Model Independent Searches in ep Collisions

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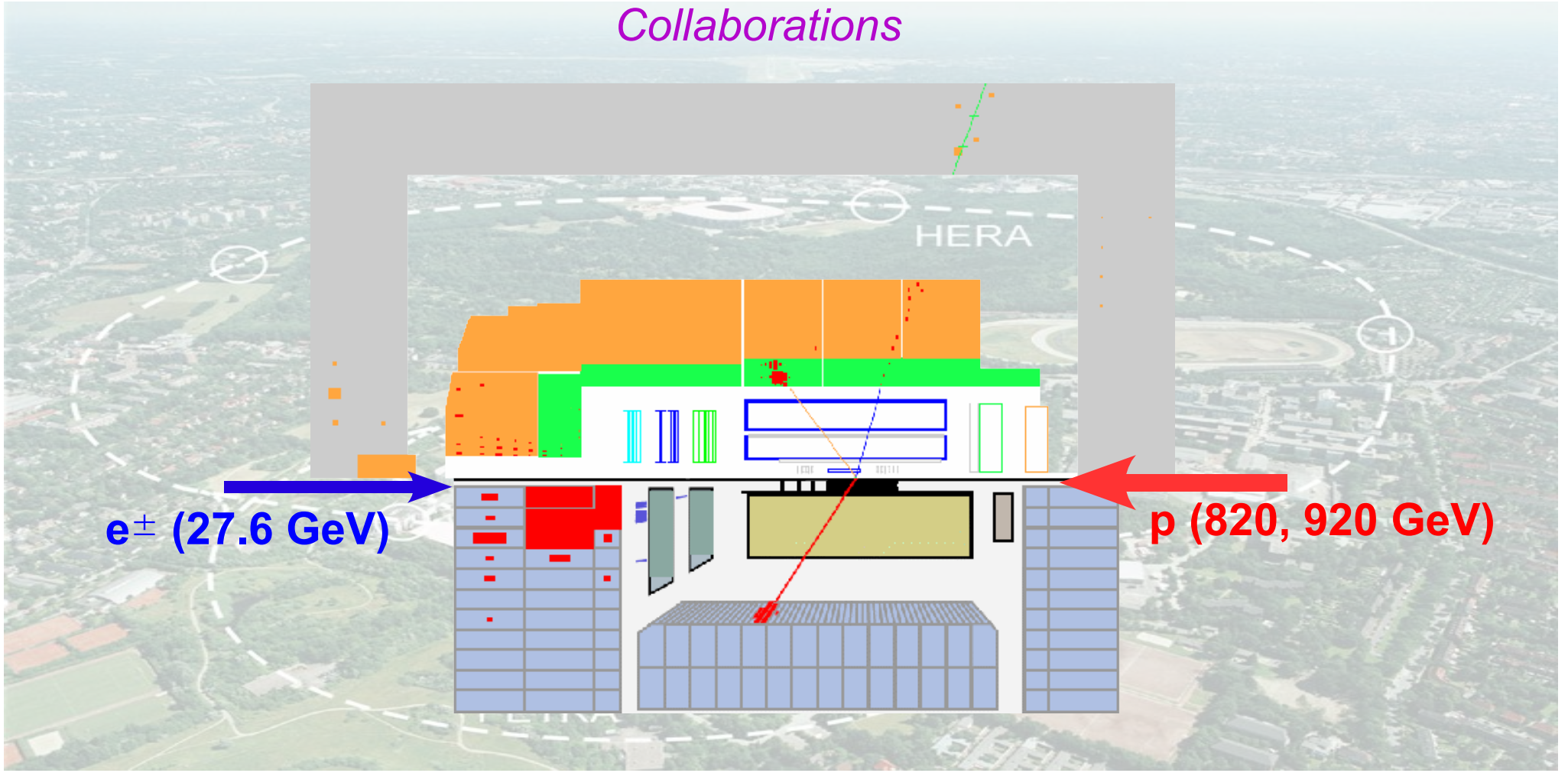
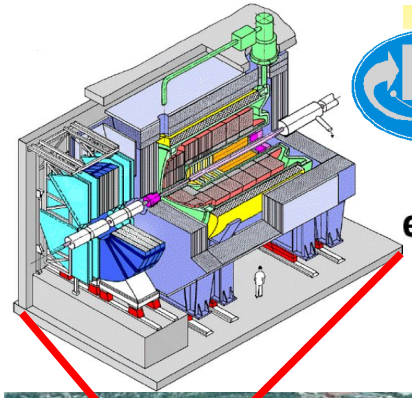
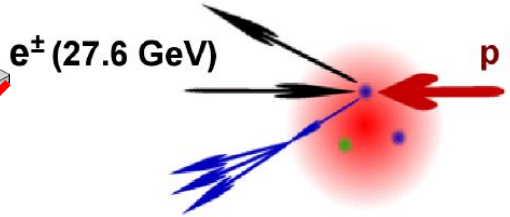
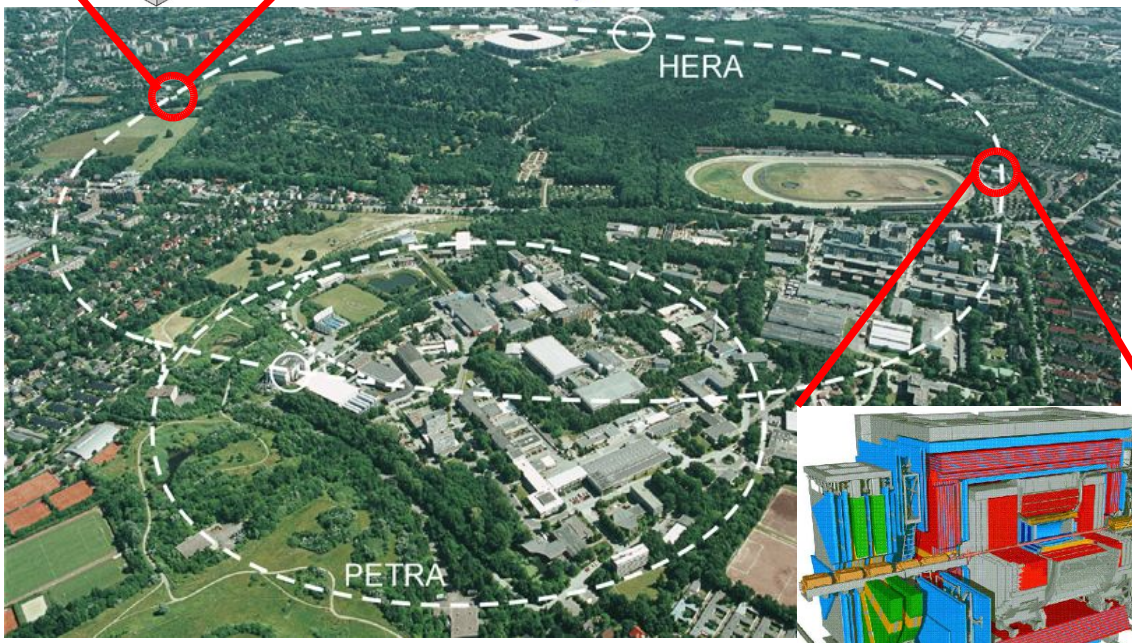
On behalf of H1 and ZEUS Collaborations

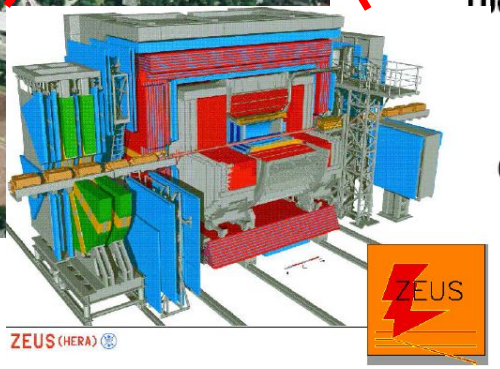


The HERA ep collider

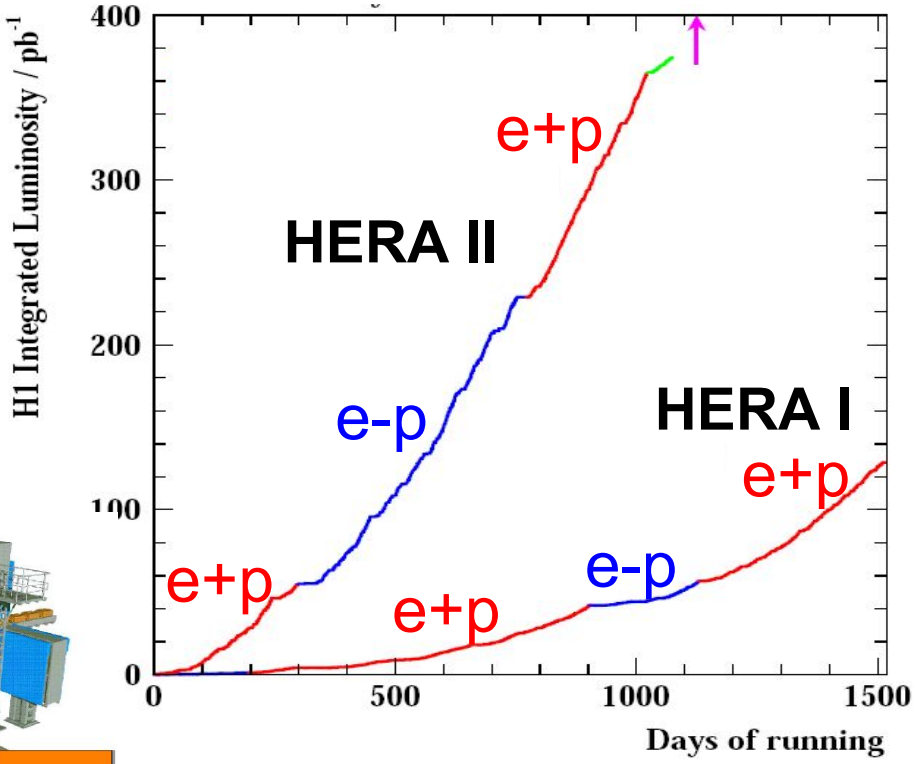








- $\sqrt{s}$ = 320 GeV



- HERA I: 1992-2000, ~120 pb^{-1} per experiment
- HERA II: 2003-2007, ~360 pb^{-1} per experiment

↘ In total H1+ZEUS together accumulated ~ $1fb^{-1}$

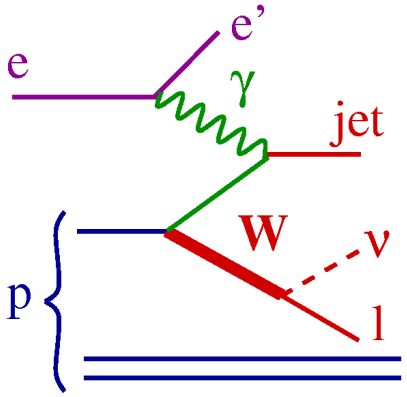
Hunting for New Physics at HERA

- The instrument: HERA is a frontier collider
  - ➔ $\mathscr{L}$ ~ 0.5 fb^{-1}: search for processes with σ < 1 pb
  - Parton luminosity: HERA collides beyond LEP
  - Backgrounds: HERA has less than Tevatron

- Model independent searches
  - Do not rely on specific exotic signatures
  - Precise data / SM comparisons in
    - ➔ Final states with a low SM expectation
    - ➔ High P_T tails of the SM: investigate all possible final states

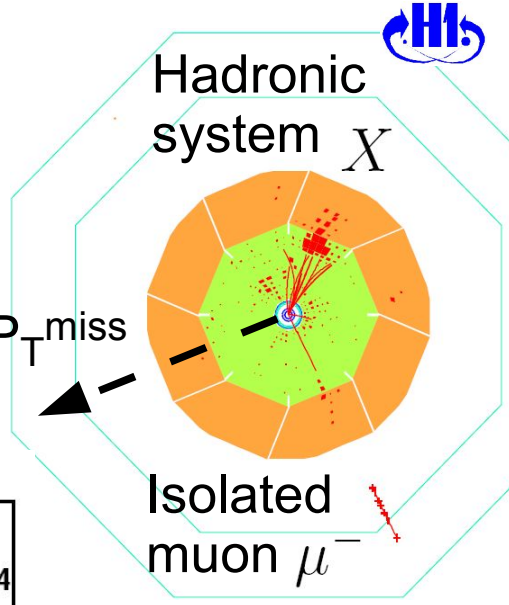
- Prerequisite:
  - Control of the detector response
  - Understanding and simulation of all SM processes

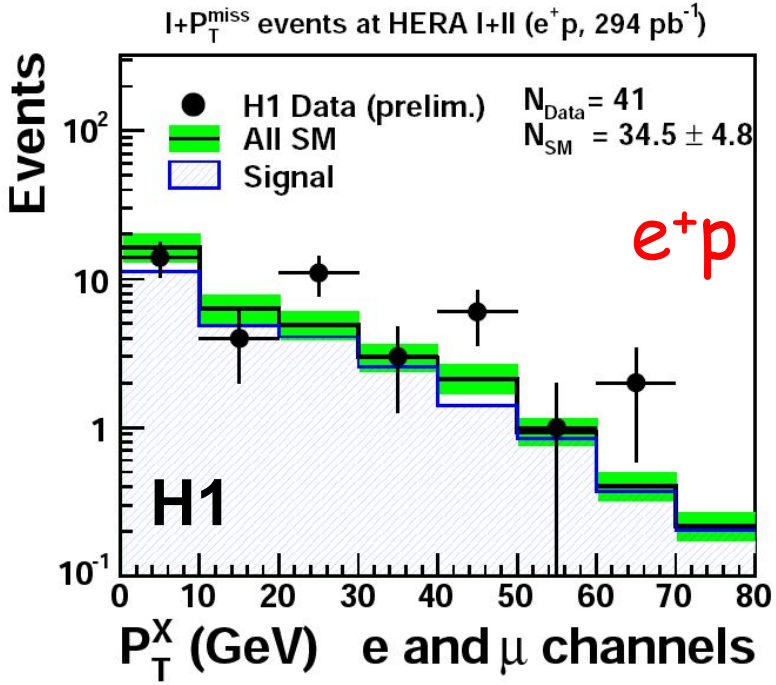
W production at HERA ($W \rightarrow e,\mu$)

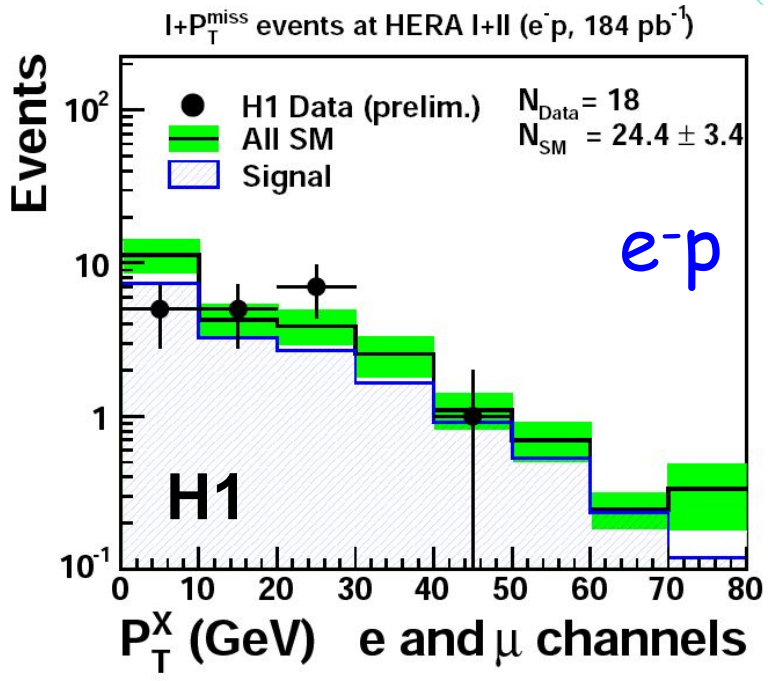


SM W: $\sigma \sim 1.3$ pb

- Events with high P_T e,μ, P_T^{miss} and hadronic system (P_T^X)
  - ➔ H1 in HERA I, for $P_T^X > 25$ GeV: an excess of data events (3σ)
- All H1 HERA I+II data: 478 pb^{-1}
  - ➔ Events at high P_T^X also observed in latest data







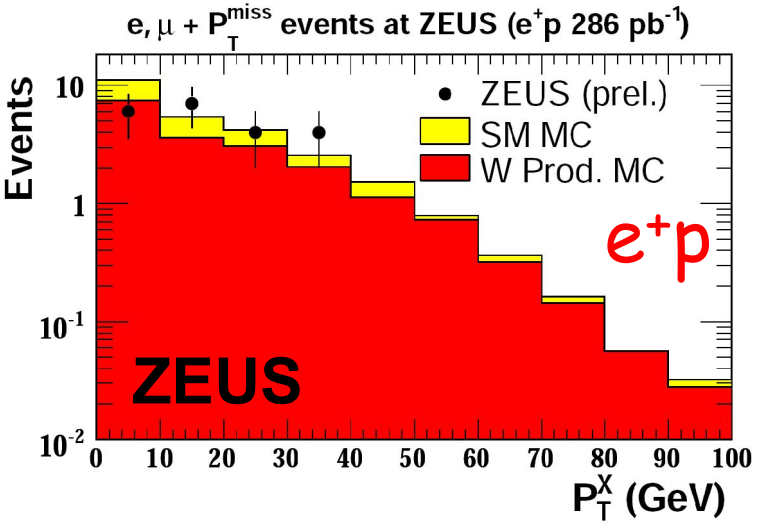
➘ Different observations in e+p and e-p

Isolated leptons: H1 and ZEUS

- Analysis also performed by ZEUS, HERA I+II data: 492 pb^{-1}

  ➔ A good agreement with the SM is observed

	P_T^X > 25 GeV		electrons data / SM	muons data / SM
e+	H1	294 pb^{-1}	11 / 4.7 ± 0.9	10 / 4.2 ± 0.7
	ZEUS	286 pb^{-1}	3 / 3.9 ± 0.6	3 / 3.6 ± 0.5
e-	H1	184 pb^{-1}	3 / 3.8 ± 0.6	0 / 3.1 ± 0.5
	ZEUS	206 pb^{-1}	3 / 3.2 ± 0.6	2 / 2.4 ± 0.4



- In e+p H1: 21 / 8.9 ± 1.5 (3 σ)

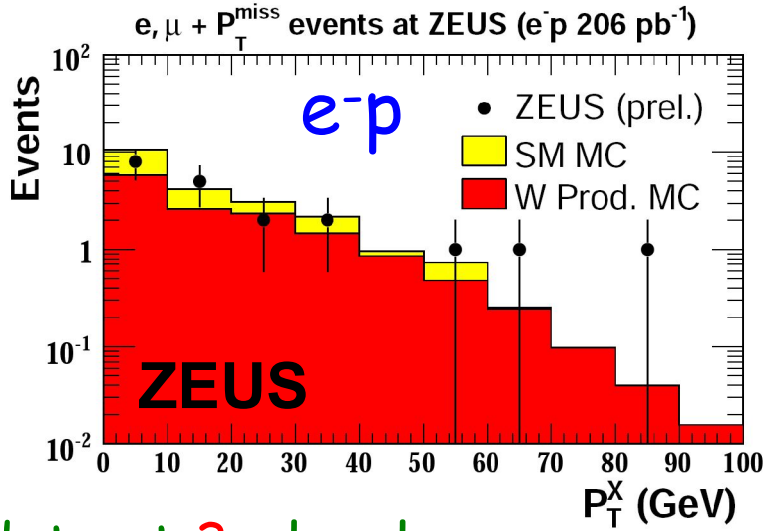
  ZEUS: agreement with the SM

- In e-p agreement with SM for both H1 and ZEUS

- Smaller acceptance for ZEUS

  H1: $\theta^{e,\mu}$ > 5° / ZEUS: $\theta^{e,\mu}$ > 15°

  ➔ But most H1 events are in ZEUS acceptance



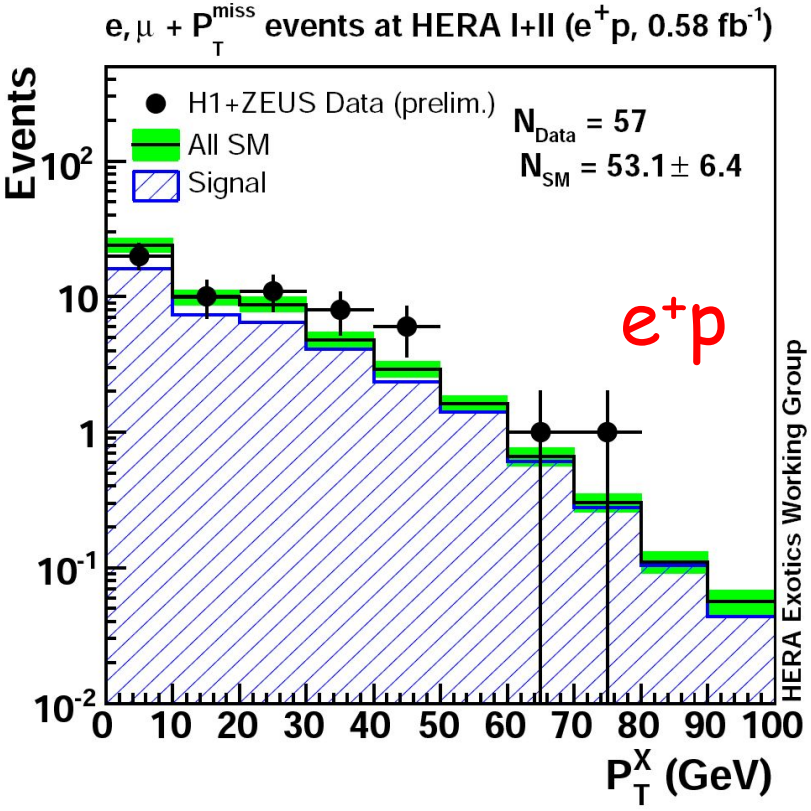
↘ H1 excess remains in e+p data at 3σ level

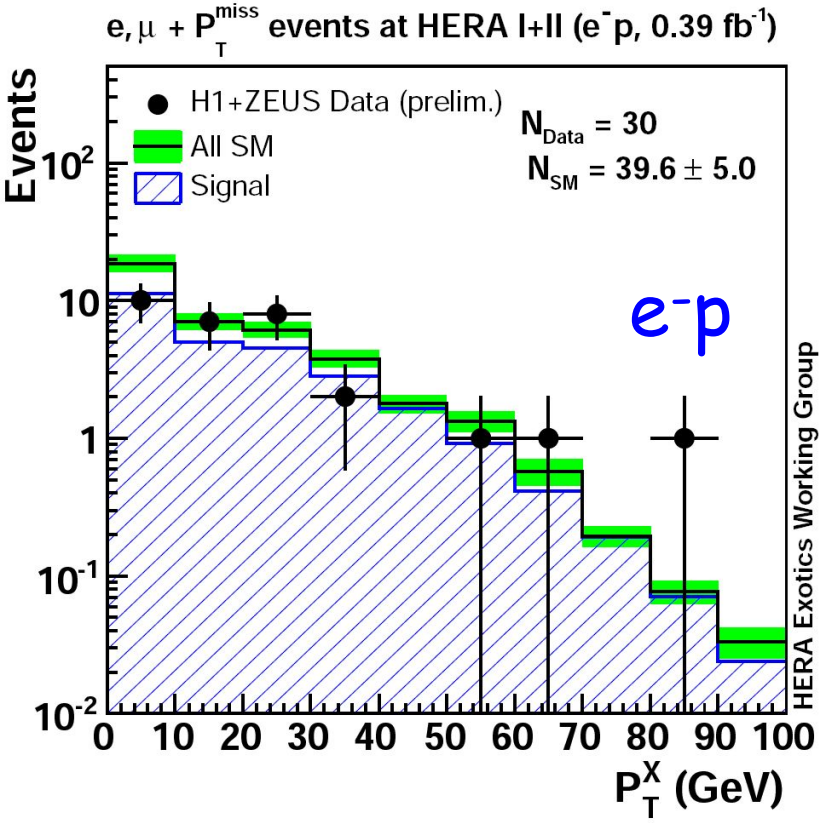
↘ Not clarified with HERA II data

H1 and ZEUS Combination

➘ H1 and ZEUS analyses combined in a common phase-space

➔ Total luminosity: 0.97 fb^{-1}





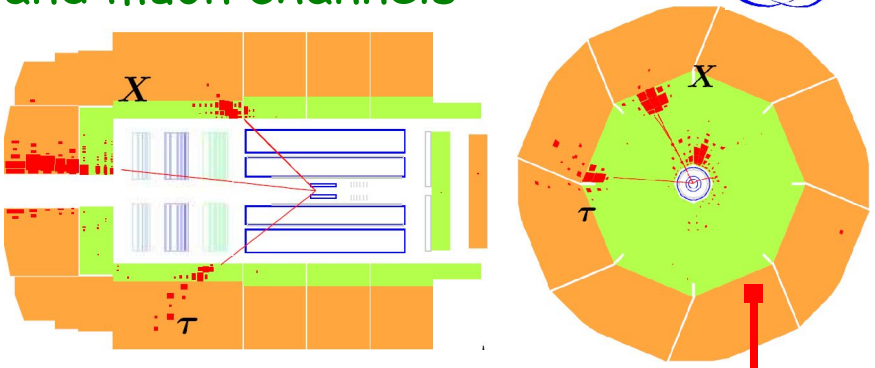
- Good agreement with the SM in the global sample
- Fluctuation in e+p for P_T^X > 25 GeV is reduced (1.8σ)

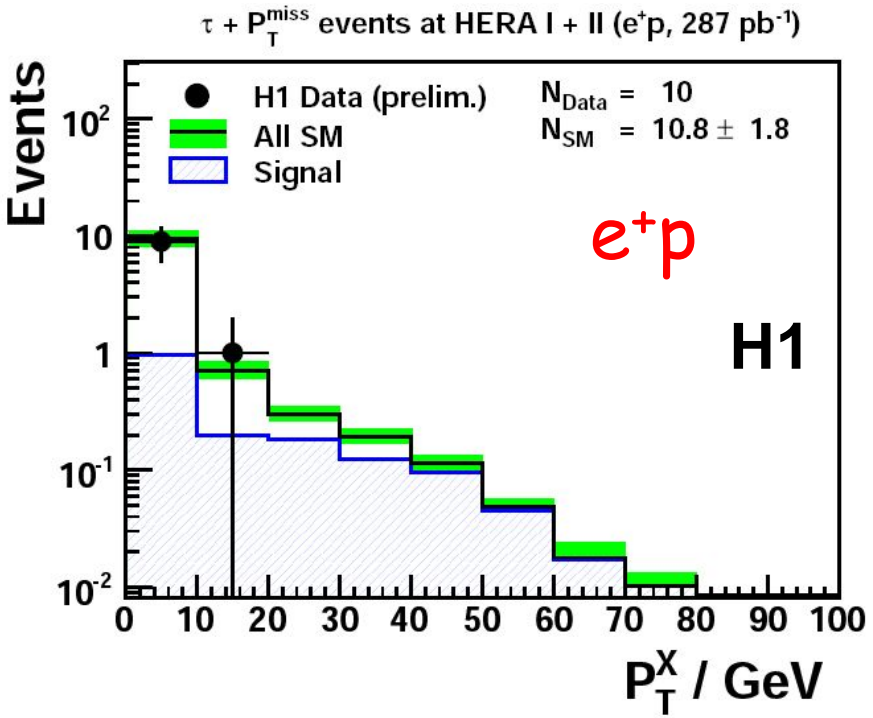
Isolated τ + P_T^{miss} events

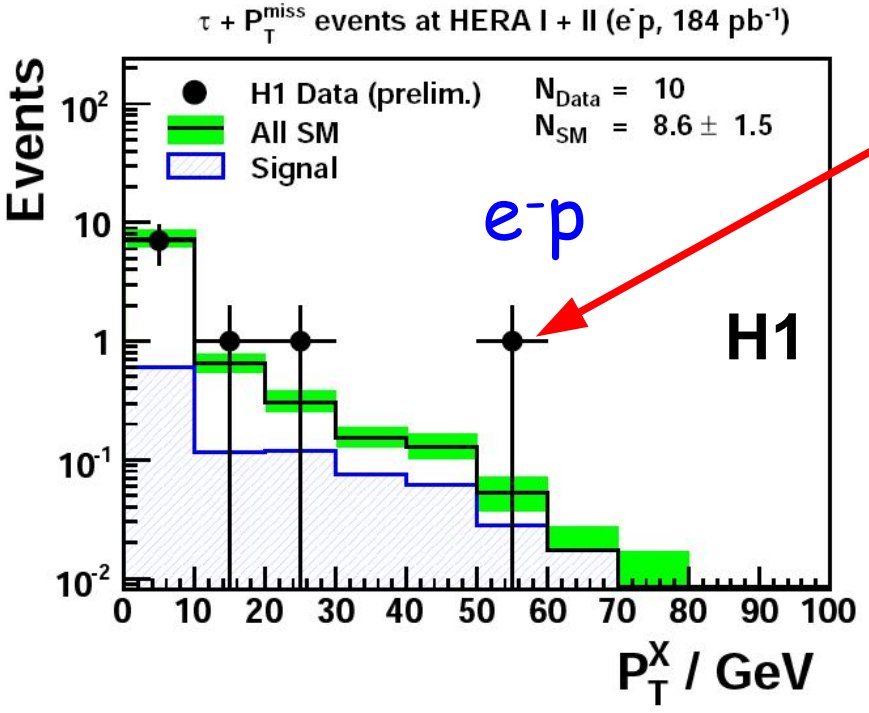
↘ To complement isolated electron and muon channels

- H1 analysis, full HERA I+II (471 pb^{-1})
- τ identified in the hadronic 1-prong decay

➔ Jets with a single track in charged current event



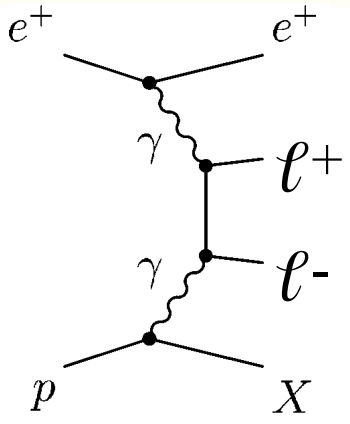




↘ Good agreement in e+p and e-p

↘ ZEUS: 2 high P_T^X events for 0.2±0.05 SM in HERA I data

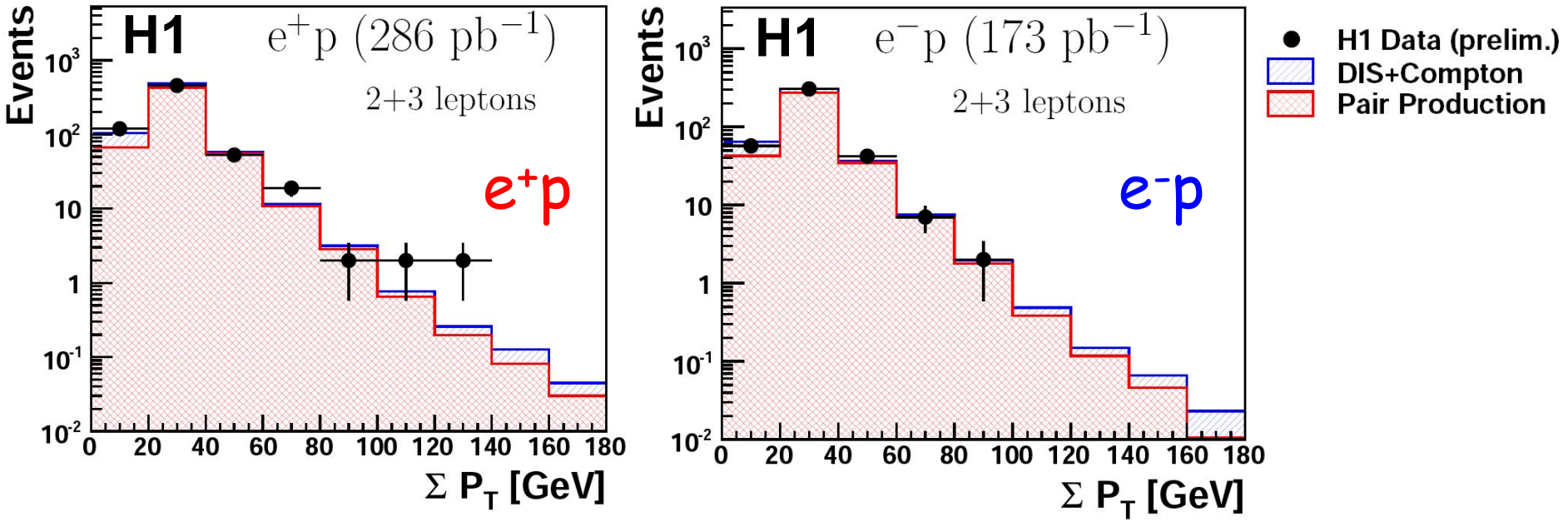
Multi-lepton events (e, μ)



σ ~ 1 pb (high P_T)

➘ Low and well controled SM contribution

- Mainly produced via γ-γ in SM
- Look for events with at least 2 isolated high-P_T leptons (e,μ)
  - ➔ ee, eee, eμ, $\mu\mu$, e$\mu\mu$
- H1 analysis performed on all HERA I+II data (459 pb^{-1})
  - ➔ ΣP_T : hardness of the events



➔ Striking events observed for ΣP_T > 100 GeV

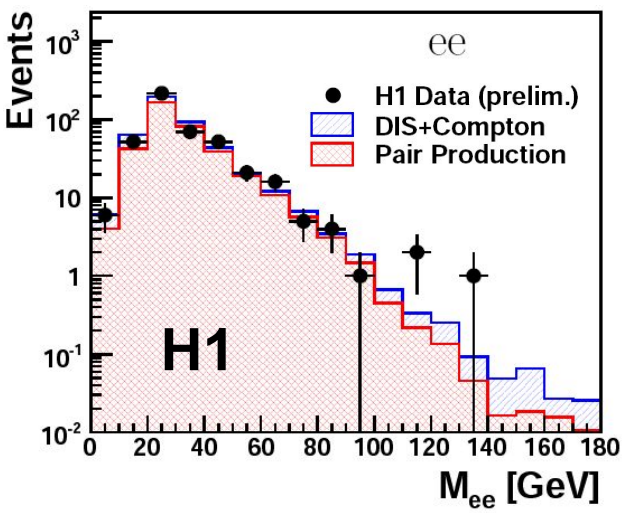
➔ In e+p only : 4 / 1.2 ± 0.2

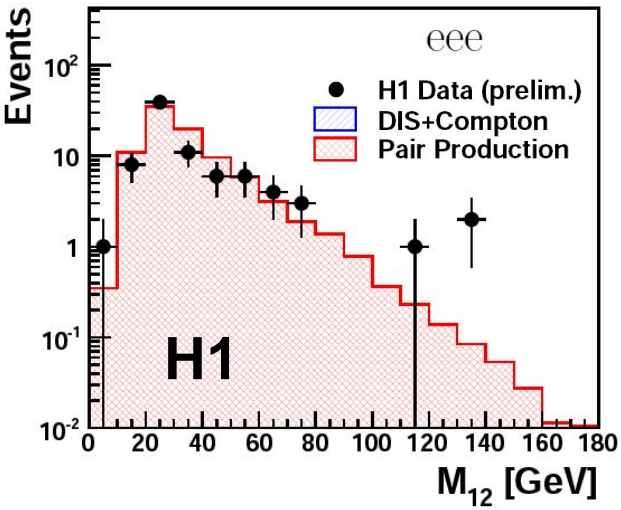
Multi-electron events: H1/ZEUS

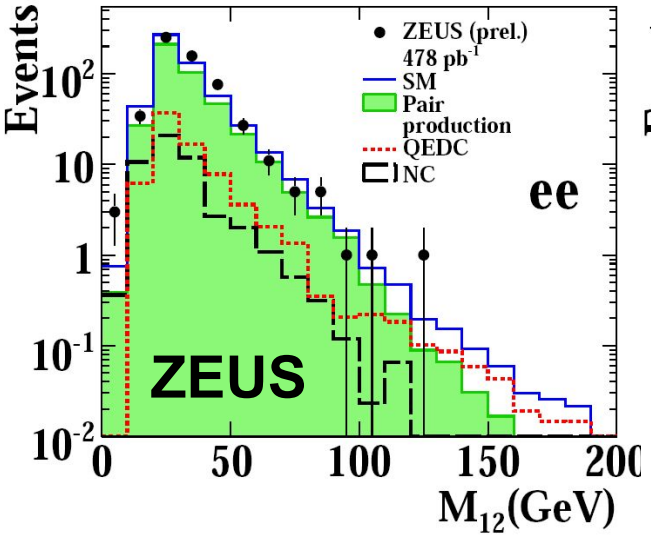
- ZEUS: analysis performed for multi-electron topologies (478 pb^{-1})
- Phase space similar to H1
- For M_{12} > 100 GeV

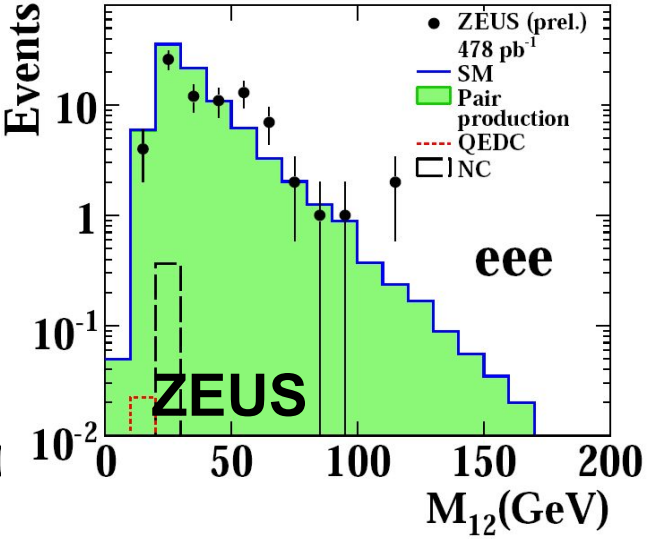
Signal Background

	data	SM	Pair prod.	DIS+QEDC
H1				
ee	3	1.5 ± 0.3	0.9 ± 0.2	0.6 ± 0.2
eee	3	0.9 ± 0.2	0.9 ± 0.2	< 0.005
ZEUS				
ee	2	1.9 ± 0.2	0.9 ± 0.1	1.0 ± 0.2
eee	2	1.0 ± 0.1	1.0 ± 0.1	< 0.005









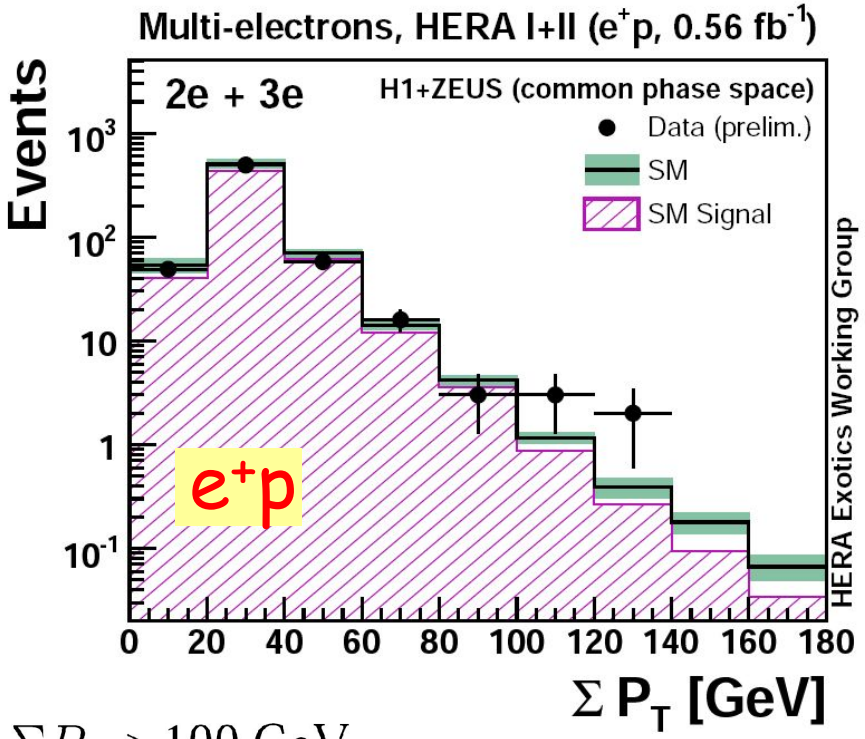
➔ H1: no new ee(e) event, HERA I excess not confirmed

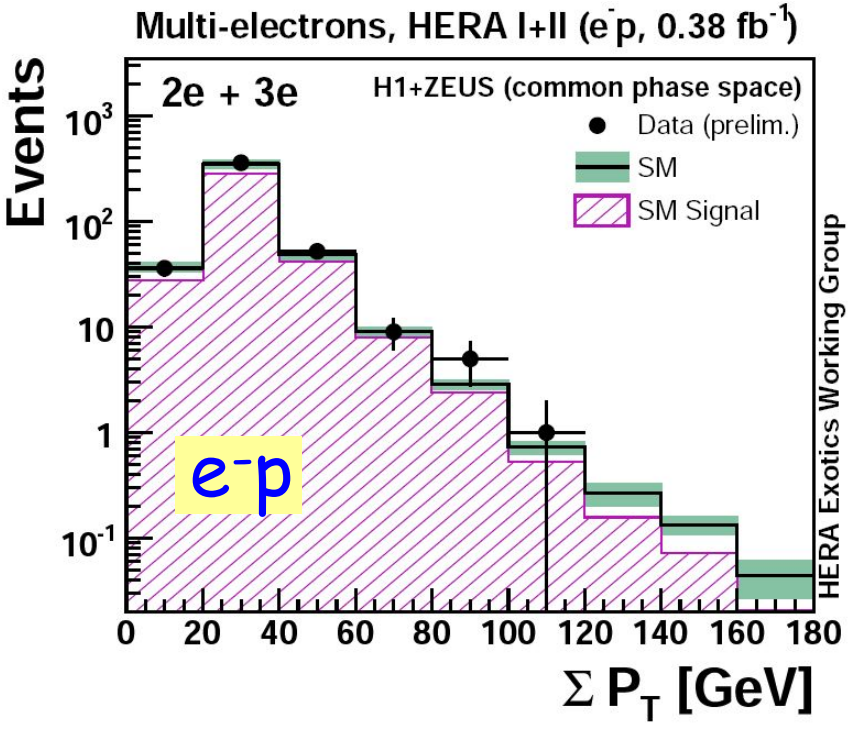
➔ ZEUS: good data/MC agreement, result comparable to H1

Multi-electron: H1 and ZEUS Combination

➘ H1 and ZEUS analyses combined in a common phase-space

➔ Total luminosity: 0.94 fb^{-1}





$\Sigma P_T > 100$ GeV

Data sample	Data	SM
e^+p (0.56 fb^{-1})	5	1.82 ± 0.21
e^-p (0.38 fb^{-1})	1	1.19 ± 0.14
$e^\pm p$ (0.94 fb^{-1})	6	3.00 ± 0.34

➔ Few high P_T events observed mainly in e+p

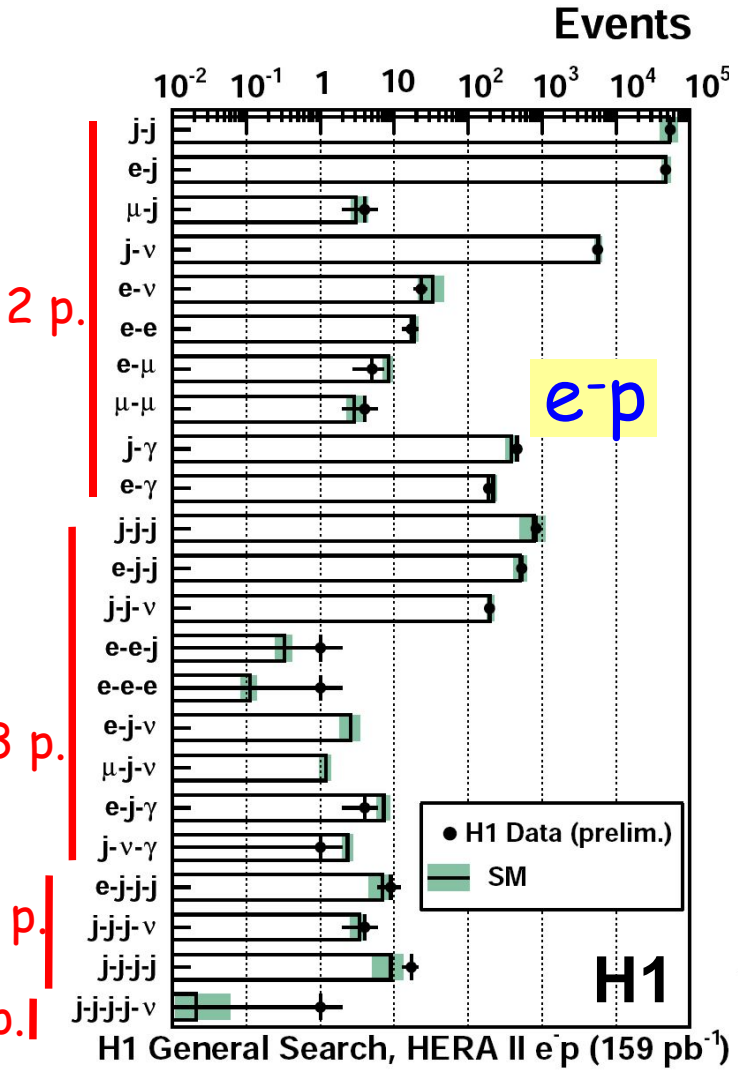
General Search

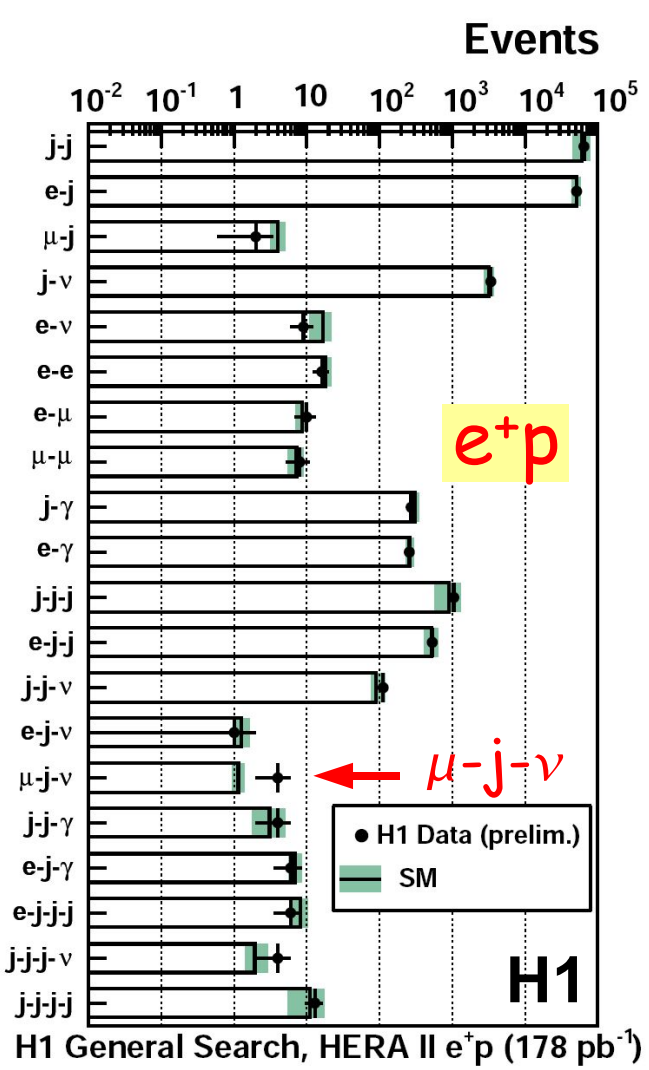
➘ A signature based search: investigate all high P_T topolgies

- H1, full HERA II data (337 pb^{-1})

  HERA I data published (117 pb^{-1}) [PLB 602(2004)14]

- Isolated particles
  - ➔ e, γ, μ, jet, ν
- A common phase space
  - ➔ P_T^{part} > 20 GeV
  - ➔ 10 < θ^{part} < 140 deg.

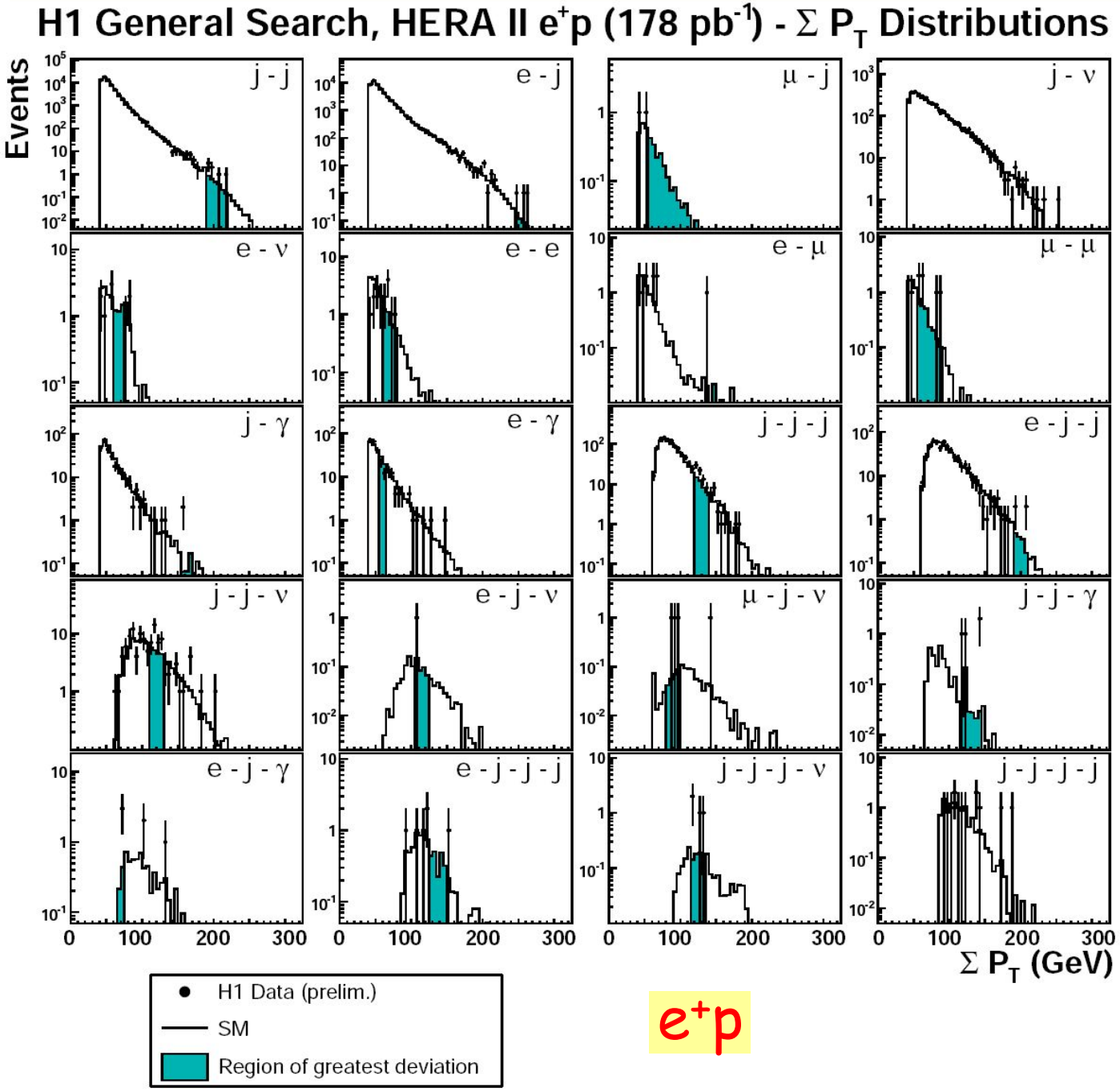




➔ Good agreement with SM in most classes

➘ Good understanding of the detector and of SM processes

General Search: Σ P_T distributions



➔ A systematical scan of all classes

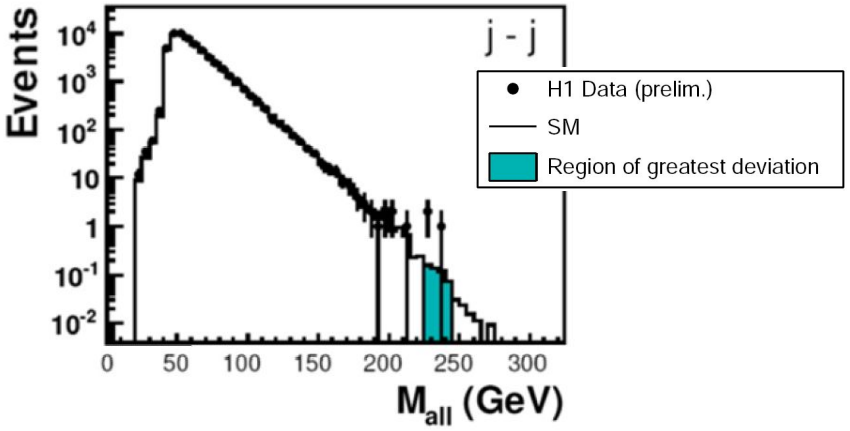
➔ Some regions with deviations found

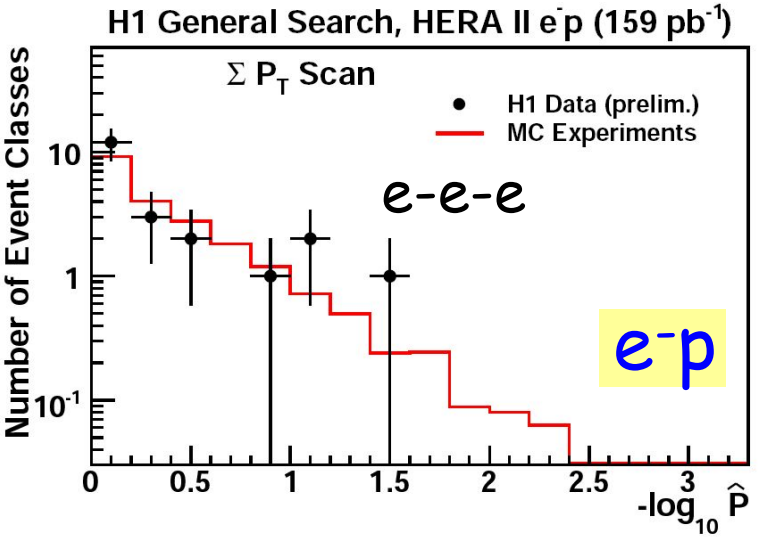
➔ Are they significant ?

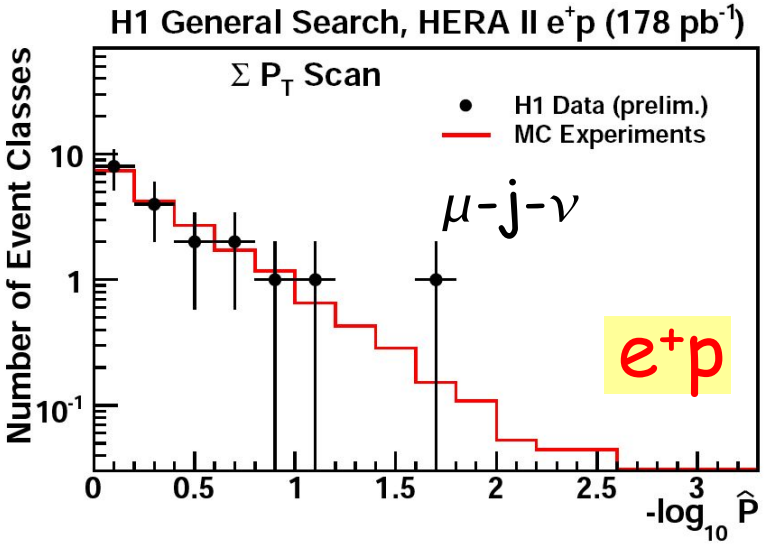
General Search: statistical analysis

➔ Classes with Nb jets >= 4 are not considered
(MC prediction not reliable enough)

- Identify regions of largest deviations data/SM
  - ➔ Investigate 1D ΣP_T and M_{all} distributions







- Statistical analysis to quantify the significance of deviations ($\hat{P}$)
  - ➔ Most significant deviation at HERA II: μ-j-ν in e+p
  - ➔ Was also the case in HERA I data ($-\log_{10}\hat{P} \sim 3$)

➘ Corresponds to the topology of isolated leptons events

Summary

- High energy running of HERA ended on March, 20 2007
  - ➔ In total: ~1 fb^{-1} collected by H1 and ZEUS together
    - ↘ Combined analyses

- Model independent searches are performed
  - ➔ Isolated lepton topologies
  - ➔ Multi-lepton topologies
  - ➔ General high-P_T search

- Agreement with the SM in most of all possible final states
  - ➔ No significant excess

- A 3σ excess remains in H1 e+p data for isolated leptons
- No excess in ZEUS data for the same channel

↘ H1 and ZEUS combinations are underway, towards final HERA results