

# Silicon photomultiplier as a detector of Cherenkov photons

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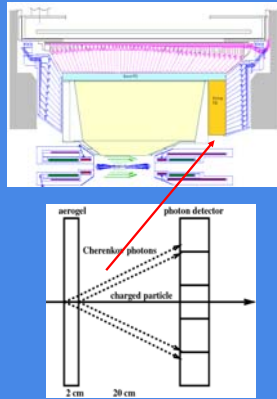
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## Motivation

Photon detector for a proximity focusing RICH in the forward region of the upgraded BELLE detector.

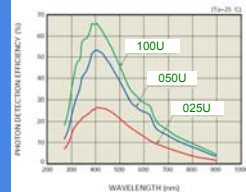
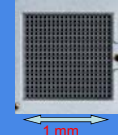
Required: operation in 1.5 T field, preferably excellent timing (advantageous for an additional TOF functionality of the RICH counter)



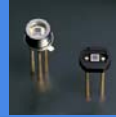
## SiPM: photon detector candidate for the Belle RICH

SiPM is an array of APDs operating in Geiger mode. Characteristics:

- low operation voltage ~ 10-100 V
- gain ~ 10<sup>6</sup>
- peak PDE up to 65% (@400nm)
- PDE = QE × ε<sub>geiger</sub> × ε<sub>geo</sub>
- ε<sub>geo</sub> – dead space between the cells
- time resolution ~ 100 ps
- works in high magnetic field
- dark counts ~ few 100 kHz/mm<sup>2</sup>
- radiation damage (p.n)

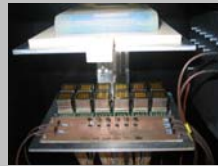
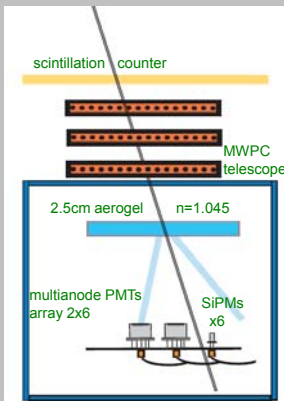


~5x more than a bialkali PMT



Hamamatsu MPPC: S10362-11

## EXPERIMENTAL SETUP



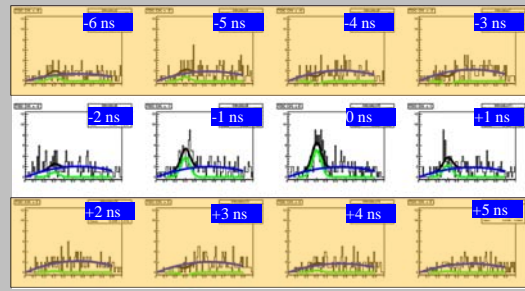
- 6 Hamamatsu SiPMs (=MPPC) of type 100U (10x10 pixels with 100μm pitch), background ~400kHz

- signals amplified (ORTEC FTA820), discriminated (EG&G CF8000) and read by multihit TDC (CAEN V673A) with 1 ns / channel

To be published in NIMA in ~3 weeks

## RESULTS

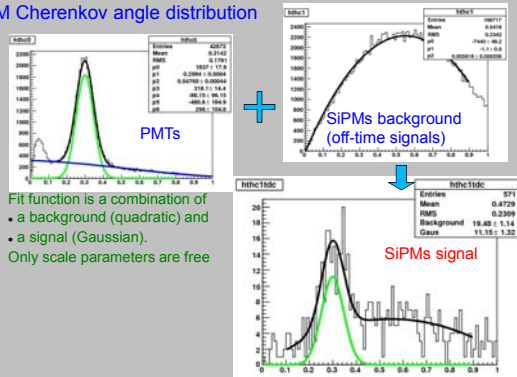
### Cherenkov angle distributions for 1ns time windows



Cherenkov photons appear in the expected time windows → First Cherenkov photons observed with SiPMs!

## RESULTS: PHOTON YIELD

### SiPM Cherenkov angle distribution

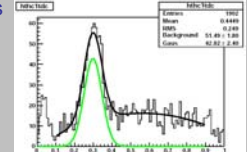
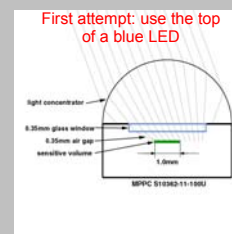


Fit function is a combination of a background (quadratic) and a signal (Gaussian). Only scale parameters are free

→ SiPMs give ~5 x more photons than PMTs per photon detector area – in agreement with expectations

## RESULTS: IMPROVING THE SIGNAL-TO-NOISE RATIO

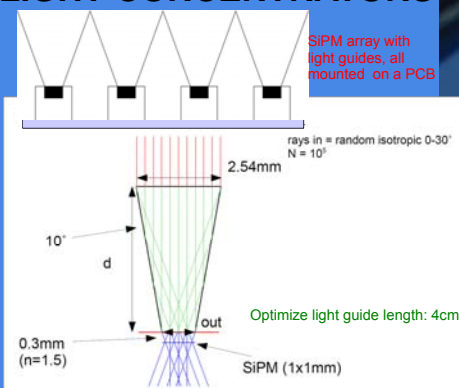
- Reduce the noise by a narrow (few ns) time window
- Increase the number of signal hits per single sensor by using light collectors and by adjusting the pad size to the ring thickness



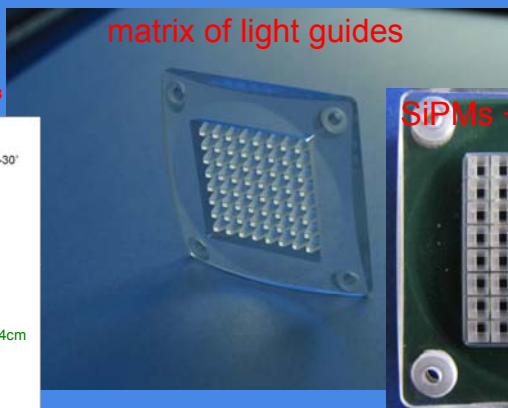
- Yield increase in agreement with the expectations
- Further improvements possible by
  - using SiPMs with a thinner protective layer
  - using a better light collector

Hits in Cherenkov space

## LIGHT CONCENTRATORS



## matrix of light guides



## SiPMs + light guides



Currently in a beam test at KEK