Overview: Where Do We Stand?

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SCALARS 2011

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Warsaw, Poland

Maria Skłodowska-Curie Year: special event on Aug 25

Topics:

- *Standard Model Higgs boson*
- *multi-Higgs models*
- *scalars in supersymmetry*
- *scalars for neutrino masses*
- *scalars in extra dimensions*
- *gauge-Higgs unification*
- *extra dimensions*
- *composite Higgs bosons*
- *scalars and unparticles*
- *scalars in cosmology*
- *experimental search for scalars*

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Two centuries.
Good beginning

The Nobel Prize in Physics 2013

Photo: A. Mahmoud

François Englert

Prize share: 1/2

Photo: A. Mahmoud

Peter W. Higgs

Prize share: 1/2

The Nobel Prize in Physics 2013 was awarded jointly to François Englert and Peter W. Higgs *"for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles, and which recently was confirmed through the discovery of the predicted fundamental particle, by the ATLAS and CMS experiments at CERN's Large Hadron Collider"*

Five years later, no further discoveries at the LHC.

Reasons to expect "Beyond the Standard Model" physics.

- The hierarchy problem
- Dark matter
- Baryon asymmetry
- Neutrino masses
- Strong CP problem
- Quantum gravity

This list has not fundamentally changed since 1st Scalars Conference in 2011.

However, there have been significant developments in almost all these areas.

The hierarchy problem

In 2011, we thought the hierarchy problem implied new physics at the TeV scale. The anthropic loophole was known, but not taken as seriously as it is now. Collider unfriendly scenarios, like Twin Higgs, were not well studied.

Since then, many new models of "neutral naturalness". The characteristic collider signals of this framework are now much better understood.

In the last few years, the hierarchy problem has been completely rethought!

The relaxion, in particular, offers a completely new approach to the hierarchy problem, as does Nnaturalness.

Overall, our field is less focused on the hierarchy problem than a decade ago.

Dark Matter

In 2011, most attention was still focused on the WIMP and Asymmetric Dark Matter frameworks. Since then, however,

- Self-interacting dark matter
- Boosted dark matter
- Dynamical dark matter.
- Double disc dark matter.
- Cannibal dark matter.
- Self-destructive dark matter.
- . . . . . .

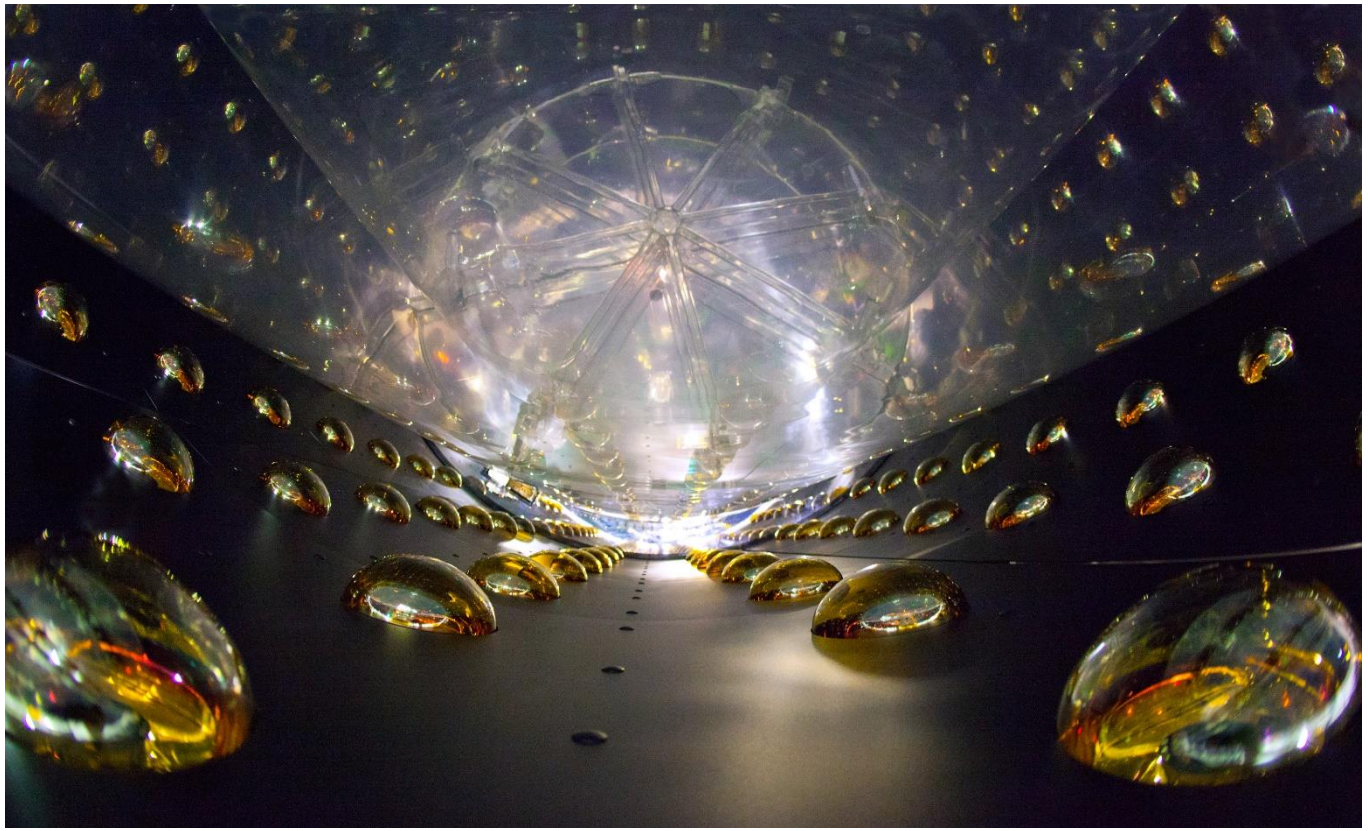
Seemingly independently, direct detection is being completely rethought.

In addition to noble gases and ionization in semiconductors, experiments based on scintillators, graphene, superconductors and superfluids have been proposed to search for light dark matter candidates.

A couple of interesting anomalies in indirect detection.

Neutrino Physics

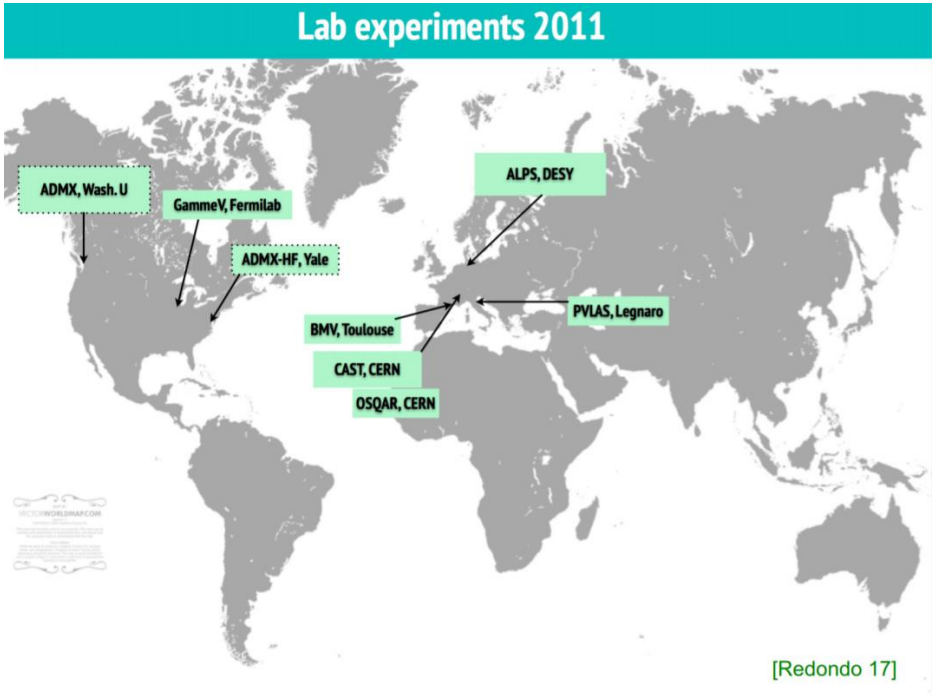
Measurement of θ_{13} at Daya Bay in 2012. All neutrino mixing angles known.

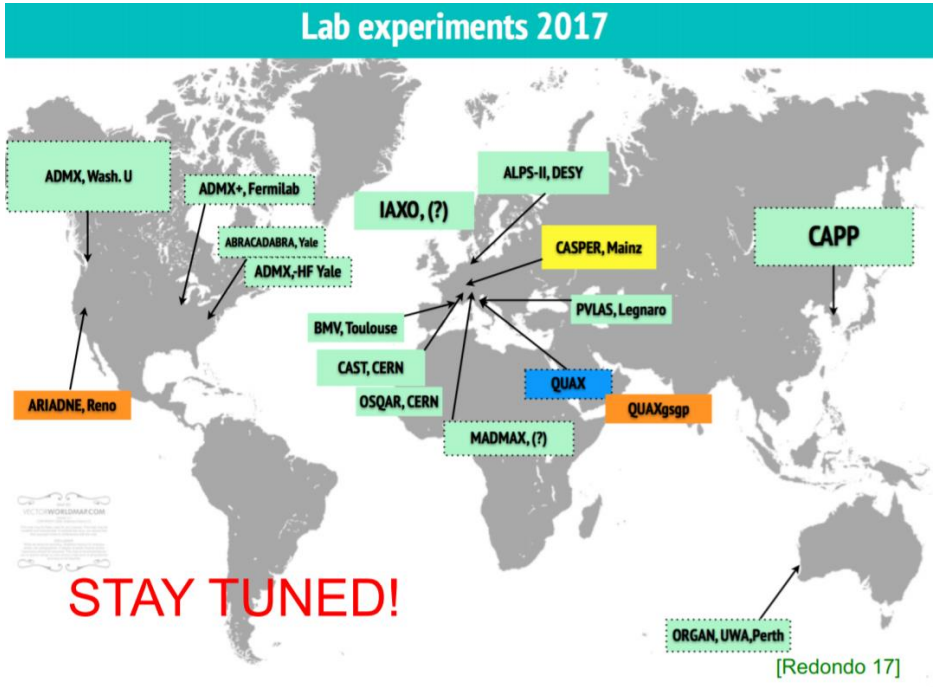


The Strong CP Problem

Since 2011 we have learnt that the QCD axion can (naturally) have a far greater range of masses and decay constants than was previously thought.

A far greater number of experiments are now involved in searches for axions. These experiments use different techniques and are sensitive in different mass ranges.





from Andreas Ringwald's talk

In spite of all this progress, there are reasons to worry.

In the absence of a major discovery in the next decade (or the financial commitment to a new collider), it is difficult to see a path forward for our field. Where could such a discovery come from?

Apart from the Higgs, there have been no new particles discovered at the LHC. Although there may still be discoveries, the low-hanging fruit is mostly gone.

The next generation of direct detection experiments will begin to run up against neutrino floor. Indirect detection plagued by unknown backgrounds.

The axion experiments, and the novel low mass direct detection experiments look promising, as does the MATHUSLA long-lived particle detector.

The precision in cosmological measurements keeps advancing at a rapid clip. Future experiments will measure the sum of neutrino masses, and may have something to say about hidden sectors, and the nature of dark matter.

Thanks to the organizers for a wonderful conference!