Search for → decay at Belle

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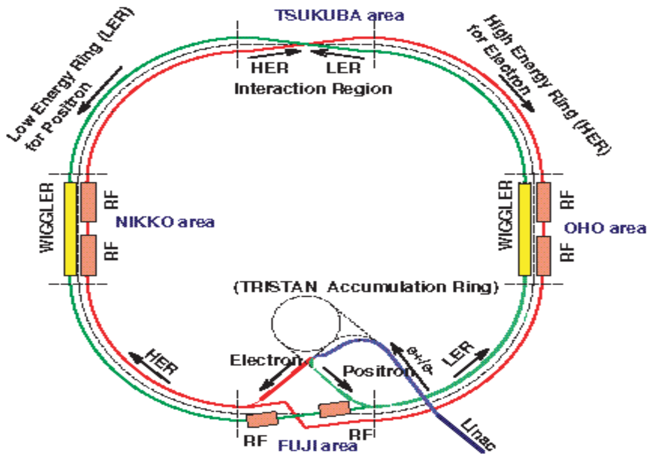
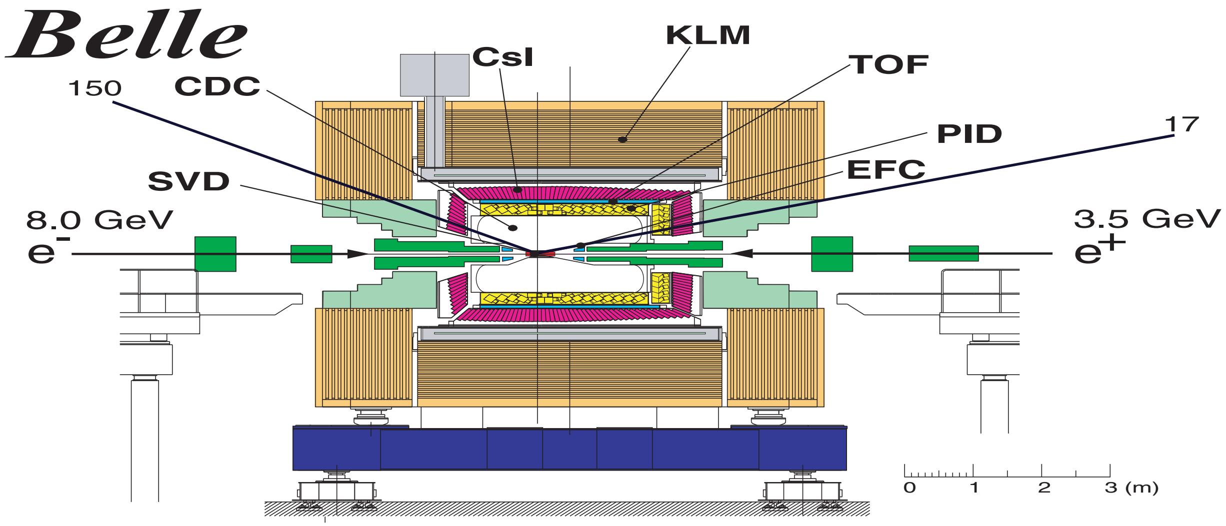
Belle Collaboration



KEKB e^+e^- Collider



Belle Spectrometor

I would like to report out search for LFV decay carried out at Upsilon(4S) resonance with Belle detector at KEKB asymmetric e+e- collider. Belle is the general purpose 4 detector to study CPV of B mesons and has been operated on for these two years successfully.

I. Data and selection-criteria

* Data: 21 fb/ **19.3M** -pairs, MC: 40M generic, 200k signal samples
BB, continuum, Bhabha, and some two-photons....

* Selection criteria

(→) + [/ + ≧0 + X(missing)]

two chg-trks + ≧ 1

➡ tag-side: e , , a1 ...

1) 2 trks (p_t > 0.1 GeV/c) w/ chg = 0;
≧ 1 (E > 0.1GeV);
p^{CM} < 4.5 GeV/c for each trk

4) 1.7 < Minv < 1.85 GeV; - 0.25 < E < 0.1 GeV

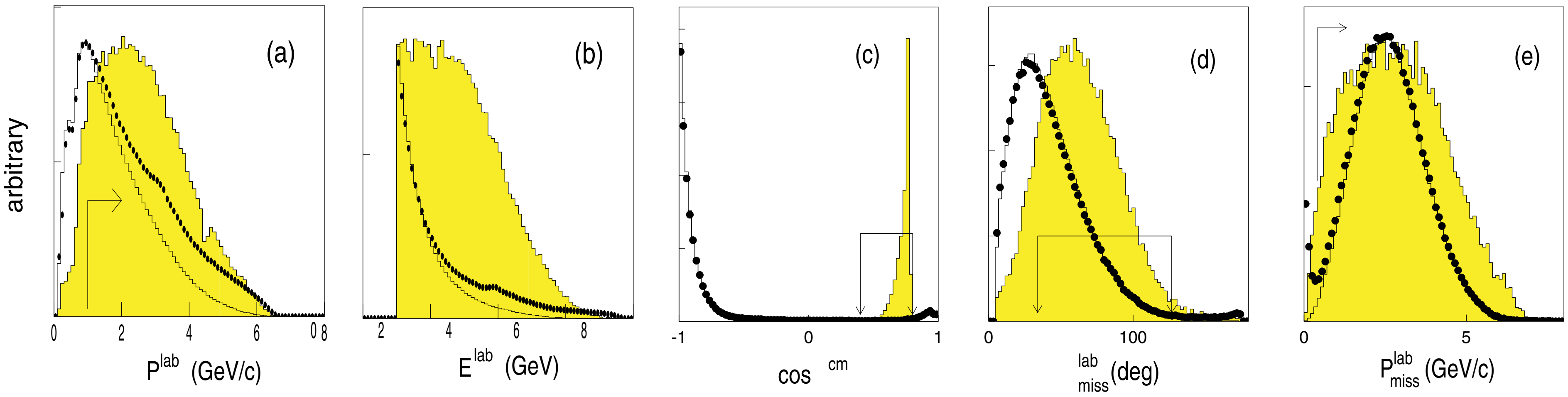
2) signal side
- -ID > 0.95; - 0.9< cos < 0.6 (barrel); p^{lab} > 1.0GeV/c
- E > 1.0GeV

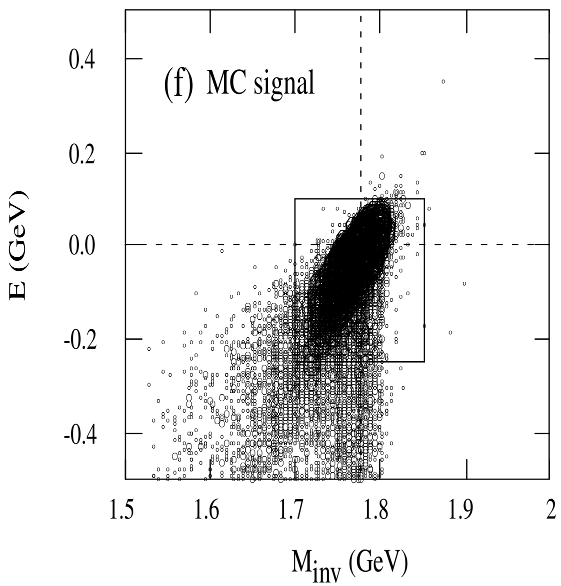
tag side
- ID < 0.80 (/)(barrel);

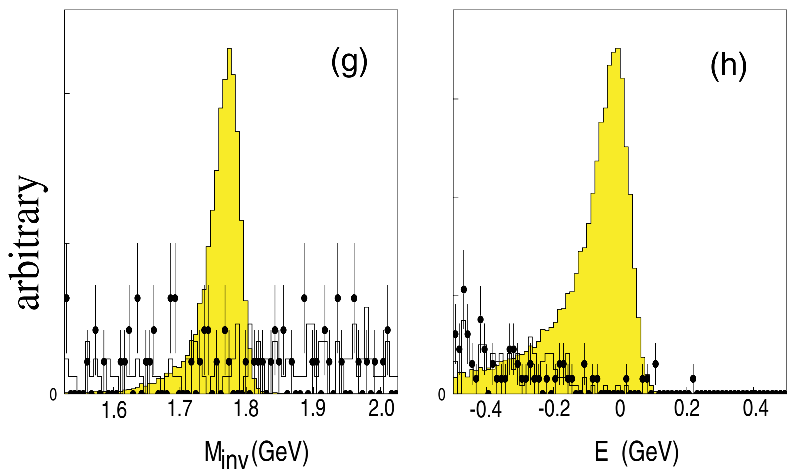
3) 0.4 < cos ^{CM} < 0.8; ^{lab} > 90 ° ;
$|p^{lab}_{miss}|$ > 0.4 GeV/c; 17 ° < $^{lab}_{miss}$ < 150 °

Data	**63** samples / (21fb^{-1})
MC signal	21.7k/200k (10.8%)
generic	115/40M = **55.4** events/ (21fb^{-1})

Data used is 21/fb (19.3 M). We searched for the events in -pair mode at which one decays to and the other decays to a charged particle but not and any number of s and some missing. Here lists the selection criteria. After these cuts, 63 events survived for data within this wide E and Minv area, on the other hand, 55.4 events survived at MC, and about 11% of signal samples remained.







Data (dots),
signal MC (yellow), and
generic MC (open hist.)

Scatter plot E vs Minv for signal MC.

Distributions show a long low energy tail due to initial and final radiations.

E = 48 MeV; Minv = 18 MeV

(E=-3.4 +-5.0 MeV; Minv=1.7761+-0.0017 GeV)

II Background evaluation

* Initial radiation is dominant BG source .
Other BG source exists.

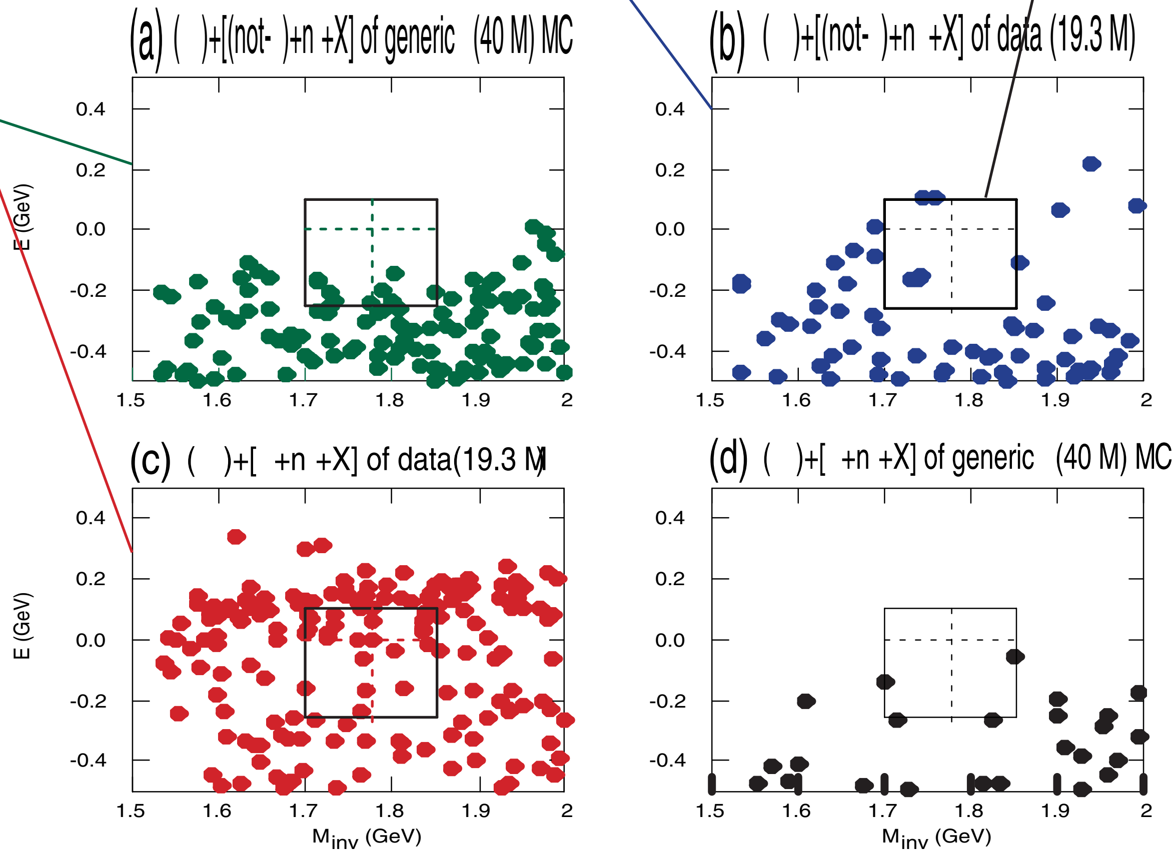
* Due to -ID inefficiency (~7%)
( ) + (+ n +X) contaminates

using Data → ( ) + (/ + n +X)

(**from MC**)

BG( ) only at E < 0.
vs
Data has events also at E > 0.

Signal-Box



$$N(BG) = N^{BG}(\quad ;MC) + N^{BG}(\ ;Data)\times(inefficiency)$$

We found from MC study that is dominant BG source and BB, conti. Bhaba, and two-photons do not make any contribution. We also noticed one other contribution which arises from ID inefficiency and it might originate from ( ). shows events only at E< 0, while the event which has a at tag-side shows a band structure at E> 0. Therefore, BG comporizes two origins. To avoid double counting di- events from the generic samples (d) have to be removed. There are 115 events from 40 M samples in this region which corresponds to 55.4 ev/21 fb^-1. The number of di- events is 175 but have to be multiplied by the ineff.~7%. It becomes about 12 events.

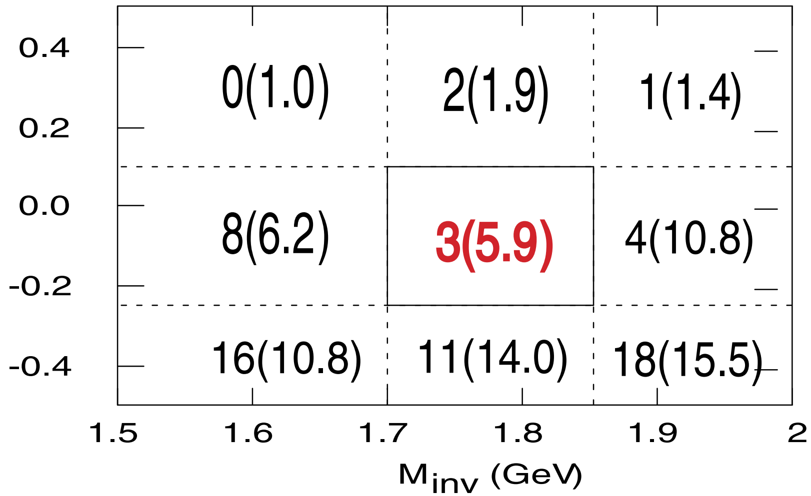
III. Upper limit and Systematics

* Signal box: 1.7 < Minv < 1.85 GeV; -0.25 < E < +0.1 GeV.
=9.4%

* BG estimate: To avoid bias in BG estimate in signal box,
- do not use a side-band approach since it largly depends upon the side-band allocation under a small number of distribution;
- do not assume any specfic functional form on BG distribution;
- rather use directly the BG obtained at previous transparency.

The wide area is sub-divided into 9 sections.

	candidate events	expected BG
Signal box	3	5.9
Total events in wide area	63	67.6+/-3.1
Total events except signal box	60	61.7



Quite good agreement is found between the observed events and estimated BG contributions with/without signal box.

* Upper-limit at 90% C.L.

s0 : signal (90% C.L.), b : expected BG, n0 : observed events

$$\frac{e^{-(s_0+b)} \sum_{n=0}^{n_0} (s_0 + b)^n}{e^{-b} \sum_{n=0}^{n_0} b^n} = 0.1$$

s0 = 3.5 events,

→ Br < s0 / (2 N) = 0.96×10^{-6}

detection sensitivity

* Take UNCERTAINTIES into the upper limit
  assuming Gaussian Prob. densities.

$$\iint G_s(s) G_{BG}(b)\, F(R,S,b)\, dS\, db = 0.1$$

$$F(R,S,b) = e^{-(R\cdot x)} \frac{\sum_{n=0}^{n_0} (R\cdot S + b)^n / n!}{\sum_{n=0}^{n_0} b^n \;\; / n!}$$

$$G_S(S) = [1/(2\sqrt{\pi}\sigma_S)]\, exp[-(S - S_0)^2 / 2\sigma_s^2]$$

$; \; G_{BG}(b) = \ldots$

S = 2eN
S0 = estimated S (3.6×10^6)
s = unsertainty of S (7.5%)

b = BG rate
b0 = estimated BG (5.9)
b = uncertainty of b (0.3ev)

n = observed # of events (3 ev)
R = Upper Limit at 90% C.L.

* Systematics

Uncertainty of s0	
m-ID ineff.	11%

Uncertainty of detection sensitivity	
track rec. eff.	2%
photon rec. eff.	5%
cut selection	1.5%
luminosity	1.4%
-ID	4%
MC statistics	0.8%
trigger eff.	1.7%
total	7.5%

Above errors $_S$ and $_b$ are doubled to see the stability of the result. Only ~3% of increment appears on the upper limit.

Conclusion

(1) Based on 21 fb^{-1} of Belle's first data, as a preliminary result we have obtaind an upper limit of the branching fraction on -> decay as

$$Br < \mathbf{1.0 \times 10^{-6}} \text{ at } 90\%\text{C.L.}$$

Further studies and the 10 fb^{-1} data still available should improve the sensitivity to an order of 10^{-7} precision in near future.

Signal box	1.7 < Minv< 1.85 GeV ; -0.25 < E< +0.1 GeV
Detection efficiency (%)	9.4
Events in signal box	3
BG estimation in signal box	5.9
Ratio between the events in data and the expected BG events excluding the signal box in the wide area	0.97
Number of signal at 90% C.L.	3.5
Upper limit at 90% C.L.	1.0×10^{-6}

(2) We have found the essential BG source arising from muon identification inefficiency. We infer it to be ( ). It could become one of the potential BGs to achieve much higher sensitivity in comming high luminosity measurement.