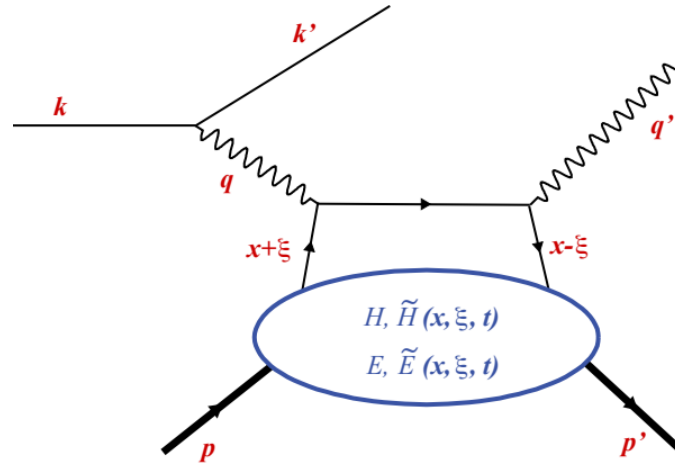


DVCS with Clas12 at JLab



CLAS collaboration meeting
2018 July 12

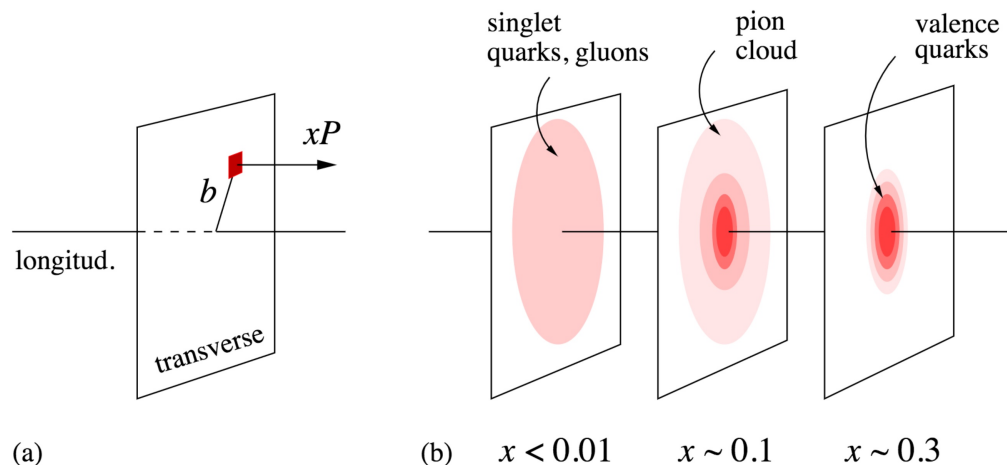
Guillaume Christiaens
(CEA Saclay, University of Glasgow)



University
of Glasgow

Physics motivation - GPD

- Generalized parton distributions (GPDs)
- GPDs : Correlations between parton transverse position and longitudinal momentum
- Thanks to GPDs:
 - 3D tomography of the nucleon
 - Angular momentum of the quarks: Ji sum rule:
 - Pressure distributions



[C. Weiss, Generalized Parton Distributions, status and perspectives
<https://arxiv.org/abs/0902.2018>]

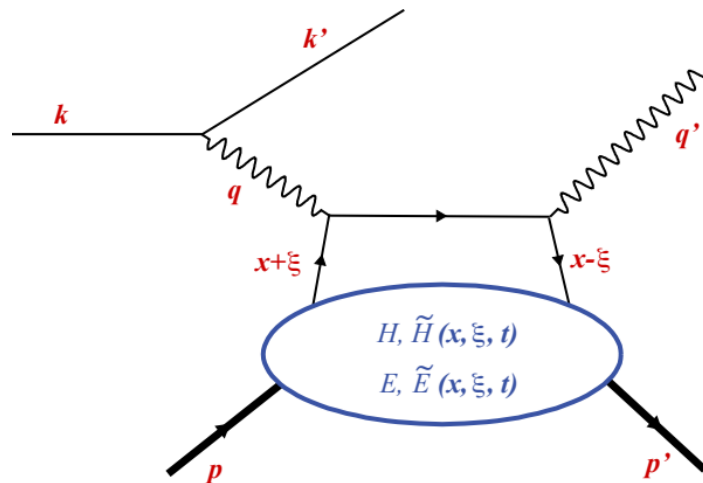
$$J^f = \int_{-1}^1 x \left[H^f(x, \xi, 0) + E^f(x, \xi, 0) \right] dx$$

Photon electroproduction

- GPDs accessible through the study of photon electroproduction $ep \rightarrow ep\gamma$
- Experimentally we measure Deeply Virtual Compton Scattering and Bethe-Heitler :

$$\sigma_{ep \rightarrow ep\gamma} \propto |A_{DVCS}|^2 + |A_{BH}|^2 + I$$

- DVCS at leading order :



Experimental observable : Asymmetry

- Beam spin asymmetry (BSA):

$$A_{LU} = \frac{d\sigma^{\rightarrow} - d\sigma^{\leftarrow}}{d\sigma^{\rightarrow} + d\sigma^{\leftarrow}}$$

- Mostly sensitive to GPD H and $\tilde{H}$
- Easier to compute:
 - simplification of acceptance and efficiency terms in the ratio
 - but need an accurate estimation of kinematical parameters for each bin

Kinematical variables

- Variables

- Virtuality $Q^2 = -q^2$

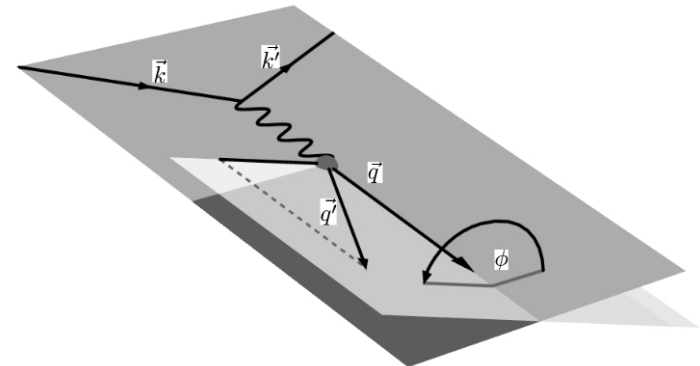
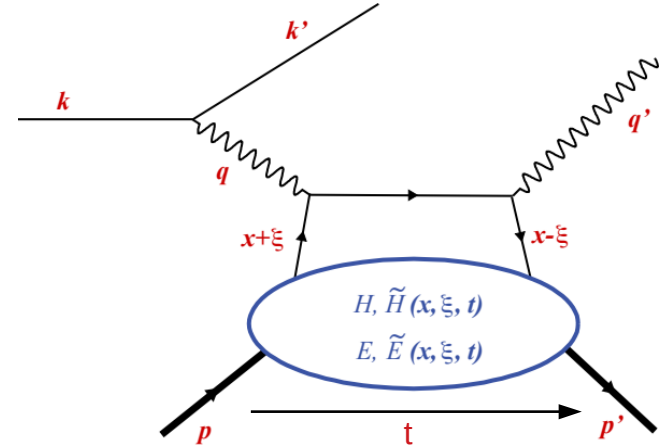
- Bjorken x $x_B = \frac{Q^2}{2M_p(k_E - k'_E)}$

- Proton momentum transfer $t = (p - p')^2$

- Mass of hadronic final state $W^2 = (p + q)^2$

- Phi : angle between leptonic and hadronic plane

ϕ_{Trento}

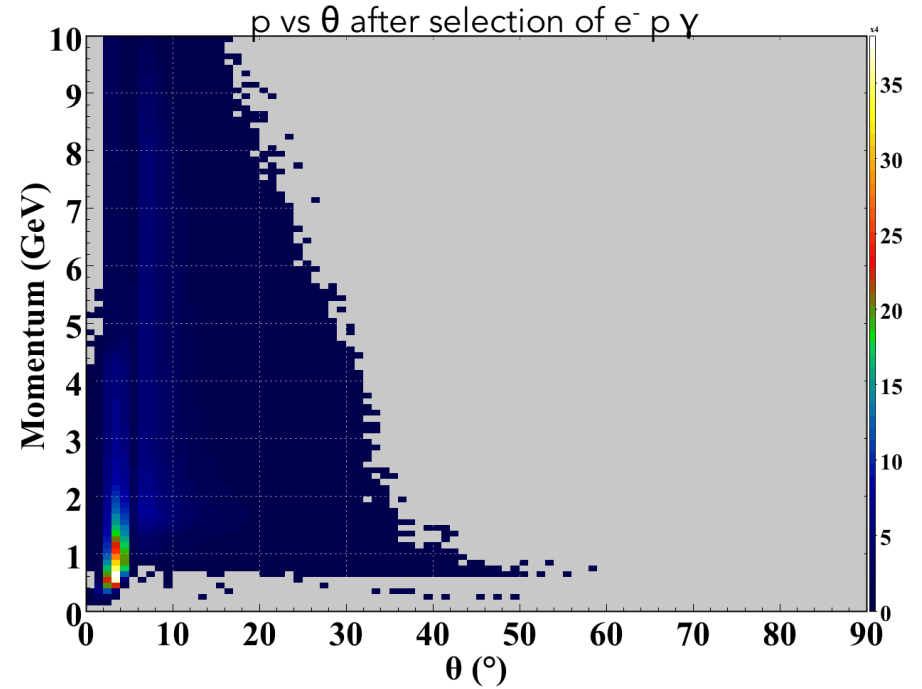
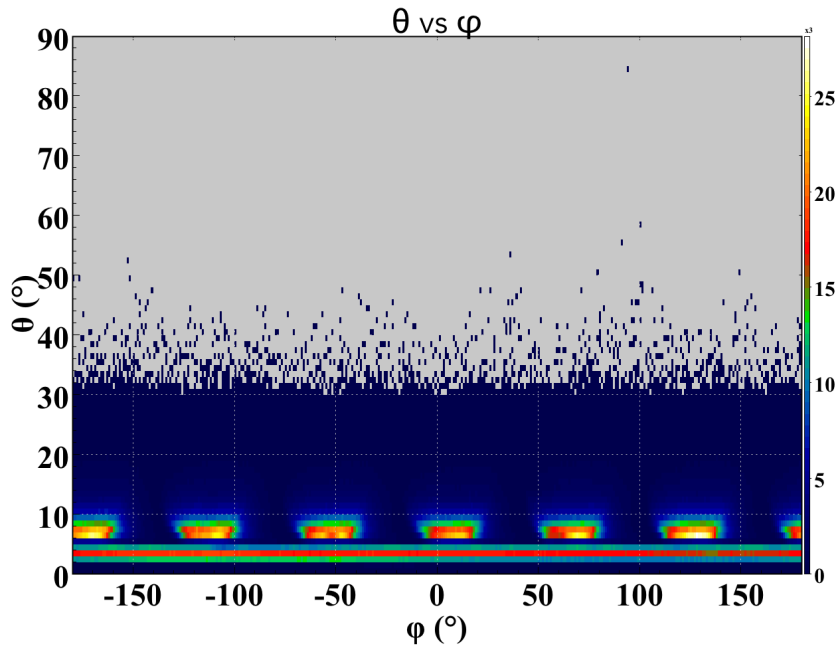


Data

- Run 3973 T+1/S-1
 - Negative outbending
 - 55 million events
 - 1100 / 1474 files
 - 11 GeV
- Run 4314 T-1/S-1
 - Negative inbending
 - 55 million events
 - 1100 / 1305 files
 - 11 GeV
- Reconstruction with Coatjava 5b.3.3
(files in /volatile/clas12/data/rg-a/current)

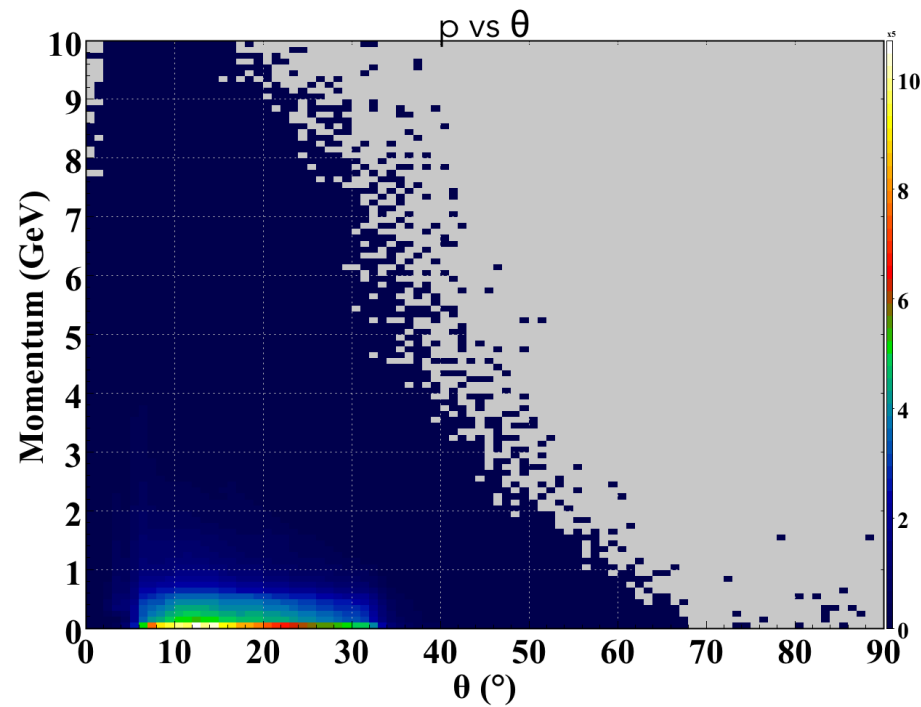
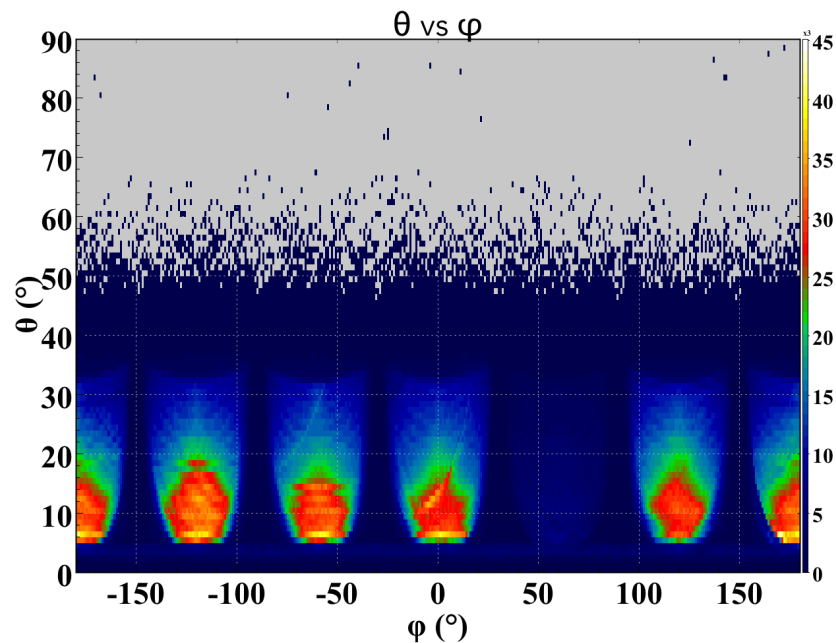
Electrons

- Before cuts
 - Run 3973 T+1/S-1
- Negative outbending



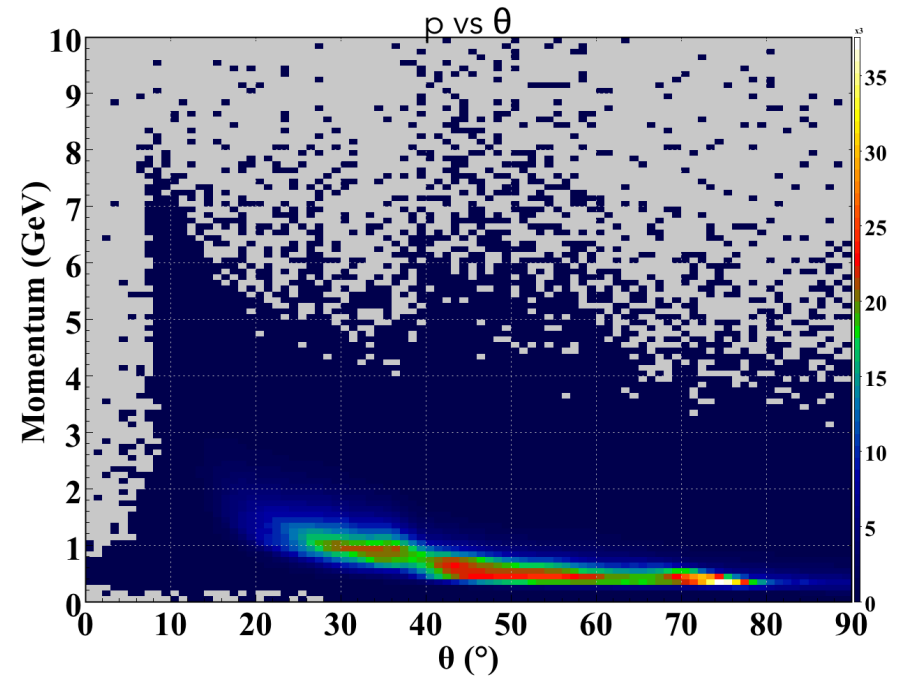
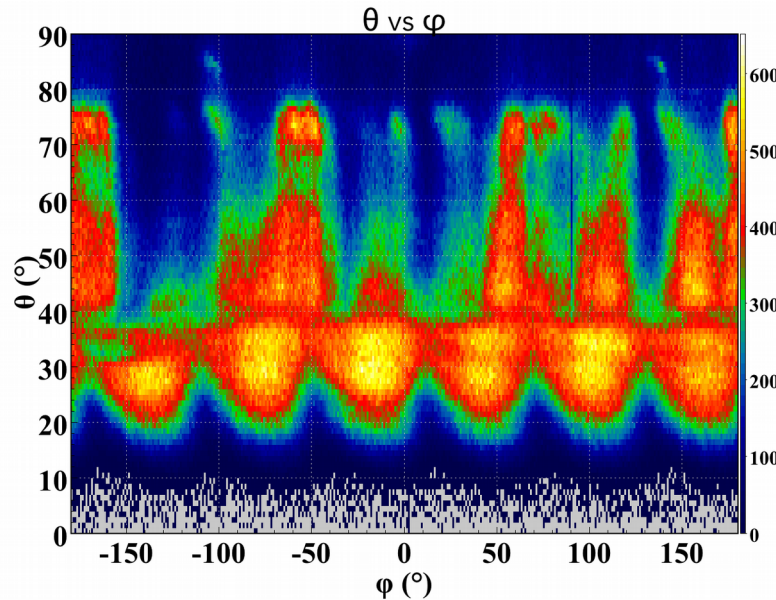
Photons

- Before cuts
 - Run 3973 T+1/S-1
- Negative outbending



Protons

- Before cuts
- Run 3973 T+1/S-1
- Negative outbending

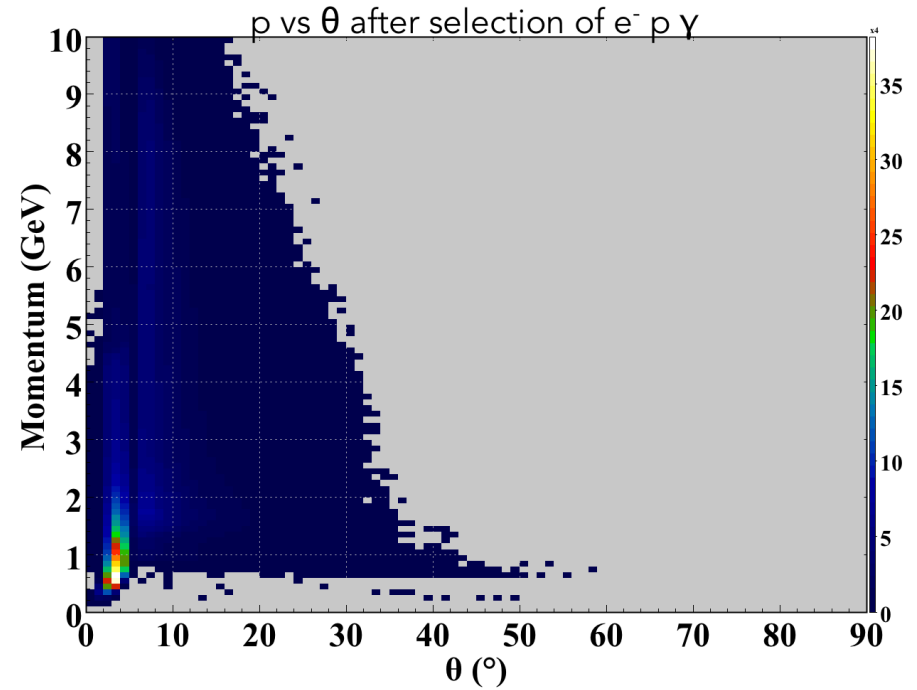
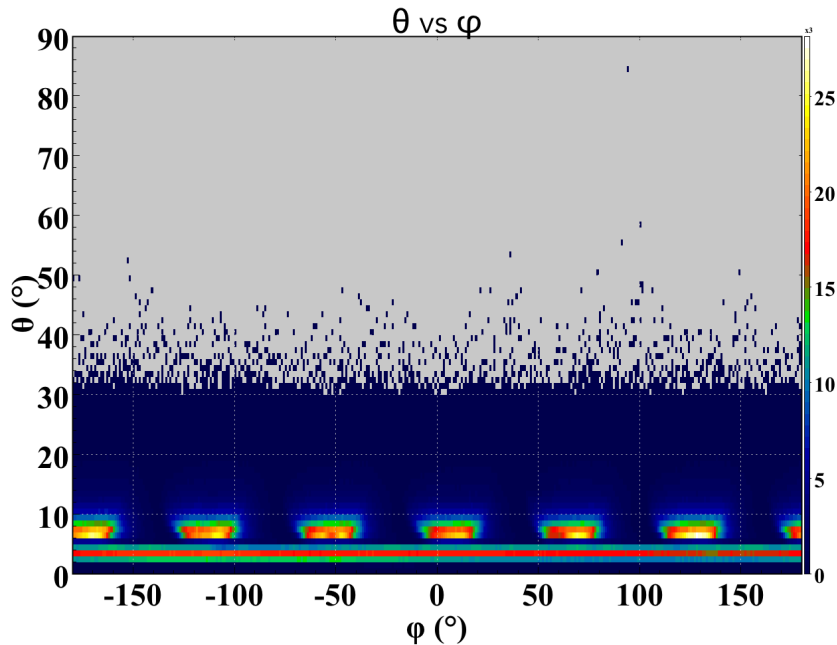


Cuts

- Selection of electrons for DVCS
 - Event builder
 - Energy > 1 GeV
 - $Q^2 > 1$ & $W^2 > 4$ (DIS regime)
- Selection of photons for DVCS
 - Event builder
 - Energy > 3 GeV (to clean events)
- Selection of protons for DVCS
 - Event builder

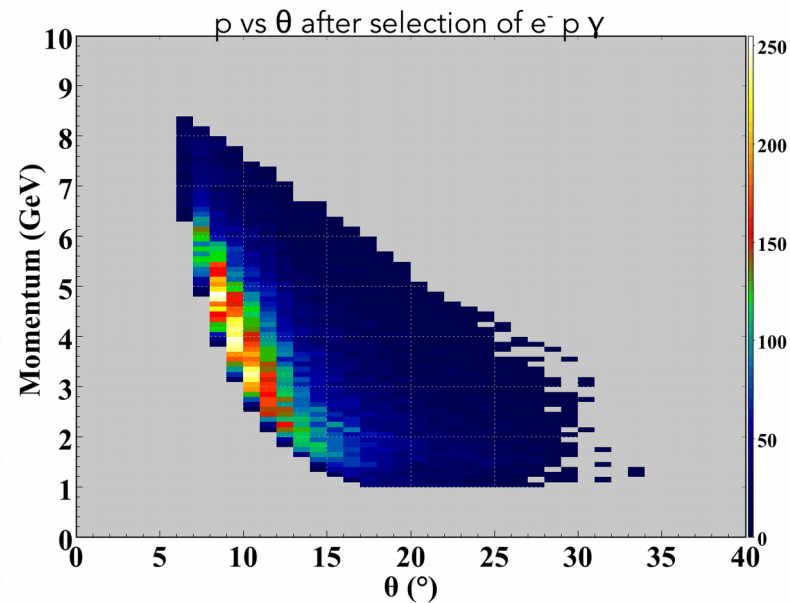
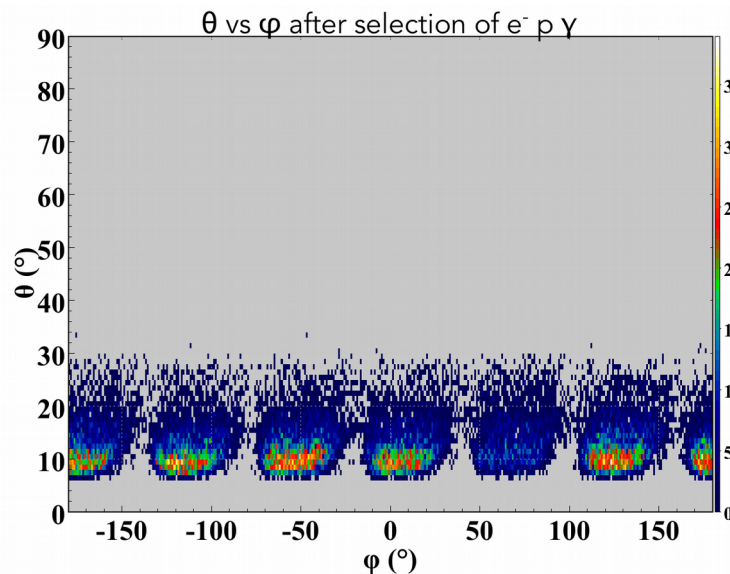
Electrons

- Before cuts
 - Run 3973 T+1/S-1
- Negative outbending



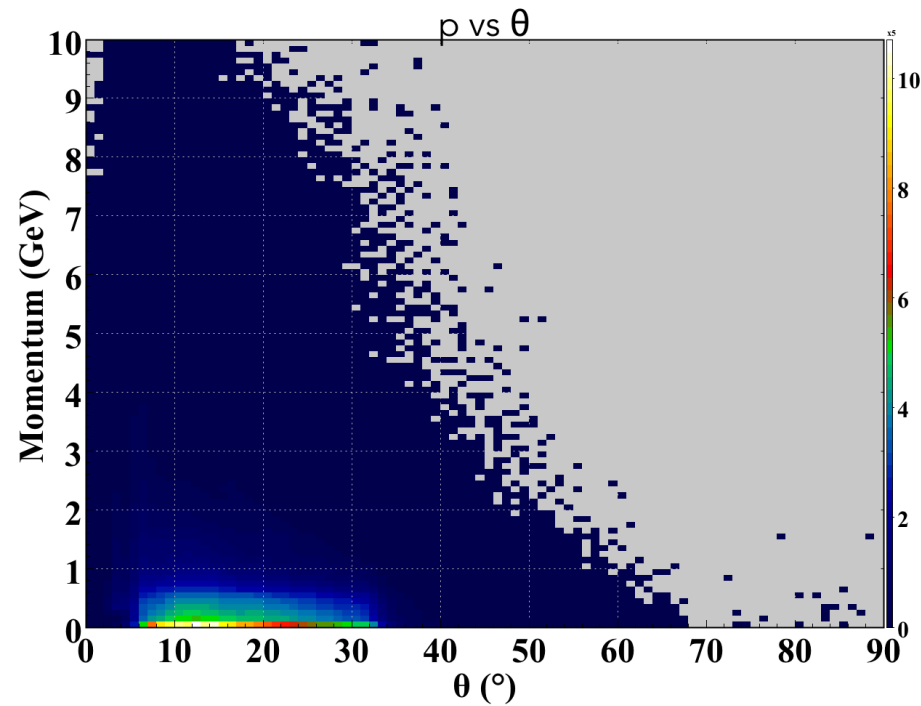
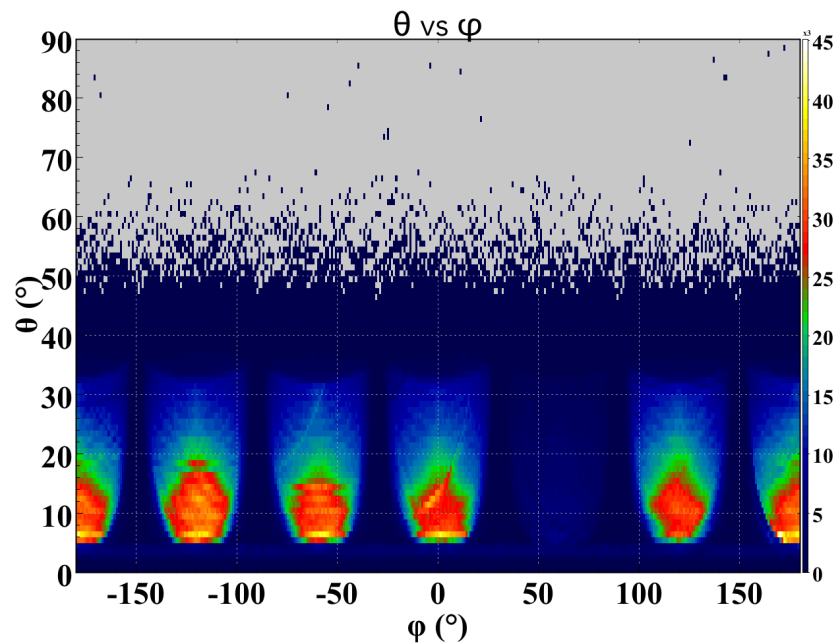
Electrons

- After selection of electron, proton, photon
- Selection of electrons for DVCS
 - Event builder
 - Energy > 1 GeV
 - $Q^2 > 1$ & $W^2 > 4$ (DIS regime)
- Run 3973 T+1/S-1
Negative outbending



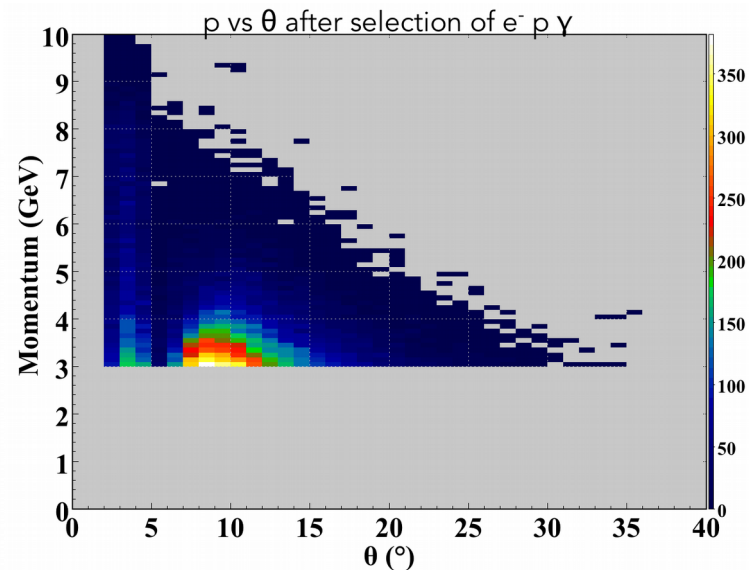
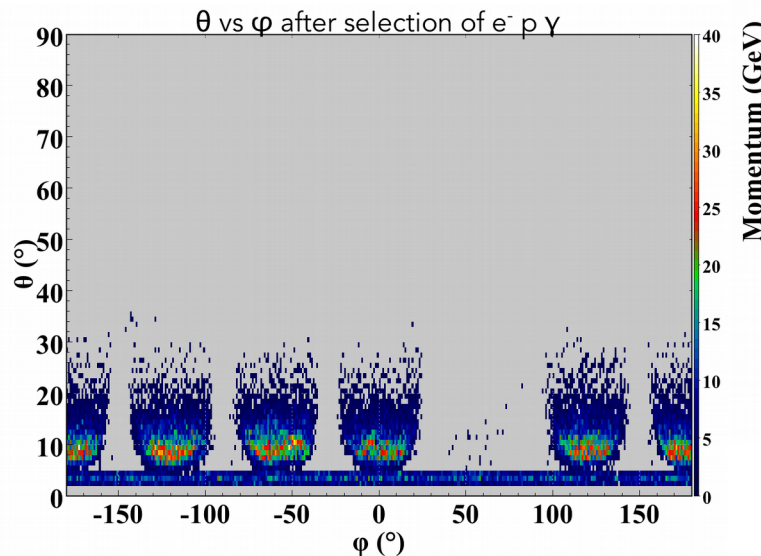
Photons

- Before cuts
 - Run 3973 T+1/S-1
- Negative outbending



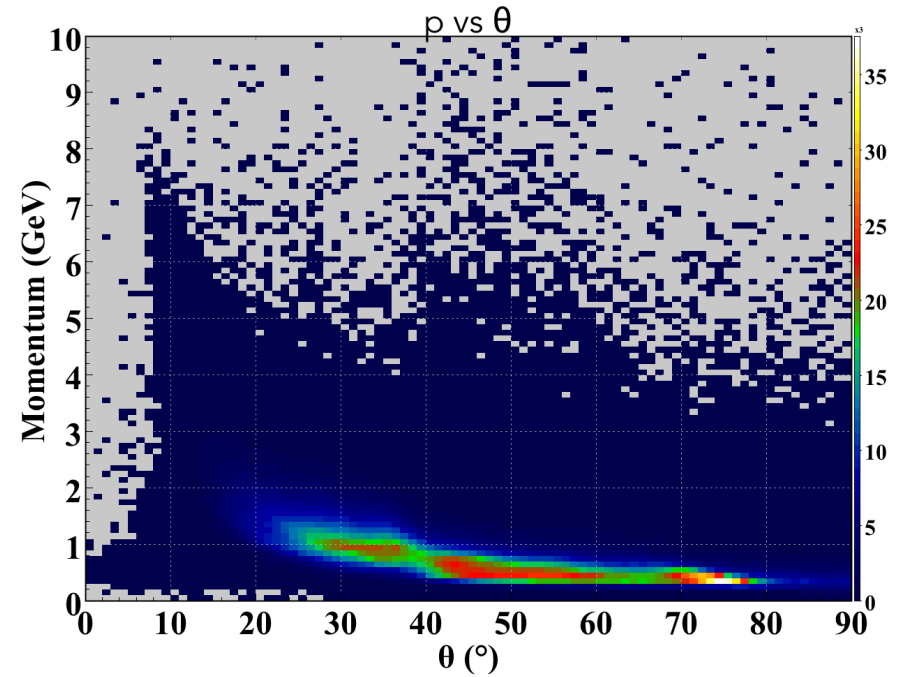
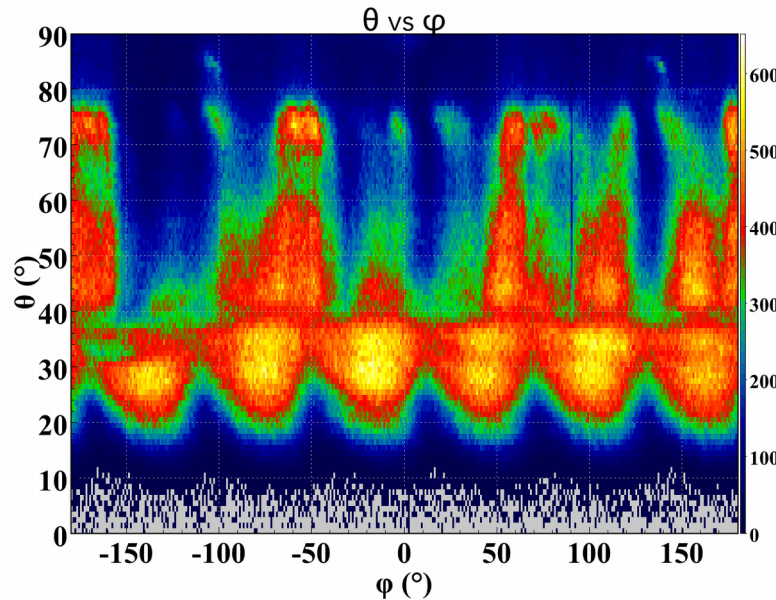
Photons

- After selection of electron, proton, photon
- Selection of photons for DVCS
 - Event builder
 - Energy > 3 GeV (to clean events)
- Run 3973 T+1/S-1
Negative outbending



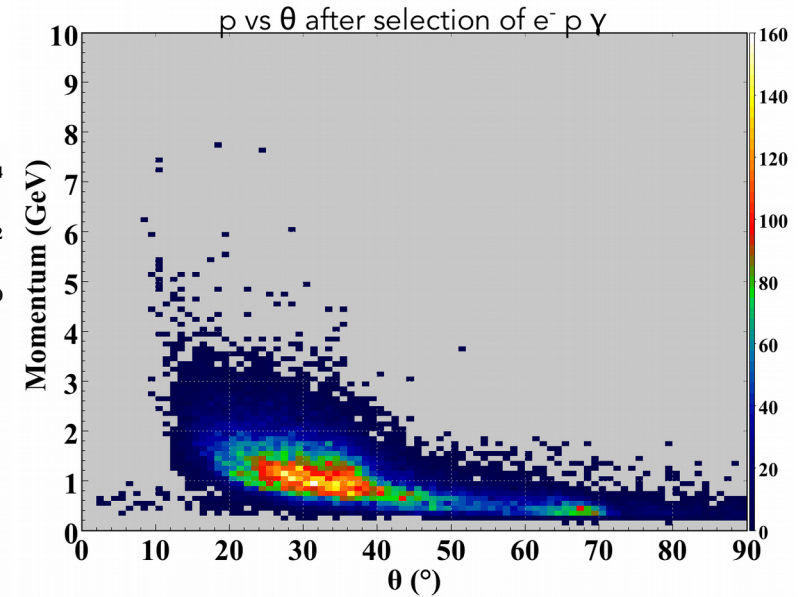
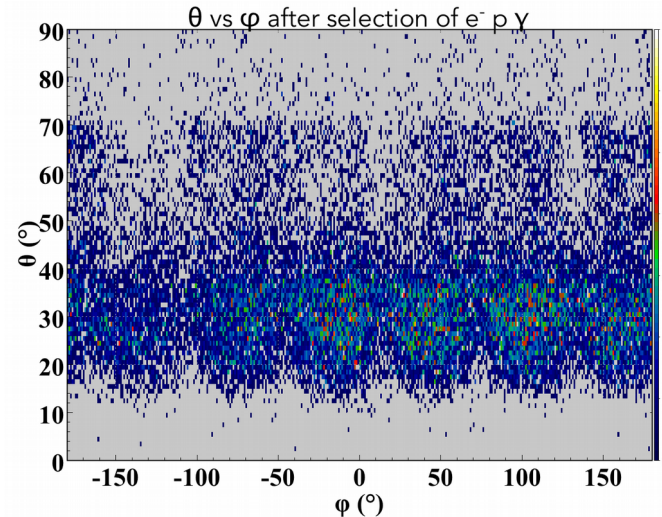
Protons

- Before cuts
 - Run 3973 T+1/S-1
- Negative outbending



Protons

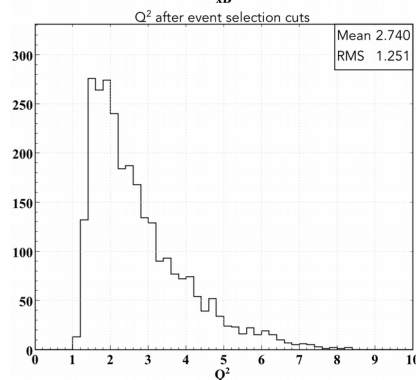
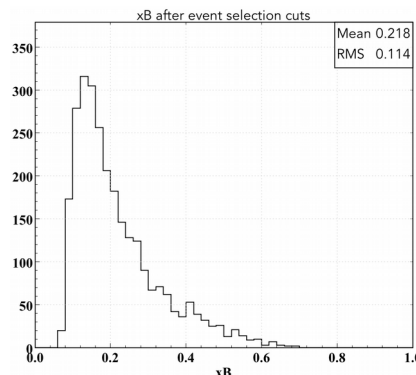
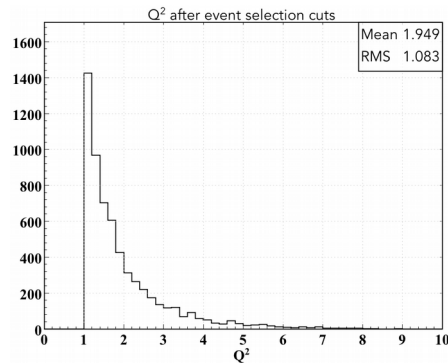
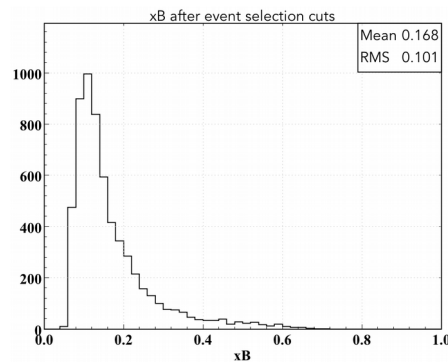
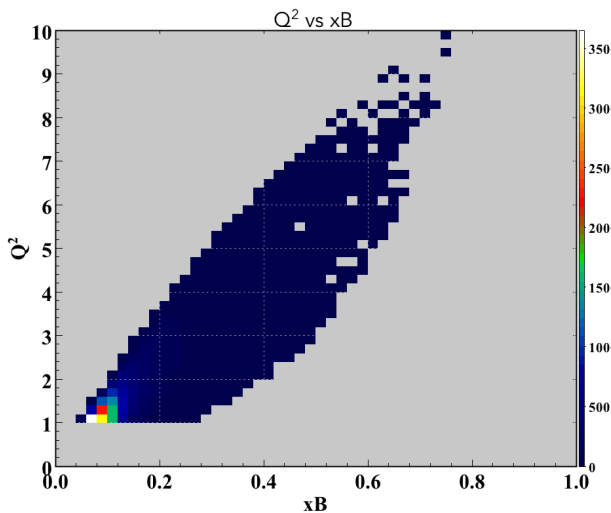
- After selection of electron, proton, photon
- Selection of protons for DVCS
 - Event builder
- Run 3973 T+1/S-1
Negative outbending



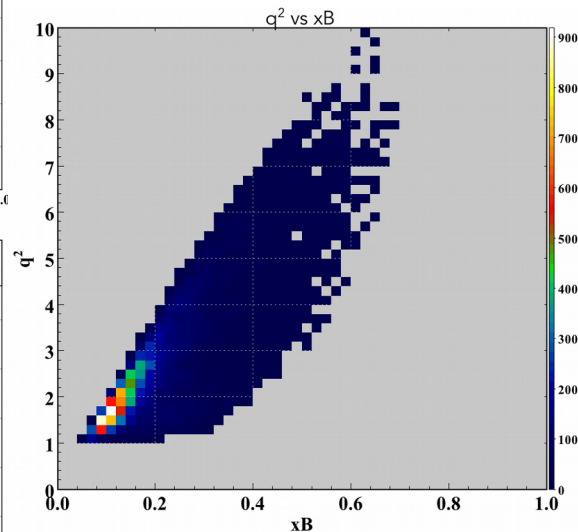
Kinematical variables

- For events with at least an electron, a proton and a photon after particle cuts

- Run 3973 T+1/S-1
Negative outbending



- Run 4314 T-1/S-1
Negative inbending

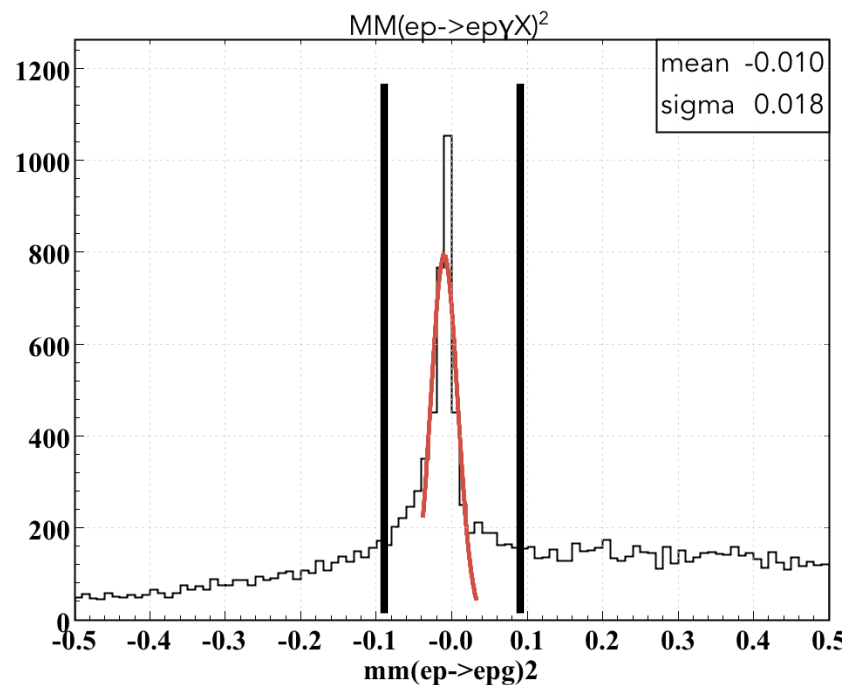


Missing mass

After particle cuts missing mass $ep \rightarrow e\gamma X$

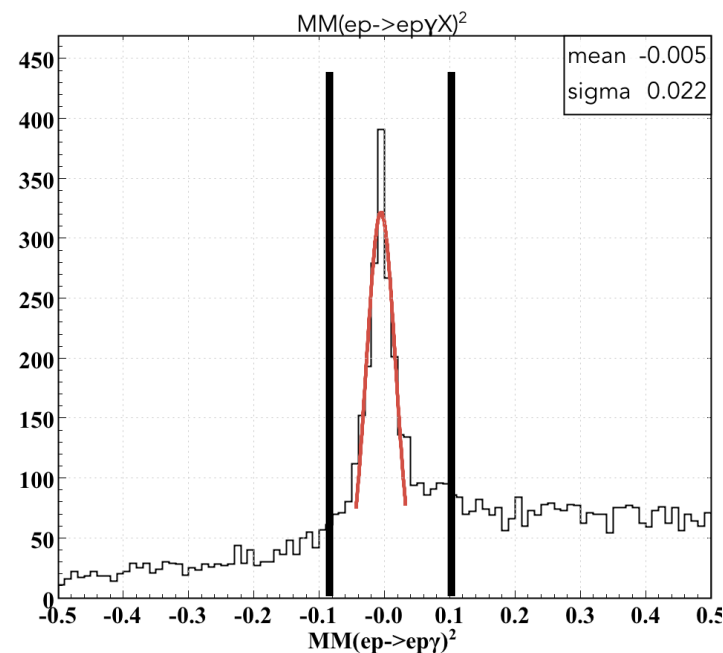
- Run 3973 T+1/S-1

Negative outbending



- Run 4314 T-1/S-1

Negative inbending



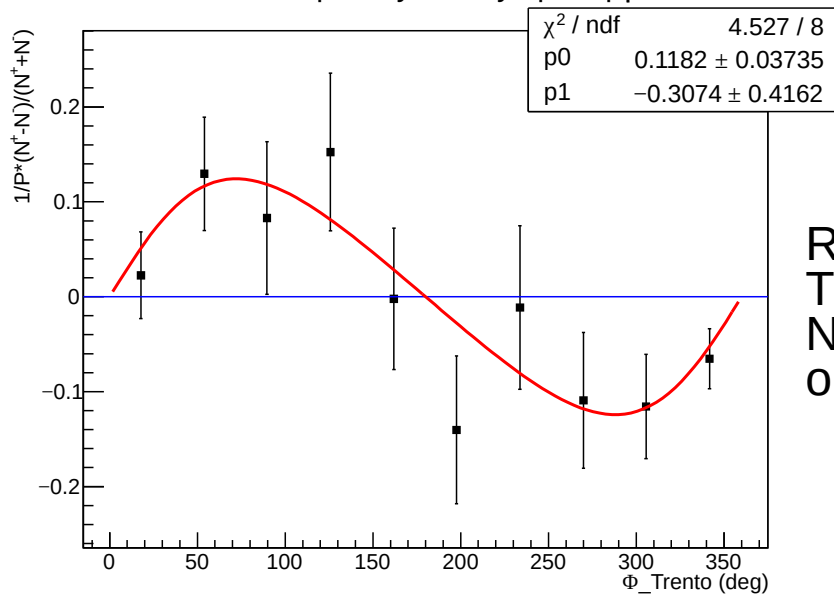
Beam-spin Asymmetry

After particle cuts and missing mass cut (no contamination/background subtraction)

$$A_{LU} = \frac{1}{\zeta} \frac{N^{\rightarrow} - N^{\leftarrow}}{N^{\rightarrow} + N^{\leftarrow}} \text{ assuming polarisation } \zeta = 0.85$$

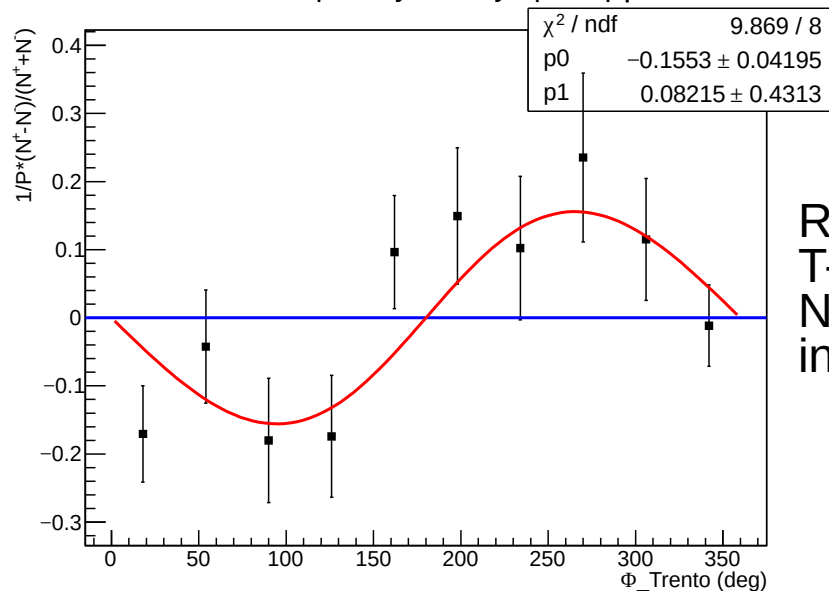
Fit with: $f(\phi) = a \sin(\phi)/(1 + b \cos(\phi))$

Beam spin asymmetry $ep \rightarrow e\gamma$



Run 3973
T+1/S-1
Negative
outbending

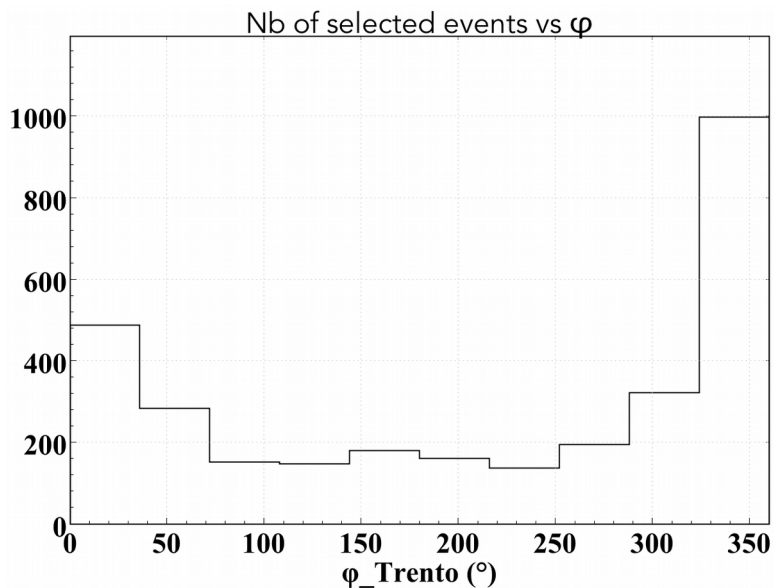
Beam spin asymmetry $ep \rightarrow e\gamma$



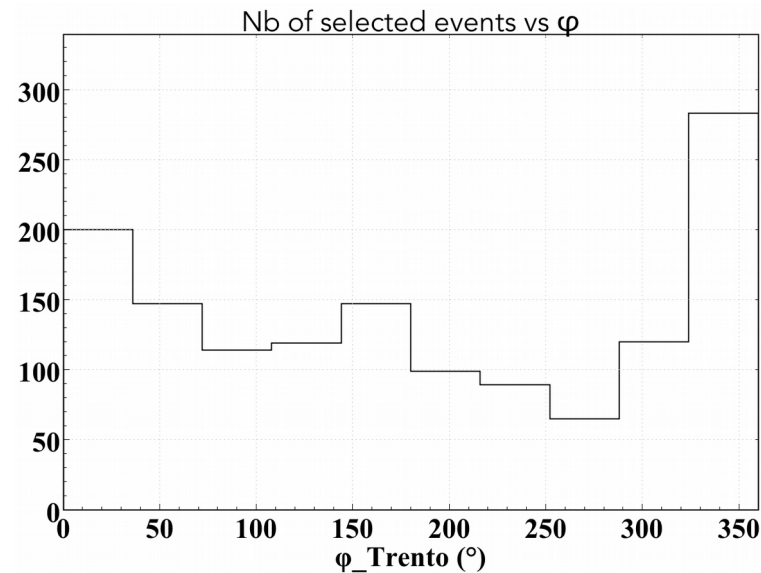
Run 4314
T-1/S-1
Negative
inbending

Beam-spin Asymmetry

After particle cuts and missing mass cut (no contamination/background subtraction)



Run 3973
T+1/S-1
Negative
outbending



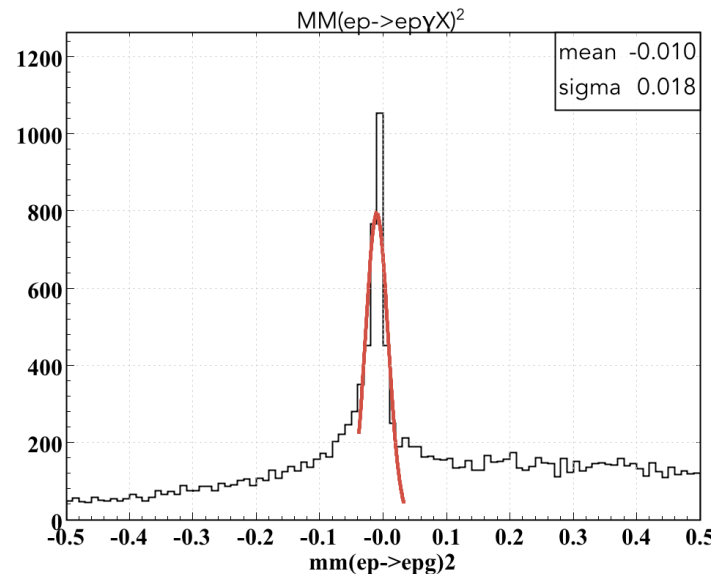
Run 4314
T-1/S-1
Negative
inbending

Contamination

- The number of events here includes DVCS or BH but also accidentals and pion electroproduction:

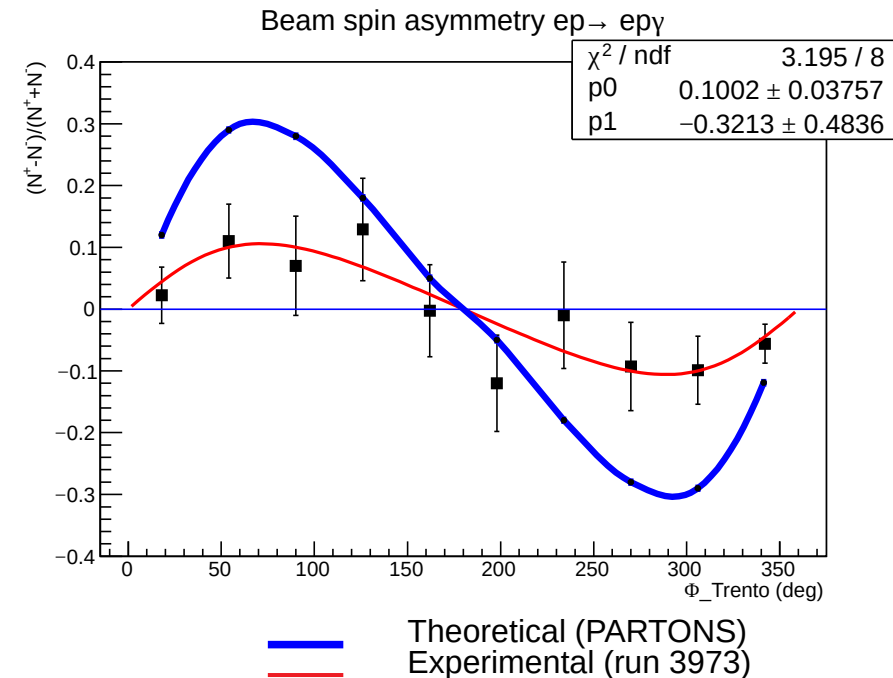
$$N = N_{|M_{ep \rightarrow ep\gamma}|^2 < 0.1} = N_{DVCS/BH} + N_{acc} + N_{\pi^0}$$

- Estimate influence of combinatorial background :
 - Random trigger
- Estimate influence of pion electroproduction background :
 - Pion data analysis and simulation



Theoretical beam-spin asymmetry

- Computation of expected theoretical asymmetry with PARTONS software
- At 10.6 GeV and using average Q^2 , x_B , t from data (1 bin) in negative outbending
- GPD model GK16, and BMJ12



[PARTONS: B. Berthou, D. Binosi, N. Chouika, M. Guidal, C. Mezrag, H. Moutarde, F. Sabatié, P. Sznajder, J. Wagner, PARTONS: PARTonic Tomography Of Nucleon Software: A computing platform for the phenomenology of Generalized Parton Distributions, <https://arxiv.org/abs/1512.06174>]

Conclusions

- Code ready to process and validate data
- Will need to run on large statistic and to add binning in $(\theta_E, E', t, \phi_{Trento})$?
- Work in progress:
 - Combinatorial background
 - Pi studies on data and simulation
- Plans for DNP :
 - Beam-spin asymmetry on few bins