

LHCb Hardware activities

Riunione gr1 14/12/2021
G. Simi on behalf of the LHCb group

Outline

- RICH
- TIMESPOT & VELO
- ECAL

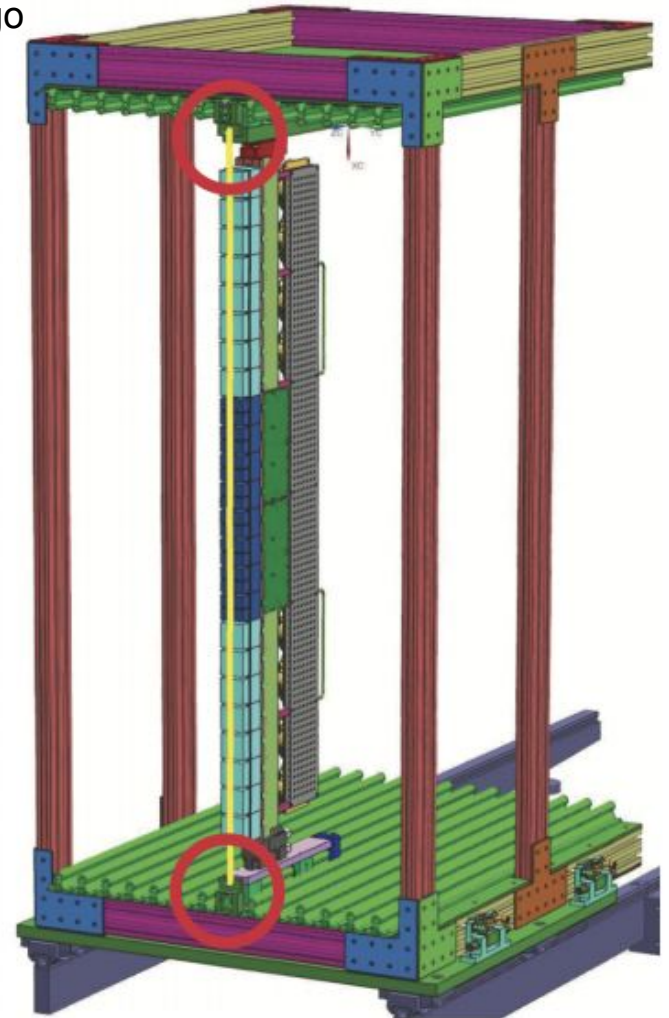
LHCb Upgrade Schedule

(Approved schedule as of Nov 2020)



RICH Upgrade I

- RICH Upgrade I (2020-2021)
 - R&D mechanics and cooling
 - Responsibility for mechanical and cooling system design and construction
 - Responsibility for characterization of PMT installed
 - Responsibility for calibration and threshold
 - Commissioning and test beams (limited)
- Request
 - A table to hold the PMT test station to be used for new or substituted PMT
 - The only test station capable of PMT characterization compatible with production
 - Cabinet for spare PMT



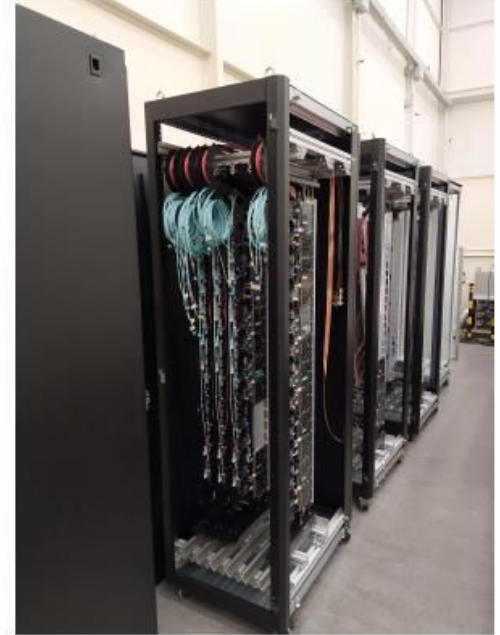
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first column
assembled at
CERN



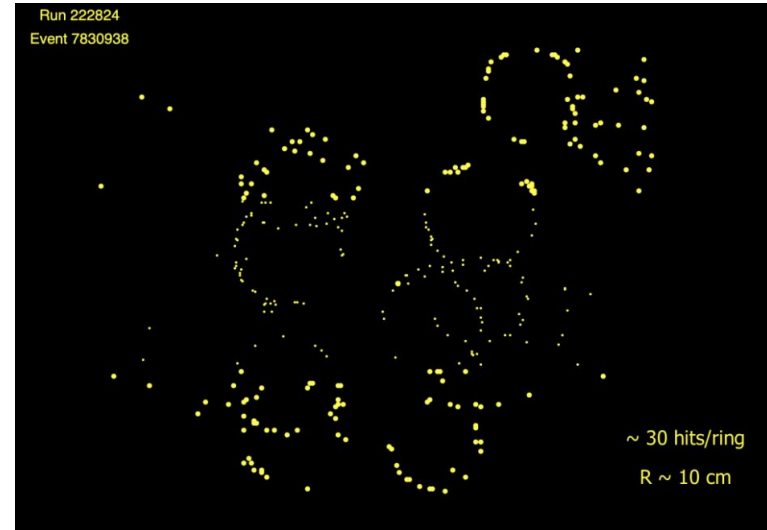
RICH 2
mechanics+readout+services
assembled



RICH Upgrade I

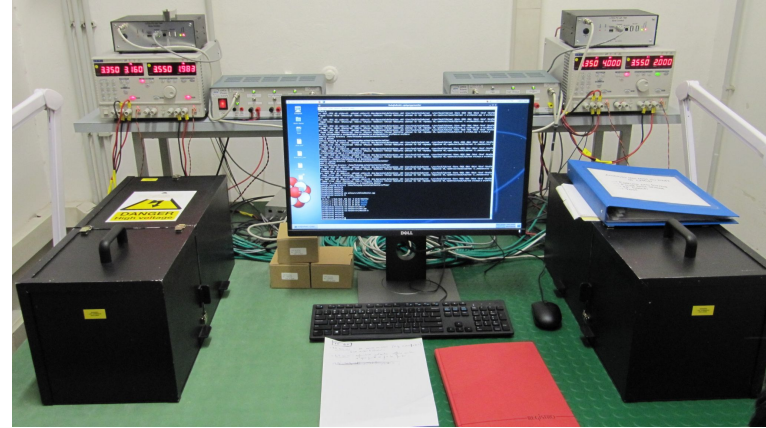
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First Cherenkov Rings in LHC pilot run



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 - A **table** to hold the PMT test station to be used for new or substituted PMT
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 - **Cabinet** (1 shelf) for spare PMT

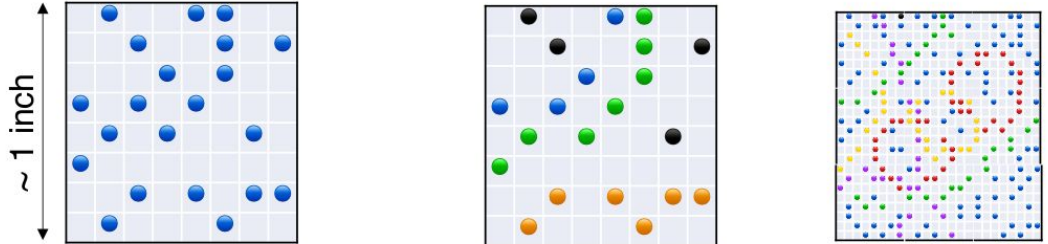


RICH Upgrade II

(Approved schedule as of Nov 2020)



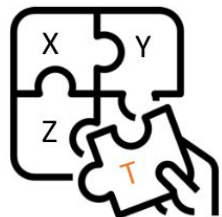
Visualisation of RICH hit maps (not representing actual patterns)



Run 3:
MAPMTs ($\sigma \sim 150$ ps)
and 3.125 ns readout bin.

Run 4:
MAPMTs ($\sigma \sim 150$ ps)
and ≤ 100 ps readout bin.

Run 5:
Novel sensor ($\sigma \leq 100$ ps)
and ≤ 100 ps readout bin.



Addition of time:
4D 'colour' picture.

Upgrade I b: consolidation of front-end electronics with fast timing readout.

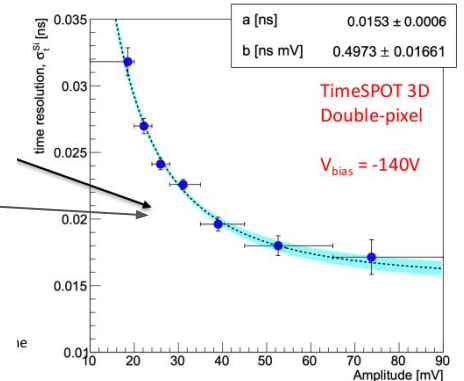
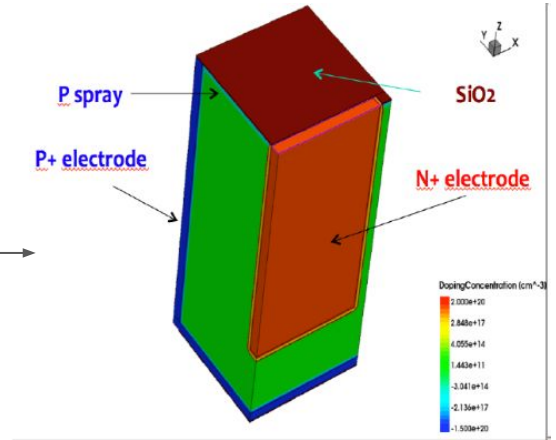
Upgrade II: novel sensors readout by (evolution of) FastIC+TDC design.

RICH Upgrade II

- **Motivation:**
 - Increase granularity for Cerenkov ring reconstruction in high luminosity LHC runs
- **Upgrade:**
 - optics, photosensors, time-resolved readout electronics, time calibration system, mechanics, cooling
- **Photosensors choices:**
 - MaPMT, SiPM at cryo temperatures, MCP
- **Padova:**
 - Characterization of SiPM: signals, time resolution, afterpulse [G.Simi, F. Borgato] collaboration with Ferrara
 - R&D on rad hardness (critical item) of SiPM at cryo temp [G. Simi, F. Borgato] collaboration with Milano
- **Padova:**
 - Mechanical design and cooling system responsibility [M.Benettoni]
- **Framework TDR in progress**
- **Requests:**
 - a table shared with TIMESPOT & VELO for CAEN digitizer, laser
 - Assembly area for mechanics and cooling R&D: time scale starting from 2023

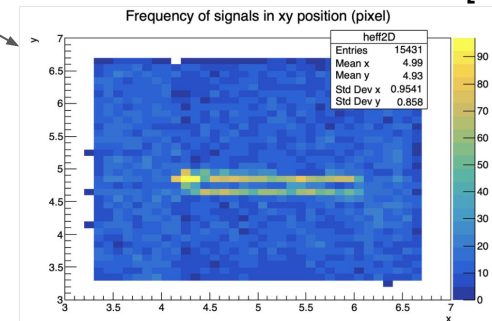
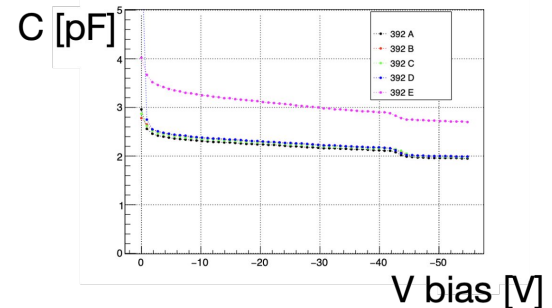
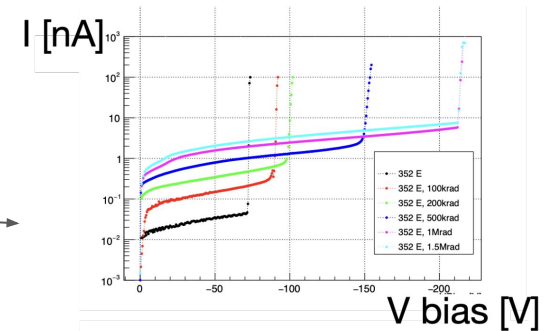
TIMESPOT

- 4-years INFN-funded gr5 project TIMESPOT
- Development of radiation hard 3D fast pixel sensors for tracking in high luminosity LHC - case study LHCb VELO
- Spatial resolution $10 \mu\text{m}$
- Time resolution 20 ps
- Radiation Hardness $>10^{16} \text{ 1MeV } n_{\text{eq}}/\text{cm}^2$
- Sensor developed at FBK showed resolution with pion test beam at PSI better than 20ps



TIMESPOT & VELO

- Padova: **Sensor static characterization**
- Padova: Sensor **efficiency** and **time resolution** tested at **Legnaro** with innovative technique at microbeam
- Padova: **Test beam and demonstrator design**



TIMESPOT & VELO Perspectives

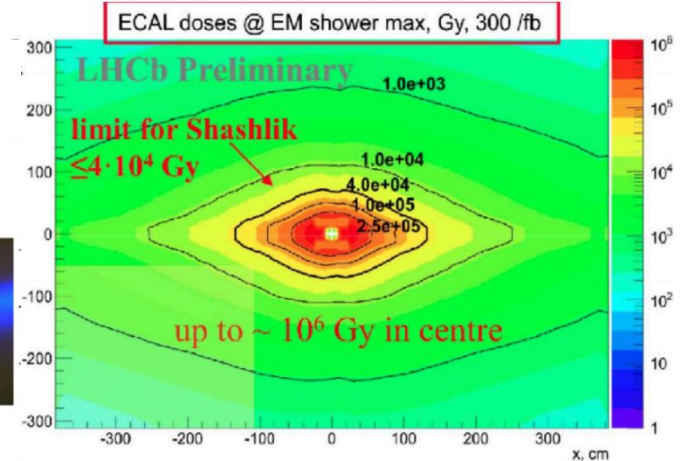
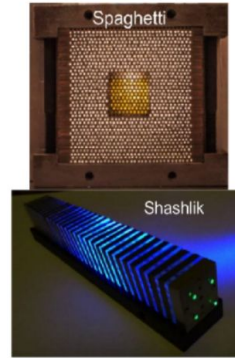
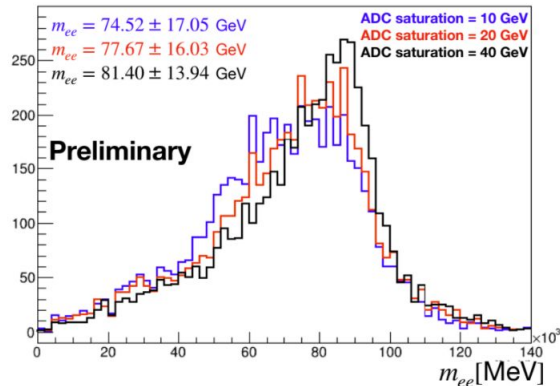
- **Next year** bring to conclusion the project
 - Full demonstrator construction and beam test
 - Static and dynamic characterization of sensor after irradiation
 - Readout electronics development and radiation hardness
- **Longer term perspective:**
 - Official involvement of Italian groups in the VELO
 - Discussion has started
- **Space requests:**
 - A **small table** for laser + oscilloscope + CAEN digitizer
 - **Cabinet space** for sensors
 - Occasional use of **Lab Silici**

ECAL upgrade activities at LHCb Padova

D. Lucchesi, L. Sestini, D. Zuliani

Motivation

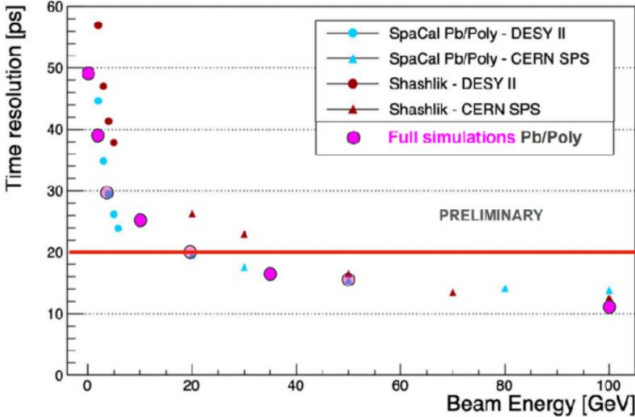
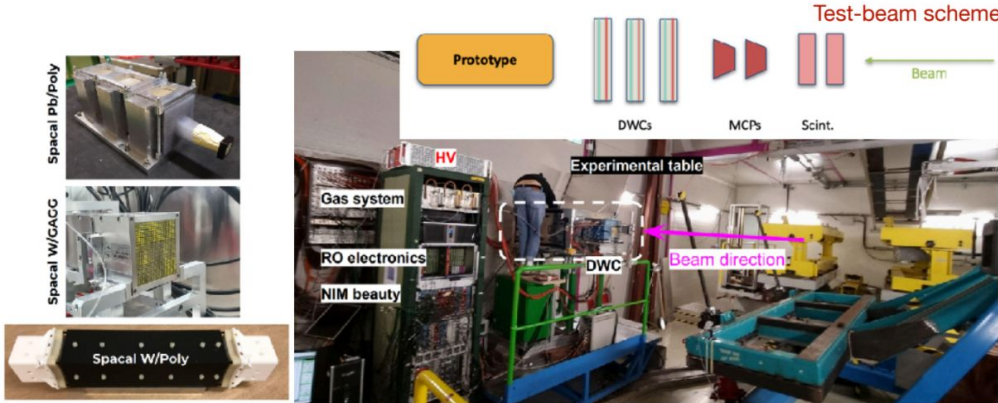
- During Run 5 the ECAL will be redesigned
 - High luminosity
 - High radiation on sensors (near the beam pipe)
- Therefore the following requirements are needed:
 - New geometry (SPACAL, Shashlik)
 - New cells dimension
 - New materials



- Main focus in high p_T physics
- $Z \rightarrow ee$ is used as main channel
 - Test different energy and time resolutions
 - Study Bremsstrahlung recovery
 - Study ADC saturation (study of double gain ADC)
- Studies are ongoing, first results in ftDR for Upgrade 2

Test beams

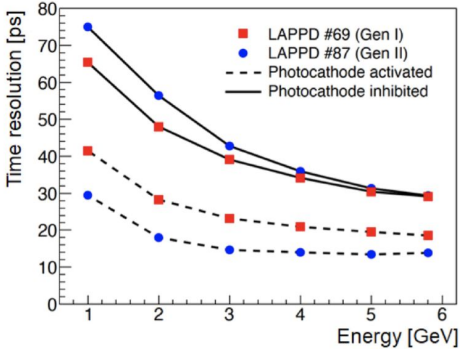
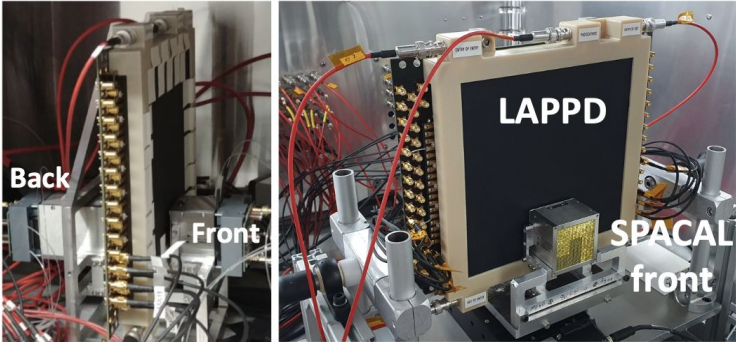
- Test-beam @ CERN (August 2021) to test different ECAL prototypes
 - Shashlik
 - SPACAL Pb/Poly
 - SPACAL W/GAGG
 - SPACAL W/Poly
- Studies on time and energy resolution



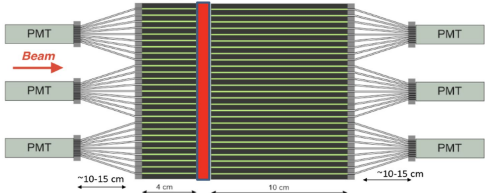
- Time resolution ps for beam energy $E_{\text{beam}} > 20 \text{ GeV}$
- Results are in agreement with simulations and previous test-beams @ DESY
- New test-beam campaign in November 2021, focused on energy resolution studies
- Detailed analysis has just started, results are coming soon

Time layer

- Collaboration with LHCb-Bologna on the development of a time layer.
- Based on micro-channel plates detector (LAPPD).
- Currently characterized in Bologna laboratory, data acquired in test beams at DESY and CERN.
- In particular we are interested in the development of the time layer digital read-out.



To be placed at shower maximum



Digital read-out

- FPGA-based digital back-end.
- We would like to develop the FPGA firmware for the Time layer.
- We have bought a CAEN module equipped with FPGA (CAEN DT5495).
- It will arrive soon in Padova, to be programmed here. We need a collocation for this device.
- Integration tests in Bologna, and hopefully the complete chain will be taken at test beams.
- Our long-term goal is to develop a machine-learning based ECAL reconstruction on FPGA.

