# Silicon photomultiplier as a position sensitive detector of Cherenkov photons

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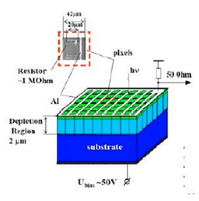
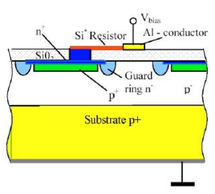
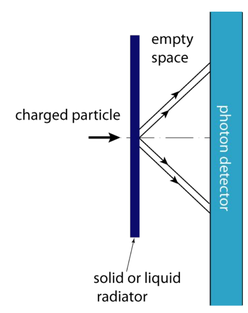


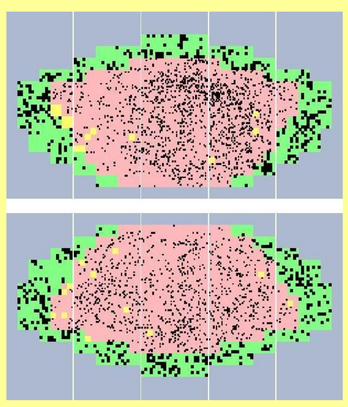

Silicon photomultipliers are semiconductor photo-sensitive devices build from an avalanche photodiode (APD) matrix on a common silicon substrate, working in the limited Geiger mode.One of the benefits if compared to other position sensitive detectors which are used in the Ring Imaging Cherenkov (RICH) Counters is their insensitivity to the high magnetic fields. They have several other advantages (lower operation voltage, less material) over the conventional photomultiplier tubes. They also have a high peak photon detection efficiency (approx 20%), a high gain of ( approx. $10^6$ ) and a good time response. Due to their dimensions, they allow compact, light and robust mechanical designs. All this would make them a very promising candidate for a photon detector of Cherenkov photons in a RICH counter.

However, due to their serious disadvantage, a very high dark rate (approx 10MHz/mm$^2$), they have up to now never been used in Cherenkov detectors, where single photon detection is required at low noise.




- **Experience** from HERA-B RICH:operated in a high occupacy environment (up to 10%).
- Need
- >20 photons per ring (had ~30) for a reliable PID.

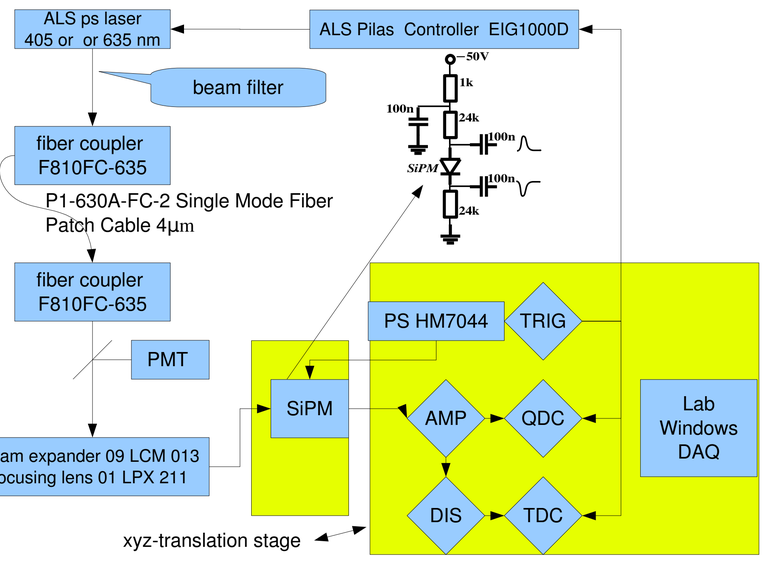
**HERA-B RICH event**

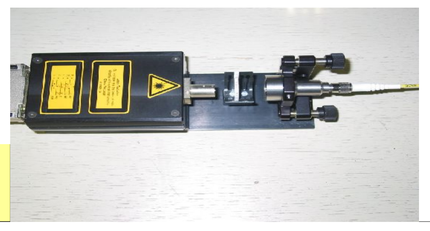


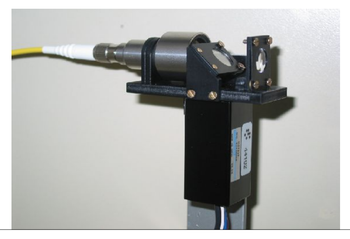
Can such a detector work, i.e.
**How to improve signal to noise ratio?**

- Reduce the noise by a narrow (~10ns) time window
- Increase the number of signal hits by using light collectors and by adjusting the pad size to the ring thickness

## 2D scan experimental setup



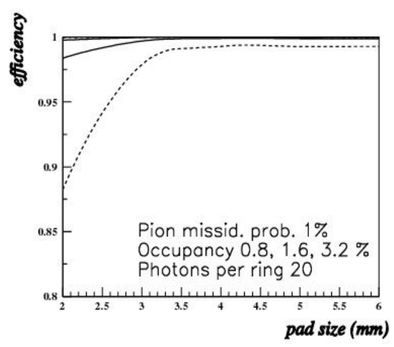





## MC simulation

MC simulation of the counter response: assume 1mm$^2$ active area SiPM with 0.8 MHz (1.6, 3.2) dark count rate, 10ns time window

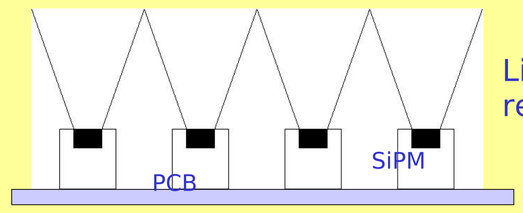
K identification efficiency at 1% π missid. probability




ε vs. p for three different background levels

ε at 4 GeV/c vs. pad size

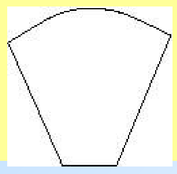
## Light collectors: three types studied



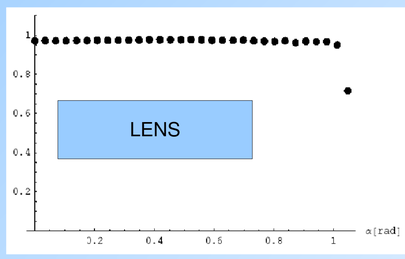

Light collector with reflective walls

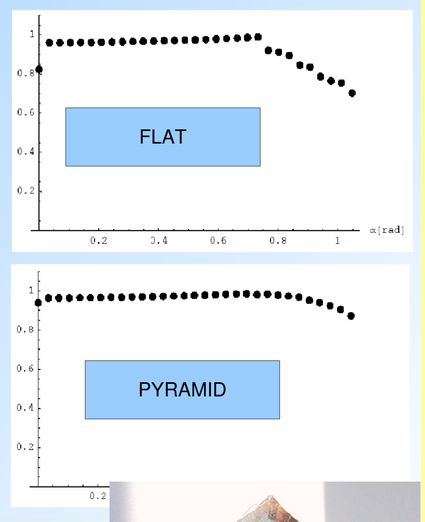
or combine a lens and mirror walls

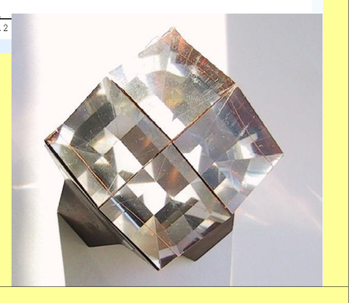
Angular acceptance



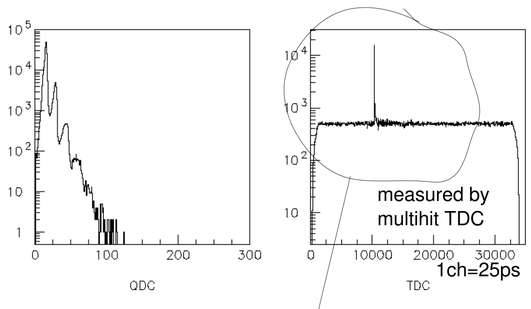
- efficiency vs. incidence angle for different types



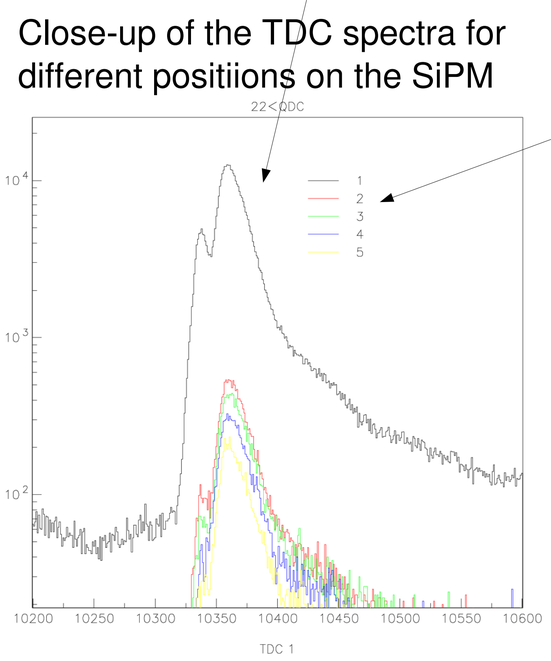



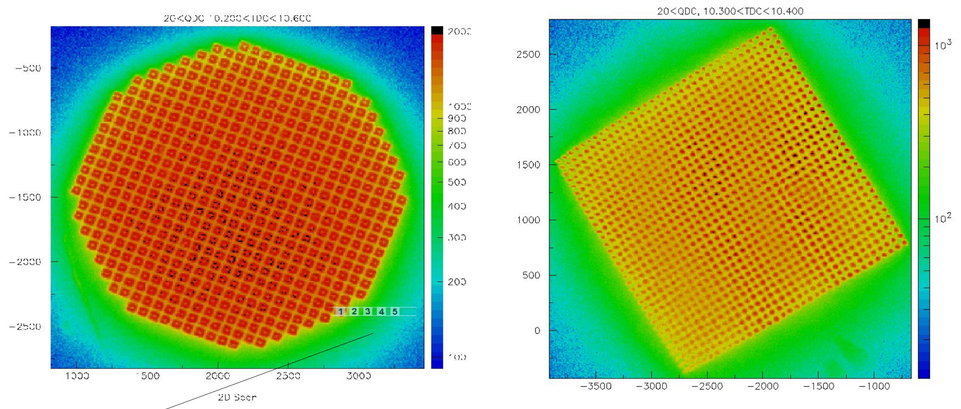
Representative ADC and TDC spectra at 10% hit probability




Close-up of the TDC spectra for different positiions on the SiPM

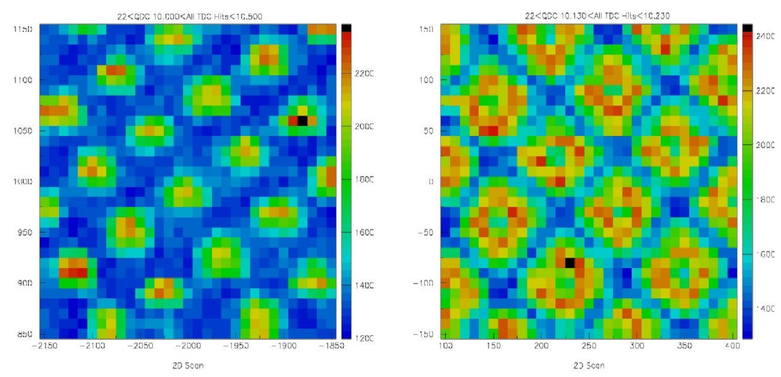



## SiPM surface sensitivity

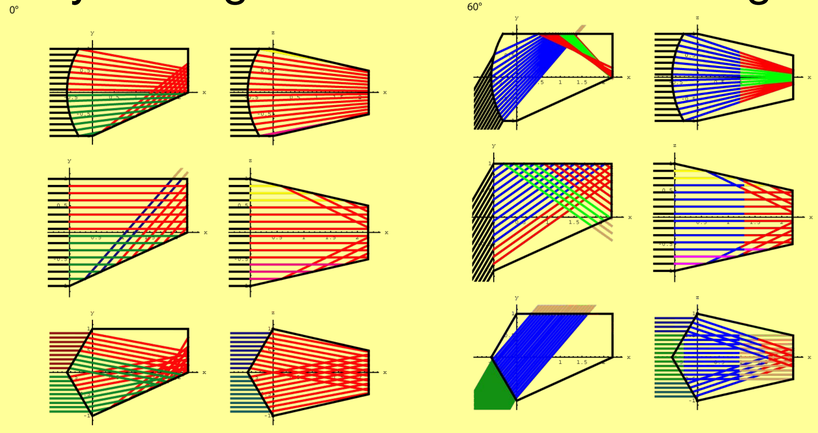


Size: ~1mm Scanned with laser, resolution ~5 μm

Close-up of the two sensors, 150μm x 150 resolution ~5μm



## Ray tracing for different incident angles




Next step: measurement of the Cherenkov photons emitted from aerogel