INT1}}}{d^5\sigma_{BH_1} + d^5\sigma_{BH_2} + d^5\sigma_{DDVCS} \mp d^5\sigma_{IN}}$$

$$\left(A^{C}_{UU}(\phi) = \frac{(d^5\sigma^{+}_{+} + d^5\sigma^{+}_{-}) - (d^5\sigma^{-}_{+} + d^5\sigma^{-}_{-})}{d^5\sigma^{+}_{+} + d^5\sigma^{+}_{-} + d^5\sigma^{-}_{+} + d^5\sigma^{-}_{-}} = \frac{d^5\sigma_{INT_1}}{d^5\sigma_{BH_1} + d^5\sigma_{BH_2} + d^5\sigma_{DDVCS}}\right.$$

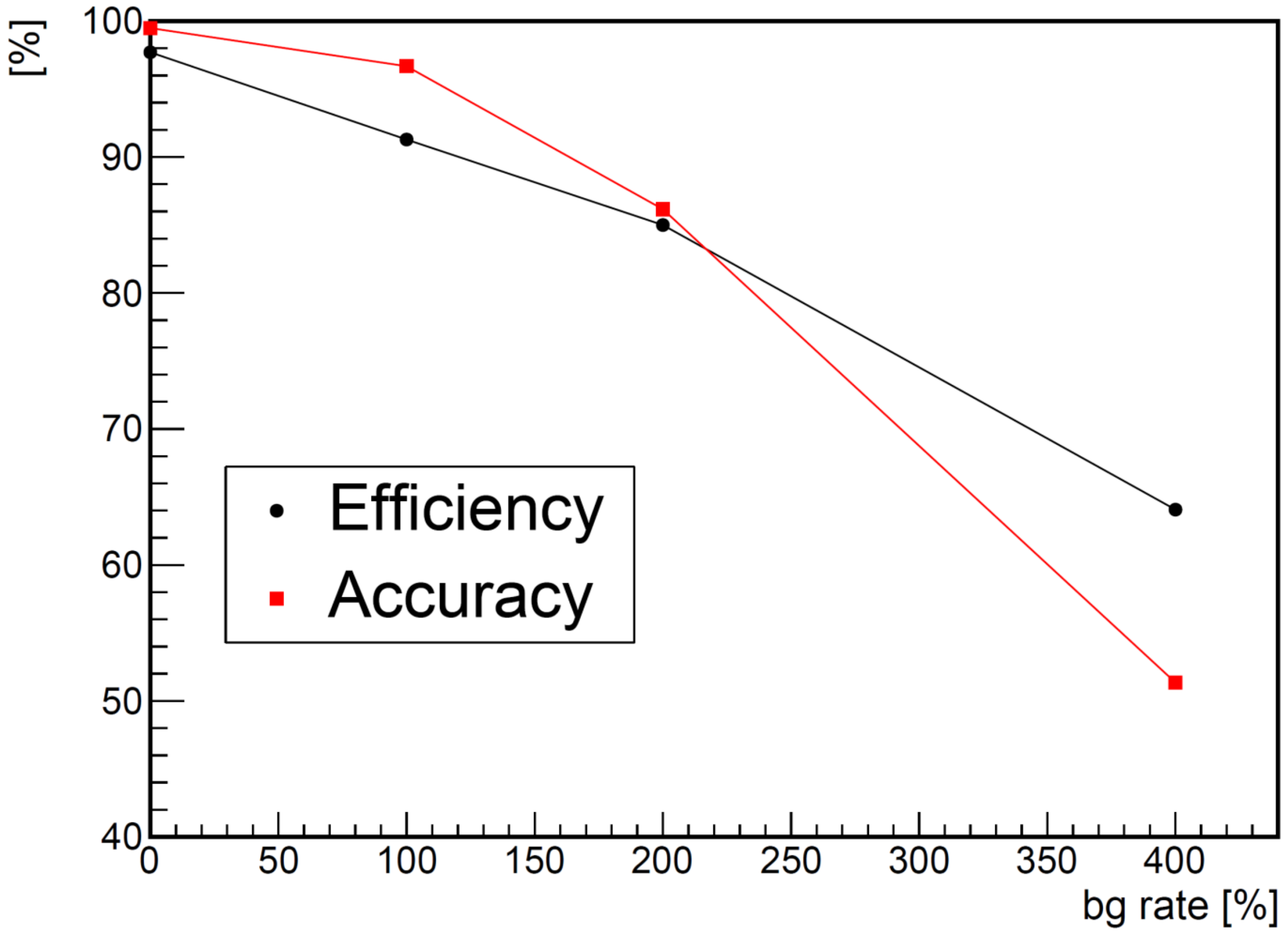
Higher luminosity possible upgrades

- J/Psi running at 3 uA on 15 cm target : limited by tracking, radiation damages and occupancies
- Current could go up to 80 uA
- Target length up to 1 meter (~1.8 10^39 $cm^{-2}s^{-1}$), typical 40 cm
- Tracker occupancy and photon background
  - Reduce amount of Copper in GEM
  - Add more planes for increased efficiency and reduce ambiguities
  - 2D readout pad readout
  - Radiation hardened silicon and MAPS
  - Possible superconducting nanowire trackers
- Calorimetry : rates, radiation damage
  - Study liquid scintillator and cryogenics calorimeter option
  - Increase granularity
  - Imaging 4D calorimeter
  - Superconducting Nanowire Detector to replace PMT (1 ns width pulse to increase rate capability)
- Particle identification
  - Microchannel plate PMTs for Cerenkov
  - Superconducting detector pixellized Nanowire detector to replace PMTs (1 ns width pulse to increase rate capability)
  - Hadron Blind Detector type Cerenkov for Large Angle calorimeter
  - LGAD
  - MRPC
  - …

6. 10^38 $cm^{-2}s^{-1}$ at 11 GeV and 3. 10^38 $cm^{-2}s^{-1}$ at 22 GeV

Technically doable mostly matter of cost

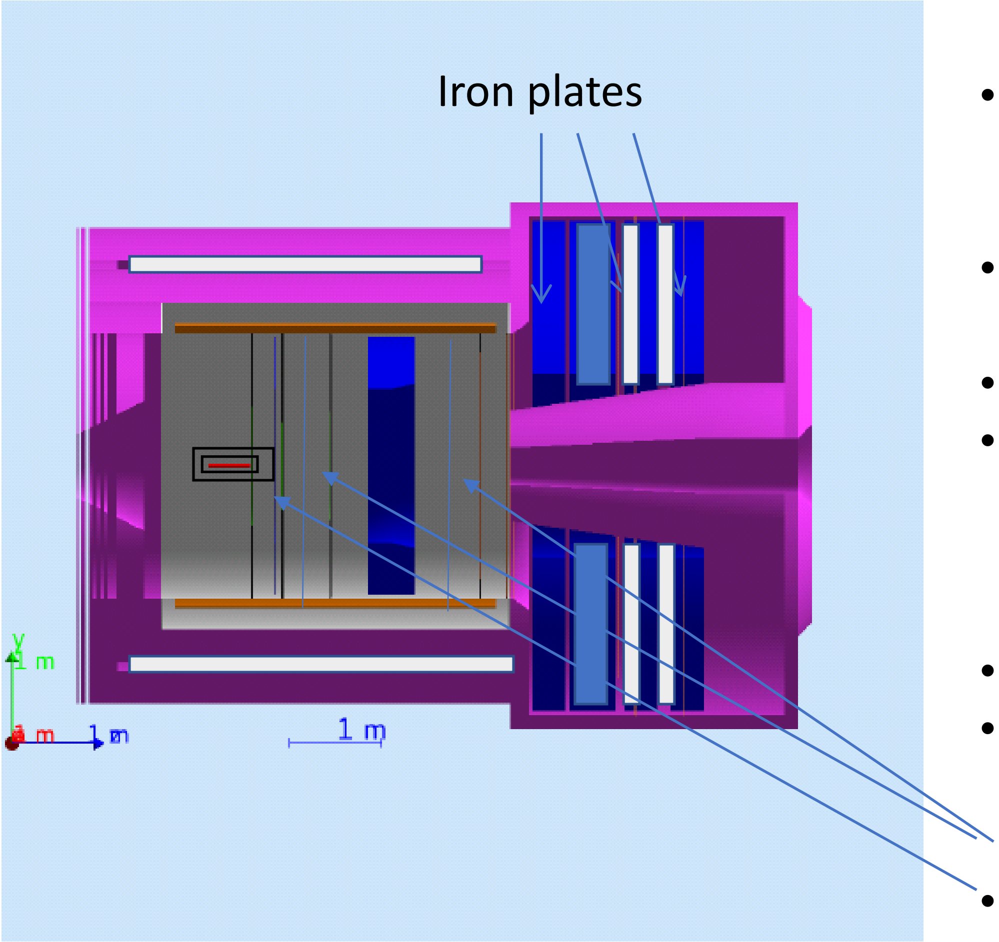
Higher luminosity J/Psi setup tracking study



Weizhi Xiong

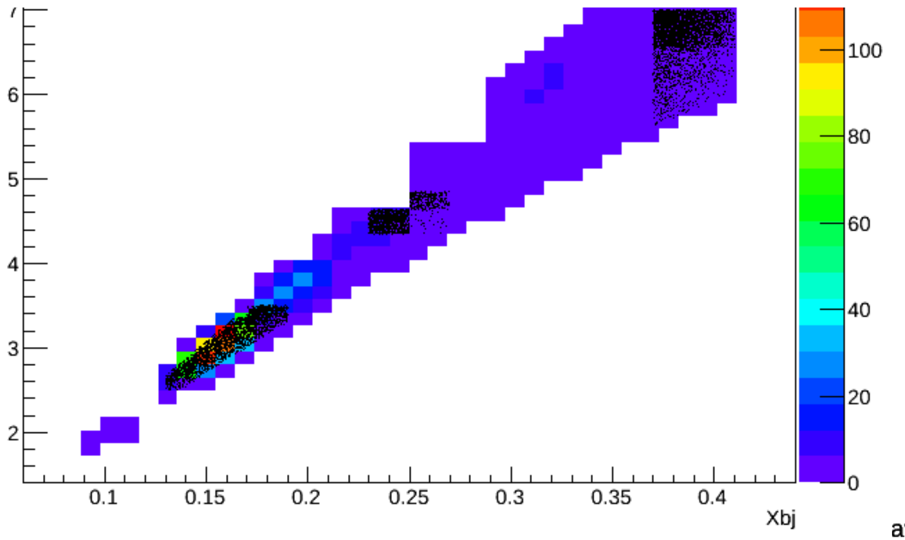
Simple
Kalman filter
tracking

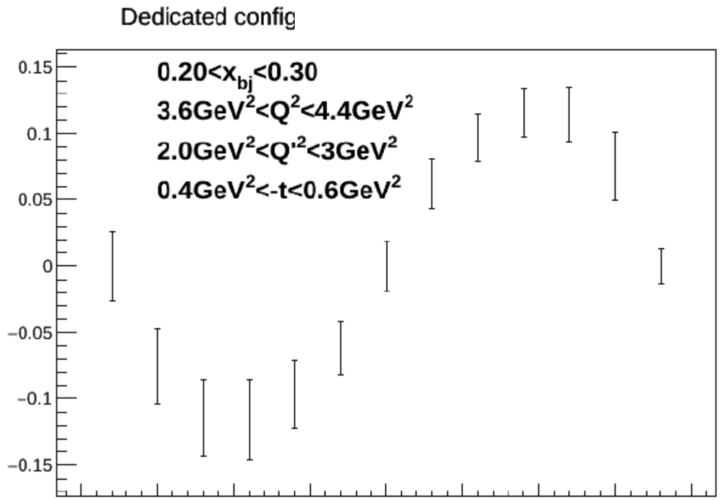
Possible dedicated setup

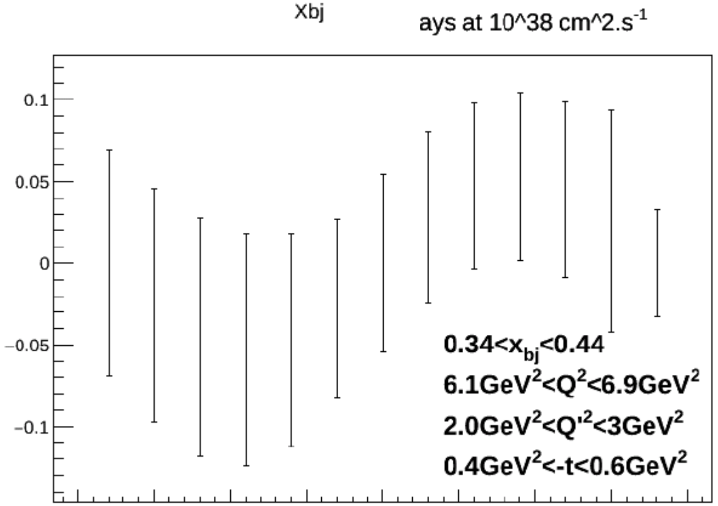


- Target moved 2m from Jpsi position inside and switch to 45 cm target
- Iron plate from 3rd layer yoke in front and behind calorimeter
- Remove Gas Cerenkov
- Try to reach 10^{38} $cm^{-2}s^{-1}$
- 30 uA on 15 cm target (typical run in Hall A no beam dump upgrade required)
- Additionnal trackers planes
- Pixellized (MAPS or GEMs or superconducting nanowire) planes to reduce combinatorial
- Possible superconducting vertex tracker for vertex cut

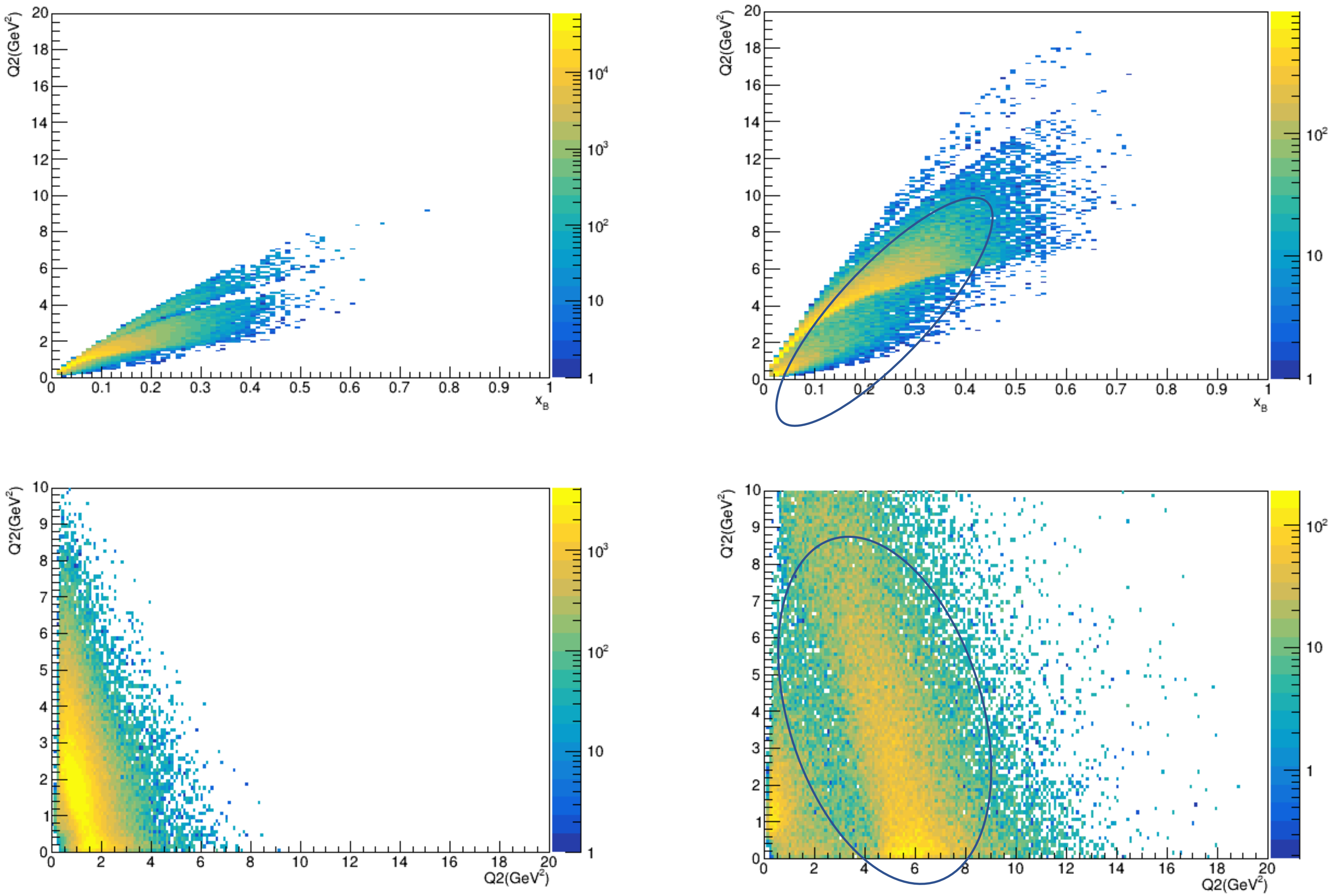
Expected accuracy dedicated setup
90 days at 10^{38} $cm^{-2}s^{-1}$





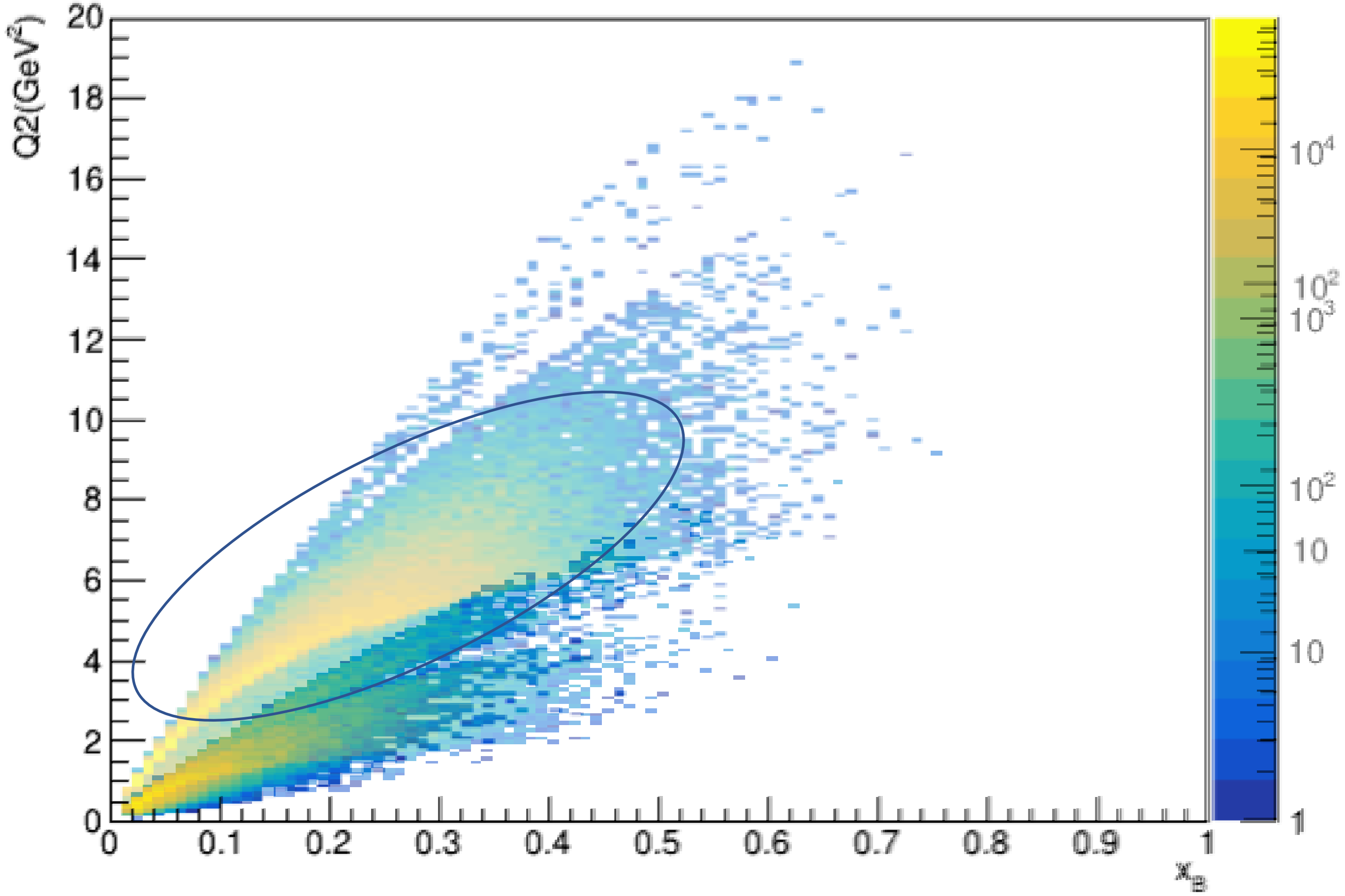


22 GeV upgrade kinematical coverage



Zhiwen Zhao (GRAPE)

11 GeV vs 22 GeV

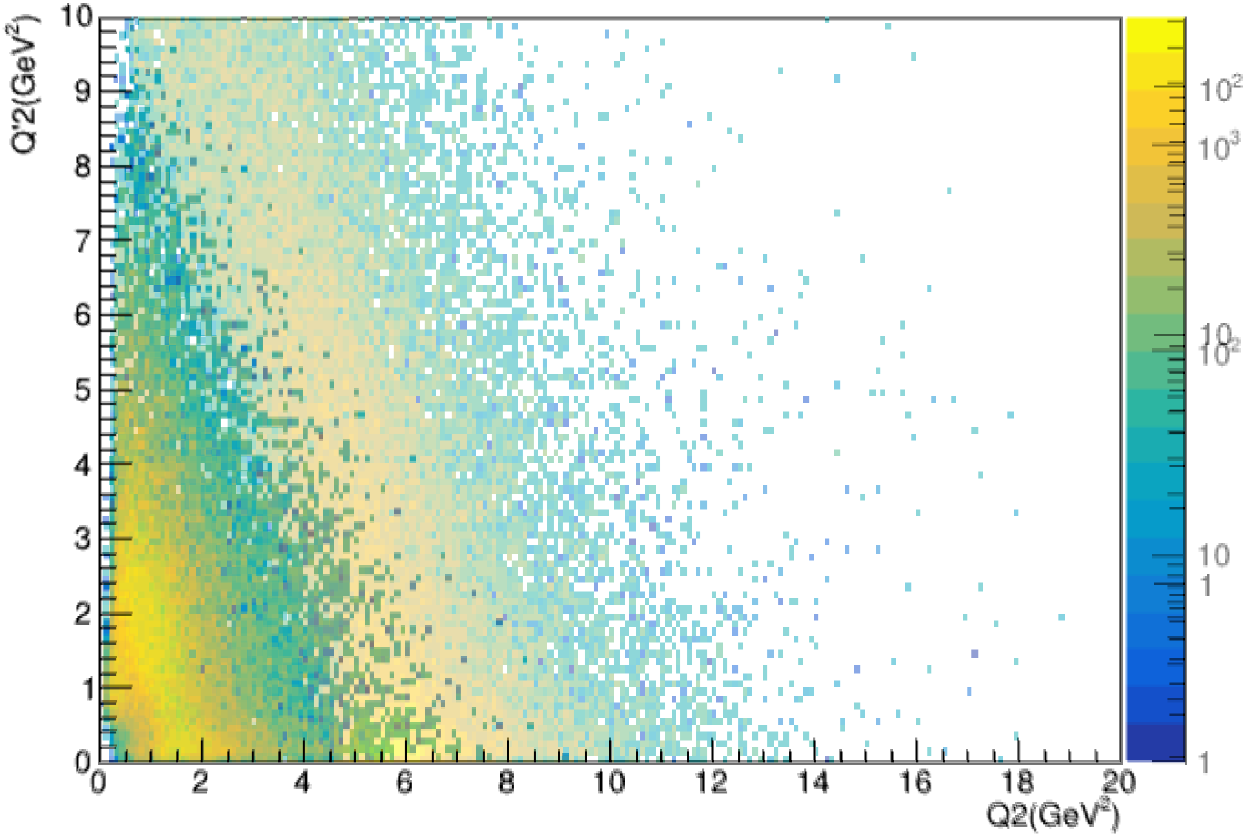


Large Q2 range

Check factorization

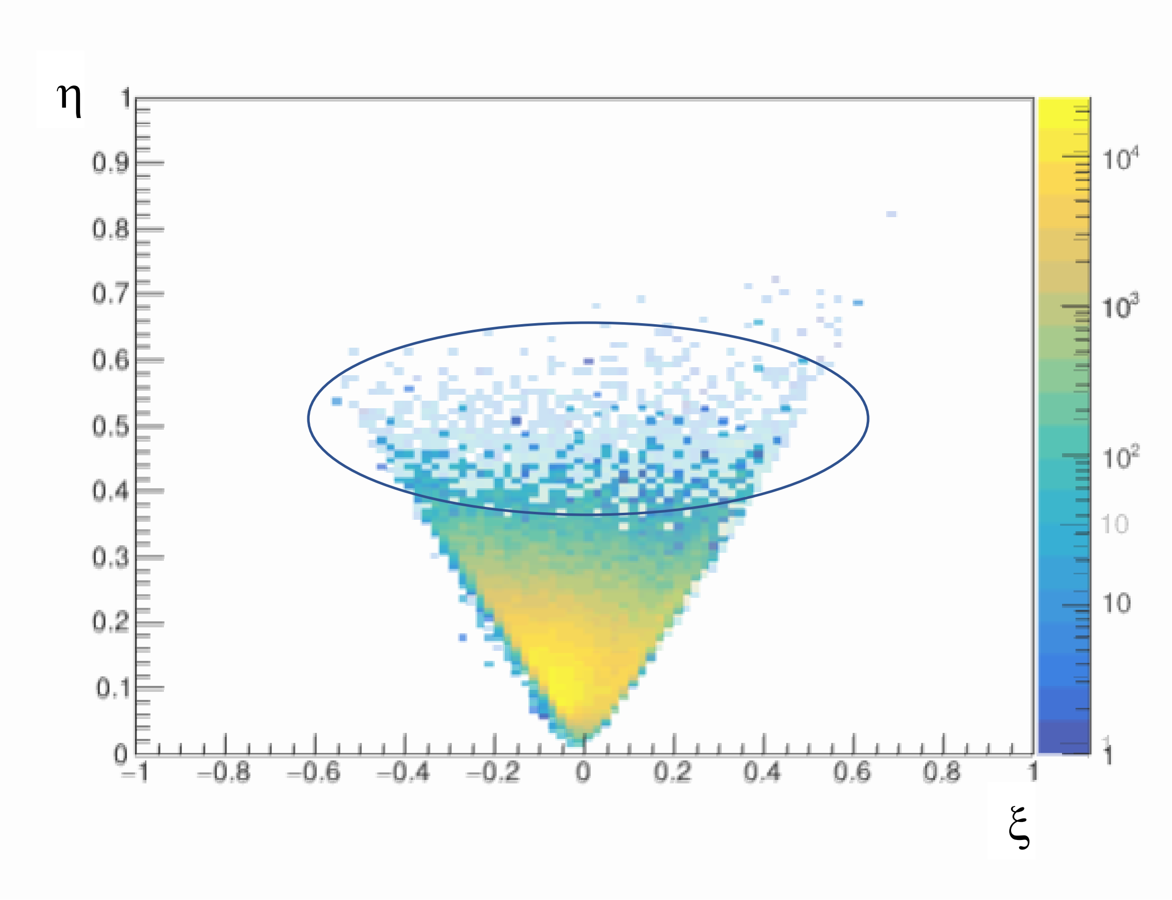
Evolution

11 GeV vs 22 GeV



Increased Q^2 Q'^2 coverage

11 GeV vs 22 GeV



Increased acceptance in ξ and η

Quick numbers for J/Psi settings

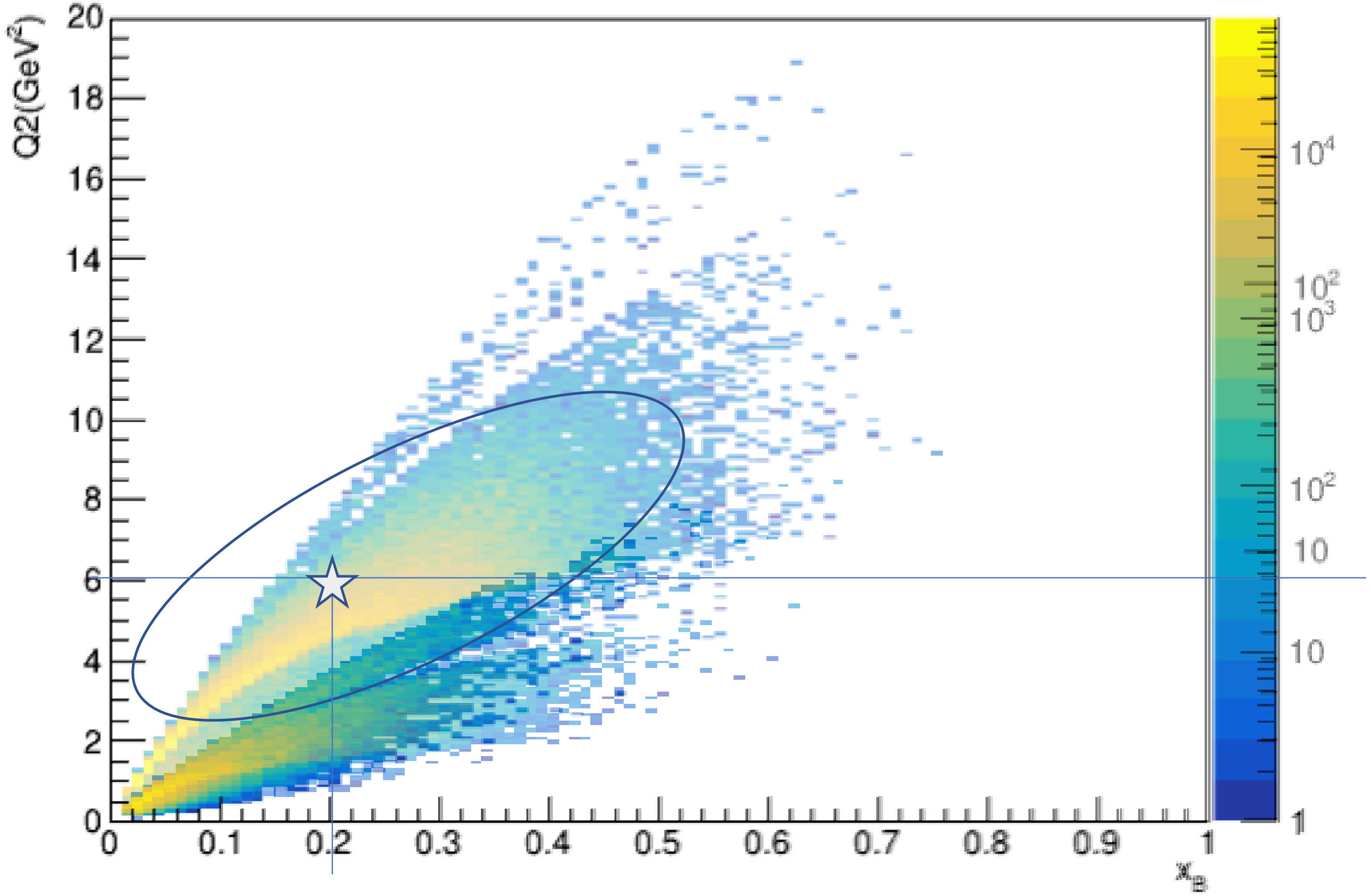
50 days at 10^37

Beam energy	e-mu-mu+
11	180156
22	51600

Cross section about 3 times lower : could run at 10 uA or with 45 cm target

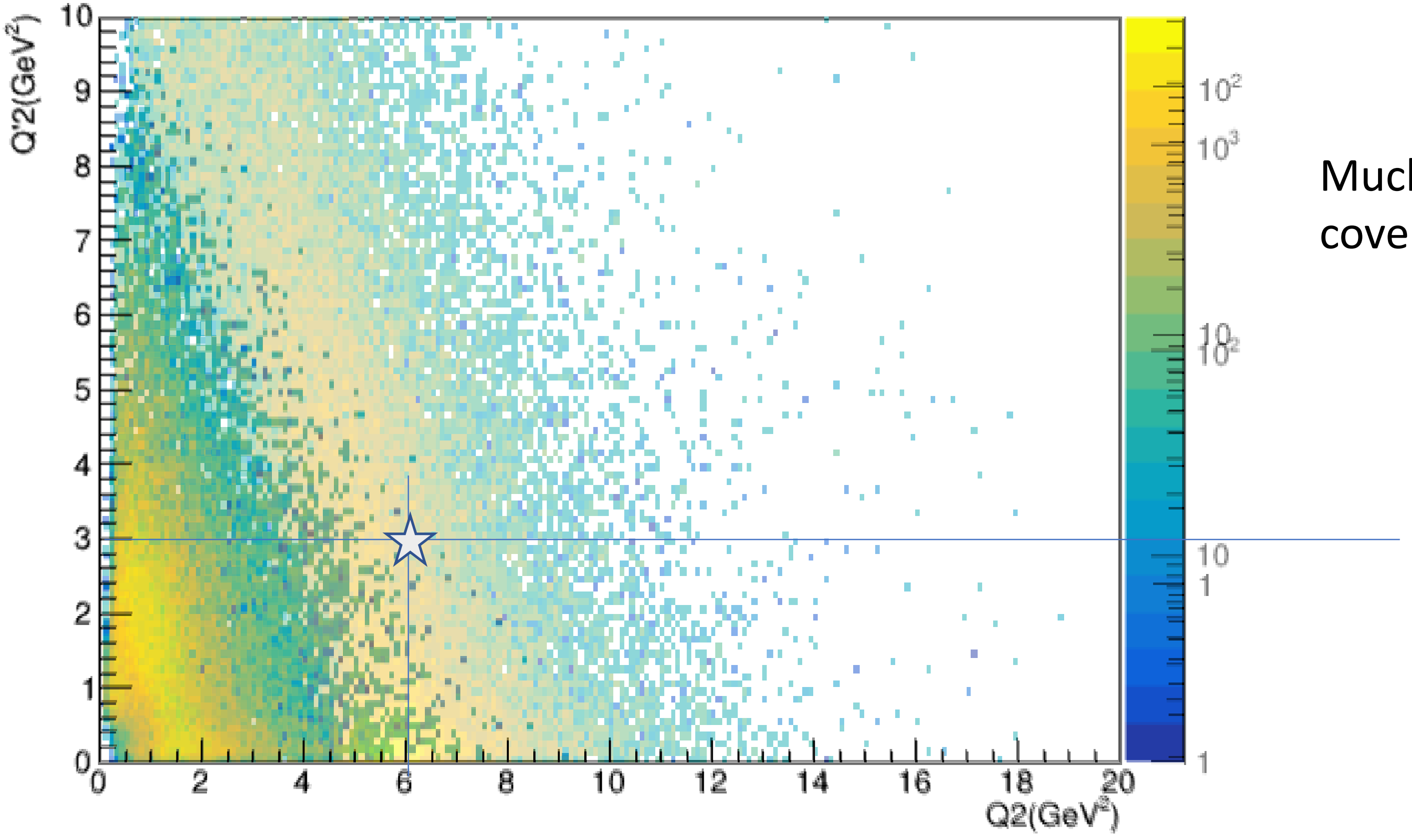
Acceptance better when detecting proton but dominated by low Q2/Q'2

11 GeV vs 22 GeV



Zhiwen Zhao (GRAPE)

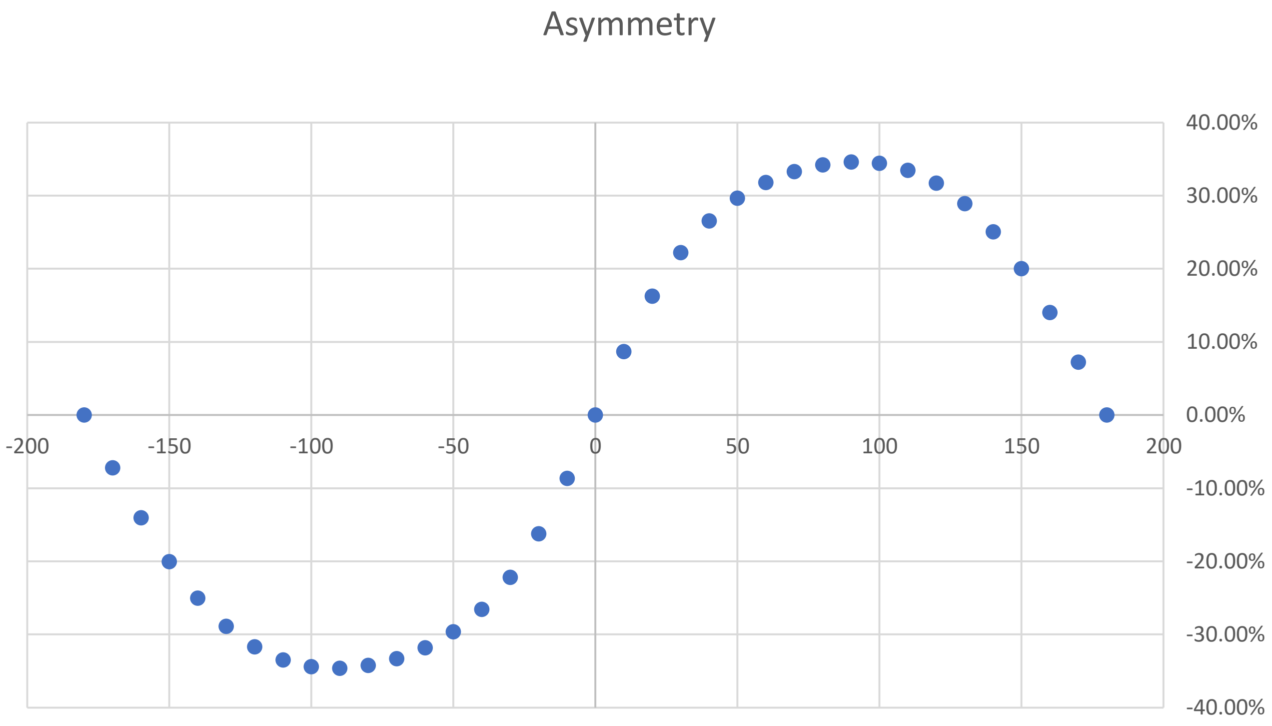
11 GeV vs 22 GeV



Much better Q2 Q'2 coverage

Asymmetry for one point

- xbj=0.20, Q2=6 GeV2,Q’2=3GeV^2, -t=0.25 GeV^2 from VGG

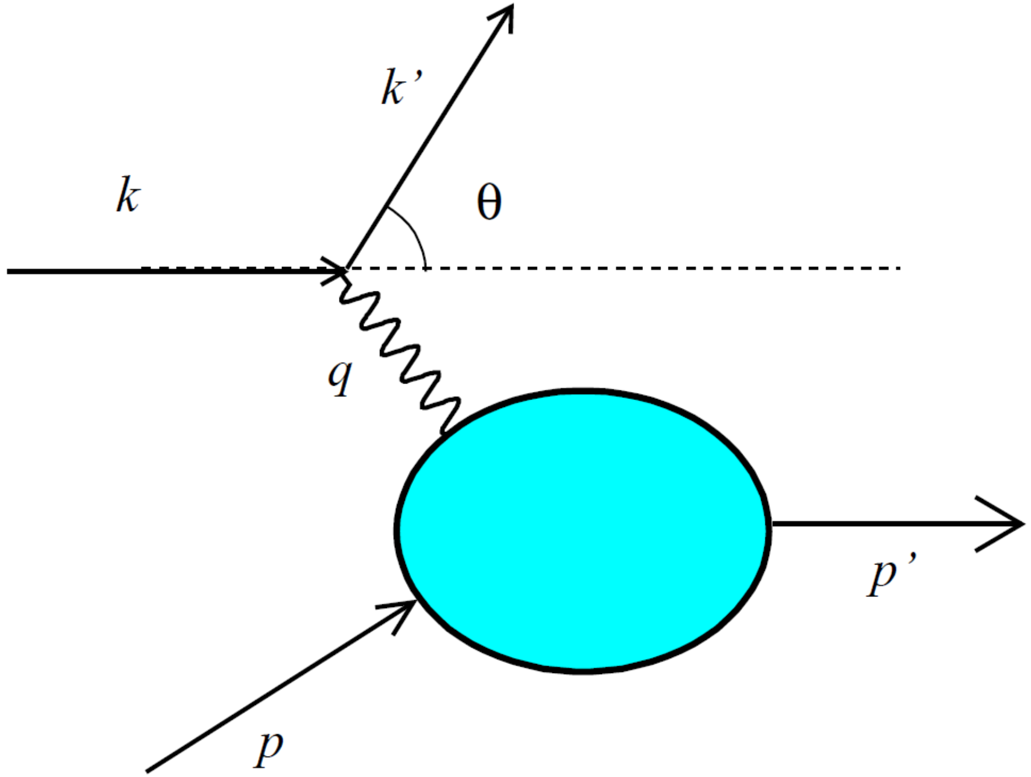


Conclusion

- Generalized Parton Distributions (GPDs) are a generalization of partons distrubutions and Form Factors. GPDs depend on additional
- GPDs can give insight of internal spatial structure of nucleons such as orbital momentum, momentum distribution as , pressure at surface of nucleons
- Extensive program of DVCS measurements measure GPDs for $x = \xi$
- Double DVCS can probe GPDs $x \neq \xi$
- SoLID DDVCS experiment by adding a muon detector to SoLID J/psi experiment
- SoLID DDVCS will take advantage of positron and energy upgrade at Jefferson Laboratory
- Could upgrade rate capability of detector to increase luminosity by factor 10 and increase DDVCS statistics at 11 and 22 GeV
- 22 GeV upgrade increase range in xi, Q2 and Q’2 with sizable asymmetries and counting rate reduction of about 3

Backup

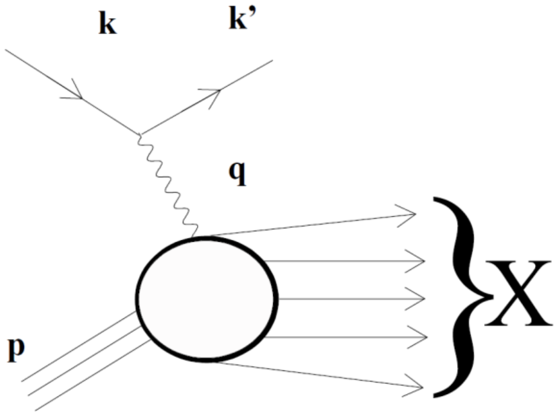
Electron scattering



$$q = k - k'$$
$$Q^2 = -q^2 = -(k - k')^2 = 4EE' \sin^2(\frac{\theta}{2})$$

Photon virtuality allows to select the scale of the interaction

Deeply Inelastic Scattering



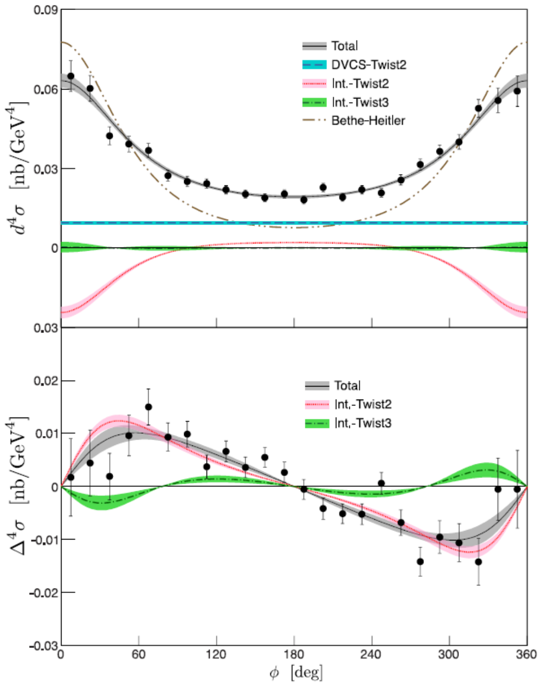
$$W_{\mu\nu} = W_1(Q^2,\nu)(-g_{\mu\nu} + \frac{q_\mu q\nu}{q^2}) + \frac{W_2}{M^2}(Q^2,\nu)(p_\mu - \frac{p.q}{q^2}q_\mu)(p_\nu - \frac{p.q}{q^2}q_\nu)$$
$$+G_1(Q^2,\nu)Mi\epsilon_{\mu\nu\lambda\sigma}q^\lambda s_h^\sigma + \frac{G_2(Q^2,\nu)}{M}i\epsilon_{\mu\nu\lambda\sigma}q^\lambda(p.qs_h^\sigma - s_h^\sigma.qp^\sigma)$$

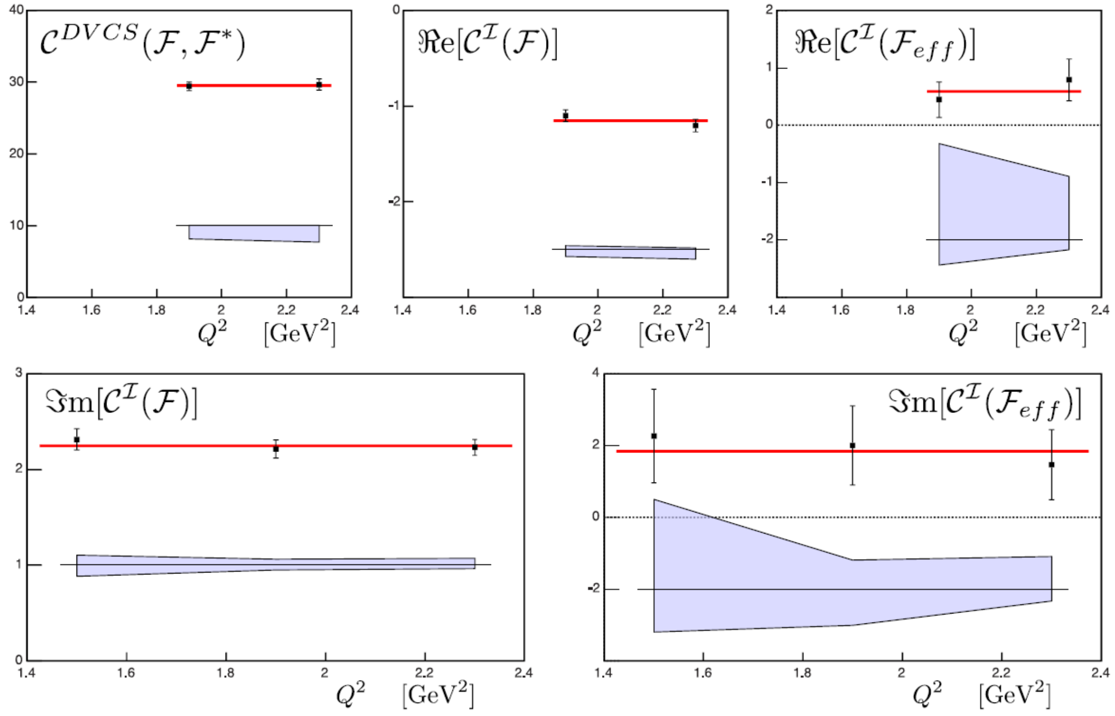
$$MW_1 = F_1(Q^2,\nu)$$
$$\nu W_2 = F_2(Q^2,\nu)$$
$$\frac{\nu}{(p\cdot q)}G_1(Q^2,\nu) = g1(Q^2,\nu)$$

$$F_1(Q^2,\nu) = \sum_{i=1}^{3} e_i q_i = \sum_{i=1}^{3} e_i(q_i^\uparrow + q_i^\downarrow)$$
$$g_1(Q^2,\nu) = \sum_{i=1}^{3} e_i \Delta q_i = \sum_{i=1}^{3} e_i(q_i^\uparrow - q_i^\downarrow)$$

6 GeV E00-110 result

- E00-110 experiment at Jefferson Lab Hall A: Deeply virtual Compton scattering off the proton at 6 GeV
- Jefferson Lab Hall A Collaboration•M. Defurne(DAPNIA, Saclay) et al. (Apr 21, 2015)
- Published in: Phys.Rev.C 92 (2015) 5, 055202 • e-Print: 1504.05453 [nucl-ex]



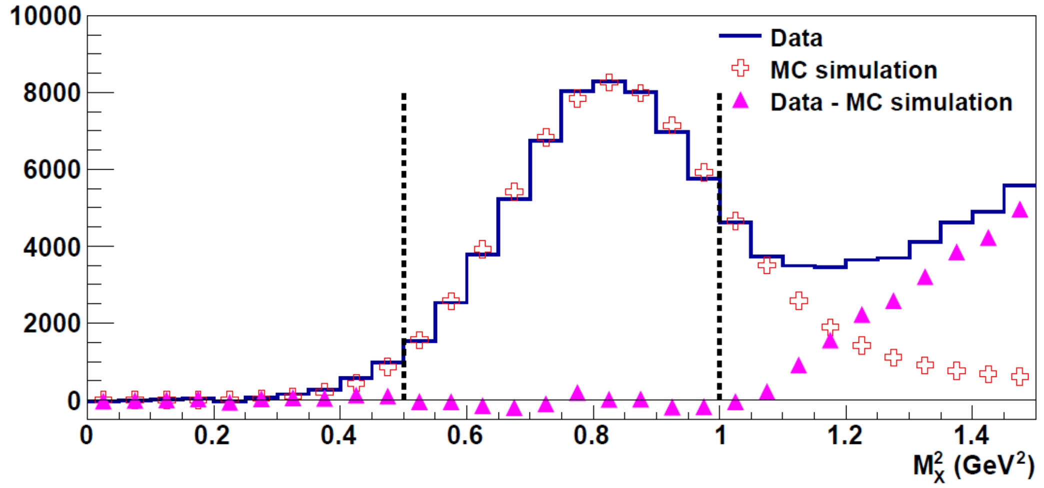


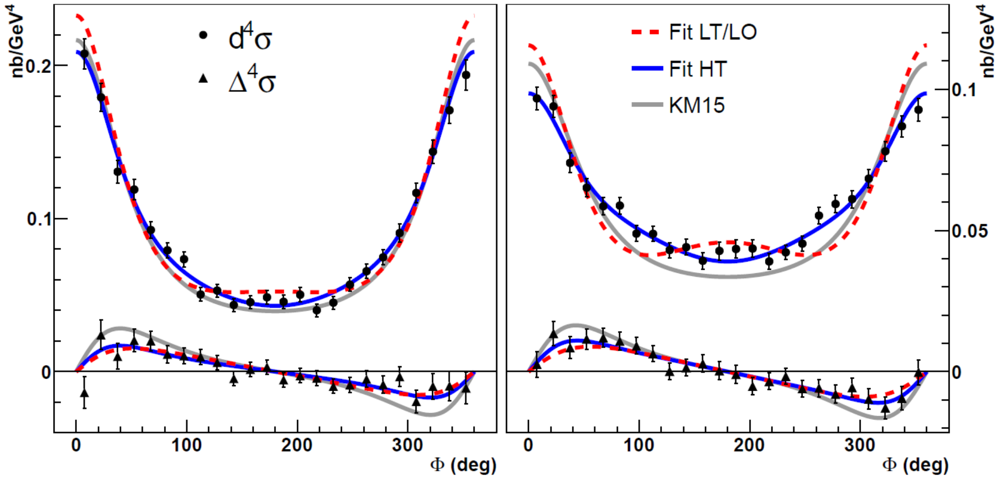
6 GeV E07-007 proton result

- A glimpse of gluons through deeply virtual compton scattering on the proton

M. Defurne(IRFU, Saclay), A. Martí Jiménez-Argüello(Orsay, IPN and Valencia U.), Z. Ahmed(Syracuse U.), H. Albataineh(Texas A-M U.-Kingsville), K. Allada(MIT) et al. (Mar 28, 2017)

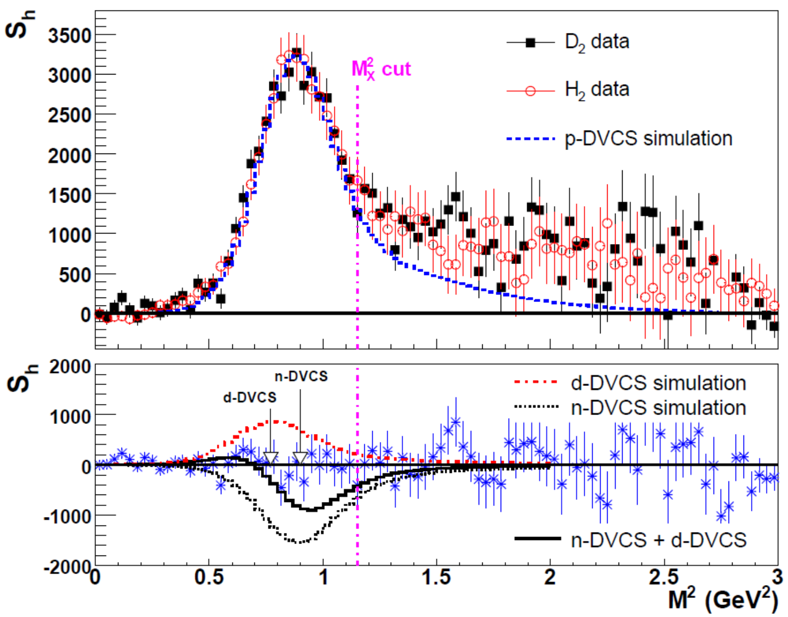
Published in: Nature Commun. 8 (2017) 1, 1408 • e-Print: 1703.09442 [hep-ex]

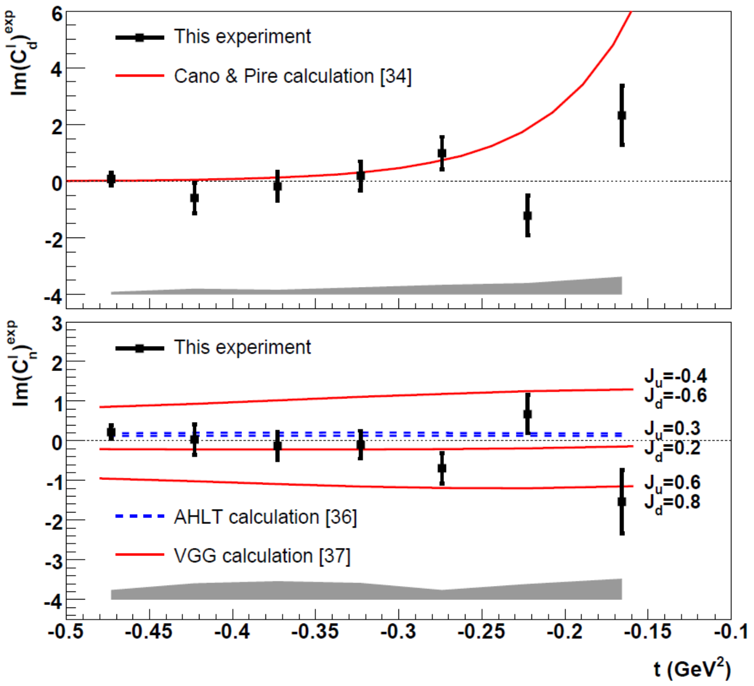




6 GeV E03-106 neutron result

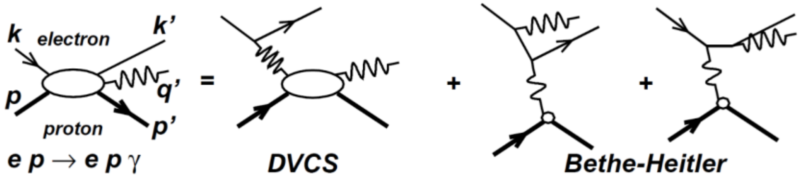
- Deeply virtual compton scattering off the neutron
- Jefferson Lab Hall A Collaboration•M. Mazouz(LPSC, Grenoble) et al. (Sep, 2007)
- Published in: Phys.Rev.Lett. 99 (2007) 242501 • e-Print: 0709.0450 [nucl-ex]





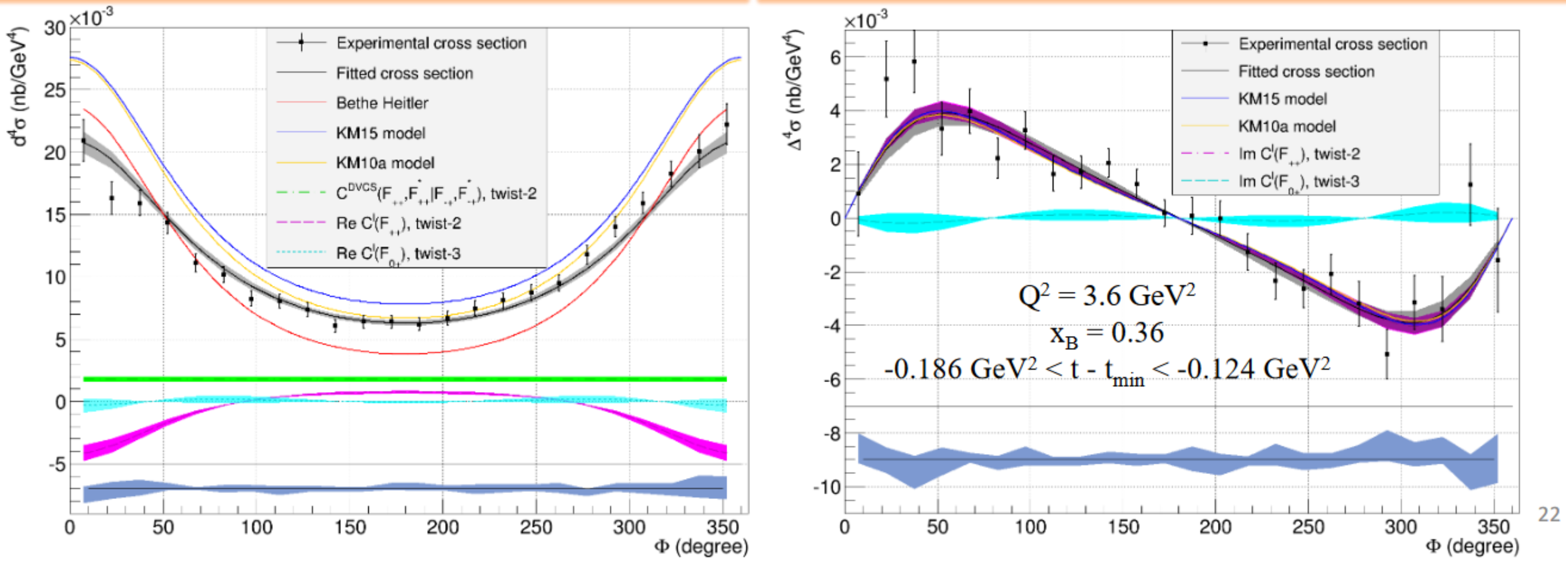
Hall A at 12 GeV: The DVCS experiment, E12-06-114

- ❑ Ran in the Fall of 2014,2016 with the goals of:
  - → testing scaling: wide Q2 scans at fixed Bjorken x
  - → separating of Re and Im parts of DVCS cross section amplitude

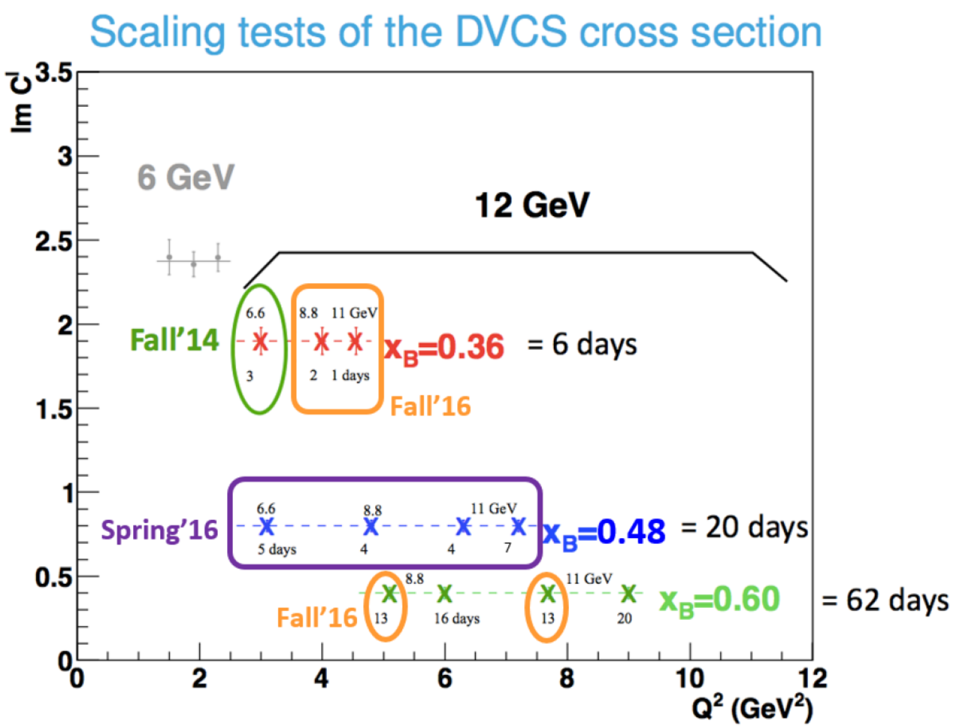


At leading twist:

$$d^5\overrightarrow{\sigma} - d^5\overleftarrow{\sigma} = \Im m\left(T^{BH} \cdot T^{DVCS}\right)$$
$$d^5\overrightarrow{\sigma} + d^5\overleftarrow{\sigma} = |BH|^2 + \Re e\left(T^{BH} \cdot T^{DVCS}\right) + |DVCS|^2$$



DVCS Cumulated Statistics - Summary

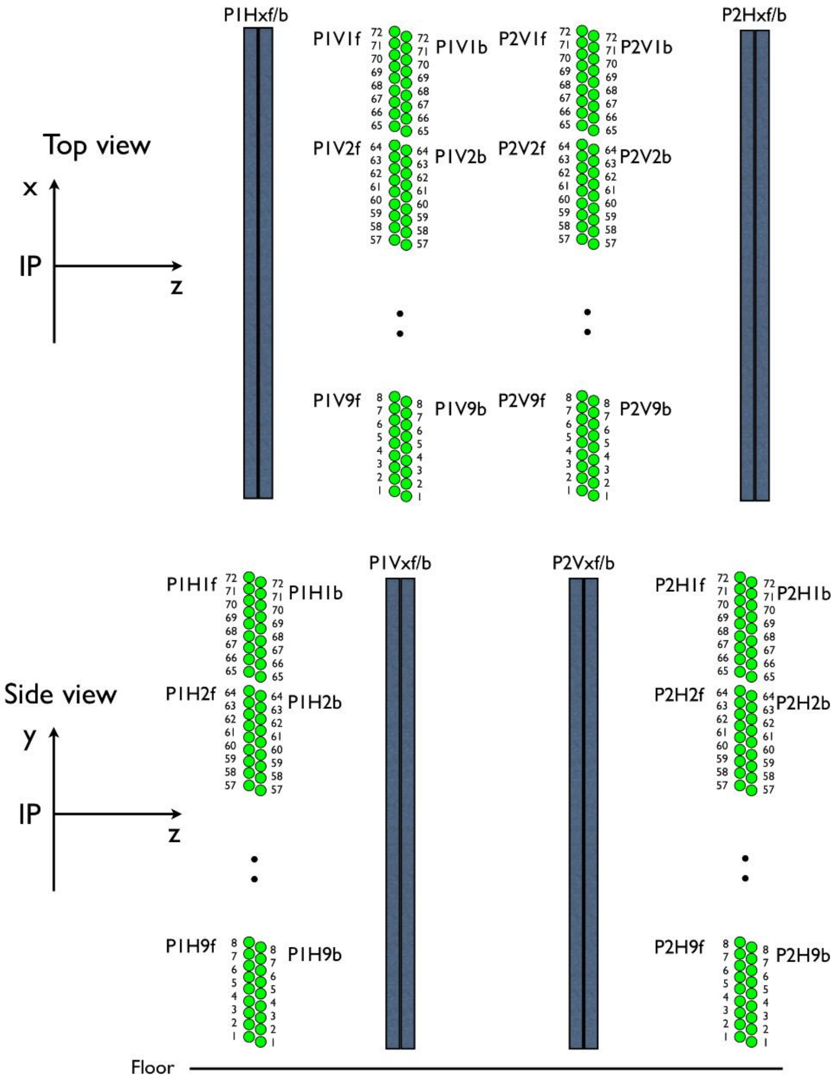


kinematic	% of target charge	PAC days
kin36_1	100.0	3
kin36_2	100.0	2
kin36_3	100.0	1
kin48_1	100.0	5
kin48_2	56.6	4
kin48_3	76.4	4
kin48_4	53.0	7
kin60_1	100.0	13
kin60_2	0.0	16
kin60_3	100.0	13
kin60_4	0.0	20

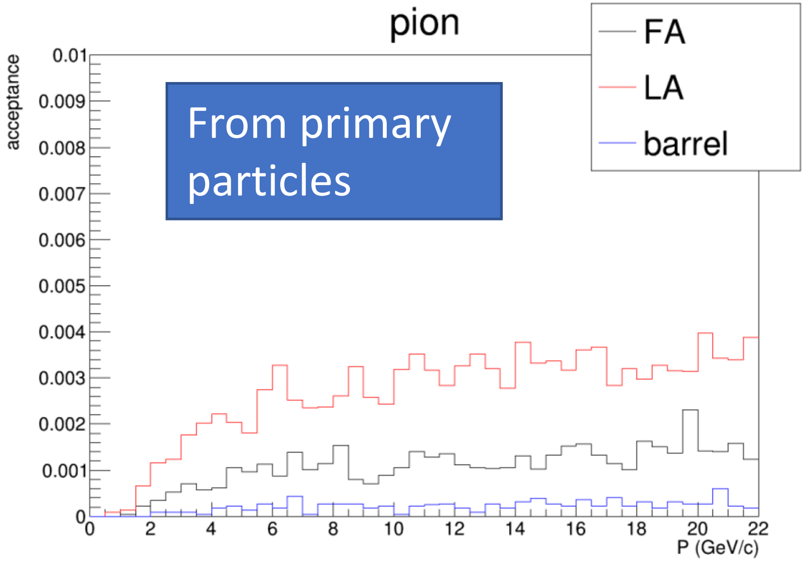
Could not go back and complete kin48_[234] because of beam energy change over the summer.

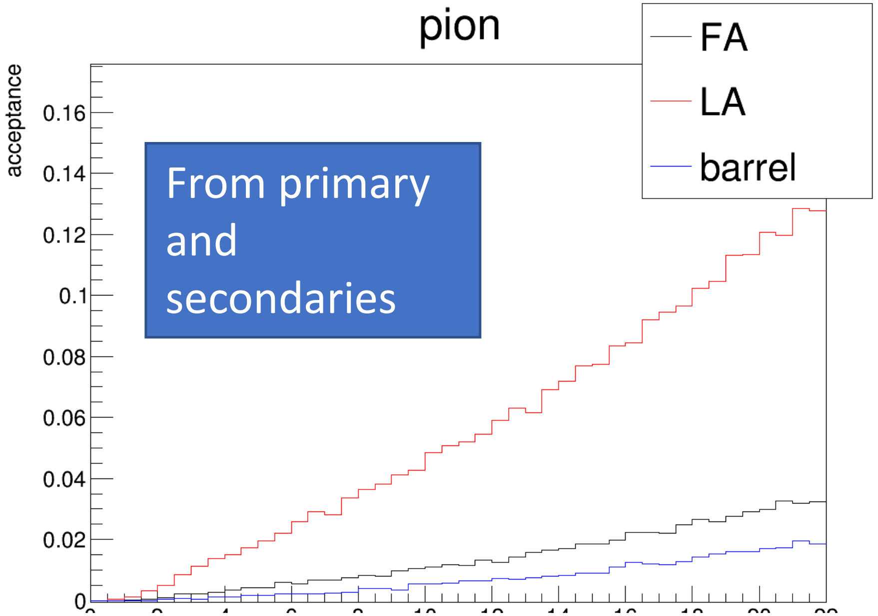
~50% of PAC allocation completed between 2014 and 2016

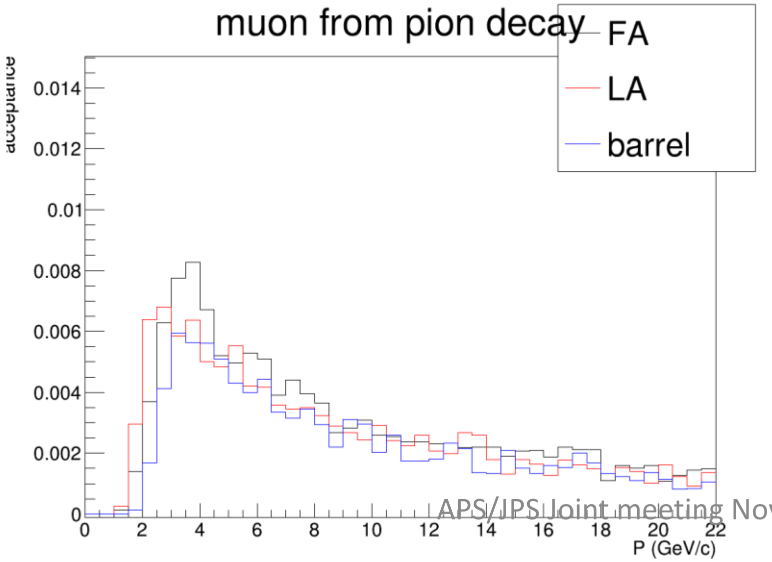
29

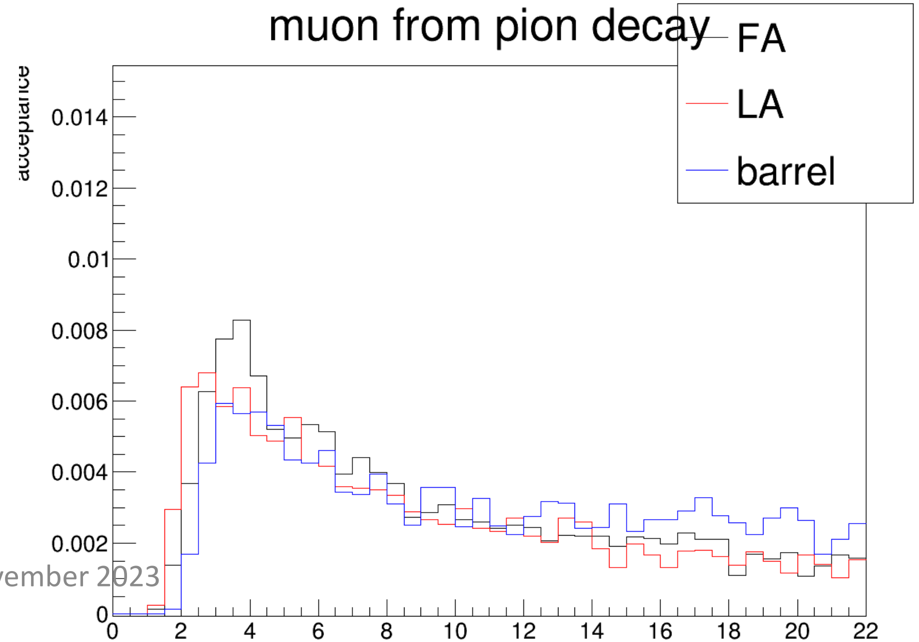

Top view
x
IP
z
P1Hxf/b
P2Hxf/b
P1V1f
P1V1b
P2V1f
P2V1b
P1V2f
P1V2b
P2V2f
P2V2b
P1V9f
P1V9b
P2V9f
P2V9b
Side view
y
IP
z
P1Vxf/b
P2Vxf/b
P1H1f
P1H1b
P2H1f
P2H1b
P1H2f
P1H2b
P2H2f
P2H2b
P1H9f
P1H9b
P2H9f
P2H9b
Floor

Surviving rate of pion and muon from pion decay at back of forward muon detector

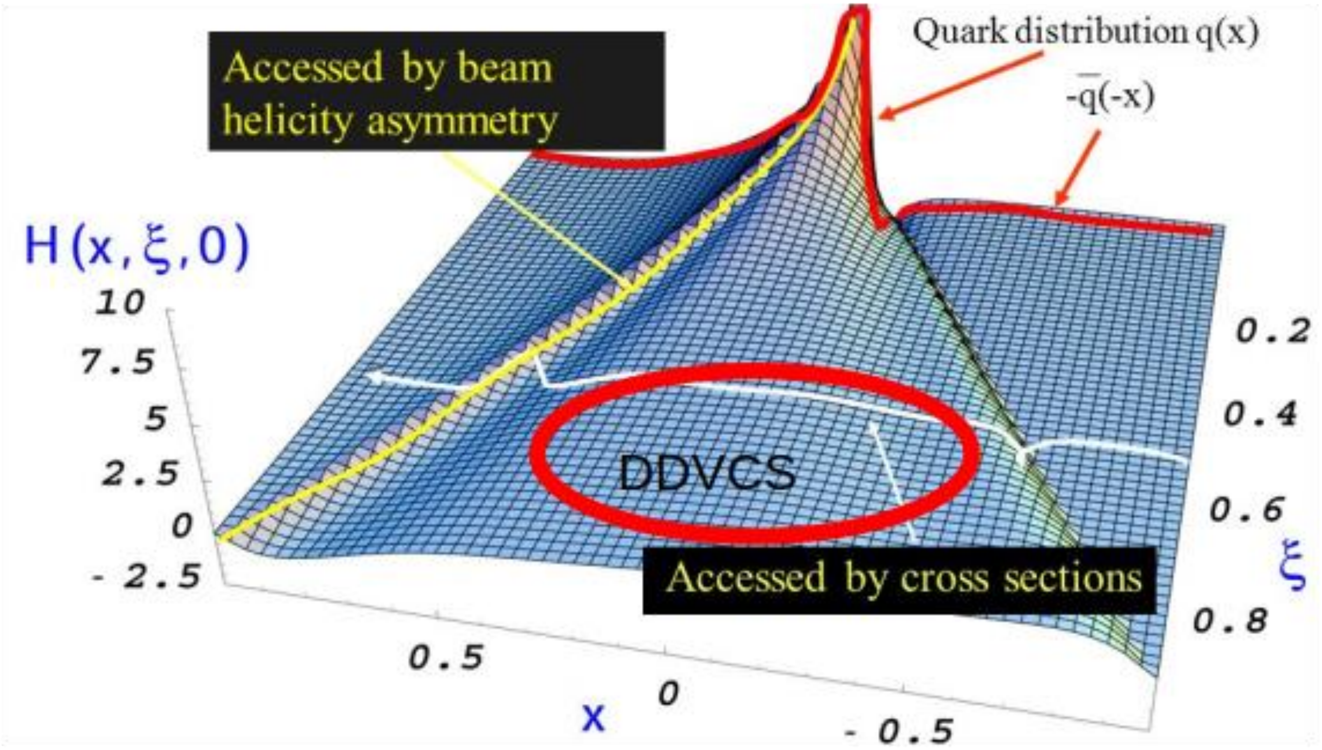








Generalized Parton Distributions from CFF fits (with DDVCS)



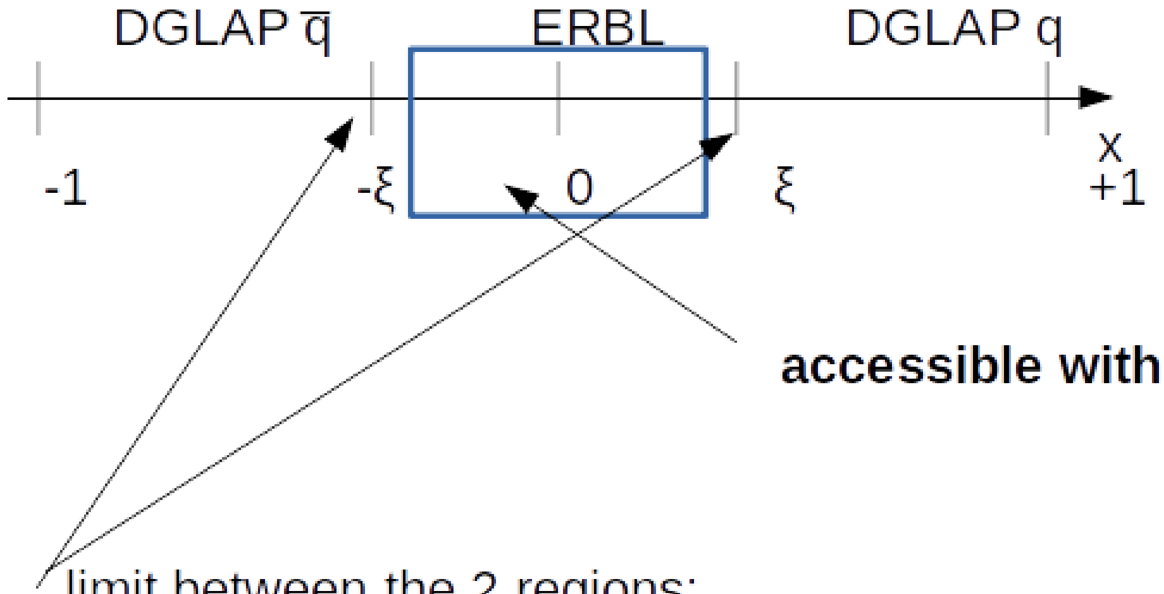
"diagonal": $T^{DVCS} \sim \int_{-1}^{+1} \frac{H(x,\xi,t)}{x \pm \xi + i\varepsilon} dx + \ldots \sim \underbrace{P\int_{-1}^{+1} \frac{H(x,\xi,t)}{x \pm \xi} dx}_{\text{Re}(\mathcal{H})} \underbrace{- i\pi H(\pm\xi,\xi,t)}_{\text{Im}(\mathcal{H})} + \ldots$

"off diagonal": $T^{DDVCS} \sim \int_{-1}^{+1} \frac{H(x,\xi,t)}{x - (2\xi' - \xi) + i\varepsilon} dx + \ldots \sim P\int_{-1}^{+1} \frac{H(x,\xi,t)}{x - (2\xi' - \xi)} dx - i\pi H(2\xi' - \xi, \xi, t) + \ldots$

Partonic interpretation, GPDs in ERBL region

What do we learn?

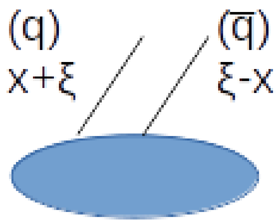
from M. Diehl's representations:



accessible with DDVCS

limit between the 2 regions:
Im(CFFs) from DVCS and TCS

partonic interpretation from M. Diehl in ERBL region



Probing quark-antiquark pairs in the nucleon

We don't know GPDs in that region, it is essential for the deconvolution and tomographic interpretations