# Search for a two-photon exchange contribution in inclusive DIS at HERMES

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# Outline

1. HERMES at

2. inclusive DIS in

3. Two-photon exchange contributions

4. Search for

Search for a two-photon exchange contribution
in inclusive DIS at HERMES

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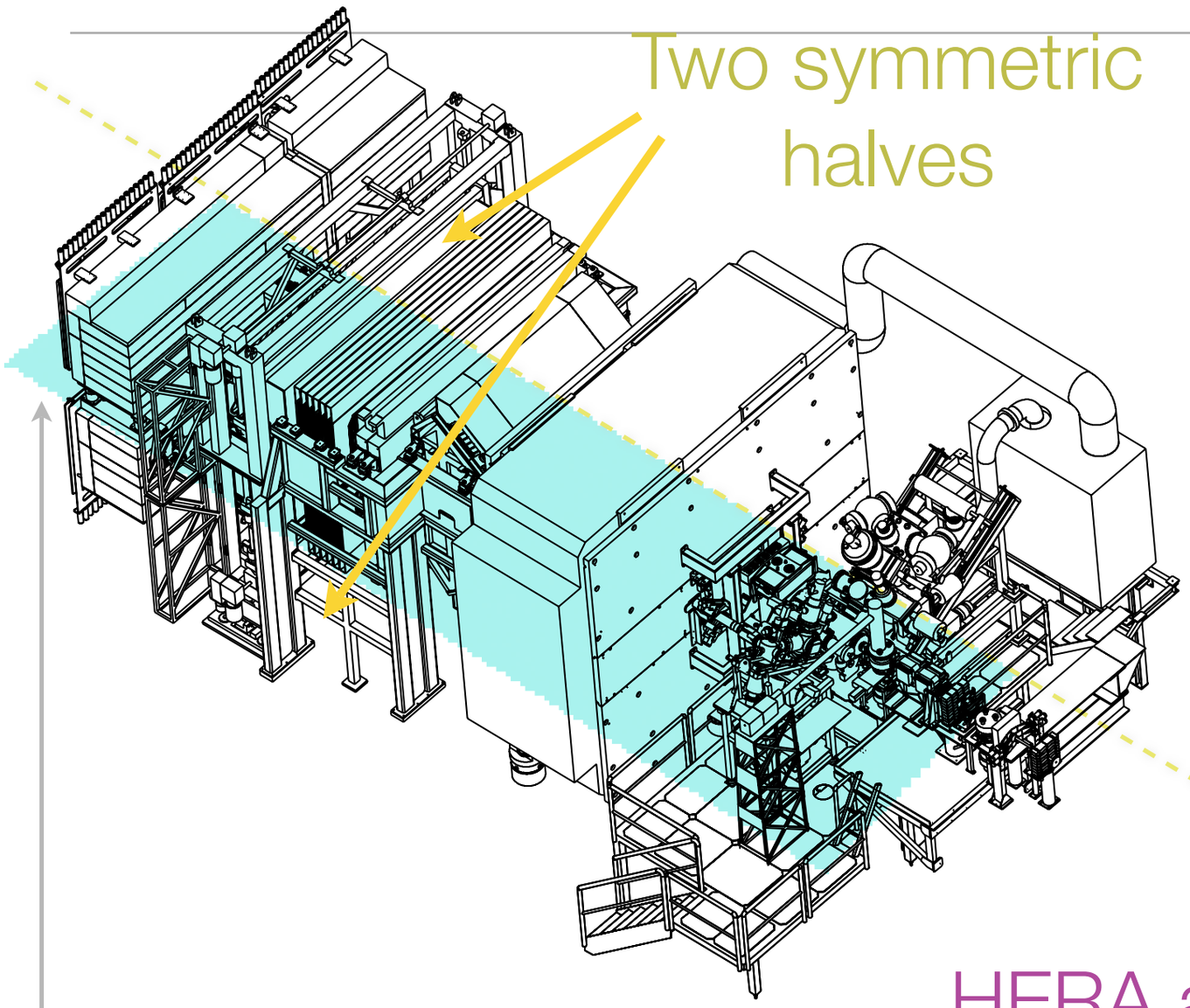
# 1. the HERMES experiment




- Forward spectrometer
- Fixed gas target:
  *Transversely polarized H*
- Target spin direction:
  *reversed every 1-3 minutes*
- Particle ID:
  *TRD + RICH + calo + preshower*

27.6 GeV
e-/e+ Beam

HERA accelerator
Hamburg

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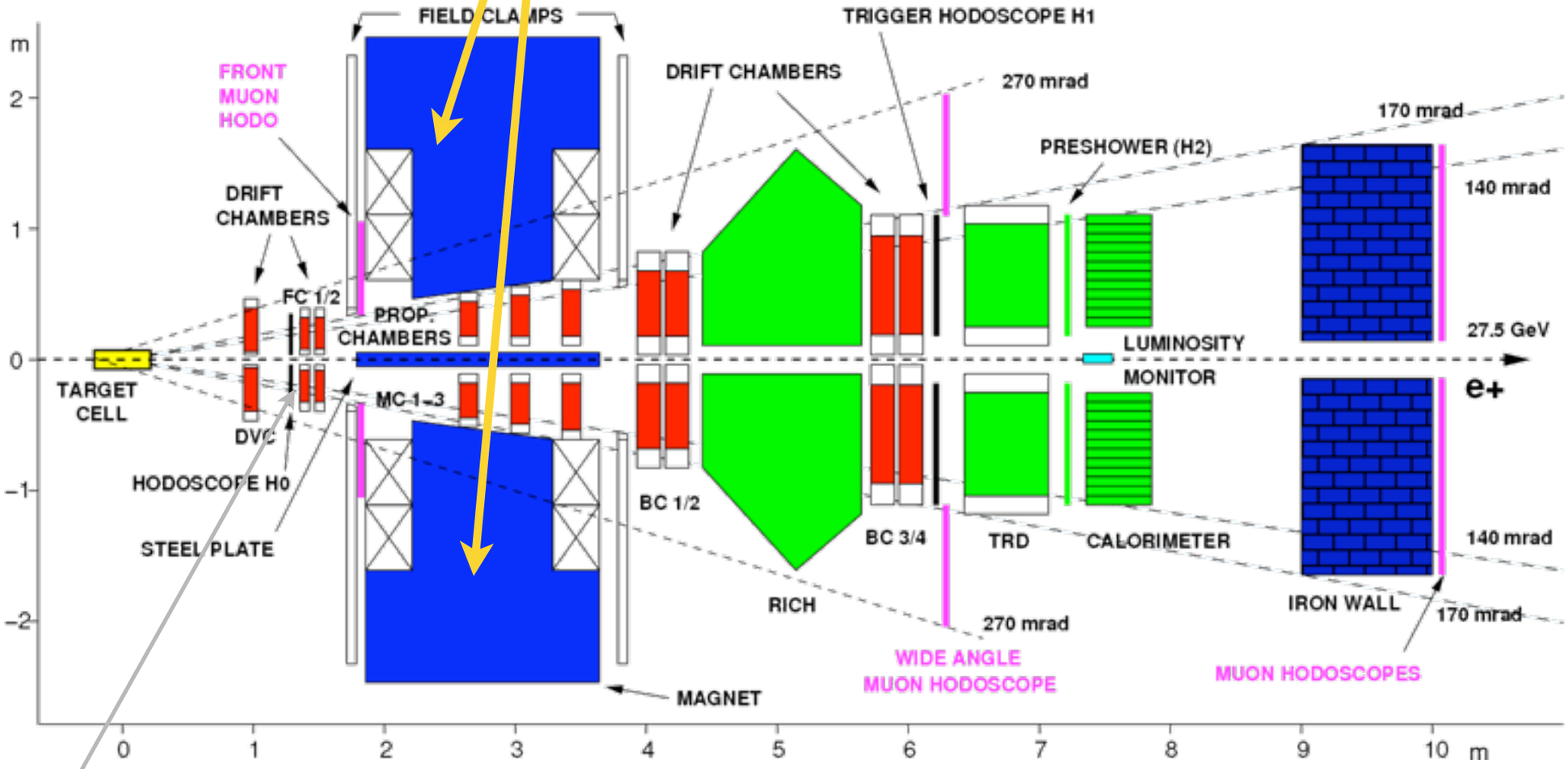
# 1. the HERMES experiment

Two symmetric halves




gap in the acceptance

HERA accelerator
Hamburg

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# 2. inclusive DIS

**Deep Inelastic Scattering**

wavelength of radiated virtual photon < size of the proton

the proton is broken: new hadrons produced

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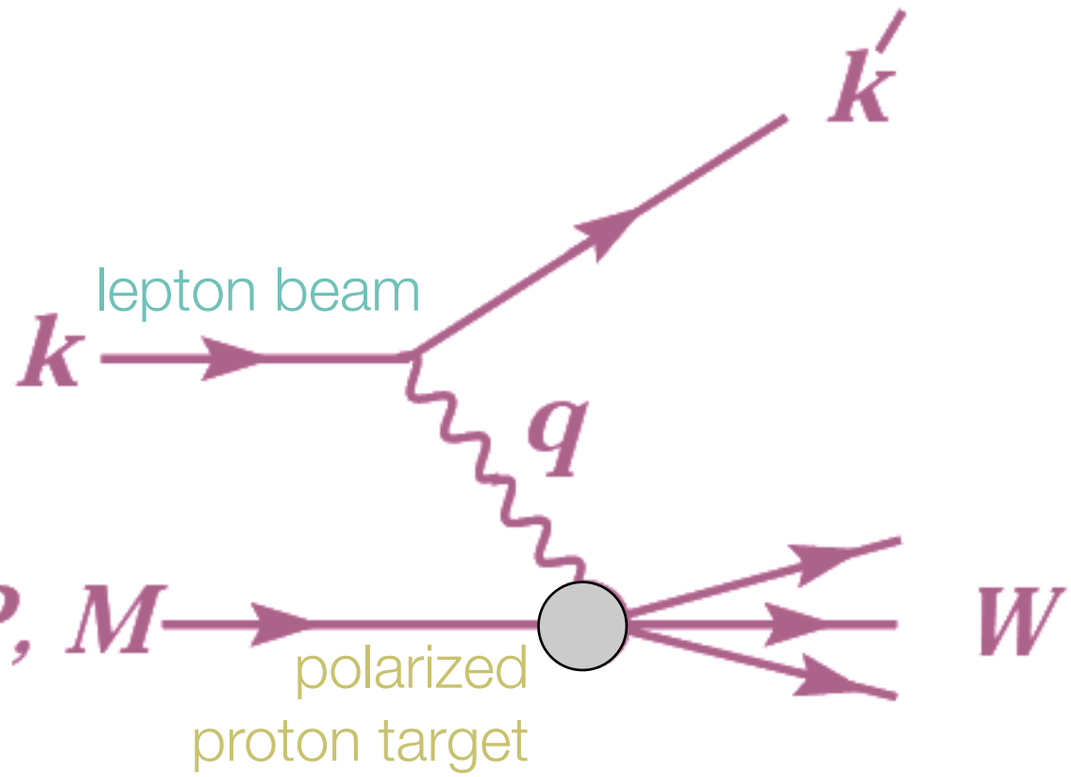
# 2. inclusive DIS

## Deep Inelastic Scattering




described by

- $x_{Bjorken} = Q^2 / 2M(E-E')$
  fractional moment of the proton
  carried by the struck quark
- $Q^2 = -(k-k')^2$
  negative squared of momentum transfer q

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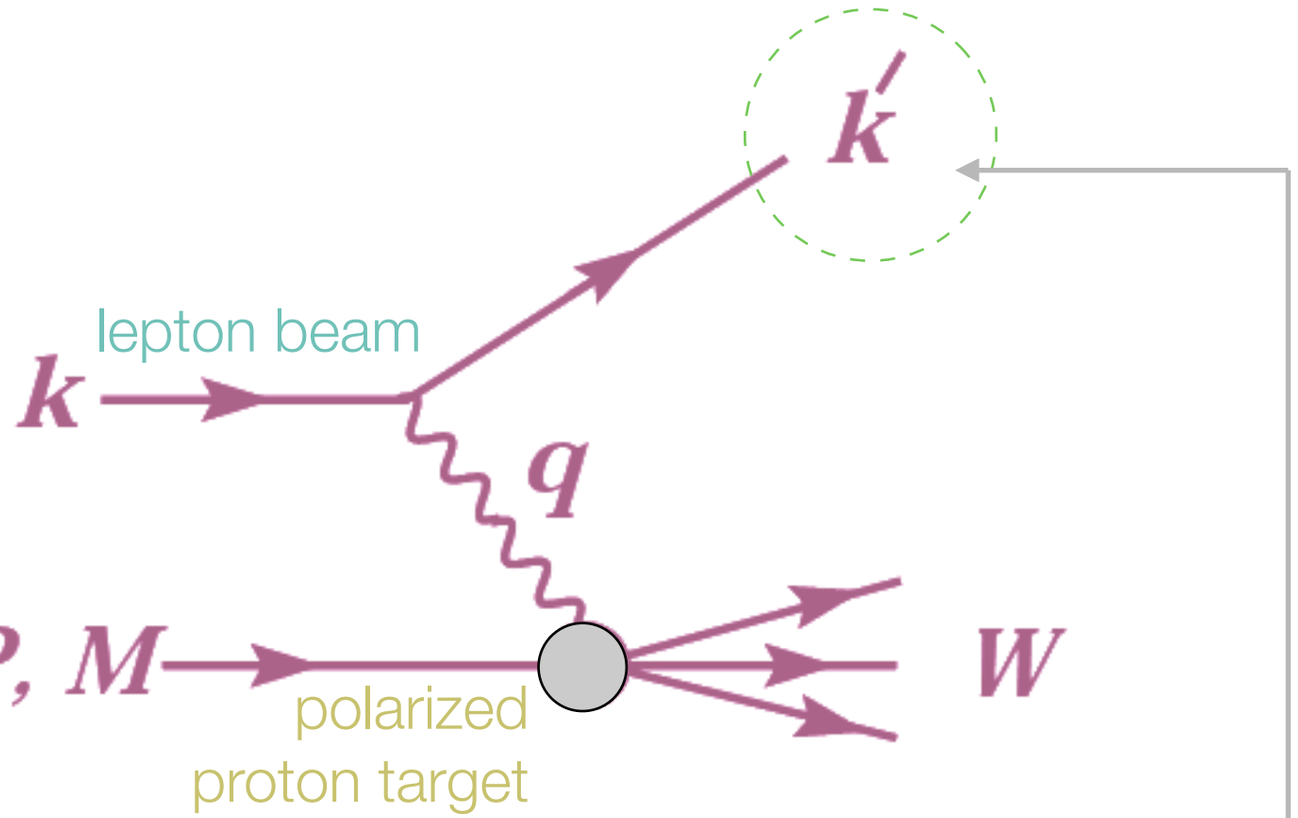
# Deep Inelastic Scattering




## Inclusive

only the scattered lepton is detected

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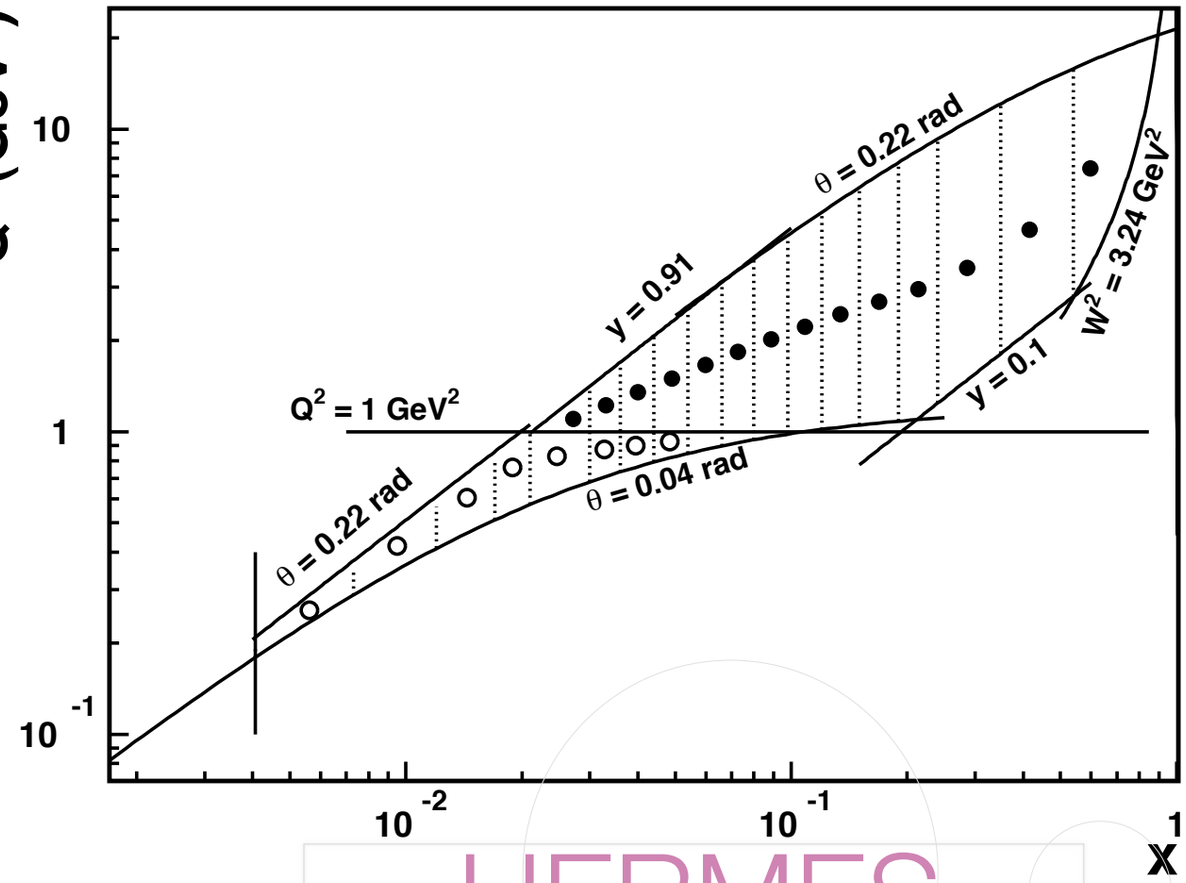
# 2. inclusive DIS

## Deep Inelastic Scattering

## kinematic plane




at HERMES

kinematic variables

$0.004 < x_{Bjorken} < 0.9$

$0.1 < Q^2 < 20\ GeV^2$

$W^2 > 3.24\ GeV^2$

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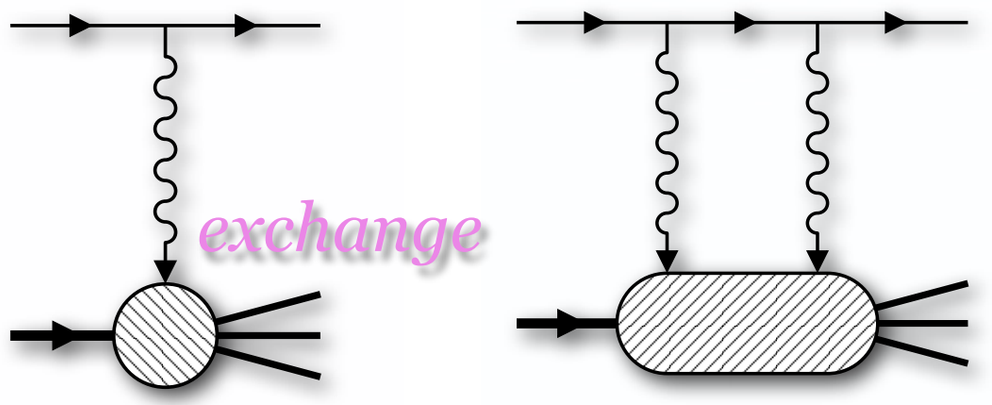
# 3. Two-photon exchange contributions

## WHAT? is that

twoPhoton




onePhoton

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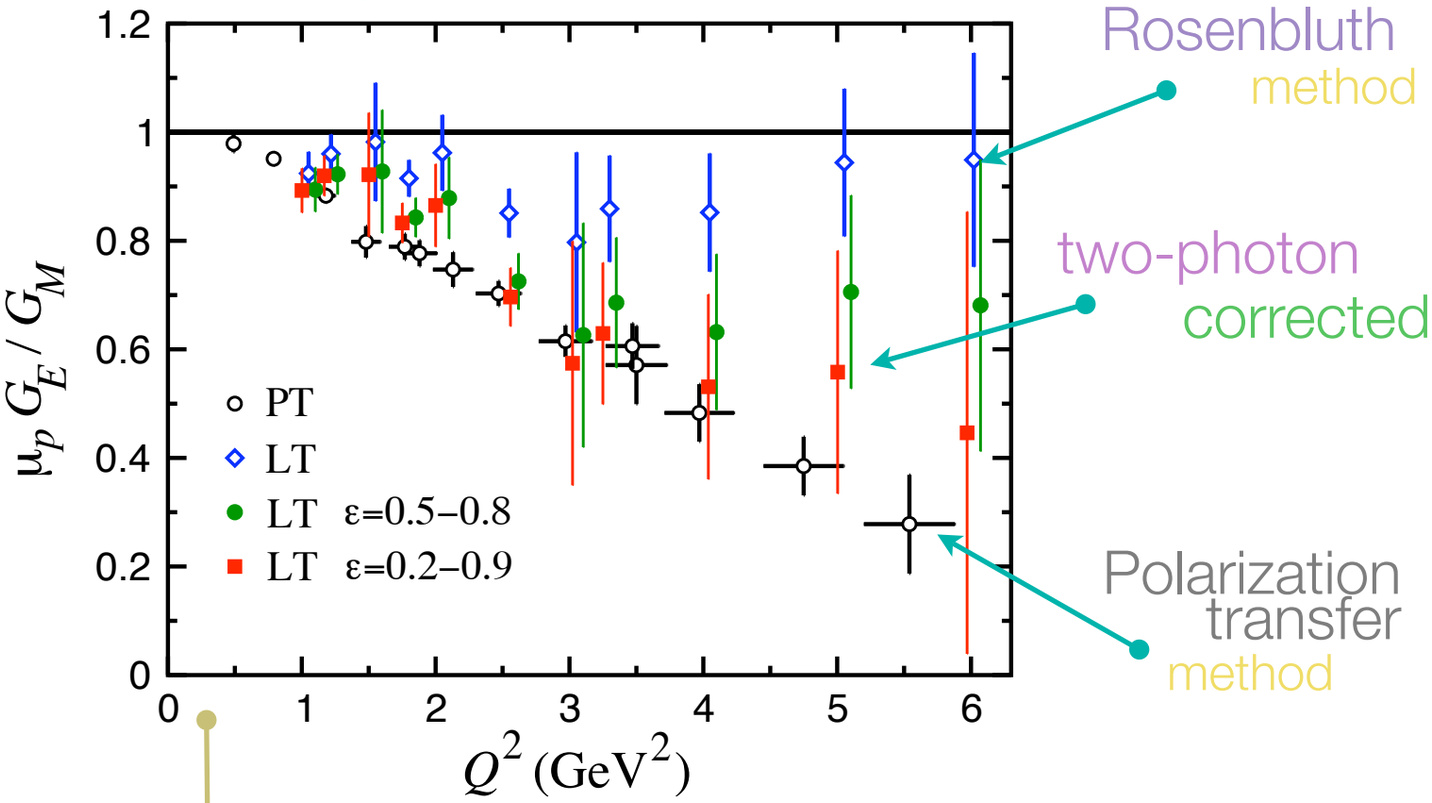
# 3. Two-photon exchange contributions

## WHy ? is it interesting

> In recent years the two-photon-exchange cross section in electron nucleon scattering has received increased attention.
>
> In elastic $ep$ scattering two photon effects are believed to be the best candidate to explain the discrepancy in the measurement of the ratio $G_E/G_M$ of the electric and magnetic form factors of the proton obtained at large momentum transfer $Q^2$ using the Rosenbluth method and the polarization transfer method [1]. It was shown [2] that the interference between the one-photon and two-photon exchange amplitudes can affect the extraction done with the Rosenbluth method to a level of a few percent, enough to explain the discrepancy between the two methods.
>
> Two-photon exchange effects have also been shown [3] to play a role in the measurement of parity violation in elastic scattering of longitudinally polarized electrons on an unpolarized target. They can lead to corrections of several percent to the parity violating asymmetry.
>
> In inclusive Deep Inelastic Scattering (DIS) $l + N \rightarrow l' + X'$ two-photon exchange is expected to give rise to normal single spin asymmetries (SSA), which, in the 1-photon exchange approximation, are forbidden by the combination of time reversal invariance and parity conservation, and the hermiticity of the electromagnetic current operator, as stated in the Christ-Lee theorem [4].

*example:*

## Ratio of proton form factors




*from* ( P. G. Blunden, W. Melnitchouk, and J. A. Tjon, Phys. Rev. C 72 (2005) 034612 )

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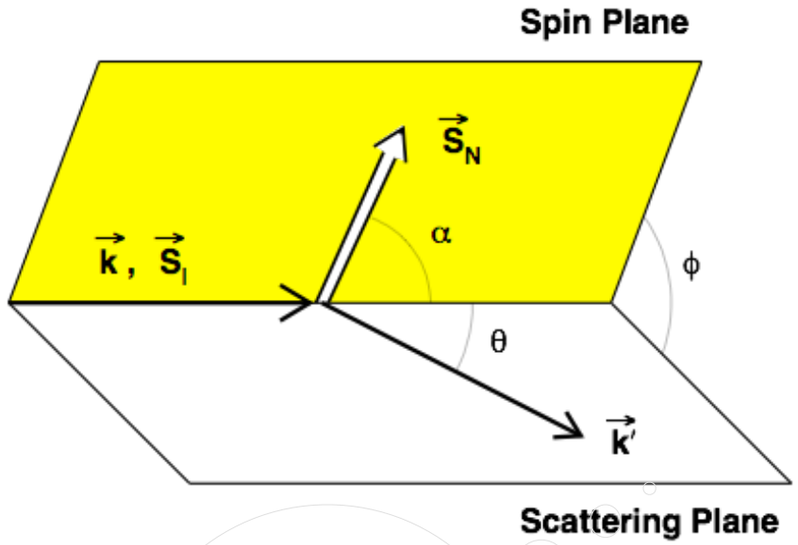
# 3. Two-photon exchange contributions

## How?
can we measure it

*theory:*

$$\sigma_{pol} \propto \vec{S}_N \cdot (\vec{k} \times \vec{k'})$$

effect is MAX when the scattered lepton is perpendicular to the transverse spin




interference of the one-photon and two-photon exchange amplitudes → inclusive Asymmetry left right

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# 3. Two-photon exchange contributions

## How?
can we measure it

*experimentally:*

inclusive
Asymmetry
left right

$$A_N = \frac{N_R - N_L}{N_R + N_L}$$

measured asymmetry

$$A_N = \chi^{HERMES} \cdot A_N^{2\pi}$$

Asymmetry in full coverage

acceptance factor

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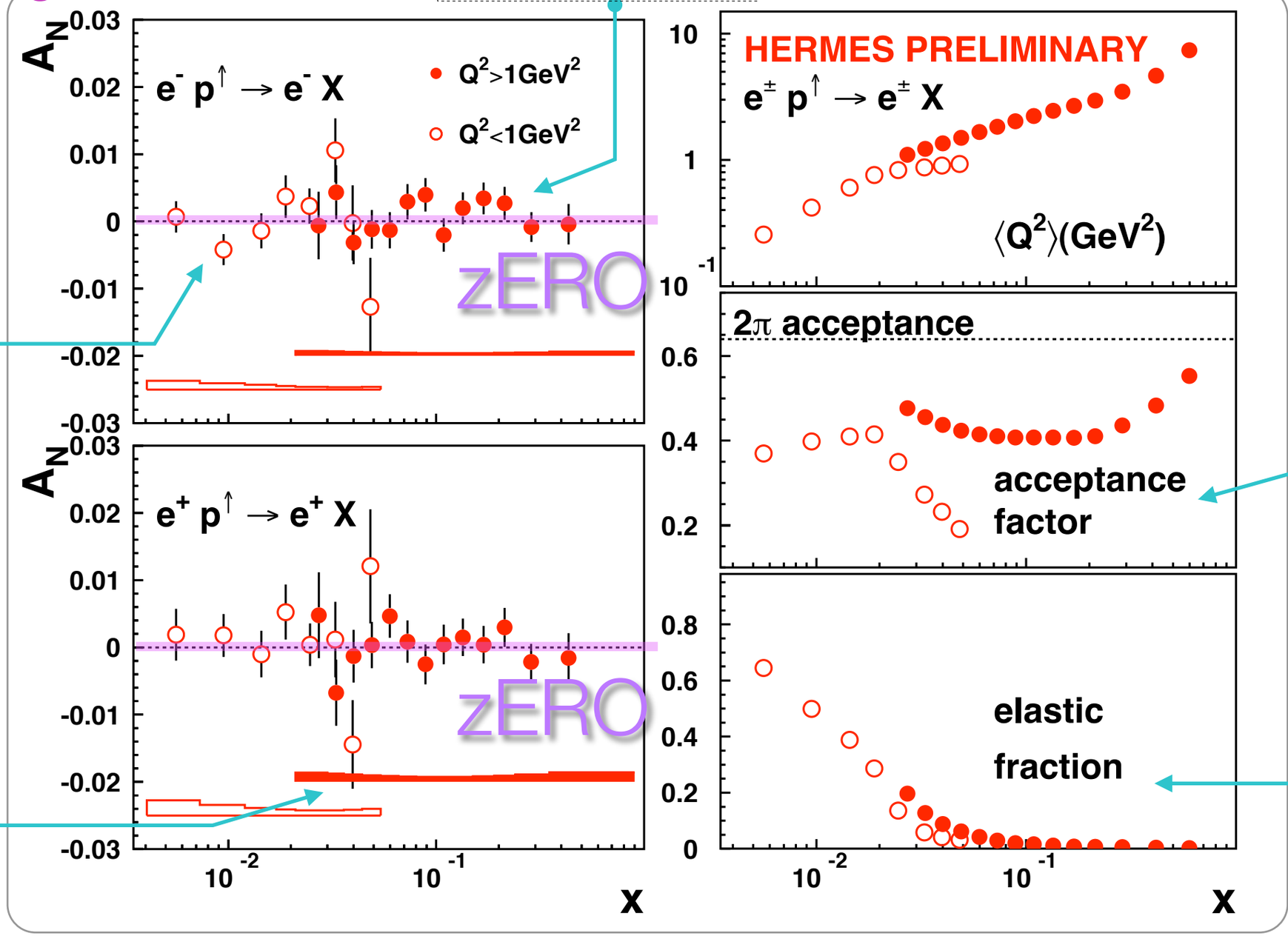
# 4. Results

inclusive
## Asymmetry
left right

DIS region




low $Q^2$
interpretation not yet clear. but it might be useful

systematic error bands included trigger eff., PID, vertex reconstrc., and more

to calculate the asymmetry in 2π coverage, beyond HERMES acceptance

to estimate the contribution from elastic scattering at low x and $Q^2$

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# Conclusions

- Inclusive single spin Asymmetries have been measured at HERMES on a transversely polarized proton target

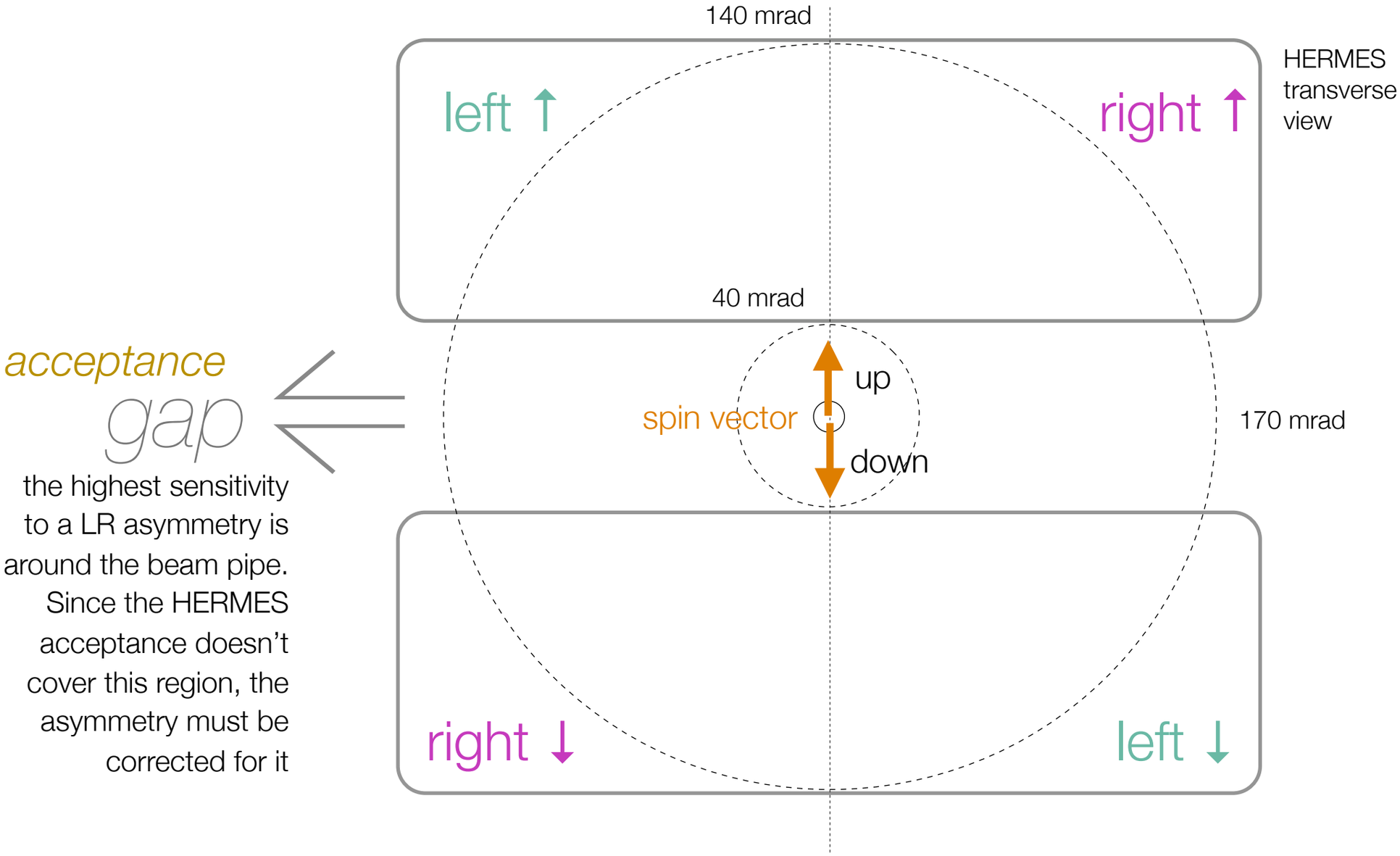
- No evidence of two-photon exchange has been observed within the experimental uncertainties of the order of $10^{-3}$

| beam | Asym. $\times 10^{-3}$ | stat. error $\times 10^{-3}$ | syst. error $\times 10^{-3}$ | $< x >$ | $< Q^2 >$ GeV$^2$ |
|---|---|---|---|---|---|
| $e^+$ | 1.28 | 1.47 | 1.35 | 0.02 | 0.6 |
| $e^-$ | 1.35 | 1.29 | 0.73 | 0.02 | 0.6 |
| $e^+$ | 0.21 | 0.90 | 0.74 | 0.14 | 2.4 |
| $e^-$ | 0.87 | 0.76 | 0.41 | 0.14 | 2.4 |

# Back-up slides

# Back-up slides

## *A note about acceptance:*




*acceptance*

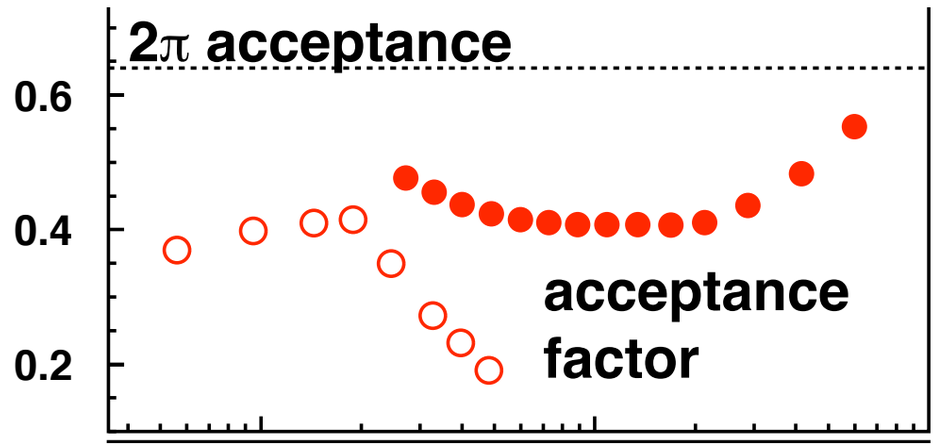
*gap*

the highest sensitivity to a LR asymmetry is around the beam pipe. Since the HERMES acceptance doesn't cover this region, the asymmetry must be corrected for it

# Back-up slides

## *A note about acceptance:*

How?
to make this plot:




1. Implement "*false*" asymmetry $A^{\sin\Phi} \cdot \sin\Phi$ in MonteCarlo
2. Extract $A_N$ as in real data for different values of $A^{\sin\Phi}$
3. since $A_N = \chi \cdot A^{\sin\Phi}$ → fit ratio $A_N / A^{\sin\Phi}$ to a line
4. Repeat step 3. for every ($x$, $Q^2$) bin