Neutrino Detectors

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Outline

DØ experiment

Central tracking

Solenoidal magnet

Preshower detectors

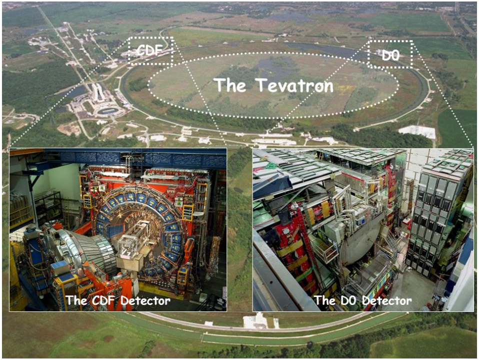
Calorimetry

Muon system

Forward proton detector

Luminosity monitor

DØ Experiment



Aerial view of Fermilab National Accelerator Laboratory

- probed $\sqrt{s} = 1.96TeV$ $p - \bar{p}$ collisions at a rate of $1.2 \times 10^{6} \frac{1}{s^{-1}}$
- recorded $120pb^{-1}$ of data in run I (1992–1996) and ...

DØ Experiment Goals

- **Precision searches:**
  - Z and W masses, widths and production cross sections
  - Forward-backward asymmetry
  - $W/Z \to q\bar{q}$
  - $\frac{\alpha_{QCD}}{\alpha_{QED}}$
- **New physics:**
  - $Z \to X\gamma; X \to l^+l^-$
  - Single top
  - Gauge boson couplings
  - **Higgs boson**
  - **Supersymmetry**
  - W', Z', heavy leptons and heavy quarks
  - Surprises are also welcomed :D

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DØ design considerations

- Electromagnetic energy resolution at the level of $\delta E/E = \frac{0.05}{\sqrt{E}}$ with good $\pi^0 - e$ separation:
  - good electron ID for narrow massive states searches and to lower electron-jet faking rate.
  - good lateral and longitudinal sampling for single γ searches with high p_T (challenging $\pi^0 - e$ separation)
- Muon momentum resolution of approximately 20%:
  - muons are less analyzed, but with charge tagging → ID them even inside jets which is important for many searches
- Hadron energy resolution of about $\delta E/E = \frac{0.8}{\sqrt{E}}$:
  - jet energies, masses and $\not{E}_T$ are critically dependent upon it.
- Missing transverse energy resolution:
  - good hadron energy resolution → uranium-liquid argon calorimerty was chosen.
  - angular coverage down to about 1°
  - minimizing dead areas in the large angle calorimetry

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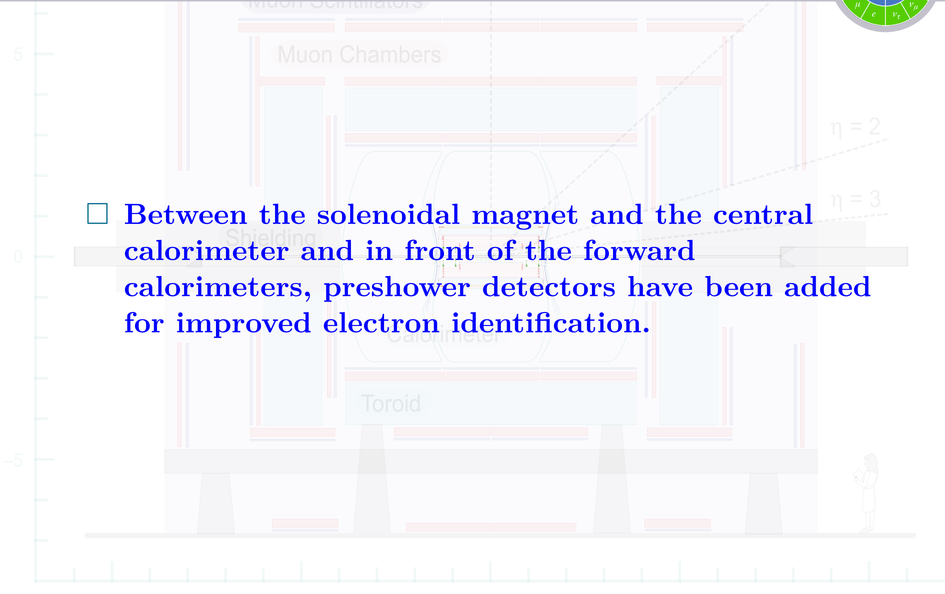
DØ Experiment

- in 2001 after the Main Injector and associated Tevatron upgrades the instantaneous luminosity increased by more than a factor of ten

DØ Experiment

- **The central tracking system was completely replaced.**
  - the old system lacked a magnetic field and suffered from radiation damage
  - improved tracking technologies are now available.
  - The new system included a silicon microstrip tracker and a scintillating-fiber tracker located within a 2 T solenoidal magnet.

DØ Experiment

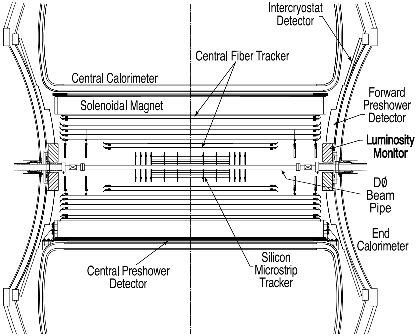


- Between the solenoidal magnet and the central calorimeter and in front of the forward calorimeters, preshower detectors have been added for improved electron identification.

DØ Experiment

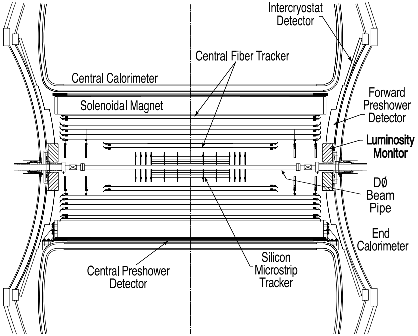
- **In the forward muon system, proportional drift chambers are replaced by mini drift tubes and trigger scintillation counters**
  - which can withstand the harsh radiation environment and additional shielding has been added.
  - In the central region, scintillation counters have been added for improved muon triggering.

Silicon Microstrip Tracker



- A silicon microstrip tracker (SMT) and a central fiber tracker (CFT) surrounded by a solenoidal magnet

Silicon Microstrip Tracker



- the primary interaction vertex resolution of about $35\mu m$ along the beamline $\rightarrow$ good measurement of lepton p_T, jet transverse energy (E_T), and missing transverse energy $\not{E}_T$. b-quark jets tagging with an impact parameter resolution of better than $15\mu m$ in $r - phi$

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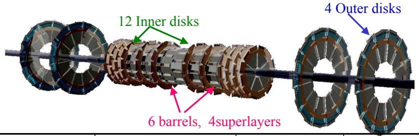

Silicon μ-strips	Barrels	Inner disks	Outer disks
Type of ladders	Single, double-sided	Double-sided	Double-sided
Stereo angle	0^o, 2^o and 90^o	7.5^o	15^o
Inner radius	2.7 cm	2.6 cm	9.5 cm
Outer radius	9.5 cm	10.5 cm	26 cm
# of channels	400K	250K	150K

▶

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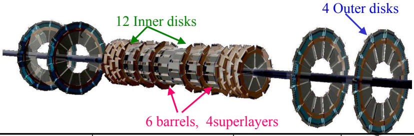

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- The SMT provides both tracking and vertexing over nearly the full η coverage of the calorimeter and muon systems.

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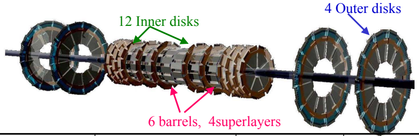

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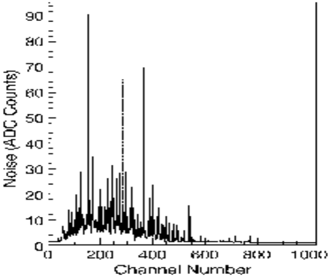
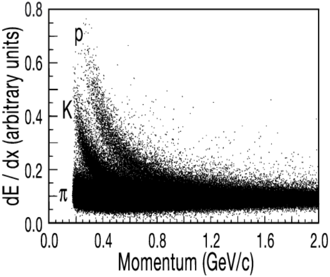
- The barrel detectors primarily measure the $r - phi$ coordinate and the disk detectors measure $r - z$ as well as $r - \phi$.

Silicon Microstrip Tracker: Operation

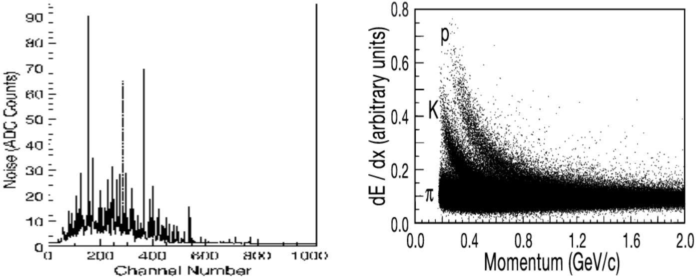




left: grassy noise seen in the Micron-supplied F-disk detectors. right: energy loss for a K-enriched sample of tracks showing π, K, and proton bands.

- during run II $\approx 90\%$ of sensors were functional

Silicon Microstrip Tracker: Operation



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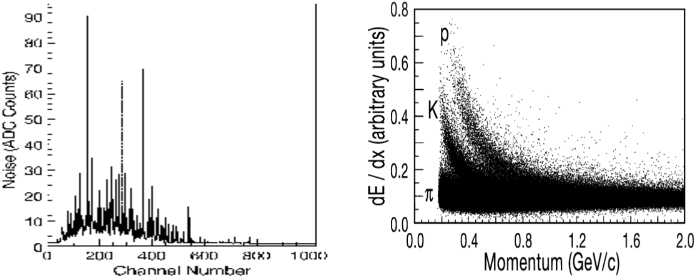
- most operational difficulties have been peripheral to the silicon detector itself. These include latchup of operational amplifiers on the interface boards, low voltage power

Silicon Microstrip Tracker: Operation



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- the most serious detector feature is “grassy noise,” which is confined to the Micron-supplied F-disk detectors (75% of the F-disk sensors). This noise is characterized by large

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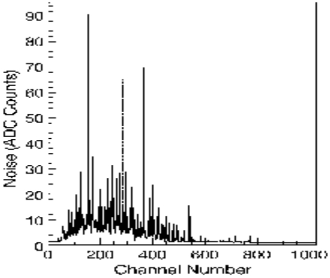

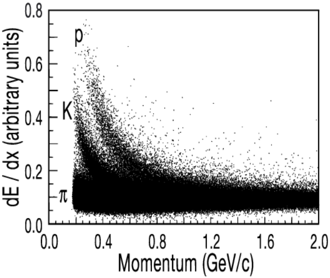

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- leakage currents typically rise to greater than $100\mu A$ within one hour of turn-on at the beginning of a store.

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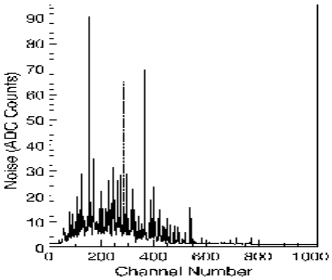

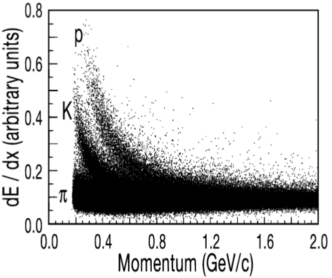

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- Alignment and calibration Signal/noise performance varies with detector type from $12 : 1 to 18 : 1$.

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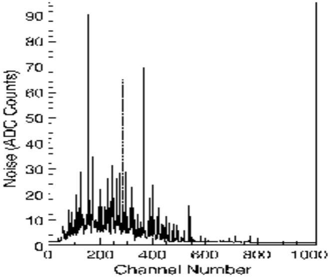

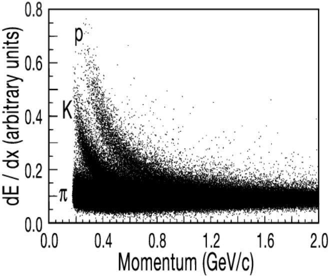

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- Coherent noise is typically one-third of the random noise.

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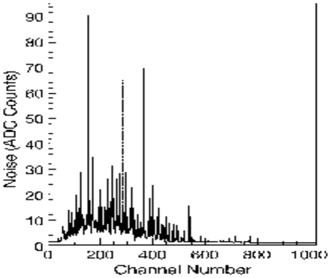

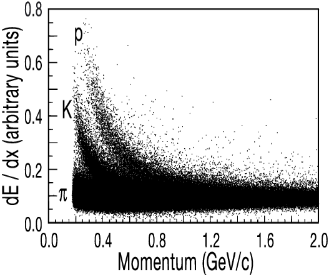

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- Gains vary among detector types with the n-sides 515% lower than the p-sides due to the larger load capacitance.

Title

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Title

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