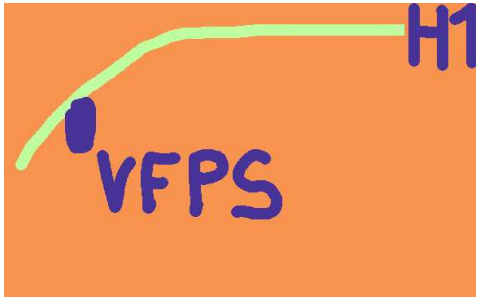
Xavier Janssen - DESY Hamburg

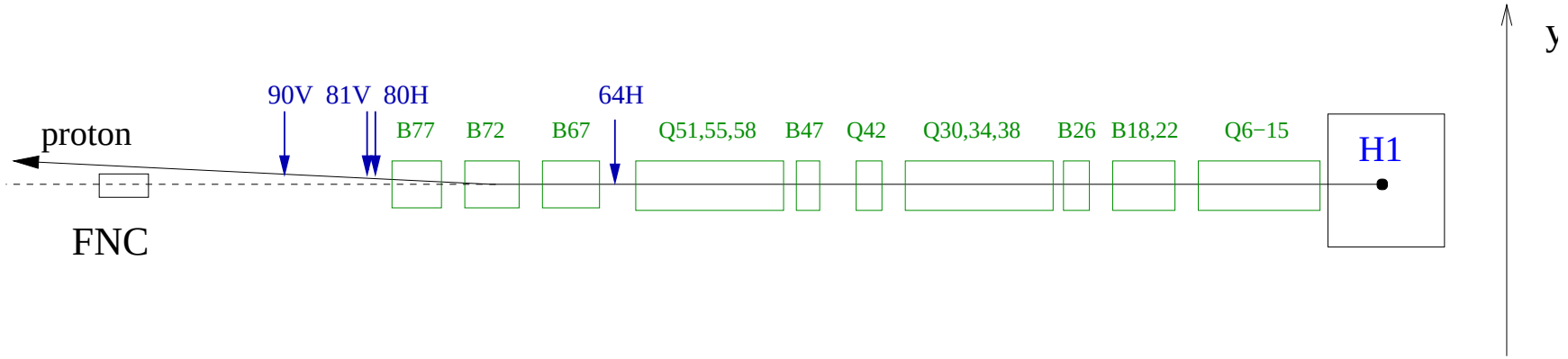


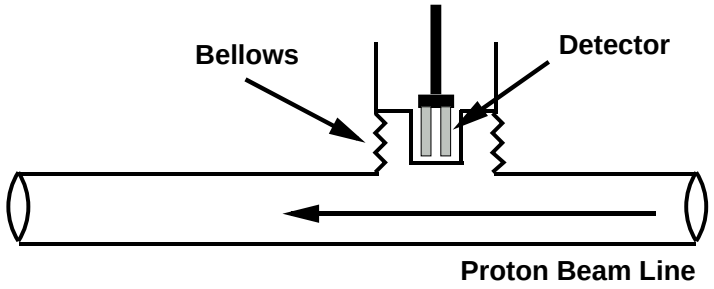
Prospects for Diffraction at HERA-II with the H1 Very Forward Proton Spectrometer (and for DVCS)

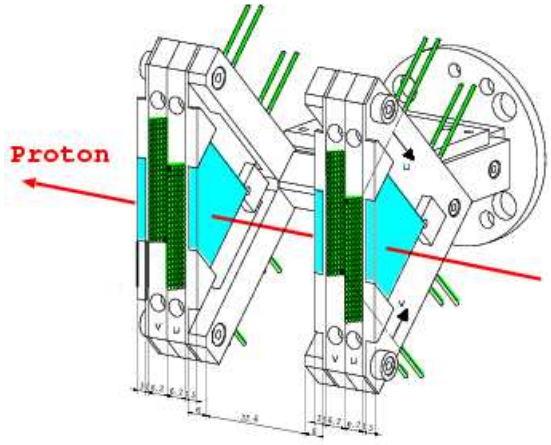
HERA-LHC Workshop

DESY, Hamburg, March 21th - 25th, 2005

HERA I: Forward Proton Spectrometer







- Scintillating fibre detector
- Free of proton dissociation bkgd
- proton 4-momentum measurement $\rightarrow$ t
- Small acceptance

HERA I Results: $F_2^{D(4)}$

$$\frac{\mathrm{d}^4\sigma_{ep\to eXp}}{\mathrm{d}Q^2\mathrm{d}x_{I\!P}\mathrm{d}t\mathrm{d}\beta} = \frac{4\pi\alpha_{em}^2}{\beta Q^4}\left(1-y+\frac{y^2}{2}\right)F_2^{D(4)}(Q^2,x_{I\!P},t,\beta)$$

Horizonal FPS Stations:

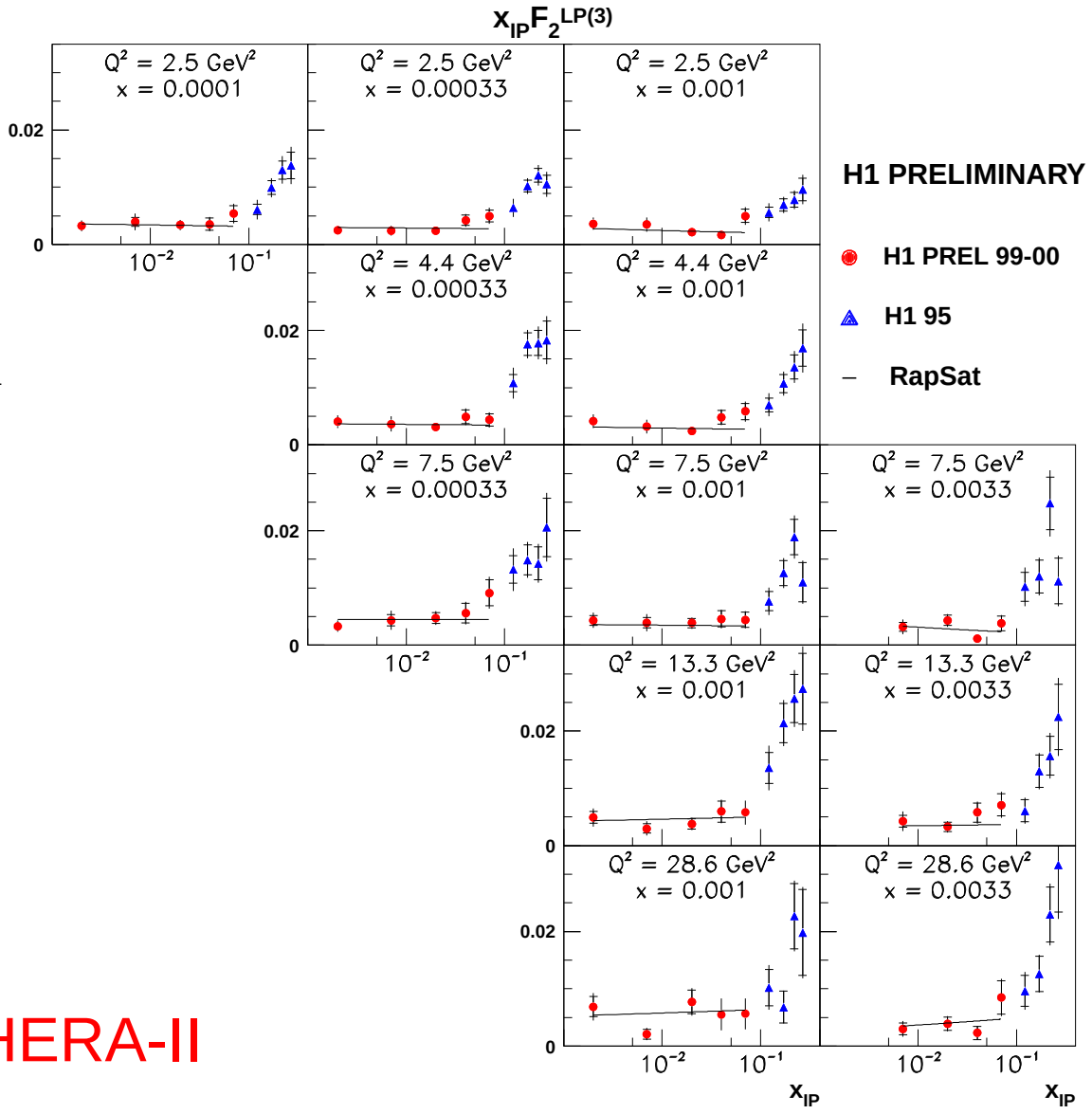
- Few % acceptance at high $|t|$ and low $x_{I\!P}$
- 99/00 data : 28.8 pb^{-1}

Vertical FPS Stations:

- Large acceptance at low $|t|$ and high $x_{I\!P}$
- 1995 data : 1.4 pb^{-1}

BUT statistically limited

More Lumi Expected at HERA-II



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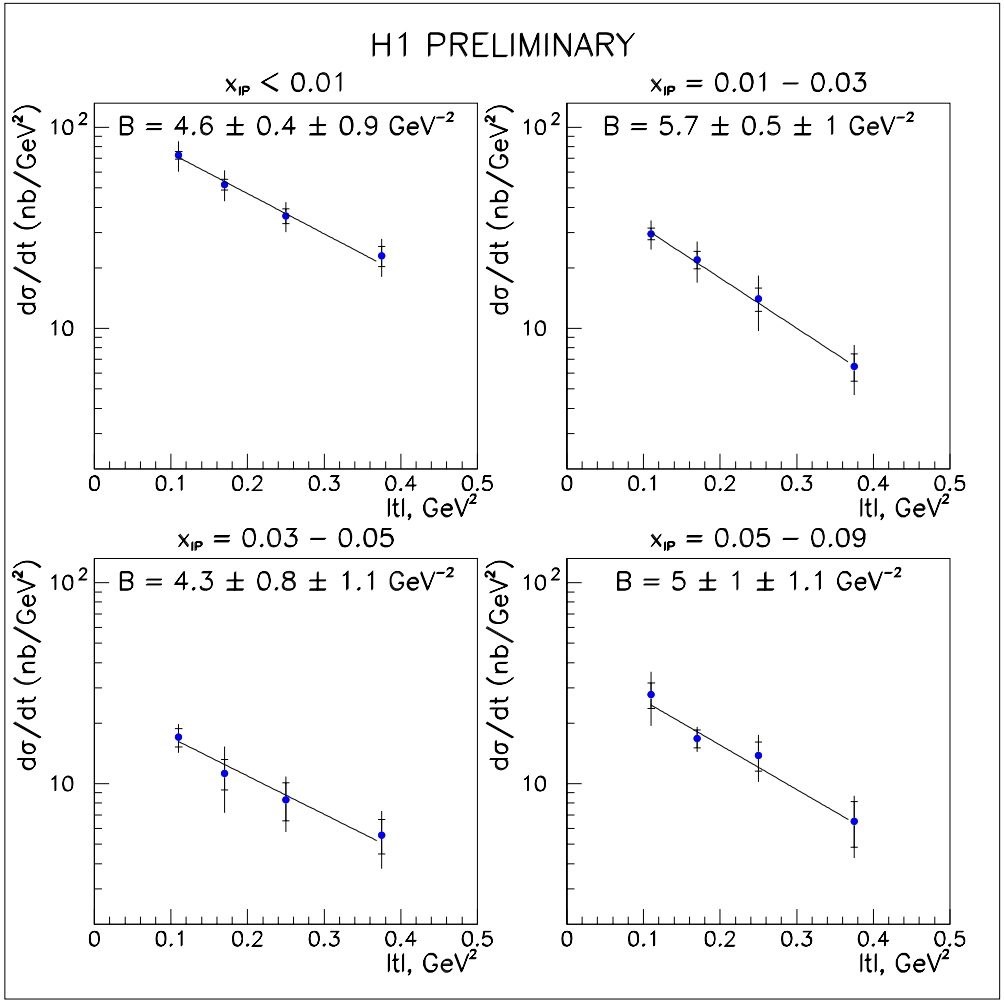


BUT statistically limited

More Lumi Expected at HERA-II

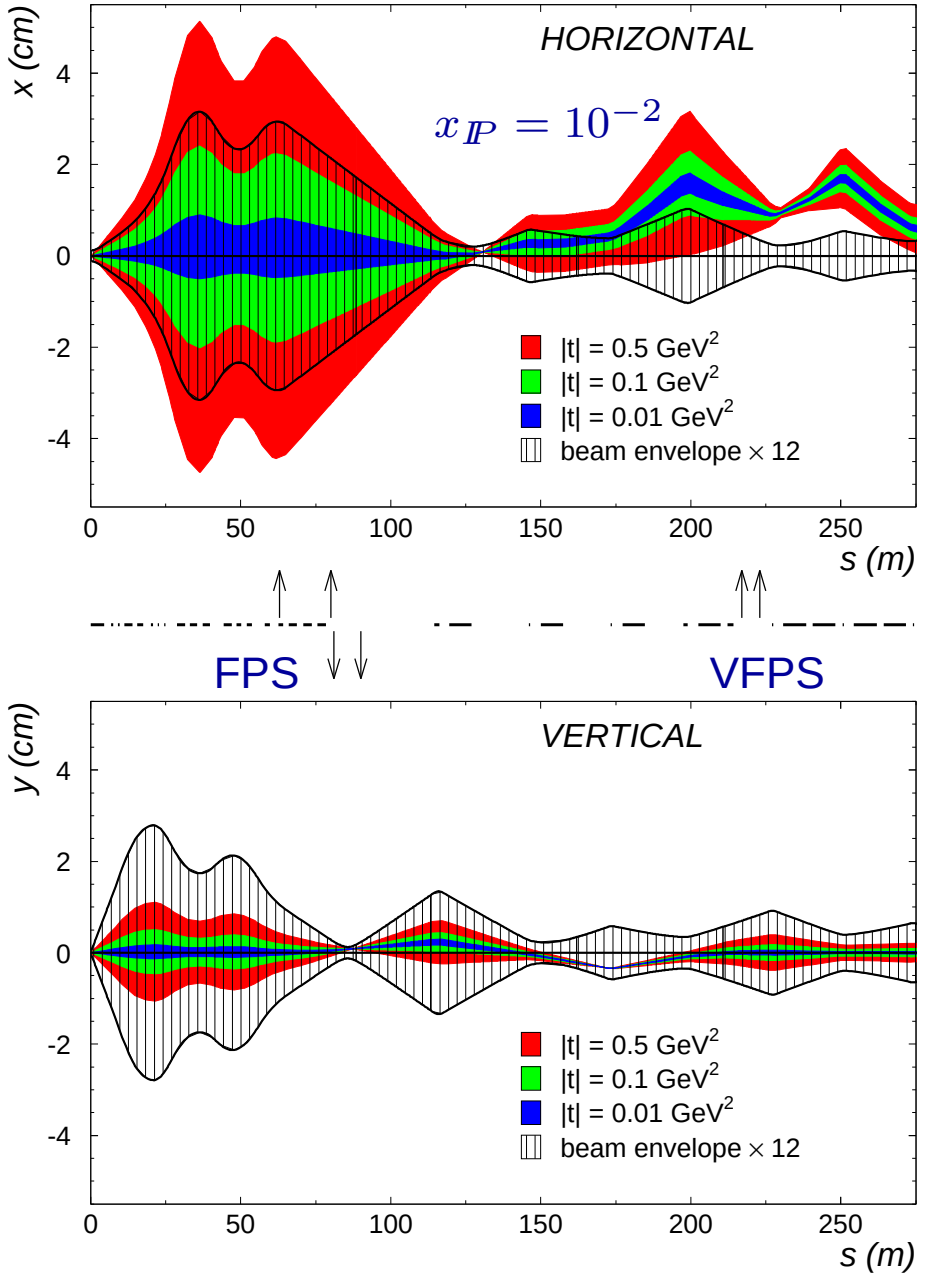
The H1 Very Forward Proton Spectrometer

Tag and measure the scattered proton at HERA II with large acceptance at low $x_{I\!P}$ and down to lowest t

$\Rightarrow$ Precision studies of $ep \to epX$

HERA II beam optic simulation :

- $\Rightarrow$ Best location is 220 m in the horizontal plane (Use HERA bend)
- $\Rightarrow$ Down to $t = 0\ \mathrm{GeV}^2$ for $x_{I\!P} \sim 10^{-2}$

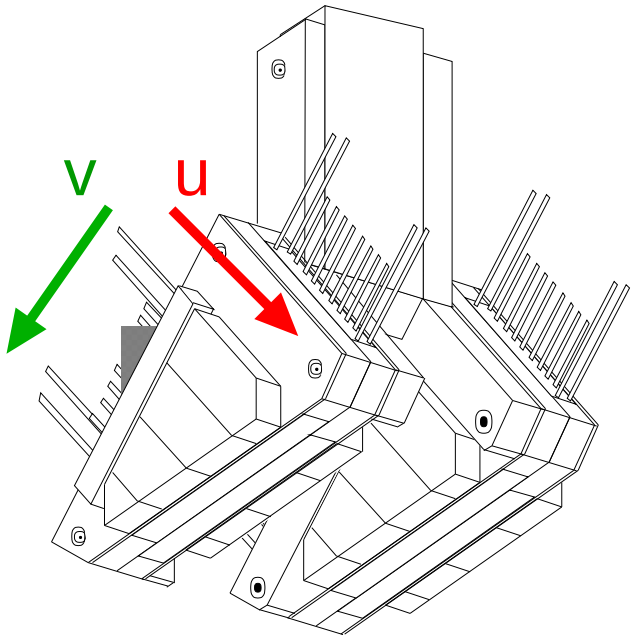


VFPS Detectors

Detectors :

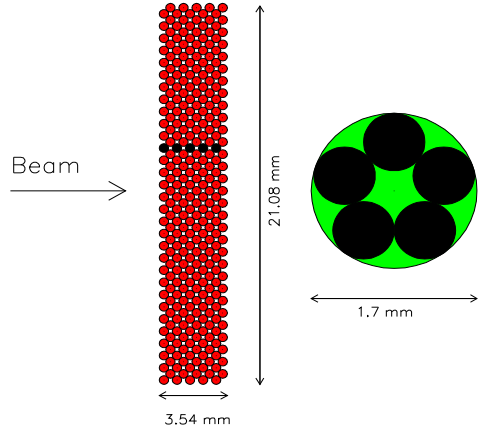
- Same design as Vertical FPS
- 2 detectors: 218 m and 222 m
- 4 Trigger Tiles / plane, 4 planes
- Fibers for spatial reconstruction

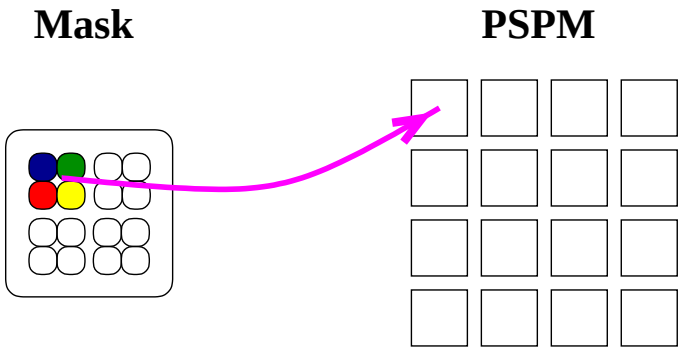
  $\longrightarrow$ Resolution = 100 μ



Optical Connection :

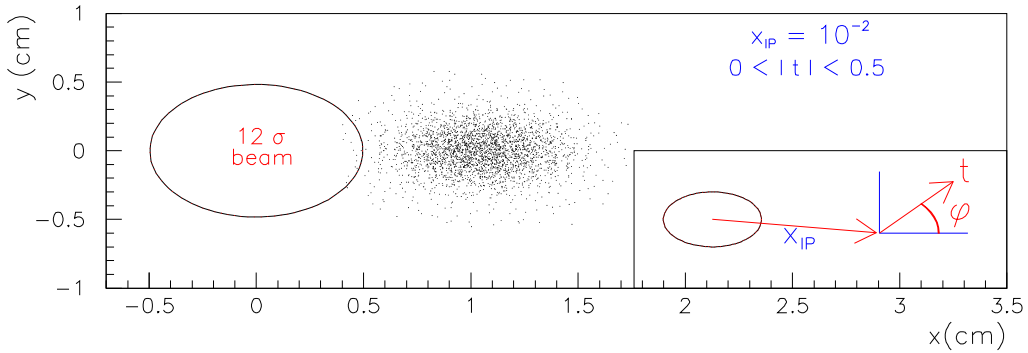
- Tiles : PM , Fibres : PSPM
- 5 fibers layers (= 1 plane) $\longrightarrow$ 1 light guide
- 4 light guides $\longrightarrow$ 1 PSPM pixel (multiplexing)

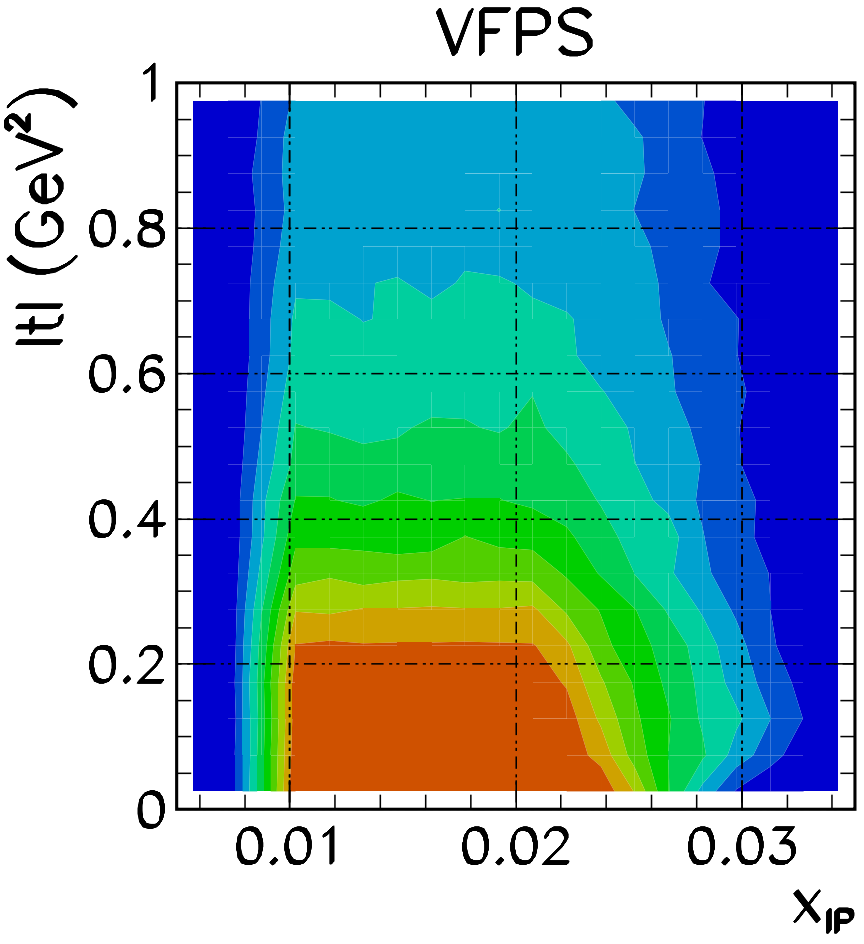




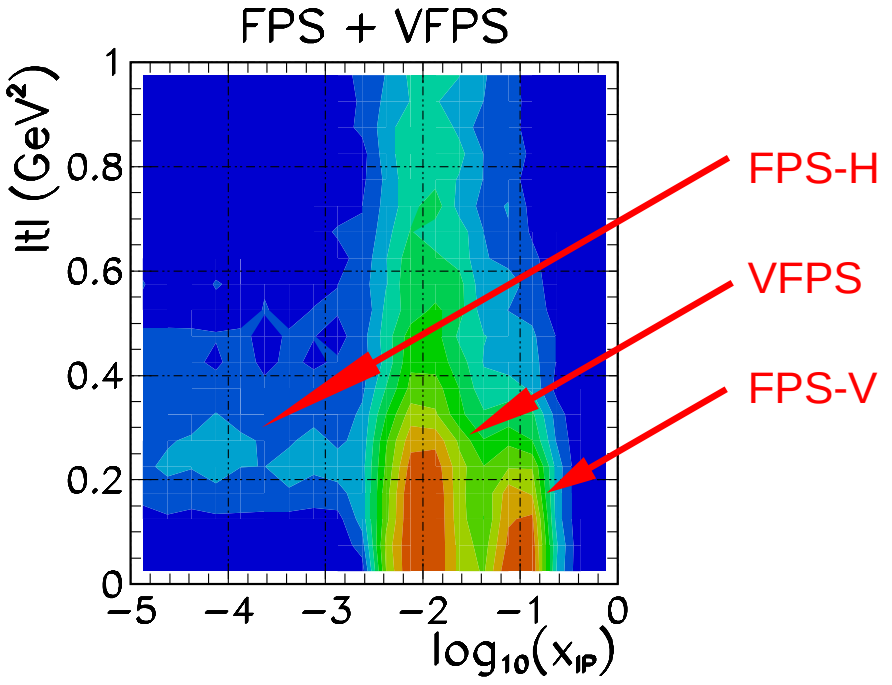
VFPS Acceptance

Acceptance defined by beam optics and envelope (12 σ detector approach limit)





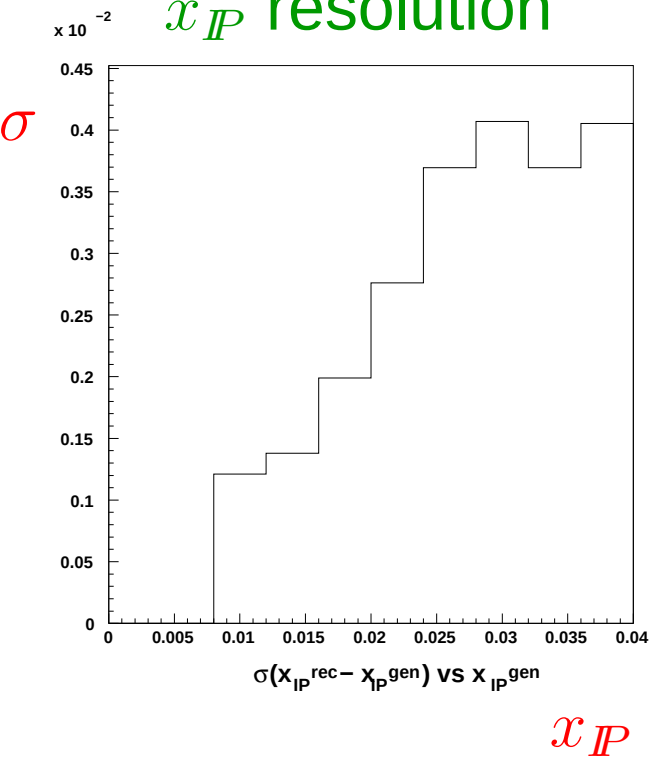
Complementary to FPS (High $x_{I\!P}$)



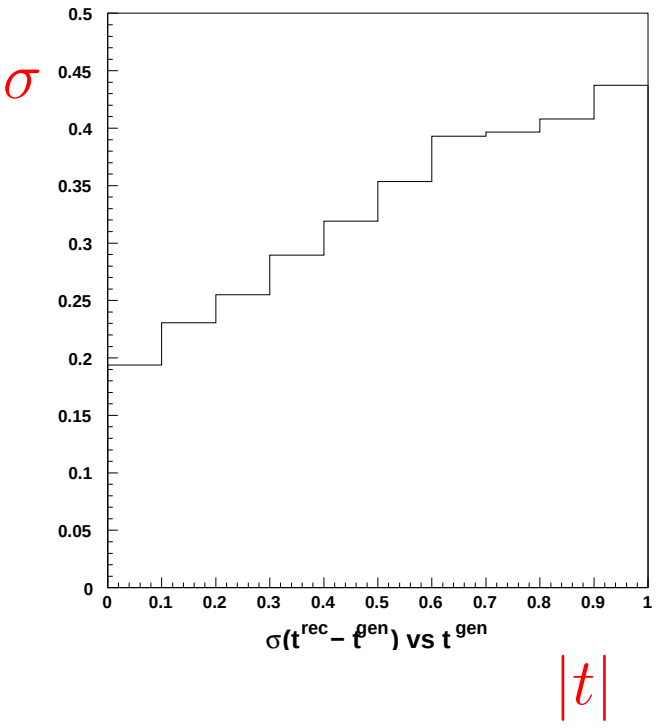
$\Longrightarrow \sim 100\%$ acceptance for $|t| \lesssim 0.2\ \mathrm{GeV}^2$ and $0.01 \lesssim x_{I\!P} \lesssim 0.02$

VFPS Resolution

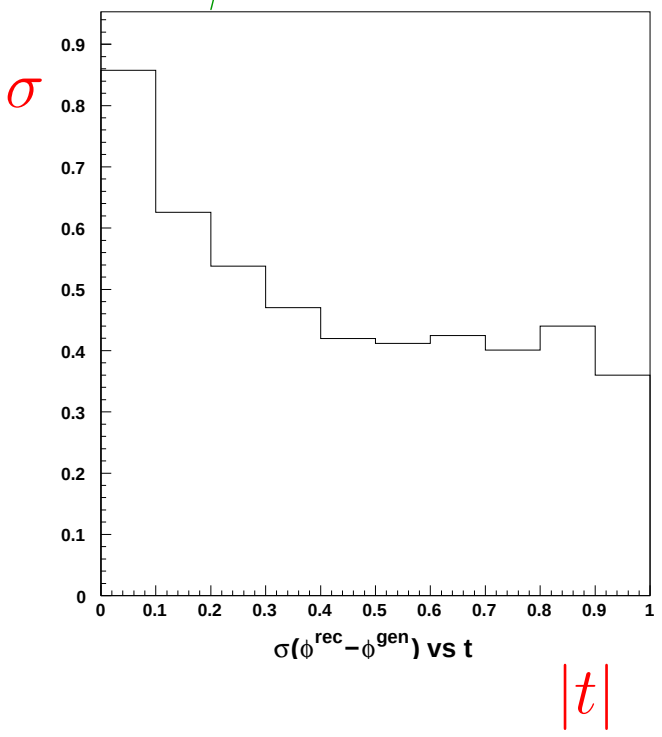
$x_{I\!P}$ resolution



t resolution



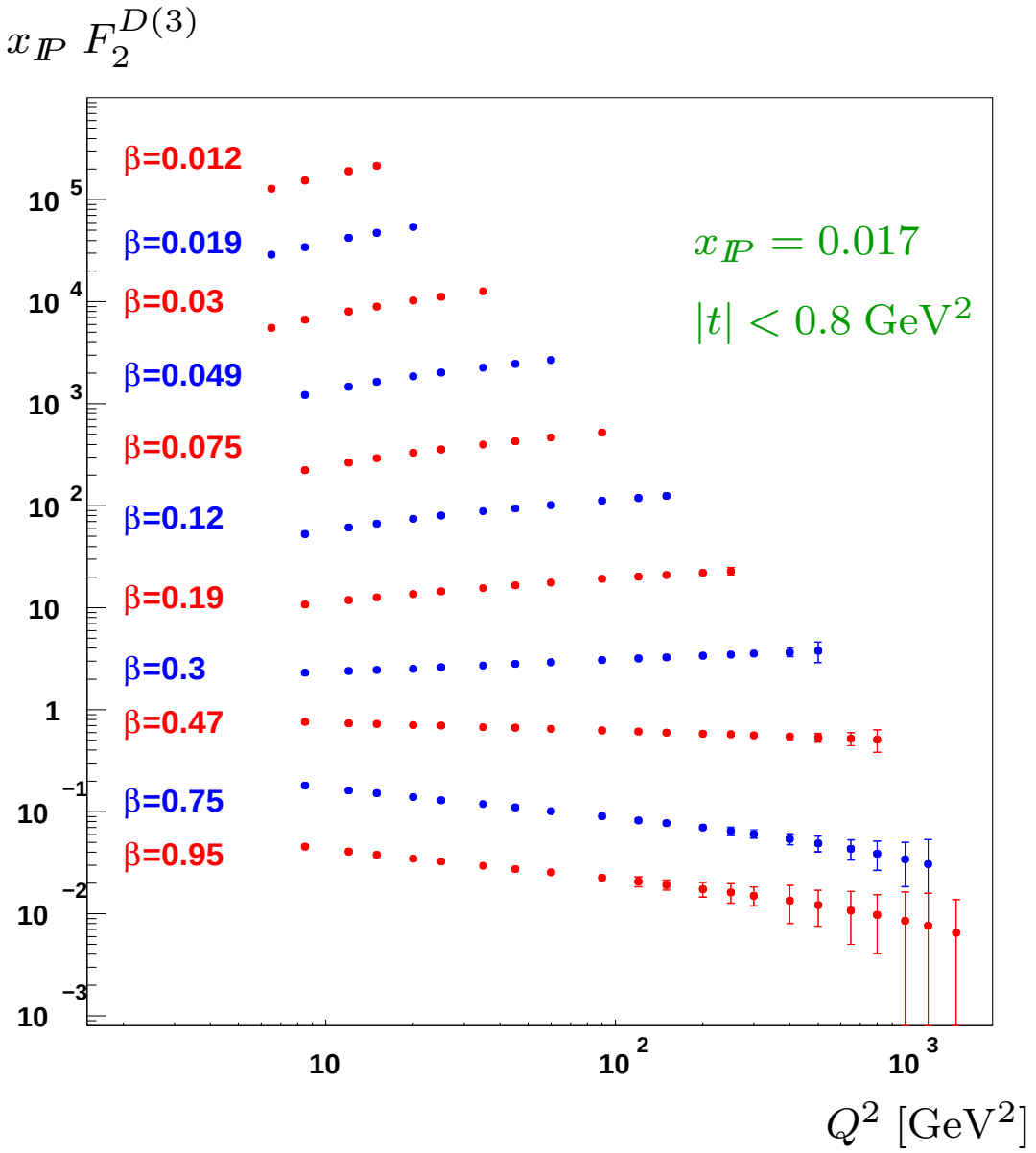
ϕ resolution



- Resolution dominated by beam characteristics
- $x_{I\!P}$ resolution competive with central H1 $x_{I\!P}$ reconstruction
- $\sim$ 4 bins in $|t|$ for $|t| < 0.4\ \mathrm{GeV}^2$
- $\sim$ 15 bins in ϕ for $|t| > 0.2\ \mathrm{GeV}^2$

Expected Results: Inclusive Diffraction

Predicted $F_2^{D(3)}$ for 350 pb^{-1} (50% VFPS operation effi ciency over 3 years)



10^6 Events for $Q^2 > 5\ \mathrm{GeV}^2$

$\longrightarrow$ Study t dependence

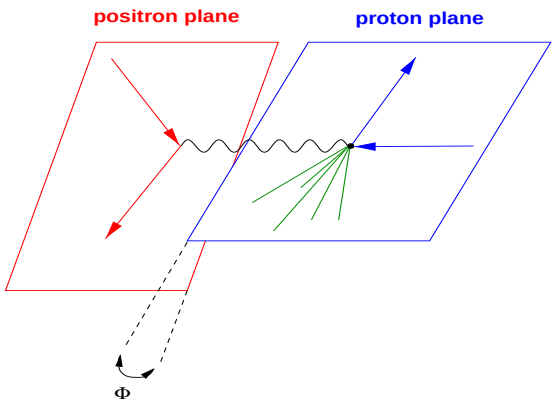
$\longrightarrow F_2^{D(4)}(Q^2, \beta, x_{I\!P}, t)$

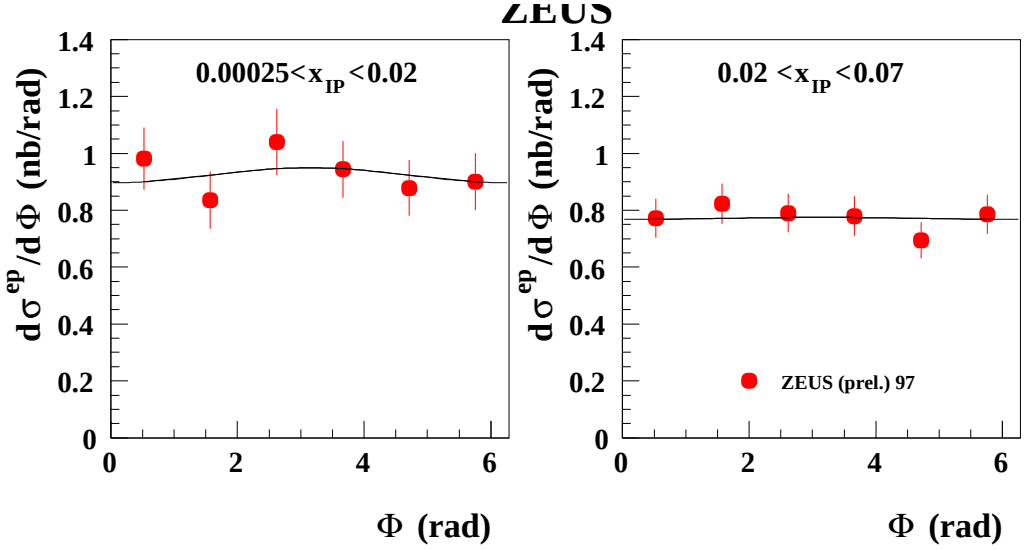
Uncorrelated systematic errors can reach 2-3 %
(similar to F_2 precision)

$\longrightarrow$ Extract diffractive pdf's at fixed $x_{I\!P}$ and t and predict final states at same $x_{I\!P}$ and t to test factorization theorem

Expected Results: F_L^D Measurments

$$\frac{\mathrm{d}\sigma^D}{\mathrm{d}\phi} \propto \sigma_T + \sigma_L - 2\sqrt{\epsilon(1+\epsilon)}\sigma_{LT}\cos\phi - \sigma_{TT}\cos 2\phi$$





ZEUS results: Assymetries are small at low β

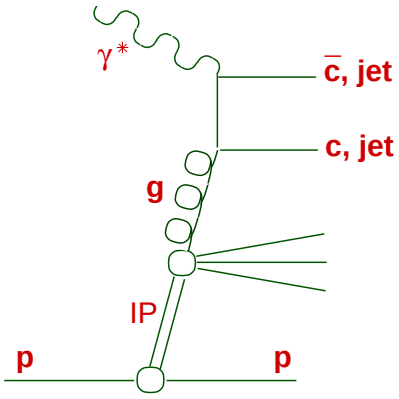
BUT:

pQCD calculable higher twist F_L^D expected dominant at high β

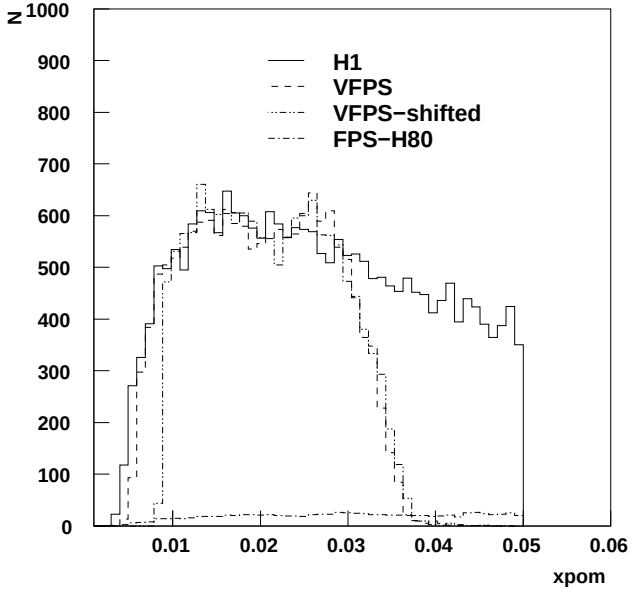
$\longrightarrow$ Measure ϕ asymmetries as function of β (and Q^2)

VFPS : 15 bins in ϕ with 10000 events each for $|t| > 0.2\ \mathrm{GeV}^2$

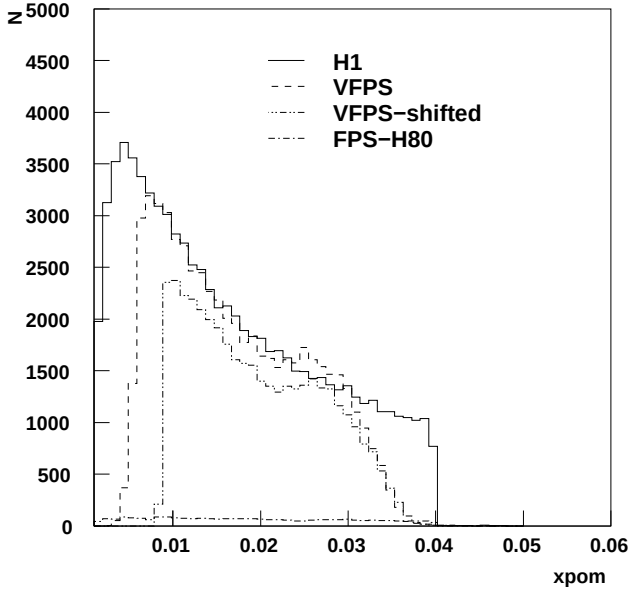
Expected Results: Final States



Di-jets



Open Charm



Di-jets electroproduction

- 96/97 analysis: 2500 events
- VFPS: expect 22900 events

Open Charm (D^*)

- 96/97 analysis: 46 ± 10 events
- VFPS: expect 380 events

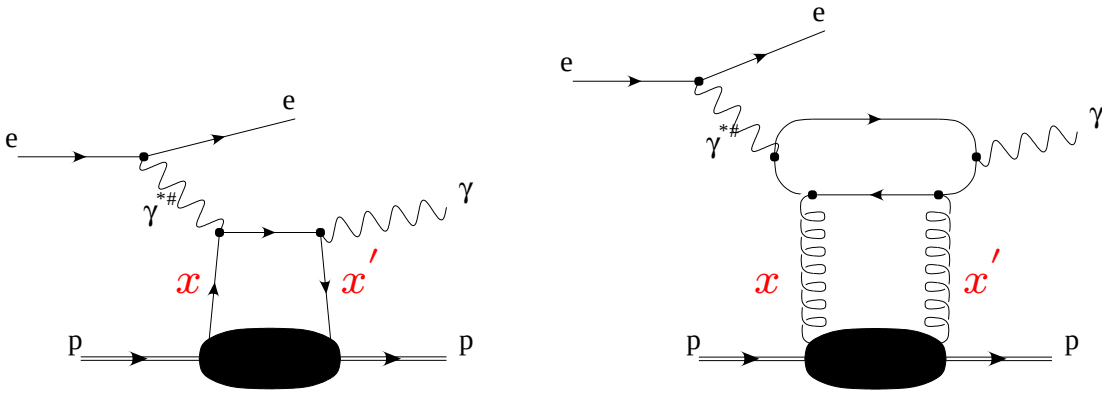
$\rightarrow$ More differential studies (in particular for D^*)

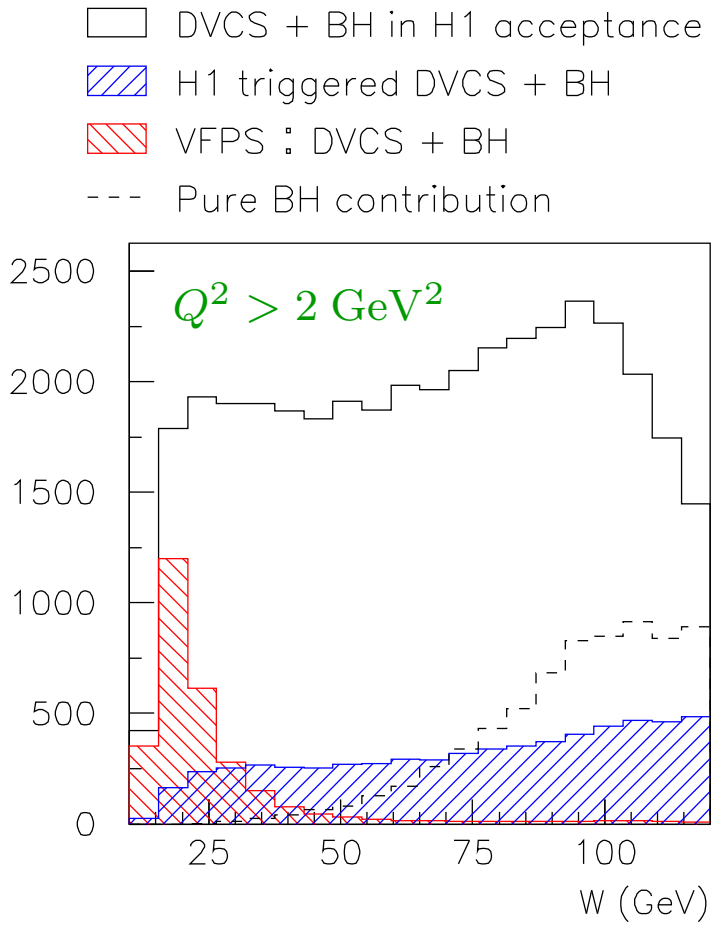
$\rightarrow$ Direct (vs) resolved photon contributions

$\rightarrow$ Test of diffractive factorization theorem

Expected Results: Exclusive Channels

Deeply Virtual Compton Scattering





Sensitive to GPD (extension of pdf for $x \neq x'$, i.e. longitudinal proton structure)

350 pb^{-1} in VFPS: $\sim$ 9000 events

Vector Meson Production

$$e + p \longrightarrow e + p + VM \quad ; \quad VM = \rho, J/\psi, ...$$

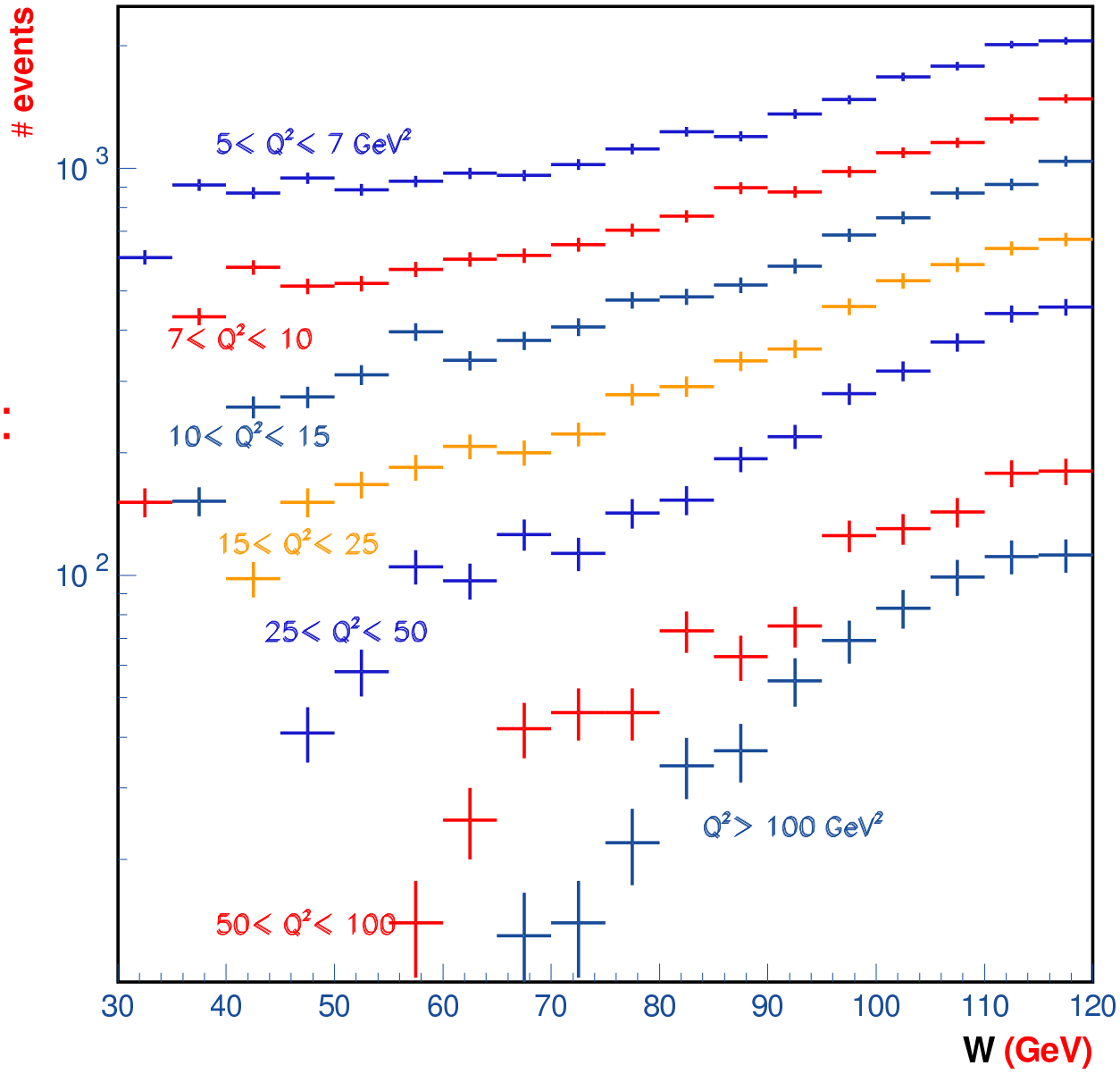
Clean elastic channel selection BUT only low W accessible

DVCS at HERA-II

Without VFPS !

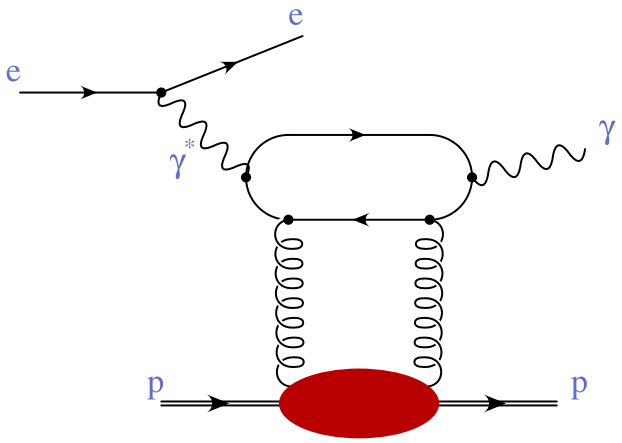
HERA-II high Luminosity:

- Up to 1 fb^{-1} (see plot)
- Polarized e^+ / e^- beam

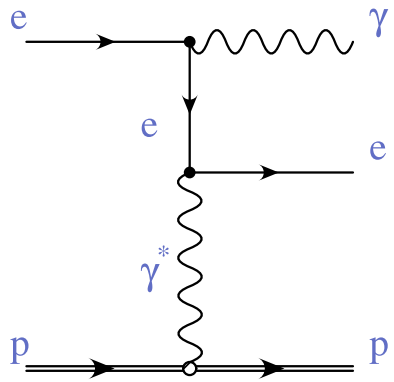


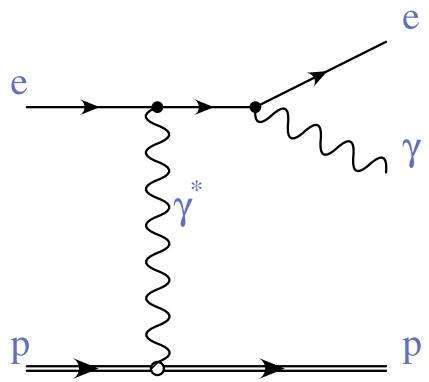
DVCS Asymetries

DVCS



Bethe-Heitler (Background + interference)





$\longrightarrow$ Interference sensitive linearly to GPDs

Helicity Asymetry:

- 2 different helicity e beams:

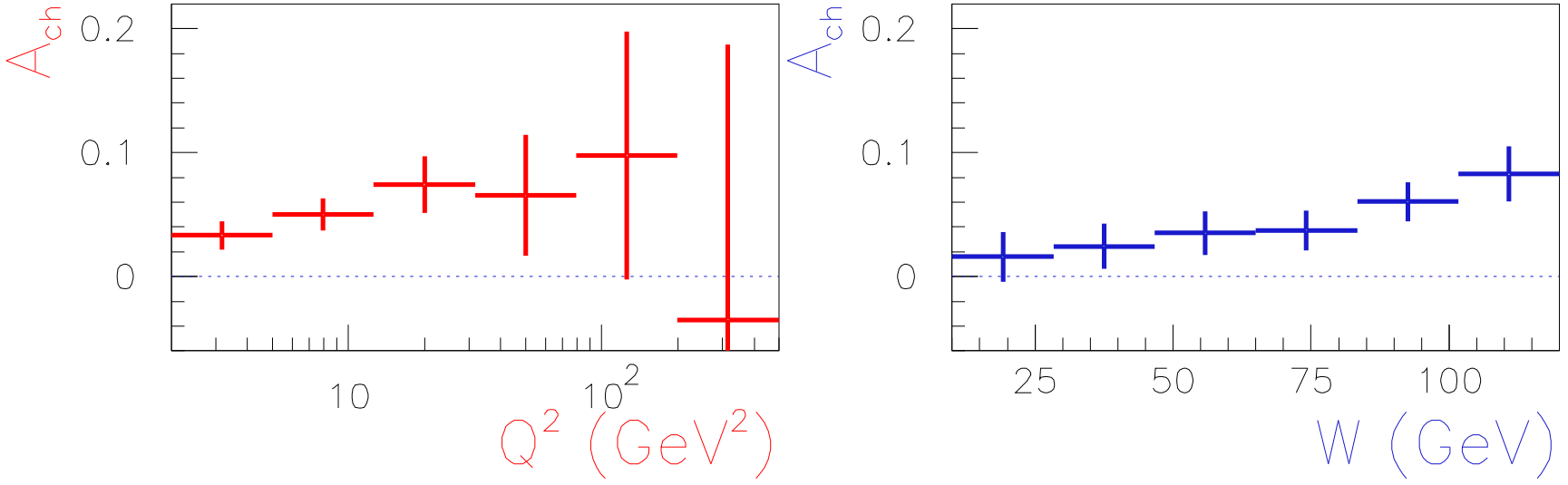
$$\Delta\sigma_{\mathrm{LU}} \sim \sin(\phi)\mathrm{Im}\mathcal{A}_{\mathrm{DVCS}}(\xi,\mathrm{x}=\xi,t,Q^2)$$

- no estimate available

DVCS Asymetries

Charge Asymetry:

- e^+ and e^- beams: $\Delta\sigma_{\rm ch} \sim \cos(\phi){\rm Re}\mathcal{A}_{\rm DVCS}(\xi,\mathrm{x},t,Q^2)$
- H1 detector simulated ($10 < W < 120{\rm GeV}$)
- Lumi assumed: 300 pb^{-1} e^+ and 300 pb^{-1} e^-



CONCLUSION

- VFPS:

  H1 has installed a new proton spectrometer (VFPS) with a large acceptance for low $x_{I\!P}$ and $0 < |t| < 0.5\ \mathrm{GeV}^2$

  $\longrightarrow$ High precision studies of diffraction :

  F_2^D , t Dependence, F_L^D and ϕ Asymmetries

  Final states (di-jets, open charm) + Test of factorization

  DVCS and Vector Meson

- DVCS at HERA-II:
  - much higher statistics
  - asymetry measurements $\longrightarrow$ access to GPDs