Looking for New Physics in the b-Quark System

Dmitri Tsybychev
SUNY at Stony Brook
On behalf of DØ Collaboration

Wine and Cheese Seminar

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Outline

- Introduction
- B_s system
  - Mixing and related quantities
- Direct CP violation in $B^+ \to J/\psi K^+$
- Summary

The CKM Matrix

- Quark Weak ≠ Mass Eigenstates

$$L = \frac{g}{\sqrt{2}} \left(\overline{u}, \overline{c}, \overline{t} \right)_L V_{CKM} \gamma_\mu \begin{pmatrix} d \\ s \\ b \end{pmatrix}_L W^\mu + h.c.$$

⇒ CKM Mixing Matrix

- 3 angles
- 1 complex phase ⇒ CP-violation
- CPV requires $m(q_i) \neq m(q_j)$
- CPV in SM is not enough to account for baryon density

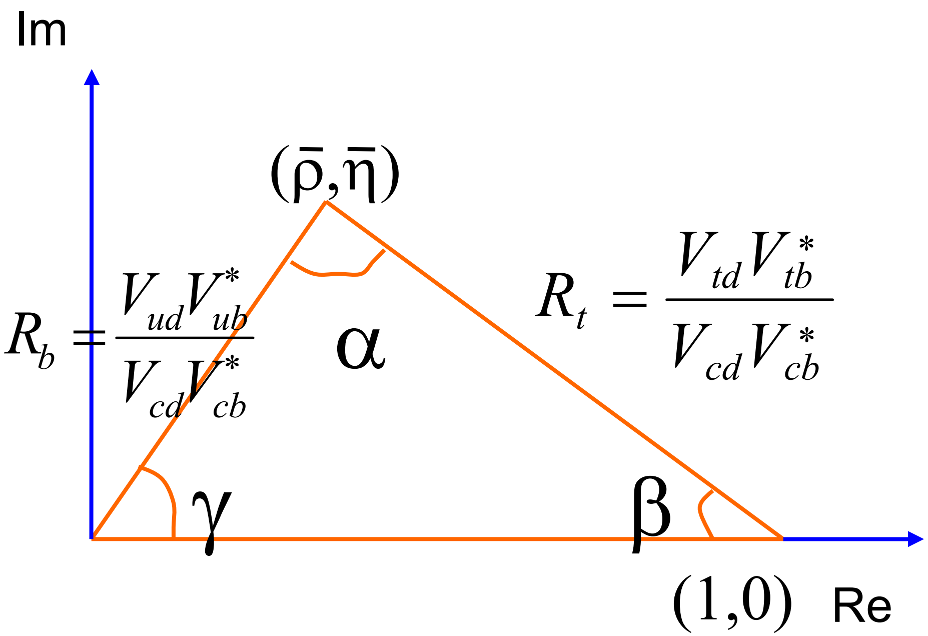
Weak $\begin{pmatrix} d' \\ s' \\ b' \end{pmatrix} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} \begin{pmatrix} d \\ s \\ b \end{pmatrix}$ Mass

⇒ Unitary:

$$V_{ud}V_{ub}^* + V_{cd}V_{cb}^* + V_{td}V_{tb}^* = 0$$

Unitarity Triangle

- Vector sum in complex plane



- In SM, has to be closed ($\alpha+\beta+\gamma=180^0$)
- Area of triangle indicates CP violation in SM due to CKM "non-flat" → $\eta \neq 0$.
- Measure all sides
- Measure all angles
- Are they consistent?

B^0_s-$\overline{B}^0_s$ Mixing and V_{td}

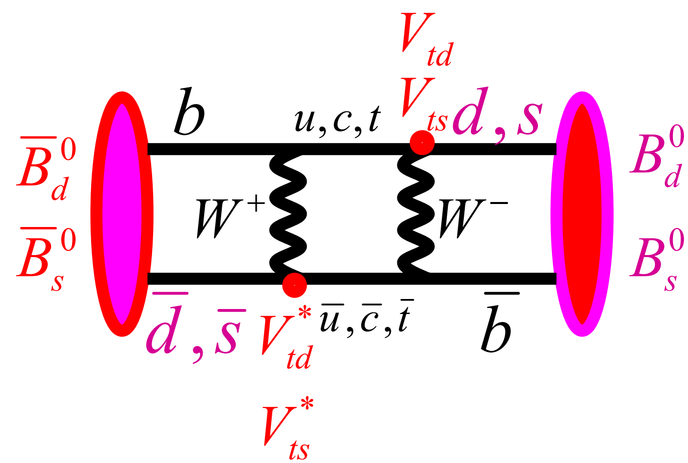
- B_d oscillation frequency:

$$\Delta m_d = \frac{G_F^2}{6\pi^2} m_{B_d} m_t^2 \, F\left(\frac{m_t^2}{m_W^2}\right) B_{B_d} f_{B_d}^2 \eta_{QCD} \left| V_{tb}^* V_{td} \right|^2$$

Well measured
Δm_d=0.509±0.004 ps^{-1}

Large uncertainty ~15-20%

Want



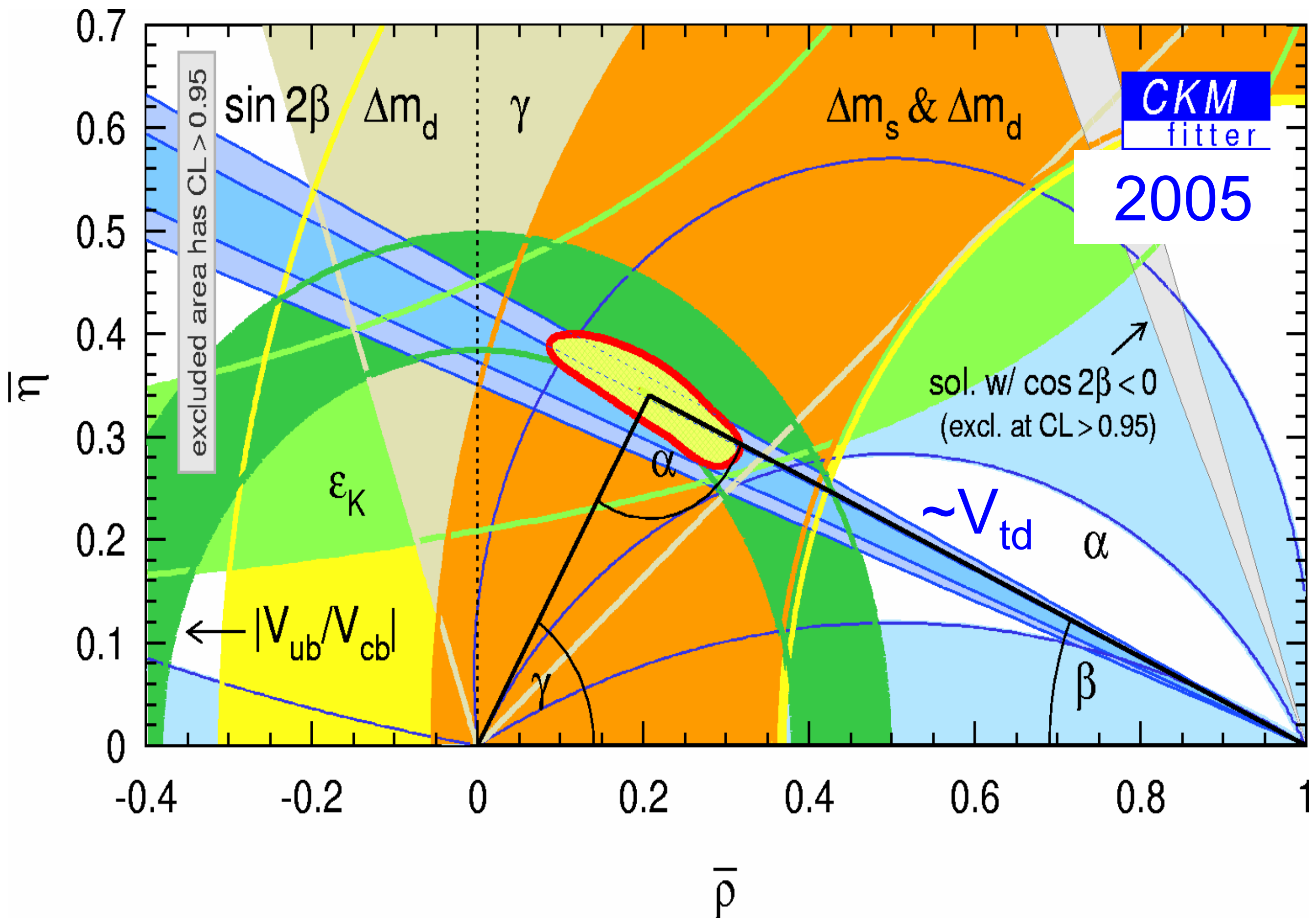
- Dominant theoretical uncertainties cancel in the ratio ⇒

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

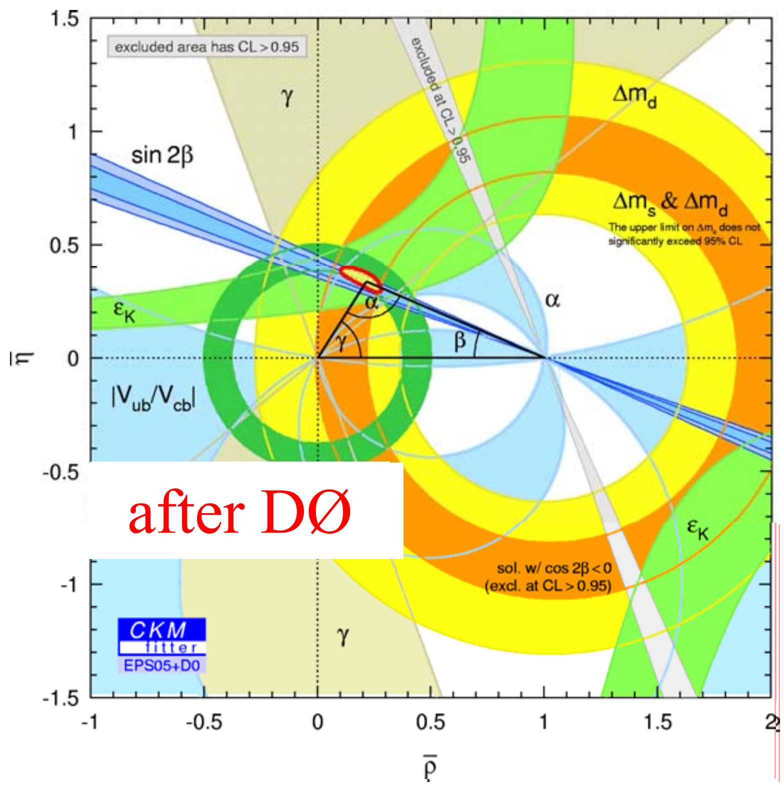
Smaller uncertainty

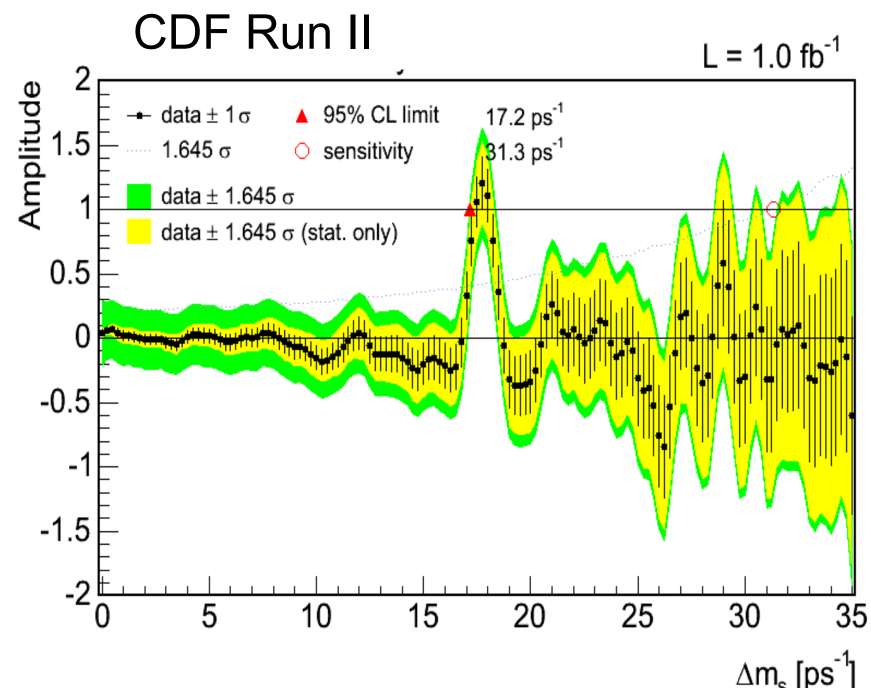
Measure Δm_s

The CKM Triangle (2005)



Δm_s and V_{td}





$$\frac{|V_{td}|}{|V_{ts}|} = 0.2060 \pm 0.0007(ex.)^{+0.0081}_{-0.0060}(theo.)$$

Rule out large new physics effects: DØ Collab. PRL 97 021802 (2006)

Precision SM measurement: CDF Collab. PRL 97 242003 (2006)

History of Mixing

- Particle ↔ antiparticle oscillation was first pointed out by Gell-Mann and Pais in 1955 (Phys. Rev. **97**,1387 (1955))

- Mixing in K0 system → charm quark
  discovery of CP violation
  third generation
- Mixing in Bd system → early indication of a heavy top
- Mixing in neutrino system → neutrinos are massive
- Mixing in the Bs system → new physics ?

B^0_s-$\overline{B}^0_s$ Mixing

- Light and heavy B meson mass eigenstates differ from flavor eigenstates:

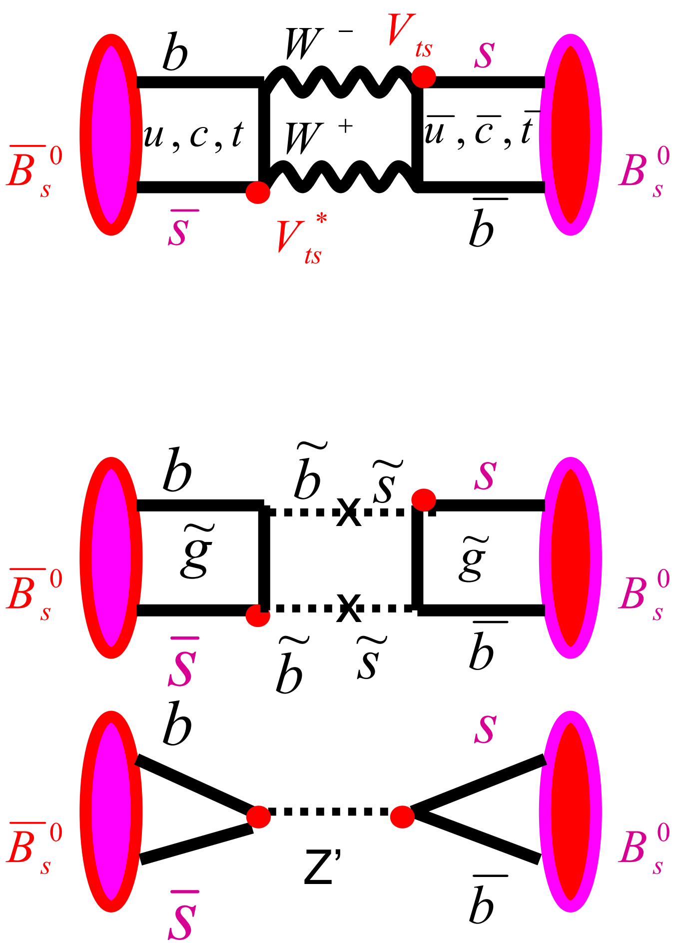
$$|B_L\rangle = p|B^0\rangle + q|\overline{B}^0\rangle$$
$$|B_H\rangle = p|B^0\rangle - q|\overline{B}^0\rangle$$

$$\hat{H}\begin{pmatrix} B^0 \\ \overline{B}^0 \end{pmatrix} = \begin{pmatrix} M - \frac{i\Gamma}{2} & M_{12} - \frac{i\Gamma_{12}}{2} \\ M_{12}^* - \frac{i\Gamma_{12}^*}{2} & M - \frac{i\Gamma}{2} \end{pmatrix}\begin{pmatrix} B^0 \\ \overline{B}^0 \end{pmatrix}$$

$$\Delta m_s = M_H - M_L \cong 2|M_{12}|$$
$$\Delta\Gamma_s = \Gamma_L - \Gamma_H \cong 2|\Gamma_{12}|\cos\varphi_s$$
$$\varphi_s = \arg\left(-\frac{M_{12}}{\Gamma_{12}}\right); \quad A_{SL} = \mathrm{Im}\frac{\Gamma_{12}}{M_{12}} = \left|\frac{\Gamma_{12}}{M_{12}}\right|\sin\varphi_s$$

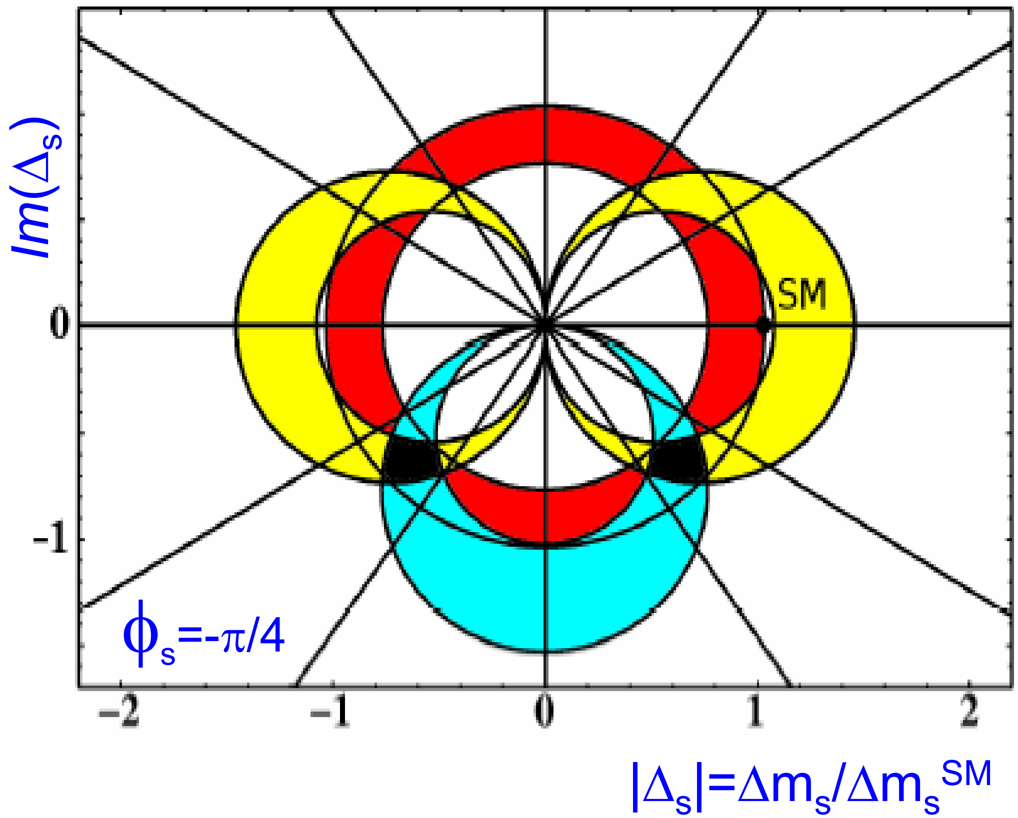
Measure all four at Tevatron

Standard Model and New Physics



- Γ^s_{12} governs decays (tree level)
  - Not sensitive to New Physics
- M^s_{12} governs oscillations(loop level)
  - Sensitive to New Physics
  - New CP-violating phase
    - $\phi_s = \phi_s^{SM} + \phi^{NP}$
    - $M^s_{12} = M^{SM}_{12} \cdot \Delta_s$, $\Delta_s = |\Delta_s| e^{i\phi NP}$
      - Reduced Δm_s
      - $\Delta_s = 1$ in SM
    - $\Delta\Gamma_s = \Delta\Gamma_s^{SM} \cdot |\cos \phi_s|$
      - Reduced width

Standard Model and New Physics



- SM prediction:

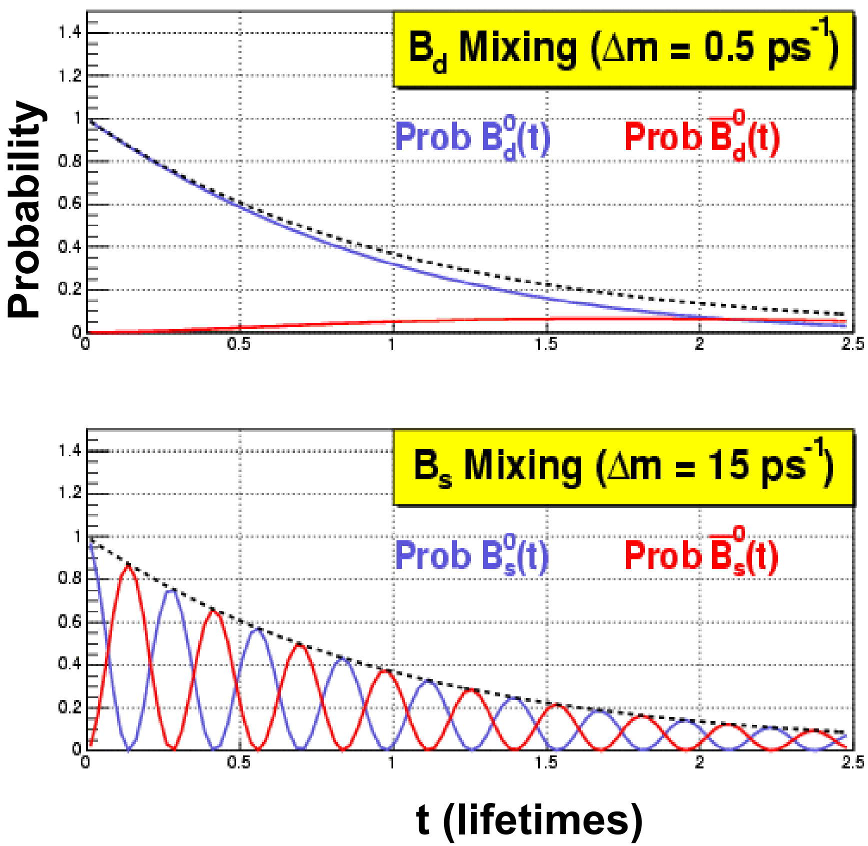
A.Lenz U. Nierste hep-ph/0612167

- $\Delta m_s = 19.3 \pm 6.7\ ps^{-1}$
- $\Delta\Gamma_s = 0.088 \pm 0.017\ ps^{-1}$
- $\phi_s = (4.2 \pm 1.4) \times 10^{-3}$

$\Delta M_s = 17.4\,\mathrm{ps}^{-1}$, $\Delta\Gamma_s = 0.068\,\mathrm{ps}^{-1}$, (Hypothetical measurements)

$\frac{\Delta\Gamma_s}{\Delta M_s} = 3.91 \cdot 10^{-3}$, $a_{\mathrm{fs}}^s = -3.89 \cdot 10^{-3}$.

B^0_s-$\overline{B}^0_s$ Mixing



$$P(B \to B) = \frac{e^{-\Gamma t}}{2}\left(\cosh\frac{\Delta\Gamma t}{2} + \cos\Delta m t\right)$$

$$P(B \to \overline{B}) = \frac{e^{-\Gamma t}}{2}\left(\cosh\frac{\Delta\Gamma t}{2} - \cos\Delta m t\right)$$

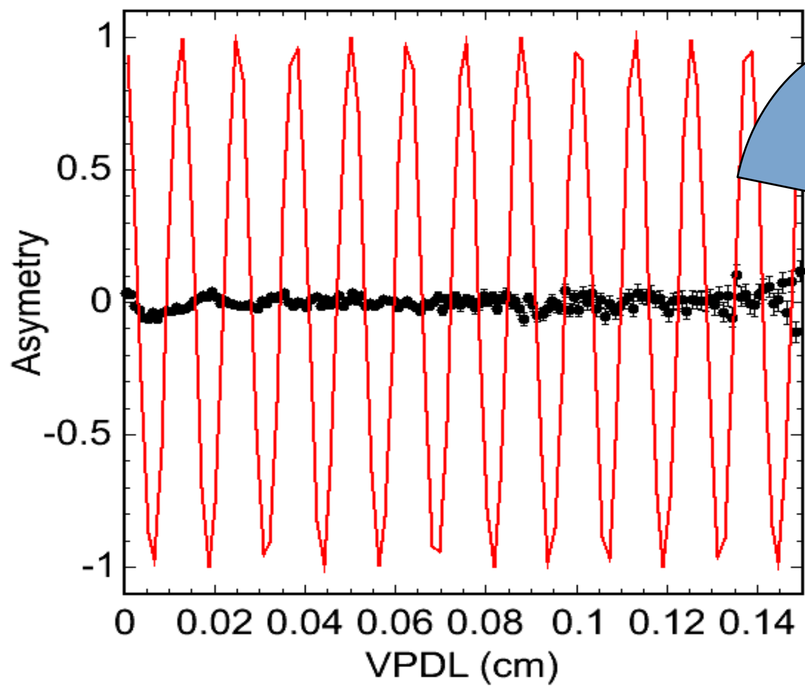
- Assume $\Delta\Gamma=0$

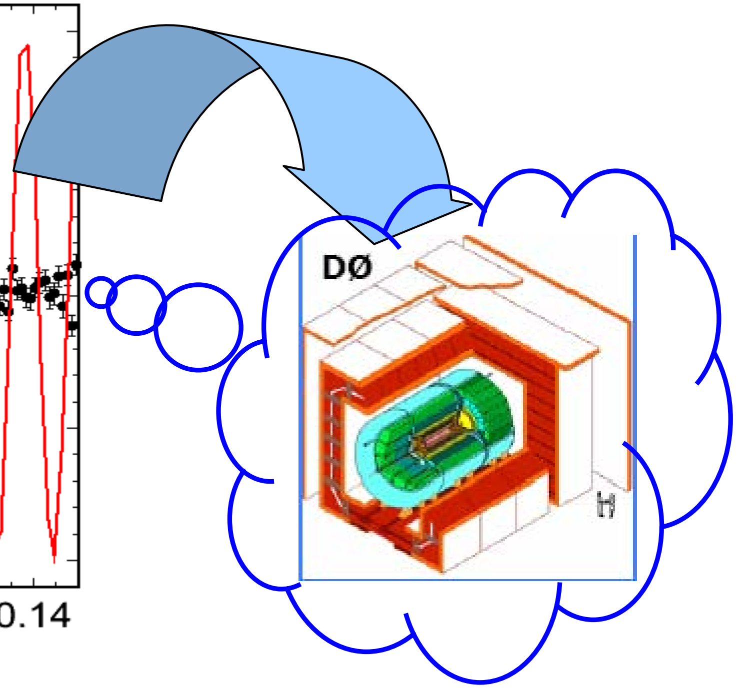
$$P_{u,m}(t) = \frac{1}{2}\Gamma e^{-\Gamma t}\left(1 \pm \cos\Delta m t\right)$$

- Δm_s large $\rightarrow$ measurement experimentally very challenging

B^0_s-$\overline{B}^0_s$ Oscillations Measurement

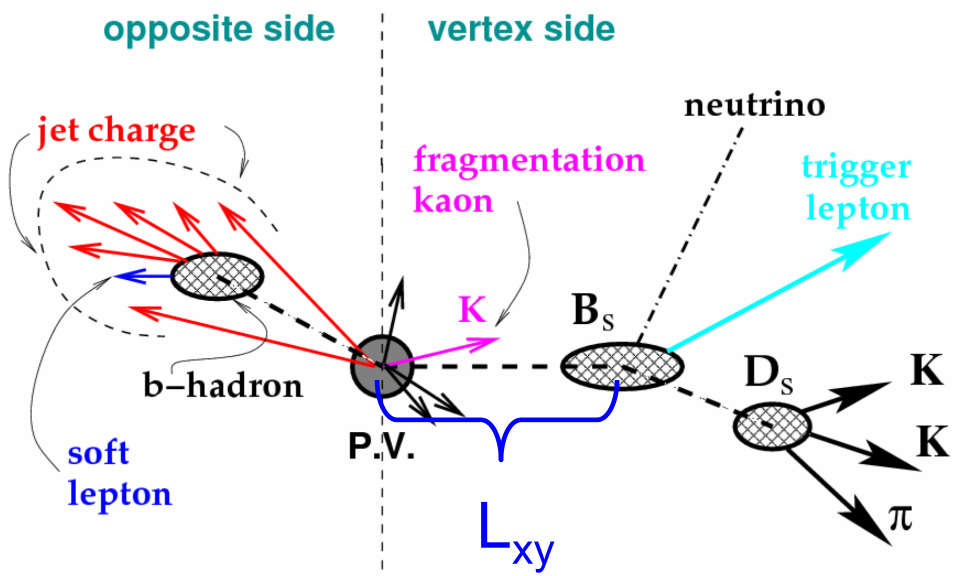
$$A(t_{B_s}) = \frac{N^{non-osc}(t_{B_s}) - N^{osc}(t_{B_s})}{N^{non-osc}(t_{B_s}) + N^{osc}(t_{B_s})} \propto \cos(\Delta m_s \cdot t_{B_s})$$



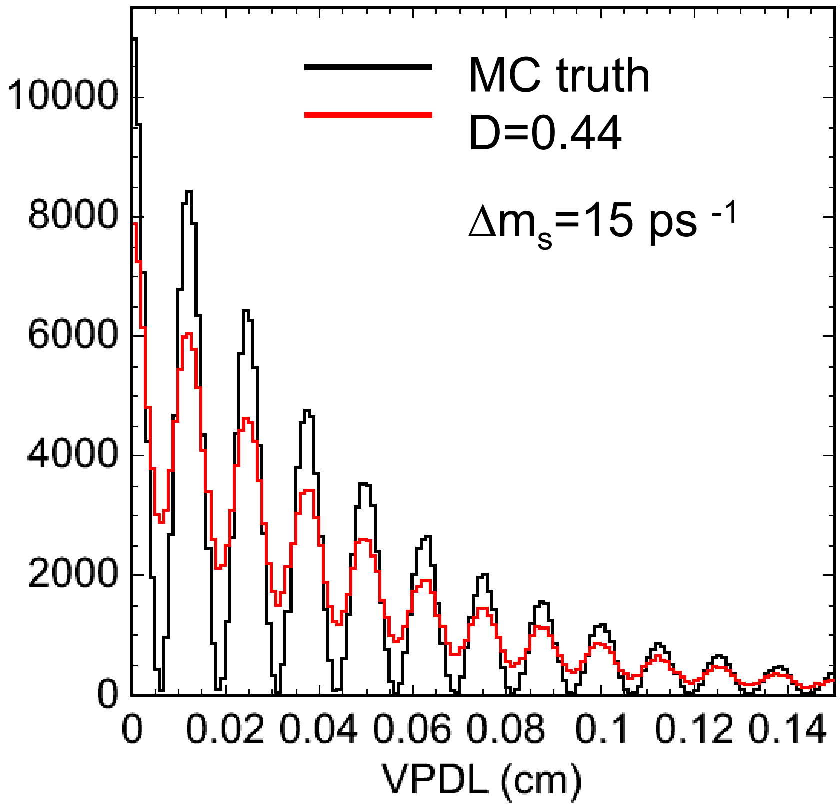


Analysis Overview

- Select final states suitable for the Δm_s measurement
  - Flavor specific decays
- Determine proper decay time: $ct = m_{Bs} L_{xy} / p_T$
  - Resolution
- Tag mixed and unmixed
  - Tag B_s meson flavor at production time (initial state)
- Fit for Δm_s



Effect of Flavor Tagging



- Lifetime distribution for unmixed B^0_s mesons

$$P_{osc,nosc}(t) = \frac{1}{2}\Gamma e^{-\Gamma t}\left(1 \mp \cos \Delta m t\right)$$

$$\Downarrow$$

$$P_{osc,nosc}(t) = \frac{1}{2}\Gamma e^{-\Gamma t}\left(1 \mp D \cos \Delta m t\right)$$

D- Dilution

Effect of Resolution

- Proper decay time resolution has contribution from decay length (L_T) and boost

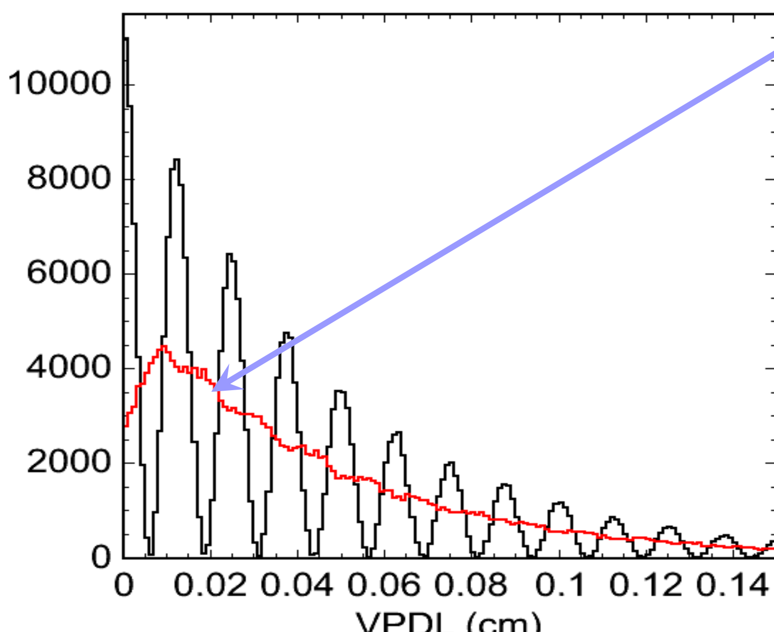
Proper decay time:

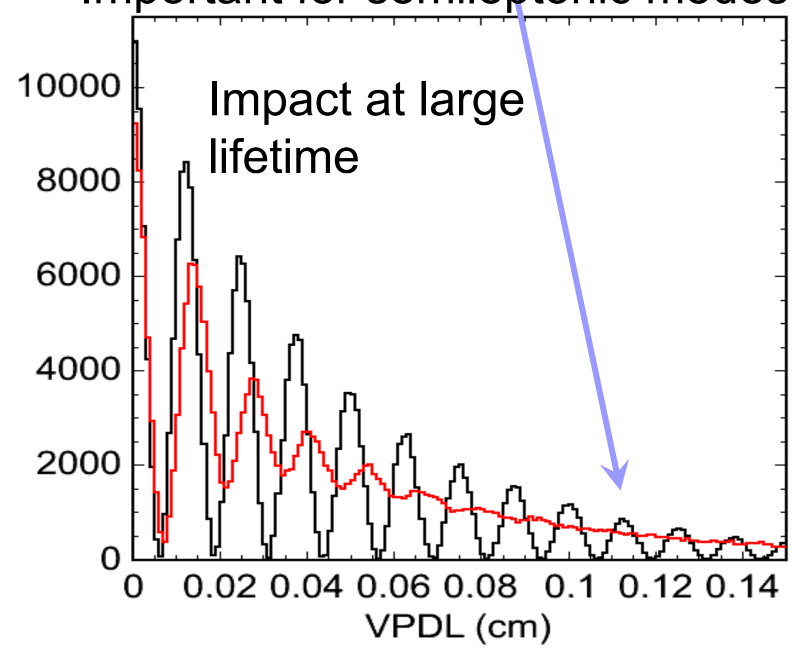
$$ct = m_{B_s} \cdot \left(\vec{L}_T \cdot \vec{p}_T^{B_s}\right) \Big/ \left(p_T^{B_s}\right)^2$$

Resolution:

$$\sigma_t^2 = \left(\frac{\sigma_L}{\gamma\beta c}\right)^2 + \left(\frac{\sigma_p}{p} t\right)^2$$

Important for semileptonic modes





Analysis Strategy

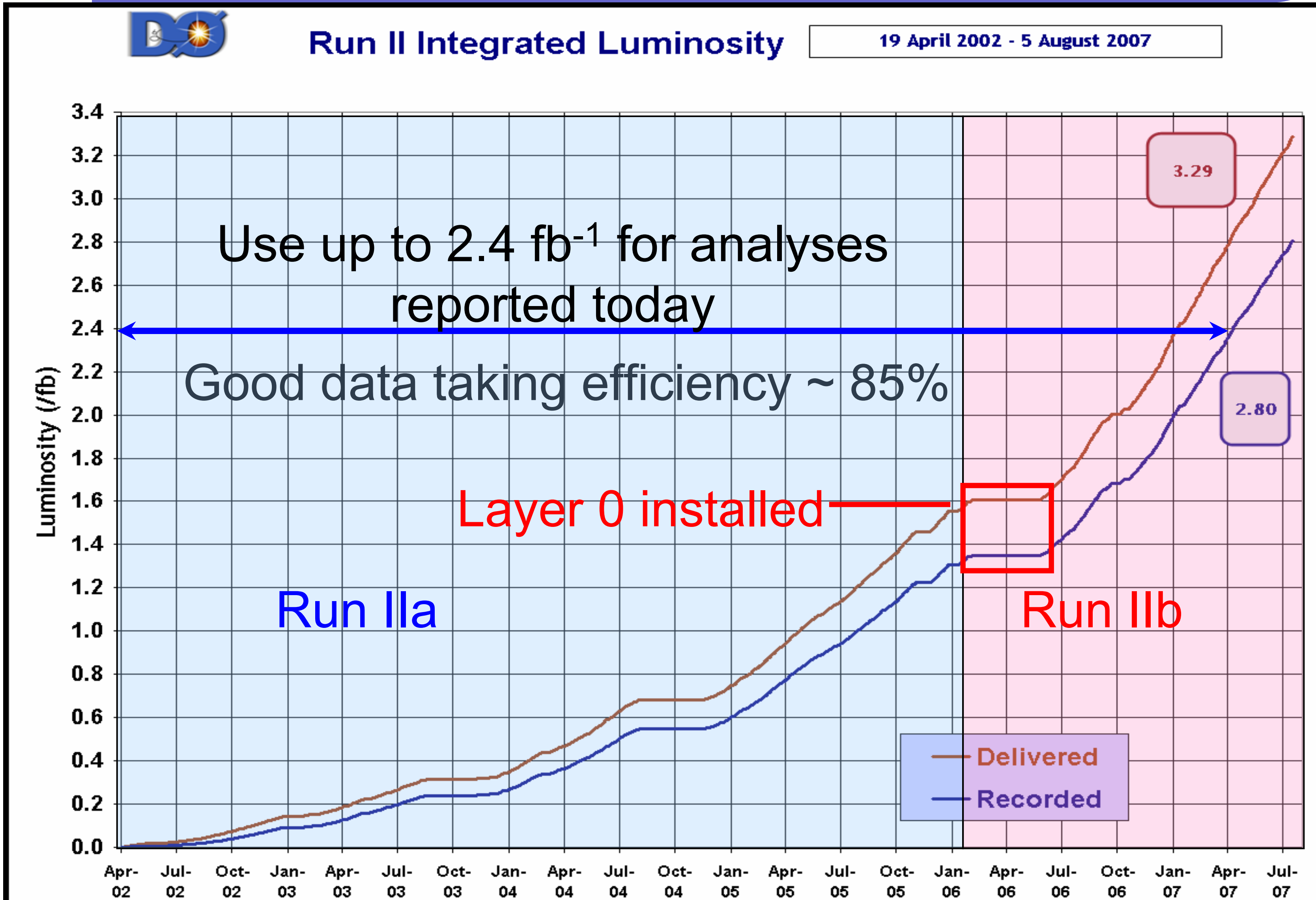
Significance of Observation

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

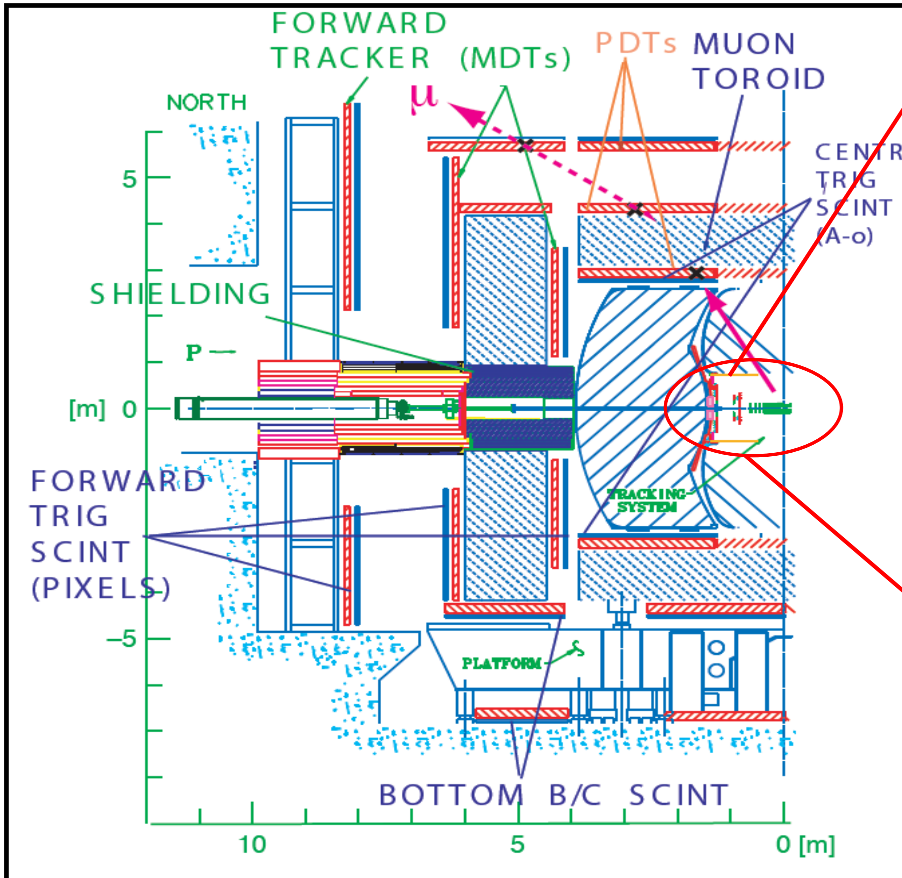
- *Add more data (S-number of signal events, B- background)*
  - *Additional channels*
    - $B_s \rightarrow D_s \pi X$, $D_s \rightarrow \phi \pi$ New!
    - $B_s \rightarrow D_s \mu \nu X$, $D_s \rightarrow \phi \pi$
    - $B_s \rightarrow D_s \mu \nu X$, $D_s \rightarrow K^* K$
    - $B_s \rightarrow D_s e \nu X$, $D_s \rightarrow \phi \pi$
    - $B_s \rightarrow D_s \mu \nu X$, $D_s \rightarrow K_s K$
- *Improve decay length resolution (σ_t)*
- *Improve initial state flavor tagging (εD^2-tagging power)*

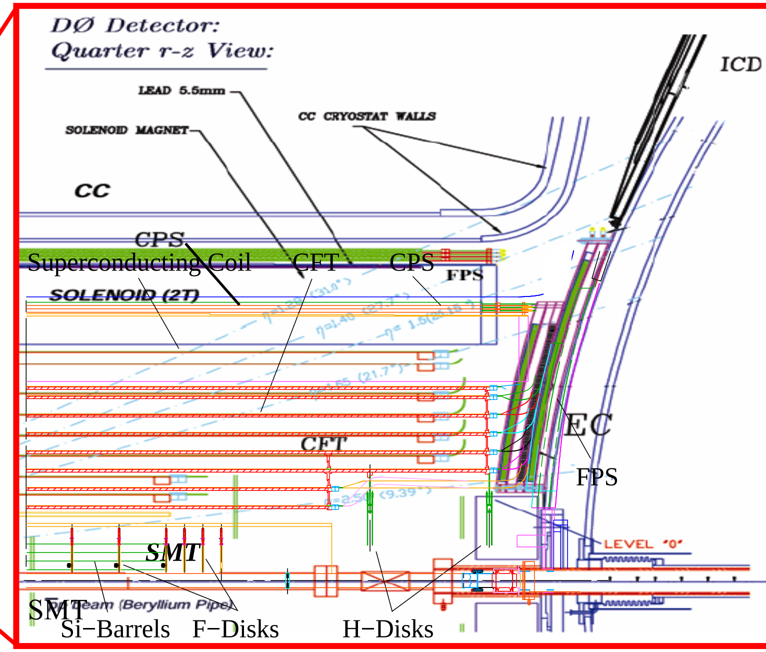
Tevatron and DØ Detector

Excellent Tevatron Performance

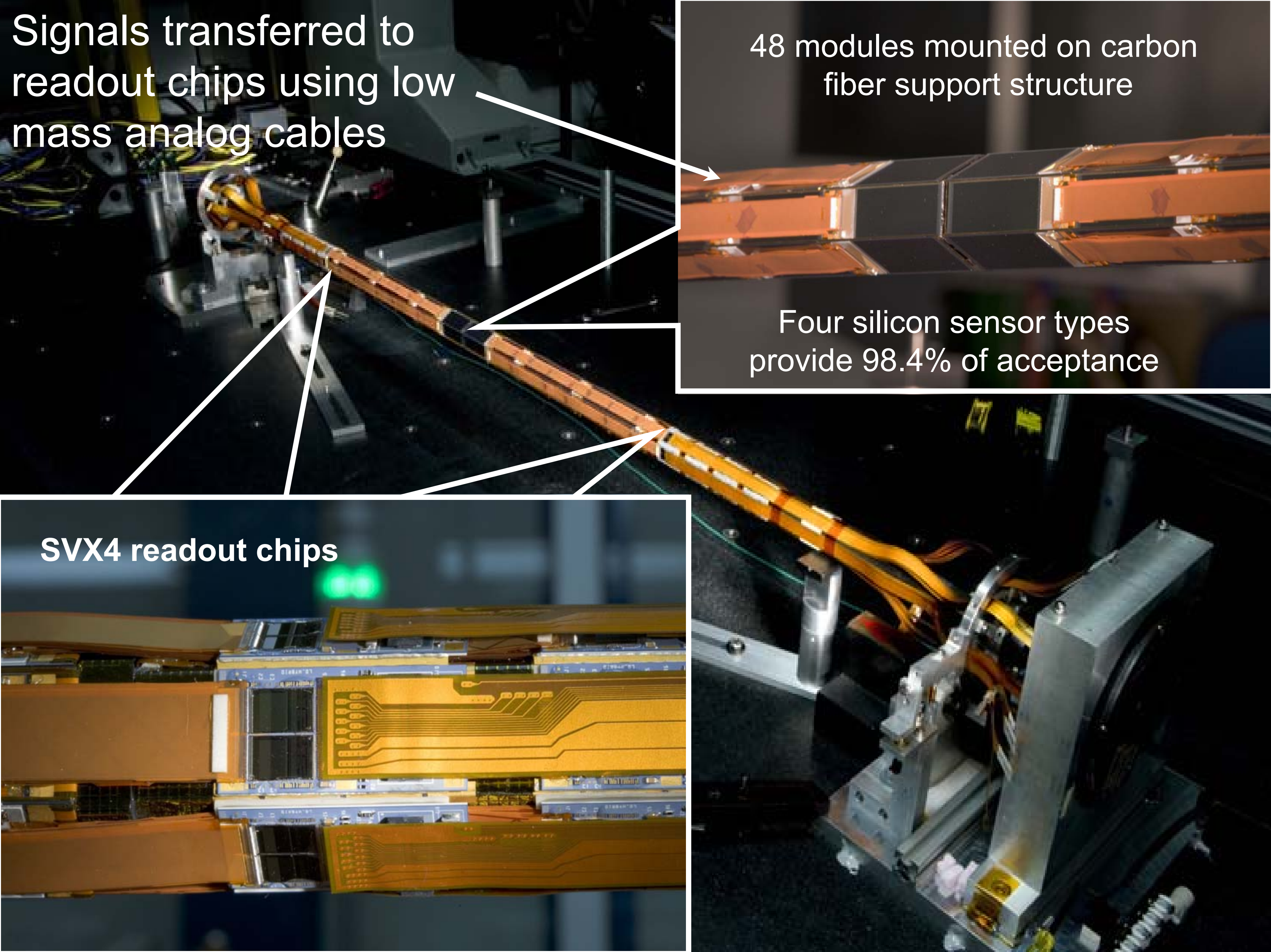


DØ Detector



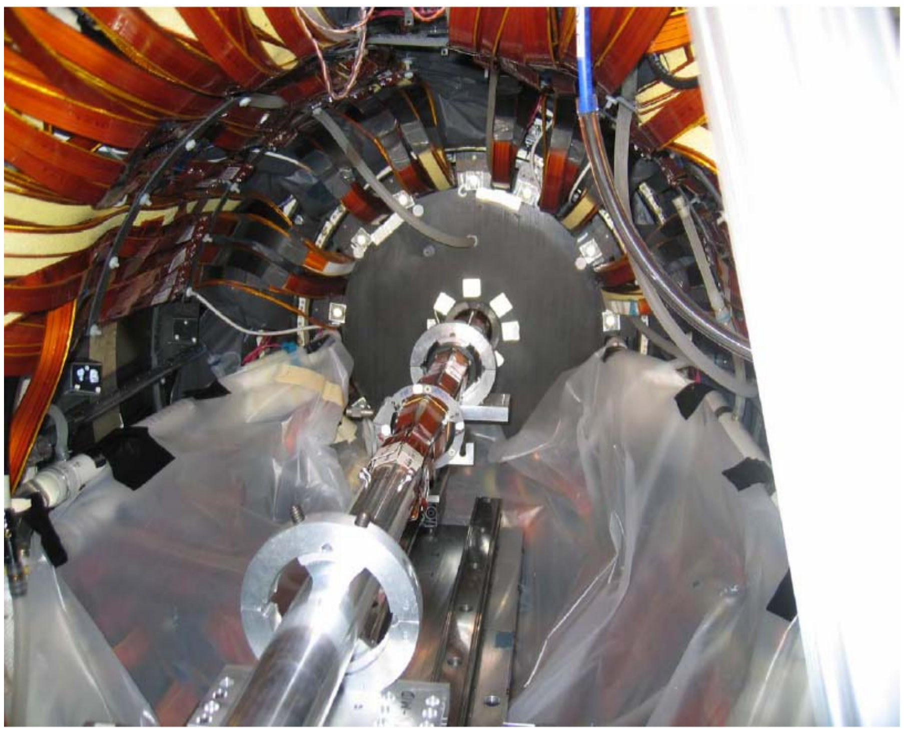


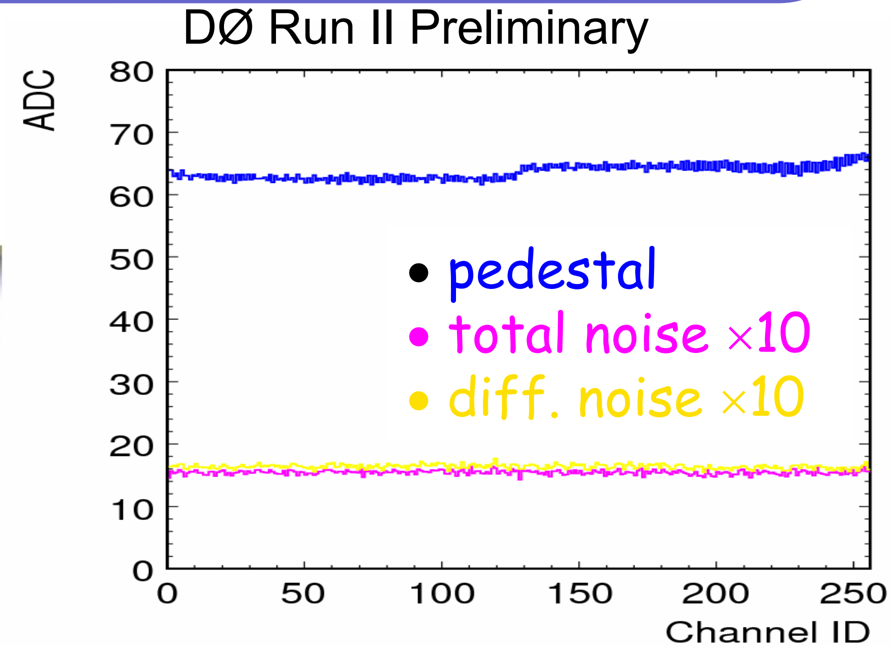
- Excellent coverage of Tracking and Muon Systems (|η|<2)
- Excellent vertex resolution
- 2T Solenoid, Toroid magnets
  - Polarity reversed bi-weekly !
  - Unique feature to DØ


Signals transferred to readout chips using low mass analog cables
48 modules mounted on carbon fiber support structure
Four silicon sensor types provide 98.4% of acceptance
SVX4 readout chips

Layer 0

Installed inside existing DØ silicon detector



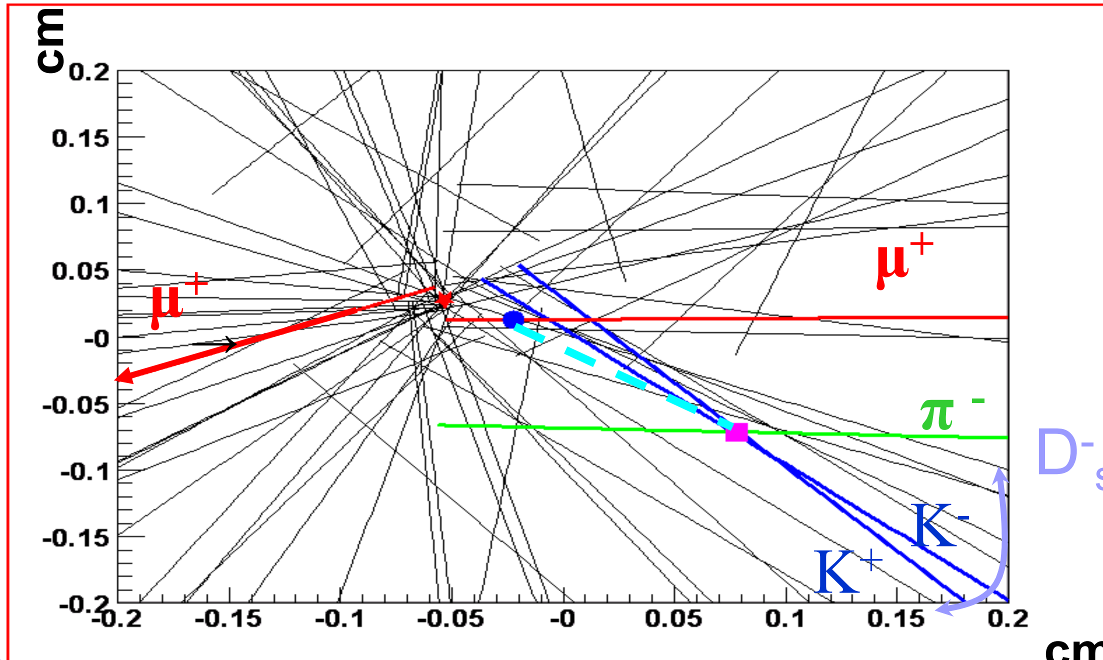


- First sensor at r=16 mm
- Outstanding noise performance for this type of device
  - ~1.7 ADC
  - Signal/Noise ~ 18

B_s Candidate Selection

- Select B_s candidate
  - Example $B_s \rightarrow l(\pi)D_sX$
- Combine two oppositely-charged tracks into $\phi \rightarrow KK$
  - Add third track (π) to form D_s
- Form B_s candidate:
  - Semileptonic decay - add lepton
  - Hadronic decay - add pion

High track multiplicity per event



$$B_s^0 \rightarrow D_s^- \mu^+ \nu X$$

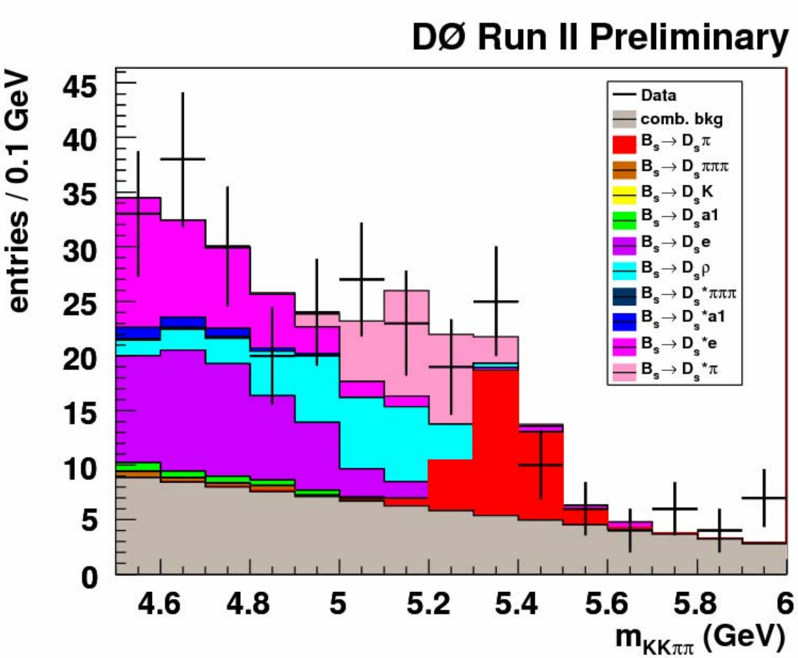
$$D_s^- \rightarrow \varphi \pi^-$$

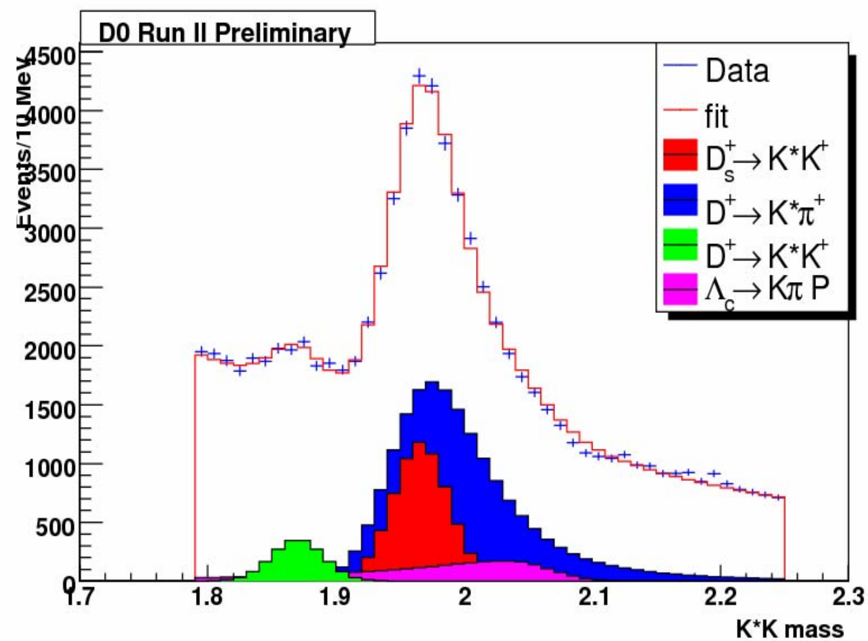
$$\varphi \rightarrow K^+ K^-$$

Samples

- Hadronic samples
  - Small BR, Low yield
  - No dedicated trigger
  - Good cτ resolution
- Semileptonic samples
  - Large BR, high event yield
  - Clean trigger
  - Poorer cτ resolution, due to missing neutrino

Sample composition



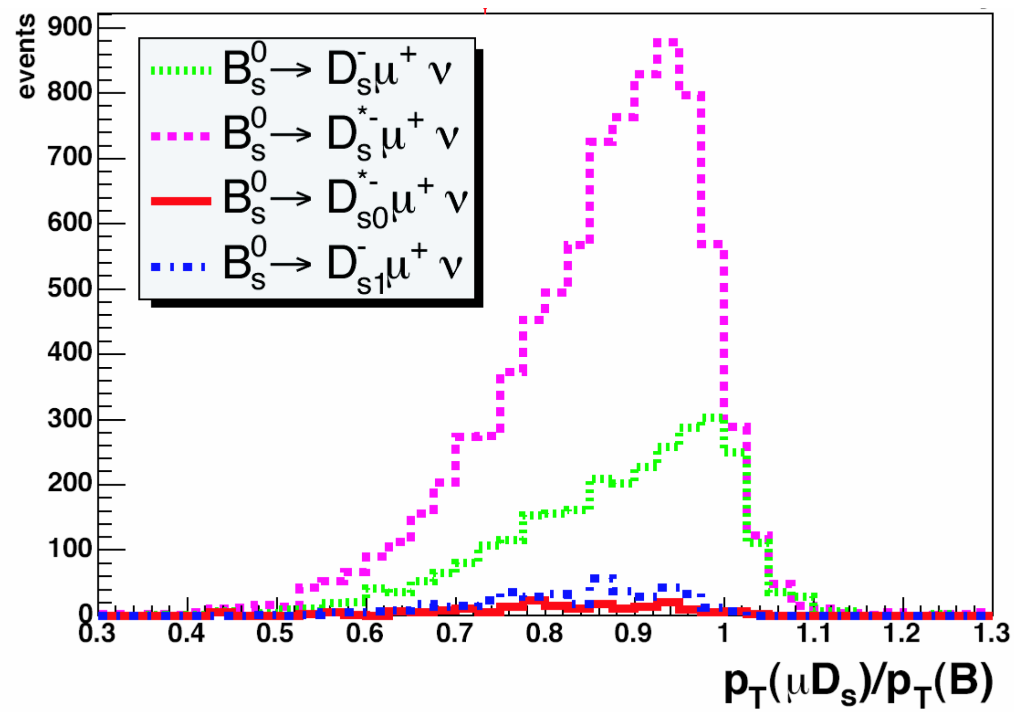


Proper Decay Length
(Partially Reconstructed Decays)

$$x^M = m_{B_s} \cdot \left(\vec{L}_T \cdot \vec{p}_T^{\,D_s\mu}\right) \Big/ \left(p_T^{D_s\mu}\right)^2$$

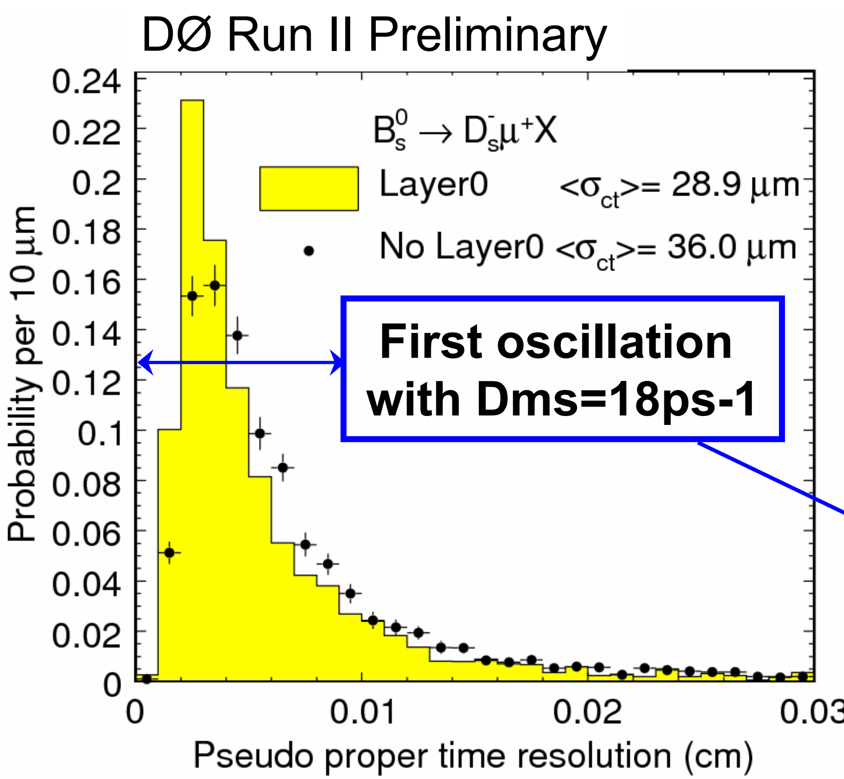
$$ct = x^M K \quad \Leftarrow \quad K = p_T^{D_s\mu} \Big/ p_T^{B_s}$$

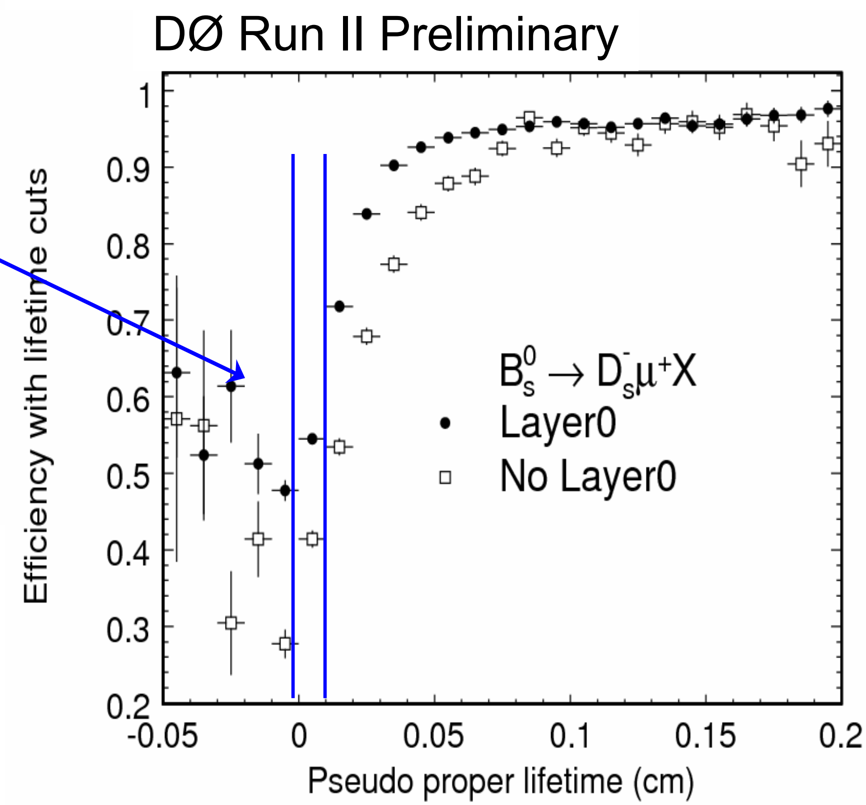
- Proper Decay Length is determined from the Visible Proper Decay Length
- K-factor takes into account the escaping neutrino and other missing particles
  - From MC for each decay mode



Proper Time Resolution

- Vertex position determined on event by event basis
  - Uncertainty per candidate included in the Δm_s fit

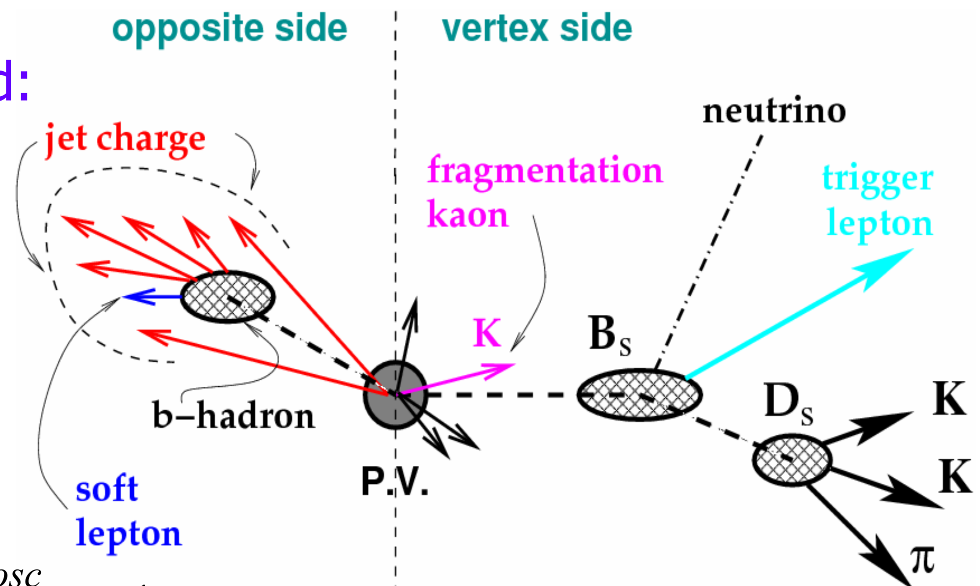




Example $B_s \to D_s \mu X$

Initial State Flavor Tagging

- Get best estimate for reconstructed B meson to contain b($\bar{b}$) at origin
  - Find set of discriminating variables $x_1,\ldots,x_n$
  - Combine different taggers using likelihood ratio method: d - combined discriminating variable redefine d [-1,1]

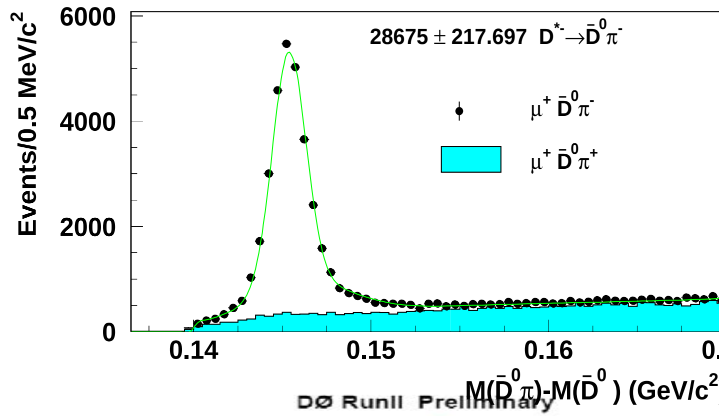


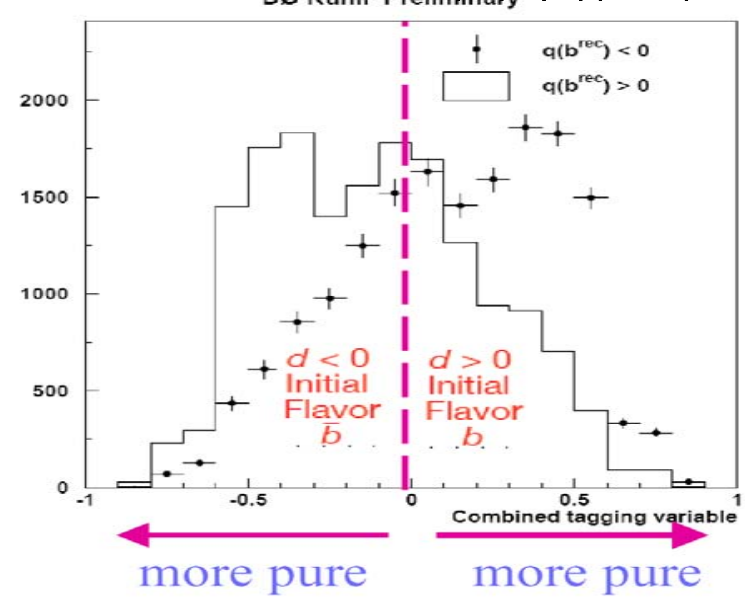
- Definitions:
  - Efficiency: $\varepsilon = \dfrac{N_{tagged}}{N_{total}}$
  - Dilution: $D = \dfrac{N_{nosc} - N_{osc}}{N_{nosc} + N_{osc}}$ ⟵ $D(d) = |d|$
  - Tagging power: $\varepsilon \cdot D^2$
    - use to compare the performance of taggers

Opposite Side Tagging (OST)

PRD 74, 112002 (2006)

- Independent from the reconstructed B side (B_u,B_d,B_s)
  - Rely on fact that b produced as b-anti b pair
- Construct P.D.Fs using $B^0_d \rightarrow \mu\nu D^*X$ sample with VPDL = [0—0.050] μm
  - 96% pure
  - Subtract background using wrong sign combination
- Measure dilutions in large $B^0_d \rightarrow \mu\nu D^*X$ and $B^\pm \rightarrow \mu\nu D^0X$ samples

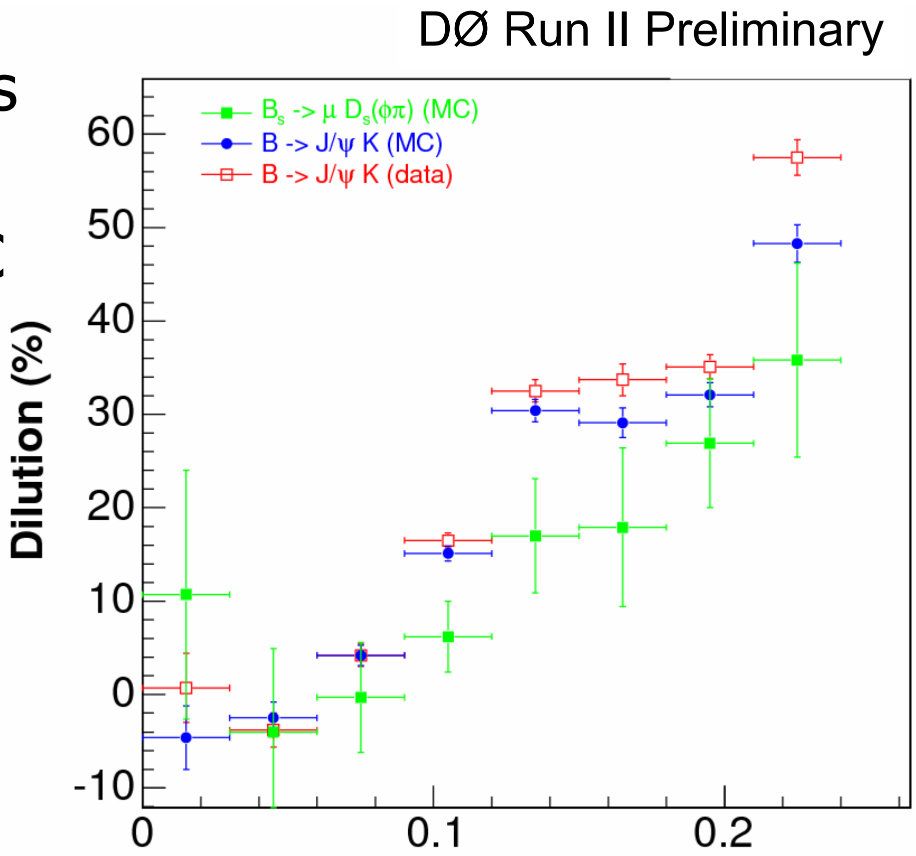




Combined discriminating variable

Same Side Tagging (SST)

- Depends on B-hadron species
  - No direct transfer $B^+, B^0 \rightarrow B_s$
- Predict SST dilution using MC
  - No PID ☹
- Use kinematic variables ΔR, p_T^{rel},
- To verify compare data and MC with known flavor for individual taggers and combination
  - i.e. $B^+ \rightarrow J/\psi K^+$



Combined discriminating variable

Combined Tagger

- Combine OST and SST if both present
  - Assume both independent
- Combine SST and "Event charge" if both present
  - Σq_i of all tracks on opposite side

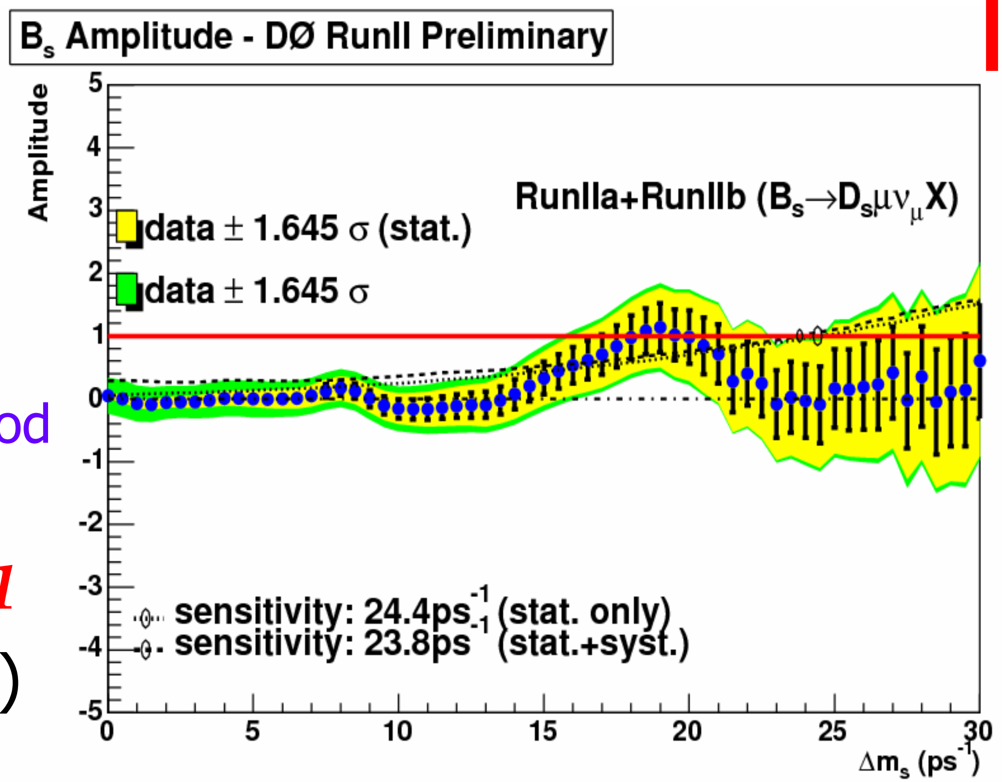
DØ Run II Preliminary

Tagger	ϵD^2
Comb. SST	$1.7 \pm 0.6\%$
Comb. OST without Evt. Charge	$2.5 \pm 0.2\%$
Evt. Charge	$1.5 \pm 0.5\%$
All	$4.5 \pm 0.9\%$

Amplitude Method

$$p_s^{nos/osc} \sim \left(1 \pm \mathcal{D}\cos\left(\Delta m_s \cdot Kx/c\right)\cdot \mathcal{A}\right)$$

- Scan Δm_s, for each value find $\mathcal{A} \pm \sigma_{\mathcal{A}}$
  - Fit of proper decay length distribution for mixed and unmixed B_s using unbinned likelihood
- If mixing signal with Δm_s, amplitude $\mathcal{A} = 1$ (statistically significant) otherwise $\mathcal{A} = 0$

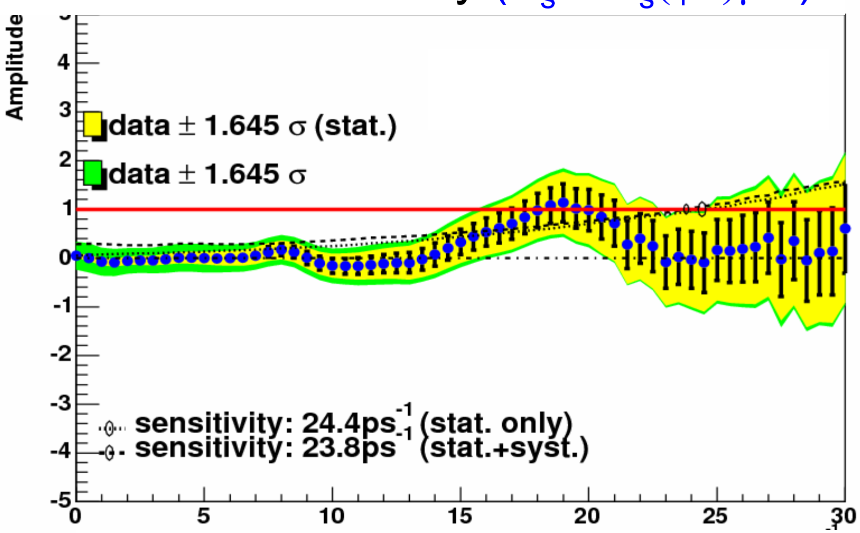


Δm_s excluded at 95%CL for $A+1.645\sigma_A < 1$

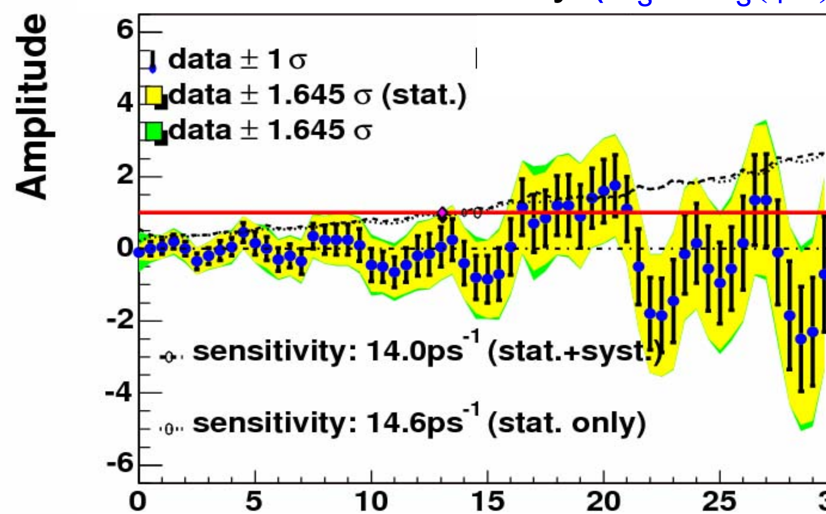
Sensitivity at Δm_s for $1.645\sigma_A$ A=0

Amplitude Scans (Ldt=2.4 fb^{-1})

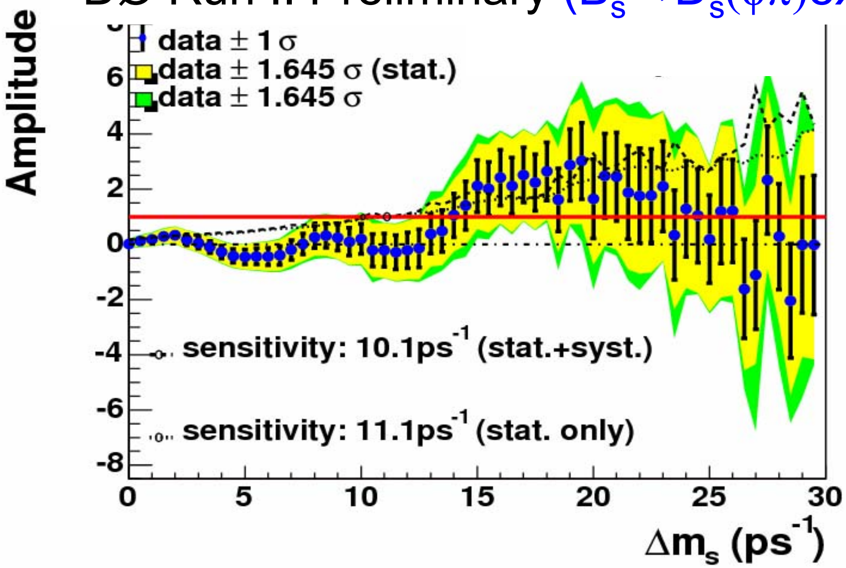
DØ Run II Preliminary ($B_s \to D_s(\phi\pi)\mu X$)



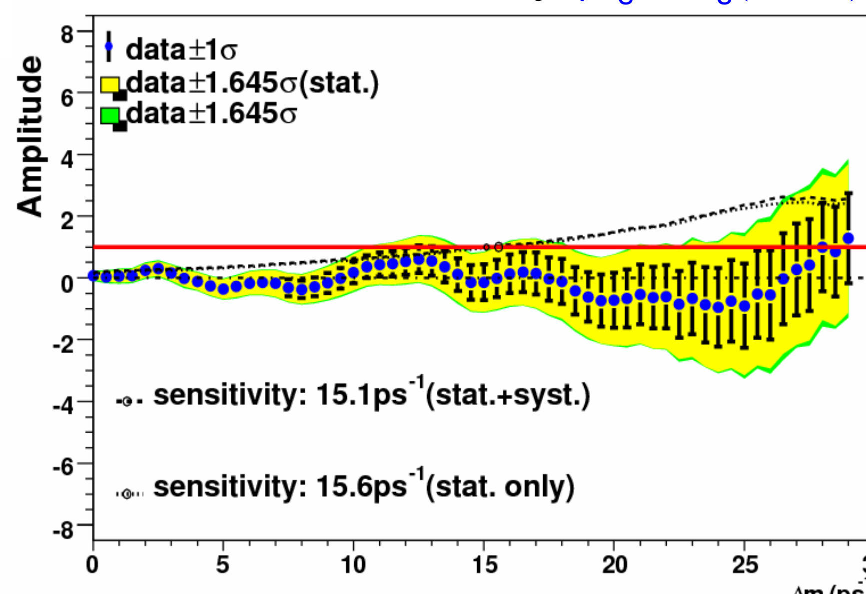
DØ Run II Preliminary ($B_s \to D_s(\phi\pi)\pi X$)



DØ Run II Preliminary ($B_s \to D_s(\phi\pi)eX$)



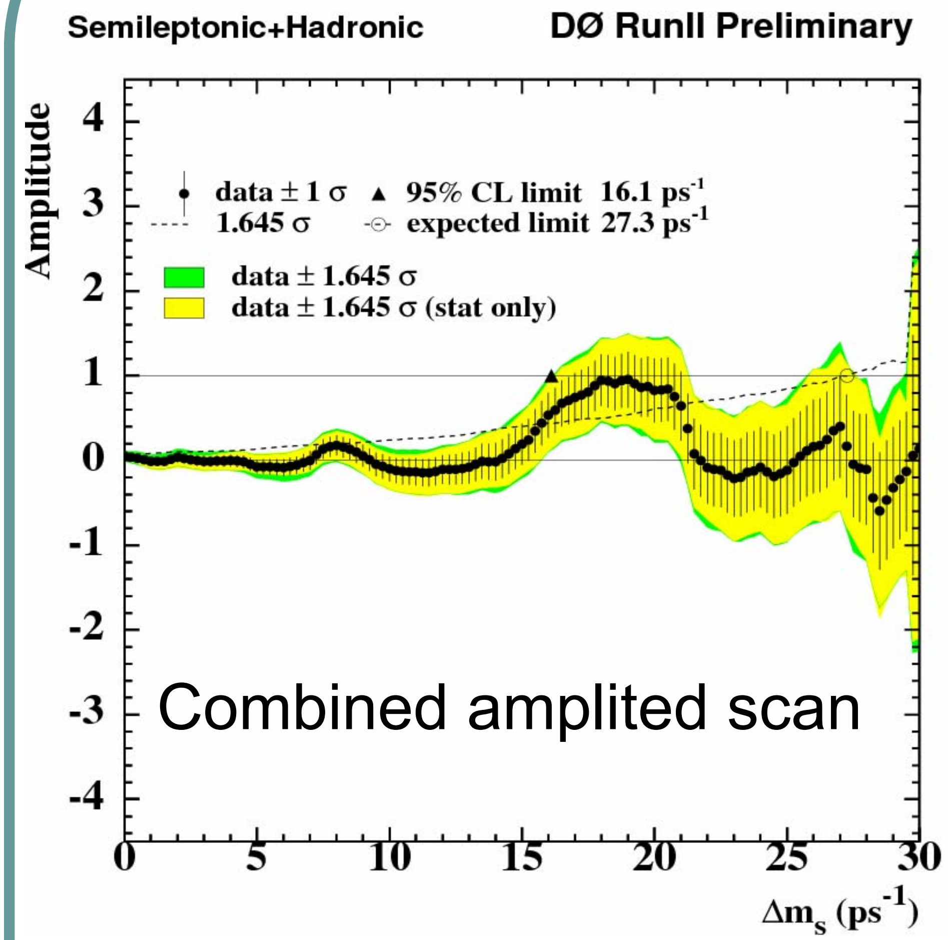
DØ Run II Preliminary ($B_s \to D_s(K^{*0}K)\mu X$)

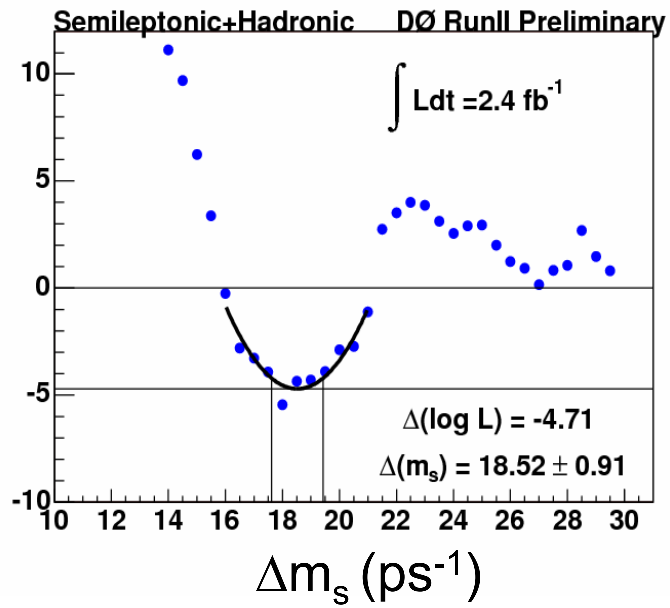


Systematics

- Vary each source separately within uncertainty
- Incorporate systematics as $\sigma^{sys}=\Delta A+(1-A)\Delta\sigma_A/\sigma_A$
- Consider following sources:
  - Dilution
  - K-factors
  - VPDL model
  - Mass fit model
  - Sample composition
  - Background description
- Systematic uncertainties are small compared to statistical

Results





- A parabolic fit to likelihood scan for Δm_s returns:
  - $\Delta m_s = 18.5 \pm 0.9\ ps^{-1}$
- 3.1σ statistical significance
- In agreement with CDF

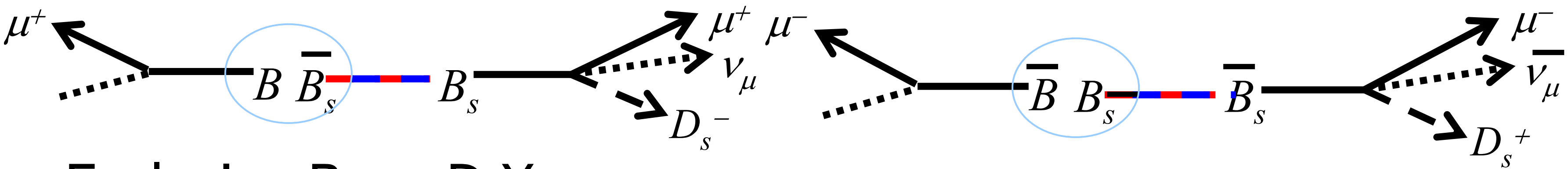
$\Delta m_s = 17.77 \pm 0.1\ (stat.) \pm 0.07\ (syst.)\ ps^{-1}$

PRL 97 242003

Other Parameters: $\Delta\Gamma_s$ and ϕ_s

Charge Asymmetry and ϕ_s

- Measurement of the charge asymmetry induced by B_s mixing



- Exclusive $B_s \rightarrow \mu D_s X$

$$A_{SL}(untagged) = \frac{N(D_s\mu^+) - N(D_s\mu^-)}{N(D_s\mu^+) + N(D_s\mu^-)} = \mathrm{Im}\frac{\Gamma_{12}^s}{M_{12}^s} \cong \frac{\Delta\Gamma}{\Delta m}\tan\phi_s$$

$$A_{SL}(B_s) = 0.0245 \pm 0.0193 \pm 0.0035$$

PRL 98, 151801 (2007)

- Inclusive same-sign $\mu\mu$ sample PRD 74, 092001 (2006)

$$A_{SL}^{\mu\mu}(tag) = \frac{N(\mu^+\mu^+) - N(\mu^-\mu^-)}{N(\mu^+\mu^+) + N(\mu^-\mu^-)} = \frac{1}{4f}\left[A_{SL}^d + \frac{f_s\chi_{s0}}{f_d\chi_{d0}}A_{SL}^s\right] = 2A_{SL}(untagged)$$

$$A_{SL}(B_s) = 0.006 \pm 0.010$$

- Charge asymmetry in semileptonic B_s

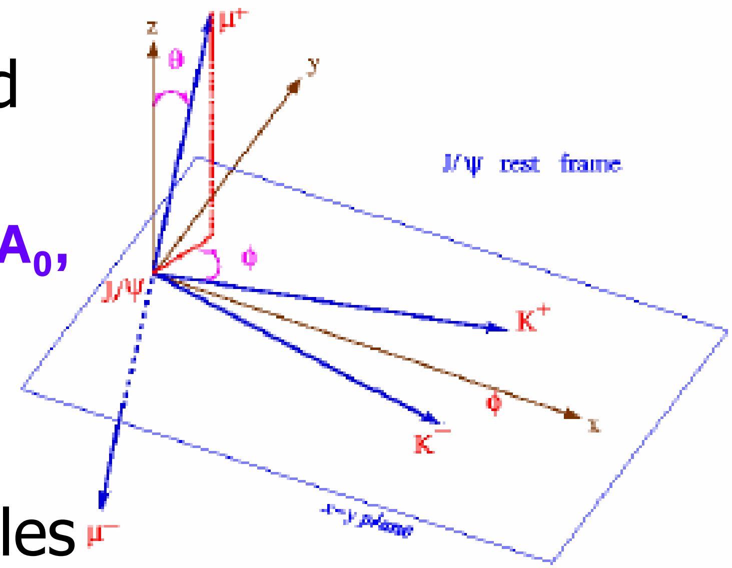
$$a_{SL}^s = 0.0001 \pm 0.0090$$

$$\Delta\Gamma_s \tan\phi_s = 0.02 \pm 0.16\ \mathrm{ps}^{-1}$$

B_s Lifetime Difference

- Measure lifetime in $B_s \to J/\psi(\mu^+\mu^-)\phi(K^+K^-)$
  - Pseudoscalar → Vector Vector
- The mass eigenstates are expected to be almost pure CP-eigenstates
  - **S,D** (CP even): linear combination of **A_0, $A_{||}$**
  - **P** (CP odd): **$A_\perp$**

cosθ=transversity



- Decay parameterized by three angles

$$\Gamma(t) \approx \left|A_{even}(\theta,\psi,\varphi,t)\right|^2 + \left|A_{odd}(\theta,\psi,\varphi,t)\right|^2$$

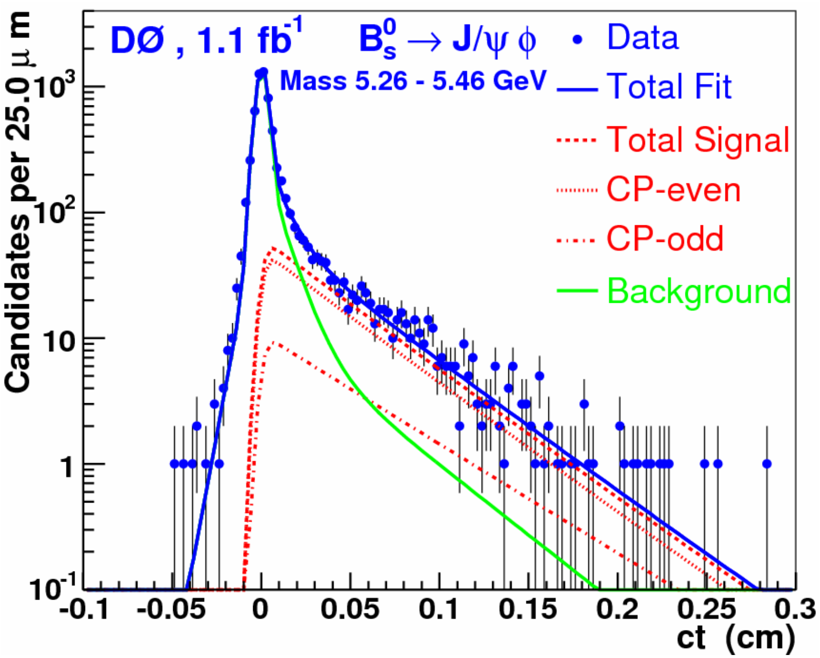
$$+A^* A(CPC)$$ CP-conserving interference

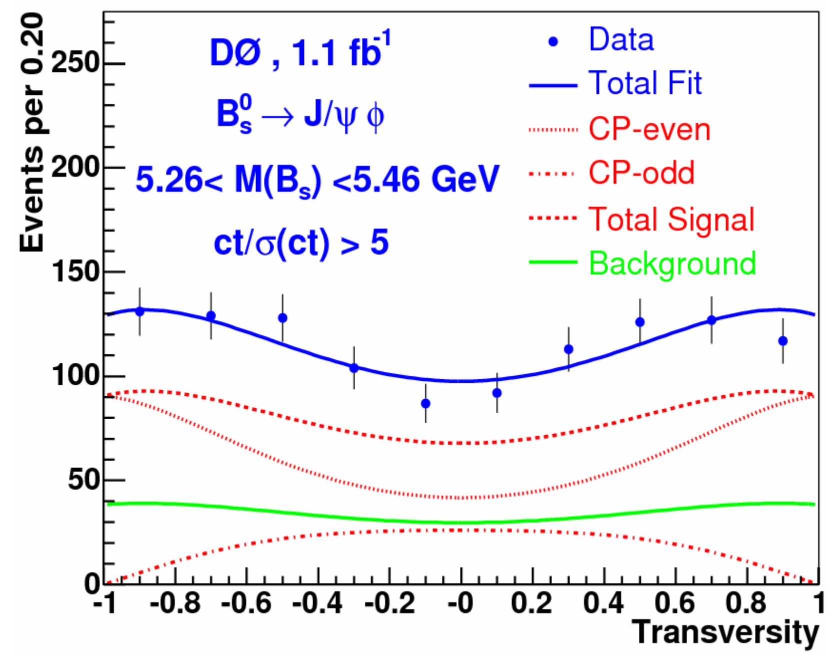
$$+A^* A(CPV)(e^{-\Gamma_L t} - e^{-\Gamma_H t})\sin\phi_s$$

CP-violating interference

- CP eigenstates - well separated in transversity (cosθ)

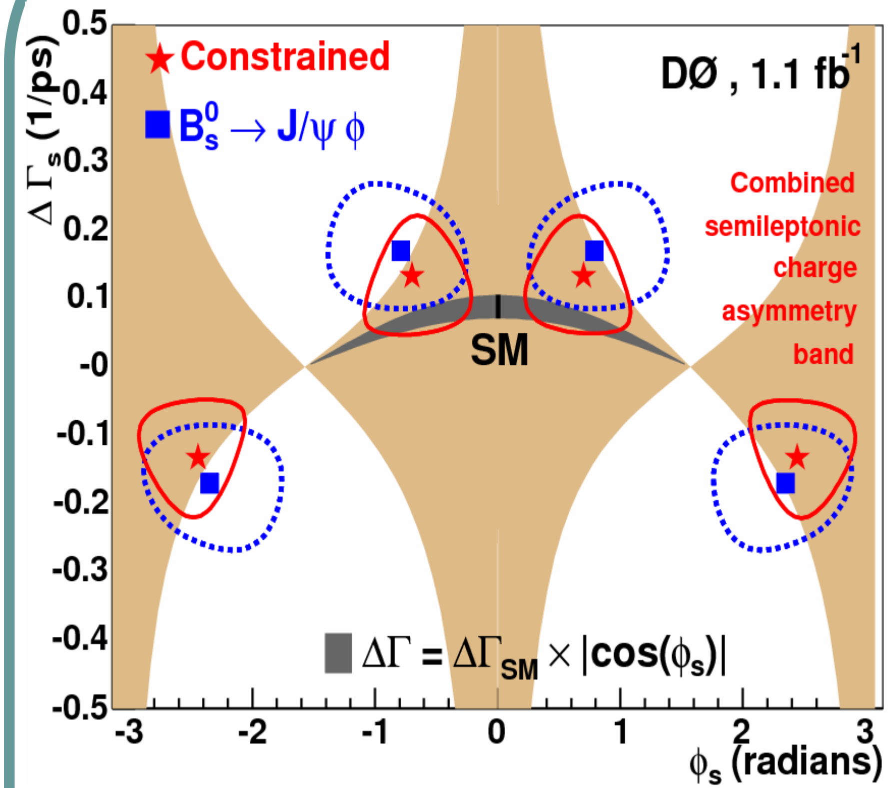
$\Delta\Gamma_s$ and ϕ_s in $B_s \rightarrow J/\psi\varphi$





- Simultaneous fit of mass, lifetimes, time-dependant angular distributions to extract $\Delta\Gamma_s$ and ϕ_s

Δm_s, $\Delta\Gamma_s$ and ϕ_s



- Fit for $\Delta\Gamma_s$ and ϕ_s using A_{sl} measurement and world average τ_{fs}

- Measured all three parameters that characterize B_s system at DØ

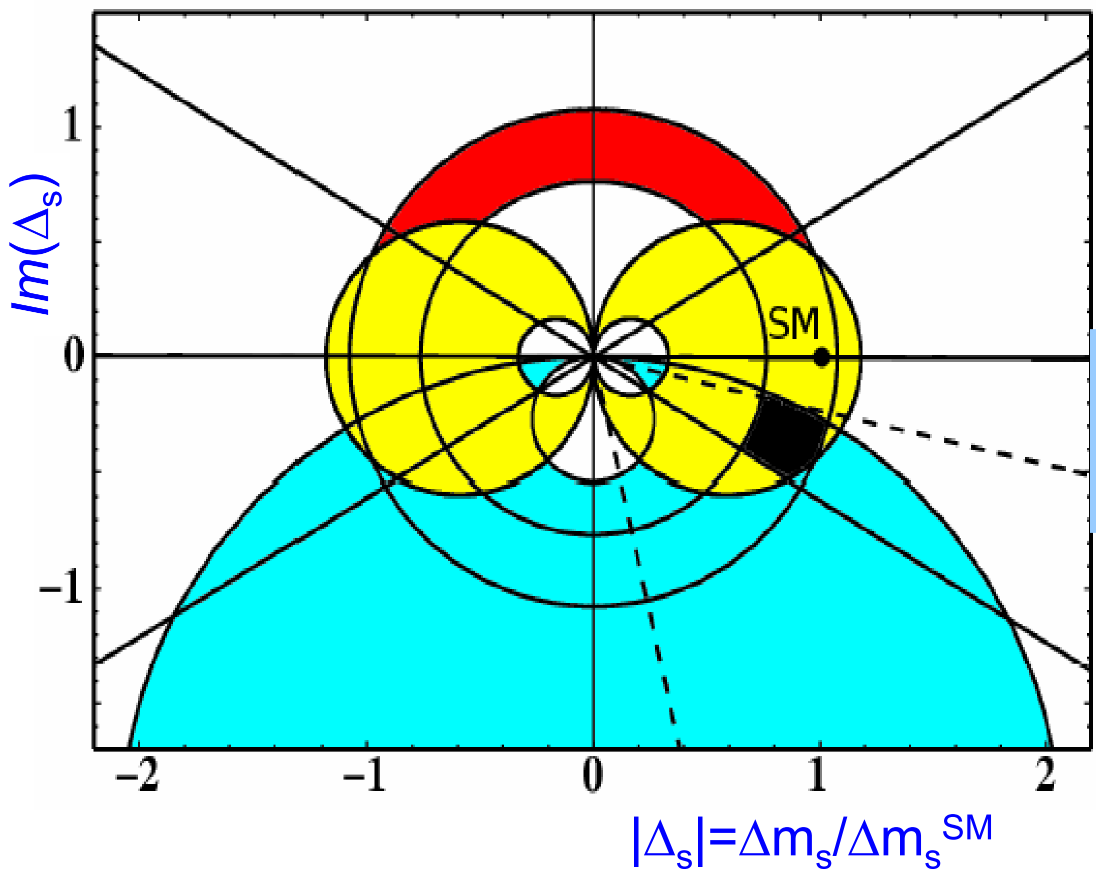
$$\Delta m_s = 18.5 \pm 0.9\ \mathrm{ps}^{-1}$$

$$\Delta\Gamma_s = 0.13 \pm 0.09\ \mathrm{ps}^{-1}$$

$$\phi_s = -0.70^{+0.47}_{-0.39}$$

$$a_{SL}^s = 0.0001 \pm 0.0090$$

Δm_s, $\Delta\Gamma_s$ and ϕ_s



$\Delta m_s = 17.77 \pm 0.11\,\text{ps}^{-1}$

$\Delta\Gamma_s = 0.13 \pm 0.09\,\text{ps}^{-1}$

$\phi_s = -0.70^{+0.47}_{-0.39}$

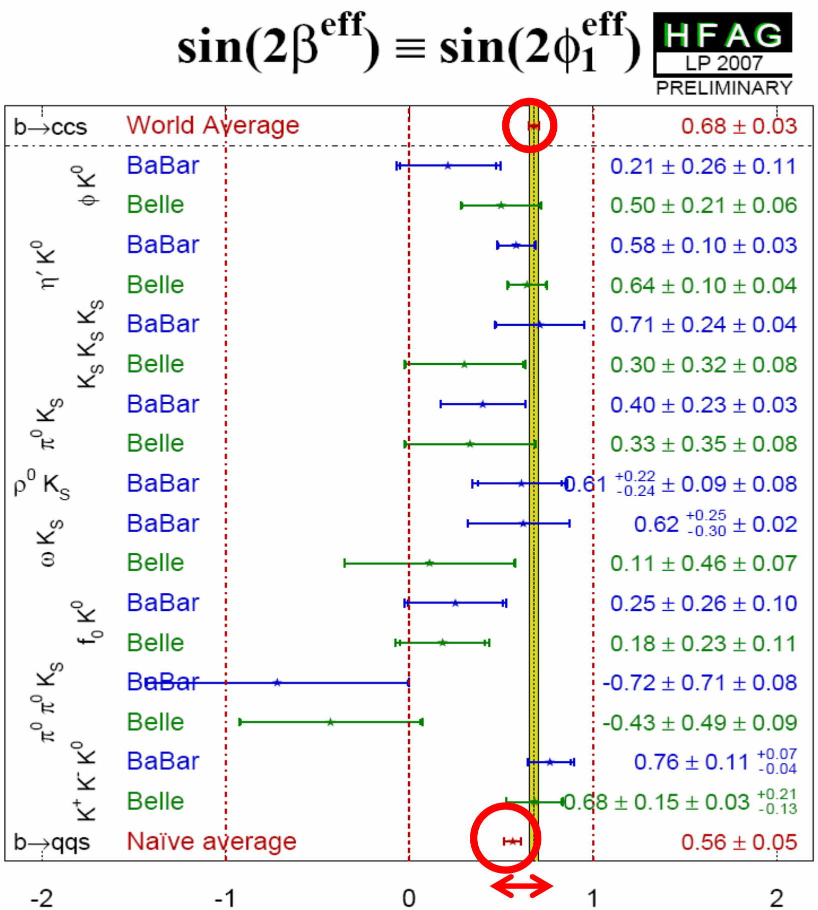
$a^s_{SL} = 0.0001 \pm 0.0090$

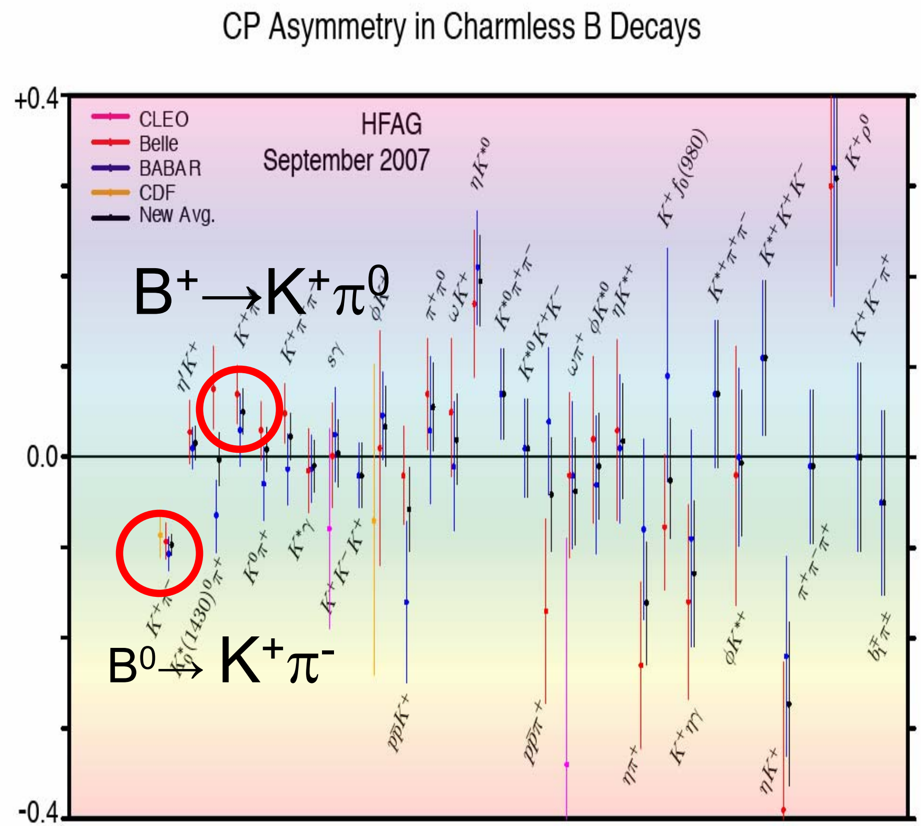
$\Delta\Gamma_s \tan\phi_s = 0.02 \pm 0.16\,\text{ps}^{-1}$

Need more data!

Direct CP Violation in $B^+ \rightarrow J/\psi K^+$

Hints for New Physics?



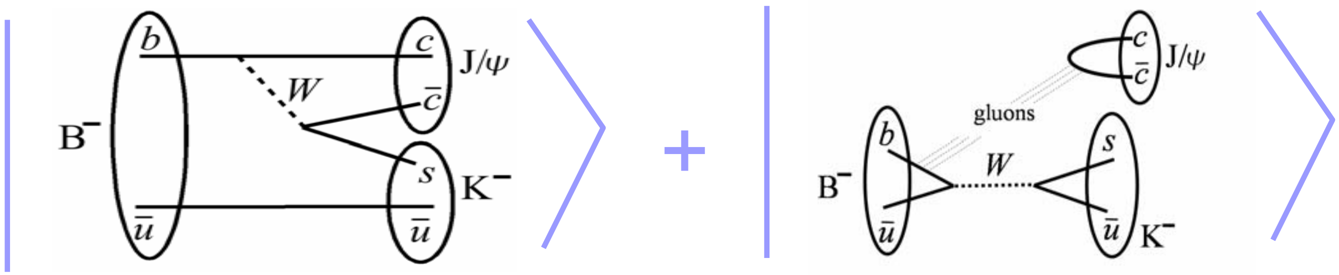


Comparison of time dependent CPV in b→c and b→s,d

Apparent discrepancy in direct CP violation

Direct CP Violation in $B^+ \to J/\psi K^+$

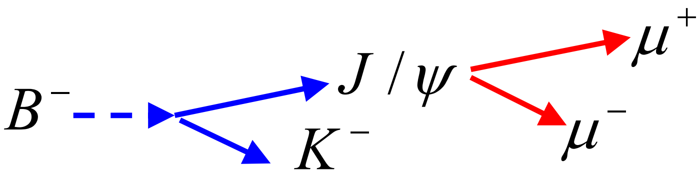
DIRECT | ANNIHILATION



$$A_{CP}(B^+ \to J/\psi K^+) = \frac{N(J/\psi K^-) - N(J/\psi K^+)}{N(J/\psi K^-) + N(J/\psi K^+)}$$

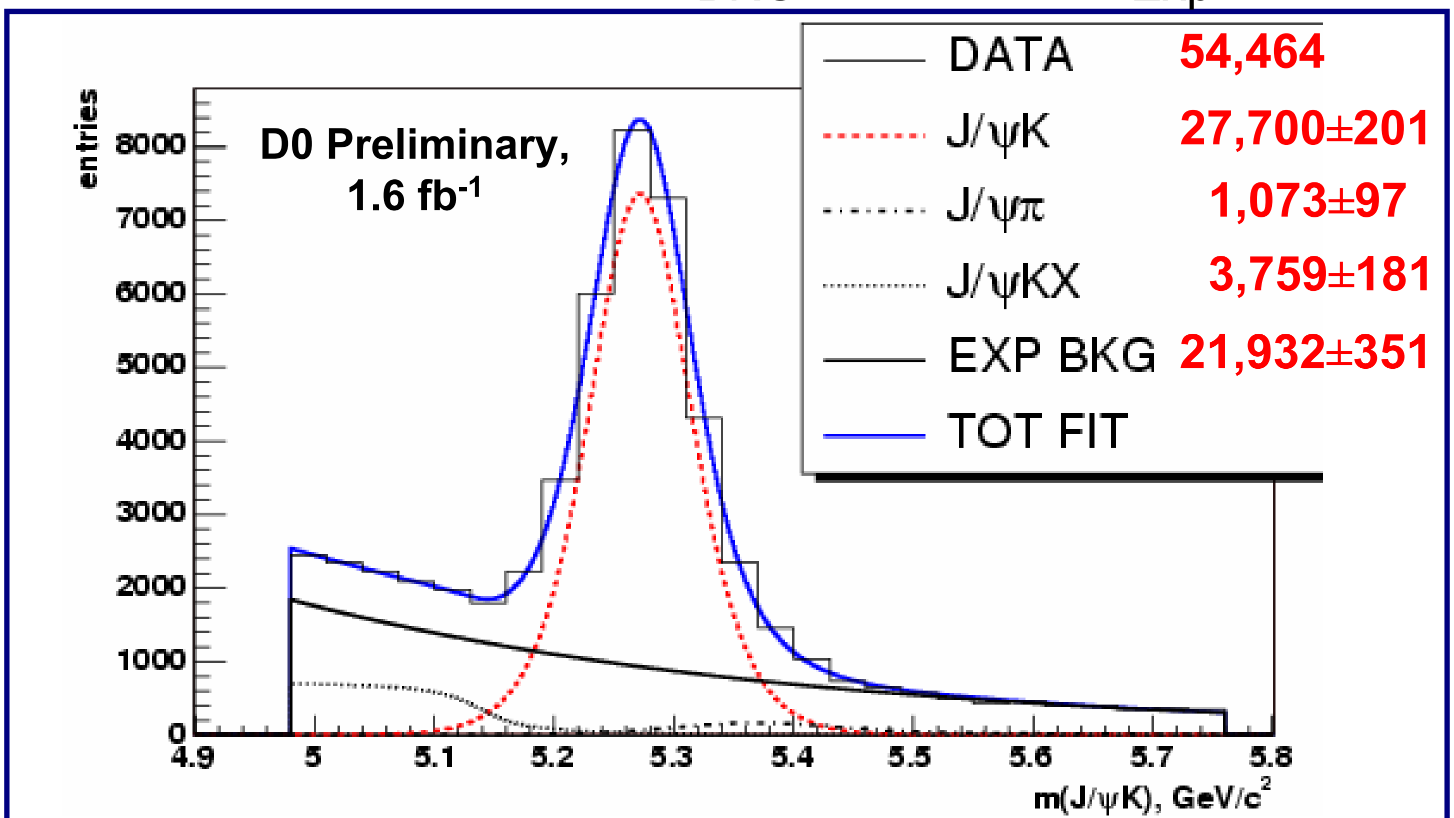
- Standard Model predicts $A_{CP}(B^+ \to J/\psi K^+) \approx 0.003$
  W. Hou et al. hep-ph/060508
- Beyond the Standard Model can be enhanced due to new couplings at tree level:
  - Four Generation Models
  - Flavor-changing Z´ between *b* and *s*
  - Charged Higgs

$B^+ \to J/\psi K^+$ sample



- $B \to J/\psi\, K$ — Gauss
- $B \to J/\psi\, \pi$ reflection — Gauss
- $B \to J/\psi\, K\, X$ — Threshold
- BKG — Exp

(The first three are) parameterized in p_K



Method

$$n_q^{\beta\gamma} = \frac{1}{4} N \varepsilon^{\beta} (1 + qA)(1 + q\gamma A_{fb})(1 + \gamma A_{NS})(1 + q\beta\gamma A_{ro})(1 + \beta\gamma A_{\beta\gamma})(1 + q\beta A_{q\beta})$$

- If N - total number of events
- ε^{β} – fraction of events with solenoid polarity

then #events with specific:

- particle charge q
- sign of particle pseudorapidity γ
- solenoid polarity β

depends on asymmetries:

- charge - the one we are after(A)
- forward-backward (A_{fb})
- North-South (detector material) (A_{NS})
- range out (A_{ro})
- the remaining two complete the system

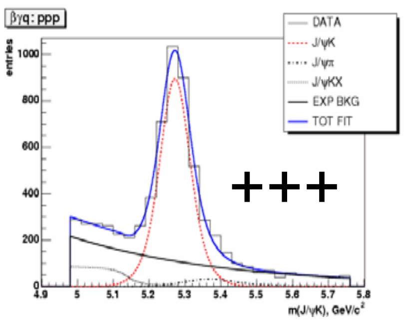
To consistently account for correlations and errors:

- Divide sample into 8 subsamples according to the signs of β,γ and q
- In each subsample extract $n_q^{\beta\gamma}$ by unbinned likelihood fit
- Solve 8 simultaneous equations for N, ε^{β}, and asymmetries

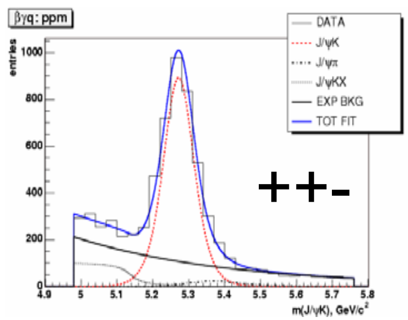
8 Subsamples

$n_q^{\beta\gamma}$ Asymmetries are small – look similar

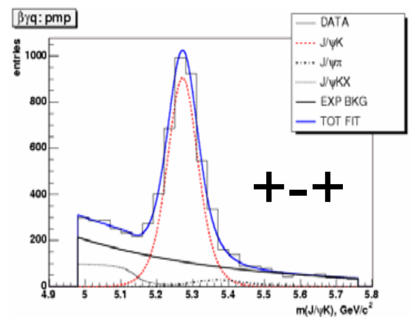
D0 Preliminary, 1.6 fb^{-1}



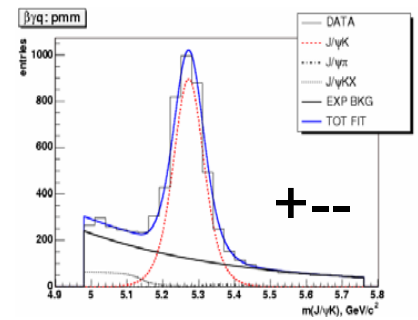
3,376±57



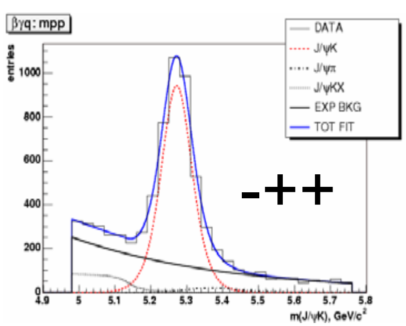
3,343±57



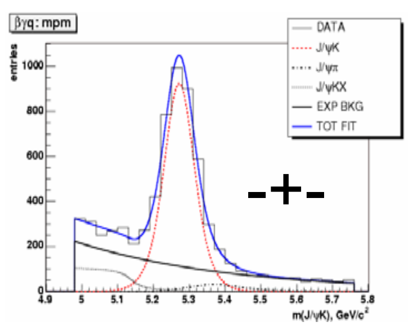
3,399±57



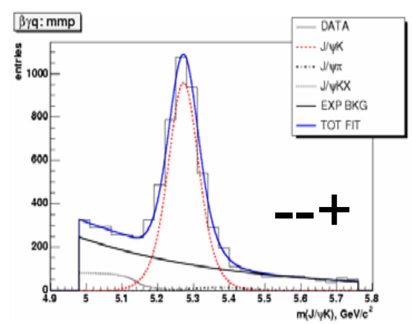
3,369±57



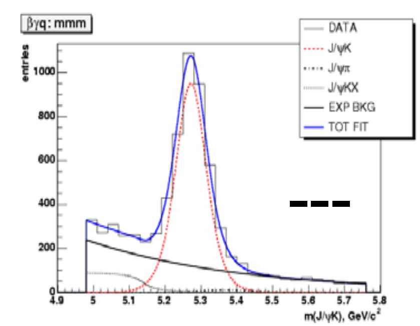
3,546±59



3,467±58



3,626±59



3,565±59

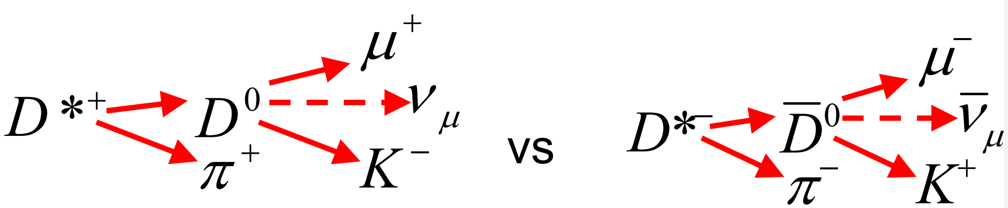
Asymmetry Measurement

In experiment Measure
A = $A_{cp}(B \rightarrow J/\psi K) + A_K$

$$A_K = \frac{N(K^+) - N(K^-)}{N(K^+) - N(K^-)} > 0$$

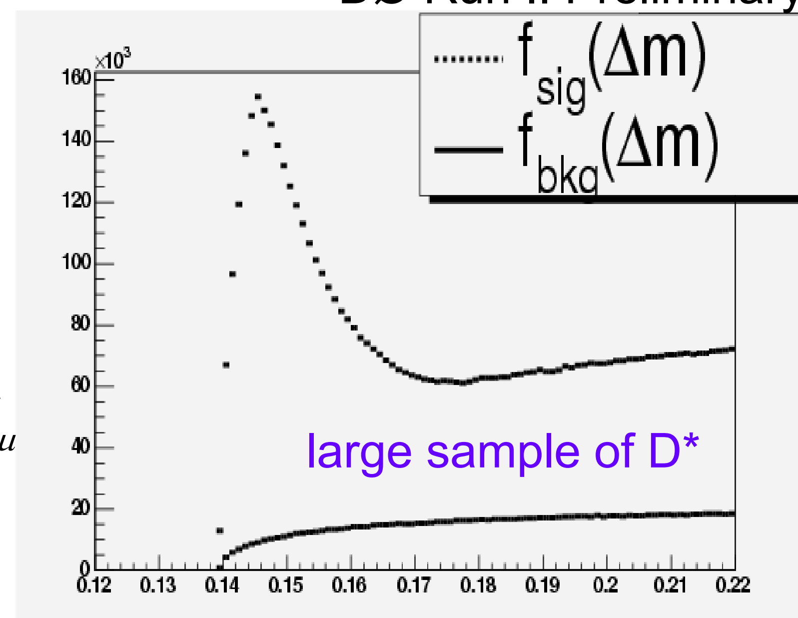
$$\sigma(K^- d_{inelastic}) > \sigma(K^+ d_{inelastic})$$

- ► **depends on material distribution,**
- ► **estimated independently from data:**



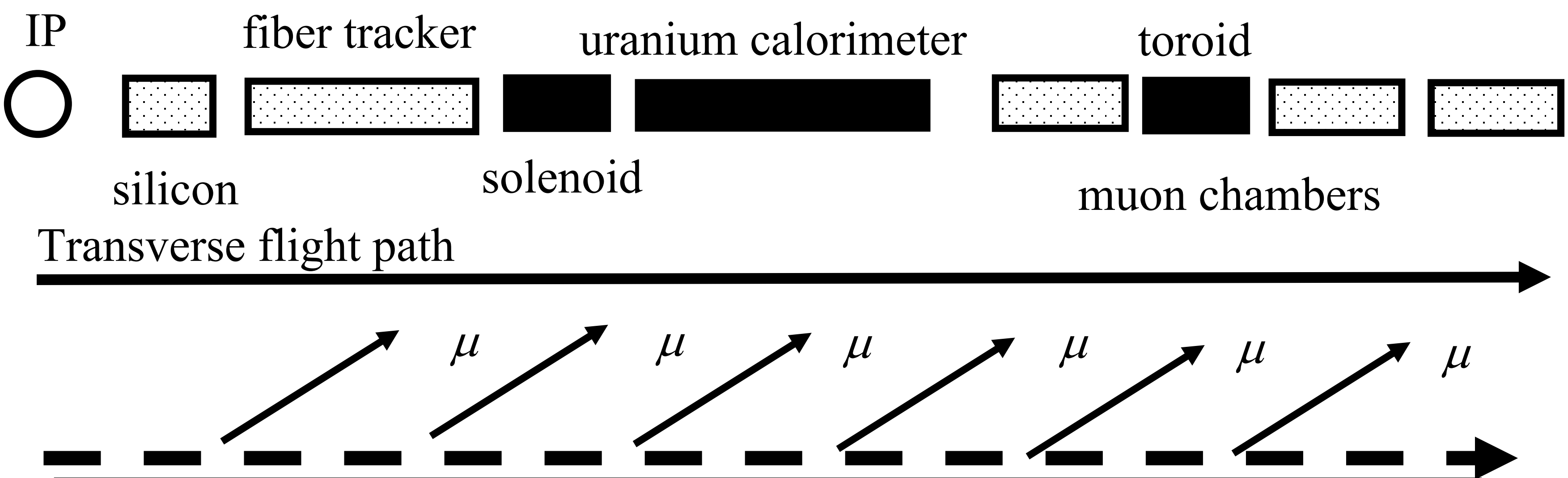
$$A_K = -A_\mu$$

DØ Run II Preliminary

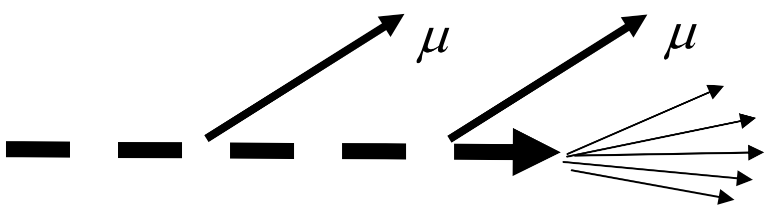


$$\Delta m = m(\mu K \pi) - m(\mu K)$$

Kaon asymmetry



K^+ produce μ^+ from weak decay $N(\mu^+) \sim exp(-x/c\tau(K))$



Measured directly in data using kaons tagged from D* decay

K^- stop more frequently in calorimeter from $K^- + N \rightarrow Y + \pi$ nuclear interactions

Detector systematics

we want: $A = \frac{n_+ - n_-}{n_+ + n_-} \Rightarrow n_q = \frac{1}{2}N(1 + qA)$

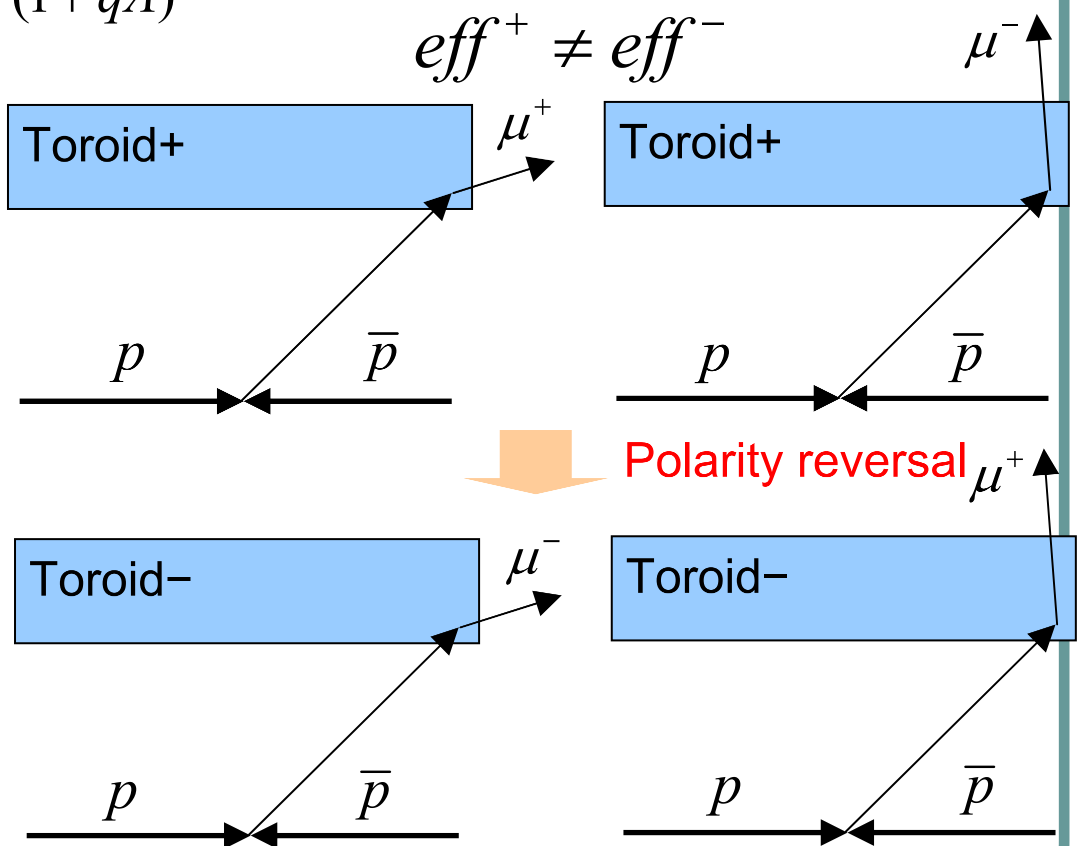
But:

Detector introduces apparent charge asymmetries. Example (for muons): range out in the toroid:

$$n_q = \frac{1}{2}N\left[1 + q(A + A_{ro})\right]$$

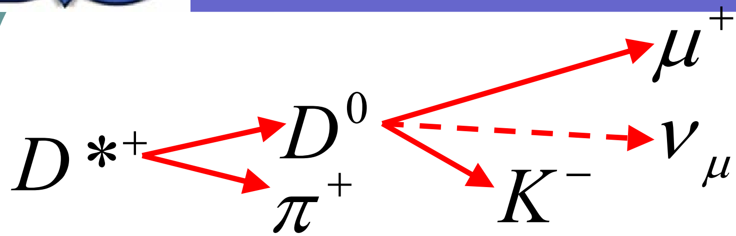
apparent A

$$n_q = \frac{1}{2}N\left[1 + q(A - A_{ro})\right]$$



Polarity reversal significantly reduces systematics from detector asymmetries

D* Extraction



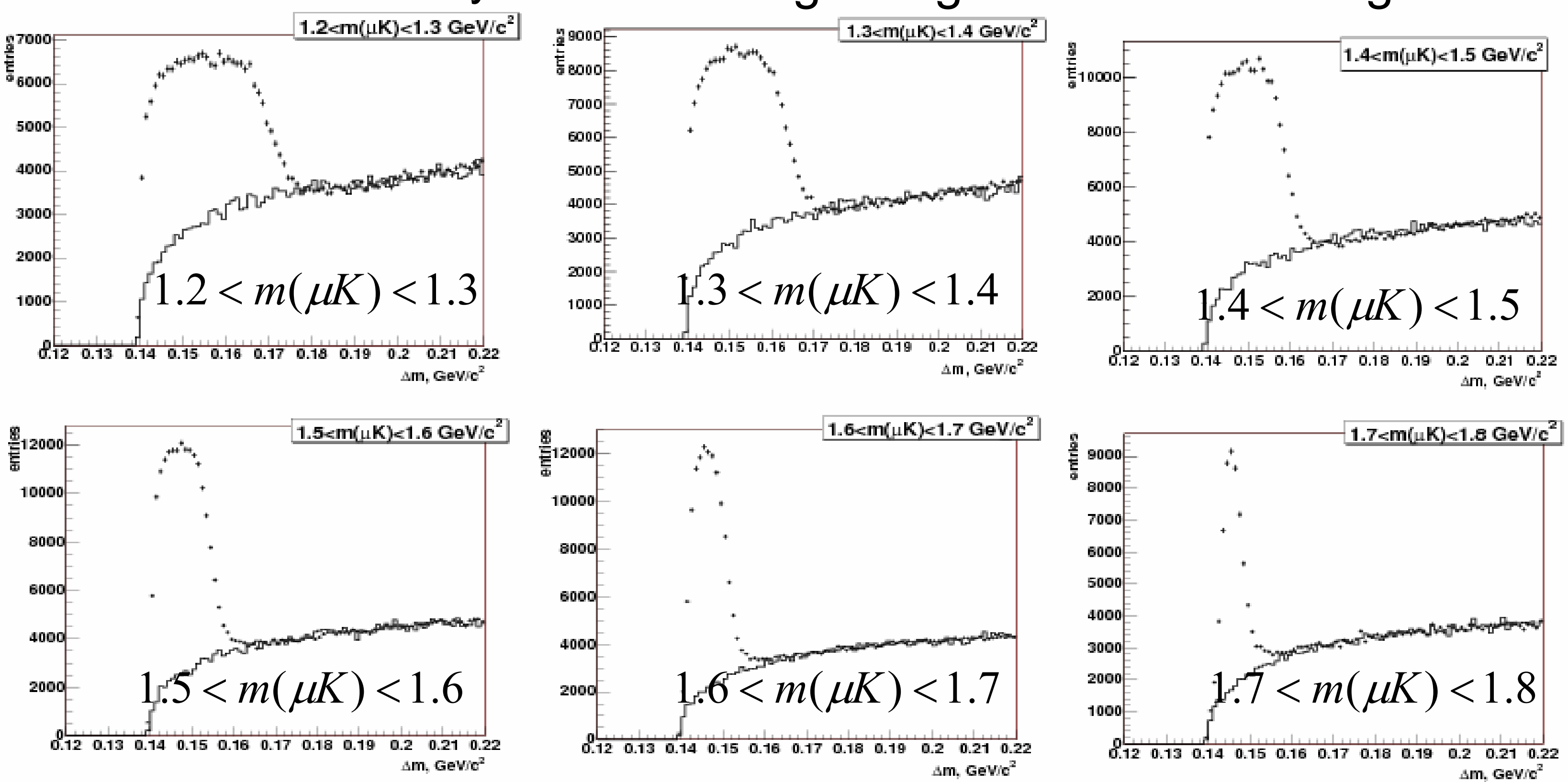
$$\Delta m = m(\mu K \pi) - m(\mu K)$$

in different $m(\mu K)$ bins:

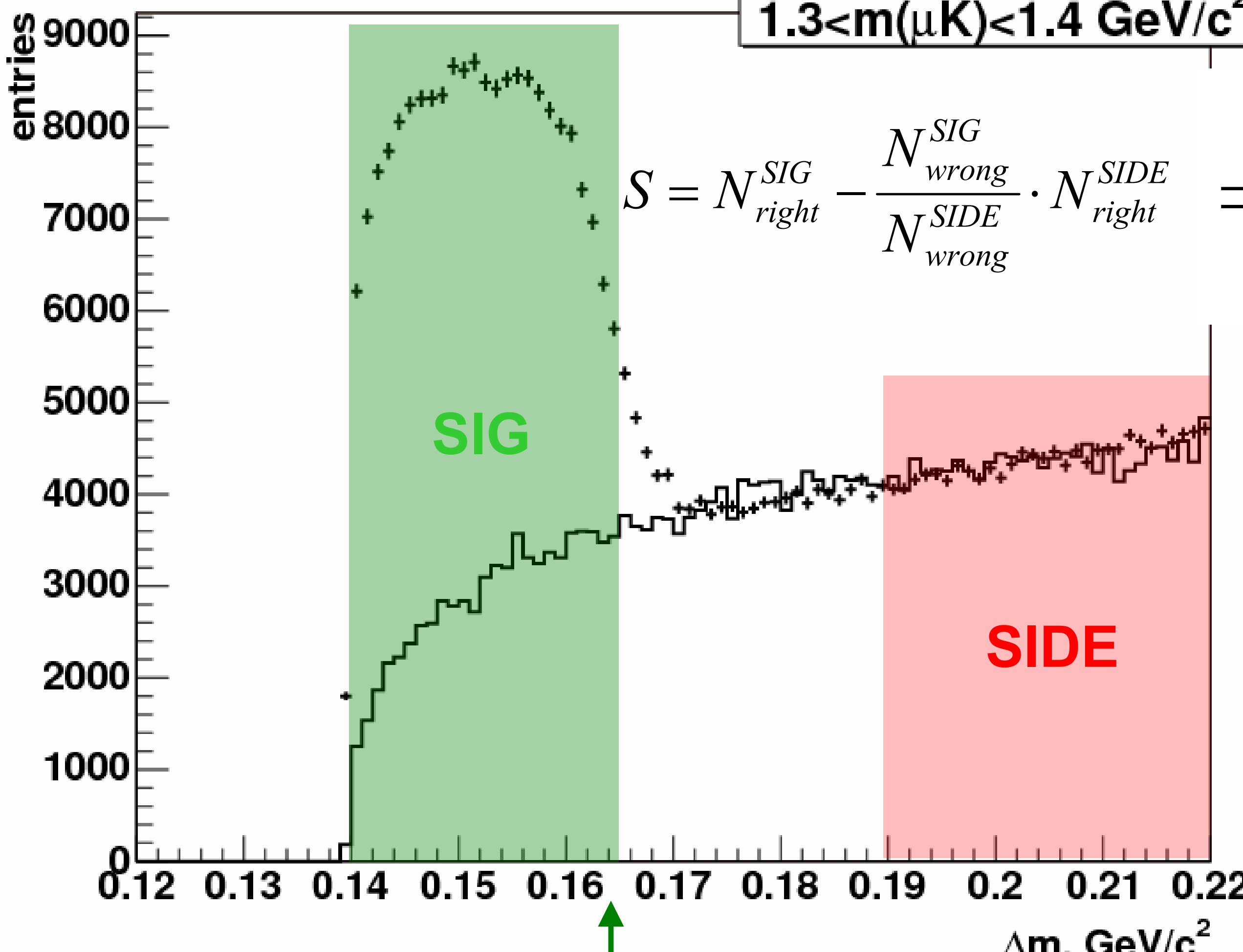
Right charge correlation - D* peak

Wrong charge correlation background

DØ Run II Preliminary



D* Extraction



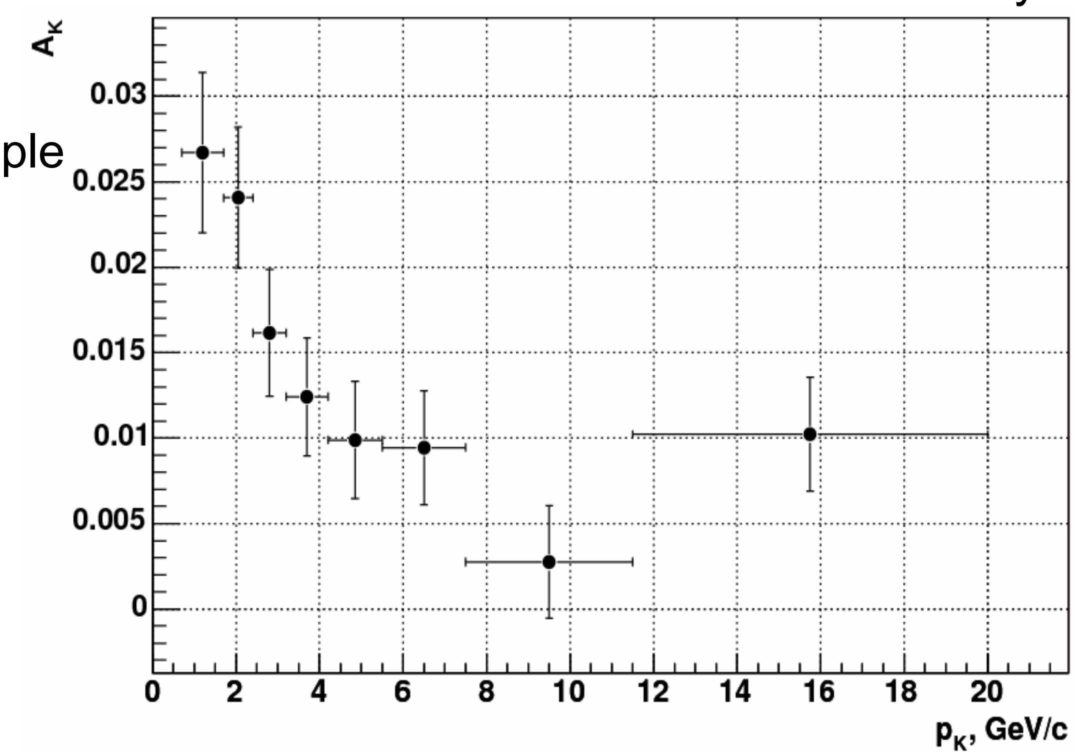
$$S = N_{right}^{SIG} - \frac{N_{wrong}^{SIG}}{N_{wrong}^{SIDE}} \cdot N_{right}^{SIDE} \Rightarrow n_q^{\beta\gamma} = \sum_{m(\mu K)} S$$

$$\max \frac{S}{\Delta S}$$

Kaon Asymmetry

- $A_K(p_K)$ was measured in D* sample
- Use same method as before
  (detector characteristics)
  - Convoluted p_K distribution in $J/\psi K$ sample

DØ Run II Preliminary



$$A_K = 0.0139 \pm 0.0013(stat) \pm 0.0004(syst)$$

Results

DØ Run II Preliminary

	$J/\psi K$	$J/\psi\pi$	$J/\psi KX$	BKG
N	$27,694 \pm 202$	$1,097 \pm 94$	$3,763 \pm 180$	$21,926 \pm 171$
ϵ^+	0.4871 ± 0.0036	0.5368 ± 0.0586	0.5053 ± 0.0198	0.4747 ± 0.0038
A	-0.0072 ± 0.0073	-0.1890 ± 0.1168	0.0035 ± 0.0498	-0.0075 ± 0.0160
A_{fb}	-0.0009 ± 0.0073	0.2192 ± 0.1160	0.0089 ± 0.0494	-0.0285 ± 0.0160
A_{det}	-0.0081 ± 0.0073	0.3333 ± 0.1060	0.0590 ± 0.0497	-0.0196 ± 0.0160
$A_{q\beta\gamma}$	0.0006 ± 0.0073	0.0354 ± 0.1228	0.0571 ± 0.0497	-0.0065 ± 0.0160
$A_{q\beta}$	0.0027 ± 0.0073	-0.2307 ± 0.1170	-0.0176 ± 0.0498	0.0319 ± 0.0160
$A_{\beta\gamma}$	0.0045 ± 0.0073	-0.0027 ± 0.1145	0.0335 ± 0.0496	-0.0071 ± 0.0160

$$A_K = 0.0139 \pm 0.0013(stat) \pm 0.0004(syst)$$

$$A_{CP}(B^+ \rightarrow J/\psi(1S)\ K^+) = +\,0.0067 \pm 0.0074(stat) \pm 0.0026(syst)$$

Systematics

- From J/ψKX: repeat the analysis with fraction of J/ψKX fixed to 0
- From A(J/ψπ), A(J/ψKX):
  - Repeat the analysis with A(J/ψπ), A(J/ψKX) artificially suppressed by fixing the ratios:
  - R = (J/ψπ fraction)/(BKG fraction), (J/ψKX fraction)/(BKG fraction)
- In every subsample to the value determined from the fit in the total sample

Fixing	$A(J/\psi K)$	$A(J/\psi \pi)$	$A(J/\psi K^*)$	A(BKG)
$J/\psi K^*$ fraction $\to 0$	−0.0079	−0.2098	–	0.0043
$R_{J/\psi\pi} \to$ "all" value	−0.0078	0.0488	−0.0581	0.0198
$R_{J/\psi K^*} \to$ "all" value	−0.0077	−0.1847	0.0035	0.0041
$R_{J/\psi\pi}, R_{J/\psi K^*} \to$ "all" value	−0.0098	−0.0086	0.0077	0.0076

this deviates maximally from the nominal

$A = -0.0072$

DØ Run II Preliminary

Direct CP Violation in $B^+ \to J/\psi K^+$

PDG-2007 pre new DØ

$A_{CP}(B^+ \to J/\psi(1S) K^+)$

VALUE		DOCUMENT ID		TECN	COMMENT
0.015 ± 0.017 OUR AVERAGE	Error includes scale factor of 1.2.				
$0.030 \pm 0.014 \pm 0.010$	636	AUBERT	05J	BABR	$e^+ e^- \to \Upsilon(4S)$
$-0.026 \pm 0.022 \pm 0.017$		ABE	03B	BELL	$e^+ e^- \to \Upsilon(4S)$
$0.018 \pm 0.043 \pm 0.004$	637	BONVICINI	00	CLE2	$e^+ e^- \to \Upsilon(4S)$

$$A_{CP}(B^+ \to J/\psi(1S)\, K^+) = +\,0.0067 \pm 0.0074(stat) \pm 0.0026(syst)$$

World's most precise!

- Systematic uncertainties are small
  - Room for improvement
  - Need more data!

Summary

- Presented today new Δm_s and $A_{CP}(B^+ \rightarrow J/\psi K^+)$
  - Measured all three parameters that characterize B_s system
  - No significant deviations from the SM are observed
  - All results are statistics limited
- Looking forward to collecting more data
  - Expected quick turn around as we collect data
  - Very exciting time to be at Tevatron experiments