

## Outreach activities at LHCb

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The LHCb collaboration has a wide outreach programme covering physics news, detector photos and videos, masterclasses and exhibitions at the CERN site. The presence on social media, and on web in general, is the first line in making the public aware of the experiment activities. At the experimental site, guides are aided by posters and real detector parts to make visitors more involved in the tour. The masterclasses in particle physics include an example of real data analysis at LHCb and are designed to inspire high-school students, the scientists of tomorrow.

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The status of the main outreach activities at LHCb will be discussed in this document, regarding the presence on the web (Sec. 1), the exhibition at the experimental site (Sec. 2) and the international masterclasses (Sec. 3).

## 1. LHCb on the web

The main tool to present the experiment activities outside CERN is the LHCb public website [1]. On the main page, relevant results are presented in short paragraphs, with an introduction on the physics case and hyperlinks for deeper explanations. The news are organised in chronological order and added about every two weeks. The web page also contains dedicated sections to introduce  $b$  physics, the detector, data collection and the LHCb collaboration. An online 3D interactive event display [2] allows to visualise and explore LHCb events during the data-taking or in history mode, as shown in Fig. 1.

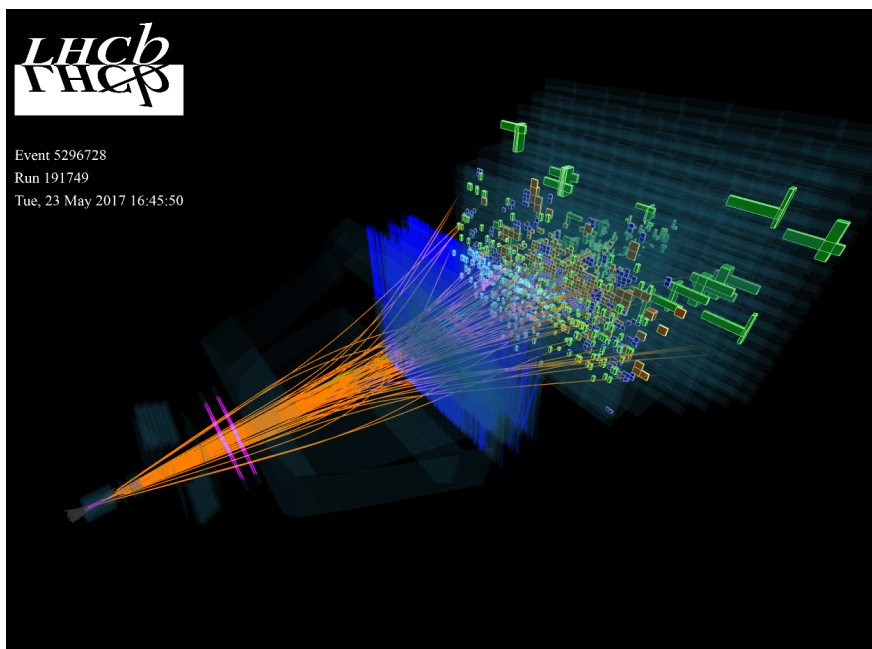


Figure 1: Interactive event display showing a real event with tracks and detector hits highlighted in different colours.

Social media has become the first place where the public seek for information on CERN experiments. LHCb has public accounts on Facebook, Twitter, Instagram and YouTube to present news and multimedia contents in a style that suits their respective format. Short and visual posts are preferred, with links to the LHCb website for more details. Since LHCb is currently undergoing a major detector upgrade, video and photos from the experimental site have also been advertised [3, 4, 5]. Many LHCb authors write articles for non-scientific journals: as an example, two recent articles on the discovery of new pentaquarks [6] and the CP violation in the charm sector [7] reached a wide audience thanks to being shared on multiple platforms.

## 2. Exhibition at the experimental site

The LHCb detector is located about 100 meters underground at Point 8 on the LHC ring [8]. Posters displayed at the entrance to the surface building give visitors an introduction to particle physics and the LHCb detector in both English and French. Large posters ( $4 \times 2 \text{ m}^2$ ) show famous LHCb results as well as photos of the detector installation. An example on  $B_{(s)}^0 \rightarrow \mu^+ \mu^-$  decays [9] is shown in the left part of Fig. 2.

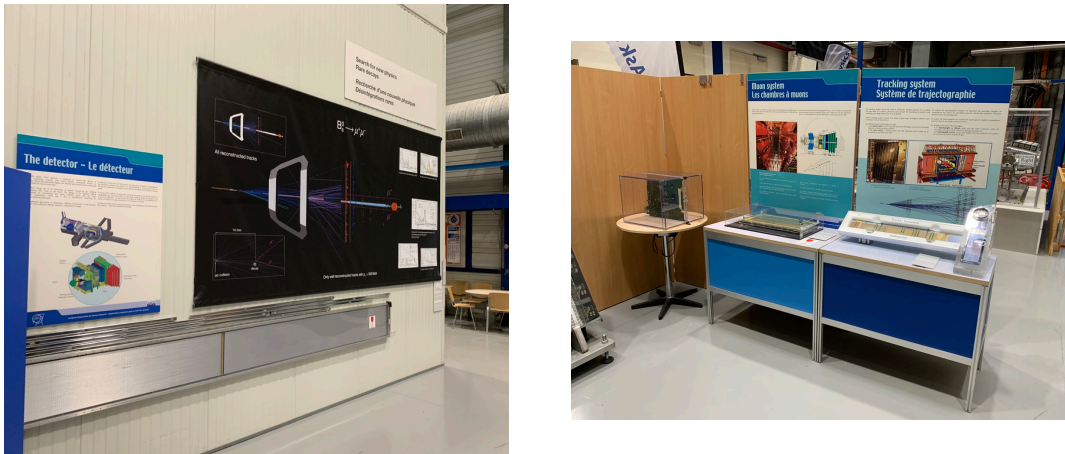


Figure 2: Left: a panel showing the LHCb detector and a poster with the  $B_{(s)}^0 \rightarrow \mu^+ \mu^-$  result. Right: a detector stand with a muon chamber and a tracking module.

Visitors can also see real parts of the LHCb detector displayed in showcases in the exhibition area, as shown in Fig. 2. The surface visit usually ends with a tour of the control room, and a brochure of LHCb [10] is given to the participants. Parts of the exhibition were recently revamped in preparation for the CERN Open Days [11] in September 2019, including displaying elements of the LHCb upgrade.

In the underground area, the dismantled Delphi detector [12] can be seen in a dedicated area. The LHCb detector itself can be viewed from raised platforms, which are also equipped with panels showing the detector and the accelerator schemes.

## 3. Masterclasses

LHCb takes part in the international masterclasses for high-school students organised by the International Particle Physics Outreach Group [13], in which institutes from all over the world participate. The LHCb masterclass is designed to immerse students in particle physics with introductory lessons in physics and detectors followed by an exercise on data analysis [14].

The analysis concerns the measurement of the  $D^0$  meson lifetime via  $D^0 \rightarrow K\pi$  decays collected at LHCb during 2011 in real  $pp$  collisions. The exercise is organised in two parts: event selection and data analysis. For the event selection, kaon and pion tracks forming a good vertex must be searched for by means of an interactive event display, as shown in Fig. 3. If a candidate with a reasonable  $K\pi$  invariant mass is found, the event can be saved for further analysis. This exercise emulates the trigger decision: the problem of an imperfect online selection is presented, and decisions based on

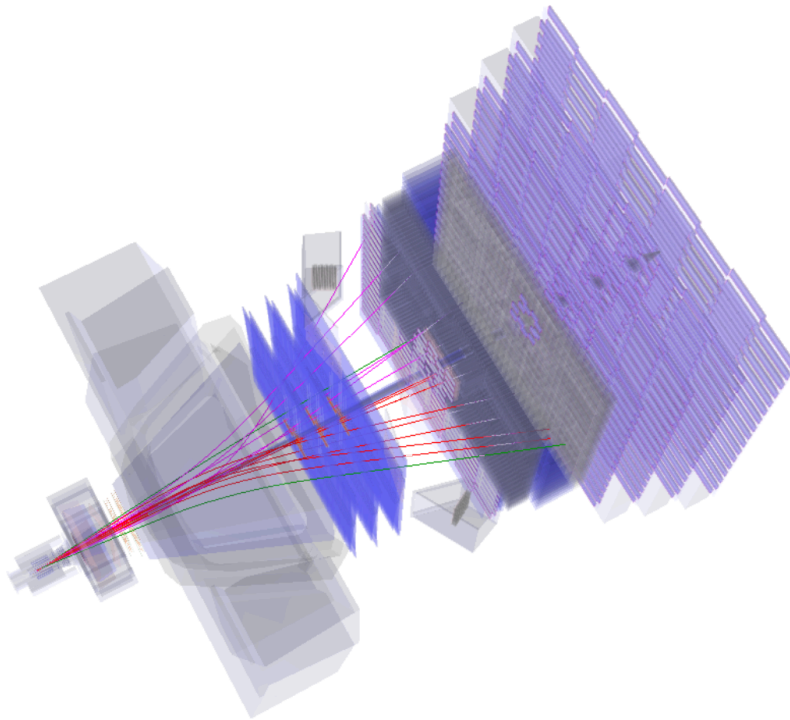


Figure 3: Event display for interactive track finding. The 3D view can be rotated and the detector can be showed in transparency.

multiple quality criteria must be taken.

The second part of the exercise is focussed on data analysis and is carried out on a larger data sample. At this stage, the concept of signal and background in statistics terms become evident: a selection based on kinematic quantities must be tuned, and the signal part is then identified via an invariant mass fit to  $K\pi$  pairs, as shown in Fig. 4. The decay time of the signal candidates is then fitted with an exponential function to extract the  $D^0$  meson lifetime. In the last part of the analysis, several lifetime measurements are made by changing the selection cuts. The results are compared to the Particle Data Group [15] value and discussed among the student groups.

The masterclass software and data packets are provided in a stand-alone ROOT [16] package available for Windows, Linux and OSX. A dedicated CERN virtual machine has also been recently setup [17].

The last activity of the masterclass is an international video call among all the participating institutes, in which the students share their knowledge and discuss the results in the spirit of a collaboration. Finally, a quiz on particle physics is proposed.

#### 4. Conclusions

Several outreach activities at LHCb target the public on the web, CERN visitors and high-school students. On one hand, the diffusion of the research activities in a simple format on the web helps to bridge the gap between researchers and the rest of the world. On the other hand,

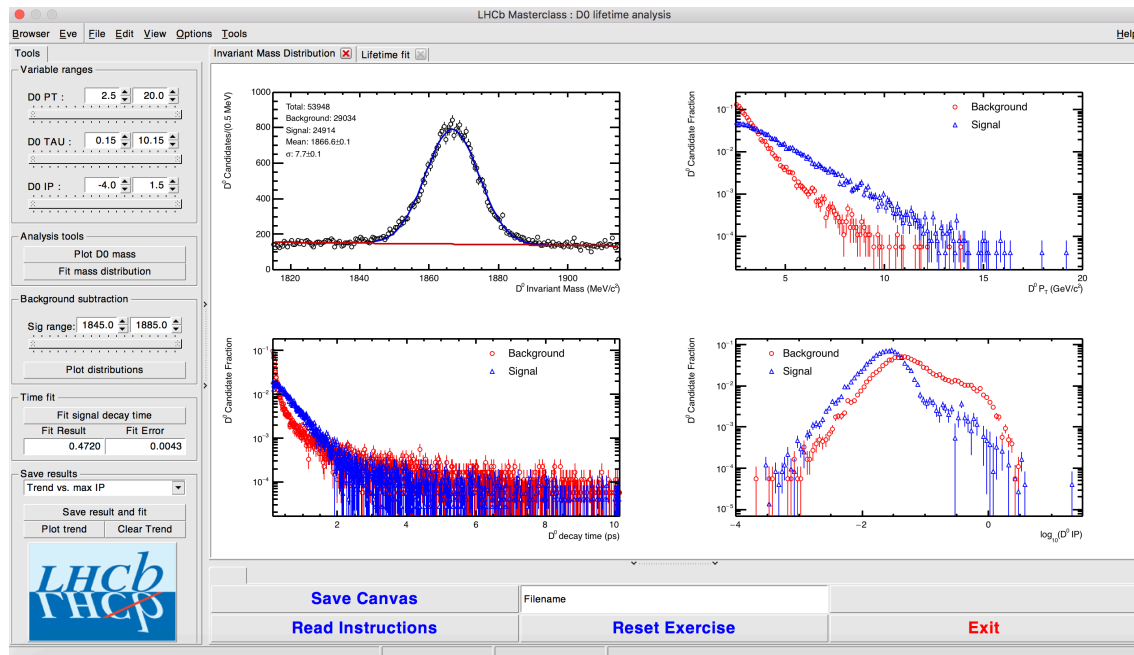


Figure 4: A window from the analysis tool showing the signal and background distribution of invariant mass, transverse momentum ( $P_T$ ), decay time and impact parameter (IP).

masterclasses for young students are of paramount importance to attract new people by giving them a glance of the real work of a researcher.

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