B physics results from DØ

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for the DØ Collaboration

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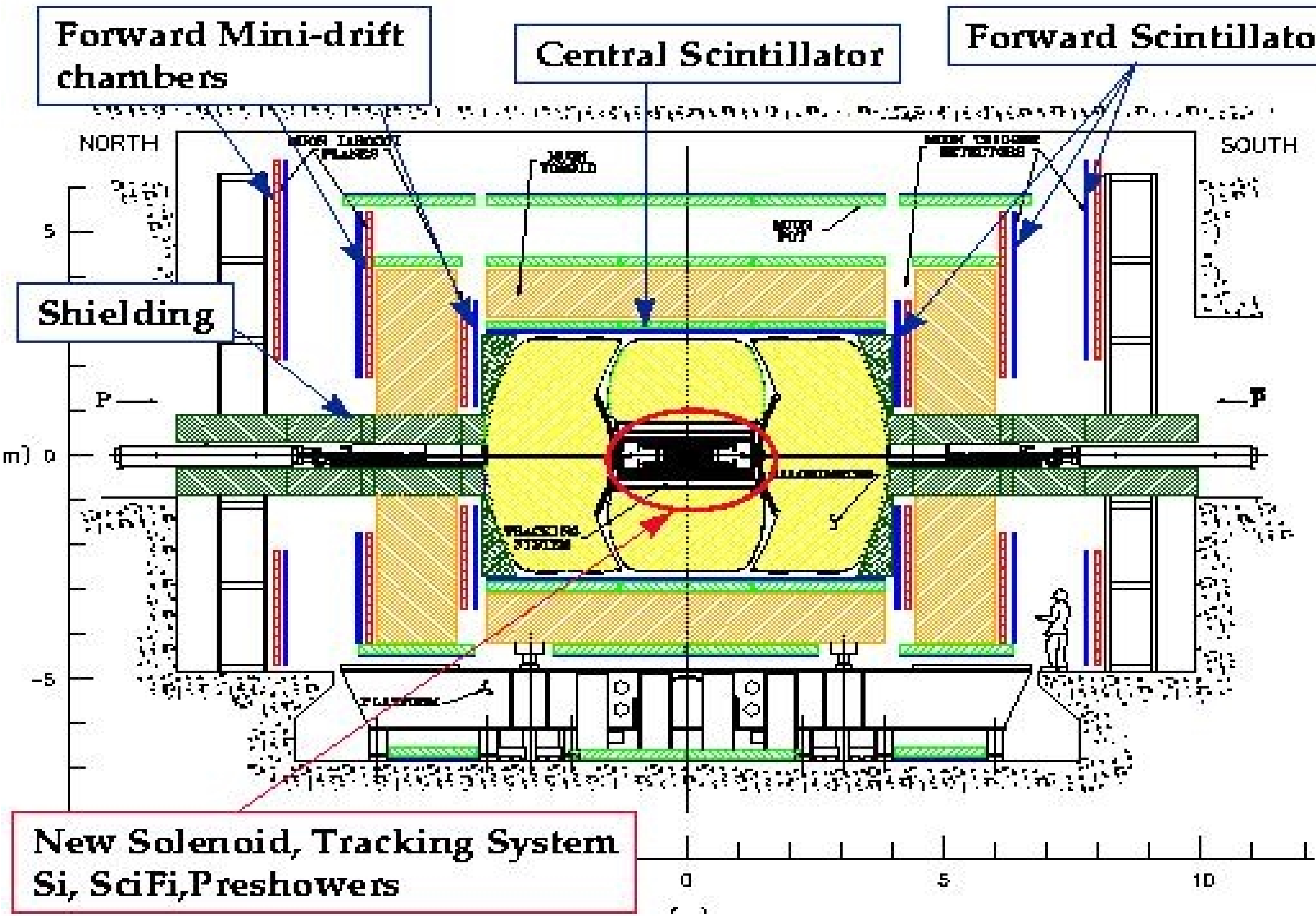
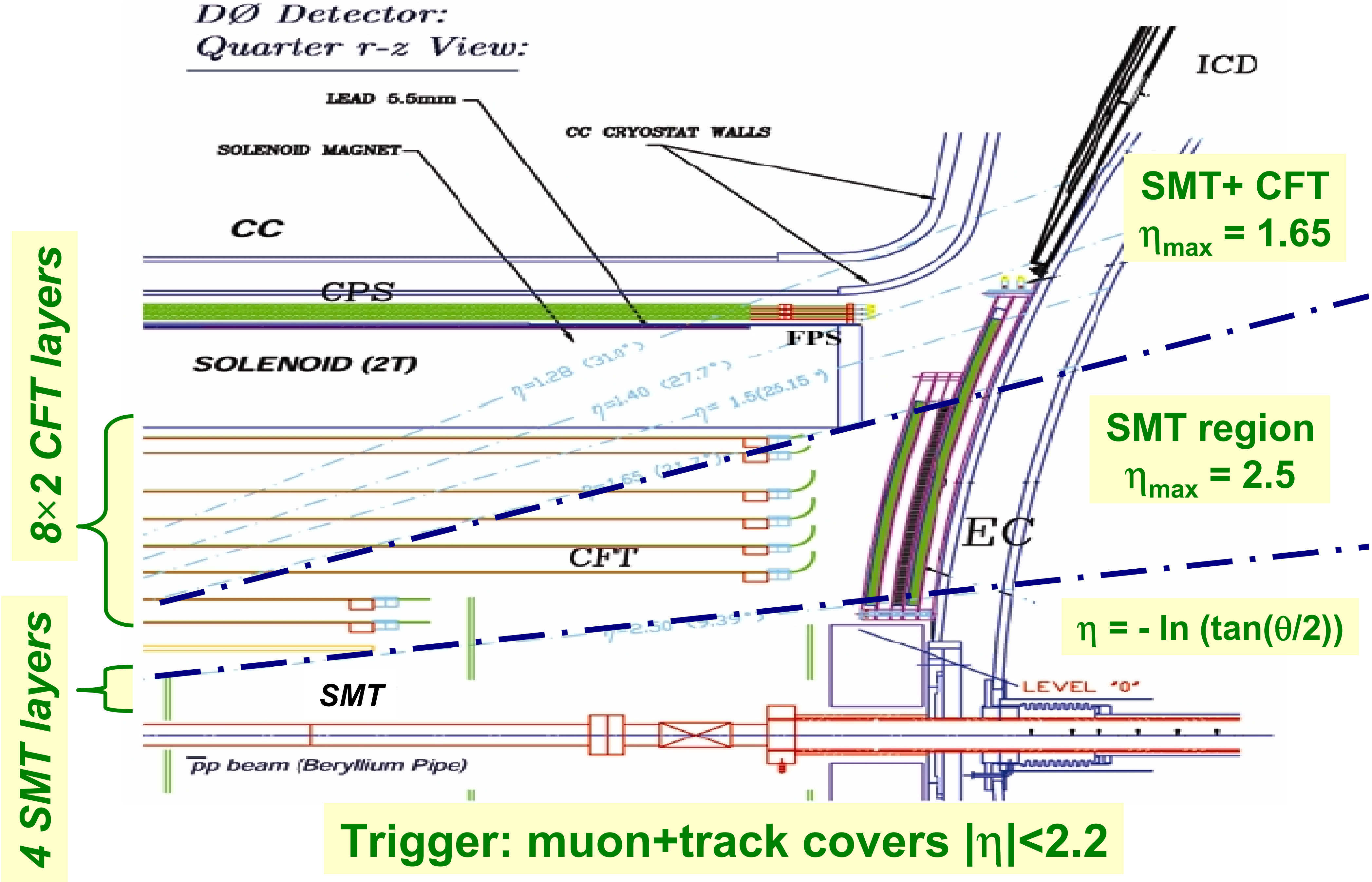
DØ detector

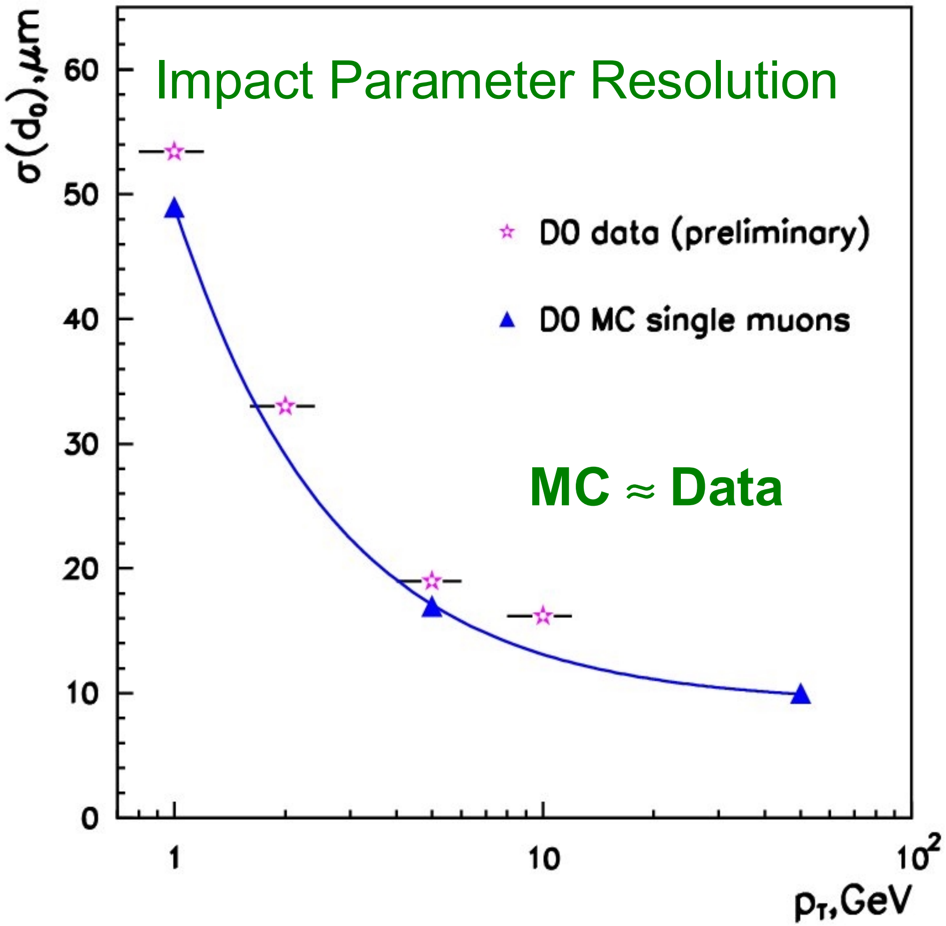

Forward Mini-drift chambers
Central Scintillator
Forward Scintillator
NORTH
SOUTH
Shielding
New Solenoid, Tracking System
Si, SciFi,Preshowers
5
0
-5
0
5
10

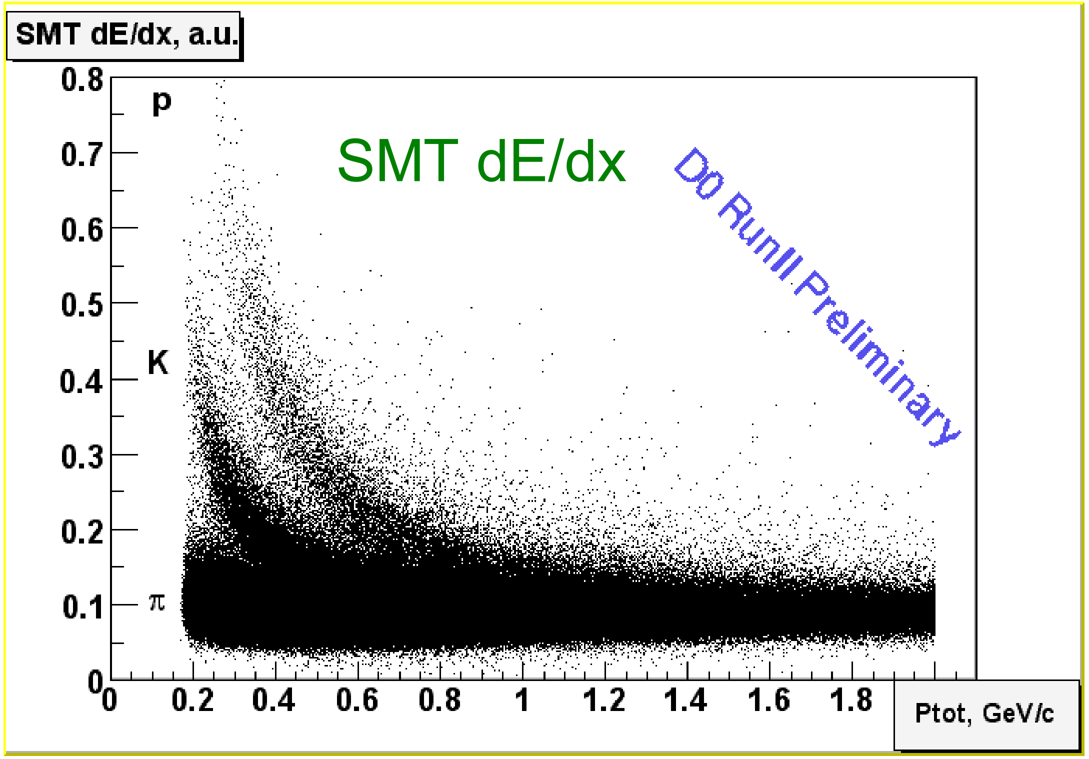
Tracker



Trigger: muon+track covers $|\eta|<2.2$

Tracking performance





σ(DCA) ≈ 53 μm @ P_T = 1 GeV and ≈15 μm @ higher P_T

Can provide

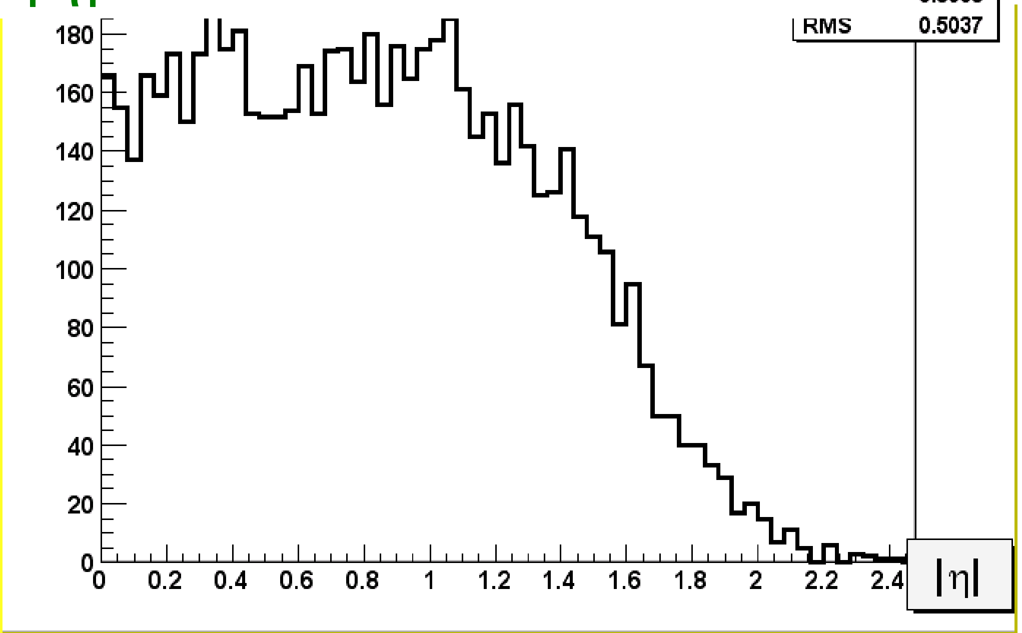
K/π separation for P_{tot} < 400 MeV
p/π separation for P_{tot} <700 MeV

NOT yet used for PID

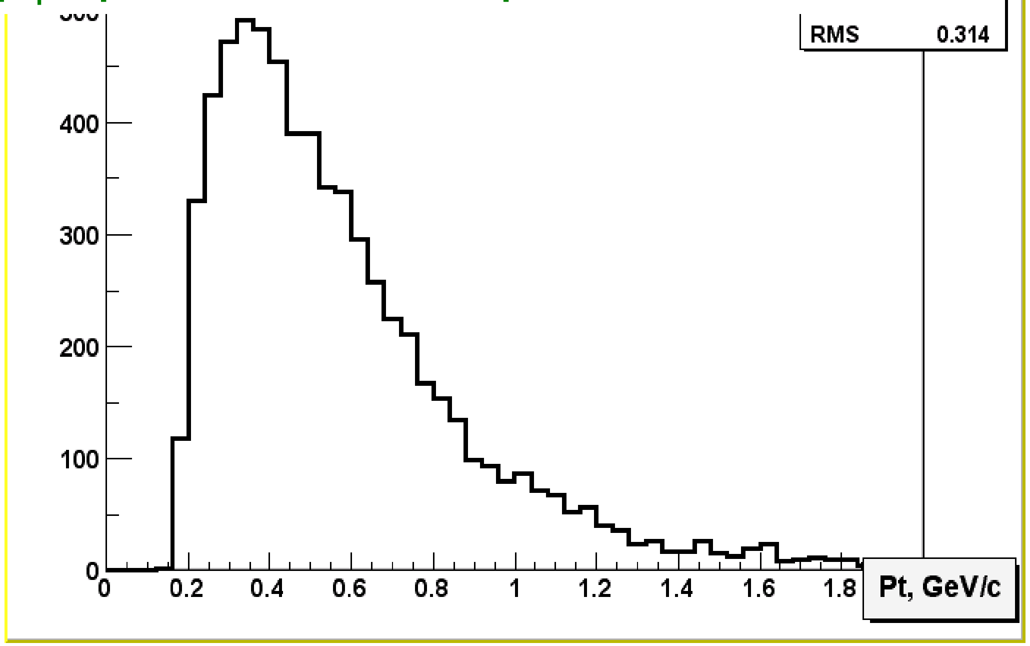
Tracking performance

Data from semileptonic decays (B $\rightarrow \mu$ D X)

$|\eta|$ for kaons from $D^* \rightarrow D^0 \pi$



p_T spectrum of soft pion from $D^* \rightarrow D^0 \pi$



Tracks are reconstructed

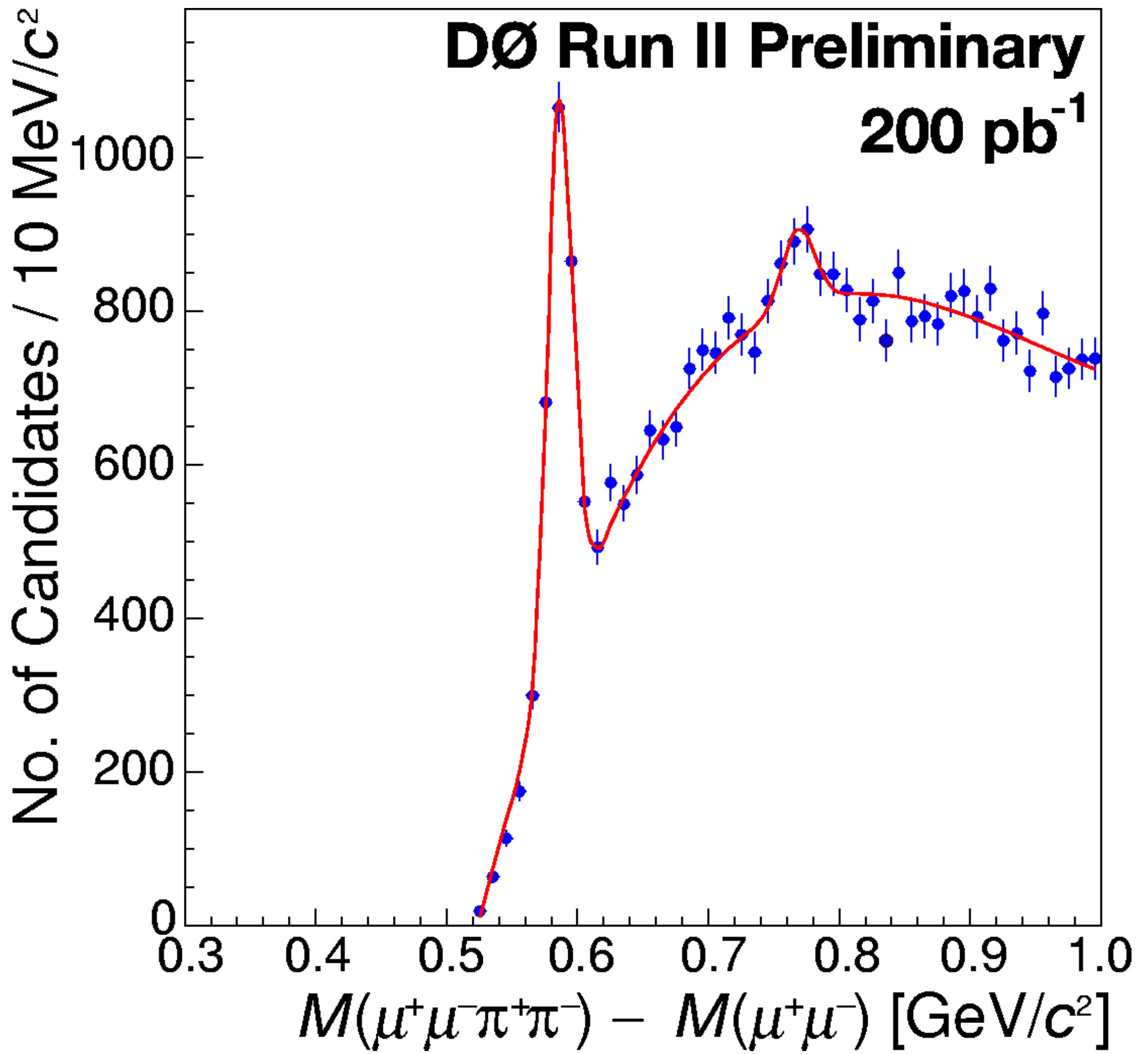
- **over a wide η range**
- **starting from p_T = 180 MeV**

Efficient muon and tracking system give us a large sample of semileptonic B decays

X(3872) → J/Ψ $\pi^+ \pi^-$

Last summer, Belle announced a new particle at ≅ 3872 MeV/c^2, observed in B^+ decays:
$B^+ \to K^+$ X(3872),
X(3872) → J/Ψ $\pi^+ \pi^-$.

Belle's discovery has been confirmed by CDF and DØ.



DØ preliminary:

300 ± 61 events

4.4σ effect

$\Delta M = 0.768 \pm 0.004$ (stat) ± 0.004 (syst) GeV/c^2

X(3872) production properties

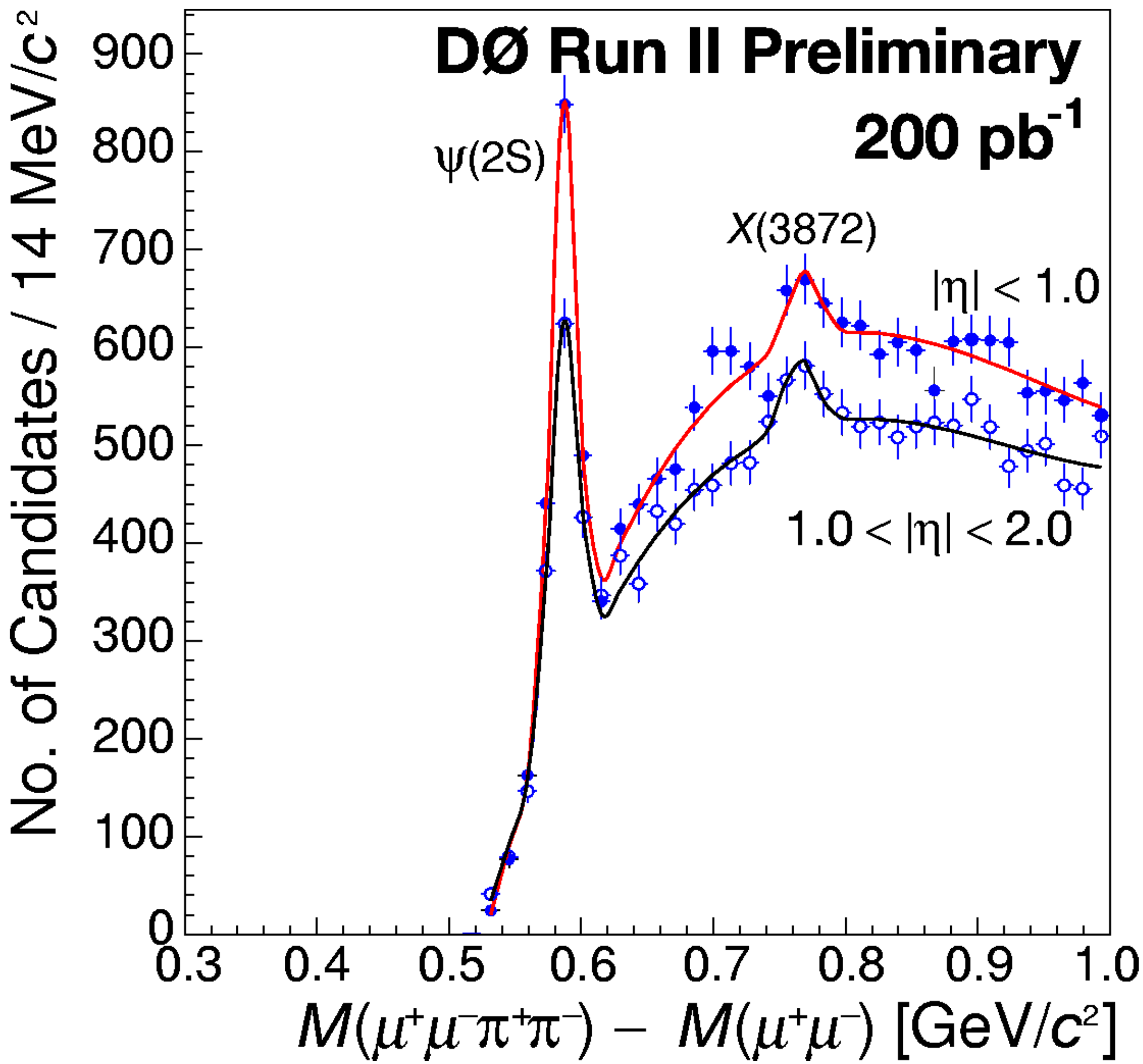
What kind of particle is the X ?

- charmonium ?
- an exotic meson molecule ?
- something else ?

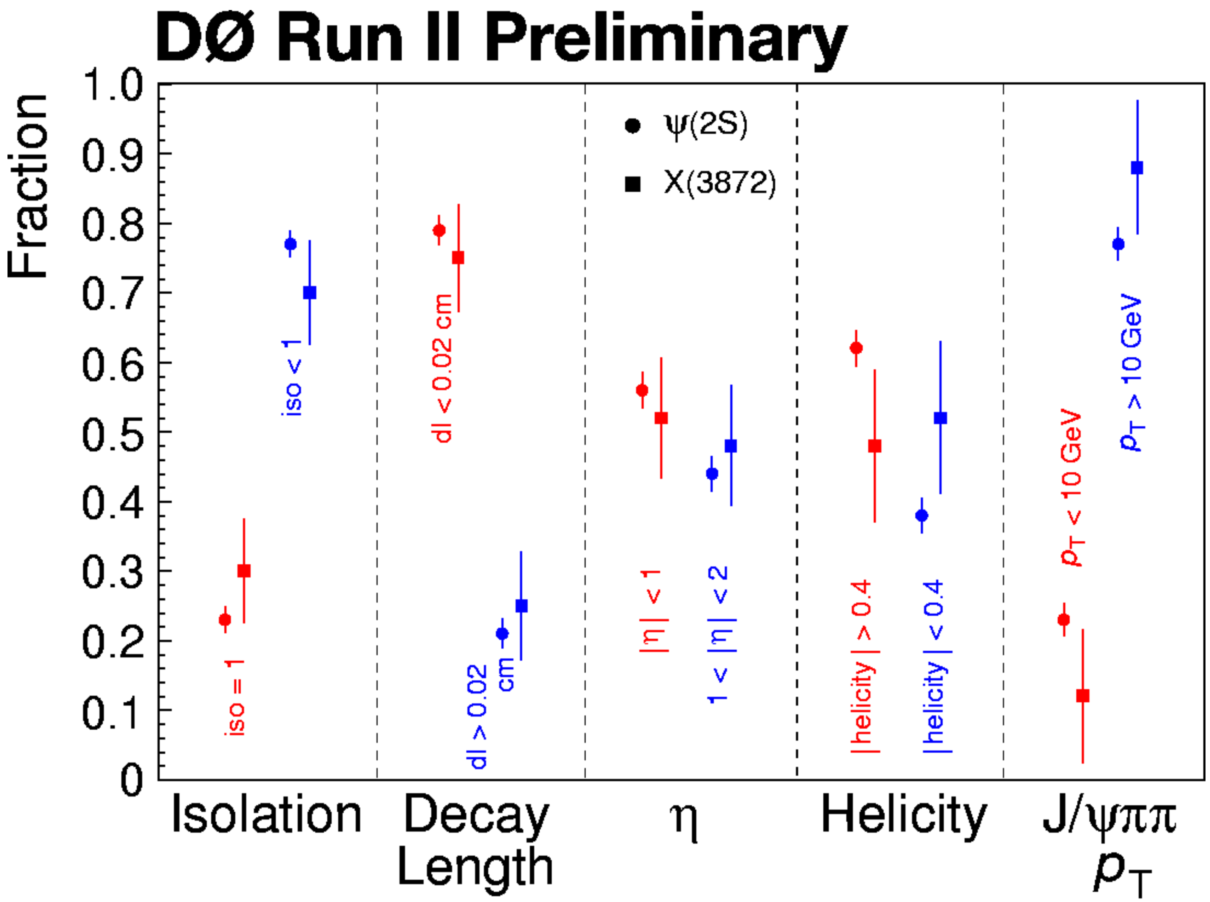
Compare our sample of X particles to our sample of Ψ(2S), e.g.

- split into two |η| regions (plot),
- two bins in decay length dl:

dl < 0.02 cm: 230 ± 59 events
dl > 0.02 cm: 77 ± 25 events



X(3872) ↔ Ψ(2S) comparison



No significant differences between Ψ(2S) and X have been observed yet.

This comparison will be even more useful once we have models of the production and decay of, e.g., meson molecules that predict the observables used in the comparison.

Observation of the charged analog $X^+ \to J/\Psi\ \pi^+\ \pi^0$ would rule out $c\bar{c}$ hypothesis.
Observation of radiative decays $X \to \gamma\ \chi_c$ would favour $c\bar{c}$ hypothesis (Belle set limit).

Use Dzero's calorimeter to identify low energy π^0 and γ : work in progress.

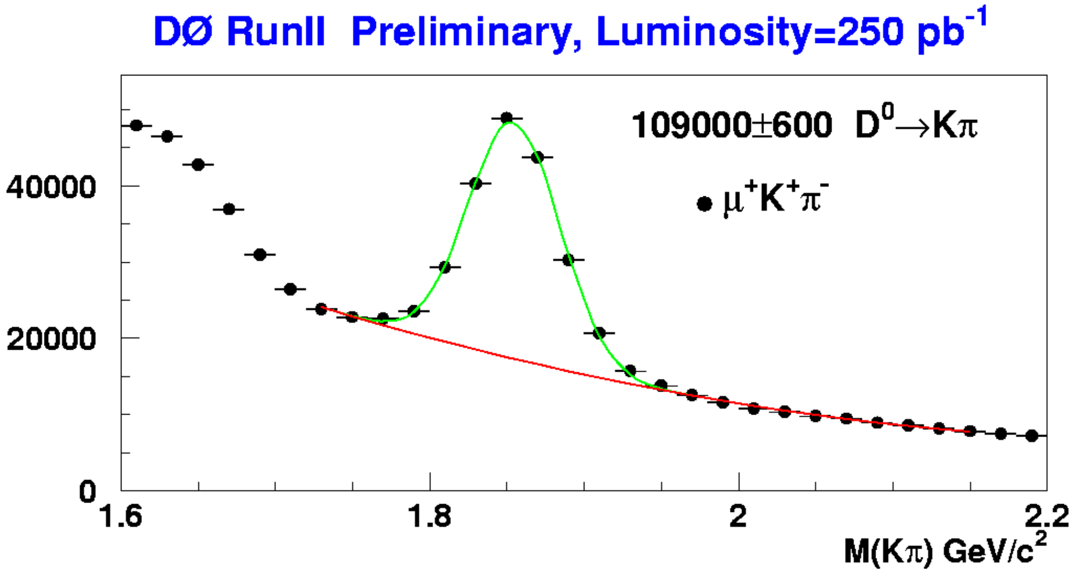
$\tau(B^+)/\tau(B^0)$ from semileptonic decays

Have record statistics of reconstructed semileptonic B^+ and B^0 decays in hand.

First application:

measure lifetime ratio $\tau(B^+)/\tau(B^0)$

will show some other applications later



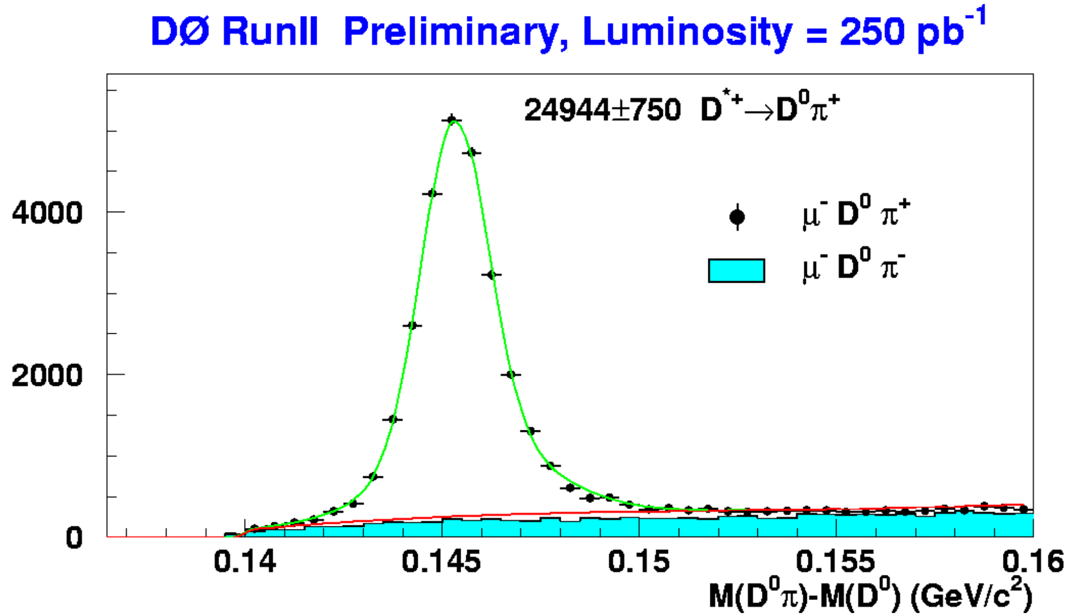
Sample compositions:

"D^0 sample": $\mu^+ K^+ \pi^-$ + (anything except slow π)

B^+	82 %
B^0	16 %
B_s	2 %

"D* sample": $\mu^+ D^0 \pi^-$ + anything

B^+	12 %
B^0	86 %
B_s	2 %



Estimates based on measured branching fractions and isospin relations.

$\tau(B^+)/\tau(B^0)$: fitting strategy

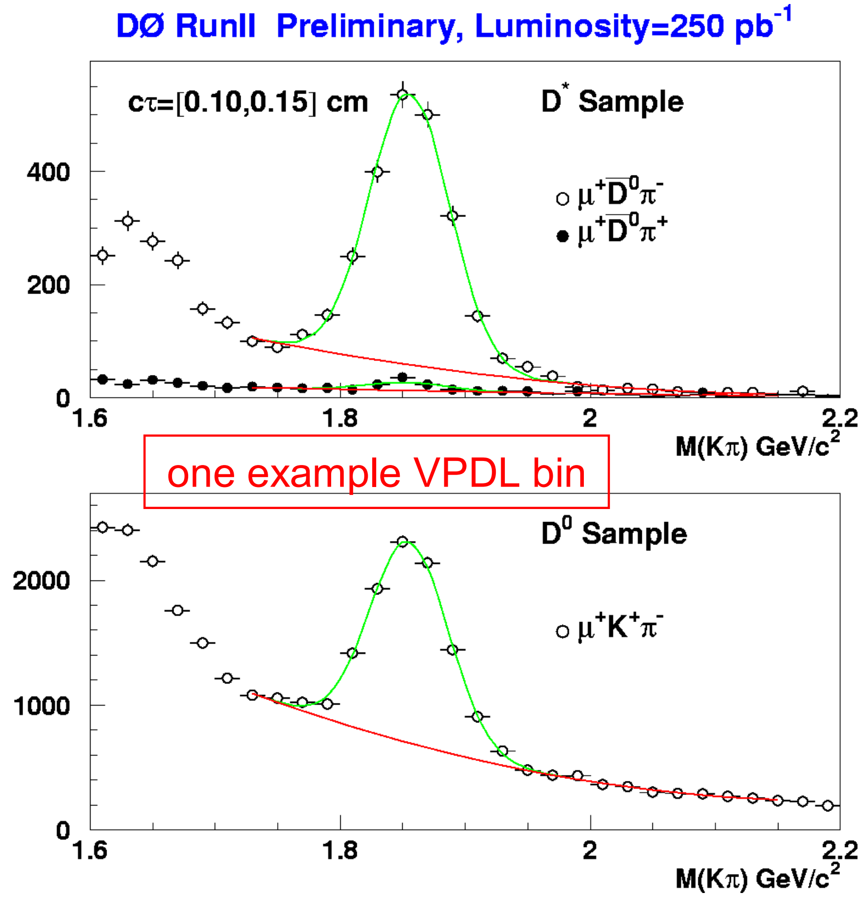
Group events into 8 bins of
Visible Proper Decay Length (VPDL):

$$\text{VPDL} = L_T \,/\, p_T(\mu\, D^0) \cdot M_B$$

L_T = transverse decay length

Measure $r_i = N(\mu^+ D^{*-})/N(\mu^+ \bar{D}^0)$ in each bin i.
Combinatorial background with true D^0 in D* sample is subtracted using wrong-sign distribution (normalisation from full sample, previous slide).

$\Rightarrow$ no need for parameterisation of background VPDL distribution

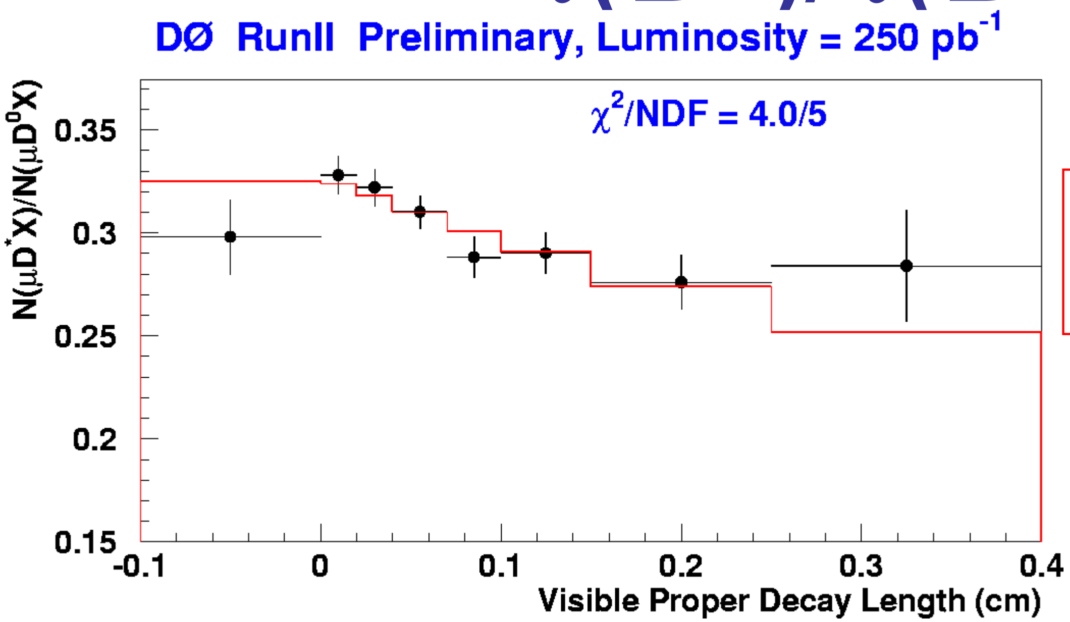


Additional inputs to the fit:

- sample compositions (previous slide)
- K-factors (from simulation)

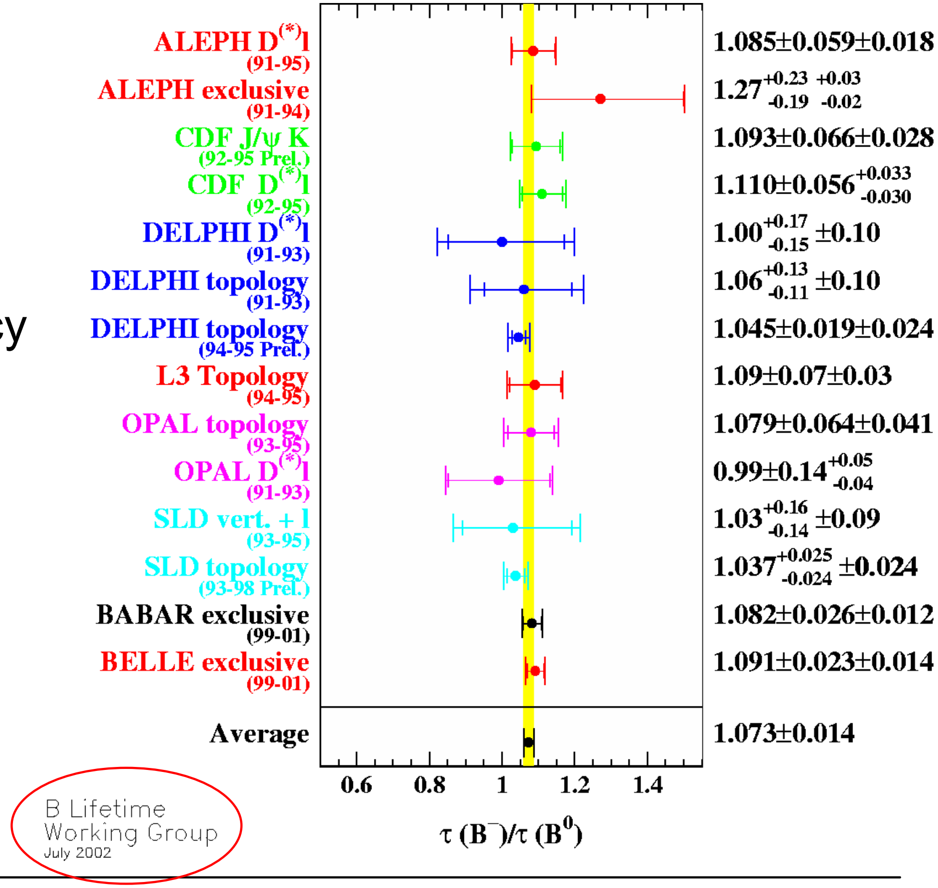
  $K = p_T(\mu D^0) \,/\, p_T(B)$ [separately for different (groups of) decay modes]
- Relative reconstruction efficiencies C_Y for different decay modes $B \to Y$ (from simulation)
- Slow pion reconstruction efficiency [flat for $p_T(D^0) > 5$ GeV (one of our cuts)]
- Decay length resolution (from simulation)
- $\tau(B^+) = 1.674 \pm 0.018$ ps [PDG]

$\tau(B^+)/\tau(B^0)$: results



Preliminary result:

$\tau(B^+)/\tau(B^0) = 1.093 \pm 0.021$ (stat) ± 0.022 (syst)



Syst. dominated by:

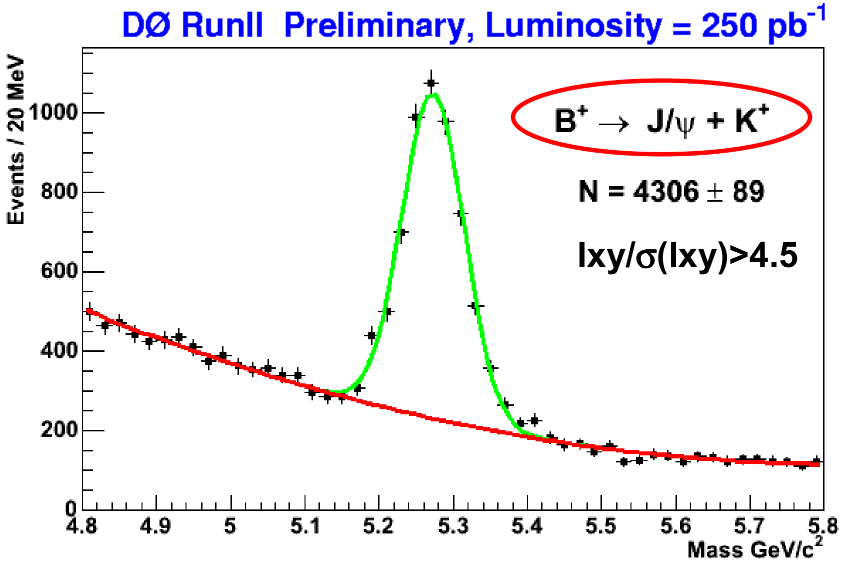
- time dependence of slow π reconstruction efficiency
- relative reconstruction efficiencies C_Y
- $Br(B^+ \to \mu^+ \nu D^{*-} \pi^+ X)$
- K-factors
- decay length resolution differences $D^0 \leftrightarrow D^*$

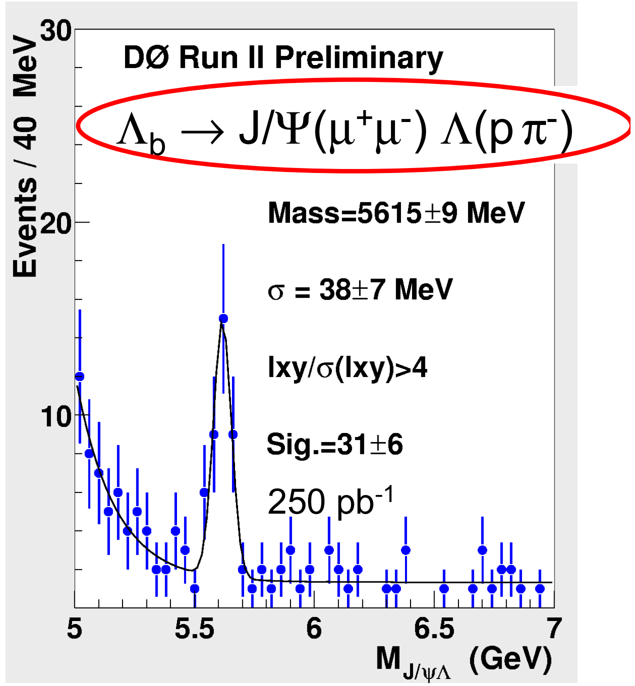
The preliminary DØ measurement is one of the most precise results, and it is consistent with previous measurements.

Exclusive B decays

Can also reconstruct hadronic B decays exclusively
($\rightarrow$ improved proper time resolution).

Some examples on the right.

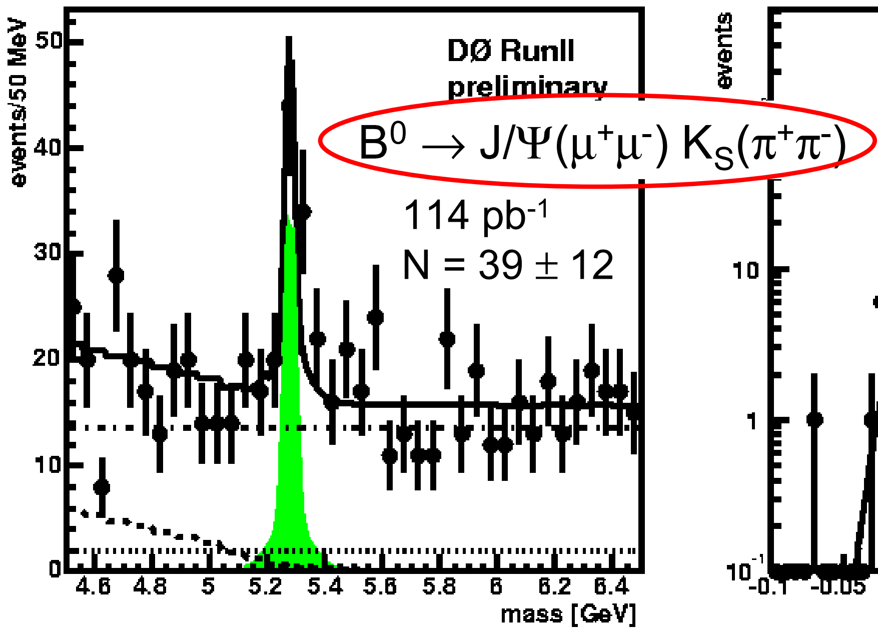


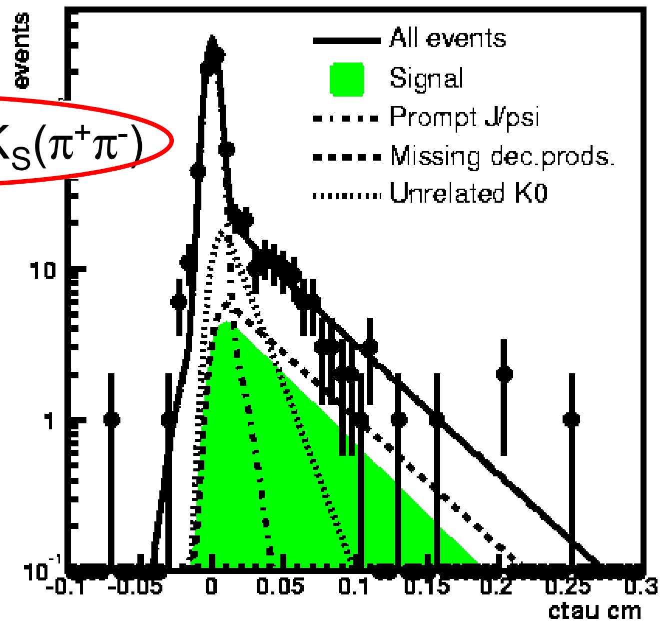


Preliminary lifetime measurement using $B^0 \rightarrow J/\Psi(\mu^+\mu^-)\ K_S(\pi^+\pi^-)$:

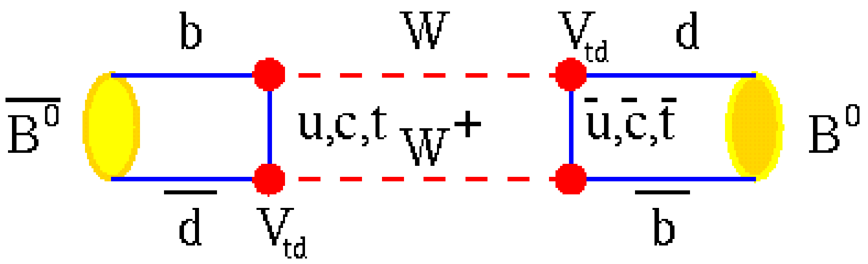
$\tau(B^0)$
$= 1.56\ ^{+0.32}_{-0.25}$ (stat) $\pm$ 0.13 (syst) ps

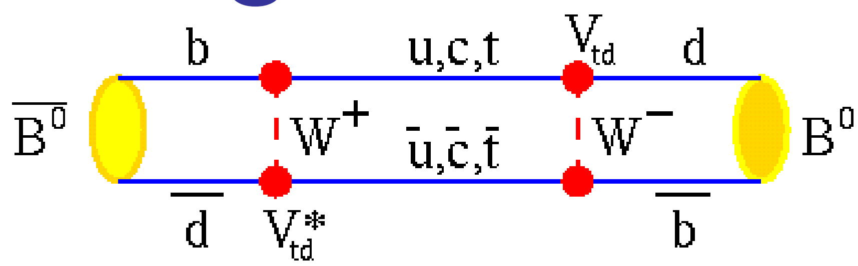
Consistent with world average:
$\tau(B^0) = 1.542 \pm 0.016$ ps [PDG]





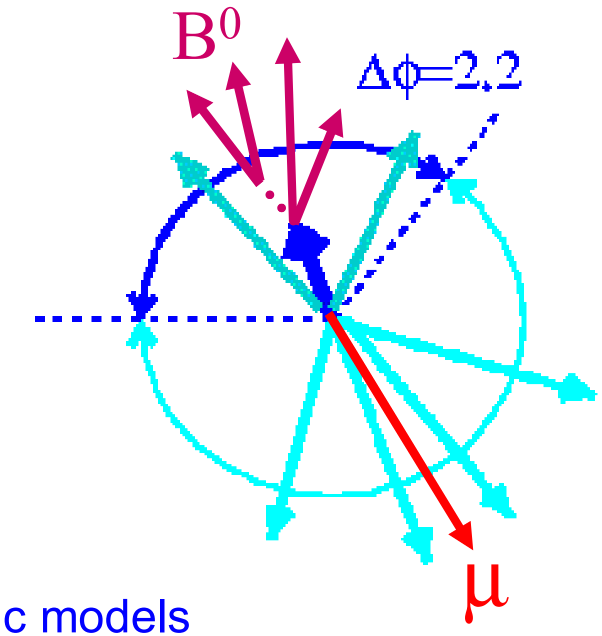
$B^0/\bar{B}^0$ mixing





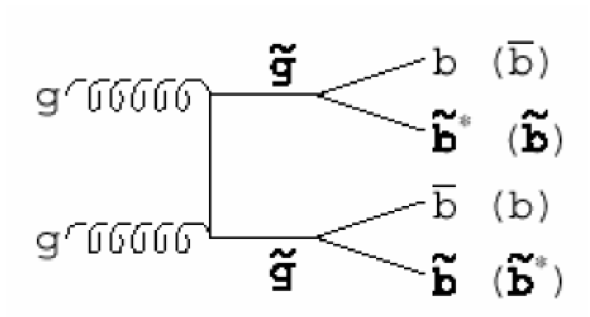
The $B^0/\bar{B}^0$ mixing frequency Δm_d has been measured with high precision, most recently at the B factories.
Measurements of Δm_d constrain $|V_{td}|$, but current limitations are due to theoretical inputs.

We use our large sample of semileptonic $B^0/\bar{B}^0$ decays to measure Δm_d:



- benchmark the initial state flavour tagging

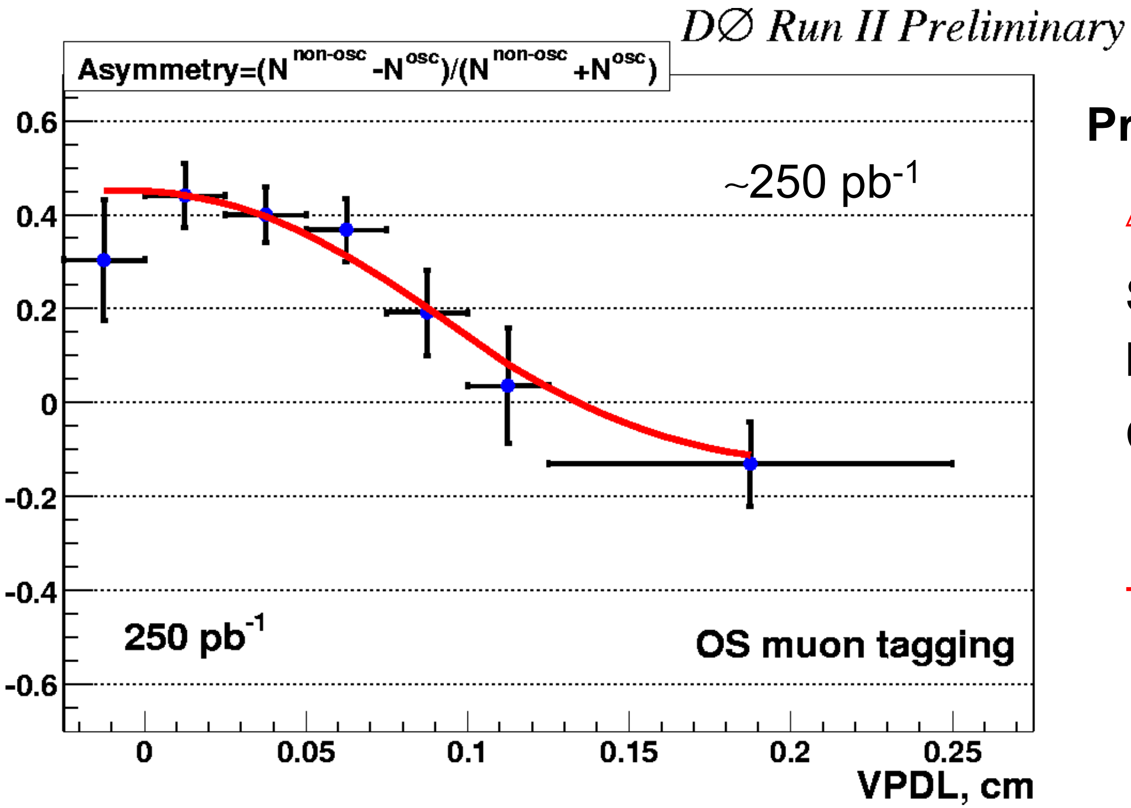
  results in this talk are based on
  opposite side muon tags



- can also constrain more exotic models of b production at hadron colliders

  e.g. Berger *et al.*, Phys. Rev. Lett. 86, 4231 (2001)

$B^0/\bar{B}^0$ mixing: results



Preliminary results:

Δm_d = 0.506 ± 0.055 (stat) ± 0.049 (syst) ps^{-1}

Syst. dominated by uncertainty on μ+D*- yield per VPDL bin.

Consistent with world average:

0.502 ± 0.007 ps^{-1}

Tagging efficiency:

$$\varepsilon = \frac{N_R + N_W}{N_R + N_W + N_{notag}} = 4.76 \pm 0.19\,\%$$

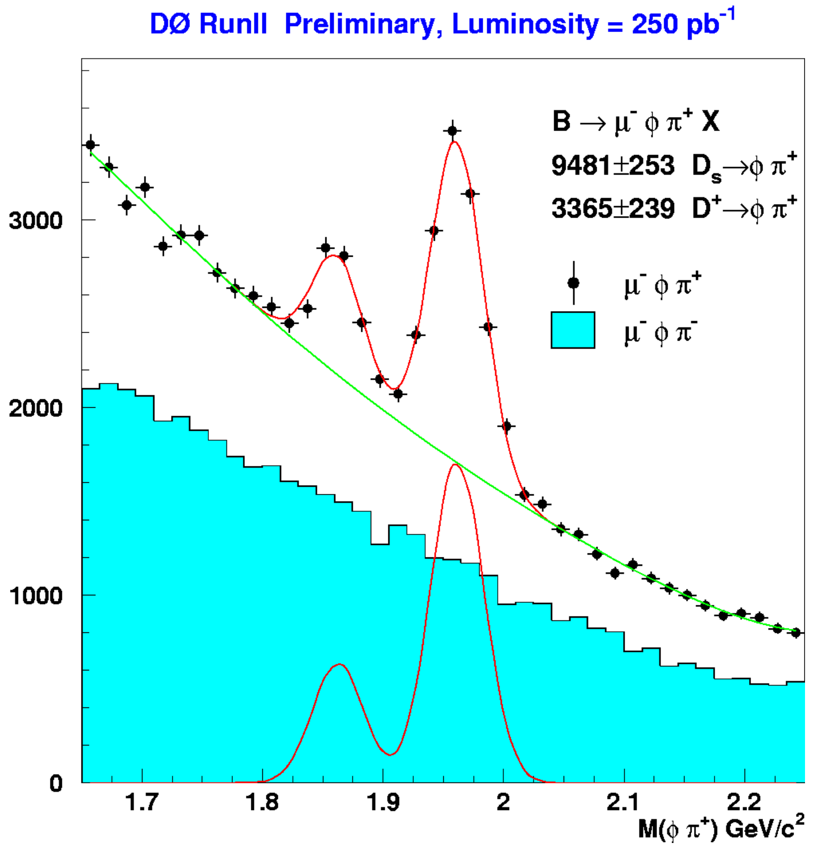
Tagging purity:

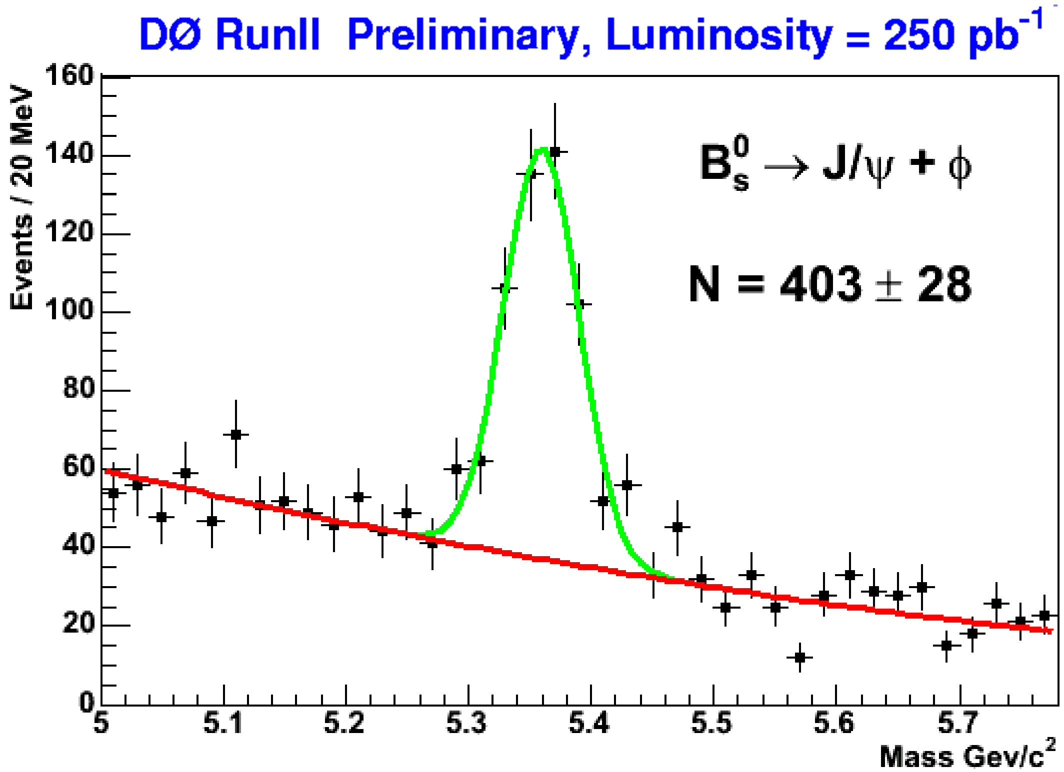
$$\kappa = \frac{N_R}{N_R + N_W} = 73.0 \pm 2.1\,\%$$

Work in progress:

- also use electron tags
- other tagging methods:
  jet charge,
  same side tagging.

B_s decays





Semileptonic decays:

- Very good statistics
- If $\Delta m_s \cong 15$ ps^{-1} expect a measurement with 500 pb^{-1}.

Fully reconstructed hadronic decays:

- Poor statistics
- Excellent proper time resolution
- Need a few fb^{-1} of data to reach $\Delta m_s \cong 18$ ps^{-1}.

Observation of $B \to \mu\, \nu\, D^{**}\, X$

Plot on the right summarises D meson spectroscopy.

Qualitative understanding from HQET (heavy quark limit)

$\Rightarrow$ Spin of heavy quark becomes conserved quantity (good quantum number).
Angular momentum of light degrees of freedom also becomes good quantum number.

$\Rightarrow$ Expect sets of doublets, e.g. (D_1, D_2^*).
Sates of this particular doublet decay via D-wave $\to$ narrow.

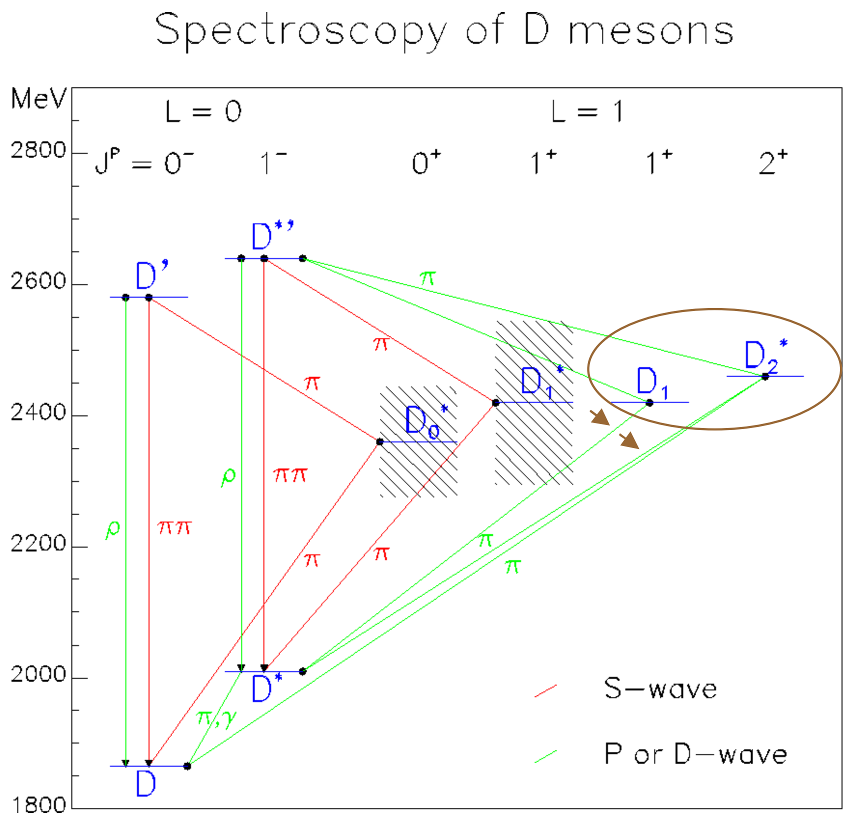


Figure from *CLEO Collaboration*, hep-ex/9908009

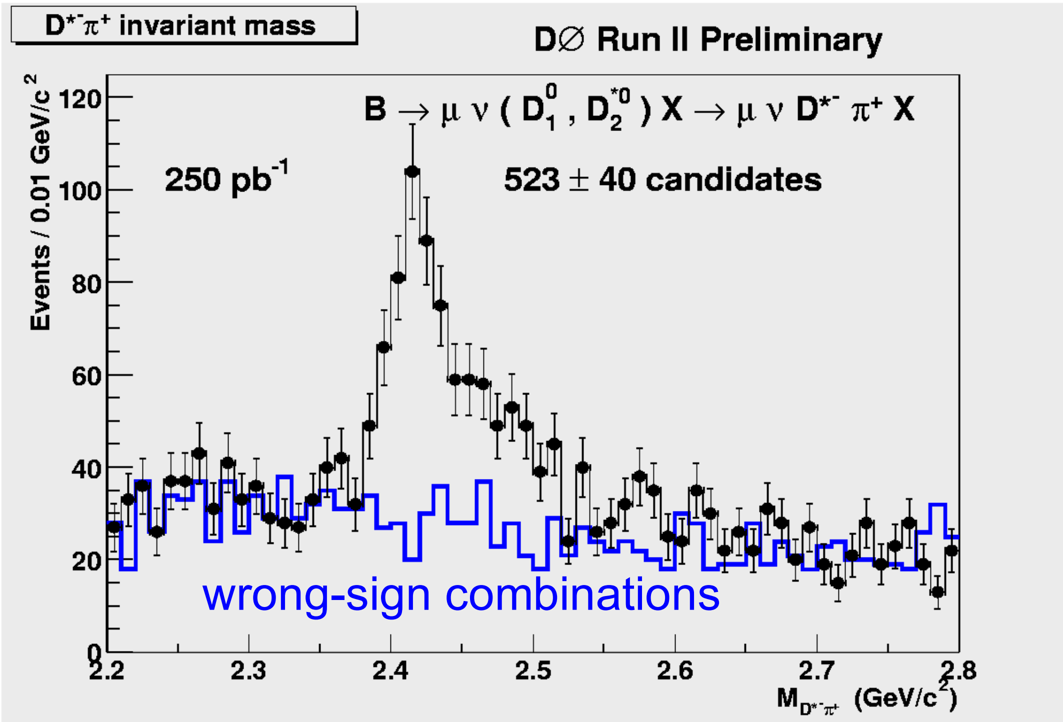
The D_1^0, D_2^{*0} have been observed and studied in several experiments, most recently by BaBar and Belle in $B^- \to D^{**0}\, \pi^-$ [hep-ex/0308026, hep-ex/0307021].

We study D_1^0, D_2^{*0} produced in semileptonic B decays.

Constrain D spectroscopy; also improve understanding of the sample of semileptonic B decays we use for lifetime, mixing, … measurements.

Observation of B $\rightarrow \mu\ \nu$ D** X

Start from our "B $\rightarrow \mu\ \nu$ D^{*-} + anything" sample, and "reconstruct another π^+".
Look at mass of $D^{*-}\ \pi^+$ system.



Excess in right-sign combinations can be interpreted as combined effect of $D_1{}^0$ and $D_2{}^{*0}$.

Work in progress: extract separate amplitude, phase for each state.

From topological analyses at LEP we know:

Br(B $\rightarrow D^{*+}\ \pi^-\ \mu\ \nu$ X) = 0.48 $\pm$ 0.10 %

DØ's preliminary result constrains the resonant contribution

Br(B $\rightarrow \{D_1{}^0, D_2{}^{*0}\}\ \mu\ \nu$ X) $\cdot$ Br($\{D_1{}^0, D_2{}^{*0}\} \rightarrow D^{*+}\ \pi^-$) = 0.280 $\pm$ 0.021 (stat) $\pm$ 0.088 (syst) % .

$B_s \to \mu^+ \mu^-$ sensitivity study

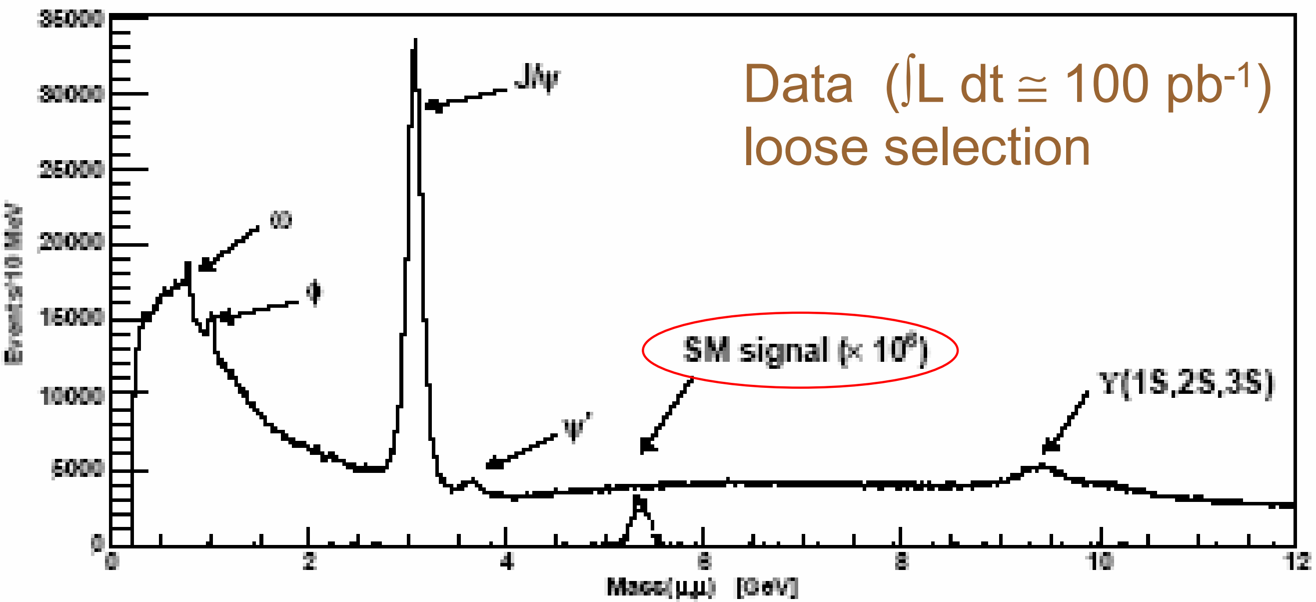
$B_s \to \mu^+ \mu^-$ is a promising window on possible physics beyond the SM.

In the SM, the expected branching ratio is small:

$Br(B_s \to \mu^+ \mu^-) = (3.4 \pm 0.5) \cdot 10^{-9}$
[Buras, Phys. Lett. **B**566 115 (2003)]

$B_d \to \mu^+ \mu^-$ is suppressed by additional factor $|V_{td}/V_{ts}| \cong 4 \cdot 10^{-2}$.

MSSM: $Br(B_s \to \mu^+ \mu^-) \propto \tan^6 \beta$
$\Rightarrow$ at large $\tan \beta$, enhancement of up to 2-3 orders of magnitude
[Dedes *et al.*, FERMILAB-PUB-02-129-T]



Background rejection via

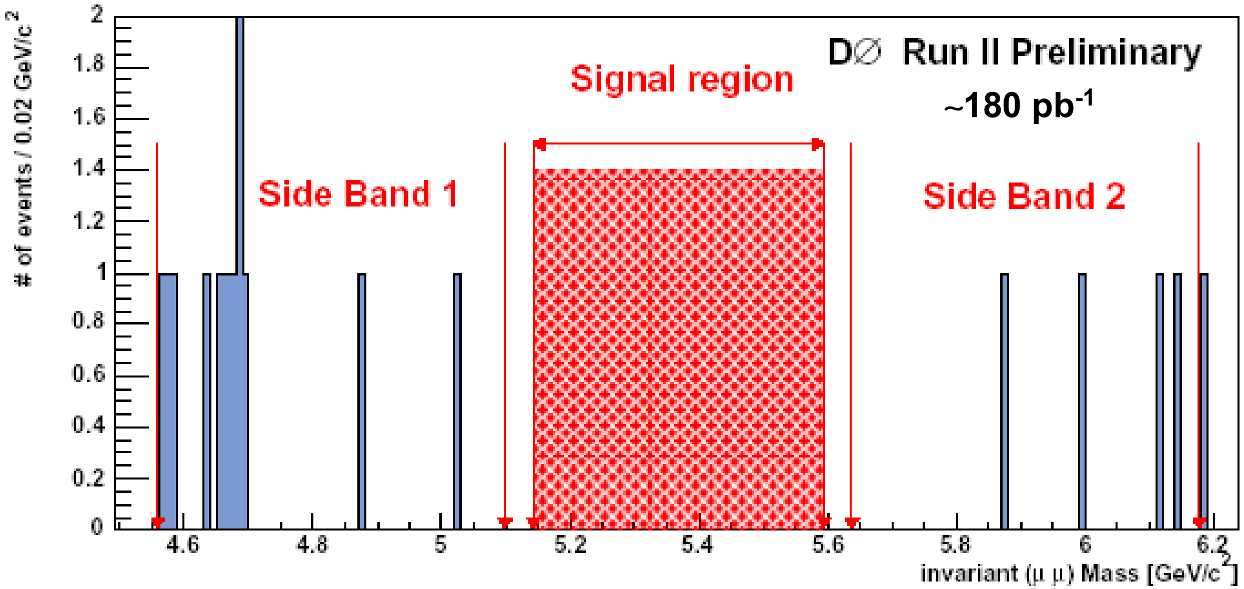
- isolation of muon pair
- decay length $|\vec{l}|$
- opening angle between $\vec{l}$ and $\vec{p}(\mu^+\mu^-)$

$B_s \to \mu^+ \mu^-$ sensitivity study

Optimised cuts using Random Grid Search [Prosper, CHEP'95; Punzi, CSPP'03] based on the mass sidebands.

After optimisation:

expect 7.3 ± 1.8 background events in signal region



The analysis has not been *unblinded* yet (signal region still hidden).

Expected limit (Feldman/Cousins):

$Br(B_s \to \mu^+ \mu^-) < 9.1 \cdot 10^{-7}$ @ 95 % CL (stat only)

$Br(B_s \to \mu^+ \mu^-) < 1.0 \cdot 10^{-6}$ @ 95 % CL (stat + syst)

(expected signal has been normalised to $B^\pm \to J/\Psi K^\pm$)

Published CDF Run I result (98 pb^{-1}):

$Br(B_s \to \mu^+ \mu^-)$
$< 2.6 \cdot 10^{-6}$ @ 95 % CL

Summary

Observation of the X(3872) at DØ;
study of production properties

Precise measurement of $\tau(B^+)/\tau(B^0)$

Measurement of Δm_d, benchmark flavour tagging

Observation of $B \rightarrow \mu\, \nu\, D^{**}\, X$ at DØ

DØ's sensitivity to $B_s \rightarrow \mu\, \mu$

The exciting times have started; stay tuned for more.

Reminder: all results are preliminary.

Backup slides

Flavour tagging: figure of merit

Opposite side muon tags:

Dilution: $D = 2\,\kappa - 1 = 0.460 \pm 0.045$

Figure of merit: $\varepsilon\, D^2 = 1.01 \pm 0.20\ \%$

Summary:

$\varepsilon\, D^2$ [%]	CDF	DØ
Opp. muons	0.66 ± 0.09	1.01 ± 0.20
Opp. electrons	in progress	in progress
Jet charge	in progress	3.3 ± 1.7
Same side	1.9 ± 0.9	5.5 ± 2.0
Opp. kaons	in progress	N/A
Same side kaons	in progress	N/A

older results