



## International Particle Physics Outreach Group

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# WG on Explaining Particle Physics to Lay Audience

(Report from WG meeting 6 May 2022)

<https://indico.cern.ch/event/1155233/>

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# How to explain the need for a new $e^+e^-$ collider to the public

## WG on Explaining PP to Lay audience

Friday 6 May 2022, 10:00 → 11:00 Europe/Zurich

Description ZOOM link:

<https://cern.zoom.us/j/2117103259?pwd=RVNGVURZbUx0YzRKNHFuREEWQWRSQT09>

Meeting ID: 211 710 3259

Passcode: 794131

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10:00 → 10:15 **Welcome by conveners**

🕒 15m

**Speakers:** Barbora Bruant Gulejova (Universitaet Bern (CH)), Thomas Naumann (Deutsches Elektronen-Synchrotron (DE))

FCC\_ElevatorPitch... Higgs and the scala... IPPOG\_WG\_Explaini... IPPOG\_WG\_Explaini... What if only Higgs?

10:15 → 11:00 **Discussion: How to explain the need of new  $e^+e^-$  colliders to society?**

🕒 45m

We aim to:

- draft a text explaining the need for new  $e^+e^-$  colliders to the public
- revisit the IPPOG Wisdom collection structure draft document ([https://docs.google.com/document/d/1XG\\_QaKNUJKnL9qOYbPixrgoNMsw40jygu5cjHJCPURQ/edit](https://docs.google.com/document/d/1XG_QaKNUJKnL9qOYbPixrgoNMsw40jygu5cjHJCPURQ/edit))
- find useful resources for the planned publication on explaining the need of new machines

**Speaker:** WG members

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# Action plan

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- ❑ Write short popular document for the public, lay persons and decision makers
- ❑ List of:
  - open physics questions
  - how future machines could answer them
  - potential of discoveries
- ❑ Starting point: Text from Thomas (Scalar era)
- ❑ Implemented Albertos, Jonivars, Ivans comments
- ❑ Simple language (detailed discussions Thomas & Barbora)

# Work in progress

## Physics in the Scalar Era

Physics for 500 years deals with forces. Forces or interactions like electromagnetism are represented by **vector fields** pointing from one point to another. Vectors are described by three coordinates at each point in space and time.

**Scalar fields** are much simpler. They represent just one number per space point. As can be seen from the figures, weather forecasts, for example, contain the scalar fields of temperature, humidity, and pressure. They are not fundamental, however, since they emerge from averaging over the microscopic properties of the air molecules. Wind maps contain vectors and are not fundamental either.

For the first time in the history of physics we go from studying fundamental vector fields of interactions to fundamental **scalar fields** which do not mediate interactions and do not have a source. They are omnipresent background fields which fill up the vacuum in the Universe. Such fundamental **scalar fields** are

- the **Higgs field**. It was predicted by Peter Higgs and Francois Englert in 1964 which earned them the Nobel prize in 2013. This field completes the standard model of particle physics and gives masses to the fundamental particles. This happened less than a billionth of a second after the Big Bang. The famous Higgs boson discovered at CERN in 2012 is an excitation of this field.
- the **hypothetical Inflation field** which is believed to have caused the accelerated expansion at the very beginning of the Big Bang. We **have to** understand what triggered the Big Bang and how its subsequent huge inflation happened.
- the **Dark Energy** or cosmological constant. This is also a mysterious new field which dominates the energy content of the Universe and causes its accelerated expansion and ultimate **fate**.

Some physicists argue that all these scalar fields are somehow connected with each other. That is why the understanding of the nature of the Higgs field and of scalar fields in general is crucial to understand the past, present and future of the Universe. This is one of the most burning questions of fundamental science in the 21st century.

Concerning the Higgs **particle** the most important open questions are:

- The **strengths** of all fundamental interactions do not depend on the interacting particles. However, the strengths of the interactions of the Higgs field with the fundamental particles vary proportional to the masses of the particles.  
**In order to understand how the Higgs mechanism works** and generates these masses we have to **test this relation as precisely** and for as many different particle masses as possible!
- Check whether the Higgs particle is an elementary fundamental or a **composite** particle
- Check whether there are **more types of Higgs bosons** (charged etc.) as predicted by extensions of the standard model!
- **In order to understand the Higgs field and its potential role in the early Universe, measure the Interactions between the Higgs bosons!**
- Check the **stability of the Higgs field** and hence of our Universe by measuring the masses of the Higgs boson and of the top quark as precisely as possible.
- **Extensions** of the standard model explain the observed low mass of the Higgs boson which is not predicted by the standard model of particle physics and propose its interactions with the mysterious dark matter dominating our Universe. Such extensions need to be investigated.

The best device to investigate all these important open questions is a new powerful electron-positron collider. Serving as a **Higgs factory**, it will produce a huge amount of Higgs bosons under very clean experimental conditions. A circular collider can later be extended to a proton-proton collider providing much higher energies and opening the window for discoveries beyond the standard model.



# Explain the need for a new $e^+e^-$ collider to the public

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- **Explain** the outstanding physics issues to the general public, lay persons and decision makers
- **Cosmic connection:**  
Macrocosm: Dark energy, Dark matter  
Microcosm: scalar fields, BSM, neutrinos, ...
- What is the role of **scalar fields** in the Universe?

**Higgs discovery in 2012 is not the end of particle physics.  
It is the beginning of a new era of physics – the scalar era!**

- Continue to investigate the SM with focus on the Higgs.
- How can new  **$e^+e^-$  colliders** (circular and linear) address this?
- Higgs **factory**: precision + statistics vs energy

# IPPOG's input is welcome

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<https://docs.google.com/document/d/19VcUDd1we-PIKVG0A9pdQZVgvfZwT7ya83vVnnWGt0s/edit>

**Please, comment!**