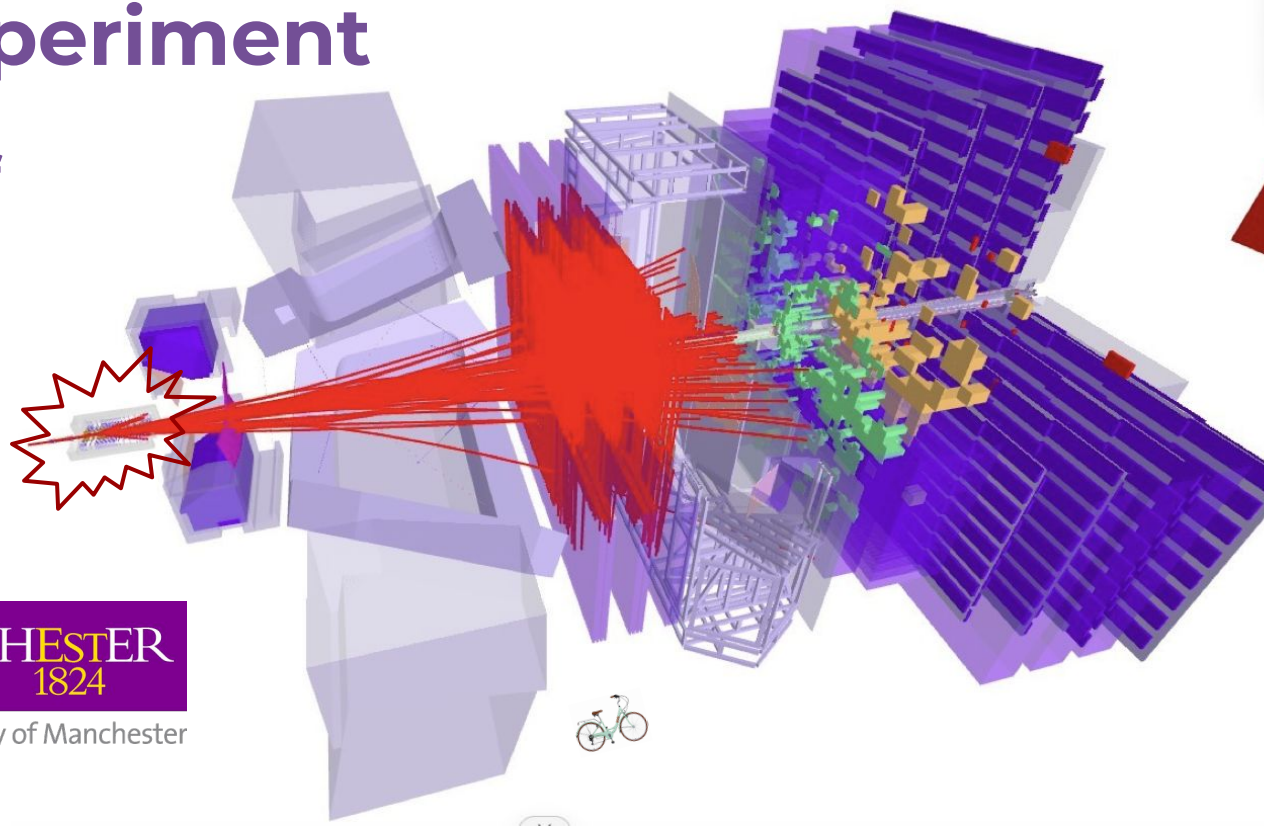
The VErtex LOcator at the LHCb Experiment

German Conference of Women in Physics

Tamaki Holly McGrath
on behalf of the VELO Group at LHCb

27th Nov 2022



The Standard Model

- The Standard Model is the model that currently best describes elementary particles and their interactions
- So far has been very successful as it has passed many precision tests
- Some big questions remain.....

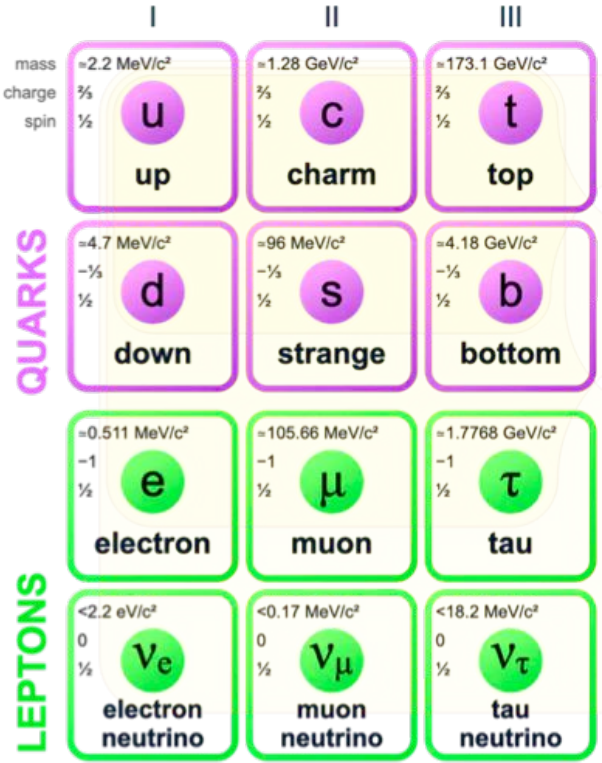
What is dark matter?

Why is there more matter than anti-matter?

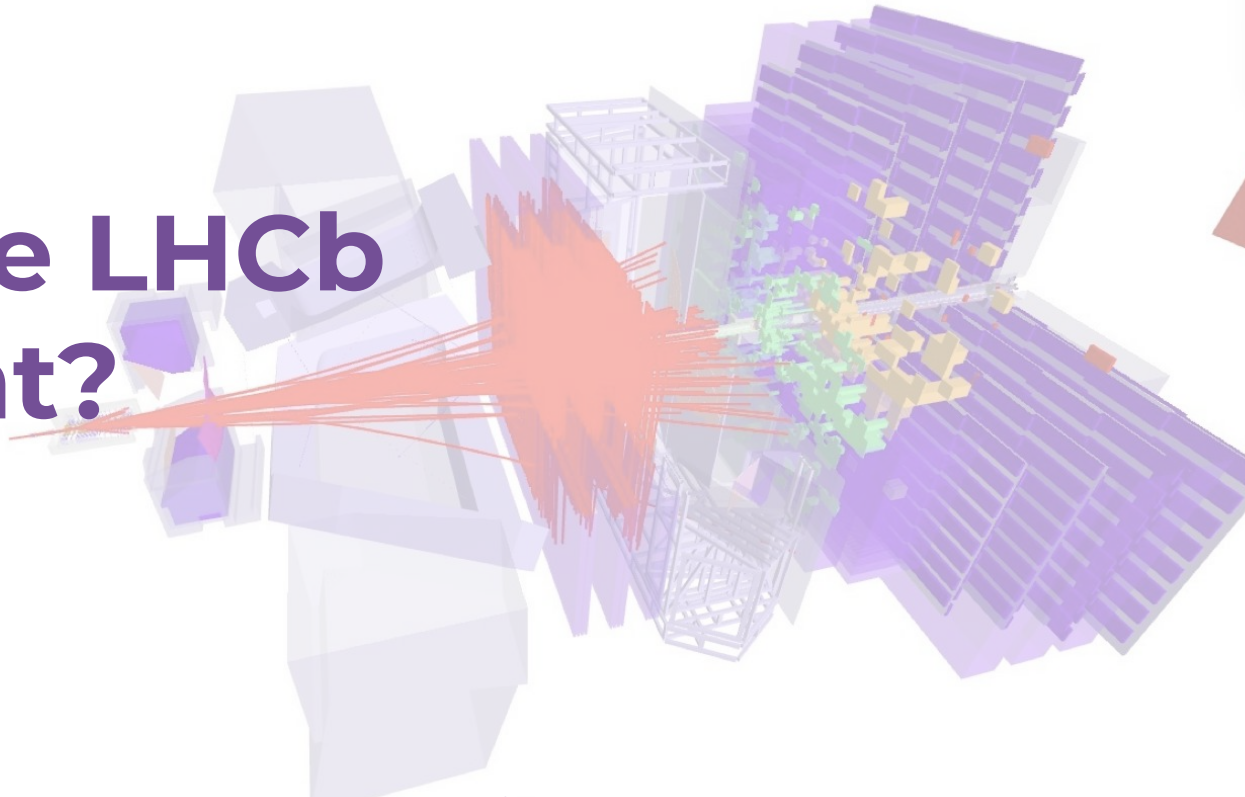
Where do neutrinos get their mass from?

Flavour in the Standard Model

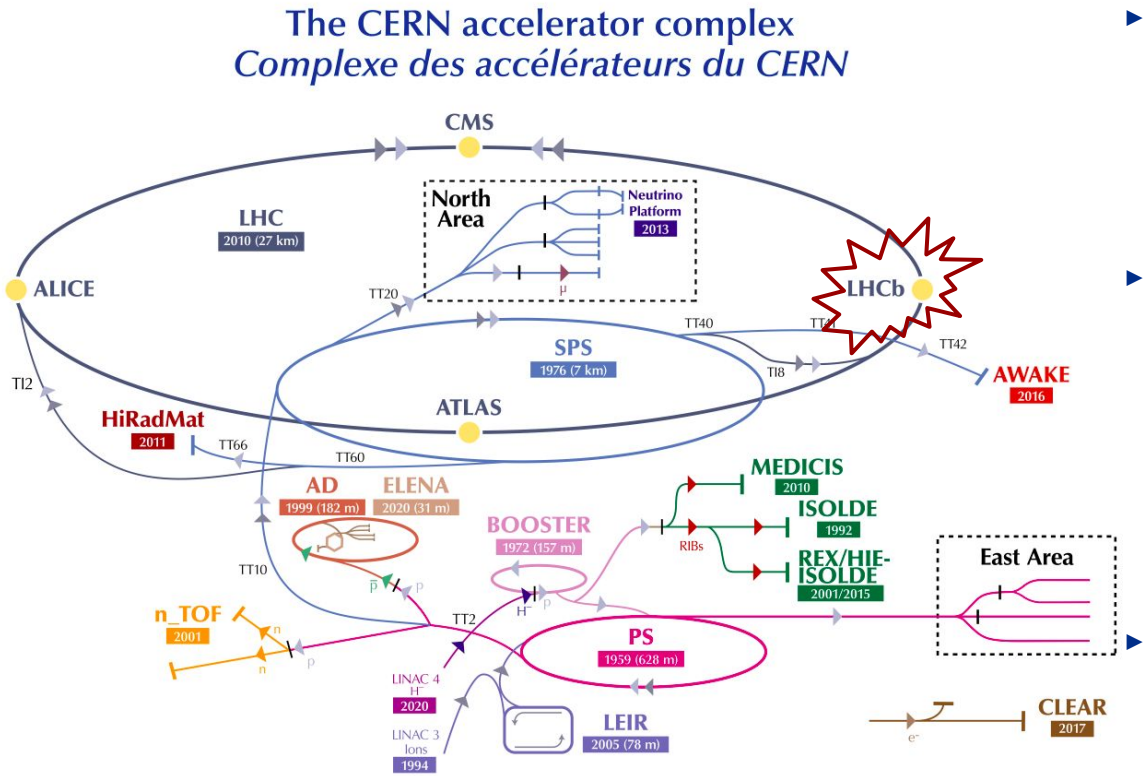
- Difference in quarks and leptons referred to as “flavour”
- Quarks combine to form hadrons
- Flavour physics experiments such as LHCb aim to test the limits of the Standard Model through the analysis of “heavy” flavour hadron decays
  - ➜ Consist of *b*- and *c*-quarks
  - ➜ Probes the existence of undiscovered particles contributing to the decay by measuring deviations from SM predictions



What is the LHCb Experiment?



The Large Hadron Collider

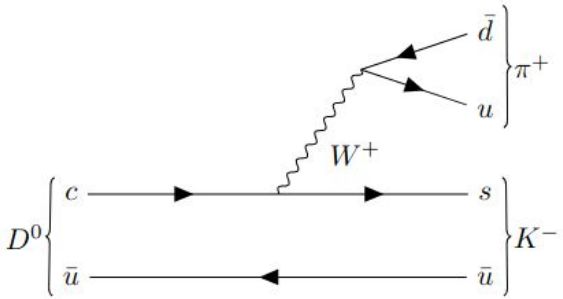


- Protons collided at the four main experiments on the LHC ring:
  - ➜ LHCb, ATLAS, CMS, ALICE
- Since 2010, there have been 2 “Runs” of data taking
  - ➜ Run I at collision energies 7 and 8 TeV
  - ➜ Run II at 13 TeV
- We have entered Run III this July with collision energies of an unprecedented 13.6 TeV!

Studying Flavour Experimentally

Say we want to study the decay:

$$D^0 \to K^- \pi +$$



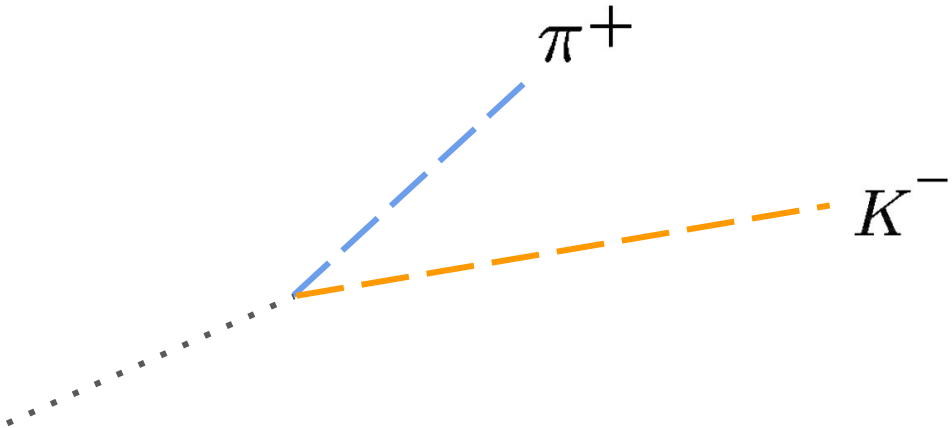
What information do we need?

Studying Flavour Experimentally

$$D^0 \to K^- \pi +$$

We need to know...

➔ What particles are leaving tracks (pions? kaons? protons?)



Studying Flavour Experimentally

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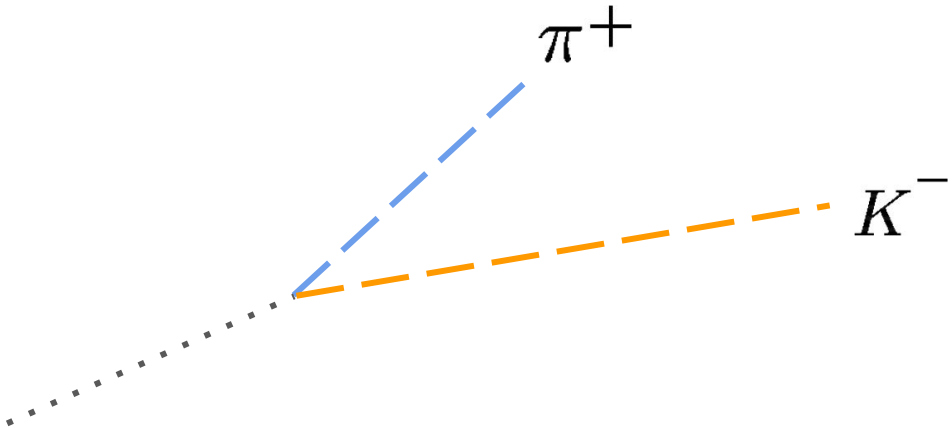

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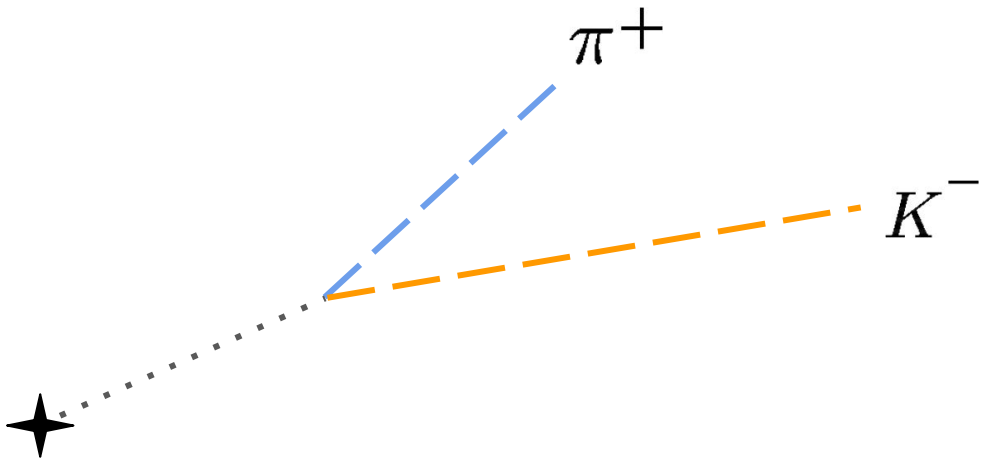

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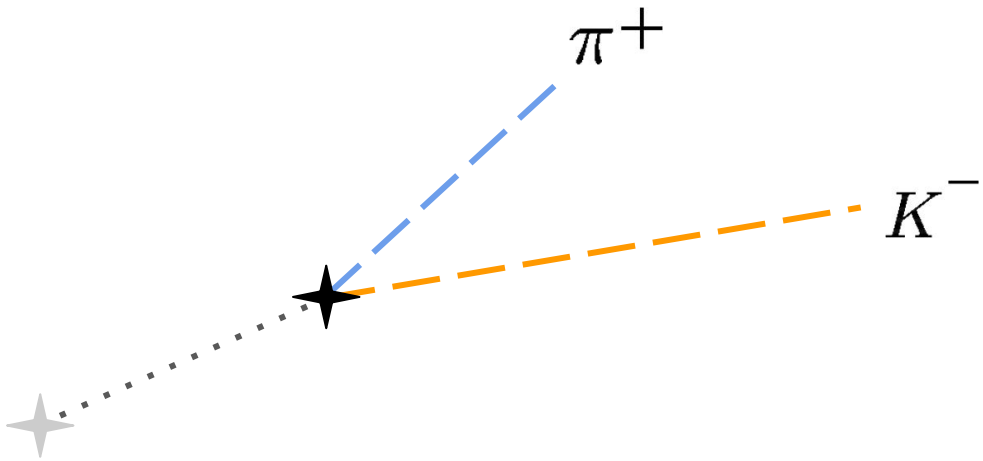
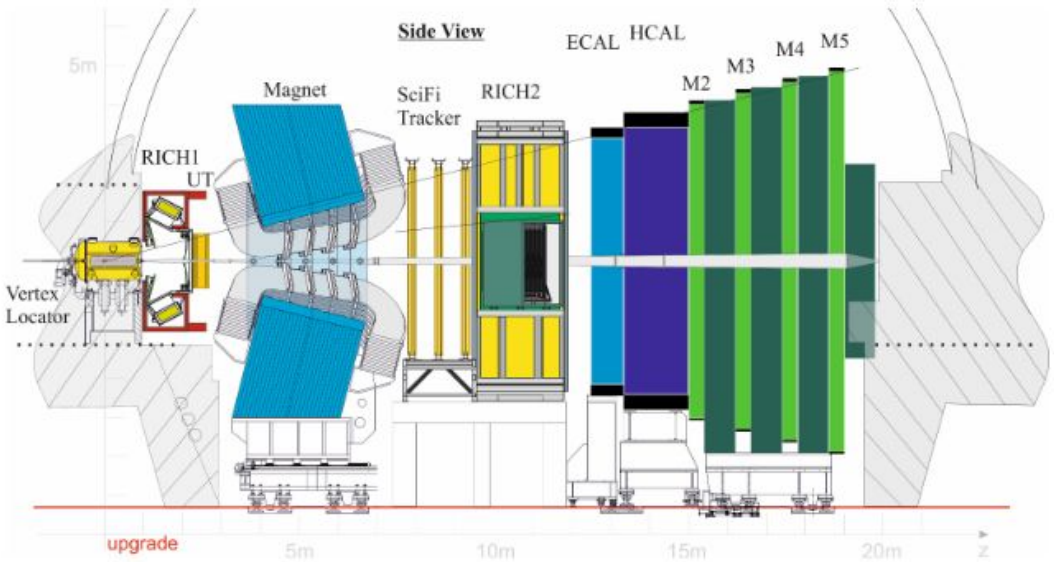


- What particles are leaving tracks (pions? kaons? protons?)
- The momentum and energy of the decay products to deduce which particle has produced them
- The *primary vertex* (PV) position where the D^0 is produced
- The *secondary vertex* position where the D^0 has decayed since heavy flavour hadrons typically travel a few cm

The LHCb Experiment

- "Large Hadron Collider Beauty" experiment

- Several features are specialised for studying *b*- and *c*- hadron decays:
  - ➜ Sub-detectors stacked in the forward region
  - ➜ Ring imaging Cherenkov detectors, calorimeters and muon detectors for particle ID
  - ➜ The trackers measure hits from charged particles before and after the magnet so that we know their trajectories and momenta



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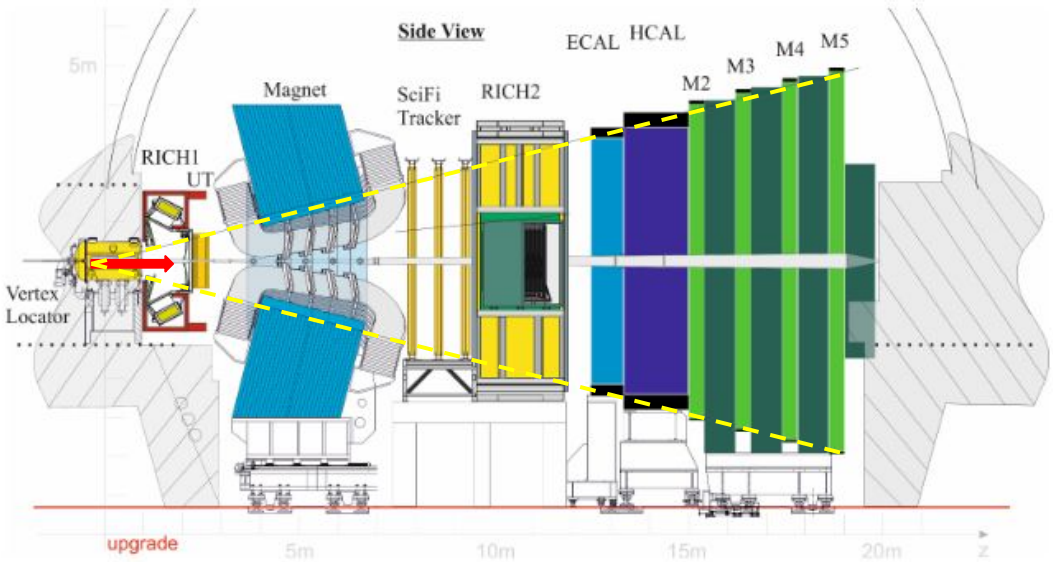

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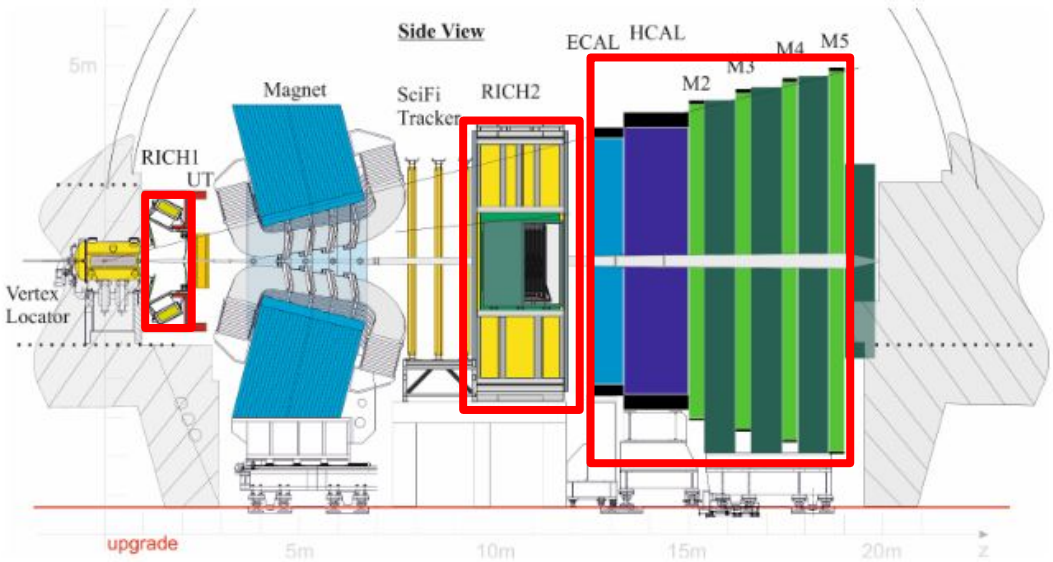

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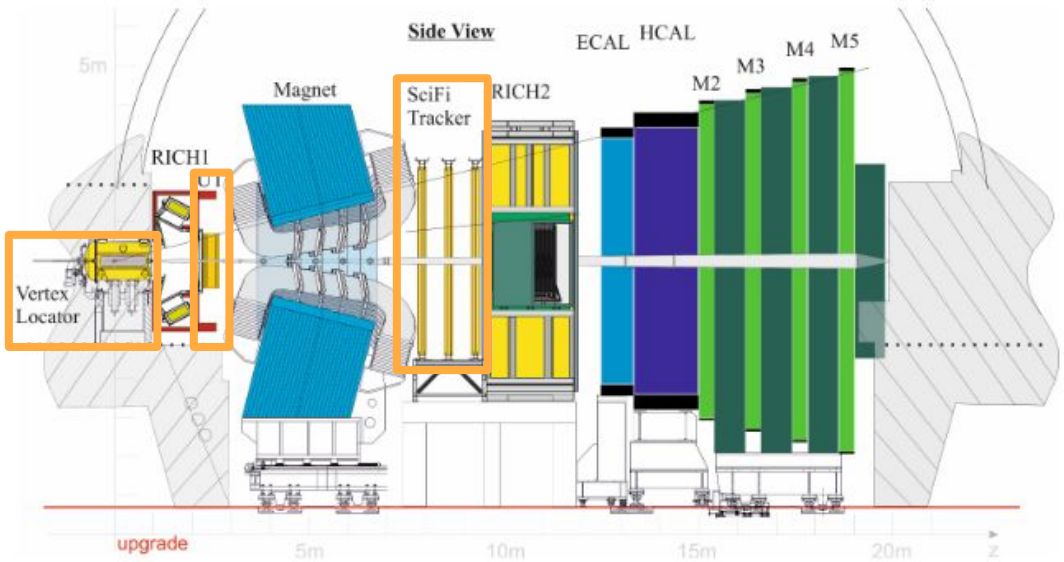

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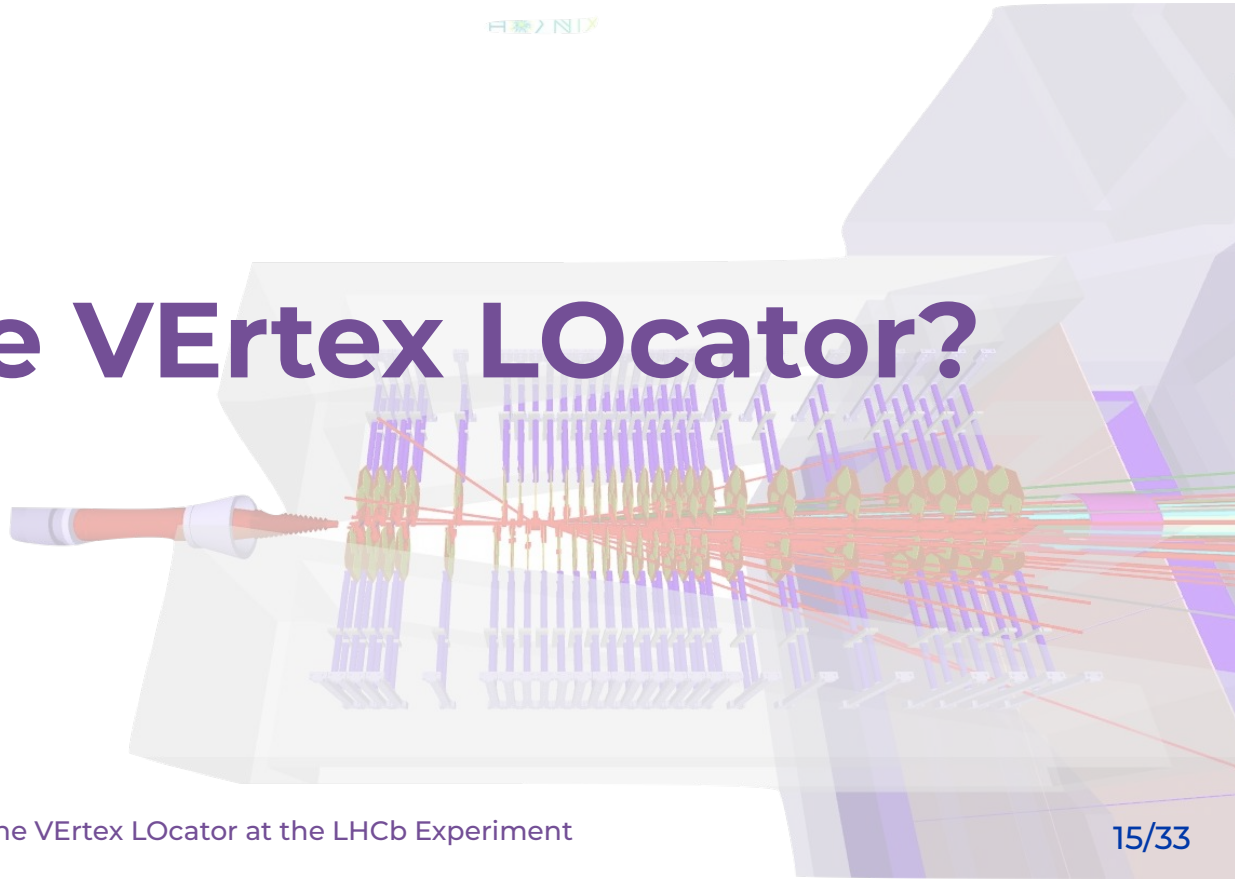
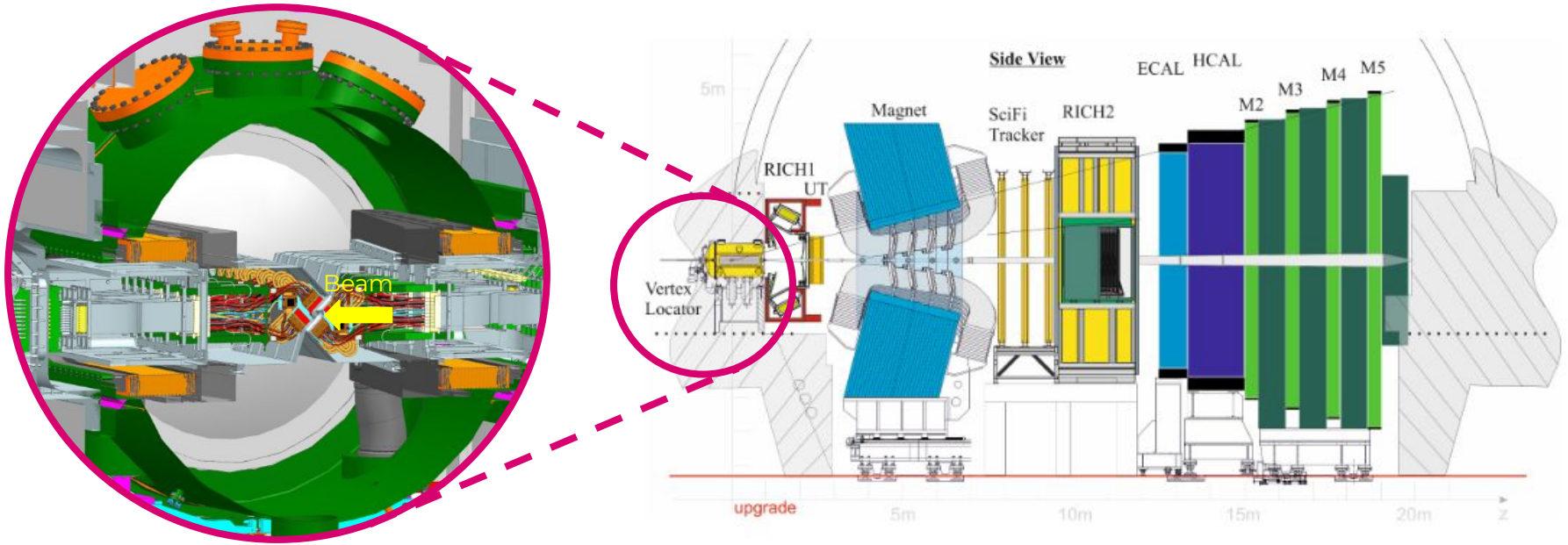
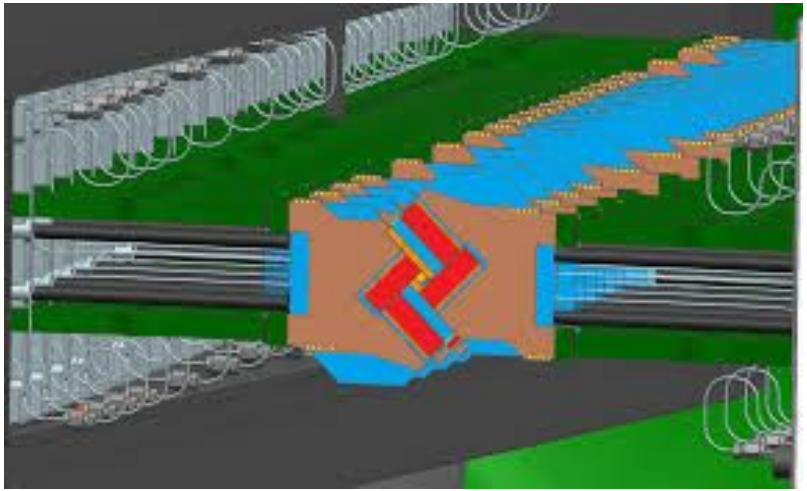


The VELO



- The tracker closest to the interaction region where the protons collide
- Tasked with crucial measurements such as the primary vertex, secondary vertex, and the closest distance between a track and the PV

The VELO



NEW!

- 52 L-shaped modules arranged in pairs with 26 rows surrounding the beam
- Silicon pixel detector developed for the upgrade for faster readout rate
- Microchannel cooling system directly beneath the sensors with biphase CO_2 as coolant

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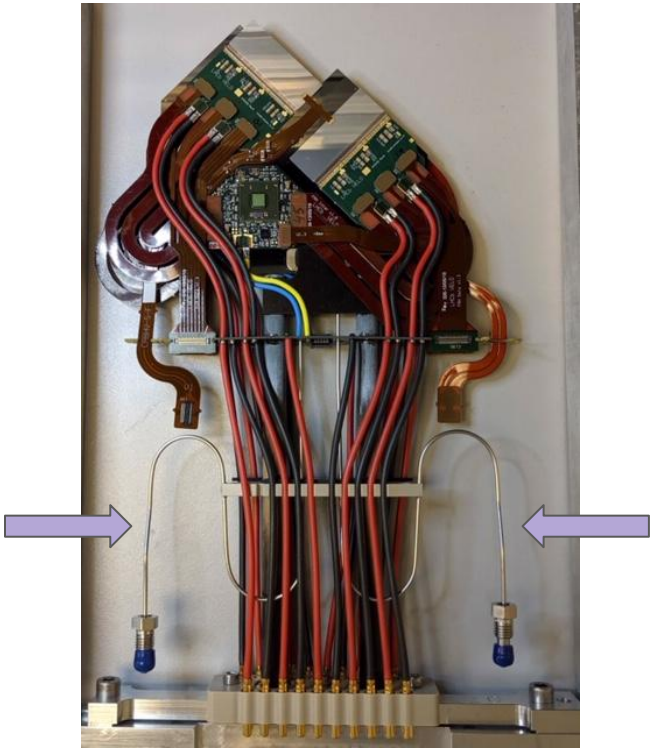

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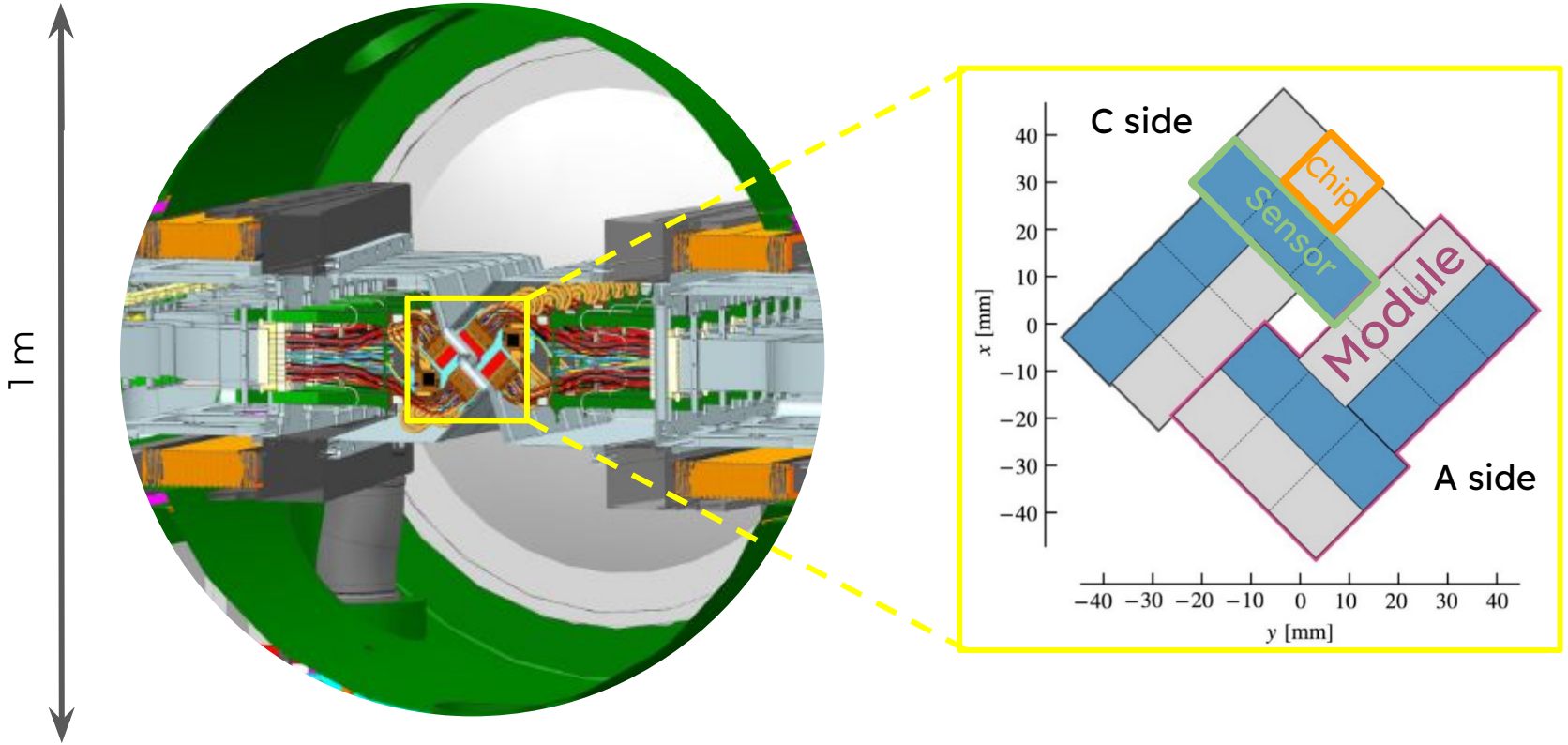
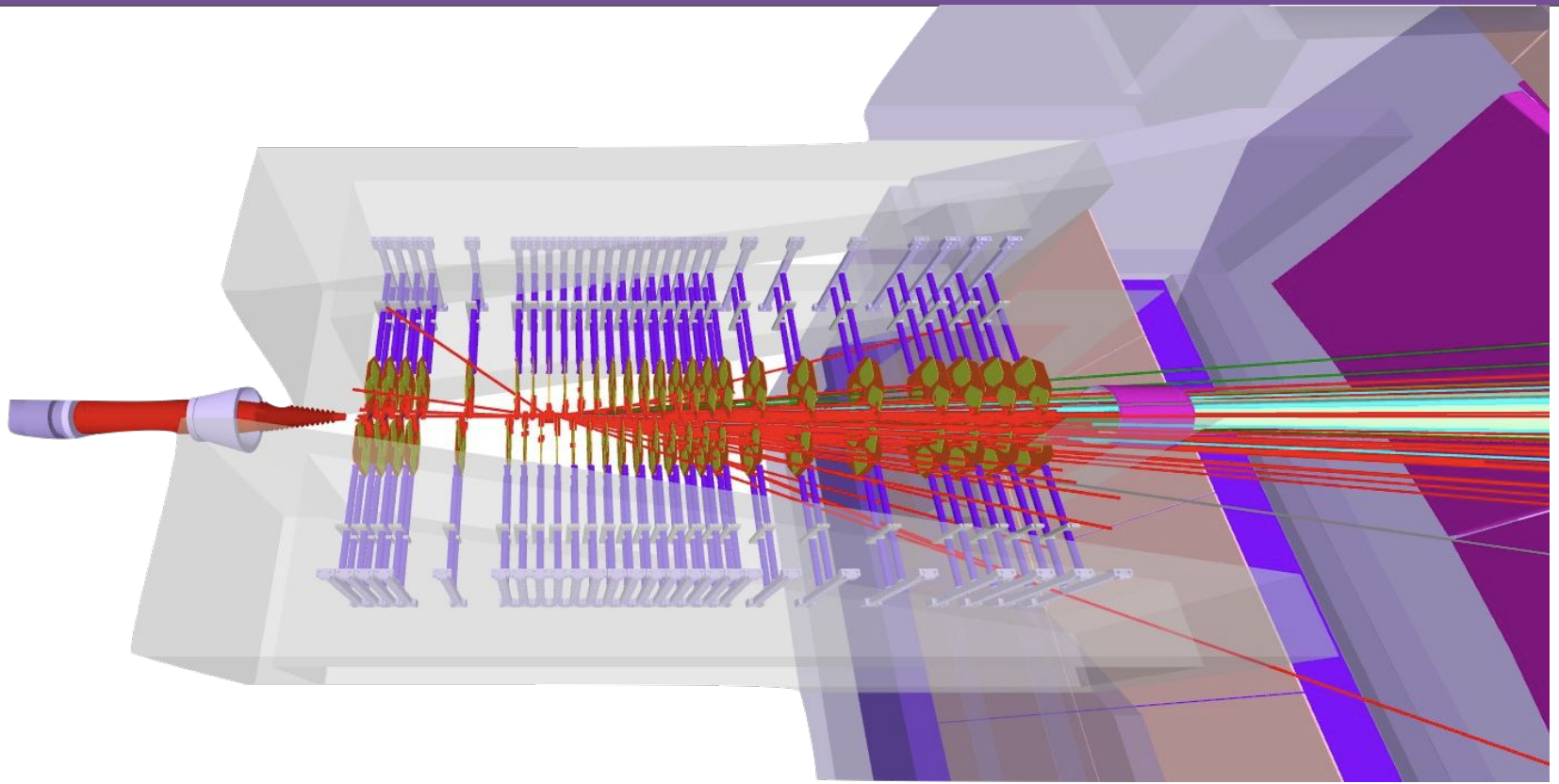
Geometry

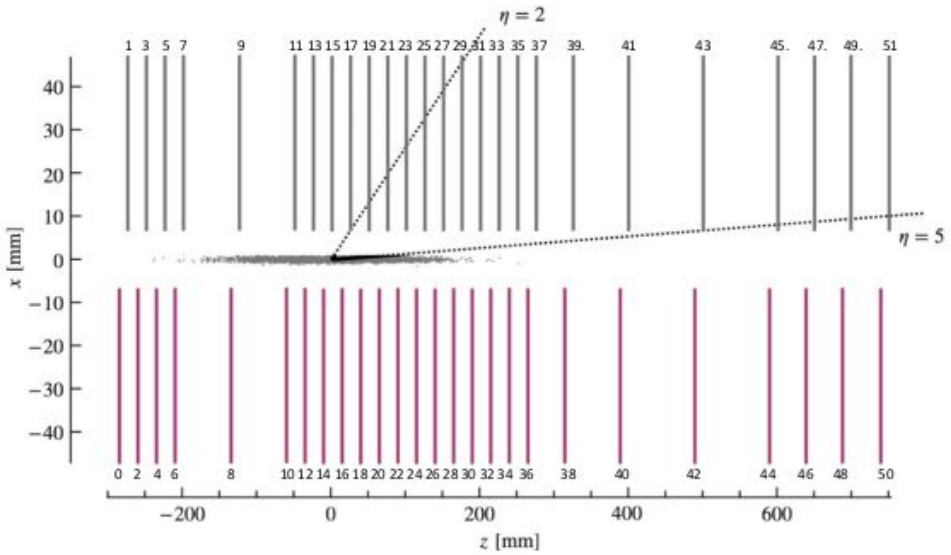

1 m
C side
A side
Chip
Sensor
Module
x [mm]
y [mm]
40
30
20
10
0
−10
−20
−30
−40

How the VELO Tracks Charged Particles



How the VELO Tracks Charged Particles

$$D^0 \rightarrow K^- \pi^+ ?$$



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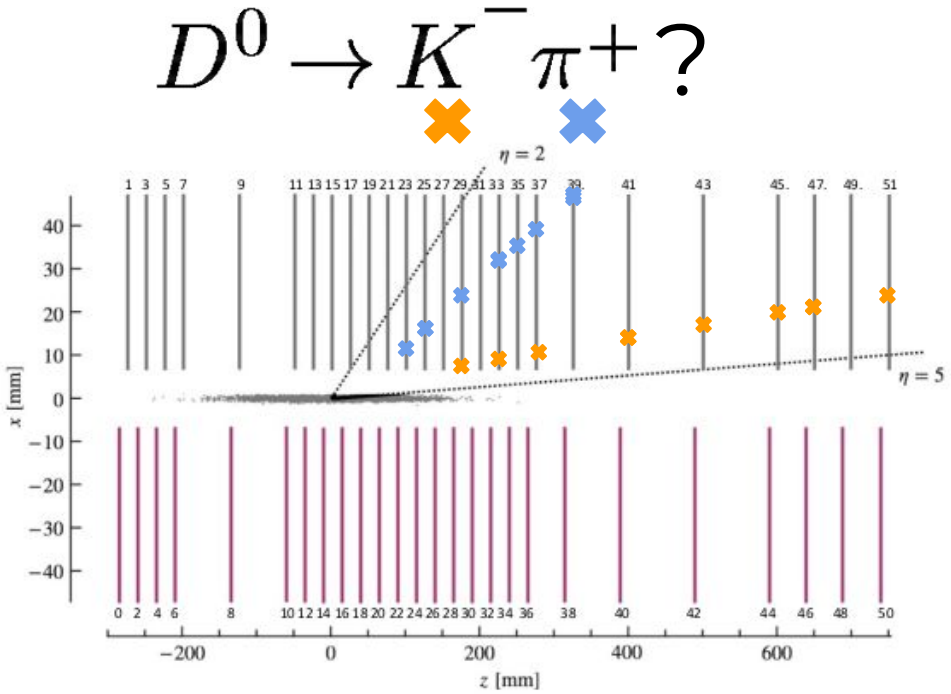

- **Clusters:** a collection of pixels registering a hit in the sensor from a traversing particle

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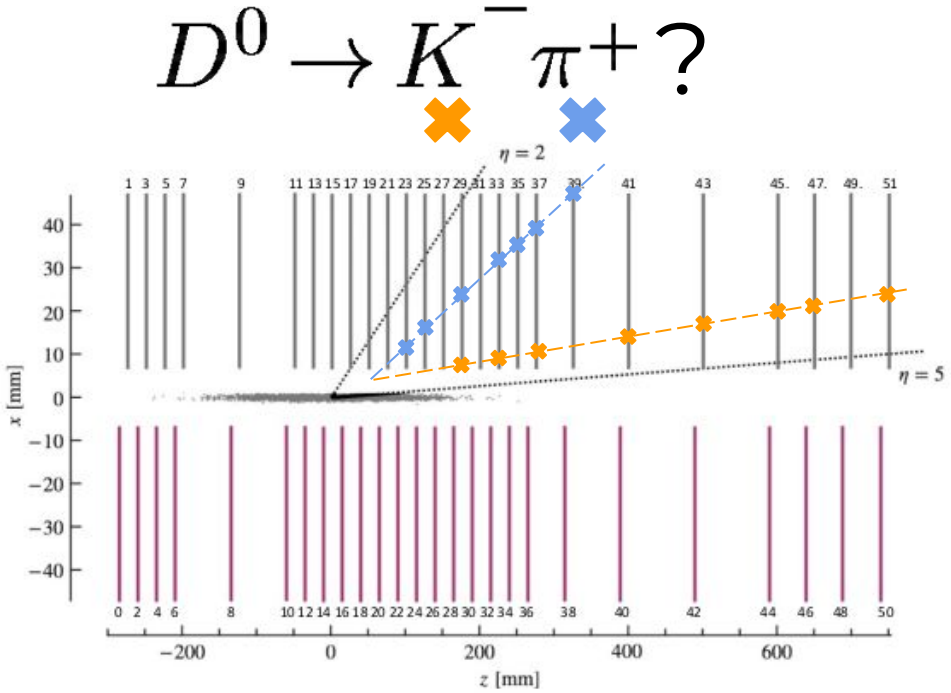

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Tracks: trajectory of particles reconstructed from clusters in at least 3 sensors

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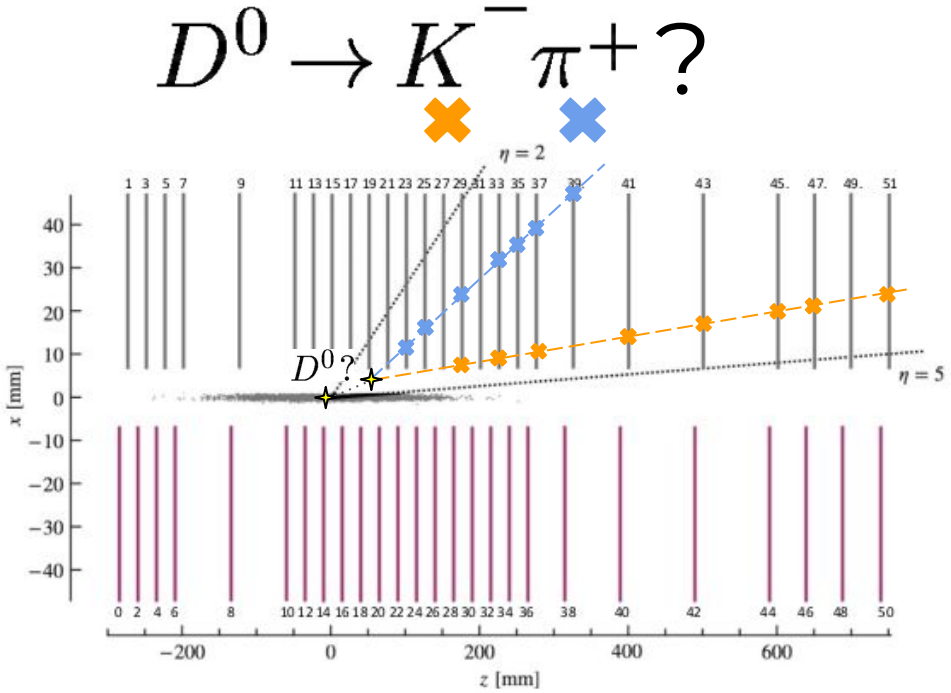
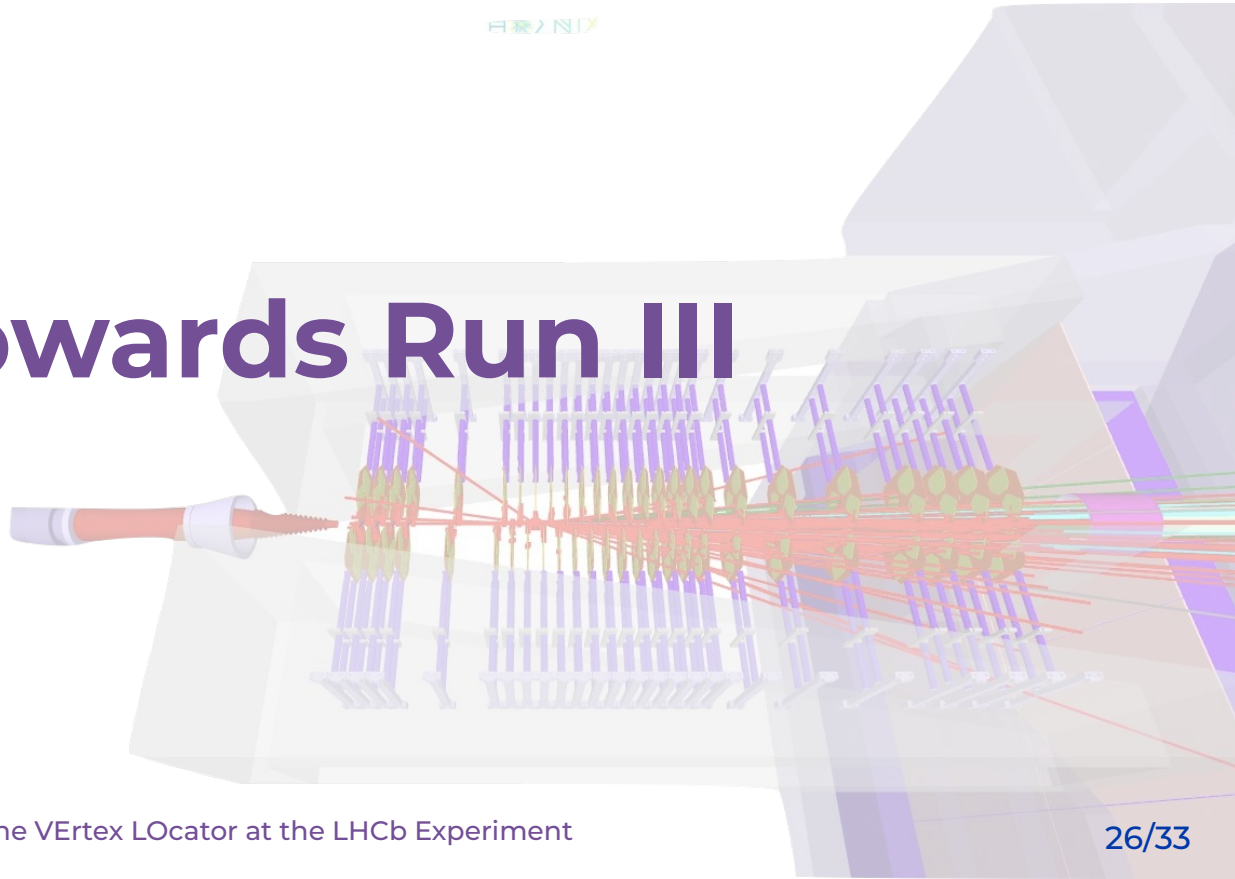


Clusters: a collection of pixels registering a hit in the sensor from a traversing particle

Tracks: trajectory of particles reconstructed from clusters in at least 3 sensors

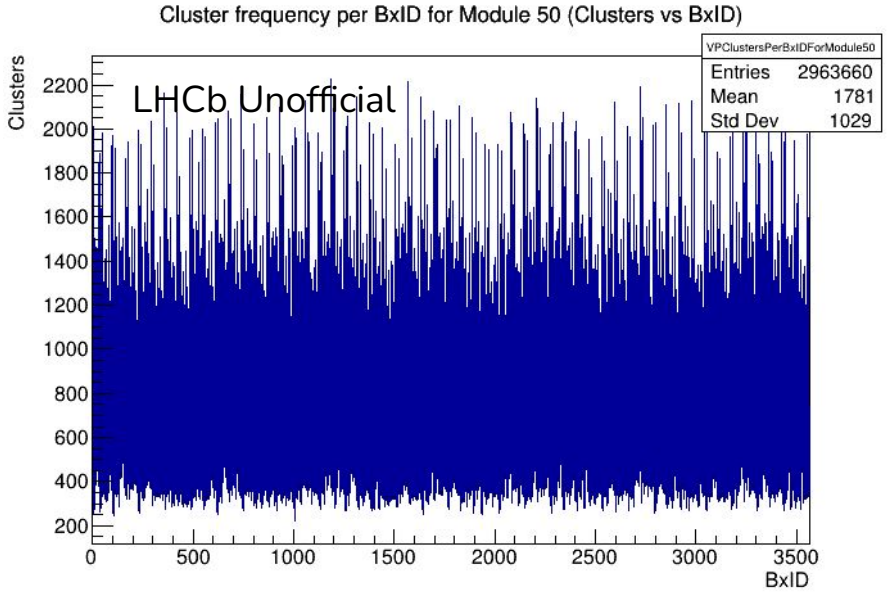
Vertices: position calculated from groups of tracks suspected to be from the same decay

Looking Towards Run III



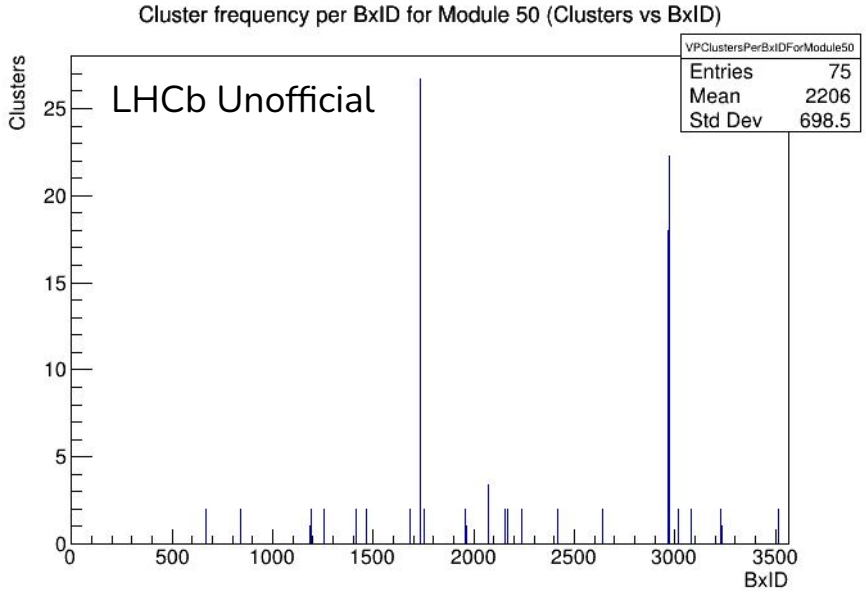
First Look 👀

- VELO fully installed in May 2022 and now in the commissioning stage!
- First glimpse of data!



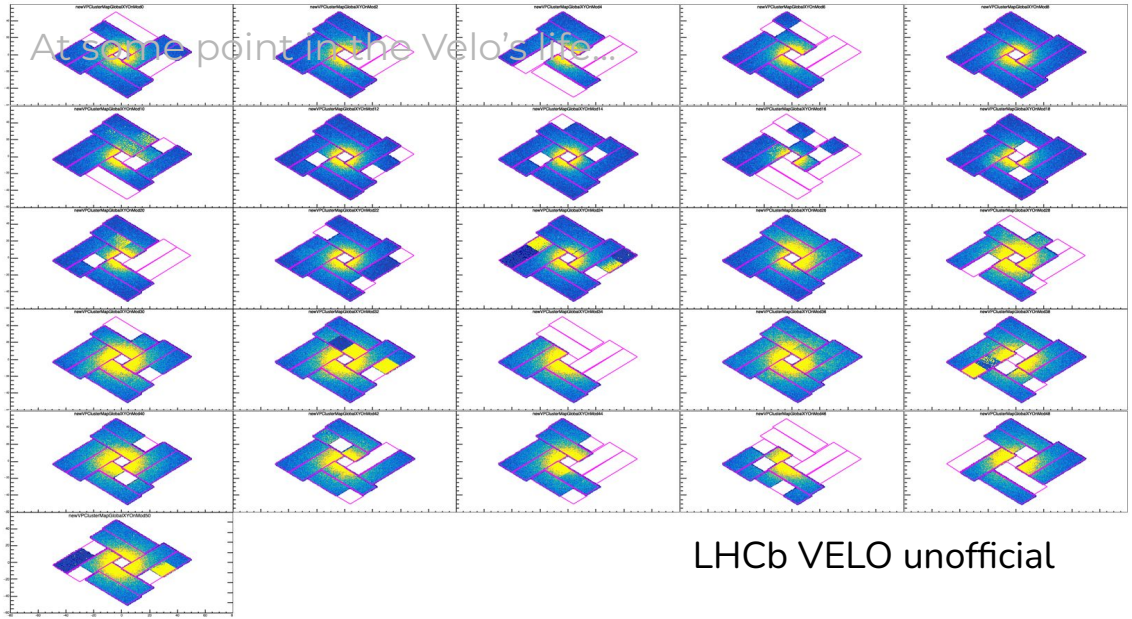
First Look 👀

- VELO fully installed in May 2022 and now in the commissioning stage!
- Then we cleaned it up a bit...



Monitoring for Commissioning

- Data quality checks



Clusters

Monitoring for Commissioning

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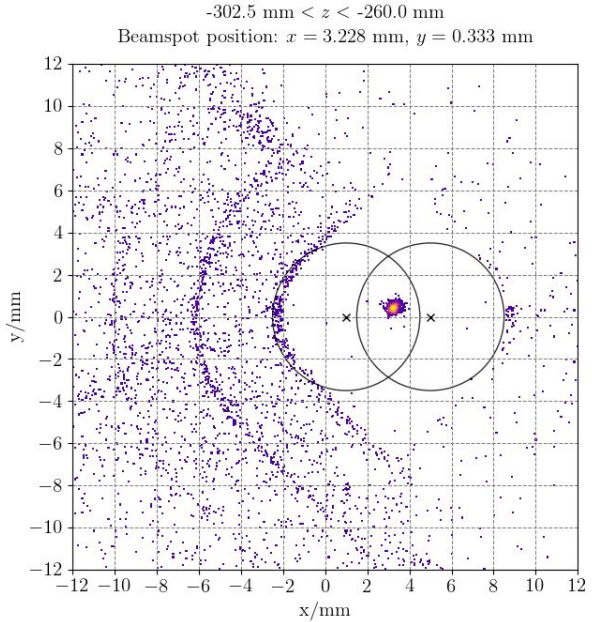

Vertices

Summary

- The Vertex Locator is a crucial sub-detector for the physics program of the LHCb detector
- The detector is currently in its commissioning phase with monitoring a big part of this
- The VELO project is a huge team effort and is the result of hard work from people from various institutions around the world

Thank You!

Monitoring for Commissioning

- Calibration