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B_s MIXING RESULTS FROM ALEPH

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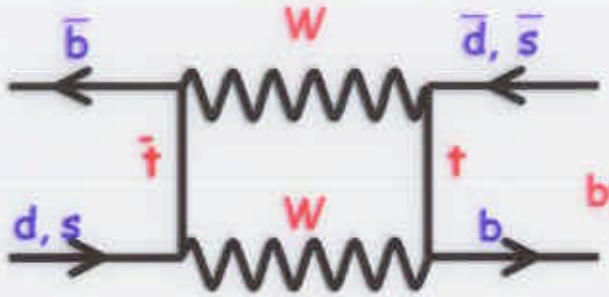
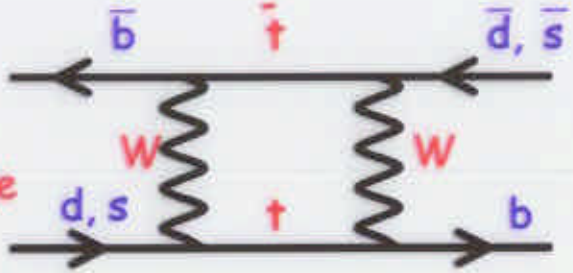
- ☆ Expectations
- ☆ Analysis ingredients
- ☆ New Fully Reconstructed B_s Analysis (Moriond 2000)
- ☆ Updated D_s-Lepton Analysis (Moriond 2000)
- ☆ New Improved Inclusive Lepton Analysis (this conference)
- ☆ ALEPH Combined

(All results preliminary)

B^0-$\bar{B}^0$ Mixing in the SM



Dominated by top exchange



$$\Delta m_q = \left|V_{tb}^* V_{tq}\right|^2 \frac{G_F^2}{6\pi^2} m_{B_q} m_t^2 \, S\left(\frac{m_t^2}{M_W^2}\right) \underbrace{\eta_{QCD} B_{B_q} f_{B_q}^2}_{\text{QCD corrections}}$$

$\sqrt{B_{B_d}}\, f_{B_d} = 240 \pm 36$ MeV

has large uncertainty (~15%)

But: the ratio has better controlled theoretical uncertainties

$$\frac{\Delta m_s}{\Delta m_d} = \frac{m_{B_s}}{m_{B_d}} \xi^2 \left|\frac{V_{ts}}{V_{td}}\right|^2 \sim \frac{1}{\lambda^2 \sqrt{(1-\rho)^2 + \eta^2}}$$

with: $\xi = 1.17 \pm 0.06$ (~6%)

Wolfenstein parametrization

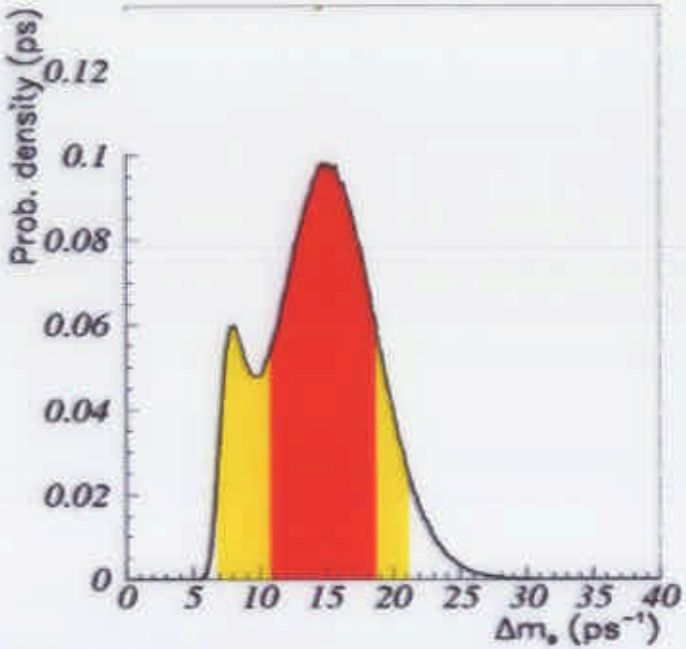
Indirect Constraints on Δm_s

From CKM fits:

Inputs:

- $|V_{ub}|/|V_{cb}|$
- $|\varepsilon_K|$
- Δm_d
- + theory...

$\Delta m_s = 15. \pm 4.\ ps^{-1}$



From $\Delta\Gamma/\Gamma$

Measurements: $\Delta\Gamma_s/\Gamma_s = 0.16\ ^{+0.08}_{-0.09}$ (with constraint $\Gamma_s = \Gamma_d = 1/\tau_d$)

NLO+Lattice calculations: $\Delta\Gamma_s/\Delta m_s = (6.5 \pm 2.) \times 10^{-3}$

(M. Beneke, update of Phys Lett B 459 (1999))

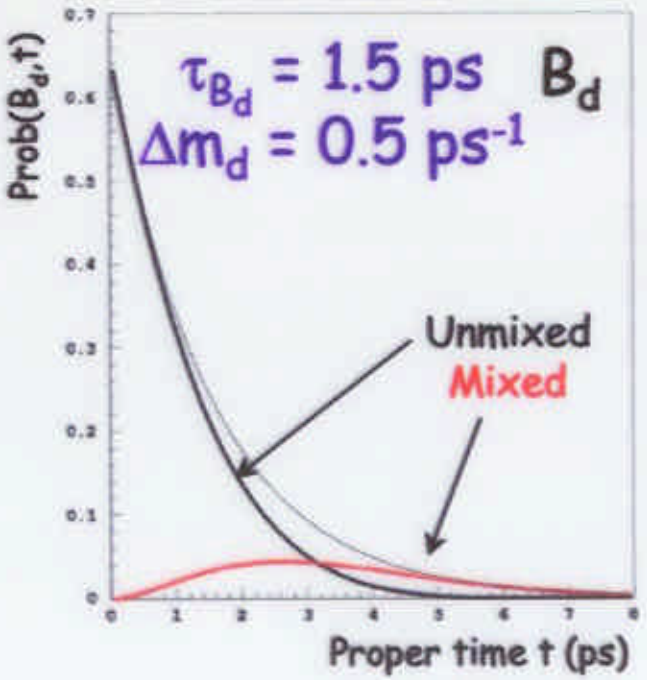
$\Delta m_s = 16.\ ^{+8.}_{-9.} \pm 5.\ ps^{-1}$

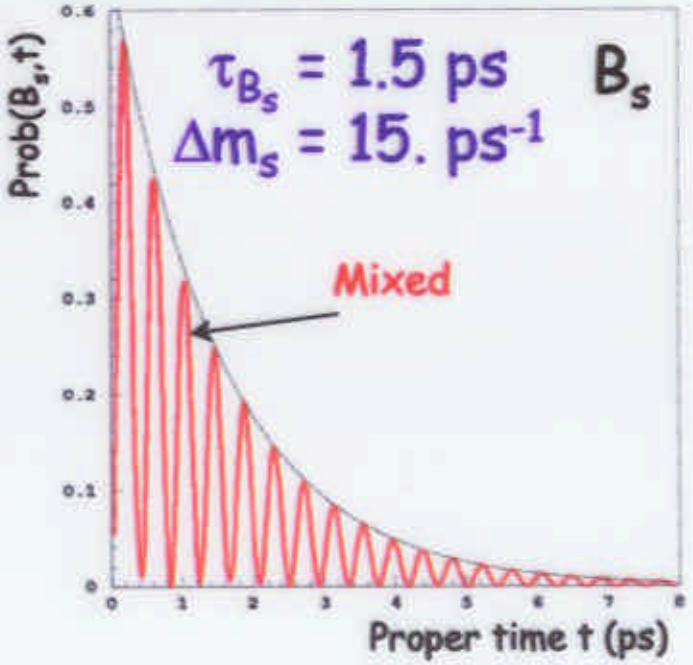
Δm_s-just around the corner?!

B^0-$\bar{B}^0$ Time Evolution

If no CP violation in B mixing and $\Delta\Gamma_q = 0$

$$\mathrm{Prob}(B_q \to B_q(\bar{B}_q), t) = \frac{\Gamma_q e^{-\Gamma_q t}}{2}\left[1 \pm \cos(\Delta m_q t)\right]$$

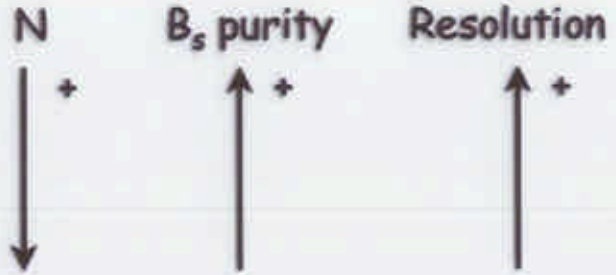




Analysis Ingredients

1) Select the sample:

Exclusive reconstruction
D_s with lepton
Inclusive lepton



2) Tag B flavour at production (Initial) and decay (Final):

Mistag: $1-2\eta = (1-2\eta_I)(1-2\eta_F)$

3) Measure the proper time from momentum and decay length

$$t = \frac{m_B}{p_B} l$$

use also event-by-event estimate of error on decay length:

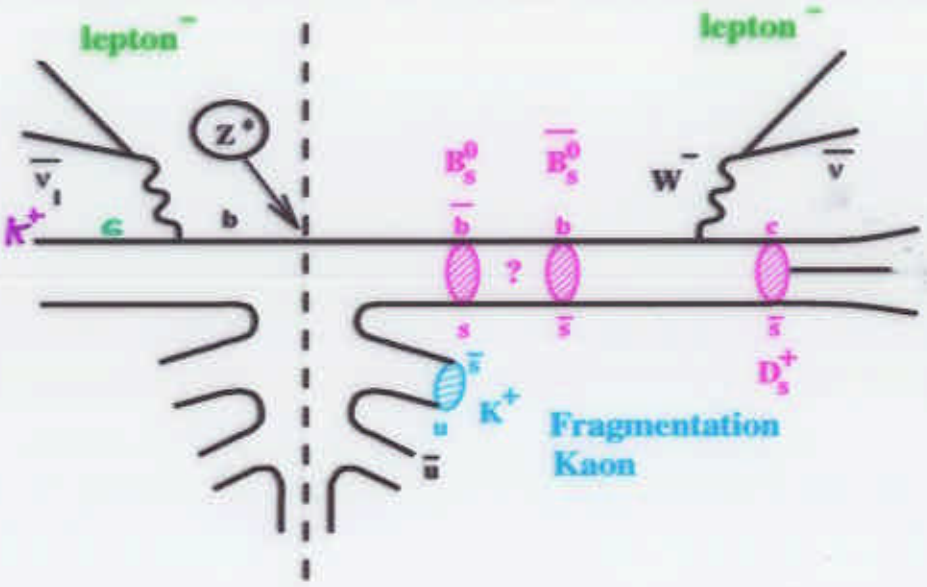
$$\sigma_t = \frac{m_B}{p_B}\sigma_l \oplus t\frac{\Delta p_B}{p_B}$$

4) Likelihood fit to the proper time distribution of tagged mixed/unmixed events

Analysis Ingredients: Tagging

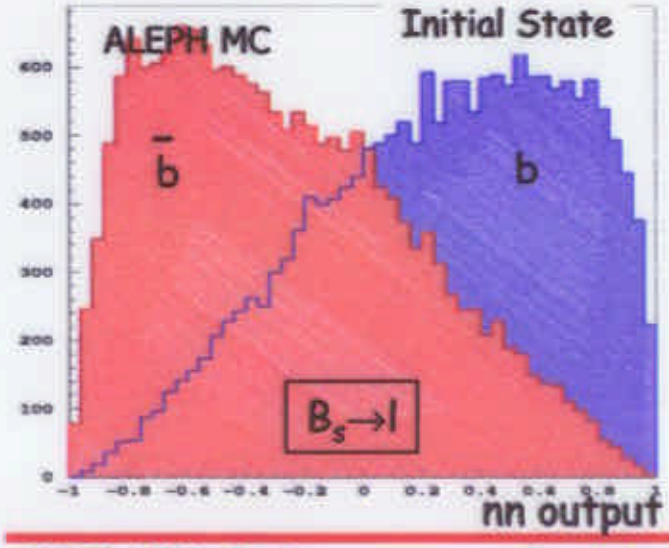
<u>opposite hemisphere</u>

prim & sec vtx charges,
jet charges,
Kaon charge,
Lepton charge and mom
P_B and decay length



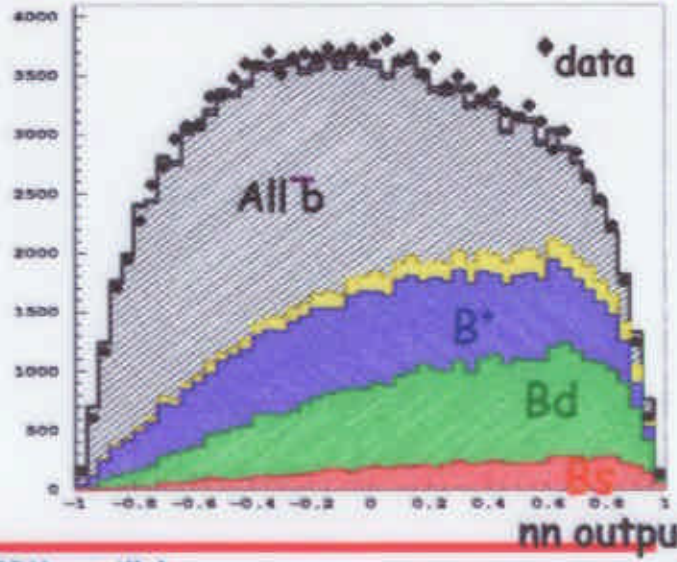
<u>Same hemisphere</u>

K_f charge
prim vtx charges



Information from both hemispheres combined in neural net

e.g. inclusive lepton analysis:
~~total~~ initial mistag ~24%
(was 29%)
26



New Fully Reconstructed B_s Analysis

★ B_s decay chain: $B_s \to D_s^- \pi^-$, $B_s \to D_s^- a_1^-$
(with fully reconstructed $D_s^- \to \phi\pi$, K^*K^-)

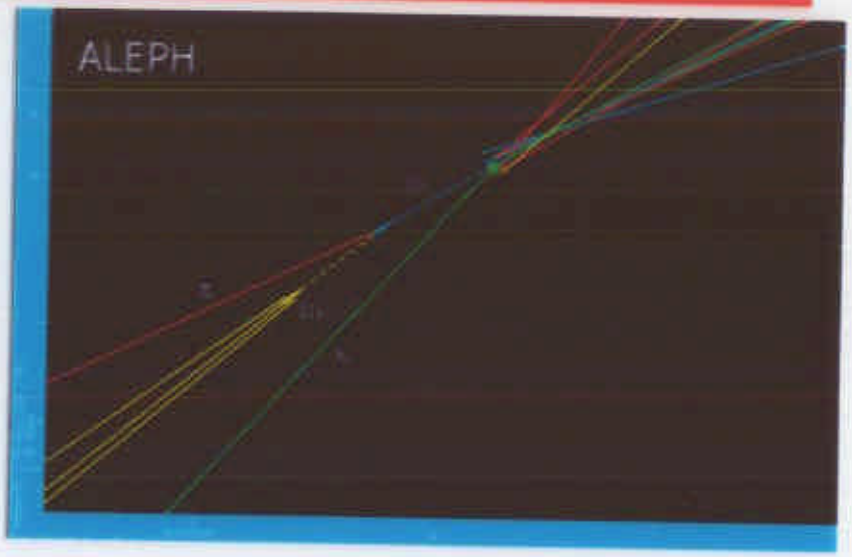
★ Broad satellite peak in mass spectrum expected from $B_s \to D_s^{*-} \pi^- (a_1^-)$ with $D_s^{*-} \to D_s\gamma$
(γ not reconstructed)

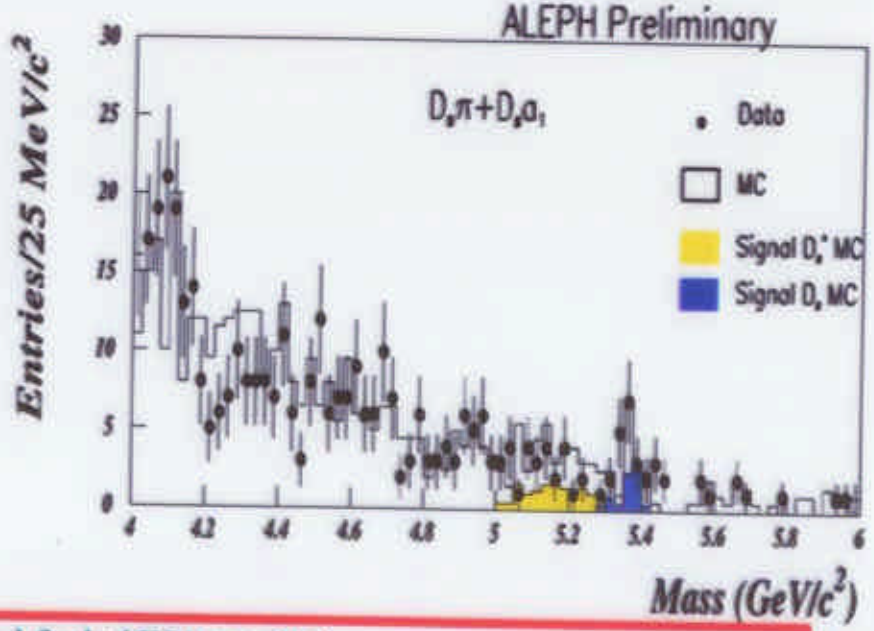
★ Statistics low- main peak: 10±3 B_s events
satellite peak: 9±4 B_s events

★ High B_s purity ~40%

★ Very good proper time resolution (no neutrino)
σ_L~150μm, σ_p/p~0.5%, σ_t~0.08ps
(factor 3 better than inclusive analysis)

★ Final State mistag is perfect!





Updated D_s-Lepton Analysis

★ 297 D_s-lepton candidates reconstructed in:
8 channels: $\varphi\pi^-$, $K^{*0}K^-$, $K^0_sK^-$, φp,
$K^{*0}K^{*-}$, $\varphi\pi^+\pi^-\pi^-$, $\varphi e\nu$, $\varphi\mu\nu$

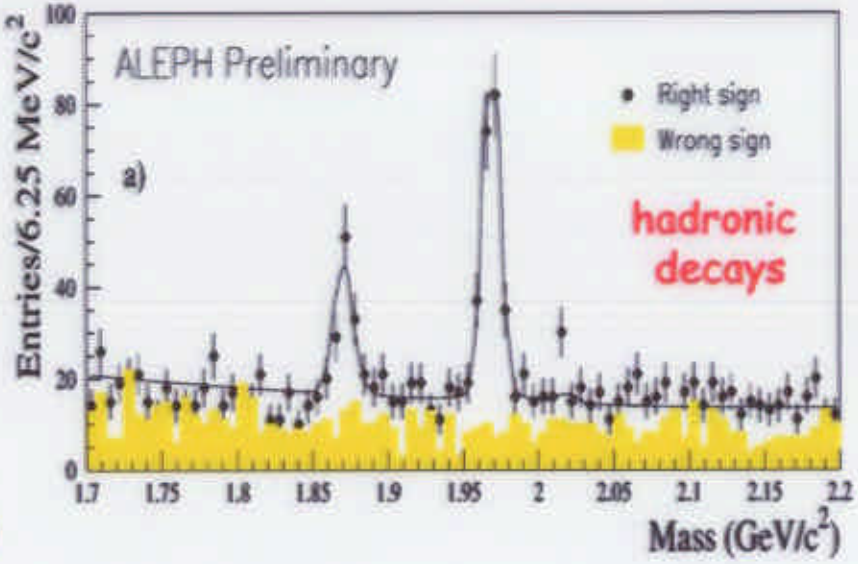
★ Dominant background from $B\to D_sDX$, $D\to lX$.
Improved knowledge ⇒ contribution higher (~*2) than previous estimate (due to 3 body component)

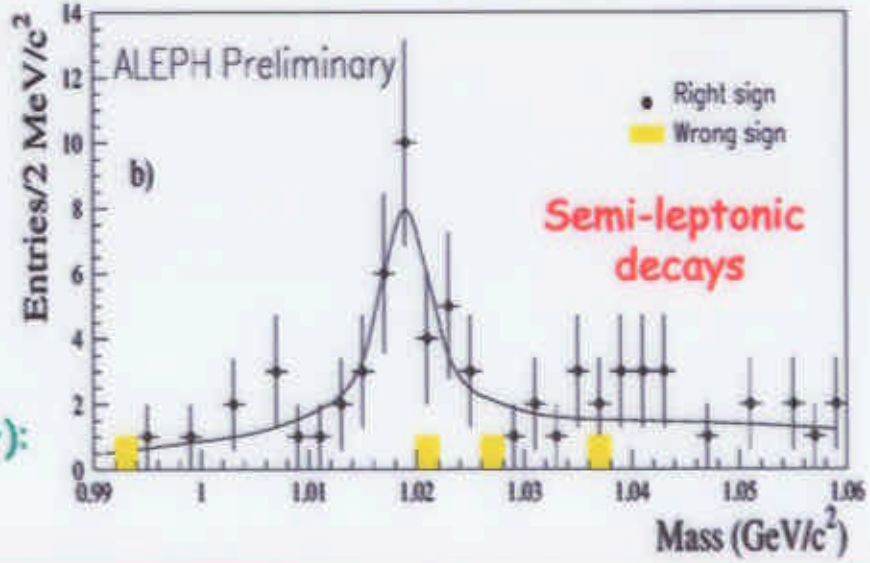
★ Average fraction of B_s in total sample ~40%

★ Discriminating variables used to identify subsamples with higher B_s fraction e.g.
P_t(lepton)>2 GeV/c ⇒ 85-95% B_s
P(lepton)>15 GeV/c ⇒ 65%-80% B_s

★ Careful parametrization of momentum and decay length resolutions

★ Proper time resolution reasonable (despite ν):
σ_L~250μm, σ_p/p~10%, σ_t~0.2ps





Aside: The Amplitude Method

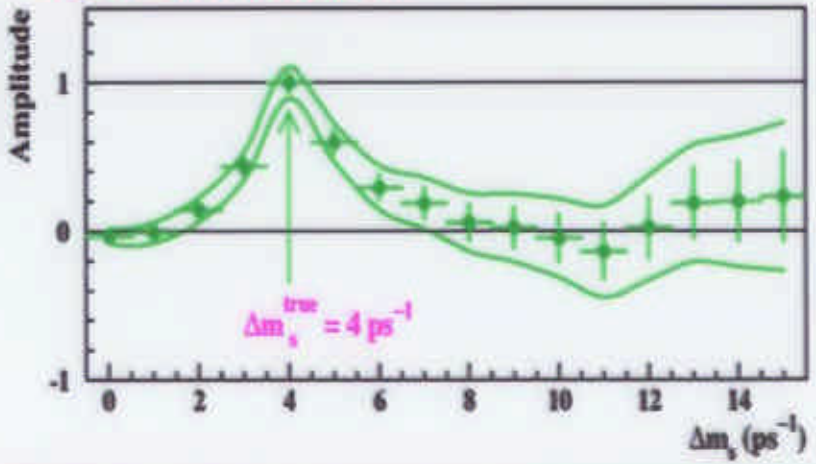
Method used to facilitate limit setting and combinations

$$\text{Prob}_{u,m}(t) = \frac{\Gamma e^{-\Gamma t}}{2}[1 \pm \cos(\Delta m_s t)] \quad \Rightarrow \quad \text{Prob}_{u,m}(t) = \frac{\Gamma e^{-\Gamma t}}{2}[1 \pm \mathbf{A} \cos(\omega t)]$$

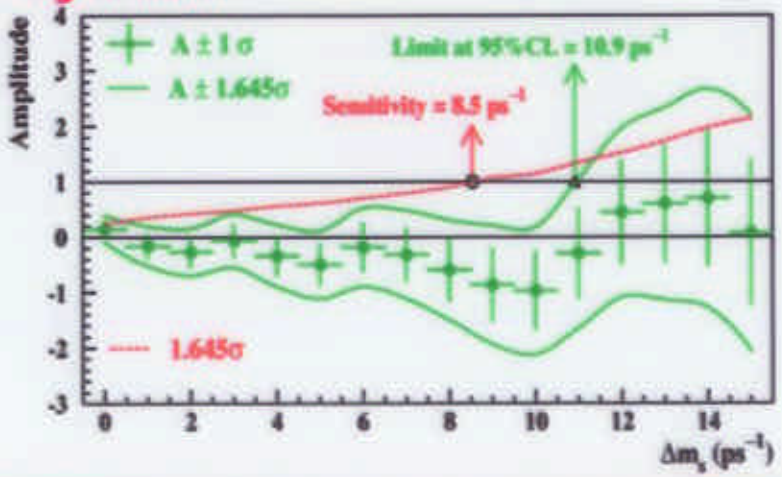
A is measured (Likelihood fit) for fixed values of the frequency ω:

(Far) below the true oscillation frequency **A** = 0.
At the true oscillation frequency **A** = 1.

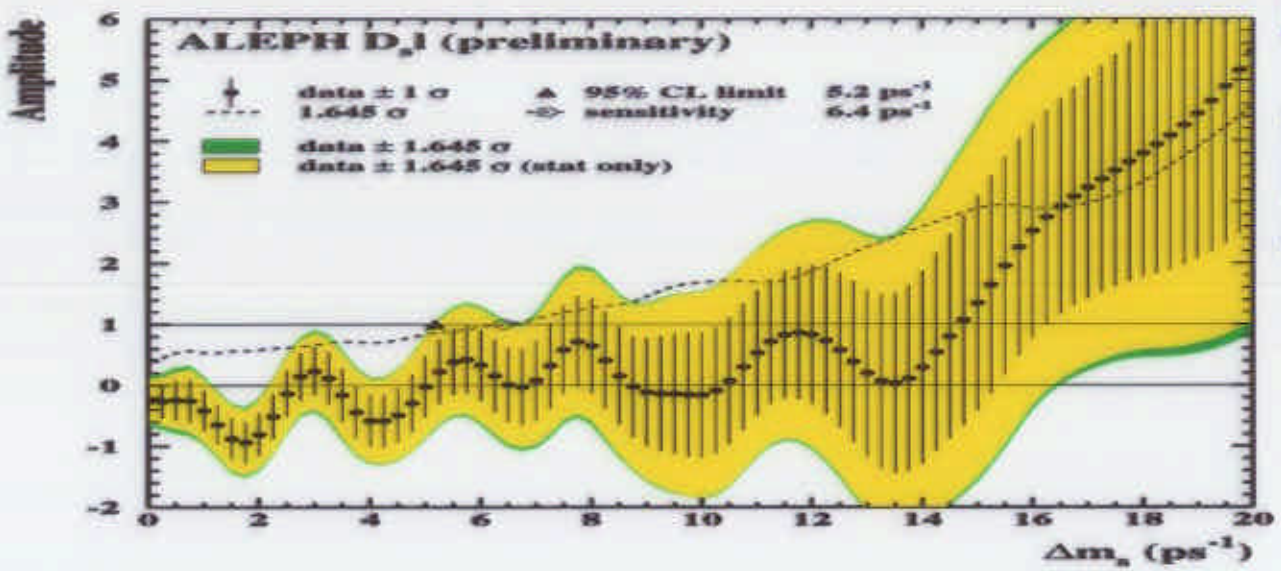
e.g. a measurement:



e.g. a limit:



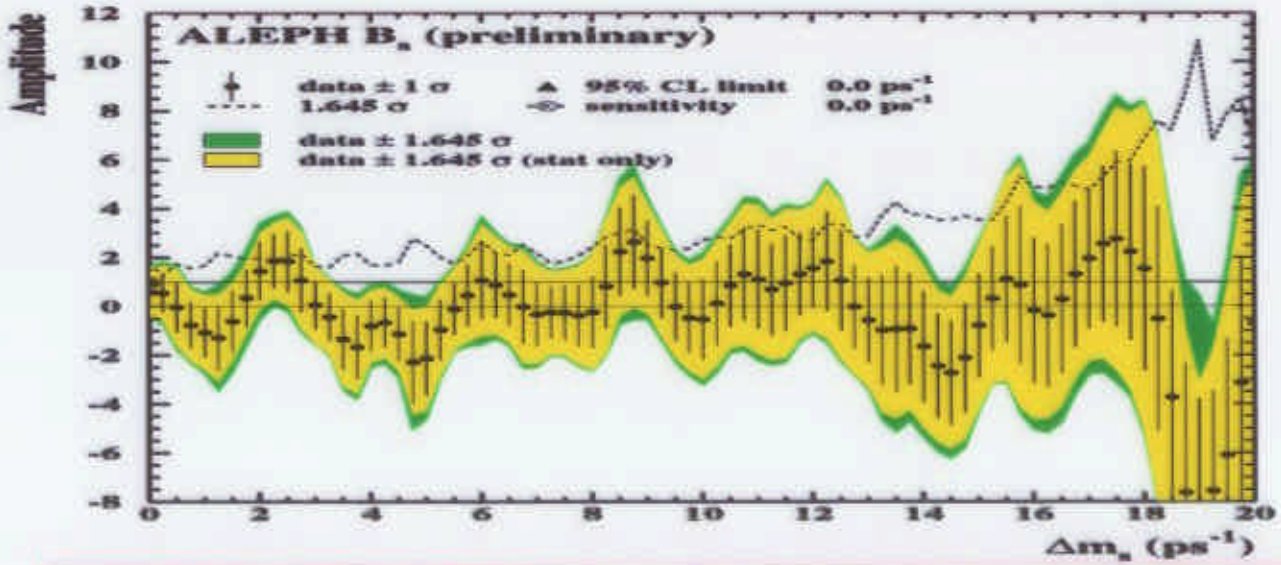
Exclusive B_s and D_s-lepton: Amplitude Plots



Ds-lepton

95% limit: 5.2ps^{-1}
Sensitivity: 6.4ps^{-1}
σ_A@15ps^{-1}: 1.7

published analysis
95% limit: 6.6 ps^{-1}
Sensitivity: 6.7 ps^{-1}
σ_A@15ps^{-1}: 1.8



Fully Reconstructed

95% limit: 0ps^{-1}
Sensitivity: 0ps^{-1}
σ_A@15ps^{-1}: 2.13

New Inclusive Lepton Analysis

- New vertexing algorithm:
  - estimate of B direction included as 'track' in the fit
  - photons added to improve charm direction

  (typically 10% better resolution)

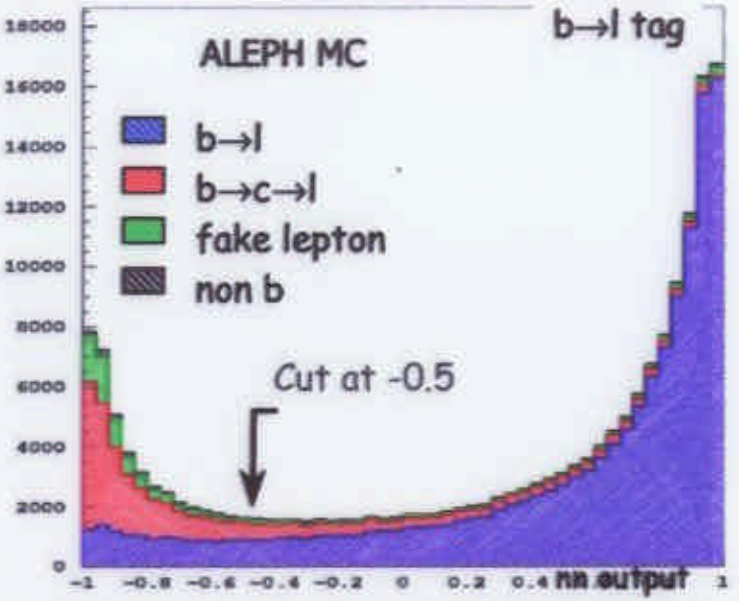
- New neural net for b→l tagging based on:
  lepton p, p_T, ν energy, lepton i.p. wrt to charm vertex.

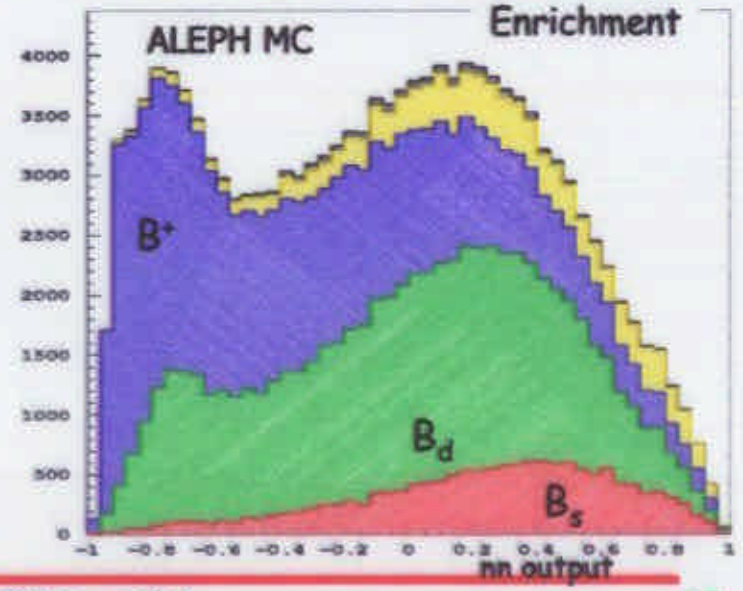
- New selection: *2.2 more events (~74k), with same resolution as old analysis

- Subclasses for decay length resolution, each with separate correction for the estimate of event-by-event decay length error

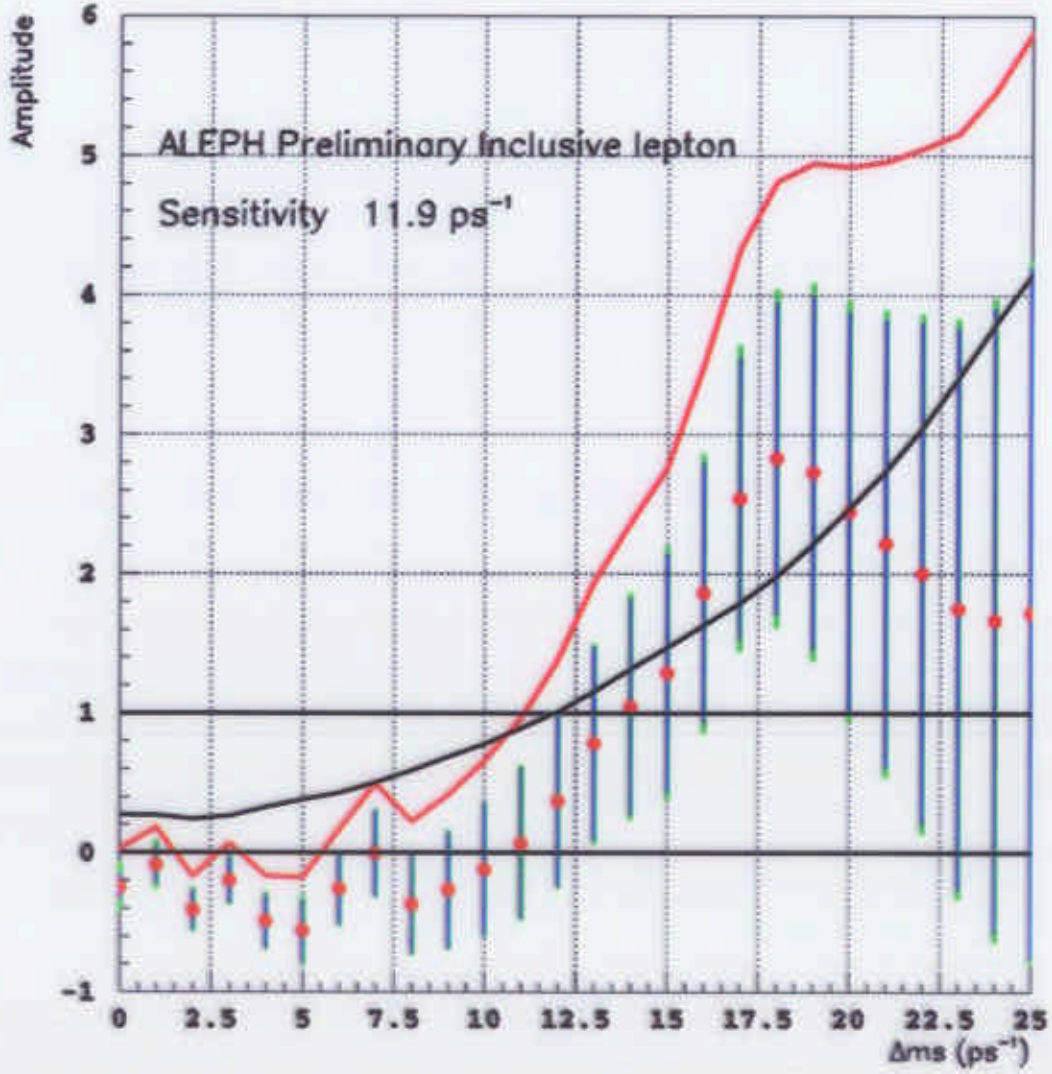
- Event-by-event B_s fraction from neural net based on:
  - charge estimators of charm vertex (B^0 vs B^+)
  - presence of decay K^+, K^0_s, φ, (B_s vs B^0)
  - presence of fragmentation K^+

- Improved ~~total~~ initial mistag from neural net (~24%)





New Inclusive Lepton Analysis: Amplitude Plot

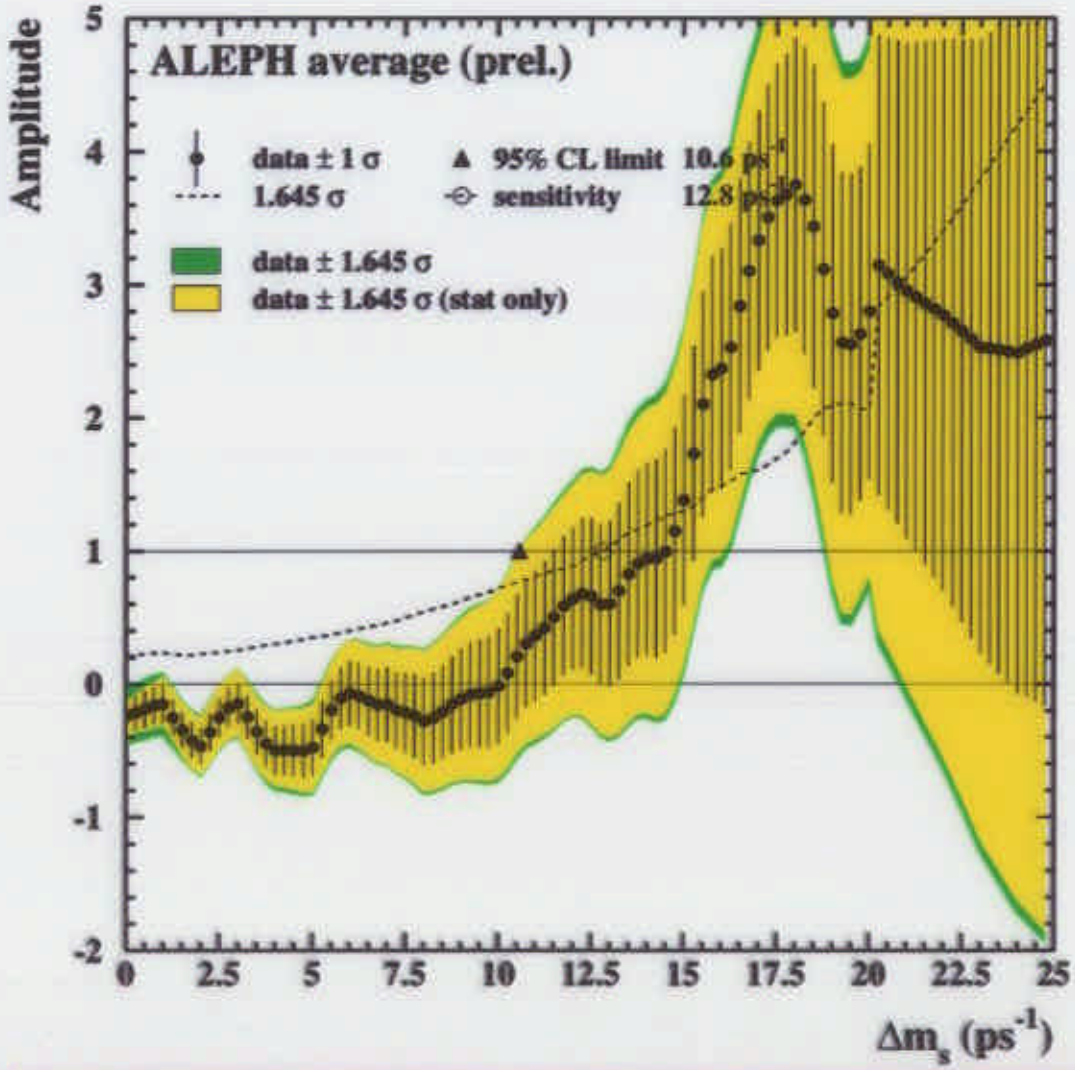


95% limit:	11.1 ps^{-1}
Sensitivity:	11.9 ps^{-1}
σ_A@15ps^{-1}:	0.9

Old published analysis:

95% limit:	9.5 ps^{-1}
Sensitivity:	9.8 ps^{-1}
σ_A@15ps^{-1}:	1.5

ALEPH combined: Amplitude plot



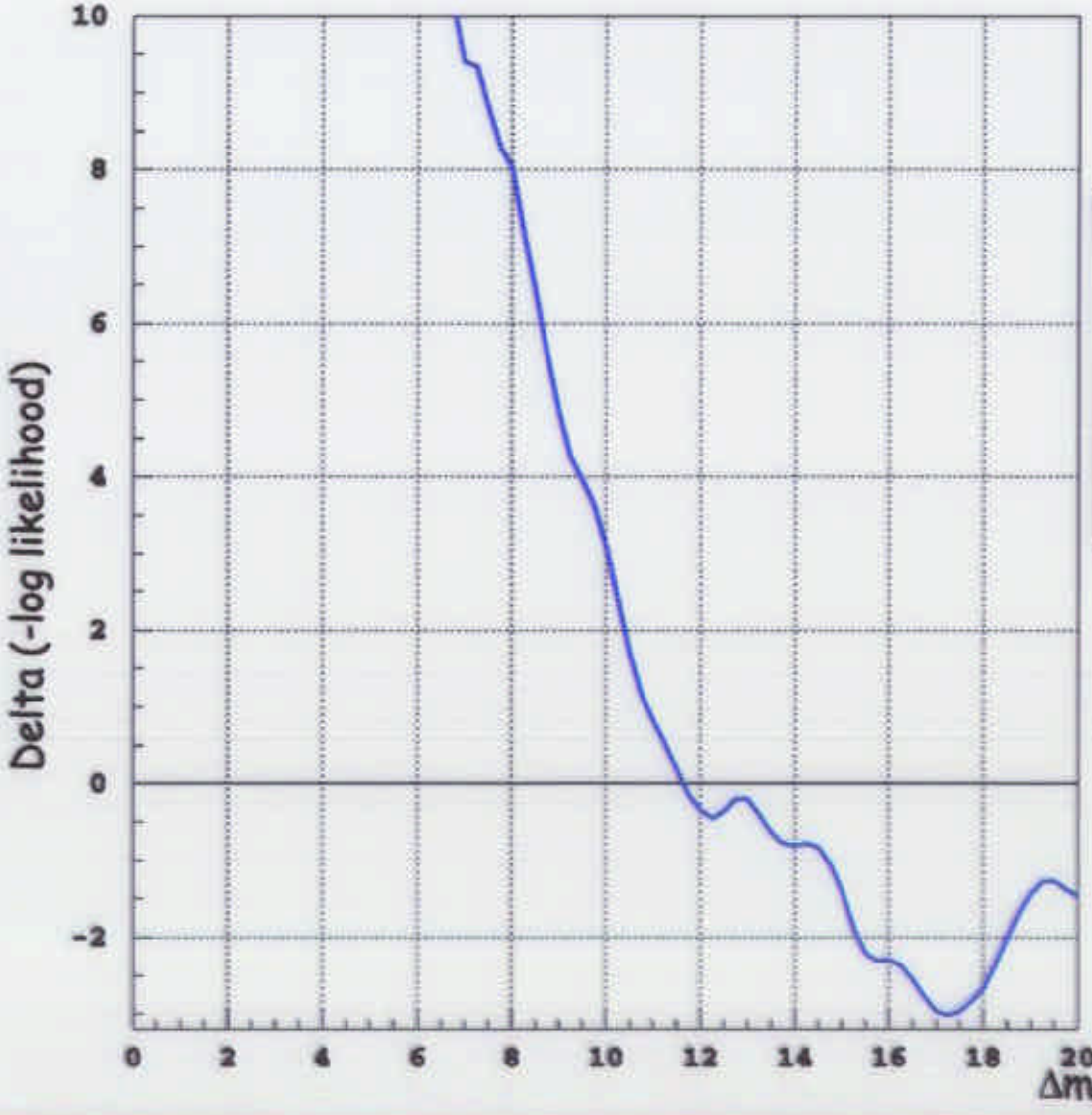
D_s-lepton events removed from inclusive-lepton sample

Also includes published D_s-hadron

95% limit: 10.6 ps^{-1}
sensitivity: 12.8 ps^{-1}

Dominant systematic:
f_s=9.7±1.2% LEPBOSC WG

ALEPH combined: Likelihood

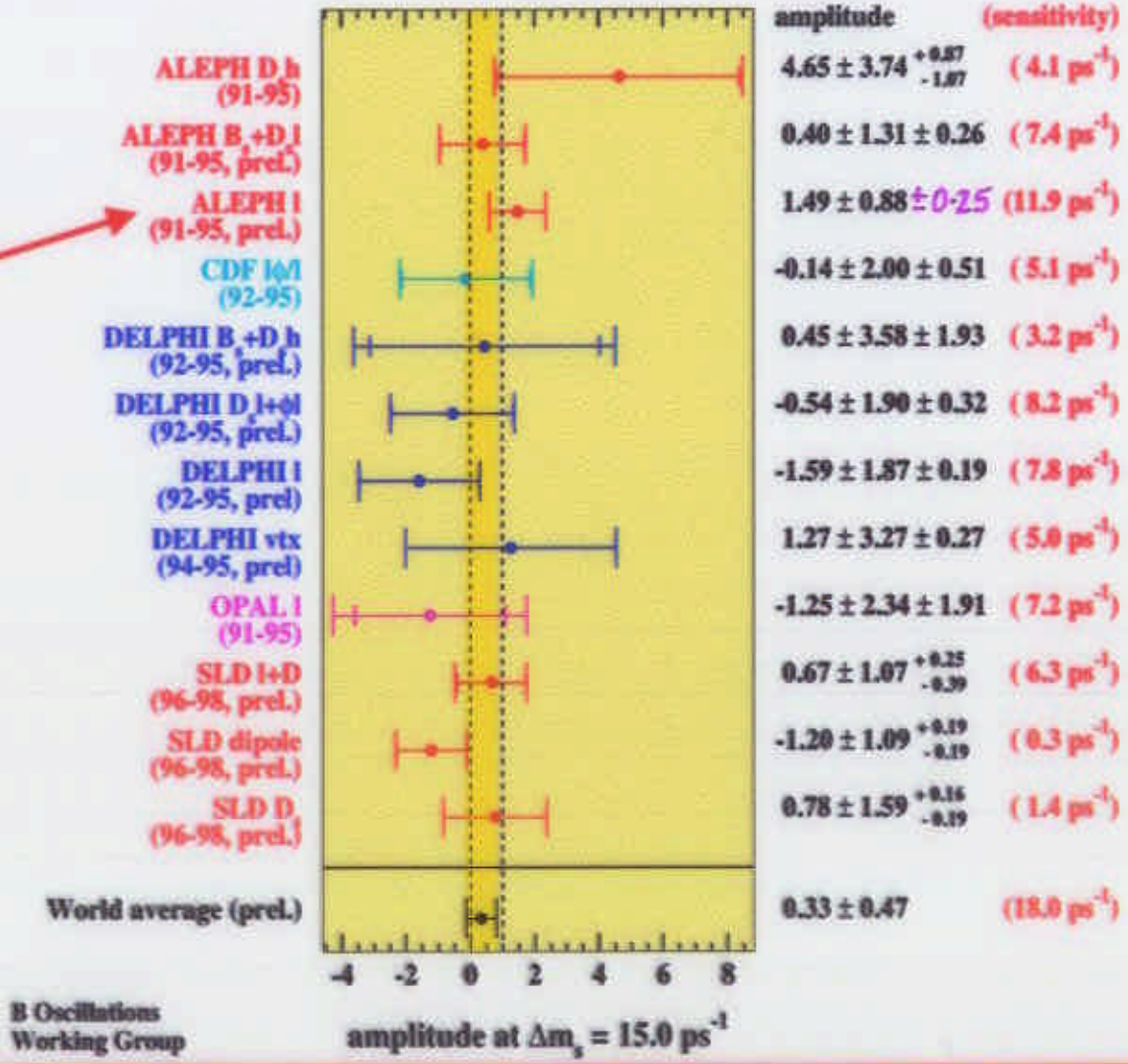


Minimum at Δm_s=17.2 ps^{-1}

Depth relative
to Δm_s at infinity= -3.01
(~2.5 sigma)

Comparison with other expts

Inclusive Lepton: still best single analysis



Summary

The SM preferred value of Δm_s is close to the present sensitivity...

Since summer 99 conferences, ALEPH have released:

-new fully reconstructed B_s analysis (useful at high Δm_s)
-updated the D_s-lepton analysis (larger D_sDX background)
-improved inclusive lepton analysis (best sensitivity for single analysis)

The ALEPH combined lower limit is improved:

$\Delta m_s > 10.6\ ps^{-1}$ at 95% CL (Tampere: $9.6 ps^{-1}$)

(Sensitivity: $12.8\ ps^{-1}$) (Tampere: $10.6 ps^{-1}$)

The "effect" in the amplitude spectrum around $17 ps^{-1}$ persists!