Measurement of $\sigma.\mathrm{Br}$ for $\mathrm{p\bar{p}} \rightarrow X\mathrm{Z} \rightarrow X\mu^+\mu^-$ at $\sqrt{s} = 2$ TeV using the DØ detector.

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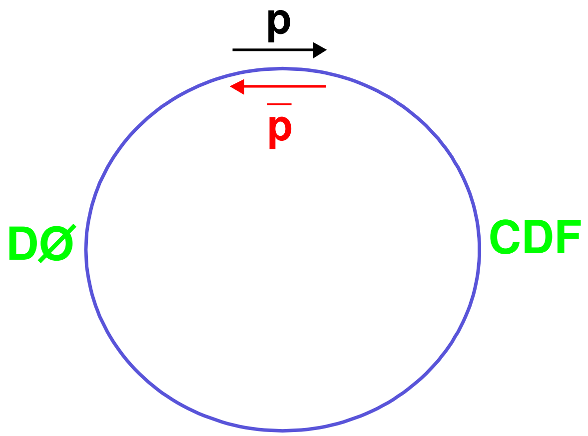
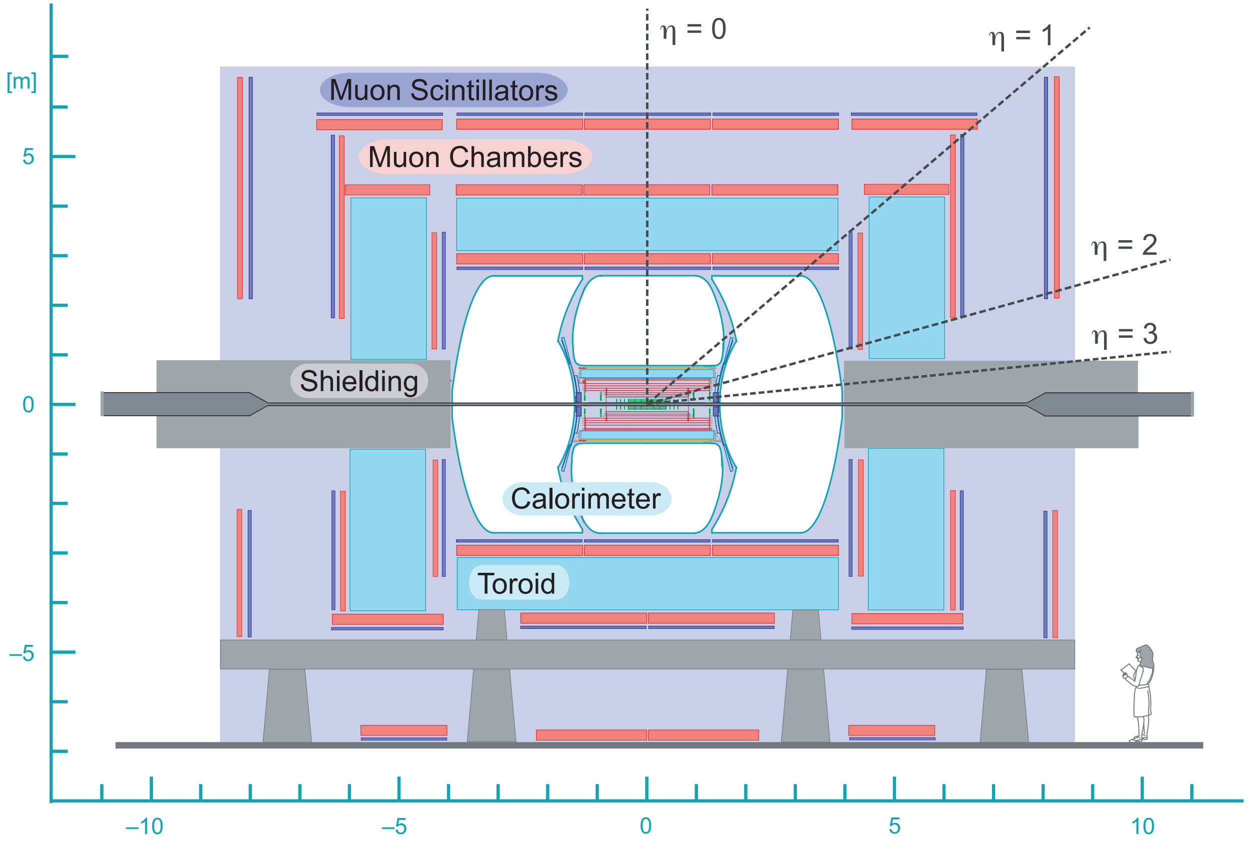
IOP April 2004

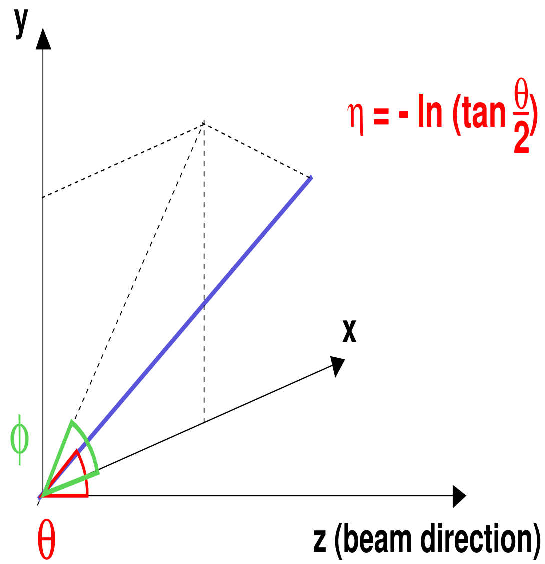
THE UNIVERSITY of MANCHESTER

- THE TEVATRON : $p\bar{p}$ collisions at $\sqrt{s} = 2$ TeV

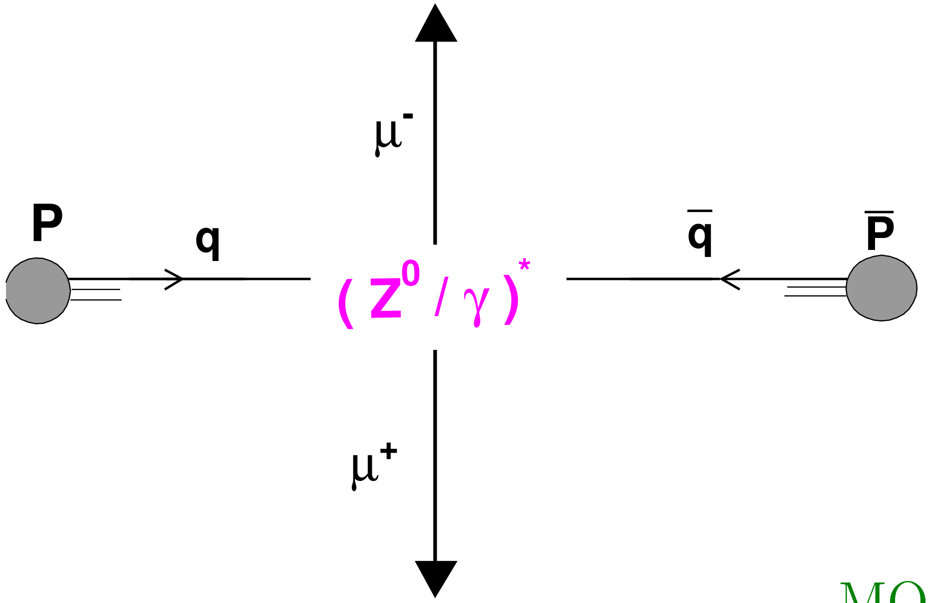


- DØ : a general purpose detector





$(Z/\gamma)^* \to \mu^+\mu^-$ at the Tevatron



SIGNATURE:

$\mu^+\mu^-$ pair with large momentum component transverse to beam.

MOTIVATION:

- benchmarks understanding of experiment
- "Standard Candle" for all high momentum leptonic processes
- electroweak precision measurements such as W width, τ_W
- compare production mechanism with QCD predictions

σ.Br **measurement**

$$\sigma.\mathrm{Br} = \frac{\mathrm{N_{cand}}(1 - f_{bckg})}{\epsilon_{\mathrm{Z}/\gamma^*} \int L}$$

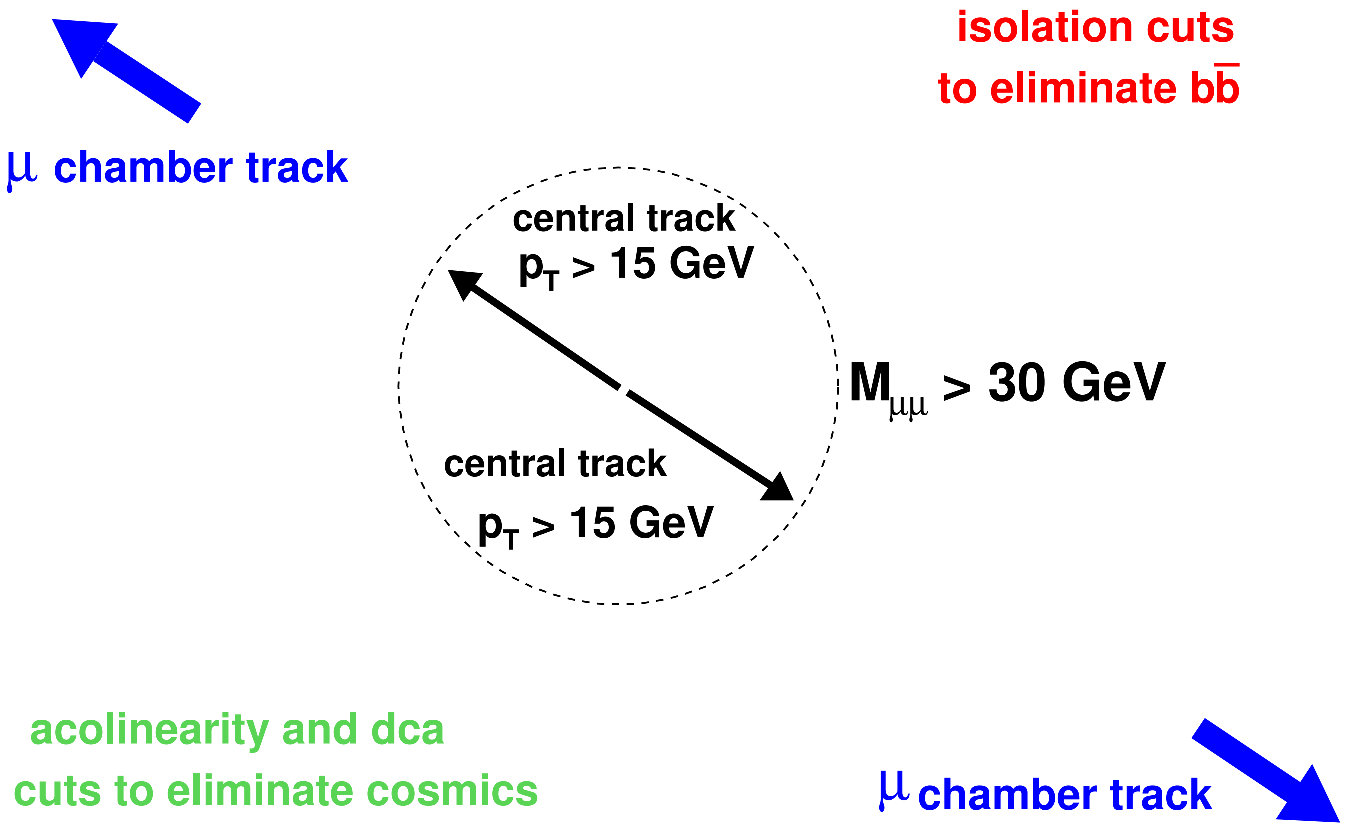
1. Count the number of candidate events, $\mathrm{N_{cand}}$
2. Calculate total efficiency of selection criteria and detector acceptance, $\epsilon_{\mathrm{Z}/\gamma^*}$
3. Estimate remaining background fraction, f_{bckg}
4. Calculate luminosity, $\int L$

$$\longrightarrow \sigma.\mathrm{Br}\ ((Z/\gamma)^* \to \mu^+\mu^-\ (\mathrm{M}_{\mu\mu}\ > 30\ \mathrm{GeV}))$$

5. Correct for events with Z/γ^* propagator

$$\longrightarrow \sigma.\mathrm{Br}\ (\mathrm{Z} \to \mu^+\mu^-)$$

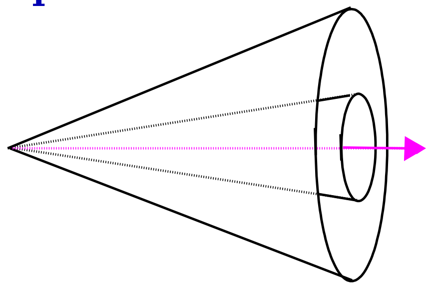
EVENT SELECTION



14790 candidate events

ISOLATION

2 of the following 4 cuts are required to pass:



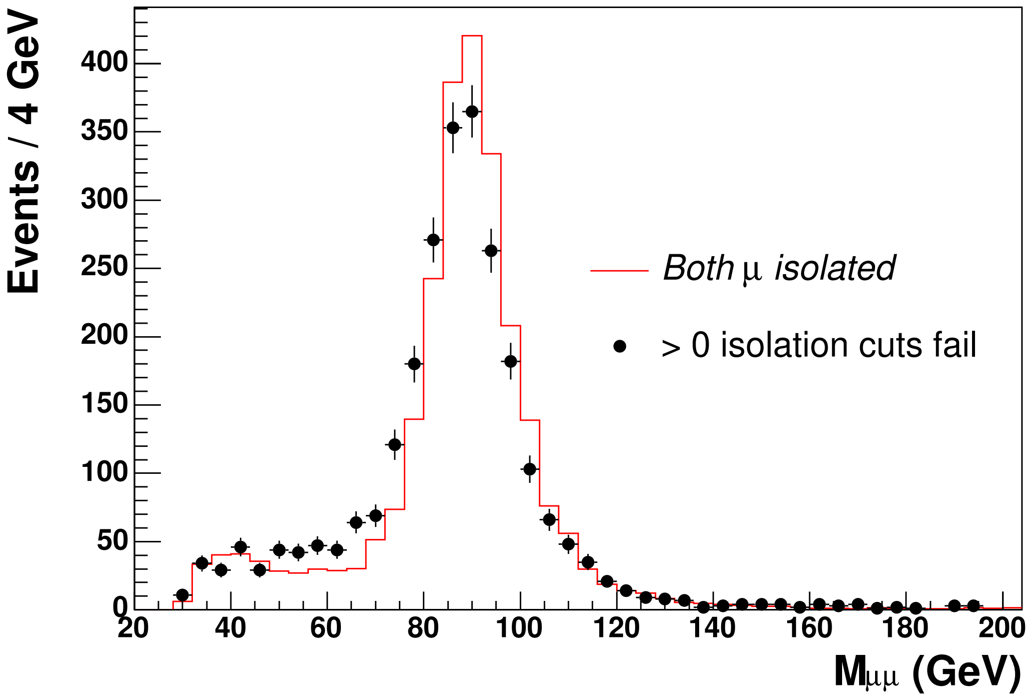
- Calorimeter isolation for μ_1
- " " for μ_2
- Central tracker isolation for μ_1
- " " for μ_2

High efficiency:

$$\epsilon_{\rm isol} = 0.994 \pm 0.003$$

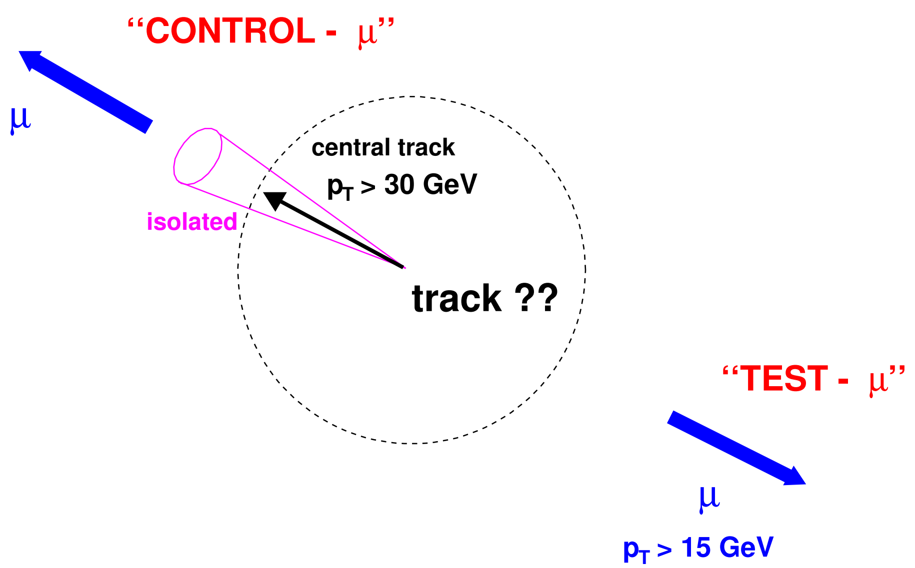
Low background:

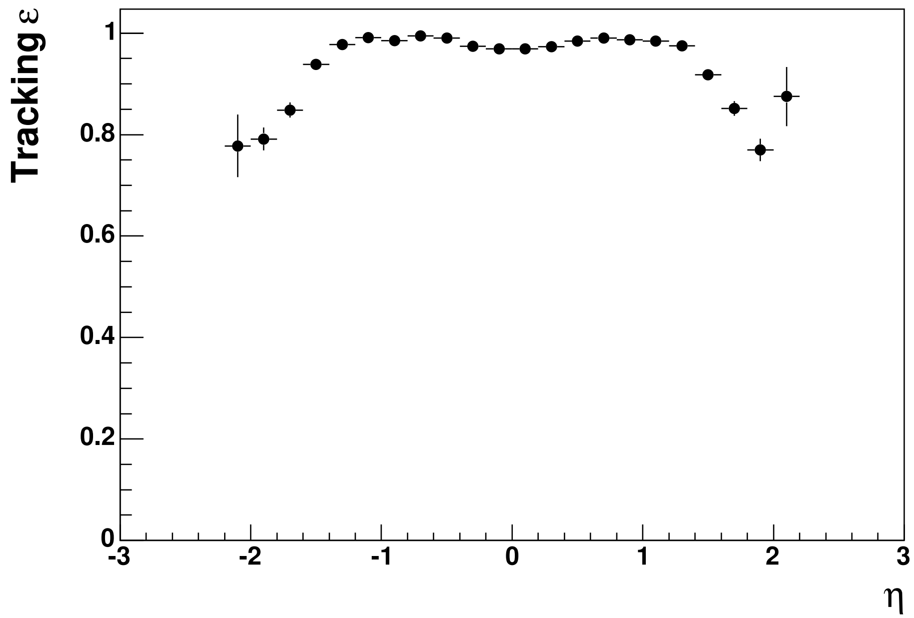
$$f_{\rm bb} = 0.006 \pm 0.003$$



CENTRAL TRACKING EFFICIENCY

Select a sample of pure $(Z/\gamma)^* \rightarrow \mu^+\mu^-$ events without the requirement that central tracks are found for both muons.

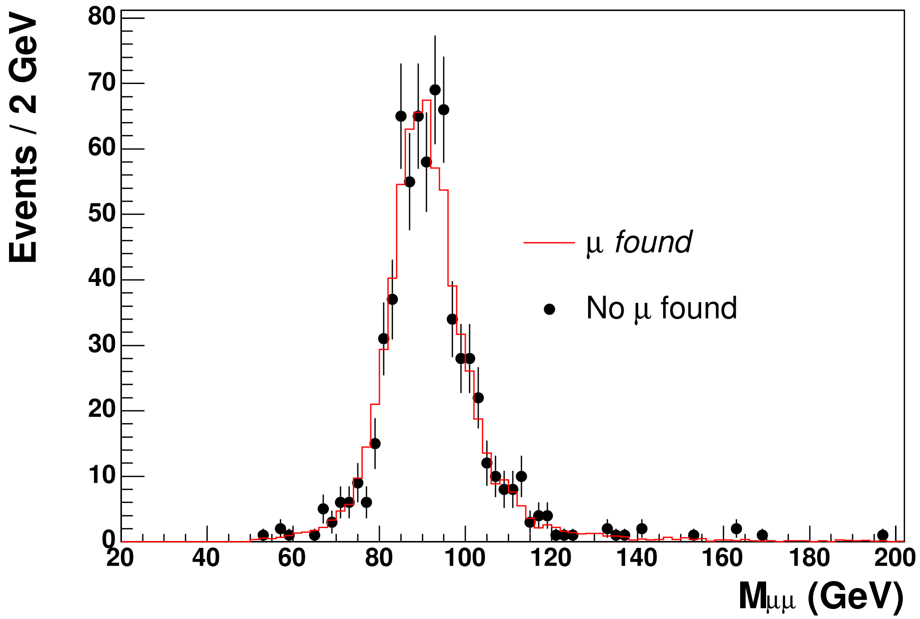


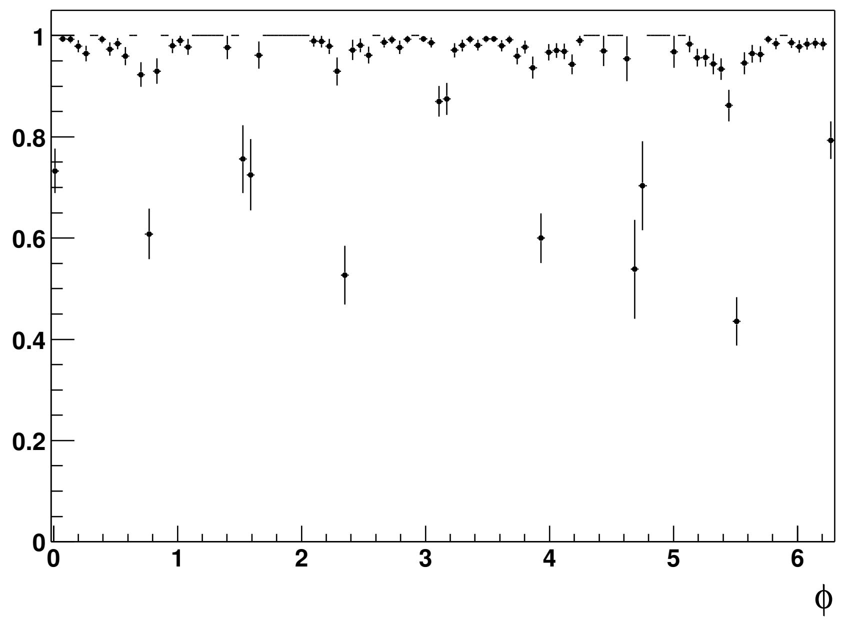


Average efficiency: $\epsilon_{\text{track}} = 0.950 \pm 0.002$

MUON CHAMBER RECONSTRUCTION AND TRIGGER EFFICIENCIES

Select a sample of pure $(Z/\gamma)^* \rightarrow \mu^+\mu^-$ events without the requirement that one of the muons is reconstructed in the muon chambers





DETECTOR ACCEPTANCE AND EFFICIENCIES

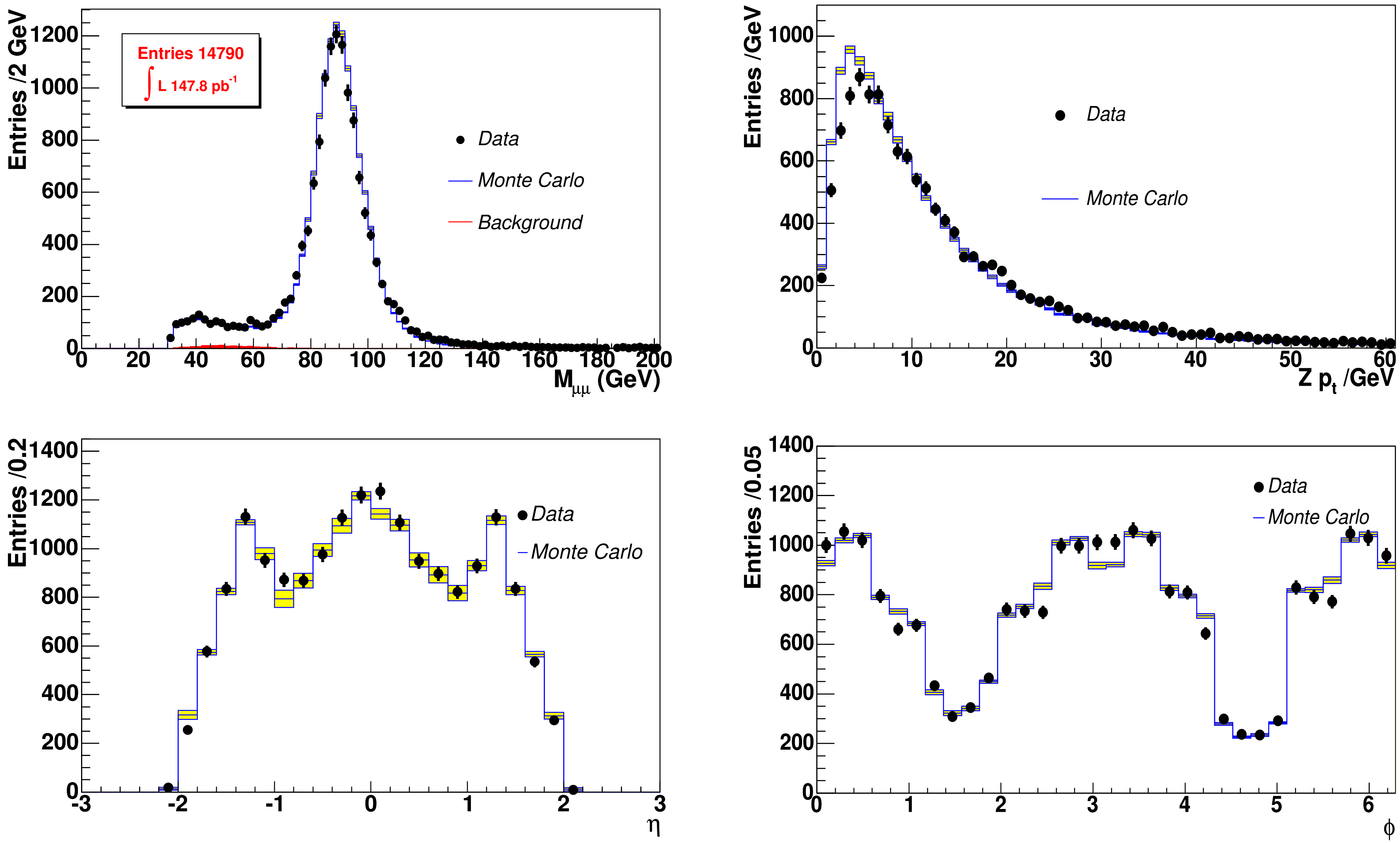
Paul Telford, University of Manchester

- All reconstruction and trigger efficiencies are measured in ϕ / η bins.
- Input them into a Parameterised Monte Carlo (using Pythia generator) which then 'accepts' a candidate muon according to

$$\varepsilon_1(\eta, \phi) \times \varepsilon_2(\eta, \phi) \times ....$$

- Monte Carlo outputs an acceptance, $\epsilon_{\rm MC}$, including kinematic cuts, all inputted efficiencies and the geometrical acceptance of the detector.
- Uncertainty on $\epsilon_{\rm MC}$ due to uncertainty on inputted efficiencies is deduced by varying them in a given bin by Gaussian distributions with widths equal to their uncertainties. Procedure repeated a number of times.

DATA - MONTE CARLO COMPARISONS



BACKGROUNDS

Remaining fractional background from $b\bar{b}$, cosmic rays and $Z \rightarrow \tau^+\tau^-$:

$$f_{bckgd} = 0.013 \pm 0.019$$

MAIN UNCERTAINTIES

- Luminosity $\rightarrow$ 6.5%
- Uncertainty due to PDFs used in acceptance $\rightarrow$ 1.7%
- Systematic due to statistical limitations on size of η / ϕ bins when input to Monte Carlo $\rightarrow$ 1.5%

σ.Br

With an integrated luminosity of 147.8 pb^{-1} $\rightarrow$

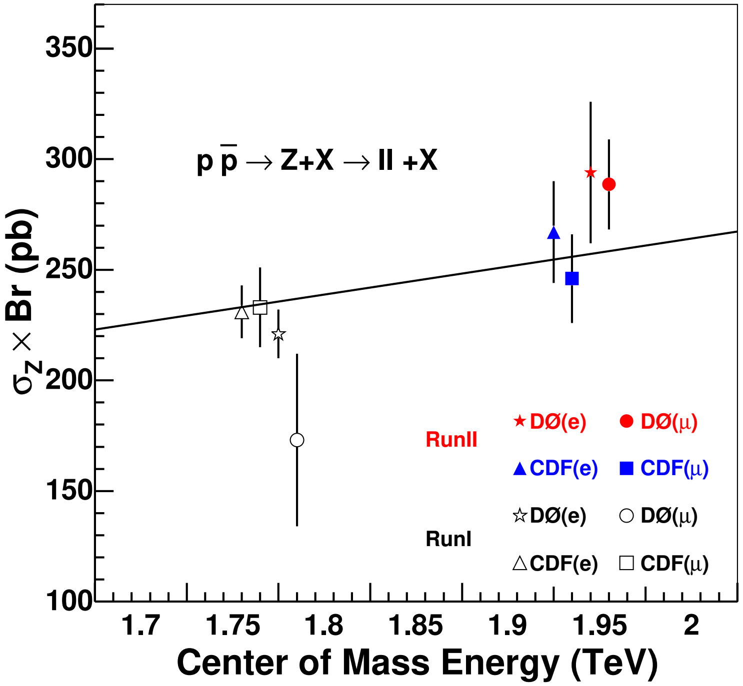
$$\sigma.\mathrm{Br}_{Z/\gamma} = 370.0 \pm 4.4(\mathrm{stat}) \pm 9.2(\mathrm{syst}) \pm 23.9(\mathrm{lumi}) \quad \mathrm{pb}$$

Correct for Z/γ^* interference and pure γ^* terms using the ratio,

$$R_\sigma = \sigma_Z/\sigma_{Z/\gamma^*} = 0.780 \pm 0.017$$

taken from Pythia $\rightarrow$

$$\sigma.\mathrm{Br}_Z = 288.6 \pm 3.4(\mathrm{stat}) \pm 7.2(\mathrm{syst}) \pm 18.8(\mathrm{lumi}) \quad \mathrm{pb}$$



NNLO SM prediction, C. Hamberg, W. van Neerven and T. Matsuura, Nucl. Phys. B359 (1991) 343.