

From the LHC to the Future

- theoretical perspective

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Initial title

≈ Particle Physics:

The next 50 years!

This is a day to start celebrating the recent decision expressed in the

European Strategy for Particle Physics

which will contribute to keep the European leadership in

Particle Physics in the next decades.

In my talk, I will often refer to "Our Group". This means

Group of Particle Physicists working
in Portugal

(GPPWP)

Our Group \equiv GPPWP

- Why do we need to have a Higgs factory and the FCC with at least 100 TeV?

- The Standard Model (SM) is one of the greatest scientific achievements of the XX century. But it cannot be the final theory: Many fundamental questions are left open.

Some of the Fundamental questions

- The Flavour Problem:

How to understand the replication of Families and the pattern of quarks and lepton masses and mixing

- How to generate the Baryon Asymmetry of the Universe (BAU)

Extra sources of CP violations are needed!!

- How to solve the Strong CP problem?
Is there a credible alternative to the **Pecci-Quinn proposal**?
- What are the couplings of the **Higgs particle** to elementary fermions?

$H \bar{e} e$,	$H \bar{\mu} \mu$,	$H \bar{\tau} \tau$	$H \bar{\nu}_\tau \tau$?
$H \bar{d} d$,	$H \bar{s} s$,	$H \bar{b} b$	$H \bar{\nu}_e e$	
$H \bar{u} u$,	$H \bar{c} c$,	$H \bar{t} t$	$H \bar{\nu}_\mu \mu$	
			$H \bar{\nu}_\tau \tau$	

Higgs factory is needed!!!

- Are there more Higgs?
eg. $2 + n$ doublets $n = 0, 1, \dots$
- What is the origin of CP violation
explicit or spontaneous?
- What is Dark Matter?
- **Neutrino Masses:**
- The first clear evidence of Beyond the Standard Model (BSM) Physics
It is easy to construct extensions of the SM where neutrino masses are generated

- Seesaw mechanism to generate naturally small neutrino masses? If so what is the scale of M_R ? Can ν_R be discovered at FCC?

- **Leptogenesis?**

- What about SUSY?

The search should continue, but it may happen that **Nature** does not choose SUSY, at least at low energies!

- Vector-like fermions?
Very simple extension of the SM.
 ν_{LQ} are "cousins" of ν_R
etc. etc. Nature likes simplicity

The groups of physicists working in Portugal have worked with great success (eg. high impact in the literature) in most of the open questions listed above.

About the Flavour Problem,
let us recall a Poem by Feynman:

Do you want to be famous?

Do you want to be a King?

Do you want more than a Nobel Prize?

Then, solve the Mass Problem!

Question: Are we going to get
some progress on this Problem in
the next 50 years?

As you know, I have only mentioned
OWL Group and not individual
names. I will now make an exception
and mention two young colleagues
from CFTP who have done exceptional
work on Flavour:

Ivo Varzielas and João Penedo

Let us go back to the initial title:

Particle Physics: the next 50 years

Can one make some educated guesses?

Let us ask ourselves the following

related question: If 50 years ago

(in 1970) we had asked the same question to the most prominent physicists at the time, what answer would ^{we} have received?

It is instructive to look at the proceedings

of ICHEP 1968, a most extraordinary Conference

In ICHEP 1968, among the participants there were 20 physicists who had already received or received later the Nobel Prize!

If you look at the Proceedings you find out that at the time "nobody" was working in unified gauge theories!!

Question: How many Portuguese physicists attended ICHEP 1968?

Answer: 0 !!

How did we get a copy of the Proceedings?

Gui's discovery at CERN!!

Conclusion

It was not easy in 1970 to guess what the next 50 years would bring to Particle Physics.

Today, it is not different: it is not possible to predict what the next 50 years will bring to Particle Physics. But this is the most exciting feature of our field of research!

Message to young people

From a scientific point of view, Portugal is today a very different country, compared to what it was in 1970

Today, if you to pursue a research career in Particle Physics you will find many competent researchers/Professors able to supervise your research work at the highest level.