Bs Mixing

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B Mixing Review
16 March 2000

$B^0 - \overline{B}^0$ *System (I)*

Wolfenstein parameterization of the CKM weak quark mixing matrix

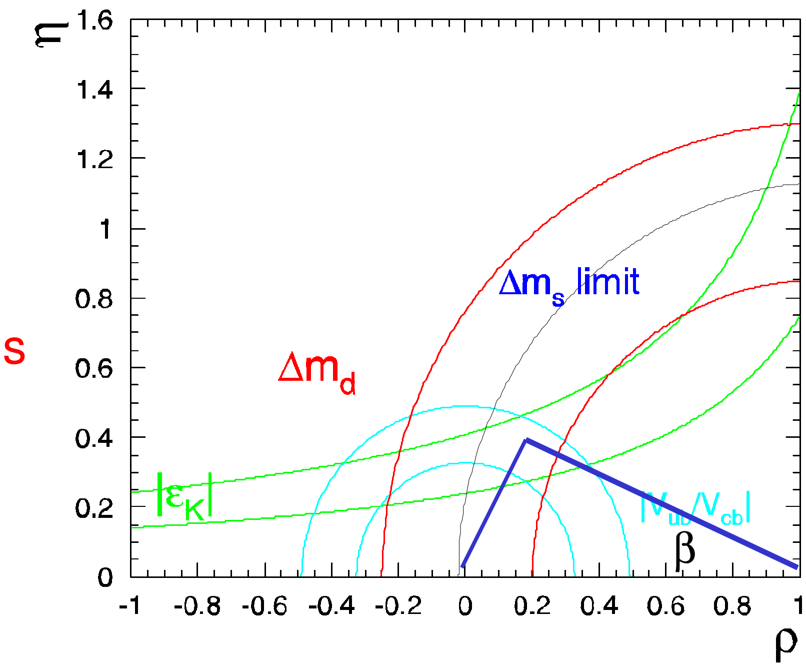
$$\begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} = \begin{pmatrix} 1-\frac{1}{2}\lambda^2 & \lambda & A\lambda^3(\rho - i\eta) \\ -\lambda & 1-\frac{1}{2}\lambda^2 & A\lambda^2 \\ A\lambda^3(1-\rho-i\eta) & -A\lambda^2 & 1 \end{pmatrix} + O(\lambda^4)$$

Measurements of the oscillations frequencies impose significant constraints on (ρ,η) = apex of unitarity triangle

$$\Delta m_s \propto |V_{ts}|^2 = A^2\lambda^4$$

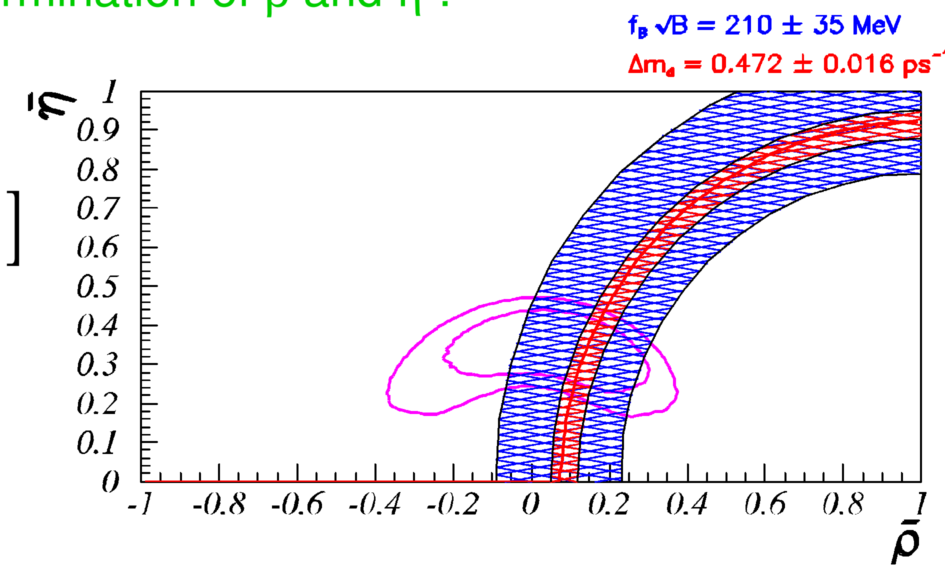
$$\Delta m_d \propto |V_{td}|^2 = A^2\lambda^6\left[(1-\rho)^2 + \eta^2\right]$$

$$\Rightarrow \quad \frac{\Delta m_s}{\Delta m_d} \approx \frac{1}{\lambda^2} \approx 20$$ $\rightarrow$ *fast* B_s oscillations



$B^0 - \overline{B}^0$ System (II)

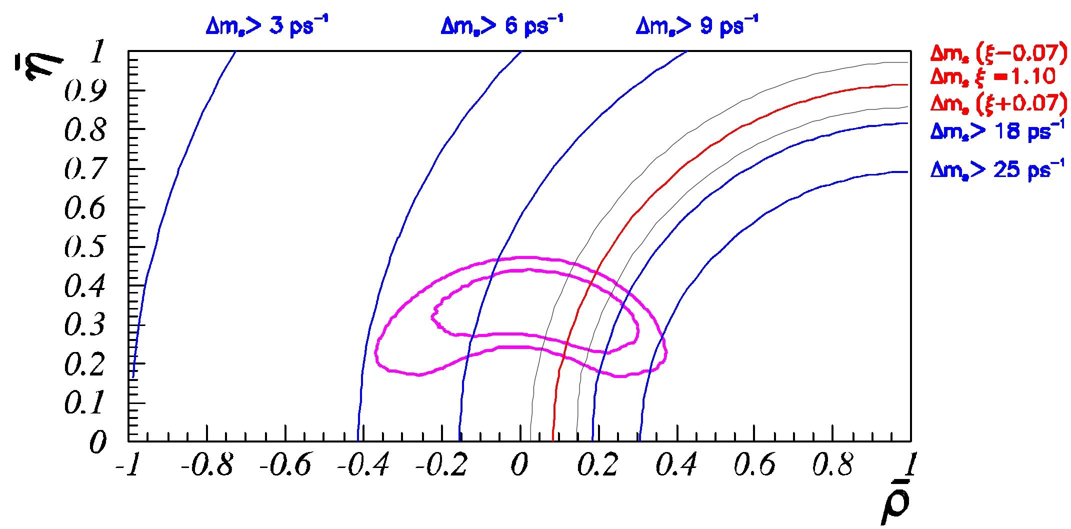
Impact of Δm_d and Δm_s on determination of ρ and η :



Measurement of Δm_d

$$\Delta m_d \propto |V_{td}|^2 = A^2 \lambda^6 \left[(1-\rho)^2 + \eta^2 \right]$$

$$\Delta m_s \propto |V_{ts}|^2 = A^2 \lambda^4$$



Lower limit on Δm_s

$\Rightarrow$ upper limit on $|V_{td}|$

$$\frac{\Delta m_s}{\Delta m_d} = (1.11 \pm 0.06)^2 \cdot \left| \frac{V_{ts}}{V_{td}} \right|^2$$

World Average Amplitude Spectrum

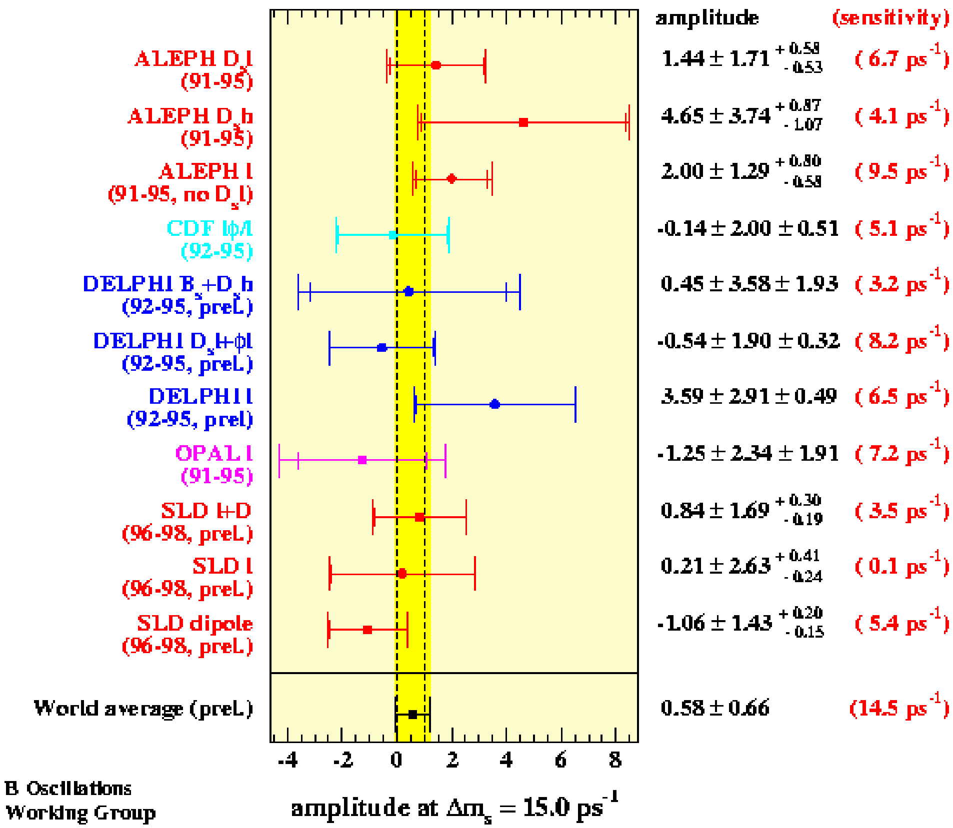
Use ALEPH, DELPHI, OPAL, SLD & CDF analyses as of the end of Summer 99

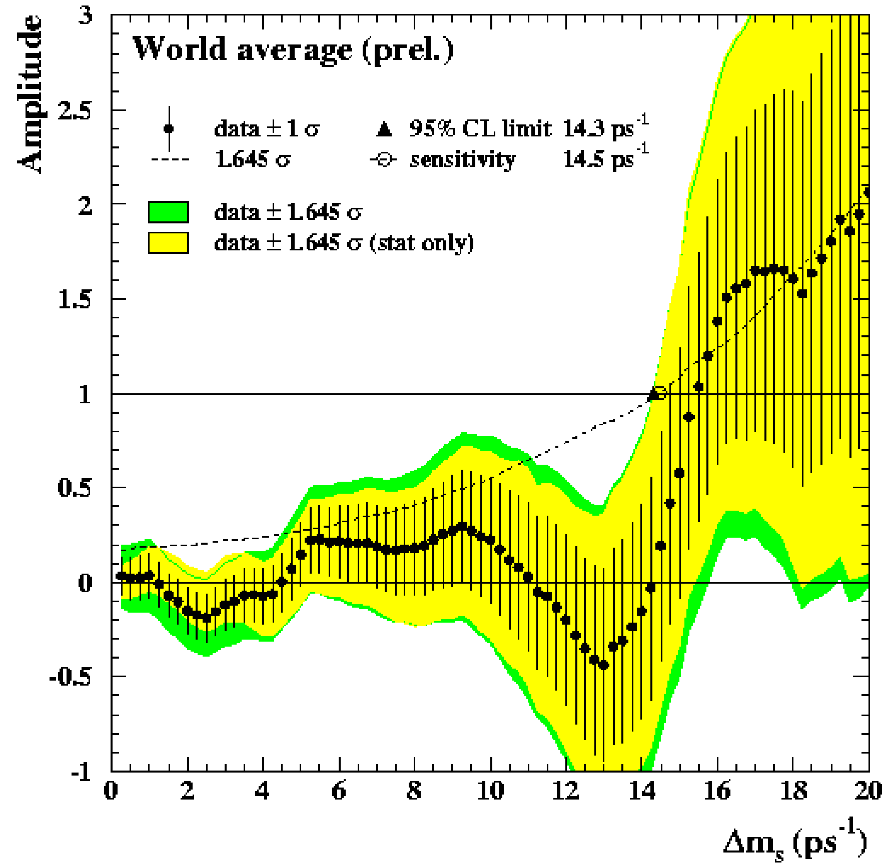
New since Lepton-Photon 99: B_s production fraction = (10.0 ± 1.2)%

Lower than assumed in most analyses (10.0 to 11.2%)

⇒ adjust statistical error and measured A *(for inclusive methods only)*

⇒ Δm_s > 14.3 ps^{-1} (95% C.L.)





CKM Unitarity Triangle Global Fit

Global fit by Caravaglios, Parodi, Roudeau & Stocchi *hep-ph 0002171*
(see A. Stocchi @ BCP3)

$\rho = 0.240^{+0.057}_{-0.047}$

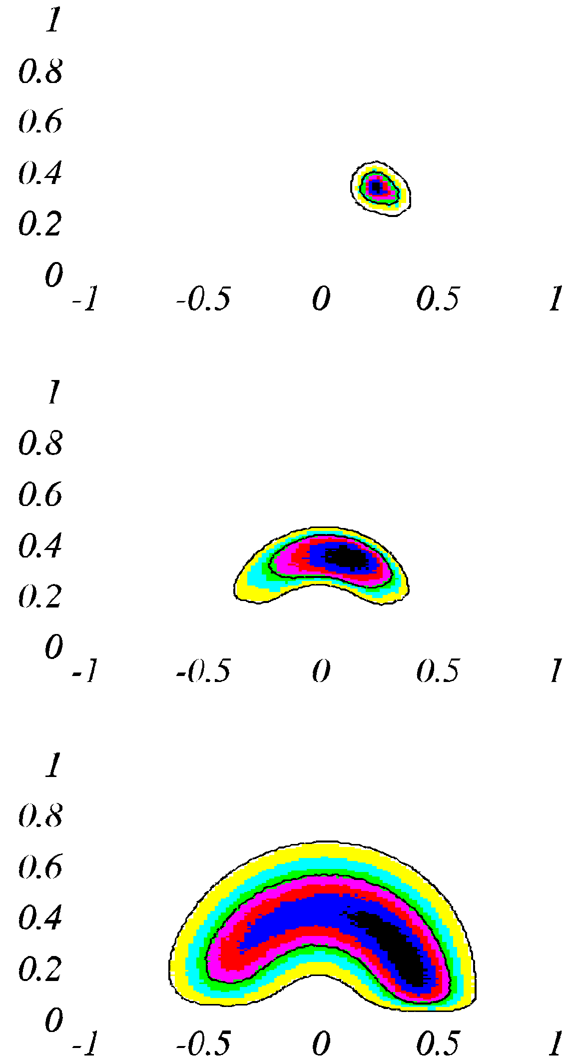
$\eta = 0.335 \pm 0.042$

$\sin 2\beta = 0.750^{+0.058}_{-0.064}$

$\sin 2\alpha = -0.38^{+0.24}_{-0.28}$

$\gamma = (55.5^{+6.0}_{-8.5})°$

Issue: interpretation of dominant theory errors

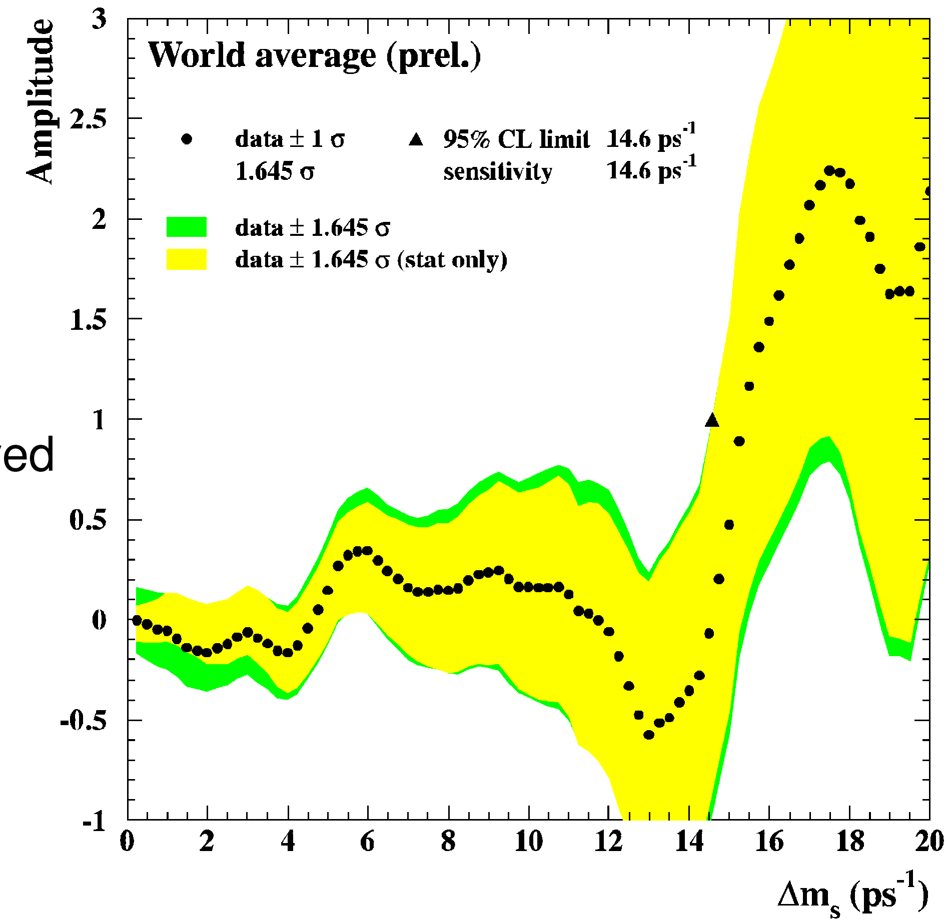


Moriond 2000 update

ALEPH: New exclusive B_s reconstruction analysis
+ update of D_s-lepton analysis

Old D_s-lepton 95% C.L. sensitivity was 6.7 ps^{-1}

New D_s-lepton+Excl. B_s sensitivity is 7.4 ps^{-1}
& amplitude uncertainty improved at higher Δm_s



Future

By Summer 2000:

ALEPH: update of inclusive lepton analysis (NN)

DELPHI: update of D_s-lepton analysis
+ new dipole-like inclusive analysis

OPAL: update of D_s-lepton (also phi-lepton) analysis

SLD: update of all analyses

1-3 years?:

HERA-B: designed trigger for exclusive reconstruction of $B_s \to D_s\, \pi$, $D_s\, \rho$
$\Rightarrow$ observe 3σ signal up to Δm_s of 27 ps^{-1} (1 year data taking)

CDF: displaced-vertex trigger for exclusive reconstruction

Future

- **CDF** Run II (2 fb^{-1})

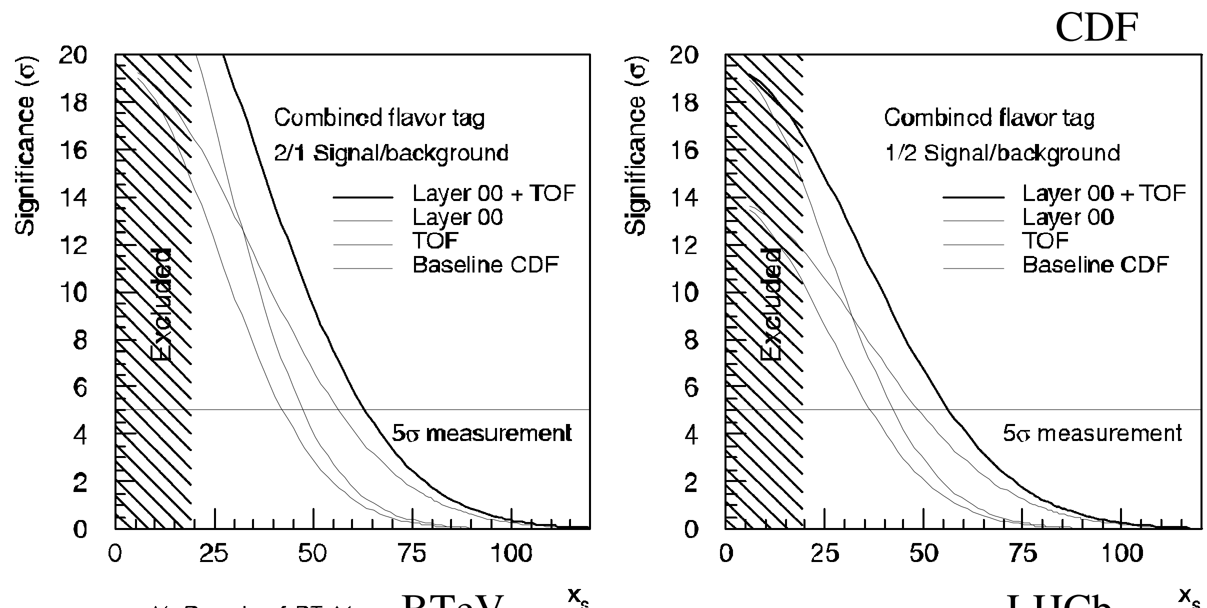
Displaced vtx trigger

+ L00 and TOF PID

exclusive $B_s \to D_s^- \pi^+$

Observe 5σ signal

up to $\Delta m_s \approx 40\ ps^{-1}$



- **BTeV & LHCb**

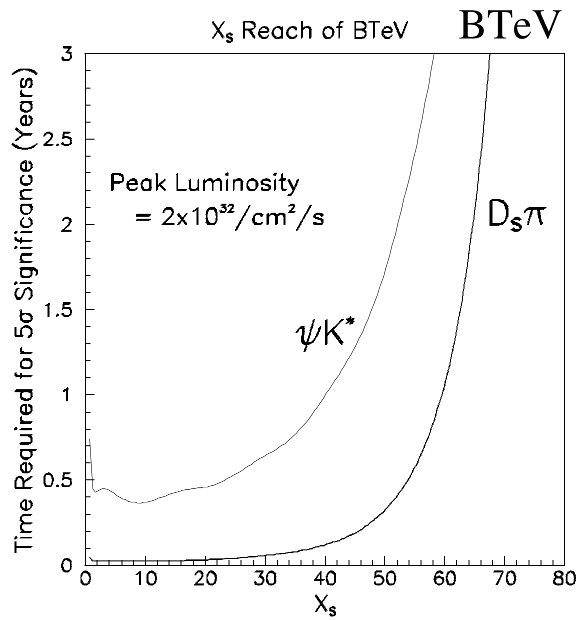
Observe 5σ signal

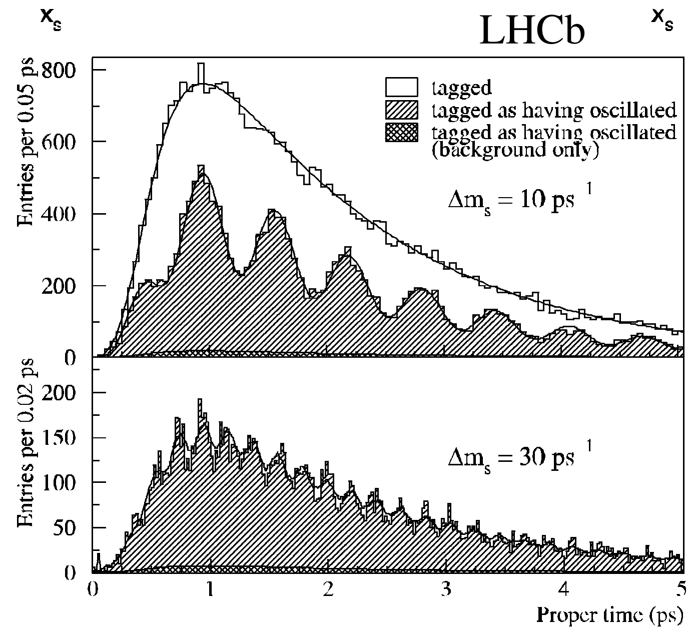
up to $\Delta m_s \approx 40\ ps^{-1}$

(BTeV)

up to $\Delta m_s \approx 48\ ps^{-1}$

(LHCb)





Mixing Ingredients

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

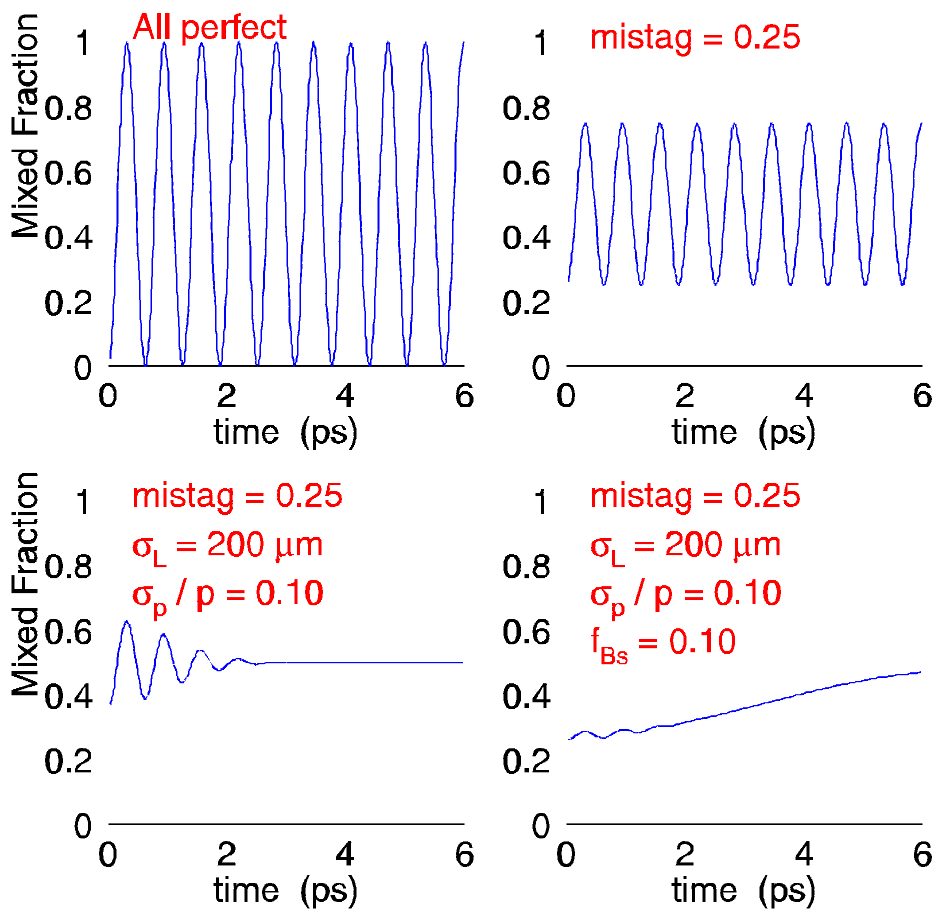
B_s purity

mistag

resolution

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

Mixed Fraction = Nmixed / (Nmixed + Nunmixed)



What's new since Aug.99?

Development of new or improved tools

- Vx-alone tracking (tracking group)

  improve charge reconstruction $\Rightarrow$ increase Bs and dipole tag purities
- Boost reconstruction (Dan Dong)

  combine LAC-based and track-based algorithms

  $\Rightarrow$ improve resolution
- Initial state tag (Thomas Moore)

  optimize for R16 & add new tags (ZVTOP3 dipole, same-side tags)
  $\Rightarrow$ improve tag purity
- Track selection (Dave Jackson, Tom Wright)

  loosen quality cuts $\Rightarrow$ improve efficiency and dipole tag purity
- Kaon ID (Jodi Wittlin)

  optimize for VXD3 (R16) & calibrate $\pi \rightarrow$ "K" misID and K $\rightarrow$ "K" efficiency
- Kalman method vertexing package (Tracy Usher)

  general package, can vertex resultant B and D vtx "tracks"

What's new since Aug.99?

Development of individual analyses

- Ds+tracks (Cheng-Ju Lin)
  Ds selection with NN $\Rightarrow$ increased efficiency
  Bs track selection and vertexing $\Rightarrow$ increased purity?
- Charge dipole (Julia Thom, Stéphane Willocq)
  looser track selection $\Rightarrow$ slightly higher Bs and dipole purities
  "D" vtx track used in B vertex fit $\Rightarrow$ decreased σ_L
- Lepton+D (Tracy Usher, Homer Neal)
  Kalman vertexing
  NN track selection $\Rightarrow$ increased efficiency and Bs purity
- Lepton+tracks (Thomas Moore)
  incorporate ZVTOP3 information $\Rightarrow$ increased overall sensitivity?

- Lepton+kaon orphan analysis…

Plans

Goal: *release new combined SLD amplitude fit before ICHEP 00 (Osaka)*
starts July 27, 2000 (include l+D, l+X, Ds+X, dipole)

Schedule:

- *Develop and test new tools and analysis cuts* by April 15
  VX-alone tracking a top priority

- *Likelihood parameterizations and amplitude fit* by May 15
  need all data and MC by May 1 (1996 data and MC?)

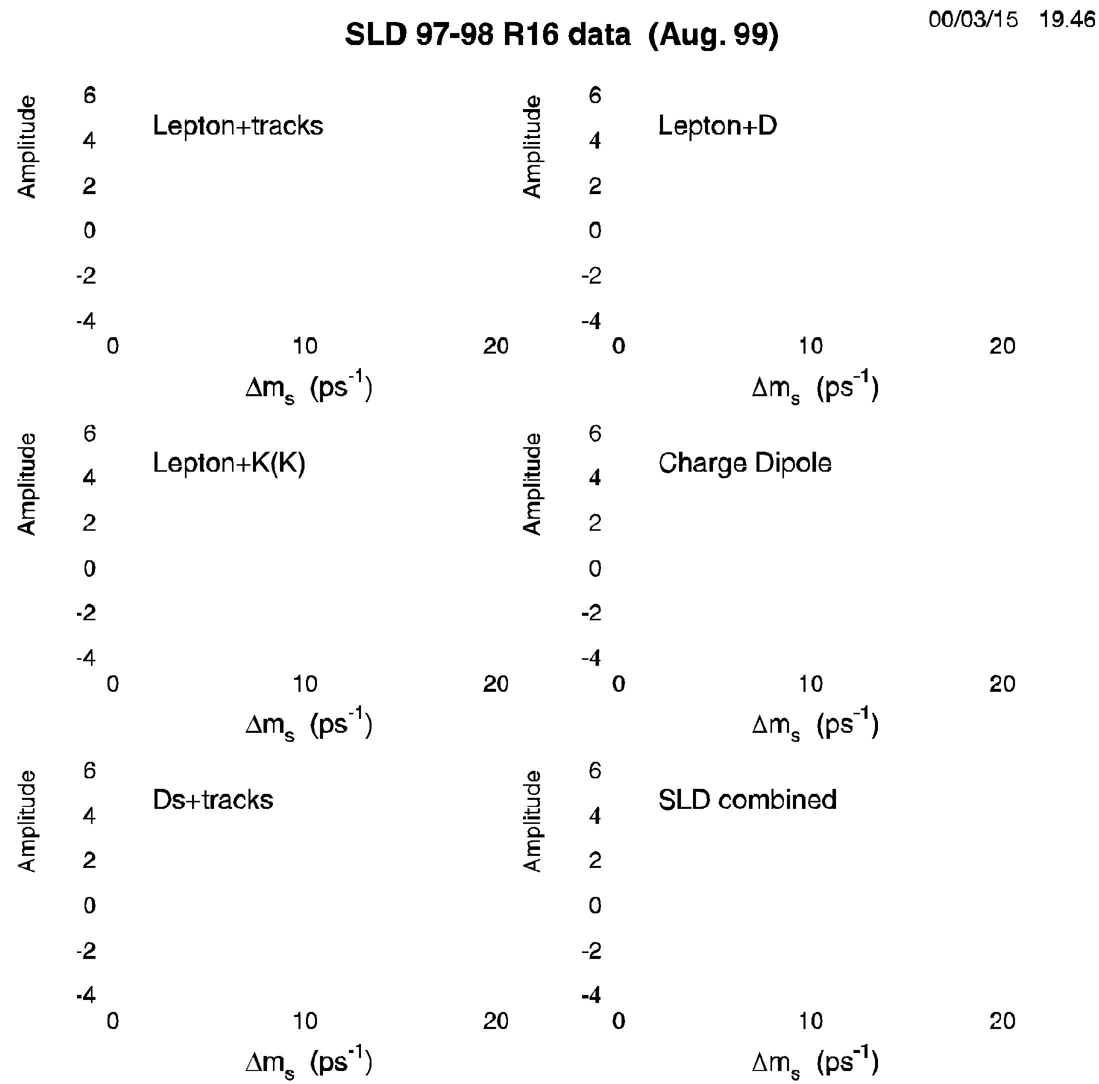
- *Cross checks, calibration and certification* by June 15

- *Systematics, SLD notes, conference papers* by July 15

Projections

Baseline

- Use amplitude fit results from Aug.99 (97-98 R16 data)
- 5 analyses:
  lepton+tracks,
  lepton+D,
  lepton+kaon,
  charge dipole,
  Ds+tracks with
  overlaps removed



Projections

Improvements

Scale amplitude error down by several multiplicative factors (use Moser formula) for lepton+tracks, lepton+D, dipole and Ds+tracks analyses

- Factor of $\sqrt{(400/350)}$ = 1.07 for adding 1996 data
- Factor of 1.10 for improved efficiency and Bs fraction due to the addition of Vxalone tracks
- Factor of 1.10 for improved initial state tag (also partially due to Vxalone tracks)

Additional factors for individual analyses:

- Lepton+D: factor of $\sqrt{1.3}$ for increased efficiency
- Dipole: factors of 1.06 for looser track selection (higher Bs fraction and dipole tag purity) and about 1.10 for improved resolutions
- Ds+tracks: factors of $\sqrt{1.5}$ for increased NN Ds efficiency and 1.15 for improved boost resolution

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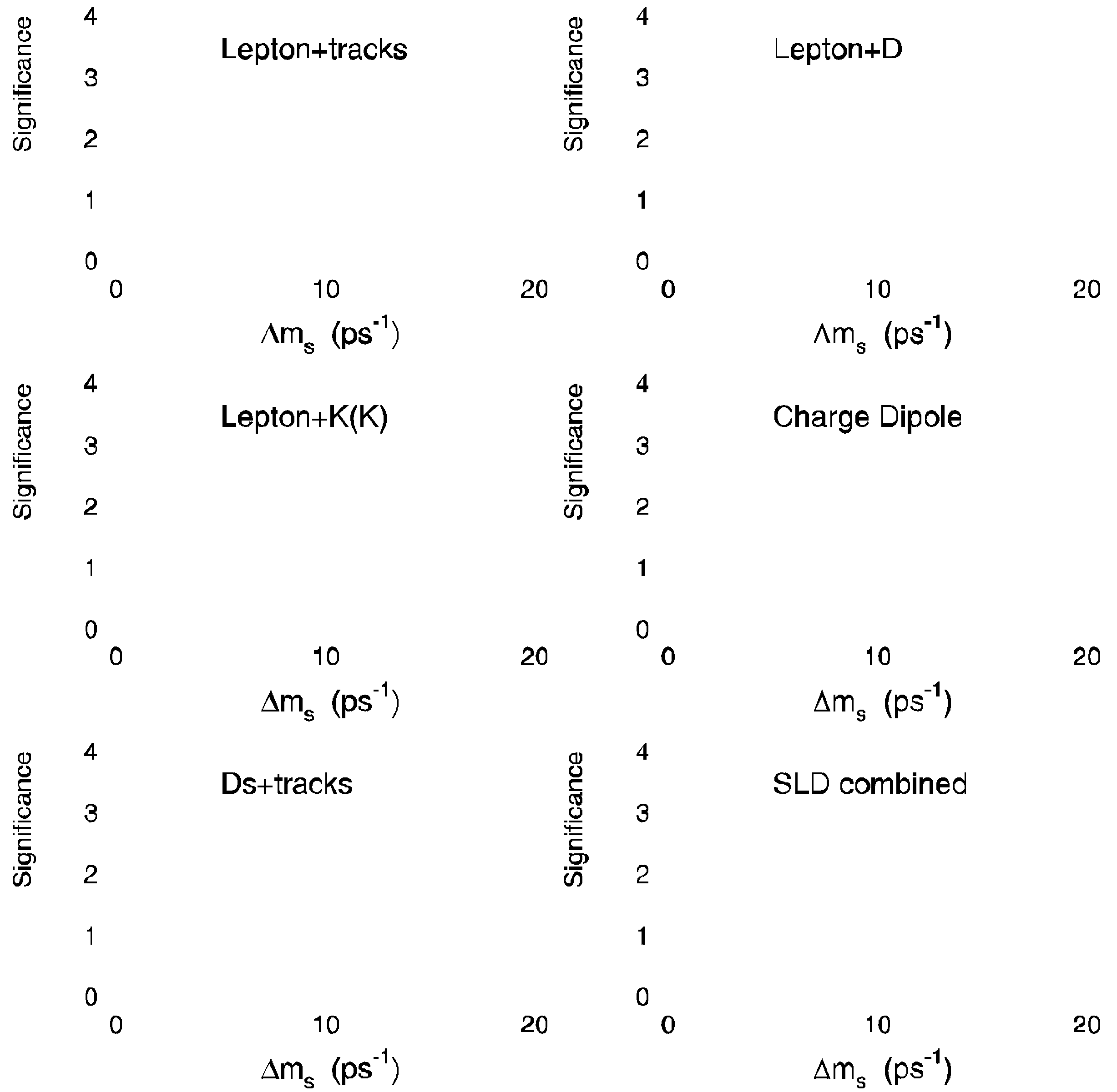
SLD 96-98 Data PROJECTIONS



Dashed lines: significance w/o improvement factors

Solid lines: significance with improvement factors

S.Willocq (UMass)

Dipole – lepton+D Overlap

Currently: if two events are shared between two separate analyses, event is removed from least sensitive analysis

⇒ Not using all available information

Example: lepton+D analysis (ca. Aug.99)

	No dipole evt	With dipole evt	Overall
Sample fraction	0.471	0.529	1.0
Bs fraction	0.104	0.197	0.153
Bs mistag rate		0.052	0.082
Fraction with Qdipole = Qlepton		0.932	
Bs mistag rate if Qdipole = Qlepton		0.020	

In Dipole - lepton+D overlap, both dipole and lepton flavor tags have correct tag probabilities of 95%.

⇒ Can improve lepton+D sensitivity with dipole information

Projections

Caveats

Assumed f(Bs) = 0.108

but latest value = 0.096

Lepton+K(K) absorbed

into other analyses

But

May get more out of

- Initial State tag
- Vxalone tracks
- Overlaps

New results should be very interesting