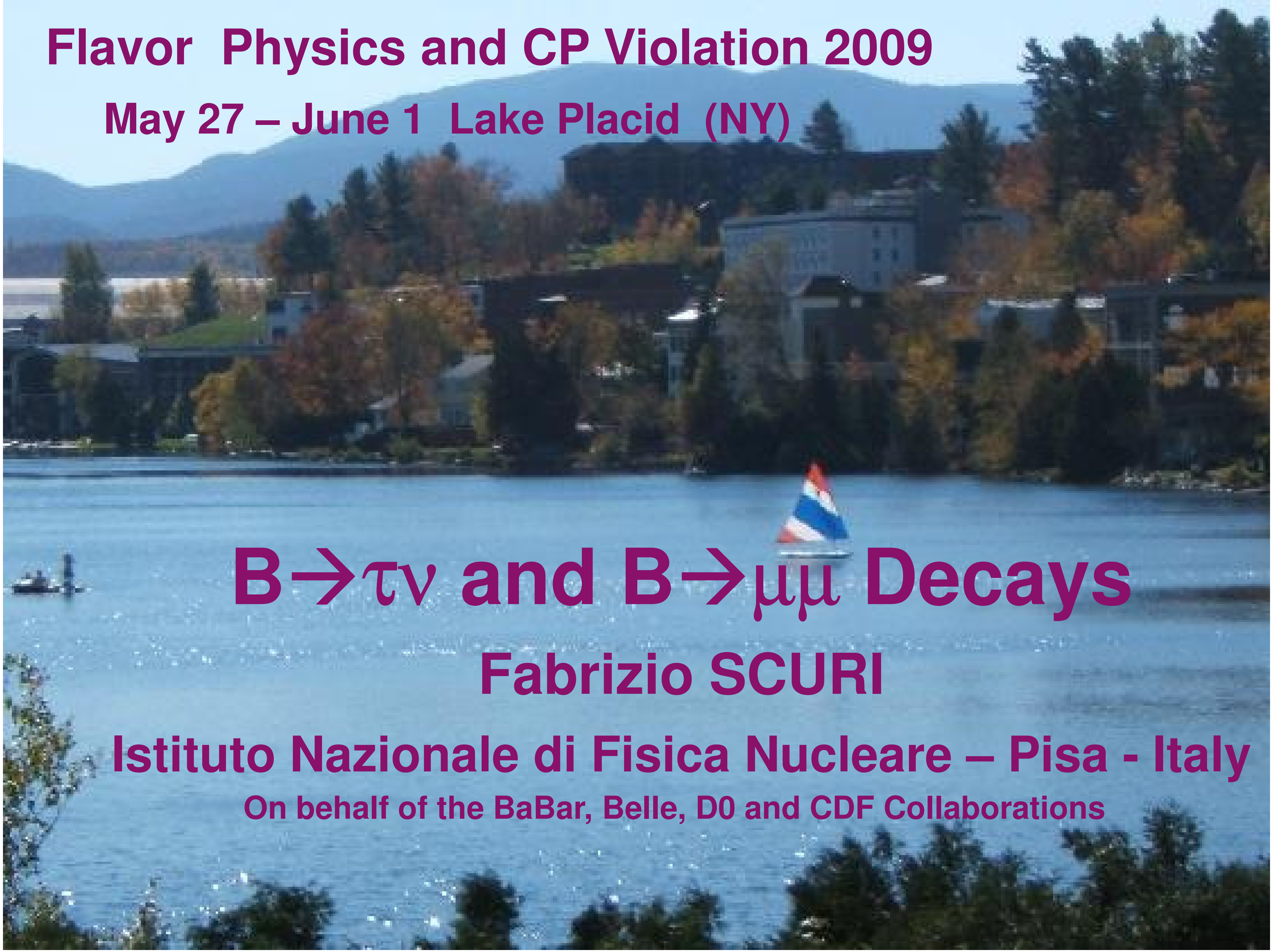


Flavor Physics and CP Violation 2009

May 27 – June 1 Lake Placid (NY)

$B \rightarrow \tau\nu$ and $B \rightarrow \mu\mu$ Decays

Fabrizio SCURI

Istituto Nazionale di Fisica Nucleare – Pisa - Italy

On behalf of the BaBar, Belle, D0 and CDF Collaborations

OUTLINE

• Charged Current in B purely leptonic decays:

→ results on *BF*($B \to \tau\nu$) from BELLE and BABAR

• Flavor Changing Neutral Current:

→ limits on *BF*($B^0_{(s)} \to \mu^+\mu^-$) from DØ and CDF

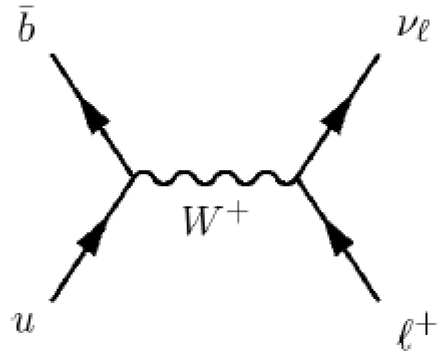
→ some "flash" on limits on *BF*($D^0 \to \mu^+\mu^-$) CDF

• **Lepton Flavor Violation:**

some "flash" on *BF*($B^0_{(s)} \to e^+\mu^-$) from CDF and BABAR

Charged Current in B leptonic decays

Tree level quark annihilation into a W boson:



Within SM: sensitive to f_B and $|V_{ub}|$

$$BF(B \to \ell \nu)_{SM} = \frac{G_F^2 m_B}{8\pi} m_\ell^2 (1 - \frac{m_\ell^2}{m_B^2})^2 f_B^2 |V_{ub}|^2 \tau_B$$

http://www.utfit.org

UTfit determination

$$BF^{UTfit}(B \to \tau \nu) = (0.83 \pm 0.12) \times 10^{-4}$$

Starting with $\bar{\rho},\bar{\eta}$ derived from UTangle w/o BF(B→τν), combined with the experimental value of $V_{ub}V_{cb}$, and adding $f_B\sqrt{B_{Bd}}$ derived from the experimental valuesof Δm_d ,Δm_s and the lattice value B_{Bd}=1.22 ± 0.12

CKM fitter Moriond 09 determination

$$BF^{CKMFitter}(B \to \tau \nu) = (0.796^{+0.154}_{-0.093}) \times 10^{-4}$$

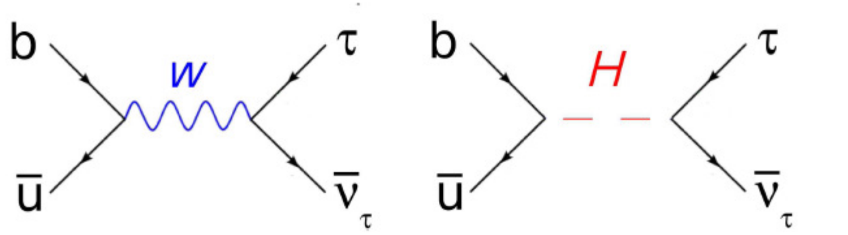
From the global fit w/o BF(B→τν) http://www.uckmfitter.in2p3.fr

Testing New Physics effects with B→τν Decays

Charged Higgs can enhance or suppress BF

$$BF(\mathrm{B}\to\tau\nu) = BF(\mathrm{B}\to\tau\nu)_{\mathrm{SM}} \times r_H$$

$$r_H = \left(1 - \frac{m_B^2}{m_H^2}\tan^2\beta\right)^2$$

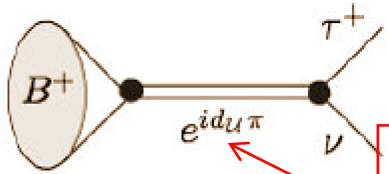


Enhancement if $\tan\beta > 0.27 m_H(\mathrm{GeV})$

W-S Hou Phys.Rev. D48, 2342 (1993)

Unparticle Physics may produce CP violation

R.Zwicky arXiv:0710.4430



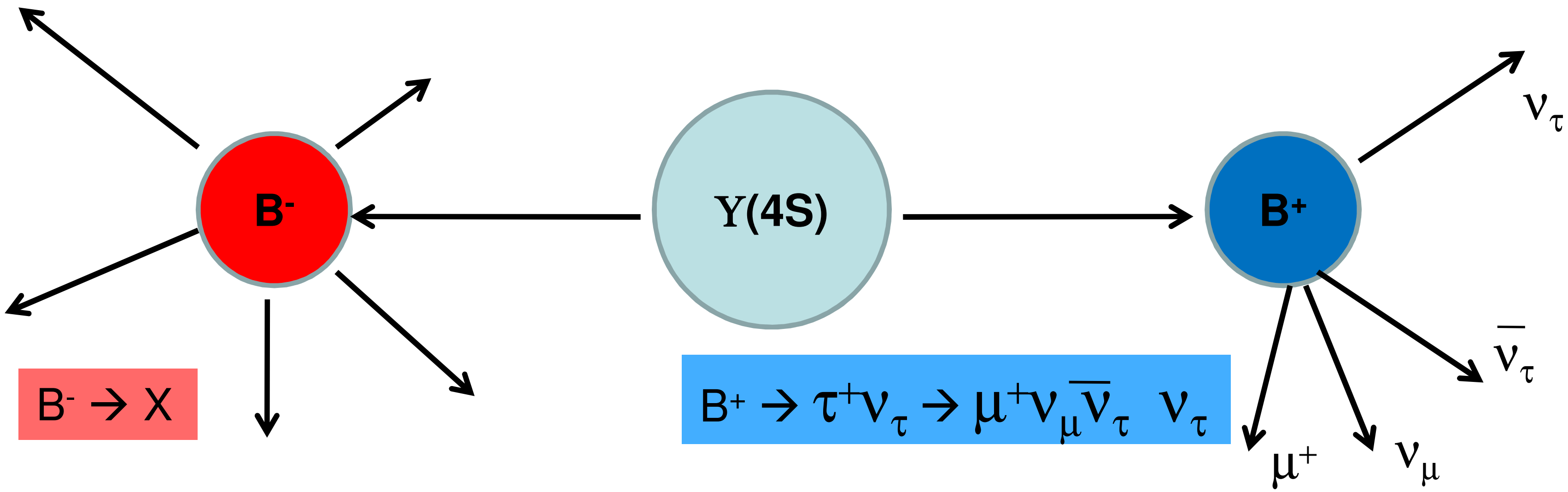
CP odd phase of the unparticle field

$$\bar{\mathcal{B}}(B^+\to\tau^+\nu) \to \mathcal{B}^{\mathrm{SM}}_{\tau\nu}(1+2\Delta_{\tau\nu}\cos(\phi)\cos(d_{\mathcal{U}}\pi)+\Delta^2_{\tau\nu}) \stackrel{\phi=\pm\pi/2}{\longrightarrow} \mathcal{B}^{\mathrm{SM}}_{\tau\nu}(1+\Delta^2_{\tau\nu})$$

$$\mathcal{A}_{\mathrm{CP}}(\tau\nu) \to \frac{2\Delta_{\tau\nu}\sin(\phi)\sin(d_{\mathcal{U}}\pi)}{1+2\Delta_{\tau\nu}\cos(\phi)\cos(d_{\mathcal{U}}\pi)+\Delta^2_{\tau\nu}} \stackrel{\phi=\pm\pi/2}{\longrightarrow} \frac{\pm 2|\Delta_{\tau\nu}||\sin(d_{\mathcal{U}}\pi)|}{1+\Delta^2_{\tau\nu}},$$

ϕ: weak phase difference

$B \rightarrow \tau\nu$ analysis concepts at the B factories



Tagging side:
reconstruct hadronic or semileptonic B decays

Signal side:
detect τ daughter particle(s)

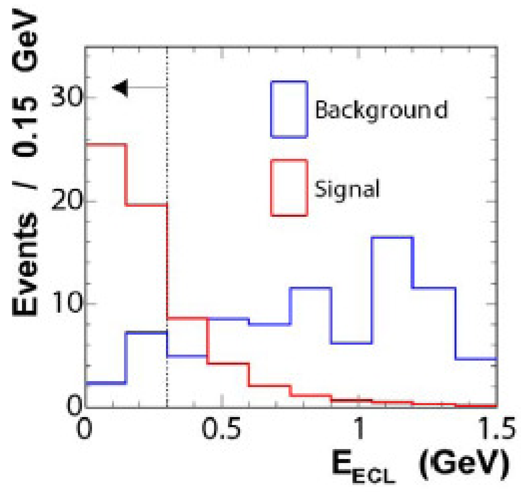
- At least two neutrinos appear in the $B \rightarrow \tau\nu$ decay cascade
- Require no particle is left after removing products of tagging B and the particle(s) for the $B \rightarrow \tau\nu$ decay

Common aspects of the BaBar and Belle analyses

• Most effective discriminant observable:

Extra Energy (E_{ECL})

(energy clusters not associated to particles from B_{tag} and B_{sig} candidates)



• Most recent results on B→ τν with reconstructed semileptonic decays of tagging B:

B_{tag} modes: $B^- \to D^{*0}\ell^-\overline{\nu}$ and $B^- \to D^0\ell^-\overline{\nu}$

Discriminant c.m.s. variables are:

$$\cos\theta_{B-D^0\ell} = \frac{2E_B E_{D^0\ell} - m_B^2 - m_{D^0\ell}^2}{2|\vec{p}_B||\vec{p}_{D^0\ell}|},$$ and P_ℓ^*

• Slightly different statistical analysis of the B->τν signal

Belle B→τν analysis

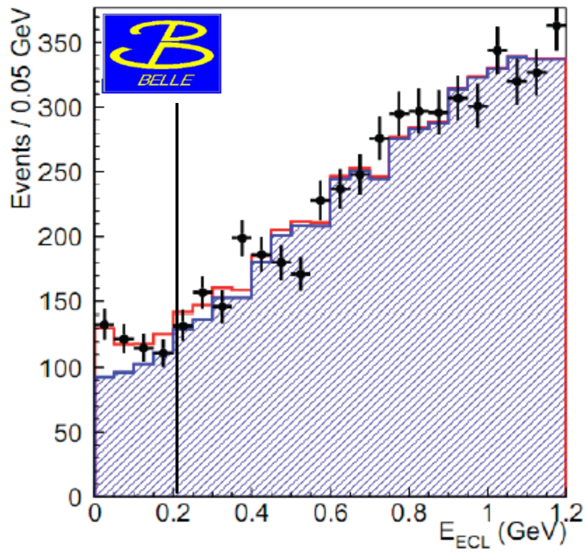
arXiV:0809.3834v1

Analyzed sample of 657x10^6 BB pairs

Found 154 B→τν decays with 3.8 σ significance

$$\mathcal{B}(B^- \to \tau^- \bar{\nu}_\tau) = (1.65^{+0.38}_{-0.37}(\text{stat})^{+0.35}_{-0.37}(\text{syst})) \times 10^{-4}.$$

(semileptonic tagging)



BaBar B→τν analysis

arXiv0809.4027

$$N_{B\bar{B}} = 459\times 10^6 \quad (\int \mathrm{Ldt} = 417\ \mathrm{fb}^{-1})$$

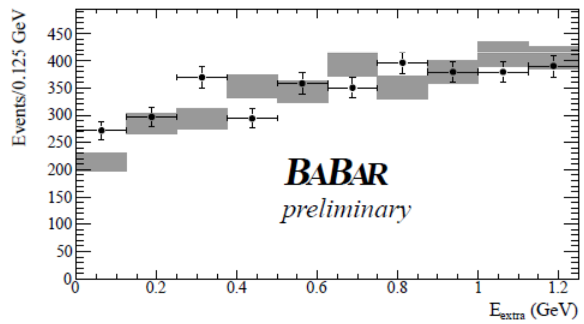
$$N_{\mathrm{OBS}} = 610 \qquad N_{\mathrm{BG}}^{\mathrm{exp.}} = 521 \pm 31$$

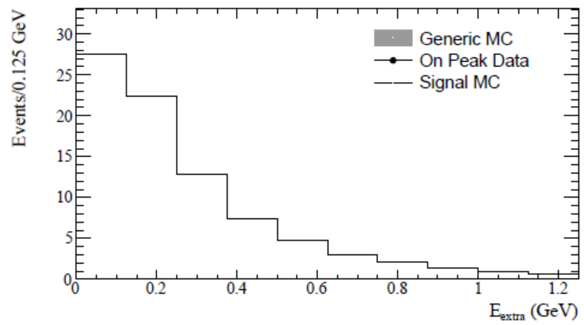
All signa l modes combined, signal region*)

*)Width of the signal region in the E_{extra} distribution depend on τ decay mode

$$B(B \to \tau^+ \nu_\tau) = (1.8 \pm 0.8(stat) \pm 0.1(syst)) \times 10^{-4}$$

(semileptonic tagging)





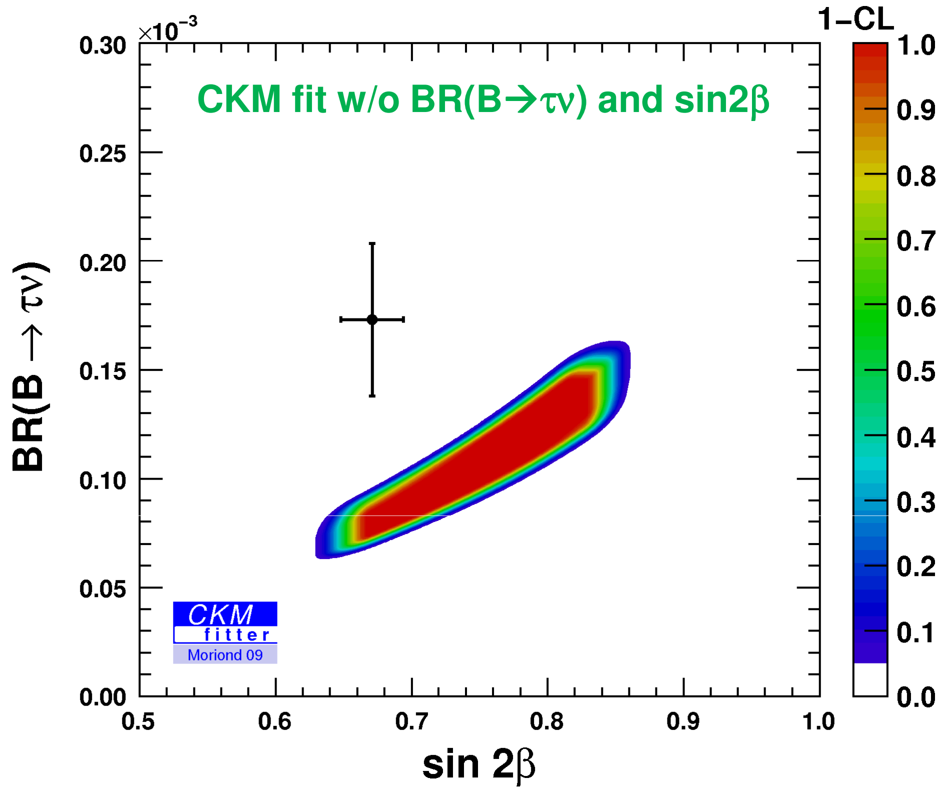
Summary of $B \to \ell\nu$ results

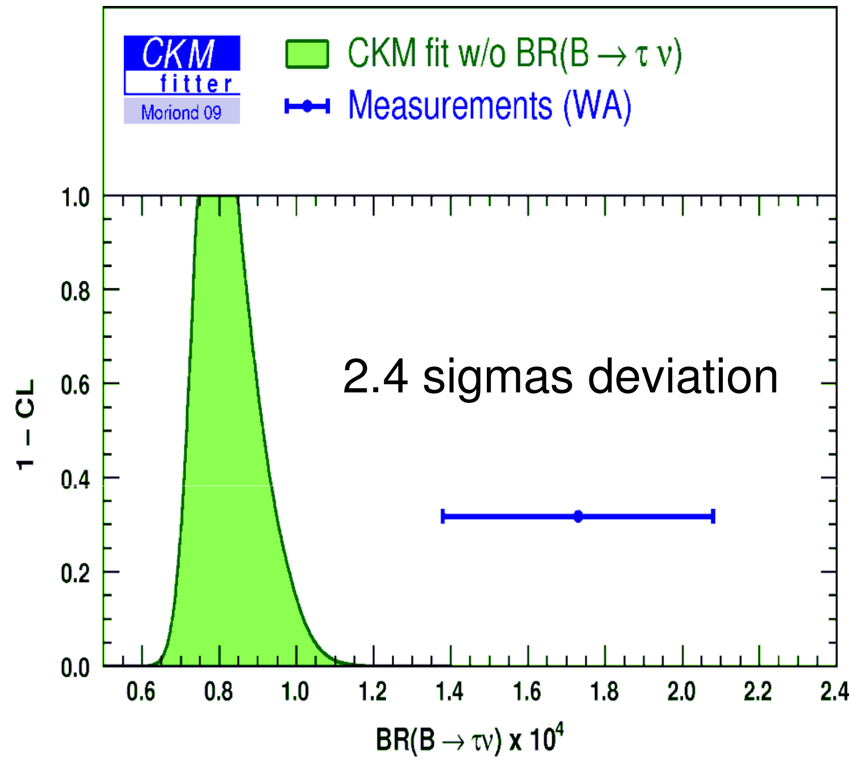
	$BF(B^+ \to \tau^+\nu_\tau)$	$BF(B^+ \to \mu^+\nu_\mu)$	$BF(B^+ \to e^+\nu_e)$
PDG 2008	$(1.4 \pm 0.4) \times 10^{-4}$	(90% C.L. limits)	
BaBar	$(1.80 \pm 0.65) \times 10^{-4}$	$< 1.3 \times 10^{-6}$	$< 5.2 \times 10^{-6}$
Belle	$(1.70 \pm 0.42) \times 10^{-4}$	$< 1.7 \times 10^{-6}$	$< 1.0 \times 10^{-6}$
World average	$(1.73 \pm 0.35) \times 10^{-4}$	(after Moriond 2009)	

B Factories $BF(B^+ \to \tau^+\nu_\tau)$ summary

	Hadronic tag	Semileptonic tag
BaBar	$[1.8^{+0.9}_{-0.8}(stat) \pm 0.4(bkg) \pm 0.2(syst)] \times 10^{-4}$	$[1.8 \pm 0.8(stat) \pm 0.1(syst)] \times 10^{-4}$
Belle	$[1.79^{+0.56}_{-0.49}(stat)^{+0.46}_{-0.51}(syst)] \times 10^{-4}$	$[1.65^{+0.38}_{-0.37}(stat)^{+0.35}_{-0.37}(syst)] \times 10^{-4}$

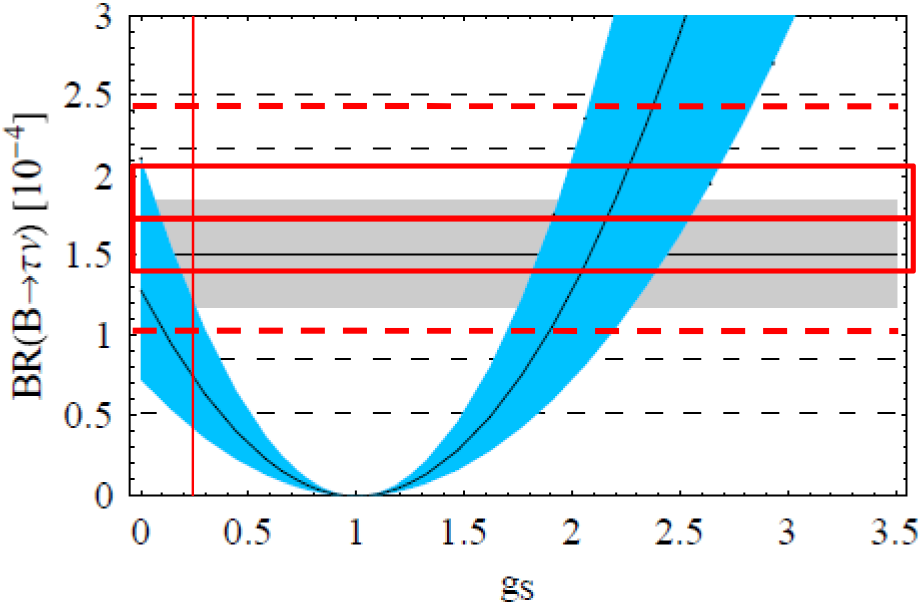
CKMfitter preliminary results as of Moriond 2009





updated results and plots available at:http://ckmfitter.in2p3.fr

Charged-Higgs effects in B→ $\tau\nu$ decays



$BF(\mathrm{B} \to \tau\nu_\tau)$

gray : previous w.a. (HFAG '08) :

$(1.51 \pm 0.33) \times 10^{-4}$

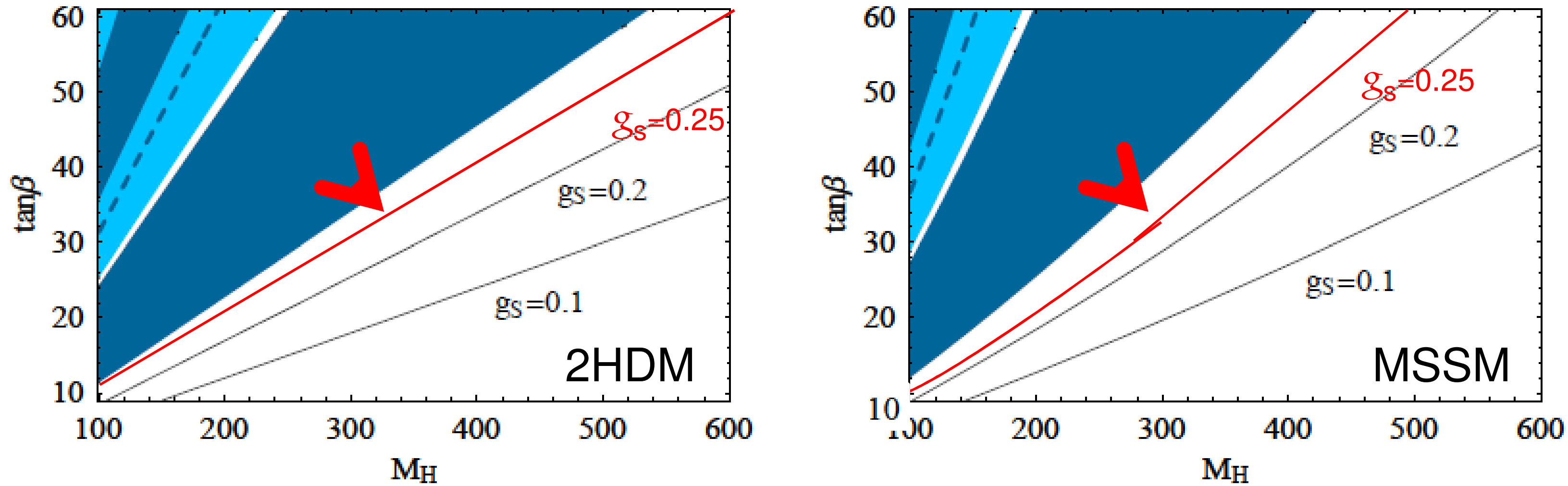
red : BaBar and Belle av. (Moriond '09) :

$(1.74 \pm 0.34) \times 10^{-4}$

$$\mathcal{B}(B \to \tau\nu)/\mathcal{B}(B \to \tau\nu)^{SM} = |1 - g_S|^2$$

$$s = \frac{M_B^2 \tan^2\beta}{M_H^2} \frac{1}{(1 + \varepsilon_0 \tan\beta)(1 + \varepsilon_\tau \tan\beta)},$$

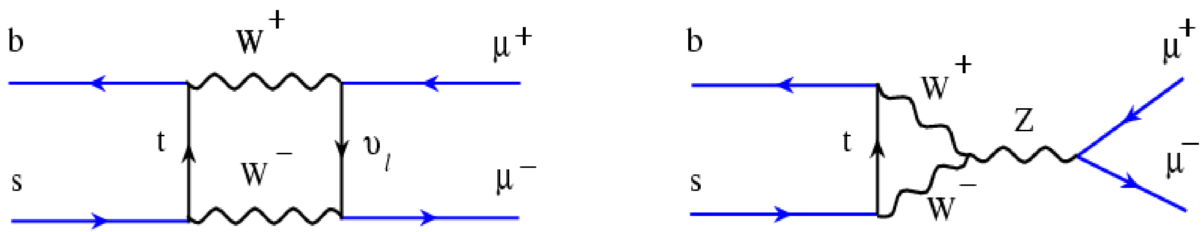
Includes s-particle loops



(original plots from S.Trine, ICHEP 08, arXiv:0810.3633.v1)

FCNC Decays: very suppressed within SM

Forbidden at tree level, proceed through loop diagrams



Recent rather precise BF predictions in SM:

$$Br(B_s \to \mu^+\mu^-) = (3.6 \pm 0.3) \cdot 10^{-9}$$

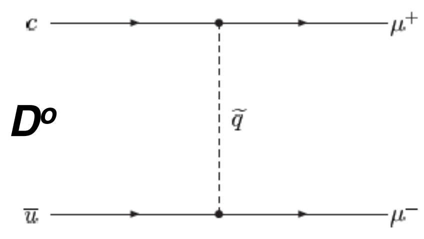
$$Br(B_d \to \mu^+\mu^-) = (1.1 \pm 0.1) \cdot 10^{-10}$$

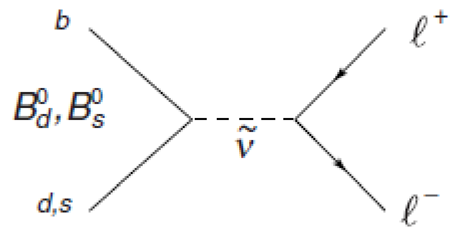
A.J. Buras arXiv:0904.4917v1

FCNC Decays: sensitive to New Physics

New Physics can appear:

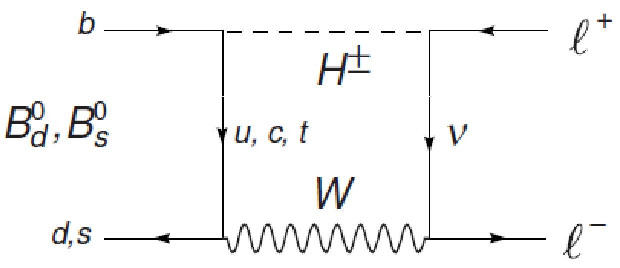
- at tree level through
  R Parity Violation in SUSY

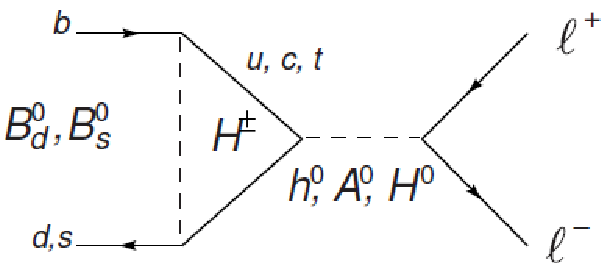




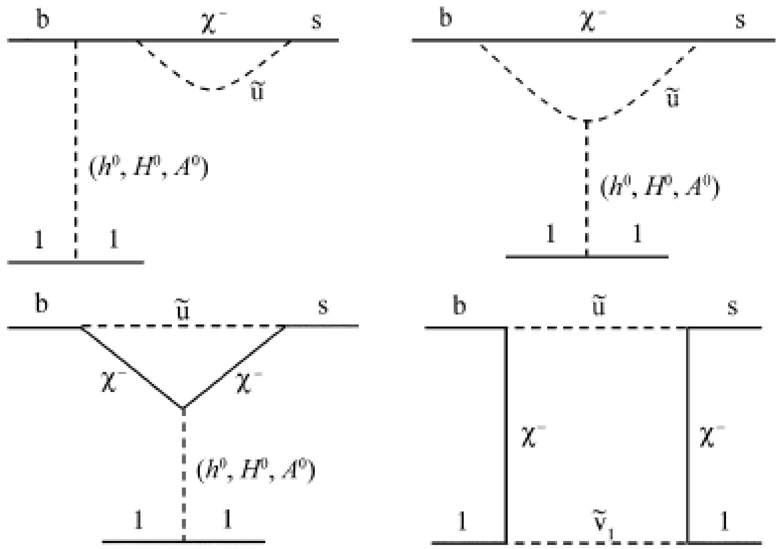
- trough loops in:

a) MFV SM extensions such as 2HDM





b) MSSM



$\mathcal{B}^{SUSY}(B \to \mu\mu) \propto (\tan\beta)^6$

$B \rightarrow \mu^+ \mu^-$ procedures at the Tevatron experiments: the 2 fb^{-1} analyses of CDF and D0

Similar general strategy:

- **Blind optimization using signal Monte Carlo sample and sideband data**
- **Normalize to the $B^+ \rightarrow J/\psi K^+$ mode:**

$$\mathrm{BR}(B_s \to \mu^+\mu^-) = \frac{N_{B_s}}{N_{B^+}} \cdot \frac{\alpha_{B^+}}{\alpha_{B_s}} \cdot \frac{\varepsilon^{tot}_{B^+}}{\varepsilon^{tot}_{B_s}} \frac{f_u}{f_s} \cdot \mathrm{BR}(B^+ \to J/\psi\, K^+) \cdot \mathrm{BR}(J/\psi \to \mu^+\mu^-)$$

- **Reconstruct normalization mode in the same data sample, applying same criteria → reduce systematics, only the ratio of efficiencies matters.**
- **Evaluate expected background, then "un-blind" the signal region and calculate BR or limit**

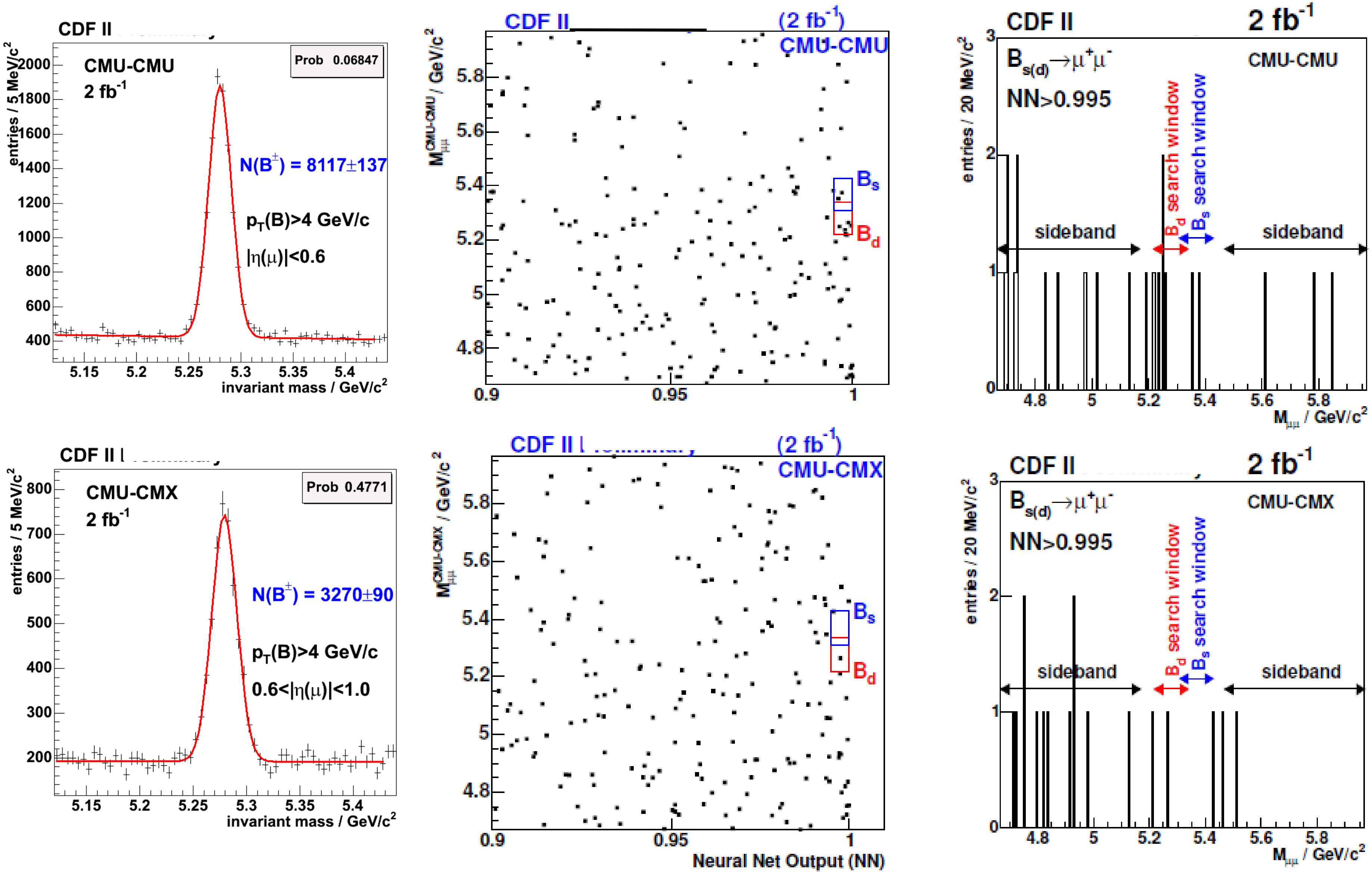
Similar discriminating observables for the pre-selection:

- **Secondary vertex displacement**
- **B pointing angle to the P.V.,**
- **B isolation**
- **…….**

Different optimization procedures and statistical analysis to set upper limits

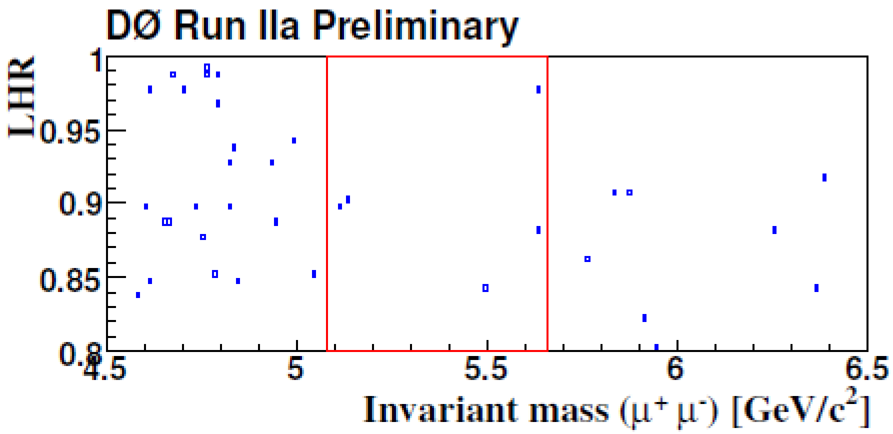
CDF B → $\mu^+ \mu^-$ analysis

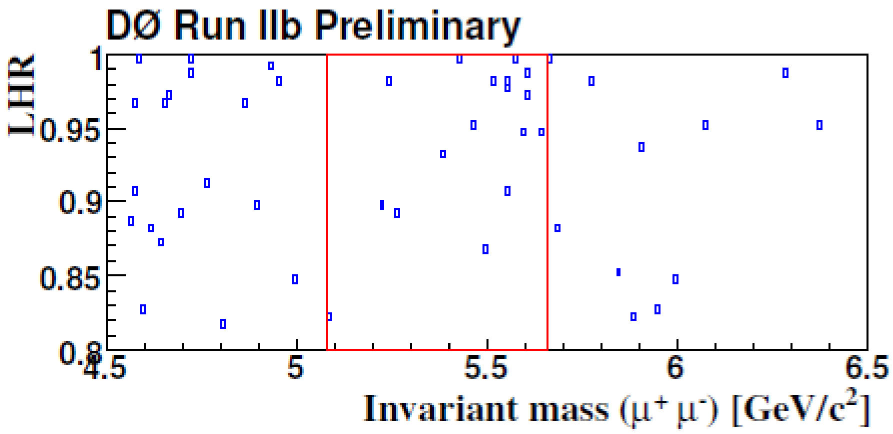
PRL 100, 101802 (2008)



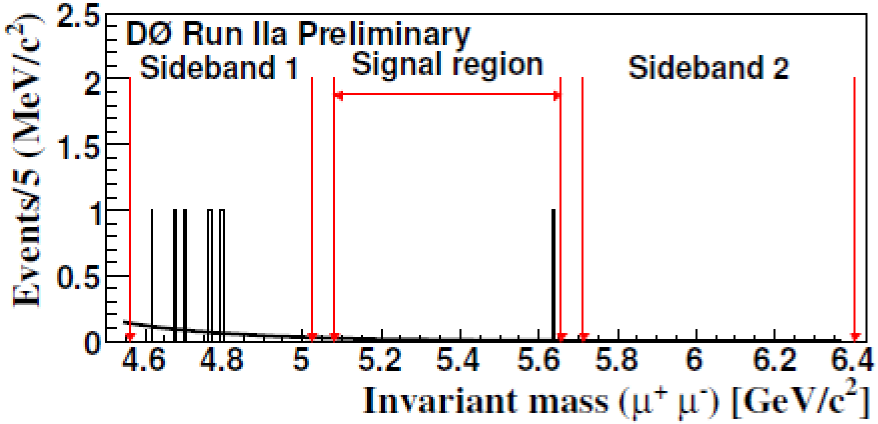
$B \rightarrow \mu^+ \mu^-$: 2 fb^{-1} D0 analysis

D0 Conf. Note 5344

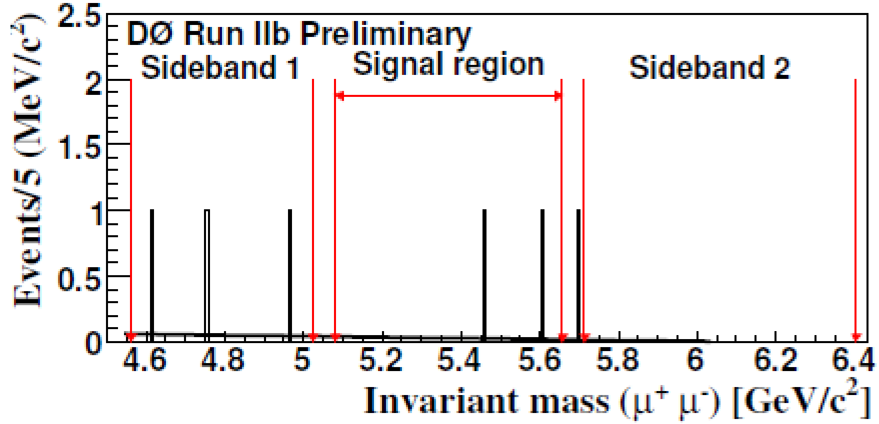




LHR > 0.946



LHR > 0.986



$B \to \mu^+ \mu^-$: result summary with 2 fb^{-1}

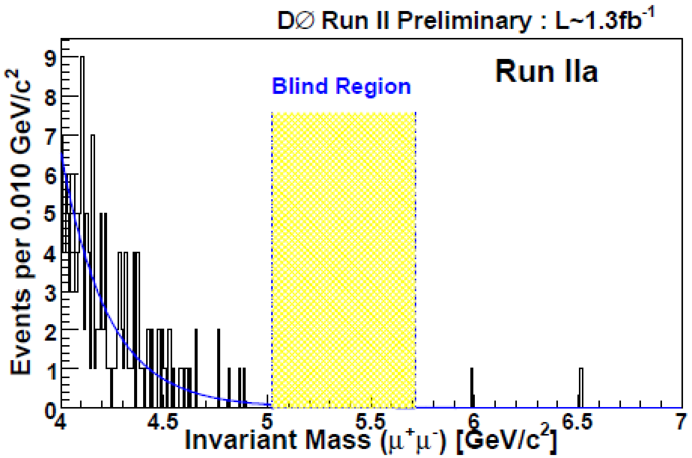
Experiment		B^0_s search		B^0_d search	
		Expected	Obs.	Expected	Obs.
CDF	~1800 pb^{-1}	3.5±0.3	3	4.0±0.3	6
D0	Run IIa (~1300 pb^{-1})	0.8±0.2	1		
	Run IIb (~500 pb^{-1})	1.5±0.5	2		

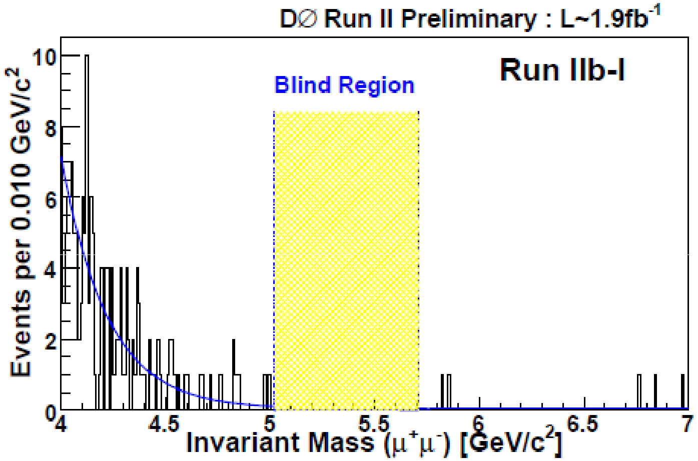
Dominant systematics

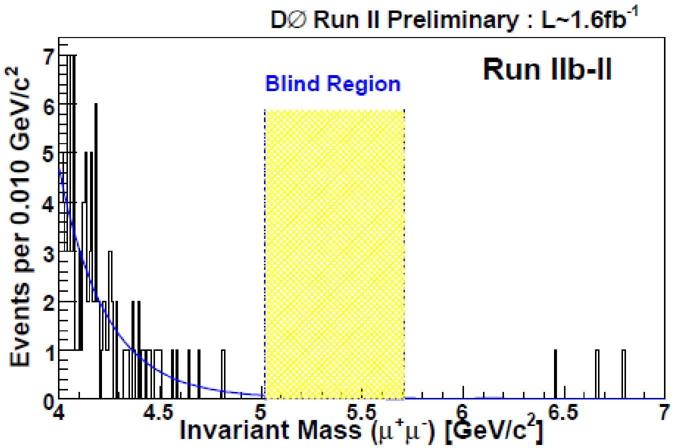
	Rel.Unc. [%]
Expected BG	**~ 30**
f_u/f_s	**~ 13**

BR limits

Limit 90% (95%) × 10^8	$B^0_s \to \mu\mu$	$B^0_d \to \mu\mu$
Previous best	9.4 (D0)	3.9 (CDF)
BaBar [PRD 77, 032007 (2008)]	n/a	5.2
DØ (2 fb^{-1})	7.5 (9.3)	n/a
CDF [PRL 100, 101802 (2008)] (2 fb^{-1})	4.7 (5.8)	1.5 (1.8)



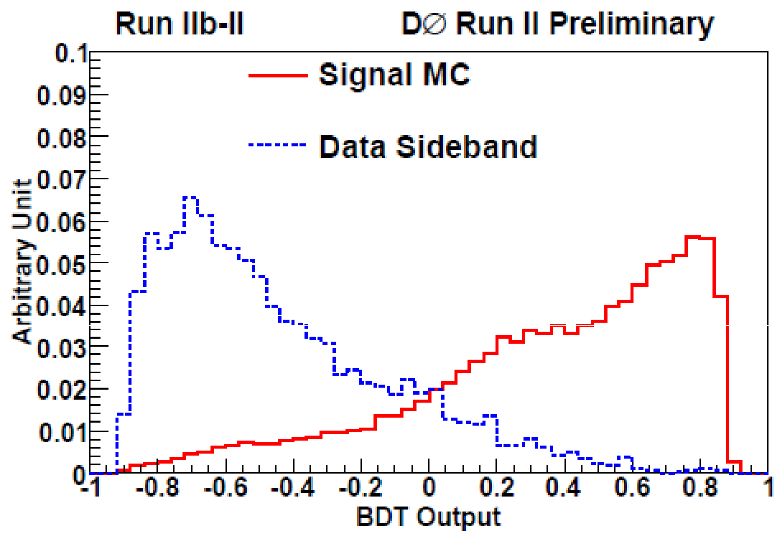




D0 *expected* limit with 5 fb^{-1}

D0 note 5906-CONF

- 4.8 fb^{-1} statistics
- New event selection procedure (**B**oosted **D**ecision **T**ree with 5 input observables)

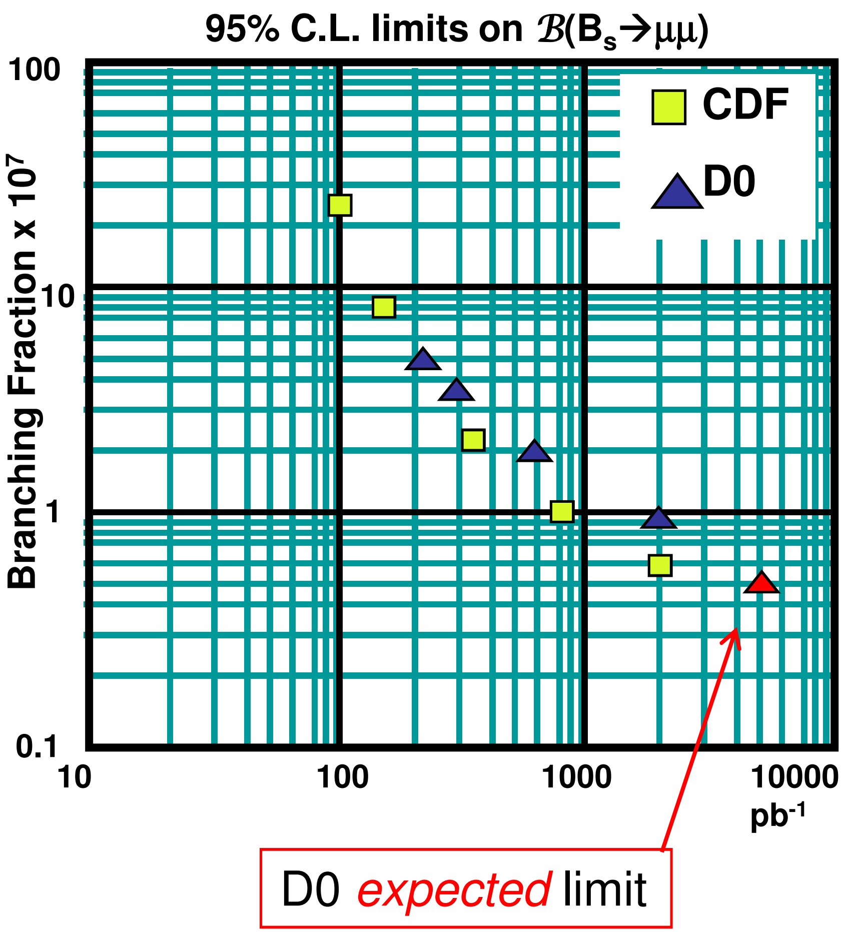


Expected limit

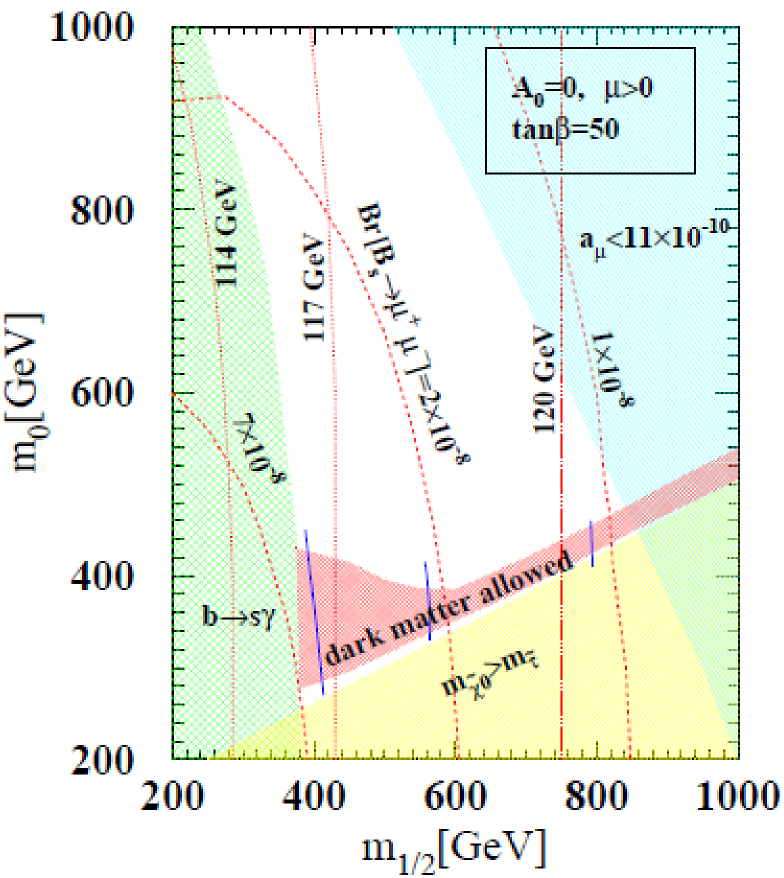
$$B(B_S^0 \to \mu^+\mu^-)_{exp.} < 4.3(5.3)\times 10^{-8} \quad 90\%(95\%)\ \mathrm{C.L.}$$

assuming no signal in the blind region

B → $\mu^+ \mu^-$ prospects and New Physics



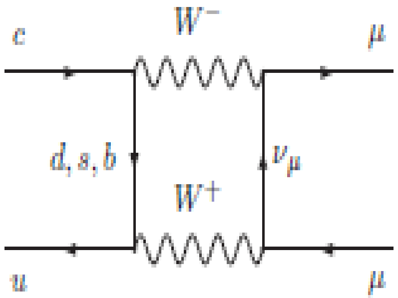
mSUGRA, Arnowitt et al. PLB 538 (2002) 121

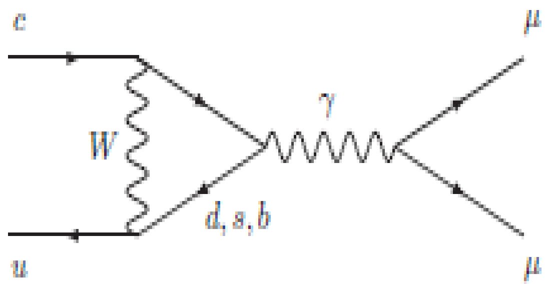


Combined measures of BR(B→μμ) at 10 fb^{-1} and of deviation from SM of the μ anom. mag. mom.(a_μ) could rule-out mSUGRA

FCNC : the $D^0 \rightarrow \mu^+\mu^-$ sector

Very suppressed in SM by the GIM mechanism $(m_q^2 / m_W^2$, no top loop)

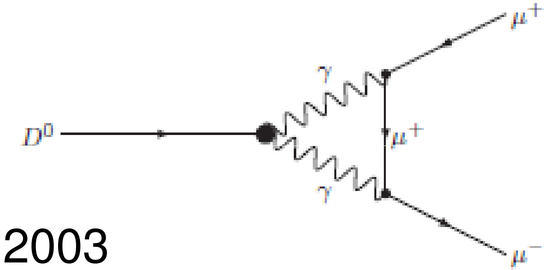




Decay rate dominated by long distance contributions

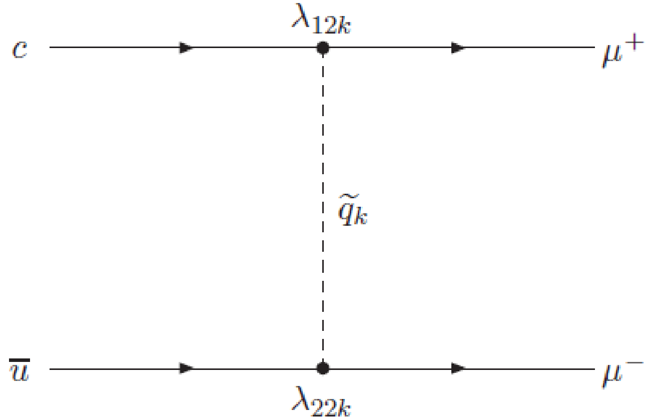
$$B_{SM}^{\mathrm{LD}}(\mathrm{D}^0 \rightarrow \ell^+\ell^-) \cong 3\times10^{-13}$$

Burdman-Shipsey, Ann.Rev.Nucl.Part.Sci.53:431-499,2003



Enhancements are possible in R-parity violating SUSY models

$$B^{\not R_p}(D^0 \rightarrow \mu^+\mu^-) = \tau_{D^0}\, f_D^2\, m_\mu^2\, m_D \sqrt{1-\frac{4m_\mu^2}{m_D^2}}\, \frac{\left(\tilde\lambda'_{22k}\tilde\lambda'_{21k}\right)^2}{64\pi\, m^4_{\tilde d_k}}$$



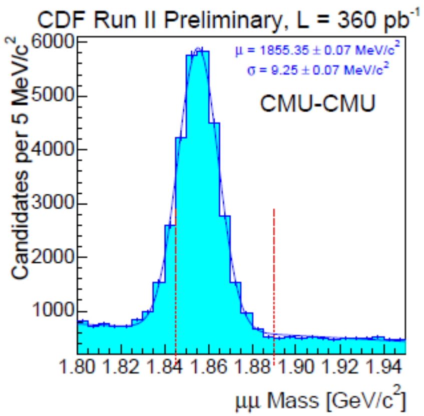
$D^0 \to \mu^+\mu^-$ results

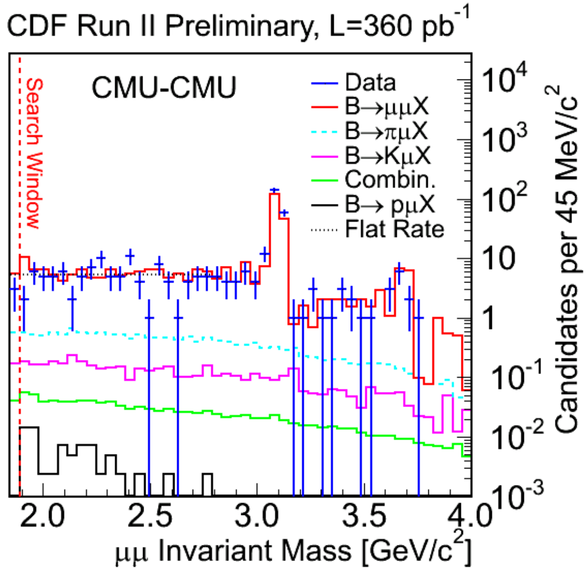
CDF result (2008): only 360 pb^{-1} analysed

$D^0 \to \pi^+\pi^-$ mode used as reference

Bayesian approach to set CLs

Dominant BG: $B \to \mu\mu X$





BR limit summary

$Br(D^0 \to \mu\mu) \times 10^7$	90% Limit	95% Limit
HERA-B [PLB 596, 173 (2004)]	20	n/a
BaBar [PRL 93, 191801(2004)]	13	n/a
CDF	4.3	5.3

this translates into a limit on the R parity violating couplings
$\lambda_{21k}\lambda_{22k} = 1.5 \sqrt{B(D^0 \to \mu^+\mu^-)} < 9.8 \times 10^{-4}$

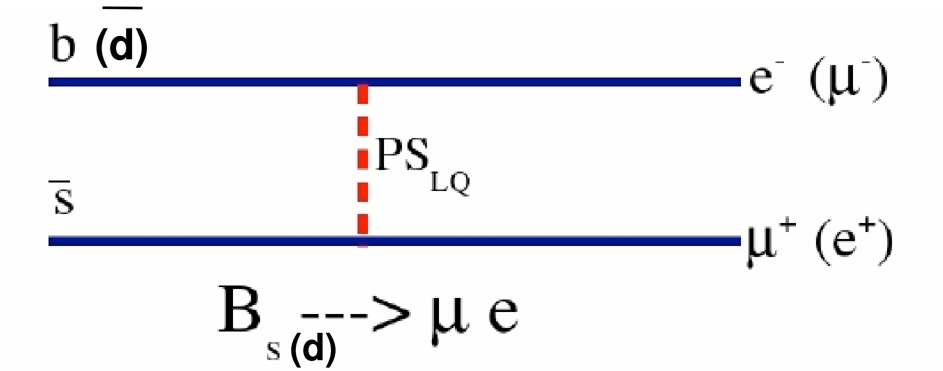
LFV: $B^0 \to e^+\mu^-$

Forbidden in Standard Model: any observation would be an evidence of NP sources such as:

a) R-parity violating SUSY

b) Pati-Salam lepto-quarks

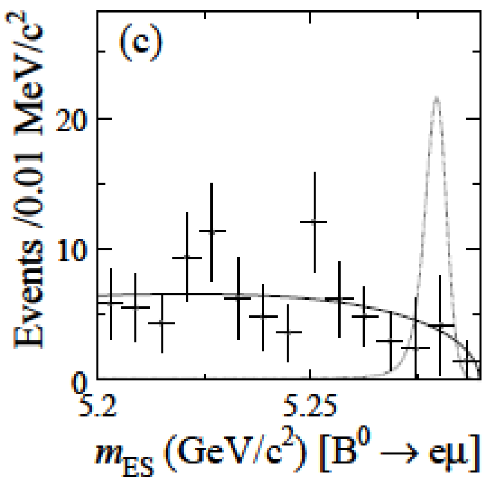
$$\mathcal{B}^{PS}(B^0_{(s)} \to e^+\mu^-) = \pi\alpha_s^2(M_{LQ})\frac{1}{M_{LQ}^4}F^2_{B^0_{(s)}}m^3_{B^0_{(s)}}R^2 \cdot \frac{\tau_{B^0_{(s)}}}{\hbar},$$



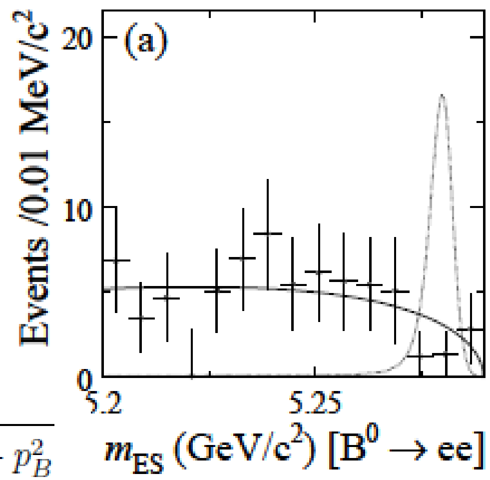
$$R = \frac{m_B}{m_b}\left(\frac{\alpha_s(M_c)}{\alpha_s(m_t)}\right)^{4/7}\left(\frac{\alpha_s(m_t)}{\alpha_s(m_b)}\right)^{12/27}$$

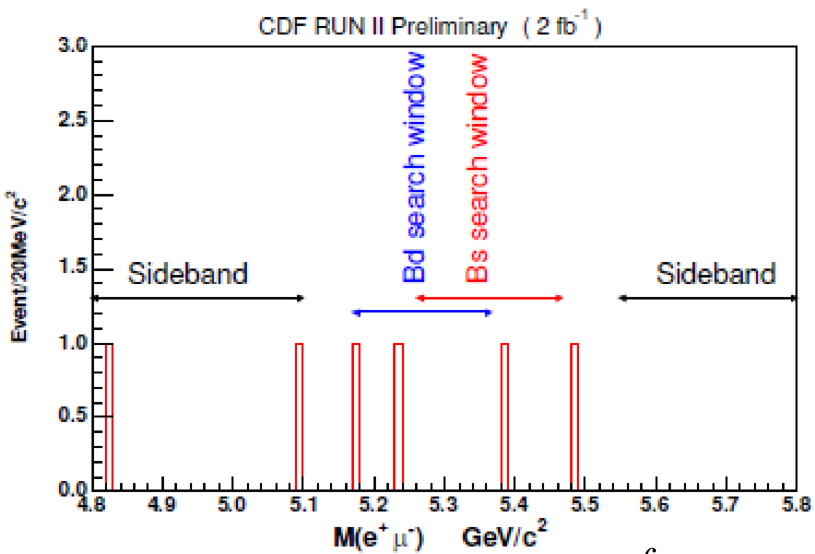
Experimental results from CDF and BaBar

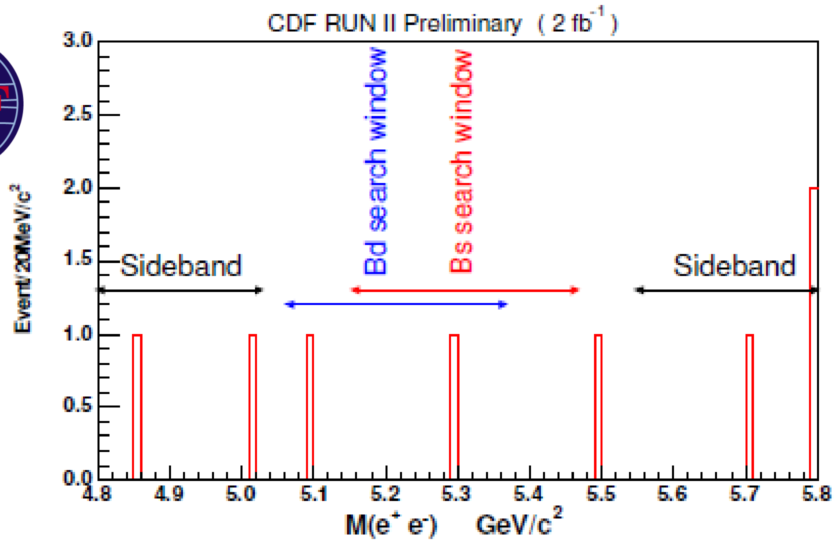
$B^0 \to e^+\mu^-$ search



$$m_{ES} \equiv \sqrt{(s/2 + \mathbf{p_0}\cdot\mathbf{p_B})^2/E_0^2 - p_B^2}$$







$$f.o.m = \frac{S}{1.5+\sqrt{B}}$$ for cut optimization

$B^0 \to e^+\mu^-(e^-)$: result summary

Event yield summary

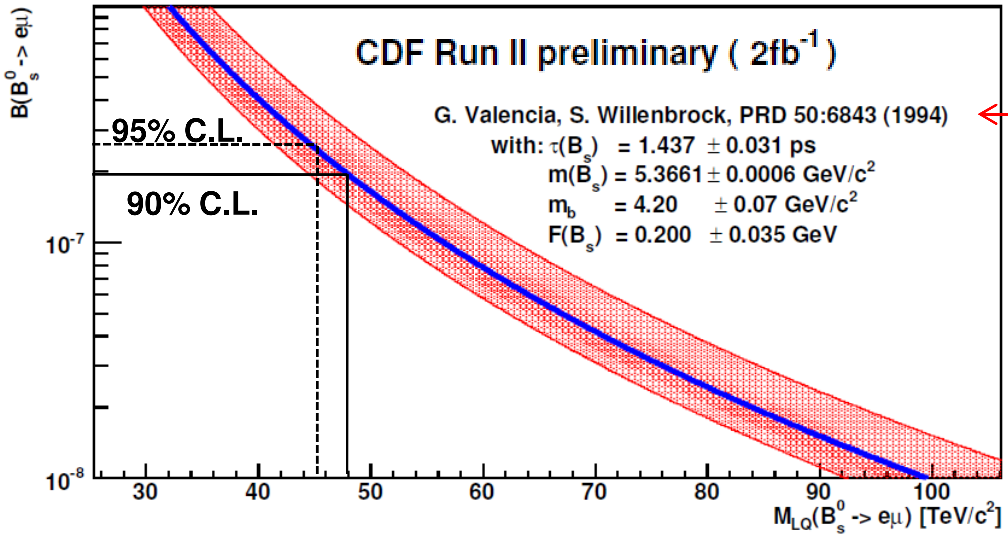
	CDF obs.	CDF exp.	BaBar obs-exp.
$B^0_s \to ee$	1	2.7 ± 1.8	n/a
$B^0_d \to ee$	2	2.7 ± 1.8	0.6 ± 2.1
$B^0_s \to e\mu$	1	0.81 ± 0.63	n/a
$B^0_d \to e\mu$	2	0.94 ± 0.63	1.1 ± 1.8

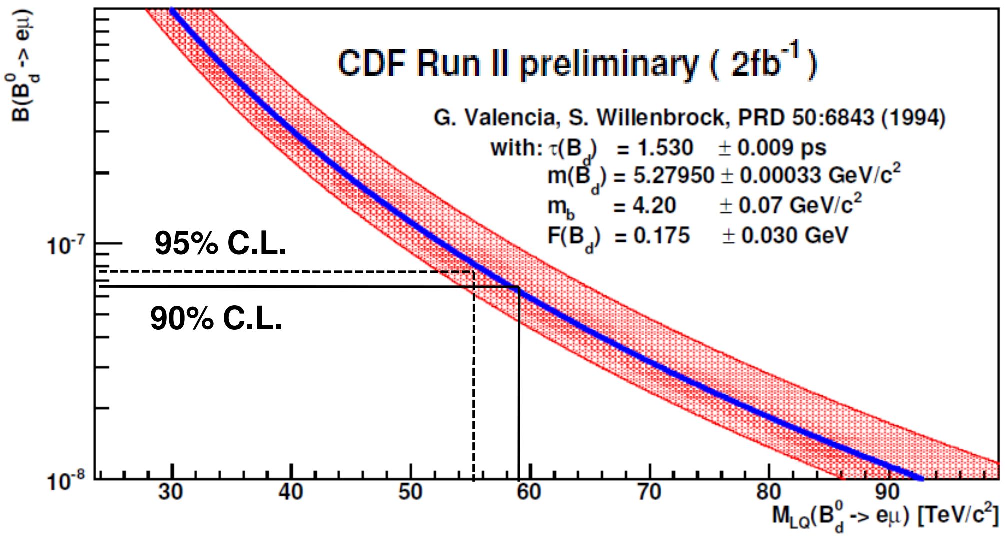
BR limit summary

Limit 90%(95%) x 10^8	$B^0_s \to e\mu$	$B^0_d \to e\mu$
BaBar BF U.L.	**n/a**	**9.2**
CDF BF C.L. limit	**20(26)**	**6.4(7.9)**

Limit 90% (95%) × 10^8	$B^0_s \to ee$	$B^0_d \to ee$
BaBar	n/a	11.3
CDF B.F. limit	28 (37)	8.3 (10.6)

Limits on Pati-Salam leptoquark mass





$$B^{LQ}(\mathrm{B}^0_{(S)} \to \mathrm{e}^+\mu^-) = \frac{\pi\alpha_S^2(M_{LQ})}{M_{LQ}^4} F^2_{B^0_{(S)}} m^3_{B^0_{(S)}} \frac{\tau_{B^0_{(S)}}}{\hbar} R^2$$

$$R = \frac{m_B}{m_b}\left(\frac{\alpha_s(M_c)}{\alpha_s(m_t)}\right)^{4/7}\left(\frac{\alpha_s(m_t)}{\alpha_s(m_b)}\right)^{12/27}$$

$$\mathrm{M_{LQ}}(B^0_S \to e\mu) > 47.7(44.6)\mathrm{TeV}$$
$$\mathrm{M_{LQ}}(B^0_d \to e\mu) > 58.6(55.7)\mathrm{TeV}$$

Areas of improvement and expected future results (1)

$B_s \rightarrow \mu\mu$

- Tevatron: expected sensitivity (CDF-D0 combined) with 10 fb^{-1}: $BR(B_s \rightarrow \mu\mu) \leq 10^{-8}$
  only 3 time above the SM value, great chance for a NP discovery !
  → still room to improve PID and acceptance.
  - CDF: a) working to include the Two Track Trigger sample (>15% more statistics)
    b) increase di-muon trigger acceptance (>10% more statistics)
  - D0: add single muon trigger

- Super B-Factories: Expected sensitivities:

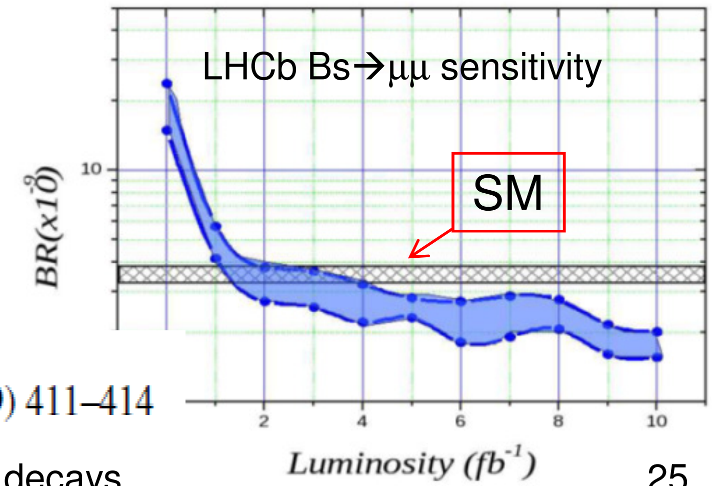
  $BR(B_s \rightarrow \mu\mu)$ (Y(5S)) < 8×10^{-9} 30 ab^{-1}

  arXiv:0709.0451

  $BR(B^0 \rightarrow \mu\mu)$ (Y(4S)) < 7×10^{-9} 50 ab^{-1}

  arXiV:physics/0512235v1

- need to wait for LHCb to reach the SM BR sensitivity with 2 fb^{-1}



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Areas of improvement and expected future results (2)

B→$\tau\nu$:

low statistics affect many contributions to the systematical uncertainty (MC stat. for signal shape, BG estimation,…) of published results

→ At the Super-B Factories, int. lum. a factor >25 larger w.r.t B-Factories

→ relative error on BR(B→$\tau\nu$) = 3%-4% at 75 ab^{-1} (arXiv0709.0451)

D→$\mu\mu$

Tevatron: great potentiality: 5.5 fb^{-1} per experiment on tape

→ CDF published result only for the first 360 pb^{-1} sample

→ Add prompt (ccbar) D^0s (double c-tag, lepton trigger samples)?

Super B-Factories: BR(D^0→mm) sensitivities:

1 x 10^{-8} 1 month @ Ψ(3770)

1-5 x 10^{-8} 5 years @ Y(4s) (75 ab^{-1})

B→eμ

Tevatron: improve lepton id., add other trigger samples (lepton triggers)

Super B-Factories: sens.< 10^{-8}?

Conclusions

- Studies of full leptonic decays of B (and D) mesons are, and will be, one of the most powerful tool to search for New Physics

- Tevatron:
  - any evidence in the FCNC sector before end of operations (10 fb^{-1}) will be evidence of NP
  - many chances for a discovery pushing limits close to the SM expectation
  - CDF and D0 results, combined with other measures, will favour or rule-out different NP models

- Present results from full leptonic B modes are generally limited by statistics

- Future accelerators for larger statistics:
  - Super B-factories will increase accuracy on BR($B\rightarrow\tau\nu$) by a factor almost 10
  - LHCb experiment will push the sensitivity in BR($B\rightarrow\mu\mu$) mesurements below the SM level .

BACK-UP SLIDES

$B \to \tau\nu$

Belle analysis details

$$f.o.m. = \frac{s}{\sqrt{s+b}}$$ evaluated in the signal region $E_{ECL} < 0.2$ for cut optimization

N_{evt}^{sig} extracted from an extended maximum likelihood fit to the E_{ECL} distribution

$$\mathcal{L} = \frac{e^{-\sum_j n_j}}{N!} \prod_{i=1}^{N} \sum_j n_j f_j(E_i)$$

$E_i = E_{ECL}$ of the i-th event

PDFs derived from MC for each signal decay mode and background type

B→τν

BaBar analysis details

Likelihood ratios (LHRs) for BB events and continuum background are used as discriminant variables in addtion to E_{ECL} (and $p_{\mathrm{sig.}\ell}$ for B→μ(e)ν and τ→μ(e)ν)

$$P_i(x) = \frac{P_s(x)}{P_s(x) + P_b(x)},$$

PDFs are built from MC for 14 variables

$$\mathrm{LHR}(x) \equiv \prod_i P_i(x).$$

LHRs are built for each sig.decay mode and bkg. type

The "Punzi" figure of merit is used to optimize cuts on the discriminant variables

$$\mathrm{FOM}_{\mathrm{Punzi}} = \frac{N_{\mathrm{sig}}}{N_\sigma/2 + \sqrt{N_{\mathrm{BG}}}}$$

$$\mathcal{B}(B^+ \to \ell^+ \nu_\ell) = \frac{N_{\mathrm{obs}} - N_{\mathrm{BG}}}{N_{B\overline{B}}\varepsilon_{\mathrm{tag}}\varepsilon_{\mathrm{sig}}},$$

B→τν

BaBar optimized cuts

Mode	E_{extra}	$LHR_{B\overline{B}}$	$LHR_{\text{cont.}}$	$p_{\text{sig }\ell}$
$\tau^+ \to e^+\nu_e\overline{\nu}_\tau$	[0,0.24] GeV	[0.74,1]	[0.16,1]	[0.00,2.25] GeV/c
$\tau^+ \to \mu^+\nu_\mu\overline{\nu}_\tau$	[0,0.24] GeV	[0.14,1]	[0.72,1]	[0.00,2.30] GeV/c
$\tau^+ \to \pi^+\overline{\nu}_\tau$	[0,0.35] GeV	[0.57,1]	[0.80,1]	-
$\tau^+ \to \pi^+\pi^0\overline{\nu}_\tau$	[0,0.24] GeV	[0.97,1]	[0.95,1]	-
$B^+ \to \mu^+\nu_\mu$	[0,0.72] GeV	[0.33,1]	[0.75,1]	[2.45,2.92] GeV/c
$B^+ \to e^+\nu_e$	[0,0.57] GeV	[0.00,1]	[0.01,1]	[2.52,3.02] GeV/c

BaBar result summary

Mode	Expected Background (N_{BG})	Observed Events (N_{obs})	Overall Efficiency (ε)	Branching Fraction
$\tau^+ \to e^+\nu_e\overline{\nu}_\tau$	91 ± 13	148	$(3.08 \pm 0.14) \times 10^{-4}$	$(4.0 \pm 1.2) \times 10^{-4}$
$\tau^+ \to \mu^+\nu_\mu\overline{\nu}_\tau$	137 ± 13	148	$(2.28 \pm 0.11) \times 10^{-4}$	$\left(1.0^{+1.2}_{-0.9}\right) \times 10^{-4}$
$\tau^+ \to \pi^+\overline{\nu}_\tau$	233 ± 19	243	$(3.89 \pm 0.15) \times 10^{-4}$	$\left(0.6^{+1.1}_{-0.5}\right) \times 10^{-4}$
$\tau^+ \to \pi^+\pi^0\overline{\nu}_\tau$	59 ± 9	71	$(1.30 \pm 0.07) \times 10^{-4}$	$\left(2.0^{+1.4}_{-1.3}\right) \times 10^{-4}$
$B^+ \to \tau^+\nu_\tau$	521 ± 31	610	$(10.54 \pm 0.41) \times 10^{-4}$	$(1.8 \pm 0.8 \pm 0.1) \times 10^{-4}$
$B^+ \to \mu^+\nu_\mu$	15 ± 10	11	$(27.1 \pm 1.2) \times 10^{-4}$	$< 11 \times 10^{-6}$ @ 90% CL
$B^+ \to e^+\nu_e$	24 ± 11	17	$(36.9 \pm 1.5) \times 10^{-4}$	$< 7.7 \times 10^{-6}$ @ 90% CL

$B \to \tau\nu$

Efficiencies of the Belle analysis

Decay Mode	Signal Yield	ε	$\mathcal{B}$
$\tau^- \to e^- \nu \bar{\nu}_\tau$	78^{+23}_{-22}	5.9×10^{-4}	$(2.02^{+0.59}_{-0.56}) \times 10^{-4}$
$\tau^- \to \mu^- \nu \bar{\nu}_\tau$	15^{+18}_{-17}	3.7×10^{-4}	$(0.62^{+0.76}_{-0.71}) \times 10^{-4}$
$\tau^- \to \pi^- \nu_\tau$	58^{+21}_{-20}	4.7×10^{-4}	$(1.88^{+0.70}_{-0.66}) \times 10^{-4}$
Combined	154^{+36}_{-35}	14.3×10^{-4}	$(1.65^{+0.38}_{-0.37}) \times 10^{-4}$

Efficiencies of the BaBar analysis

Mode	ε_{sig}	$\varepsilon(\times 10^{-4})$
$\tau^+ \to e^+ \nu_e \overline{\nu}_\tau$	$(1.987 \pm 0.043)\%$	3.38 ± 0.07
$\tau^+ \to \mu^+ \nu_\mu \overline{\nu}_\tau$	$(1.610 \pm 0.038)\%$	2.73 ± 0.06
$\tau^+ \to \pi^+ \overline{\nu}_\tau$	$(2.48 \pm 0.05)\%$	4.21 ± 0.08
$\tau^+ \to \pi^+ \pi^0 \overline{\nu}_\tau$	$(0.859 \pm 0.028)\%$	1.46 ± 0.05
$B^+ \to \tau^+ \nu_\tau$	$(6.94 \pm 0.08)\%$	11.78 ± 0.13
$B^+ \to \mu^+ \nu_\mu$	$(30.92 \pm 0.36)\%$	32.54 ± 0.36
$B^+ \to e^+ \nu_e$	$(36.98 \pm 0.38)\%$	40.43 ± 0.40

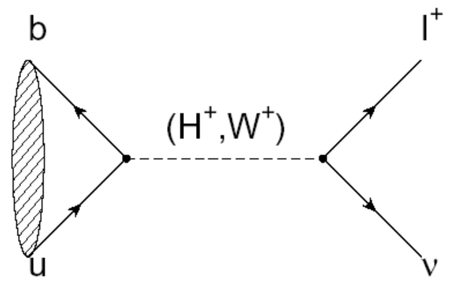
$B \to \tau \nu$

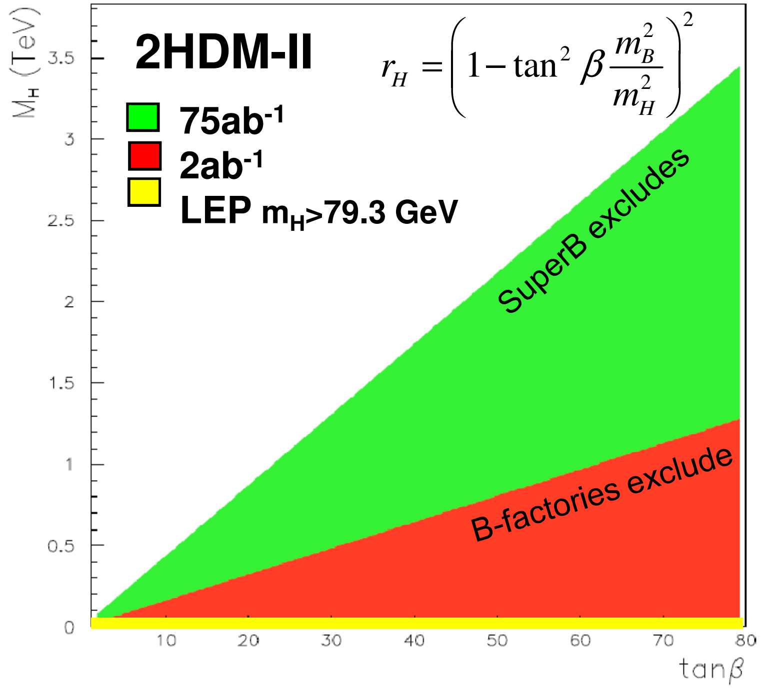
Charm equivalent: $D_s^+ \to \mu^+\nu$, $\tau^+\nu$

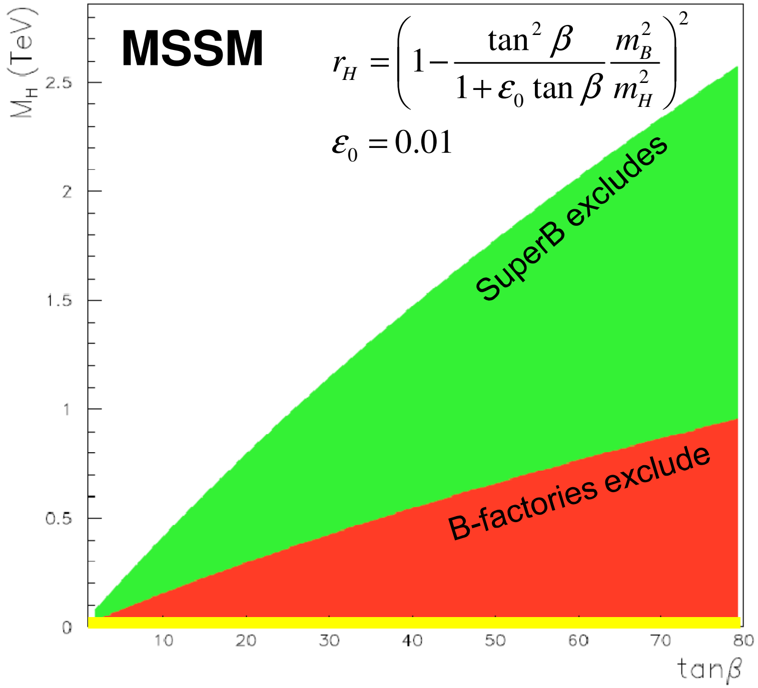
Super B-Factories excludes

- Higgs mediated MFV:

$$r_H = \frac{\mathcal{B}_{SM+NP}}{\mathcal{B}_{SM}}$$

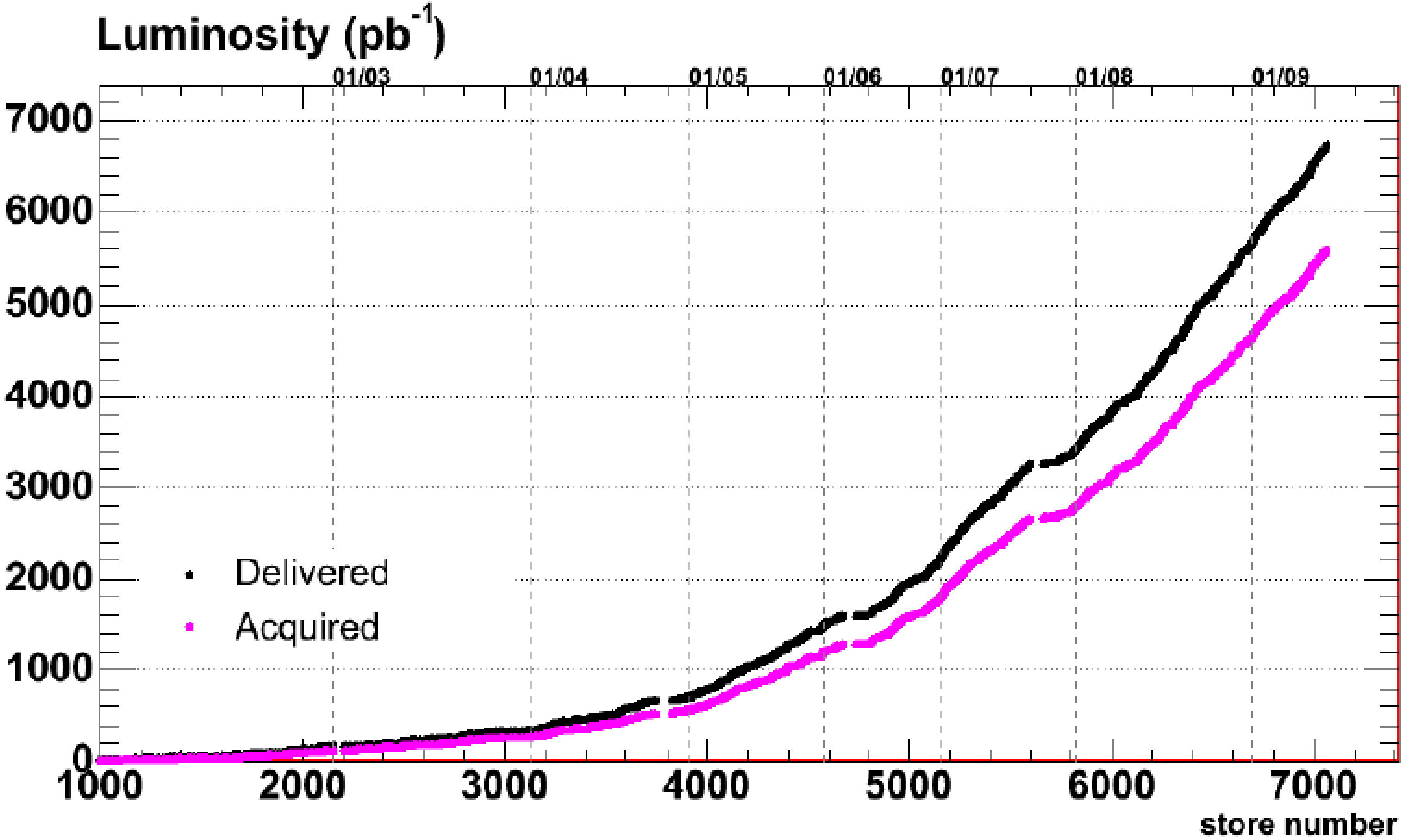




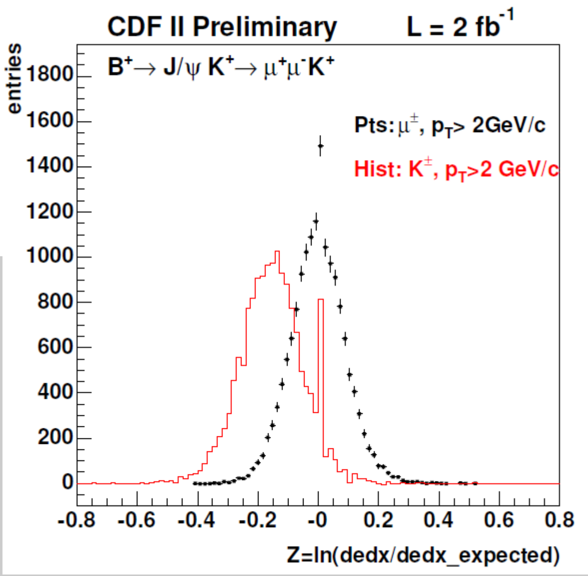


- Multi TeV search capability for large tanβ.

Integrated luminosity: CDF



CDF B → $\mu^+ \mu^-$ analysis details



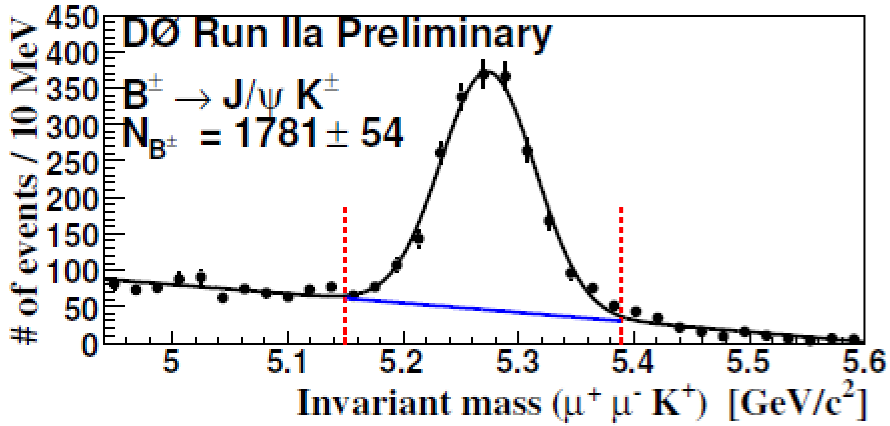
Optimization and statistical treatment

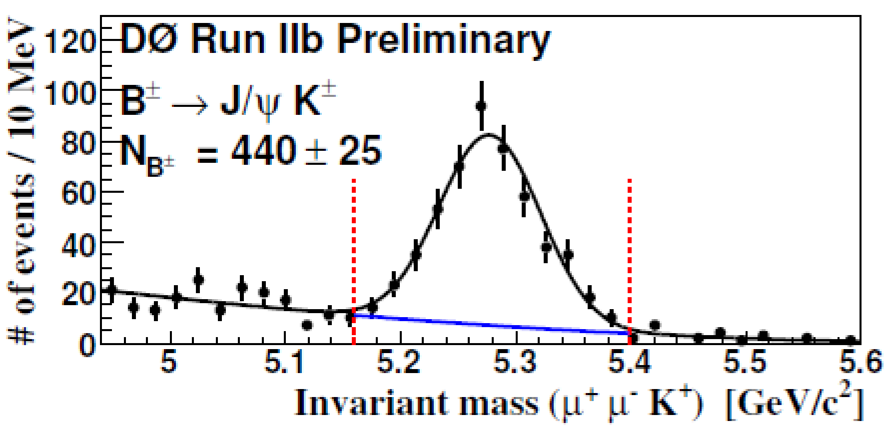
- Muon identification and B→hh backgroud rejection improved by combining muon likelihood and PID with dE/dx
- An *a priori* optimization to achieve the best expected limit on BR assuming SM yield for the signal
- Limits are computed with the CLs method incorporating Gaussian uncertainties on signal acceptance and efficiency and on background estimates
- the output distribution of a NN with 6 event observable inputs and the di-muon mass distribution are used to build 2-D PDFs for signal (from MC) and background (sidebands extrapolation plus residual B→hh bkg)
- Signal and background are estimated from a 2-D fit in the NN-$m_{\mu\mu}$ plane; Each 2-D bin is a single bin count experiment and the overall limit is computed by combining all bins and accounting for correlated uncertainties.

$B \rightarrow \mu^+ \mu^-$: 2 fb^{-1} D0 analysis

D0 Conf. Note 5344

Normalization mode





Optimization and statistical treatment

•construct a lilkelihood ratio L_R with six discriminating observables and

• optimize L_R cut on
a): $\varepsilon_{\mu\mu} / \langle n_{up.lim.}(n_{exp.bkg.}) \rangle$
b): $\varepsilon_{\mu\mu} /(1+sqrt(B))$
→ almost same optimal values

• use a Bayesian approach to set upper limits on BRs

• treat RunIIa and RunIIb (pre and post insertion of the inner layer of the SMT) as different experiment and combine results

$D^0 \rightarrow \mu^+\mu^-$

D0 new analysis: background composition in the signal window

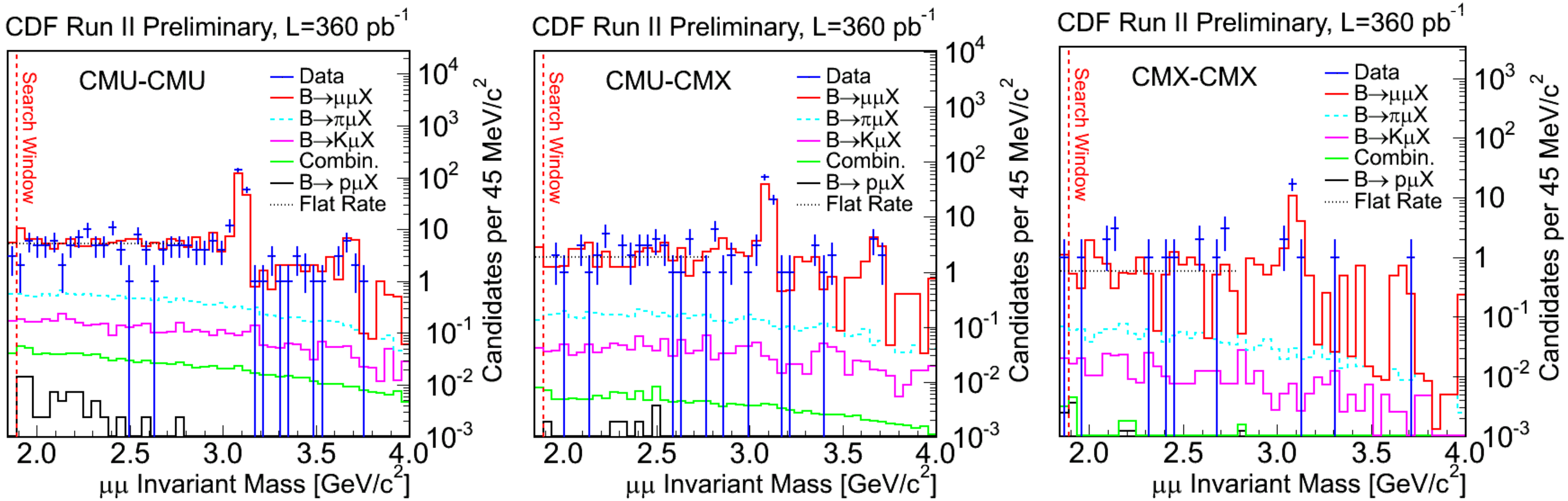
-	Run IIa	Run IIb-I	Run IIb-II
$N(B^0 \rightarrow K^+\pi^-)$	0.044 ± 0.029	0.045 ± 0.030	0.032 ± 0.021
$N(B_s^0 \rightarrow K^+K^-)$	0.124 ± 0.051	0.125 ± 0.051	0.090 ± 0.037
Dimuon background	1.99 ± 0.62	3.56 ± 1.07	2.03 ± 0.62
Total background	2.16 ± 0.62	3.73 ± 1.07	2.15 ± 0.63
SM $N(B_s^0 \rightarrow \mu^+\mu^-)$	0.192 ± 0.034	0.193 ± 0.034	0.139 ± 0.025

Recent results only from Tevatron (CDF)

$D^0 \to \mu^+\mu^-$

- Two Track trigger sample => displaced verteces
- $D^{*-} \to D^0\pi^-$ tag required to suppress BG
- Two track candidates reconstructed in the $\mu\mu$ hyp.
- $D^0 \to \pi^+\pi^-$ mode used as reference
- Muon mistag suppressed by likelihood muon id. and dE/dx sep.
- Defined a seach region to count observed and expected evts from a blind analysis

$$\mathcal{B}(D^0 \to \mu\mu) = \frac{N(\mu\mu)}{N(\pi\pi)} \cdot \frac{\epsilon(\pi\pi)}{\epsilon(\mu\mu)} \cdot \mathcal{B}(D^0 \to \pi\pi) \qquad N(\mu\mu) = N_{obs} - N_{BKG}^{exp}$$

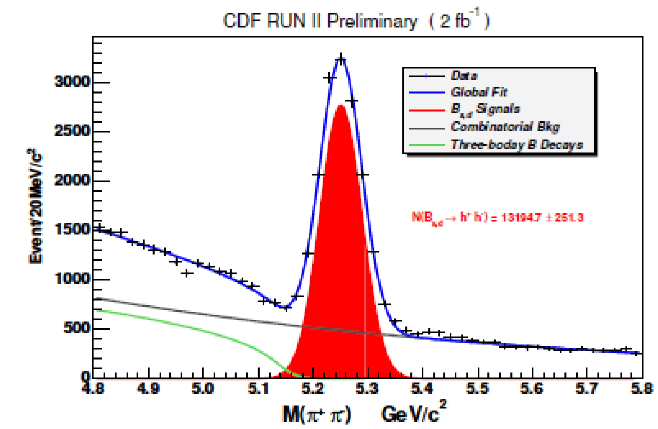


$B^0 \to e^+\mu^-$: analysis procedure

CDF (2fb^{-1}) arXiv:0901.3803

- Two Track trigger sample => displaced verteces
- Two track candidates reconstructed in the μμ hyp.
- $B^0 \to K^+\pi^-$ mode used as reference

$$\mathcal{B}(B_s^0 \to e^+\ell^-) = \frac{N(B_s^0 \to e^+\ell^-) \cdot \mathcal{B}(B^0 \to K^+\pi^-) \cdot f_d/f_s}{\epsilon^{rel}_{B_s^0 \to e^+\ell^-} \cdot N(B^0 \to K^+\pi^-)}.$$



- efficiency relative to $B \to hh$ about 0.2%
- BG suppression with lepton id. and dE/dx separation.
- Dominant BGs from $B \to hh$ and semileptonic B-decays
- Defined a search region to count observed and expected evts from a blind analysis
- Bayesian approach to set limits

Babar PRD 77:032007,2008

- Data sample: 386 x 106 BB events (347 fb^{-1})
- PID to reduce contamination from misidentified leptons and hadrons
- Likelihood function $\mathcal{L}(N_{ll'})$ with PDFs based on m_{ES}, ΔE and Fisher discriminant ($\mathcal{F}$)
- BF $$BF \equiv \frac{N_{ll'}}{\epsilon_{ll'} N_{B\overline{B}}}$$
- $\varepsilon_{ll'}$ about 15%
- Bayesian approach to set Upper Limits (UL): $$\int_0^{UL} \mathcal{L}(BF)\, dBF \Big/ \int_0^{\infty} \mathcal{L}(BF)\, dBF = 0.9.$$

B→l+l-

CDF PID with dE/dx

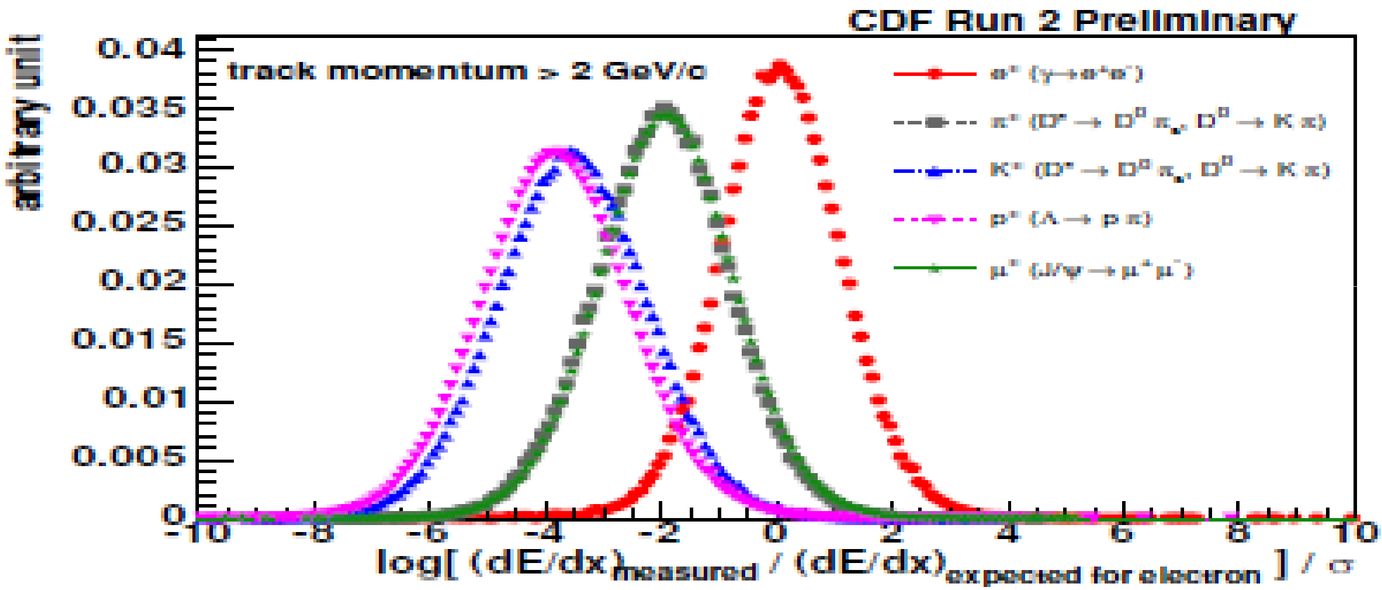
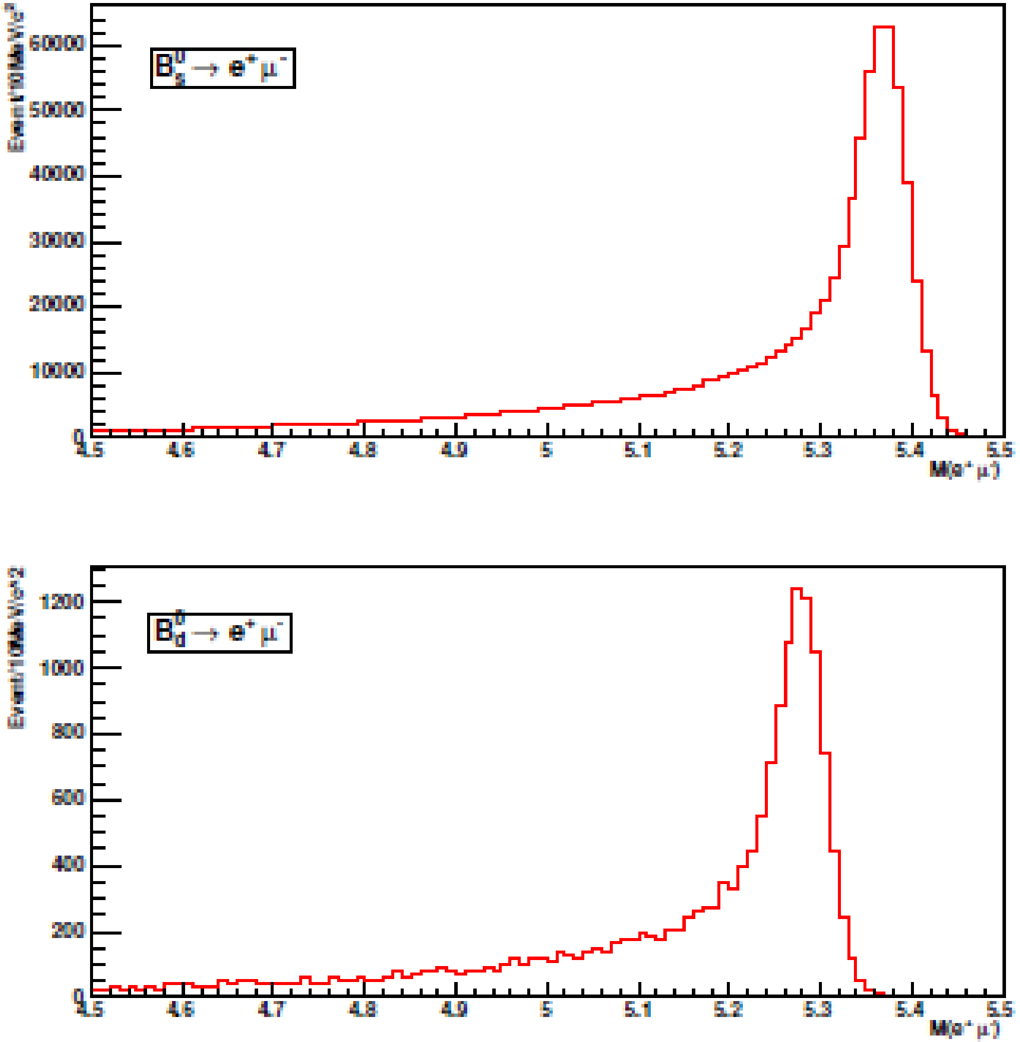


Figure 7: *Distributions of the Z_e pull charged tracks with $p_T > 2\ GeV/c^2$.*

B→e⁺μ⁻

CDF

Electron energy loss effects on the invariant mass



$B \rightarrow e^+\mu^-$

Marciano approximation assumed to evaluate $\alpha_s(M_{LQ})$

W. Marciano Physical Review D vol 29, 580 (1984).