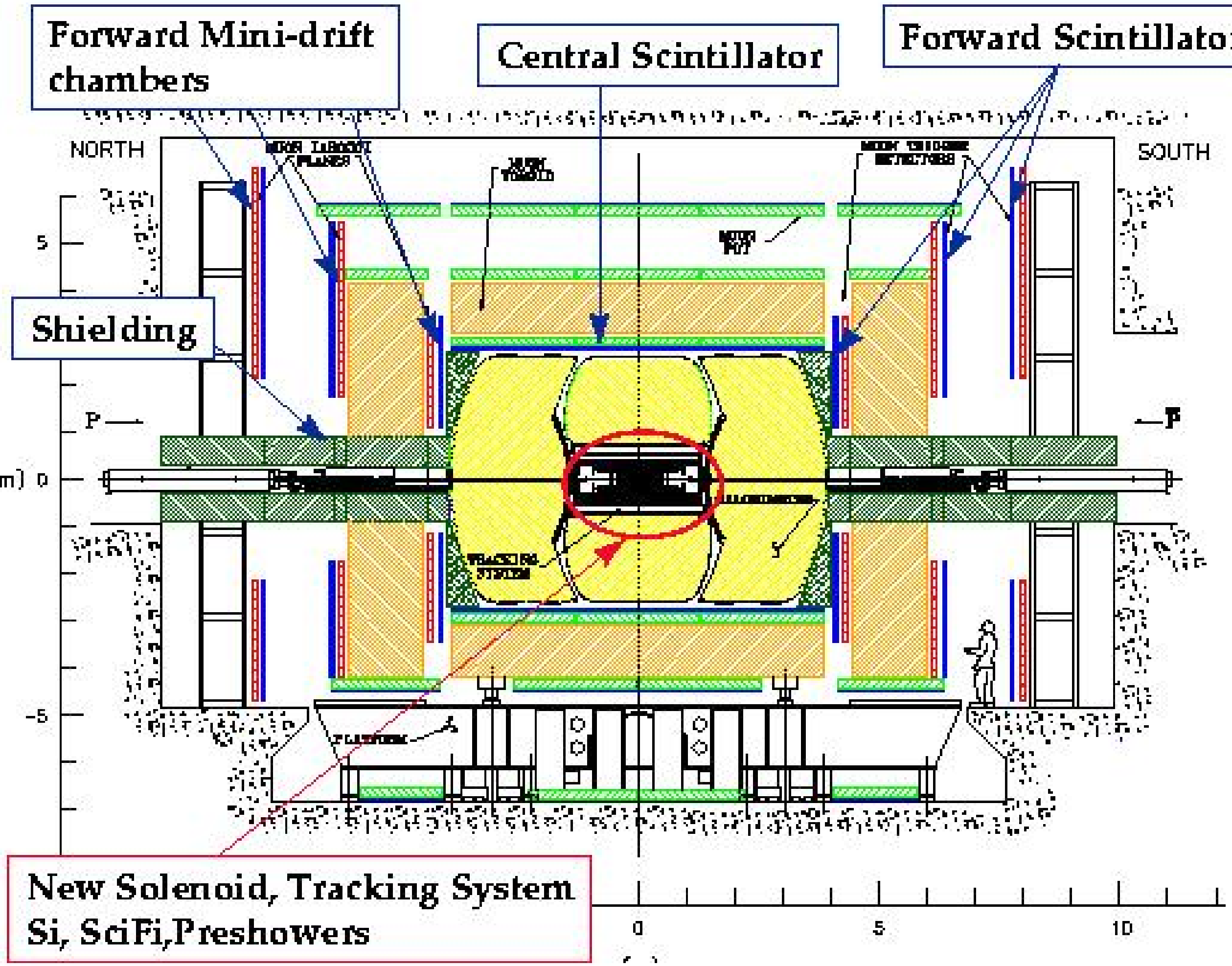
Recent Run II Electroweak and QCD Results from DØ

Robert Kehoe
Michigan State University

for the DØ collaboration

3/12/03
Les Recontres de Physique de la Vallée d'Aoste

- **Measurement of the Dijet Mass Cross Section**
- **Measurement of the $Z \rightarrow \mu\mu$ σ*BR**
- **Search for Z' in Dielectron Decays**



DØ at the Tevatron

a multipurpose collider detector:

Tracking

- silicon vertex detector
- fiber tracker

Calorimetry

- preshowers
- U/LAr calorimeters

Muon

- drift tubes and scint.

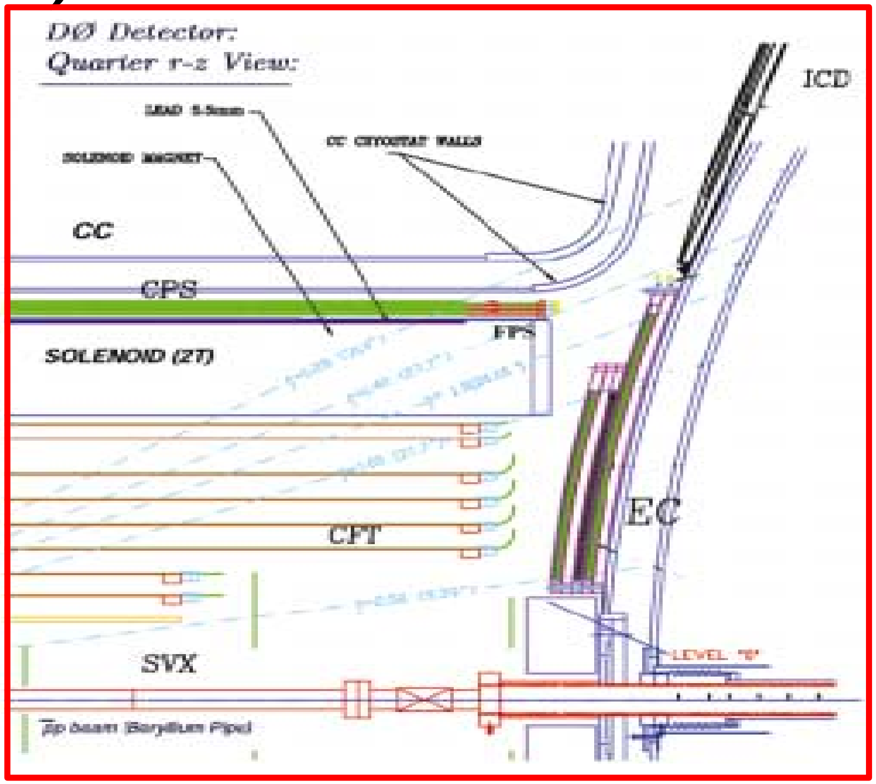
Pipelined 3-level trigger

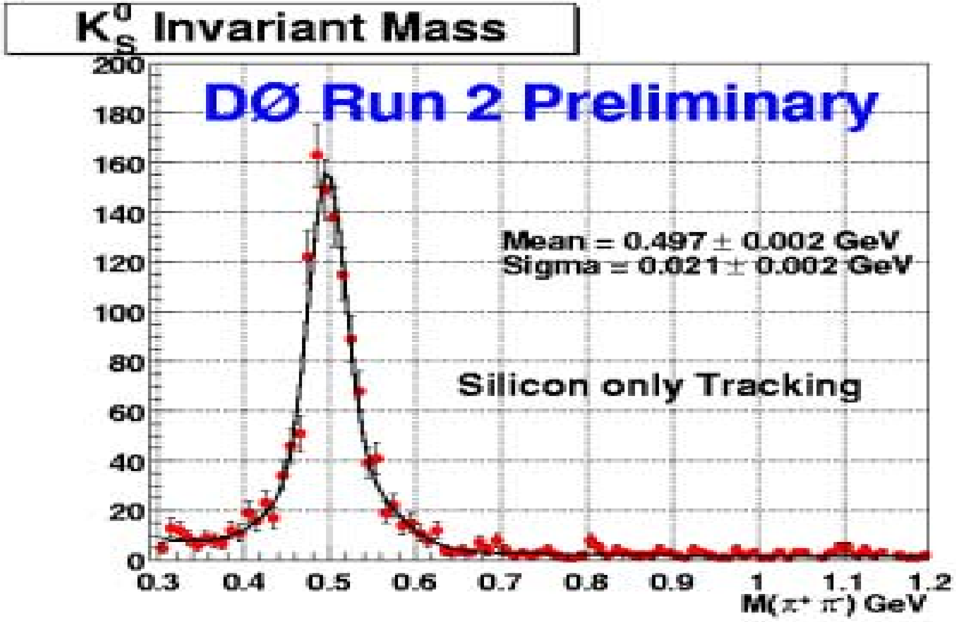
current L1 trigger rate	**1 kHz**
"" L2 trigger rate	**0.6 kHz**
"" L3 trigger rate	**50 Hz**

current operating efficiency: 80% - 85%

New Tracking for DØ

- **Silicon Microstrip Tracker (SMT)**
  - 840k channels
  - 4 layer barrels - 3D tracking
  - detached vertex detection
    - **b-tagging**
    - **triggering**
  - fully commissioned



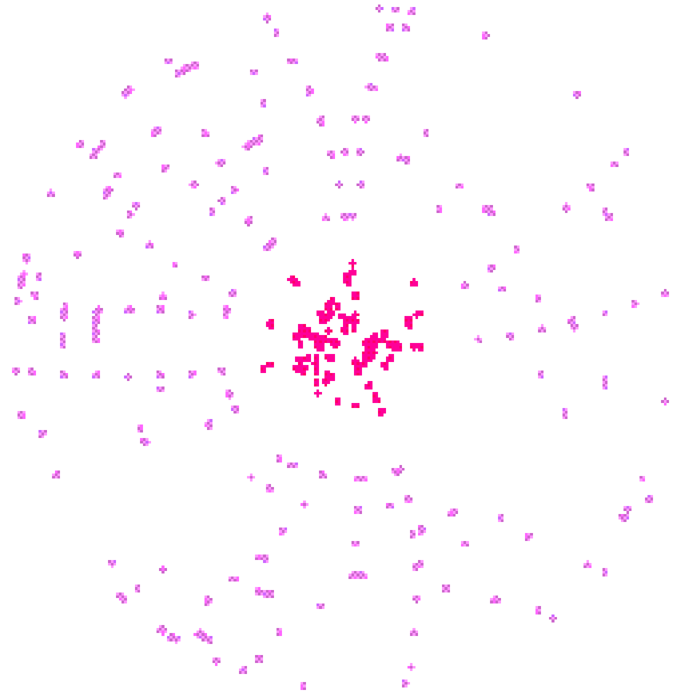


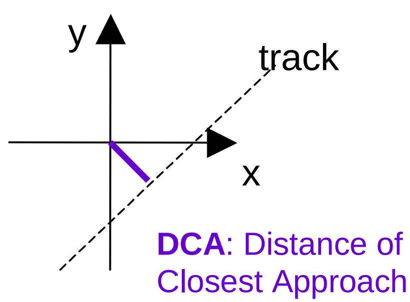
2T superconducting solenoid

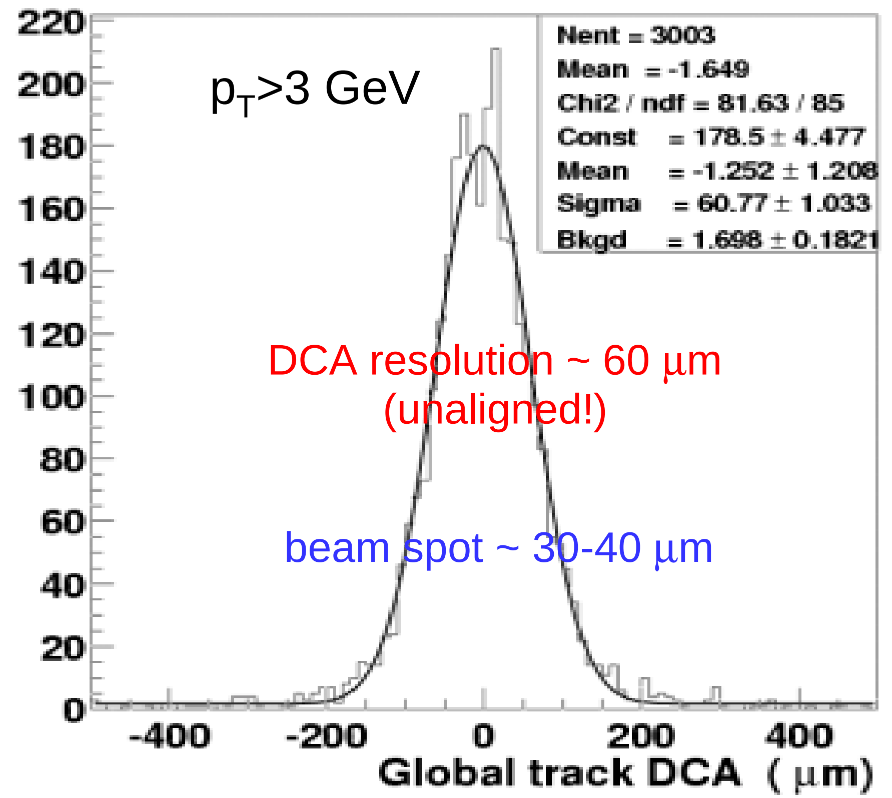
momentum, charge

New Tracking for DØ: CFT

- **Central Fiber Tracker**
- **77k channels with VLPC readout**
  - first sci-fi / VLPC tracker at collider
  - VLPC's
    - **9K operating temp.**
    - **85% QE, excellent S/N**
- **8 layers fiber doublets**
- **tracking trigger**
- **fully operational**
- **E/p measurement**
  - improved calibration

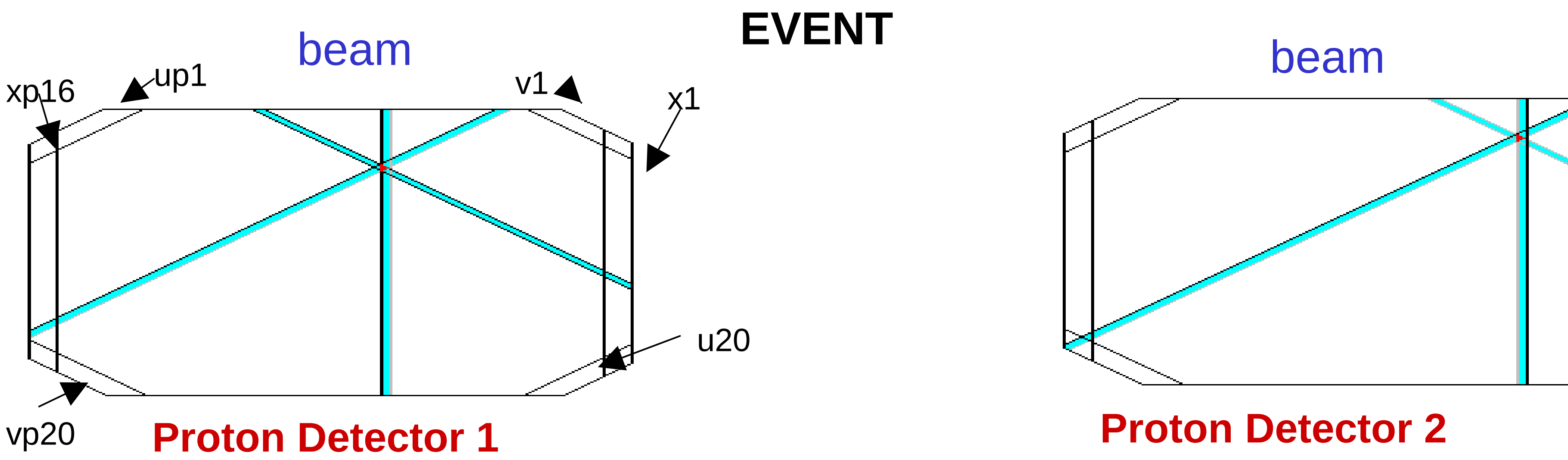




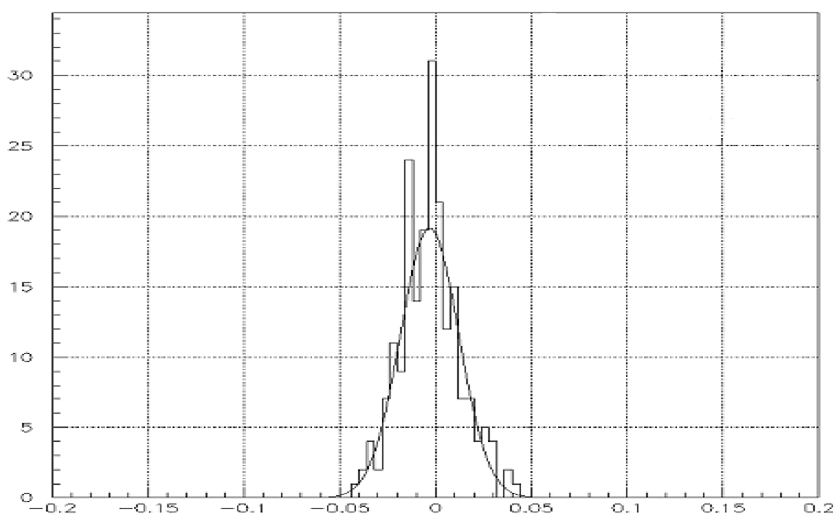


Forward Proton Detector

Scintillating fiber detectors in Roman pots near beam used to tag protons and anti-protons



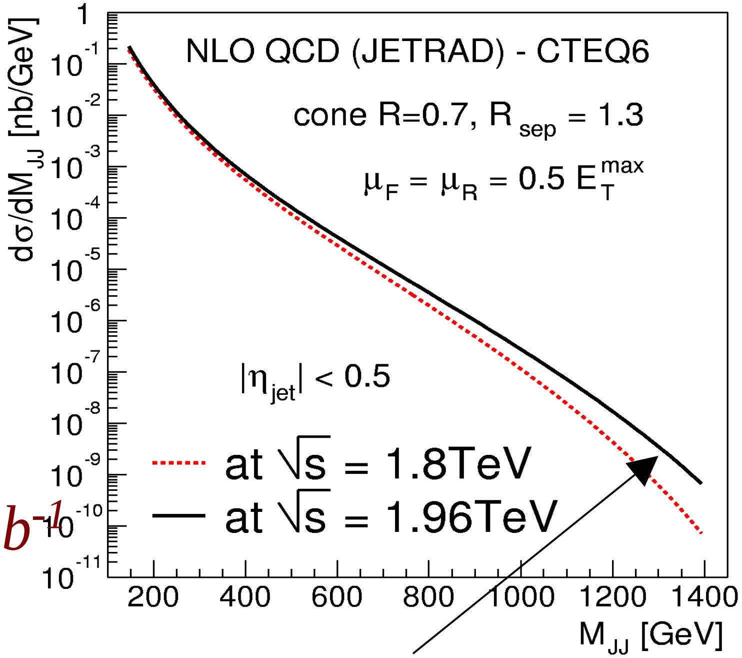
ξ(= Δp/p) distribution for a sample of clean elastic events



Commissioning in progress, integration with central detector in summer

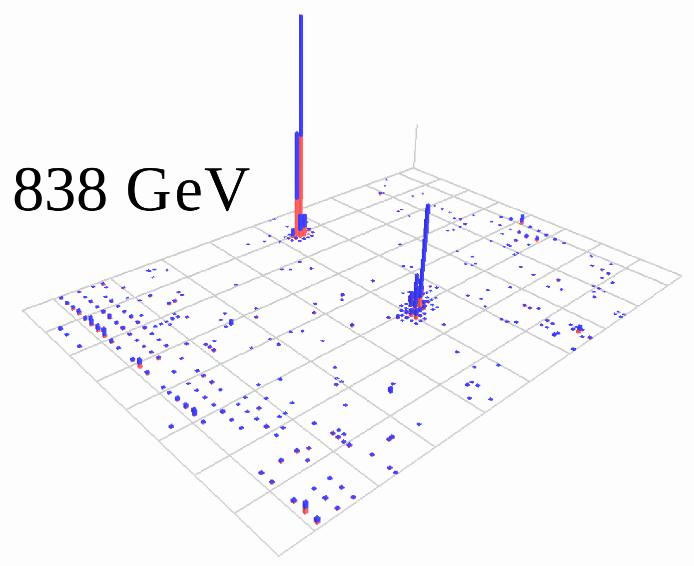
Dijet Mass Cross Section

- probe of
  - QCD
  - hunting for resonances
  - proton structure at large *x*
  - *quark compositeness*
- *data sample:* *34.1 pb^{-1}*
  - $\not{E}_T / P_{Tj1} < 0.7$
  - *primary vertex:* $|z_{vtx}| < 50$ cm, $N_{trks} > 4$
- *selection & sample definitions*
  - $\Delta R = 0.7$ *cone jets*
  - $|\eta_{jet}| < 0.5$
  - $N_{jet} > 1$
  - *calculate invariant mass of leading two jets*



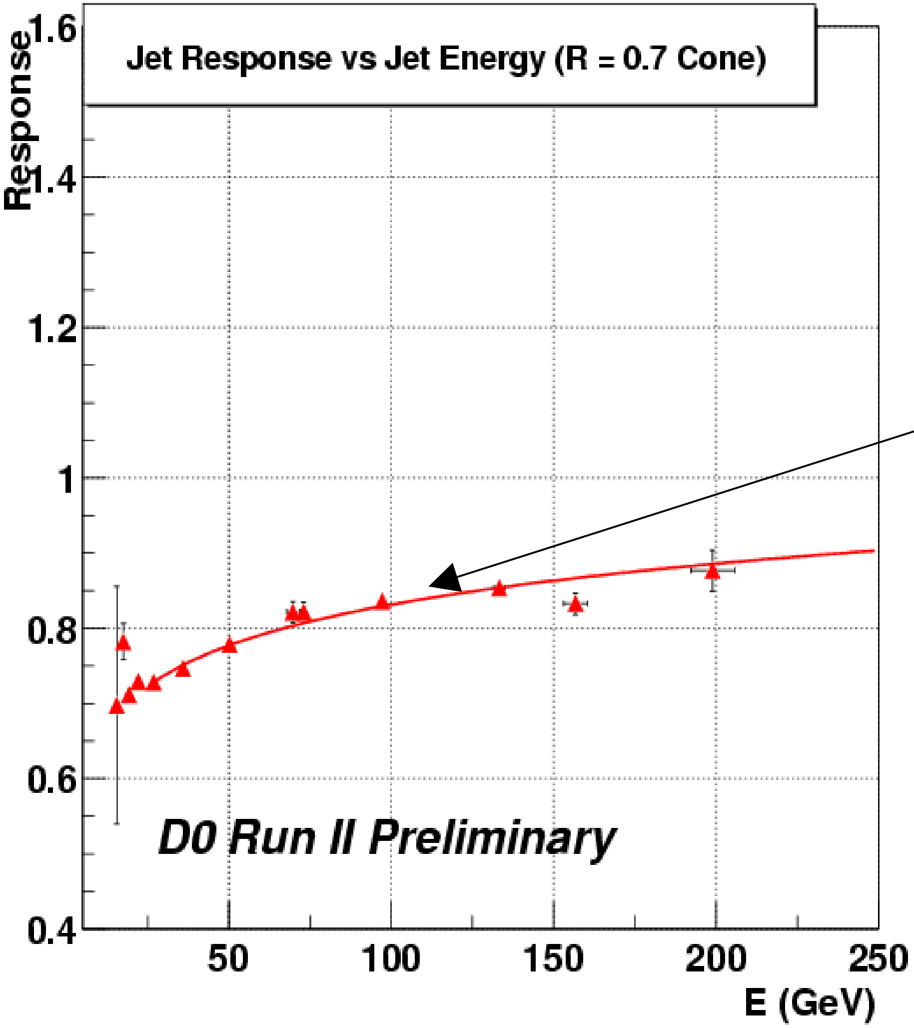
twice the σ at 1.96 TeV

M_{jj} = 838 GeV



Jet Energy Scale

$$E_{corr} = (E_{uncorr} - O)/ R*S$$

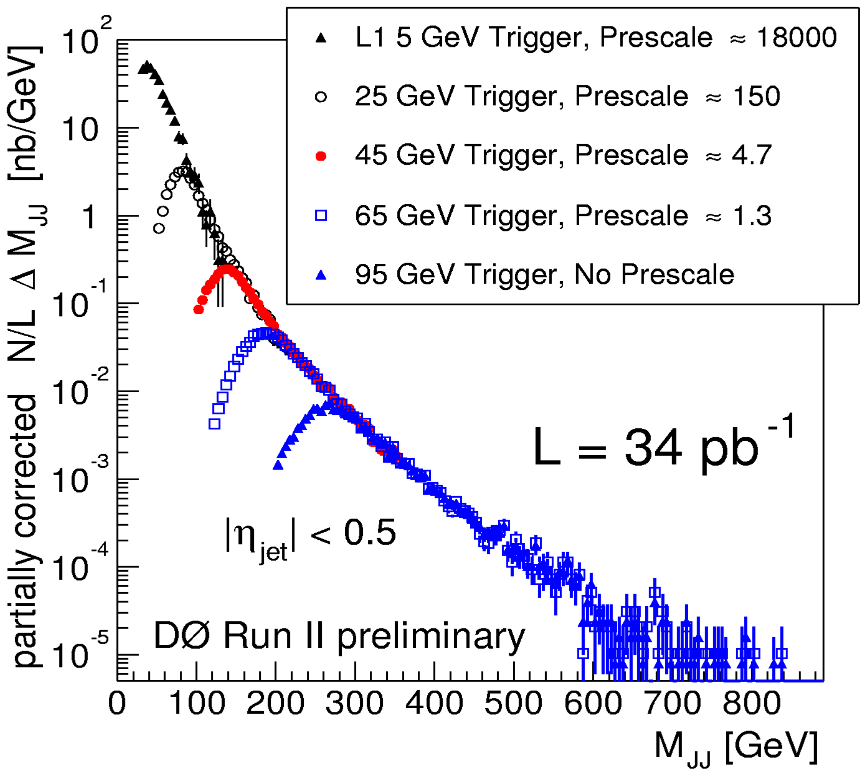


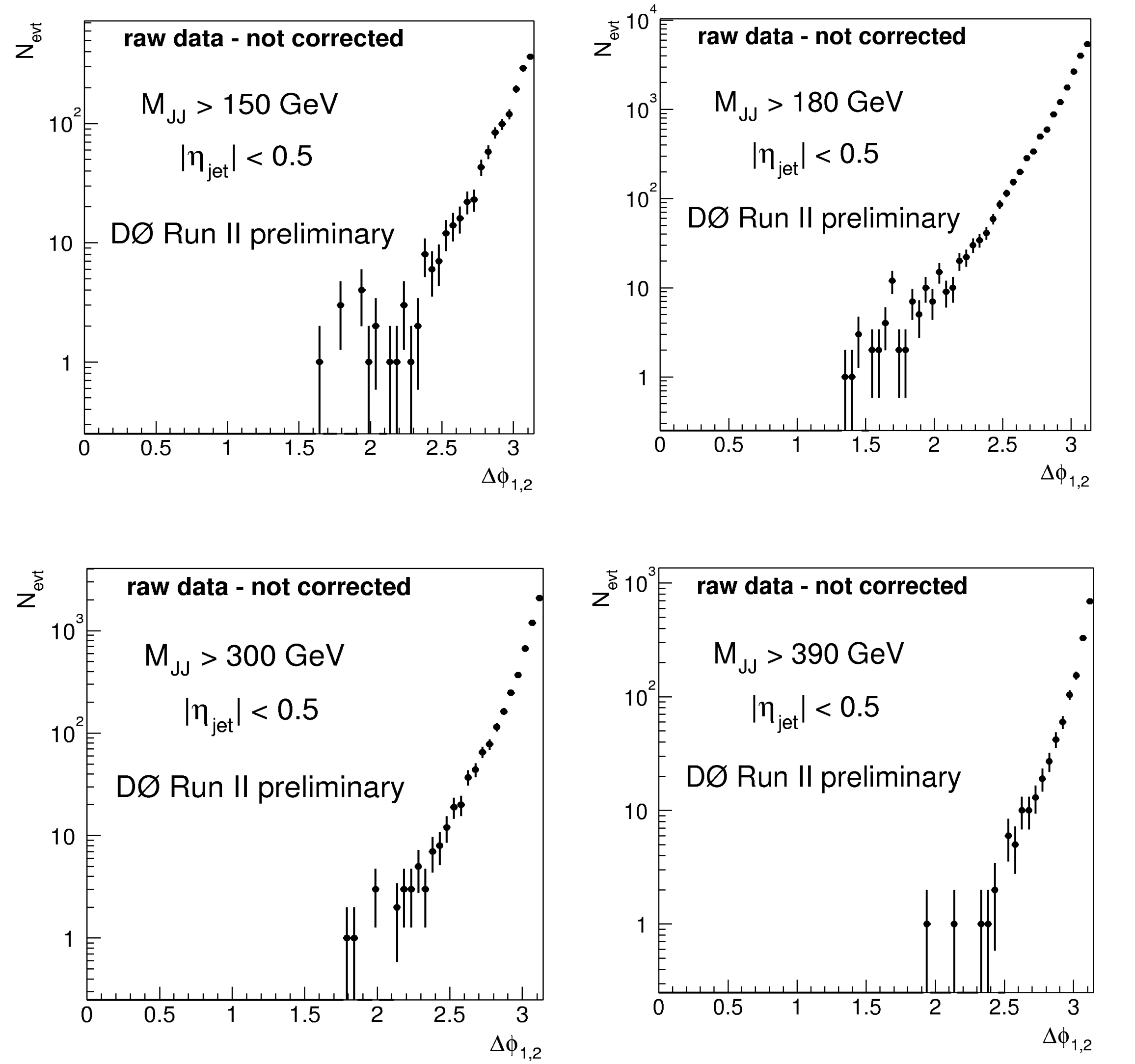
- methods currently used
  - O: underlying event, noise
    - minimum bias events
  - R: non-linearities, dead material
    - direct photon candidate events
    - statistics up to 200 GeV energy
  - S: particle showers
    - jet transverse shapes in data
- errors
  - large statistical errors
  - substantial systematic errors
    - increase with energy due to extrapolation

Trigger Selection

- four triggers utilized
  - L3 E_T threshold offline M_{jj} cut

25 GeV
45 GeV
65 GeV
95 GeV



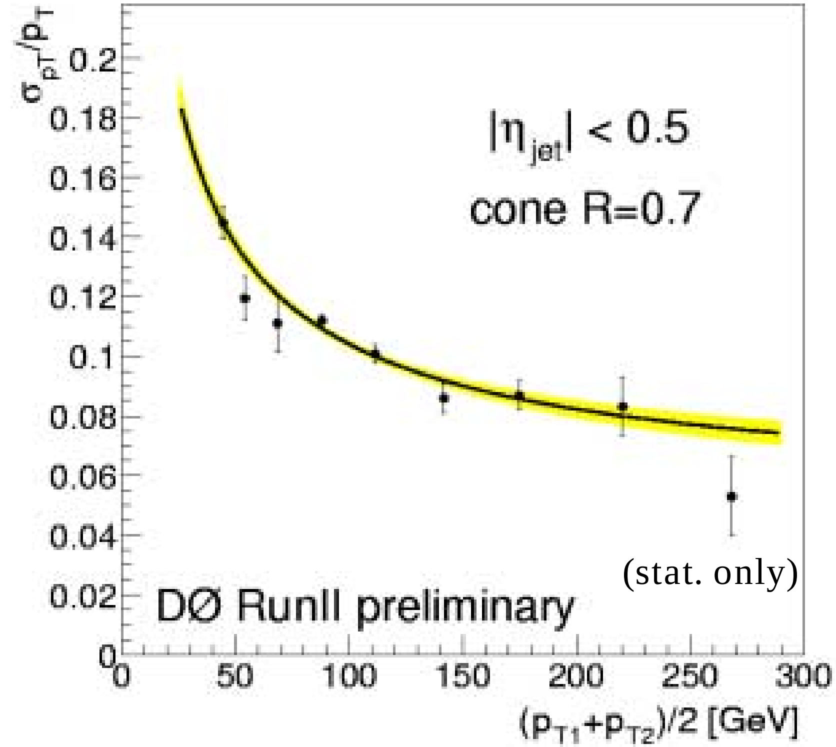


Energy Resolutions

- use dijet events in data
  - same sample as M_{jj} analysis
  - asymmetry measurement

$$A = \frac{p_T^{jet1} - p_T^{jet2}}{p_T^{jet1} + p_T^{jet2}}$$

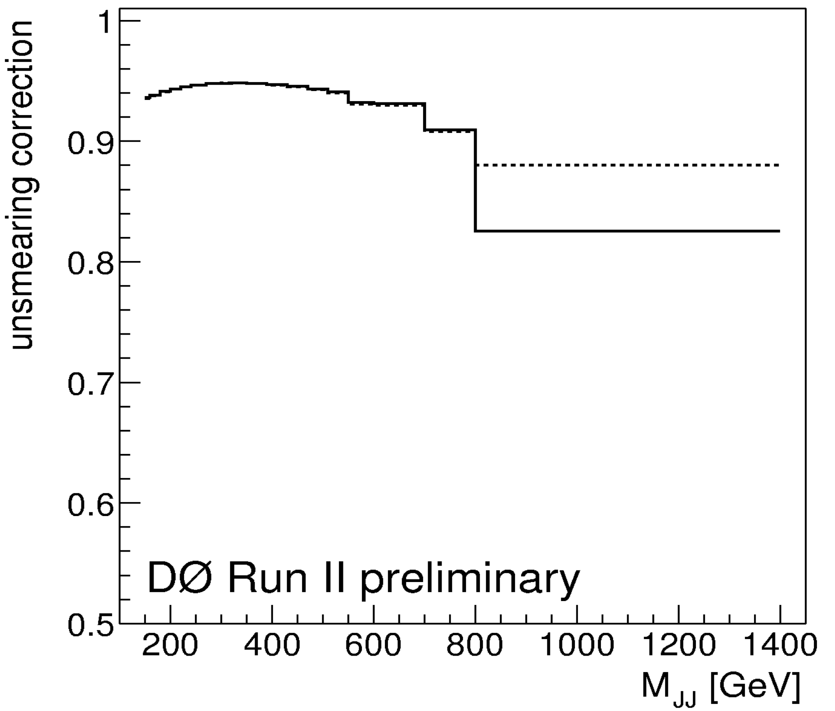
- corrected for unfound third jets
- particle jet resolution corrected for



- use to determine dijet mass resolution
  - smear PYTHIA events in mass bins
  - gaussian fit to $\Delta M_{jj}/ M_{jj}$ in each bin
  - fit to

$$\frac{\sigma_{M_{JJ}}}{M_{JJ}} = \sqrt{\frac{N^2}{M_{JJ}^2} + \frac{S^2}{M_{JJ}} + C^2}$$

  - determine unsmearing correction

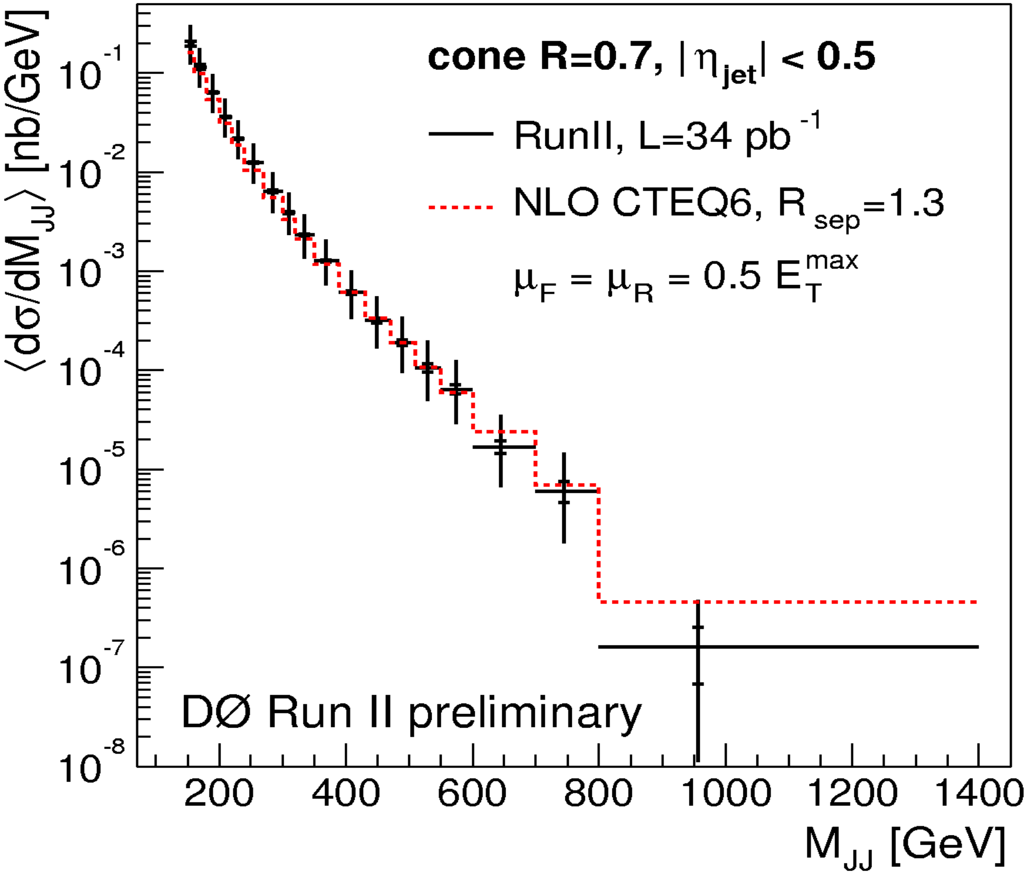


Observed Cross Section

- calculated by

$$\left\langle \frac{\mathrm{d}\sigma}{\mathrm{d}M_{JJ}} \right\rangle = \frac{N_{evt}}{L} \frac{1}{\varepsilon_{eff}} C_{unsmear} \frac{1}{\Delta M_{JJ}}$$

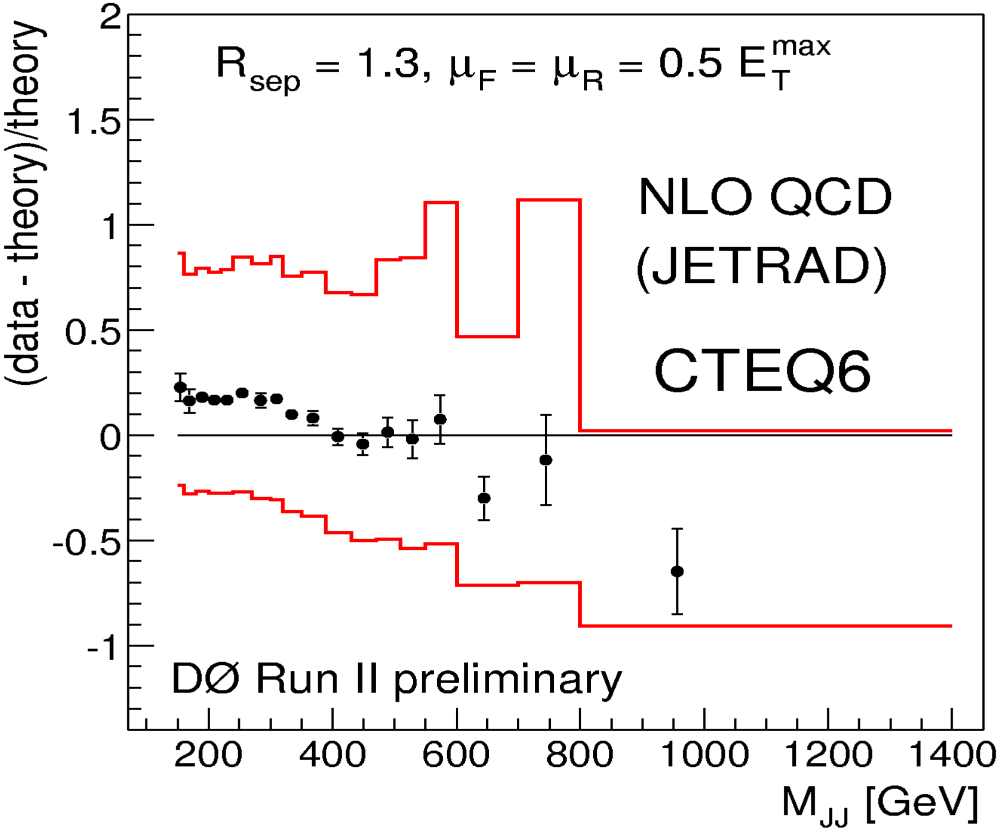
  - cut efficiencies
    - estimated from data
    - vertex quality: ~78%
    - jet quality: ~97%

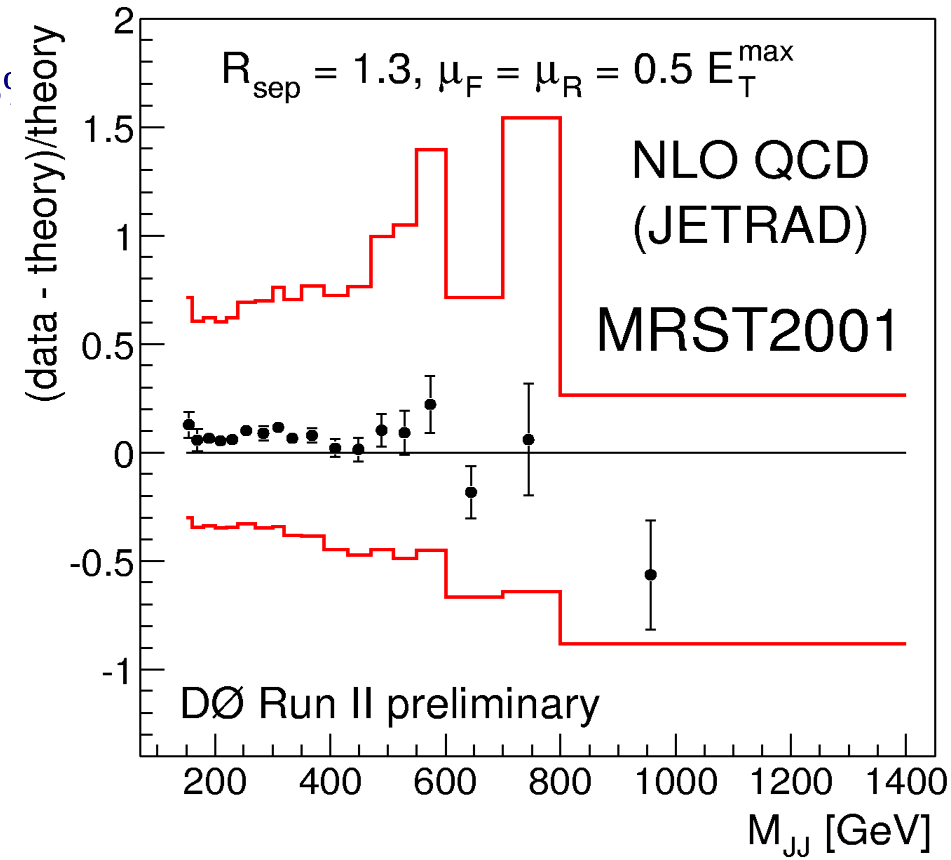


- cross section
  - with total error
  - luminosity error
    - additional 10%
    - fully correlated bin-to-bin and not shown
  - compare to NLO theory
    - CTEQ6 pdf
    - $R_{sep} = 1.3$

Comparison to Theory

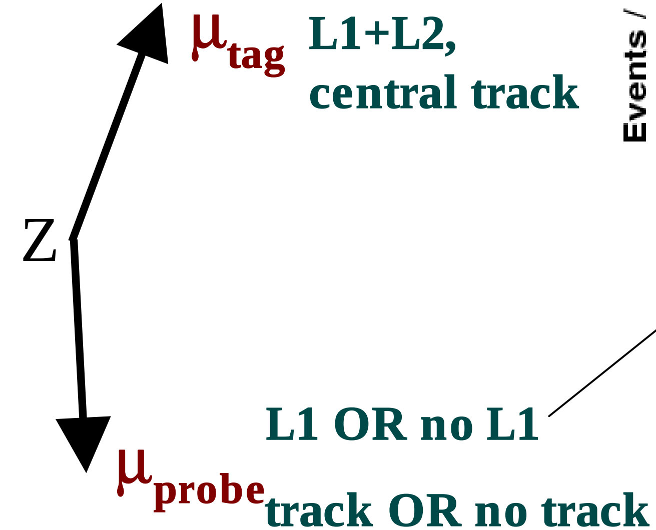
- agrees within uncertainties
- main uncert.: jet energy scale, P_T resolution, jet quality
  - dominated by jet energy scale
    - 150 to 160 GeV: +52% - 38
    - 800 to 1400 GeV: +190%



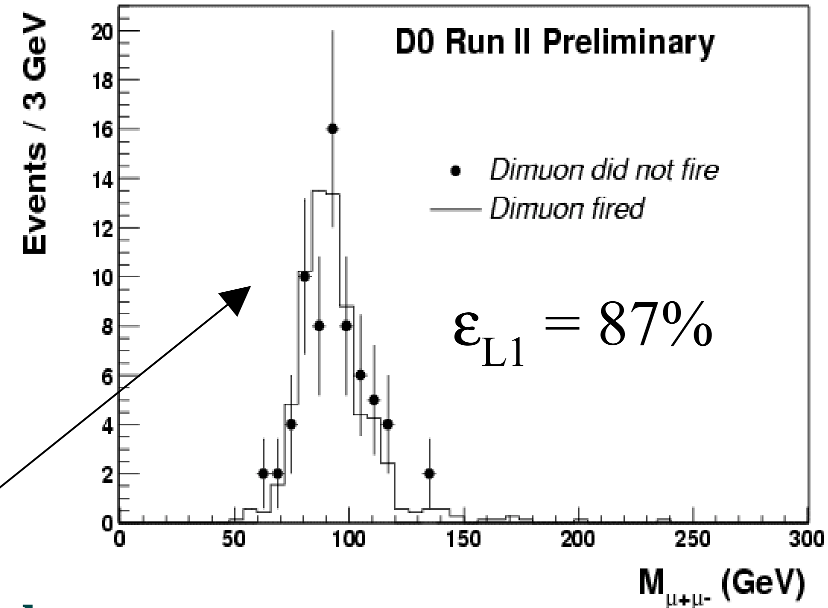


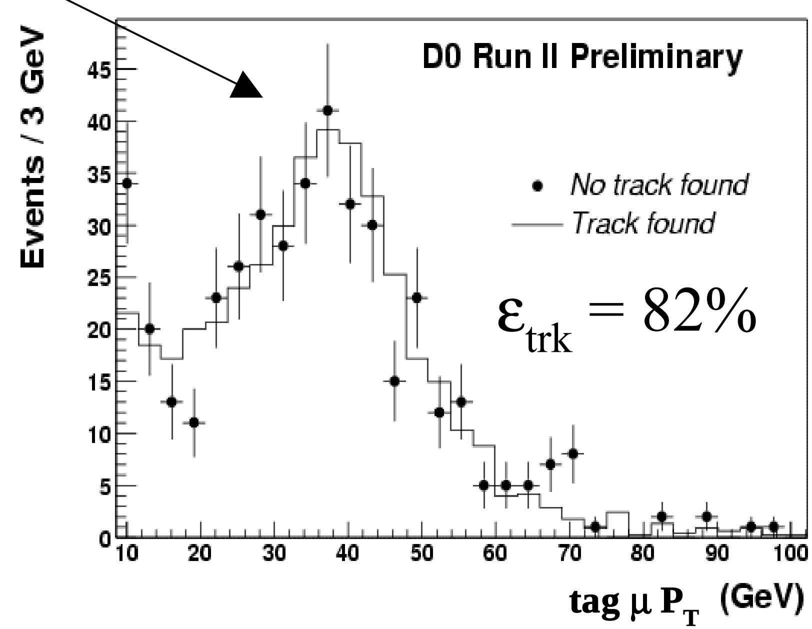
10% luminosity uncertainty not included

$Z \rightarrow \mu\mu$ σ*BR

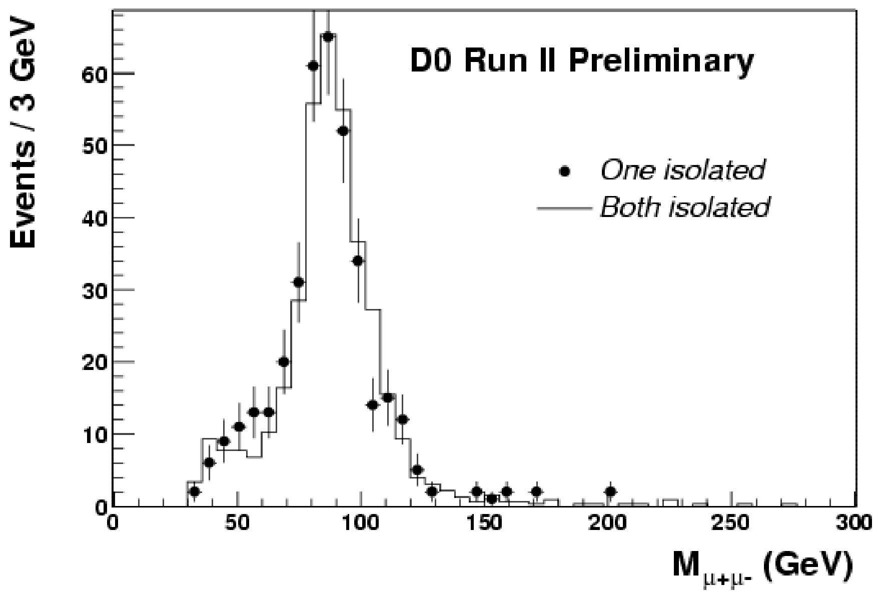


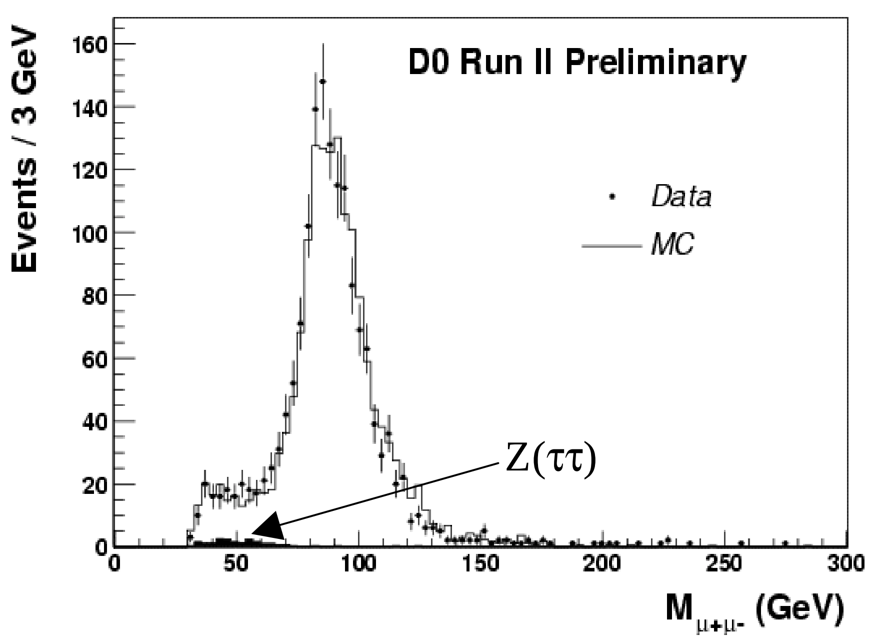
- data sample:
  - 31.8 pb^{-1}
- selection
  - $|\eta^{\mu}| < 1.8$
  - pair of oppositely charged muons
    - $P_T > 15$ GeV (central track required)
    - $DR_{\mu\mu} > 2.0$
    - require one be isolated in calorimeter AND tracker
    - timing cut to remove cosmics
  - di-muon trigger
    - efficiency calculated from data
- 1585 events pass cuts





Dimuon Backgrounds





- cosmics negligible
- heavy flavor ( )
  - compare dimuon events
    - two isolated muons
    - one isolated muon
  - two samples agree well
    - < 1% non-isolated muons
    - ∴ 1% ± 1% BG
- Z–> ττ –> μμ
- Drell-Yan
  - PYTHIA + fast detector simulation
    - Z and Z / γ*
    - muon resolution tuned to data
    - correction factor = $N_Z / N_{Z,\gamma}$

Measured σ*BR(Z→μμ)

- calculation of efficiency

$$\epsilon_Z = \epsilon_{MC}^{eff} \times \epsilon_{fz} \times \left(2\epsilon_{L2} - {\epsilon_{L2}}^2\right) \times \epsilon_{opposite\_q} \times \epsilon_{isol} \times \epsilon_{cosmic}$$

- contributions
  - contributes most to error on cross section
  - components:

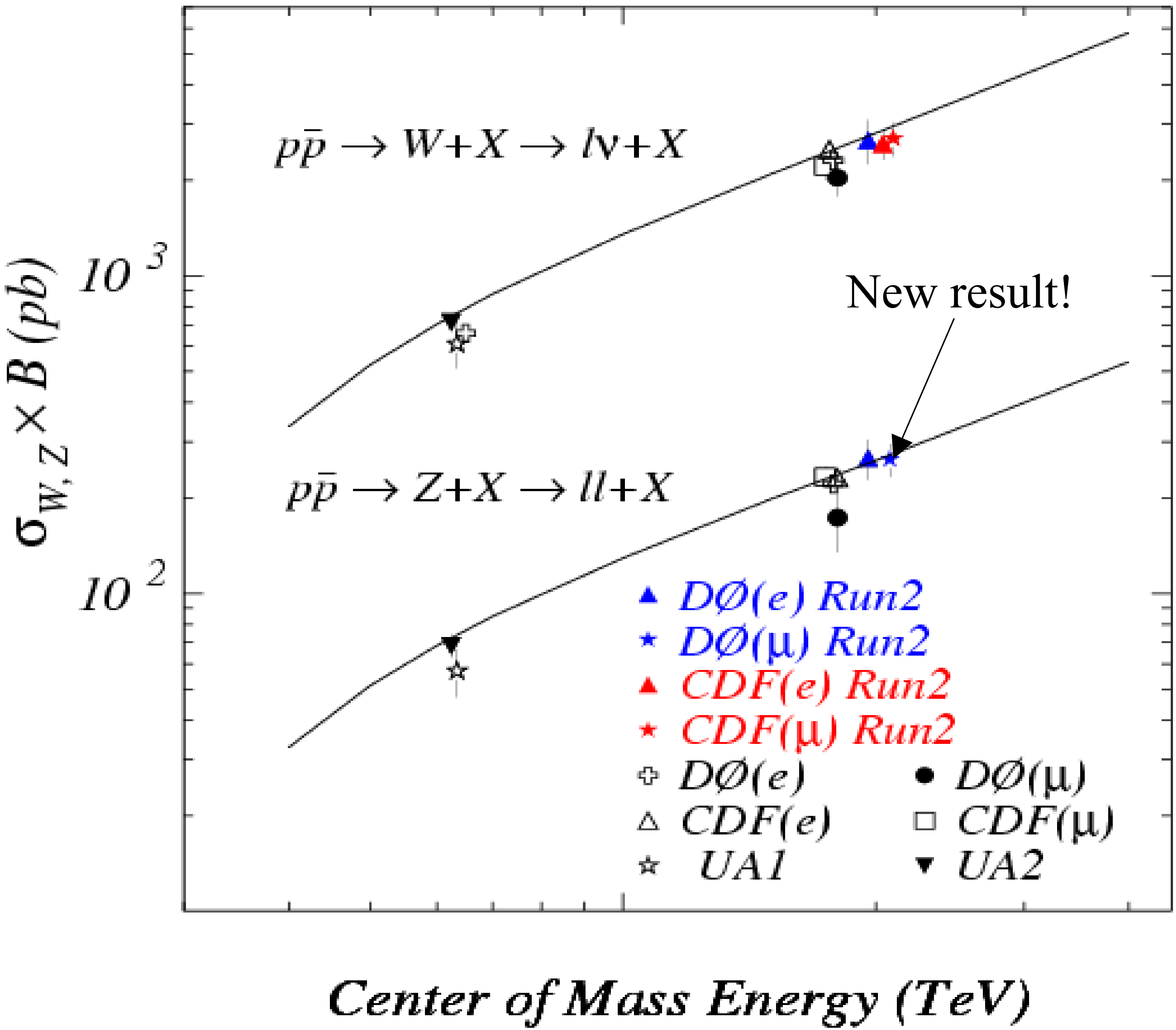
    effic. error

    - Monte Carlo 0.403 0.012
    - Level 1 muon 0.912 0.017

- **σ*Br = 263.8 ± 6.6 (stat) ± 17.3 (sys) ± 26.4 (lum) pb**

    - loose muon identification 0.909 0.01
    - track efficiency 0.822 0.014

DØ and CDF Run2 Preliminary



$Z' \rightarrow ee$ Search

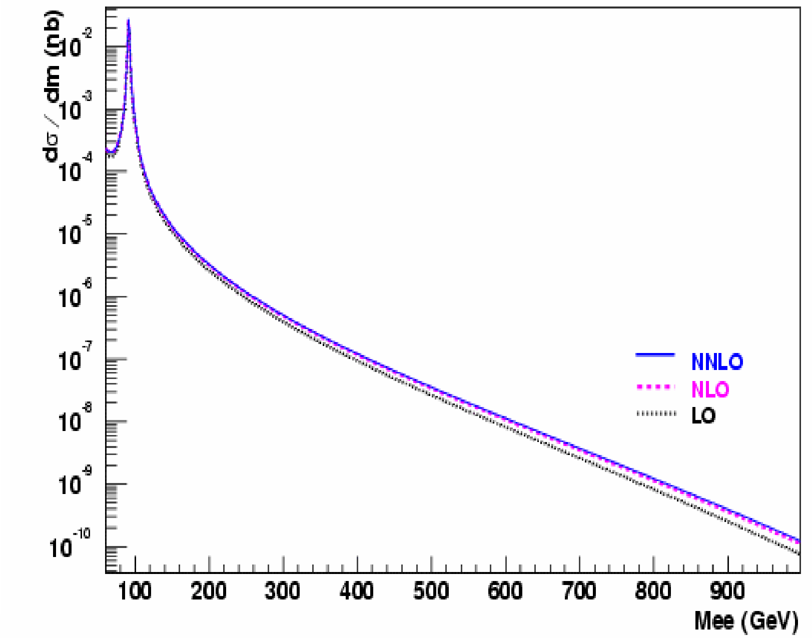
- expected in many models, including left-right symmetric models

- data sample
  - 50 pb^{-1}
  - selection
    - single electron trigger
    - $|\eta| < 2.5$
    - $E_T > 25$ GeV

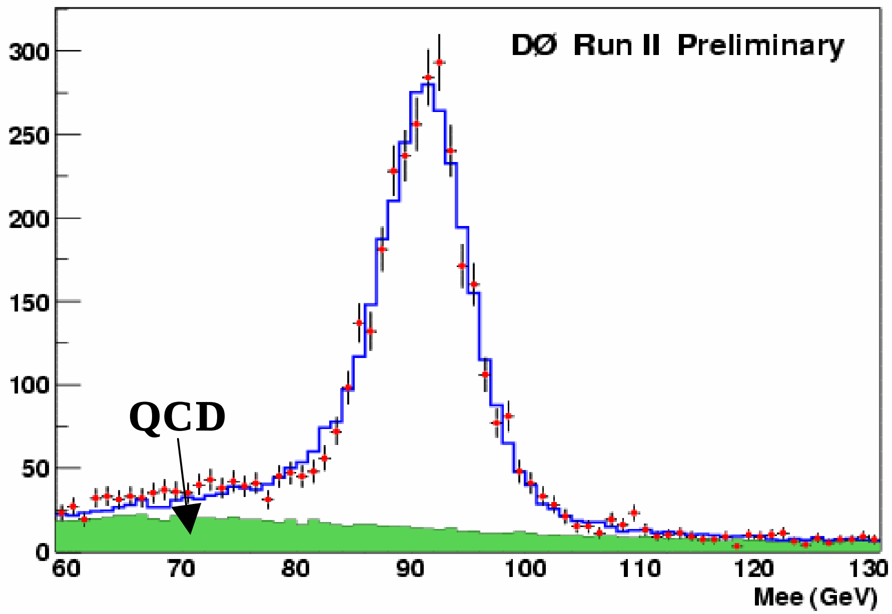
- *electron identification*
  - *isolation, energy fraction in electromagnetic layers*
  - shower shape
    - studied using GEANT
      - $M_{Z'}$ 300 thru 800 GeV with PYTHIA
    - P_T dependent shower shape cut

Backgrounds

- Z + Drell-Yan
  - use fast detector simulation
    - resolutions tuned to data
  - PYTHIA+CTEQ4L
    - correct LO cross section vs M_{ee}
      - Hamburg, van Neerven, Matsura, Nucl. Phys. B359, 343 (1991)

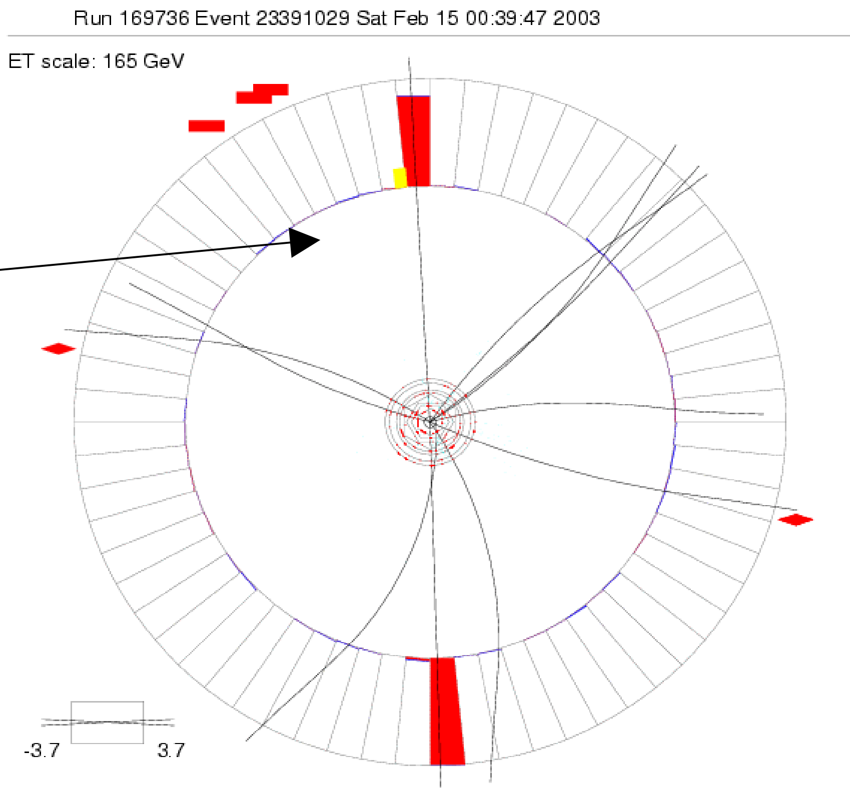


- QCD fake background
  - mainly dijets to leading π^0's
  - dominates at high mass
  - M_{ee} distribution from data
- normalize Z/γ^* + QCD
  - 65 GeV < M_{ee} < 115 GeV

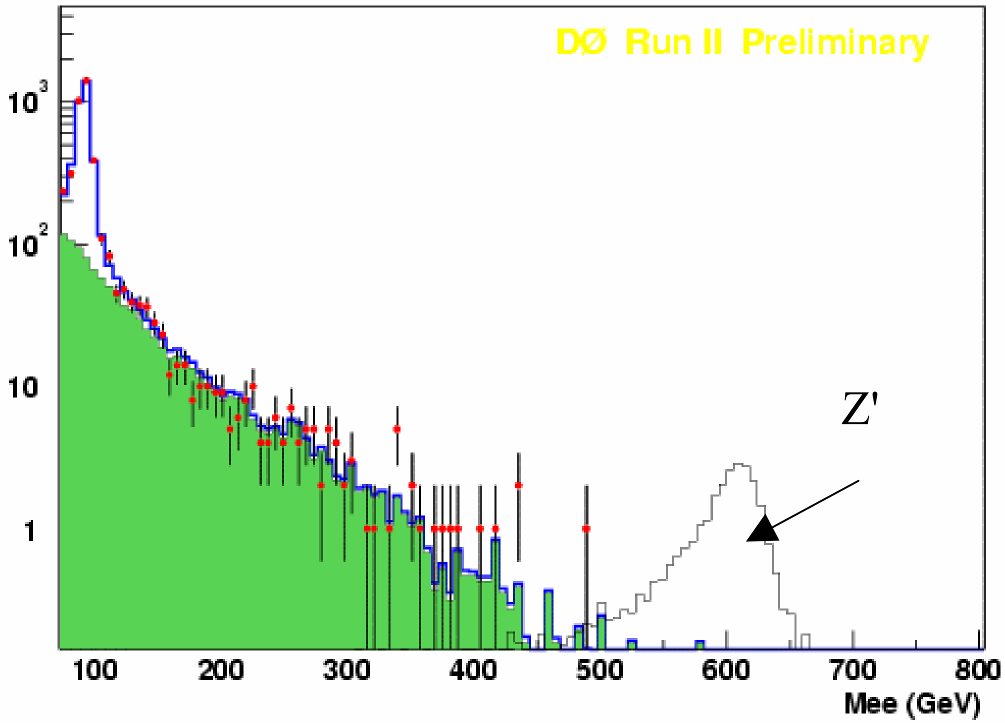


Data at High Mass

highest mass central-central event: **M_{ee} = 386 GeV**



- estimated Z→ee cross section
  - consistent with existing measurement

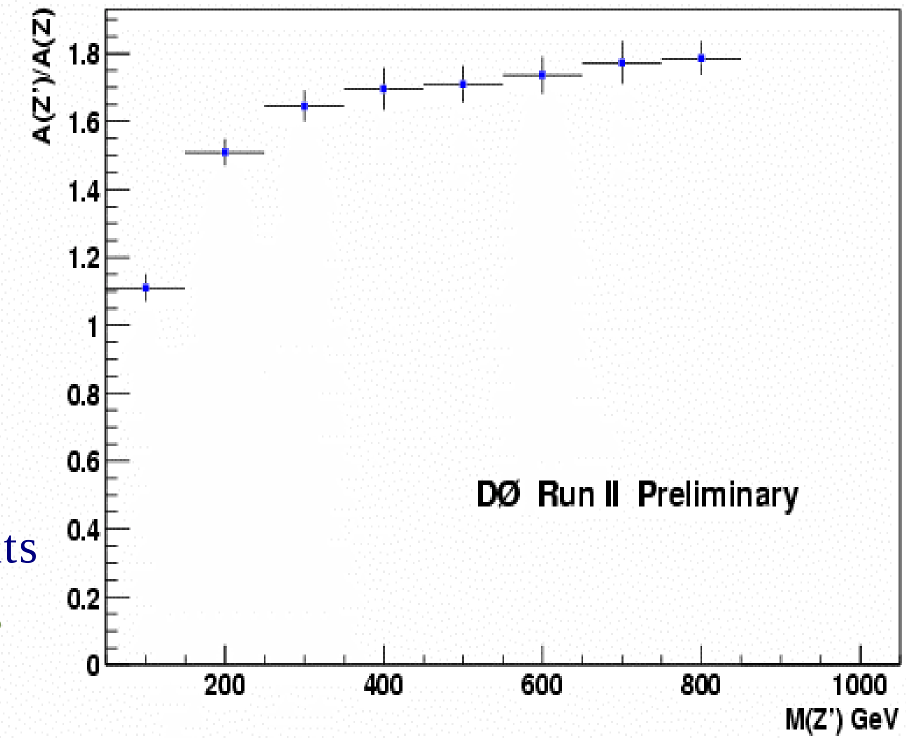


data *vs*. expected background

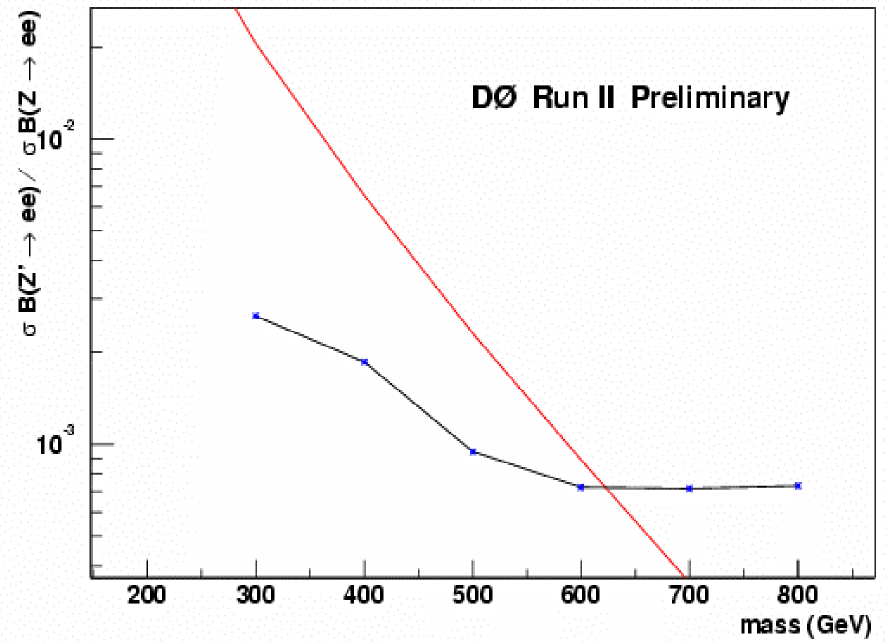
- agree well at high mass
- no excess observed

Results

- reference model
  - couplings to quarks and leptons
    - assume same as standard model Z
    - top decays available when $m_{Z'}$ permits
  - assume Z' width scales with mass
  - decay to Z is suppressed



- acceptance
  - calculated relative to Z
    - PYTHIA
    - fast detector simulation



- $M_{Z'}$ > 620 GeV @ 95% c.l.

Summary

- probing highest mass scales with new energy
- QCD
  - dijet mass cross section
    agrees with NLO theory, even at high mass
  - inclusive jet cross section very soon
  - near-term plan
    - substantially reduce jet energy scale errors
    - expand use of forward pseudorapidity coverage
  - ultimately improve errors and E resolution with tracking
- W/Z production
  - $Z \rightarrow$ dimuon
    $\sigma * Br = 263.8 \pm 6.6\ (stat) \pm 17.3\ (sys) \pm 26.4\ (lum)$ pb
  - $W \rightarrow \mu\nu$, and W/Z electron channels well-advanced
- $Z' \rightarrow ee$ search $M_{Z'} > 620$ GeV @ 95% c.l.