The LHCb RICH photon detector system

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Introduction to the system

Photon-detector: the pixel HPD

Building the system

Test results

Conclusions and Outlook

The real LHCb

RICH2

RICH1

Measuring Cherenkov Photons

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 $\sim 30\text{G}$

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

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 $\sim$ 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

Readout
chip

Silicon
sensor

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

RICH2 being installed in LHCb underground cavern

HPD modules
inserted here

Installing the system in LHCb

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

Spare Slides

LHCb Cherenkov Detectors

RICH1

Tracking
detectors

RICH2

Polar angle of particles vs momentum

50 G Shielded tube
2.5 G Unshielded tube