INTERNATIONAL MASTERCLASSES

Current Status of International Particle Physics Masterclasses

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ICHEP 2020, Prague

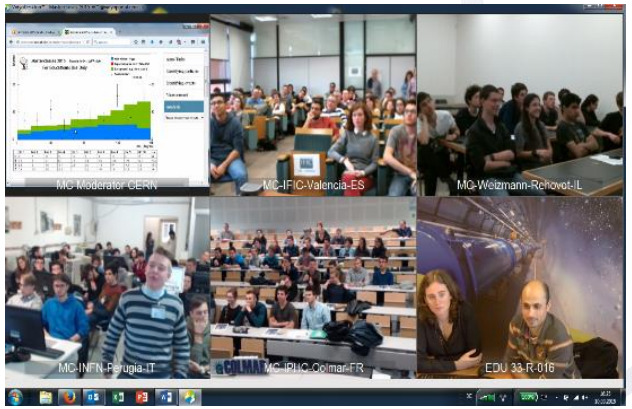
Overview

What is a Masterclass?

- “Particle physicist for a day”
- Intro
- Tour
- Analyze authentic HEP data
- Videoconference

International Masterclasses

- 60 countries
- > 220 research labs
- > 10^4 Students
- Videoconferences at CERN, Fermilab, KEK, GSI, TRIUMF
- Organized by IPPOG, http://ippog.org/



Broadening the Physics Scope

Historically: LEP → LHC

Today:

- LHC (since 2005)
- MINERvA (since 2019)
- Belle II (since 2020)
- Particle Therapy (since 2020)

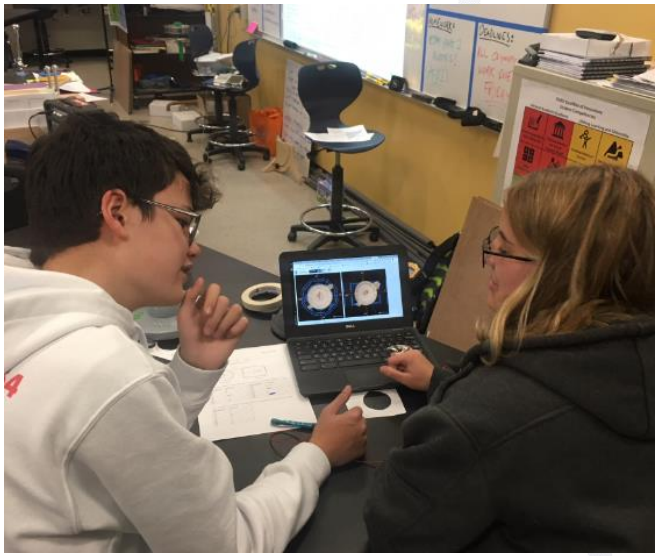
New:

- Darkside

Under development:

- MicroBooNE

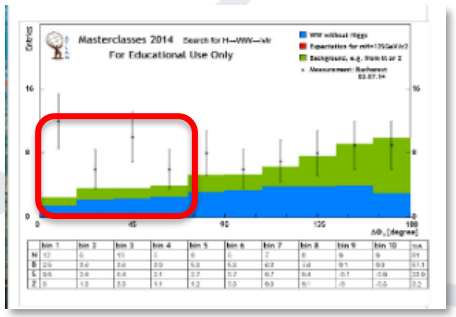
More on the way…

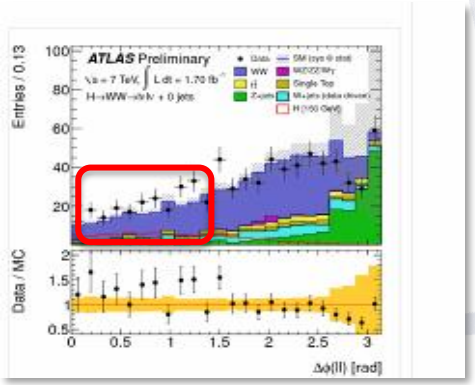


LHC Masterclasses: ATLAS W and Z

W-path

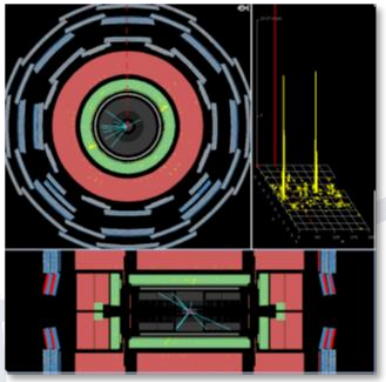
- Students analyze event
- Identify W bosons
  - W+/W-
- Identify W pairs and measure azimuthal opening angle $\Delta\varphi_{ll}$
  - Gain insight into the process of discovering the Higgs at CERN
- http://cern.ch/go/**MHr6**

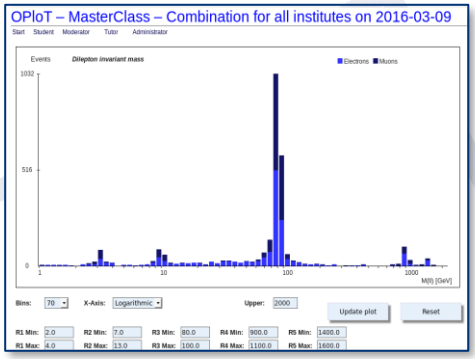




Z-path

- Students search for 2-lep, γγ, or 4-lep events, build invariant mass distributions
- Find 2-lep particles: Z^0, J/ψ, Υ
- Search for new particles
- Gain insight into the process of discovering the Higgs at CERN
- http://cern.ch/go/**cNW9**

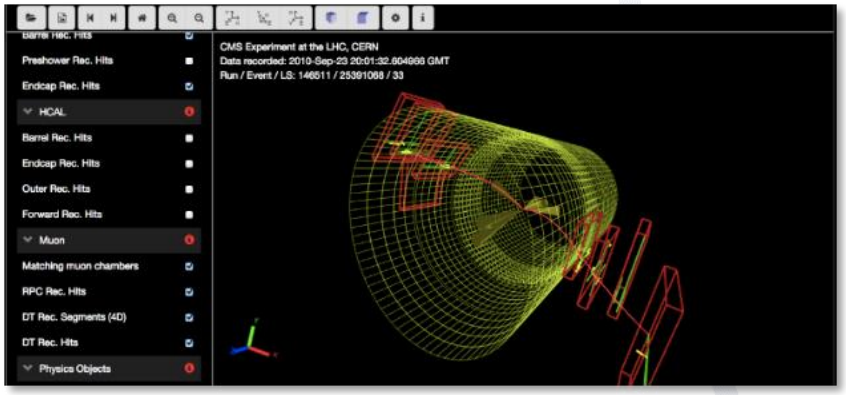




LHC Masterclasses: CMS and LHCb

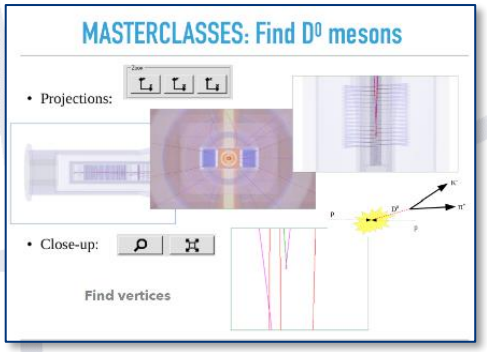
CMS

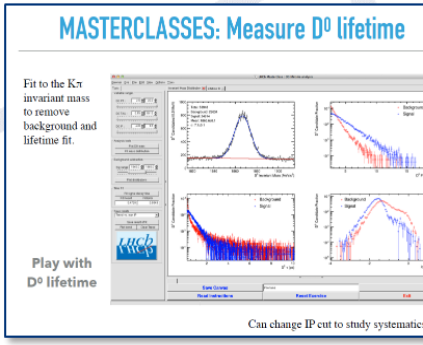
- 1-, 2-, and 4-lepton events
- 1-lep (plus ν): W boson
- 2-lep and 4-lep: mass plots of standard model particles, plus hint of Higgs
- Ratios W+/W-, e/m
- http://cern.ch/go/**Xg8z**



LHCb

- Students search for the $D^0 \rightarrow K\pi$ decay
- Students perform a lifetime measurement at the 1 % level
- Live merging of histograms from all groups in the VC
- http://cern.ch/go/**s7s7**





LHC Masterclasses: ALICE in 2.5 flavors

Strange particles

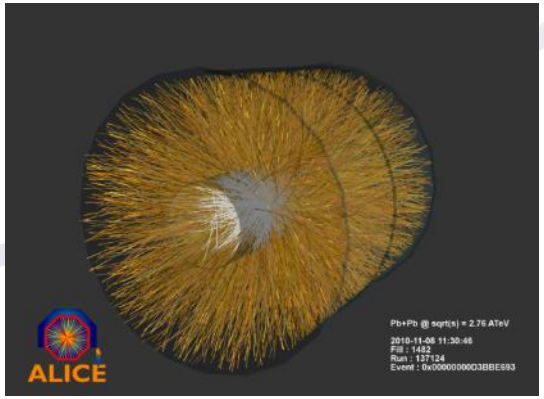
- First part: visual analysis of ~ 15 V0 events per group
- Second part: Calculate numbers of Ks, Λ , anti-Λ from different centrality regions in Pb-Pb collisions
- Observe strangeness enhancement
- http://cern.ch/go/**79HV**

Nuclear modification factor

- event-display analysis
  - R_{AA} simply via counting of tracks
- ROOT based large scale analysis
  - R_{AA} from various Pb-Pb centralities
  - students discover jet suppression!
- http://cern.ch/go/**q7Gq**

New J/ψ measurement

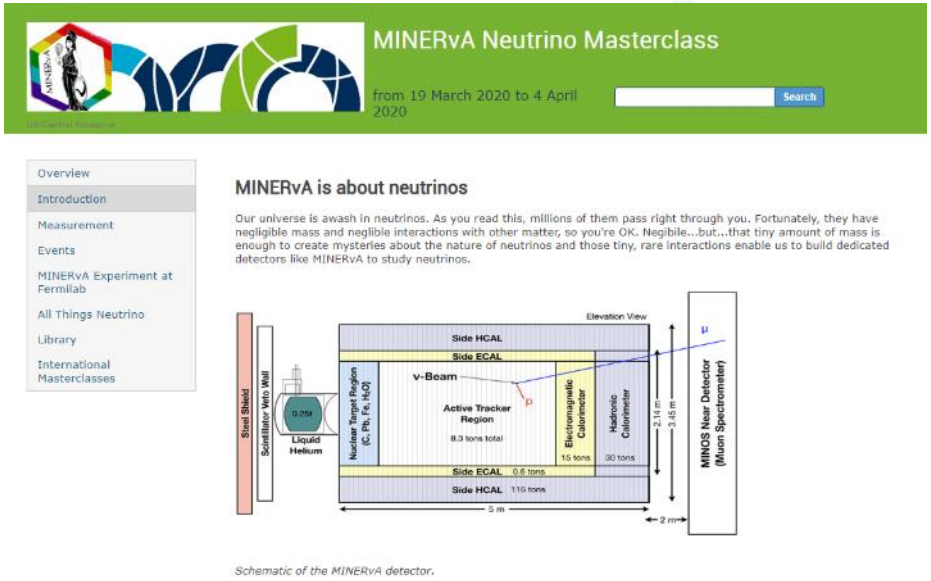
- Electron identification via dE/dx measured in TPC
- Workflow:
  - load charged-particle tracks
  - fill PID and inverse mass histograms
  - extract J/ψ yield
- Standalone app



Neutrino Masterclasses: MINERvA and more

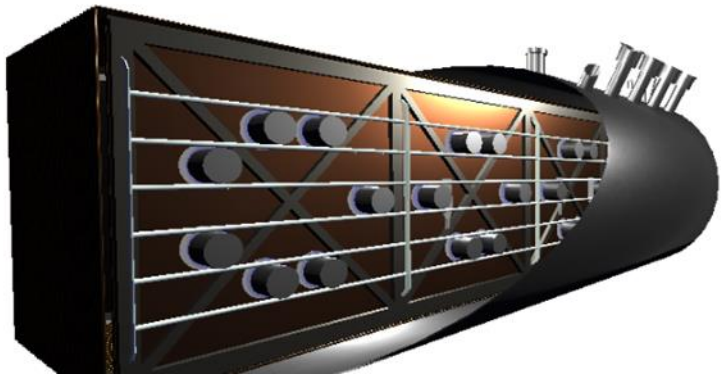
MINERvA

- Muon neutrinos interact with carbon target
- Discover Fermi motion
- Measure carbon nucleus to test interaction model
- https://indico.fnal.gov/event/22340/



In development

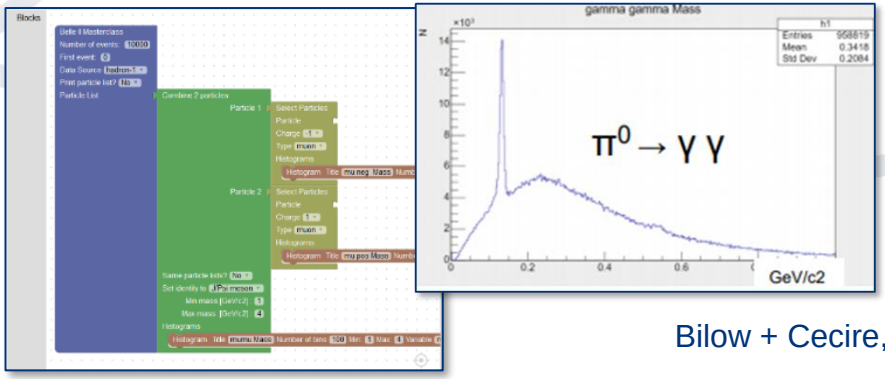
- MicroBooNE instrumentation masterclass
  - Argon purity
  - Electron drift velocity
- NOvA neutrino oscillation (just starting)



Belle II and Particle Therapy Masterclasses

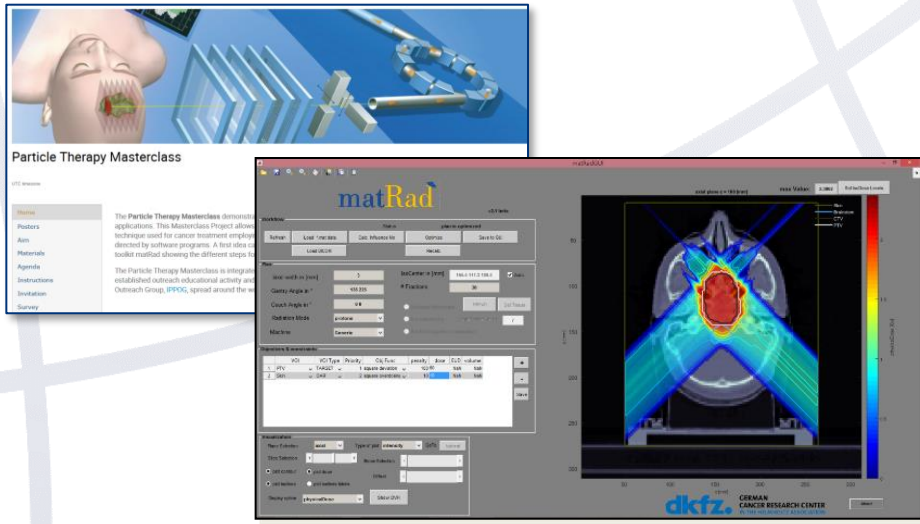
Belle II

- Students code B-physics analysis
  - Describe decays, make cuts, “discover” particles
  - Visual code editor Blockly
- Run from the web or virtual machine
- Analysis of 6M clean reconstructed events
- Basic/advanced level; KEK videocon
- http://cern.ch/go/**wcr8**



Particle Therapy

- Particle treatment planning
- highlights benefits for society from the particle physics technology
- Particularly in demand in Latin America
- http://cern.ch/go/**8WR8**



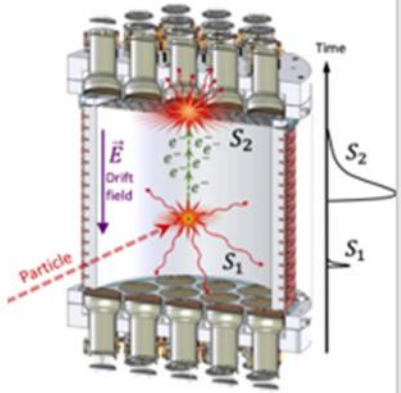
Future Masterclasses

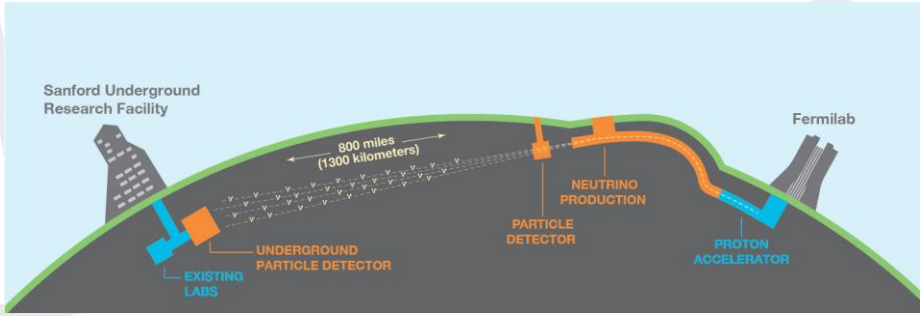
Darkside (Gran Sasso)

- By Francesca Carnesecchi, University and INFN of Bologna, Centro Fermi Roma, et al.
- Dark Matter / WIMPs in Ar TPC
- Data analysis via excel
  - Reconstruction position part (few events): exclude background
  - Analysis of ~20000 events: background and few “good” WIMPs
  - pilot in Jan 2020, 2 remote events during lockdown
- http://cern.ch/go/**Jkt7**

Darkside experiment: how to detect WIMP

- WIMP-nucleus elastic collisions revealed by a detector capable of unambiguously identifying a small number of nuclear recoils
- **Dual phase (gas + liquid) Argon TPC** for direct detection of WIMPs





Further neutrino masterclasses

- OPERA discussed
- DUNE is the goal

Impact of the COVID-19 pandemic

- all videoconferences suspended by March 18
- only ~ 25 % of Masterclasses completed

Our response:

1) **BAMC** (Big Analysis of Muons in CMS)

   Simplified analysis, online support, teachers involved

   ~700 students participated, Apr and May; ~35K events analyzed

2) **Masterclass@home**

   Masterclass delivered online to groups of individual students, lectures+analysis spread over two afternoons

3) **IMC Summer VCs**

   arranged end of June, offered to all IMC institutes, very low turnout

Interested to get involved?

At your institute

- Does your institute participate? Search http://cern.ch/go/**8V7h**
- Organize an event / help as a tutor at your research lab
  - How to get started: http://cern.ch/go/**9B77**

At CERN/Fermilab

- Moderate videoconferences with high school students
  - Training provided
  - Moderate in pairs, 2-3 „shifts“, newcomers are paired with „veterans“

Next International Masterclasses: Feb/March 2021

Interested? Contact: uta.bilow@tu-dresden.de or kcecire@nd.edu

More info on www.physicsmasterclasses.org

@physicsIMC