W/Z physics at DØ

RunII detector and data
How W/Z measurements are done
Review W/Z cross section measurements at DØ
Comparison with CDF
Wγ production
Future prospects

All results are preliminary
The DØ detector for Run II

- **Build on strengths of Run I:**
  - State of the art calorimetry, hermetic detector
  - **2T superconducting solenoid**
  - **Inner tracker** (silicon microstrips, scintillating fibers)
  - **Preshower detectors**
  - Increased **shielding**, upgraded muon system
  - **Faster readout electronics**
  - **New trigger and DAQ**
Data taking

Full data reprocessing of pre Sep 03 data finished Jan 15

Data taking efficiency routinely around 85% (and above) with full detector readout
Measurement strategy

- Reduce reliance on full detector simulation
- **Data used to measure trigger, reconstruction and identification efficiencies**
  - pure samples of $Z \rightarrow l^+l^-$ selected without applying tight selection criteria to both leptons
- **Data derived parametrisation of efficiencies used in fast simulation of detector response for calculation of acceptance and overall detection efficiency**
- **Pythia used for event generation**
  - cross checks performed using Resbos based event generator
- **Backgrounds measured using data**
- **Full simulation used only as cross-check**
Electron identification

Use calorimeter & tracking information:
- large fractional energy deposit in EM sector
- isolation (fraction of energy in hollow cone between $\Delta R=0.2$ and 0.4)
- shower shape distribution
- track match ($\Delta \eta$, $\Delta \phi$ and $E/p_T$)

Efficiencies measured using $Z\rightarrow ee$ decays
(trigger 100% above 30 GeV, ID >90%, track matching – include $E/p_T$ - 75-80%)

Probability of misidentification measured using dijet events
Muon identification

Muon track measured twice:
- toroidal spectrometer (position and timing information before & after magnet)
- precision $p_T$ measurement in central tracker
- track match (position and momentum)

Veto $\mu$ from jets (mostly b) using isolation (measured with calorimeter and tracks)

Veto cosmics using timing information, veto additional $\mu$, tracker information

Trigger efficiency (single $\mu$): 50 %
Tracking efficiency $> 95\%$ inside the acceptance
Isolation 91%
Measuring ID efficiencies

- Select pure Z sample with tight cuts on one lepton
- 2nd lepton provides unbiased sample for efficiency measurement
- Only biases come from kinematic or geometrical correlations
Select $Z \rightarrow \mu\mu$ events

- Select 2 opposite charge $\mu$ with $p_T > 15$ GeV
- $|\eta| < 1.8$
- Invariant mass $> 30$ GeV
- At least 1 $\mu$ pass isolation criteria
- Timing and distance of closest approach cuts to veto cosmics

**Backgrounds:**
- $Z \rightarrow \tau\tau$ (use MC): $0.5 \pm 0.1\%$
- $bb$ (use like-sign pairs): $0.6 \pm 0.3\%$
**Z → μμ events**

- Correct from Z/ * to Z using MC
- \( \sigma = (261.8 \pm 5.0 \pm 8.9 \pm 26.2) \text{pb} \)

**Main systematic uncertainties:**
- Drell-Yan correction
- Parton Distribution Functions (using CTEQ6)
- Acceptance

Also starting to measure WZ bosons differential cross sections
2 isolated electrons with $E_T > 25$ GeV
- no track match requirement
- $|\eta| < 1.1$
- 41.6 pb$^{-1}$
- 1139 candidates after bkgd subtraction

Bkgd shape from data (dijet)
$\sigma = (275\pm9\pm9\pm28)$pb

Main systematics:
- $E_{mid}$
- PDF
- Background
W → eν events

- 1 electron with p_T > 25 GeV in |η| < 1.1, E_T > 25 GeV
- Determine and subtract QCD background using track match, residual background W → τν and Z → ee
- 27.4K candidates in 41.6 pb^{-1}
- σ = (2844±21±128±284)pb
- Main sources of syst uncertainties as for Z → ee

W and Z physics at D0 22/3/2004
1 isolated $\mu$ with $p_T > 20$ GeV in $|\eta| < 1.6$, $\not{E}_T > 20$ GeV
- veto additional muons
- 8305 candidates after bkgd subtraction in 17.3 pb$^{-1}$
- large (11.8%) contamination from $W \rightarrow \tau\nu$ and $Z \rightarrow \mu\mu$
- $\sigma = (3226 \pm 128 \pm 100 \pm 322)$ pb
- understanding of QCD background main syst
Z\rightarrow \text{events}

- Proof of principle, can observe $\tau\tau$ resonances
- 1 $\tau$ decays into $\mu\nu$, other $\tau$ hadronic 1 prong decay
- Backgrounds: QCD with $W\rightarrow\mu\nu$ plus 1 jet, $Z\rightarrow\mu$
- Observe small number of events compatible with SM predictions

DØ RunII Preliminary

$\mu\tau$ visible mass (GeV) 68 pb$^{-1}$
Cross section summaries

Last time you see this plot with different normalizations. CDF and DØ have agreed to use a common normalization for Run II. CDF already uses it, new DØ results will use it (already used for other results presented at this conference).

![Graphs showing cross sections for W and Z physics at D0](image-url)
## CDF/DØ comparison

<table>
<thead>
<tr>
<th>Channel</th>
<th>Candidates &amp; purity</th>
<th>Integrated luminosity (pb⁻¹)</th>
<th>Efficiency * acceptance</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDF W→eν</td>
<td>37.6K (95%)</td>
<td>72</td>
<td>14.39%</td>
</tr>
<tr>
<td>DØ W→eν</td>
<td>27.4K (98%)</td>
<td>41</td>
<td>18.40%</td>
</tr>
<tr>
<td>CDF W→μν</td>
<td>31.7K (90%)</td>
<td>72</td>
<td>17.94%</td>
</tr>
<tr>
<td>DØ W→μν</td>
<td>8.3K (88%)</td>
<td>17</td>
<td>13.20%</td>
</tr>
<tr>
<td>CDF Z→ee</td>
<td>4242 (1.5%)</td>
<td>72</td>
<td>22.74%</td>
</tr>
<tr>
<td>DØ Z→ee</td>
<td>1139 (--------)</td>
<td>41</td>
<td>9.30%</td>
</tr>
<tr>
<td>CDF Z→μμ</td>
<td>1785 (1.5%)</td>
<td>72</td>
<td>10.18%</td>
</tr>
<tr>
<td>DØ Z→μμ</td>
<td>6126 (1.1%)</td>
<td>117</td>
<td>16.40%</td>
</tr>
</tbody>
</table>
Photon identification

- Photons are identified as electrons but:
  - Veto track(s) in cone around EM cluster
  - Require $\Delta R$ separation from lepton of 0.7
  - $E_T > 8$ GeV (CDF 7 GeV, results not directly comparable)
- Efficiency measured from data using $W\gamma$ sample (and jet sample to simultaneously fit for $Wj$ background): $(47\pm13)\%$ (largest systematic error in cross section measurement)
Wγ final state

- **Electron channel**: $|\eta|<1.1$ and $1.6<|\eta|<2.3$, $p_T>25$ GeV, $E_T>25$ GeV, $M_T>40$ GeV
- **Muon channel**: $|\eta|<1.6$, $p_T>20$ GeV, $E_T>20$ GeV
- **Backgrounds**: $W+jets$, lepton+electron+X, $Z\gamma$, $W\gamma\rightarrow\tau\nu\gamma$
Observe 146 candidates (e, 162.3 pb$^{-1}$), 77 (µ, 82.0 pb$^{-1}$)

$\sigma = (17.8 \pm 3.6 \pm 5.3 \pm 1.1)$ pb (electrons)

$\sigma = (22.0 \pm 4.2 \pm 7.3 \pm 1.4)$ pb (muons)

$\sigma = (19.3 \pm 6.7 \pm 1.2)$ pb

Theory (Baur + K factor): $\sigma = (16.4 \pm 0.4)$ pb
Future prospects

- Expect first publications with O(200 pb⁻¹) in the next months on:
  - W/Z cross sections using full angular acceptance
  - Universality tests in charged current interactions and indirect measurement of $\Gamma_w$
  - $W_\gamma$ and $Z_\gamma$ cross sections (limits on anomalous couplings, search for radiation zero)
  - $WW$ cross section evidence
  - Limit on $WZ$ cross section in trilepton channel
  - Differential cross sections for $Z/\gamma^*$ and $W$ (angular asymmetries, pT)
  - Direct measurement of $\Gamma_w$