Bringing the world’s largest science experiment into the “classroom”

Konrad Jende, TU Dresden on behalf of the International Particle Physics Outreach Group (IPPOG)

Outline

- Introduction
- IPPOG’s International Masterclasses
  - Physics Analyses
- Evaluation
- Participation
- Summary
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.)

**Funded By:**

- Coordinating: LHC Upgrade
- DVD Production
- US Partner Programme
- Experimental Data Videoconference
- National Funding Agencies
Objectives

- stimulate students interest in physics
- demonstrate scientific research process
- let students explore fundamental forces and building blocks of matter
- offer authentic experience
**Event** - create an International Collaboration among students (together with U.S. partner QuarkNet)

- ~4 weeks period in March every year
- 117 (+30 from U.S. partner) institutes from 31 countries
- central organization at TU Dresden: Michael Kobel and Uta Bilow
- Website: [http://www.physicsmasterclasses.org](http://www.physicsmasterclasses.org)

![Number of participants in International Masterclasses over the years](Fig. 2 - Number of participants in International Masterclasses over the years)
IPPOG’s International Masterclasses

Fig. 3 - World Map of Masterclasses attendees
IPPOG’s International Masterclasses

Fig. 4 - Typical Masterclasses day

Lectures

Measurement on real data

Combination of measurement’s results

Videoconference
IPPOG’s International Masterclasses
Physics Analyses

- 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
based on visual event identification of event displays of proton-proton-collisions using tools of physicists
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)
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.
ATLAS W measurement (K. Jende, M. Kobel et al. 2012)

Fig. 10 - using histograms to determine selection criteria like physicists do
ATLAS Z measurement (Farid Ould-Saada, Maiken Petersen et al. 2012)

**OPIoT - MasterClass – Combination for all institutes on 09.03.2012**

Choose new date

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**Invariant Mass**

- **Region:**
  - Events: 183, 270, 2004, 103
  - Mean: 3.96, 9.70, 9.13, 9.97
  - Width: 0.18, 1.02, 3.87, 3.97

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**FROM SIMULATED DATA**

**Fig. 11 - Building histograms and identify particles like physicists do**
IPPOG’s International Masterclasses

Physics Analyses

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

Fig. 12 - using 3-D event displays
IPPOG’s International Masterclasses

Physics Analyses

.documentation online:

- ALICE: http://aliceinfo.cern.ch/public/MasterCL/MasterClassWebpage.html
- ATLAS: http://www.cern.ch/kjende/start.htm

available in 13 languages (translated by IPPOG members)

contains: descriptions, animations, measurement’s tasks, public real data events,

Fig. 13 - Screenshots of websites

Thursday, August 2, 12
IPPOG’s International Masterclasses
Evaluation


**What students say about Masterclasses**

**GREAT EXPERIENCE! Thanks a lot.**

*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'expériences.
(Reduce theory for more experiments.)
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)


![Graph showing gender independence of previous knowledge of attendees](image)

*Fig. 15 - Gender independence of previous knowledge of attendees*
IPPOG’s International Masterclasses Evaluation

- Online survey in 2010 to understand what students wish to do in LHC Masterclasses

**WHAT KIND OF DATA DO YOU PREFER TO WORK WITH?**

- real data: 78%
- I don’t care: 13%
- simulated data: 5%
- I cannot decide: 4%

**SURVEY: KONRAD JENDE, 2010**

Fig. 16 - Student wish to work with real data from the experiments
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](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](http://ippog.web.cern.ch/resources) or send an e-mail to ippog.admin@cern.ch
• Workshop “Experiencing data analysis from the world’s largest science experiment” on JULY 4 2012 at 1pm in room Smart Class II
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
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 in 2011)
- 2011: eight (further developing) teacher programmes in Germany, two Teacher Programmes at CERN, two programmes for students at CERN, 9 research projects done by students
- Please see: http://www.teilchenwelt.de for further information

CMS (under development)

- toolkit with software, real data
- toolkit + local physicist are sent to school
IPPOG’s International Masterclasses
Physics Analyses - Technical Platforms and tools

ATLAS

- **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