Search for new physics in rare B decays at BaBar

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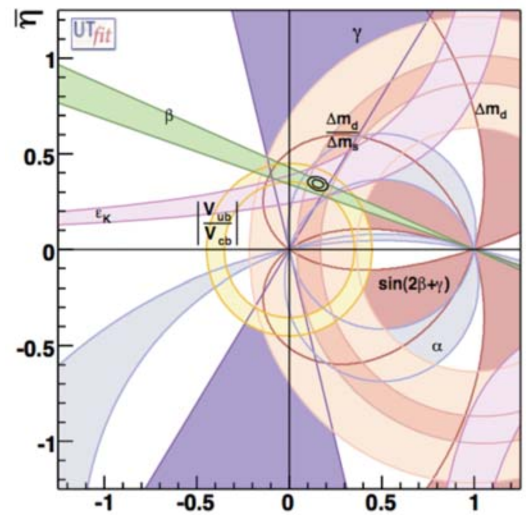
5^{th} International Conference
on Flavor Physics 2009,
Sept 24-30, 2009, Hanoi - Vietnam

Outline

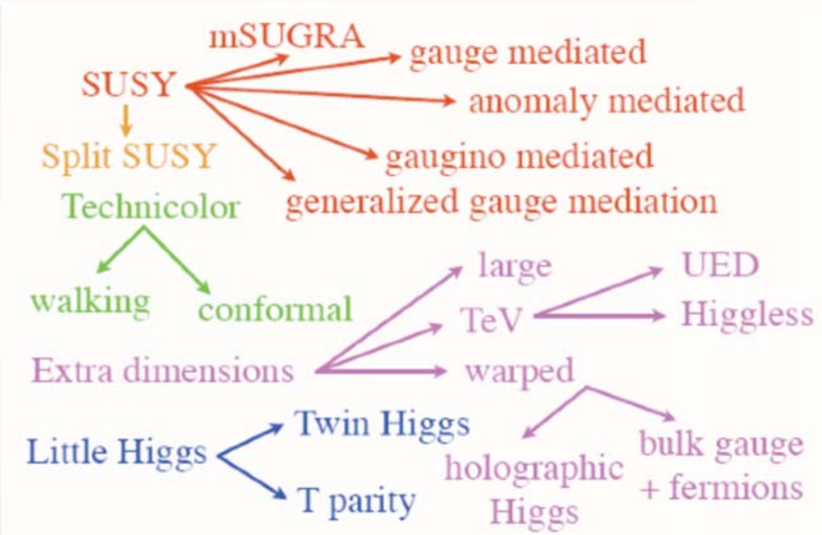
- ✓ New Physics searches: how to
- ✓ BaBar detector and dataset
- ✓ Kinematics constraints
- ✓ Experimental results
  - $B \to l\nu$ ($l=\tau, \mu, e$)
  - $B \to D^{(*)}\tau\nu$ (not so rare actually!)
  - $B \to K^{(*)}ll$
  - $B \to K^{*}\nu\bar{\nu}$
- ✓ Conclusions

Rare decays and New Physics (I)

- ✓ Standard Model (SM) predictions in the flavor sector successfully confirmed by experimental results
- ✓ Many open questions present in the SM picture → SM is not the ultimate model



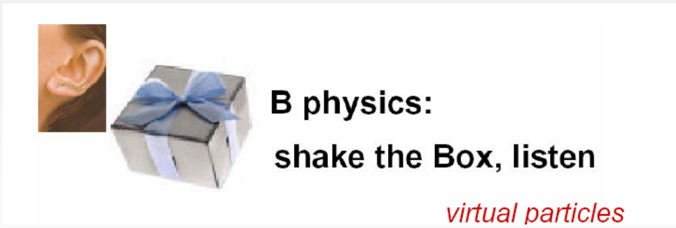
- ✓ ..but which one is the right one?



- ✓ ...try to answer by comparing experimental results and SM predictions
  → constrain New Physics (NP) parameters or claim evidence for NP if measurements are inconsistent with theory

Rare decays and New Physics (II)

✓ 2 complementary approaches to detect New Physics effects



R. Cahn

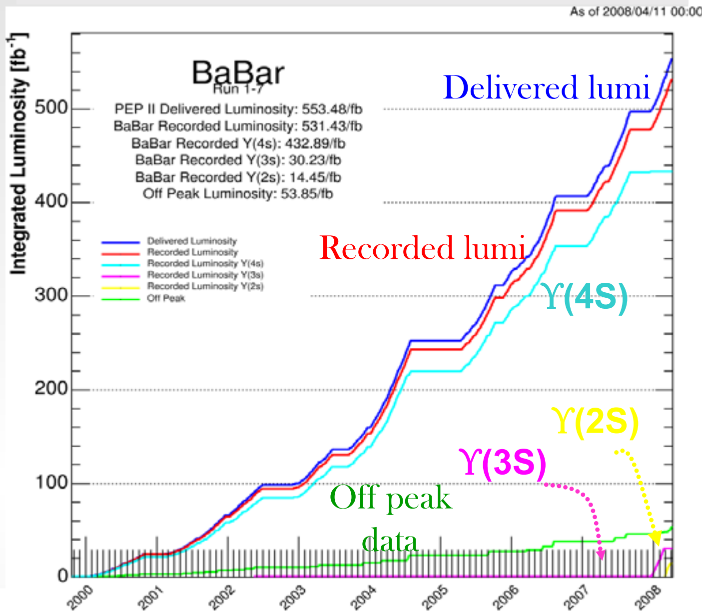
✓ "Shake the box" where..

- NP effects are of the same order of SM contributions
- physical quantities are predicted with small theoretical uncertainties in the SM

→ RARE DECAY Branching Fractions, ASYMMETRIES (A_{CP}, A_{FB})

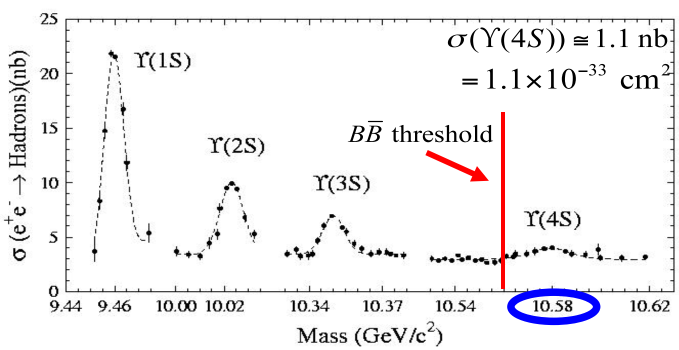
decay	$O(BR_{SM})$
$B \to \tau\nu$	10^{-4}
$B \to K^{(*)} ll$	10^{-6}
$B \to K^{*} \nu\bar{\nu}$	10^{-6}

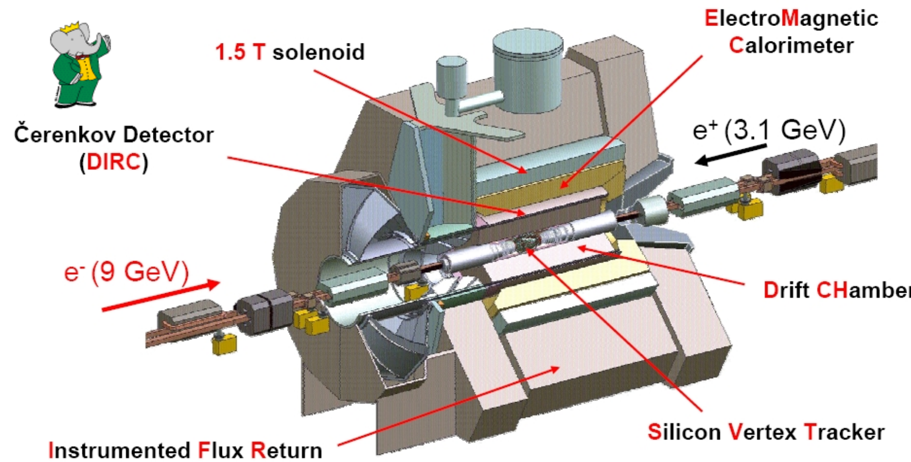
BaBar detector and datasets



BaBar @ PeP-II B factory

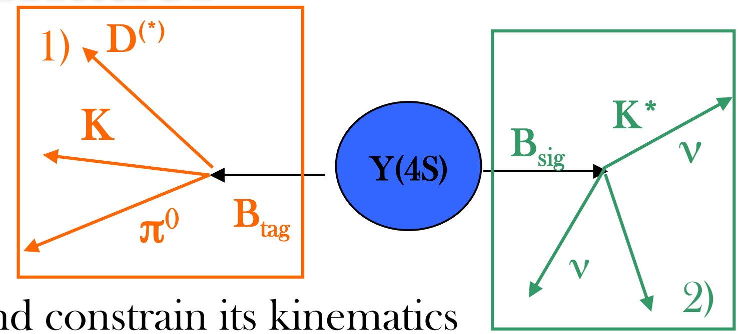
- ✓ E_{e+} = 3.1 GeV,
  E_{e-} = 8.0-9.0 GeV
- ✓ Y(4S) boost : βγ=0.56
- ✓ Data samples
  - @ Y(4S) : ~ 430 fb^{-1} → 471M $B\bar{B}$
    @ Y(3S) : ~ 30 fb^{-1} , @ Y(2S) : ~ 15 fb^{-1}





Exploiting B decay kinematics

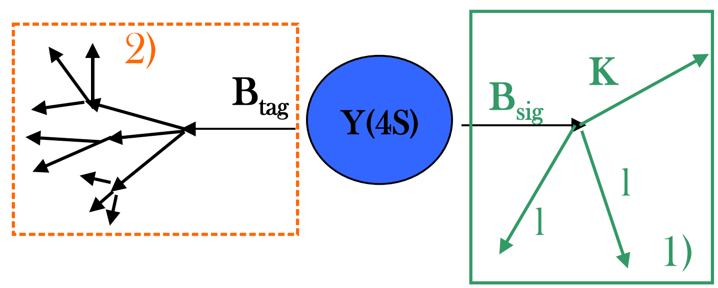
How to exploit the kinematics



✓ RECOIL ANALYSIS:

- fully reconstruct one B in the event in semileptonic or hadronic modes (B_{tag}) and constrain its kinematics
- search in the rest of the event for the signal signature (B_{sig})

→ used when there are undetectable particles in the signal side; B_{tag} reconstruction efficiency $O(10^{-2} \div 10^{-3})$, very clean sample



✓ INCLUSIVE ANALYSIS:

- reconstruct the B_{sig} decay products and constrain its kinematics OR use extra- tracks and neutrals to reconstruct B_{tag} (with 1 ν in the signal side)

→ higher efficiency and background contamination

$$m_{ES} \equiv \sqrt{E^{*2}_{beam} - p^{*2}_{B}}$$

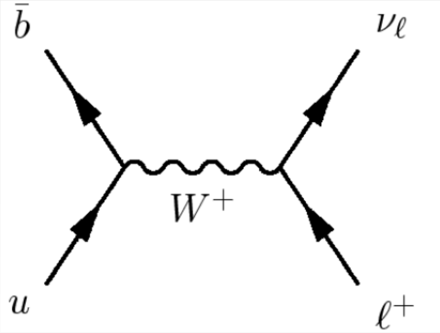
$$\Delta E \equiv E^{*}_{B} - \sqrt{s}/2$$

$B \to l\nu$

B→lν theoretical overview (I)

✓ SM predictions:

$$\mathcal{B}(B \rightarrow l\nu)_{SM} = \frac{G_F^2 m_B m_l^2}{8\pi}\left(1-\frac{m_l^2}{m_B^2}\right) f_B^2 |V_{ub}|^2 \tau_B$$



✓ Using: f_B = 200 ± 20 MeV (V. Lubicz et al. Nuovo Cim. 123B,67 (2008))

$|V_{ub}|$ = (36.7 ± 2.1) x 10^{-4} (average of inclusive and exclusive res. M.Bona et al. [UTfit collaboration], arXiv:0908.3470[hep-ph])

→ $\mathcal{B}(B^+ \rightarrow \tau^+\nu)_{SM}$ =(0.98 ± 0.24) x 10^{-4}

✓ SM prediction using the SM Unitary Triangle fit

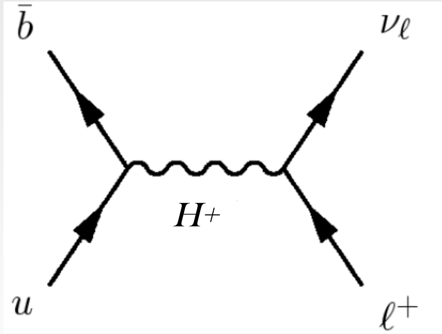
→ $\mathcal{B}(B^+ \rightarrow \tau^+\nu)_{SM}^{fit}$ =(0.84 ± 0.11) x 10^{-4}

(M.Bona et al. [UTfit collaboration], arXiv:0908.3470[hep-ph])

✓ Channels with lighter leptons: $\mathcal{B}$ suppressed of a factor $(m_l/m_\tau)^2$

- $\mathcal{B}(B\rightarrow\mu\nu)_{SM} \cong 10^{-7}$
- $\mathcal{B}(B\rightarrow e\nu)_{SM} \cong 10^{-11}$

B→lν theoretical overview (II)



- NP models
  - SUSY : charged Higgs can mediate the annihilation

$$R_{H2DM} = \frac{\mathcal{B}(B \to l\nu)_{exp}}{\mathcal{B}(B \to l\nu)_{SM}} \approx \left(1 - \tan^2\beta \frac{m_B^2}{m_H^2}\right)^2$$

(W.S. Hou Phy.Rev. D 48, 2342 (1993))

  - MFV : $R_B^{\mu/\tau} = \frac{\Gamma(B \to \mu\nu)}{\Gamma(B \to \tau\nu)}$ $R_B^{e/\tau} = \frac{\Gamma(B \to e\nu)}{\Gamma(B \to \tau\nu)}$

with Lepton Flavor violation sources, effects expected to be large in e and μ channels, negligible in τν final state

→ enhancement of factor $O(10^2\text{-}10^3)$ for μ-e with respect to SM values

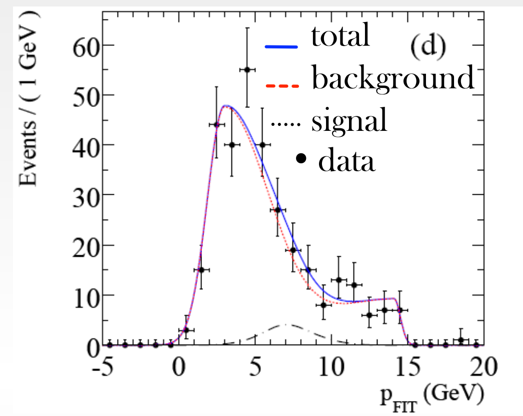
(G.Isidori & P.Paradisi Phys.Lett. B 639, 499)

B→e,μ ν : inclusive analysis

Phys.Rev.D79:091101 (2009)
468x10[6] $B\overline{B}$ pairs

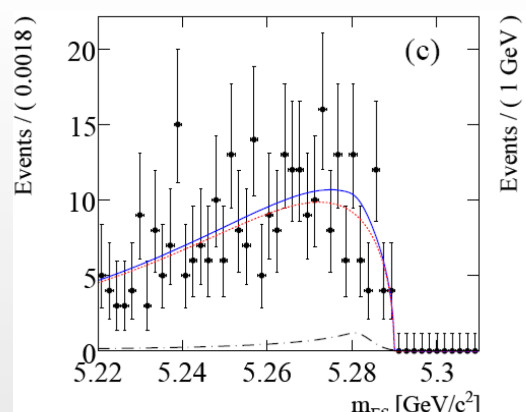
- ✓ B_{sig} = highest momentum lepton (tight particle ID) + missing energy
  B_{tag} = extra tracks and neutrals

B→eν



- ✓ Background suppression:
  - B_{tag} ΔE and transverse momentum, Fisher discriminant (to suppress qq background)
  - → main background left: qq, $B \to X_u l\nu$, Xh with misidentified h, two-γ events for the electron channel

- ✓ Yield extraction:
  - 2-dim fit to B_{tag} m_{ES} and $p_{FIT} = a_0 + a_1 p_l^{CM} + a_2\, p_l^{B,REST}$



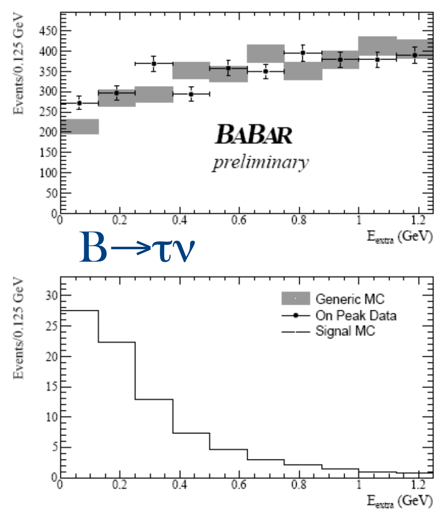
Most stringent limits reported to date

	B→eν	B→μν
ε_{sig}	(4.7±0.3)%	(6.1±0.2)%
N_{sig}	18±18	1±17
$UL_{90\%}$	1.9×10^{-6}	1.0×10^{-6}

$B \to l\nu$ in the SL recoil

arXiv:0809.4027, preliminary
459×10^6 $B\bar{B}$ pairs

- ✓ $B_{tag} \to D^{(*)} l\nu$, l=e,μ vs $B_{sig} \to l\nu$
  - eν, μν,
  - τν
    - ↳ eνν, μνν
    - πνν, $\rho(\pi\pi^0)\nu$
- ✓ Lepton momentum in the B_{sig} rest frame ($p_l^{B,REST}$) to distinguish $\tau(l\nu\nu)\nu$ - $l\nu$
- ✓ Background suppression: optimize cuts on
  - PDFs of event shape and kinematical variables combined in 2 Likelihood ratios one for $e^+e^- \to qq$, one for BB events
  - $p_l^{B,REST}$ and extra neutral energy in the calorimeter neither associated to B_{sig} nor to B_{tag} (E_{extra})
- ✓ Background estimation from E_{extra} sideband



Mode	Expected Background (N_{BG})	Observed Events (N_{obs})	Overall Efficiency (ε)	Branching Fraction
$B^+ \to \tau^+\nu_\tau$	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→τν: phenomenological constraints

$$\mathcal{B}(B^+ \to \tau^+\nu)_{EXP} = (1.73 \pm 0.34)\times 10^{-4}$$

(Average of Belle and BaBar results)

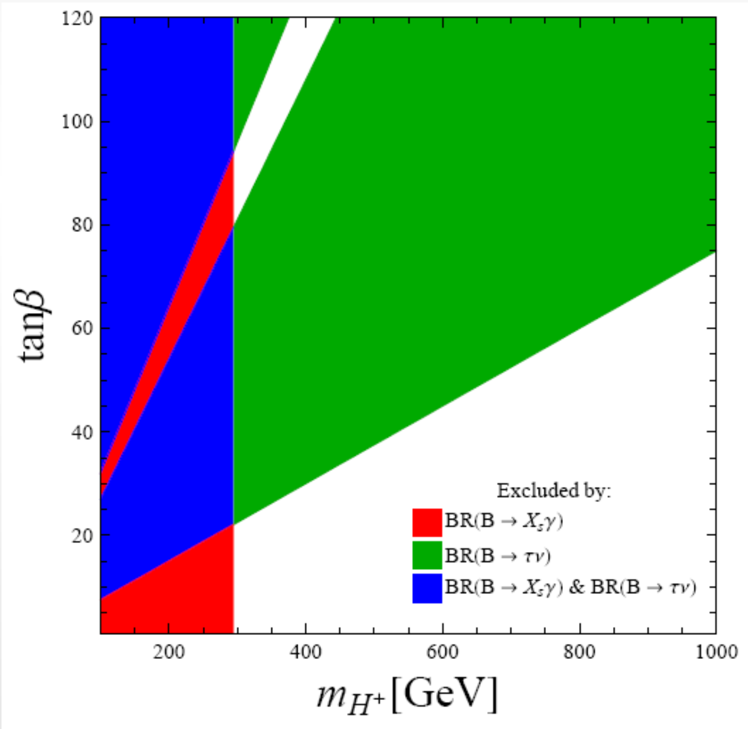
✓ BR estimation from the Universal Unitary triangle fit (common to SM and Two Higgs Doublet Models I and II) (M.Bona et al. [UTfit collaboration], arXiv:0908.3470[hep-ph])

$$\mathcal{B}(B^+ \to \tau^+\nu)^{fit}_{UUT} = (0.87 \pm 0.20) \times 10^{-4}$$

✓ $$R_{H2DM} = \frac{\mathcal{B}(B \to l\nu)_{exp}}{\mathcal{B}(B \to l\nu)_{UUT}} \approx \left(1 - \tan^2\beta \frac{m_B^2}{m_H^2}\right)^2$$

→ constraints on the m_H-tanβ plane

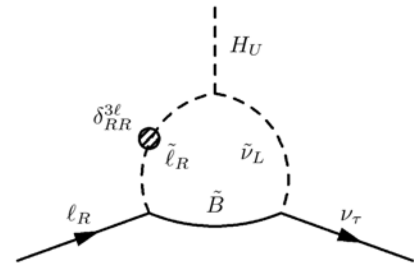
- combine B→τν and B→$X_s\gamma$ measurements (M. Misiak et al., Phys.Rev.Lett.98,022002(2007))
- large values of tanβ for sub-TeV m_H disfavored



B→μν: phenomenological constraints

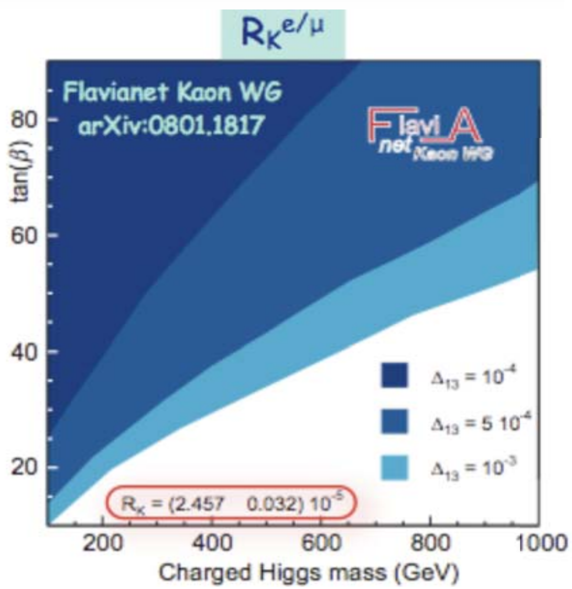
$$\left(R_B^{\mu/\tau}\right)_{LFV}^{MSSM} \approx \left(R_B^{\mu/\tau}\right)^{SM}\left[1+\frac{1}{R_{B\tau\nu}}\left(\frac{m_B^4}{M_H^4}\right)\left(\frac{m_\tau^2}{M_\mu^2}\right)\left|\Delta_R^{23}\right|^2\frac{\tan^6\beta}{(1+\varepsilon\tan\beta)^2}\right]$$

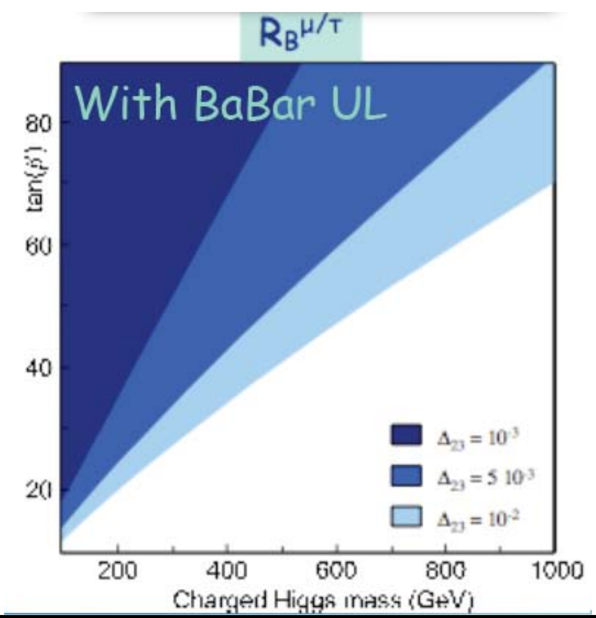
$$R_{B\tau\nu}=\frac{\mathcal{B}(B\to\tau\nu)_{exp}/\Delta m_{d,exp}}{\mathcal{B}(B\to\tau\nu)_{SM}/\Delta m_{d,SM}}\quad,\quad \Delta_R^{23}\propto\frac{\alpha}{4\pi}\delta_{RR}^{31}$$



(A. Masiero et al., PR D74:011701 (2006))
(G. Isidori et al. Phys.Lett.B639:499-507,(2006))

- R_K measured with 0.1% precision
- comparable limits on the tanβ-m_H plane from B→μν (UL on the branching fraction)





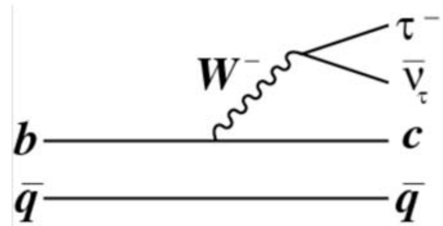
$B \rightarrow D^{(*)}\tau\nu$

$B \to D^{(*)} \tau \nu$: theoretical overview

- ✓ SM: b→c transition mediated by W boson , precise calculation of the SM branching fraction

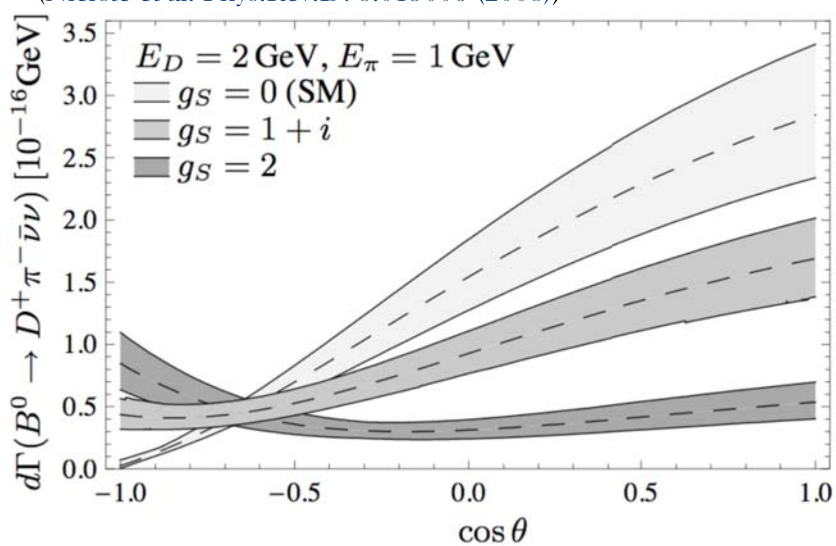
Decay Mode	$\mathcal{B}$ (%)
$\overline{B}^0 \to D^- \tau^- \overline{\nu}_\tau$	0.69 ± 0.04
$\overline{B}^0 \to D^{*-} \tau^- \overline{\nu}_\tau$	1.41 ± 0.07

(Chen et al., hep-ph/0608166 Falk et al., PLB 326 145 (1994))



- ✓ Sensitive to charged Higgs coupling in multi-Higgs doublet models:
  - complementary to B→τν searches but with more precise SM prediction (do not rely on f_B)
  - H boson coupled to lepton mass → NP effects stronger in τ channel

(Nierste et al. Phys.Rev.D78:015006 (2008))



$\tau \to \pi\nu$

g_s = Higgs coupling constant

$$\cos\theta = \frac{(m_B - E_D - E_\pi)^2 - 2(E_D^2 - m_D^2) - m_{miss}}{2(E_D^2 - m_D^2)}$$

$B \rightarrow D^{(*)}\tau\nu$: analysis strategy (I)

Phys.Rev.D79:092002 (2009)
232×10^6 $B\overline{B}$ pairs

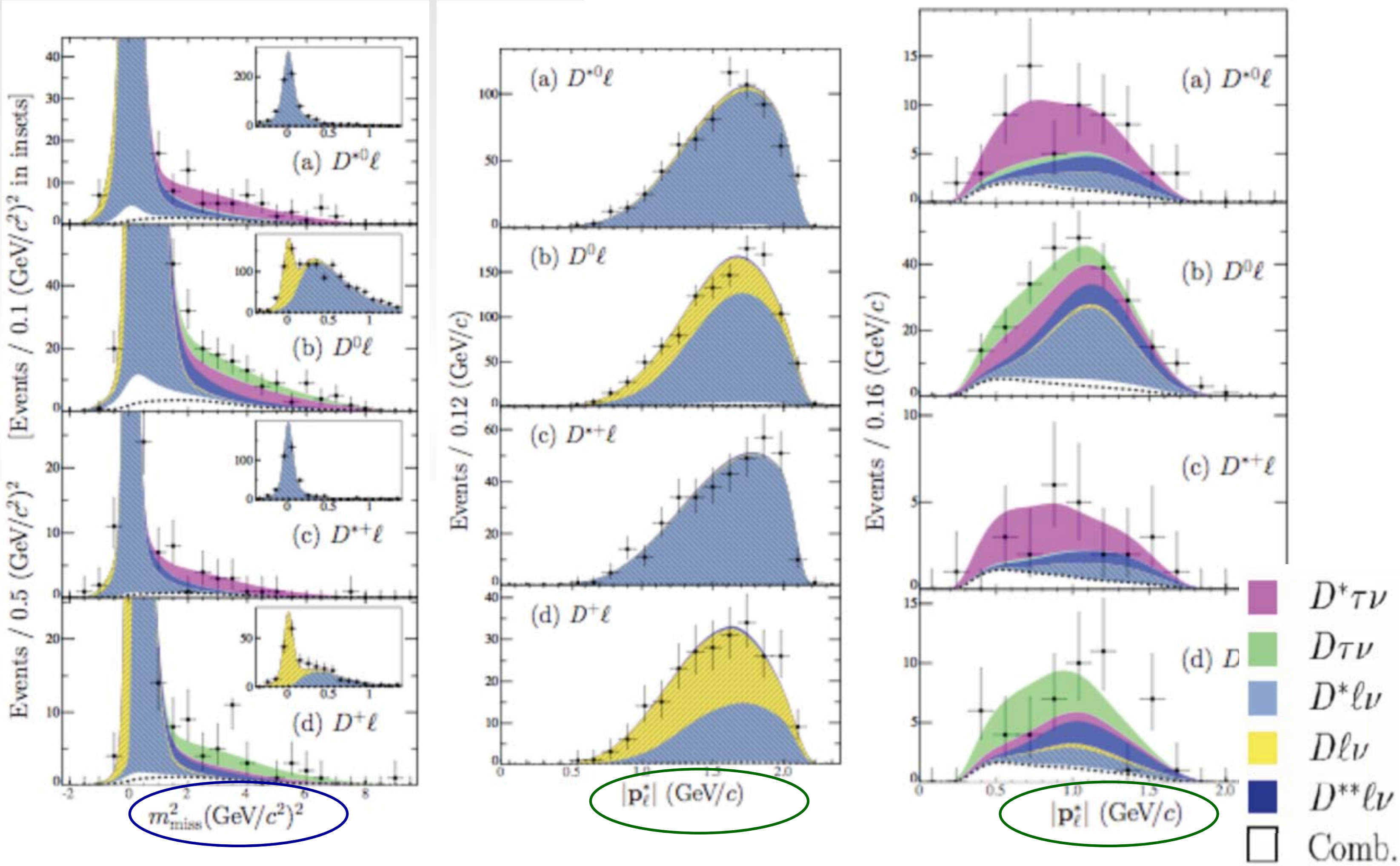
- ✓ Fully reconstruct hadronic B_{tag} decays
- ✓ Search for B_{sig} decay with a D(*) + e/μ + missing energy
  - primary light lepton or from τ decay
- ✓ Separate primary and secondary e/μ samples by exploiting: p_{miss}, m_{miss}, p_l
- ✓ Largest background surviving the selection from $B \rightarrow D^{(*)}l\nu$ for both $B \rightarrow D/D^{*}\tau\nu$
- ✓ Use $B \rightarrow D^{(*)}l\nu$ sample as normalization and simultaneously extract $B \rightarrow D^{(*)}l\nu$ and $B \rightarrow D^{(*)}\tau\nu$ yields by fitting m^2_{miss} and p_l distributions.
- ✓ Measurements in agreement with SM expectation

Signal mode	$\varepsilon_{sig}/\varepsilon_{norm}$
$B^- \rightarrow D^0\tau^-\overline{\nu}_\tau$	1.85 ± 0.02
$B^- \rightarrow D^{*0}\tau^-\overline{\nu}_\tau$	0.99 ± 0.01
$\overline{B}^0 \rightarrow D^+\tau^-\overline{\nu}_\tau$	1.83 ± 0.03
$\overline{B}^0 \rightarrow D^{*+}\tau^-\overline{\nu}_\tau$	0.91 ± 0.01

Mode	$\mathcal{B}$ [%]	σ_{tot} (σ_{stat})
$B^- \rightarrow D^0\tau^-\overline{\nu}_\tau$	0.67±0.37±0.11±0.07	1.8 (1.8)
$B^- \rightarrow D^{*0}\tau^-\overline{\nu}_\tau$	2.25±0.48±0.22±0.17	5.3 (5.8)
$\overline{B}^0 \rightarrow D^+\tau^-\overline{\nu}_\tau$	1.04±0.35±0.15±0.10	3.3 (3.6)
$\overline{B}^0 \rightarrow D^{*+}\tau^-\overline{\nu}_\tau$	1.11±0.51±0.04±0.04	2.7 (2.7)
$B \rightarrow D\tau^-\overline{\nu}_\tau$	0.86±0.24±0.11±0.06	3.6 (4.0)
$B \rightarrow D^*\tau^-\overline{\nu}_\tau$	1.62±0.31±0.10±0.05	6.2 (6.5)

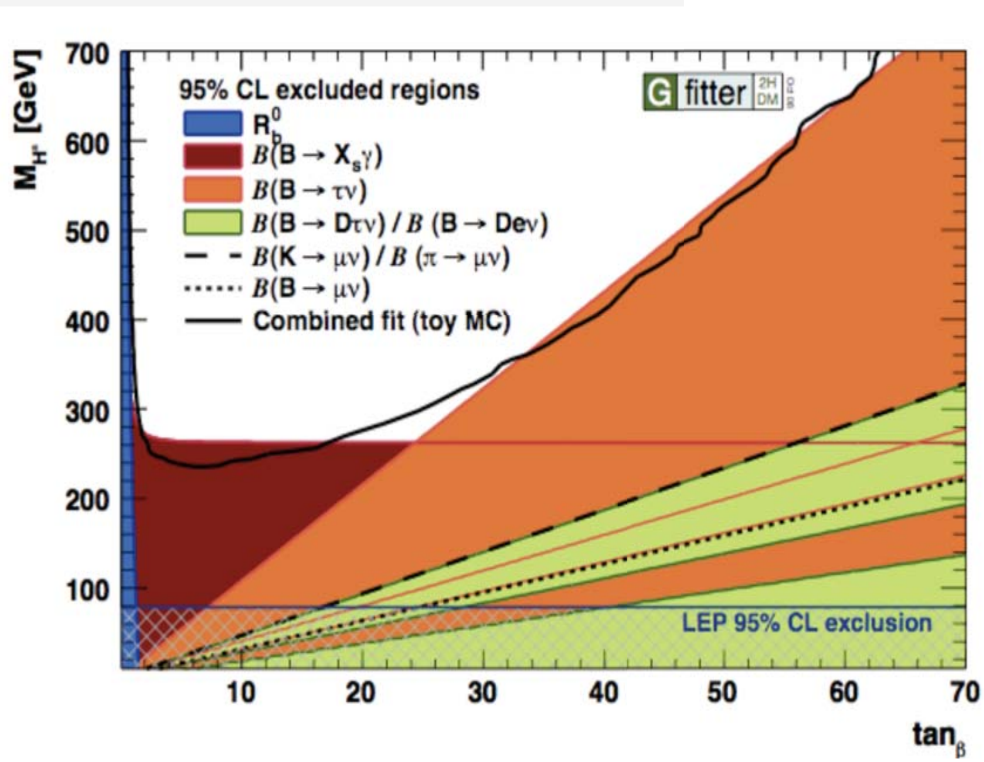
σ_{stat} ↑ σ_{syst} ↑ ↑ σ_{norm}

B→D(*)τν: analysis strategy (II)

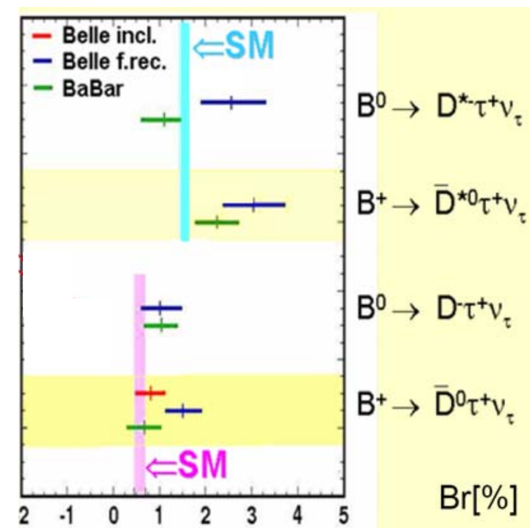


$B \to D^{(*)}\tau\nu$: phenomenological constraints

- ✓ Branching fractions world averages and constraints on m_H-$\tan\beta$ plane



Branching Fraction

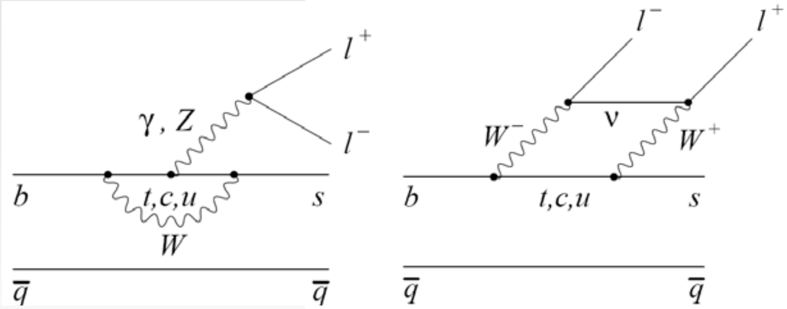


Statistical errors only
$Br = R(D^{(*)}) \times Br(D^{(*)}l\nu)$

(H. Flächer et al., Eur. Phys. J. C 60, 543 (2009))

$B \to K^{(*)}ll$

B→K(*)ll theoretical overview



✓ Operator Product Expansion framework: 3 effective Wilson coefficients govern the b→sll process

- C_7 : electromagnetic penguin
- C_9 : vector part of electroweak diagrams
- C_{10} : axial-vector part of electroweak diagrams

→ NP can change magnitude and relative sign of C_i wrt SM predictions

✓ All the following results from PRL 102, 091803 (2009), PRD 79, 031102 (2009) , $350 fb^{-1}$ → 384×10^6 $B\overline{B}$

$B \rightarrow K^{(*)}ll$: event selection and signal yield

- ✓ Event selection: $e^+e^-/\mu^+\mu^-$ pair + {K^+,K_s,$K^+\pi$, $K^+\pi^0$, $K_s\pi^+$}
- ✓ Signal window defined by B_{sig} m_{ES}, ΔE and $m(K\pi)$ for K^*
- ✓ Background suppression:
  - di-leptonic bkg from B or D
  - continuum $ee \rightarrow cc$, $c \rightarrow sl\nu$
  - → Neural Networks:

  kinematics and event shape variables, vertexing info

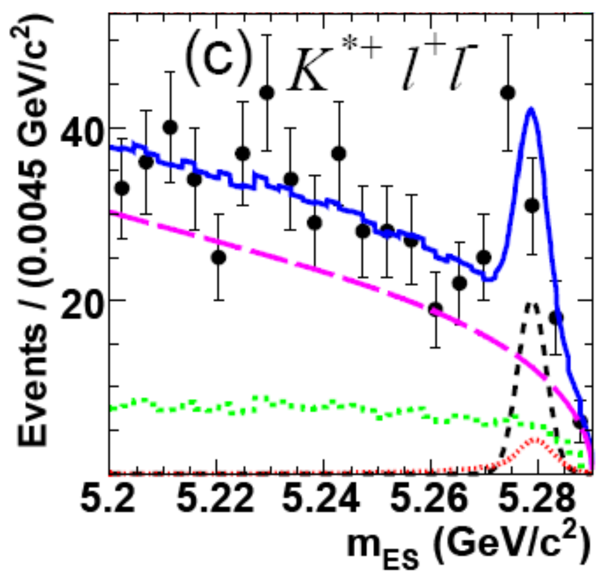
  - $B \rightarrow D(K^*\pi)\pi$: veto by cutting on $m(K^*\mu)$
  - $B \rightarrow J/\psi(ll)X_s$: veto by cutting on $q^2 = m_{ll}$

  → fits in 2 q^2 bins, one bin in the low-q^2 region and the other in the high-q^2 region

- ✓ Yield extraction: unbinned ML fit to m_{ES}

data (dots); signal MC;
peaking; hadronic;
combinatorial; total

$B^+ \rightarrow K^{*+}ll$

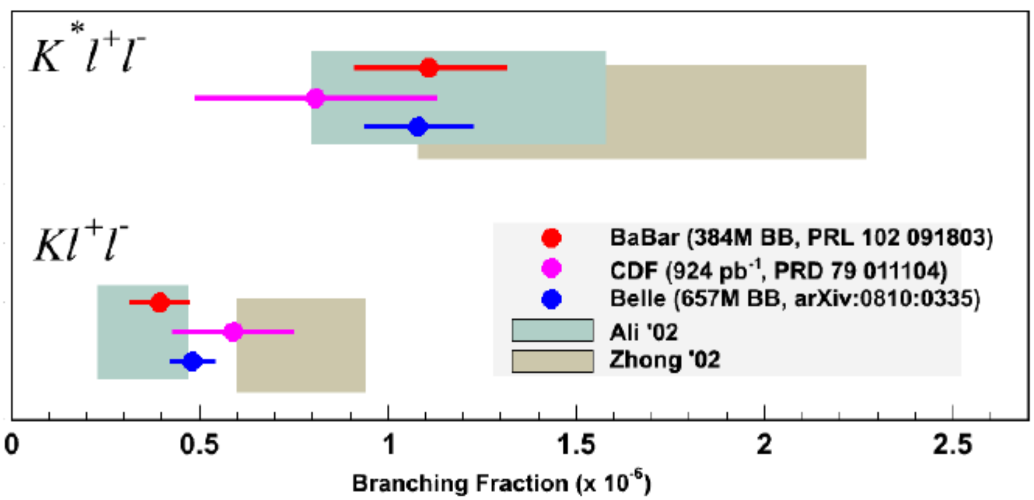


B→K$^{(*)}$ll : branching fraction

- ✓ Experimental results:
  - relative uncertainties ~ 18%

B→Kll	B→K*ll
(0.39±0.07±0.02) x 10^{-6}	($1.11^{+0.19}_{-0.18}$±0.07) x 10^{-6}

- ✓ Agreement with the Standard Model expectation
  - theoretical error ~ 30%



$B \to K^{(*)} ll$: direct CP asymmetry and Lepton Flavor Ratio

$$A_{CP} \equiv \frac{\Gamma(\overline{B} \to \overline{K}^{(*)} l^+ l^-) - \Gamma(B \to K^{(*)} l^+ l^-)}{\Gamma(\overline{B} \to \overline{K}^{(*)} l^+ l^-) + \Gamma(B \to K^{(*)} l^+ l^-)}$$

$$R_{K^{(*)}} \equiv \frac{\Gamma(B \to K^{(*)} \mu^+ \mu^-)}{\Gamma(B \to K^{(*)} e^+ e^-)}$$

- ✓ A_{CP}:
  - $O(10^{-3})$ in the SM; enhancement up to 10% in generic NP scenarios (Bobethet al., JHEP0807, 106(2008))
  - experimental results consistent with null direct CP violation

	A_{CP}
$K^* l^+ l^-$	$0.01^{+0.16}_{-0.15} \pm 0.01$
$K l^+ l^-$	$-0.18 \pm 0.18 \pm 0.01$

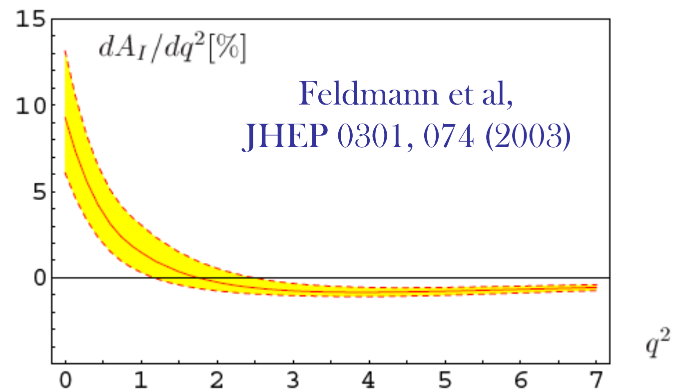
- ✓ $R_{K^{(*)}}$:
  - in the SM: $R_K \sim 1$, $R_{K^*} \sim 1$ (0.75 including the $q^2 < 2m_\mu$ region where the e channel is enhanced);
  - SUSY with large tanβ : enhancement up to 10% (Higgs preferentially couples to μ) (Yan al., Phys.Rev.D62, 094023(2000))
  - experimental results: agreement with the SM prediction

R_K	$0.96^{+0.44}_{-0.34} \pm 0.05$
R_{K^*}	$1.10^{+0.42}_{-0.32} \pm 0.07$
R_{K^*} (w $q^2 < (2m_\mu)$)	$0.56^{+0.29}_{-0.23} \pm 0.04$

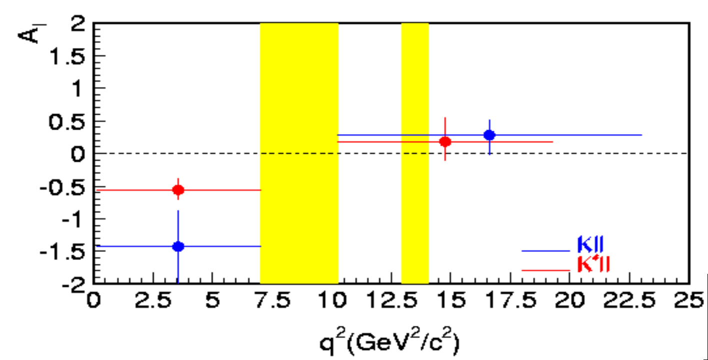
$B \to K^{(*)}ll$: Isospin Asymmetry

$$A_I^{K^{(*)}} \equiv \frac{\Gamma(B^0 \to K^{(*)0} l^+ l^-) - (\tau_0/\tau_+)\Gamma(B^\pm \to K^{(*)\pm} l^+ l^-)}{\Gamma(B^0 \to K^{(*)0} l^+ l^-) + (\tau_0/\tau_+)\Gamma(B^\pm \to K^{(*)\pm} l^+ l^-)}$$

- ✓ SM expectation: very small asymmetry, reaches O(%) at lowest q^2
- ✓ Experimental results:
  - no isospin violation at high q^2
  - at small q^2 :



$A_I(B \to K^* ll)$	$-0.56^{+0.17}_{-0.15} \pm 0.03$
$A_I(B \to Kll)$	$-1.43^{+0.56}_{-0.85} \pm 0.05$



- difference from null $A_I(B \to K^{(*)}ll)$: $3.9\sigma_{stat+syst}$

B→K*ll : angular fits (I)

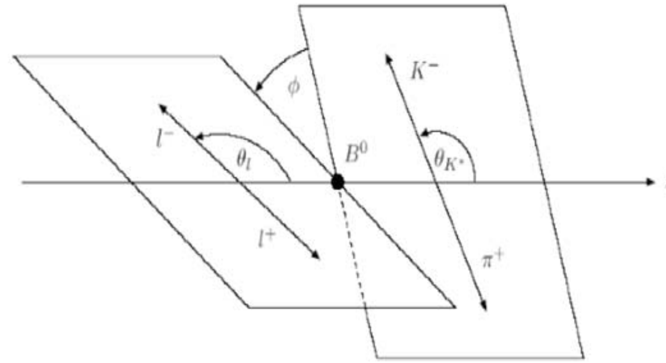
✓ K* longitudinal polarization fraction F_L :

θ_K : angle between K and B in K* rest frame

fit to $\cos\theta_K$:

$$\frac{3}{2}F_L\cos^2\theta_K + \frac{3}{4}(1-F_L)(1-\cos^2\theta_K)$$

→ determination of F_L



both quantities sensitive to NP:
- F_L at low q^2
- A_{FB} in the full q^2 region

✓ Forward-Backward asymmetry A_{FB}

$$A_{FB}(s) = \frac{\int_{-1}^{1} d\cos\theta_l \frac{d^2\Gamma(B\to K^* l^+ l^-)}{d\cos\theta_l ds} \mathrm{Sign}(\cos\theta_l)}{d\Gamma(B\to K^* l^+ l^-)/ds}$$

$s \equiv q^2/m^2_B$

θ_l angle between $l^+(l^-)$ and $B(\bar{B})$ in ll rest frame

fit to $\cos\theta_l$:

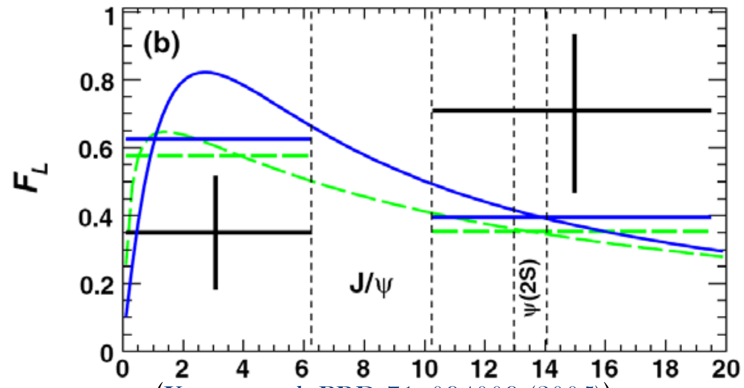
$$\frac{3}{4}F_L(1-\cos^2\theta_l) + \frac{3}{8}(1-F_L)(1+\cos^2\theta_l) + A_{FB}\cos\theta_l$$

→ determination of A_{FB}

B→K*ll : angular fits (II)

✓ Experimental result for F_L :

Low q^2	High q^2
0.35 ± 0.16	$0.71^{+0.20}_{-0.22}$

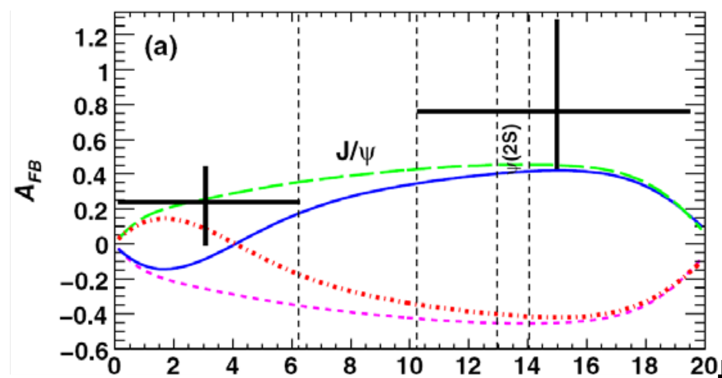


(Krüger et al. PRD 71, 094009 (2005))

SM $C_7=-C^{SM}_7$

✓ Experimental result for A_{FB}:

Low q^2	High q^2
$0.24^{+0.18}_{-0.23}$	$0.76^{+0.52}_{-0.32}$



(Ali et al. PRD 61, 074024 (2000)
Buchalla et al. PRD 63, 014015 (2001)
Ali et al. PRD 66, 034002 (2002)

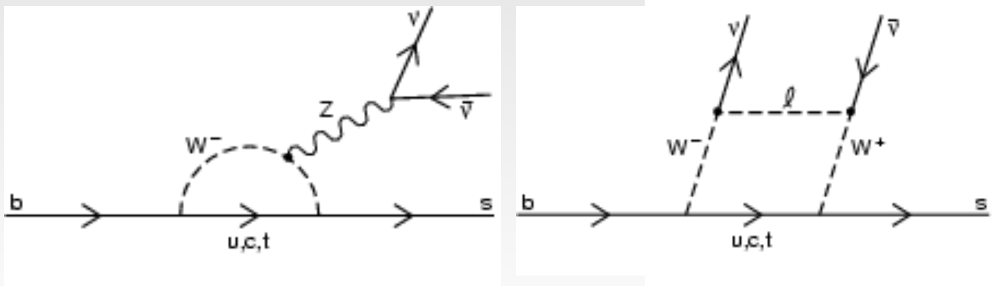
Krüger et al. PRD 61, 114028 (2002)
Krüger et al. PRD 71, 094009 (2005))

SM
$C_7=-C^{SM}_7$
$C_9C_{10}=-C^{SM}_9C^{SM}_{10}$
$C_7=-C^{SM}_7$ $C_9C_{10}=-C^{SM}_9C^{SM}_{10}$

$B \to K^* \nu\nu$

$B \rightarrow K^{(*)}\nu\nu$: theoretical overview

- ✓ $b \rightarrow s\nu\nu$ diagrams in the SM model



- ✓ SM prediction: $\mathcal{B}(B \rightarrow K^* \nu\nu) = (6.8^{+1.0}_{-1.1})x10^{-6}$

  (G.Altmannshofer et al., JHEP 0904:022,2009 (2009))

- ✓ NP effects:

  - Non-standard Z coupling: enhancement of a factor 10 (G.Buchalla et al. Phys. Rev. D 63, 014015 (2000))
  - New sources of missing energy: production of light dark matter via Higgs mediated vertex, $\mathcal{B}_{NP}$ up 50x$\mathcal{B}_{SM}$ (C. Bird et al. Phys.Rev.Lett.93:201803 (2004))

$B \to K^* \nu\nu$: analysis strategy

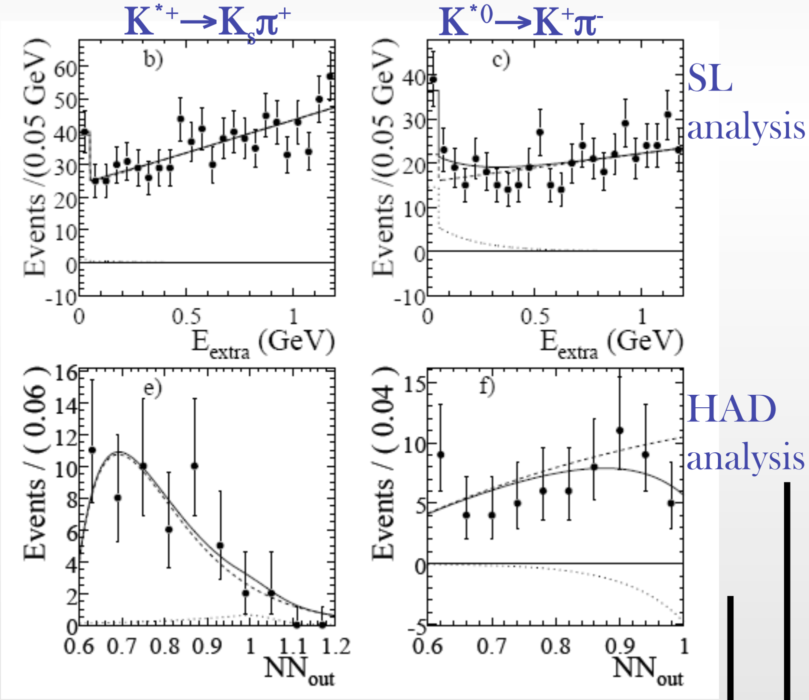
PRD 78, 072007 (2008), 454 x 10^6 $B\overline{B}$ pairs

- ✓ Combined results from the semileptonic and hadronic recoil analyses
- ✓ Reconstruct K^* as $K^+\pi^-$, $K_s\pi^+$, $K^+\pi^0$
- ✓ Semileptonic analysis: cut based selection + fit to E_{extra} to exctract signal and background yields
- ✓ Hadronic analysis: selection variables combined in a Neural Network + fit to the NN output for signal and background estimation
- ✓ No evidence for signal in any K^* channel

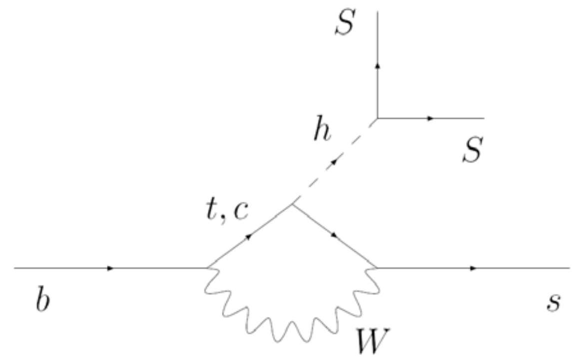
SL analysis	$K^{*+} \to K^+\pi^0$	$K^{*+} \to K_S\pi^+$	$K^{*0} \to K^+\pi^-$
ε (10^{-4})	5.6±0.7	4.3±0.6	6.9±0.8
Had analysis			
ε_{Bsig} (10^{-5})	5.8±0.5	5.2±0.6	16.6±1.4

UL @ 90%CL	$B^+ \to K^{*+}\nu\nu$	$B^0 \to K^{*0}\nu\nu$	$B \to K^*\nu\nu$
Combined	8×10^{-5}	12×10^{-5}	8×10^{-5}

Most stringent limits reported to date



B→K*νν and light dark matter



- ✓ Light scalar dark matter candidate S (m_S < 2.5GeV)
  - b→s SS transition mediated by a Higgs boson (h) with coupling λ

related to the dark matter abundance in the universe

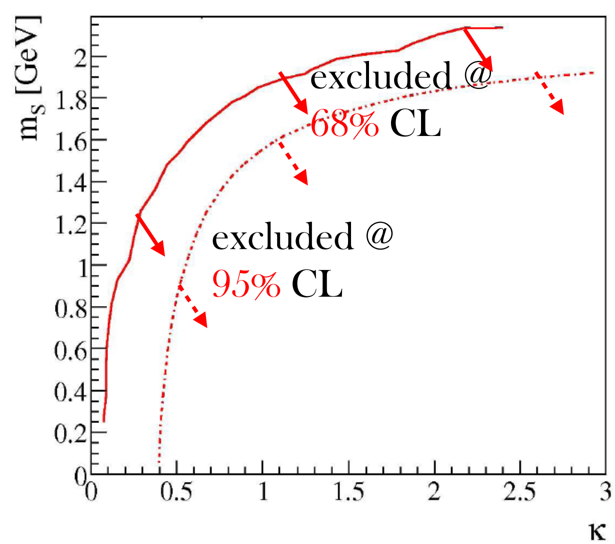
$$\kappa^2 = \lambda^2 \left(\frac{100\text{GeV}}{m_h}\right)^4$$

m_h = Higgs mass

for low m_S, κ~O(1) (Bird et al. Phys.Rev.Lett.93,201803 (2004.)
Burgess et al. Nucl.Phys. B619, 709 (2001))

- ✓ Use the measured UL to constrain m_S vs κ
  - use BaBar UL and Buchalla et al PRD 63, 014015 for SM prediction
  - for high κ: light higgs with strong coupling to SS

→ h→SS can saturate the higgs decay rate making impossible the Higgs discovery at LHC



Conclusions

Conclusions

- ✓ Search for rare decays: test for the Standard Model and probe for New Physics
- ✓ High statistics and clean data samples provided by B-factories
  - indirect search for NP
  - complementary to direct search @ high energy machines
  - reached sensitivity $O(10^{-7})$
- ✓ Comparison between experimental measurements and SM prediction
  - a few inconsistencies found but more statistics needed to claim for NP evidence
  - constrain parameters defining NP ($\tan\beta$-m_H)
- ✓ Much more can be done at LHCb and at a Super Flavor Factory

  only place where further searches for rare decays with undetectable particles are feasible