Triggering on B events at DØ

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Overview
- Introduction: B_s mixing
- DØ detector and trigger framework
- Level-3 trigger: Vertexing, impact parameter and invariant mass tools
- Semi-leptonic B sample

B_s mixing

- Oscillations between B_s and $\overline{B}_s$ mesons
- Frequency given by $\Delta m_s = B_H - B_L$
- SM "predicts" $8\ ps^{-1} < \Delta m_s < 17\ ps^{-1}$, World limit $> 14.4\ ps^{-1}$ at 95% CL (HFAG)
- Δm_s with Δm_d permits extraction of CKM elements

$$\frac{\Delta m_s}{\Delta m_d} = \frac{m_{B_s}}{m_{B_d}} \cdot \frac{\left|V_{ts}\right|^2}{\left|V_{td}\right|^2} \cdot \frac{F_{B_s}^2 B_{B_s}}{F_{B_d}^2 B_{B_d}}$$

~6% uncertainty

- Hadronic modes: Low statistics, good proper time resolution
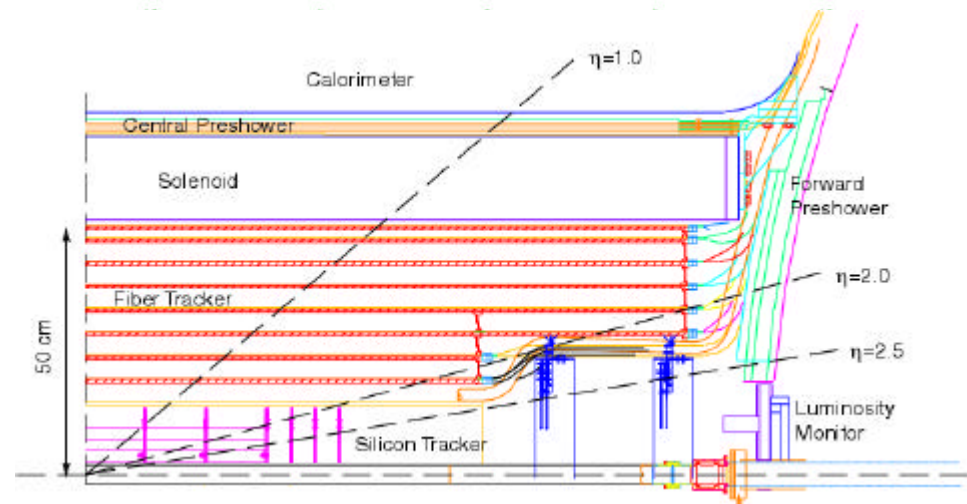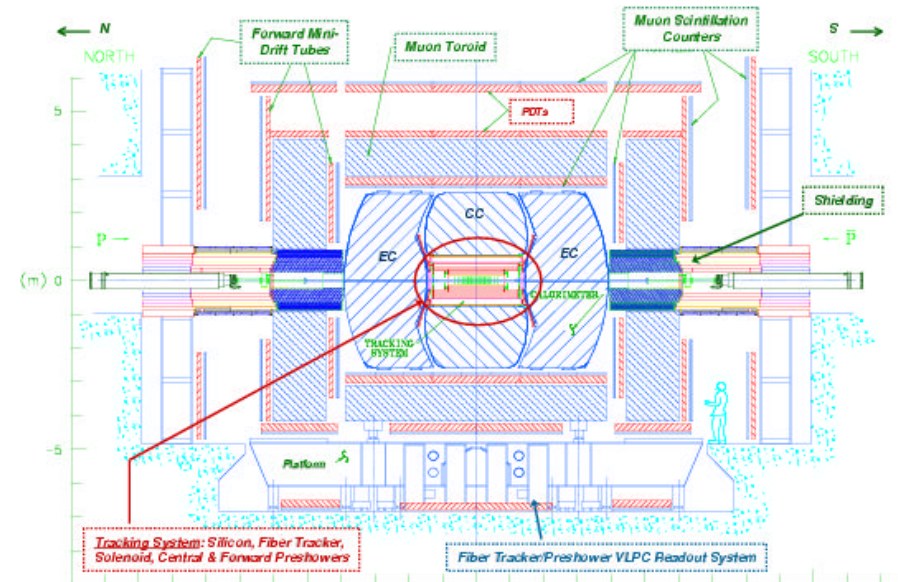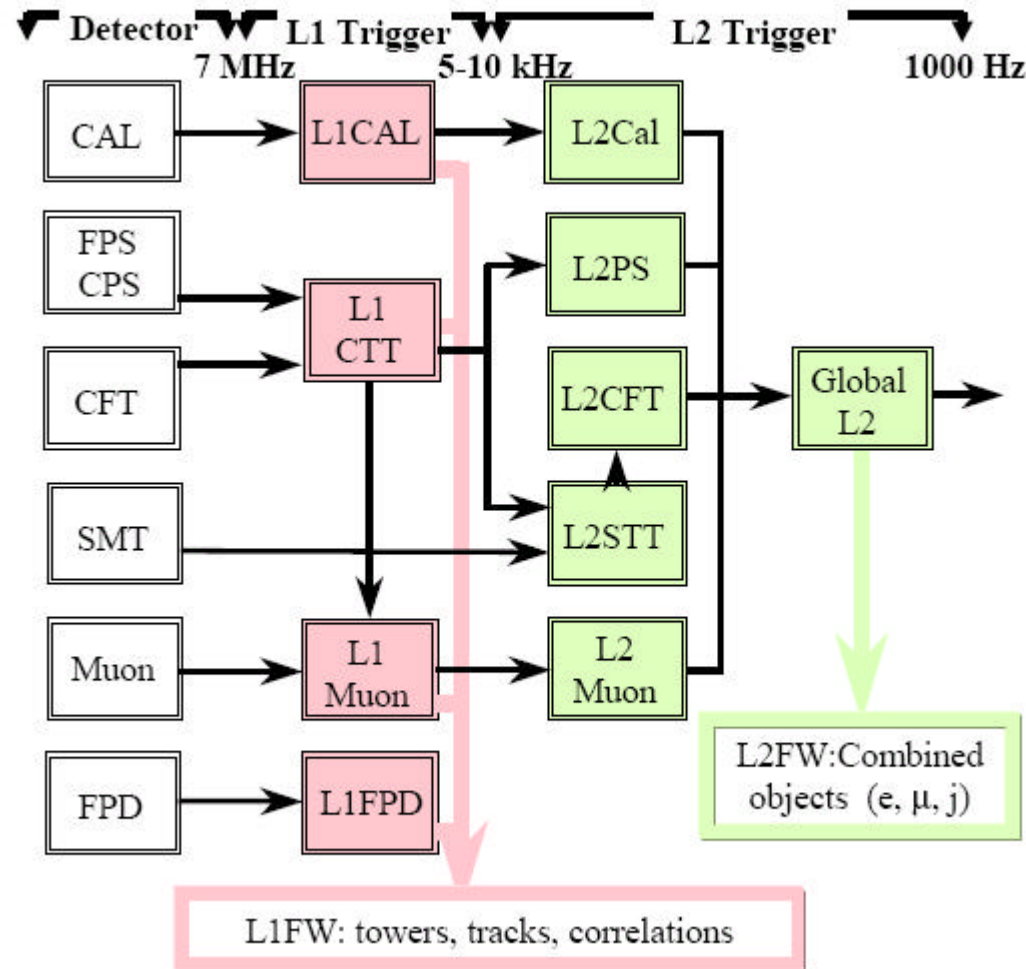- Semi-leptonic modes: High statistics, poor proper time resolution

DØ

- Utilise excellent muon coverage and trigger on single and di-muons
- Triggering extremely important

New in Run II

- Silicon vertex detector

- Central fibre tracker

- 2T solenoid

- Central and Forward Preshowers

- Forward muon system

- Upgraded DAQ/trigger

- L2 silicon track trigger

DØ Trigger

L3 Trigger   Tape

50 Hz

L3: 128 nodes running linux
    Full detector readout
    Partially reconstruct event
    Budget ~100ms per event

Why do vertexing at L3?

- Z component : calculation of transverse energy, E_t
  jet and missing E_t triggers
  trigger on events in SMT fiducial region
  sharpens turn on curves
- XY component: essential for b tagging
 used in impact parameter and b jet probability triggers

Algorithms

- Z and XY finding split - saves time if only Z is needed
- Z component: uses histogramming weighted by P_t
- XY component: uses Z position
  linearises tracks
  iterative impact parameter minimization
  beamspot weighted
 ~10ms

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- Original tool written by Ray Beuselinck
- Modified to use P_t histogramming:

   histogram tracks according to zca

   weight bin by total P_t

   choose highest 2 adjacent bins and average values

B_s -> D_s **p** + 0.8 min bias event

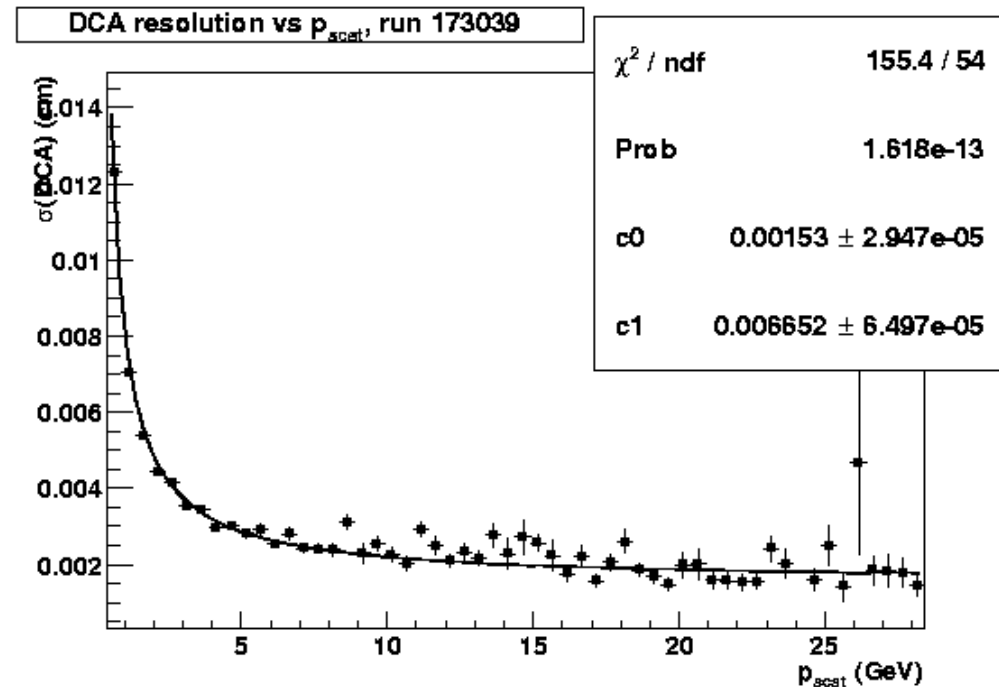incorrect vertex returned   correct vertex returned
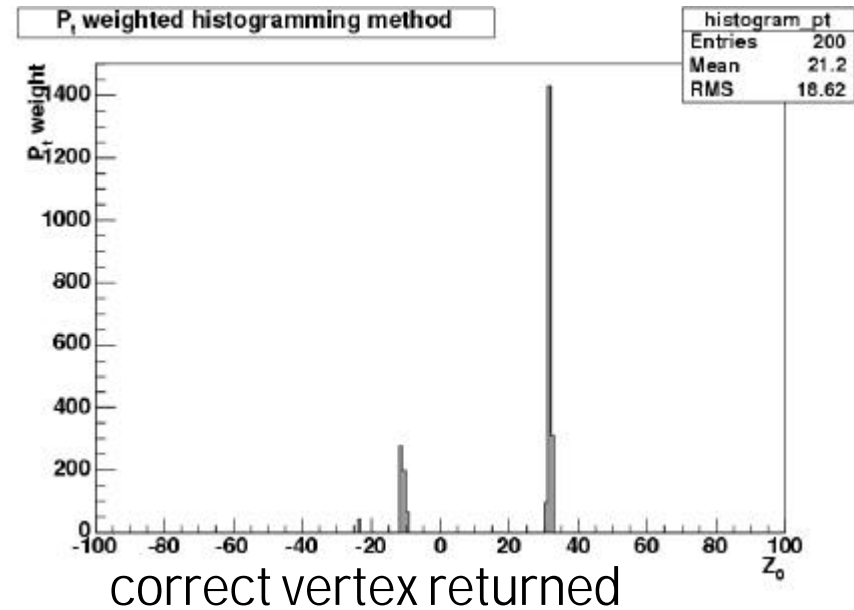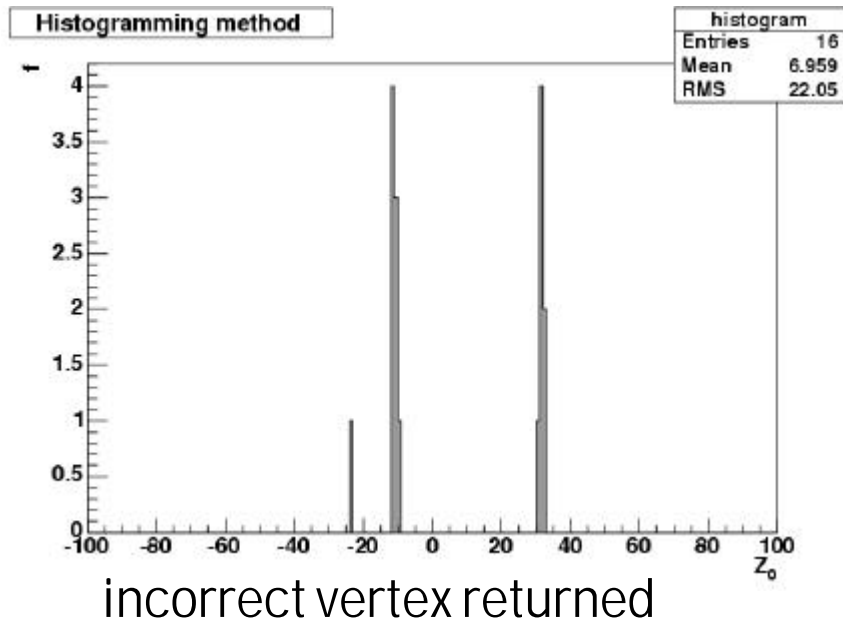
- Impact parameter minimization in 2 dimensions using linear tracks
- Requires inversion of one 2×2 matrix - FAST
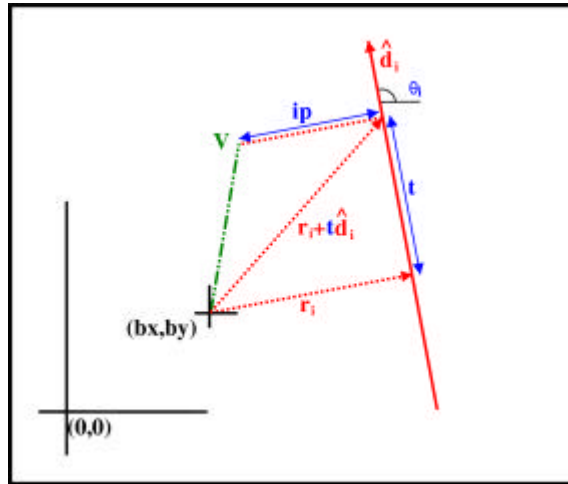
$$\text{Minimise } \mathbf{c}^2 = \sum_{i=1}^{numtracks} \frac{\left| r_i + d_i [V.d_i] - V \right|^2}{(s_i^{ip})^2} + \sum_{i=x,y} \frac{V^2}{(s_i^{b})^2}$$

DCA resolution in data

- $P_{scat} = P \sin^{3/2} \mathbf{q}$
- Material causes multiple scattering
- Large P_{scat} – low multiple scattering
- ~ 15 μm asymptotic value!

DCA resolution vs p_{scat}, run 173039

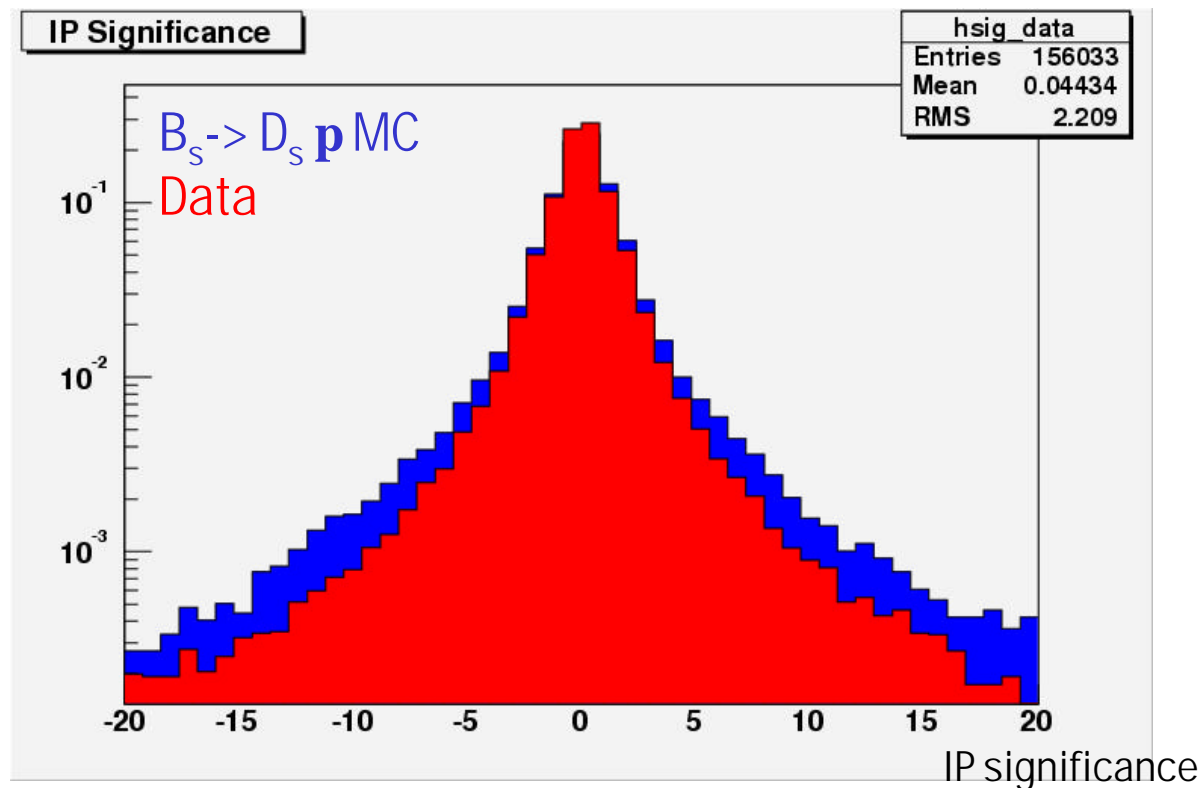| χ^2 / ndf	155.4 / 54
Prob	1.618e-13
c0	$0.00153 \pm 2.947e\text{-}05$
c1	$0.006652 \pm 6.497e\text{-}05$

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Track impact parameter significance
- useful for B physics, new phenomena
- Trigger on multiple tracks with
  ip significance > x

Muon impact parameter significance
- Match muon to central track
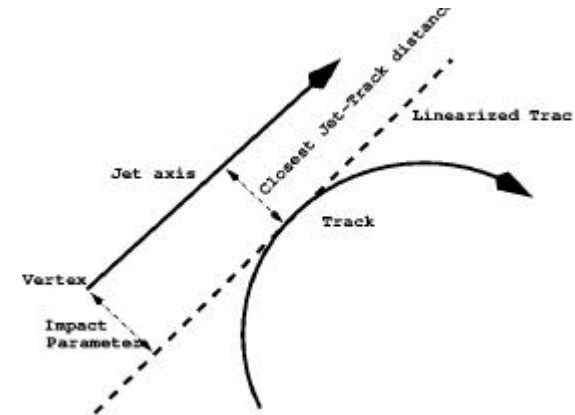- Trigger on muon impact parameter
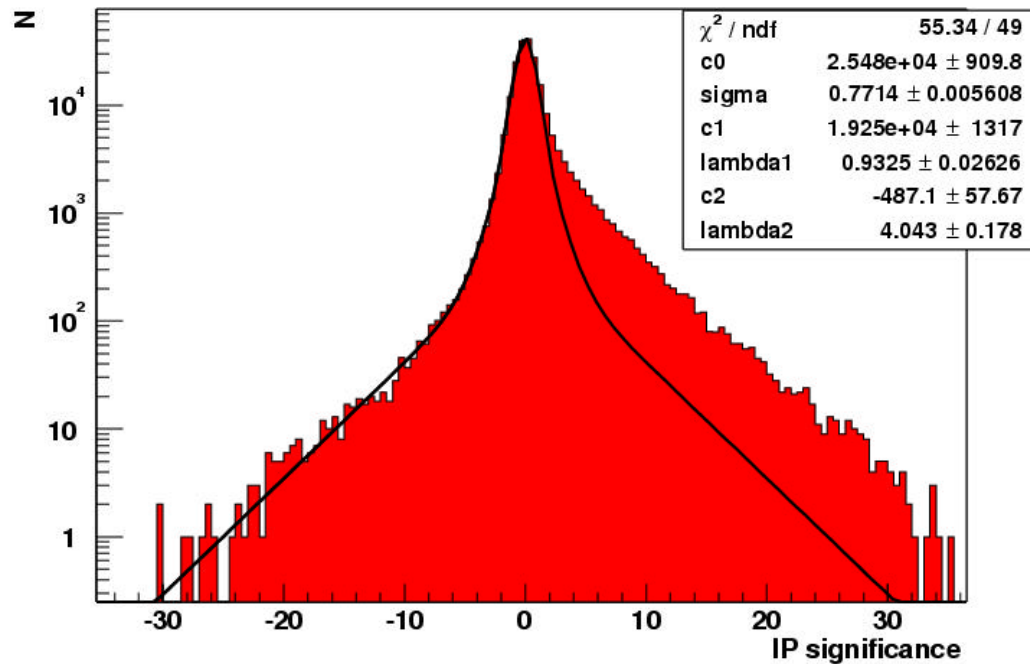- Unbiased

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B jet tagging

- useful for Higgs and top physics
- signed impact parameter requires jets

bb P_t >100 GeV MC

2D Impact Parameter Significance, bb Pt > 100 GeV, +0.5 min bias

χ^2 / ndf	55.34 / 49
c0	2.548e+04 ± 909.8
sigma	0.7714 ± 0.005608
c1	1.925e+04 ± 1317
lambda1	0.9325 ± 0.02626
c2	-487.1 ± 57.67
lambda2	4.043 ± 0.178

- Fit negative side to get background distribution

- Developed 2 track invariant mass tool
- Can find **f**'s at Level 3!
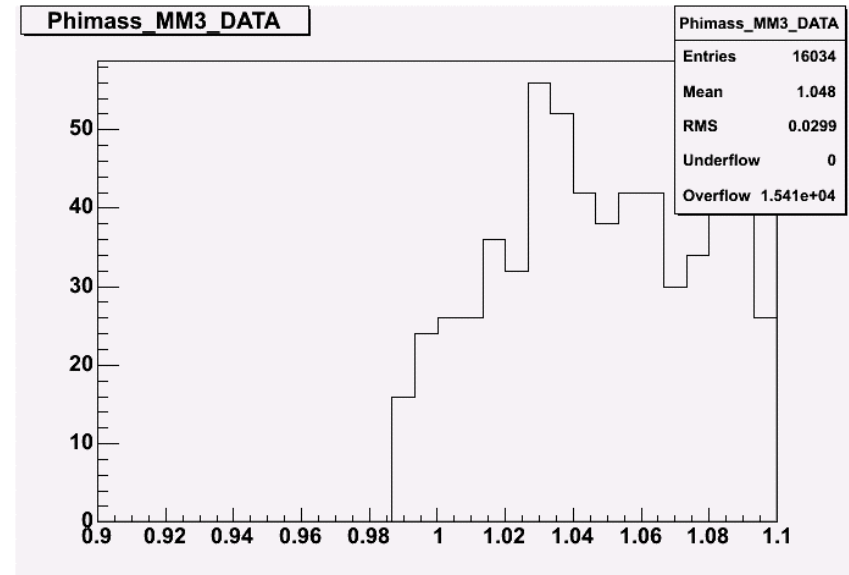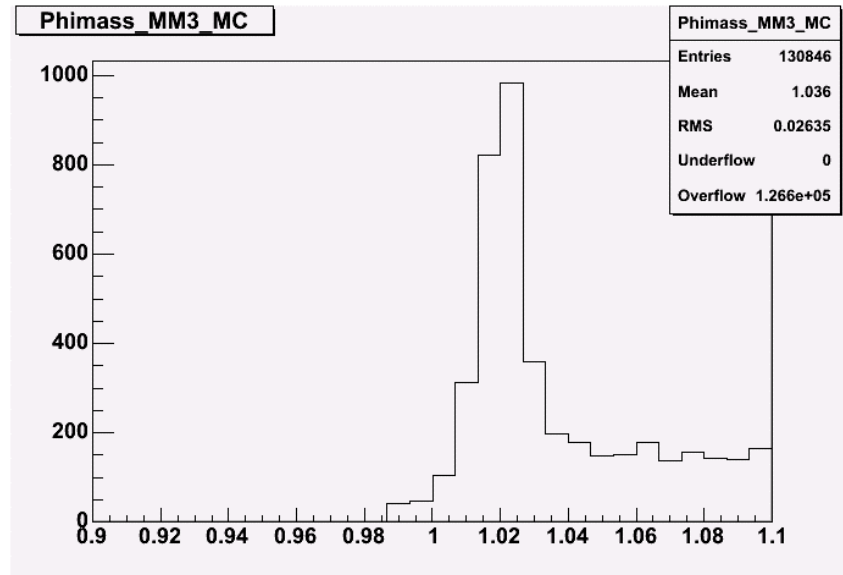
Slight mass shift in data

- Can also be used for D^0, J/**?** and di-jet invariant masses
- Provides enhanced sample
- Can be extended to 3 track invariant mass – D_s, D^* etc

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Large B_s semi-leptonic sample for mixing

$B_s \to D_s \mu ?,$

Cuts:
Muon $P_t > 3.0$ GeV
Track $P_t > 0.7$ GeV
$L_{xy}/s_{xy}D_s > 3$

DØ RunII Preliminary, Luminosity = 250 pb^{-1}

$B \to \mu^- \phi \pi^+ X$
9481 ± 253 $D_s \to \phi \pi^+$
3365 ± 239 $D^+ \to \phi \pi^+$

$\mu^- \phi \pi^+$
$\mu^- \phi \pi^-$

$M(\phi \pi^+)$ GeV/c^2

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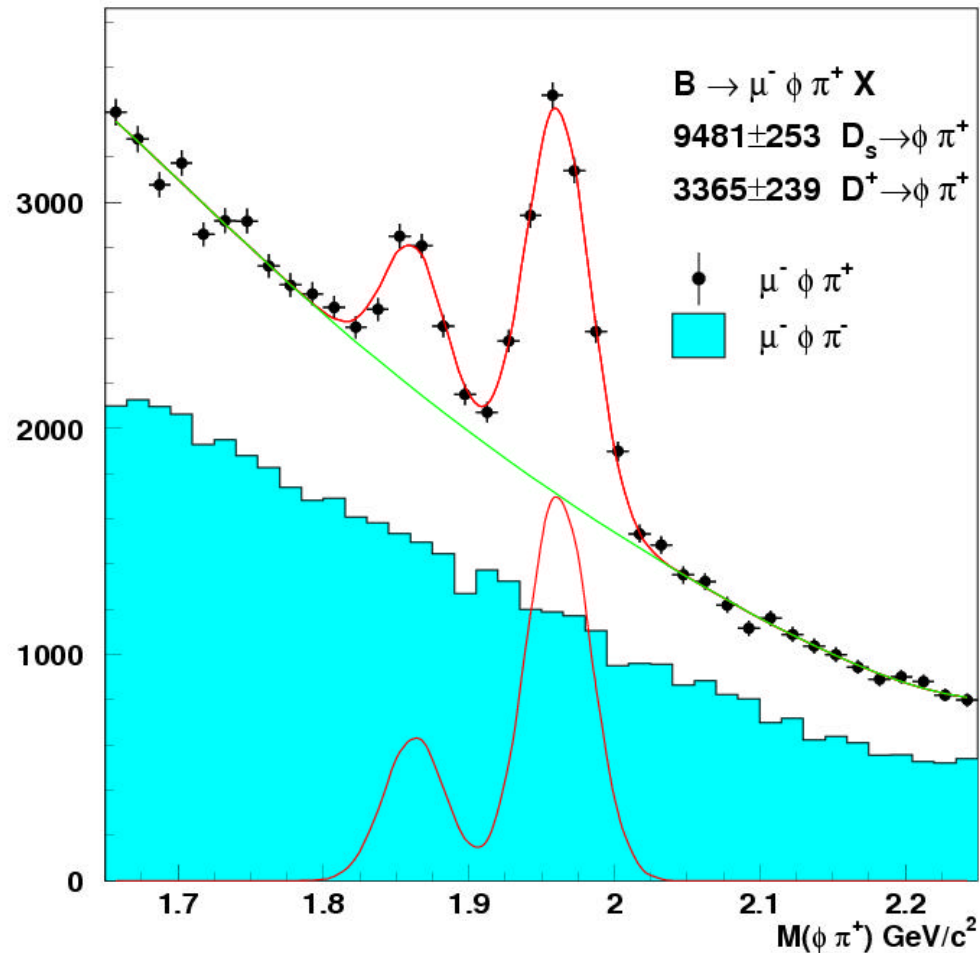
- Tevatron performing well – delivering higher luminosity

- Detector and trigger working well

- STT running now – improve capabilities

- First B_s mixing results this summer (?)

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