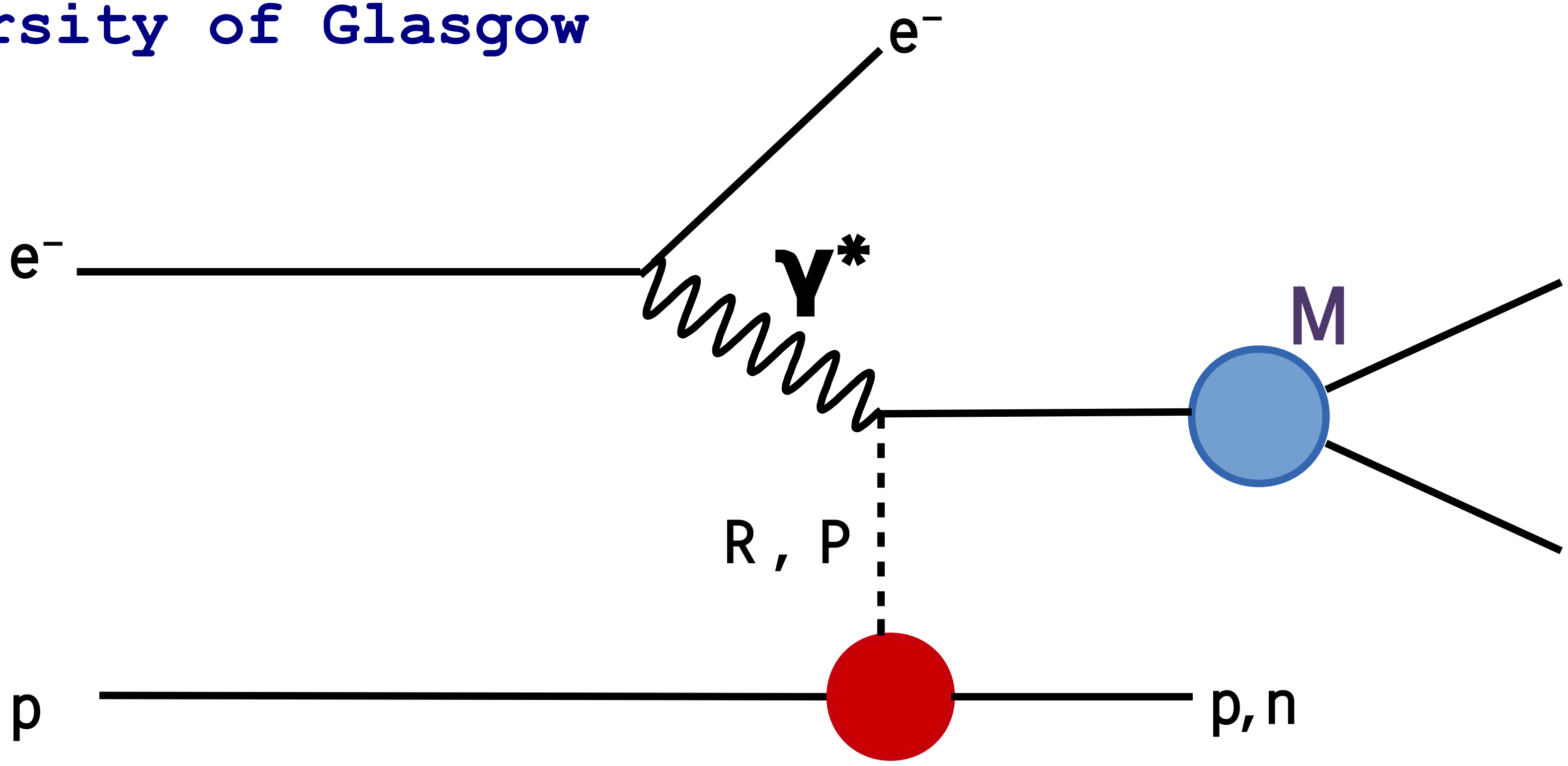
Kinematics of small Q^2 diffractive production for EIC

Derek Glazier
University of Glasgow



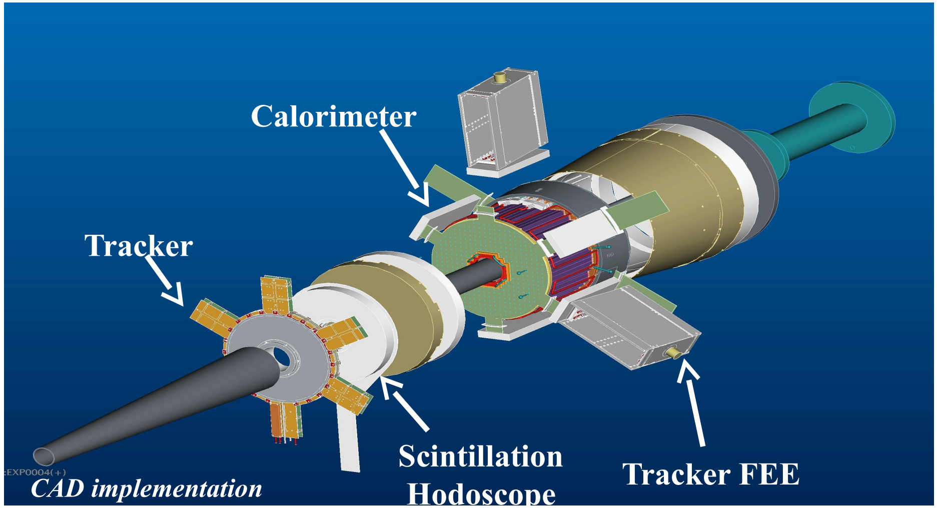
CLAS12 - Forward Tagger

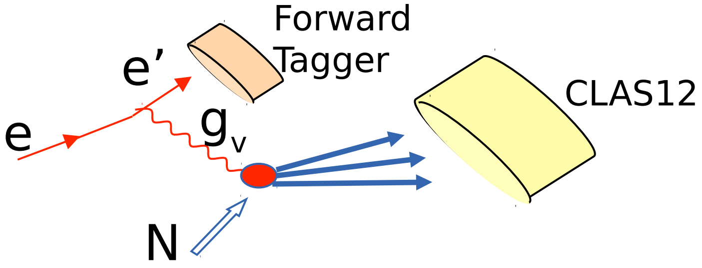
Detect electrons at small angle to perform quasi-real photo-production experiments.

Calorimeter: electron energy/momentum
Photon energy (ν=E-E')
Polarization $\varepsilon^{-1} \approx 1 + \nu^2/2EE'$
$PbWO_4$ crystals with APD/SiPM readout

Scintillation Hodoscope: veto for photons
Scintillator tiles with WLS readout

Tracker: electron angles, polarization plane
MicroMegas detectors





$E_{scattered}$	0.5 - 4.5 GeV
θ	2.5^o - 4.5^o
ϕ	0^o - 360^o
ν	6.5 - 10.5 GeV
Q^2	0.01 - 0.3 GeV^2 ($< Q^2 >$ 0.1 GeV^2)
W	3.6 - 4.5 GeV

CLAS12 MesonEx Experiment

11 GeV e- scattering in 5cm lH_2 target

Luminosity ~ $10^{35} cm^{-2} s^{-1}$

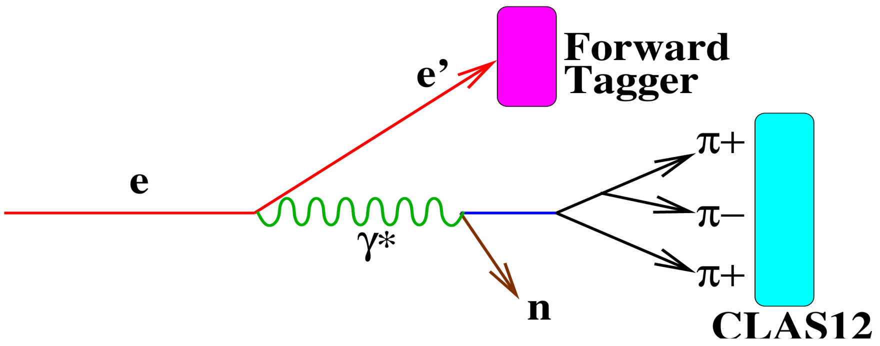
e' detected in forward tagger

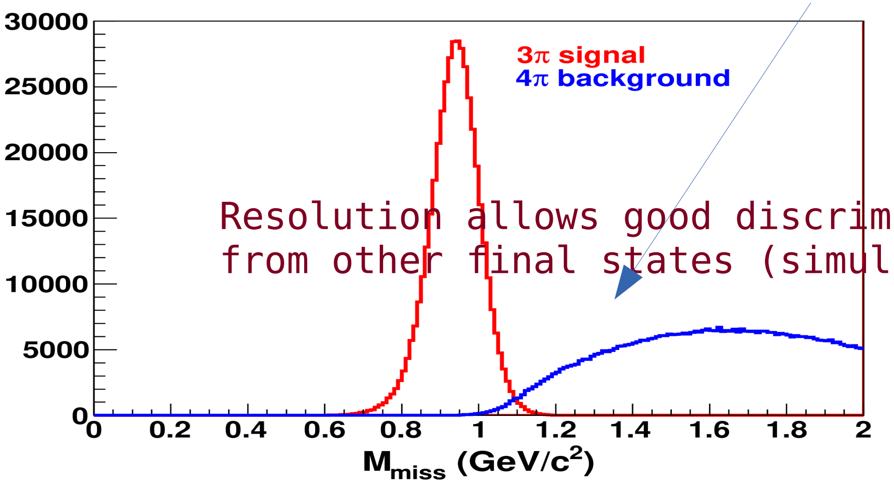
→γ energy (7-10.5 GeV) and polarisation

- σ_E= 0.02-0.07 GeV

3π detected in CLAS12

- σ_p=0.5 %, σ_θ=1 mrad , σ_φ=3 mrad

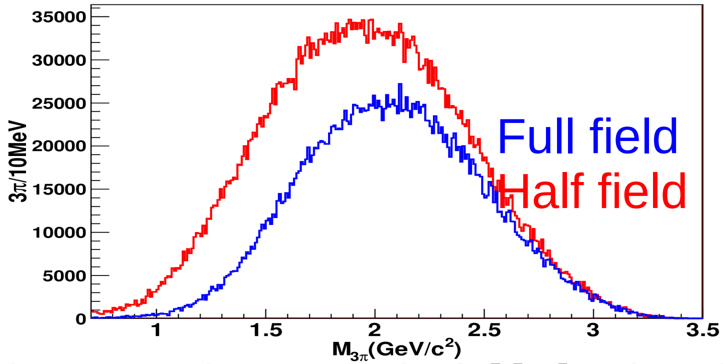




Resolution allows good discrimination from other final states (simulation)

Neutron reconstructed by missing mass

Expected number of reconstructed events from initial low luminosity data (20 days)



80 day experiment with full luminosity

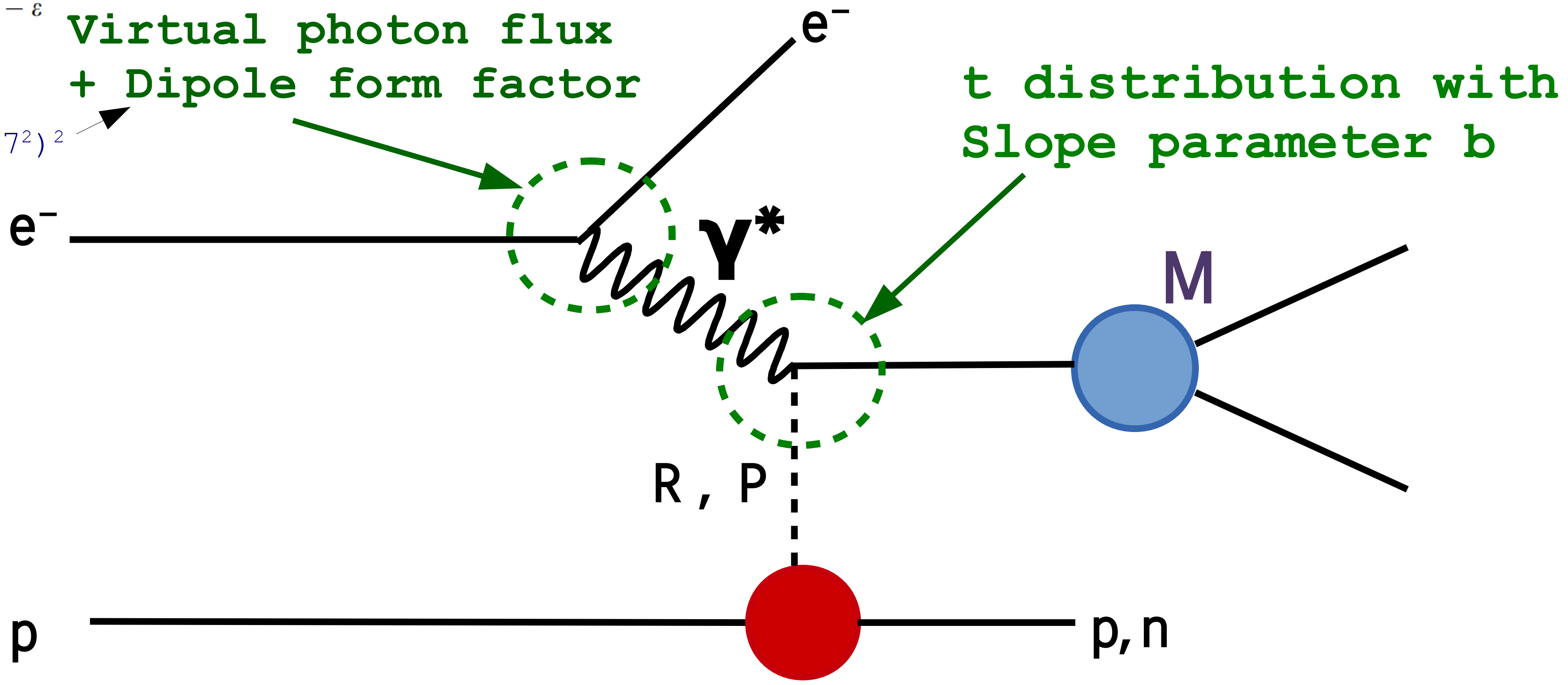
80 X more events or 10^6/10MeV

Similar simple model as for CLAS12-MesonEx proposal :

$$\varepsilon = \frac{2E_0^2 E^2 \sin^2\theta'}{2E_0^2 E^2 \sin^2\theta' - q_\mu^2 \mathbf{q}^2},$$

$$\Gamma = \frac{\alpha}{4\pi^2}\frac{k}{-q_\mu^2}\frac{E}{E_0}\frac{2}{1-\varepsilon}.$$

Factorise 2 photon vertices



(Approximate) Generator :

E_e = 10 GeV e- along z-axis

No crossing angle

E_p = 100 GeV protons opposite z-axis

Boost e- to proton rest frame

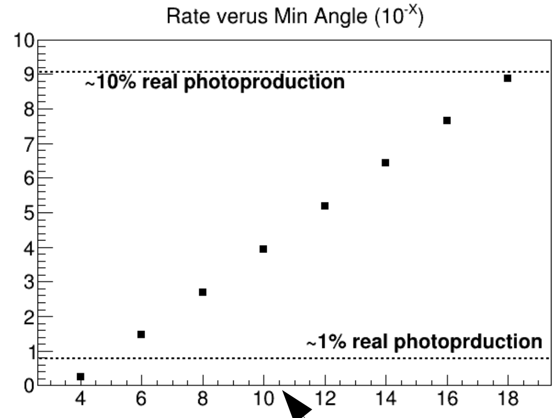
$E_e^{p,rest} = E_0 = 2132$ GeV

Capped at 1%
Of photo

Randomly sample

$0.01 * E_0 < E_e' < 0.99 * E_0$ and $10^{-5} < \theta_e' < 10^{-2}$ rad

from virtual photon flux * Form Factor distribution



Means 10^{-10} etc

Gives γ*, Boost to LAB

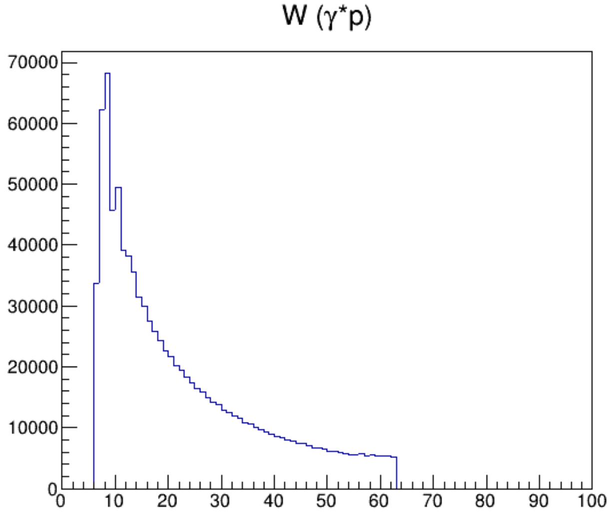
Create reaction CofM for γ* + p

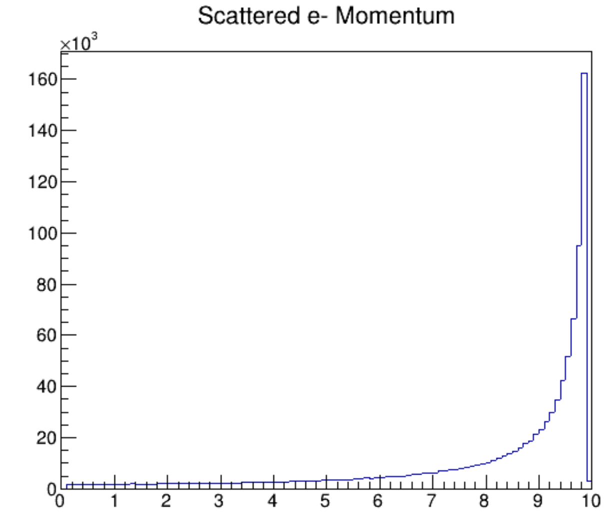
Decay to meson and proton

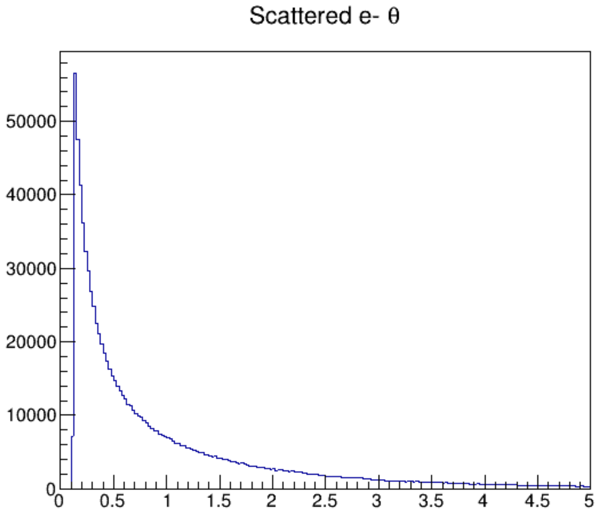
Sample t from t-distribution

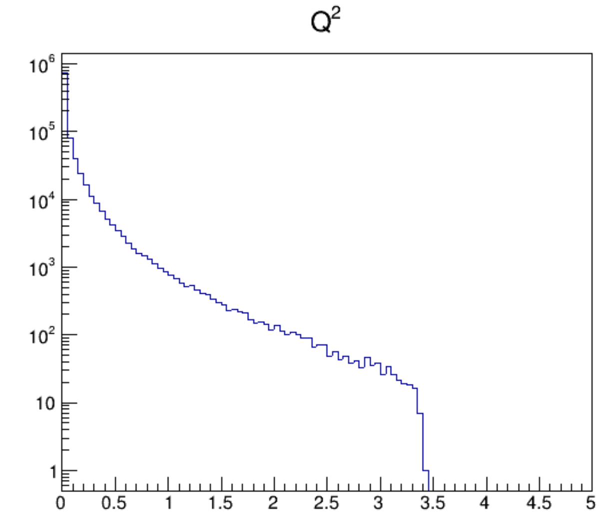
Boost to LAB

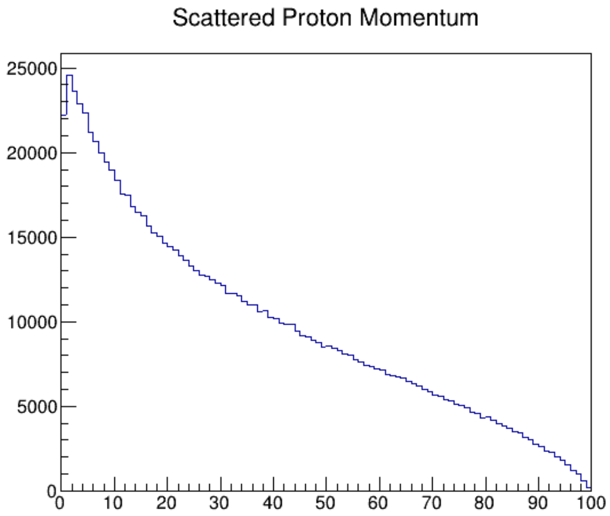
Phase space e+e- production with virtual photon

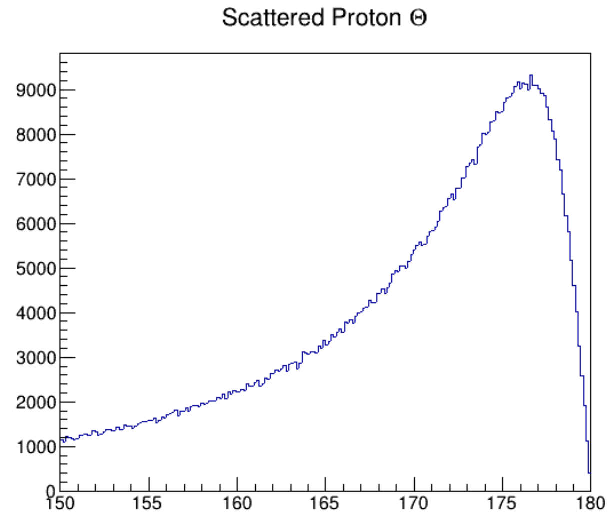




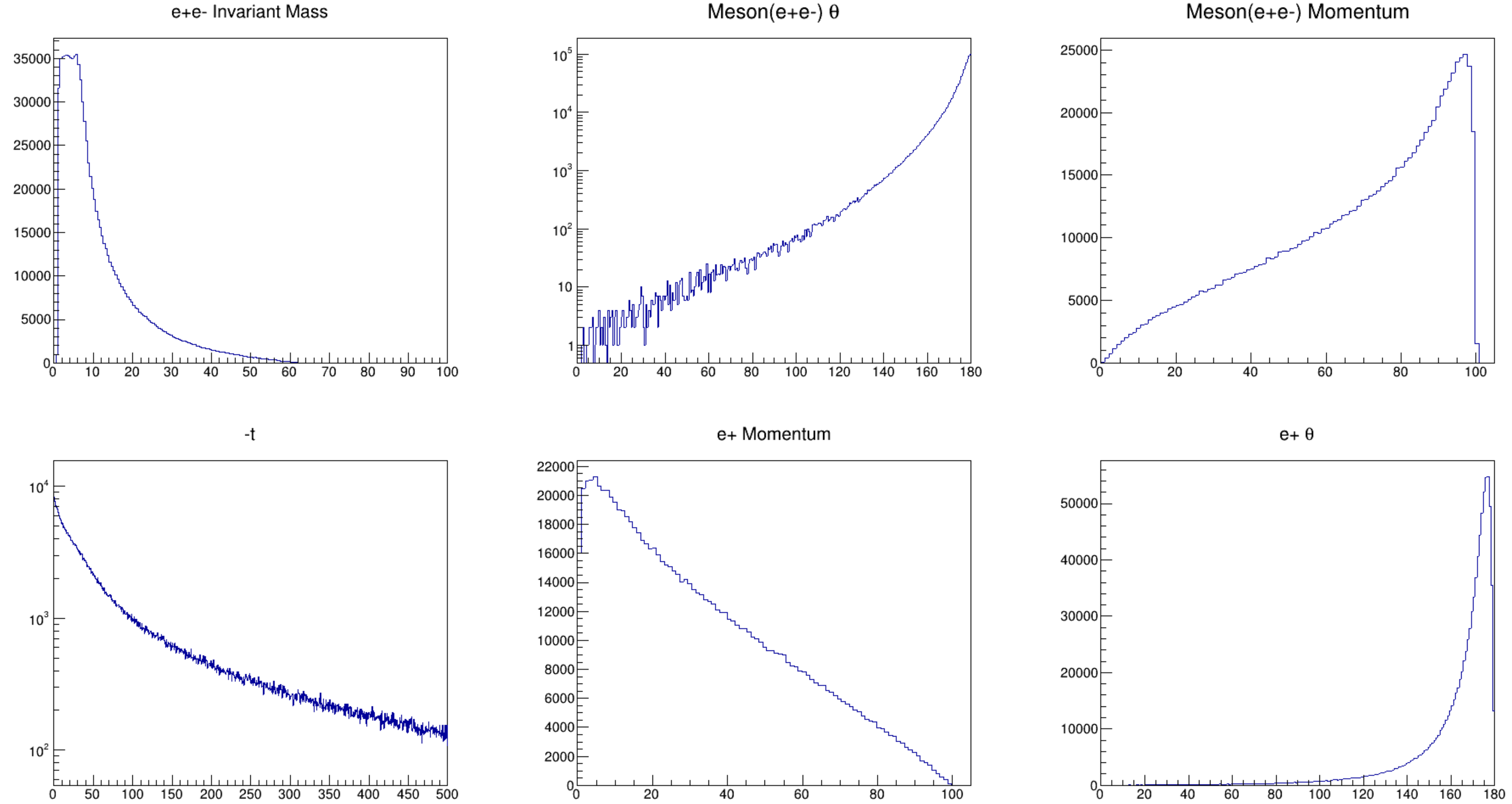








Phase space e+e- production with virtual photon



I. J/psi->e^+e^-

Use σ = 25 nb (W~20GeV)
and b = 4

L=10^{-34}cm^{-2}s^{-1}

Rate = $L\sigma\int V(E_e,\theta_e)\,dE\,d\theta$

Branch Ratio =0.06

Time = 1 day

events = 70k (@0.8Hz)

The European Physical Journal C - Particles and Fields
July 2002, Volume 24, Issue 3, pp 345–360 | Cite as

Exclusive photoproduction of J/ψ mesons at HERA

~20k e+e- Jpsi events?

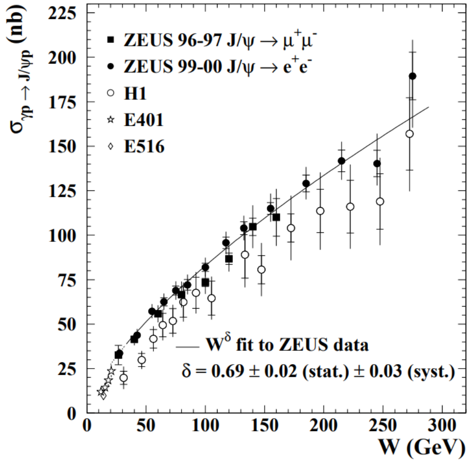


Figure 4: *The exclusive J/ψ photoproduction cross section as a function of W for $J/\psi \to \mu^+\mu^-$ and $J/\psi \to e^+e^-$. The inner bars indicate the statistical uncertainties; the outer bars are the statistical and systematic uncertainties added in quadrature. Results from the H1 [15], E401 [44] and E516 [45] experiments are also shown. The solid line is the result of a fit to the ZEUS data of the form $\sigma \propto (W/90\ GeV)^\delta$ and the dotted line is the extrapolation of the fit.*

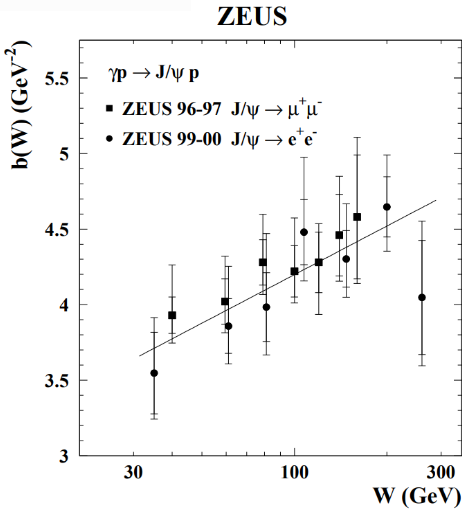
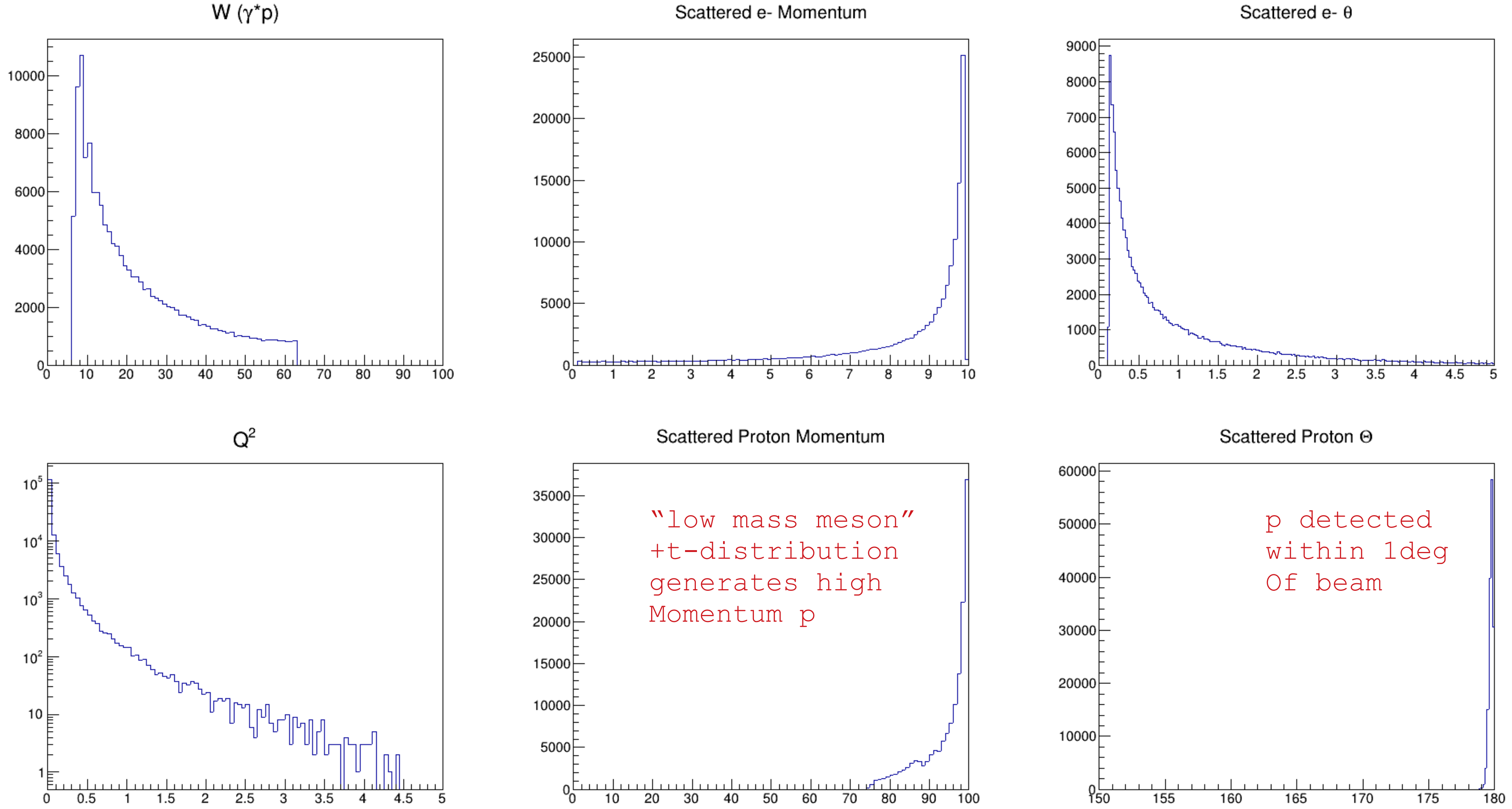
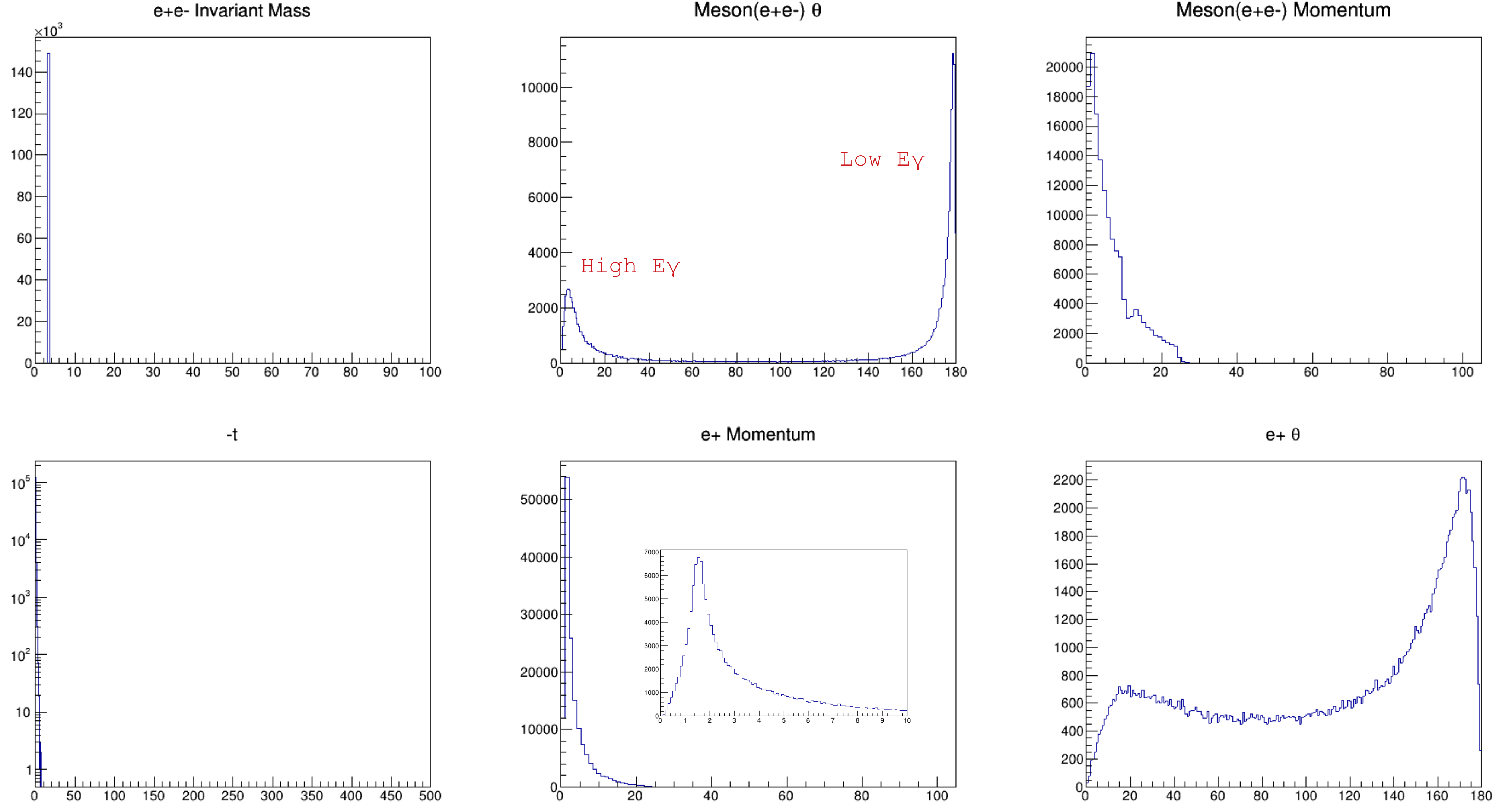


Figure 7: *Values of the slope, b, of the t distribution, plotted as a function of W. The line shows the result of a fit of the form $b(W) = b(90\ GeV) + 4 \cdot \alpha'_{I\!P} \ln(W/90\ GeV)$.*

J/psi e+e- production



J/psi e+e- production



I. X(3872) →ππ J/psi ->e^+e^-

Actually 3pi cross section

Use σ = 25/14*0.07 nb
and b = 4

L=$10^{-34}cm^{-2}s^{-1}$

Rate = $L\sigma\int V(E_e,\theta_e)\,dE\,d\theta$

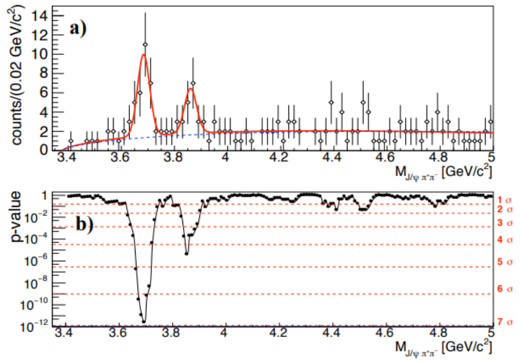
Branch Ratio =0.06 (Jpsi)

Time = 1 day

events = 700 (@0.008Hz)

Search for muoproduction of $X(3872)$ at COMPASS and indication of a new state $\widetilde{X}(3872)$

The COMPASS Collaboration



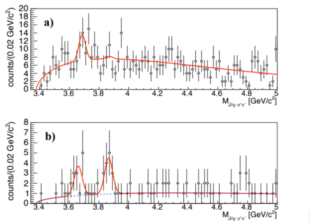
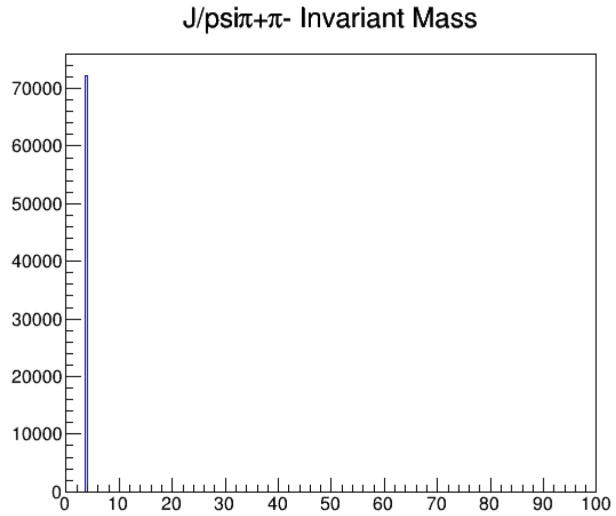
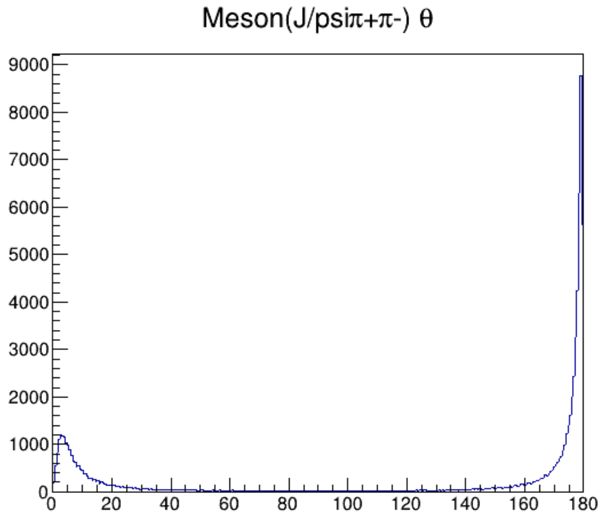
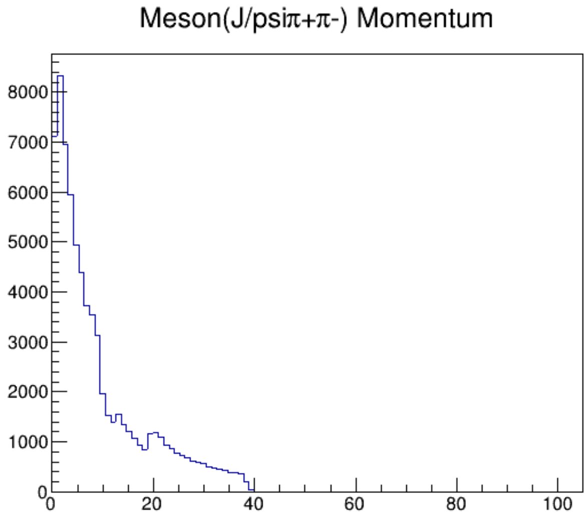


Fig. 4: (a) The $J/\psi\pi^+\pi^-$ invariant mass distributions for the $J/\psi\pi^+\pi^-\pi^\pm$ final state (two entries per event) for non-exclusive events (-12 GeV $< \Delta E < -4$ GeV) and (b) for exclusive events (-4 GeV $< \Delta E <$ 4 GeV) with missing mass M_{miss} above 3 GeV/c^2 (see text for the definition of M_{miss}).

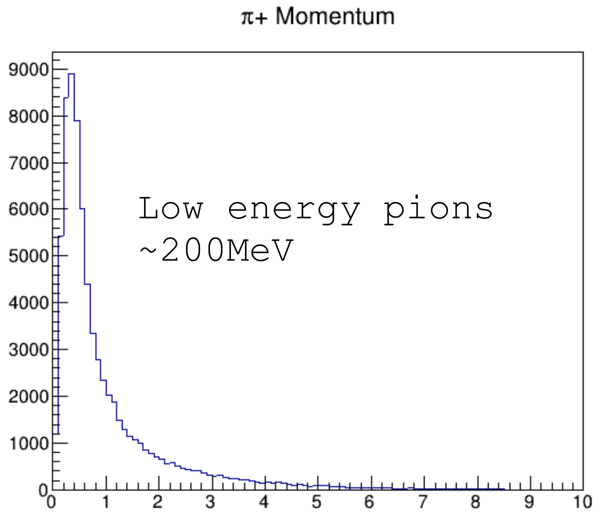
X(3872) to ππJ/psi e+e- production

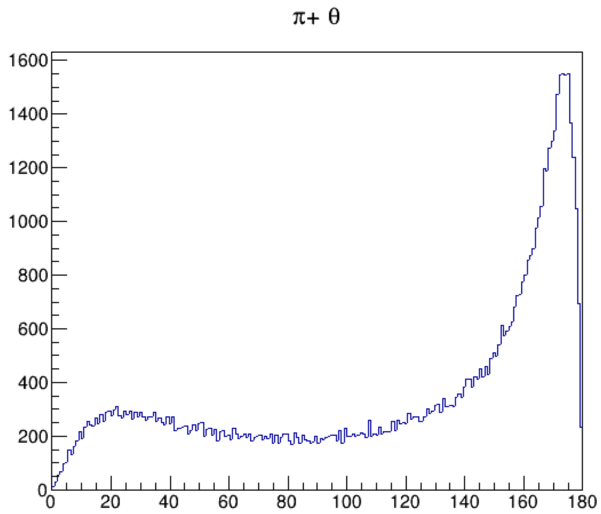






Other kinematics
Similar to Jpsi





I. $\Upsilon(1S) \to e^+e^-$

Use σ = 0.05 nb (W=20GeV)
and b = 4

$L = 10^{-34} cm^{-2} s^{-1}$

Rate = $L\sigma \int V(E_e, \theta_e)\, dE\, d\theta$

Branch Ratio =0.025

Time = 1 day

events = 60 (@0.7mHz)

EXCLUSIVE PHOTOPRODUCTION OF Υ: FROM HERA TO TEVATRON

ANNA RYBARSKA*,*, WOLFGANG SCHÄFER*, ANTONI SCZUREK*,%
* *Institute of Nuclear Physics PAN, PL-31-342 Cracow, Poland*
% *University of Rzeszów, PL-35-959 Rzeszów,Poland*

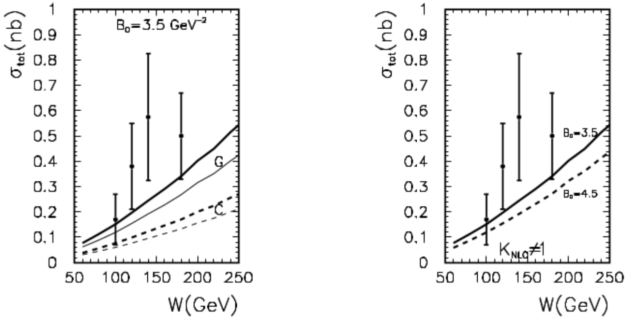
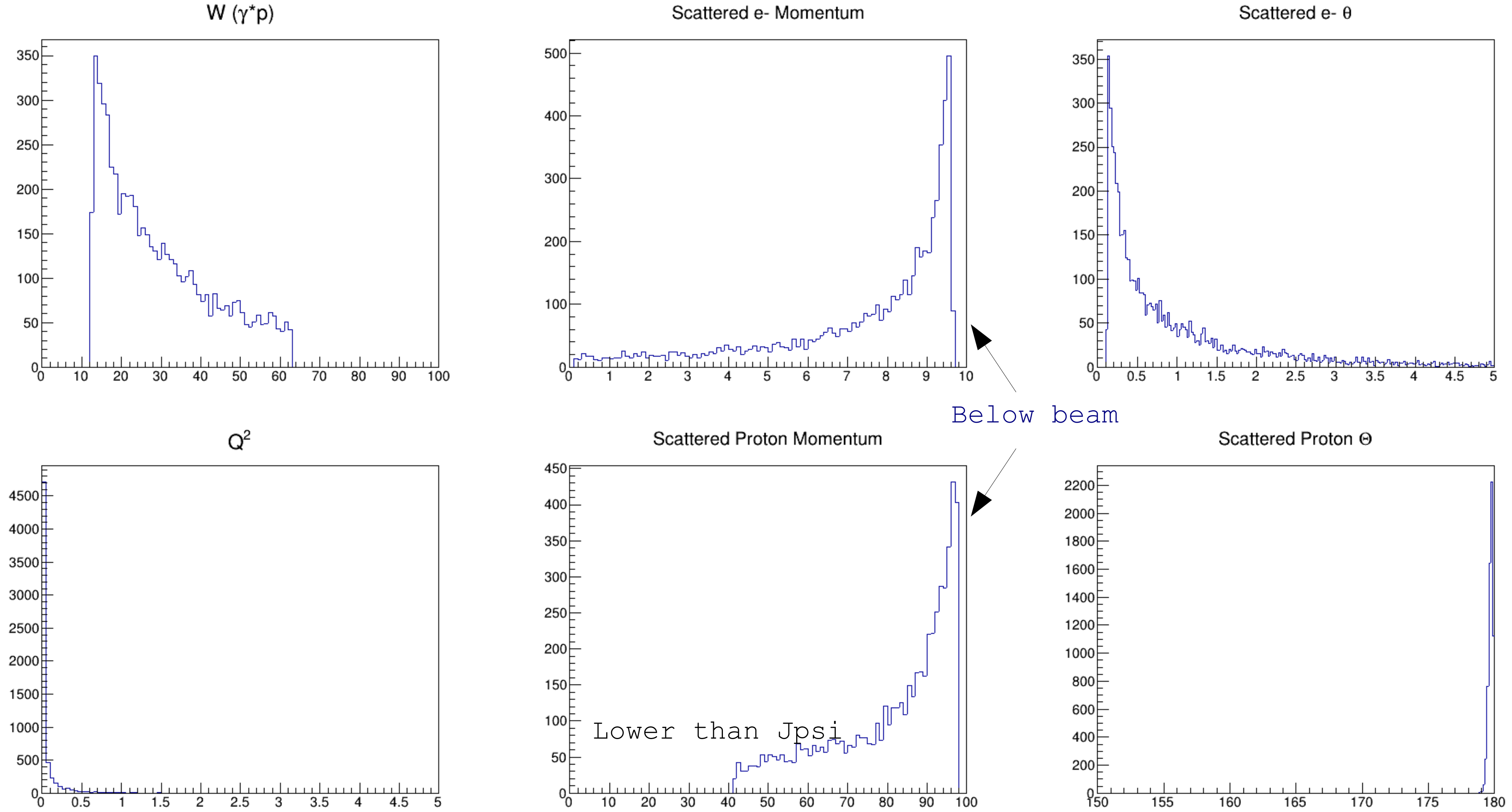
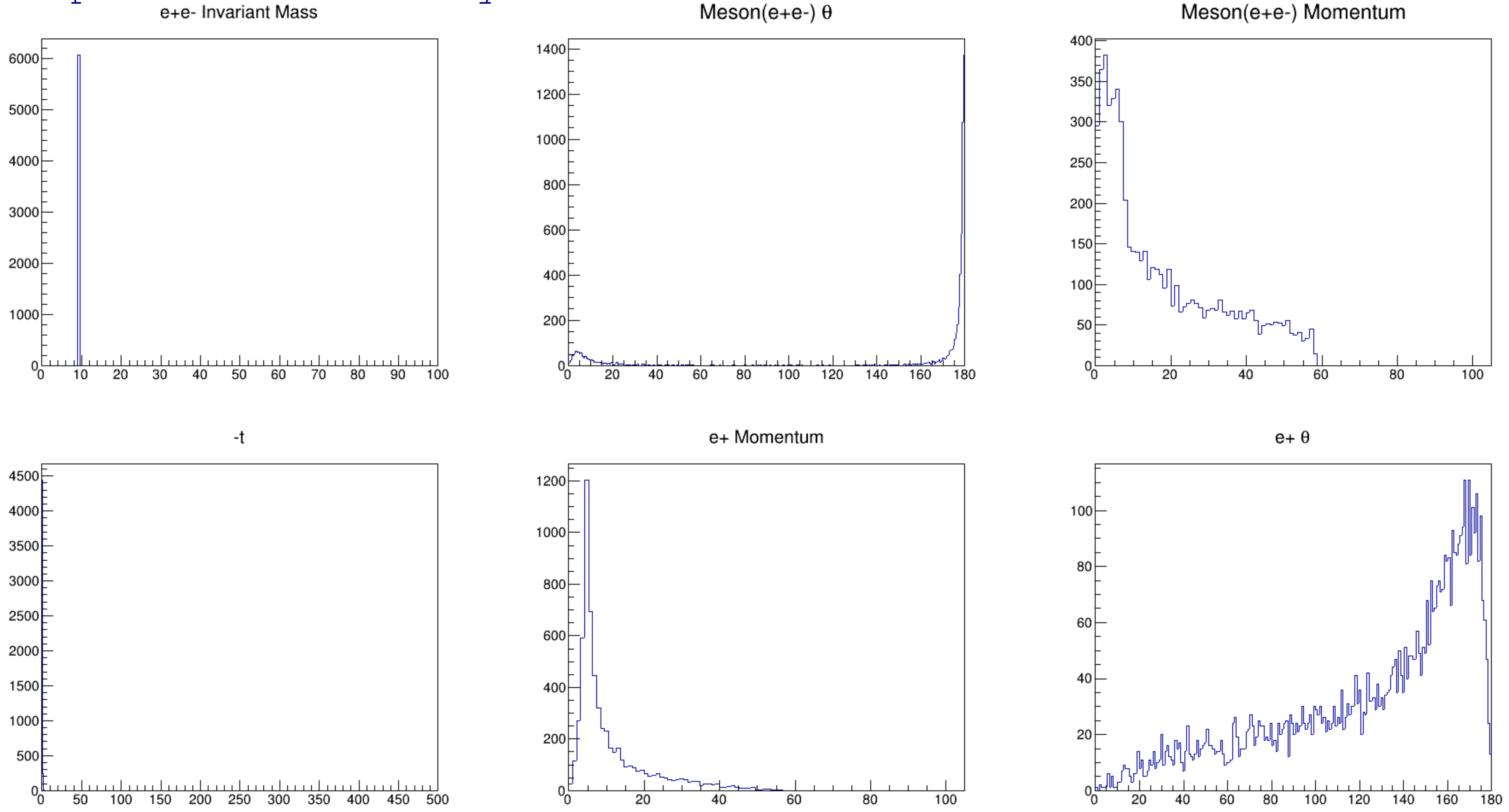


Fig. 1. Total cross section for the $\gamma p \to \Upsilon(1S)p$ as a function of energy. The experimental data are taken from paper [2]. **Left panel**: solid curves - Gaussian (G) wave function, dashed curves - Coulomb (C) wave function. Thick lines were obtained including the NLO correction for the Υ decay width, thin lines are for $K_{NLO} = 1$. **Right panel**: solid curves - $B_0 = 3.5\ GeV^{-2}$, dashed curves - $B_0 = 4.5\ GeV^{-2}$.

Upsilon e+e- 100days



Upsilon e+e- 100days



Detector Considerations

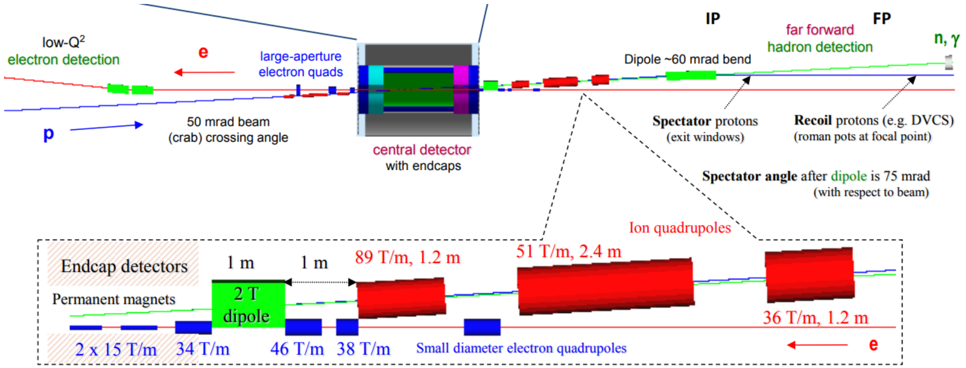
Scattered electron and proton detection at 0 degrees!

Far-forward detectors

Tag scattered particle

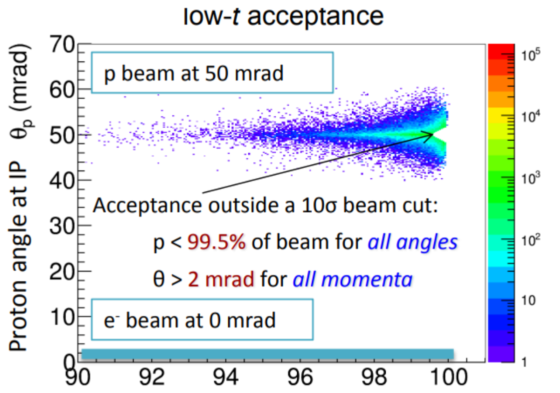
Determine momentum

Far-forward e-



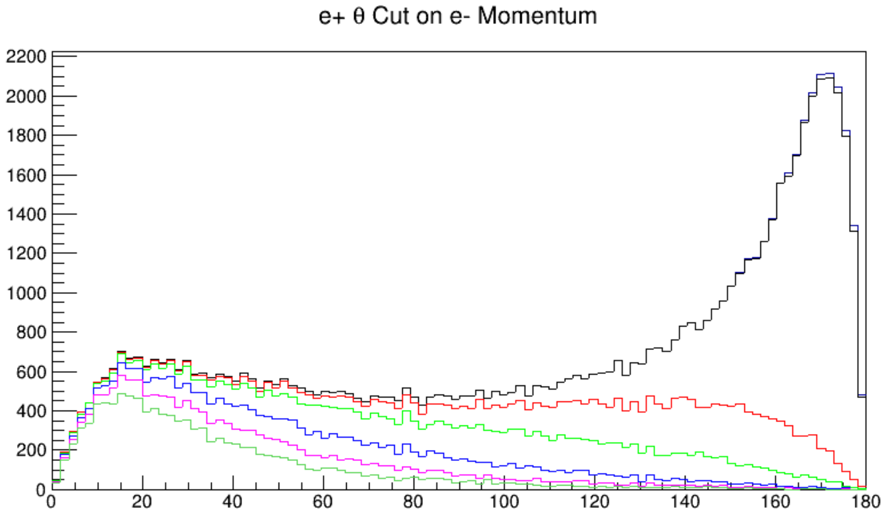
MEIC from white paper

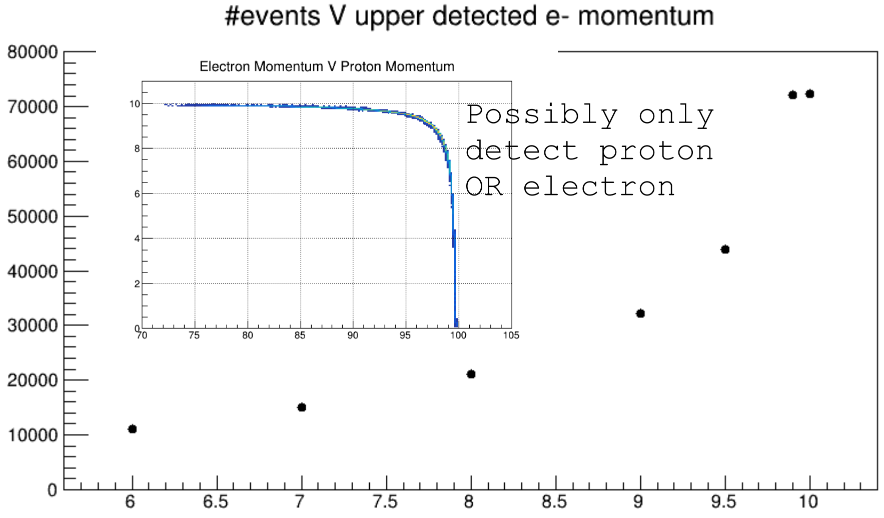
Far forward ion

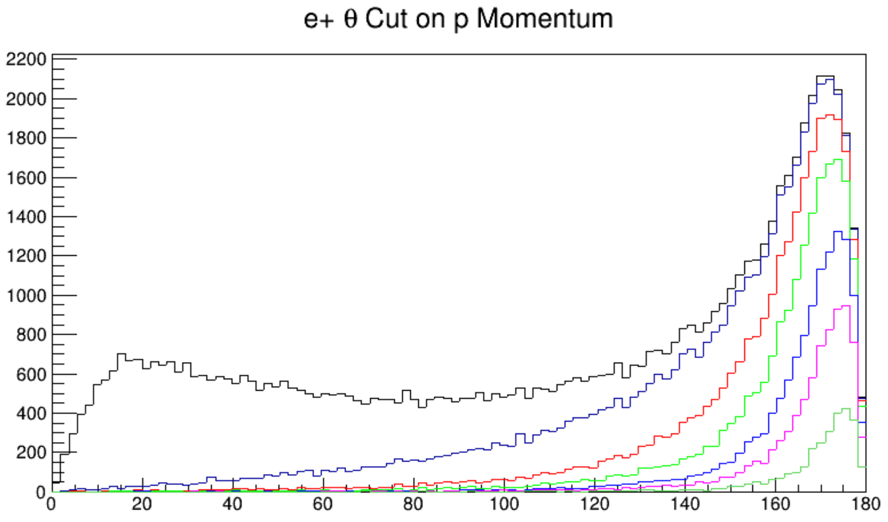


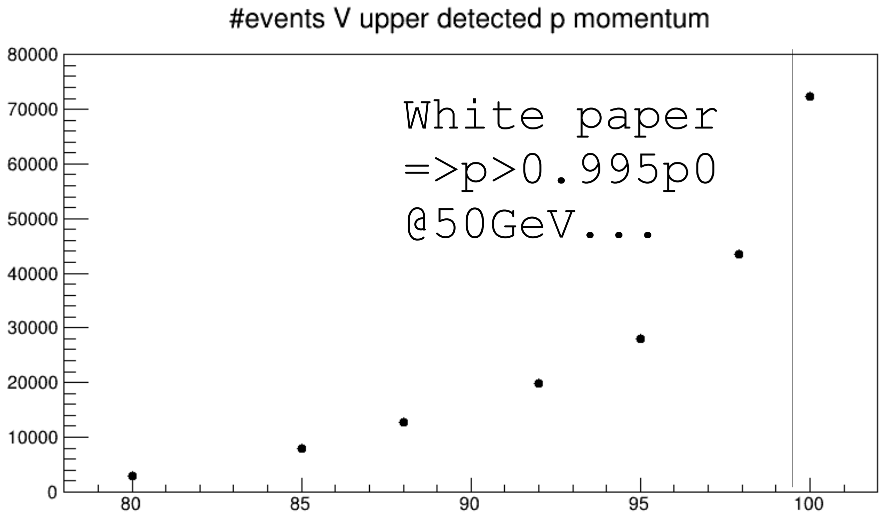
Lower momentum threshold?

Back to Jpsi : Events cut on scattered particle acceptance

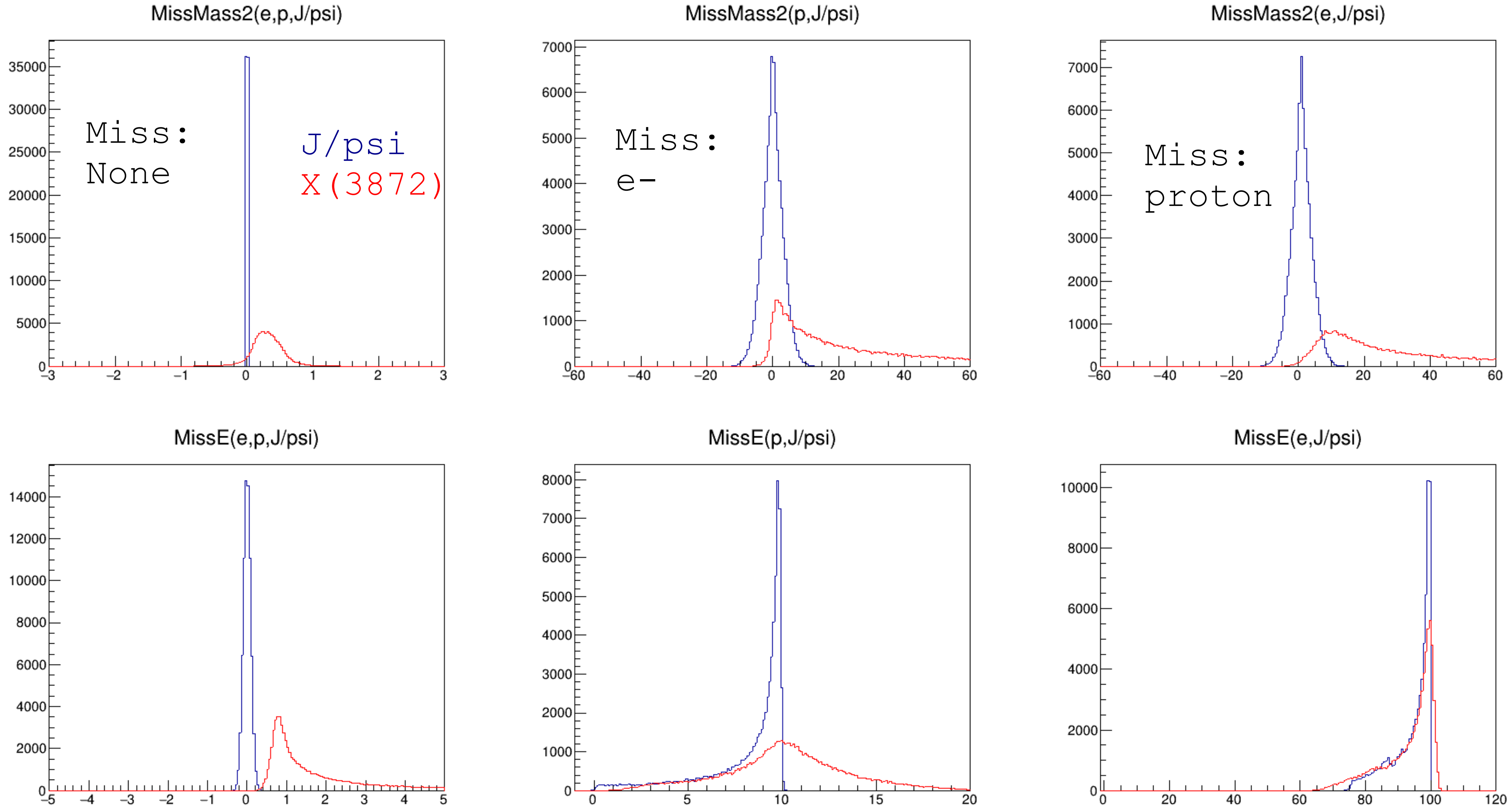








Exclusivity :Assume p and e- momentum resolutions of 0.001P



Summary :

Reasonable numbers of mesons from low Q2 electroproduction diffractive processes can be produced at an EIC

There are two distinct regimes: High Eγ and Low Eγ

- High Eγ => meson follows e- beam
- Low Eγ => meson follows proton beam

Detection of scattered proton may allow access to Low Eγ

Detection of scattered e- may allow access High Eγ

Exclusive measurements will give excellent background rejection

With resolutions <1E-3 may also be possible with 1 missing particle

Detector Considerations

Scattered electron and proton detection at 0 degrees!

- Far-forward detectors
- Tag scattered particle
- Determine momentum
- $P_{scat} < P_{beam}$ (how much less before detected?)

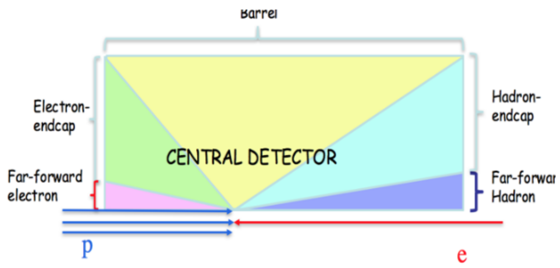


Figure 6: Regions in the JLEIC Central Detector.

Far forward ion

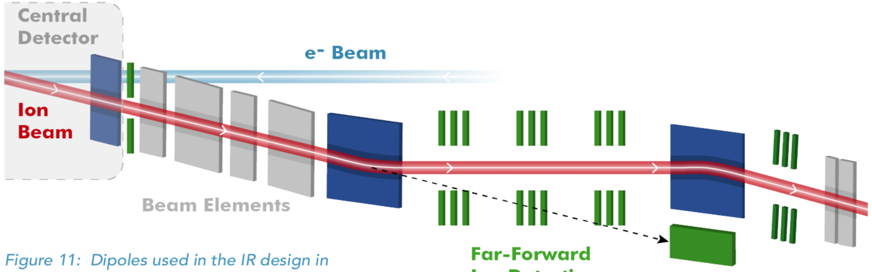
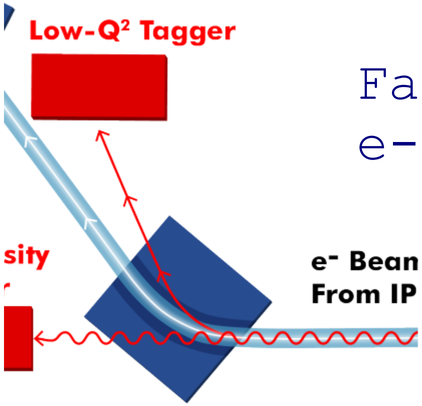


Figure 11: Dipoles used in the IR design in far-forward hadron direction.



Far-forward e-

Or Roman Pots?

Exclusivity :Assume p and e- momentum resolutions of 0.01P