Search for $\tau \rightarrow e\gamma$ / $\mu\gamma$

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Belle Collaboration

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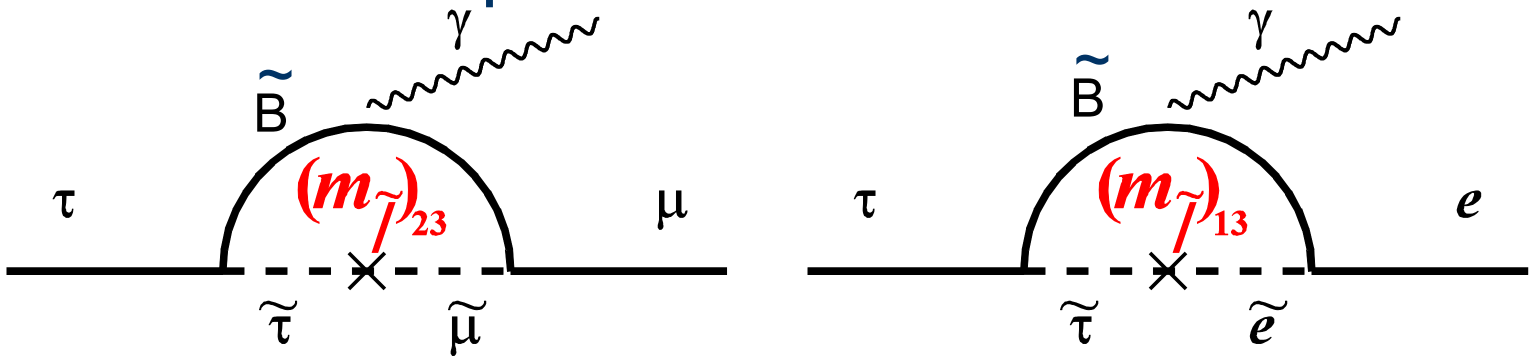
Introduction

- Lepton Flavour Violating (**LFV**) process: forbidden in SM ⇔ probe of new physics
- SUSY model predicts:

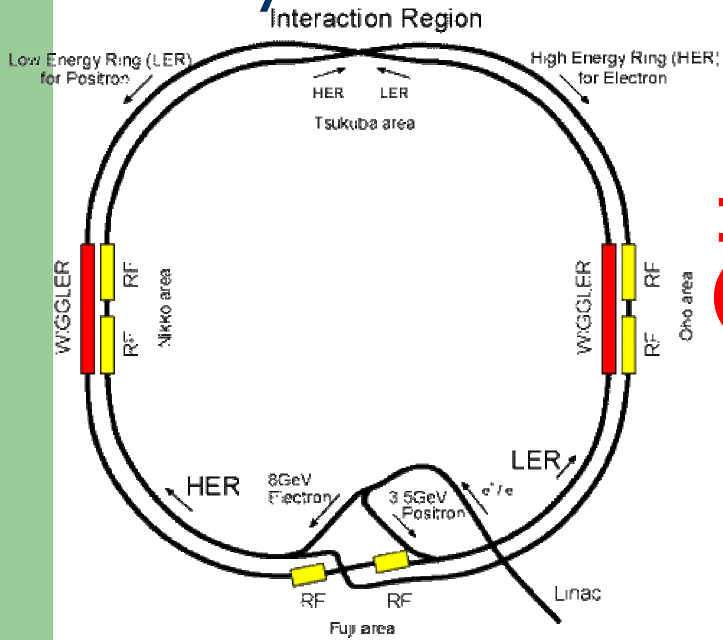


most sensitive mode in the **LFV** decays.

- We **SHOULD** search for **not only for** $\tau\to\mu\gamma$ **but also for** $\tau\to e\gamma$.

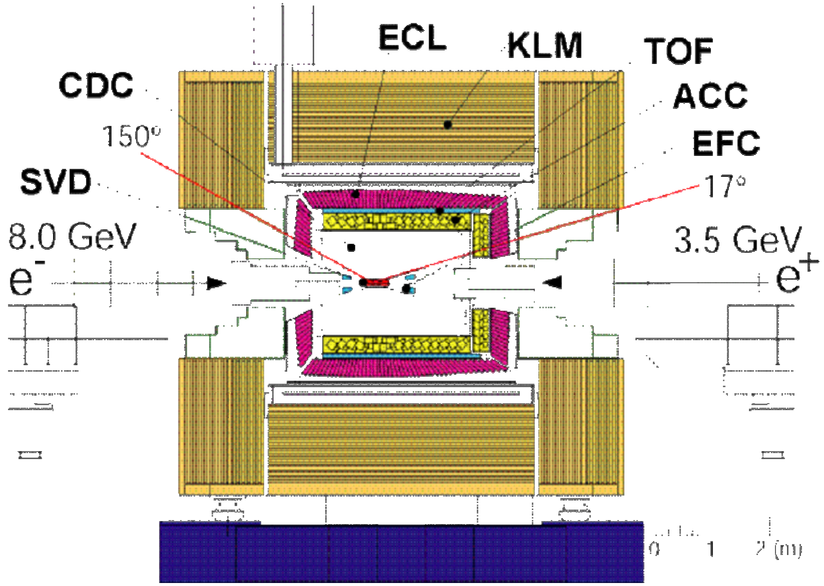
KEKB accelerator/Belle detector

- asymmetric collider



Peak Lum. **1.4x10^{34} (cm^{-2}s^{-1})**
Total Logged Lum. **288fb^{-1}**

- asymmetric detector



- **cross section@ s~110GeV²**

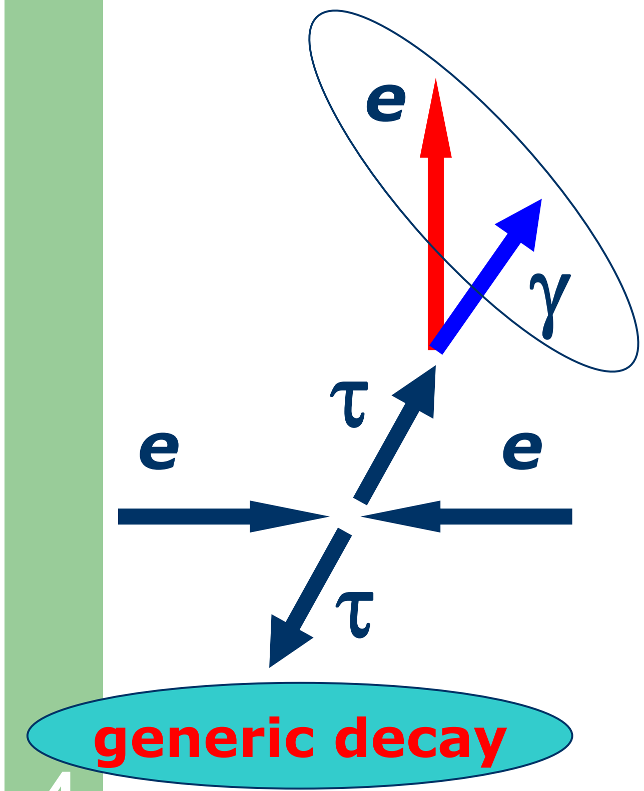
$\sigma(b\bar{b}):\sigma(\tau\tau)$=1.05:0.912

- μ–ID:eff. 87.5%
- e-ID:eff. 92.4%

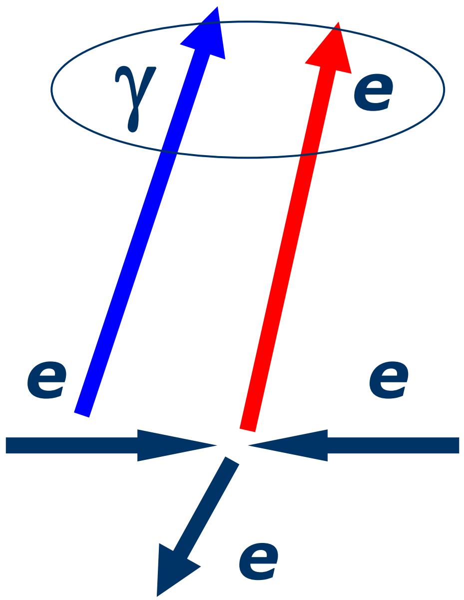
▶**A B-factory is also a τ-factory!**

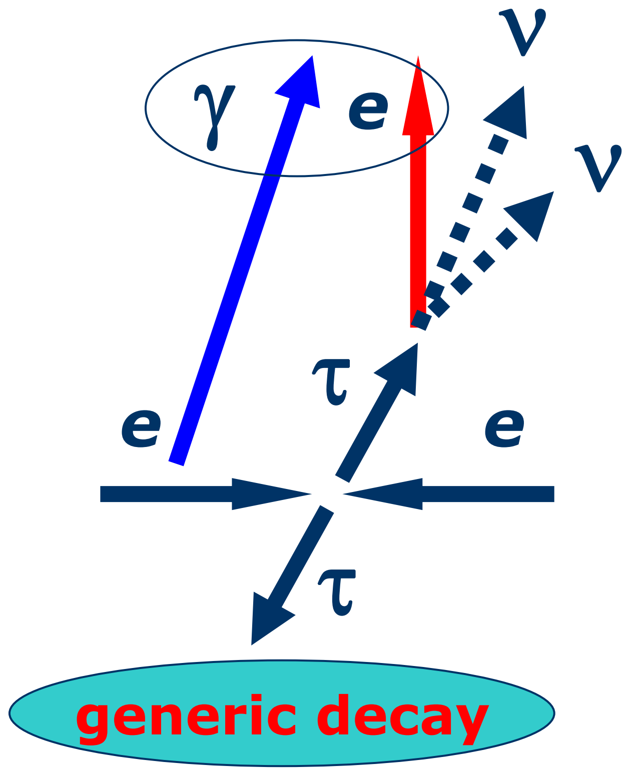
Signatures of the Signal and of the BGs

- **Signal Event**
  - $(e+\gamma)+(\not{e}+n\gamma)$

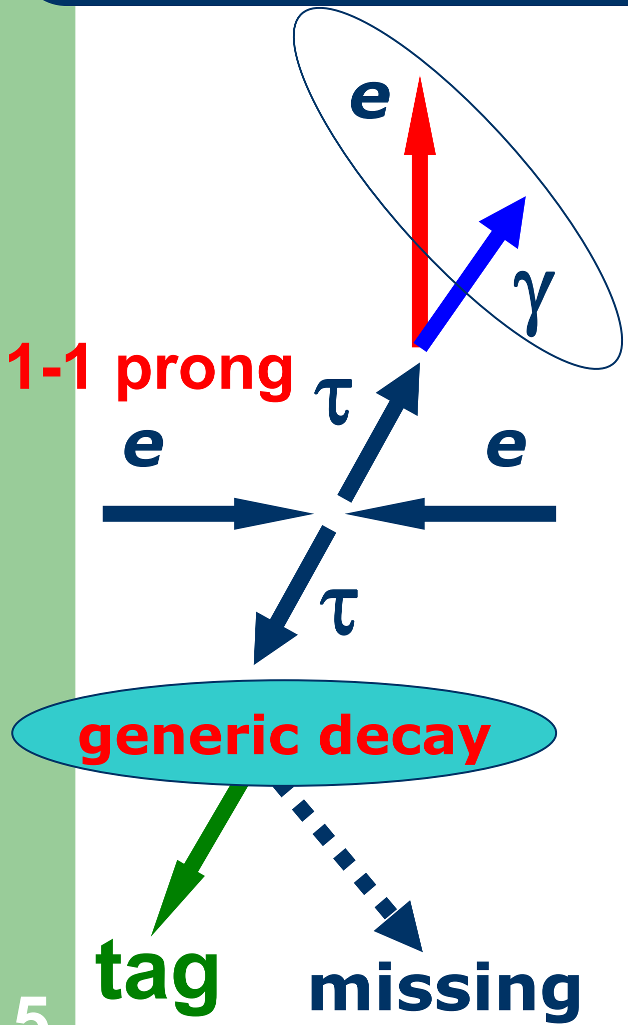


- Expected BG Events
  - Bhabha process
  - ττ process





Selection Criteria



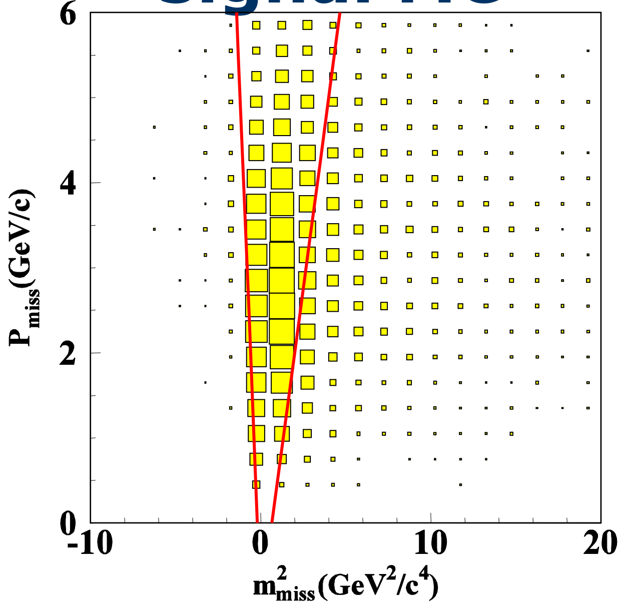
- 2 charged tracks + more than 1 γ
  - **signal side : 1 charged+1 photon**
  - **tag side : 1 charged+ *n* photons**
- **e-ID>0.9 & e-ID<0.1**
- restrict kinematical variables
  - momentum *e*,tag,γ,missing
  - polar angle *e*,tag,γ,missing
  - opening angle
    - *e*-tag, *e*-γ, tag-missing
  - missing mass vs missing mom.
- analysis for 87fb^{-1} data sample

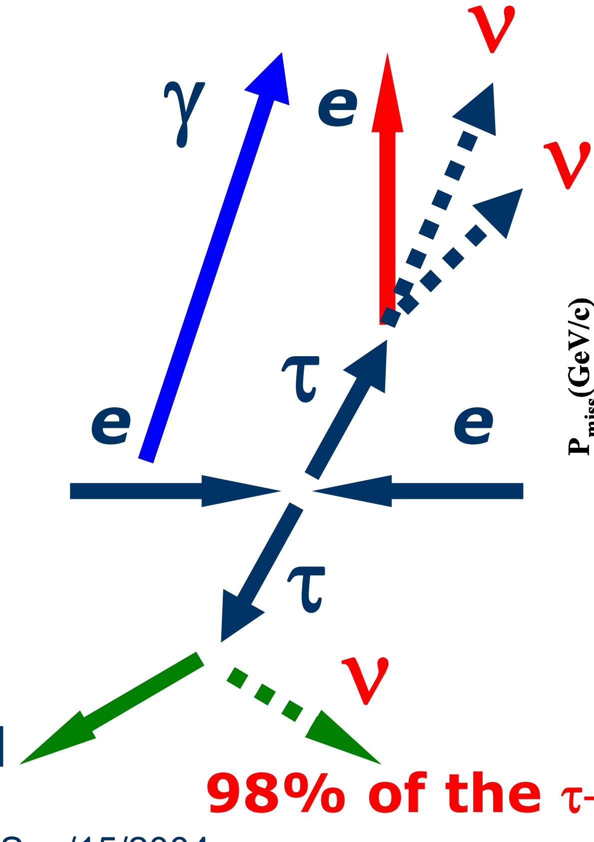
Nagoya Cut

- P_{miss} vs m^2_{miss}

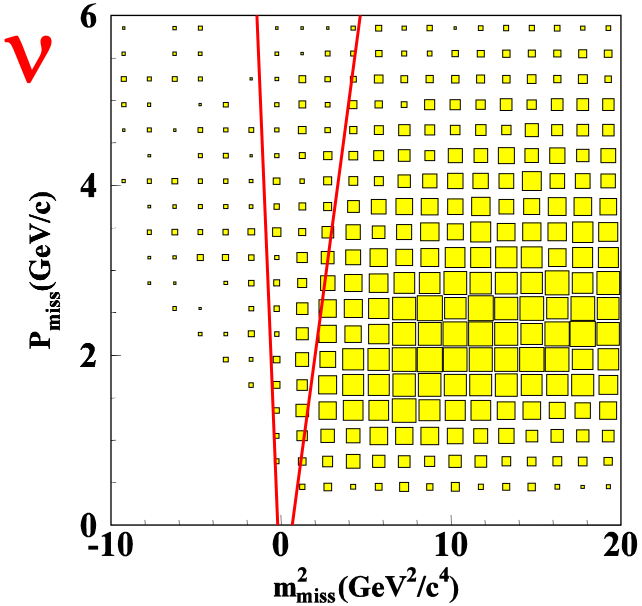
ττ events have **large** missing mass

signal MC





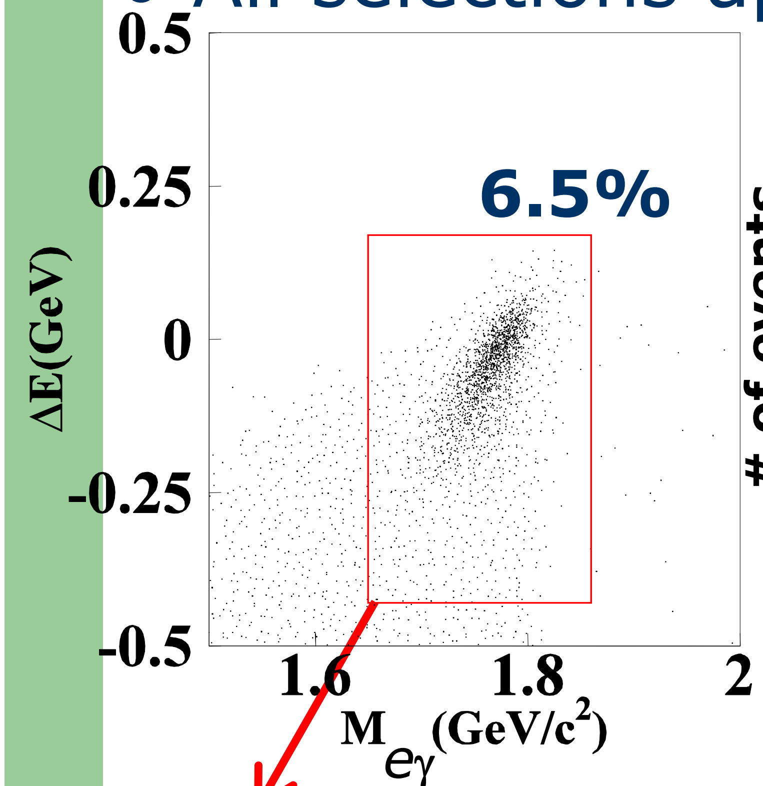
ττ MC



98% of the τ+τ− bkg is removed.

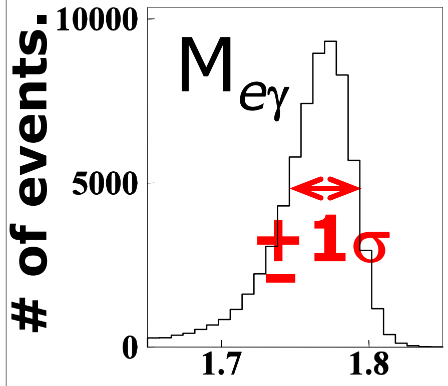
$M_{e\gamma}$ and ΔE resolutions

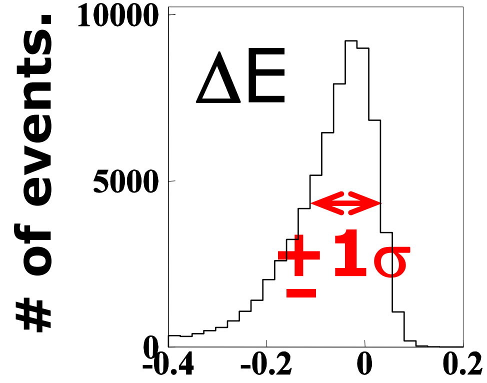
- All selections applied for signal MC events



±5σ region

- **Asymmetric Gaussian**





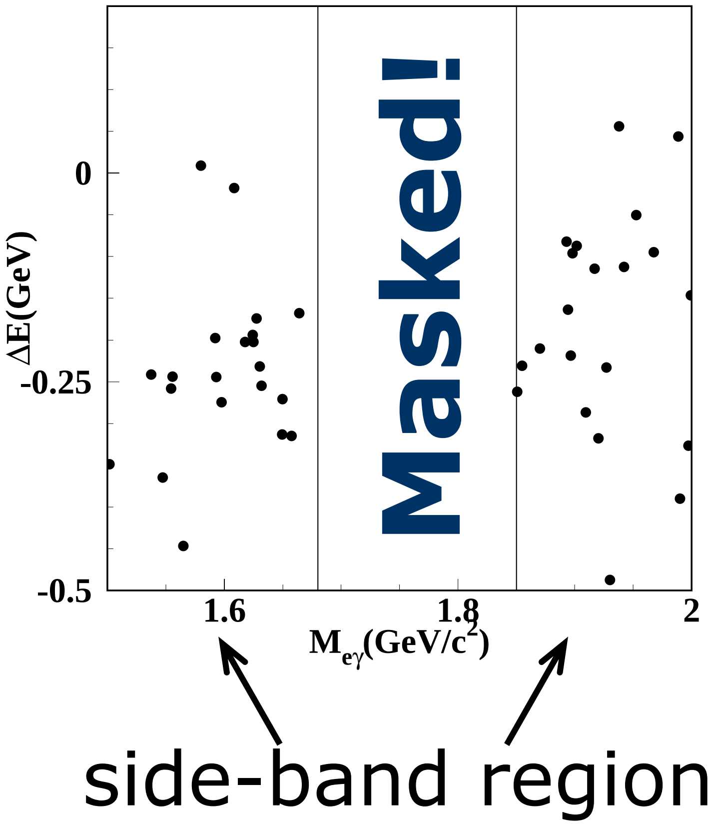
25.7/14.3MeV/c² 84.8/36.0MeV

$\Delta E = E_e + E_\gamma - E_{beam}$ @CM

$M_{e\gamma} = \sqrt{(P_e + P_\gamma)^2}$

Blind Analysis

- Signal dominant region is masked.



$\tau\tau$BG : $\tau\tau$MC

Bhabha BG : data

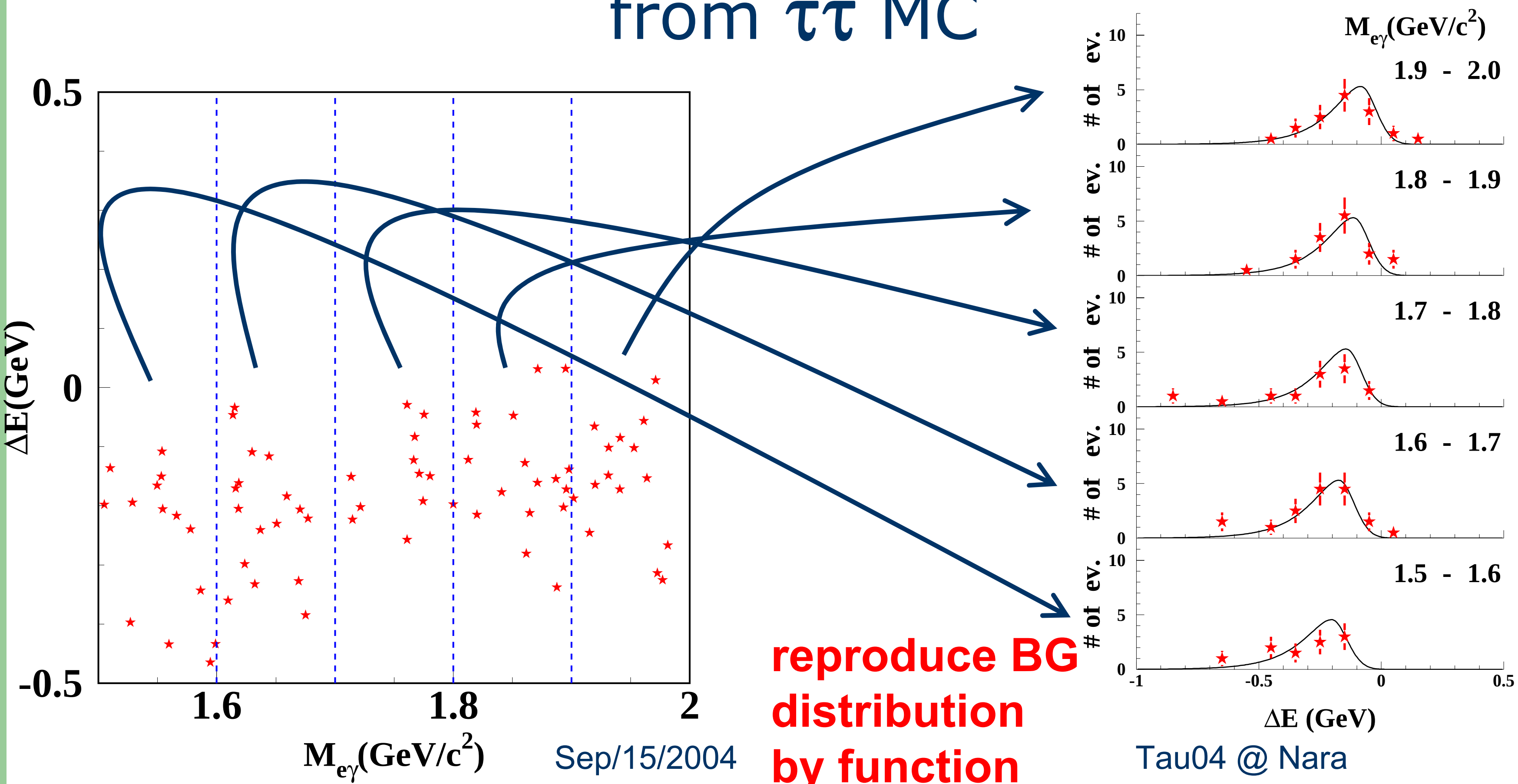
Shape of BG distribution is evaluated.

Its height is decided with data distribution of the side-band region.

BG distribution (MC)

- Estimate BG distribution from ττ MC

curve (Landau+Gauss)



reproduce BG distribution by function

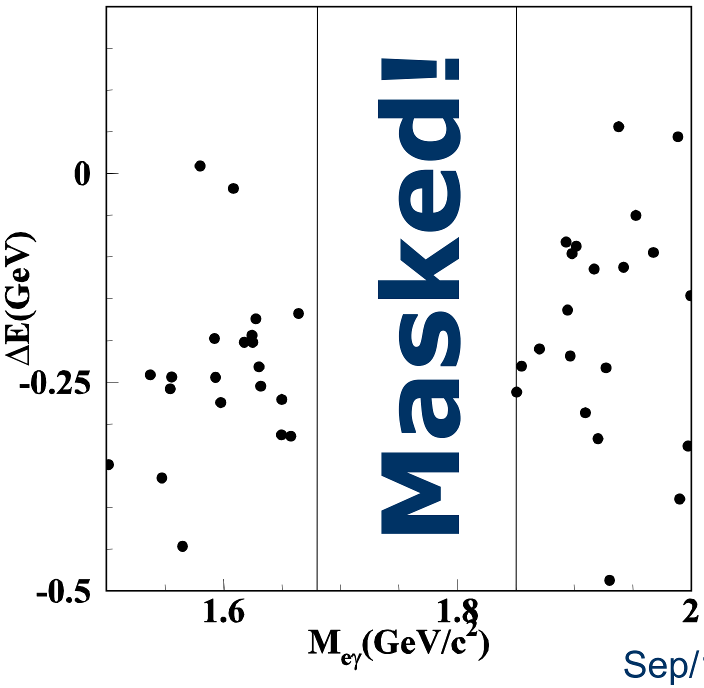
BG distribution (data)

- Estimate from MC and side-band of data

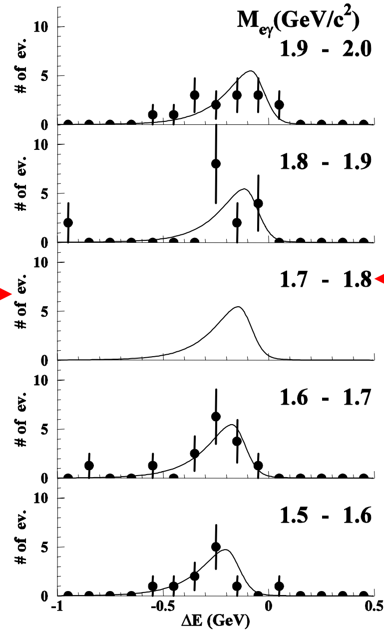
data(side band) $\tau\tau$ **MC** **ee**

64 $\cong$ **61** **3**

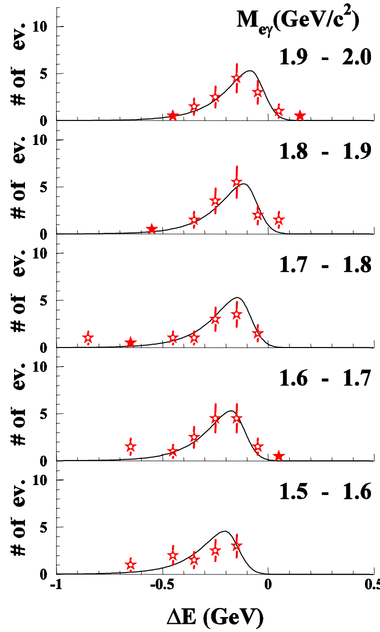
$\tau\tau$MC



profile plot

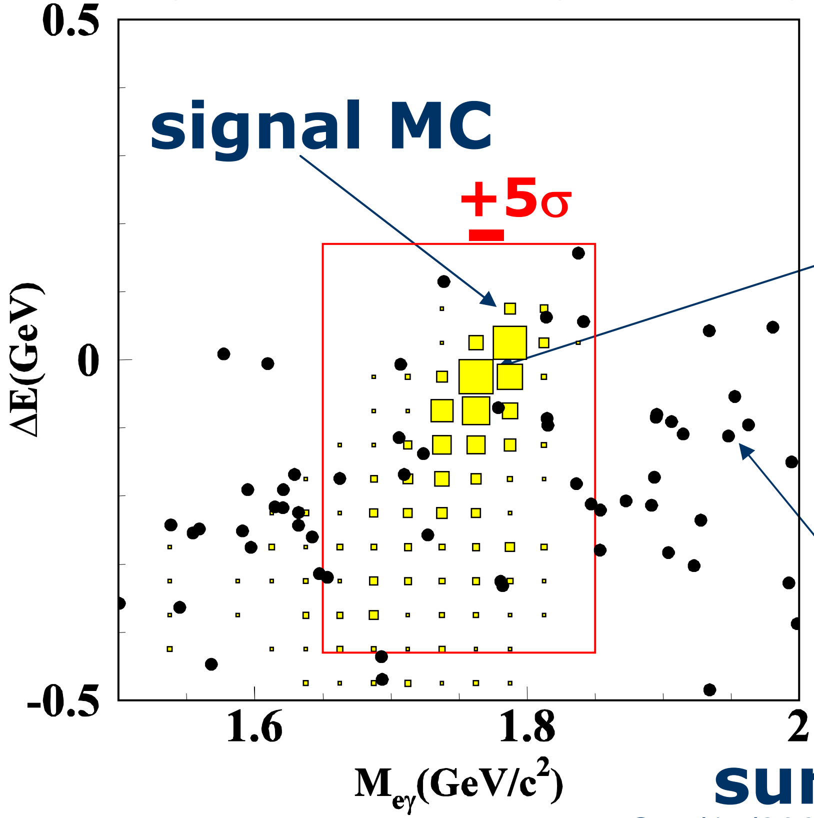


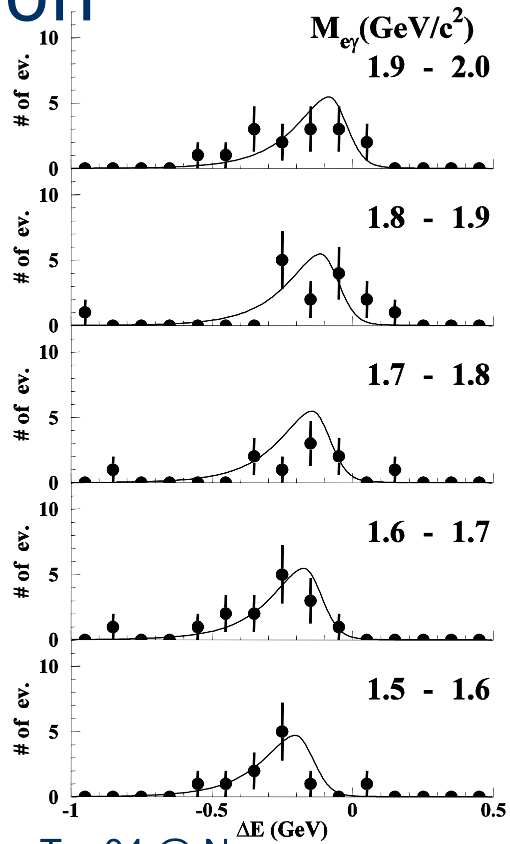
curve (Landau+Gauss)



Final Candidates ($\tau \to e\gamma$)

- 60 events found. (# of estimated BG:64)
- 20 events survived in $\pm 5\sigma$ region





Evaluation of signal events

- fit by unbinned expanded maximum likelihood with signal and BG shape → $s_0=0, b_0=20$
- Estimation for U.L. of s_{90} @ 90%CL
  - ▶by Toy MC: generate 10000 events

result

- $s_{90}=3.8$ events

- **Branching fraction**

$$Br=s_0/2\varepsilon N_{\tau\tau}<\mathbf{3.8\times10^{-7}}$$

ε:detection efficiency

$N_{\tau\tau}$:total event number

Signal yield : s_0

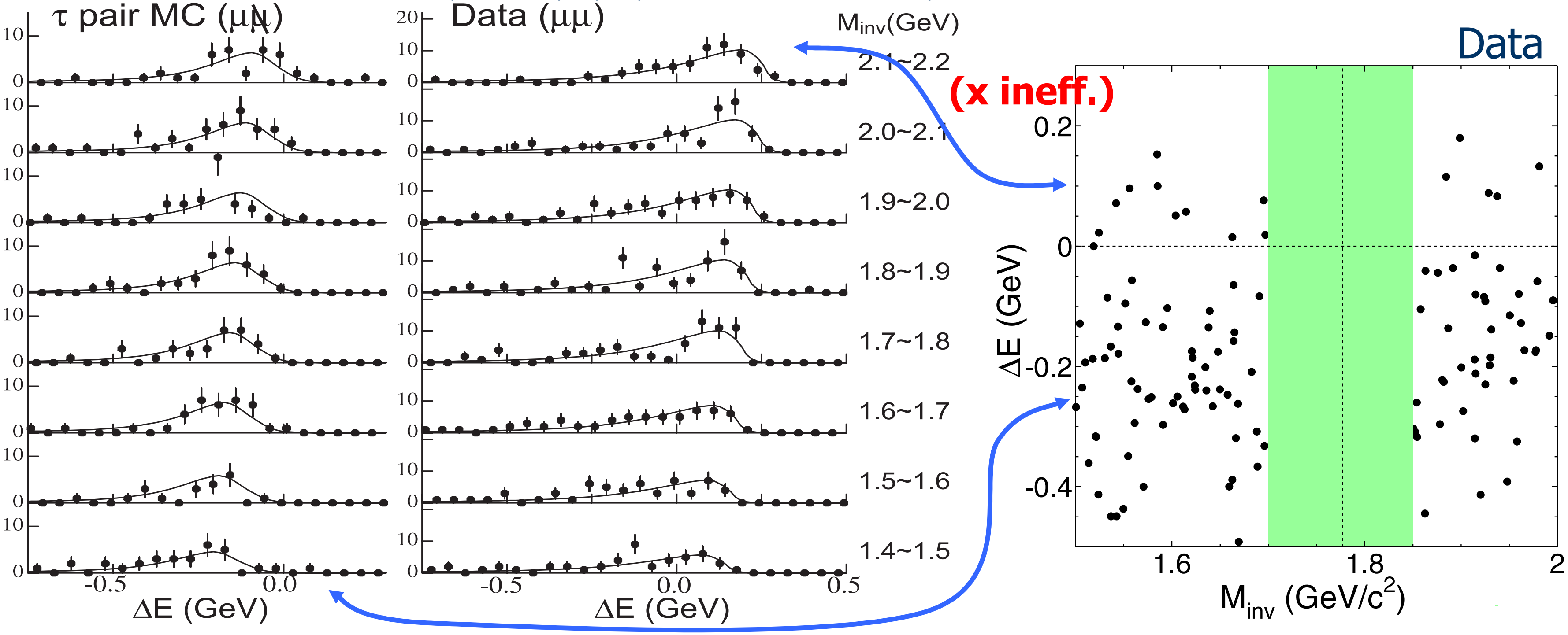
e-ID ineff.	0.01/0.02 ev.
BG function	0.13 ev.

Efficiency & Luminosity : $2\varepsilon N_{\tau\tau}$

Track rec. eff.	2.0%
Photon rec. eff.	2.8%
Selection criteria	2.5%
Luminosity	1.4%
Trigger eff.	5.0%
MC statistics	0.2%
Total	6.8%

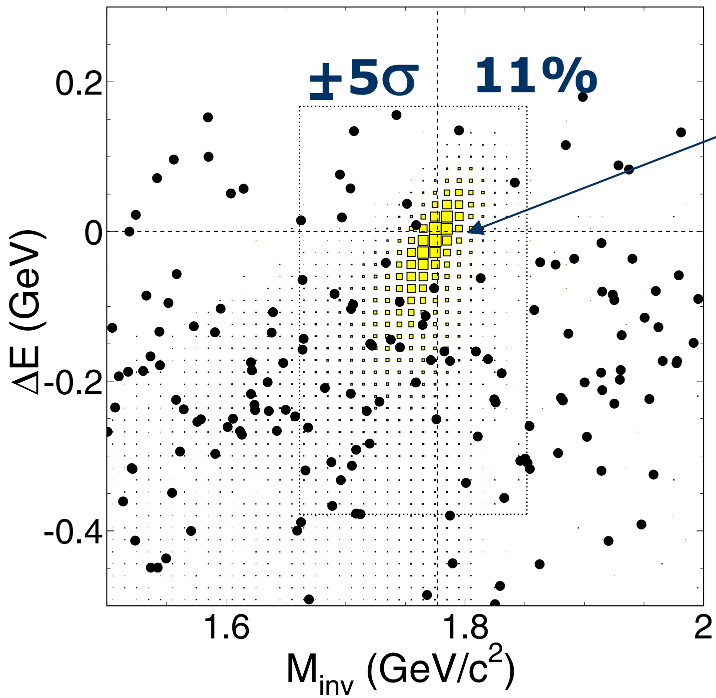
Search for $\tau \to \mu\gamma$

- Almost same selection criteria as $\tau \to e\gamma$
  - for tag side track, require not to be μ
- Main BG: $\tau\tau\gamma$ & $\mu\mu\gamma$(←from μ-ID ineff.)



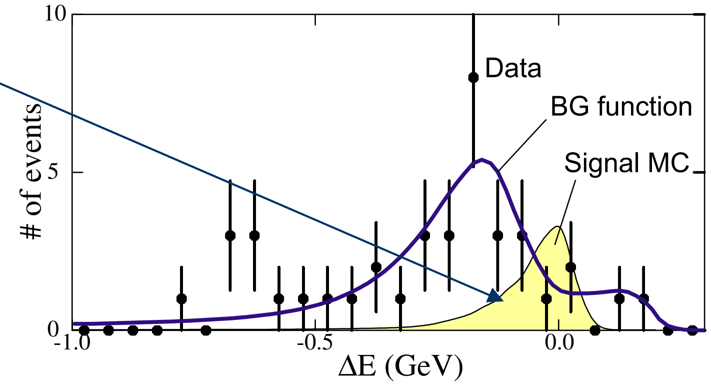
Final Candidates ($\tau \to \mu\gamma$)

- 54 events survived in $\pm 5\sigma$ region



signal MC

1.71<M$_{inv}$<1.82GeV/c^2



- **fitting result(UEML)**
  - **s=0**

Evaluation for U.L.

- **s=5.1ev. @90%C.L.**
- **Br<3.1x10^{-7} @90%C.L.**

including systemaric uncertaunties

Conclusion & Summary

- Obtain BR UL's with blind analyses.
- BG distributions are modeled well.
- Results are 10 times more sensitive than CLEO's.

$\tau \to e\gamma$ (86.7fb^{-1})	$\tau \to \mu\gamma$ (86.3fb^{-1})
• $N_{\tau\tau}=7.90\times10^{7}$	• $N_{\tau\tau}=7.87\times10^{7}$
• 20 observed events	• 54 observed events
• ε=6.5%	• ε=11%
• s=3.8ev. @90%C.L.	• s=5.1ev. @90%C.L.
• **Br<3.8×10^{-7}** @90%C.L.	• **Br<3.1×10^{-7}** @90%C.L.

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cf. Br<2.7×10^{-6}@90%C.L. (CLEO)	cf. Br<1.1×10^{-6}@90%C.L. (CLEO)