B_s decays at Belle

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Outline

- Introduction.
- First Belle results at Y(5S) with 1.86 fb^{-1}.
- New Belle result at Y(5S) with 23.6 fb^{-1}:

  First measurement of $B_s \to X \ell^+ \ell^- \nu$ decay.

  First observation of $B_s \to \phi\gamma$ decay and search for $B_s \to \gamma\gamma$.
- Conclusion.

New results with 23.6 fb^{-1} are *preliminary*.

Introduction

Asymmetric energy e^+e^- colliders (B Factories) running at Y(4S) :
Belle and BaBar

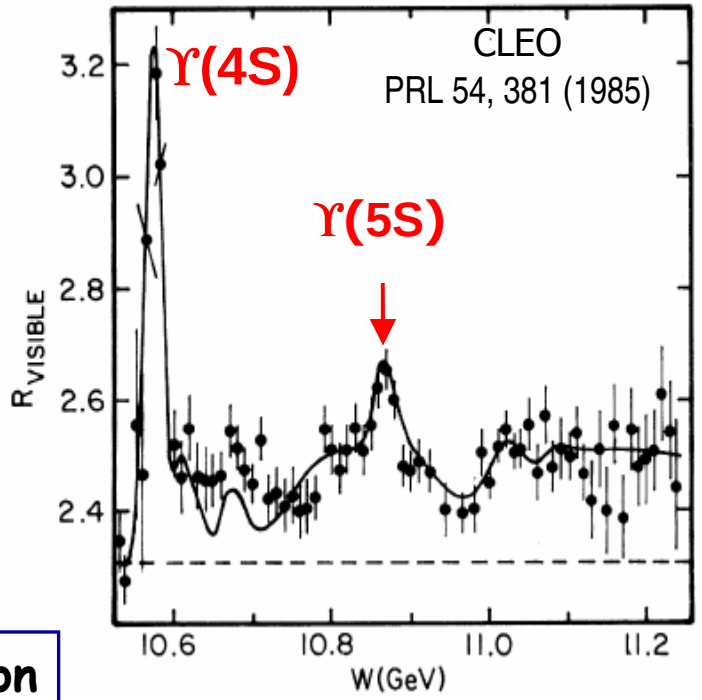
All Y(5S) data:

1985: CESR (CLEO,CUSB) ~ 0.1 fb^{-1}

2003: CESR (CLEO III) ~ 0.42 fb^{-1}

2005: Belle, KEKB ~ 1.86 fb^{-1}

2006: Belle, KEKB ~ 21.7 fb^{-1}



$e^+ e^-$ ->Y(4S) -> $B\bar{B}$, where B is B^+ or B^0 meson

$e^+ e^-$ -> Y(5S) -> $B\bar{B}$, $B^*\bar{B}$, $B^*\bar{B}^*$, $B\bar{B}\pi$, $B\bar{B}\pi\pi$, $B_s\bar{B}_s$, $B_s^*\bar{B}_s$, $B_s^*\bar{B}_s^*$

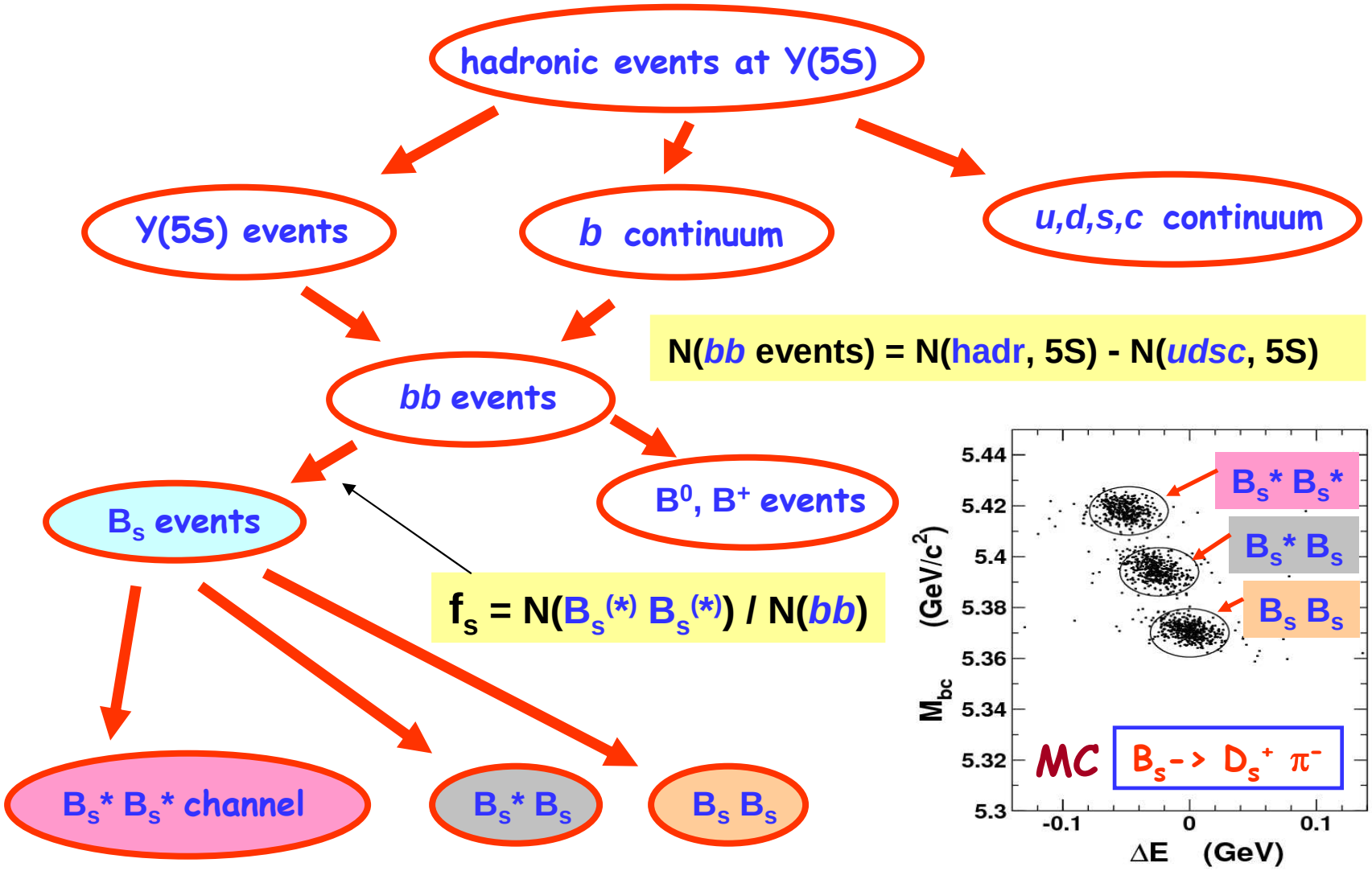
where B^* -> B γ and B_s^* -> B_s γ

M(Y(5S)) = 10865 ± 8 MeV/c^2 (PDG)

Γ(Y(5S)) = 110 ± 13 MeV/c^2 (PDG)

B_s rate is (19.5 $^{+3.0}_{-2.2}$)% => high lumi e^+e^-collider at Y(5S) -> B_s factory.

Hadronic event classification



Belle results at Y(5S) with 1.86 fb^{-1}

CLEO found first evidence of B_s production at Y(5S) using 0.42fb^{-1}, 4 papers were published (exclusive and inclusive B_s production).

First Y(5S) results from Belle with 1.86 fb^{-1} are recently published:
Inclusive decays at Y(5S): *A.Drutskoy et al* **(Belle)** ***PRL*****, 98 (2007) 052001.**
Exclusive B_s decays: *A.Drutskoy et al* **(Belle)** ***PRD*** **76 (2007) 012002.**

Belle results (1.86 fb^{-1}):

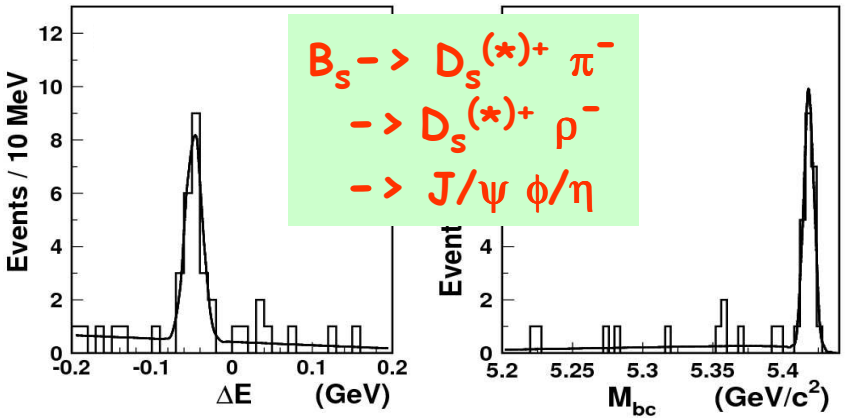
Bf (Y(5S) -> D_s X)/ 2 = (23.6 ± 1.2 ± 3.6) %

Bf (Y(5S) -> D^0 X)/ 2 = (53.8 ± 2.0 ± 3.4) %

Bf (Y(5S) -> J/Ψ X)/ 2 = (1.030 ± 0.080 ± 0.067) %

$f_s = N(B_s^{(*)} B_s^{(*)}) / N(bb)$

f_s = (18.0 ± 1.3 ± 3.2)%



B_s -> $D_s^{(*)+}$ π^-
-> $D_s^{(*)+}$ ρ^-
-> J/ψ φ/η

$N(B_s^* B_s^*) / N(B_s^{(*)} B_s^{(*)})$ = (93± $^{7}_{9}$ ±1)%

M (B_s^*) = 5418 ± 1 ± 3 MeV/c^2

M (B_s) = 5370 ± 1 ± 3 MeV/c^2

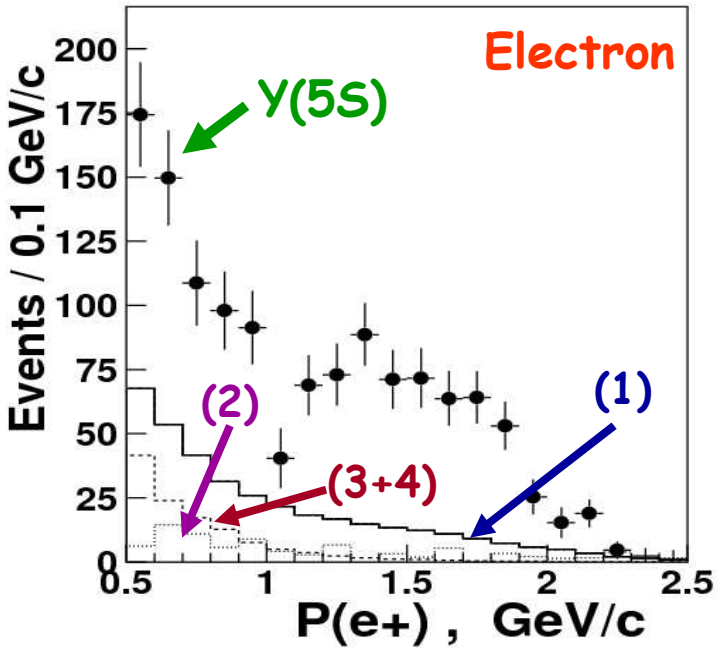
Searches for several rare decays.

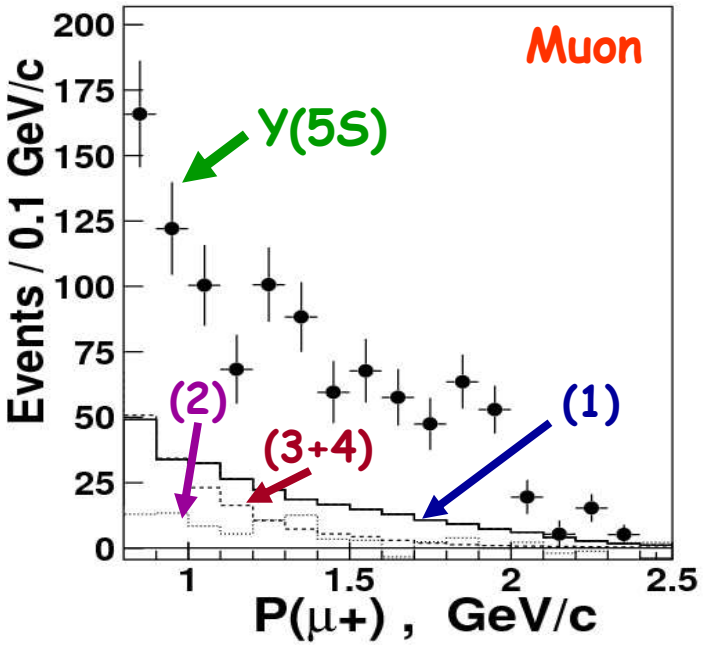
First measurement of $B_s \to X^+ \ell^- \nu$ decay

Lepton spectrum is measured at Y(5S) using D_s tag with same sign.

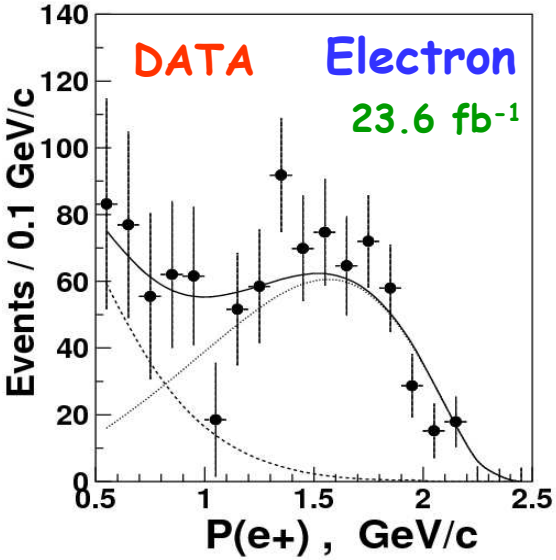
Backgrounds for same-sign D_s & ℓ events (to separate pure B_s decays):

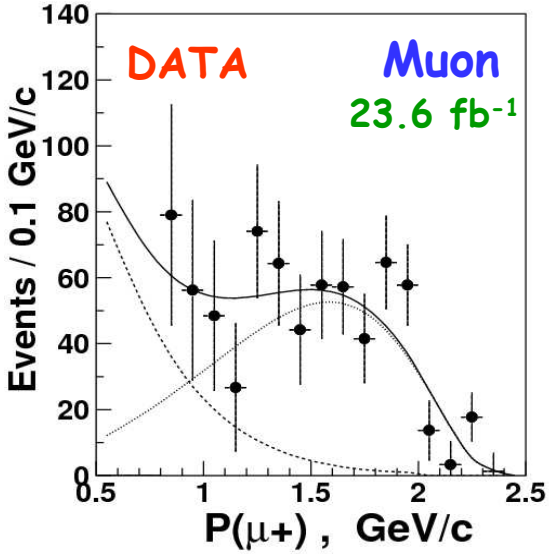
1. BB event background (subtracted using Y(4S) data).
2. Continuum background (subtracted using continuum data).
3. Leptons from J/ψ decays, γ-convertion, $K^+ \to \mu^+$ decays (MC est.).
4. Misidentified leptons (obtained from MC).

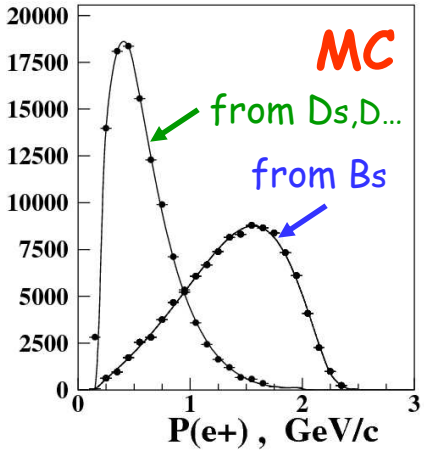




First measurement of $B_s \to X^+ \ell^- \nu$ decay







preliminary

Electron : $Bf(B_s \to X^+ e^- \nu) = (10.9 \pm 1.0 \pm 0.9)\%$

Muon : $Bf(B_s \to X^+ \mu^- \nu) = (9.2 \pm 1.0 \pm 0.8)\%$

Combined fit (electron+muon) :

$Bf(B_s \to X^+ l^- \nu) = (10.2 \pm 0.8 \pm 0.9)\%$

preliminary

Assuming similar decay widths and $\tau(B_s)/\tau(B^0)=1.00\pm0.01$ (theory; exp.diff.~2.3σ)
it can be compared to PDG 2007: $Bf(B^0 \to X^+ l^- \nu) = (10.33 \pm 0.28)\%$

Signal calibration for $B_s \to \phi\gamma$, $B_s \to \gamma\gamma$ analyses

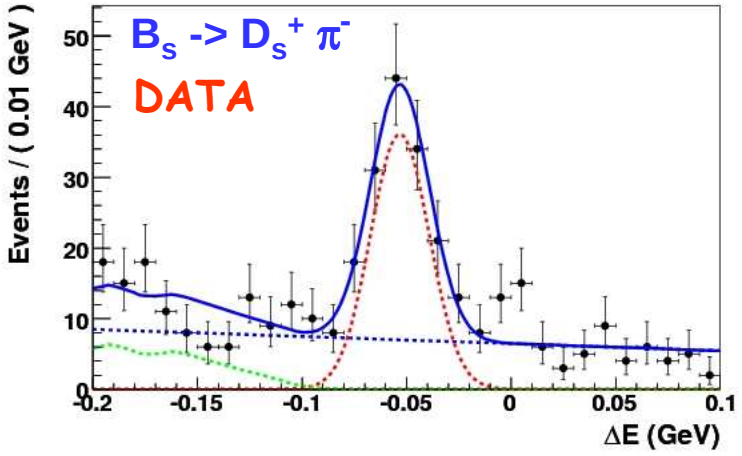
Details of $B_s \to \phi\gamma$ and $B_s \to \gamma\gamma$ analyses were discussed in Jean Wicht EPS07 talk "Radiative and EW penguin B decays at Belle".

To adjust MC to real B_s parameters, like M_{bc}, ΔE, resolutions, et al, decay mode $B_s \to D_s^+ \pi^-$ is reconstructed using new Y(5S) data.

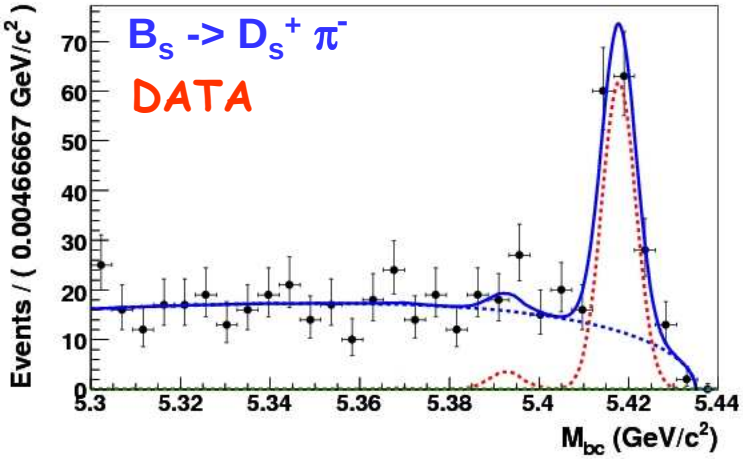
Analysis of $B_s \to D_s^+ \pi^-$ decay is not yet finished => *calibration plots*.

Only decay channel $e^+ e^- \to Y(5S) \to B_s^* B_s^*$ is observed.

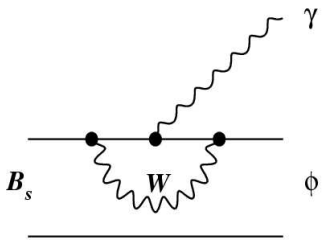
$$\Delta E = E^*_B - E^*_{beam}$$



$$M_{bc} = \sqrt{E^{*2}_{beam} - P^{*2}_B}$$

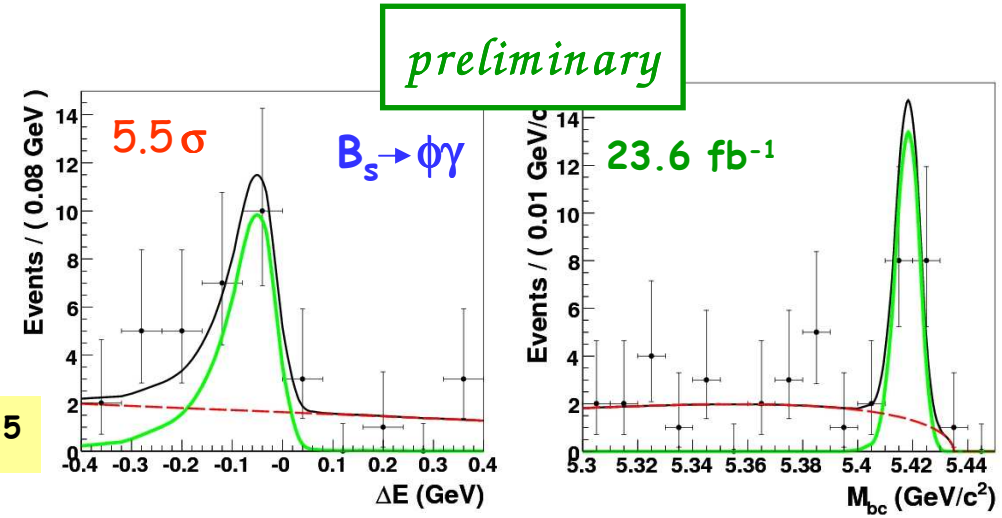


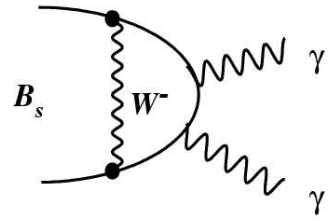
First observation of $B_s \to \phi\gamma$, search for $B_s \to \gamma\gamma$



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

PDG: $Bf(B \to K^{*0}\gamma) = (4.1 \pm 0.20) \times 10^{-5}$

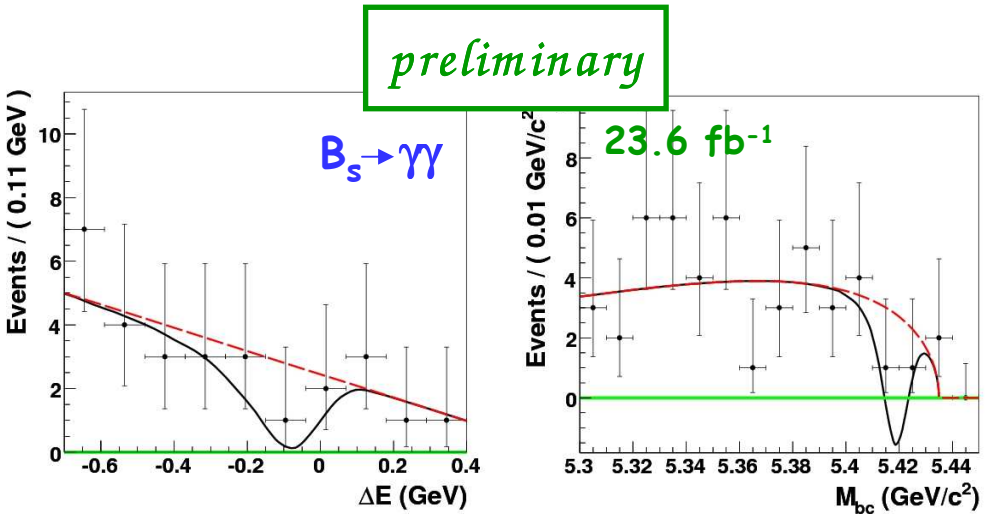




$Bf(B_s \to \gamma\gamma) < 8.6 \times 10^{-6}$ (90% CL)

Our prev. : $Bf(B_s \to \gamma\gamma) < 5.3 \times 10^{-5}$

SM: $Bf \sim (0.5\text{-}1.0) \times 10^{-6}$



Conclusions

- First B_s studies with 23.6 fb^{-1} at Y(5S) are presented.
- Total inclusive semileptonic $B_s \to X^+ l^- \nu$ decay is measured for the first time:

$$Bf(B_s \to X^+ l^- \nu) = (10.2 \pm 0.8 \pm 0.9)\%$$

- Radiative $B_s \to \phi\gamma$ decay is observed for the first time:

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

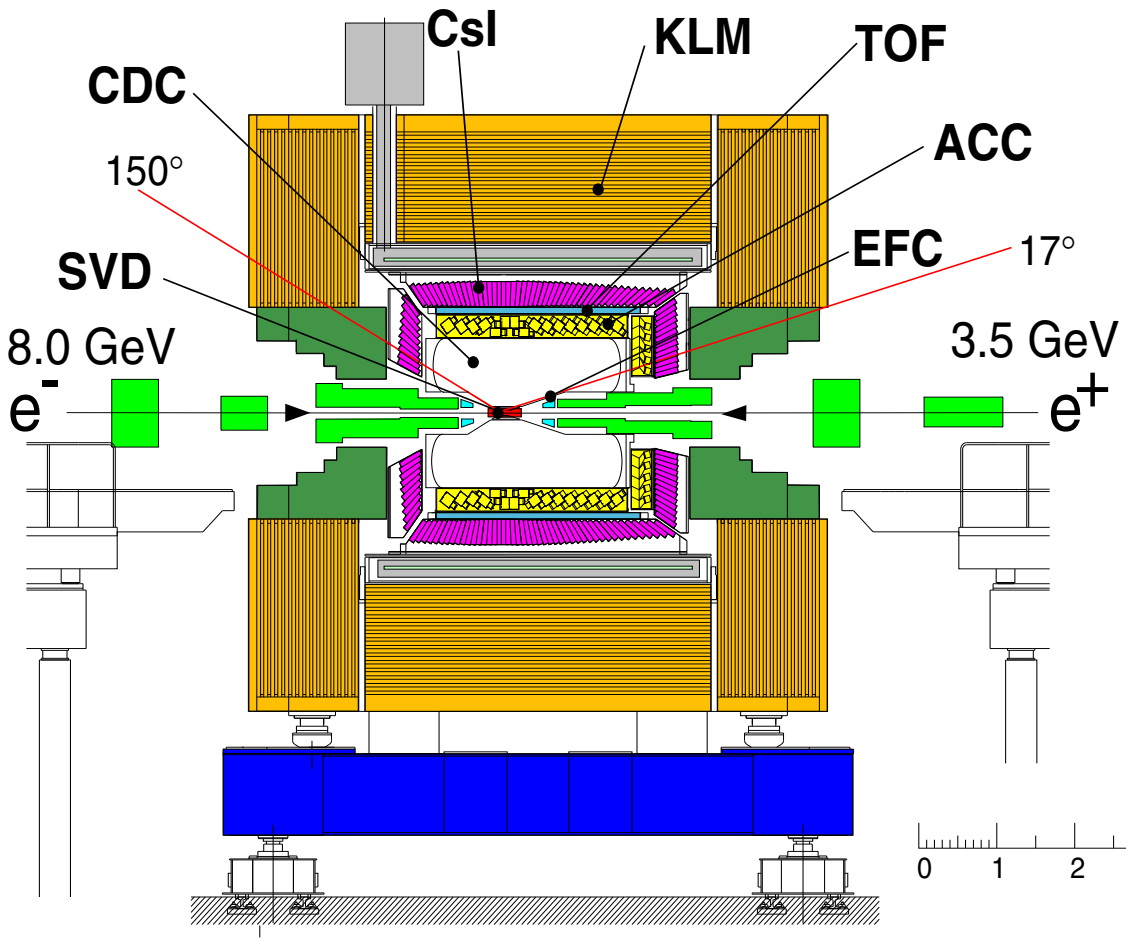
- The world's best $B_s \to \gamma\gamma$ upper limit is obtained:

$$Bf(B_s \to \gamma\gamma) < 8.6 \times 10^{-6} \text{ (at 90\% CL)}$$

- Y(5S) is a good place for B_s studies, similar to B at Y(4S). Our results are complementary and competitive with Tevatron.

Background slides

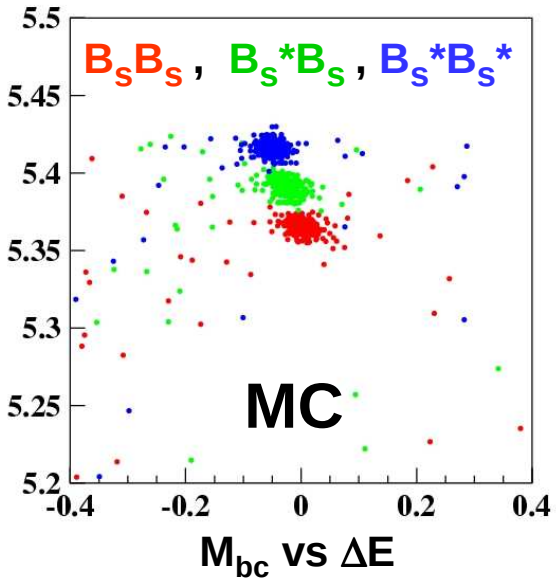
Belle Detector

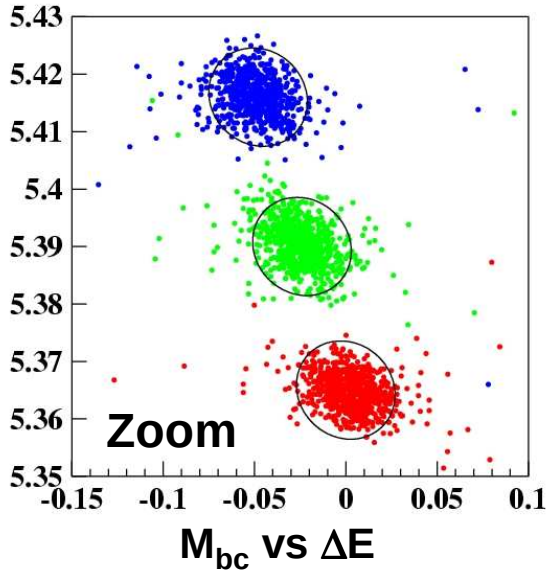


Electron and positron beam energies have to be increased by 2.7% (same Lorentz boost $\beta\gamma = 0.425$) to move from Y(4S) to Y(5S).

No modifications are required for Belle detector, trigger system or software to move from Y(4S) to Y(5S).

Signature of fully reconstructed exclusive B_s decays





$e^+ e^-$ -> Y(5S) -> B_sB_s, $B_s^*B_s$, $B_s^*B_s^*$, where B_s^* -> $B_s \gamma$

Reconstruction: B_s energy and momentum, photon from B_s^* is not reconstructed.

Two variables calculated: $M_{bc} = \sqrt{E^*_{beam}{}^2 - P^*_B{}^2}$, $\Delta E = E^*_B - E^*_{beam}$

Figures (MC simulation) are shown for the decay mode B_s -> D_s^- π+ with D_s^- -> ϕ π- .

The signals for B_sB_s, $B_s^*B_s$ and B_s^* B_s^* can be separated well.

Production of same-sign D_s and lepton

From $B_s\bar{B}_s$ events:

1. B_sà $D_s^+ X^-$ & B_sà $X^- Lep^+ \nu$: mix prob ~0.5
2. B_s à $D_s^+ X^-$ & mixB_sà D_s^+(Y $Lep^+ \nu$) X^- : low P tail (Bf~8%)
3. Lepton misID – should be small

From $B\bar{B}$ events (can be modeled using Y(4S) data):

4. B^0à $D_s^+ D X$ & mixB^0à $X^- Lep^+ \nu$: mix prob ~0.2 x 0.5 (B^+)
5. B à $D_s^+ D X$ & Bà D^+(Y $Lep^+ \nu$) X : low momentum tail

From continuum (can be modeled using continuum data):

From $c\bar{c}c\bar{c}$ processes or due to lepton misID : very small

Others: Residual leptons from J/ψ, converted photon : very small