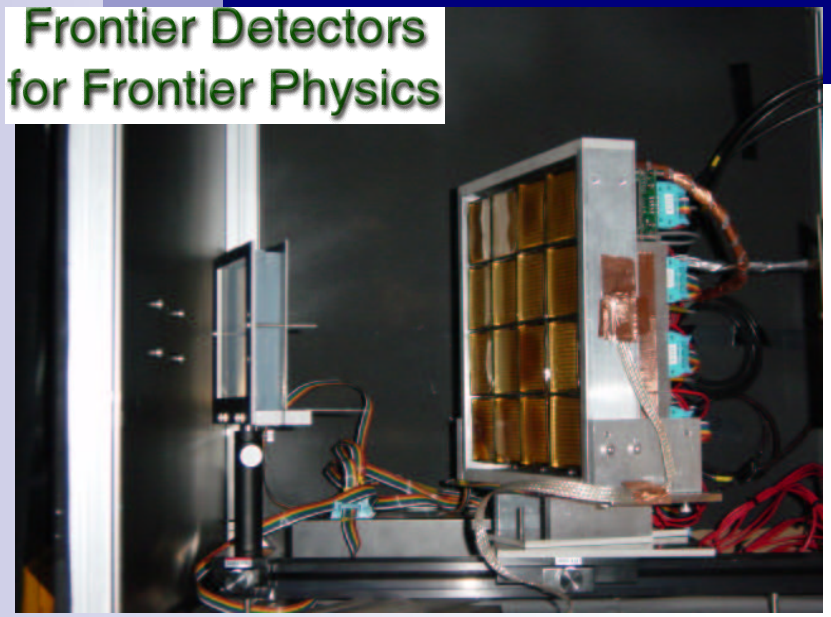
Studies of a Proximity focusing RICH with Aerogel Radiator



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9th Pisa Meeting on Advanced Detectors

25-31, May, 2003, La Biodola, Isola d'Elba

Collaborators

- Belle Aerogel RICH R&D group
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  - Jozef Stefan Institute, Ljublijana, Slovenia
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  - KEK, Tsukuba, Japan
    - I.Adachi, K.Suzuki, S.Saitoh
  - Nagoya University, Nagoya, Japan
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  - Toho University, Funakoshi, Japan
    - S.Ogawa, Y.Uchida

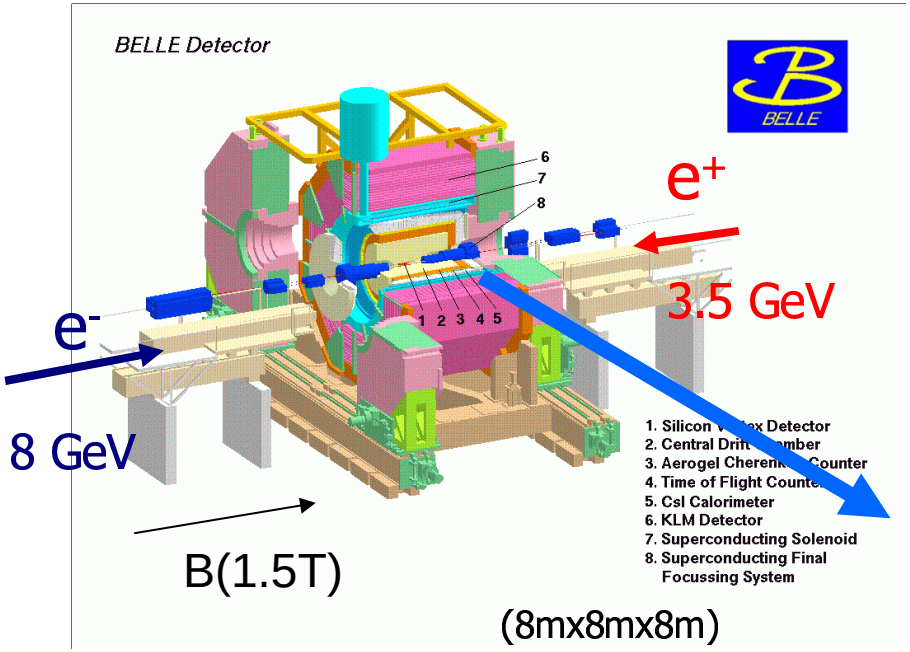
Motivation

- Towards Super KEKB project [L_{peak}~10^{35}/cm^2/s, 2006~?]
  - ~10^8 B's were corrected at KEKB. L_{peak}=10^{34}/cm^2/s achieved!
    But 10^9 ~ 10^{10} B's are needed for real new physics search!
- Requirements for interesting physics topics
  - π/K separation in the forward (high momentum) region
    → B→few body decays, b→dγ/sγ etc.
  - Low momentum(<1 GeV/c) e/μ/π separation → B→Kll
- Upgrade of Aerogel counter
  1. Threshold Aerogel counter : Limited performance

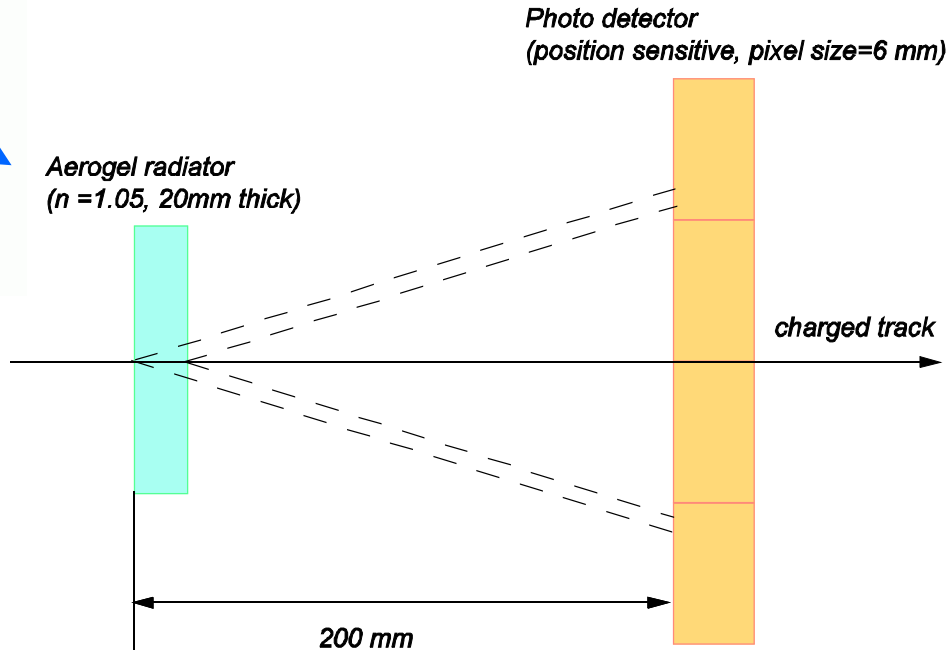
  → Aerogel RICH counter [forward region]

  Cover 0.7 ~ 4 GeV/c, >4σ π/K separation

Proximity focusing RICH with Aerogel radiator [forward region]



- Measure Cherenkov angle from photons from Aerogel radiator
- Limited space
  → `Proximity focusing



- π/K separation at 4 GeV/c
  - θc(π) = 308 mrad
  - θc(π) – θc(K) ~ 23 mrad
  - σ_θ ~ 12 mrad (1 photon)
  - N_{pe}~10 → ~6σ separation

R&D issues

The principle of the detector was understood by the 1st beam test(2001) [N_{pe}/ring ~ 2.7, σ_θ ~10mrad]. But we need to increase photo electrons by improving Aerogel & photo detector, also need to develop photo detector operated under strong magnetic field(1.5T).

- Aerogel radiator
  - Better transmission length with n=1.05
  - uniformity, cracks…
- Photo detector
  - Large effective area
    - MAPMT(Hamamatsu R5900-M16) 36% → Flat panel PMT 84%
  - Multi channel PMT readout → ASIC
  - Immune to magnetic field (B=1.5T) →H(A)PD

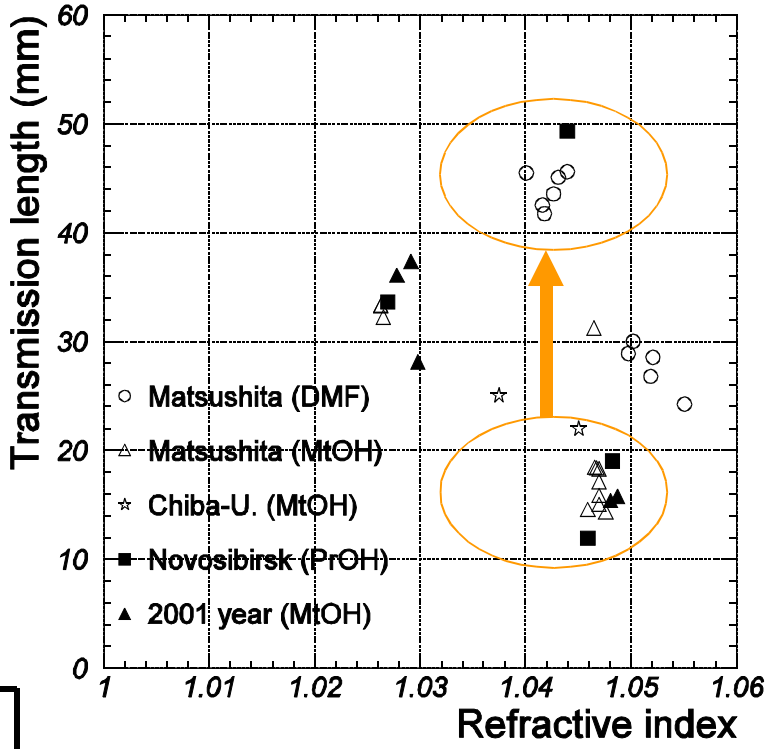
Color : 1st beam test/2nd beam test /under R&D

Aerogel radiator

- Optimization for n=1.05
  - n=1.01~1.03 range was optimized in the Belle construction, but not for n=1.05

  →Cooperative research with Matsushita Co. Ltd.
- Improvement in transmission length, Λ(@400nm)

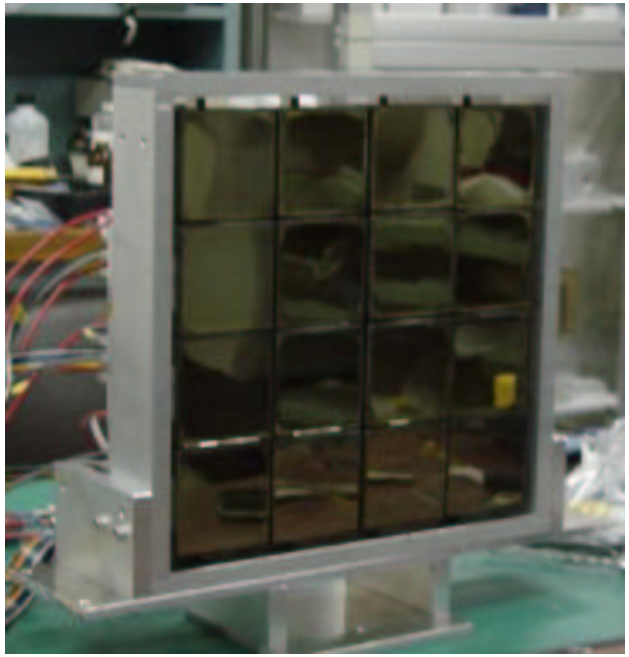
  15mm → 45 mm [n=1.05]



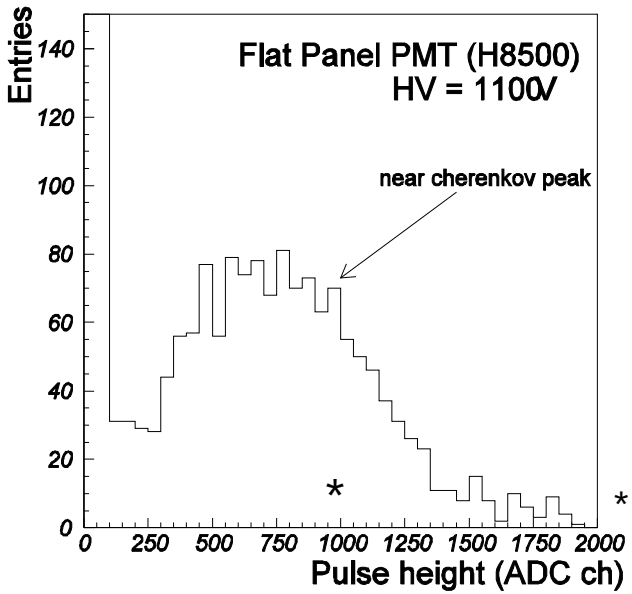
Solvent	methyl alcohol →di-methyl-formamide(DMF)
Precurser	Methyl-silicate-51 from different company

*Novosivirsk's one : hydrophilic

Flat panel PMT (Hamamatsu H8500)



- Large effective area, 84%
  - 64ch (pixel size = 6mmx6mm)
  - aligned with 52.5 mm pitch
- Response for Cherenkov photon

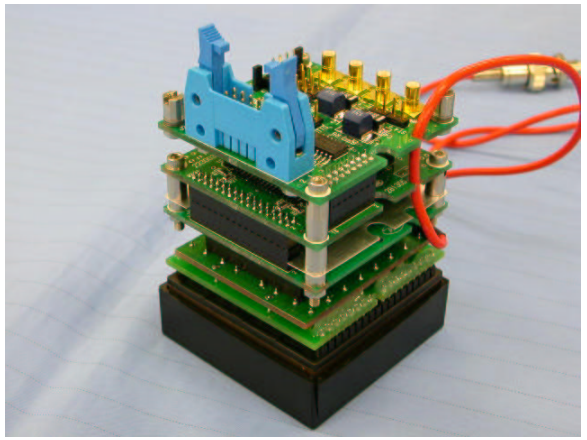


* for the best PMT

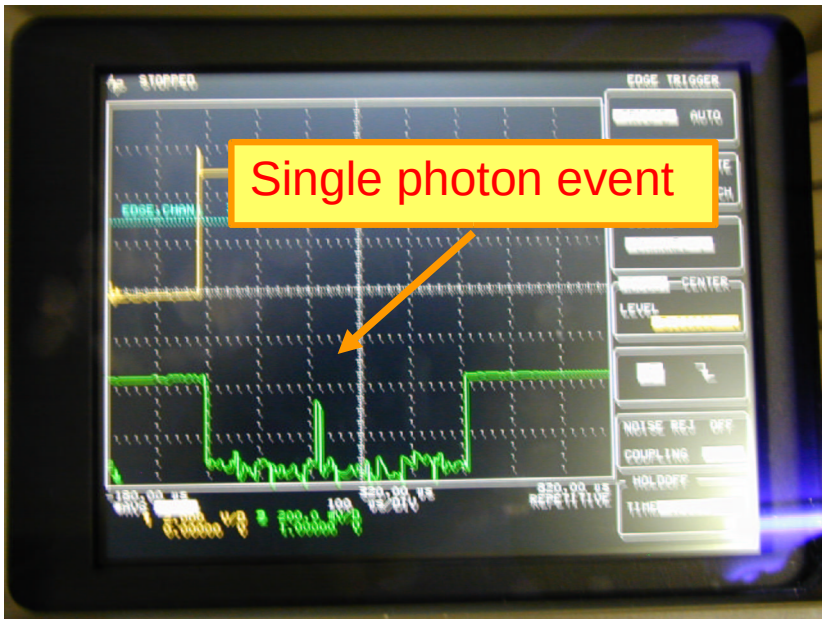
- Still under developing…
  →Large variation among 16 PMTs
  - Q.E. : 16~25% (@400nm)
  - Gain : 1~6 x 10^6

Read out electronics

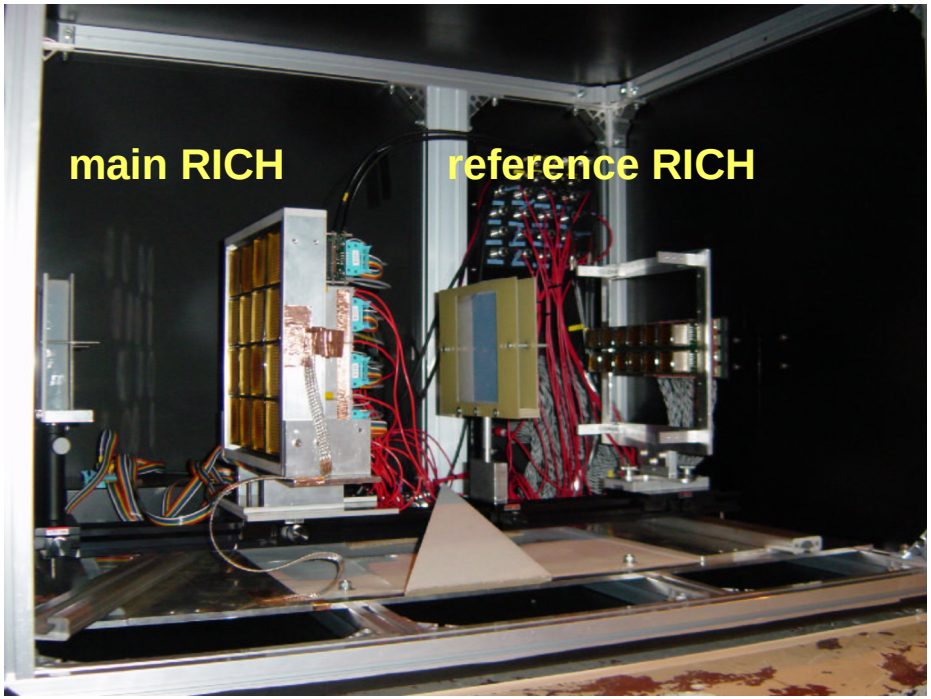
- Use Analog memory chips developed by H.Ikeda(KEK)
- 1 analog memory chip : 32ch preamplifier, 8 memories (1μs x 8)
- Output serial signal
  - V(output) = V(last) – V(first),
  - 256ch → serial signal (10μs/ch)
  - 1024 ch readout → 4ch VME ADC



Assembled Flat Panel PMT



Beam test (KEK-PS π2 beam line)

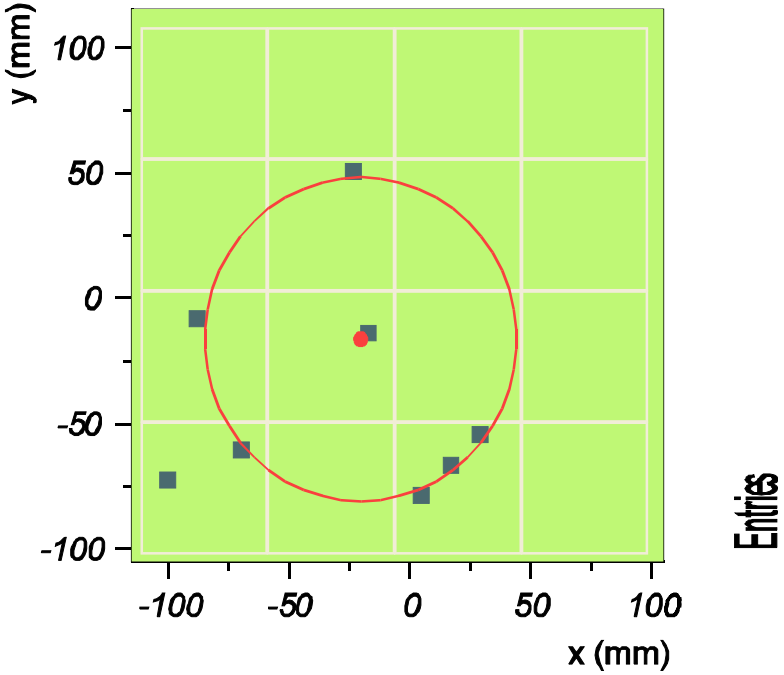


- 1st beam test (Nov.,2001)
  - Confirmed basic performance with reference RICH
- 2nd beam test (Nov.,2002)
  - Trying to increase N_{pe} with flat panel PMT and better Aerogel

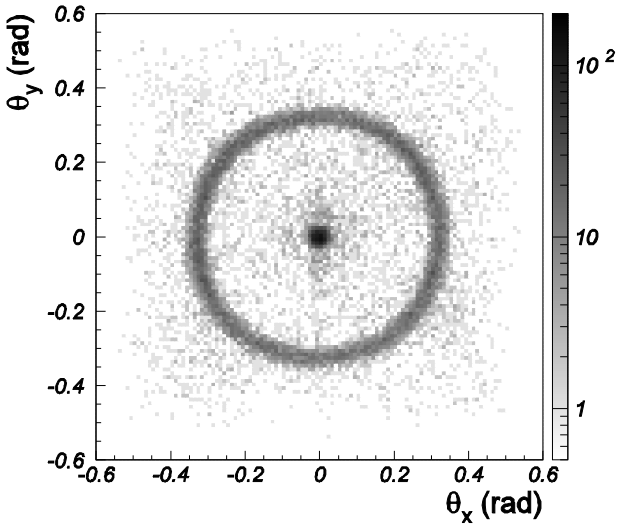
- π^- beam (0.5 – 4.0 GeV/c) with various Aerogel samples (different thickness, transmission length) *Mostly at 3 GeV/c
- 2 RICHs were used for comparison of PMT

Cherenkov ring image

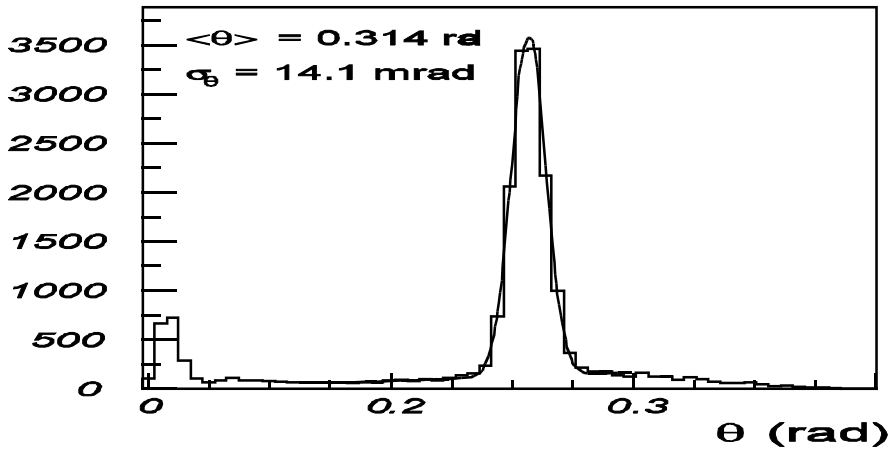
Event Display



Accumulated hits



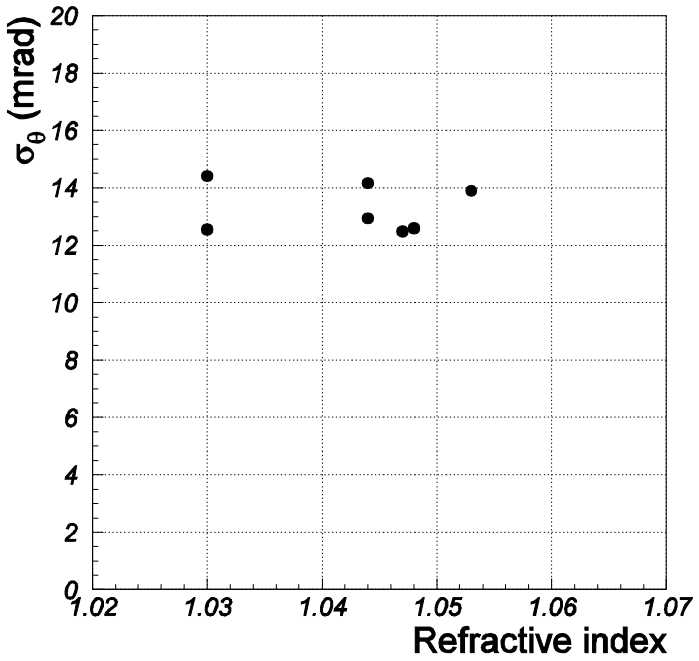
Cherenkov angle



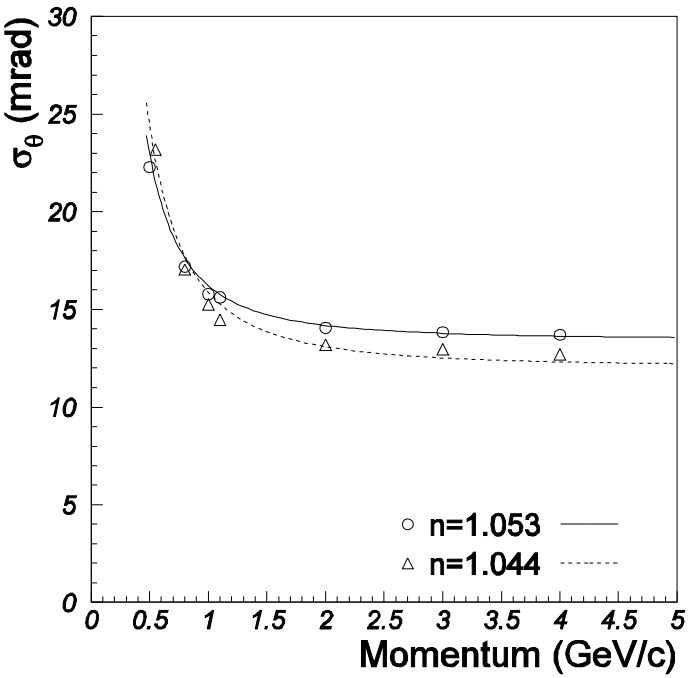
Clean ring image!

Angular resolutions

Typical resolution



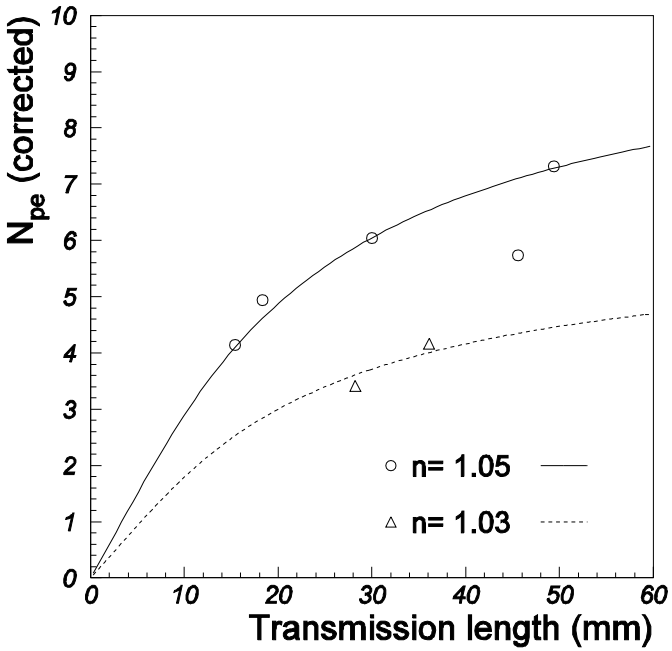
Momentum dependence



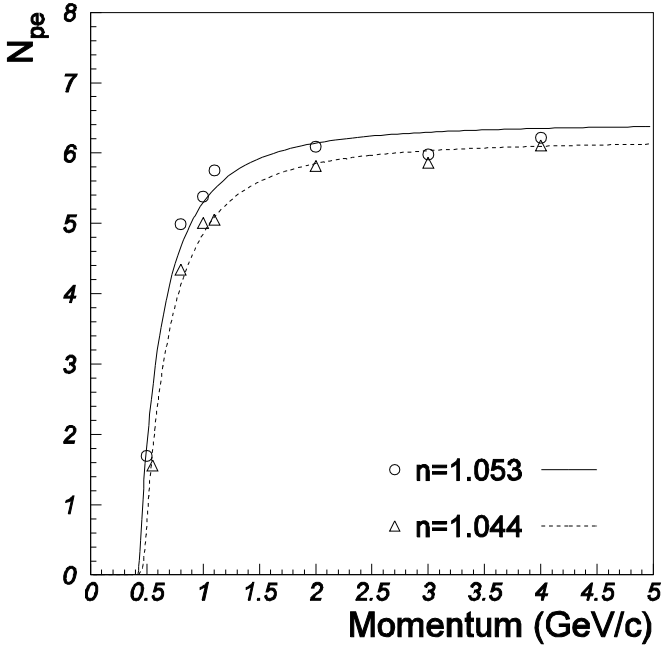
- Typical resolution : σ_θ ~ 13mrad
  - Mostly from Aerogel thickness and pixel size of PMT
- lower momentum region
  - Effect of the multiple scattering starts to become important

Number of photo electrons

Transmission length dependence



Momentum dependence



- Improved detected photo electrons ~x1.5
  - Transmission length L(@400nm) : 15mm →45mm
- High momentum range : N_{pe} ~ 6

π/K separation

- Measured N_{pe} ~6, σ_θ ~13 mrad give naïve resolution per track: $\sigma_\theta/\mathrm{sqrt}(N_{pe})$ ~ 5.3 mrad

  *contribution from bkg. is small

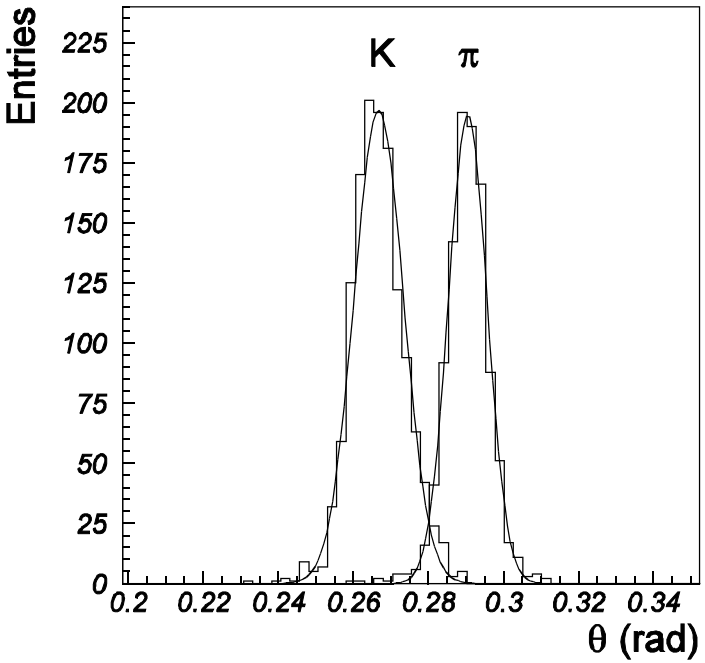
  - π/K sep. @4 GeV/c → ~ 4σ
- N_{pe} is strongly affected by performance* of PMT
  - Normalized N_{pe} with the best PMT →~9

    → better separation is expected in near future

    *Q.E and threshold cuts to the pulse height distribution

Cherenkov angle/track for π/(pseudo)K (@ 4 GeV/c)

*Pseudo K →π 1.1 GeV/c)

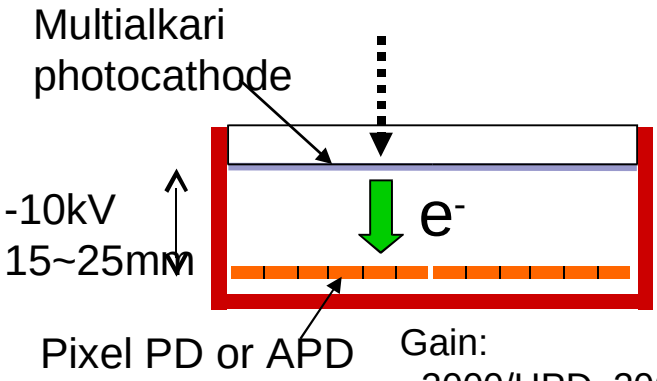


NB. pseudo K has some effect from multiple scattering

R&D for H(A)PD [Real PMT for Aerogel RICH]

- Photo detector with large effective area, immune to magnetic field

  →multi-anode H(A)PD R&D with Hamamatsu Photonics K.K.

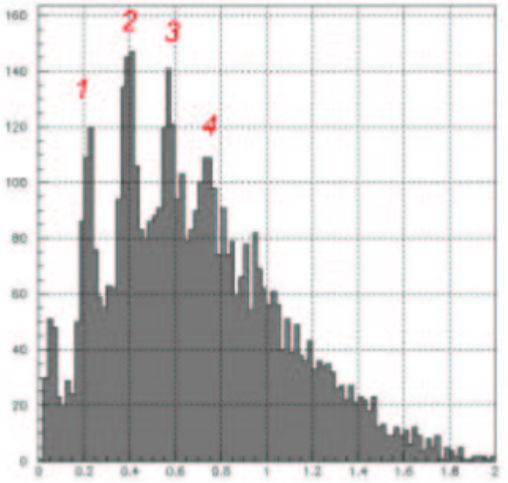


Gain:
~2000/HPD, 20000/HAPD

Package	73x73mm
Number of pixels	12x12=144
Effective area	8x8mm² (6x6/chip)

Response to multi-photon

*Single channel HPD(TO-8)



Pulse height distribution

- We plan to test full spec. H(A)PD this year. Readout with ASIC is also under preparing.

Summary

- Proximity focusing Aerogel RICH is developed for the higher luminosity B factory (Super KEKB)
  - 1st Beam test(Nov.,2001) →Principle was proved.
  - 2nd beam test(Nov.,2002)
    - Used better Aerogel, PMT with large effective area, new read-out system → enhanced number of photons, promising results
    - Better understanding of the detector
- Remaining R&D issues
  - Development of a PMT for high magnetic fields and its read-out electronics
  - Mass production of large Aerogel tiles