Recent Results from D0

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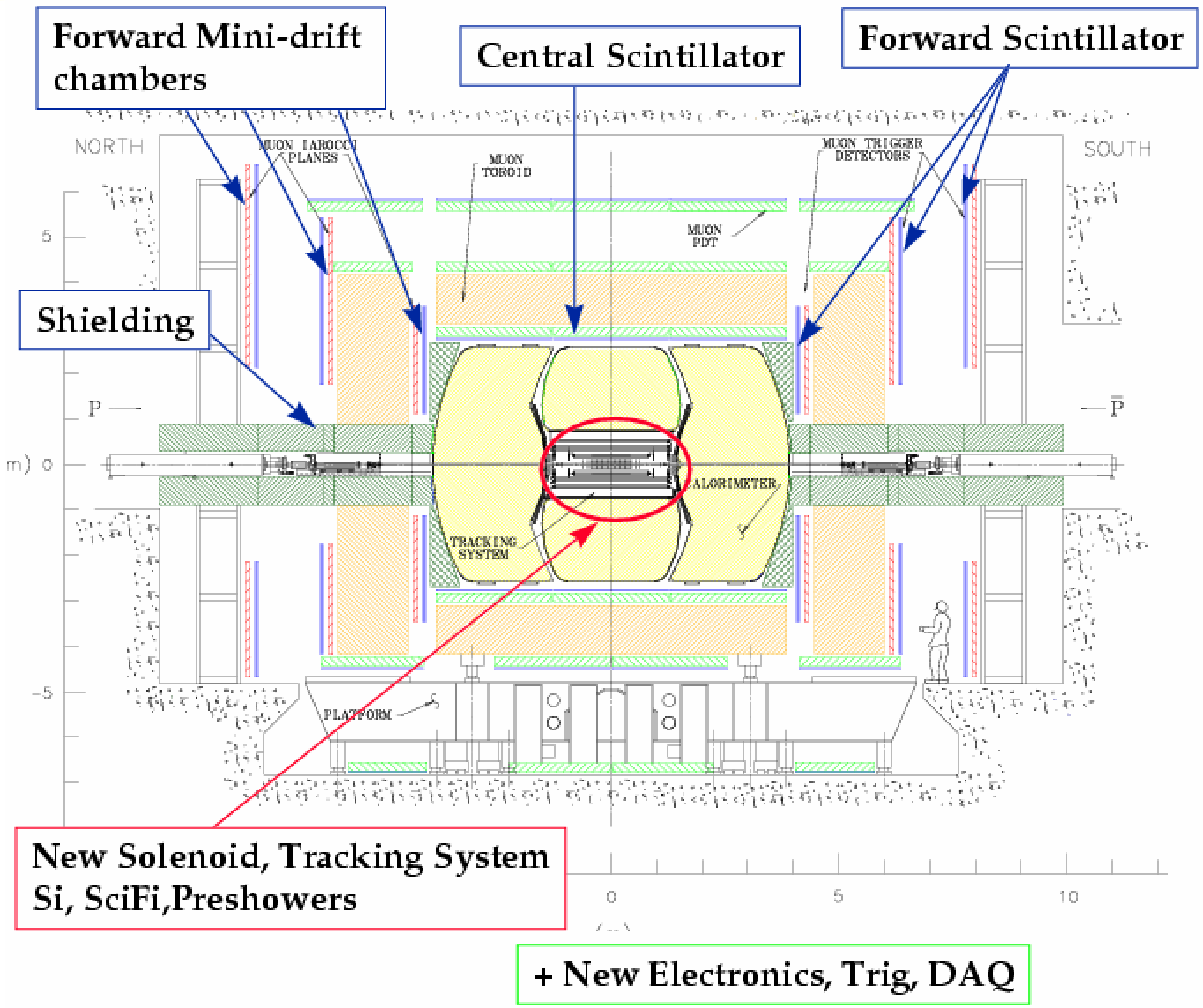
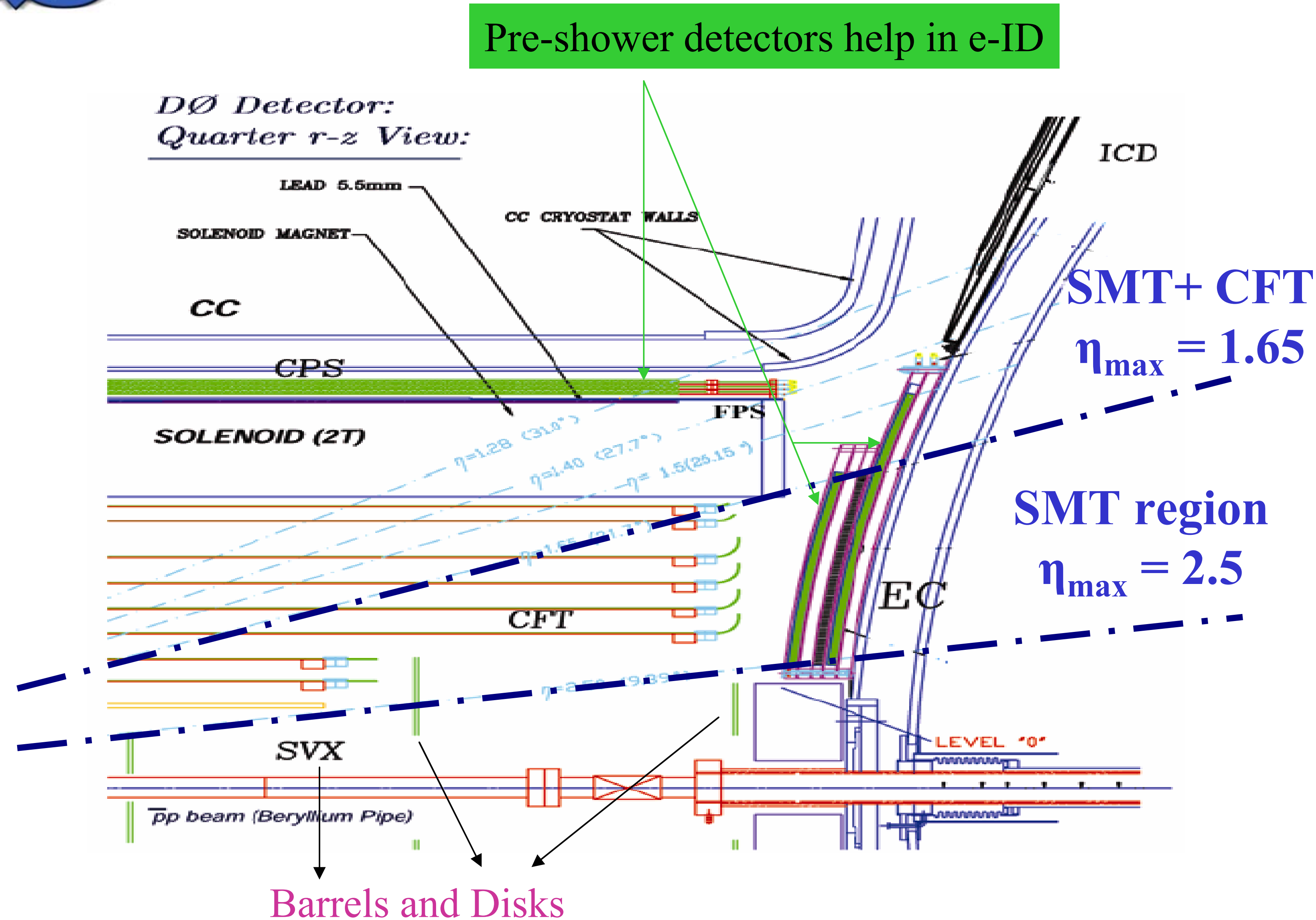
(D0 Collaboration)

Beauty 2003

D0 Upgrade


Forward Mini-drift chambers
Central Scintillator
Forward Scintillator
Shielding
NORTH
SOUTH
MUON IAROCCI PLANES
MUON TOROID
MUON TRIGGER DETECTORS
MUON PDT
TRACKING SYSTEM
PLATFORM
P
P̄
5
0
-5
10
New Solenoid, Tracking System
Si, SciFi,Preshowers
+ New Electronics, Trig, DAQ

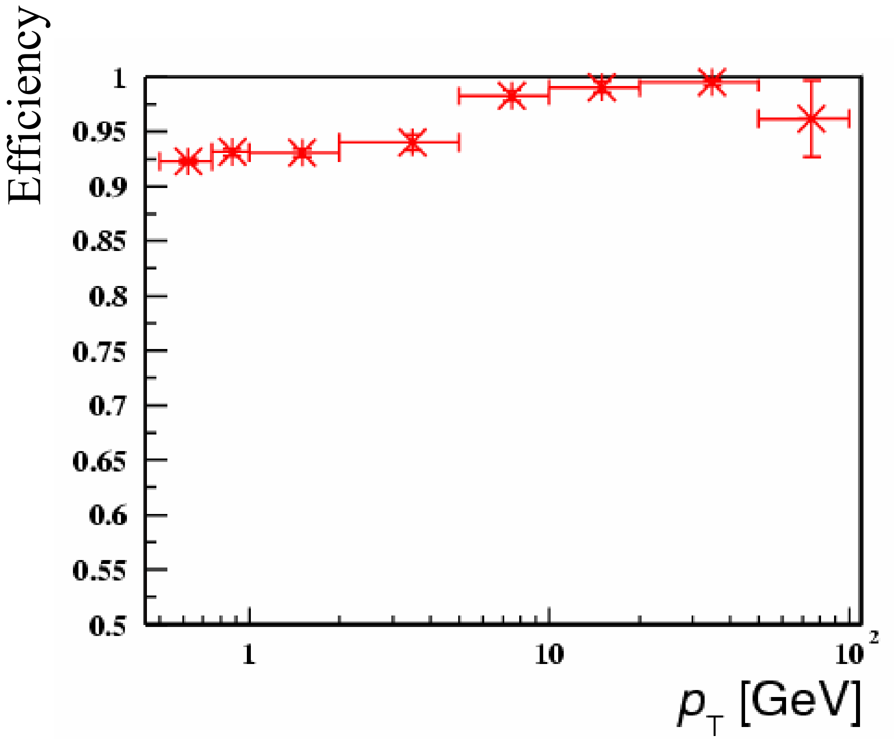


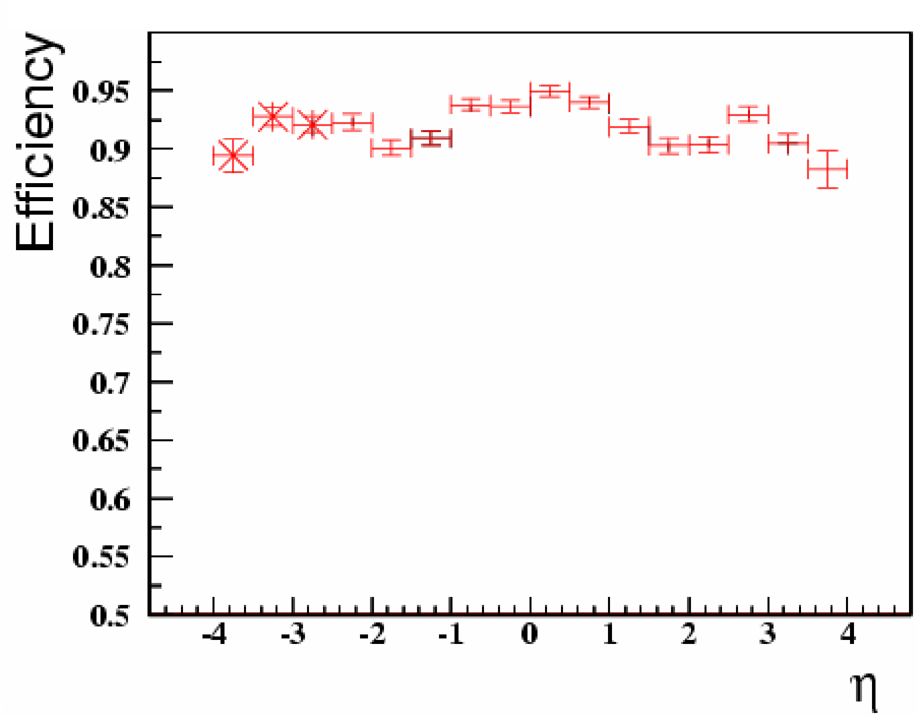
Pre-shower detectors help in e-ID
DØ Detector:
Quarter r-z View:
LEAD 5.5mm
SOLENOID MAGNET
CC CRYOSTAT WALLS
ICD
CC
CPS
FPS
SOLENOID (2T)
SMT+ CFT
η_{max} = 1.65
SMT region
η_{max} = 2.5
EC
CFT
SVX
LEVEL "0"
p̄p beam (Beryllium Pipe)
Barrels and Disks

Excellent Tracking acceptance:

SMT+CFT for |η|<2

SMT only for |η|>2



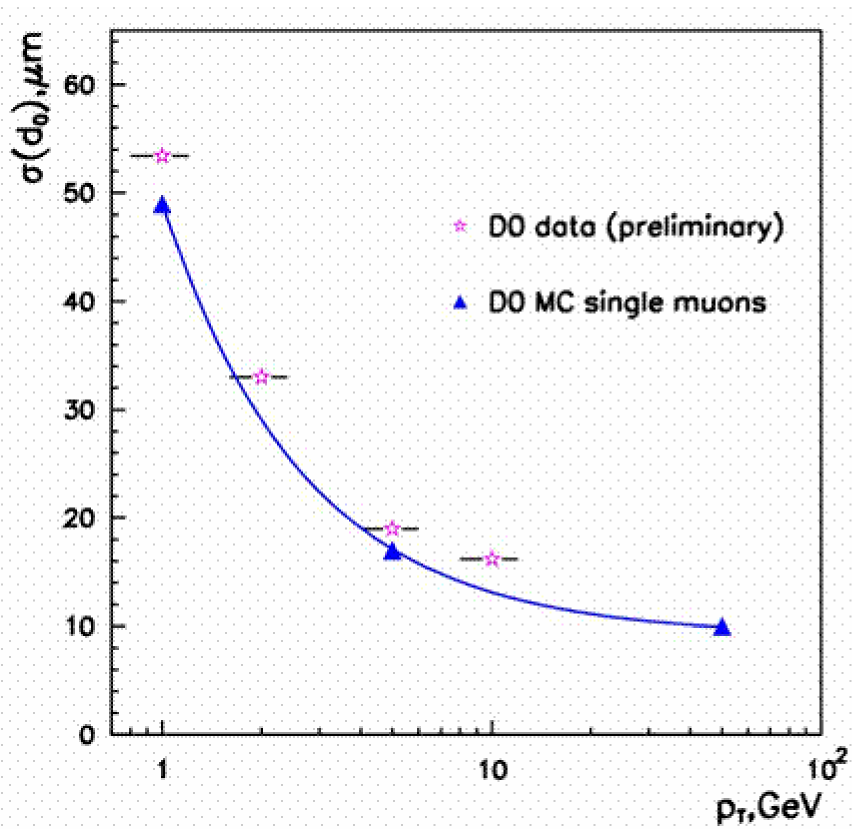


These are MC estimates – checking in data

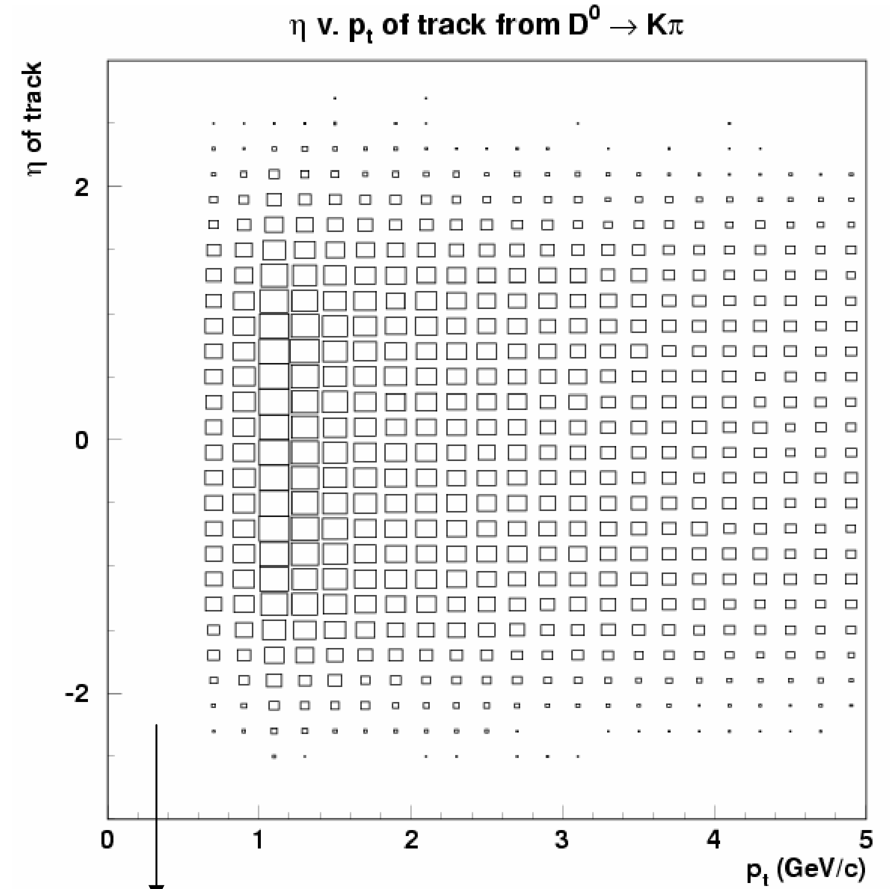
$B \rightarrow D^0 \mu X, \quad D^0 \rightarrow K^- \pi^+$

$p_T(\mu) > 2\ \mathrm{GeV}, \quad |\eta(\mu)| < 2.2$

All tracks



σ(DCA)≈53μm @ P_t=1GeV
and better @ higher P_t

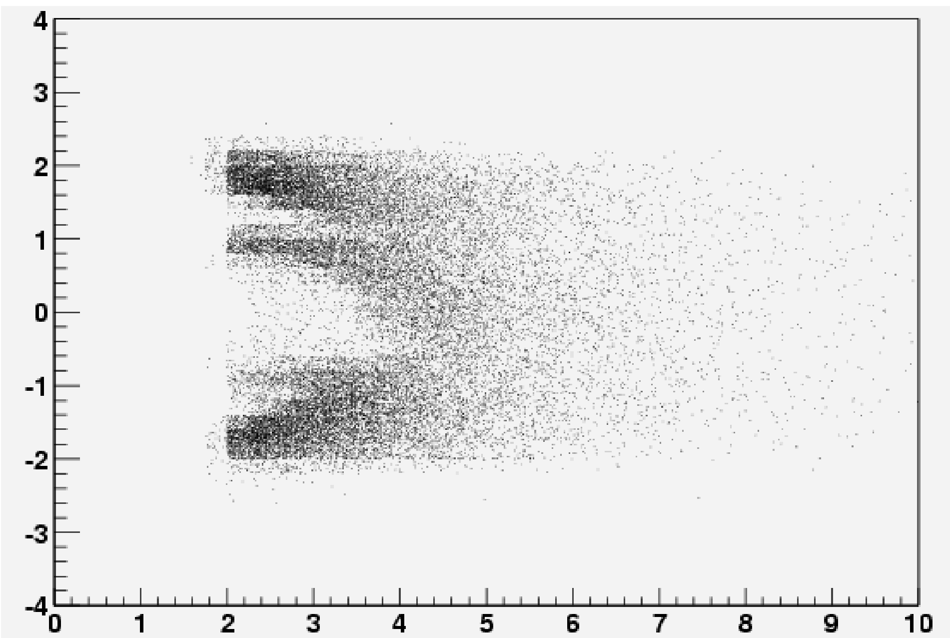


Analysis cuts – pT>0.7 GeV

Excellent Lepton Acceptance

Muon ID:

MC: $B \to D^0 \mu X, \quad D^0 \to K^- \pi^+$



η

p_T of reconstructed muon – very tight ID

Overall efficiency (from data) plateaus at about 85-90%

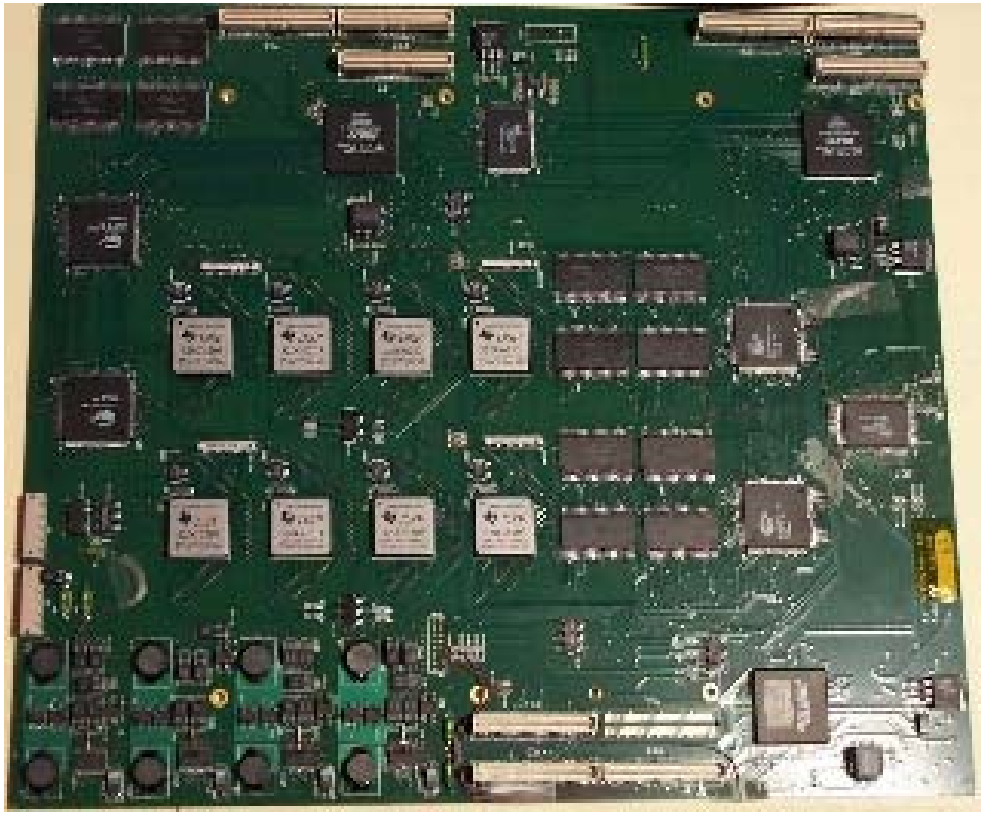
- $|\eta| < 0.6$ - at pT $\approx$ 4.5 GeV
- $0.6 < |\eta| < 1.2$ pT $\approx$ 3.5 GeV
- $|\eta| > 1.2$ - at pT $\approx$ 2.5 GeV

Electron ID:

- Calorimeter goes out to $|\eta| \approx 4$
- Low pT electron ID is in progress
- At present, we can detect electrons with pT>3 GeV and $|\eta| < 1.1$
  Average efficiency is about 75%
- Working to extend to higher values of $| \ |$ and lower pT threshold

Silicon Track Trigger is built and is being commissioned

Expect to start taking data soon after the shutdown



Track Fit Card

B Physics Program at D0

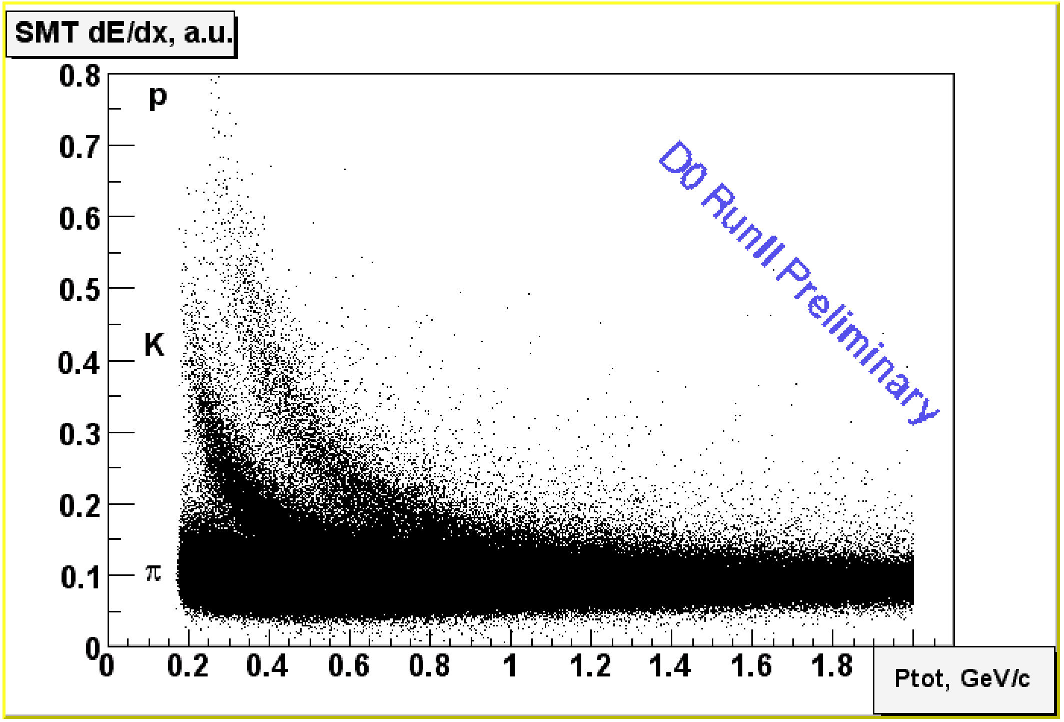
- Unique opportunity to do B physics during the current run
- Complementary to program at B-factories (SLAC, KEK)

- B_S mixing, $\frac{\Delta\Gamma_S}{\Gamma_S}$

- Rare decays: $B_S \to \mu^+\mu^-$ In some SUSY models rate is large
- Beauty Baryons, Λ_b lifetime…
- Other particles, e.g., B_C

- b production cross-section: In Run I, measd. Rates x(2-3) higher
- Quarkonia - $J/\psi, \Upsilon$ production, polarization …

- No dedicated Particle ID – Silicon provides limited separation

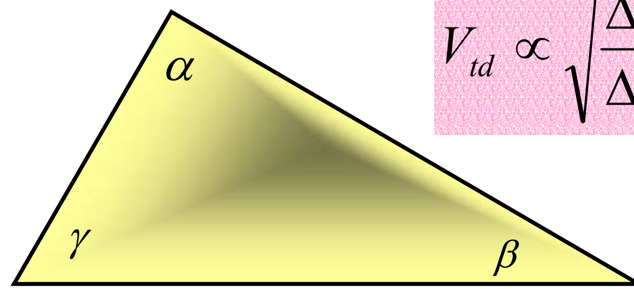


Is not used yet for PID

Can provide

- **K/π separation for P_{tot}<400 MeV**
- **p/π separation for P_{tot}<700 MeV**

Mixing is high priority



$$V_{td} \propto \sqrt{\frac{\Delta m_d}{\Delta m_S}}$$

We need:

- Final State reconstruction (Eckhard Von Toerne's talk on Wed.)
- Ability to measure B decay length (Daria Zieminska's talk on Thurs.)
- B flavour at decay and production (Ting Miao's talk on Thurs.)

Significance of mixing measurement

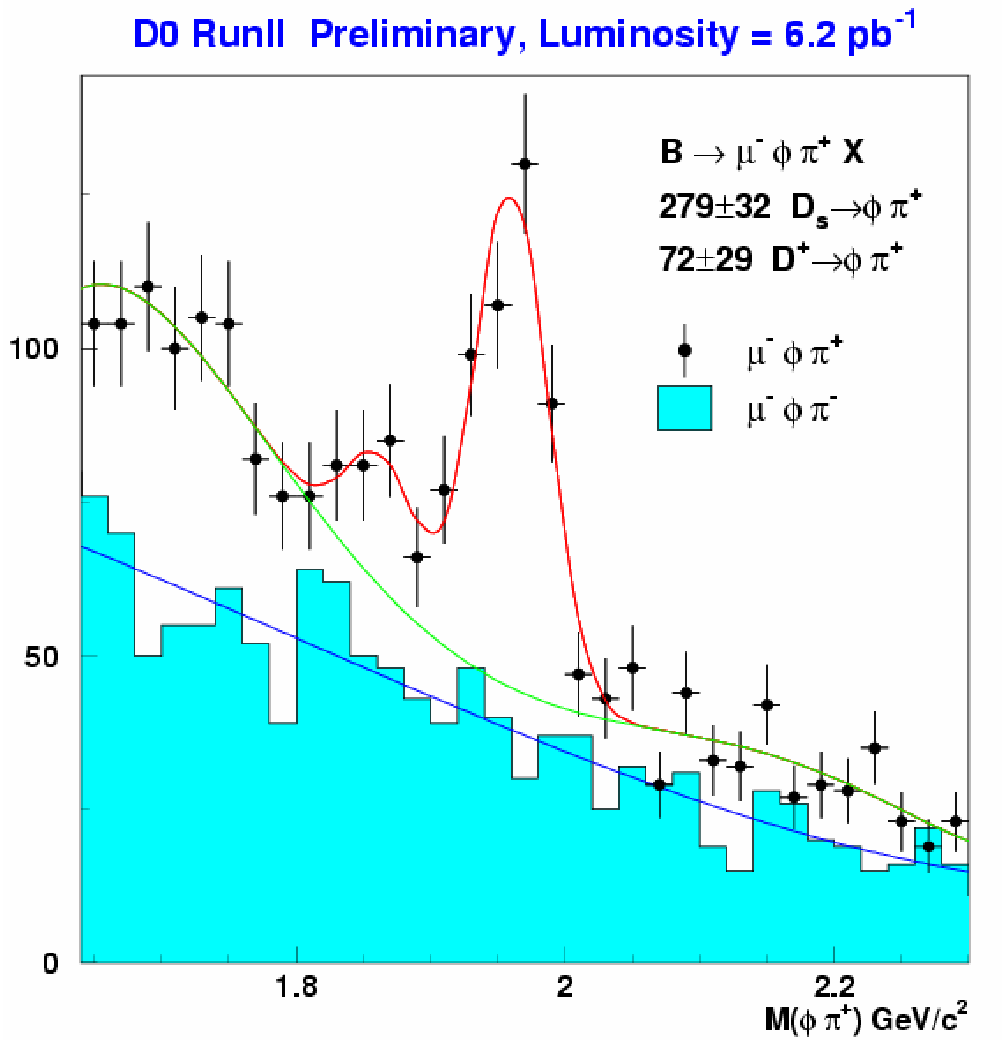
$$= \sqrt{\frac{N\varepsilon D^2}{2}} e^{-(\Delta m * \sigma_t)^2 / 2} \sqrt{\frac{S}{S+B}}$$

One can reconstruct B_S in hadronic and semi-leptonic modes

- Hadronic modes, e.g., $B_S \to D_S^{(*)-} \pi^+$
  - Pros: Very good proper time resolution
  - Cons: Low branching fraction ($\approx 0.5\%$), triggers
- Semi-leptonic modes, e.g., $B_S \to D_S^{(*)-} \mu^+ \nu$
  - Pros: Large Branching fraction $\approx 10\%$, triggers
    - Use both Muon & Electron final states
  - Cons: Poorer proper time resolution

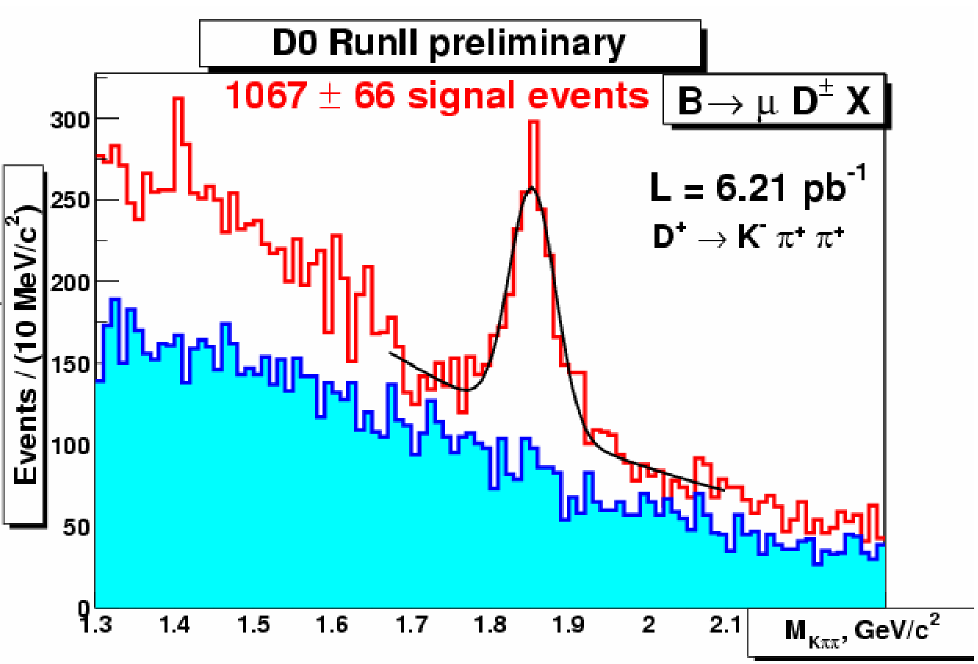
SL modes have large yields

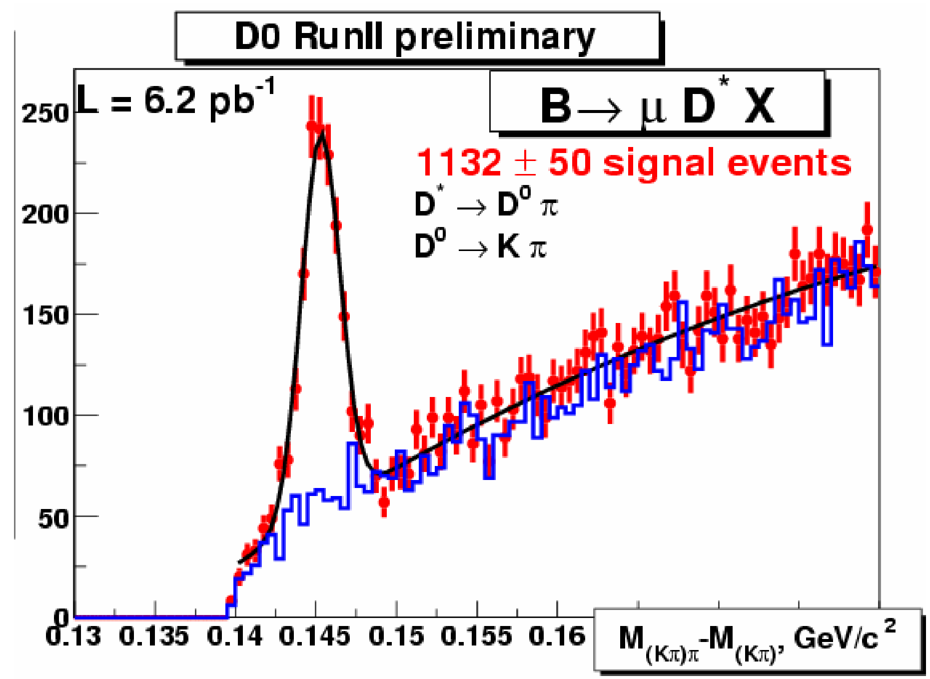
$$B_S \to D_S^- \mu^+ \nu X$$



$$\text{Yield} \approx (30-40)\ \text{events}/\text{pb}^{-1}$$

Use for mixing, lifetimes, etc.





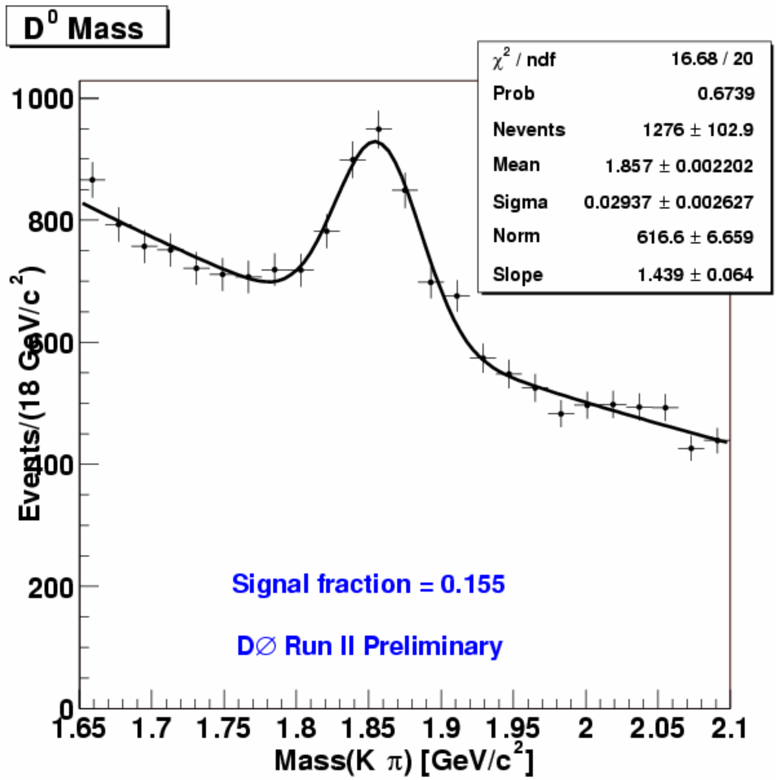
$$B \to D^- \mu^+ \nu X$$

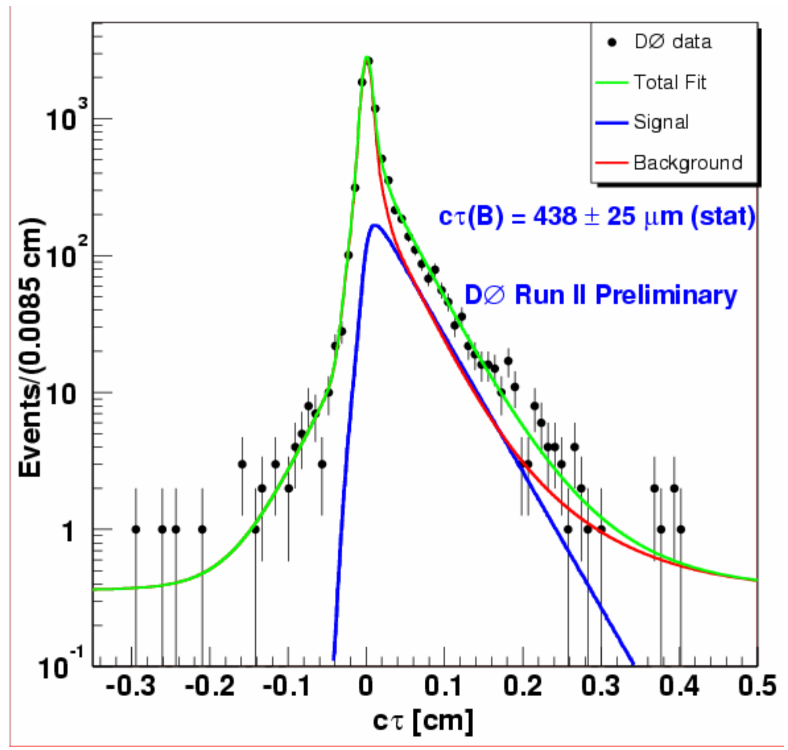
$$\text{Yield} \approx 150\ \text{events}/\text{pb}^{-1}$$

$$B \to D^{*-} \mu^+ \nu X$$

$$\text{Yield} \approx 175\ \text{events}/\text{pb}^{-1}$$

Inclusive B lifetime using $B \rightarrow \overline{D}^0 \mu^+ \nu X$





$L \approx 12\ pb^{-1}$

$c\tau = 438 \pm 25(\text{stat})\ \mu\text{m}$ $\langle PDG \rangle = 472 \pm 2$

- Also looking at hadronic modes
- Plan to reconstruct the semi-electronic final state
- Working on getting an estimate of the proper time resolution for the semi-leptonic mode – this is crucial

Flavour tagging

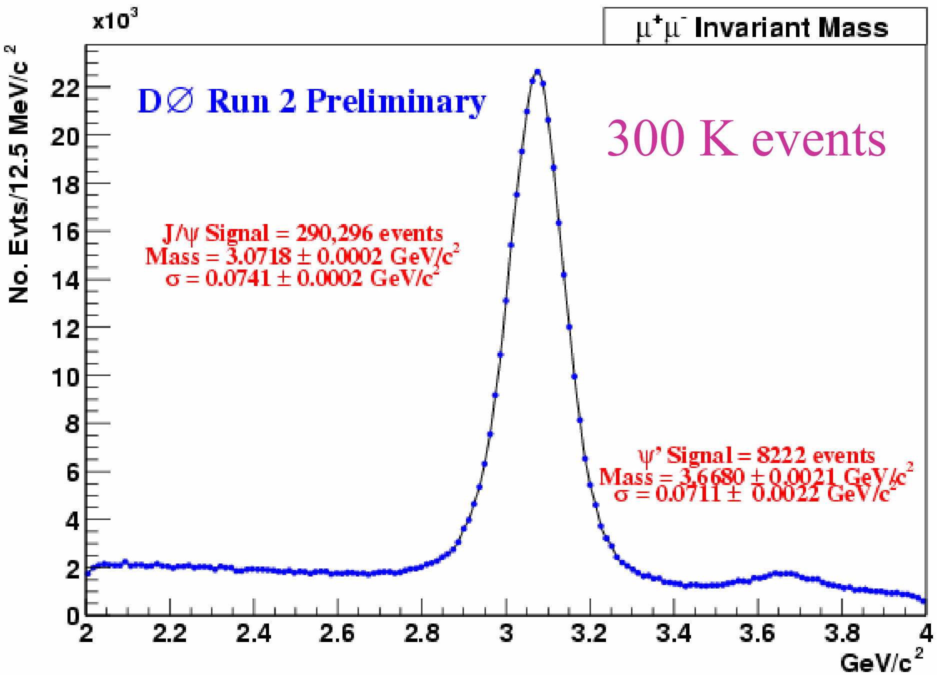
- Use flavour-specific decays to get flavour of B at decay
- To get flavour of B at production use

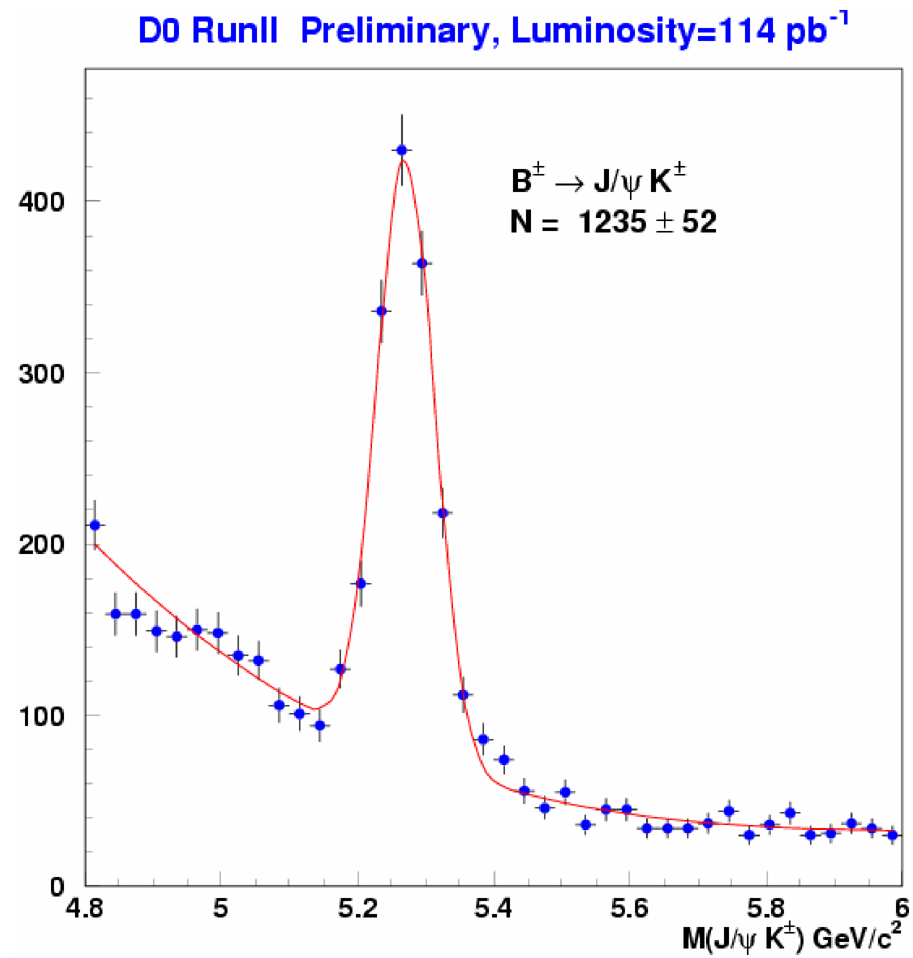
Soft-lepton tags – High tagging power, low efficiency
(SL decay of other B)

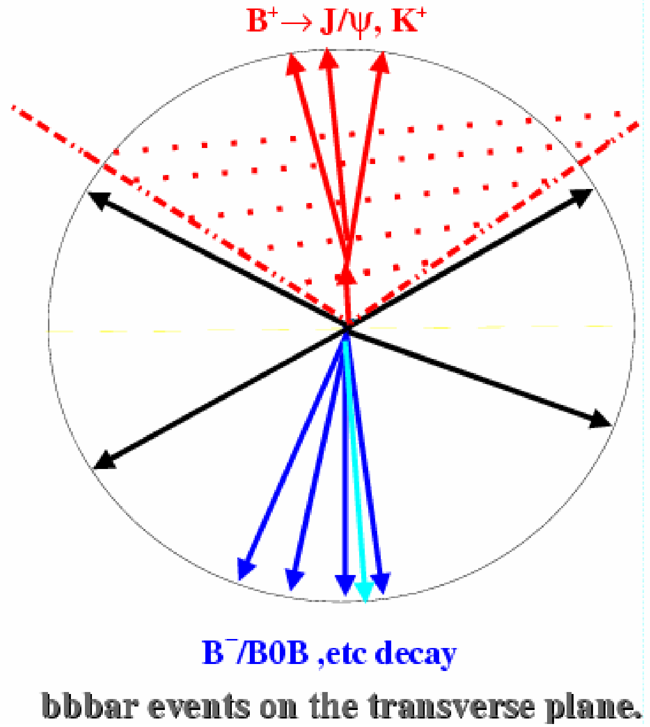
Jet Charge tag - Poorer tagging power, high efficiency
(track-jet from other b quark)

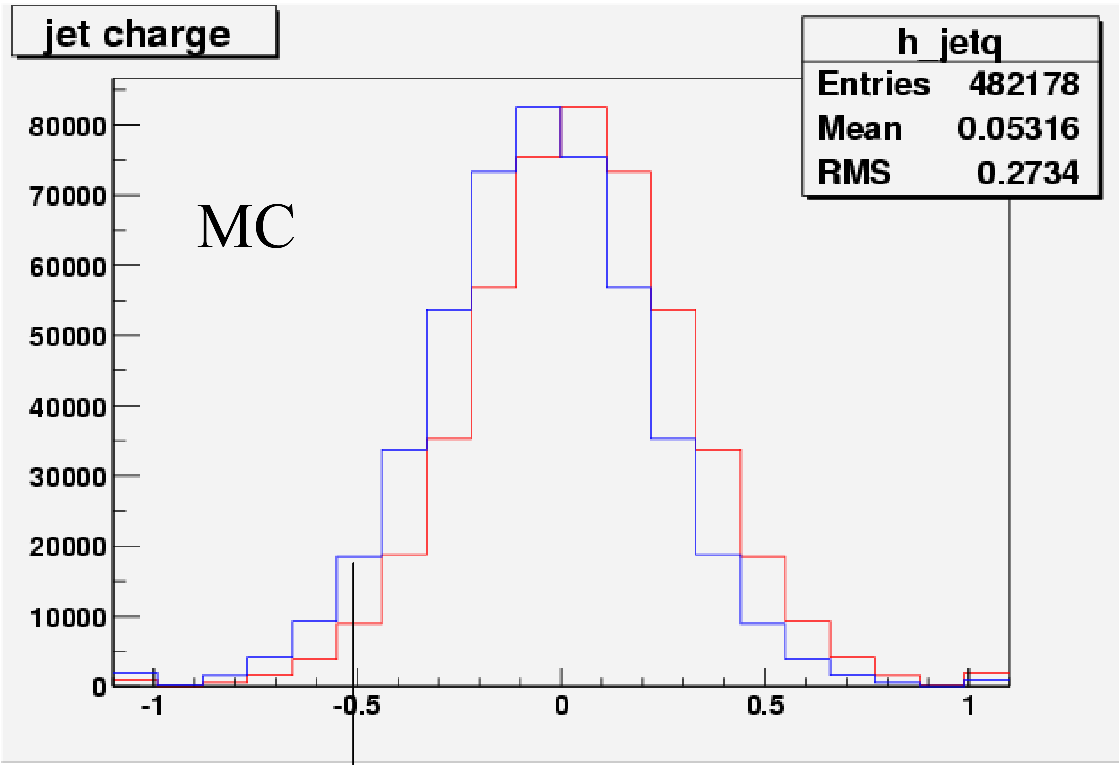
Same Side tagging - Poorer tagging power, high efficiency
(fragmentation, B**)

Use the signal to benchmark the flavour tags









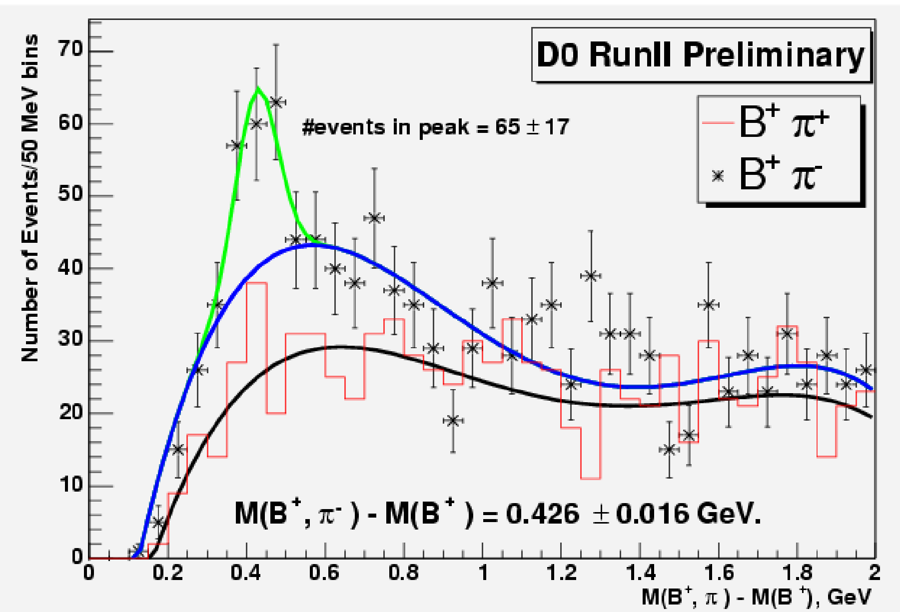
Make track jets for jetQ tag

$$\text{Jet Q} = \frac{\Sigma p_T^i . q^i}{\Sigma p_T^i}$$

Require $|Q| > 0.2$

$Q < 0 \Rightarrow b$ (B+ MC)

Same Side Tag Algorithm

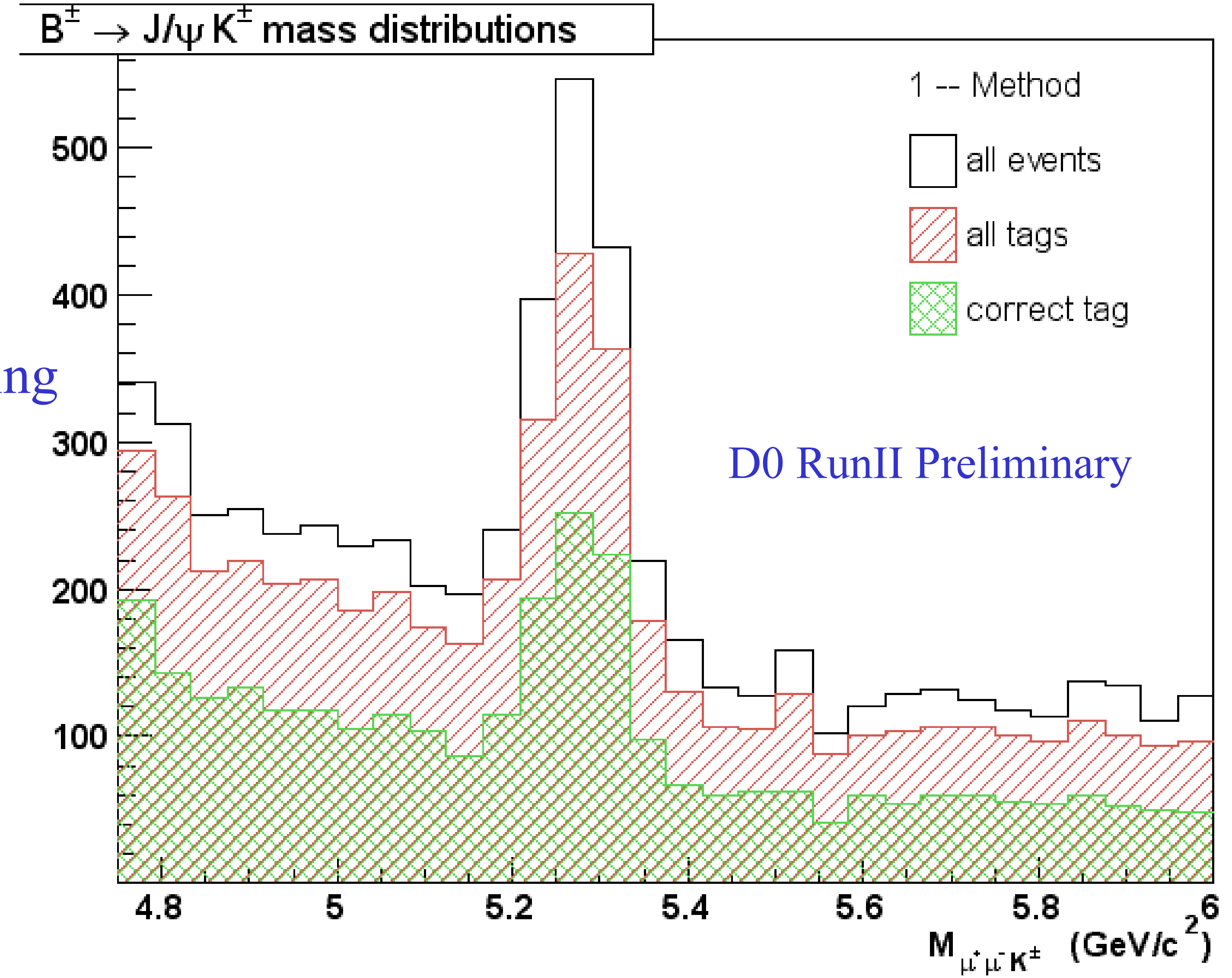


$$B^{**0} \rightarrow B^{+}\pi^{-}$$

- Make cone (dR<0.7) around B^{+}
- Remove tracks belonging to B^{+}
- Choose track with highest pT (try other criteria too)
- $Q_t = -Q_K$ means correct tag

One source of pions for same side tags

Same Side Tagging



Results based on B^+ signal – D0 RunII Preliminary

Method	Epsilon ε	Tagging power or Dilution (D)	Figure of Merit εD^2 (%)
Soft Muon	5%	57%	1.6 ± 1.1
Jet Charge	47%	27%	3.3 ± 1.7
Same Side	79%	26%	5.5 ± 2.0

$$\varepsilon = \frac{N_R + N_W}{N_R + N_W + N_{notag}}$$

$$D = \frac{N_R - N_W}{N_R + N_W}$$

Will also use electrons

Investigating with B^0/B_S

Triggers:

- Most useful trigger for mixing is the low pT inclusive single muon trigger (pT > 2-4 GeV, depending on η)

  We can use it for $B_S \to D_S^{(*)-} \mu^+ \nu$ and

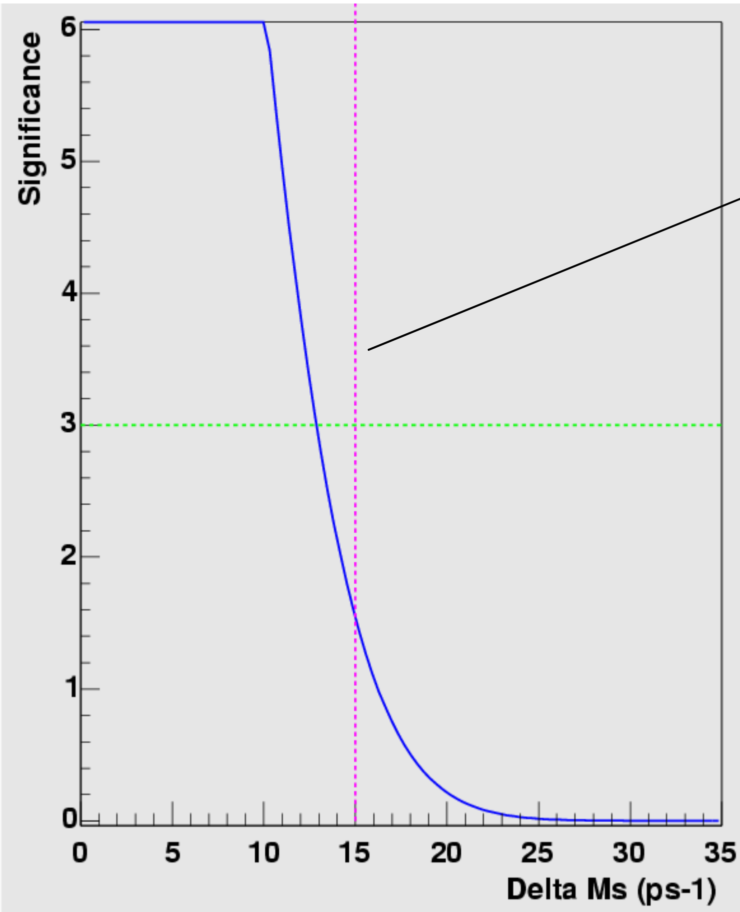
  $B_S \to D_S^{(*)-} \pi^+$ and $B_S \to D_S^{(*)-} e^+ \nu$ - μ used as flavour tag

- Can also use dimuon trigger for semi-muonic mode

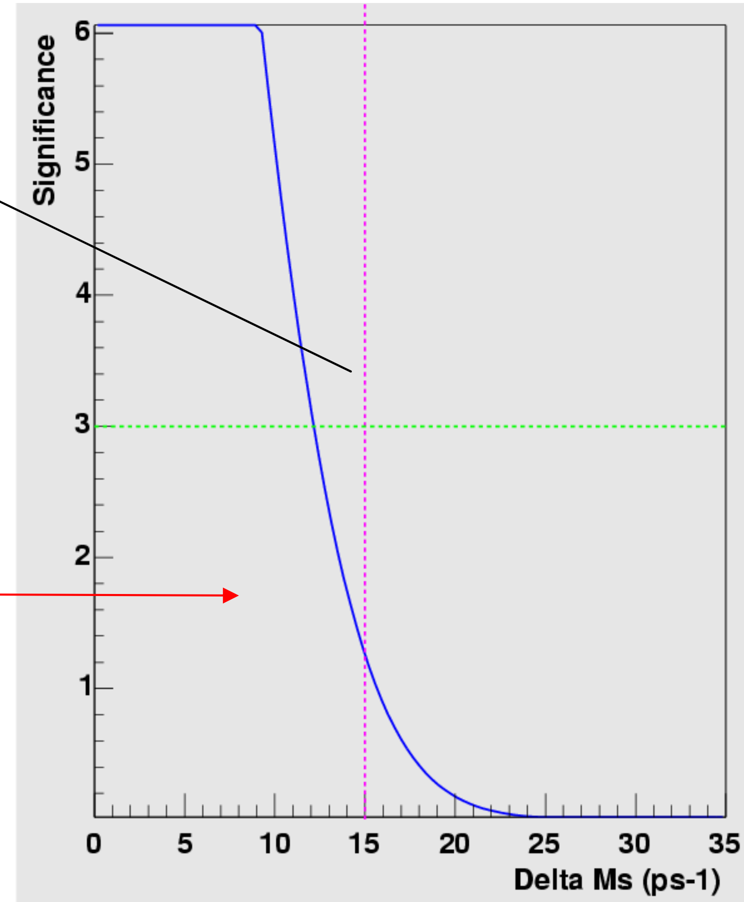
- Investigating trigger/DAQ upgrade for B physics

Projections for 500 pb^{-1}

$B_S \to D_S^- \mu^+ \nu X$ Single Muon Trigger:



$B_S \to D_S^- \mu^+ \nu X$ Di-Muon Trigger:



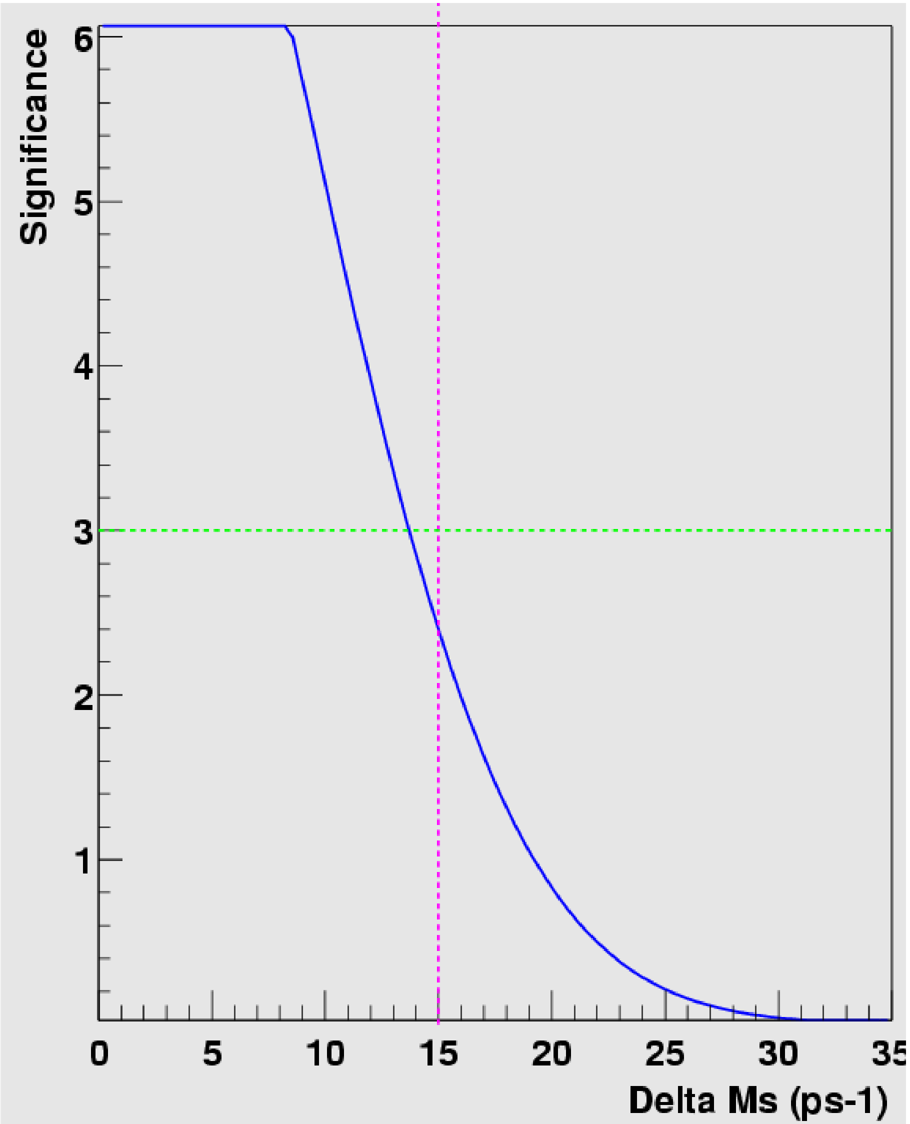
Current limit

Also applies for electron events on Single Muon trigger line

Yield – 15K $\varepsilon D^2 = 0.1, \ \sigma_t \approx 150 fs$

Yield – 2K $\varepsilon D^2 = 0.5, \ \sigma_t \approx 150 fs$

Projections for 500 pb^{-1}



Single Muon Trigger:

$B_S \rightarrow D_S^{(*)-} \pi^+$

Yield – 700

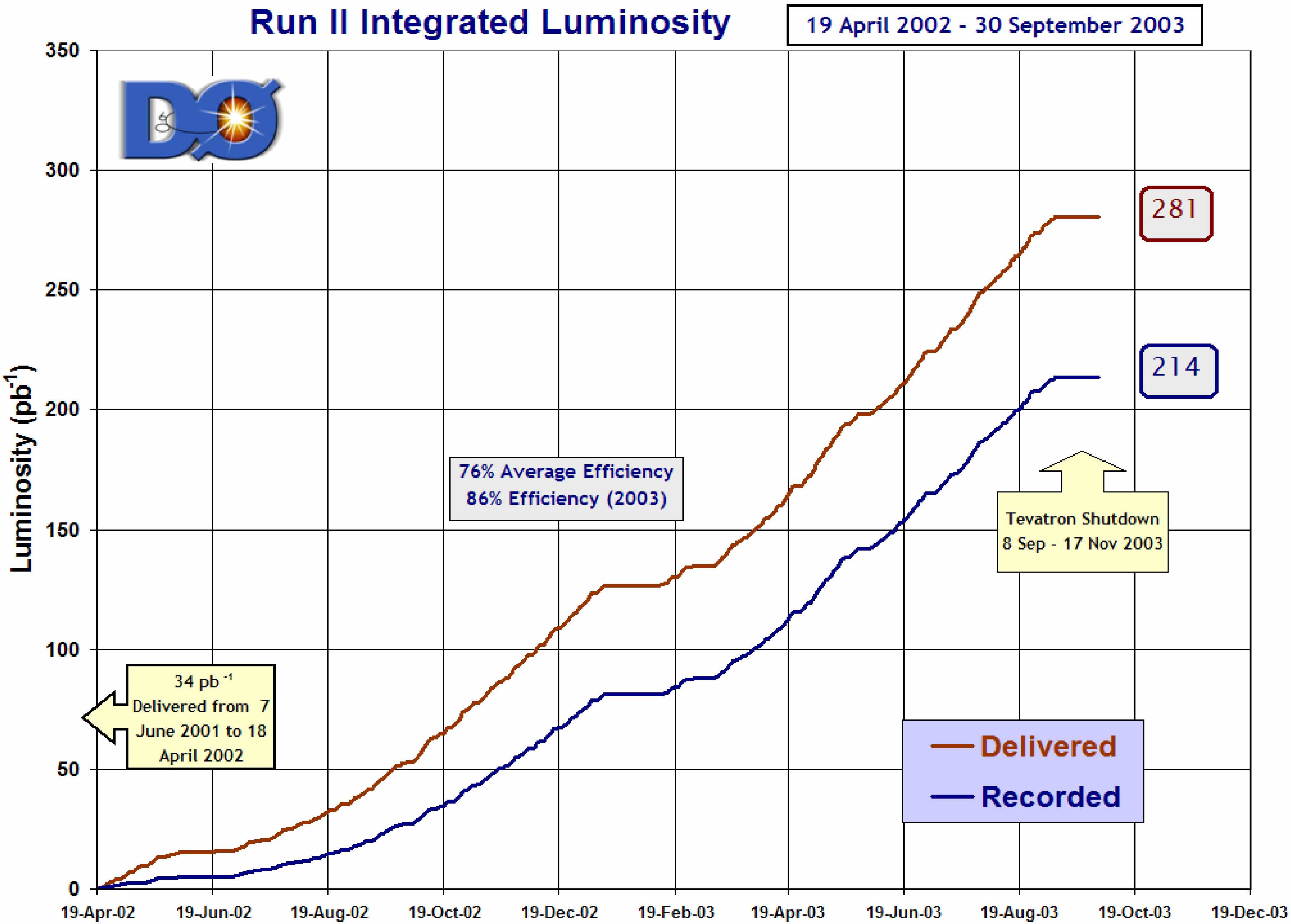
one decay mode

$\varepsilon D^2 = 0.5, \ \sigma_t \approx 110 fs$

We can combine the SL and hadronic modes and obtain a better limit/result

Quarkonia at D0

- Have older results on J/Psi production. Will update
  - Cross-section as a function of pT and η
- Started to look at Upsilon production characteristics
  - We presented a preliminary pT distribution at QWG'03
  - Once we re-process our data, we will also produce absolute cross-sections.



Run II Integrated Luminosity
19 April 2002 - 30 September 2003
Luminosity (pb-1)
350
300
250
200
150
100
50
0
19-Apr-02
19-Jun-02
19-Aug-02
19-Oct-02
19-Dec-02
19-Feb-03
19-Apr-03
19-Jun-03
19-Aug-03
19-Oct-03
19-Dec-03
281
214
76% Average Efficiency
86% Efficiency (2003)
Tevatron Shutdown
8 Sep - 17 Nov 2003
34 pb -1
Delivered from 7
June 2001 to 18
April 2002
Delivered
Recorded

Conclusions

- Making good progress in understanding our detector – lifetimes, flavour tags …
- Measure Δm_d to benchmark analysis tools
- Investigating Trigger/DAQ upgrade for B physics
- Exciting times ahead…

Backup Slides

Details of flavour tagging

method	# N_total	#N_R	#N_W	Efficiency (%)	Dilution (%)	εD^2 (%)
Muon	1964	63	37	5.0 ± 0.7	57.0 ± 19.3	1.6 ± 1.1
JetQ	1020±55	301±25	174±22	46.7±2.7	26.7±6.8	3.3 ± 1.7
Same Side	1025±52	507±30	295±25	79.2 ± 2.1	26.4 ± 4.8	5.5 ± 2.0

5. Estimating efficiency & dilution for signal events

- We know the fraction of background events in the mass window (before tagging): 51.9%
- This corresponds to 968.7 (1046.8) background (signal) events.
- I'm using the sideband tagging efficiency (4.9±0.3)% as the background tagging efficiency
- We have 100 tagged events in the mass window; (4.9±0.3%)×968.7 = 47.5±3.0 of those must be background.
- So, the # of signal events must be 100−47.5=52.5±3.0; this gives a signal efficiency of 52.5/1046.8 = (5.0±0.7)%
- If I write down the raw dilution as

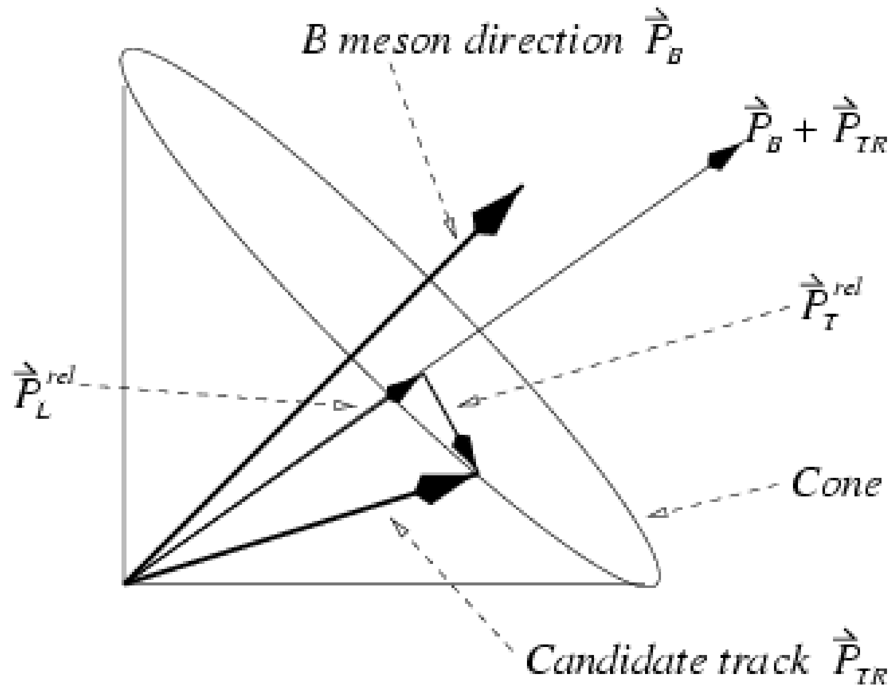
$$D_{\text{raw}} = \frac{S_{\text{correct}} + B_{\text{correct}} - S_{\text{wrong}} - B_{\text{wrong}}}{S_{\text{correct}} + B_{\text{correct}} + S_{\text{wrong}} + B_{\text{wrong}}} = \frac{63-37}{63+37}$$

after some math I end up with

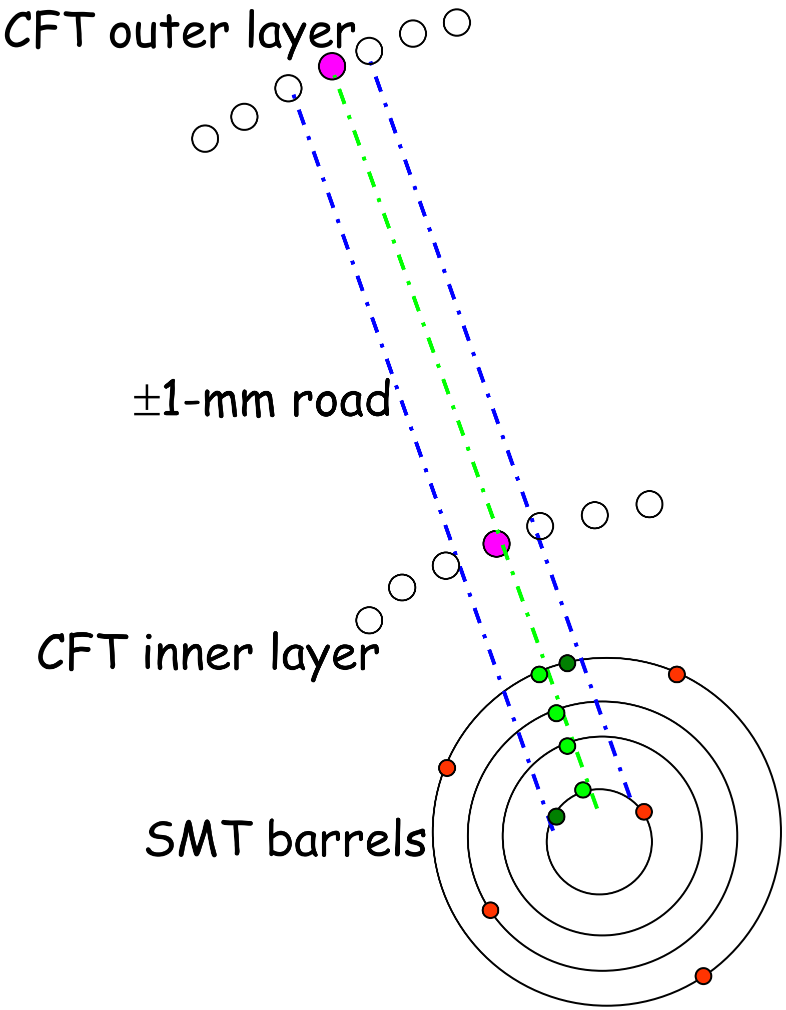
$$D_{\text{signal}} = \frac{D_{\text{raw}} - (1-\alpha)\times D_{\text{bgd}}}{\alpha}$$

where α: the fraction of signal events in tagged sample (52.5/100)
and D_{bgd}: the sideband's dilution (−8.2±6.4 %)

Same side tagging



Track Fit Card (TFC) Design

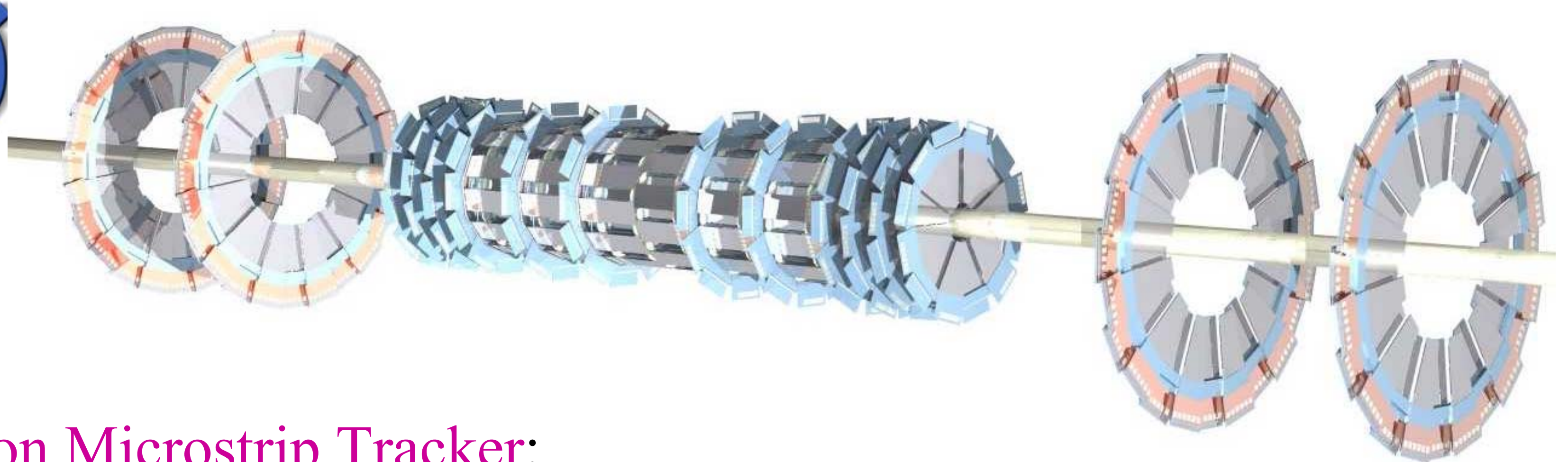


Performs final silicon cluster filtering and track fitting

- Lookup table used to convert hardware (e.g., channel, etc.) to physical coordinates (r, ϕ)
- 8 300-MHz 32-bit integer Texas Instruments DSPs perform a linearized track fit

$$\phi(r) = \frac{b}{r} + \kappa r + \phi_0$$

- Fit using precomputed matrix stored in lookup table

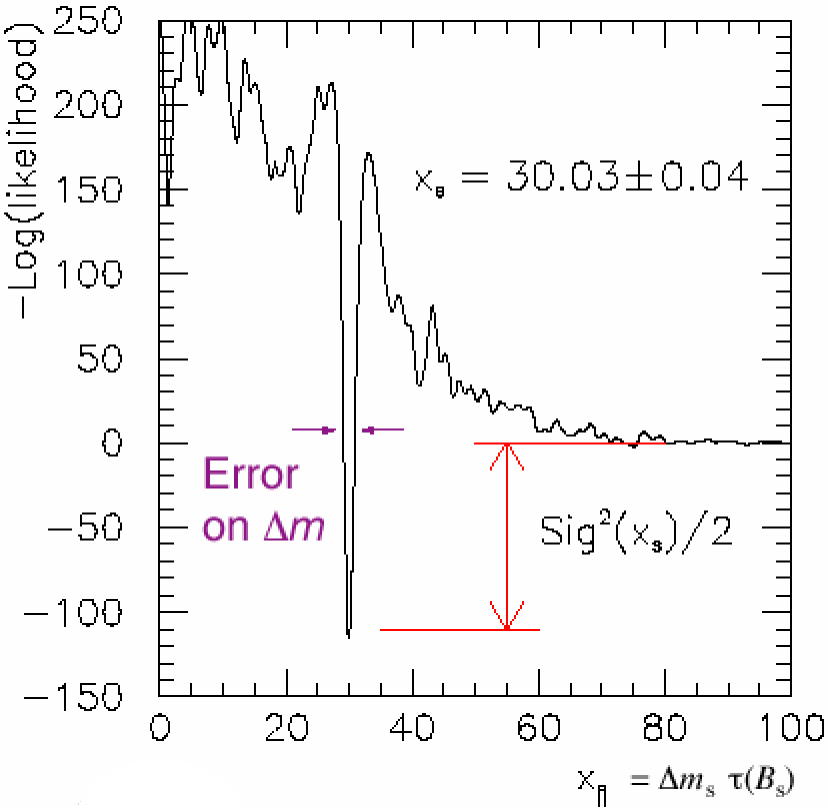


- Silicon Microstrip Tracker:
- 6 Barrels: 4-layers, Single/Double sided, 2/90 deg. stereo, |z|<0.6 cm, Radius: 2.7-10 cm
- 12 Central F disks: D-Sided, $\pm$ 15 deg stereo
- 4 Forward H disks: S-sided, $\pm$ 7.5 deg stereo, $|z| = \pm$ 1.1/1.2 m, Radius: 9.5-20 cm
- Tracking to $\eta \approx 3$ $(\theta \approx 6^{\circ})$

793K channels
>95% active

Rad. hard to
1 MRad

Hit resolution is 10 μ
Signal/Noise > 10



$$\mathrm{Signif} = \sqrt{2\Delta \log L}$$

$$Signif = \sqrt{\frac{N\varepsilon D^2}{2} e^{-\frac{(\Delta m_s \sigma_\tau)^2}{2}}} \sqrt{\frac{S}{S+B}}$$

- "Depth" of dip of likelihood in frequency space, *not* significance of error on Δm
- Toy MC's also being studied

SM expectation $\Delta m_s \leq 29\ \mathrm{ps}^{-1}$ (95% CL)