



# International Masterclasses Steering Group

## Approval of measurements

11.09.2020

International Masterclasses (IMC) are currently experiencing an expansion, not only in numbers of participating countries and institutes, but also with regard to measurements being made available for high school students participating in the program. To ensure the quality of the whole program the steering group (SG) has written a document describing the process of approval for measurements in International Masterclasses.

**Preliminary remarks:**

1. International Masterclasses are organized each year, preferentially around March, in a period between February and Easter.
2. International Masterclasses address high school students, aged 15 – 19.
3. Students engage with and preferably come to research labs for one single day, often without any previous knowledge of particle physics.
4. All Masterclasses follow a typical agenda, which can be found here: www.physicsmasterclasses.org/index.php?cat=local_organisation&page=orga_intro
    1. In the first part, students are introduced to particle physics.
    2. Additional visits, lab tours, or Q&A sessions are optional.
    3. The main part should be about 2 hours related to the measurement or exercise, where students work in pairs on PCs.
    4. Students´ results are discussed.
    5. A videoconference with a research infrastructure such as CERN, Fermilab, KEK, GSI or others can be arranged. Participants are 3 - 5 institutes that performed the same measurements (if possible on different data sets) and moderators. Results (e.g. mass plots, histograms, tables) are presented, combined (if possible) and discussed, followed by Q&A.

**Guideline for measurements in IMC:**

1. The basic idea of the measurements is a question related to particle physics or associated technologies and applications. The outcome of the measurements leads students to fundamental insights in this field.
2. Measurements include visual elements, e.g. event display analyses,.
3. All tools and programs used by the students have to be adapted to high school students´ needs and abilities.
4. As far as possible students should be able to follow the processing of results; black boxes should be avoided.
5. All tools and programs used by the students have to run on PCs with MacOS, Windows or Linux (webbrowser, java, …) everywhere.
6. Results obtained by students have to be presented in a graphical way (histograms, tables, …).
7. Experiments have to provide real data, but they may use Monte Carlo data to make a specific educational point or if the experiment does not yet have data available.

**Procedure:**

1. The steering group approves every new measurement, and measurements that undergo major modification or extension.
2. Pilot tests with student groups under the conditions of a Masterclass are mandatory before including a new measurement in the program. Pilot tests need to be completed by Oct 15.
3. An evaluation of the pilot tests with report on success and problems has to be presented to the steering group before Oct 31.
4. Each measurement has to provide a package with program and datasets for the IMC website before Jan 15. If translations by IPPOG members are requested the deadline is Nov 15.
5. Guidelines for local organizers and material for moderators have to be provided by Jan 31.
6. Deadlines have to be respected.
7. Measurements not meeting the deadlines or without sufficient maintenance can be excluded from IMC.

**Orientation for the development of new Masterclasses**

Suggested learning objectives of Masterclasses

The learning objectives are assigned to four competence areas.

1) Specialist knowledge

The participants:

a) name topics of current research in astroparticle, elementary particle or hadron and nuclear physics (depending on the focus of the Masterclass)

b) identify charges, interactions, and particles as the three basic concepts of the Standard Model of particle physics and describe their interrelationship

c) name technological applications and/or spin-off technologies (e.g. hadron therapy)

2) Gaining knowledge

The participants:

a) evaluate experimental data on a simplified and didactically reduced level, using authentic methods of analysis typical for the subject. In particular

i) identify particles based on interactions and signatures in the detector

ii) reconstruct processes on the basis of the resulting particles

iii) recognize the concept of the background and its significance for evaluation

iv) make a physical interpretation of the measurement results

b) describe the process and organisation of research with regard to

i) the interplay between experiment and theory

ii) the formulation and testing of hypotheses

iii) the importance of international collaborations

c) can describe a connection to the physics which they study in high school

3) Communication

The participants:

a) use appropriate forms of presentation (e.g. diagrams, plots, tables) to visualize their results (e.g. energy or mass distributions)

b) discuss their results

c) formulate their own questions

d) use common terms of technical language in verbal communication appropriately

4) Evaluation

The participants:

a) assess the importance of research for society in terms of

i) human curiosity

ii) technical applications

iii) the credibility of general and especially scientific reporting

b) reflect on their image of scientists

During the Masterclass, participants also experience their own self-efficacy.