# M1 Intership proposal for 2025

## Title
Luminosity measurement with the SciFi detector at LHCb

## Laboratory/research team
Laboratoire Leprince-Ringuet, École polytechnique / LHCb

## Local team

*Experimentalists: Heavy ions*
Oscar Boente Garcia (postdoc), Frédéric Fleuret (DR, CNRS), Chenxi Gu (postdoc), Qiuchan Lu (PhD student), Kara Mattioli (postdoc), Émilie Maurice (Assistant Professor, École polytechnique), Elisabeth Maria Niel (CR, CNRS), Gabriel Ricart (PhD student, CEA)
*Luminosity*
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## Research project

The LHCb experiment is one of the 4 large experiments running at the Large Hadron Collider (LHC). The LHCb detector has been upgraded to take data at higher instantaneous luminosity during the Run 3 of the LHC (2022-2026)[1]. Luminosity is a quantity proportional to the number of interactions happening when two bunches of the LHC crosses. Higher luminosities mean higher number of interactions and thus a higher occupancy of the detector.

A **precise measurement of luminosity** is fundamental for both the physics cross-section measurements performed at LHCb and to tune the performance of the whole experiment.

In order to keep the performance of the detector under control, LHCb is voluntarily reducing the luminosity to an optimal value using a procedure called luminosity levelling.
To do so, a precise luminosity measurement is needed, and this is provided by a dedicated luminosity detector called PLUME[1].

However, redundant measurements are fundamental to verify the correct functioning of PLUME and to have a backup in case PLUME is not working correctly. For this reason, during 2022-2024 several sub-detectors have implemented alternative ways to measure luminosity using different "**luminosity counters**", which use quantities that are proportional to luminosity (such as number of vertices, number of tracks, number of hits) . These counters are calibrated during dedicated data taking periods called van der Meer (vdM) scans, to obtain an absolute luminosity measurement.

In particular, we have implemented a set of real time counters for the **Scintillating Fibre Tracker (SciFi)**[1], the largest tracker of the LHCb experiment made of scintillating fibres readout by silicon photo multipliers (SiPMs). The "SciFi luminosity counters" are counting hits reconstructed in the detector, a quantity that is proportional to luminosity. They are obtained directly in the electronics almost in real time (without needing to pass through the full LHCb data-taking chain).

**The goal of this project is to calibrate the SciFi luminosity counters** to make them available for the luminosity measurement of LHCb.

The first week will be dedicated to bibliography, to get familiar with luminosity concepts and the LHCb experiment. Then you will analyze the data of the vdM scan of May 2024 (using either python or c++) to obtain the calibration, where information from both the accelerator (LHC) and the SciFi detector will be used. Finally, you will have to make the calibrated counters accessible to the LHCb experiment (deployment phase) for the first "SciFi online luminosity measurement" using the LHCb online framework. Depending on the time available, the SiPMs currents, another good luminosity counter of SciFi, can also be calibrated. The "currents counters" have the advantage of being completely decorrelated from the detector status and works even if the data acquisition system of LHCb has problems, however they provide a less precise measurement overall.

Depending on the student's progress during the project, results can be presented in LHCb-wide meetings and a detector paper and/or a public note describing the work can be published.

[1] LHCb Upgrade I, LHCb-DP-2022-002
[2] LHCb PLUME: Probe for LUminosity Measurement, CERN/LHCC2021-002

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