General Analysis of HERA II Data

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H1 Collaboration

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Eidgenössische Technische Hochschule Zürich
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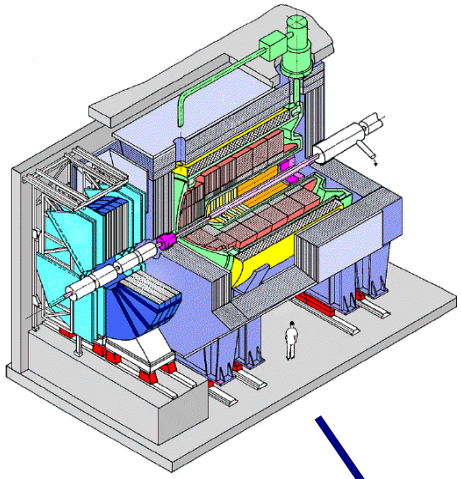
ETH Institute for Particle Physics

EPS Conference, HEP 2007
19-25 July, Manchester, UK

27.5 GeV electron – 920 GeV proton

HERA



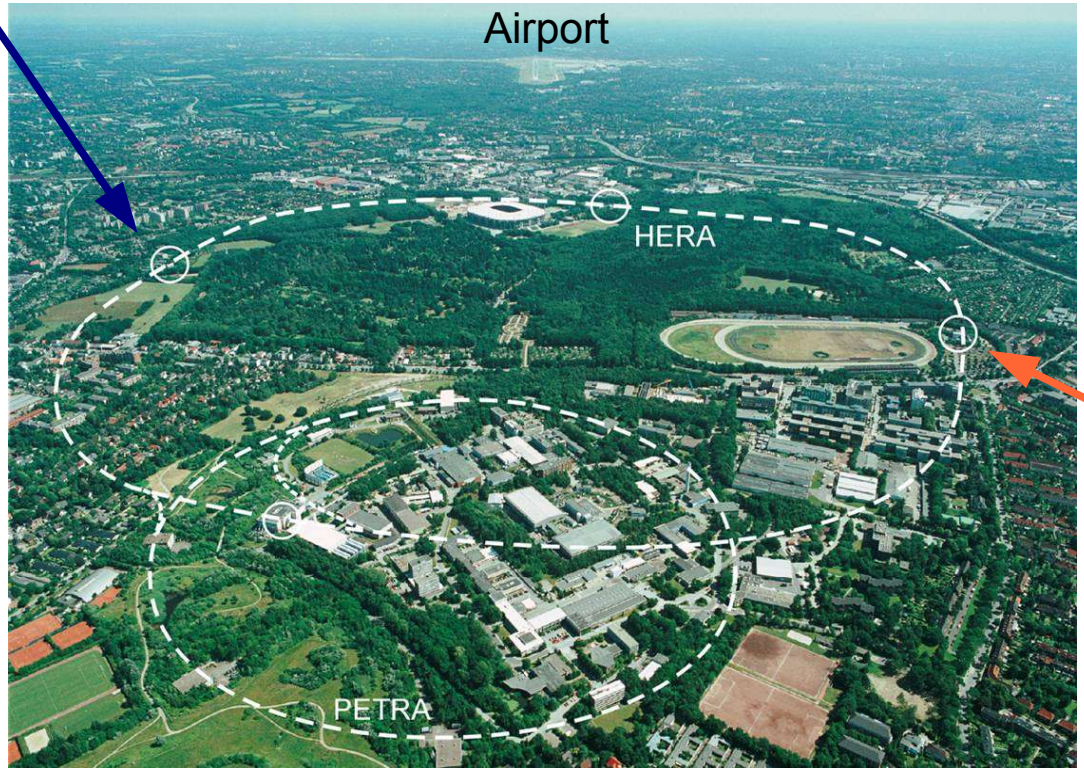
H1

"Hadron-Electron Ring Anlage"

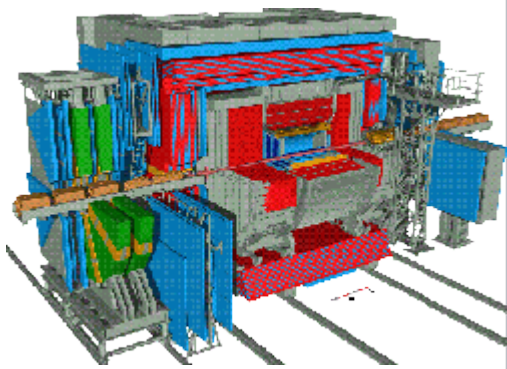
protons: 920 (820) GeV
electrons/positrons: 27.5 GeV

→ cms = 318 (300) GeV

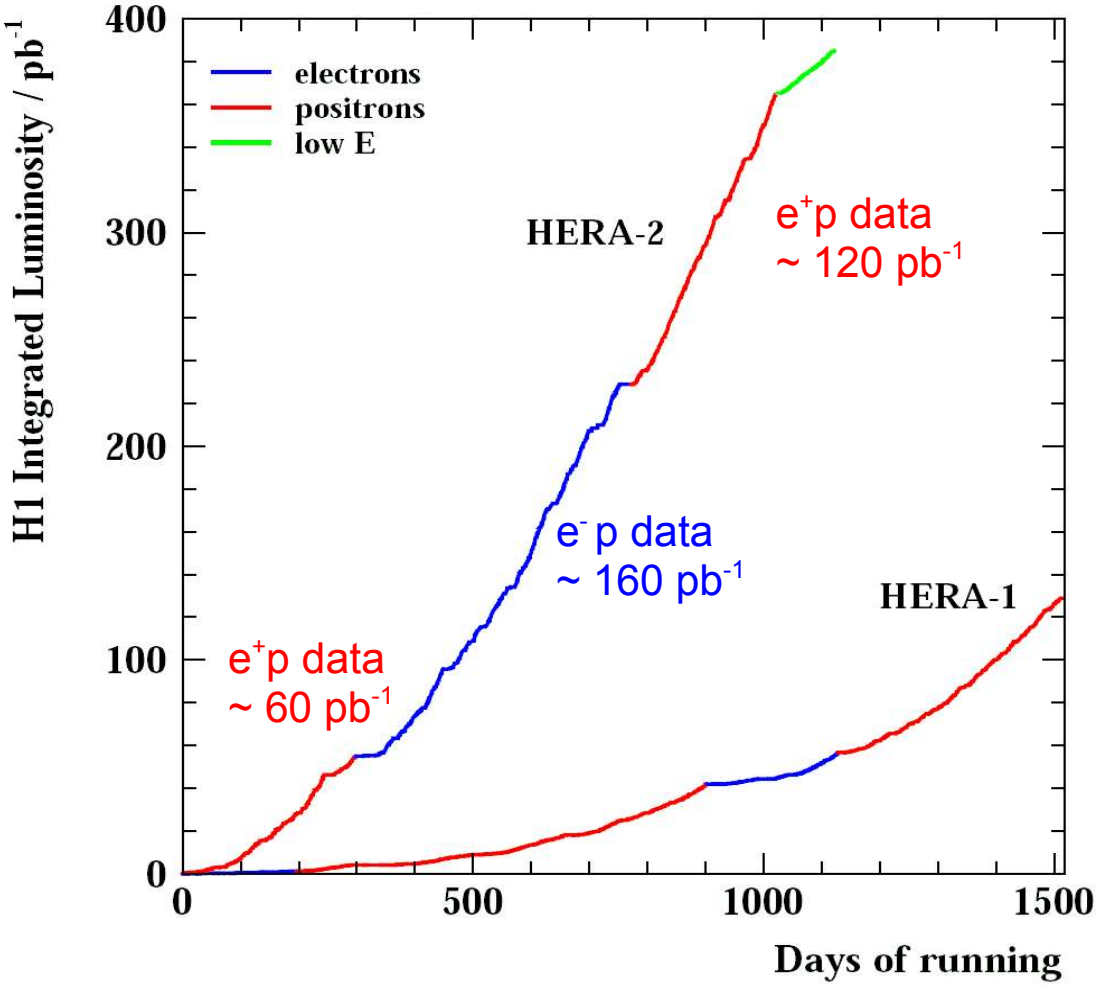
City of Hamburg



ZEUS



HERA I+II Running



HERA II: 2003-2007

- more than three times more lumi than at HERA I
- large e^-p data sample
- longitudinally polarised leptons

new Preliminary analysis:

HERA II: 2003-2007

- e^+p data ~ 178 pb^{-1}
- e^-p data ~ 159 pb^{-1}

previous published analysis (PLB602,p14 2004):

HERA I: 1994-2000

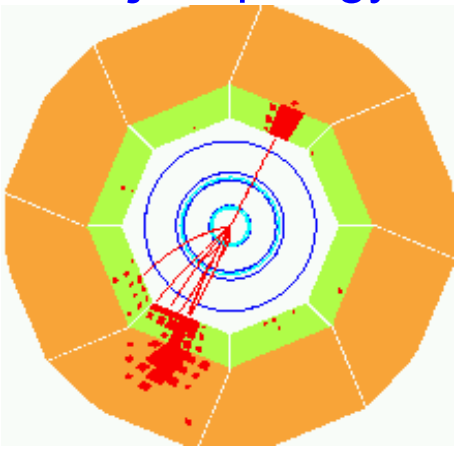
- e^+p data ~ 100 pb^{-1}
- e^-p data ~ 15 pb^{-1}

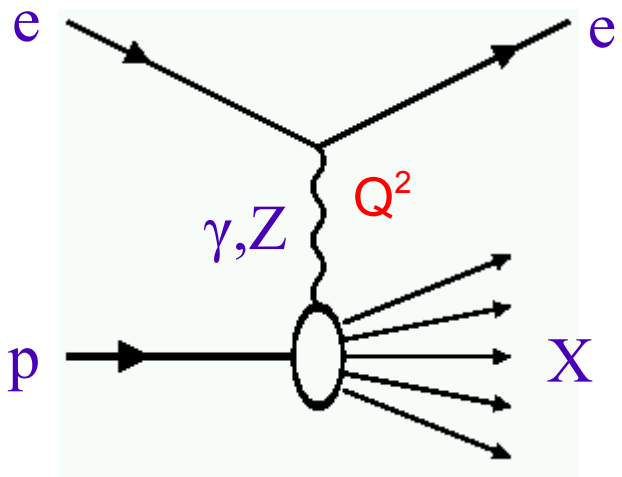
HERA Kinematics + SM Processes

- Dominant processes at high p_T:

NC DIS: $ep \rightarrow eX$

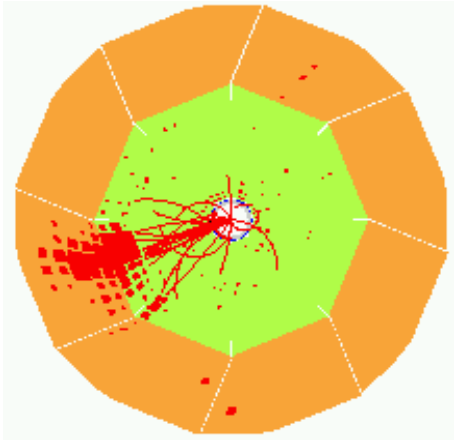
ej - topology

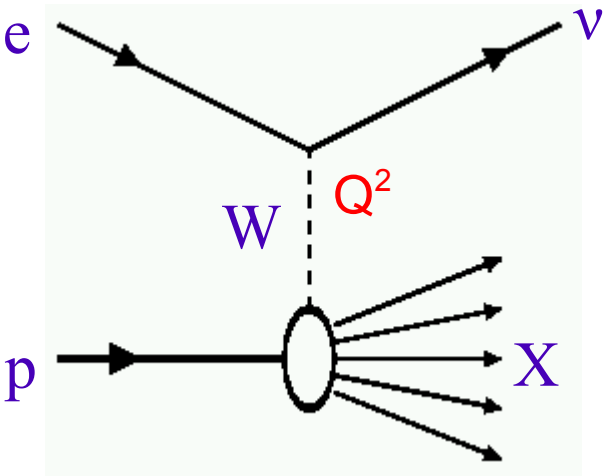




CC DIS: $ep \rightarrow \nu X$

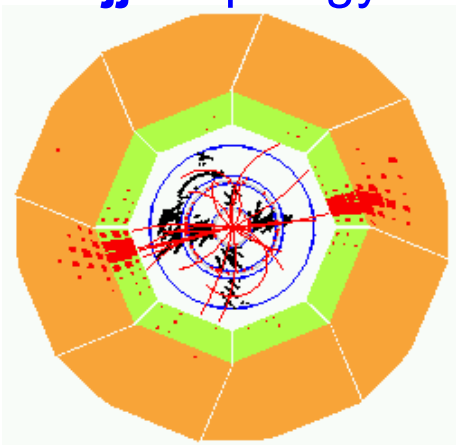
eν - topology

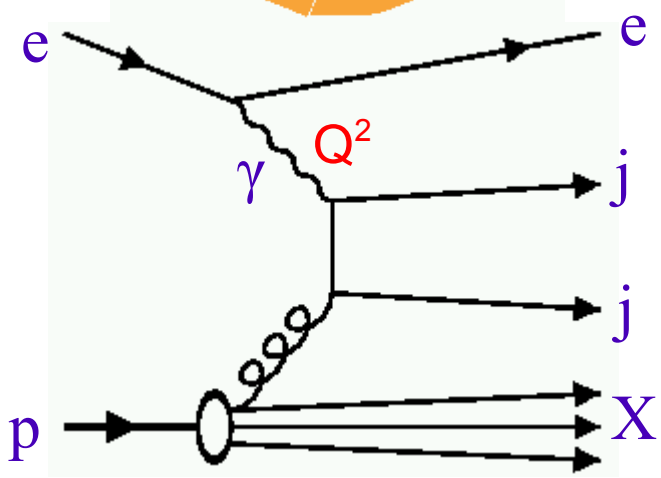




photoproduction: $\gamma p \rightarrow jj$

jj - topology





General Search HERA I

H1 Collab., Phys Lett B602 (2004)14

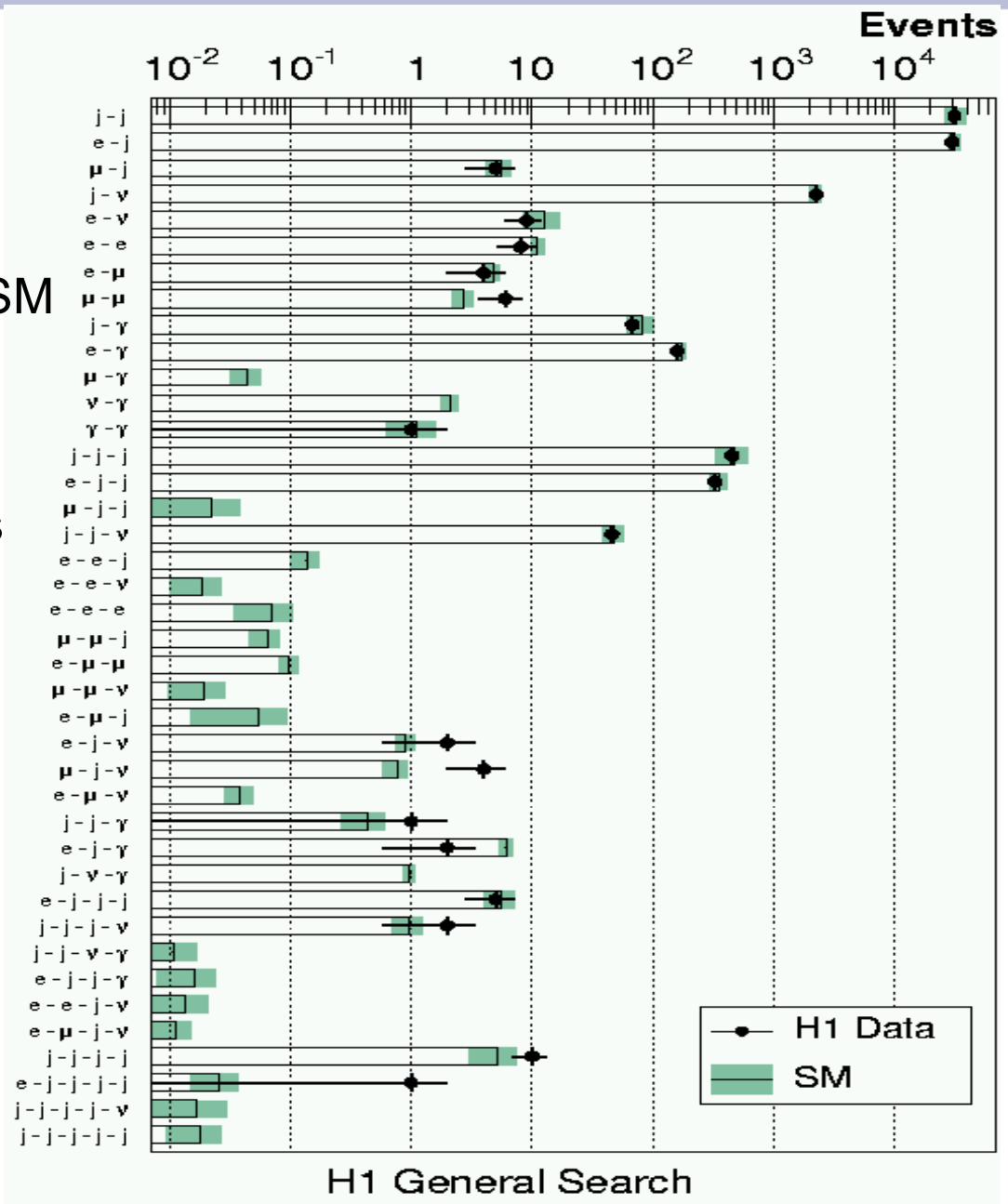
- study of ALL <u>high p_T final states</u>
  in a single coherent analysis
- <u>model independent:</u>
  → search for deviations from the SM

objects: e, μ, γ, jet ,ν

$p_T > 20$ GeV

$10° < \Theta < 140°$ → define classes

- investigate differential distributions
- peform a <u>global</u> statistical inter-
  pretation → check SM consistency

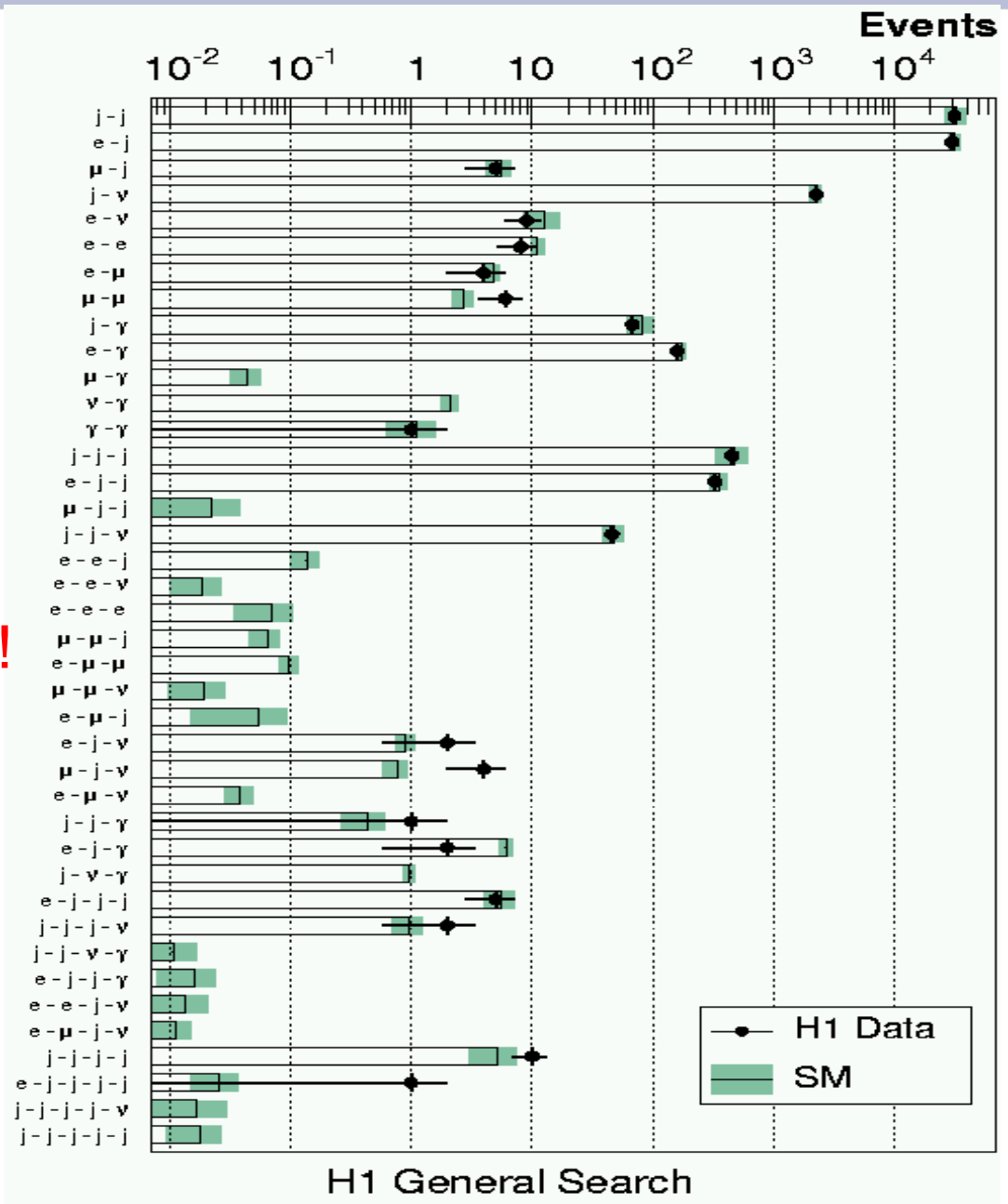


General Search HERA I

H1 Collab., Phys Lett B602 (2004)14

in general:

good agreement with the SM!



General Search HERA I

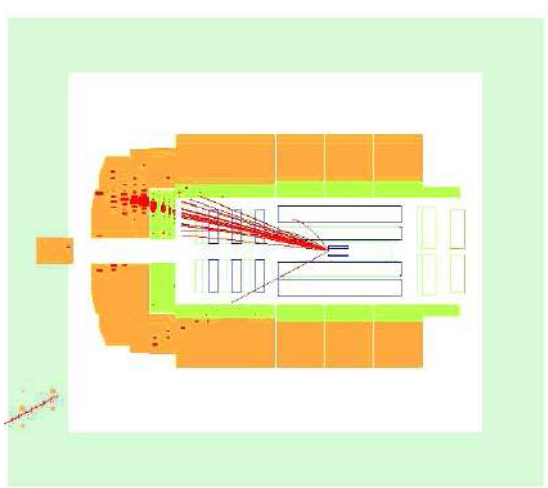
H1 Collab., Phys Lett B602 (2004)14

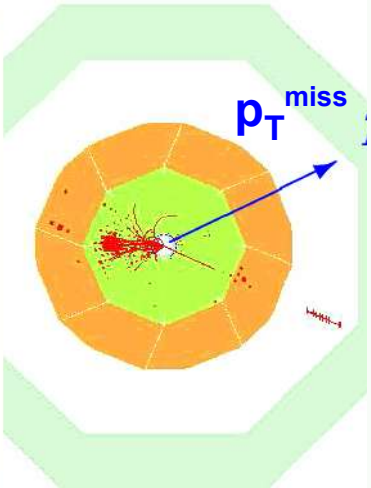
Isolated Lepton + Missing p_T classes:

- $(ej\nu)$
- $\mu j\nu$

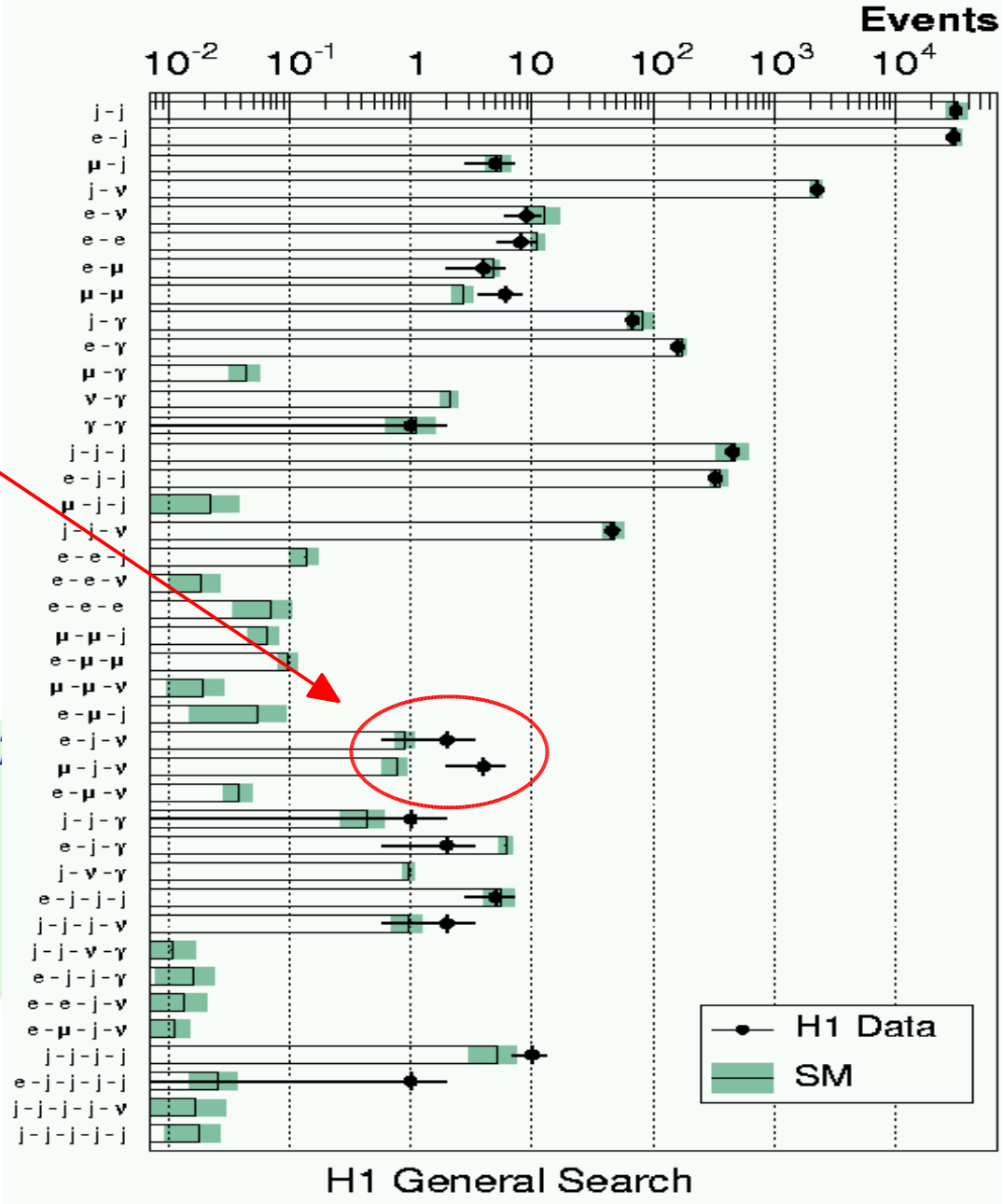
SM process W production:

- $ep \to (e)WX \to (e)\ell\nu j$
- SM cross section $\approx 1\ pb$

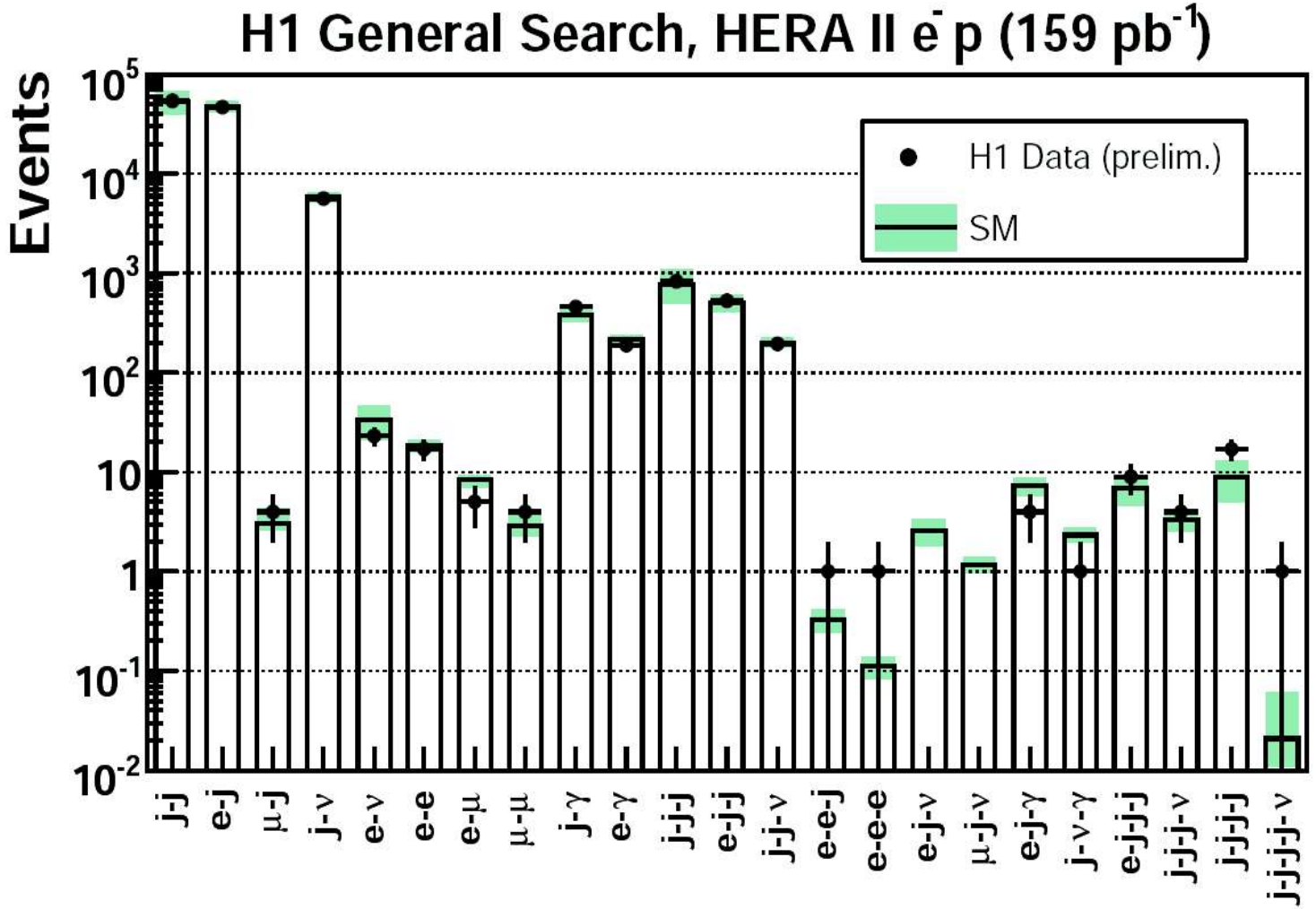




latest HERA results → talk by D. South

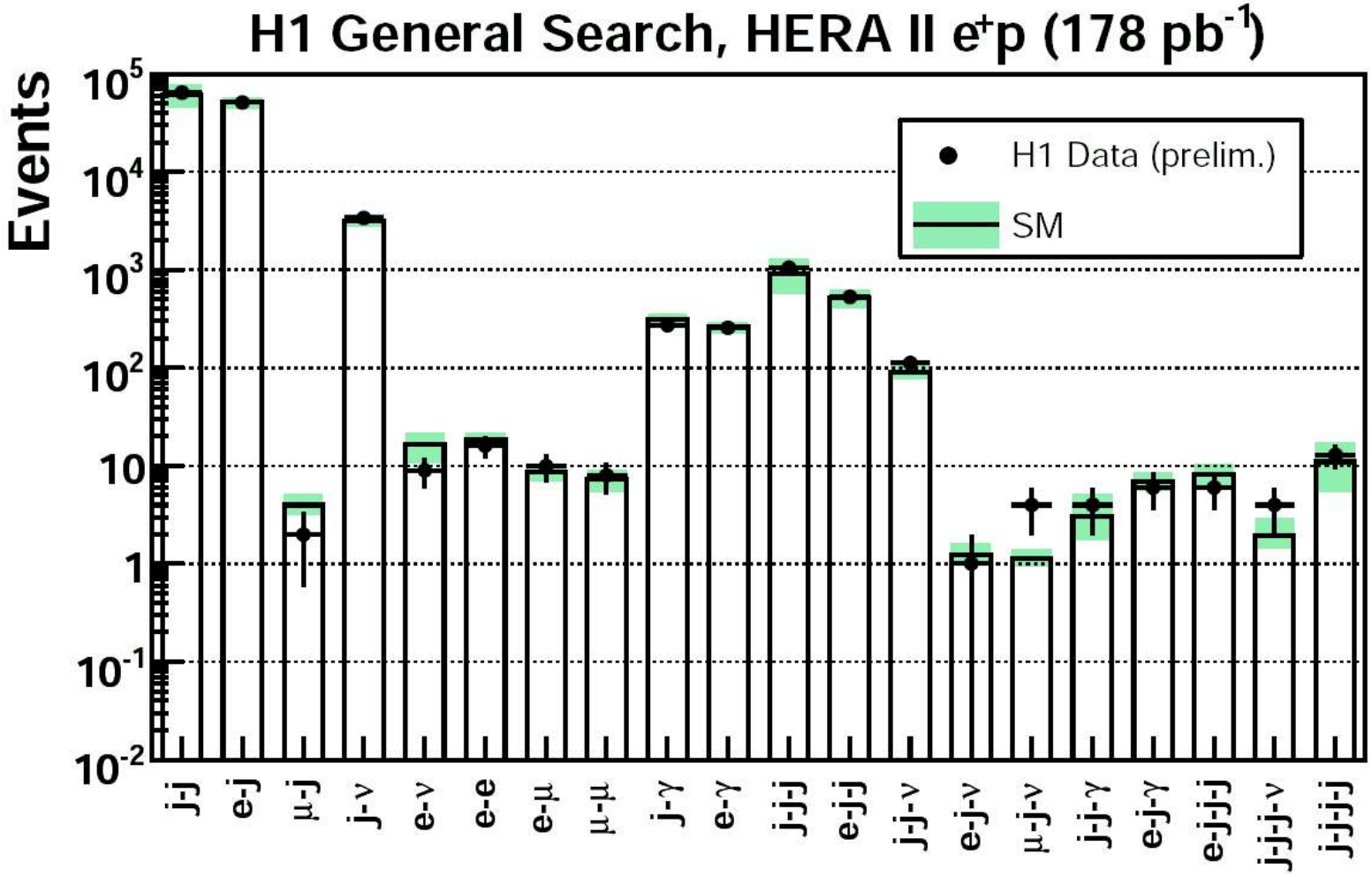


New HERA II Results: $e^- p$



very good agreement with the SM expectation !

New HERA II Results: e^+ p



again: very good agreement with the SM expectation !

Statistical Interpretation of General Search

Look in differential distributions with high sensitivity to BSM processes:

- M_{all}: invariant mass of all objects
- $\sum p_T$: scalar sum of tranverse momenta

Quantify possible deviations (deficit or excess)

- new algorithm to find region of largest deviation in distribution:

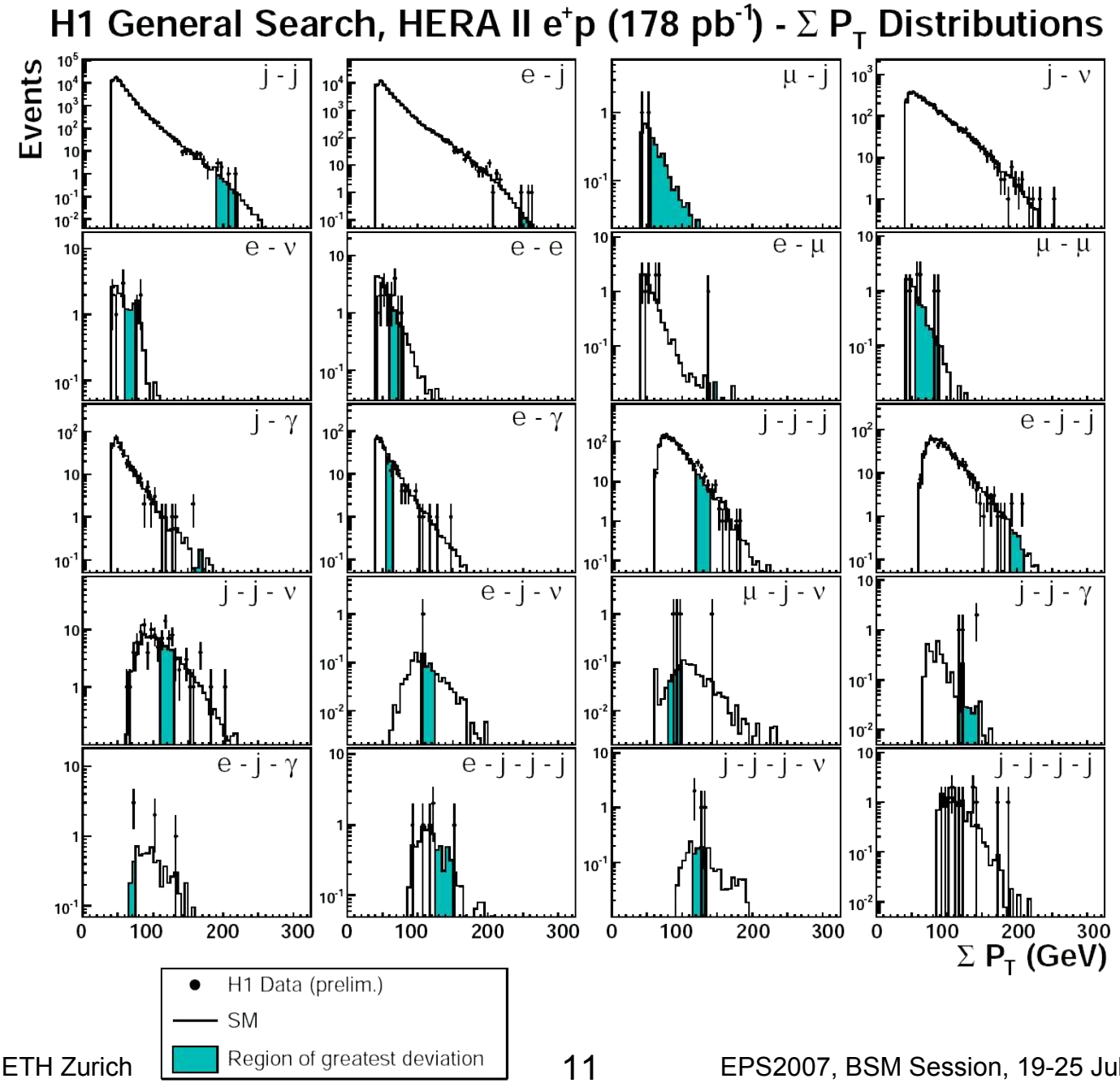
$$p_{\mathrm{region}} = G_{\mathrm{syst}}(\mathrm{BG}) \otimes P_{\mathrm{Poisson}}(N_{obs} \geq N_{SM}, N_{obs} < N_{SM})$$

N_{SM} = number of **expected** events in region

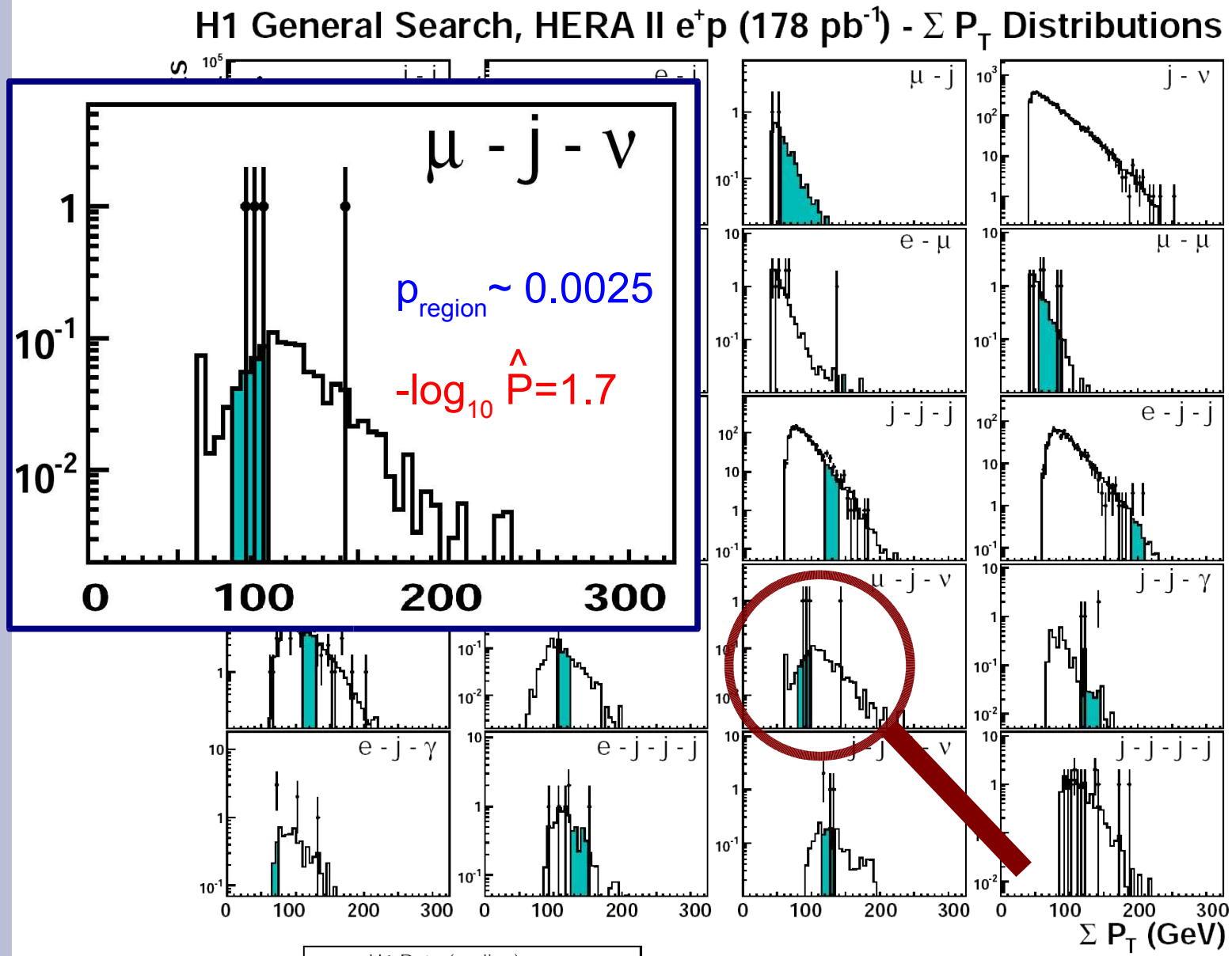
N_{obs} = number of **observed** events in region

- significant deviation: $p_{\mathrm{region}} \ll 1$

Statistical Interpretation of General Search



Statistical Interpretation of General Search



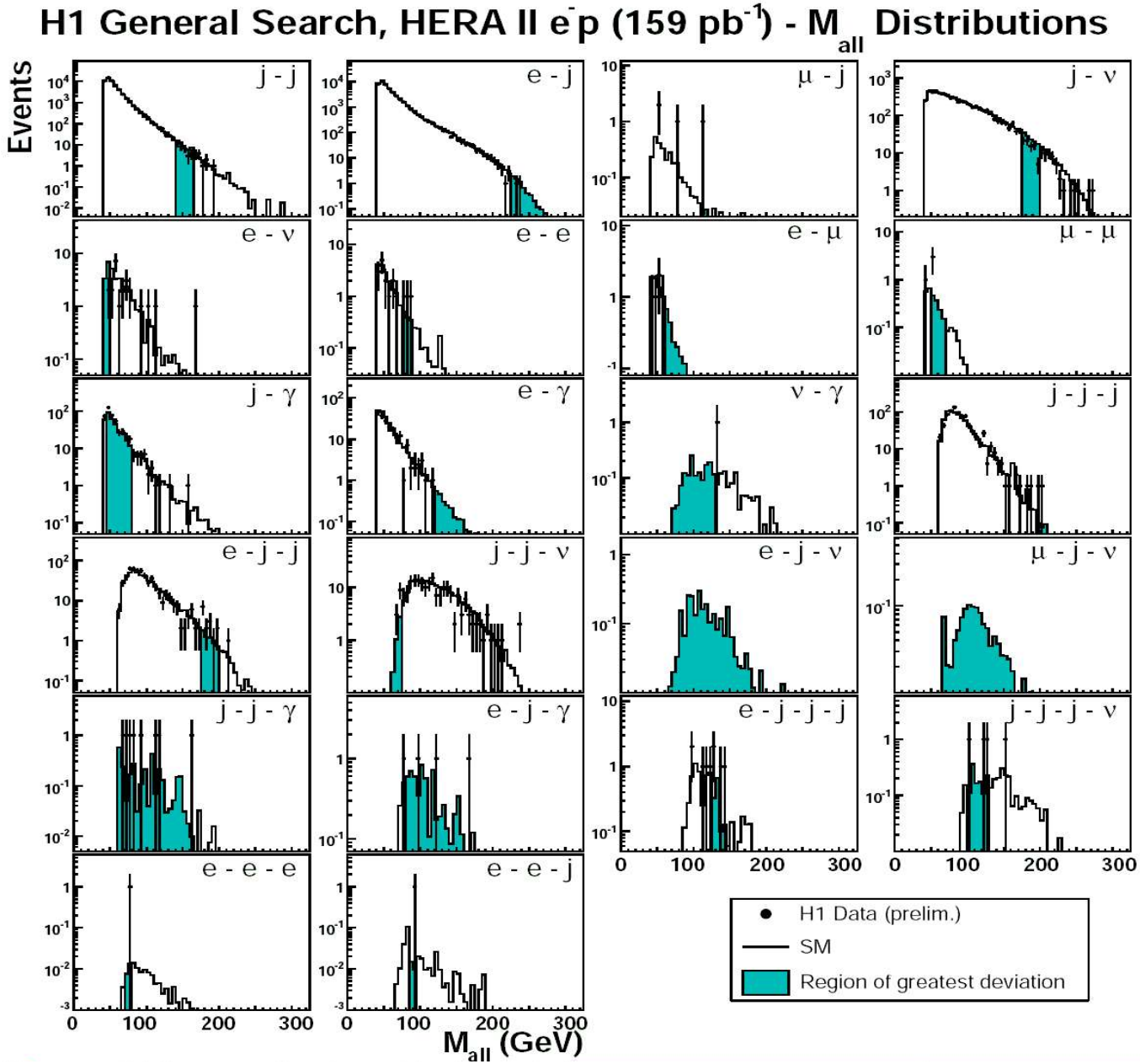
- calculate from excess/deficit:

  p_{region}

- determine from MC experiments probablility $\hat{P}$ for finding:

  $p < p_{region}$

Statistical Interpretation of General Search



Systematic Uncertainties

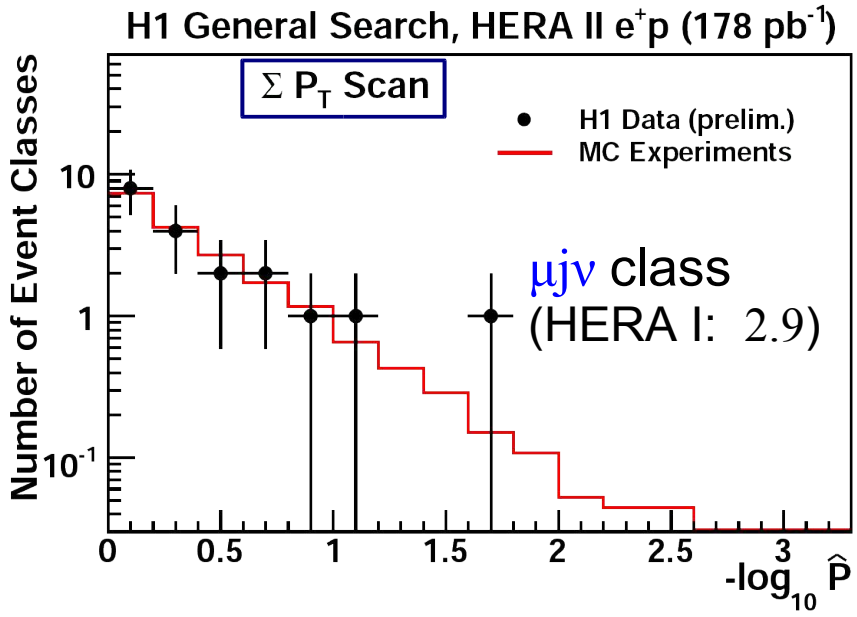
Object	Energy Scale	θ (mrad)	Identification efficiency
Jet	2%	5–10	–
Electron	1–3%	1–3	3–5%
Photon	1–3%	1–3	5–15%
Muon	5%	3	5%

Table 1: Systematic uncertainties attributed to the measurement of energies, polar angles and to the identification efficiencies of particles.

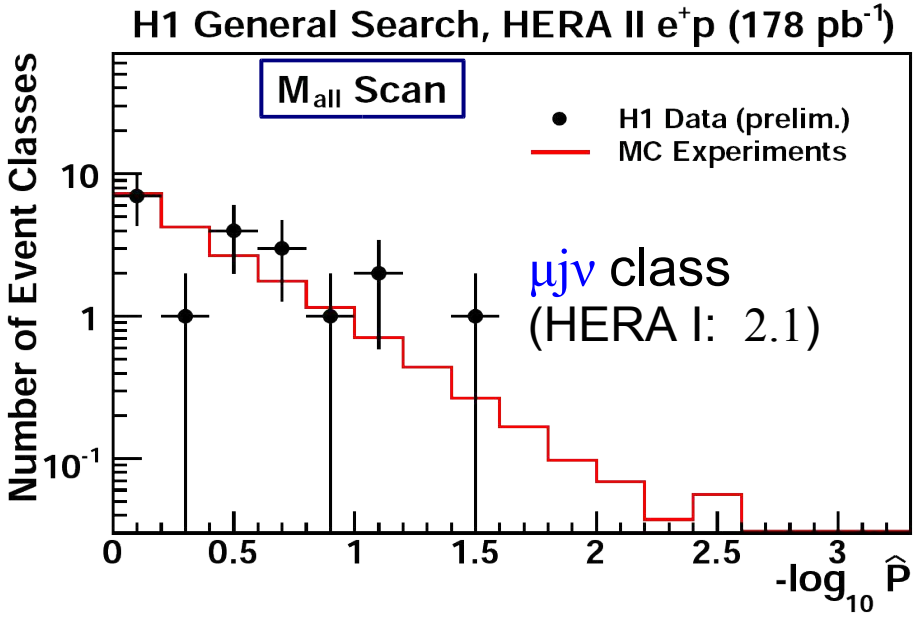
Process	Uncertainty
$ep \to jjX$ and $ep \to j\gamma X$	15%
$ep \to j\nu X$ and $ep \to jeX$	10%
$ep \to jj\nu X$ and $ep \to jjeX$	15%
$ep \to \mu\mu X$ and $ep \to eeX$	3%
$ep \to WX$ and $ep \to WjX$	15%
$ep \to e\gamma X$ and $ep \to e\gamma j$	10%
$ep \to e\gamma p$	5%

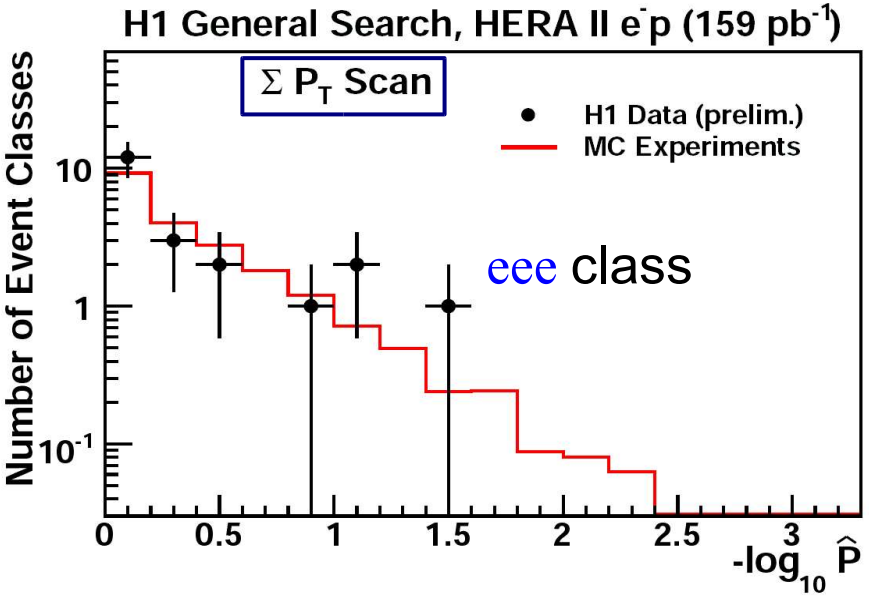
Table 2: Theoretical uncertainties attributed to the simulation of different SM processes.

Class Probabilities HERA II

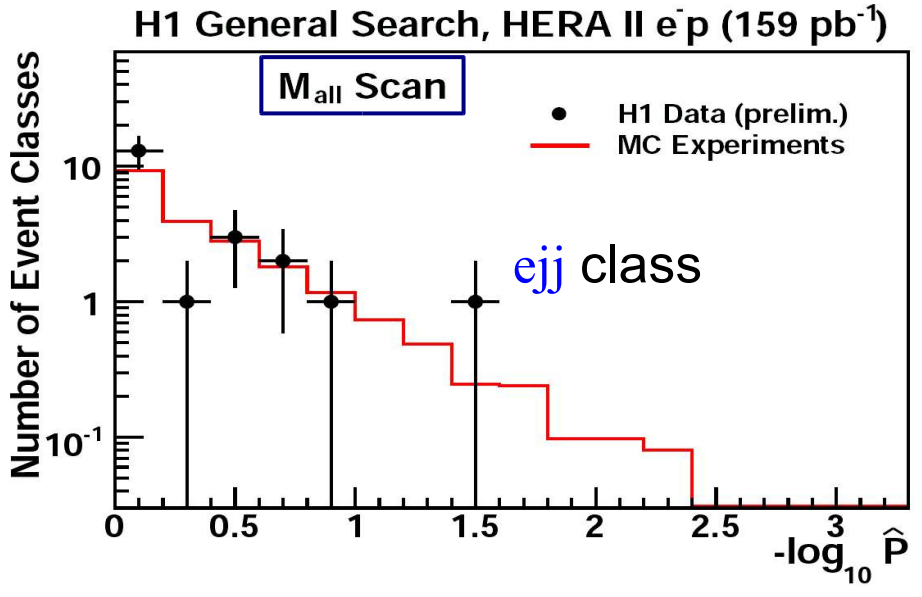


e+p





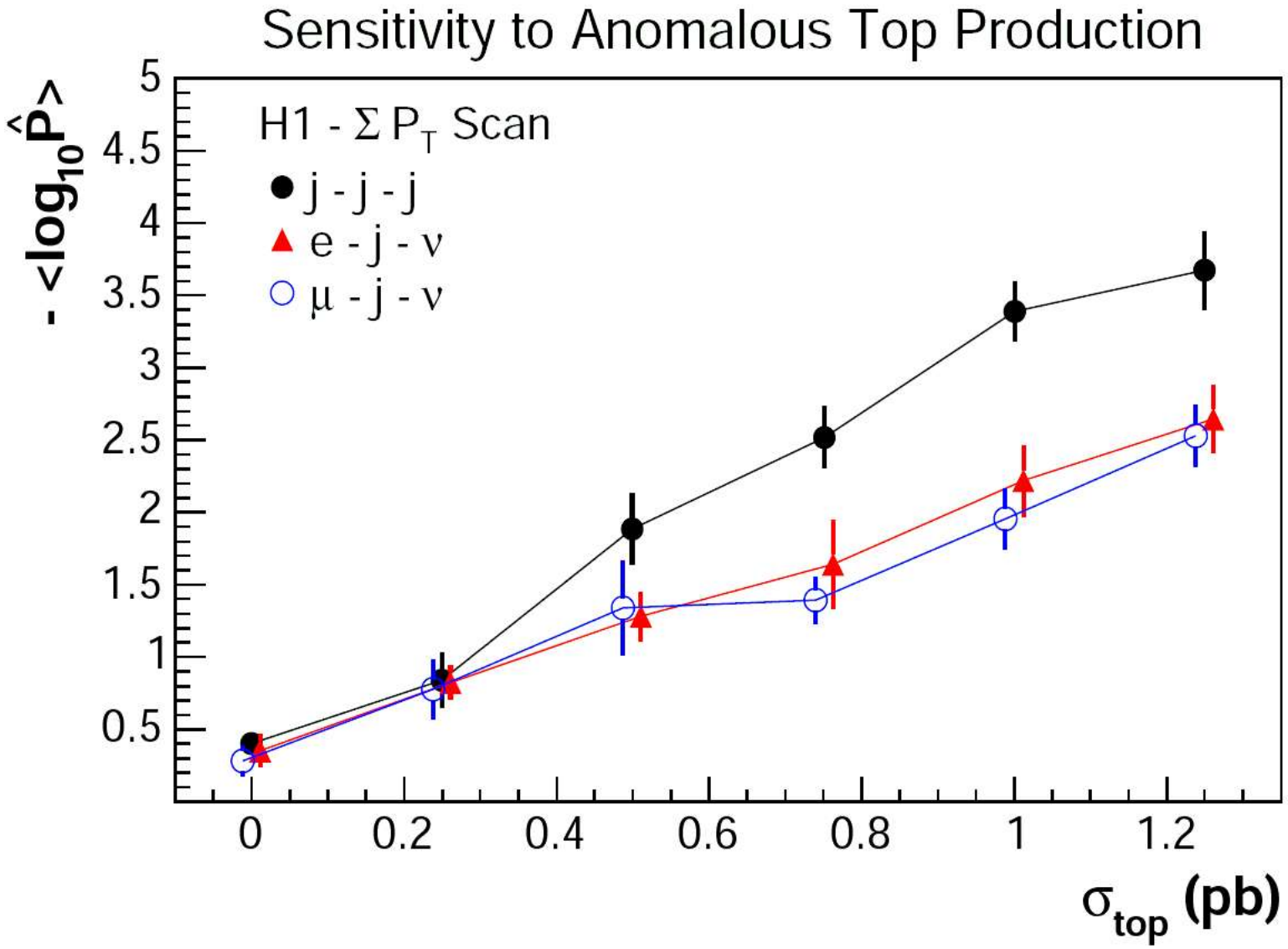
e-p



Anomalous Top Prod. Sensitivity

H1 Collab., Phys Lett B602 (2004)14

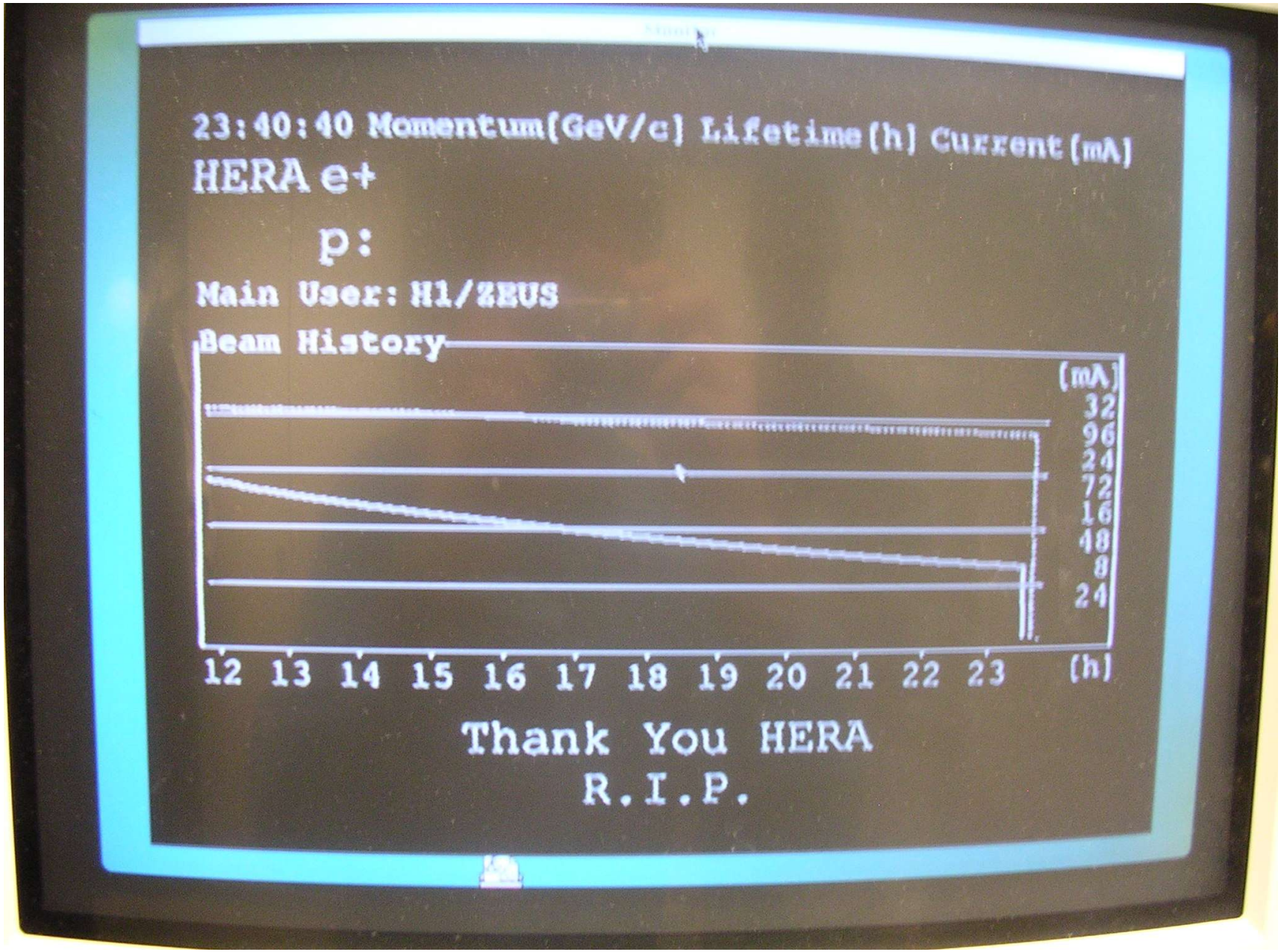
FCNC: eu → et decay: t → W b → jjb, lνb



Summary

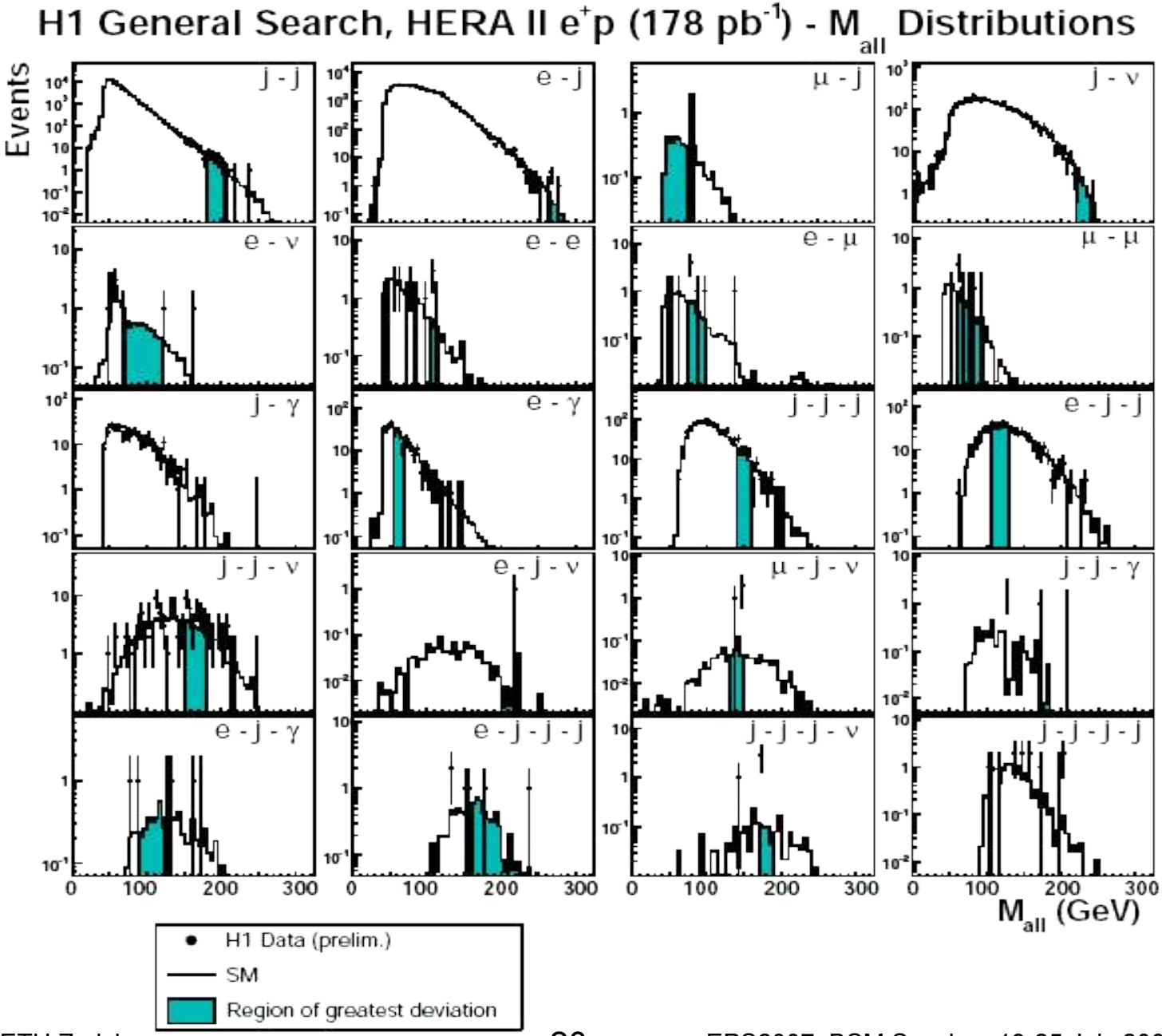
- general analysis of all classes containing at least two objects with p_T>20 GeV:
  - electron
  - photon
  - jet
  - muon
  - neutrinos (missing momentum)
- model-independent search for deviations from the SM
- new 2003-2007 HERA II data investigated
  (completing previous HERA I analysis)
- total event yields and differential distributions studied
- very good agreement with the SM found for both e^+p / e^-p

HERA Last Fill (30.06.2007)

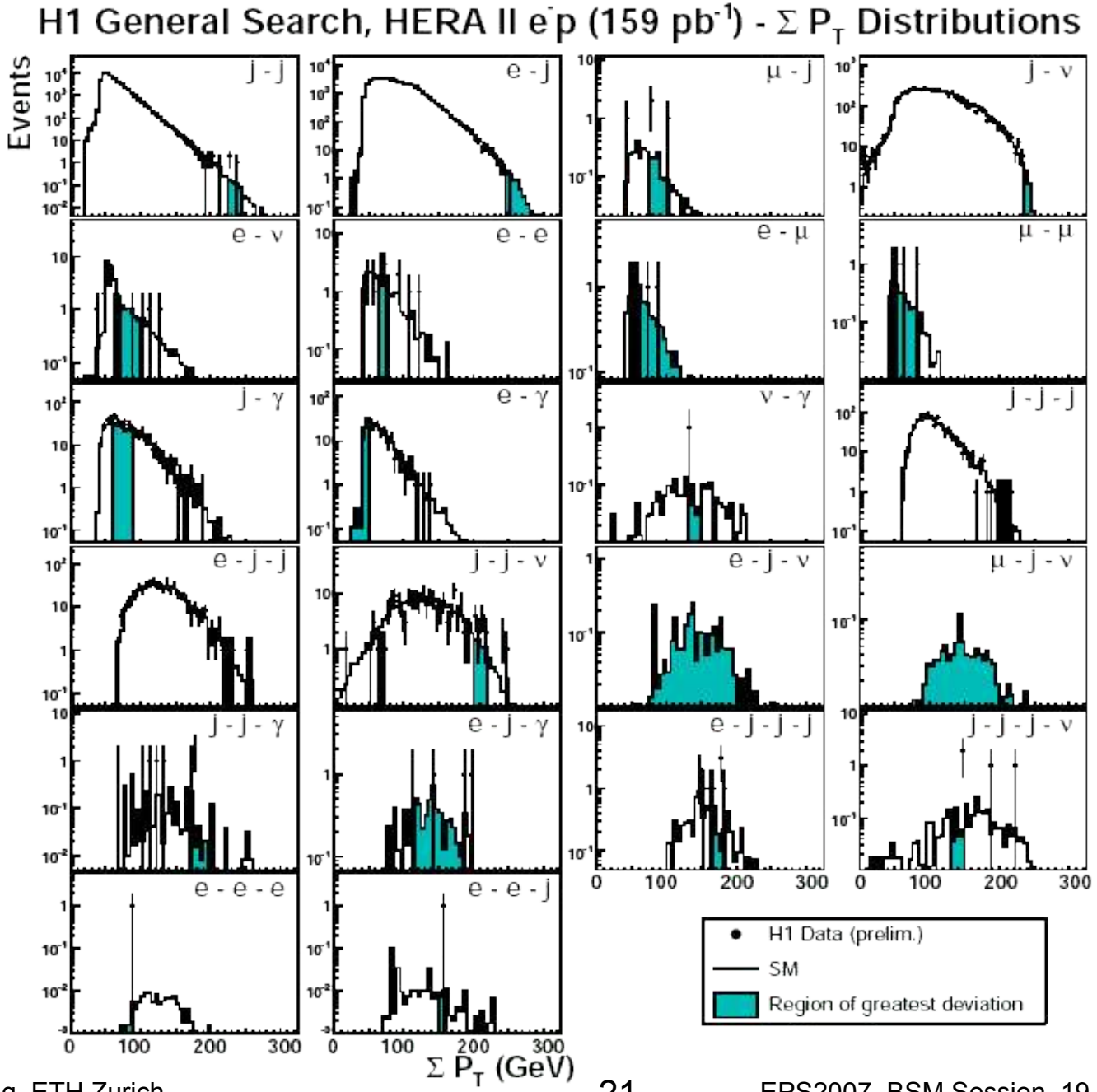


Backup

Distributions e^+p M_{all}



Distributions e^-p ΣP_T

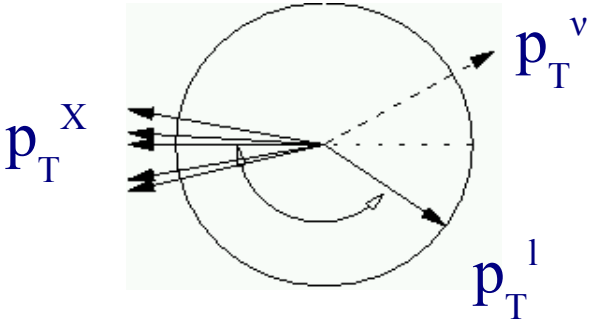


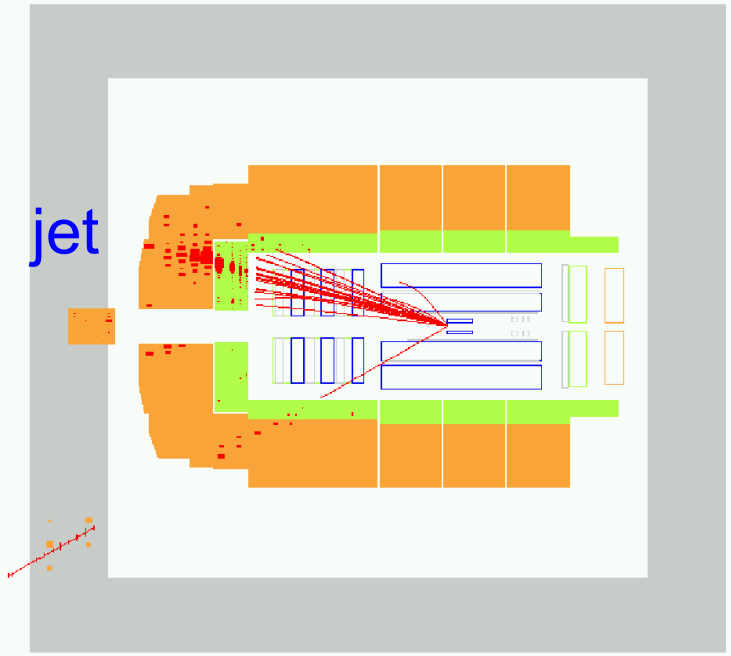
Isolated Lepton Events

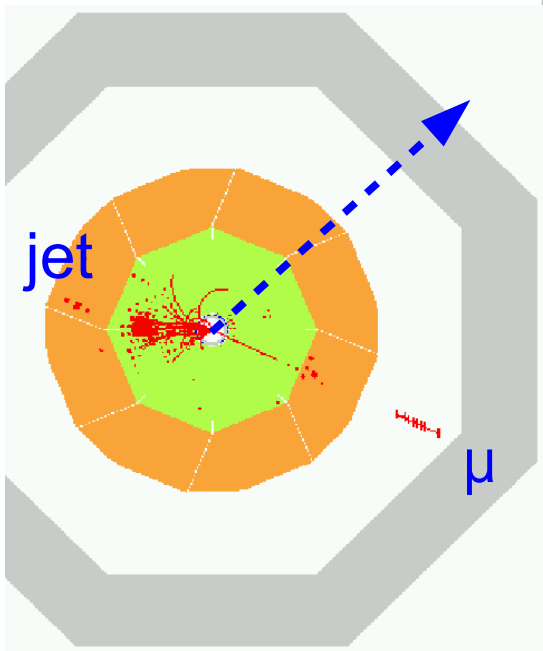
H1 Collab., Phys. Lett. B561 (2003) 241; ZEUS Collab. Phys. Lett. B559 (2003) 153

latest HERA results → talk by D. South

- Topology:







- SM Process:

  W-production (p_T^X small)

  $ep \rightarrow eX\,W$, $W \hookrightarrow l\,\nu$

- BSM Process:

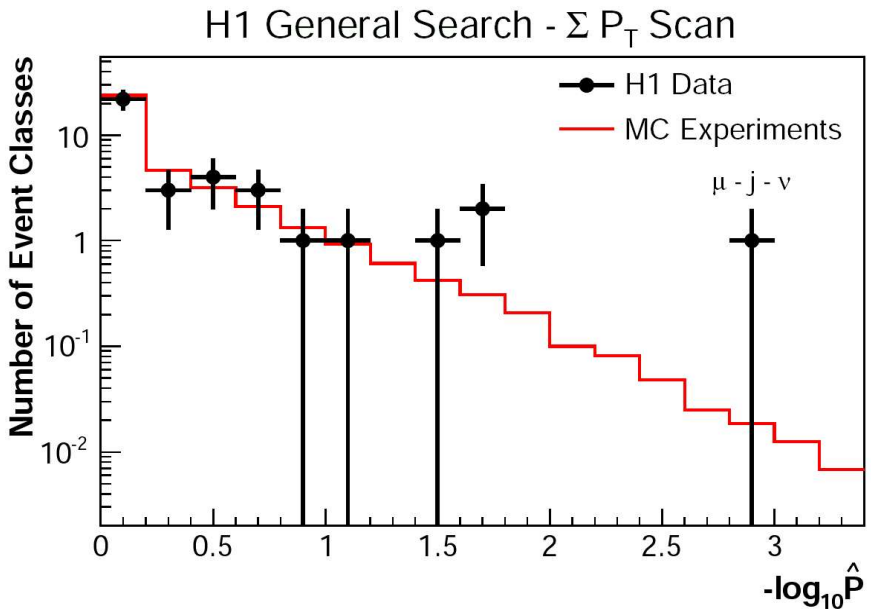
  ➔ anomalous single top production

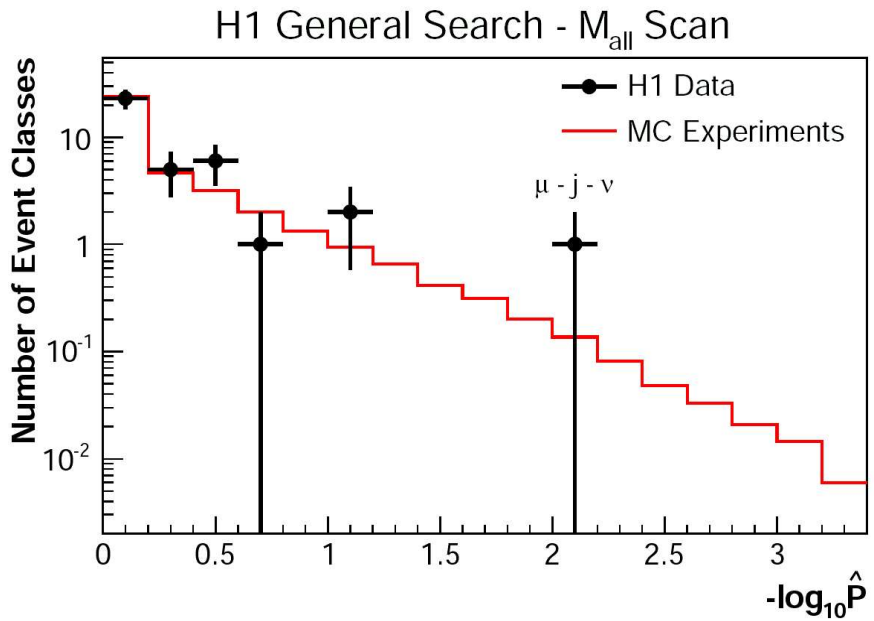
  ➔ RPV SUSY: stop

  predict high p_T^X !

Class Probabilities HERA I

H1 Collab., Phys Lett B602 (2004)14

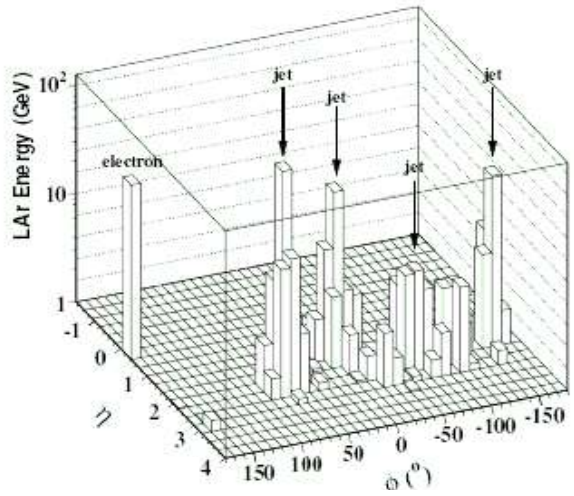




General Search HERA I

H1 Collab., Phys Lett B602 (2004)14

Interesting $ejjjj$ event observed



- total invariant mass M_{all} = 262 GeV
- SM exp. from higher order QCD is ~ 0.02 events
- Other (rare SM/BSM) explanations:
  - (anomalous) top quark production
  - WW production, Higgs ?