

Neville's Fest

Prologue

It is an honour and a privilege to share memories of the involvement of Neville in the LHCb RICH and the unforgettable imprint given by his personality, professionalism and charisma.

The LHCb RICH Project started from the very beginning of the experiment design, when the need for a powerful and reliable hadronic particle identification was identified. At that time (~1992), not many RICH detectors were around and that technique was considered somewhat novel and “difficult”.

As we saw the years pass by, time has matured the detectors beautifully and the results spell success for the whole experiment.

I shall try to give a quick sketch of the **twenty or more years** passed together with Neville to design, build and operate our detectors.

Neville's Fest

Prologue

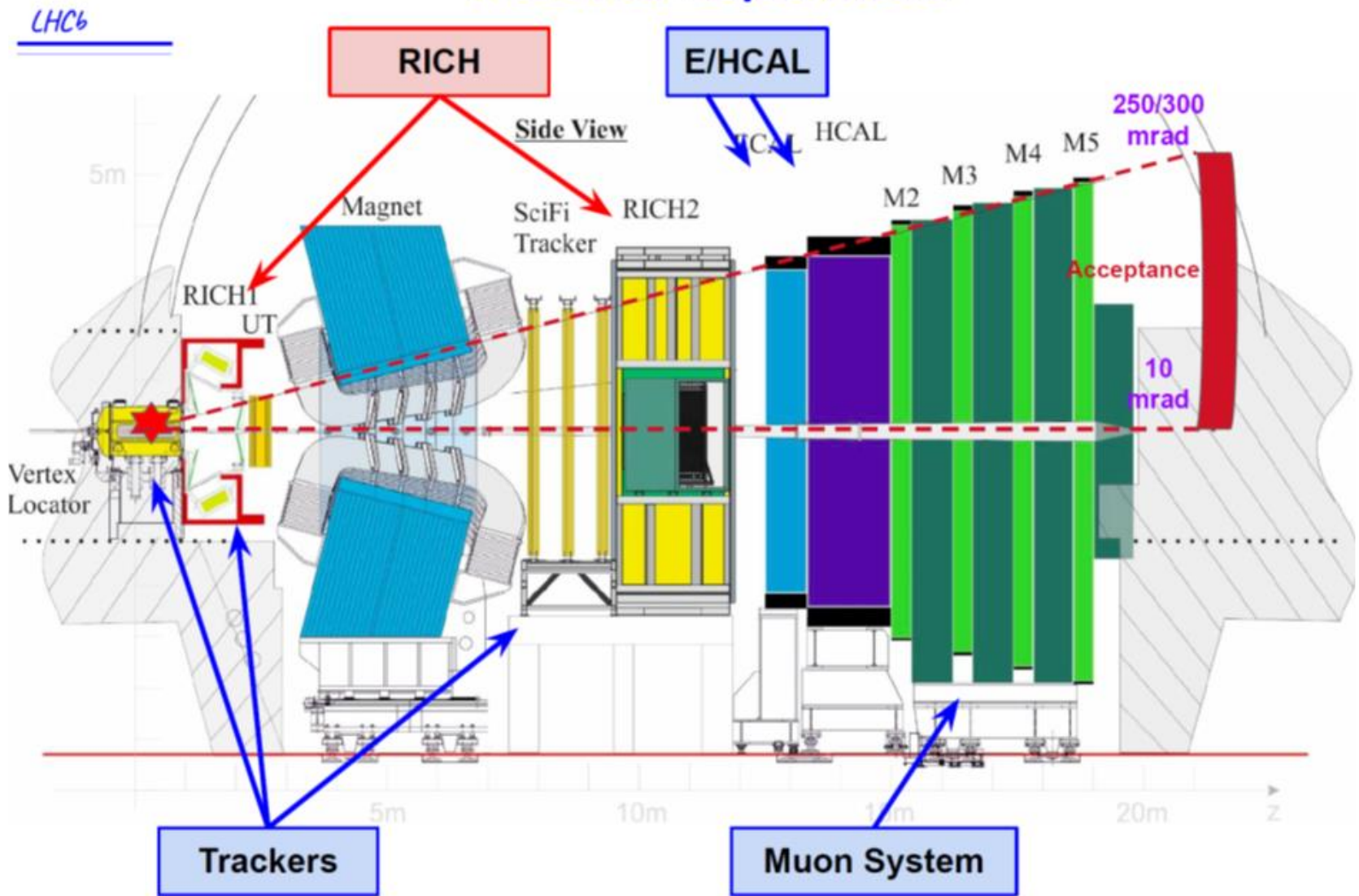
- The LHCb first RICH system (1998 to 2018)
- The LHCb upgraded RICH system (2006 to present)
- The LHCb TORCH detector (2012 to present)

Epilogue

The LHCb RICH Collaboration is composed of institutes from
CERN, Italy, Poland, Romania, Slovenia and United Kingdom

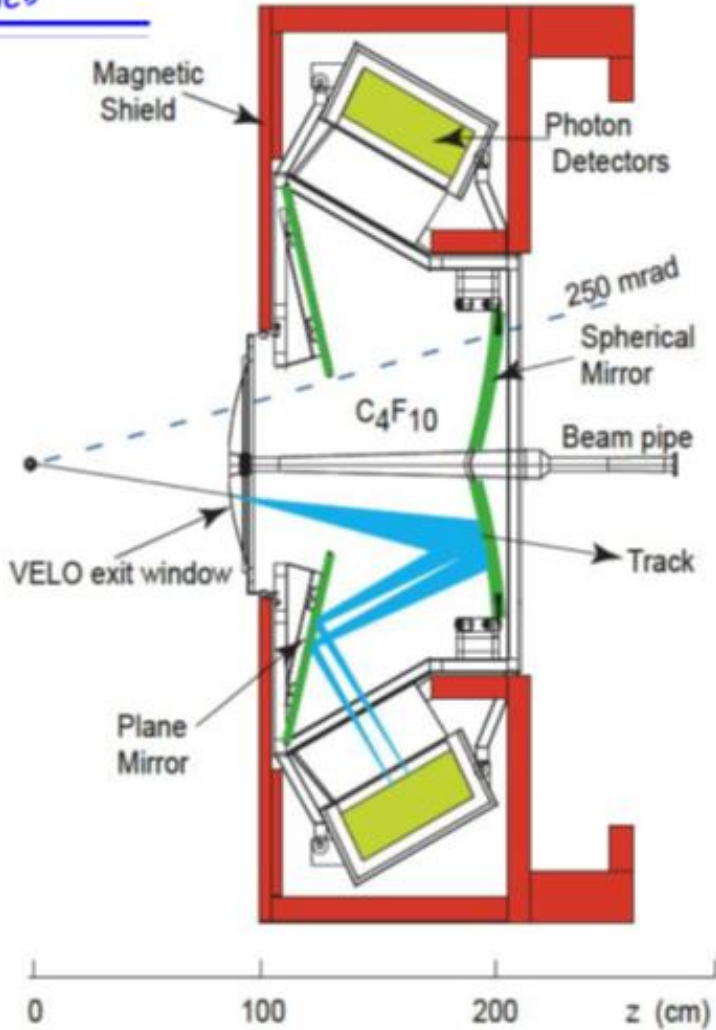
From the beginning of the experiment, **Neville** decides to collaborate in building the RICH system, composed of two gaseous and aerogel RICH detectors.

THE LHCb Experiment

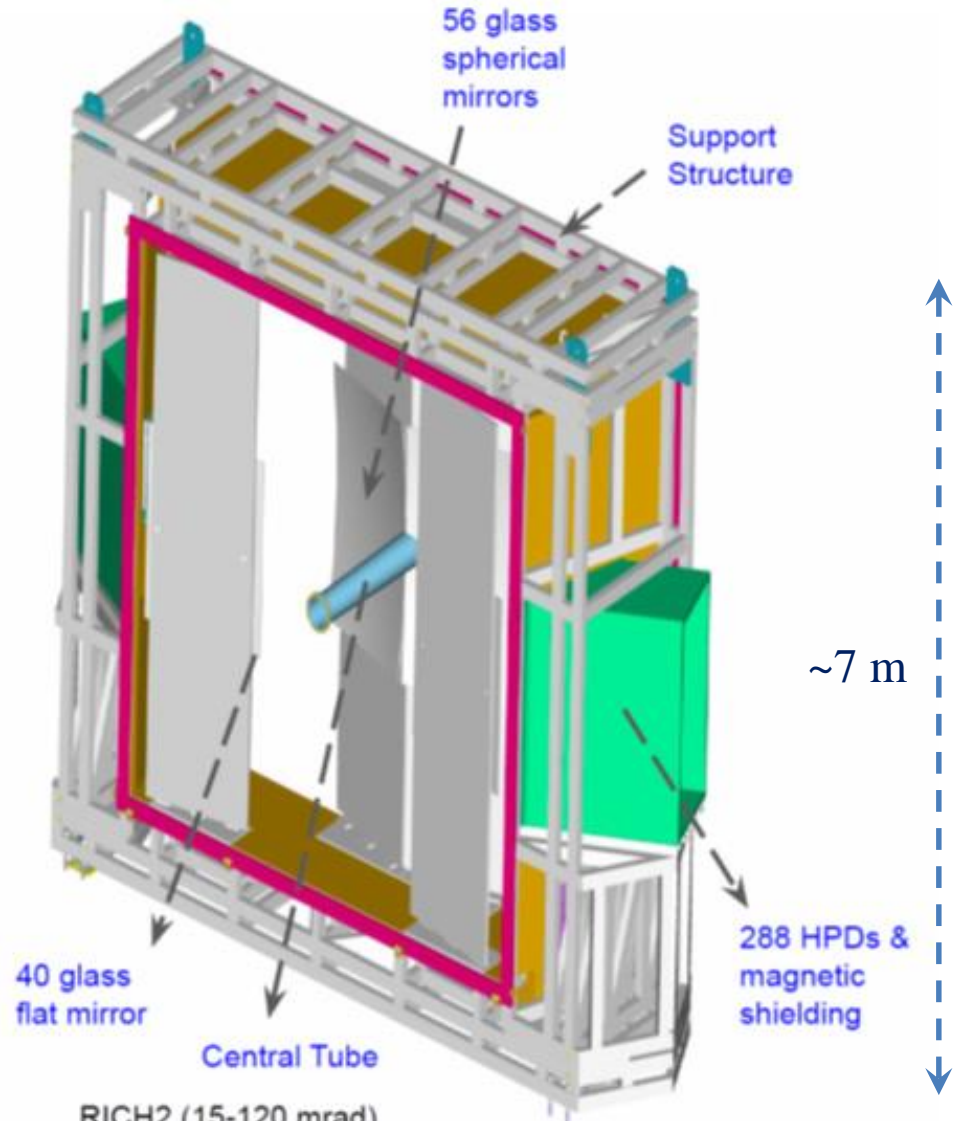


RICH Detectors

LHCb



RICH1 (250-300 mrad)
 $4 \text{ m}^3 \text{ C}_4\text{F}_{10}$ $n = 1.0014$, up to 60 GeV



RICH2 (15-120 mrad)
 $100 \text{ m}^3 \text{ CF}_4$ $n = 1.0005$, up to ~100 GeV

Little did he know

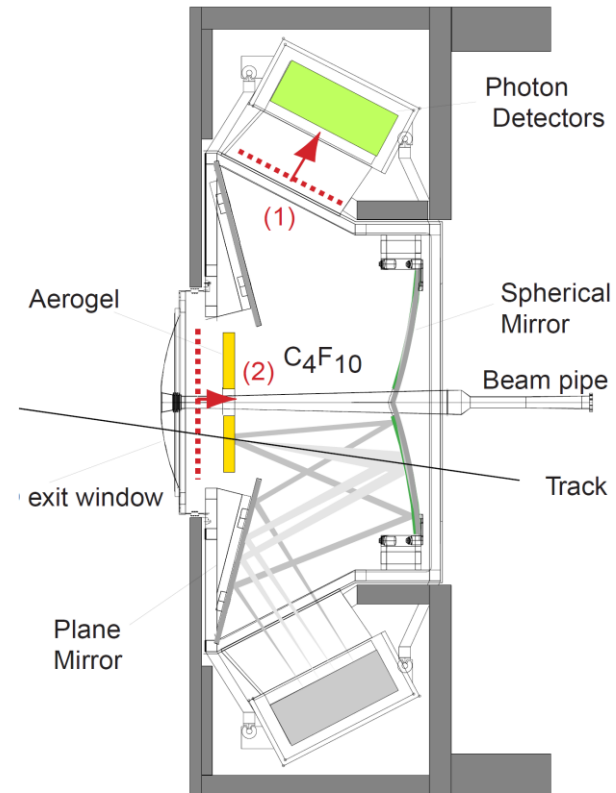
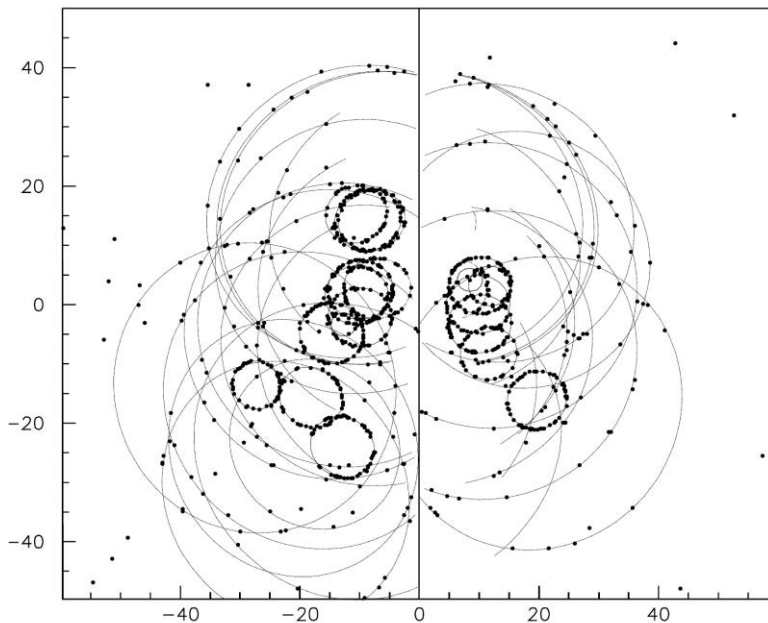


He can see the rocks and the sea below and, on top, the sky
But, ... how far up is the top, how difficult the climb?

The RICH System of LHCb (up to 2018)

Studies started in the nineties on the design of the RICH system in LHCb It has evolved over time during conception, construction, consolidations and upgrade(s)... I'll describe it briefly, together with Neville's contribution from its inception. From 1997 to 2003, years saw design, re-design, various R&D, risk evaluation and management, lots and lots of meetings, but one element stood out all those years as a priority: **the choice of the photodetector technology.**

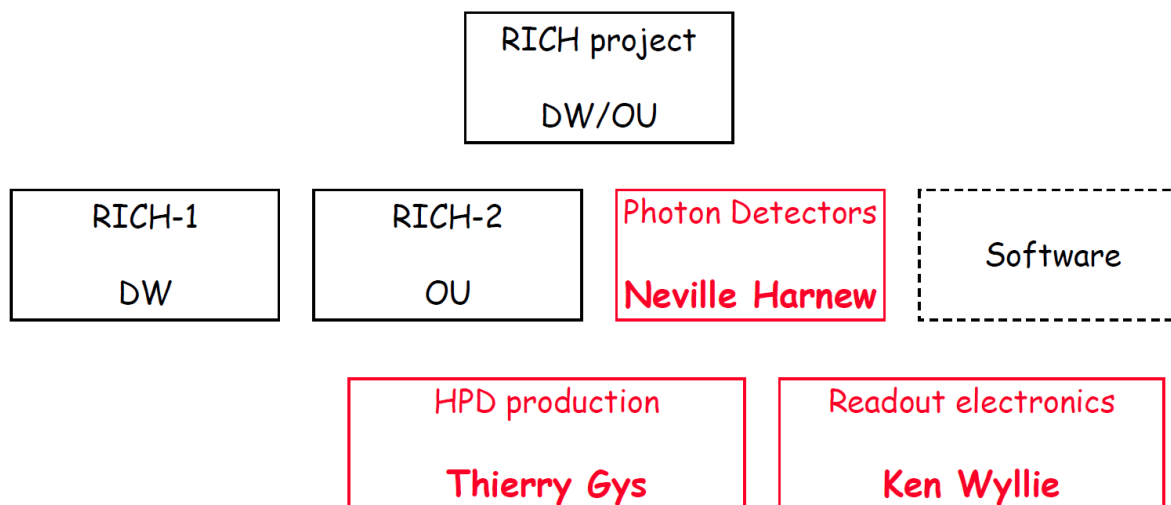
Aerogel and C_4F_{10} radiators combined in single device [S. Easo]



The choice of photodetectors (Pixel-HPDs)

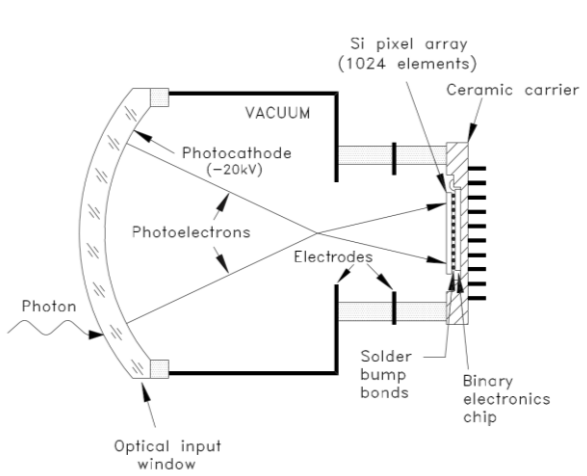
Took a long (justified) time to choose between MaPMTs and Pixel-HPD, but the moment the choice was there, **Neville** was the first person coming to mind to lead the photodetector project (2003)

3. HPD project



HPD Workshop at Imperial College: 4 -5 December
Neville to report on further details later

Shortly after Neville became the Project Leader (2004 – 2008)



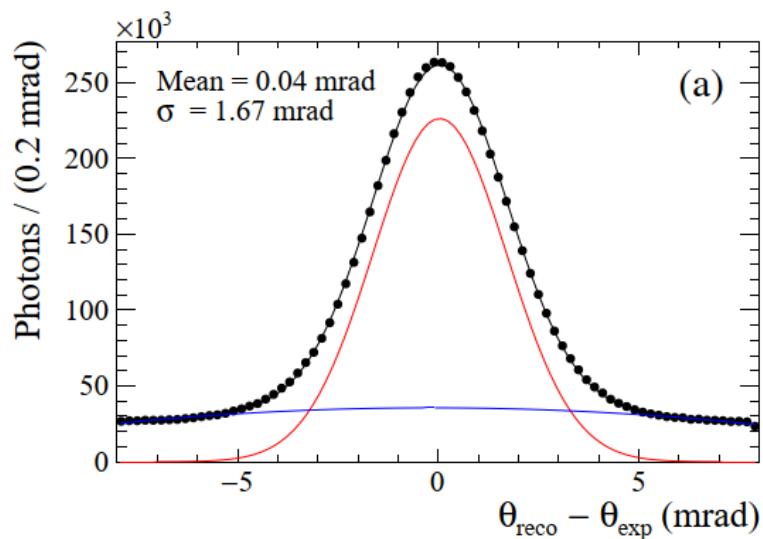
The encapsulated electronics operates at a maximum read-out rate of 1 MHz; (not compatible with 40 MHz readout)



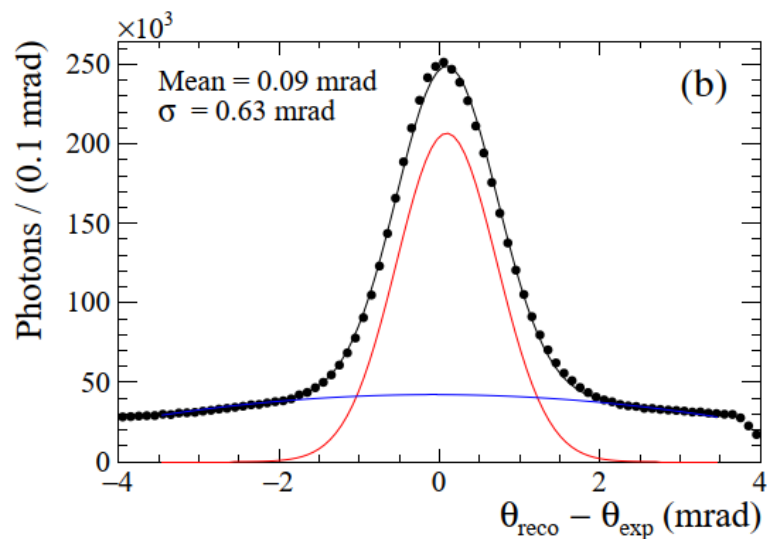
Through Neville's lead, Oxford also designed and produced the **Level-0 readout board**, which was the interface between the **Pixel-HPD** and the DAQ framework (the so-called UKLevel-1 DAQ cards), besides many other contributions, of course.

The RICH system of LHCb worked beautifully between 2009 to 2018

It has been an indispensable (and indisputable) element of the LHCb experiment and of the produced physics results in these last years (what we call RUN 1 and 2).....



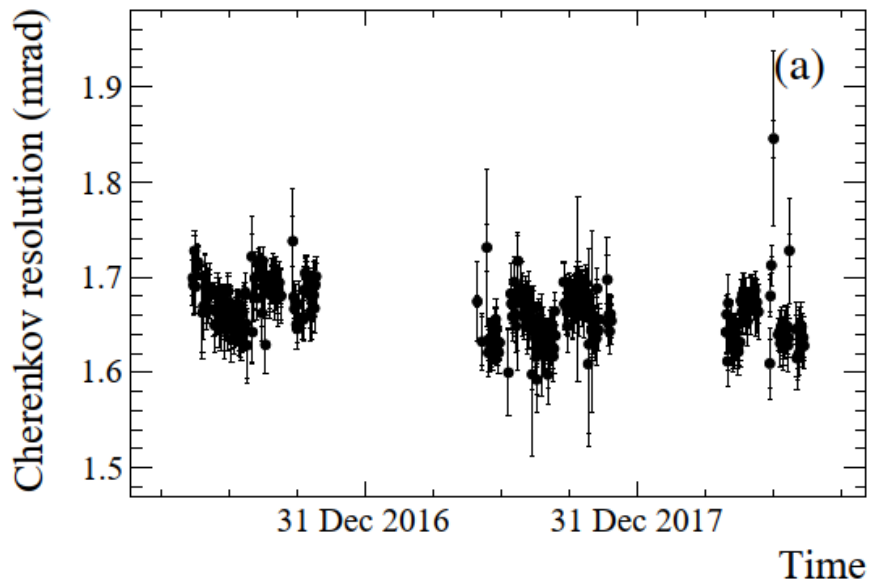
RICH 1



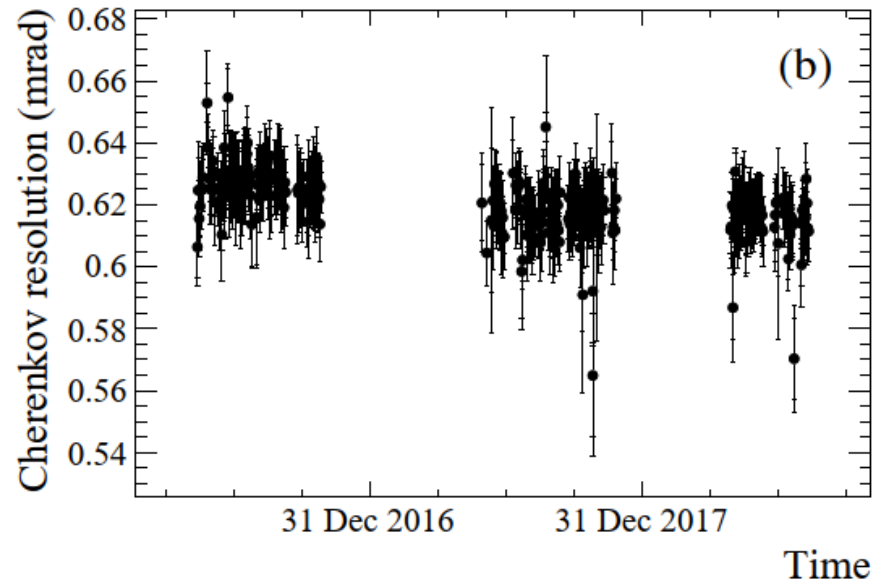
RICH 2

.....with its beautiful angular resolutions

From "Performance of the LHCb RICH detectors during LHC Run 2",
R. Calabrese et al, 2022 *JINST* 17 P07013



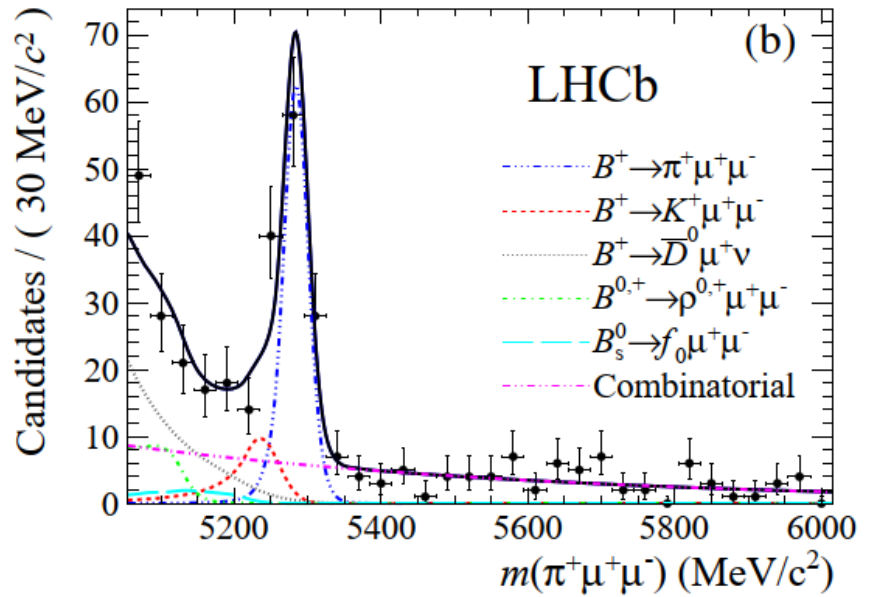
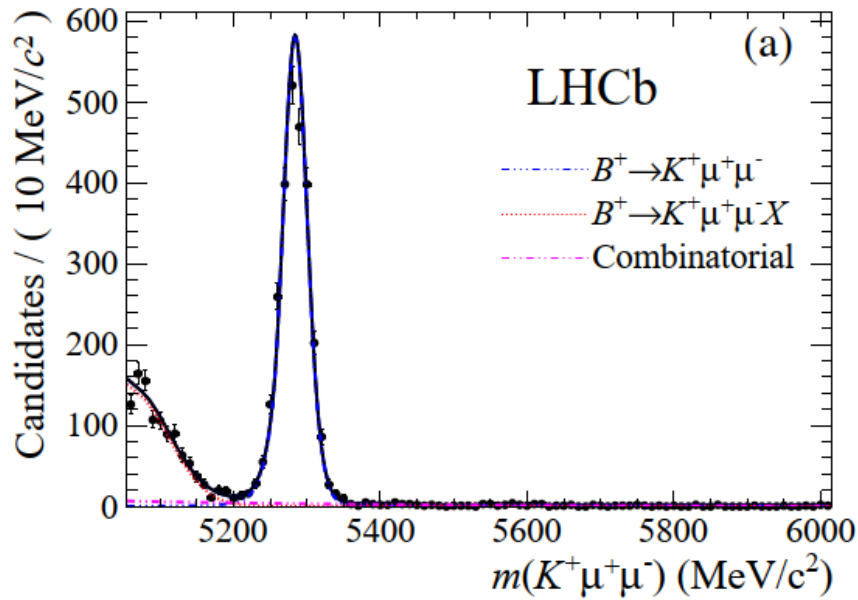
RICH 1



RICH 2

..... reproducibility and reliability

From “Performance of the LHCb RICH detectors during LHC Run 2”,
R. Calabrese et al, 2022 *JINST 17 P07013*



..... and precision and performance .

* First measurement of the differential branching fraction and CP asymmetry of the $B^\pm \rightarrow \pi^\pm \mu^+ \mu^-$ decay, JHEP 10 (2015) 034 [arXiv:1509.00414]

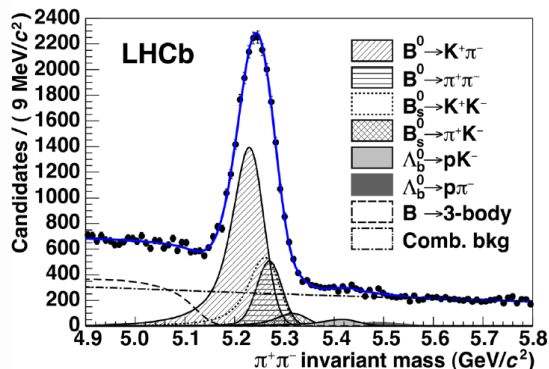
Importance of particle identification

Distinguishing between final states with the same topology

b-hadrons two-body decays into charmless charged hadrons at LHCb

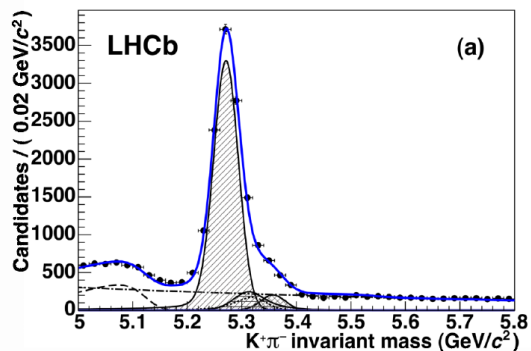
→ with PID

↓ without PID

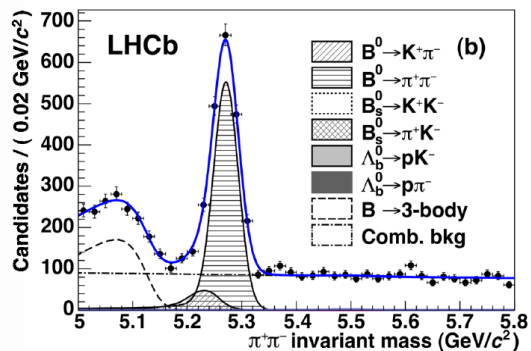


[LHCb, JHEP 10 (2012) 37]

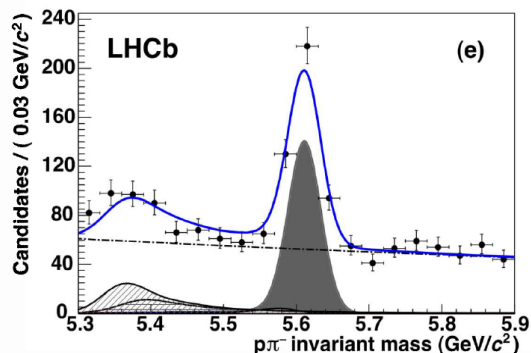
$$B^0 \rightarrow K\pi$$



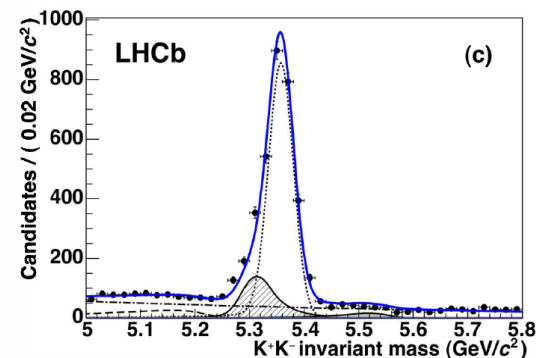
$$B^0 \rightarrow \pi\pi$$



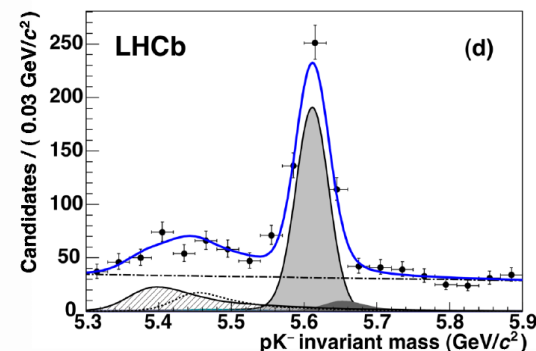
$$\Lambda_b \rightarrow \rho\pi$$



$$B_s^0 \rightarrow KK$$



$$\Lambda_b \rightarrow pK$$



Hadron identification is a key ingredient in *b*-physics & hadron spectroscopy

LHCb RICH (Silvia G.)

To say that Neville was one of the major forces behind this success is “to state the blinding obvious”!

Roger describes him like this:

... (Neville) stood out through his drive and inspirational leadership: he has acted as a magnet to bring people together towards a common goal, He led the project to full success, with his group developing and delivering essential read-out electronics.

The RICH System of LHCb for Upgrade I

Now, what? Well an upgrade is needed!!

From an e-mail from **March 2006**:

Dear Project Leaders,

Upgrade plan for the LHCb detector is still very uncertain. On the other hand, there is already quite some pressure to indicate required resources for the luminosity upgrade from various funding agencies, including CERN.For the coming upgrade meeting on Monday, could you please think about necessary R&D and required resources for that if you have to run your subsystem with a luminosity of **10^{*33} and 40 MHz readout**? Clearly our utmost priority is to complete the detector construction and start the experiment, but **if you have some spare time**

Thank you very much, yours
Tatsuya

Neville, as Project Leader at that time followed

RICH : Luminosity Upgrade

LHCb Upgrade Meeting 11-12/01/07

Edinburgh

Neville Harnew (Oxford)

RICH : Luminosity Upgrade N. Harnew 12-01-07 LHCb Upgrade Workshop

1

A couple of years after, Neville was nominated RICH Upgrade Coordinator,

which culminated in 2013 with:

RICH2019: A Proposal for the LHCb-RICH Upgrade

Proponents*: Alessandro, Carmelo, Christoph, Sajan (CERN, Genova, RAL)

Our FW-TDR asks for a detector capable of

$2 \times 10^{33} \text{ cm}^{-2} \text{ s}^{-1}$ @ 40 MHz readout rate

Change the opto-electronic chain

Baseline option: 64 pixels MAPMT + custom FE chip + support card + motherboard + GBTs

Backup option: HPD with ext electronics

Major Specs for the Photon Detector Plane:

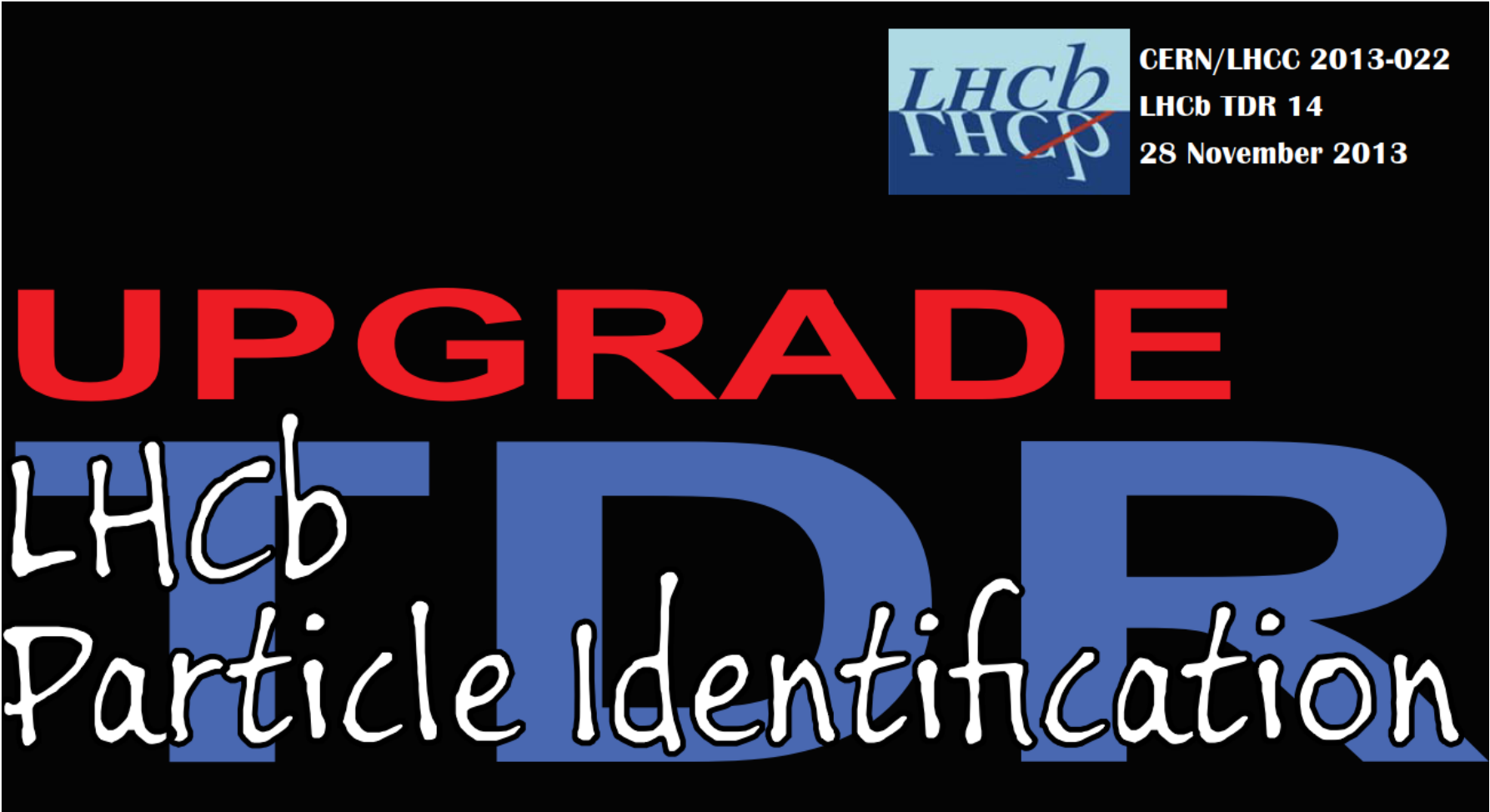
High single photon sens., <3 mm pixel size, operation in magn. field, no spillover (<25 ns)

*This work is the conclusion of several upgrade meetings, where most of the RICH community took part. It is therefore almost impossible to name all the people, who directly or indirectly have contributed to it. Allow us therefore to thank first the whole RICH team and then the LHCb collaboration for their help and interest. Carmelo on behalf of RICH2019, CERN, 17.06.2013

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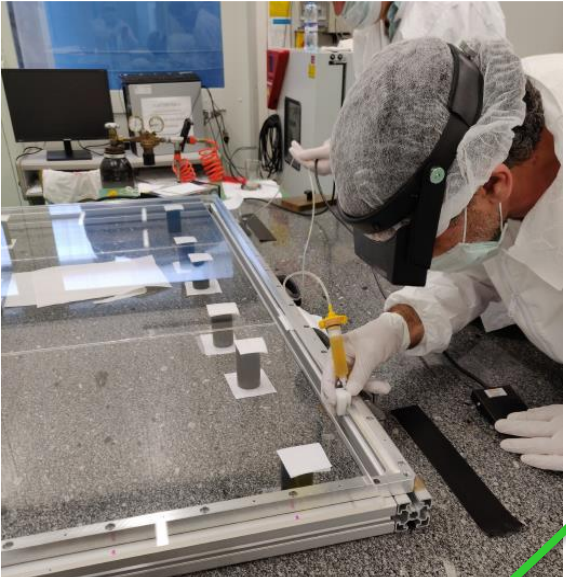
... and the Technical Design Report,

which was produced only a few months after, thanks to his tireless work and motivation.

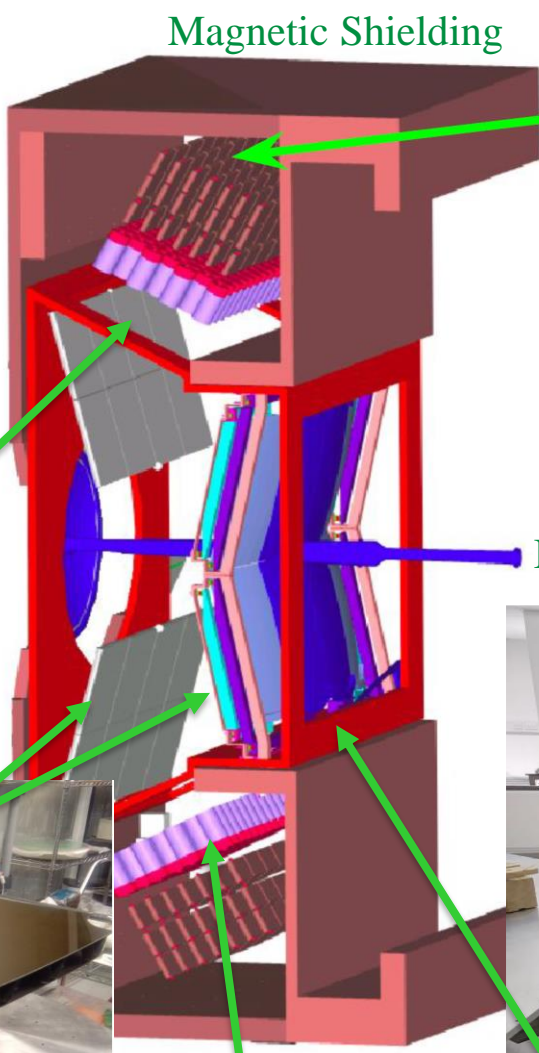


The image shows the cover of a technical design report. In the top right corner, there is a logo for LHCb (Large Hadron Collider beauty) with the text 'LHCb' in blue and 'TDR' in white, crossed out with a red diagonal line. To the right of the logo, the text reads: 'CERN/LHCC 2013-022', 'LHCb TDR 14', and '28 November 2013'. The main title 'UPGRADE' is written in large, bold, red capital letters. Below it, 'LHCb' is written in a white, handwritten-style font. The word 'TDR' is written in very large, blue, blocky capital letters. At the bottom, 'Particle Identification' is written in a white, handwritten-style font.

Neville focused on and led RICH-1 development and construction



The quartz windows

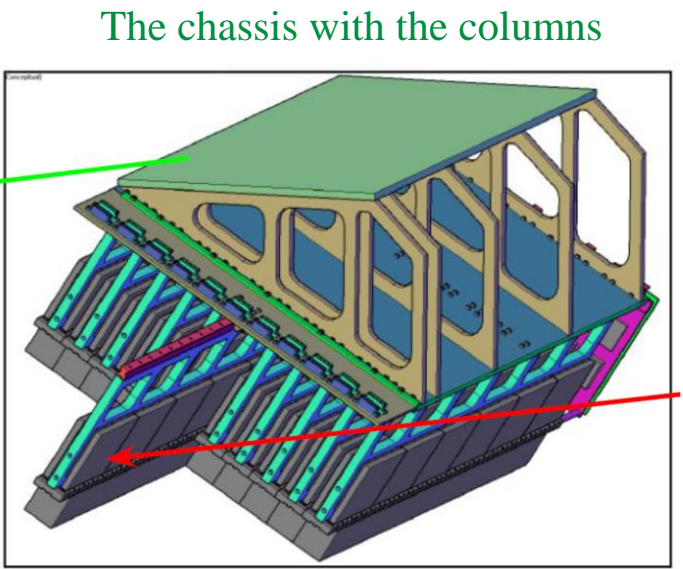


Magnetic Shielding

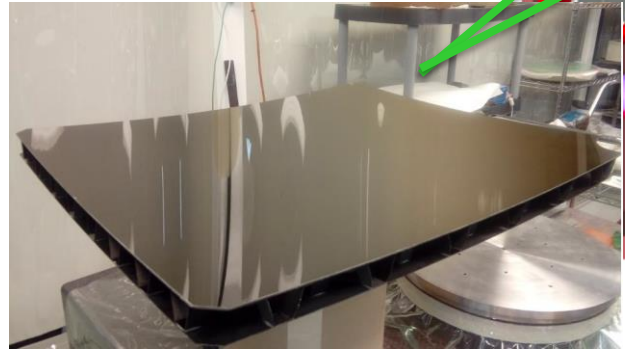
The Mirrors

The Sensors

Beam Pipe and seal to Velo



The chassis with the columns



The gas vessel

Carmelo, Neville's Fest, 28 Sep

One incident proved to be particularly hard to stand (August 2019):

Here Neville is in the CERN Lab., where we glued three quartz panes to form a RICH1 window!



One incident proved to be particularly hard to stand (August 2019): the completed window is shown here



Carmelo, Neville's Fest, 28 September 2022

One incident proved to be particularly hard to stand (August 2019): ...and here four happy people!



One incident proved to be particularly hard to stand
(August 2019): the window on its way to RICH1

Mike Booth, Mike McCann,
Johan Pretorius, NH



Carmelo, Neville's F

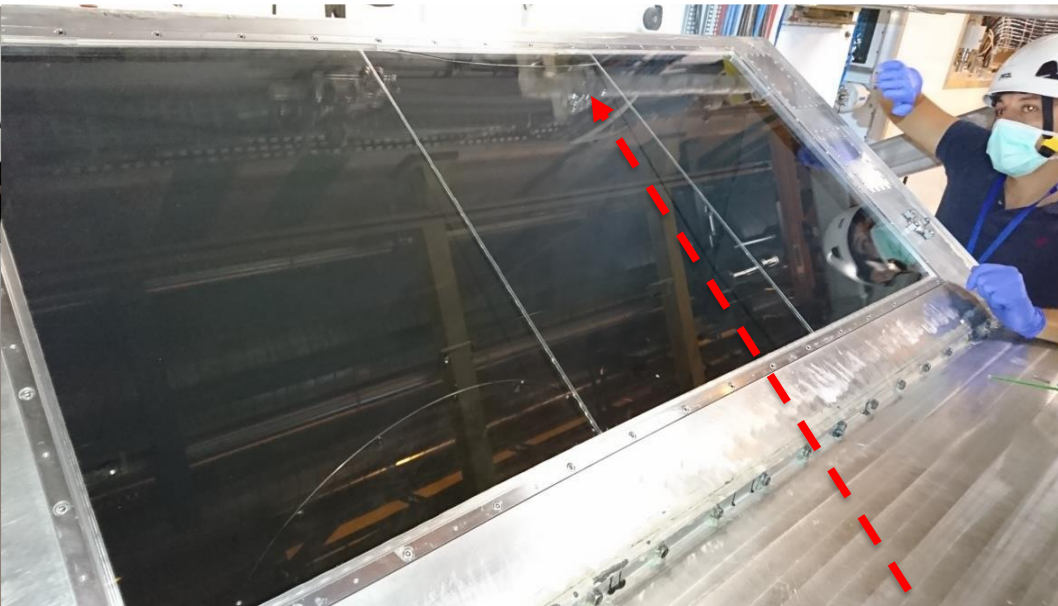
One incident proved to be particularly hard to stand (end of August 2019):

I was enjoying this view, far from everyday-life troubles,



when I got the info that **the quartz window had cracked!**

From here 😊



to here 😞



It may have looked like a **disaster**, yet **team spirit*** remained strong and we managed in only **4 weeks** to receive new quartz panes and **build a new one!**

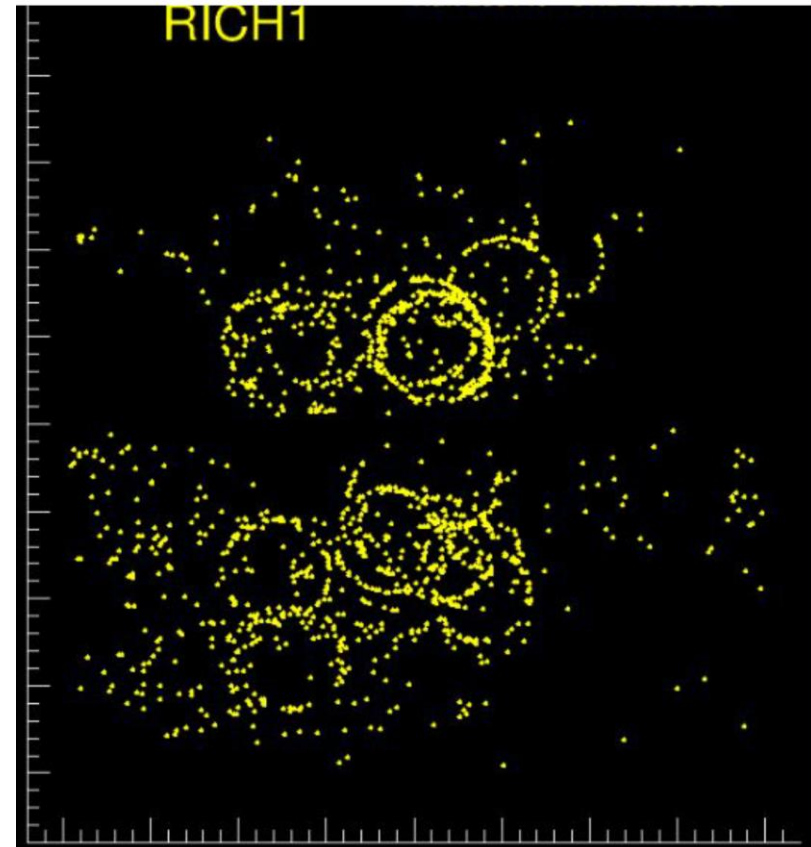
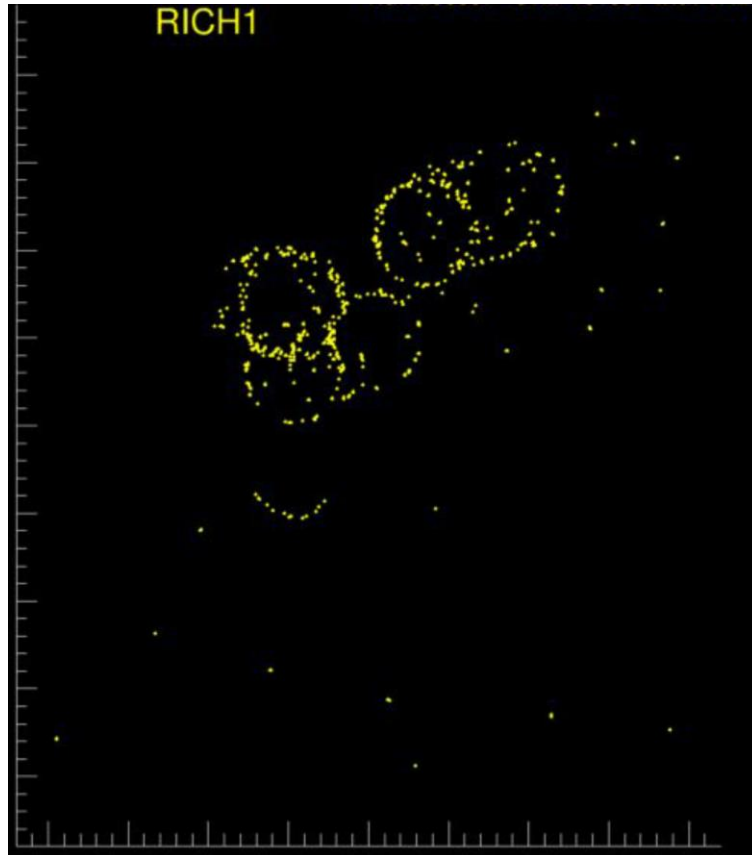
Meanwhile we investigated the **reasons of that failure**, corrected what there was to correct and installed the new one, which is now in place since a couple of years and no issues have arisen.

RICH 1 installation was finished before the end of last year and it is now taking LHC beam data together with RICH2, **ready to physics in 2023.**

* I am sure Neville will join me in thanking again our CERN and Oxford Teams for their excellent response to that crisis

First results from all our efforts over these years start to be recorded.

Present to 2026



Carmelo, Neville's Fest, 28 September 2022

... and finally for Neville, the end of the RICH climb!



Courtesy of Roger

He can touch the sky (or almost, as Arthur 'seat is not high enough), ...
he should be happy, satisfied, ...

... but, ... he starts a new project! The TORCH

Well, actually he had already started it some years ago and, true to his determined character, he has devoted and will continue to devote plenty of his never-ending energies to achieve it!

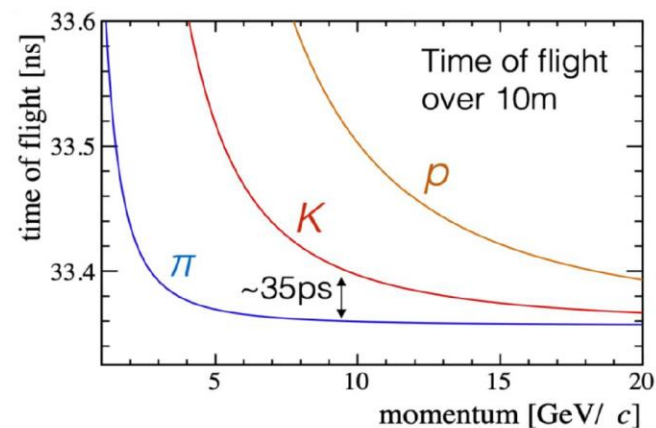
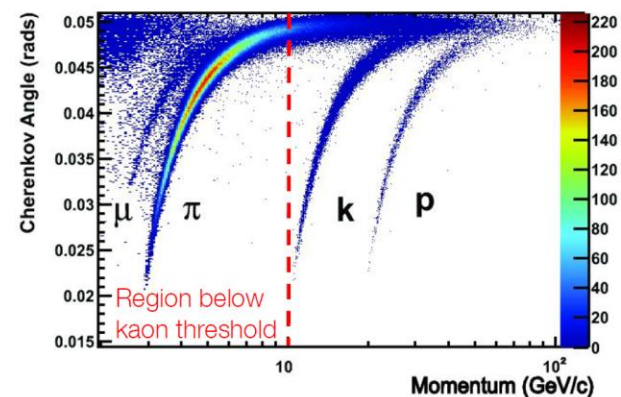


The TORCH Detector



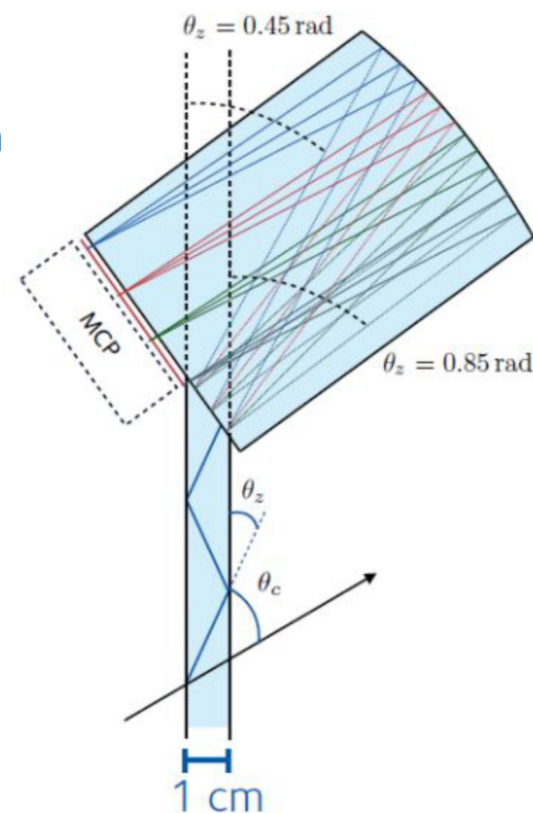
Introduction

- PID at LHCb currently provided by 2 RICH detectors
- **TORCH:** Proposed solution to enhance low momentum (2-20 GeV/c) particle identification at LHCb:
 - Covers region where kaons are below threshold in the LHCb RICH detectors
- **Exploit time-of-flight (ToF) for particle ID:**
 - $\Delta\text{ToF}(K-\pi) \sim 35\text{ps}$ for a 10m flight path
 - Aim for $\sim 10\text{-}15\text{ps}$ per track for 3σ K/ π separation



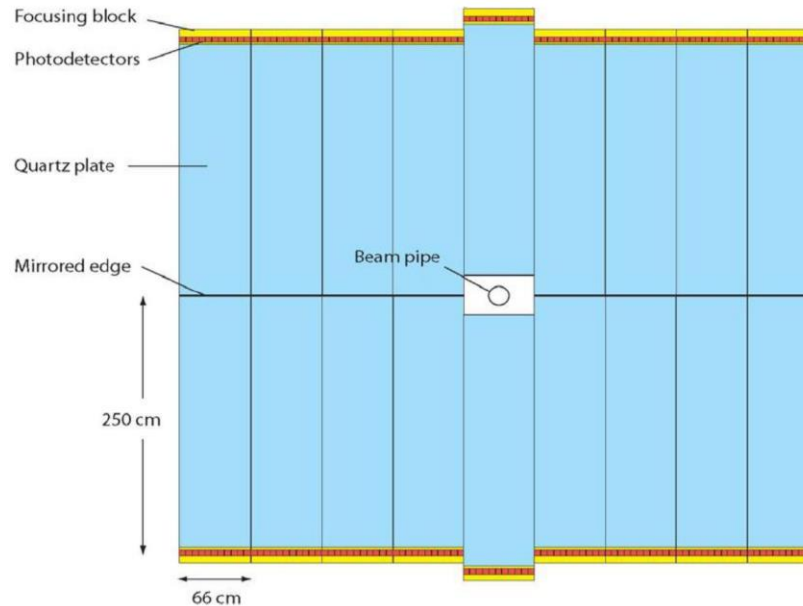
The TORCH principle

- Charged particles passing through a quartz plate generate prompt Cherenkov photons
- Photons are propagated via total internal reflection to the periphery of the detector
- A cylindrical focusing block focuses the photons onto an array of photon detectors
 - MCP position maps to θ_z
- Photon arrival time and position is measured to derive:
 - Cherenkov angle and path length
 - Photon propagation time
 - Expect ~ 30 detected photons per track ($\sigma_t = 70\text{ps}$)
- Method is related to that used by the BaBar DIRC and Belle II TOP



TORCH design

- 18 identical modules $250 \times 66 \times 1 \text{ cm}^3$ (covering and area of $\sim 5 \times 6 \text{ m}^2$)
- Full TORCH implementation now planned for future LHCb upgrade at the HL-LHC ([LHCb upgrade II framework TDR \[LHCB-TDR-023\]](#))
- See Maarten Van Dijk's talk tomorrow for more details on design and photon detectors



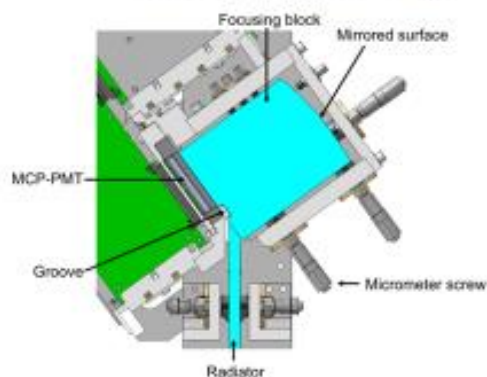
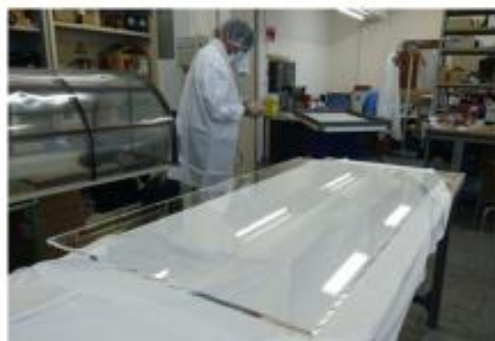
I sincerely believe Neville will also rise to this challenge!

And I would have been the sadder one not having him in the RICH, if it were not for the fact that there are synergies between the two projects, which will surely keep both of us close enough.

As can be observed in this slide, where a familiar lab. and face can be seen

A prototype of the TORCH detector

- A prototype of the TORCH detector has been developed: ProtoTORCH
- Optics sourced from Nikon
 - Full-width, half-height radiator
 - Full-sized focusing optics
 - Glued with Pactan 8030



Epilogue

Neville has so many qualities, quite impossible to summarize here.

However, one of the most important is:

His ability to make things happen!

Entertaining, scrupulous, methodical, clever, professional and very knowledgeable....

.... he does sometimes need someone who can listen and comfort him

(I was more than happy to be the one for the RICH 😊).

Neville has a **willpower of steel**,



even when **interminable meetings** will stretch his amazing endurance to a **limit...** 🤪

His mastery of the English language has made many of us so much better at that!

Here some of Neville's traditional Britannic sayings:

- Sorry to state the blinding(ly) obvious, but ... (it happened a couple of times);
- It never rains, it pours ... (that happened for example with the quartz window);
- Throwing a hand grenade in the meeting (used several times, whenever someone would propose a new idea, too late in time or too expensive to be taken in consideration);
- Throwing a spanner in the cogs (similar to before..., but in confidence! 🤪)
- You can't polish a t..d (I am not allowed to mention in which occasion this was said!);
- Taking coals to Newcastle (stating that this never happens in our project 😊);
- Teaching your grandmother to suck eggs (we are the grandmothers here).

Not to mention the many amazing presentations and performances in various meetings and conference ... dinners, the only regret is to not have a recording of those!

Again, I am honoured to share these moments with you all and especially with Neville.

For many reasons, I want to believe that we can continue to work together for still a long time.

In any case, whatever the future, dear Neville, I* wish you an exciting new chapter in life, together with all your family, friends and ... collaborators ... 😊

Thank you, Neville!

* and with me all our great collaborators and friends, who worked hard to achieve our goals