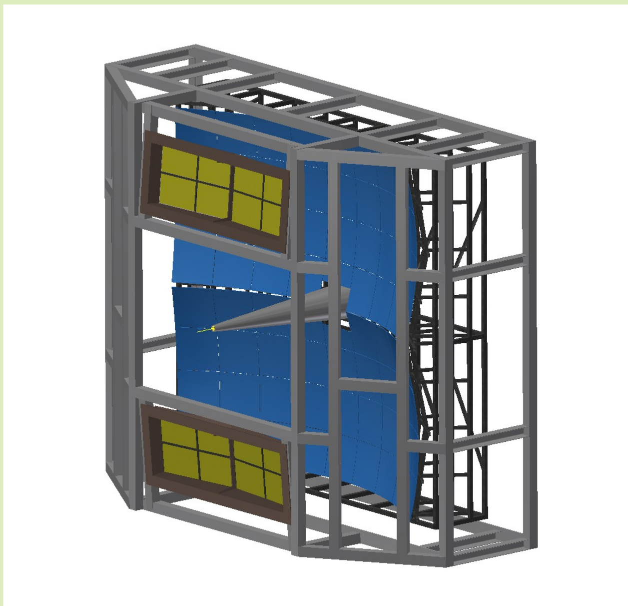
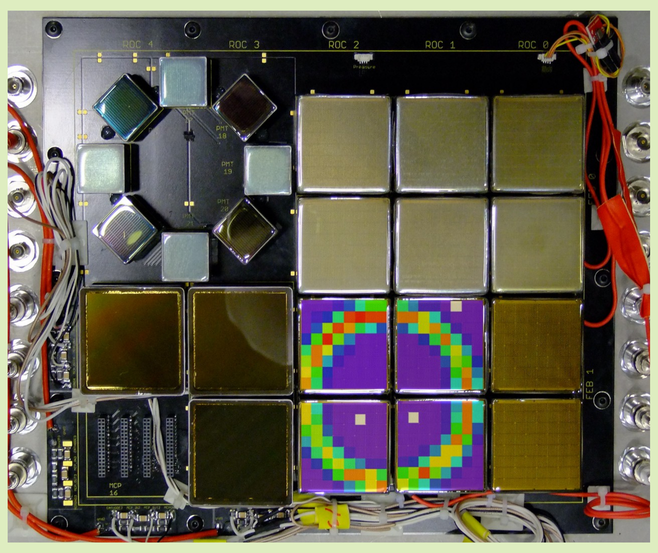
Development of the photon detection system for the CBM-RICH

C. Pauly for the CBM-RICH collaboration
Bergische Universität Wuppertal, Germany, contact pauly@physik.uni-wuppertal.de

Overview



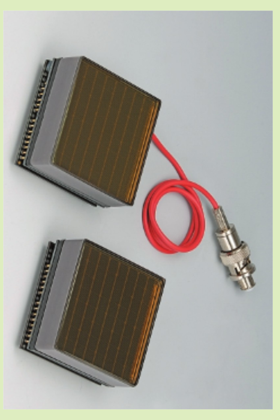
- Two separate photon detection planes above / below beam line
- Each 2 x 0.6 m², about 2.4 m² total active area
- Pixel size: ca. 6x6 mm² , ca. 55k individual pixel channel
- Spectral sensitivity: 180nm - ~ 600nm, matching CO_2 spectral transmission
- Up to 500 kHz/pixel single photon rate
- Multianode Photomultiplier (MAPMT) or Microchannel Plate (MCP) readout
- Gas-tight carrier PCB with photon sensors, no additional optical windows
- Wavelength shifting coating on PMTs to enhance UV quantum efficiency
- Iron shielding box around photon camera to reduce magnetic stray field from CBM magnet to below 1mT



Prototype camera with different types of sensors on common carrier PCB.

Sensor candidates

Hamamatsu H8500-03 MAPMT



- Design baseline for CBM-RICH
- 52x52 mm², 89% active area
- 64 channels, pixel size 5.8x5.8 mm²
- Integrated active divider (150 µA)
- 12 dynodes (Bialkali, max 25% q.e.
  8 dynodes (Super Bialkali, max 35% q.e.)
- Time resolution: ~400ps, 0.8ns risetime
- Non-optimal single-photon capabilities

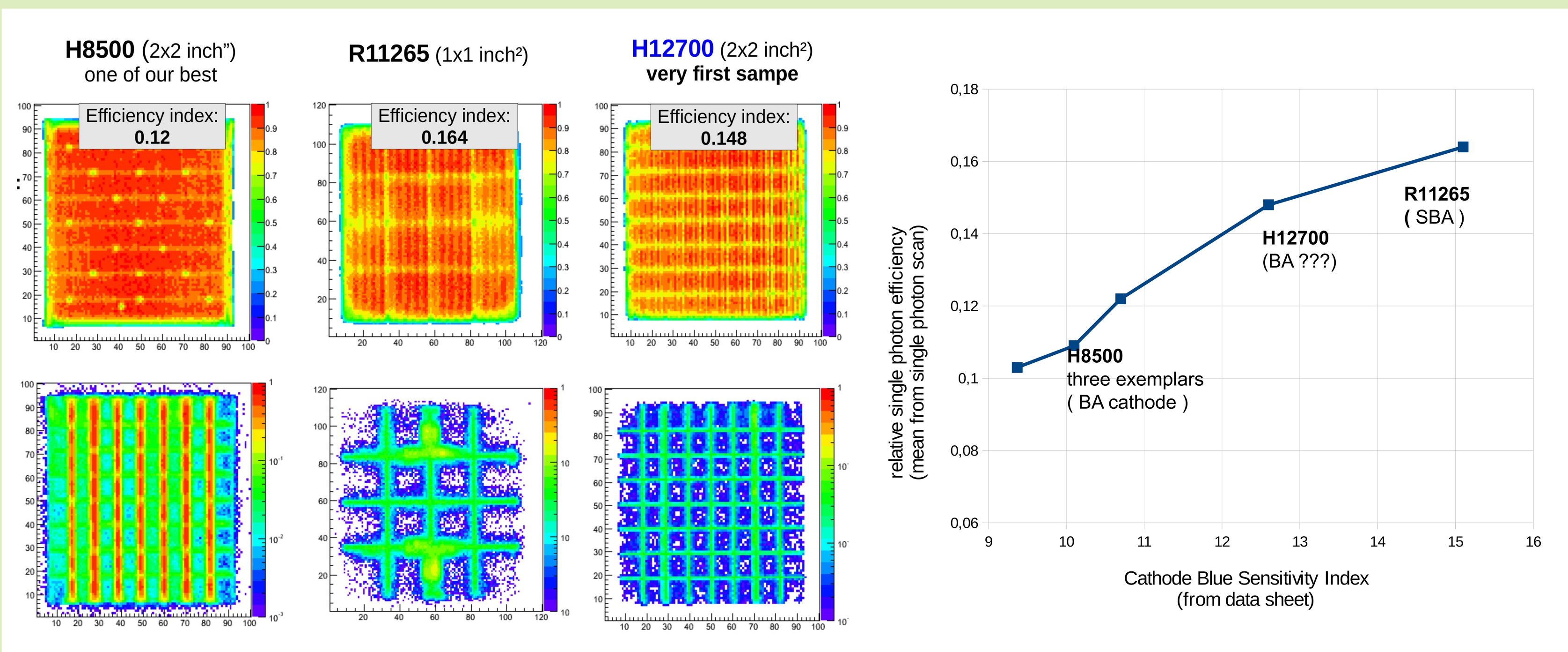
Photonis XP85012/A1-Q MCP

- 59x59 mm², 80% active area
- 64 channels, similar pixel size as H8500
- excellent time resolution (< 100ps)
- 25 µm pore size
- Immune to magnetic fields up to ~1T
- Limited life time / total accumulated charge

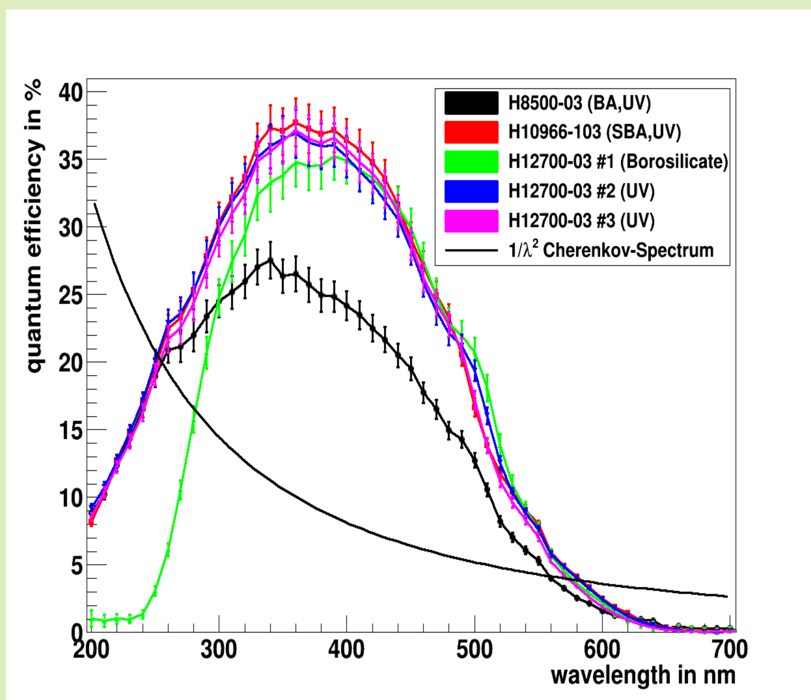
Hamamatsu H12700 MAPMT

- New MAPMT from Hamamtsu
- Same geometrical outline as H8500
- Dynode structure from R11265
- Optimized for single photon detection
- “Advanced Bialkali Cathode” (SBA ?)
- Increased collection efficiency
- Much improved single photon spectrum
- **First prototypes available for testing**

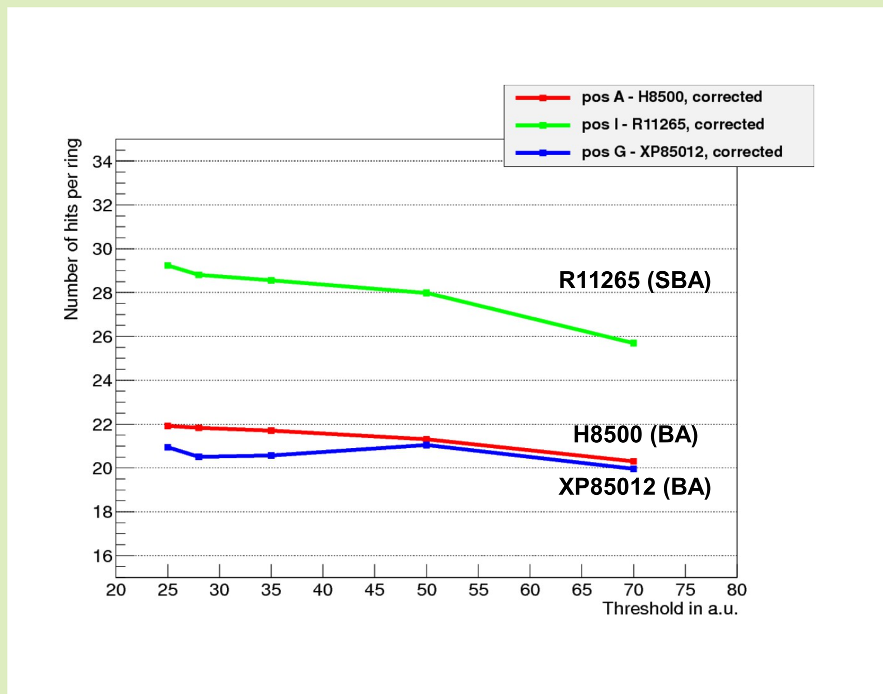
Sensor evaluation



Spatially resolved single photon scans for different sensor types showing the fraction of single photon events with >=1 detected hit pixel (upper line of plots) and >=2 hit pixels, the latter showing regions of increased cross talk.
H8500 shows fairly smooth detection efficiency with very strong cross talk between horizontally neighboured pixels. R11265 and H12700 show much reduced cross talk. The “efficiency index” gives the average over the active area. It is strongly correlated with the “Blue Sensitivity Index” from the PMT data sheet.

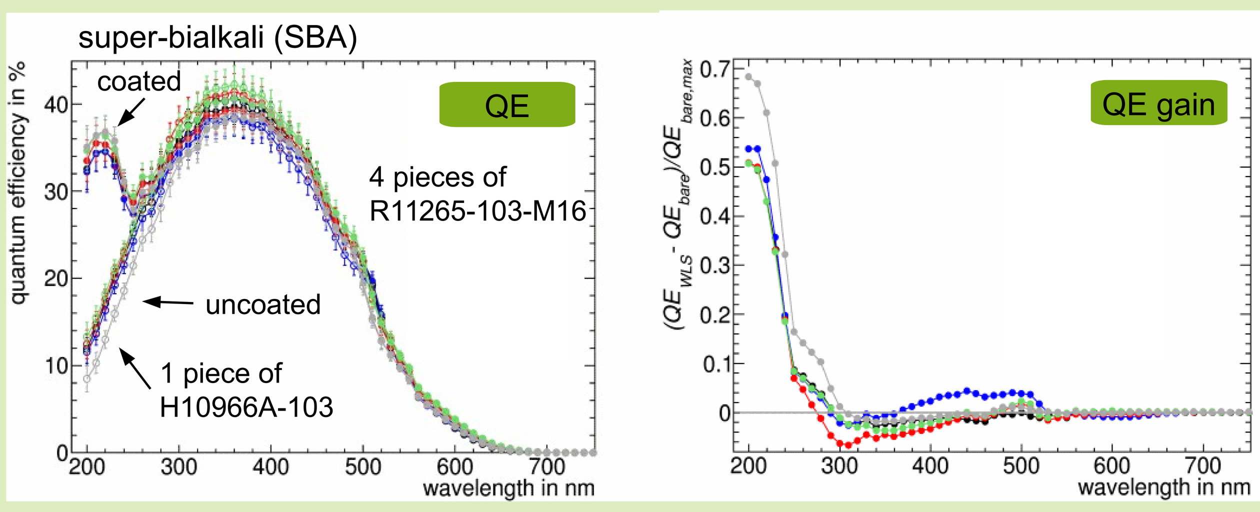


Quantum efficiency for standard **H8500 MAPMT** (BA cathode) and the **new H12700 MAPMT** with “enhanced BA cathode”, as measured in the lab for two protoyopes of H12700 with UV window, and one with Borosilicate window.



Comparison of different photon sensors in terms of “detected photons per Cherenkov ring”, measured with CBM-RICH prototype at CERN test beam. Additional hits from cross talk were subtracted.

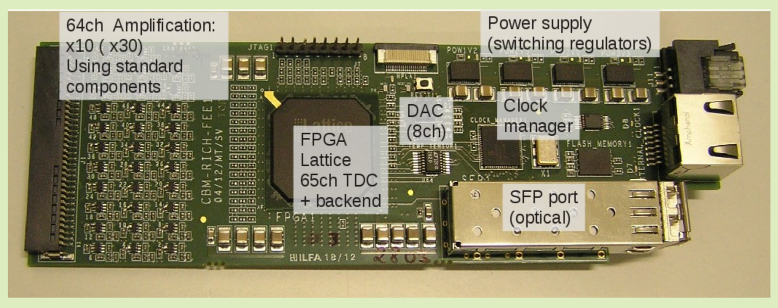
Wavelength shifting coating



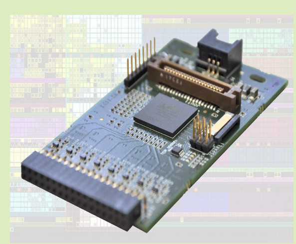
A wavelength shifting coating (WLS) can substantially increase the quantum efficiency in the UV region by shifting UV photons (~200-300 nm) to the region of maximum quantum efficiency (~ 380nm). We use **P-terphenyl (PT) as WLS**, applied directly on the MAPMT front window via a **dip-coating** process.
~20% gain in detected photons per Cherenkov ring could be observed with thickness optimized WLS films in a test beam at CERN.
Only minor degradation of position resolution, decay constant for reemission ~1ns.

Readout concept

HADES TRB3 [3]
256 FPGA-TDC channels



CBMRICH FPGA-TDC prototype
64 channels Discriminator + TDC on a single FPGA, 52x130 mm²



PADIWA:
A 16 channel discriminator frontend implemented on a single FPGA

The CBM-RICH readout scheme will be based on a **fully self-triggered** acquisition concept using FPGA TDCs. A first prototype module, combining TDC, signal discrimination, and data backend on a single FPGA (based on the HADES TRB3) has been successfully tested in beam at CERN.
Goal: **time precision <<1ns**, amplitude information via **Time-over-Thresh.**

[1] J. Adamczewski-Musch et al, "The CBM RICH project", NIMA (2014)
[2] J. Adamczewski-Musch et al, "Wavelength shifting films on multianode PMTs with UV-extended window for the CBM-RICH detector", NIMA (2014)
[3] M. Traxler et al, “A compact system for high precision time measurements [...]”, JINST 6 12004 (2011)