INTERNATIONAL MASTERCLASSES
HANDS ON PARTICLE PHYSICS

Nantes
A day of immersion in particle physics for 16-18 year old pupils

Typical day of International Masterclasses

**Morning**: introductory lectures on
- Particle physics (elementary particles, forces, Standard Model and beyond)
- Detectors – accelerators – experimental methods
Visit of laboratory / experimental site / discussion with scientists and graduate students

**Lunch**: usually offered by the Host Institute

**Afternoon**: students analyse data from an LHC experiment and do a physics measurement
They work in groups of 2 per computer; analysis is visual in most cases

**At the end of the day**: Video Conference
moderated by two physicists at CERN and connecting up to 5 institutes
presentation / merging/ discussion of results, answering questions, quiz
A bit of history and present status

1996: Started in UK
2005: Adopted by EPPOG (European Particle Physics Outreach Group) for all Europe
   Use data from LEP (the Large Electron Positron collider, CERN, 1989-2000)
   OPAL Identifying Particles
   DELPHI Hands on CERN
   Z0 decays / calculation of branching ratios
2006: U.S. joined program
2010: preparing to move to LHC-based Masterclasses
2011: Start using data from LHC

   ATLAS W+W- (MINERVA) structure of the proton
   ATLAS Z0 (HYPATIA) mass, width (+Z' from MC)
   CMS J/Ψ (in 2011) and W/Z (in 2012)
   ALICE Looking for strange particles (V0 decays)
   ALICE Nuclear modification factor
   LHCb Measurement of the D° lifetime

Central organisation TU Dresden (Uta Bilow, Michael Kobel)
International Masterclasses

16th International Masterclasses 2020

Each year more than 13,000 high school students in 55 countries come to one of about 225 nearby universities or research centres for one day in order to unravel the mysteries of particle physics. Lectures from active scientists give insight in topics and methods of basic research at the fundamentals of matter and forces, enabling the students to perform measurements on real data from particle physics experiments themselves. At the end of each day, like in an international research collaboration, the participants join in a video conference for discussion and combination of their results. See here for media coverage.

International Masterclasses 2020 will take place from 26.2. - 8.4.2020.

Discover the world of Quarks and Leptons with real data

- get out of school for one day and come to a nearby university or research centre
Video Conference

• Presentation of the moderators
• Welcome of the participating institutes
• General questions from the participating institutes
• Presentation of the results of the measurements by institutes
• Merging of results by moderators
• Comments, discussion, more questions
• Quiz

➢ General appreciation of the International Masterclasses very positive
➢ New countries join every year

Often it is the highlights of the day
Statistics International Masterclasses

- Countries: 18
- Institutes: 58
- Masterclasses: 72
- Students: 3k
- Video conferences: 12

2005 - 2018

- Countries: 52
- Institutes: 225
- Masterclasses: 307
- Students: 14k
- Video conferences: 82
THE 2019 MASTERCLASSES

Masterclasses: 7.3. - 16.4.2019
54 countries
239 institutes
15k students (preliminary number)
1k teachers (preliminary number)

Coordination.: QuarkNet

- 51 institutes (48)
- 54 LHC Masterclasses (50)
  - 22 ATLAS (19)
  - 32 CMS (31)
    (Incl. TRIUMF program)
- 12 MINERvA Masterclasses

Coordination.: TU Dresden

- 188 institutes (177)
- 266 LHC Masterclasses (257)
  - 30 ATLAS W (35)
  - 101 ATLAS Z (104)
  - 64 CMS (58)
  - 41 LHCb (39)
  - 27 ALICE SP (18)
  - 3 ALICE R_AA (3)
Some information

International Masterclasses are typically announced in October
In 2019: 7 March – 17 April

Limiting factors:
Computer rooms available at Institutes
Number of institutes per video conference (maximum 5)

In Sweden: Masterclasses in Uppsala – Lund (?) – Stockholm

LHC World Wide Data Day launched in 2016
[https://quarknet.org/content/world-wide-data-day](https://quarknet.org/content/world-wide-data-day)

This year it took place on 15 October 2019
ALICE measurement  [http://aliceinfo.cern.ch/public/MasterCL/MasterClassWebpage.html](http://aliceinfo.cern.ch/public/MasterCL/MasterClassWebpage.html)

4 short videos explaining the aim of the exercise and the use of the software tools

New web site  [https://alice-masterclass.web.cern.ch/MasterClassInstallation.html](https://alice-masterclass.web.cern.ch/MasterClassInstallation.html)

Contact : despina.hatzifotiadou@cern.ch
Virtual Box version (requires Virtual Box 6 preinstalled):

1. Install VirtualBox software on your machine

   1.1. If on Windows, download it from https://www.virtualbox.org/

   1.2. If on Linux, install using "apt-get install virtualbox" (or similar, if your system is using a different package manager)

2. Open the VirtualBox app, select File->Import Appliance...

3. Import the provided "OVA" file*

4. Start the virtual machine, wait for it to boot up

5. Double click the MasterClass icon on the desktop inside the virtual machine to start the MasterClass

• The .OVA file MasterclassP_ver6.ova can be downloaded from

https://cernbox.cern.ch/index.php/s/zG9kQCF4TbkHkgn
Standalone Linux application (no preinstalled ROOT required)

https://cernbox.cern.ch/index.php/s/jD58xur05dOnTEI

Instruction how to use it.

When you unpack the .tar.gz archive, there is a file called: ALICE_MasterClasses-x86_64.AppImage

To run it, the required prerequisites for Ubuntu Linux are the following:

1. Install the "required" (skip the optional ones) build prerequisites from your system's repository as mentioned here: https://root.cern.ch/build-prerequisites
   For Ubuntu, this is:
   ```
sudo apt-get install git dpkg-dev cmake g++ gcc binutils libx11-dev libxpm-dev libxft-dev libxext-dev
   ```

2. Install the GNU Scientific Library
   For Ubuntu, this is:
   ```
sudo apt-get install gsl-bin
   ```

If this is done, you can even double click the "ALICE_MasterClasses-x86_64.AppImage" file and it will run the Masterclass.