DØ Expectations and Aspirations for B Physics in Run II

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Workshop on

B Physics at the Tevatron

Run II and Beyond

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DØ Run II B Physics Goals and Aspirations

QCD tests

- cross sections
- correlations
- charmonium polarization

CP violation and CKM angles

- $\sin(2\beta)$ $B \to J/\psi + K_S$
- $\sin(2\alpha)$ $B \to \pi^+\pi^-$
- possibly γ $B_S \to D_S^{\pm} K^{\mp}$

Non SM CP violation

- $B_s \to J/\psi + \varphi$

B_S mixing

- $B_s \to D_s + n\pi$
- $B_s \to J/\psi + K^*$

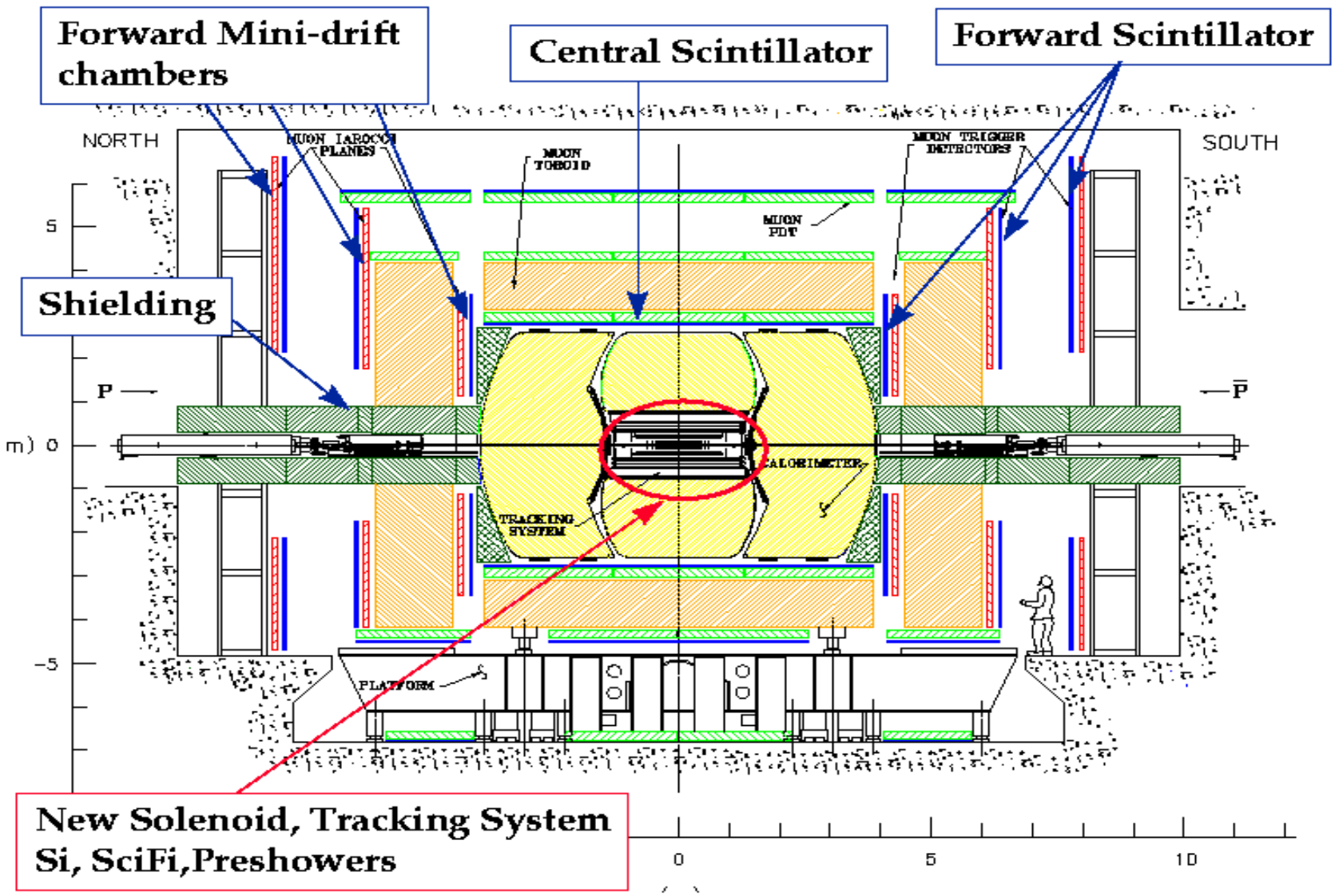
Spectroscopy and lifetimes

- $B^0, B^+, B_s, B_c, \Lambda_b$

Rare and radiative decays

- $B \to l^+ l^-$ $B \to l^+ l^- X_s$
- $B_S \to K^* \gamma$

The DØ Upgrade



The DØ Upgrade

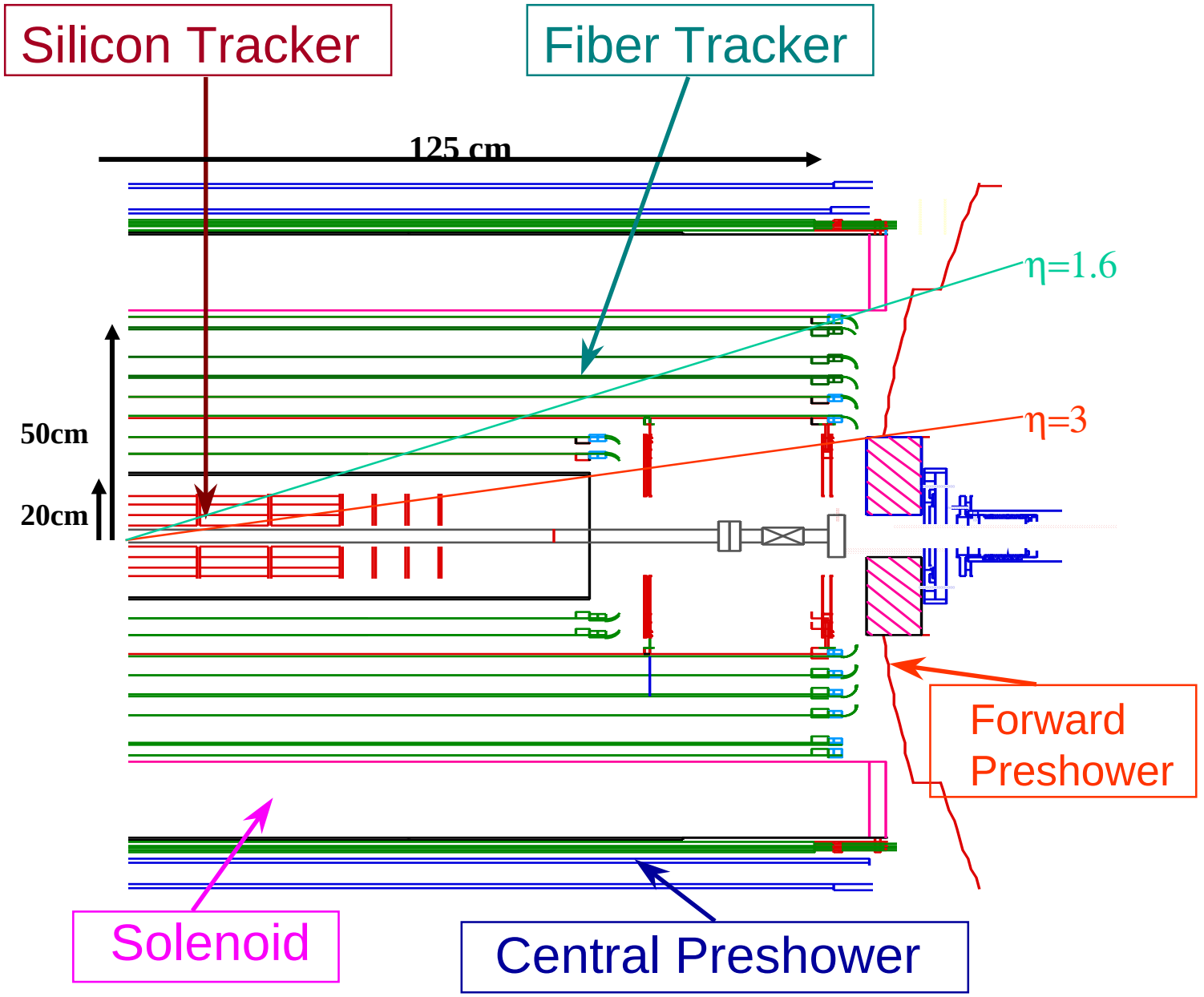
Built on previous strengths:

- excellent calorimetry
- good muon coverage and purity

Significantly improved tracking and triggering capabilities:

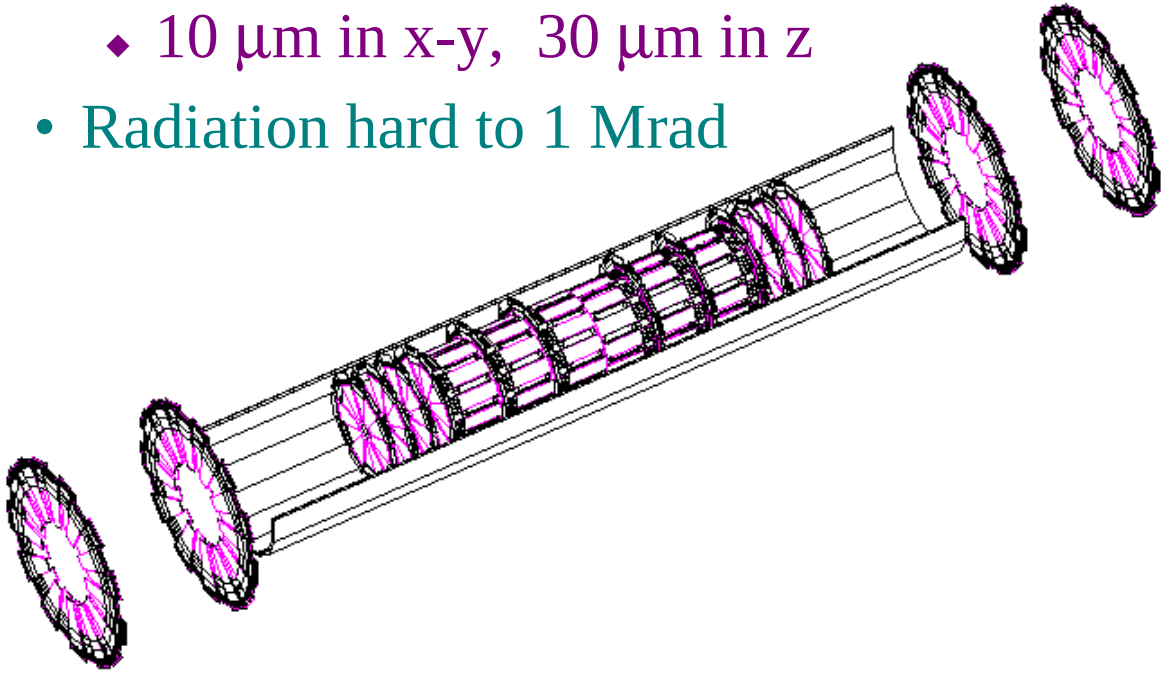
- new inner tracker with silicon vertex detector and scintillating fiber tracker
- 2 Tesla magnetic field
- enhanced muon triggering
- pre-shower detectors for electron ID and triggers
- level II impact parameter trigger

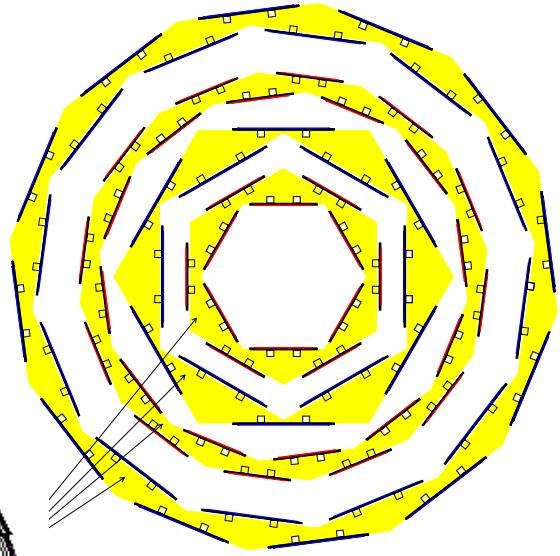
The DØ Inner Tracking System

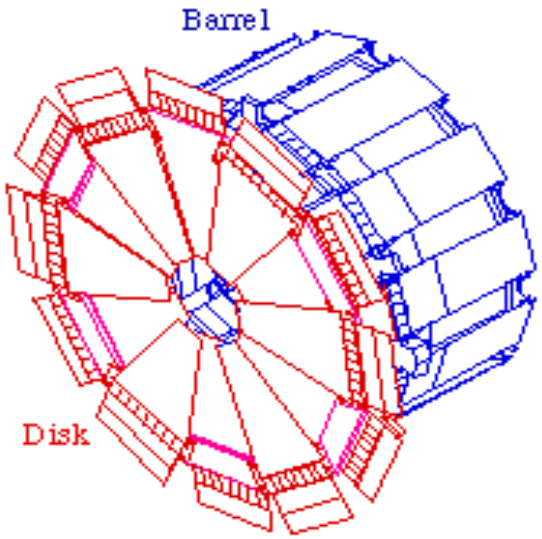


The DØ Silicon Detector

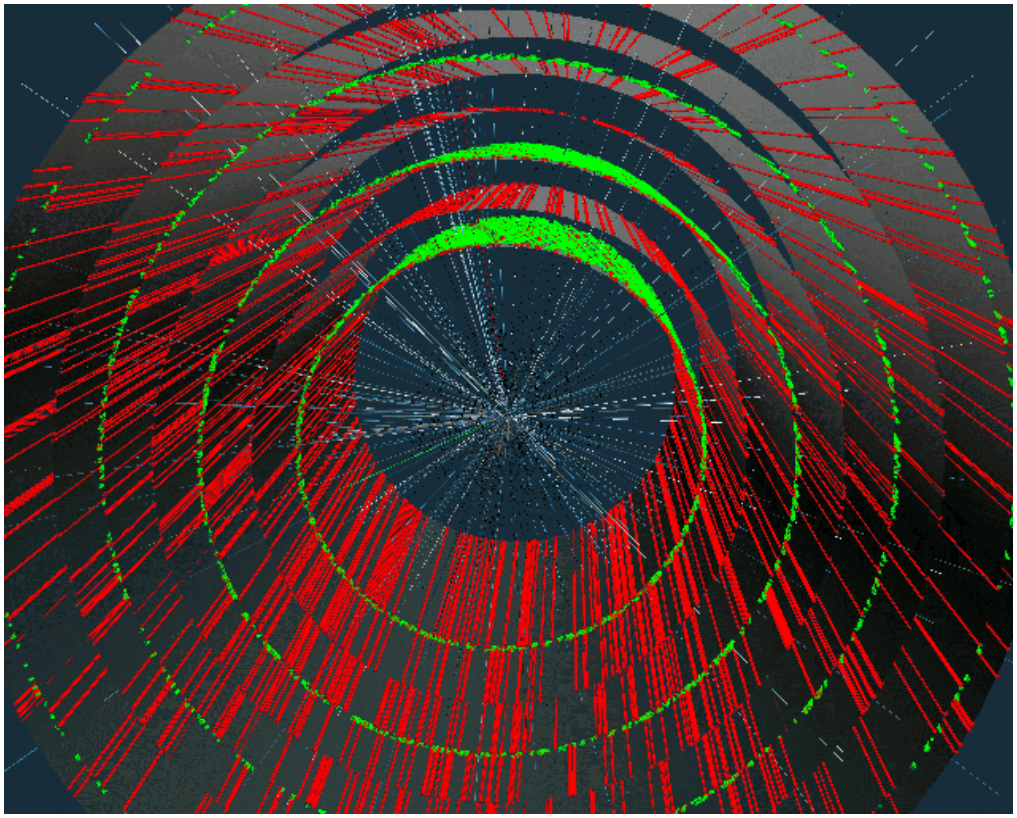
- 6 barrels (12cm) with 4 layers each
- 16 disks
- Hit resolution: 10 μm
- Primary vertex resolution:
  - 10 μm in x-y, 30 μm in z
- Radiation hard to 1 Mrad





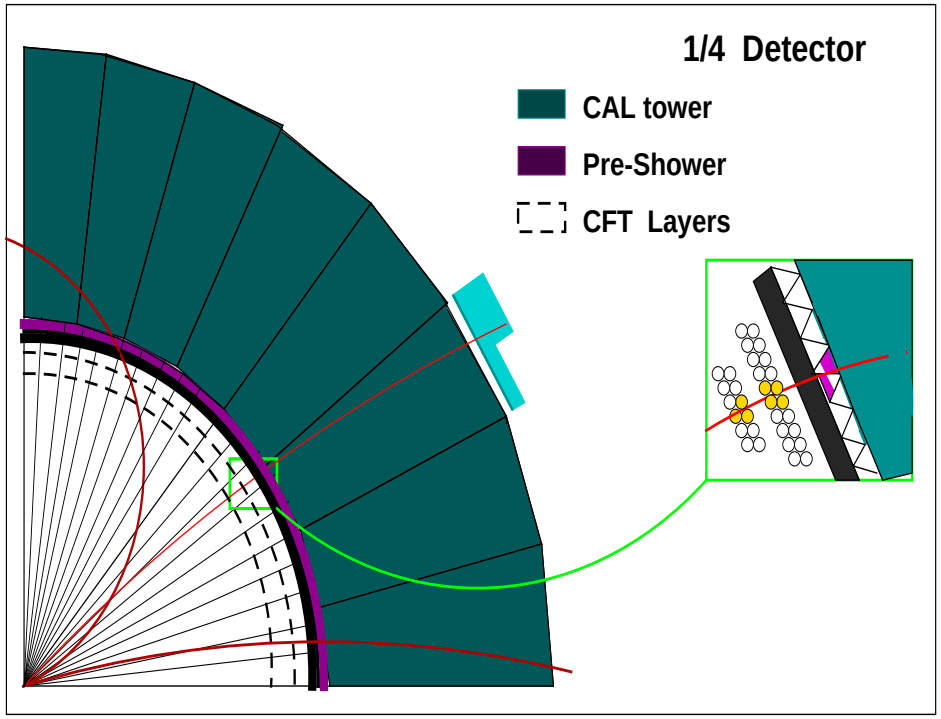


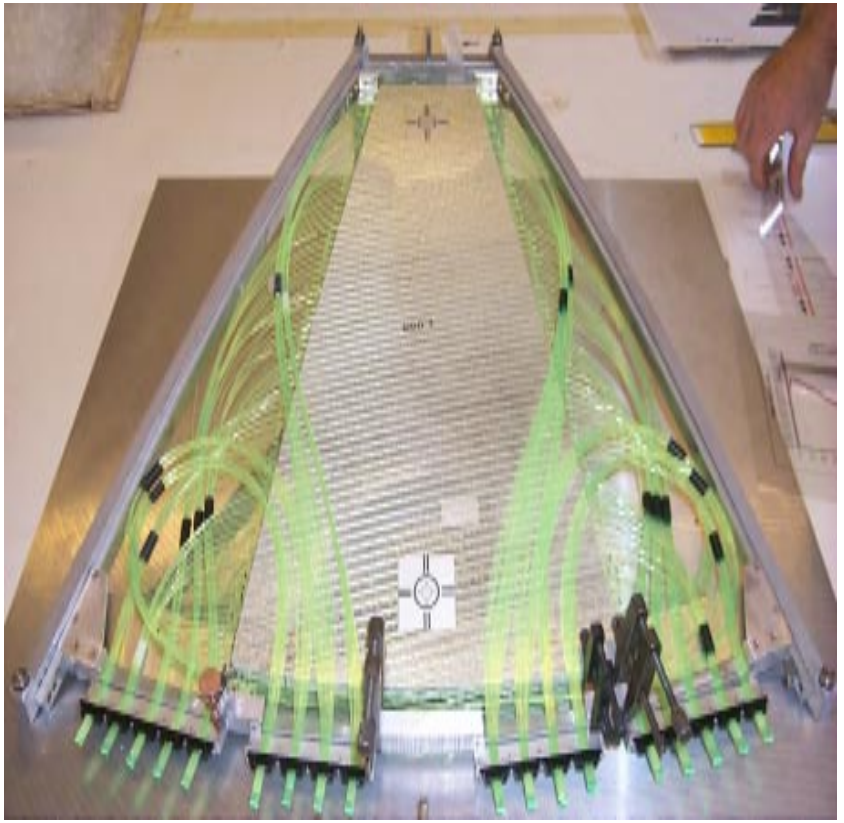
The DØ Fiber Tracker



- 8 cylinders with 4 layers of 830 μm scintillating fibers each
- Radial and alternating u v (2^{o}) stereo doublets
- Fast response, good resolution, low mass

The DØ Pre-shower Detectors





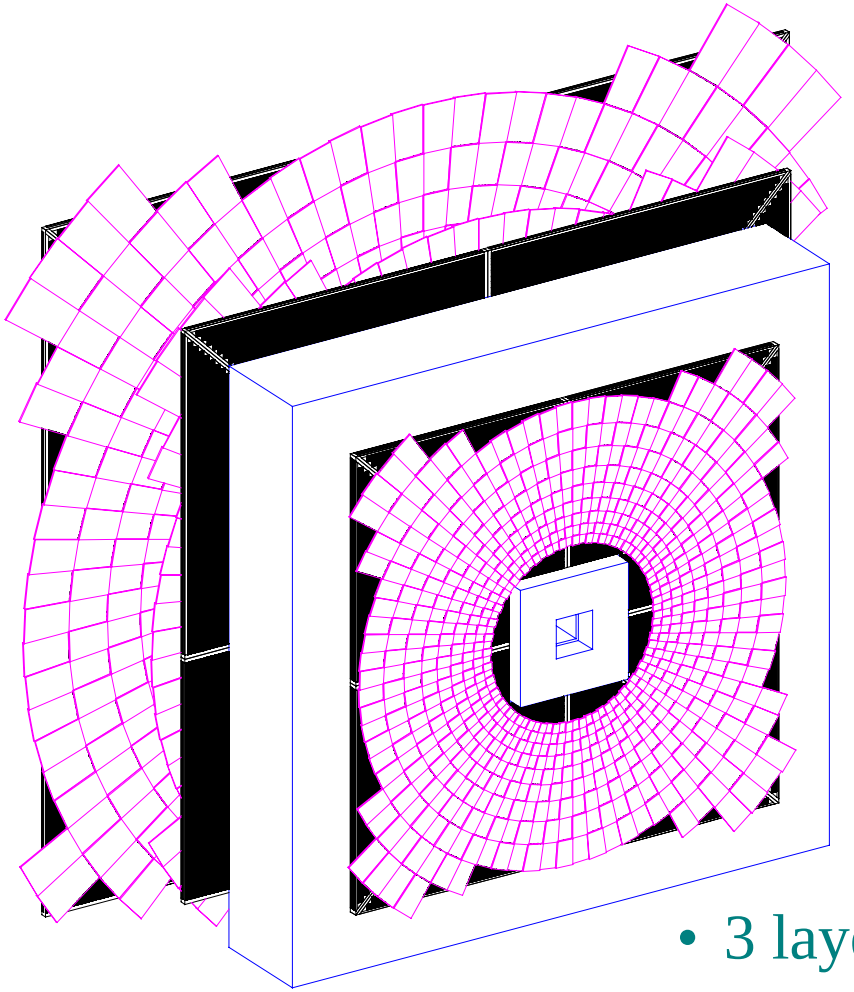
- 2 X_0 pre-radiator (solenoid + lead)
- Triangular scintillator strip layers
  - central: 3 layers (axial + 20^o stereo u-v)
  - forward: 4 layers (22.5^o stereo u-v)

DØ Central Muon Scintillators

A-ϕ Counters

- 630 scintillation counters
- ($\Delta\eta$ x $\Delta\phi = 0.2$ x 4.5°)
- full coverage in the central region
- allow low p_T muon triggers
  - pT > 1.5 GeV/c

The DØ Forward Muon System



- 3 layers of high granularity mini drift tubes
  - position resolution of ~ 350 μm
- 3 scintillator pixel layers
  - ($\Delta\eta$ x $\Delta\phi$ = 0.1 x 4.5^o)

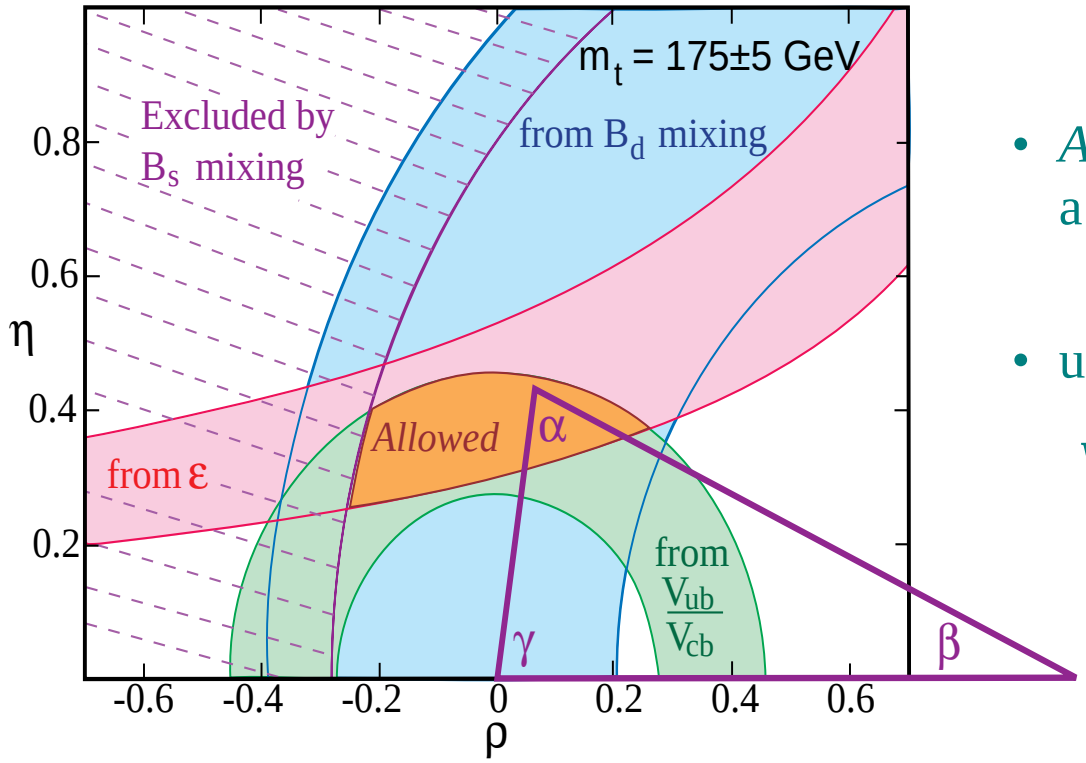
DØ Upgraded Detector Performance

- Good Momentum resolution:
  - $dp_T/p_T^2 = 0.002$ (Silicon + Fiber tracker)
- High tracking efficiency:
  - at least 95 % $|\eta| < 3$ (Silicon disks)
- Vertex Reconstruction:
  - primary vertex: $\sigma^{vertex} = 15\text{-}30\ \mu m$ (r-ϕ)
  - secondary vertex: $\sigma^{vertex} = 40\ \mu m$ (r-ϕ) , $100\ \mu m$ (r-z)
- Excellent lepton coverage trigger and ID efficiency:
  - muons: $p_T > 1.5$ GeV, $|\eta| < 2$
  - electrons: $p_T > 1$ GeV, $|\eta| < 2.5$
- Impact parameter trigger

B Physics in the 21st Century

Experiments will confront the Standard Model interpretation of CP violation

$$\begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} \approx \begin{pmatrix} 1-\lambda^2/2 & \lambda & A\lambda^3(\rho - i\eta) \\ -\lambda & 1-\lambda^2/2 & A\lambda^2 \\ A\lambda^3(1-\rho-i\eta) & -A\lambda^2 & 1 \end{pmatrix}$$

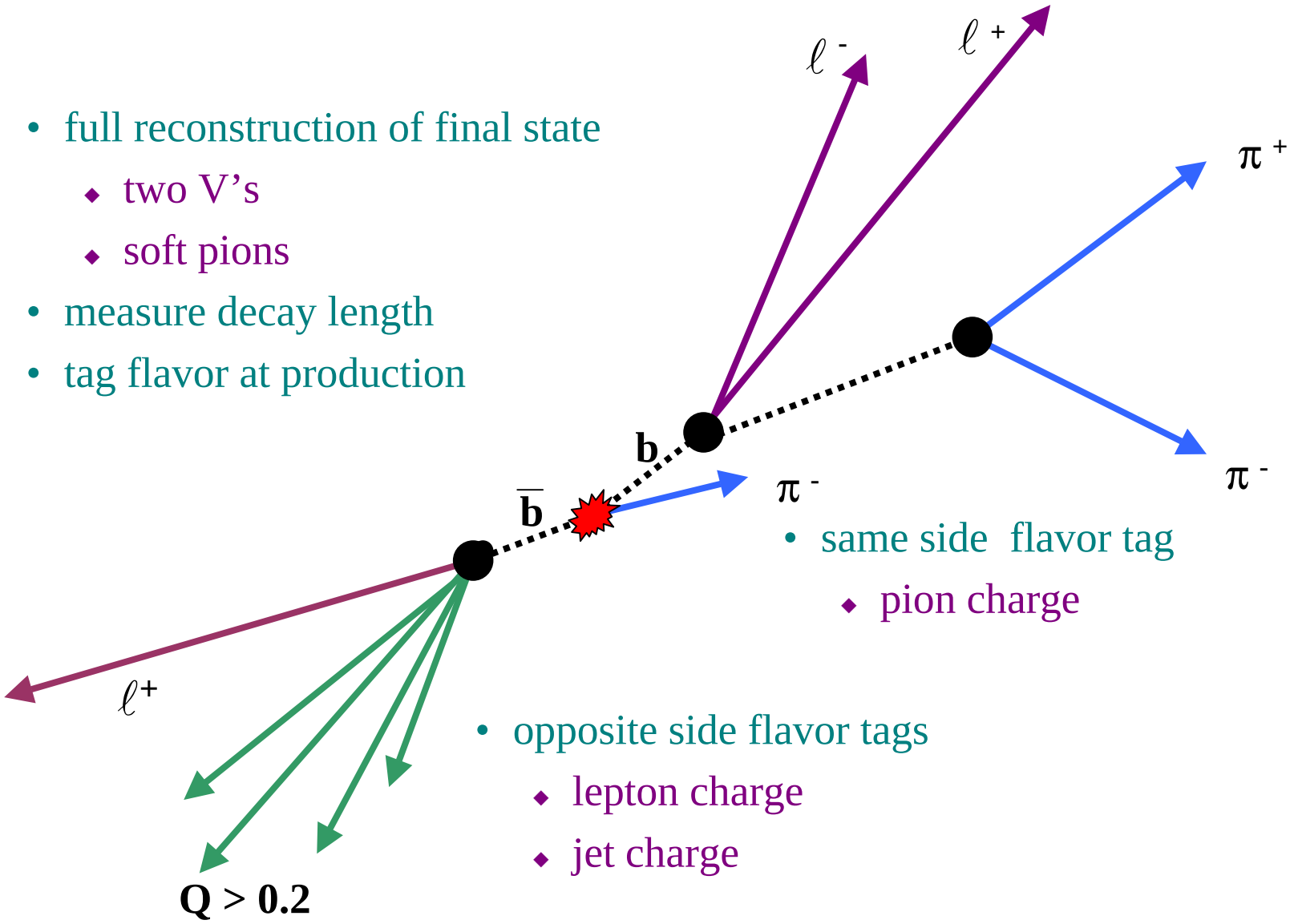


- A and λ have been measured to a few percent
- unitarity condition:

$$V_{tb}^* V_{td} + V_{cb}^* V_{cd} + V_{ub}^* V_{ud} = 0$$

Sin(2β) via $B \to J/\psi K_S$

- full reconstruction of final state
  - two V's
  - soft pions
- measure decay length
- tag flavor at production

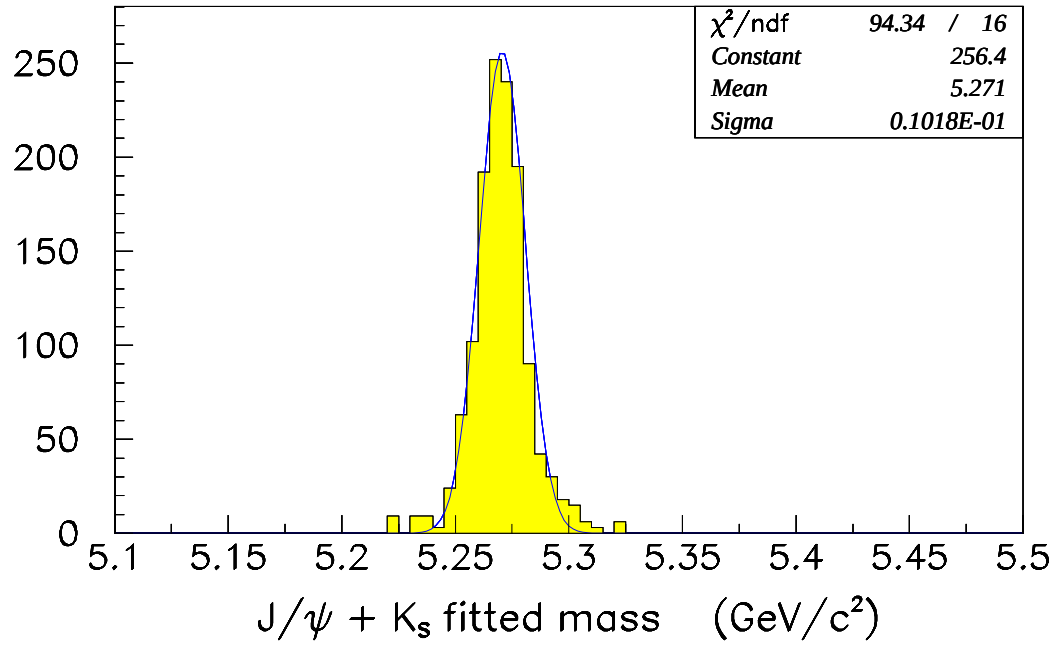


- same side flavor tag
  - pion charge

- opposite side flavor tags
  - lepton charge
  - jet charge

$B \rightarrow J/\psi K_S$ Reconstruction

- $J/\psi \rightarrow \mu^+\mu^-$ require two central tracks with $p_T > 1.5$ GeV/c
- $K_S \rightarrow \pi^+\pi^-$ use long lifetime to reject background: $L_{xy}/\sigma > 5$
- Perform 4-track fit assuming $B \rightarrow J/\psi + K_S$
  - constrain $\pi\,\pi$ and $\mu\,\mu$ to mass of K_S and J/ψ respectively
  - force K_S to point to B vertex and B to point to primary



Sin2β Expectations for 2fb^{-1}

For a time independent analysis:

$$\sigma(\sin 2\beta) \approx \frac{1+x_d^2}{x_d} \frac{1}{\sqrt{N\varepsilon D^2}} \sqrt{1+\frac{B}{S}}$$

- (S/B ~ 0.75)
- $\varepsilon D^2 \sim 7\ \%$

mode	$J/\psi \to \mu^+\mu^-$	$J/\psi \to e^+e^-$
trigger eff. (%)	32	25
reco'd events	8,500	6,500
$\sigma(\sin 2\beta)$	0.13	0.15
	0.10	

But, since most of the background is at small *t*'s, a time dependent analysis gives reduced error: $\sigma(\sin 2\beta) \sim 0.07$

And this is just in the first two years - 2 fb^{-1}. We won't stop there……

New Director - New Run II Plan

- No long shutdowns
- Gradual luminosity improvements as we run
- Run until LHC results tell us to stop
- 5 fb^{-1} per year at peak

L (fb^{-1})	Number of $B \rightarrow J/\psi K_S$	$\sigma(\sin 2\beta)$
2	15 K	0.07
5	38 K	0.04
10	75 K	0.03
20	150 K	0.02

Sin(2β) Measurement

Goals for this workshop:

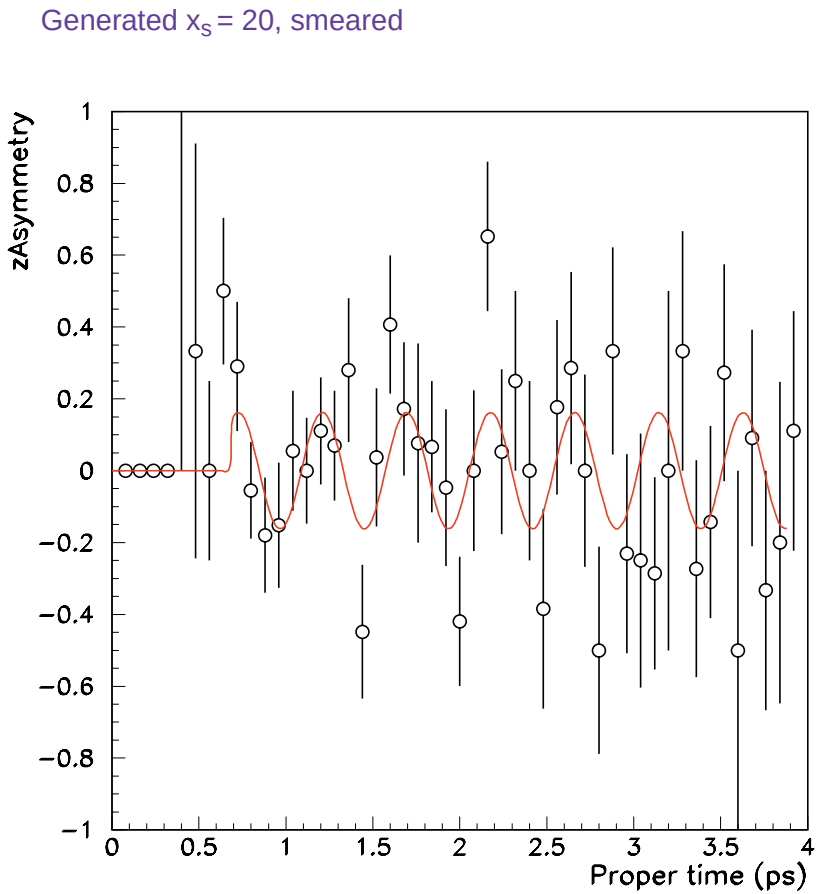
- work on reconstruction algorithms
- determine tagging efficiencies and dilution factors
  - does neural net tagging help ?
- can a (combined) Tevatron measurement scoop Babar/Belle ?

B_S Mixing

Use fully reconstructed events

- $B_S \rightarrow D_S \pi^+$
- $B_S \rightarrow D_S \pi^+\pi^-\pi^+$
- $B_S \rightarrow J/\psi + K^*$
  - $\varepsilon D^2 \sim 5\ \%$
  - $\sigma(t) \sim 60$ fs

Need opposite side lepton for trigger



B_S Mixing

Goals for this workshop:

- study all decay modes
- use of kinematic fits to improve proper time resolution
  - can we fit for missing ν in semileptonic decays ?
- find a better way to trigger on these events !

Conclusion

What we hope to achieve at this workshop:

- recruit people into B physics
- study our capabilities for key measurements
- exchange ideas with our friends across the ring and in the high rise
  - combined Tevatron measurements ?
- confirm that we have the proper triggers
- test and develop our Run II software
  - do current reconstruction algorithms work for B physics ?
  - develop new tools: V finding, kinematic fits, neural nets

Make sure that we have the necessary tools and understanding to make significant and timely B physics measurements in Run II