Preliminary Studies for $B_s^0 - \bar{B}_s^0$ Mixing with the DØ Detector in Run II

G. Lima (UERJ/Brazil)
for the DØ Collaboration

Workshop on B-Physics at the
Tevatron – Run II and Beyond
September 24, 1999

Outline:

- Introduction
- Preliminary Study
  - Event generation and selection
  - Trigger and reconstruction
  - Simulating oscillations and dilution
- Conclusions

Introduction

- **Goal is to evaluate the observability of time-dependent $B_s^0 - \bar{B}_s^0$ oscillations using the upgraded DØ Detector**
- **Experimental observation:**

$$N_{\text{nomix}}(t) = N(B_s^0 \to B_s^0) = A\ \exp\left(-\frac{t}{\tau}\right)\ \frac{1}{2}\left[1 + \mathcal{D}\cos\left(x_s \frac{t}{\tau}\right)\right]$$

$$N_{\text{mix}}(t) = N(B_s^0 \to \bar{B}_s^0) = A\ \exp\left(-\frac{t}{\tau}\right)\ \frac{1}{2}\left[1 - \mathcal{D}\cos\left(x_s \frac{t}{\tau}\right)\right]$$

The time-dependent ratio $\mathcal{R}(t)$ is defined as:

$$\mathcal{R}(t) = \frac{N_{\text{mix}} - N_{\text{nomix}}}{N_{\text{mix}} + N_{\text{nomix}}} = \mathcal{D}\cos\left(x_s \frac{t}{\tau}\right)$$

where $t = \frac{M(B_s^0)L}{pc}$ is the proper decay time of the B_s^0 meson, τ is the lifetime of the B_s^0 meson and x_s is called the oscillation parameter, to be measured.

$\longrightarrow$ Full reconstruction of the final state is desirable to optimize momentum and proper-time resolution.

Preliminary Study

- **Some of the best modes for studying B_s^0 Mixing:**

Decay Mode	Product BR
$B_s^0 \to D_s^-(\to K^-K^+\pi^-)\pi^+$	1.1×10^{-4}
$B_s^0 \to D_s^-(\to K^-K^+\pi^-)\pi^+\pi^-\pi^+$	2.8×10^{-4}
$B_s^0 \to J/\psi K^*$	5.1×10^{-6}
$B_s^0 \to D_s^-(\to K^-K^+\pi^-)\ell^+\nu$	3.6×10^{-3}

- **First study using:**

$B_s^0 \to D_s^-\pi^+\pi^-\pi^+$

$D_s^- \to \phi\pi^-$,

$\phi \to K^+K^-$

- **Isajet and QQ used for event generation and selection**

  - **Isajet:** **Twojet** $b\bar{b}$ **events,** $2 < p_T^b < 100 GeV$, **keeping all events with** B_s^0

  - **QQ:** **The whole decay chain was forced:**

Decay Mode	Branching Ratios
$B_s^0 \to D_s^- 3\pi^\pm$	6.3×10^{-3} **(assumed)**
$D_s^- \to \phi\pi^-$	$(\ 3.6 \pm 0.9)\%$
$\phi \to K^+K^-$	$(49.1 \pm 0.6)\%$
combined	1.1×10^{-4}

  - **All events with a** B_s^0 **were selected**

- **MCFast used for fast detector simulation**

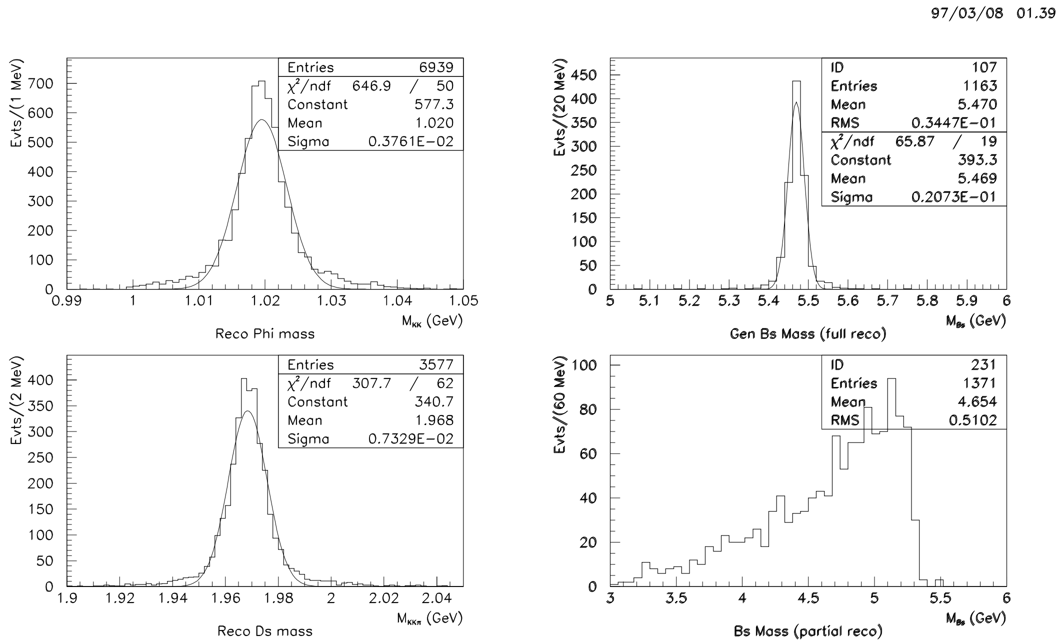
  Track and vertex reconstruction parametrized according to expected DØ performace

- **Trigger**

  - **Require a lepton (semileptonic decay of other-side b-hadron)**
  - **Tracks with large impact parameter at L2**

- **Track Reconstruction:**

  All tracks within tracker acceptance, and $p_T(\mathrm{hadrons}) > 0.5 GeV$.



- **Mass Resolution:**

  Important for background rejection

$$\begin{array}{lccl} \mathbf{1.01} & < & M(K^+K^-) & < \mathbf{1.03\ GeV} \\ \mathbf{1.95} & < & M(\phi\pi^\pm) & < \mathbf{1.99\ GeV} \\ \mathbf{5.42} & < & M(D_s^-\pi^+\pi^-\pi^+) & < \mathbf{5.52\ GeV} \end{array}$$

- **Flavor Tagging:**

  - **At production, by the semileptonic decay of the recoil b-hadron**
  - **At decay, by the charge configuration of the final state**

- **Estimated yields for Run II:**

  $\sim$ **270** $B_s^0 \to 2K^\pm + 4\pi^\pm$ **evts/fb**$^{-1}$

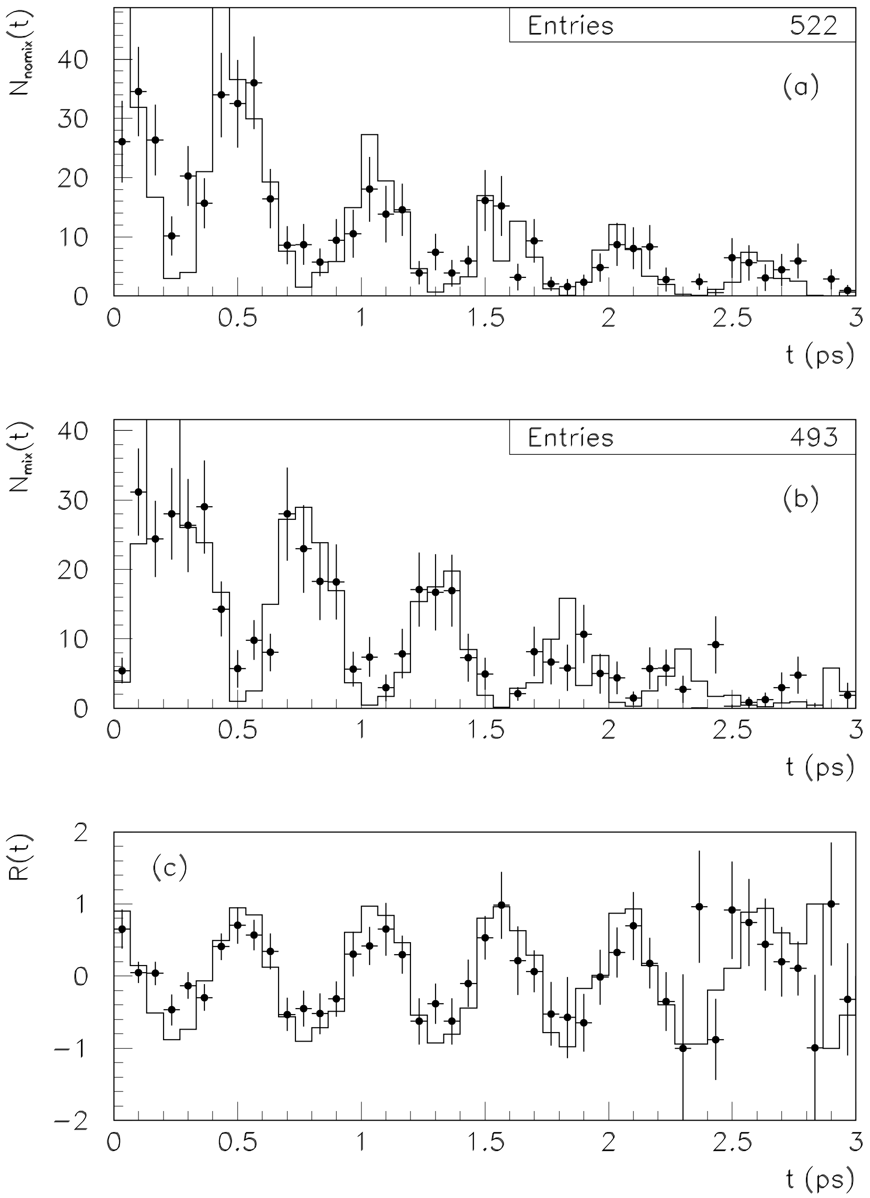
  fully reconstructed and flavor-tagged (μ **only)**

Simulating Oscillations

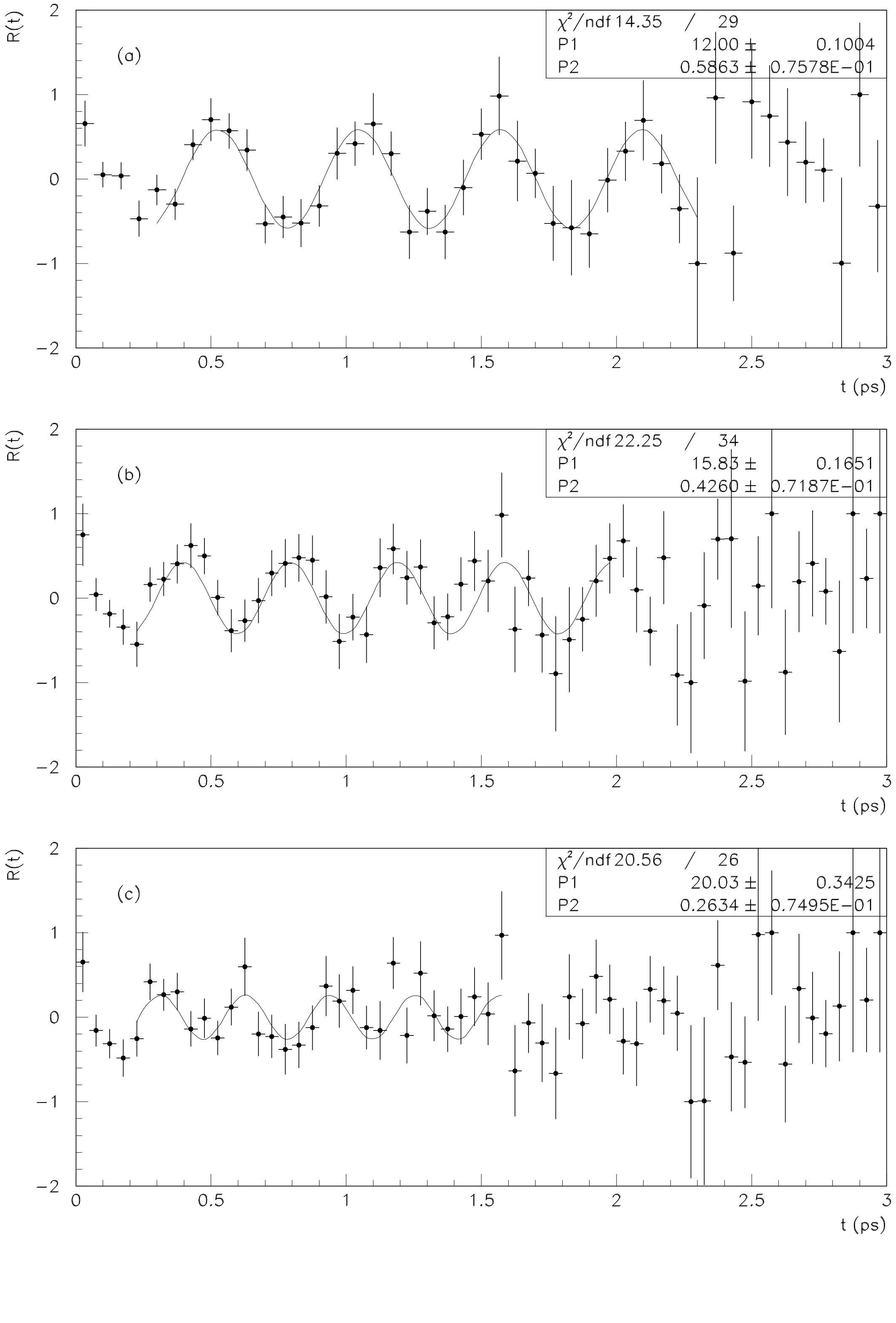
- **Time dependence of mixing oscillations were introduced by hand, using weights:**

$$\omega_{\rm mix} = 1 + \cos\left(x_s \frac{t}{\tau}\right)$$

$$\omega_{\rm nomix} = 1 - \cos\left(x_s \frac{t}{\tau}\right)$$



- **The values of the mixing parameter x_s are extracted from a fit**



Dilution Parameter

The observed decay asymmetry is smaller than the real asymmetry:

$$A_{\rm obs} = \mathcal{D} A_{\rm CP} \qquad \text{with} \qquad \mathcal{D} = d_1 d_2$$

where:

$d_1 = \sqrt{S/(S+B)} \longrightarrow$ **background contamination in the final sample**

$d_2 = 1 - 2p_{\rm mistag} \longrightarrow$ **flavor mistagging due to:**

- possible mixing in the tagging side

- sequential decays (negligible at DØ!)

- tagging lepton is fake or comes from other sources (negligible at DØ!)

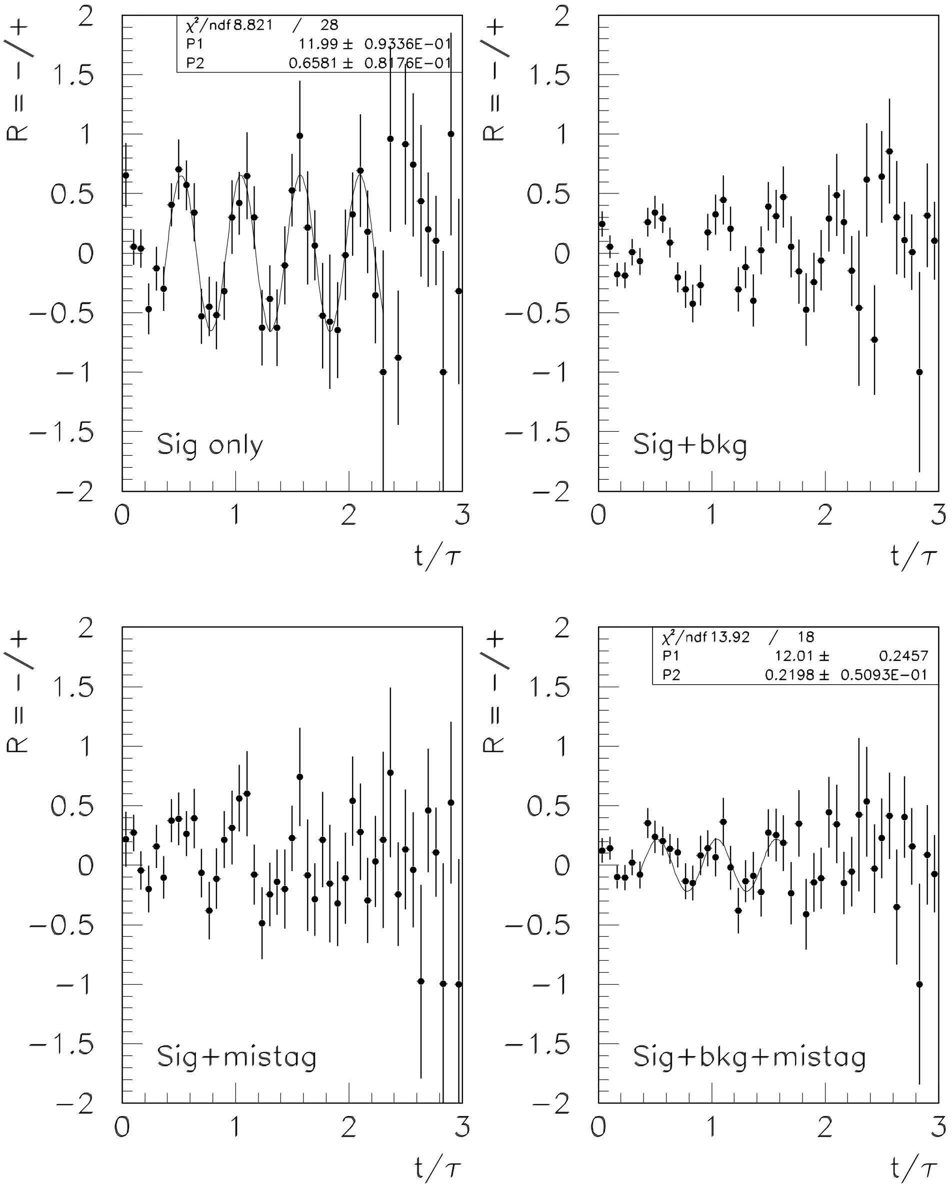
<u>**For $B_s^0 - \bar{B}_s^0$ mixing:**</u>

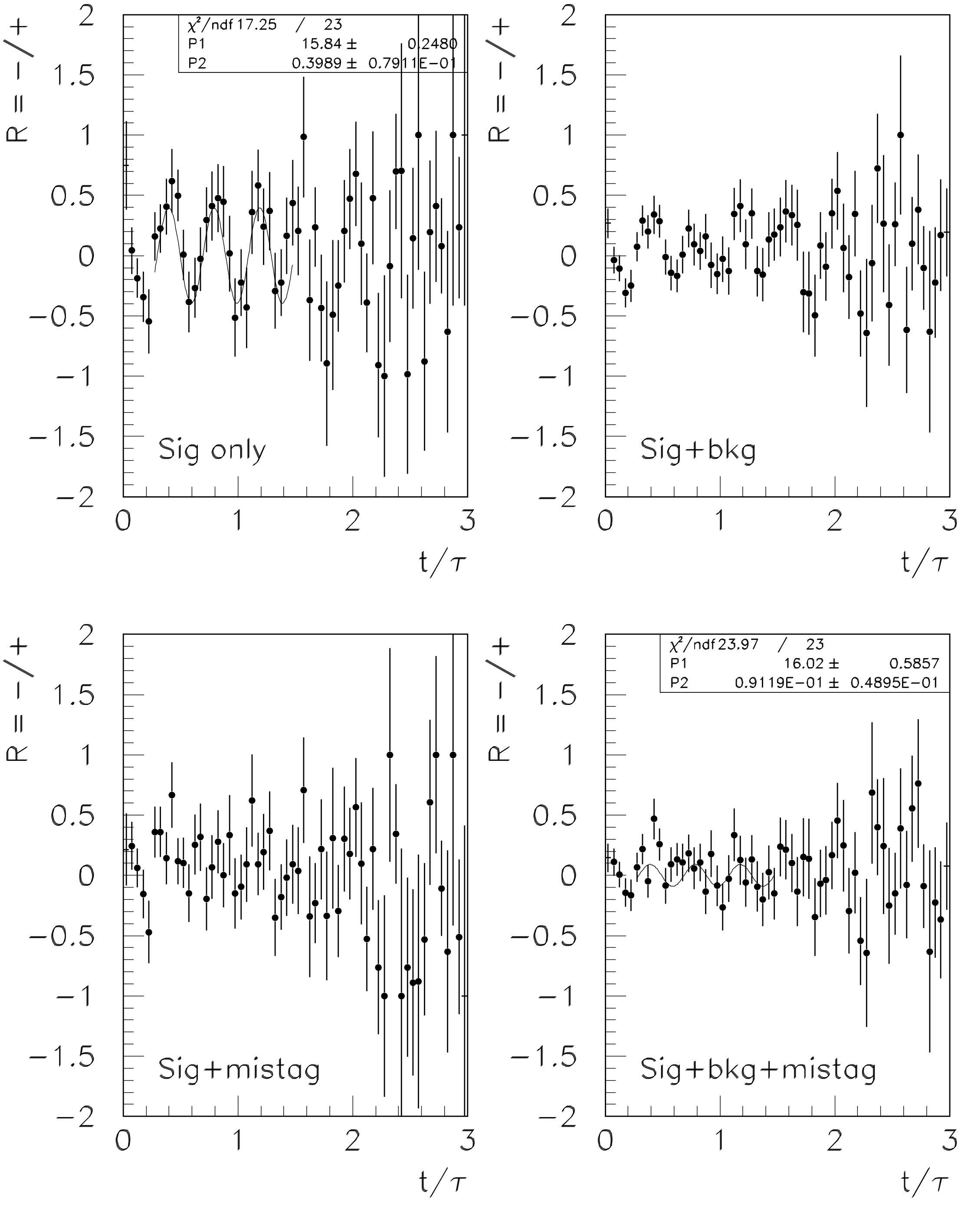
- **assuming a 1:1 S/B ratio,** $d_1 = 0.71$
- $p_{\rm mistag} = 0.25 \qquad \longrightarrow \qquad d_2 = 0.50$

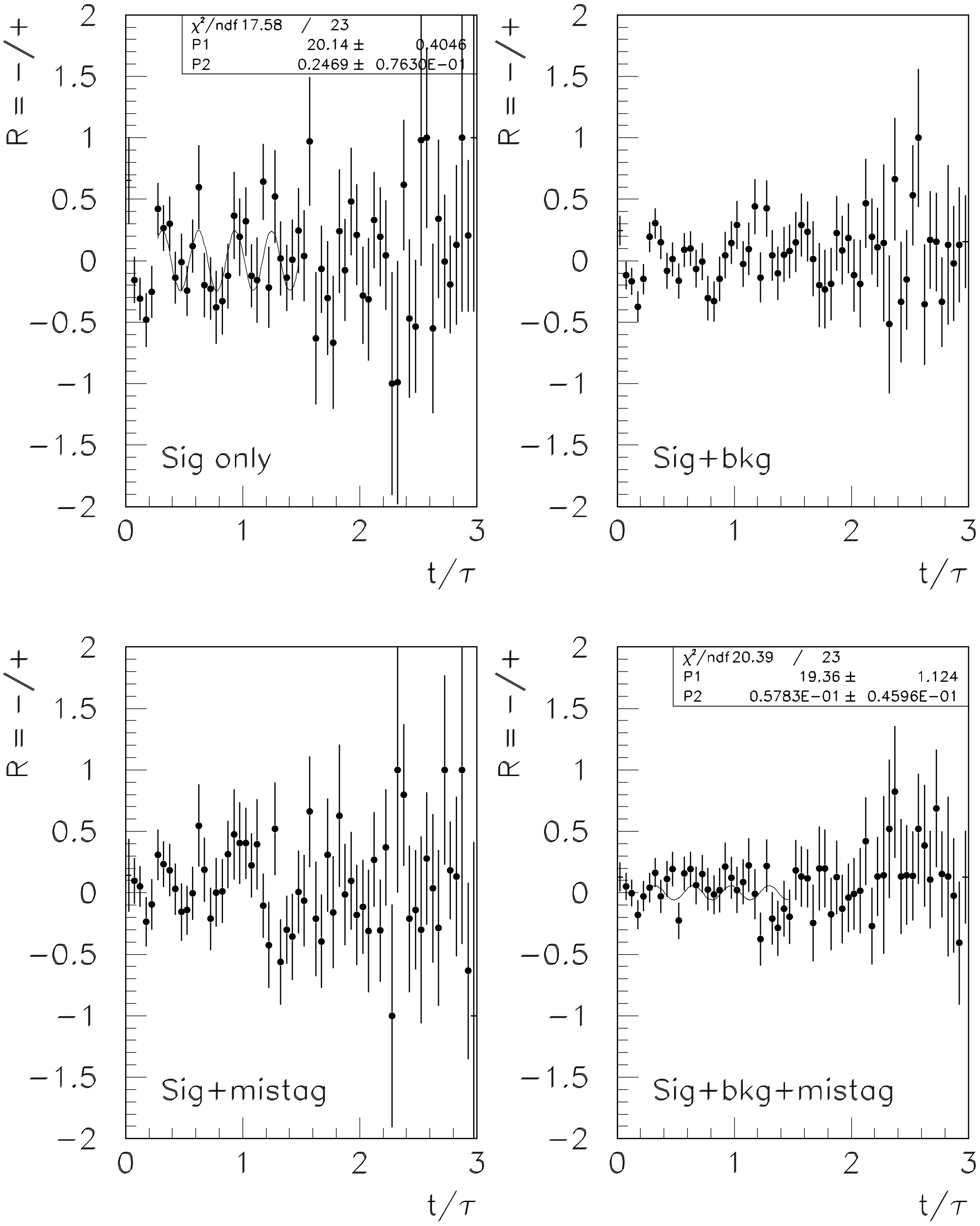
Therefore, $\mathcal{D} = 0.35$

- **Dilution effects:**

  - **<u>background</u>: 1:1 rate,** $\tau_{\rm bg} = 0.5\,\tau(B_s^0)$
  - **<u>mistag</u>: 25% probability**




χ²/ndf 17.25 / 23
P1 15.84 ± 0.2480
P2 0.3989 ± 0.7911E-01
Sig only
Sig+bkg
Sig+mistag
χ²/ndf 23.97 / 23
P1 16.02 ± 0.5857
P2 0.9119E-01 ± 0.4895E-01
Sig+bkg+mistag
R = −/+
t/τ



χ²/ndf 17.58 / 23
P1 20.14 ± 0.4046
P2 0.2469 ± 0.7630E-01
Sig only
Sig+bkg
Sig+mistag
χ²/ndf 20.39 / 23
P1 19.36 ± 1.124
P2 0.5783E-01 ± 0.4596E-01
Sig+bkg+mistag
R = −/+
t/τ

Preliminary Conclusions

- $B_s^0 - \bar{B}_s^0$ mixing may be a possible analysis topic for DØ in Run II. But more studies needed, using more appropriate simulation and reconstruction tools.
- Statistics must be improved by using additional decay modes, electron tagging. Other strategies?
- Amplitude fits and other fit techniques may be useful to reach higher x_s values.
- Key item for improvement is creative triggering

Work to do:

- Detailed studies on triggering
- Redo this analysis for other channels
- Can we use semileptonic B_s decays in this study?
- How far in x_s we can go for 2 fb^{-1}? 5 fb^{-1}? 10 fb^{-1}?