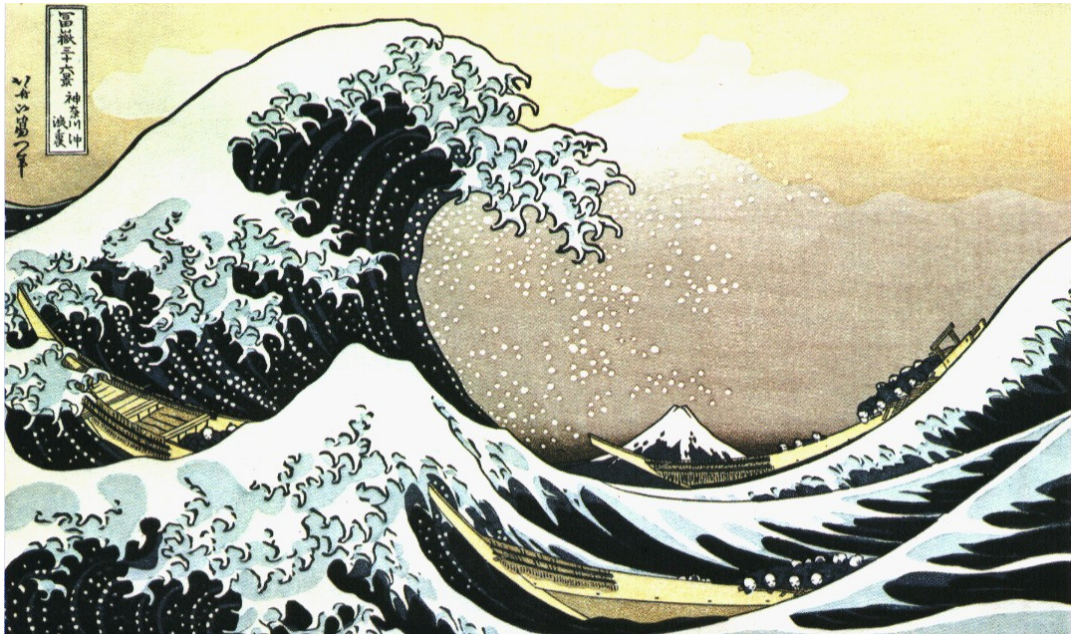
Radiative and electroweak penguin B decays at Belle



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EPS HEP2007
19-25 July 2007

Radiative penguin B_s decays at Belle

$$B_s \to \phi\gamma$$

$$B_s \to \gamma\gamma$$

Preliminary!

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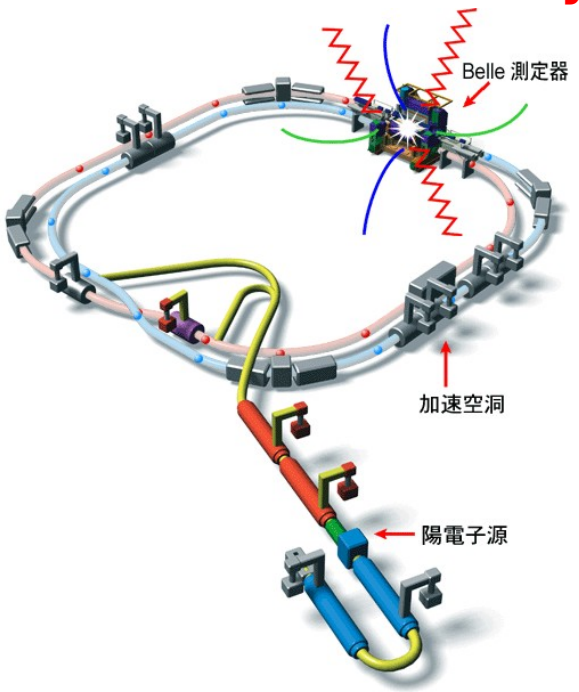
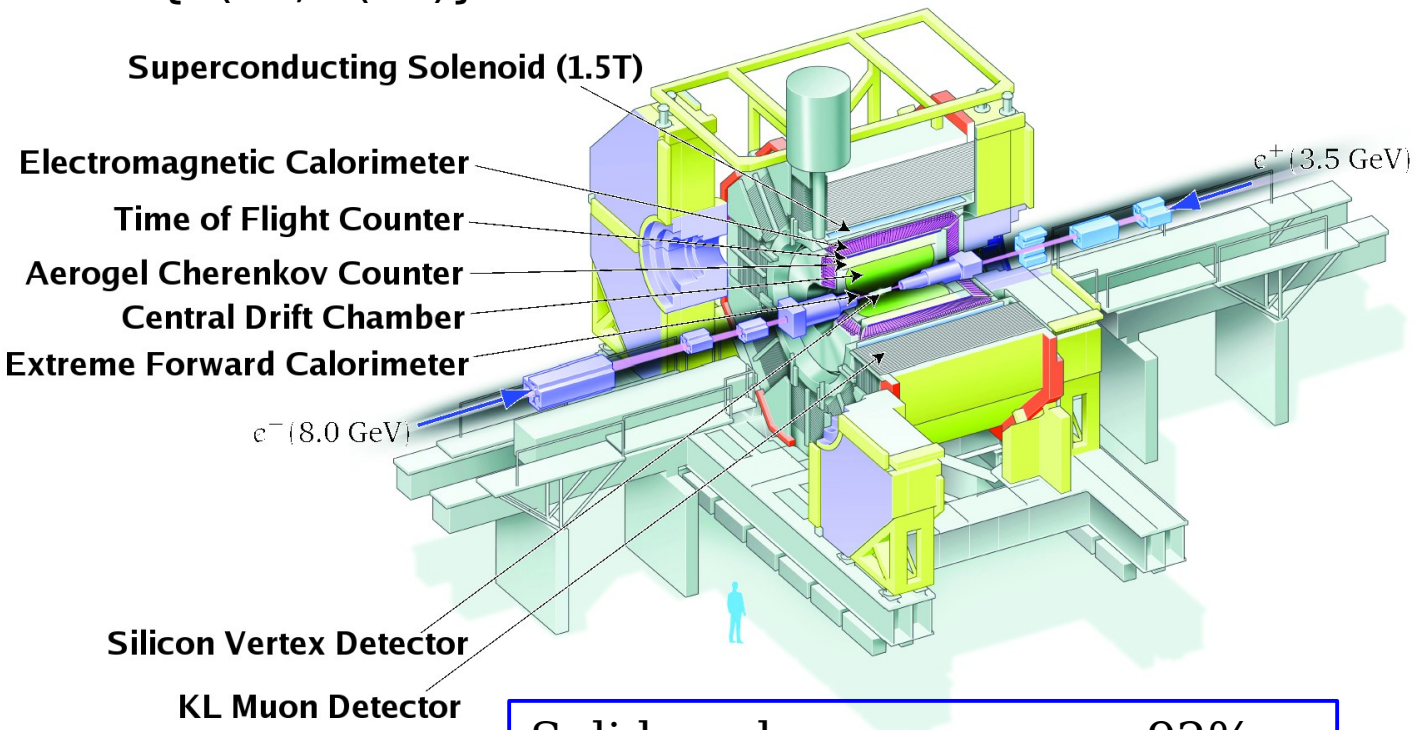
KEKB and Belle detector

KEKB : asymmetric e^+e^- collider (3.5-8.0 GeV) located in Tsukuba, Japan

B meson factory : $e^+e^- \rightarrow \{\Upsilon(4S, \Upsilon(5S)\} \rightarrow BB$



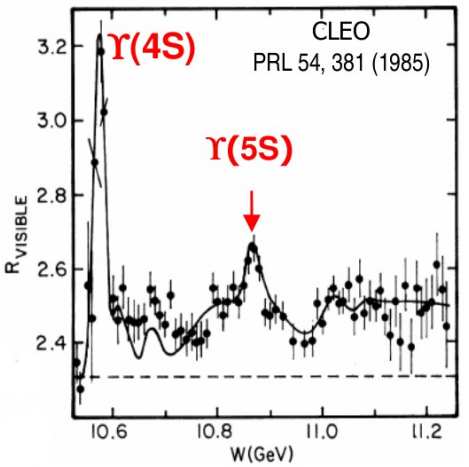


Luminosity

Peak	$1.71 \times 10^{34}/cm^2/s$
Integrated	710 fb^{-1}
	605 fb^{-1} at $\Upsilon(4S)$ (~660M BB pairs)
	23.6 fb^{-1} at $\Upsilon(5S)$ (~2.6M B_s mesons)
Daily	up to 1.2 fb^{-1}

Solid angle coverage	~92%
Particle identification	π,K,e,μ,p

Belle and $\Upsilon(5S)$



- Beam energies increased by 2.7%
  - **smooth running!**
- Two samples :
  - June 2005 : 1.86 fb^{-1}.
  - June 2006 : 21.7 fb^{-1}.
- **Today's results : 23.6 fb^{-1}.**

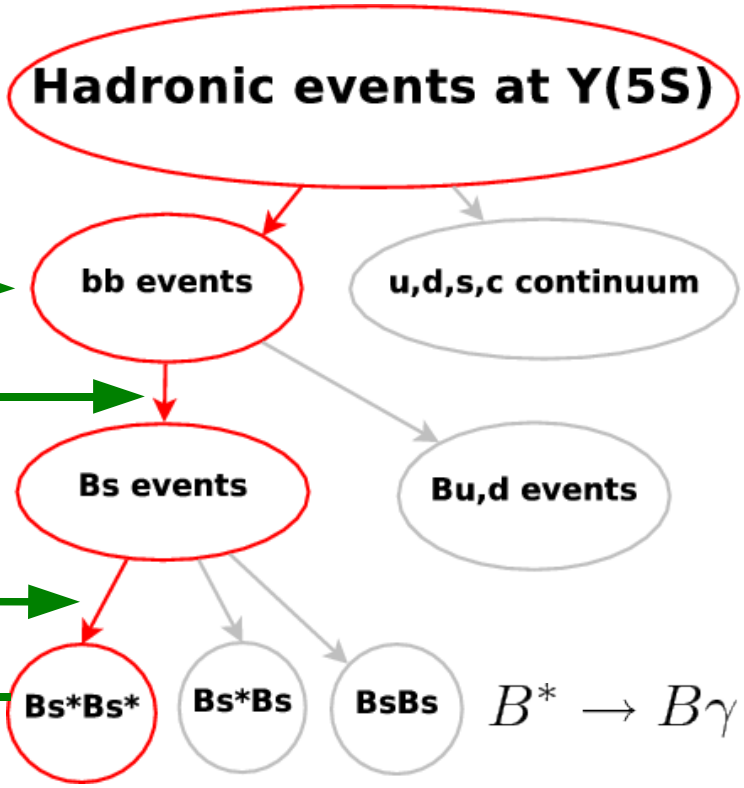
PRL 98, 052001 (2007)
PRD 76, 012002 (2007)

$\sigma_{b\bar{b}}^{\Upsilon(5S)} = (0.302 \pm 0.015)$ nb

$f_s = (19.5^{+3.0}_{-2.3})\%$
PDG2007

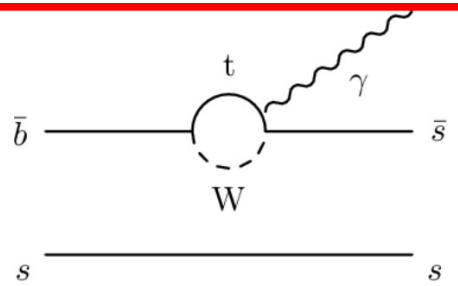
$f_{B_s^* B_s^*} = (93^{+7}_{-9})\%$

$N_{Bs}(23.6\ fb^{-1}) = 2.6 \times 10^6$
~20% uncertainty

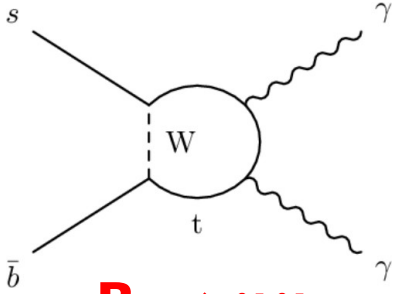


$B_s \to \phi\gamma$ and $B_s \to \gamma\gamma$

Lowest diagram : one loop penguin decay
Good probe for New Physics : new particles can enter the loop



$B_s \to \phi\gamma$



$B_s \to \gamma\gamma$

- Not observed yet : BF<12×10^{-5} CL90%
  CDF, PRD 66, 112002 (2002)
- SM : BF = $(4\pm1)\times10^{-5}$. PRD 75, 054004 (2007)
- Partner of $B^0 \to K^*(892)^0\,\gamma$
  - First penguin decay observed
    CLEO, PRL 71, 974 (1993)
  - BF = $(4.01\pm0.20)\times10^{-5}$.
    - Measured precisely by Belle and BABAR.

- Not observed yet : BF<53×10^{-6} CL90%
  Belle, PRD 76, 012002 (2007)
- SM : BF = $(0.5\text{-}1.0)\times10^{-6}$.
  PRD 56, 5805 (1997)
  JHEP 0208 054 (2002)
- Very sensitive to **New Physics**! Up to one order of magnitude enhancement.
  - 4^{th} quark generation hep-ph/0302177
  - SUSY with broken R-parity
    PRD 70, 035008 (2004)

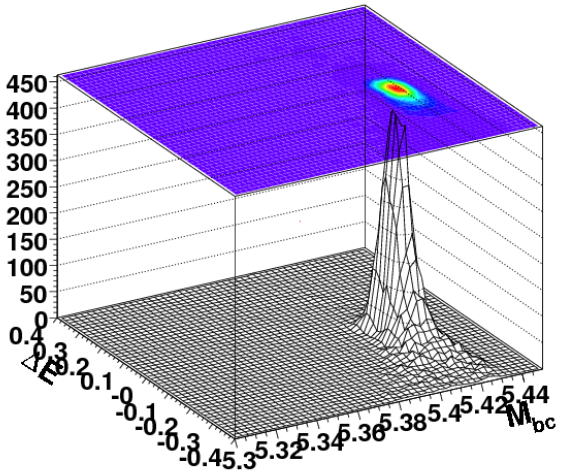
B_s candidates selection

Standard "B-factory" analysis.

- **ϕ candidates** : K^+ and K^- with an invariant mass 12 MeV/c^2 around nominal ϕ mass (2.5σ requirement).
- **B_s candidates** selected using the **M_{bc}** (M_{ES}) and **ΔE** variables :

$$M_{\rm bc} = \sqrt{(E^{\rm CM}_{\rm beam})^2 - (p^{\rm CM}_{B_s})^2}$$
$$\Delta E = E^{\rm CM}_{B_s} - E^{\rm CM}_{\rm beam}$$

Signal peaks at $M_{bc} = M_{Bs^*} \approx 5.42$ GeV/c^2 and $\Delta E = M_{Bs} - M_{Bs^*} \approx -50$ MeV.



$B_s \to \phi\,\gamma$ MC signal

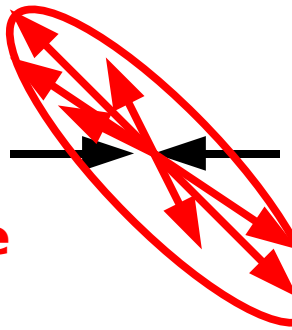
- We don't fully reconstruct **B_s^*** : γ is too slow.
- Main background is continuum : $e^+e^- \to \{uu, dd, ss, cc\}$.

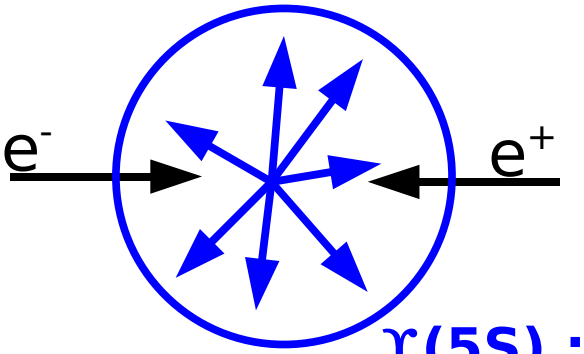
Continuum suppression

- Continuum is suppressed using modified **Fox-Wolfram moments** describing event topology and **π^0/η suppression**.

$$e^+e^- \to q\bar{q}$$

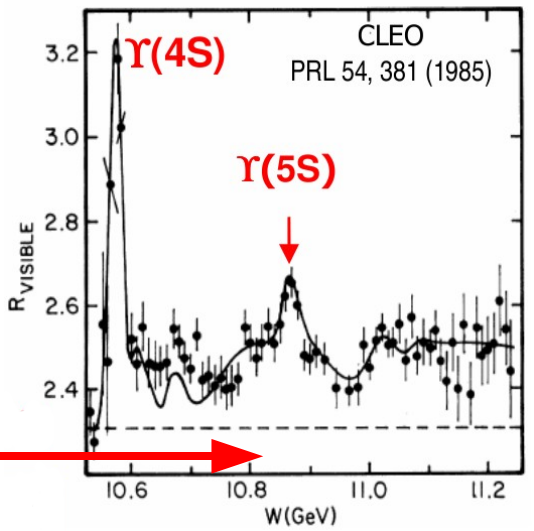
$$q = \{u, d, s, c\}$$

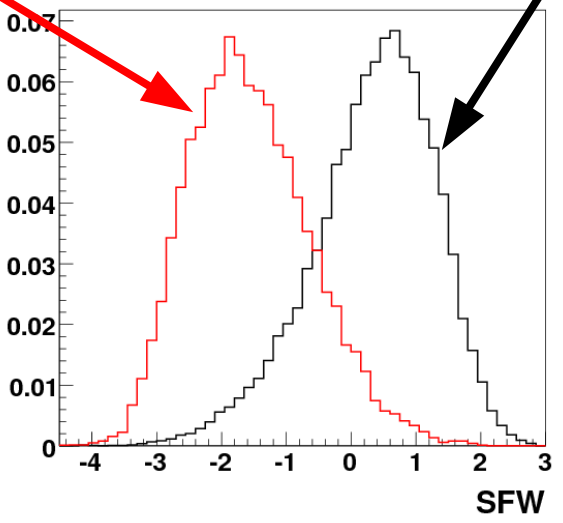




Continuum : jet-like

Υ(5S) : spherical





Result : $B_s \to \phi\gamma$

Unbinned extended maximum likelihood fit to

M_{bc} **ΔE** **$\cos(\theta_{hel})$**.

Signal : smoothed MC histogram x $1-\cos^2(\theta_{hel})$

Continuum : ARGUS x 1st order polynomial x constant

$$\mathcal{B}(B_s \to \phi\gamma) = (5.7^{+1.8+1.2}_{-1.5-1.7}) \times 10^{-5}$$

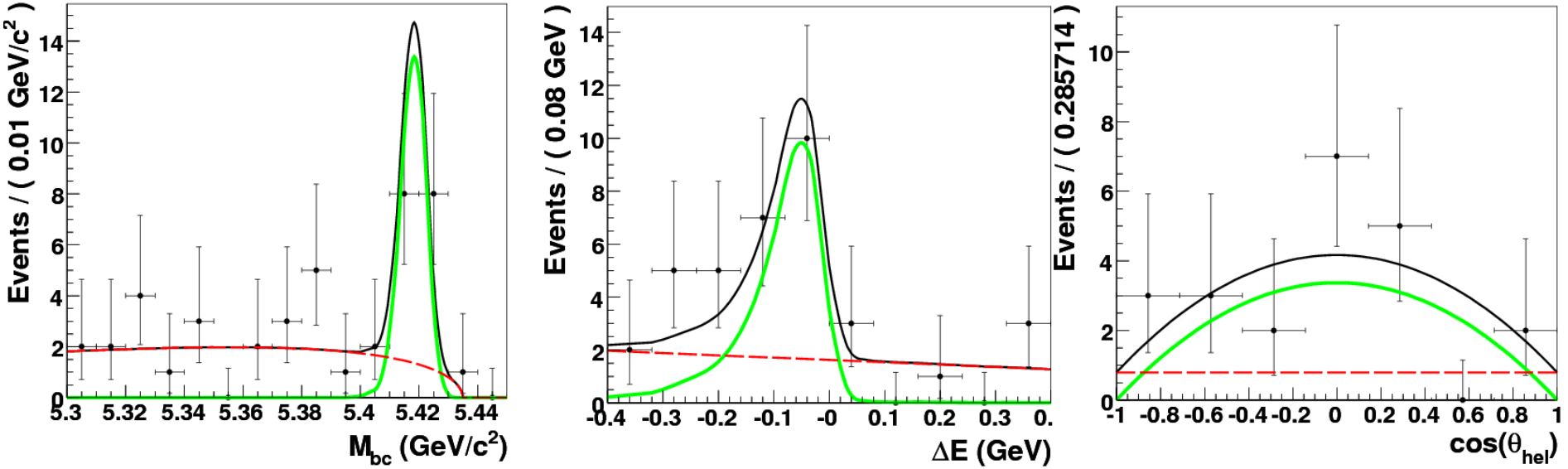
↔ 18±6 signal events

$$\text{Significance (including systematics)} = \sqrt{2|\ln\mathcal{L} - \ln\mathcal{L}_0|} = 5.5$$

First observation of a B_s radiative penguin decay!

$\theta_{hel} \equiv \measuredangle(B_s$ and K^+ in ϕ CM)

Projections in signal region

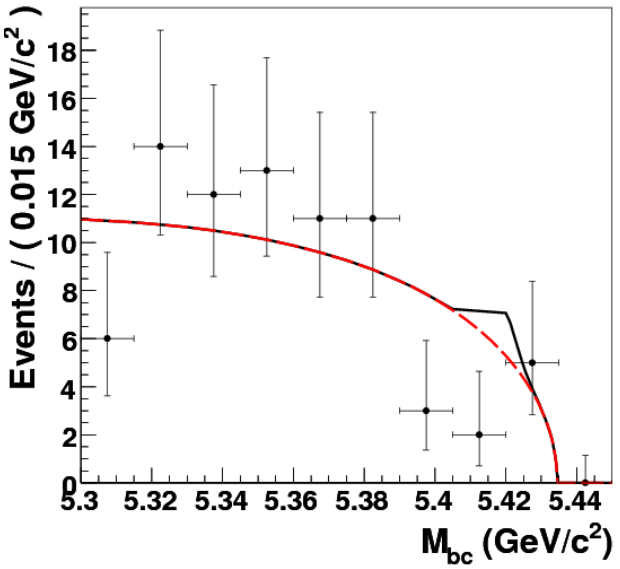


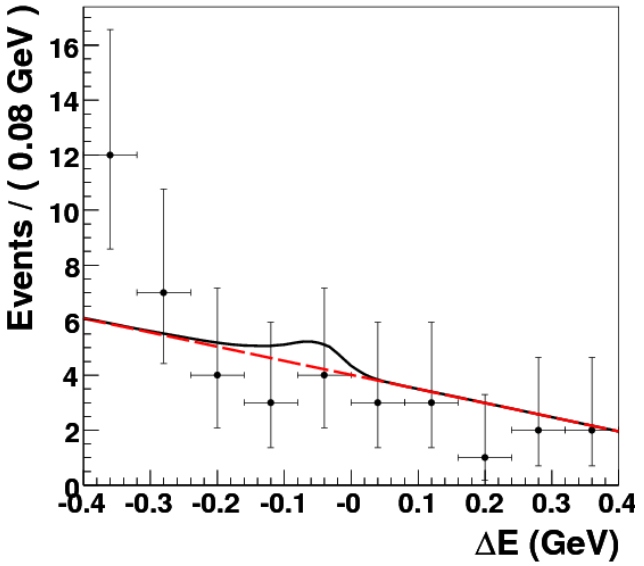
Sideband control : $B_s \rightarrow \phi\gamma$

We perform a fit in the ϕ mass sideband : 1.1 GeV/c^2 < m_{KK} < 1.2 GeV/c^2.

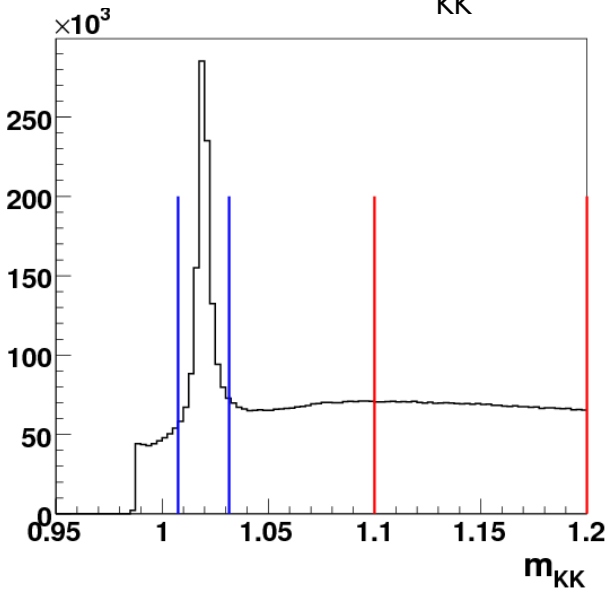
No peaking background is observed!

Projections in signal region





Inclusive m_{KK}



Result : $B_s \to \gamma\gamma$

Unbinned extended maximum likelihood fit to

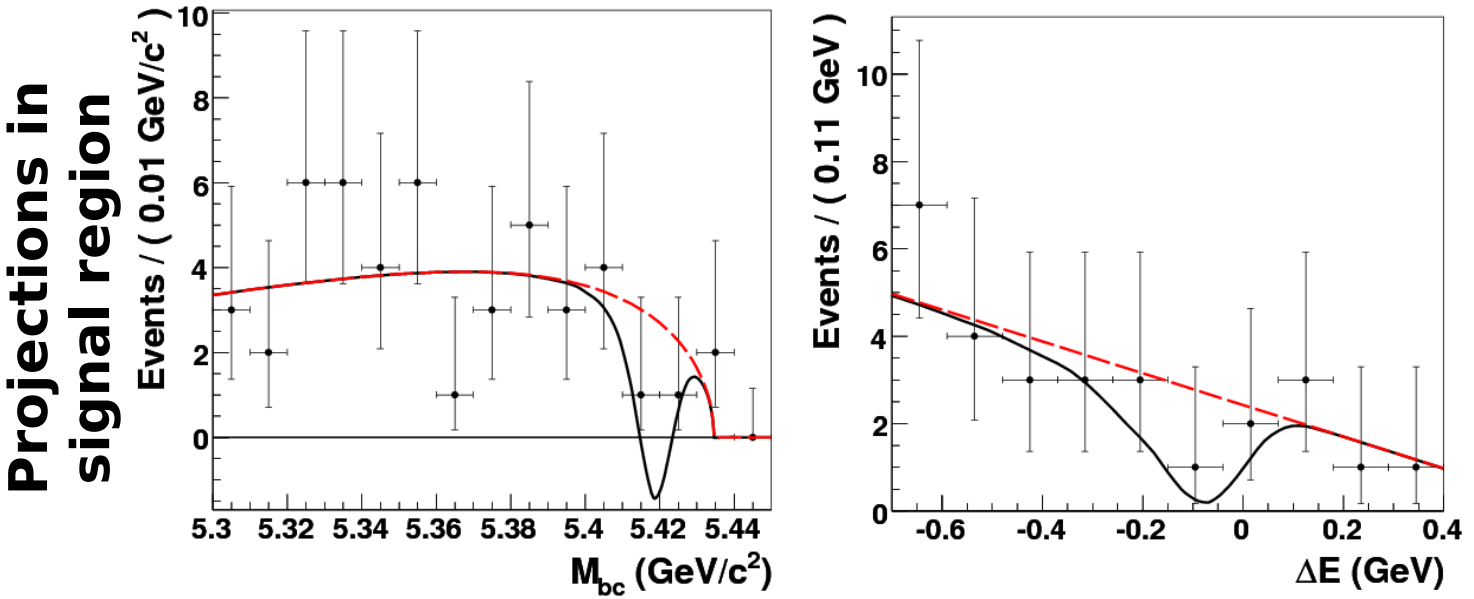
M_{bc}, ΔE

Signal : smoothed MC histogram

Continuum : ARGUS x 1st order polynomial

No signal!

$$\mathcal{B}(B_s \to \gamma\gamma) < 8.6 \times 10^{-6}\ (90\%\ \mathrm{CL})$$



Conclusion

$B_s \to \phi\gamma$

- With a **23.6 fb^{-1}** sample collected on the **Υ(5S)** resonance, Belle has observed **for the first time** a radiative penguin decay of the **B_s** meson!
- We measure with a significance of **5.5σ** :

$$\mathcal{B}(B_s \to \phi\gamma) = (5.7^{+1.8+1.2}_{-1.5-1.7}) \times 10^{-5}$$

Preliminary!

- In agreement with the SM prediction and BF($B^0 \to K^*(892)^0\,\gamma$).

$B_s \to \gamma\gamma$

- We do not observe any significant signal and we set an upper limit :

$$\mathcal{B}(B_s \to \gamma\gamma) < 8.6 \times 10^{-6}\ (90\%\ \mathrm{CL})$$

- This limit is about 6 times more restrictive than the previous one.
- New Physics can enhance the branching fraction up to ~5x10^{-6}. We need more data! We need a **Super B factory**!