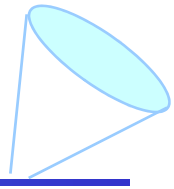
Detector R&D: Belle PID upgrade

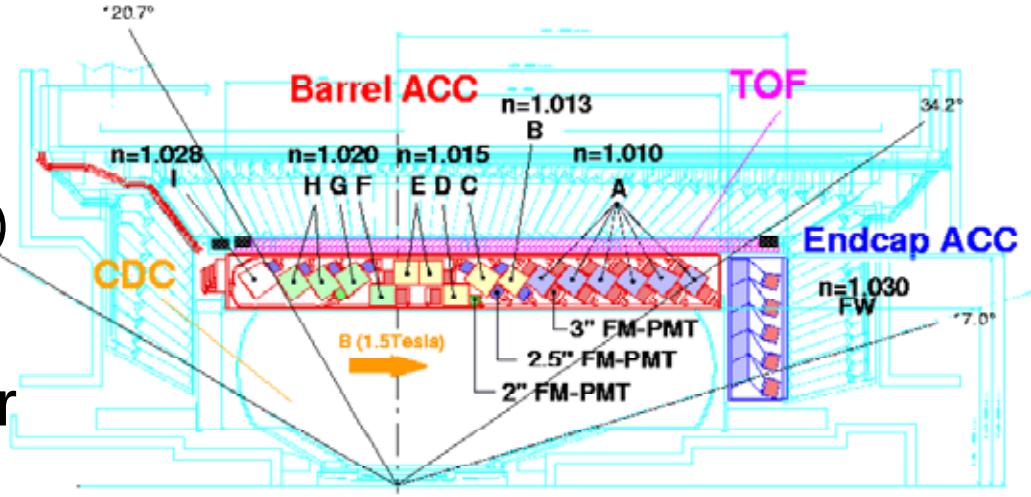
- Barrel
  - TOP counter
- Endcap
  - Aerogel RICH

K. Inami (Nagoya-u)
and Belle PID group



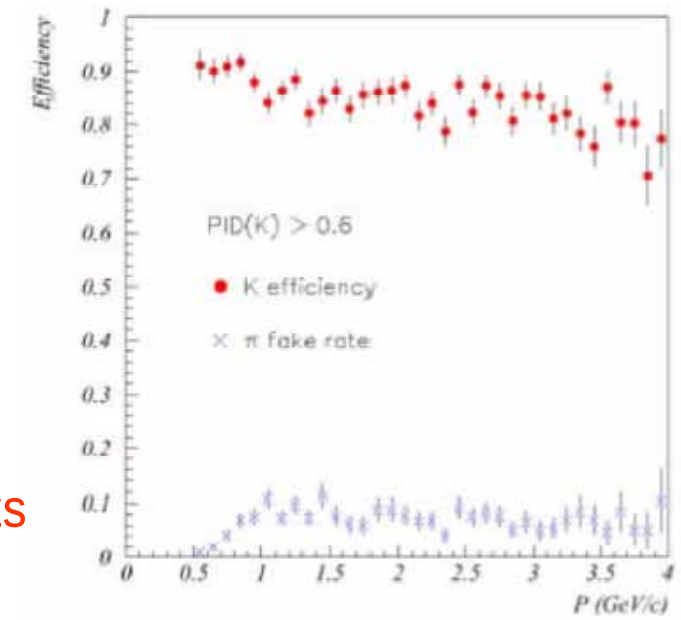
Current Belle

- PID of $\pi^{\pm}/K^{\pm}$
  - Aerogel Cherenkov counter (Threshold type)
  - TOF counter
  - dE/dx in drift chamber



- Contribute to flavor discrimination.

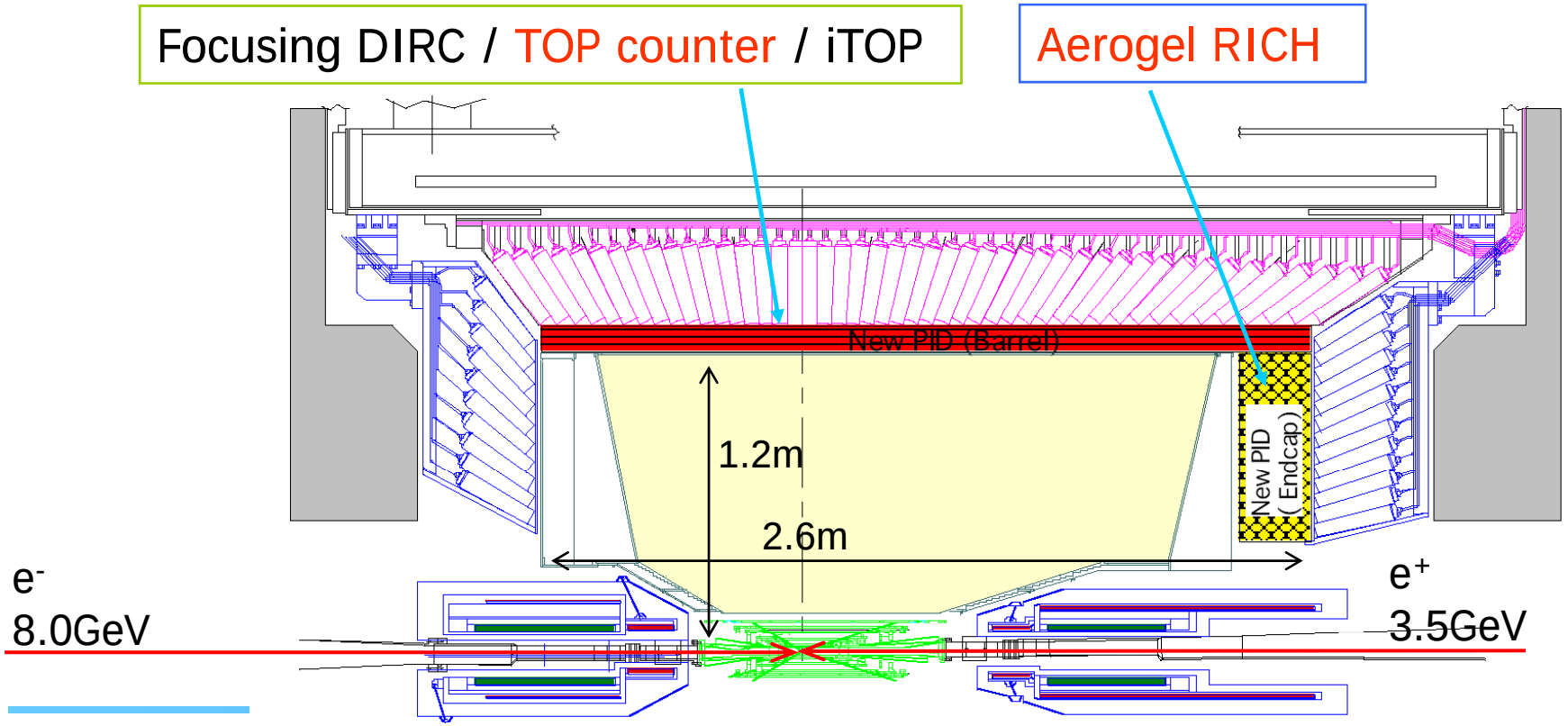
- Current performance
  - Efficiency; 90~80%
  - Fake rate; 5~10%



- Want less fake rate for precise measurements

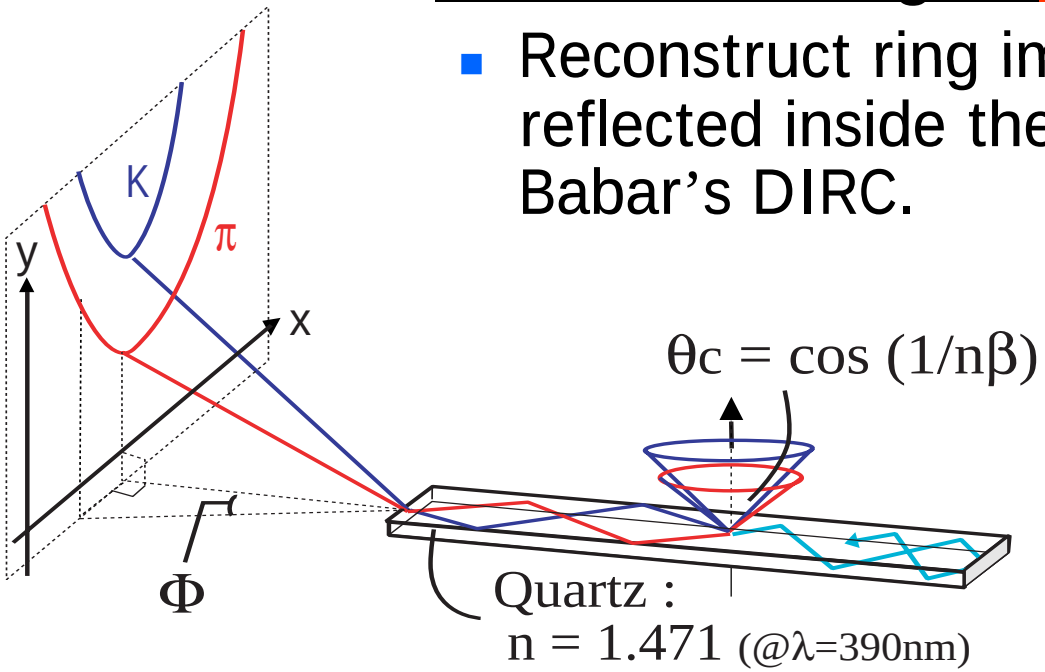
Belle PID upgrade

- PID (K/π) detectors
  - Barrel PID and Aerogel RICH counters are both Cherenkov ring imaging detectors.
  - dE/dx in drift chamber

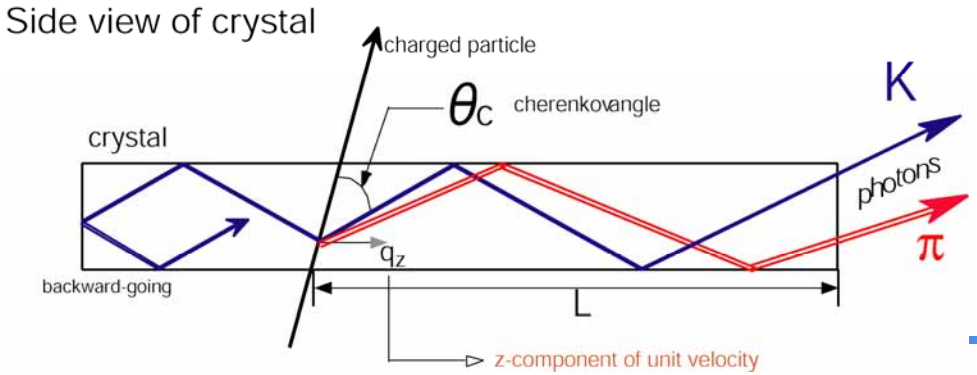


Barrel PID detector

- Cherenkov ring in quartz bar
  - Reconstruct ring image using ~20 photons reflected inside the quartz radiator as a Babar's DIRC.

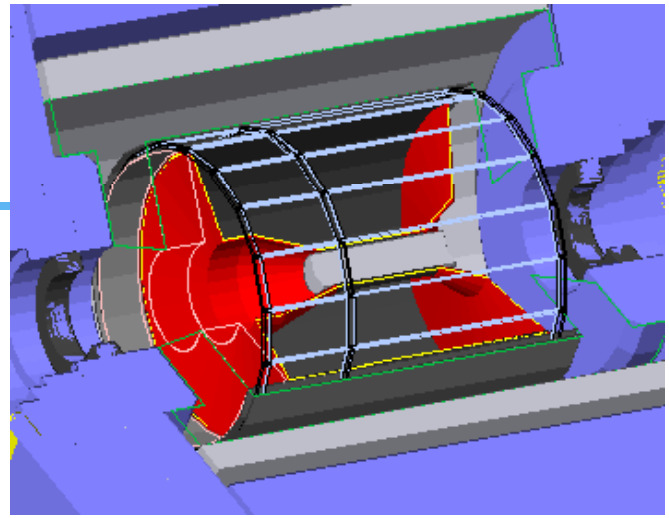


- Utilize 3D information
  - Arrival position (x,y)
  - Arrival timing (t)

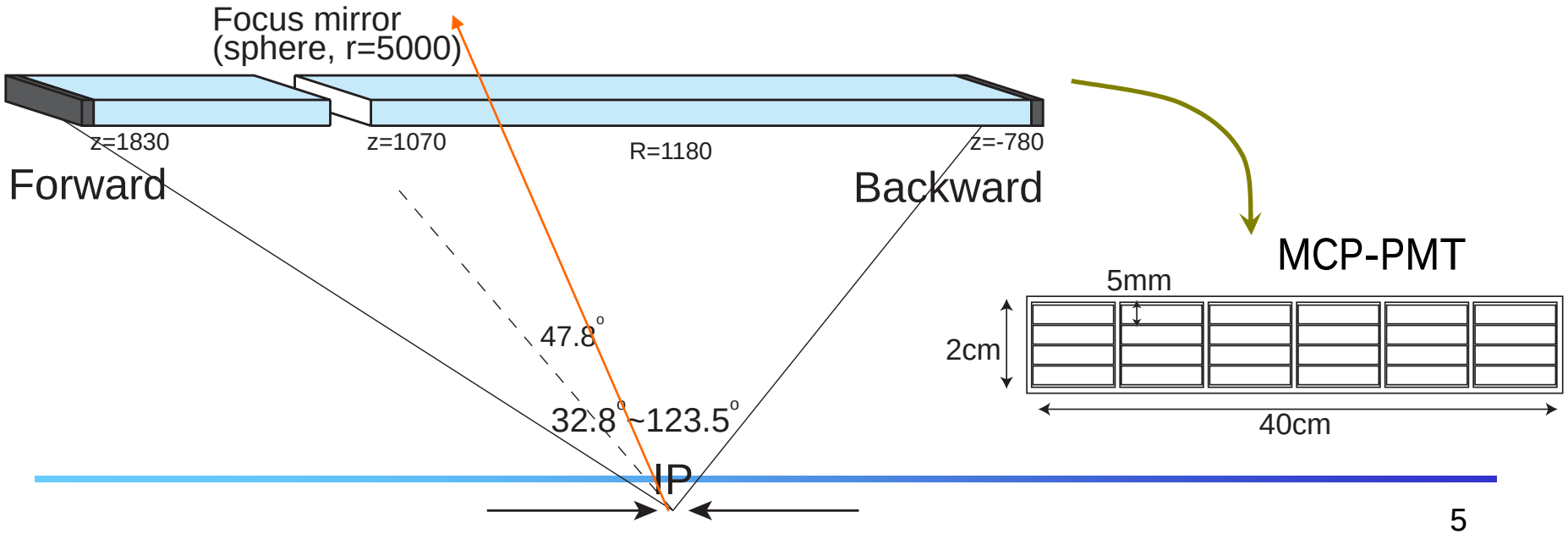


- TOP counter
  - Difference of propagation time for K/π
    - ΔT~100ps

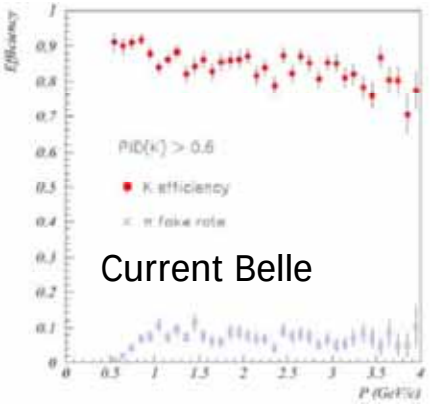
TOP counter



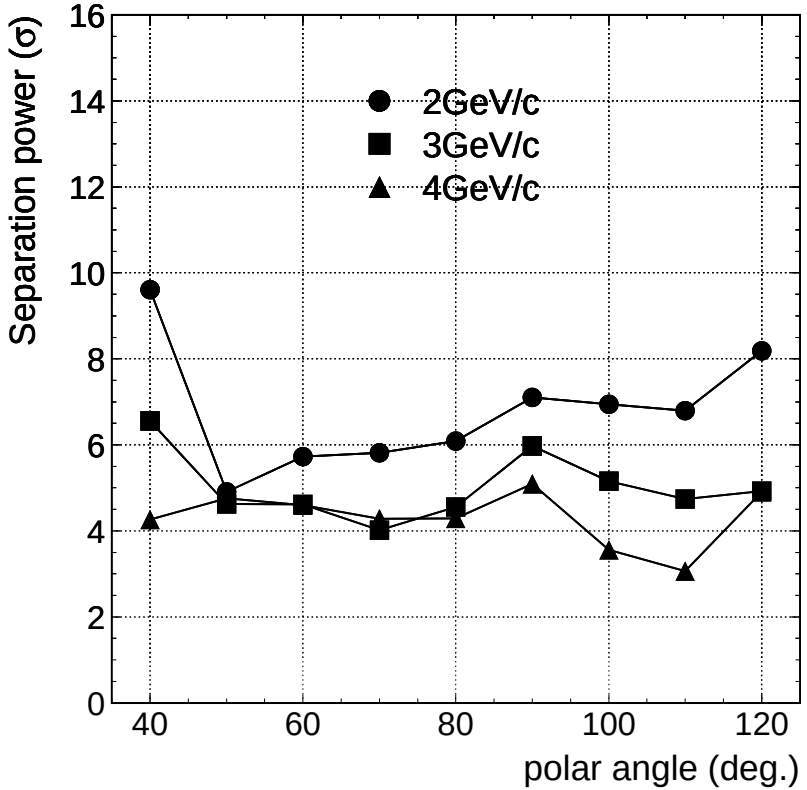
- Quartz: $255cm^{L}$ x $40cm^{W}$ x $2cm^{T}$
  - Focus mirror at 47.8deg.
    to reduce chromatic dispersion
- Multi-anode (GaAsP) MCP-PMT
  - Linear array (5mm pitch), Good time resolution (<~40ps)
  - → Measure Cherenkov ring image with timing info.

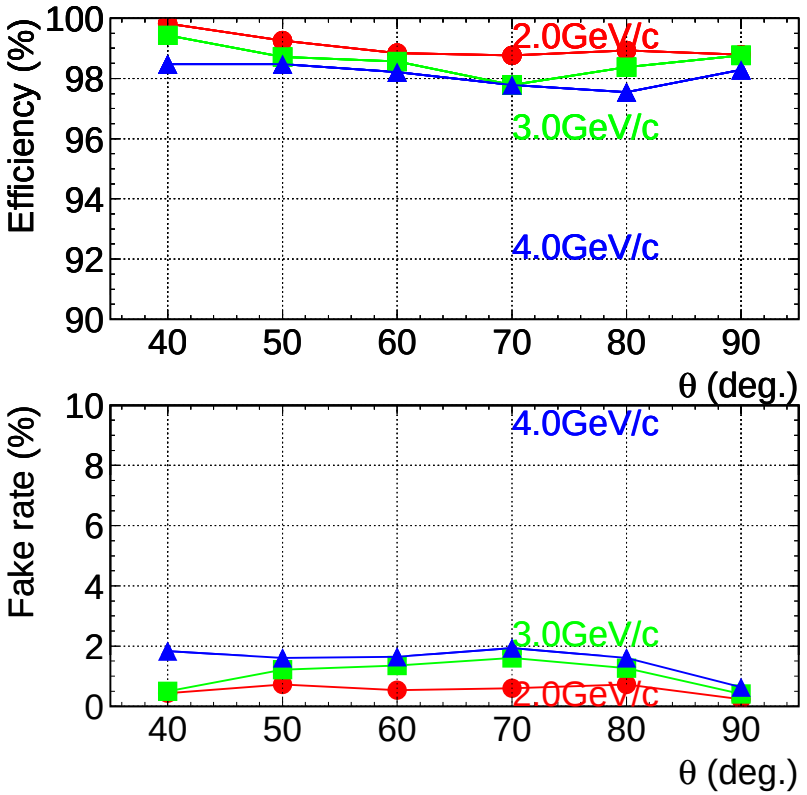


Expected performance



- K/π separation power
  - GaAsP photo-cathode + Focusing mirror





>4σ K/π upto 4 GeV/c, θ<90°

Beam test

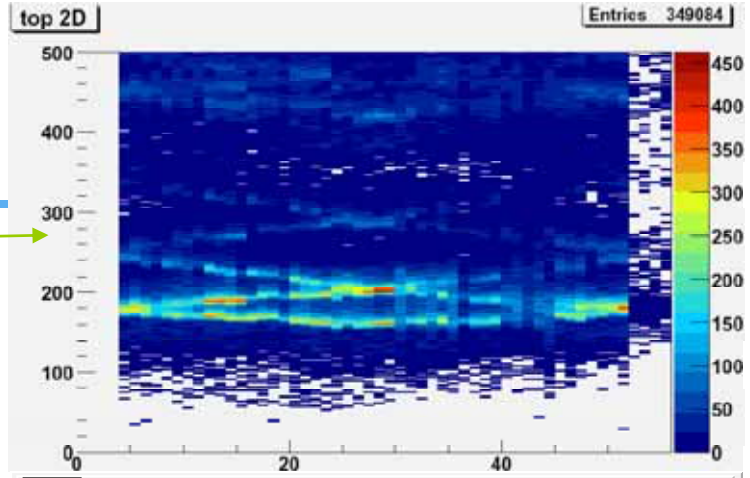
- At Fuji beam line in June (e^- 2GeV)
- Using real size quartz and MCP-PMT
  - MCP-PMT: Multi-alkali p.c., C.E.=60%

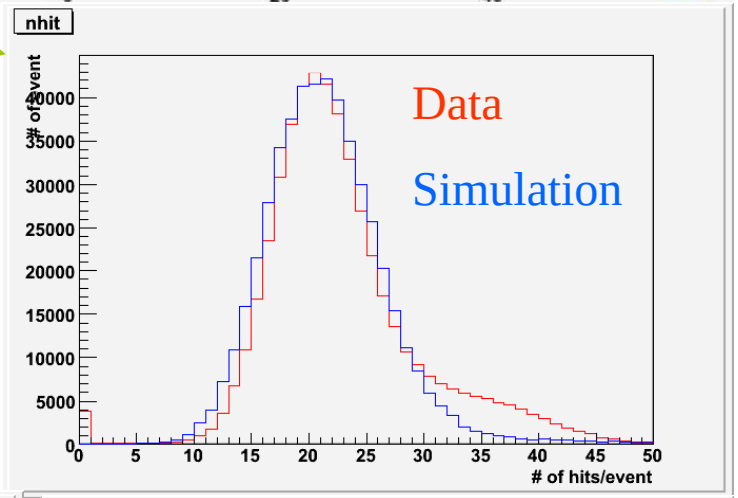
Quartz + support jig

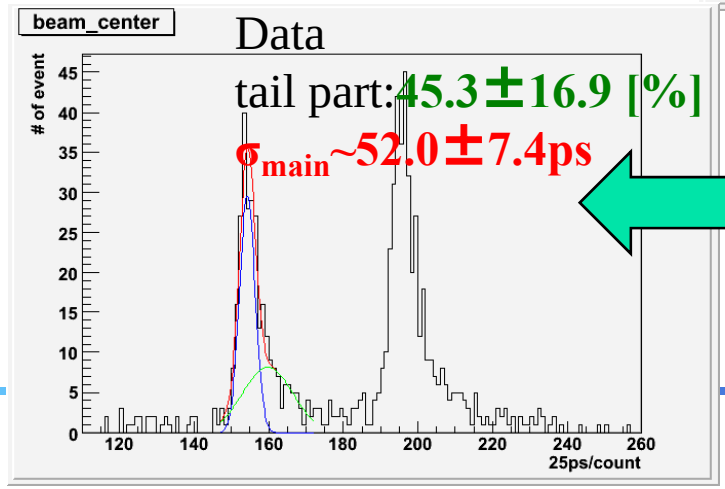
- Check
  - Ring image
  - Number of photons
  - Time resolution

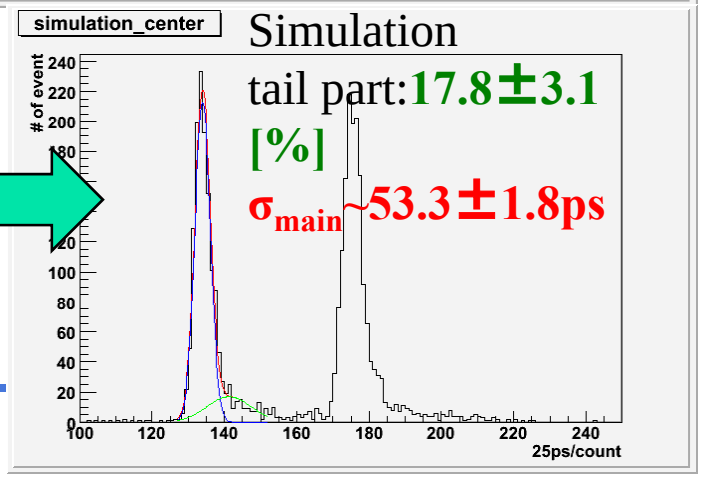
Beam test results

- Ring Image
  - Similar with Simulation
- Number of photons
  - N~20; as expected
    - Tail due to EM shower in triggers
- Time resolution
  - Main part; expected time resolution
  - Rate of tail seems large.
    - Not in MCP-PMT and readout



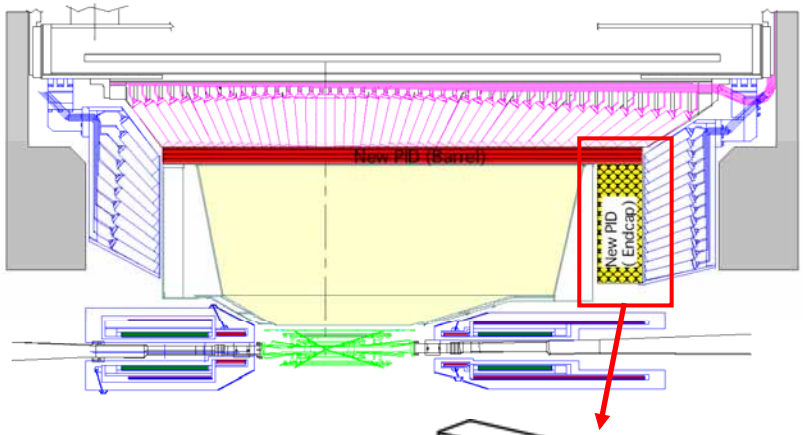




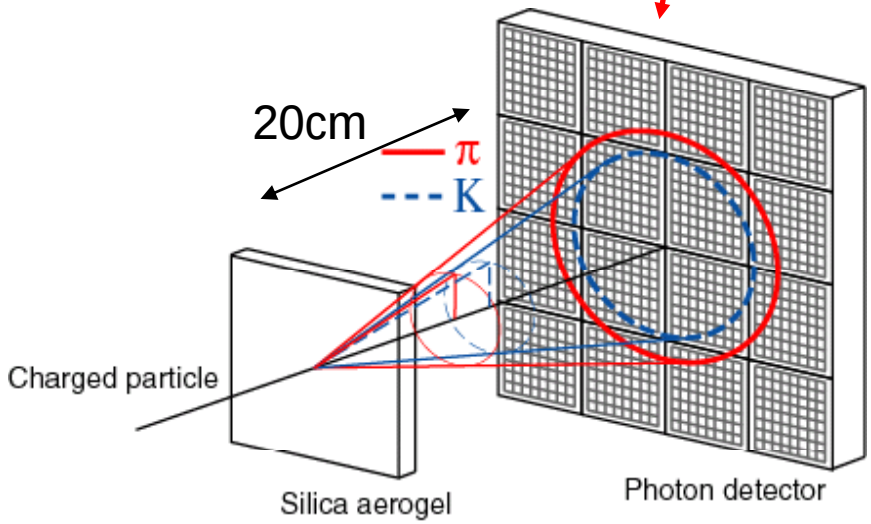


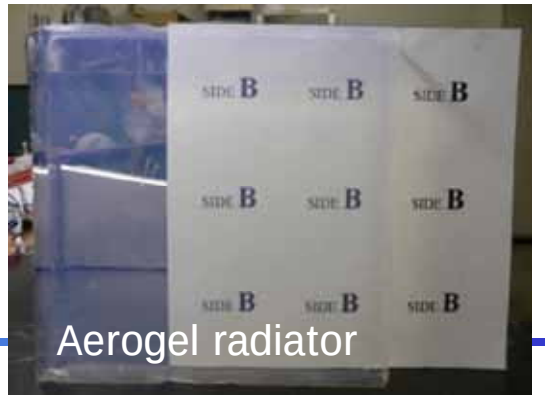
Aerogel RICH

- Endcap PID upgrade
  - For 4σ K/π sep. for 4 GeV/c



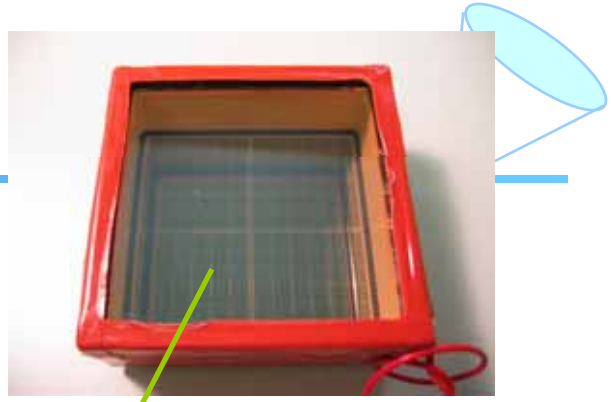
- Proximity focusing RICH
  - Silica aerogel
    - n~1.05
  - Photon detector
    - Single photon sensitive
    - A few mm^2 pixel channels
    - Tolerant to magnetic field

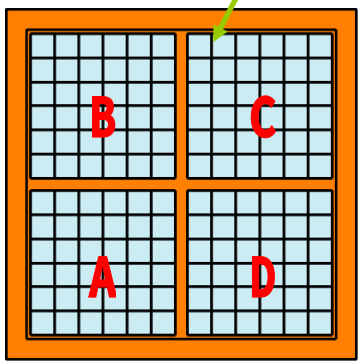




Hybrid Photon Detector

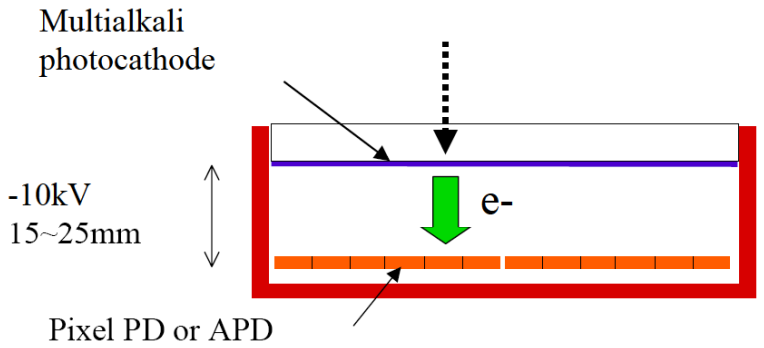
- Developed with Hamamatsu
  - Two options: HPD or HAPD





4 avalanche diodes in one HAPD

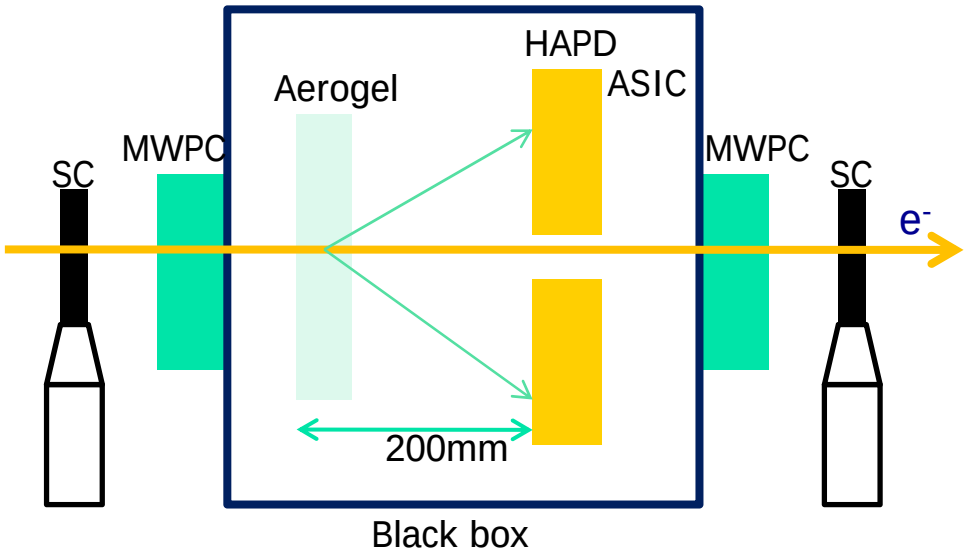
Package	72x72 mm^2	
# of pixels	12x12(6x6/chip)	
Pixel size	5x5 mm^2	
Effective area	64 %	
	PD	APD
Gain	2000	20000
Cd	10 pF	80 pF
I(leak)	10 nA	30 nA

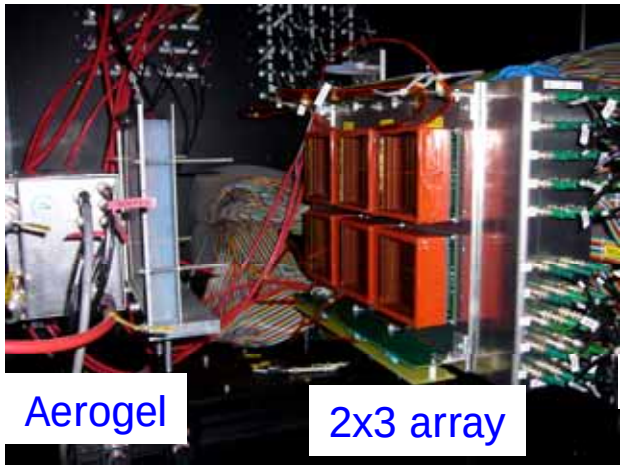


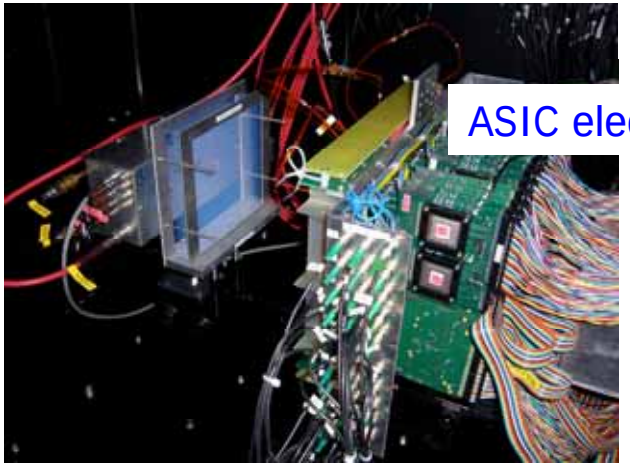
Total gain = bombardment gain(~10^3) x avalanche gain(~40)

Beam test

- At Fuji beam line in June (e^- 2GeV)
- Prototype counter with 6 HAPDs



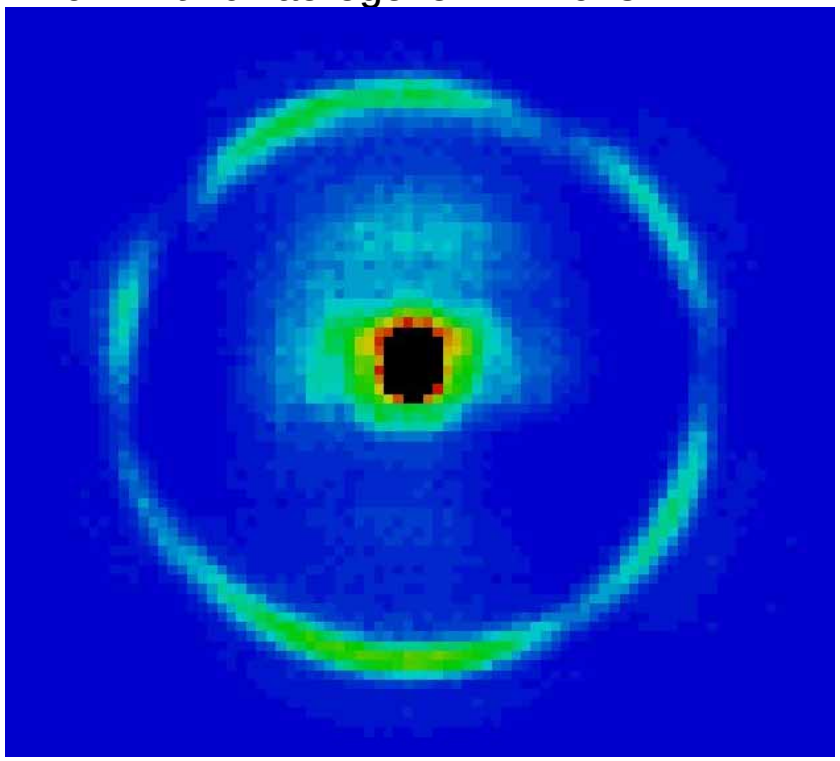




- Measure
  - Ring image
  - Number of photons
  - Cherenkov angle resolution

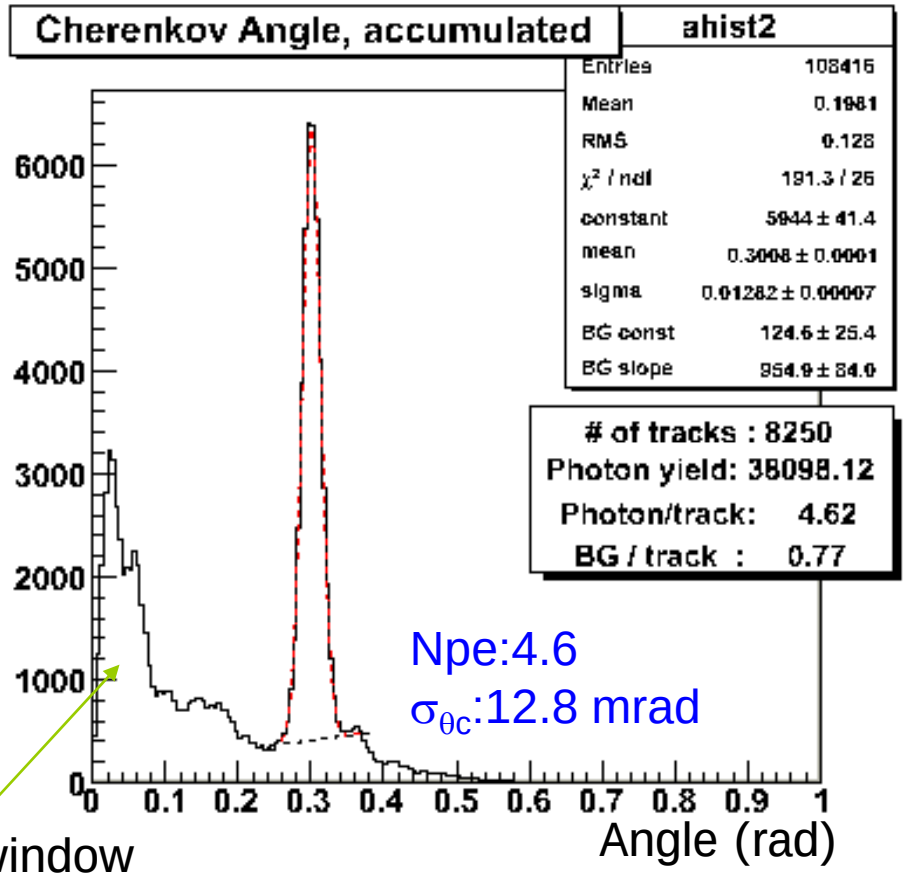
Cherenkov ring and angle

20mm-thick aerogel of n=1.045



Clear Cherenkov image observed

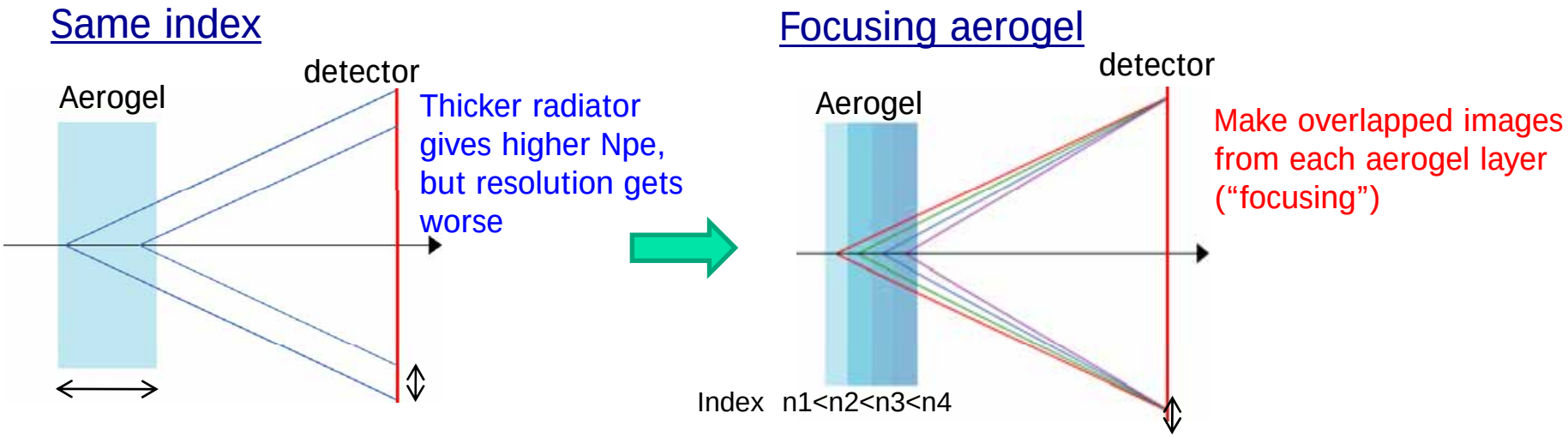
4.6 photoelectrons per ring detected, which is consistent with previous beam test results done in 2005

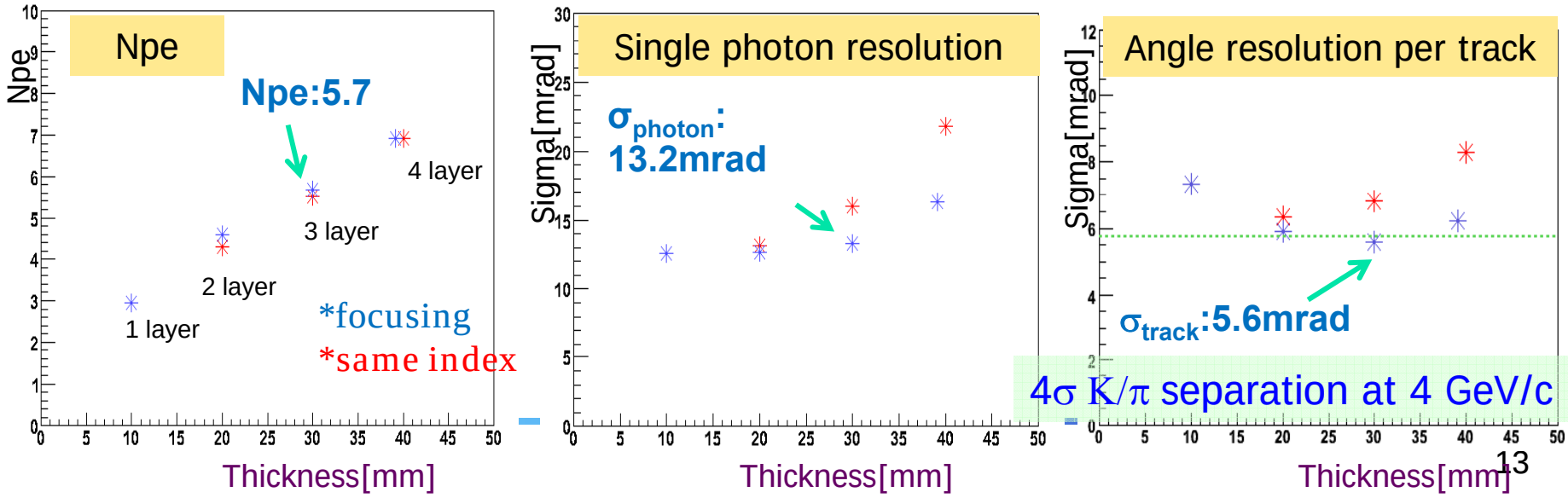


Cherenkov from PMT window

Focusing scheme

- Tested focusing aerogel radiator scheme





Summary

- Many R&Ds in progress!

- Barrel PID
  - Focusing DIRC, TOP, iTOP options
  - Cherenkov ring imaging with position and precise timing (<50ps)
  - Quartz + Photon detector
    - Developing MCP-PMT (TTS<40ps for single photon)
  - TOP Prototype shows the expected performance.
    - Expected ring image, N_{photon}~20, time resol.~50ps
- Endcap PID
  - Aerogel-RICH
  - Proximity focusing RICH with silica aerogel
  - Several photo detector options
    - HAPD, MCP-PMT, MPPC
  - With focusing aerogel prototype, reach 4σ K/π sep. for 4GeV/c