



## Particle Physics Outreach in the LHC era: Higgs - what's next?

Explaining and reaching out particle physics to specialists, to decision makers, to young students and to the broad public is a critical necessity for all involved in particle physics research to engage in. This is not an easy task and a concerted and systematic effort towards presentation and popularization of science in general and of particle physics in particular is an essential ingredient in many respects. IPPOG, the International Particle Physics Outreach Group, discusses the significance of new results in particle physics research along with how to communicate and reach out best particle physics to each target audience. As an example, the significance of the Higgs discovery in 2012 at LHC is the opening of a new scalar era and not the closing of the Standard Model, as is often presented. Engaging in outreach provides a potent antidote to overspecialization and brings out clearly what is significant in current research, and as a result of it, science becomes a more integral part of the culture of today. IPPOG is there to provide tools and resources readily useful for reaching out particle physics worldwide, beneficial for those engaging in, and for those being reached out.



IPPOG – International Particle Physics Outreach Group

# Particle Physics Outreach in the LHC era: Higgs - what's next?



Hans Peter Beck  
IPPOG co-chair  
University of Bern  
Switzerland



**ICNFP 2015**

**4<sup>th</sup> International Conference on New Frontiers in Physics**

**23-30 August 2015**

**Crete, Greece**

First Stable Beams



An amazing achievement!  
the biggest complex machinery ever built  
possible with a world-spanning collaborative effort,  
advancing knowledge in the most fundamental questions  
about our Universe!

proton-proton collisions at 13 TeV

Run: 266904  
Event: 9393006  
2015-06-03 10:40:31 CEST



# Critical Outreach

Explaining and reaching out particle physics is a critical necessity for all involved in particle physics research to engage in.

Essential for continued support from

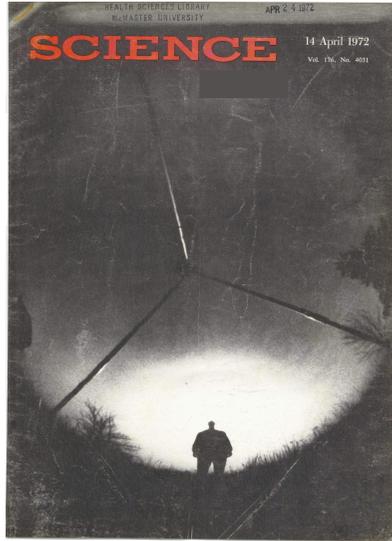
- Decision makers
  - Politicians and funding agencies
- Young students
  - The young students of today are the potential particle physicists of tomorrow, the potential decision makers of tomorrow, will be the tax payer of tomorrow, and will be the voters of tomorrow
- Broad public
  - These are today's tax payers and deserve to be kept informed from first hand



# A concerted and systematic effort for outreach

Good outreach is not easy but crucial

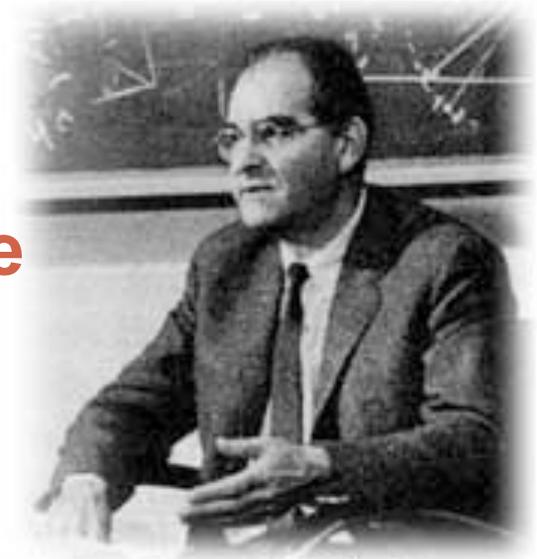
- **If overdone**
  - Particle Physics will be seen as over-advertized
    - There is the highly respected reputation of science at stake
- **Getting the right level**
  - Being too close in a specific topic will easily drag you too far
    - Keep your explanations simple but avoid being trivial
- **When engaging in outreach**
  - you will find your personal antidote against overspecialization and learn how to focus on the really relevant questions and topics and how to best explain and present these



## The Significance of Science

### Victor F. Weisskopf

14 APRIL 1972  
SCIENCE, VOL. 176



Victor Weisskopf  
1908 - 2002

*“More **concerted and systematic effort** toward **presentation and popularization of science** would be helpful in many respects; it would provide a **potent antidote to overspecialization**; it would **bring out clearly what is significant in current research**, and it would **make science a more integral part of the culture of today.**”*



# Critics

Not all of the public want to know and not everybody cares in advancing knowledge

some ignore

some are even against

Should we care ?

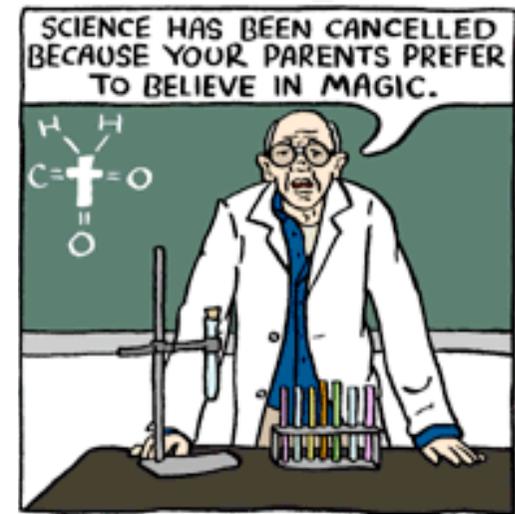
**Yes !**

**Science literacy of a society is as important as literacy itself**

We live in a modern world

A basic understanding of the tools and methods developed by a scientific approach that shape so much our daily life is indeed relevant

**If we fail, we risk an unbridgeable gap in society**



©Brian McFadden (2001-2009)



# Reaching out further

Education, Communication and Outreach

How to reach out to the ignorant ?

This is a **challenge** that cannot be addressed with exposing scientific tools and methods even stronger

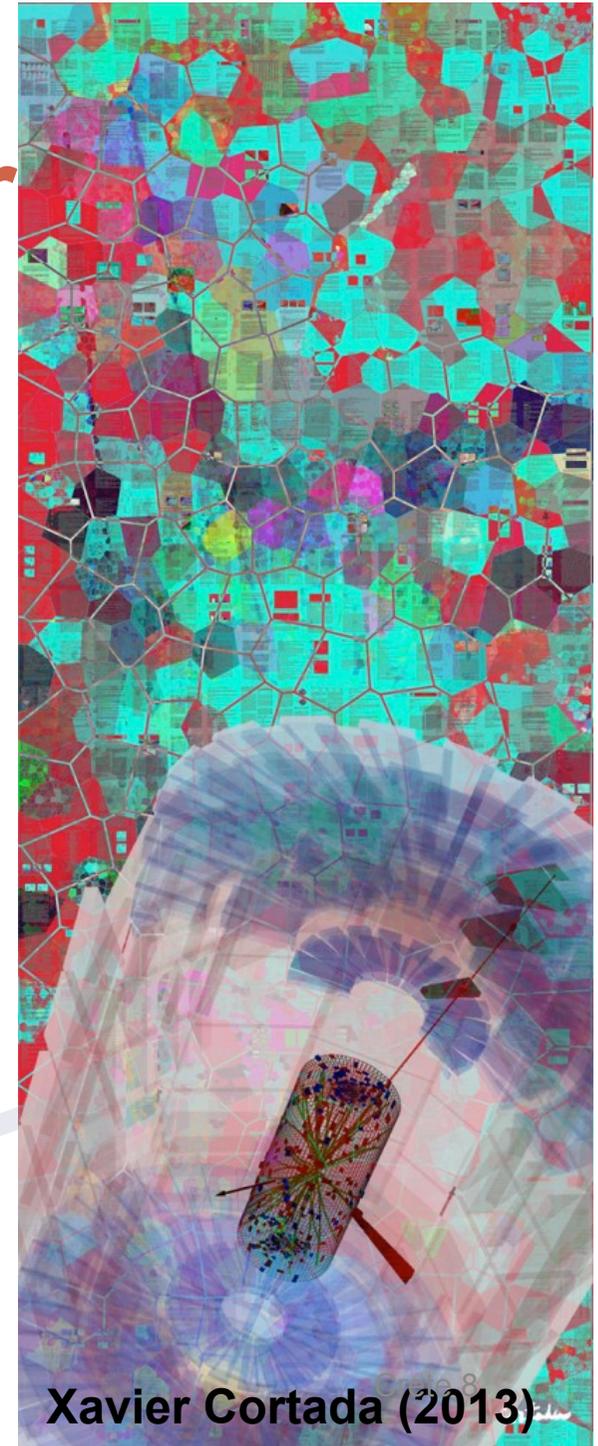
However, **different routes** can **share our enthusiasm** with a wider audience

**Art projects** involving science topics have a **big potential** to widen the audience

**to share excitement**

**to trigger reflections inside people's minds on the universe, on science, etc. that otherwise would never happen**

**And many (all?) of these art projects are even good and interesting for all of us to play, think, and wonder about!**



Xavier Cortada (2013)



# Things that need correcting

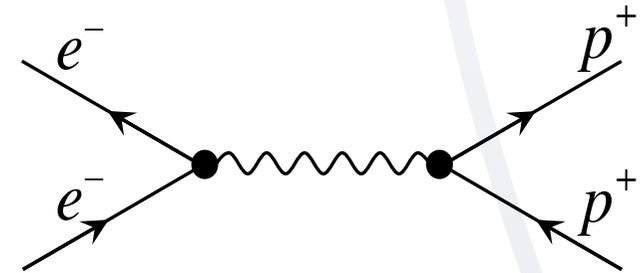
**prejudices and perceptions  
of the broad public  
that could come up**



# Things that need correcting

Physics is often perceived as the ‘**science of things**’ and therefore detached (i.e. irrelevant) from life, the universe and everything.

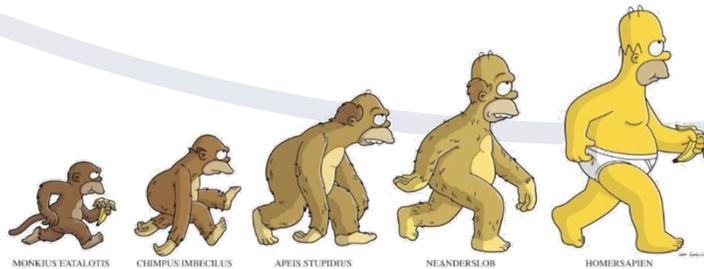
Don't be shy to state that (particle-) physics is the basic for all understanding of life, the universe and everything



Chemistry is based on physics  
quantum mechanics, (quantum-)electrodynamics

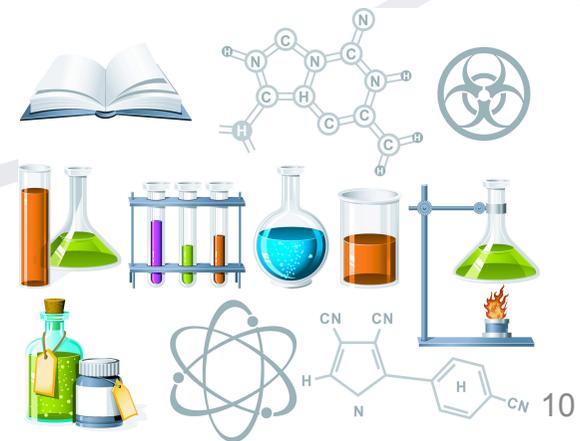
Biochemistry is based on chemistry

Life is based on biochemistry



Hans Peter Beck HOMERSAPIEN

ICNFP 2015





# Things that need correcting

Everything can be calculated and **there is no need for experiments** other than giving **toys for boys (and girls)**

Use the **chess analogy** to counter state  
Physics elaborates on **finding the rules**  
**on how the Universe works**

These rules are like the rules of  
the game chess

**Knowing the rules opens up to understand**  
**chess and play the game**

**However, an individual chess game is way open on how it can**  
**evolve.**

**Further, the rules we found have been validated only within a limited energy**  
**scale** (high energy frontier, low energy precision measurements), that we  
cannot rely on these rules beyond the limits these are validated.

**New physics, i.e. extending the rules we know, is possible and is a big**  
**driving force** in fundamental research.





# Things that need correcting

What is explained by science becomes dull and loses its mysteries, fascination and wonders.

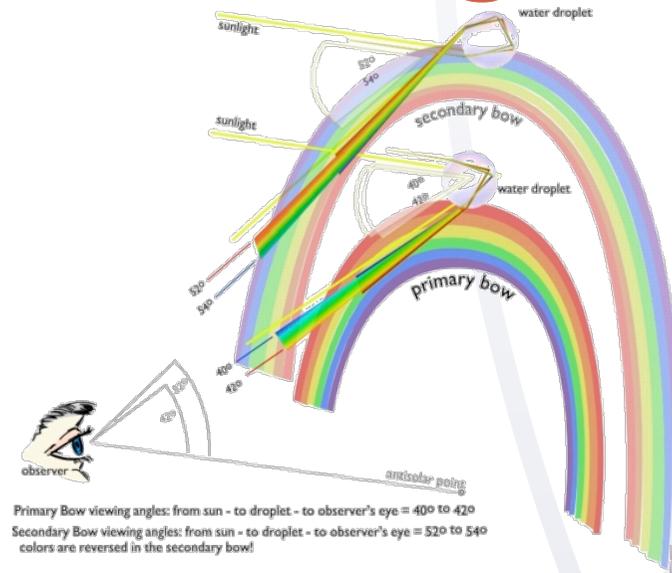
The contrary is true !

Use the **archeological site analogy**

If you don't know about the site you are visiting, all you see is a pile of old stones and perhaps some funny (maybe appealing) ornaments and scripture.

The more you know about the ancient culture, their habits and their lives, the more interesting the archeological site becomes.

**Physics opens up understanding nature**, and allows enjoy nature more and more.





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# Things that need correcting

New findings by particle physics experiments are so detached from real life and from real problems that these are of no concern anyhow and therefore of no use.

It's true that **knowing the Higgs existing and its mass doesn't change every days life.**

Knowing that there is a **Higgs mechanism** responsible for **mass of elementary particles**, and that **mass is fundamentally needed** for allowing **structure** to build up in the Universe, put's this knowledge on a different scale. **We simply wouldn't exist without it!**

All after all, **it's all about the Universe in the end being Intelligible and in a combined effort, we can learn how it works.**



# Things that need correcting

Established knowledge is only valid for a short moment in time and thrown over board immediately when new findings come in. As this happens iteratively, there will never be anything useful worth trusting. Science (and scientists) can't be trusted.

Although **bad examples do exist** e.g. in clinical studies based on too small or biased samples, **this is not true in general.**

The work and findings of e.g. Newton and many, many more, is still valid today; although **general relativity supersedes Newtonian mechanics**, we now know exactly how good Newtonian mechanics works and where the limits are.

**Empirical established knowledge will stay forever as part of human culture.**

**The existence of the Higgs boson will stay, but it's role in nature is still open for future refinements.**



# Good Metaphors Help

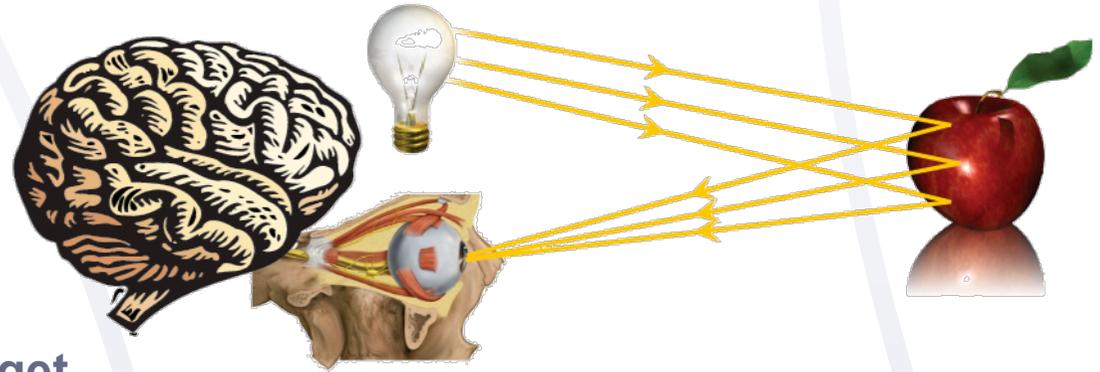
**When interacting with  
the interested audience  
and  
the critical minds**



# Humans are particle detectors too

The **act of 'seeing'** involves all elements of a modern particle physics experiment.

- **Accelerating particles**
  - You need a photon gun, i.e. a light bulb, a torch or simply the sun
- **Particles scattering of a target**
  - These photons have to scatter off an object being watched
- **Measuring scattered particles**
  - On your retina, photons within an energy range of 1.6-3.3 eV are measured and converted in electrical signals
- **Reconstruction and analysis**
  - Energy, momentum, and the rate (i.e. intensity) of photons is the information content transported to the visual cortex via the optic nerve for online pattern recognition and reconstruction.



→ we perceive an image of the target object in the brain with colour coding the energy of scattered photons.

**Colour is truly perceived pseudocolour.**



# A flat earth is not completely wrong

Imaging the world as being flat yields a reasonably good approximation of our local environment

- **No need to know the earth radius to build a house or a bridge across a river or a valley**



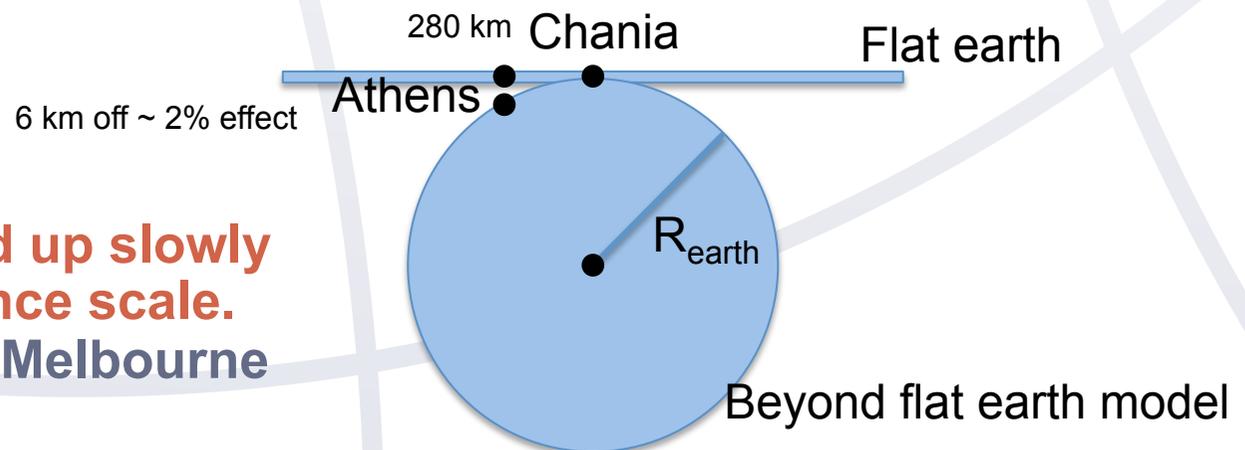


# Measuring the Standard Model at unprobed energy scales

Even a good and axiomatically well motivated mathematical model i.e. flat earth – or, if you want, the Standard Model, is only as good as it has been tested by experiment.

Predicting the coordinates in absolute space, given direction and distance, of Athens from Chania and assuming a flat earth is straight forward to do.

Traveling to Athens and carefully measuring via triangulation the true coordinates of Athens takes an effort and will lead to a sizeable discrepancy between theoretical prediction and measurement.



Discrepancy will build up slowly with increasing distance scale.

i.e. take New York, or Melbourne rather than Athens.



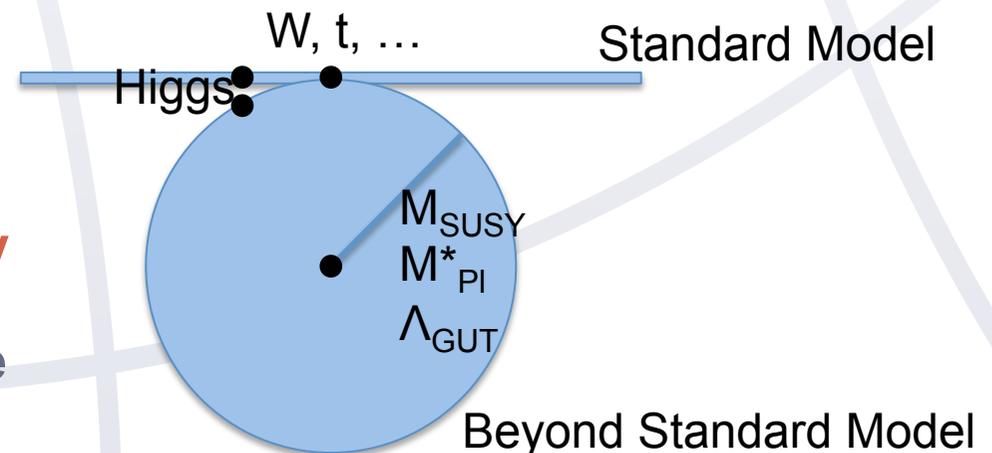
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# Measuring the Standard Model at unprobed energy scales

**Scales matter – even when a model is axiomatically well defined**

**Expanding the scale** at which a model is probed will either further strengthen the validity of the model or will tell when the model collapses and a new model will need to be found.

**It is exactly the deviation from the predicted value that tells how a better model can be constructed.**

**Old models embed in the new and better model describing the world and keep their validity within a limited but now well understood scope.**

**As discussed already with Newtonian mechanics and Einstein's general relativity.**

**Abandon Popper – a pure falsification paradigm leads to nowhere !**



# Measuring the Standard Model at unprobed energy scales

Why does it matter ?

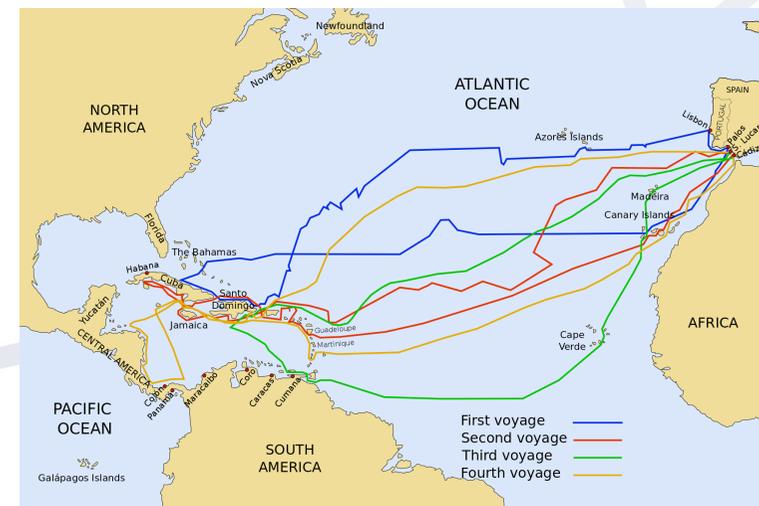
Again the **flat earth analogy** helps:

Knowing the earth is round doesn't help building a better house – your architect doesn't rely on knowing  $R_{\text{earth}}$  when drawing your new house.

Reaching out to India via going West, however, is adding new concrete possibilities.

You may detect further unknown territory while on your way.

We may be in a position to **understand Dark Matter** or even **Dark Energy** once we know how to **expand out of the Standard Model**.





**Having found the Higgs**

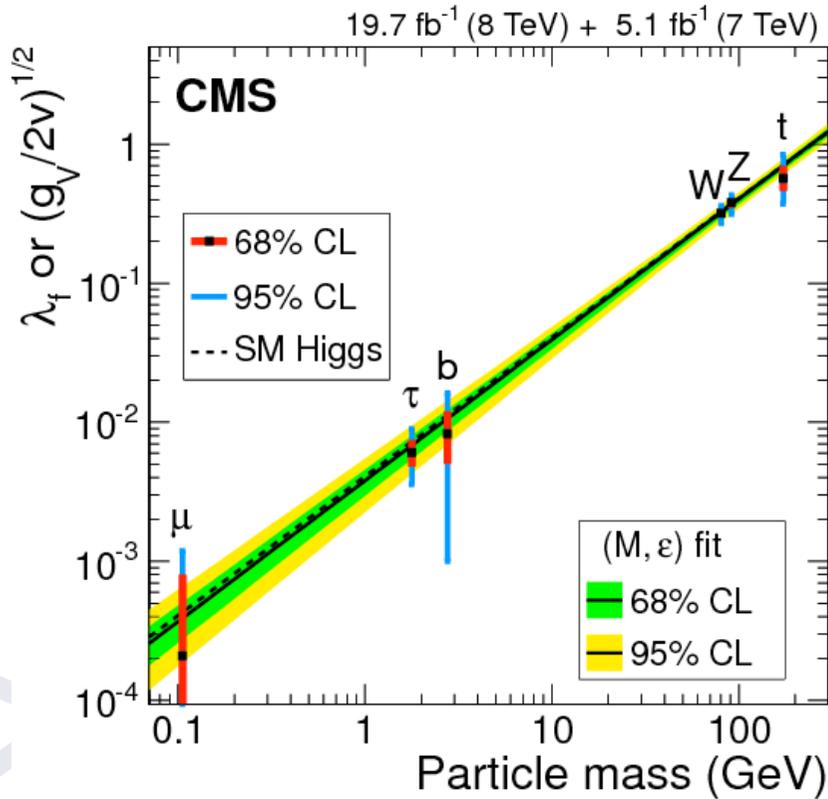
**The end of Particle Physics ?**

**or**

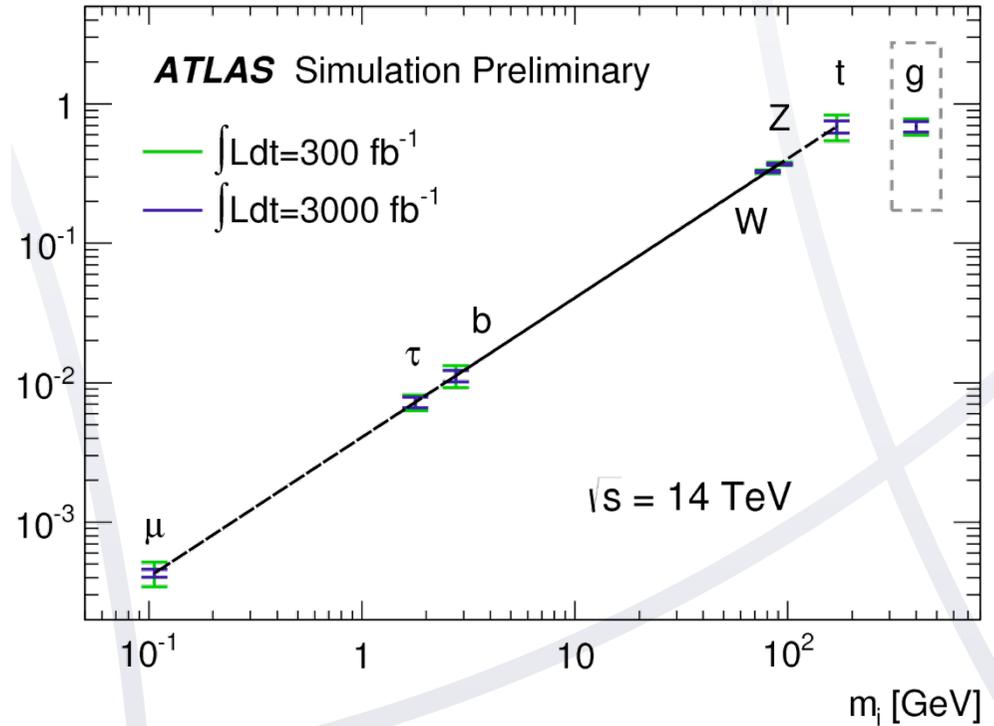
**The beginning of a New Scalar Era ?**



# What if only one SM like Higgs ?



Today



LHC potential with 3 ab<sup>-1</sup>



# Only one SM Higgs – what now ?

Tendency in public + funding agencies:  
now you have the Nobel + the Higgs - be happy + silent !

Needs a **LHC Run 2 communication strategy** and also paving the way for **future projects after LHC**

**FCC ?** (Geneva, China, ... ?)

**ILC ?**

Needs **support from the public**, a next generation of **young physicists**, and support from the **funding agencies**

**Higgs is the only elementary scalar particle** (as we know today), and marks the **beginning of a new scalar era**.

There are more scalar fields out there, which need exploring:

**Inflaton (?)**

**Cosmological constant ↔ Dark Energy (?)**

**Cosmological questions drive particle physics beyond Higgs !!**



**IPPOG**

# International Particle Physics Outreach Group

**an example for concerted and systematic  
effort for outreach**



# IPPOG

## The International Particle Physics Network

*IPPOG was **formed in 1997** under the joint auspices of the European Committee for Future Accelerators ([ECFA](#)) and the High Energy Particle Physics Board of the European Physical Society ([EPS-HEPP Board](#)). Initially IPPOG was called European Particle Physics Outreach Group (EPPOG) **which transformed to IPPOG in 2011**, to reflect its true international stature.*

Education & Outreach

HOME | ABOUT | MEMBERS | RESOURCES | MASTERCLASSES

### The International Particle Physics Outreach Group (IPPOG)

IPPOG is a network of scientists, science educators and communication specialists working across the globe in informal science education and outreach for particle physics. Particle physics is the science of matter, energy, space and time. IPPOG brings new discoveries in this exciting field to young people and conveys to the public that the beauty of nature is indeed becoming understandable from the interactions of its most fundamental parts - the elementary particles.

Current member come from the 21 member states of CERN, Ireland, Romania, South Africa, the USA, and from DESY, CERN and five of the major experiments at the Large Hadron Collider (LHC).

Marge Bardeen (FNAL) and Hans Peter Beck (University of Bern), co-chairs of IPPOG.

#### Latest Resources

- Hand-outs for...**  
to prepare secondary school children for Particle Physics Masterclasses  
0 comments
- Particle Physics:...**  
to teach secondary school children about research in particle physics  
0 comments
- The ATLAS-Detector**  
to inform secondary school children about the ATLAS Project  
0 comments

#### PhD TV: The Higgs Boson Explained

A clever animation explaining what the Higgs Boson is and how the LHC will find it (if it exists).

Film / Video, Book

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



# IPPOG – an International Network

31 members representing 26 countries + CERN, DESY, FNAL and 4 experiments

International network of physicists who commit a fraction of their time in education and outreach.

These are your local contacts in your country, laboratory, and experiment.

Get in contact with your representative when you need resources, advice, help, support, in your education and outreach activities.



New countries, laboratories, experiments engaged in all fields of particle physics are welcome to [http://ippog.web.cern.ch/ippog\\_membership](http://ippog.web.cern.ch/ippog_membership) strengthen IPPOG further.

IPPOG



# IPPOG'S PURPOSE

**Strengthening the sustainability, reproduction and growth of outreach activities in particle physics**

through the provision of reliable and regular discussion forums and information exchange for science institutions and laboratories as well as for individual scientists engaged in science outreach and informal science education world-wide

**Raising standards**

for outreach and informal science education initiatives by proposing and implementing strategies designed to share lessons learned and best practices for outreach in particle physics and related fields

**Providing explanatory materials**

for helping disseminate results from particle physics and related subjects.



# IPPOG an umbrella for making outreach global

CERN Courier June 2014

Education



High-school students from all geographical regions master real event-display programmes, software tools and analysis methods. Having been introduced to the problem, they identify electrons, muons, photons and jets by exploiting their characteristic signals in various detector elements, perform event selection and categorization, and achieve the final analysis goals. (Image credits, left to right: Caroline Hamilton/CoEPP/University of Melbourne, Jayne Ion/iON creative, Franziska Viebach/TU Dresden.)

IPPOG

## International Masterclasses in the LHC era

Each year in spring, the International Particle Physics Outreach Group organizes the International Masterclasses, which give students the opportunity to analyse data from the LHC.

The International Masterclasses (IMCs) began in 2005 as an ini-

ATLAS "discovery" data are available for students to study the Higgs boson, CMS approved 13 Higgs candidates in the data of interest, which are mixed with a more abundant sample of Z events, for "treasure hunt" activities; ALICE data are used to study the relative production of strange particles, via a tell-tale signal of quark-gluon plasma production; I studies how to measure the lifetime of the D meson, containing b and c quarks are studied extensively to solve the mystery of antimatter in the universe.

Students quickly master real event-display progra

## IPPOG Reaching out with particle physics

How do we communicate about the LHC as a discovery machine, following the Higgs boson of 2012? How do we take the particle-physics masterclasses to new countries, age groups and settings? What makes a good educational game? How do we join in the existing national cosmic-ray-detector programmes, to take them further? These were some of the questions addressed at the 9th meeting of the International Particle Physics Outreach Group (IPPOG), which took place in Paris on 16–18 April.



IPPOG's participants in Paris. (Image credit: Dominique Longieras/LAL-Orsay.)

**International Masterclasses,** the flagship activity of IPPOG trained over **10'000 students** in **Spring every year !**

**Over 200 institutions** in over **46 countries** participating.

CERN Courier June 2015

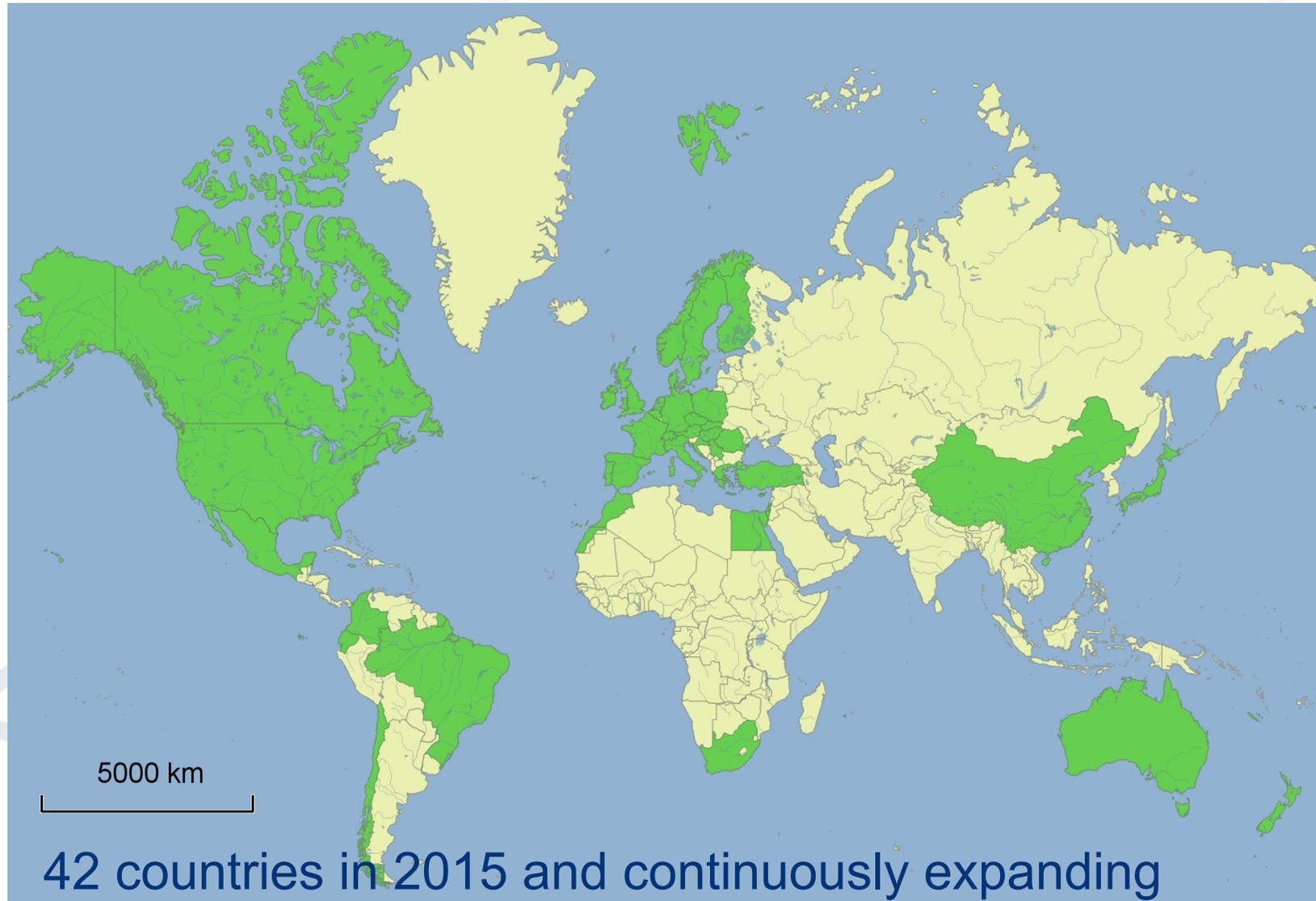
Faces & Places

**CERN Courier**  
**June 2014 edition**  
**&**  
**June 2015 edition**

common project or for an activity going on in only one country. Between the meetings, work continues and ideas are tested: do they work, for example, with real students and teachers? Other topics on the agenda of the recent meeting included discussions on how to boost the educational use of CERN open-access data, and how to bring science education and outreach to particle-physics conferences in a more effective way. There was also news on web resources, exhibits and programmes for teachers and students in the

the communication between researchers, teachers and participants goes on across a longer timescale, may become particularly important. At the other end of the spectrum are the "masterclasses in a box", which are based on printed images and foreseen for settings where no computers are available. There were also presentations on activities such as the most recent edition of the International Cosmic Day and the International Muon Week. These are crucial when the goal is to have more modern and

# Masterclasses: Worldwide spread





# IPPOG NEWSLETTER

SEPTEMBER 2015

Number 1



International Particle  
Physics Outreach Group

## A word from the coordination team



Dear IPPOGers!

We are very happy to share with you this first issue of the IPPOG newsletter, which will appear twice a year between IPPOG meetings. The aim of this new tradition is to keep IPPOG spirit alive also in between the meetings and maintain you informed about the most important happenings in our community, and thus to facilitate even closer collaboration of our team. This little periodical would also allow us to show to the interested external eyes what IPPOG is and does.

After a very interactive and productive spring meeting in Paris <https://indico.cern.ch/event/354555/> IPPOG is now ready to take several new actions and continue its mission with full power and new sources! The future of IPPOG is very promising and a lot of upcoming initiatives are in the pipeline!

We hope you enjoy this first number of IPPOG newsletter and looking forward to see you at the next meeting in autumn at CERN.

*Hans Peter, Marge and Barbara*

**‘Universe of Particles : Explore, Discover, Understand, be Inspired!’**  
 International network of scientists, science educators and explainers engaged in informal science and education and outreach for particle physics across the globe.  
**Vision for the future:**  
 Understanding and enthusiastic support of particle physics and related sciences from all audiences.

IPPOG's current members come from CERN's 21 member states, plus Ireland, Romania, South Africa and USA, prominent laboratories and institutions in Europe and USA and 5 major experiments of LHC. Since 2013 the co-chairs of IPPOG are Marge Bardeen and Hans Peter Beck.

*"The discovery of Higgs boson is not the end of the story... it is just the beginning of a new era... The scalar era!"*  
- IPPOG on LHC as a discovery machine

**"Higgs-what now?"**  
IPPOG feels the need for LHC Run 2 communication strategy especially in the context of the future of fundamental research in particle physics and non-scientific audience acceptance.  
"How to prepare/approach the discoveries beyond the Standard Model?"

*"The nature of dark matter cannot be explained without the LHC upgrade..."*  
- IPPOG on LHC as a discovery machine

## IN THIS ISSUE

★ **IPPOG worldwide**

- EPS outreach prize
- Article about IPPOG in CERN Courier
- IPPOG at conferences
- IPPOG outreach session at EPS

**IPPOG internas**

- IPPOG on the way towards official collaboration
- New support in IPPOG coordination team
- 10th IPPOG meeting at CERN

**IPPOG activities**

- Masterclasses 2015 and 2016
- Cosmic rays becoming global



# Outreach

The general public needs and wants to be informed

Some (i.e. many!) of the wide public want to know more and in better detail !

Communicators and science journalists can help, but only that far

There is a risk of HEP communication being perceived as a PR machine if not based on a solid wealth of information accessible to all who want to learn more.

Here, physicists have a duty

It's a deep obligation to participate in a dialogue with society



# Outreach

**The general public needs and wants to be informed**

**Physicists** are in charge of explaining **more accurately** and in **bigger detail** what the communicators did communicate in headlines and press releases

**Obviously a complex task**

but **the public got hungry** and now needs to be fed with more accurate information

**concepts, tools** and **methods** **need to be made understandable** to all those who want to know more

**needs a bit more time** with the audience to engage

Many are willing to listen, to learn and are asking questions

**As a direct reward, when engaging with the public, you will immediately feel their excitement**



# Recommendations

## **If you are a young physicist**

engage a small fraction of your time in EC&O activities

## **If you are a group leader**

engage a small fraction of your time in in EC&O activities

support your group members who are active in EC&O

(not all will be active and not all do need to be active in EC&O)

## **If you are hiring a new postdoc or faculty member**

make sure the person you will hire has good communication skills

in case this person has a track record in EC&O activities, even better!



**Thank you for your attention**

**Get in contact your IPPOG delegate  
in your country**

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

**for all about outreach**



# The European strategy update – 2013

CERN-Council-S/106

What the European Strategy for Particle Physics says on the

## Wider impact of particle physics

n) Sharing the excitement of scientific discoveries with the public is part of our duty as researchers. Many groups work enthusiastically in public engagement.

They are assisted by a network of communication professionals (EPPCN) and an **international outreach group (IPPOG)**.

For example, they helped attract tremendous public attention and interest around the world at the start of the LHC and the discovery of the Higgs boson.

*Outreach and communication in particle physics should receive adequate funding and be recognised as a central component of the scientific activity.*

*EPPCN and IPPOG should both report regularly to the Council.*