New Particle Limits from $B_s \rightarrow \mu^+\mu^-$ Using CDF Run2 Data

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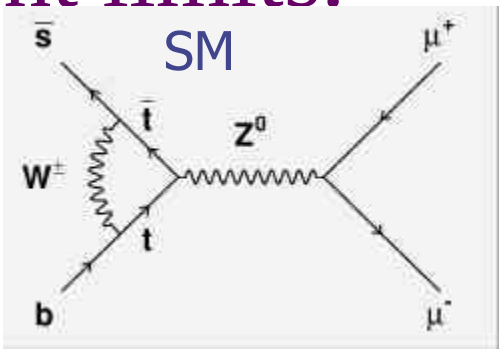
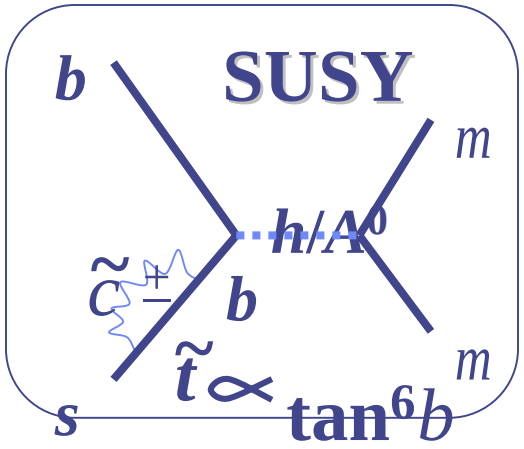
Outlines

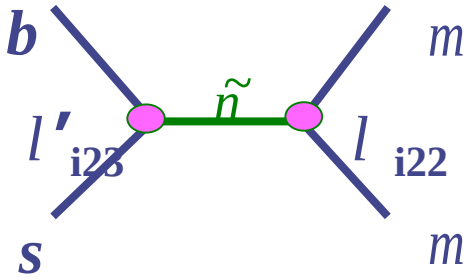
- Motivations. Existing limits.
- Br($B_s \rightarrow \mu^+\mu^-$) analysis strategy.
  - Data. Cuts selection.
  - Background: MC, data.
  - Limits with $113 pb^{-1}$.
- Theoretical implications.
  - Supersymmetry:
    - RPV
    - SO(10)
- Summary and plans

Theoretical motivations. Current limits.

- Flavor Changing Neutral Current.
  Loop contribution only in SM.
  - $Br_{SM}(B_s \rightarrow \mu^+\mu^-)=(3.5\pm1.0)*10^{-9}$
- Only upper experimental limit exists:
  - $Br_{exp}(B_s \rightarrow \mu^+\mu^-)<2.0*10^{-6}$ 90% C.L.
    CDF RunI @100/pb
- Limits are far away from the SM value: can test for a possible new physics.
- MSSM: Br(B→μ⁺μ⁻) enhanced by tanβ>10 terms ~tan⁶β.
  Up to ~100 over the SM prediction.
  Run2 @15/fb is promising for mSUGRA.
- R-parity violating models can give tree level contributions.
- Universal extra dimensions. Up to ~+70% for $B_s \rightarrow \mu^+\mu^-$







Data. Cuts selection.

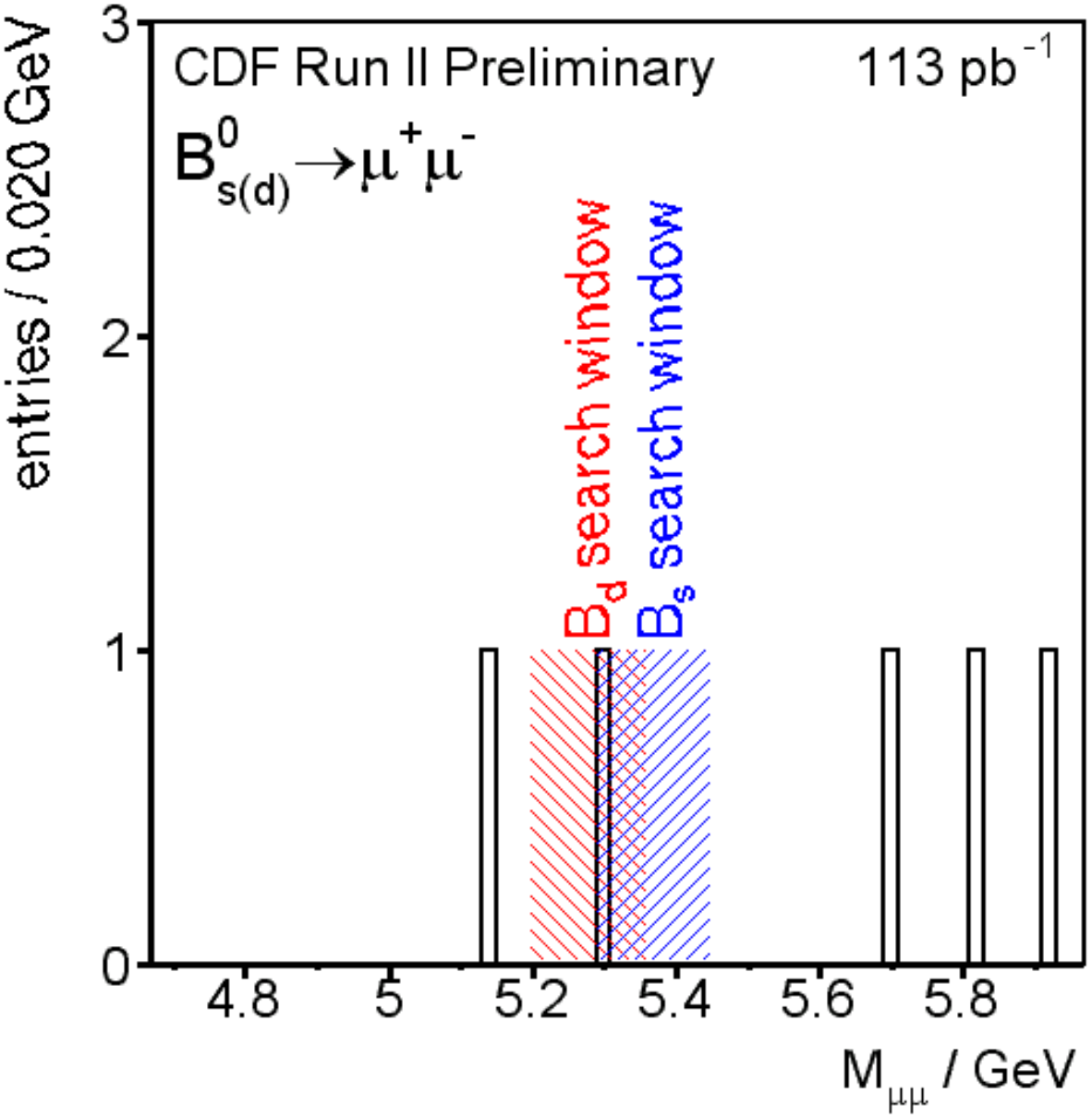
- We are using ~113pb-1 of RareB low pT di-muon data sample (from Mar 2002 to May 2003),

- The four discriminating variables that we use to select $B_{(s,d)} \rightarrow \mu\mu$ events and suppress backgrounds are:
  - Invariant mass,
  - Pointing angle ($\Delta\phi$), angle between di-muon momentum vector and the vertex axis (from IP to secondary vertex),
  - $c\tau$: Lxy*M/Pt_B
  - isolation: Pt_B/(Σ_trk + Pt_B),

- The expected number of background events is obtained from the mass side-bands. We factorize the expected rejection for each cut separately to improve the uncertainty on the background estimate,

- We chose to optimize the analysis based on the final physics quantity, which is the expected limit on the branching ratio.

Bs→μμ Open Box



We got one event within the Bs and Bd search window.

The expected bkg is 0.54 ±0.20 (for Bs) and 0.59 ±0.22 (for Bd).

Bs→μμ Summary

For optimized cuts of $(c\tau, \Delta\phi, \text{iso}) = (>200\ \mu m, <0.10\ \text{rads}, >0.65)$
and a $\pm$ 80 MeV window around world avg Bs mass

$\alpha\times\varepsilon = 1.89 \pm 0.21\%$,which corresponds to a
single-event-sensitivity = 2.54 E-7 in 113 pb-1

accepted bgd xsec = 0.0048 ± 0.0018 pb
which corresponds to the following expectation
<bgd> = 0.54 ± 0.20 events in 113 pb-1

We observed 1 event which yields a limit of:
9.5E-7 @ 90% CL
1.2E-6 @ 95% CL

Current best published limit = 2.6E-6 @ 95% CL (CDF Run I)

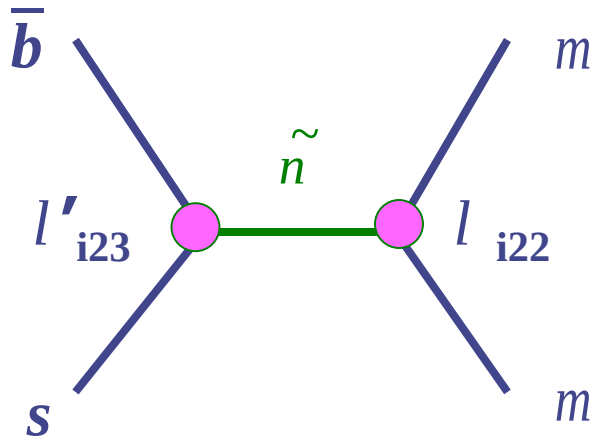
Theoretical implications.

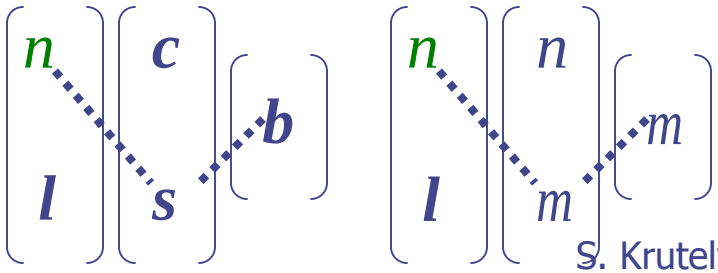
- New limits can be set for:
  - RPV, SO(10) supersymmetry theories.
  - theories with leptoquarks
- Other theories either
  - do not predict a large enhancement of the Br($B_s \rightarrow \mu^+\mu^-$) over the SM predictions.
  - Or have the regions excluded by other experiments (e.g. $b \rightarrow s\gamma$ for mSUGRA)
  - Or not known yet.

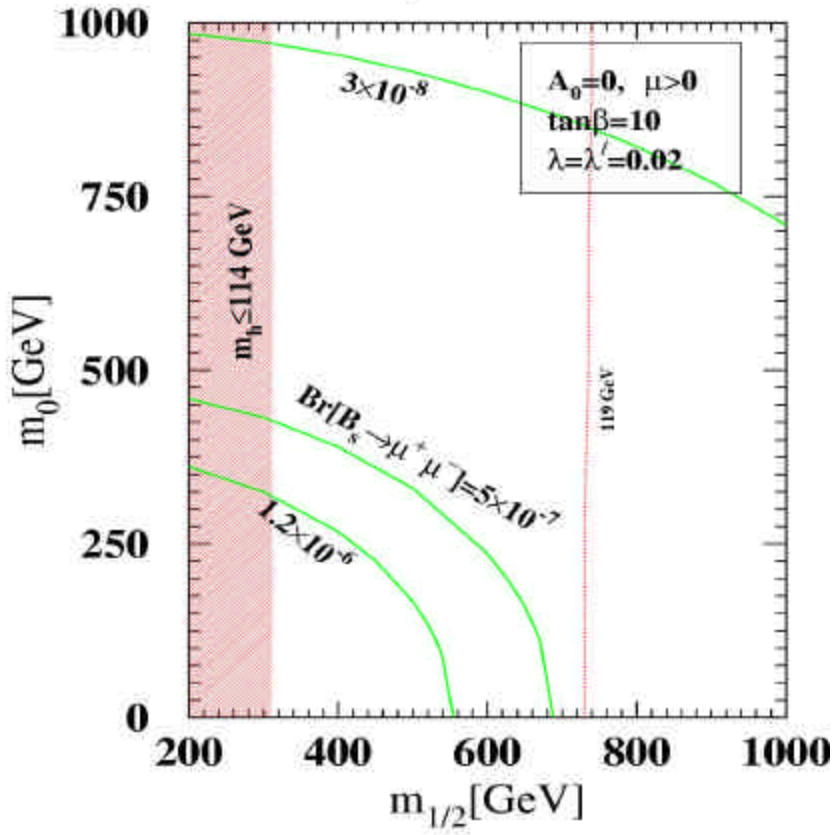
R_P Violation 1.

R. Arnowitt *et al.*, hep-ph/0203069, PLB 538 (2002) 121 , new plots by B.Dutta

e.g., $W_{TRPV} = \lambda_{ijk} L_i L_j E_k + \lambda'_{ijk} L_i Q_j D_k + \lambda''_{ijk} U_i D_j D_k$







R_P Violation 2.

R. Arnowitt *et al.*, hep-ph/0203069, PLB 538 (2002) 121, new plots by B.Dutta

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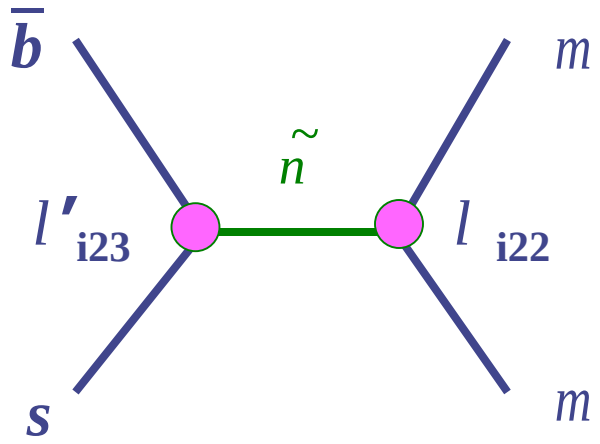
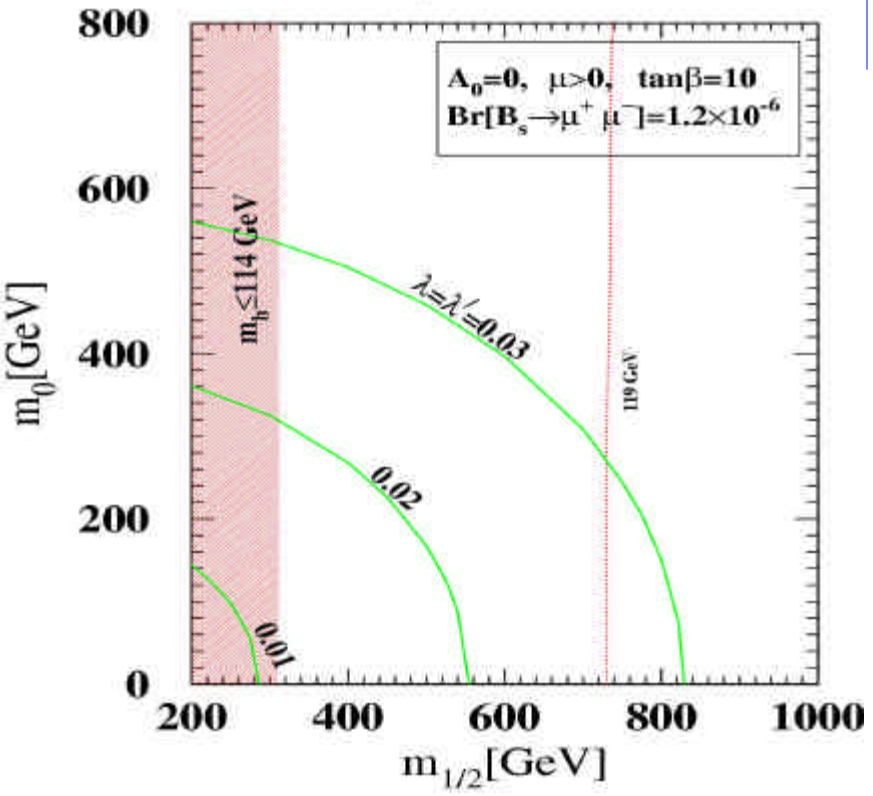
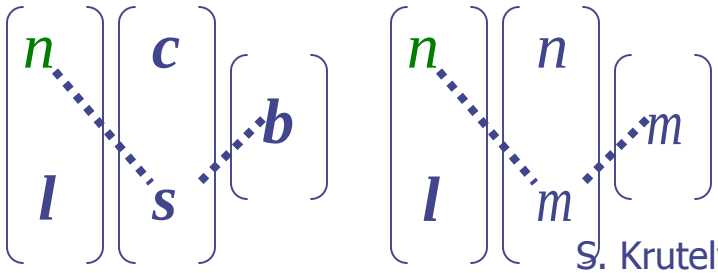


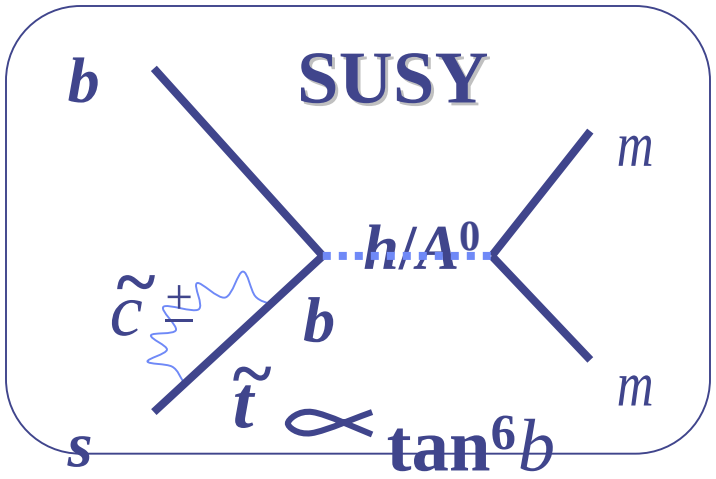


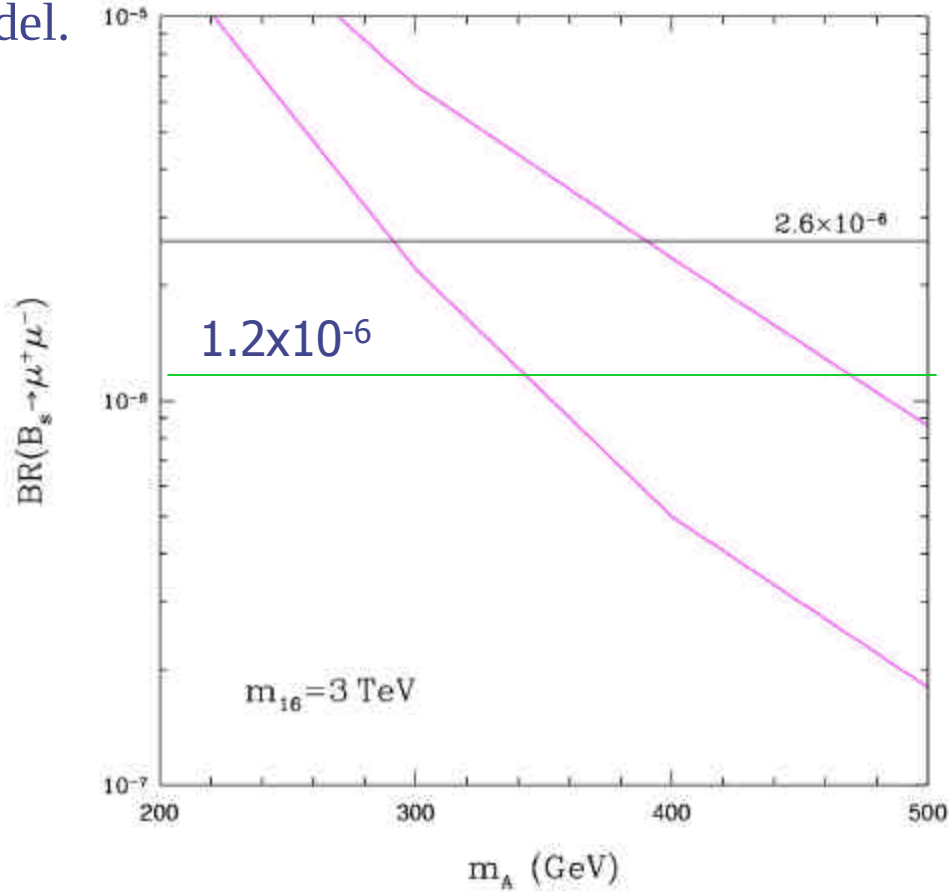


SO(10) SUSY 1.

R. Dermisek *et al.*, hep-ph/0304101

- Minimal SO(10) SUSY model.
  - $W=\lambda f(16_3)H(10)f(16_3)$
  - $M_{1/2}$, m_{16}, m_{10}, A_0, μ, $\tan\beta$
  - favors large $\tan\beta$
  - $Br(B_s \rightarrow \mu^+\mu^-) \sim M_A^{-4}$





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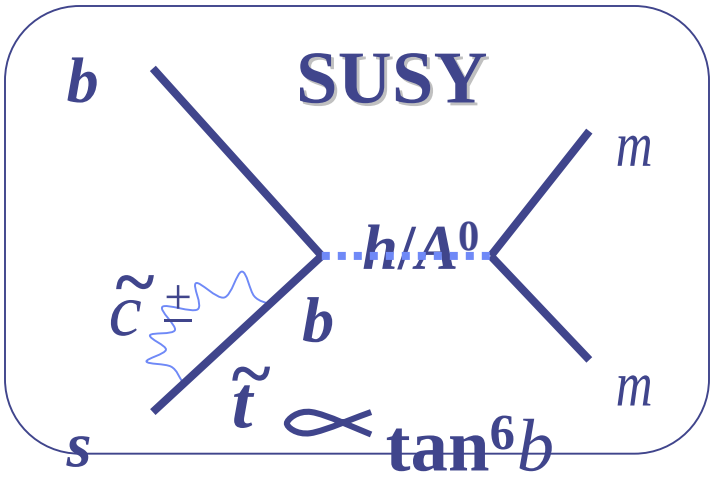
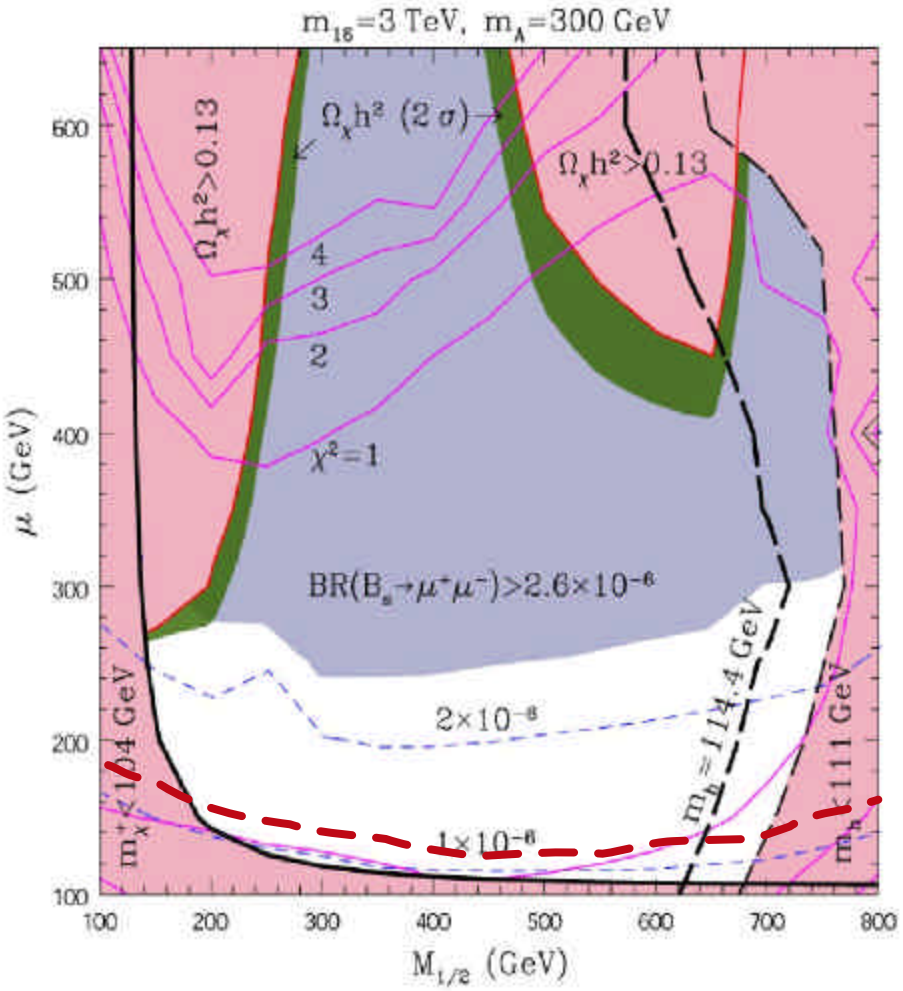




Summary

- $Br_{exp}(B_s \rightarrow \mu^+\mu^-) < 1.2*10^{-6}$ 95% C.L.
  CDF RunII preliminary @113/pb
  - New best result.
  - Results are interesting to the theorists.
  - Ready to show at LP2003
- Plan to include CMX and the data up to the shutdown.
  - Then go for the publication.

$B_{d(s)} \rightarrow mm$: Run I Results

CDF, PRD 57, 3811 (1998)

$\int Ldt$ = 98 pb^{-1} (~5 x 10^{12} collisions)

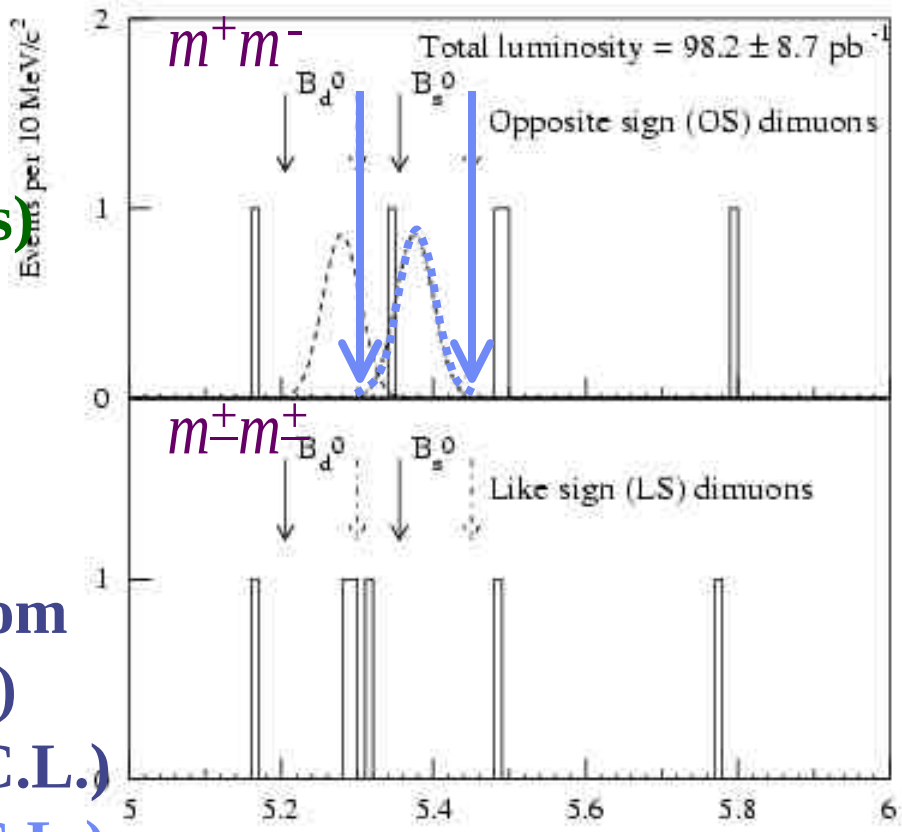
B_d: 5.205-5.355 GeV/c^2

B_s: 5.300-5.450 GeV/c^2

N_{obs} = 1 with 5.344 GeV/c^2
(consistent with an expectation from the Standard Model backgrounds)

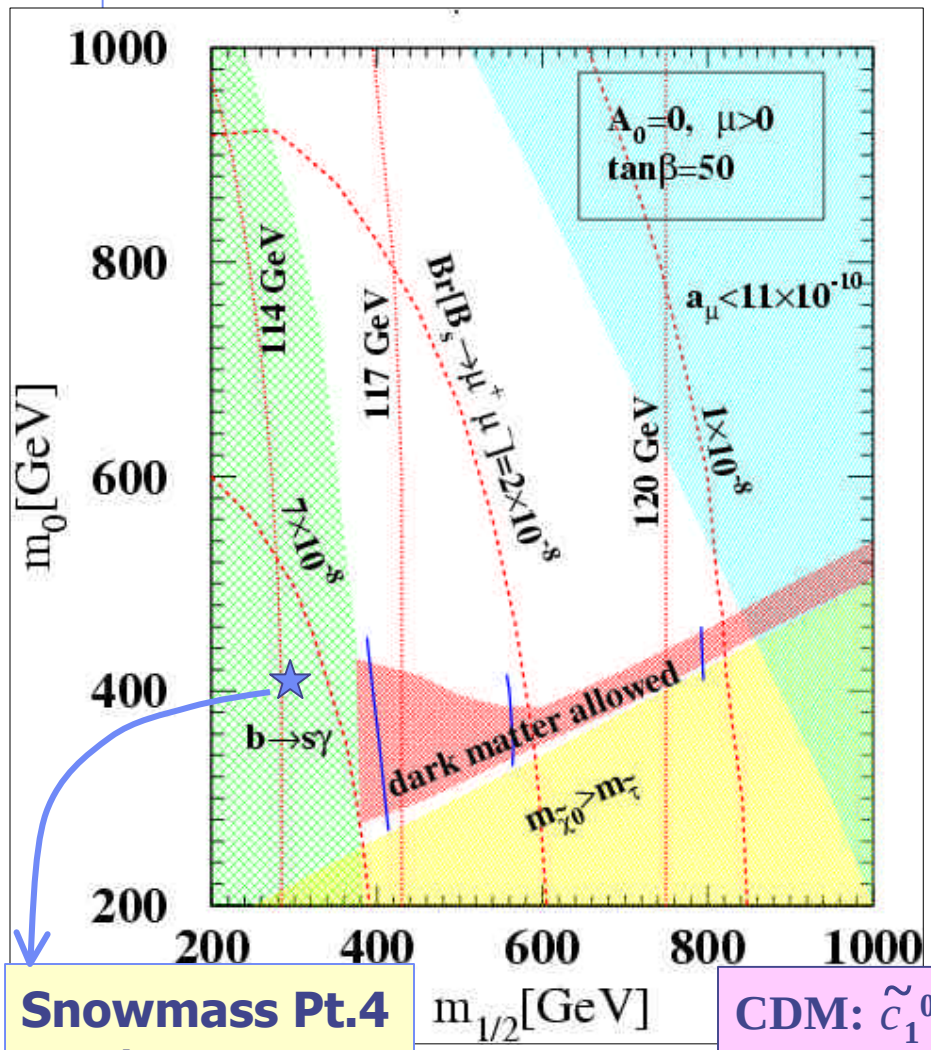
$Br(B_d \rightarrow mm) < 8.6 \times 10^{-7}$ (95% C.L.)

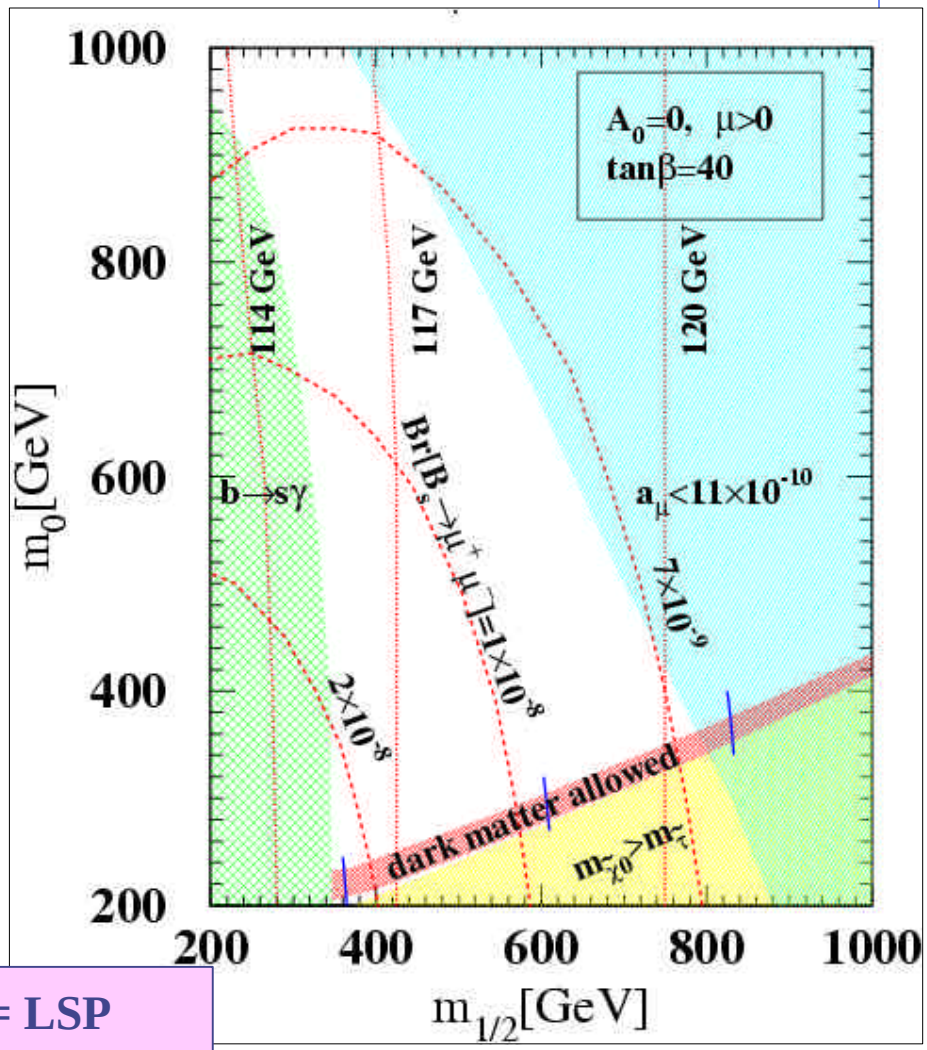
$Br(B_s \rightarrow mm) < 2.6 \times 10^{-6}$ (95% C.L.)



m_0 vs. $m_{1/2}$ (A_0= 0), mSUGRA

R. Arnowitt *et al.*, hep-ph/0203069, to appear in PLB





Snowmass Pt.4
A/H→bb,t t

CDM: $\tilde{c}_1^0$ = LSP
$0.07 < W_{LSP} h^2 < 0.25$