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”!
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.
The material can be used for many other purposes.

http://physicsmasterclasses.org/

International Masterclasses
14th International Masterclasses 2018

Each year more than 13,000 high school students in 52 countries come to one of the research centres for one day in order to unravel the mysteries of particle physics. The students get an insight in topics and methods of basic research at the fundamentals of matter and forensic sciences using real data from particle physics experiments themselves. At the end of their research collaboration, the participants join in a video conference for discussion and press media coverage.

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.

Well structured project
• procedures
• instructions
• material
• translations

Not difficult for newcomers
• teachers
• institutes

Details during
MC Demos at QM
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)
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

- 18 countries
- 58 institutes
- 72 masterclasses
- 3k students
- 12 video conferences
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….
Schedule and Moderators

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

and more!
www.physicsmasterclasses.org/index.php?cat=schedule#moderators
e-group ippog-masterclass-moderators@cern.ch
IMC Surveys

Number of students per country from CERN Videoconference

Prelim: What did you like best about the masterclass?

Prelim: Video link rating

Efforts and Working Group to reach as many countries as possible
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
- Well prepared Institutes
  - Orientation for institutes
- Well prepared Videoconference and Moderators
  - Training for moderators (2 h) https://indico.cern.ch/event/696223/
  - twiki, manual for videoconference
  - Equiped dedicated rooms
  - Vidyo support at every session

Thank you T-Shirts for moderators!
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.
Hands on Particle Physics Masterclasses

Physics

- What are the fundamental building blocks of matter?
- How can I identify them?
- Which forces hold them together?
- How do these forces work?
- How far have the secrets of forces and matter been understood so far?

Find the answers to these and other questions by browsing, reading, and working through some of the educative materials on particle physics which is collected here. Most of the material contains interactive elements, some even real particle physics events for making your own measurements, and understanding particle physics "hands-on". The material was collected for the EPPOG Particle Physics Masterclasses, where some of the measurements form the practical exercises for high school students spending a day at one of the Research Institutes. More info on the teaching systems, which are suited for a wide range of readers, is accessible via the menu in the left column.

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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

MCs for girls

– Female lecturers and tutors
– Videoconferences with female moderators

Teachers Day

Local MasterClasses, laptops at schools
Press release

Template for institutes

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

Top mention earned 620 engagements:
@CHIPP_news

for the: #WomenScienceDay
Leonora Vesterbacka: PhD student at @ETH_en
Zürich, based at @CERN, searching for Supersymmetric particles at the @CMSexperiment detector I moderator at the International masterclasses for high school girls goo.gl/1JK0yT @physicsIMC #CHaICERN pic.twitter.com/l2F9z0bRWy
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

Inspect visually

Run algorithms
Fill histograms

Deliver results and interpretation!!

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

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

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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!
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)
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Alena Harlenderova
Edgar Perez Lezama
Michael Habib
Jerome Jung
Sebastian Scheid
Fabian Pliquett
Carsten Klein

**ALICE Strangeness**
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Ramona Lea
Fabio Colamaria
Marianna Mazzilli

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Klaudia Burka

**LHCb**
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