HERA-B Meeting, PWG3 session, Feb. 9, 1999

Overview: mixings

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- B_s mixing overview
  - Pedestrian's reminder
  - Results of studies carried out so far (T. Oest et al)
  - Competition
- D^0 mixing overview
- Some simple kinematics

B_s mixing measurement - a reminder

Start with a perfectly tagged case, and a B_s at t=0: then the probability to see a $\bar{B}_s$ decay as a function of proper time is

$$1 - cos(x_s t/\tau)$$

Imperfect tagging and background reduce the amplitude of the cosine term by a factor known as dilution (D)

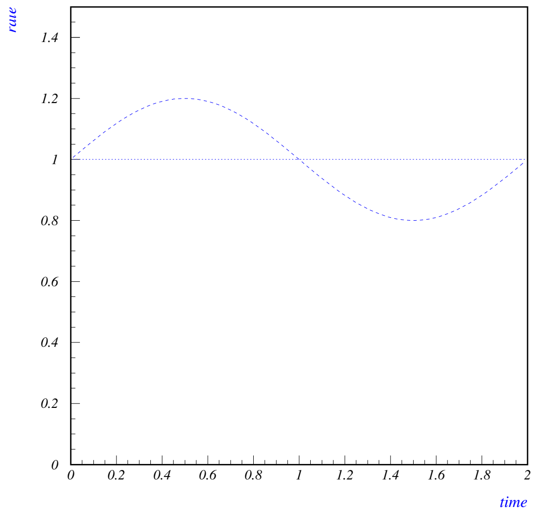
$$1 - Dcos(x_s t/\tau)$$

with a value of about $D \approx 0.18$ for lepton tagged events of the type $\ell^+ D_s \nu$.

The amplitude is then further reduced by the finite resolution in proper time t.

Resolution: amplitude dilution

In the limit of a very good resolution ($\sigma_t << x_s \tau$), a simple quantitative estimate of the effect can be made by observing that the amplitude is reduced by events moving from the up side of the wave to the low side, the effect being most important in an interval of order σ_t around the zero value of cosine. In this region cosine can be approximated as a linear function, and the fraction of events (=integral) in this interval can be roughly estimated to $\frac{\sigma_t^2 x_s^2}{2\tau^2}$.



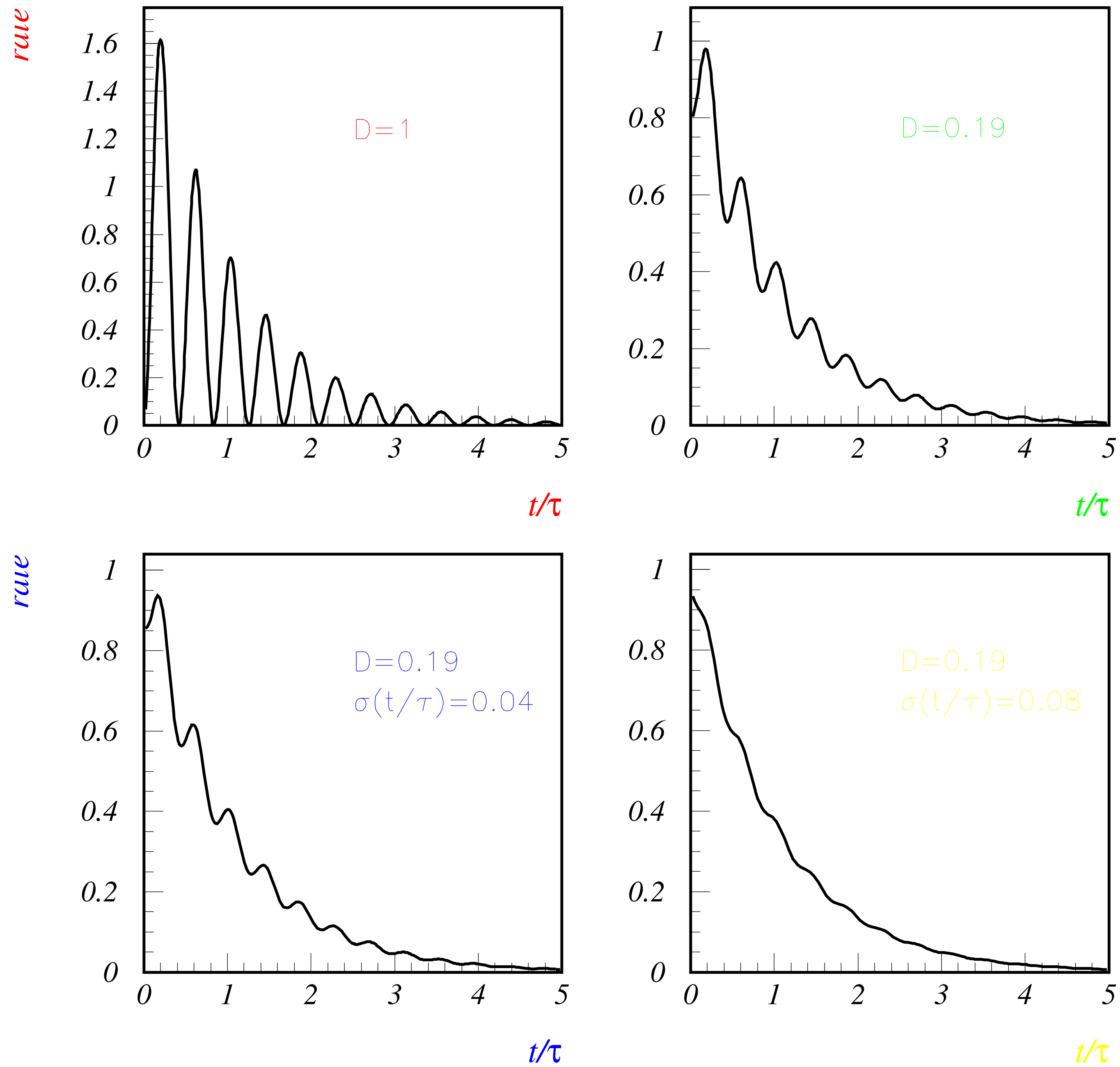
A proper derivation involves of course a convolution of the time evolution curve and the detector response. As a result, we get a function of the form

$$1 - D' cos(x_s t/\tau)$$

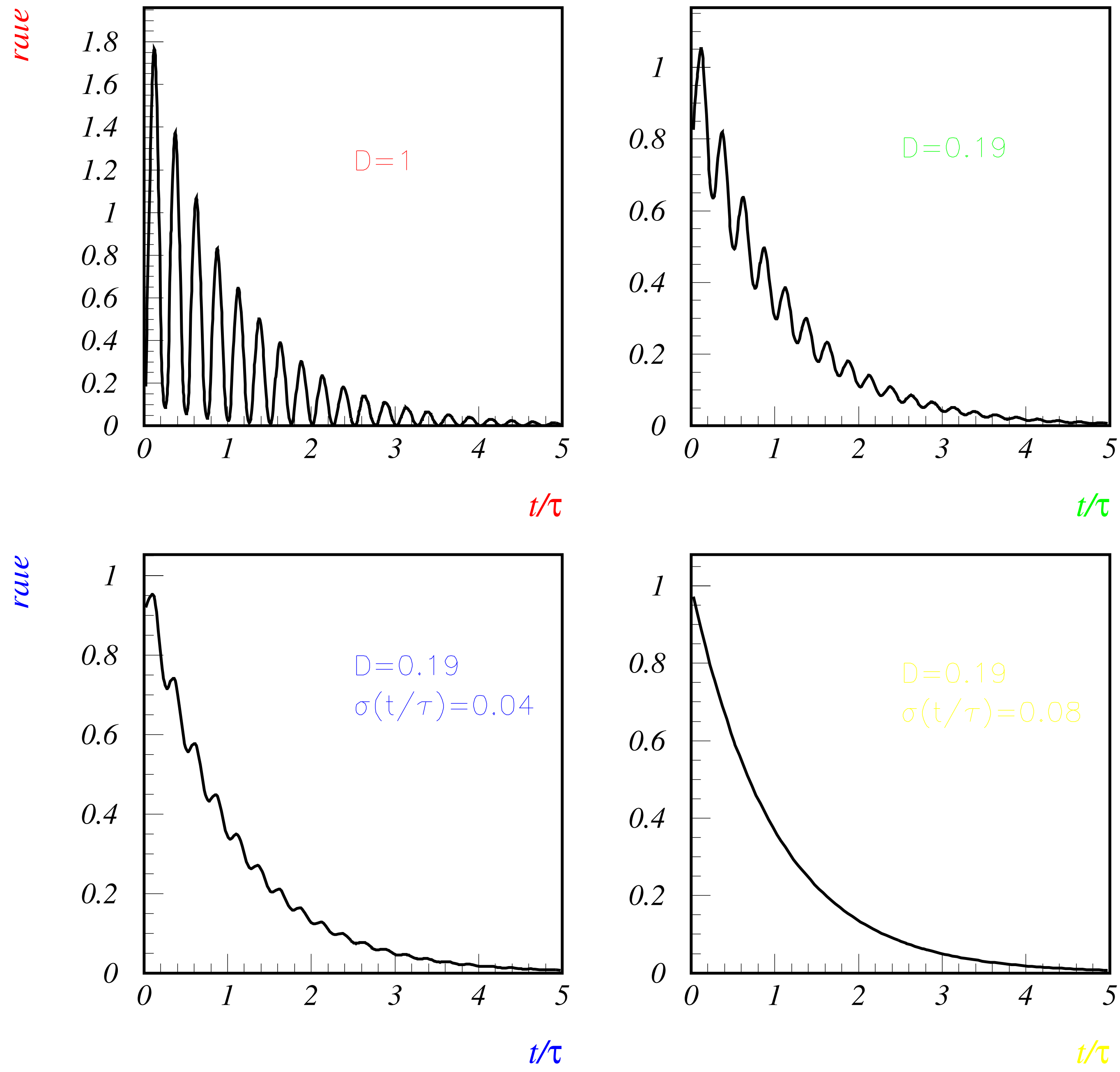
with the dilution D replaced by

$$D' = De^{-\frac{\sigma_t^2 x_s^2}{2\tau^2}}$$

Example: for $x_s = 15$ ($\Delta m_s = 10ps^{-1}$)



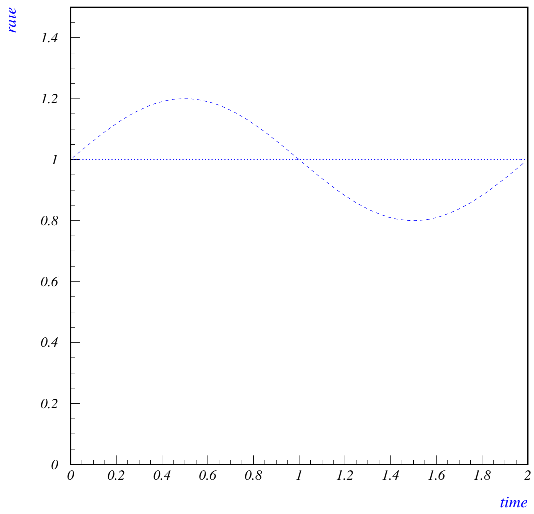
Example: for $x_s = 25$ ($\Delta m_s = 17 ps^{-1}$)



Dilution vs. reach

A simple estimate of the statistics required for a measurement can be made if we fix x_s, and divide the events in two classes:

- up part of the wave
- down part of the wave



Oscillation amplitude differs from zero if the two classes are differently populated. The distribution over the two classes is binomial, with probability for up part equal to

$p = \frac{1}{2} + cD'$

where c is a constant of order 1.

The error on p is in case we have made measurement with N events

$\sigma(p) = \sqrt{\frac{p(1-p)}{N}} \approx \frac{1}{2}\frac{1}{\sqrt{N}}$

for $p \approx \frac{1}{2}$, and resulting error on the amplitude D'

$\sigma'_D = \frac{1}{2c\sqrt{N}}$

and the 'significance'

$D'/\sigma'_D = 2c\sqrt{N}De^{-\frac{\sigma_t^2 x_s^2}{2\tau^2}}$

B_s mixing experimental status

B_s mixing summary

1. $B_s \to J/\psi K^{*0}$
   - reliable estimates, good t resolution
   - limited by statistics
   - 2 σ effect can be obtained
   - not sufficient for a mixing observation
2. $B_s \to \ell D_s X$
   - unclear estimates for events/year (trigger)
   - high-pt lepton trigger ($p_t > 1.5$ GeV) ??
   - limited by resolution (and statistics ?)
3. $B_s \to D_s \pi^+ (\pi^+ \pi^+ \pi^-)$
   - good t resolution, 3 σ effect at $x_s = 20$
   - unclear estimates for events/year (trigger)

B_s mixing competition

Competitor: CDF

D Mixing

theoretical predictions:

	$\Delta m_D/\Gamma$
standard model	$10^{-5} - 10^{-4}$
two Higgs model	$> 10^{-4}$
4th generation	10^{-2}
flavor-changing neutral Higgs	$10^{-2} - 10^{-1}$
SUSY	$10^{-5} - 10^{-4}$
LR symmetry	$10^{-5} - 10^{-4}$

measured quantity

$$r_d = \frac{D^0 \to f}{D^0 \to \overline{f}}$$

the time evolution:

in case of D^0 mesons the cosine term can be expanded to yield

$$\Longrightarrow |<\overline{D^0}|D^0(t)>|^2 \approx e^{-\Gamma t}\left(\frac{\Delta m t}{2}\right)^2$$

D mixing: experimental status

D^0 tag: $D^{*+} \to D^0\pi^+$

$D^0 \to K^-\ell^+\nu$:

E791: (1200 $D^0 \to K^-\ell^+\nu$ decays):

$r_d < 5 \cdot 10^{-3} \Longrightarrow \Delta m/\Gamma < 0.1$

$D^0 \to K^-\pi^+(\pi^+\pi^-)$:

CLEO:

$r_d = (7.7 \pm 3.5) \cdot 10^{-3}$

but: possibly dominant contribution of doubly Cabibbo suppressed decays

How to do it at HERA-B?

a) tag with lepton charge

$\overline{B^0} \to D^{*+}\ell^-\bar{\nu}$

$\epsilon_{trigger} \approx 10\% \Longrightarrow 9000 - 18000$ decays / year

Factor ≈ 3 (?) improvement in Δm_D

b) tag with the lepton from the associated c quark

$\overline{D}D^0 \to \ell\ell X$

$\epsilon_{trigger} \approx 0.06\% \Longrightarrow \approx 10^7$ lepton pairs / year

$\Delta m_D <$??

D^0 mixing competition

Competitor: CLEO with $D^0 \to K^-\pi^+(\pi^+\pi^-)$,
plus vertex information to resolve mixing from DCSD.

Reach: $r_d = 10^{-5}$, $\Delta m_D = 5 \cdot 10^{-3}$

Some simple kinematics in B decays

Just as an exercise we have plotted the momentum distribution of B's.

Fix: one channel is $B^0 \to J/\psi K_s^0$.

The momentum distribution is least wide in the naive p,p c.m.s. with $\beta\gamma \approx 22$ $->$

Angular distribution $->$

Summary

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