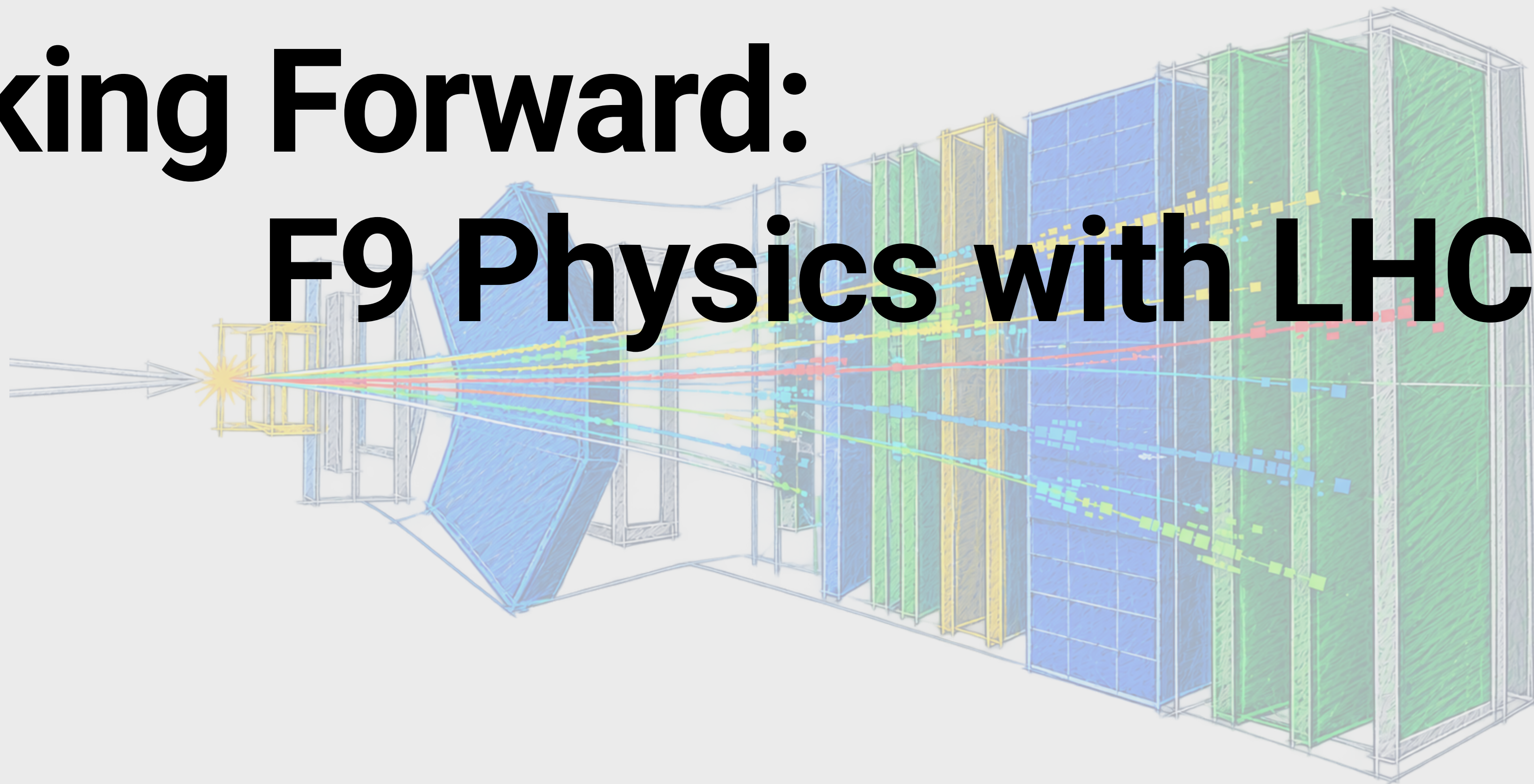


Looking Forward: F9 Physics with LHCb



Contents

- LHCb experiment
- LHCb collaboration
- History of F9 involvement
- Short-term physics and computing plans
- Long-term plans
- LHCb Upgrade II



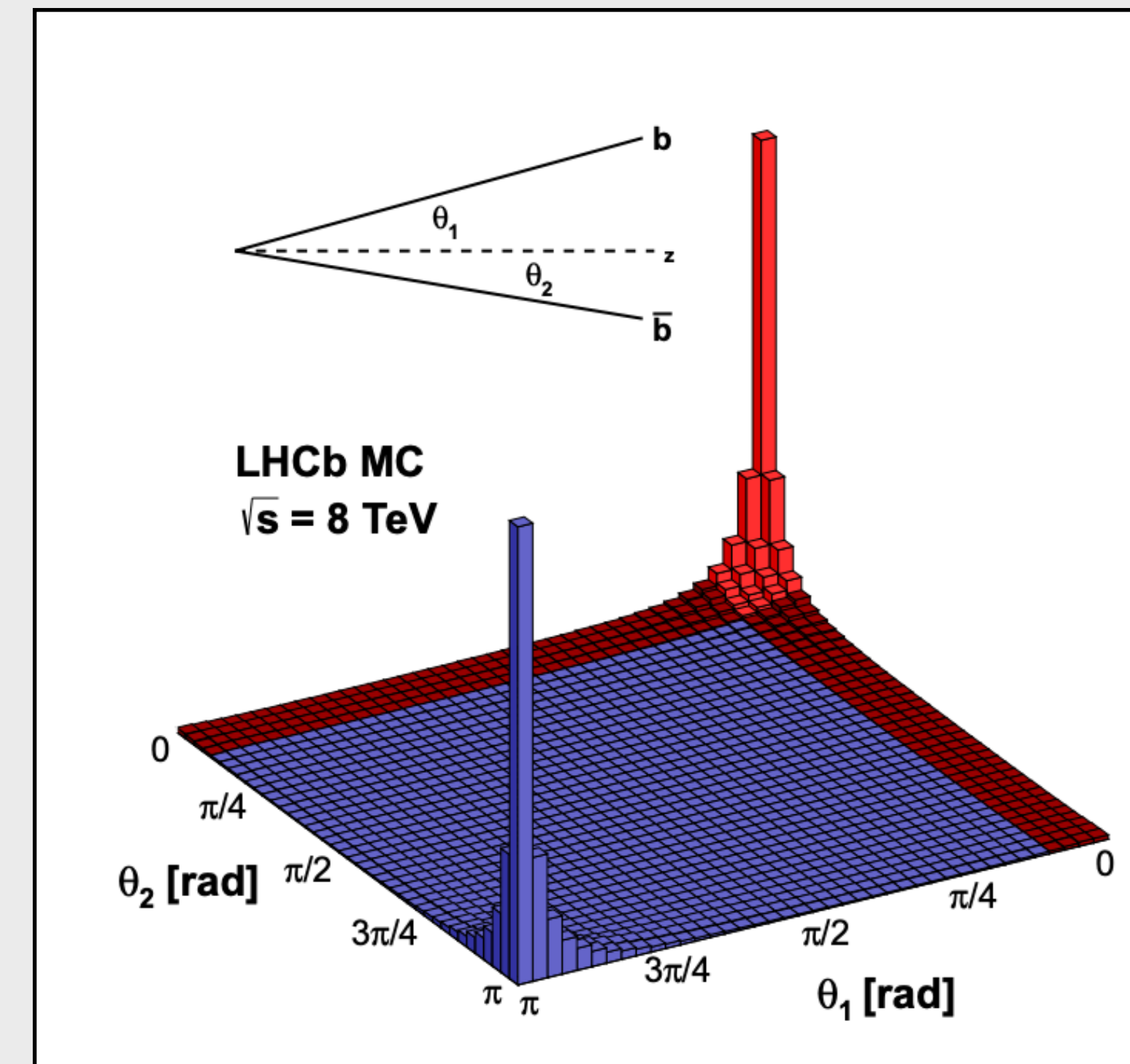
LHCb Experiment

LHCb experiment basics

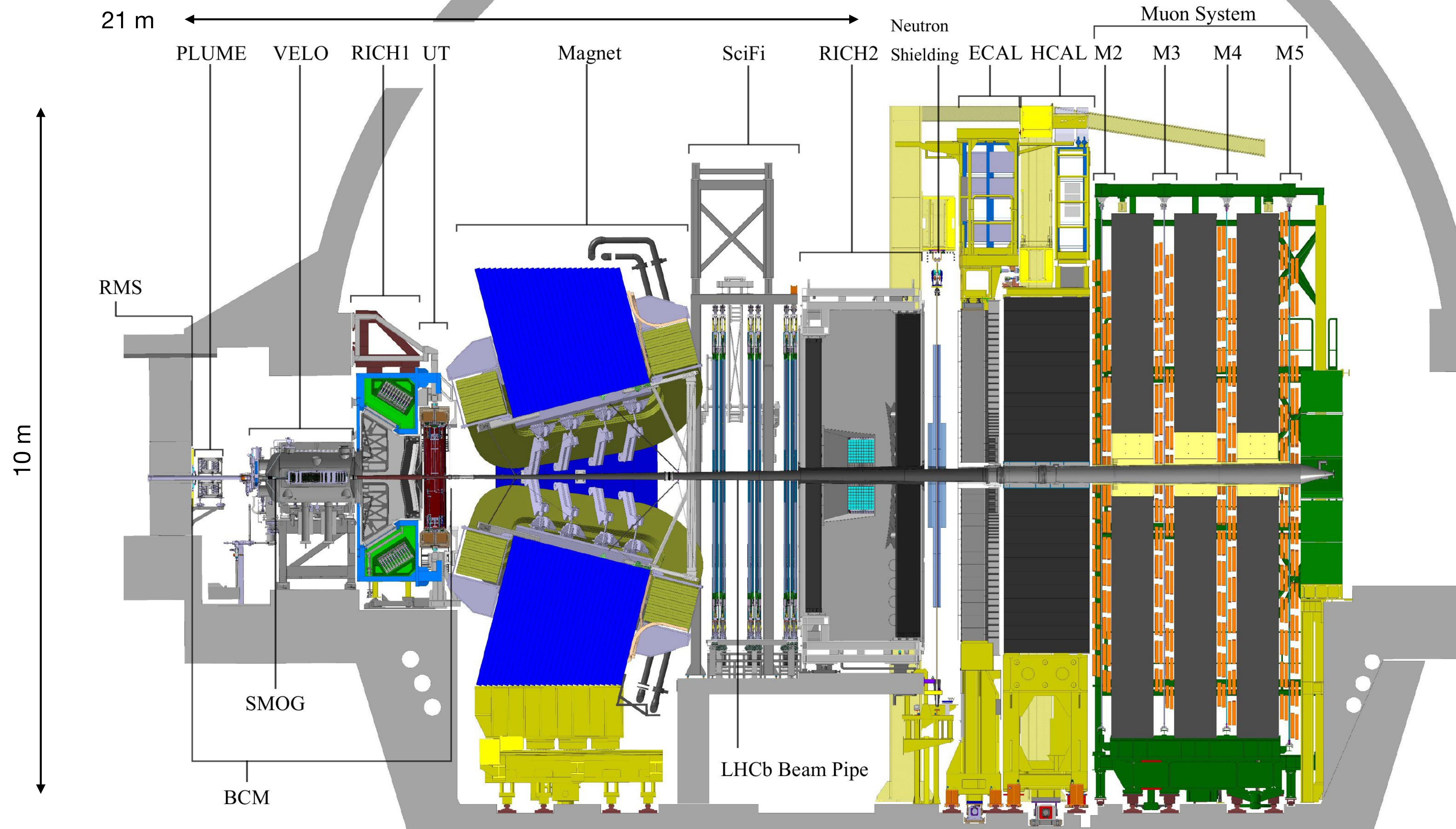


- LHCb is a **single-arm forward-region spectrometer** located at the interaction point 8 of the LHC, covering the pseudorapidity range $2 < \eta < 5$, i.e., $\theta \in [0.8^\circ, 15.4^\circ]$.
- The choice of detector geometry is justified by the fact that both b and $\bar{b}$ **hadrons are predominantly produced** in the same **forward or backward cone**.
 - “If our collaboration had the budget of the ministry of defence we would probably have built two LHCb detectors, to catch both the forward and backward pairs.” [[arXiv:2005.11226](https://arxiv.org/abs/2005.11226)]
- **Excellent performance** of the detector allowed the **physics programme to be extended** very rapidly to explore also charm, electroweak, and even heavy ion physics.

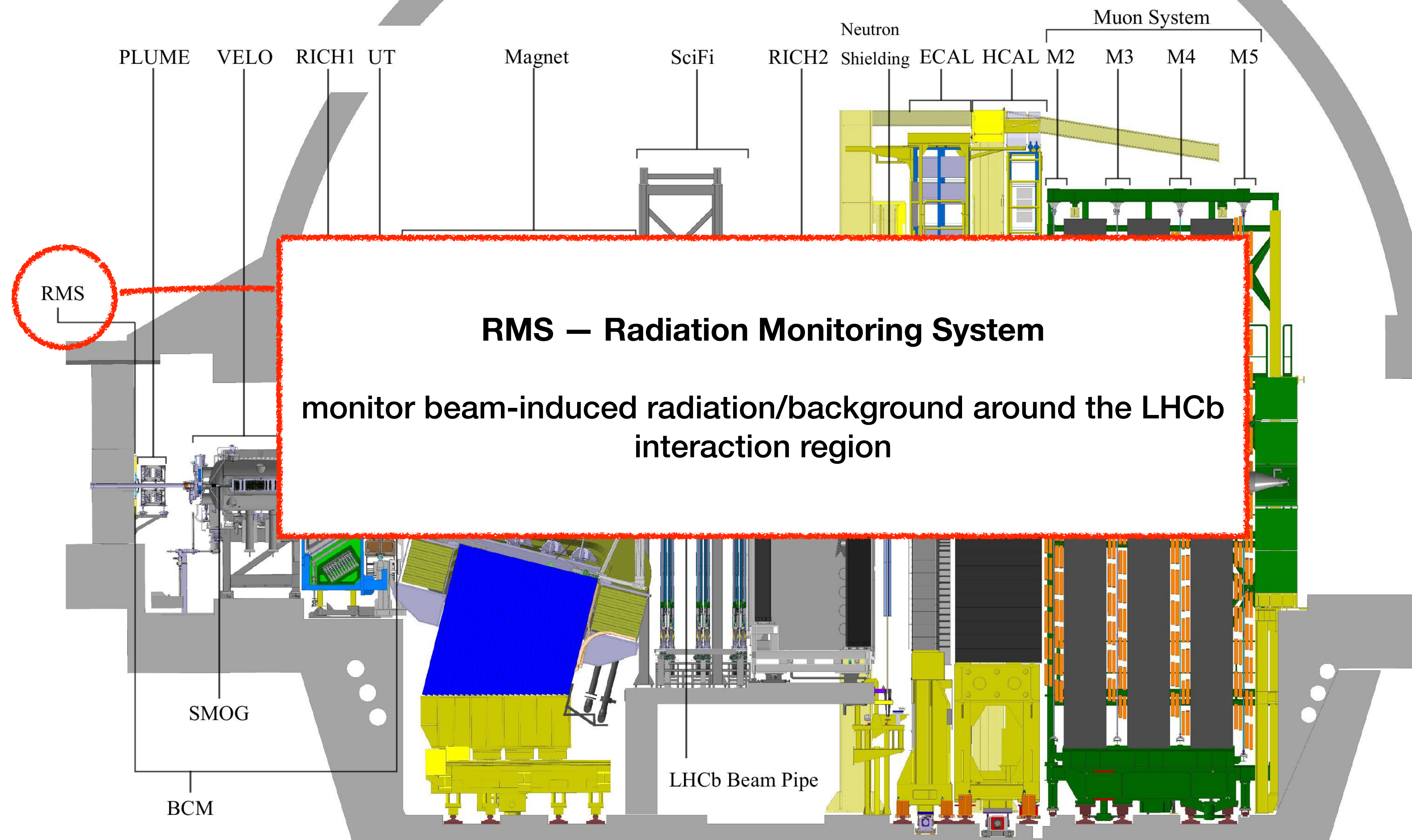
 - LHCb acceptance



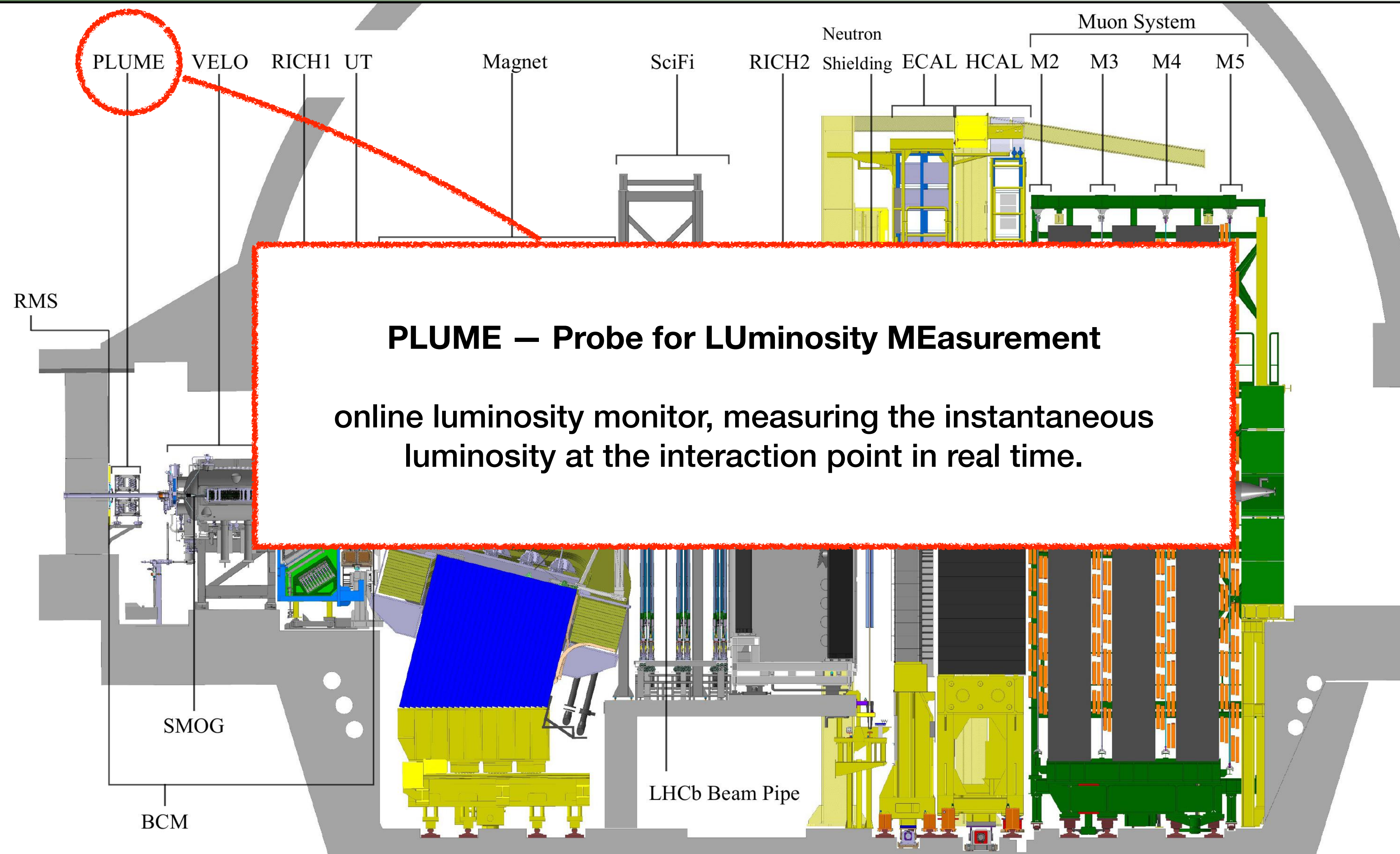
LHCb experiment layout



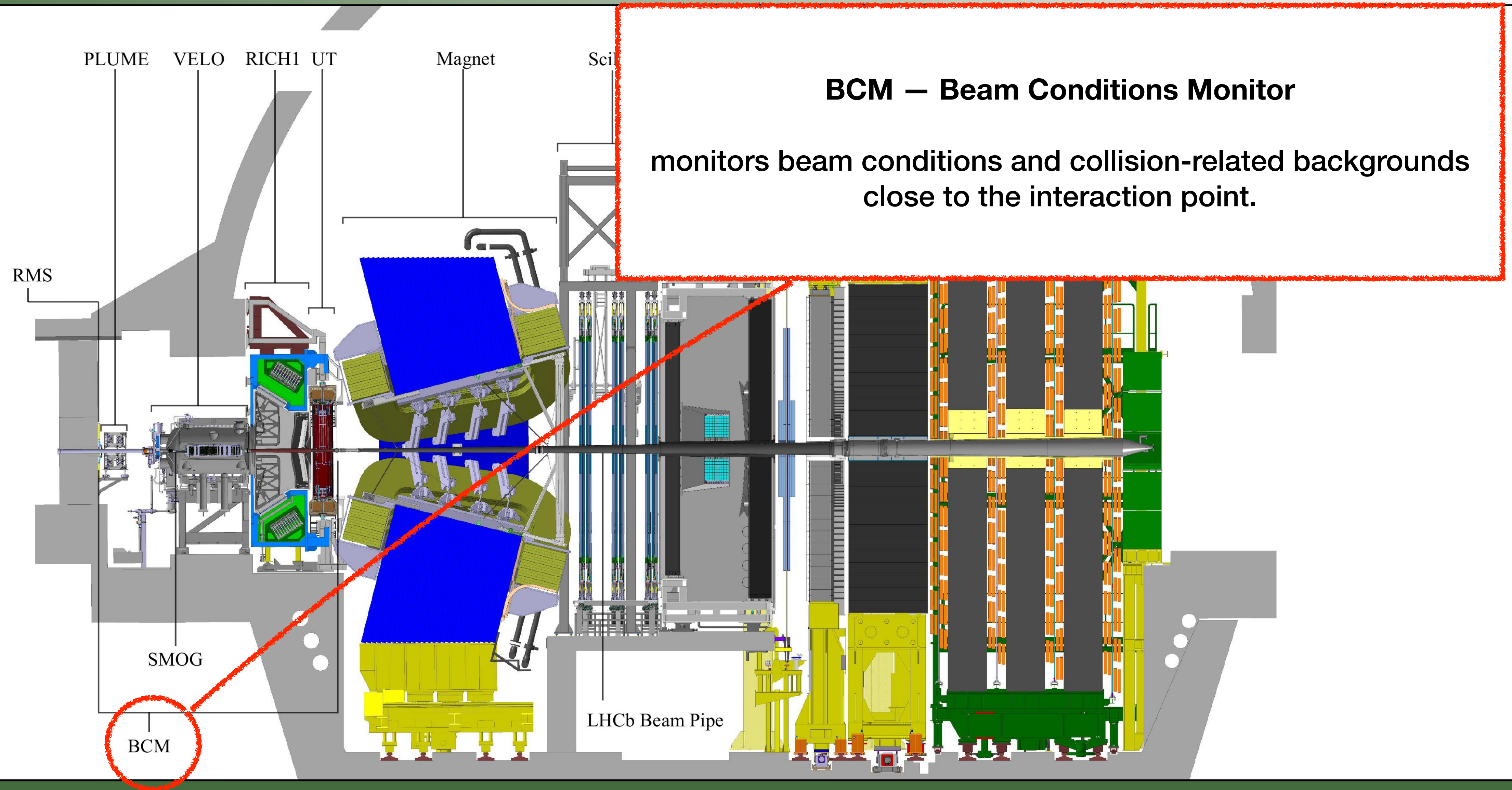
LHCb experiment layout



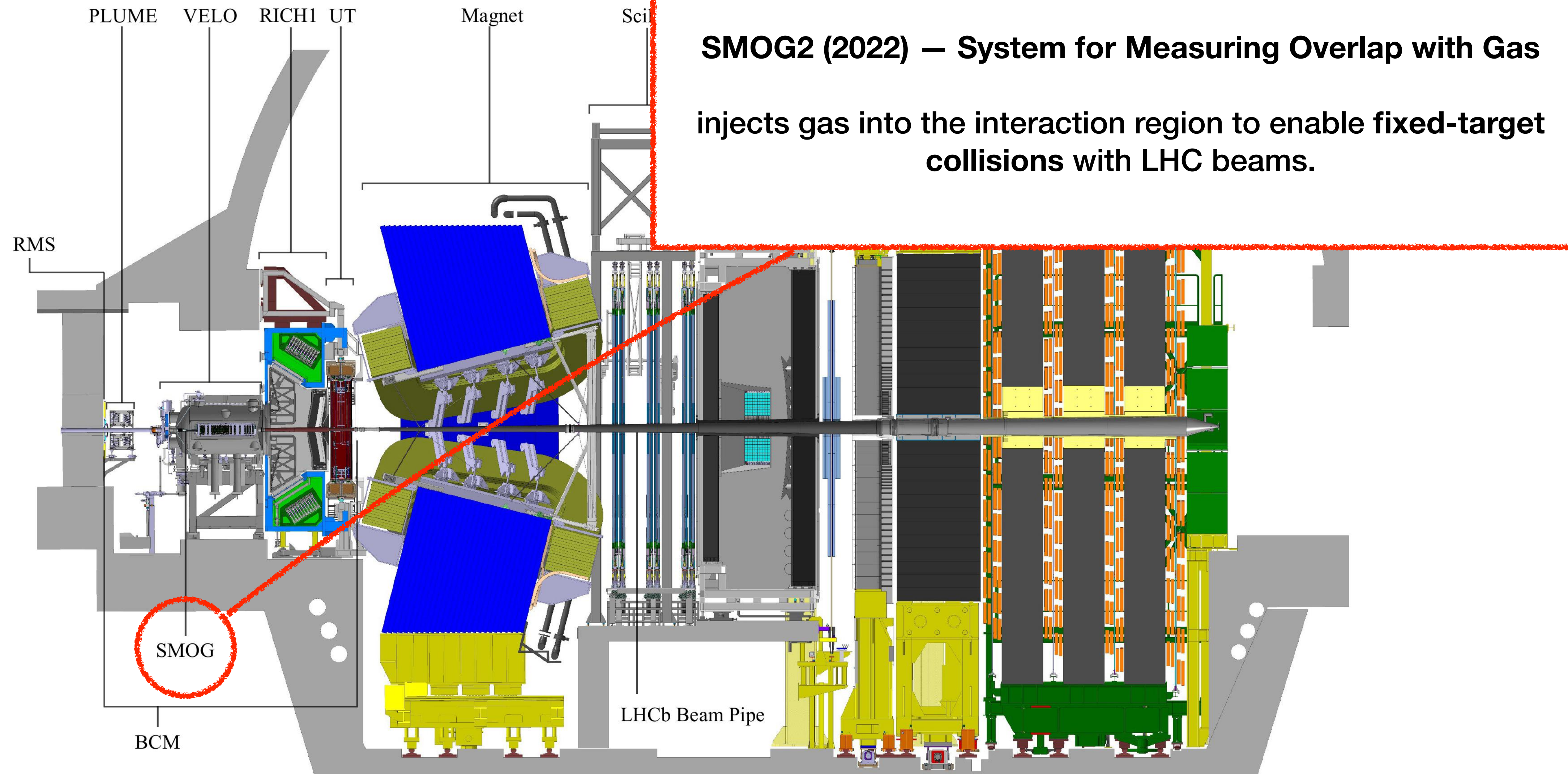
LHCb experiment layout



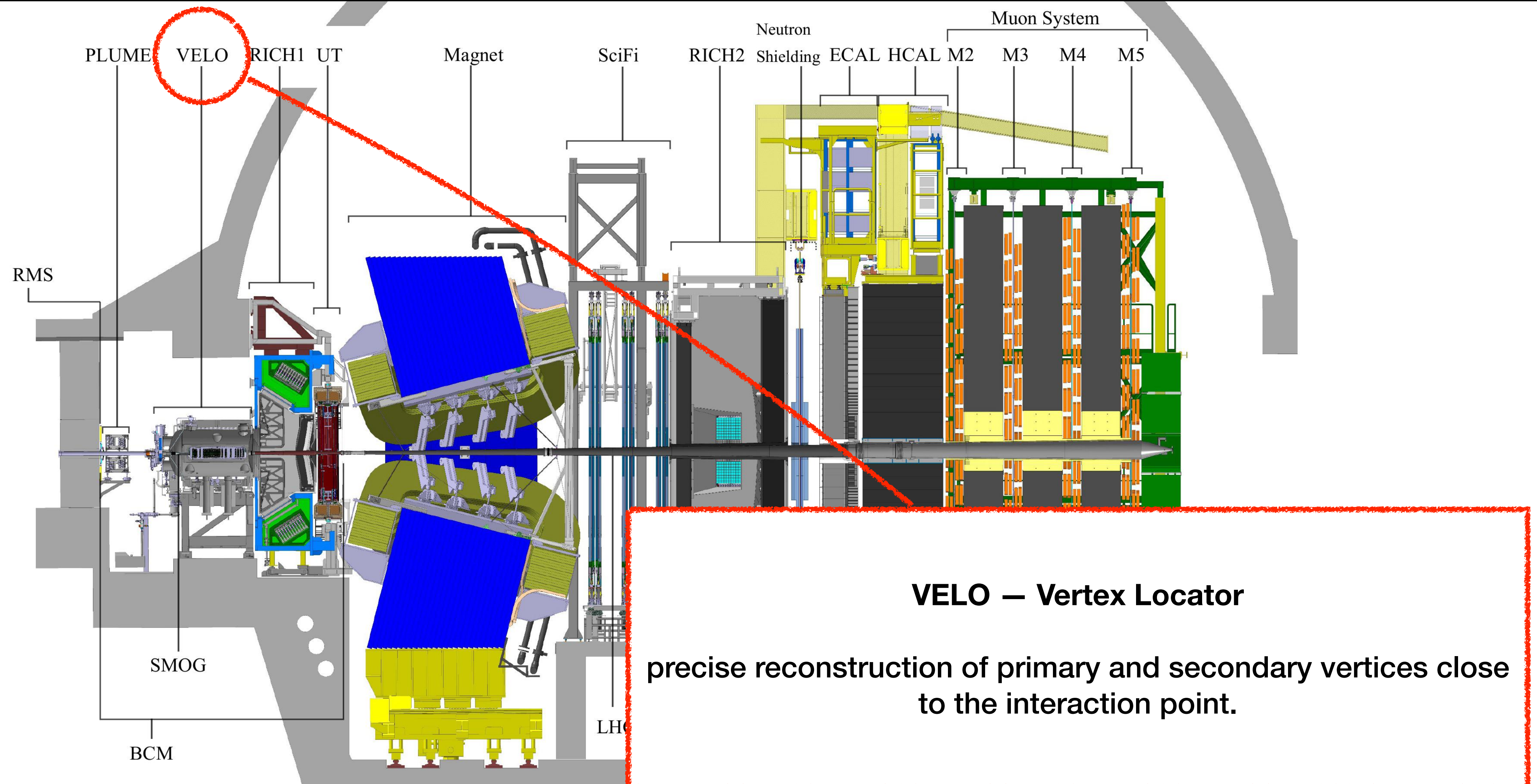
LHCb experiment layout



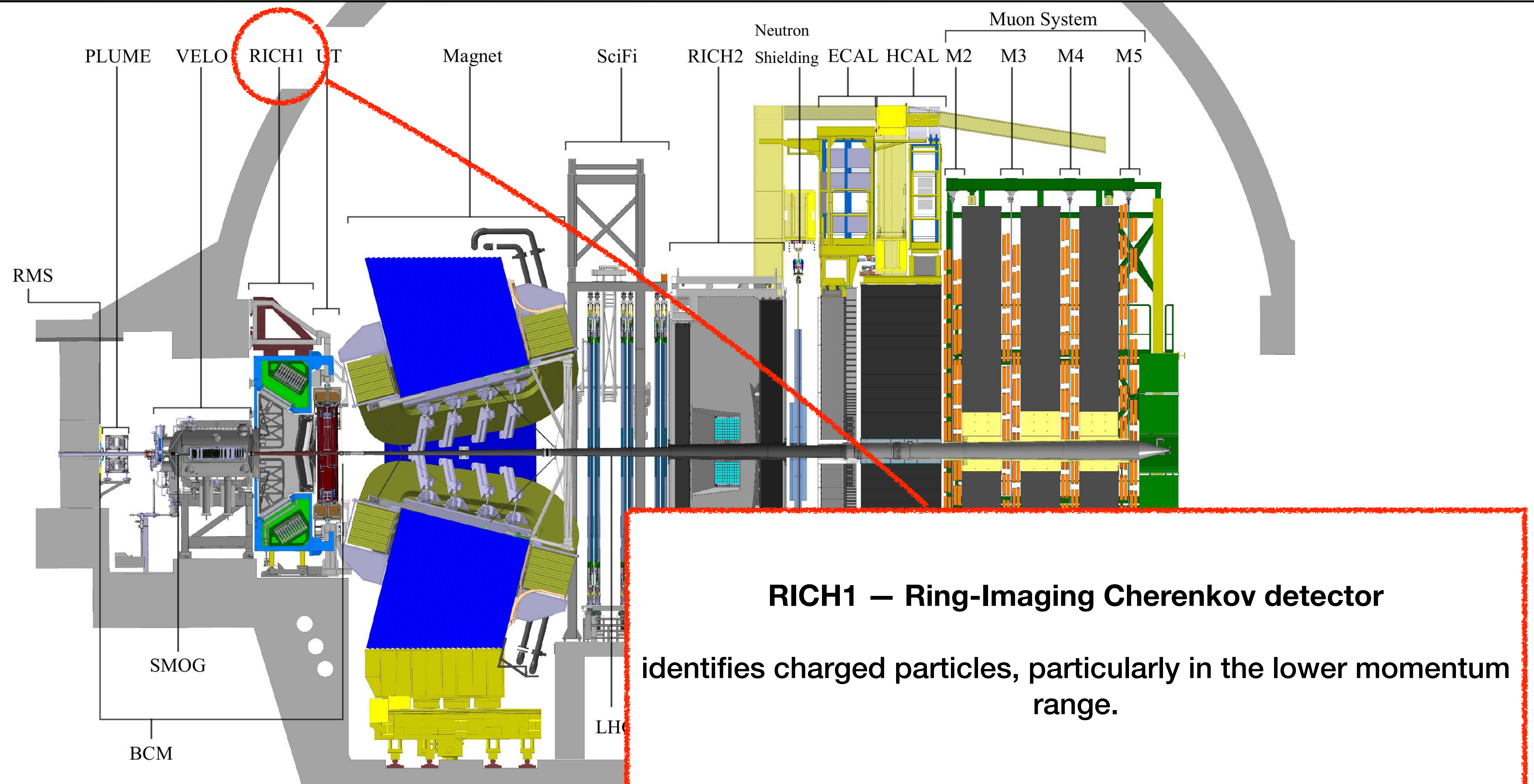
LHCb experiment layout



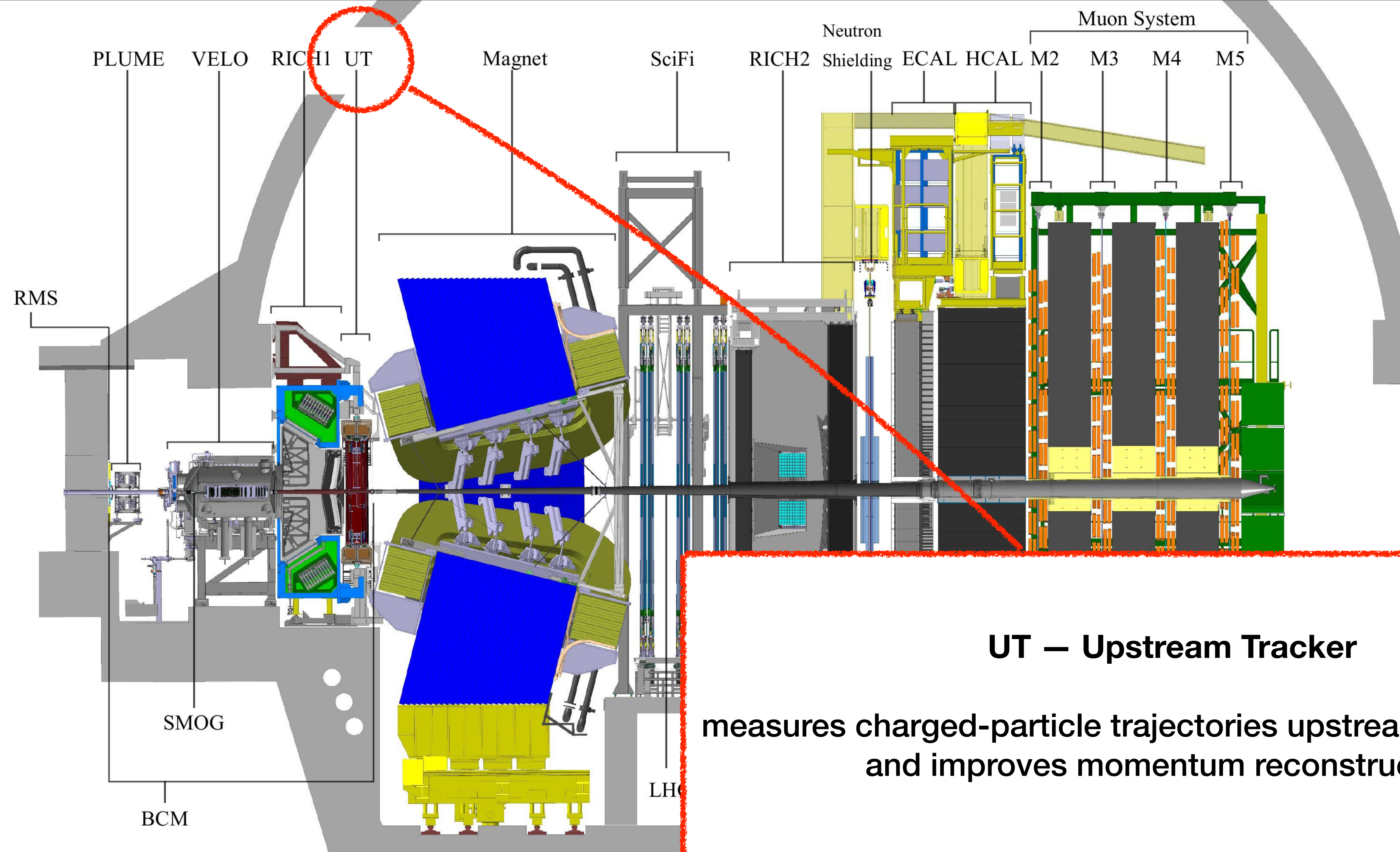
LHCb experiment layout



LHCb experiment layout



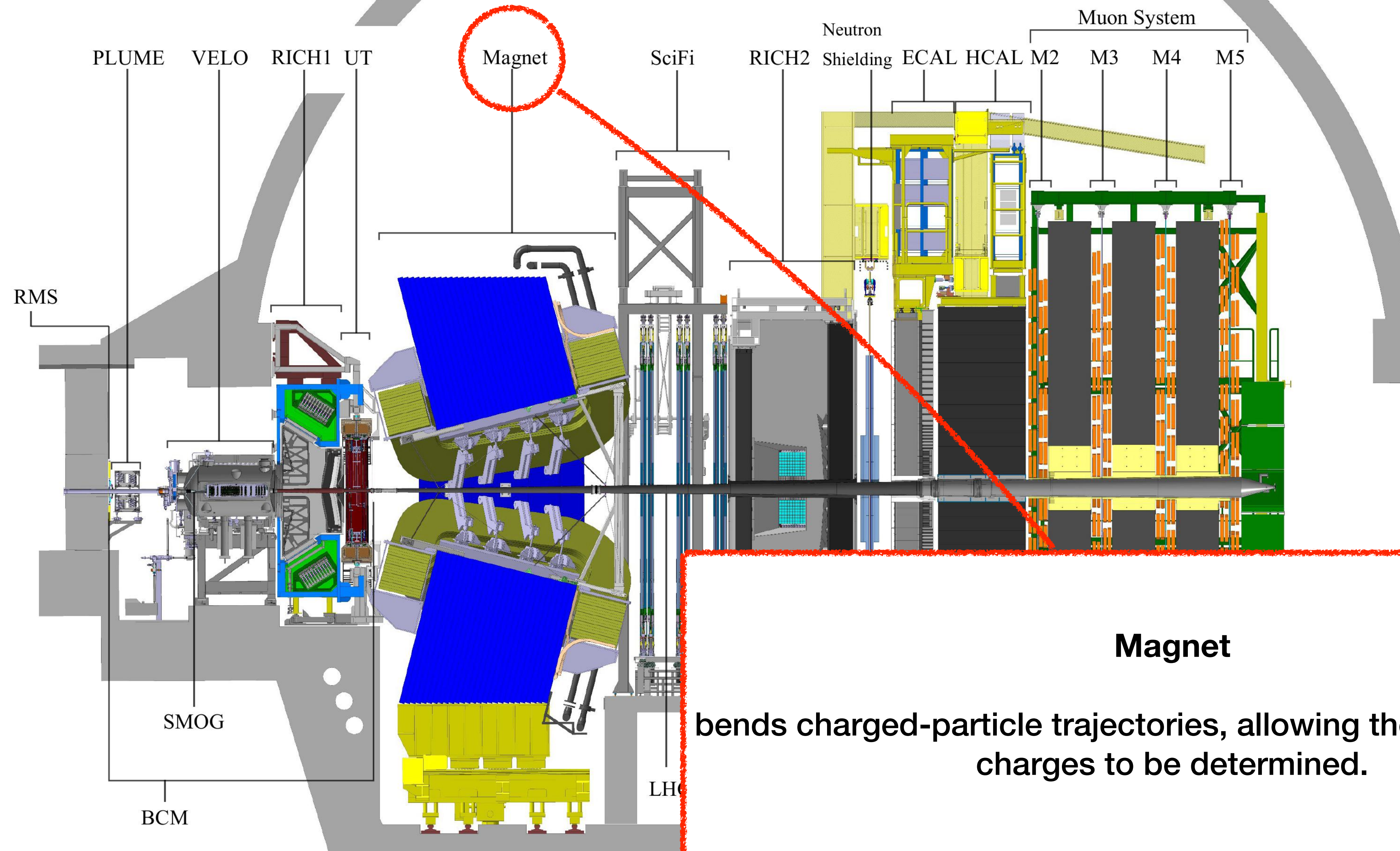
LHCb experiment layout



UT – Upstream Tracker

measures charged-particle trajectories upstream of the magnet and improves momentum reconstruction.

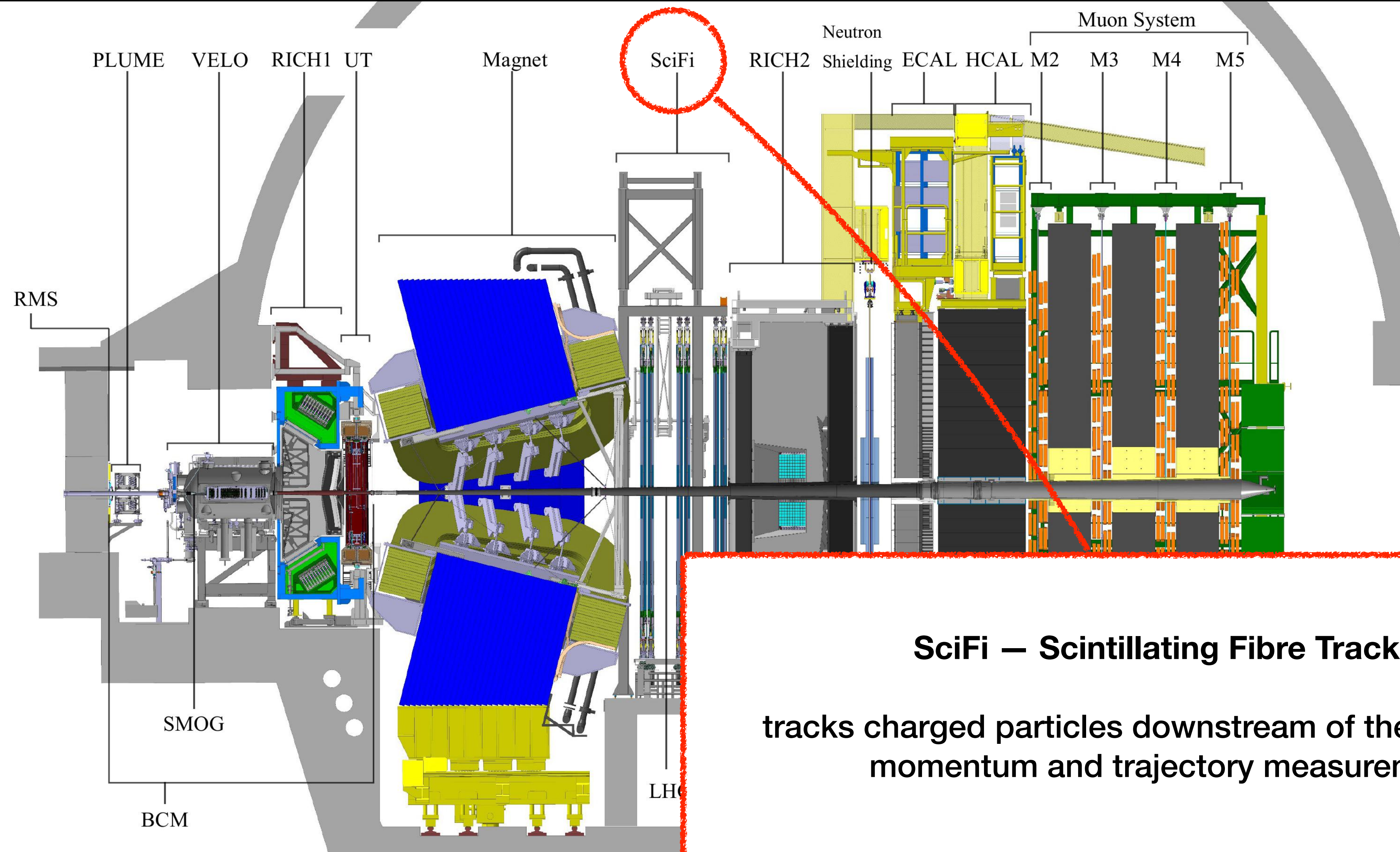
LHCb experiment layout



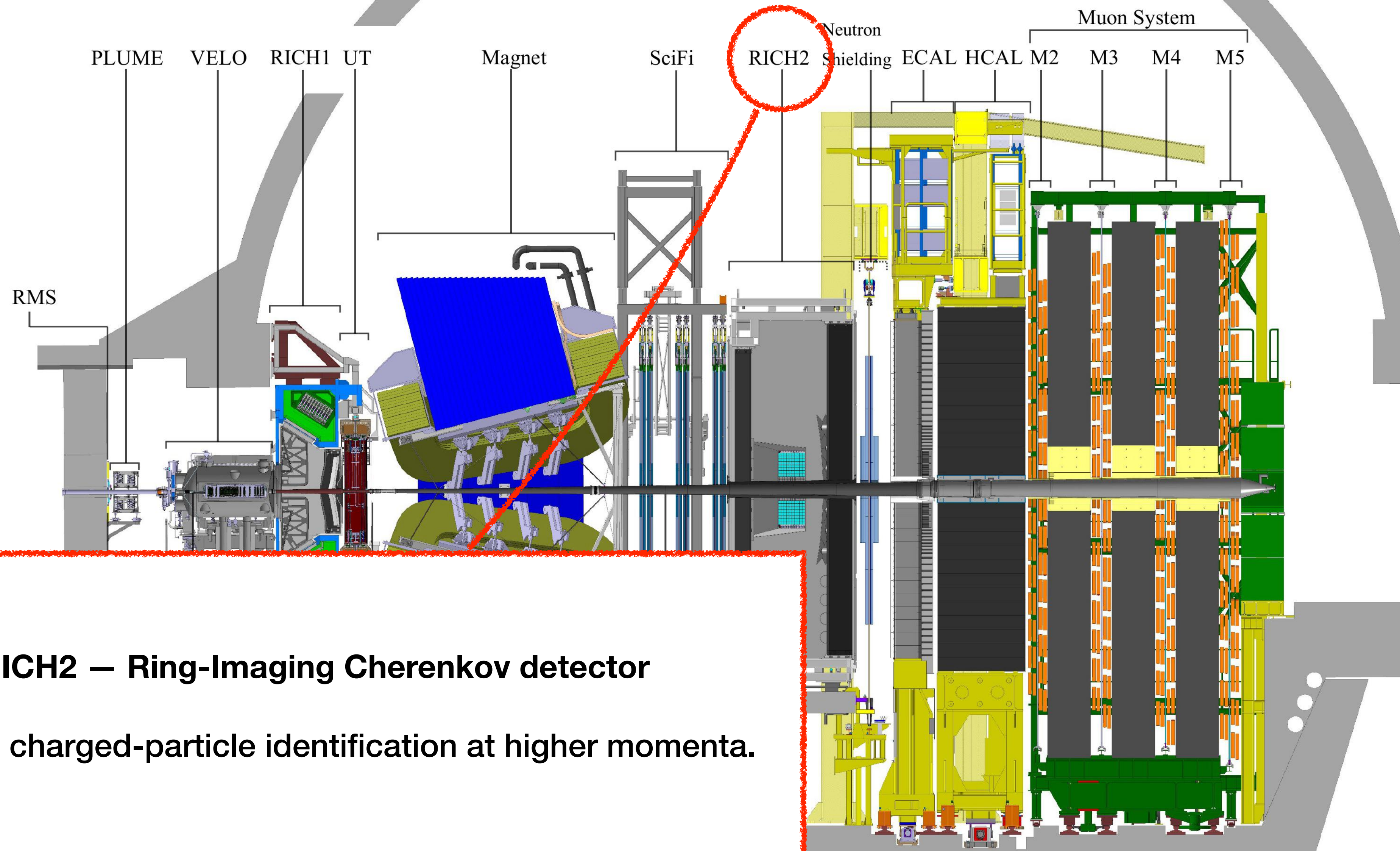
Magnet

bends charged-particle trajectories, allowing their momenta and charges to be determined.

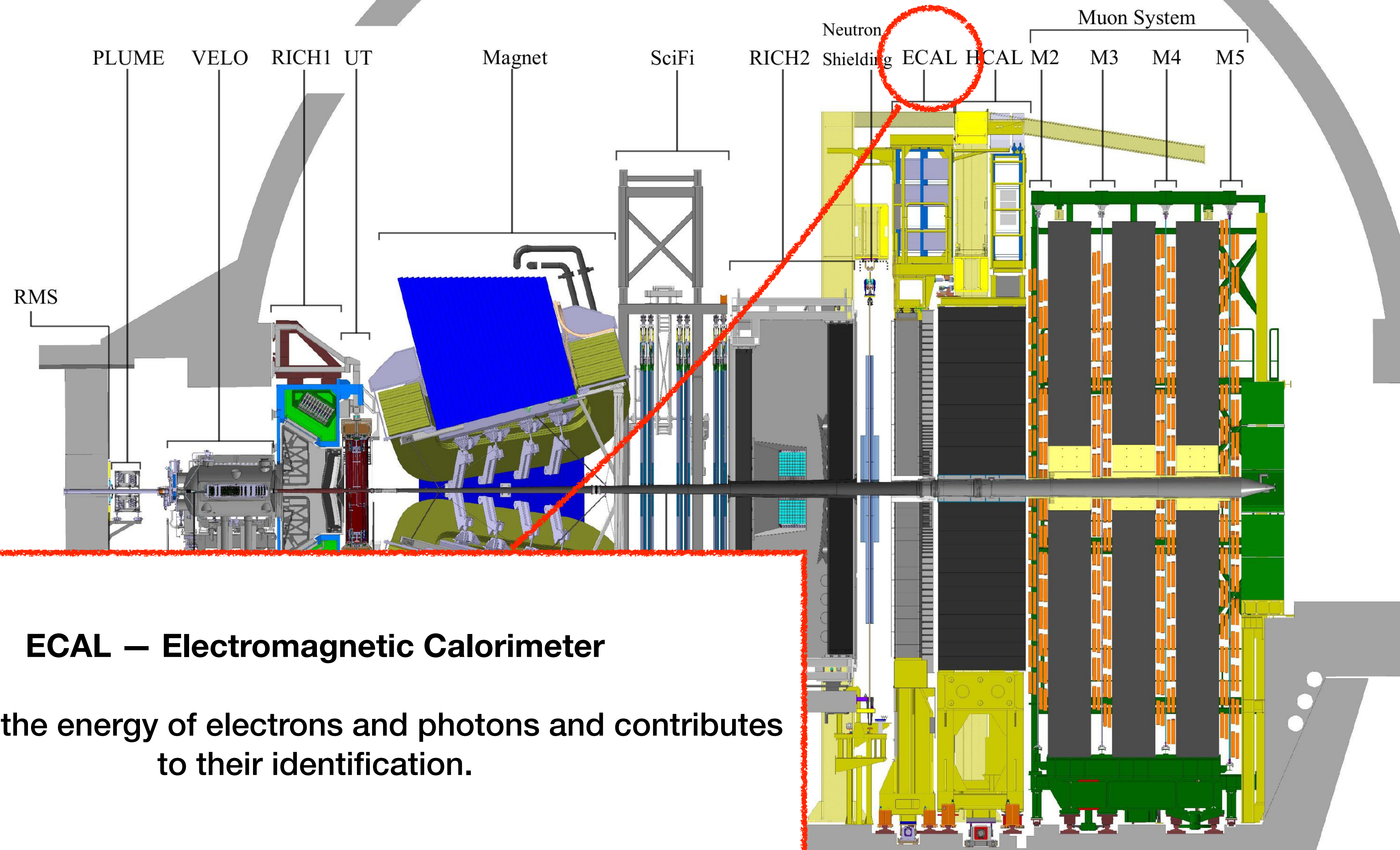
LHCb experiment layout



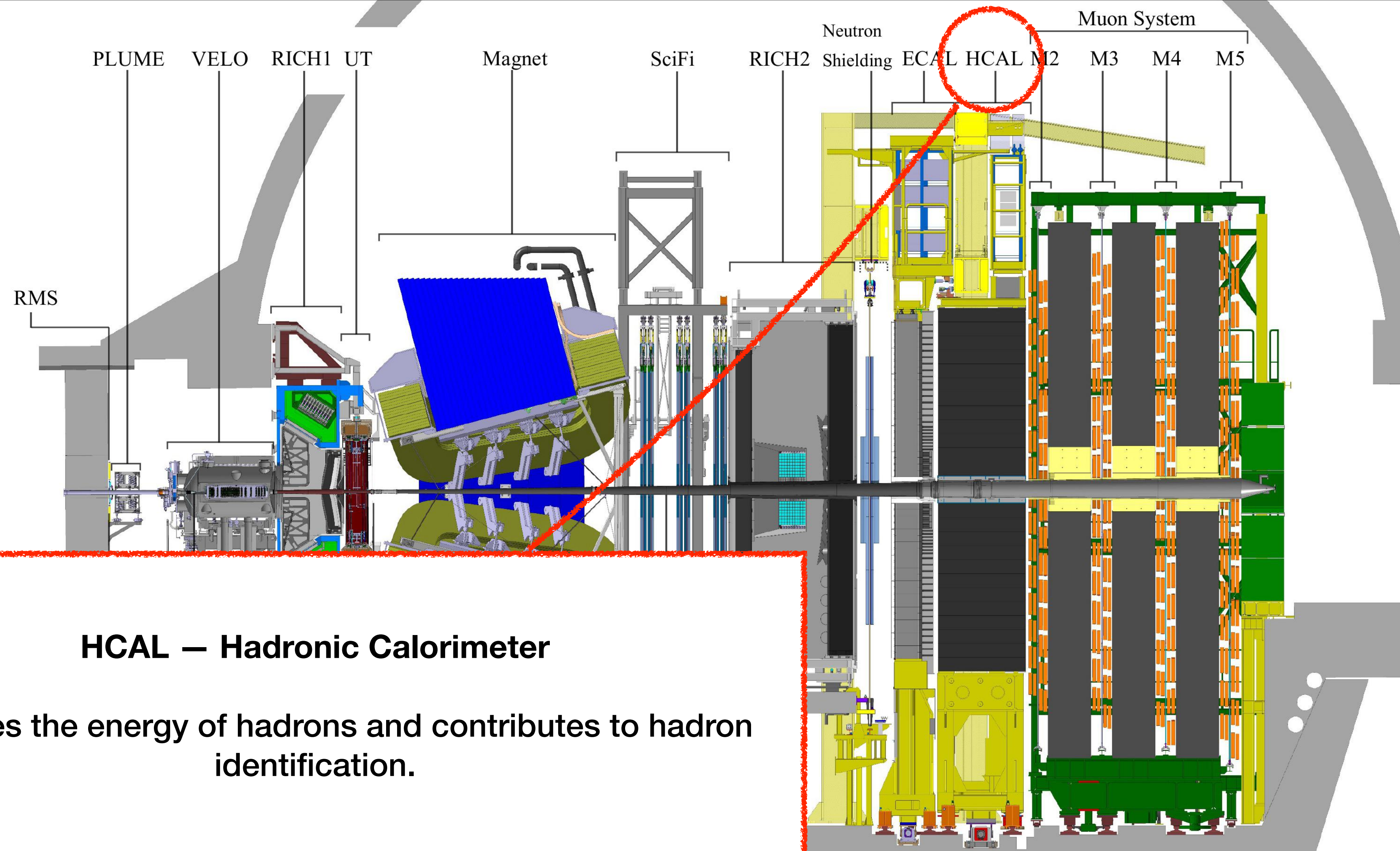
LHCb experiment layout



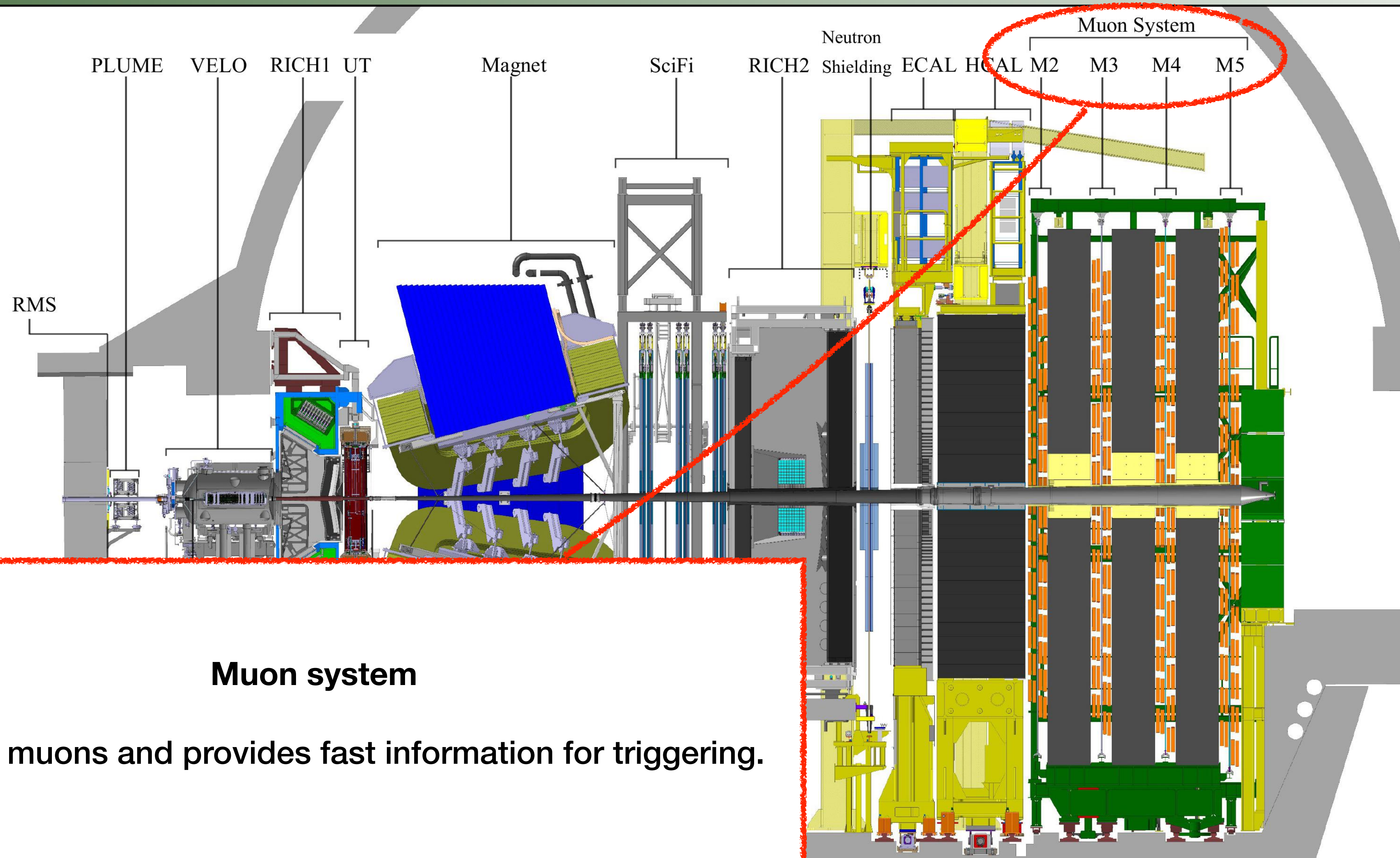
LHCb experiment layout



LHCb experiment layout



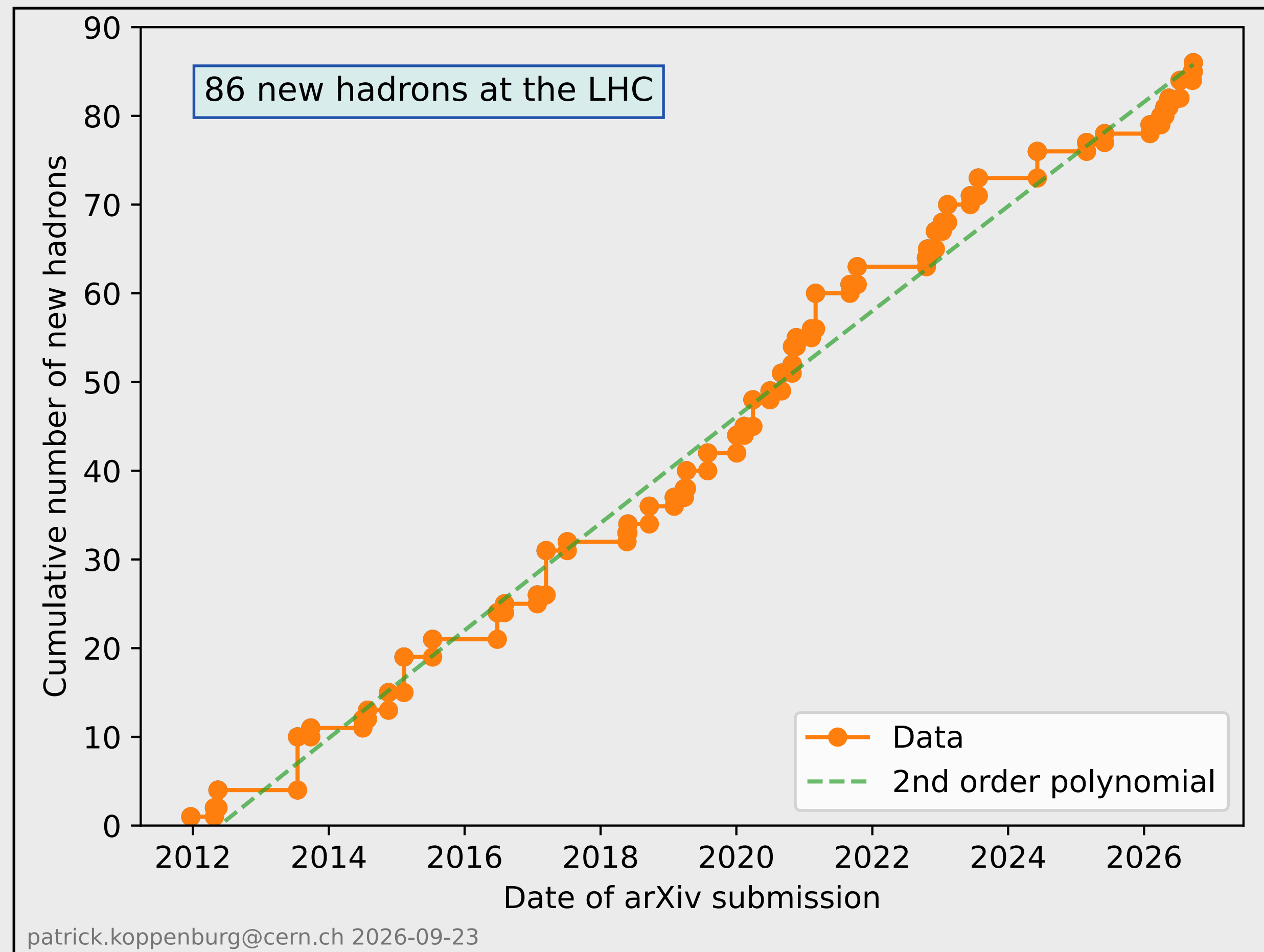
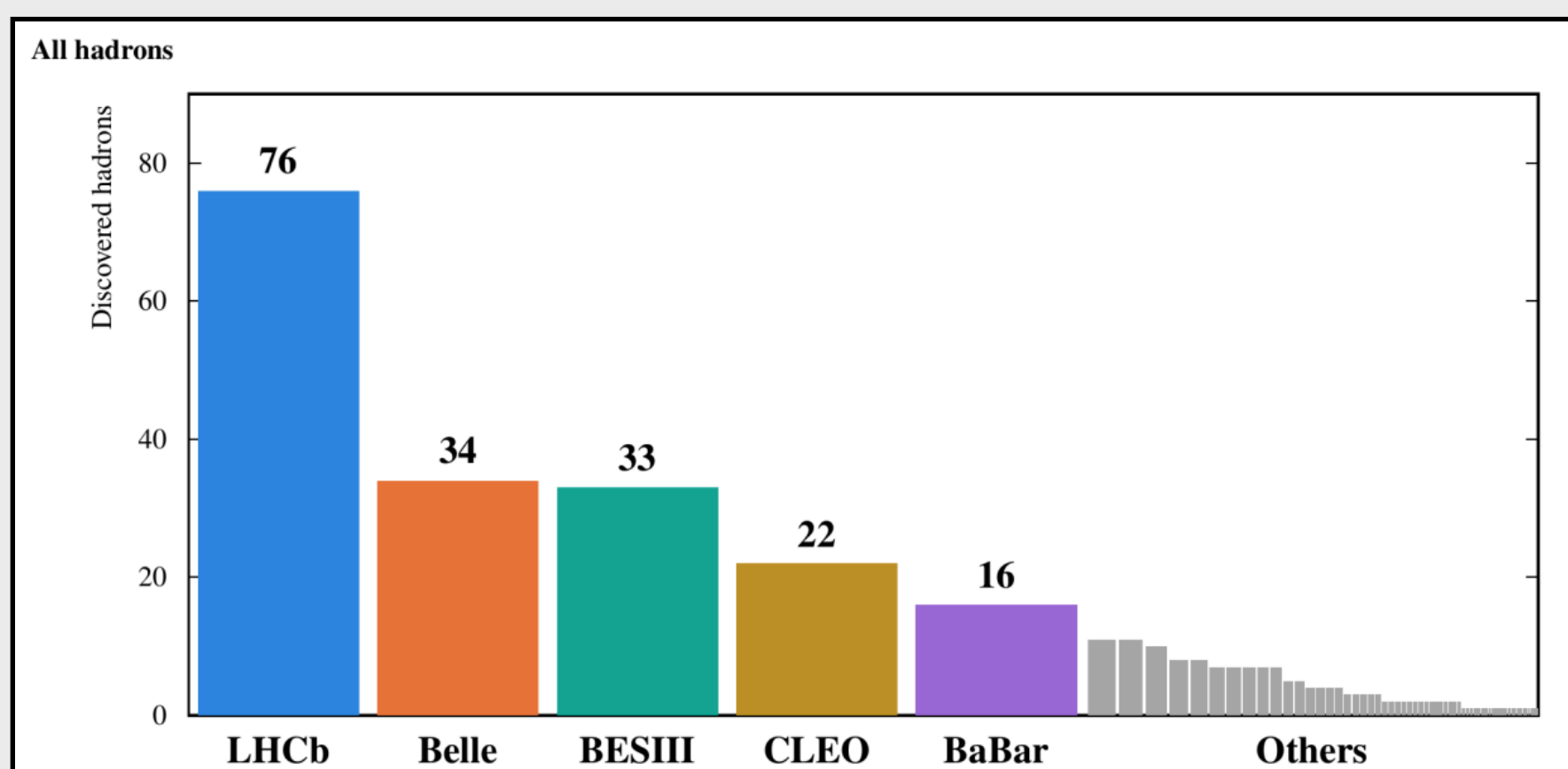
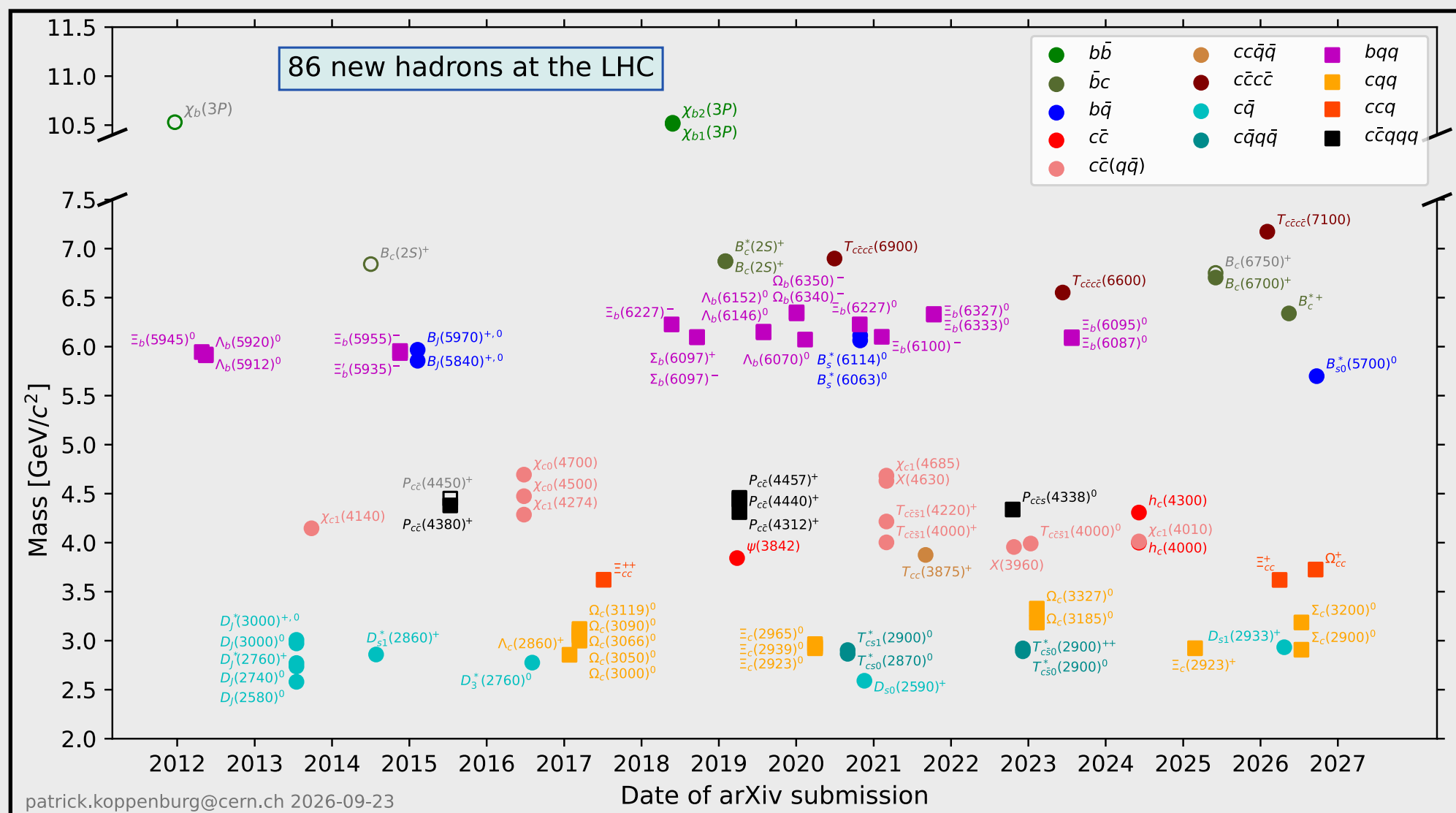
LHCb experiment layout



LHCb experiment success



- So far **86 hadrons** have been discovered at the LHC, of which **76 by LHCb**.





LHCb Collaboration

- **1995:** Letter of Intent
- **1998:** Experiment approved
- **2008:** First data
- **2019–22 (LS2):** Upgrade I - over 90% of its active electronics, detector channels, and the data acquisition system replaced.
- **LS4:** Upgrade II for Run 5 and Run 6 era
- **1876 members** from 112 institutes in 28 countries
- **1194 authors** from 120 institutes

⁴⁸ Jozef Stefan Institute, Ljubljana, Slovenia

Team Leader: Rok Pestotnik

Members: Andrej Lozar, Andrej Seljak, Blaž Leban, Boris Gardinovacki, Frank Bernard Grijalva Iii, Kristof Spenko, Rok Dolenec, Rok Pestotnik

 JSI

Jozef Stefan Institute

Official institute in LHCb

 Country
Slovenia

 Code
003996

 Team leader
Rok Pestotnik

 Deputy team leaders
Blaz Leban

Members status
8 active members

 REGISTRATION REQUESTS

Participations

Active participation

Status
Official

Start date
2026-02-19

End date
-

Comments
-

Closed participation

Status
Technical Associate

Start date
2018-06-13

End date
2026-02-18

Comments
-

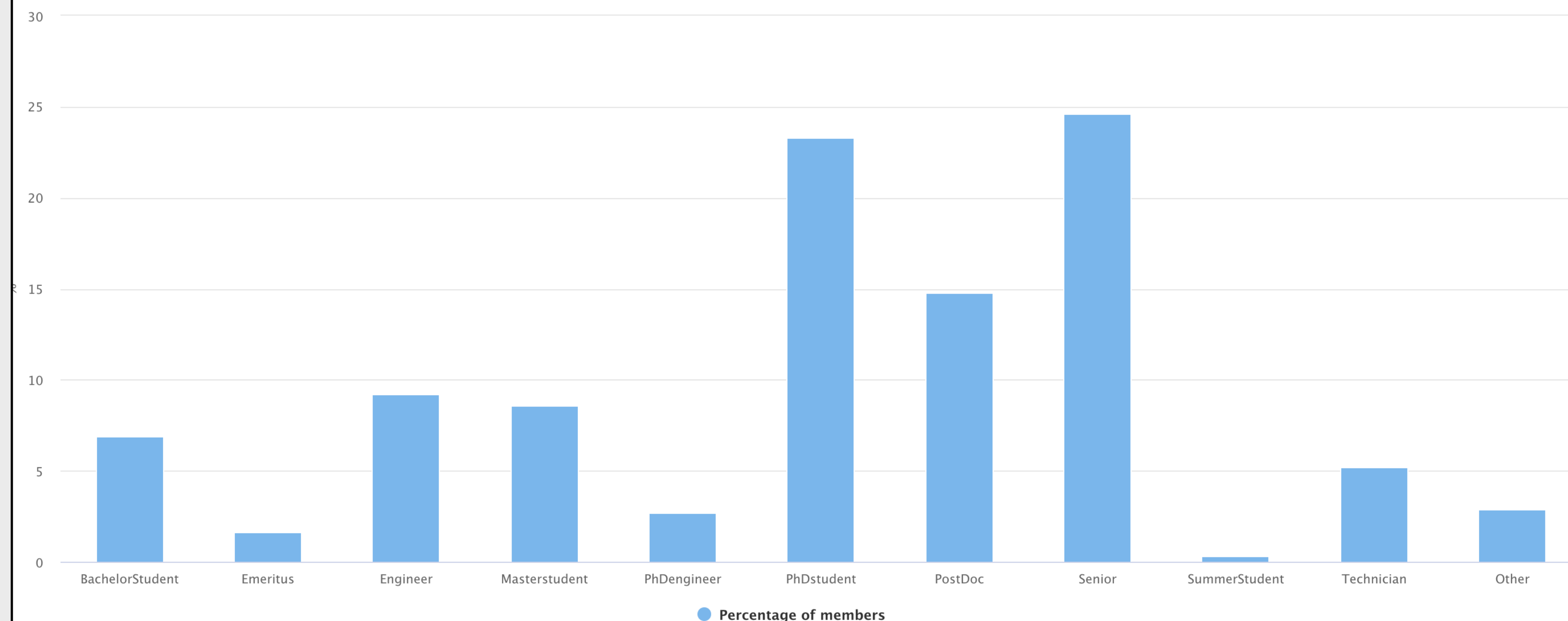
Associated to
Particle Physics, Department of Physics

LHCb Collaboration

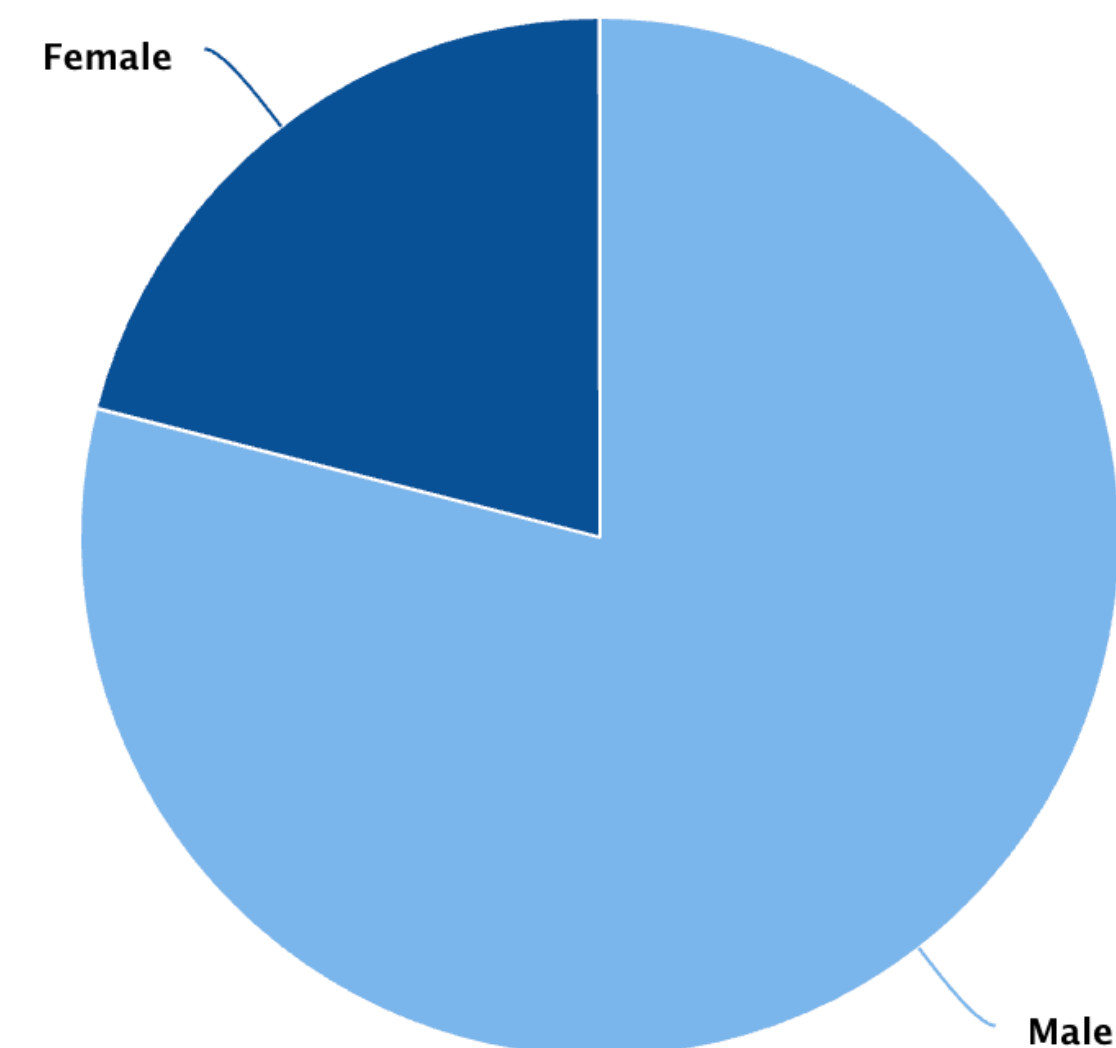


- **PhD students: 23.3%**
- **Postdocs: 14.8%**
- **Seniors: 24.5%**

Member distribution by profession



Gender distribution in LHCb





Past, present, future...

- 13 Jun 2018 - 18 Feb 2026: **Technical Associate** through the University of Oxford.
- Contributed to detector R&D:
 - RICH,
 - TORCH (withdrawn from Upgrade II).
- Involved in beam tests since 2021.
- LS3 Enhancement:
 - Responsible for the design and production of the electronics backboard, quality assurance, and radiation hardness of the electronics.
- Upgrade II:
 - Evaluation of the photosensor and mitigation strategies for the detectors.

JSI becomes a Full Member



European Organization for Nuclear Research
Organisation européenne pour la recherche nucléaire

CERN
CH 1211 - GENEVA

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Email: menzemer@physi.uni-heidelberg.de

Professor Rok Pestotnik
Josef Stefan Institute
Experimental Particle Physics
Department
Jamova 39
PO Box 3000
1001 Ljubljana
Slovenia

Geneva, 03rd of March 2026

Dear Professor Pestotnik,

It is our pleasure to inform you that the LHCb Collaboration Board decided to accept the application of your group at Josef Stefan Institute, in Ljubljana, Slovenia as a Full Member of the LHCb experiment in its meeting on 19th of February 2026.

The CB highly appreciates your significant involvement in RICH and TORCH efforts in the past and is looking forward to your future contributions to the RICH project and to the general operation of the experiment. The CB welcomes your huge expertise in flavor physics. It is excited about upcoming analysis efforts of your group but likes to remind you to carefully separate those from the Belle II involvement of parts of your institute.

These contributions must be formalised in the form of an addendum to the existing Memorandum of Understanding for operating the LHCb experiment, to be signed by your University or Funding Agency.

We are looking forward to a fruitful collaboration.

Yours Sincerely,

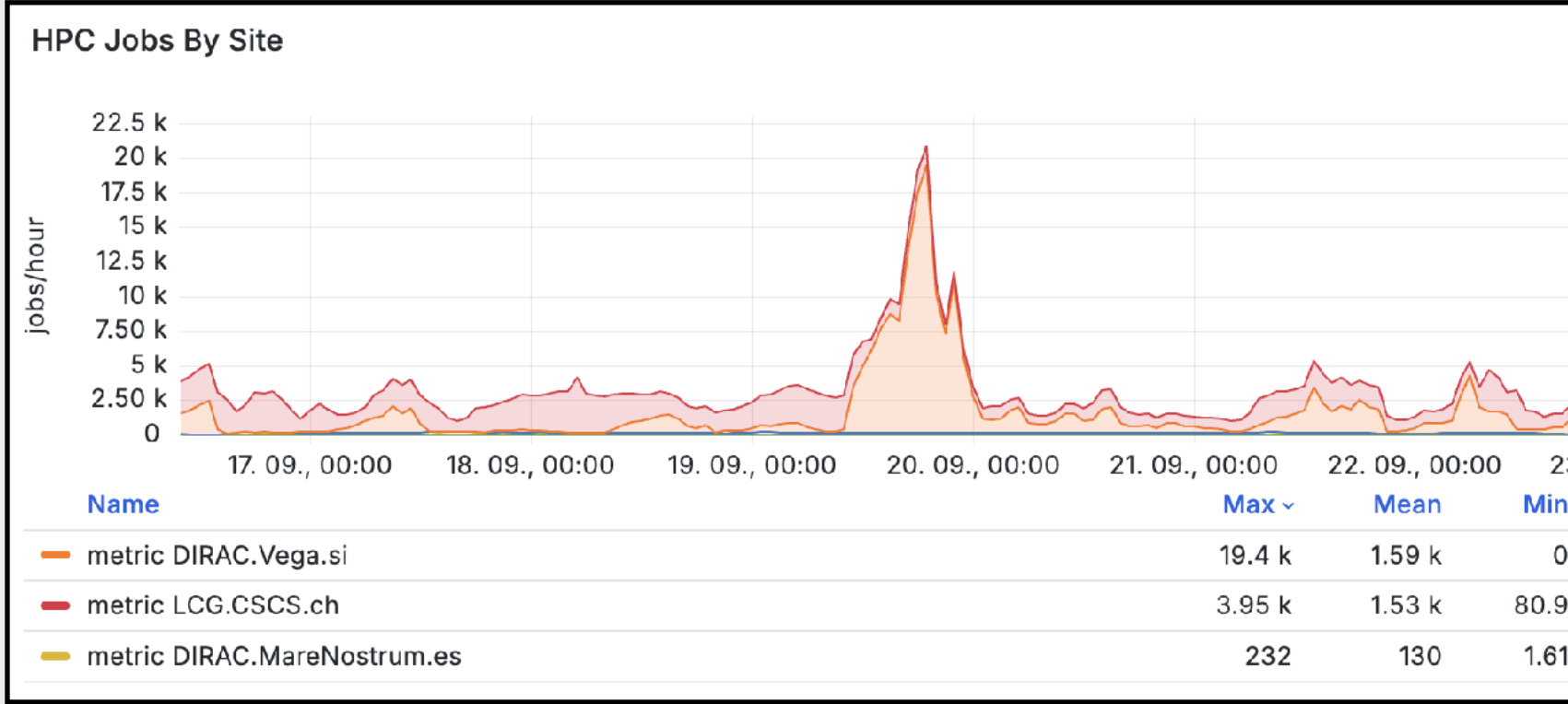

Vincenzo Vagnoni
Spokesperson of the LHCb Collaboration


Stephanie Hansmann-Menzemer
Chair of the LHCb Collaboration Board

cc :
Gautier Hamel de Monchenault, CERN, Director for research and computing

home.cern

- Building visibility within the collaboration:
 - Taking **shifts**, which helps us get to know the LHCb software.
 - Improving **tutorials and documentation**.
 - Participating at **collaboration events**.
- We are currently offering **opportunistic use of the Vega HPC**. If there are no site issues, a few thousand jobs are running.



Assignments						
August 2026						
Mon	Tue	Wed	Thu	Fri	Sat	
27	28	29	30	31	1	
DQCS Shift	DQCS Shift	DQCS Shift	DQCS Shift	DQCS Shift	DQCS Shift	DQCS Shift
3	4	5	6	7	8	
DQCS Shift	DQCS Shift	DQCS Shift	DQCS Shift	DQCS Shift	DQCS Shift	DQCS Shift
10	11	12	13	14	15	
MC production chi	MC production chi	MC production chi	MC production chi	MC production chi		
17	18	19	20	21	22	
MC production chi	MC production chi	MC production chi	MC production chi	MC production chi		
24	25	26	27	28	29	
MC production chi	MC production chi	MC production chi	MC production chi	MC production chi		
31	1	2	3	4	5	
MC production chi	MC production chi	MC production chi	MC production chi	MC production chi		

LHCb Run 3 Starterkit

HOME

First Analysis Steps

Second Analysis Steps

The Run 3 Data Set

Contributing

Interesting Links

Welcome to the Run 3 LHCb Starterkit

If you have any problems or questions, you can [send an email to jls](#)

Prerequisites

Before starting you should be familiar with using a shell, like bash, and with programming. The *analysis essentials* course has an introduction to these topics, as does the *software* course. Both include many other useful computing tools.

Credits

The Run 3 LHCb Starterkit was originally authored by:

Miguel Fernandez Gomez

Janine Gooding

Luke Guzzetta

George Hillier

Andy Morris

Enay Muhammad

Nicola Sciamanna

Mark Smith

Aldin Wierchold

With additional contributions by:

Ahmed Abdelmotaleb

Chris Burr

Ross Hunter

Patrick Koopman

Blaž Leban

Lorenzo Piccolo

Sascha Stahl

Wed Sep 23rd, 2026

LHCb

LHCb

Large Hadron Collider beauty experiment

HOME

LHCb NEWS

PHYSICS

DETECTOR

FILTERING DATA

COLLABORATION

INSTALLATION

ACTIVITIES

The LHCb activity book

Enjoy the activity book by the LHCb Collaboration, written for kids (and adults) of all ages!

The LHCb Experiment colouring book introduces kids to the field of High-Energy Physics with special focus to the physics research at LHCb Experiment: the search of new particles.

Free download

The LHCb Experiment activity book – English

Le livre d'activités de l'expérience LHCb – Français (French)

Il libro d'attività dell'esperimento LHCb – Italiano (Italian)

Das Aktivitätsbuch zum LHCb-Experiment – Deutsch (German)

Livro de atividades da Experiência LHCb – Português (Portuguese)

Kritička aktivnosti za eksperiment LHCb – Srpskohrvatski (Serbo-Croatian)

LHCb实验活动书 – 中文 (Chinese)

Download: zvezek eksperimenta LHCb – Slovenski (Slovenian)

El libro de actividades del experimento LHCb – Español (Spanish)

LHCb Experimenten jarduera liburua – Euskara (Basque)

LHCb гуримтын даалгавартай ном (Mongolian)

LHCb كتاب أنشطة الفيزياء (Arabic)

Het LHCb-experiment: een werkboek (Dutch)

Leabhar oibre an Tuirgnimh LHCb – Gaeilge (Irish)

Terms of Use and Credits

The LHCb Experiment Activity book is free to download for personal and educational use.

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Credits:

Illustrations by Yasmine Amis

Text and Activities by Violaine Boilee and Silvia Borghi

With many thanks to those who helped to translate into other languages and proof reading: Rolf Linde, Carla Göbel, Vava Gilepov, Aleksandra Felkova, Yinghui Hou, **Blaž Leban**, Alejandro Perez Casas, Mary-Elizabeth Richardson-Sipper, Eleonora Ciani, Janina Nicolini, Carina Trippel, Nathan Heatley.

LHCb

LHCb

Powered by WordPress | Theme: Vantage by ThemeForest modified by LHCb-JC

August 15



Jan Peter Wagner

15:09

Hi,

thanks for all the valuable work in the simulation right now, last week and now

Let me know if I can support you with anything 😊

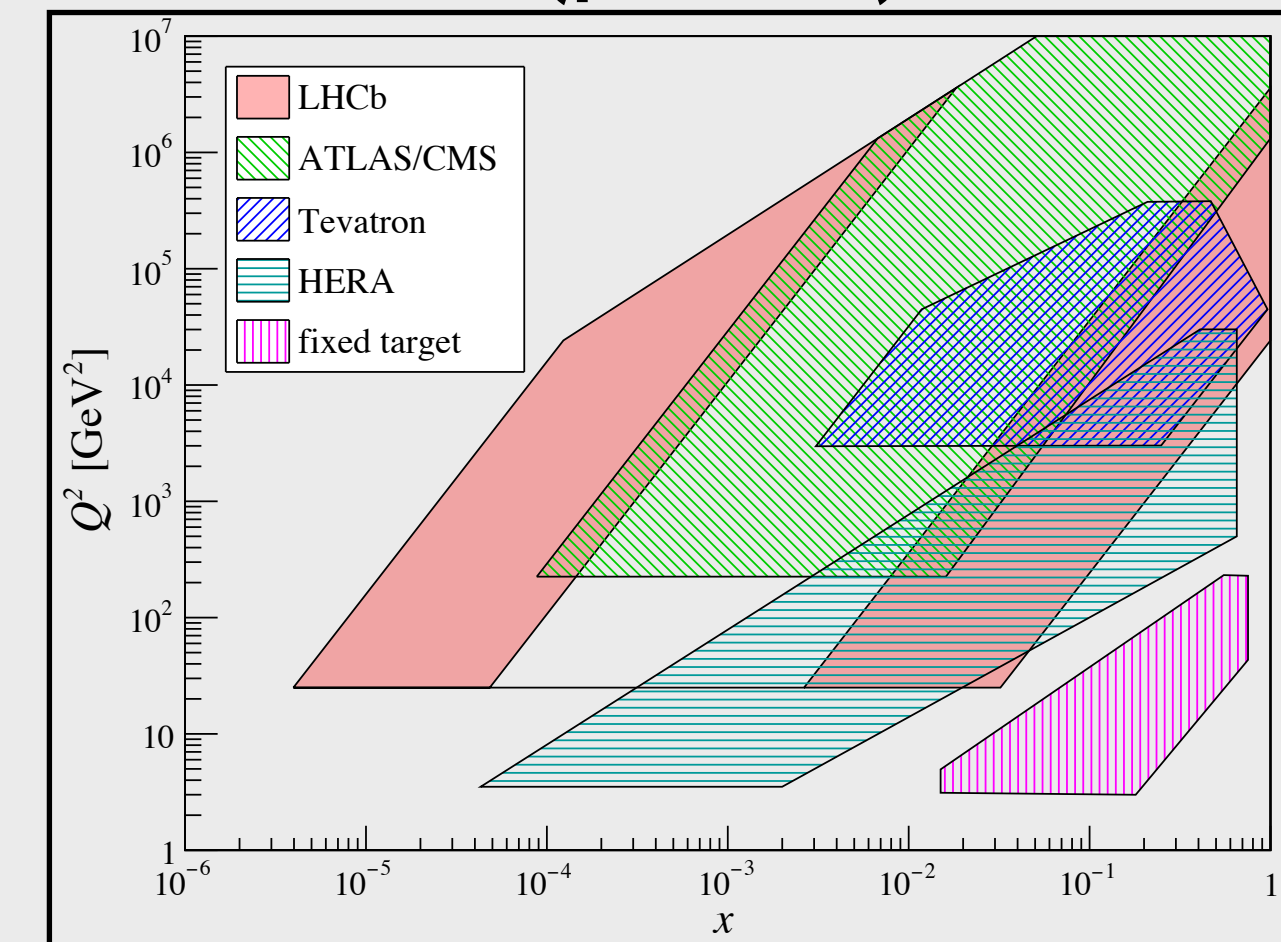
Analysis identifier	Paper identifier ↓	Assignment accomplished	Status	Contacts
QEE-XsectionV0Ratios-2024 🔗	LHCb-PAPER-2026-045	No	Waiting for second draft	Lukas Calefice; Noah Albin Behling
BandQ-Bspi0-Runs12 🔗	LHCb-PAPER-2026-021	Yes	Submitted	Liupan An; Marco Pappagallo; Yuhao Wang; Zifan Li

- Based on our experience in BSM exotic physics, we are **joining the QCD, Electroweak and Exotica (QEE) working group**.
- Due to **restricted access** to physics content until mid-summer, it was **challenging to identify** the most suitable **entry point**.
- Following discussions with the QEE WG coordinators (some of whom share similar past involvement in ATLAS), the recommendation was to begin with a relatively straightforward SM **measurement using Run 3 data**, e.g., a measurement of diboson (WW, ZZ), or W/Z +jets cross-section. We are in contact with:
 - *Davide Zuliani (Padova)* about contributing to Run 3 Z +jets analysis and potentially starting a Z +heavy flavour (HF) jets analysis (which includes common ML flavour tagging studies).
 - *Hengne Li (SCNU)* about contributing to ZZ analyses, with $H \rightarrow ZZ^*$ and electron channel feasibility study.
- This approach allows our group to **quickly integrate** into the WG operations and **build familiarity** with current software tools before progressing to more advanced and exotic BSM topics that better match our core expertise, while still providing **valuable contributions to the community**.

Postdoc Research Project Proposal



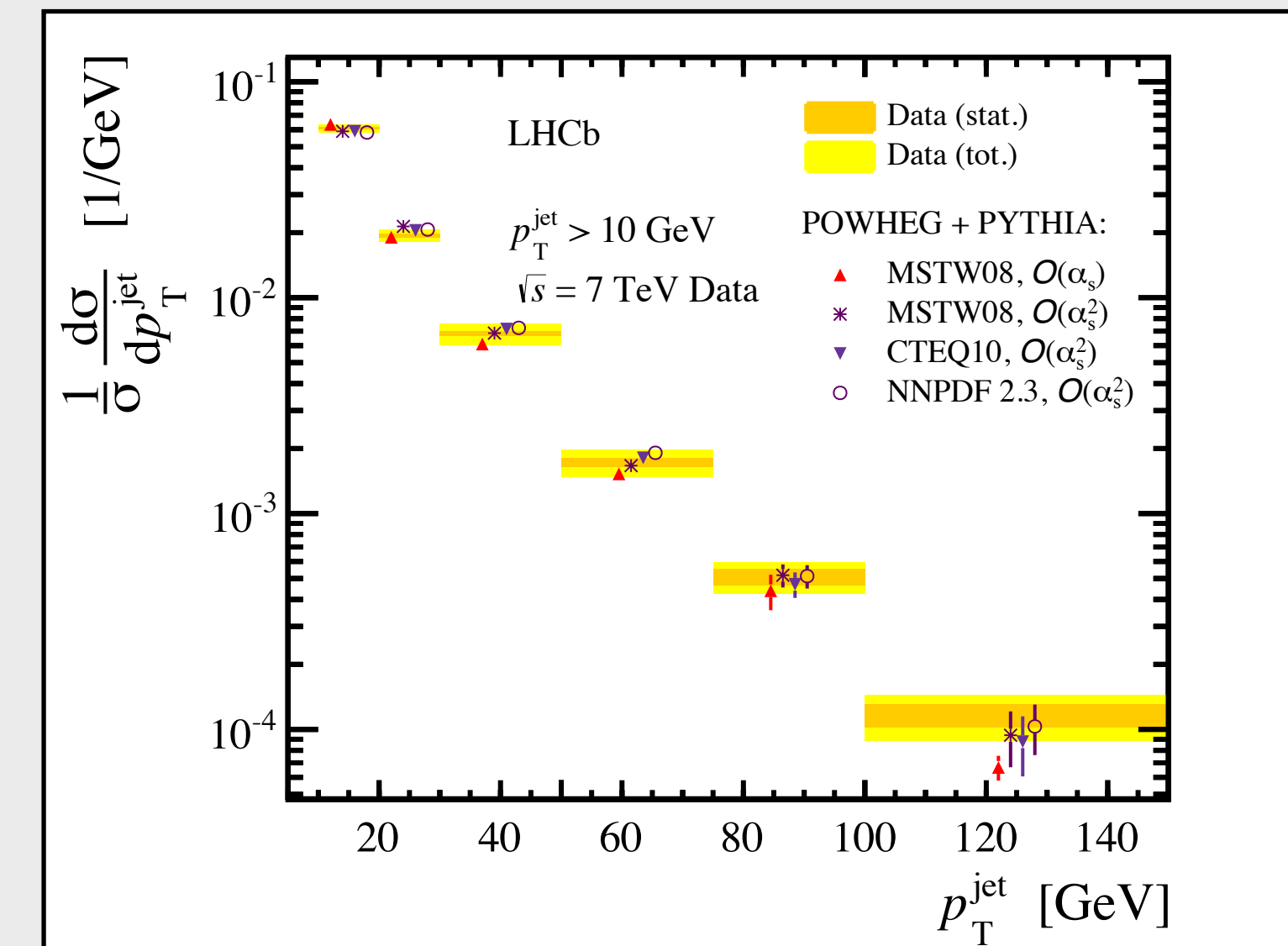
- The **Standard Model is highly successful but incomplete**, which motivates precision tests and indirect searches for new physics.
- **V +jets and diboson production** provide sensitive tests of perturbative QCD (pQCD) and the electroweak sector.
- **LHCb's unique forward acceptance** probes a complementary kinematic regime, including very high and very low Bjorken- x .
- **Run 2 + Run 3 datasets** provide substantially more statistics and higher collision energies than previous LHCb measurements.
- Precision measurements can **constrain PDFs, test SM predictions, and provide inputs to BSM searches**.
- Goal: **extend LHCb's electroweak physics reach** through precision measurements in a largely unexplored phase-space region.



Z+HF jets: Precision QCD and PDFs



- **Measure Z +jets production cross-sections** using the full Run 2 + Run 3 LHCb dataset and extend previous LHCb measurements to $\sqrt{s} = 13$ and **13.6 TeV**, with significantly improved statistical precision.
- **Method:**
 - Exploit LHCb's forward acceptance to probe **parton distributions at extreme Bjorken- x** .
 - Compare measurements with **state-of-the-art QCD predictions and Monte Carlo generators**.
 - Target **clean muon final states**, followed by a feasibility study of an extension to **electron states**.
- **Result:**
 - Measure **differential cross-sections** in Z and jet kinematics and their correlations.
 - Provide **new constraints for global PDF fits** and tests of pQCD.
- **Bonus:**
 - Develop improved forward-jet reconstruction/tagging, including **modern ML-based jet-tagging**.



ZZ: First measurement in the forward region



- **Motivation:**

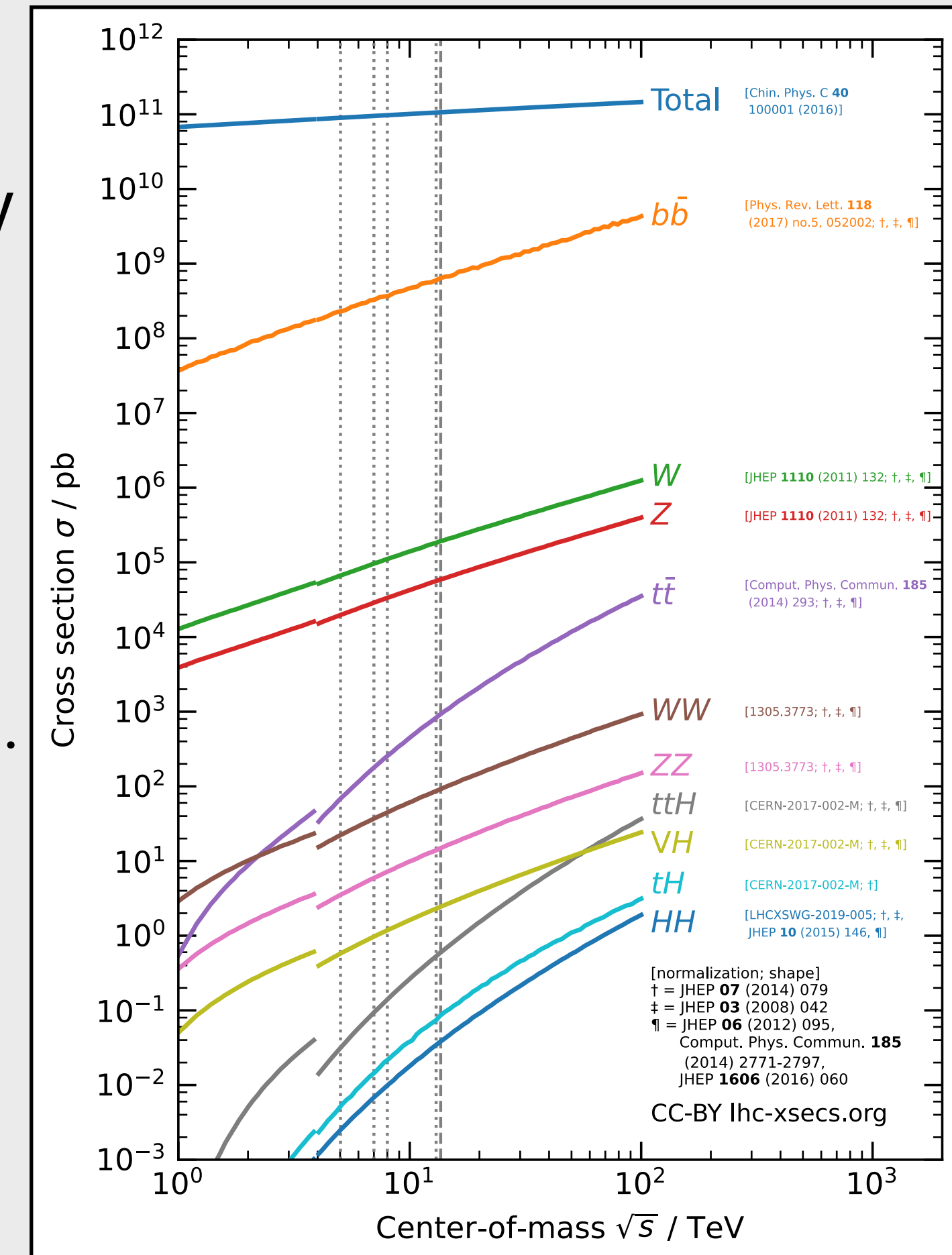
- **First measurement** of ZZ production in the LHCb acceptance - a previously unexplored region.
- ZZ production provides a **precision test** of the electroweak sector and **sensitivity to anomalous triple gauge couplings** (aTGC).

- **Method:**

- Start from the $ZZ \rightarrow 4\mu$ channel and contribute to existing Run 2 analyses.
- Study the feasibility of including **electron final states** ($4e$, $2e2\mu$) to increase signal yield and precision.
- Evaluate detector performance, electron identification, reconstruction and systematic uncertainties.

- **Bonus:**

- Assess the feasibility of Higgs “golden channel” search in the forward region and potentially establish a new avenue for studying $H \rightarrow ZZ^* \rightarrow 4\ell$ at LHCb.



Long-term physics plans



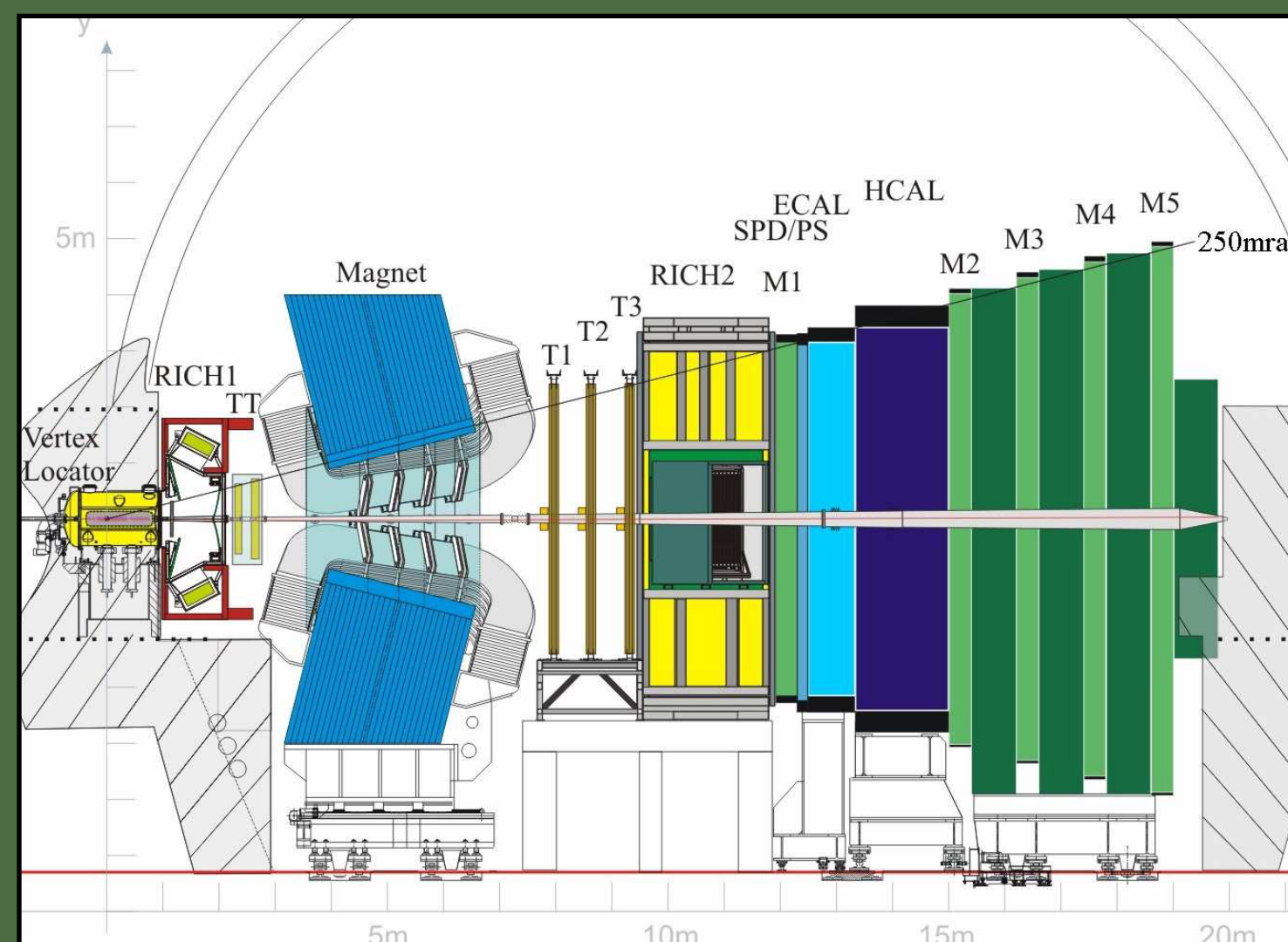
- Depending on **person power** and **interests**, a progression towards flavour physics would open a larger field of physics opportunities:
 - Possible collaboration with flavour-physics theory colleagues from the F1 department, who previously expressed interest in our joining the LHCb experiment.
 - We will need to be careful to stay orthogonal to Belle II physics at F9, to avoid potential overlap or conflict of interest.
 - We will need a good strategy to bring in more people (or bring people back) in order to stay broad.
- Personally, I definitely want to stay within the Simulation Project.
- If LHCb gets pledged allocation at Vega, somebody (me) will need to take care of its maintenance.

Future?
• Likelihood to stay with LHCb: 9/10 • Likelihood to stay in charm: 7/10 • Would pursue CPV in multibody D decays • Preference between detector and software: software • Would stay in RTA

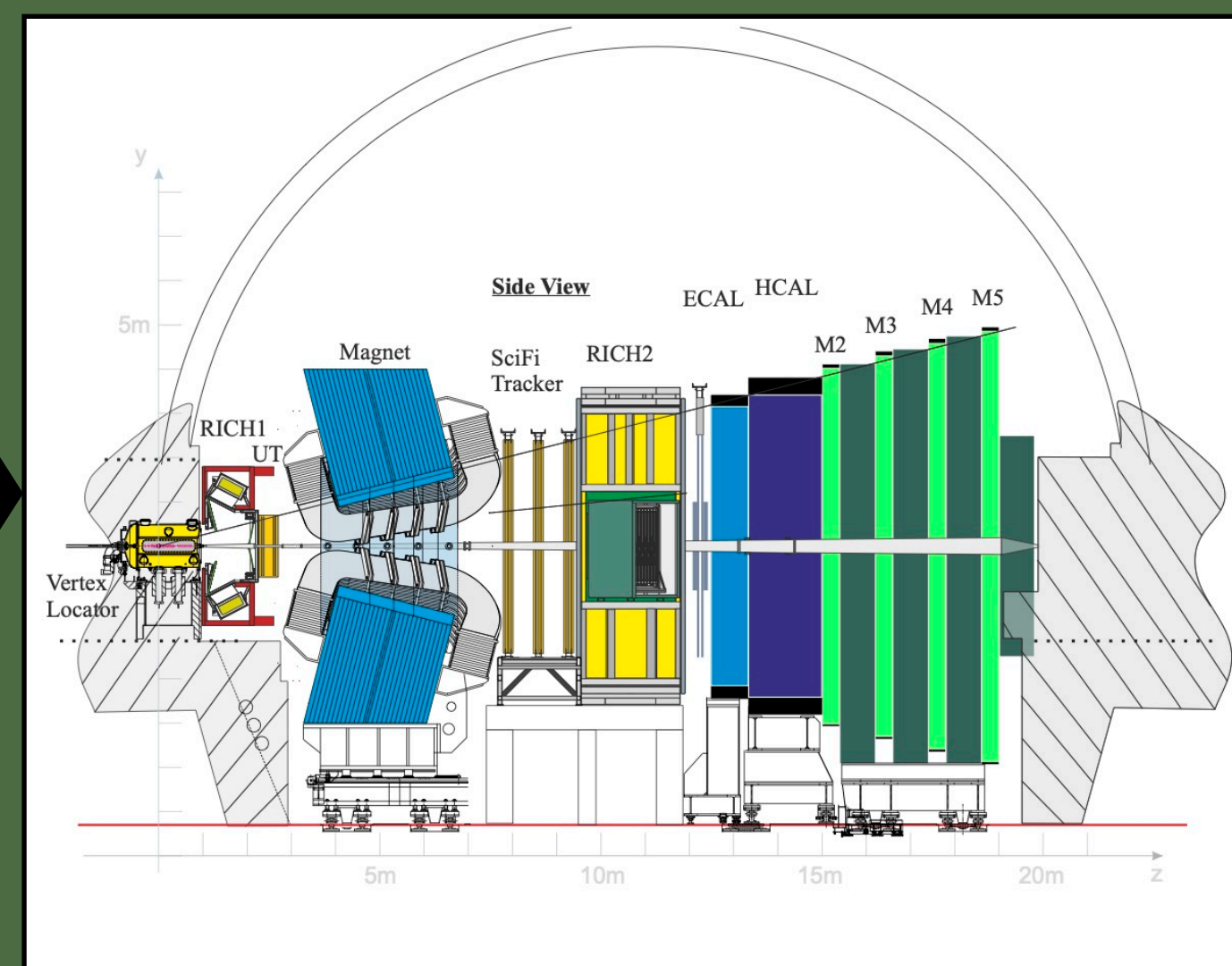
T. Nanut Petrič, Strateško srečanje sodelavcev Odseka za eksperimentalno fiziko osnovnih delcev, 21.-23. 9. 2022

From the last F9 strategic meeting in 2022.

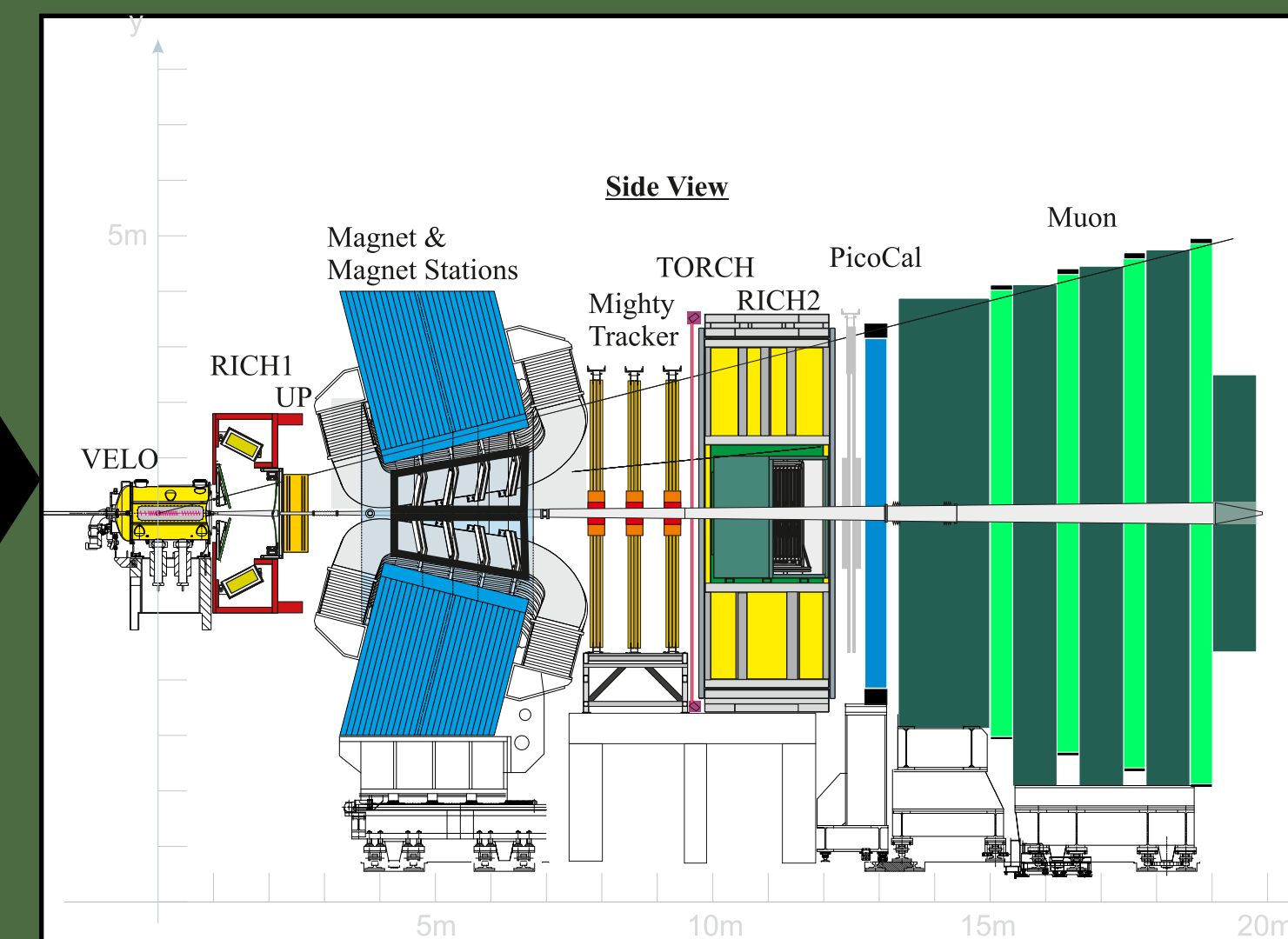
LHCb Upgrade II



Original detector layout



Upgrade I detector layout

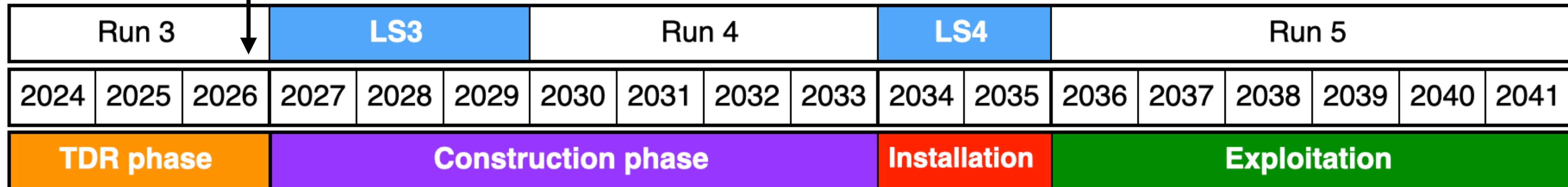


Upgrade II detector layout

Upgrade II timeline



We are here



Running luminosity
 $\sim 2 \times 10^{33} \text{ cm}^{-2} \text{ s}^{-1}$.

Greatly improved tracker and
PID granularity, GPU trigger
performing a near-full detector
reconstruction.

Maintain the running luminosity at
 $\sim 2 \times 10^{33} \text{ cm}^{-2} \text{ s}^{-1}$.

Enhanced PID with improved timing.

Increase the running luminosity to
 $\sim 1 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$.

Employ 4D (including timing) in new
tracking, PID, and new high
granularity pixel detector.

Upgrade II funding scenarios



- Uncertain funding prospects have recently forced LHCb to focus on a low-scope scenario.
 - UKRI: UII “Not prioritised for further funding”.
- Optimisation studies are underway:
 - reduced acceptance** in the high η region,
 - cheaper technology** for VELO mechanics,
 - increased reuse** of current detectors in the RICH,
 - single readout** in most PicoCal modules,
 - no** Magnet Stations and TORCH **subdetectors**.
- Studies suggest that differences in physics performance can be minimised.
 - The uniqueness and excitement of the LHCb Upgrade II physics programme will be retained.

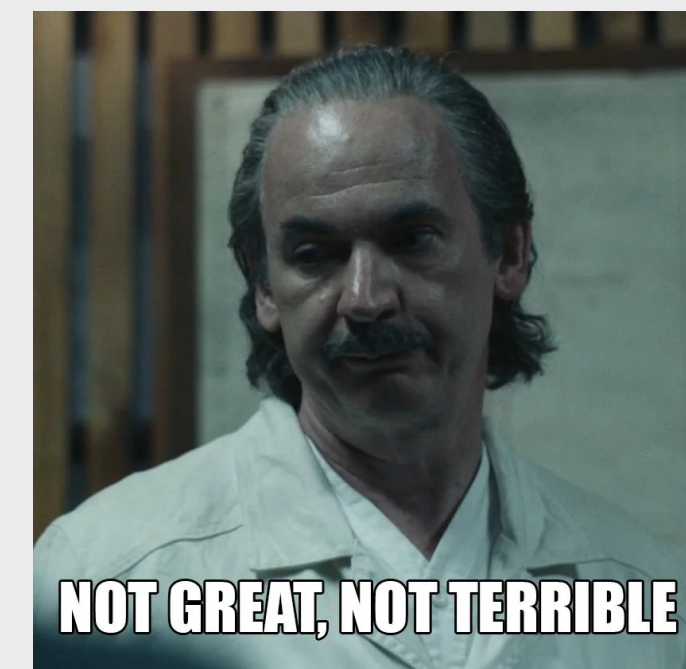
	Baseline	Middle	Low
$L_{\text{peak}} (10^{34} \text{ cm}^{-2} \text{ s}^{-1})$	1.5	1.0	1.0
Total recorded $L_{\text{int}} (\text{fb}^{-1})$ (round optics)	297	262	262
Cost (MCHF)	181.5	156.3	124.7

Middle vs Baseline

- ~12% luminosity loss, reduced flexibility to run at higher pile-up
- longer levelling time → better data taking stability
- comparable detector performance

Low vs Middle

- significant degradation in detector performance
- reduced acceptance, worse signal background separation
- much reduced breadth of programme

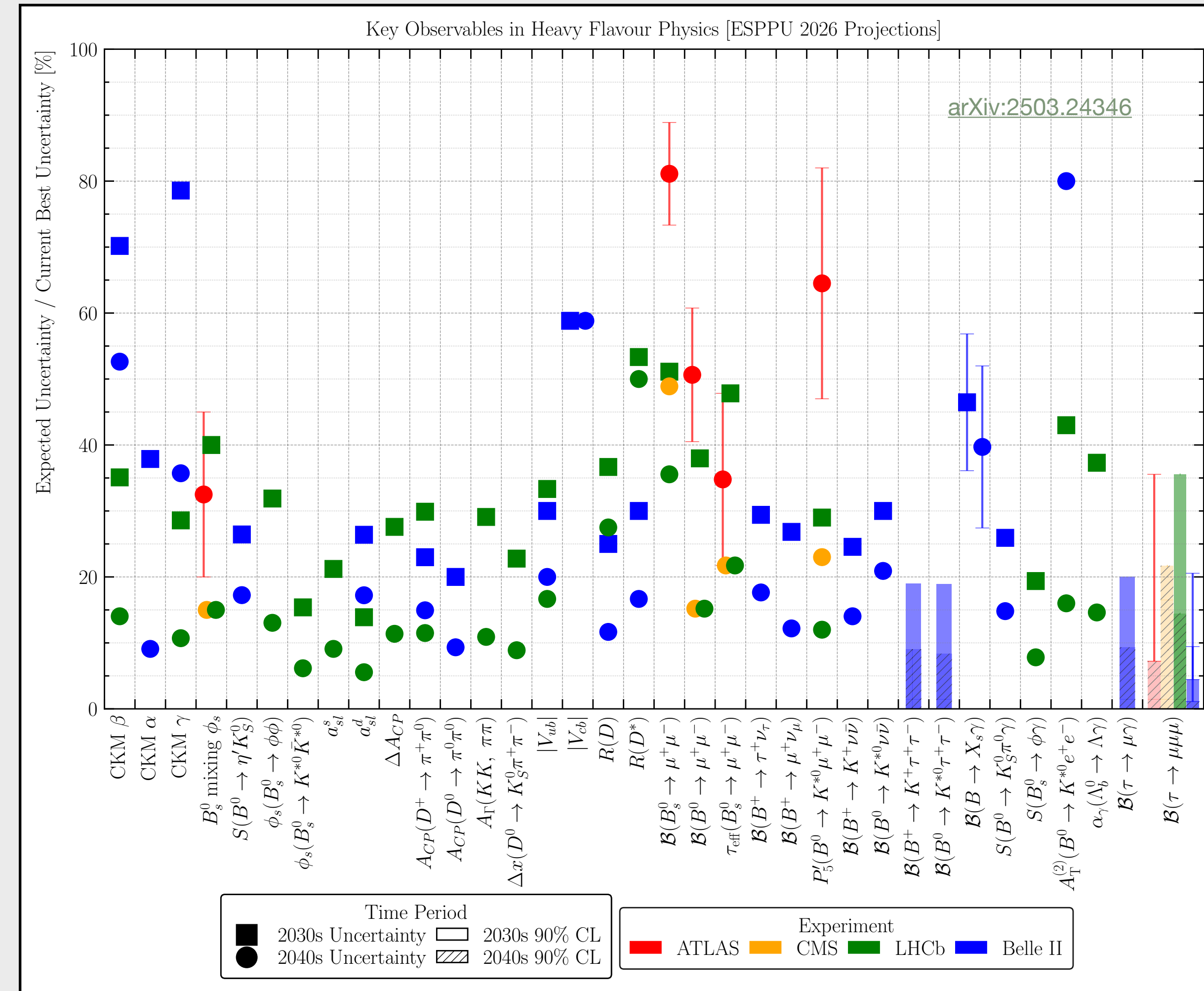


Projections in HF physics



- European Strategy for particle physics:
 - LHCb Upgrade II (middle scenario) ● would give the best precision to the broadest range of key observables.
 - Belle II ● has a unique capability for modes with multiple neutrals or missing particles.
 - ATLAS ● and CMS ● will be competitive for modes with multiple muons.

NOTE: The LHCb Upgrade II physics programme also includes spectroscopy, heavy ion physics, EW precision measurements, dark sector searches ...



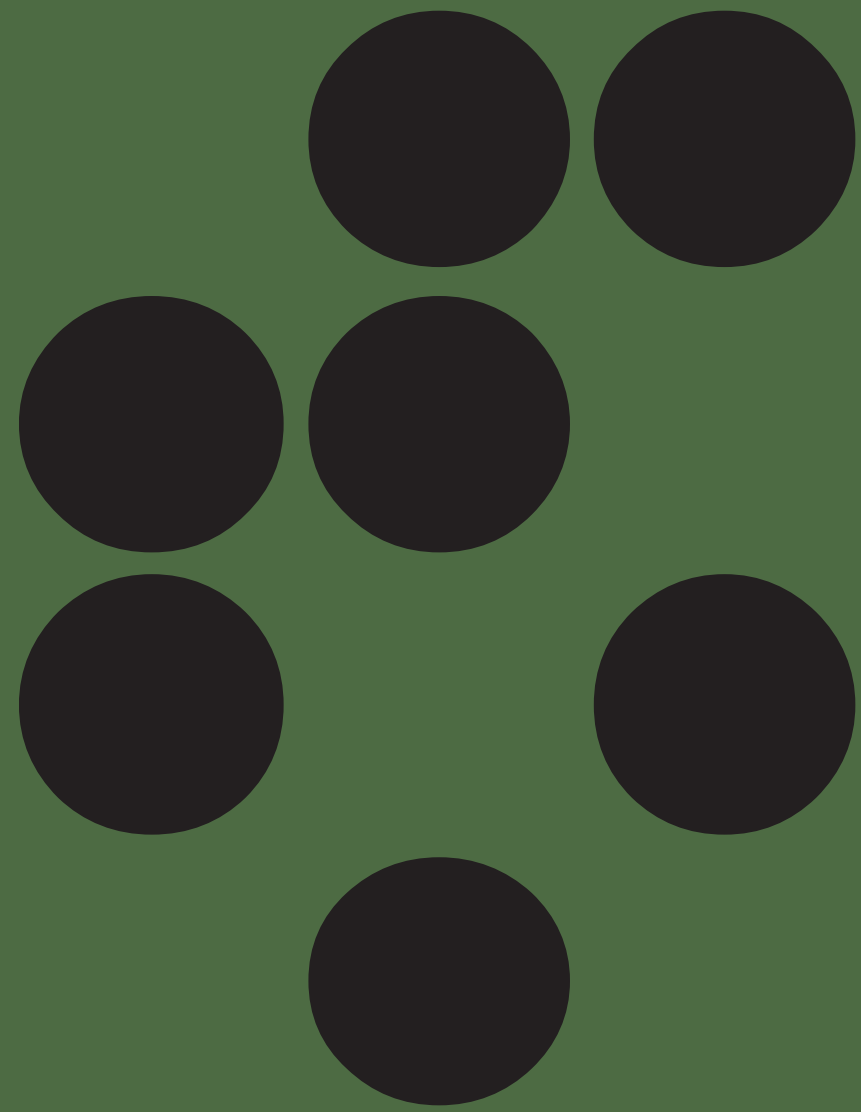
- LHCB-TDR-026



Conclusions

- F9 has recently become a Full Member of **another major collaboration**.
- Valuable earlier work by our colleagues made the transition to Full Member **smooth and straightforward**.
- We are keen to expand our visibility and contributions:
 - We need new Master's and PhD students, postdocs.
 - We need experience in flavour-physics analyses.





IJS