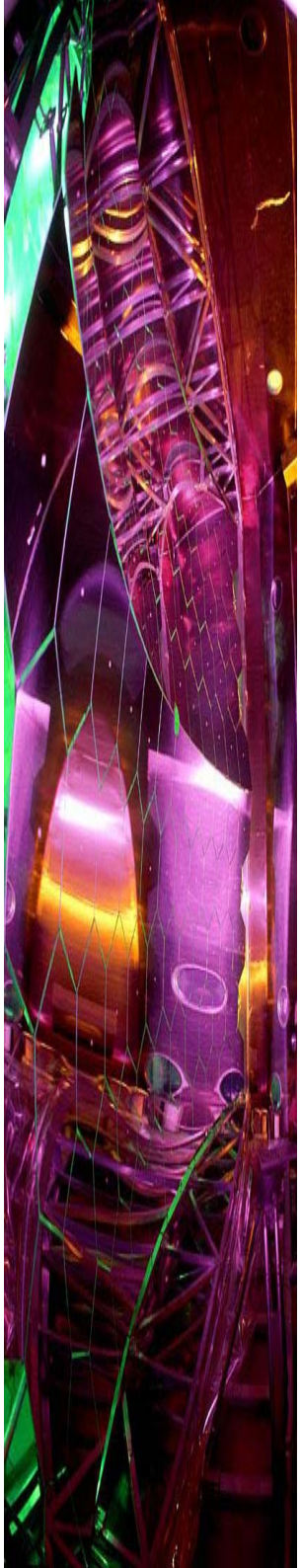
Il RICH-1 di COMPASS dopo l'upgrade: progetto, realizzazione e caratterizzazione del rivelatore durante la presa dati 2006

M. Chiosso

Congressino di Sezione, Torino 23/01/07



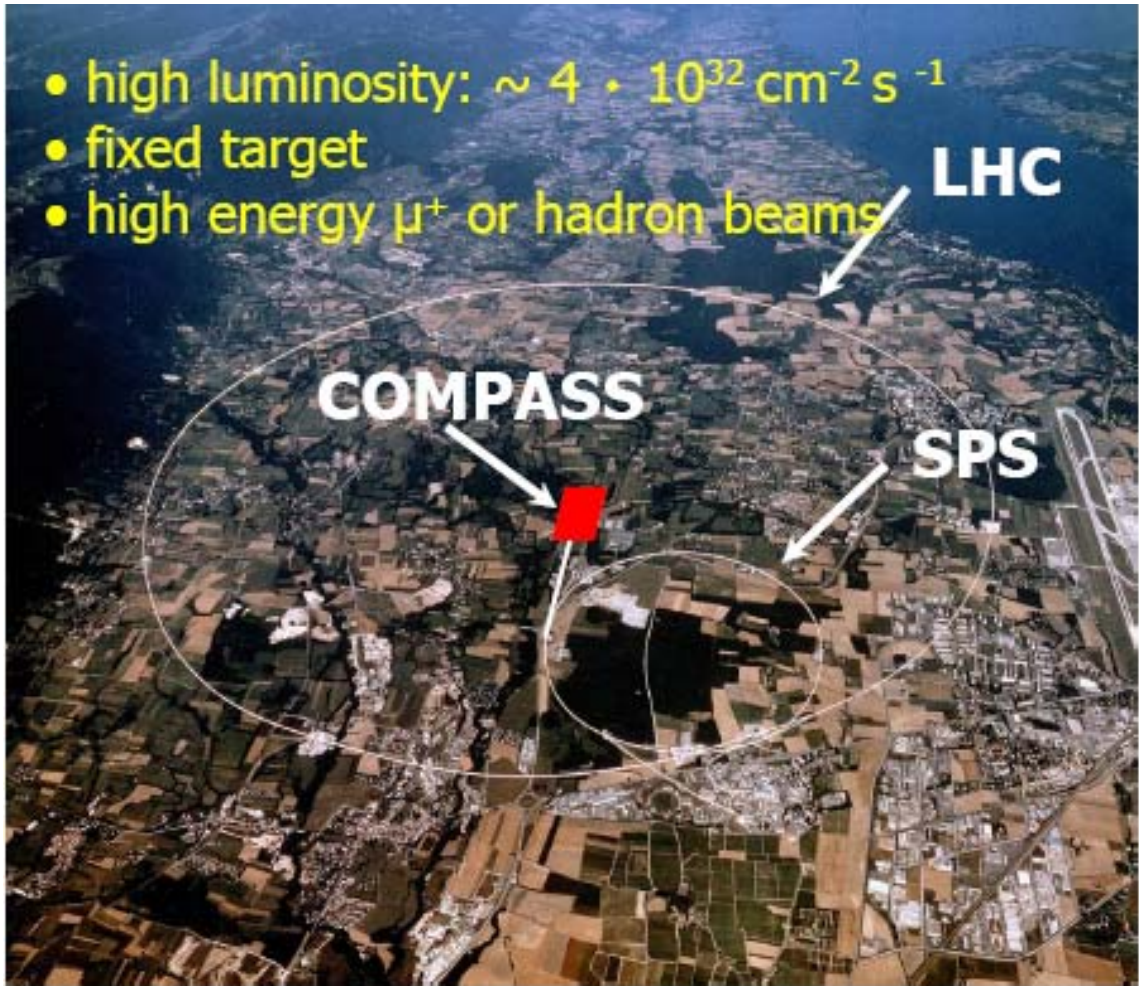
The RICH upgrade

- Introduction
- Motivation of the project
- The detector upgrade
  - optics
  - photon detectors
  - read-out electronics
  - installation
- Preliminary characterization
- Project of an upgraded front-end chip: C-MAD

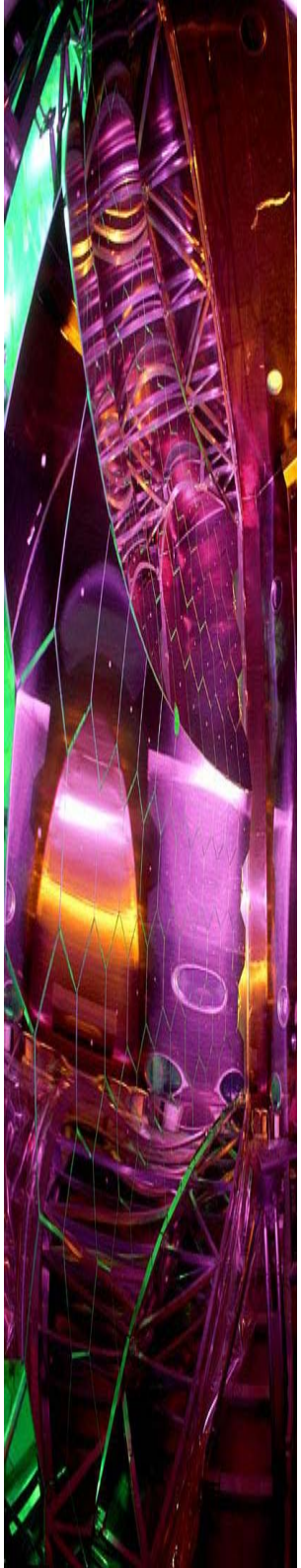
The COMPASS experiment

COmmon Muon Proton Apparatus for Structure and Spectroskopy

270 physicists, 25 institutes, 11 countries



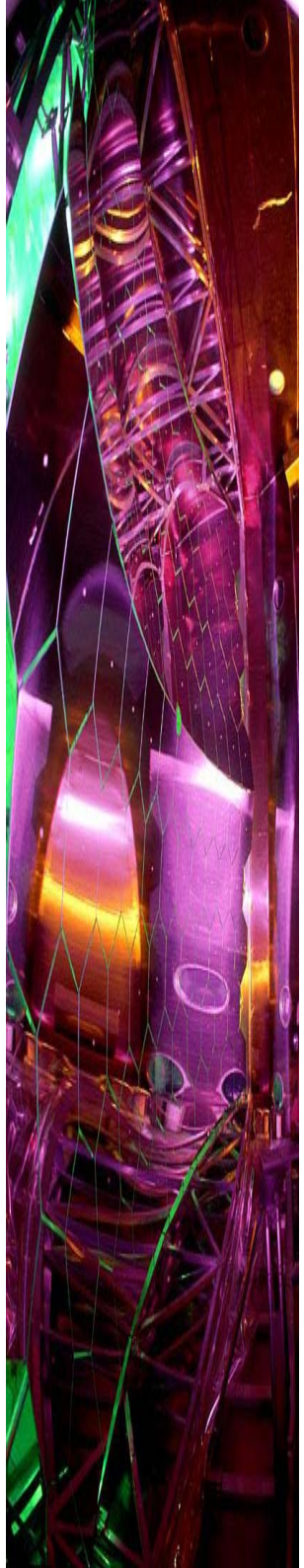
- nucleon structure measurements
- hadron spectroscopy measurements



The COMPASS experiment

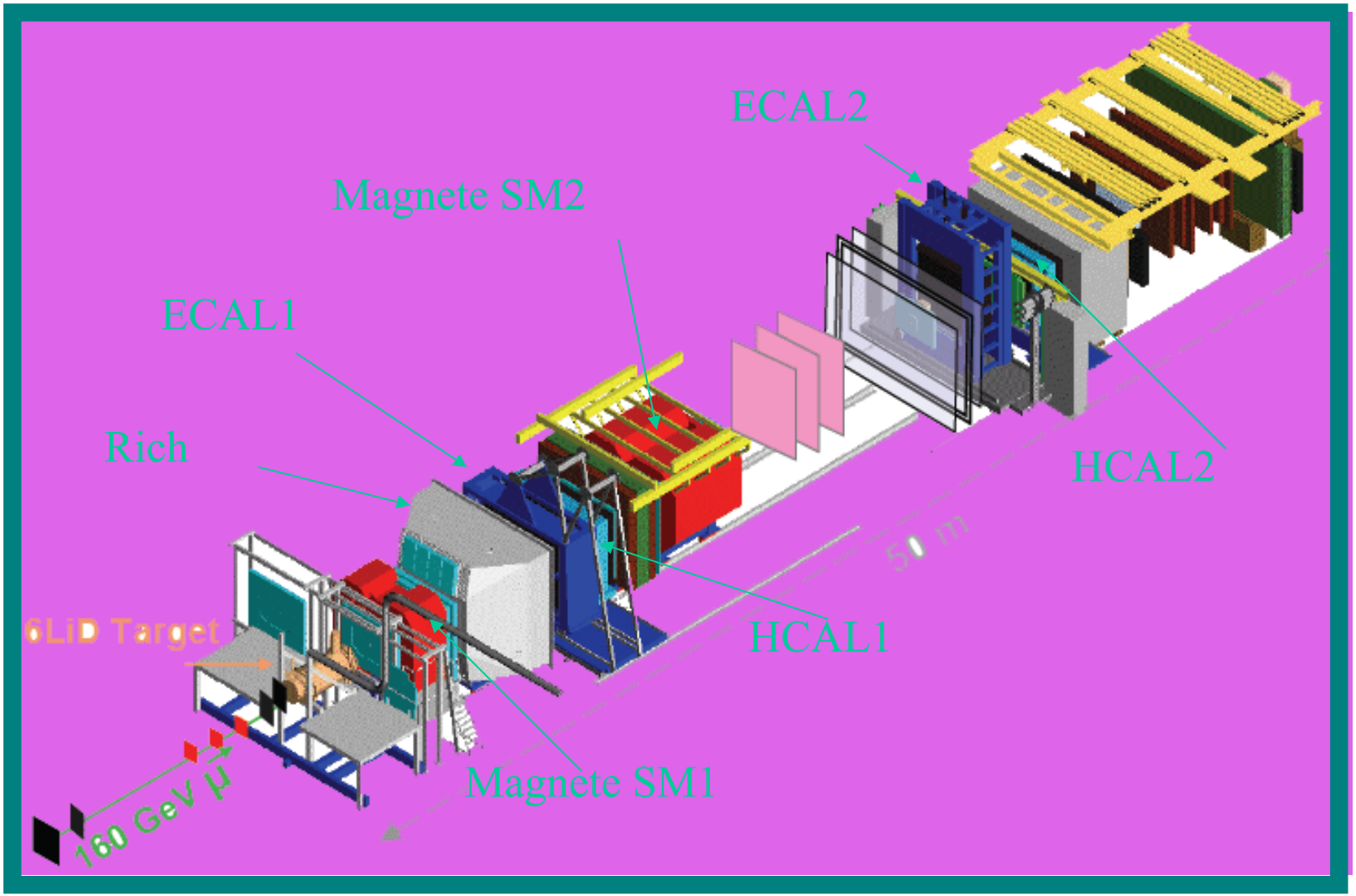
COmmon Muon Proton Apparatus for Structure and Spectroskopy

- Approved by CERN in October 1998
- 2001: technical run
- 2002-2004: physics runs
- 2005: spectrometer upgrade (during shutdown of CERN accelerator)
- 2006: resumed data taking
- Up to now only muon data were taken, apart from a two weeks pilot run with pion beam, in 2004

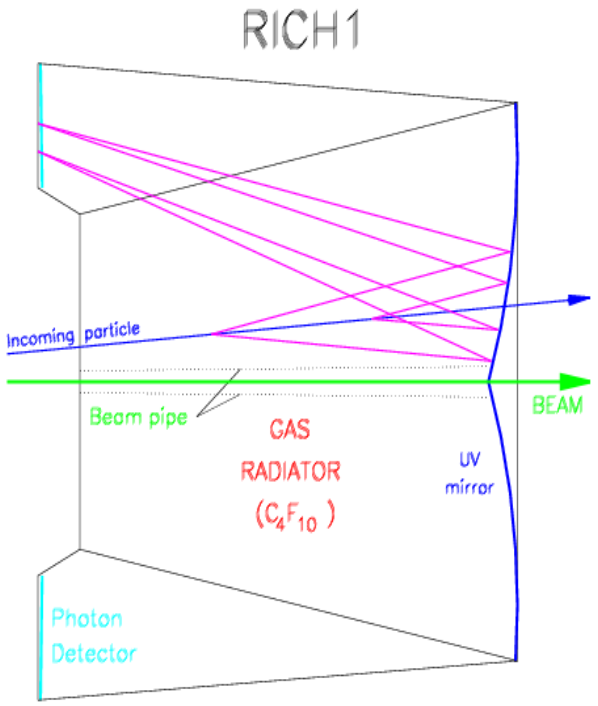


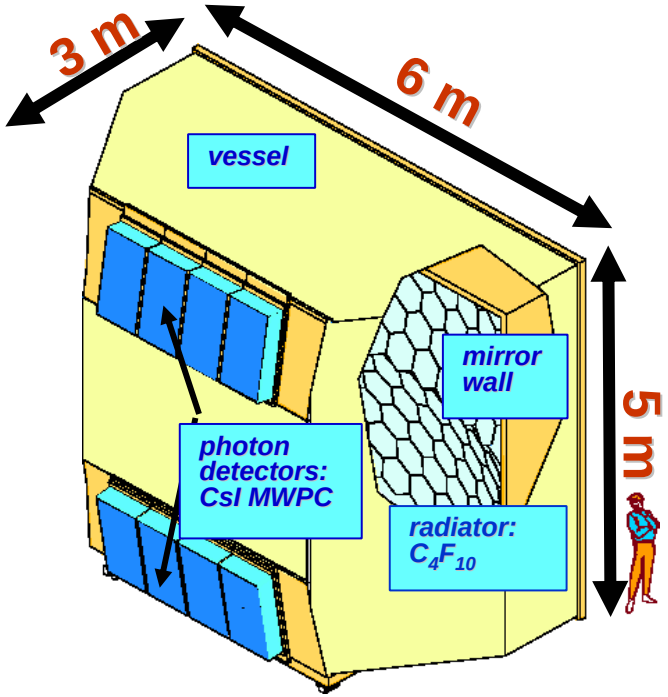
The COMPASS spectrometer

COmmon Muon Proton Apparatus for Structure and Spectroskopy



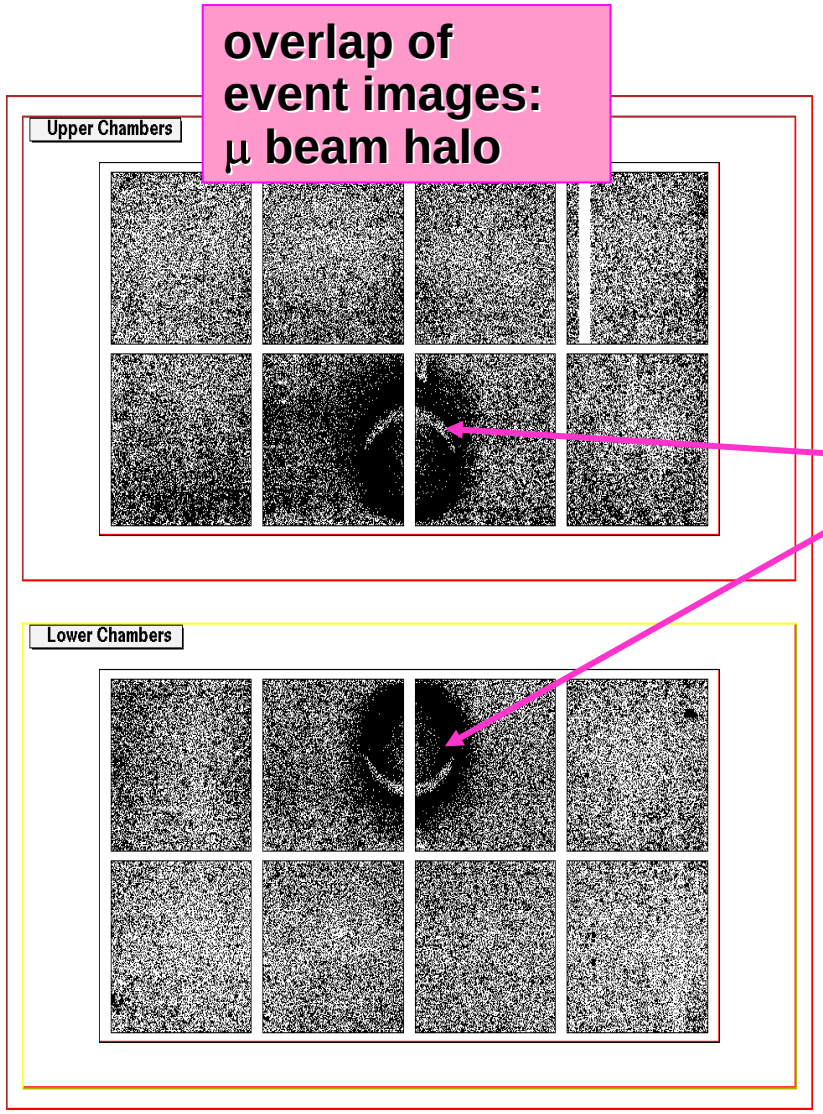
Il RICH di COMPASS





- radiator gas: C_4F_{10}
- mirrors: 21 m^2 di superficie
- photon-detectors: Multi Wire Proportional Chamber (MWPC): 82944 18x18 mm^2 pad channels
- Angular acceptance: horizontal ±250 mrad, vertical ±180 mrad
- Wavelength range: 165 nm → 200 nm

The upgrade motivations



- Readout electronics based on Gassiplex chip (3μs integration time)
- THE EXPERIMENTAL ENVIRONMENT:

  large photon flux in the center (μ-halo)

  → high uncorrelated background
- New photon detection with MaPMT:

  excellent time-resolution → μ-halo rejected

  using time information
- In addition, higher rate operation:

  previously: 20 kHz

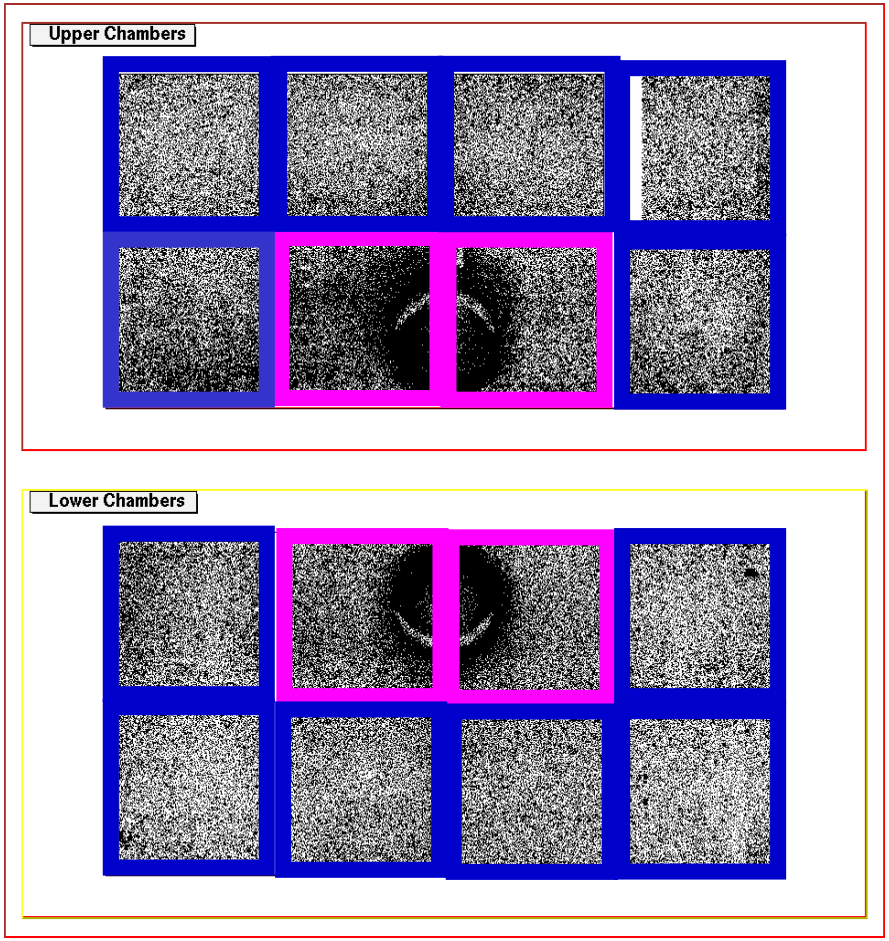
  now: up to 100 kHz

The upgrade project

MWPCs with CsI Photocathodes
(already in use since 2001)

read-out:
APV chip
negligible dead time
time resolution (MWPC + r-o):
~ 3 μs → ~ 400 ns

NOT DISCUSSED IN THIS TALK

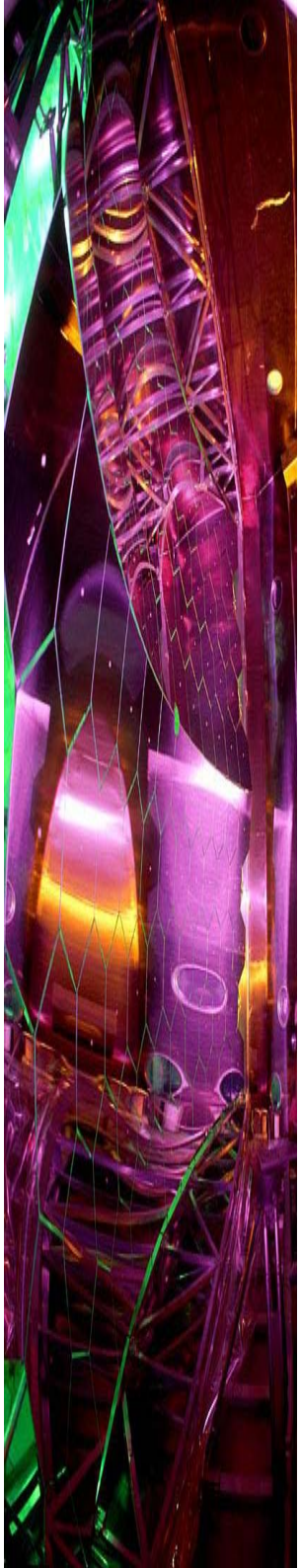


FAST photon detection system

- **MAPMTs** **576 in total**
- telescopes of fused silica lenses

- read-out :
  → sensitive FE:
  MAD chip
  → TDC: F1

  Time resolution: few ns



Performances

Before upgrade

photons / ring ($\beta \approx 1$)
14

$\sigma_{\theta\text{-ph}}$ ($\beta \approx 1$) : 1.2 mrad

σ_{ring} ($\beta \approx 1$) : 0.6 mrad

2.5σ π/K separation up to 43 GeV/c

Expected after upgrade

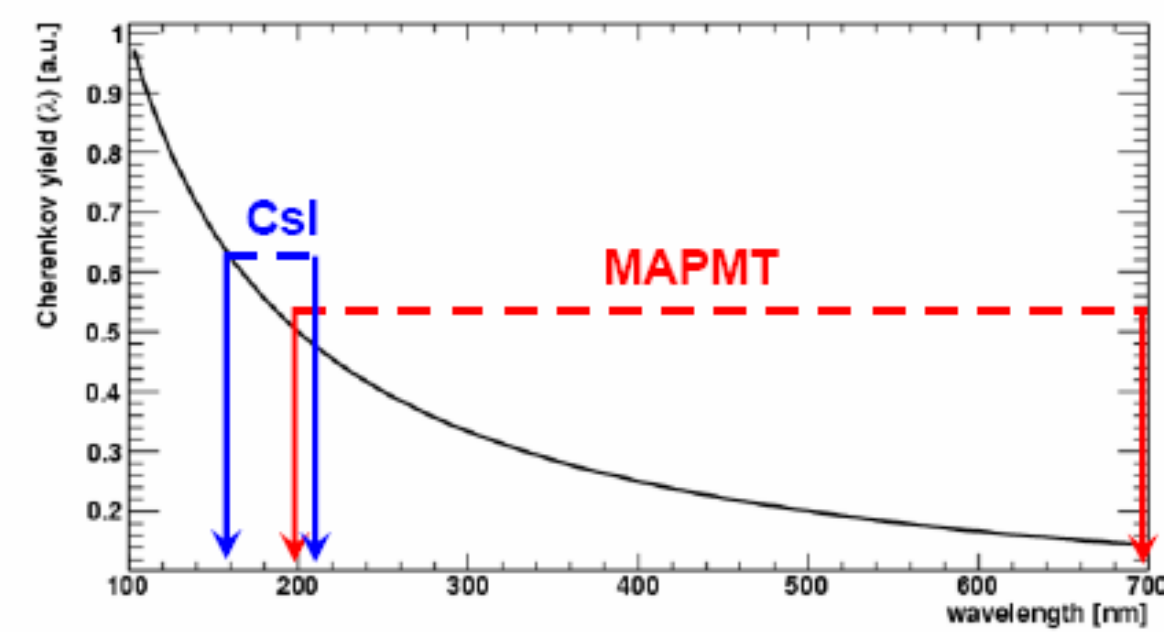
photons / ring ($\beta \approx 1$)
50-60

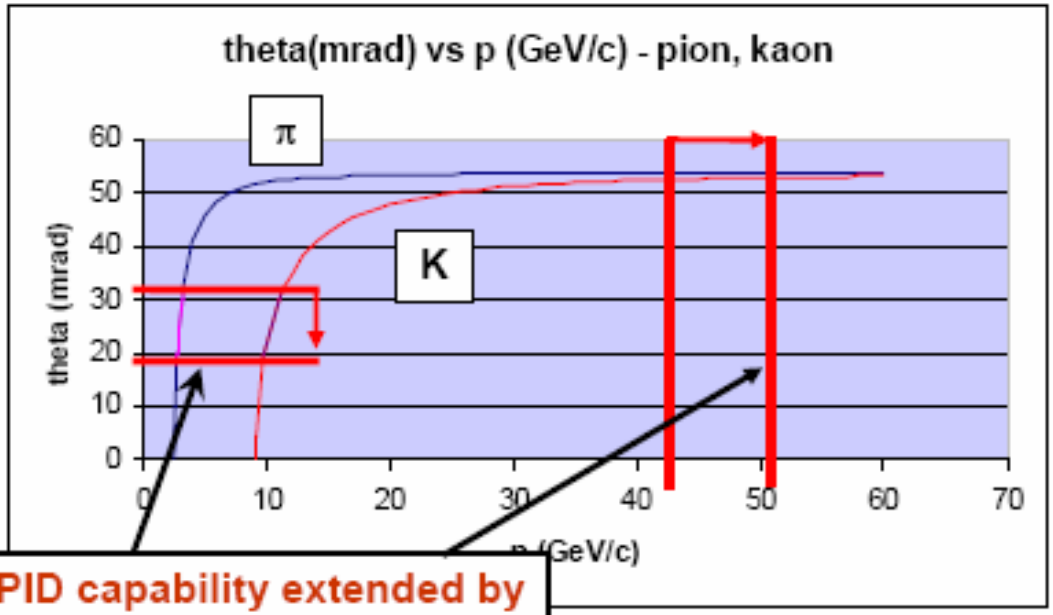
$\sigma_{\theta\text{-ph}}$ ($\beta \approx 1$) : 1.7 mrad

σ_{ring} ($\beta \approx 1$) : 0.4 mrad

2.5σ π/K separation up to 50 GeV/c

Upgraded Rich resolution





PID capability extended by increase in number of γ

Phast photo-detection system

Photon detectors : MAPMT

- wide wavelength range
- time resolution < 1 nsec
- adequate for high rate operation – up to which rate ?
- robust

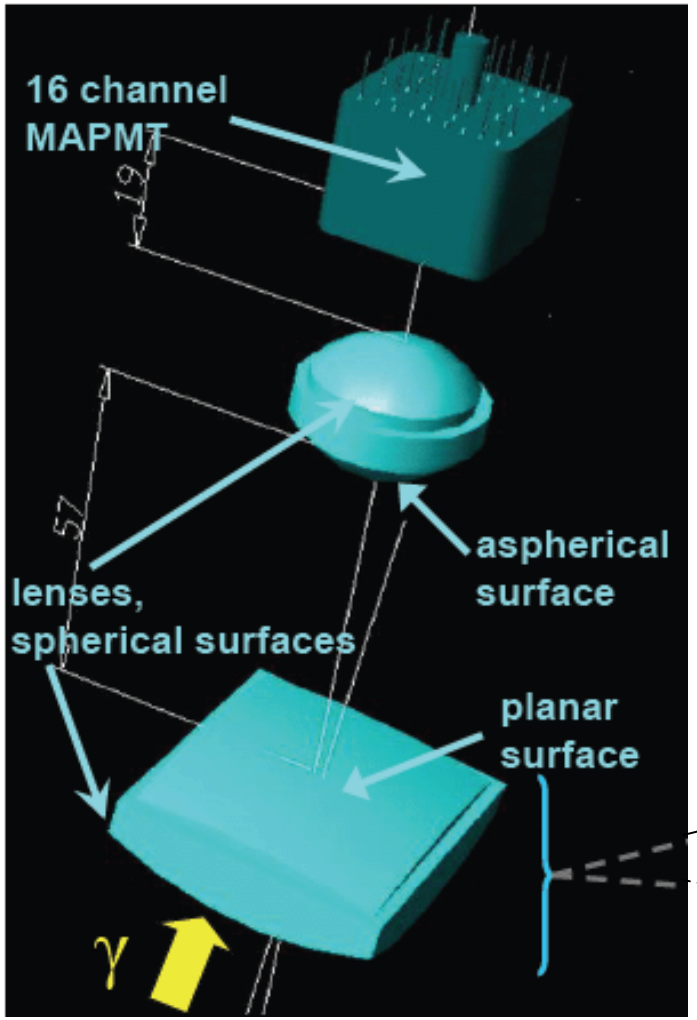
Summarising:

- good for next RICH generation
- but expensive for large surfaces

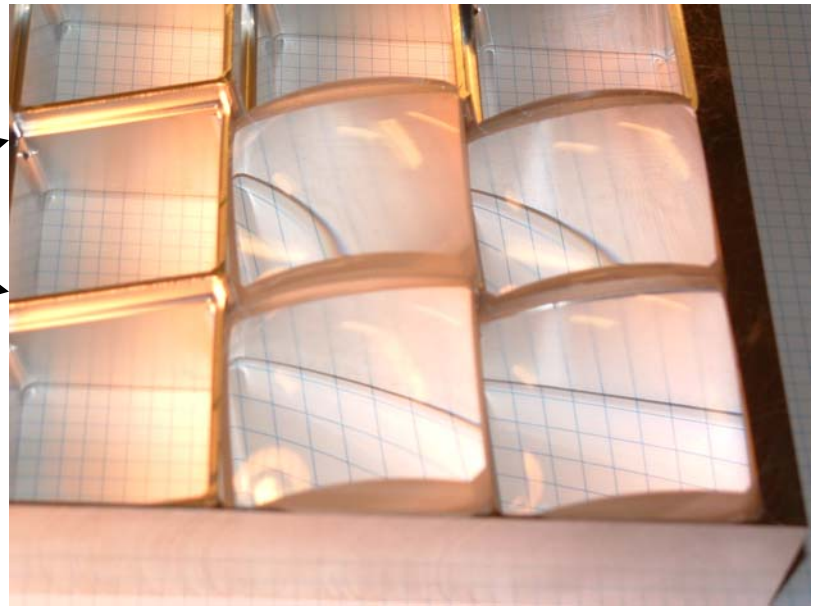
→ our challanges:

- large ratio of the collection and photocathode areas with minimal image distortion
  → ratio = 7.3 achieved ←→ LENS SYSTEM, critical design
- make use of the UV range ←→ fused silica LENSES
- couple to a read-out system able to guarantee efficiency, high rate operation and to preserve time resolution

576 telescopes



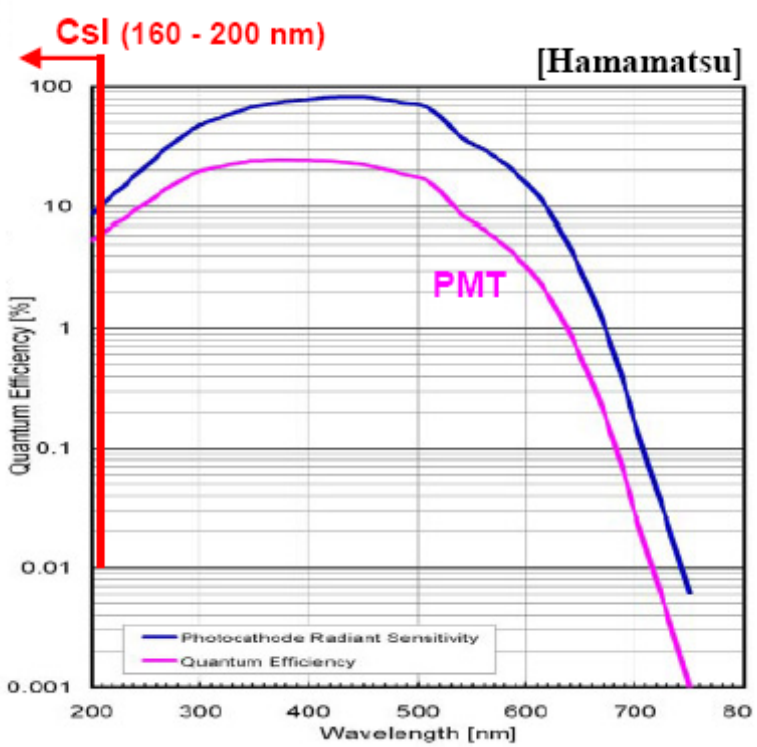
- Purpose: focusing cherenkov photons on MaPMTs
- UV transparent quartz lenses
- Large geometrical acceptance
- Minimum image distortion

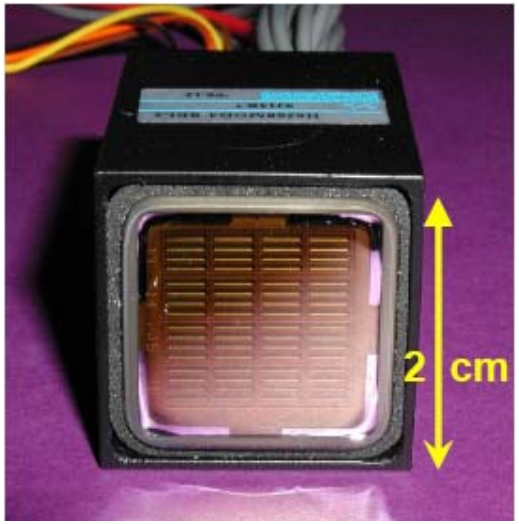


Mapmt

Hamamatsu R7600-03-M16:

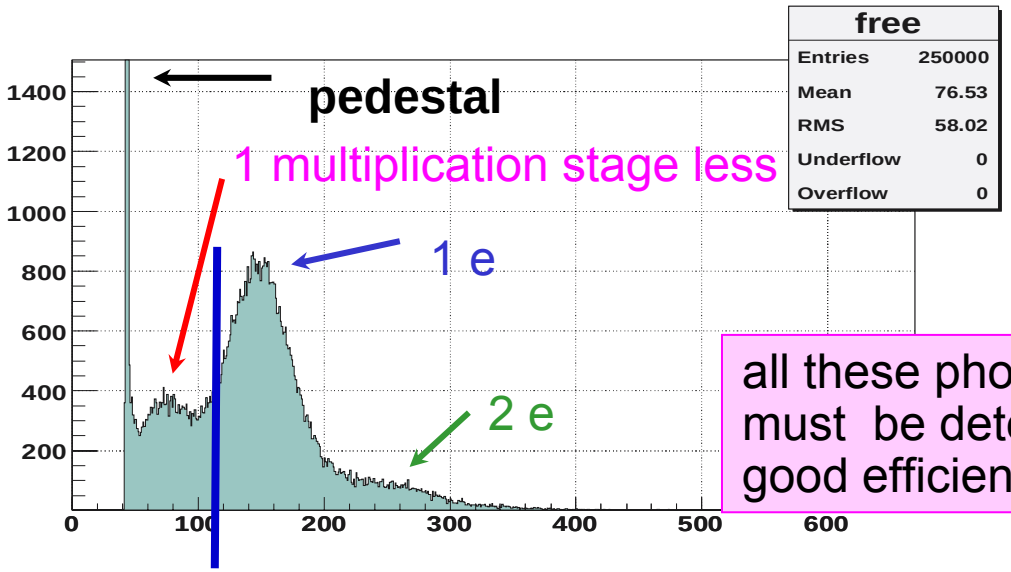
- bialkali photocathode, 18x18 mm^2 active surface, 16 pixels
- UV extended glass window with borosilicate glass (200 – 700 nm)





PMT in soft iron box

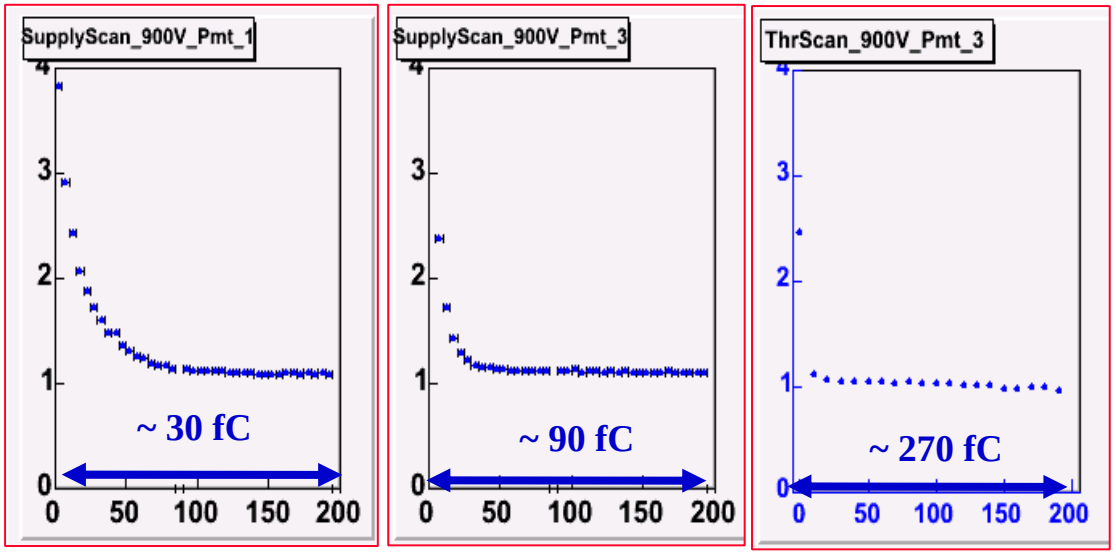
Single photoelectron detection



Wide dynamic range

all these photoelectrons must be detected for good efficiency

Hit multiplicity per event vs threshold



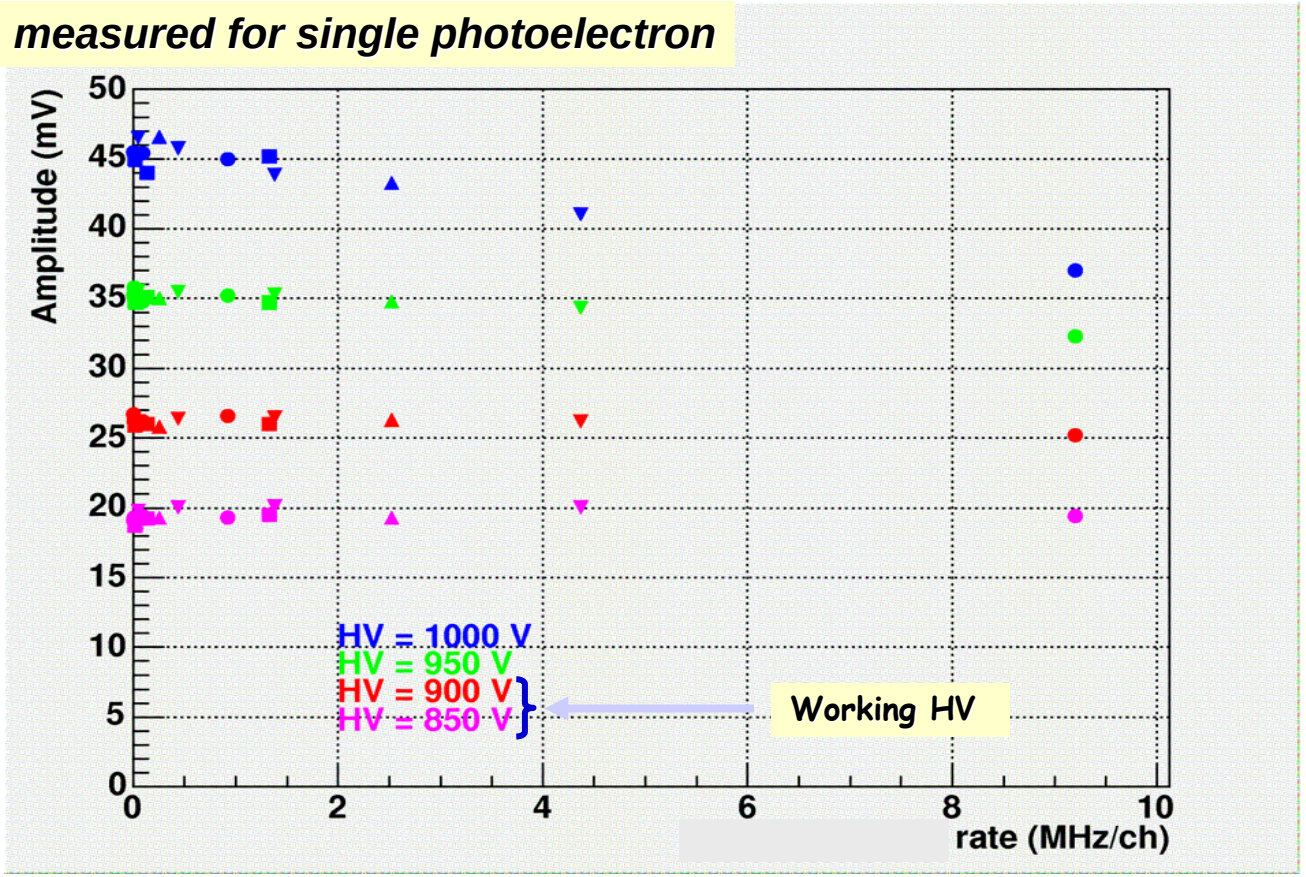
Large flat region between cross-talk and detection losses region

Detection at high rate

mean signal amplitude versus rate/pixel

pulsed light source synchronus to trigger + random background from lamp

measured for single photoelectron

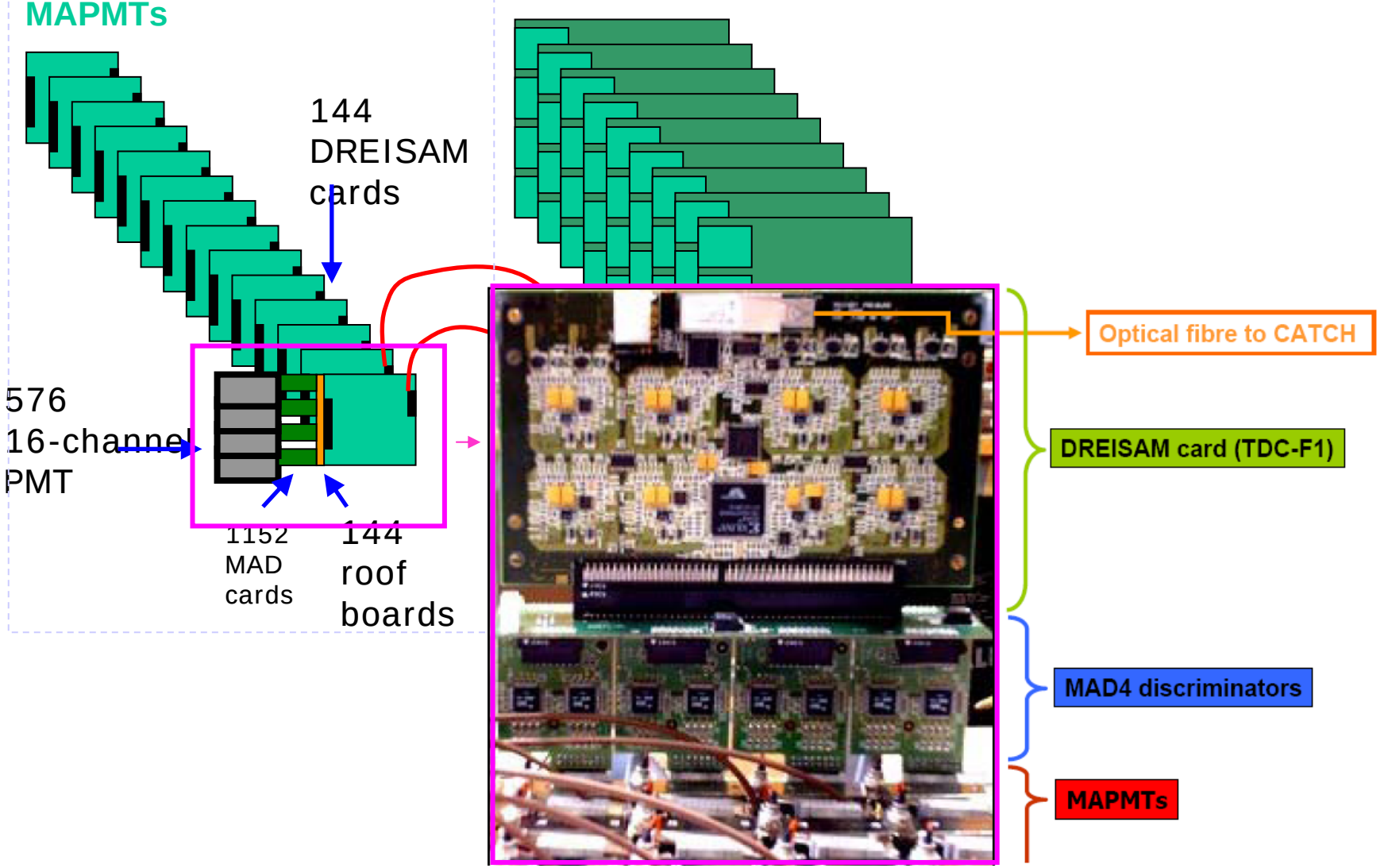


Goal
(for the future needs of COMPASS): operate up to 5MHz/pixel single photoelectron rates

no rate limitation from MAPMT

MaPMT readout

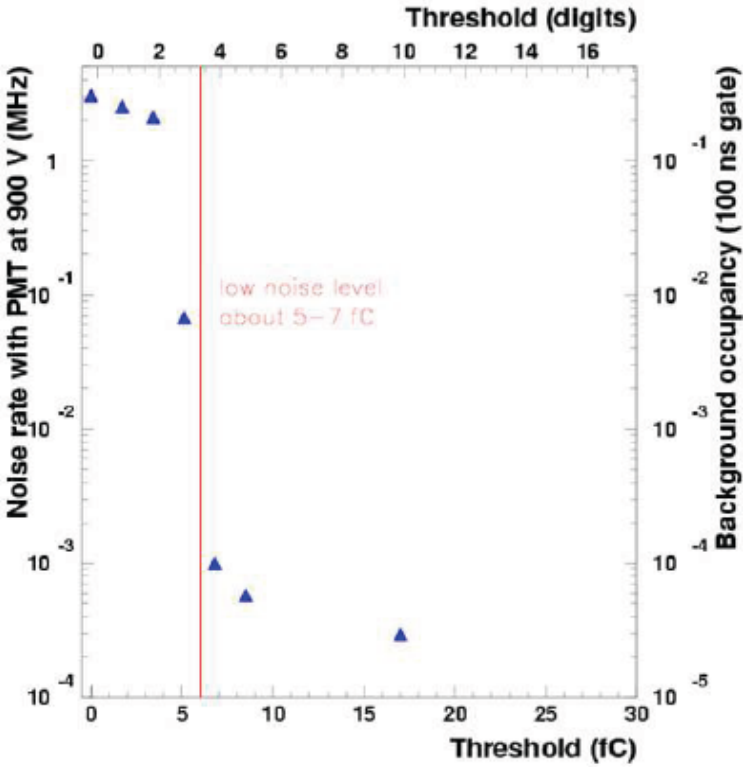
MAD cards and Dreisam cards mounted close to the MAPMTs

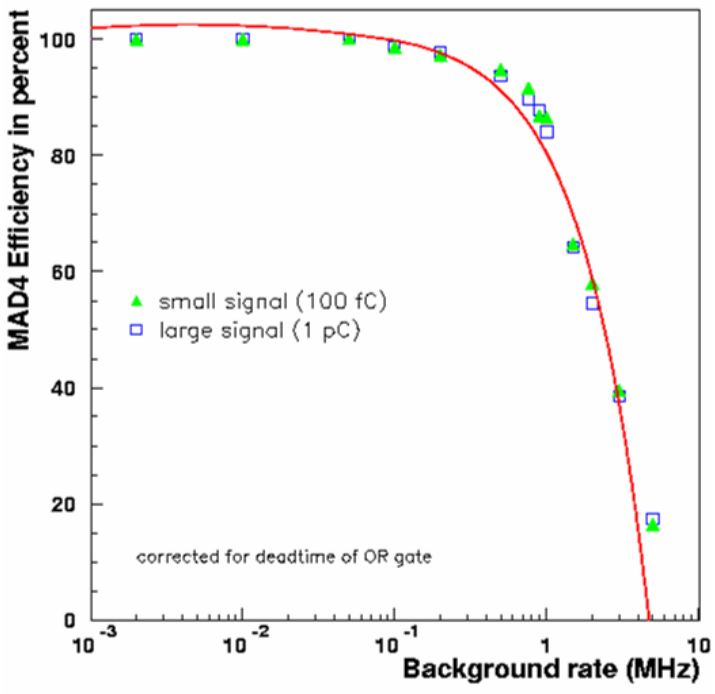


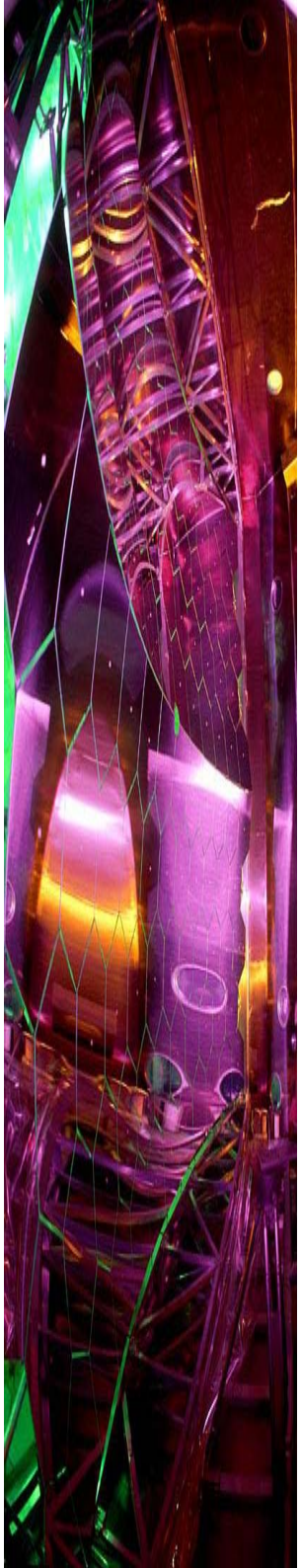
FE electronics: MAD cards + roof board

TORINO

- Based on MAD4 chip:
  Pre-amplifier + shaper + comparator
- Low noise (connected to PMT):
  5-7fC
- Average PMT signal: 1pC
- Up to 1MHz/channel

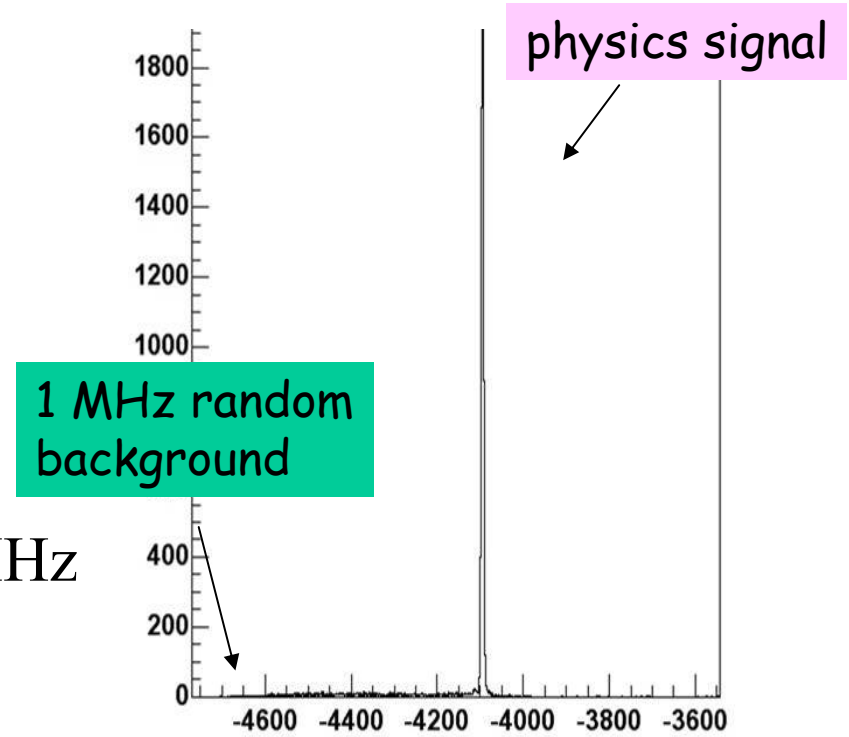




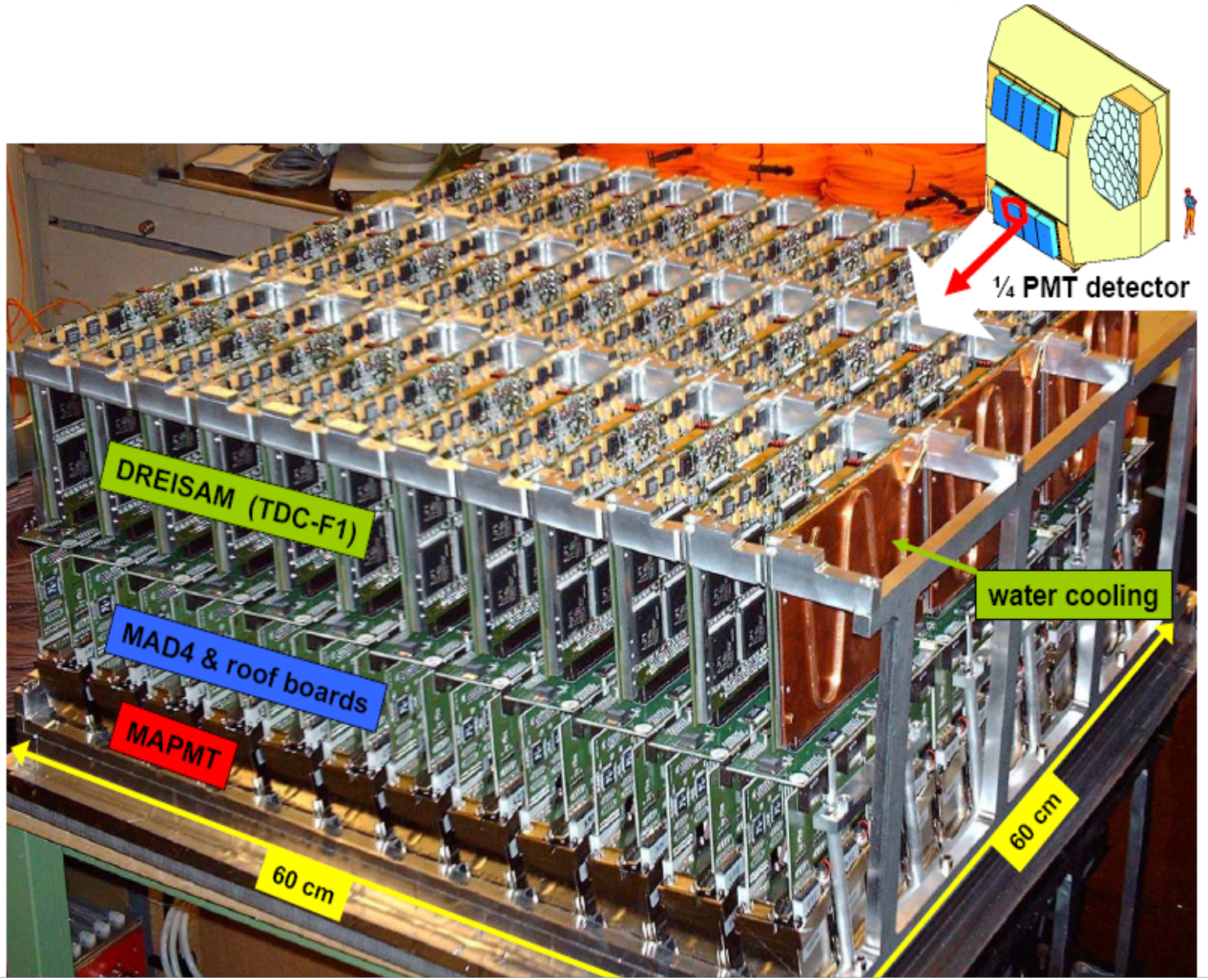


Digital readout electronics: DREISAM card

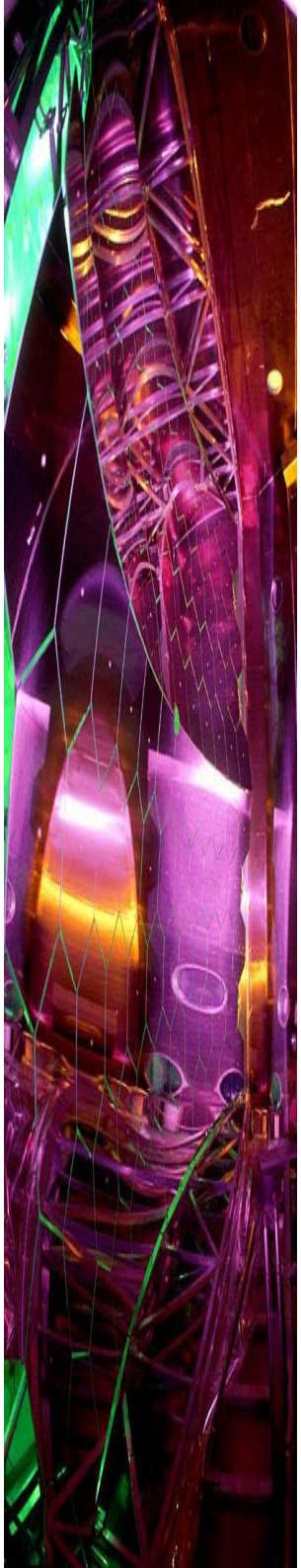
- Based on dead-time free F1-TDC chip
- 64 channels per board
- Time resolution < 120 ps
- Max rate per channel: up to 10 MHz at 100 kHz trigger rate

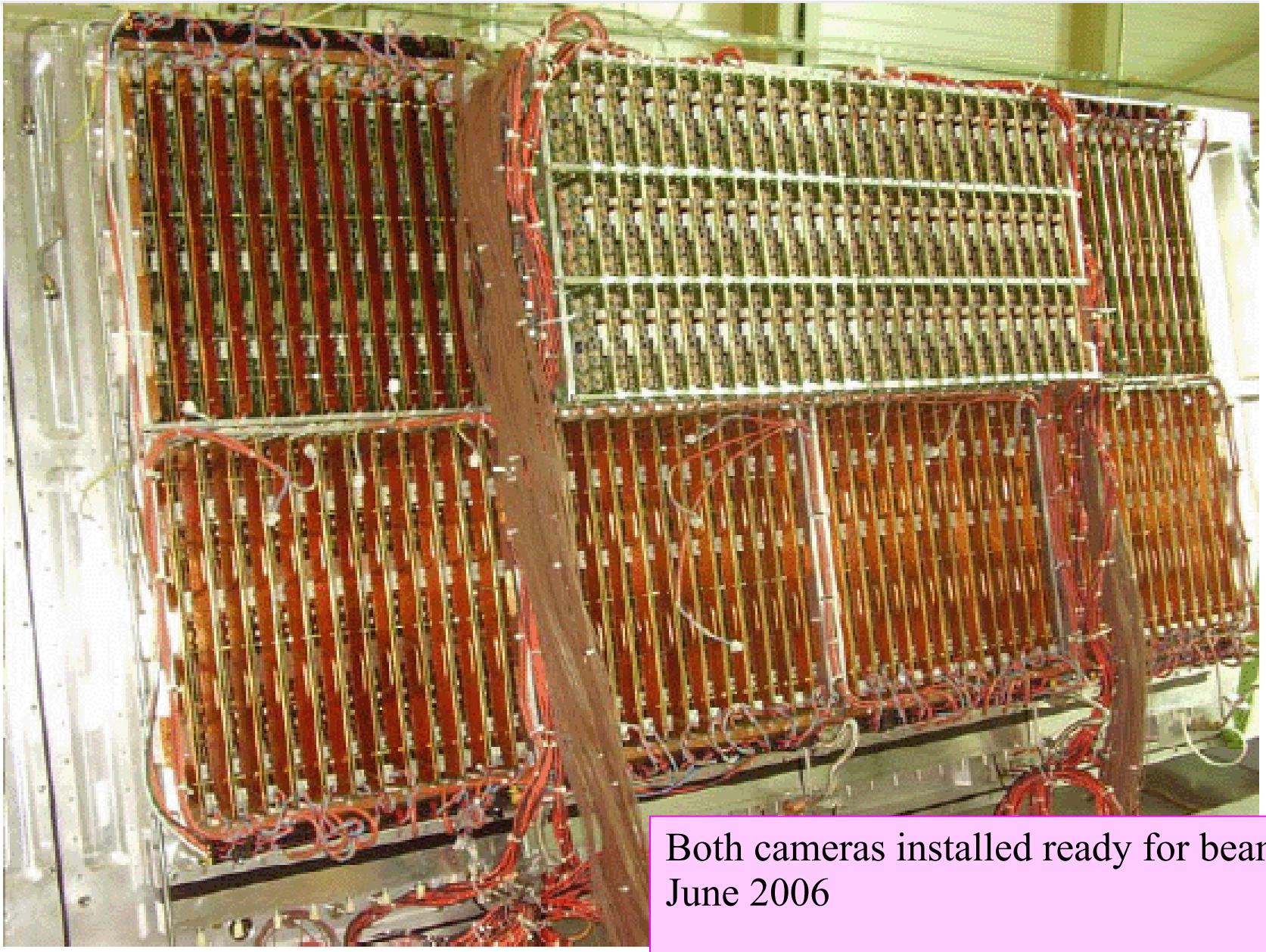


Readout electronics of 1 quarter



A full detector



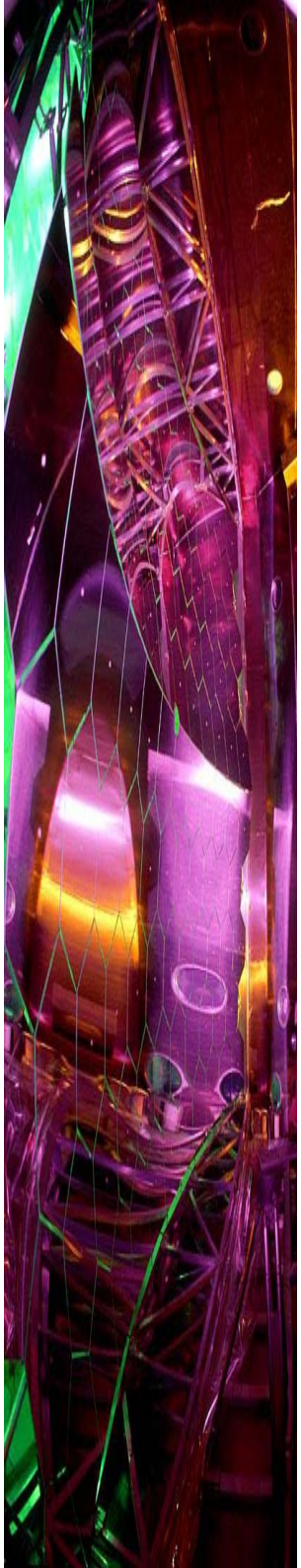


Both cameras installed ready for beam June 2006

Data taking during Compass run 2006

Installation

Installation

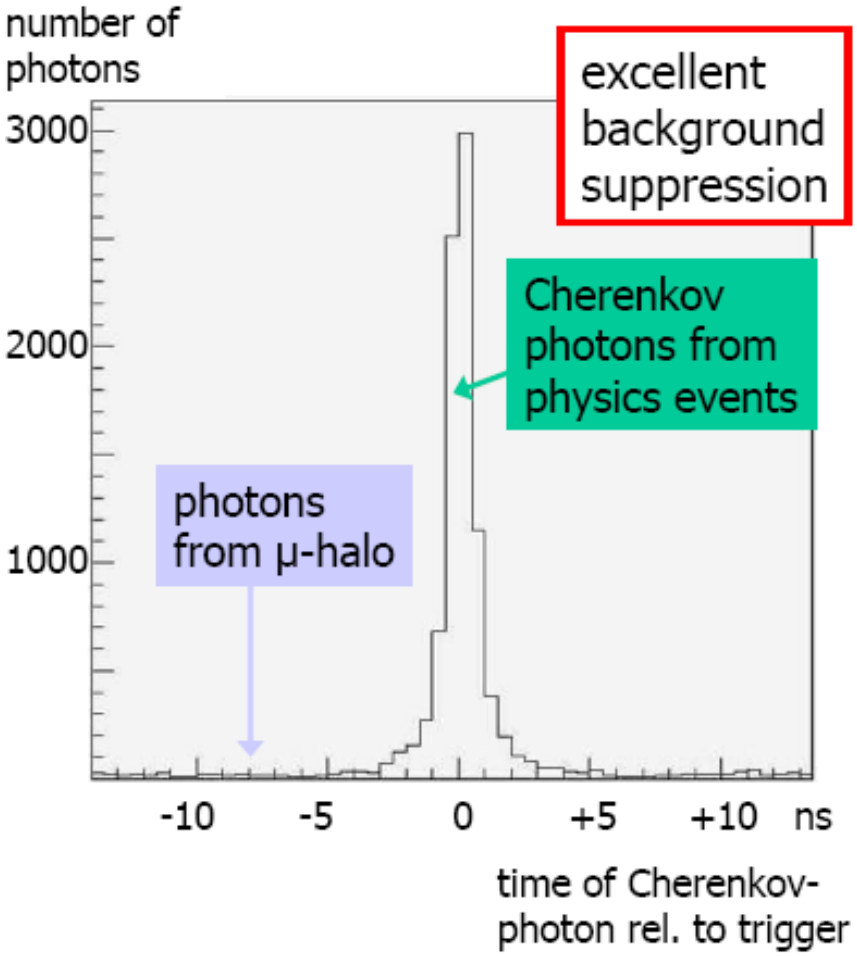


Milestones and Status

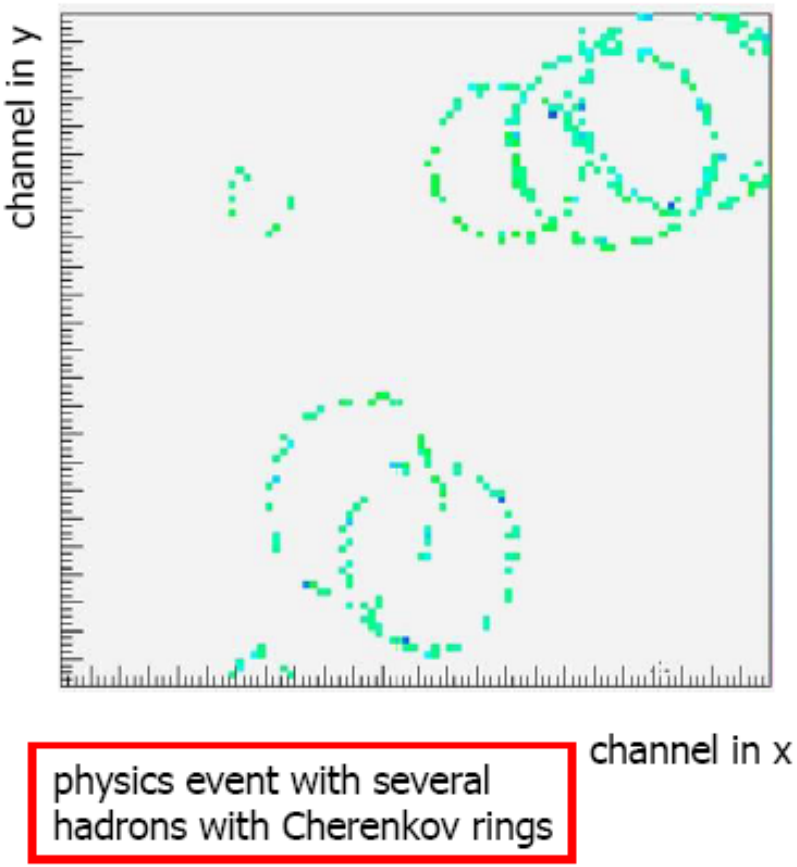
- Preliminary studies up to October 2004
- Project design: November 2004 – March 2005
- Material procurement and constructions: April 2005 - March 2006
- Assembly: April-May 2006
- Ready for beam: June 2006
- Characterization from data 2006 goin on
- Next future upgrade: C-MAD project

First look on 2006 RICH data

Time spectrum



Cherenkov ring



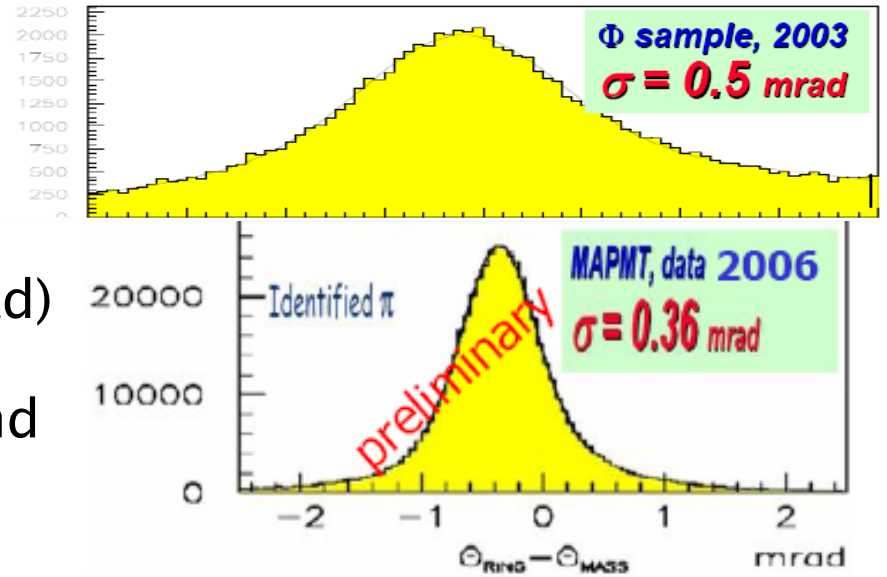
Performances of the upgraded MaPMT RICH (2006 data, preliminary)

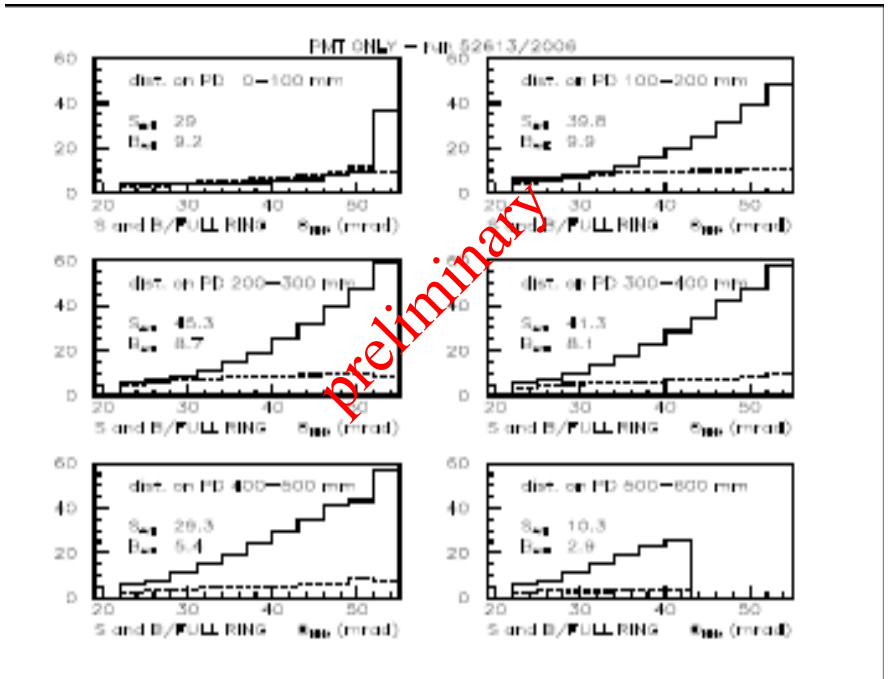
Number of photons per ring at saturation:
65 (before 14)

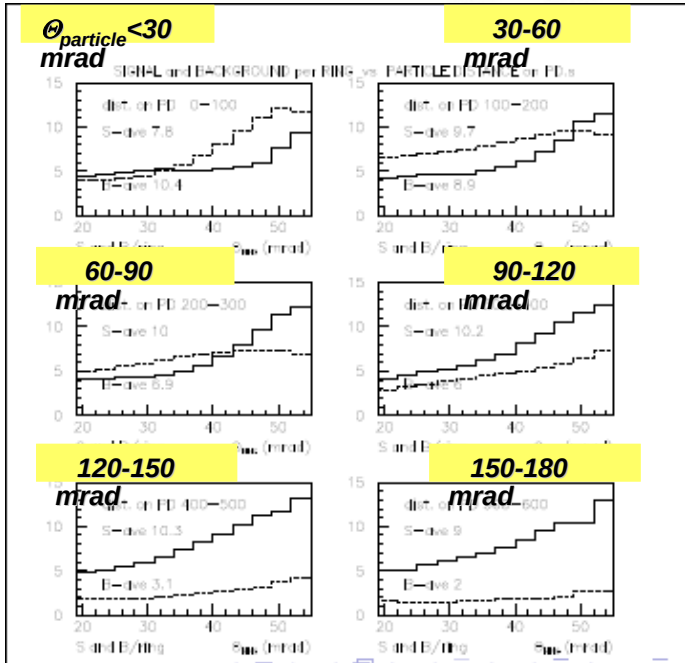
Time resolution:
≈ 1 ns (3 ms)

Ring resolution: 0.36 mrad (0.5 mrad)

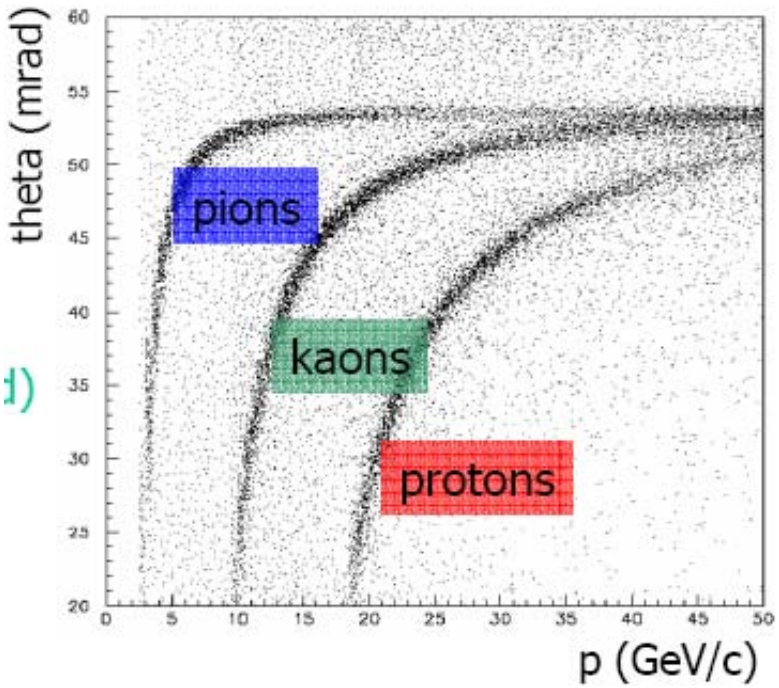
Improved suppression of background from μ-halo

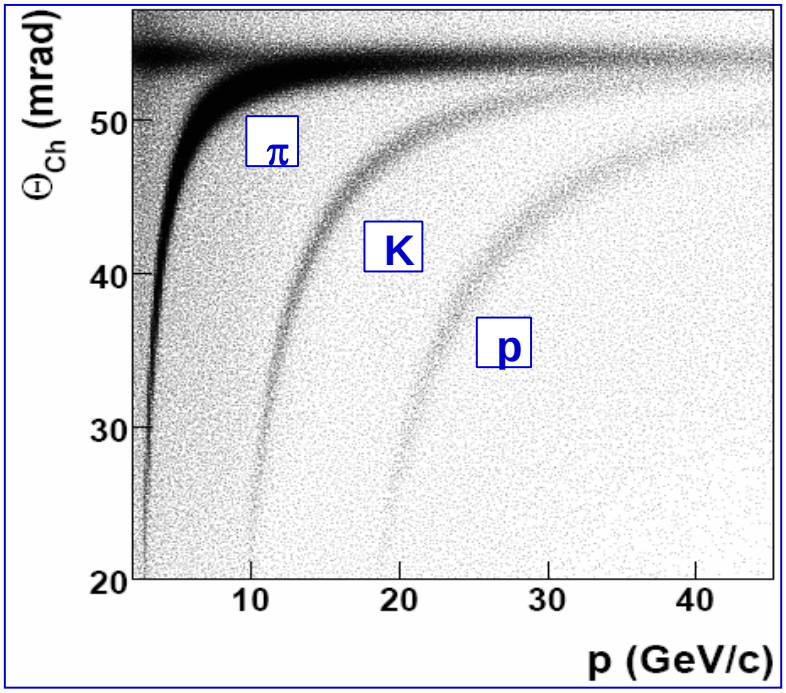


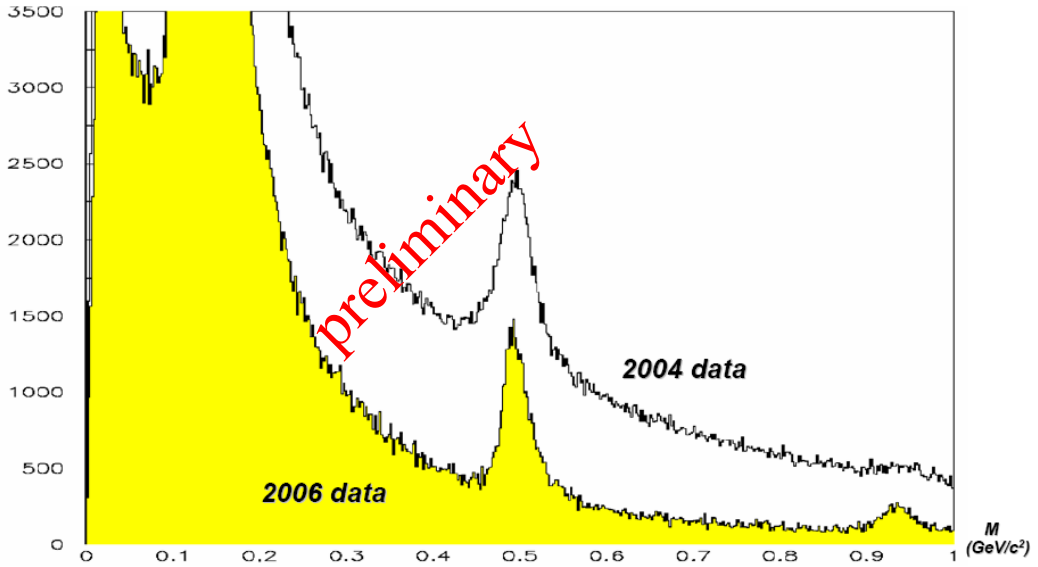


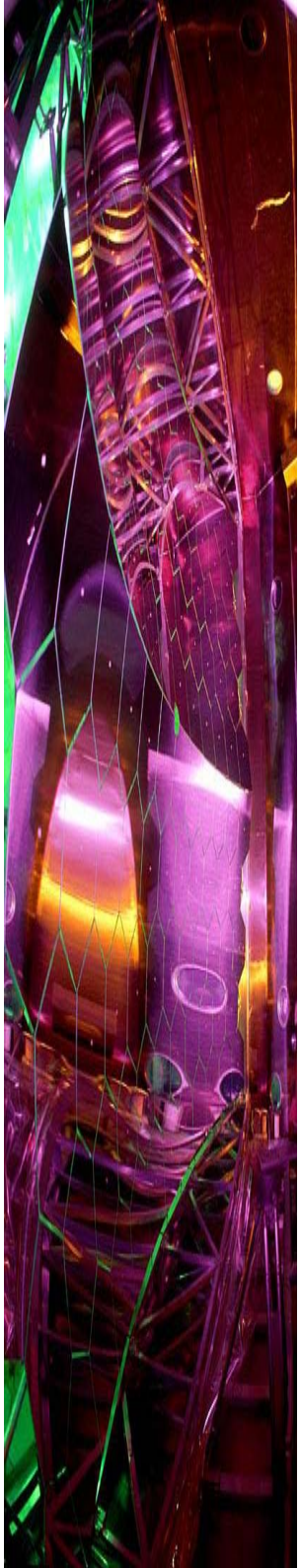


New PID performances









Future upgrade:
C-MAD

CMAD, an upgrade of MAD4 chip for Compass Rich-1: characterization of the prototype

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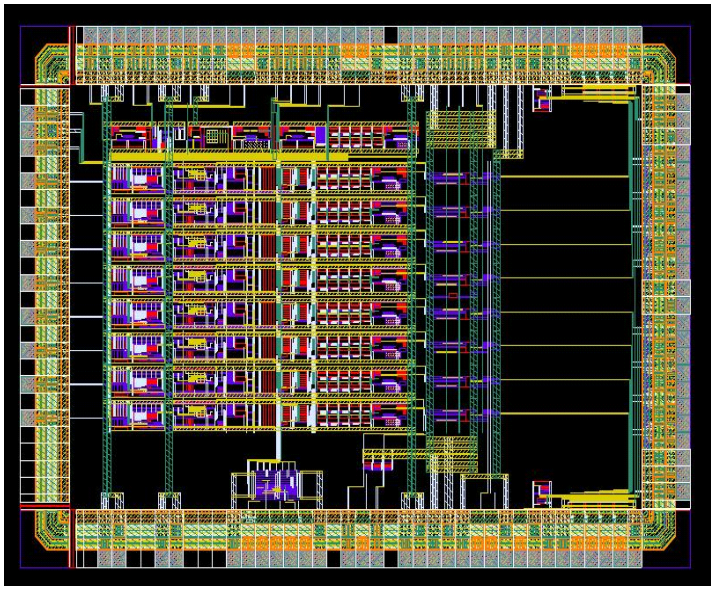
I.N.F.N & University of Torino

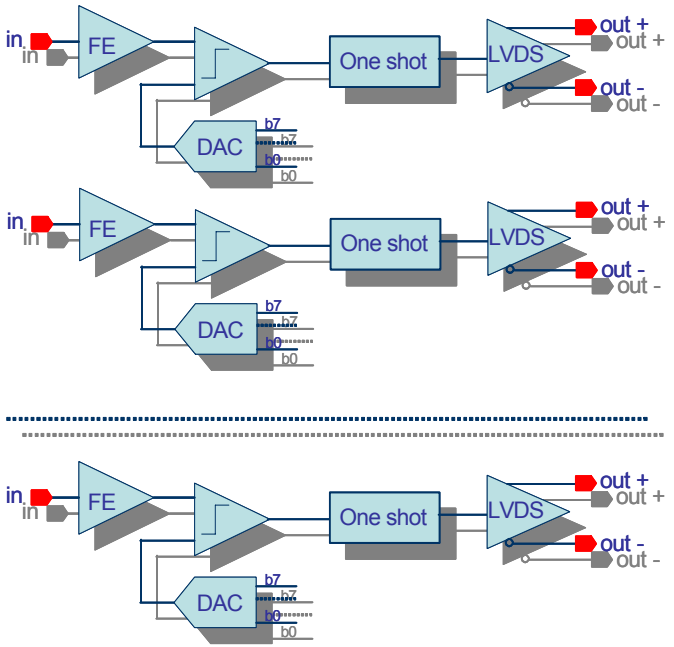
CMAD-V2 full size prototype

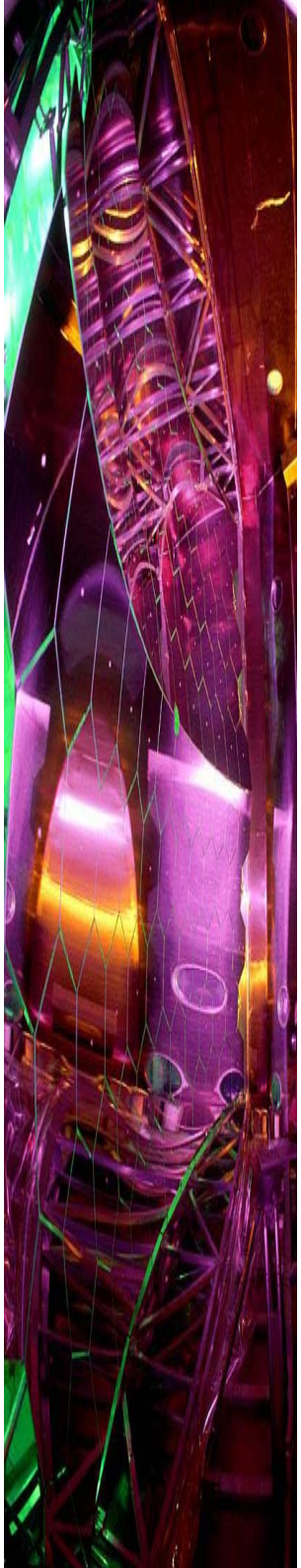
- 8 channels f*ull-custom Asic prototype*

each single channel consists of:

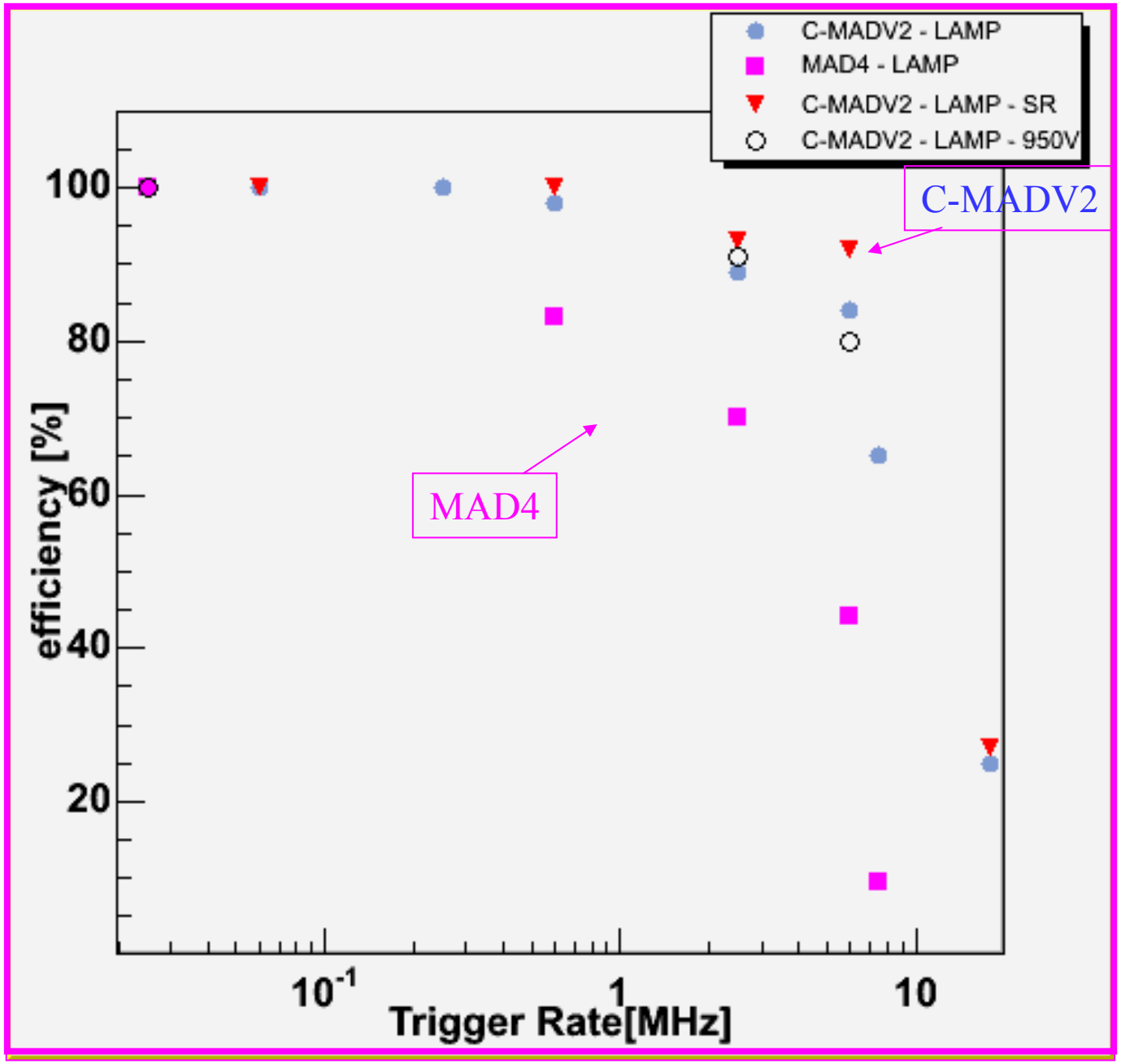
- *a pre-amplifier with adjustable R-C feedback network*
- *a shaper with baseline restorer*
- *a comparator with adjustable threshold*
- *programmable one-shot*
- *LVDS output driver*

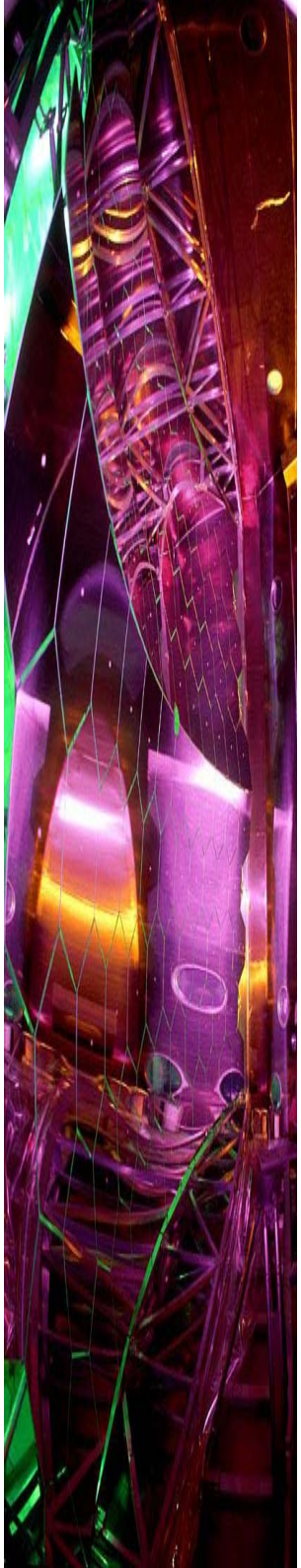






Efficiency at high rate





Time Schedule

End of february → submission of the third prototype

End of february – End of may → design and production of new front-end boards

End of may → prototype delivering

June → test of prototype chips mounted on new front-end boards

June and July → full test of the prototype

End of july → start of mass production

End of october → delivery of whole production (chips and boards)

november - december → mounting and testing

January 2008 → ready to install

Thanks to many colleagues…
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