Rare B decays

at B factories

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Outline

Rare and beautiful…

Radiative/EW decays

1. $B \to X_s \gamma$
2. $B \to X_{s,d} \gamma$
3. $B \to K^{(*)} l^+ l^-$
4. $B \to X_s l^+ l^-$
5. $B^+ \to K^+ \tau^+ \tau^-$
6. $B \to \gamma\gamma$

Tauonic decays

7. $B \to \tau \nu$
8. $B \to D^{(*)} \tau \nu$

Exotic decays

9. $B^+ \to D^- l^+ l^+$

Charmless had decays

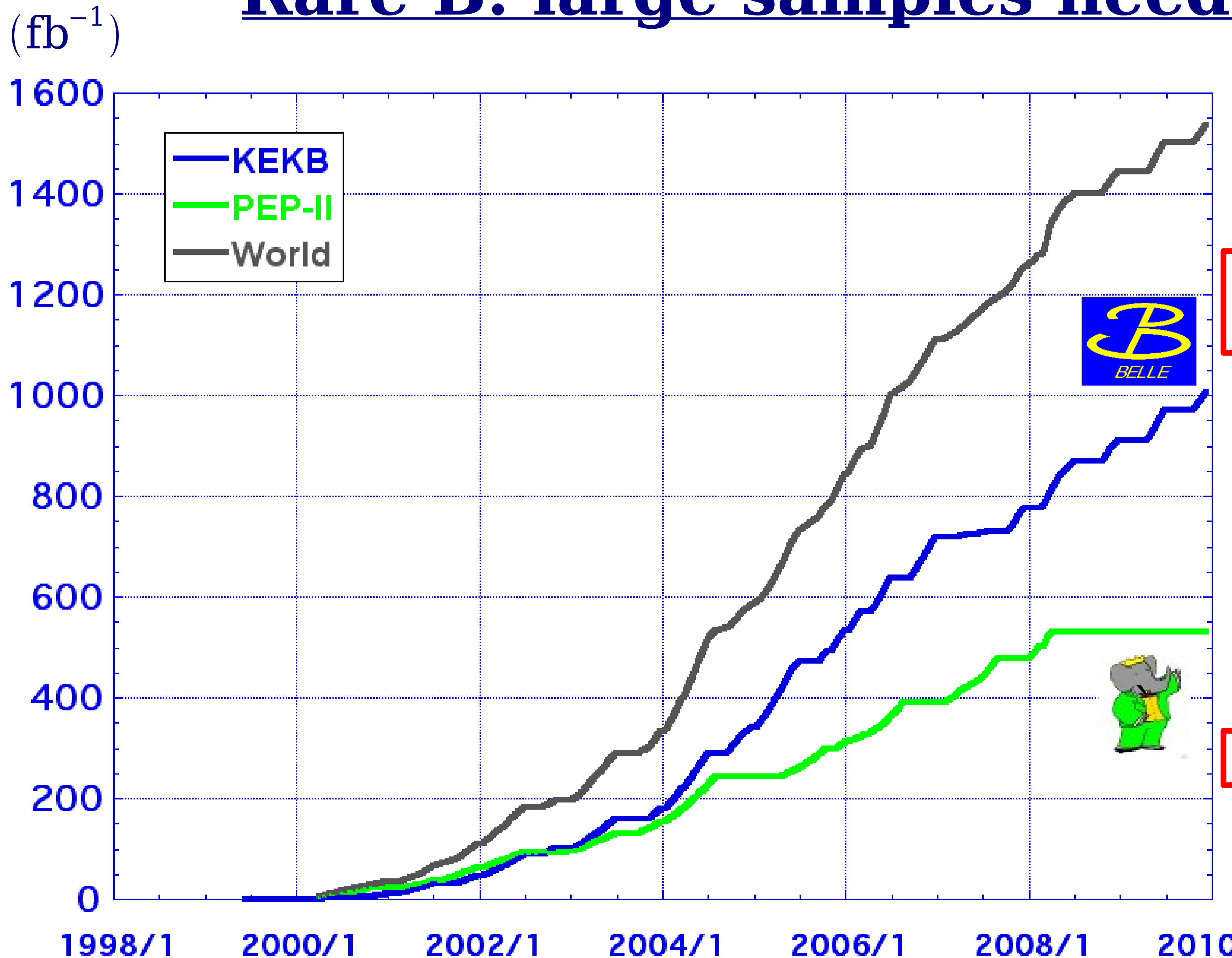
10. $B \to \eta' h$
11. $B \to X_s \eta$

at $\Upsilon(5S)$

12. rare B_s

…

Rare B: large samples needed



> 1 ab^{-1}

On resonance:

$\Upsilon(5S)$: 121 fb^{-1}

$\Upsilon(4S)$: 711 fb^{-1}

$\Upsilon(3S)$: 3 fb^{-1}

$\Upsilon(2S)$: 24 fb^{-1}

$\Upsilon(1S)$: 6 fb^{-1}

Off reson./scan:

~ 100 fb^{-1}

~ 550 fb^{-1}

On resonance:

$\Upsilon(4S)$: 433 fb^{-1}

$\Upsilon(3S)$: 30 fb^{-1}

$\Upsilon(2S)$: 14 fb^{-1}

Off resonance:

~ 54 fb^{-1}

~770 M $B\bar{B}$ for Belle, ~ 470 M $B\bar{B}$ for BaBar

~14M B_s also! ($\Upsilon(5S)$ runs)

Radiative and Electroweak Penguin Decays

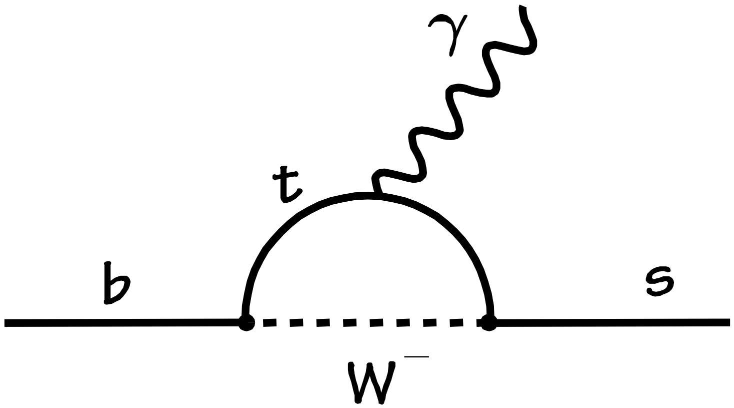
Radiative and Electroweak Penguin Decays are Flavor Changing Neutral Currents (FCNC) occuring in the Standard Model only at the **loop** level

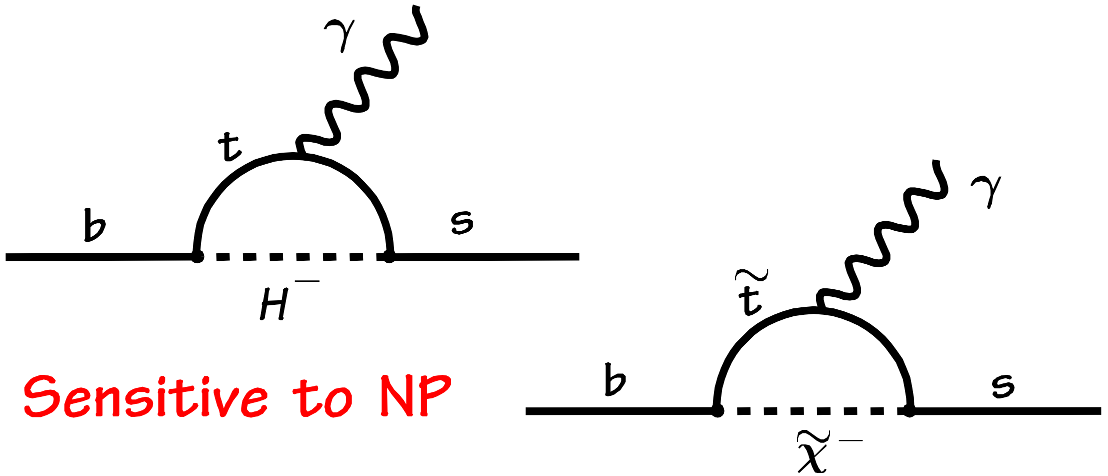
⇒ high sensitivity to **New Physics** (NP)
(can appear in the loop with size comparable to leading SM contributions)

⇒ Complementary to the direct production of new particles expected at LHC

Huge datasets collected at the two B-factories, BaBar and Belle, have made it possible to explore precisely these decays in **exclusive** channels and **inclusive** measurements

$B \to X_s \gamma$





Sensitive to NP

NNLO SM calculation:

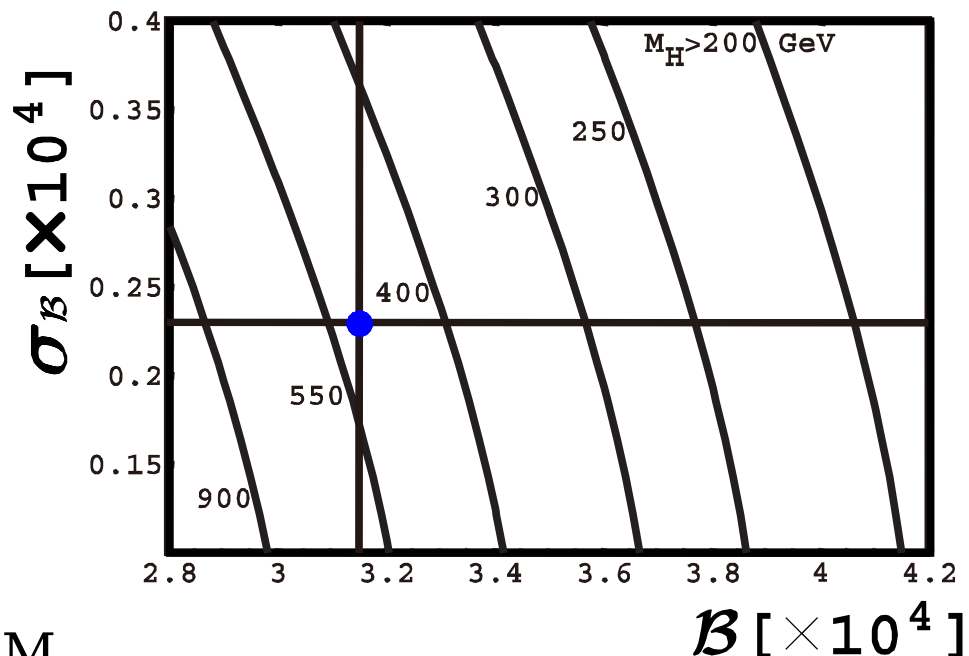
$$B_{SM}(B \to X_s \gamma) = (3.15 \pm 0.23) \times 10^{-4}$$

(for $E_\gamma > 1.6$ GeV)

M.Misiak et al.
PRL 98, 022002 (2007)

(see also talk of Soumitra Nandi)

Charged Higgs (2HDM Type II) bound



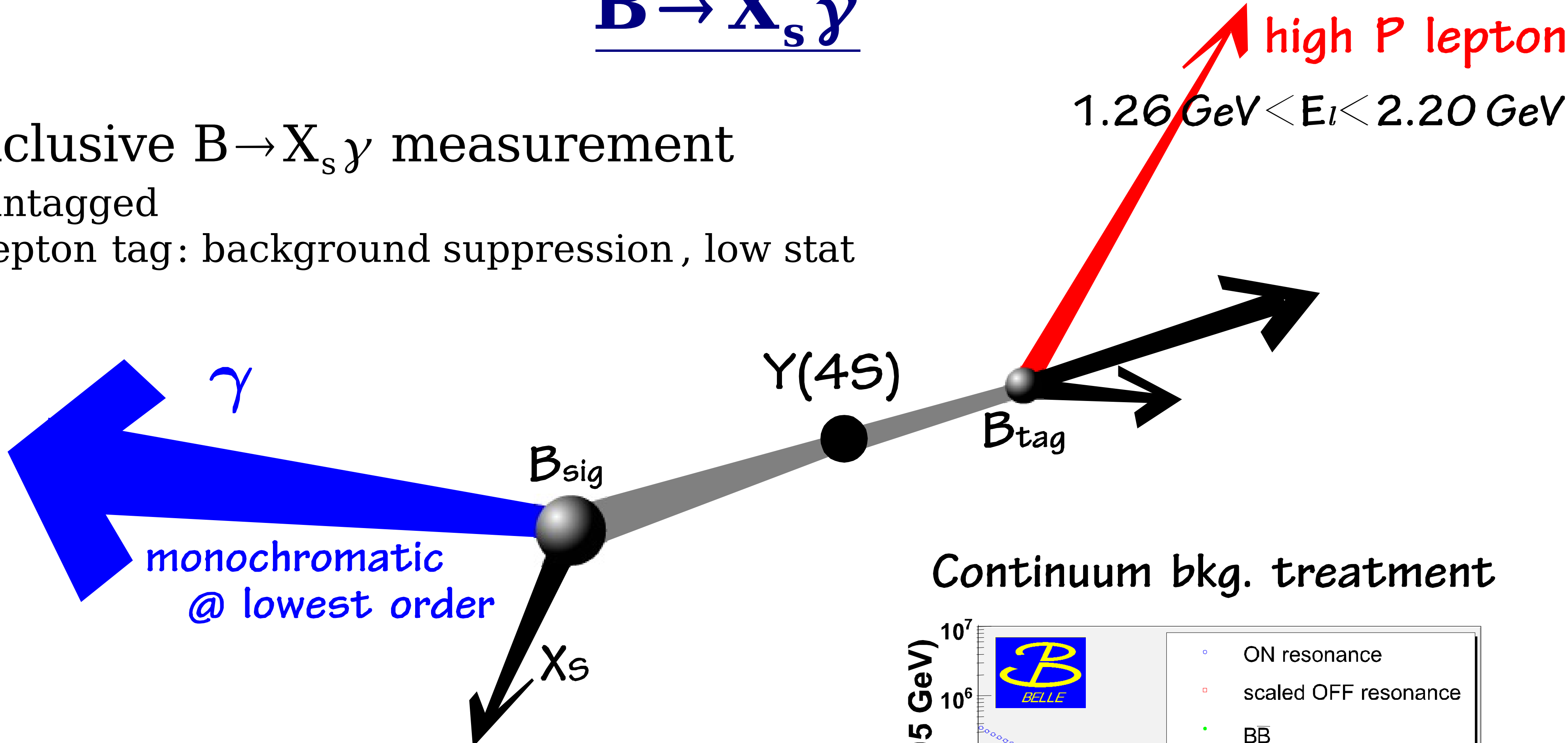
The lower γ energy threshold
the smaller the model uncertainties in SM,
but the larger background in measurement

$B \to X_s \gamma$

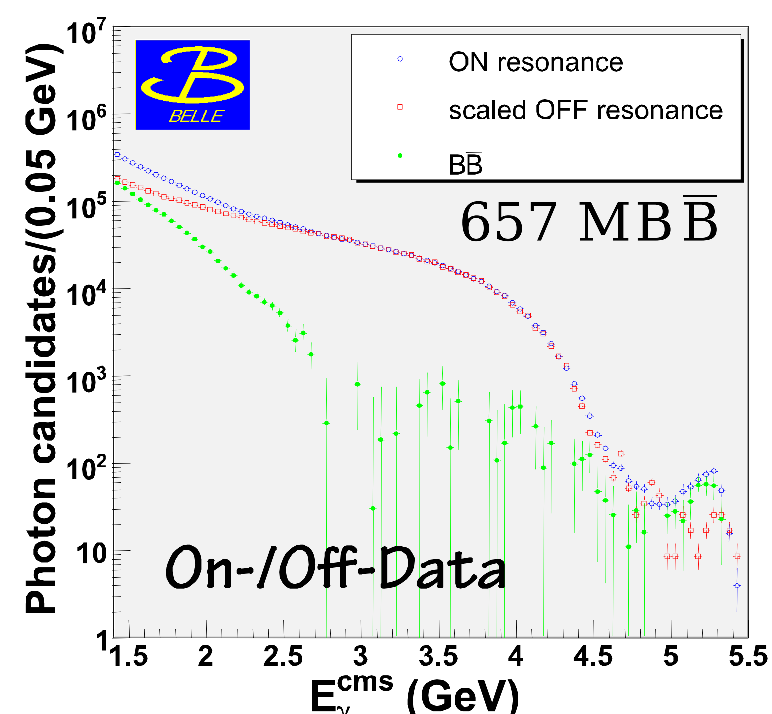
inclusive $B \to X_s \gamma$ measurement

untagged

lepton tag : background suppression , low stat



Continuum bkg. treatment



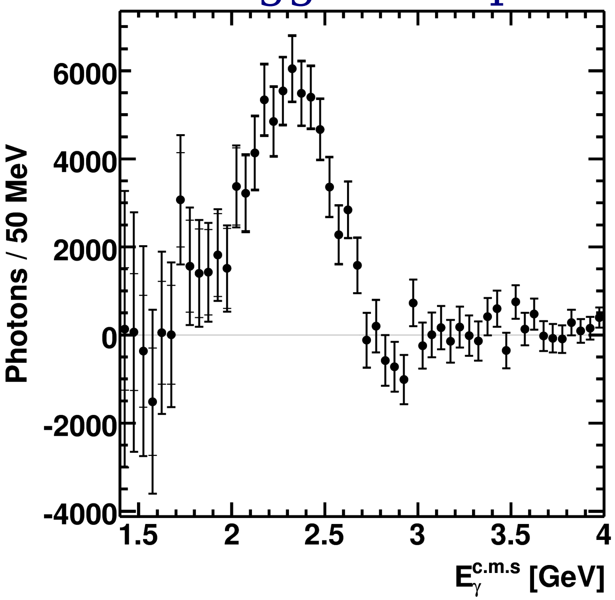
- No kinematic constraints
- Only a high energy photon measured in $\Upsilon(4S)$ rest frame
- Lower E_γ threshold (1.7 GeV)

$B \to X_s \gamma$ spectrum

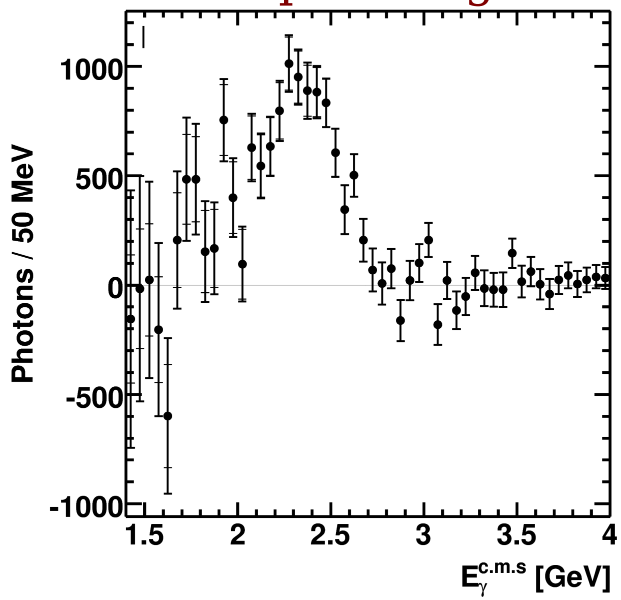
PRL 103, 241801 (2009)

Background subtracted

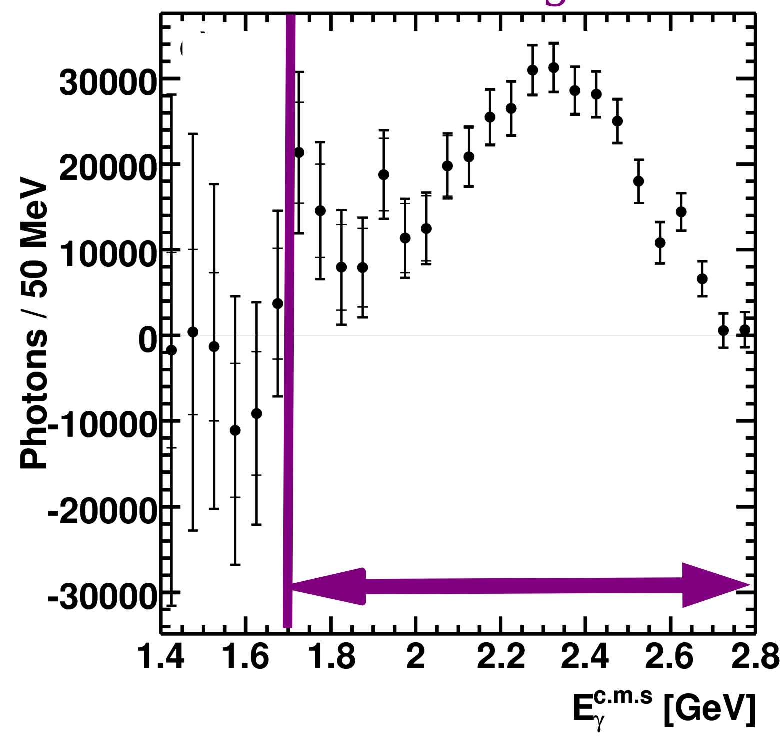
untagged sample



lepton - tag



Efficiency corrected
and averaged



$$\mathcal{B}(B \to X_s \gamma) = (3.45 \pm 0.15 \pm 0.40) \times 10^{-4} \quad (\text{for } E_\gamma > 1.7 \text{ GeV})$$

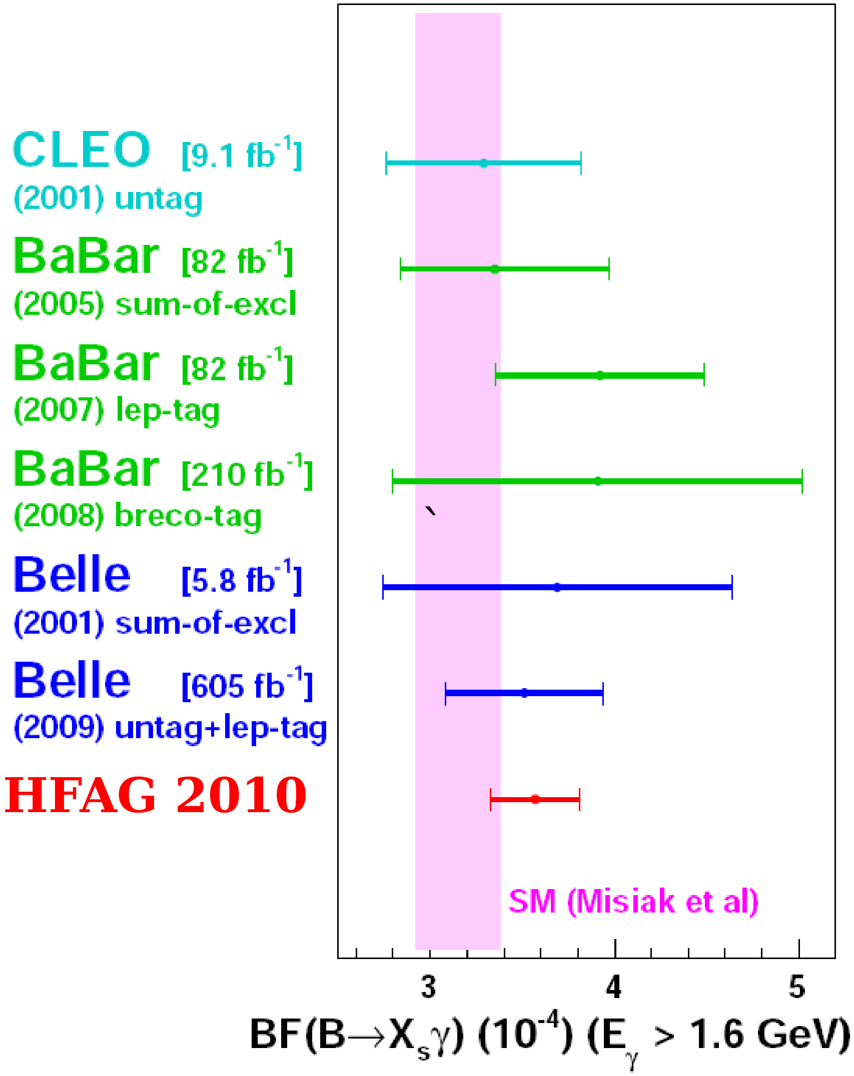
- Most precise measurement of $\mathcal{B}(B \to X_s \gamma)$ (lowest E_γ threshold)
- Crucial input for global fit to extract $|V_{ub}|$ and $B \to X_s \gamma$ decay rate
  (see Florian Bernlochner's talk)
- $\mathcal{B}$ is given for E_γ thresholds: 1.7, 1.8, 1.9, 2.0 GeV
- Systematic error is dominated by off-resonance subtraction !

$B \to X_s \gamma$

HFAG 2010: $\mathcal{B}(B \to X_s \gamma) = (3.55 \pm 0.26) \times 10^{-4}$ (for $E_\gamma > 1.6$ GeV)

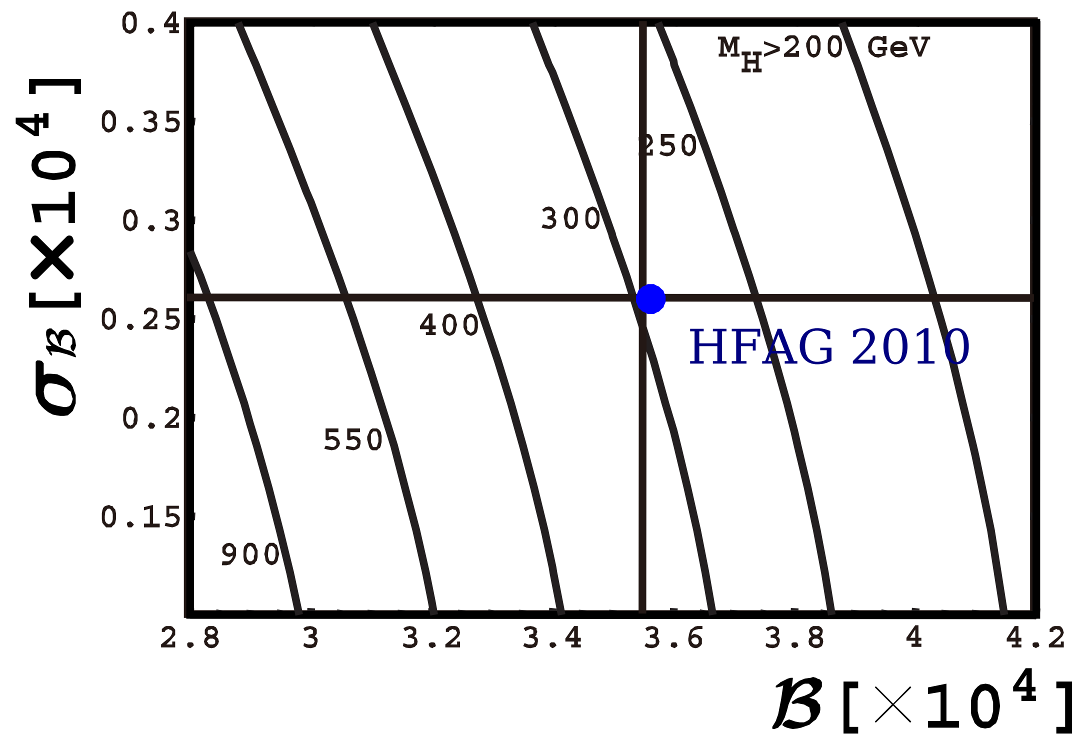
vs

SM: $\mathcal{B}(B \to X_s \gamma) = (3.15 \pm 0.23) \times 10^{-4}$ (for $E_\gamma > 1.6$ GeV)



Charged Higss bound (2HDM TypeII)

$M_{H^+} > 300$ GeV

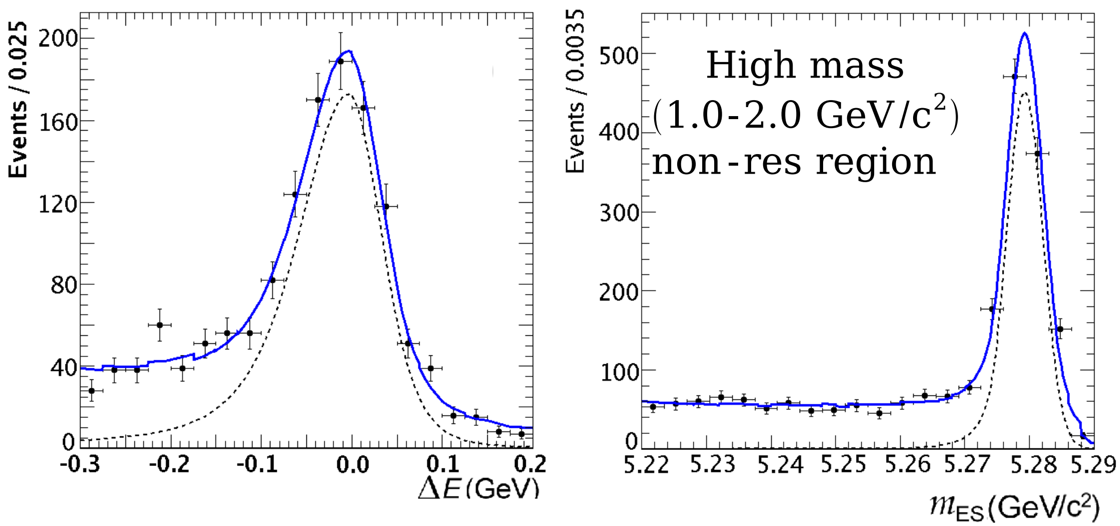


$B \to X_{s,d}\gamma$

see Deborah Bard's talk
arXiv:1005.4087

- 471 $MB\bar{B}$
- Sum of seven exclusive final states:

$B^0 \to K^+\pi^-\gamma$, $K^+\pi^-\pi^0\gamma$, $K^+\pi^-\pi^+\pi^-\gamma$, $B^+ \to K^+\pi^0\gamma$, $K^+\pi^-\pi^+\gamma$, $K^+\pi^-\pi^+\pi^0\gamma$, $K^+\eta\gamma$



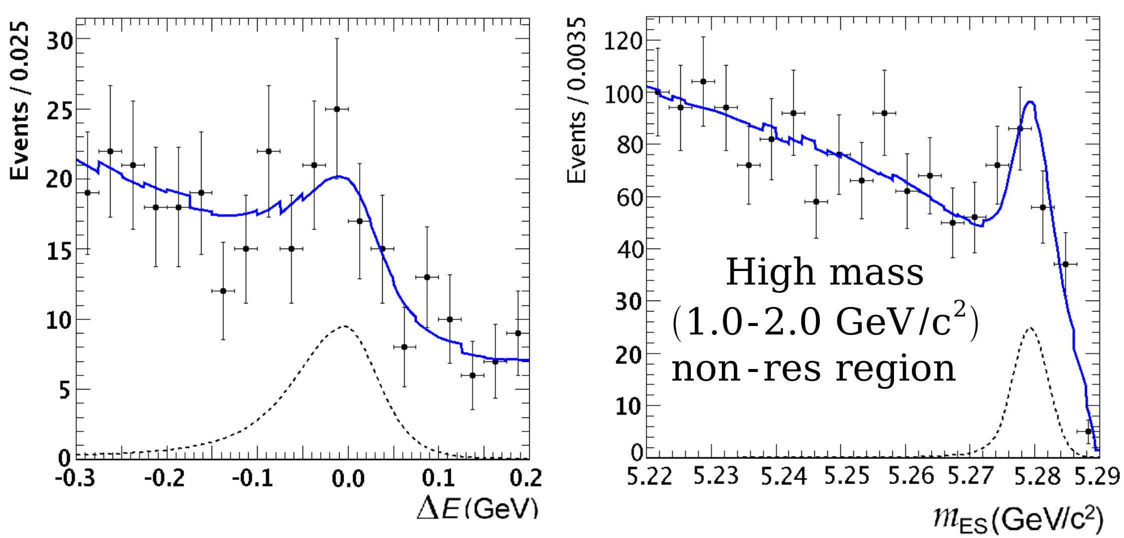
$$\mathcal{B}(B \to X_s\gamma) = (23.0 \pm 0.8_{stat} \pm 3.0_{syst}) \times 10^{-5}$$

$(M(X_s) < 2.0\ GeV)$

$b \to d\gamma$ CKM suppressed w.r.t $b \to s\gamma$ by a factor ~ 20 (in SM)

- Sum of seven exclusive final states:

$B^0 \to \pi^+\pi^-\gamma$, $\pi^+\pi^-\pi^0\gamma$, $\pi^+\pi^-\pi^+\pi^-\gamma$, $B^+ \to \pi^+\pi^0\gamma$, $\pi^+\pi^-\pi^+\gamma$, $\pi^+\pi^-\pi^+\pi^0\gamma$, $\pi^+\eta\gamma$



$$\mathcal{B}(B \to X_d\gamma) = (9.2 \pm 2.0_{stat} \pm 2.3_{syst}) \times 10^{-6}$$

$(M(X_d) < 2.0\ GeV)$

mass range covers ~ 60% of total spectrum in $b \to s, d\ \gamma$

$|V_{td}|/|V_{ts}|$ using...

B-mixing average:

$$\frac{|V_{td}|}{|V_{ts}|} = 0.2059 \pm 0.001_{exp} \pm 0.008_{th}$$

...inclusive $X_{s,d}\gamma$

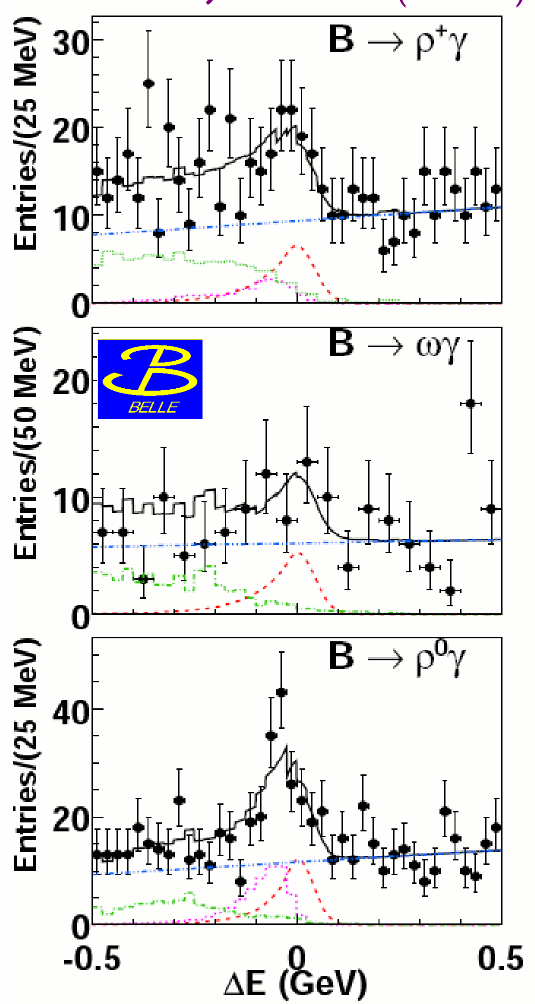
arXiv:1005.4087

$$\Rightarrow \frac{|V_{td}|}{|V_{ts}|} = \mathbf{0.199 \pm 0.022_{stat} \pm 0.012_{syst} \pm 0.027_{extrapol} \pm 0.002_{th}}$$

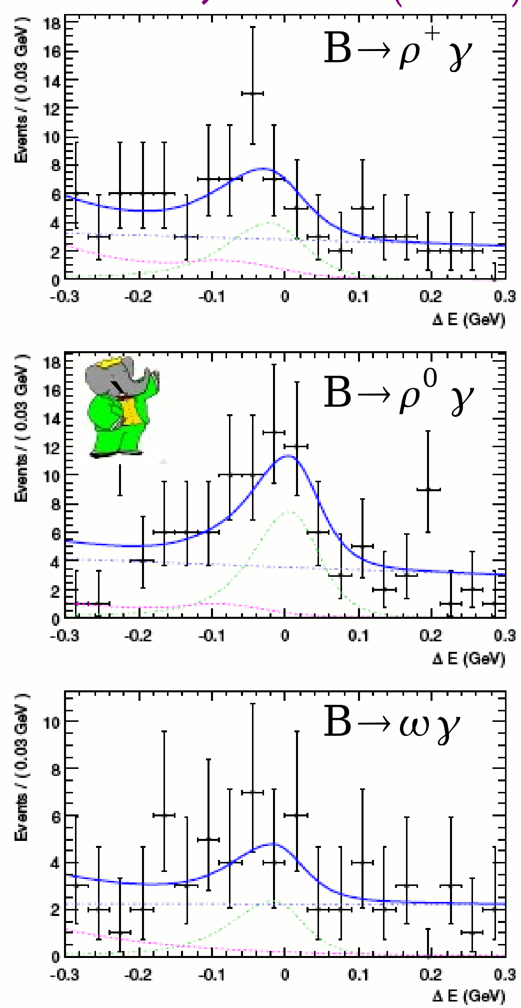
theory error ~1%

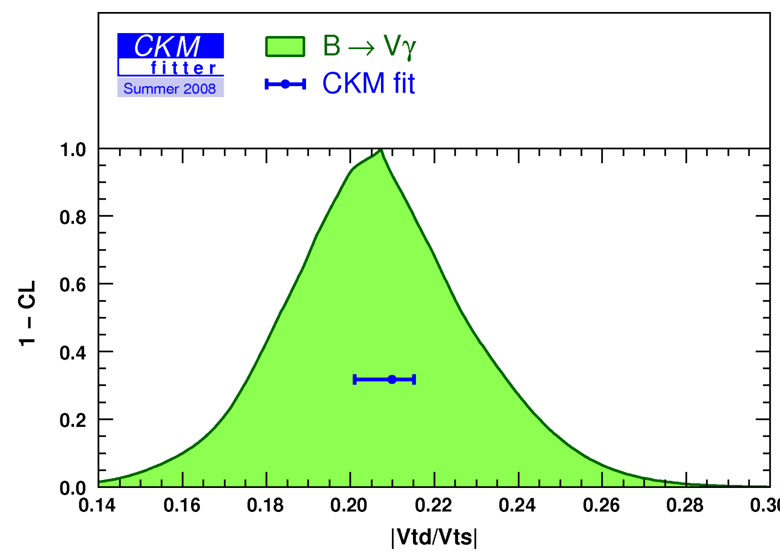
...exclusive modes: $B \to (\rho/\omega)\gamma$, $K^*\gamma$

PRL101, 111801 (2008)



PRD78, 112001 (2008)

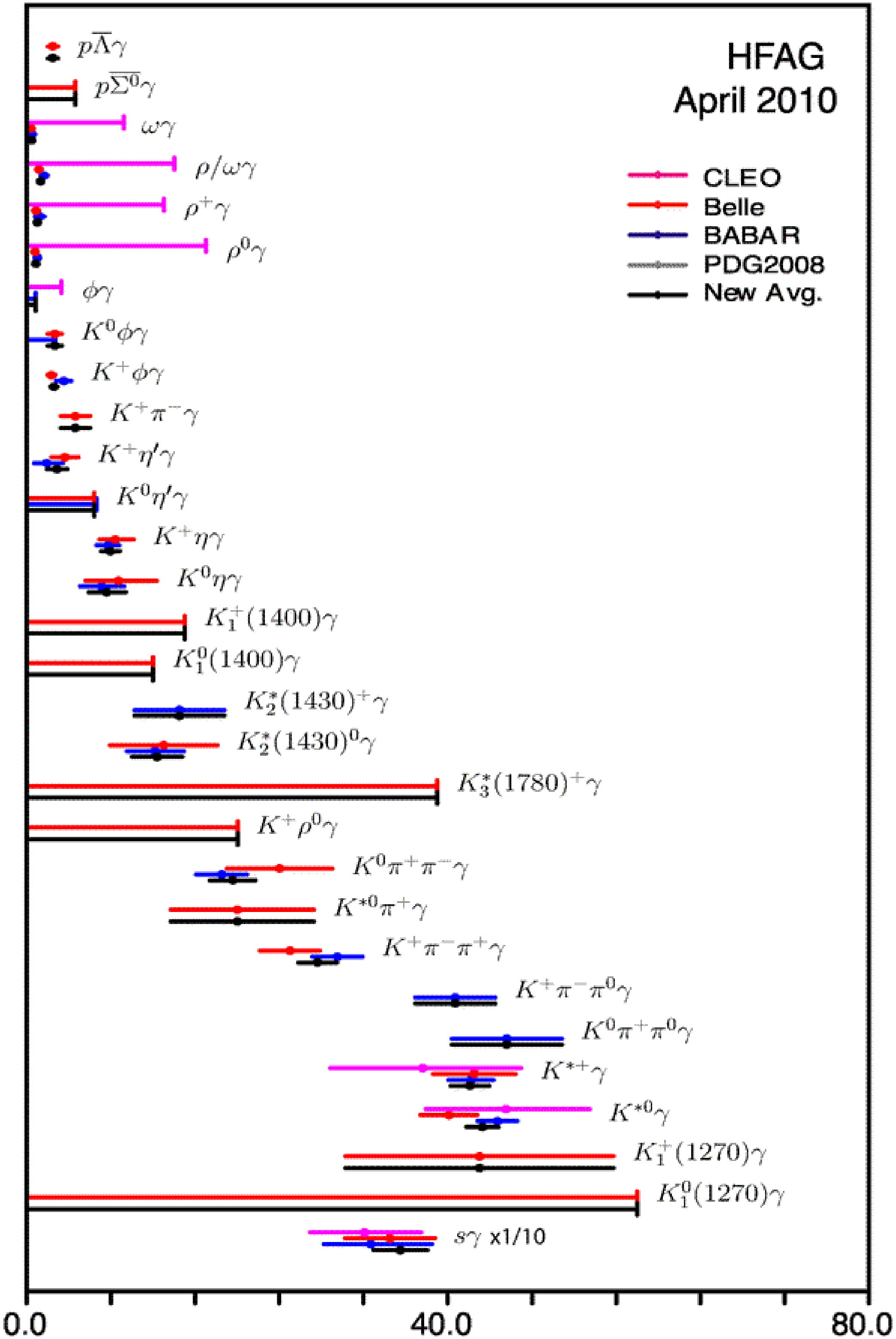




$$\Rightarrow \frac{|V_{td}|}{|V_{ts}|} = \mathbf{0.207^{+0.030}_{-0.032}}$$

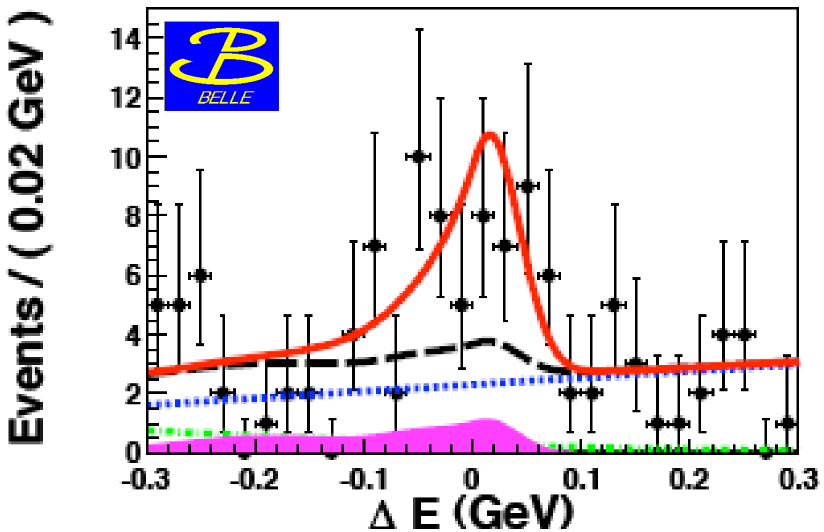
theory error ~8%

$B \to X_{s,d}\gamma$



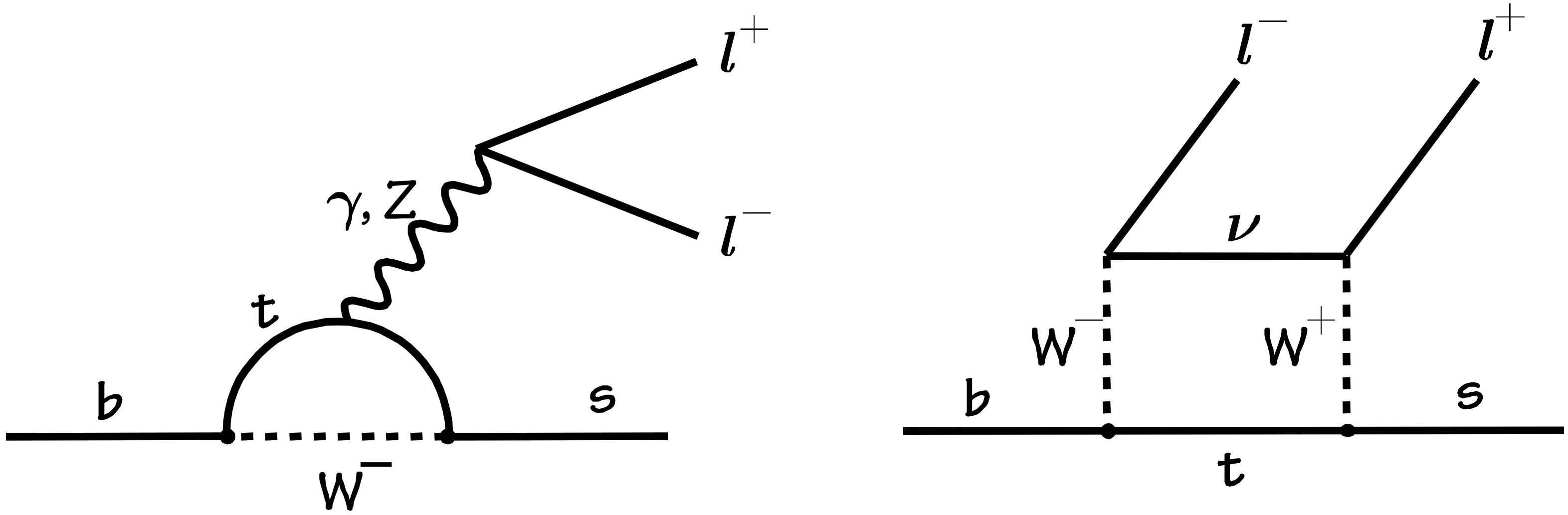
$B(10^{-6})$

arXiv:0911.1779 $B \to \phi K_S \gamma$



see Himansu Sahoo's talk

$b \to s\, l^+ l^-$



$\Rightarrow$ 2 orders of magnitude smaller than $b \to s\gamma$ but rich NP search potential

Amplitudes from
- electromagnetic penguin: C_7
- vector electroweak: C_9
- axial-vector electroweak: C_{10}

may interfere w/ contributions from NP

Many observables:
- Branching fractions
- Isospin asymmetry (A_I)
- Lepton forward-backward asymmetry (A_{FB})

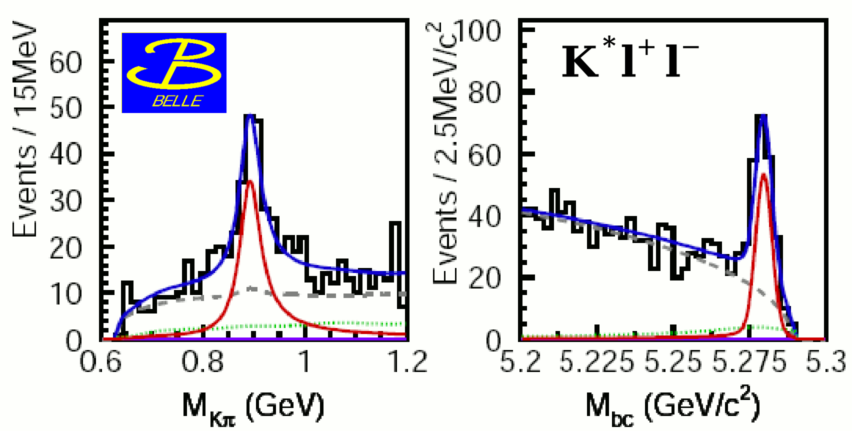
(many other observables: Tobias Hurth's talk)

$\Rightarrow$ Exclusive ($B \to K^{(*)} l^+ l^-$), Inclusive ($B \to X_s\, l^+ l^-$)

Exclusive $B \to K l^+ l^-$ and $B \to K^* l^+ l^-$

$K = K^+$ or K^0_S, $K^* = K^{*0} \to K^+ \pi^-$, $K^{*+} \to K^0_S \pi^+$, $K^+ \pi^0$, $l = e$ or μ

Various observables: Forward-backward asymmetry, F_L, isospin, lepton flavor...



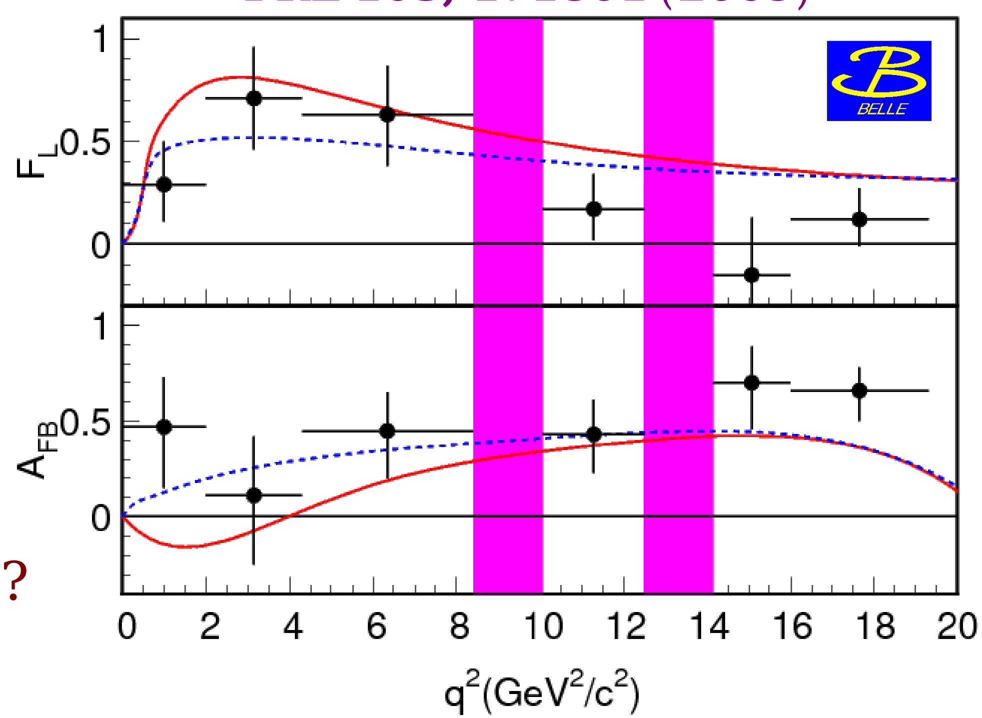
~ 250 $K^* l^+ l^-$ events

~ 160 $K l^+ l^-$ events

$$A_{FB}(q^2) = -C_{10}^{eff}\, \xi(q^2)\left[\mathrm{Re}(C_9^{eff})\, F_1 + \frac{1}{q^2} C_7^{eff} F_2\right]$$

$q^2 = m^2_{l^+l^-}$

PRL 103, 171801 (2009)



$C_7 = -C_7^{SM}$

SM

No crossing ?

opposite sign C_7 ?

Hints of anomalously large positive A_{FB} at low and high q^2

similar situation in BaBar's case

PRD 79, 031102 (2009)

being updated

$b \to s\gamma$, $s l^+ l^-$ and Wilson coefficients

NP effects can be parameterized as deviations from SM in Wilson coefficients C_7, C_9, C_{10}: $C_i = C_i^{SM} + C_i^{NP}$

$b \to s\gamma$ (sensitive to $|C_7|$ only)

$$B(b \to s\gamma) = \frac{G_F^2 \alpha_{em} m_b^5 |V_{ts}^* V_{tb}|^2}{32\pi^4} |\mathbf{C_7^{eff}}|^2 + \text{corr.}$$

$b \to s l^+ l^-$ (sensitive to C_7 sign, C_9, C_{10})

$$\frac{d\Gamma(b \to s l^+ l^-)}{dq^2} = \left(\frac{\alpha_{em}}{4\pi}\right)^2 \frac{G_F^2 m_b^5 |V_{ts}^* V_{tb}|^2}{48\pi^3} (1-q^2)^2$$
$$\times [(1+2q^2)(|C_9^{eff}|^2 + |C_{10}^{eff}|^2) + 4(1+\frac{2}{q^2})|\mathbf{C_7^{eff}}|^2 + 12\,\mathrm{Re}(\mathbf{C_7^{eff}} C_9^{eff})] + \text{corr.}$$

Inclusive differential branching fraction is sensitive to Wilson coefficients (no form factor uncertainties of $B \to K^* l^+ l^-$)

Opposite-sign C_7 makes the branching fraction larger

(in SM, $C_7 < 0$ and $C_9 > 0$)

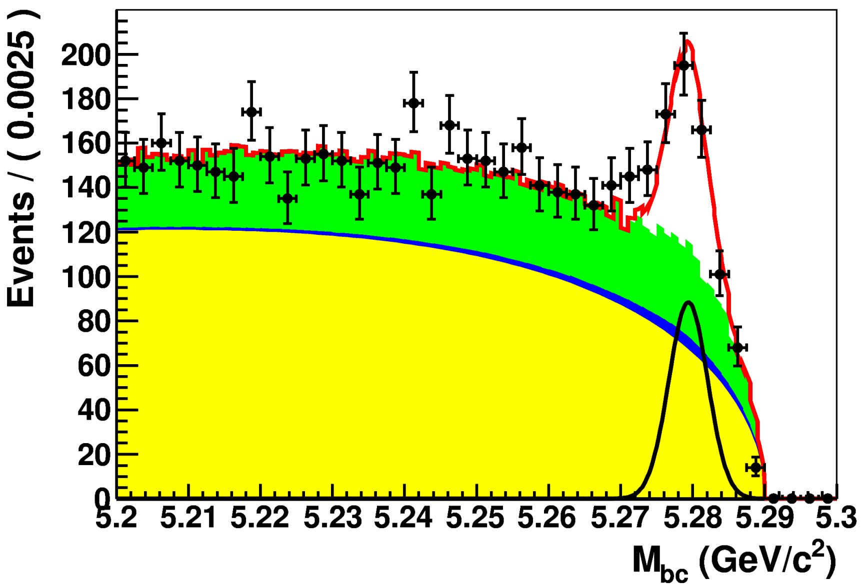
$B \to X_s l^+ l^-$

see Cheng-Chin Chiang's talk

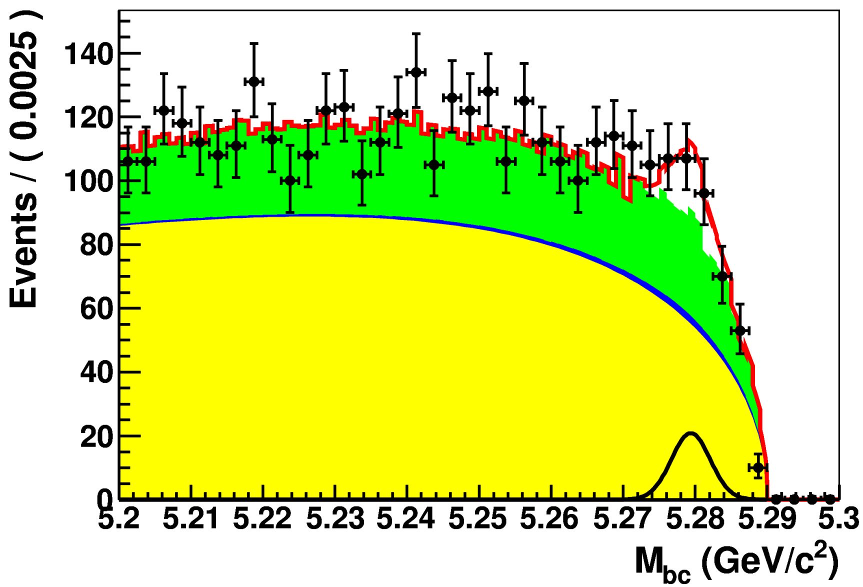
Full inclusive measurement is not feasible so far,
sum-of-exclusive technique has been used by Belle/BaBar

X_s reconstructed by: 1 ($K^{\pm}$ or K_S) + 4π's ($N\pi^0 \leq 1$) (36 modes)

$\Rightarrow$ Belle (657 M$B\bar{B}$), preliminary (previous 152 M$B\bar{B}$)



10σ signal for entire $M(X_s)$



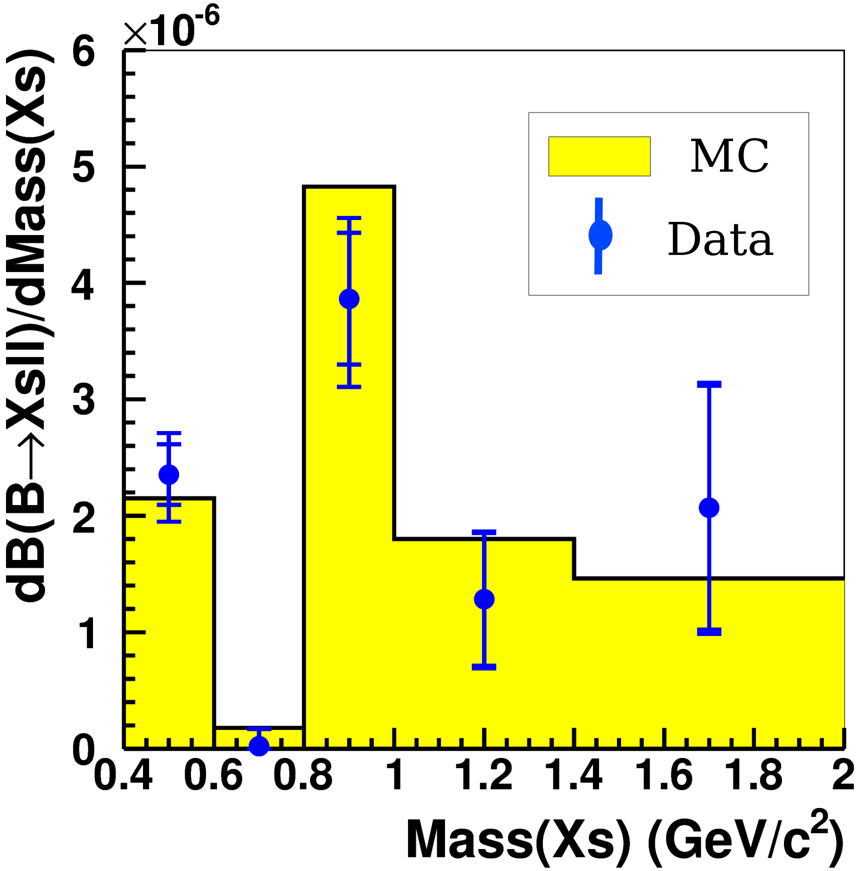
3σ signal for $M(X_s)$>1.0 GeV

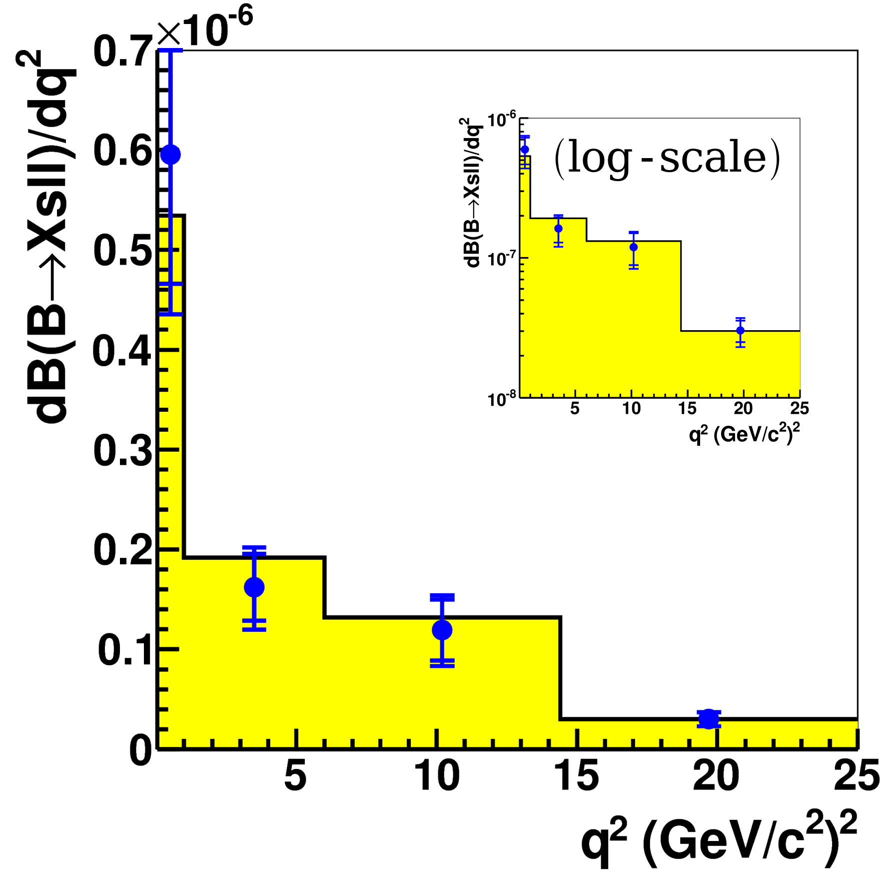
Combinatorial BG (semi-leptonic B decays, continuum)

Self Cross-Feed

Peaking BG $B \to X_s \pi^+ \pi^-$ (double mis-id), leakage from J/ψ and ψ' veto, charmonium higher resonances...

$B \to X_s l^+ l^-$





$$\mathcal{B}(B \to X_s l^+ l^-) = (3.33 \pm 0.80^{+0.19}_{-0.24}) \times 10^{-6}$$

[$q^2 > 0.2\ \mathrm{GeV}^2/c^4$, extrapolated for J/ψ, ψ', and $M(X_s) > 2.0$ GeV]

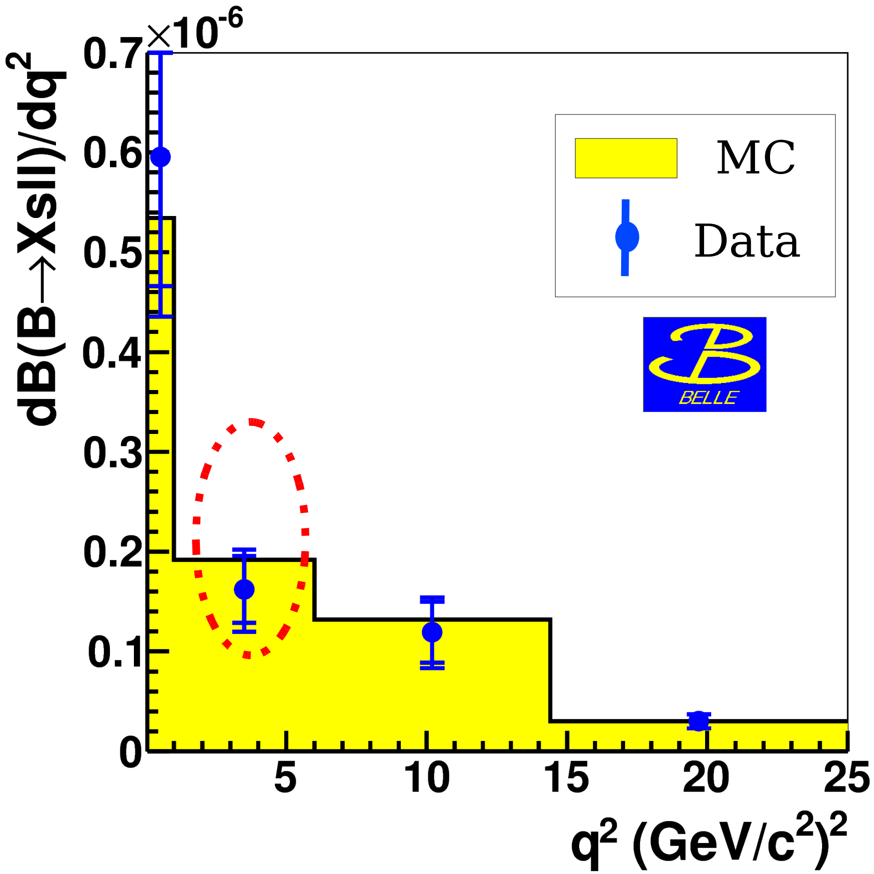
HFAG average: $\mathcal{B} = (3.66^{+0.76}_{-0.77}) \times 10^{-6}$

SM (Ali et al): $\mathcal{B}_{SM} = (4.2 \pm 0.7) \times 10^{-6}$

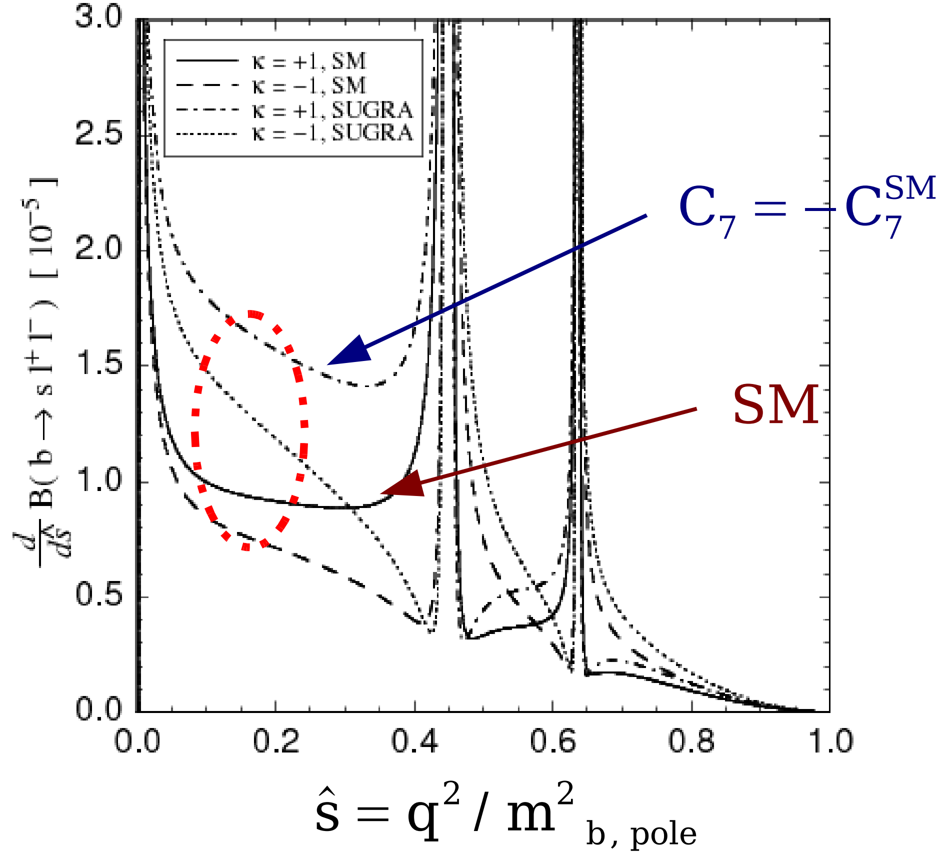
SM (Gambino et al): $\mathcal{B}_{SM} = (4.4 \pm 0.7) \times 10^{-6}$

PRL 94, 061803 (2005)

q^2 spectrum in $B \to X_s l^+ l^-$



T.Goto et al
PRD 55, 4273 (1997)



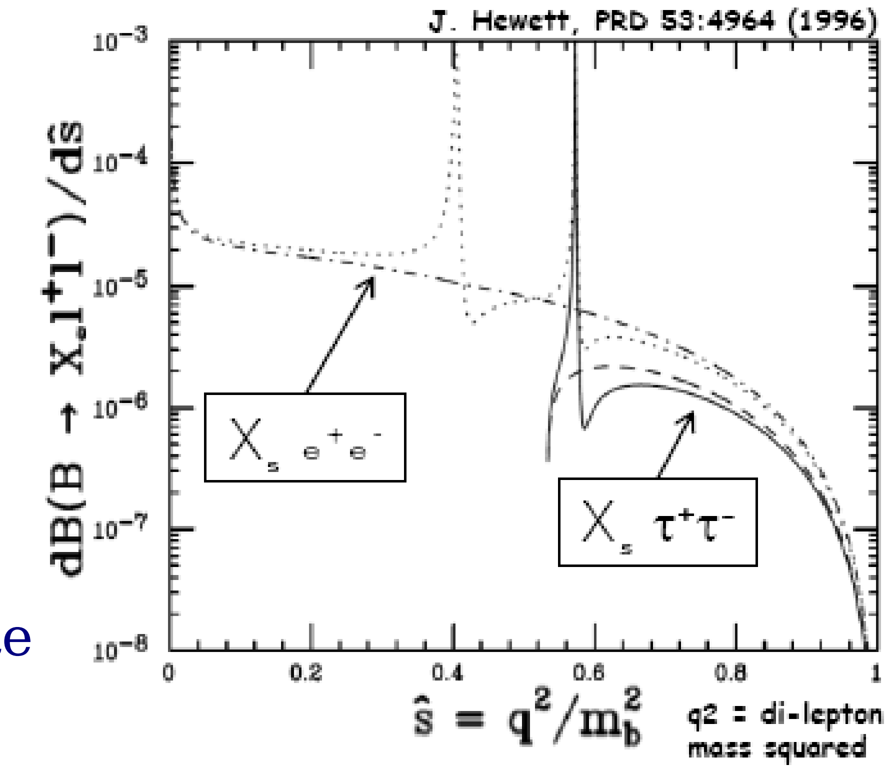
⇒ No branching fraction enhancement in this region

strongly disfavor the case with the flipped sign of C_7

(other less extreme NP possibilities are still allowed)

$\mathbf{B^+ \to K^+ \tau^+ \tau^-}$

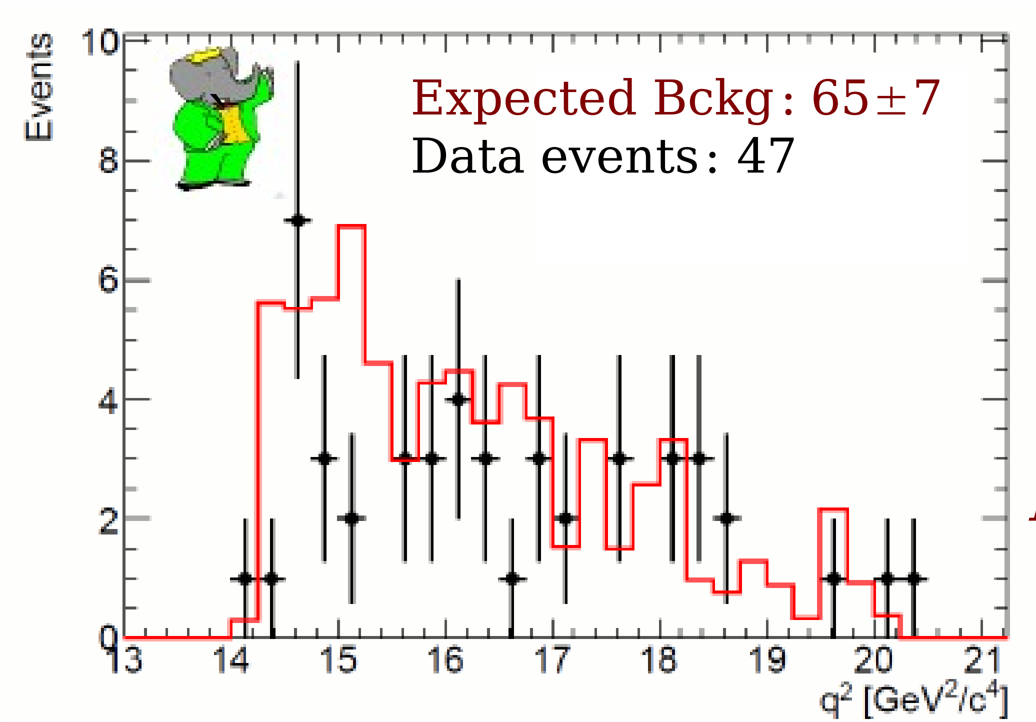
see Kevin Flood's talk



$0.6 \le \hat{s} \le 1$:

$$B_{SM}(B^+ \to X e^+ e^-) = 8.5 \times 10^{-7}$$
$$B_{SM}(B^+ \to X \mu^+ \mu^-) = 8.5 \times 10^{-7}$$
$$B_{SM}(B^+ \to X \tau^+ \tau^-) = 4.3 \times 10^{-7}$$

- rate can be **enhanced by NP** (NMSSM rate could be $\propto (M_\tau^2/M_\mu^2) \sim 280$)
- $B^+ \to K^+ \tau^+ \tau^-$ is ~ 50% of total inclusive rate

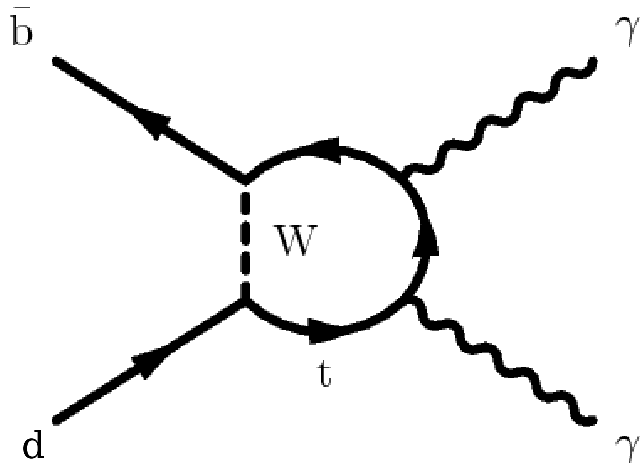


- First search (preliminary)
- 468M $B\bar{B}$
- Hadronic tag ($\epsilon \sim 0.2\%$)
- $\tau \to e\bar{\nu}\nu$, $\mu\bar{\nu}\nu$, $\pi\nu$ (2-4 neutrinos in the final state)

$$\boldsymbol{B(B^+ \to K^+ \tau^+ \tau^-) < 3.3 \times 10^{-3}}$$ **@ 90% C.L.**

$B_d \to \gamma\gamma$

see Kevin Flood's talk



$B_{SM} \sim 3\times10^{-8}$

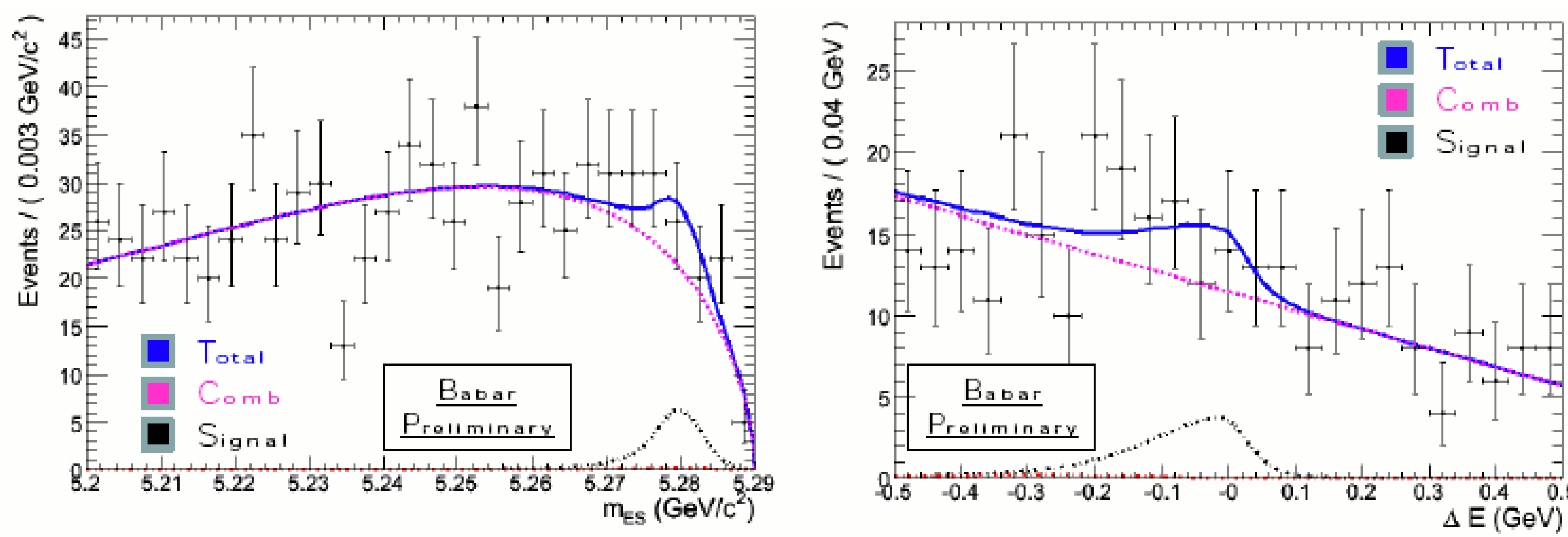
Bosch and Buchalla

JHEP 0208:054 (2002)

$(B_{SM}(B_s \to \gamma\gamma) \sim 1\times10^{-6})$

after continuum background rejection and π^0, η vetoes

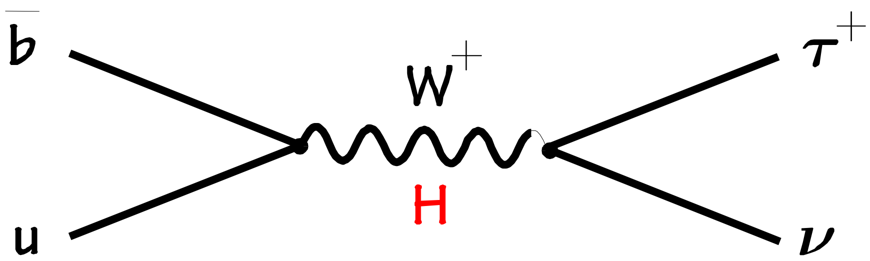
2d fit to m_{ES} and ΔE, $N_S = 21.3^{+12.8}_{-11.8} \pm 1.4$

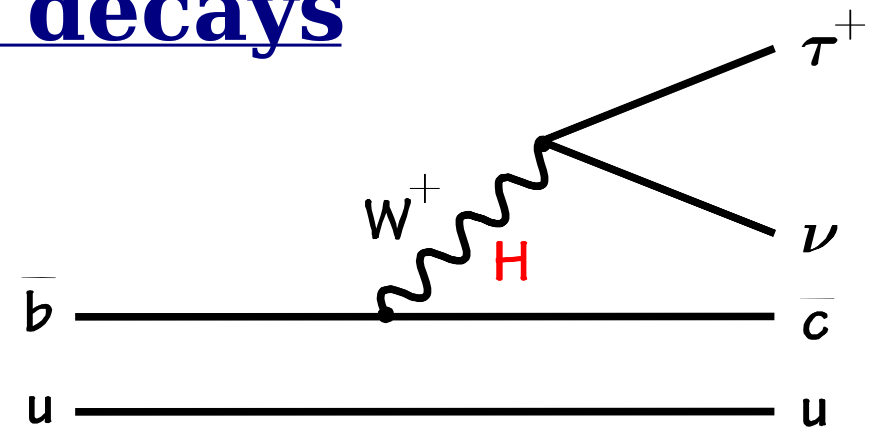


$B(B^0 \to \gamma\gamma) < 3.2 \times 10^{-7}$ @ 90% C.L.

$B(B^0 \to \gamma\gamma) < 6.1 \times 10^{-7}$ @ 90% C.L. (using 104 fb^{-1}) [PRD73, 051107 (2006)]

Tauonic B decays





$B \to \tau \nu$

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

2HDM (type II): $\mathcal{B}(B^+ \to \tau^+ \nu) = \mathcal{B}_{SM} \times \left(1 - \frac{m_B^2}{m_{H^+}^2}\tan^2\beta\right)^2$

uncertainties from f_B and $|V_{ub}|$ can be reduced to B_B
and other CKM uncertainties by combining with precise Δm_d

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

2HDM (type II): $\mathcal{B}(B \to D \tau^+ \nu) = G_F^2 \tau_B |V_{cb}|^2 f\left(F_V, F_S, \frac{m_B^2}{m_{H^+}^2}\tan^2\beta\right)$

uncertainties from form factors F_V and F_S can be studied
with $B \to D l \nu$ (more form factors in $B \to D^* \tau \nu$)

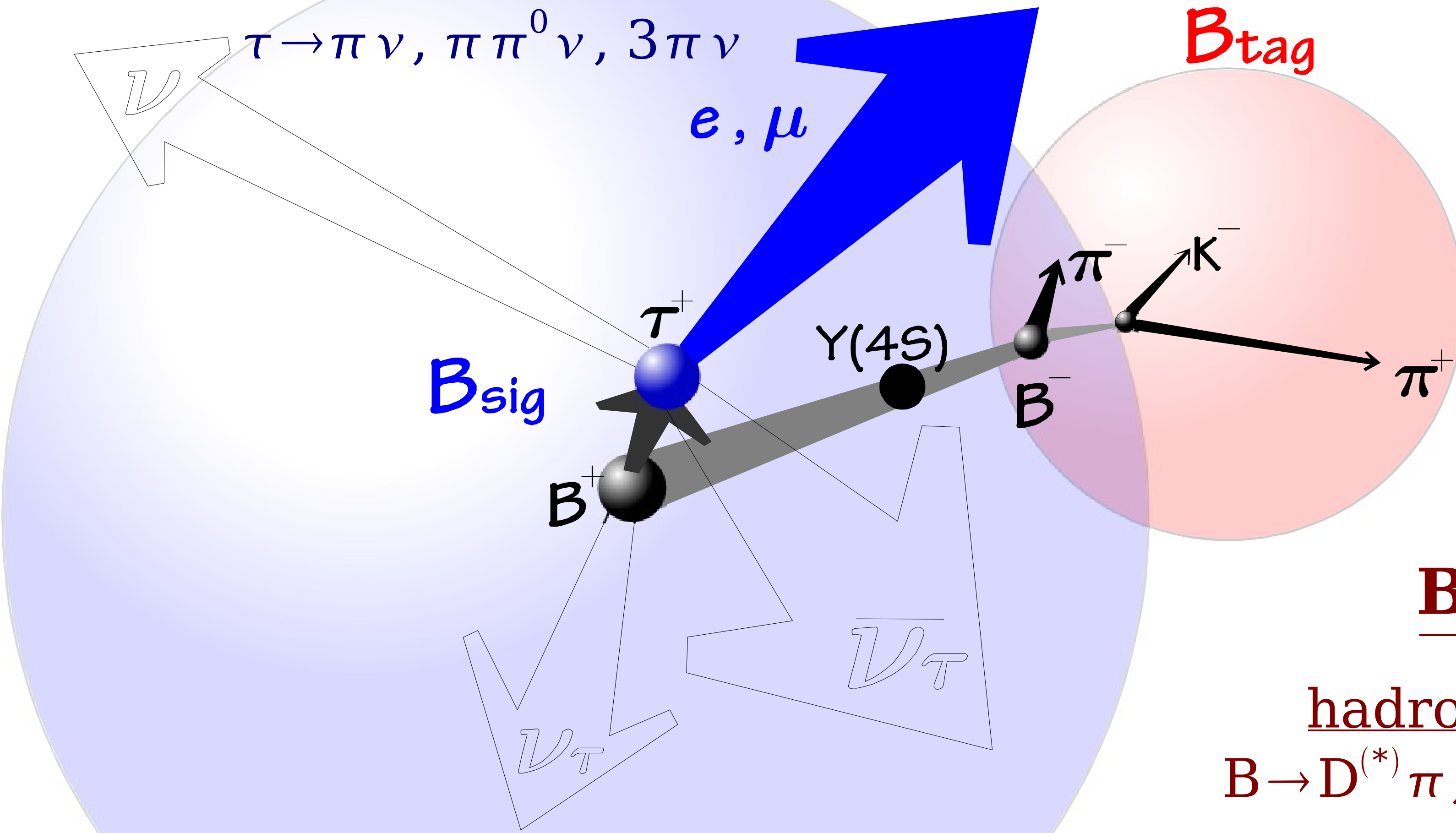
Event reconstruction in $B \rightarrow \tau \nu$

$B_{sig} \rightarrow \tau \nu$

(70 % of all τ decays)

$\tau \rightarrow e \nu \nu$, $\mu \nu \nu$,

$\tau \rightarrow \pi \nu$, $\pi \pi^0 \nu$, $3 \pi \nu$



Require no particle
and no energy left
after removing B_{tag}
and visible particles of B_{sig}

B_{tag}

hadronic tag

$B \rightarrow D^{(*)} \pi$, $D^{(*)}$rho....

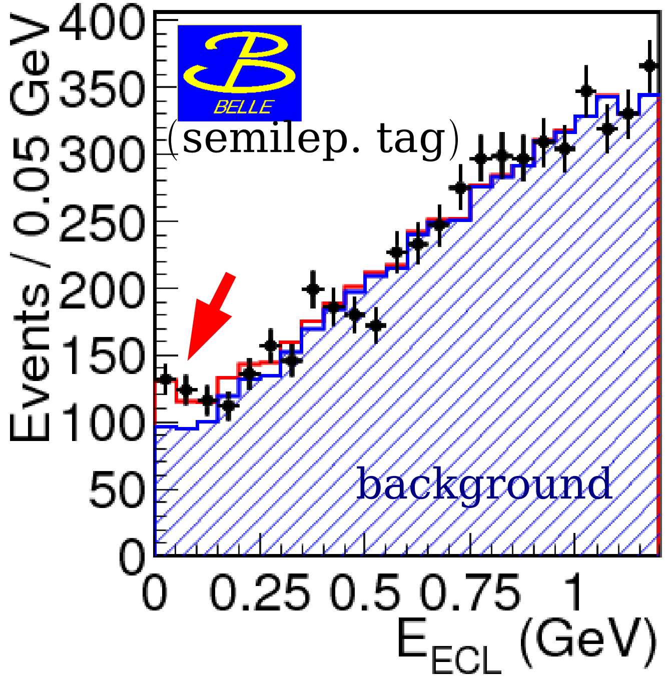
$\epsilon \sim 0.2\,\%$

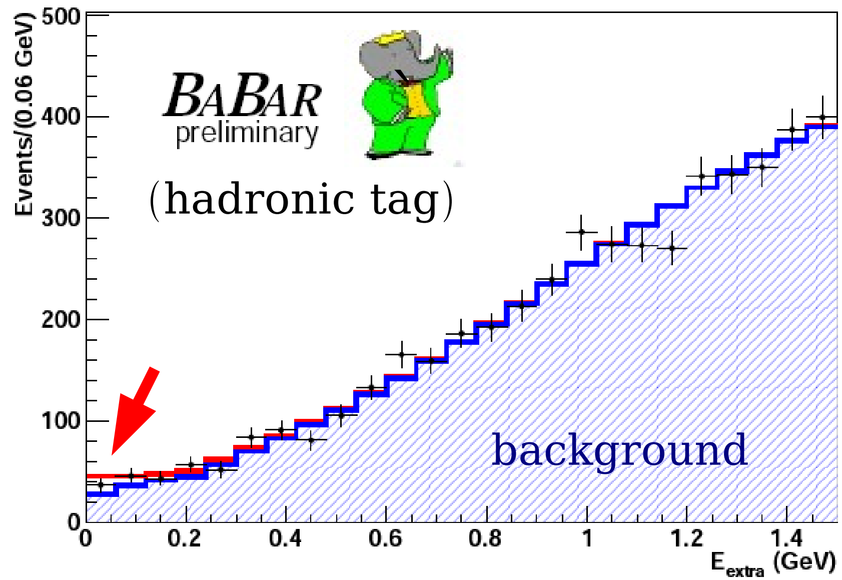
semileptonic tag

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

$B^+ \to \tau^+ \nu$ results

see De Nardo Gugliemo and Jacek Stypula's talks





Extra calorimeter energy: $E_{ECL/extra}$ (GeV)

Belle	$N_{B\bar{B}}$	$\mathcal{B}\,(10^{-4})$	$\Sigma\,(\sigma)$	
Hadronic tag	(449 M)	$(1.79^{+0.56}_{-0.49}{}^{+0.46}_{-0.51})$	3.5	PRL97, 251802 (2006)
⇒ Semilep. tag	(657 M)	$(1.54^{+0.38}_{-0.37}{}^{+0.29}_{-0.31})$	3.6	arXiv:1006.4201
BaBar				
⇒ Hadronic tag	(468 M)	$(1.80^{+0.57}_{-0.54} \pm 0.26)$	3.6	preliminary
Semilep. tag	(459 M)	$(1.7 \pm 0.8 \pm 0.2)$	2.3	PRD81, 051101 (2010)

$B^+ \to \tau^+ \nu$ results

World average: $\mathcal{B}(B^+ \to \tau^+ \nu) = (1.68 \pm 0.31)\times 10^{-4}$

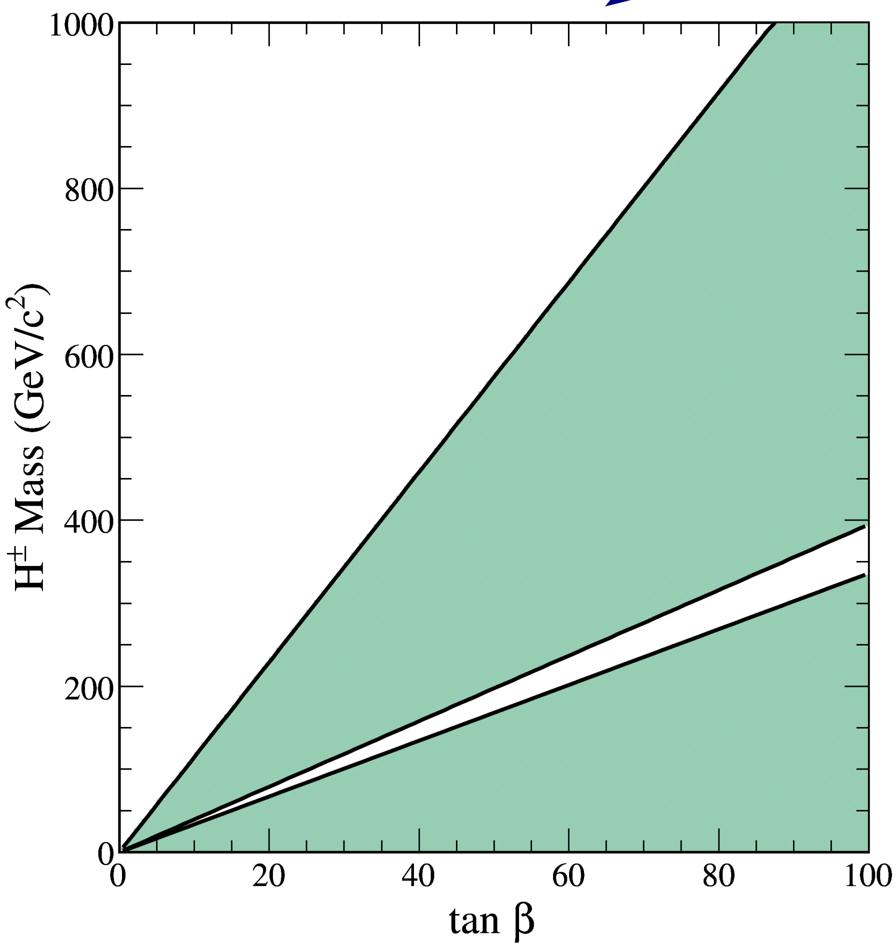
2HDM (type II):

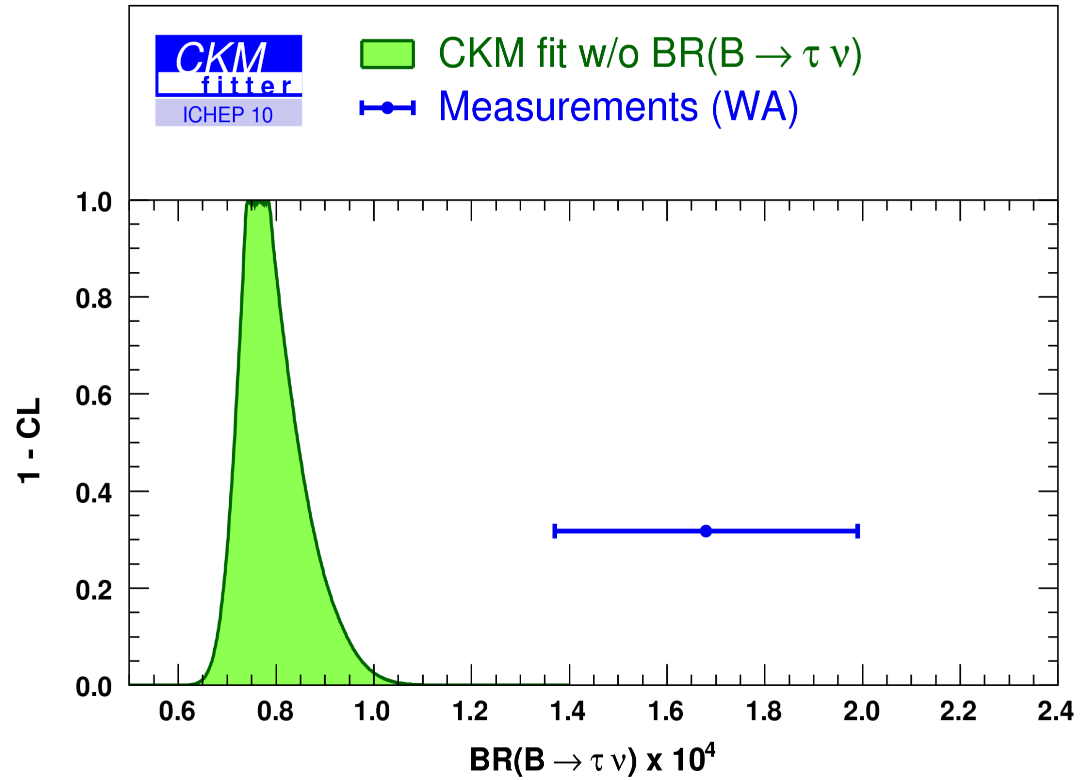
$$\mathcal{B}(B^+ \to \tau^+ \nu) = \mathcal{B}_{SM} \times \left(1 - \frac{m_B^2}{m_{H^+}^2}\tan^2\beta\right)^2$$

$\mathcal{B}_{SM}(B^+ \to \tau^+ \nu) = (1.20 \pm 0.25)\times 10^{-4}$
using f_B (HPQCD), $|V_{ub}|$ (HFAG)

CKMfitter: $\mathcal{B}_{SM}(B^+ \to \tau^+ \nu) = (0.763\,^{+0.114}_{-0.061})\times 10^{-4}$

2.8σ difference



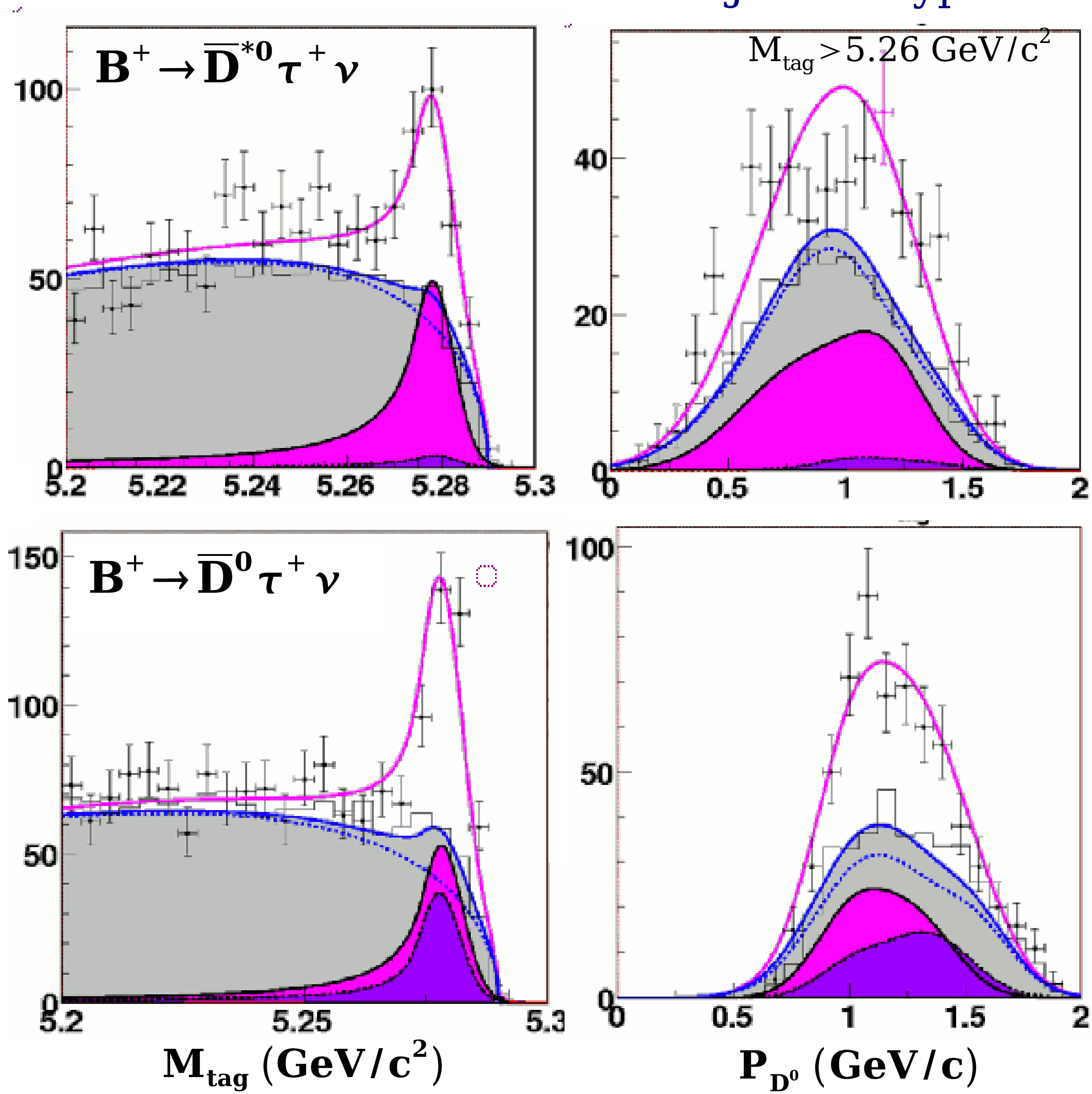


see Stephane T'Jampens and Cecilia Tarantino's talks

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

see Jacek Stypula's talk

arXiv:1005.2302
submitted to PRL



- 657M $B\overline{B}$
- same method than for $B^0 \to D^{*-} \tau^+ \nu$

B_{sig}:

$D^0 \to K\pi,\ K\pi\pi^0$

$\tau^+ \to e^+ \nu_e \overline{\nu}_\tau,\ \mu^+ \nu_\mu \overline{\nu}_\tau,\ \pi^+ \overline{\nu}_\tau,\ \rho^+ \overline{\nu}_\tau$

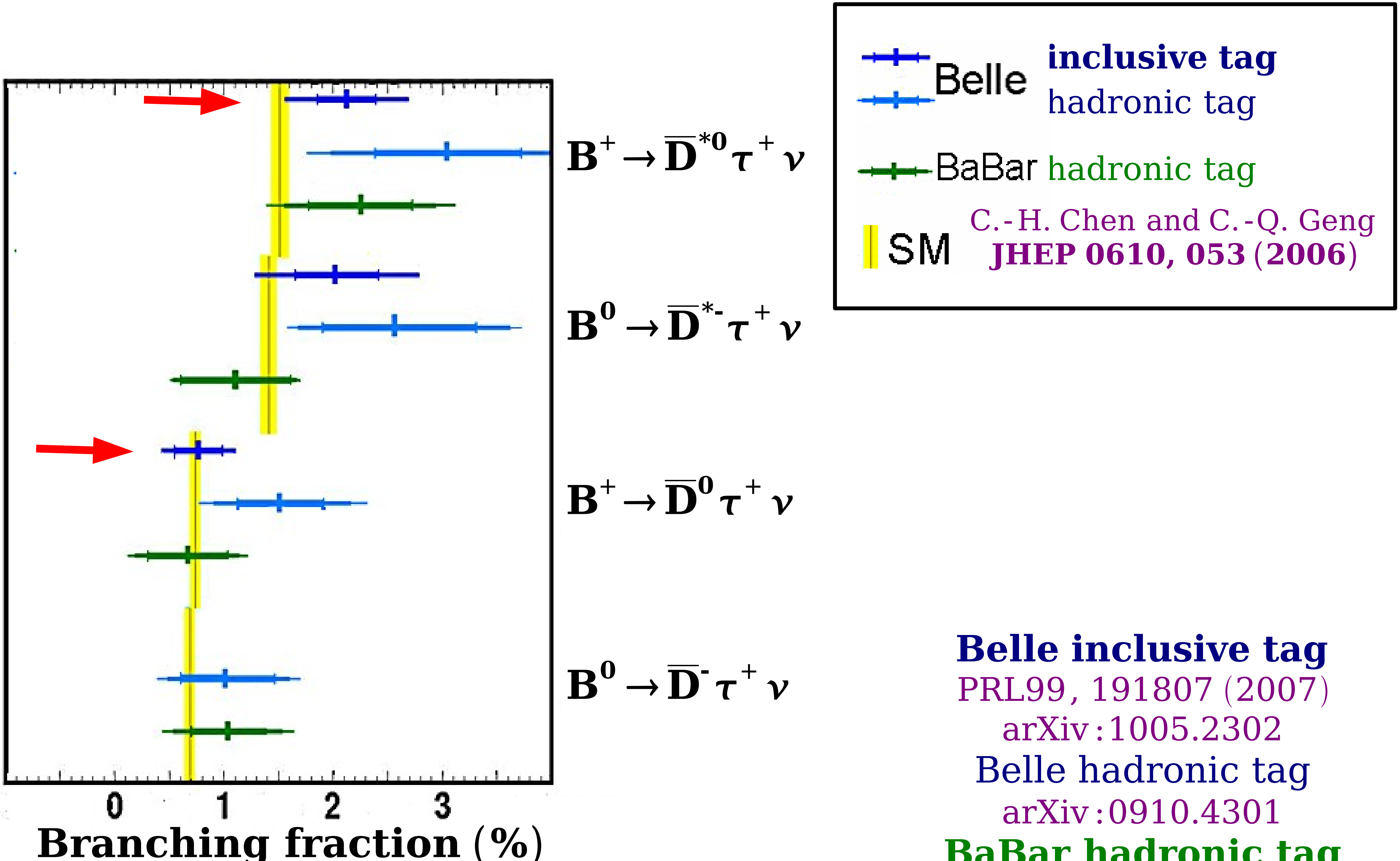
13 different decay chains

B_{tag}: all remaining particles

First $B^+ \to \overline{D}^0 \tau \nu$ evidence !

	N_S	$B(\%)$	$\Sigma(\sigma)$
$B^+ \to \overline{D}^{*0} \tau^+ \nu$	446^{+58}_{-56} (226)	$2.12^{+0.28}_{-0.27} \pm 0.29$	8.1
$B^+ \to \overline{D}^{0} \tau^+ \nu$	146^{+42}_{-41} (15)	$0.77 \pm 0.22 \pm 0.12$	3.5

$B^+ \to D^{(*)} \tau^+ \nu$ summary

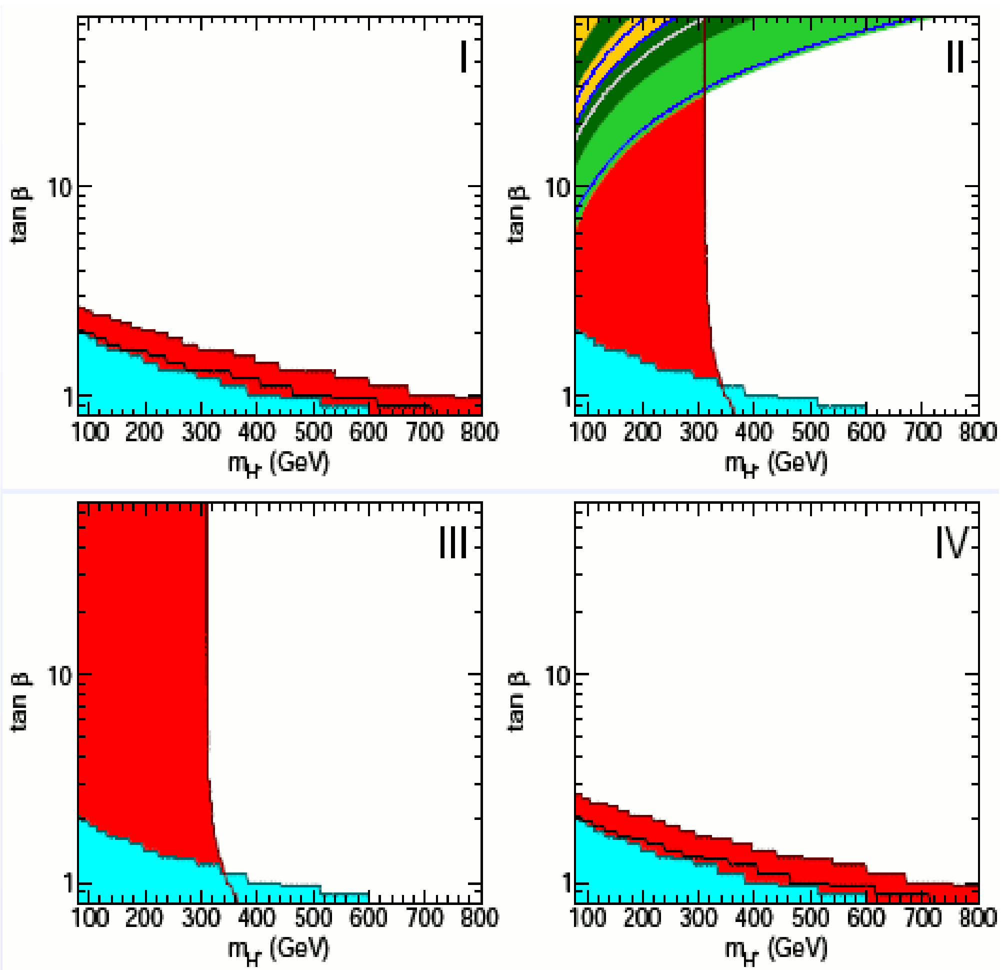


Belle inclusive tag
PRL99, 191807 (2007)
arXiv:1005.2302
Belle hadronic tag
arXiv:0910.4301
BaBar hadronic tag
PRL100, 021801 (2008)

Combined charged Higgs bound from B-factories

(see Nazila Mahmoudi's talk)

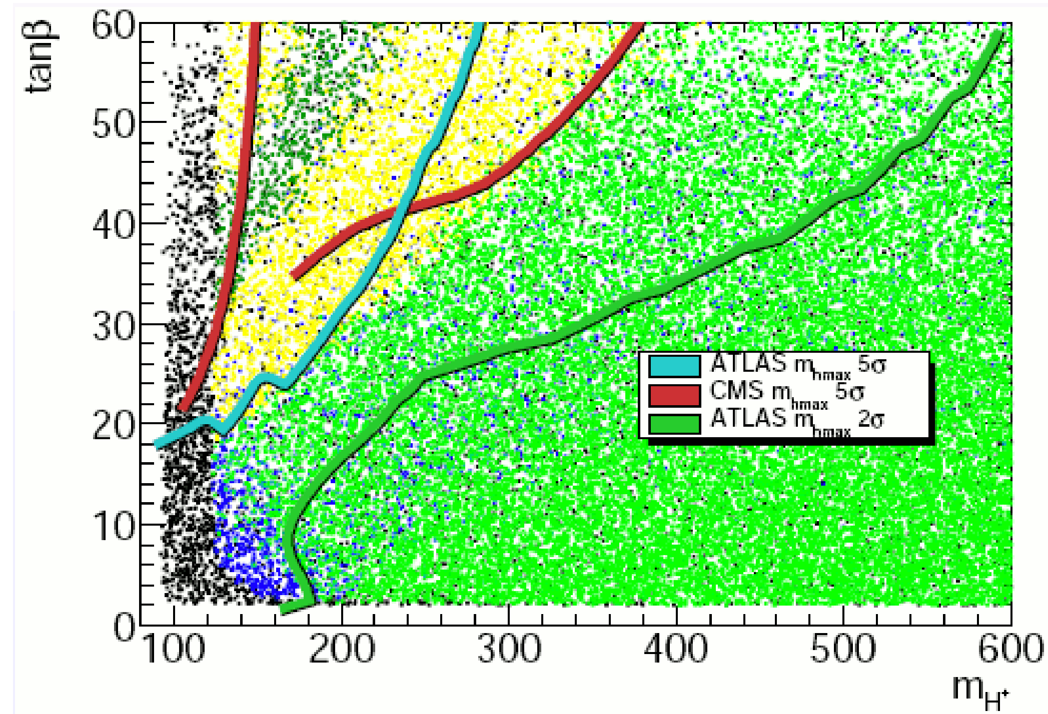
2HDM (Type I-IV)



$\mathcal{B}(B\to X_s\gamma)$ (red), $\mathcal{B}(B\to\tau\nu)$ (blue)
$\mathcal{B}(B\to D\tau\nu)$ (yellow)

F.Mahmoudi and O.Stal
PRD81, 035016 (2010)

NUHM scenario
(non-universal Higgs mass models)



$\mathcal{B}(B\to X_s\gamma)$ (blue), $\mathcal{B}(B\to\tau\nu)$ (yellow)
$\mathcal{B}(B\to D\tau\nu)$ (dark green), allowed region (green)

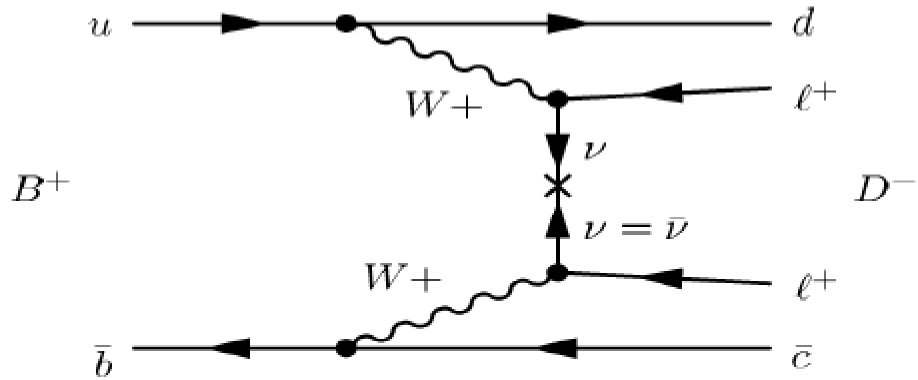
D.Eriksson et al
JHEP, 0811 (2008)

see also: U.Haisch et al (arXiv:0805.2141), O.Deschamps et al (arXiv:0907.5135)...

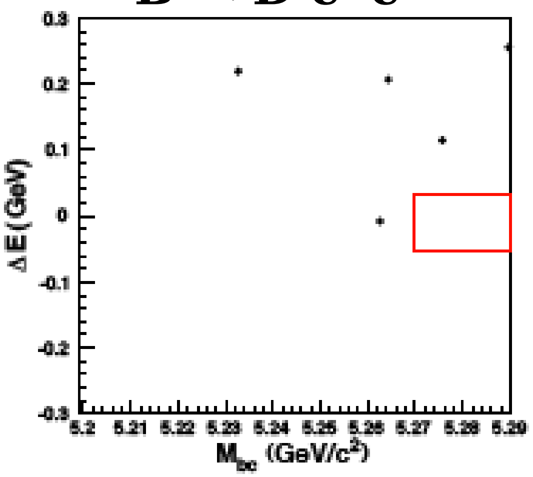
$B^+ \to D^- l^+ l^+$

see K.Hayasaka's talk

Majorana neutrinos allow lepton number violating process
as $B^+ \to h^- l^+ l^+$ $(h = D, \pi \ldots)$

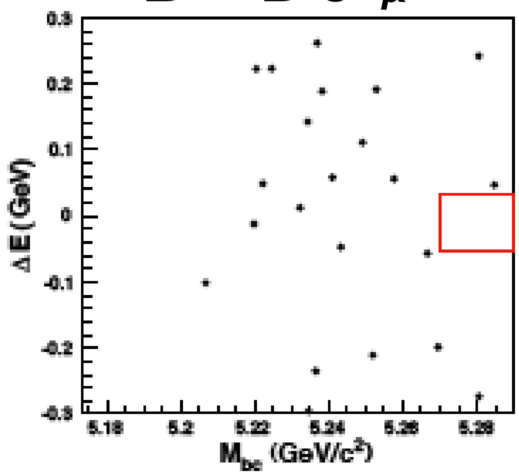


$B^+ \to D^- e^+ e^+$



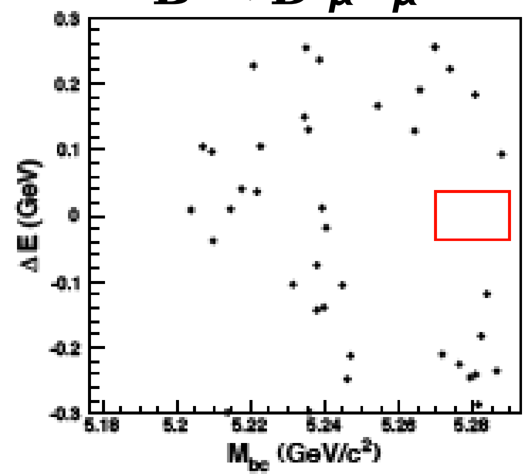
$\mathcal{B} < 2.7 \times 10^{-6}$

$B^+ \to D^- e^+ \mu^+$



$< 1.9 \times 10^{-6}$

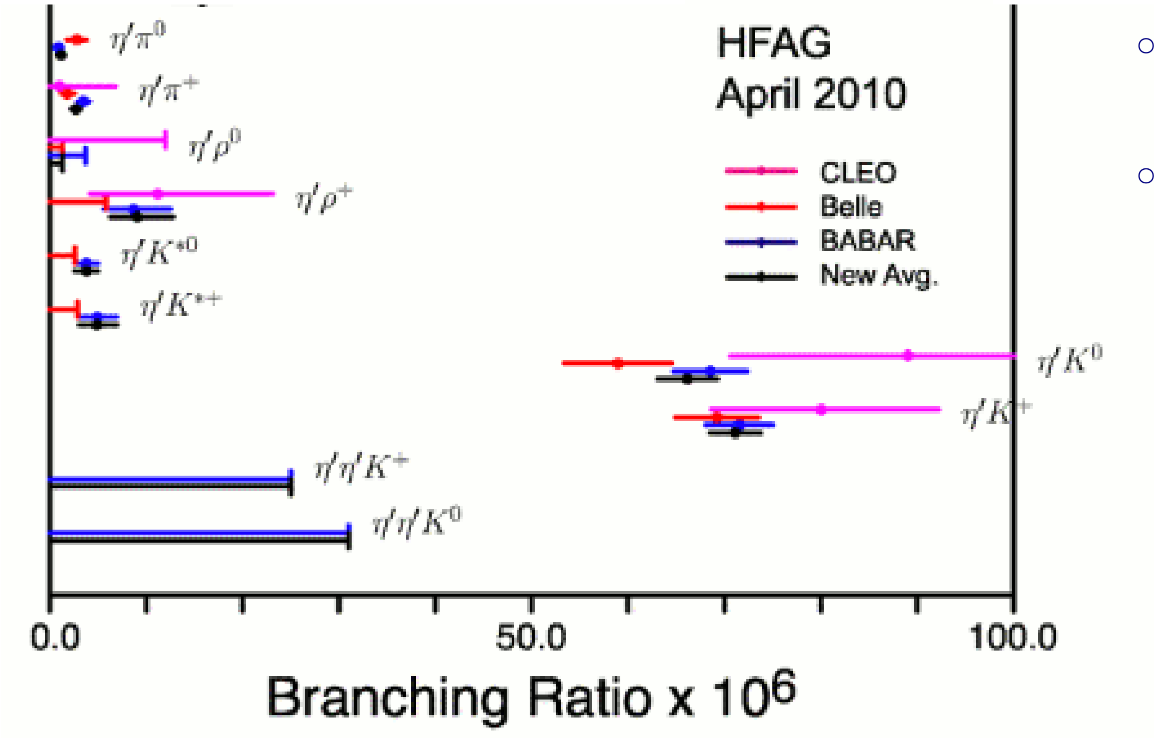
$B^+ \to D^- \mu^+ \mu^+$



$< 1.1 \times 10^{-6}$ @ 90% C.L.

First search of such decay : no event found
⇒ will extend to other LV charmful B decays

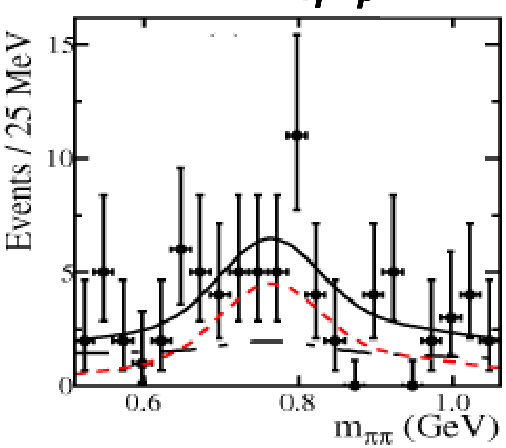
$B \to \eta' h$



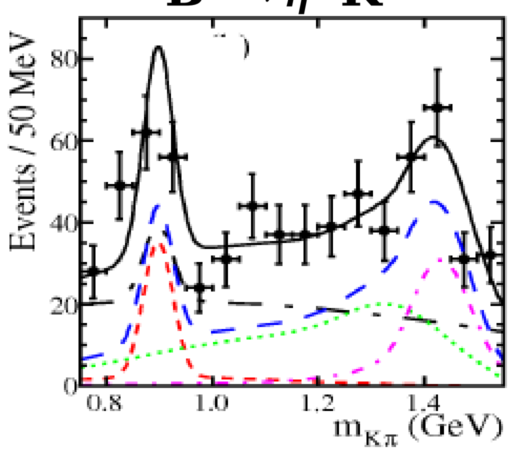
- $\mathcal{B}(B \to \eta' K) > \mathcal{B}(B \to \eta' K^*)$
  (whereas $\mathcal{B}(B \to \eta K^*) > \mathcal{B}(B \to \eta K)$)
- poor agreement between Belle and BaBar for $B^+ \to \eta' \rho^+$

(see Alessandro Gaz's talk)
arXiv:1004.0240

$B^+ \to \eta' \rho^+$



$B^0 \to \eta' K^{*0}$



- confirm $\mathcal{B}(B \to \eta' K) > \mathcal{B}(B \to \eta' K^*)$
- confirm $B^+ \to \eta' \rho^+$ signal
- observe $B^+ \to \eta' K_0^*(1430)^0$, $\eta' K_2^*(1430)^0$ ...

$B(B \to \eta' K_2^*(1430)) > B(B \to \eta' K_2^*(1430))$ as in ωK^*

$B \to X_s \eta$

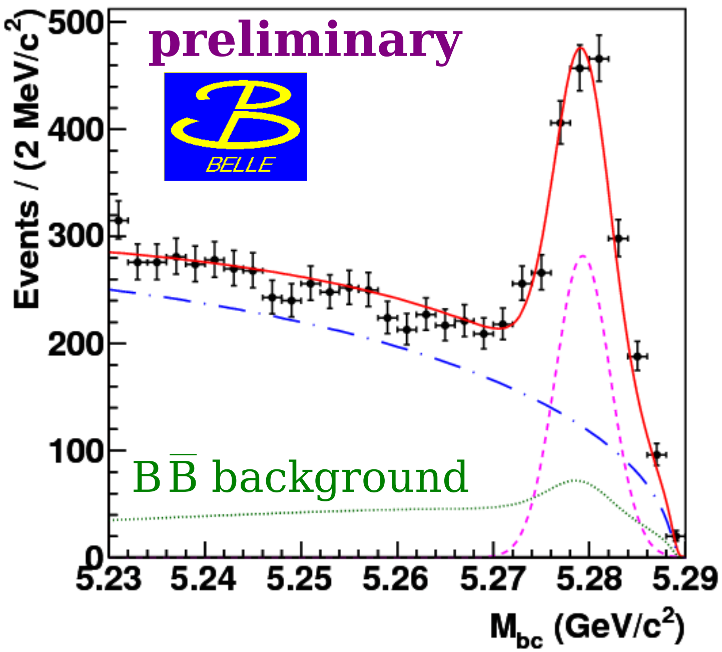
(see MinZu Wang's talk)

Unexpected large BF at large X_s mass

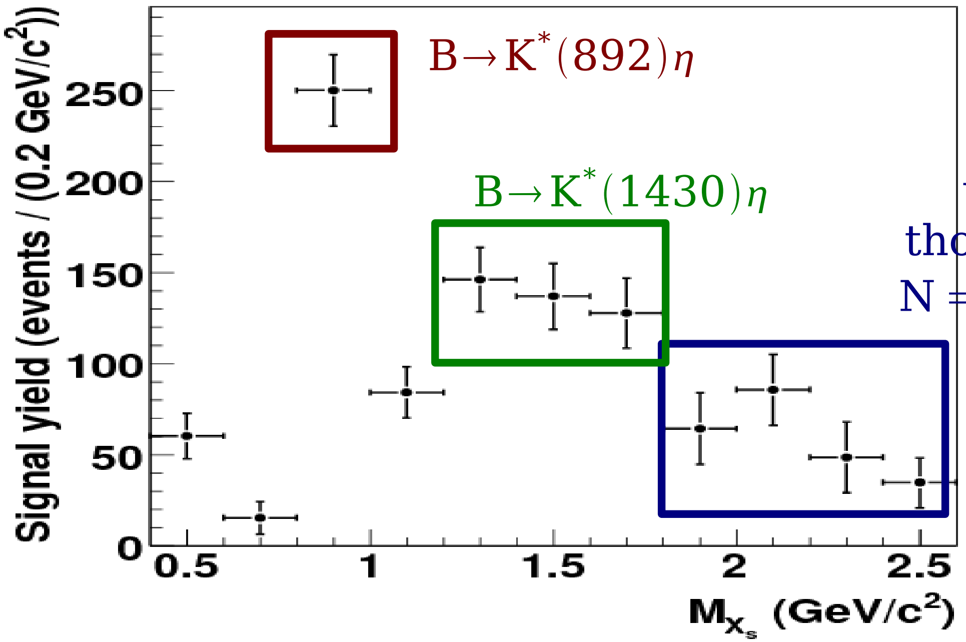
- $657\,M B\bar{B}$
- Sum of exclusive: $K\,n\pi$ $(n \leq 4,\ n_{\pi^0} \leq 1)$
- $p_\eta^{CM} > 2.0$ GeV/c

$$N(B \to X_s\,\eta) = 1054 \pm 54 \pm 18$$

$(M_{X_s} < 2.6$ GeV/$c^2)$



Signal yields are extracted by fitting the M_{bc} in bins of $M(X_s)$

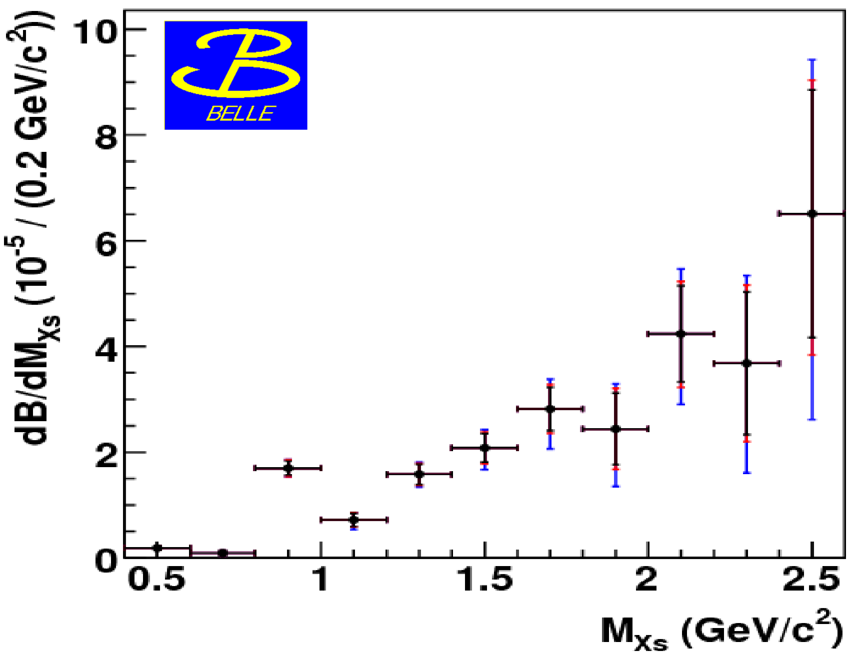


what are those events ?

$N = 233 \pm 34^{+13}_{-15}$

$\Sigma = 7\sigma$

$B \to X_s \eta$

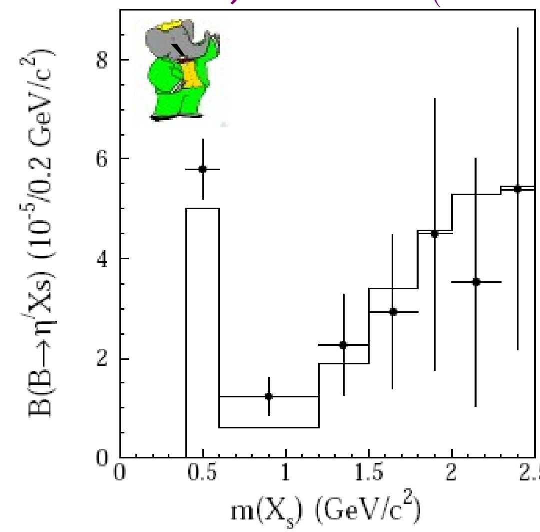


Partial BF in $0.4 < M(X_s) < 2.6$ GeV/c^2

$$\mathcal{B}(B \to X_s \eta) = (26.1 \pm 3.0\ ^{+1.9}_{-2.1}\ ^{+4.0}_{-7.1}(\text{model})) \times 10^{-5}$$

$B \to X_s \eta'$ from BaBar

PRL93, 061801 (2004)

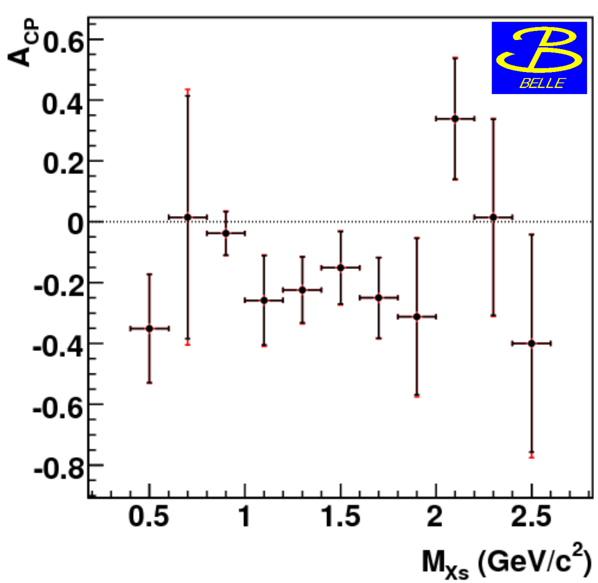


Large signals for $M(X_s) > 2$ GeV

for both η/η' channels

rule out η' specific mechanisms

(e.g. ''large $\eta' g g$ coupling'')

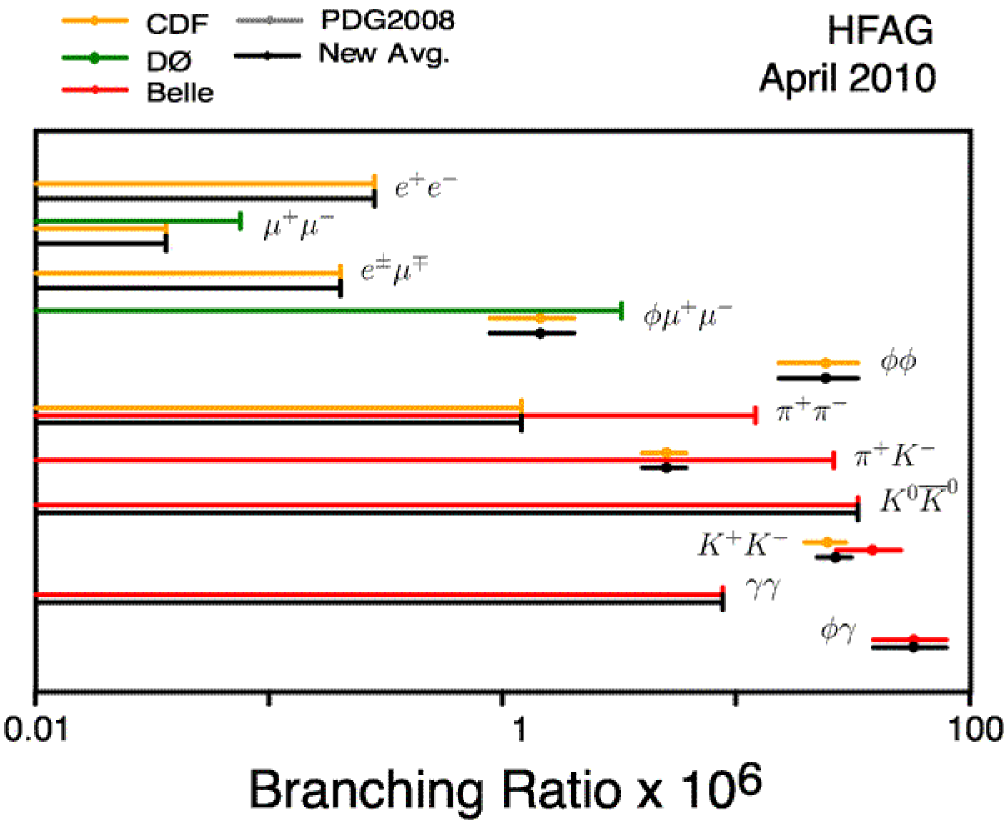


$$A_{CP}(B \to X_s \eta;\ M_{X_s} < 2.6\text{GeV}/c^2) = -0.13 \pm 0.04\ ^{+0.02}_{-0.03}$$

$$\Sigma = 2.6\sigma\ (\text{incl. syst})$$

Rare B_s decays

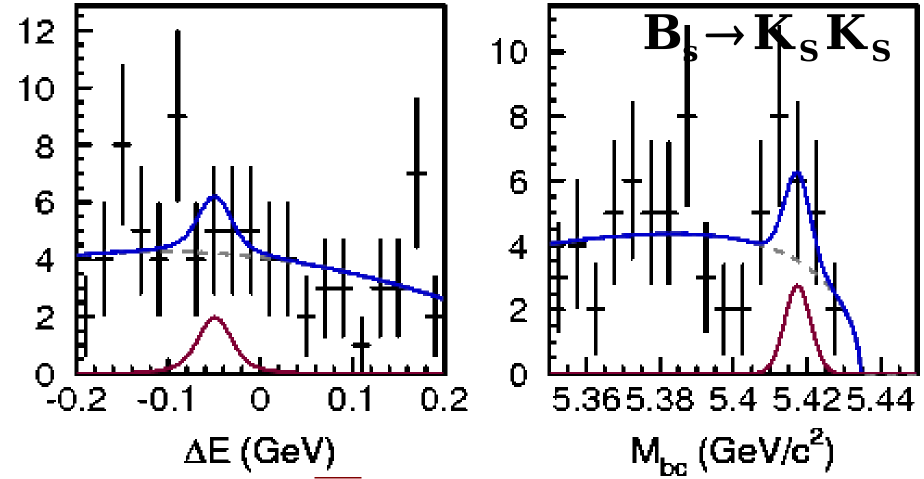
using 1/5 of the $\Upsilon(5S)$ data sample available



$\Rightarrow$ complementarity between B-factories and LHCb

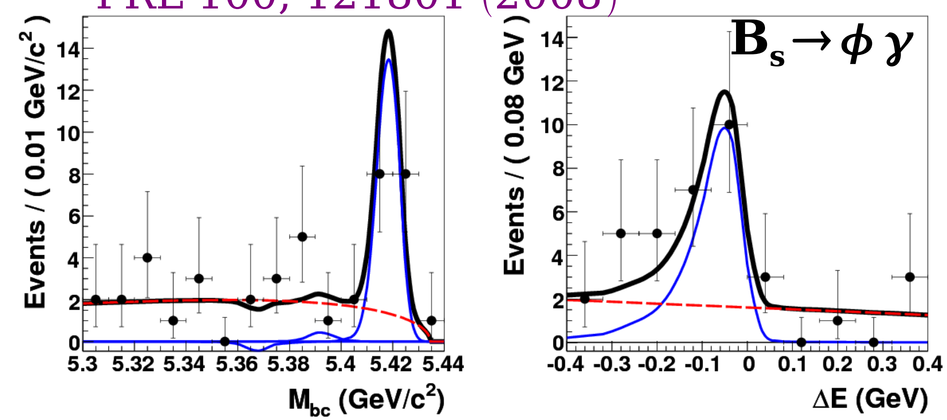
Belle can do neutrals, cleaner, but will have less statistics...

arXiv:1006.5115

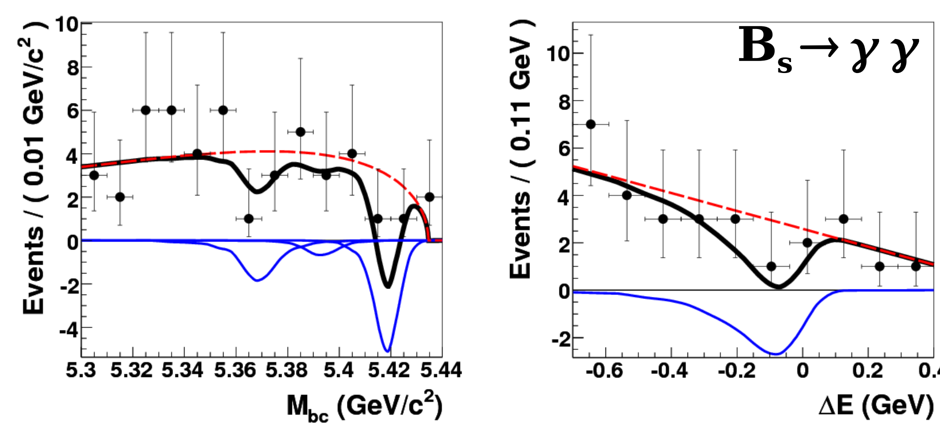


$B(B_s \rightarrow K^0\overline{K^0}) < 6.6\times10^{-5}$ @ 90%C.L.

PRL 100, 121801 (2008)



$B(B_s \rightarrow \phi\gamma) = (57^{+18}_{-15}(\text{stat})\ ^{+12}_{-11}(\text{syst}))\times10^{-6}$



$B(B_s \rightarrow \gamma\gamma) < 8.7\times10^{-6}$ @ 90%C.L.

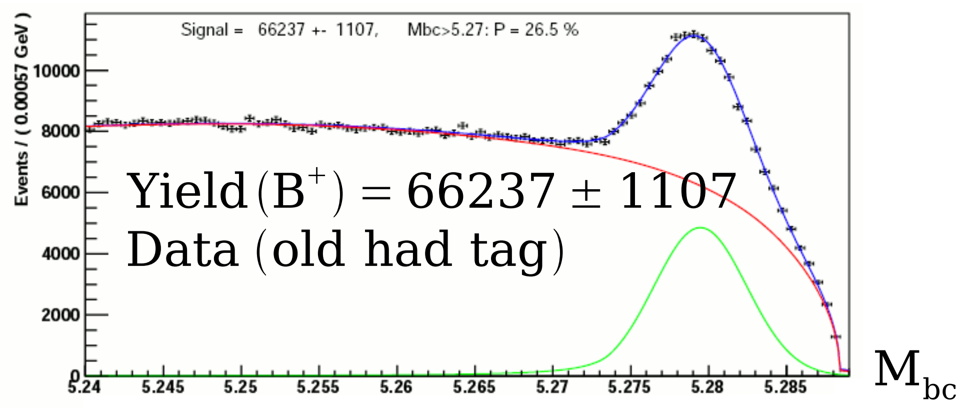
What is coming next ?

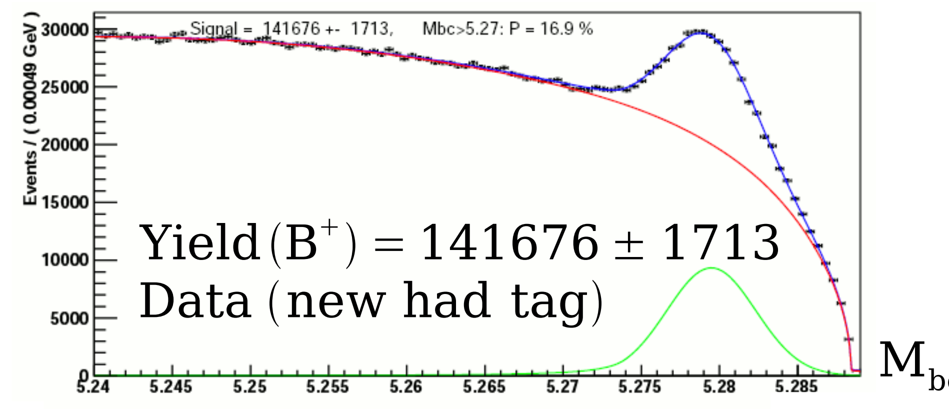
Finalizing BaBar and Belle results with full data samples...

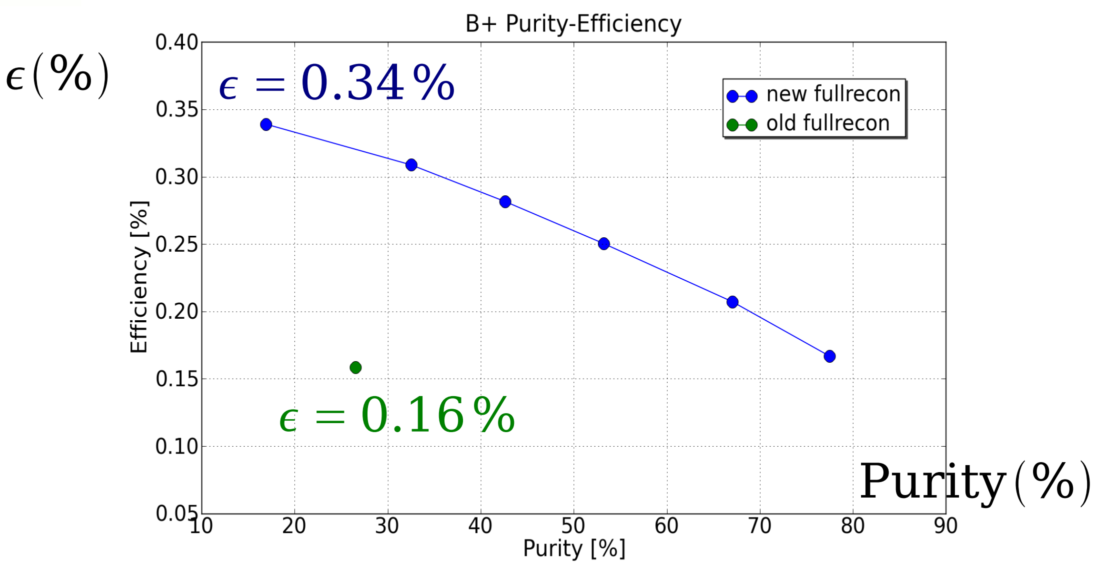
BaBar: ''Two years after the end of the data taking, BaBar continues to exploit its rich dataset, more results will be coming...'' (Alessandro Gaz)

Belle:

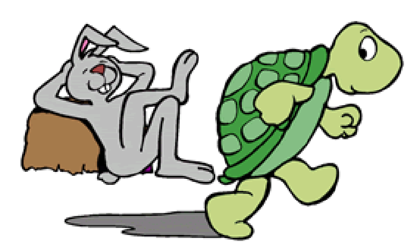
- ◦ reprocessed data sample with improved tracking efficiency
- ◦ none of the results shown for rare B decays use full data sample yet
- ◦ hadronic tag efficiency improved: effective luminosity improved by factor $\sim \times 2$







⇒ new results coming soon !



and then... Super B factories !

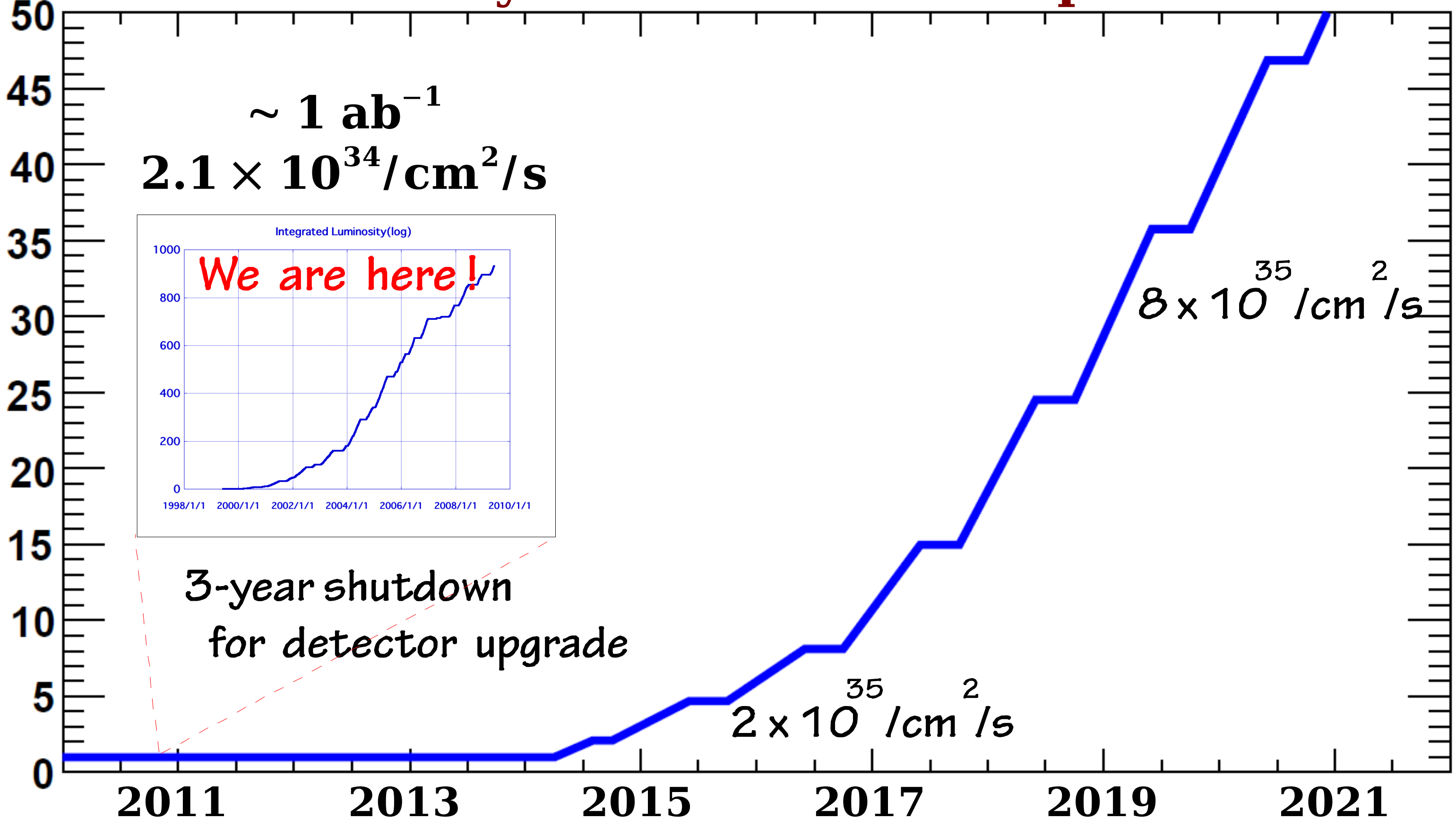
⇒ physics with $O(10^{10})$ B, τ, D....

2 Super B Factories projects: SuperB (in Italy) and SuperKEKB/Belle II (in Japan)

⇒ KEKB upgrade has been approved (see Y.Ushiroda's talk)

100 oku yen(*) for machine (FY 2010-2012)

50 ab^{-1} by 2020-2021 = 50 × present



(*) 100 oku yen ~ 88.6M euros (Jul 26, 2010)

Summary

$b \to s\gamma$, $b \to d\gamma$, $b \to s l^+ l^-$, $B^+ \to \tau\nu$, $B \to D\tau\nu$... measured
$\Rightarrow$ provide tests of SM predictions and interesting BSM constraints

- Charged Higgs bounds from $b \to s\gamma$, $B^+ \to \tau\nu$, $B^+ \to D\tau\nu$
- Constraints on Wilson coefficients C_7, C_9 and C_{10}
- Constraints on $|V_{td}|/|V_{ts}|$

$\Rightarrow$ Interesting signatures

- $\mathcal{B}(B^+ \to \tau^+\nu)$ direct measurement versus CKM fit
- large forward-backward asymmetry of $K^* l^+ l^-$

Final Belle/BaBar data samples are yet to be analyzed !

Even more interesting results at Super B factories with two orders of magnitude larger data samples !