Review on B^0-$\overline{B^0}$ mixing and b-lifetimes measurements at CDF/LEP/SLD

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In the last decade at LEP/SLD and CDF :

- New weakly decaying B-hadrons have been observed (B_s^0, Λ_b, Ξ_b)
- The production and decay of B hadrons have been intensively studied :

$$\tau, \Delta m, \Delta\Gamma$$

using inclusive and semi-exclusive decays.

This thanks to :

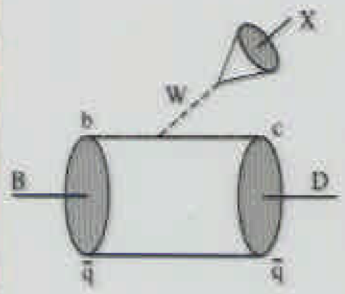
- the excellent performance of the machines,
- the excellent performance of the detectors : these measurements would have not been possible without the development of SILICON DETECTORS,
- the development of experimental/analysis techniques, conceived and improved within fruitful collaborations (LEP/SLD/CDF Working Groups)

b-Lifetime Measurements

All lifetimes of weakly decaying B hadrons have been precisely measured (apart for Ξ_b and Ω_b)

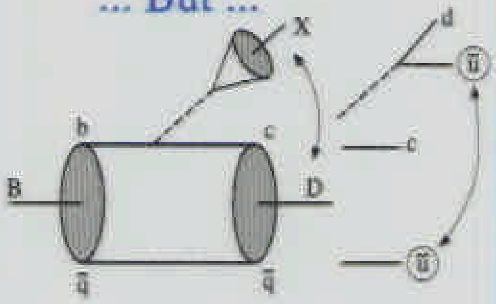
IMPORTANT TEST of B decay DYNAMICS

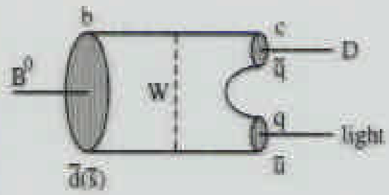
Not only



spectator diagram

... But ...

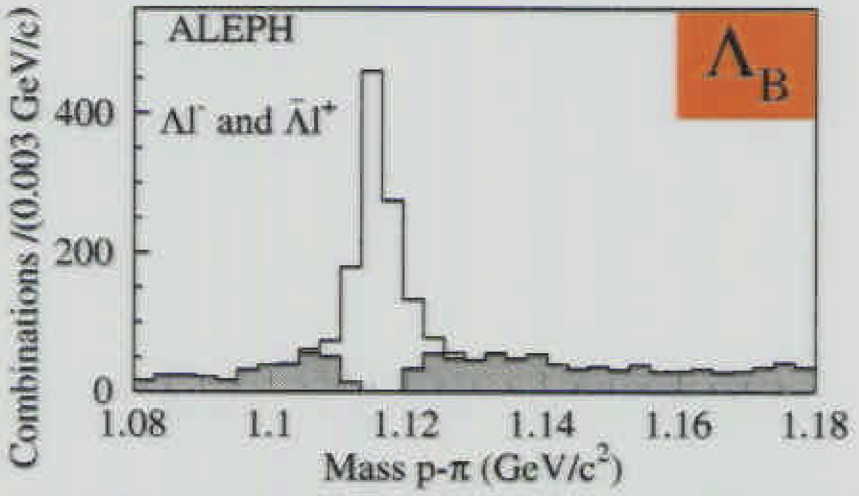


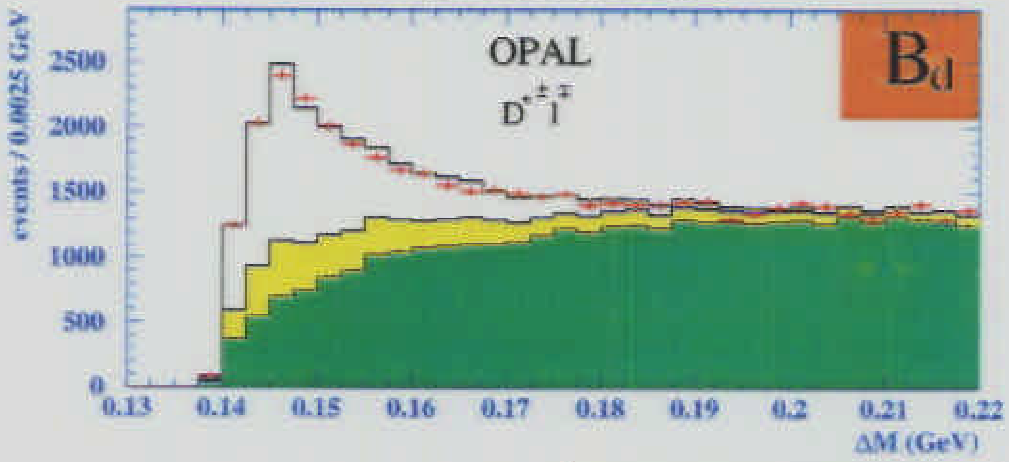


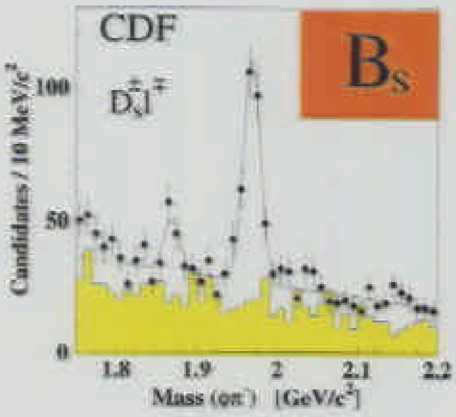
exchange diagram

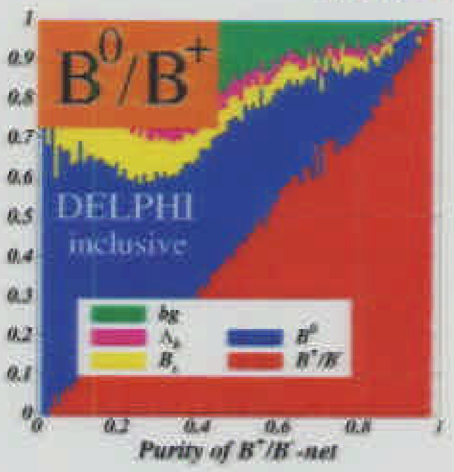
annihilation diagram

Techniques to separate B-hadrons







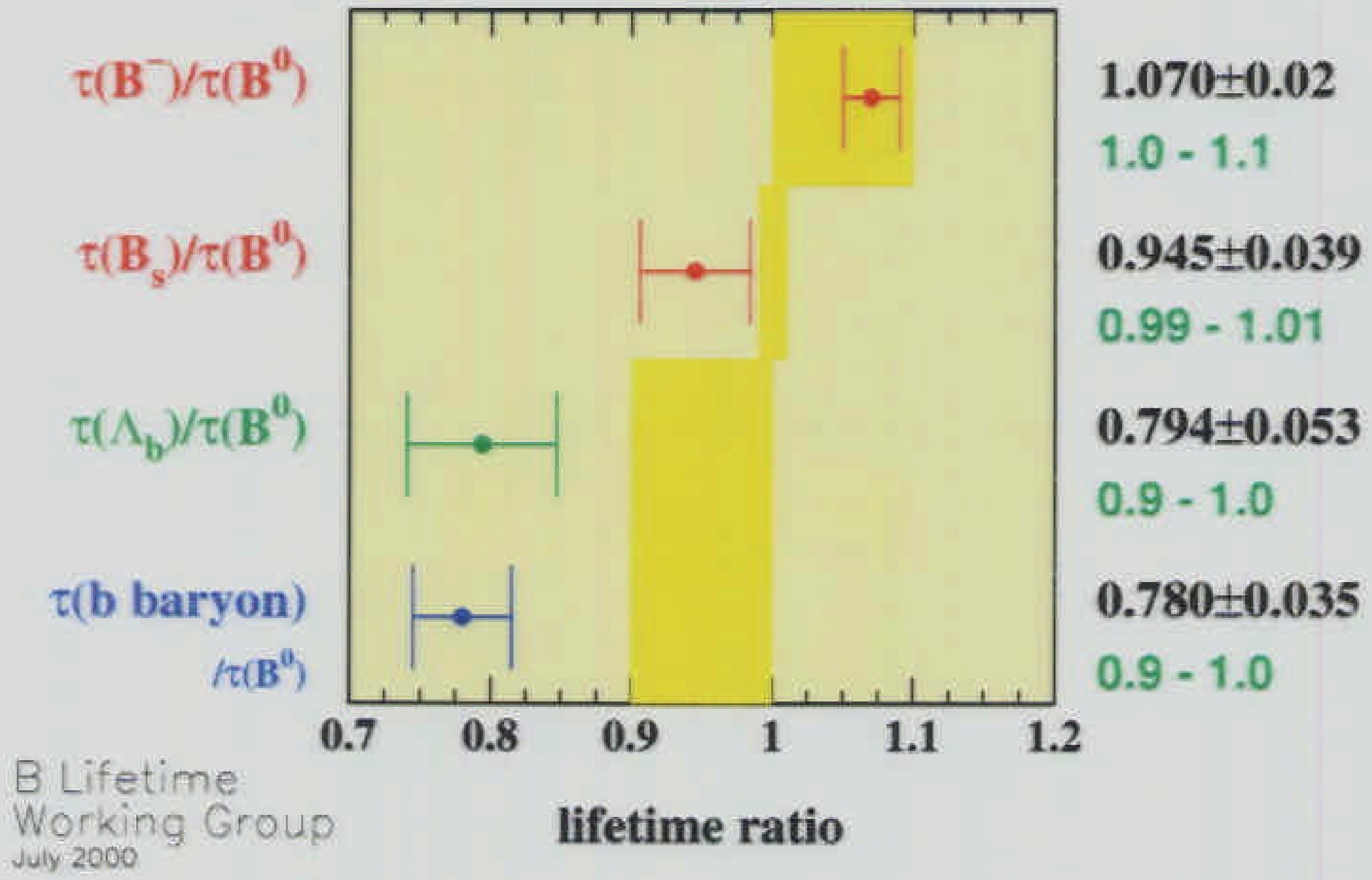


News since last year :

$\tau(B_d^0)$ much improved ($D^*\ell$ (ALEPH,OPAL); incl. vtxs (DELPHI))

$\tau(B^+)$ improved (incl. vtxs (DELPHI))

$$\tau(B^0) = 1.548 \pm 0.021 \text{ ps}$$
$$\tau(B^+) = 1.647 \pm 0.021 \text{ ps}$$



The hierarchy was correctly predicted !

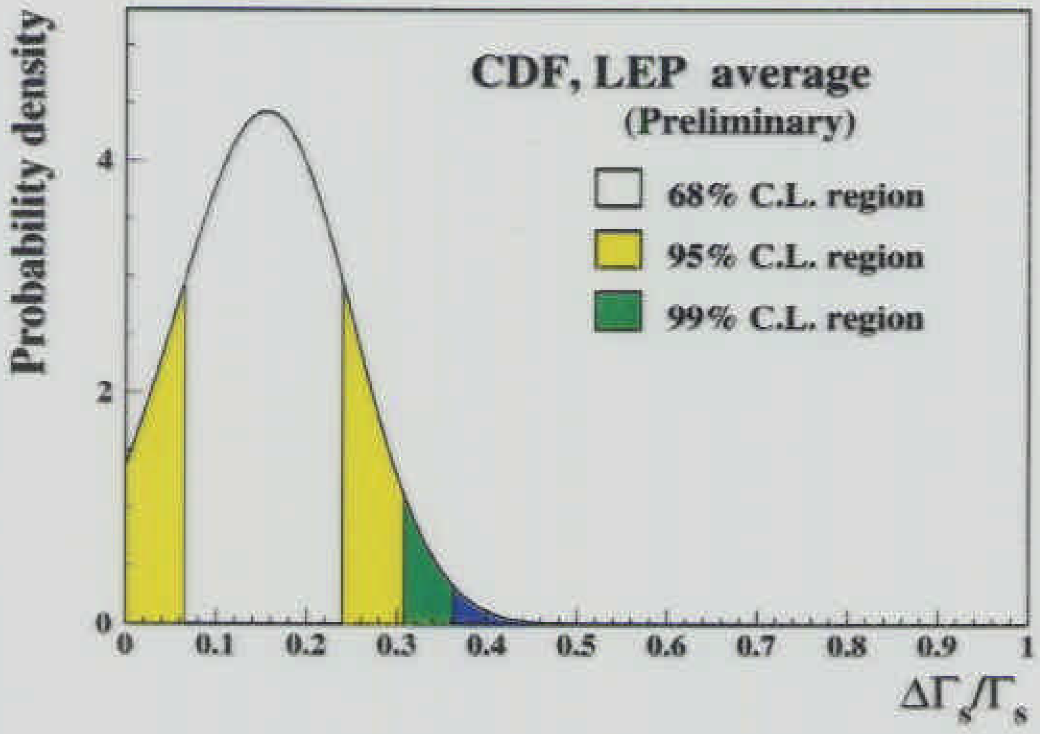
$\tau(B^+)/\tau(B^0) \rightarrow 3\sigma$ effect in agreement with theory

$\tau(B_s^0)/\tau(B^0) \rightarrow 1\sigma$ diff. wrt theory $\rightarrow$ new data needed.....

Λ_b Problem $\rightarrow$ the precision of the results push for a better understanding of the theory

Lifetime Difference : $\Delta\Gamma_s$

- Benefit from the work done on lifetime
- Interest : $\frac{\Delta\Gamma}{\Delta m_s} \simeq \frac{3}{2}\pi(\frac{m_b^2}{m_t^2})$ (naively)
  $\rightarrow$ possible visibility for $\Delta\Gamma_s$
  Δm_s accessible via $\Delta\Gamma_s$ (important if Δm_s is too high)
- Caveat : Theory still uncertain.
  Recent result : $\Delta\Gamma_s/\Gamma_s = 0.047 \pm 0.015 \pm 0.016$
  D.Becirevic, D.Meloni, A.Retico, V.Giménez, V.Lubicz, G.Martinelli, hep-ph/0006135



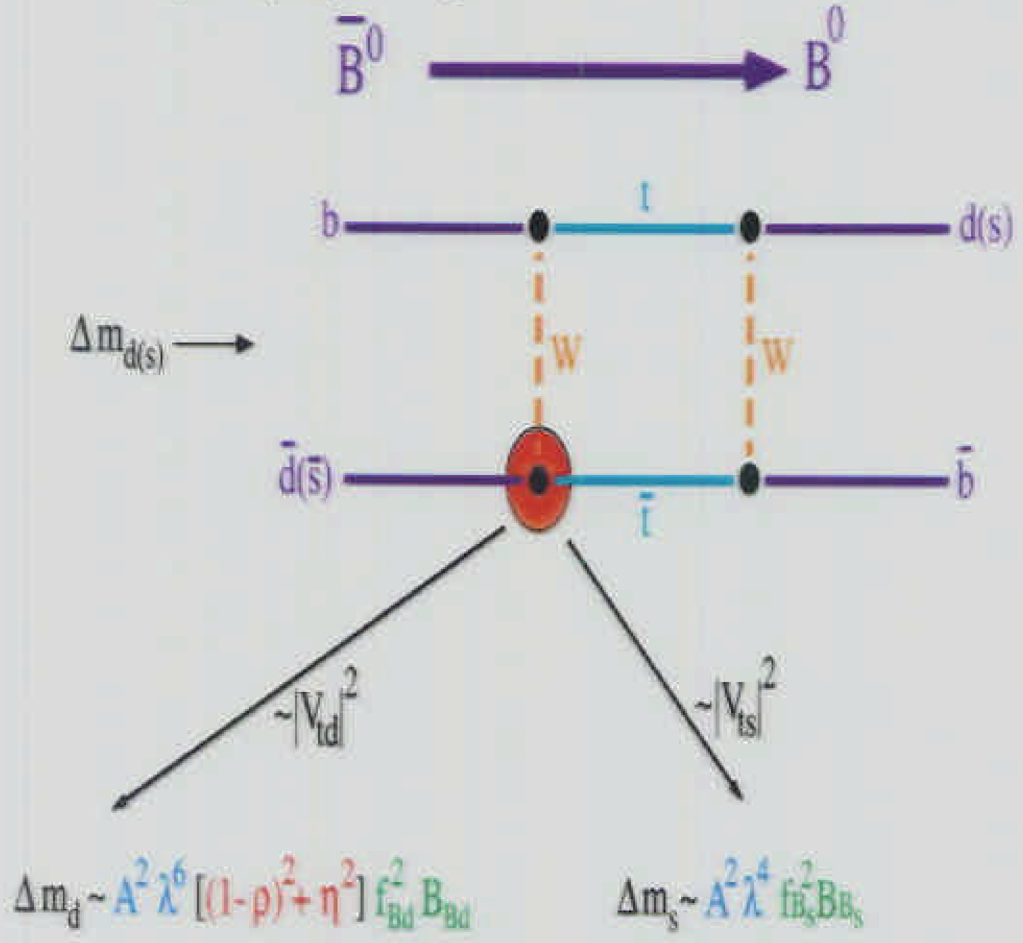
$$\Delta\Gamma_s/\Gamma_s = 0.16^{+0.16}_{-0.13}$$

$$\Delta\Gamma_s/\Gamma_s < 0.31 \text{ at } 95\ \% \text{ C.L.}$$

(assuming $\tau(B^0) = \tau(B^0_s)$)

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

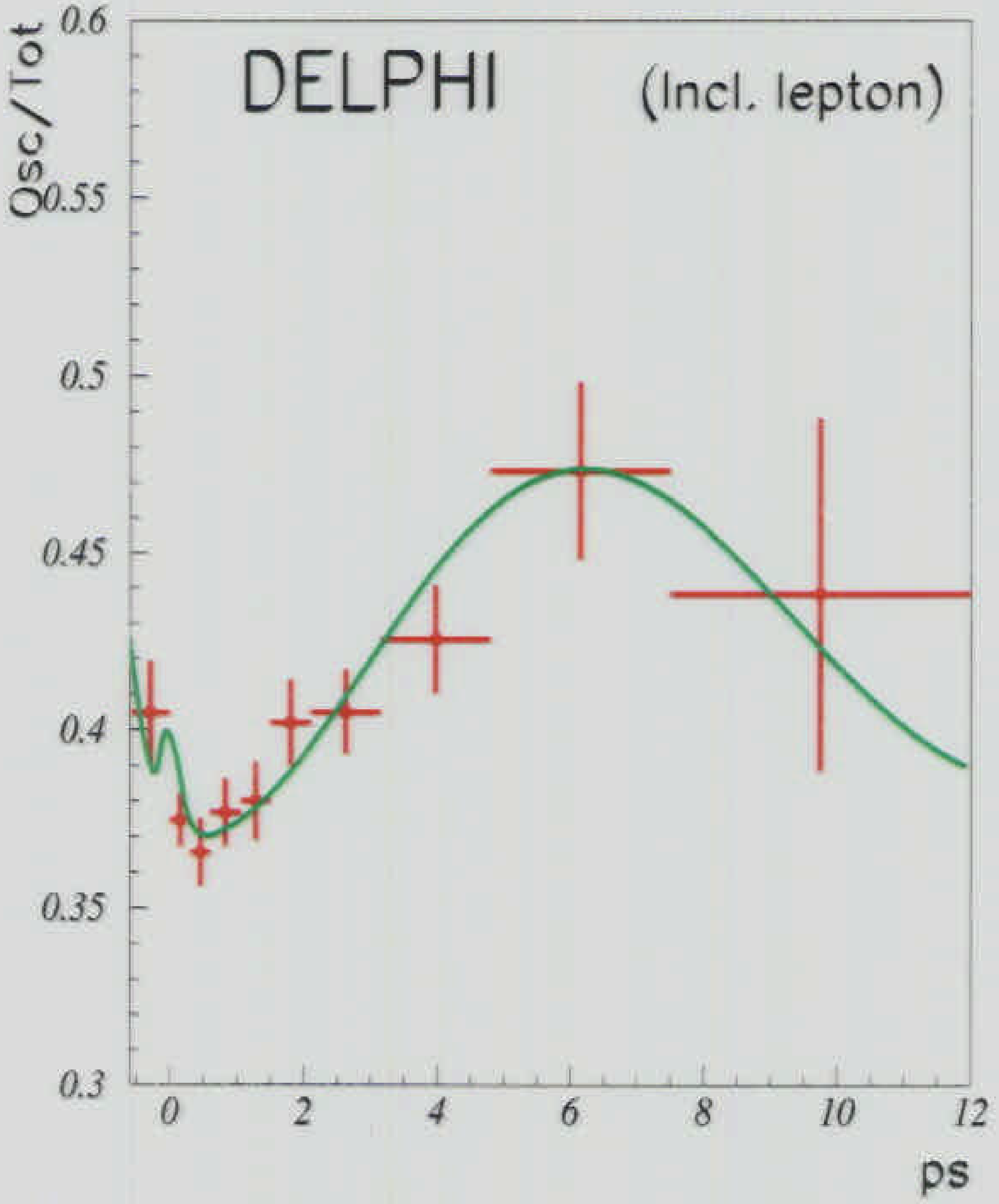
$$P_{B^0_q \to B^0_q(\overline{B}^0_q)} = \frac{1}{2} e^{-t/\tau_q} (1 \pm cos\Delta m_q t) \qquad (1)$$



- $\Delta m_s \simeq 20 \times \Delta m_d \qquad (20 \propto 1/\lambda^2)$
- $\frac{\xi^2}{\lambda^2} \frac{\Delta m_d}{\Delta m_s} = (1 - \bar{\rho})^2 + \bar{\eta}^2 \quad ; \qquad \xi = \frac{f_{B_s}\sqrt{B_{B_s}}}{f_{B_d}\sqrt{B_{B_d}}}$

$B_d^0 - \overline{\mathrm{B}_d^0}$ Oscillations : Δm_d

A TextBook Plot !



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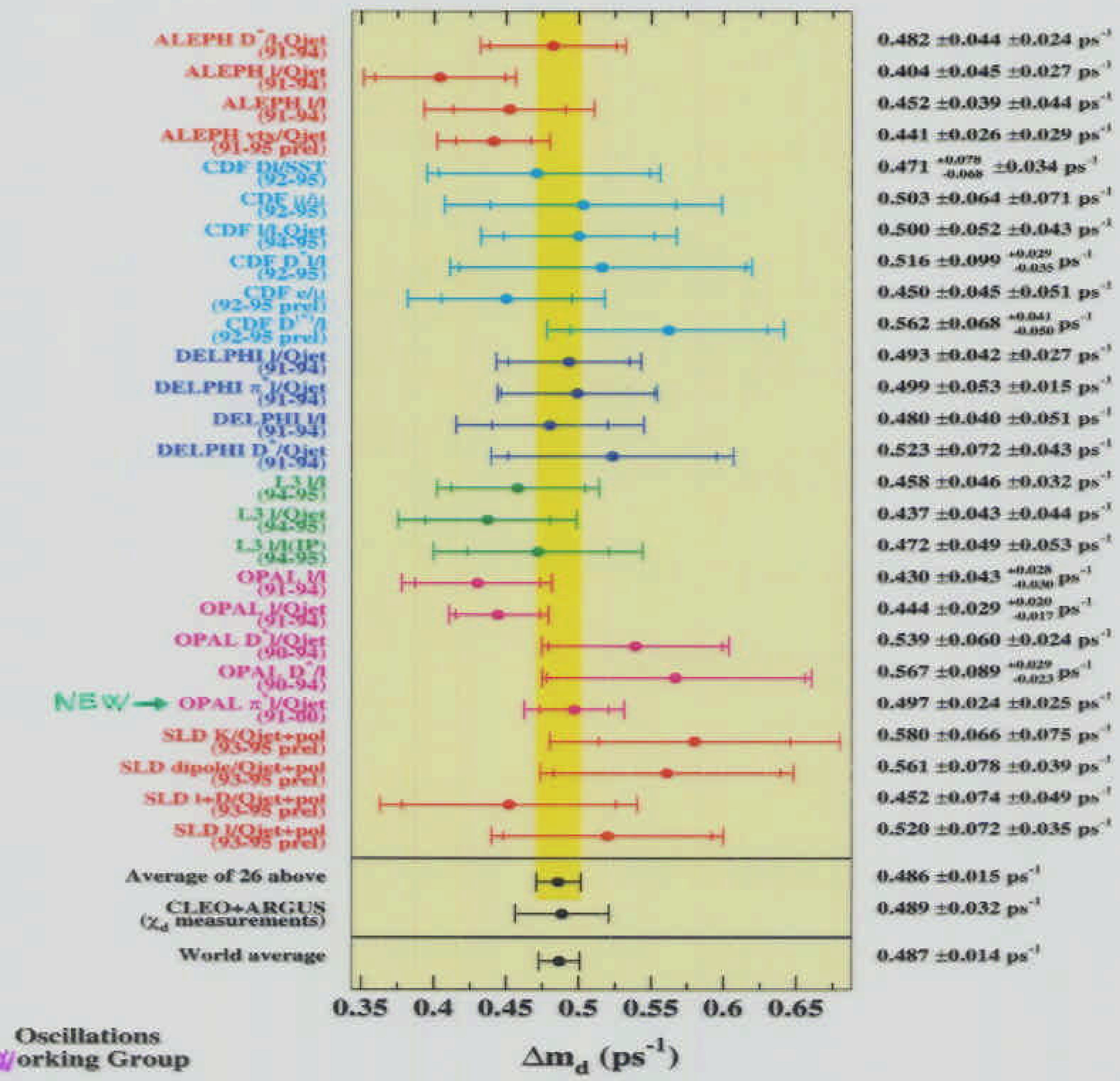


$$\Delta m_d = 0.487 \pm 0.014 \text{ ps}^{-1}$$

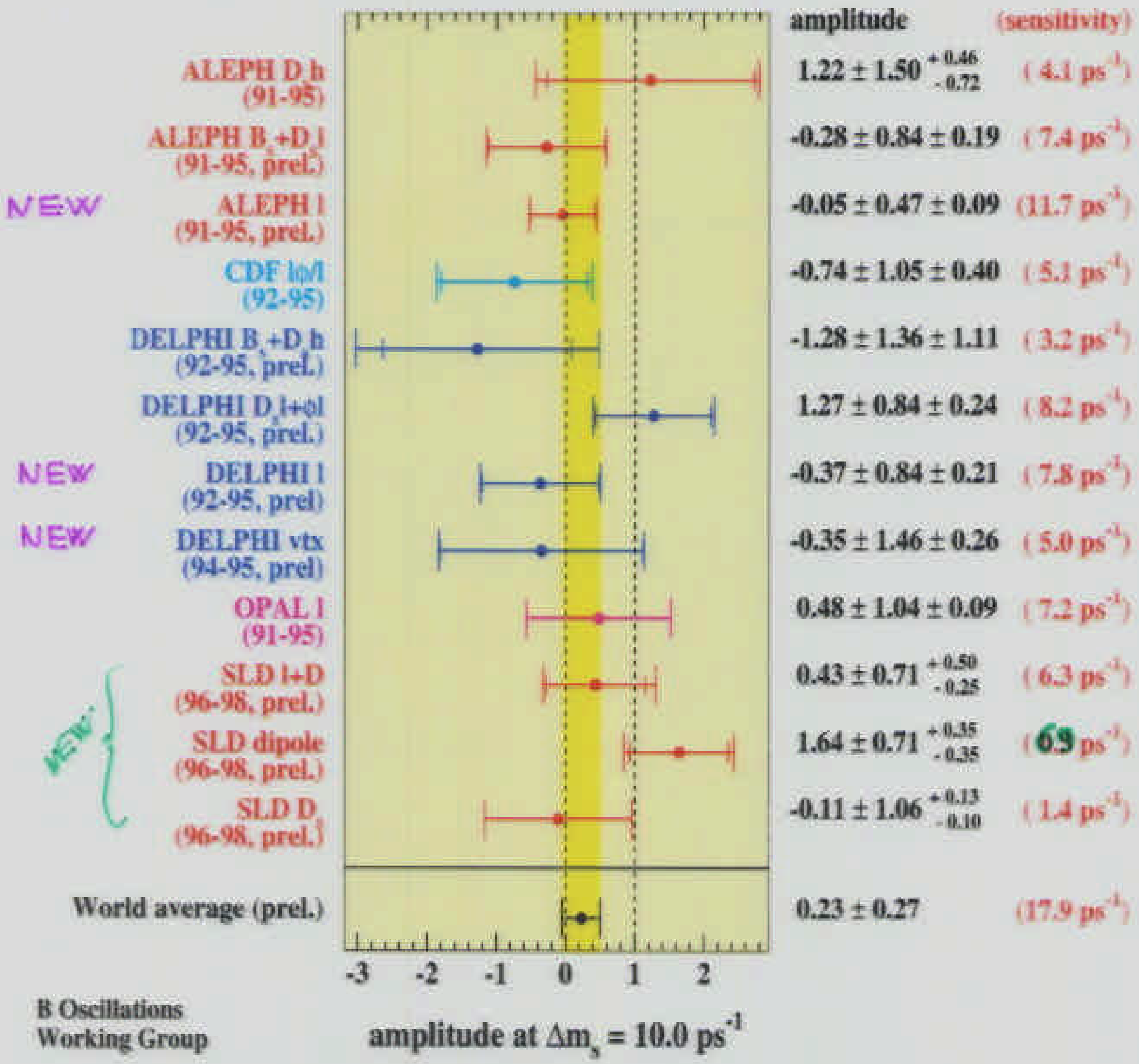
known with 2.9% precision !

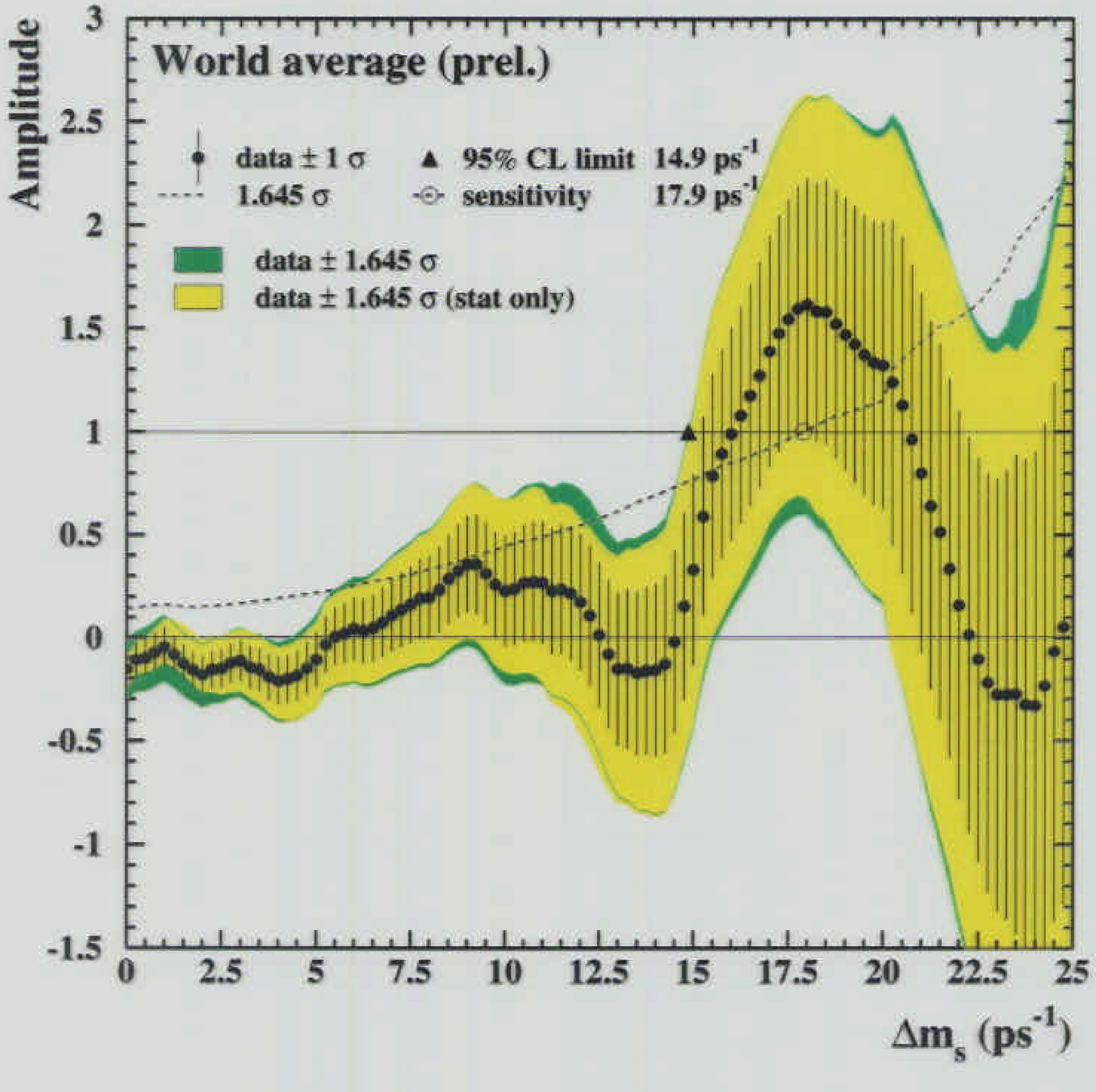
$B^0_s - \overline{B^0_s}$ Oscillations : Δm_s

A lot of activity in the last few years.

For more details on the analyses see

→ T. Usher and P. Coyle talks





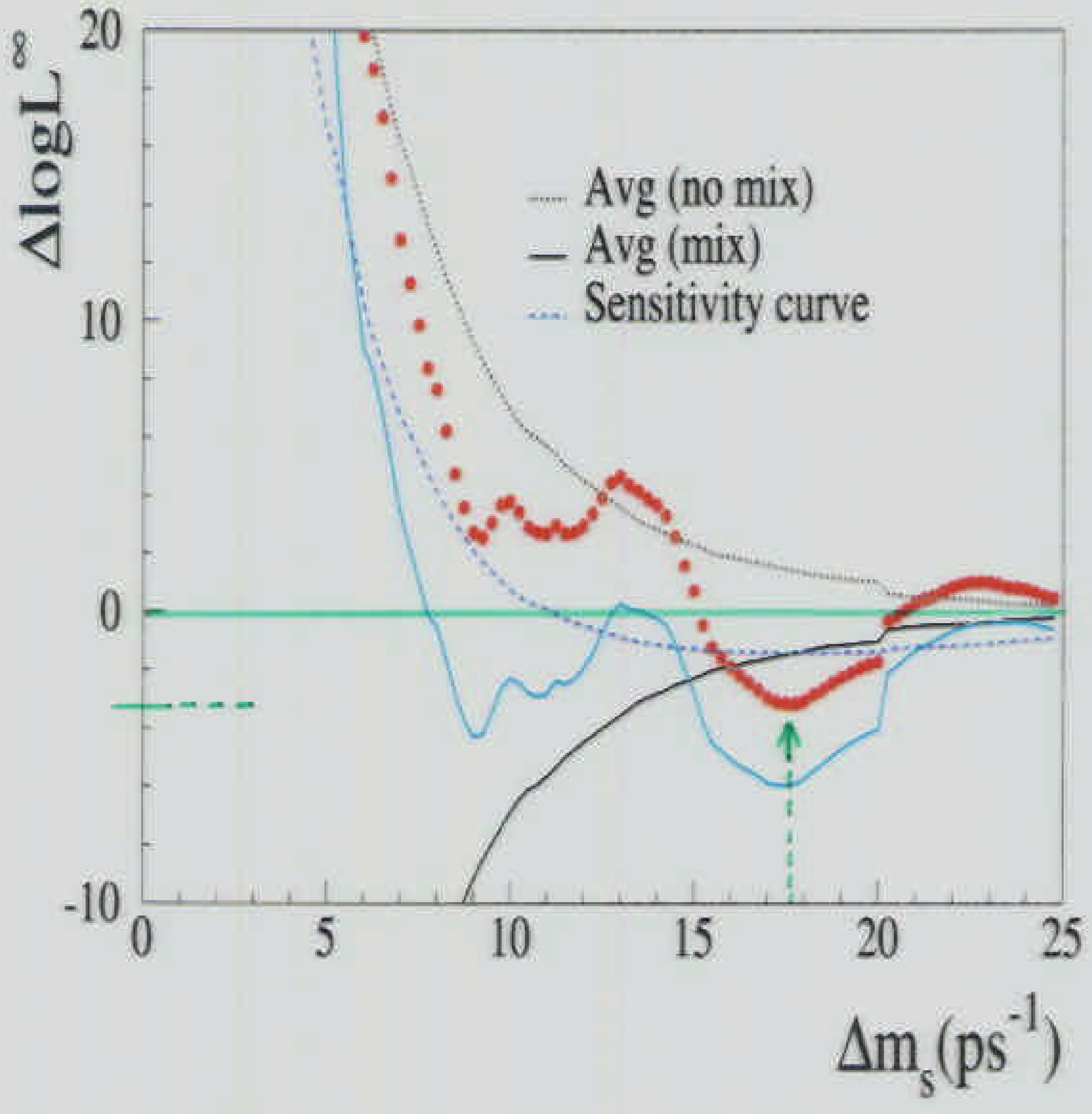
sensitivity 17.9 ps^{-1} was 14.7 ps^{-1} (last year)

limit 14.9 ps^{-1} was 14.3 ps^{-1} (last year)

Probability of a background fluctuation ≥ observed one at any Δm_s

~ 2.5 %

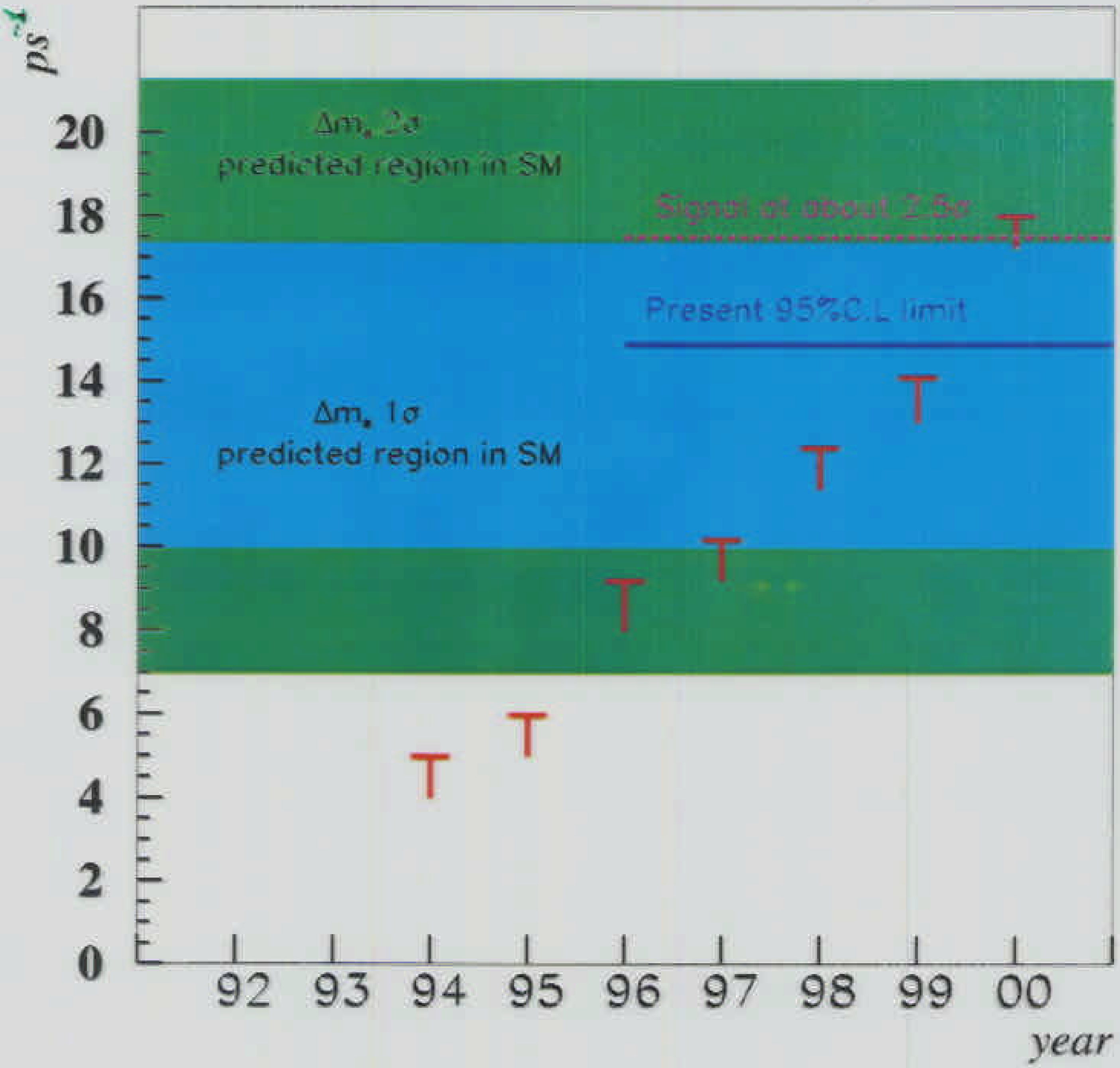
$\Delta \log L^{\infty} = (0.5-A)/\sigma_A^2$



is a " 2.5σ signal" at about 17.5 ps^{-1}

the sensitivity has bridged over the signal

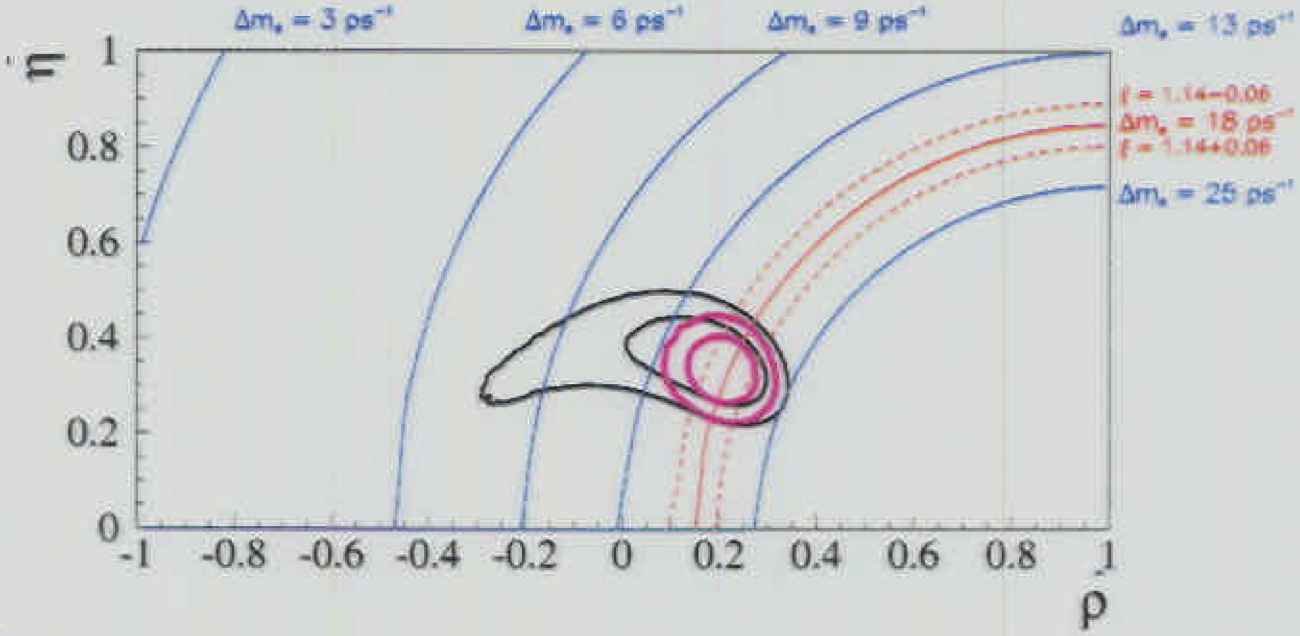
Evolution of Δm_s sensitivity



Unitarity Triangle

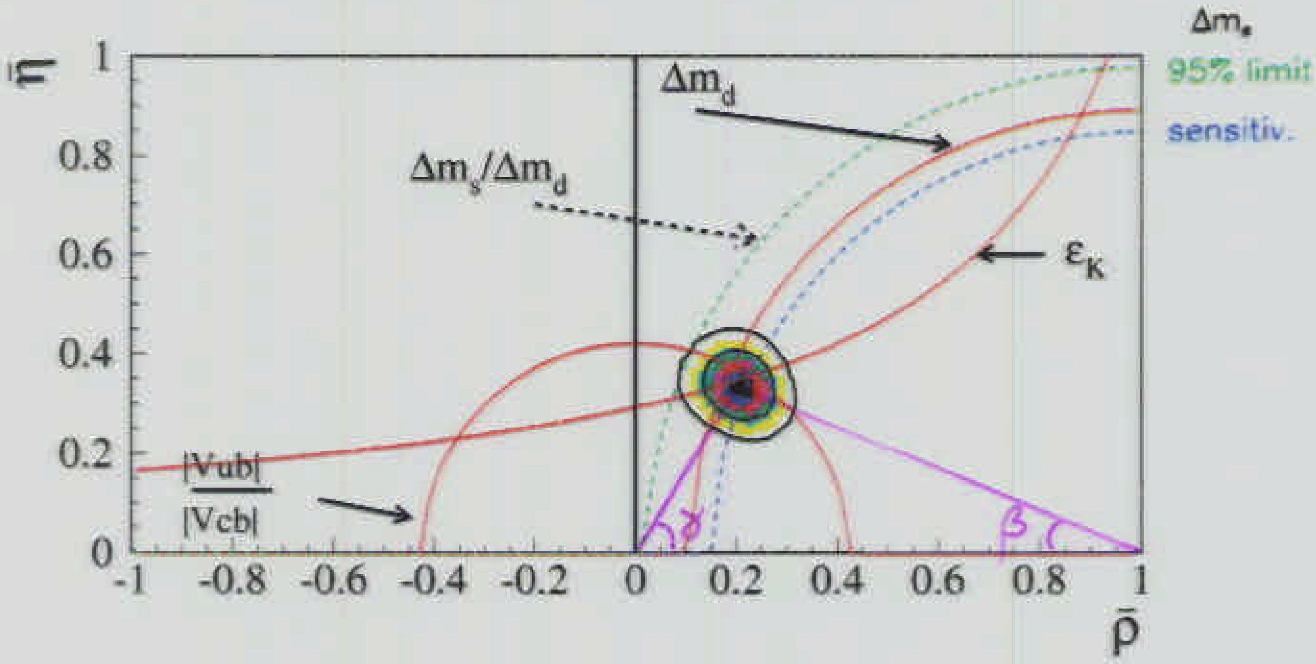
Measurement	V_{CKM}×other	Constraint
$b \to u/b \to c$	$\lvert V_{ub}/V_{cb}\rvert^2$	$\bar{\rho}^2 + \bar{\eta}^2$
Δm_d	$\lvert V_{td}\rvert^2 f_{B_d}^2 B_{B_d} f(m_t)$	$(1-\bar{\rho})^2 + \bar{\eta}^2$
$\frac{\Delta m_d}{\Delta m_s}$	$\left\lvert \frac{V_{td}}{V_{ts}} \right\rvert^2 \frac{f_{B_d}^2 B_{B_d}}{f_{B_s}^2 B_{B_s}}$	$(1-\bar{\rho})^2 + \bar{\eta}^2$
ϵ_K	$f(A, \bar{\eta}, \bar{\rho}, B_K)$	$\propto \bar{\eta}(1-\bar{\rho})$

Importance of Oscillation Results



- M. Ciuchini et al. ICHEP2000 paper
- LEP/SLD/CDF Steering Groups

Results on $\bar{\rho}$ and $\bar{\eta}$



$$\bar{\rho} = 0.205 \pm 0.045$$
$$\bar{\eta} = 0.336 \pm 0.045$$

$$sin2\beta = 0.716 \pm 0.067$$
$$sin2\alpha = -0.29 \pm 0.27$$

$$\gamma = (58.5 \pm 7.1)^o$$

Conclusions

B lifetimes and oscillations have been intensively studied during the last 10 years at CDF/LEP/SLD and spectacular improvements have still been obtained THIS year
AND IT IS NOT FINISHED YET !

All b-lifetimes known with high precision.
$\tau(\mathrm{B}^+)/\tau(\mathrm{B}^0)$ Hierarchy has been observed

$$\tau(B^0) = 1.548 \pm 0.021 ps \rightarrow 1.4\%$$
$$\tau(B^+) = 1.647 \pm 0.021 ps \rightarrow 1.3\%$$
$$\tau(\mathrm{B}^0_s) = 1.464 \pm 0.057 ps \rightarrow 3.9\%$$
$$\tau(\Lambda_b) = 1.208 \pm 0.051 ps \rightarrow 4.2\%$$

The time dependence of the oscillations has been precisely measured :

$$\Delta m_d = 0.487 \pm 0.014 \text{ ps}^{-1} \rightarrow 2.9\%$$

Δm_s Sensitivity at 17.9 ps^{-1} (last year was at 14.7 ps^{-1})

"a 2.5σ signal" at about 17.5 ps^{-1}

improvements can be still expected

The Unitarity triangle parameters are today already known with a good precision within the Standard Model:

$$\bar{\rho} = 0.205 \pm 0.045$$
$$\bar{\eta} = 0.336 \pm 0.045$$

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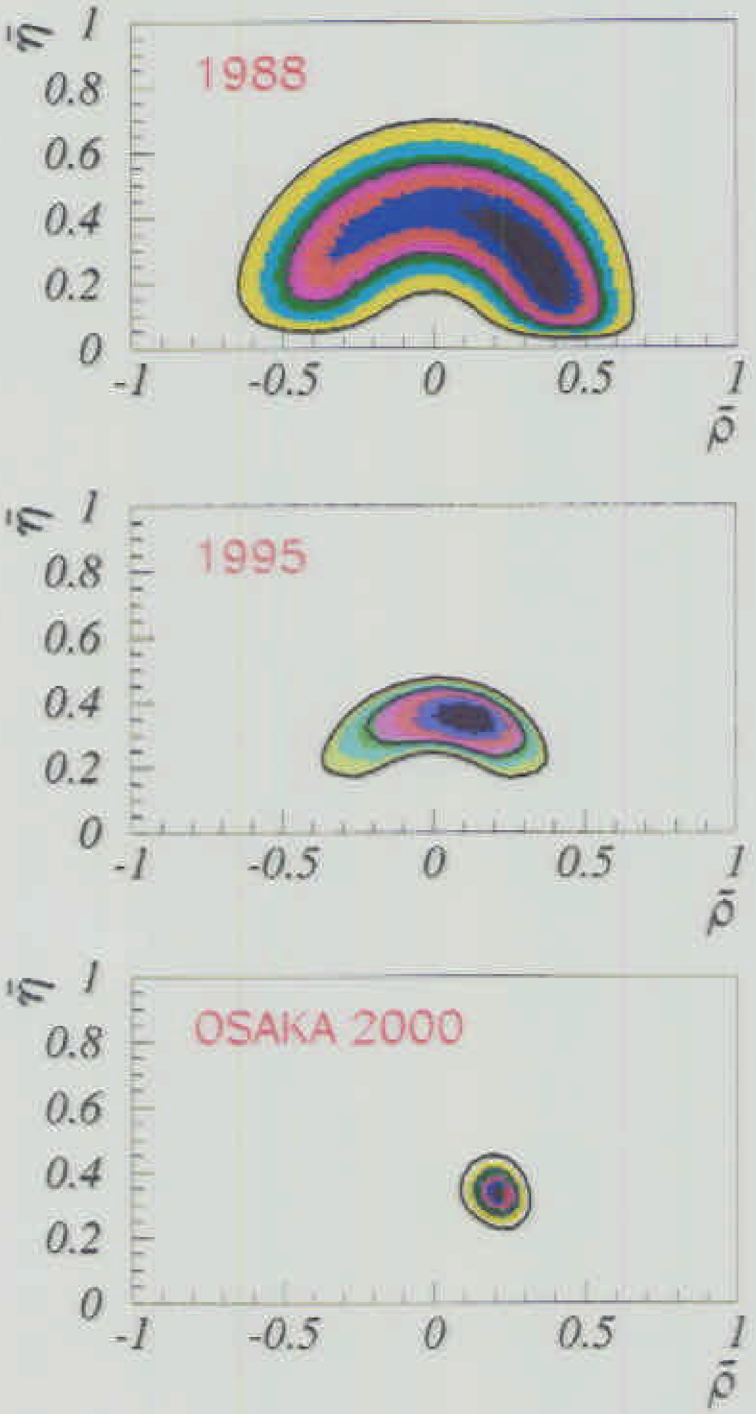
1988
1995
OSAKA 2000
$\bar{\eta}$
$\bar{\rho}$
0
0.2
0.4
0.6
0.8
1
-1
-0.5
0
0.5
1