General search for new phenomena at high P_T with H1

- Analysis strategy
- Standard Model processes
- HERA-I Results
- Search and quantification of deviations
- HERA-II results

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Introduction

- HERA-I (1994-2000, $\mathcal{L}(e^+,e^-) = 115\ pb^{-1}$, $\sqrt{s}$=300-320 GeV):
  - Important goal at HERA => Search for physics beyond SM
  - New physics likely to appear at large scale ~ at large P_T

- Dedicated searches :
  - BSM models studied in detail (FCNC, SUSY, H^{++})
  - Cuts chosen so that signal sensitivity the highest possible

    → Maximise ratio S(BSM)/B(SM)

- Generic searches :
  - Investigate all high P_t final states in a coherent way in one analysis
  - Search for deviations from SM in a BSM-model independent way

    → Minimise B(SM)

Analysis strategy (1)

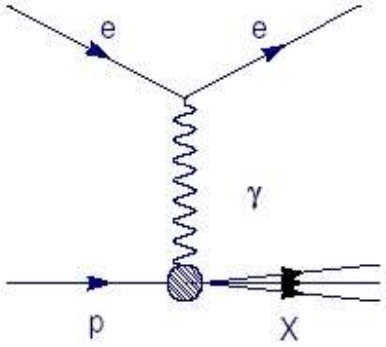
- Selection of common phase space :
  - P_T (object) > 20 GeV
  - $10^o < \theta$ (object) $< 140^o$
  - Isolation criteria : $R_{\eta\phi}$ (object) > 1.0
- Analysis of all topologies with ≥ 2 objects
- Final states with electrons, muons, photons, jets and neutrinos (e, μ, γ, j, ν) considered

→ Definition of exclusive channels according to final states objects : e-j, j-j ...

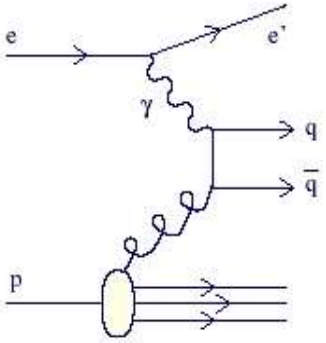
- Search for deviations in all channels between data and SM in
  Invariant mass spectrum M_{all} and ΣP_T spectrum
- Quantification of the deviations found by statistical significance

Standard Model Processes

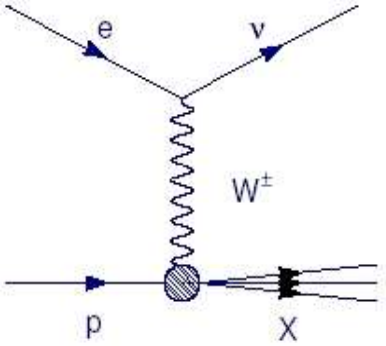
→ General Search needs SM prediction for all processes at HERA



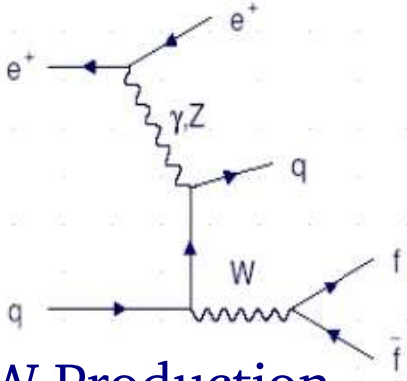
- DIS Neutral Current
- e-j, e-j-j ...



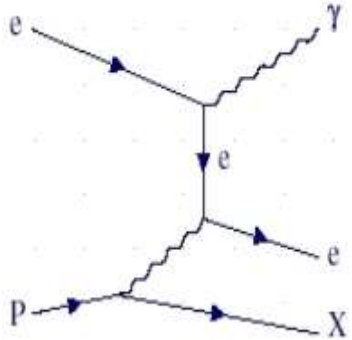
- Photoproduction
- j-j, j-j-j ...



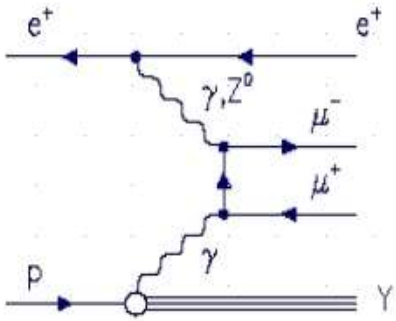
- DIS Charged Current
- j-ν, j-j-ν ...



- W Production
- e-j-ν, μ-j-ν ...



- QED Compton
- e-γ



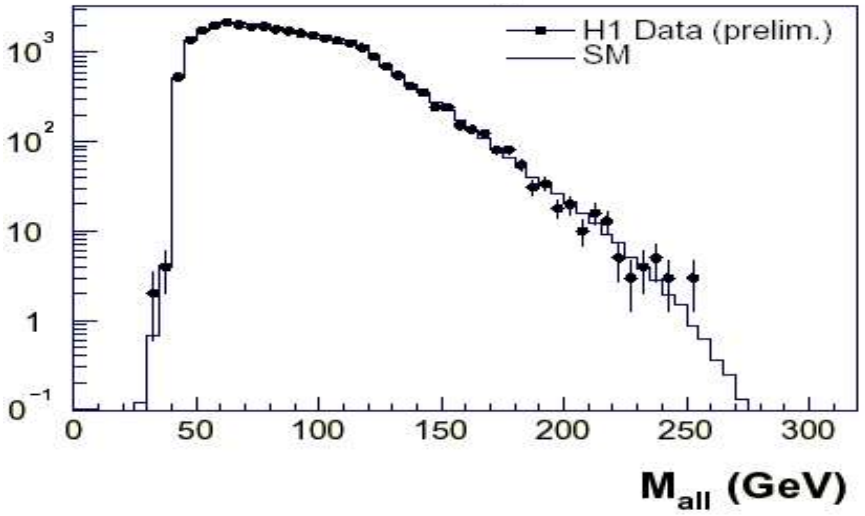
- Lepton pairs
- e-e, μ-μ

→ QED processes : $O(\alpha^2)$ + PS QCD processes : $O(\alpha_s)$ + PS (MEPS/CDM)

Results – Dominant processes

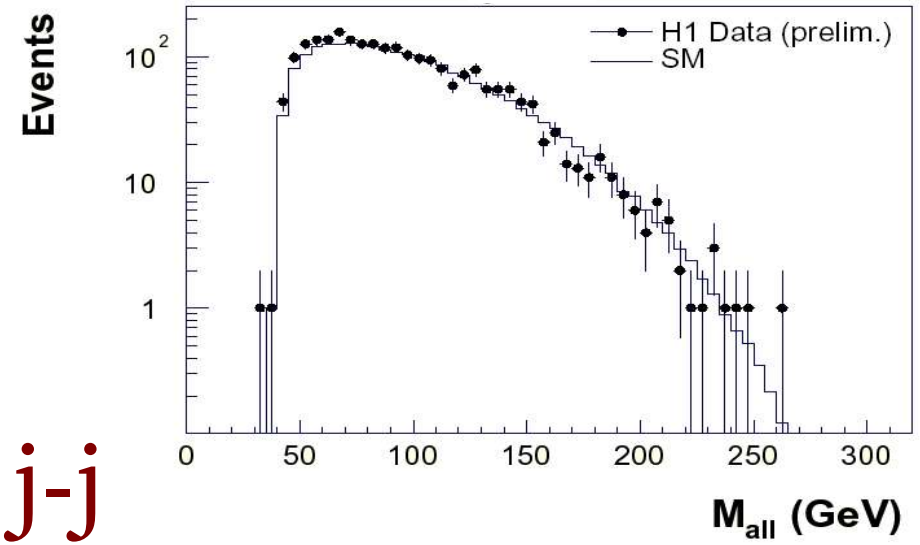
e-j

NC DIS



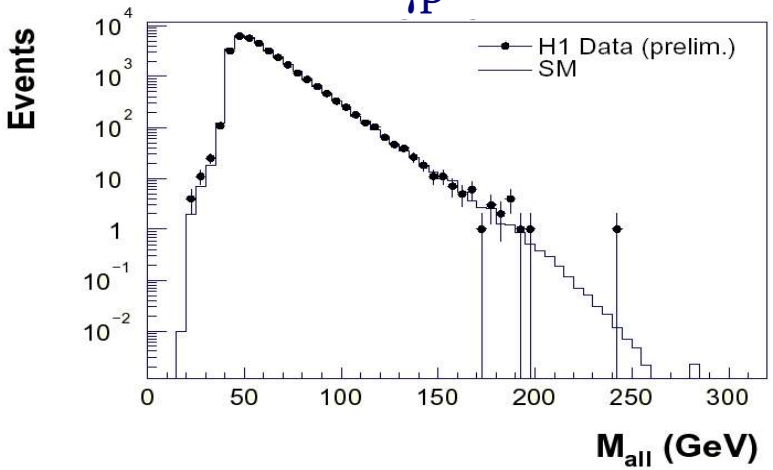
j-ν

CC DIS



j-j

γp

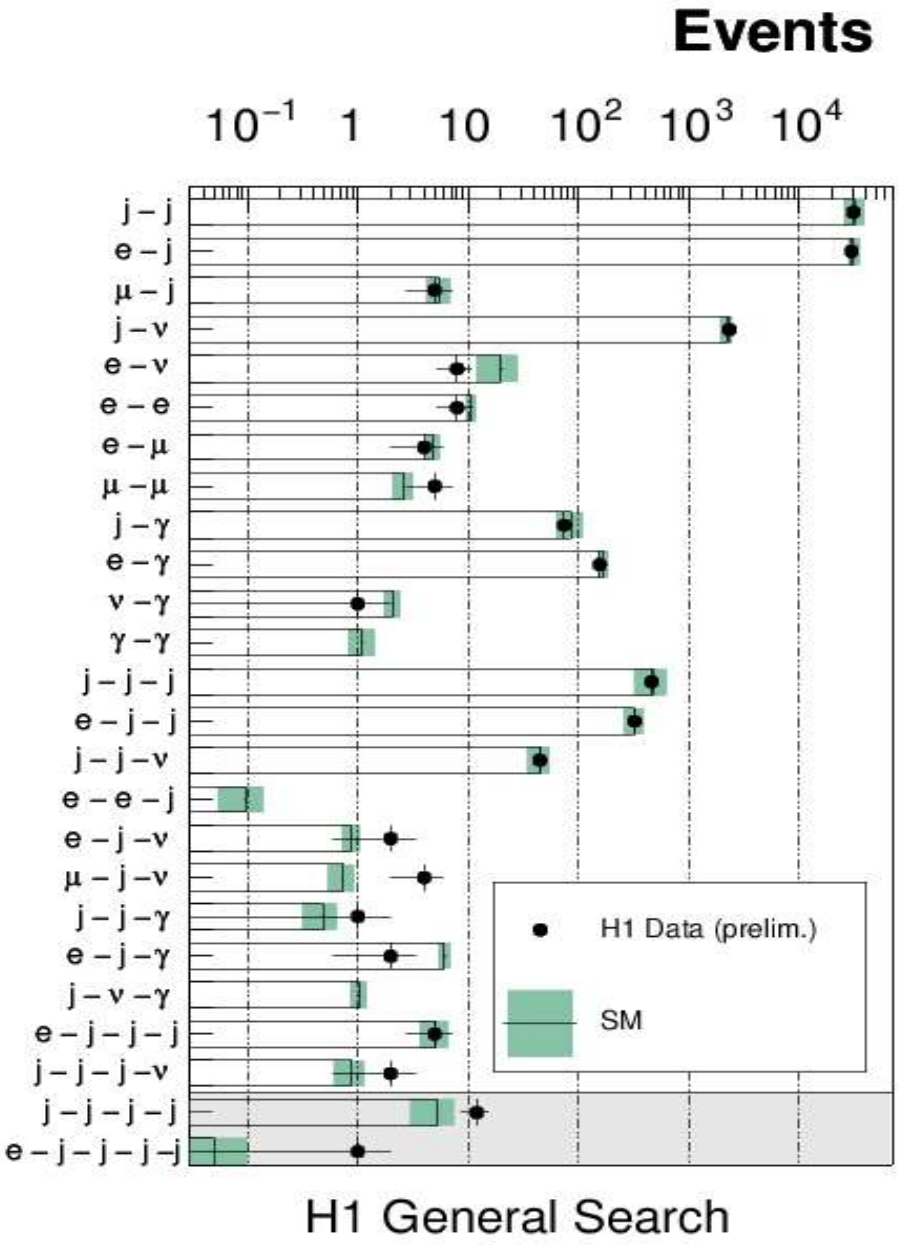


→ Good unterstanding of SM physics up to borders of phase space

Results – Event yields

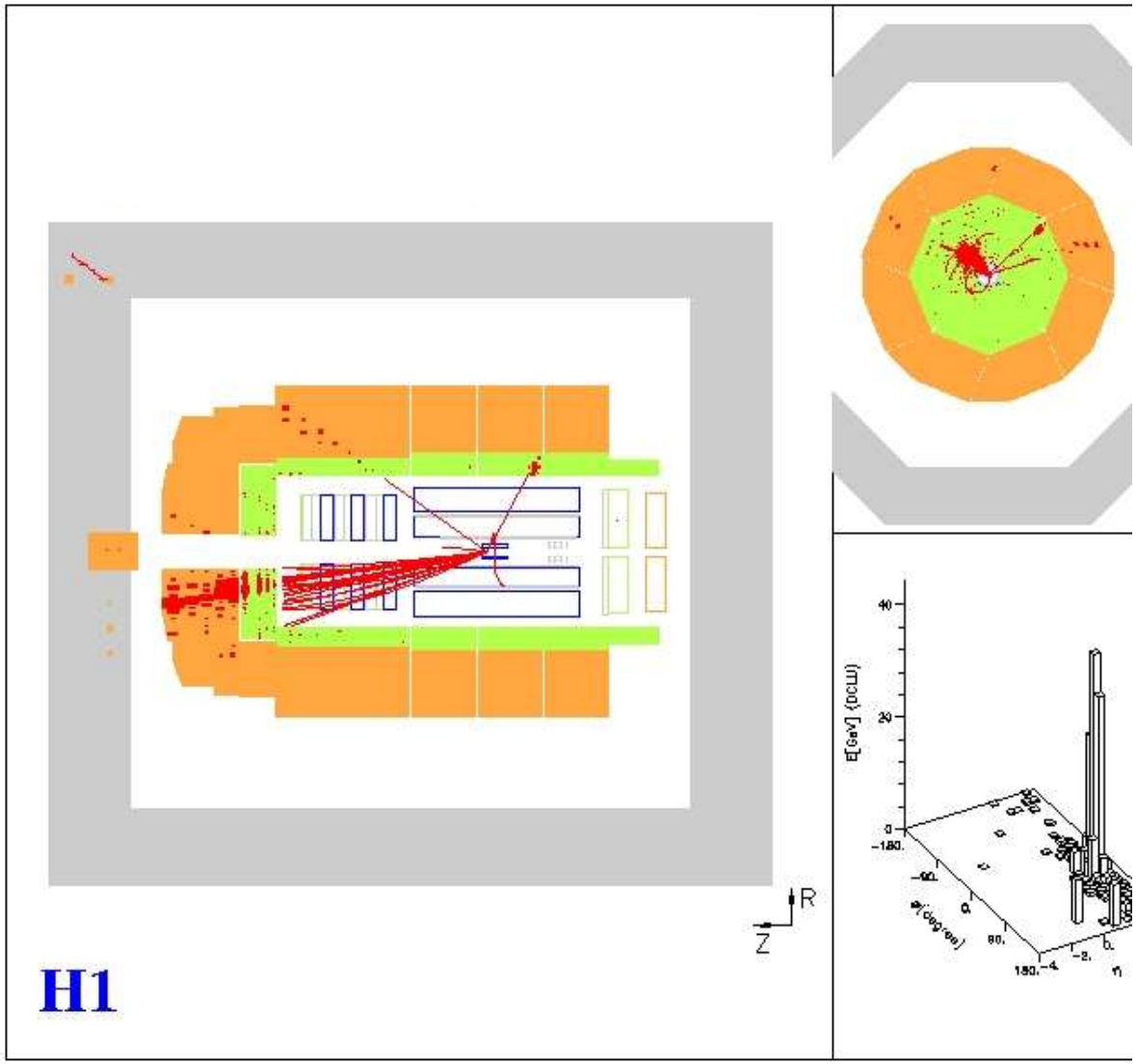
- Dominant processes : γp, NC and CC
- Rare events :
  - Leptonic channels
  - Channels with radiative processes
  - j-j-j-j and e-j-j-j-j not passed through statistical analysis

→ Good agreement between data and MC in most event classes



Outstanding event : μ-j-ν class

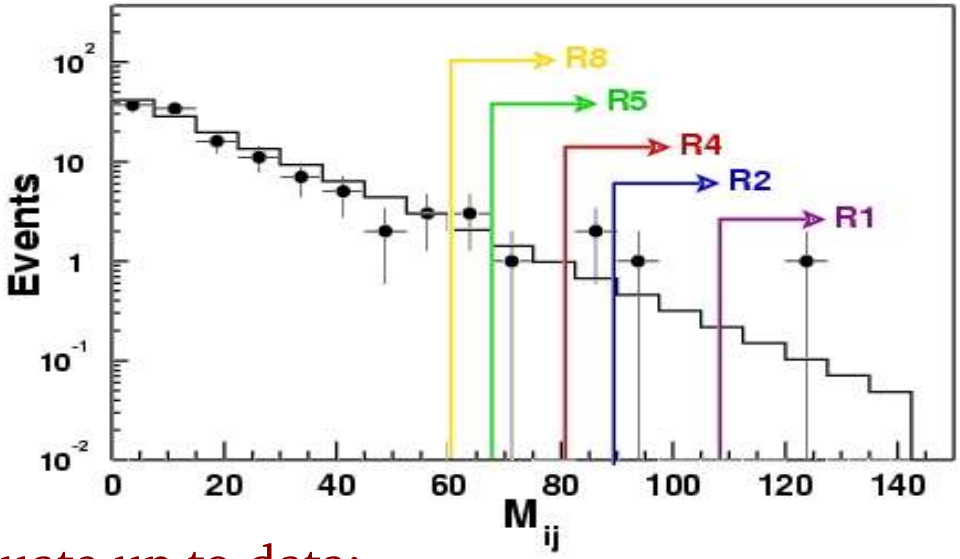
$$e^+p \to e^+\mu^- X$$



Search for deviations (1)

- Search for deviations between data and SM prediction in distributions of invariant mass M_{all} and $\sum P_T$
- Find region of largest deviation :

→ Check all possible regions :



→ Calculate probability for MC to fluctuate up to data:

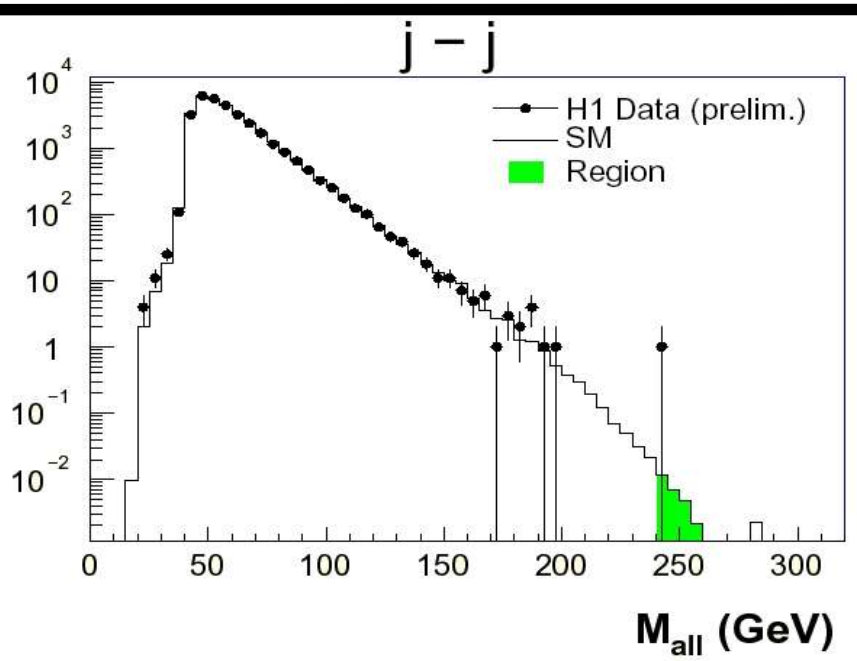
$$p_{N \geq N_{obs}^{data}} = \sum_{i=N_{obs}}^{\infty} \int_0^{+\infty} db \quad G(b; b_R; \delta b_R) \quad \frac{e^{-b} b^i}{i!}$$

Systematic errors

Statistical error

Search for deviations (2)

- Region of greatest interest :
  p_{min} (data) = min $p_{N \geq Nobs}$(data)



- Significance of deviation :

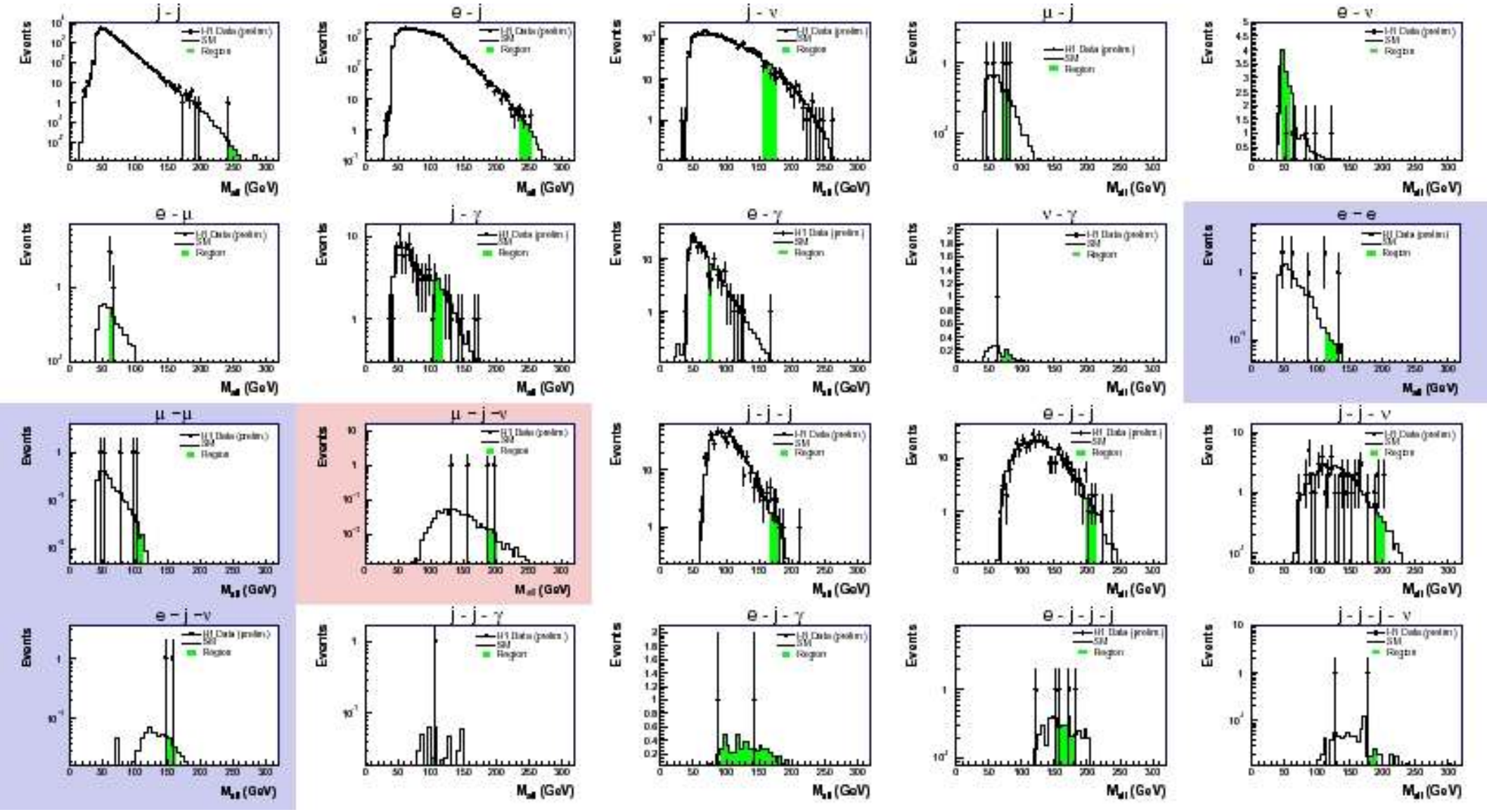
  → Do MC experiment according to SM expectation (and errors)

  → Calculate probability p_{min}(exp) for each experiment

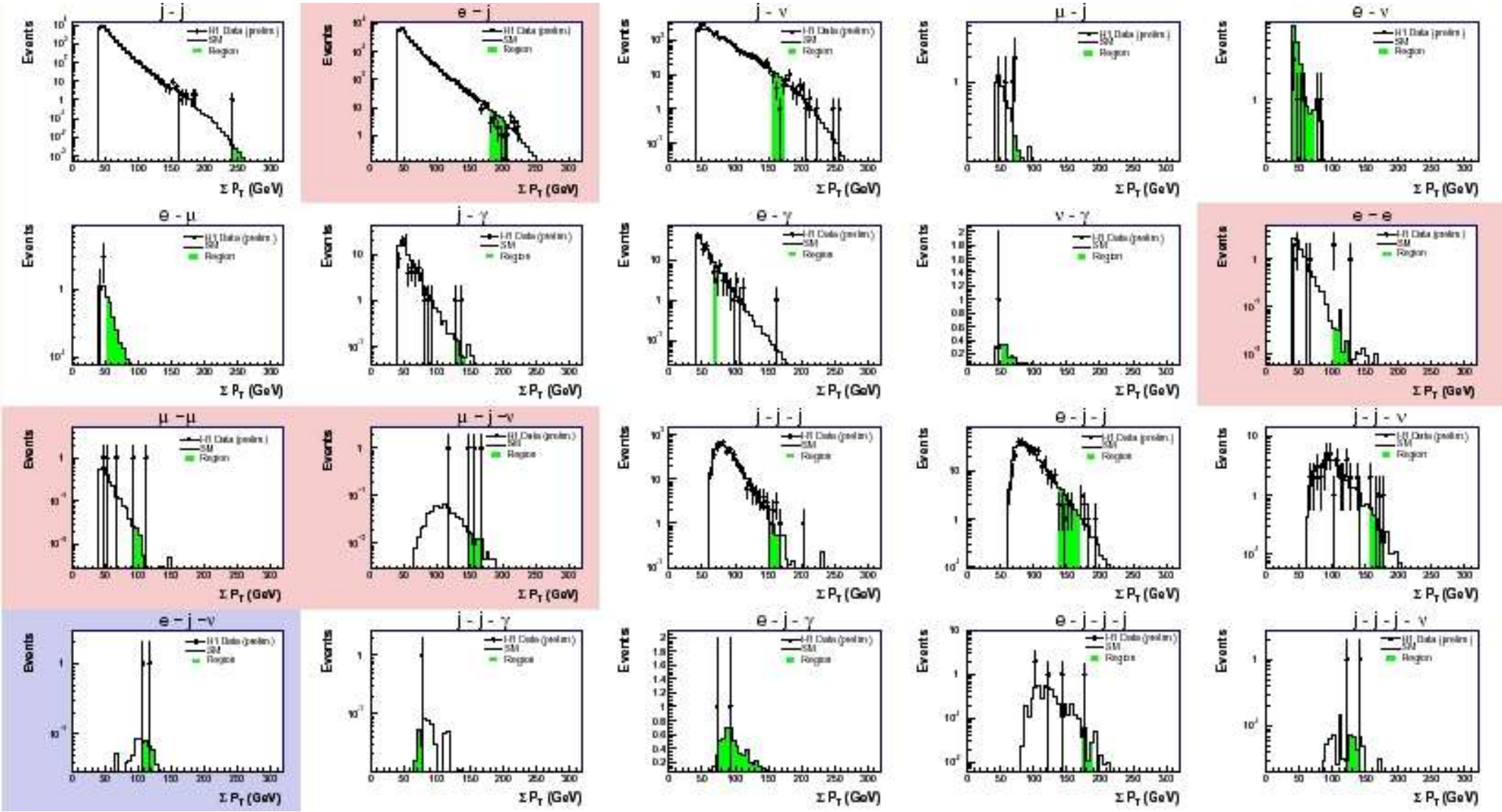
  → Count occurrences of p_{min}(exp) < p_{min} (data) : $\hat{P}$

- If deviations are due to fluctuations
  → $\hat{P}$(data) and $\hat{P}$(MC) are compatible

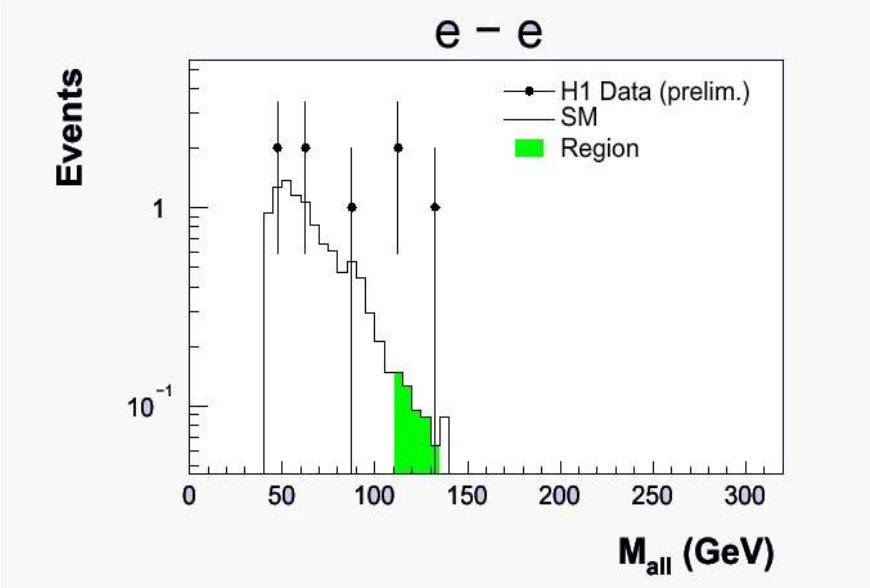
Selected Regions - M_{all}

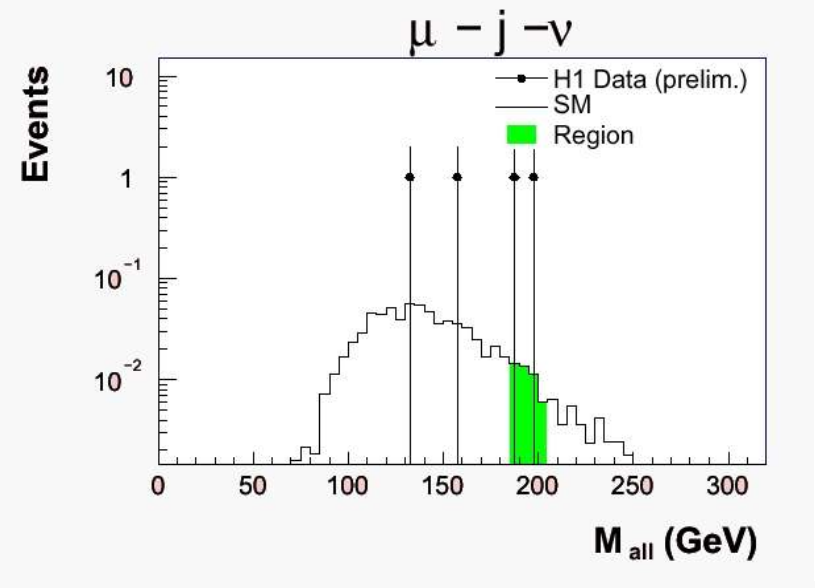


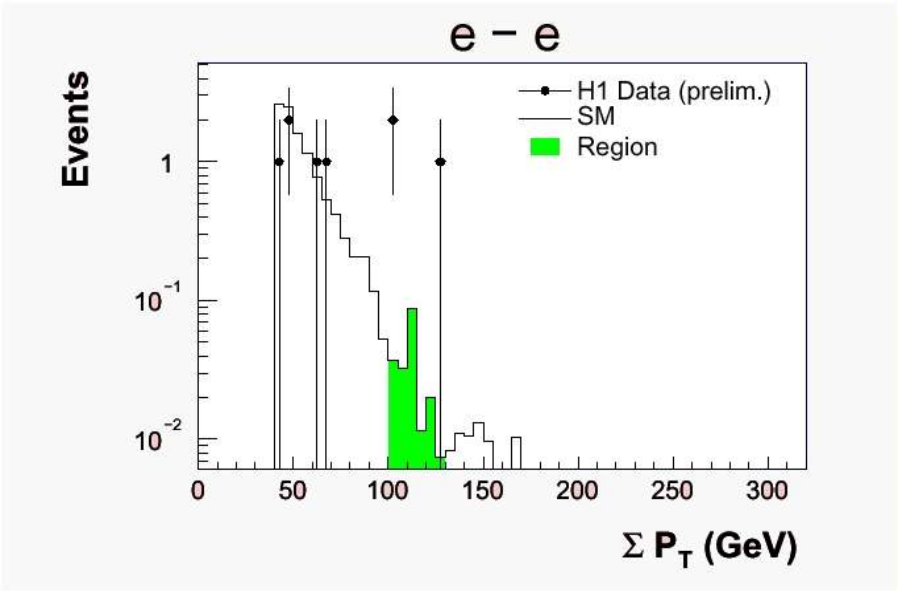
Selected regions - ΣP_T

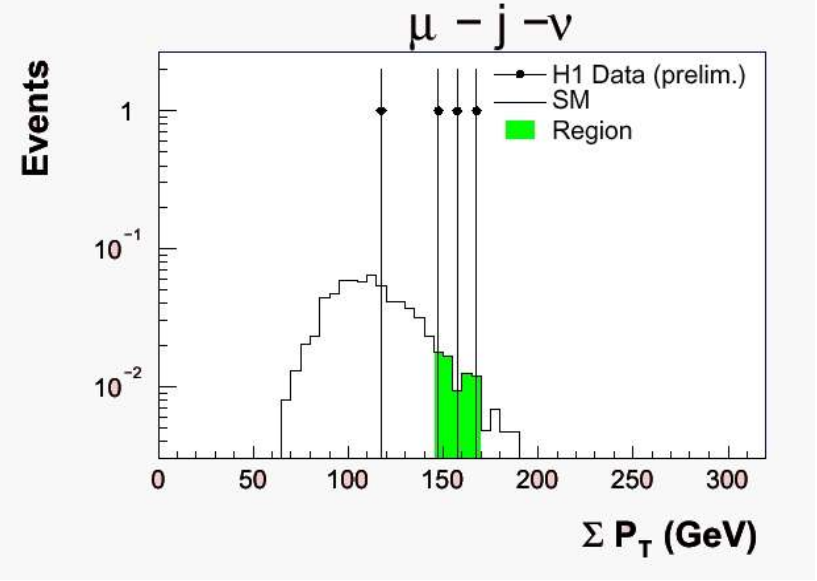


Most interesting regions



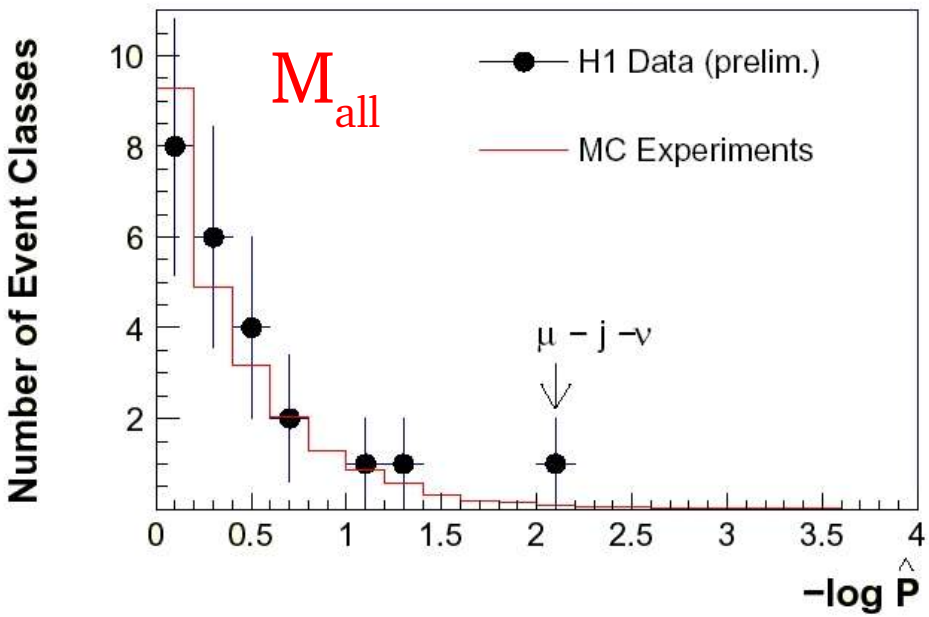


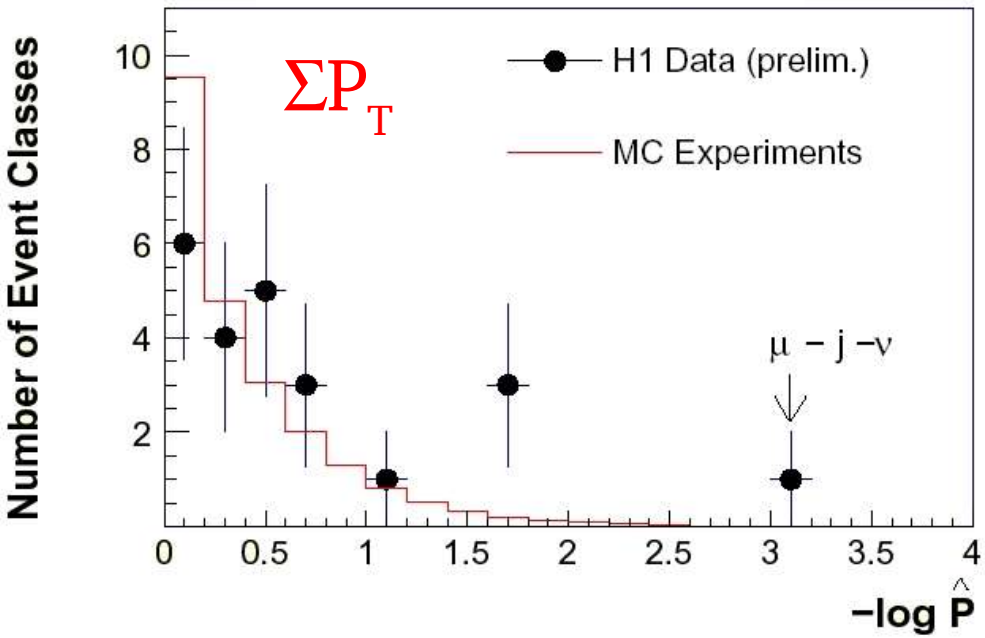




→ Significant deviations in high mass and high P_T regions

Results



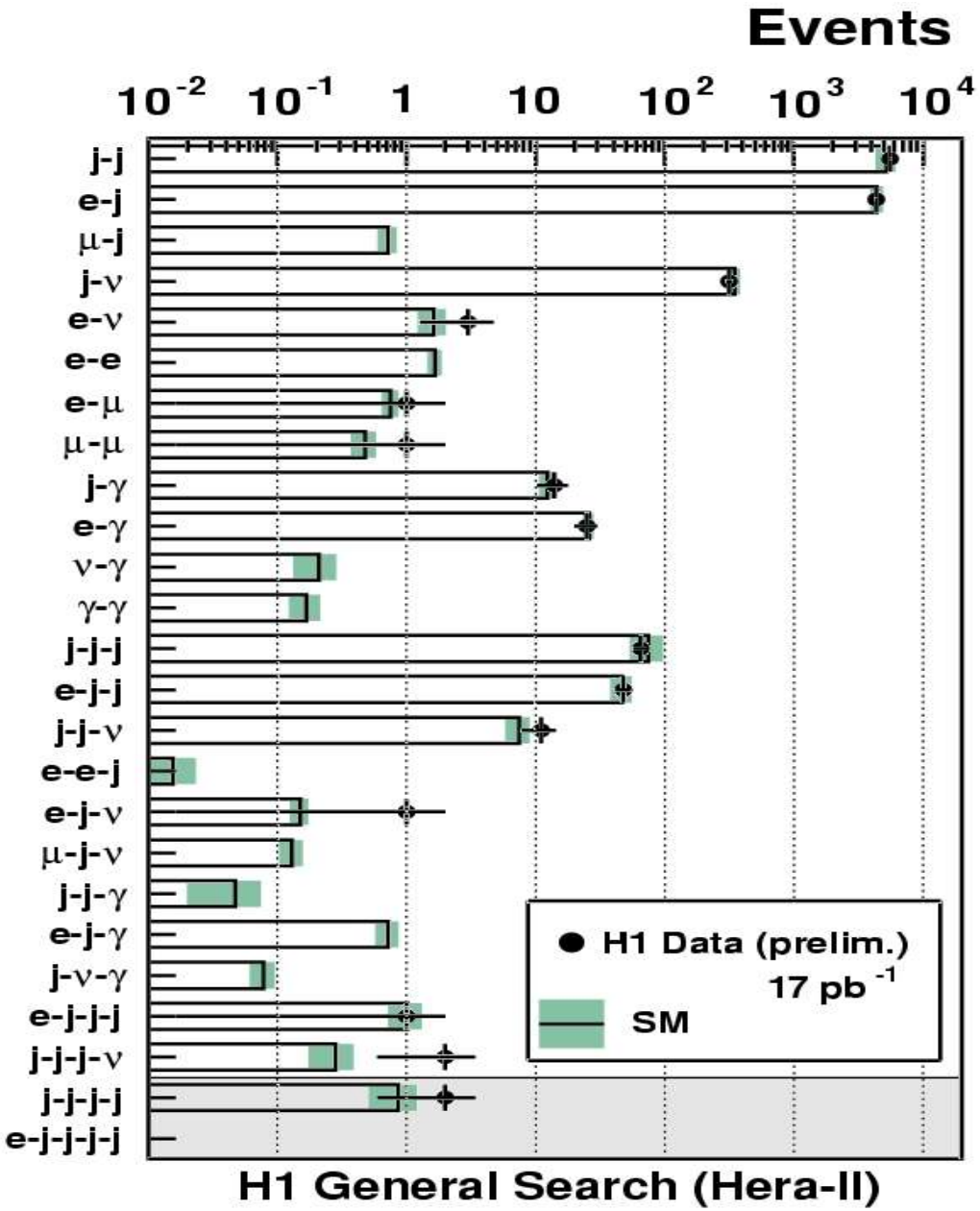


- M_{all} :
  - Good agreement between data and MC experiments
  - Probability to find one event class with $\hat{P} \leq 0.01$ (μ-j-ν) is 25%
- ΣP_T :
  - Larger deviations than in the mass distributions
  - Probability to find one event class with $\hat{P} \leq 0.0008$ (μ-j-ν) is O(2%)

HERA-II : results

- Data set :
  - October 2003 – April 2004
  - $\mathcal{L} = 17\ \mathrm{pb}^{-1}$

→ No significant deviation found



Summary

- HERA-I :
  - Invariant mass and ΣP_T distributions with e, j, μ, ν, γ at high P_T have been investigated (up to 6 bodies)
  - Good agreement between data and SM found in most of the event classes
  - Most interesting event class μ-j-ν
  - No new significant deviation found
- HERA-II :
  - First results show good agreement between data and SM

$\rightarrow$ 1 fb^{-1} expected to come!