Bottomium production & B_s Mixing at the DØ experiment

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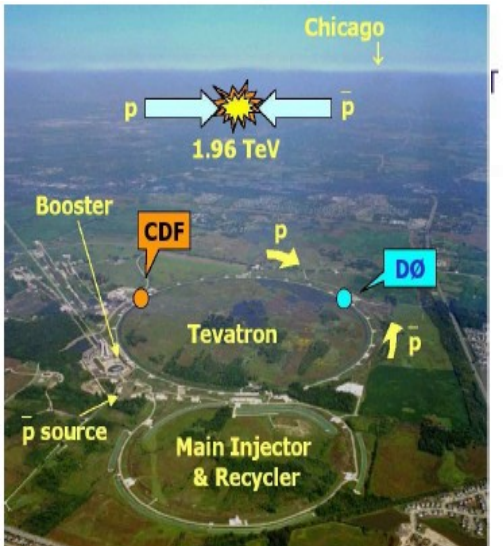
B-Physics at DØ

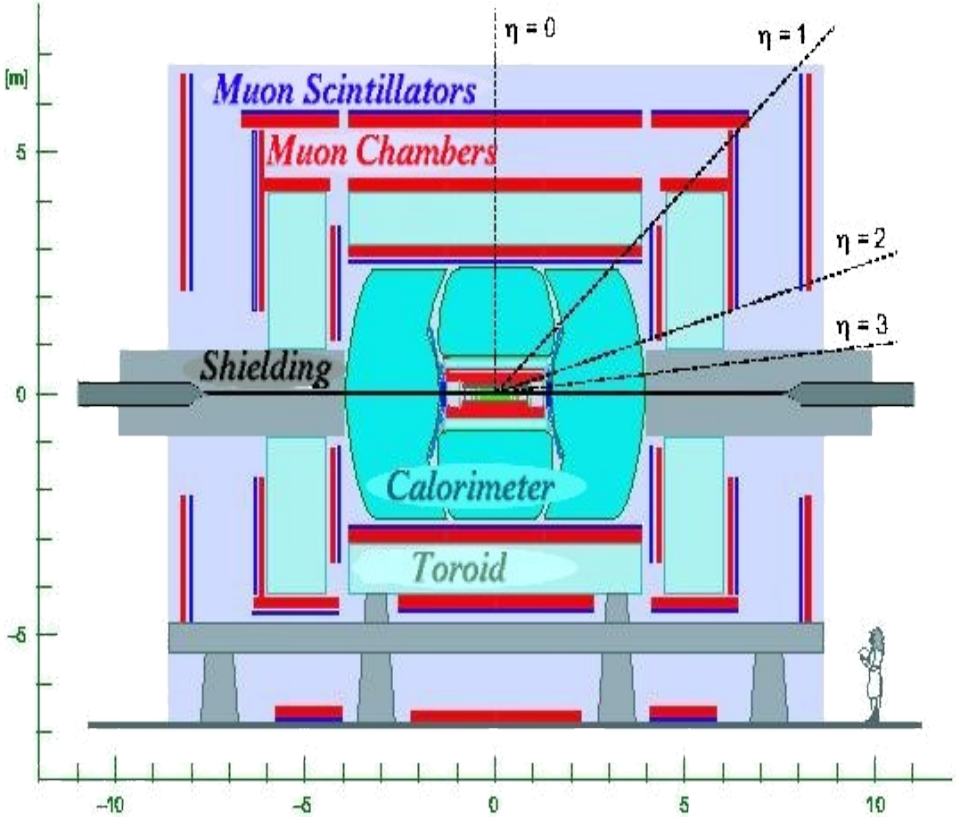
- Large b-quark production cross section: ~30 μb
- all kind of b-hadrons produced (B_d, B_s, B_c,Λ_b ...)
- Huge spectrum of analyses:
  - Production: differential cross sections, helicity....
  - B-Properties: Life time, mass, decays ...
  - B_s/B_d mixing
  - New Particles, new physics
- Huge background $\rightarrow$ need effective trigger
- Complicated event structure (many tracks)

Here:

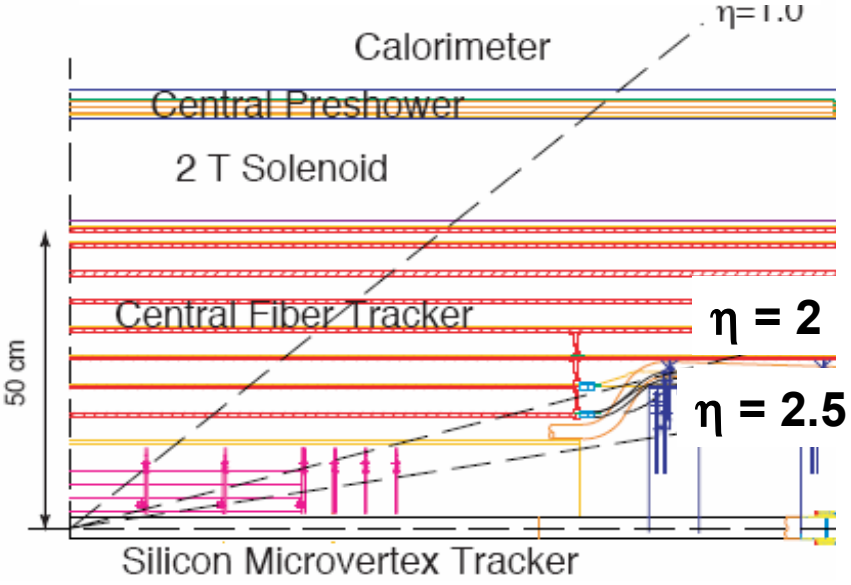
- bottomium production ($\Upsilon(1S)$)
- X(3872) (possible charmonium state)
- B_s mixing

Tevatron and DØ Detector





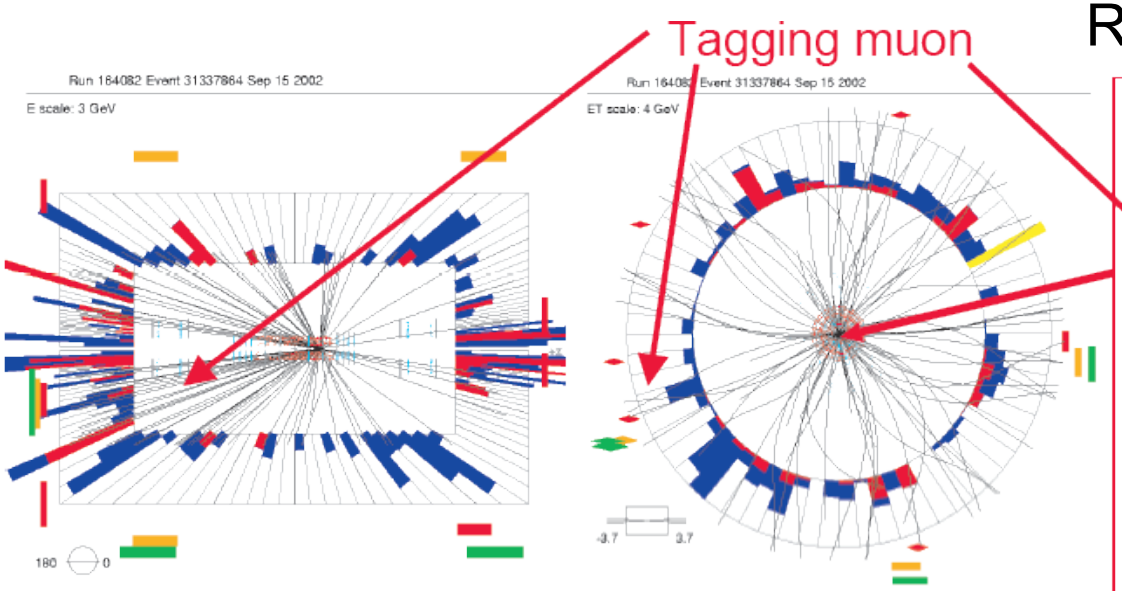
Recorded data: ~1.2 fb^{-1}
Efficiency: 85-90 %



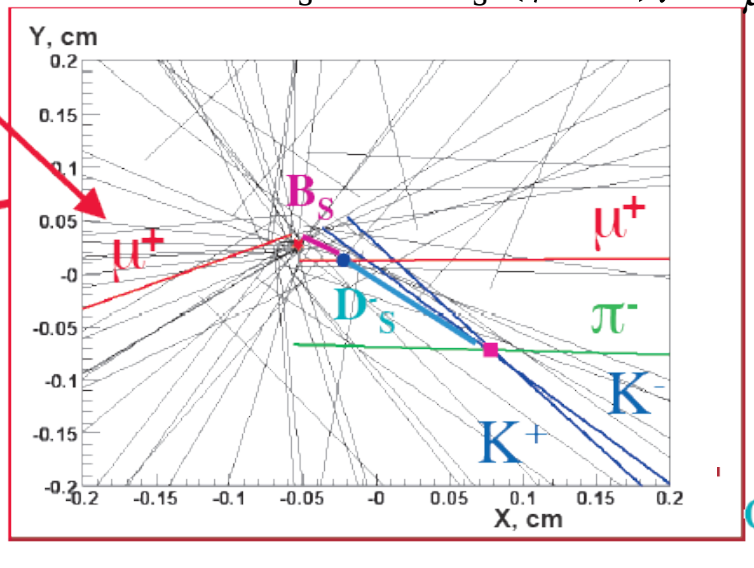
\+ very good muon system

\- Compact tracking system

Challenge



Real data: $B_s^0 \rightarrow D_s^{\pm}(\phi\pi^{\pm})\mu\nu_{\mu}$



Muon system:

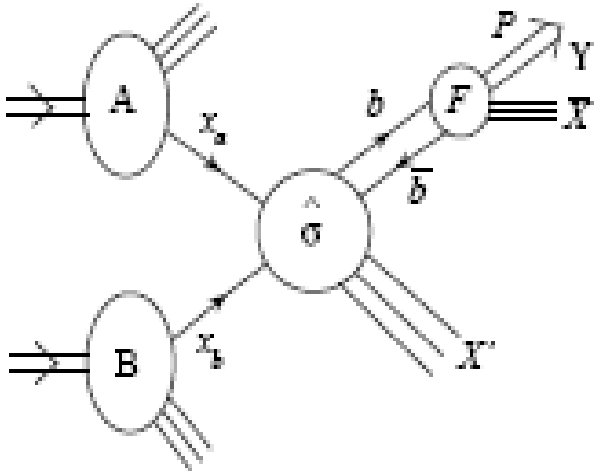
- 1.8 T toroid field
- large angular acceptance (up to η=|2|)
- trigger highly efficient (close to 100% for $p_t(\mu)$> 5GeV)
- unbiased (impact parameter cuts only for highest luminosity)

Tracking:

- huge tracking density capability
- Angular coverage up to $|\eta|$=3

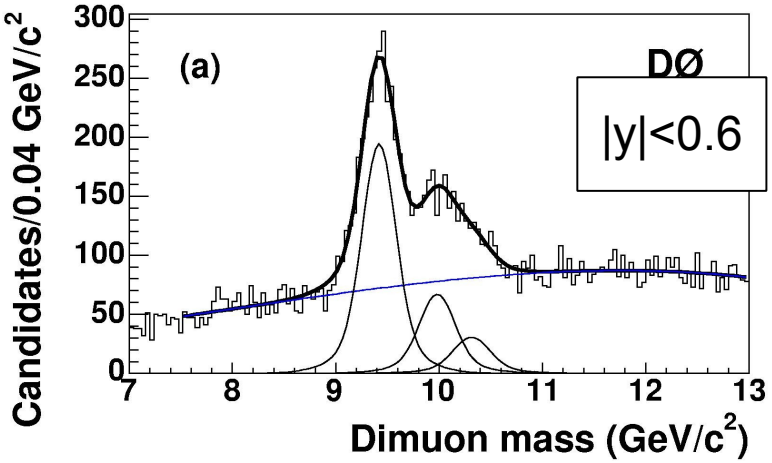
Bottomium production

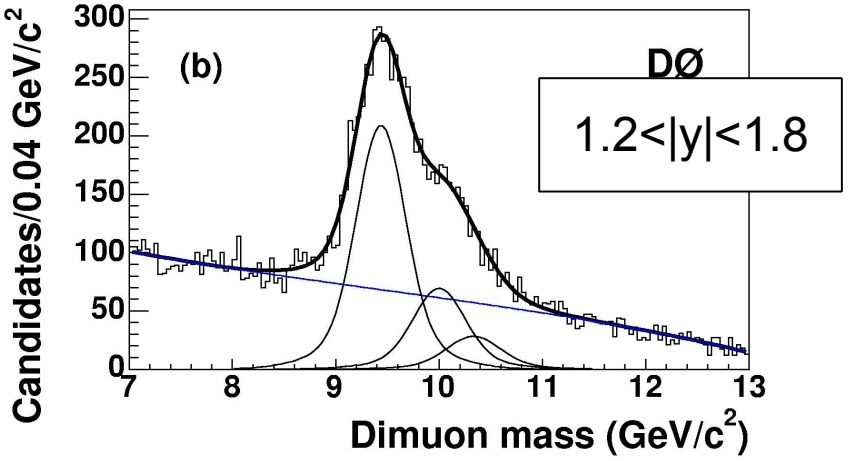
- insight into the nature of the strong force
- factorized into two steps:
  - production of a heavy quark-antiquark pair
  - two quarks forming a particle of a color-singlet quarkonium state
- Measurement: test of different models
- Models differ in cross sections and polarisation
- Recent phenom. paper (Phys. Rev. D 71 034007 (2005)) describes data at Tevatron RunI (CDF result with coverage of $|y|<0.4$)
- New DØ analysis: $|y|<1.8$, and differential cross section in p_t and y



Signal selection

- $\mathcal{L}$=160 pb^{-1}
- Di-muon trigger
- Two opp. Charged muons with p_t>3 GeV, $|y_\mu|$<2.2
- Total sample: ~50000 events
- Acceptance: 15...28%
- Trigger efficiency: 70...82%
- Corrections for data/mc differences in tracking, triggering, quality (e.g. Cosmics): 0.7...0.95
- Clear Υ(1S) signal
- Υ(2S),Υ(3S) not resolvable

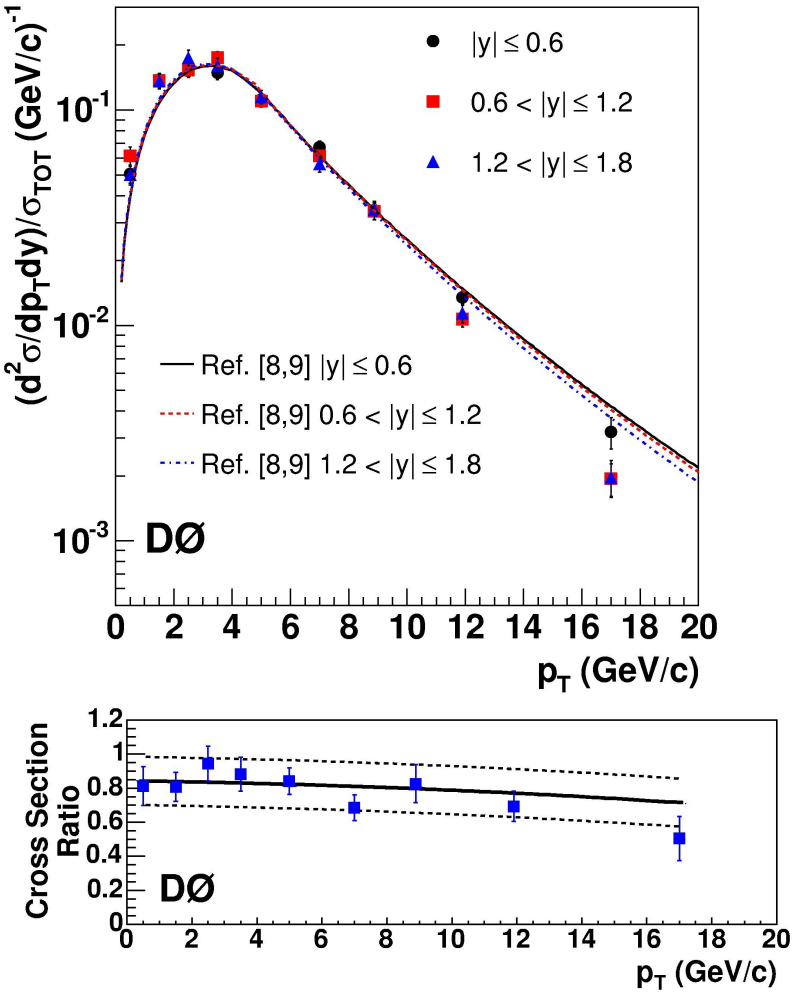




p_t bin: 4 GeV<p_t(Υ)<6 GeV

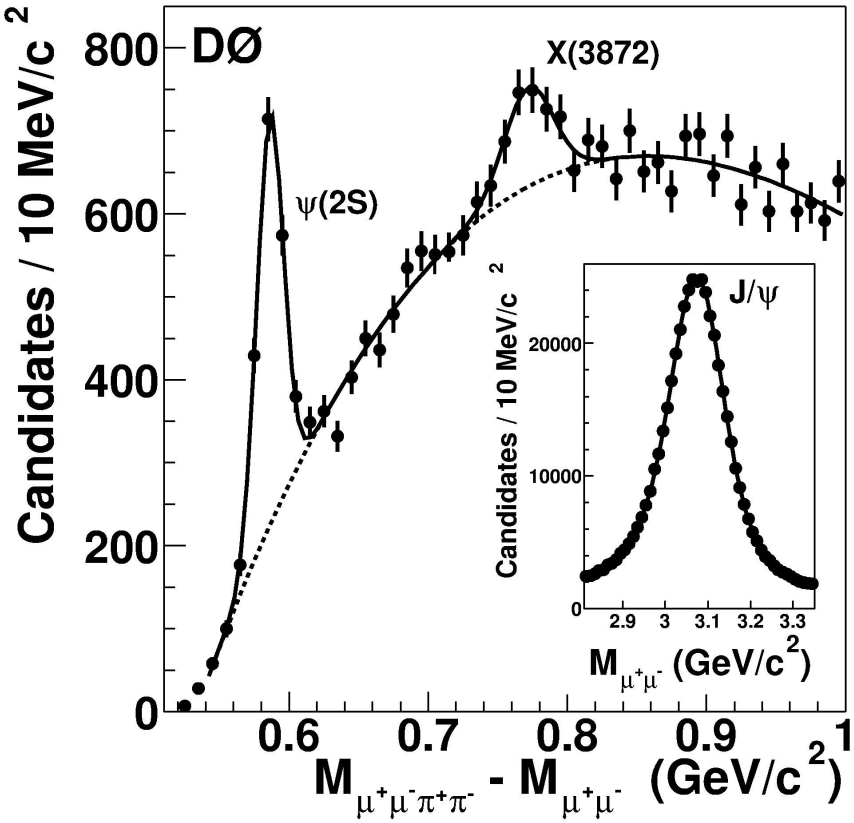
Cross section

- Total Υ(1S) cross section:
  - 695±14(stat)±68(sys)±45(lumi)pb |y|<1.8
- Differential cross section:
  - 9 bins p_t
  - 3 bins y
- y<0.6: agreement with CDF |y|<0.4
- Lower plot: ratio beween result for |y|<0.6 and 1.2<|y|<1.8: no deviation to theory



X(3872)->J/$\Psi\pi^+\pi^-$

- Is X(3872) a charmionum mode?
- Selection: X(3872)$\rightarrow$J/$\Psi(\mu^+\mu^-)\pi^+\pi^-$
- Luminosity: 230 pb^{-1}
- 522 $\pm$ 100 events
- Δm:=m(J/$\Psi\pi^+\pi^-$)–m(J/Ψ)
  =774.0 $\pm$ 3.1(stat) $\pm$ 3.0(sys) MeV

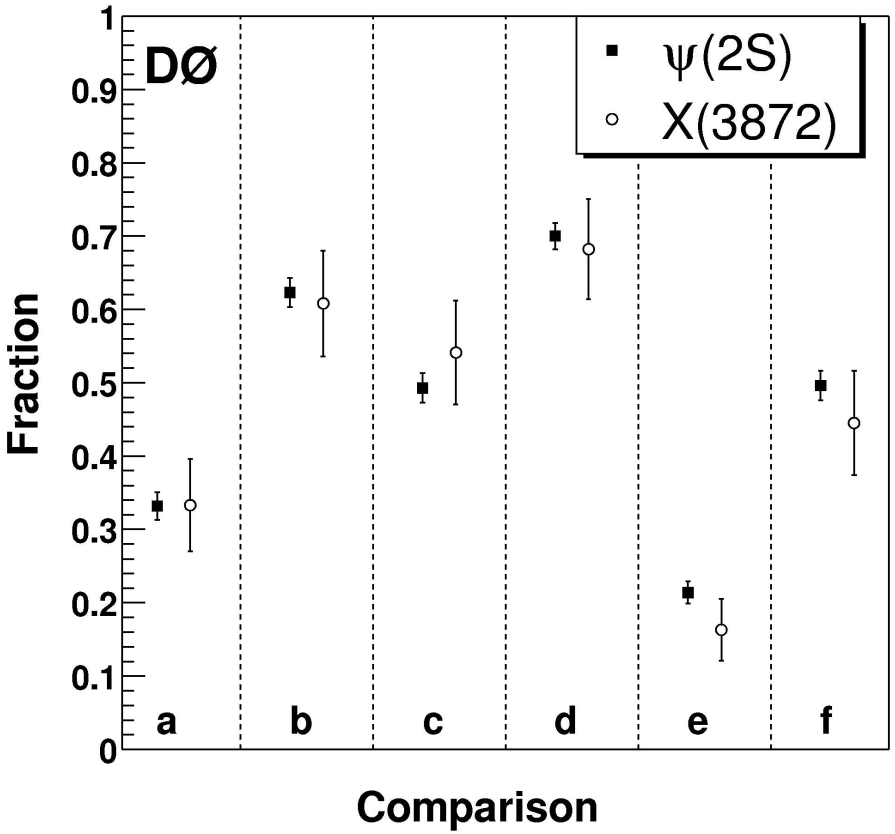


X(3872)->J/$\Psi\pi^+\pi^-$

- Comparison of 5 kinematic variables with $\Psi(2S) \rightarrow$ very similar distributions
- compatible to $J=1^{--}$, 1^{++} and 2^{-+}

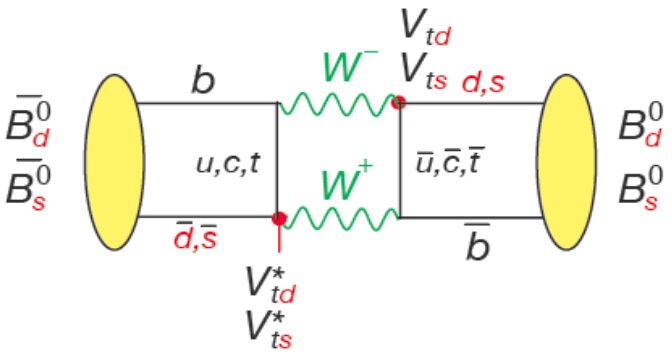
Fraction of:

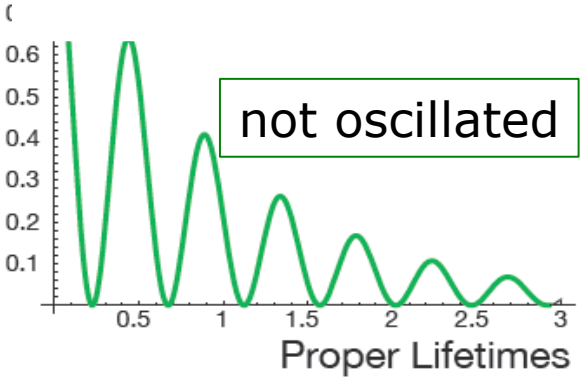
a) pt>15 GeV
b) |y|<1
c) $\cos(\theta_\pi)$
d) dl<0.01cm
e) isolation=1
f) $\cos(\theta_\mu)$

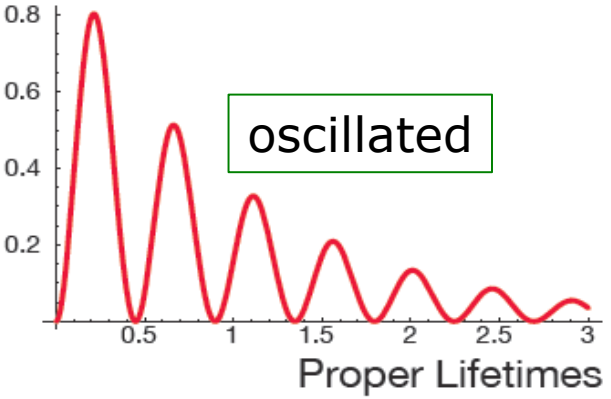


B_s mixing

Goal: V_{td} measurement



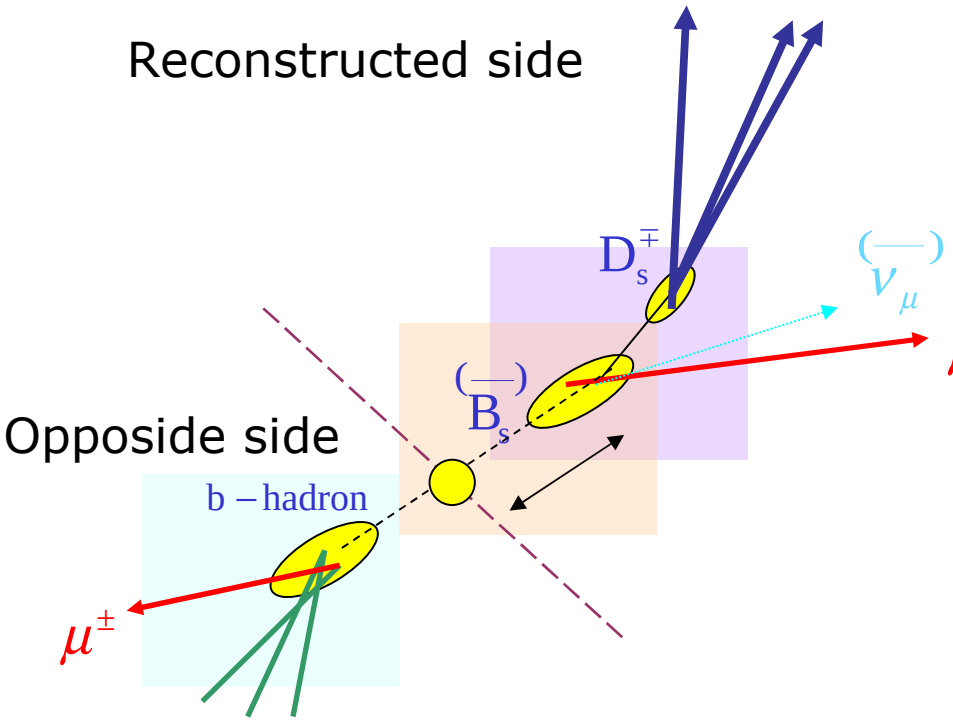




Measurement of Δm_d and Δm_s:
V_{td} measurement

$$\frac{\Delta m_s}{\Delta m_d} = \frac{m_{B_s^0}}{m_{B_d^0}} \cdot \frac{B_{B_s^0} \cdot f^2_{B_s}}{B_{B_d^0} \cdot f^2_{B_d}} \cdot \frac{|V_{ts}|^2}{|V_{td}|^2}$$

Measurement Principle



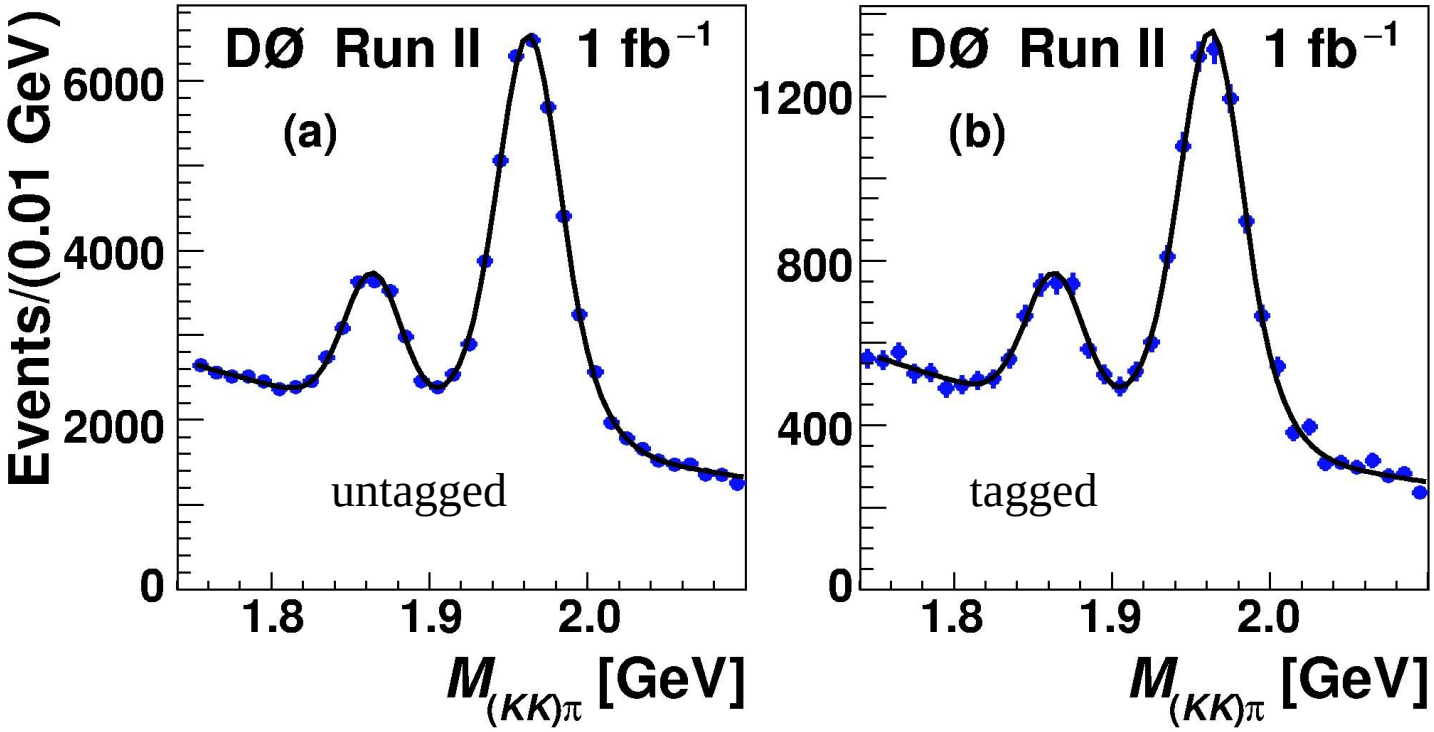
- Final state reconstruction:
  - b-flavor at decay
  - b momentum (missing: p_{ν})

- proper lifetime $c\tau = m_B \frac{L_{xy}}{P_T(B)}$

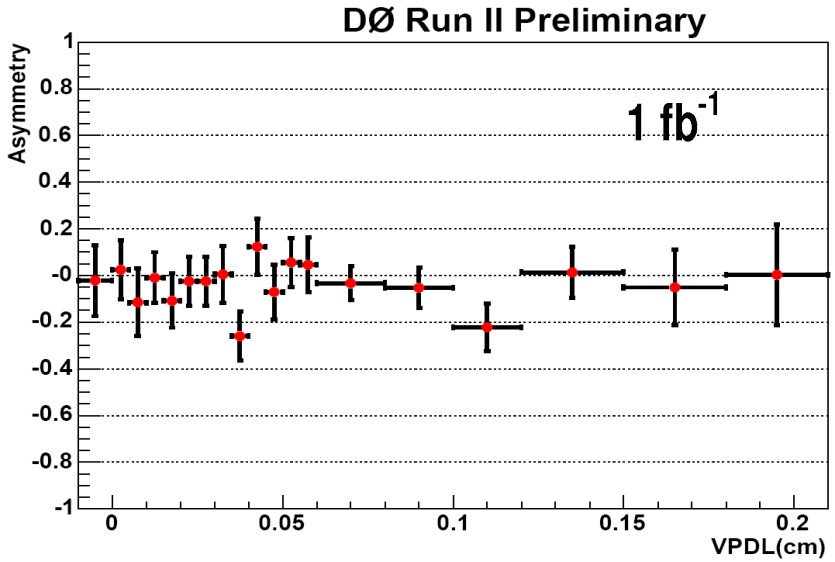
- Initial state (opposide side):
  - lepton charge
  - sec. vtx/lepton jet charge

Data samples

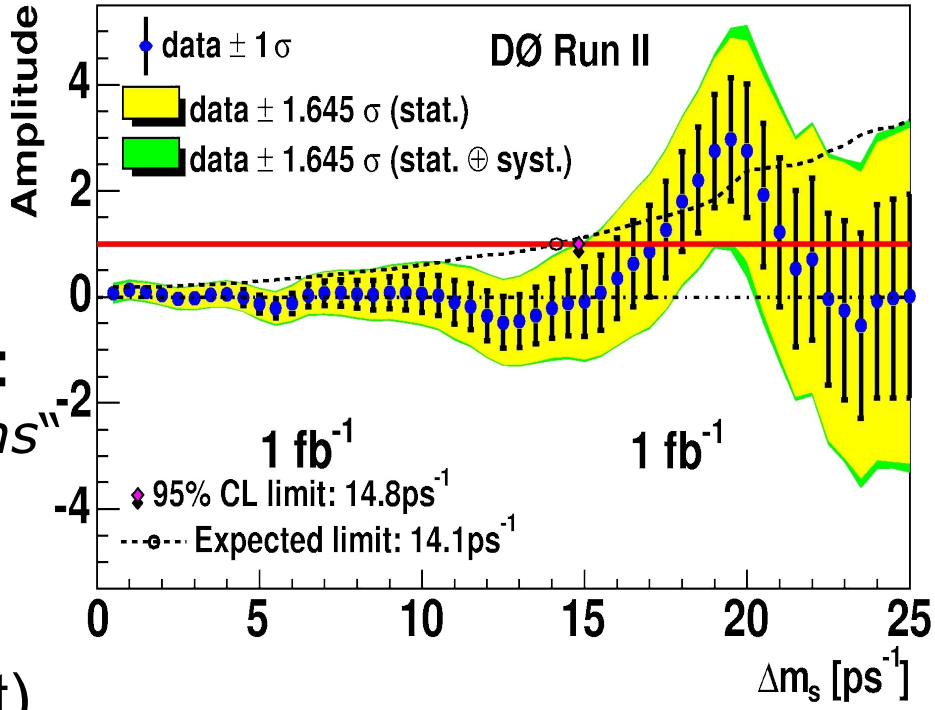
- Very big untagged B_s sample (~26.7k)
- After initial flavour tagging ~5.6k
  ε=21.0%; εD^2= 2.48%



DØ B_s mixing limit: Asymmetry



$$\text{Asymmetry}(t)=\frac{N(t)_{\text{unmixed}}-N(t)_{\text{mixed}}}{N(t)_{\text{unmixed}}+N(t)_{\text{mixed}}}$$



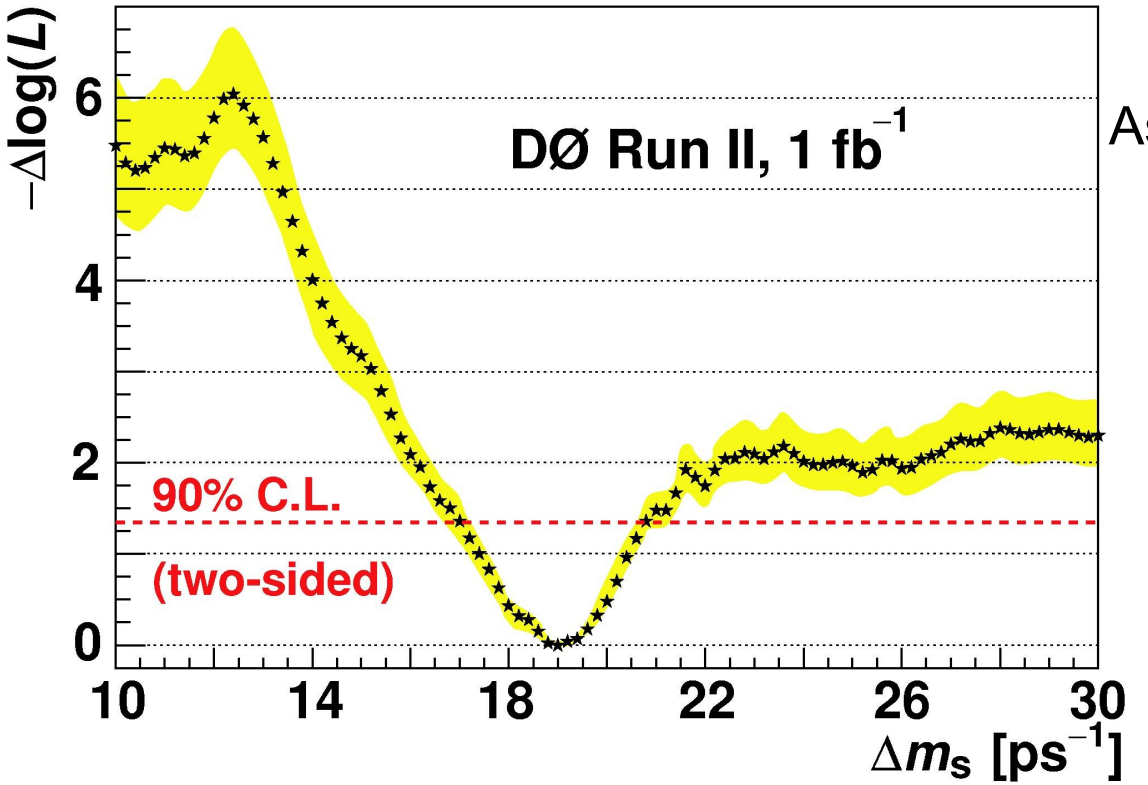
Unbinned Fit of amplitude:

- *„probability density functions"*
  - o Mass distribution
  - o Resolution
  - o Dilution

$$\text{Asymmetry}(t)= A \cdot D \cdot \cos(\Delta m \cdot t)$$

Δm_s measurement

ΔLog(L) for different Δm_s and fixed A=1:



Asymmetry(t)= A•D•cos(Δm•t)

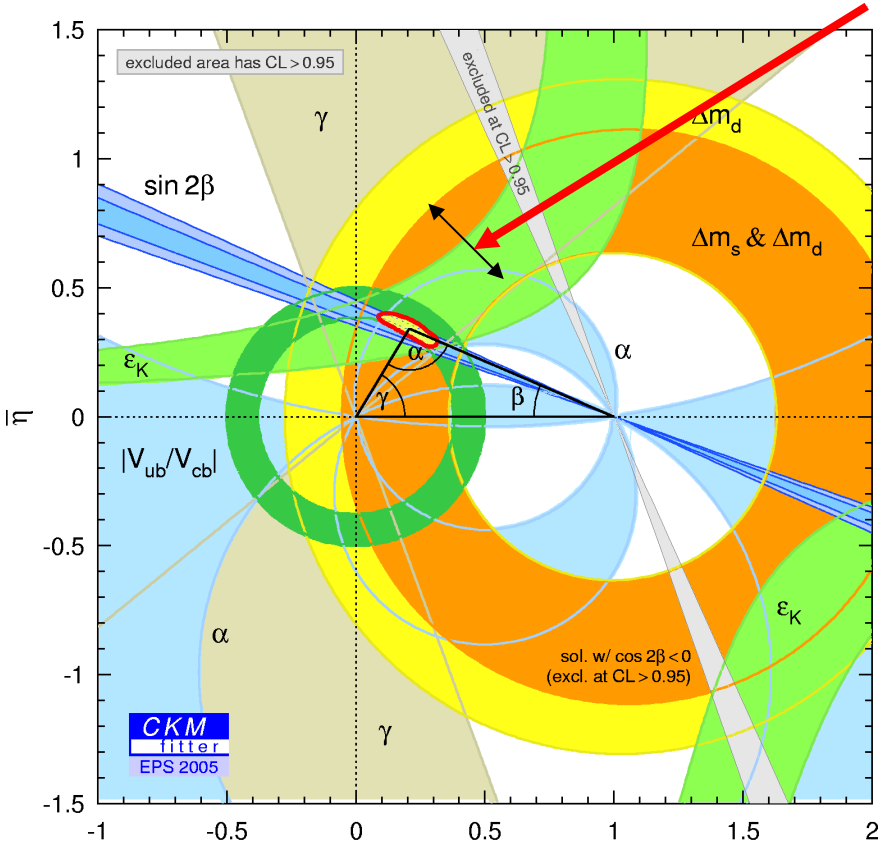
$17ps^{-1} < \Delta m_s < 21ps^{-1}$
(90% CL assuming Gaussian error)

(arXiv:hep-ex/0603029 v1 15 Mar 2006)

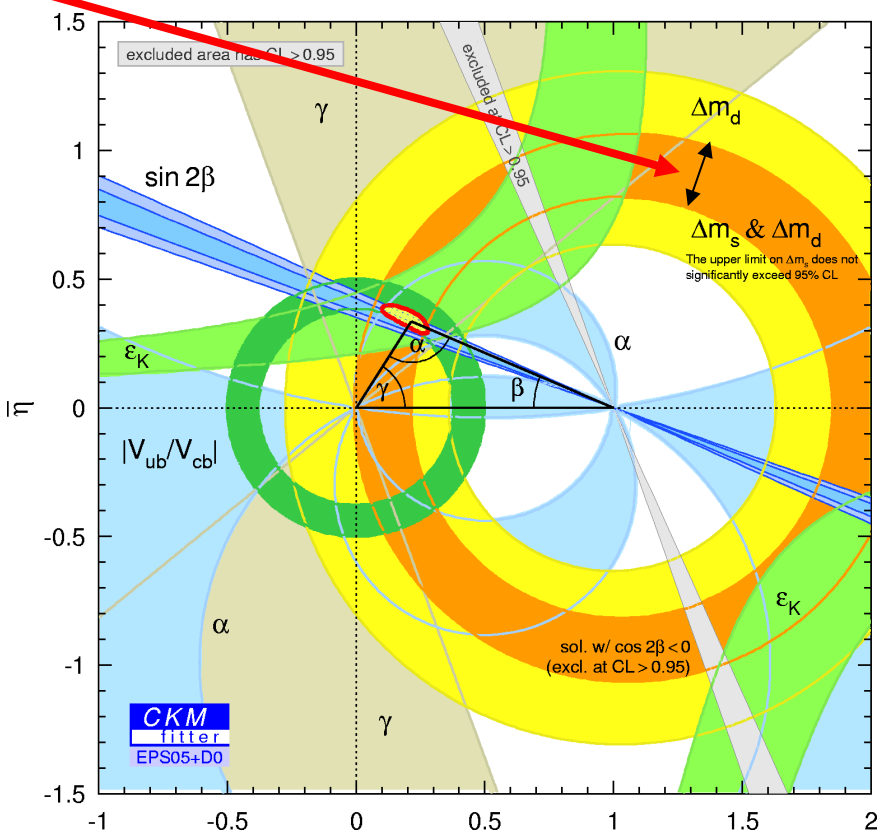
Unitarity triangle

$$\frac{\Delta m_d}{\Delta m_s} = \frac{m_{B_d^0}}{m_{B_s^0}} \cdot \frac{B_{B_d^0} \cdot f_{B_d}^2}{B_{B_s^0} \cdot f_{B_s}^2} \cdot \frac{|V_{td}|^2}{|V_{ts}|^2}$$

restriction



without DØ



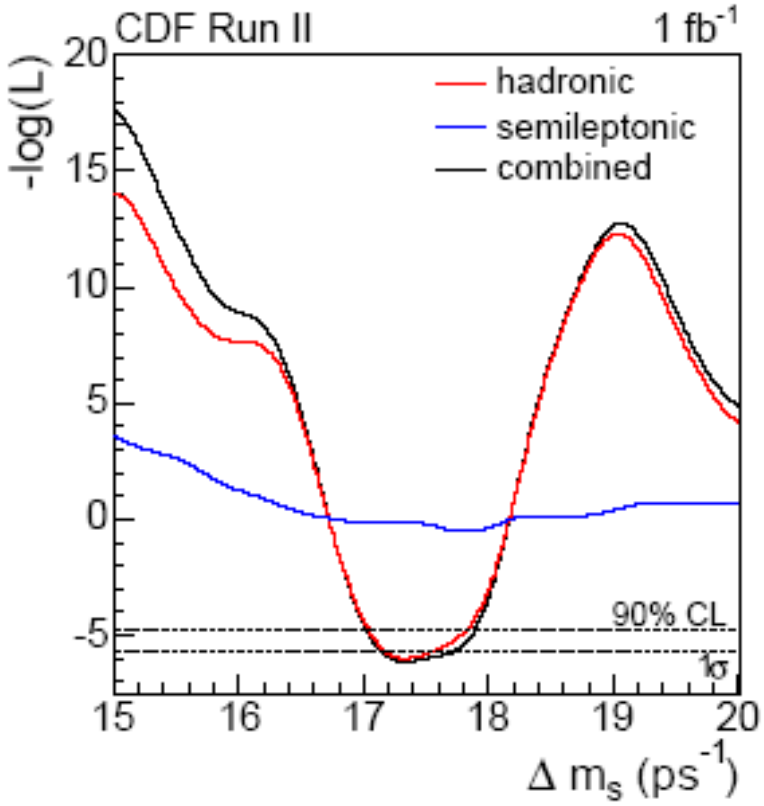
with DØ result

(Theoretical error dominates uncertainty)

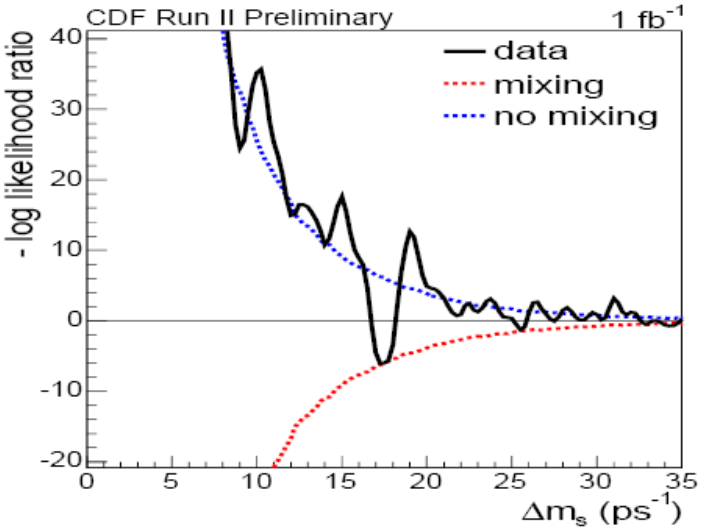
Summary

- DØ: large spectrum of B-physics analyses with up to $1fb^{-1}$ data
- Bottomium $\Upsilon(1S)$:
  - Cross section: $695\pm14(stat)\pm68(sys)\pm45(lumi)$ $|y|<1.8$
  - differential cross section: no deviation from theory,
- X(3872)$\rightarrow$ compatible with charmionium state
- Bs mixing measurement
  - amplitude methode:
    - Sensitivity $\Delta m_s > 14.1 ps^{-1}$ mit 95% CL
    - Limit $\Delta m_s > 14.8 ps^{-1}$ mit 95% CL
  - Log likelihood of Δm_s:
    - $17 ps^{-1} < \Delta m_s < 21 ps^{-1}$ (90% CL, assuming gaussian error)
    - New CDF result: $17.33\pm0.42\pm0.07\ ps^{-1}$

CDF result



- Result dominated by hadronic Channel
- Impact parameter trigger
- Good same side (Kaon) tagging



$$\Delta m_s = 17.33^{+0.42}_{-0.21}(stat.) \pm 0.07(syst.)\text{ps}^{-1}$$

Systematic dominated by the *ct* scale, any other effect very small

31, G. Gómez-Ceballos, April 2006, FPCP, Vancouver, Canada