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- Introduction
- Current and future measurements
- $B_s$ mixing and physics beyond the SM
Best channel: $B_s^0 \rightarrow D_s^\pm \pi^\pm$, $D_s^\pm \rightarrow \phi \pi^\pm$, $\Phi \rightarrow KK$

The flavor of the $B_S$ at production is determined by different Tagging methods (opposite side or same side tagging)

The $D_s^\pm$ is used to tag the flavor of the $B_S$ at decay time.

**Good proper time resolution needed!**
## Summary table

<table>
<thead>
<tr>
<th></th>
<th>Event Yield</th>
<th>$\delta \Delta m_s ,[\text{ps}^{-1}]$</th>
<th>$\Delta m_s ,$ reach</th>
<th>$\Delta m_d$</th>
</tr>
</thead>
<tbody>
<tr>
<td>SM</td>
<td></td>
<td>&gt;14.6 &lt;31.2(4)</td>
<td></td>
<td></td>
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<tr>
<td>World ave.</td>
<td></td>
<td>&gt;14.9(‘01)(4)</td>
<td>(0.486+/-0.015) (3)</td>
<td></td>
</tr>
<tr>
<td>Babar</td>
<td></td>
<td>0.507+/-0.015+/-0.022(3)</td>
<td>0.10-0.16 (1)**</td>
<td></td>
</tr>
<tr>
<td>Belle</td>
<td></td>
<td>0.456+/-0.008+/-0.030(3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CDF/D0</td>
<td>20k (CDF)</td>
<td>60/22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BteV 103 k/yr</td>
<td>0.10</td>
<td>Up to 55*</td>
<td>30(6)</td>
<td></td>
</tr>
<tr>
<td>Atlas 30fb$^{-1}$/yr</td>
<td>0.05-0.16 (1)**</td>
<td>38.5(1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CMS 4.5 k/yr</td>
<td>0.11(20ps$^{-1}$)(6)</td>
<td>30(6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LHCb 86 k/yr</td>
<td>0.011(6)</td>
<td>Up to 60(2)*</td>
<td>48(6)</td>
<td></td>
</tr>
</tbody>
</table>

*assuming Bs lifetime = 1.464 ps  **for $\Delta m_s =$20 and 38.5 ps$^{-1}$, respectively
Upper limit sensitive to specific models
Ranges don’t tell the whole story: chi-sq minima might be quite different for the various models
\( \Delta M_s \) does not seem to be a sure candidate in ruling out/ establishing SUSY. One needs to get lucky.

Model dependence in terms of single parameter \( f \)

\[
\Delta M_s = \Delta M_s(SM) [1 + f]
\]

- \( f = 0 \) (SM): \( 14.6 \leq \Delta M_s \leq 31.2 \)
- \( f = 0.2 \) (mSUGRA): \( 14.6 \leq \Delta M_s \leq 35.5 \)
- \( f = 0.4 \) (non-mSUGRA): \( 14.9 \leq \Delta M_s \leq 39.4 \)
- \( f = 0.75 \) (non_SUGRA): \( 15.1 \leq \Delta M_s \leq 48.6 \)
Fits to $f$

2 degrees of freedom ($\rho$ and $\eta$):
→ $\chi^2_{\text{min}} > 2$ are disfavored
→ Models with $f > 0.6$ disfavored in current data
Seems like a powerful way to distinguish between models, but quite optimistic

Assuming $\Delta M_s = 17.7 \pm 1.4$ ps$^{-1}$

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<tr>
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<th>ATLAS</th>
<th>CMS</th>
<th>LHCb</th>
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<tbody>
<tr>
<td>Measurable values of up to:</td>
<td>30 ps$^{-1}$</td>
<td>26 ps$^{-1}$</td>
<td>48 ps$^{-1}$</td>
</tr>
<tr>
<td>95% CL excl. of $\Delta M_s$ values up to:</td>
<td>-</td>
<td>29 ps$^{-1}$</td>
<td>58 ps$^{-1}$</td>
</tr>
<tr>
<td>$\sigma(\Delta M_s)$ for $\Delta M_s = 20$ ps$^{-1}$</td>
<td>0.11</td>
<td>-</td>
<td>0.011</td>
</tr>
</tbody>
</table>
Other factors

The chi-sq fits to $f$ depend on $\eta$ and $\rho$ and hence the angles of the unitarity triangle. (Specifically $\sin 2\beta$)

By making precise measurements of the angles one can reduce the Allowed regions for $f$.

$\rightarrow$ Might be able to rule out specific models.

Hard to make more quantitative statements at this point.
Limiting factors for $\Delta M_s$

Theoretical limitations:

Hadronic matrix elements calculated in lattice QCD to $\sim 10\%$ (leptonic decay constants $f_{B_s}$ and B parameters $\hat{B}_{B_s}$)

\[
\Delta M_s = \frac{G_F^2 M_W^2}{6\pi^2} \eta_B S_0(x_t) M_{B_s} \hat{B}_{B_s} f_{B_s}^2 |V_{ts}|^2
\]

Theory errors are reduced in the ratio $\Delta M_s / \Delta M_d$. 
Limiting factors for $\Delta M_s$

**Experimental limitations:**

**Proper time resolution**

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<tr>
<td>Proper time resolution</td>
<td>50 fs (60.5%)</td>
<td>65 fs</td>
<td>43 fs</td>
<td>43 fs</td>
</tr>
<tr>
<td></td>
<td>93 fs (39.5%)</td>
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For a proper time resolution reduced by 25%, Atlas could achieve a $\Delta M_s$ of 50 ps$^{-1}$ instead of 38.5 ps$^{-1}$! (1)

Other factors: Mistag rates. (Atlas assumes 0.22 for the muon mistag rate by which the wrong charge sign is assigned).

Backgrounds (B$_d$ decays, combinatorical backgrounds).
Conclusions

$\Delta M_s$ will be measured at the Tevatron, and the LHC

Better values of the angles of the CKM matrix result in smaller variance of $\Delta M_s$ for different models

→ In an optimistic scenario the measurement of $\Delta M_s$ can serve to rule out theoretical models

Future Experiments need to have very good proper time resolution to have an impact on $\Delta M_s$. 

2) LHCb technical proposal: http://lhcb-tp.web.cern.ch/lhcb-tp/


7) A. Buras et al., hep-ph/0107048