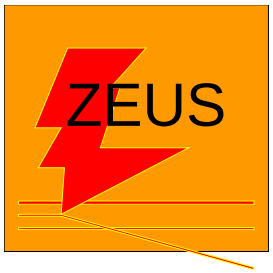


Damir Lelas

Isolated τ leptons in events with large missing P_T at ZEUS

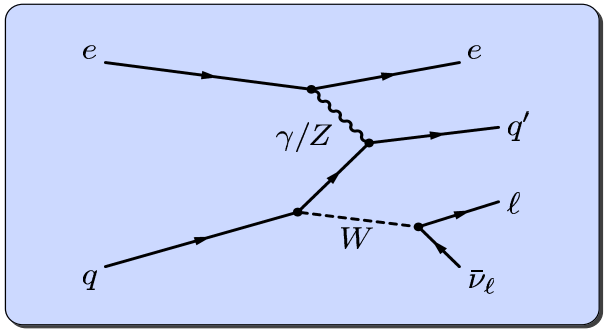
for the ZEUS Collaboration

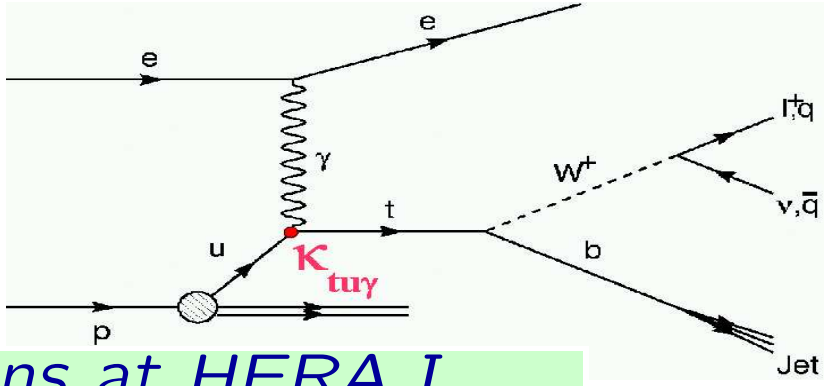
DIS 2003, St. Petersburg

25. April 2003

- Motivation
- Analysis description
- τ identification method
- Results
- Summary

Motivation





Isolated Leptons at HERA I

H1 94-00 e^+p (104.7 pb^{-1})	**Electron** obs./exp. (W)	**Muon** obs./exp. (W)
$25 < P_T^X < 40$ GeV	1 / 0.95 ± 0.14 (0.82)	3 / 0.89 ± 0.14 (0.77)
$P_T^X > 40$ GeV	3 / 0.54 ± 0.11 (0.45)	3 / 0.55 ± 0.12 (0.51)

ZEUS 94-00 $e^\pm$p (130.1 pb^{-1})	**Electron** obs./exp. (W)	**Muon** obs./exp. (W)
$P_T^X > 25$ GeV	2 / $2.90^{+0.59}_{-0.32}$ (45%)	5 / $2.75^{+0.21}_{-0.21}$ (50%)
$P_T^X > 40$ GeV	0 / $0.94^{+0.11}_{-0.10}$ (61%)	0 / $0.95^{+0.14}_{-0.10}$ (61%)

H1 sees excess, ZEUS compatible with the SM

the is to look in the τ channel !!

Isolated Leptons: Event Selection

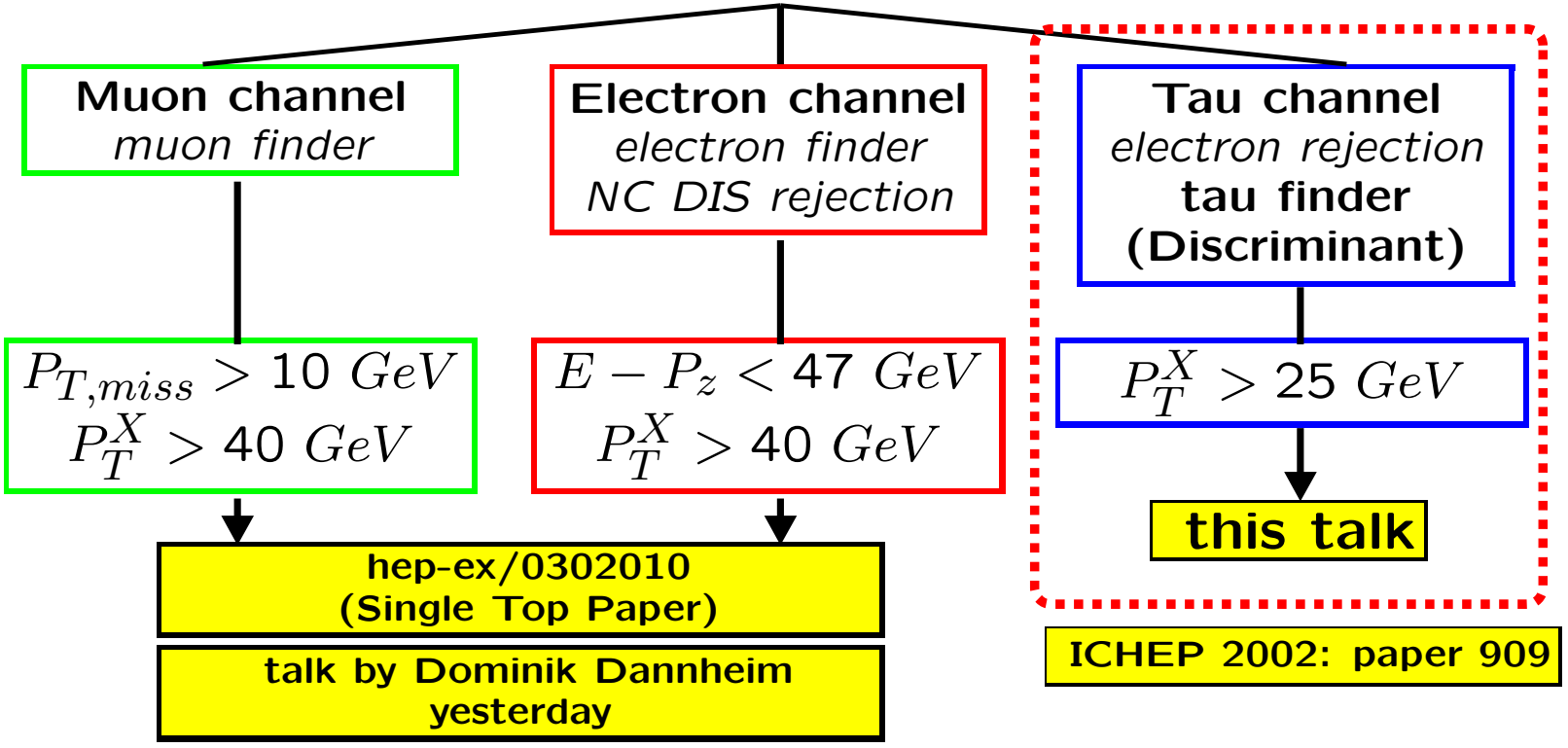
1.) Selection of isolated tracks:

- **Cleaning cuts on vtx, timing, track pattern**
- $P_T^{CAL} > 20 GeV$
- **Hadronic jet with** $E_T > 5GeV$, $\theta > 10^\circ$
- **Track with** $P_T > 5GeV$, **3 radial SL**, $\theta < 114^\circ$
- **Track isolation w.r.t. other tracks/jets:**

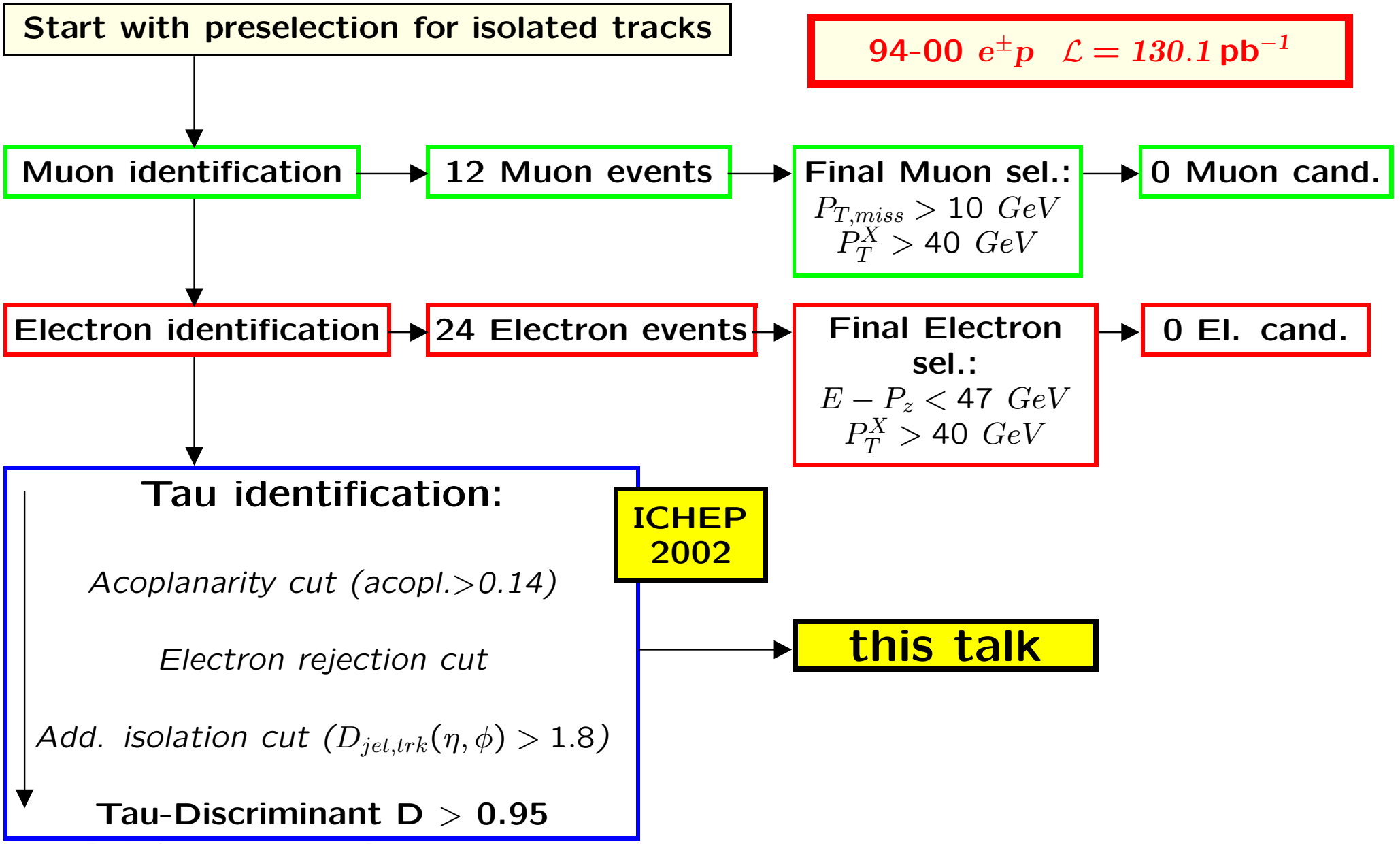
  $D_{trk}(\eta, \phi) > 0.5$ **and** $D_{jet}(\eta, \phi) > 1.0$ *(longit. inv. k_T cluster algorithm)*

2.) Lepton identification:

3.) Final Selection:



Isolated Leptons: Candidates found



τ identification: Description

- Search for hadronic τ decays (65 % branching ratio) (predominantly in one charged hadron)
- Aim: separate τ induced jets from QCD jets
- τ jets are collimated (pencil-like) with low charged particle multiplicity and charge $\pm$ 1
- Prev. τ finding at ZEUS: LFV (PR D65 (2002) 092004)

τ identification: Description

Multiobservable Discrimination Technique

- Select MC samples:

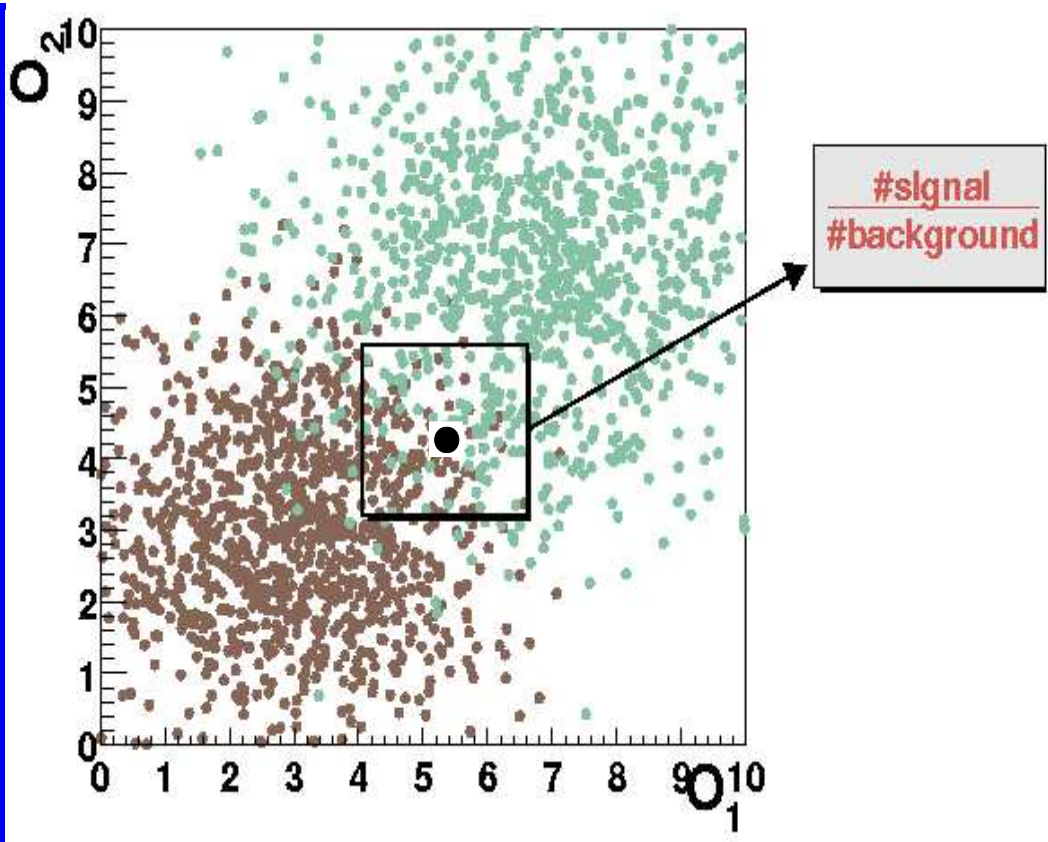
  signal: W$\rightarrow \nu\tau$, 214k events

  background: CC DIS, 450k events

- Select 6 jet shape observables
- For each event to be classified calculate, in a 6-dim. box with fixed size, the No. of signal and background events. Calc. the discriminant:

  $$D = N_{signal}/(N_{BG} + N_{signal})$$

- Tricky points: enough statistics, box size
- *hep-ex/0211019* for more about multiobservable discrimination technique



Sketch of the 2-dim. phase space (say, green→sig. and brown→bg.)

τ identification: Jet shape observables entering D

- **The first and the second moment of the radial extension of the jet energy deposition:**

$$rmean = \langle R \rangle = \frac{\sum_{icell} E_i \cdot R_i}{\sum_{icell} E_i}; \qquad rrms = \sqrt{\frac{\sum_{icell} E_i (\langle R \rangle - R_i)^2}{\sum_{icell} E_i}}$$

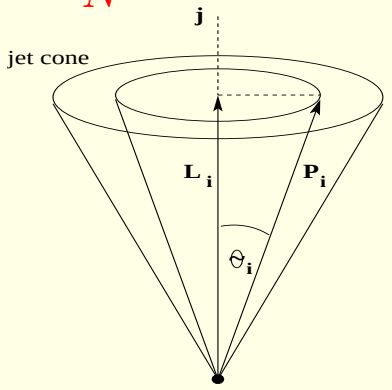
$E_i \rightarrow$ *energy of the calorimeter cell i*

$R_i = \sqrt{\Delta\phi_i^2 + \Delta\eta_i^2} \rightarrow (\eta, \phi)$ *distance between cell i and jet axis*

- **The first and the second moment of the projection of the energy depositions on the jet axis:**

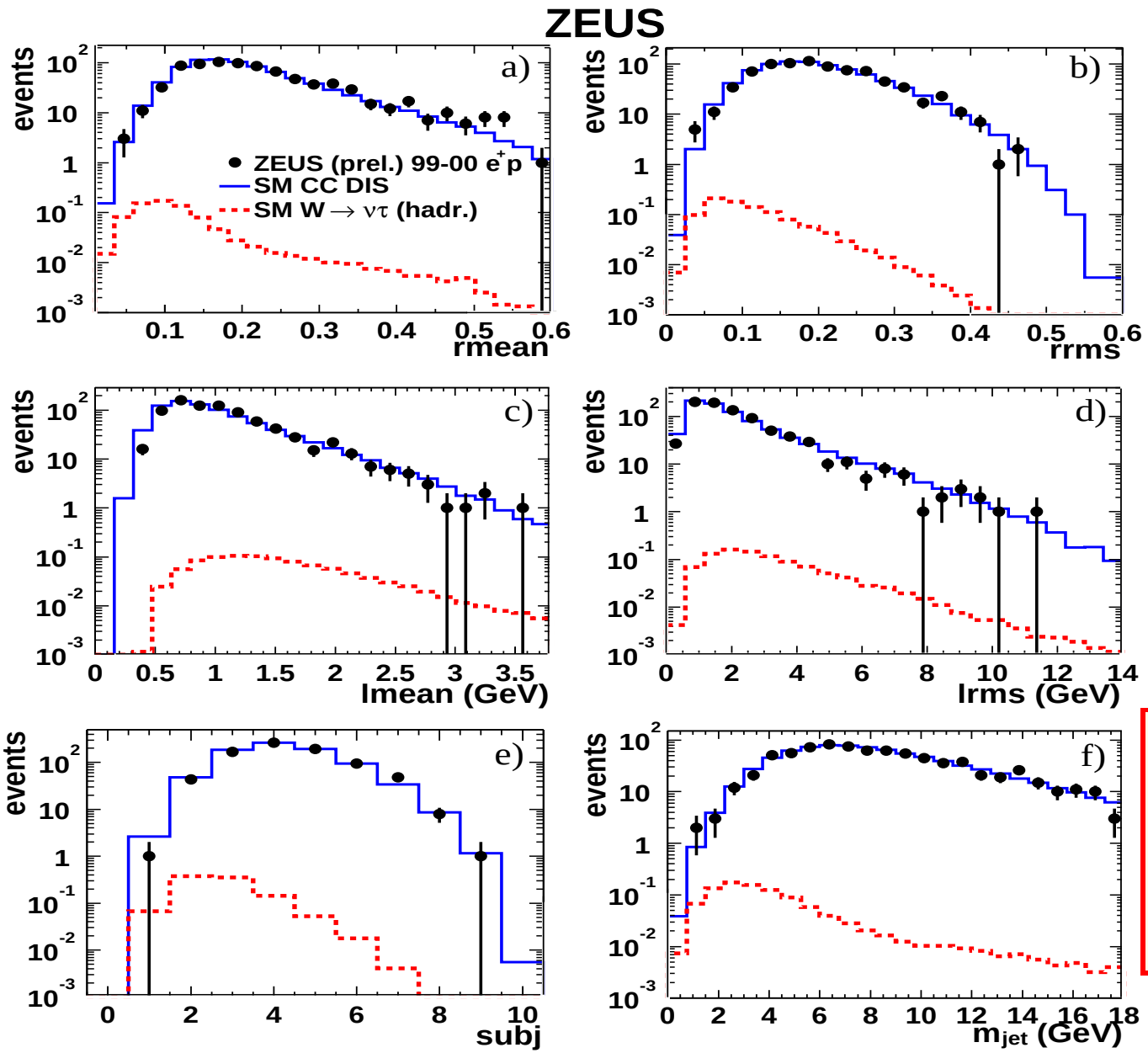
$$lmean = \langle L \rangle = \frac{\sum_{icell} L_i}{N}; \qquad lrms = \sqrt{\frac{\sum_{icell} (\langle L \rangle - L_i)^2}{N}}$$

$L_i = p_i \cdot cos\theta_i$ *(see the scatch);* $N \rightarrow$ *number of cal. cells*



- **The subjet multiplicity** ($y_{cut} = 5 \cdot 10^{-4}$)
- **The jet invariant mass**

τ identification: Jet shape observables entering D



Inclusive CC DIS data selection :

$P_{T,CAL} > 20$ GeV

$E - P_z < 40$ GeV

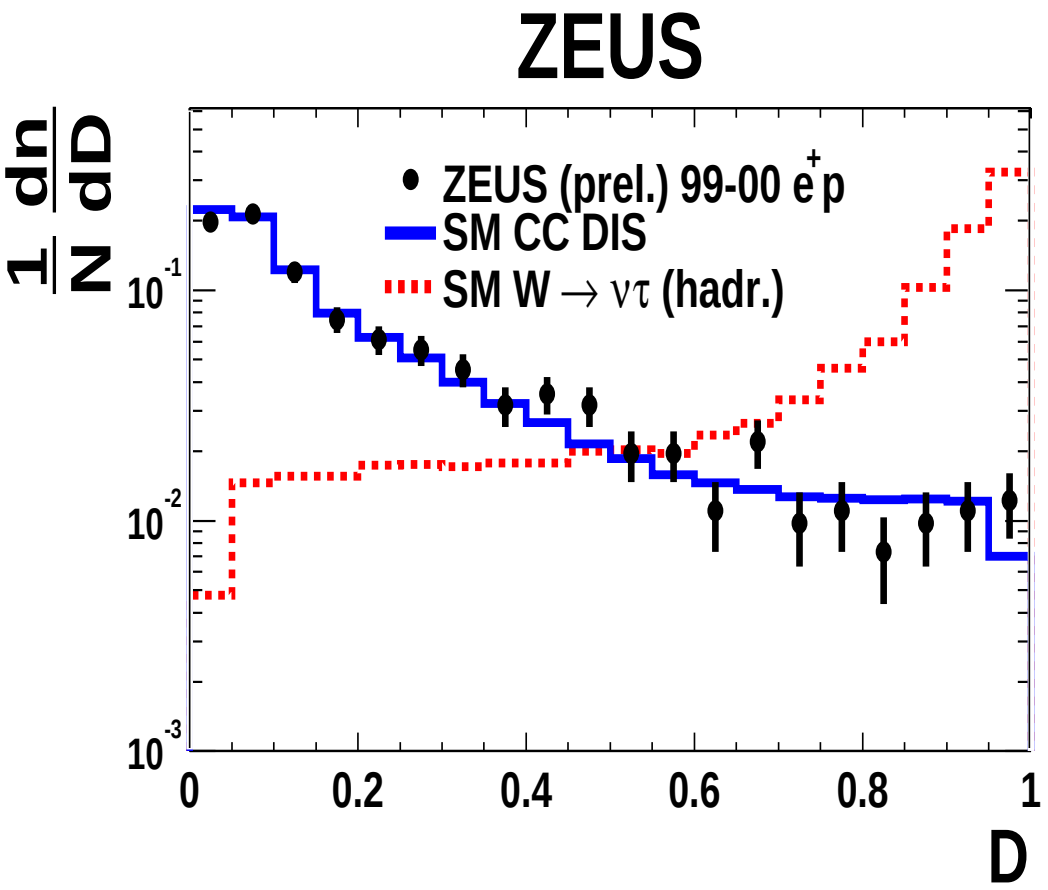
$P_{T,CAL}/E_T > 0.5$

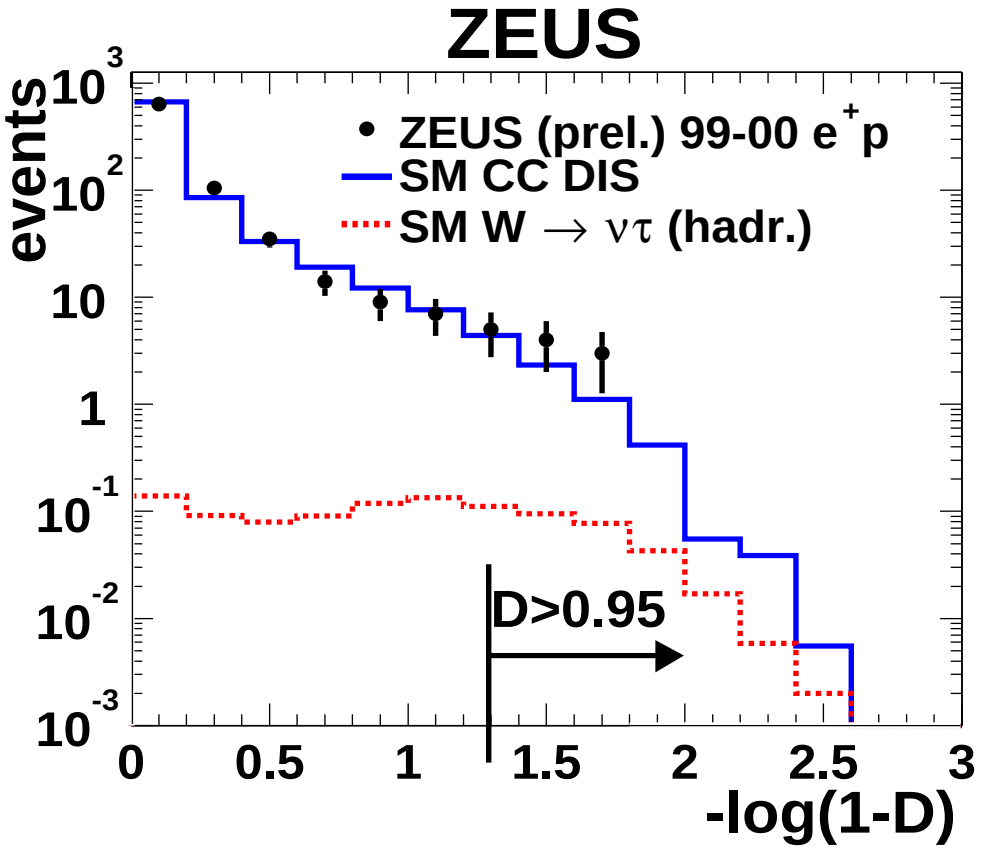
non-ep rejection

electron rejection

Jet observables well described by CC DIS MC (no difference CDM/ MEPS observed)

τ Discriminant





Efficiency: $\epsilon = N_{\tau,sel.}/N_{\tau}$

Rejection: $R = N_{QCD}/N_{QCD,sel.}$

Separation: $S = R \times \epsilon$

Cut on $D > 0.95$:

$\epsilon = 32$ %

$R = 154$

$S = 50$

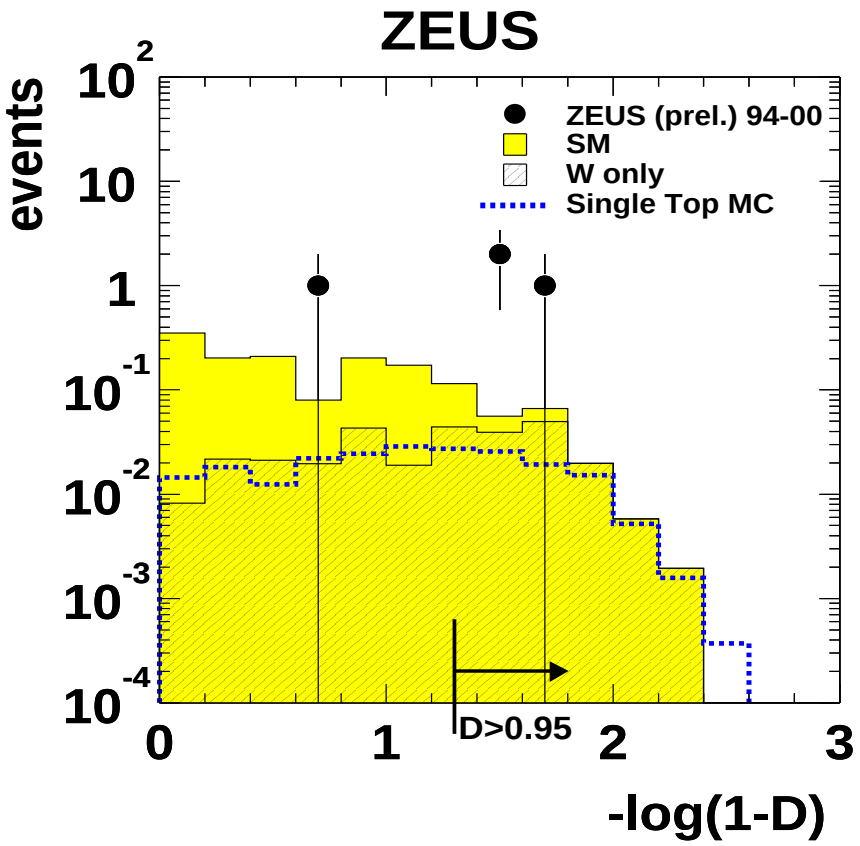
With ntrk=1:

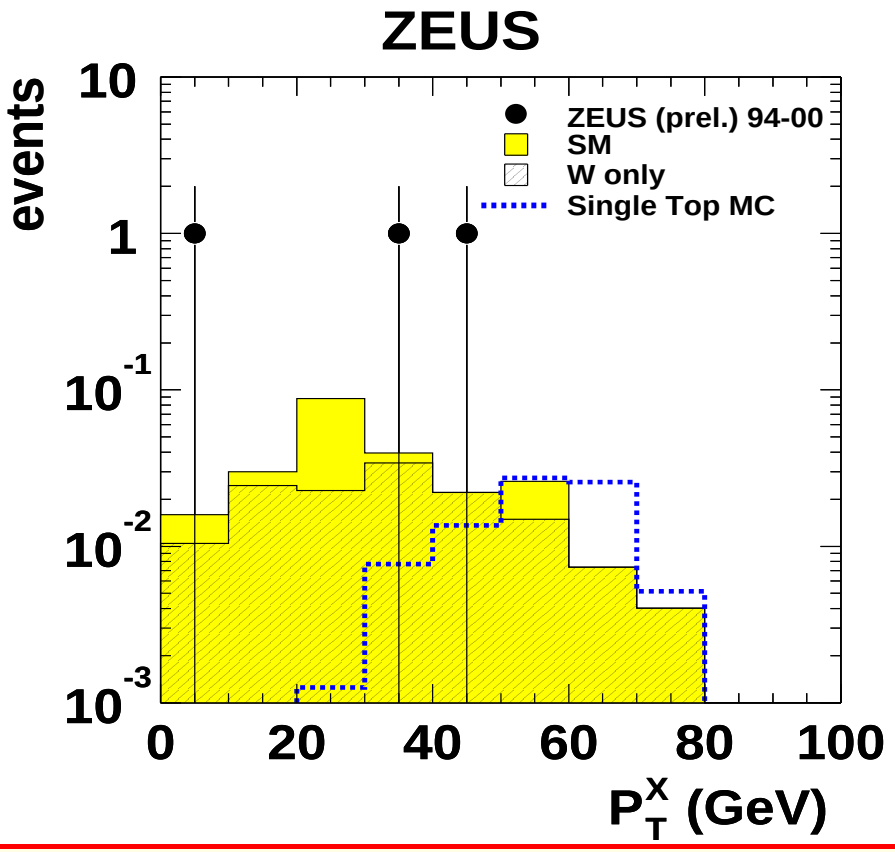
$\epsilon = 24$ %

$R = 561$

$S = 132$

τ lepton candidates

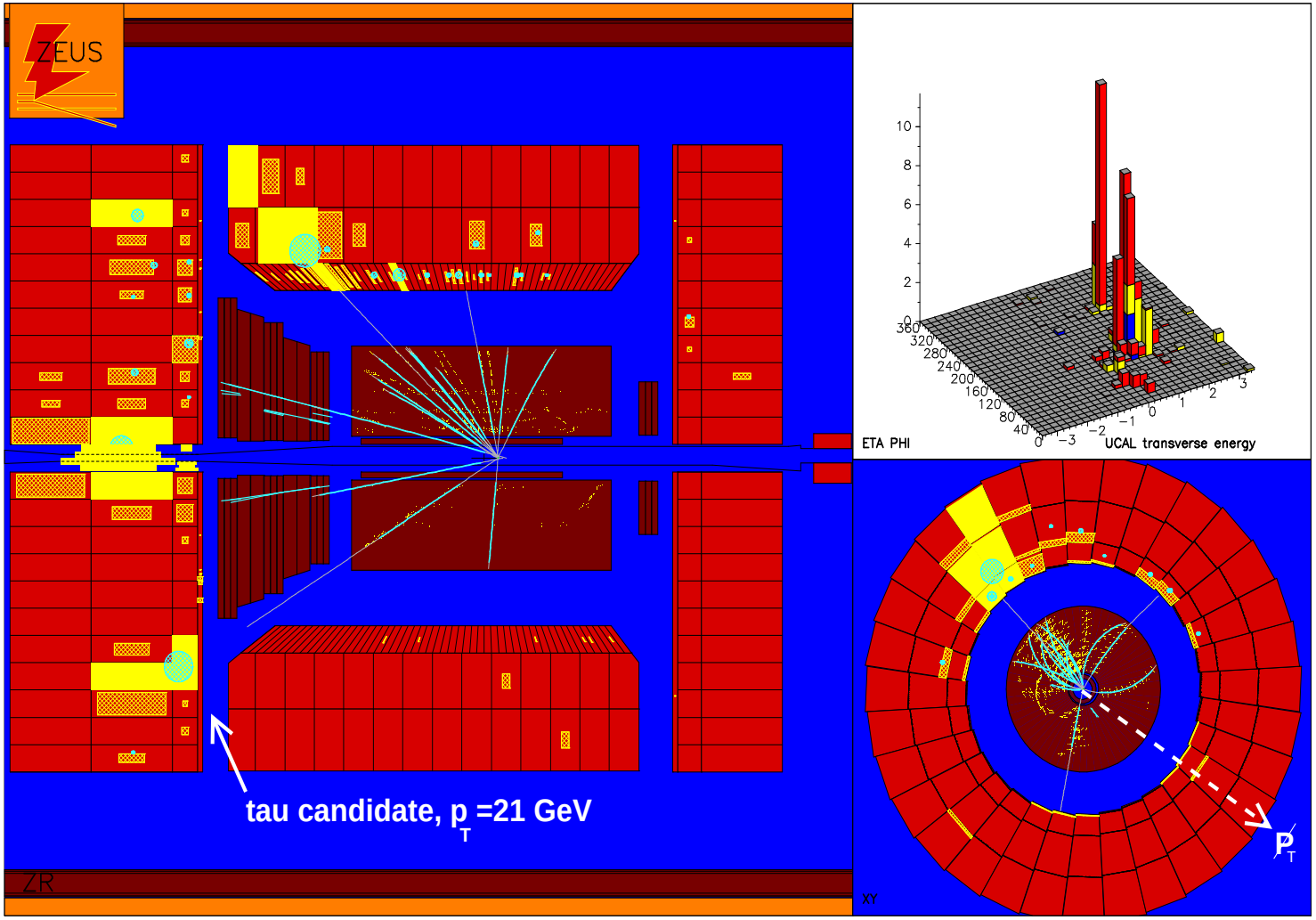




- **3** data events observed with D>0.95
- 0.23 $\pm$ 0.06 events exp. from SM:
  - 0.04 from CC
  - 0.14 from W production
  - 0.06 from PHP

- **2** data events observed with P_T^X >25 GeV
- 0.12 $\pm$ 0.02 events exp. from SM:
  - 0.10 from W production
- Poisson probability $6.4 \cdot 10^{-3}$

τ lepton 1^{st} candidate



$P_{T,CAL} = 37$ GeV

$P_T^X = 48$ GeV

$E - P_z = 30$ GeV

tau-candidate:

$\theta_\tau = 31°$ $\phi_\tau = 256°$

$D_{trk} = 1.48$

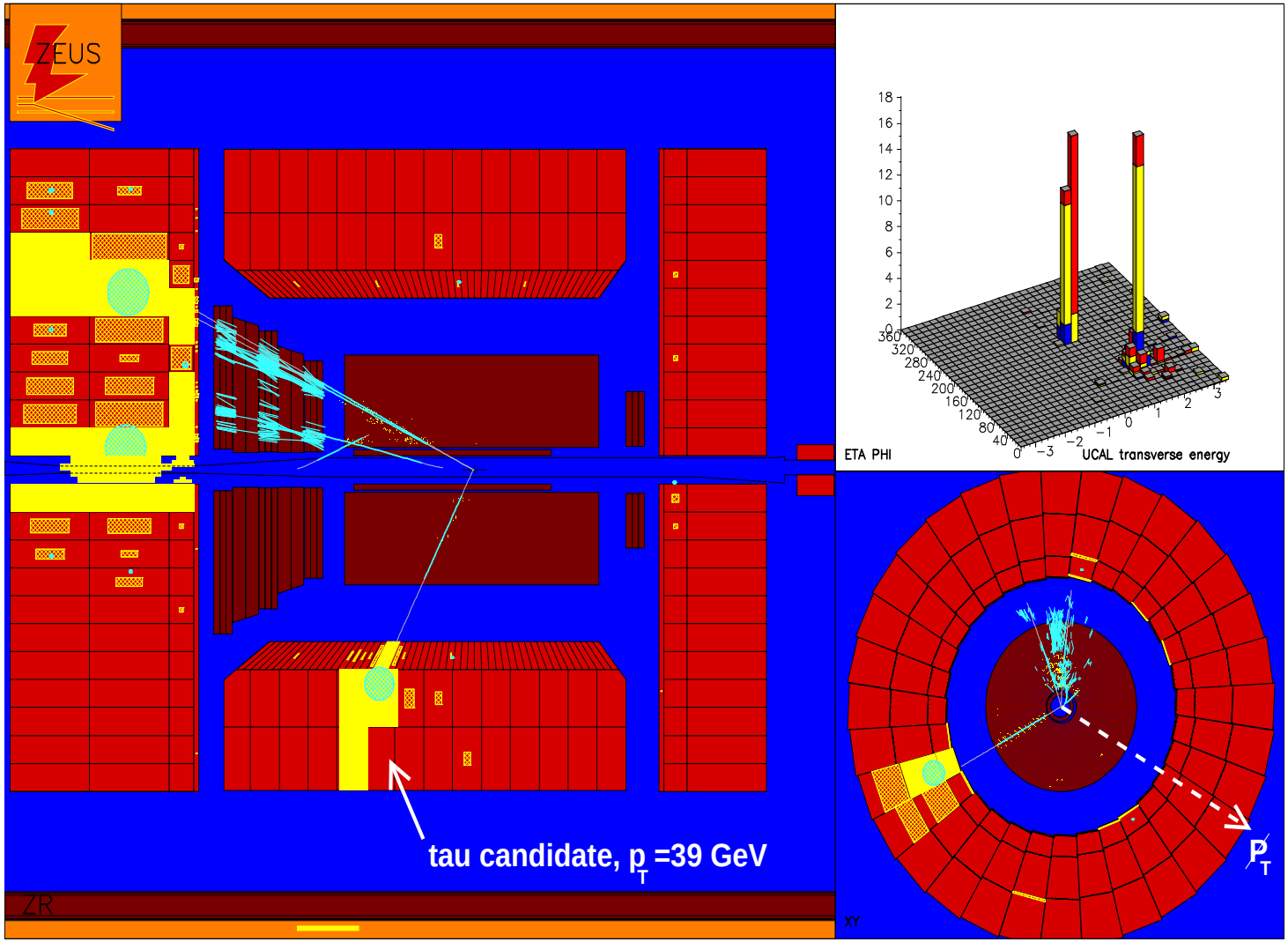
$D_{jet} = 2.24$

$P_{T,\tau,jet} = 20.7$ GeV

$P_{T,\tau,track} = 9.0$ GeV

$M_T = 32$ GeV

τ lepton 2^{nd} candidate



$P_{T,CAL} = 39$ GeV

$P_T^X = 38$ GeV

$E - P_z = 29$ GeV

tau-candidate:

$\theta_\tau = 64°$ $\phi_\tau = 205°$

$D_{trk} = 2.03$

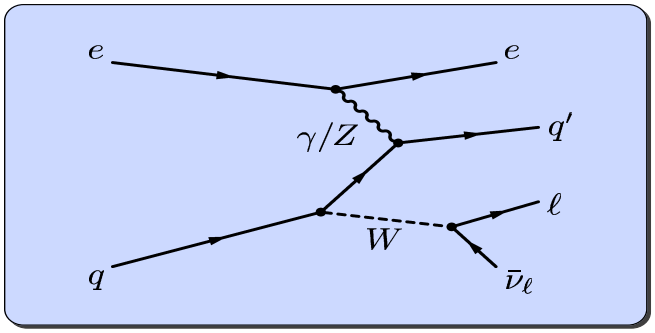
$D_{jet} = 2.23$

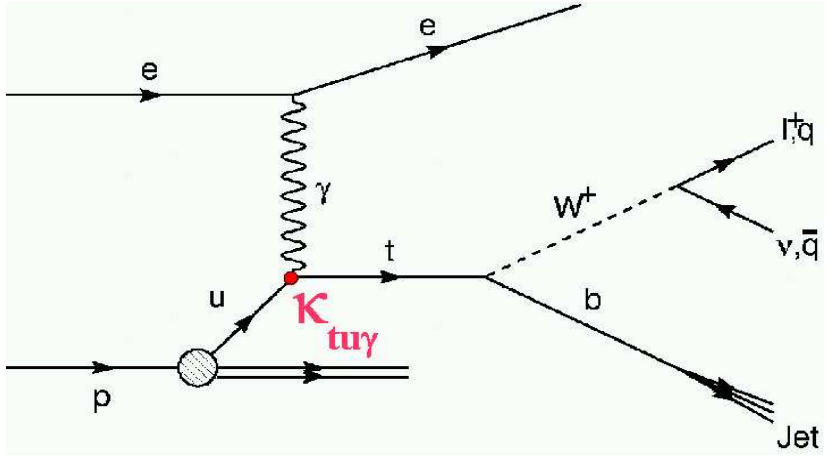
$P_{T,\tau,jet} = 39$ GeV

$P_{T,\tau,track} = 27$ GeV

$M_T = 70$ GeV

ZEUS isolated leptons





ZEUS 1994-2000 $e^{\pm}p$ $\mathcal{L} = 130.1\,\mathrm{pb}^{-1}$	Electron obs./exp. (W)	Muon obs./exp. (W)	Tau obs./exp. (W)
$P_T^{\mathrm{had}} > 25\,\mathrm{GeV}$	$2 / 2.90\ ^{+0.59}_{-0.32}\ (45\%)$	$5 / 2.75\ ^{+0.21}_{-0.21}\ (50\%)$	$2 / 0.12 \pm 0.02\ (0.10)$
$P_T^{\mathrm{had}} > 40\,\mathrm{GeV}$	$0 / 0.94\ ^{+0.11}_{-0.10}\ (61\%)$	$0 / 0.95\ ^{+0.14}_{-0.10}\ (61\%)$	$1 / 0.06 \pm 0.01\ (0.05)$

- **The observed τ events are unlikely to be explained by direct $W^{\pm}$ production**
- **The observed τ events correspond to a cross section for single-top production $\sigma(ep \to etX, \sqrt{s} = 320GeV) \sim 6pb$ which is higher than the excluded cross section of $\sigma < 0.225pb$ at 95% C.L., obtained from elect., muon and hadronic decay channels.**
- **Single-top hypothesis is unlikely to explain the observed τ events.**

Summary

- **ZEUS collaboration has extended search for high P_T Leptons to τ channel**
- **τ finding technique established**
- **2 τ events at high P_T^X ($P_T^X > 25GeV$) found, 0.12 ± 0.02 exp. ($P_{95\%} = 0.64$ %)**
- **If not statistical fluctuation, difficult to imagine an explanation without breaking lepton universality**
- **HERA "the DIS Goddess" (part II) will tell us much more**