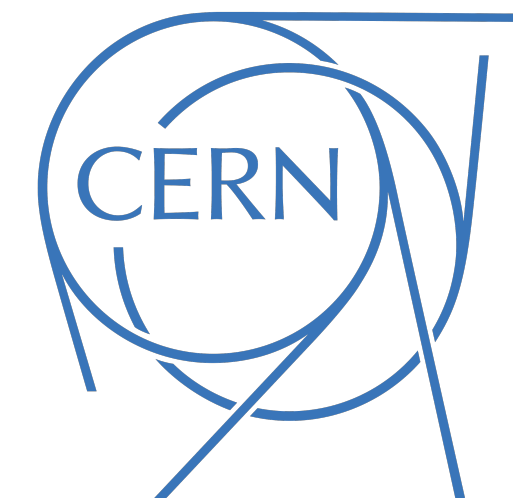


COMMISSIONING AND EARLY DATA FROM THE LHCb UPGRADE

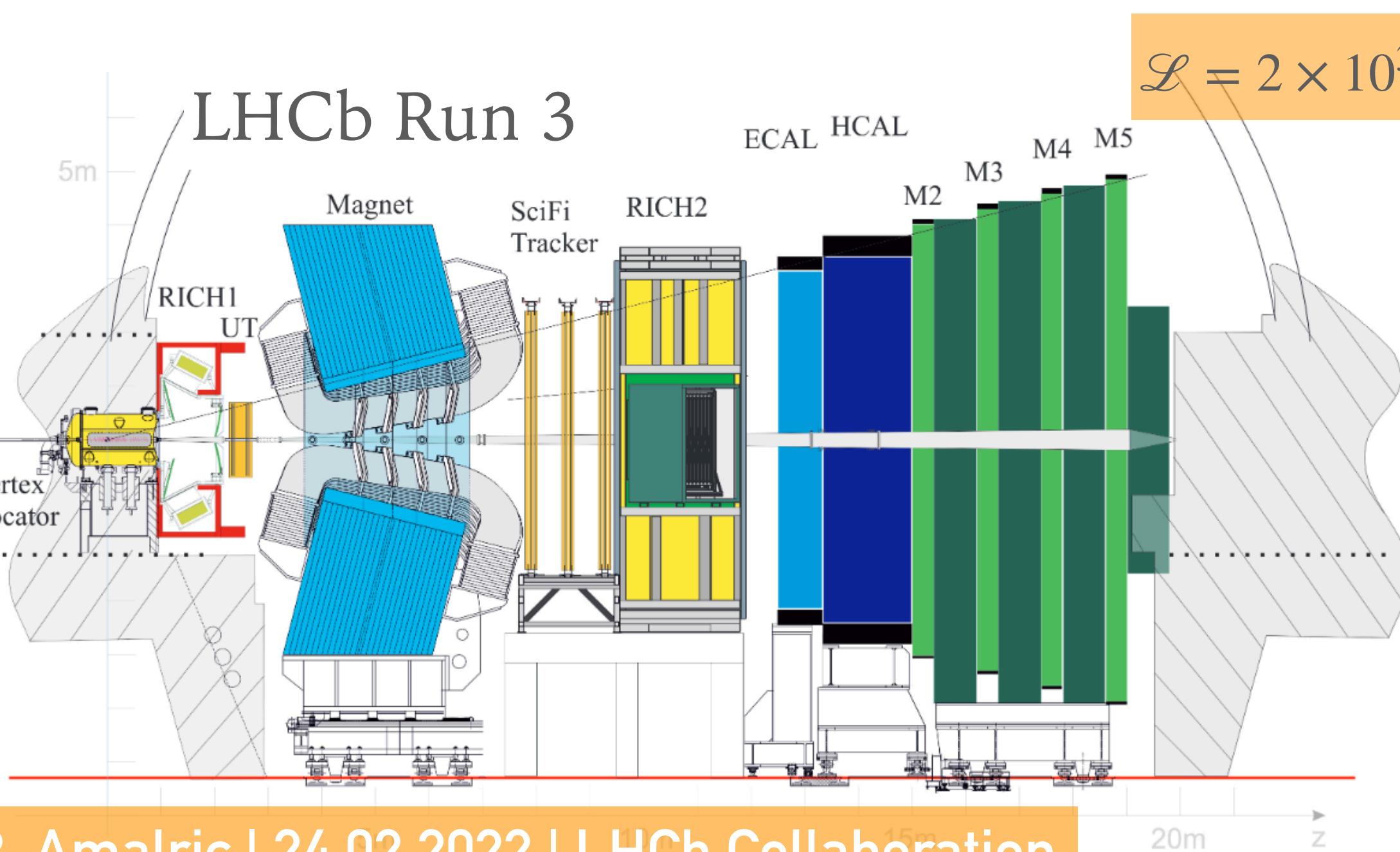
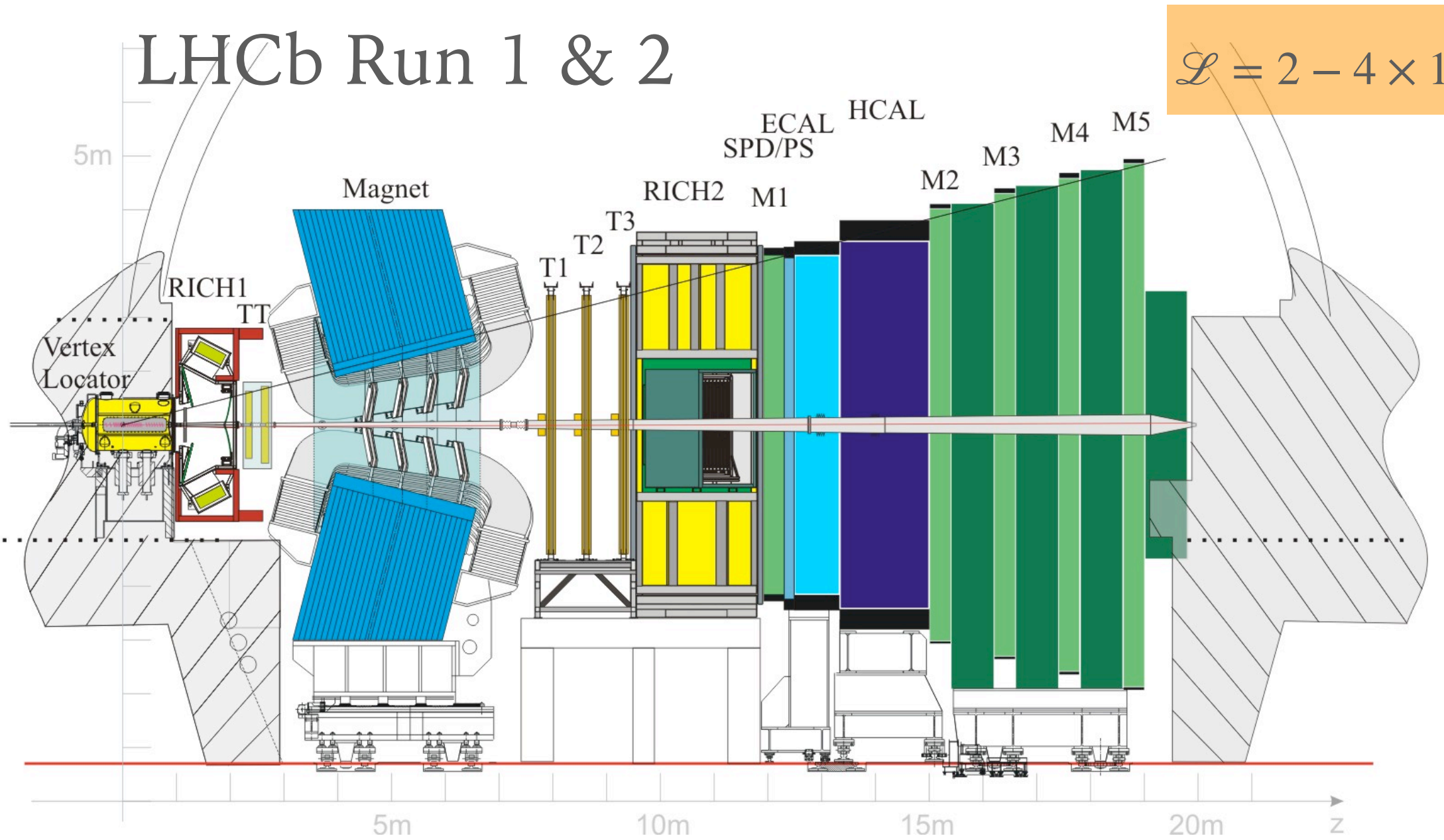
Renaud Amalric - LPNHE, Paris

On behalf of the LHCb Collaboration

Lake Louise Winter Institut - 24/02/2023



UPGRADE 1

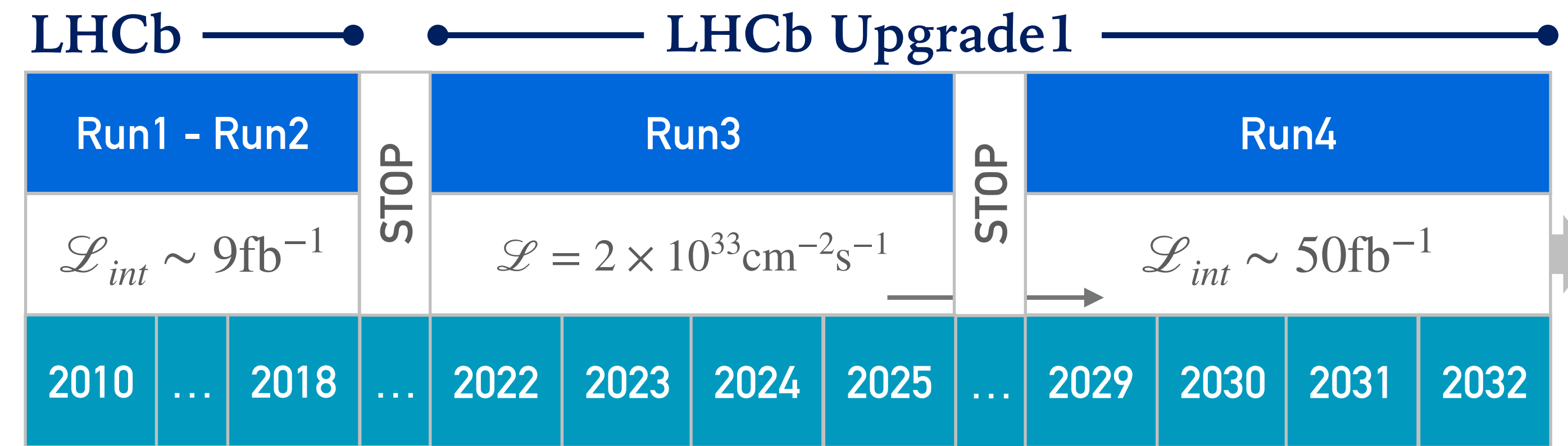
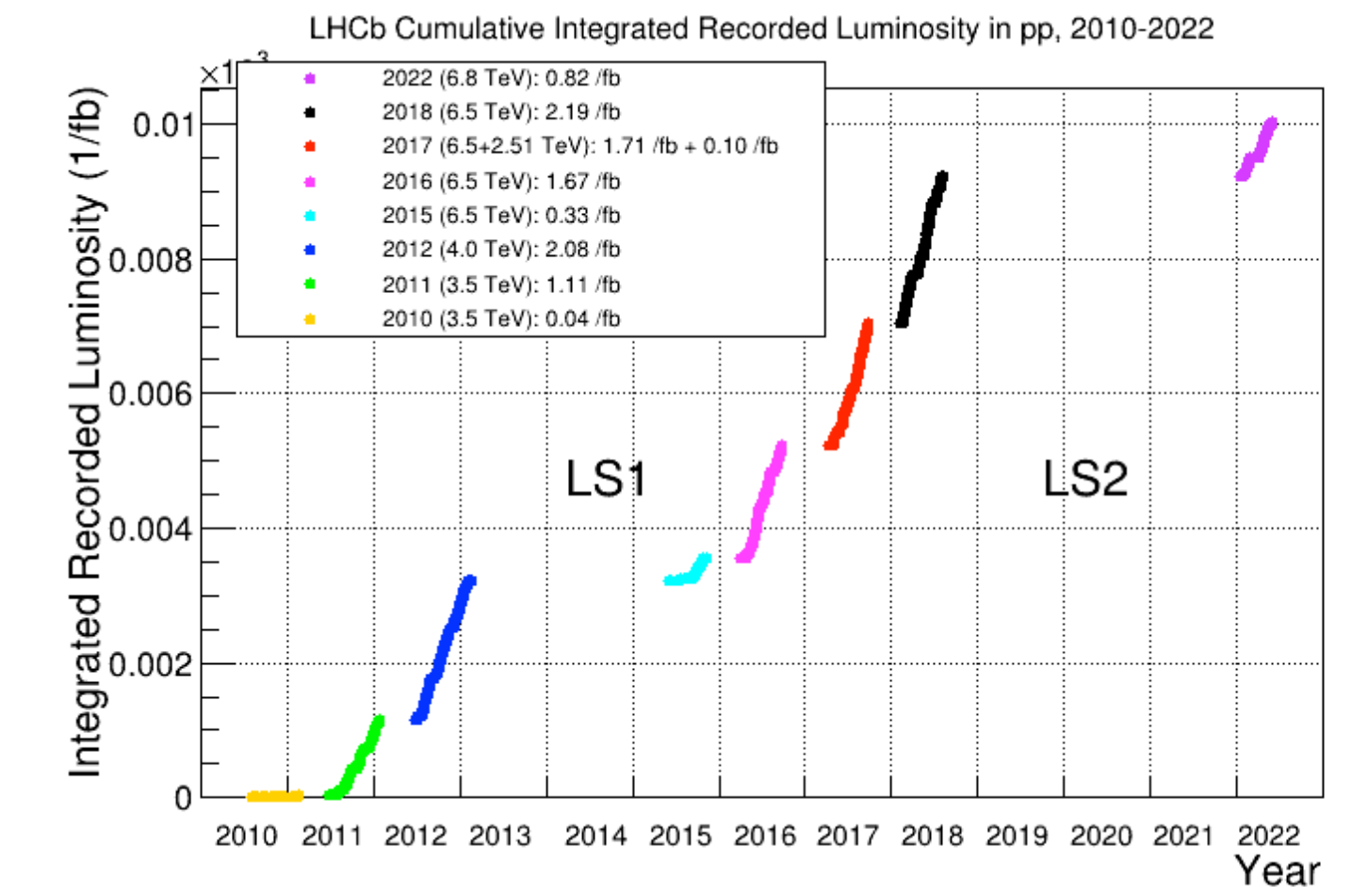


→ Forward spectrometer, optimised for the study b and c decays

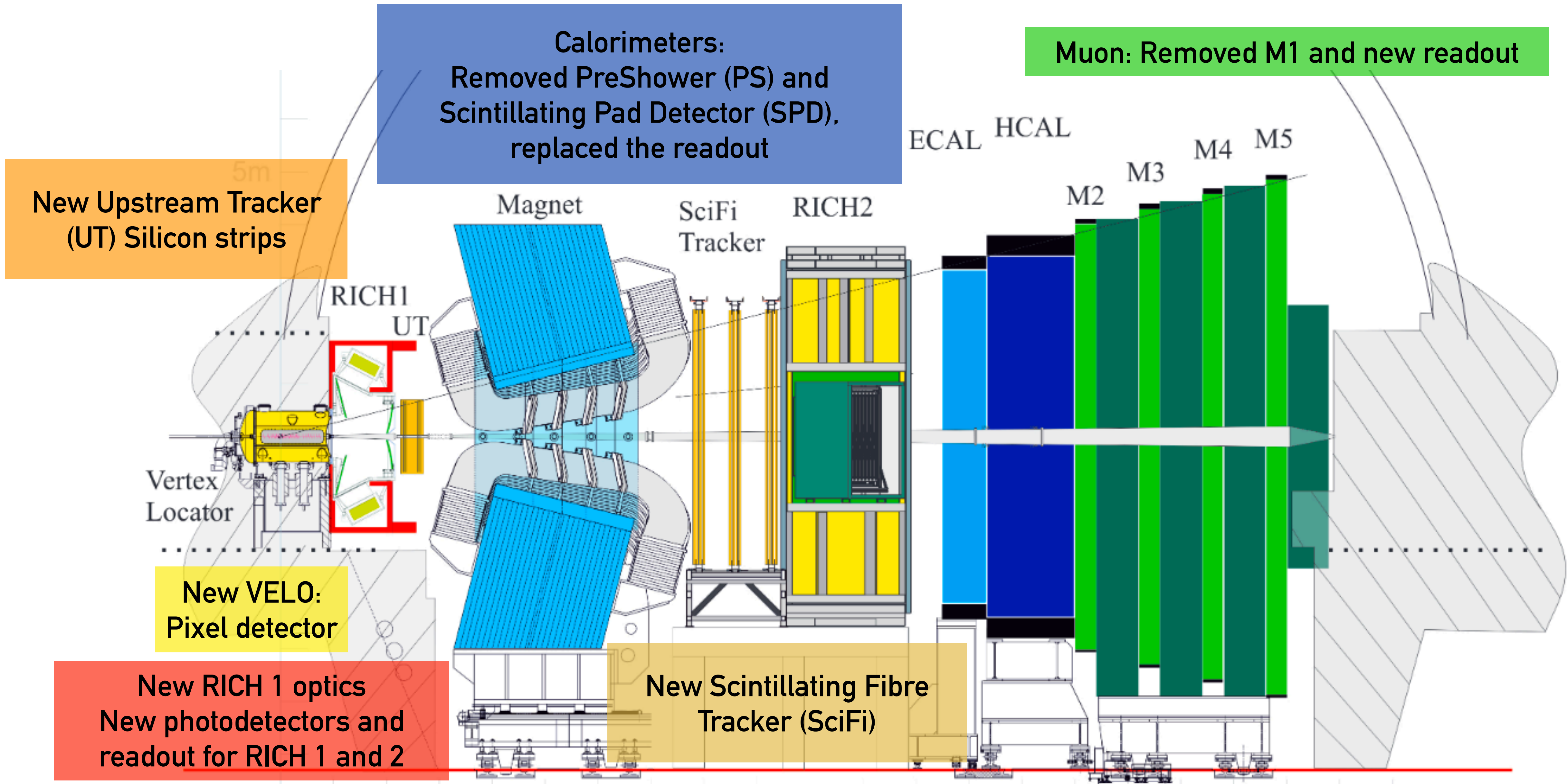
- $2 < \eta < 5$ acceptance
- Excellent vertexing, tracking and Particle IDentification ($K/\pi/p/\mu/e/\gamma$)

→ 2022 :

- Installation
- Commissioning
- Start of Run 3

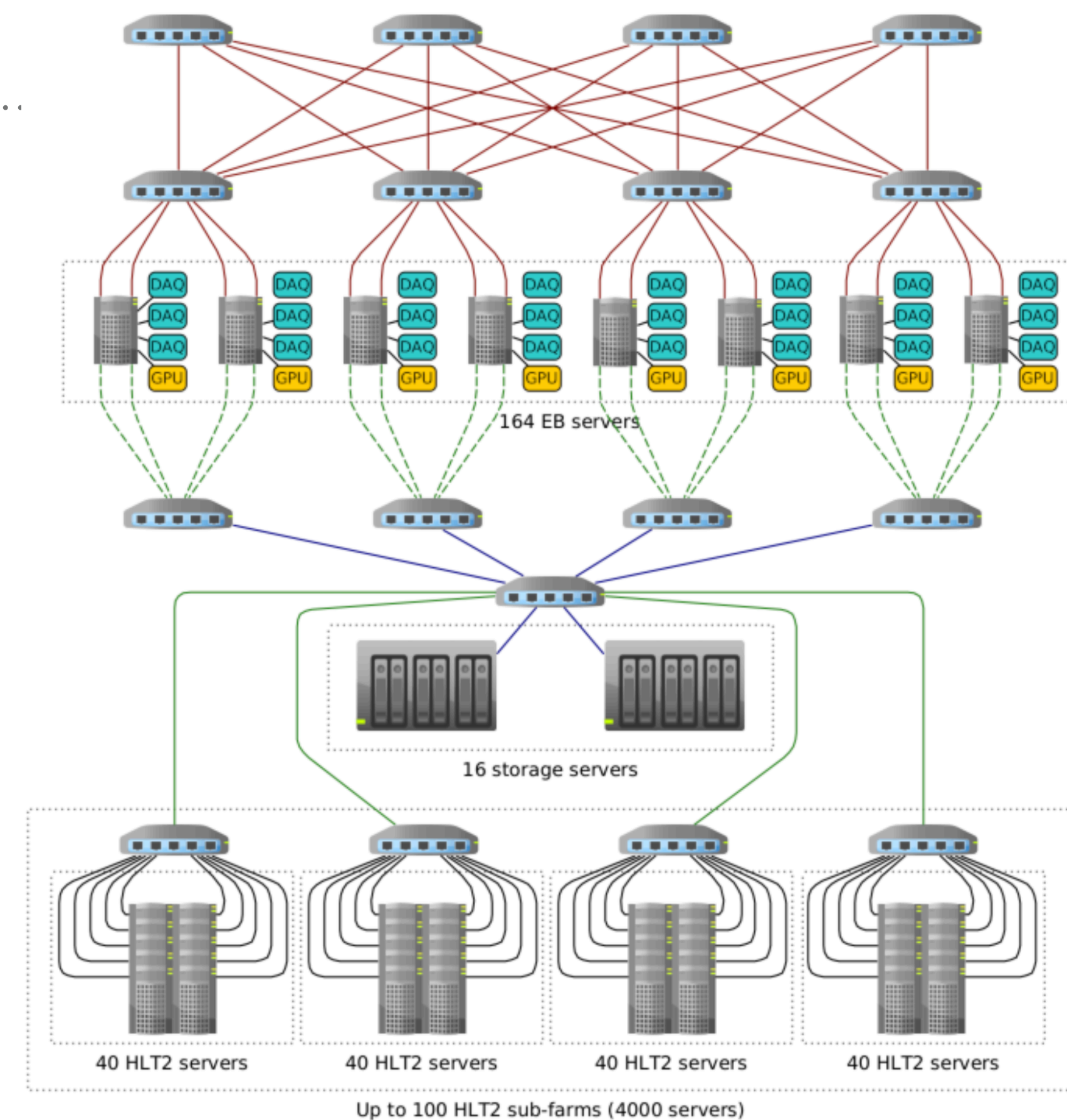


LHCb UPGRADE - DETECTOR

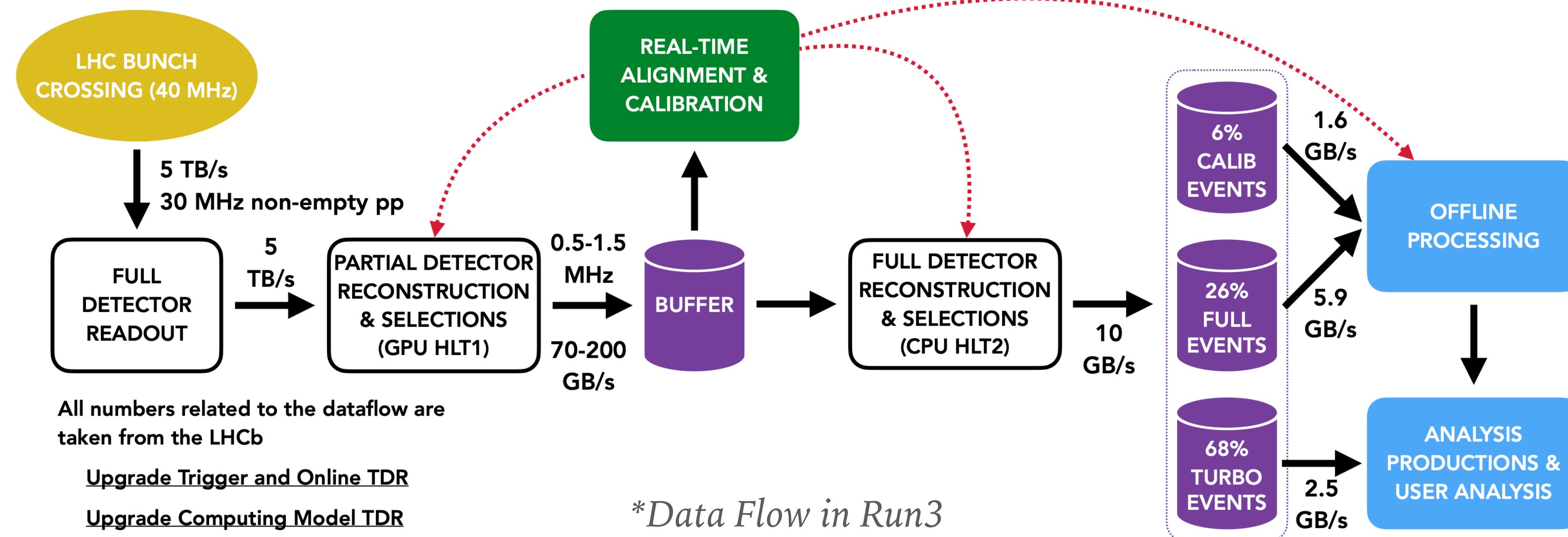


LHCb UPGRADE - TRIGGER AND PROCESSING

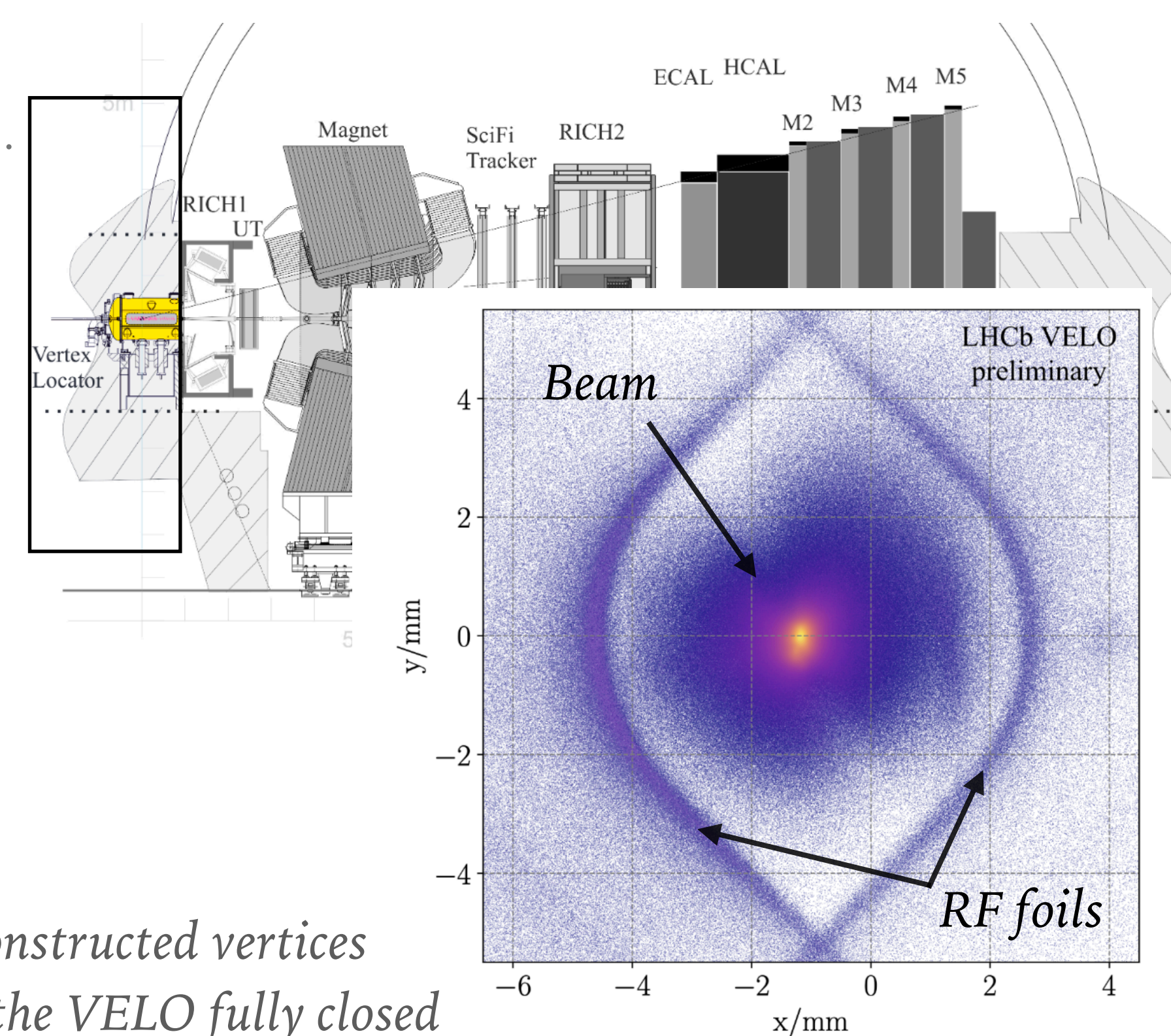
- Removed the hardware trigger (L0)
- Readout at bunch-crossing rate
- Two-stage software trigger
 - HLT1 - on GPUs (30MHz → 1MHz)
 - HLT2 - on CPUs
- Maintain current reconstruction performance in a harsher environment



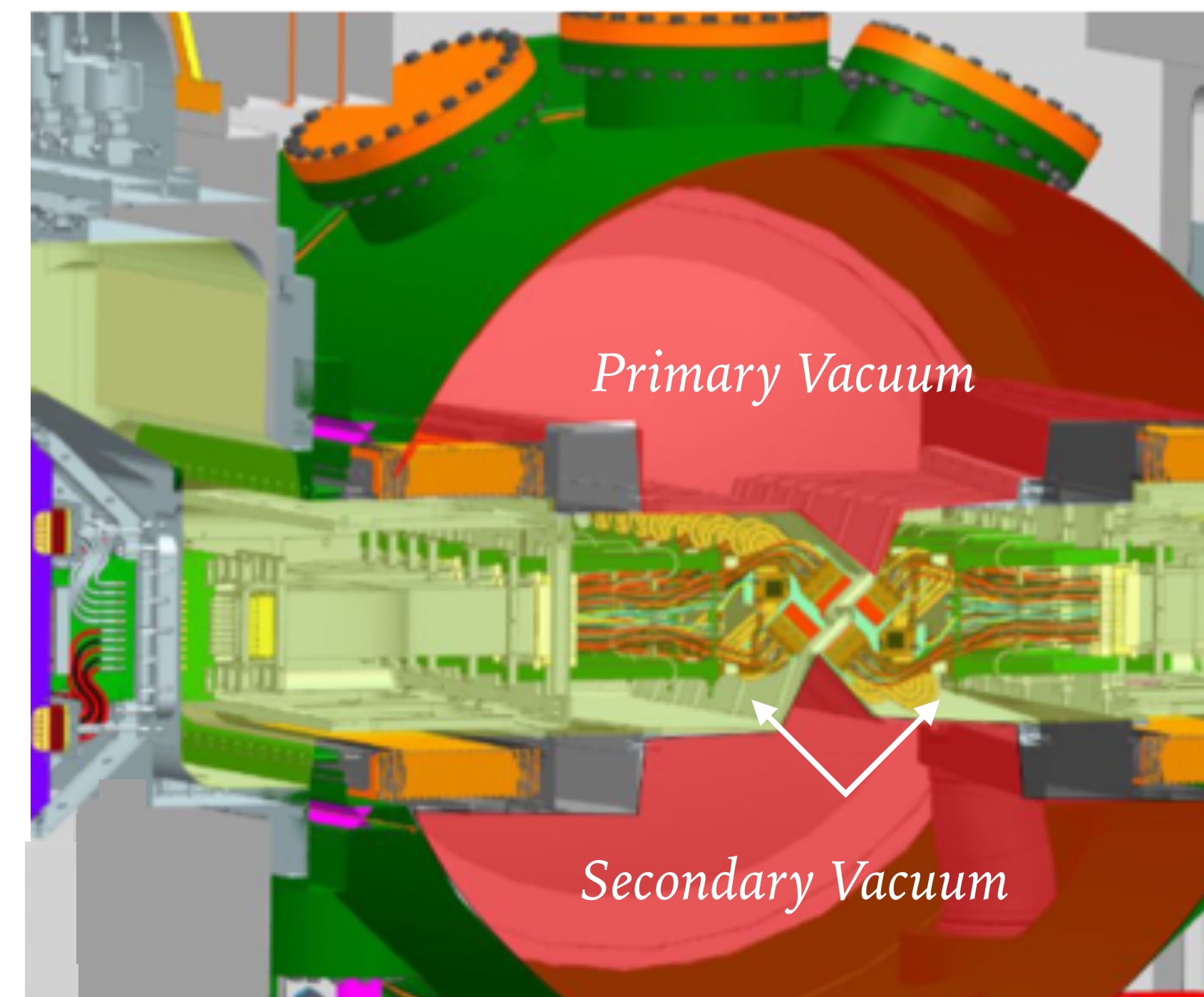
**Architecture of the online data processing*



- First full closure on the 25/10/2022
- Micro-channel CO₂ cooling system operating successfully
- Material position mapping from vertexing of hadronic interactions
- Successfully used for data taking and for track reconstruction



**Reconstructed vertices with the VELO fully closed*



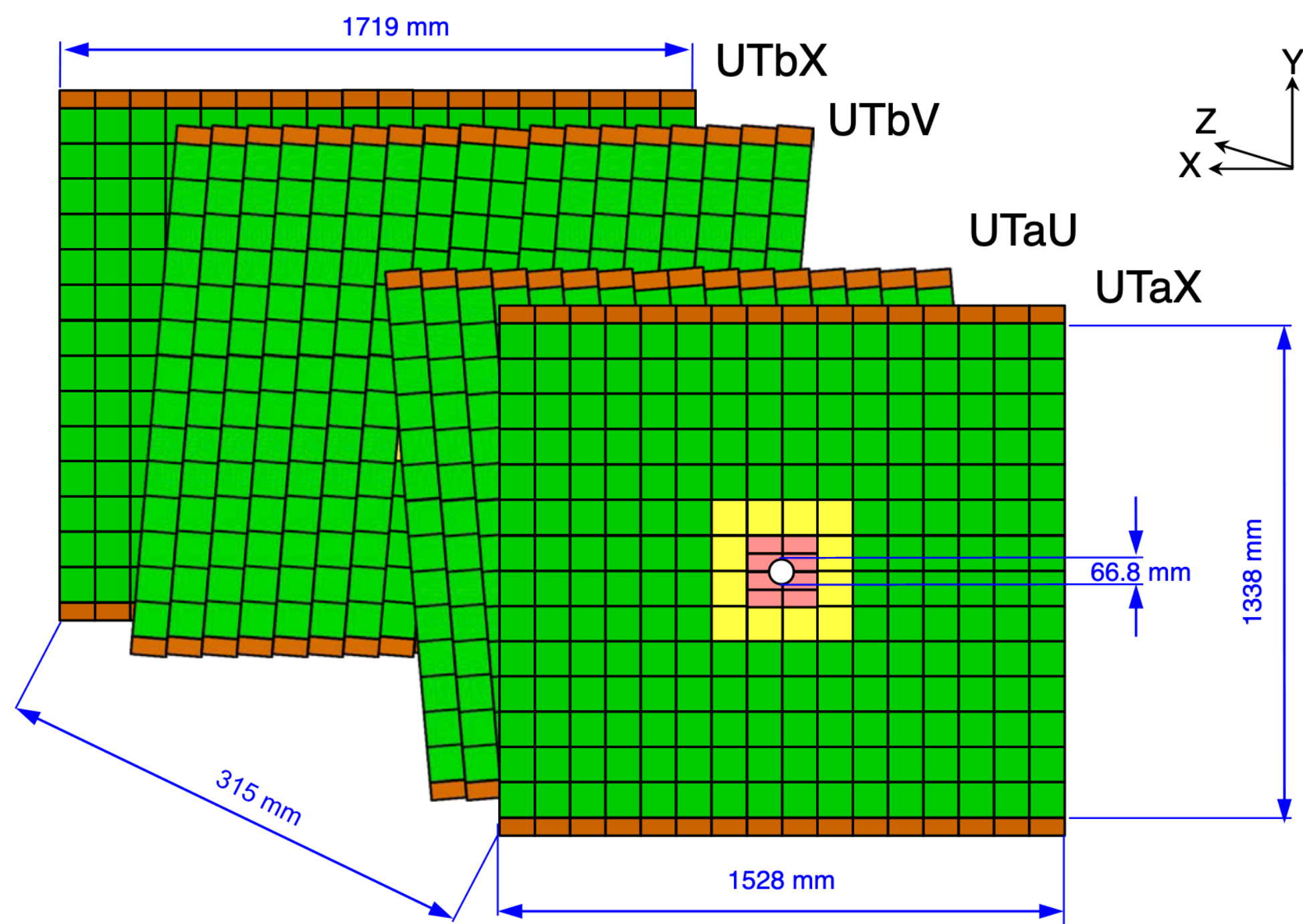
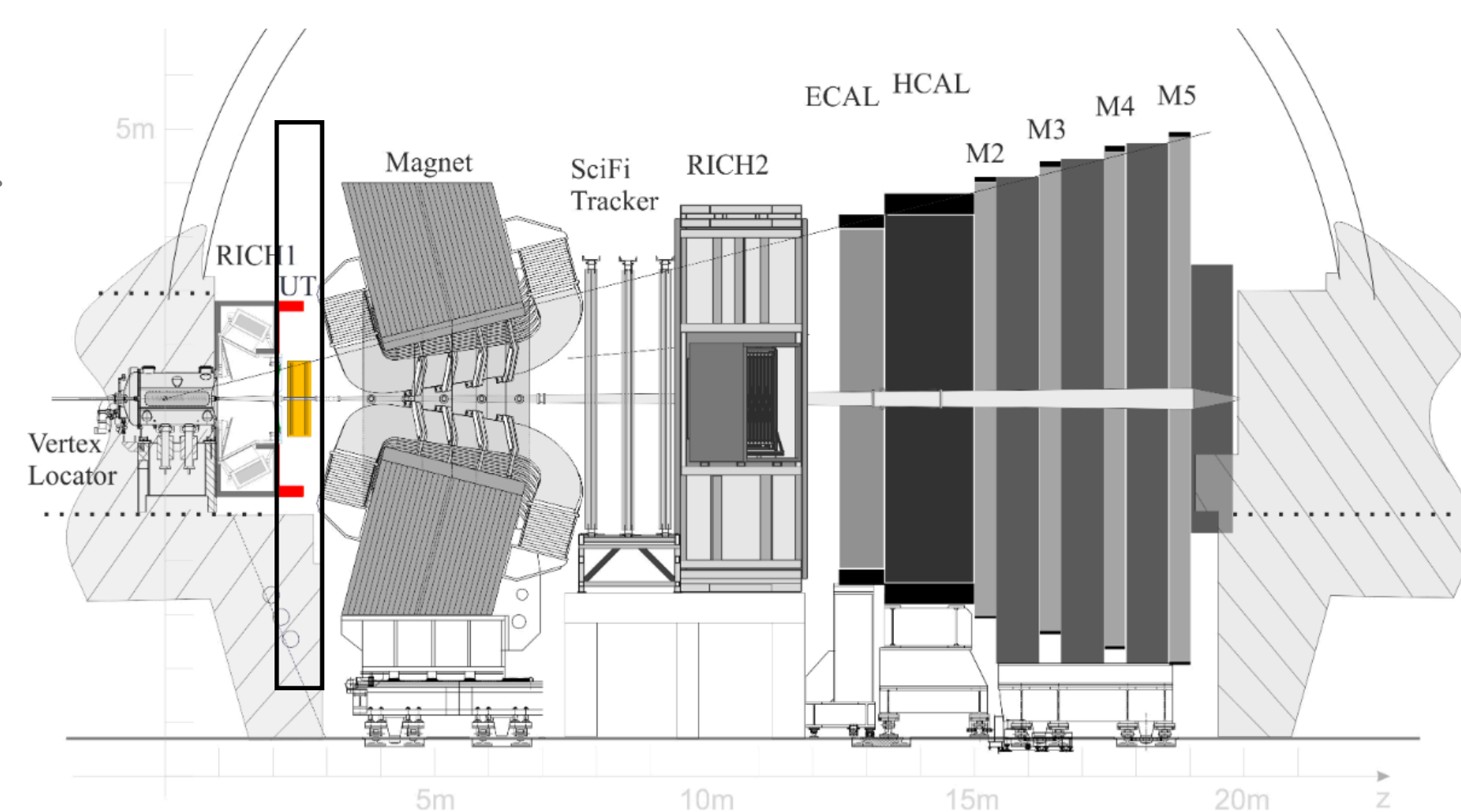
Upgrade I - VELO incident

- Damage of the RF box between VELO and Primary Vacuum 10/1/23
- Multiple equipment failures resulted in a build up of pressure beyond specification between VELO and beam volumes
- RF foils have been deformed. VELO modules do not show damage
- Foil to be replaced in shutdown, current or year end
- Physics programme significantly affected in 2023

UPSTREAM TRACKER - UT

CERN-LHCC-2014-001

- Not installed for the runs of 2022
- Installation well advanced and progressing well
- Should be installed by the start of LHC in 2023

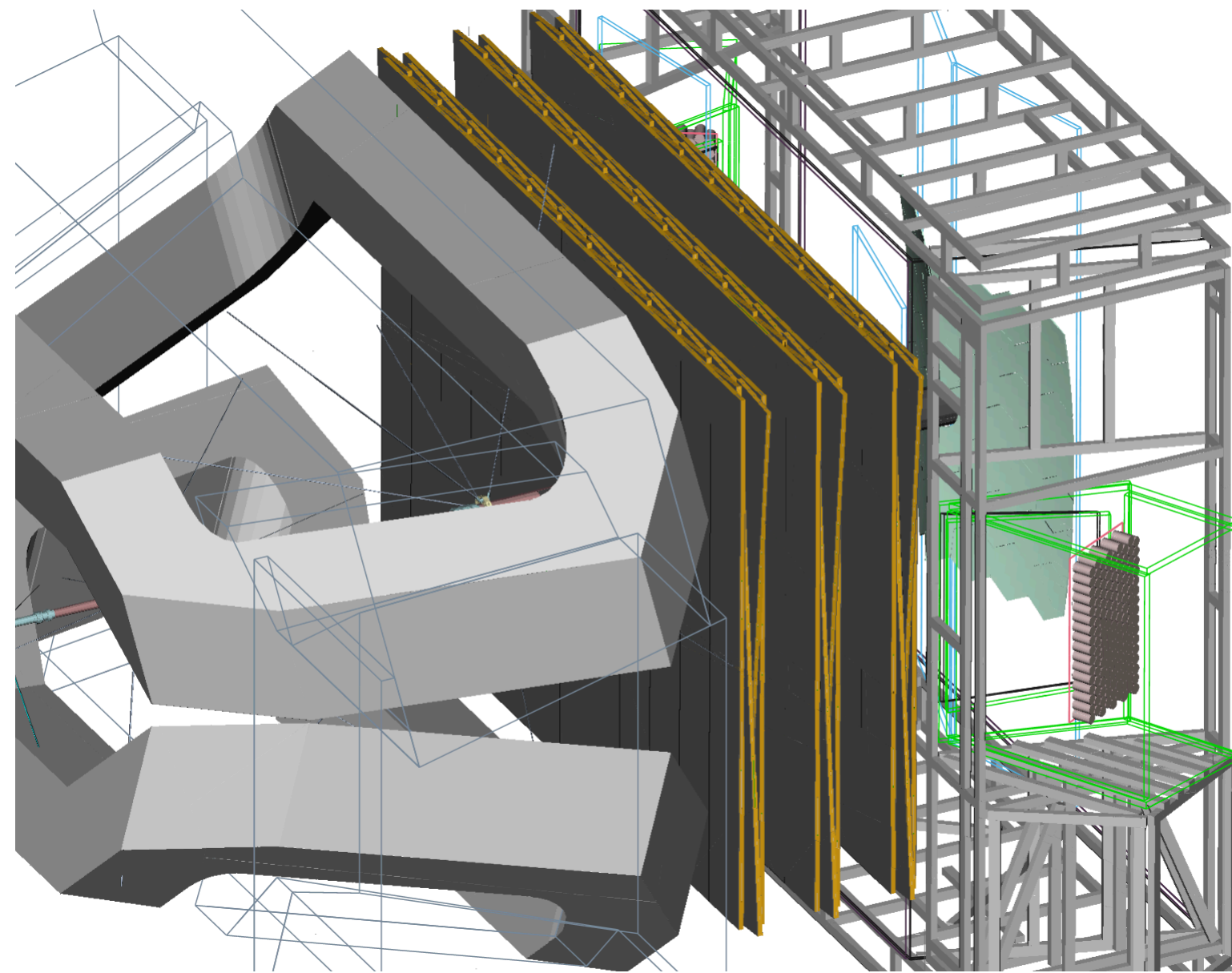
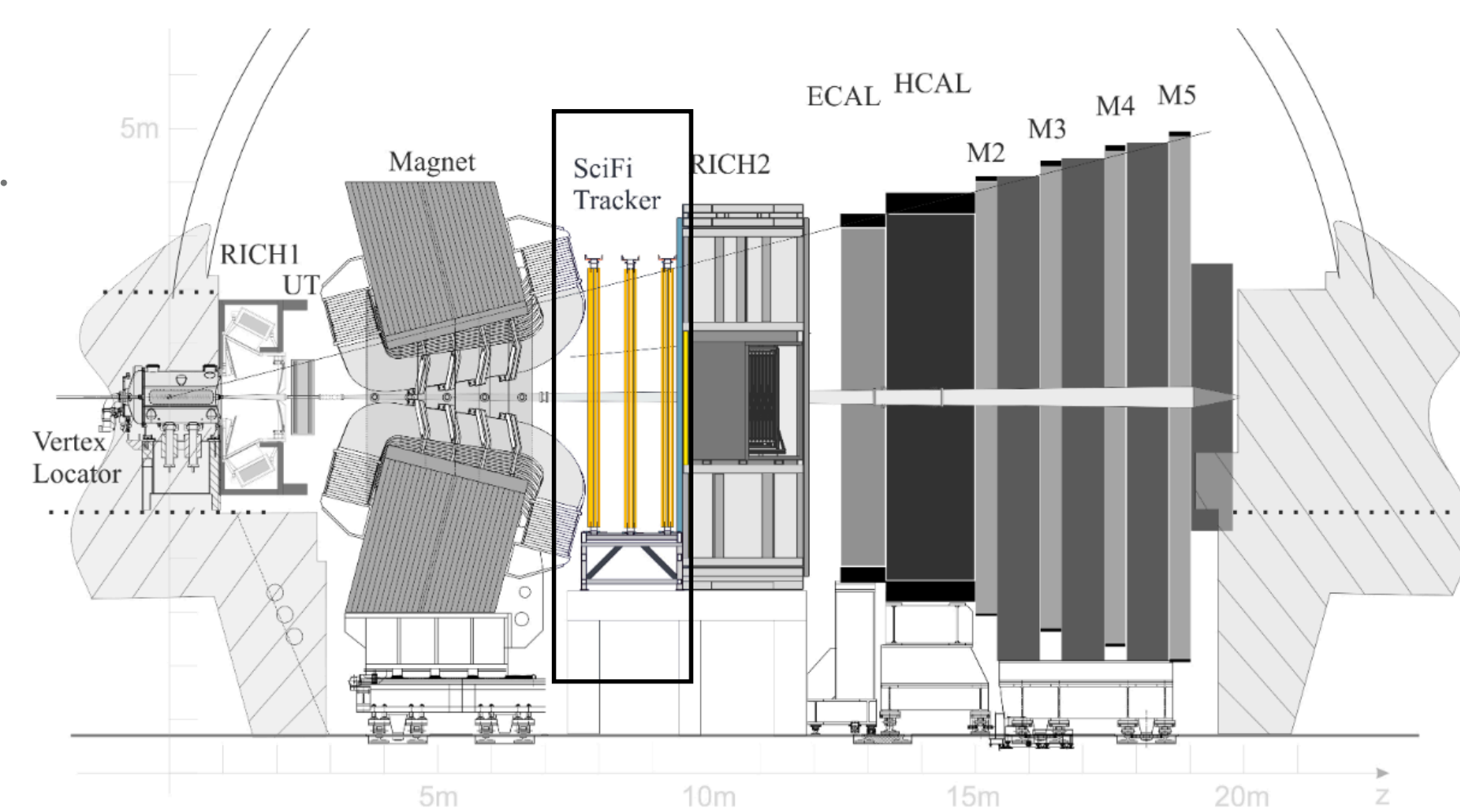


*Layout of the UT

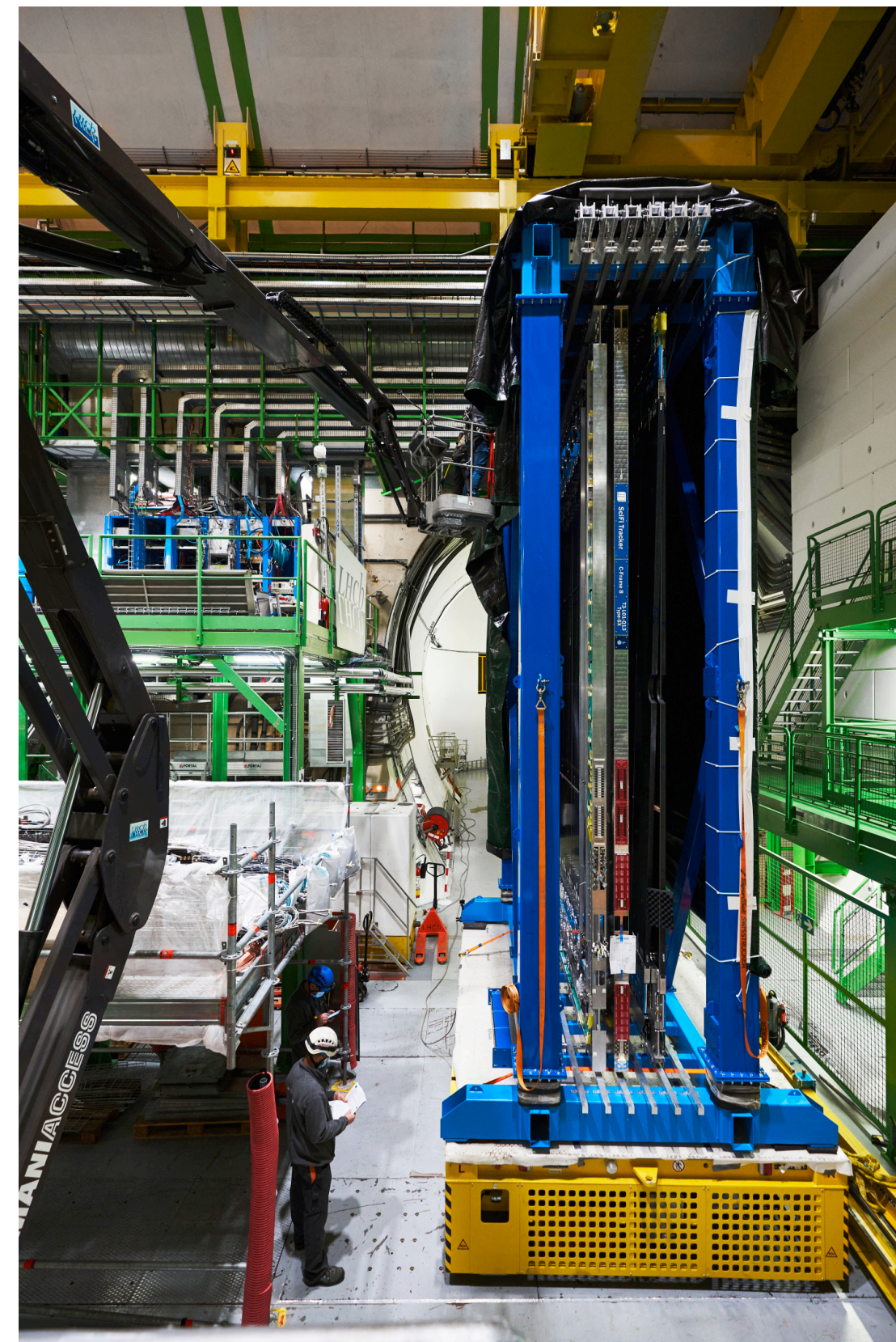


*Installation of the UT in the clean rooms

- Operational and integrated in LHCb
- Coarse and fine time-alignment
 - Focused on improving the stability of the alignment
- Successfully used for data taking and for track reconstruction

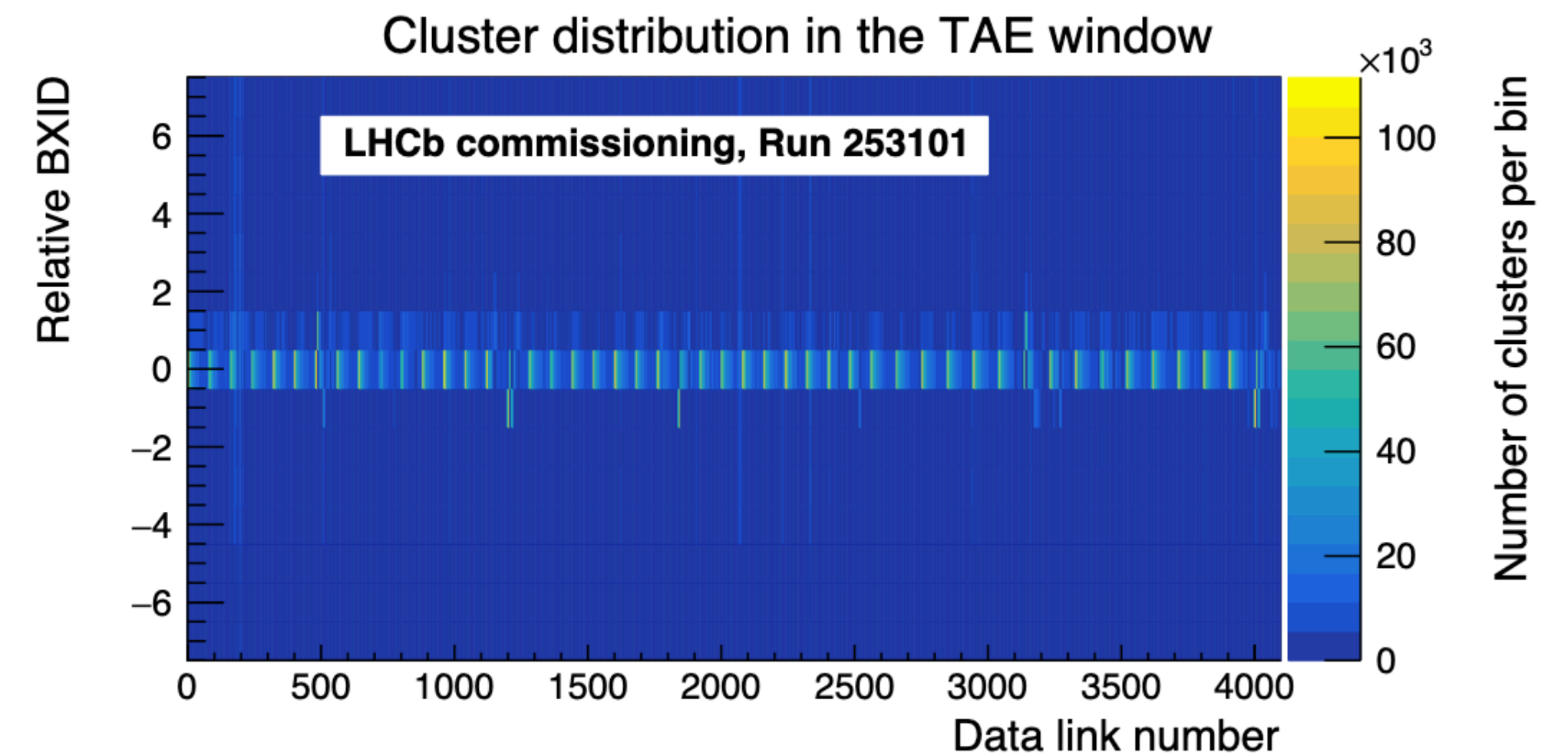


**Layout of the SciFi*



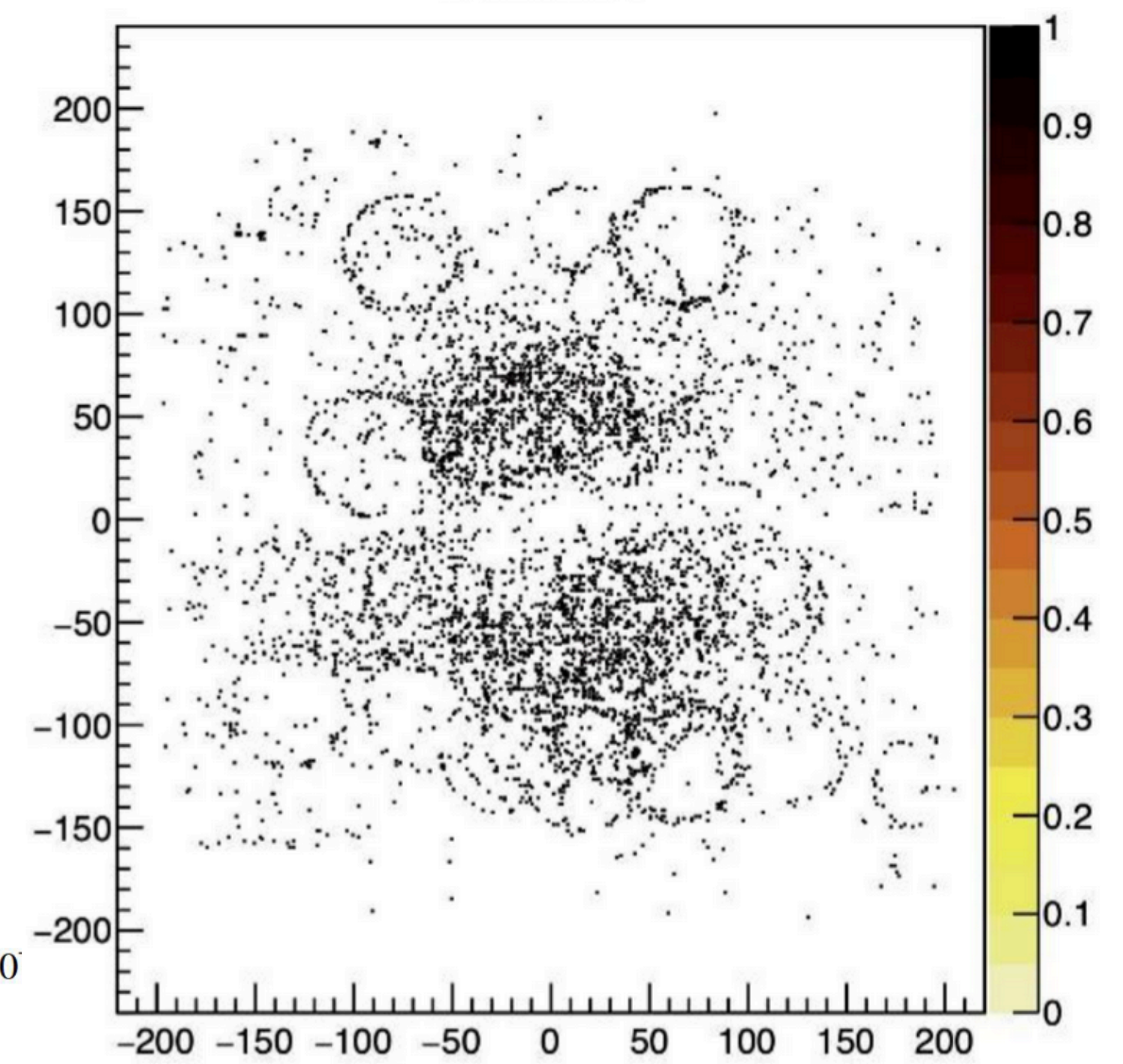
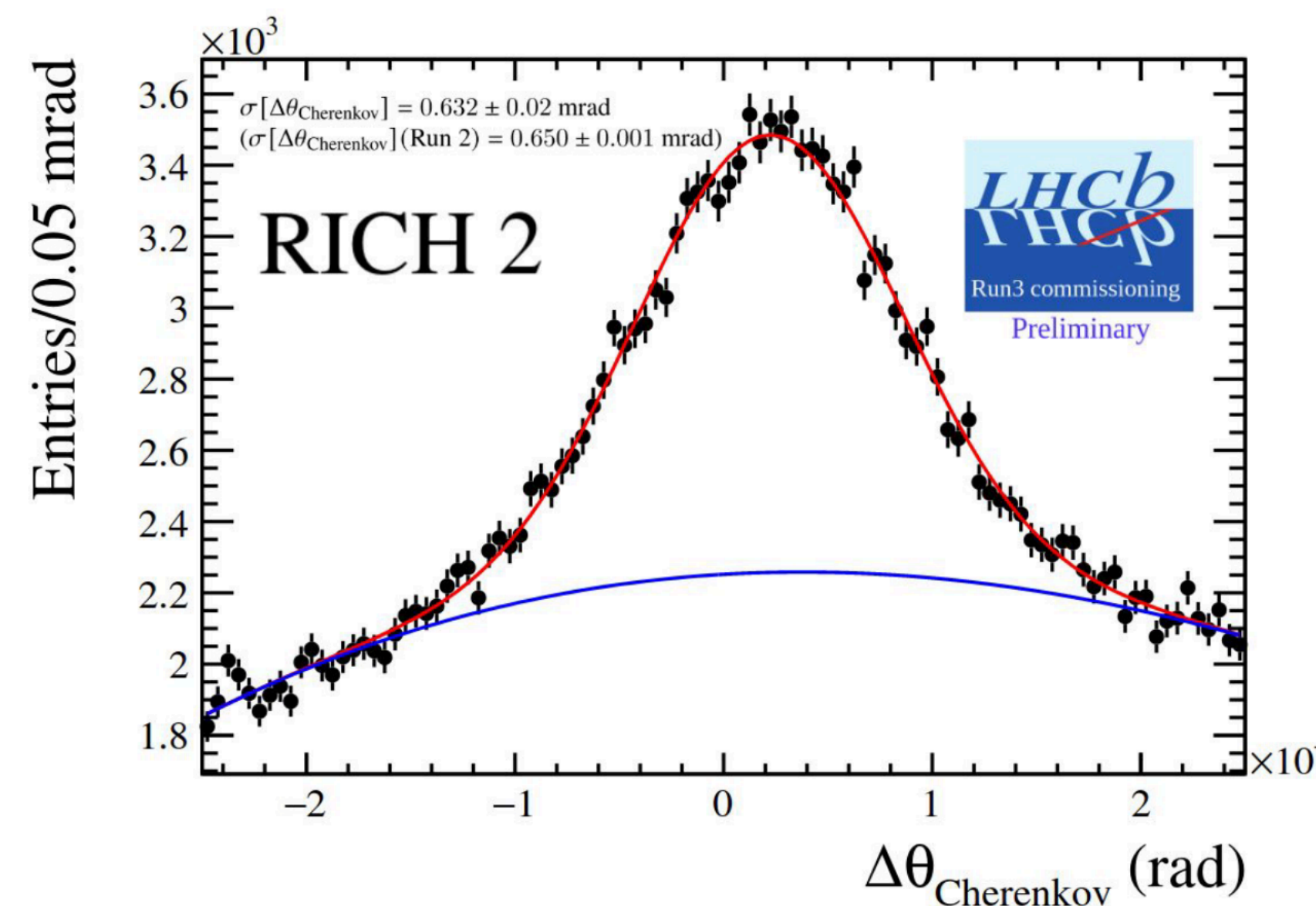
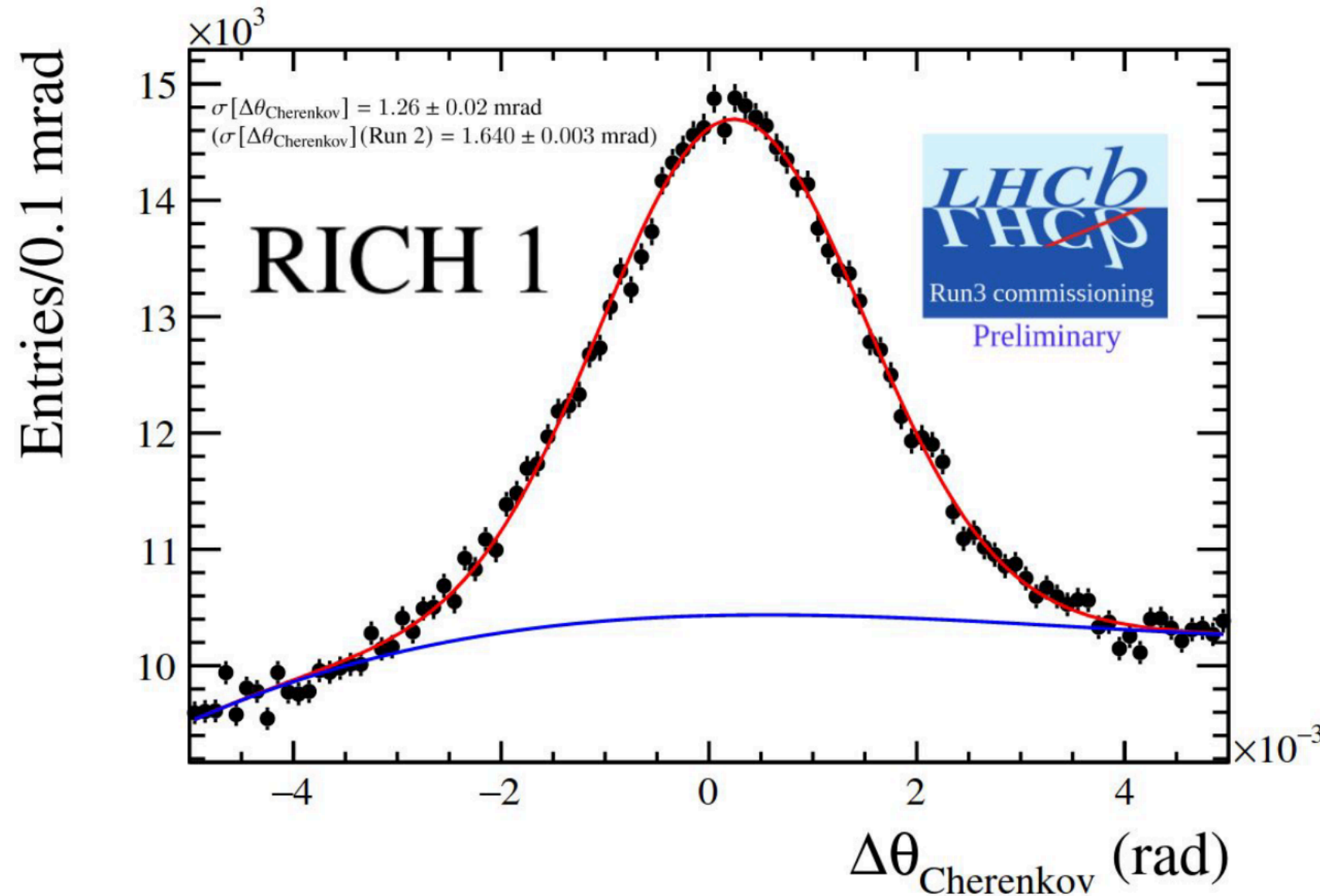
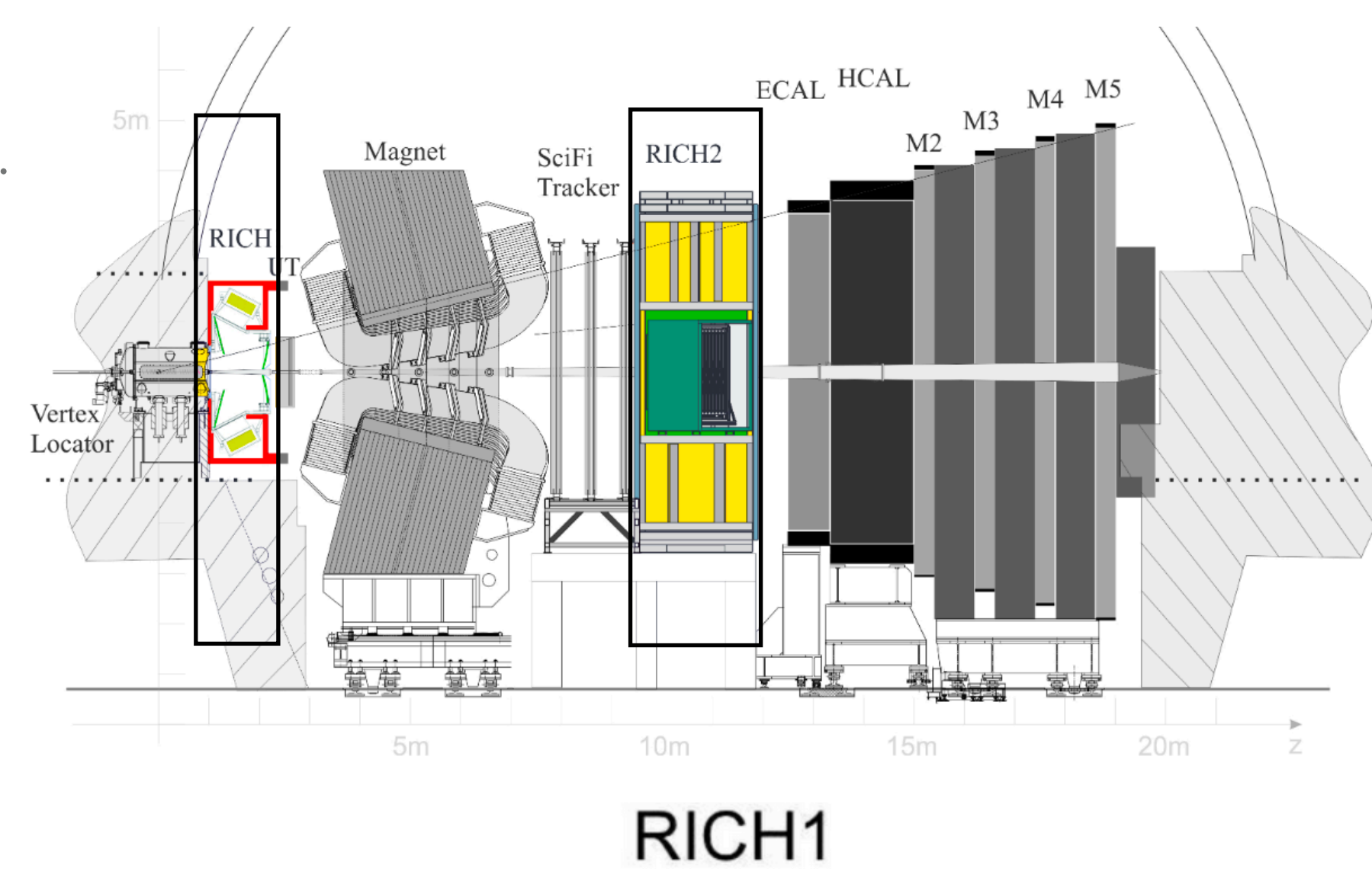
**SciFi in the LHCb cavern for installation*

LHCb-FIGURE-2022-017



**SciFi cluster time distribution after fine time alignment*

- Fully functional and time aligned
- First runs show good ring reconstruction
- Cherenkov angle resolution are comparable/better than those of Run2
- Background separation

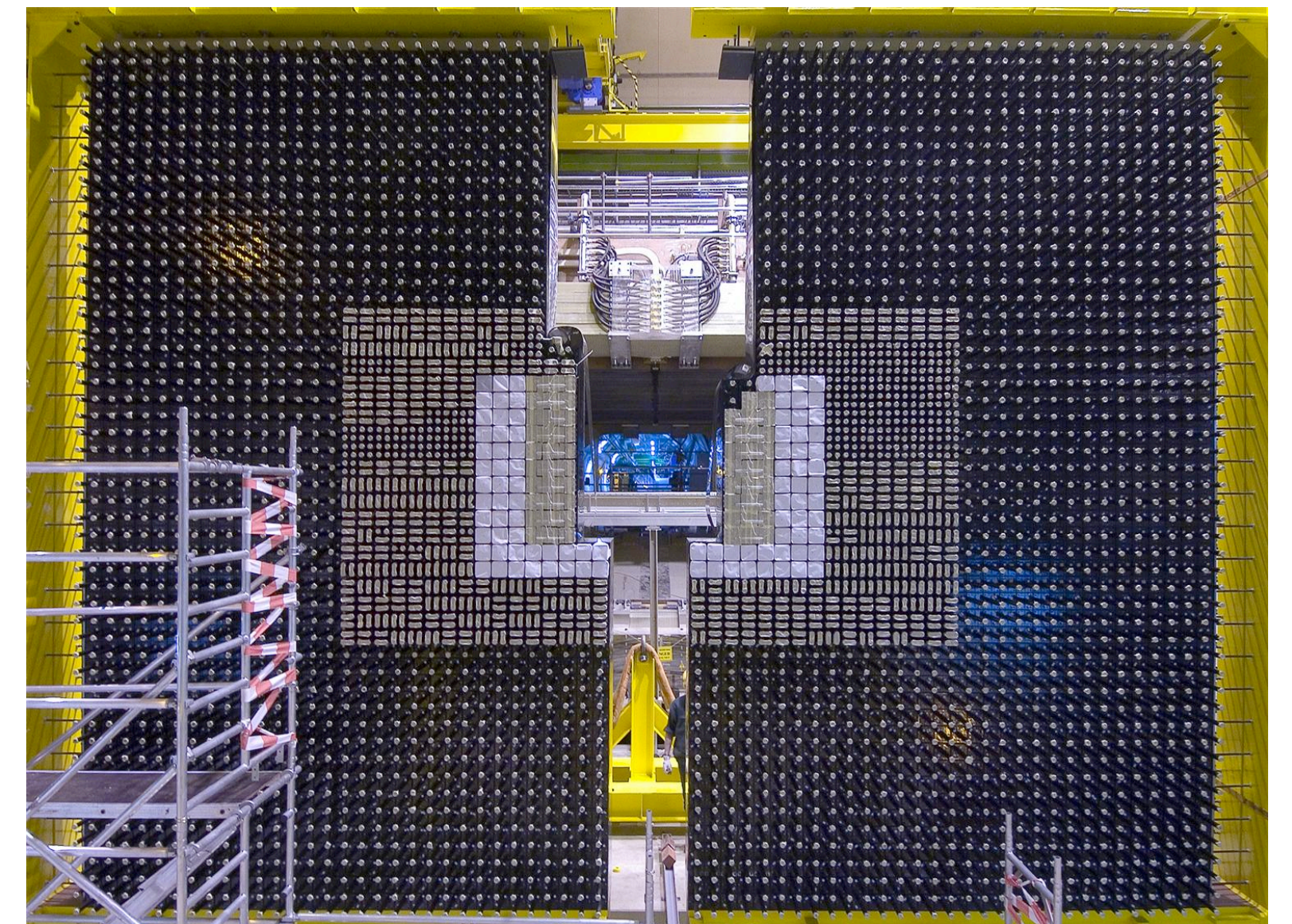
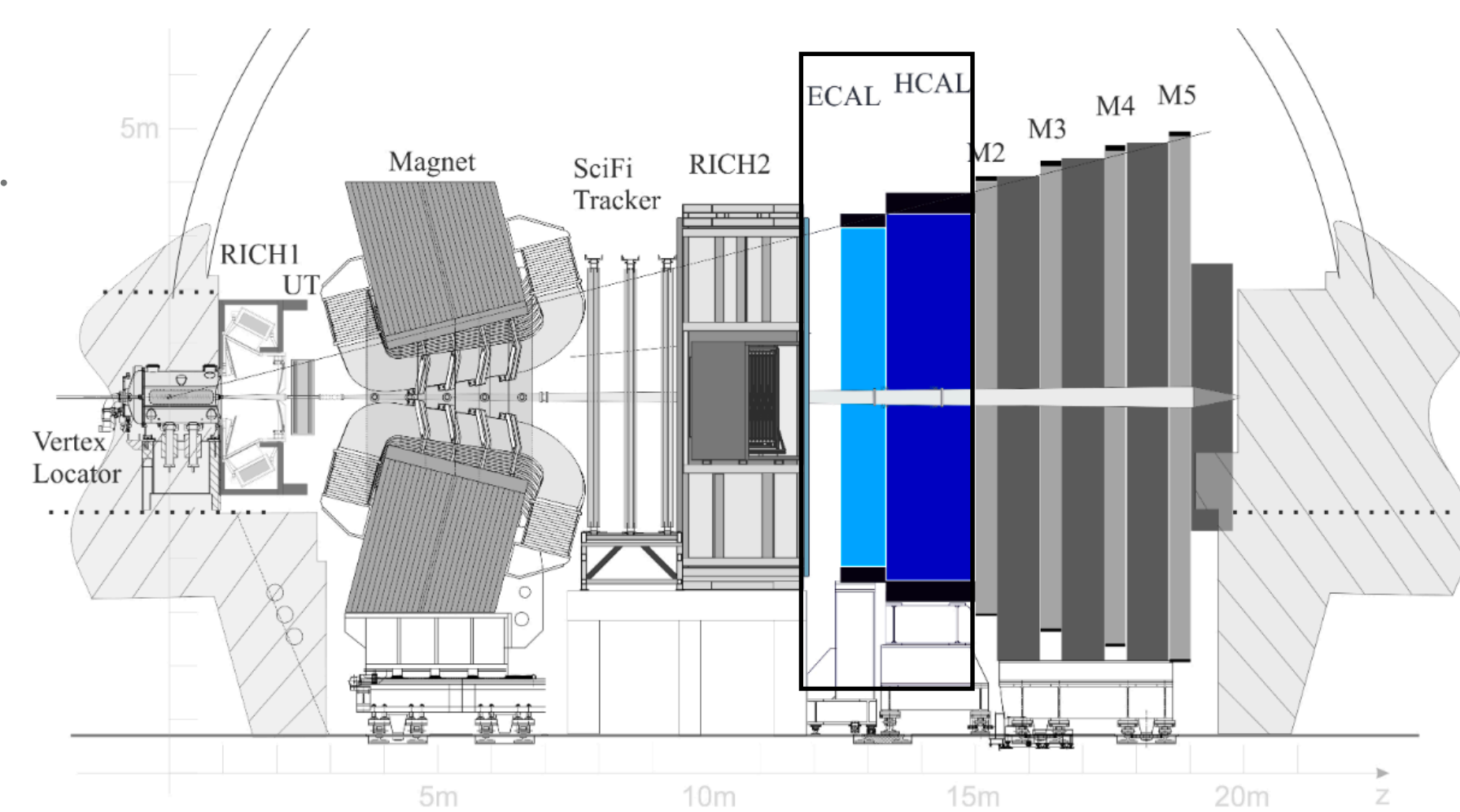


*Cherenkov angle resolutions for RICH 1 and 2

*Rings in the RICH1 detector

CALORIMETERS

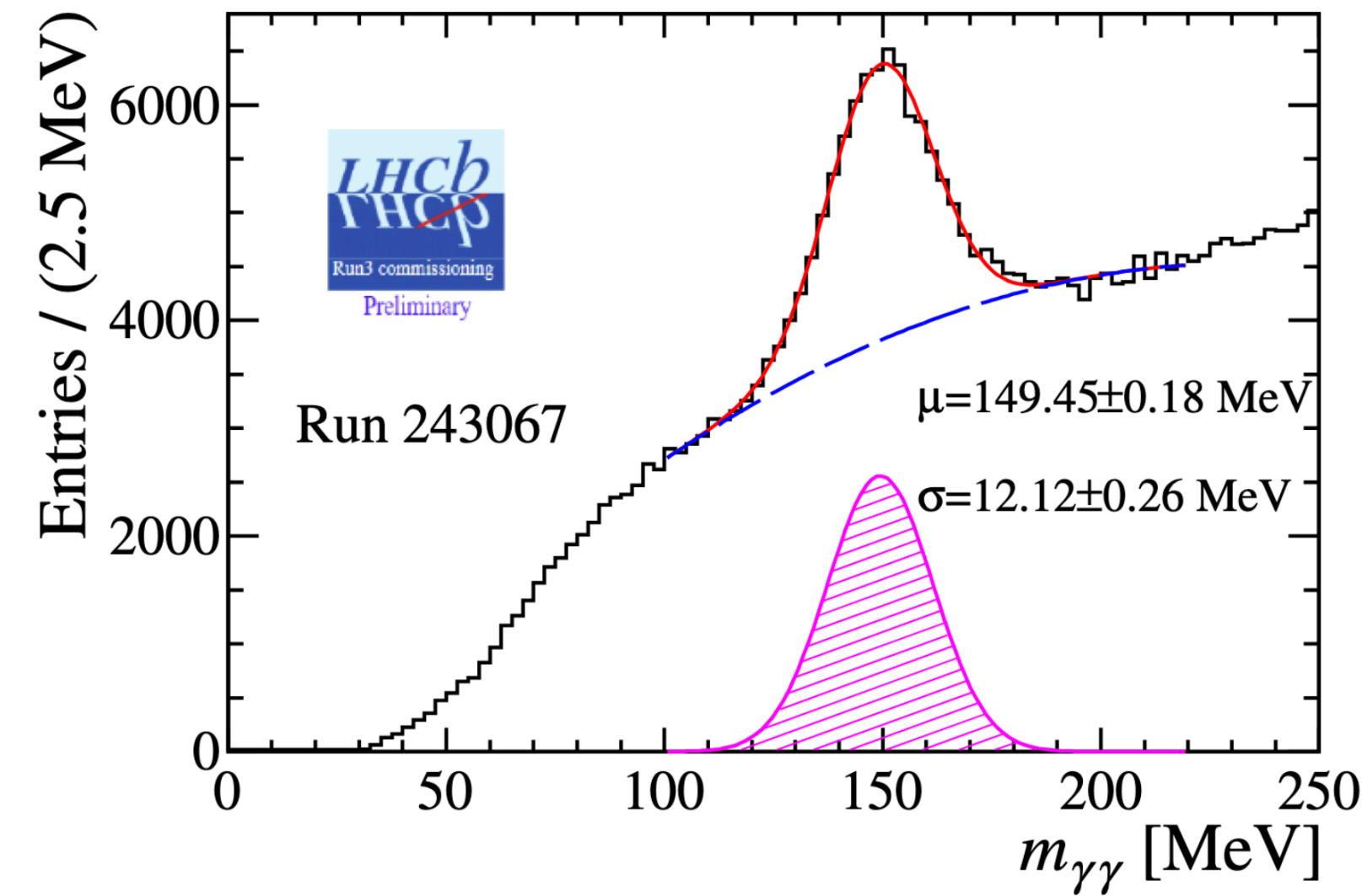
CERN-LHCC-2013-022



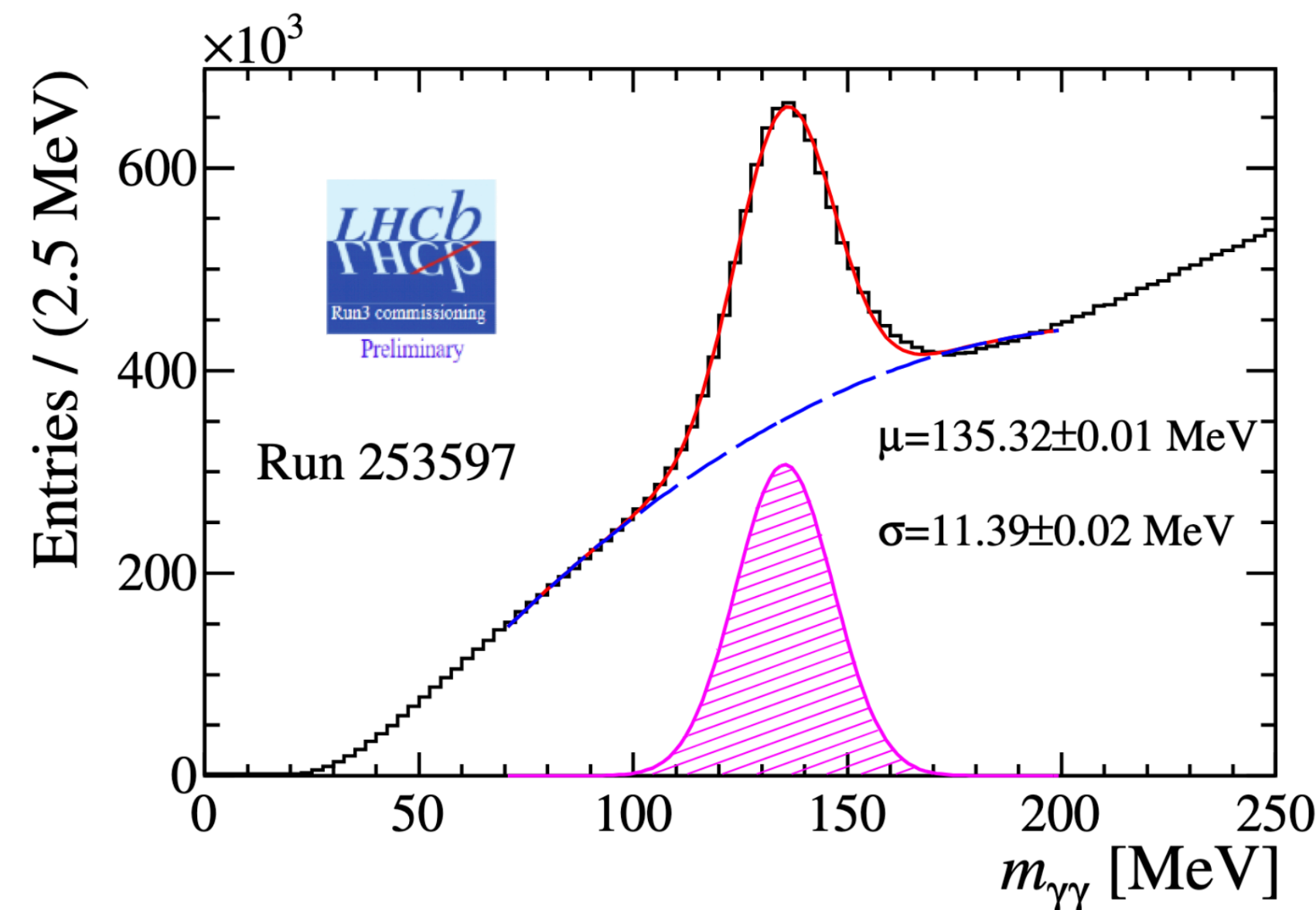
*ECAL

- Fully functional
- Enable's photon and electron reconstruction at HLT1 level
- Reconstruction of π^0 , clear improvements after calibration

LHCb-FIGURE-2022-019



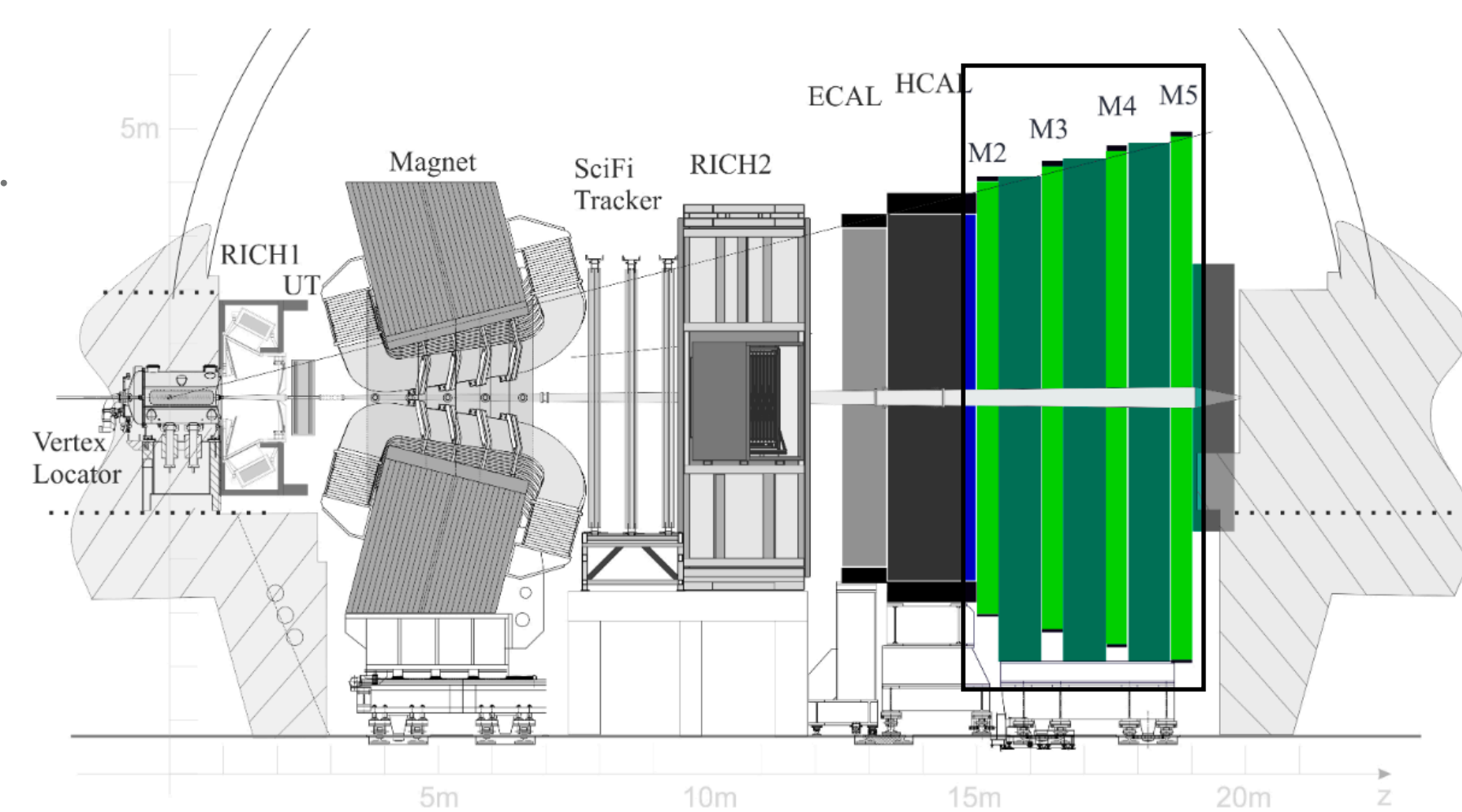
*Distribution of the invariant mass of the π^0 candidate without calibration



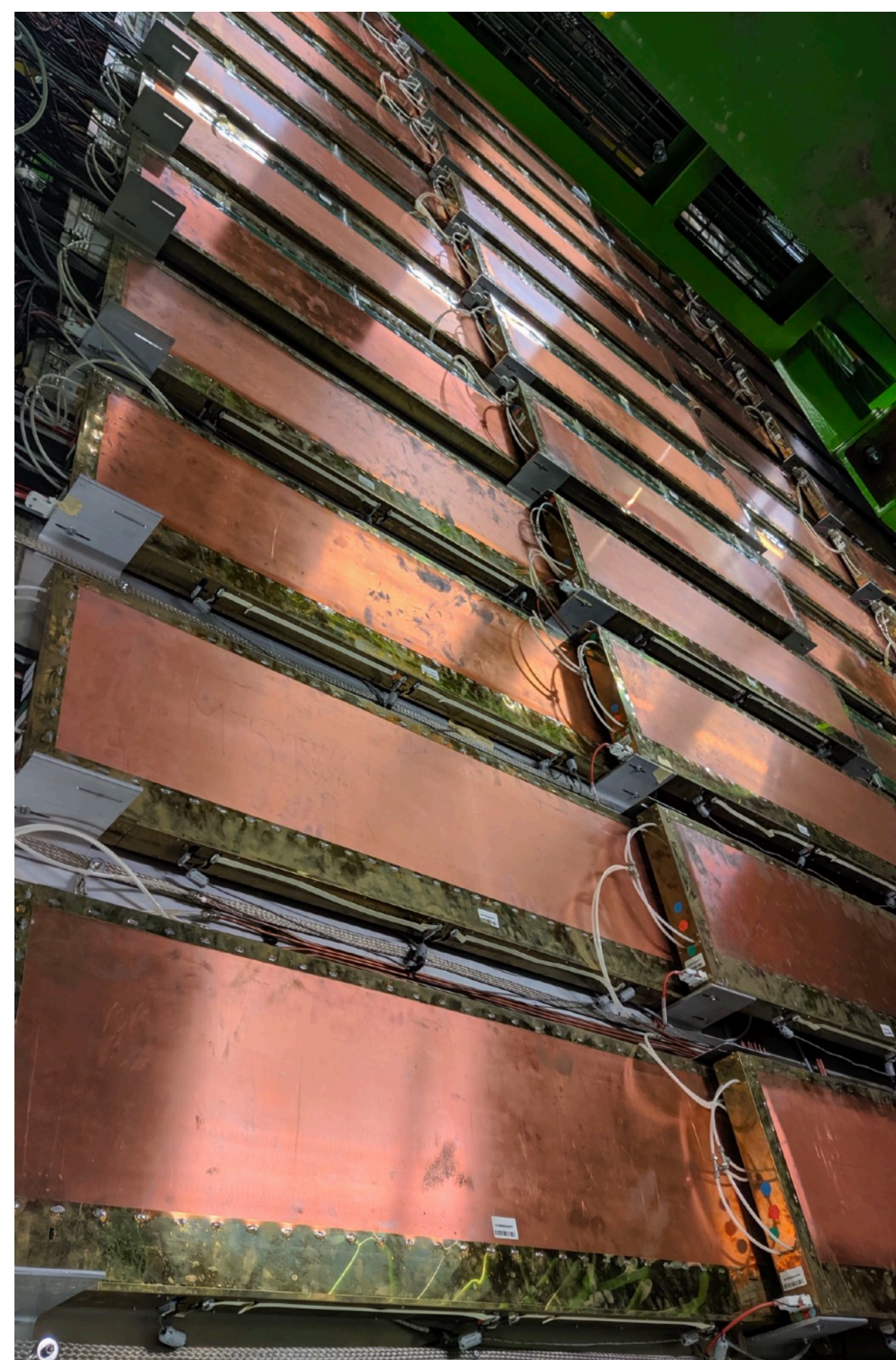
*Distribution of the invariant mass of the π^0 candidate with calibration

MUON SYSTEM

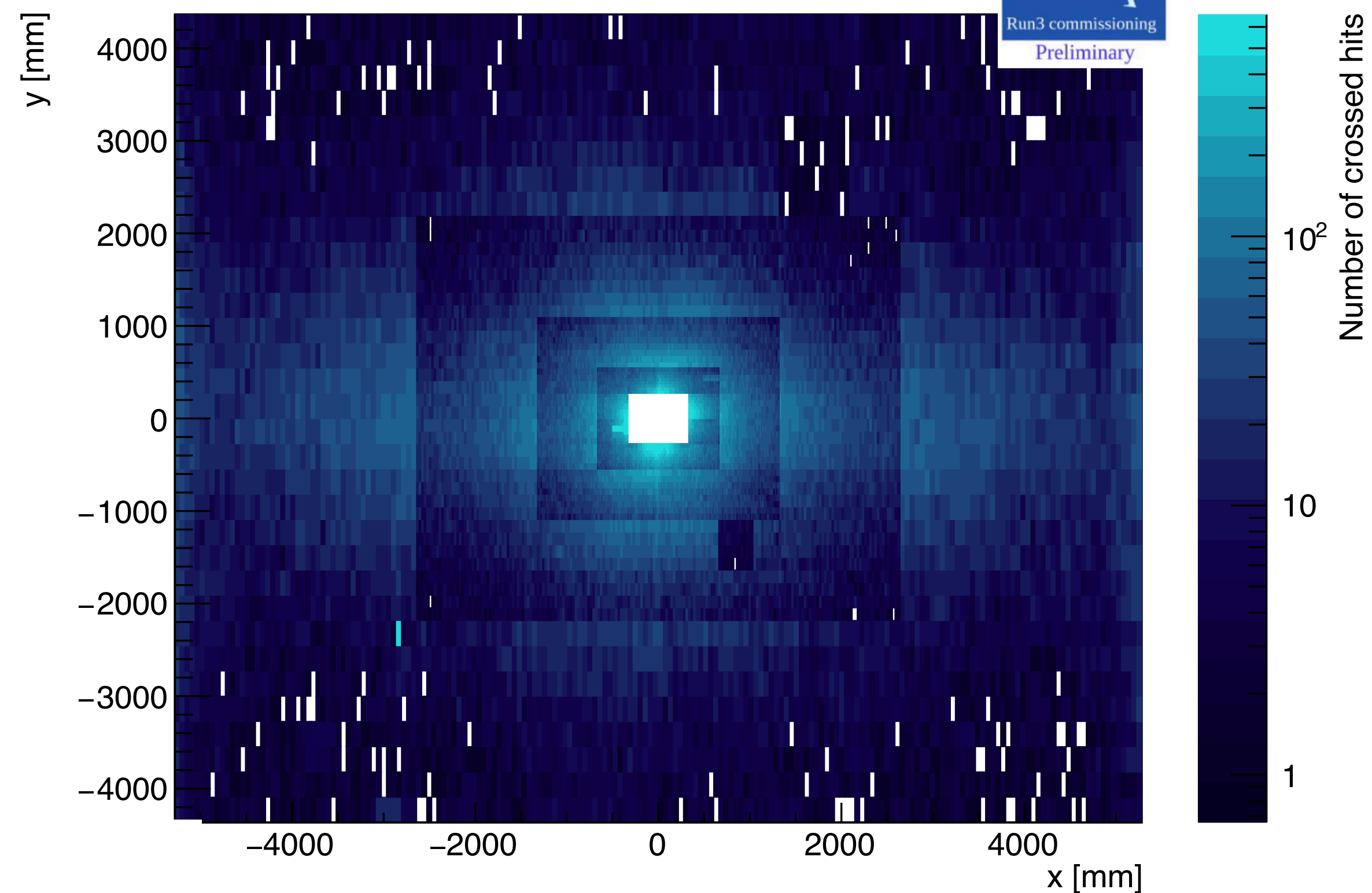
- Fully functional and installed
- New readouts commissioned
- First time alignment realised - focused on improving this in 2023
- Finalising standalone muon track reconstruction (in HLT1)



Hit Map Station M3



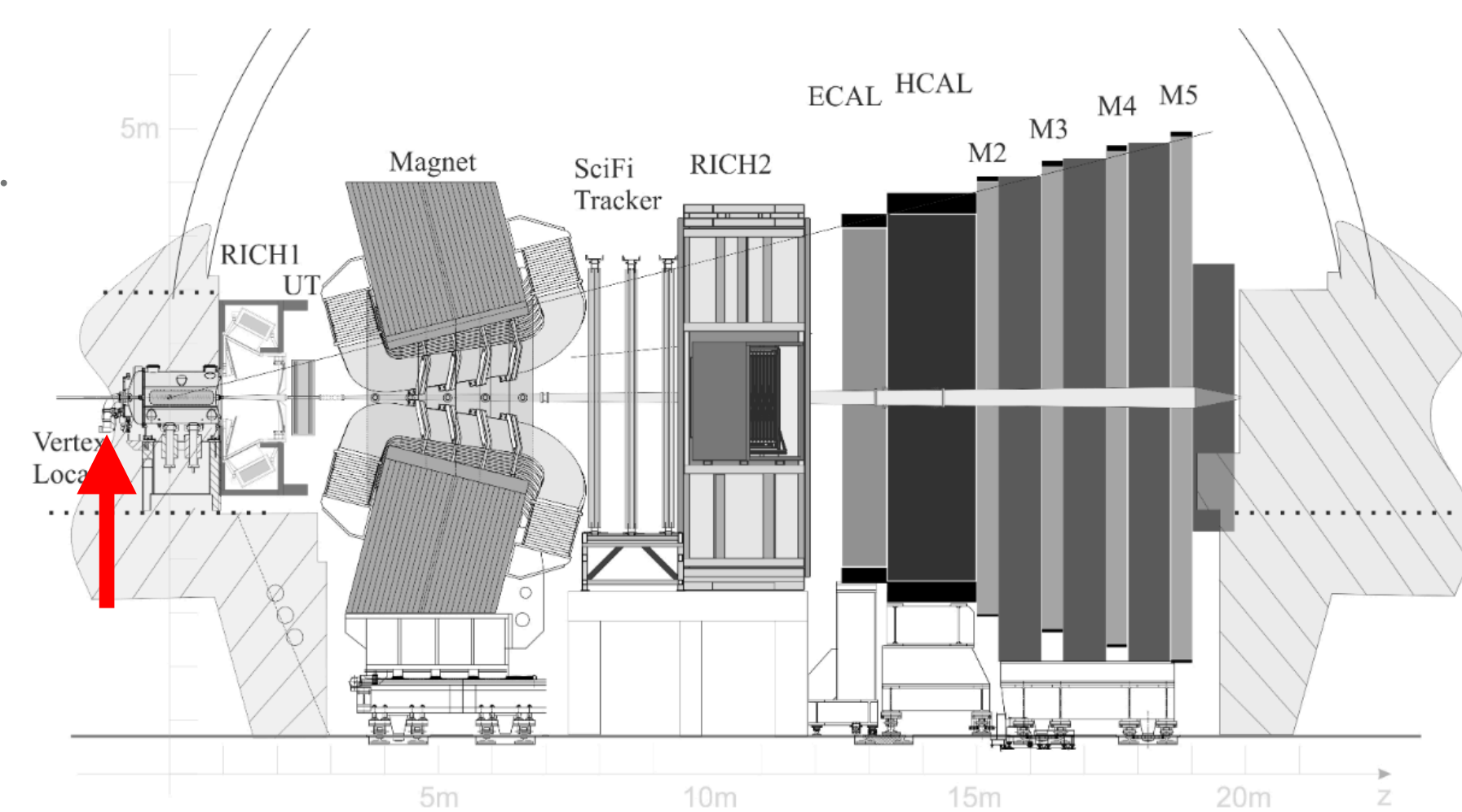
*Muon station



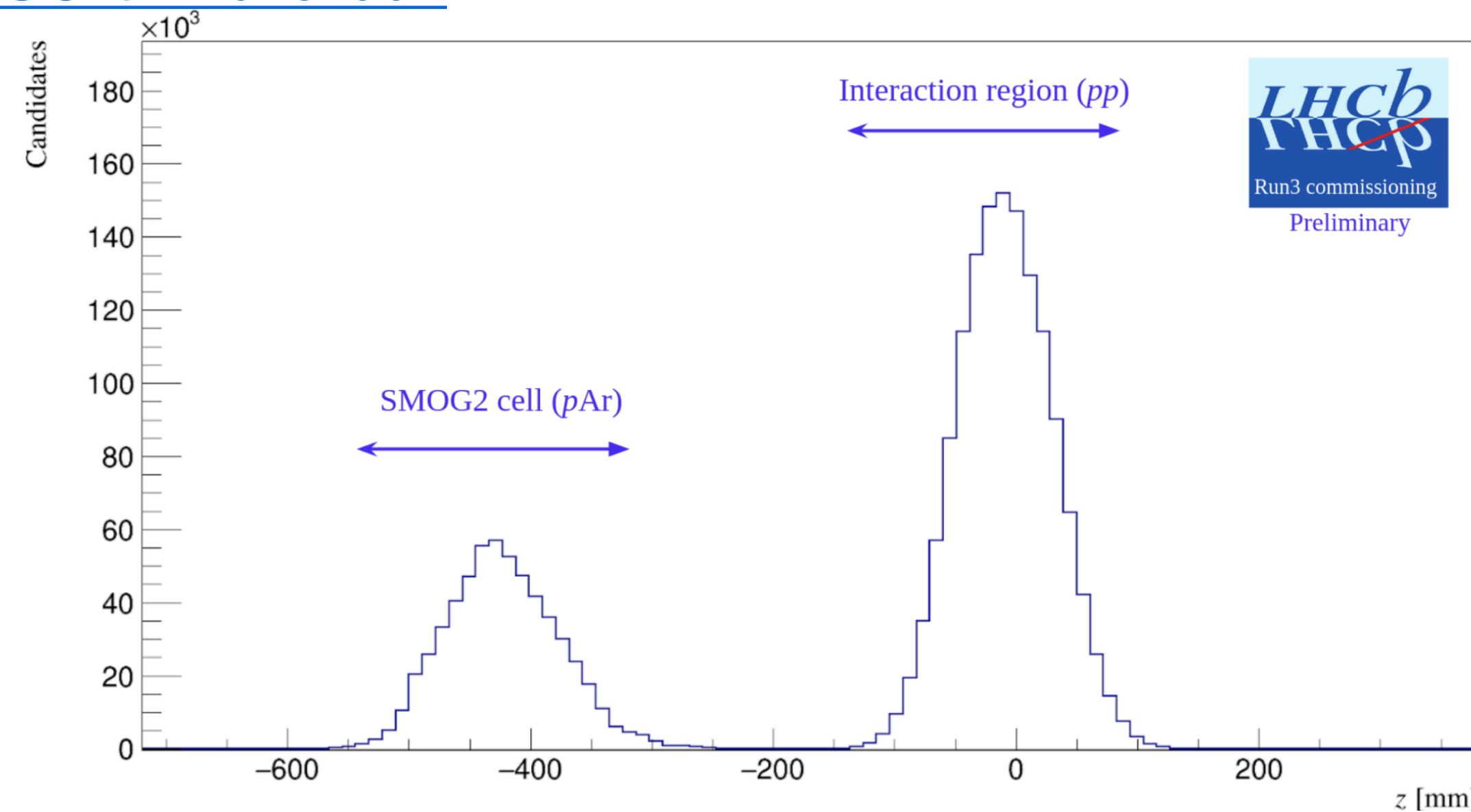
*Illumination map of the M3 muon station

SMOG2

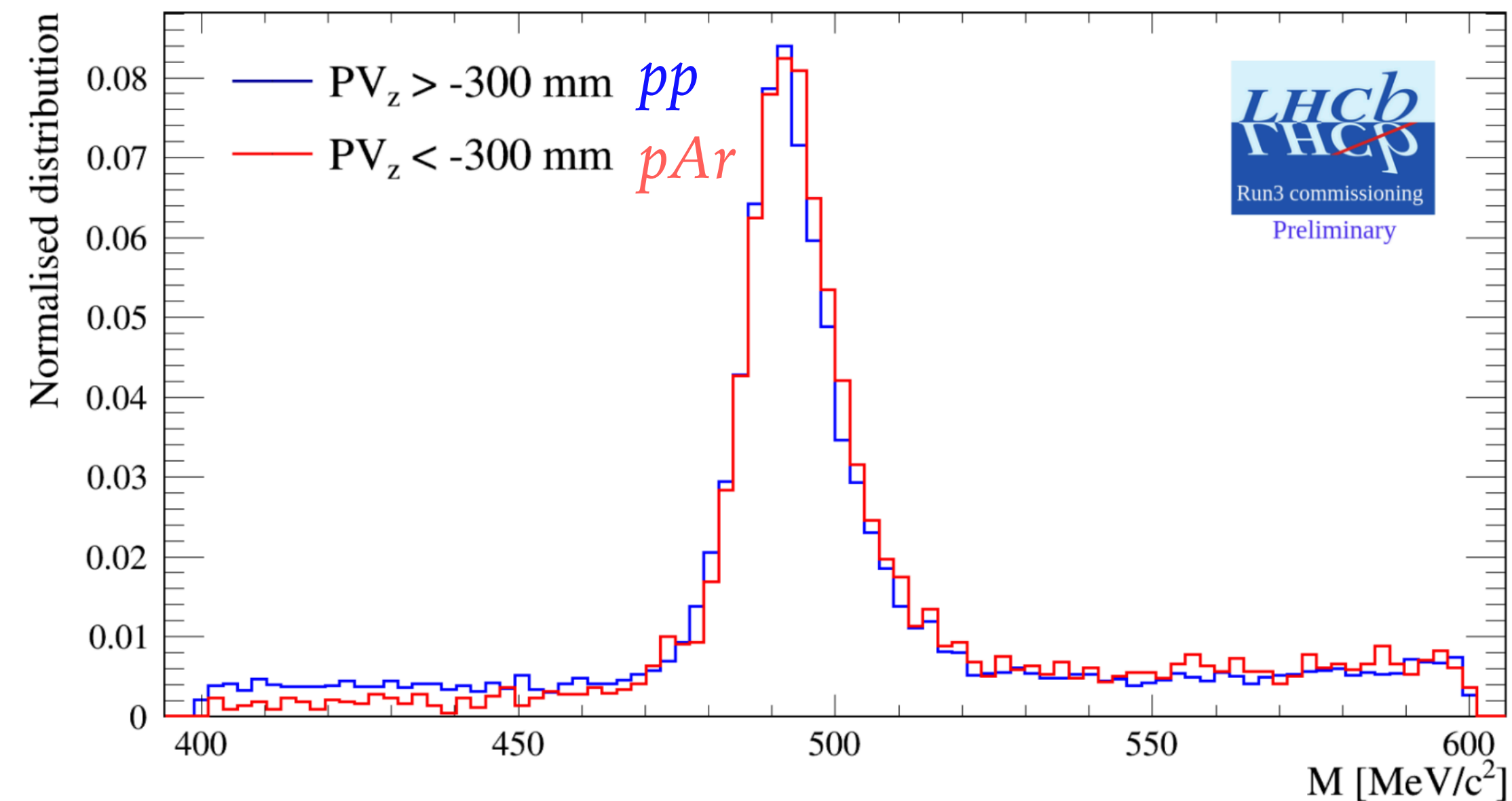
- LHCb's upgraded gas injection system, fixed target program
- System commissioned with VELO closed injecting: He, Ne, Ar and H₂
- Used in Van Der Meer scan and ghost charge measurement
- Simultaneous beam-beam + beam-gas data acquisition
⇒ 2 interaction points, LHCb exclusive



[LHCb-FIGURE-2023-001](#)



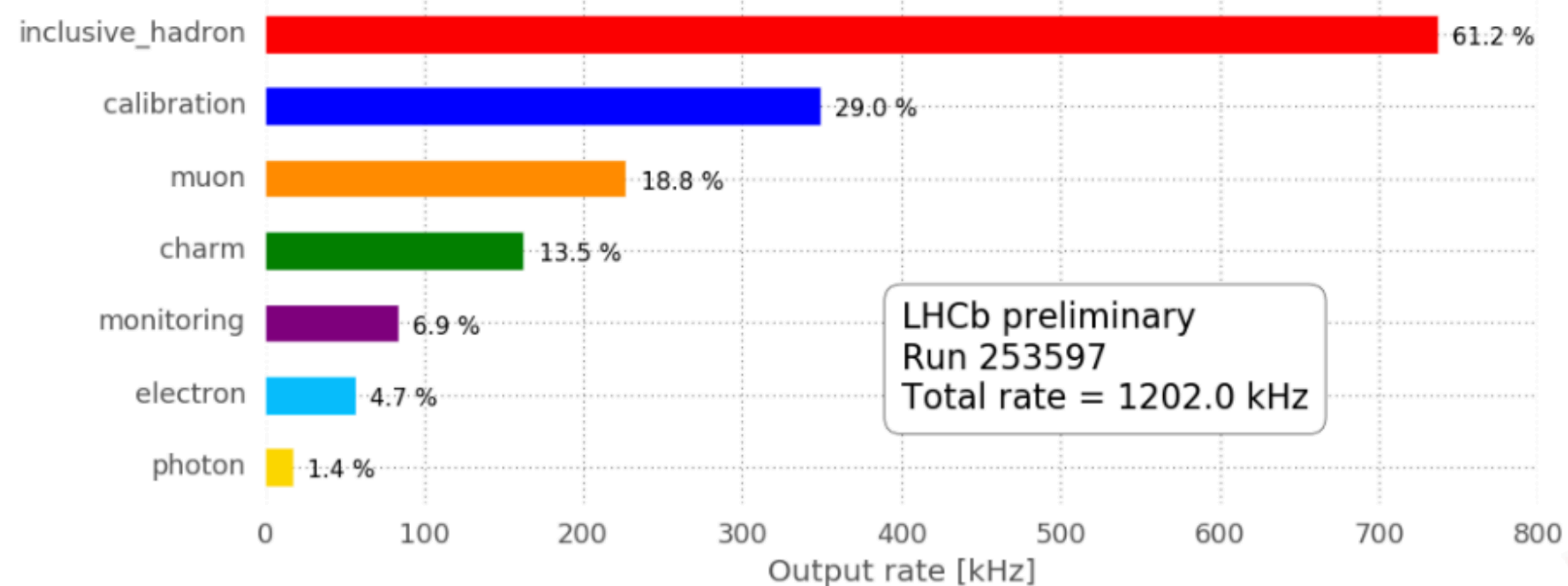
*Primary vertices found in the SMOG2 cell with pp collisions



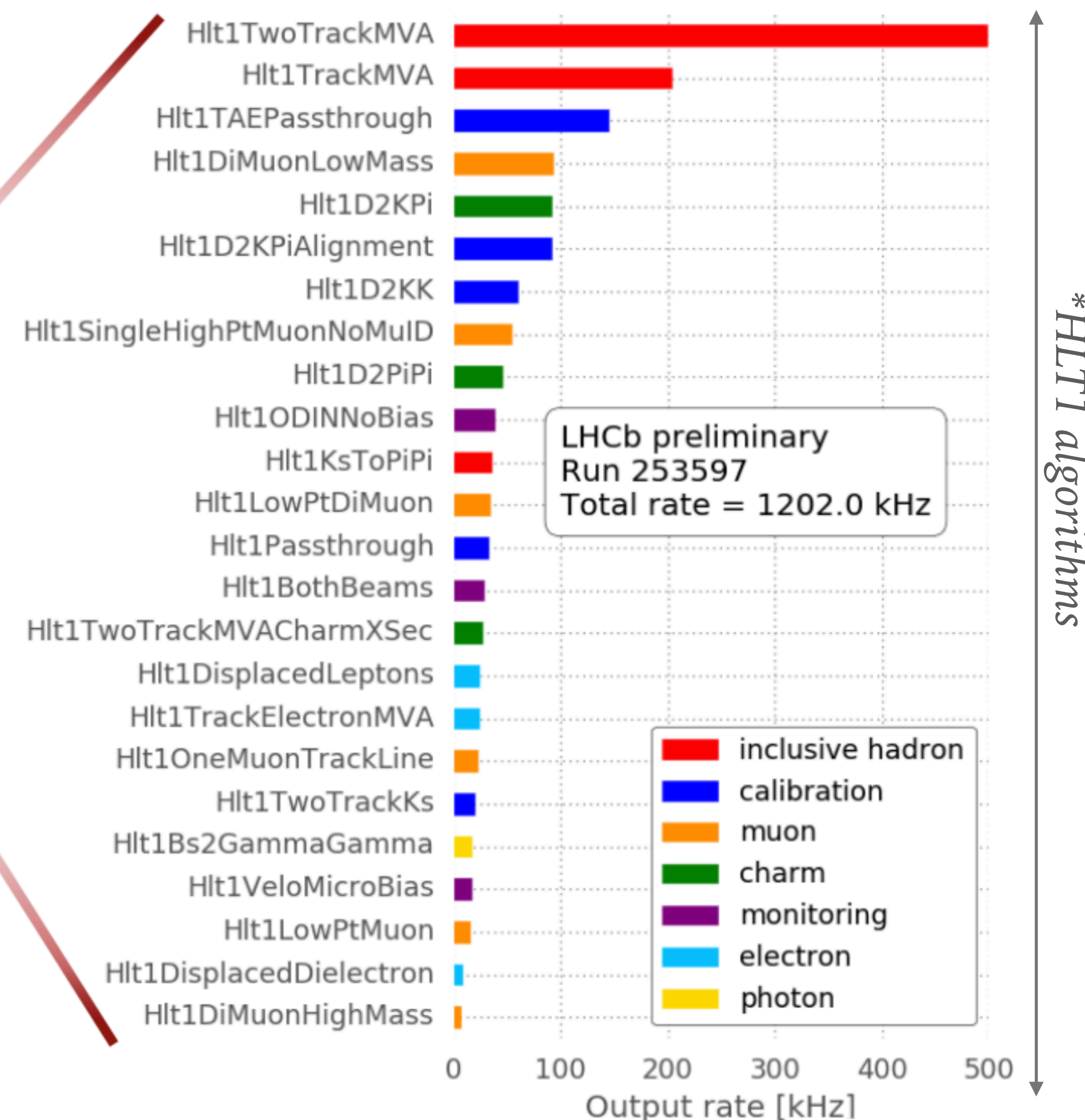
*Comparison of the normalised invariant mass distributions for K_S^0 candidate from pAr and pp

HLT1 & HLT2 PERFORMANCE

- HLT1 successfully commissioned with normal reconstruction and selection sequence (at 20MHz and $\mu = 1.1$)
- HLT1 successfully reduce the output rate to 1 MHz

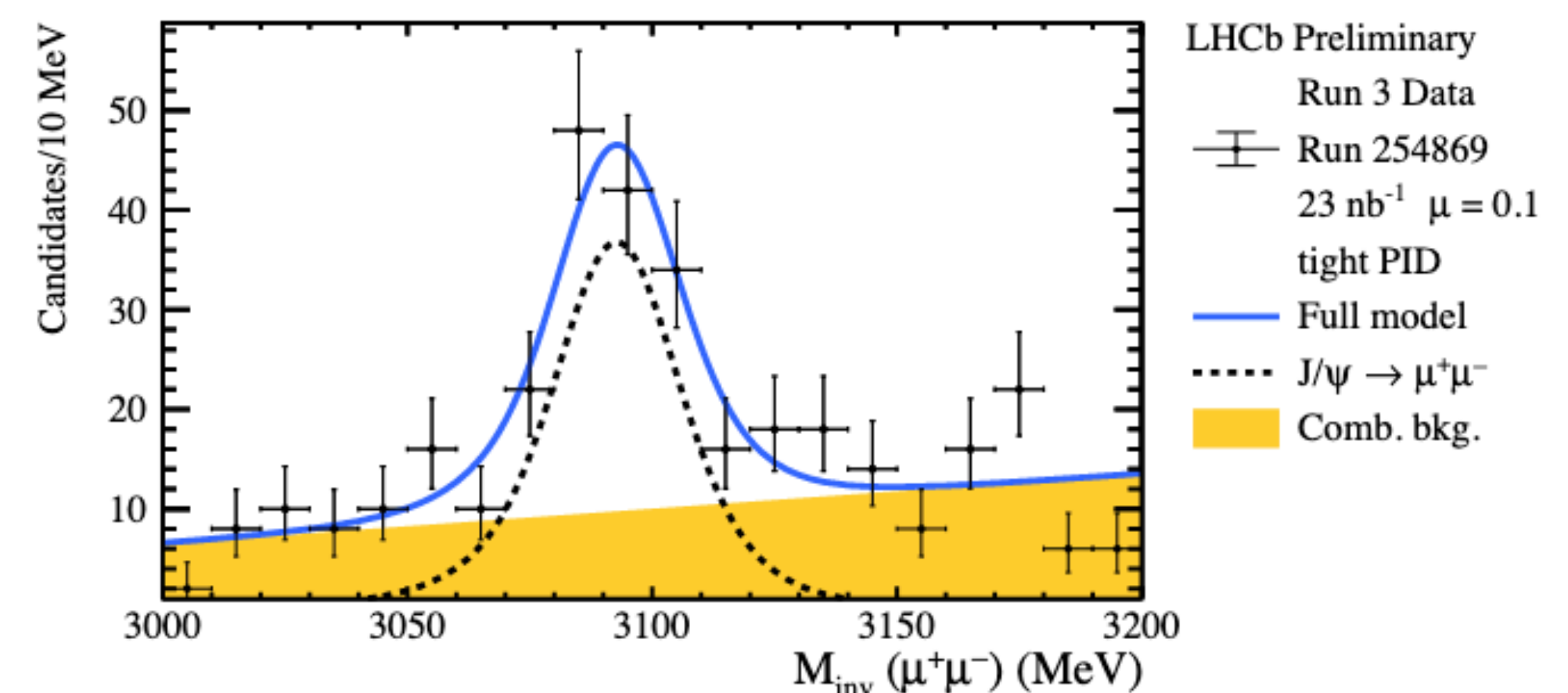
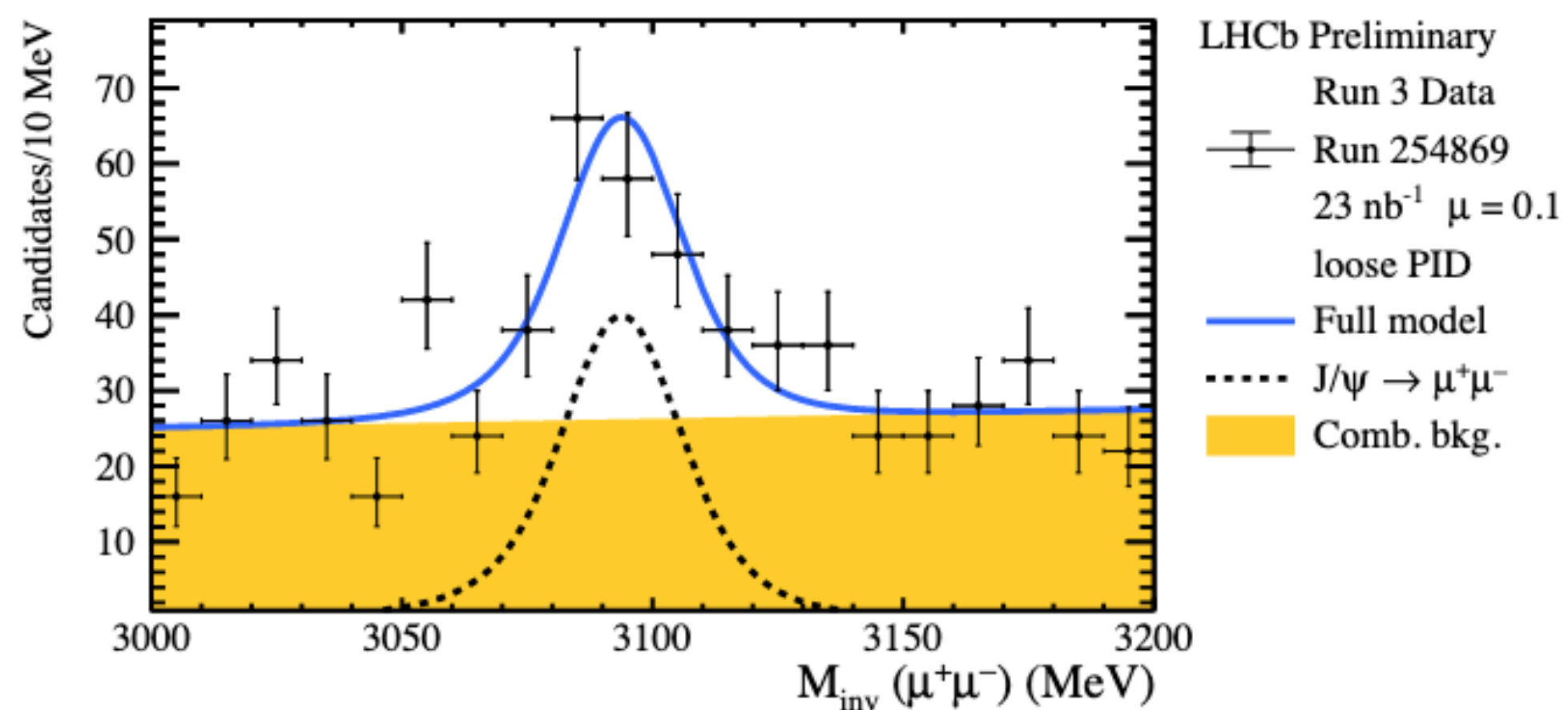
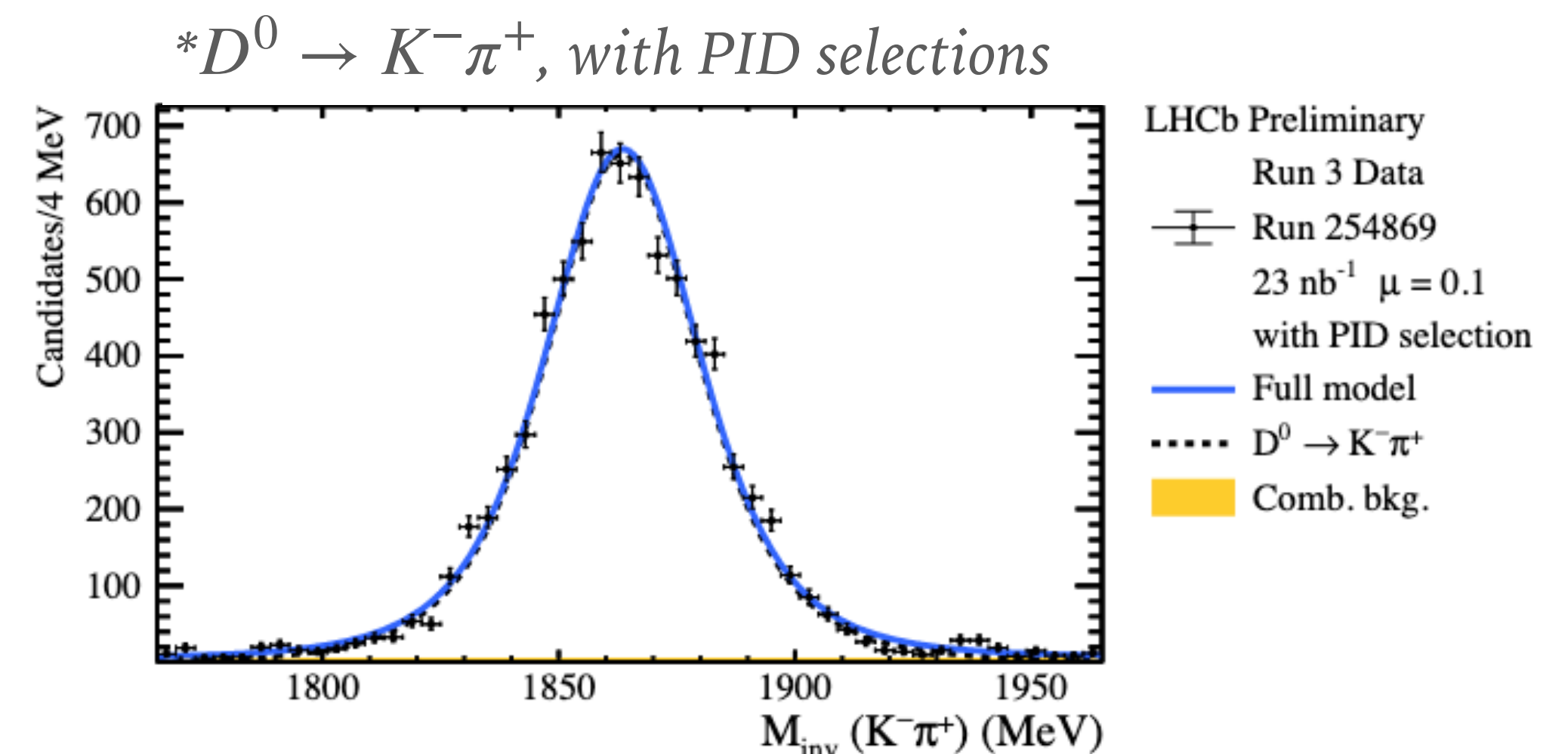
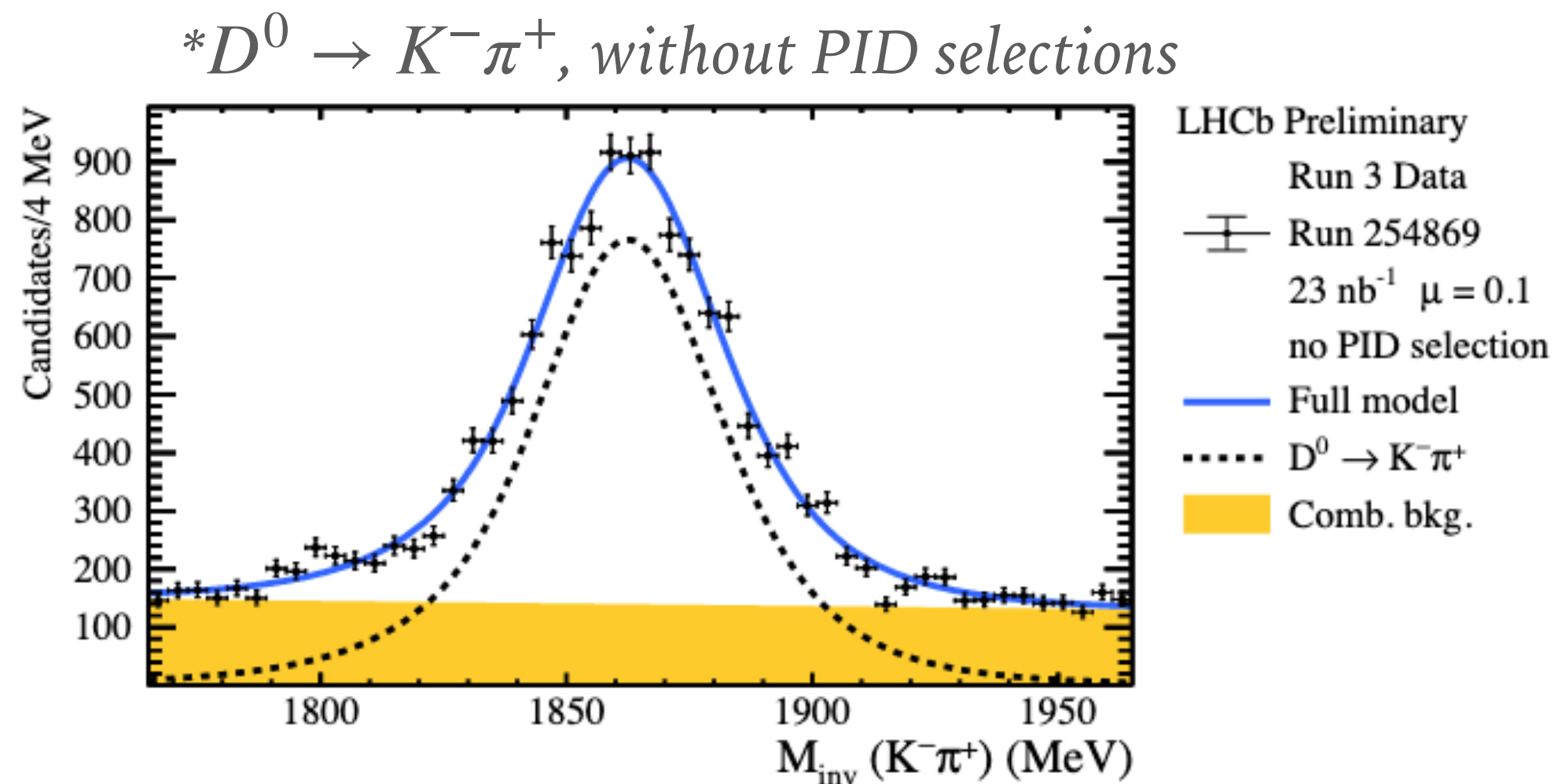


*Output rate of the HLT1 trigger lines



HLT1 & HLT2 PERFORMANCE

- First mass peaks! With HLT1 filtering and HLT2 reconstruction and PID
- Even if preliminary and based on very little data, **Important Milestone**



** $J/\psi \rightarrow \mu^+ \mu^-$, with loose PID selections*

** $J/\psi \rightarrow \mu^+ \mu^-$, with tight PID selections*

LAST WORDS

- Intense and successful commissioning year of the newly upgraded LHCb detector
- Validation of the full detector chain, from the on-detector electronics to the trigger and reconstruction.
- Early Measurement Task Force, first look at the new physics data.
- Plans for 2023 : improving the performance and understanding of the detector in order to efficiently record high-quality collision events for the remainder of the LHC Run 3

Various milestones

- ▶ *Commissioning of the new DAQ system*
- ▶ *Deployment and test of fully GPU based HLT1*
- ▶ *Coarse time alignment of all the install sub-detectors*
- ▶ *Successfully operating at conditions approaching Run3 design conditions*
- ▶ *Alignment for all sub-detectors either running or under study*





THANK YOU FOR YOUR ATTENTION
