The LHCb RICH photon detector system

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on behalf of the LHCb RICH Group

Introduction to the system

Photon-detector: the pixel HPD

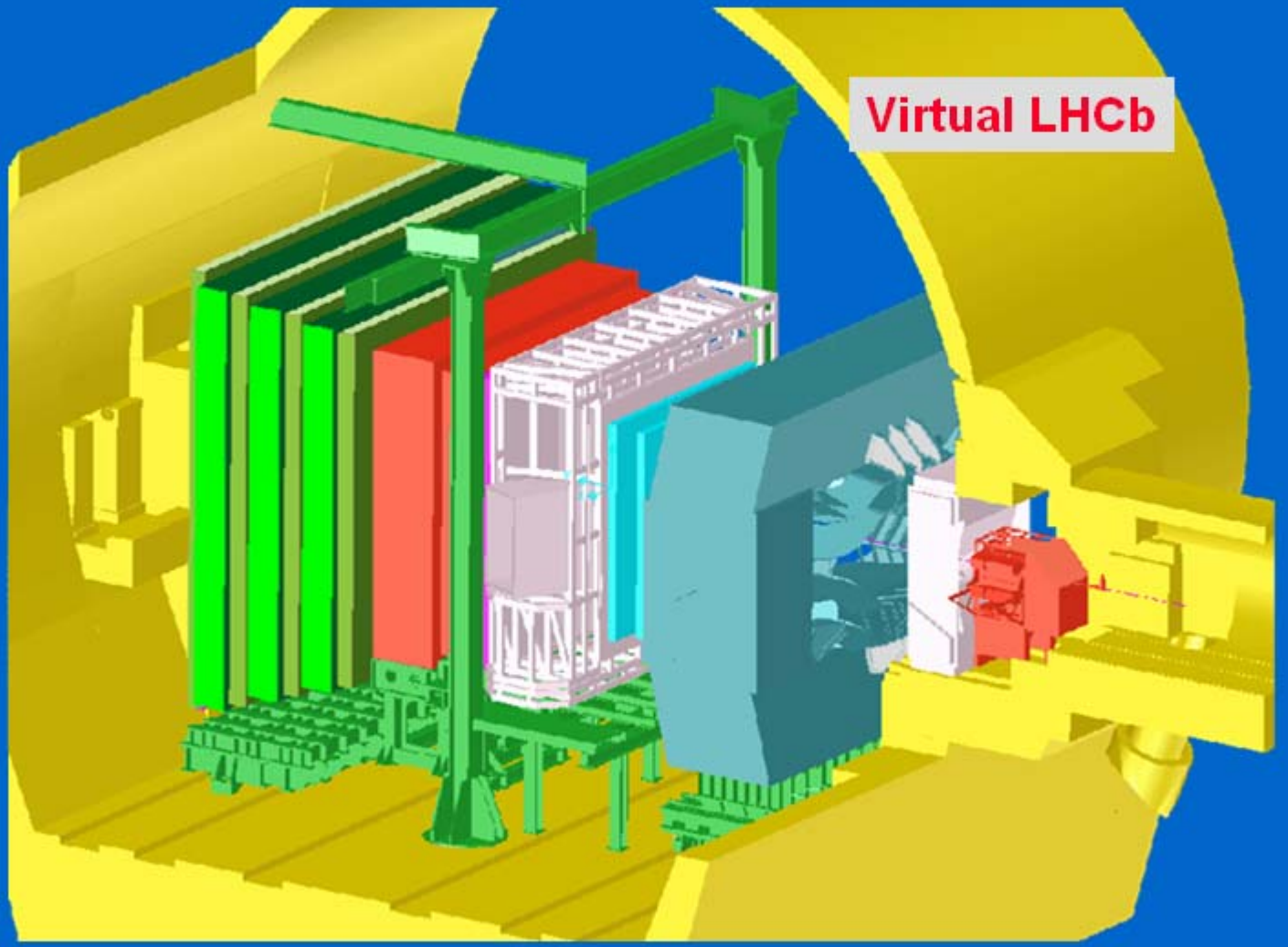
Building the system

Test results

Conclusions and Outlook

The LHCb detector and its RICHs

Designed to study B-physics – RICH detectors for particle identification



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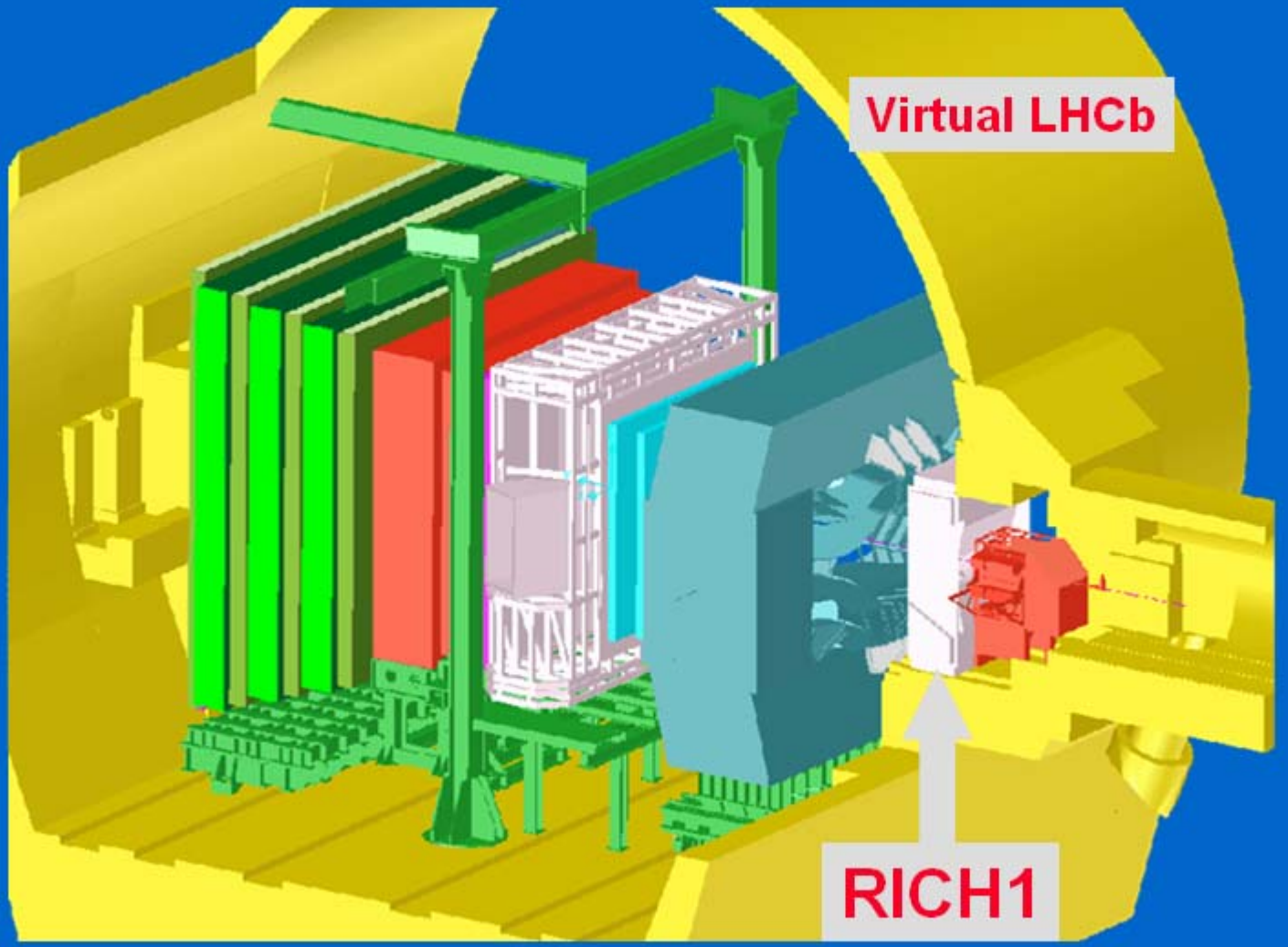

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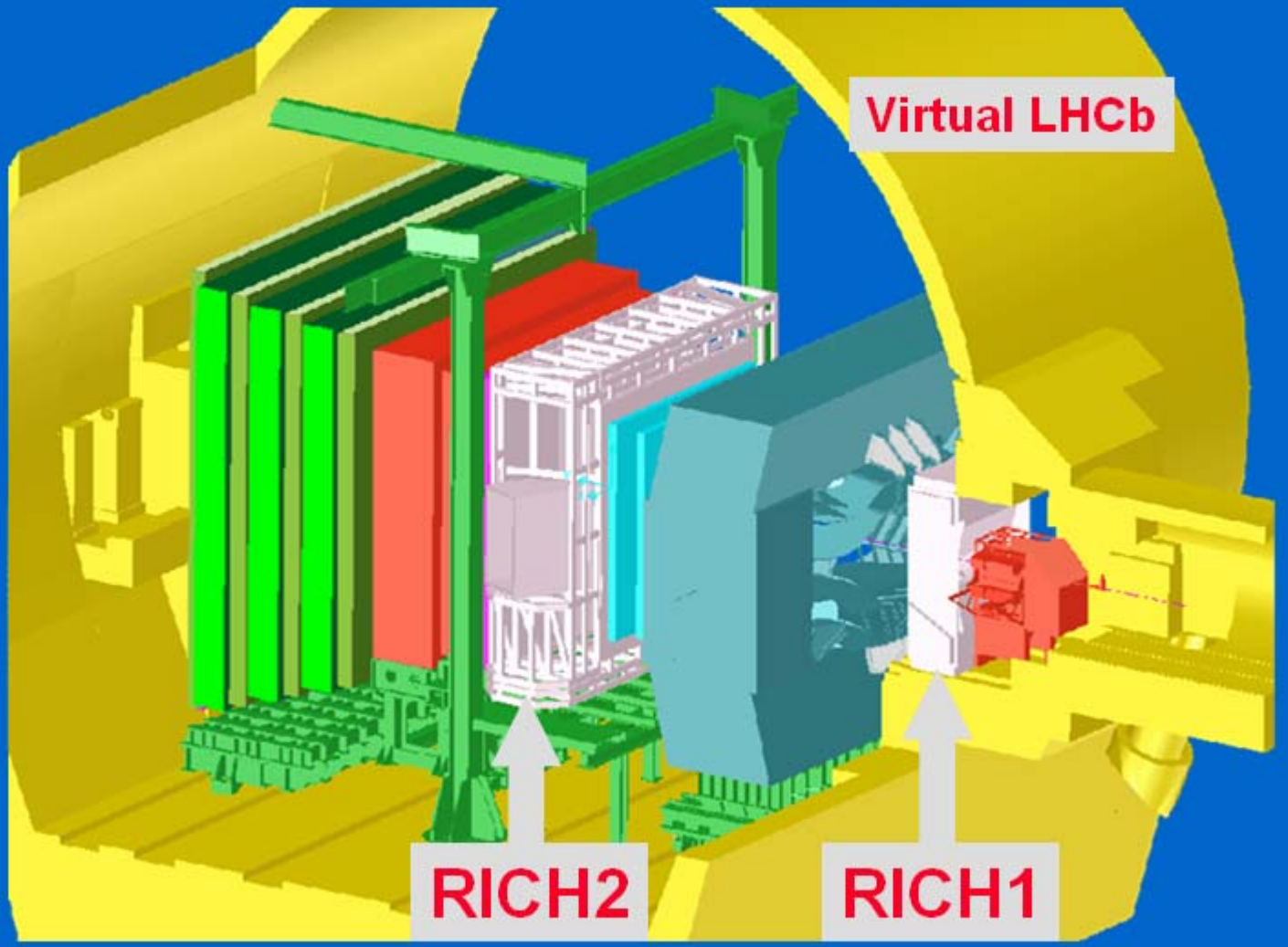
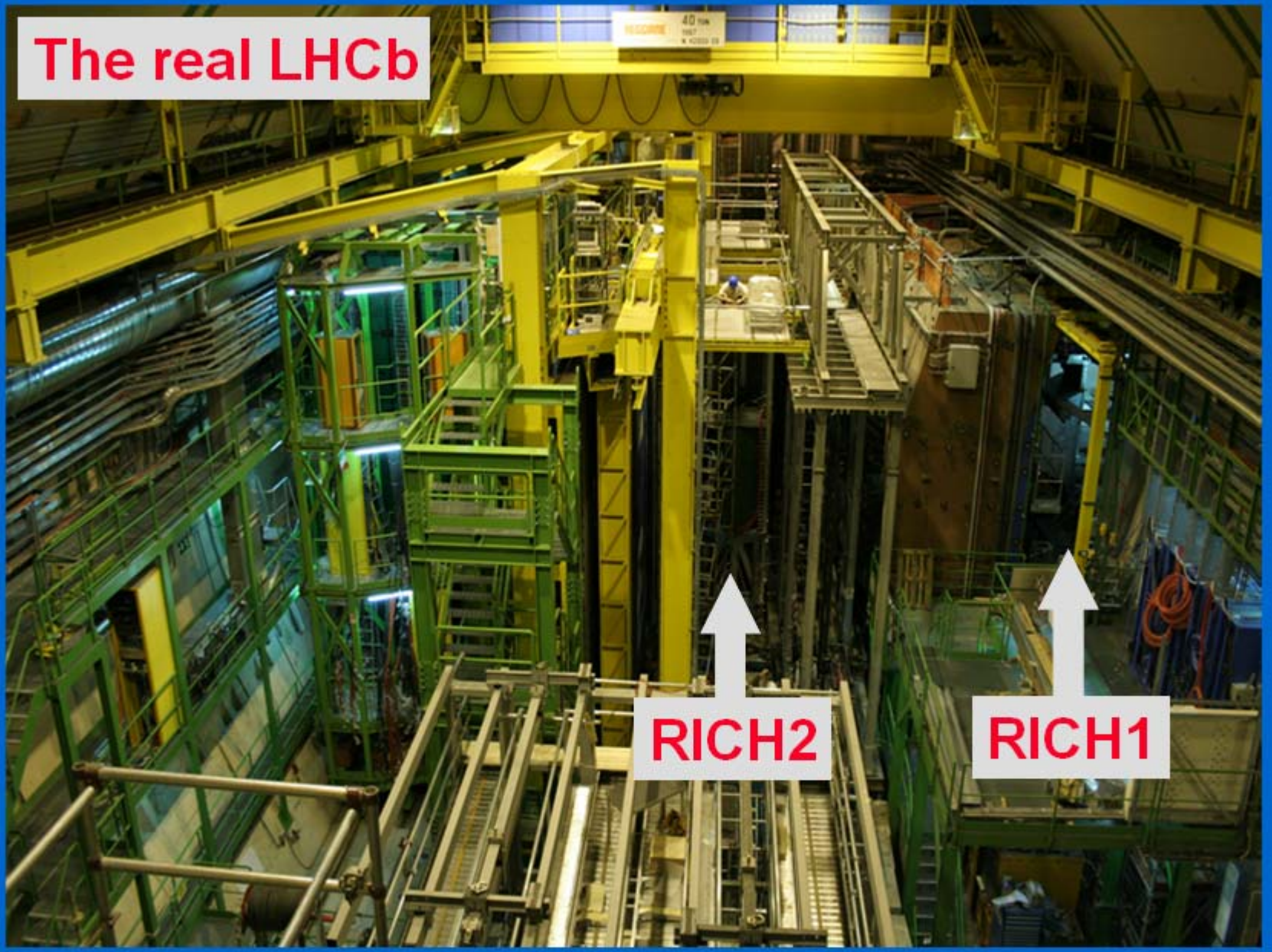
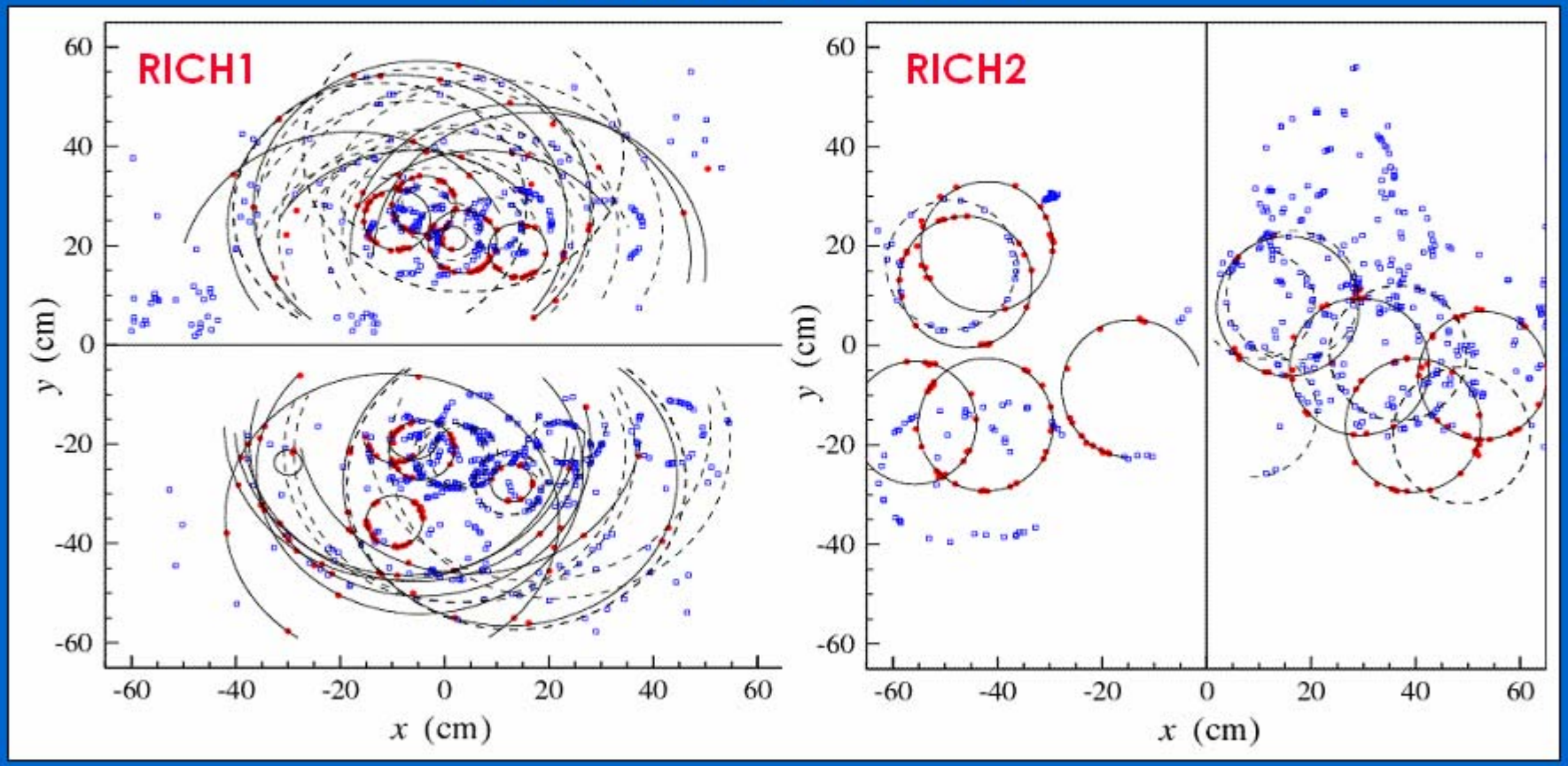


The real LHCb



Measuring Cherenkov Photons

Simulation of Cherenkov Rings



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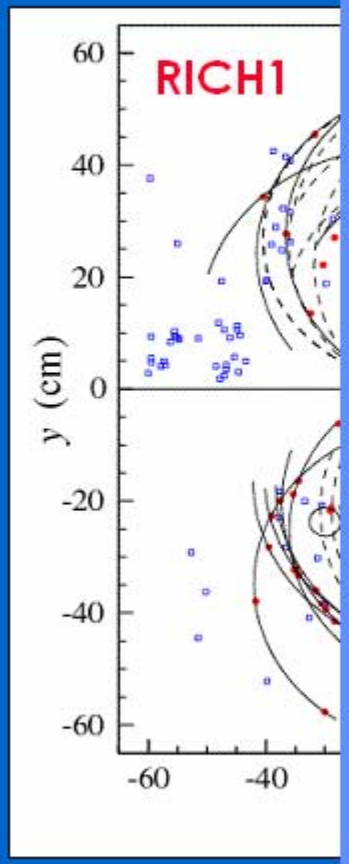


Photon detector requirements

Sensitive to single photons 200nm to 600nm

Detection area 2.9m^2, active fraction > 65%

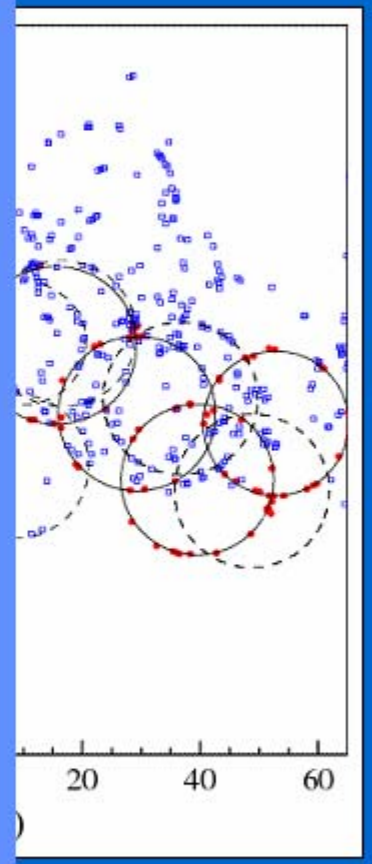
2.5mm x 2.5mm channel size

25ns time precision (40MHz LHC frequency)

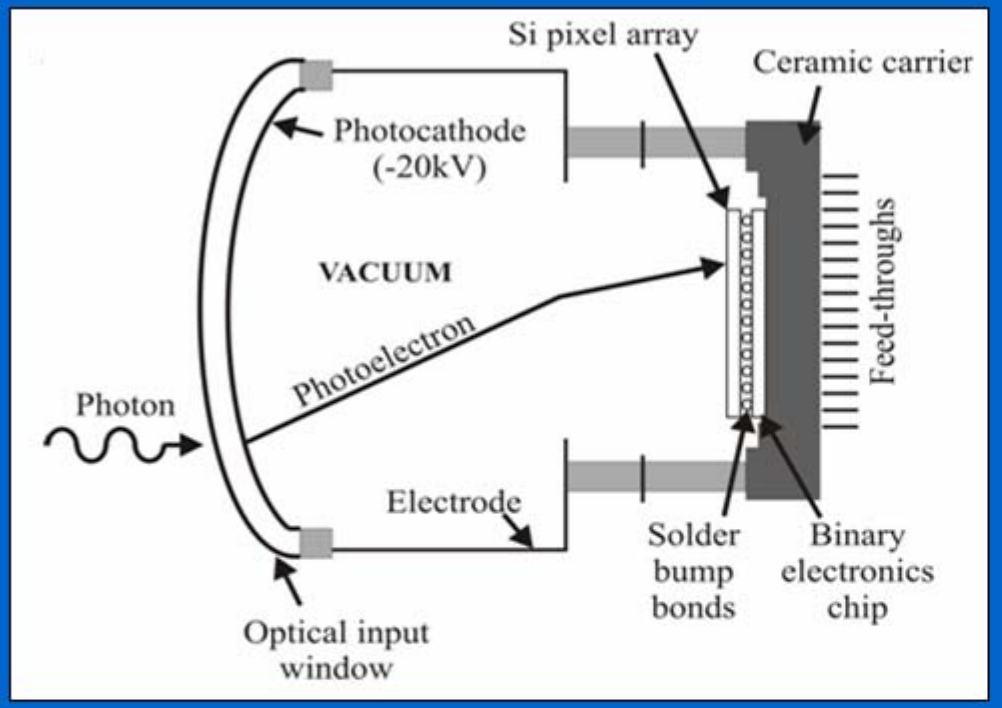
1MHz event rate

Low noise rate

Tolerant to B-field ~ 30G



The pixel hybrid photon detector (HPD)



DEP, the Netherlands

Advantages of this hybrid, pixel structure:

low noise = excellent resolution of single photoelectrons

high channel number/density = position resolution

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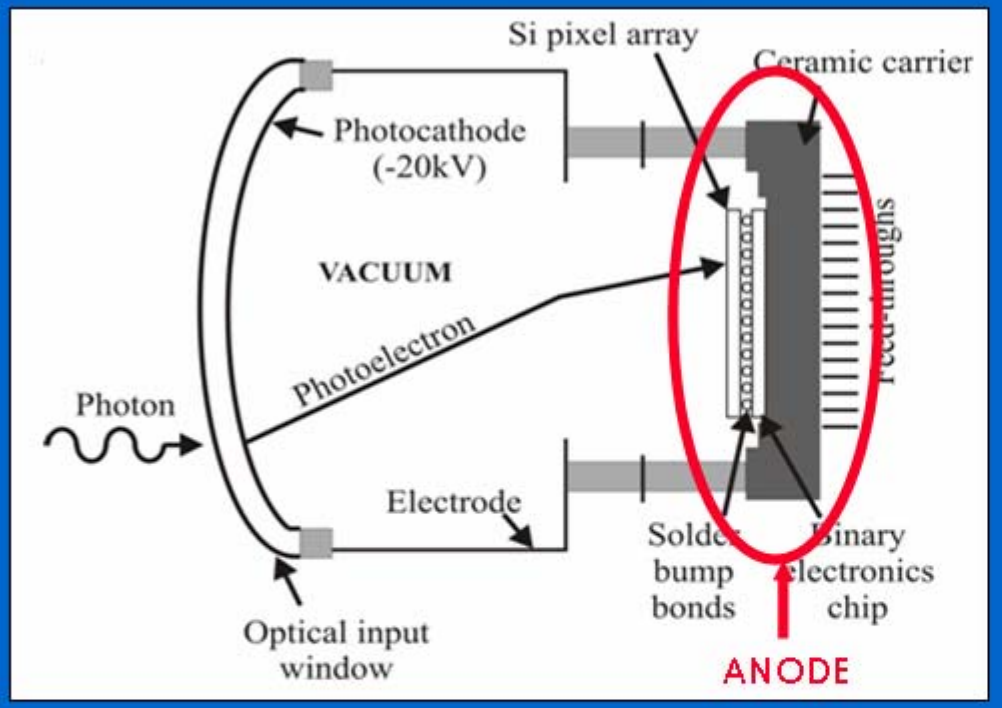

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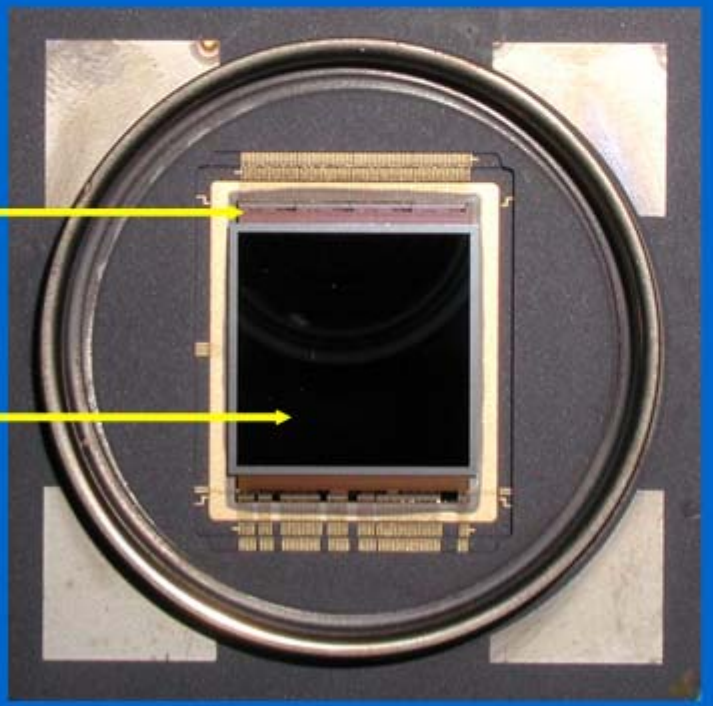
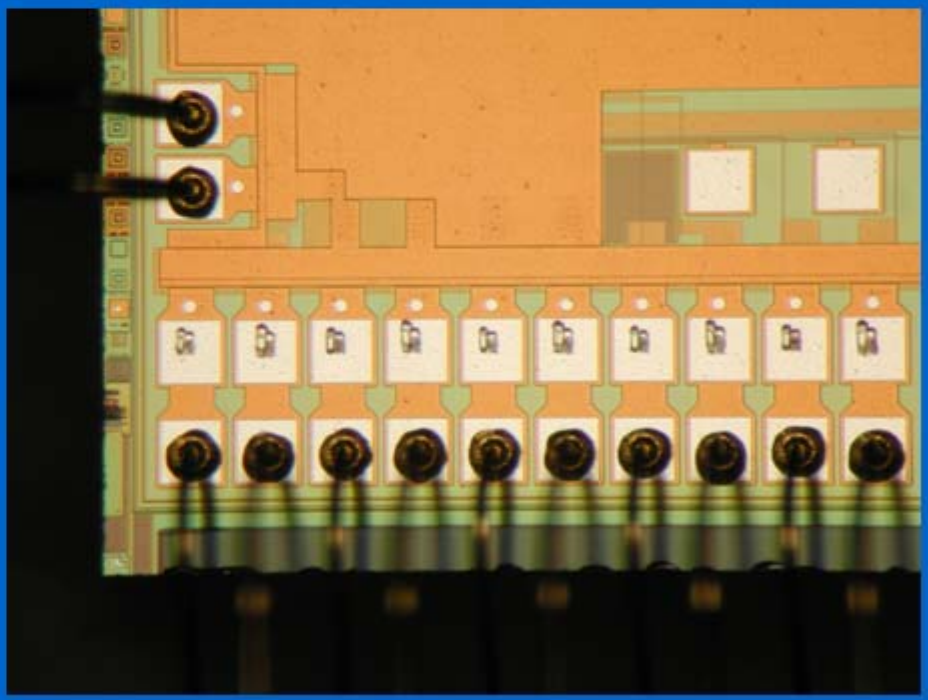
The HPD anode

Active pixel electronics mounted within HPD vacuum, binary (threshold) readout:

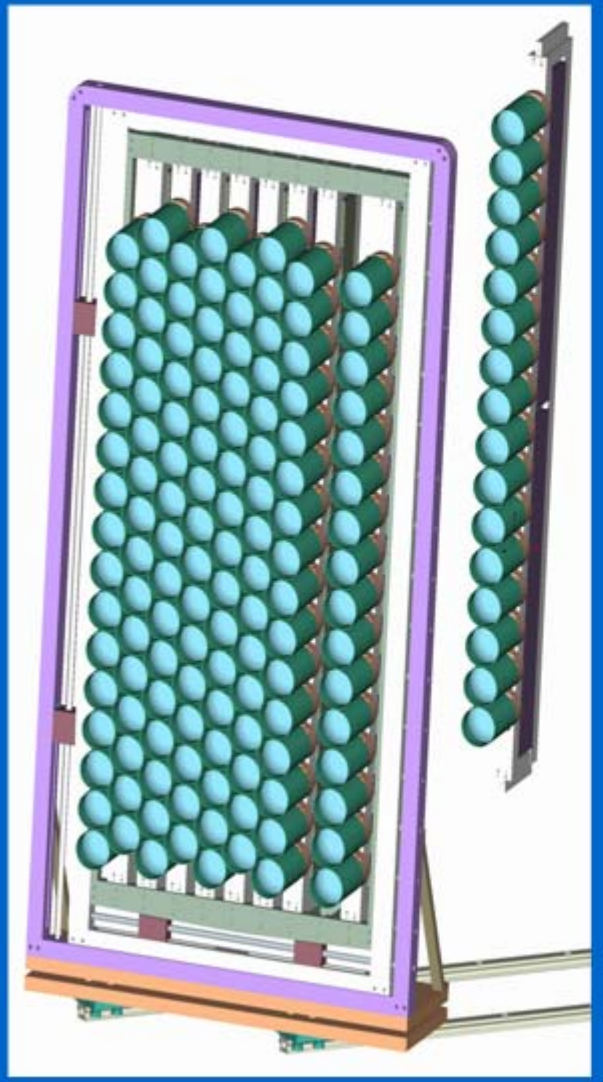
8192/1024 channels	(two different modes of resolution)
Low noise	160 e^- (signal ~ 5000 e^-)
Threshold low & uniform	mean 1200 e^- with RMS 100 e^-

High density flip-chip interconnects (bump-bonds) developed for HPD application with VTT, Finland – capable of withstanding T-cycling of vacuum processing





Building the photon detector system



484 HPDs all produced

500,000 pixels (4 million in high resolution)

Mounted in column modules
Columns closely packed

Module contains:


20kV distribution

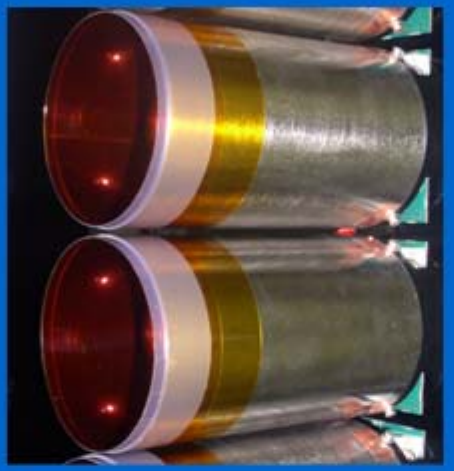

optical data transmission
(1.6Gb/s per HPD)


local magnetic shielding


active cooling

Building and testing the system

Bare HPDs



With mu-metal shield

36-HPD system tested in lab & test-beam using a mini-RICH detector with different gas radiators

What the Cherenkov photons see is this

Test results

Lab tests with DC LED & pulsed laser

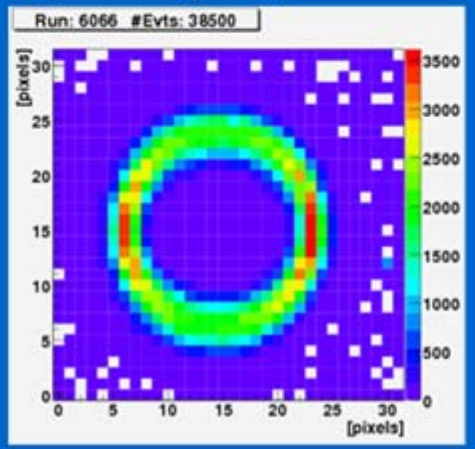
⇒Optimum efficiency & low noise (dark-counts) rate < 0.005 hits per HPD per event

Test-beam with 500MeV electrons

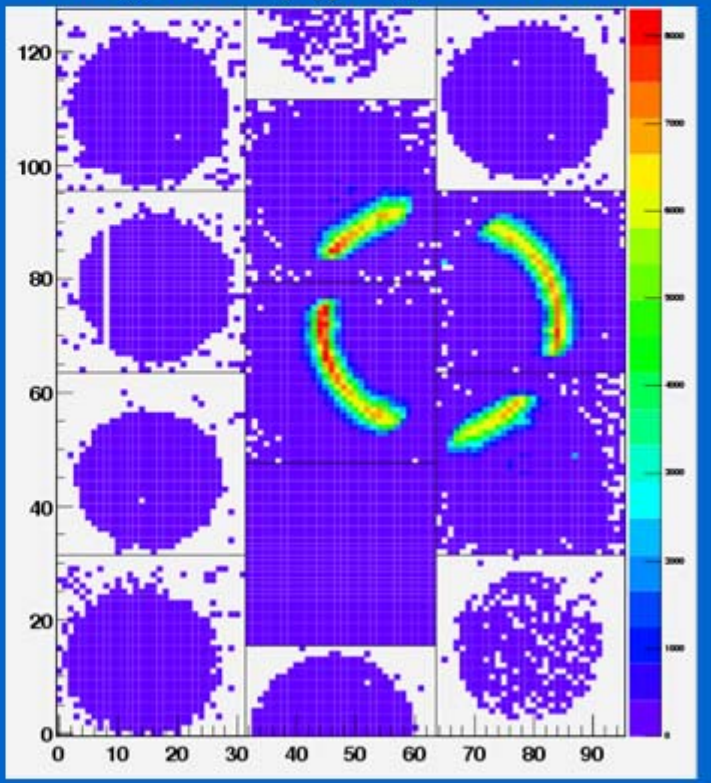
Rings from different radiators

⇒photon yields as expected
⇒optimising pattern recognition for LHCb

Integrated N_2 rings on one HPD

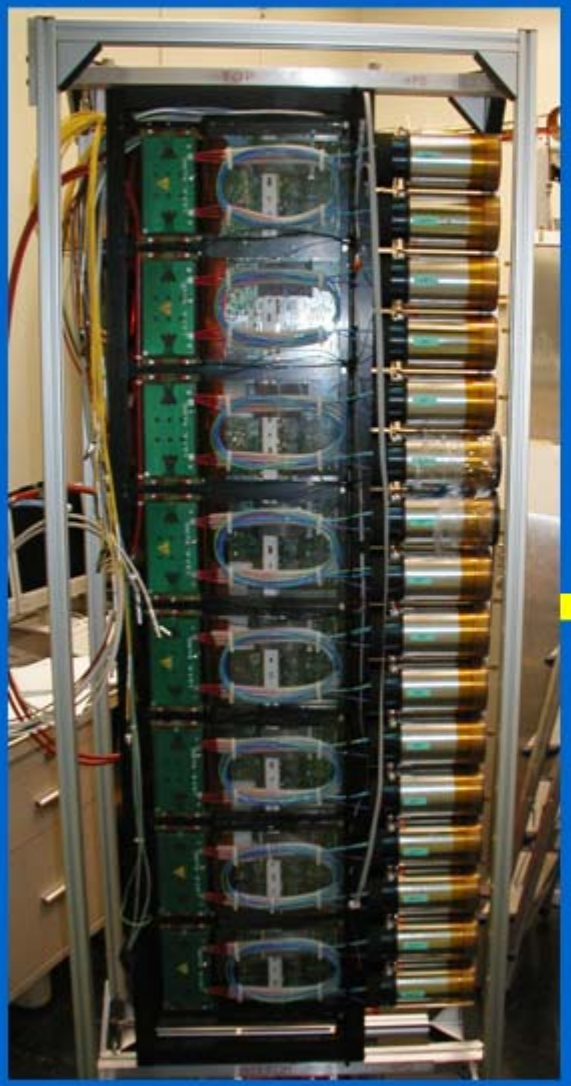


Integrated C_4F_{10} rings on four HPDs



Installing the system in LHCb

HPD column module



HPD modules inserted here

RICH2 being installed in LHCb underground cavern

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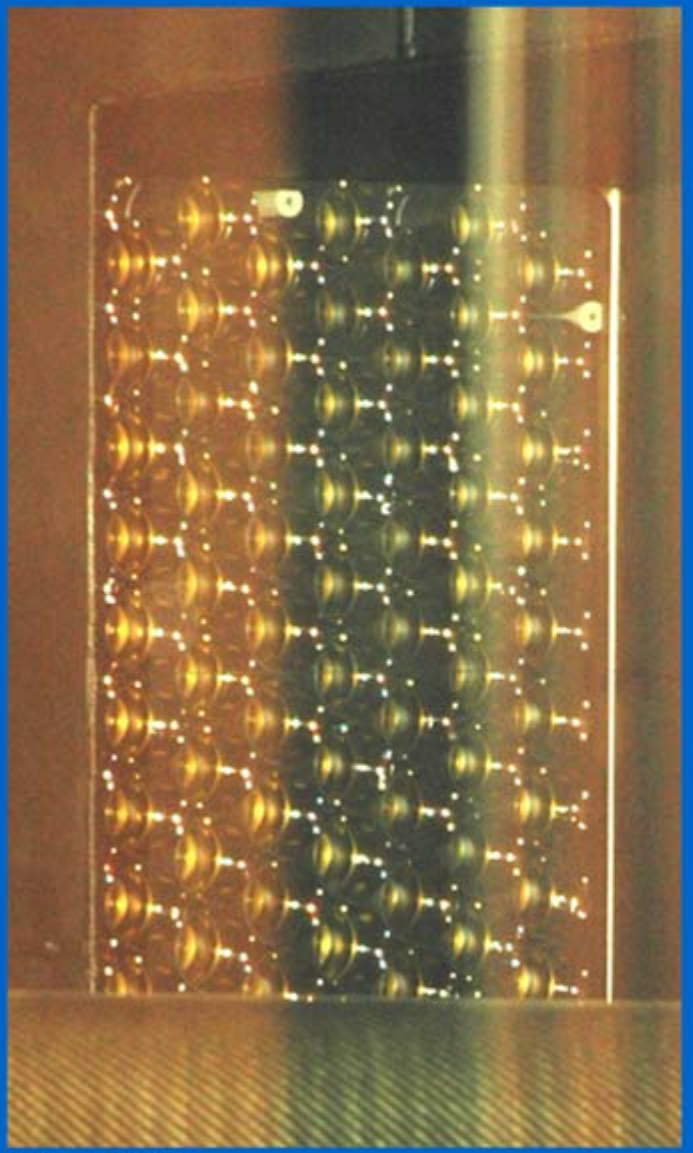

Photographing inside RICH2 – it's dark!

What the Cherenkov photons see is this

60% of the HPD system is installed and being commissioned

Testing is underway with controlled light sources to ensure system is ready for data-taking with the LHC beam next year

Conclusions and Outlook

Pixel HPD designed to meet harsh requirements of the LHCb system - proven to be an elegant & efficient detector for this type of application

Specific chip, sensor & interconnects developed for HPD application

Smaller-scale systems of HPDs tested successfully

Full system of 484 HPDs, readout electronics and services under installation for start of LHC collisions in 2008