

# INTERNATIONAL MASTERCLASSES HANDS ON PARTICLE PHYSICS

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<http://physicsmasterclasses.org/>

on behalf of the

IPPOG Masterclass Steering Group

QM2018 13.05.2018 Venice



# International MasterClasses



How to best share our results with the broader public ?

In particular, students, high-school children...

**Motivate the next generations of scientists !**

**The “International Masterclasses” IMC project  
is an educational activity that brings the excitement  
of cutting-edge high-energy physics research into the classroom !!**

# High-energy physics MasterClasses

Classes by experts, Masters, are common in the world of art

In our case

- the topic is high-energy physics
- the Master is a physicist

**Pupils are given the opportunity to analyze real LHC experimental data the same way that scientists do.**

**Become “scientists for a day” !**

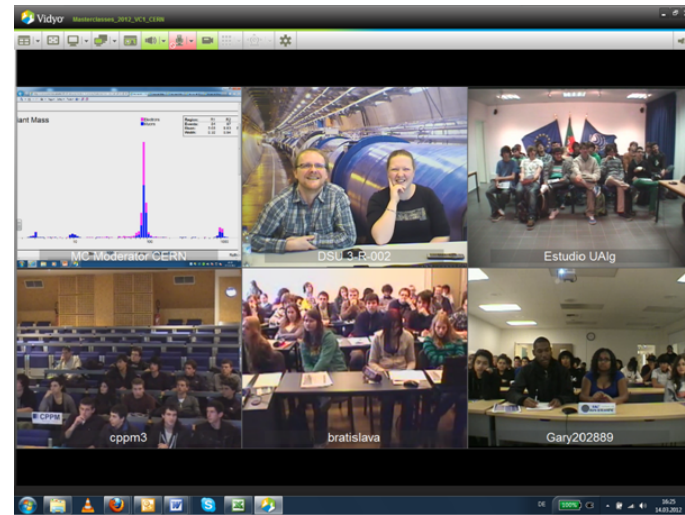


# Concept of International MC

Every year, during the months of February-March school-children (15-19 year old) are invited to an institute of their area.

They are exposed to the world of high-energy physics

- **Hands-on measurements with real LHC data**
- **International video conference (3-5 institutes) moderated by CERN or Fermilab**



# Example programme of a IMC day

## LOCAL TIME: ACTIVITY

8:30 - 9:00 Registration and Welcome

9:00 - 10:00 Introductory lectures

10:30 - 11:30 Visit of a lab or experiment

12:00 - 13:00 Lunch

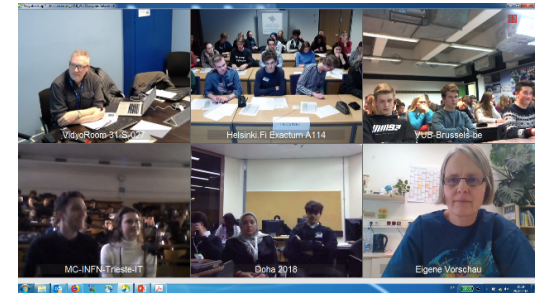
13:00 - 15:00 Hands-on session

- Instructions and interactive demo
- Measurements on real LHC data

15:00 - 16:00 Merge and discuss results locally

16:00 - 17:00 **Video conference CERN, Fermilab**

- Discussion, combination of results
- Q&A
- Quiz



**The aim is to get insight into topics and methods of research!**  
**Not to teach rigorously particle physics.**



International Particle  
Physics Outreach Group

INTERNATIONAL



MASTERCLASSE

hands on particle physics

## Well structured project

- procedures
- instructions
- material
- translations

Home

Information for  
High School Students

Information for  
Teachers and Educators

Information for  
Institutes and Physicists

Schedule

Intl. Day of Women  
and Girls in Science

<http://physicsmasterclasses.org/>



International Masterclasses

14<sup>th</sup> International Masterclasses 2018

Each year more than 13.000 high school students in 52 countries come to one research centres for one day in order to unravel the mysteries of particle physics. insight in topics and methods of basic research at the fundamentals of matter and for measurements on real data from particle physics experiments themselves. At the end of the research collaboration, the participants join in a video conference for discussion and here for media coverage.

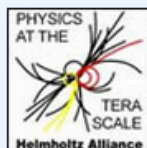
## Not difficult for newcomers

- teachers
- institutes

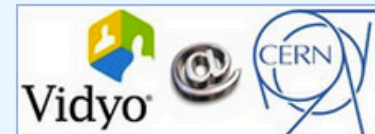
## Details during MC Demos at QM

This program is organized at TU-Dresden in the framework of the International Particle Physics Outreach Group IPPOG. The video linkup between the institutes is realized with valuable technical support from the Vidyo support at CERN IT. We gratefully acknowledge financial support from the Helmholtz Alliance "Physics at the Terascale", the BMBF German Federal Ministry of Education and Research, EPS HEPP High-Energy and Particle Physics Division of the European Physical Society, and from TU Dresden. An offline version of this website is available as DVD from the organizers and distributed to all participating students.

**The material can be used for many other purposes**

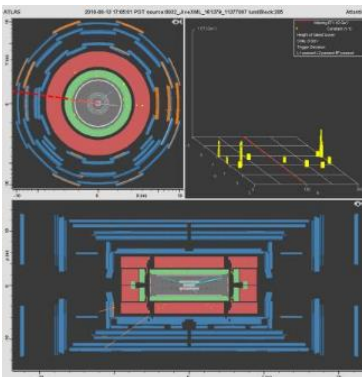
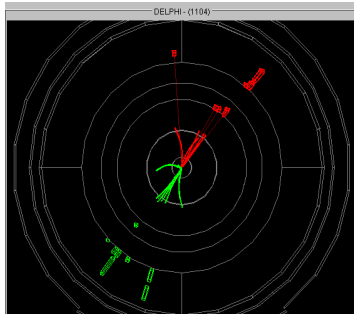
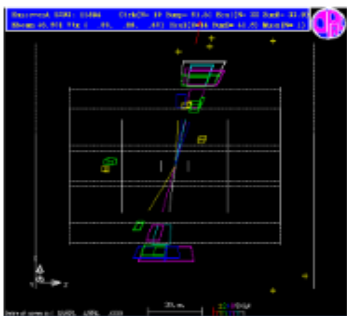


Federal Ministry  
of Education  
and Research



# How it all begun...

- Idea from UK, 1996 (R. Barlow et al.)
- 1997: Masterclass in UK with 7 institutes
- 1998: Nationwide uptake
- **2005: In Europe adopted by EPPOG/IPPOG**
  - Use of LEP data
    - OPAL Identifying Particles
    - DELPHI Hands on CERN
- 2006: U.S. joined program (QuarkNet)
- **2011: LHC-based Masterclasses**
- **2014: All 4 LHC experiments**



<http://cerncourier.com/cws/article/cern/55890> (How it all begun)

<http://cerncourier.com/cws/article/cern/57305> (MC in the LHC era)

# IPPOG

The International MasterClass project was developed within the framework of **IPPOG (EPPOG) : International Particle Physics Outreach Group.**

IPPOG is a network of scientists, science educators and communication specialists, engaged in worldwide outreach and informal science education for high-energy physics.

**IPPOG has recently become a formal collaboration and is expanding with new countries, international laboratories and experiments joining.**

## **Representatives from**

- **27 states (including CERN member states)**
- **CERN, DESY, Fermilab**
- **LHC experiments**

<http://ippog.web.cern.ch/>



# IMC Coordination and preparation

The International MasterClass is coordinated by the Steering Group

- members representing the developed measurements packages
- overall coordination by TU Dresden, Germany and Fermilab/QuarkNet, US  
(possibility that KEK will coordinate institutes at the east)

The IMC coordinators and steering group prepare the event every year

- Contact the national representatives  
who contact the universities and schools of their countries
- Prepare the analysis packages and quiz
- Provide material in web pages (translations in different languages)
- Prepare videoconference
- Prepare tutors and moderators  
via dedicated instructions material and training session
- Feedback and surveys

# IMC Statistics

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

18

countries

52

58

institutes

225

72

masterclasses

307

3k

students

14k

12

video conferences

82

# International MasterClasses 2018



15 Feb – 28 Mar 2018

52 countries



Coordination : Fermilab, QuarkNet / TU Dresden



- 48 institutes
- 50 Masterclasses
  - 31 CMS
  - 19 ATLAS



- 177 institutes
- 257 Masterclasses
  - 35 ATLAS W
  - 104 ATLAS Z
  - 58 CMS
  - 39 LHCb
  - **18 ALICE Strangeness**
  - **3 ALICE RAA**

# Videoconference

Depending on the time zone,  
CERN or Fermilab moderate

- **61 with CERN**  
**50 moderators**
- **18 with Fermilab**  
**18 moderators**
- **1 with TRIUMF**

**Features: discussion as in collaborations**

- Use Indico
- Compare to published results

**Even with this simple procedure  
pupils get the message that this  
is not one person's job....**

QuarkNet CMS Masterclass Sat 24 Mar A

Saturday, March 24, 2012 from 14:00 to 14:53 (US/Central)  
at FNAL ( WH1E )

**Material** [Combination Mass Plot](#) [Data upload spreadsheet](#) [Map](#) [iSpy-online](#)

**Video Services** Vidyo public room : QuarkNet\_CMS\_Masterclass\_Sat\_24\_Mar\_A [Join Now!](#) | [More Info](#)

**Saturday, March 24, 2012**

14:00 - 14:08	Intro and Warm-up 8'
14:08 - 14:10	Mayaguez report 2' Material: <a href="#">mass plot</a>
14:10 - 14:12	Sao Paulo report 2'
14:12 - 14:14	Auckland report 2'
14:14 - 14:16	West Lafayette report 2' Material: <a href="#">pictures</a>
14:16 - 14:30	Discussion/Q&A/Wrap-up 14'



# Schedule and Moderators

	Mon, Mar 12	Tue, Mar 13	Wed, Mar 14	Thu, Mar 15	Fri, Mar 16	Sat, Mar 17
topic	VC 1: ATLAS Z	VC 1: ATLAS Z	VC 1: ATLAS W	VC 1: ATLAS Z	VC 1: ATLAS W	VC 1: ATLAS Z
	Milan 	Geneva CERN 	Cosenza 	Oxford 	Dresden 	Lisbon IST 
	Brookhaven 	Rakovnik / Prague CU 	Rome Tor Vergata 	Nijmegen 	Krakow AGH 	Covilhã 
	Linz 	Oxford 	Amsterdam 	Natal 	São Paulo USP 	Coimbra 
	Wuppertal 	Ljubljana 	Genova 	Annecy 	Olomouc 	Lisbon FCUL 
	Bielsko Biala 	Würzburg 	Ponta Delgada 	Riverside 	Copenhagen 	Bucharest 
topic	VC 2: LHCb	VC 2: ALICE S.P.	VC 2: CMS	VC 2: ALICE RAA	VC 2: LHCb	
	Geneva CERN 	Nantes 	Geneva CERN 	Münster 	Paris 	
	Ferrara 	Lyon 	Istanbul, Ozyegin 	Frankfurt 	Barcelona 	
	Dublin 	Strasbourg 	Aachen 	Darmstadt 	St. Petersburg 	
	Syracuse 		Padova 	Padova 	Heidelberg 	
			Cyprus 		Frascati 	

## Moderators 2017:

	Andreas Albert (CMS)		Mike Albrow (CMS)		Muhammad Alroob (ATLAS)		Mahmoud Alstary (ATLAS)
	Paula Alvarez (LHCb)		Friederike Bock (ALICE)		Elvire Bouvier (CMS)		Lorenzo Capriotti (LHCb)
	Ina Carli (ATLAS)		Adrian Carmona (Theory)		Mirko Casolino (ATLAS)		Maria Cepeda (CMS)
	Leo Cerda (ATLAS)		André David (CMS)		Francesca Dordei (LHCb)		Mike Fenton (ATLAS)
	Alejandro Gomez (CMS)		Julia Gonski (ATLAS)		Rebeca Gonzalez Suarez (CMS)		Despina Hatzifotiadou (ALICE)
	Michael Hauschild (ATLAS)		Alexander Held (ATLAS)		Thibaud Humair (LHCb)		Roland Jansky (ATLAS)
	Jason Kamin (CMS)		Henning Kirschenmann (CMS)		Katharine Leney (ATLAS)		Chris Martin (ATLAS)
	Pedja Milenovic (CMS)		Marcus Morgenstern (ATLAS)		Stefanie Morgenstern (ATLAS)		David Morse (CMS)

and more!

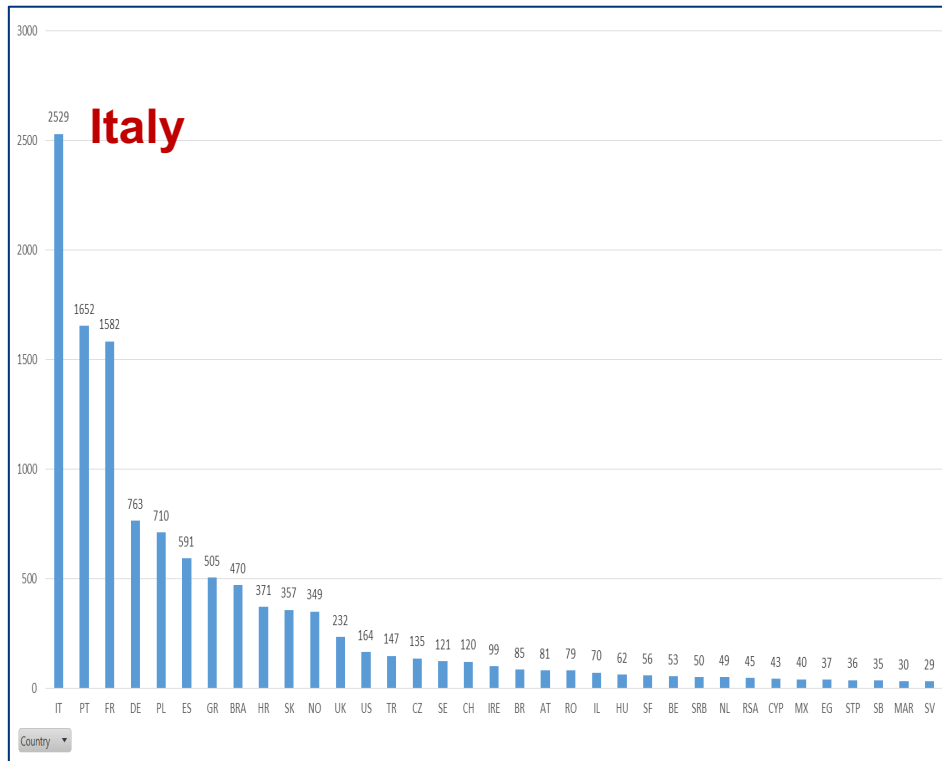
[www.physicsmasterclasses.org/index.php?cat=schedule#moderators](http://www.physicsmasterclasses.org/index.php?cat=schedule#moderators)

e-group [ippog-masterclass-moderators@cern.ch](mailto:ippog-masterclass-moderators@cern.ch)

**Pupils get excited to talk to scientists  
at their working place  
at CERN or Fermilab**

# IMC Surveys

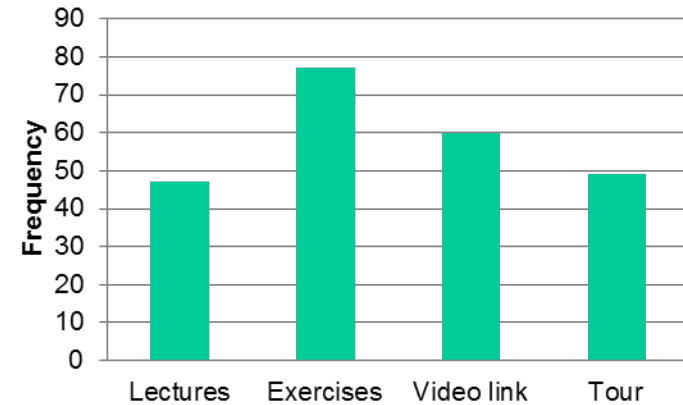
Number of students per country  
from CERN Videoconference



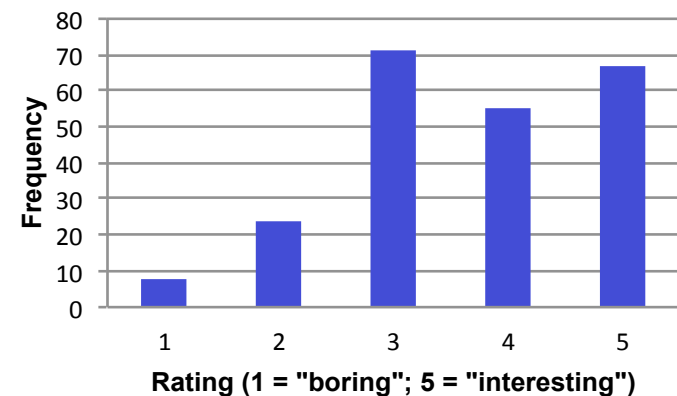
**Efforts and Working Group  
to reach as many countries as possible**

From US surveys

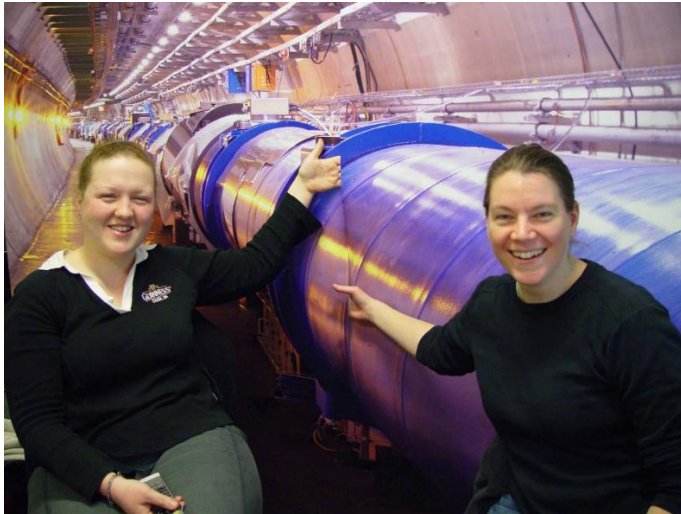
**Prelim: What did you like *best*  
about the masterclass?**



**Prelim: Video link rating**



# IMC in a nutshell



## The basic needed elements

- package providing experimental data to students
- tutors at institute
- moderation center, moderators for video-conference
- ... school children...

**A lot of existing material  
and well tested procedures**

## Key factors

- **Well tested Measurements**

**Thank you T-Shirts for moderators !**

- **Well prepared Institutes**

- (bi)weekly circulars [http://physicsmasterclasses.org/index.php?cat=local\\_organisation&page=organisation](http://physicsmasterclasses.org/index.php?cat=local_organisation&page=organisation)
- Orientation for institutes

- **Well prepared Videoconference and Moderators**

- Training for moderators (2 h) <https://indico.cern.ch/event/696223/>
- twiki, manual for videoconference  
[http://www.physicsmasterclasses.org/downloads/manual\\_local\\_organizers\\_2018\\_02\\_06.pdf](http://www.physicsmasterclasses.org/downloads/manual_local_organizers_2018_02_06.pdf)
- Equiped dedicated rooms
- Vidy support at every session

International Masterclasses – hands on  
particle physics

# INTERNATIONAL MASTERCLASSES

hands on particle physics

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**facebook**

Name:  
International  
Particle Physics  
Masterclasses

## **Detailed instructions and documentation** **Hands on Particle Physics Masterclasses** **ORGANISATION**

Welcome in the organisation section of the IPPOG Masterclasses!

Here, we hope to provide you with all that you'll need in order to organise an event that students, teachers and staff will never forget.

Therefore, you can find:

- an **introduction** to the overall organising scheme
- some example **lectures**
  
- information on the **measurements**
  
- a **manual** for the video conference, including information on the new quiz
  
- **corporate material** to prepare e.g. invitation letters or participation certificates
  
- **english press release**
- **german press release**

We also provide information how we would like to

- **present participating institutes** on our website or how you can
- **contribute in translating the exercises.**





# MasterClass material for other events

## World Wide Data Day

<http://tiny.cc/w2d2-17>

Data analysis at school, physics discussion in VC

Report: <http://tiny.cc/94lrsy>

## International Day of Women and Girls in Science













UN: Feb 11th, since 2016

[www.un.org/en/events/women-and-girls-in-science-day/](http://www.un.org/en/events/women-and-girls-in-science-day/)

MCs for girls

[http://physicsmasterclasses.org/index.php?cat=women\\_in\\_science](http://physicsmasterclasses.org/index.php?cat=women_in_science)

- Female lecturers and tutors
- Videoconferences with female moderators

	Mon, Feb 12	Mon, Feb 12
	<b>VC 1: ATLAS W</b>	<b>VC 2</b>
moderators	Stefanie	Marianna
moderators	Rosa	Leonora
	Paris APC  webpage	Barcelona (ATLAS Z)  webpage
	Czech Technical University Prague  webpage	Cagliari (LHCb)  webpage
	Cosenza  webpage	Madrid CIEMAT (CMS)  webpage
	London UC  webpage	
	Lund  webpage	
<b>Moderators:</b>		
	 Marianna Fontana (LHCb)	 Stefanie Morgenstern (ATLAS)
	 Rosa Simoniello (ATLAS)	 Leonora Vesterbacka (CMS)

## Teachers Day

Local MasterClasses, laptops at schools

# Masterclass Press and Social Media

## Press release Template for institutes



IQBAL PITTALWALA/UC RIVERSIDE/CONTRIBUTED IMAGE

UC Riverside physics Professor Bill Gary, standing on left, and San Jacinto High School teacher Mark Bonnard assist San Jacinto High physics students, left to right, Jensine Junus, Anna Sivils, Jesus Mondragon Legorreta and Cristina Millar, analyze particle physics data from the European Center for Nuclear Research.

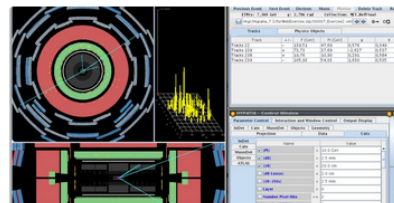
**Top media Tweet** earned 4,559 impressions

@Fermilab-connected masterclasses have begun! Yesterday, Rio de Janeiro, Brazil and Quincy, Illinois. More today!  
[pic.twitter.com/ZWZeOJCN7Q](https://pic.twitter.com/ZWZeOJCN7Q)




**Top Tweet** earned 5,685 impressions


Looking for decays of Z bosons and searching for the #Higgs. High school students at @UU\_University, @HumboldtUni + @desy Zeuthen, Univerzita Mateja Bela in Banska Bystrica, @unizar, and @UniOslo. #LHCIMC18  
[pic.twitter.com/l2VOFngmLD](https://pic.twitter.com/l2VOFngmLD)



**Top mention** earned 623 engagements

 **CHIPP\_news**  
@CHIPP\_news - Feb 1

for the: #WomenScienceDay Leonora Vesterbacka: PhD student at @ETH\_en Zürich, based at @CERN, Searching for Supersymmetric particles at the @CMSexperiment detector! moderator at the International masterclasses for high school girls [goo.gl/1JK3yT](https://goo.gl/1JK3yT) @physicsIMC #ChatCERN [pic.twitter.com/j2F9z0bRWy](https://pic.twitter.com/j2F9z0bRWy)



1 18 69

# MasterClasses Demos at QM

At Palazzo de Casino

## Coffee Breaks at CSN

- Mon 16:00
- Tue 10:40
- Wed 10:40
- Wed. 16:20

## Poster Session at CSN

Tue 17:00-19:30

## Lunch Break at CSN

Fri 14:00

**ALICE, ATLAS, CMS and LHCb**

# Masterclass methods

Example: CMS W/Z Investigation

Get the data  
and tasks



## Main features of all measurements

First a visual analysis

Students get easily an impression of how particles  
and decays are seen by detectors

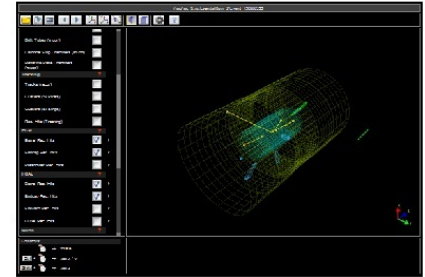
What is the effect of magnetic field etc

Then run “offline” on a “large statistics sample”  
fill histograms, perform fits...  
calculate particle yields, ratios...

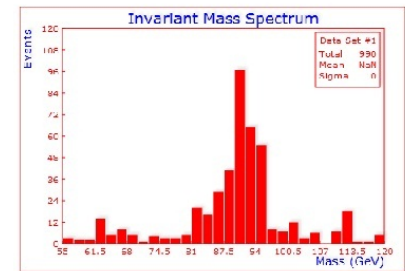
Given needed (correction) factors  
letting them know that this is the work a PhD student!

Final results close to the published results

Inspect  
visually



Run algorithms  
Fill histograms



**One of the requirements was  
that it should be as close as possible  
to the real experiment**

Deliver results  
and interpretation!!



# ALICE measurements

## The tools

- Simplified event display, **close to the real one used at the experiment**
- Visual analysis of small event sample (50 events)
- Large statistics analysis including background and “writing code”

## The data

- First LHC data (900 GeV proton proton) : develop / run masterclasses 2011
- 7 TeV proton proton data in 2012
- 2.76 TeV Lead-Lead data in 2012

**Excercise 1:** decay patterns of strange particles  
developed 2010-11

**Excercise 2:** momentum spectra of unidentified particles (RAA)  
developed 2012

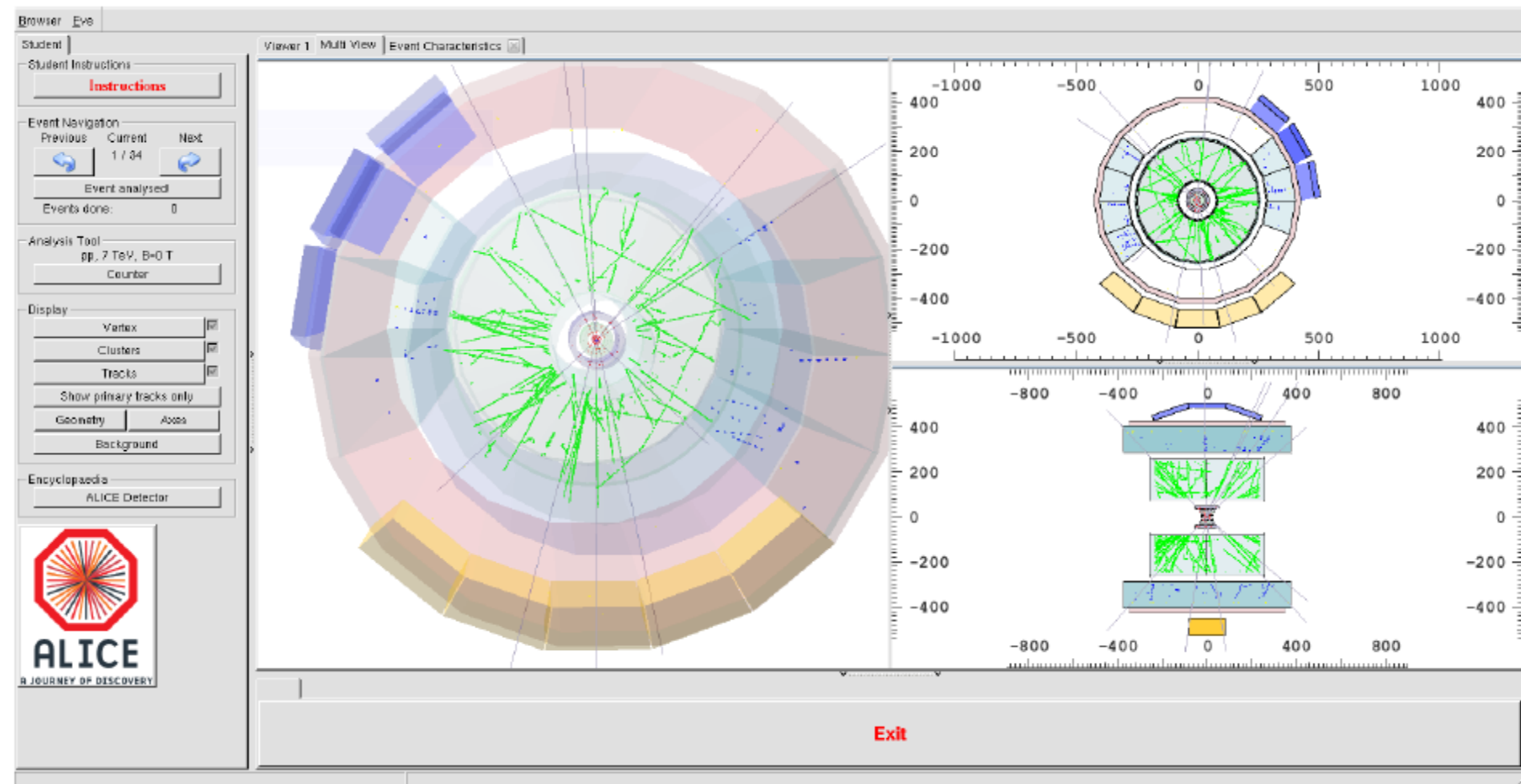
**V0 measurement adapted by LHCb for D0 studies**

# Visual analysis

## Proton-proton (pp) event

Introduce concepts and visual analysis tools, fill histograms

Interactive!  
Grab and rotate



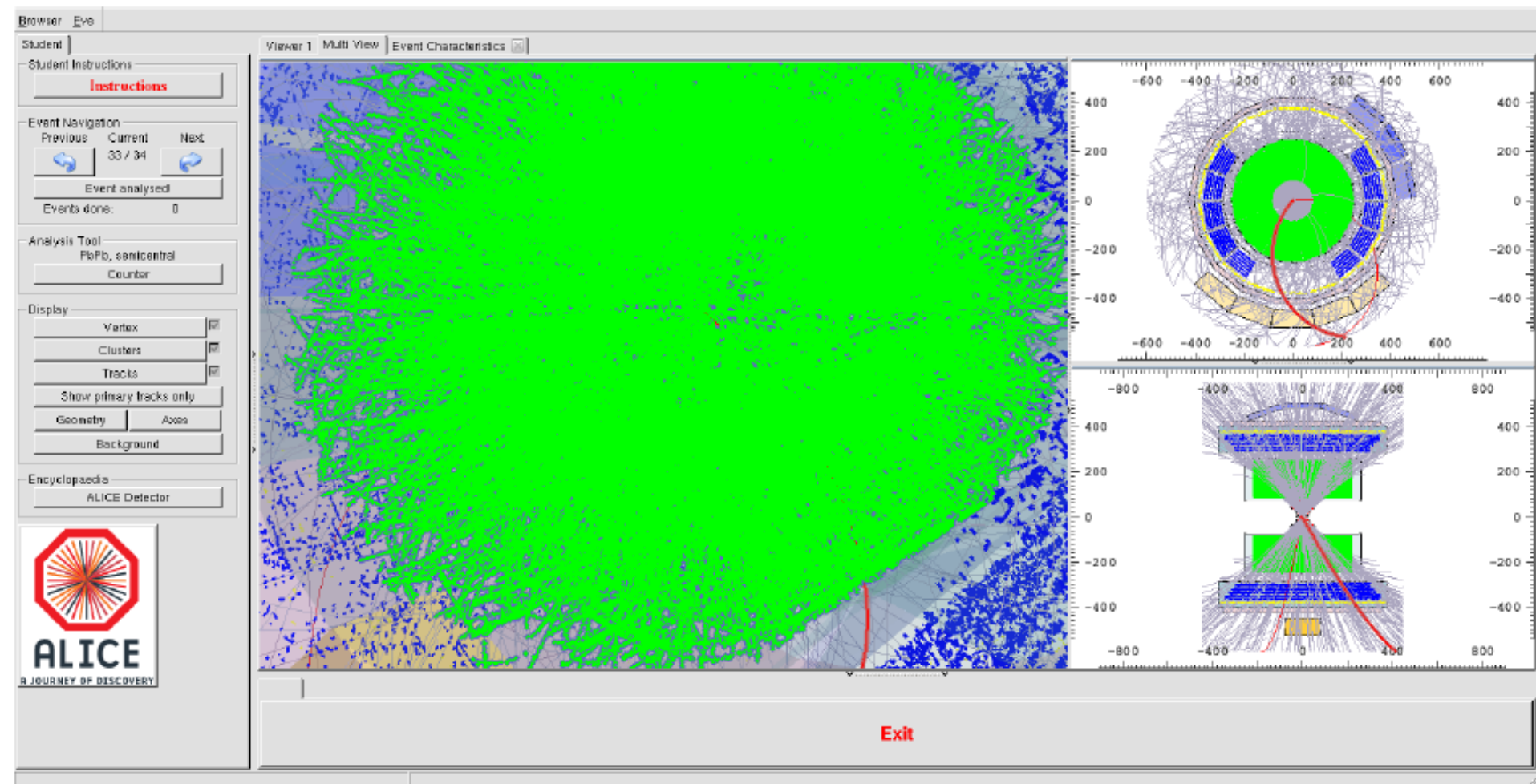
Track reconstruction, effects of magnetic field... relate curvature with momentum...

# Visual analysis

## Lead-Lead (PbPb) event

Visual impressions: PbPb is different than pp

Visual analysis has limits



relate multiplicity with centrality





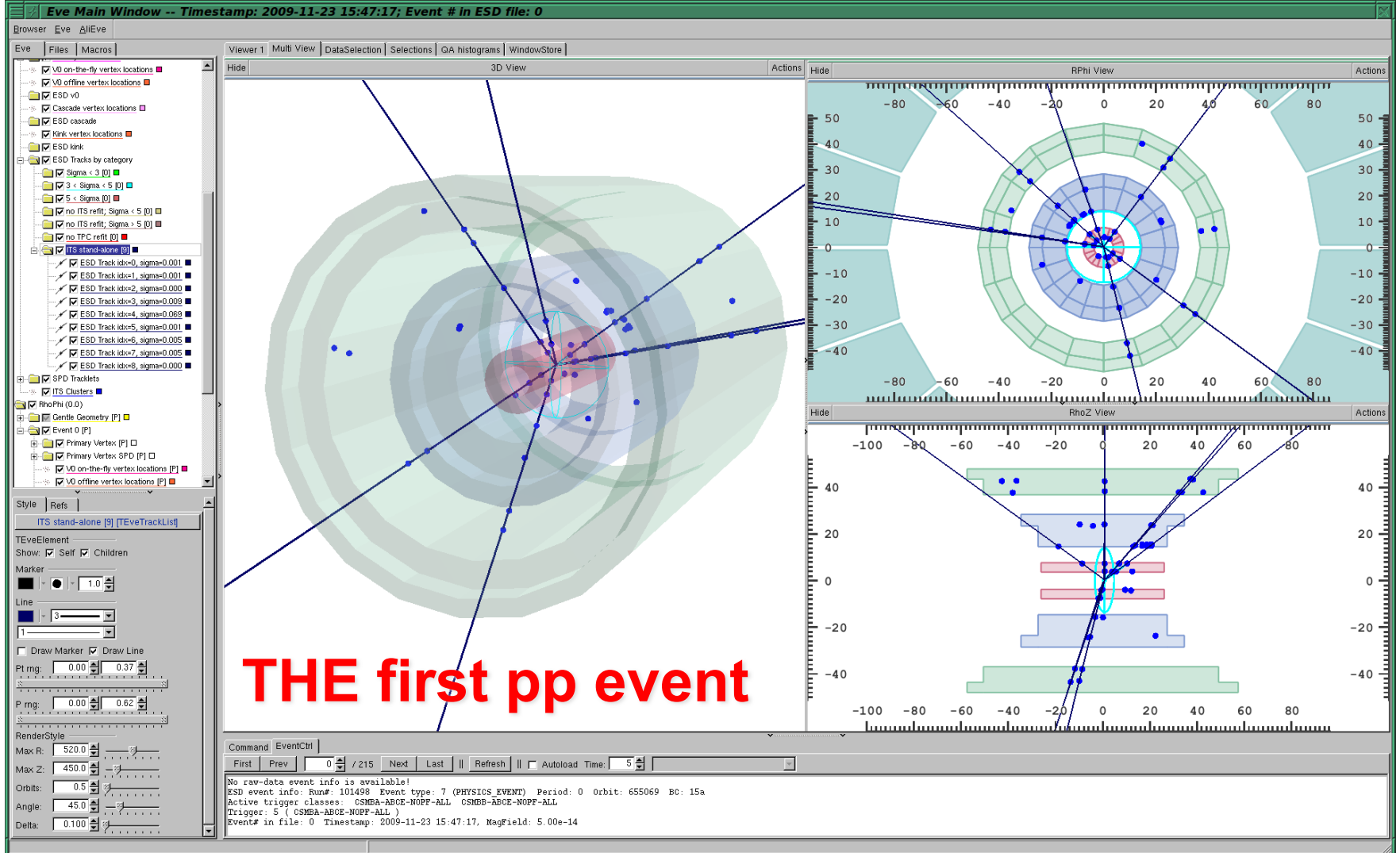


**200 students in Padova !**

Used at real experiment  
Waiting for first collisions !



2009/11/23

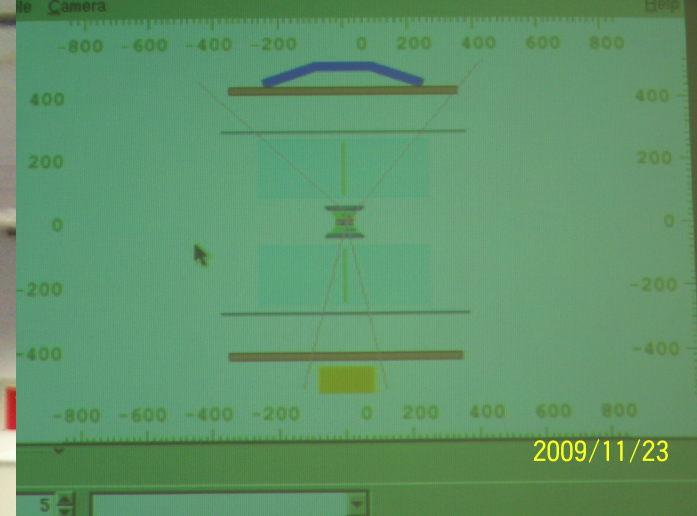


At 17:21 the beams were dumped and the run closed with **284** events

At 17:28 the first mails with the first online reconstructed event were sent to the institutes

# First collisions at LHC

scanning team



# Outlook

**Possibility to implement Masterclass measurement for different experiments  
re-use of existing MC or develop new in flexible and economic way**

introduce data (particles, decays)

introduce geometry

LHCb D0 implement for ALICE, STAR...

ALICE RAA implement for ATLAS....

## Summer Student Proposal from ALICE

Supervisors: Redmer Alexander Bertens, Friederike Bock

**Starting: June 2018**

This summer student project is aimed at improving and expanding the current ALICE MC  
and at developing a **general, experiment independent framework**  
for displaying detector geometry  
and reading in and manipulating open data.

**Contacts and Task Force ?**

# Thanks to IMC Demo Contributors

**ALICE RAA GSI** (Ralf Averbeck) and **IKF** (Henner Buesching)

Sebastian Hornung

Alena Harlenderova

Edgar Perez Lezama

Michael Habib

Jerome Jung

Sebastian Scheid

Fabian Pliquetf

Carsten Klein

## **ALICE Strangeness**

Ester Anna Rita Casula

Ramona Lea

Fabio Colamaria

Marianna Mazzilli

**Thanks to  
Conference Committees,  
Outreach Coordinators...**

## **CMS**

Padova: Ezio Torassa, Alberto Bragagnolo

QuarkNet: Frank Geurts, Daniel Brandenburg

## **ATLAS**

Iwona Grabowska-Bold

Klaudia Burka

## **LHCb**

Bartosz Piotr Malecki