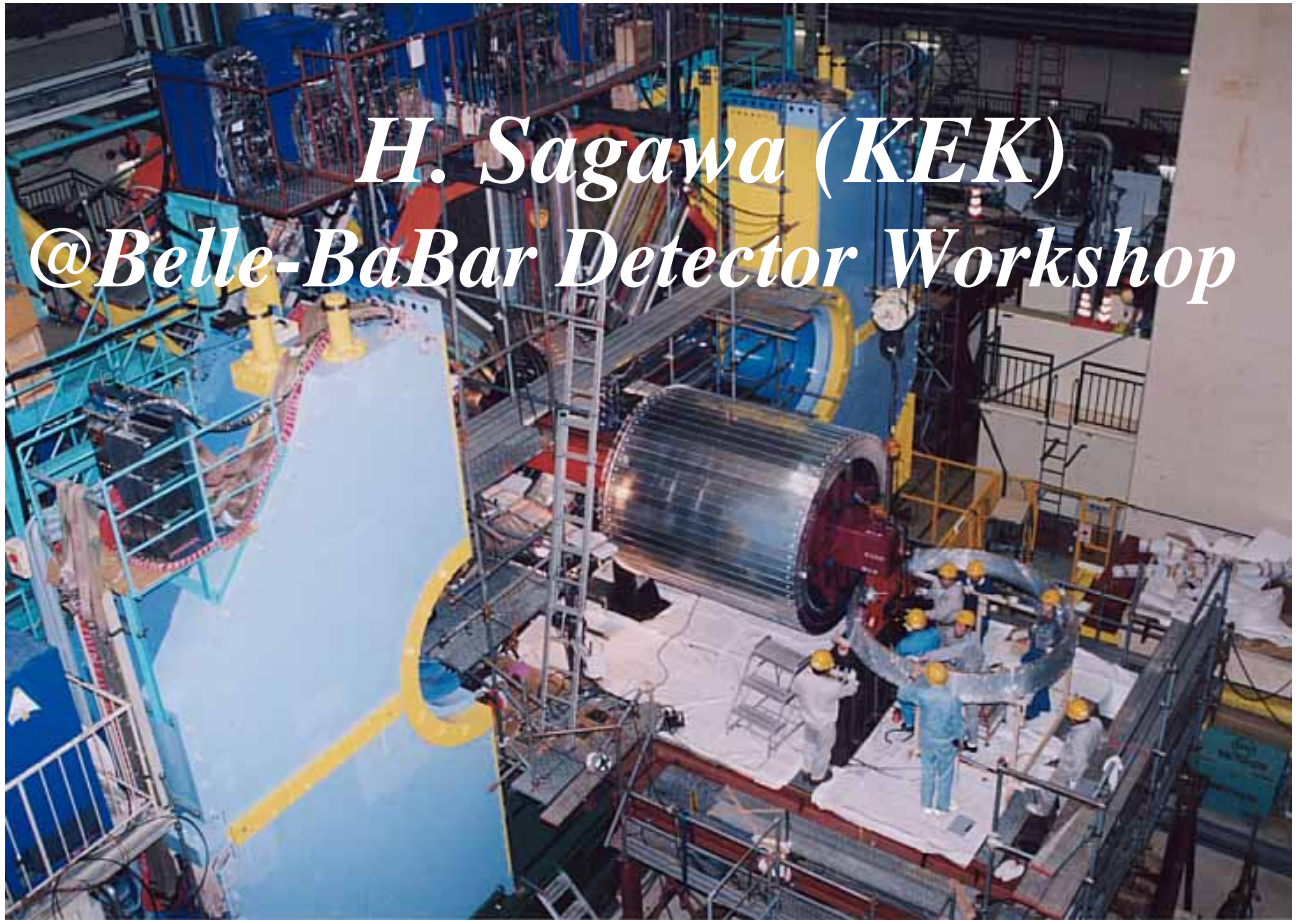
Belle Calorimeter



H. Sagawa (KEK)

@Belle-BaBar Detector Workshop

outlook

- *Introduction*
- *Configuration*
  - *Global configuration, CsI counters, electronics*
- *Trigger*
- *Performance*
  - *Mass resolutions ($\pi^0, \eta, K_S(\rightarrow \pi^0\pi^0)$)*
  - *Energy/angle resolution of photons*
  - *Electron identification*
- *Summary*

Role of electromagnetic calorimeter

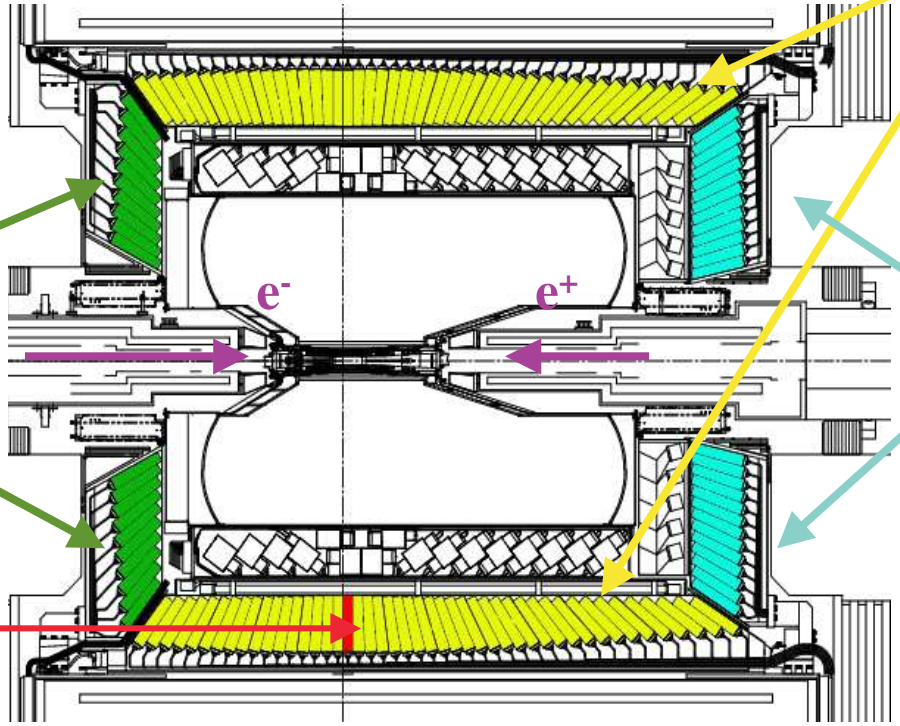
- *Measurement of*
  - *Energy/angle of photon* **(20MeV~8GeV)**
  - *Electron identification*
  - K_L *detection together with KLM* **(not mentioned here)**
- *Trigger*
  - *Redundant trigger*
  - *Neutral trigger*
- *Measurement of luminosity*
  - *Online/offline luminosity*

Belle calorimeter

- # of counters (8736)
- Crystal producers
  - ISC(Kharkov, Ukraine)+BINP(Russia) ~68%
  - SIC(Shanghai, China) ~21%
  - Crismatec (France) ~11%
- Crystal size : (5.5x5.5~6.5x6.5)x30cm^3 (16.2Xo)
- θ coverage : 12^o – 155^o

Layout of electromagnetic calorimeter

- **Total number of crystals = 8, 736**
- **Total weight is ~43ton**



Electronics

- ***photodiode***
- ***preamplifier***

} *just behind the crystal*

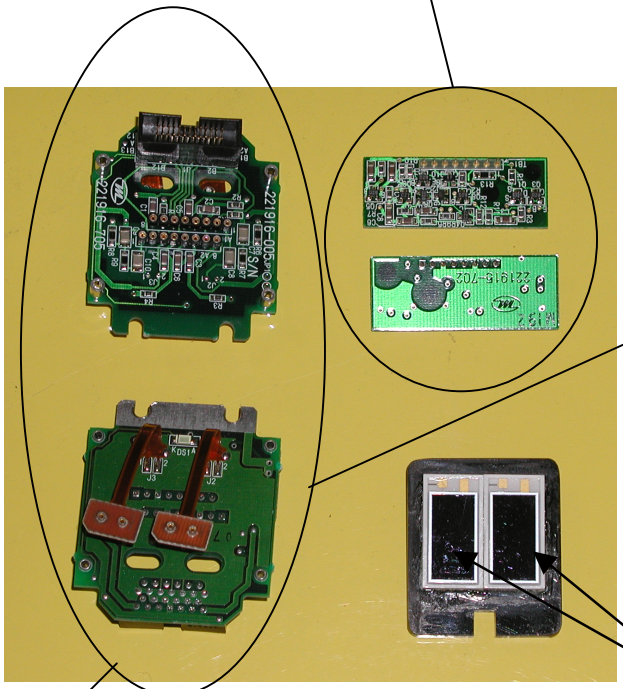
- ***shaper***
- Q→T

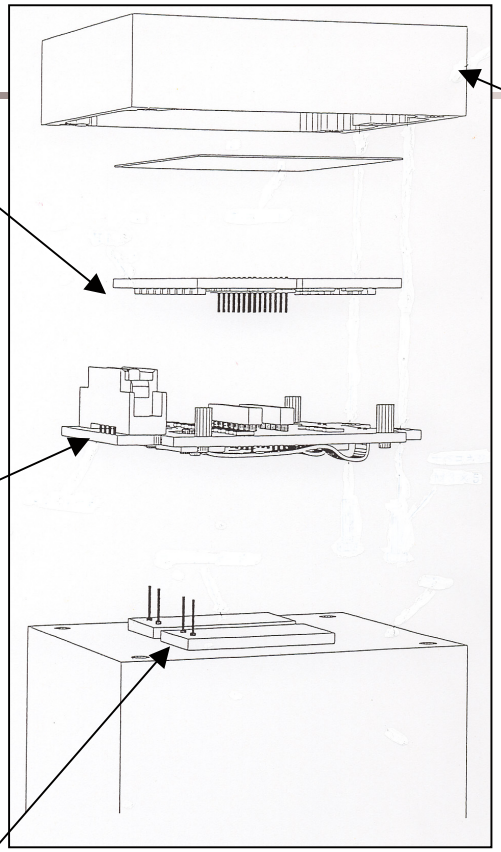
} *10m from the crystal*

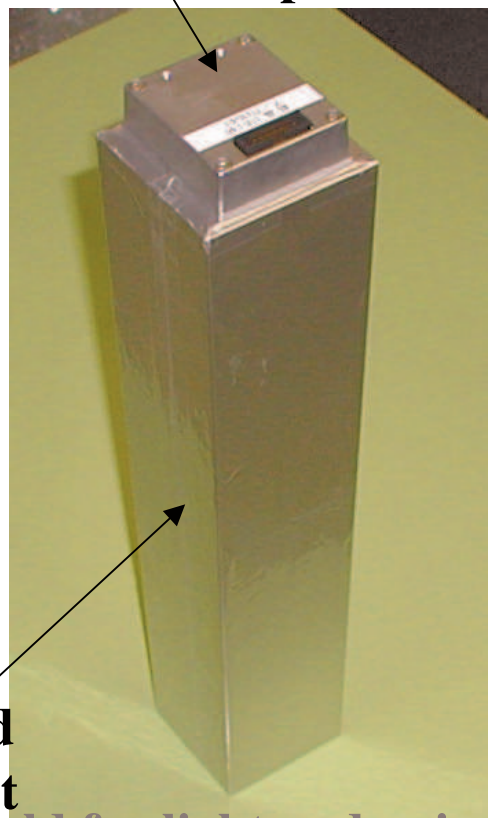
- T→D
- ***trigger***

} *30m from the shaper*

Structure of CsI counter







Preamp. cards

CsI counter

Preamp box

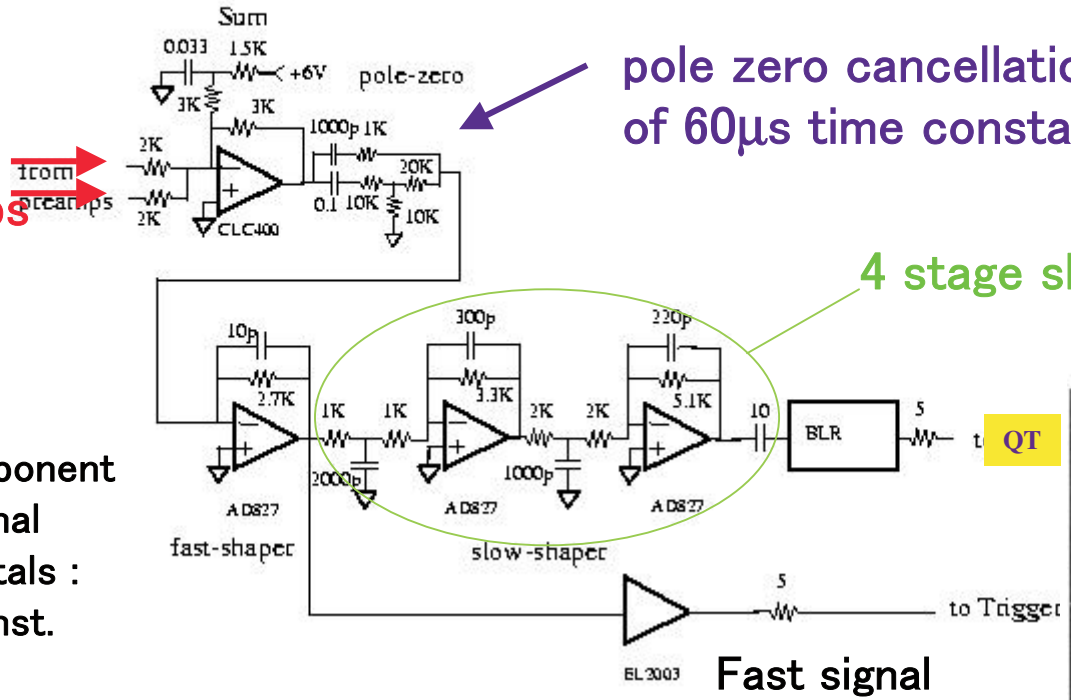
Mother board

Photodiodes
S2744-08
（1cm x 2cm）

Aluminized
Mylar sheet
(shield for light and noise)

Shaper

Signal From Preamps

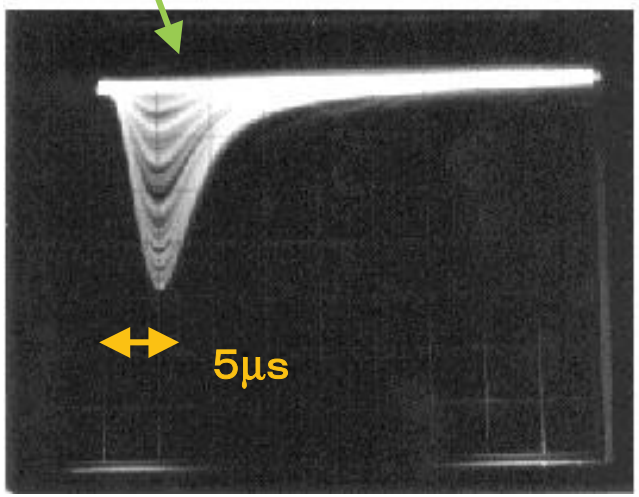


pole zero cancellation : remove component of 60μs time constant from preamp

4 stage shaping with τ=1μs

Main component of the signal from crystals : Decay const. ～1μs

Fast signal →trigger



Charge→Time (LRS MQT300A)

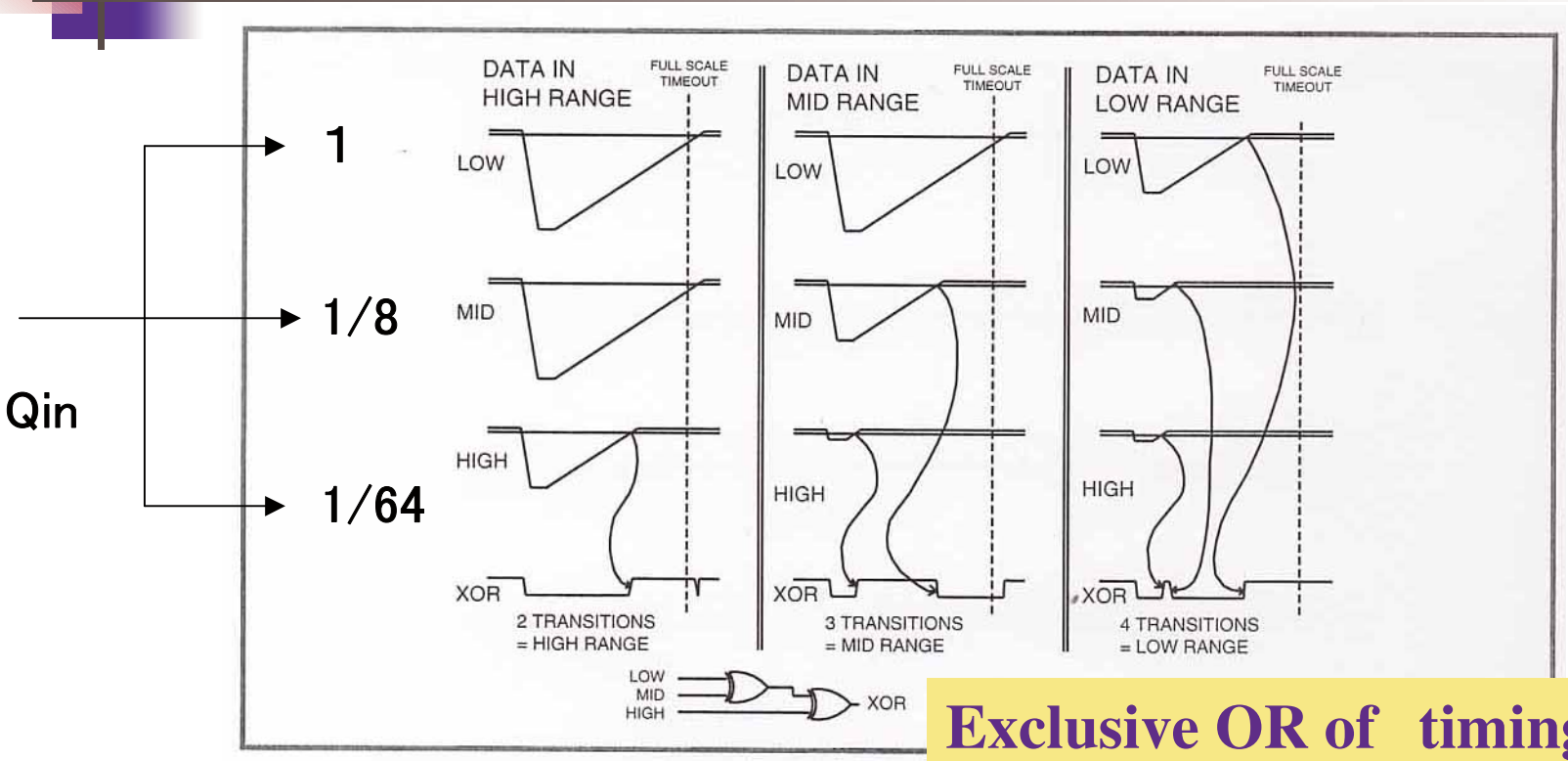
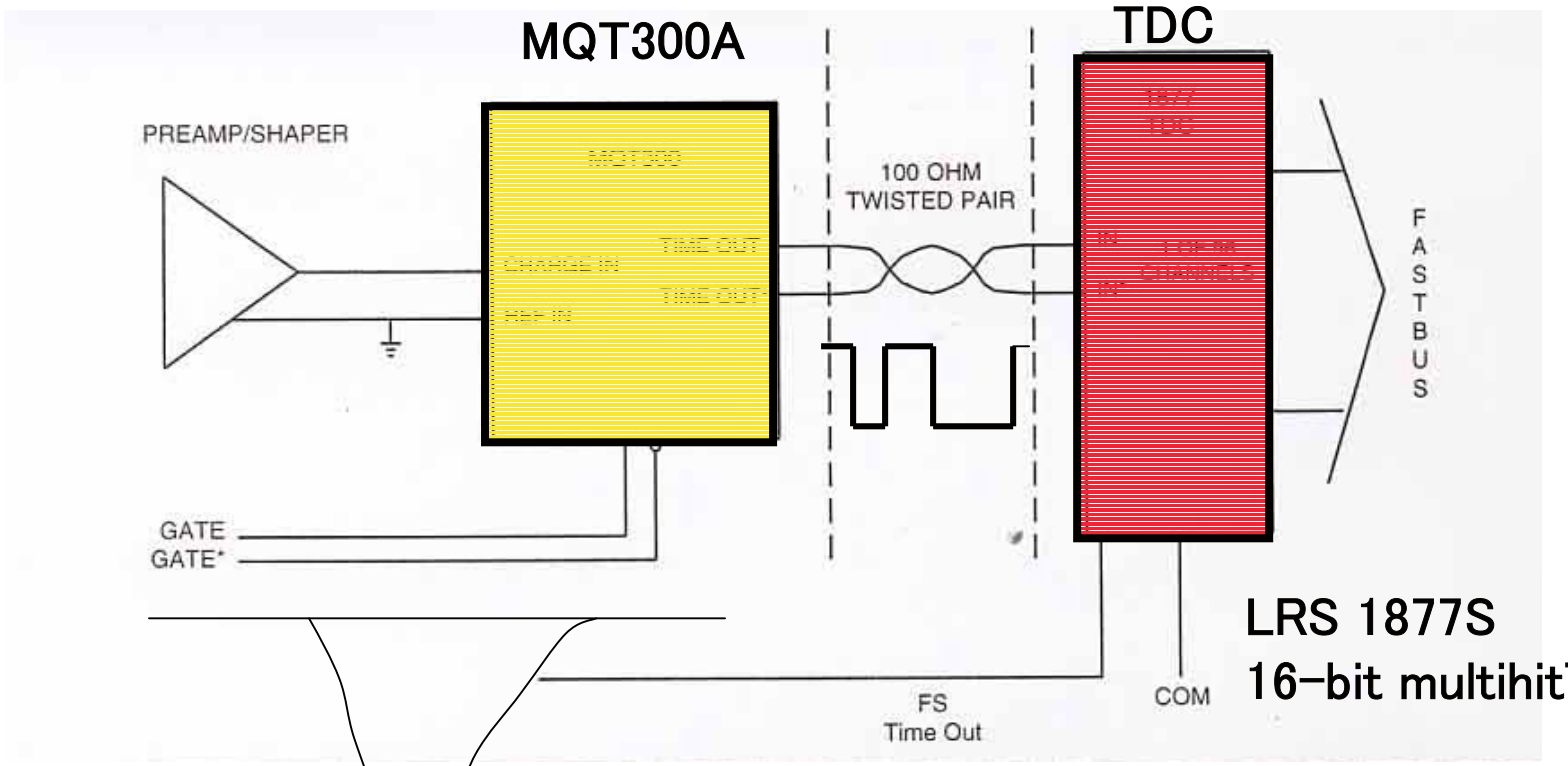


Figure 4: Operation of the three range front-end

Exclusive OR of timingedges proportional to inputs with 3 gains
1channel →1line

CDC, ACC, TOF, ECL, EFC use this chip.

charge →time →digital



LRS 1877S
16-bit multihitTDC

100ns gate width

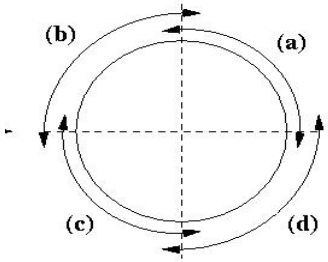
Calorimeter Trigger

- *Trigger Concept/requirement*
  - ***Suppress beam-background and cosmic events***
  - ***Separate physics events from Bhabha events***
  - ***Fast trigger decision < 1.85 μs***
  - ***Good timing resolution***

Calorimeter Trigger

- **Cluster counting trigger**
  - Trigger Cell (TC:4x4 crystals) > 100 MeV
  - ICN : isolated cluster counting logic (merge adjacent TCs)
  - **cosmic-veto trigger**

    (not back-to-back in r-ϕ plane)



$\overline{A \otimes C \oplus B \otimes D}$

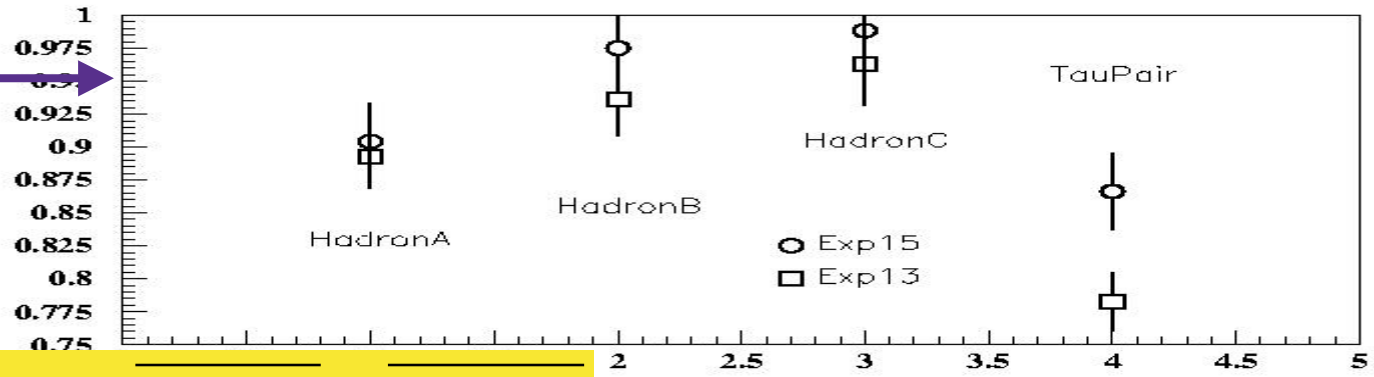
- **Energy trigger**
  - Total Energy trigger Etot (0.5, 1, 3GeV)
  - Bhabha trigger (~5GeV) back-to-back topology

- **physics trigger : Etot>1GeV & ICN>3**

EM Cal. Trigger Efficiency

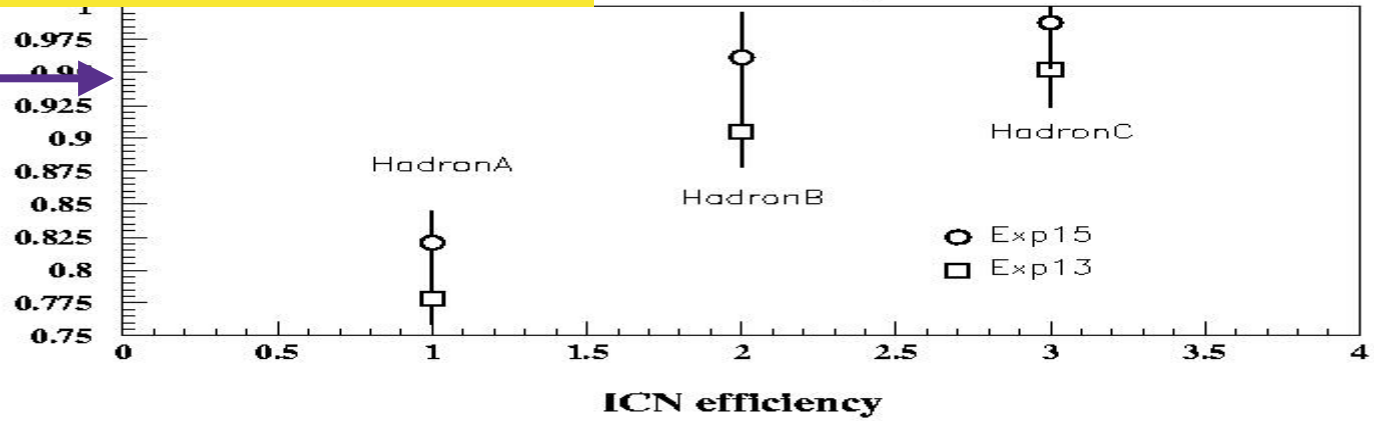
$Etot > 1GeV \otimes \overline{Cosmic} \otimes \overline{Bhabha}$

95%



$ICN > 3 \otimes \overline{Cosmic} \otimes \overline{Bhabha}$

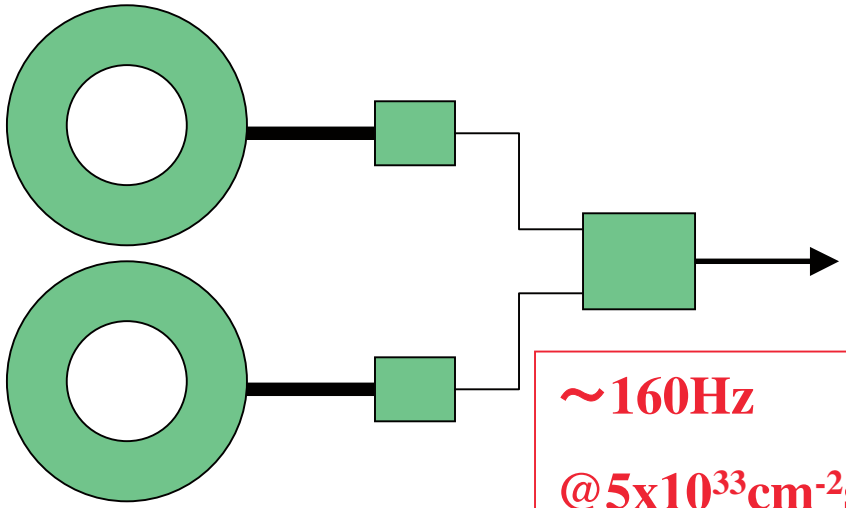
95%



Online Luminosity monitor

Bhabha counting rates of Fwd&Bwd endcap

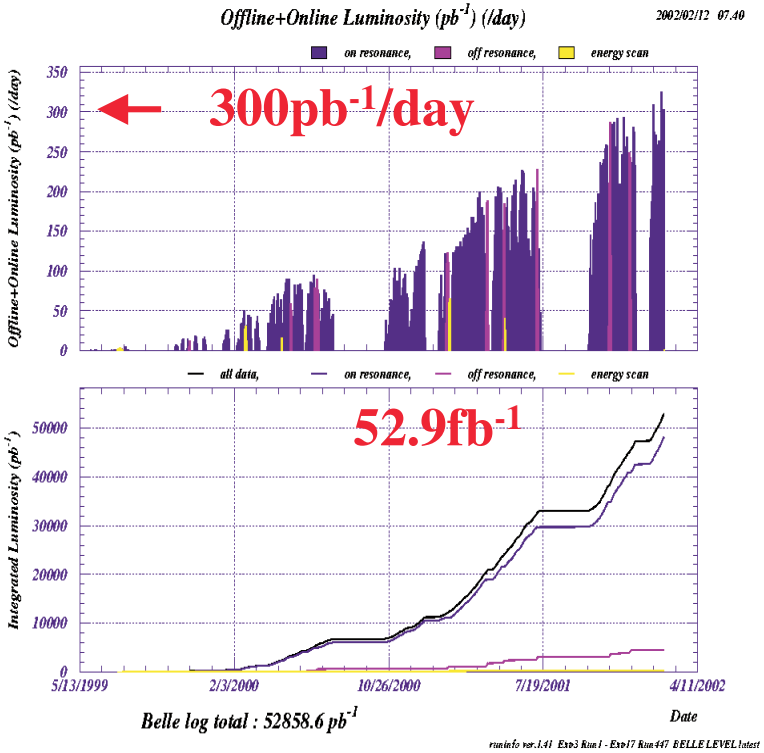
Fwd CsI endcap



Bwd CsI endcap

~160Hz

@5x10^{33}cm^{-2}s^{-1}



2002 Feb 12

Recently with ϕ segmentation
→robust against beam background

Offline luminosity

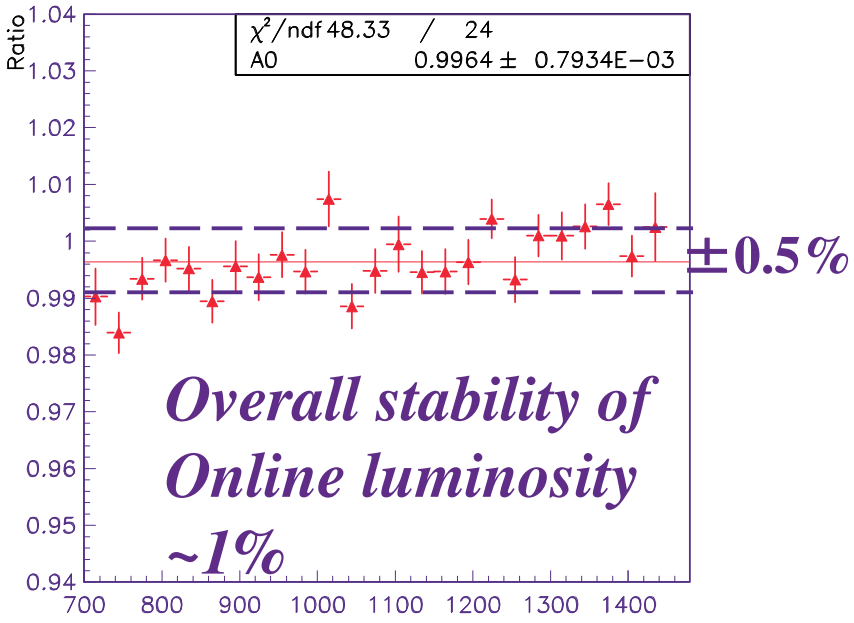
- ***Selection of Bhabha events***
  - Back-to-back 2 tracks in barrel part
  - 2 EM clusters (Esum>4GeV)
- ***Uncertainty of offline luminosity measurement***
  - the difference of front material between real data and MC 0.2%
  - Other physics background negligible
  - Accuracy of generators 1.3%
  - Accuracy of run-dependent correction 0.4%

  →accuracy of experimental measurements 0.4%

  accuracy of MC 1.3%

Online/offline luminosity

Online lum. / Offline Bhabha lum.

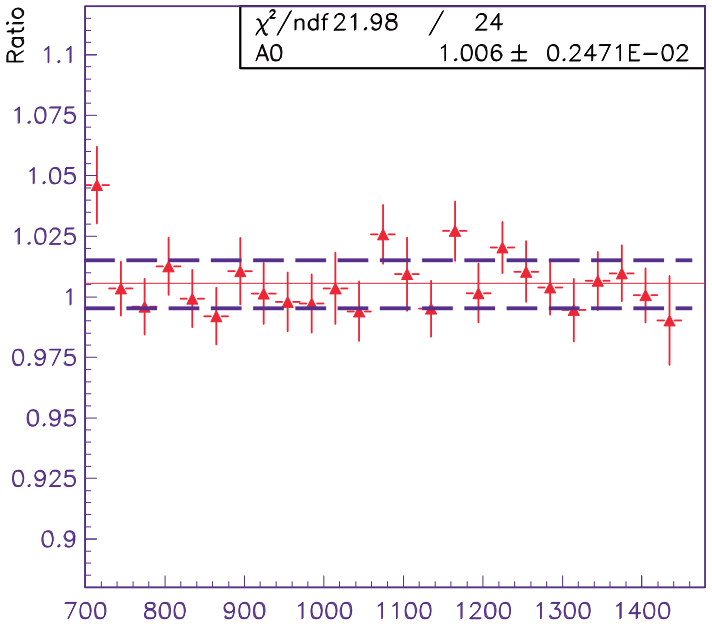


±0.5%

Overall stability of Online luminosity ~1%

every 15 runs

Offline γγ lum. / Offline Bhabha lum.



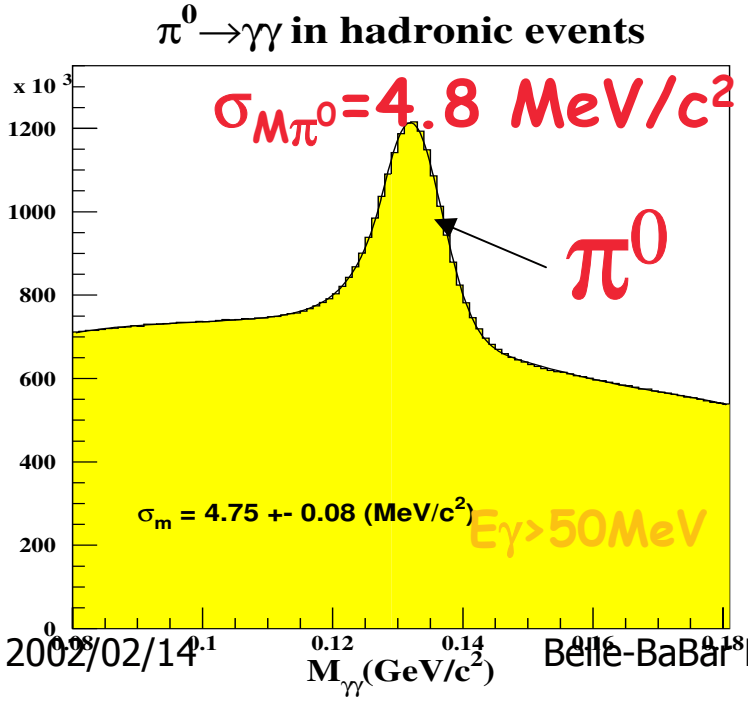
±1%

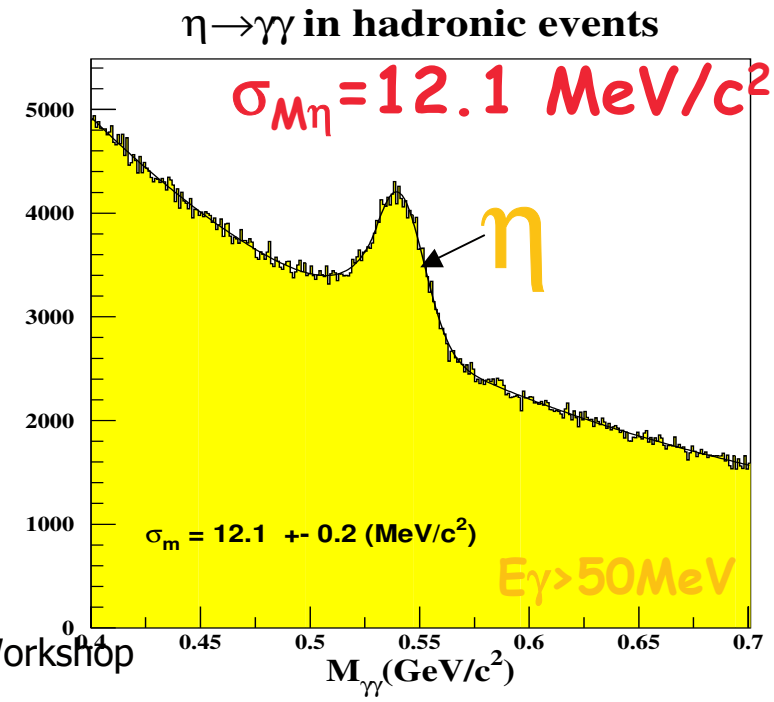
every 15 runs

Stably working

Mass distribution of $\gamma\gamma$ (π^0,η)

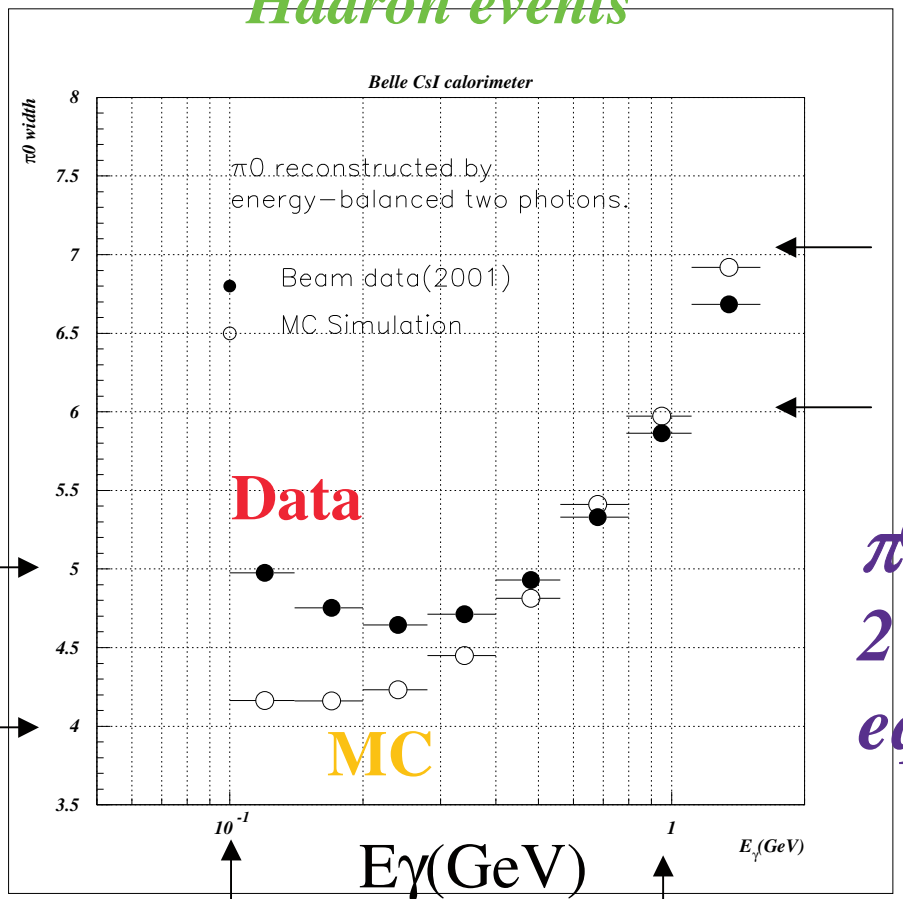
Hadron events





π^0 mass resolution

Hadron events



$\sigma_{M\pi^0}$

7MeV/c^2

6MeV/c^2

5MeV/c^2

4MeV/c^2

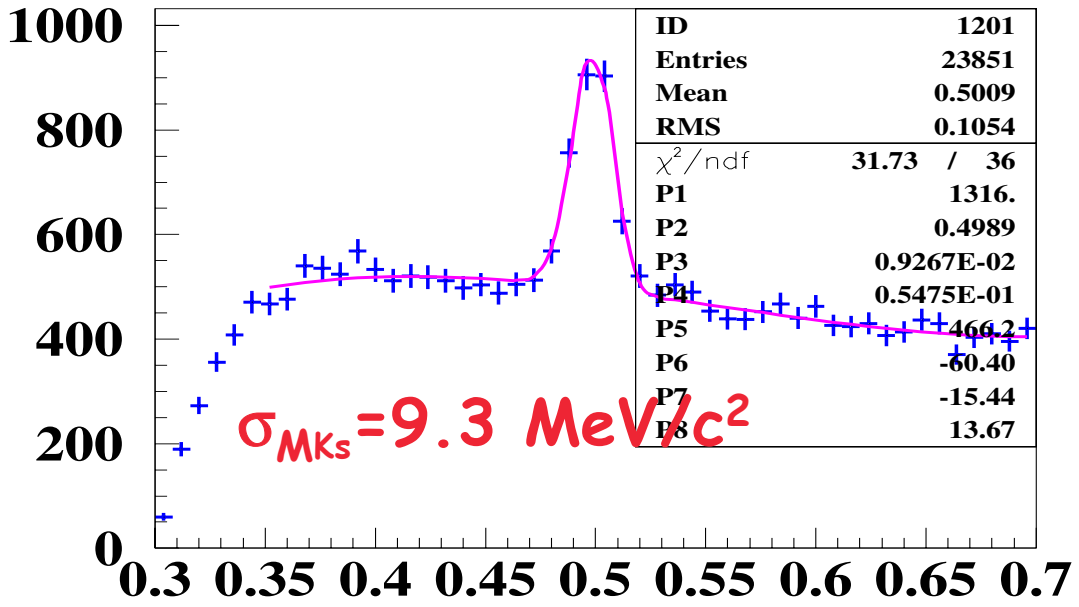
100MeV

1GeV

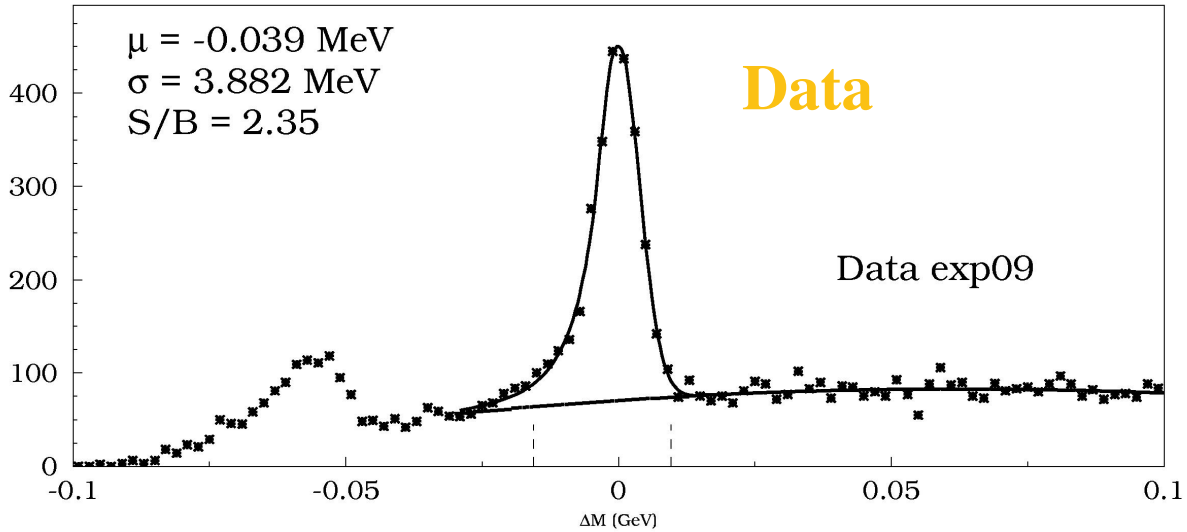
π^0 from 2γs with almost equal energies

$K_S \to \pi^0\pi^0$

$M(K_S \to \pi^0\pi^0)$ in inclusive J/ψ events (GeV/c^2)



$M(D^{*0}) - M(D^0)$
$D^{*0} \rightarrow D^0(\rightarrow K\pi)\gamma$



$E\gamma > 300MeV$

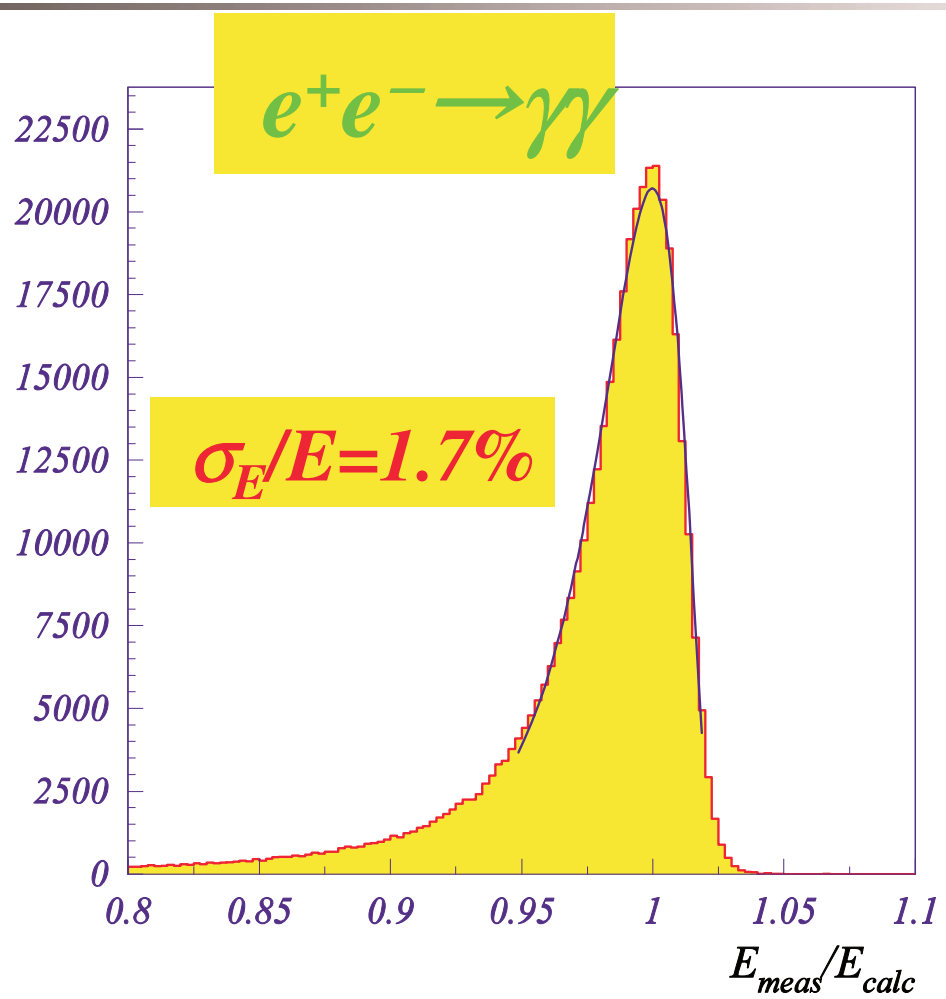
$\langle E\gamma \rangle \sim 400MeV$

σ=3.88 MeV

$\rightarrow \sigma_E/E \sim 2.6\%$

(after subtraction of angular contribution)

Energy resolution of γ(>3.5GeV)



Real data

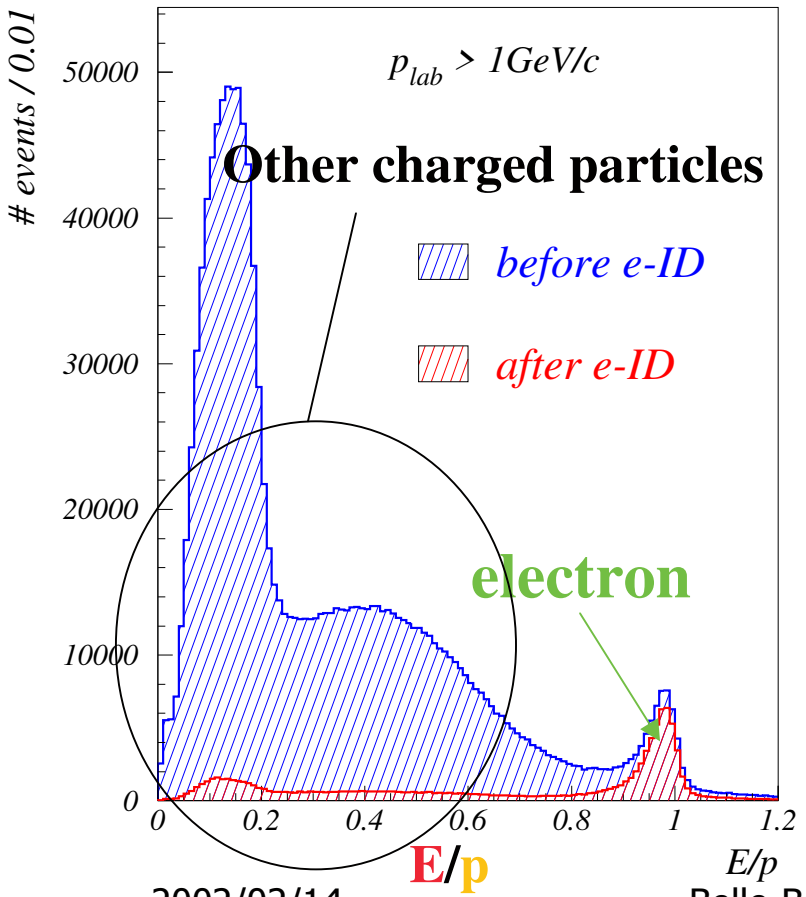
(similar resol. for MC)

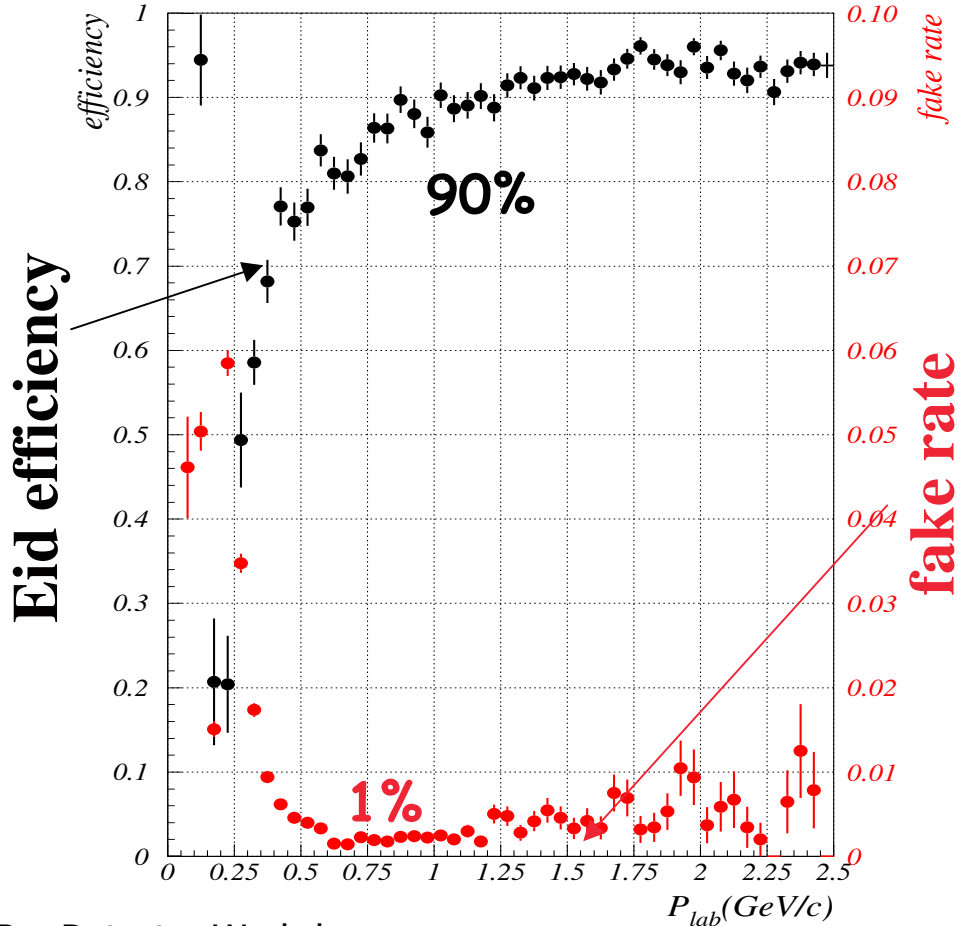
Detail in Parallel session

Electron identification

- *E(CsI)/P(CDC)*
- *EM shower shape*
- *Matching between track extrapolation and EM shower position*
- *dE/dx(CDC), TOF, ACC*

Electron identification





Radiation effect to CsI(Tl)

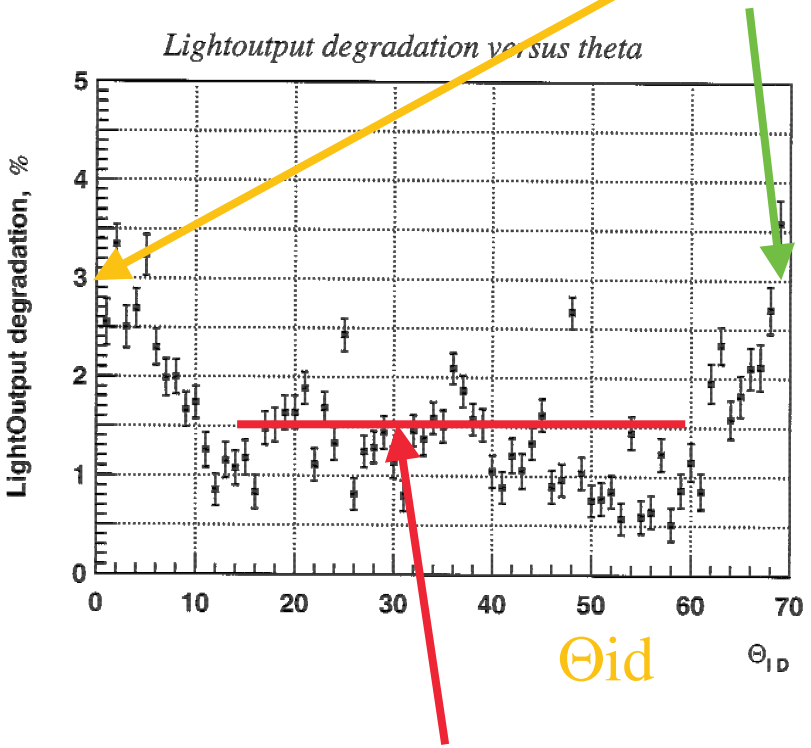
Light Output Monitor by cosmic rays

30fb^{-1} until Jul.2001

Degradation is as expected.

Detail in Parallel session

3% loss for
Innermost endcap (fwd,bwd)



1.5% loss for barrel part

Summary

- *Belle EM calorimeter is working well.*
- *Mass resolution*
  - π^0 : *4.8MeV/c²*
  - η : *12.1MeV/c²*
  - *Ks*($\pi^0\pi^0$) : *9.3MeV/c²*
- *Energy resolution of* γ*(>3.5GeV) 1.7%*
- *Luminosity measurement is stable ~1%*

Parallel session

- ***ECL calibration*** *by A.Kuzmin*
  - ***Bhabha events/Gamma-gamma events***
  - ***π^0 mass peak***
- ***Background effect*** *by A.Kuzmin*
  - ***Noise level***
  - ***Dark current increase***
  - ***Radiation damage***

will be presented at the parallel session.