INTERNATIONAL MASTERCLASSES HANDS ON PARTICLE PHYSICS

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^o lifetime

Central organisation TU Dresden (Uta Bilow, Michael Kobel)

International Masterclasses - hands on particle physics

International Particle Physics Outreach Group

INTERNATIONAL MASTERCLASSES

hands on particle physics

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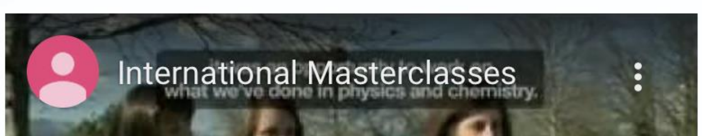
International Masterclasses

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 fundaments 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

Often it is the highlights of the day

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

Statistics International Masterclasses

2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018

2005		2018
18	countries	52
58	institutes	225
72	masterclasses	307
3k	students	14k
12	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
IPPOG http://ippog.web.cern.ch/
International Masterclasses http://physicsmasterclasses.org/

LHC World Wide Data Day launched in 2016
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

Einstein in the 21st Century

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Looking for strange particles in ALICE

1. Overview

The exercise proposed here consists of a search for strange particles, produced from collisions at LHC and recorded by the ALICE experiment. It is based on the recognition of their V0-decays, such as $K^0_s \rightarrow \pi^+\pi^-$, $\Lambda \rightarrow p + \pi^-$ and cascades, such as $\Xi^- \rightarrow \Lambda + \pi^-$ ($\Lambda \rightarrow p + \pi^-$). The identification of the strange particles is based on the topology of their decay combined with the identification of the decay products; the information from the tracks is used to calculate the invariant mass of the decaying particle, as an additional confirmation of the particle species.

In what follows the ALICE experiment and its physics goals are first presented briefly, then the physics motivation for this analysis. The method used for the identification of strange particles as well as the tools are described in detail; then all the steps of the exercise are explained followed by the presentation of the results; then all the steps of the exercise are explained followed by the presentation of the results as well as the method of collecting and merging all results. In the end the large scale analysis is presented.

2. Introduction.

ALICE (A Large Ion Collider Experiment), one of the four large experiments at the CERN Large Hadron Collider, has been designed to study heavy ion collisions. It also studies proton proton collisions, which primarily provide reference data for the heavy ion collisions. In addition, the proton collision data allow for a number of genuine proton proton physics studies. The ALICE detector has been designed to cope with the highest particle multiplicities anticipated for collisions of lead nuclei at the extreme energies of the LHC.

3. The ALICE Physics

Quarks are bound together into protons and neutrons by a force known as the strong interaction, mediated by the exchange of force carrier particles called gluons. The strong interaction is also responsible for binding together the protons and neutrons inside atomic nuclei.

Even though we know that quarks are elementary particles that build up all known hadrons, no quark has ever been observed in isolation: the quarks, as well as the gluons, seem to be bound permanently together and confined inside composite particles, such as protons and neutrons. This is known as confinement. The exact mechanism that causes it remains unknown.

Although much of the physics of strong interaction is, today, well understood, two very basic issues remain unresolved: the origin of confinement and the mechanism of the generation of mass. Both are thought to arise from the way the properties of the vacuum are modified by strong interaction.

The current theory of the strong interaction (called Quantum Chromo-Dynamics) predicts that at very high temperatures and very high densities, quarks and gluons should no longer be confined inside composite particles. Instead they should exist freely in a new state of matter known as quark-gluon plasma.

https://indico.cern.ch/event/579011/ 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

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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/jD58xur05dOnTEl

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 prerequisities 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.