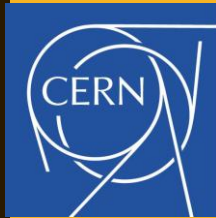




# MASTERCLASSES IN LHCb

FRANCESCA DORDEI  
CERN

On behalf of LHCb Collaboration



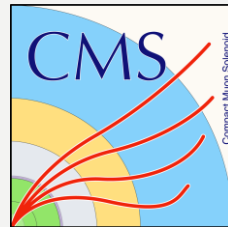
LHCP2017, SHANGHAI - 15TH OF MAY



# WHAT ARE MASTERCLASSES?

The **IPPOG** (International Particle Physics Outreach Group) organises the **International Masterclasses**, a hands-on particle physics for all LHC experiments:

<http://physicsmasterclasses.org/index.php>



- A chance for 15- to 19-years old students to **become a physicist for a day**, performing measurements with real LHC data;
- A chance for students to **experience the collaborative international nature of HEP** through an international videoconference with other schools and CERN;
- A chance for us to **rediscover how magical our day-to-day work** can be seen from the students.



# THE NUMBERS OF MASTERCLASSES

The program started 13 years ago. This year at CERN it took place from 1.03 to 11.04.2017 :

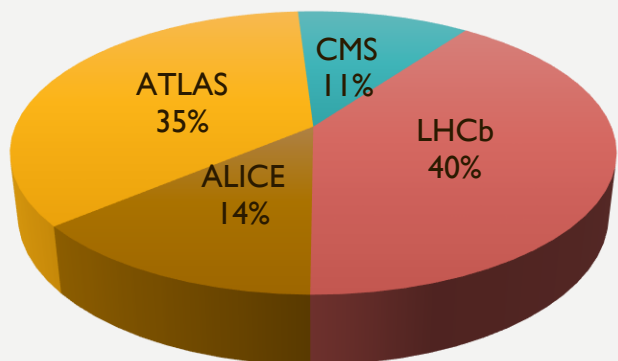
- **276** Masterclasses,
- **59** videoconferences,
- **52** countries,
- **200** particle physics research institutes,
- More than **13.000** participants worldwide!



# MASTERCLASSES IN 2017

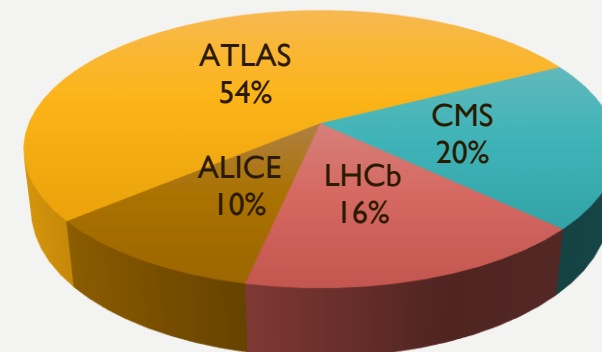
- Number of Masterclasses per experiment in 2017:
  - ATLAS: 148
  - CMS: 54
  - LHCb: 45
  - ALICE: 29

## Number of Masterclasses per experiment/size of collaboration



■ ATLAS ■ CMS ■ LHCb ■ ALICE

## Number of Masterclasses per experiment



■ ATLAS ■ CMS ■ LHCb ■ ALICE

However if we take into account size of collaborations:

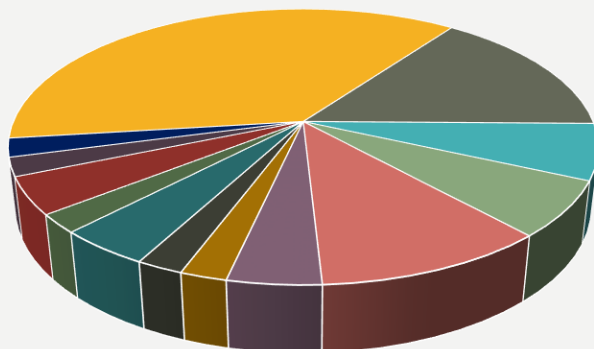
**LHCb has a leading role among the different CERN experiments!**

# LHCb MASTERCLASSES

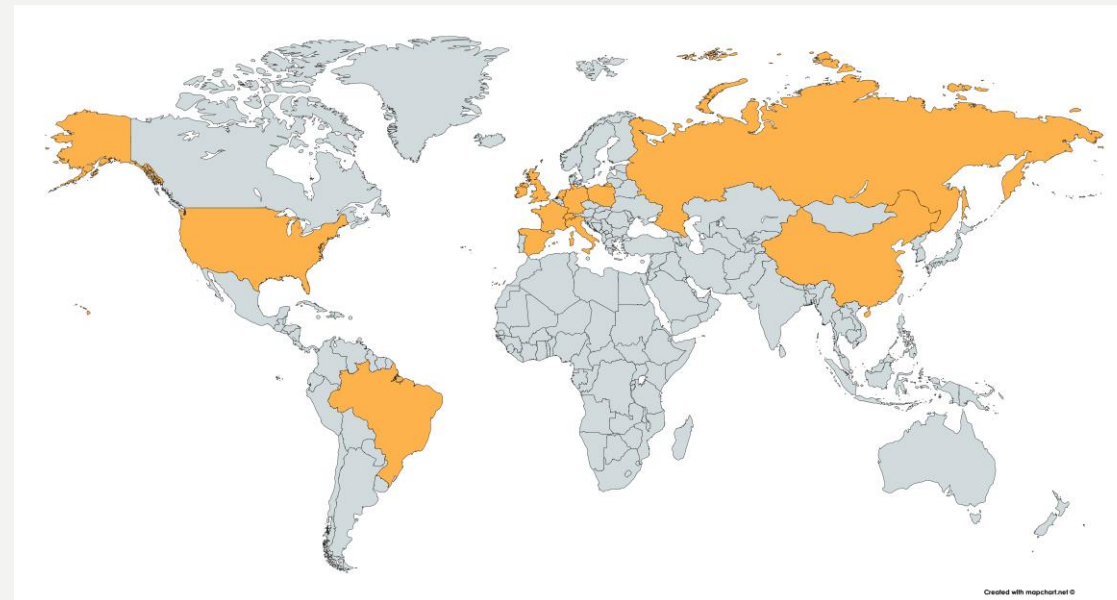
This year we organized official Masterclasses:

- In **13** countries;
- In **31** cities;
- With on average **40** students per Masterclass.

Number of Masterclasses per country



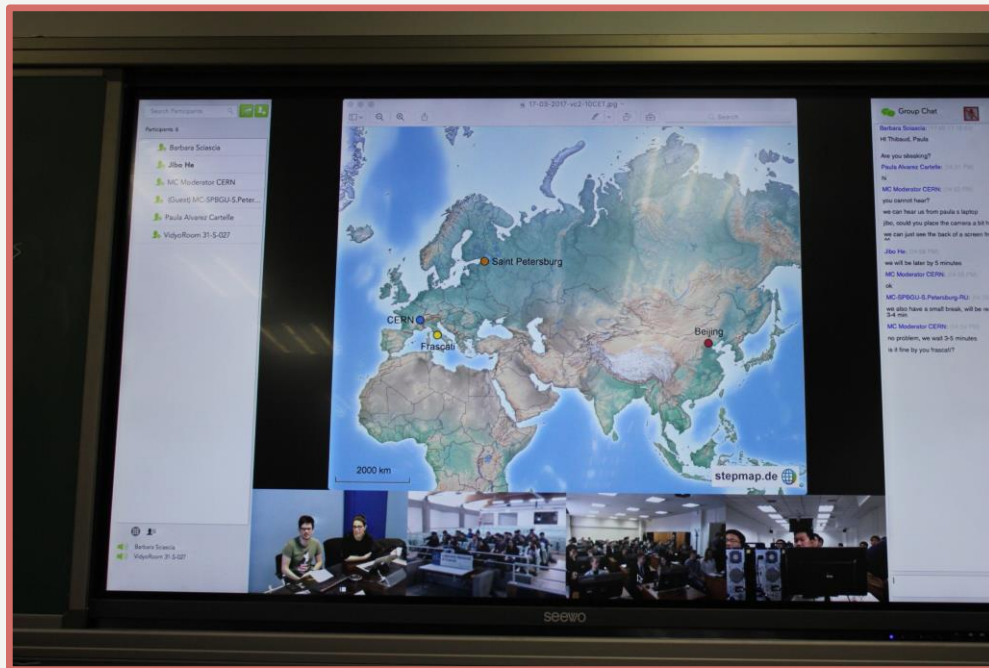
- |               |           |           |               |
|---------------|-----------|-----------|---------------|
| ■ Italy       | ■ France  | ■ Germany | ■ Spain       |
| ■ USA         | ■ Russia  | ■ China   | ■ Netherlands |
| ■ England     | ■ Ireland | ■ Poland  | ■ Brazil      |
| ■ Switzerland |           |           |               |



Italy and France are the most involved countries

# FIRST TIME OF CHINA

For the first time we had **two institutes from China**, Beijing UCAS and Tsinghua, participating in a LHCb Masterclass!





# TYPICAL STRUCTURE OF A MASTERCLASS DAY

- 09:00-09:30 Participants arrival and welcome
- 09:30-12:00 Lectures
  - Introduction to the Standard Model
  - Introduction to the LHCb experiment
- 12:00-13:00 Hands-on particles physics
- 13:00-14:00 Lunch
- 14:00-15:40 Working session
- 15:45-16:00 Break
- 16:00-17:00 Videoconference with CERN and other institutes
- 17:00-17:30 Awarding participation certificates and bye-bye

The schedule is sometimes adapted to **include visits to nearby laboratories/scientific campus** and/or to synchronise wrt to the other institutes for the videoconference.



# WHAT EXERCISES ARE AVAILABLE?

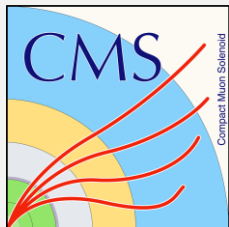


ALICE

- **Looking for strange particles:** search for  $K_s^0$ ,  $\Lambda^0$  and  $\Xi^-$  candidates
- Measurement of the **nuclear suppression factor**  $R_{AA}$  in pp and PbPb collisions



- **W path:** selection of W candidates, ratio of  $W^+/W^-$ , find Higgs events
- **Z-path:** selection of Z/H candidates



- Selection of **W/Z/H** candidates
  - Discrimination of particles based on decays into muons or other products
  - Build a mass plot of different particles

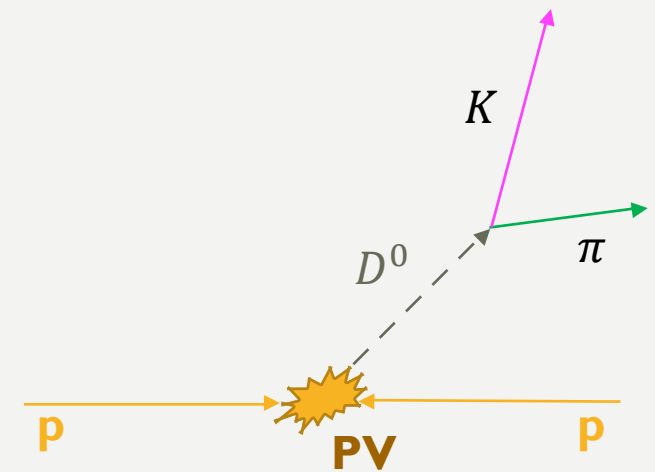
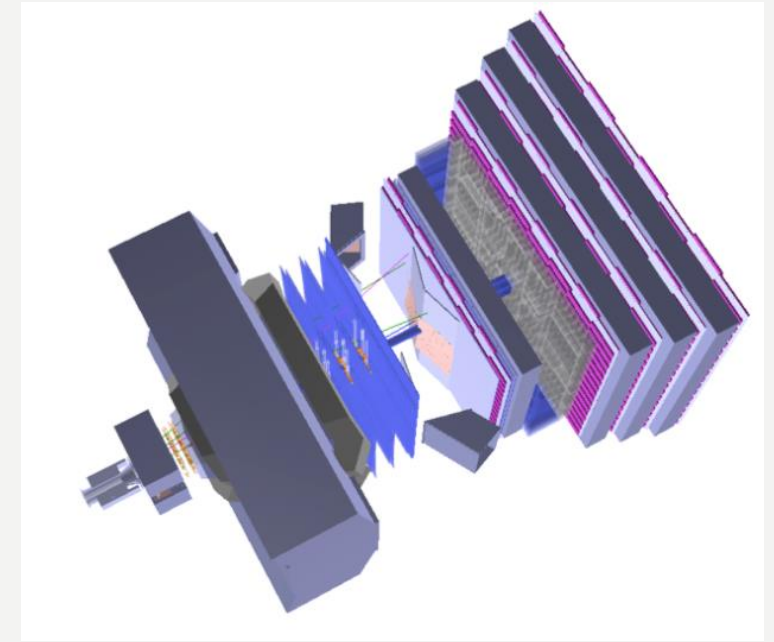
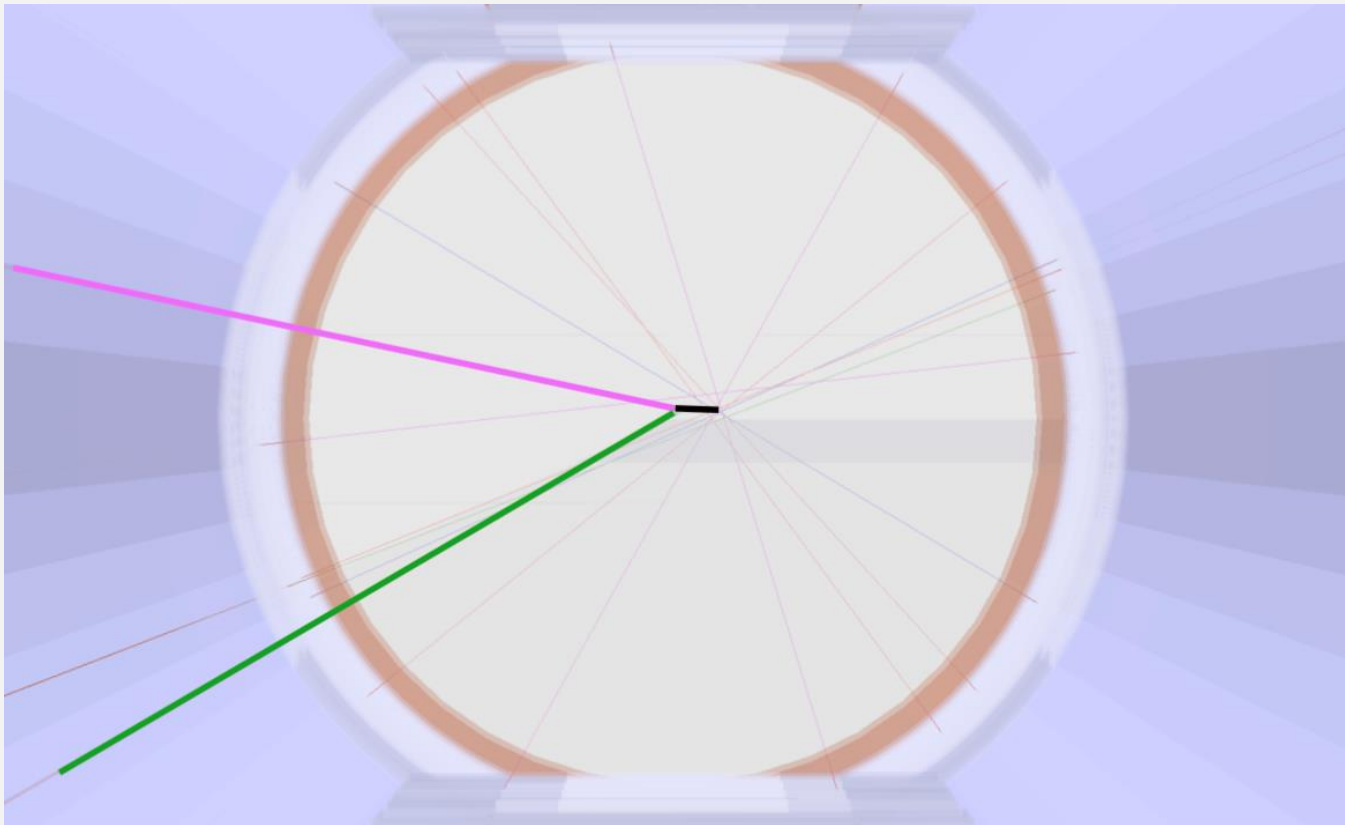


- Measuring **properties of the charmed  $D^0$  meson**
  - Selection of events and measurement of  $D^0$  mass
  - Measurement of  $D^0$  lifetime



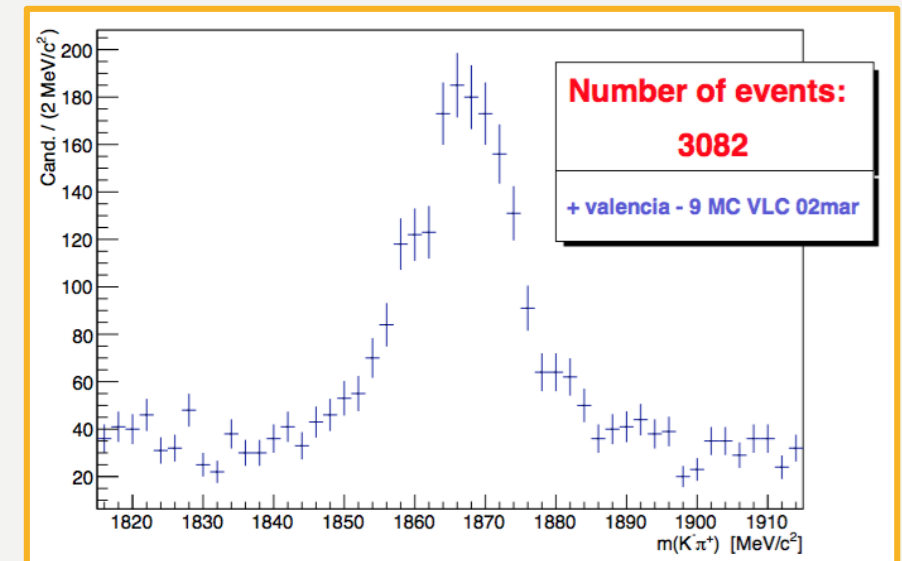
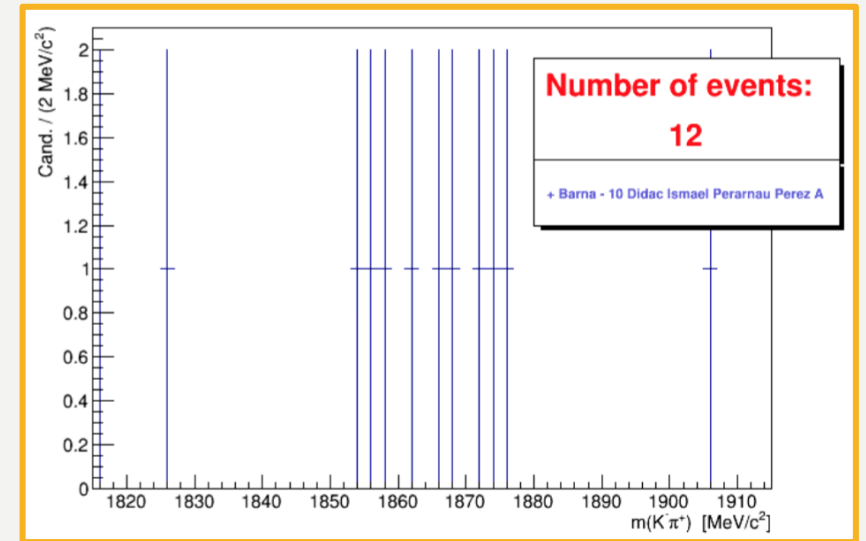
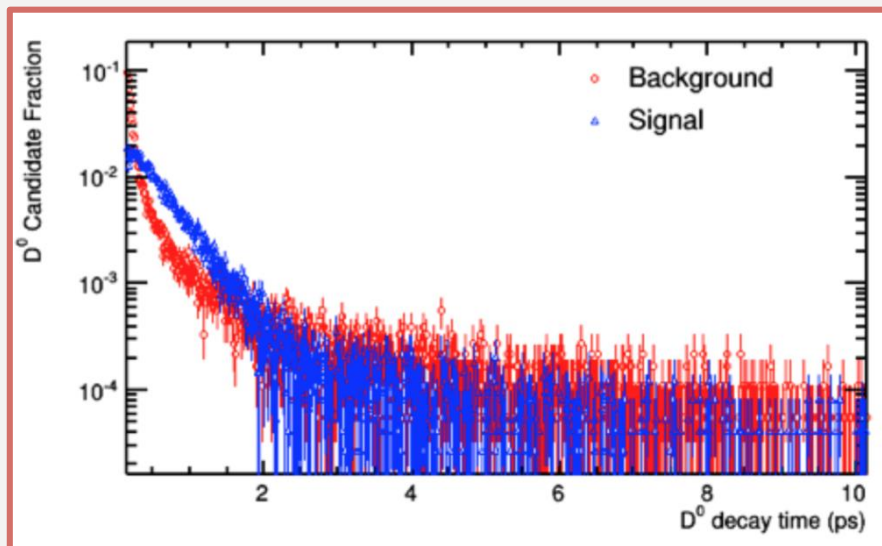
# THE LHCb EXERCISE

Search for  $D^0 \rightarrow K \pi$  decays using an event display, which is crucial for students to visualize the physics and understand the functioning of the detector.



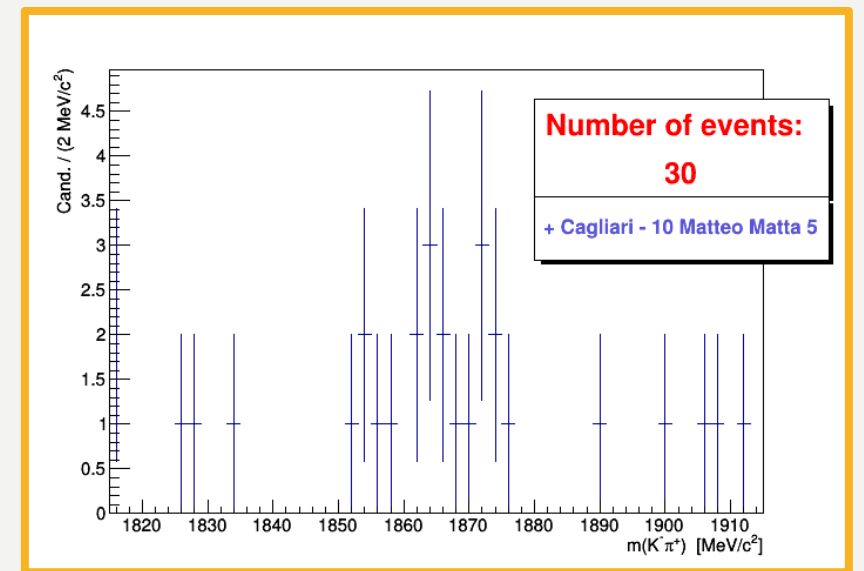
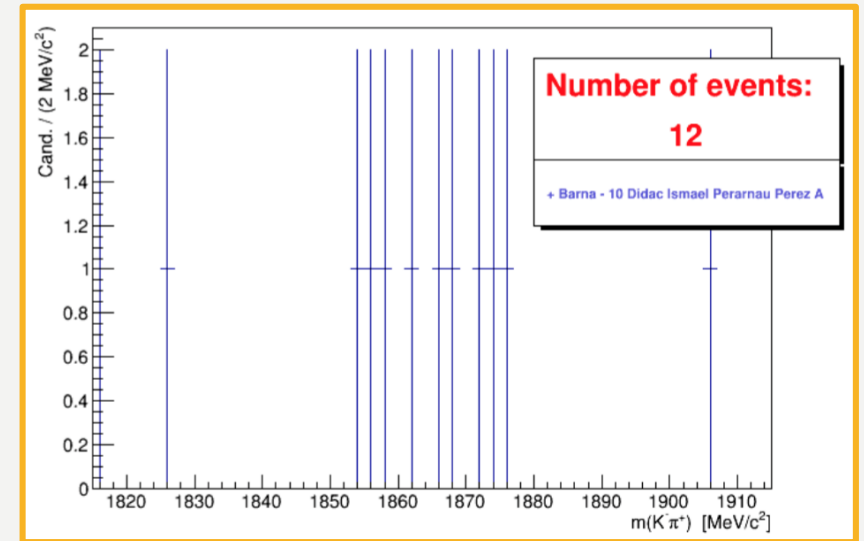
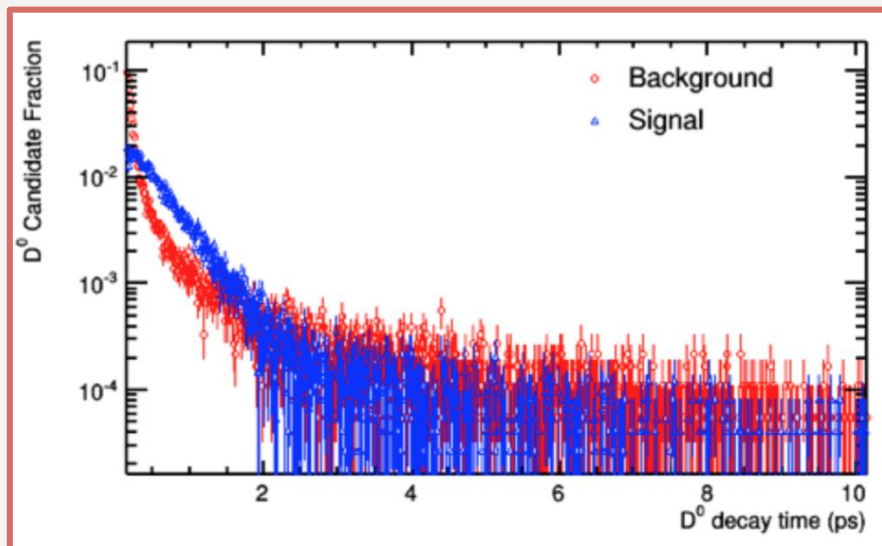
# THE LHCb EXERCISE

- Reconstruct the  $D^0$  invariant mass histogram to see a **hint of the signal** using independent data sets;
- Added up for the whole class, it allows to measure the  $D^0$  mass, showing **impact of collecting more statistics**;
- Students are then given a larger dataset, learn to subtract background and make a **1% accuracy measurement of the  $D^0$  lifetime**.



# THE LHCb EXERCISE

- Reconstruct the  $D^0$  invariant mass histogram to see a **hint of the signal** using independent data sets;
- Added up for the whole class, it allows to measure the  $D^0$  mass, showing **impact of collecting more statistics**;
- Students are then given a larger dataset, learn to subtract background and make a **1% accuracy measurement of the  $D^0$  lifetime**.





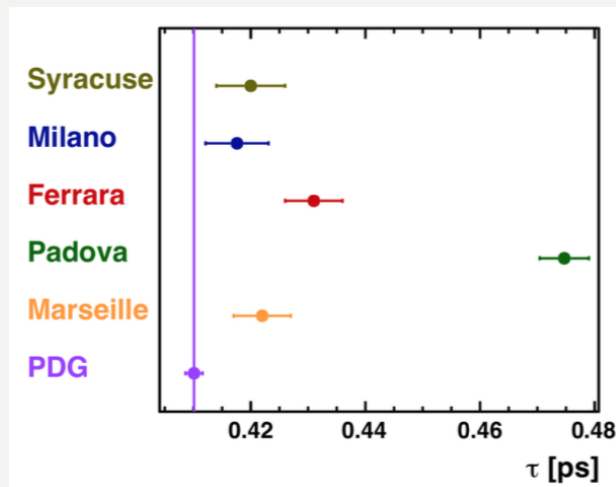
# CERN CONFERENCE & LHCb TOUR

- Program of video conference:
  - 16:00: Hello to every institute – ice breaking
  - 16:10: Results presentation
  - 16:15: Comments on results from CERN and first round of questions
  - 16:35: **LHCb tour (UNIQUE from LHCb!!)** and more questions
    - A researcher connect to the MC directly from the LHCb cavern.
  - 16:50: Quiz and bye-bye



Picture taken live  
at the videoconference!

At CERN, **we merge and present results on behalf of Institutions:**



- This gives us more time to discuss with the different institutes and answer questions
- This year we got **several questions by the students**, usually there was not enough time to answer all of them!!
- Usually questions related to LHCb and LHC physics, more rarely curiosities on a physicist's life.

# FEEDBACK AND FUTURE PLANS

- This year the **connection with the institutes worked pretty well:**
  - Minimal sound or video problems;
  - All the institutes connected well in time to test the audio.
- According to local organizers **students really enjoy these events!**
  - Students had several curiosities to ask;
  - Students really enjoy the underground tour, an unique opportunity to visit LHCb!!
- The LHCb Masterclass work well, however we would like to make it even better.  
**New exercise is under preparation** about 'CP violation in B mesons':
  - Select invariant mass of beauty meson;
  - Split plots according to charge;
  - CP violation is seen even with small statistics!

# CONCLUSIONS

- The **international masterclass programme is a huge success!!**
- All of this could not have happen without the availability and support of many people, from CERN organizers and teachers to local organizers.

**So many thanks to the whole MASTERCLASS team!!**

- All together, **we managed to introduce thousands of high-school students to particle physics and to spark their interest in HEP research.**
- You can find more info:
  - On the official Website: [link](#)
  - On the LHCb Masterclass page: [link](#)
  - On Facebook: [link](#)

