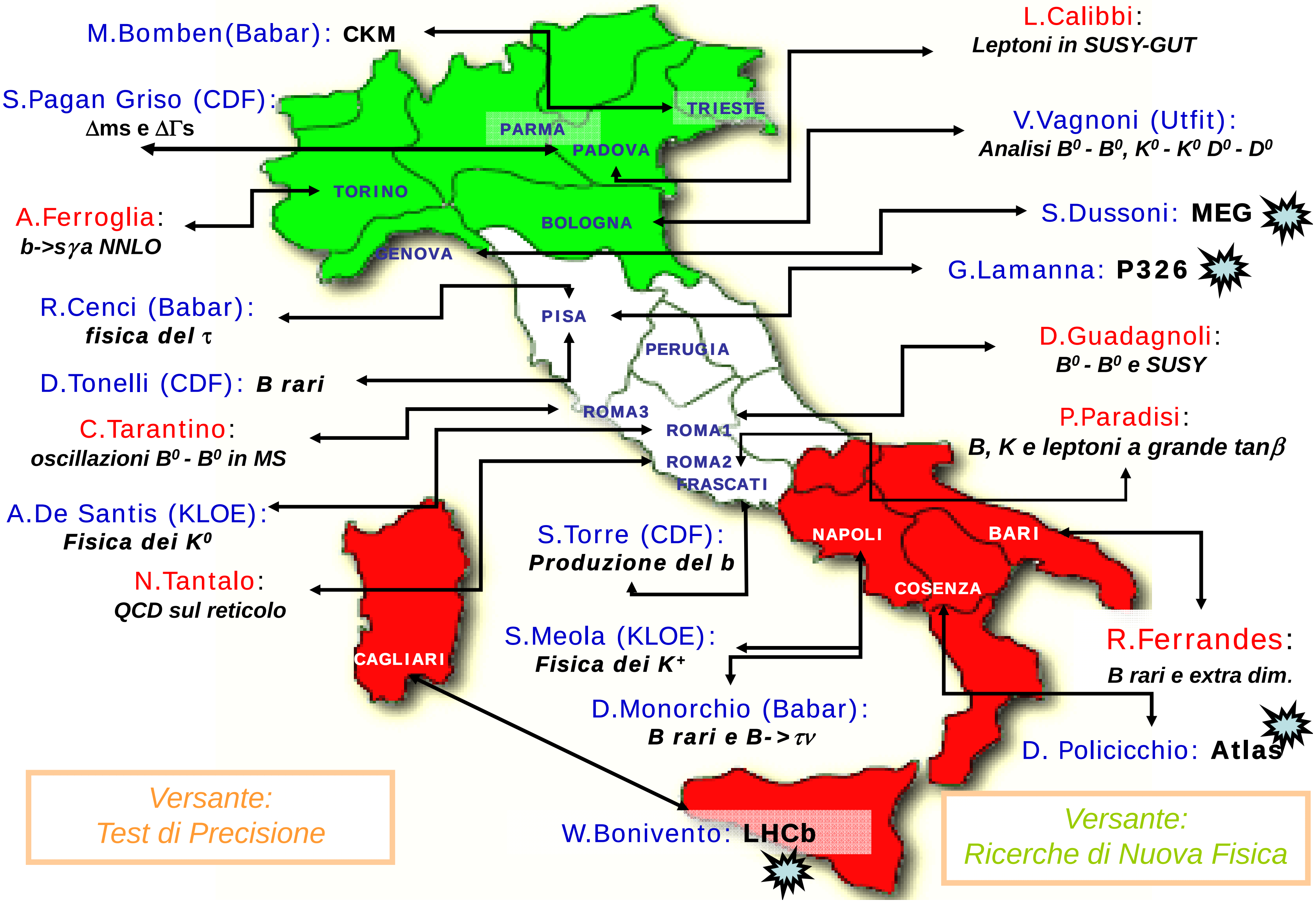
Fisica del Sapore

Federico Mescia e Marco Rescigno
INFN-Frascati   INFN-Roma1

IFAE 2007 - 11-13 Aprile, 2007 - Napoli

Il Sapore d'Italia



Flavour Physics – Introduction

$$\text{Measurements} = \mathcal{L}_{SM}(A_i, Q_i, L_i, H) + \left(\sum_i \frac{c_i^6 \cdot O_i^6}{\Lambda_{flav}^2} + \right) \ldots$$

$\mathcal{L}_{lept}(L_i)$

$\mathcal{L}_{QCD}(Q_i, A)$

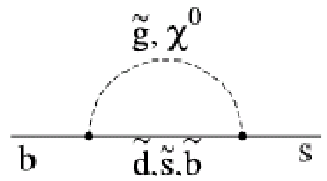
$$\mathcal{L}_{weak} \propto \overline{U}_L \gamma_\mu V^{CKM} D_L W^\mu$$

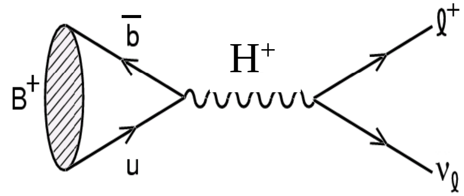
$$V_{CKM} = \begin{pmatrix} \mathbf{V_{ud}} & \mathbf{V_{us}} & \mathbf{V_{ub}} \\ 1-\lambda^2/2 & \lambda & A\lambda^3(\rho - i\eta) \\ \mathbf{V_{cd}} & \mathbf{V_{cs}} & \mathbf{V_{cb}} \\ -\lambda & 1-\lambda^2/2 & A\lambda^2 \\ \mathbf{V_{td}} & \mathbf{V_{ts}} & \mathbf{V_{tb}} \\ A\lambda^3(1-\rho-i\eta) & -A\lambda^2 & 1 \end{pmatrix}$$

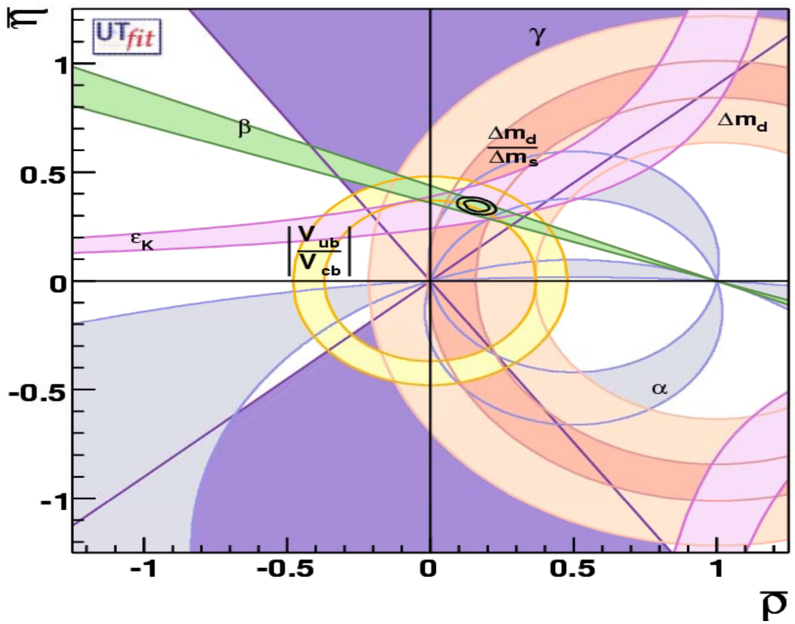
- flavour violation → • **B, D, K FC decays**
- unitary matrix → • strong correlations
  - $|V_{us}|^2+|V_{ud}|^2=1$ & U.T.
- one phase → CP violation studies

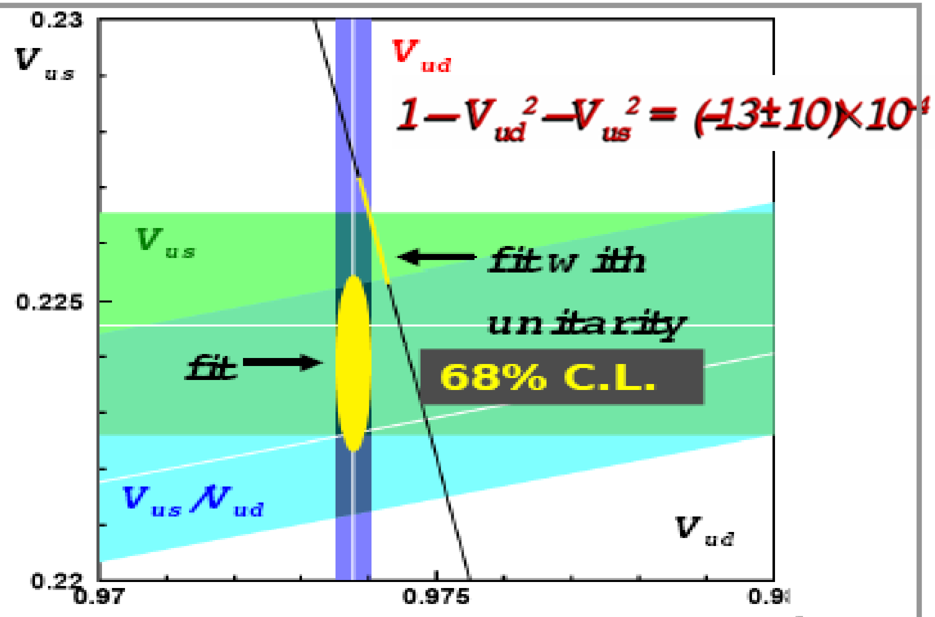
new physics contributions

- **Indirect searches of NP ->**
  thanks new virtual particles, mediating Lepton & B, D, K decays









<u>*Exp. inputs from*</u>

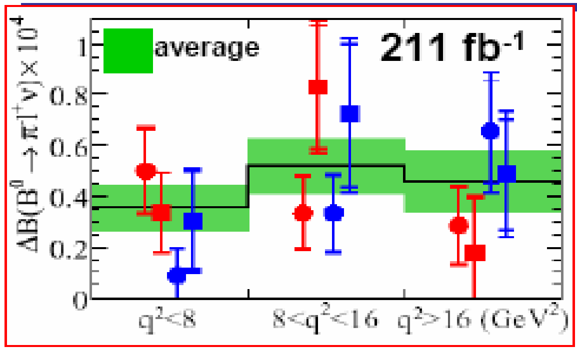
- Babar-Belle: B_d,B^+ physics -> **sin(2β), γ, α, B->πlν, B->D*lν** ... Bomben's
- CDF- D0: B_s physics -> $\mathbf{\Delta m_s}$, $\Delta\Gamma_s$ ... Pagan Griso's
- KLOE-NA48: K physics: ε_K,$\mathbf{K_{\ell 3}}$, $\mathbf{K_{\ell 2}}$ ... Meola's & De Santis

Excellent overall consistency

Experimental effort dilute by theory precision. Tough to improve it!

- Lattice QCD: B_K, f_B, B_B **Tantalo's**
- OPE at small scales?: V_{ub} **Ferrero e Di Giustino's**, b->sg NNLO **Ferroglia's**

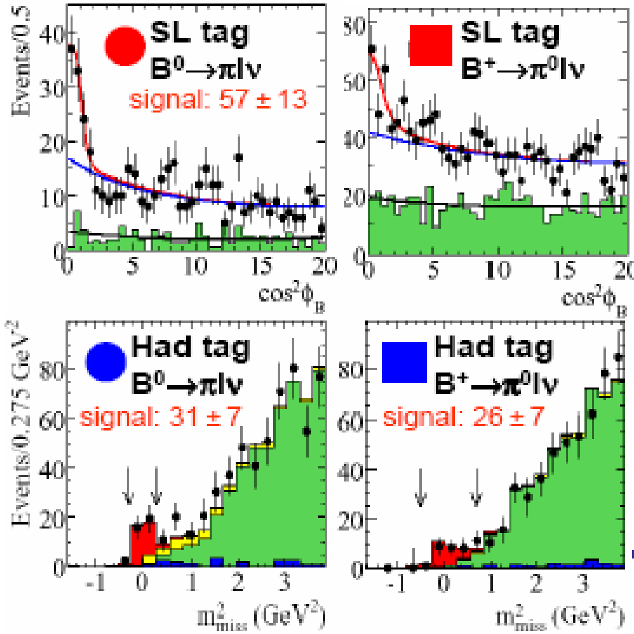
Exclusive $|V_{ub}|$ (tagged)



Measurement of $|V_{ub}|$ from tagged $B \to \pi l \nu$ decays
Phys. Rev. Lett. **97**, 211801 (2006)

- Tagged $B \to \pi l \nu$ reconstruction in 3 q^2 bins
- Combination of semileptonic and hadronic t…

15%



$$BF(B^0 \to \pi \ell \nu) = (1.33 \pm 0.17_{stat} \pm 0.11_{syst}) \times 10^{-4}$$

$$|V_{ub}| = (4.5 \pm 0.5_{stat} \pm 0.7_{syst}{}^{+0.7}_{-0.5\,FF}) \times 10^{-3} \quad \text{(HPQCD)}$$

- Statistically limited!!!
- Very promising with increasing BaBar dataset!!!

– UT angles and sides @ *BaBar* – IFAE 2007, Napoli 15

Charmonium K^0 modes

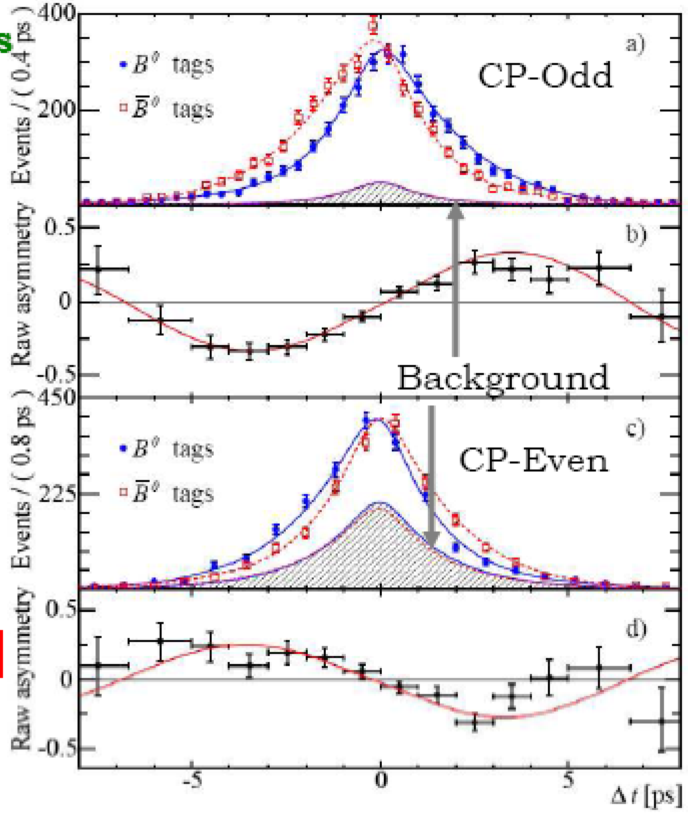
hep-ex/0703021, submitted to PRL — **384 M BB pairs**

Sample	N_{tag}	$P(\%)$	$\sin 2\beta$	$\lvert\lambda\rvert$
Full CP sample	12677	75	0.714 ± 0.032	0.952 ± 0.022
$J/\psi K^0_S (\pi^+\pi^-)$	4459	96	0.702 ± 0.042	0.976 ± 0.030
$J/\psi K^0_S (\pi^0\pi^0)$	1086	88	0.617 ± 0.103	0.812 ± 0.058
$\psi(2S) K^0_S$	687	83	0.947 ± 0.112	0.867 ± 0.079
$\chi_{c1} K^0_S$	313	89	0.759 ± 0.170	0.804 ± 0.102
$\eta_c K^0_S$	328	69	0.778 ± 0.195	0.948 ± 0.141
$J/\psi K^0_L$	4748	55	0.734 ± 0.074	1.061 ± 0.063
$J/\psi K^{*0}$	1056	66	0.477 ± 0.271	0.954 ± 0.083
$J/\psi K^0$	10275	76	0.697 ± 0.035	0.966 ± 0.025
$J/\psi K^0_S$	5547	94	0.686 ± 0.039	0.950 ± 0.027
$\eta_f = -1$	6873	92	0.711 ± 0.036	0.935 ± 0.024
1999-2002 data	3084	79	0.735 ± 0.063	0.987 ± 0.045
2003-2004 data	4850	77	0.728 ± 0.052	0.940 ± 0.035
2005-2006 data	4725	74	0.681 ± 0.054	0.940 ± 0.037

$$\sin 2\beta = 0.714 \pm 0.032\,(\text{stat}) \pm 0.018\,(\text{syst})$$

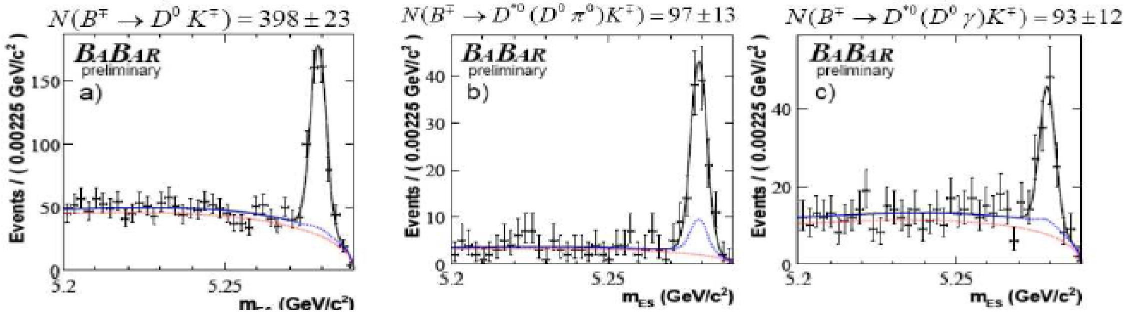
$$\lvert\lambda\rvert = 0.952 \pm 0.022\,(\text{stat}) \pm 0.017\,(\text{syst})$$

4%



Bomben

$B^+ \to D^{(*)0} K^+$: GGSZ (Dalitz)



45%

$$\gamma = (92 \pm \underset{(stat)}{41} \pm \underset{(syst)}{11} \pm \underset{(Dalitz)}{12})^\circ$$

$$\delta_B = (118 \pm 63 \pm 19 \pm 36)^\circ$$

$$\delta_B^* = (-62 \pm 59 \pm 18 \pm 10)^\circ$$

Bomben

$$0.00 < r_B < 0.140$$

$$0.017 < r_B^* < 0.203$$

one standard deviations constraints

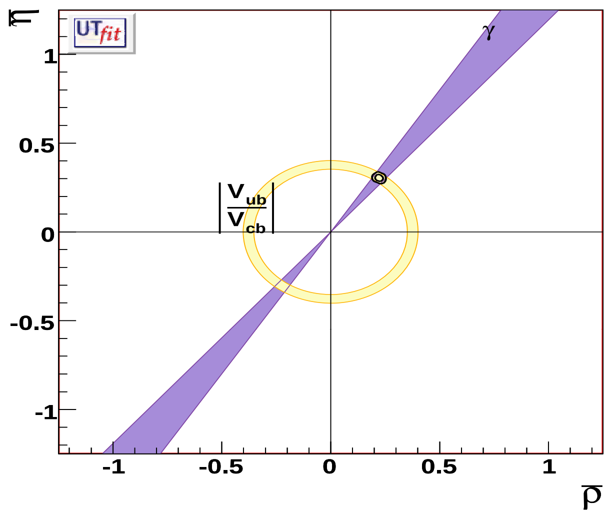
hep-ex/0607104

$347 \times 10^6 \, B\bar{B}$ pairs

20% average

With LHCb at L=10 fb^{-1} (around 2014)

- **γ will be known at about 2°**



$\sigma(\bar{\rho}) / \bar{\rho} = 6.7\%$

$\sigma(\bar{\eta}) / \bar{\eta} = 4.5\%$

Vagnoni

Sensitivities to γ from $B \to DK$ decays

B mode	D mode	Method	$\sigma(\gamma)$, 2 fb^{-1}
$B^+ \to DK^+$	$K\pi$ + $KK/\pi\pi$ + $K3\pi$	ADS+GLW	5°–15°
$B^+ \to D^*K^+$	$K\pi$	ADS+GLW	Under study
$B^+ \to DK^+$	$K_S\pi\pi$	Dalitz	8°
$B^+ \to DK^+$	$KK\pi\pi$	4-body "Dalitz"	15°
$B^+ \to DK^+$	$K\pi\pi\pi$	4-body "Dalitz"	Under study
$B^0 \to DK^{*0}$	$K\pi$ + KK + $\pi\pi$	ADS+GLW	7°–10°
$B^0 \to DK^{*0}$	$K_S\pi\pi$	Dalitz	Under study
$B_s \to D_sK$	$KK\pi$	tagged, A(t)	13°

} Signal only, no accept. effect

- All channels combined (educated guess):
  - $\sigma(\gamma)$ = 4.2° with 2 fb^{-1}
  - $\sigma(\gamma)$ = 2.4° with 10 fb^{-1}

Bonivento

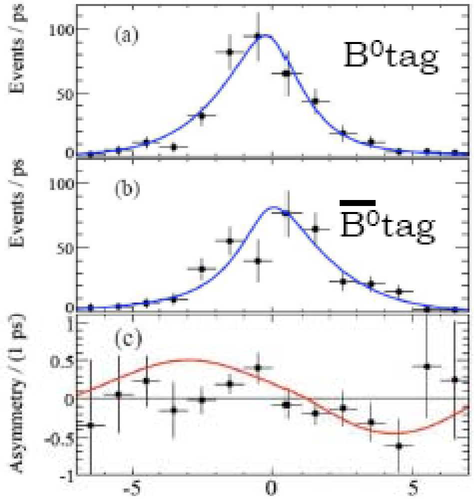
Flavour Physics Report:

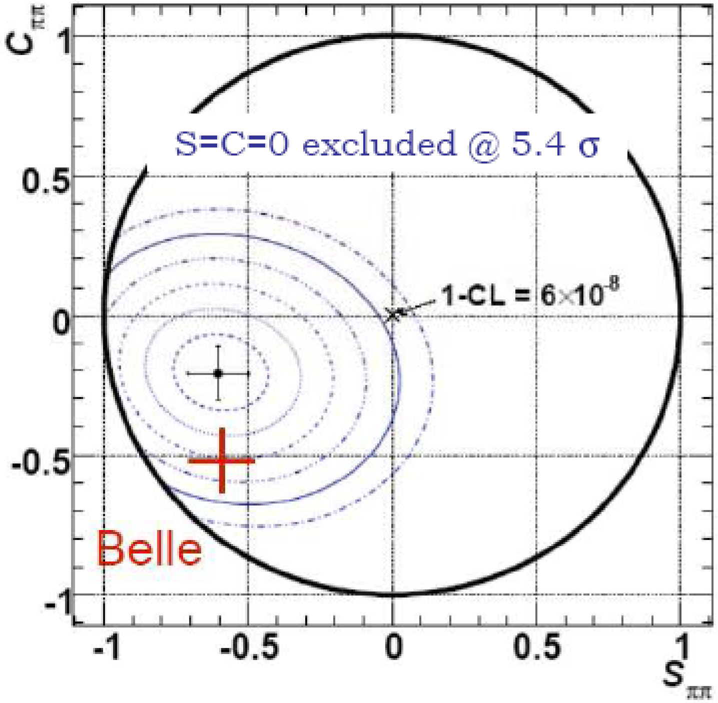
$B^0 \to \pi^+\pi^-$ & $B^0 \to K^+\pi^-$

NEW

383 M BB pairs; hep-ex/0703016

α





Bomben

$$N_{\pi\pi} = 1139 \pm 49$$
$$N_{K\pi} = 4372 \pm 82$$

$\sin(2\alpha_{eff})$

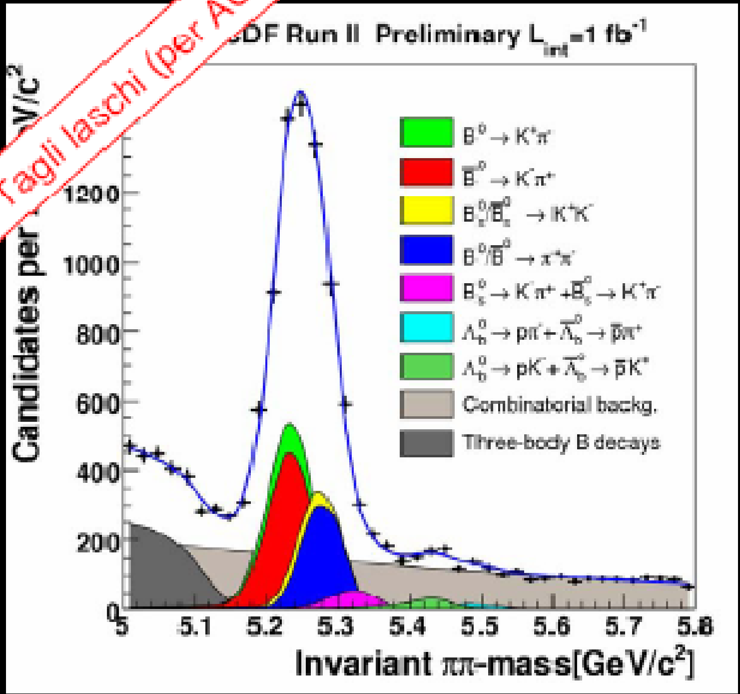
$$S_{\pi\pi} = -0.60 \pm 0.11 \pm 0.03\,(5.2\sigma)$$
$$C_{\pi\pi} = -0.21 \pm 0.09 \pm 0.02\,(2.2\sigma)$$
$$A_{K\pi} = -0.107 \pm 0.018\,^{+0.007}_{-0.004}\,(5.5\sigma)$$

$$A_{CP} \propto \sin\gamma \sin\delta \quad C_{f_{CP}} = \frac{1-|\lambda_{f_{CP}}|^2}{1+|\lambda_{f_{CP}}|^2} \quad \lambda_{f_{CP}} = \frac{q}{p}\frac{\bar{A}}{A}$$
$$S_{f_{CP}} = \frac{-2\,\mathrm{Im}\,\lambda_{f_{CP}}}{1+|\lambda_{f_{CP}}|^2}$$

$$A_{f_{CP}}(t) = \frac{\Gamma\left(\bar{B}^0_{phys}(t) \to f_{CP}\right) - \Gamma\left(B^0_{phys}(t) \to f_{CP}\right)}{\Gamma\left(B^0_{phys}(t) \to f_{CP}\right) + \Gamma\left(\bar{B}^0_{phys}(t) \to f_{CP}\right)}$$

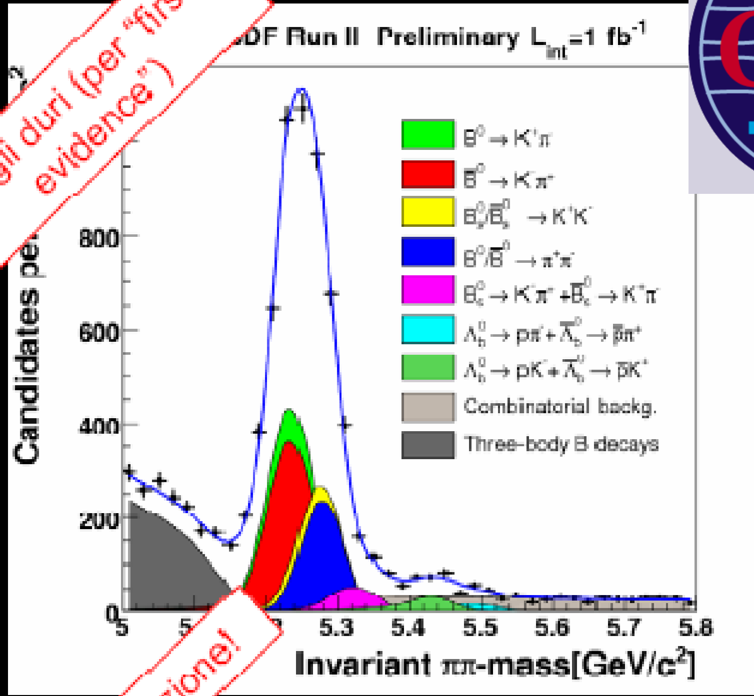
$$A_{f_{CP}} = -C_{f_{CP}} \cos(\Delta m t) + S_{f_{CP}} \sin(\Delta m t)$$

Tagli laschi (per ACP)



parameter	fraction	yield
$B^0 \to \pi^+\pi^-$ + c.c.	(0.160 ± 0.009)	1121 ± 63
$B^0 \to K^+\pi^-$ + c.c.	(0.577 ± 0.010)	4045 ± 84
$B_s^0 \to K^+K^-$ + c.c.	(0.186 ± 0.009)	1307 ± 64

Tagli duri (per "first evidence")

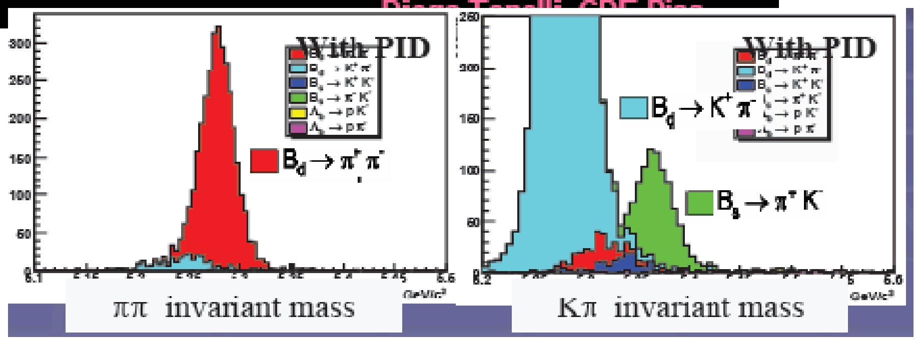


prima osservazione!

...meter	fraction	yield
$B_s^0 \to K^-\pi^+$ + c.c.	(0.040 ± 0.006)	230 ± 34
$\Lambda_b^0 \to p\pi^-$ + c.c.	(0.019 ± 0.003)	110 ± 18
$\Lambda_b^0 \to pK^-$ + c.c.	(0.027 ± 0.003)	156 ± 20

IFAE - 12 Aprile 2007

La promessa



$A_{CP} \propto \sin\gamma \sin\delta$

Asimmetria in $B^0 \to K^+\pi^-$

$$A_{CP} = \frac{N(\overline{B}^0 \to K^-\pi^+) - N(B^0 \to K^+\pi^-)}{N(\overline{B}^0 \to K^-\pi^+) + N(B^0 \to K^+\pi^-)} = -0.086 \pm 0.023\ (stat.) \pm 0.009\ (syst.)$$

Circa 3.5σ differente da zero e compatibile con risultati delle *B*-factories

$$A_{CP}^{Babar} = -0.107 \pm 0.018(\mathrm{stat.})^{+0.007}_{-0.004}(\mathrm{syst})$$

$$A_{CP}^{Belle} = -0.093 \pm 0.018(\mathrm{stat.}) \pm 0.008(\mathrm{syst})$$

Incertezze sistematiche di CDF al livello di quelle delle *B*-factories.

Questa misura usa solo 1 fb^{-1} . Con statistiche previste nei prossimi due anni ci aspettiamo migliore misura al mondo (<1%)

CDF ha opportunita' di confrontarla con l'asimmetria nel $B^0_s \to K^-\pi^+$ seguendo un test model-independent della presenza di NP proposto da Lipkin (Lipkin, Phys.Lett.B621:126, 2005).

Sembrerebbe favorita una grande (~40%) asimmetria nel $B^0_s \to K^-\pi^+$
Misura preliminare.

$$A_{CP} = 0.39 \pm 0.15\ (stat.) \pm 0.08\ (syst.)$$

Promettente in vista di campioni multi-fb^{-1}.

$K^{\pm}$ at KLOE - summary

Absolute **BR($K^+ \to \mu^+\nu(\gamma)$)** with **0.27%** accuracy

Phys.Lett.B 632:76-80,2006

Independent determination of $\mathbf{V_{us}}$ at **1%** level

$K^{\pm} \to \pi^0 l^{\pm}\nu_l$ absolute BR and **lifetime**: **preliminary** results

Together with the results on neutral kaons gives a significant contribution to the determination of $\mathbf{V_{us}}$ x **$f^+(0)$ 0.2%** level

BR($K^{\pm} \to \pi^{\pm}\pi^0$) in progress

Using 2 fb^{-1} collected KLOE will measure:

$K^{\pm} \to \pi^0 l^{\pm}\nu_l$ form factors, BR($K^{\pm} \to \pi^0\pi^0 l^{\pm}\nu_l$)

BR($K \to e\nu$)/BR($K \to \mu\nu$) to test e-μ universality

About 6 x 10^4 Ke2 events produced with 2.5fb^{-1}

Meola

Flavour Physics Report: SM tests

De Santis

Test CPT: relazione di Bell-Steinberger

$$\left(\frac{\Gamma_S + \Gamma_L}{\Gamma_S - \Gamma_L} + i\tan\phi_{SW}\right)\left(\frac{\mathrm{Re}(\epsilon)}{1+|\epsilon|^2} - i\mathrm{Im}(\delta)\right) = \frac{1}{\Gamma_S - \Gamma_L}\sum_f \mathcal{A}_L(f)\mathcal{A}_S^*(f)$$

$\not{C}P$ $C\not{P}T$

Principali input sperimentali di KLOE:

- BR assoluti del K_L **[PLB632(2006) 43]**
- Vita media del K_L **[PLB626(2005) 15]**
- $BR(K_L \to \pi^+\pi^-)/BR(K_L \to \pi\mu\nu)$ **[PLB638(2006) 140]**
- $BR(K_S \to \pi^+\pi^-)/BR(K_S \to \pi^0\pi^0)$ **[EPJC48 (2006) 767]**
- $BR(K_S \to \pi e\nu)$ **[PLB636(2006) 173]**
- $BR(K_S \to \pi^0\pi^0\pi^0)$ **[PLB619(2005) 61]**

Risultato KLOE [JHEP12(2006) 011]

$\mathrm{Re}\,\varepsilon = (159.6 \pm 1.3) \times 10^{-5}$
$\mathrm{Im}\,\delta = (0.4 \pm 2.1) \times 10^{-5}$

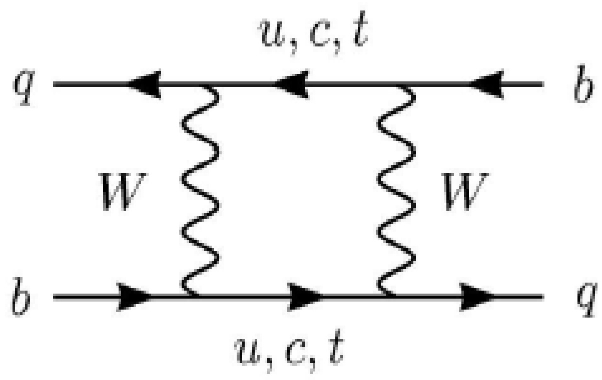
Antonio De Santis - IFAE 2007 – Napoli 11-13 Aprile 2007   *12*

22 exp. Inputs, mostly from kloe

1. Particle - antiParticle Oscillations

$B_d^0 - \overline{B_d^0}$

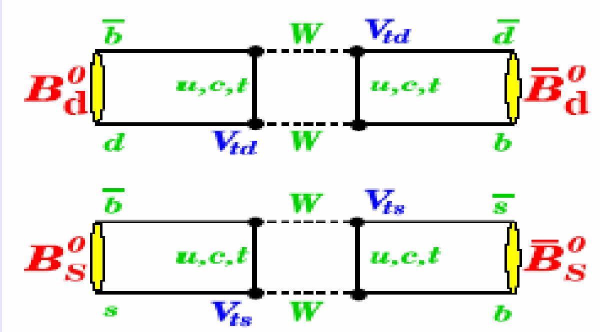
$B_s^0 - \overline{B_s^0}$



$K^0 - \overline{K^0}$

$D^0 - \overline{D^0}$

Sistemi $B_q^0 - \overline{B}_q^0$ (q=d,s)



Tarantino

$$\hat{H} = \hat{M} - \frac{i}{2}\hat{\Gamma}$$

$$\hat{M} = \begin{pmatrix} M_{11} & M_{12} \\ M_{12}^* & M_{11} \end{pmatrix} \qquad \hat{\Gamma} = \begin{pmatrix} \Gamma_{11} & \Gamma_{12} \\ \Gamma_{12}^* & \Gamma_{11} \end{pmatrix}$$

Oscillazione Decadimento

Autostati: $|B_q^{L,H}\rangle = p_q |B_q^0\rangle \pm q_q |\overline{B}_q^0\rangle$

Osservabili Fisiche:

$$\Delta m_q = 2|M_{12}^q| \qquad \Delta\Gamma_q = -2|M_{12}^q| \mathrm{Re}\left(\frac{\Gamma_{12}^q}{M_{12}^q}\right)$$

$$\tau_{B_q}^{-1} = \Gamma_{B_q} = \Gamma_{11}^q \qquad A_{SL}^q = -2(|q/p|_q - 1) = \mathrm{Im}\left(\frac{\Gamma_{12}^q}{M_{12}^q}\right)$$

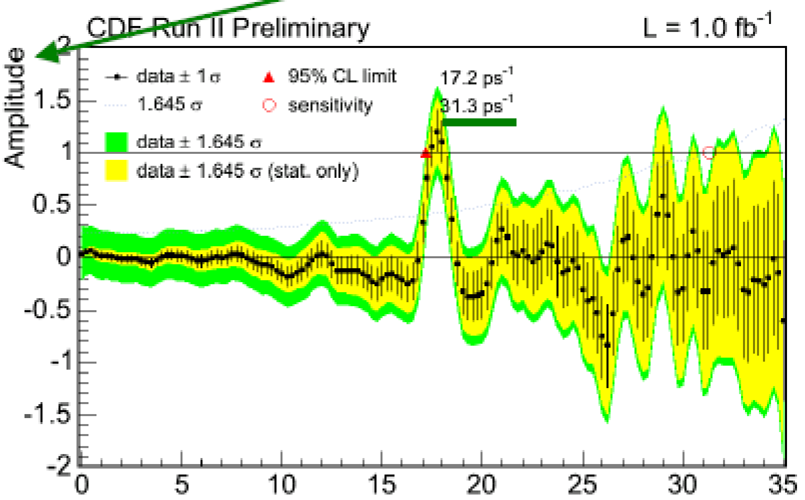
Γ_{12}^q descrive il decadimento (solo in particelle dello SM) → Insensibile a NP

M_{12}^q descrive l'oscillazione tramite i diagrammi a box → Sensibile a NP → $M_{12}^q = (M_{12}^q)_{SM} C_{B_q} e^{2i\varphi_{B_q}}$

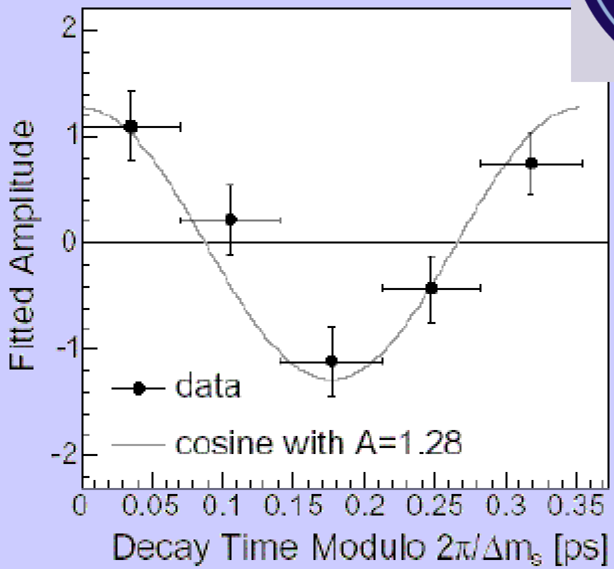
Δm_s @ CDFII - Result

[CDF Collaboration; PRL 97, 242003 2006]

$$P(t;A)_{B_s\to\bar{B}_s} = \frac{1}{2\tau}e^{-\frac{t}{\tau}}(1\pm A\cos(\Delta m_s t))$$



$\Delta m_s = 17.77 \pm 0.10(\text{stat}) \pm 0.07(\text{sys})$



Compatible with SM prediction:
$\Delta m_s^{SM} = 19.30\pm 6.68$ ps^{-1}
[Lenz, Nierste; hep-ph/0612167]

Pagan Griso

$$\frac{|V_{td}|}{|V_{ts}|} = 0.2060 \pm 0.0007(\text{exp})\,^{+0.0081}_{-0.0060}(\text{theor})$$

Recent measurements from the Tevatron $\Delta\Gamma_s$, Γ_s and ϕ_{Bs}

$\Delta\Gamma_s$, ϕ_s and the SM

Redo $B_s \to J/\Psi\phi$ fit with the constraint

$$\Delta\Gamma_s \cdot \tan\phi_s = A^s_{SL} \cdot \Delta m_s$$

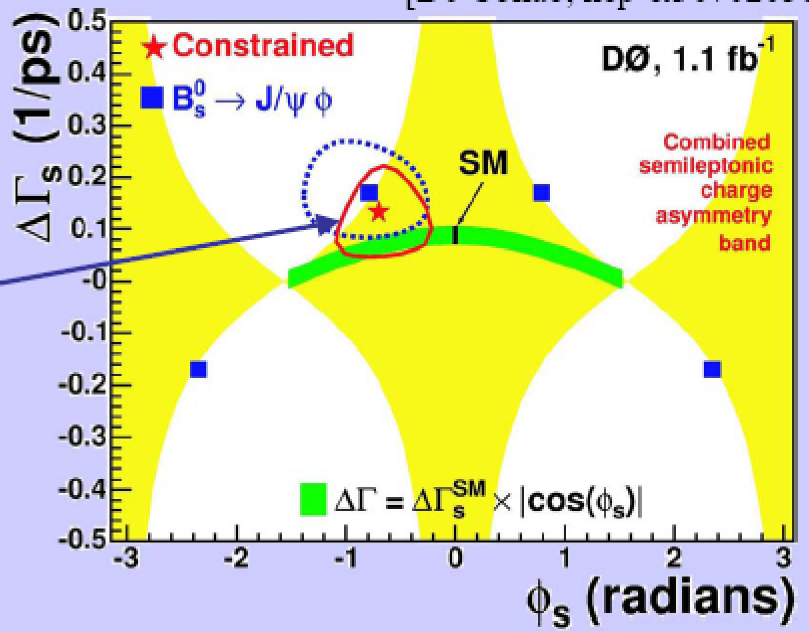
$$A^{s,combined}_{SL} = 0.0001 \pm 0.0090$$

[D0 Collab, hep-ex/0702030]

Fit results:

$$\Delta\Gamma_s = 0.13 \pm 0.09\, ps^{-1}$$

$$\phi_s = -0.70^{+0.47}_{-0.39}$$



Pagan Griso

SM still compatible, but room for new physics!

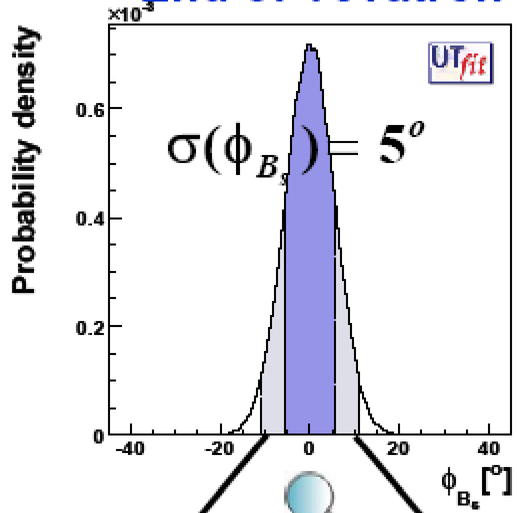
$$A^s_{fs} = \mathrm{Im}\frac{\Gamma_{12}}{M_{12}}$$

Γ_{12}^q descrive il decadimento (solo in particelle dello SM) → Insensibile a NP

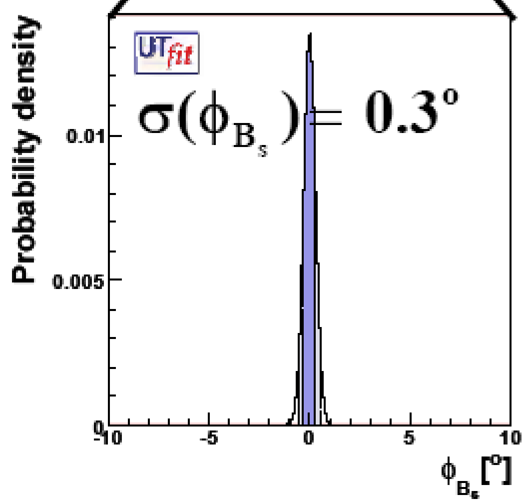
M_{12}^q descrive l´oscillazione tramite i diagrammi a box → Sensibile a NP → $M^q_{12} = (M^q_{12})_{SM} C_{B_q} e^{2i\varphi_{B_q}}$

Perspectives in the (not-so-far) future

End of Tevatron



Vagnoni



Relevant impact of LHCb on the B_s mixing phase and on γ

- can bring down the sensitivity to the NP contribution ϕ_{Bs} from 5° at the end of the Tevatron to 0.3°
- γ will be known at about 2°

With LHCb at L=10 fb^{-1} (around 2014)

Significant improvements in the B_d sector expected at a SuperB-Factory

Medie sperimentali:

$\frac{\Delta\Gamma_d}{\Gamma_d} = (9 \pm 37) \cdot 10^{-3}$, $\frac{\Delta\Gamma_s}{\Gamma_s} = (14 \pm 6) \cdot 10^{-2}$ [Media mondiale inufficiale, talk di R.Van Kooten@FP&CP2006]

[HFAG, 2006]

	Base vecchia	Base nuova
$\frac{\Delta\Gamma_d}{\Gamma_d}$	$2.3(8)10^{-3}$	$4.1(6)10^{-3}$
$\frac{\Delta\Gamma_s}{\Gamma_s}$	$7(3)10^{-2}$	$13(2)10^{-2}$

Predizione teoriche aggiornate: Media basi vecchia e nuova + incertezza stimata dallo shift

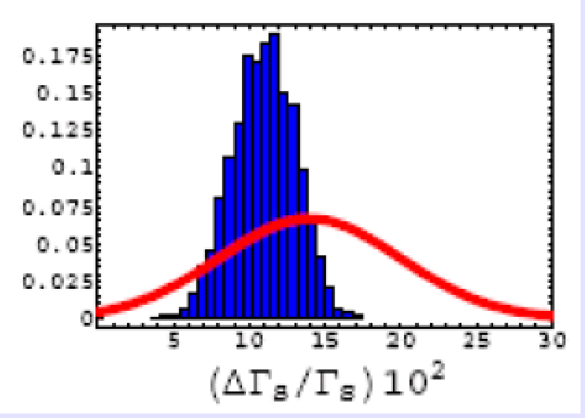
$$\frac{\Delta\Gamma_d}{\Gamma_d} = (3.6 \pm 1.0) \cdot 10^{-3}, \quad \frac{\Delta\Gamma_s}{\Gamma_s} = (11 \pm 4) \cdot 10^{-2}$$

[C.T.,hep-ph/0702235]

Lenz e Nierste trovano $(12.7\pm2.4)\cdot10^{-2}$: Ottimo accordo!

Le incertezze non-perturbative hanno un impatto minore nella nuova base

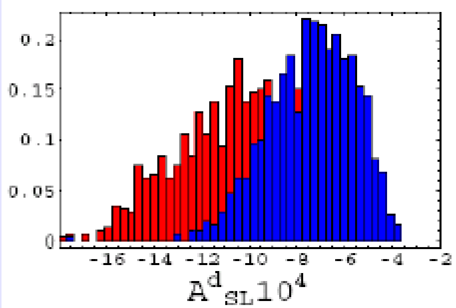
th. vs exp.

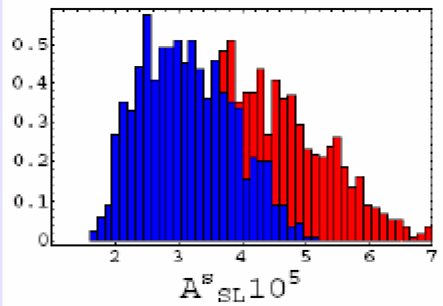


Tarantino: SM predictions

Asimmetrie Semileptoniche

Distr. NLO vs Distr. LO





Medie sperimentali:

$A^d_{SL} = -(30 \pm 78) \cdot 10^{-4}$, $A^s_{SL} = (2450 \pm 1930(\text{stat.}) \pm 350(\text{syst.})) \cdot 10^{-5}$

[HFAG, 2006] [D0, 2006]

Predizioni teoriche al NLO + contributo di $O(1/m_b^4)$:

$A^d_{SL} = -(6.4 \pm 1.6) \cdot 10^{-4}$, $A^s_{SL} = (2.7 \pm 0.6) \cdot 10^{-5}$

[M.Ciuchini, E.Franco, V.Lubicz, F.Mescia, C.T., 2003]

Nelle combinazioni di coefficienti di Wilson che intervengono qui, il cambio di base non aiuta

	Base vecchia	Base nuova
A^d_{SL}	$-6.4(16)10^{-4}$	$-6.6(17)10^{-4}$
A^s_{SL}	$2.7(6)10^{-5}$	$2.8(6)10^{-5}$

$\Delta F=2$ oscillations New Physics Searches/Constraints

Two General Strategies

Model-independent fits

$$C_q e^{2i\phi_q} = \frac{\langle F | H_{eff}^{full} | F \rangle}{\langle F | H_{eff}^{SM} | F \rangle}$$

In the CKM fit, we fix ρ, η, C_{Bq}, ϕ_{Bq}, $C_{\varepsilon K}$ and $C_{\Delta mK}$ simultaneously, assuming no NP on tree-level processes

Vagnoni - UtFit

Explicit Models

MSSM-(MFV) at small $\tan\beta$

Guadagnoli

MFV at large $\tan\beta$

Paradisi

Bounds on the mixing phases

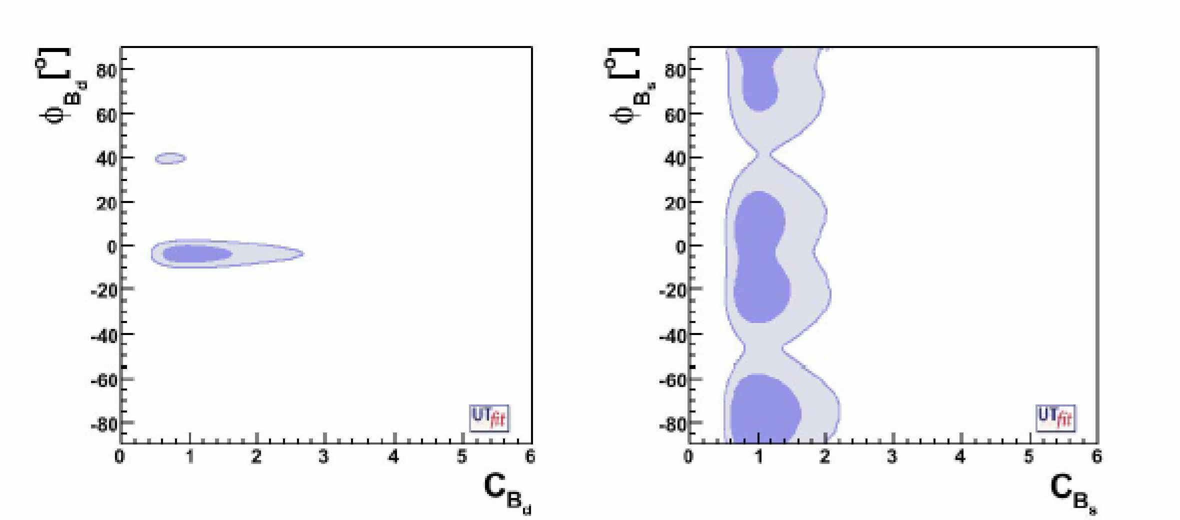
B_d mixing:

ϕ_{Bd}= (-4±2)°

B_d mixing phase very well contrained but still ample room for a large B_s phase

B_s mixing:

ϕ_{Bs}=(-75±14)° U (-19±11)° U (9±10)° U (102±16)°



New Physics scales (lower bounds) Perspectives for detection at LHC

$\Lambda_{\rm flav}$

	strong/tree	α_s loop	α_W loop
MFV (small $\tan\beta$)	5.5 TeV	0.5 TeV	0.2 TeV
MFV (large $\tan\beta$)	5.1 TeV	0.5 TeV	0.2 TeV
Higgses in MFV at large $\tan\beta$	870 GeV (loop-mediated)		
NMFV	12 TeV	1.2 TeV	0.4 TeV
General	2600 TeV	260 TeV	90 TeV

Vagnoni - UtFit

$$\mathcal{H}_{\rm eff}^{B_q-\bar{B}_q} = \sum_{i=1}^{5} C_i Q_i^{bq} + \sum_{i=1}^{3} \tilde{C}_i \tilde{Q}_i^{bq} \qquad C_i(\Lambda) = F_i \frac{L_i}{\Lambda^2}$$

$\Lambda_{\rm flav}$

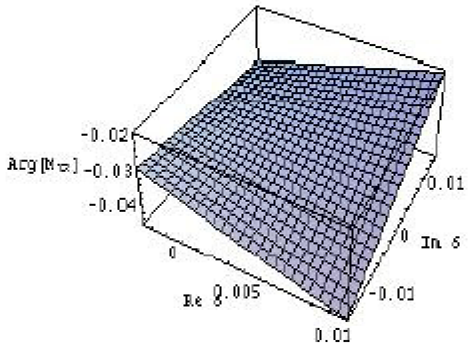
- F_i: function of the NP flavour couplings
- L_i: loop factor (in NP models with no tree-level FCNC)
- Λ: NP scale (typical mass of new particles mediating $\Delta F=2$ transitions)

- Minimal Flavour Violation with one Higgs or two Higgs doublets with small or moderate tanβ
  - $F_1 = F_{SM}$, $F_{i\neq1} = 0$, where F_{SM} are CKM matrix elements in the top-quark mediated SM mixing amplitudes
- Minimal Flavour Violation at large tanβ
  - Additional contribution in B_q mixing by C_4 which differentiates B-meson mixing from Kaon mixing
- Next-to-Minimal Flavour Violation
  - $|Fi| = F_{SM}$ with arbitrary phases
- Arbitrary flavour structure, i.e. no CKM suppression in NP transitions
  - $|Fi| \sim 1$

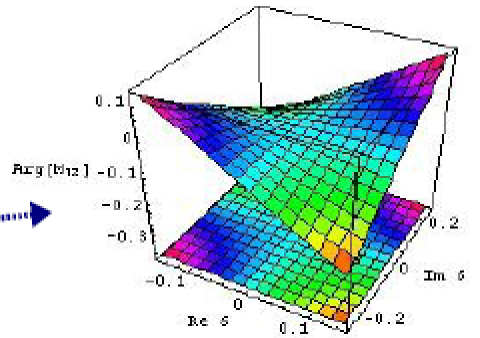
Implication on the B_s – mixing phase

✔ In the SM one has $Arg\, M_{12}^{SM} \equiv Arg\{\langle \bar{B}_s | H_{eff,\,SM}^{\Delta B,\,S=2} | B_s \rangle\} = 2\lambda^2 \eta \simeq 0.04$

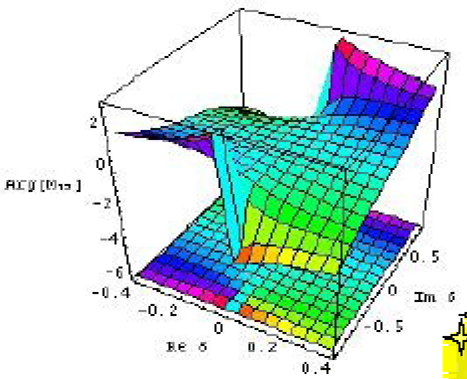
☞ What is the allowed range for $Arg\, M_{12}^{MSSM}$ with the previous limits on the δ's ?



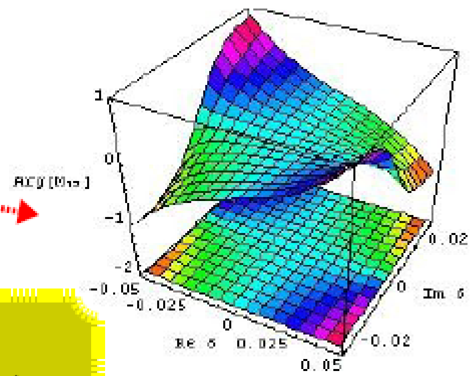
LR only, tan β=3
no sizable deviations
from the SM



LL only, tan β=3
~ 10 × SM value are allowed



RR only, tan β=3
~ 100 × SM value are easy to get
(but RR is still mildly constrained...)



LL=RR, tan β=3
~ 100 × SM value are again easy
(yet LL=RR is severely constrained!)

The CP asymmetry in $B_s \to \psi\phi$
will provide a truly fantastic probe!

D.Guadagnoli, IFAE 07, April 11-13, 2007

Guadagnoli

2. Decadimenti radiativi:

- $b \rightarrow s\gamma$

- Decadimenti leptonici
  - $B \rightarrow \tau\nu$
  - $B \rightarrow e/\mu\ \nu$
- Decadimenti semileptonici
  - $B \rightarrow K^{(*)}ll$
  - $B \rightarrow \pi ll$

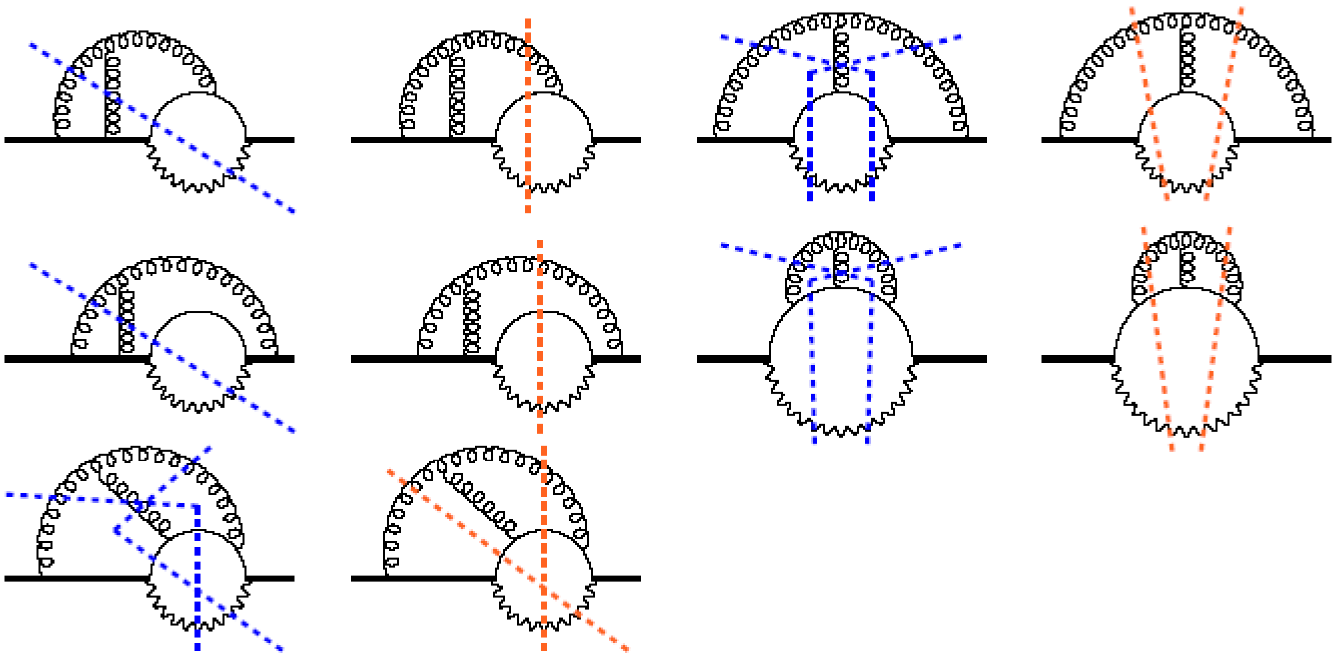
Talk da Babar,CDF,Atlas nella sessione

THEORY PROGRESS

$\overline{B} \to X_s\gamma$ AT NNLO IN THE SM

Bieri, Greub, Steinhauser ('03), Misiak, Steinhauser ('04), Gorbahn, Haisch ('04), Gorbahn, Haisch, Misiak ('05), Melnikov, Mitov ('05), Blokland, Czarnecki, Misiak, Slusarczyk, Tkachov ('05), Asatrian, Hovhannisyan, Poghosyan, Ewerth, Greub, Hurth ('06), Asatrian, Ewerth, AF, Gambino, Greub ('06), Czakon, Haisch, Misiak ('06)

some of the contributions



Ferroglia

EXPERIMENTAL VALUE ($E_\gamma > 1.6\,\mathrm{GeV}$)

$$\mathcal{B}\left(\overline{B} \to X_s\,\gamma\right) = (3.55 \pm 0.24^{+0.09}_{-0.10} \pm 0.03) \times 10^{-4}$$

7%

NNLO ESTIMATE ($E_\gamma > 1.6\,\mathrm{GeV}$)

$$\mathcal{B}\left(\overline{B} \to X_s\,\gamma\right) = (3.15 \pm 0.23) \times 10^{-4}$$

Misiak *et al.*

The result is lower than the NLO results and it is about 1σ lower than the experimental average

Uncertainties: non-perturbative (5%), parametric (3 %), higher order (3%), m_c interpolation ambiguity (3 %)

Combined experimental error $\longrightarrow$ same size as the expected NNLO QCD corrections to $\Gamma(b \to X_s\,\gamma)$, larger than the non-perturbative corrections

$b \to s\gamma$: risultati

Challenging !

BR x 10^{-6} (estrapolato a Eγ>1.6 GeV)

349 ± 20 (stat) $^{+59}_{-46}$ (syst) $^{+4}_{-3}$ (shape) — semi-inclusiva 81.5 fb^{-1}

392 ± 31(stat) $\pm$ 36(syst) $\pm$ 30(th) $\pm$ 4(shape) $\pm$ 6(dγ) — inclusiva 81.5 fb^{-1}

369 ± 58 (stat) $\pm$ 46 (syst) $^{+56}_{-60}$ (shape) — semi-inclusiva 5.8 fb^{-1}

350 ± 32 (stat) $^{+30}_{-31}$ (syst) $\pm$ 2(shape) $\pm$ 2(dγ) — inclusiva 140 fb^{-1}

Recenti calcoli al NNLO hanno ridotto il valore della predizione S.M.: [c.f. NLO prediction was $(3.57 \pm 0.30) \times 10^{-4}$]

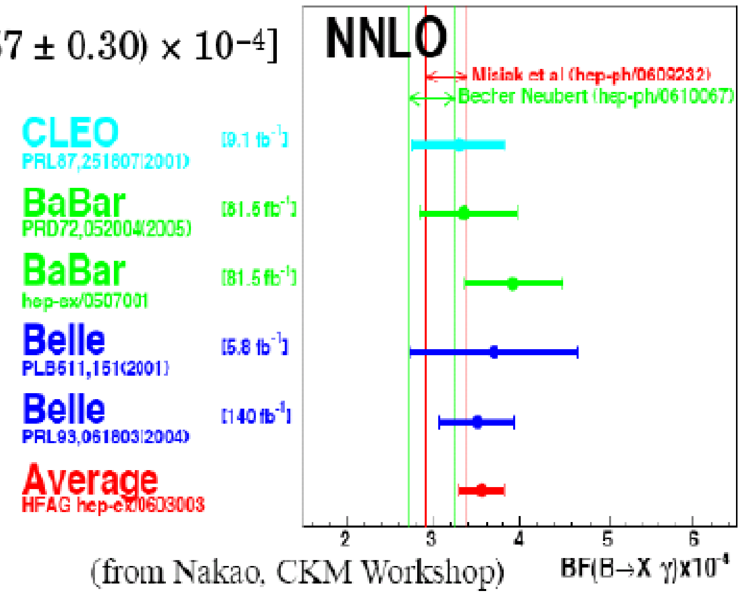
$\mathcal{B}(B \to X_s\gamma) = (3.15 \pm 0.23) \times 10^{-4}$ PRL 98, 022002

$\mathcal{B}(B \to X_s\gamma) = (2.98 \pm 0.26) \times 10^{-4}$ PRL 98, 022003

Media delle misure sperimentali

$$\mathrm{BR} = (3.55 \pm 0.24_{exp}{}^{+0.09}_{-0.10}{}_{shape} \pm 0.03_{d\gamma}) \times 10^{-4}$$

Misure con più statistica e minori incertezze sistematiche sono attese per verificare se questa differenza può essere attribuita a Nuova Fisica



(from Nakao, CKM Workshop)

Monorchio (babar)

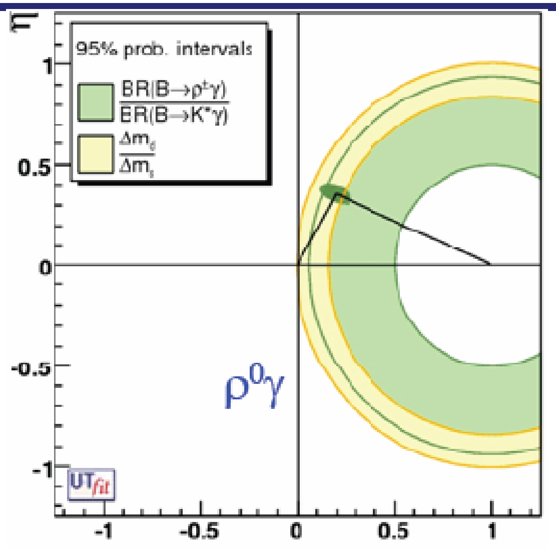
Determinazione di $|V_{td}/V_{ts}|$

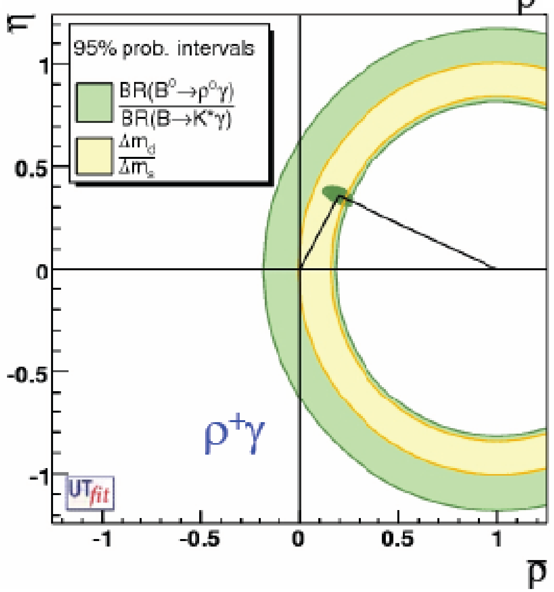
		B.F. (10^{-6})	significance
$B^- \to \rho^-\gamma$		$0.55^{+0.42+0.09}_{-0.36-0.08}$	(1.6σ)
		$1.10^{+0.37}_{-0.33} \pm 0.09$	(3.8σ)
$B^0 \to \rho^0\gamma$		$1.25^{+0.37+0.07}_{-0.33-0.06}$	(5.2σ)
		$0.79^{+0.22}_{-0.20} \pm 0.06$	(4.9σ)
$B^0 \to \omega\gamma$		$0.56^{+0.34+0.05}_{-0.27-0.10}$	(2.3σ)
		$0.40^{+0.24}_{-0.20} \pm 0.05$	(2.2σ)

- Dai rapporti BR($B \to \rho\gamma$)/BR($B \to K^*\gamma$) :
- $|V_{td}/V_{ts}|\rho^0\gamma = 0.23 \pm 0.02$
- $|V_{td}/V_{ts}|\rho^+\gamma = 0.17 \pm 0.03$
- Ottimo accordo col valore determinato dalle misure di mixing:

$$\left|\frac{V_{td}}{V_{ts}}\right|_{\Delta m_d/\Delta m_s} = 0.2060 \pm 0.0007^{+0.0081}_{-0.0060}$$

CDF Phys.Rev.Lett.97:242003 (2006)

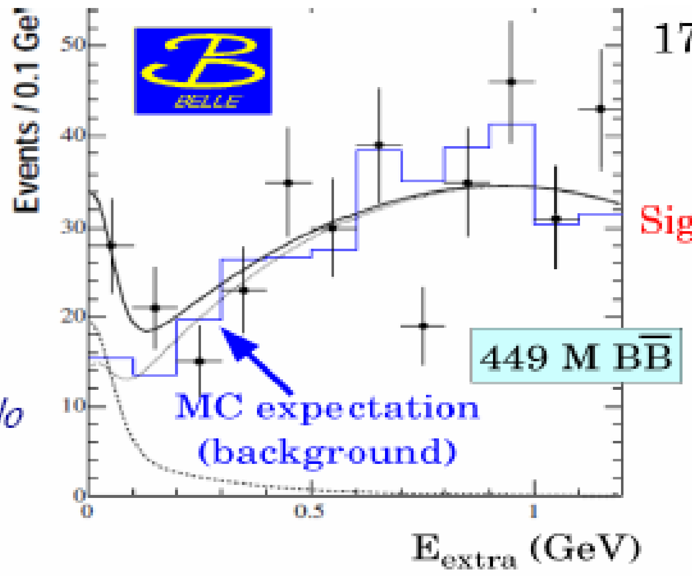




Monorchio (babar)

$B \to \tau\nu$: risultati

PRL 97 251802 (2006)



$17.2^{+5.3}_{-4.7}$ events

Significance 3.5σ

Tag adronico

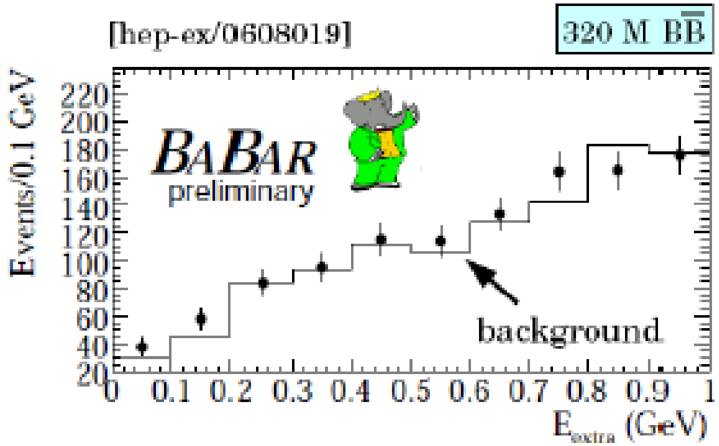
Fit di likelihood ad E_{extra}

$$\mathcal{B} = (1.79^{+0.56}_{-0.49}\,{}^{+0.39}_{-0.46}) \times 10^{-4}$$

$$f_B = 0.229\,{}^{+0.036}_{-0.031}\,{}^{+0.034}_{-0.037}\ \text{GeV}$$

Consistente con calcoli di QCD su reticolo

$f_B = 216 \pm 22$ MeV



Tag semileptonico

Likelihood ratio combina le probabilità poissoniane dei singoli canali

Segnale consistente con zero a 1.3σ

$$\mathcal{B} = (0.88^{+0.68}_{-0.67} \pm 0.11) \times 10^{-4}$$

$< 1.80 \times 10^{-4}$ @ 90% C.L.

BaBar ha anche pubblicato una misura di U.L. con tag adronico su un campione di ~90M BB

$\mathcal{B}(B \to \tau\nu) < 4.2 \times 10^{-4}$ @ 90% CL

L'update di questa misura ad un campione di più elevata statistica è atteso a breve.

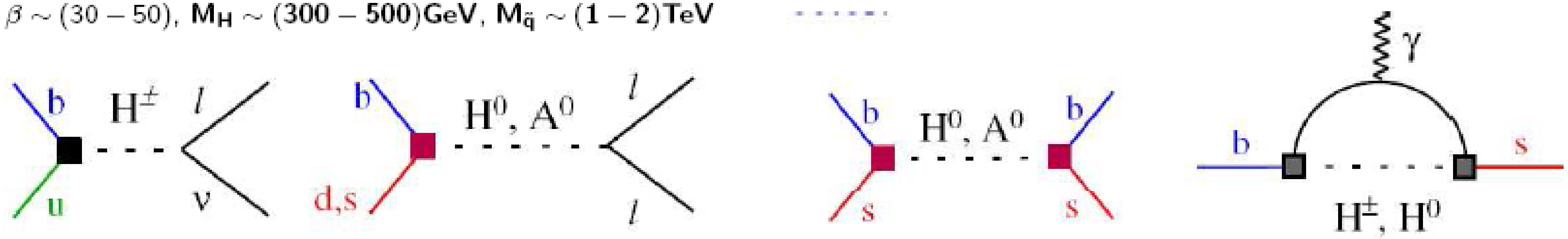
Monorchio (babar)

New Physics Searches/Constraints

Phenomenology of MFV at large $\tan\beta$

D'Ambrosio *et al.*, '02

$\tan\beta \sim (30-50)$, $M_H \sim (300-500)$GeV, $M_{\tilde{q}} \sim (1-2)$TeV



$B^\pm \to l^\pm \nu$ — $\sim (10-30)\%$ suppression

$B_{s,d} \to l^+ l^-$ — up to $10\times$ enhancement

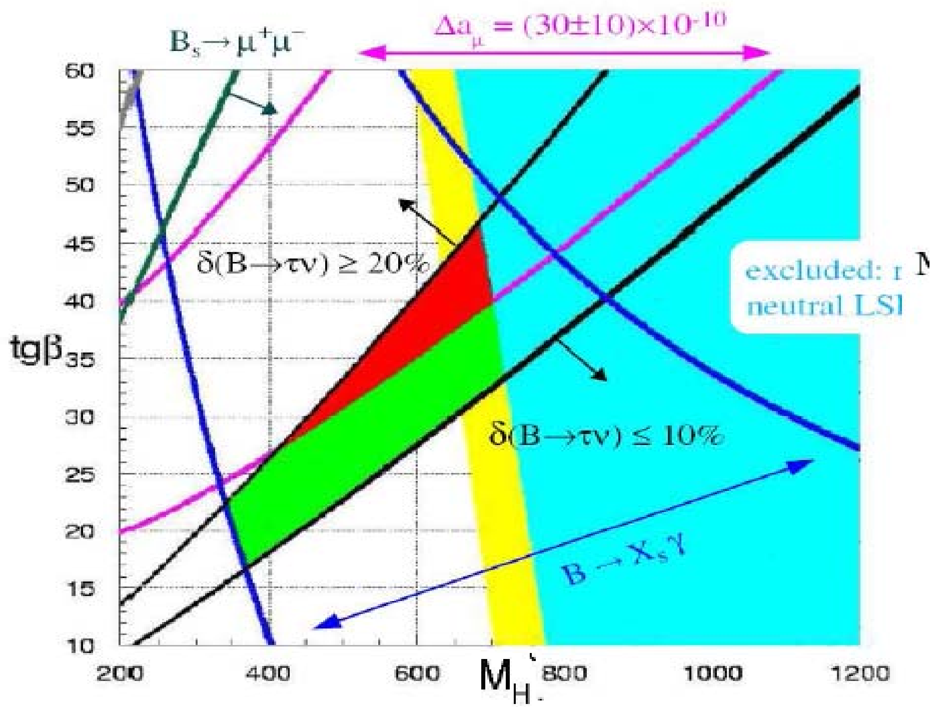
ΔM_{B_s} — $\sim (0-10)\%$ suppression

$B \to X_s \gamma$ — up $\sim (0-20)\%$ enhancement

No significant deviations from SM, but the +/- pattern looks consistent with present data

- $B \to X_s\gamma$: $[1.01 < R_{Bs\gamma} < 1.24]$
- a_μ : $[2 < 10^{-9}(a_\mu^{exp} - a_\mu^{SM}) < 4]$
- $B \to \mu^+\mu^-$: $[\mathcal{B}^{exp} < 8.0 \times 10^{-8}]$
- ΔM_{B_s} : $[\Delta M_{B_s} = 17.35 \pm 0.25\ \mathrm{ps}^{-1}]$
- $B \to \tau\nu$: $[0.8 < R_{B\tau\nu} < 0.9]$

Paradisi

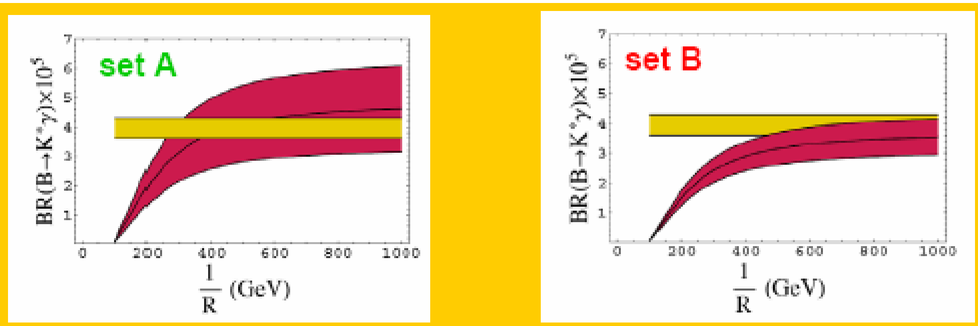


Probing Universal Extra Dimensions through rare B decays

Minimal Flavour Violation
(no new operators; CKM matrix)

It is possible to establish a lower bound on 1/R by comparing theoretical predictions with experimental data.

$B \to K^* \gamma$



set A allows to put $\frac{1}{R} > 300$ GeV

set B allows to put $\frac{1}{R} > 400$ GeV

Bound from $\bar{B} \to X_s \gamma$: $\frac{1}{R} > 600$ GeV

Haisch et al., hep-ph/0703064

Ferrandes

New physics on the flavour sector

Do' scappi!

LFV

- *zero in the SM*

μ→eγ

MEG

Ottobre 2007

Dussoni (MEG)

Lepton Universality in K and B

SM tree-level contribution accessible to very high precision

Paradisi

Monorchio (babar)

Rare K decays:

- *e.w loops*
- highest CKM suppression
- $\Delta S=1$ coupling→ like ε'/ε
- very clean→ like $sin2\beta$

Giugno 2007

Lamanna (P326)

B rare Decays

$B_d \rightarrow \mu\mu$

$B_s \rightarrow \mu\mu$

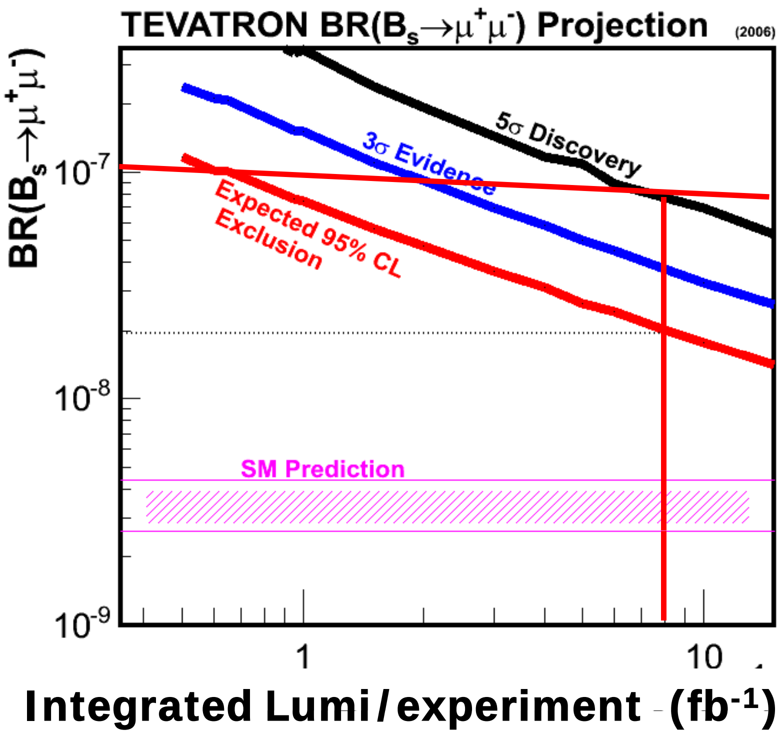
Tonelli CDF

Monorchio (babar)

Policicchio (Atlas/CMS)

Bonivento (Lhcb)

B rare Decays

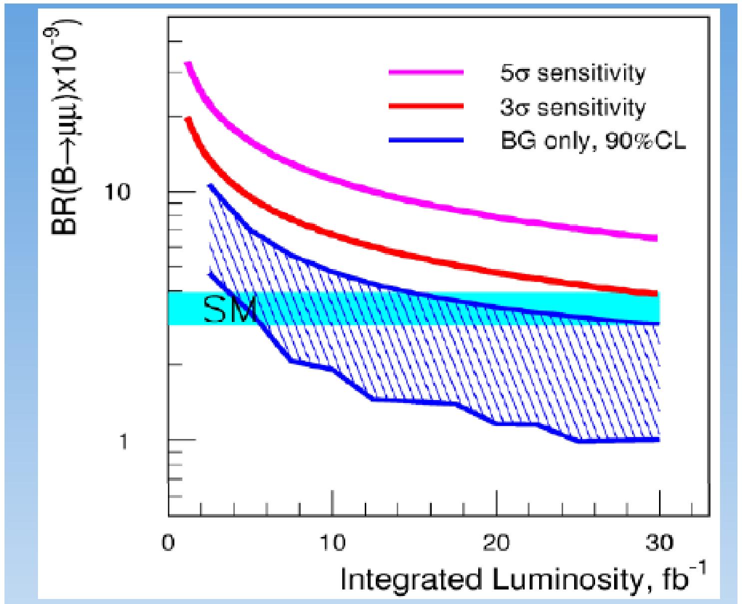


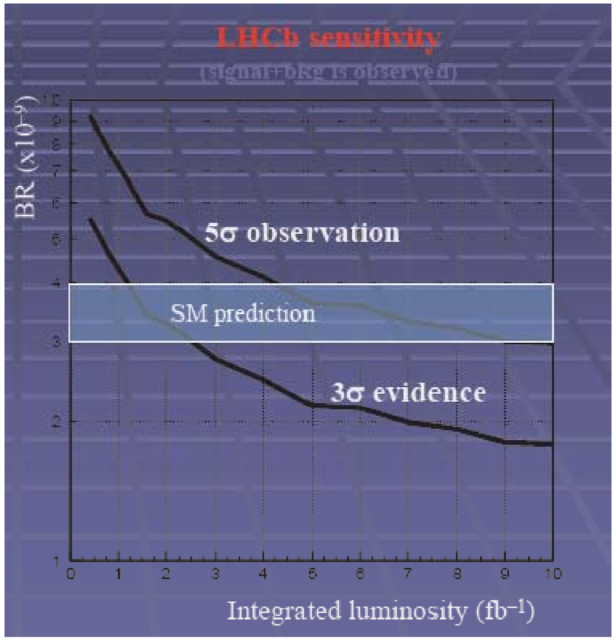
$B_s \to \mu\mu <= 8\ 10^{-8}$

Molte chance di uccidere $B_s \to \mu\mu$

SUSY -> $B_s \to \mu\mu\ 10^{-8}$

SM -> $B_s \to \mu\mu = 3\ 10^{-9}$





principali differenze costruttive tra MEG e MEGA

- campo disuniforme anziche' solenoidale
- calorimetria diretta del fotone (Lxe) anziche' conversione in e-e+

inoltre, miglioramento delle prestazioni dei singoli rivelatori

MIGLIORAMENTO DEL LIMITE SU

$\mathcal{B}_{\mu\to e\gamma}$

DI ~~QUASI TRE~~ ORDINI DI GRANDEZZA

DUE

$\mu\to e\gamma <= 1.2\ 10^{-11}$

Exp./Lab	Year	$\Delta E_e/E_e$ (%)	$\Delta E_\gamma/E_\gamma$ (%)	$\Delta t_{e\gamma}$ (ns)	$\Delta\theta_{e\gamma}$ (mrad)	Stop rate (s^{-1})	Duty cyc. (%)	BR (90% CL)
SIN	1977	8.7	9.3	1.4	-	5×10^5	100	3.6×10^{-9}
TRIUMF	1977	10	8.7	6.7	-	2×10^5	100	1×10^{-9}
LANL	1979	8.8	8	1.9	37	2.4×10^5	6.4	1.7×10^{-10}
Crystal Box	1986	8	8	1.3	87	4×10^5	(6..9)	4.9×10^{-11}
MEGA	1999	1.2	4.5	1.6	17	2.5×10^8	(6..7)	1.2×10^{-11}
MEG	2006	0.8	4	0.15	19	2.5×10^7	100	1×10^{-13}

$\mu\to e\gamma$

MEG

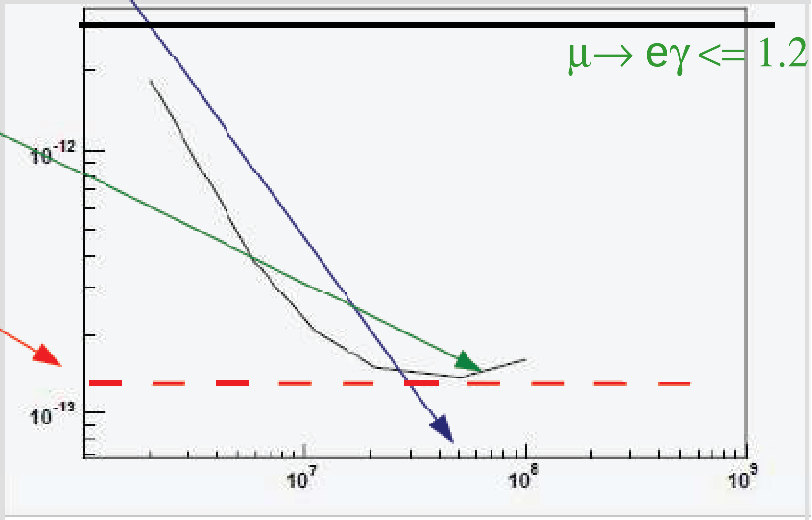
Rivelatore molto ambizioso come prestazioni

Dussoni (MEG)

Dussoni (MEG)

Andamento della sensibilita' in funzione del tempo di misura, nel caso di mancata osservazione del decadimento limite superiore):

- andamento decrescente fino a ~2 anni di presa dati
- a questo punto, saturazione dovuta al background con peggioramento della misura
- limite massimo: ~ 1.2×10^{-13}

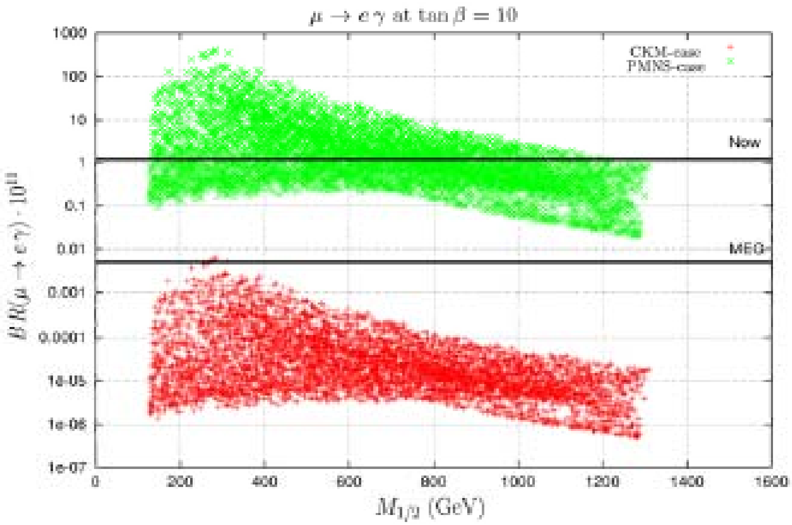


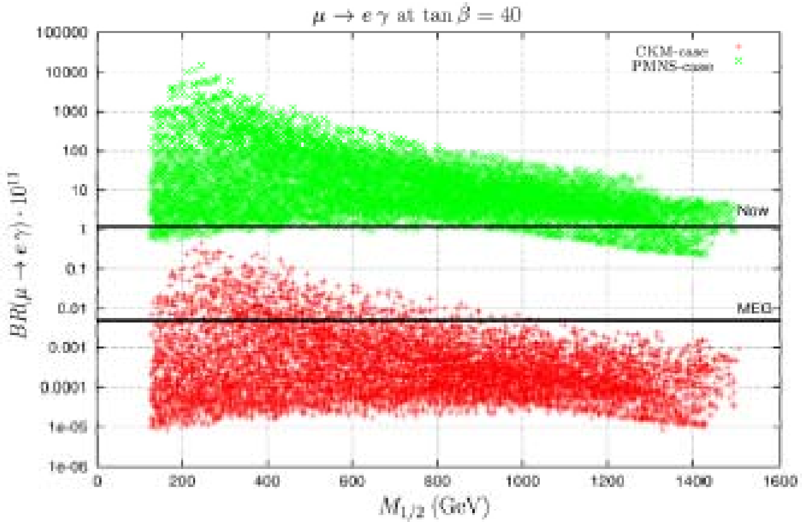
1 ordine di grandezza meglio del current limit dopo 1 mese di presa dati

$\mu \rightarrow e\gamma <= 1.2\ 10^{-11}$

Ottobre 2007

$\mu \to e\,\gamma$ and **MEG** sensitivity reach



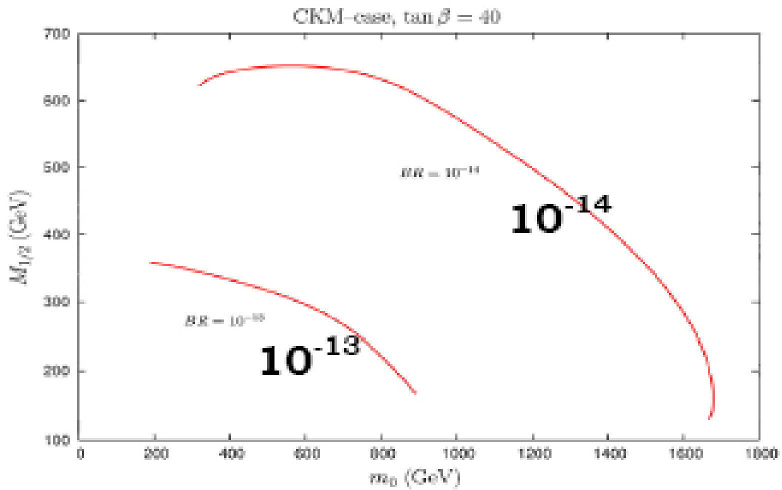


- Maximal mixing (PMNS), high tanβ case, already ruled out in the LHC accessible region.

MEG will test it well beyond the LHC.

- Minmal case (CKM) presently unconstrained.

MEG will test, for high values of tanβ, the region $(m_0, m_{\tilde{g}}) \lesssim 1$ TeV

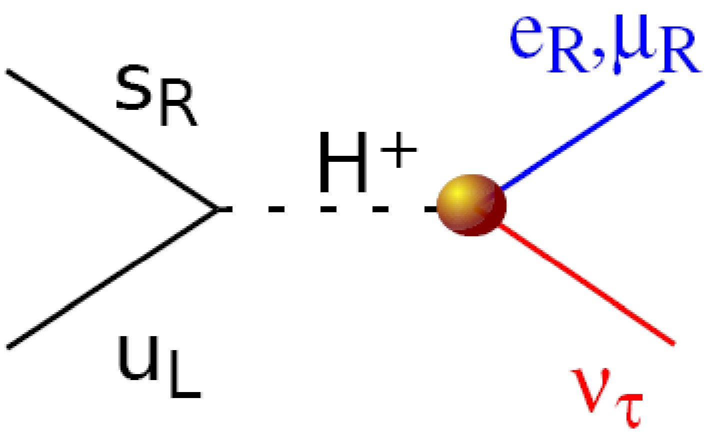


But in the PMNS case, the rate depends on $U_{e3}\ldots$

$$(\Delta_{LL})_{i\neq j} = -\frac{3m_0^2 + A_0^2}{16\pi^2} \sum_k Y_{\nu\,ik} Y^\dagger_{\nu\,kj} \ln\left(\frac{M_X^2}{M_{R_k}^2}\right)$$

$\mu - e$ universality in $M \to l\nu$

$$R_K = (1+\Delta r_K^{e-\mu}) = \frac{\sum_i K \to e\nu_i}{\sum_i K \to \mu\nu_i} \simeq \frac{\Gamma_{SM}(K \to e\nu_e) + \Gamma(K \to e\nu_\tau)}{\Gamma_{SM}(K \to \mu\nu_\mu)}$$



$$eH^\pm \nu_\tau \to \frac{g_2}{\sqrt{2}} \frac{m_\tau}{M_W} \Delta_R^{31} \tan^2\beta$$

$$\Delta_R^{31} \sim \frac{\alpha_2}{4\pi} \delta_{RR}^{31}$$

$$\Delta_R^{31} \sim 5 \cdot 10^{-4} \quad t_\beta = 40 \quad M_{H^\pm} = 500\mathrm{GeV}$$

$$\Downarrow$$

$$\Delta r_{K\,SUSY}^{e-\mu} \simeq \left(\frac{m_K^4}{M_{H^\pm}^4}\right)\left(\frac{m_\tau^2}{m_e^2}\right) |\Delta_R^{31}|^2 \tan^6\beta \approx 10^{-2}$$

Paradisi

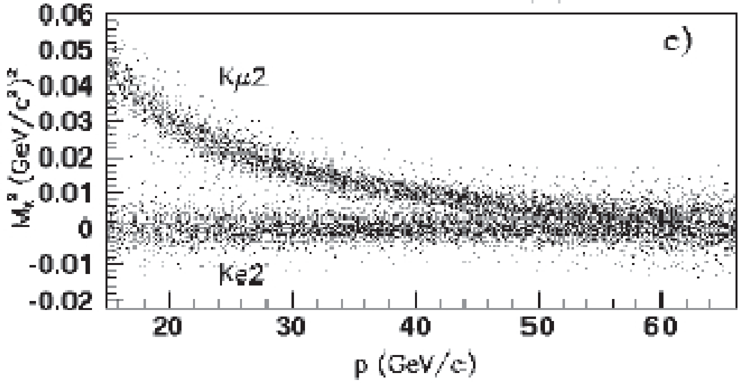
$$\Delta r_{K\,SUSY}^{e-\mu} \approx 10^{-2} \quad \Longrightarrow \quad Br^{th.(exp.)}(\tau \to eX) \leq 10^{-10(-7)}$$

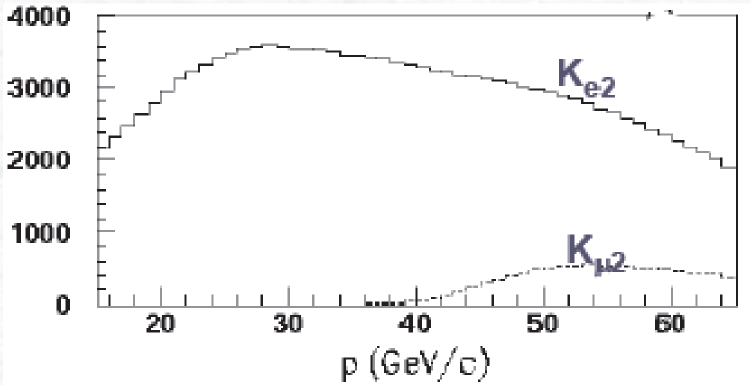
Masiero, P.P, Petronzio, Phys. Rev. D 74, 011701 (2006).

Ke2: Run 2007

Lamanna

- Migliore separazione cinematica con 75 GeV/c e dP/P=1.8 %
- Migliore risoluzione con aumento Pt_{Kick} del magnete (120 -> 263 MeV/c)
- Richiesti 120 giorni di Run (60% di efficienza dell'SPS): ~$1.6 \cdot 10^5$ spills (39.6/9.6 s)
- Con stesso trigger del MB 2004 attesi ~ 150.000 Ke2
- Miglioramenti nel trigger possibili usando condizioni sulla distribuzione dell'energia nel LKr e/o sulla presenza di tracce nello spettrometro





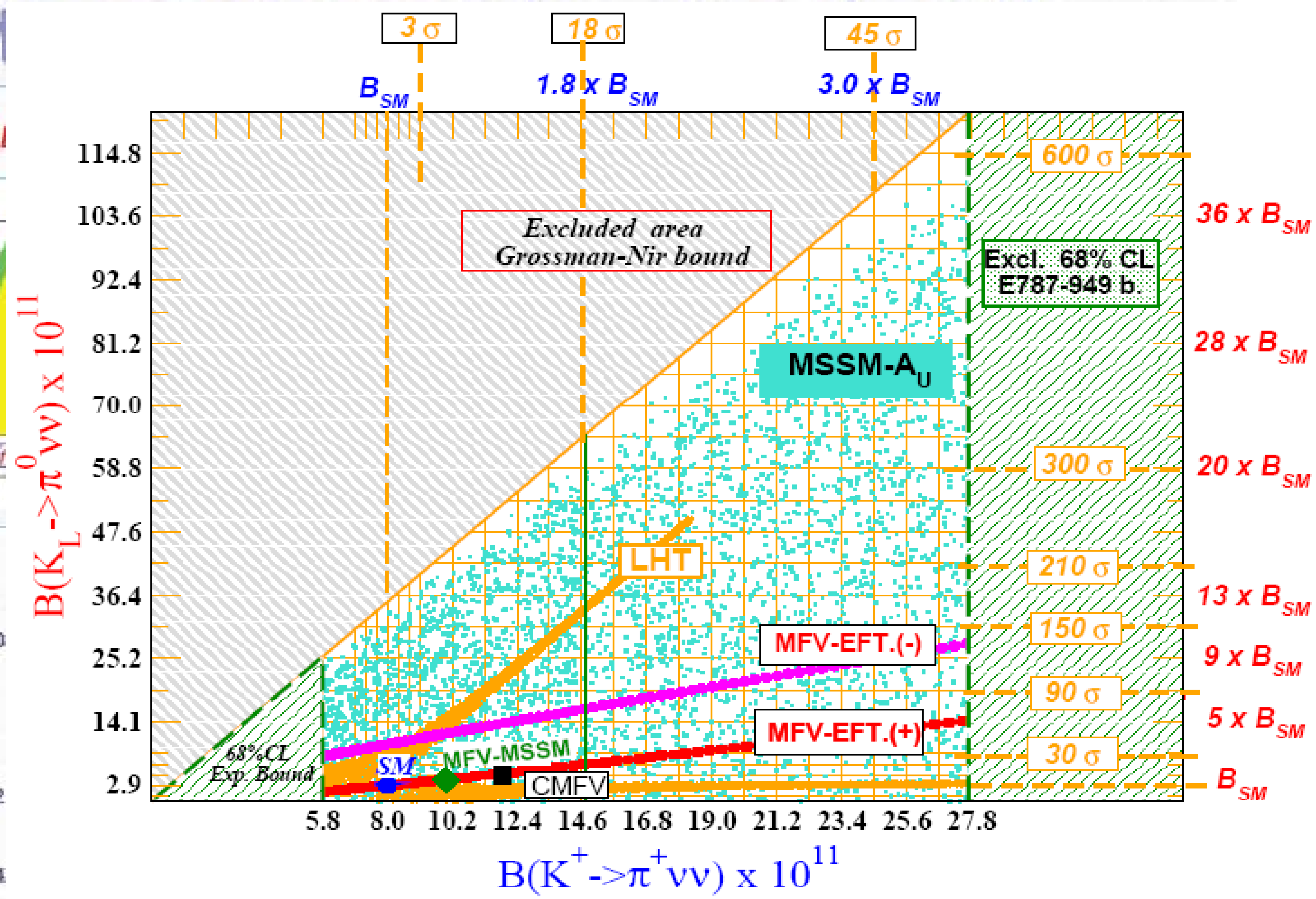
12.04.2007 Gianluca Lamanna

- Errore (statistico+trigger+sottrazione del fondo) su R_K~0.34%
- Piccolo contributo da altre sistematiche
- Ottima opportunità di osservare eventuali effetti di SUSY (per favorevoli valori dei parametri)

Effetti gia' 1%

P326 Mot

E787/E949: l



SM

MFV
hep-ph/031020

EEWP
NP B697 133

EDSQ
hep-ph/040702

MSSM
hep-ph/040814

e del

- Misura del rapporto R_K con un errore <1% (*approvato in presa dati dal 18/6 al 12/11*)
- Misura del BR di $K \to \pi\nu\bar{\nu}$ con circa 80 eventi (*in attesa di approvazione per run nel 2009-2010*)

Lamanna

Tau LFV decays: summary

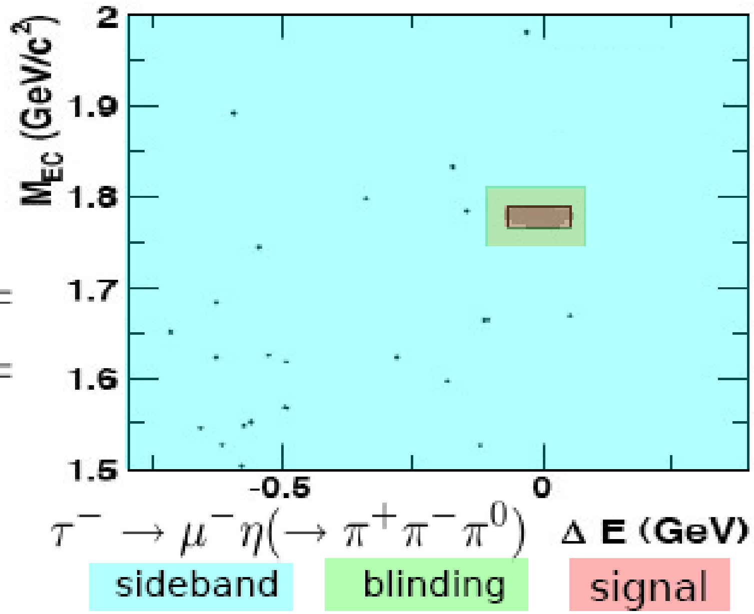
$$\tau^- \rightarrow l^-(\pi^0, \eta, \eta')$$

$$\tau^- \rightarrow h^-\overline{\Lambda^0}, h^-\Lambda^0$$

$\mathcal{B.R.}(\Lambda \rightarrow p\pi^-) = 0.639 \pm 0.005$

τ^- Decay	$\mathcal{U.L.}(10^{-7})$ @ 90% C.L.
$e^-\pi^0$	1.3
$\mu^-\pi^0$	1.1
$e^-\eta$	1.6
$\mu^-\eta$	1.5
$e^-\eta'$	2.4
$\mu^-\eta'$	1.4
$\overline{\Lambda^0}\pi^-$	0.59
$\Lambda^0\pi^-$	0.58
$\overline{\Lambda^0}K^-$	0.72
Λ^0K^-	1.5

NEW



$\tau^- \rightarrow \mu^-\eta(\rightarrow \pi^+\pi^-\pi^0)$

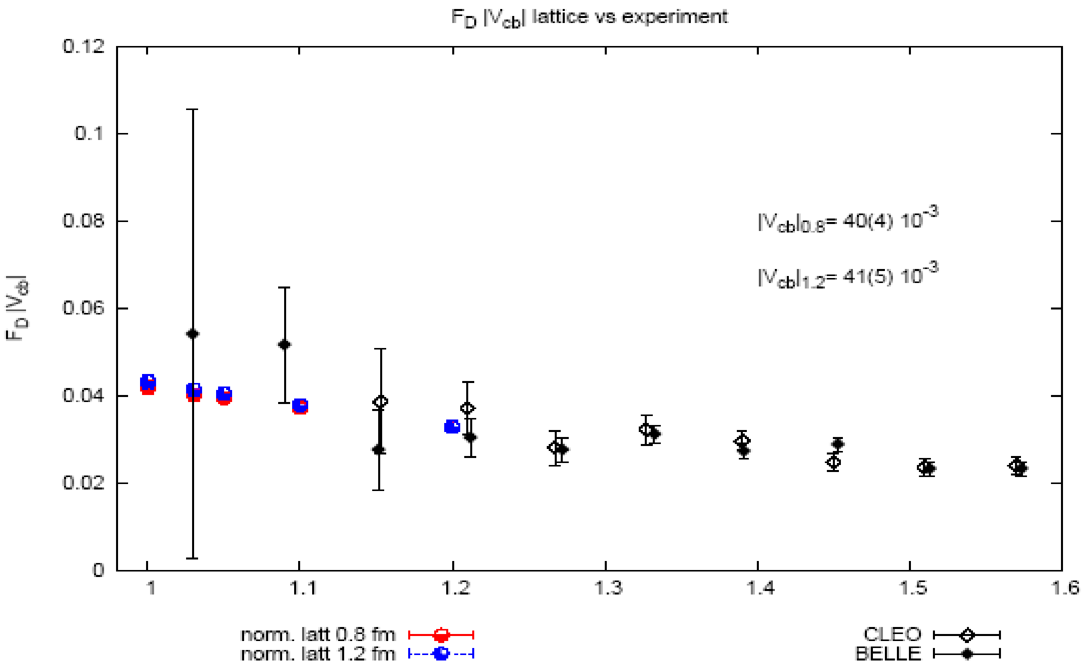
- Blinded analyses, 2D unbinned ML fit to estimate bkg from sidebands
- **Bkg for** $\tau^- \rightarrow l^-(\pi^0, \eta, \eta')$:
  $\tau^- \rightarrow e\nu_\tau\overline{\nu}_\tau\gamma, \rho\nu_\tau$
- **Bkg for** $\tau^- \rightarrow h^-\overline{\Lambda^0}, h^-\Lambda^0$:
  continuum, K_s and γ conversion

Some Prospects from theory side

Tantalo

the step scaling method, heavy-light mesons

V_{cb}



Ferrera – Di Giustino

Modelling non perturbative correction in inclusive B decays

Inclusive decays involve large logarithmic perturbative corrections and non perturbative effects. Large theoretical uncertainties arise from the modeling these effects.
We propose a general model based on NNLL threshold resummation and on an effective QCD coupling which we have tested with precise LEP and SLD data. It reproduce with good accuracy the experimental data of the B-factories.

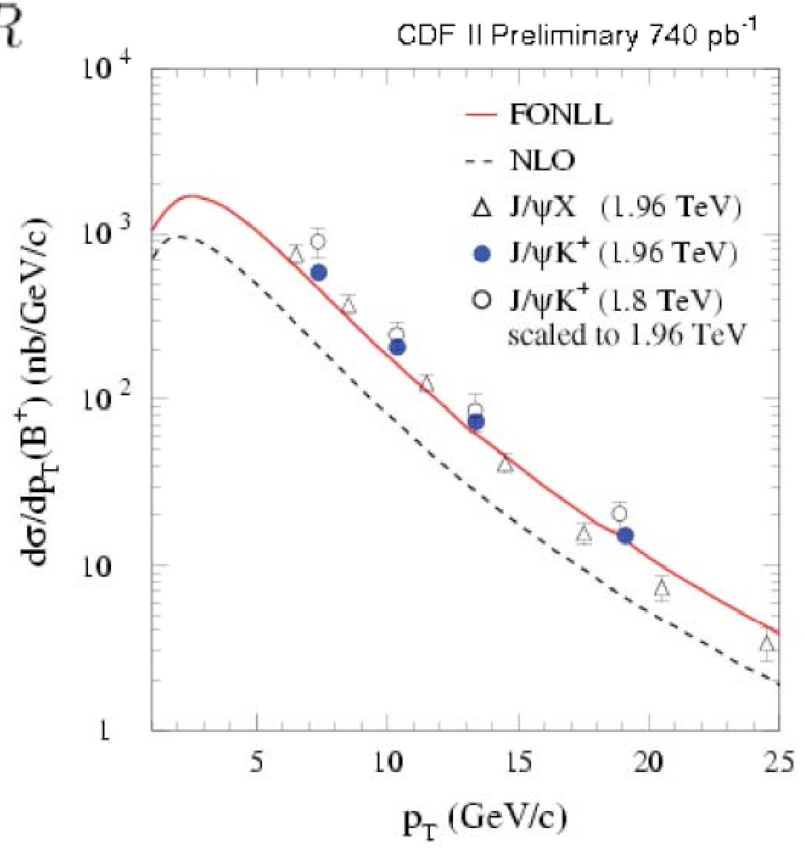
V_{ub}

$$\frac{d\sigma(B^+)}{dp_T} = \frac{N/2}{\Delta p_T \times \mathcal{L} \times \mathcal{A}_{\rm corr} \times BR}$$

$\sigma_{B^+}(p_T \geq 6$ GeV/c, $|y| < 1) =$ (2.78 ± 0.24) μb (4% stat)

R = 2.80 ± 0.24 (NLO)

- In agreement with RUN II J/ψX measurement
- Within values predicted by the FONLL calculation



Flavour physics in the LHC era will play a leading role in determining the relevant NP model parameters, in exploring higher energies and in providing us with clues on the physics at M_{GUT}.

- complementarity to Atlas/CMS direct searches ⇒ new particles

- New dedicated high sensitivity experiments starting up
  - more diverse experimental panorama in the (very) near future

- Theory uncertainties?

Grazie a tutti i presentatori