The D0 Run II Upgrade

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for the D0 Collaboration

– Introduction
– Silicon Tracker
  (more details Wed 4:30pm, S. Kesisoglou)
– Fibre Tracker
– Preshower Detectors
  (more details Fri 3:05pm, S. Hou)
– Muon System
  (more details Sat 9:30am, R. McCroskey)
– Calorimeter
– Trigger System
  (more details Sat 9:45am, J. Linnemann)
– Run IIb
– Conclusions
Introduction
– Tevatron Upgrade –

– Major Changes wrt Run I:
  – higher energy (1.8 TeV → 2 TeV)
  – shorter bunch spacing (3500 ns → 396/132 ns)

– Current Status:
  – magnets reach 1025 GeV before quenching
  – protons accelerated up to 980 GeV
  – antiprotons in Main Injector

– First collisions expected soon...
Introduction
– D0 Upgrade Overview –

- New Tracking System
- New bunch spacing requires
  - major rework of trigger and DAQ system
  - new calorimeter readout electronics
- Preshower Detectors
- Upgraded Central, new Forward Muon System
New Silicon Vertex Detector ($\eta < 3$) and Scintillating Fiber Tracker ($\eta < 2$) within 2 T field of superconducting solenoid (inner radius 52 cm)
792576 channels for 3D precision tracking/vertexing up to $|\eta| < 3$

- 6 4-Layer-Barrels (6 x 12 cm in z, 2.7 < $r$ < 9.4 cm):
  - double-sided 2° and 90° stereo for inner barrels
  - single-sided for half of outer barrels
- 12 F-disks (2.6 < $r$ < 10 cm):
  - double-sided wedges with ±15° stereo
- 4 H-disks (9.6 < $r$ < 23.6 cm):
  - single-sided wedges (glued back-to-back) with ±7.5° stereo

- almost all sensors in hand
- installation in two stages (1st half September, 2nd half November)
3 barrels complete (4th this week)

Ladder alignment monitored with CMM → impact of placement precision on hit resolution < 3μm
D0 Silicon Tracker

- Status -

6 F-disks and 1 H-disk complete

Readout tests after bonding, mounting and completion of barrel/disk → generally about 1% dead channels, 0.5% noisy

Dead Channels per F-wedge
- 8 layers with 2 doublets (axial, $3^\circ$ stereo)
- Multiclads 3HF fibers ($835 \mu m$)
- $20 < r < 51$ cm, $|z| < 1.26$ m ($0.83$ m for inner 2)
- 76800 VLPC readout channels (axial at L1)
- hit resolution about $100 \mu m$
- Ribbons of 256 fibers glued on cylinders
- Cylinder Nesting monitored with CMM
- completed May 2000
- about 0.25% compromised channels
- Fiber positioning: $\sigma_{r\phi} \approx 33\mu m$

All axial layers, $\sigma_{r\phi}$ and $\sigma_r$ (incl. correct.)

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>RMS</th>
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<tbody>
<tr>
<td></td>
<td>0.8946E-05</td>
<td>0.1440E-02</td>
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<tr>
<td>Constant</td>
<td>2228.</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>0.2671E-04</td>
<td></td>
</tr>
<tr>
<td>Sigma</td>
<td>0.1320E-02</td>
<td></td>
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Scintillating Fiber Tracker
– Installation –

The CFT on its way...

...into DAB

Clearance: < 100μm...

...is enough
Scintillating Fiber Tracker

- Waveguides -

Curved Connectors at interface Cylinder-Waveguide

- Clear Multiclud Fibers (8-11 m)
- Production in progress (until August)
- Averaging about 0.25% fibers with low transmission
- Commissioning of installed fibers August-September

Not shown: cables for $10^6$ Si channels
Scintillating Fiber Tracker
– VLPCs –

- Quantum efficiency about 85%
- Gain up to 60000
- Low noise at 9 K (→ LHe...)
- Efficient at high rates (20 MHz and beyond)
- Characterisation complete, 40% installed

![Diagram of scintillating fiber tracker](image)

![Histogram of gain distribution](image)
Scintillating Fiber Tracker
– Cosmic Ray Test –

- Pre-Production Cylinder 3
- Production Waveguides
- 4000 channels of VLPC readout
- MIP light yield measurement
- for tracks in D0, 8-out-of-8 trigger efficiency 100%
Central Preshower (CPS):
- 3 layers (axial,u,v) of scintillator strips with embedded WLS fiber (7680 channels)
- lead radiator on coil
- provides 3D spacepoint, energy measurement and EM-Trigger for $\eta < 1.3$

Forward Preshower (FPS):
- "MIP" layers $(u,v)$ and "Shower" layers $(u,v)$, 15616 channels
- lead radiator after MIP layer
- provides 3D spacepoint, energy measurement and Electron-Trigger for $1.5 < \eta < 2.5$
- CPS (and solenoid) installed May 1998
- Waveguide Production complete
- CPS Module tested at Lab3 Cosmic Ray Test
- FPS installed April 2000
- Waveguide production in progress
- FPS Module tested at Lab3 Cosmic Ray Test

(b) FPS 11m

Events/0.5 pe

\[ Q_{clr} \cos \theta \]

- singlet
- doublet
D0 Muon Upgrade
– Overview –

- Central PDTs upgraded with faster gas+electronics
- New Trigger Scintillators in central and forward region
- New forward shielding
- New Drift tubes (MDTs) for forward tracking
D0 Muon Upgrade

- A-Φ-Counters installed
- Cosmic Cap&Bottom installed
- PDTs installed
- Central Muon Commissioning started 12/99
- Outer MDT Layer installed
- Pixel installation in progress

North A-Layer MDTs in place

A-Layer Scintillator Pixels
D0 Calorimeter Upgrade

- Run I energy resolution maintained with PS
- Readout Electronics upgraded for 396/132ns bunch spacing

SCA analog delay >4μs, alternate
Additional buffering for L2&L3
new calibrated pulse injection

Replace cables for impedance match
Shorter shaping 400ns
new low noise PreAmp & Driver

- PreAmp- and Calibration System complete
- Shaper/BLS in progress
D0 Trigger Upgrade

Analog Pipelines
32 crossings

Front End Buffers
16 events

Inputs from Cal, CFT, CPS, FPS, Muon
FPGAs generate trigger terms
Tracks (CFT), EM (Tracks+CAL+PS)
Muons (Muons+Tracks), Jets (CAL, Tracks)
L1 Framework sets 128 trigger bits

Fast Pickoffs

digitize

7 MHz
4.2μs

Input Buffers for 16 events
deadtime <5%
Alpha Processors (VME + MagicBus)
Parallel Preprocessing by Subdetector
Global Processor combines all information
3d PS–Clusters, CAL Em– and Jet–Clustering

readout

10 KHz
100μs

Farm of Intel Processors (Windows NT)
Partial event reconstruction
3d tracking, primary vertex, b–tagging
Shower Profiles in PS+CAL
Multivariate discriminants

Fiber Optics Link to FCC (tape robot)
Streaming according to Trigger

1 KHz
50 ms

50 Hz
D0 Upgrade
– Schedule –

205 days left until start of Run II

<table>
<thead>
<tr>
<th>2000</th>
<th>2001</th>
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<tbody>
<tr>
<td>M</td>
<td>A</td>
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<tr>
<td>FPS</td>
<td>ICD</td>
</tr>
<tr>
<td>1st CFT crate operational</td>
<td>First 10</td>
</tr>
<tr>
<td>Fabricate/test CFT digital boards</td>
<td>First 10</td>
</tr>
<tr>
<td>Low mass cables procured</td>
<td>Produce/test SMT interface cards</td>
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<tr>
<td>Fabricate/test Muon Farmer Cards</td>
<td>Install C- and B-layer MDTs &amp; pixels</td>
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Phase I
Central Muon, DAQ, RECO, Trigger

Detector Hookup/Commissioning
Phase II
Tracker Hookup (CFT, SMT, PS), VLPCs, Trigger, Forward Muon

Phase III
Cosmic Ray Commissioning: Tracker & Muon Systems, Cosmic Triggering
D0 Run IIb Upgrade
- Again?

- Maximum Si Depletion Voltage 120 V

- Inner Layer dead after 3-4 fb$^{-1}$
- Second Layer dead after about 11 fb$^{-1}$
→ need another upgrade to reach 15 fb$^{-1}$ or more
Several options under discussion

- **Partial Replacement**
  - replace silicon layers 1+2 with single-sided back-to-back
  - need to keep layers 3+4 cold

- **Full Replacement**
  - replace all silicon layers with single-sided back-to-back
  - minimizes length of shutdown
  - big project...

- **Additional Silicon Layers**
  - Layer 0 Strips
  - Layer 0 Pixels
  - Replace CFT inner layers with Silicon Layer 5

- **CFT Stereo Trigger**
  - use L1 Stereo to reduce occupancy
D0 Upgrade
– Conclusions –

– All D0 Systems undergoing major upgrades
– Production nearing completion
– Installation well underway
– Commissioning efforts have started
– Run IIb upgrade under study

*Stay tuned for first results next year!*