B Lifetime and B_s Parameters
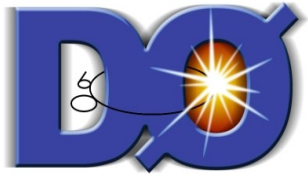
Thorsten Kuhl

Manchester EPS 2007

- Motivation
- Results
- Conclusion and outlook

bmb+f

Großgeräte
der physikalischen
Grundlagenforschung

JOHANNES
GUTENBERG
UNIVERSITÄT
MAINZ

Introduction

- B-physics active area at DØ. This year:

  - 2 published papers

  - 6 submitted papers

- Topics:

  - Λ_B lifetime measurements (-> Eduard de la Cruz Burelo)
  - B_s mixing parameter measurements Δm_s, $\Delta\gamma_s$, ϕ_s
  - Charge asymmetries (->Kosta Holubyev)
  - $B_s \rightarrow \mu^+\mu^-$ (->Artur Maciel)
  - New particle: Ξ_{b} (-> Eduard de la Cruz Burelo)
  - L=1 B-Meson observation and properties
  - Branching ratios: $B_s \rightarrow D_s^* D_s^*$
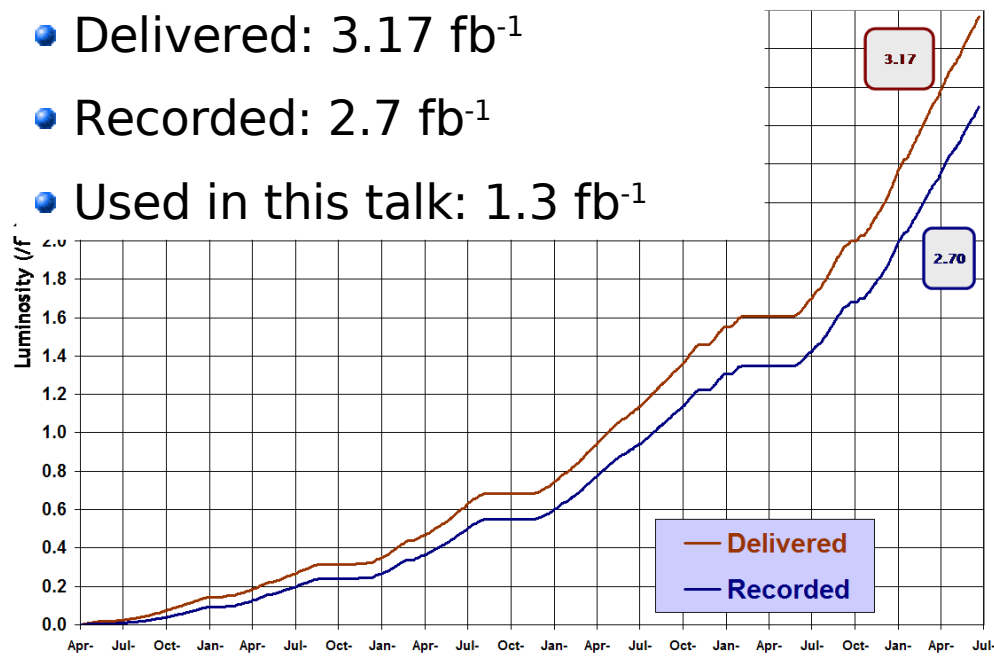 - Upsilon polarisation (->Valentin Kuzmin)
  - ...

Tevatron

- pp collisions @ √s = 1.96 TeV
- Bunch spacing: 396 ns
- Inst. luminosity: max. $2{,}85 \cdot 10^{32}$ cm^{-2}s^{-1}
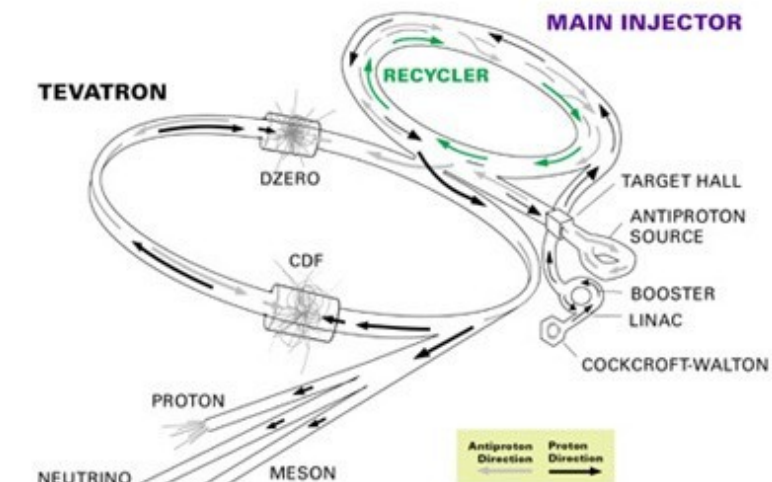
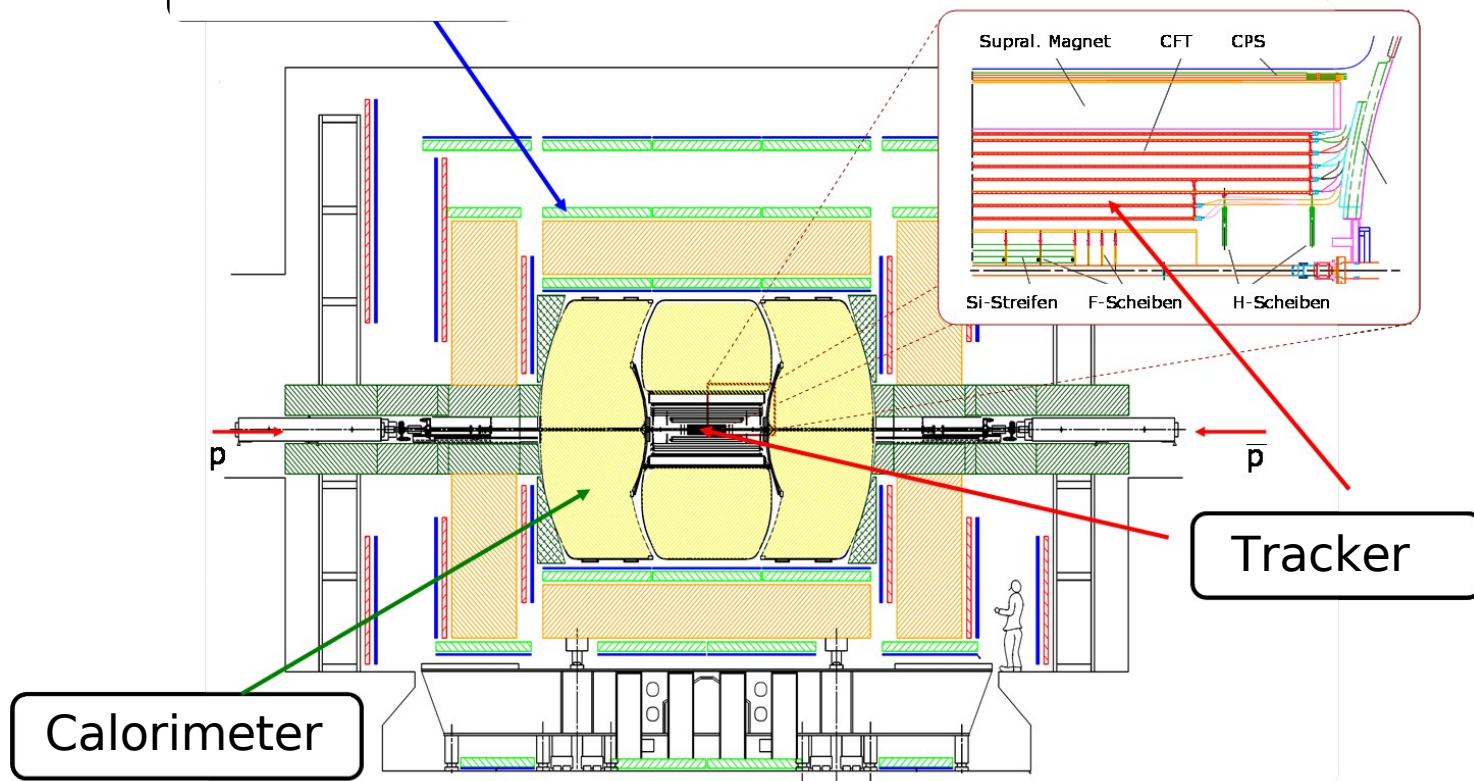**Run II Integrated Luminosity** | 19 April 2002 – 8 July 2007

- Delivered: 3.17 fb^{-1}
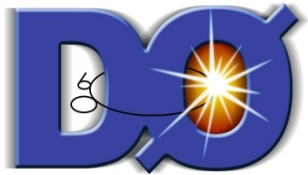- Recorded: 2.7 fb^{-1}
- Used in this talk: 1.3 fb^{-1}

B lifetime and Bs Parameters at D0
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Muon system

Supral. Magnet   CFT   CPS

Si-Streifen   F-Scheiben   H-Scheiben

p $\bar{p}$

Tracker

Calorimeter

- Compact tracking system $|\eta|=3$

- High muon acceptance up to $|\eta|=2$

HQET and Lattice QDC provide precise prediction for ratios of llifetimes of B mesons decaying weekly

- well below threshold for strong decays

- theory improvements (2003) by unquenched lattice QCD calculation

$$\frac{\tau_1}{\tau_2} = 1$$

$$+ \left(\frac{\Lambda}{m_Q}\right)^2 \cdot ((\text{small}) \text{ isospin breaking})$$
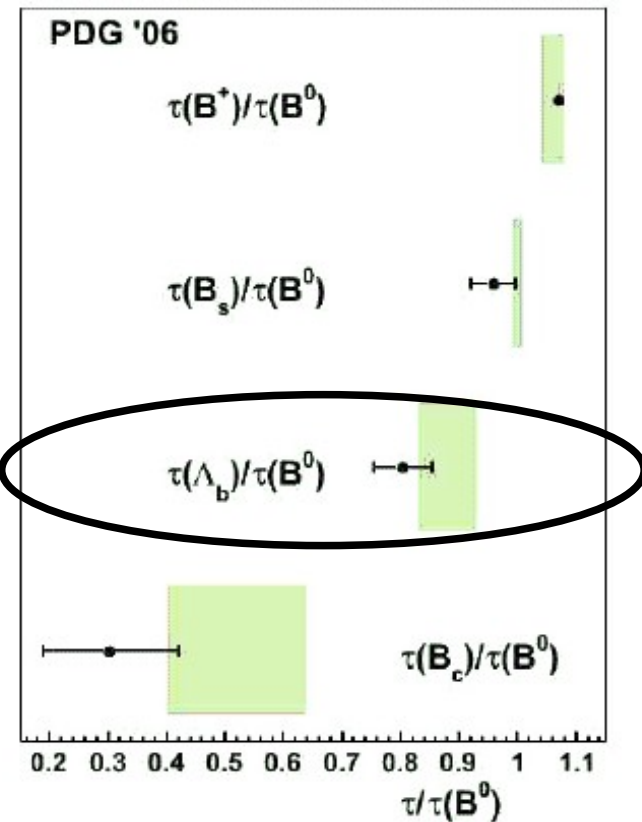
$$+ \left(\frac{\Lambda}{m_Q}\right)^3 \cdot (\text{spectator effects})$$

$$+ \cdots$$

- New measurement of CDF (2006, 1fb^{-1})

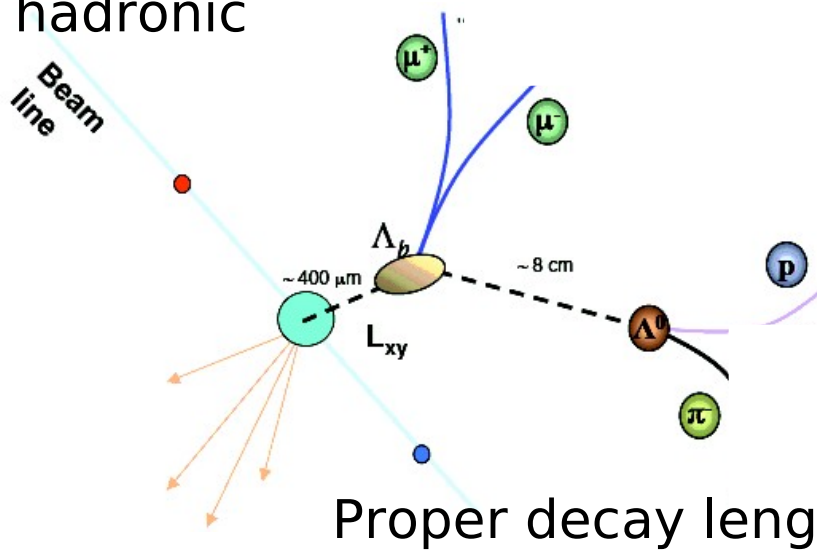$$\frac{\tau(\Lambda_b)}{\tau(B^0)} = 1.041 \pm 0.057$$

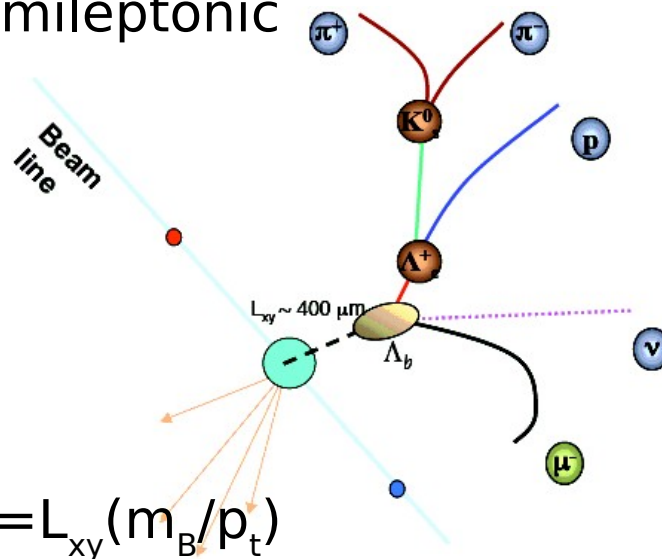- Two new DØ measurements: $\Lambda_B \to J/\Psi\ \Lambda$ and $\Lambda_B \to \Lambda_c^+ \mu^- \nu$

PDG '06

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

$\tau(B_s)/\tau(B^0)$

$\tau(\Lambda_b)/\tau(B^0)$

$\tau(B_c)/\tau(B^0)$

0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1 1.1

$\tau/\tau(B^0)$

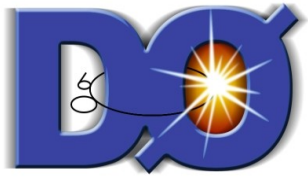hadronic

semileptonic


Proper decay length: $l=L_{xy}(m_B/p_t)$

- Fully reconstructable

- boost known

- low statistics

- hep-ex 0704.3909 (submitted to PRL → Talk from Eduard de la Cruz Burelo)

- more ambiguities

- need to correct for missing neutrino momentum

- large statistics

- hep-ex 0706.2358 (submitted to PRL)

$\Lambda_B \rightarrow \Lambda_C^+ \mu^- \nu_\mu$
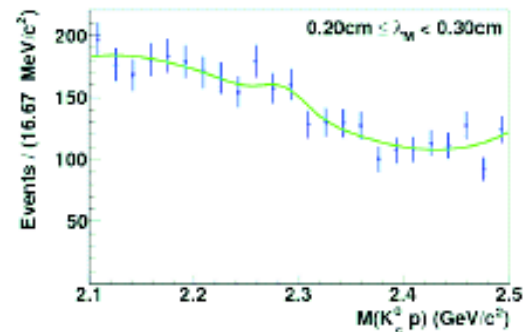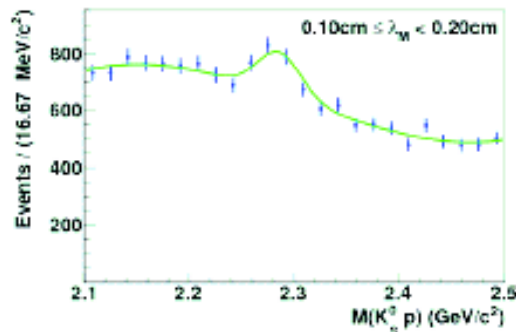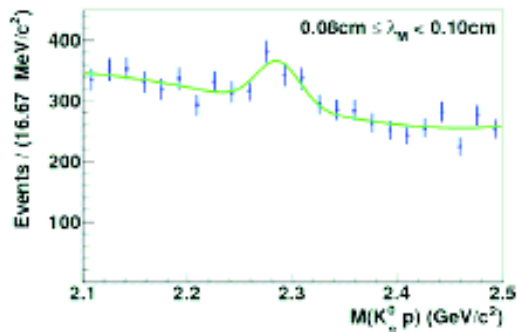
- Huge background after cuts:

  multivariate likelihood selection

  - Discriminating variables:

    several p_t, $M(\Lambda_B)$, isolation

  - Reference distributions

    from data
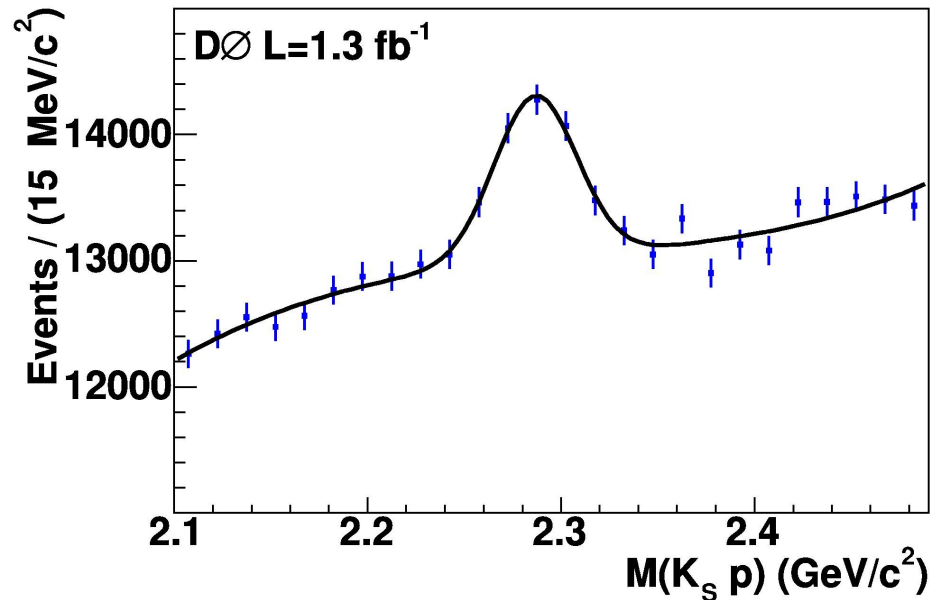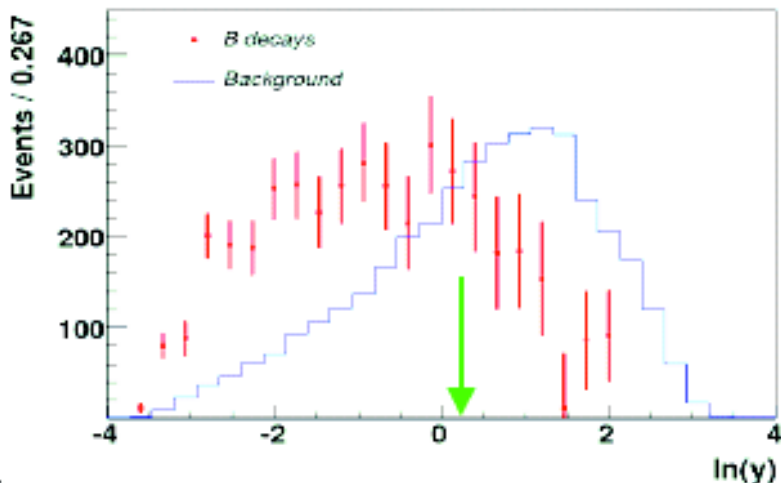
- Final signal sample:

  4437±329 events
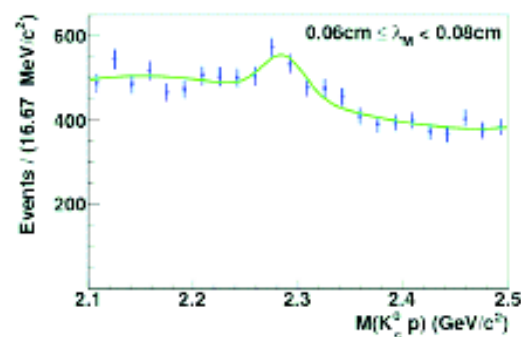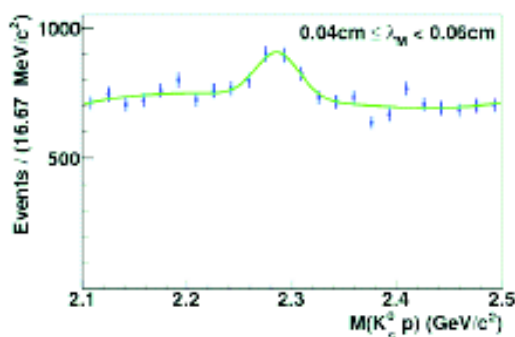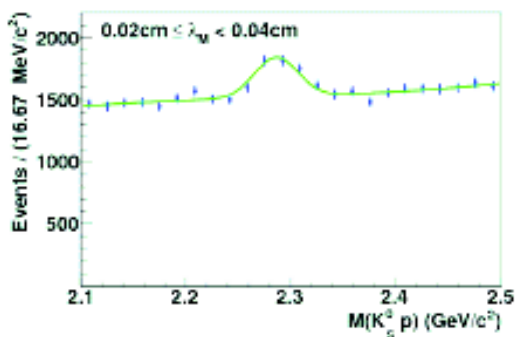
- Systematics of unbinned maximum likelihood would be completely dominated by background modeling

- Use binned χ^2 and fit mass in every bin for yield

- background still dominates systematic error

B lifetime and Bs Parameters at D0
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- Distribution of measured VPDL:

$$F_s(\lambda_M) = \int d(K) H(K) \left[\frac{K}{c\tau(\Lambda_b)} e^{-K\lambda/c\tau(\Lambda_b)} \otimes R_l(\lambda_M - \lambda, s) \right]$$

- Resolution function

$$R(\lambda_M - \lambda, s) = \int P(\sigma) G(\lambda_M - \lambda, \sigma, s) d\sigma$$

- Scale factor for the impact parameter in the data about 1.19

- 3 parameters in the fit:
  - N_{tot}
  - charm-fraction
  - lifetime
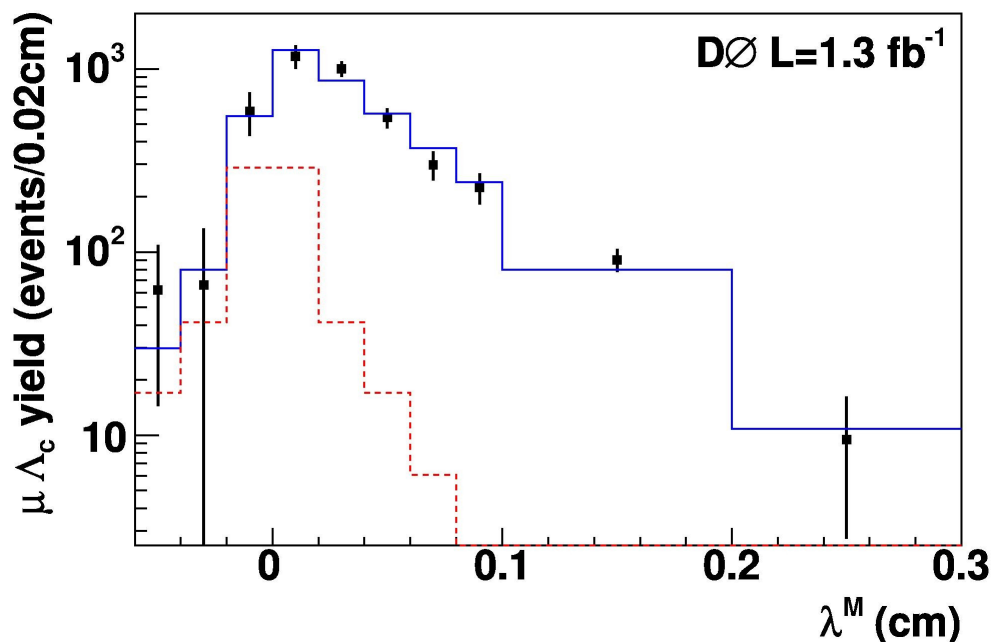
$$\tau(\Lambda_b) = 1.290^{+0.119}_{-0.110}(stat)^{+0.087}_{-0.091}(syst)\, ps$$

D∅ L=1.3 fb⁻¹

Combination and conclusion

- Two new DØ results for Λ_b lifetime

- Combined result:

    $\tau = 1.25 \pm 0.10$ ps

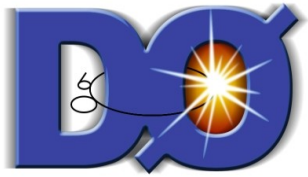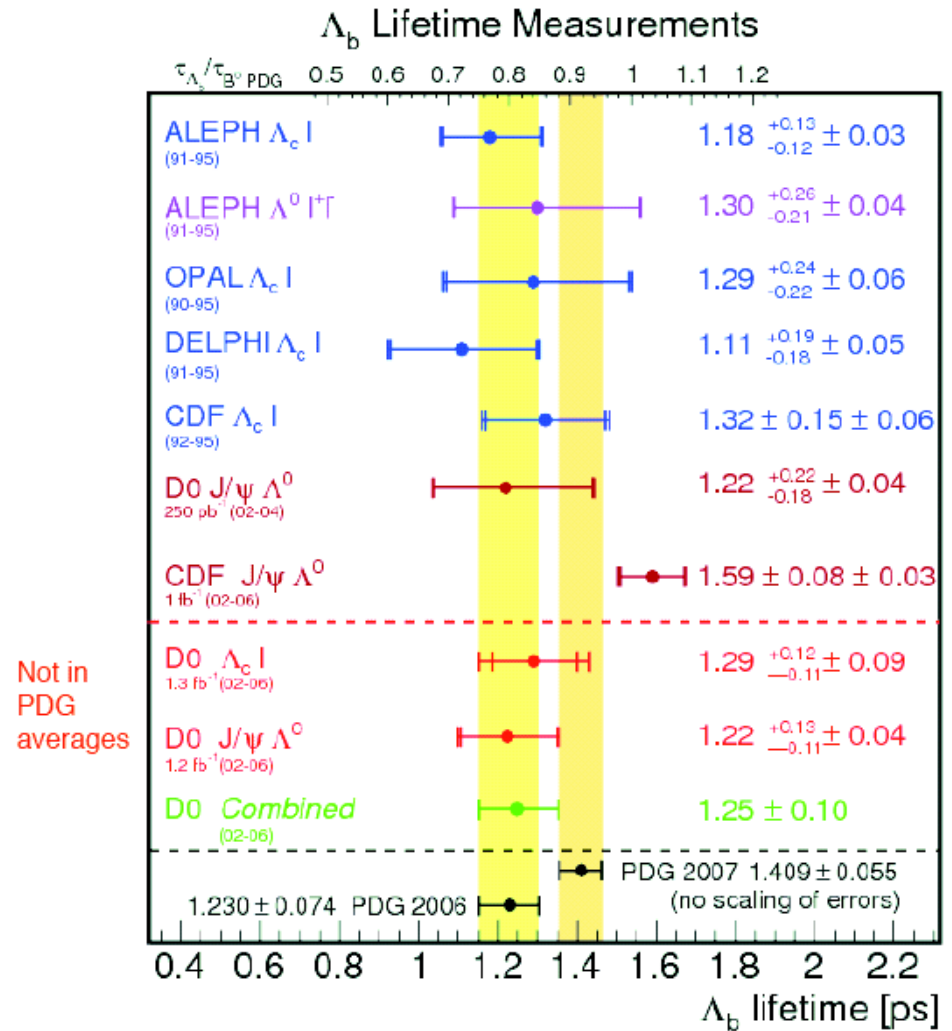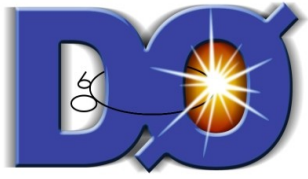- Combined results same order of precision like the CDF result from 2006

- Everything matches well except CDP measurement

Λ_b Lifetime Measurements

ALEPH Λ_c l (91-95)		$1.18\ ^{+0.13}_{-0.12} \pm 0.03$
ALEPH Λ^0 l$^+$l$^-$ (91-95)		$1.30\ ^{+0.26}_{-0.21} \pm 0.04$
OPAL Λ_c l (90-95)		$1.29\ ^{+0.24}_{-0.22} \pm 0.06$
DELPHI Λ_c l (91-95)		$1.11\ ^{+0.19}_{-0.18} \pm 0.05$
CDF Λ_c l (92-95)		$1.32 \pm 0.15 \pm 0.06$
D0 J/$\psi\ \Lambda^0$ 250 pb^{-1} (02-04)		$1.22\ ^{+0.22}_{-0.18} \pm 0.04$
CDF J/$\psi\ \Lambda^0$ 1 fb^{-1} (02-06)		$1.59 \pm 0.08 \pm 0.03$
D0 Λ_c l 1.3 fb^{-1} (02-06)		$1.29\ ^{+0.12}_{-0.11} \pm 0.09$
D0 J/$\psi\ \Lambda^0$ 1.2 fb^{-1} (02-06)		$1.22\ ^{+0.13}_{-0.11} \pm 0.04$
D0 *Combined* (02-06)		1.25 ± 0.10

Not in PDG averages

PDG 2007 1.409 ± 0.055 (no scaling of errors)

1.230 ± 0.074 PDG 2006

Λ_b lifetime [ps]

- Oscillation of neutral meson $\left|B_s^0\right\rangle$ into its antiparticle $\left|\overline{B_s^0}\right\rangle$

- 3 Observables:

  - Mass difference: Δm_s (see PRL 97,021802 (2006))

  - Width difference: $\Delta\Gamma_s$

  - Phase between CP and mass eigenstate: $\phi = \arg(\Gamma_{12}/M_{12})$

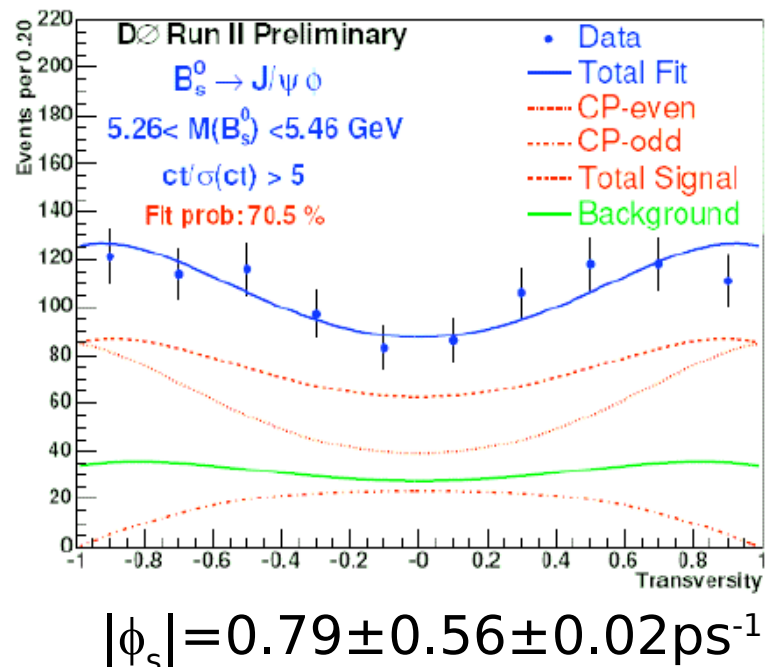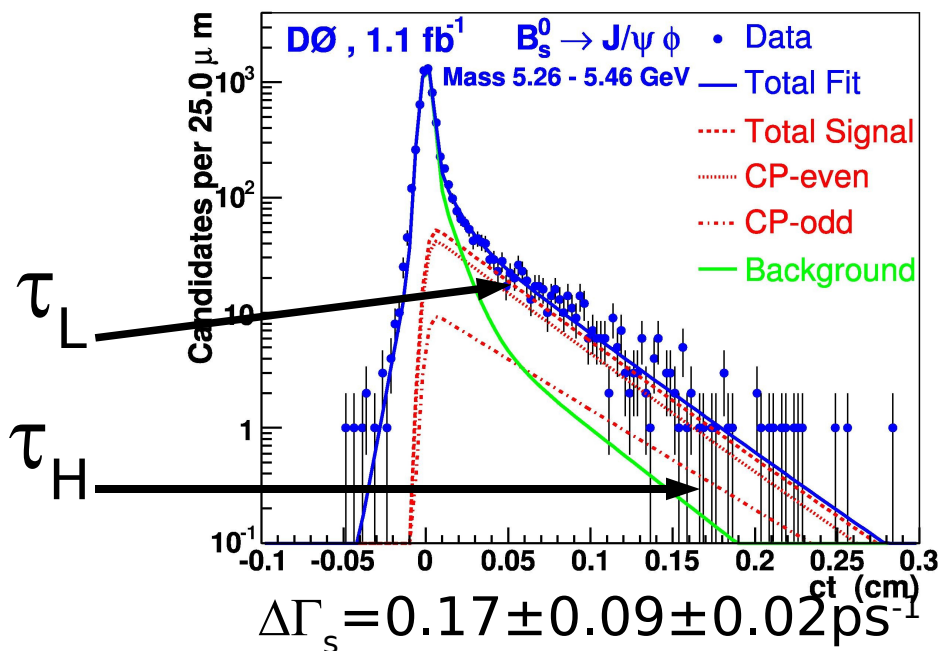- CP breaking phase direct measurable in decay of B_s into CP eigenstates

$$i\,\frac{\partial}{\partial t}\begin{pmatrix} B_s^0 \\ \overline{B_s^0} \end{pmatrix} = \begin{pmatrix} m-\dfrac{i}{2}\Gamma & m_{12}-\dfrac{i}{2}\Gamma_{12} \\ m_{12}^{*}-\dfrac{i}{2}\Gamma_{12}^{*} & m-\dfrac{i}{2}\Gamma \end{pmatrix}\begin{pmatrix} B_s^0 \\ \overline{B_s^0} \end{pmatrix}$$
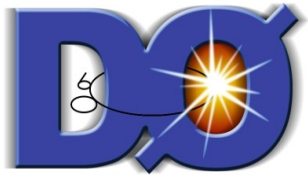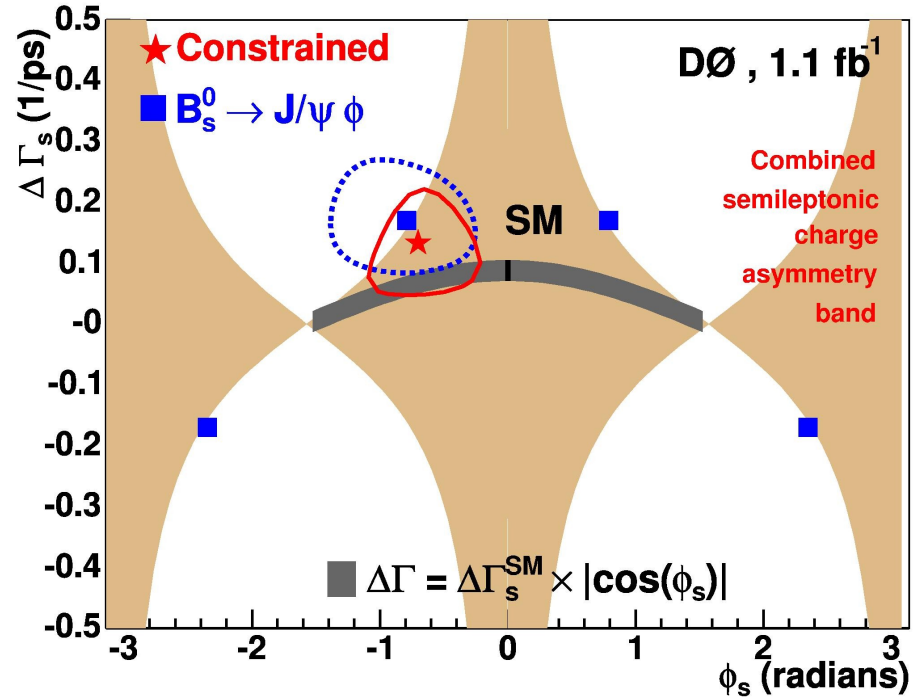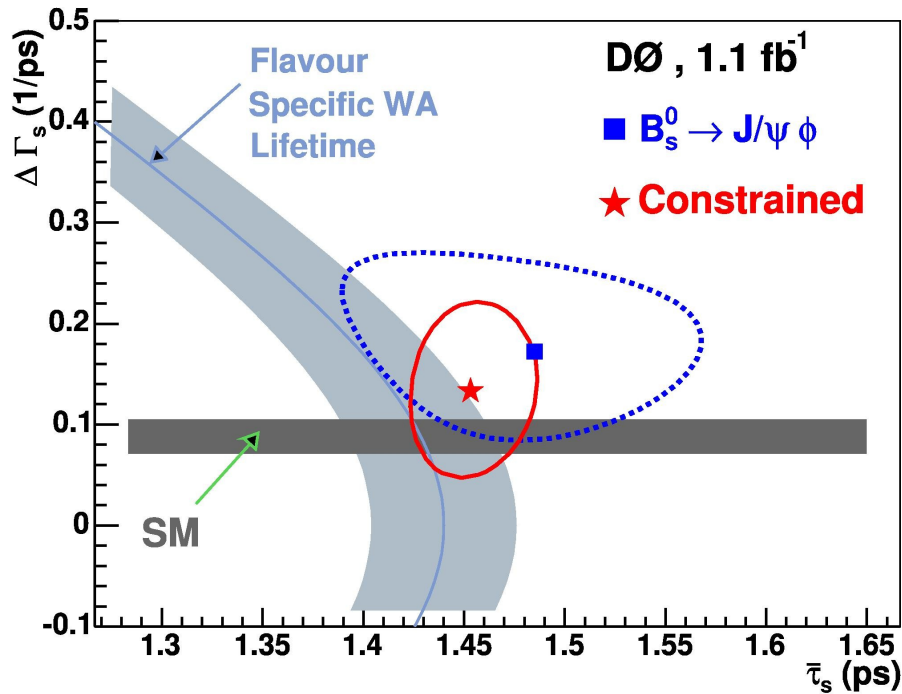
P wave

CP odd

B_s

$J/\psi\ \phi$

CP even

S,D wave
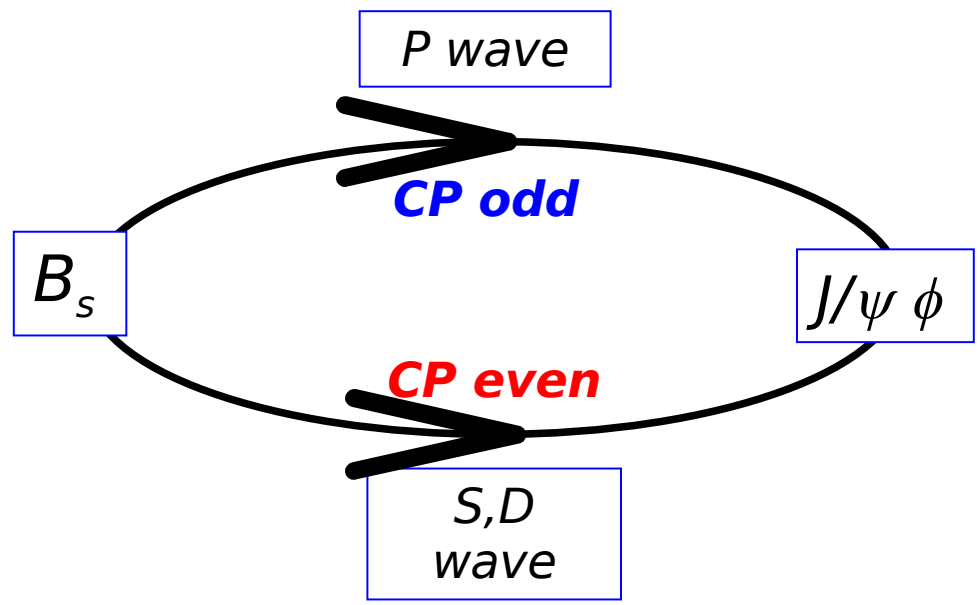
- Measurements (PRL 98,121801 (2007)):
  - $\Delta\Gamma \rightarrow$ difference of τ_L and τ_H
  - $\phi_s \rightarrow$ angular correlation (decay plane of J/Ψ and ϕ)
  - Simultaneous fit

$\Delta\Gamma_s = 0.17 \pm 0.09 \pm 0.02 \text{ps}^{-1}$

$|\phi_s| = 0.79 \pm 0.56 \pm 0.02 \text{ps}^{-1}$
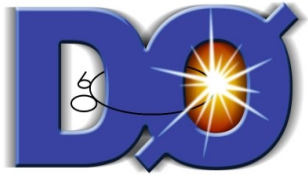
- brown: charge asymmetry measurement (talk from K. Holubvey)
- blue: J/$\Psi\phi$ → four fold ambiguity
- red: combination with charge asymmetry

Summary

- Λ_b lifetime: two new measurements by DØ

  - $\Lambda_b \to \Lambda_c \mu \nu$: $\quad \tau = 1.290 \pm 0.119$(stat.)$\pm 0.091$(syst.)ps

  - $\Lambda_b \to J/\Psi \, \Lambda$: $\tau = 1.218 \pm 0.130$(stat.)± 0.042(syst.)ps

  - Combined: $\quad \tau = 1.250 \pm 0.10$ ps
  - Combination as sensitive as CDF result from 2006
  - Compatible with calculation and earlier measurements

- B_s parameters: measurement of $\Delta\Gamma$ and first measurement of $\Delta\phi$ in B_s decay into CP-eigenstate $J/\Psi \, \phi$

  - $\Delta\Gamma_s = 0.17 \pm 0.09$ps^{-1}; $\quad |\phi_s| = 0.79 \pm 0.56$

  - with $|\phi_s| = 0$ (SM): $\Delta\Gamma_s = 0.12 \pm 0.09$ps^{-1}

  - Improvement in combination with charge asymmetry measurements: (K. Holubyev)

  - Δm_s: Next update will include same side tagging, more channels and luminosity; expect a much higer sensitivity

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