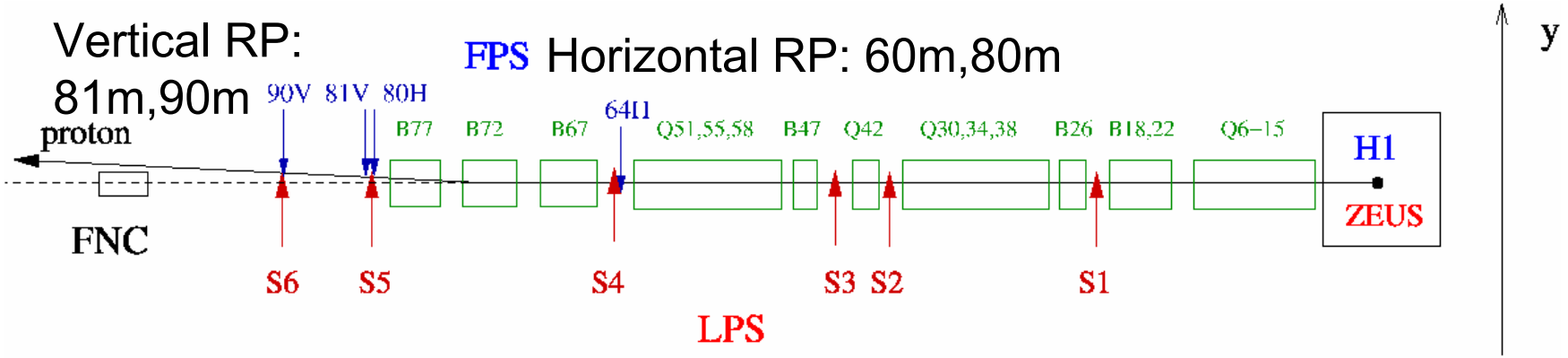
H1 Roman Pots: experience and perspectives

- Recent results: measurement of diffractive DIS with a leading proton (HERA-I)
- Forward Proton Spectrometer at 60-90m: performance in HERA-2
    - luminosity, acceptance
    - momentum reconstruction
    - event statistics
- Very Forward Proton Spectrometer at 220m:
    - luminosity, acceptance
    - event statistics

H1 Roman Pots: method and detectors

- detection of leading proton p' in Forward Proton Spectrometer



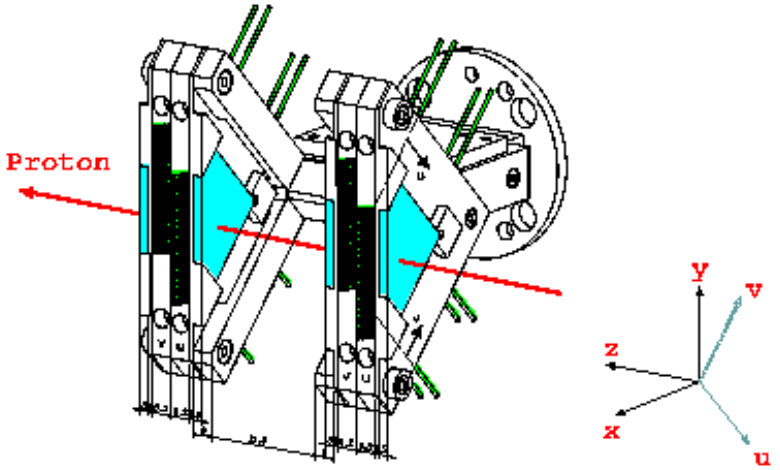
FPS method (Horizontal Roman Pots):

- x_{IP} measurement: $x_{IP} = 1 - E_p'/E_p$
- t-measurement: $t \simeq -p_T^2/(1-x_{IP}) - t_{min}$
- access to high x_{IP} range: $x_{IP}<0.1$

➔better constrain IR contribution

- but low acceptance → low statistics
- free of p-dissociation background: $M_Y = m_p$
- Are FPS and LRG methods compatible?
  LRG / FPS ratio ➔ p-dissociation in LRG data ($M_Y<1.6$ GeV)

H1 Horizontal fiber detectors:



H1 FPS: Test Proton Vertex Factorization

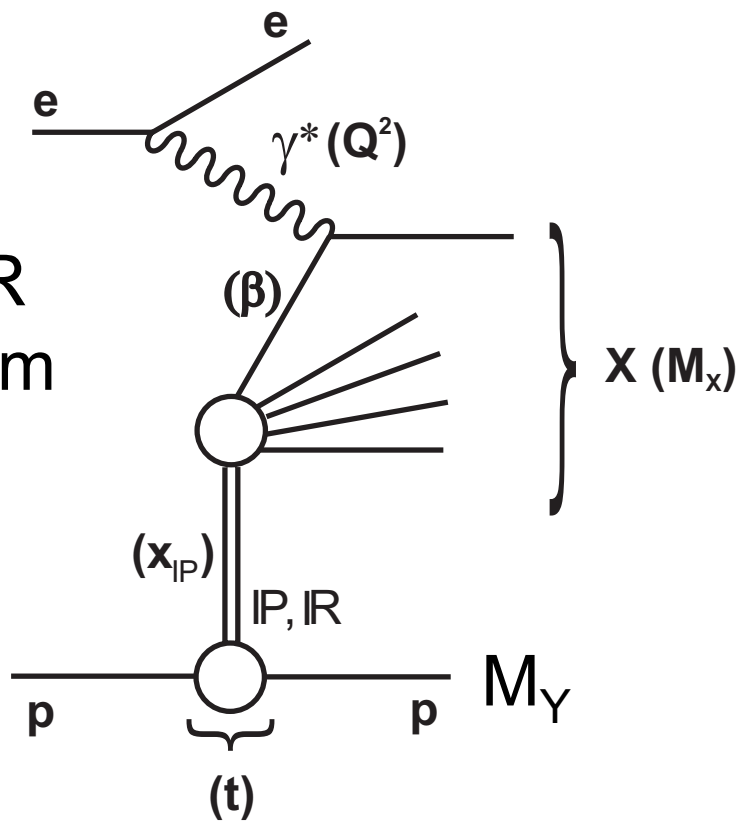
Diffractive Deep Inelastic Scattering with a Leading Proton at HERA → EPJ, C48(2006) 749, hep-ex/0606003

Proton vertex factorization of β, Q^2 from x_{IP}, t and M_Y dependences

$$f_i^{D}(x, Q^2, x_{IP}, t) = f_{IP/p}(x_{IP}, t) \cdot f_i^{IP}(\beta = x / x_{IP}, Q^2)$$

IP flux | IP PDF

+IR term



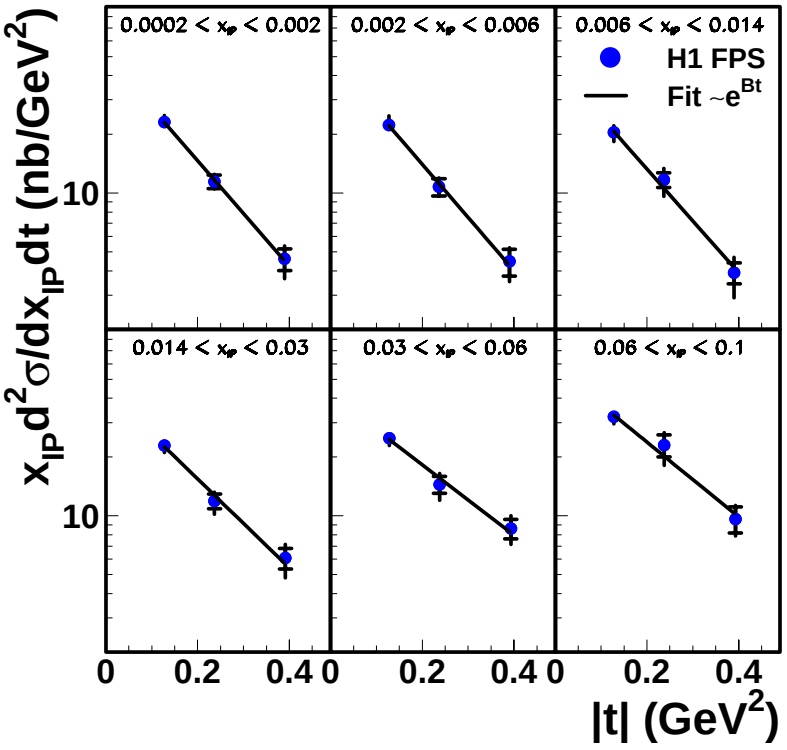
IP flux independent on β, Q^2

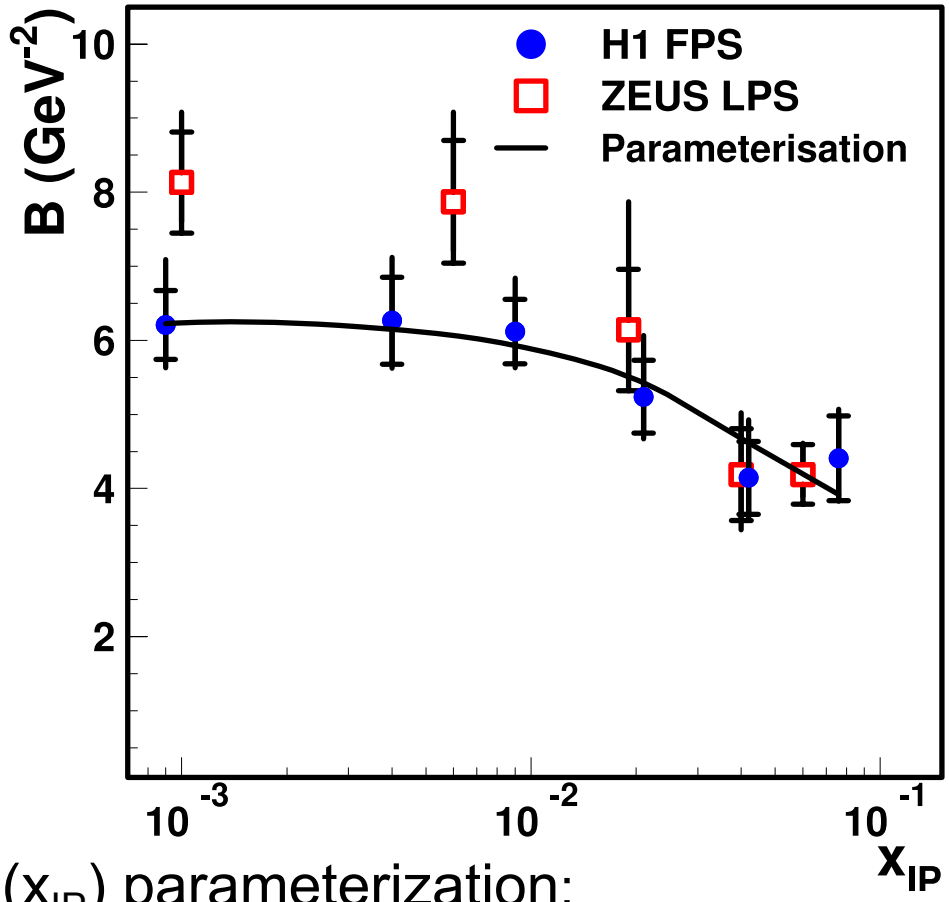
FPS ➔ is x_{IP}, t dependence of diffractive cross section universal for different β, Q^2 ?

LRG vs FPS ➔ is β, Q^2 dependence universal for M_Y<1.6 GeV and Y=p ?

H1 FPS: t-dependence in bins of x_{IP} (DIS)

Fit to *exp(Bt)* in bins of x_{IP}





B(x_{IP}) parameterization:

$$B_{IP,IR}(x_{IP}) = b_{IP,IR} + 2\alpha'_{IP,IR}\ln(1/x_{IP})$$

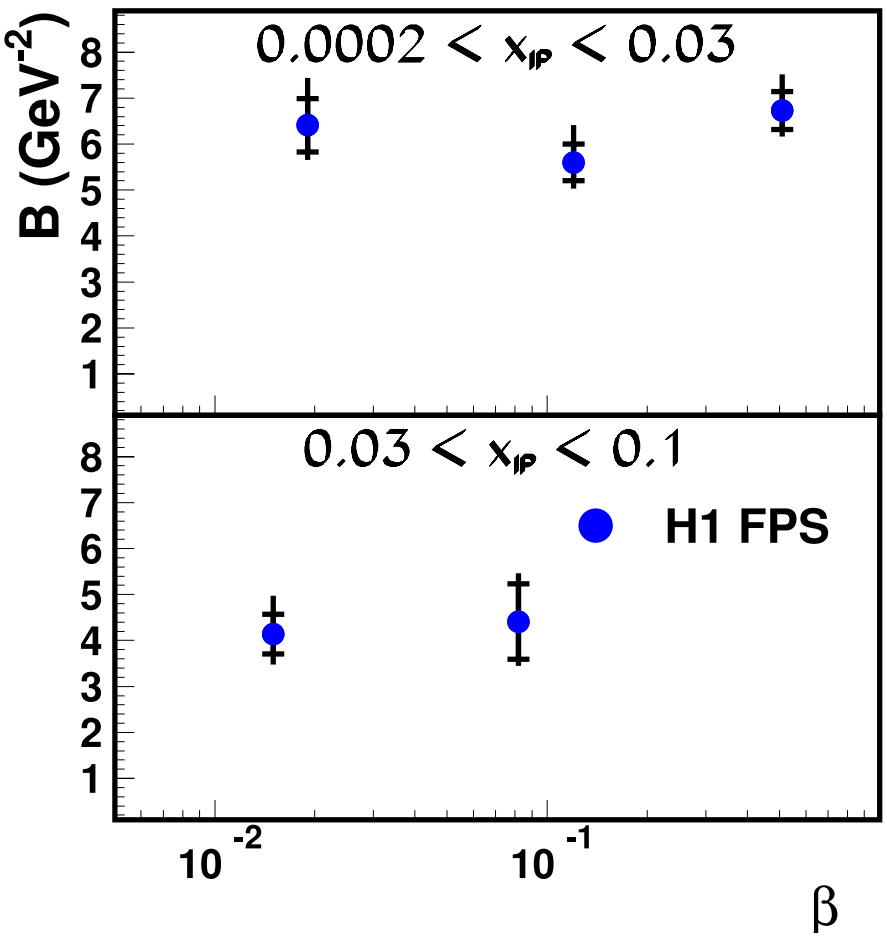
$$f_{IP,IR}(x_{IP},t) = \exp(B_{IP,IR}t)\Big/ x_{IP}^{\,2\alpha_{IP,IR}(t)-1}$$

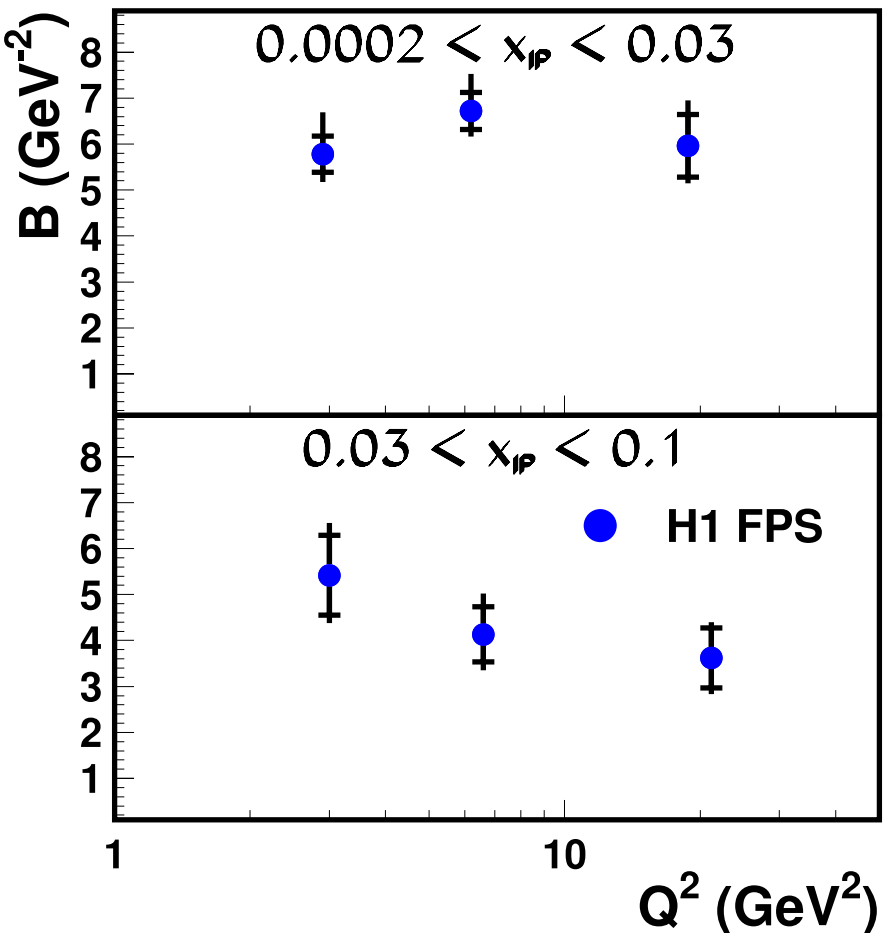
$$\alpha_{IP,IR}(t) = \alpha_{IP,IR}(0) + \alpha'_{IP,IR}\,t$$

$$b_{IP} = 5.5 \mp^{0.7}_{2.0}\ GeV^{-2} \qquad \alpha'_{IP} = 0.06 \pm^{0.19}_{0.06}\ GeV^{-2}$$

$$b_{IR} = 1.6 \mp^{1.6}_{0.4}\ GeV^{-2} \qquad \alpha'_{IR} = 0.3 \pm^{0.6}_{0.3}\ GeV^{-2}$$

H1 FPS: t-slope dependence on β, Q^2





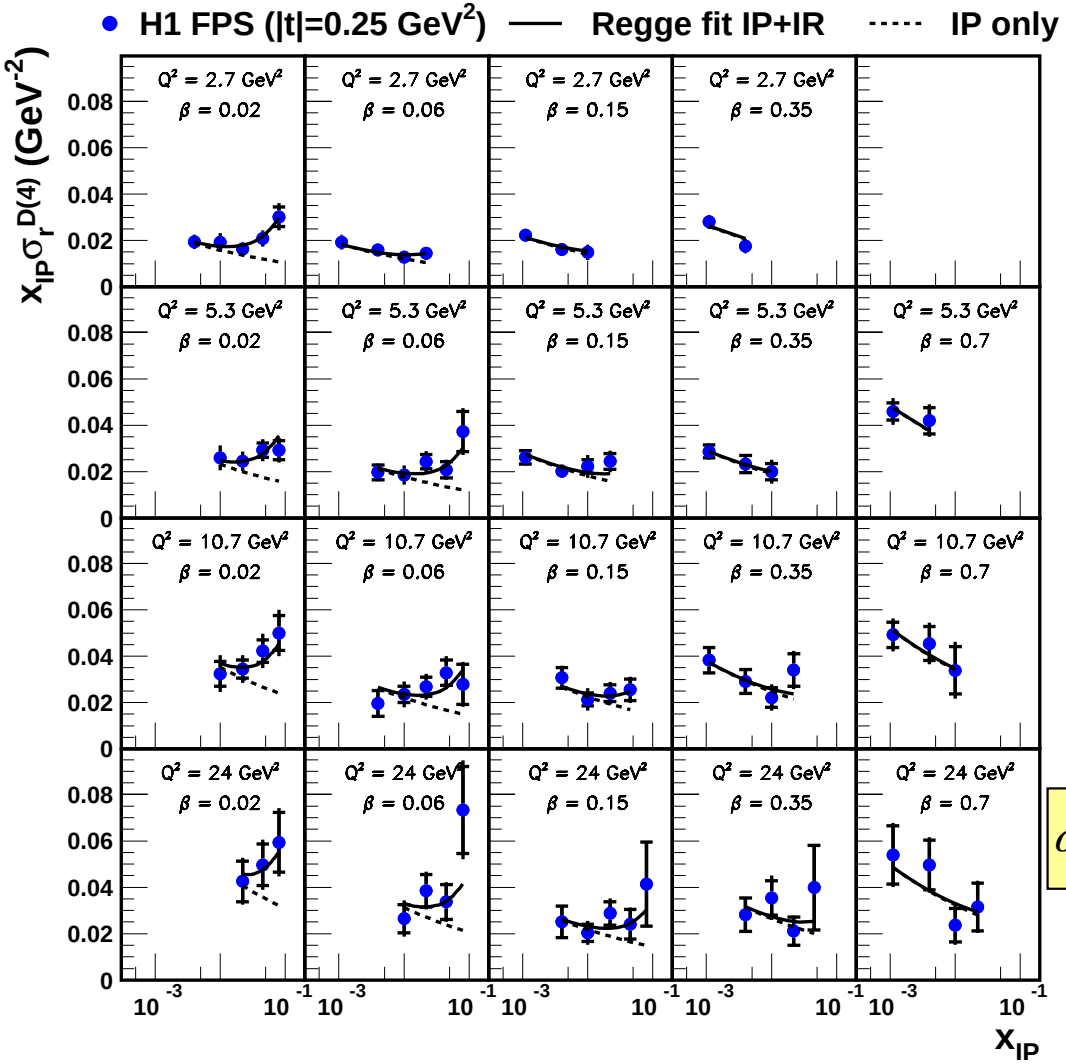
- t-slope measured double differentially as a function of (β or Q^2) and x_{IP}

➔ no dependence on β or Q^2 within the errors

➔ consistent with Proton Vertex Factorization for t-dependence

H1 FPS: $F_2^{D(4)}$ measurement

$2.7<Q^2<24$ GeV^2



- $F_2^{D(4)}(t,x_{IP},\beta,Q^2)$ measurement at $t=-0.25$ GeV^2
- Regge motivated fit to extract $\alpha_{IP}(0)$:
- t-dependence for IP and IR from $B=f(x_{IP})$ parameterization
- IR → PDF(π) Owens
- $\alpha_{IP}(0)$, $A_{IP}(\beta,Q^2)$, N_{IR} – free parameters

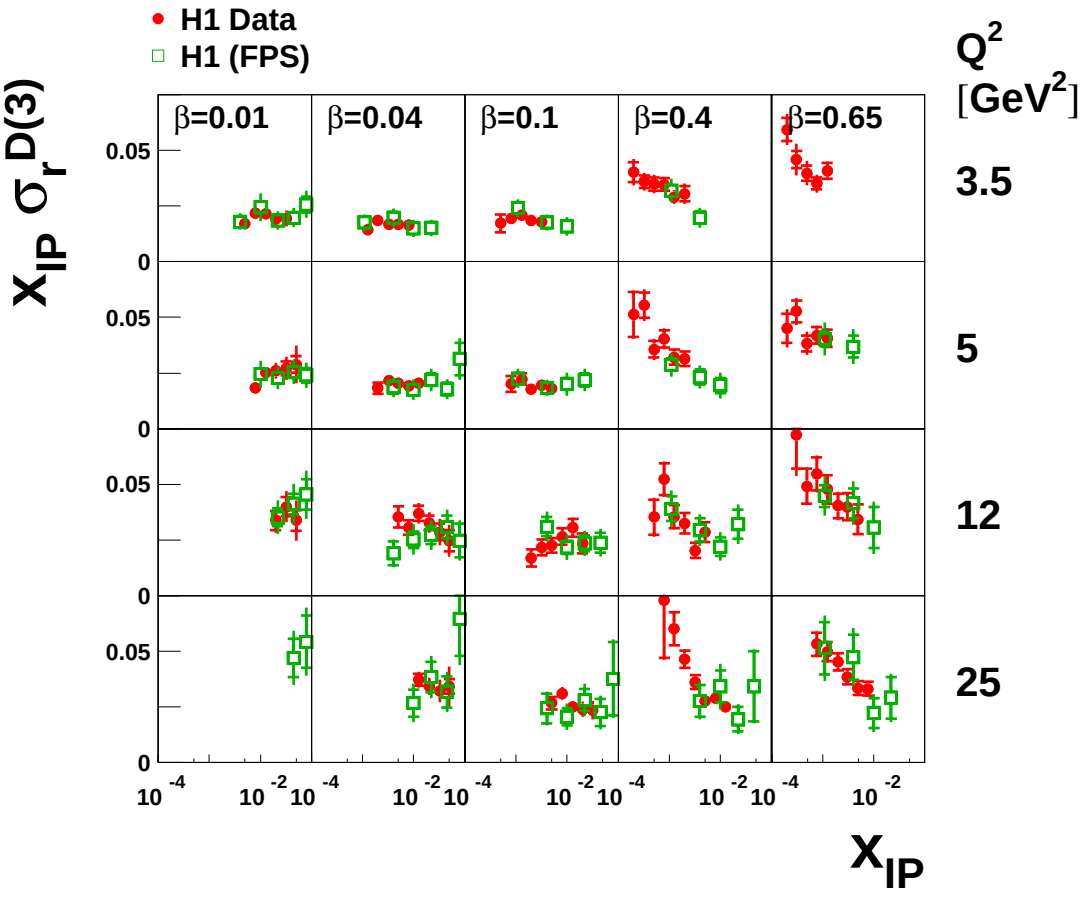
$$A_{IP}(\beta,Q^2)\cdot f_{IP}(x_{IP},t)+N_{IR}\cdot PDF_{IR}(\beta,Q^2)\cdot f_{IR}(x_{IP},t)$$

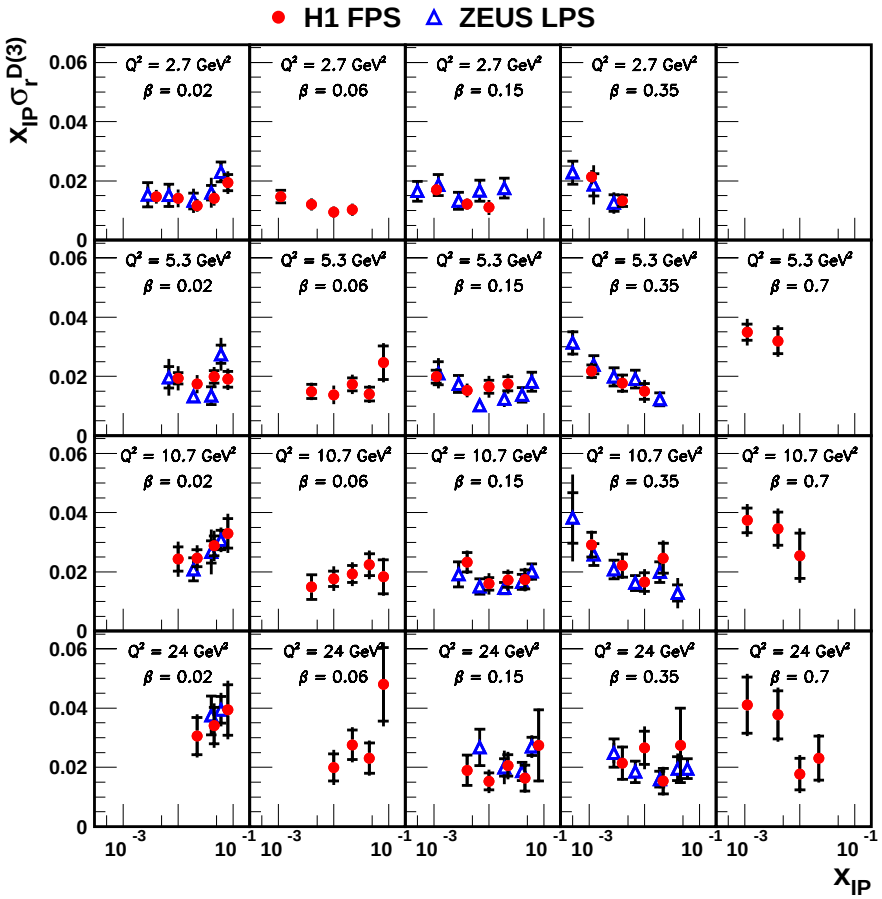
$$\alpha_{IP}(0)=1.114\pm0.018(stat.)\pm0.012(syst.)^{+0.040}_{-0.020}(theory)$$

Consistent with H1 LRG measurement:

$$\alpha_{IP}(0)=1.118\pm0.008(\exp.)^{+0.029}_{-0.010}(theory)$$

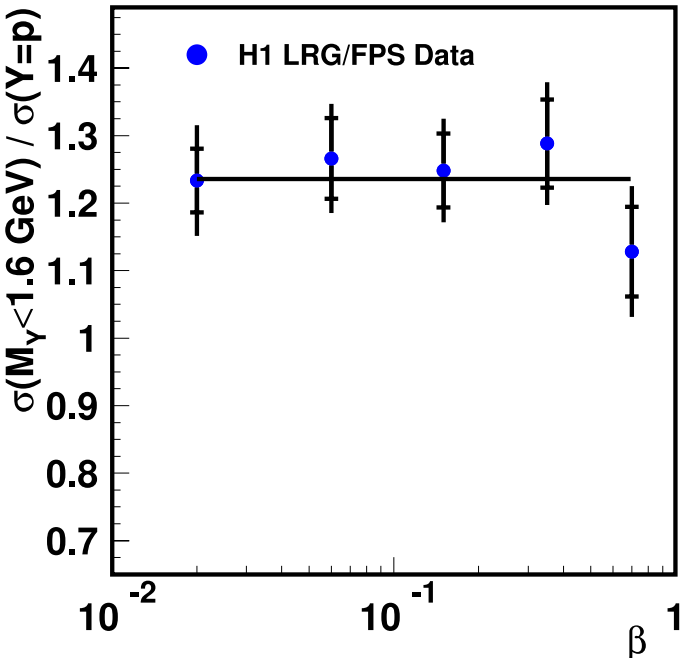
Comparison of H1 LRG, H1 FPS and ZEUS LPS

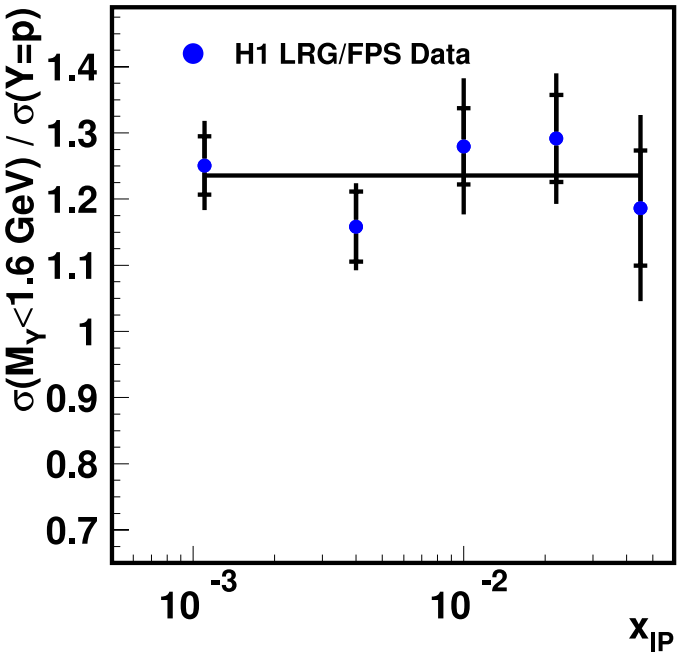


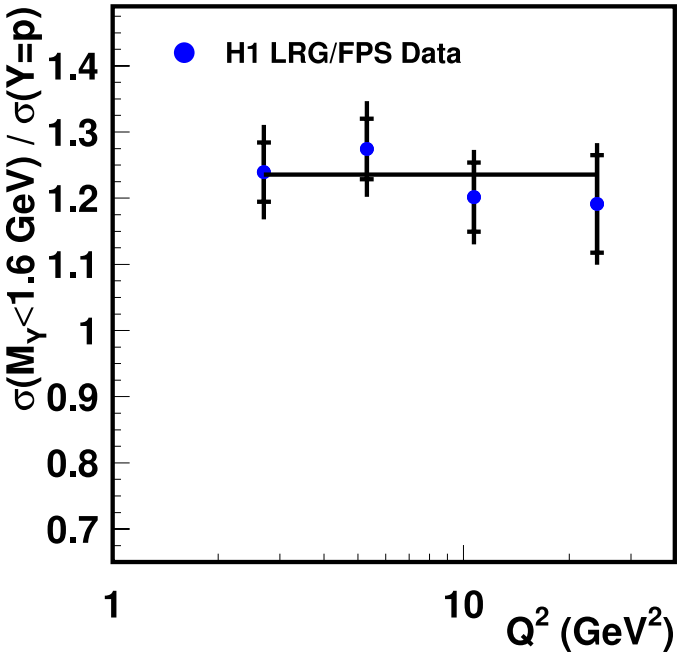


- H1 FPS and ZEUS LPS agree in normalization to 8%
- Good agreement between leading proton and LRG methods after accounting for proton dissociation

Comparison LRG vs FPS cross sections





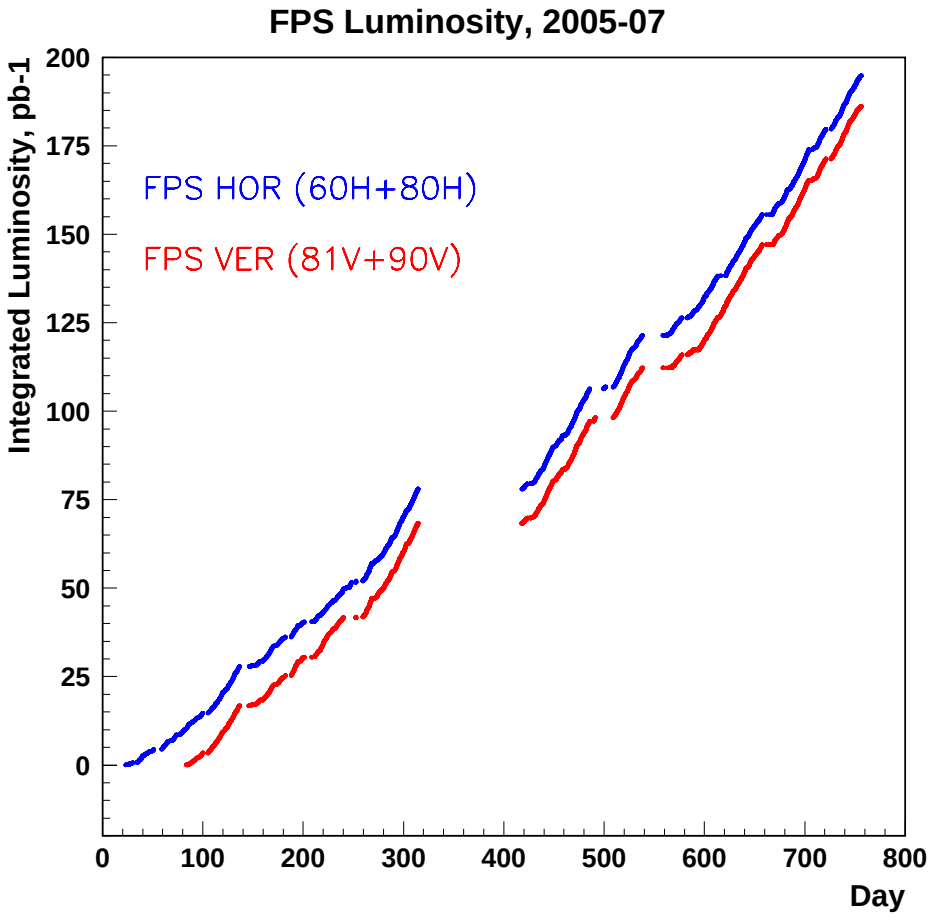


• Ratio of cross sections as a function of β, Q^2, x_{IP} after integration over others

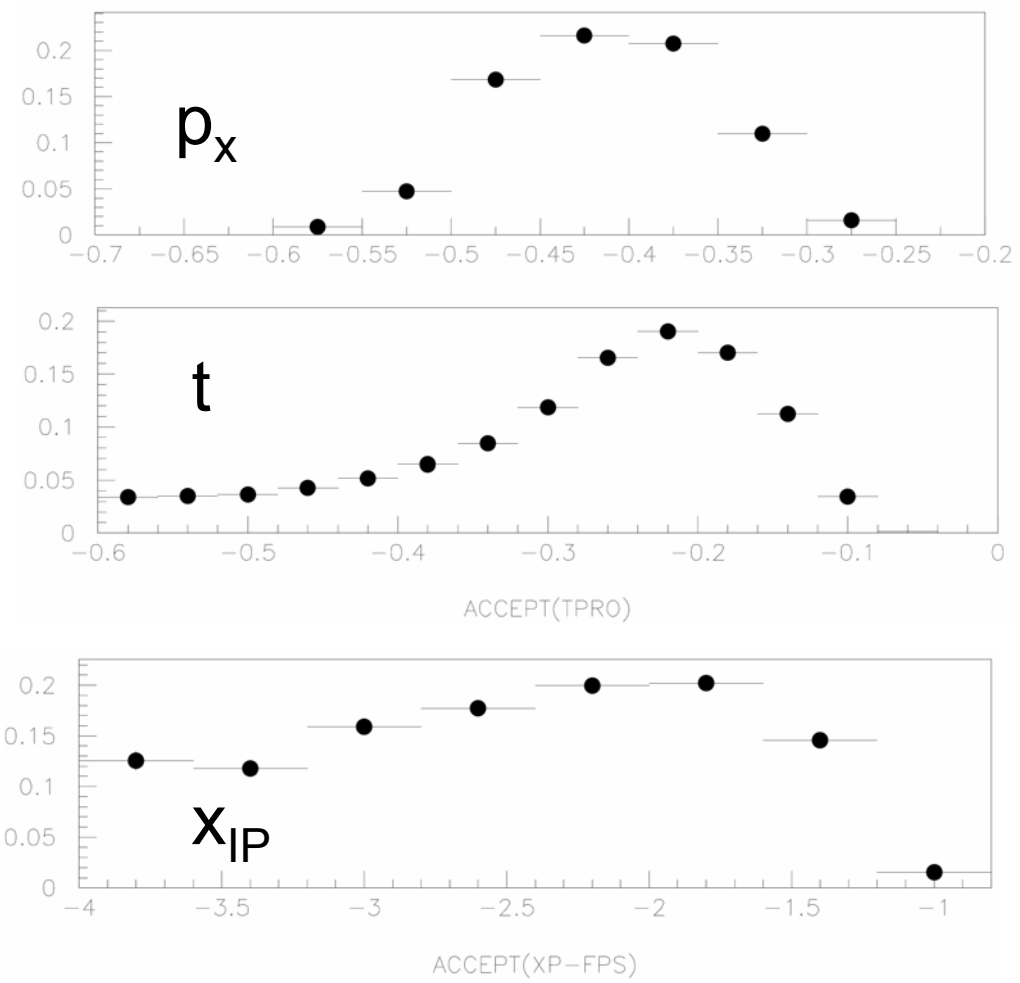
$$\frac{\sigma(M_Y < 1.6GeV)}{\sigma(Y = p)} = 1.23 \pm 0.03(stat.) \pm 0.16(syst.)$$

➔ M_Y dependence factorize within 10% non-normalization errors

HERA-2: FPS Luminosity / Acceptance



Horizontal FPS acceptance in HERA-2:

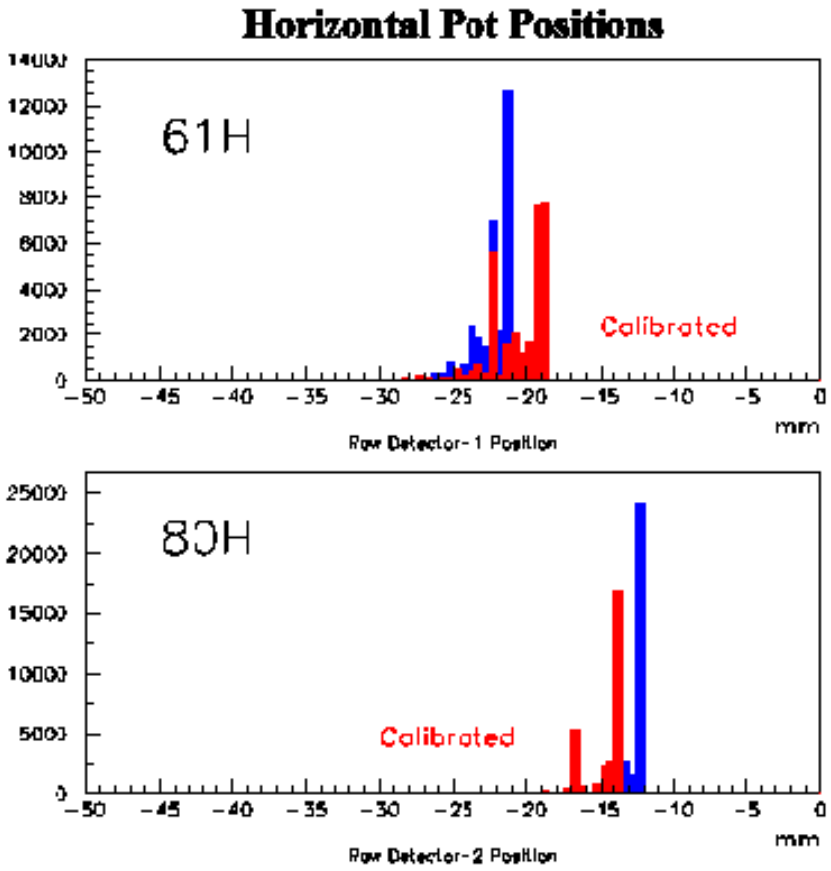


Horizontal Roman Pots (x_{IP}<0.1): ~200 pb^{-1}

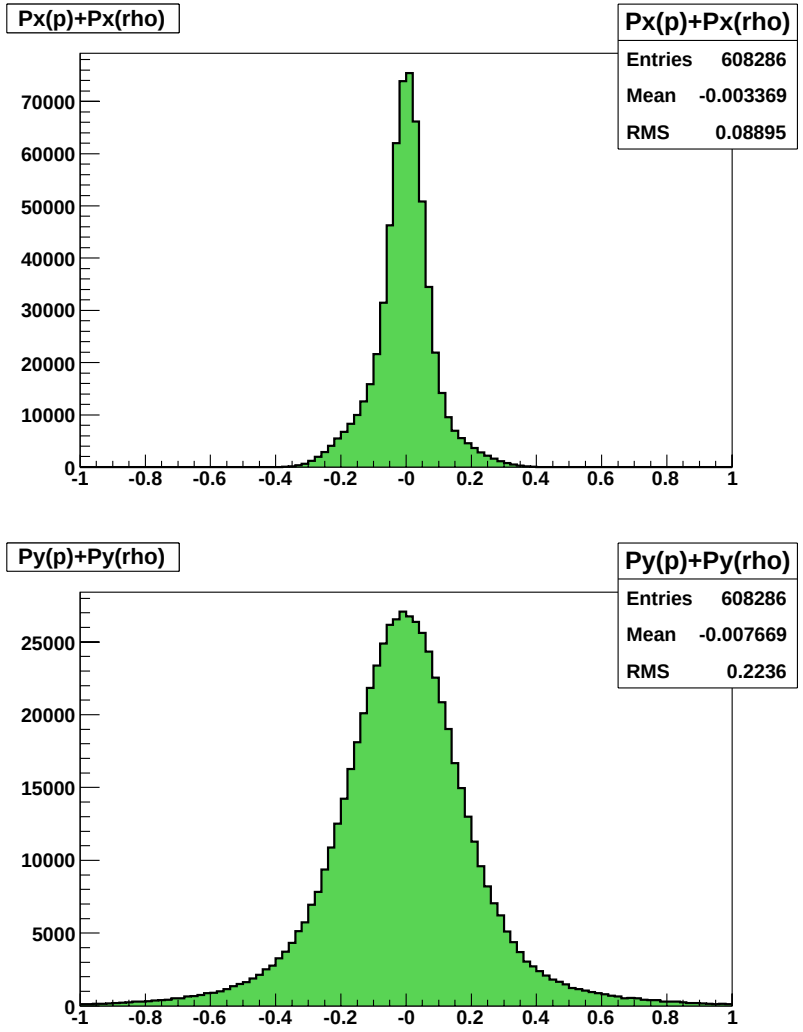
Vertical Roman Pots (0.1<x_{IP}<0.3): ~190 pb^{-1}

H1 FPS: Horizontal Pot position alignment

- based on elastic ρ photo-production events p γ → p ρ → p π^+ π^-
- beam line optics and detector positions & survey

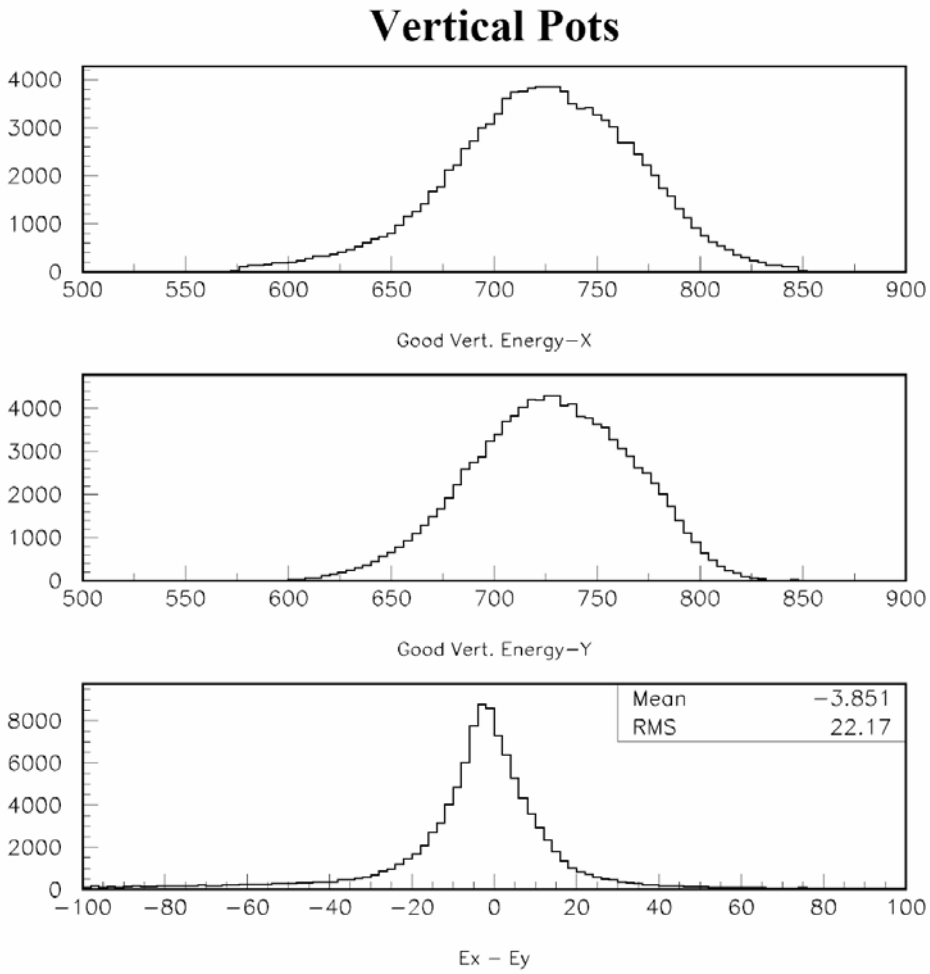


- p_T balance between leading proton and ρ-meson in agreement with p-beam spread



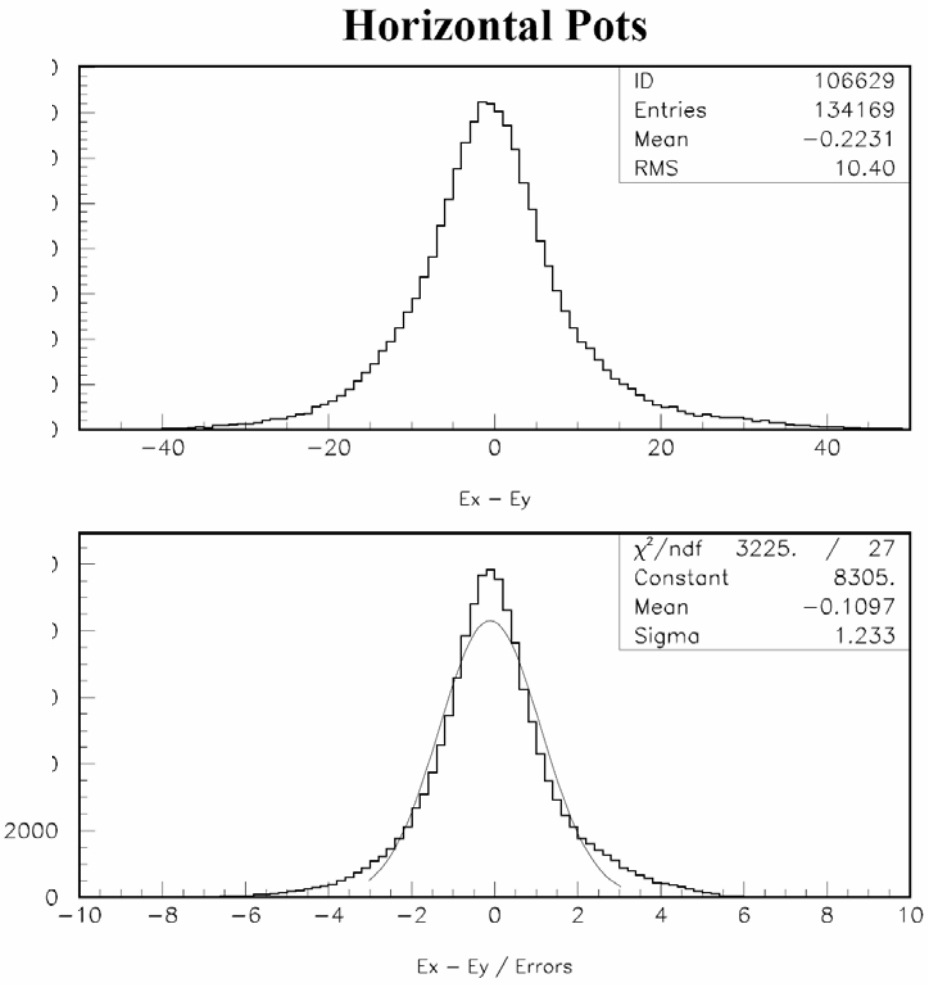
Distance to proton orbit: 60H ~ 20 mm, 80H ~ 15 mm

H1 FPS: Momentum reconstruction

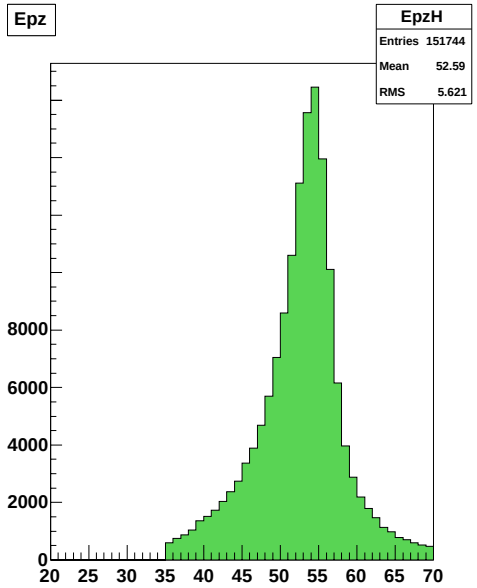


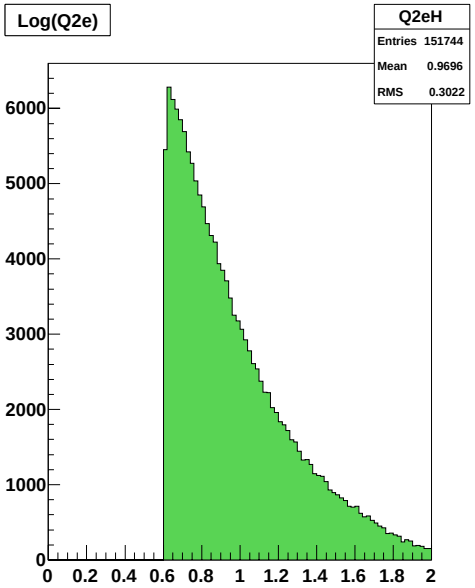
Vertical Roman Pots: kinematical method → larger systematical errors

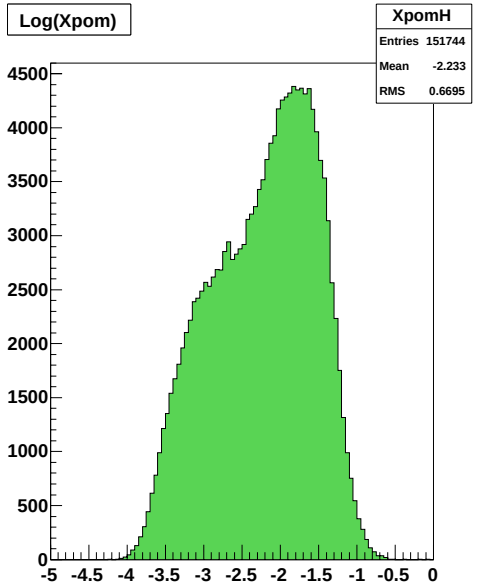
- cross check with energy measurement in X and Y projections

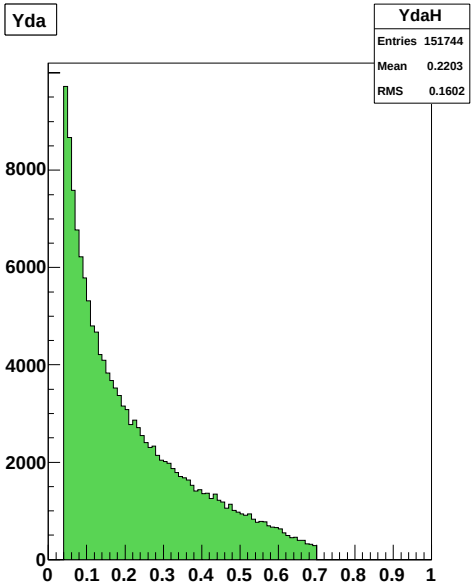


DIS with proton in Horizontal FPS









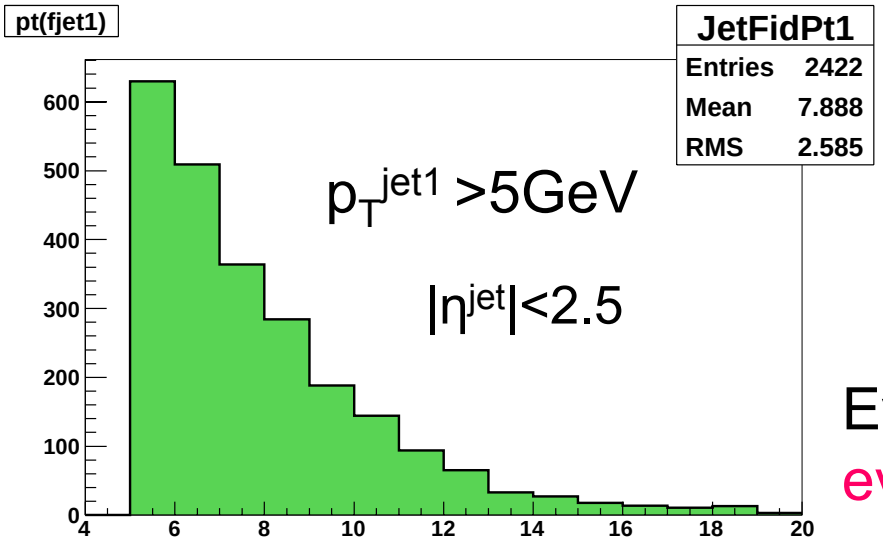
DIS event selection:

- $Q^2>4$ GeV^2, $0.04<y<0.7$
- leading proton in Horizontal FPS ($x_{IP}<0.1$)

Event statistics (2005-January 2007): ~150.000 DIS events

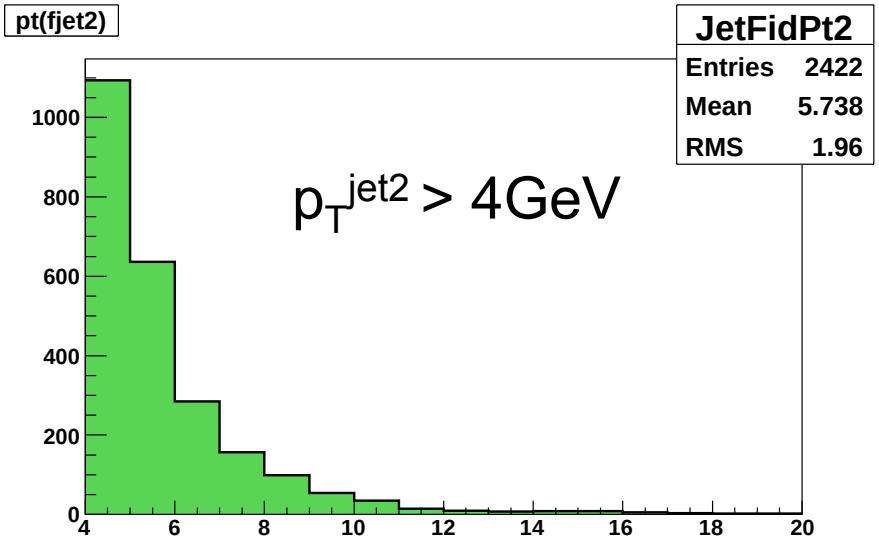
Statistics comparable with HERA-I H1 LRG data

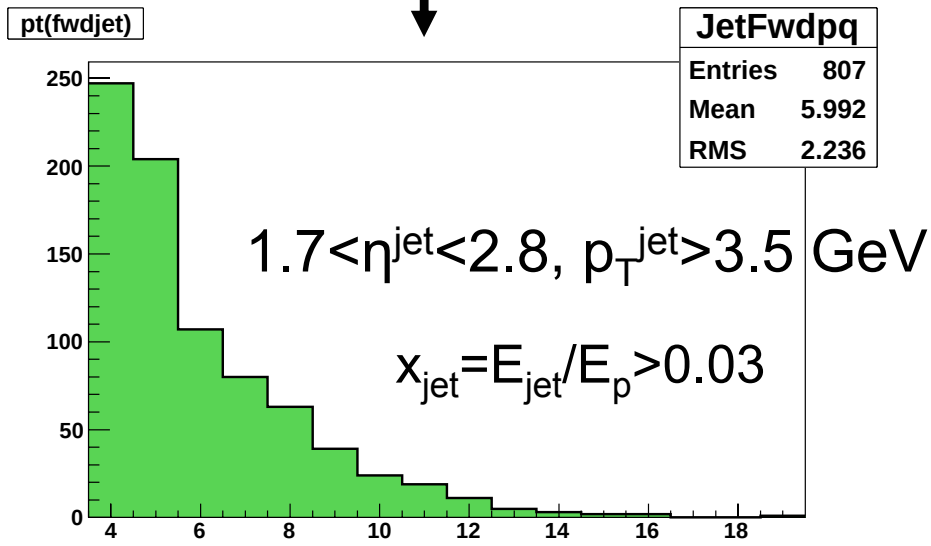
Dijet DIS with proton in Horizontal FPS



leading proton in Horizontal FPS (x_{IP}<0.1)

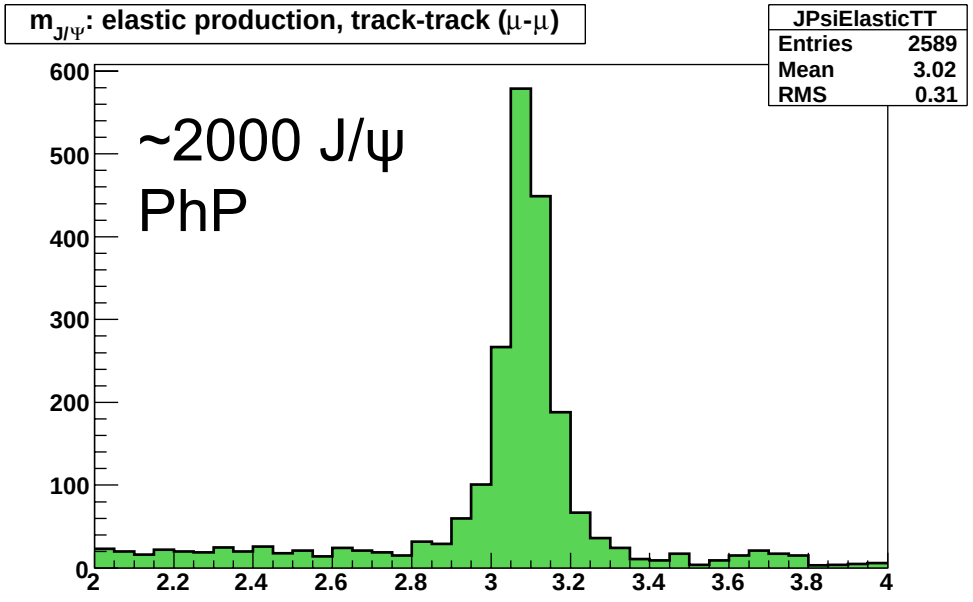
Event statistics ~800 Forward jet DIS events sufficient for forward jet analysis

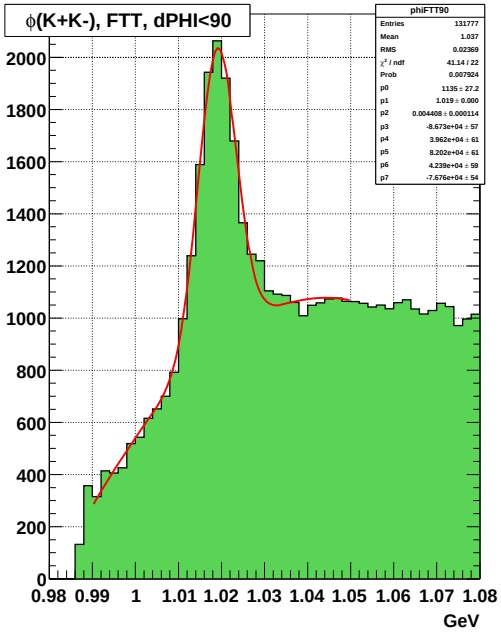




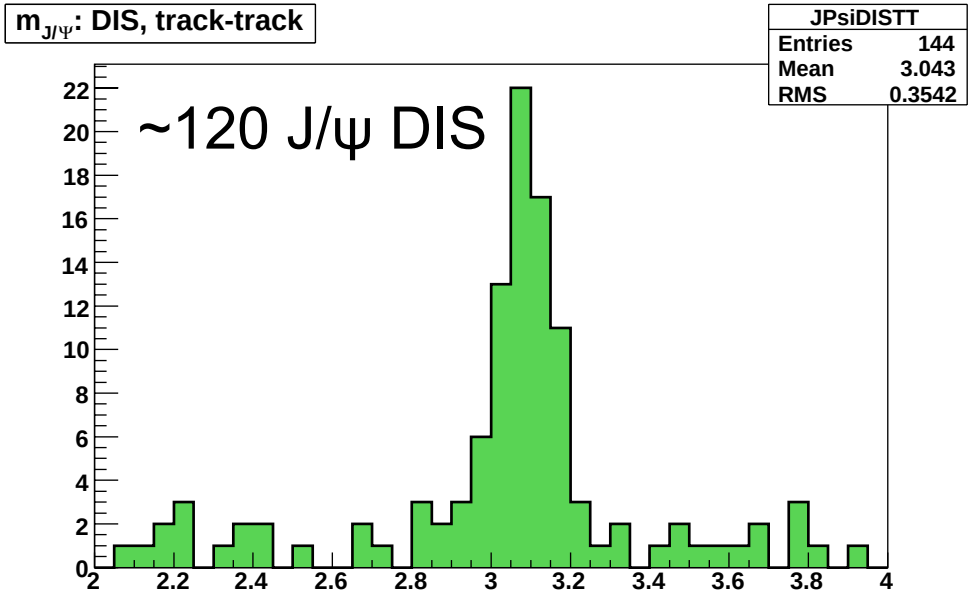
Event statistics ~2400 Dijet DIS events comparable with HERA-I LRG data

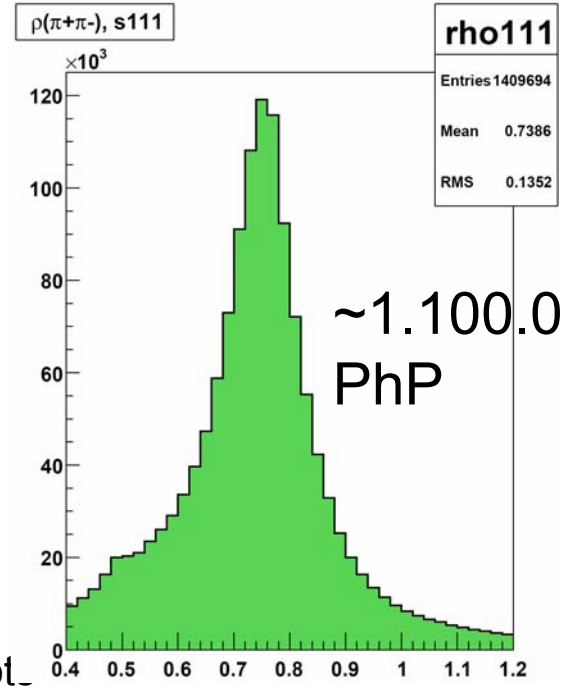
VM production with proton in Horizontal FPS





~9000 φ
PhP





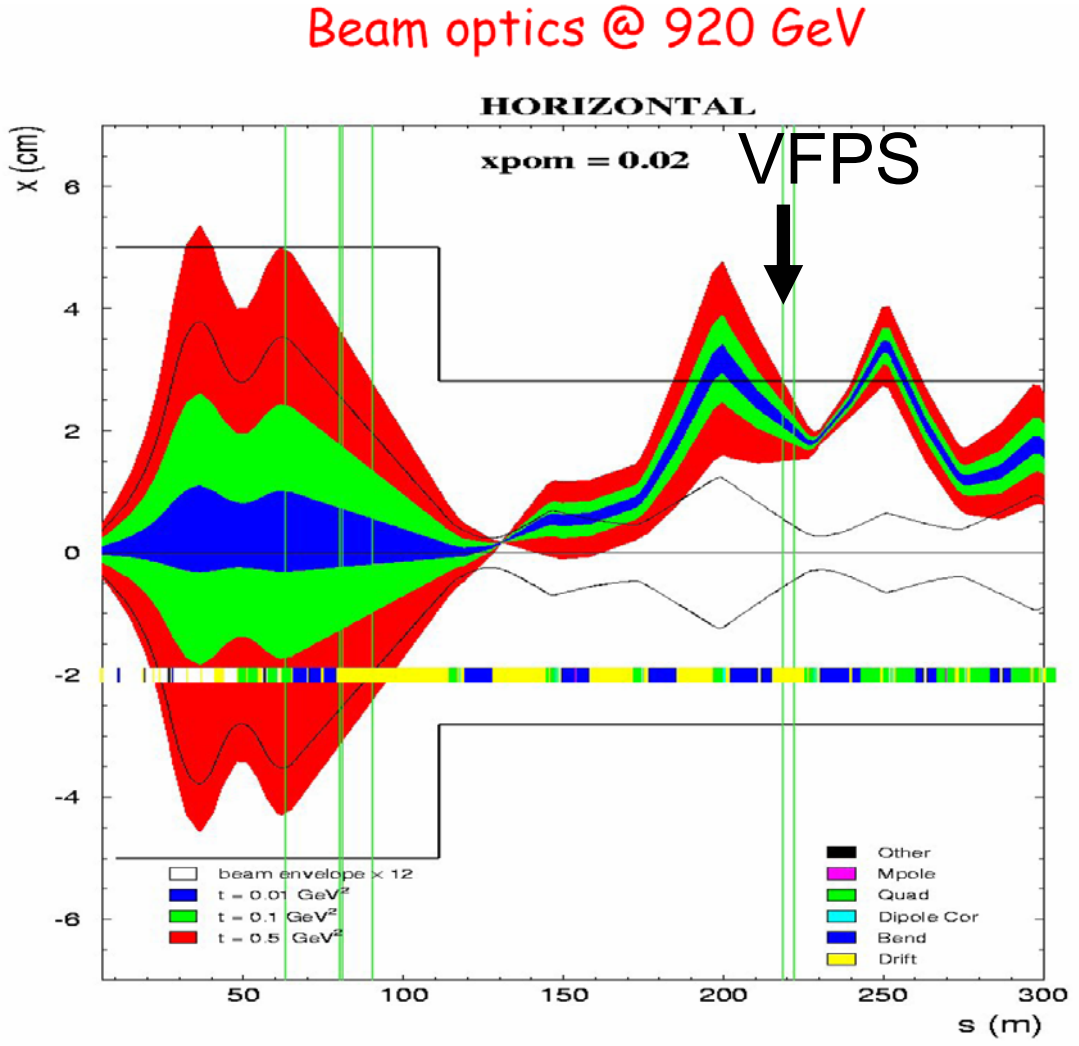
~1.100.000 ρ
PhP

HERA-2: H1 FPS event statistics

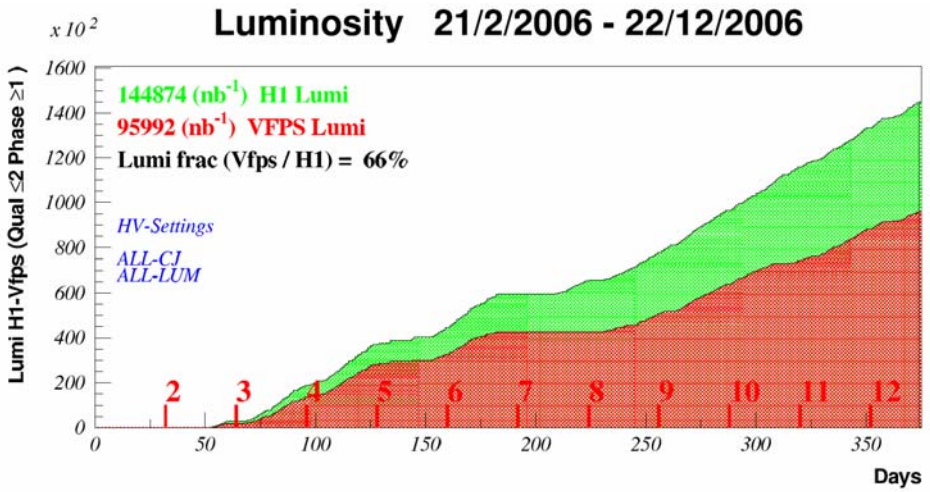
	Incl DIS: $F_2^{D(4)}$, $d^2\sigma/dtdx_{IP}$	DIS: Dijets / Fwd Jets	D* all / DIS	J/ψ php / DIS	φ php / ρ php
Hor FPS $x_{IP}<0.1$	150.000	2.400 / 800	120 / 40	2000 / 120	9000 / 1.100.000
Vert FPS $0.1<x_{IP}<0.3$	220.000	6.400 / 2.200	240 / 80	700 /	

FPS statistics is comparable with LRG HERA-I data

Very Forward Proton Spectrometer at 220m



VFPS status: Luminosity and Acceptance



VFPS Luminosity:

2005: 32 pb^{-1}

2006: 96 pb^{-1}

2007: 20 pb^{-1}

Total: 145 pb^{-1}

VFPS operation efficiency: ~70%

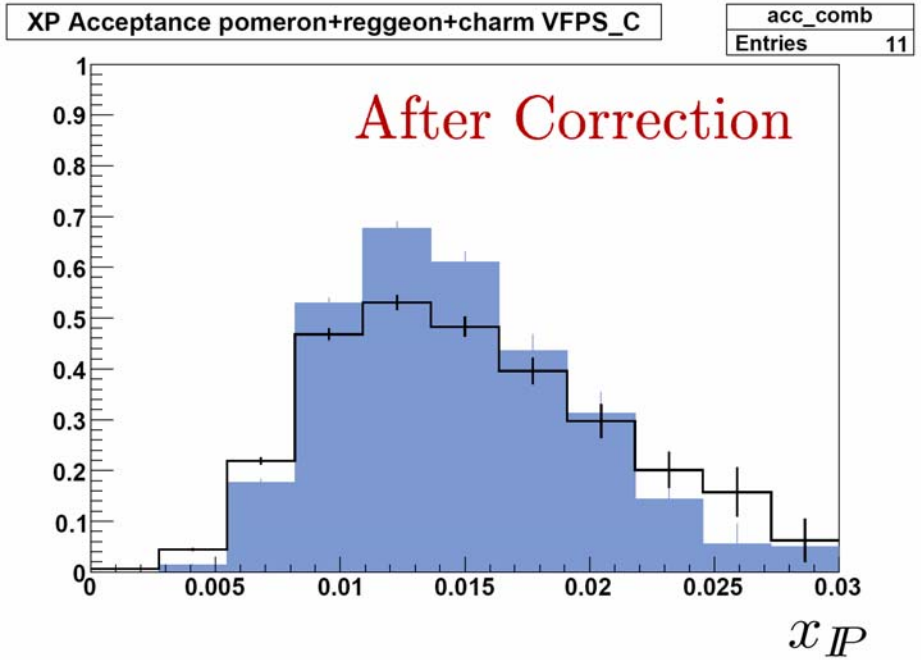
VFPS acceptance:

- LRG data with η_{max}<2.5 and proton tagged in VFPS
- correction for measured Pot positions

To do: Pot position alignment

using kinematical method:

$1 - E'_p(VFPS) / E_p = x_{IP}(LRG)$



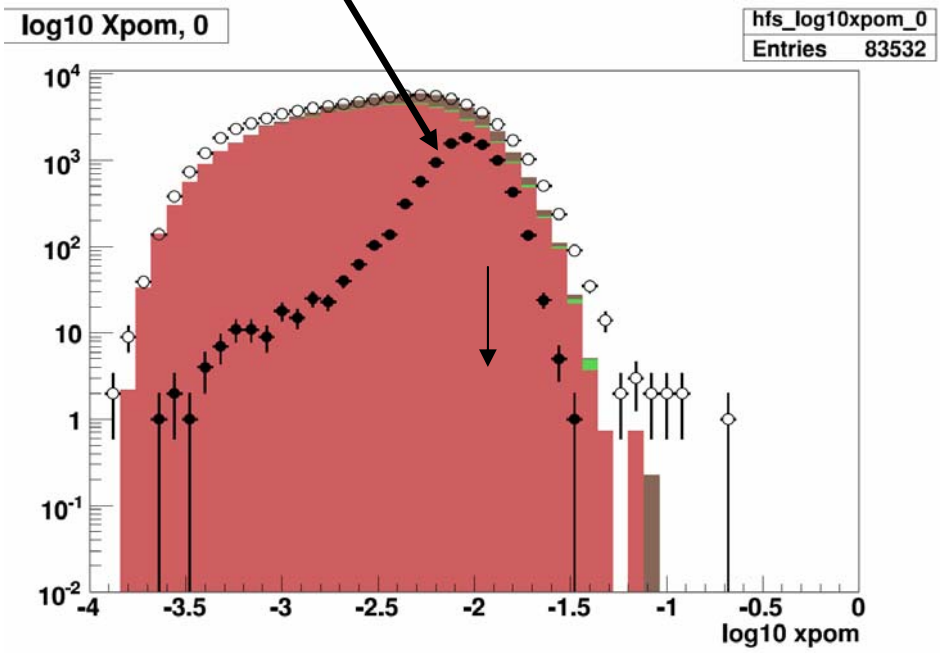
VFPS acceptance: $0.005<x_{IP}<0.025$

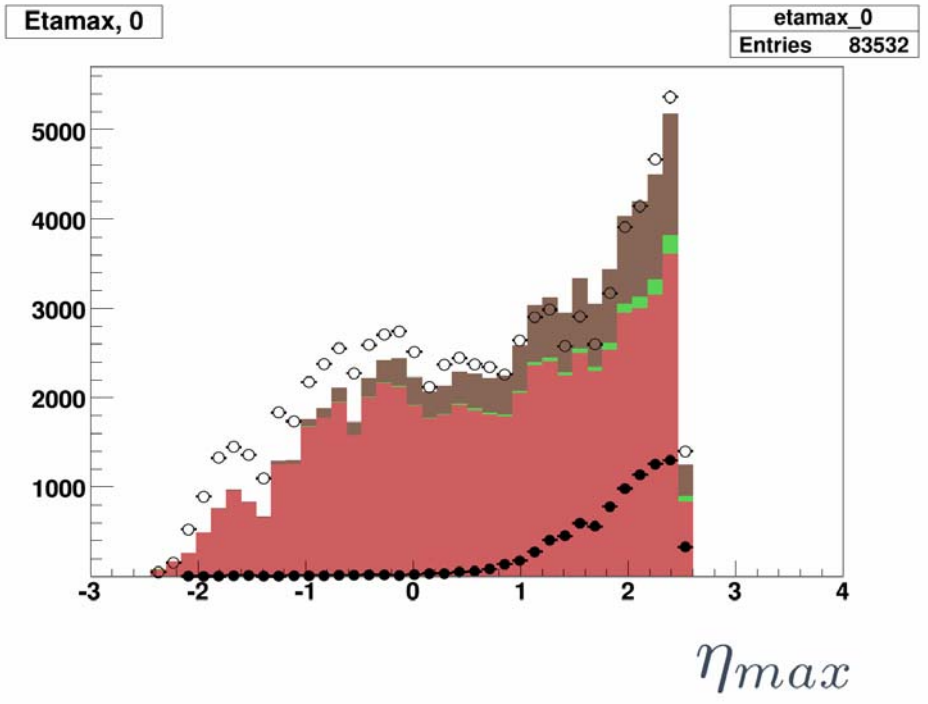
Diffractive DIS with proton tagged in VFPS

Inclusive diffractive DIS: $Q^2>10GeV^2, \eta_{max}<2.5$
~600.000 events with proton tagged in VFPS

Plans:
- $F_2^{D(3)}$ with tagged p
- $F_2^{D(4)}$ with measured p kinematics (need Pot position alignment)

events tagged in VFPS





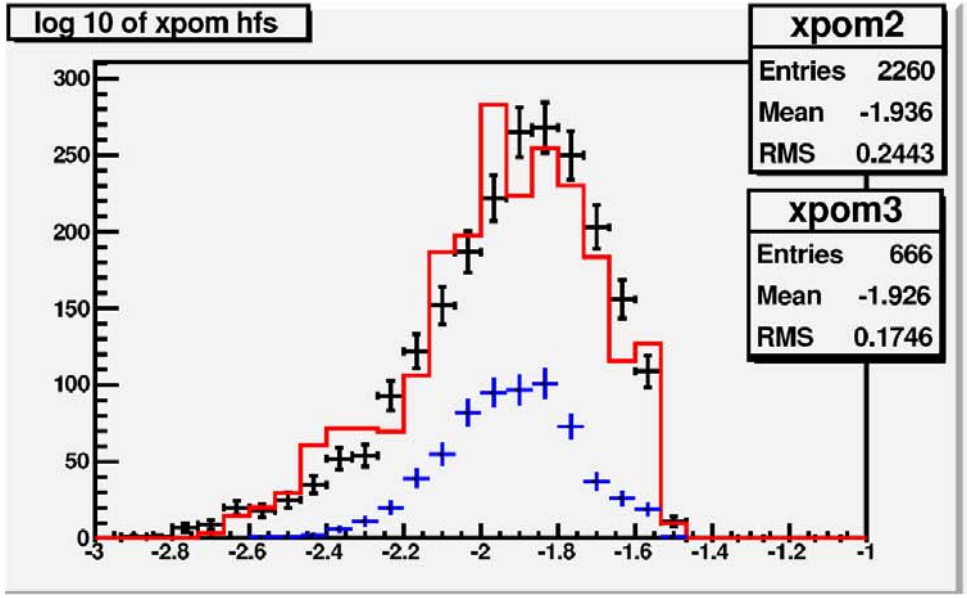
VFPS: $0.005<x_{IP}<0.025$ $\log_{10} x_{I\!P}$

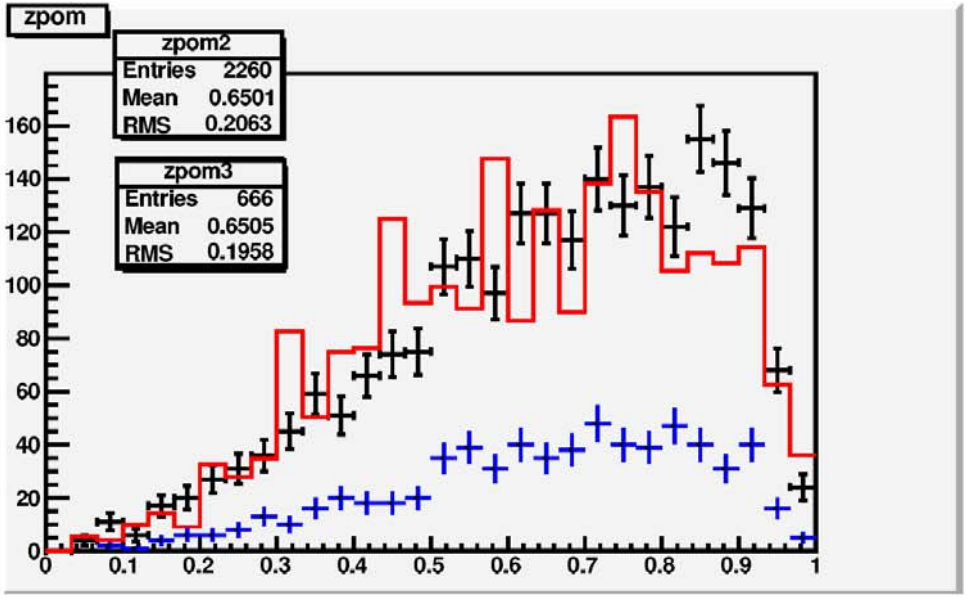
Diffractive Dijets in DIS and PhP with VFPS

$p^*_{T,1}>5.5$GeV, $p^*_{T,2}>4$ GeV, $-1<\eta_{j1,j2}<2$, $\eta_{max}<2.5$

~1000 diffractive Dijet events in DIS with proton tagged in VFPS

~6000 diffractive Dijet events in photo-production with VFPS





Plans:

- Dijets in DIS: QCD factorization tests, extract gluon PDF
- Dijets in PhP: test factorization breaking: is t-slope different from DIS?

DVCS with proton tagged in VFPS

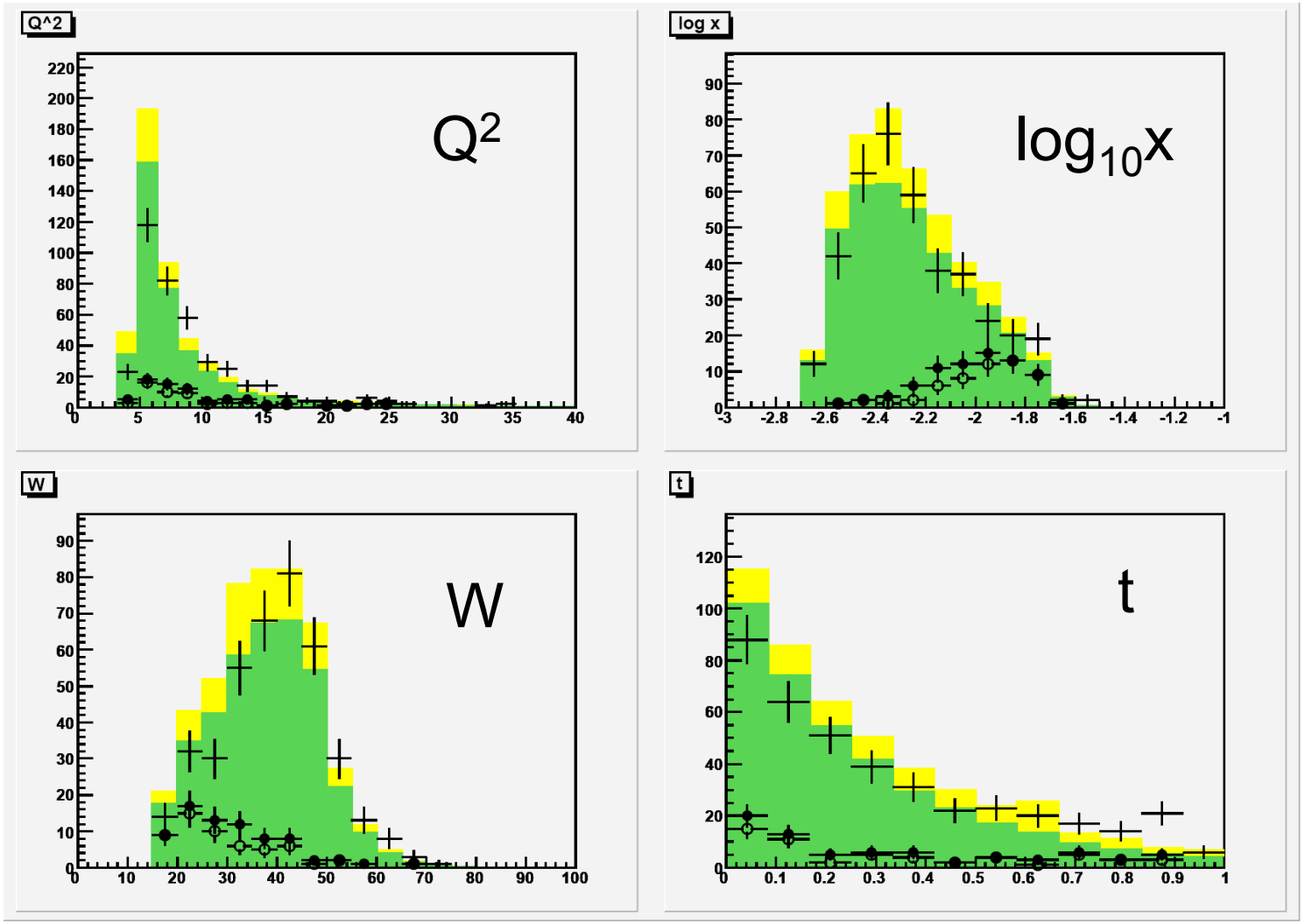
- Higher VFPS acceptance at large x / low W as expected
- DVCS with VFPS: ~150 events

Kin.range:

$Q^2>4.5$ GeV^2

W>15GeV

$|t|<1$GeV^2

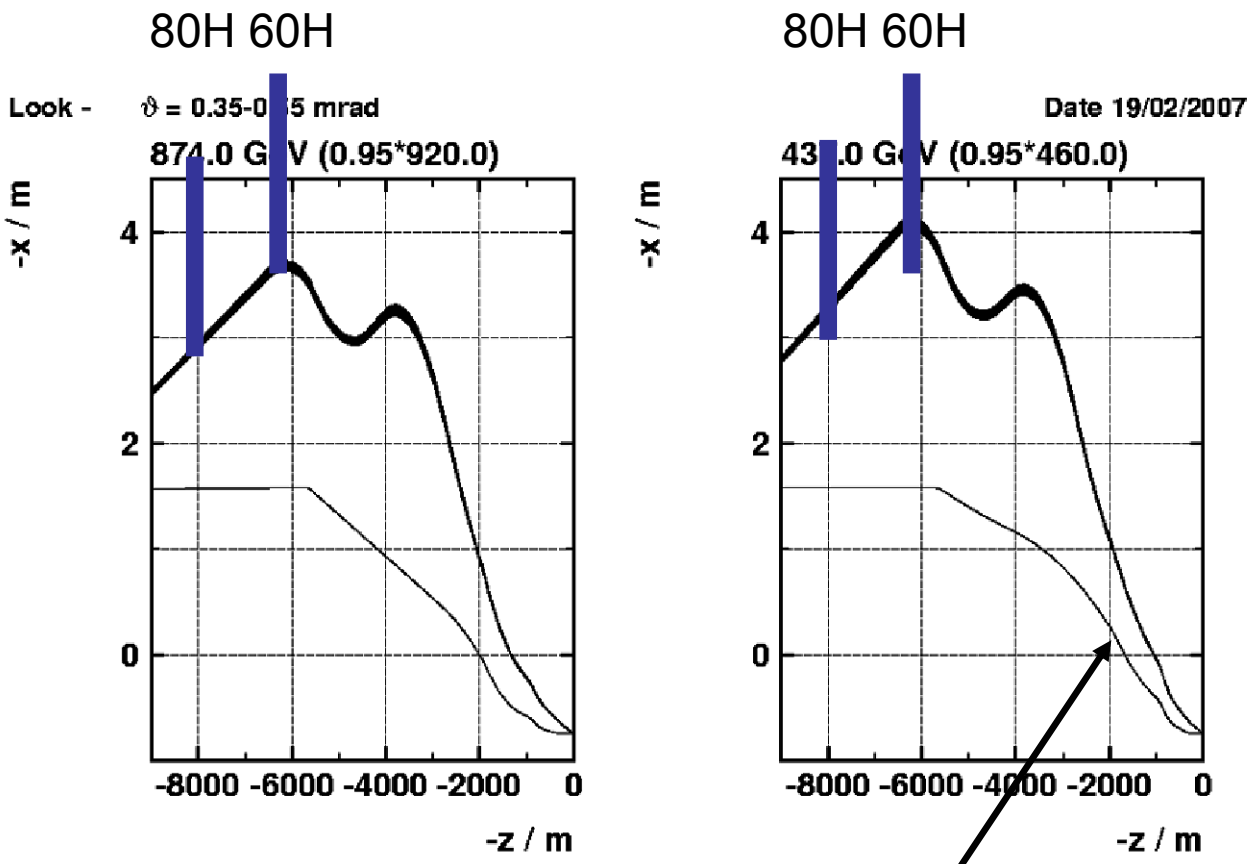


H1 Roman Pots: Summary

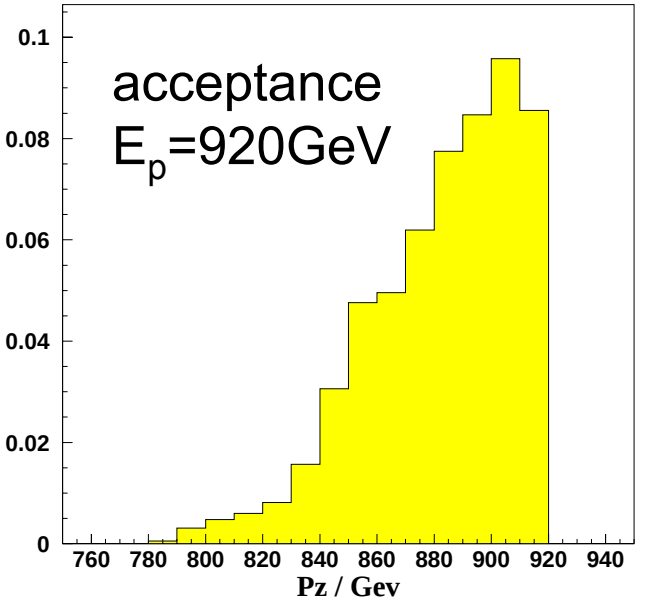
- Measurement of diffractive DIS with leading proton in FPS (HERA-I)
  - t-slope of differential cross section is ~6 GeV^{-2} at low x_{IP}<0.01 and decreases to ~4 GeV^{-2} at high x_{IP}~0.05-0.1
  - No strong Q^2 and β dependence of t-slope at low x_{IP}
  - Effective IP intercept extracted from Regge fit of $F_2^{D(4)}$ is consistent with $\alpha_{IP}(0)$ from H1 LRG measurement
  - Ratio LRG / FPS gives contribution of p-dissociation in H1 LRG data of ~23% independently of Q^2 , β and x_{IP} within uncertainties
- FPS performance in HERA-2: stable operation; collected much higher statistics than in HERA-I
- VFPS performance: stable running since end 2005; expected high acceptance confirmed by data; Pot alignment and momentum reconstruction to be done

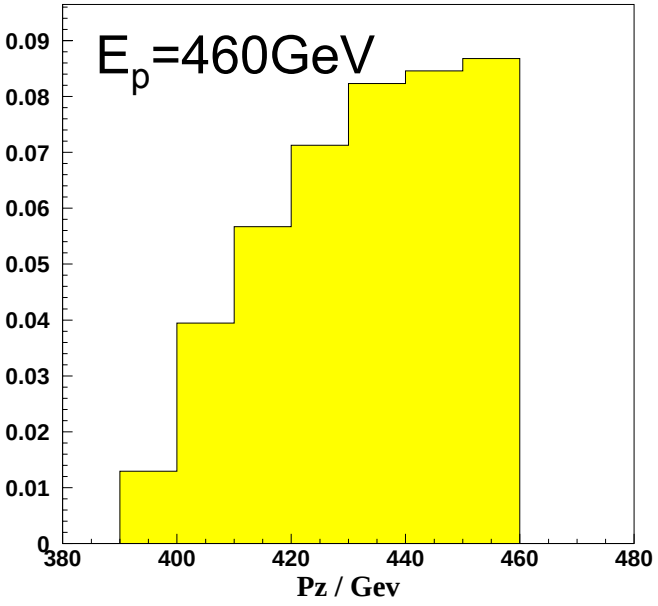
Horizontal FPS acceptance (low energy run)

Proton trajectory for x_{IP}=0.05, -0.55<θ_x<-0.35 mrad



Trajectory of nominal proton beam





FPS acceptance for E_p=460 GeV estimated to be similar to that for E_p=920 GeV