



LHCb RICH Upgrades

Strateško srečanje F9

Krvavec

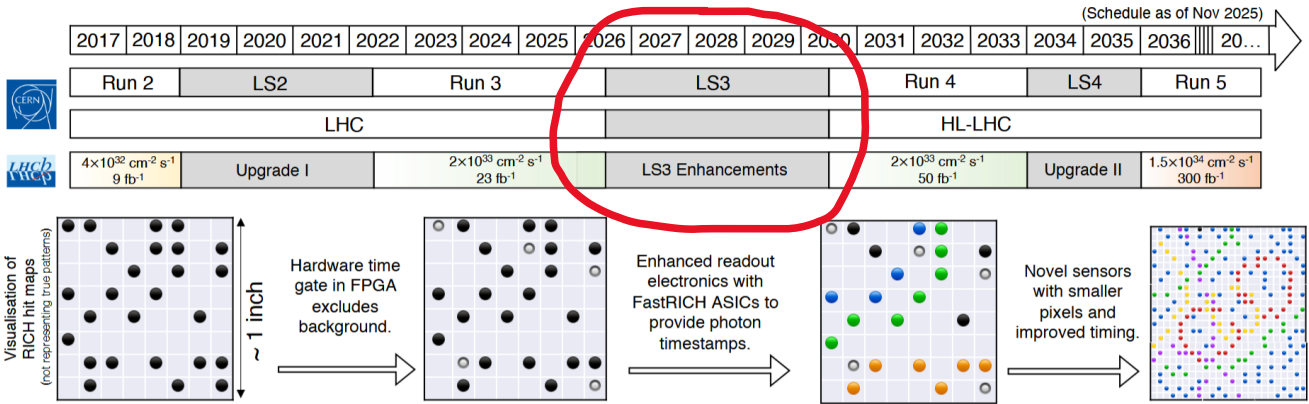
28.9.2026



Outline of today's presentation:

- Context and LHCb experiment upgrade
- FastRICH ASIC based electronics
- Photodetectors
- Prototypes and operation at the SPS beam tests

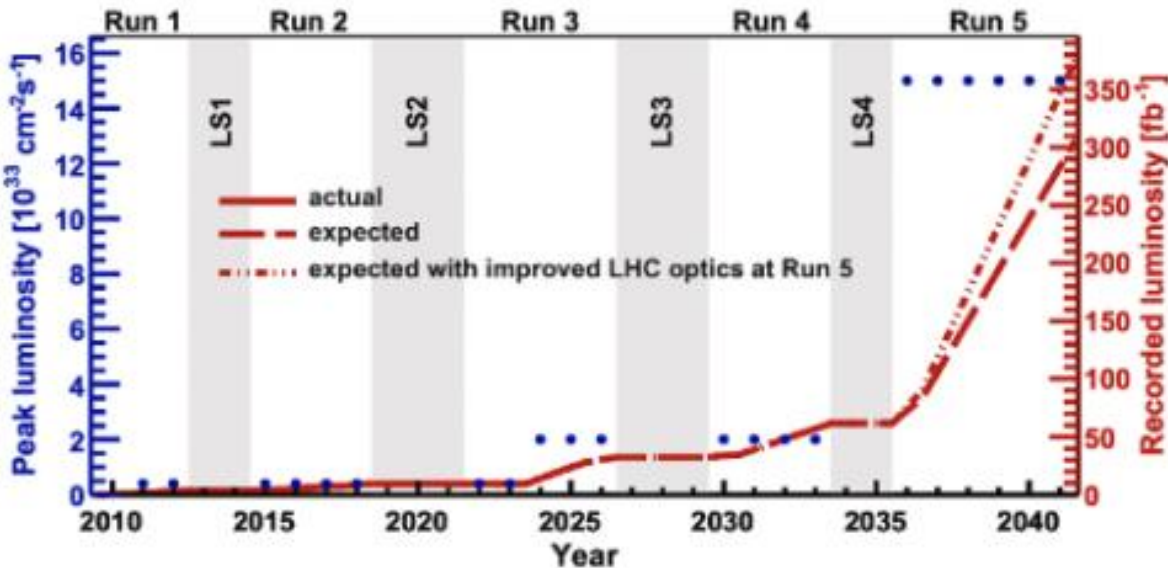
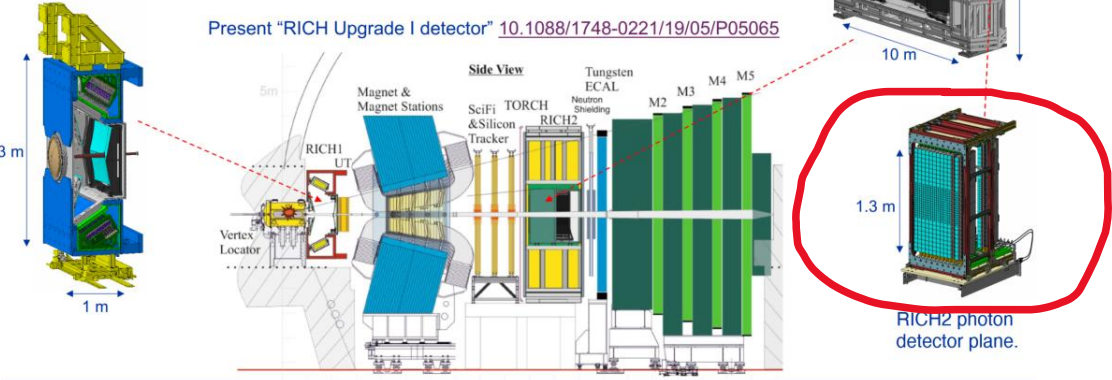


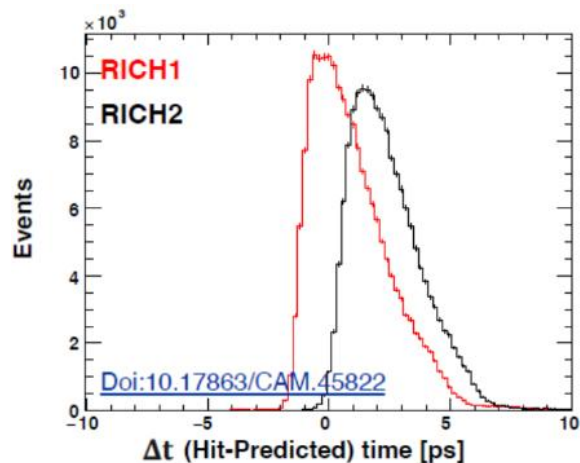


RICH detectors at the LHCb experiment

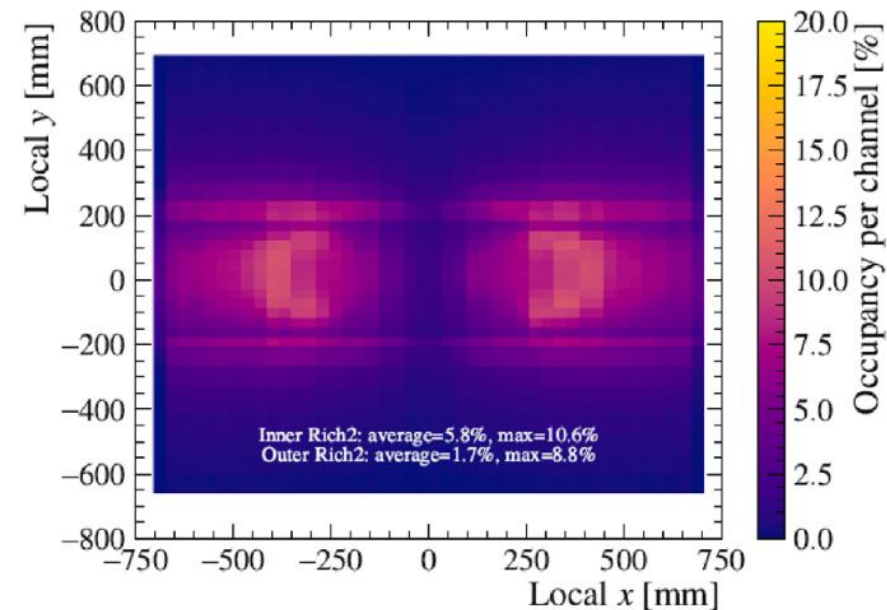
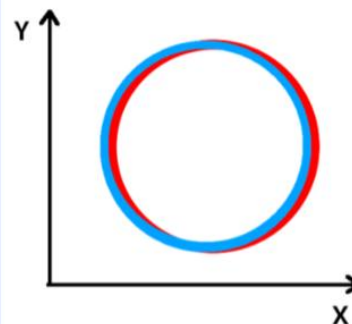
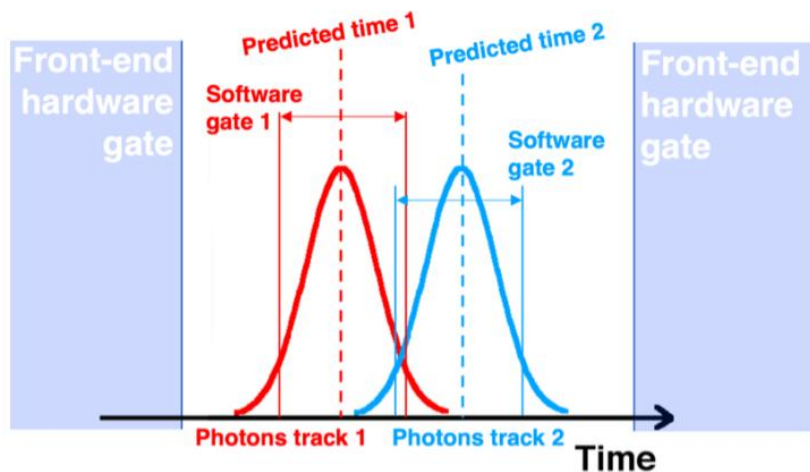
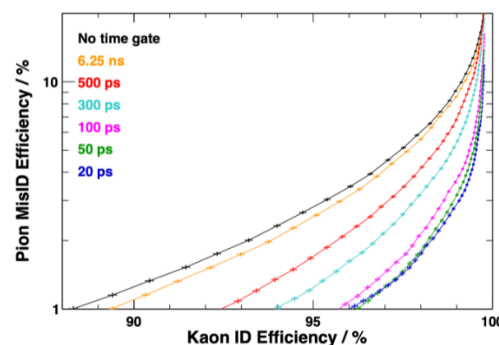
RICH1 for PID from 3 GeV/c (veto mode) to 40 GeV/c using ~4 m³ volume of C₄F₁₀.

RICH2 covering 15 to 100 GeV/c using ~100 m³ volume of CF₄.





- **Picosecond** timestamps in electronics
→ compare to predicted times in reconstruction to strongly reduce combinatorics and improve PID.



Full Length Article

The upgrade II of the LHCb RICH System[☆]

C. Gotti[✉], on behalf of the LHCb RICH Collaboration

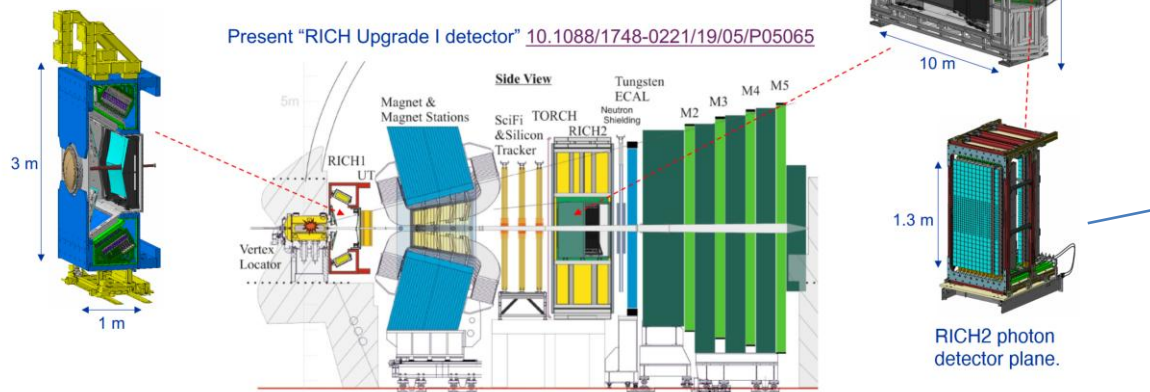
INFN Milano Bicocca, Piazza della Scienza 3, 20126, Milano, Italy

RICH detectors at the LHCb experiment

RICH1 for PID from 3 GeV/c (veto mode) to 40 GeV/c using $\sim 4 \text{ m}^3$ volume of C_4F_{10} .

RICH2 covering 15 to 100 GeV/c using $\sim 100 \text{ m}^3$ volume of CF_4 .

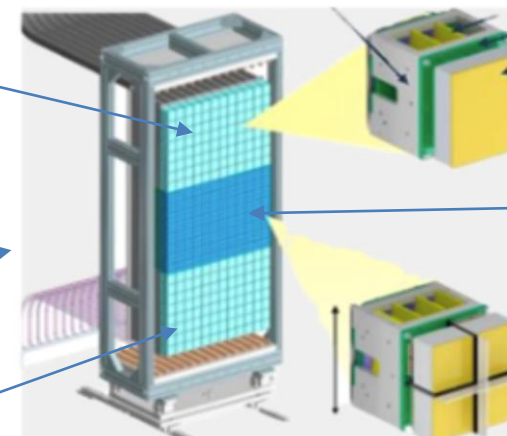
Present "RICH Upgrade I detector" [10.1088/1748-0221/19/05/P05065](https://cds.cern.ch/record/10.1088/1748-0221/19/05/P05065)



half resolution

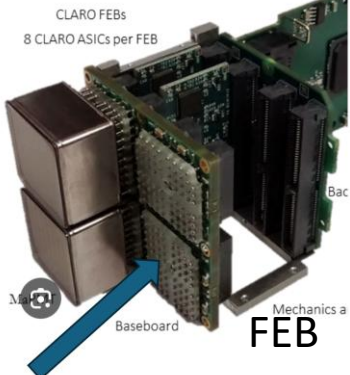
full resolution

half resolution



Backboard

MaPMT



Carrier

Elementary cell (5x5 cm)

- 4 x 64ch MA PMT
- Baseboard (BB)
- Front end board (FEB)
- Backboard
- Carrier boards

- **Two frames**, 12 columns each (populated with elementary cells)
- Each frame has: 2x12x8 (half resolution) **24576 channels**
1x12x8 (full resolution) **24576 channels**

Total: around 100k channels

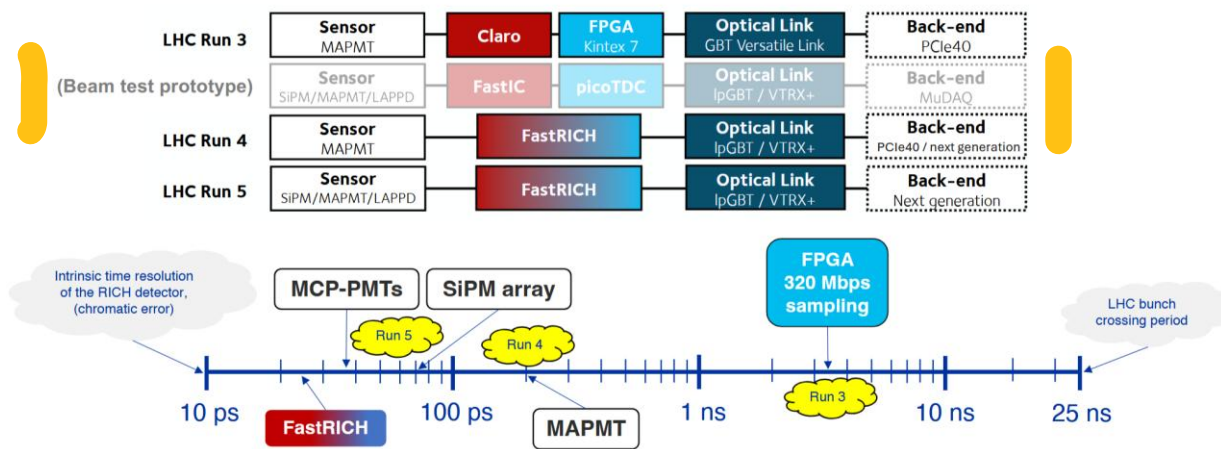
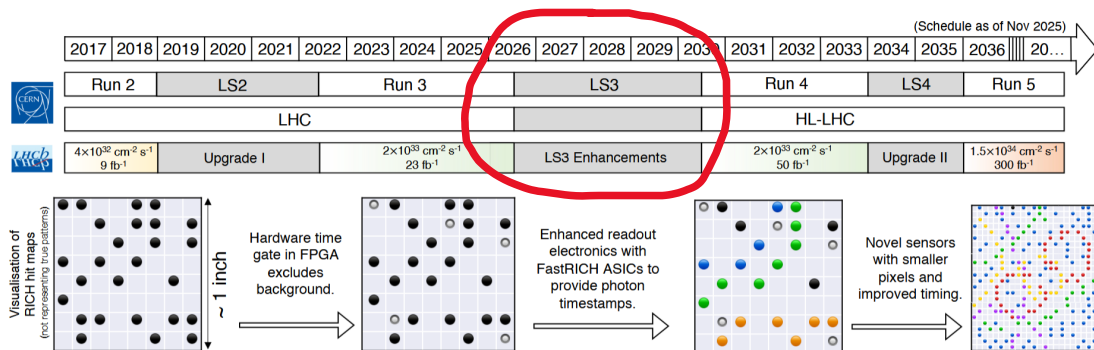
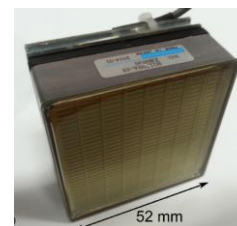
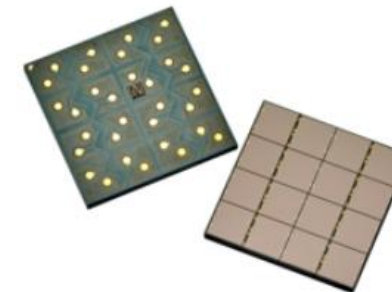


Photo detector candidates:

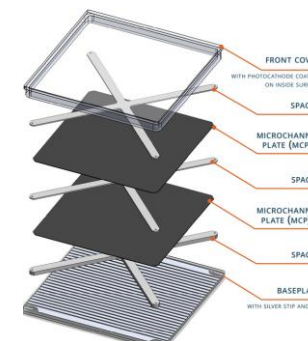
- Ma PMT : - No device with pixel smaller than 3mm pitch
- Signal saturation at high rates
- SiPM: - Small pixel – good for solving occupancy
- high hadron fluences damages the silicon lattice
- MCP PMT - Large area
- Requires complex electronics to reach mm pixel



Ma PMT



SiPM



MCP PMT

FASTIC based electronics

Prototype: FastIC + picoTDC + IpGBT/VTRx+

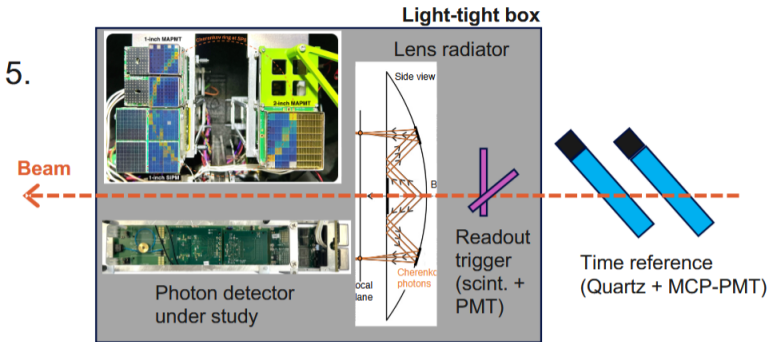
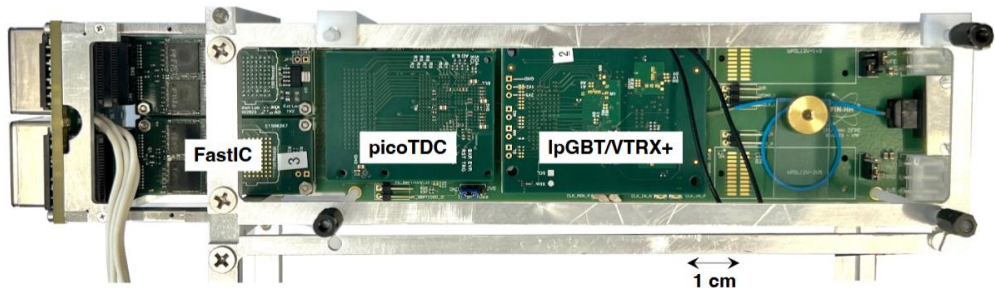


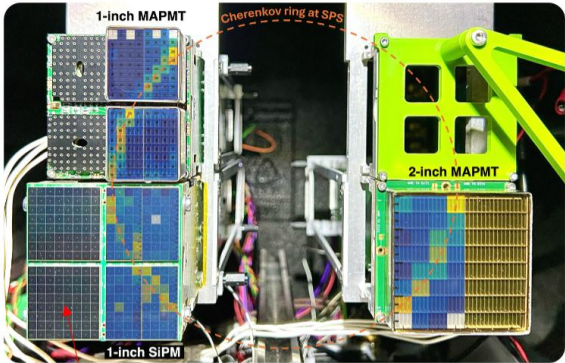
Table 1. SPTR results for 1-inch and 2-inch MAPMTs, with a bias of -1000 V and a FastIC threshold of 2.45 μ A. The FWHM is converted to a gaussian σ via $\sigma = \text{FWHM}/2\sqrt{2\ln 2}$. $\langle X \rangle$ represents the mean of X over all channels.

MAPMT size	$\langle \text{r.m.s.} \rangle$	$\langle \text{FWHM} \rangle$ [ps]	$\langle \sigma_{\text{meas}} \rangle$ [ps]	$\langle \sigma_{\text{pixel}} \rangle$ [ps]	$\sigma_{\text{pixel,min}}$ [ps]
1-inch	188 ± 10	433 ± 50	184 ± 21	181 ± 21	138 ± 2
2-inch	178 ± 5	341 ± 28	144 ± 12	141 ± 12	119 ± 3

Coated borosilicate **lens** on beam:

1. **generate** Cherenkov photons,
2. **reflect** internally and
3. **focus** into ring at photon detector.

[DOI:10.1088/1748-0221/12/01/P01012](https://doi.org/10.1088/1748-0221/12/01/P01012),
[DOI:10.1088/1748-0221/20/03/P03034](https://doi.org/10.1088/1748-0221/20/03/P03034)



S13361-3050 SiPM arrays
5x5 cm, 256 channels

FASTRich based electronics



Jožef Stefan Institute

Angelo Cotta Ramusino on behalf of

the FASTRICH FEB / FASTRICH FEB QC System developers at INFN-FE, INFN-PG

New FEBs:

- FASTRICH ASIC, 65 nm CMOS QFN 88 package, 12mW/channel (16 channel, Front End, TDC and event driven transmission)

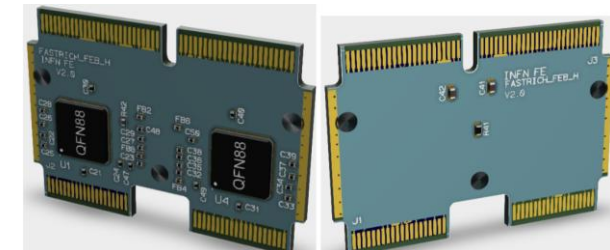
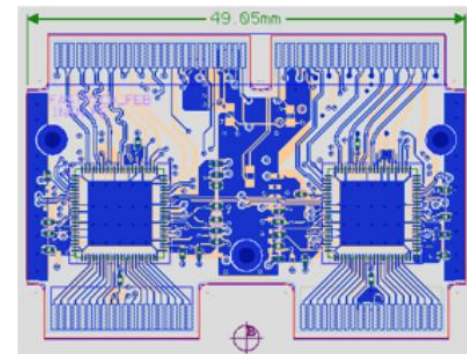
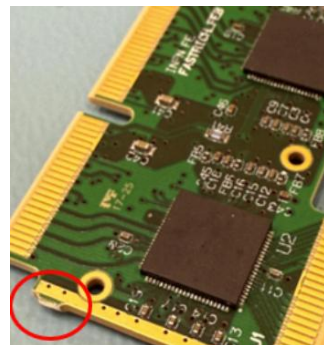
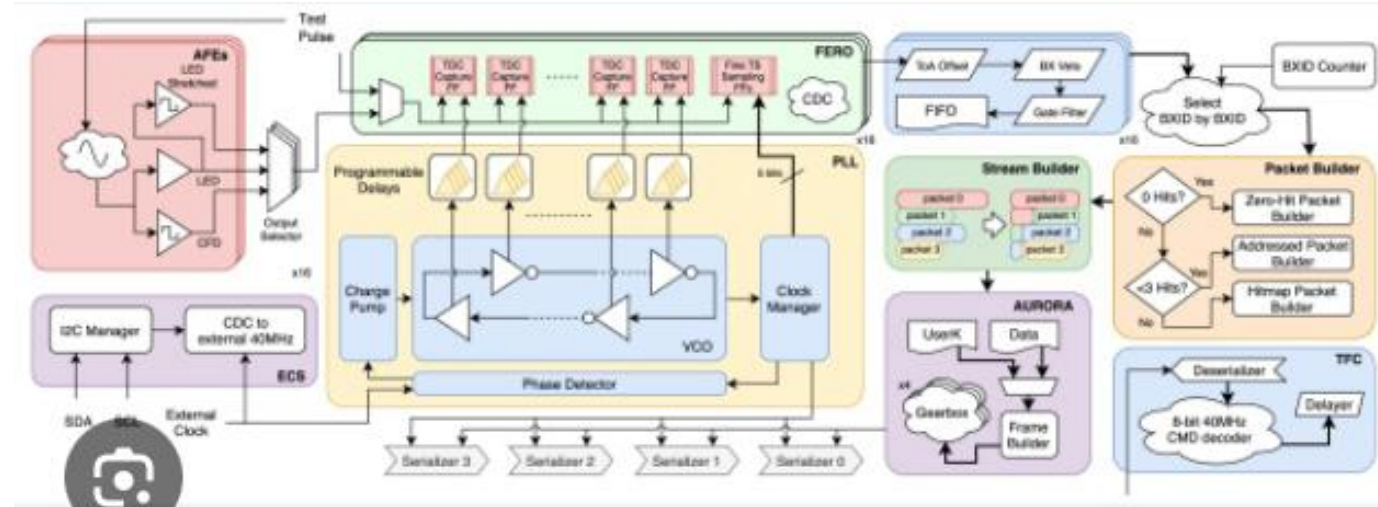
Two versions:

Type R (1 inch MAPMT)

- 4 FASTRICH ASICs –64 channels/FEB

Type H (2 inch MAPMT)

- 2 FASTRICH ASIC - 32 channel FEB

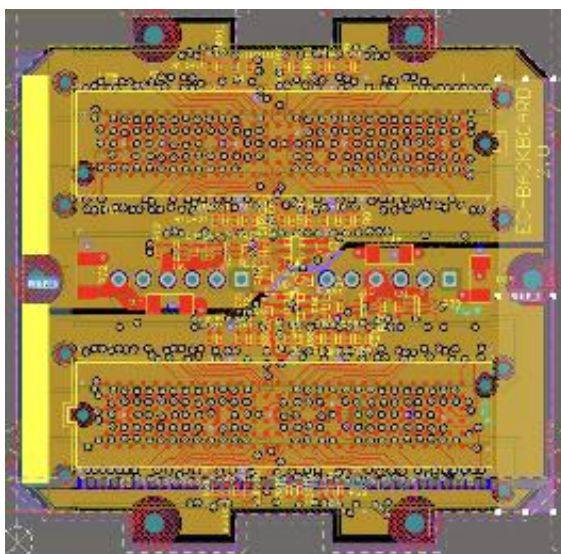


FASTRich based electronics

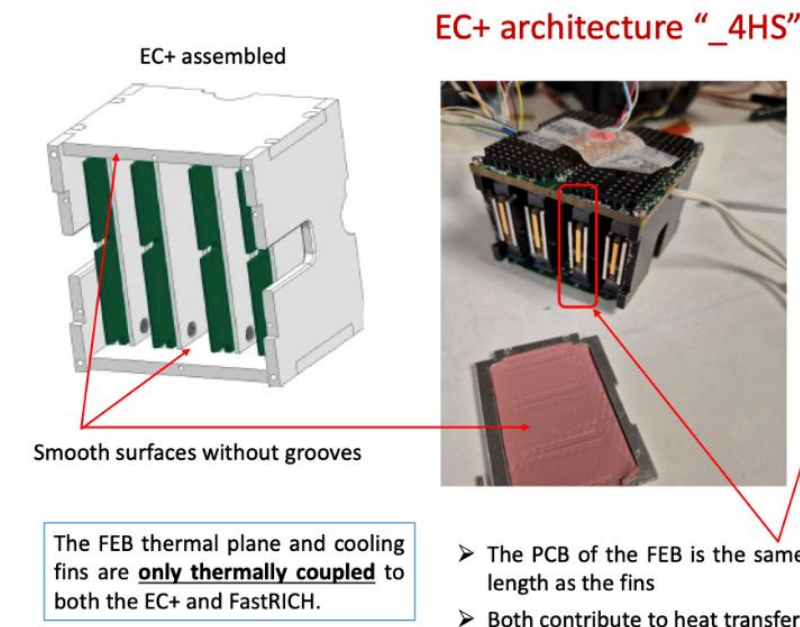
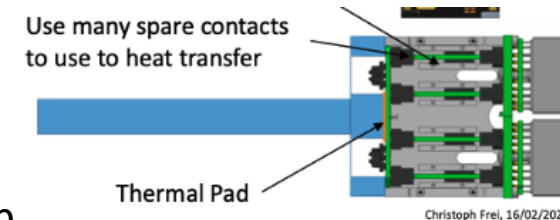
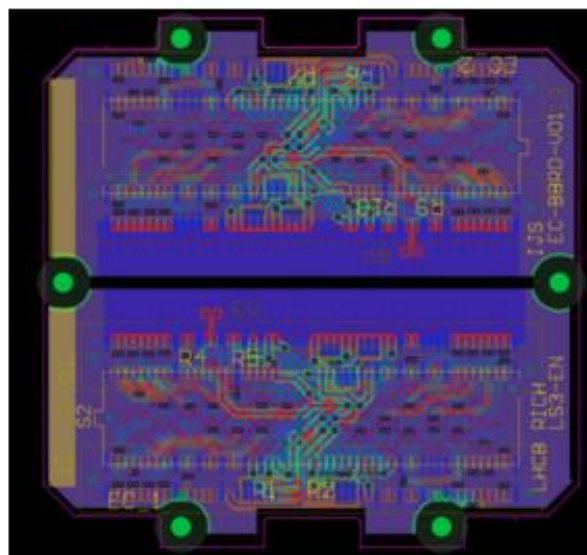
Electronics description

New Backboards

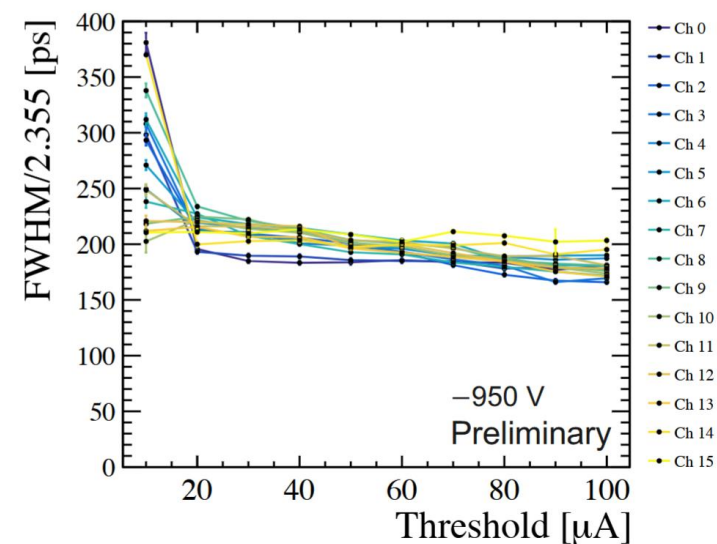
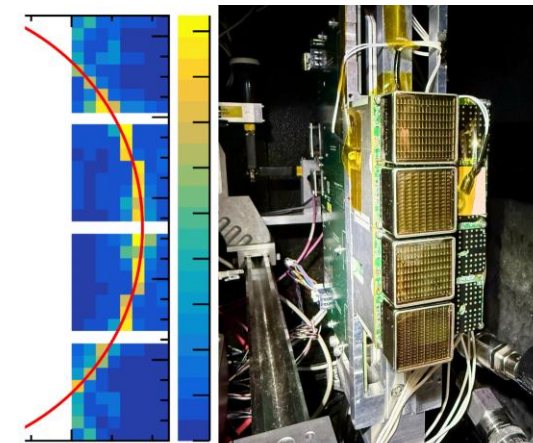
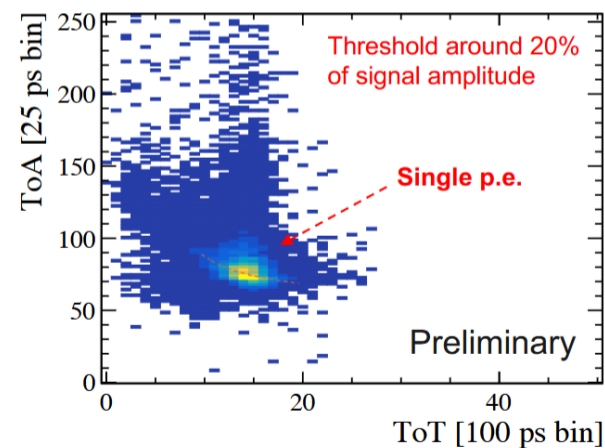
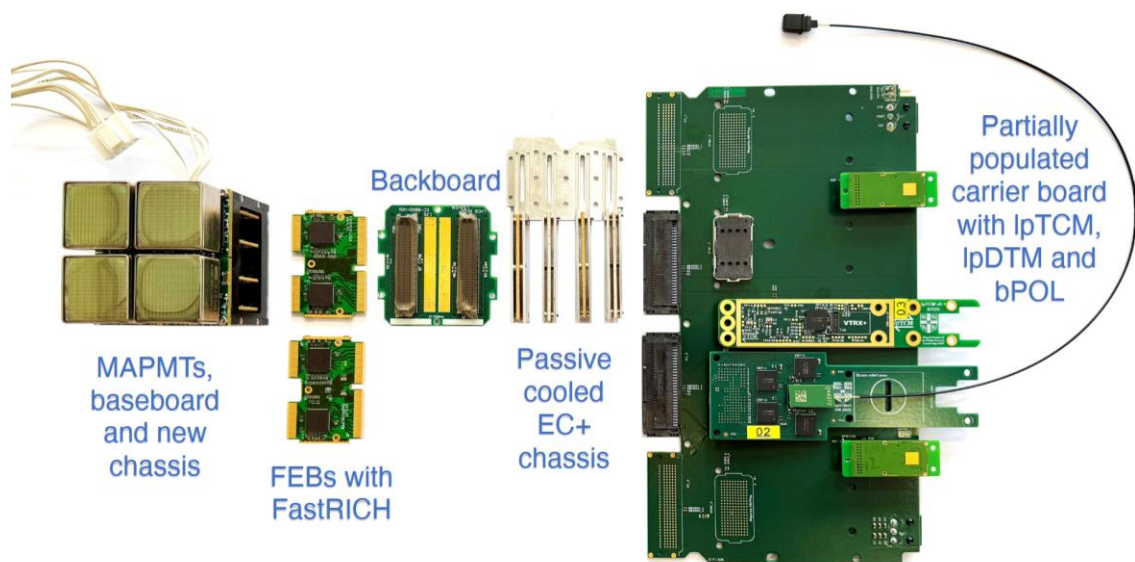
- New design is improved respect the to the original CLARO backboard
- We managed to obtain symmetry (more clean and efficient routing, simp
- **Two versions for H (in development) and R (tested)**



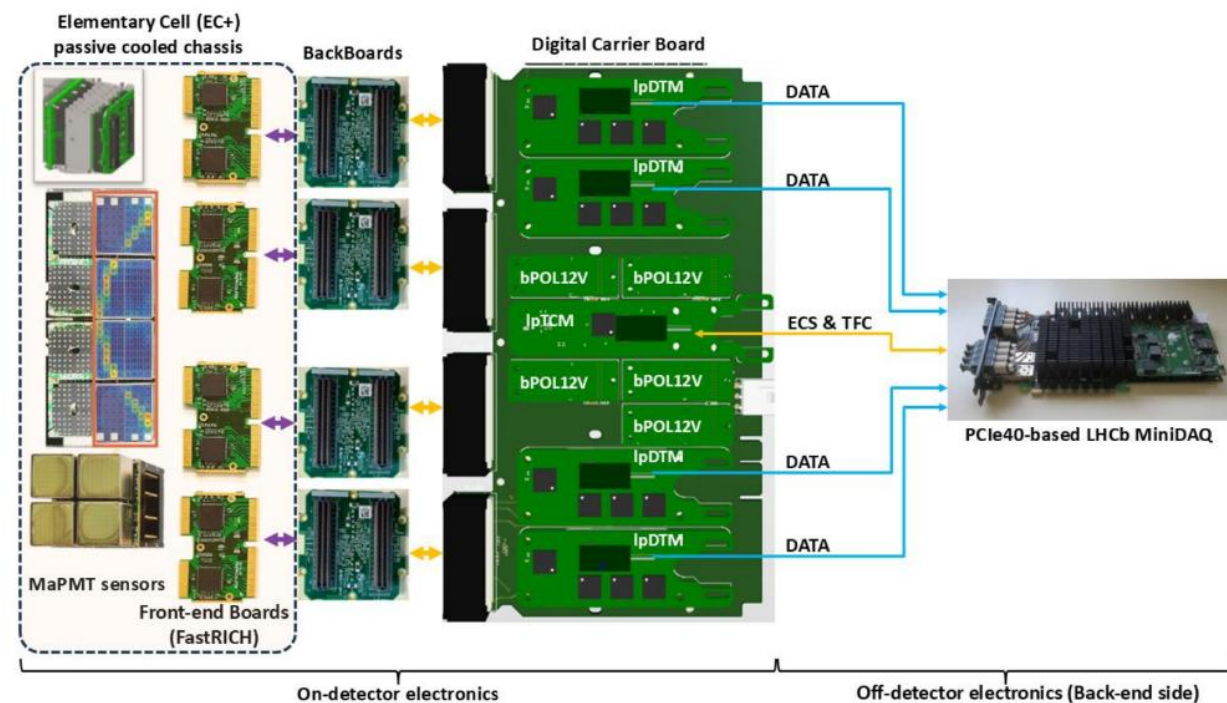
Details in the following talks



RICH Front-end Run 4 prototype FastRICH module



Towards a LHCb RICH Electronics Readout Chain



<https://fastrich.docs.cern.ch/vlad-mihai.placinta@cern.ch>

BCKP



Hotel Rey Don Jaime · Castelldefels, Barcelona, Spain · SEPTEMBER 28 - OCTOBER 2

Topical Workshop on Electronics for Particle Physics



Outlook

Outlook of today's Context and LHCb experiment upgrade:

- **FastRICH ASIC based electronics**
Proven technology
- **Photodetectors**
Mitigate SiPM radiation hardness issues
LAPPD needs electronics development (new ASICs)
- **Prototypes and operation at the SPS beam tests**
Promising results, development continues
Integration into frame is challenging
- **Future forecast:**
This system will not work with pixel pitch below 3 mm, needed for high lumi.
Something completely new needs to be thought for the future! Some ideas are emerging!

