# Design and Status of COMPASS FAST-RICH

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Beaune

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- Motivations
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# Requirements for a fast RICH

General motivations:

- Hadron PID is essential for present and future HEP experiments
- good hadron PID performances are needed at:
  - *high luminosities, i.e.*
    *high beam intensities*
    *high trigger rates*
    $\longrightarrow$ *deadtime-less readout is crucial*
  - *highly crowded environments*

The expected future conditions in COMPASS suggest the need of a FAST RICH:

- beam intensities $\sim$100 MHz (presently 40 MHz)
- trigger rates above 100 kHz (presently $\sim$20 kHz)
- highly crowded environments:
  - *large near and far $\mu$ beam halo (rate $\sim$1/2 of the beam rate)*
  - *expected interaction rate of h beam $>10^6$ Hz (target + detectors)*

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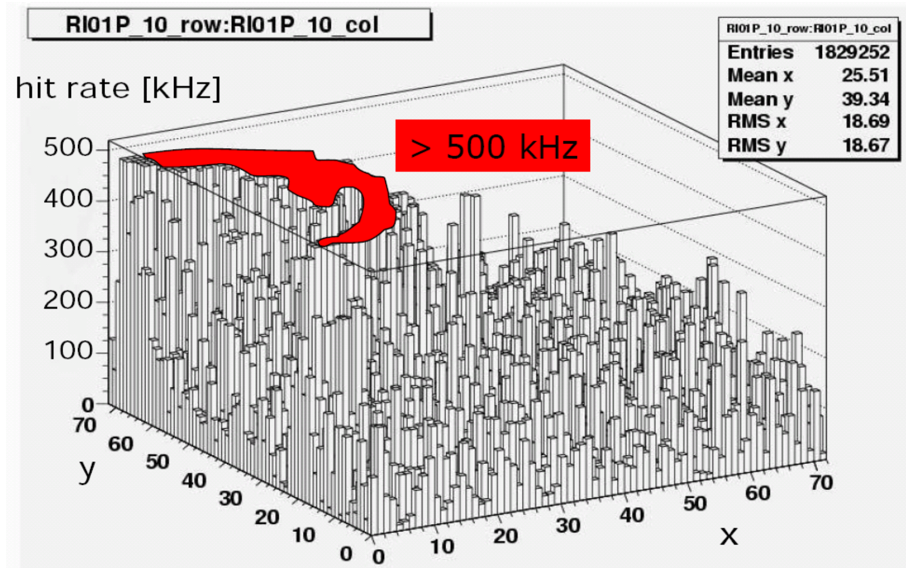

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COMPASS IS AN IDEAL TEST BENCH FOR A FAST RICH

The development of a FAST RICH is also financially supported by EU

(I3HP, JRA9)

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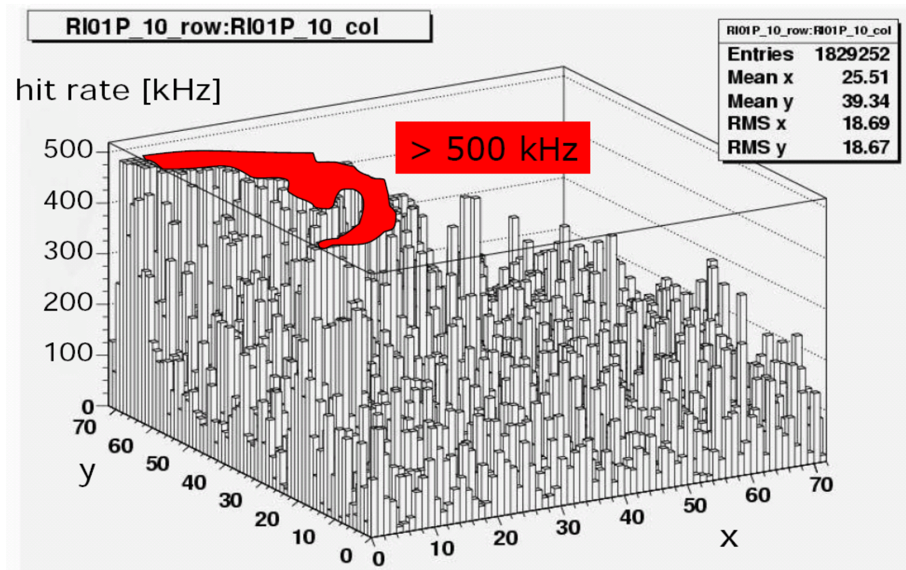

# MAPMT type and assembly

- very robust and reliable (from literature and experience)
- efficient single-photon detection and effective cross-talk reduction with the appropriate frontend electronics (see testbeam results later)
- light-tight envelope and resistive divider
- naked PM $\longrightarrow$ optimize dimensions and price

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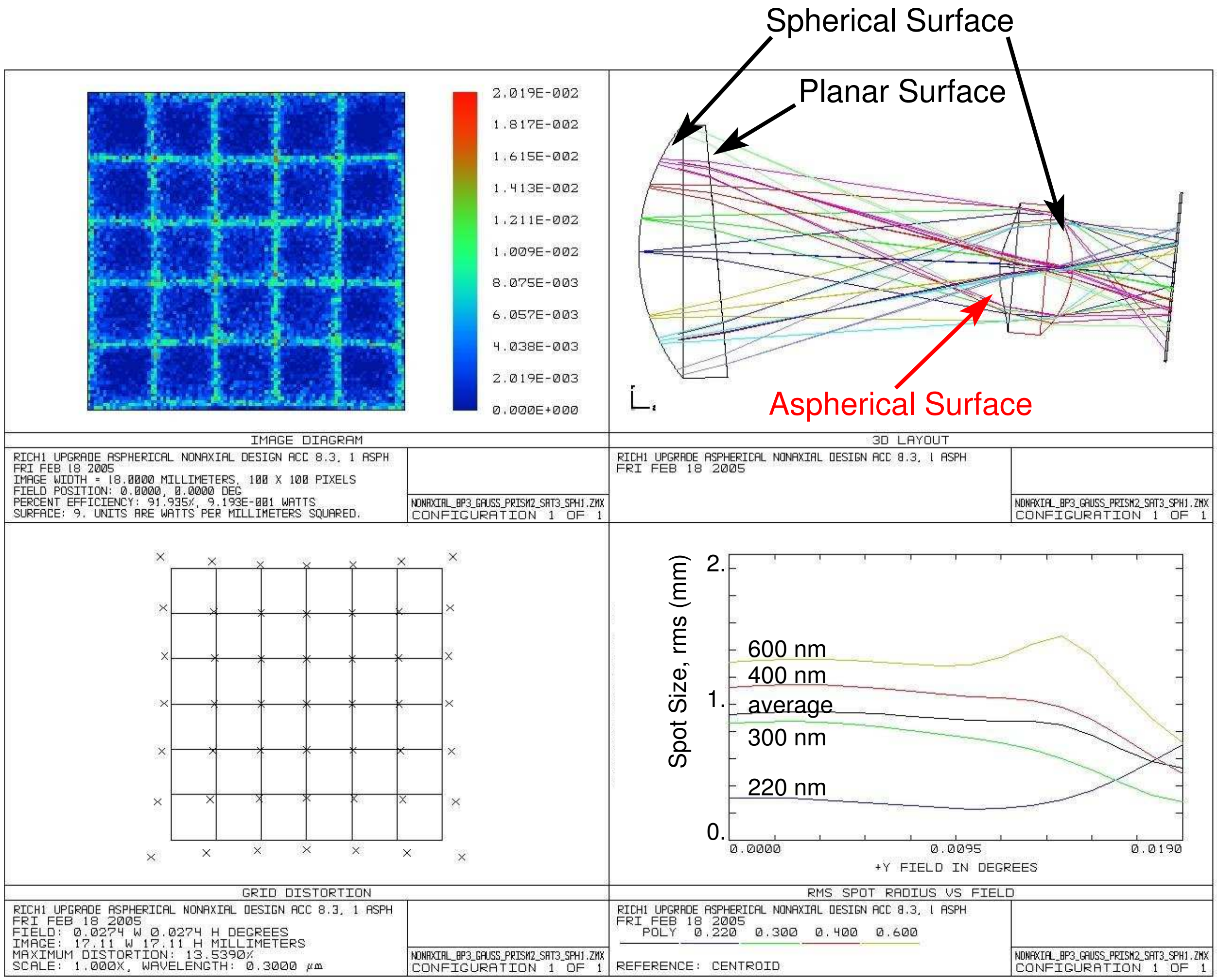
In COMPASS (see Damien's talk) the max. SM1 fringe field in the MAPMT region is $\sim$ 200 gauss along the PM axis $\longrightarrow$ shielding of phototubes is needed! (see later)

# Optics and Cherenkov light collection

- the design ratio of the photon collection/photon sensitive surfaces is $> 6$:
  - *multi-lens optics with aspherical surfaces to reduce distorsion/aberration*
- optimization criteria:
  - *limited image distorsion* → *ring resolution*
  - *angular acceptance*
  - *mechanical constraints*



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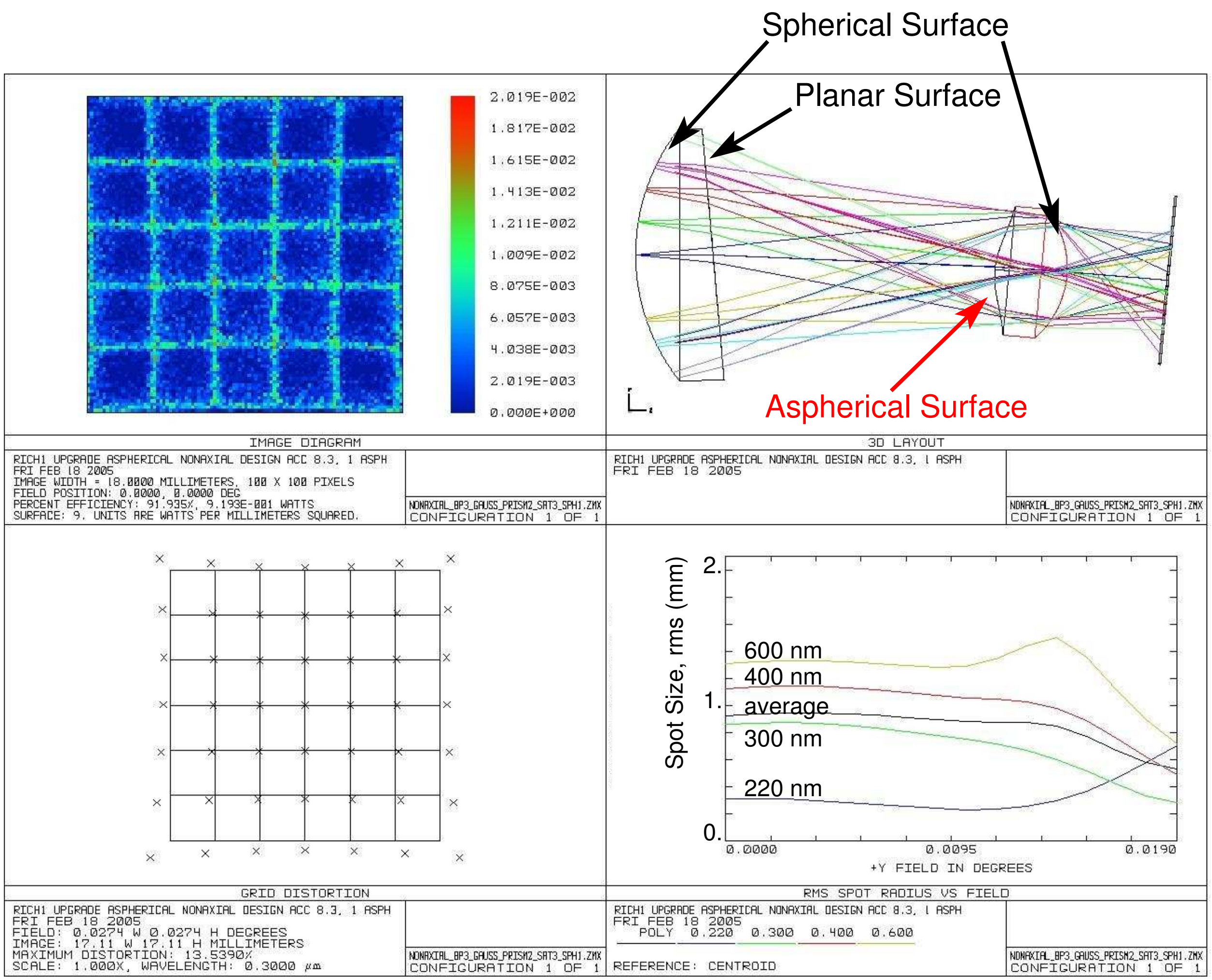
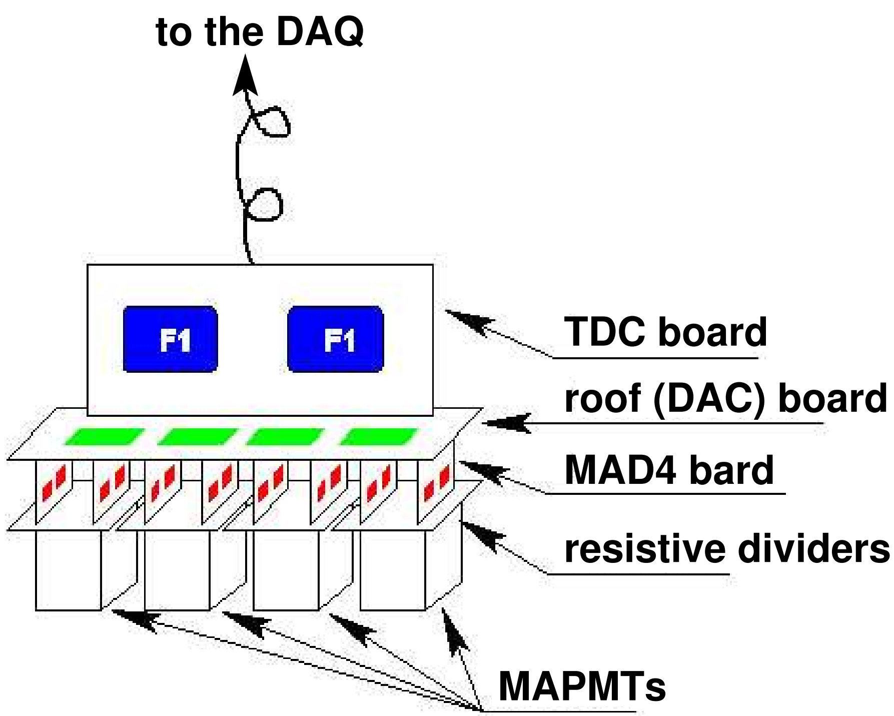



The choosen optical design provides an angular acceptance of $\pm 9.5^\circ$ and good distortion/spot size with one single aspherical surface

# Readout electronics




- readout based on the MAD4 discriminator chip and the F1 TDC chip
- key features:
  - *discriminator boards directly connected to photomultiplier HV basis (no cables)*
  - *PM signals are recorded with a time resolution of ∼130 ps*
  - *trigger rates up to 100 kHz thanks to the pipelined, deadtime-less readout architecture*
  - *data trasmission through 40 Mb/s optical links*

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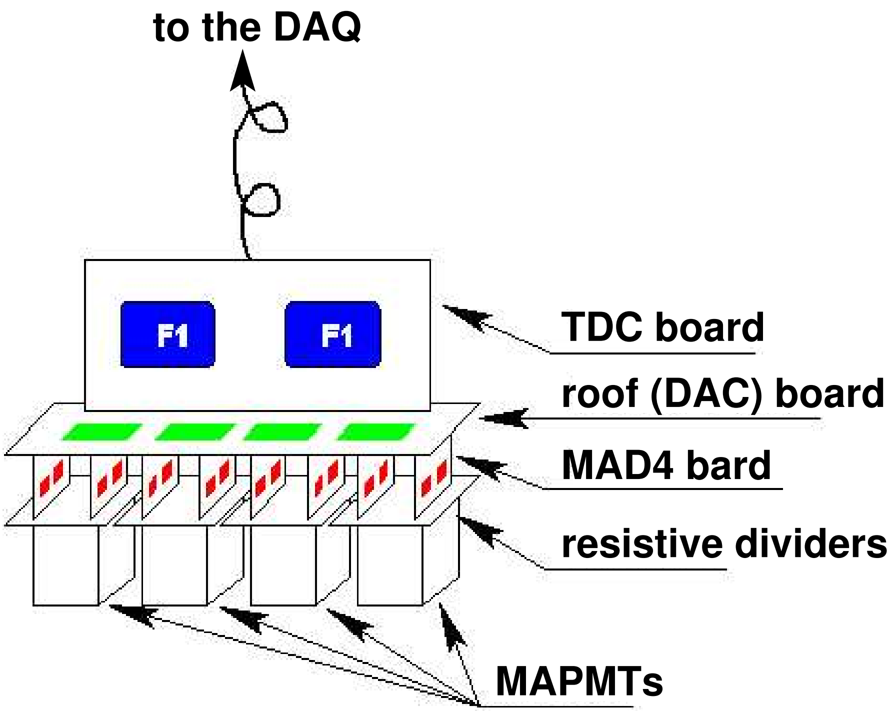


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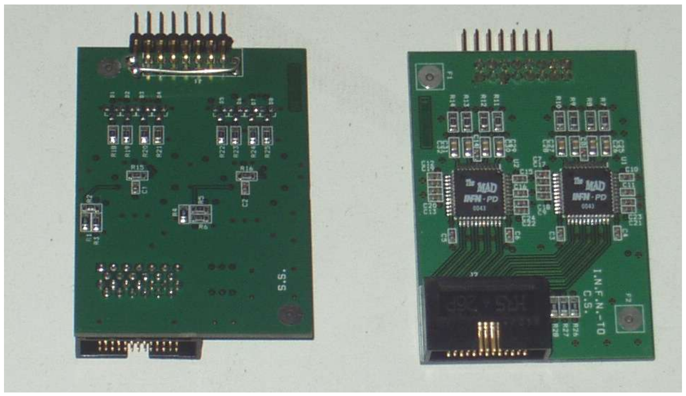
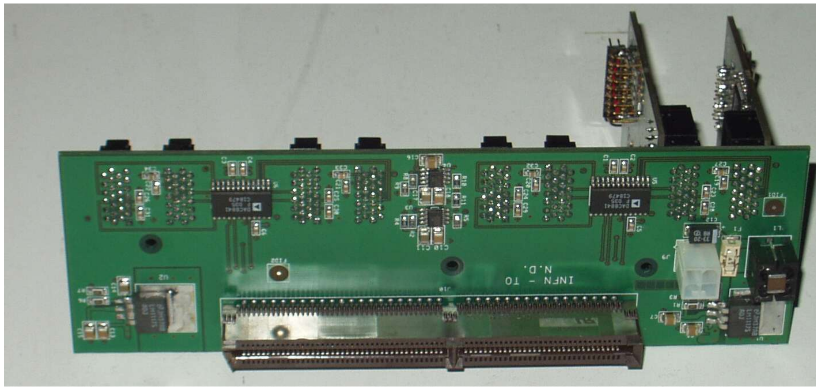
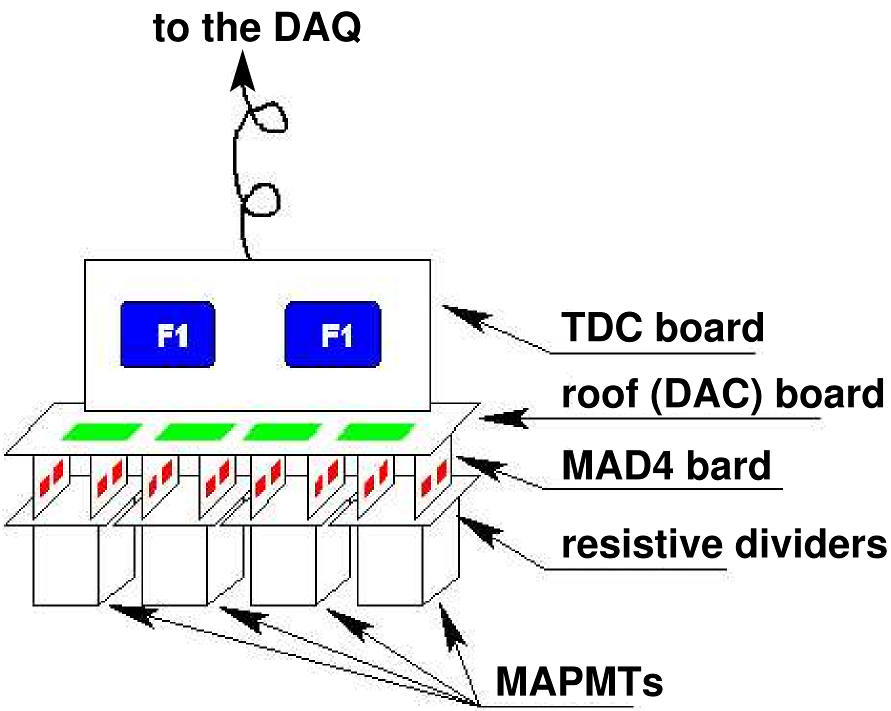


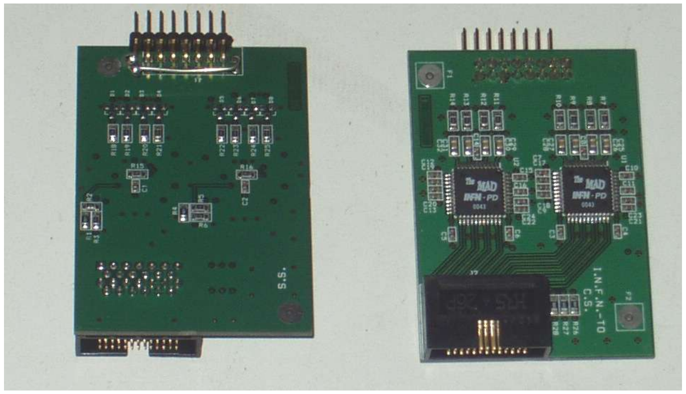
MAD4 boards - prototipes



Roof (DAC) board - prototipe

# Readout electronics



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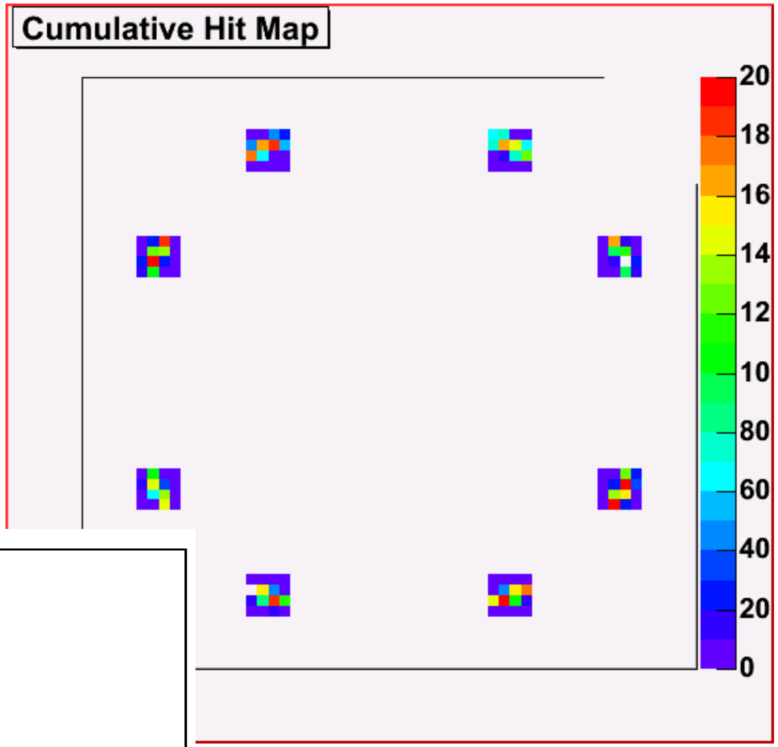
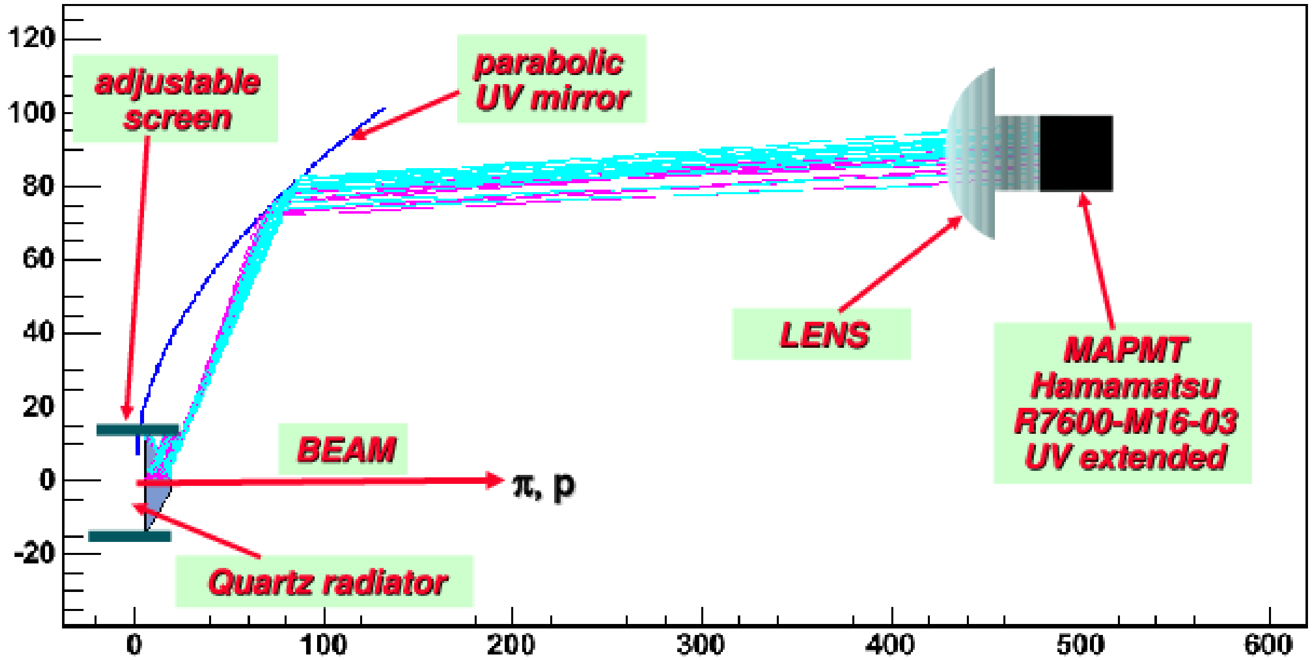
  - *data trasmission through 40 Mb/s optical links*
- A modified version of the MAD4 chip (C-MAD) is under develoment:
  - *8 inputs with larger dynamic range*
  - *independent threshold for each channel*
  - *input rates up to 6 MHz*

# 2004 Testbeam: setup (I)

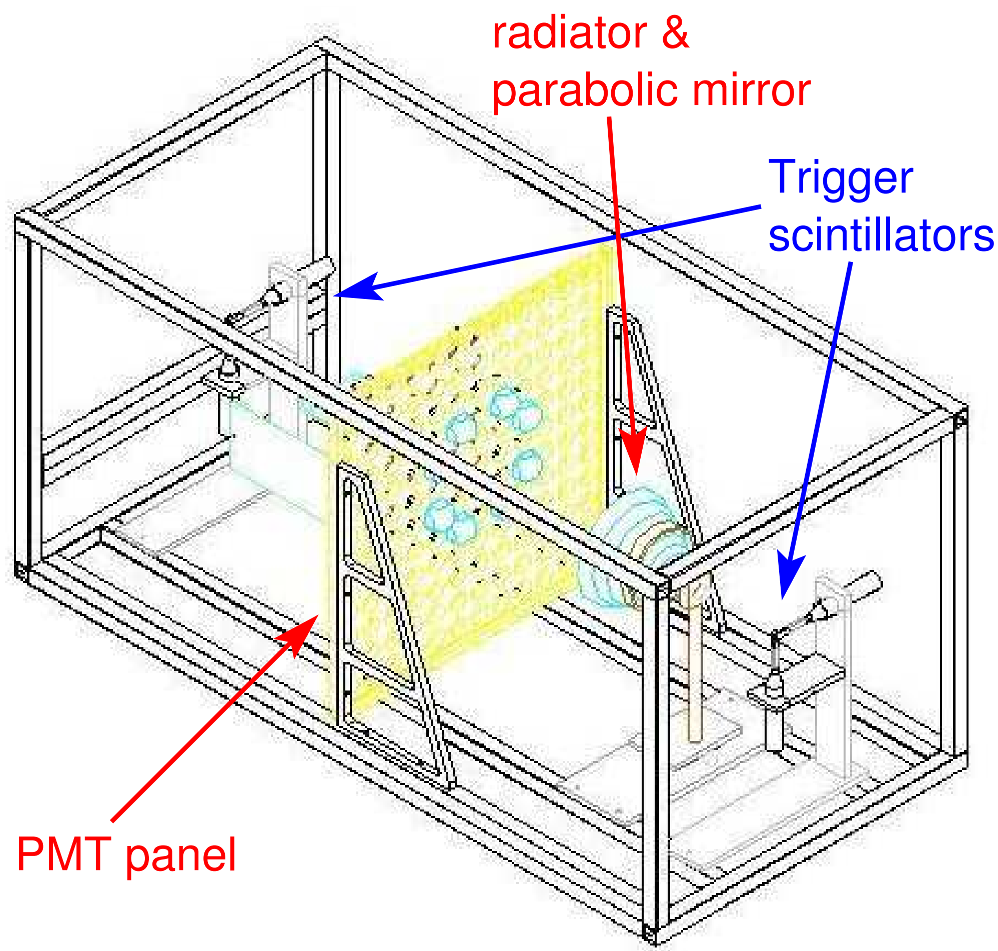
- beam: $\pi, p$ @ 3 GeV
- radiator: quartz cone with adjustable screen
- parabolic UV mirror to deflect the emitted photons $\sim \perp$ to the PM surface
- radiator/mirror relative position adjustable to simulate different ring radii



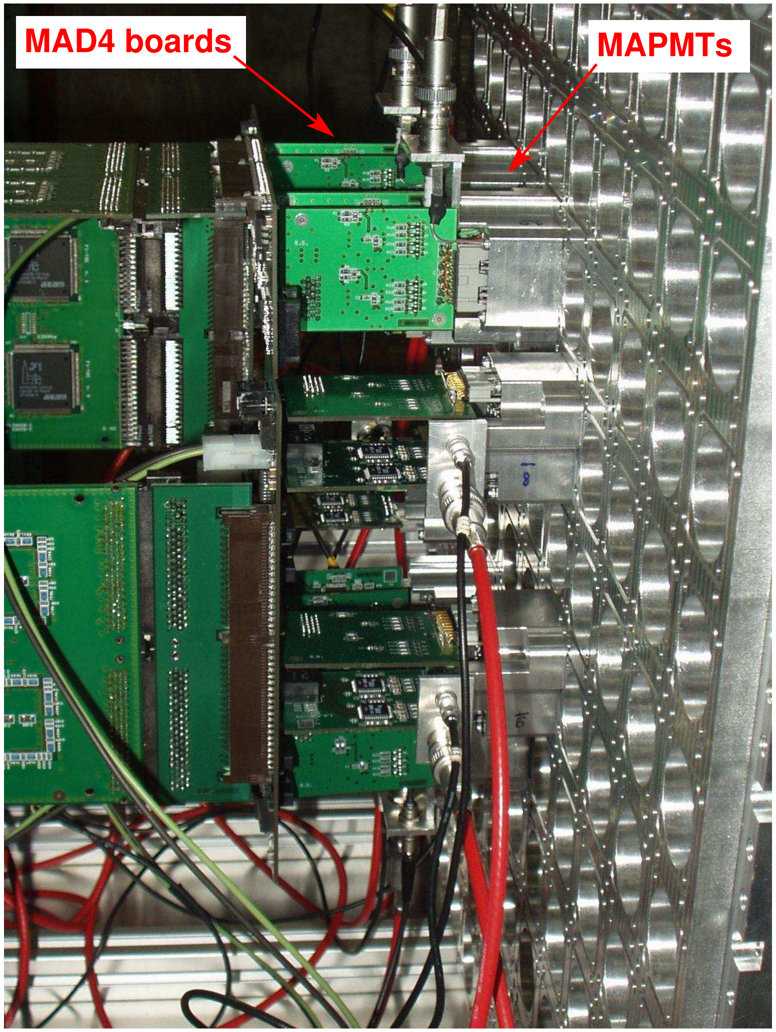



# 2004 Testbeam: setup (II)

Schematical drawing

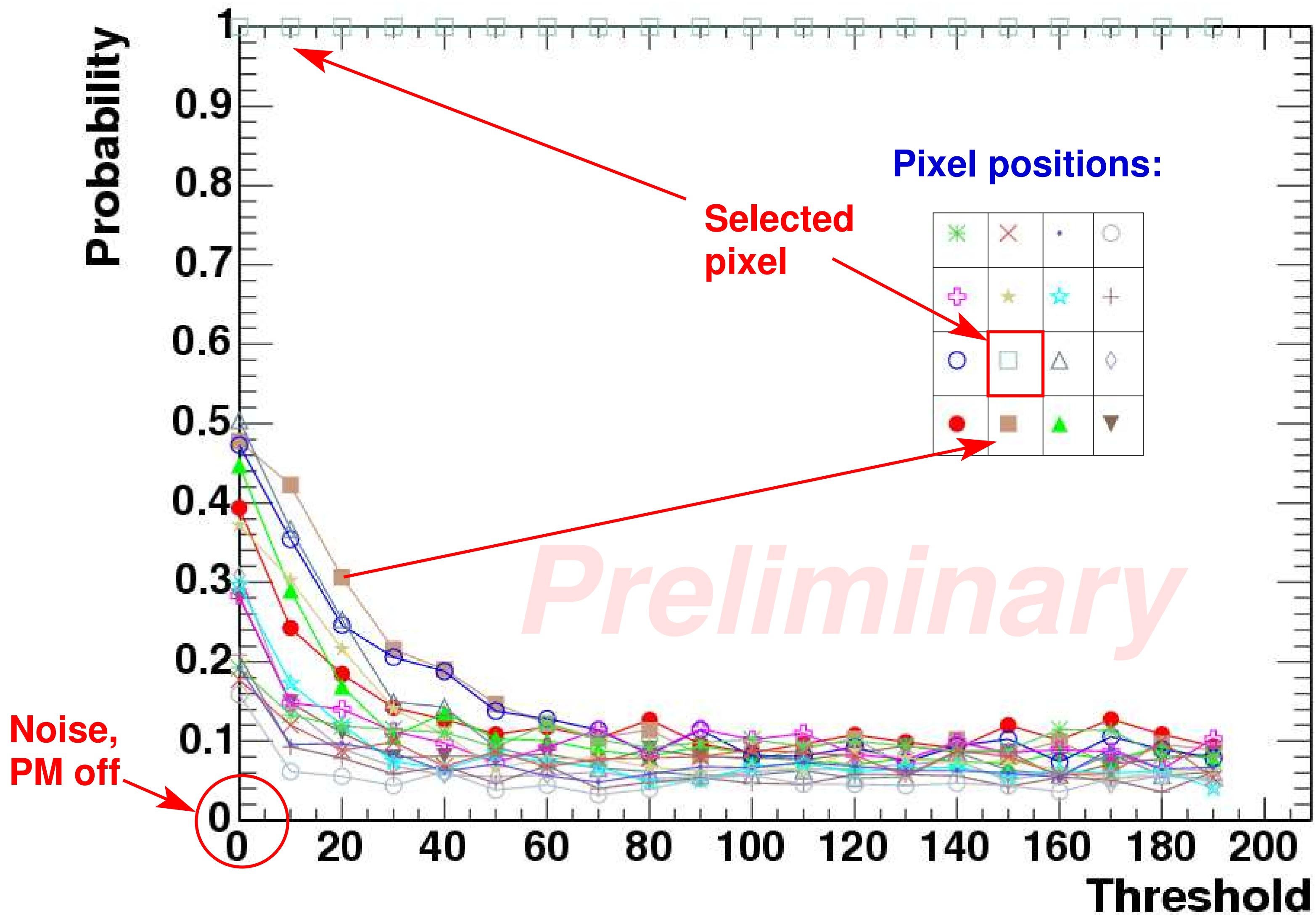



Electronics & MAPMT fixation



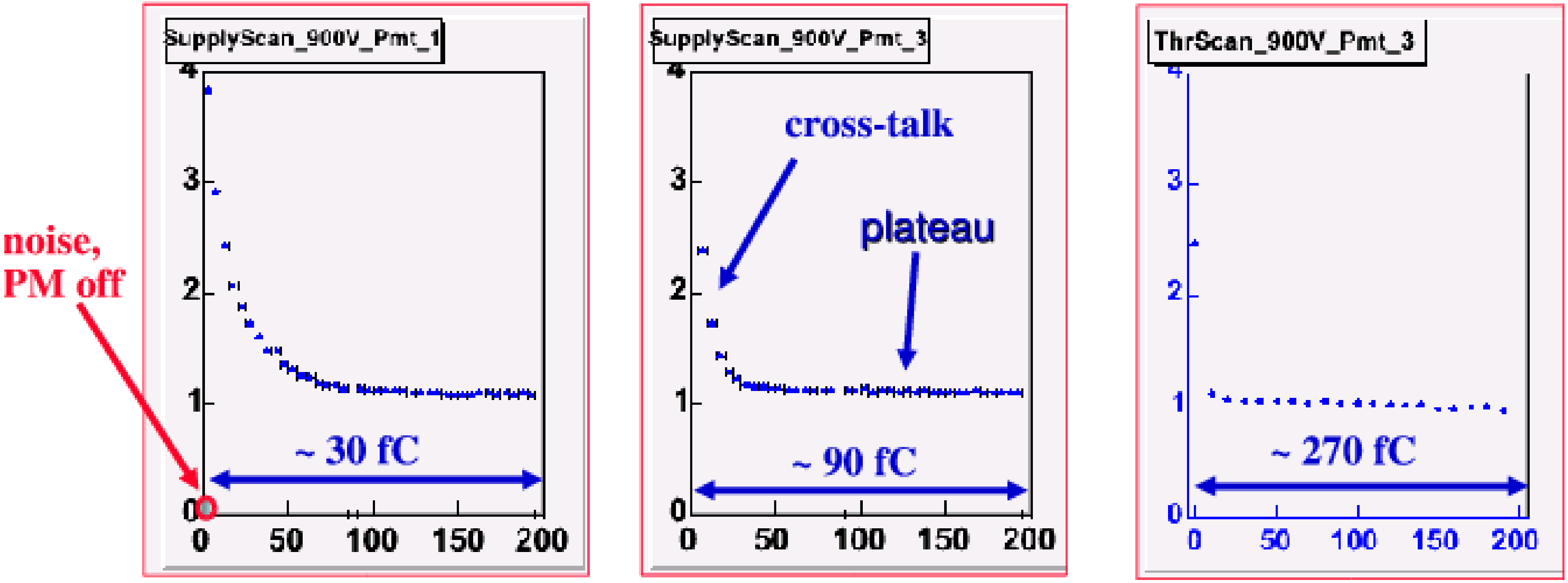
# 2004 Testbeam: results (I)

Hit probability vs. pixel & threshold (hit required on pixel #6)



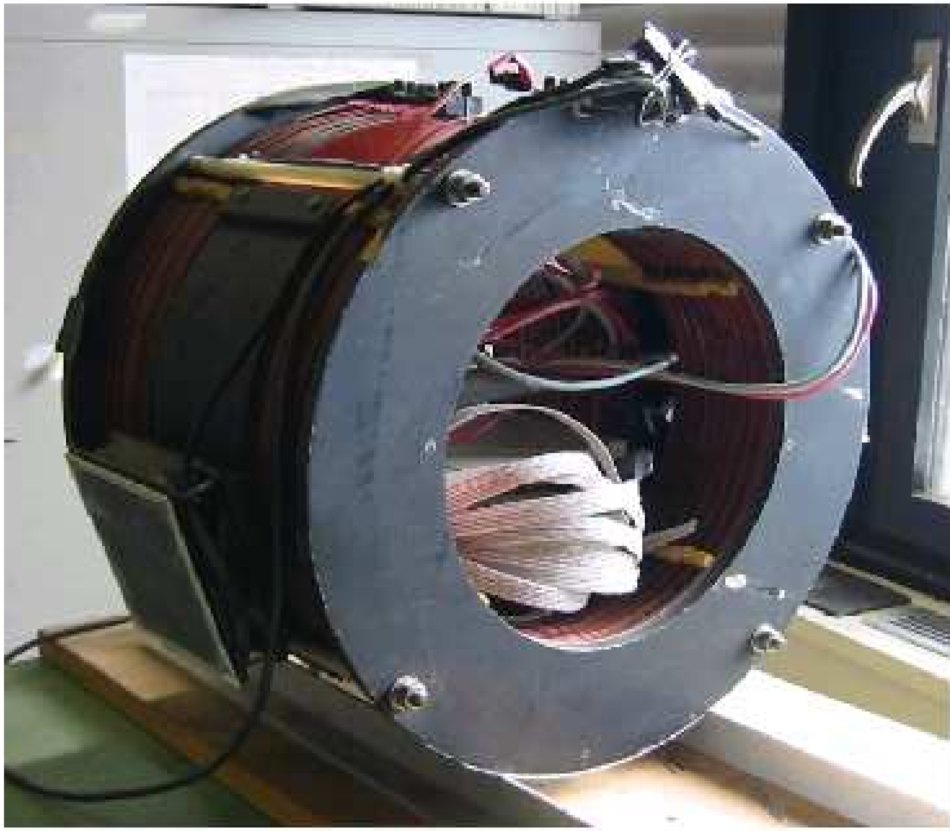
# 2004 Testbeam: results (II)

**Plots: hit multiplicity / event vs threshold setting, arbitrary units**




**a completely flat region (no photon loss), good for safe threshold setting, is clearly identified between the cross-talk region (low thr. setting) and the region where there are detection losses (visible in the third plot)**

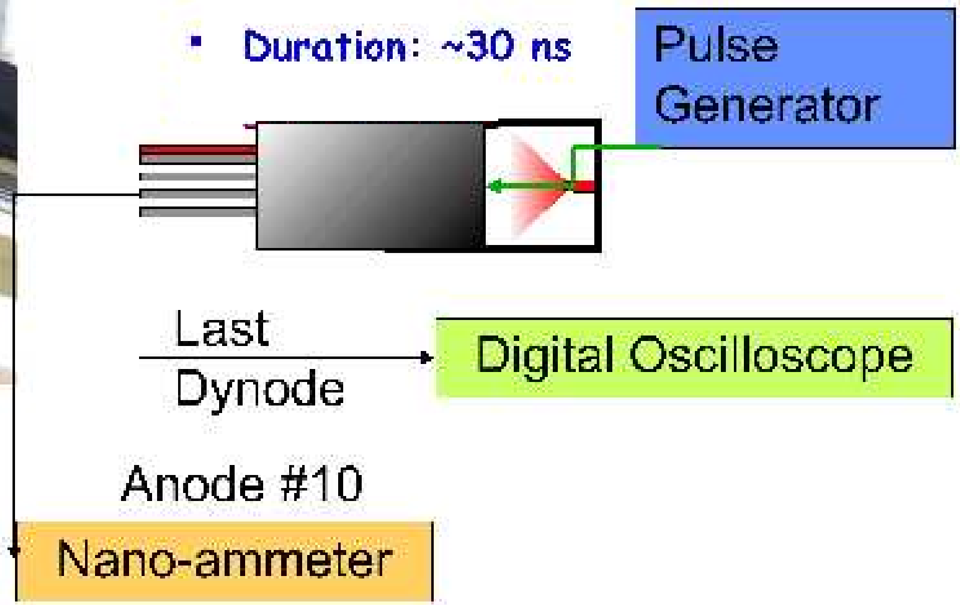
# MAPMT characterization in magnetic field



- Lab. Helmholtz magnet
  - Up to ~400 Gauss at 10 A
  - Bore: 24 cmϕ, 26 cm long

RICH-1: B < 200 G

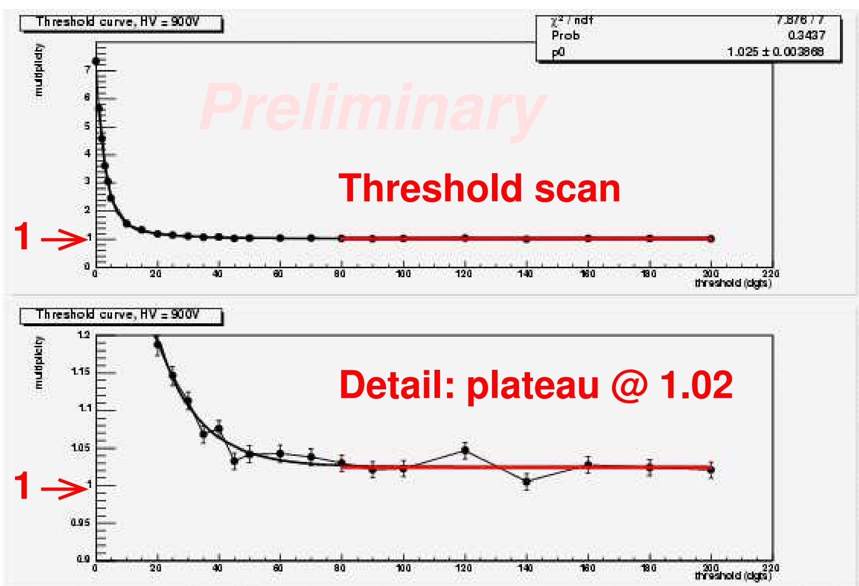
- MAPMT
  - 1 Hamamatsu
    R7600–M16–03
- Light source
  - Blue LED
  - Duration: ~30 ns



# MAPMT tests with magnetic field

- Quasi-single photon source used for the tests: expected hit multiplicity for the whole MAPMT is $\sim$1
- Field direction LONGITUDINAL to the MAPMT axis
- Hit multiplicity measured at nominal HV and relatively high discriminator thresholds to avoid noise/crosstalk effects

Hit multiplicity at 0 gauss: 1.02



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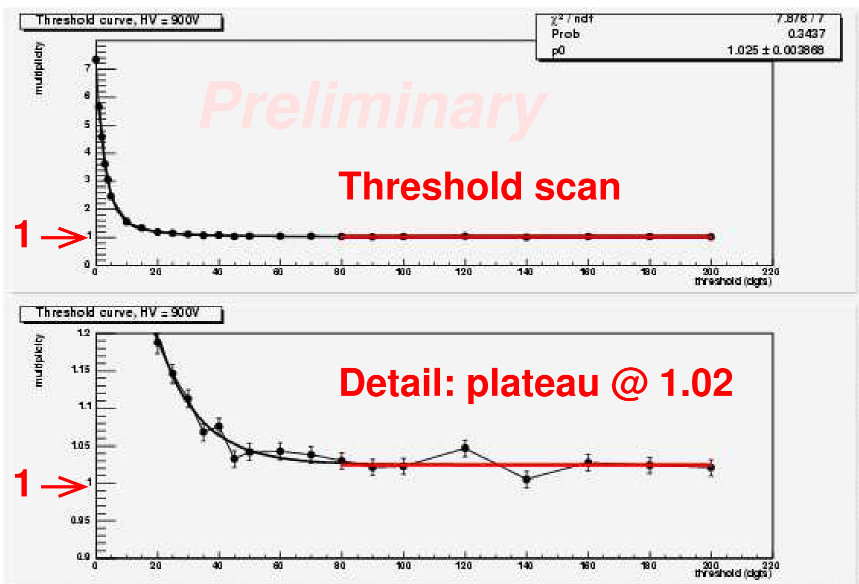
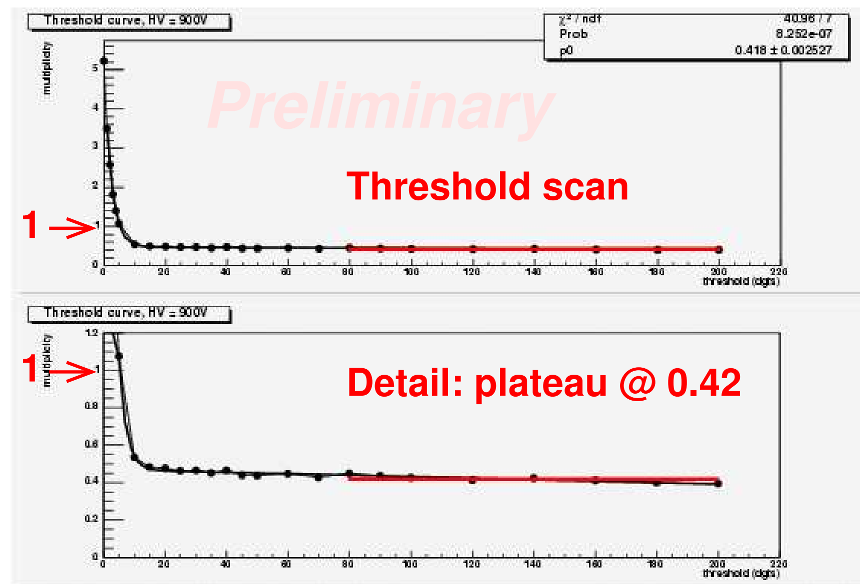
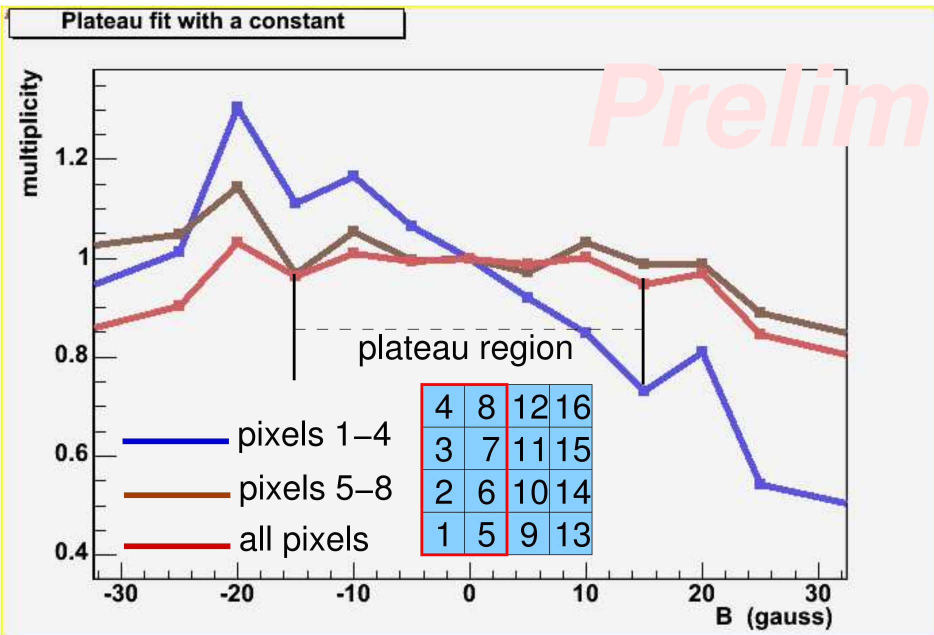


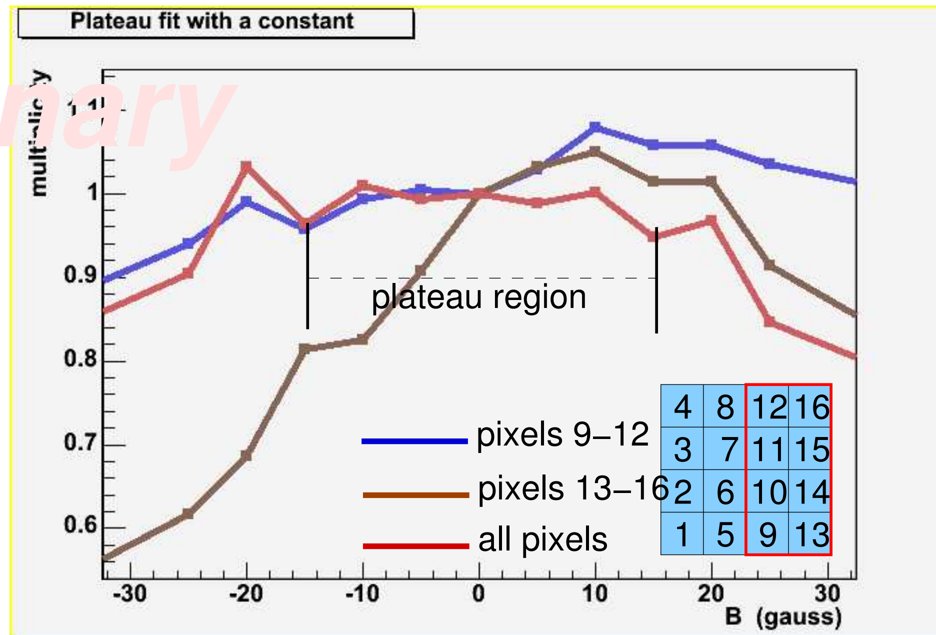

Hit multiplicity at 180 gauss: 0.42



# Hit multiplicities vs. field

- Fitted plateau multiplicity measured as a function of **B**
- Only the overall multiplicity for vertical groups of 4 pixels and for the whole MAPMT is plotted
- Stronger dependence shown by the leftmost and rightmost pixel columns




- For $|\mathbf{B}| < 15$ gauss the overall MAPMT multiplicity is constant and $\sim 1 \longrightarrow$ no efficiency losses, only "redistribution" of hits

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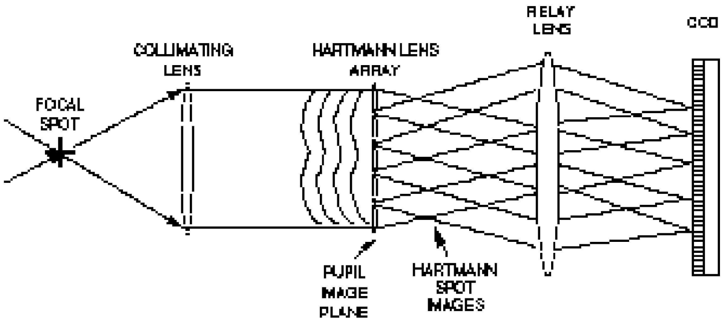
  - noise and cross-talk efects are under control with our read-out architecture
- Our measurements show no efficiency losses for $|\mathbf{B}| < 15$ gauss
- GOOD PERSPECTIVES FOR FUTURE IMPLEMENTATION IN COMPASS

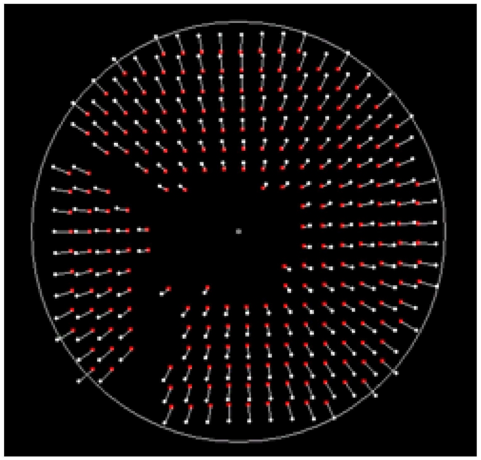
# Backup Slides

# Test procedure of the optical system

- <u>**Hartmann method**</u>

**Features**
- Low Cost
- Easy to Use
- Real-Time Measurement and Display
- Intuitive Displays
- Inspect Optical Components Conveniently
  Flexible Display Options
- Broad Wavelength Capability
- Model Options in Zemax for UV, VIS Primary Wavelength



- **A simple version of this method is not time consuming**
- **DEVICE CONSTRUCTION STARTED**
  **(~ 2 months)**

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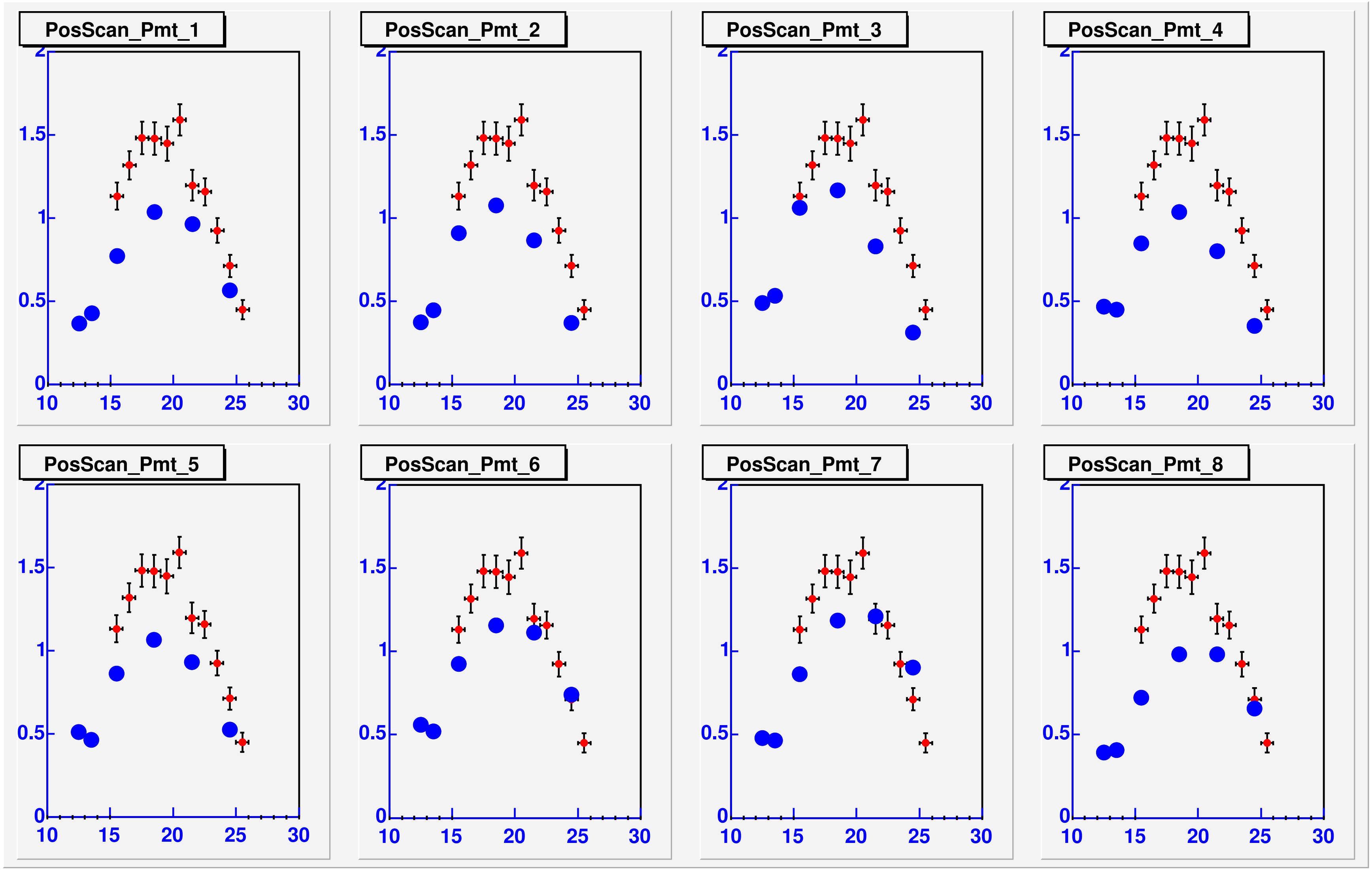
Scan of radiator/mirror relative position: MonteCarlo vs. measured points



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