16TH PISA MEETING ON ADVANCED DETECTORS

LEVERHULME TRUST

Large Area Picosecond Photodetector for the Upgrade II of the LHCb RICH

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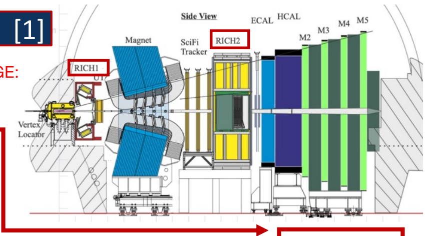
The University of Edinburgh

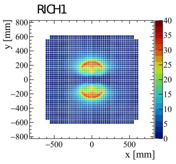
LHCb RICH Upgrade II [1]



LHCb Upgrade II, RICH CHALLENGE:

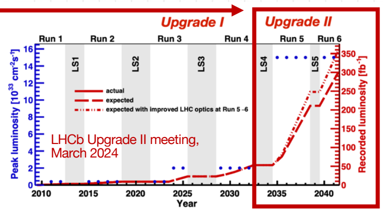
Cope with the increase of instantaneous luminosity of Upgrade II, in particular being able to detect single photons in extremely high occupancy regions.

Simulation of LHCb Upgrade I (current)



Peak occupancy~40%

->would reach 100% in Run5!



Possible solution to recover the PID performance: add timing readout to RICH photon detectors and upgrade the current MAPMTs with faster photon detectors, with improved spatial resolution

Main technologies considered: SiPMs and MCP based solutions (eg LAPPD)

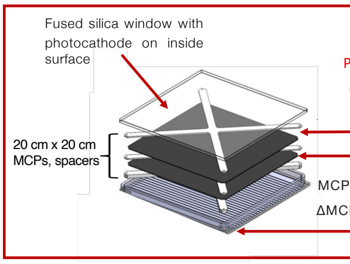
R&D on photon detectors essential to determine the best suitable technology

LAPPD technology

LAPPD supplied by INCOM (US) [2]

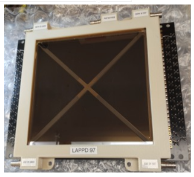
Large Area Picosecond Photon Detector

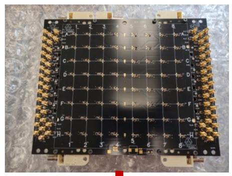
Micro Channel Plate photomultiplier, Dimension 20 x 20 cm^2



LAPPD 97 in Edinburgh

- Gen II LAPPD, pixel readout, 20µm pores
- Spectral response 160-650 nm
- 5 taps for independent voltage control of the photocathode and entry/exit of each MCP





INCOM readout board 64 pixels

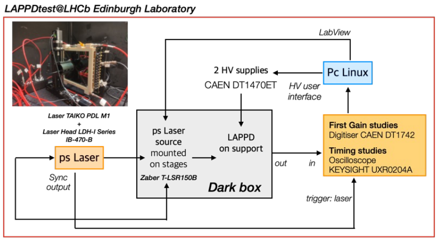
Pixel size:

25 mm pitch to pitch

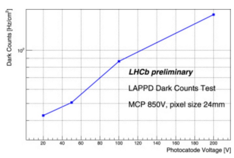
(24 x 24 mm^2 active area, 1 mm dead gap)

LAPPD test bench

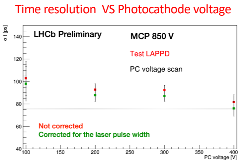
INCOM board used for these tests



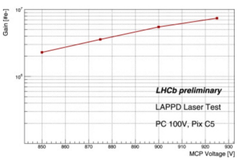
Dark Counts VS Photocathode voltage [3]



Time resolution VS Photocathode voltage



Gain VS MCP voltage [3]



LAPPD custom board

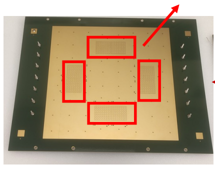
Edinburgh board
Custom readout board V0, 512 pixels

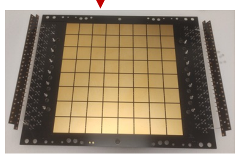
Pixel size:

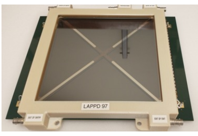
3 mm pitch to pitch

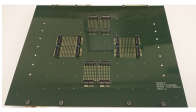
(2.9 x 2.9 mm^2 active area, 0.1 mm dead gap)

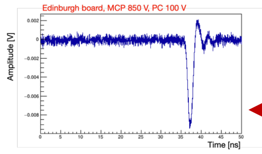
Active area (512 pixels)

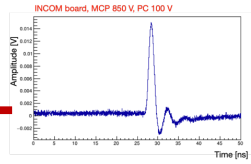












Acquired with oscilloscope

Digitisation rate 128 GS/s Bandwidth 20GHz, 50Ω Termination

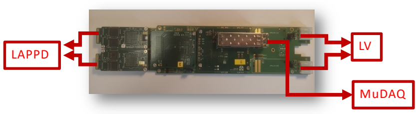
LAPPD setup at CERN SPS

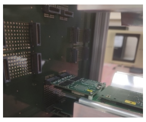
The RICH group tested the LAPPD in September 2023 and April/May 2024 at CERN SPS, coupled to a multi channel fast electronics chain.

Multi-channel fast electronics chain

LAPPD → FastIC → PicoTDC → Optical link → Backend (MuDAQ)

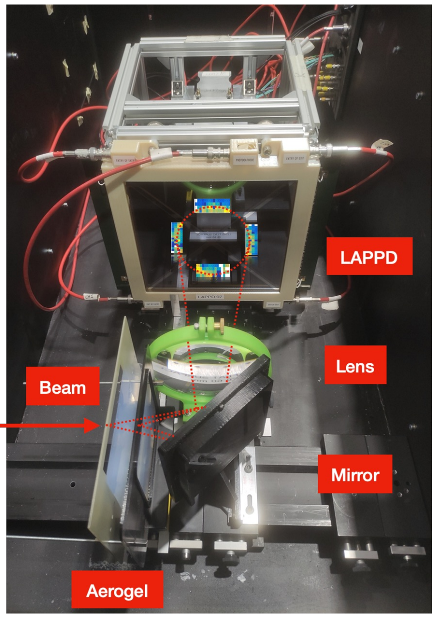
- ✓ 64 channels readout with a single carrier board
- ✓ Mechanical supports for the carrier board and slides to easily connect the fastIC pluINs to SAMTEC connectors on the back of the LAPPD
- ✓ 2 boards available for LAPPD and connected in parallel during the test beam (128 channels)





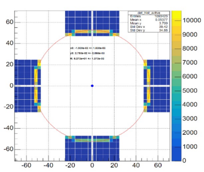
- ✓ Optics already used in a previous test beam of the group
- ✓ Simulation package available

- Top and bottom board connected in parallel
- Boards position changed to readout also upstream and downstream sides
- Ongoing offline analysis to better study the coupling of the LAPPD with the fast electronics and extract the ultimate time resolution of the sensor

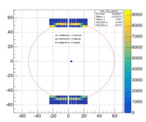


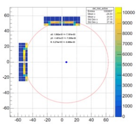
Simulation

LAPPD geometry simulated in the software

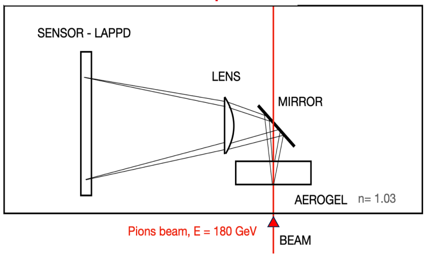


- ✓ Only 2 carrier boards enough to reconstruct the ring offline





LAPPD box and optics



References

[1] Framework TDR Upgrade II, CERN/LHCC 2021-012, LHCb TDR 23, March 2022;
[2] INCOM (US), https://incomusa.com/lappd;
[3] Large Area Picosecond Photodetector for the Upgrade II of the LHCb RICH, F.Oliva (LHCb RICH collaboration), Nucl.Instrum.Meth.A 1057 (2023).