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Muon Pair Production

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Introduction

$$ep \longrightarrow (e)\mu\mu X$$

Aim:

- **Inclusive measurement of isolated muon pair production (☛ first H1 prelim. results)**
- **Elastic / Inelastic production**

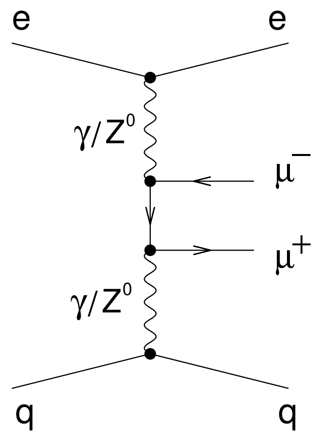
Searches at H1:

- **Isolated μ are a clear signature**
  eg.: $\gamma\gamma \longrightarrow \mu(\mu)$ BG for W search
  ➜ missing μ fakes ν

Production Processes:

- **Two photon process**
- **Bremsstrahlung γ/Z^0**
- **Υ-resonance**

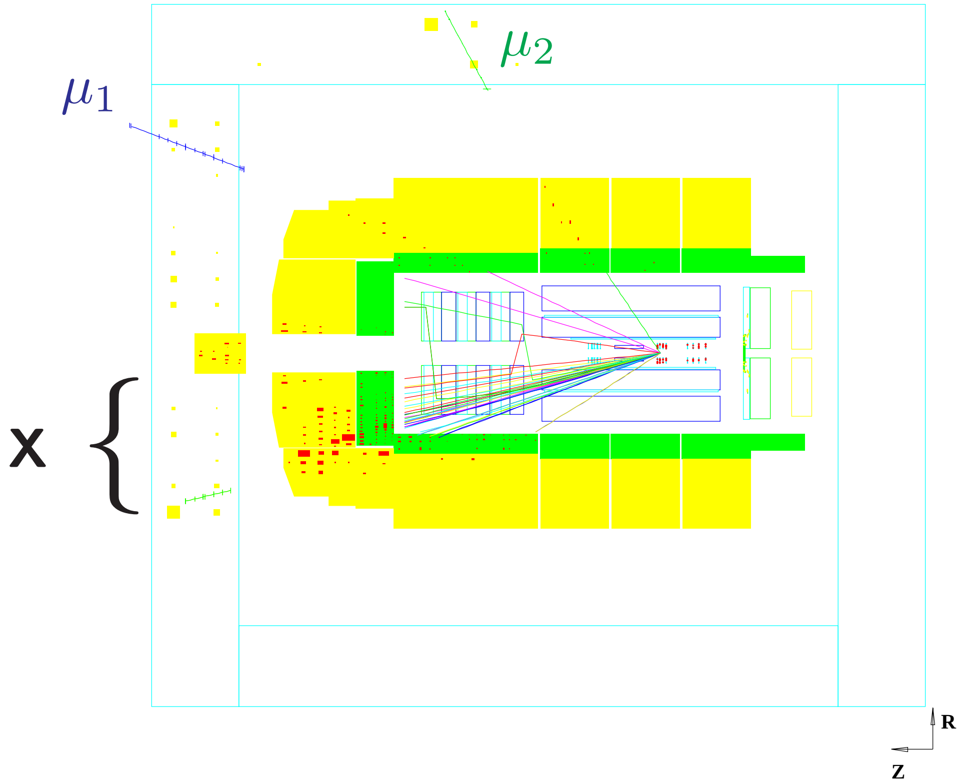
➤ $\gamma\ \gamma \longrightarrow \mu\ \mu$



Similar to LEP

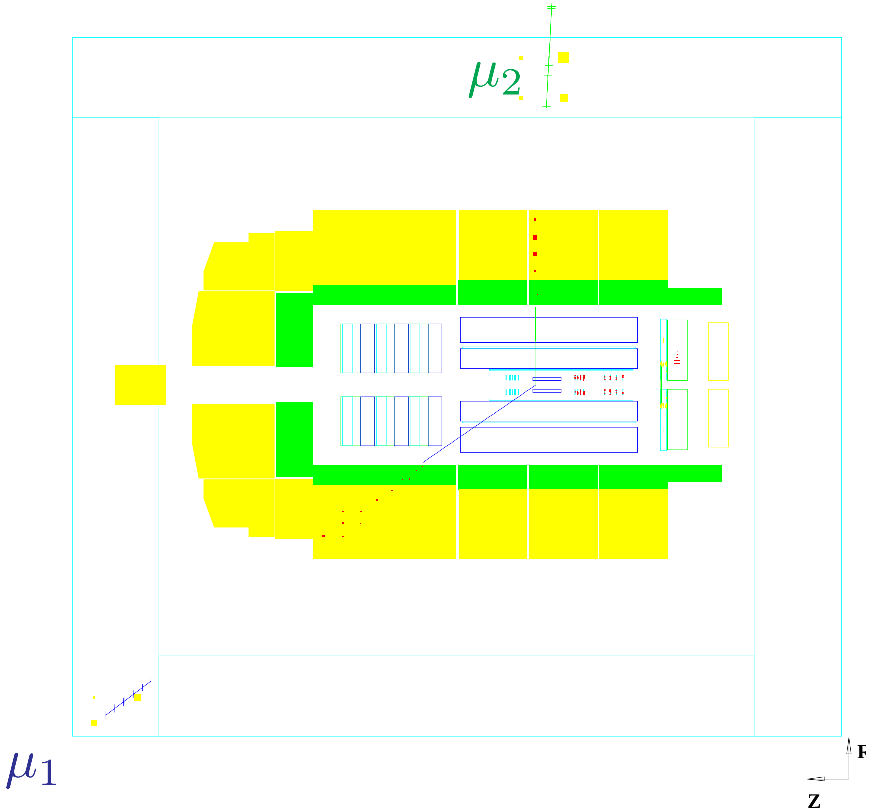
Muon Events

inelastic $ep \longrightarrow e\mu\mu X$



$P_t^X = 47$ GeV

elastic $ep \longrightarrow ep\mu\mu$



$M_{\mu,\mu} = 80$ GeV

Selection

Muon:

Track in the Central Muon Detector linked to inner Track
Minimal ionising particle in LAr Calorimeter linked to inner Track

Phase Space:

- $M_{\mu\mu} > 5$ GeV
- $20^\circ < \theta_\mu < 160^\circ$
- $P_t^{\mu 1} > 2.0$ GeV
- $P_t^{\mu 2} > 1.75$ GeV

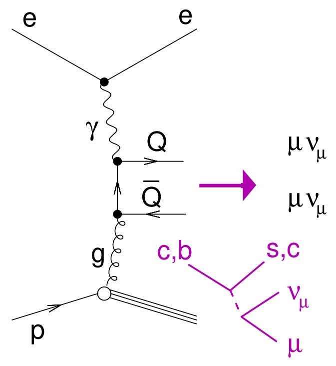
Background:

- **Isolation of μ:** $D^{(\eta\phi)}_{\mu,Track} > 1.0$, $D^{(\eta\phi)}_{\mu,Jet} > 1.0$
  - ➜ π-Suppression
  - ➜ Suppression of $\mu\mu$ from semi-leptonic decays of $Q\bar{Q}$
- **Opening Angle:** $\alpha_{\mu,\mu} < 165^\circ$
  - ➜ Cosmic Rejection

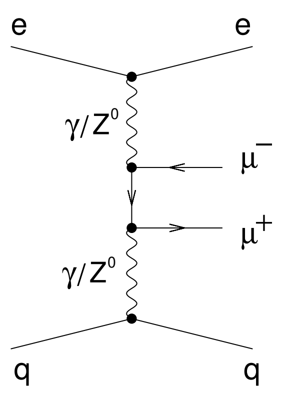
Data (99/00): $\mathcal{L} = 70.9$ pb^{-1}

Events selected: 1242

Comparing Data to Predictions

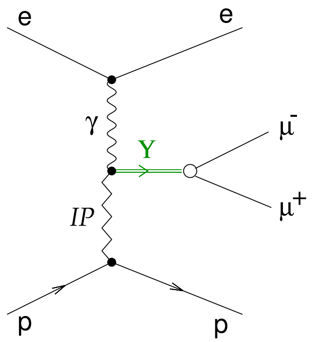


Lpair



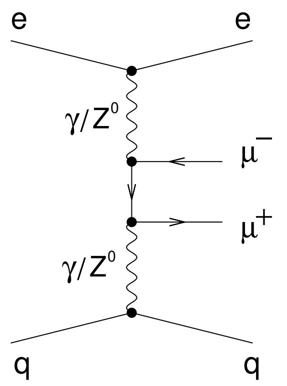
SM:

- **GRAPE (LO calculation + ISR/FSR)**
- **open heavy flavour quark production ($c\bar{c}$,$b\bar{b}$)**
- $\Upsilon \longrightarrow \mu\mu$
- $\gamma\gamma \longrightarrow \tau\tau \longrightarrow \mu\mu$

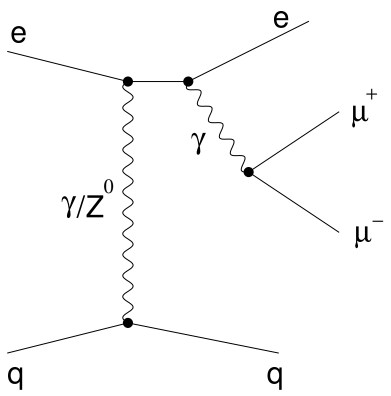


Υ-production

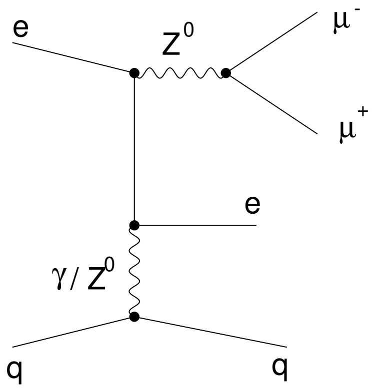
Grape



Bethe-Heitler



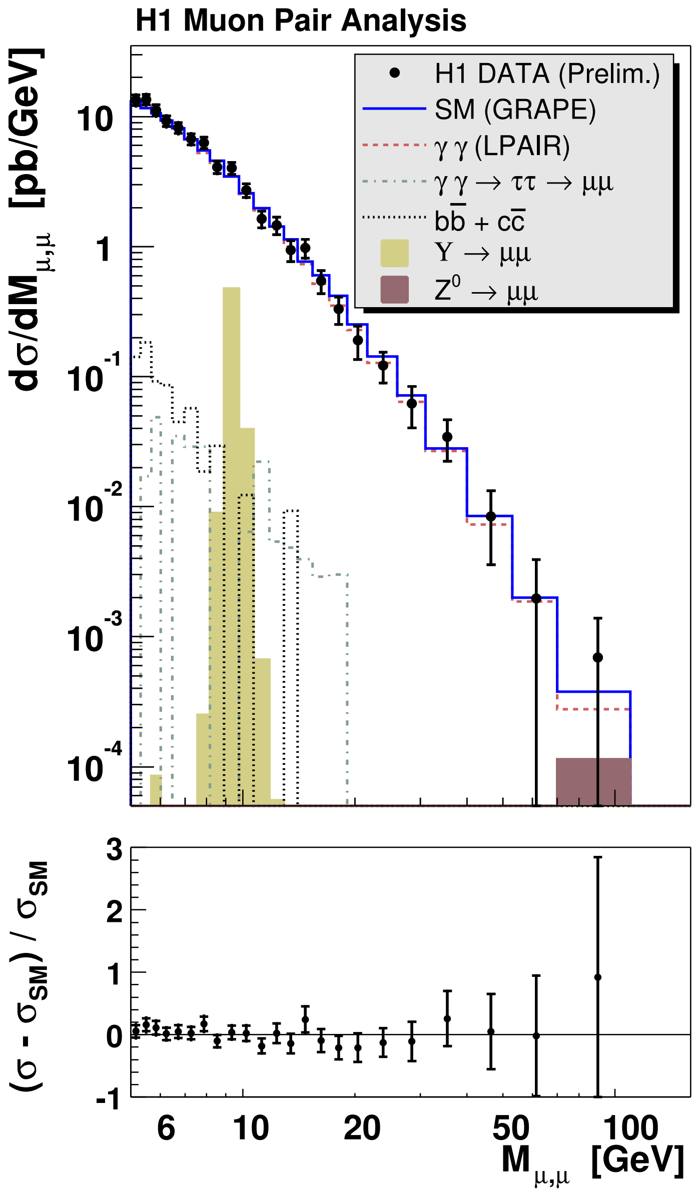
QED-Compton



Z^0-production

☛ **data corrected to the defined phase space**

Invariant Mass



➜ Spectrum covers 4 decades

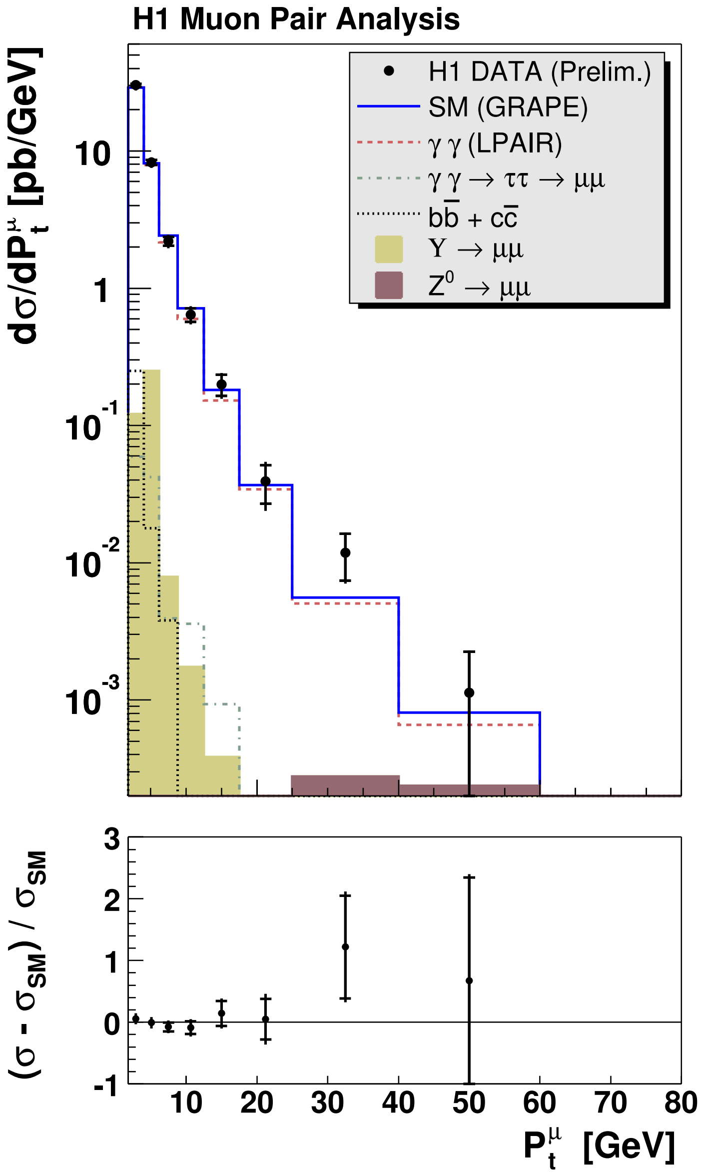
➜ Masses up to 80 GeV

➜ $\gamma\gamma$ dominates also at M_Z

➜ Data agrees well with SM over the entire mass range

➜ $\gamma\gamma$ almost explains data

Transverse Momenta

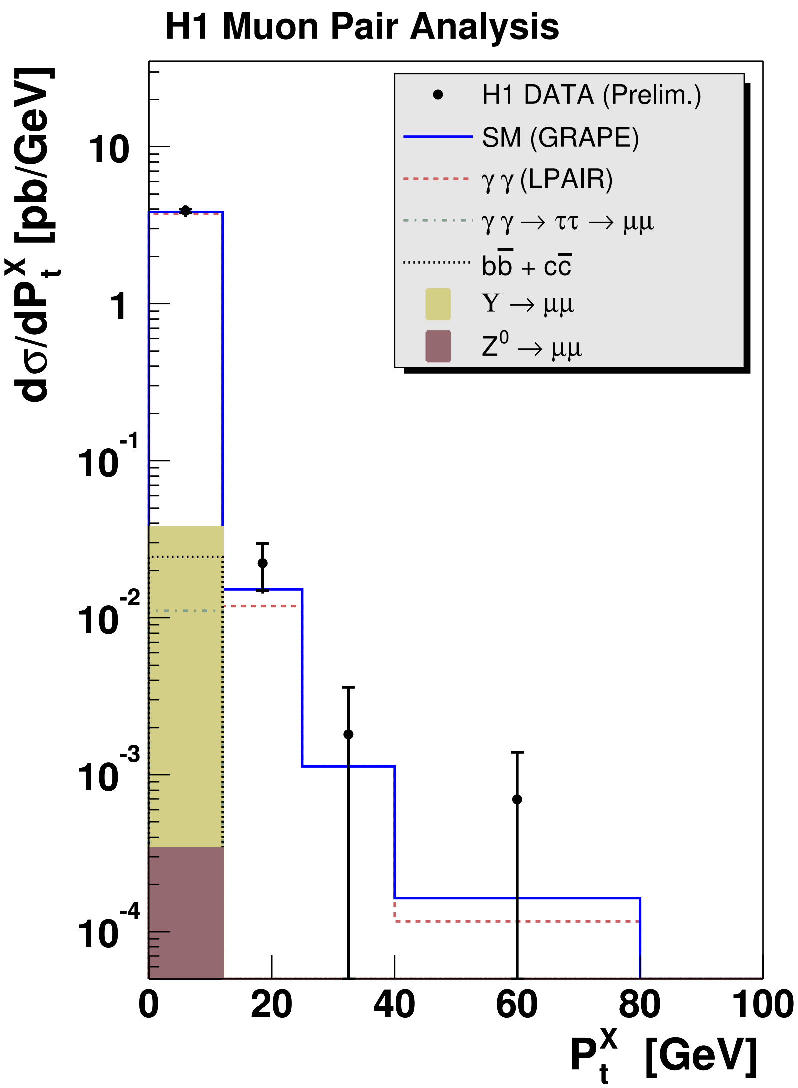


➜ Measure P_t^μ up to 50 GeV

➜ Bin size at high P_t^μ reflects tracker resolution

➜ No significant deviation from SM ($\sim$ 1 σ at P_t^μ 25-40 GeV)

Hadronic Transverse Momentum



➜ Highest P_T^X event is found at 47 GeV !

➜ MC Expectatation in the high P_T^X regime is very low

➜ Data and MC agree well

Distinguishing Elastic and Inelastic Muon Production

experimental:

- Detection of the proton remnant
  like in diffractive analysis

theoretical:

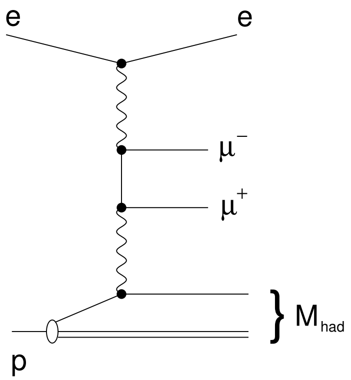
- elastic: $ep \longrightarrow ep\mu\mu$
  $M_{had} = M_P$

- inelastic: $ep \longrightarrow e\mu\mu X$
  $M_{had} > M_P + M_\pi$

inelastic ➜ quasi-elastic + DIS

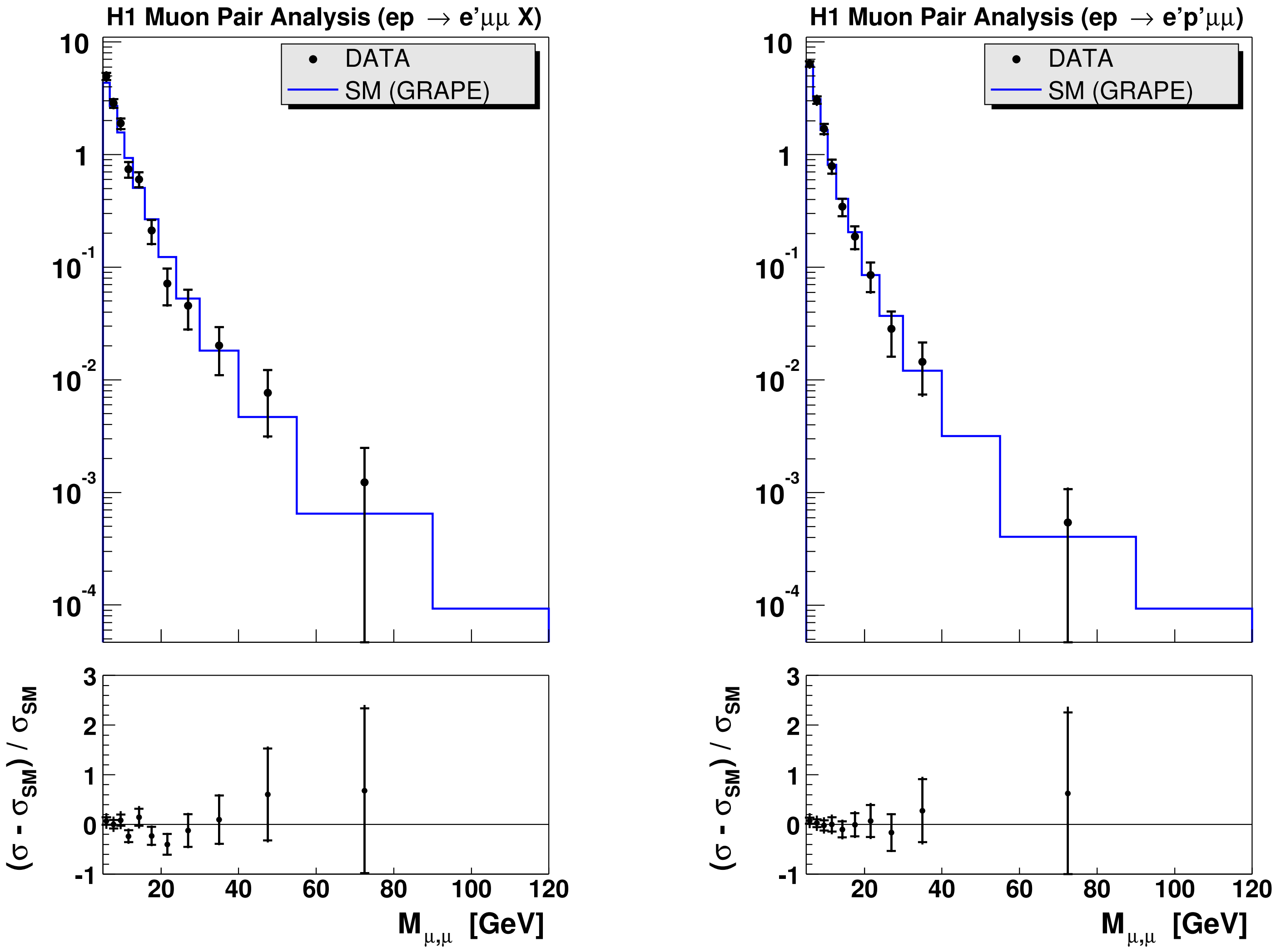
Parametrisations of structure functions
Brasse / ALLM 97

Parton density function
CTEQ 5L



M_{had} mass of the hadronic system

Inelastic and Elastic Muon Production



➜ **Elastic Muon Production dominates at small $M_{\mu,\mu}$**

Total Cross Sections

Inclusive

$$\begin{array}{llll} ep \longrightarrow & \gamma\gamma & \longrightarrow & \mu\mu \\ ep \longrightarrow & \gamma/Z^0 & \longrightarrow & \mu\mu \end{array}$$

$$\sigma_{incl}^{vis} = (46.5 \pm 1.3 \pm 4.7) \text{ pb}$$

$$\sigma_{incl}^{GRAPE} = 46.2 \text{ pb}$$

Inelastic

$$\begin{array}{llll} ep \longrightarrow & \gamma\gamma & \longrightarrow & e\mu\mu X \\ ep \longrightarrow & \gamma/Z^0 & \longrightarrow & e\mu\mu X \end{array}$$

$$\sigma_{inel}^{vis} = (20.8 \pm 0.9 \pm 3.3) \text{ pb}$$

$$\sigma_{inel}^{GRAPE} = 21.5 \text{ pb}$$

➜ Total cross sections are well described by GRAPE

➜ inelastic: error from separation ela/ine causes deviation (within errors) for σ_{inel}^{vis}

Conclusion

- First H1 (prelim.) measurements of the inclusive process $ep \longrightarrow e\mu^+\mu^- X$

- Cross section measurement

$$\frac{d\sigma}{dM_{\mu,\mu}}, \frac{d\sigma}{dP_t^{\mu}}, \frac{d\sigma}{dP_t^{X}} \quad \text{and} \quad \frac{d\sigma^{ela}}{dM_{\mu,\mu}}, \frac{d\sigma^{ine}}{dM_{\mu,\mu}}$$

  ➜ **Two photon process $\gamma\gamma \longrightarrow \mu\mu$ dominates all differential distributions**

- Total cross section for inclusive and inelastic sample

$$\sigma_{incl}^{vis} = (46.5 \pm 1.3 \pm 4.7)\ \text{pb} \qquad \sigma_{inel}^{vis} = (20.8 \pm 0.9 \pm 3.3)\ \text{pb}$$

- No events with more than 2 muons have been observed

All distributions are in good agreement with the Standard Model