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

International Particle Physics Outreach Group

Introduction to Particle Physics Masterclasses

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International Particle Physics Outreach Group

Outline

- Introduction
- IPPOG's International Masterclasses
  - Physics Analyses
  - Evaluation
  - Participation
- Summary

IPPOG's International Masterclasses

International Particle Physics Outreach Group

- **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.)

FUNDED BY:

PHYSICS AT THE TERA SCALE Helmholtz Alliance — **COORDINATOR**

Federal Ministry of Education and Research — **MASTERCLASSES LHC UPGRADE**

EPS — **DVD PRODUCTION**

NSF — **US PARTNER PROGRAMME**

CERN — **EXPERIMENTAL DATA VIDEOCONFERENCE**

+ NATIONAL FUNDING AGENCIES

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

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://www.physicsmasterclasses.org

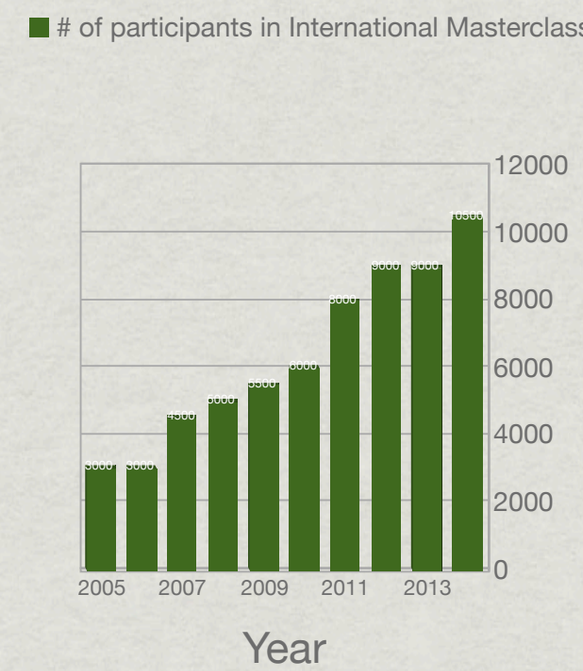

Fig. 2 - Number of participants in International Masterclasses over the years

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IPPOG's International Masterclasses

Fig. 3 - World Map of Masterclasses attendees

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

Videoconference

Fig. 4 - Typical Masterclasses day

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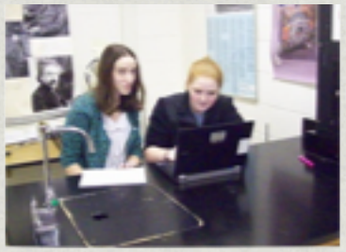
Physics Analyses



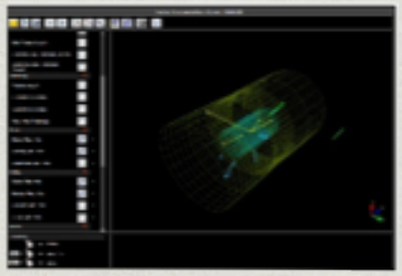


Fig. 5 - Process during data analysis in Masterclasses

- 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

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Physics Analyses

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

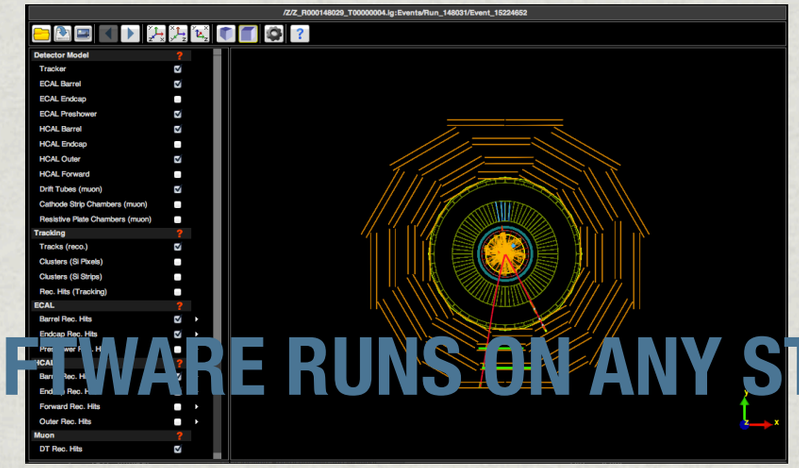

Fig. 6 - CMS event display

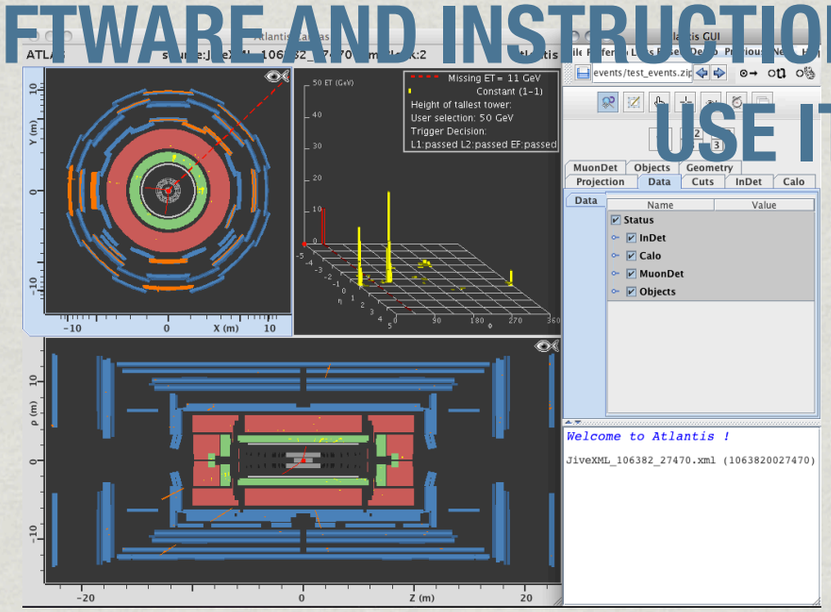

Fig. 7 - ATLAS event display

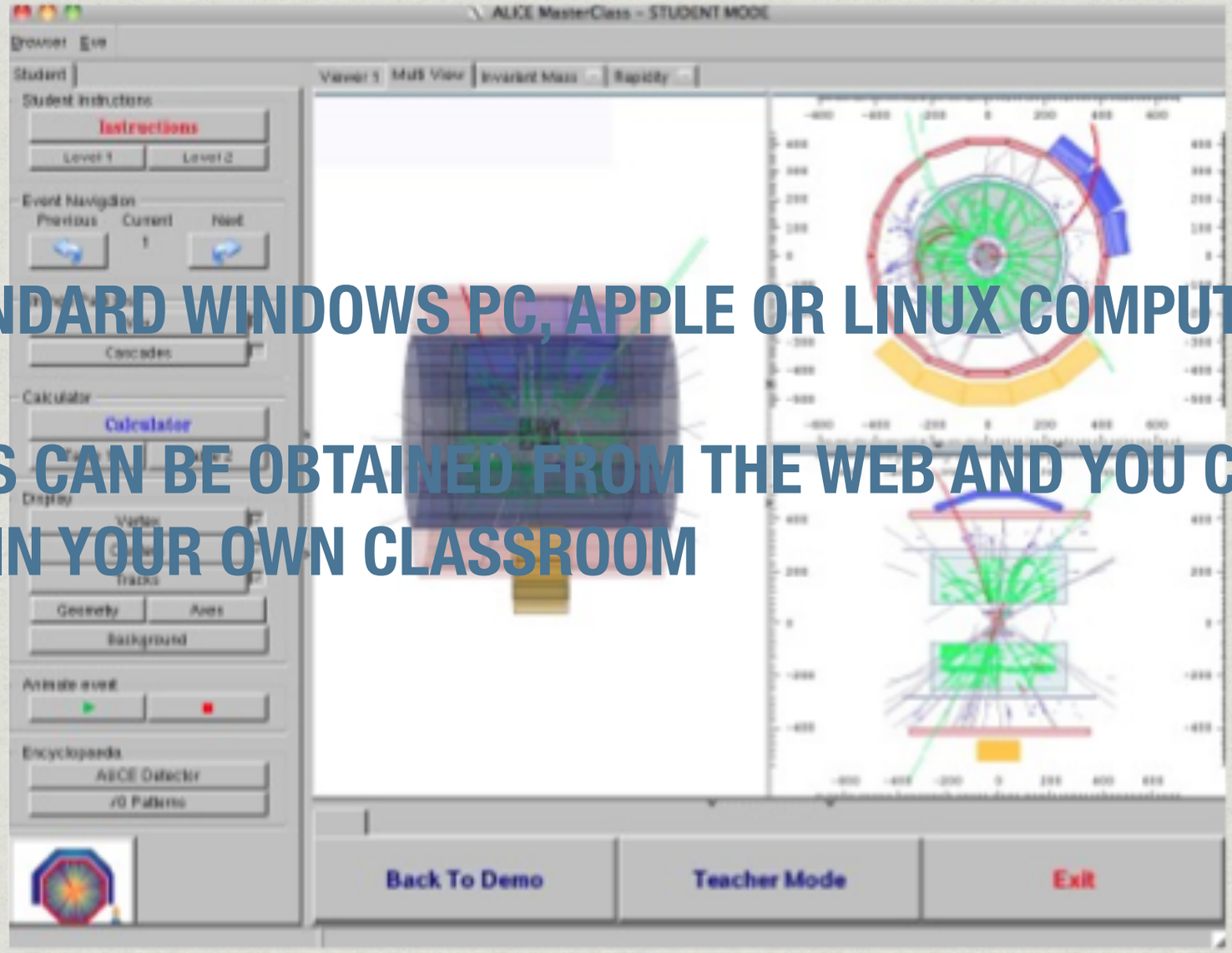

Fig. 8 - ALICE event display

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

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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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Physics Analyses

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

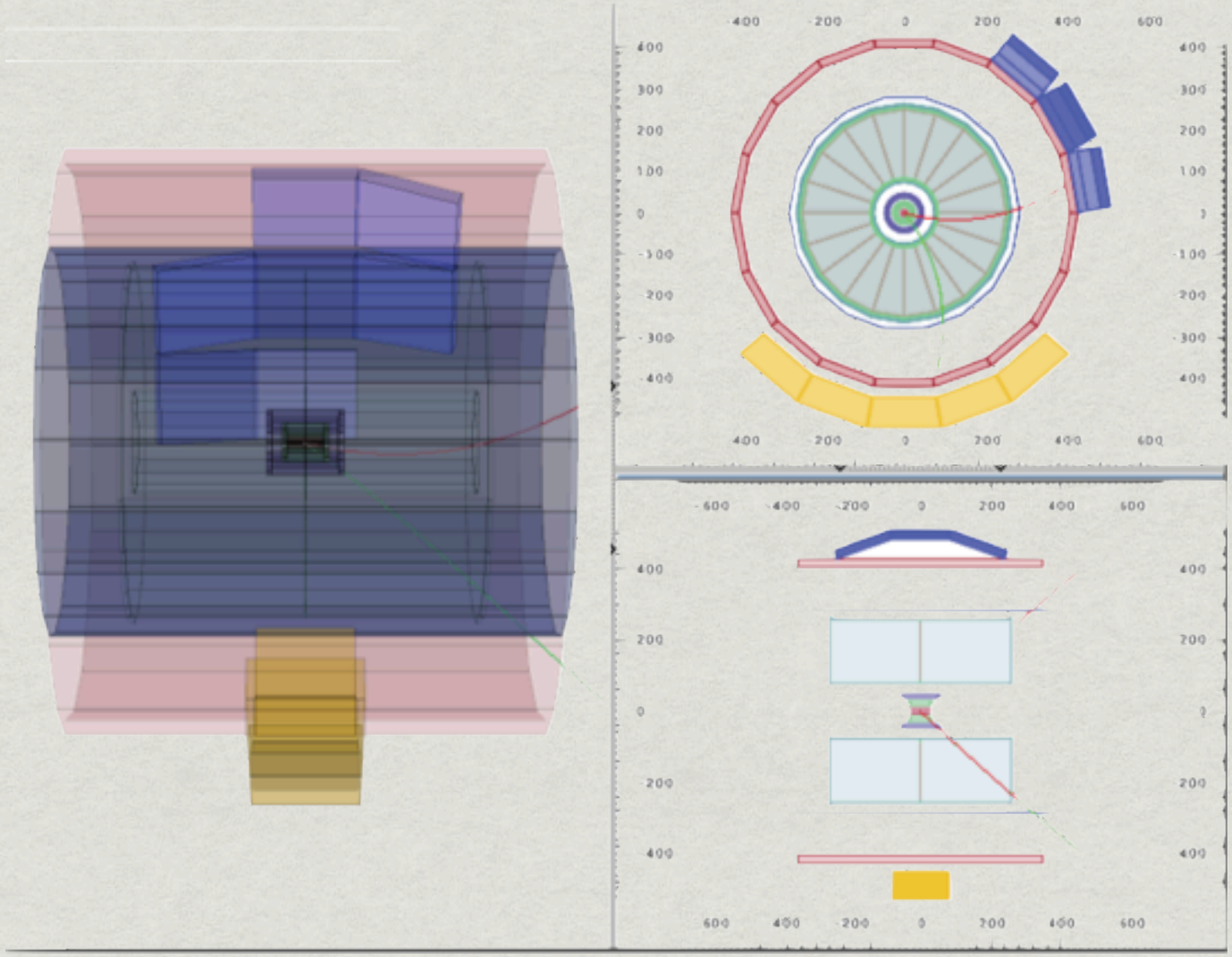

Fig. 9 - Electric neutral particles can be only seen in the inner detector when they decay into electric charged particles, where the tracks build a "V" - that is why we call them V0 events

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Physics Analyses

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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Physics Analyses

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

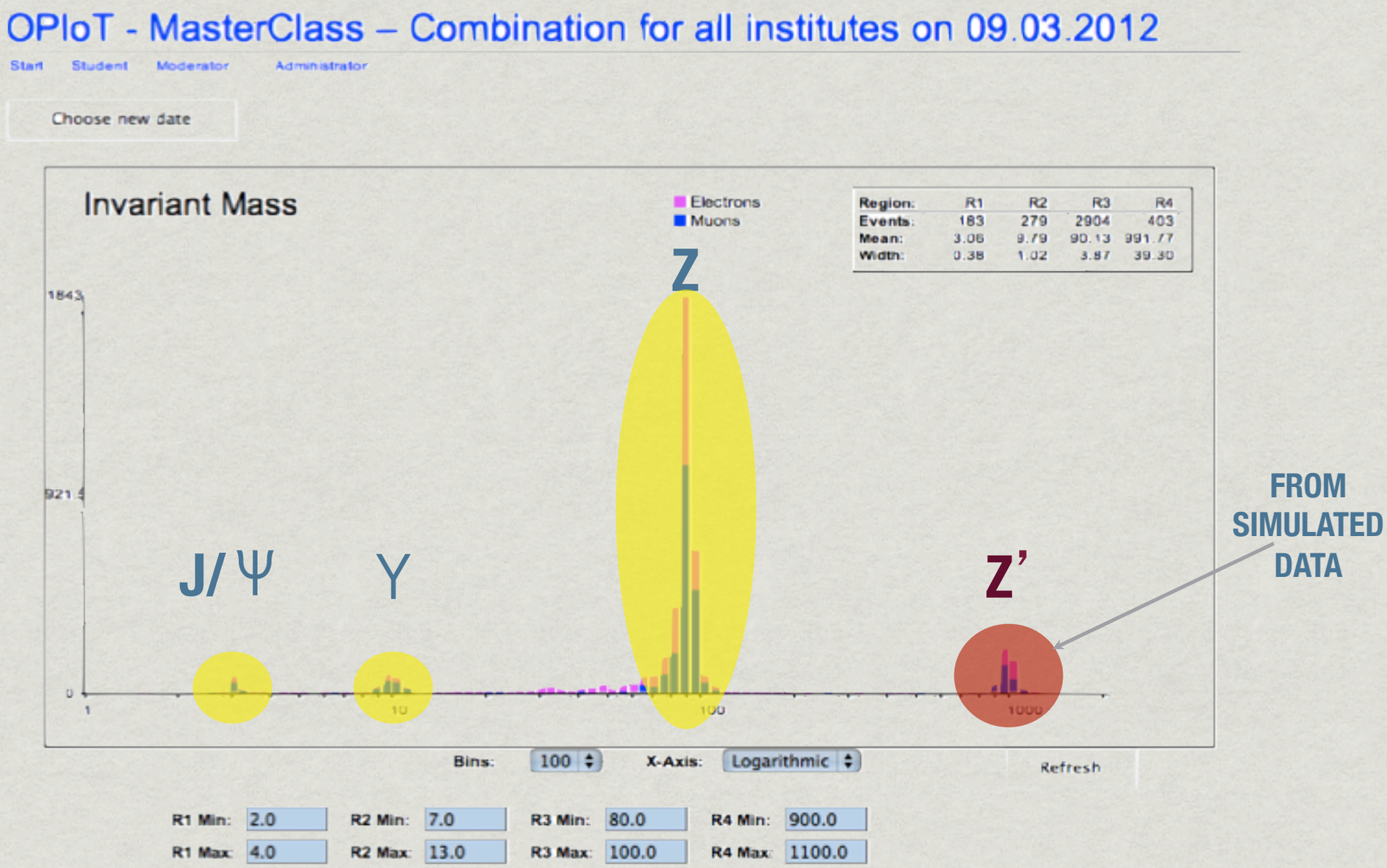

Fig. 11 - Building histograms and identify particles like physicists do

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Physics Analyses

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

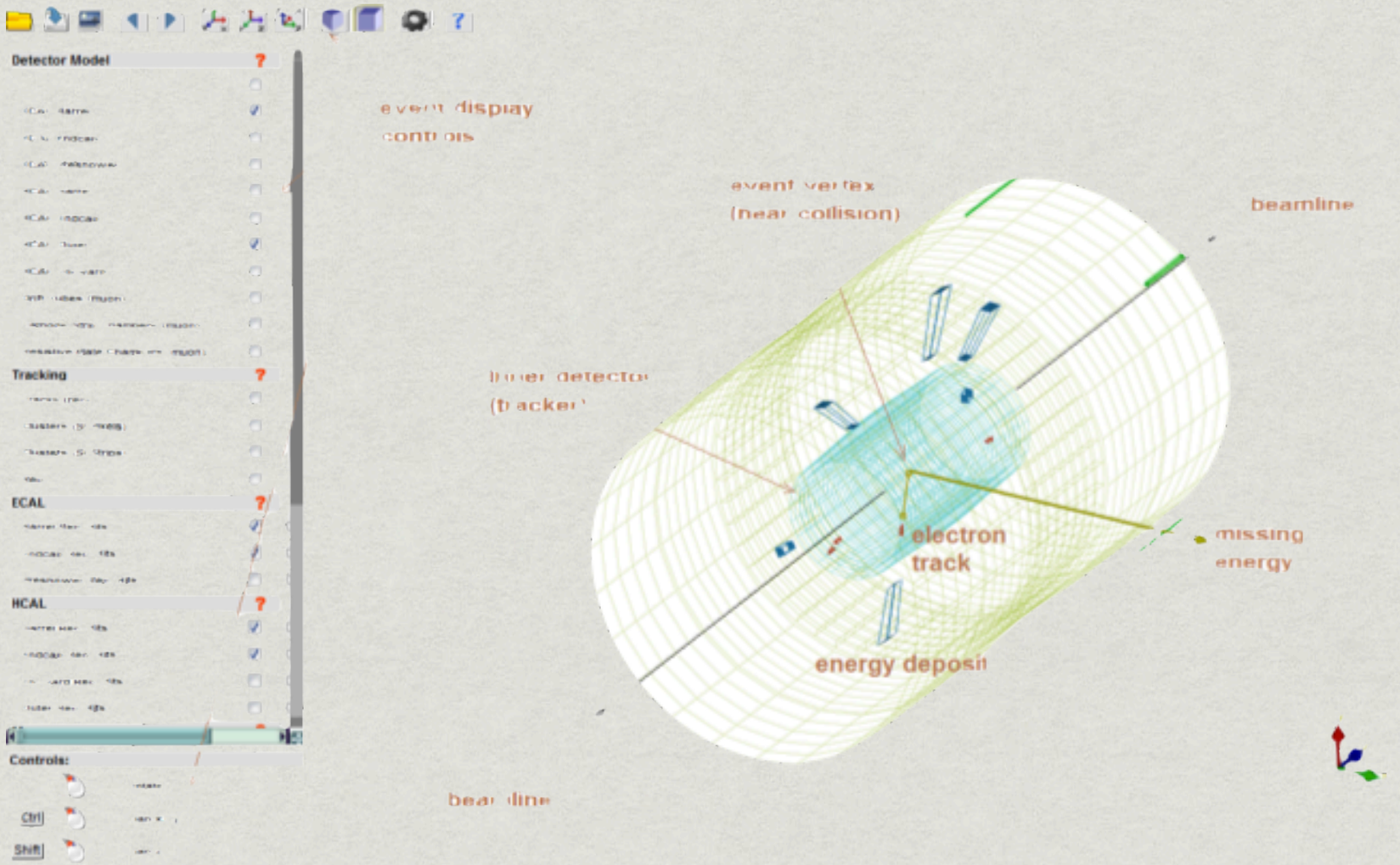

Fig. 12 - using 3-D event displays

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Physics Analyses

LHCb measurement (2014)

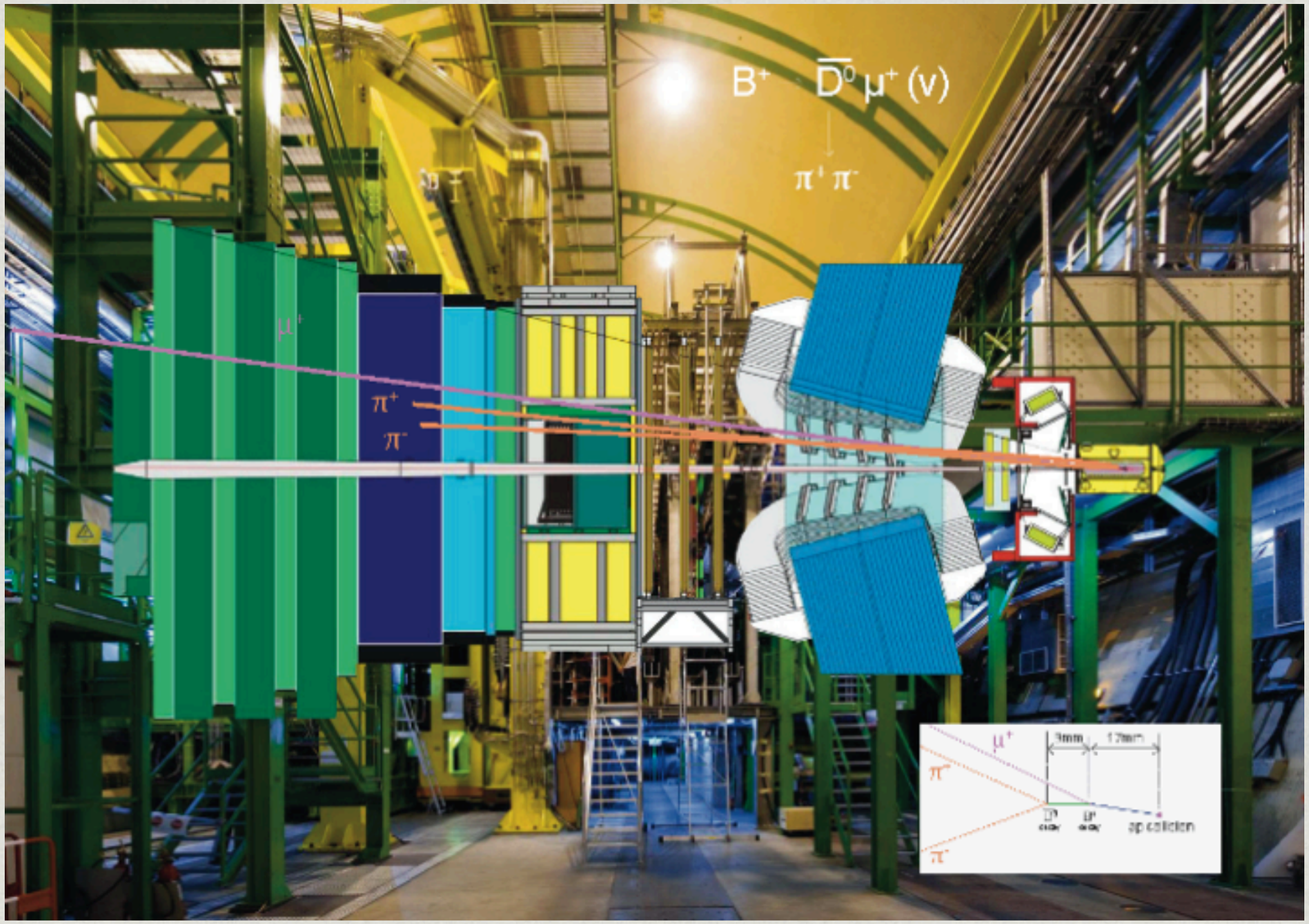
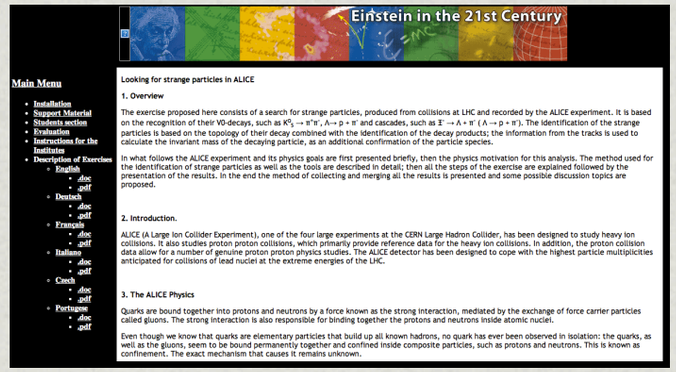


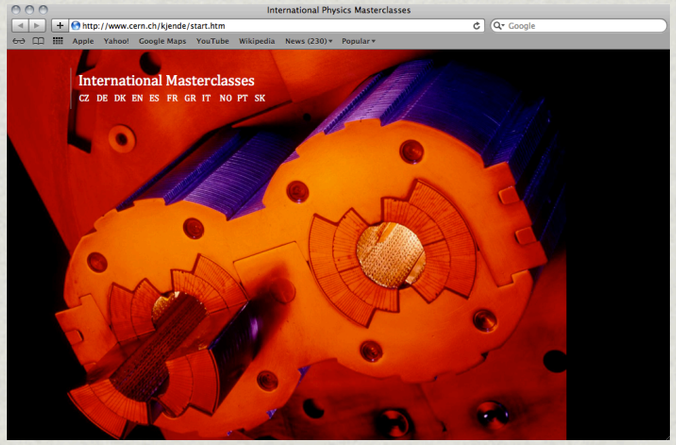
Fig. 12 – Measuring the lifetime of neutral particles (D^0)

IPPOG's International Masterclasses

Physics Analyses

- documentation online:
  - ALICE:
    http://alice.physicsmasterclasses.org/MasterClassWebpage.html
    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





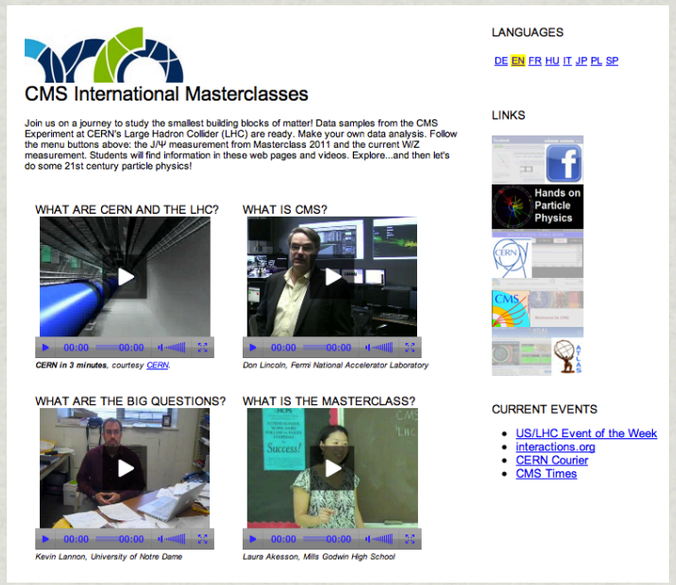


Fig. 13 - Screenshots of websites

IPPOG's International Masterclasses

Evaluation

- 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.)

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IPPOG's International Masterclasses

Evaluation

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

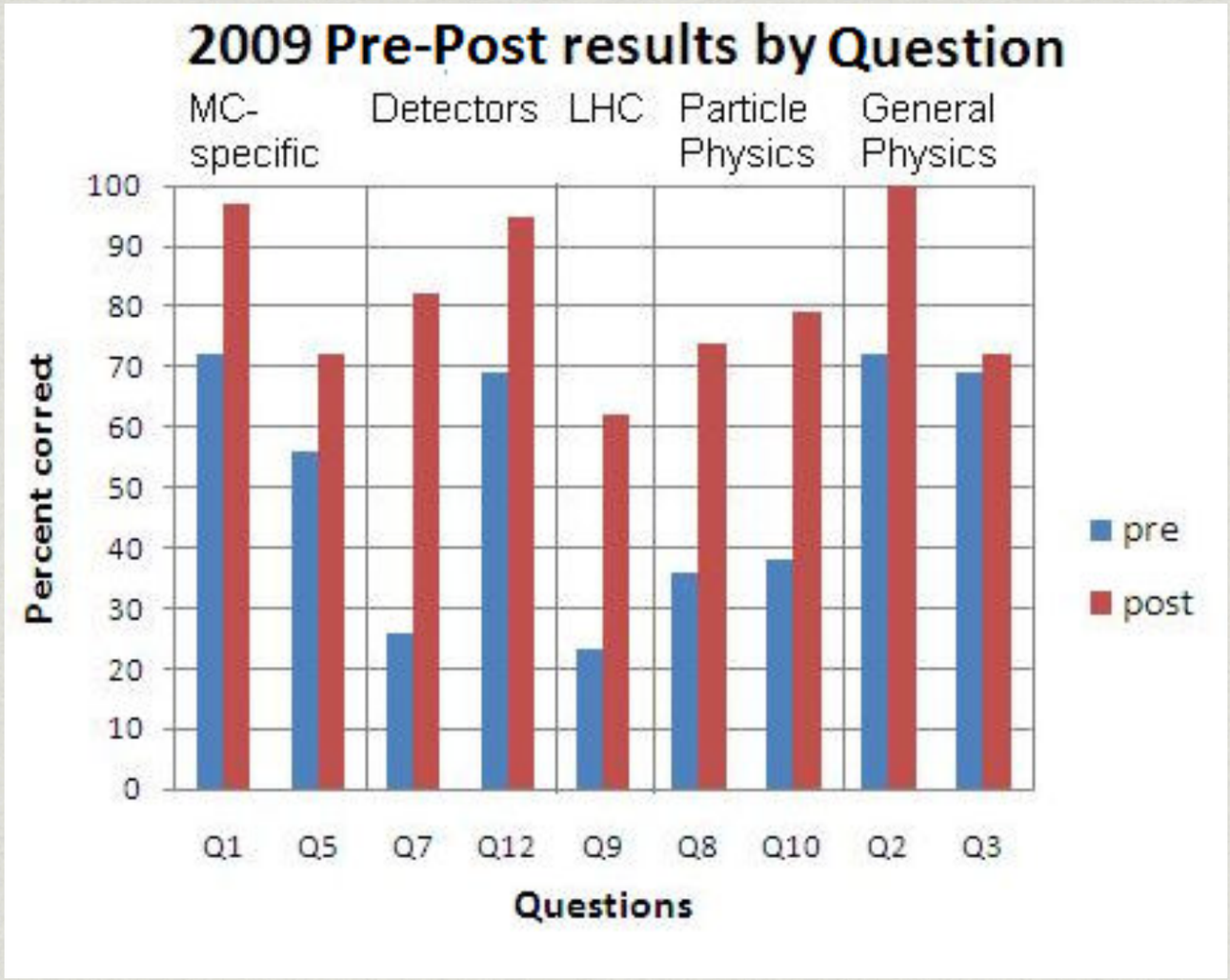

Fig. 14 - pre and post test performed by QuarkNet

IPPOG's International Masterclasses

Evaluation

- 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.

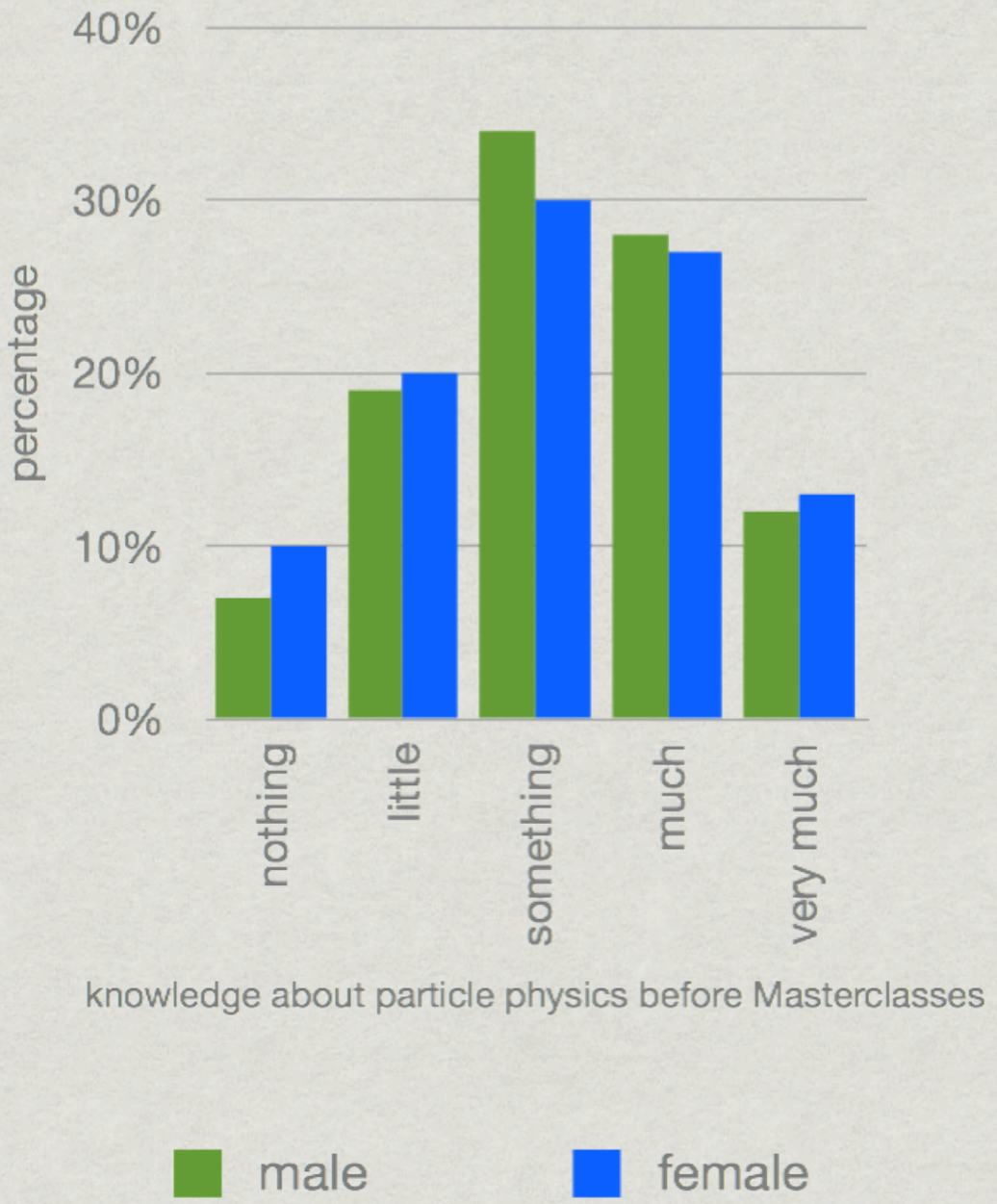

Fig. 15 - Gender independence of previous knowledge of attendees

IPPOG's International Masterclasses

Evaluation

International Particle Physics Outreach Group

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

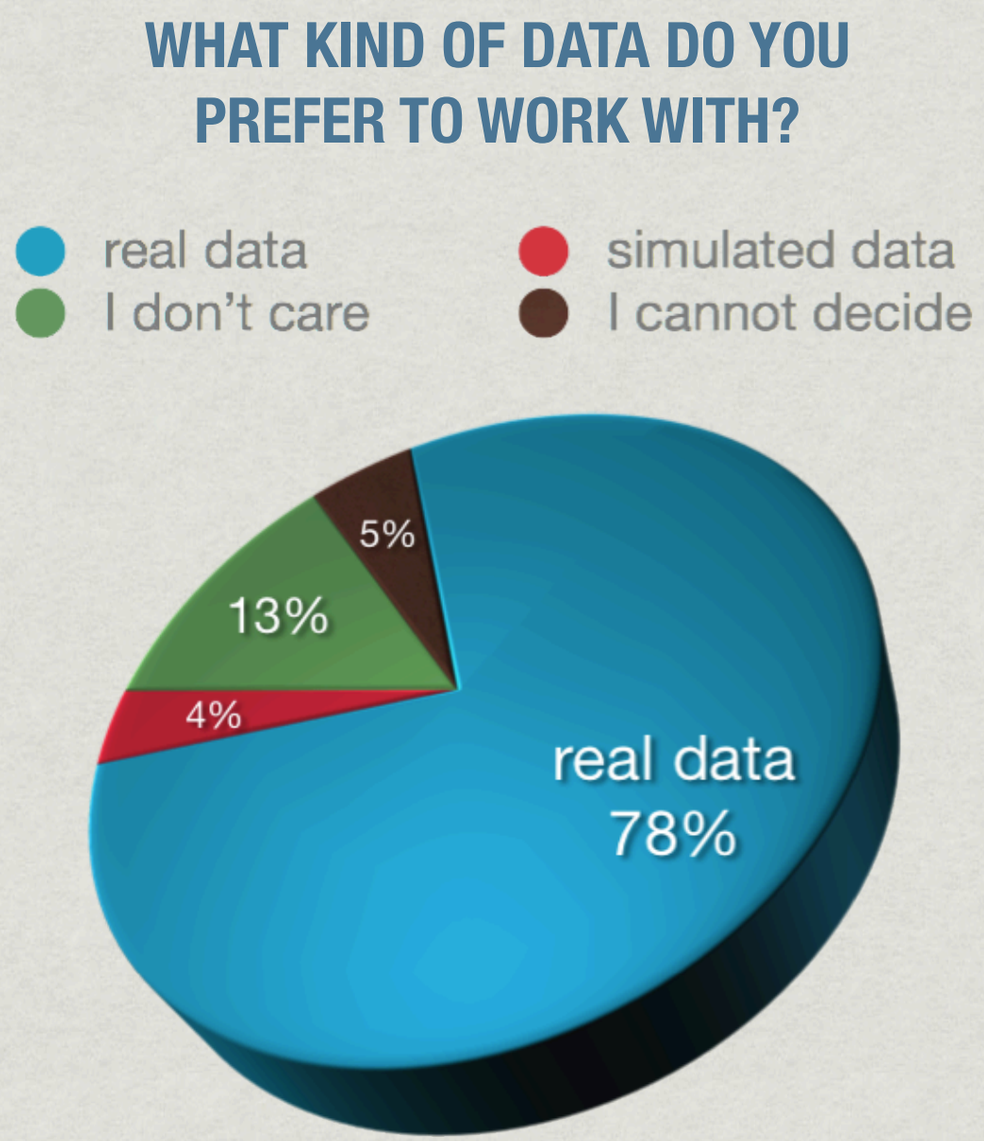

Fig. 16 - Student wish to work with real data from the experiments

IPPOG's International Masterclasses
Participation

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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

International Particle Physics Outreach Group

IPPOG's International Masterclasses

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

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IPPOG's International Masterclasses

Back up slides

- Taking the idea further (by IPPOG members)
- International Masterclasses - Physics Analyses - Technical Platforms and tools

IPPOG's International Masterclasses

Taking the idea further (by IPPOG members)

Germany - Netzwerk Teilchenwelt (ran since 2010)

- Masterclasses-like activity (Ph.D. students go into schools; 120 MC every year)

- Please see: http://www.teilchenwelt.de for further information

CMS

- toolkit with software, real data

- toolkit + local physicist are sent to school

IPPOG's International Masterclasses
Physics Analyses - 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. Kourkoumelis et al.) based on ATLANTIS: http://hypatia.phys.uoa.gr

CMS

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

ALICE

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

Bibliography

1. 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.

- C. Ilgner, T. Trefzger: *Ziele der Forschung am Large Hadron Collider.* In: H. Schwarze (publisher): *Large Hadron Collider.* Themenheft aus "Praxis der Naturwissenschaften - Physik in der Schule„ **60** No 2 (März 2011) 5-16.