Events with an isolated lepton and missing transverse momentum at ZEUS

Katherine Korcsak-Gorzo, University of Oxford, ZEUS

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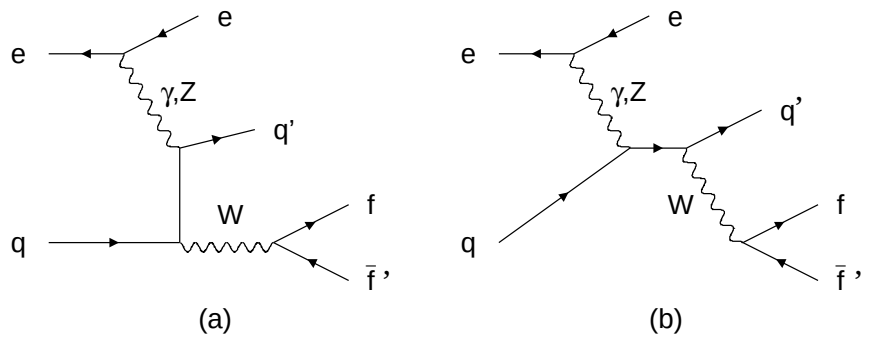
Single W production

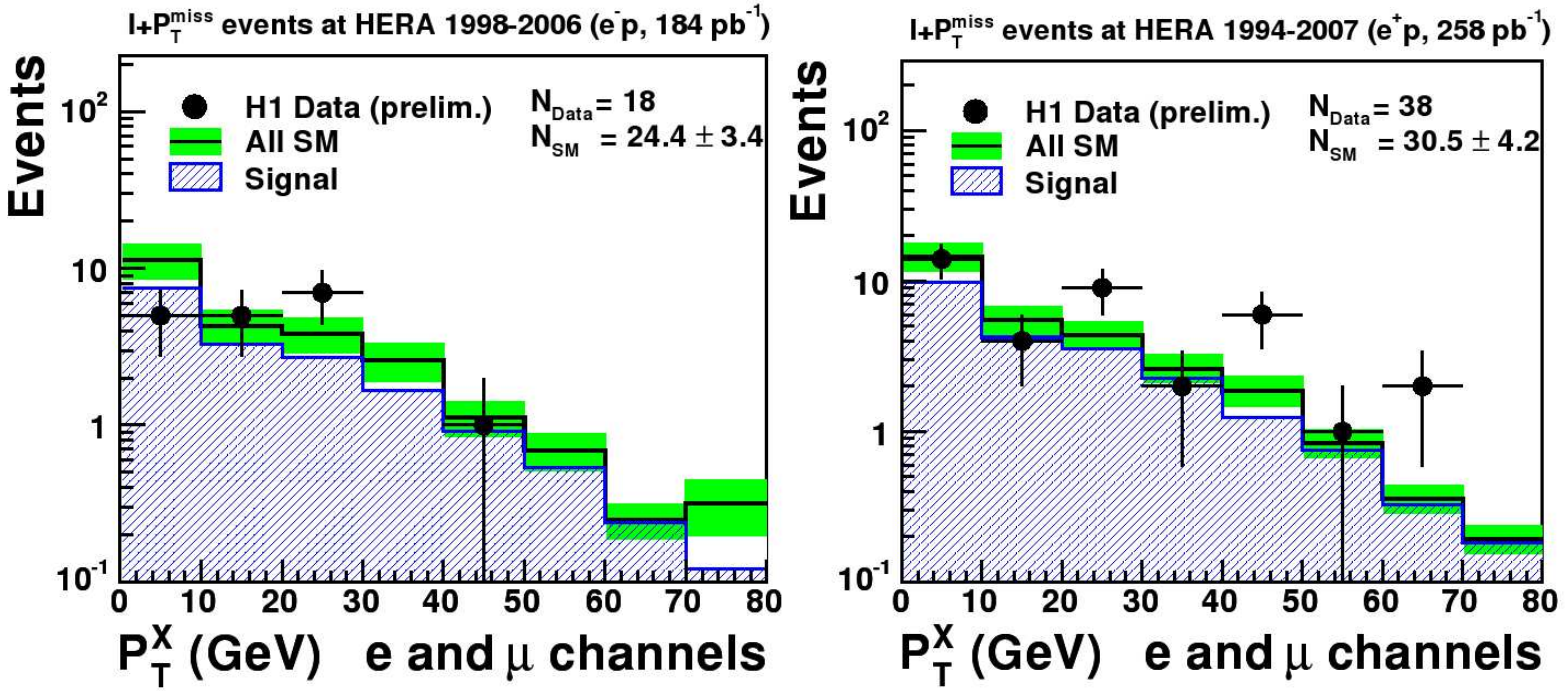


- Main SM process producing isolated leptons & P_T^{miss}
- At HERA $\sigma(\mathrm{W}) \approx 1.1$ pb (1 in 10^6 events)
- $BR(W^{\pm} \to l\nu) = 11\%$

Motivation

- Background to physics beyond Standard Model
- Check anomaly observed by H1 in electron & muon channel

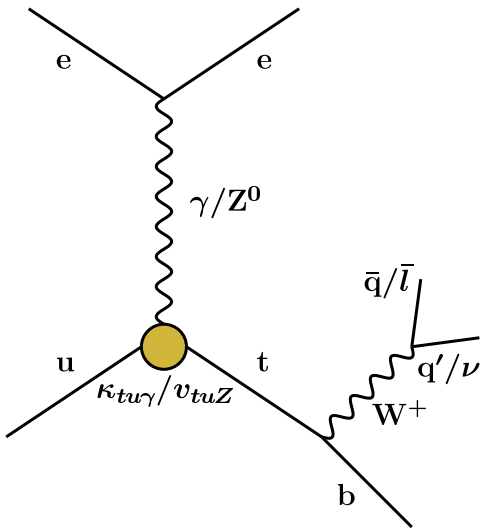
H1 search - excess observed

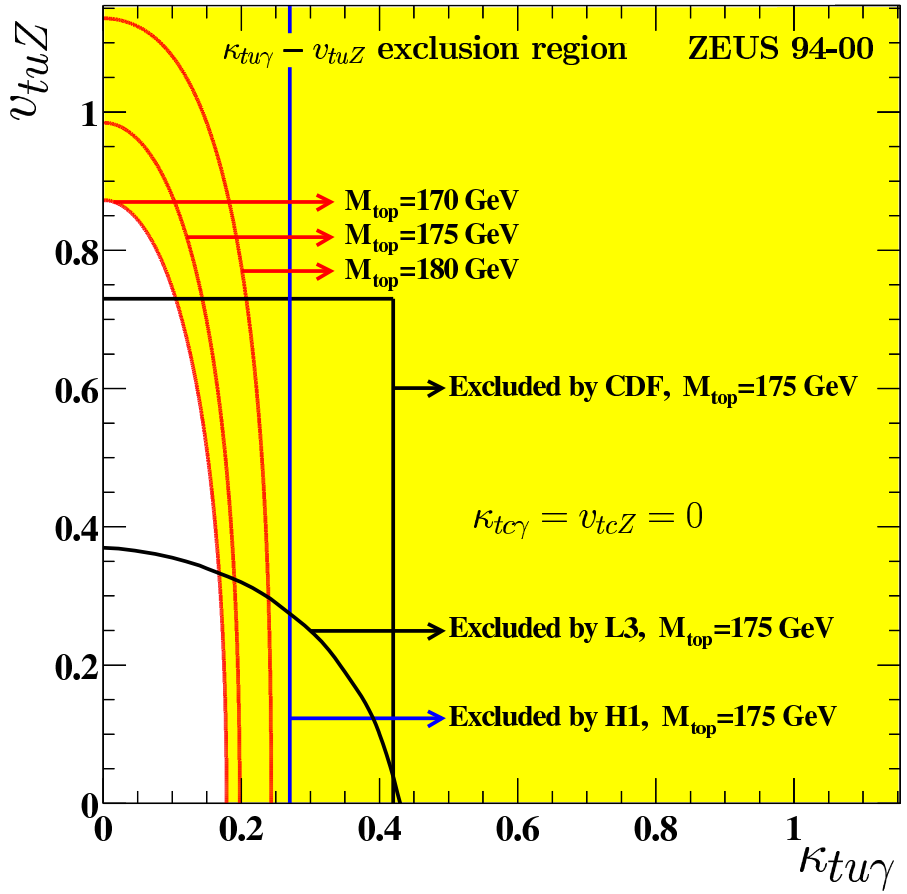


H1 Preliminary $P_T^X > 25$ GeV	e channel obs./exp. (signal)	μ channel obs./exp. (signal)	e and μ obs./exp. (signal)
$e^- p$ 184 pb^{-1}	$3/3.8 \pm 0.6$ (61%)	$0/3.1 \pm 0.5$ (74%)	$3/6.9 \pm 1.0$ (67%)
$e^+ p$ 258 pb^{-1}	$10/4.1 \pm 0.8$ (75%)	$8/3.7 \pm 0.6$ (85%)	$18/7.8 \pm 1.3$ (80%)

Anomalous single top

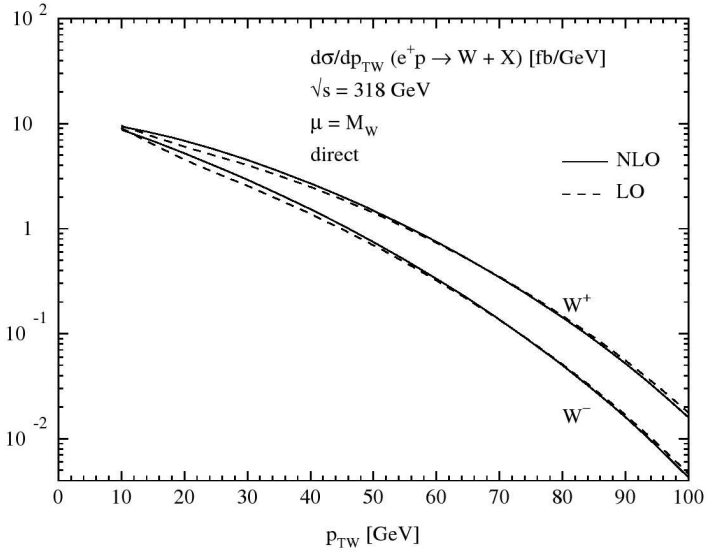
- FCNC coupling $\kappa_{tu\gamma}$ could cause such an excess.
- Within SM top production negligible at HERA.





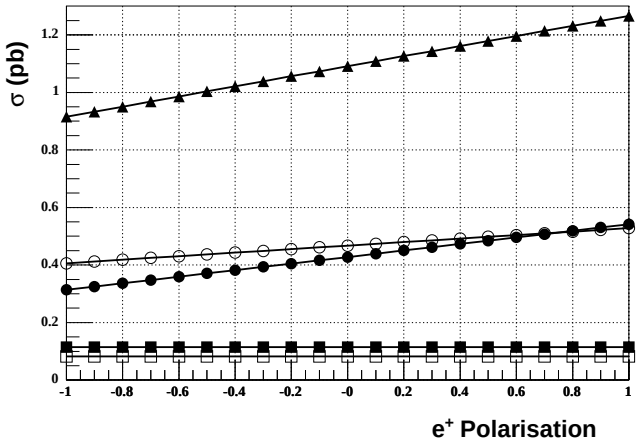
Process signature

- High-P_T isolated lepton: $P_T^l > 10$ GeV, isol. > 0.5 in $\{\eta, \phi\}$
- Large missing P_T: $P_T^{\text{miss}} > 12$ GeV
- Large hadronic P_T: $P_T^X > 25$ GeV

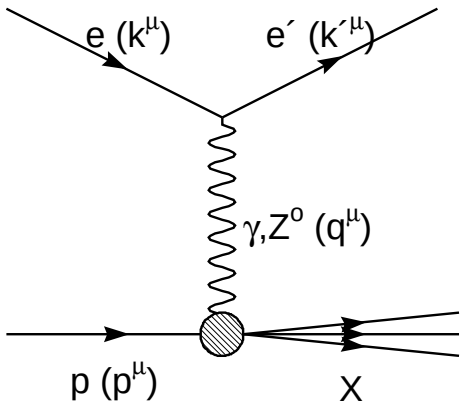
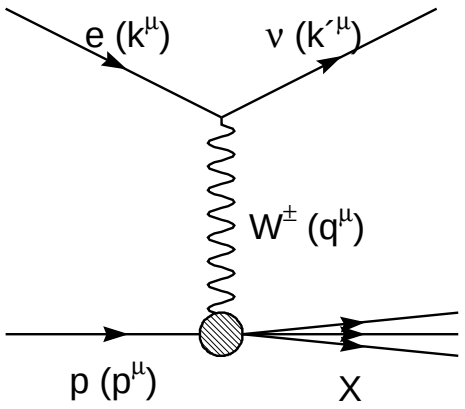
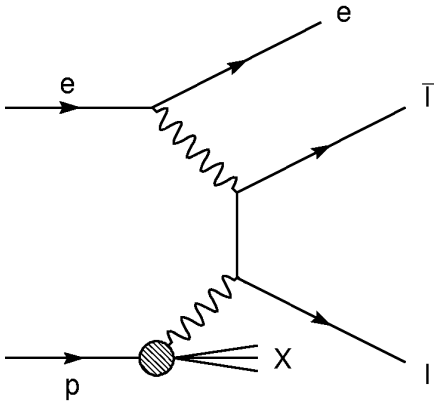


- W produced at small P_T (see fig)
- Polarisation dependence small (see fig)

- Leading order MC for W (EPVEC)
- Main QCD (NLO) correction $O(10\%)$ (hep-ph/0203269)
- Uncertainty from 30% (LO) to 15% (NLO)



Backgrounds

NC DIS	CC DIS	Dilepton production
		
Genuine lepton and fake P_T^{miss} due to mismeasurement	Misidentified lepton and genuine P_T^{miss}	Genuine lepton and fake P_T^{miss} due to mismeasurement
DjangoH + Ariadne/MEPS	DjangoH + Ariadne/MEPS	Grape Dilepton
$\sigma \approx 8000$ pb	$\sigma \approx 40$ pb	$\sigma \approx 30$ pb

c.f. $\sigma(\mathrm{W}) \approx 1$ pb

Data selection

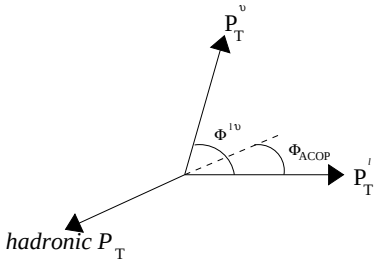
Data

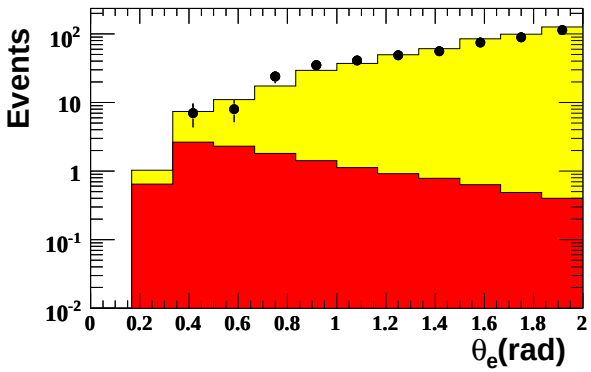
96-06 e^+p	228 pb^{-1}
98-06 e^-p	204 pb^{-1}

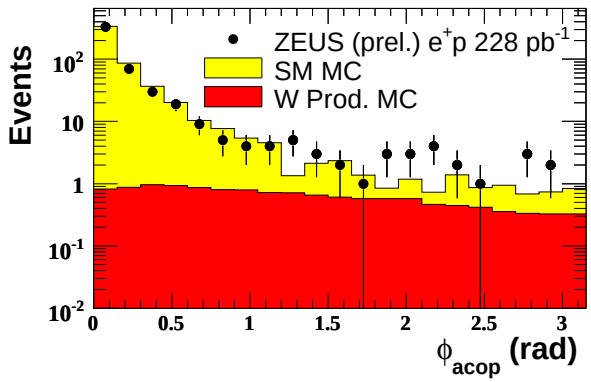
Preselection

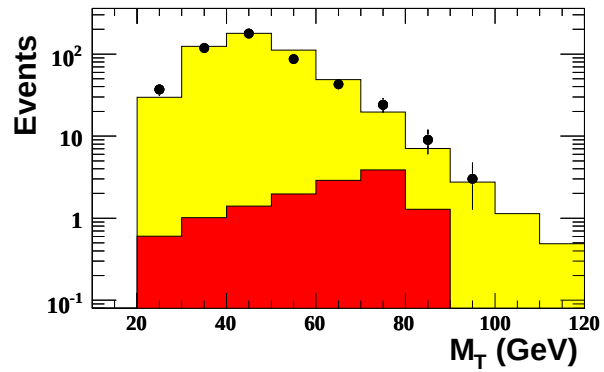
- $P_T^l > 5$ GeV (e), > 10 (μ)
- $P_T > 12$ GeV
- P_T(-1st CAL ring) > 9 GeV
- $P_T^X > 9$ GeV (μ only)
- $\theta < 2$ rad
- lepton trk iso > 0.5 in $\{\eta, \phi\}$
- lepton CAL iso: $E < 4$ GeV in a cone $R = 0.8$ in $\{\eta, \phi\}$
- $M_T > 10$ GeV (e), > 5 (μ)

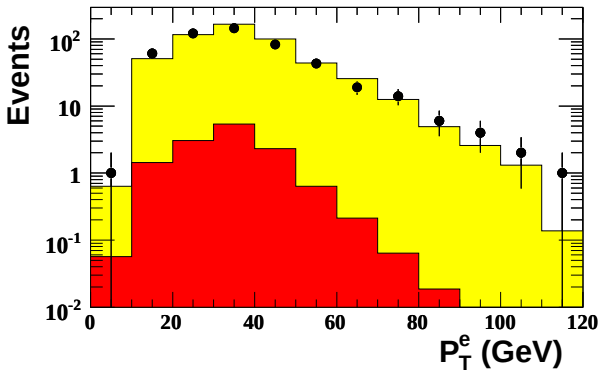
Preselection 96-06 e^+p electron-channel

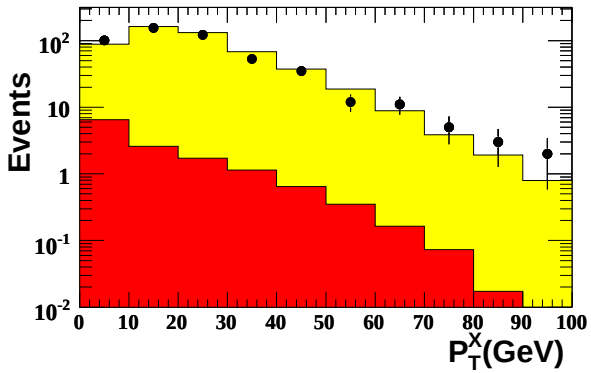


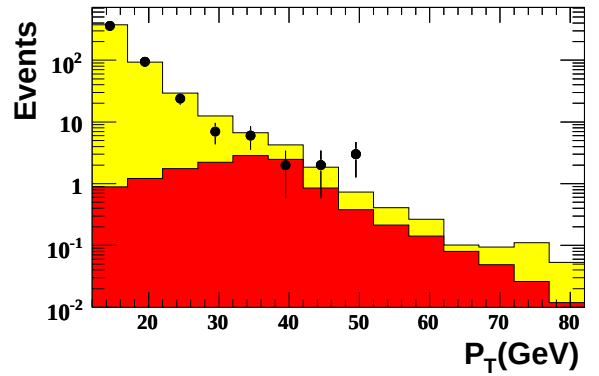




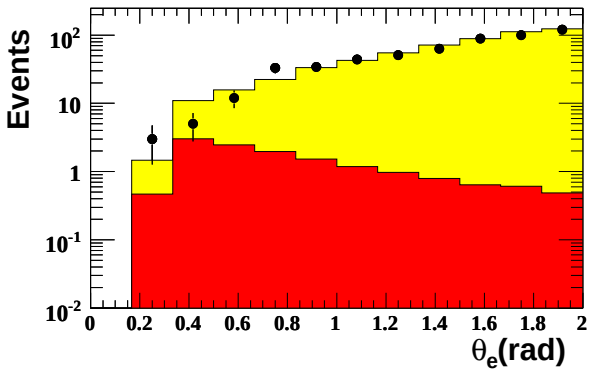


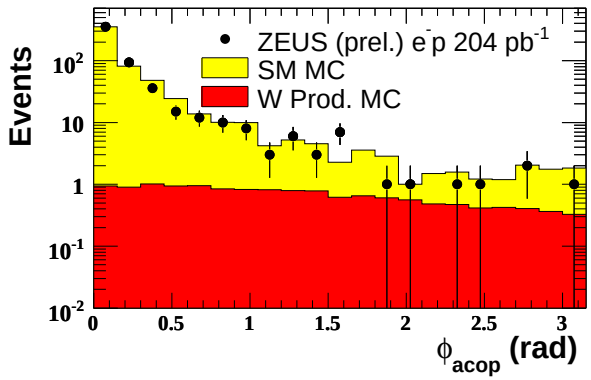


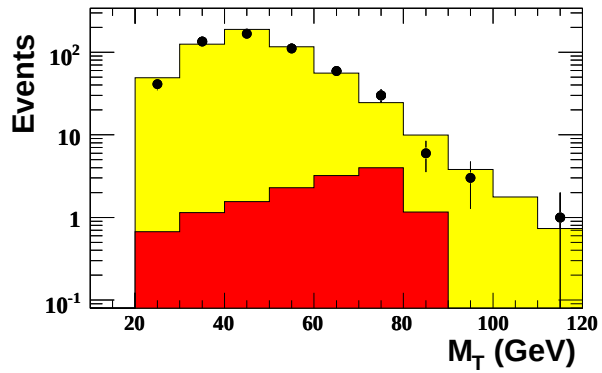


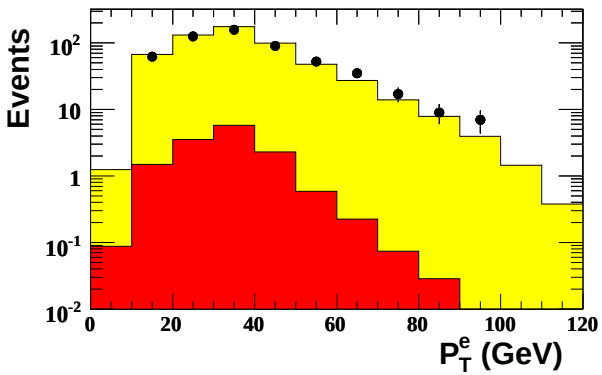


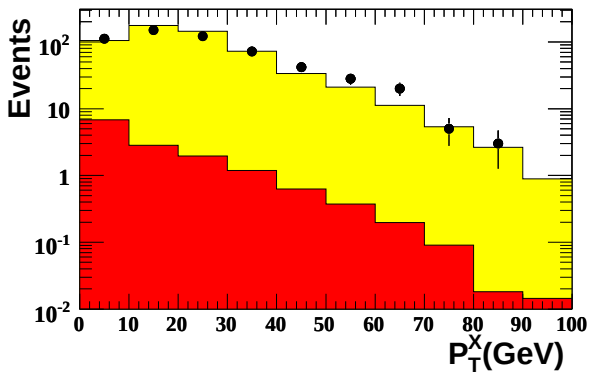
Preselection 98-05 $e^- p$ electron-channel

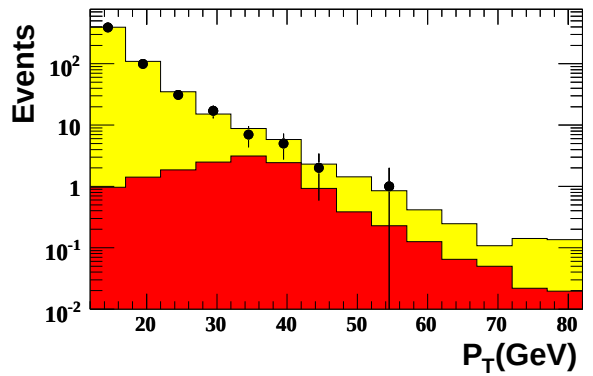




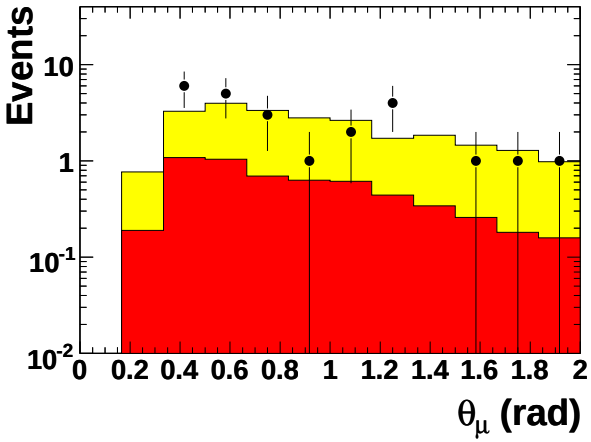


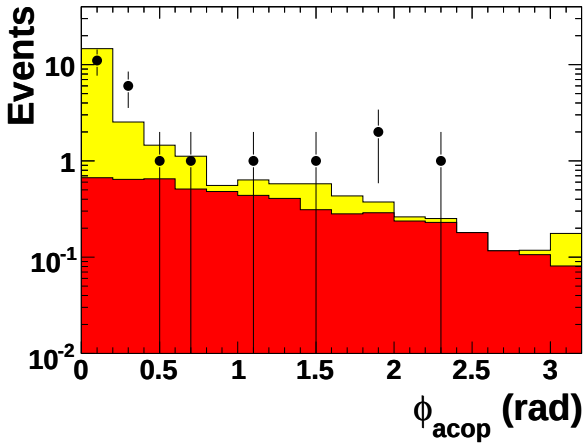


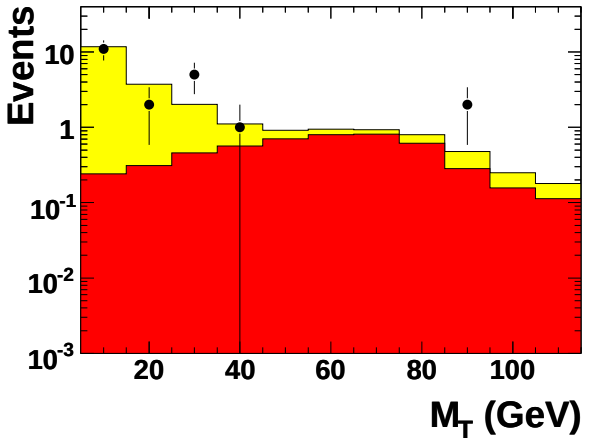


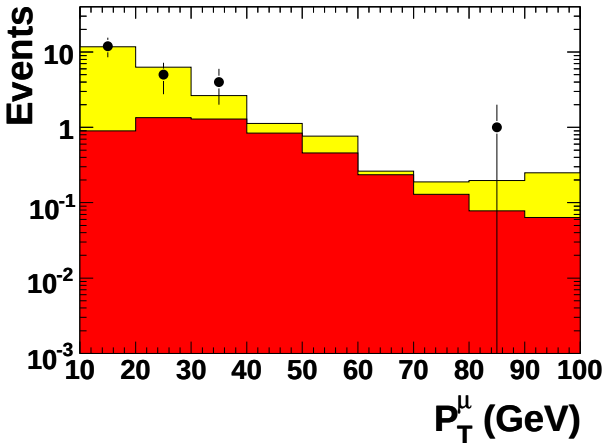


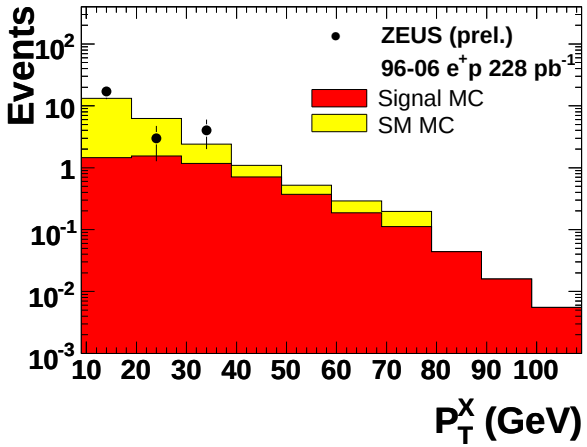
Preselection 96-06 e^+p muon-channel

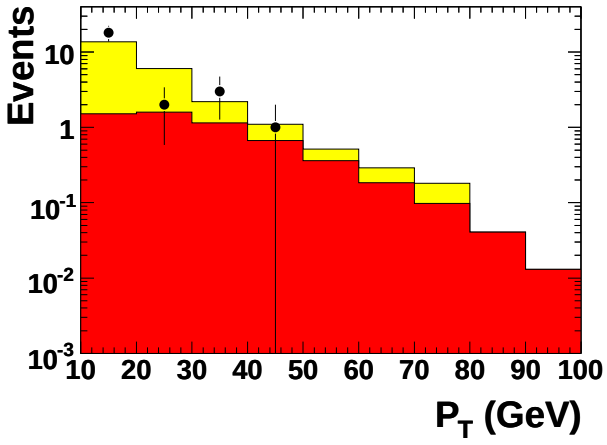




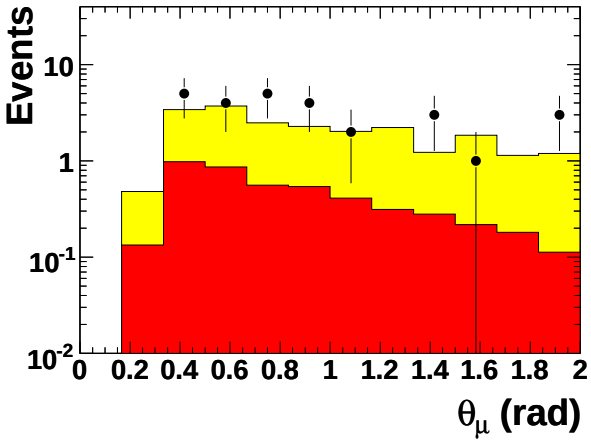


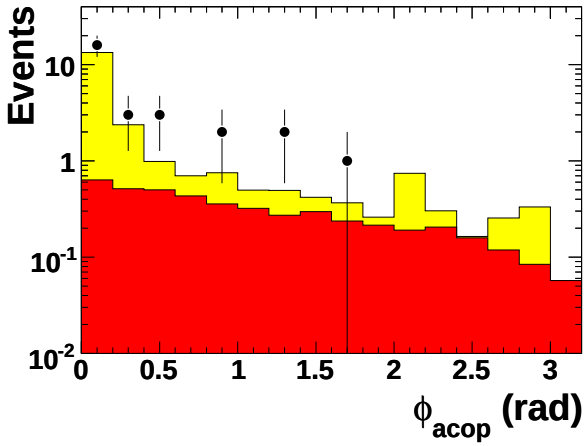


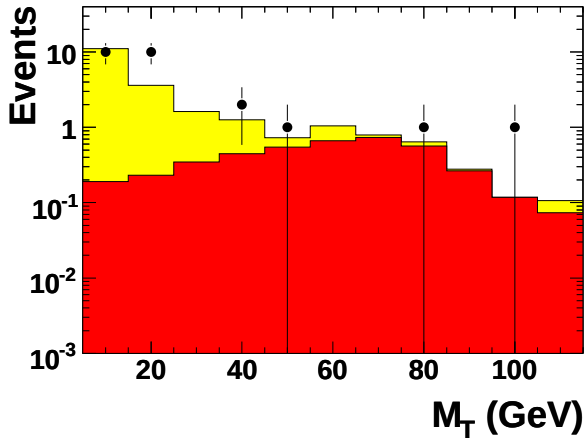


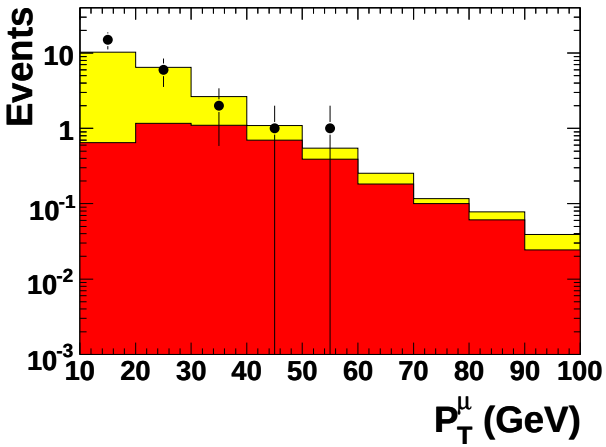


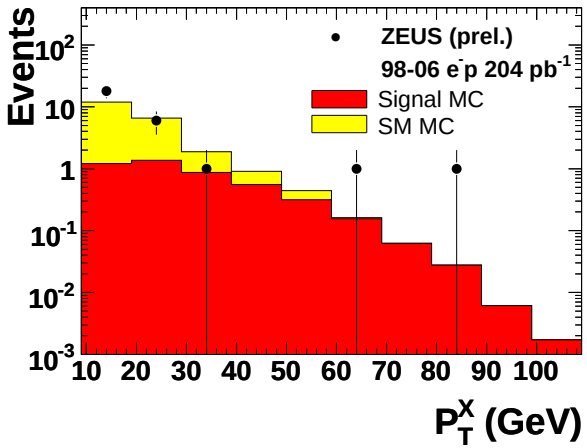
Preselection 98-06 $e^- p$ muon-channel

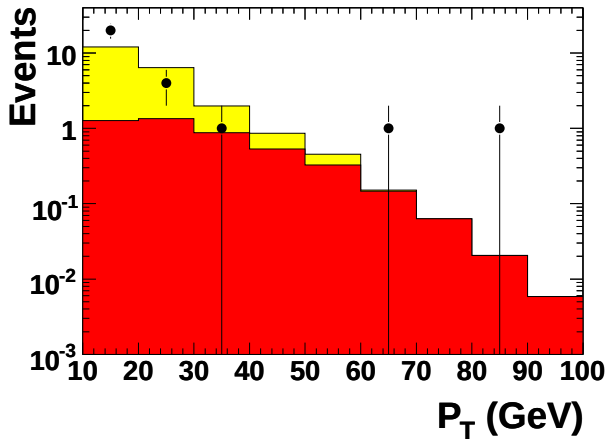












Final selection

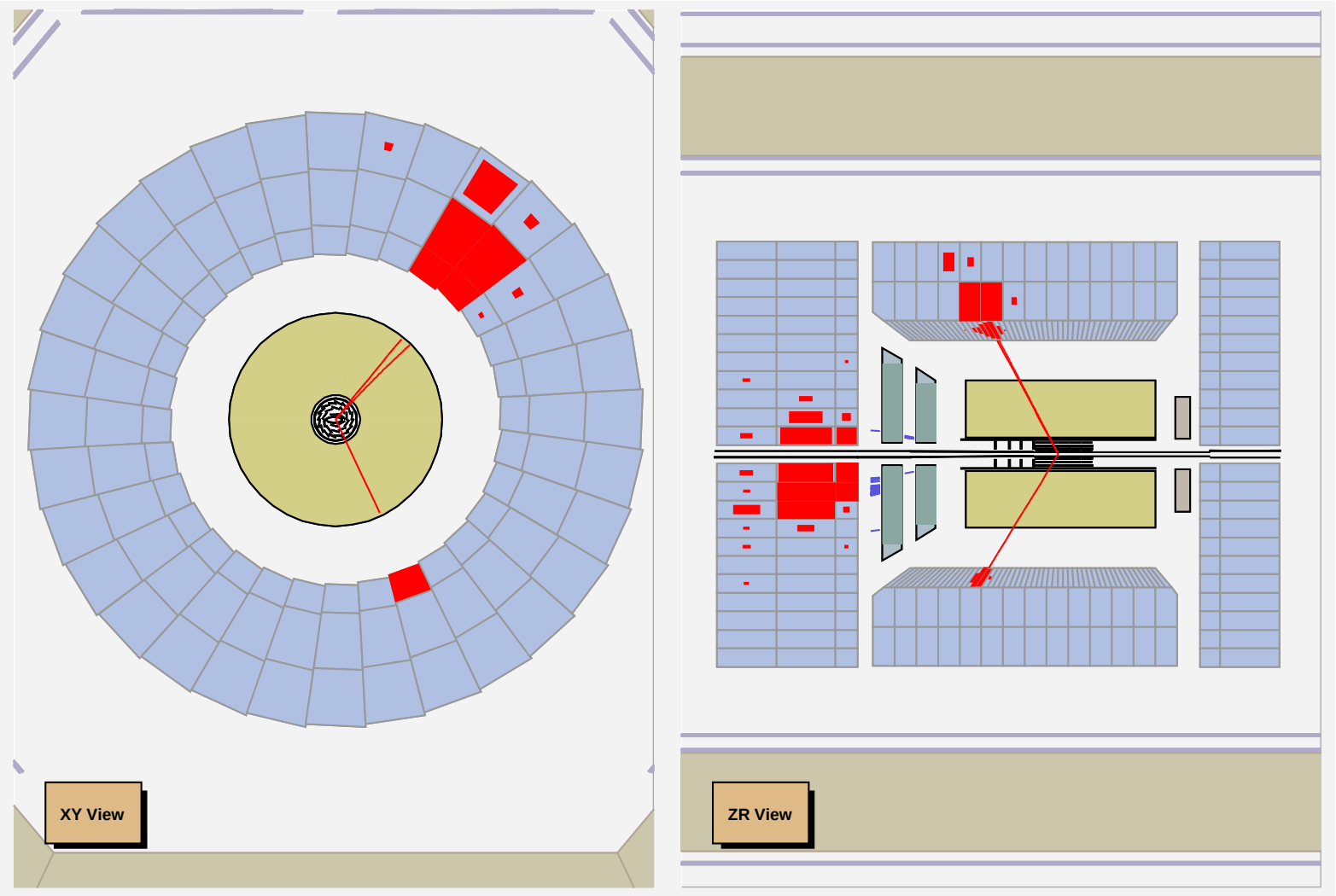
Electron final selection:

- $\delta < 50$ GeV
- $\phi_{\mathrm{acop}} > 0.3$ for $P_T^X > 4$ GeV
- $Q_e^2 > 5000$ GeV^2 OR $P_T^{\mathrm{tot}} > 25$ GeV
- $p_T^{e,\mathrm{trk}} > 5$ GeV
- $p_T^e > 10$ GeV

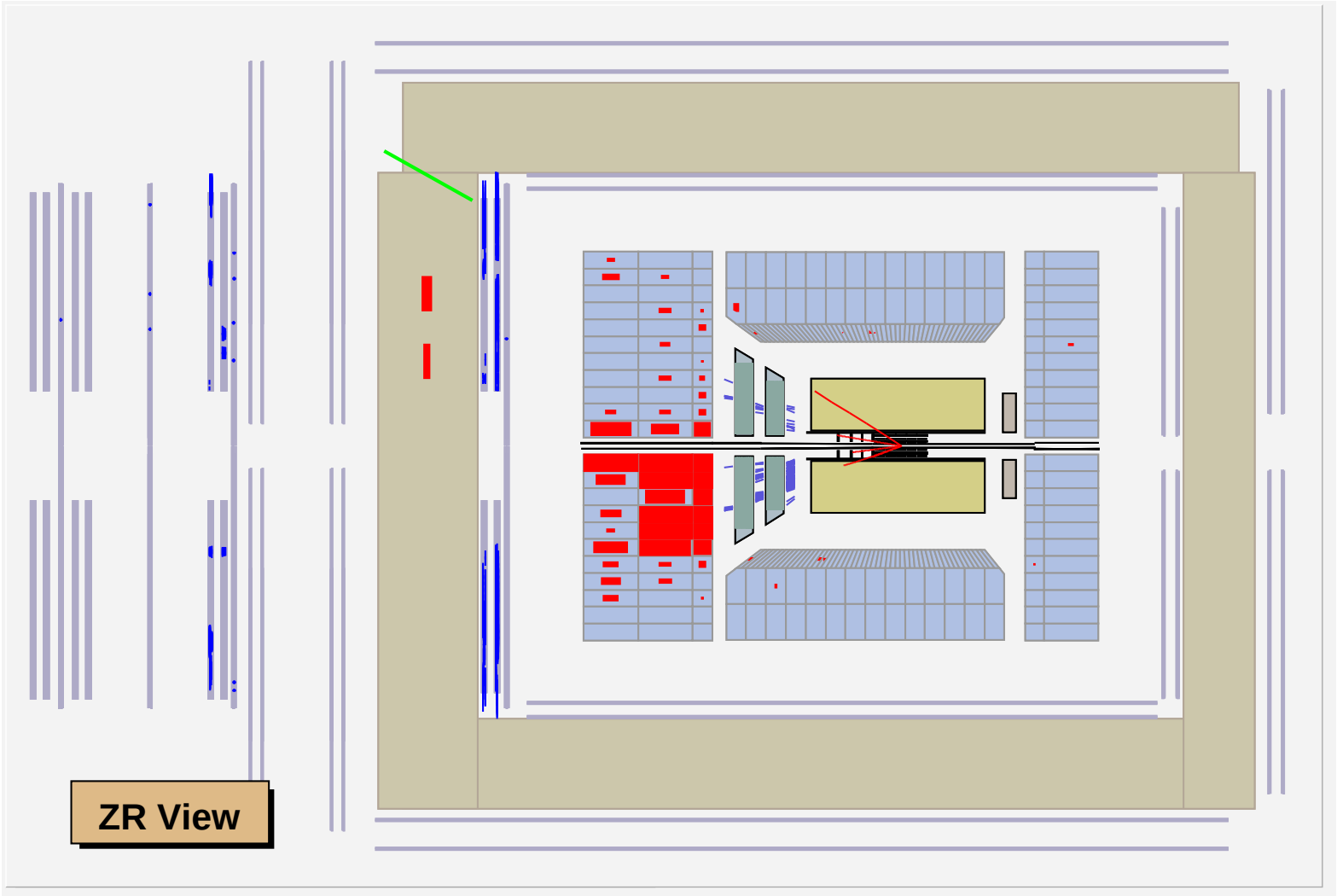
Muon final selection:

- $\phi_{\mathrm{acop}} > 0.2$ rad
- $P_T^X > 12$ GeV.
- $P_T^{\mathrm{miss}} > 12$ GeV

Isolated electron $P_T^X = 20$ GeV ($P_T = 35$ GeV, $P_T^l = 48$ GeV)



Isolated muon $P_T^X = 82$ GeV ($P_T = 77$ GeV, $P_T^l = 37$ GeV)



Summary tables I

Isolated e	$12 < p_T^X < 25$ **GeV**	$p_T^X > 25$ **GeV**
ZEUS (prel.) 98-06 $e^- p$ (204 pb^{-1})	**6**/2.9 ± 0.5 (56%)	**5**/3.8 ± 0.6 (55%)
ZEUS (prel.) 96-06 $e^+ p$ (228 pb^{-1})	**4**/2.8 ± 0.5 (63%)	**1**/3.2 ± 0.4 (75%)
ZEUS (prel.) 96-06 $e^\pm p$ (432 pb^{-1})	**10**/5.7 ± 0.7 (60%)	**6**/7.0 ± 0.7 (64%)

Isolated μ	$12 < p_T^X < 25$ **GeV**	$p_T^X > 25$ **GeV**
ZEUS (prel.) 98-06 $e^- p$ (204 pb^{-1})	**2**/2.2 ± 0.3 (68%)	**2**/2.2 ± 0.3 (86%)
ZEUS (prel.) 96-06 $e^+ p$ (228 pb^{-1})	**3**/2.6 ± 0.5 (68%)	**3**/3.1 ± 0.5 (80%)
ZEUS (prel.) 96-06 $e^\pm p$ (432 pb^{-1})	**5**/4.8 ± 0.5 (68%)	**5**/5.3 ± 0.6 (82%)

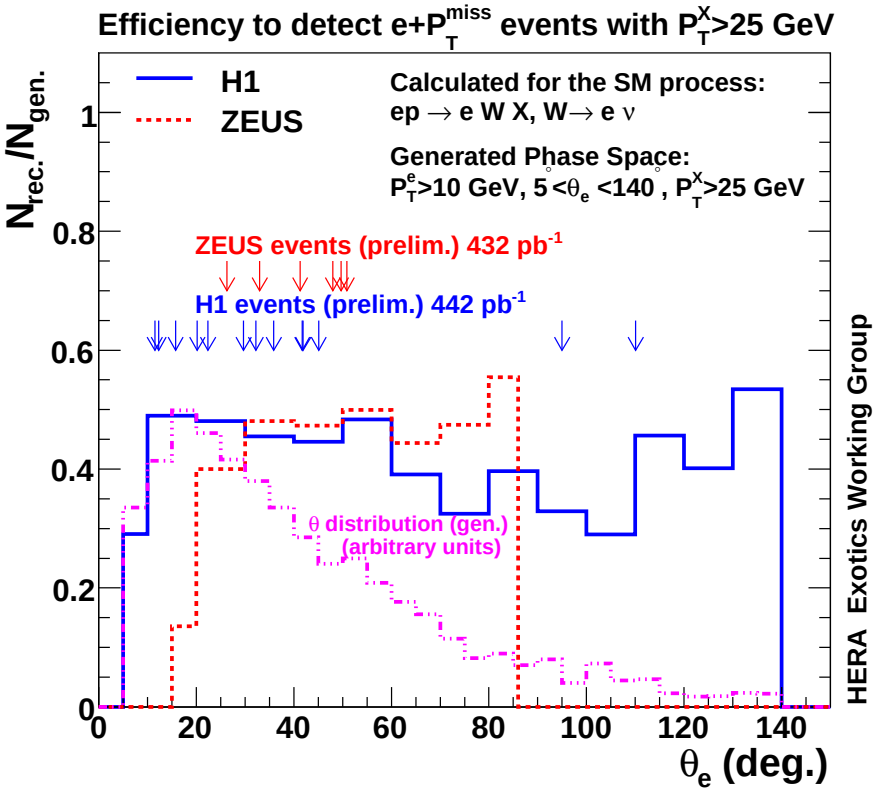
Summary tables II

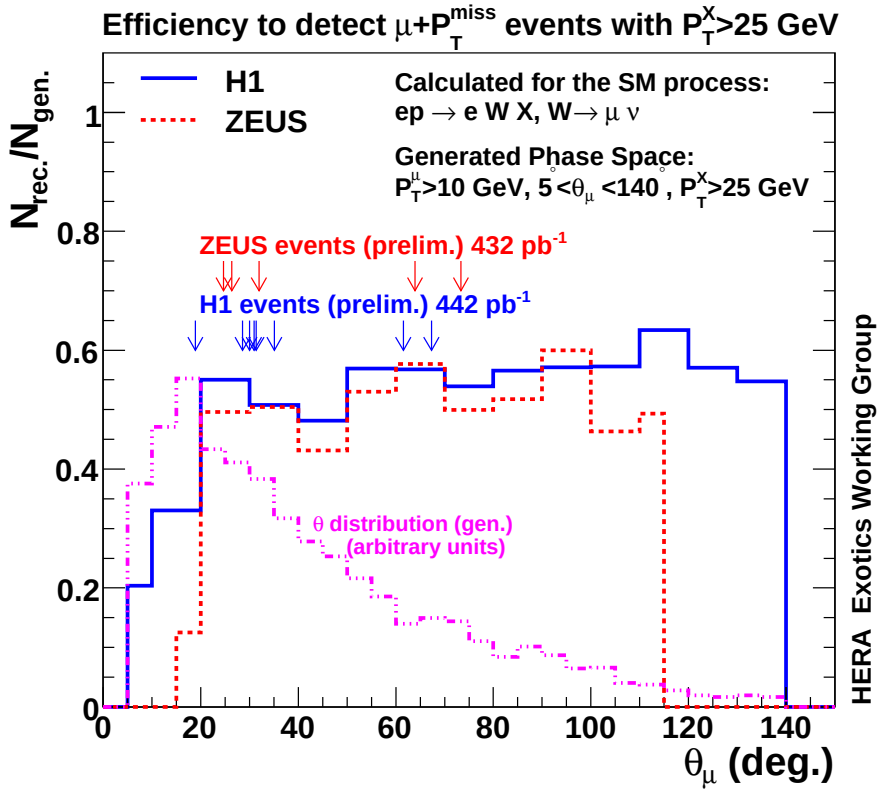
ZEUS $P_T^X > 25$ GeV	e channel obs./exp. (signal)	μ channel obs./exp. (signal)	e and μ obs./exp. (signal)
$e^- p$ 204 pb^{-1}	$5/3.8 \pm 0.6$ (55%)	$2/2.2 \pm 0.3$ (68%)	$7/6.0 \pm 0.7$ (60%)
$e^+ p$ 228 pb^{-1}	$1/3.2 \pm 0.4$ (75%)	$3/3.1 \pm 0.5$ (80%)	$4/6.3 \pm 0.6$ (77%)

H1 Preliminary $P_T^X > 25$ GeV	e channel obs./exp. (signal)	μ channel obs./exp. (signal)	e and μ obs./exp. (signal)
$e^- p$ 184 pb^{-1}	$3/3.8 \pm 0.6$ (61%)	$0/3.1 \pm 0.5$ (74%)	$3/6.9 \pm 1.0$ (67%)
$e^+ p$ 258 pb^{-1}	$10/4.1 \pm 0.8$ (75%)	$8/3.7 \pm 0.6$ (85%)	$18/7.8 \pm 1.3$ (80%)

Excess observed by H1 cannot be confirmed by ZEUS.

H1 & ZEUS acceptance

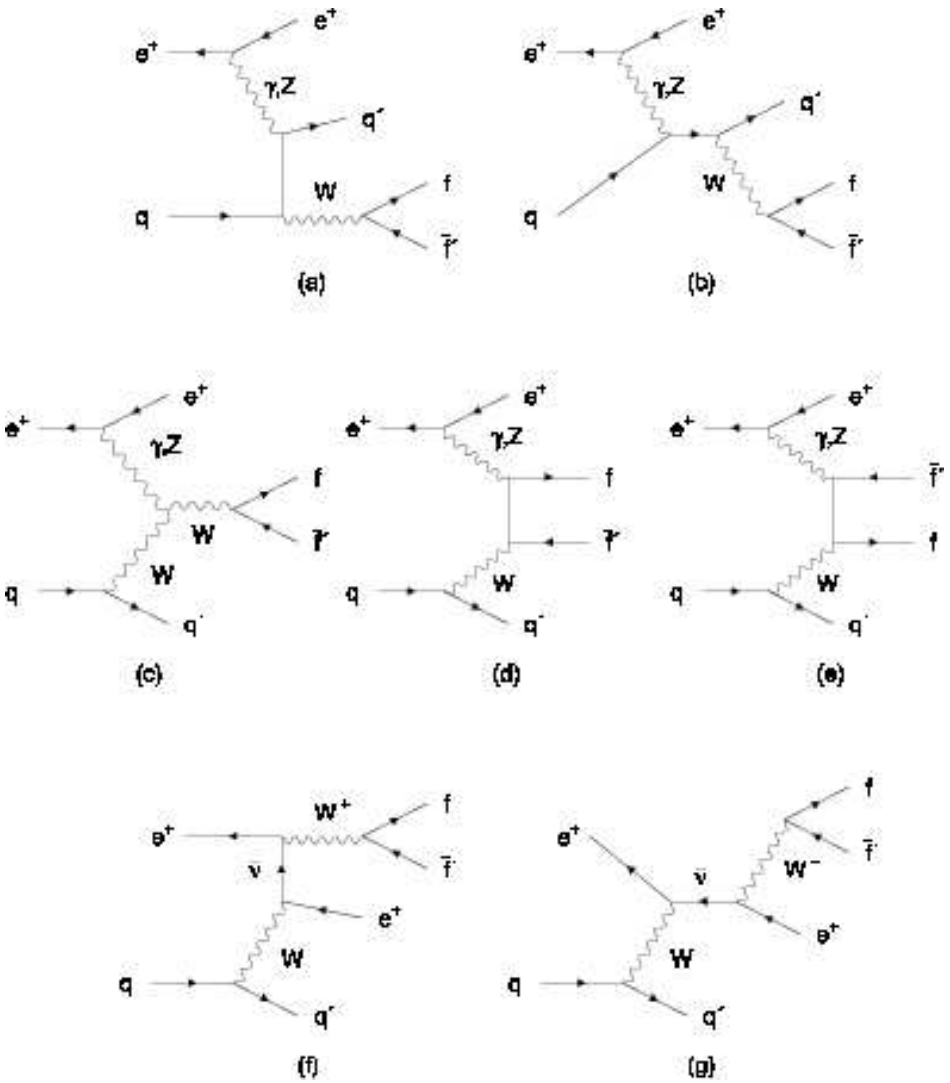




Conclusions

- Previously H1 has observed an excess of isolated leptons at high P_T^X
- A possible source could be a BSM FCNC coupling.
- ZEUS conducted search for isolated leptons
- Analysed 432 pb^{-1} data from 96-07
- Excess observed by H1 is not confirmed by ZEUS

LO Feynman diagrams for Single W production



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8 LO Diagrams in EPVEC:

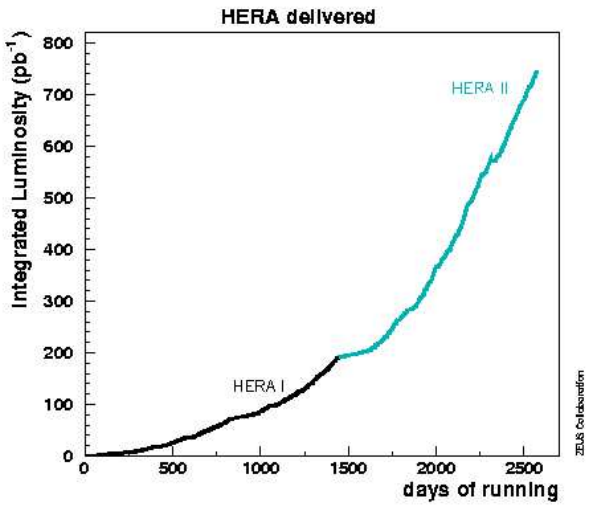
- (a) and (b) dominant diagrams
- (c) involves TGC
- (d) and (e) EM gauge invariance
- (f) and (g) suppressed (2^{nd} W)

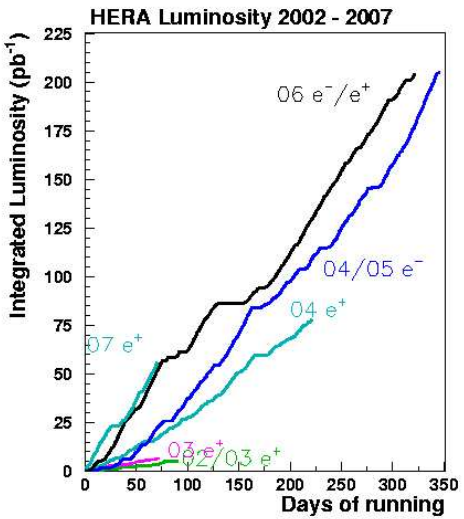
CC diagrams are similar but σ order of magnitude lower

2 run phases (each with e^+ and e^- on p)

- HERA I: 93 - 00
  ZEUS $\mathcal{L} \sim 130\ \mathrm{pb}^{-1}$

HERA II: 02 - 07
ZEUS $\mathcal{L} \sim 300\ \mathrm{pb}^{-1}$





Major upgrade of ZEUS between run phases in 2000:

- Inserted vertex detector & better forward tracker
- Higher luminosity $\longrightarrow$ benefits search for rare decays

Electron selection

General:

- CTD only tracking (Hera 1)
- Calorimeter timing cuts (not applied to MC)
- Events with only back-to-back muon tracks rejected.
- $n_{\rm trk}^{\rm vtx} > 0.2 \times (n_{\rm trk} - 20)$
- $|Z_{\rm vtx}| < 50$ cm
- $5 <$ corrected $\delta < 60$ GeV
- $P_T^{\rm tot,corr} > 12$ GeV
- P_T excl. inner ring > 9 GeV
- $M_T > 10$ GeV

Final selection:

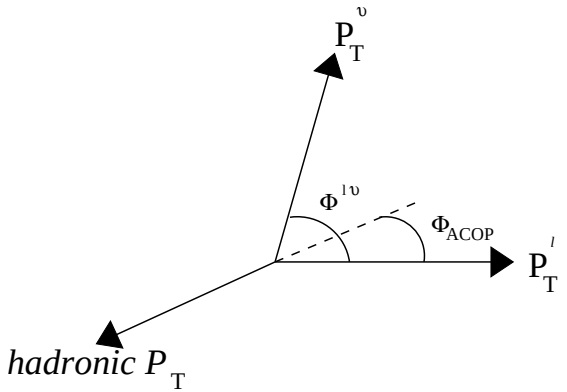
- $\delta < 50$ GeV
- $\phi_{\rm acop} > 0.3$ for $P_T^X > 4$ GeV
- $Q_e^2 > 5000$ GeV^2 OR $P_T^{\rm tot} > 25$ GeV
- $p_T^{e,{\rm trk}} > 5$ GeV
- $p_T^e > 10$ GeV

EM electron:

- Energy corrected using EMcorr3.
- $E_{\rm corr}^e > 8$ GeV
- DCA < 10 cm
- $E_{\rm ncone} < 4$ GeV, cone radius 0.8
- $p_T^e > 5$ GeV
- $\theta < 2$ rad
- trk iso to prim vtx trks > 0.5 $\{\eta, \phi\}$

Hera II (in addition to above):

- REG tracking
- Track passes superlayer 3.



Muon selection

Trigger:

- DST 34
- FLT 60
- SLT EXO 04
- TLT EXO 02 or EXO 06

Cosmic & beam-gas:

- Cosmic back-to-back rejection
- CAL timing cuts (not applied to MC)
- $n_{\rm trk}^{\rm vtx} > 0.2 \times (n_{\rm trk} - 20)$

Other cuts on event:

- $\delta < 70$ GeV.
- $|Z_{\rm vtx}| < 50$
- P_T excl. inner ring > 9 GeV
- hadronic $P_T > 9$ GeV
- $P_T^{\rm corr} > 12$ GeV (Cor&Cut total CAL mom.)
- $M_T > 5$ GeV
- Only one muon with: $P_T > 1$ GeV quality > 0 found by MV with MV probability > 0.6 (new)

Cuts on isolated muon:

- found by MV with prob. > 0.6
- prim. vtx. track
- $p_T^\mu > 10$ GeV (from track)
- $\theta < 2$ rad
- quality ≥ 0
- Track isolated by 0.5 in $\{\eta, \phi\}$ from other primary vtx tracks with $p_{\rm T} > 0.2$ GeV from jets candidates with: $E_{\rm jet} > 5$ GeV $|\eta_{\rm jet}| < 3.0$

Final selection:

- $\phi_{\rm acop} > 0.2$ rad
- $P_T^X > 12$ GeV.
- $P_T^{\rm miss} > 12$ GeV