The RICH2 Detector of the LHCb Experiment

Carmelo D'Ambrosio (CERN)
on behalf of the LHCb RICH Group

1. Introduction to LHCb RICHes
2. RICH2 Optical and Mechanical Structure
    1. Main Mechanical Elements
    2. Main Optical Elements
3. Alignment and Monitoring of the Optical Element
4. Conclusions

Few slides will not be discussed, but made available on the ieee web site for people interested

Introduction to the LHCb RICHes

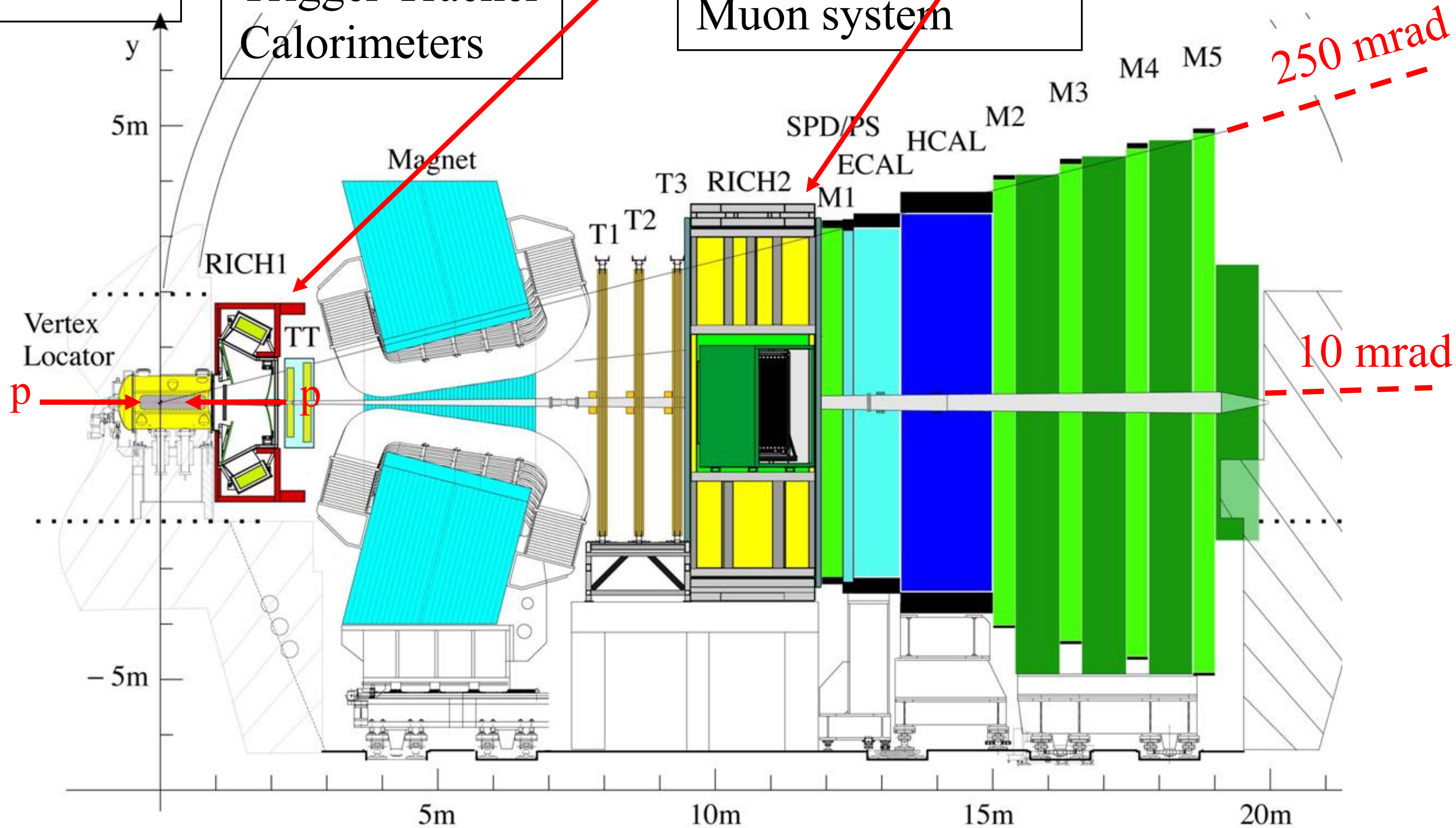
Introduction - LHCb detector (see talk from R.Lindner)

Vertex Reconstruction
VELO

Trigger system
VELO
Trigger Tracker
Calorimeters

Particle ID
RICH1 and RICH2
Calorimeters
Muon system

Kinematics
Magnet + Trackers
Calorimeters



RICH 1:

Aerogel: 2→10 GeV/*c*

n=1.03

(nominal at 540 nm)

C_4F_{10} up to ~70 GeV/*c*

n=1.0014

(nominal at 400 nm)

Acceptance:

25→250 mrad (vertical)

300 mrad (horizontal)

RICH 2:

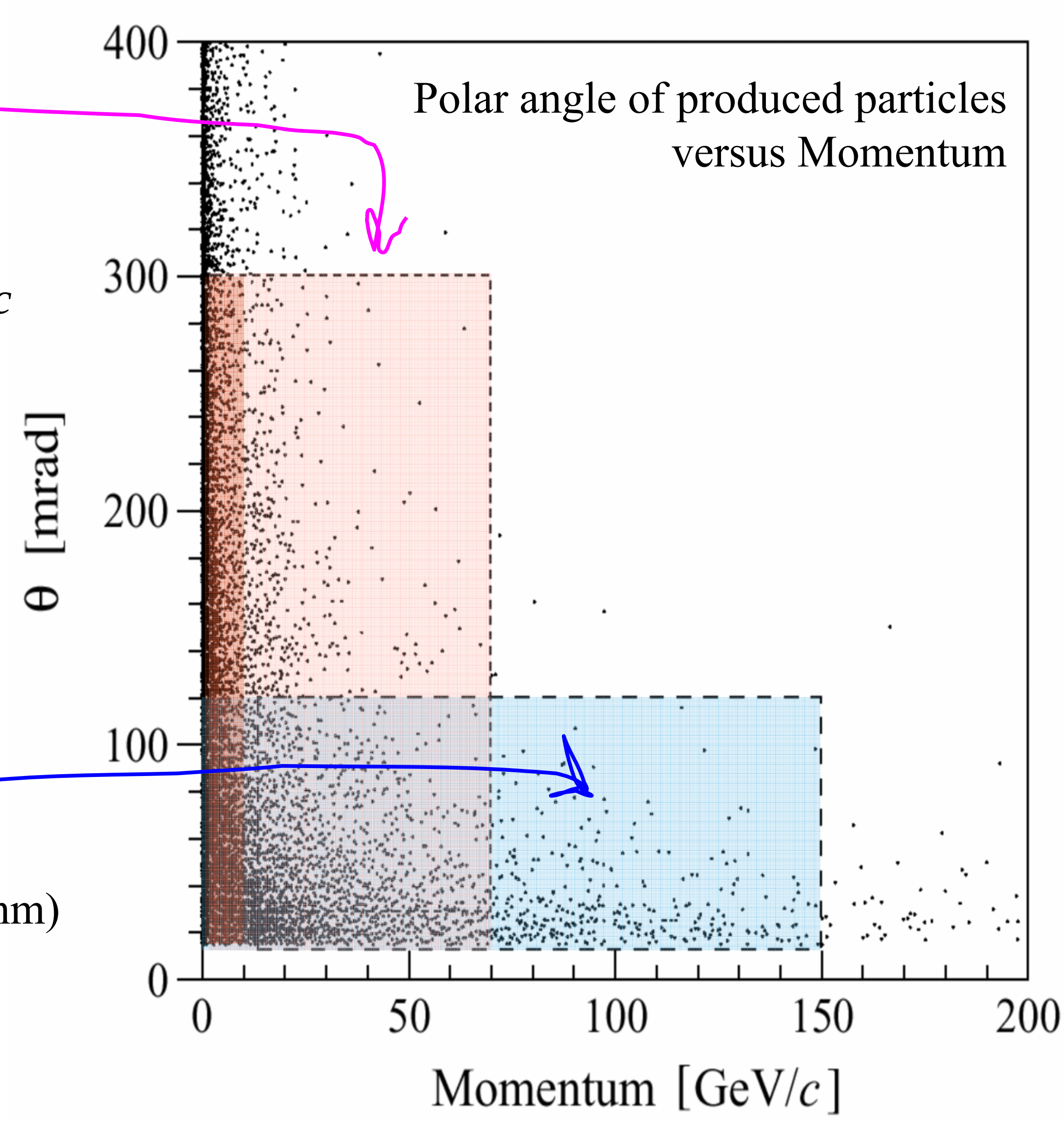
CF_4 up to ~100 GeV/*c*

n =1.0005 (nominal at 400 nm)

Acceptance:

15→100 mrad (vertical)

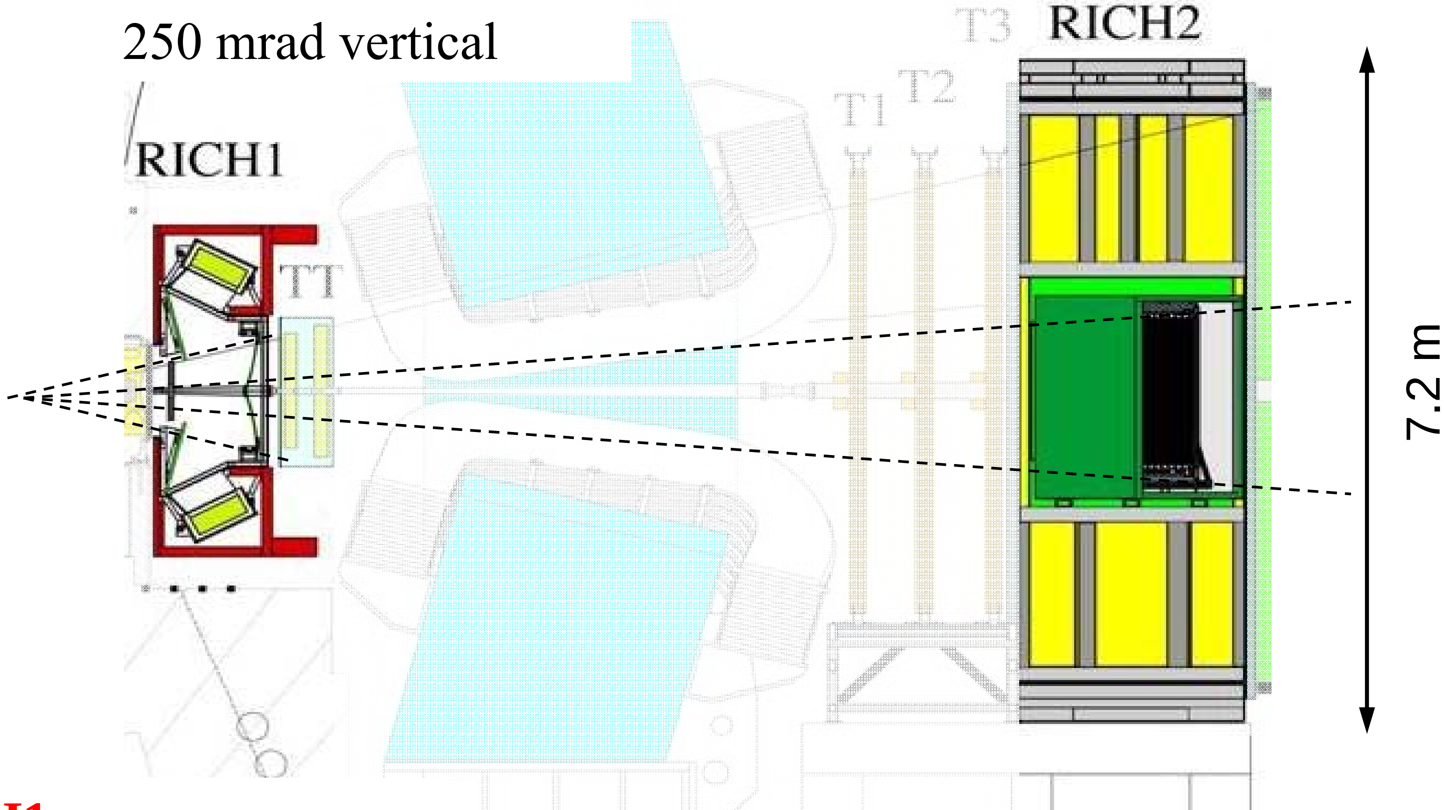
120 mrad (horizontal)



The two RICHes

Acceptance: 300 mrad horizontal
250 mrad vertical

For hadron ID
Efficient p/K separation up to ~100 GeV/c



RICH1:
Low momentum tracks,
Wide acc. angle
- Aerogel: 2 - 10 GeV/c
- C_4F_{10}: 10 - 70 GeV/c

RICH2:
High momentum tracks,
Small acc. Angle, 120 mrad
- CF_4: 16 - 100 GeV/c

The LHCb RICHes are sensitive to near UV – VIS Cherenkov light

Choice due to:

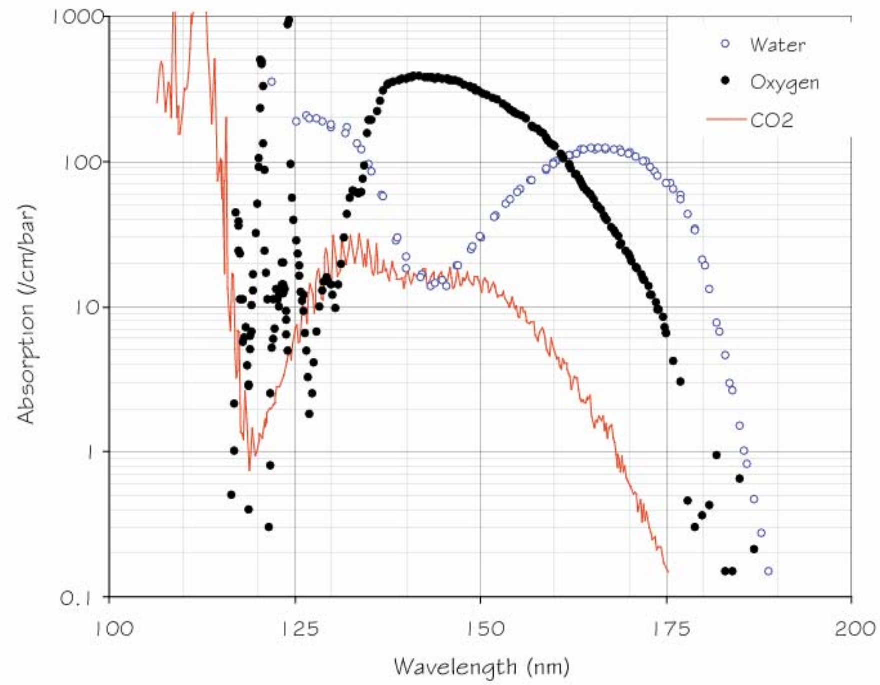
Excellent radiator gas transmission and reduced contamination effects on gas transparency for λ > 200nm

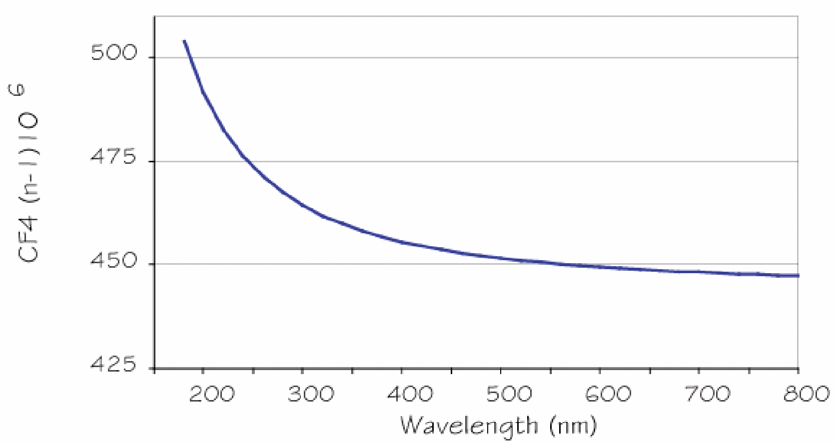
Small chromatic aberration contribution on the Cherenkov angle uncertainties

Long-life and cheap mirror reflective coating

High granularity and Q. Eff., fast and reliable vacuum photon detectors (pixel-HPDs and MAPMTs).

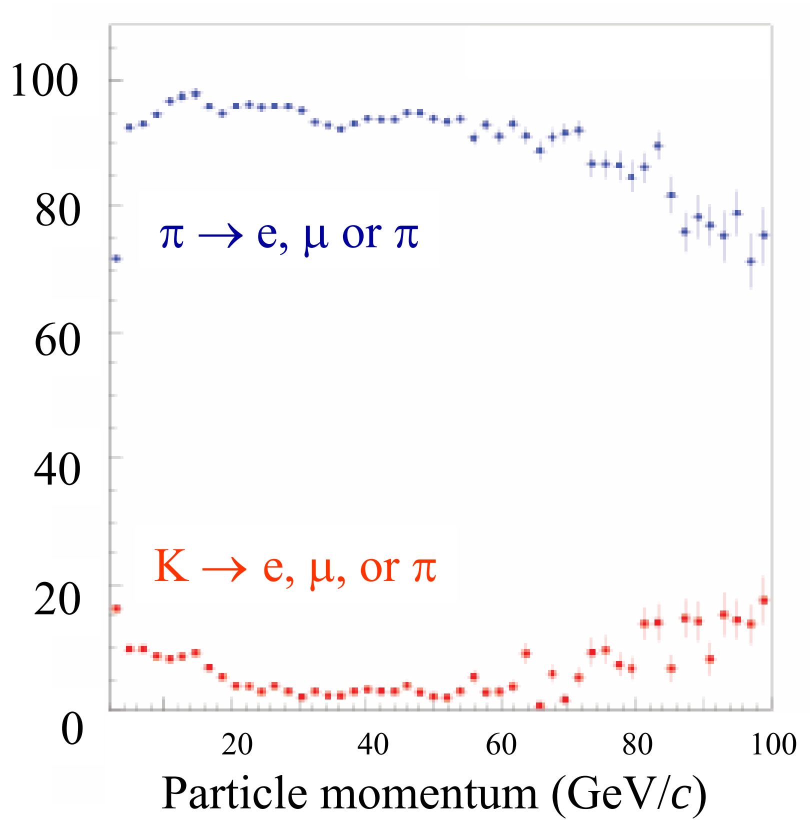
RICH2 features a total Cherenkov angle uncertainty of ~0.8 mrad with ~25 detected photons over a wide momentum range.

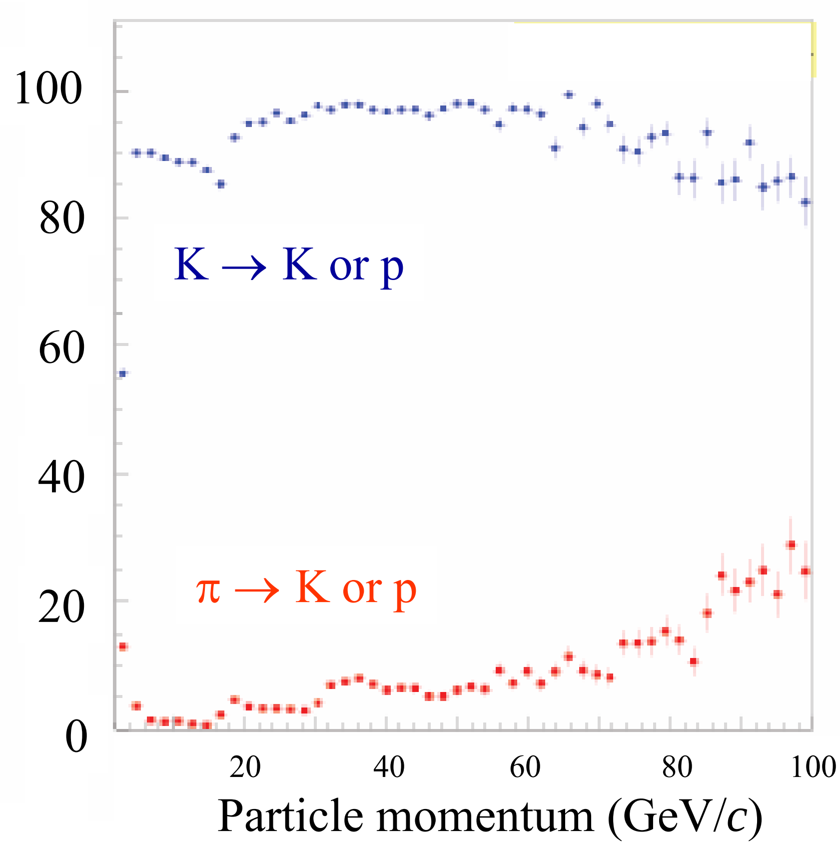




Expected RICHes performance (full detector simulation)

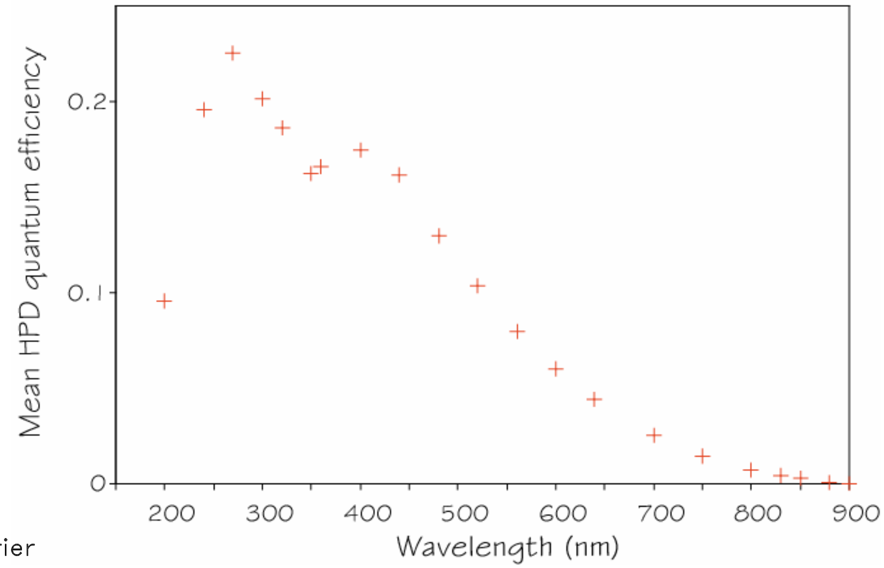
Efficiency (in %) of pion and kaon identification
and
Probability (in %) of misidentifying pion and kaon



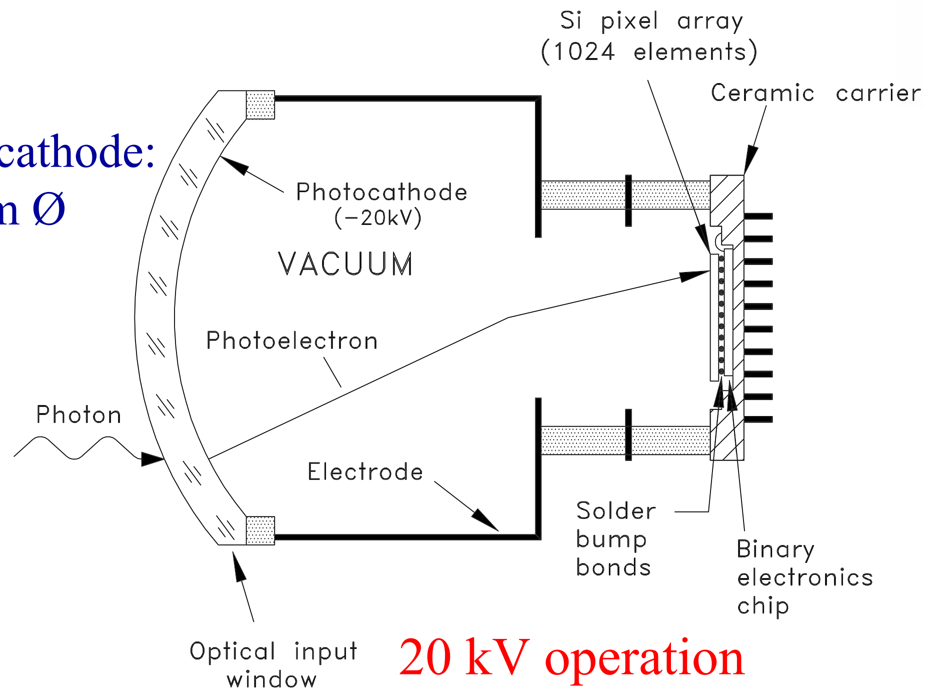


The Pixel - Hybrid Photon Detector (see F. Muheim talk)

Requirements:
2.6 m² coverage with ~65% active area
2.5 x 2.5 mm² granularity
Single photon efficiency
40 MHz readout



S20 photocathode: 75 mm Ø active



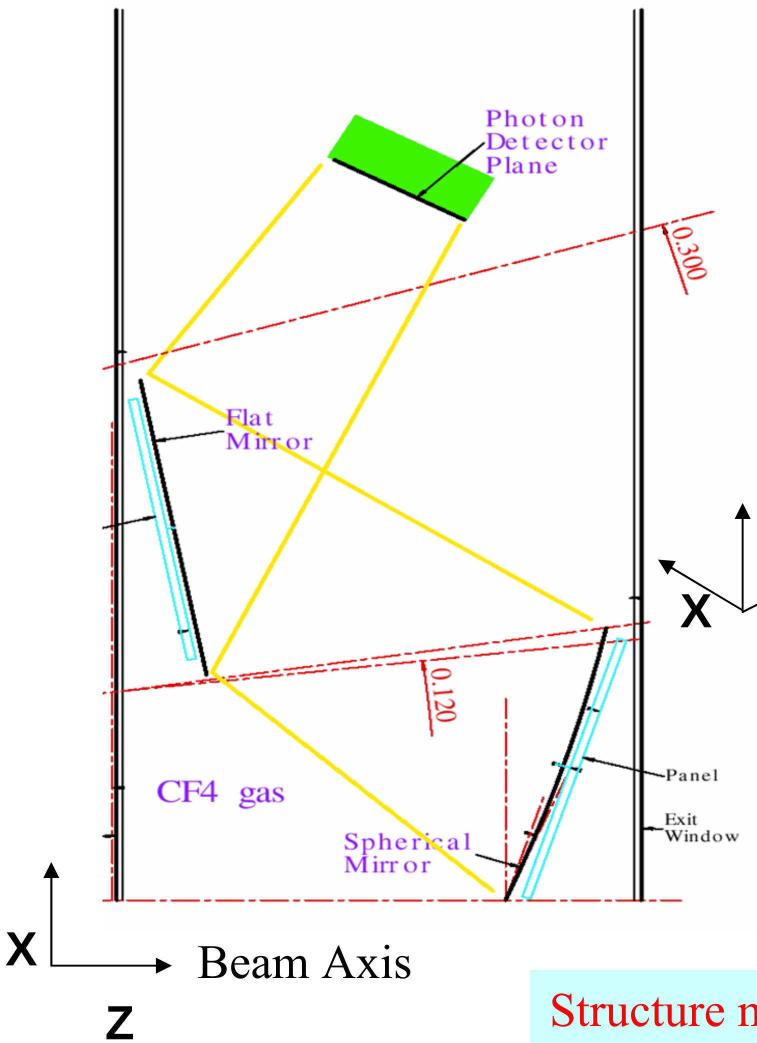
20 kV operation

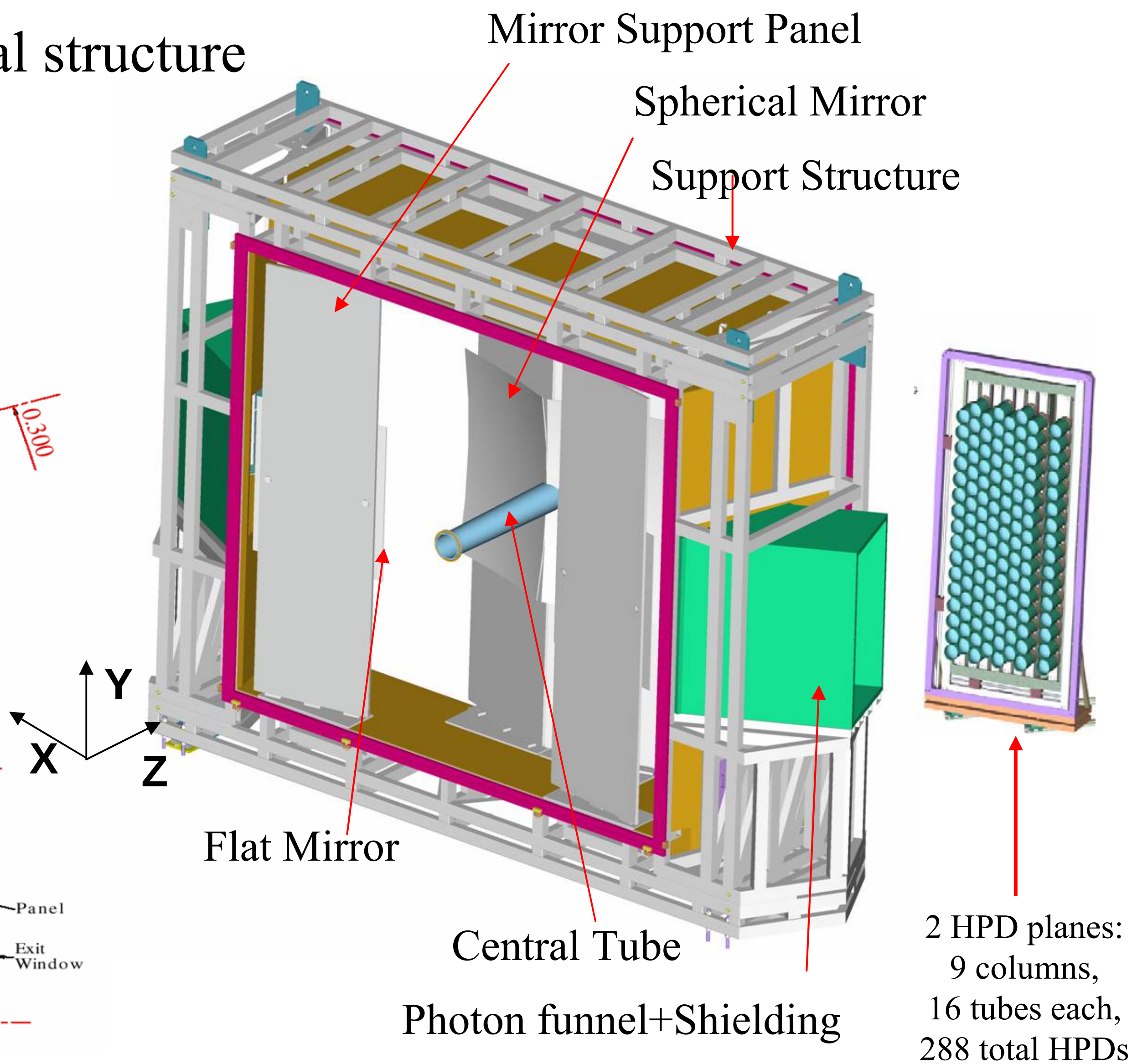
Cross-focused, 83 mm diameter,
encapsulated binary electronics 32 x 32 pixels (500 μm x 500 μm).

RICH2 Opto-mechanical Structure

RICH2 opto-mechanical structure

RICH2 Optics Top View



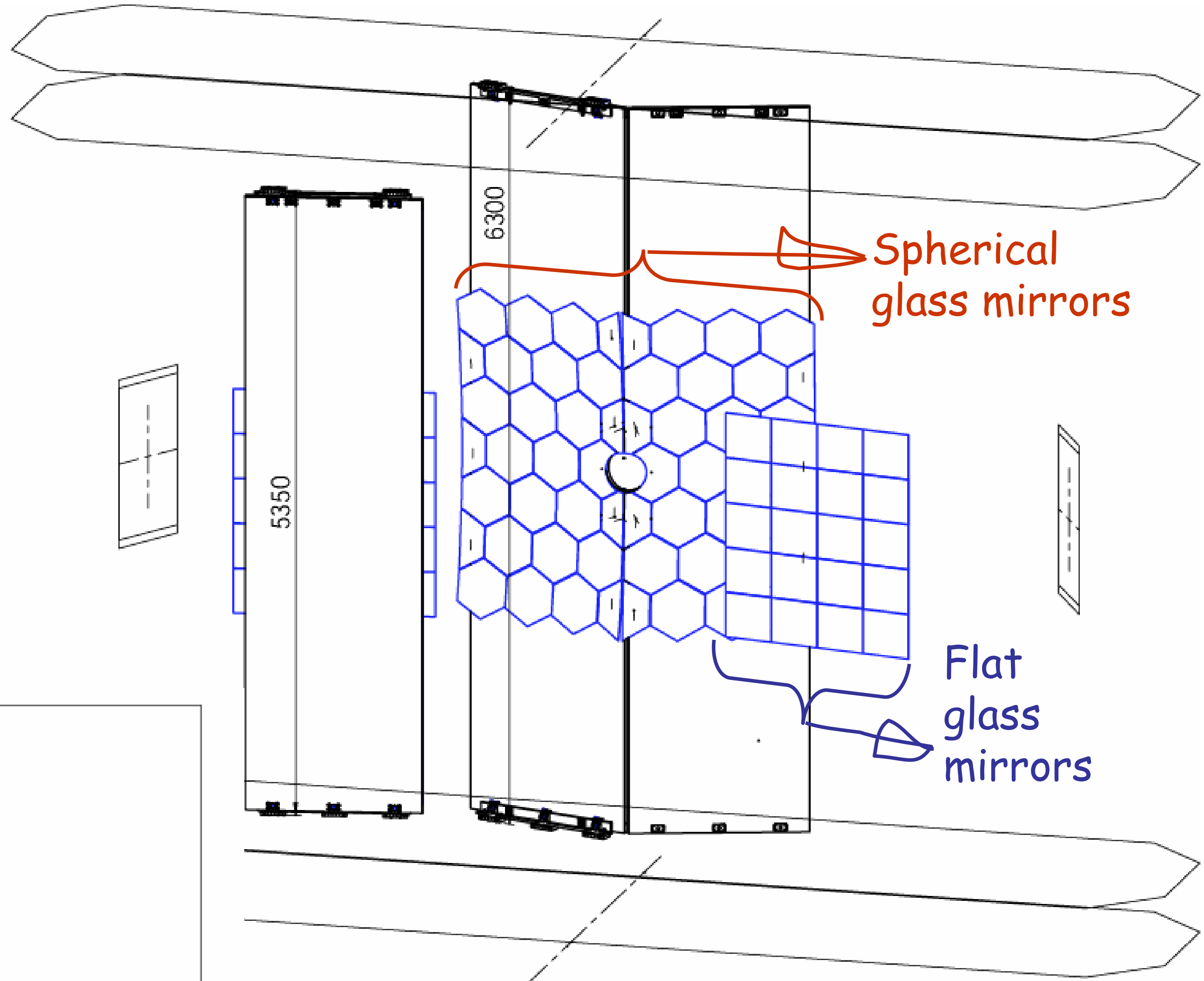


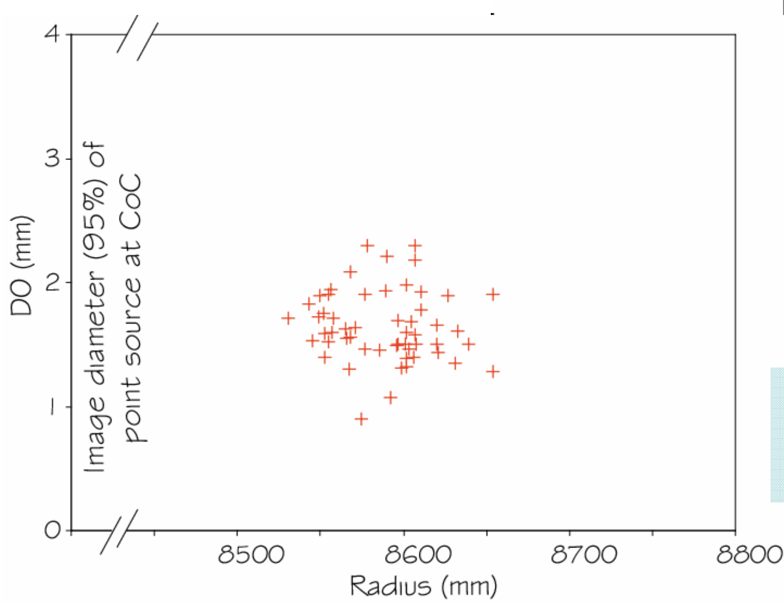
Structure made of Al hollow beams. The entrance and exit windows (not shown) are made of composite material (carbon fibres+foam+epoxy, 1.16% Xo, Al sheets+foam+epoxy, 2.74% Xo)

RICH 2 Optics

6 mm Simax
glass substrate
(prod. By Compas Ltd.,
Turnov)

Spherical mirrors (56)
R ~ 8600 mm (+0.5%)
Do~1.8 mm (<2.2 mm)





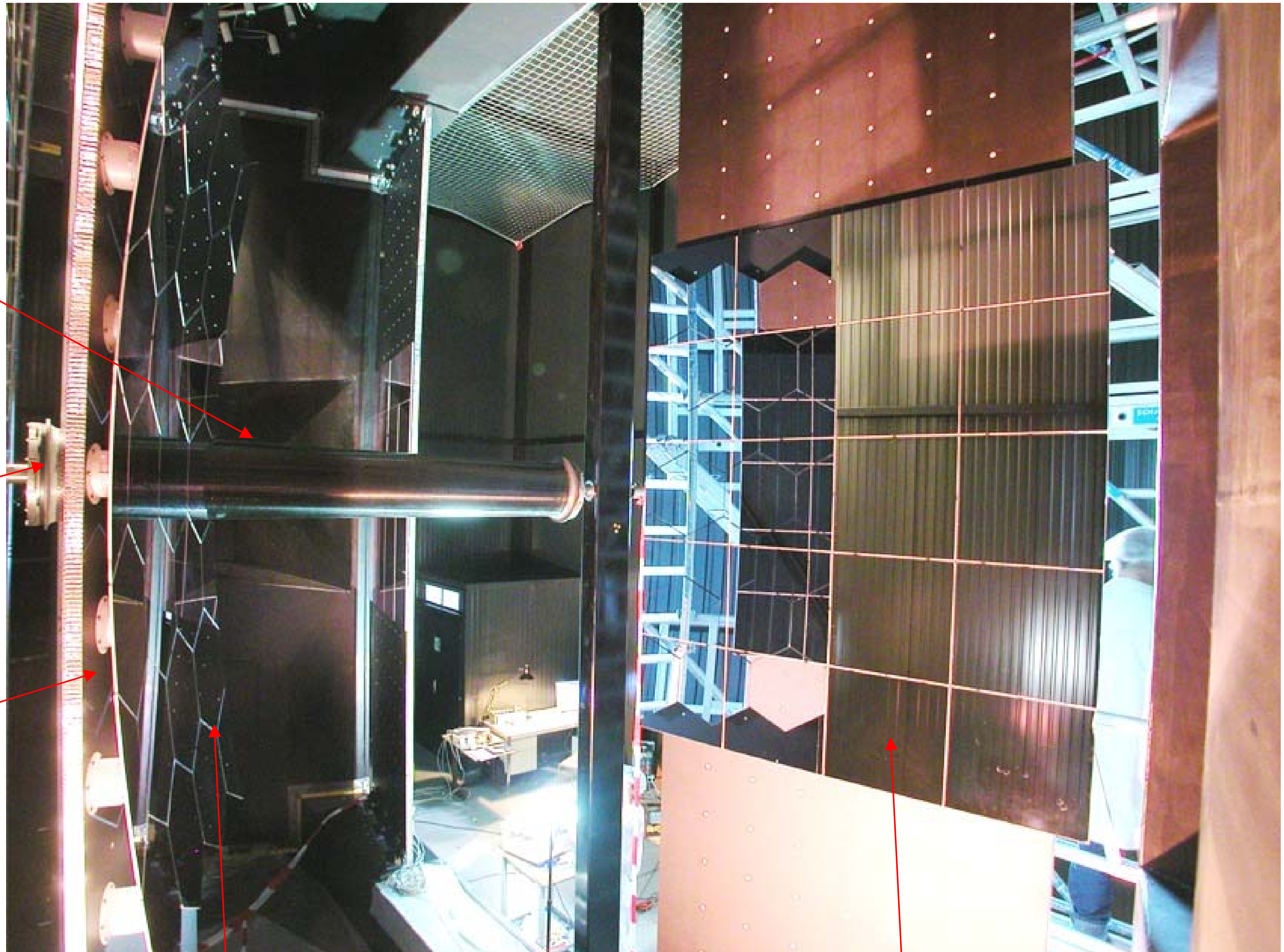
"Flat" mirrors (40)
R ~82000 mm

Coating (done at CERN):
Cr+Al+SiO2+HfO2
Refl. ~97% at 300 nm

Central carbon fibre tube to allow for the beam pipe

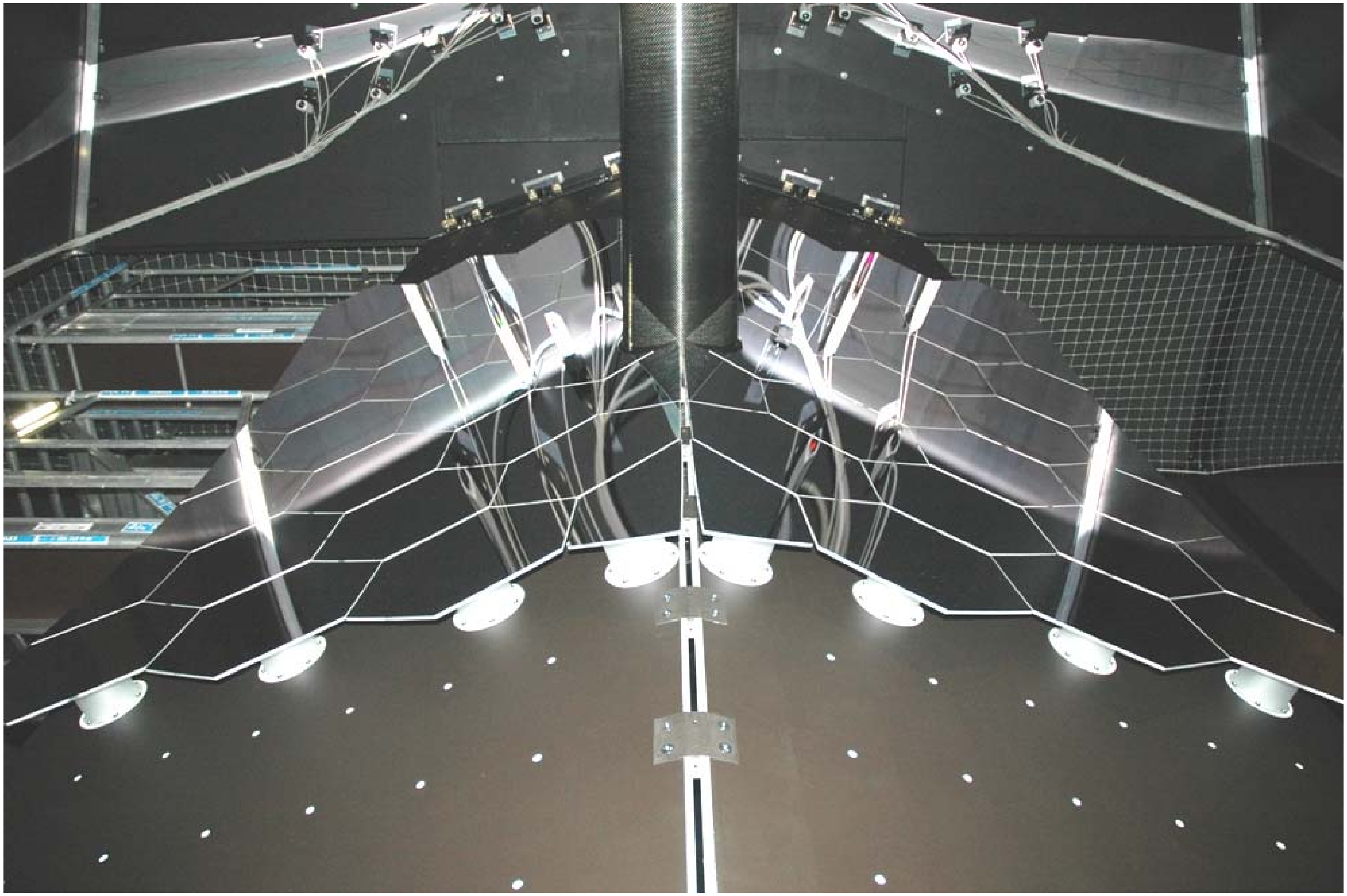
Mirror support and fine adjustment

Panels honeycomb structure



Spherical mirrors array

Flat mirrors array



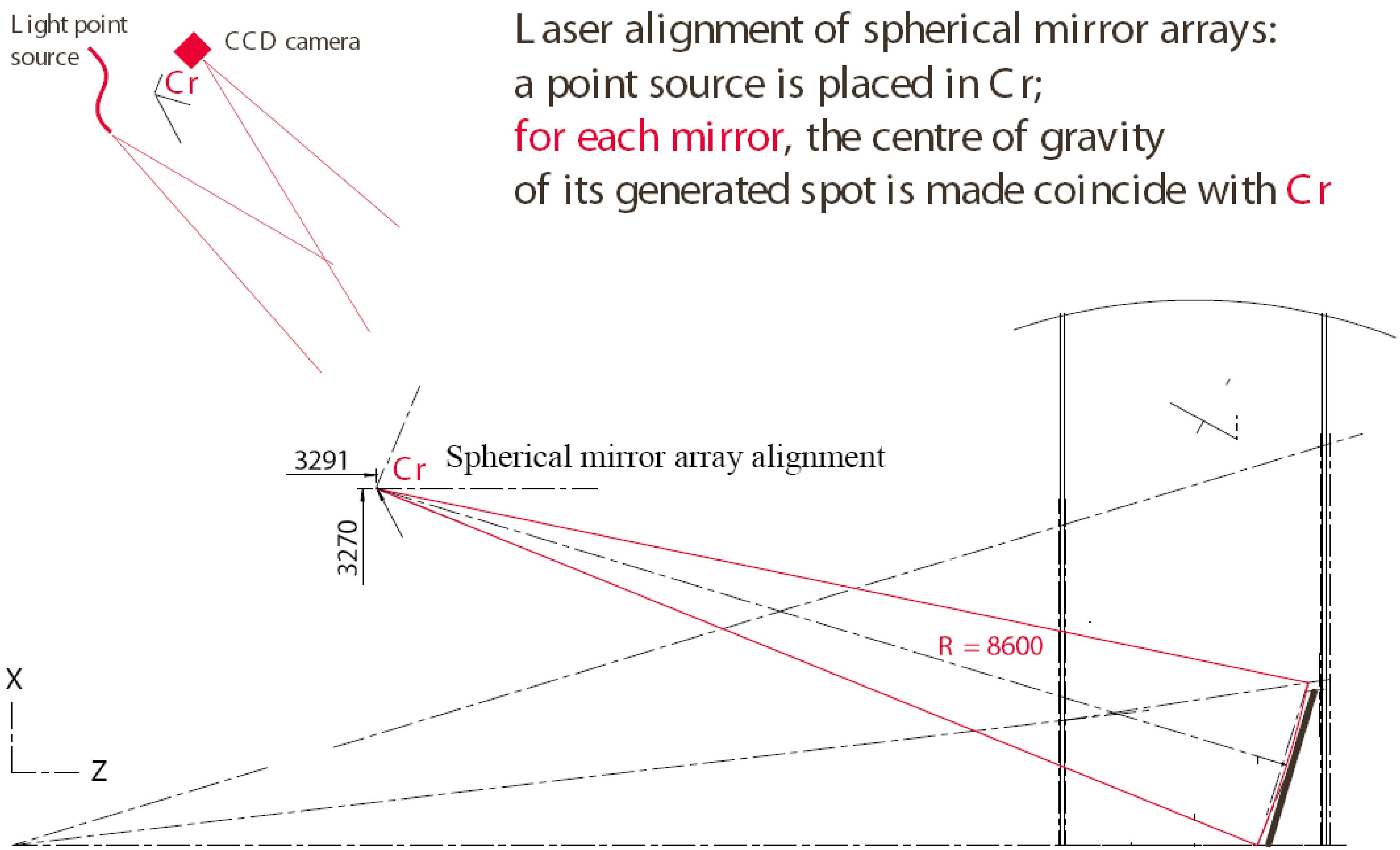
View (from the bottom) of the spherical mirror array

Note: the two Al – Honeycomb panels and the polycarbonate supports.

RICH2 Mirror Alignment

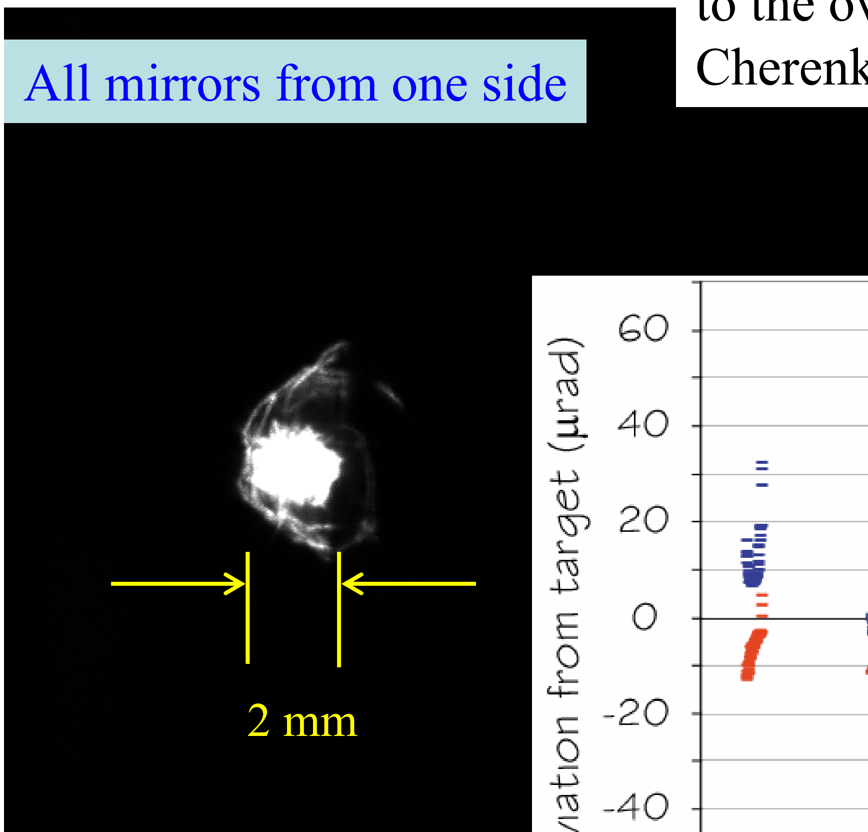
RICH 2 Mirrors Alignment 1

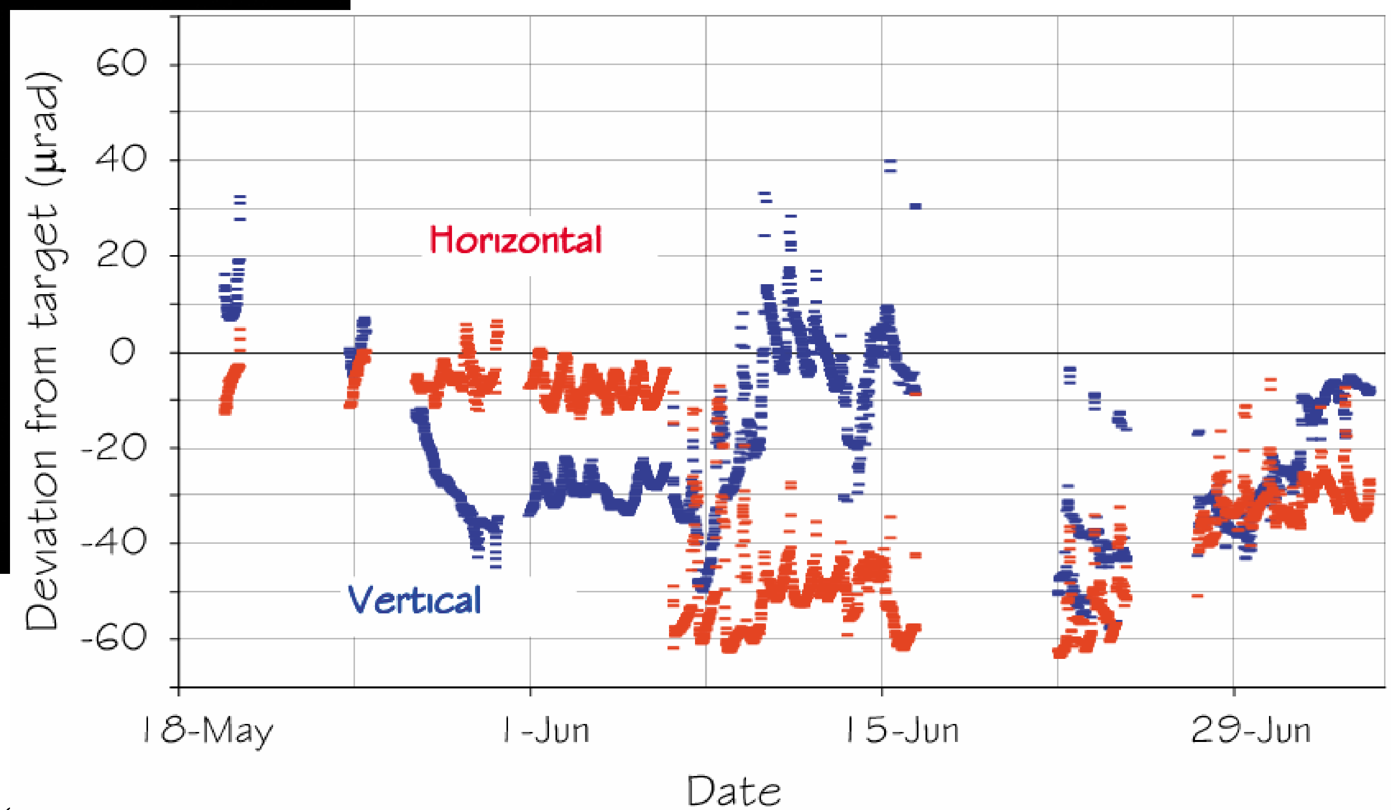
Laser alignment of spherical mirror arrays:
a point source is placed in Cr;
for each mirror, the centre of gravity
of its generated spot is made coincide with Cr



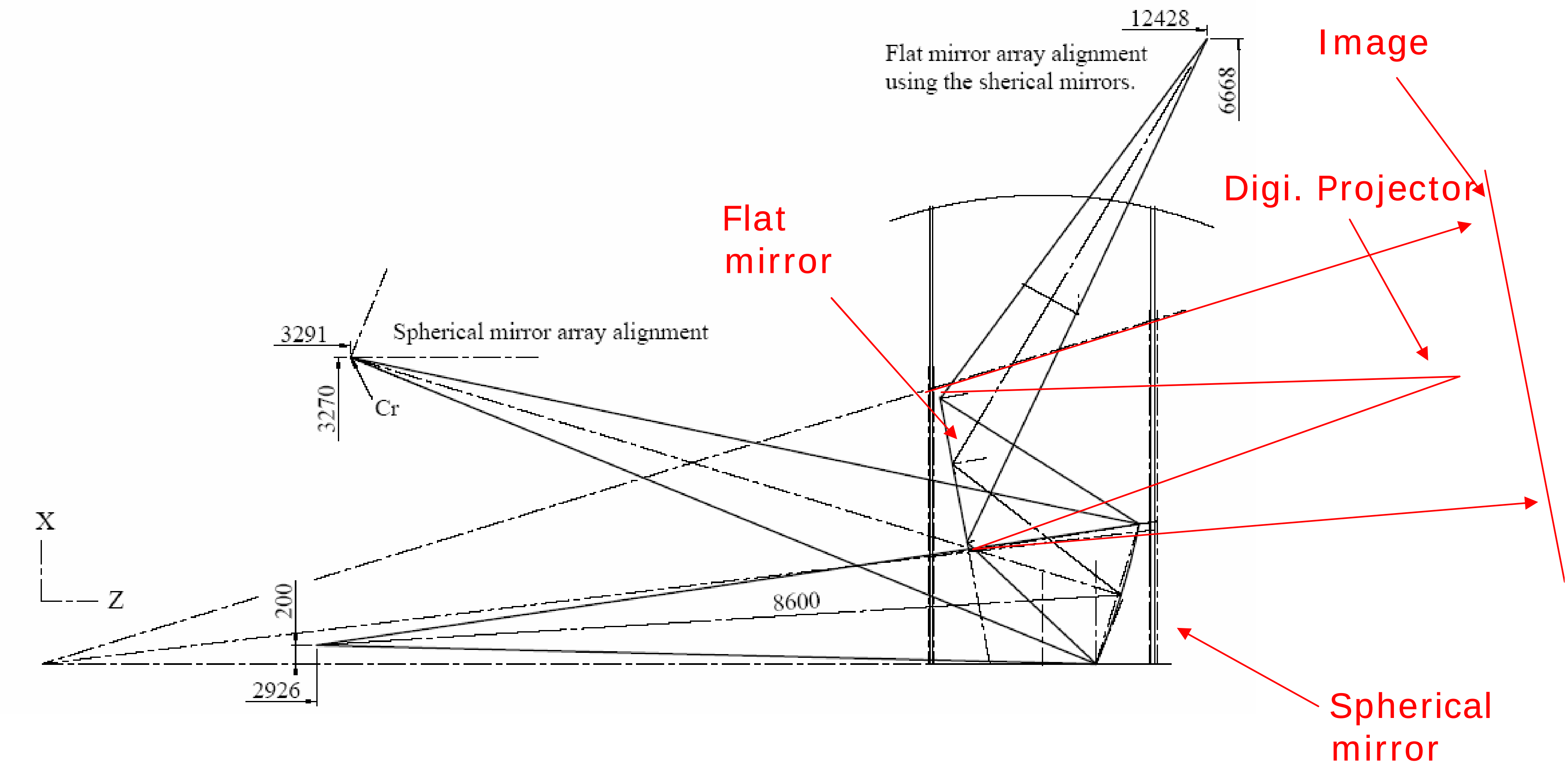
RICH 2 Spherical Mirrors Alignment

Alignment and stability set a <30 μrad contribution to the overall uncertainty in the single photon Cherenkov angle reconstruction

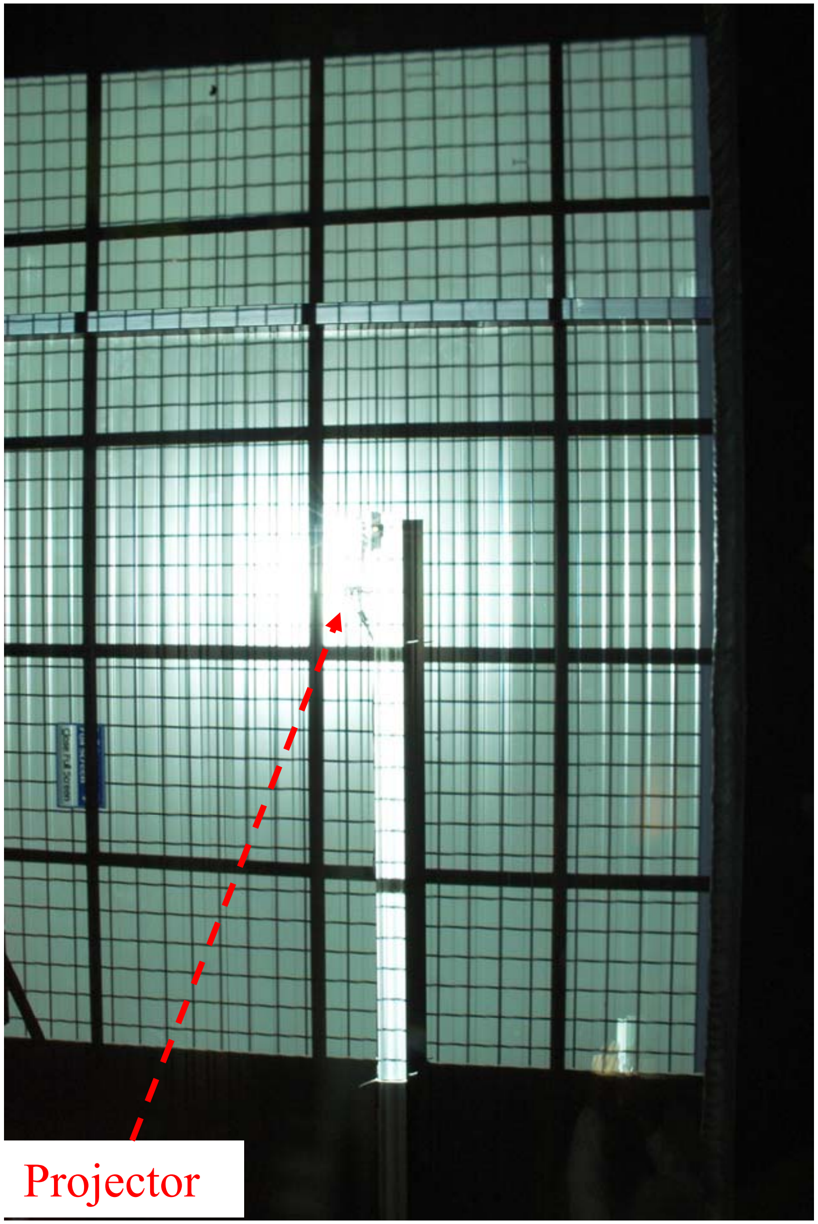




RICH 2 Mirrors Alignment 2



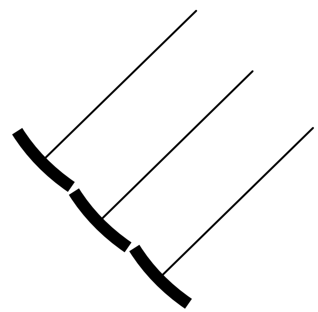
RICH 2 Mirrors Alignment 3



Simply align until the vert. and horiz. lines are aligned.

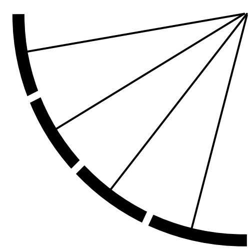
The separations between mirrors reflect the fact that they are not really flat (R = 82 m).

These mirrors are aligned “as if” they were flat.



Parallel normal vectors

And not



Common centre of curvature

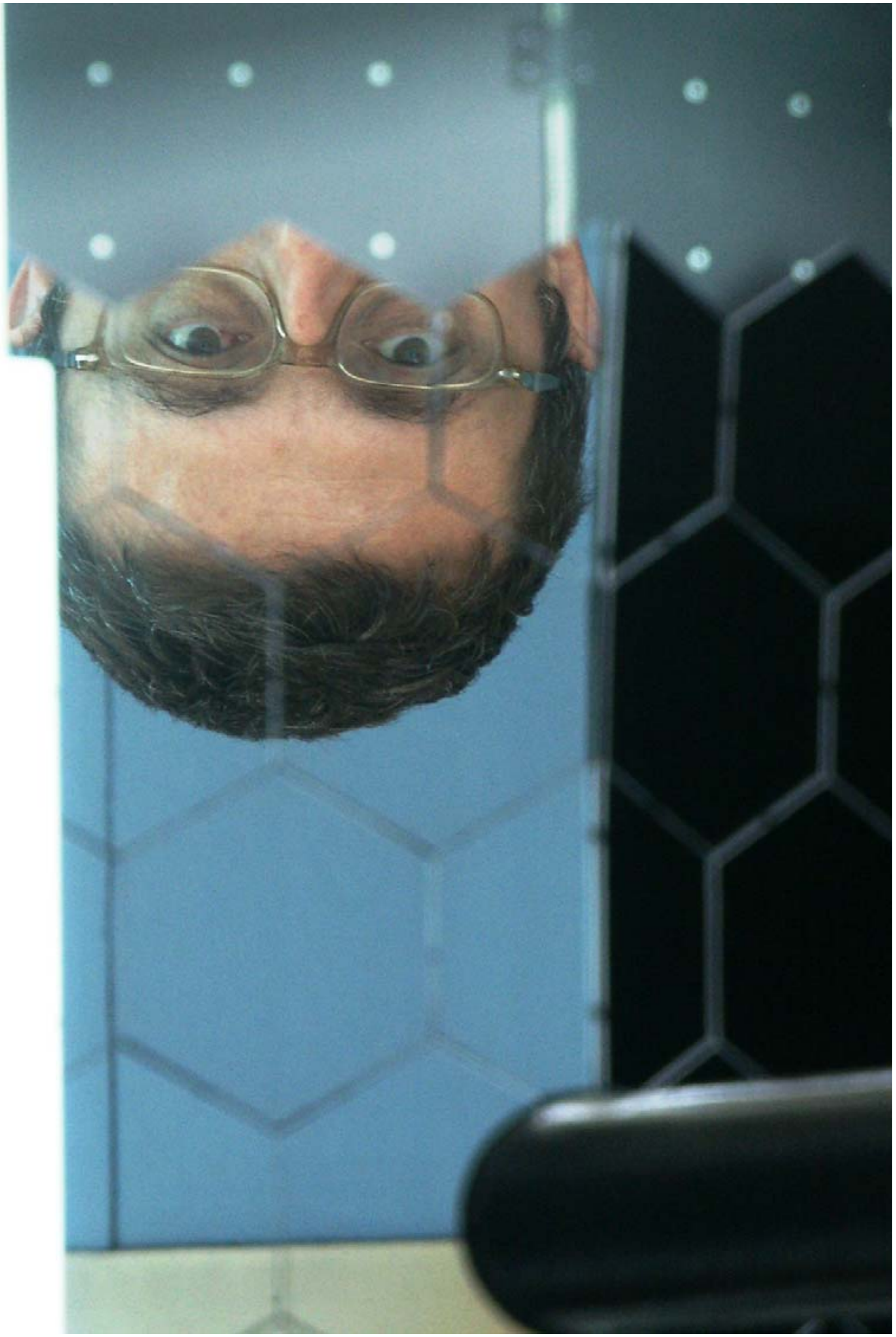
RICH2 Monitoring Systems

Environmental Monitoring

Present Mirror Monitoring

Data-taking Mirror Monitoring

Magn. Distortion Monitoring



Carmelo D'Ambrosio (CERN) on behalf of the LHCb RI(

RICH 2 Environmental Monitoring

RICH2 is provided with temp., pressure, humidity sensors. They provide monitoring and control of the environment inside RICH2. Gas flow and purity monitoring is also together with all needed monitoring for safety (see also poster from F. Fontanelli)

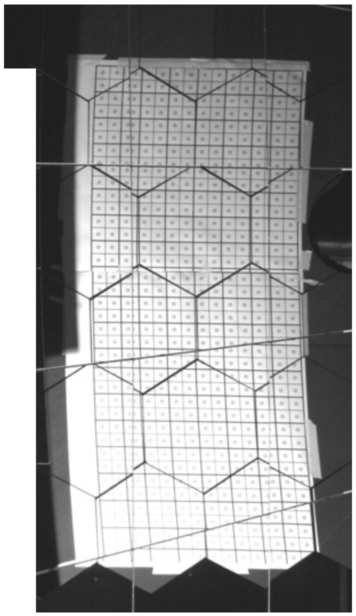
RICH 2 Mirrors Monitoring 1

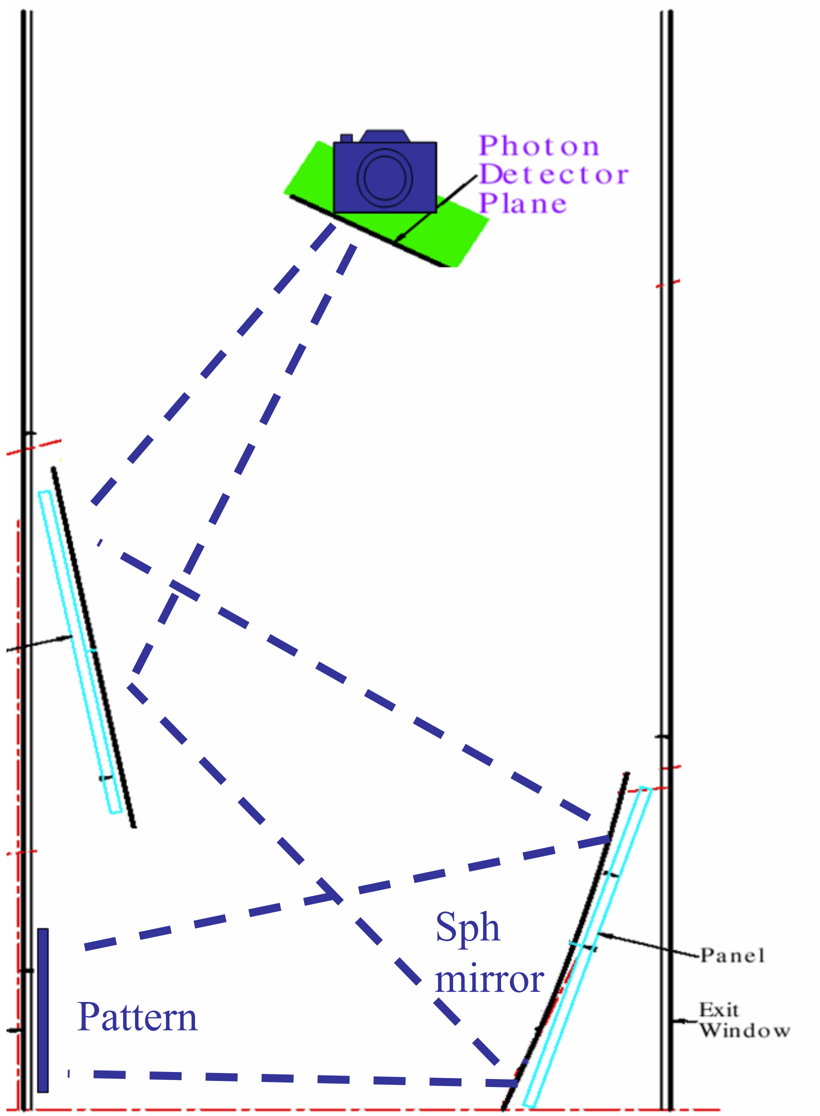
RICH2 is transported to the experimental pit with all the optics finely adjusted to <0.1 mrad !!

A photograph of a pattern is automatically taken, for example, every 20 sec

Each picture is subtracted with "picture zero"

A movie is then produced.



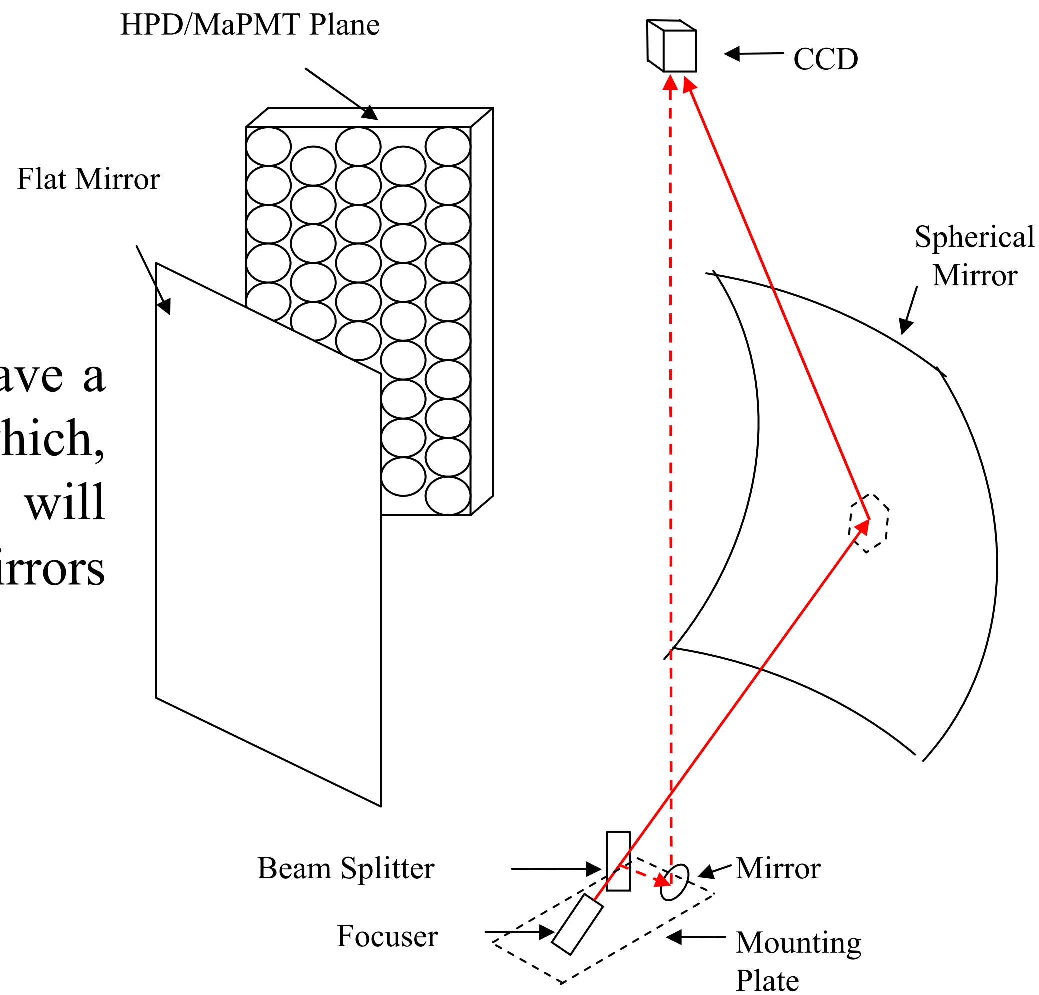


By subtracting images before, during and after transportation, it is possible to assess whether or not the optical system gets misaligned with a ~0.2 mrad sensitivity

Movie available for interested people

RICH 2 Mirrors Monitoring 2

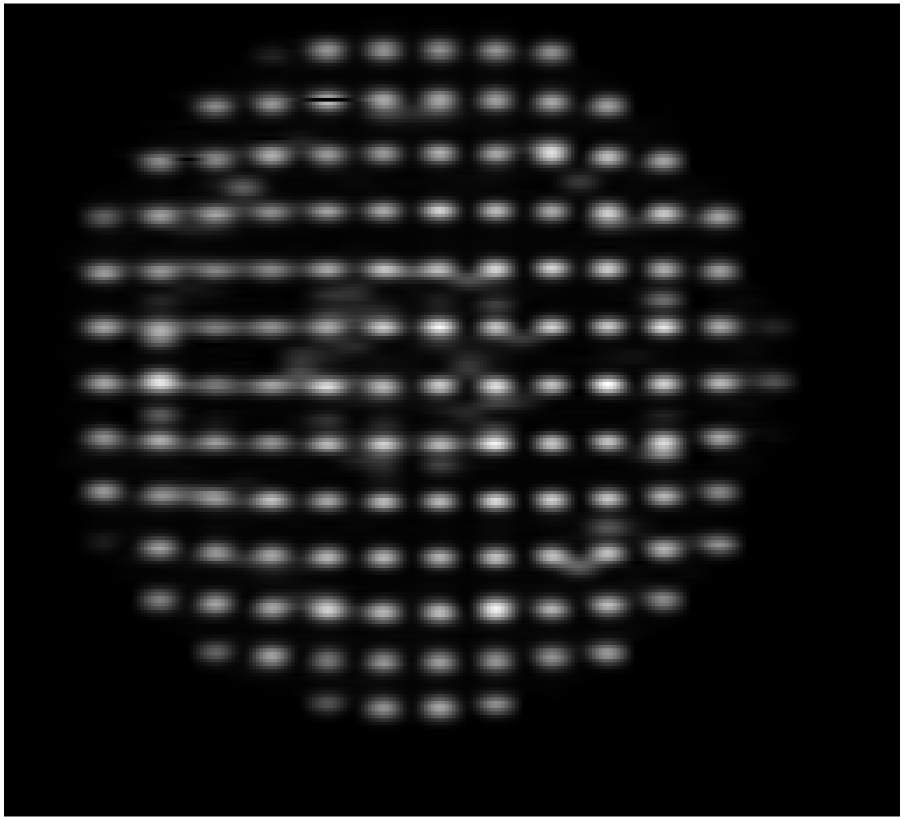
During data taking, RICH2 will have a mirror monitoring system, which, together with off-line analysis, will allow θ_c corrections in case of mirrors movements



RICH 2 Mirrors Monitoring 3

During data taking, fringe magn. field will distort the opto-electronic images, therefore RICH2 will have a magn. distortion correction system

Magn. Field varies between 0 and 40 G



The system consists basically in projecting a pattern on the photon detector plane without and with magn. field, thus allowing the extraction of a correction LUT and a off-line data correction.

Conclusions

RICH2 is ready and about to move to the experimental pit

The superstructure, the magnetic shielding boxes and the windows are all in places and thoroughly tested

The opto-mechanical system is aligned, …and think will stay so after the move

Part of the monitoring system is in place and more will be added in the pit

HPDs + electronic system will be placed beginning of 2006

We expect it to perform as previously simulated

We are looking forward to the first collisions….

And a thank to all institutions and people who worked hard for its achievement