Tests of a proximity focusing RICH with aerogel as radiator

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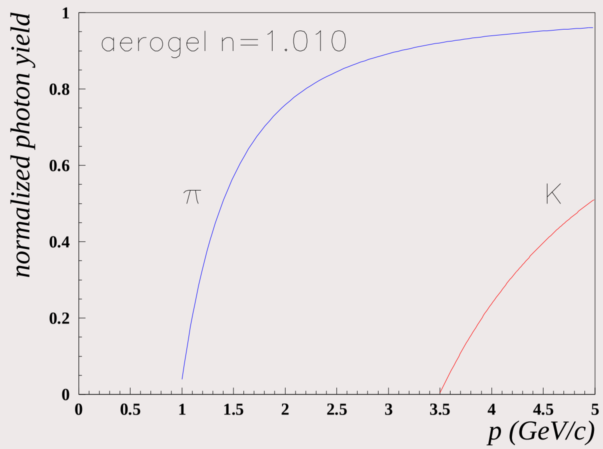
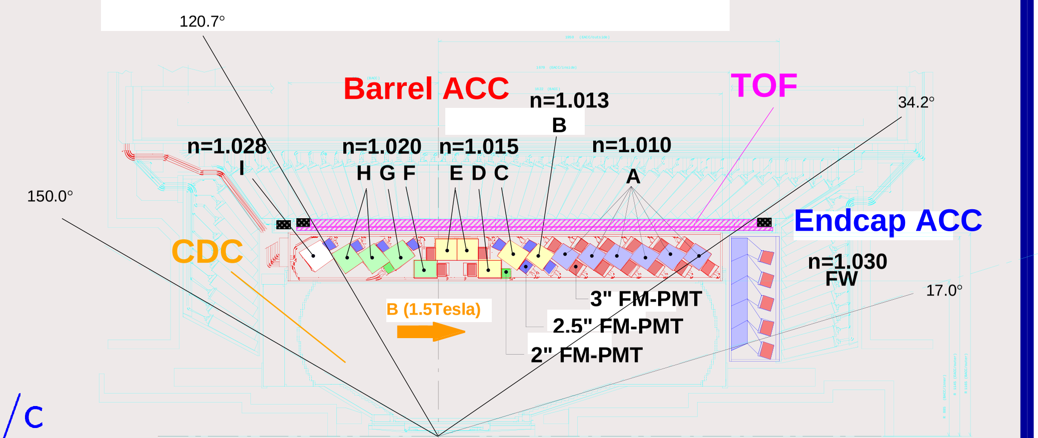
- Introduction, motivation
- Beam test results
- Summary, plans

Belle present: aerogel threshold Čerenkov

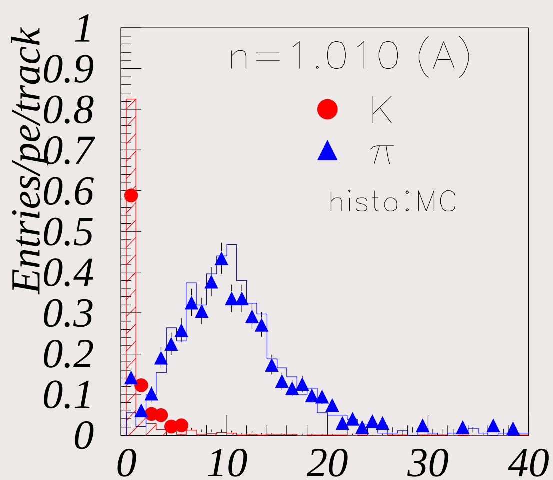
expected average yield vs p



separation of K (below) vs. π (above thr.): properly choosing n for a given kinematic region



measured for 2 GeV/c< p <3.5 GeV/c



Barrel: covers both tagging and $B \to \pi\pi, K\pi$

Forward: tagging only

Upgrade motivation

Physics motivation for the PID upgrade of the Belle spectrometer

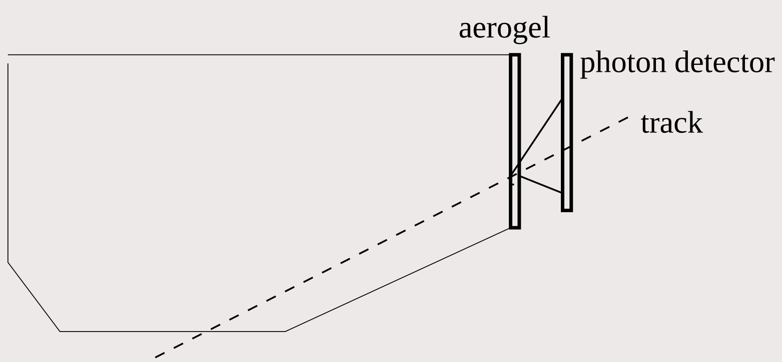
- improve π/K separation in the forward (high momentum) region for few-body decays of B's
- good π/K separation for $b \to d\gamma$ / $b \to s\gamma$
- improve purity in fully reconstructed B decays ('full reconstruction tag')
- low momentum (< 1 GeV/c) $e/\mu/\pi$ separation (e.g. in $B \to Kll$)

Forward direction: a proximity focusing RICH with aerogel as radiator is being studied

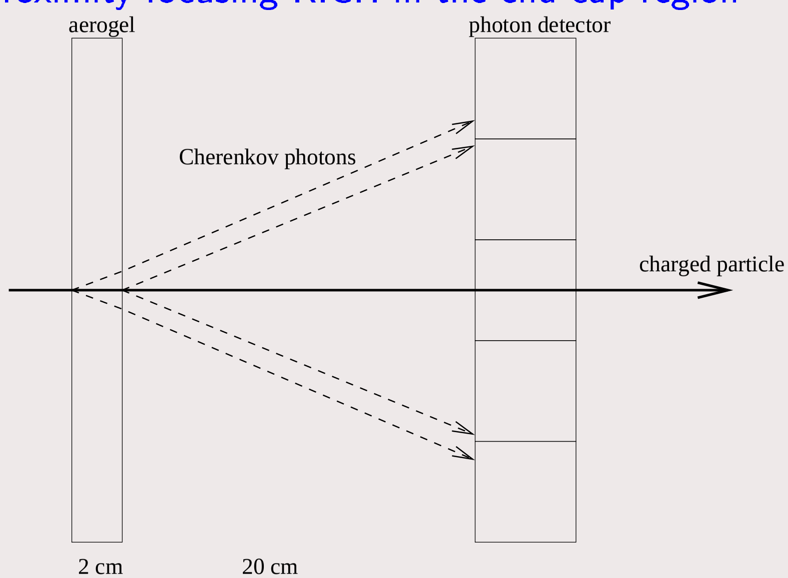
Belle Aerogel-RICH R+D group: Chiba-KEK-Nagoya-TMU-Ljubljana

Proximity focusing RICH in the forward region

Forward region: two-body decay products have momenta of up to 4 GeV/c



Proximity focusing RICH in the end-cap region



Proximity focusing RICH - principle

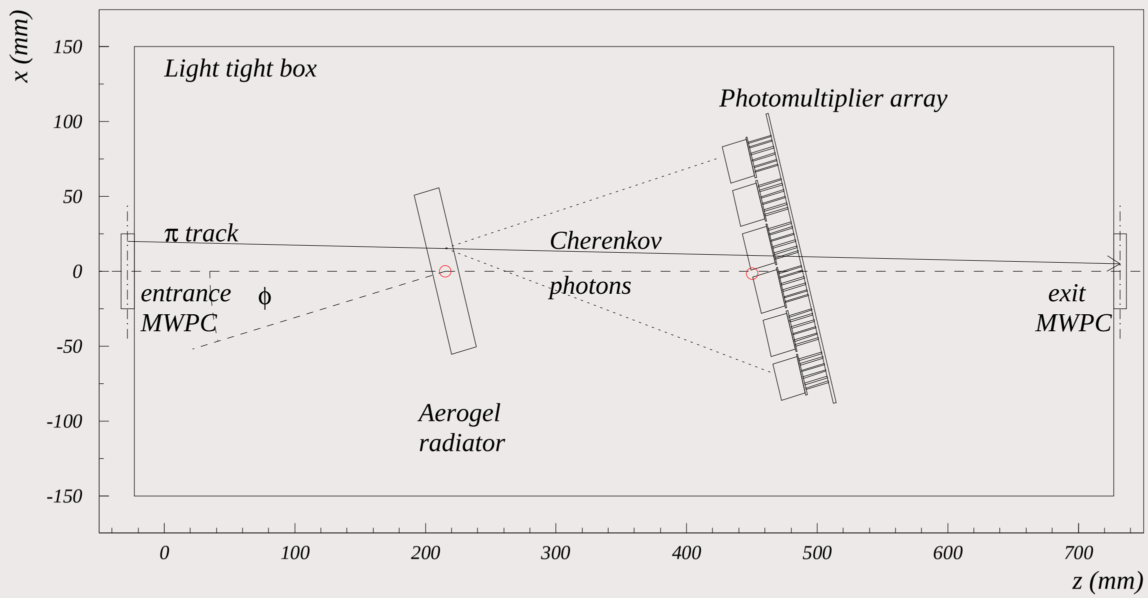
Aerogel as radiator:

n=1.03: $\theta_c(\pi) = 240$ mrad,
$\theta_c(\pi) - \theta_c(K) = 31$ mrad at 4 GeV/c
number of photons in 2 cm of aerogel: 10
($N_0 = 90$/cm, no absorption)

n=1.05: $\theta_c(\pi) = 310$ mrad,
$\theta_c(\pi) - \theta_c(K) = 23$ mrad at 4 GeV/c
number of photons in 2 cm of aerogel: 17
($N_0 = 90$/cm, no absorption)

Beam test - set up

Beam test of a prototype was carried out in November/December 2001 at a pion beam line at KEK.



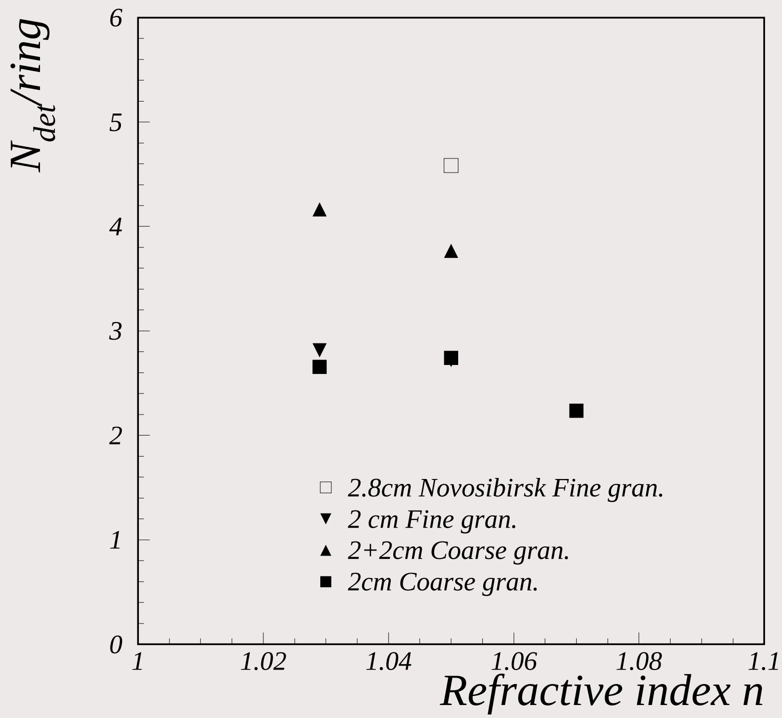
Photon detector: Hamamatsu R5900-00-M16 16 channel multianode PMTs.

A wide variety of parameters was investigated

- refractive index, thickness and type of aerogel
- beam momentum and angle of incidence
- behavior at the boundary of the aerogel tiles

Beam test results - number of photons

number of hits per ring for different aerogels
(refractive index, production method)



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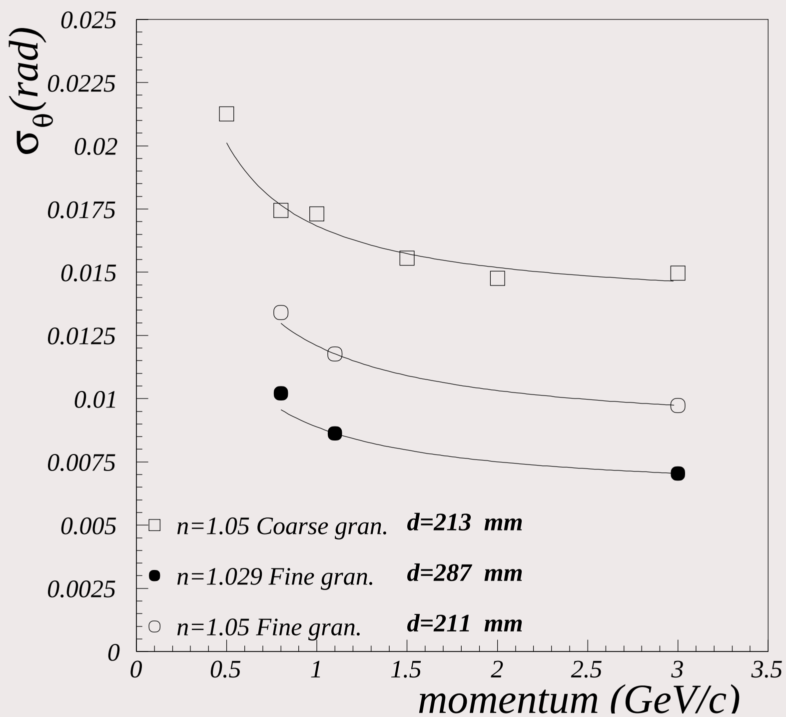
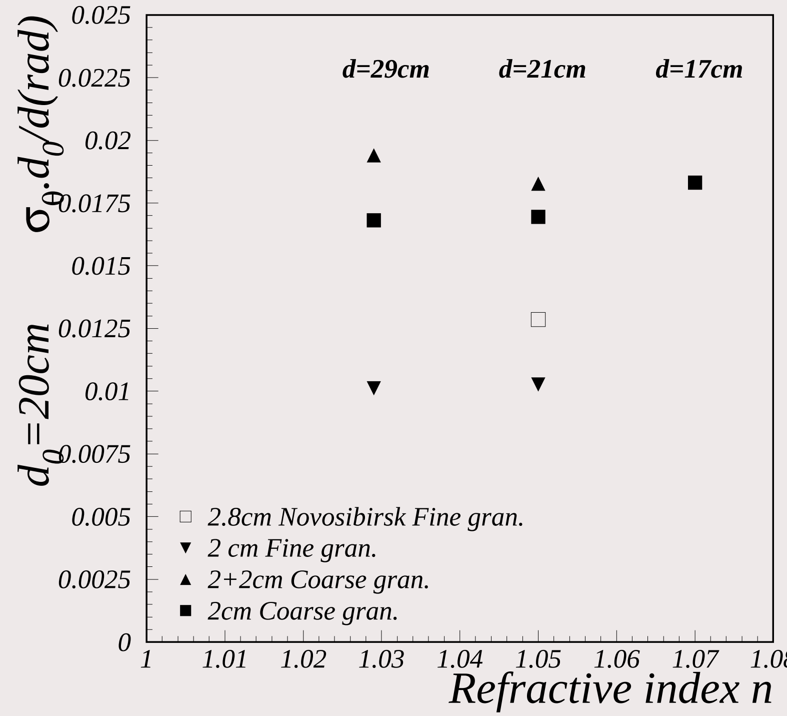
- higher ref. index does not produce more photons because of absorption
- doubling the thickness does not double the photons
- Novosibirsk aerogel has a considerably higher yield

Beam test results - resolution



resolution vs ref index

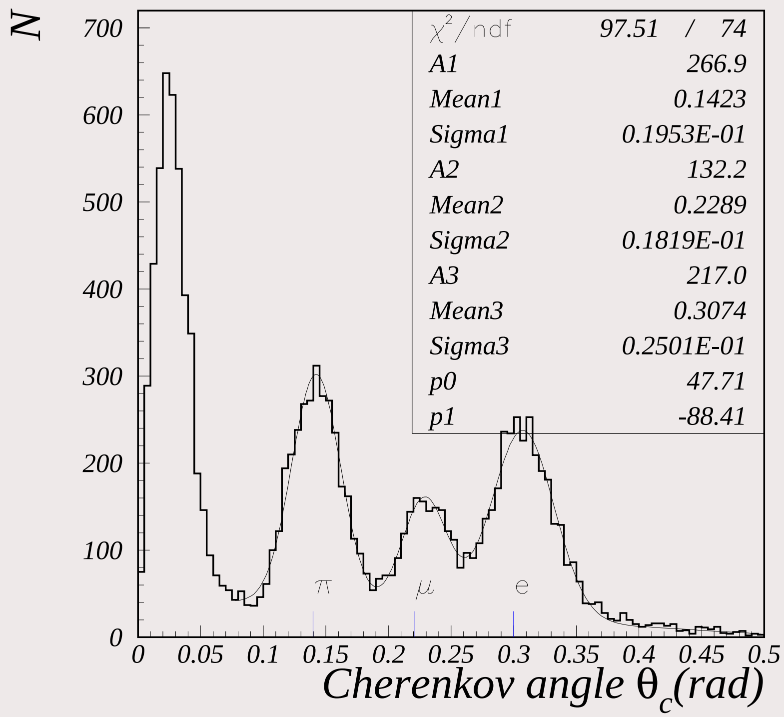


resolution vs momentum: at lower momenta, multiple scattering starts to become important

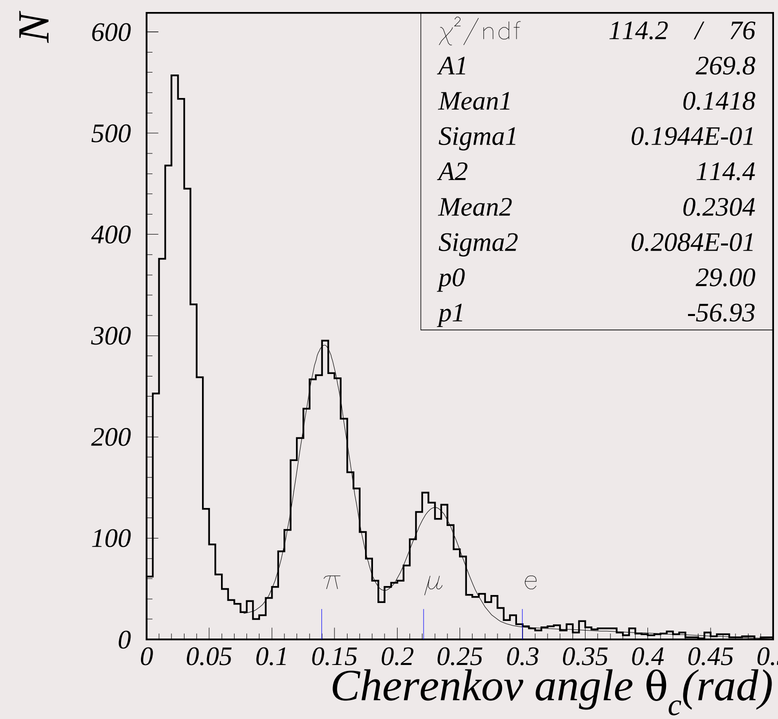
to compare the resolutions with various set-ups (distance was varied to accommodate the full ring on the photon detector) we normalize to a given distance (200nm) between the radiator and the photon detector

Beam test results - $e/\mu/\pi$ separation

Another benefit from such a counter: $e/\mu/\pi$ separation at low momenta, of importance for the $B \to Kll$ decays



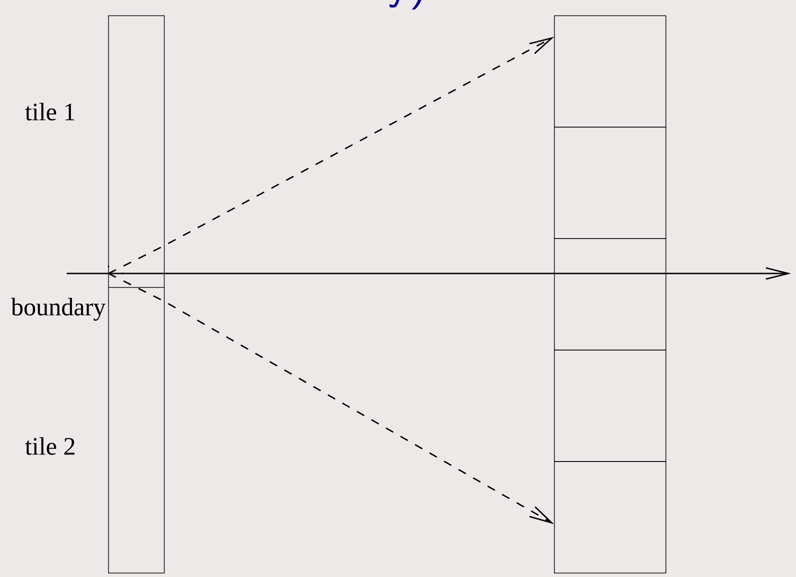
Čerenkov angle distribution for single photons, at $p = 0.8$ GeV/c

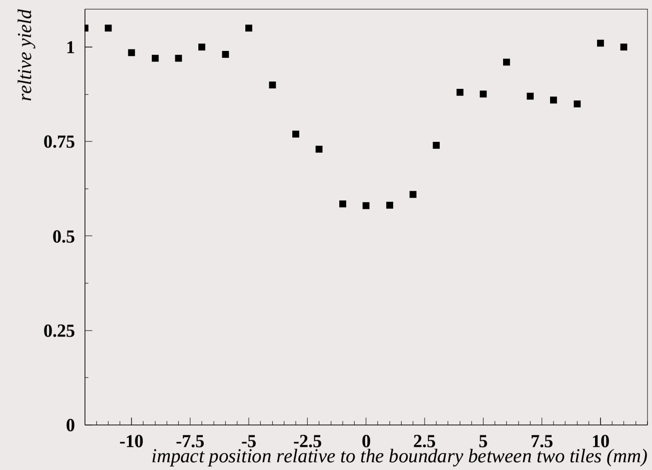


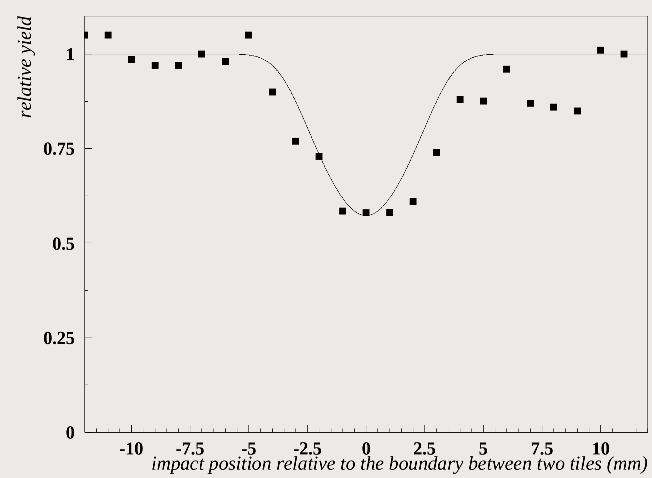
same, but with electrons vetoed with a CO_2 threshold Čerenkov counter

Beam test results - effects of the tile boundary

Scan with the beam over the vicinity of the boundary between two tiles, determine yield as a function of the impact point position (x=0 on the boundary)







As expected, the yield is affected over a few mm in the vicinity of the boundary.

A simple model (all photons hitting the boundary get lost) accounts for most of the dependence.

Beam test results - summary

- the first beam test of a proximity focusing RICH with aerogel as radiator showed that the method is feasible
- the counter performed according to expectations
- the contributions to the resolution are well understood (no contribution from aerogel material)
- the number of photons has to be increased for the detector to become a reliable PID tool
- the test was performed with Hamamatsu R5900-M16 PMTs, a well understood single photon detector (HERA-B RICH) which will not work in a high magnetic field environment

ref. index	Ndet measured	Ndet expected	σ_θ measured	σ_θ expected
1.029	2.6	2.7	7.0	6.7
1.050	2.7	2.9	9.8	9.7

Next steps

Photon detector R+D

- Develop detector of single photons which works efficiently in a high magnetic field (1.5 T)
- Increase the number of photons by developing photon detectors with a higher active area fraction (multianode PMTs: 36%) or by using light collection systems

Radiator R+D

- find a method to produce hydrophobic aerogel with low absorption and large tile size.

Next beam test

An itermediate step:

- use an array of 16 flat pannel PMTs
- use recently produced aerogels from University of Chiba, Matsushita and Novosibirsk
- test a new read-out scheme

Starts this Saturday at KEK.

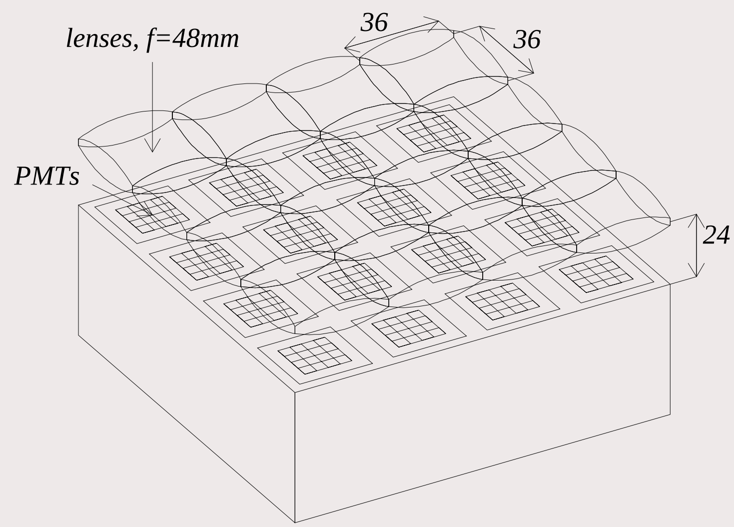
Summary

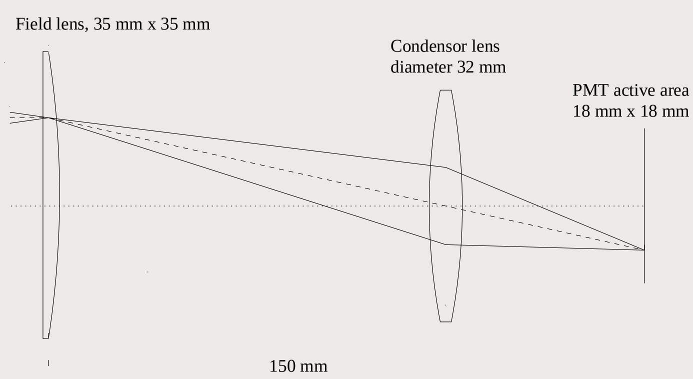
- Beam test was a successful proof of principle
- Beam test confirmed the results of our simulation tools, and showed where further R+D has to go
- A wide range of R+D activities was started (together with the industry) with the aim to develop an efficient photon detector with a high active area to work in high magnetic fields
- Radiator R+D has already given some encouraging results
- We are looking forward to the next beam test next week

Light collection system

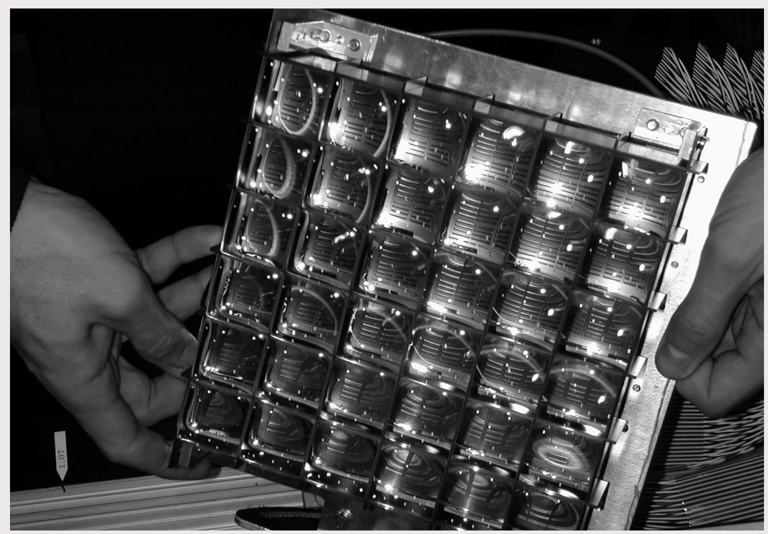
Increase the number of photons by using a light collection systems

- single lens system
- two lens device
- light guides



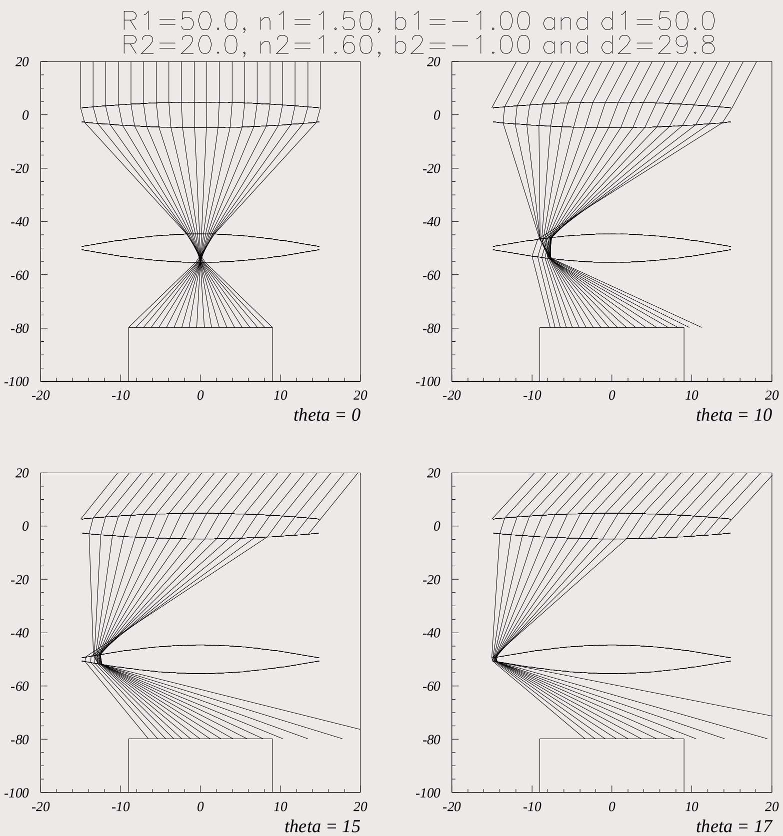


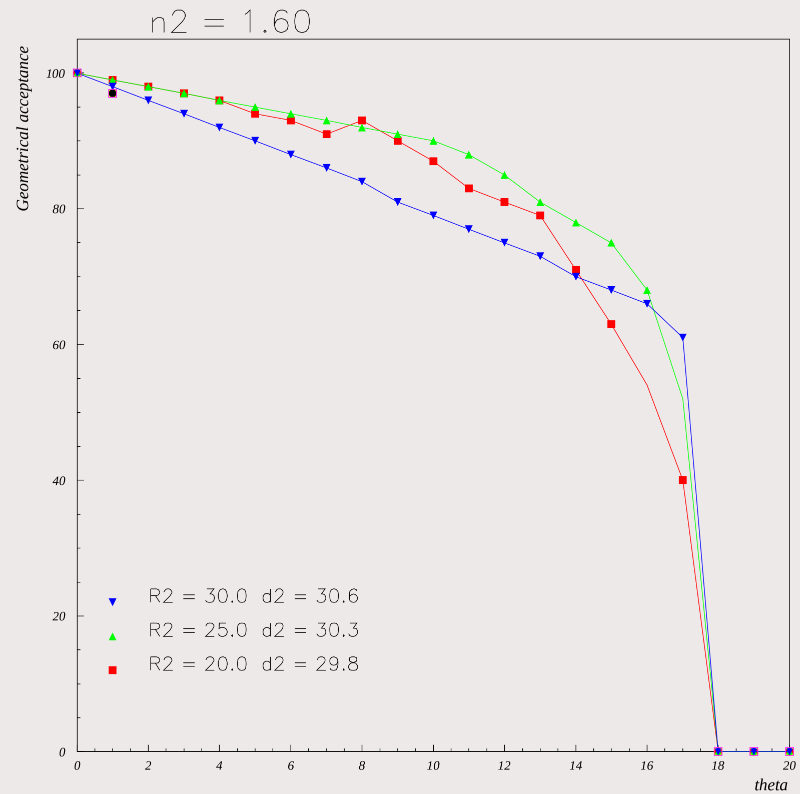
system of plastic lenses (HERA-B RICH)



Two lenses as light collection system

ray tracing vs angle of incidence





acceptance vs angle

optimize the parameters of the two lenses