



---

**REPORT**  
from  
**13th IPPOG meeting**  
**CERN, 20-22 April 2017**  
(by Barbora Bruant Gulejova)

**PARTICIPANTS**

**COORDINATION TEAM (CT):**

*Hans-Peter Beck (University of Bern), Steven Goldfarb (University of Melbourne), Barbora Bruant Gulejova (CERN)*

**MEMBERS REPRESENTATIVES:**

*Pedro Abreu (Portugal), Nicolas Arnaud (France), Marge Bardeen (USA), Panja Luukka (Finland), Ivan Melo (Slovakia), Farid Ould-Saada (Norway), Catia Peduto (Italy), Dirk Ryckbosch (Belgium), Gabriel Stoicea (Romania), Charles Timmermans (Netherlands)*

**CANDIDATE MEMBERS REPRESENTATIVES:**

*Andrej Gorisek (Slovenia), Despina Hatzifotiadou (ALICE), Natascha Krammer (Austria), Rasmus Mackeprang (Denmark), Jiri Rames (Czech Republik), Kate Shaw (ATLAS), Jon-Ivar Skullerud (Ireland), Peter Watkins (UK)*

**ASSOCIATES:**

*Angelos Alexopoulos (CERN), Katarina Anthony (ATLAS), Uta Bilow (TU Dresden), Beatrice Bressan (TOTEM), Kenneth William Cecire (University of Notre Dame, US), Catarina Espirito Santo (LIP), Yiota Foka (GSI/FAIR), Christine Kourkoumelis (University of Athens), Marzena Lapka (CMS), Celso Martinez Rivero (IFCA, Spain), Achintya Rao (CMS)*

**WEBPAGE**

<https://indico.cern.ch/event/622184/>

---

## CONTENTS

|  |    |
|--|----|
| <b>1. GENERAL IPPOG ISSUES</b> .....   | 3  |
| 1.1. WORD from LIP MANAGEMENT.....   | 3  |
| 1.2. IPPOG NEWS.....   | 3  |
| 1.3. IPPOG INTERNAL AFFAIRS .....  | 4  |
| 1.4. IPPOG PUBLIC WEBPAGE and EXTERNAL COMMUNICATION .....                                 | 4  |
| <b>2. IPPOG STORIES / IMPACT</b> .....   | 6  |
| 2.1. AN INSIDE VIEW FROM IPPOG.....  | 6  |
| <b>2.1.1. Advantages of ALICE’s membership in IPPOG</b> .....                              | 6  |
| <b>2.1.2. How USA/Fermilab/Quarknet benefits from membership in IPPOG</b> .....            | 7  |
| 2.2. INSPIRING SUCCESS STORIES.....  | 7  |
| <b>2.2.1. Event "Nuit des Ondes Gravitationnelles"</b> .....                               | 7  |
| <b>2.2.2. Local masterclasses in Greek schools within the framework of CREATIONS</b> ..... | 8  |
| <b>2.2.3. Local Story of Uta’s Masterclass CDs</b> .....                                   | 8  |
| <b>3. WORKING GROUPS</b> .....   | 9  |
| 3.1. PUBLICATIONS AND SPEAKERS COMMITTEE .....   | 9  |
| 3.2. WG on MASTERCLASSES in NEW COUNTRIES .....  | 9  |
| 3.3. WG on EXPLAINING HOT PP TOPICS to LAY AUDIENCE.....                                   | 10 |
| <b>4. PANEL DISCUSSIONS</b> .....  | 12 |
| 4.1. REACHING TO NEW AUDIENCES / NON-CONVENTIONAL METHODS .....                            | 12 |
| 4.2. IMPACT OF SCIENCE ON SOCIETY.....   | 13 |
| 4.3. EXHIBITIONS and EVENT HIGHLIGHTS.....   | 14 |
| 4.4. IMPACT OF EDUCATIONAL PROGRAMS for STUDENTS and TEACHERS.....                         | 16 |
| <b>5. VARIOUS REPORTS</b> .....  | 17 |
| 5.1. MASTERCLASSES 2017.....   | 17 |
| 5.2. PHYSICS FOR EVERYONE – FIELD, SYMMETRIES, MASS.....                                   | 21 |
| 5.3. IMPACT of SCIENCE on SOCIETY and SUSTAINABLE DEVELOPMENT – showcased by CERN .....    | 22 |
| 5.4. COSMIC RAYS GOING GLOBAL – STATUS QUO AND PLANS .....                                 | 25 |
| 5.5. INTERNATIONAL PHYSICS OLYMPIAD 2018.....  | 26 |
| 5.6. AGENCY CIENCIA VIVA.....  | 27 |
| 5.7. COUNTRY, EXPERIMENT and LAB HIGHLIGHTS .....  | 28 |
| <b>5.7.1. USA/FERMILAB/Quarknet: International Muon Week</b> .....                         | 28 |
| <b>5.7.2. PORTUGAL - Upgrading the communications &amp; outreach structure @ LIP</b> ..... | 28 |
| <b>5.7.3. UK – STFC Report</b> .....   | 29 |

---

# 1. GENERAL IPPOG ISSUES

## 1.1. WORD from LIP MANAGEMENT

Presented by Prof. Gaspar Barreira

Portuguese delegate to the CERN Council and Director of LIP, Prof. Gaspar Barreira welcomed IPPOG in Lisbon and outlined the important impact of PP in his talk on ‘Science, Particle Physics and Peace’.

He recalled the memory of the ECFA meeting in Slovakia more than 20 years ago, where the concept of communication and outreach have been discussed and CERN DG supported the idea of communicating PP to external audience. This was a year after invention of www. Today, after many years, there have been a lot of development in the domain and situation is very different.

Prof. Barreira is also very touched by the story of Science and Peace in SESAME, scientific facility and international collaboration inaugurated in Mai 2017. Project is in the middle of Jordania with members from Cyprus, Egypt, Iran, Israel, Pakistan, Palestin, Turkey. 10 million people in the middle of Jordania, out of which 5 million are refugees. They cooperate together following the example of CERN for last 60 years of CERN – science with no discrimination. SESAME is the only place where these nations meet together. CERN is trying to improve the communication of SESAME a lot. 1<sup>st</sup> president of SESAME council was Hervig Schopper, now it’s Chris Llewellyn Smith and next one will be Rolf Heuer.

## 1.2. IPPOG NEWS

Presented by Hans Peter Beck

“International Particle Physics Outreach Group - an example for concerted and systematic effort for outreach - enabling Outreach Globally as a Collaboration in a collaborative effort.”

**IPPOG** is now an **established Collaboration**.

December 19, 2016 marks the birthday of IPPOG entering a new phase in its 20 years history from EPOG (1997) to IPPOG (2010) and to the IPPOG Collaboration (2016). The 10<sup>th</sup> signatory of the MoU by CERN according to the MoU defines the entry into force of the MoU and thus the birth of the official IPPOG Collaboration.

**IPPOG headlines:**

- CERN Courier March 2017: [Viewpoint Article](#)
- INFN Newsletter – [article on IPPOG](#)
- EPS newsletter – [contribution on IPPOG](#)

**IPPOG members:** Netherlands, Germany, Norway, Portugal, Sweden, Switzerland, Slovak Republic, Romania, Finland, Belgium, CERN, Italy, France, Poland, Australia, USA. See details with exact dates of MOU signature on page 5 in [H-P Beck presentation](#).

**IPPOG Candidate members:** IPPOG Members as of the pre-collaboration phase that have not yet signed the MoU automatically are now Candidate Members – until 18 December 2018. These are:

Austria, Bulgaria, Czech Republic, Denmark, Greece, Ireland, Israel, Spain, South Africa, UK, ATLAS, ALICE, CMS, LHCb, TOTEM, DESY (as representing itself as a lab). Candidates shall have no voting rights and no annual membership fees shall be due.

**New URL:** <http://ippog.org> for the IPPOG home page replacing was [ippog.web.cern.ch](http://ippog.web.cern.ch). CERN is a Member in IPPOG (with adequate and negotiated support to IPPOG), and not the other way round; i.e. IPPOG is a truly international body.

**New Collaboration bodies / e-groups:**

- [ippog-ct@cern.ch](mailto:ippog-ct@cern.ch) : IPPOG Coordination Team: Chair(s) and Scientific Secretary

- [ippog-forum@cern.ch](mailto:ippog-forum@cern.ch) :All and everybody in IPPOG.  
**TO DO:** Use this list for lively discussions on all aspects related to IPPOG matters. This list is still to quiet...
- [ippog-cb@cern.ch](mailto:ippog-cb@cern.ch) : Collaboration Board (includes Member Reps and Candidate Member Reps.)

**New representative of Finland:** As Kati Lassila-Perini has been nominated to the new Teacher and Student Forum at CERN, [Panja Luukka](#) has been appointed by HIP as the new Finish representative to IPPOG. Panja is based in Helsinki, is very well involved in and informed of the various outreach activities taking place in Finland.

#### Interest expressed by membership in IPPOG:

- [Brazil](#) has expressed their formal wish to join IPPOG formally. Marcelo Gameiro Munhoz, Universidade de São Paulo, Brazil, member of the ALICE collaboration and member of the Education Committee of the Brazilian Physics Society has been in contact with IPPOG CT and Brazilian National Network of High Energy Physics ([RENAFAE](#)) is the ideal organization to represent Brazil in IPPOG.
- [Turkey](#) –Bilge Demirkos is coordinating and running Masterclasses in Turkey, and is interested to make Turkey a Member in IPPOG.
- [GSI/FAIR](#) – Yiota Foka is with us here in Lisbon, well known to IPPOG through the ALICE Masterclass program, and is interested to bring GSI/FAIR closer to IPPOG.
- [Belle II](#) – Toru Iijima and Zdenek Dolezal have been joining the previous IPPOG meeting at CERN in November 2016. They are waiting for the final addenda to the MoU, explaining the modalities for Collaborations to join.
- [DUNE](#) – Mark Thomson, Spokesperson of DUNE, invited the IPPOG CT to a brownbag lunch at CERN, when DUNE had its Collaboration meeting in January 2017. DUNE is highly interested in Outreach and IPPOG, but still in an early phase.

**Proposal:** To establish an Executive / Steering Board / Group (IPPOG CT and WG conveners)

### 1.3. IPPOG INTERNAL AFFAIRS

The IPPOG MoU and new Addenda and Annexes has been discussed and subject to vote of IPPOG Collaboration Board during the [first IPPOG CB meeting](#) on Saturday 22<sup>nd</sup> of April. See the report of the 1<sup>st</sup> IPPOG CB [here](#).

### 1.4. IPPOG PUBLIC WEBPAGE and EXTERNAL COMMUNICATION

*Presented by Steven Goldfarb, Barbora Bruant Gulejova*

#### 1) **WEB & Resource Database: Findings**

**Discussions until Now:**

- 2014 Working Group on Resource DB
- 2015 Working Group on Web Pages
- 2016 Panel on Resource DB and Web Pages

#### Proposed New Structure and Layout of DB

- Curated categories (17 from 44 topics, 9 from 41 item types, 4 from 6 filtering options, etc.)
- Searching by filter on the left & 4 big topic categories in the middle
- Evaluation by visitors

**TO DO:**

- Curation Committee
- Select Resources to be transferred to new DB
- Assign new tags and categories

---

### Website Requirements:

- **Sustainable:** Theme we can develop and maintain
- **Professionally Designed:** proposed Organisational Structure:  
Main menu bar: Home, Members, Resources, Masterclasses, Cosmic Rays, National Resources, Publications,  
Sidebar: New DB resources, Events calendar, Upcoming conferences, Newsletter, Social media links
- **Appealing:** Professional Graphics

**TO DO:** Develop Design Guidelines, Theme, and Graphic Elements

### **Development Strategy:**

#### Development Steering Group:

- Goal to oversee new design and implementation
- Members: B. Gulejova (principle developer), S. Boutas (CERN webmaster), M. Lapka, P. Watkins, S. Goldfarb, H.P. Beck

#### External Web Design Expertise

- Prepare Design Guidelines: Clarified Goals, Messages, Target Audiences  
Layout that enforces organisational structure
- Develop Drupal Theme: CERN approved (for maintenance)  
Drupal 8
- Provide Graphic Elements

### **Progress So Far:**

- We are now [ippog.org](http://ippog.org) ☺ (Login: ippog.web.cern.ch)
- Steering Group in place, ready to work; iterating on Technical Specifications for Design Experts; Preliminary budget proposed
- Graphical Elements: INFN (Catia) provided original logo design & CERN Design Team developed vectorised files defined colours and font (Arial)

## **2) External Communication: Findings**

**Discussion until Now:** Group on IPPOG Advertising and External Communication (Nov. 2015):

- Audiences: Particle Physics community, Teachers, Schools / Students, Broad Public, Politicians, decision makers, public opinion makers
- Messages: we exist, what we do, how to contact us, how they can get involved
- Communication Channels: *Delegates* (it should be stated in the MoU Addenda); *Conferences* (limited audience); *Meetings of Experiments* (weekly meetings, collaboration weeks), *Labs, Boards,...*; *Keen young students*; *E-Mail*; *Screens at Labs and Institutes*; *Articles in PP community journals*; *Newsletters of other communities / professional societies*; *IPPOG newsletter*; *Social Media*; *Wikipedia* ([https://en.wikipedia.org/wiki/Physics\\_outreach](https://en.wikipedia.org/wiki/Physics_outreach))

### **Progress So Far:**

- Social Media Set Up: Facebook: @ippog; Twitter: @ippogorg (working on getting @ippog)
- External Communication Coordination:
  - Develop strategy for posting material to home, social media;
  - Coordinate content development
  - Encourage activity from IPPOG members: Sharing, following, reposting, liking, etc.

**TO DO / Call for Volunteers** to Maintain Social Media: Must be regularly fed by content

---

## 2. IPPOG STORIES / IMPACT

### 2.1. AN INSIDE VIEW FROM IPPOG

#### 2.1.1. Advantages of ALICE's membership in IPPOG

Presented by Despina Hatzifotiadou

Despina is a member of EPPOG / IPPOG since 2009 representing ALICE as ALICE outreach coordinator. From the very beginning when she learned about EPPOG (from Nick Tracas and Yiota Foka), she very much liked the concept of masterclasses and participated in OPAL masterclass at CERN.

##### **Benefits from IPPOG:**

- Inspiration and ideas
- Sharing of news
- Material (IPPOG database)
- Deeper understanding of physics topics (Higgs,...)
- Stimulating discussions
- Networking
- Friends

At CERN there is an LHC Outreach Group (LOG), which holds monthly meetings. IPPOG is obviously a much wider and much more diverse network, and our interaction is enriching for all.

##### **Some of the IPPOG activities with great impact / potential:**

- Masterclasses in particle physics
- IPPOG and particle physics outreach in conferences
- Cosmic rays going global

ALICE Masterclasses: first and second version of strange particles measurement; RAA measurement

Advantages: „ALICE is becoming more broadly known“

- Diploma thesis based on masterclasses development
- Involve young ALICE members as moderators
- Involve colleagues / institutes
- Increase visibility of ALICE inside CERN (part of HST program for Sweden, Italy + other outreach activities), HEP community, members' countries / institutes (Greece, New Zealand)
- Bring ALICE to places with no ALICE involvement (e.g. new participants in 2016 and 2017: Mexico, Russia, Bangladesh etc.)

##### IPPOG and outreach in conferences:

The systematic effort, these last years, to include talks on IPPOG and the importance of outreach in conferences and to organise outreach sessions in conferences benefits the whole HEP community.

- Giving people concrete examples of success stories
- Encouraging, especially the young, to spend some of their energies in outreach activities

##### Highlights in the last 4 years:

- Outreach talk during plenary session (ALICE weeks) = opportunity to bring news, ideas etc from IPPOG and publicise IPPOG activities (increase of masterclasses)
- The MoU for Scientific Collaborations foresees commitment for in-kind contribution : this will make it easier for some manpower to be allocated to work for outreach resources

„Thank you IPPOG!“

---

## 2.1.2. How USA/Fermilab/Quarknet benefits from membership in IPPOG

Presented by Marge Bardeen

Advantages:

- Ideas – to take home, e.g. US adapted an idea of Cascade from Pete (UK) and from Spain, where HS students build a demo to explain physics concept + competition with prizes (choice of winners by scientists but also normal people, parents). The project in US is called Physics Carnival and it is part of Family Open House (where 3700 people came in 2017).
- Connections – Ken was in Africa for MC, even more outreach for US!
- Collaborators and Friends - „IPPOG is a great group of people, it is nice to see them twice a year!“
- Masterclasses- very beneficial and really important for US as LHC has Big Data and US funding agencies love Big Data
- Cosmic Rays Studies – International Muon Week organised by Quarknet – engage students with data from cosmic rays

## 2.2. INSPIRING SUCCESS STORIES

### 2.2.1. Event "Nuit des Ondes Gravitationnelles"

Presented by Nicolas Arnaud

- A global multi-thematic event: [Night of the Gravitational Waves](#), March 20th, 18:00 to 22:30
- A joint initiative of the CNRS and of the SFP (French Physics Society)
- A free public event to celebrate the anniversary of the gravitational wave detection
- Simultaneously in a dozen locations in France and Italy (Florence) - interconnected during part of the event
- Educational part: 4 contests open to schools and to the general audience - How to detect chirp signals buried in noise; How to generate « gravitational waves » (quadrupolar); Novel or comics; Shoot pictures with the [Pocket Black Hole app](#) to simulate a black hole; Interactive quiz – sites compete against one another!
- Winner found among the audience of the winning site by drawing lots; prize: a trip for two to visit the site of the Virgo experiment
- Debate about science and cinema – from the « Grand Rex » Famous theater in Paris (2700 people!)
- 5000 participants from both sites; 850 students from 40 classes in Paris
- Media: [website](#), Twitter [#NuitDesOG](#), Periscope [Facebook live](#), 30 000 connections that night!; webcast to watch the event live from remote: ≥ 300 connections continuously

#### Lessons learned

- Need a good topic - Scientifically important and relatively easy to grasp for the general public
- A light central structure and dedicated local teams with good match (10 months to put together)
- Total budget about 70 k€: small central budget (~25 k€) from the main research institutes + auto-financing of all local events with money from Universities, clusters, etc.
- Good mixture of science and fun
- Sites out of campuses are always a plus even if more costly: « Aim big, think big »
- Social media mandatory to target young people / students

#### What next?

- Resources developed to be reused for two future events : Nobel prize & First gravitational wave detection including data from Virgo
- One suggestion: illustrate every year the Nobel prizes in physics
- Extension to other countries welcome

---

## 2.2.2. Local masterclasses in Greek schools within the framework of CREATIONS

Presented by *Christine Kourkoumelis*

Creations - Horizon 2020 European outreach project to Develop an Engaging Science Classroom

- 36 months (Oct 15->Oct 18), 1.8 ME, 16 partners
- Coordinator: University of Bayreuth
- Improve skills of youngsters in STEM subjects
- HEP partners are UoA/IASA, UoBirmingham, Art@CMS, STFC (some partners focus on combining science and art and boost creativity in schools, e.g. Global Science Opera, Cultural Collisions, science using theater)

A successful local Masterclass (half-day) in a school involves:

- Analysis with online HYPATHIA + VV and LHC experiment
- Long Q&A session including impact assessment using
  - "Pisa like" assessment questions at each phase (3 possible answers, all correct)
  - Indicators on the success of the event analysis (# of Z's found, # of Higgs found, e-pair/ $\mu$ -pair)
  - Pre and post creativity questionnaires (Does their interpretation of the three shapes change given the exposure to HEP??)
- 39 runs with ~520 students answering all 2\*4 questions; 7 parameters built in HYPATHIA (giving rating from low, medium, high), 2 more assesment tool to be added soon
- Good thing is that students dont know, that we are measuring this!

Conclusions: First indicators show very positive results; Students are enthusiastic, eager to learn

## 2.2.3. Local Story of Uta's Masterclass CDs

Presented by *Yiota Foka*

### International Conference on New Frontiers in Physics / ICNFP

Success story: one day there was an unexpected request from Warner Bros television series Big Bang Theory asking the permission to use their posters (which was CERN material).

- IPPOG presentation at plenary session of ICNFP 2013 in Crete, Greece
- Uta brought in bags as conference material Masterclass CDs – these travelled a lot around the world and have been very useful: South Africa (Cape Town, Johannesburg - Muronga activities, school, remote villages), Russia (Moscow, Saint Petersburg)
- People asked, what is it good for => the idea of the public event after ICNFP:

### Ions for Cancer Therapy, Material and Space Science, 27 – 30 august 2017, immediately after ICNFP

- Cancer therapy was pioneered at GSI/FAIR
- Centre in Heidelberg, 70% of patients treated have no secondary effects

### Outreach activity in Laboratory of Ultra High Energy Physics of Saint-Petersburg State University

- The Laboratory (SPbSU) is considering outreach activity as a must for researcher
- International Master-class "Hands-on Particle Physics" took place [06.03.2017](#)
- The plan is to see set-up MC also in DUBNA
- First remote ALICE master-classes for schoolchildren in Moscow on [16.02. 2016](#) - simplified option of looking for strange particles with ALICE detector was prepared (in October 2016) and adapted for the kids of 10-11 years old. It was done independently and completely by the high class pupils of the Moscow school!
- Yandex and Saint-Petersburg State University, LHCb masterclass on [17.03.2017](#)
- Students enjoyed very much, using CDs from Uta and USB keys



---

## 3. WORKING GROUPS

**TO DO for all WGs:** Every WG should have a short document describing the tasks and mandate, conveners, status... This will be internal document helping to sustain the IPPOG Collaboration work.

### 3.1. PUBLICATIONS AND SPEAKERS COMMITTEE

*Pedro Abreu, Angelos Alexopoulos, Marge Bardeen, Beatrice Bressan, Yiota Foka, Steven Goldfarb, Despina Hatzifotiadou, Christine Kourkoumelis, Panja Luukka, Rasmus Mackeprang, Celso Martinez Rivero, Ivan Melo, Farid Ould-Saada, Gabriel Stoicea, Peter Watkins*

After the last IPPOG meeting, where it was agreed that this will be a Committee and not a Working Group, there was still some momentum for S&P Committee to continue in an open spirit discussing in bigger group. From now on, only a group of 4 elected persons (underlined above) will work under their mandate during the whole year and they will report at the next IPPOG meeting.

**TO DO:** The document outlining the mandate and rules of the S&P Committee shall be completed and amended by the following details:

**Question:** Who can comment on the abstract? **Answer:** Only persons in S&P Committee ensuring that the abstract have been discussed with all relevant people in IPPOG before its submission.

**Suggestion:** Some IPPOGers think, that we should all as a Collaboration have a change to see and discuss the abstracts and other contributions...

**TO DO/ Suggestion:** Everybody must be notified and everything should be put on the website. In the meantime the google doc (regularly updated google spreadsheet) will be used. See [documents here](#).

**TO DO /Suggestion:** Moving from publishing on behalf of IPPOG to publishing as IPPOG Collaboration. This brings some questions: Who would be the authors? Authorship rules, how to give credit to corresponding authors, who are people – not IPPOG real members – countries, experiments and labs – these can't be authors. Therefore it is unclear and needs more discussion.

### 3.2. WG on MASTERCLASSES in NEW COUNTRIES

*Pedro Abreu, Angelos Alexopoulos, Uta Bilow, Beatrice Bressan, Kenneth William Cecire, Catarina Espirito Santo, Steven Goldfarb, Natascha Krammer, Marzena Lapka, Rasmus Mackeprang, Celso Martinez Rivero, Kate Shaw, Gabriel Stoicea*

- New countries that had joined IMC2017: Russia, Georgia, Bangladesh, Philippines, and Montenegro. Rwanda almost joined – they scheduled but had to cancel. Ethiopia did not join but a CMS masterclass, not in IMC, was later held there.
- Other countries that might present opportunities in the future are Azerbaijan, Belarus, Hong Kong, and Taiwan for ATLAS.
- Other ATLAS countries and also Macao and Mozambique could to be brought into IMC (Kate)
- Marzena made a list of 16 CMS countries we can approach.
- Physics Without Frontiers (Kate)– insight to countries with university-level masterclasses, Kate gave MC2NC contact information on groups that might be more likely to join IMC after their experience with Physics Without Frontiers.

#### Several new initiatives:

- 1) Return to the “expanding masterclasses” concept and explore ways to offer more masterclass experiences to students - several initiatives on this front are underway:
  - W2D2 (allows for simple-but-significant masterclass measurements from ATLAS and CMS that can be done by high school teachers and students with little or no assistance);

- Neutrino physics is very important and can be the subject of interesting masterclasses (one underway from IceCube, though not part of IMC, efforts to bring accelerator-based neutrino masterclasses into IMC: MINERvA for IMC2018, MicroBooNE for IMC2019, DUNE for longer-term goal)
  - Belle II masterclass in the offing
- 2) One of the key ways to expand masterclasses to new countries, especially in the developing world, is to create a Masterclass-in-a-Box, a masterclass low- or no-bandwidth kit that a teacher can unpack at a school with few resources.
- In the past, the measurement was a simplified version of existing ATLAS and CMS masterclasses. However, World Wide Data Day found success with a different pair of measurements, still from ATLAS and CMS, that should work well in a low/no-bandwidth environment but probe interesting physics without the appearance of shortcuts.
  - This problem solved, the next question is how to adapt the “box” to this and improve it as well.

**TO DO / Suggestion:**

- Expanding to younger audience – below 3rd year of HS, one needs mixture of lectures and hands-on activities, nice explaining materials... W2D2 could be a good approach, or playing with PP cards first (10-15 minutes interactive session with questions to find out what are they interested in and what to avoid) then take it to SM.
- Expanding to university level – we need something more complicated, maybe course on MC, students would do also coding and tutoring

**TO DO:** Create a webpage on IPPOG website to keep the members informed on what is going on in MC

### 3.3. WG on EXPLAINING HOT PP TOPICS to LAY AUDIENCE

*Angelos Alexopoulos, Hans Peter Beck, Beatrice Bressan, Barbora Bruant Gulejova, Catarina Espirito Santo, Steven Goldfarb, Panja Luukka, Rasmus Mackeprang, Celso Martinez Rivero, Ivan Melo, Farid Ould-Saada, Jiri Rames, Dirk Ryckbosch, Jon-Ivar Skullerud, Gabriel Stoicea*

Based on discussion already at the 10th IPPOG meeting in 2015 at CERN the unknown and hidden PP subjects have been identified by IPPOGers (dark matter, antimatter, gravity, scales, new dimensions etc)- see 4.1. in the corresponding [report](#) and [Newsletter No.2](#). These are already quite complicated subjects. Where to start?? We need to explain more basis questions first. How about the fundamental concepts?

#### 1) What is a particle?

- Particle-wave duality: is particle a marble or wave? People are not used to the concept that particle is a wave. How to explain it easily? It may be too complicated to say: Everything is field which fluctuates, we do waves in the fields, just like waves in water, which have some amplitude. But these amplitudes are quantized in Quantum Mechanics, and this quantum corresponds to the elementary particle.

- Different scales – definition of particle depends on scale, rules are different at every point of scale. You start at point where is easy – level of atom, molecule, objects, planets – this can be explained using „marble, ball“ analogy, however when we scale down to the different level – the boundary knowledge of today - smallest particles (proton, quark, lepton), the analogy breaks-down, particle is not ball anymore, and quantum theory is demolished- we enter to elementary particle physics, where particle is a wave. Take fractals as an example – you see different things from far (big picture) and when you zoom in. Nice animations/videos 10-10 (zooming in) used to be on the CERN old webpages – this give people the image, understanding, imagination of different scales! Planet can be a particle from the point of view of galaxy... We must convey the message that the theories have limits, boundary conditions (in line with the analogies we use)

---

- Properties of particle-mass, flavour, colour, spin?

Spin: assuming that people usually understand charge and electromagnetic field, they also know what happens when particle with charge goes through e-m field. Spin explanation could be a quantum equivalent of what happens when particle has a spin.

**2)What are fields?** (How to introduce?, Interacting fields = particles) – see report 5.2. below

**Challenges** (Things get difficult):

- Present knowledge is limited – we say: as far as we know today, with our present knowledge... But we don't want to say that SM is wrong! We must be careful in phrasing. We have to show, that this is the test model we have.
- Analogies break down – see 5.2. below – example on Higgs analogy about celebrity reception from Thomas Naumann given in the [Newsletter No 4.](#), different analogy: a culture of fishes living in the ocean for millions of years. They do not feel their mass since their home = their vacuum is the ocean where they are weightless. Only if you take a whale out of the ocean it weighs hundred tons. So the question is what is the true ground state or vacuum - our air or their water.
- Concepts become very abstract – we miss that lay audience don't understand

**TO DO:** Based on the agreement during last IPPOG meeting, Barbora, Dirk and Farid will start the collection of the explanations, analogies, etc... the audience of this IPPOG made collection would be explainers of physics. Include also limitations of the explanations and analogies – when they are not valid anymore and give recognition „suggestion from XY“.

**TO DO:** Collect examples (Farid started – send us what you have). Barbora, Farid, Dirk discuss on the collection, its structure and other questions like: What is best format (no slides, only text, images, videos...)? How to distribute further afield? Determine "best practices"?

**TO DO:** Exchange among IPPOG members. We need to show each other other how do we explain things!

**TO DO:** To be collected: Talk of H-P Beck in public event in Tel Aviv – explaining Higgs mechanism in 20 minutes – write it up and give to B+D+F

**Examples not to forget for the collection:**

- CERN backgrounders
- Article from Julia Woithe, et al. – [Let's have a coffee with the Standard Model of particle physics!](#) „All that's never been measured except gravity is in SM“
- Lecture of David Tong, Uni Cambridge, Quantum Fields: The Real Building Blocks of the Universe on Quantum field theory – on [youtube](#). All fields, waves, including Higgs, everything about interaction of fields, Q&A session

**Some more explanations/tricks:**

- Wave package - if you take a group/combination of waves, rather than 1 individual wave, you can arrive at a "package" that is compact in both space and time. When explaining this, there is certainly a tendency to outline something finite in size with your hands – like a box.
- See waves as baggy balls: even if we picture particles as little balls, there is always the fuzzy nature of their surface caused by the wave behaviour. In some slang you could call this "baggy" balls. Dirk would rather prefer fuzzy balls.
- In book "A brief history of time" Stephen Hawking gives an explanation of spin in terms of the rotation of objects (like arrows). However, it only works for spins 0, 1 and 2, and not for our most common spin 1/2 case.
- Turning plate in the hand from up to down to illustrate different spin objects - analogy for the spin 1/2 particles: these require a rotation over 720degrees to come back to the original situation - see [video](#).

---

## 4. PANEL DISCUSSIONS

### 4.1. REACHING TO NEW AUDIENCES / NON-CONVENTIONAL METHODS

*Pedro Abreu, [Angelos Alexopoulos](#), Hans Peter Beck, Beatrice Bressan, Yiota Foka, Steven Goldfarb, Marzena Lapka, Catia Peduto, Dirk Ryckbosch, Kate Shaw, [Jon-Ivar Skullerud](#), Gabriel Stoicea*

The outreach we do in IPPOG reaches the group of middle class well off people...

#### **New audiences — hard to reach groups?:**

- Socially disadvantaged groups, like low socioeconomic status groups, Prisoners, Refugees (parts of CMS were built in Pakistan supported by Ministry of Justice, they were very proud!)
- Remote communities, Older people, Disabled people (Diversity at CERN!)
- Primary school teachers and students

Where science is not popular, politicians are not interested

#### **Unconventional methods:**

- Cartoons, computer games: entertainment industry links?
- Music festivals
- Physics busking, flash mobs
- History, drama?

#### **Primary schools**

- Primary schools are nice to target, a lot of curiosity
- In PP community there is resistance to go to primary schools, but there are many evidences (UK), that it works well
- Primary school teachers often afraid of physics
- CMS training courses for primary school teachers
- Selected disadvantaged schools in Greece, validated pilot exercises
- Pupils: Cartoons — partnerships with Marvel Comics etc; Computer games (Big Bang Legends)

#### **Challenges:**

- Translate the materials like cartoons (maybe IPPOG could help?)
- Find the vocabulary to be understood by public (proton, LHC,...)
- Scientists can learn a lot from interaction with other audiences...

#### **Beyond STE(A)M:**

STEAM is embraced by EU Commission – „A“ stands originally for „Arts“, but EU says „ALL“

- Arts@CERN, Arts@CMS...
- Music festivals (meeting those who we usually dont meet!); [Montreux Jazz Festival 2013–2015](#), [Womad 2016](#), [BlueDot 2016](#), [MoogFest 2017](#)

„Music and science are both universal languages!“

#### **TO DO / Strategies:** Create a STEAM TEAM?

- Evaluate what worked, what did not work
- Schedule for music festivals and other events?

---

## 4.2. IMPACT OF SCIENCE ON SOCIETY

*Pedro Abreu, Hans Peter Beck, Uta Bilow, Beatrice Bressan, Barbora Bruant Gulejova, Yiota Foka, Steven Goldfarb, Natascha Krammer, Marzena Lapka, Rasmus Mackeprang, Ivan Melo, Farid Ould-Saada, Dirk Ryckbosch, Kate Shaw, Jon-Ivar Skullerud, Gabriel Stoicea*

„The report on Impact of Science of Society and Sustainable Development (see 5.3. below) made me feel proud that I am PP scientist“, Ivan Melo

Particle Physics is through CERN a global voice of science – responsibility and pride of our community!

### 1) How to justify public funding of science

Sources of science funding: government, industry, philanthropy.

US example: Before 1945 research was funded by industry and philanthropy. In 1950, President Harry Truman created the National Science Foundation. For 55 years federal funding expanded. In 2006 expansion stopped. Federal spending on R&D peaked at 2% in 1970s, today only 0.78%.

**Industry** is focused on development, and if research than applied research that will result in the development of products with immediate commercial application.

How to communicate with policy makers?

- Nice examples are **events with decision makers** in Germany (DESY - Thomas Naumann, GSI – Yiota Foka) and Portugal (Pedro)
- **Politicians want to be part of prestigious things, be involved.**
- We need **nice sentences** like: R.R. Wilson: "PP will do nothing directly to defend our country except to help make it worth defending." or F. Gianotti: "CERN is a concrete example of worldwide, international cooperation and a concrete example of peace. The place which makes, in my opinion, better scientists, but also better people"
- Should we be **reactive or proactive**? Proactivity and more engagement with politicians can pay off (example in Slovakia – Barbora - funding of HST program and MoU signing among first 10).

Resources we have:

- Report 5.3. below and [CERN brochure](#) is a good starting point, but is CERN oriented.
- STFC (UK) also published [similar brochure](#) like CERN (research, innovation, skills)).
- CMS brochure on people who do something interesting for society (see p.2 [here](#)) and also CMS Knowledge transfer examples to be found [here](#) (under KT).
- Are there some more??
- Article in Physics World about former PhD student who did experiment at CERN and now teacher in UK, wrote about how his work at CERN benefited him – see [here](#).

### TO DO / Suggestions:

- We need more local examples! See more brochures (Australia, GSI, EPS?) or examples simply!
- In IPPOG we could use for example how many students changed/influenced by MC? (important if EC funding should be obtained for IPPOG projects)
- Use events/dates which make headlines: Use opportunities such as International Cancer Day (or Hadron therapy event in Norway) which make headlines to bring PP into spotlight and show its role.
- CERN Alumni program – people trained at CERN start successful business – invite them as an example to IPPOG together with a person from funding agency (is there a brochure?)
- Find sentences which capture imagination (especially the sentences which ministries like to hear), find ways how to convince people that science is important
- Summary of ideas/sentences/activities to show possible future outreachers that what they'll do will have impact (Find examples concentrating on how this will impact their every day life)

- Summary of convincingly specific impacts of PP in Society (PET Scanners, WWW, Hadron therapy, Int.Collaboration, Peace...) – see Report 5.3. below
- Ambassadors concept (key people "nominated" as special ambassadors of PP, some celebrities!)
- We can encourage national companies, council members etc. To give a keynote speech at IPPOG meeting (like in Norway, millions go to Hadron therapy)

## 2) How to convey impact of Particle Physics in Society

More ideas on impact:

- keep the young curious (in whatever they'll like to do in the future)
- Passion in science, scientific way of thinking, change mindsets and push for new ideas/processes, convey creativity in science, think out of the box,...
- Impact on teachers (and motivate them to go further)
- Impact of science is infinite – we don't know yet!
- Cultural aspects
- Cooperative skills – research among physics graduates in US showed that cooperative skills are one of the most important skills (interesting also for big multinational companies!)

## 4.3. EXHIBITIONS and EVENT HIGHLIGHTS

*Angelos Alexopoulos, Katarina Anthony, Nicolas Arnaud, Marge Bardeen, Kenneth William Cecire, Catarina Espirito Santo, Despina Hatzifotiadou, Christine Kourkoumelis, Panja Luukka, Celso Martinez Rivero, Catia Peduto, Charles Timmermans, Peter Watkins*

### EVENTS

France (Nicolas): La Nuit des ondes gravitationnelles

CERN (Despina): International Day of Girls and Women in Science 2017

- The week 6-10 February 2017 CERN sent women to local schools to talk about their job, CERN, LHC, particle physics etc; to act as role models for girls
- 36 women (physicists, engineers, computer scientists) went to 42 schools (21 in Switzerland, 21 in France, elementary, collège, lycée)
- Children asked lots of questions, event successful, to be repeated

ALICE (Despina): ALICE elementary school at Preveessin – Ecole ALICE

- Inauguration : Saturday 11 March 2017 - official ceremony to celebrate opening of this primary school - see [article](#) in ALICE matters
- CERN and ALICE were there: with help of ECO group lot of activities were provided (Drole de physique - big success, virtual visit of cavern, cosmic piano - scintillators detecting muons, soundwaves, building ALICE from LEGO and cardboard, colouring, etc...)
- People were happy and the relations with CERN neighbourhood improved

Netherlands (Charles): Cosmic Teepee

- Detector inside the tent, wooden frame at bottom, wires goign through the structure of tent and LEDS are glued;
- Scintillators are in the box in the middle, whenever one of the scintillators are hit by particles, the structure if the tent lightens up with blue LED – magic blue atmosphere

US (Marge): Family Open House 2017, Fermilab

- Teachers who did MC where asked if they would be interested to show some nice demos to students

- Inspired by „Experimenta 2010“ in Valencia, Spain, Marge and Bill Bardeen adapted the idea for US and started the Family Open House
- It costs nothing, many volunteers, they gave T-shirts, competition for HS...
- There is Ask a Scientist, a couple of science shows, drinks, a dark room with lights, lenses, etc. and the carnival which are demos that high school students create for little kids - they set them up and run the physics carnival for the families who come.

## EXHIBITIONS

### Italy (Angelos): Exhibitions in framework of Creations: STEAM

STEAM is an educational and innovation framework bringing science, technology and engineering together with the arts/other disciplines and types of learners with the goal of being more engaging, creative and naturally successful for all members of any educational system.

„Scientific knowledge is the product of creative thinking“, Osborne et al. 2003

„Art is an excellent tool to help students learn science“, Ashley, 2011; Merten, 2011

STEAM is about expanding STEM education through arts integration

Students who are involved in the arts are:

- 4 times more likely to participate in a math & science fair
- 3 times more likely to win an award for school attendance
- 4 times more likely to be recognized for academic achievement

### **Art and science across Italy** - Infusing creativity in science education and outreach

- See [website](#), Facebook@artandscienceacrossitaly, [Milano artworks catalogue](#)
- part of Creations, reach to students beyond science stream
- engage young people with HEP: students and teachers from science, humanities and art lycées; 2 months project
- Seminars at schools and INFN about HEP and INFN/CERN research
- Teams of students (3-4) create artworks with the help of teachers and scientists; they report about it + feedback (assessment, questionnaire before and after)
- Best artworks awarded and exposed at the “I colori del bosone di Higgs” exhibition in Napoli, where students will act as guides during the exhibitions.
- Winners will be invited to visit CERN!

**1<sup>st</sup> sciart workshop | Graz, Austria** - 5-7 Jun 2013, 62 students, arts and science teachers!

### UK (Pete): Large Hadron Collider Roadshow – see [website](#)

- Traveling exhibition, [LHC on tour](#), 600 000 people visited over many years, summer 2017 it stops travelling and will be just in north of UK.
- Could be a good entry point for IPPOG DB, as it is nicely explained

### Spain (Celso): Exhibition „Physics in our lives“

#### **More Spain highlights 2016-2017**

- European Researchers' night 2016
- Scientific Coffee
- Science Week 2015
- [Gamma Hunters](#) in IFAE (Barcelona) using MAGIC telescope data - Web application for high energy astrophysics addressed to secondary school students which combines physics and computing

---

### Italy (Catia): Extreme permanent exhibition in Milan

- produced by the Museum in partnership with CERN and INFN – see [website](#)
- immersive, interactive – nice and easy concept
- particle juke box – you push the particle and there are information + music from the year when particle was discovered -15 000 euros
- Dark matter – touch screen, moving dark matter stuff which is projected on the screen
- Extra-dimensions: more immersive, you see yourself on left or right – in other dimension

#### Uomo virtuale / Virtual man:

- exhibition in Pisa, March –July 2017
- about all medical applications of PP, hadron therapy etc.

**TO DO / Proposal** (Catia): What if we establish a WORKING GROUP on EXHIBITS?

Motivation: difference between exhibition and exhibit. It would be useful to have correct information on those exhibit items, which would really be easy to bring elsewhere, to make a collection of these items and instructions how to reproduce them + treatment of IP rights

Plan: Next 6 months: understand if it makes sense, Questionnaire: Catia sends email

## 4.4. IMPACT OF EDUCATIONAL PROGRAMS for STUDENTS and TEACHERS

*Katarina Anthony, Nicolas Arnaud, Marge Bardeen, Uta Bilow, Barbora Bruant Gulejova, Kenneth William Cecire, Catarina Espirito Santo, Despina Hatzifotiadou, Christine Kourkoumelis, Panja Luukka, Rasmus Mackeprang, Celso Martinez Rivero, Ivan Melo, Farid Ould-Saada, Charles Timmermans, Peter Watkins*

### What is impact of MC on students? Has it changed anything?

- MC is outreach event, not an educational event! Impact of MC as education in itself meaningless
- In terms of recruitment of students to physics: Uta and Ken have done a [survey amongs Alumni in Netzwerk Teilchenwelt](#)
- Historical data from the US "mature program"
- Difficult to get the information on what happened after MC as people often change addresses...

**TO DO / Suggestions:** website etc...

- Suggest contexts for use of MC in class elements. Ask teachers / IPPOG members who do MC, what are the subjects in normal curriculum which are in connection with MC (examples: relativity, QM, momentum conservation laws, spin)
- Enrich the MC website part for Educators and Teachers by materials for MC preparation and follow-up + curriculum suggestions
- Add information on other possibilities for teachers, like CERN teacher programmes, Fermilab programs, visits etc...
- Collect surveys on MC (many countries did it!), Alumni report from Netzwerk teilchenwelt, PhD thesis from Konrad??
- Put together existing sources (from Uta, Marzena, Nicolas...)
- Get best practices: What worked in US, Greece etc..

**TO DO / Suggestions:** Get hold of teachers:

- Ask CERN the list of teacher contact
- Make sure IPPOG is introduced at CERN teacher's program (propose IPPOG contact and details at the end of each national teacher programme)



- 
- Make sure visiting school classes leave with the name and contact info of their national IPPOG representative
  - Would be interesting to know the feedback from teachers after CERN NTP (Jeff?)

## 5. VARIOUS REPORTS

### 5.1. MASTERCLASSES 2017

Presented by *Ken Cecire, Uta Bilow*

#### **International Masterclasses 2017 central coordination:**

General numbers: 1.3-11.4.2017 - 50 countries, growing in TU Dresden (173 institutes, 264 MC), stable in Quaknet (43 institutes, 50 MC)

Statistics 2005 vs 2017: 18 to 50 countries, 58 to 216 institutes, 72 to 314 MC, 3K to 15K students, 12 to 81 videoconferences

New participants: Russia, Georgia, Bangladesh (after 2 years effort), Philipinnes, Montenegro, Rwanda

Videoconferences: 57 with CERN, 25 with FNAL, 1 with TRIUMF.

Given that in the past the moderators were bottle neck for the program, now this is solved. Call for moderators at CERN was very succesful: around 60 people subscribed, some put on emergency list.

Issue: Some moderators thought that they could do it remotely (especially on Saturday), not possible at CERN. In FNAL it was tried and works well, but in general it is better and easier to coordinate between moderators so the remote connection of moderators should stay as an exception!

Key factors for success:

- Preparing institutes
  - (bi)weekly [circulares](#) – sent to > 500 people, they really read it, good!
  - Orientation for Fermilab institutes – for teachers and students
  - [Manual](#) for videoconference
- WG videoconference (M. Hauschild, K. Leney, Marzena, Kate, Uta)
  - [Training](#) for moderators (2 h), twiki, manual (restricted access, due to password exposure), new quiz, rooms at CERN
- Vidyoteam / Marek Domaracky + videoconference team at Fermilab
- Maureen – rooms and T-Shirts for moderators

Outcomes:

- 4 video conferences recorded: [ATLAS W](#), [CMS](#), [ALICE S.P.](#), [ATLAS Z](#),
- [Photos](#)
- [Media coverage](#)

**Social media:**

Twitter account@physicsIMC, #LHCIMC17, 242 tweets, 389 followers

Team: Ken, Nicolas, Kate, Uta, help from Clara Nellist

Improving from year to year, but the number of tweets is still relatively small, still a lot of room for improvement. Around 400 followers is not that much, but one must start from somewhere and be patient.

**Suggestion:** Moreover, it needs dedicated person and concept! We need to recruit people!

Who is the target audience? We dont know much, we are not selective. Students talk about MC before and after, Hashtag allows to have online repository on IMC.

---

**TO DO:** Avoid that people register and don't participate. Statement at the beginning that if they must cancel, they should inform in advance. Send reminder 1 week before (special alert taking into account the time zone differences).

**Different MC:**

**ATLAS Z-path:** stable, success, well understood statistical fluctuation through 2 photon exercise

- intention to bring dark matter (missing energy) not too much extra work, just add 2D graph
- Z-path is now funded project by 180 K for 3 years – sponsorship by wealthy person, in contact through the rector of the university, for student education program, will be used also for Z-path webpage improvement, more content, entry point for HS teachers and students
- 35 students came to CERN – success

**ATLAS W-path:** measured values of charge ratio worked well

- Can be improved: Remove event number from spreadsheet of results (confusing and time consuming); Show jet objects in event display?

**CMS WZH:** overall great success

- New tool to choose leptons: iSpy – WebGL – awareness of this characteristics must be improved, people don't know, that they should use this option so far...
- CIMA (Updated to accommodate A and B), the histogram is not changed, it doesn't update automatically, it is important to make people aware of how things work
- Important to find more ways how to integrate iSpy and CIMA
- Get more data, new paths / departures

**LHCb:** changed the layout of the connection with CERN once again

- Final quiz will not be carried out if questions keep coming up from the students – they can perform the quiz later at their institutes!
- Problems with video – bottleneck every year! They sent email with instructions, but still is too bad, sometimes they can't even do MC...
- Great feedback from newcomers (Russia, China)
- Still a lot to do: test institute to institute questions; Implement a new exercise in the Masterclass software
- No manpower, MC software based on ROOT (not flexible, but stable) sitting there and not used

**ALICE – looking for strange particles:** stable from 2014

- Google docs for collection and presentation of results – very clear for institutes and moderators; moderators were pulling the results instead of institutes presenting them, what made things quicker and more effective
- Can be improved: some problems depending on ROOT version, ideally browser based analysis package...
- If MoU signed: in kind contribution would mean putting manpower to development of MC package

**ALICE – Nuclear modification factor  $R_{AA}$**  - stable

- Simplified version of „large scale analysis“ established („copy&paste“ of analysis code instead of actual coding); also pupils with zero programming experience produce a result!
- all institutes could contribute to the final result (produced on the spot by moderators of video conference)
- more data and particle identification could be added
- new measurement under development/tested: J/ψ production in heavy-ion collisions – again question of manpower, CMS and ATLAS heavy ion communities could maybe help there...

**Proposal from Yota:** she could maybe have a Master thesis well defined software project to develop for example ALICE D0 or strangeness analysis... it would be nice, if IPPOG could invite the student to IPPOG meeting or send him to some other conference to present his project...

---

## Videoconference 2017

- Central part end point of the day
- NEW CONCEPT: to skip the repetitive reports what students would do. It was announce in circulars and in manual, at training to moderators, also said to old moderators not to use the old way... Feedback is good fro both moderators and institutes
- General comment: Videoconferencw always depends on moderators and also local HS teachers / studenst to prepare – one must be pushing / convinncing studenst to talk in english in front of everybody, important to motivate students to stan dup during the break before the videoconference... good person could be chosen to interact, take microphone, they shoud be briefed... if there are 2-3 together instead of just 1, there is less pressure and they share the responsibility, also 50%/50% girls and boys – request to institutes
- Troubleshooting: if problem with sound, they can allways use chat!
- Despite of tests, there are always many problems, people dont mute etc...

**Suggestion / TO DO:** Can we get questions for moderators beforehand to prepare? Have a catalogue of questions..to improve the questions in general...Also if there is a question on different subject out od the scope of MC like cosmology, moderator should not try to answer during 5 minutes, but be consice and move to other question to cover MC topics.

## Worlwide Data Day (W2D2)

- New logo
- Meet studenst all around the world in 24 hours, CERN, FNAL, TRIUPF, CoEPP
- Inspired by ICD
- Takes only 2 hours per institute including videoconference!
- ATLAS, CMS simple measurements of dimuon events, ...
- Used online version of HYPATHIA
- Pilot year about 20 groups, base at schools to reduce burden to IMC tutors
- Website : <http://tiny.cc/w2d2>
- People from IPPOG were spread around
- Informal online survey for teachers
- Much simpler and easier than MC
- Given materials for students and teachers to prepare – 1 class period to prepare
- Teachers have much more direct role than in MC, no lecture by scientist as in MC, but only teachers prepare them... easier for US teachers who are in general better prepared
- IPPOG members recruited folks to help – very good!

**Message:** - PP is fun, it's not that mysterious, can be still analysed...

– You measured „dangerous“ radiation! As people think, that we do somethig very dangerous, and like this they see that it is not the case...

**Recommendation:** it could be targeted to younger groups!

**Question:** Do we want to scale up and make it a regular event every year?

## International Women Day in Science: [website](#)

- Dec 2015 UN General Assemby established an International Day to recognize the critical role women and girls play in science and technology communities - [website](#)
- Aim: Support and promote the access of women and girls to science education and research activities
- 11th of February 2017 – Saturday
- MC launched on that day, extend the celebration to Friday 10th of February already
- 10 MC, 3 VC, female lecturers and tutors, 320 girls (between 7-98 per institute)
- All institutes tried to do something on national level

**Barcelona:** 40 girls, also visit to data center, astroparticle physics, nice [website](#) with posters of women in science, 20th century and now, nice role models..

**Cosenza (Italy):** 30 girls, physics department decided to adopt this day for every year! [website](#)

---

Paris: 24 girls, 2 young researchers gave introduction (not from LHC circles, maybe for next time it would be good to have somebody also from LHC), [website](#)

Praque: 20 girls, lot of media attention, television, 2 long article in newspapers, discussion about gender issues in science, [website](#)

CERN: many lectures at local schools around CERN done by women from CERN – went well!

**Conclusions**: even without having very famous role models, like Fabiola, it worked quite well without forcing. Young girls identify more with PhD students than with DG.

**TO DO**: Start earlier with organisation, but avoid mixing with IMC 2018.

**Concern**: Next year 11th of February falls probably into IMC 2018, what can take all girls and only boys would be moderators!

**TO DO**: Get more publicity. It was good with CERN coordination, but no webpage.

### Neutrino MC

*Neutrino is the only Dark matter we know, it brings so much information from cosmos, about the Sun!*

- Fermilab centric: Minerva, MicroBoone, LBNE, MINOS...
- Ultimate goal is DUNE in very long baseline, but until is built we don't have data

Minerva experiment: planned to include in IMC 2018

- measurement of muon momentum, energy transfer, muon and electron interactions, using momentum conservation, not perfect measurement, but one gets vaguely Gaussian.
- Tried few times with teachers who found it very exciting. See [website](#).

MicroBoone: running, but more complicated, work in progress.

- Measure purity of liquid argon in the detector using cosmic ray data & charged particle multiplicity; compare with Monte Carlo
- Event displays – VENU for introduction (nice [video](#)); Derivative of Argo for measurement (also used for MINERVA)

Plans for IMC: SBND, NOVA (see [website](#)), DUNE

Project plan: April 2017 – March 2019 - quite full with different experiments and measurements

Discussion planned at the meeting at FNAL 15th of May... message there is that students can do this even if they already did LHC MC

**Important comment / TO DO**: Do not separate IMC (LHC) and Neutrino MC! IMC is a brand for all PP so we must keep this all together within IMC and not call it Neutrino MC! It would be called Minerva-Neutrino path...

**Suggestion**: Why only neutrino, and not gamma rays (Yiota)

### General TO DOs / suggestions for MC...

**TO DO**: Translate German online course on MC for teachers to English!

**TO DO**: 4 booklets to be translated

**TO DO**: Webpage should be updated, professionalised, with more easy going information and steps to follow: how to use Hypatia? How to follow up at classroom? How to prepare?

**TO DO**: Find ways how to link MC to curriculum of countries to suggest to teachers when they can use what they learned in MC, how to include it to their curriculum (for example everybody has conservation law) – prepare the list of subjects how teachers can link MC to their curriculum (Farid)

**TO DO**: Try to provide the precise guidelines / slides for the analysis exercise for all paths to ensure the good quality of every MC regardless of who is doing it.

**TO DO/Proposal**: As other communities and those who never did MC have no clue about MC, we should get the experience from MC written down and maybe publish (at least on the website)! Write into a document how students profit from MC.

---

## 5.2. PHYSICS FOR EVERYONE – FIELD, SYMMETRIES, MASS

Presented by Dirk Ryckbosch

„Fields, symmetry, mass... You expect me to understand all that?“

**FIELDS:** Why were fields introduced?

Why and how can we interact with each other? Push, touch... But how do we communicate by distance? How does Moon know, that there is Earth?

How is it possible that you can hear me? (There is a medium in between, sound waves, air molecules squeeze)...

Example of water surface: waves know to transfer the information from one side to another!

Field is necessary for „action at distance“. Disturbance of the field is wave, smallest waves is a particle.

People tend to accept the duality of wave and particle like they tend to accept the relation between mass and energy ( $E=mc^2$ ).

Different fields: the only field, people seem to know / feel is magnetic field, maybe also gravitational and electric field (even if they don't feel it), but how about Higgs fields?

Analogies to different mediums: propagation is different in water vs air.

**SYMMETRY BREAKING:** (Electroweak) symmetry breaking: mass of  $\gamma$  vs.  $W, Z$

Some nice examples to show spontaneous symmetry breaking due to disturbance of background field:

1) Donkey, who is going to the right or left...

2) Wedding dinner, everything at the table is clear, but small plate with little bread: some people will reach on the right and some on the left, there will be spontaneous symmetry breaking on the left or right.

3) Pencil in vertical position on the table should not fall, but it will! There is always disturbance of the background field, which will make it drop in some of the directions. Once it fell, symmetry is broken.

**How this relates to mass?**

4) The „hat“ could be shown with the ball falling down at one direction – symmetry breaking.

5) Little fun exercise which people will remember: Many people standing with one hand up and make everybody to break symmetry by moving hand – all people waving hands – memorable!

Mass = coupling to Higgs field = Interaction with field leads to mass (concept of  $E=mc^2$  is quite understood).

**Illustrations by analogies:**

6) Reception - celebrity enters a full room and the bulk of people surrounding the celebrity slows down its motion like honey

7) Swimming pool - nobody would swim in fur coat – too much interaction with water, heavy!

**Crucial is to show limits of analogy.** These analogies can be also misleading - see the [Newsletter No. 4](#) and WG on Explaining Hot PP Topics to Lay Audience Report above!

Our analogies fail miserably, but this failure can be used also to explain how science works.

Everybody has a picture of microscopic world, but try to visualise subatomic world (not so easy)!

Illustration of scientific process: Understand physics - Build model - Refine understanding - Go to better analogy.

### Other examples:

- 1) Scalar field (meteorology) – see the [report from previous meeting](#), p14.
- 2) Precision (flat earth) - see [Newsletter No. 2](#)
- 3) Spin (angular momentum)...solar system in terms of mass is only sun, if you look at the angular momentum, it's spinning planets -> mass over angular momentum
- 4) Radiation – you run, you sweat
- 5) Higgs particle – drop – splash in the water – manifestation of Higgs particle in the Higgs field!  
Or spoon in water, in honey, the same spoon feels heavy, surrounding is like Higgs field, filling universe. Vortex from Higgs field is an evidence of particle
- 6) Luminosity – number of collisions per second, how many people can go through metro?

**TO DO:** IPPOGers are asked to provide/ share the good analogies for the above and especially below examples of subjects to be explained to lay audience

- 7) Neutrino/meson oscillations
- 8) Dark energy, vacuum pressure
- 9) Particle decay
- 10)  $5\sigma$

## 5.3. IMPACT of SCIENCE on SOCIETY and SUSTAINABLE DEVELOPMENT – showcased by CERN

Presented by *Barbora Bruant Gulejova*

Updated version of the talk given to HST 2017 is to be found [here](#).

### Motivation:

- Everything is interconnected: Academia/Research/Science is feeding Education through teaching and Technologies through Knowledge Transfer, which are then feeding the economy, industry and business. The priorities of the society are shaped by policy makers.
- The investment to research and science is being diminished and there is a big pressure on its funding, every scientific project must be justified, nothing is granted. Positive news is the fashion of „impact investing“ of high profit making business who want to balance profit by benefits for society.
- Data needed to measure / justify / quantify / demonstrate impact? - quantitative and verifiable, policy makers like numbers, cost savings, changes your research had on policy documents, standards, protocols, testimonials / quotes, evidence of public debate / media, licences, patents awarded and brought on the market, investment funding awarded (for spin-offs, start-ups)

**CERN: Impact on society** – much of examples below taken from [new brochure](#), but wider scope is given

#### **1) Scientific knowledge**

- Understanding of universe, addressing questions: dark matter, antimatter, ...
- Major discoveries and inventions (rare pion decays, wire chamber, W,Z, higgs bosons, WWW, ...)
- Unique worldclass facilities (LHC, detectors, data center,...)
- 900 peer reviewed research papers, 600 PhD theses / year
- 4 Noble prices (Charpak, Rubbia, Van de Meer, Higgs & Englert).

However between 1936 –2011 69 Nobel prices awarded in physics – out of which 24 in accelerators!

Open Science: “CERN’s commitments to carry out purely fundamental research and to make all of its work public have ensured peaceful collaboration between scientists, from all countries.” Rolf Heuer, former CERN DG

- CERN provides open access to scientific publications, data and technologies free of charge (participates in Open Source Software initiative with CERN-extended model „Open Hardware Licences“: knowledge-exchange in wide community of electronic designers), SCOAP3 (Open Access Publishing in Particle Physics)

## **2) Innovation, knowledge transfer and the economy**

Fundamental research at CERN is driver of innovation! Ambitious scientific goals of PP require cutting edge instruments and innovative technologies that have many applications in many fields.

- CERN actively engages with experts in science, technology, industry to transfer its technology and know-how to accelerate innovation (in 2015 **know-how disseminated** to 100 external partners (industry, labs, universities,...))
- **Knowledge Transfer group** provides: advice, support, training, consultancy, network and infrastructure to ease KT, encouraging entrepreneurship, spin-offs, public-private R&D partnerships...
- CERN established a network of 9 **Business Incubation Centres** (BICs) throughout its Member States to assist entrepreneurs and small technology businesses in taking CERN technologies and expertise to the market
- There are currently **18 start-ups and spin-offs using CERN technologies** with applications in domains as diverse as biotechnology, the oil and gas industry and material science
- **CERN Openlab** has partnership with leading ICT companies (Huawei, Intel, Oracle, Siemens) who profit from **Big Data** storage and analysis and test their latest products
- 50% of CERN's budget (500 MCHF) is invested into **contracts with industry** in its member states (R&D, know-how, experiences, methods brought back to the home countries + increased turnover of companies)
- There are thousands of **particle accelerators and detectors** (originally invented as tools for research) **in operation** in the world of which only small percentage is used in basic research -applications from medical diagnosis, therapy to computer chip manufacture

### **Examples of applications:**

- WWW invention at CERN (1993) driven by need of better communication of scientist worldwide, had a huge impact: # of internet users from 14 millions to 3.2 billions from 1993 till 2015-contribution to 2,9% of world global GDP ~ 1672 billion US\$ (in 2011)
- World-wide LHC computing grid: 500 000 CPUs and 500 PB of data storage > 200 computer centers in 35 countries
- CERN was pioneer in breakthrough technologies, such as touchscreen
- Inspiration for solar cells technology based on ultra high vacuum
- Hadron therapy -treating tumours with beams of protons and light ions reducing the radiation exposure of healthy tissue (3 HT centres in Europe built in collaboration with CERN; CERN supports development of miniature linear accelerators for proton therapy)
- Medical imaging: PET, MRI and others (PET using new type of dense scintillating crystals; CERN has pioneer contribution to forerunner of PET; PET and MRI imaging combined in single device thanks to new generation of CERN detectors)
- Software for simulating particles interactions in detectors -used to calculate precise radiation dose for cancer treatment - space applications
- Pixel detector technologies "Medipix" (medical diagnostics, industrial processes, X-ray based material analysis, X-rays by detectors invented by Charpak in 1968 need fraction of dose required by photographic methods, International Space Station)
- TERABEE—sensor technology used in drones to explore places with difficult access
- INVENIO—digital library and document repository used by providing cloud based digital library system for UN

- CLOUD experiment could be mentioned: exploring the influence of cosmic rays on cloud formation in the Earth's atmosphere giving important input to global climate models
- Radiation protection—dosimeters

### **3) International collaboration**

Science is a common language. CERN's mission extends beyond science: it also aims to bring nations together.

- CERN: 22 member states, 6 associate states, 16 000 scientists, 110 nationalities (diversity), 70% worldwide PP community

#### **CERN model:**

- Spirit of open access, collaboration, tolerance and freedom of thought - **CERN model** serves as a 'blueprint' for open global collaboration - evokes calls for similar multinational research effort in other fields (CERN for oceans, human brain research, genomics, agricultural science).
  - Article in Economist 2013, Big multinational companies ask how 4000 physicists, engineers and technicians, different languages, cultural and educational backgrounds manage to build LHC...???
- The successful and **efficient management of Big, Global project** as LHC lies in SHARED PASSION FOR "NOBLE VALUES" (KNOWLEDGE) and a common goal that draws collaborators together.

#### **Science for peace**

- CERN -more than 60 years building **peace through science**.
- 16000 scientists from more than 110 nationalities work on research at CERN together in peace (CERN is open to scientists from all nations), irrespective of their religion or system of government, some from countries that are opponents at the political stage.
- All important decision are being made in cafeteria!
- During cold war, CERN served as a **bridge between East and West**: in 1968 agreement between CERN and Soviet IHEP Lab became a model for an agreement between USA and Soviet Union.
- In cooperation with UN, CERN provides the **IT infrastructure** to **UNOSAT** programme of UNITAR hosted at CERN, to be at te forefront of satellite analysis technology - -15 years of humanitarian mapping: disaster risk reduction, regional capacity development, -damage assessment, climate services, water and food security,...
- CERN also helped to build **SESAME**: -light source in Jordan, which follows CERN model and promotes scientific collaboration in Middle East; unique joint venture bringing together scientists from: Bahrain, Cyprus, Egypt, Iran, Israel, Jordan, Pakistan, Palestinian Authority and Turkey.

#### **CERN and UN partnership**

- Since 2012 CERN as an **observer to UN General Assembly** serves as a **leading voice for global science**.
- CERN has cooperation with agreements with 8 UN organizations: UNESCO, UNOSAT, UNITAR, ITU, WIPO, WMO, WHO, UNOG, and IPU
- Participating in several platforms and initiatives, e.g. Geneva Peacebuilding Platform, Diplo Foundation, Club Diplomatique, Science Hub.

### **4) Education and outreach**

Education – one of CERN's core missions: Inspiring the rising generation of new scientists

#### **Education of High school students and teachers**

- 70 000 school children visit CERN every year
- 10 000 teachers have been trained at CERN since 2006 impacting more than a million students
- 4000 school students each year perform hands-on experiments on modern physics at S'Cool LAB
- 200-300 teams from schools around the world engages in "Beamline for Schools" competition



- 
- 15000 pupils in 46 countries analyse real LHC data through “International Masterclasses” organised by IPPOG

#### Education of **Young researchers**

- 2400 PhD students are registered at CERN either in research, academia or industry
- 600 PhD thesis completed every year, continuing their career in different domains:
- steady stream of highly qualified young people with excellent technical skills and international experience for business and industry (80%).
- 300 undergraduate students participate at summer internship programme
- 1000 highly trained and qualified young physicists and engineers thanks to specialized CERN schools or opportunity to work at CERN on their high university studies
- 500 postdoctoral Fellows working in research, applied physics, engineering and IT

#### **Outreach:**

- **Visits and Exhibitions:** 120 000 visitors per year (half-day guided tour at CERN), 25 heads of state and 168 ministers made
- CERN **travelling exhibitions:** 76 locations in 15 countries > million visitors from MS protocol visits between 2011 and 2015
- 500 visits by **world media** per year - 166 000 articles related to CERN published in world’s newspapers with 9.9 billion of potential readers;
- 20 000 sessions per day and 4.3 million unique visitors yearly at CERN website
- 2 million mentions of CERN per year on social media (Twitter, Facebook)
- Arts at CERN: bringing Arts and Science closer; attracting brilliant artists for 1-3 month residencies

#### **CERN and Sustainable Development**

- World leaders adopted 2030 Agenda for Sustainable Development to transform our world.
- 17 Sustainable Development Goals (SDGs) came into force in 2016 each one with specific targets to be met over the next 15 years to end poverty, protect the planet and ensure prosperity for all
- CERN is **de -facto contributing to the implementation of five SDGs:** SDG 3 (Good health and well-being), SDG 4 (Quality Education), SDG 9 (Industry, Innovation and Infrastructure), SDG 16 (Peace, Justice, Strong Institutions), SDG 17 (Partnerships for the goals).

## 5.4. COSMIC RAYS GOING GLOBAL – STATUS QUO AND PLANS

Presented by *Charles Timmermans, Marge Bardeen*

Motivation: “In the sky there are accelerators which are more powerful than LHC.”

Charles gave his personal view on the **role of IPPOG in the enabling cosmic rays worldwide.**

Workshop on “High school cosmic ray experiment” took place in Rome, Centro Fermi 15-16 February 2017, see details at [website](#). The main goal was the inventory of worldwide (Europe/US) activities:

- Permanent Cosmic Ray setups (constantly taking data)
- Non-Permanent (classroom) activities
- Smaller units: spark chambers, cloud chambers, cosmic arch
- Activities like CREDO or International Muon Week, International Cosmic Day... where experiments are combined

Tantalizing **questions on the home pages on cosmic rays are not really addressed by the activities** (likely in class) - discrepancy:

- What are they?
- Where do they come from?

- Where do they get all that energy?
- How often do they arrive?
- How do we see them

#### **Possible IPPOG Roles:**

- Scientific Masterclass support (similar to LHC)
- Community building by organizing workshops as we did in Rome
- Supporting collaboration and outreach using the permanent setups (EEE, HiSPARC, Showers of Knowledge,...)

**What is added value of the initiative**, given that International Muon Week and International Cosmic Day seems to be handled well by Quarknet and DESY respectively?

- Cosmic rays are everywhere, getting out of the “LHC circles”
- Sun never sets for IPPOG – we are everywhere around the world, and this should be used!
- From experience of IMW (Ken), kids are captured by simple experiments, they love instrumentation so if they could build a detector in long-term activity, they can do some really interesting things...

**Outcome of meeting in Rome:** preliminary [webpage](#) on **Global Cosmic Ray Studies**

- Marge and Caroline Schwerdt prepared collection of the projects for high school students, the educational activities which are on DESY website: <https://icd.desy.de/e49245/>
- There are several projects around the world that address young people and teachers giving them the opportunity to explore the cosmic particles
- These include: Finland, France, Germany, Russia, Spain, Sweden, Taiwan, UK, USA...
- Having these 10 partners on board IMW and ICD can reach out to more audiences
- It is more motivating for kids to have their own detector
- Data format??

**TO DO:** Make a list of events where this website „consortium“ / website could be used, like solar eclipse in August!

**TO DO:** Next step should be a working, not talking meeting / hack meeting to work on coding?

**Suggestion:** See if IPPOG and APPEC can get funding for common data formatting...

## 5.5. INTERNATIONAL PHYSICS OLYMPIAD 2018

Presented by *Pedro Abreu*

**International Physics Olympiad (IphO) 2018** (21-29 July) will be in Lisbon, organised by the Portuguese Physics Society.

1) Level A – up to 14 years old (end of 9th school year, transition to high school)

- competition by team of up to three students/team
- possibility to participate later in the EUSO –European Science Olympiad (Physics + Chemistry + Biology) - organized inside the Ministry of Education

2) Level-B - up to 16-years old (end of 11th year of school, 2nd of high-school)

- individual competition
- possibility to participate later in the IPhO and/or in OIBF (Olimpiada Ibero-americana de Fisica—this participation is responsibility of SPF

---

### Organisation:

- is much harder than national physics olympiads
- Budget comparison (Swiss 2016 at ~4 M€; Spain 2005 at ~1,4 M€; Portugal at ~1,1 M€)

### Selection:

- At school: team of up to 3 students from level A, up to 3 students from level B
- At region: 5 regions in Portugal, 3 level A teams get medals, 3 level B students get medals, 7 level B students get mentions

### History:

- IPO started in 1967 with only european countries
- Now 90 countries, state level representation, ministries, physics society...
- Portugal part of IPO delegation from 1994

## 5.6. AGENCY CIENCIA VIVA

Presented by *Cristina Fernandes*

„Nothing in science has any value if it is not communicated“, Anne Roe

Portuguese agency **Ciencia Viva** is the main agency for science outreach in Portugal

- About 50 people in head office, 19 centers
- Ciencia Viva in Summer: many activities all around the country (visits, activities for all public who want to attend)
- Bringing astronomy to general public: long-term partnerships with astronomers telling about the sky to public
- Astronomy Association: Many extra activities during 2009 (International Astronomy Year)
- Collaboration with CERN, ESA...
- ESERO project (European science education resources office) – through contract with ESA, way of putting space into the classroom, giving teachers resources developed by ESA, so that they can teach their curricula by using examples from space context (e.g. about food in space, conservation etc.), live-connection with astronaut; contest: students should launch a little satellite to 800 m and do measurements...
- Primary schools (6-9) are coming for 1 week to special classroom, they don't go to school but to LIP / Ciencia Viva „Pavillon of Knowledge“ also with their teachers and they do normal curriculum but also with extra-scientific activities! Full year calendar is fully saturated covering big Lisbon area, not all schools can be included

**Inspiration for IPPOG:** Start to build curiosity and exploration drive already by little kids

**Target audiences** of centers in Portugal:

- targeting all audiences but especially students
- inspiring teachers to teach with fun!
- Also policy makers: since 2005 debating science at all levels = **Science coffee at the parliament** – nice interesting action where people from politics and academia meet...

---

## 5.7. COUNTRY, EXPERIMENT and LAB HIGHLIGHTS

### 5.7.1. USA/FERMILAB/Quarknet: International Muon Week

Presented by Marge Bardeen

#### **International Muon Week 2017** (March 13-17)

- 47 schools from 10 countries: U.S., Canada, Mexico, Puerto Rico, Japan, China, India, Georgia, UK, Germany

#### **2017 Solar Eclipse Project** (21 August 2017)

- Event how to test if sun is a source of cosmic rays
- Measuring muon rate from directions near the sun

Ask Marge, if you are interested to do the same!

### 5.7.2. PORTUGAL - Upgrading the communications & outreach structure @ LIP

Presented by Maria Espirito Santo

- 2016 was a special year – transition year dominated by the celebration of the 30th anniversary of LIP
- Exhibition: Particles: from the Higgs boson to dark matter (see 4.4.2 in [report from 10th IPPOG meeting](#))

#### **New LIP ECO office:** Fostering and coordinating the ECO-related activities carried on at LIP

##### - Corporate communications:

- Redefine goals, strategies and responsibilities
- More efficient communication of LIP's image, activity, impact
- LIP community, direct partners, academia are priorities

##### - Education and Outreach:

- Pursue/consolidate the existing program and flagship initiatives
- Maintain partnerships — Ciência Viva, CERN, IPPOG
- Reinforce development of Instrumentation for education purposes

##### - Advanced training:

- Increase LIP's capability to attract the best graduate students
- Coordinate training offers for graduates and undergraduates
- Improve follow-up of students at LIP

#### **Communications:**

- New LIP communication's strategy + creation of the LIP brand, guideline for all communication actions and materials
- Restructure LIP annual reports
- Detailed report for stakeholders + public report (accessible and attractive!)
- Renewal of LIP public website
- Main communication tool restructured: LIP Bulletin, newsletter, social media, interactive panels, short videos, LIP events...

**Celebrating 31st anniversary in 2017** – open day at new LIP in May!

---

### 5.7.3. UK – STFC Report

Presented by Peter Watkins

**Institute for Research in Schools - CERN@school** – see [here](#)

- a charity that aims to engage school students and their teachers with fundamental research held the third CERN@school Symposium, which saw over 100 students coming together at the Rutherford Appleton Laboratory in November

**School and teacher visits to CERN**

- evaluation of visits by new questionnaires before and after visits – now from 38 teachers
- average rating 4.34 from 5
- questions like: they felt welcome, inspired, relevant to their curriculum, useful for their teaching, help to highlight possible careers to students, would repeat and recommend, new skills, activities, tools for classroom, ...
- most of them would like to learn more about what they have learned when they get back...
- top visits: Microcosm, Universe of particles, ATLAS, SM18
- also some recommendations to improve...

**UK Masterclasses** - see [here](#)

- 19 institutes, 1000 students in 2017

**STFC Public Engagement Funding Schemes** – see [here](#)