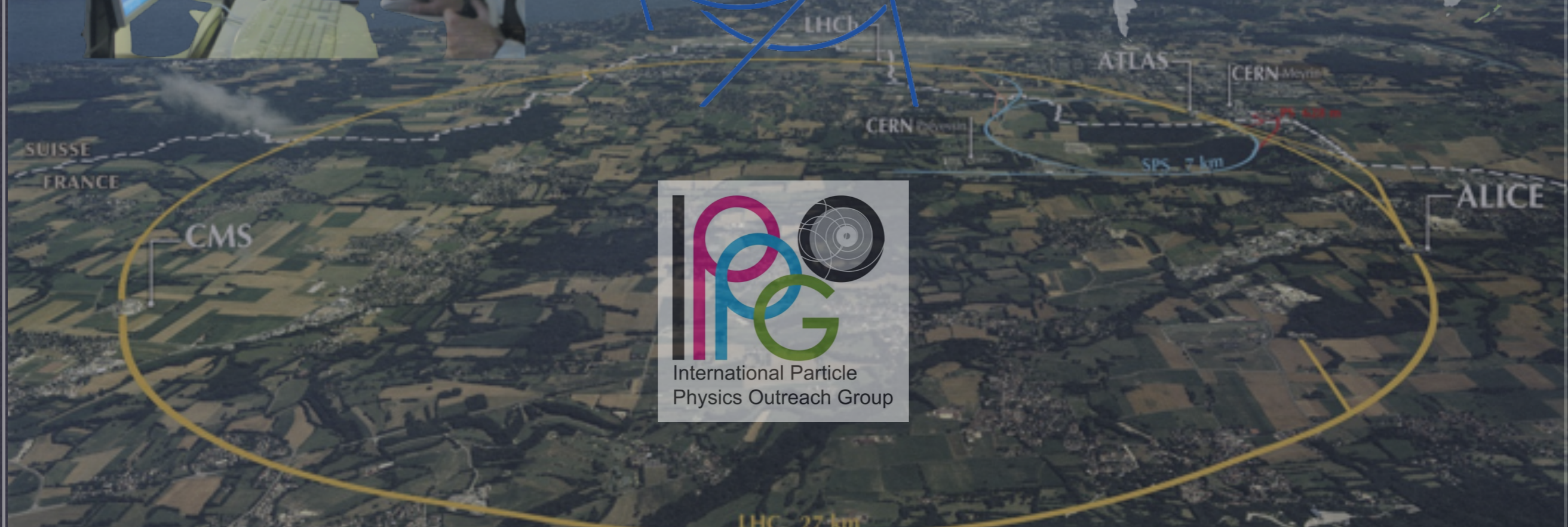




Konrad Jende

Introduction to Particle Physics Masterclasses

Bringing the world's largest science experiment into the "classroom"



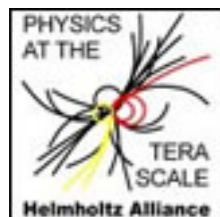
Introduction to Particle Physics Masterclasses

Konrad Jende, High School Teacher Programme 2014

outline

1. Introduction
2. IPPOG's International Masterclasses
3. Summary

FUNDED BY:



COORDINATOR



MASTERCLASSES
LHC UPGRADE



DVD
PRODUCTION



US PARTNER
PROGRAMME



EXPERIMENTAL DATA
VIDEOCONFERENCE

+
NATIONAL
FUNDING
AGENCIES

2. IPPOG's International Masterclasses

Concept:

- Students (15 -19 years old) spend 1 day at research institute,
- experience science from scientists “The Master” and
- carry out measurements based on analyses of real data from particle physics experiments,
- discuss their results with colleagues
- basic idea from UK (1996, Roger Barlow et al.)

2. IPPOG's International Masterclasses

Objectives:

- stimulate students interest in physics
- demonstrate scientific research process
- let students explore fundamental forces and building blocks of matter
- offer authentic experience

2. IPPOG's International Masterclasses

Event - create an International Collaboration among students (together with U.S. partner QuarkNet)

- ~4weeks period in March every year
- 144 (+38 from U.S. partner) institutes from 41 countries
- central organization at TU Dresden:
Michael Kobel and Uta Bilow
- Website: [http://](http://www.physicsmasterclasses.org)

www.physicsmasterclasses.org



Fig. 2 - Number of participants in International Masterclasses over the years

2. IPPOG's International Masterclasses



Fig. 3 - World Map of Masterclasses attendees

2. IPPOG's International Masterclasses



9:30
Lunch break
1:30
3:30
4:30

Lectures



9:30
Lunch break
1:30
3:30
4:30

Measurement on real data



9:30
Lunch Break
1:30
3:30
4:30

Combination of measurement's results

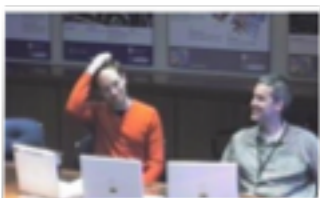
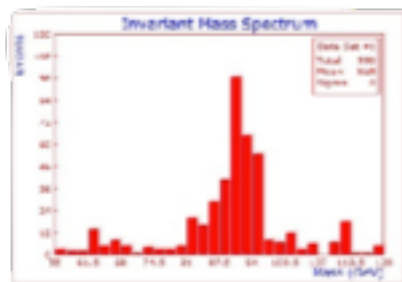
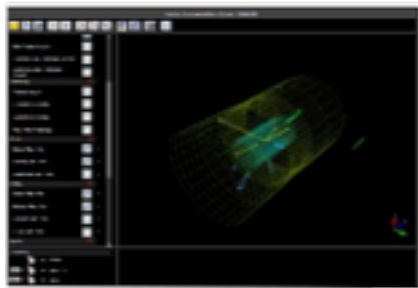
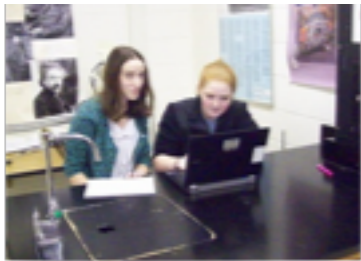


9:30
Lunch break
1:30
3:30
4:30

Video Conference

Fig. 4 - Typical Masterclasses day

2. IPPOG's International Masterclasses



- students work in pairs in front of computers, where
- they identify particles visually in event displays of proton-proton-collisions and thus assign an event to predetermined classes of events
- produce plots (histograms) out of their results and
- discuss them afterwards at the venue and during the videoconference

2. IPPOG's International Masterclasses

- based on visual event identification of event displays of proton-proton-collisions using tools of physicists

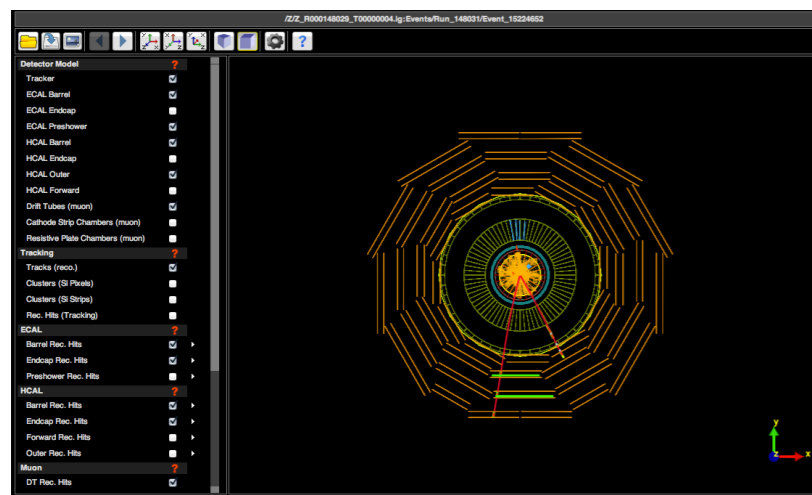


Fig. 6 - CMS event display

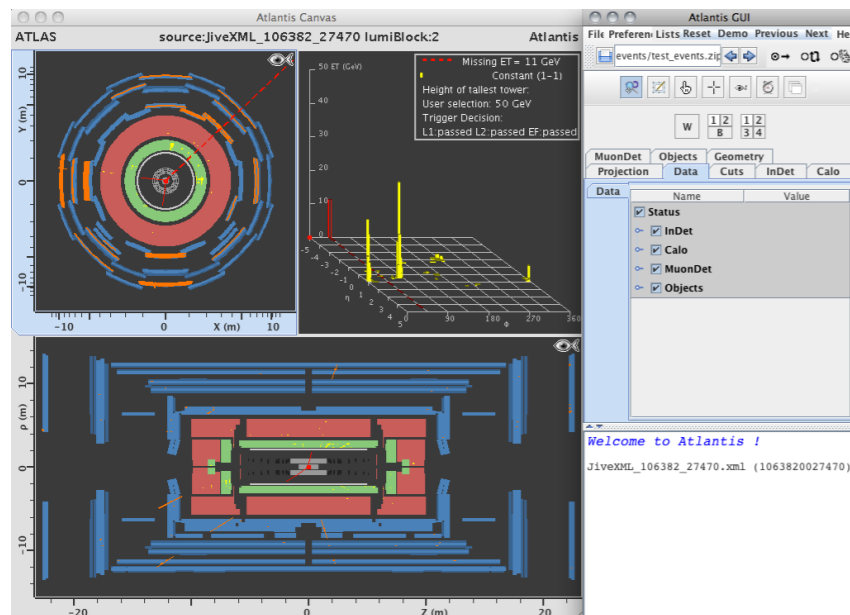


Fig. 7 - ATLAS event display

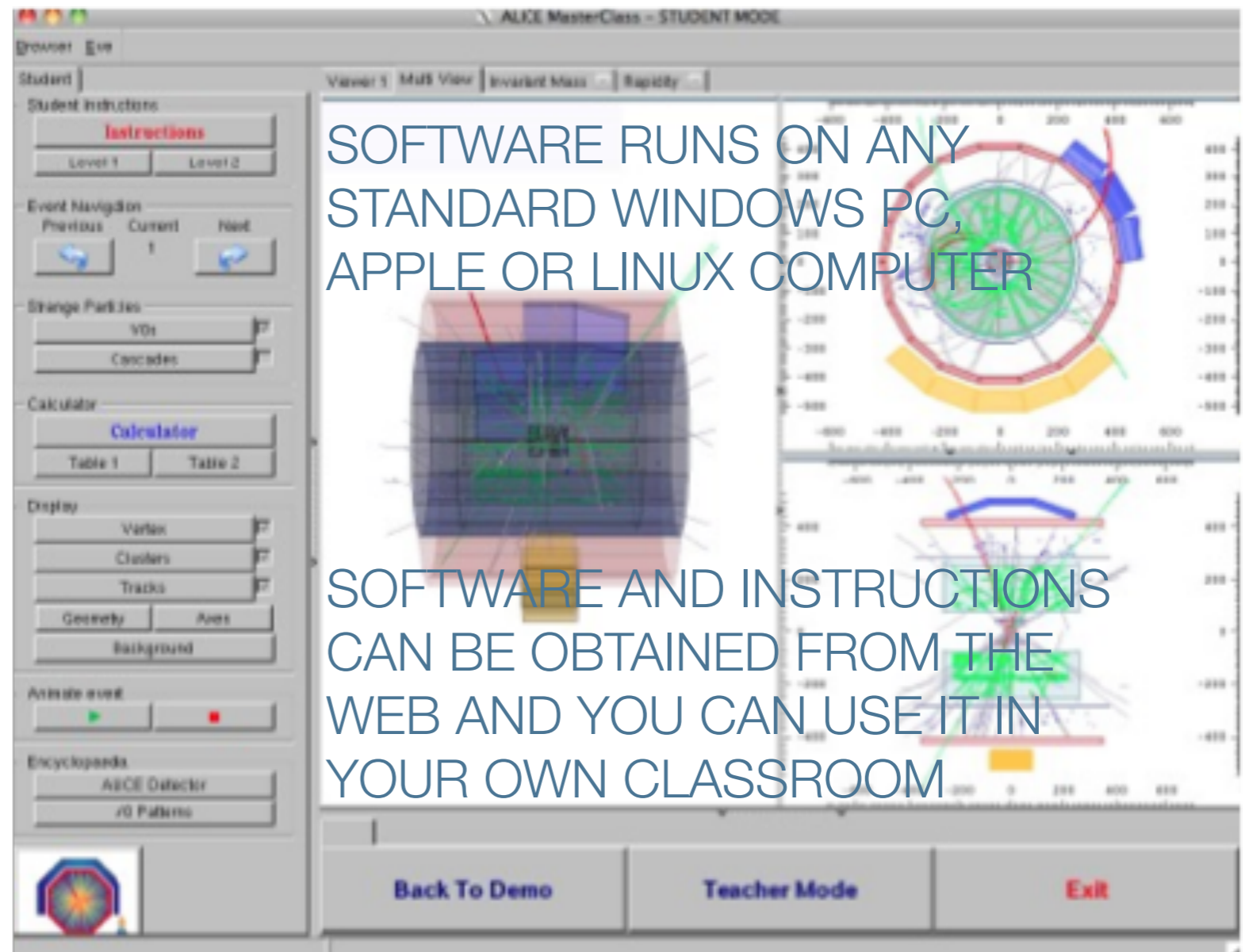


Fig. 8 - ALICE event display

SOFTWARE RUNS ON ANY STANDARD WINDOWS PC, APPLE OR LINUX COMPUTER

SOFTWARE AND INSTRUCTIONS CAN BE OBTAINED FROM THE WEB AND YOU CAN USE IT IN YOUR OWN CLASSROOM

Back To Demo

Teacher Mode

Exit

2. IPPOG's International Masterclasses

Physics Analyses:

- based on visual event identification of event displays of proton-proton-collisions using tools of physicists
- various exercises/measurements on real data are provided by the LHC experiments ALICE, ATLAS and CMS, where students:
- identify particles/events by using different techniques (e.g. invariant mass calculation, looking at momentum conservation)
- identify particles/events in order to explore the inner structure of the proton, search for not yet discovered particles (with the help of simulated data)

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ALICE measurement (D. Hatzifotiadou et al., 2012)

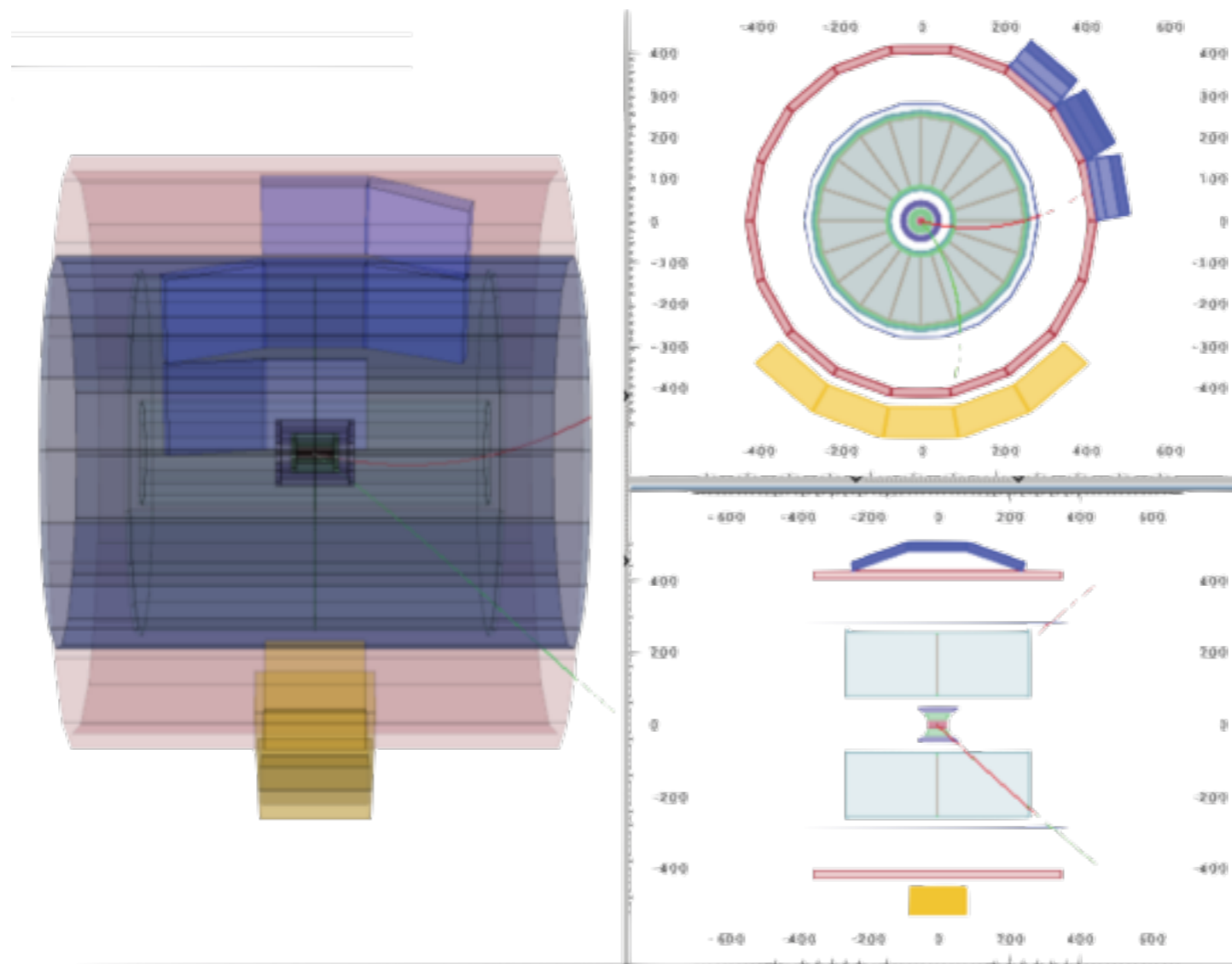


Fig. 9 - Electric neutral particles can be only seen in the inner detector when they decay into electric charged particles, where the tracks build a “V” - that is why we call them V0 events

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ATLAS W measurement (K. Jende, M. Kobel et al. 2012)



Fig. 10 - using histograms to determine selection criteria like physicists do

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ATLAS Z measurement (Farid Ould-Saada, Maiken Petersen et al. 2012)

OPlot - MasterClass – Combination for all institutes on 09.03.2012

Start Student Moderator Administrator

Choose new date

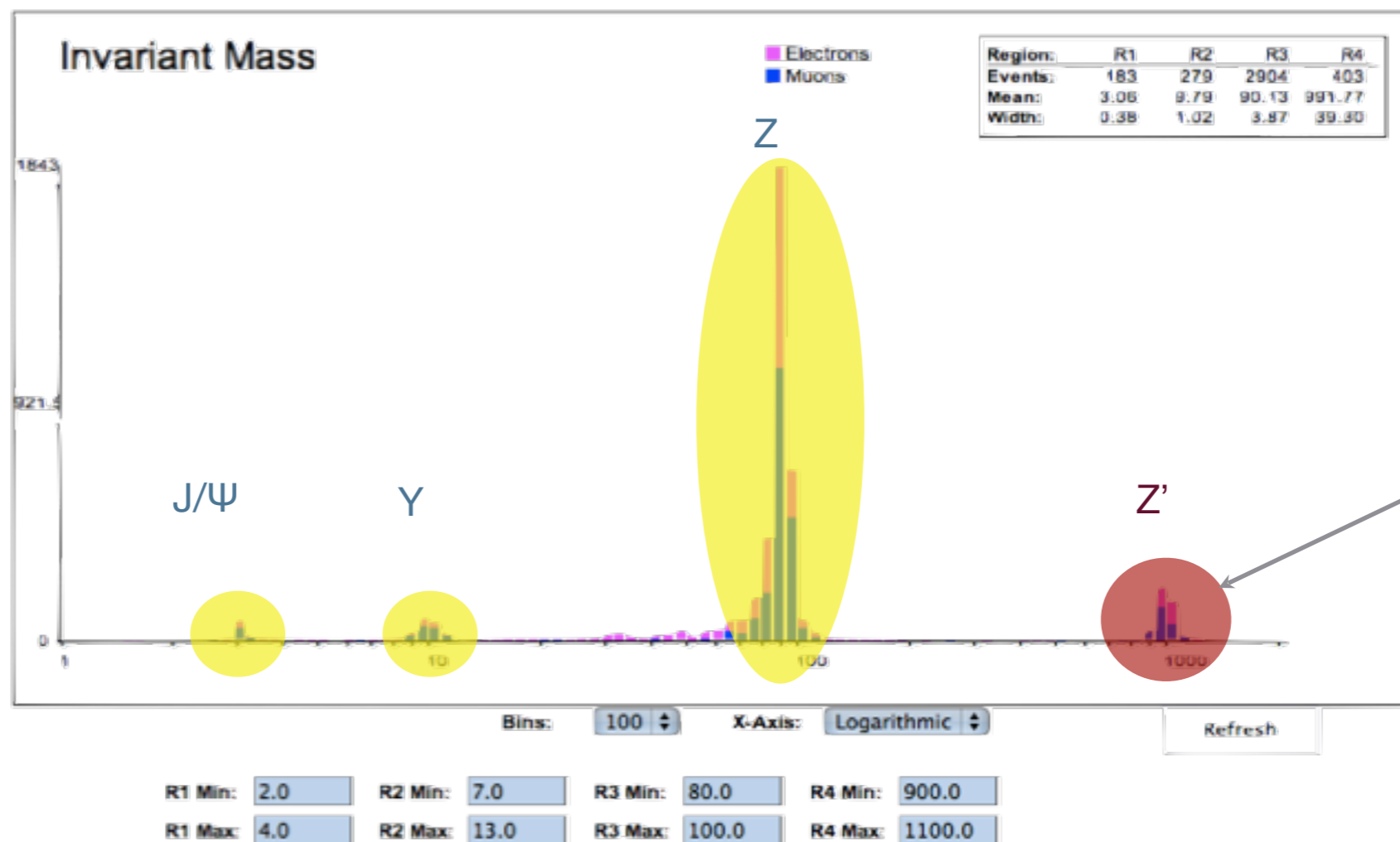


Fig. 11 - Building histograms and identify particles like physicists do

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CMS measurement (M. Hategan, K. Cecire et al. 2012)

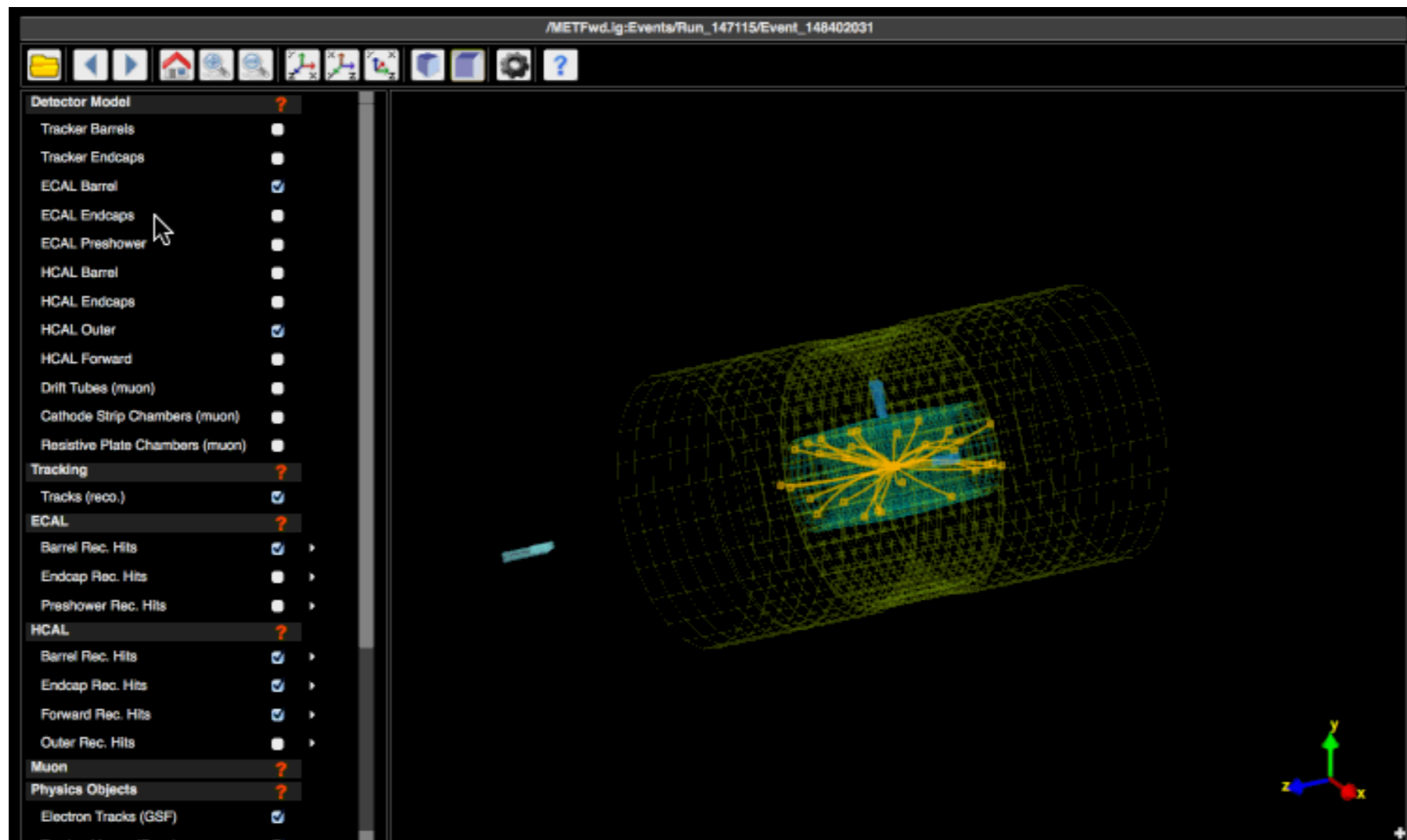


Fig. 12 - using 3-D event displays

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LHCb measurement (2014)

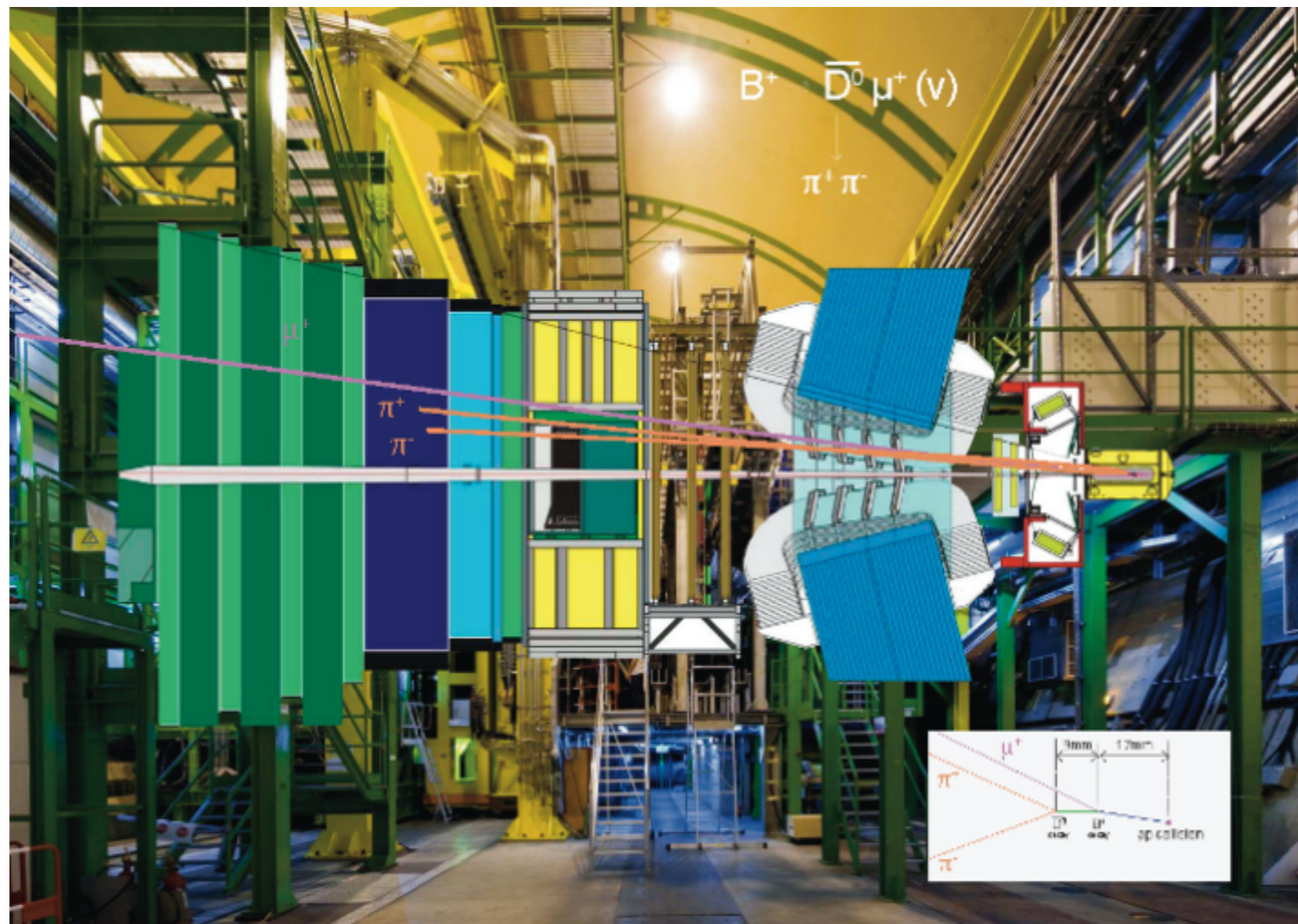


Fig. 12 – Measuring the lifetime of neutral particles (D^0)

2. IPPOG's International Masterclasses

- documentation online:
 - ALICE: <http://alice.physicsmasterclasses.org/> <http://aliceinfo.cern.ch/public/MasterCL/MasterClassWebpage.html>
 - ATLAS: <http://www.cern.ch/kjende/start.htm>
 - CMS: <http://www.physik.uzh.ch/lectures/MC2012/dvd/exercises/CMS/cms.html>
 - LHCb: <http://lhcb-public.web.cern.ch/lhcb-public/en/LHCb-outreach/masterclasses/en/>
- available in 14 languages (translated by IPPOG members)
- contains: descriptions, animations, measurement's tasks, public real data events, analysis tools

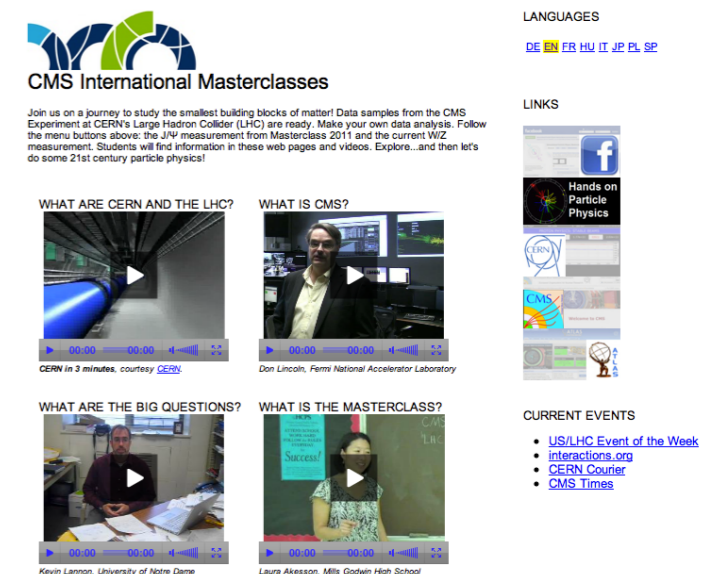
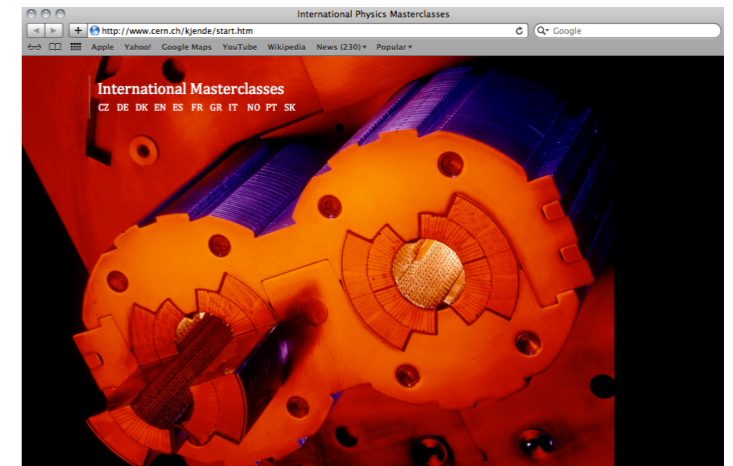


Fig. 13 - Screenshots of websites

2. IPPOG's International Masterclasses

- Surveys in 2005, 2007 (published), 2009 (QuarkNet), 2010, 2012 (to be published)

What students say about Masterclasses

GREAT EXPERIENCE! Thanks a lot.

MASTERCLASS IS Totally AWESOME!

It was great!

I think it was great! You should organise more, in different topics too! :) and advertise it more! (so every student will have the opportunity to take part in it)

**Die Umfrage ist vorzüglich, abwechslungsreich und spannend.
(The survey is excellent, varied and exciting.)**

**This was an amazing
experience and I'm so
excited to come back
tomorrow.**

**Réduire la théorie pour plus d'experiences.
(Reduce theory for more experiments.)**

2. IPPOG's International Masterclasses

- Surveys in 2005, 2007 (published), 2010 (Quarknet), 2012 (to be published)
- QuarkNet study

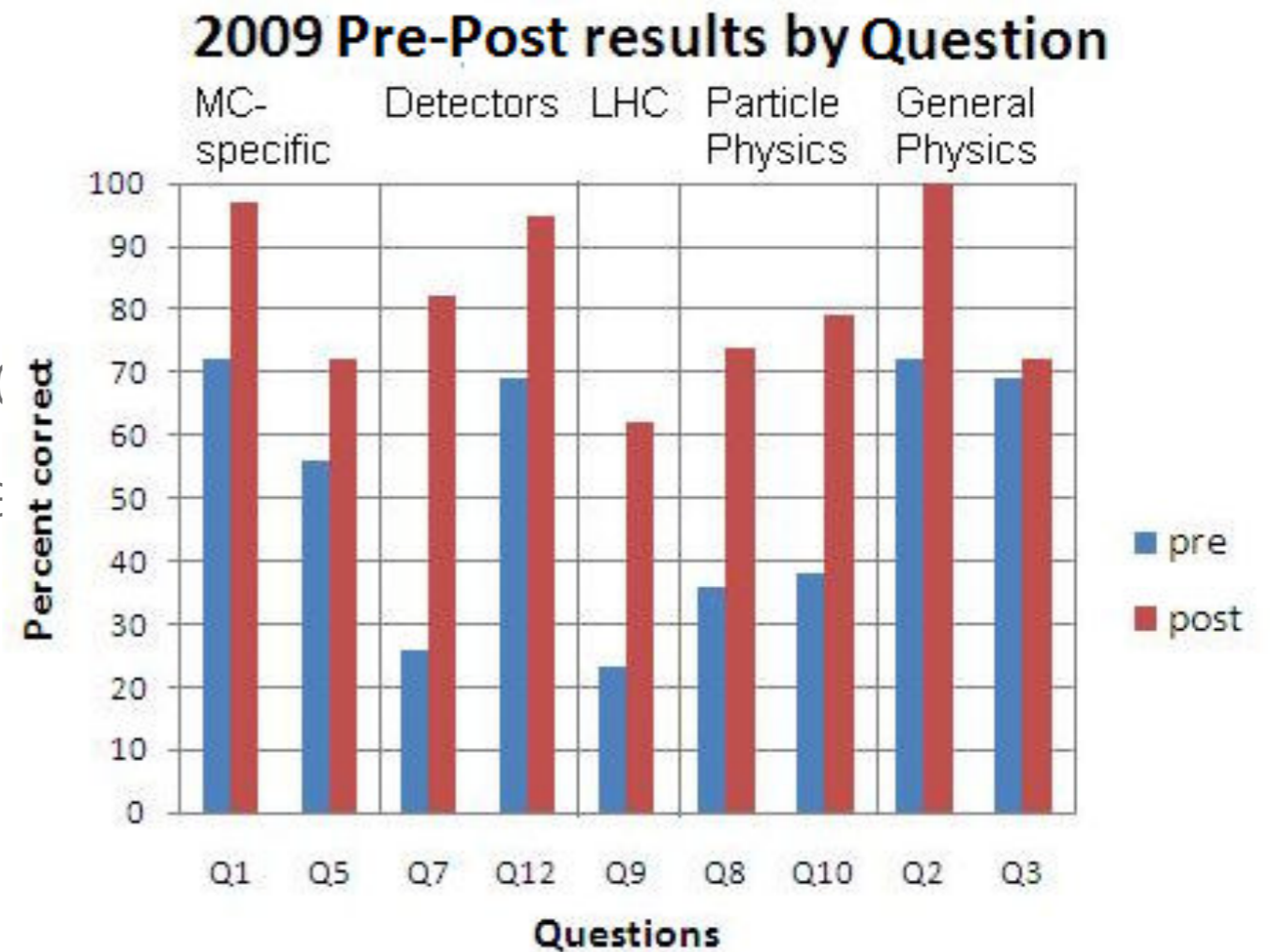


Fig. 14 - pre and post test performed by QuarkNet

2. IPPOG's International Masterclasses

- Surveys in 2005, 2007 (published), 2009 (Quarknet), 2010, 2012 (to be published)
- Publication: K.E. Johansson, M. Kobel, D. Hillebrandt, K. Engeln, M. Euler: European Particle Physics Masterclasses make students Scientists for a Day. In: Phys. Educ. 42 No 6 (November 2007) 636-644.

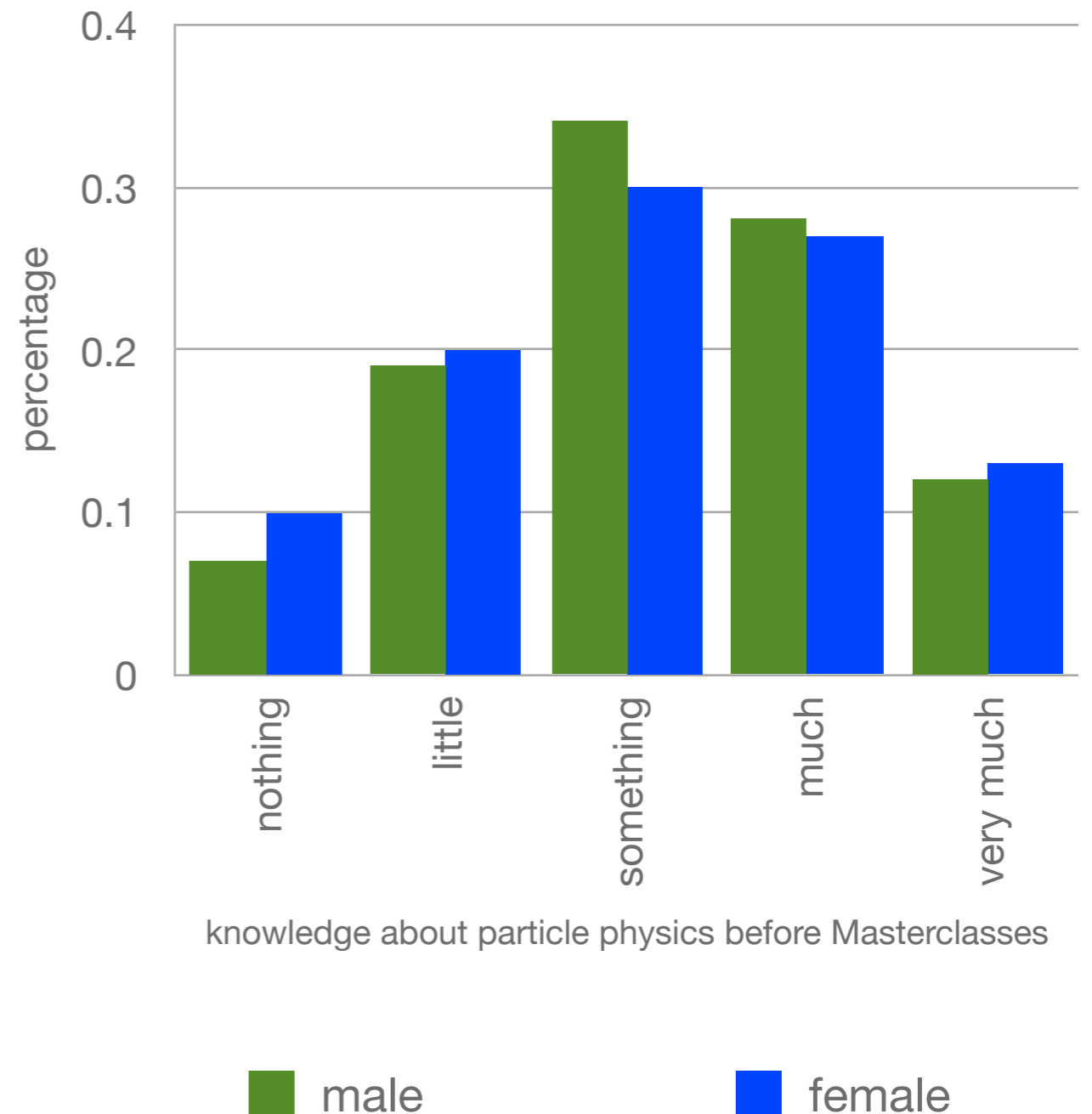
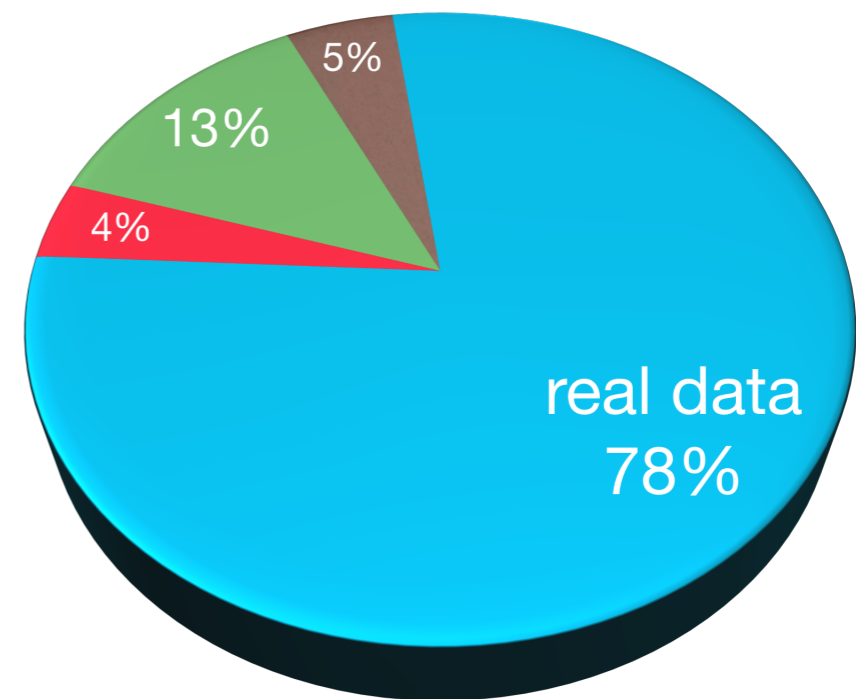


Fig. 15 - Gender independence of previous knowledge of attendees

2. IPPOG's International Masterclasses

- Surveys in 2005, 2007 (published), 2010, 2012 (to be published)
- Online survey in 2010 to understand what students wish to do in LHC Masterclasses

WHAT KIND OF DATA DO YOU PREFER TO WORK WITH?



SURVEY: KONRAD JENDE, 2010

Fig. 16 - Student wish to work with real data from the experiments

2. IPPOG's International Masterclasses

How you can get involved ...

- Physics Institutes willing to host a Masterclass ...
- Schools, teachers, students who want to attend a Masterclass ...

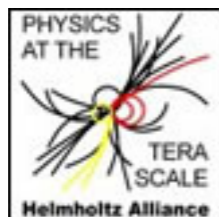
Please see our website <http://www.physicsmasterclasses.org> or contact the organizer by e-mail via masterclass@physik.tu-dresden.de

[How we can benefit from each other](#) ...

- Outreach Database was established to share material related to particle physics (videos, brochures, ideas for hands-on activities, posters, talks available in various languages): Use it, share it, upload your material!
- Please see: <http://ippog.web.cern.ch/resources> or send an e-mail to ippog.admin@cern.ch

3. Summary

- world-wide collaboration of 15-19 years old high-school students experiencing cutting-edge particle physics
- analyzing real data from “today” and largest science experiments on earth
- discussing results and reflecting activities
- going home with the feeling “we learned something about today’s research”
- hopefully coming back to universities to study physics or science subjects

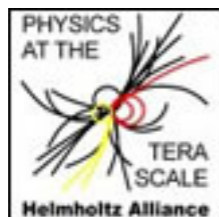




Thanks very much!

3. Summary

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2. IPPOG's International Masterclasses

Technical platforms and tools:

ATLAS

- MINERVA (M. Wielers, P. Watkins, T. McLaughlan et al.) based on ATLANTIS: <http://atlas-minerva.web.cern.ch>
- HYPATIA (C. Kourkouvelis et al.) based on ATLANTIS: <http://hypatia.phys.uoa.gr>

CMS

- [iSpy online](http://iguana.web.cern.ch/iguana/ispy/) (P. Nguyen, T. McCauley et al.) in collaboration with QuarkNet (US): <http://iguana.web.cern.ch/iguana/ispy/>

ALICE

- ALICE [masterclass application](http://aliceinfo.cern.ch/public/MasterCL/MasterClassInstallation.html) (P. Debski, Y. Foka et al.) simplified ALICE event display in ROOT environment: <http://aliceinfo.cern.ch/public/MasterCL/MasterClassInstallation.html>