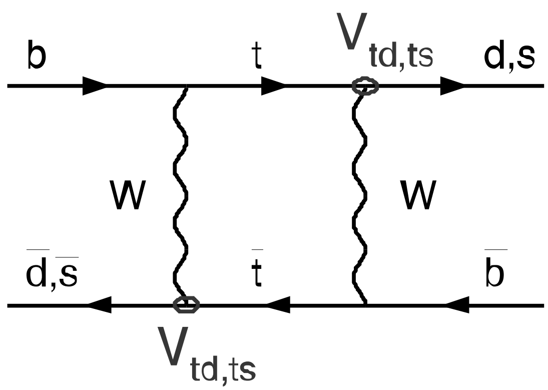
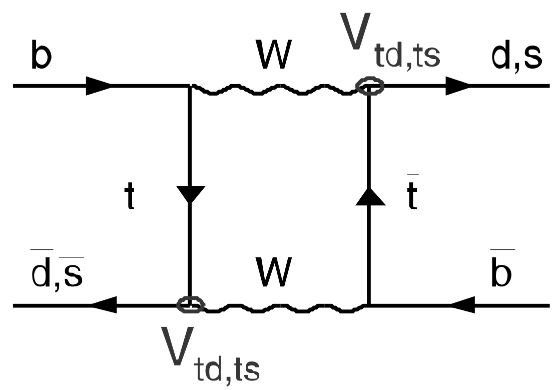
B_s Mixing at SLD





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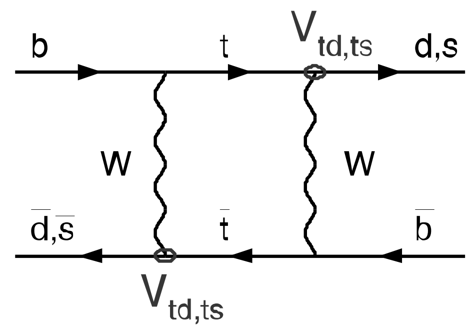
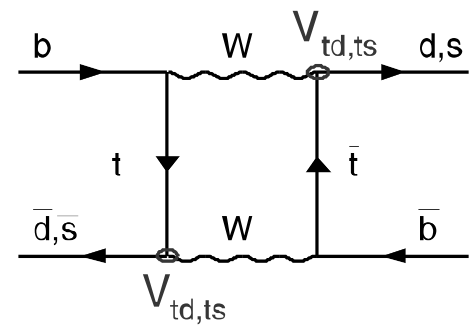
The SLD Collaboration

$B^0 - \overline{B}^0$ System

- $B^0 \leftrightarrow \overline{B}^0$ transitions occur via second order weak interactions





- B_d^0 mixing frequency:

$$\Delta m_d = \frac{G_F^2}{6\pi^2} m_{B_d} m_t^2 F\left(\frac{m_t^2}{m_W^2}\right) B_{B_d} f_{B_d}^2 \eta_{QCD} \left| V_{tb}^* V_{td} \right|^2 = 0.484 \pm 0.010\,\mathrm{ps}^{-1}$$

LEP/SLD/CDF/CLEO/ARGUS/BABAR/BELLE Mar. 2001

But extraction of V_{td} from Δm_d is affected by a ~20% uncertainty mostly due to theoretical uncertainties in $\sqrt{B_{B_d}}\, f_{B_d}$

$\rightarrow$ reduced theoretical uncertainties and most precise determination of V_{td} obtained by measuring $\Delta m_s / \Delta m_d$

$$\frac{\Delta m_s}{\Delta m_d} = \frac{m_{B_s} f_{B_s}^2 B_{B_s}}{m_{B_d} f_{B_d}^2 B_{B_d}} \cdot \left|\frac{V_{ts}}{V_{td}}\right|^2 = \frac{m_{B_s}}{m_{B_d}} \cdot (1.16 \pm 0.05)^2 \cdot \left|\frac{V_{ts}}{V_{td}}\right|^2 \approx \frac{1}{\lambda^2} \approx O(20)$$

S.Aoki BCP4

Mixing Ingredients

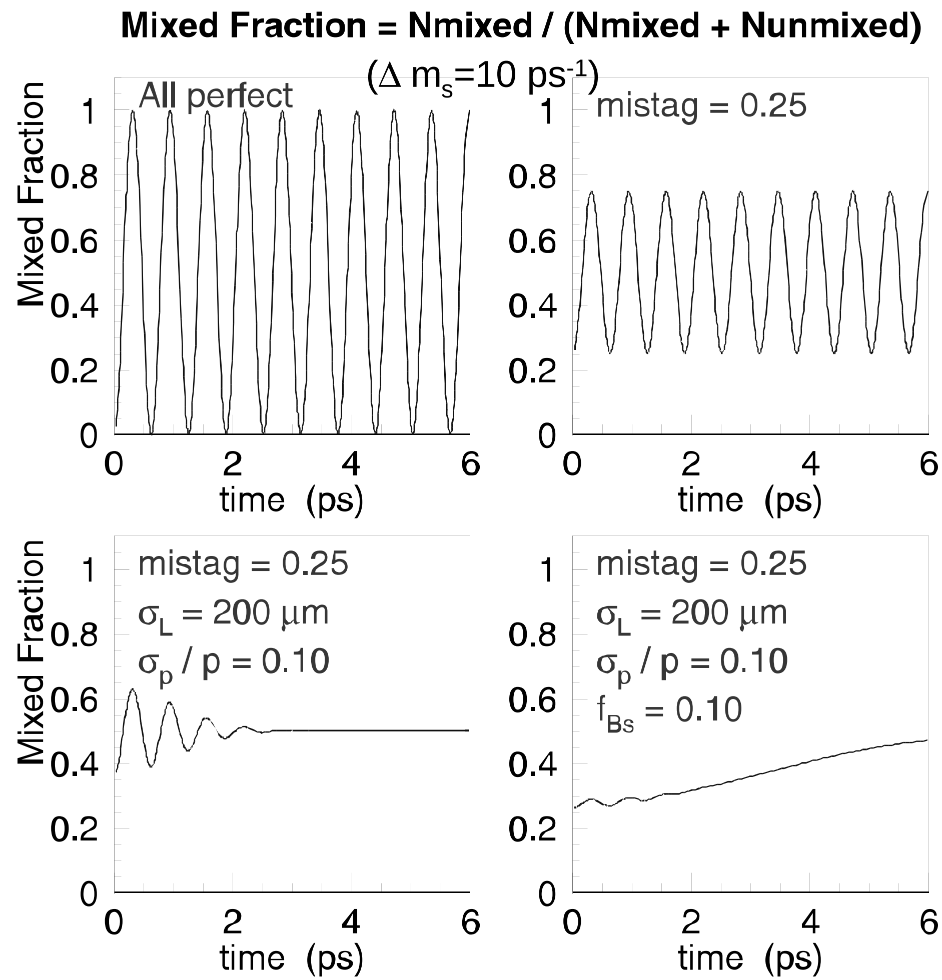
1. Reconstruct B decay vertex & determine proper time
2. Determine B^0 or $\bar{B}^0$ flavor at production
3. Determine B^0 or $\bar{B}^0$ flavor at decay

Significance for B_s mixing signal:

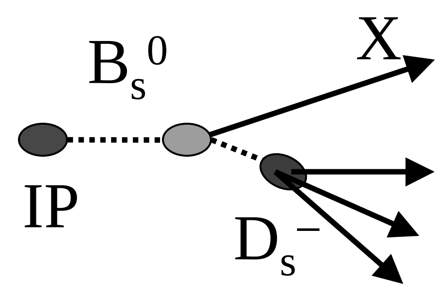
$$S = \sqrt{\frac{N}{2}}\, f_{B_s}\, (1-2w)\, e^{-\frac{1}{2}(\Delta m_s \sigma_t)^2}$$

statistics, B_s purity, mistag, resolution

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



Semi-exclusive Method: D_s + tracks analysis



Partial reconstruction of $B_s \to D_s^- X$

full reconstruction of D_s decay

$D_s^- \to \phi\pi^-, K^{*0}K^-$

particle ID with Cherenkov

Ring Imaging Detector (CRID)

Neural Network D_s selection yields

280 $D_s^- \to \phi\pi^-$ candidates

81 $D_s^- \to K^{*0}K^-$ candidates

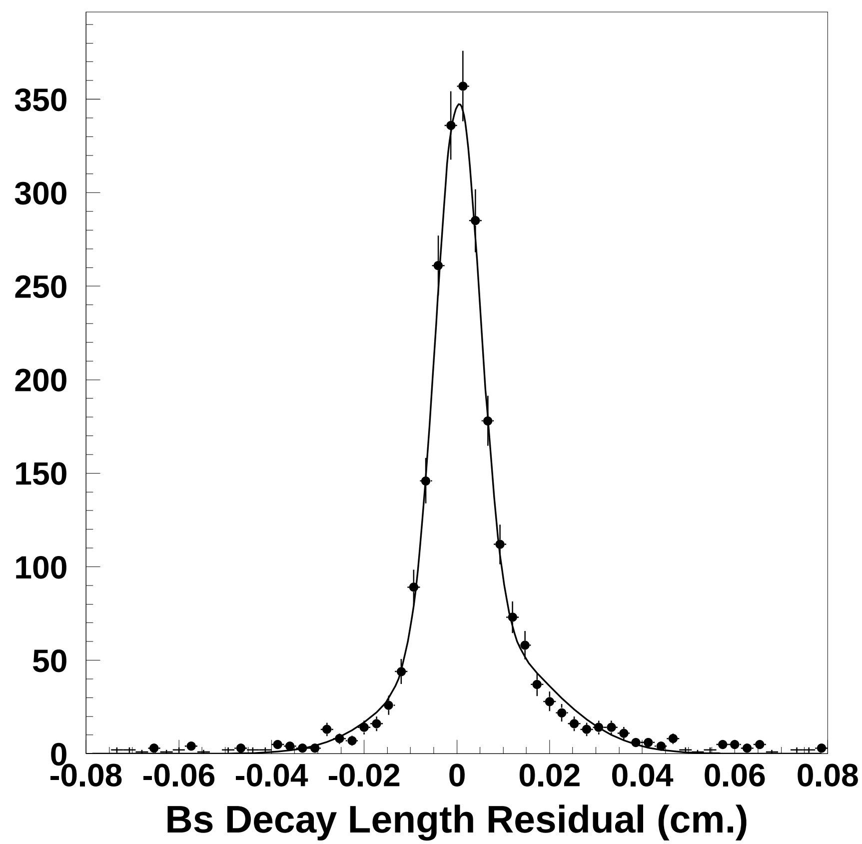
superb decay length resolution

σ_L = 48 μm (60%) & 152 μm

σ_p / p = 0.08 (60%) & 0.19

high B_s purity: $f(B_s)$ = 38% overall

good tagging: final state mistag ≅ 10%



Inclusive Methods: lepton+D analysis

Select identified lepton

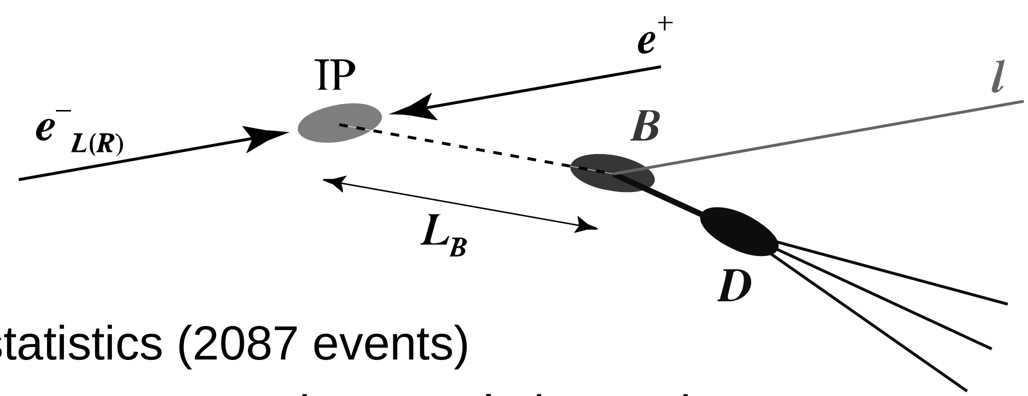
$\rightarrow$ lepton charge tags decay flavor (b $\rightarrow$ l^-)

Reconstruct D meson decay vertex topologically

$\rightarrow$ B vtx = intersection of lepton trajectory and D vtx "track"

Use Neural Network to suppress (b $\rightarrow$ c $\rightarrow$ l^+)

$\rightarrow$ very low mistag w = 0.04



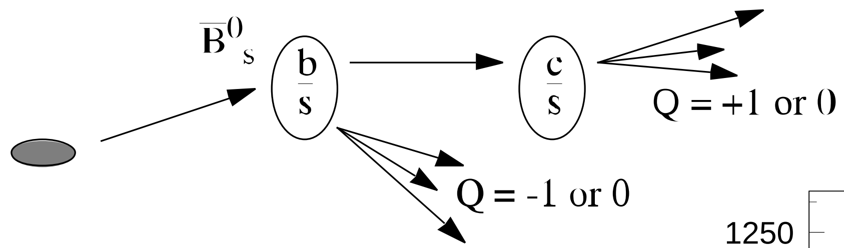
Pros: higher statistics (2087 events)

Cons: slightly worse proper time resolution and lower B_s purity than semi-exclusive method

$\Rightarrow$ Include variables sensitive to proper time resolution, mistag probabilities and B_s purity on an event-by-event basis

Inclusive Methods: Charge Dipole analysis

- FULLY inclusive reconstruction



Reconstruct both secondary and tertiary vertices

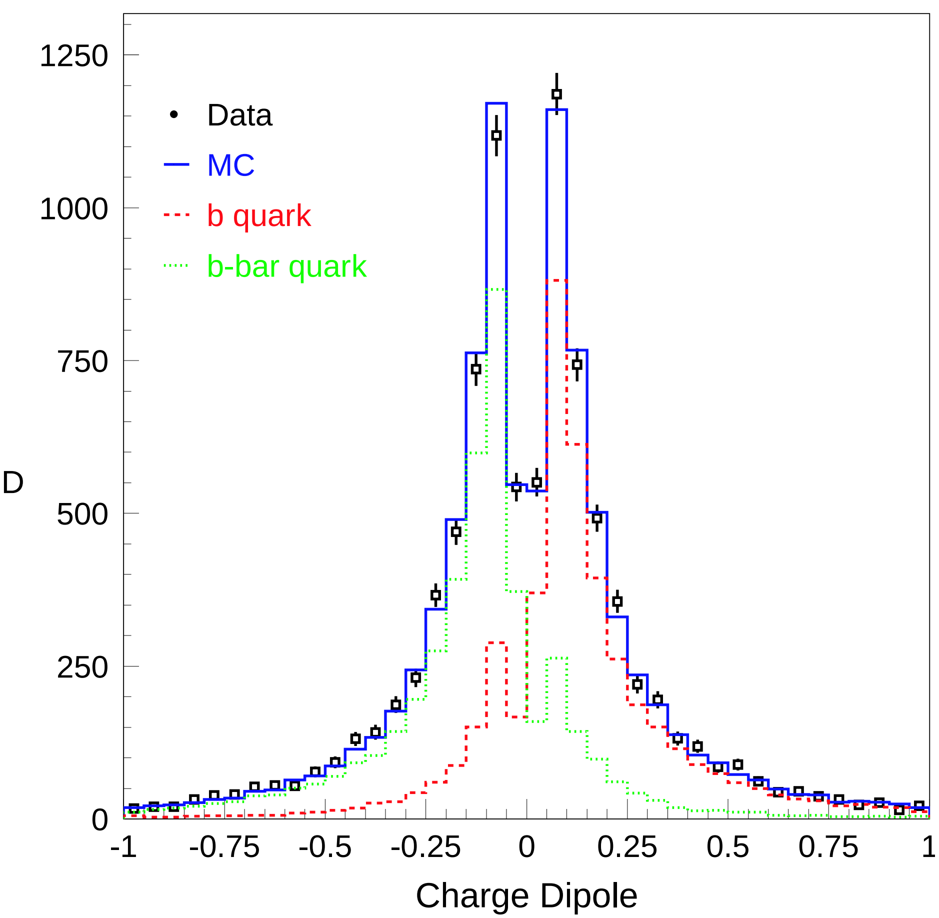
Tag flavor with "charge dipole"

$\delta q = \text{sign}(Q_D - Q_B) * \text{Distance}_{B\ to\ D}$

final state mistag ≈24%

Select 8556 neutral decays

i.e. statistics ~4x higher than lepton+D analysis



Amplitude fit results

⇒ ideally suited for Fourier Analysis

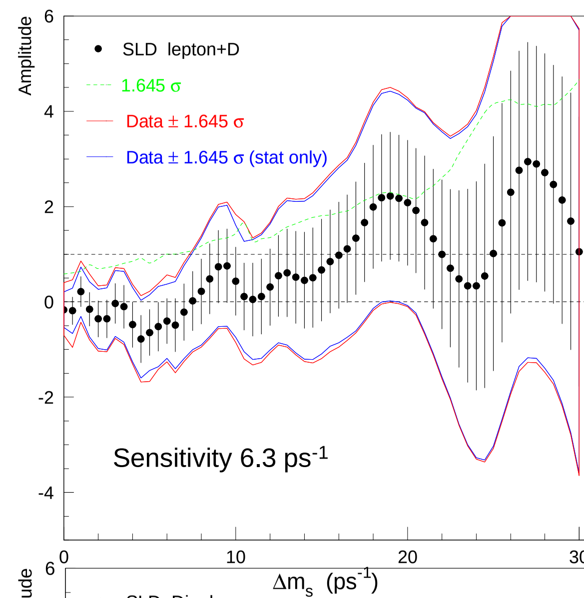
⇒ measure oscillation amplitude A at fixed frequency Δm_s

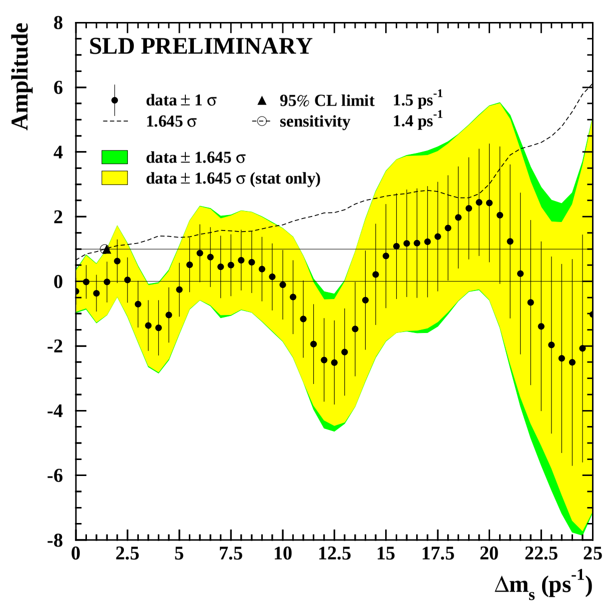
$$P_{mix,unmixed} = \frac{1}{2}\Gamma e^{-\Gamma t}\left(1 \mp A\cos\Delta m_s t\right)$$

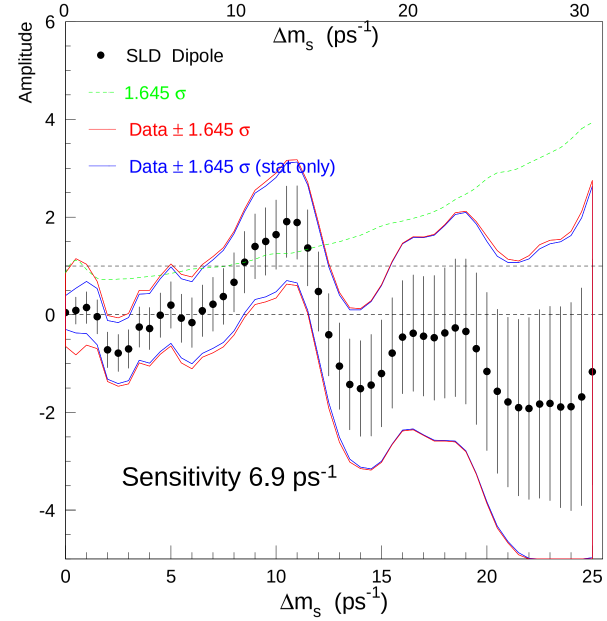
Expect A = 1 for frequency = true Δm_s

A = 0 for frequency ≠ true Δm_s

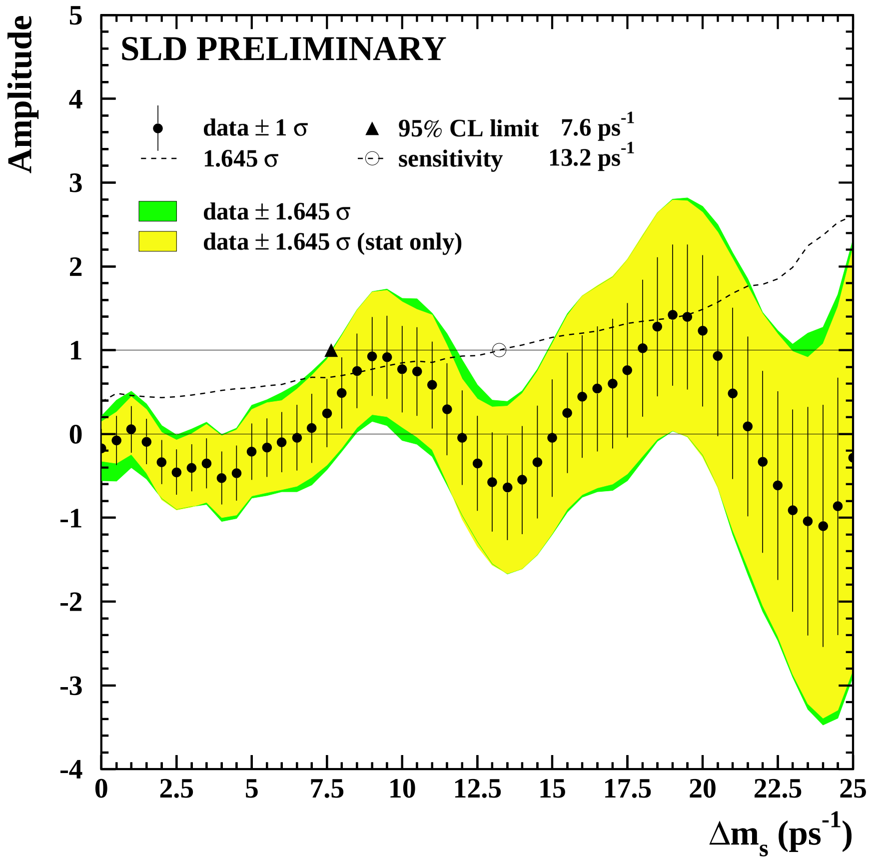
Sensitivity: Δm_s value for which $1.645\,\sigma_A = 1$

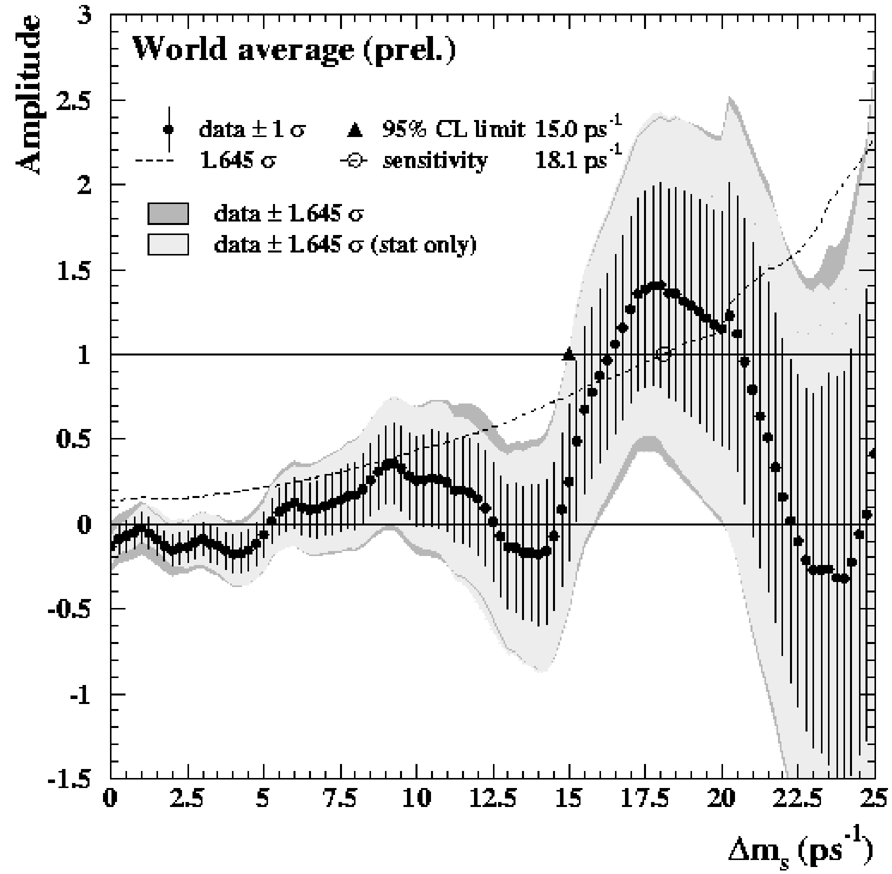






B_s Oscillation Amplitude: SLD, LEP and CDF





SLD 400K Z^0: Sensitivity = 13.0 ps^{-1}

Excluded at 95% C.L.:

$\Delta m_s <$ 7.6 ps^{-1}

$11.8 < \Delta m_s < 14.8$ ps^{-1}

WORLD Sensitivity = 18.1 ps^{-1}

Excluded at 95% C.L.:

$\Delta m_s <$ 15.0 ps^{-1}

Summary

- SLD provides significant input to the world limit on Δm_s. There will be an update to the SLD results for Summer, 2001.
- Sophisticated analyses have pushed the limit on Δm_s

ALEPH+CDF+DELPHI+OPAL+SLD: $\mathbf{\Delta m_s > 15.0\ ps^{-1}}$ **(95% C.L.)**

may have hint now *but oscillations are yet to be conclusively observed*

- Near future should see precise measurement of Δm_s (unless >> SM) at CDF, D0, BTeV, LHCb (expect very good statistical precision ~0.1%)
- Stay tuned!