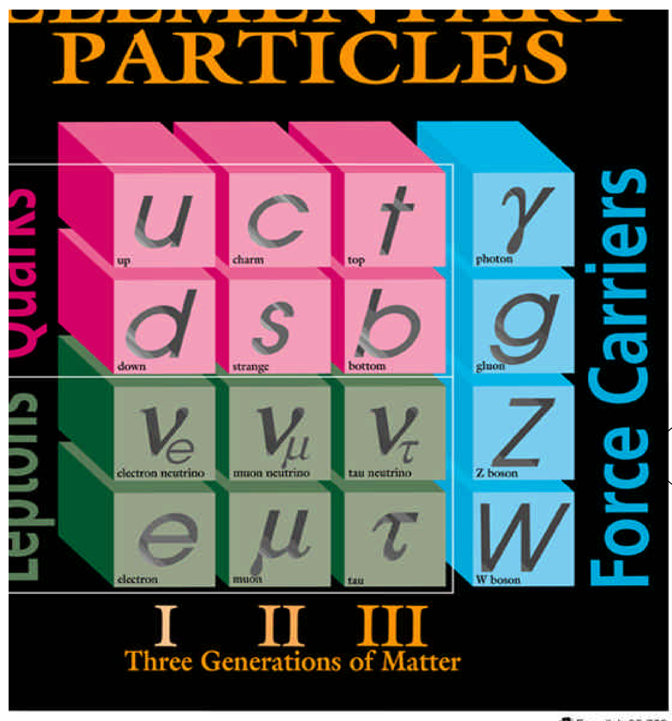


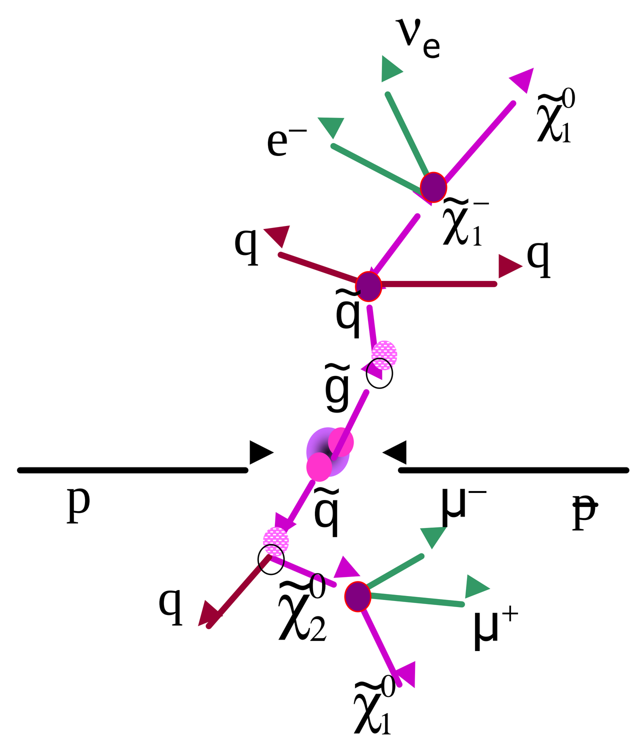
Standard Model (SM)

New Physics « New Particles

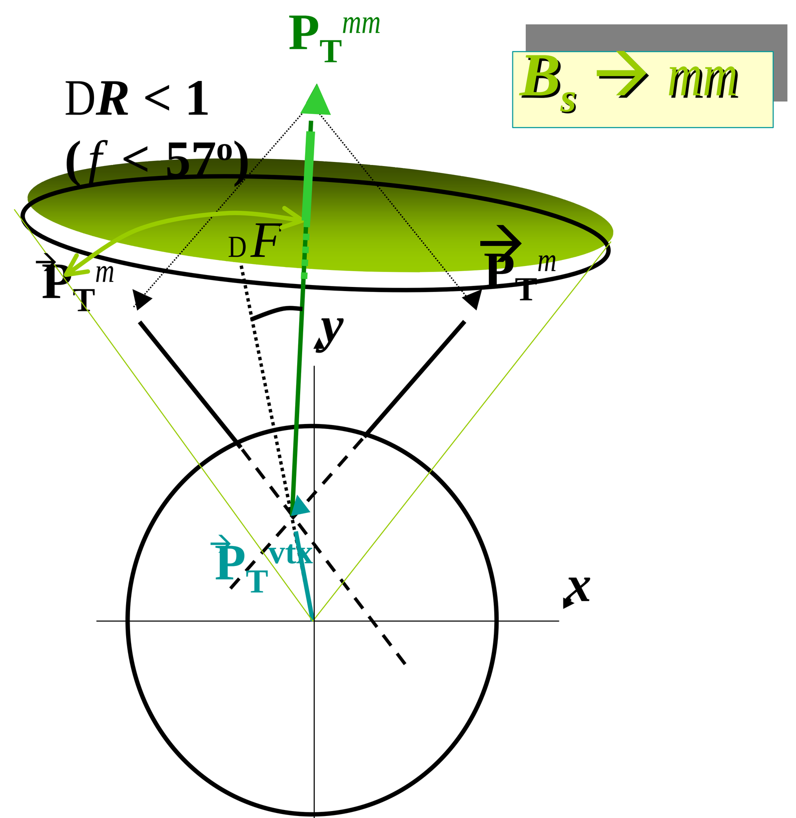
Have 171pb^{-1} or 10 trillion collisions

Expect to detect few events that might only look like $B_{s(d)} \to \mu^+\mu^-$ (background

- One way to search for the new particles is create them in a collision.



Example New Physics (SUSY) production diagram



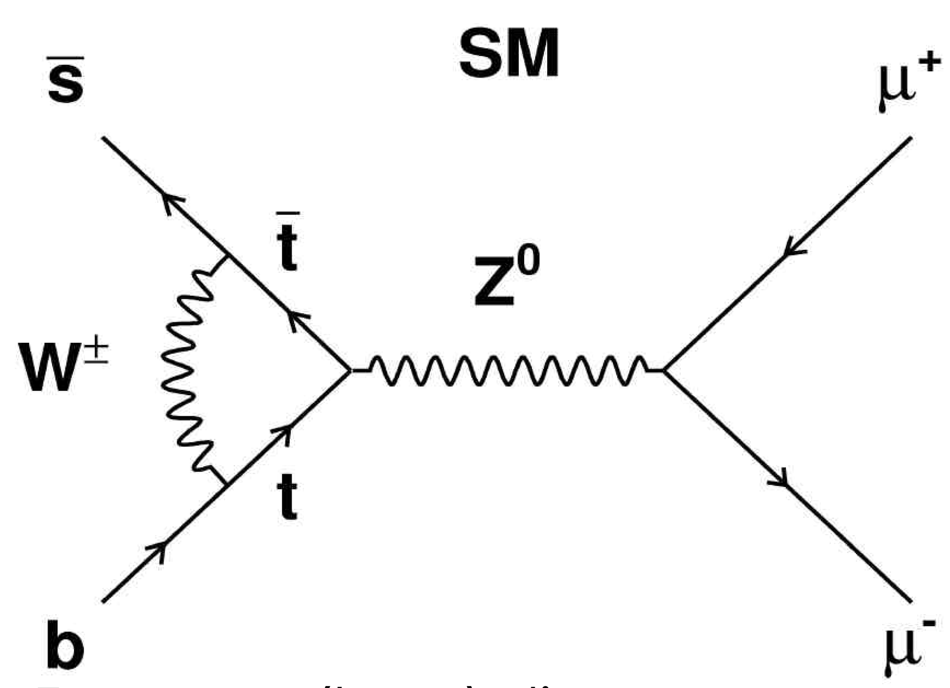
$B_s \to \mu^+\mu^-$ cuts illustration

Most Promising Discriminating Variable
- Invariant mass
- $c\tau$: $L_{xy} \frac{M}{P_t(B)}$
- $\Delta\Phi$: $\phi(B) - \phi(vtx)$
- Isolation: $\frac{P_t(B)}{P_t(B) + \sum_{\Delta R<1} P_t(trk)}$

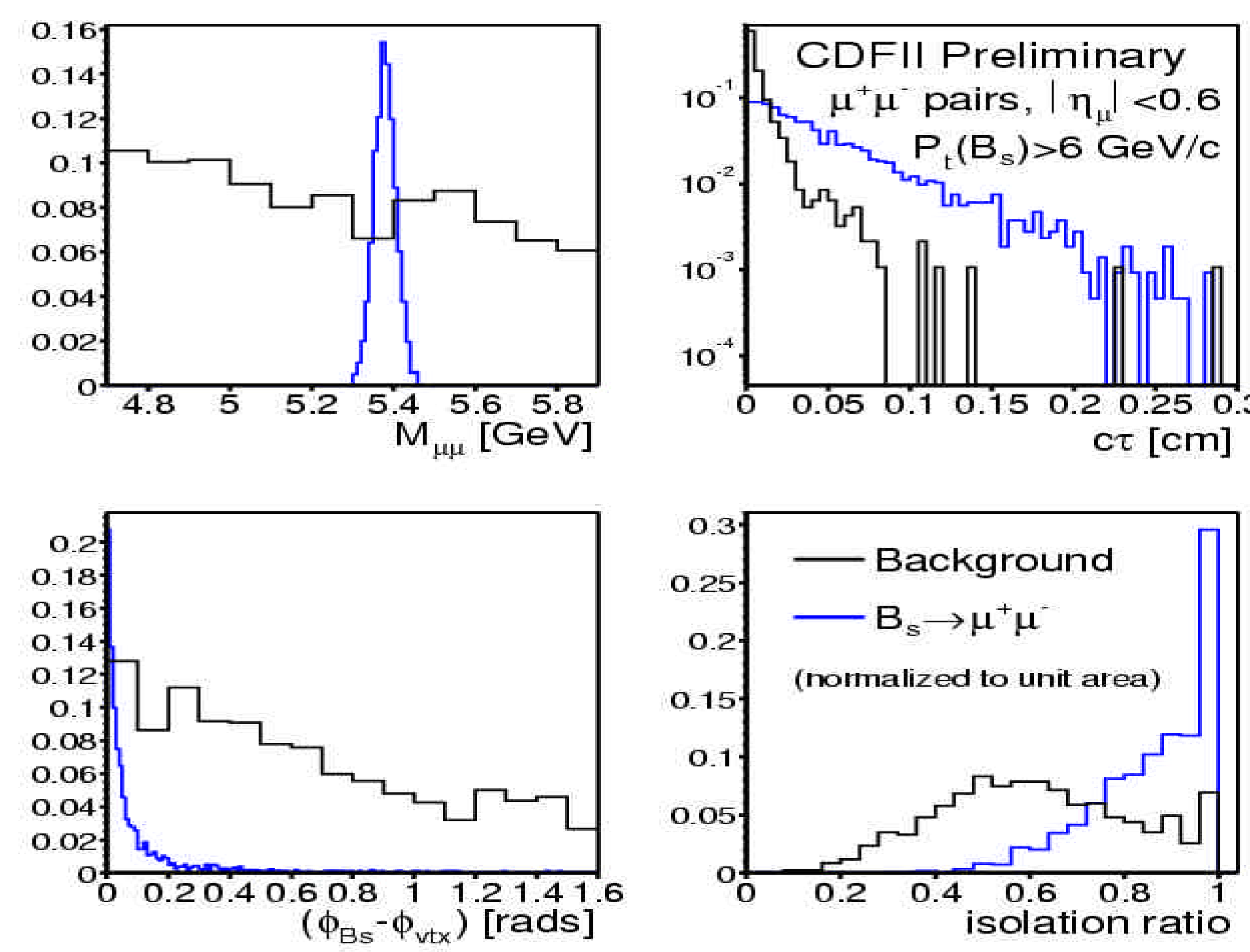
- Another way is to look at the signs of their virtual production, e.g. loop diagram.

Rare Decays

- Flavor Changing Neutral Current in the Standard Model has loop contributions only.
- $Br_{SM}(B_s \to \mu^+\mu^-) = (3.5 \pm 1.0) \times 10^{-9}$



Feynman (loop) diagram contributing to $B_s \to \mu^+\mu^-$ decay



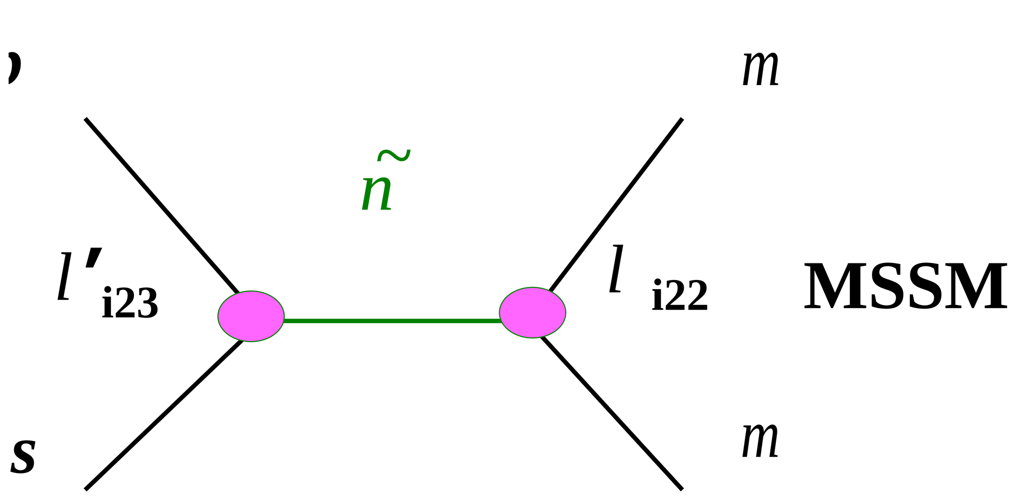
Background vs MC signal for $\mu^+\mu^-$ events

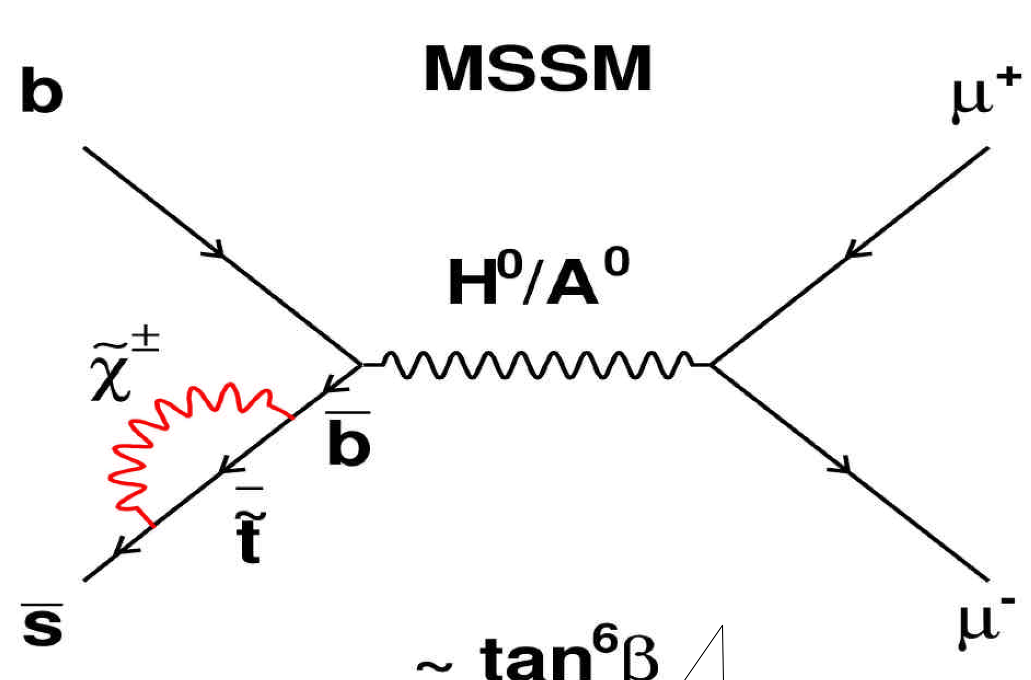
- Only upper experimental limit:
- $Br_{exp}(B_s \to \mu^+\mu^-) < 2.0 \times 10^{-6}$ 90% C.L. CDF RunI @100/pb

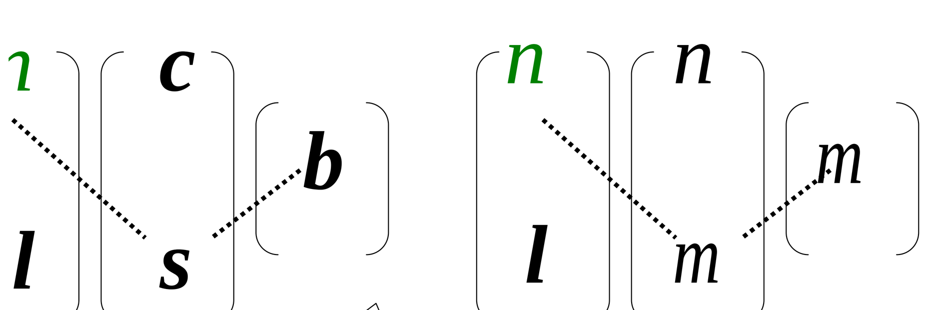
A theory/model that predicts MUCH more?

SUperSYmmetry a.k.a. SUSY

- symmetry between fermions and bosons
- Each SM particle acquires its superpartner







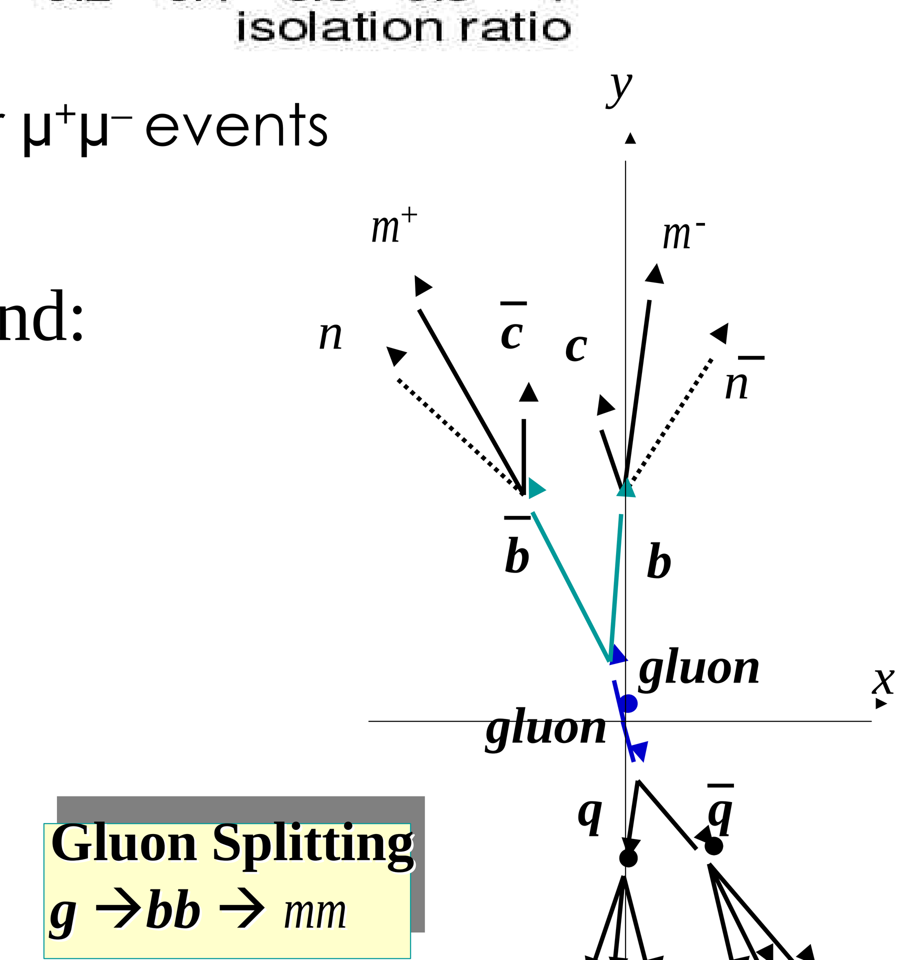
R-parity violating models

models with large tan*b* :

SO(10), some mSUGRA

- Both allow values up to current experimental limit.
- $B_d \to \mu^+\mu^-$ is relatively suppressed, expect most from $B_s \to \mu^+\mu^-$

Potential sources of background:
- continuum qq->μμ
- sequential semi-leptonic
  - b->c->μμX,
- b/c->μX+fake, fake+fake
- double semi-leptonic
  - g->bb->μμX



$B_{s(d)} \to \mu^+\mu^-$ Blind Analysis Paradigm

$$\langle BR(B_s \to mm)\rangle = \frac{(N_{candidates} - Bgd)}{a \cdot e_{total} \cdot s_{Bs} \cdot \int L dt}$$

- demonstrate understanding of background events
- accurately estimate α (acceptance) and ε (efficiency)
- intelligently optimize cuts

use (Mμμ, cτ, ΔΦ, Isolation) to discriminate Signal

develop improved method to estimate expected background, <bgd>

perform studies that determine B→h+h- contribution (amounts to .00 times smaller than expected limit)

cross-check the method in several control samples

Optimize selections for the best exclusion limit

Data Samples

- OS+ : opposite-sign muon pairs, ctau > 0
  our signal sample – not used for xchecks
- OS- : opposite-sign muon pairs, ctau < 0
- SS+ : same-sign muon pairs, ctau > 0
- SS- : same-sign muon pairs, ctau < 0

Background Estimation

N(bgd) = N(sideband|cτ,ΔΦ)*R(iso)*R(Mμμ)

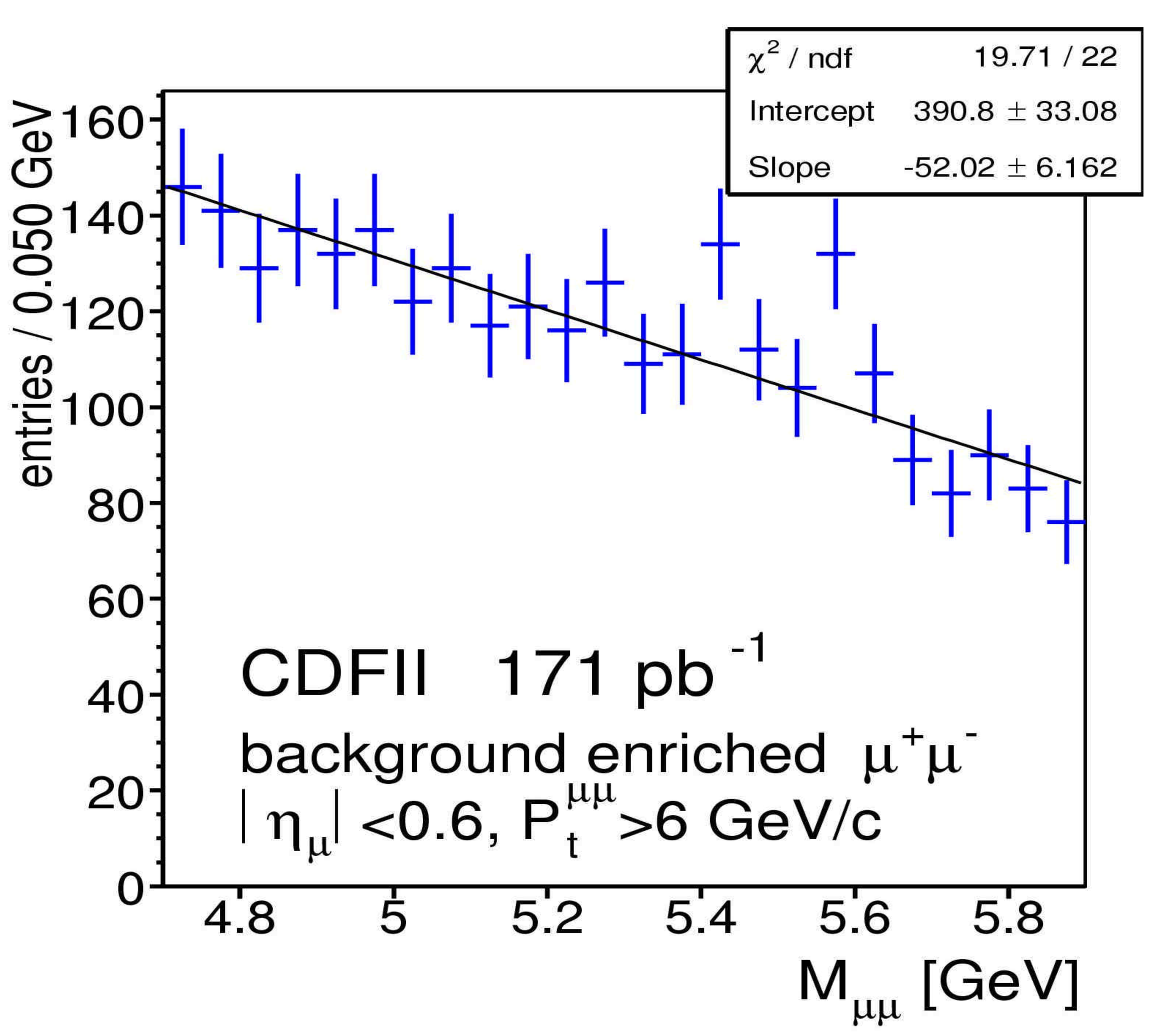
- N(sideband|cτ,ΔΦ) == sideband events passing cτ and ΔΦ cuts
- R(iso) == fraction of bgd expected to survive an isolation cut
- R(Mμμ) == given N(sideband), estimate of N(signal window)

If uncorrelated (ρ<<1), can determine R(iso) and R(Mμμ) on sample w/ NO cτ, ΔΦ cuts

$$r_{xy} = \frac{1}{N-1}\cdot\frac{\sum (x_i-\hat{x})(y_i-\hat{y})}{s_x s_y}$$

	OS+	OS-	SS+	SS-
r(Iso-ct)	-0.14	-0.05	-0.00	0.05
r(Iso-DF)	0.02	-0.08	-0.02	-0.02
r(Iso-M)	0.03	0.03	-0.02	-0.01
r(ct-M)	-0.03	-0.05	-0.02	0.00
r(DF-M)	0.05	0.06	0.06	0.01
r(DF-ct)	-0.30	-0.21	-0.20	-0.20

If Mμμ is linear, can use sidebands to estimate background



Background dominated data Mμμ distribution

Cross-Check

Cuts	N(expctd)	N(obsrvd)	P(>=obs|exp)
loose	23 ± 3	27	20%
optimal	8 ± 1	11	17%
tight	1.2 ± 0.3	2	34%

—Sample = OS- + SS+ + SS-

$\alpha \cdot \varepsilon_{total} = \alpha \cdot \varepsilon_{trig} \cdot \varepsilon_{reco} \cdot \varepsilon_{zvtx} \cdot \varepsilon_{final}$

- take trigger and reconstruction efficiencies from J/Ψ→μ⁺μ⁻ data
  - ±10% syst due to kinematic differences in data J/Ψ and signal Bs
- use Monte Carlo to for efficiency of cuts on discriminating variables
  - cross-check MC modeling of above by comparing MC to Data in sample of B+→J/ΨK+ (±5% syst)
- total relative uncertainty is ± 11% dominated by systematics

Results

For (cτ,ΔΦ,Iso) = (>200 μm, <0.10 rad, >0.65) and mass window ± 80 MeV around world avg Bs(d): 5.369 GeV (5.279 GeV)

Bs(d): α*ε(total) = (2.0 ± 0.2)% (α≈6.6%, ε(total)≈30%)

Accepted bgd σ = (6 ± 2) fb

<Bgd> in 171/pb = 1.1 ± 0.3 events

observed 1 – shared by Bs and Bd

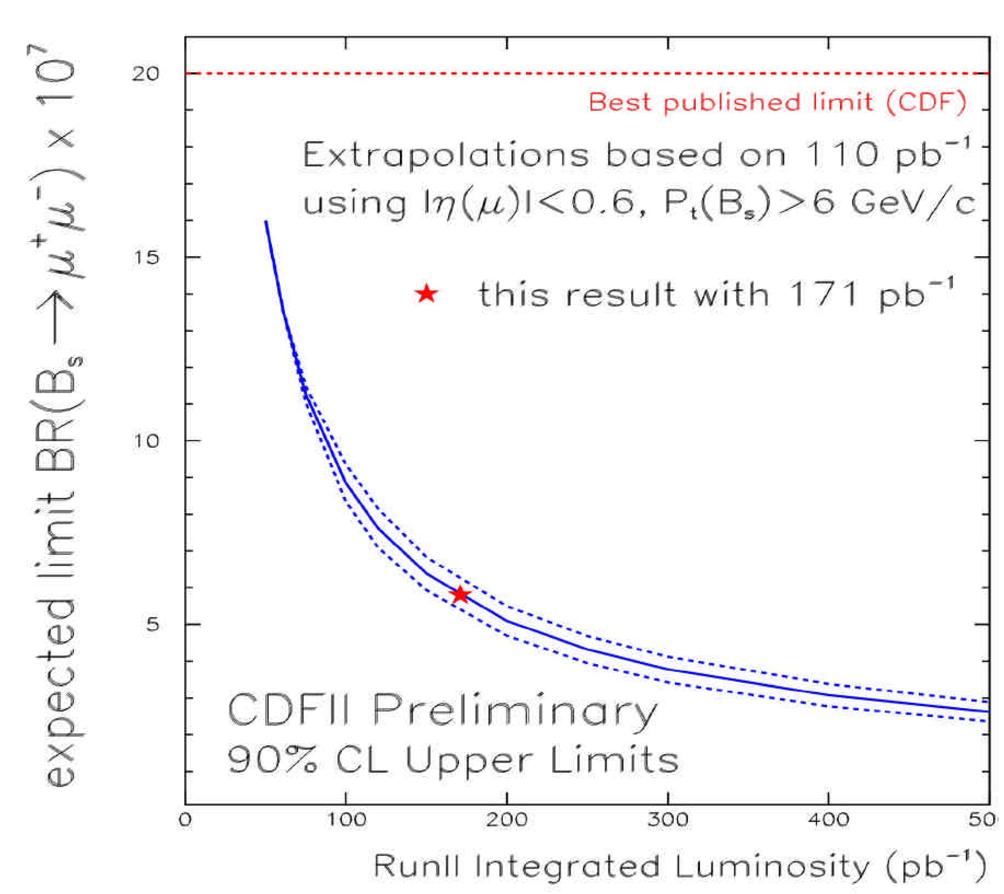
Best world limits

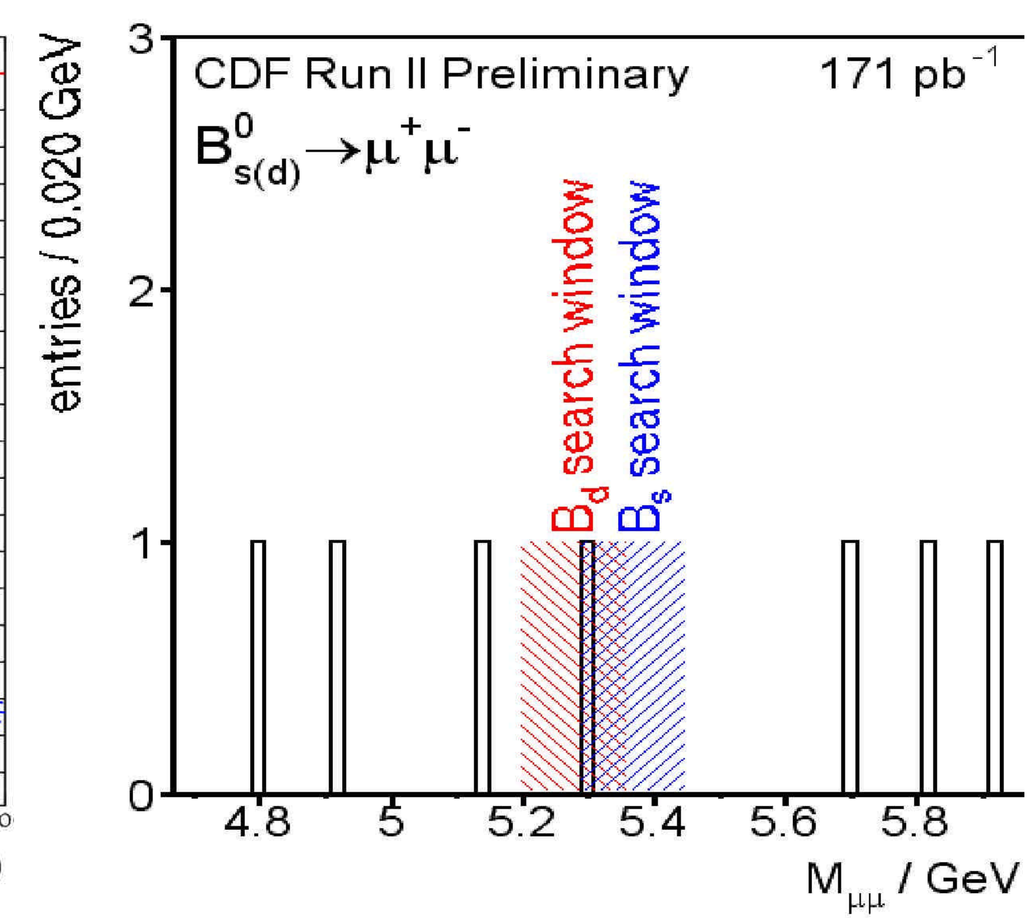
BR(B_s→μ⁺μ⁻) < 5.8x10⁻⁷ 90% C.L. (7.5x10⁻⁷ 95% C.L.)

3 times better than Run I (previous world best)

BR(B_d→μ⁺μ⁻) < 1.5x10⁻⁷ 90% C.L. (1.9x10⁻⁷ 95% C.L.)

slightly better than (1.6x10⁻⁷ 90% C.L., just published) B-factory/Belle result





expected limit for BR(B_s→μ⁺μ⁻)

data Mμμ distribution

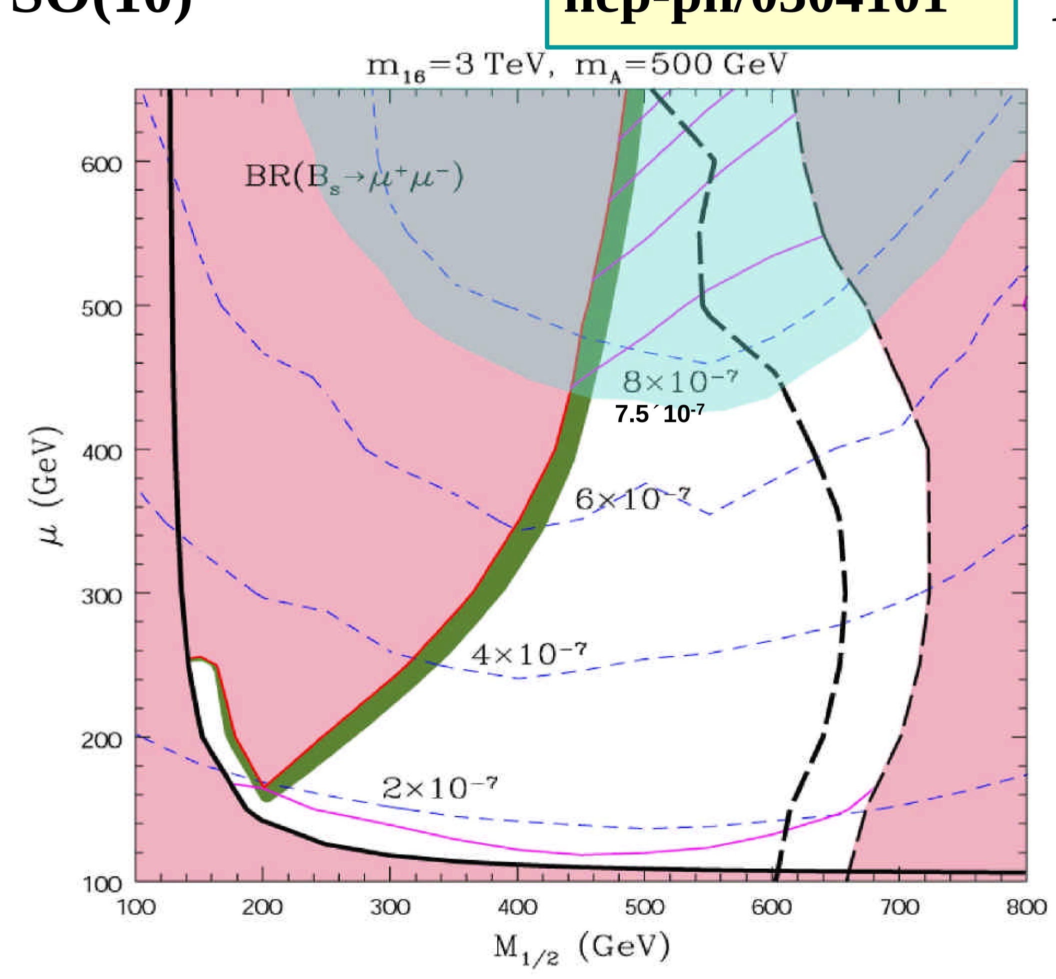
Results to appear in PRL

Improved limits are on the way

Conclusions for SUperSYmmetry

SO(10)

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



R-parity violating

R. Arnowitt et al., PLB 538 (2002) 121 new plot by B.Dutta