Fast Photon Detection for Particle Identification with COMPASS RICH-1

Frank Nerling
Universität Freiburg, Physikalisches Institut

on behalf of the
COMPASS RICH Upgrade Group

Outline:

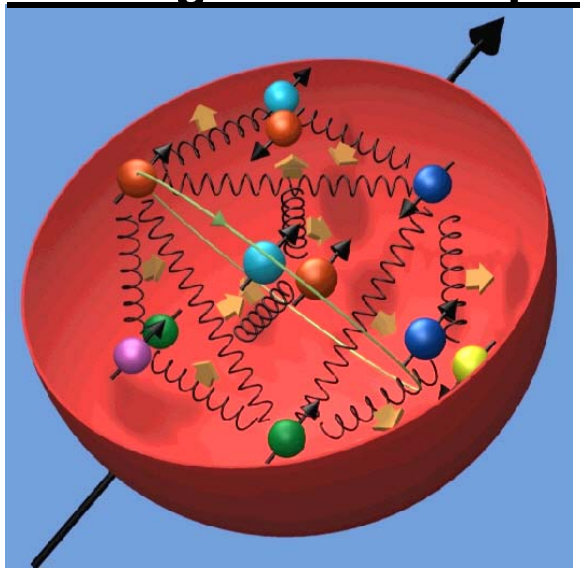
- Introduction
- Motivation of the project
- The detector upgrade:
  - optics
  - read-out electronics
  - constructions & monitoring
- Status & prospectives

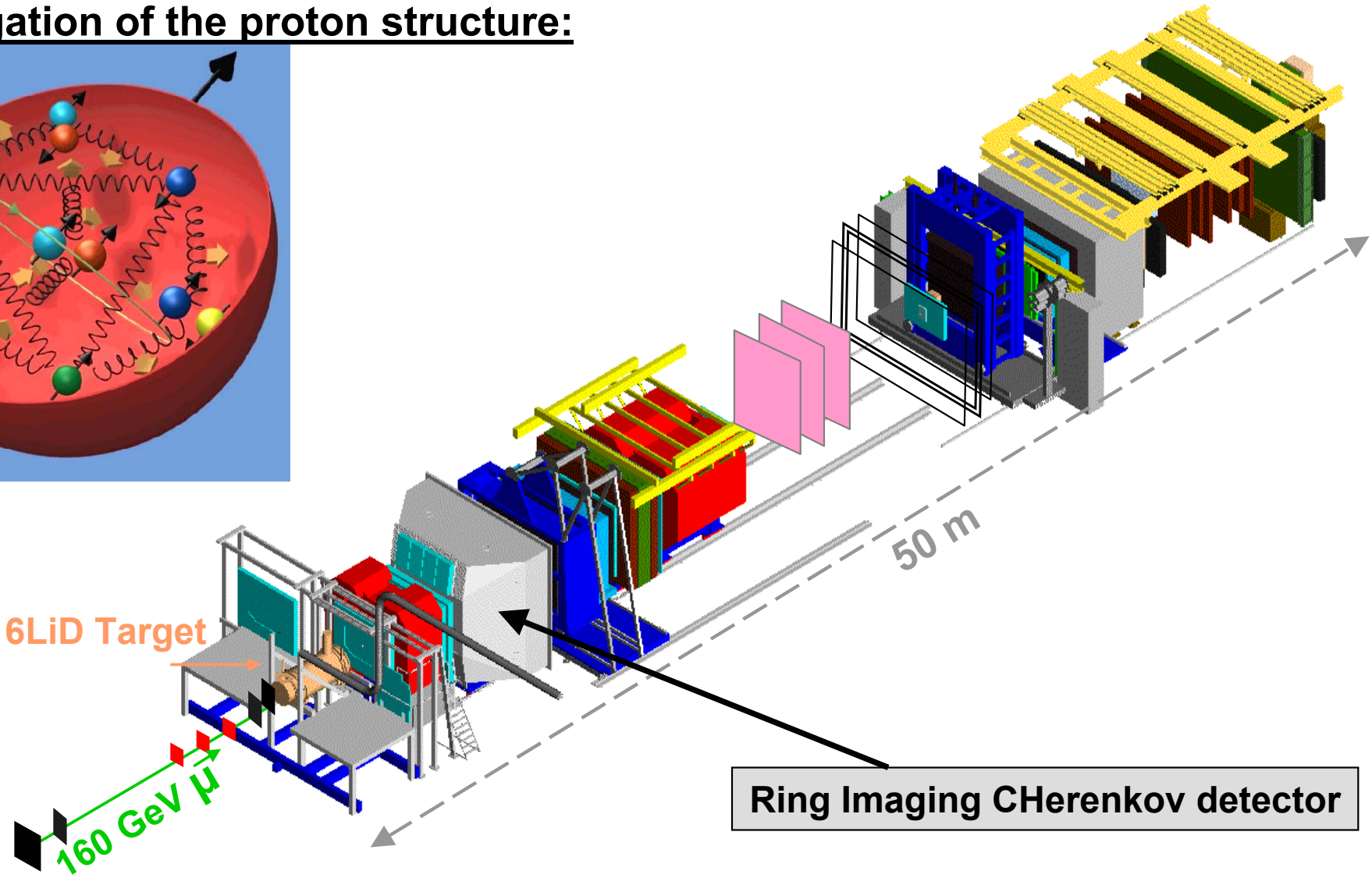
bmb+f - Förderschwerpunkt
COMPASS
Großgeräte der physikalischen Grundlagenforschung

The COMPASS experiment

COmmon Muon Proton Apparatus for Structure and Spectroscopy
(272 physicists, 25 institutes, 11 countries)

Investigation of the proton structure:





The COMPASS RICH

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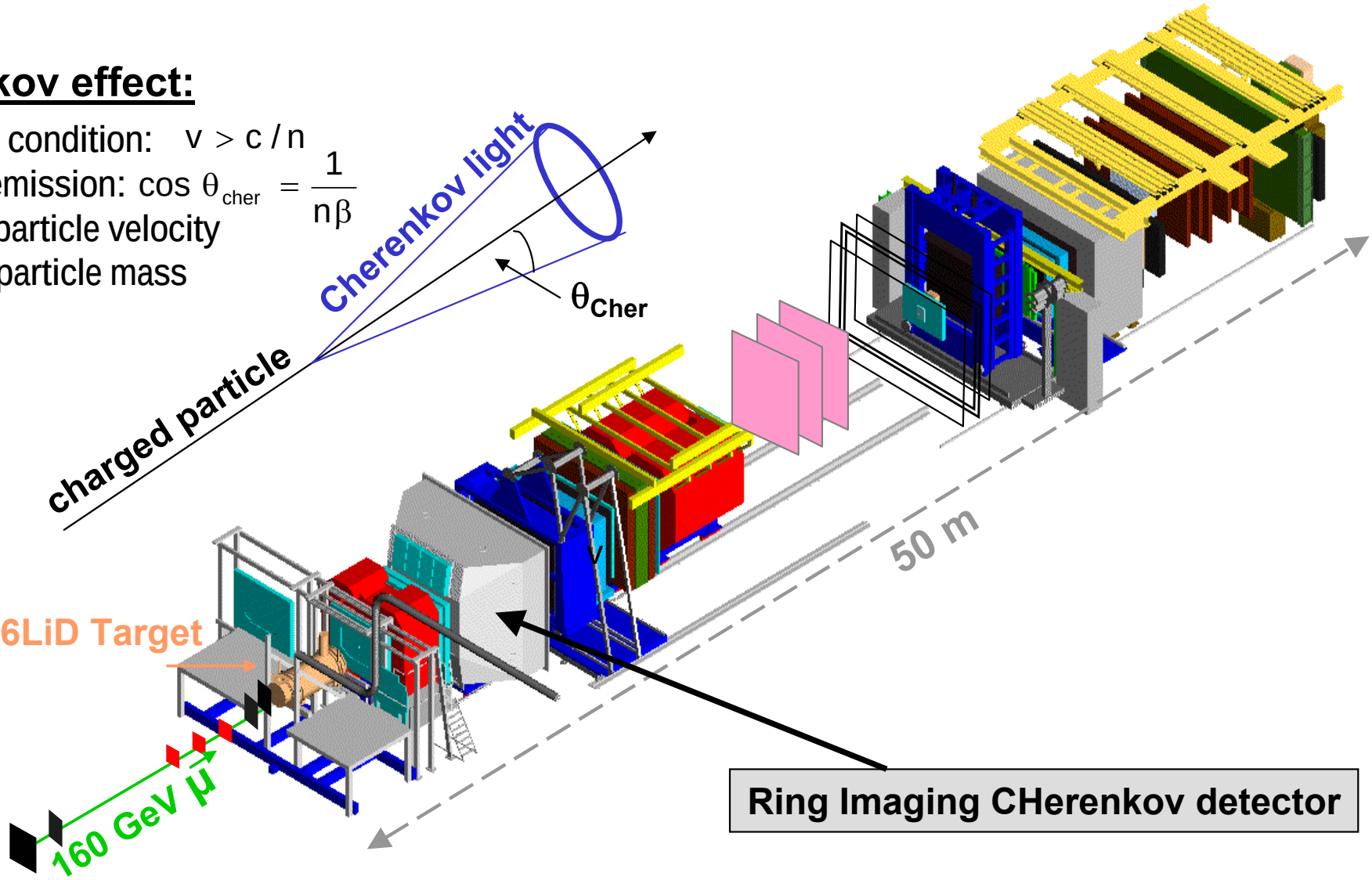
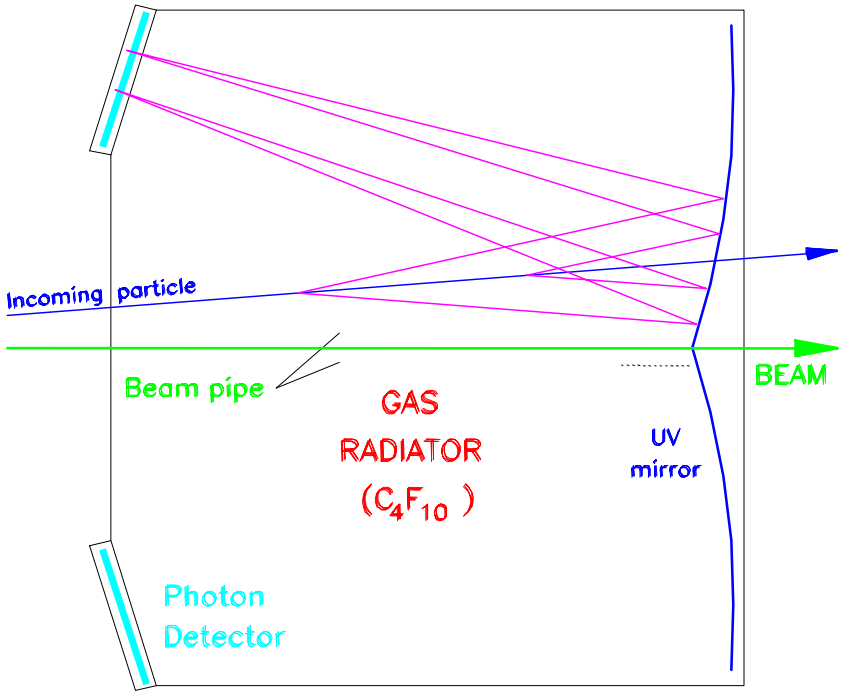
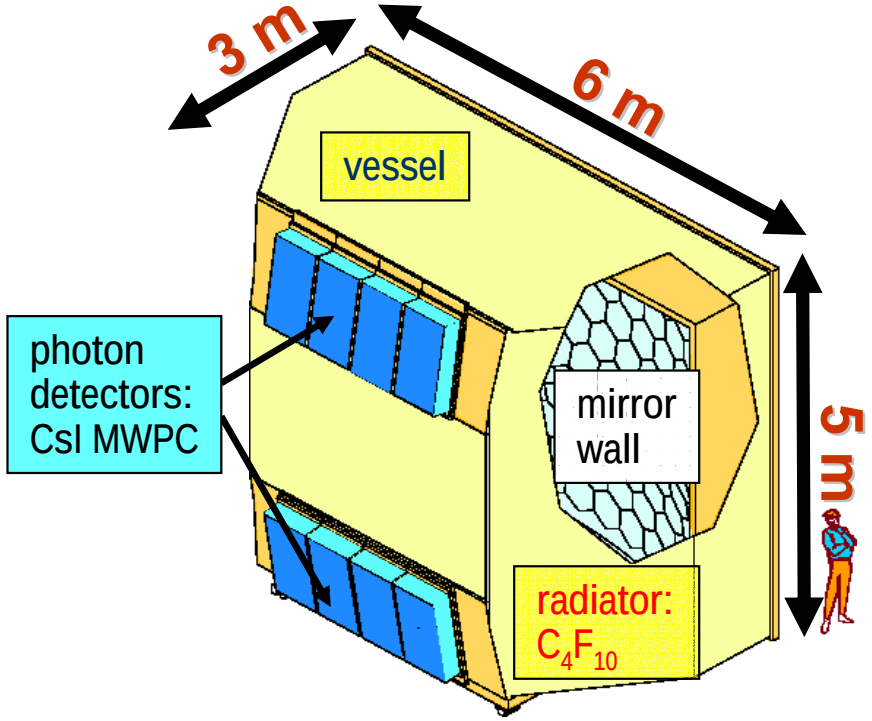
Cherenkov effect:

- threshold condition: $v > c / n$
- angle of emission: $\cos \theta_{cher} = \frac{1}{n\beta}$
- θ_{Cher} => particle velocity
  => particle mass



The COMPASS RICH detector





- **radiator gas:** $C_4 F_{10}$
- **mirror:** 20 m^2 surface
- **photon-detectors:** Multi Wire Proportional Chamber (MWPC)
- **angular acceptance:** ± 250 mrad horizontal, ± 200 mrad vertical
- **read-out:** 83.000 channels (pixels)

Upgrade motivation: Experimental challenges

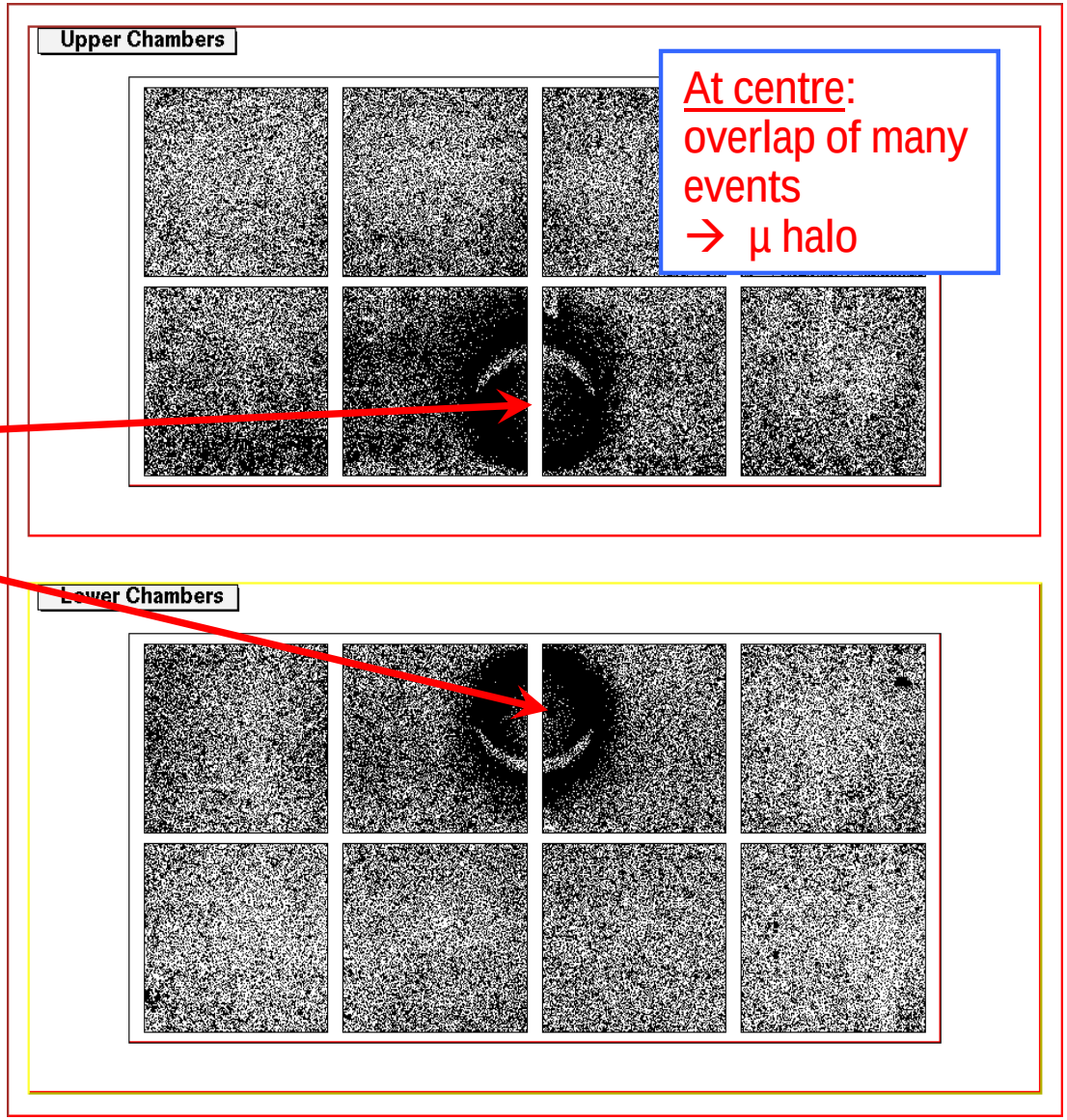
- **Present /previous read-out:**
  Gassiplex-chip, dead time ~3μs

- **Experimental environment**
  - large uncorrelated background
  (memory of MWPC + read-out,
  muon halo)

- **High rate operation**
  → increased beam intensity:
  presently: 40 MHz
  goal: 100 MHz

  → increased trigger rates:
  presently: 20 kHz
  up to: 100 kHz

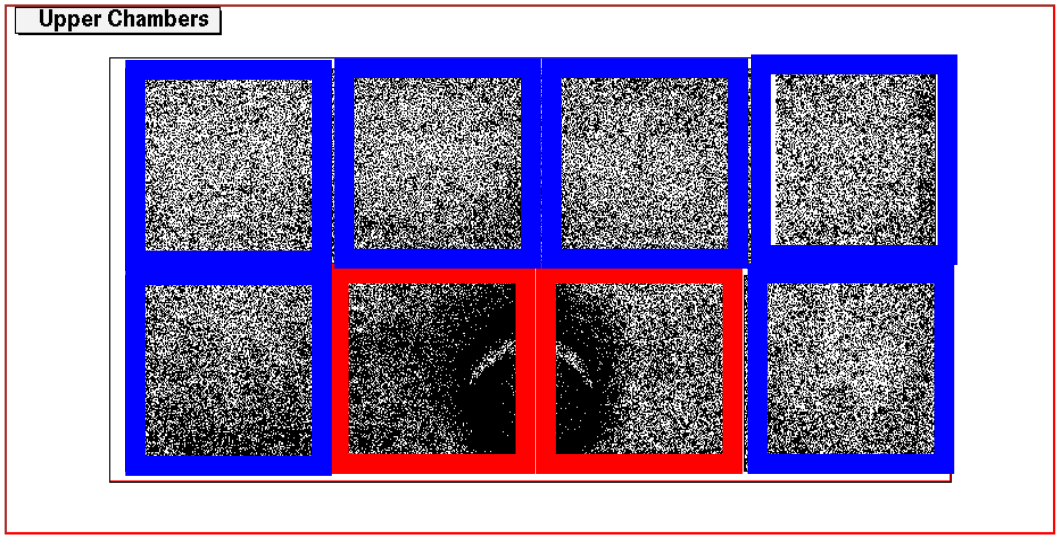
  → no dead time (Luminosity)



The upgrade project for 2006 data taking

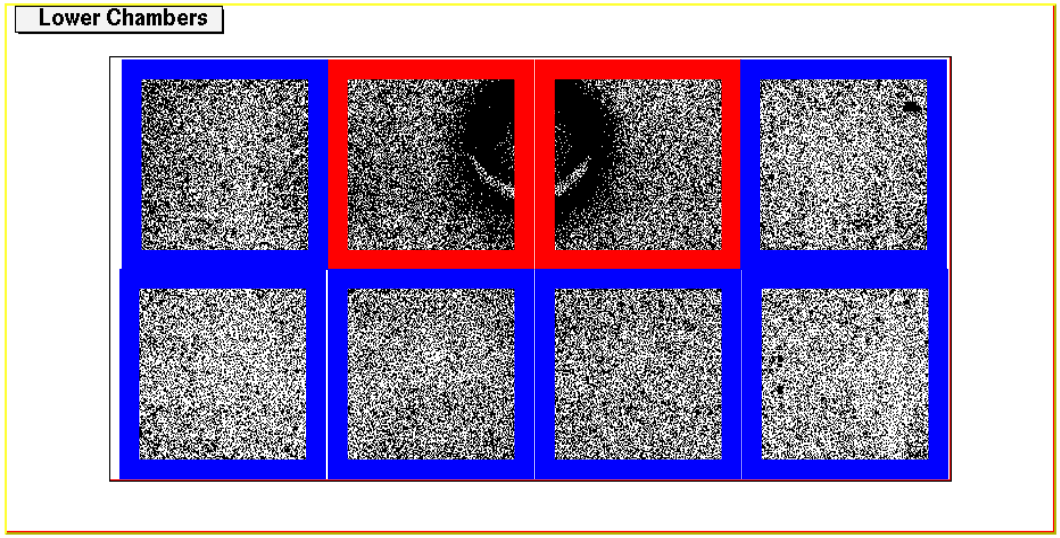
Multi Wire Proportional Chambers:
(MWPC, in use since 2001)

- CsI photo cathodes
- new read-out system: APV chip
  (negligible dead time)
- time resolution (CsI with MWPC + ro):
  ~ 3 µs → < 400 ns



Fast photon detection:

- Multi Anode PMTs (MAPMT, 576 pc)
- Individual telescopes
- Read-out
  → sensitive FE: MAD chip
  → high resolution TDC: F1 chip
- time resolution: few ns
- no MWPC



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not discussed in this talk

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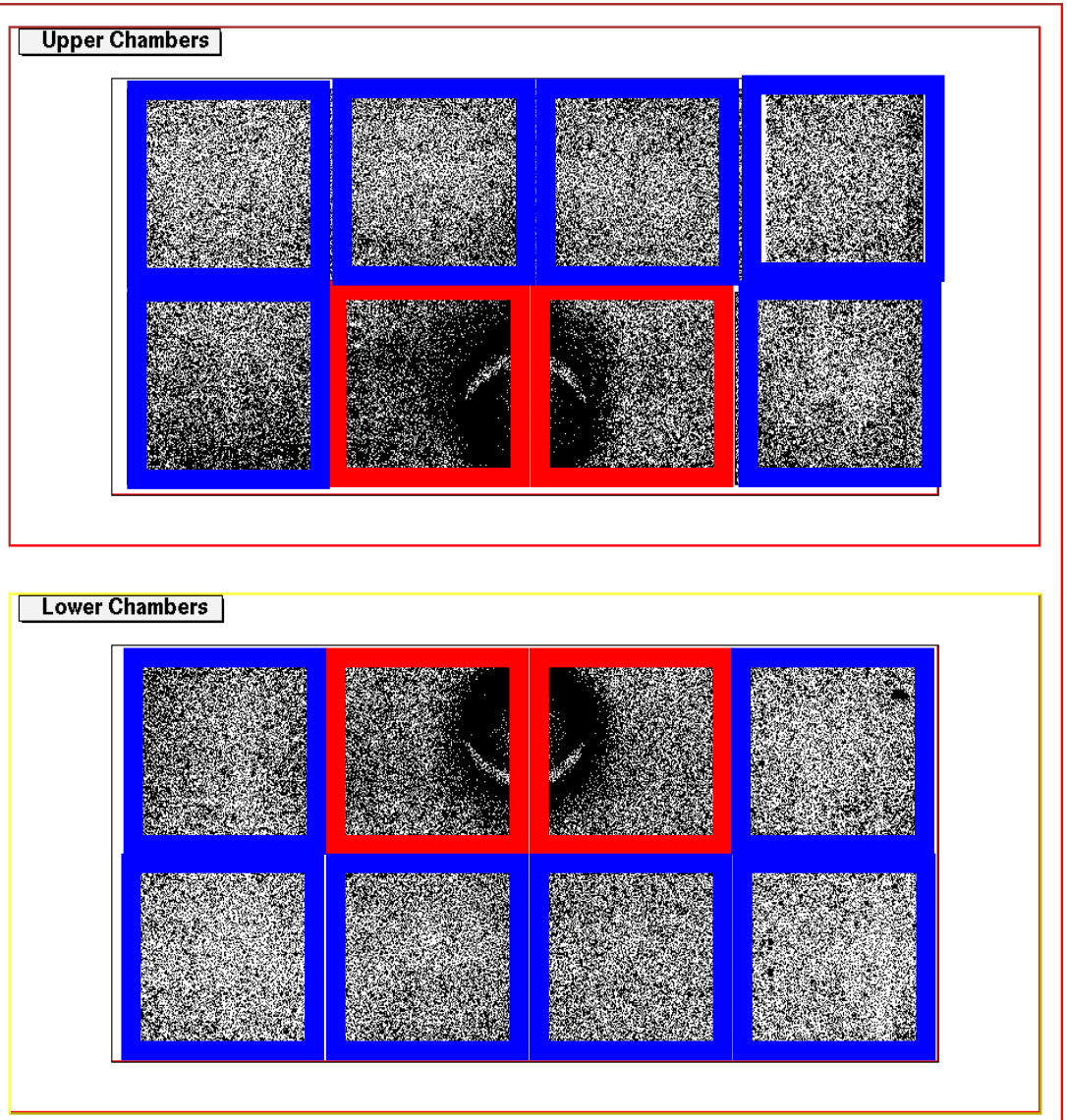
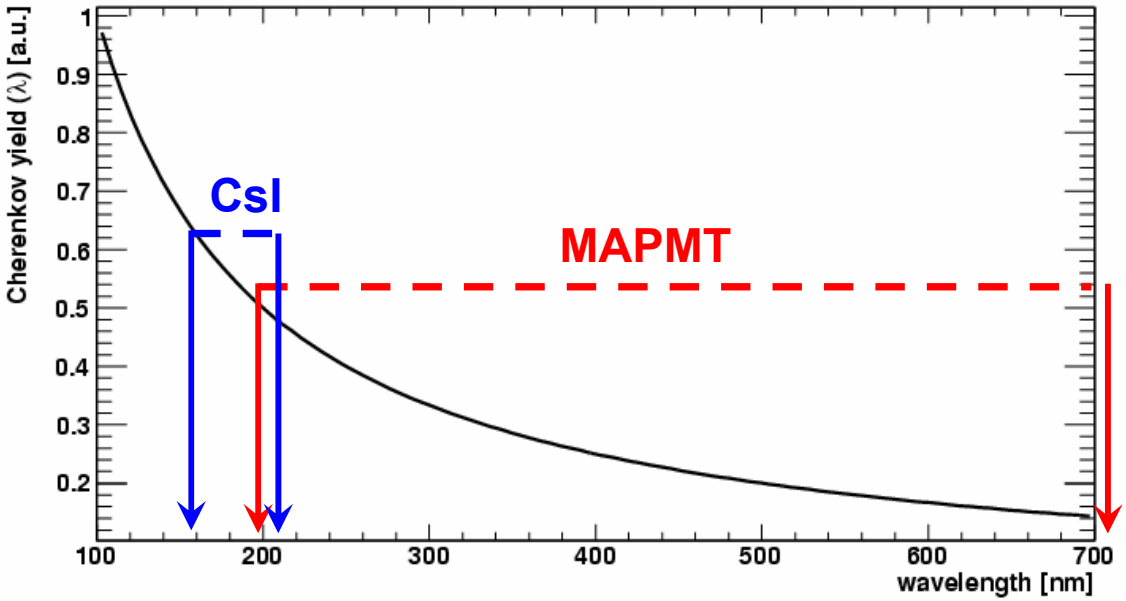


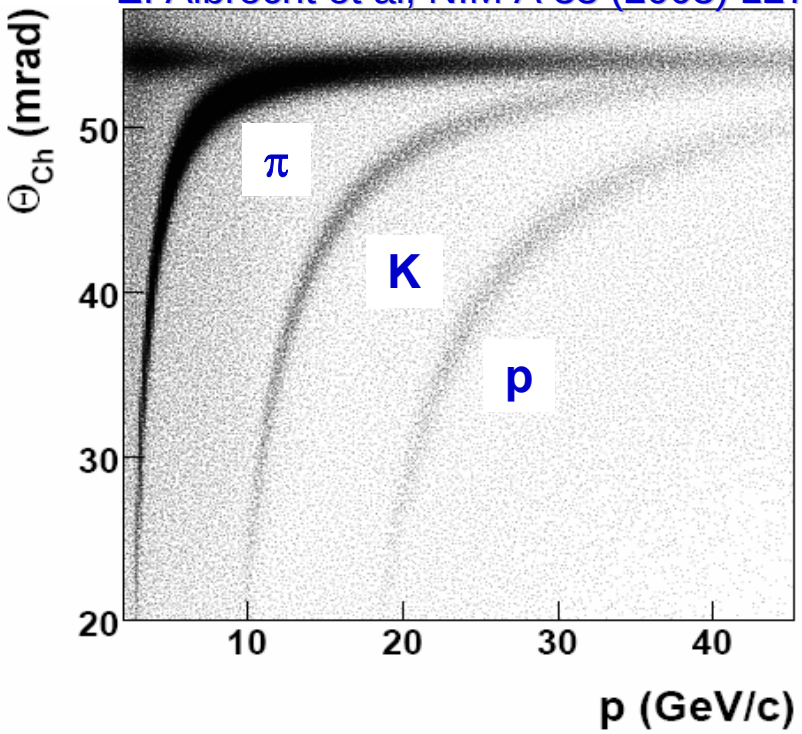
Upgraded RICH resolution

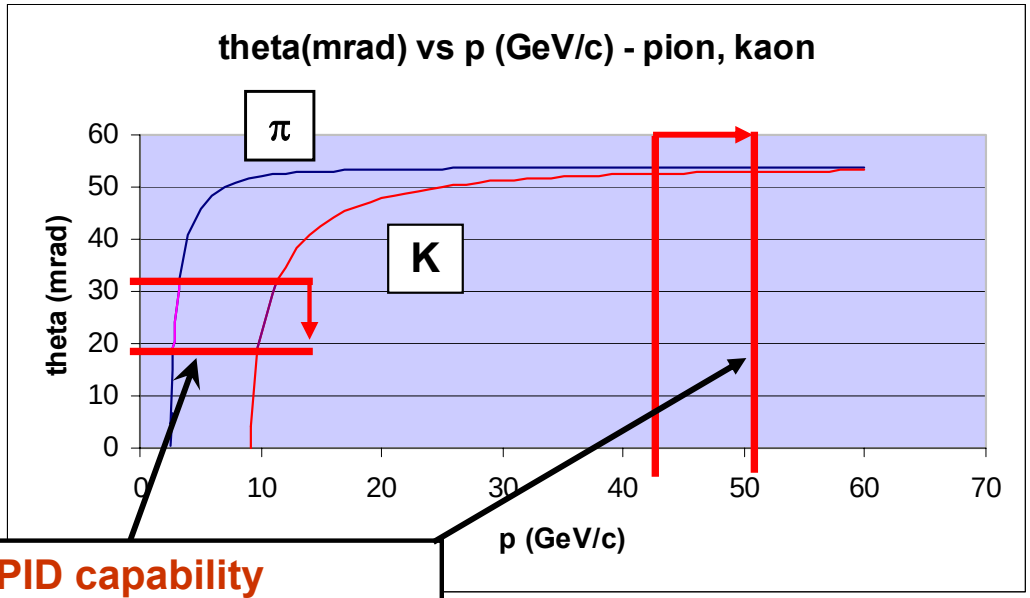
Expected performances:

- σ_{ph} = 2.4 mrad (ß~1) - *before: 1.2 mrad*
- N_{ph}/ring ~ 40 (ß~1) - *before: 14*
- σ_{ring} ~ 0.4 mrad (ß~1)
  - *before: σ_{ring} = 0.6 mrad*
- 2σ π/K separation at p ~ 50 GeV/c
  - *before: p ~ 40 GeV/c*
- PID efficiency > 95% (ß > 0.9993)

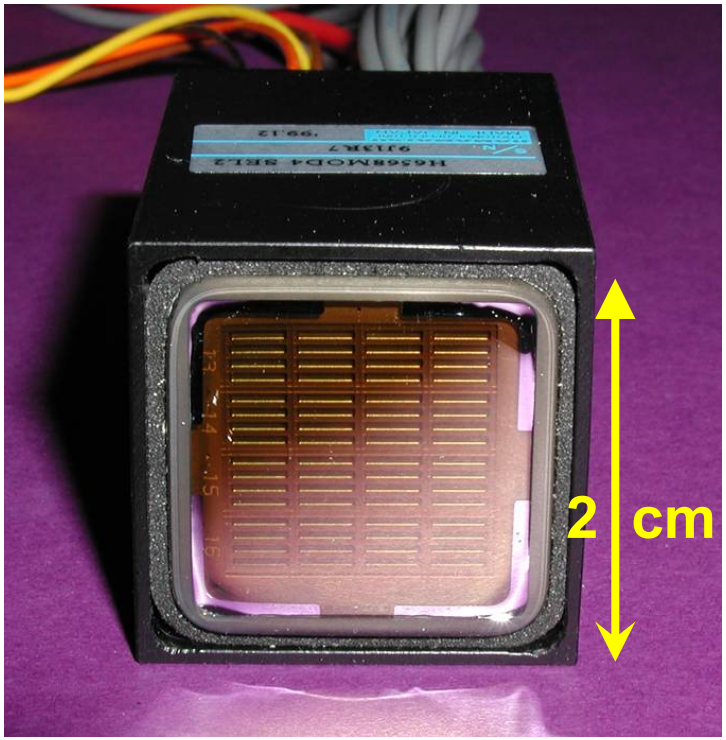


E. Albrecht et al, NIM A 33 (2003) 127



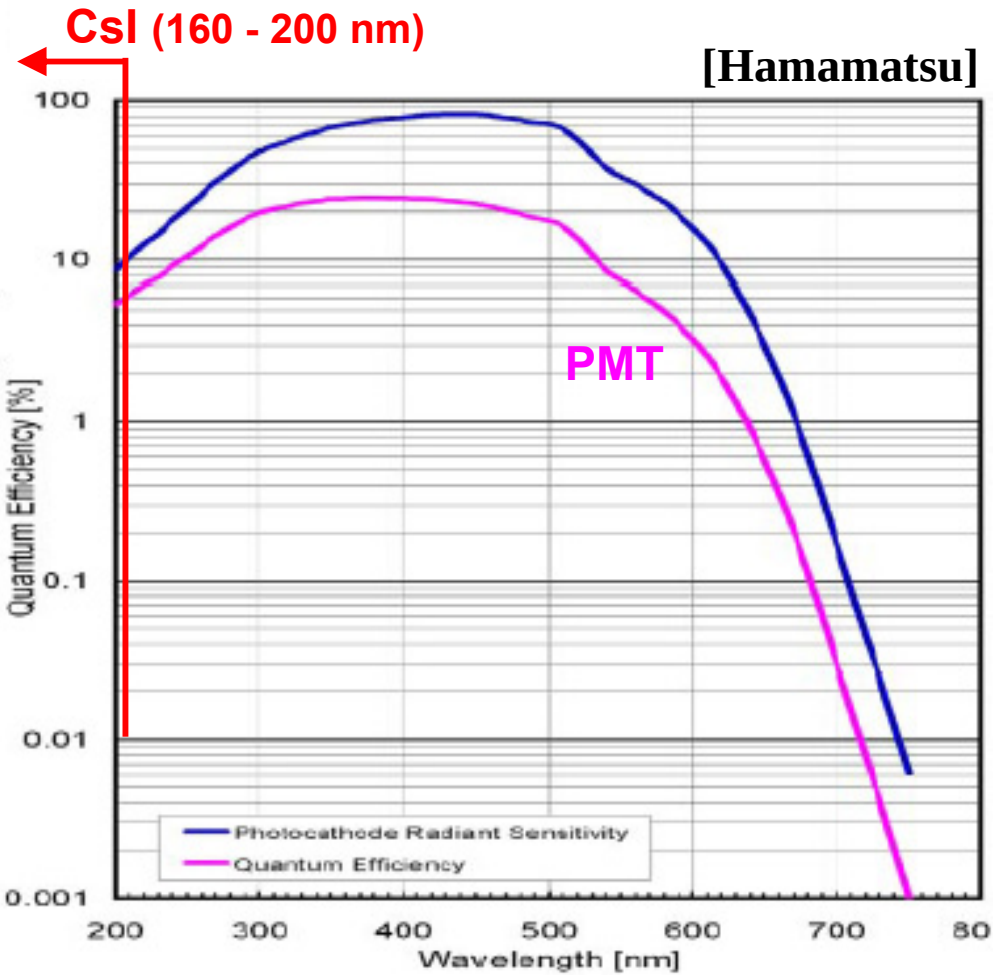


Hamamatsu H7600-03-M16 photomultiplier



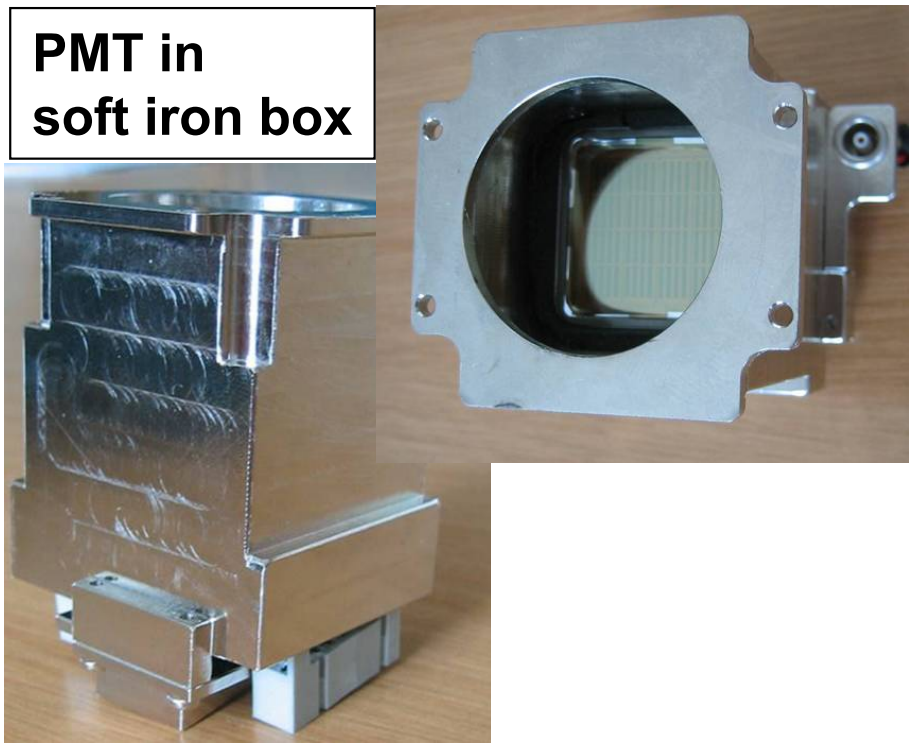
- bialkali photocathode
- 18 x 18 mm^2 active area
- 16 pixel
- time resolution 300 ps
- UV transparent borosilicate glass window

Larger number of detected Cherenkov photons, due to larger wavelength range:



Hamamatsu H7600-03-M16 photomultiplier

PMT in soft iron box



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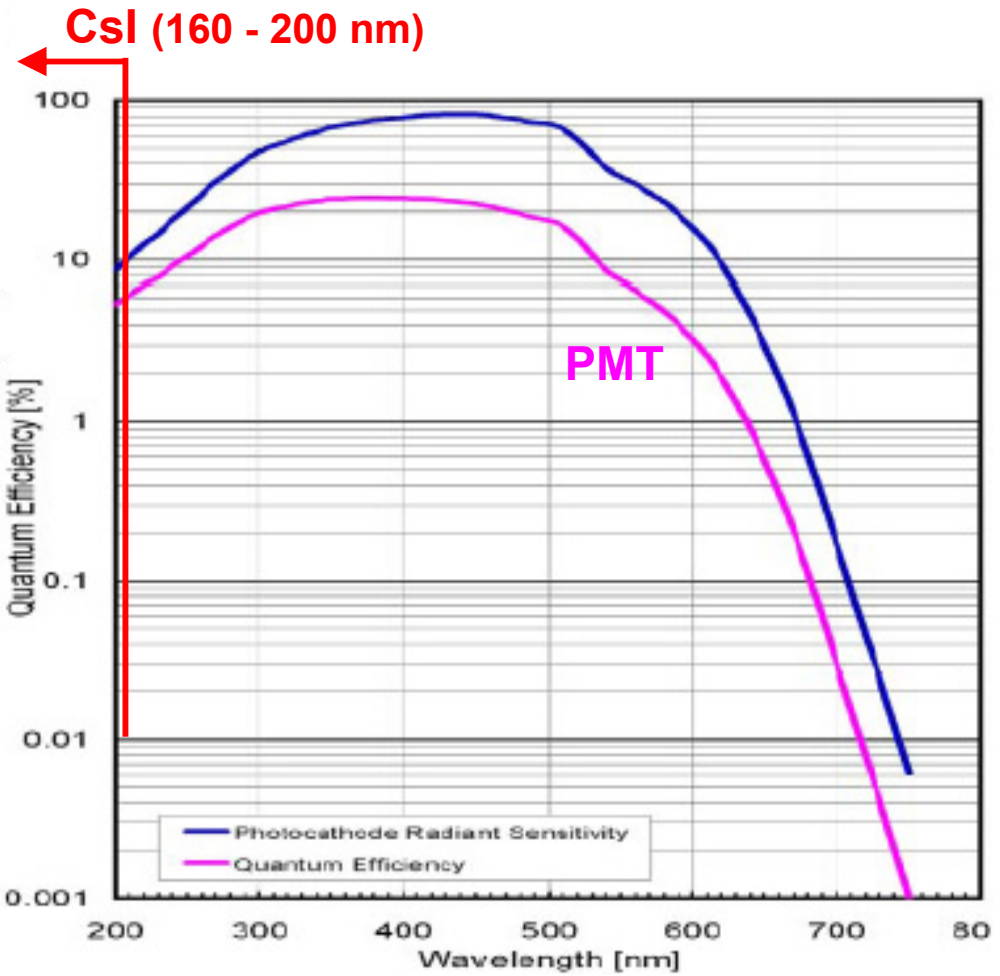

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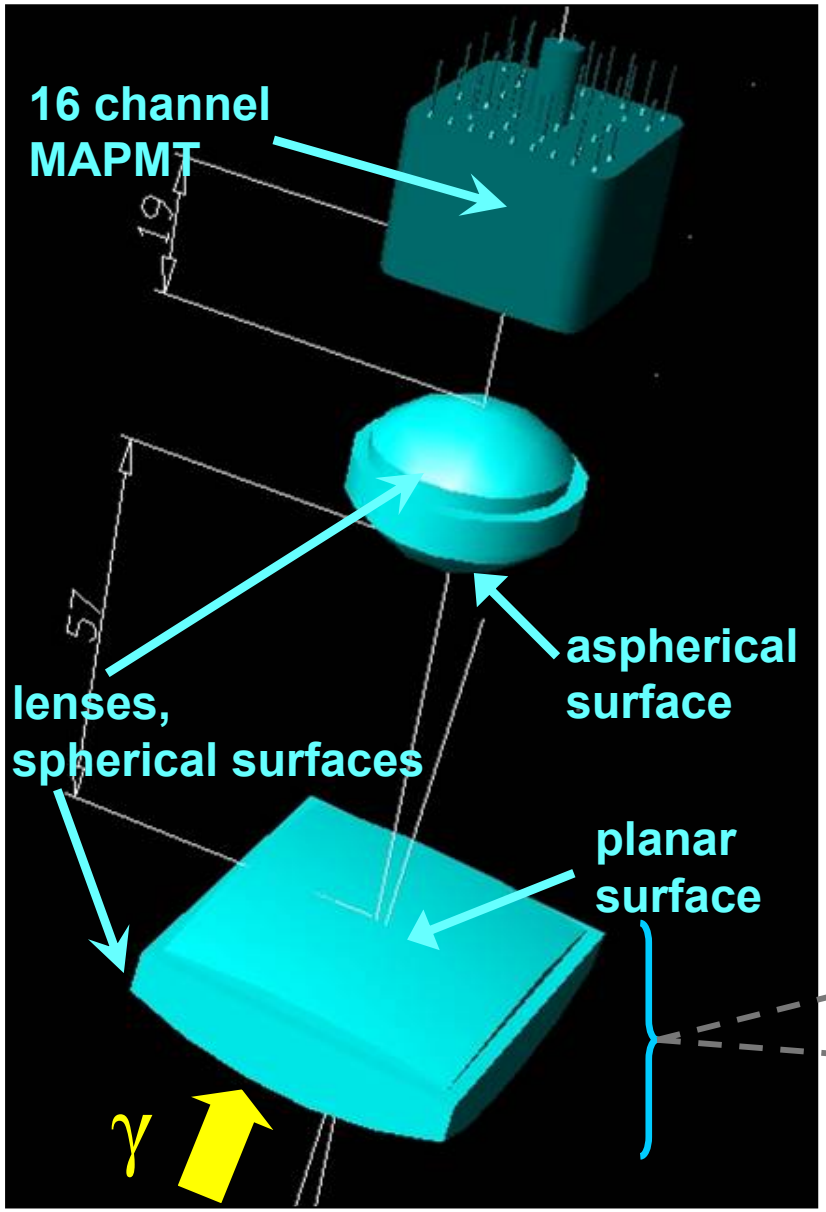
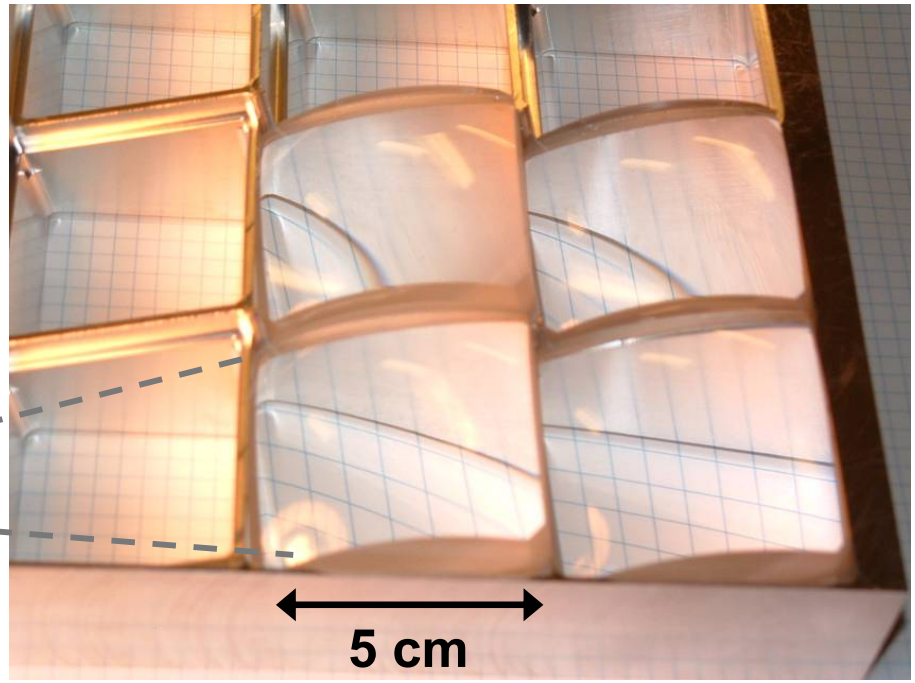
576 telescopes made of silica lenses



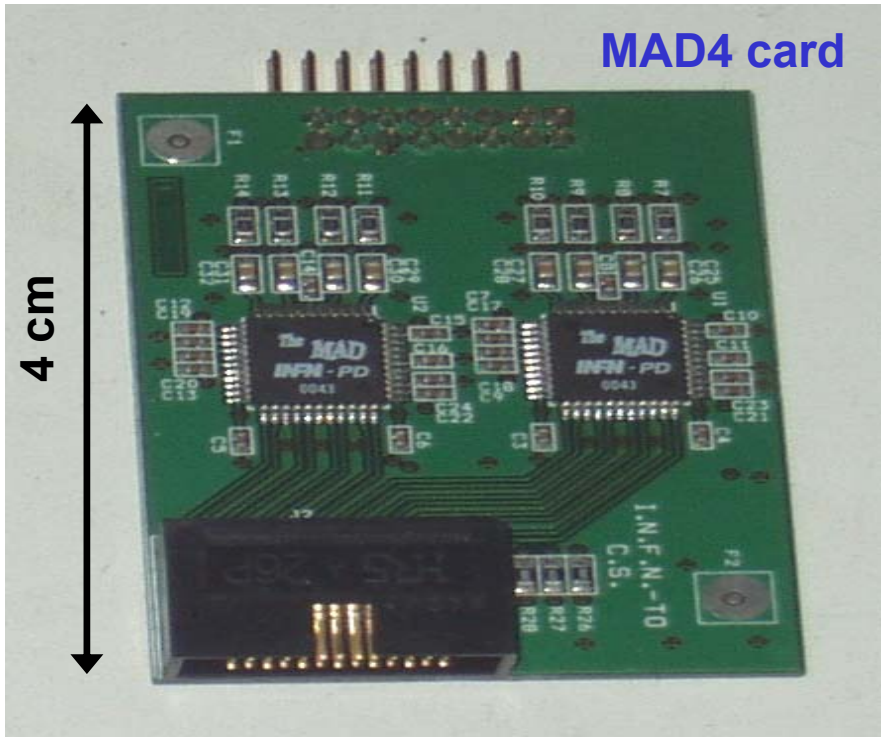
Telescope system consisting of 2 lenses:

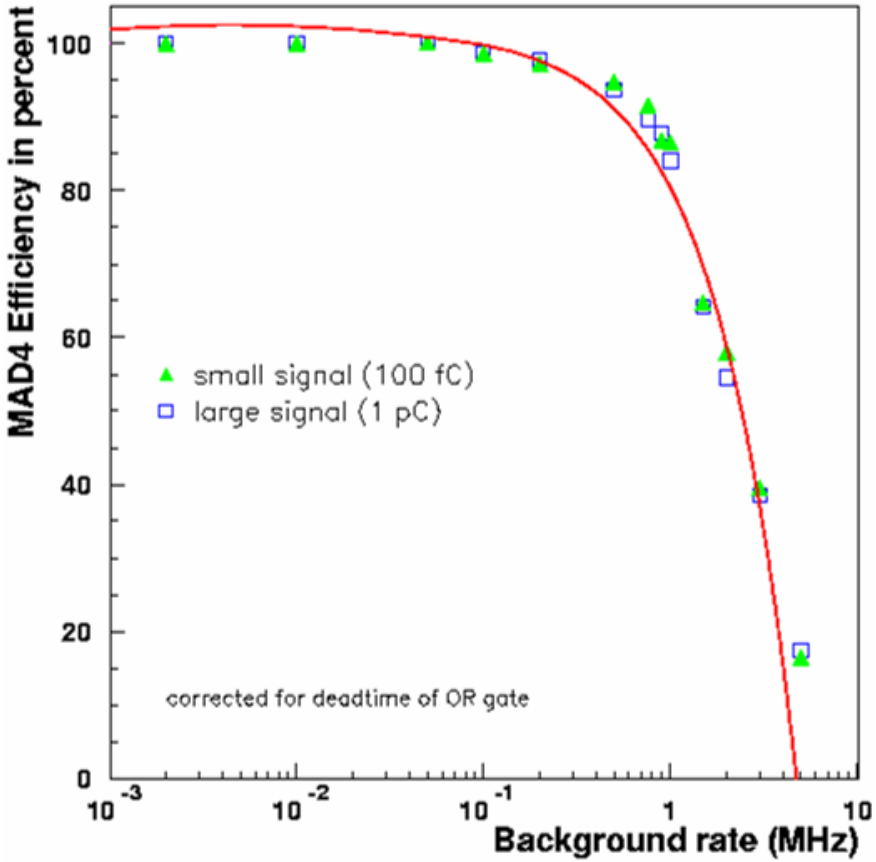
- Purpose: Focussing Cherenkov photons on MAPMTs (factor 7)
- UV transparent quartz lenses
- large geometrical acceptance
- minimum image distortion
- optimised by Zemax simulation



Analogue read-out electronics: MAD4 pre-amplifier

- up to ~ 1 MHz/channel; possible upgrade next year CMAD ~ 5 MHz hit rate per channel
- low noise (connected to PMT) ~ 5-7 fC
- PMT signal (single photon) ~ 1 pC (at 900 V)
- clear separation signal / noise



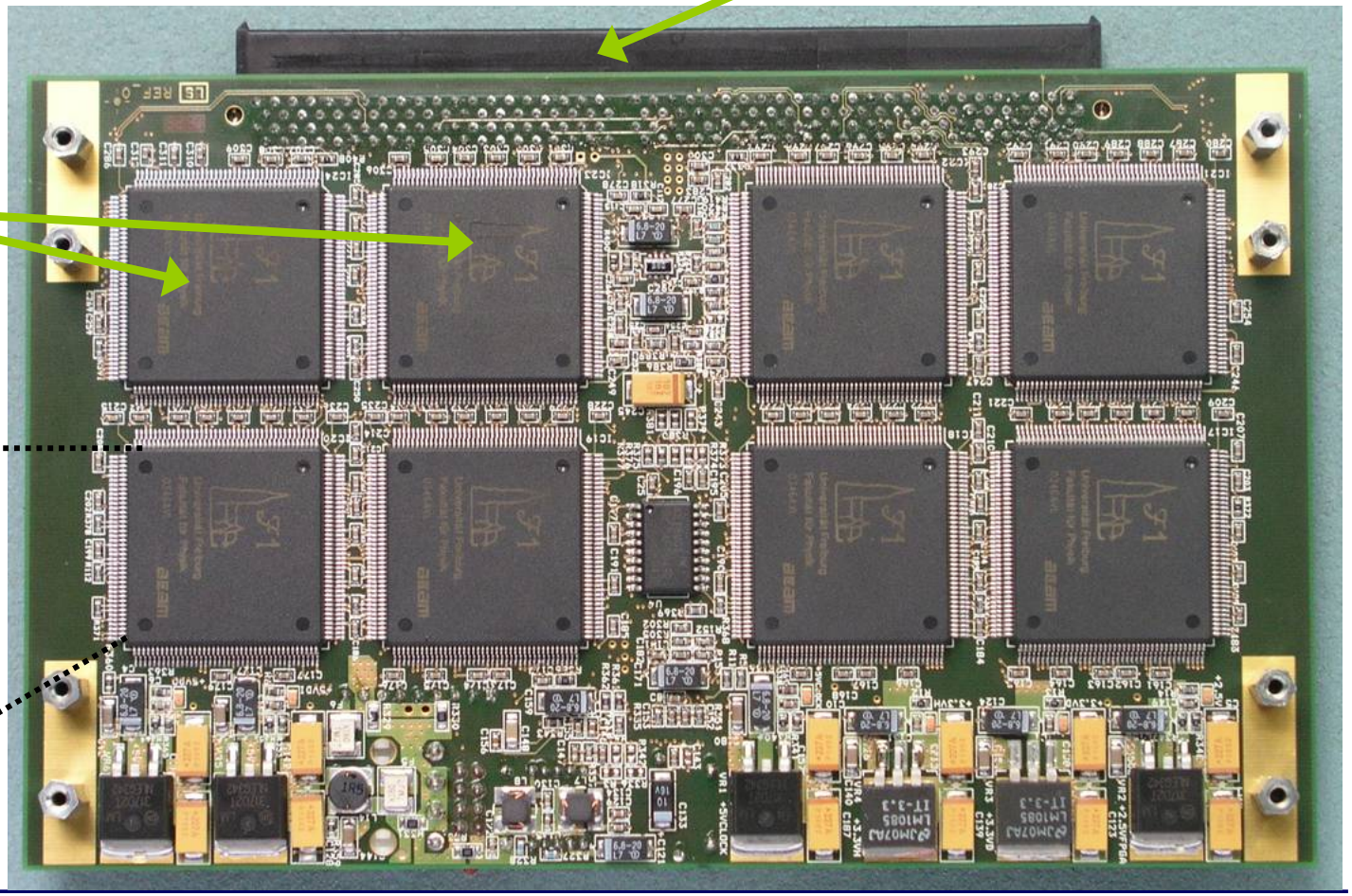


Digital read-out electronics: DREISAM card (Dreisam is a small river in Freiburg)

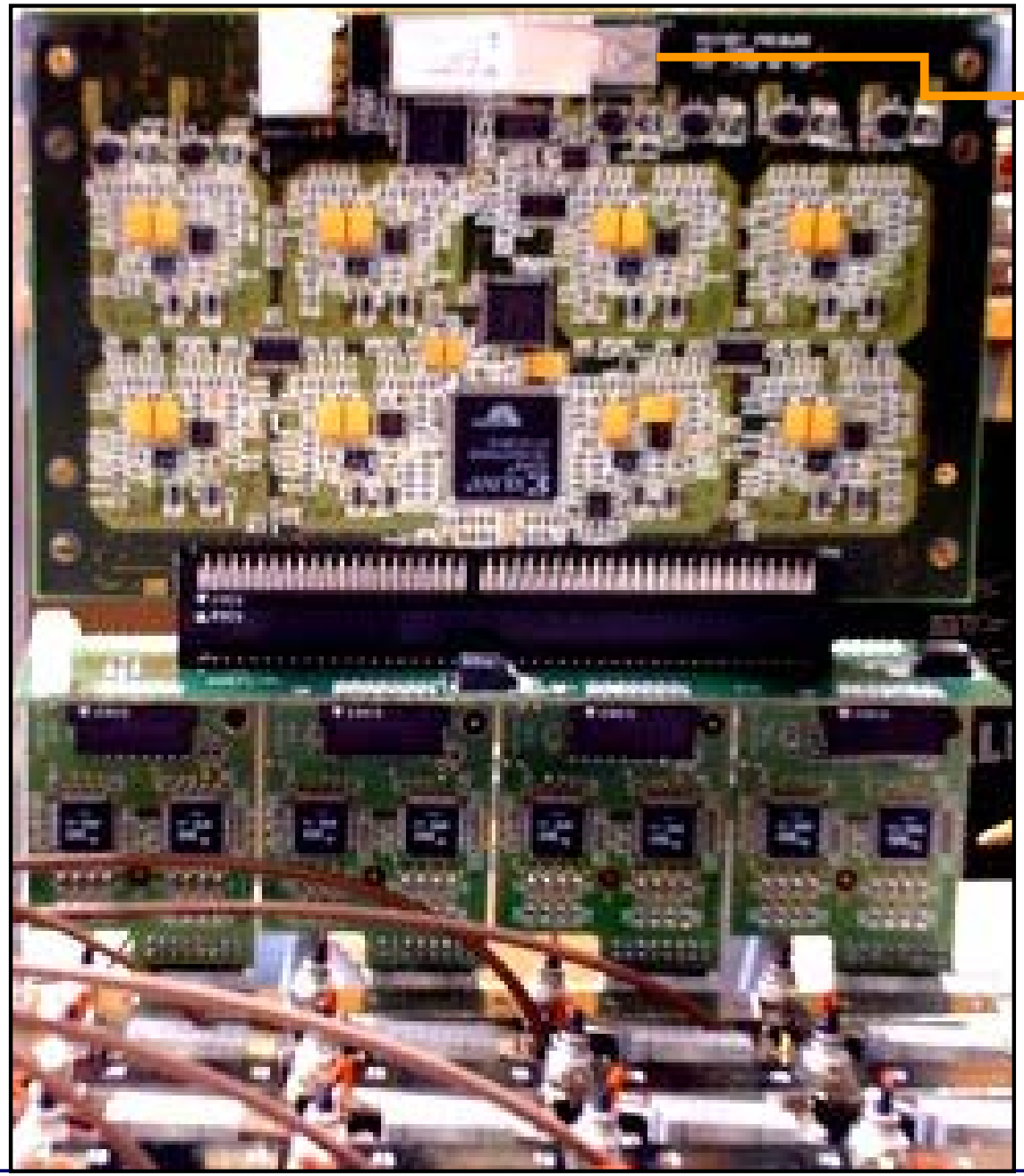
- 64 channels per card , compact solution
- data transfer optically (40 MByte/s)
- max rates per channel 10 MHz @ 100 kHz trigger rate
- time resolution < 120 ps
- based on dead time free F1-TDC

Connector to MAD4

8 F1-TDCs



Complete FE set-up



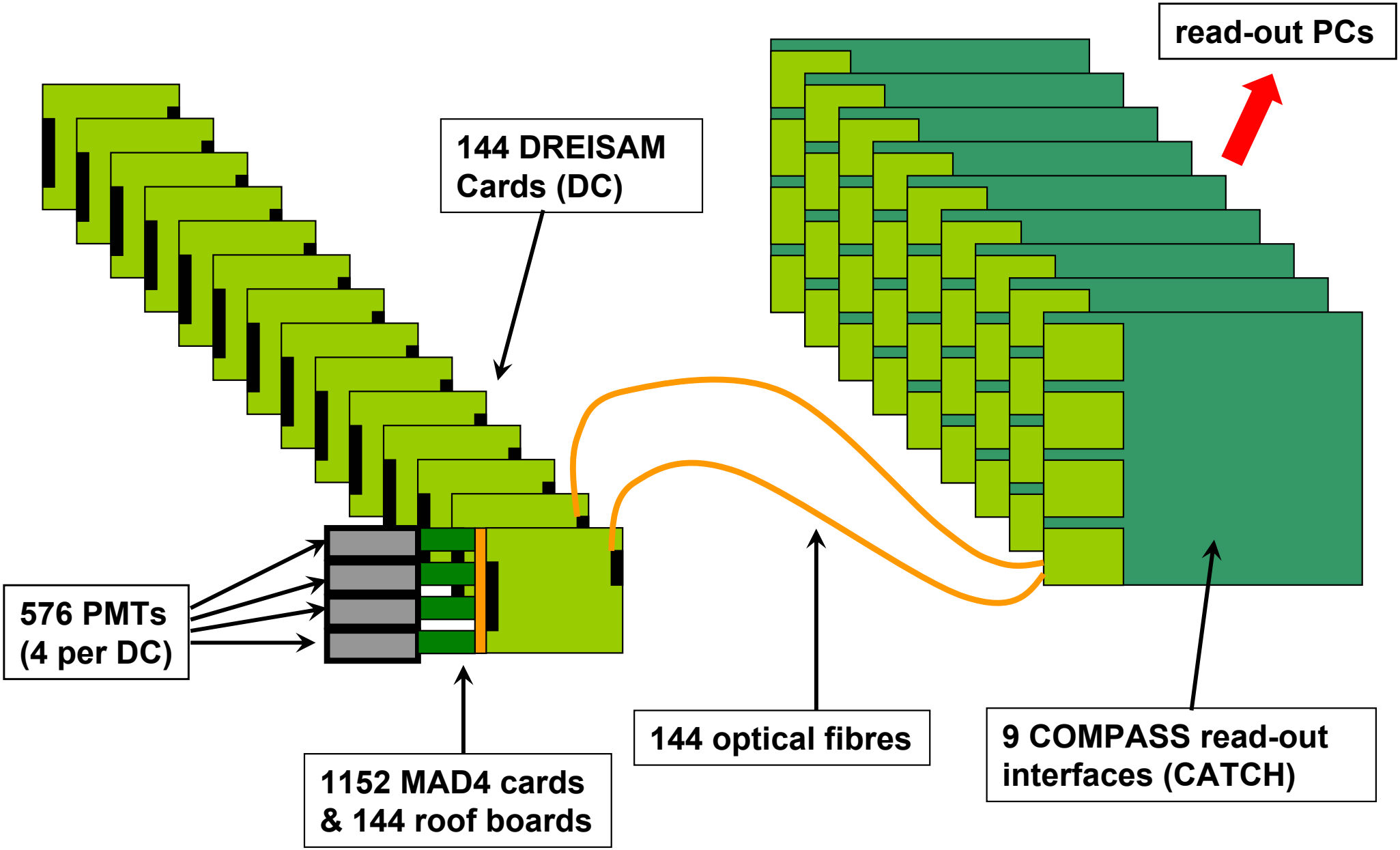
Optical fibre to CATCH

DREISAM card (TDC-F1)

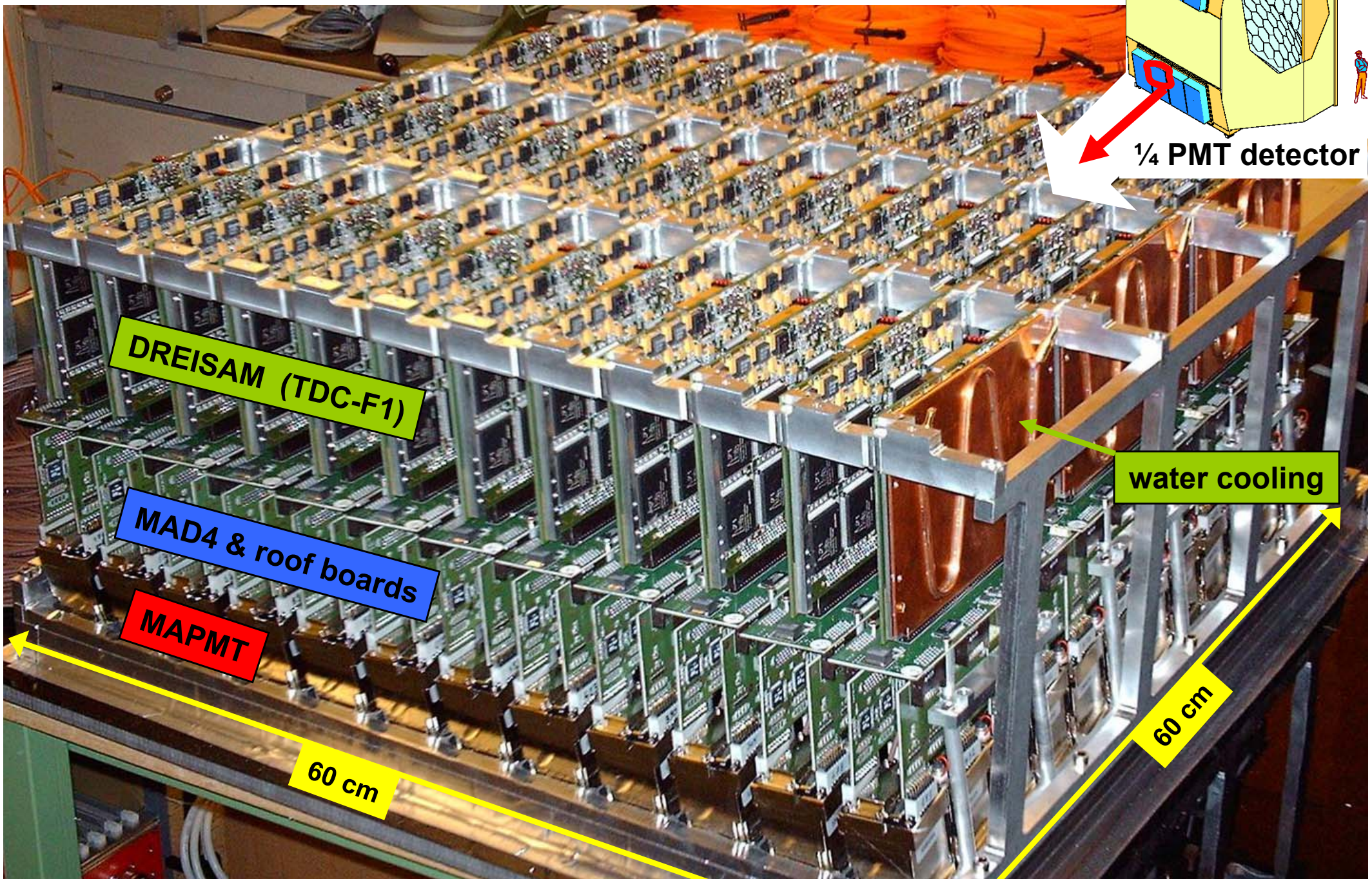
MAD4 discriminators

MAPMTs

Data transfer

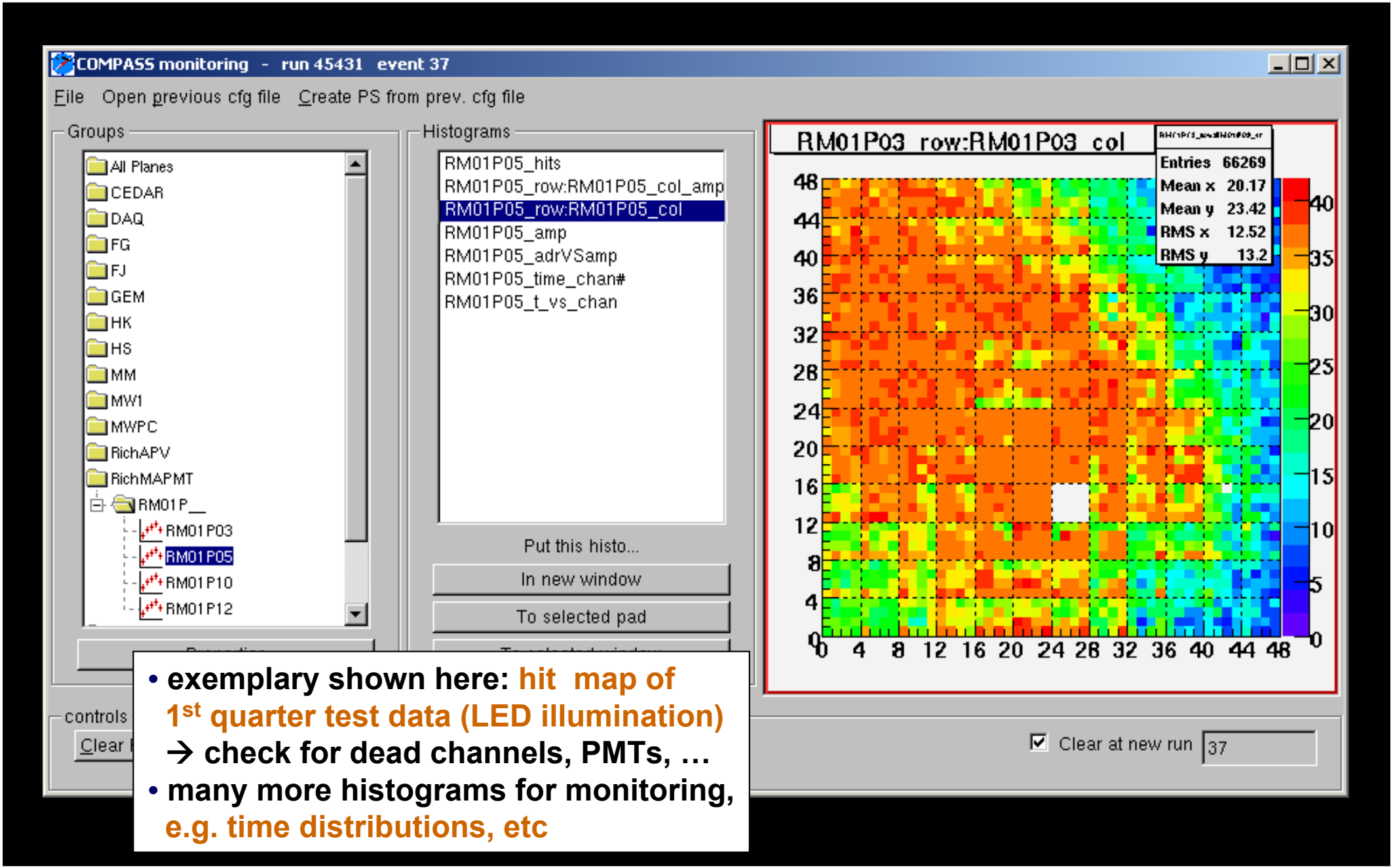


Read-out electronics of 1st quarter



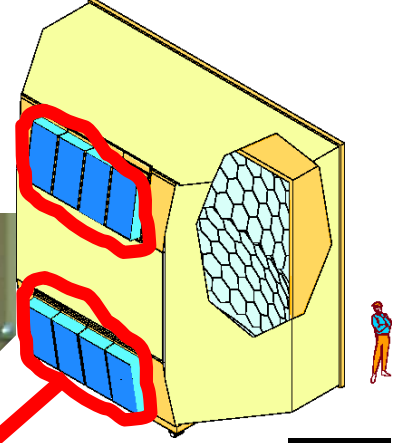
Monitoring of RICH MAPMT with COOOL

(COMPASS Object Oriented Library)



- **exemplary shown here: hit map of 1st quarter test data (LED illumination)**
  → check for dead channels, PMTs, …
- **many more histograms for monitoring, e.g. time distributions, etc**

Status & prospectives



- Full detector, i.e. all 4 quadrants assembled & tested
- Monitoring software available
  → ready for beam June 2006
- SPS beam scheduled July 2006
  → stay tuned for new exciting COMPASS results

Status presented thanks to many colleagues …
The COMPASS RICH upgrade team:

(Note: Apart from prel. studies, ~ 2 years for constr. & realisation only)

P.Abbon(11), M.Alekseev(12), H.Angerer(9), M. Apollonio(13), R.Birsa(13), P.Bordalo(7), F.Bradamante(13), A.Bressan(13), L.Busso(12), M.Chiosso(12), P.Ciliberti(13), M.L.Colantoni(1), S.Costa(12), N.Dibiase(12), T.Dafni(11), S.Dalla Torre(13), V.Diaz(13), V.Duic(13), E.Delagnes(11), H.Deschamps(11), W.Eyrich(4), D.Faso(12), A.Ferrero(12), M.Finger(10), M.Finger Jr(10), H.Fischer(5), S.Gerassimov(9), M.Giorgi(13), B.Gobbo(13), D.von Harrach(8), F.H.Heinsius(5), R. Joosten(2), B.Ketzer(9), K.Königsmann(5), V.N. Kolosov(3)*, I.Konorov(9), D.Kramer(6), F.Kunne(11), S. Levorato(13), A.Maggiora(12), A.Magnon(11), A.Mann(9), A.Martin(13), G.Menon(13), A.Mutter(5), O. Nähle(2), D.Neyret(11), F.Nerling(5), P.Pagano(13), S.Paul(9), S.Panebianco(11), D.Panzieri(1), G.Pesaro(13),C. Pizzolotto(4), J. Polak(6), P.Rebourgeard(11), E. Rocco(13), F.Robinet(11), P.Schiavon(13), C.Schill(5), P.Schoenmeier(4), L.Silva(7), M.Slunecka(10), L.Steiger(10), F.Sozzi(13), M.Sulc(6), M.Svec(6), F.Tessarotto(13), A.Teufel(4), H. Wollny(5)

(1) INFN, Sezione di Torino and Universita' del East Piemonte, Alessandria, Italy

(2) Universität Bonn, Helmholtz-Institut für Strahlen- und Kernphysik, Bonn, Germany

(3) CERN, European Organization for Nuclear Research, Geneva, Switzerland

(4) Universität Erlangen–Nürnberg, Physikalisches Institut, Erlangen, Germany

(5) Universität Freiburg, Physikalisches Institut, Freiburg, Germany

(6) Technical University of Liberec, Liberec, Czech Republic

(7) LIP, Lisbon, Portugal

(8) Universität Mainz, Institut für Kernphysik, Mainz, Germany

(9) Technische Universität München, Physik Department, Garching, Germany

(10) Charles University, Praga, Czech Republic and JINR, Dubna, Russia

(11) CEA Saclay, DSM/DAPNIA, Gif-sur-Yvette, France

(12) INFN, Sezione di Torino and Universita' di Torino, Torino, Italy

(13) INFN, Sezione di Trieste and Universita' di Trieste, Trieste, Italy