



Strategy for Neutrino physics

Introduction for discussion

EUROPEAN PARTICLE PHYSICS STRATEGY UPDATE

UK COMMUNITY MEETING: FROM OPEN SYMPOSIUM TO DRAFTING SESSION

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Neutrinos

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Phenomenology questions for the future

1. What is the nature of neutrinos?
 2. What are the values of the masses? Absolute scale and the ordering.
 3. Is there CP-violation?
 4. What are the precise values of mixing angles?
 5. Is the standard picture correct? Are there NSI? Sterile neutrinos? Non-unitarity? Other effects?
- Very exciting experimental programme now and for the future.**

2013 Strategy

f) *Rapid progress in neutrino oscillation physics, with significant European involvement, has established a strong scientific case for a long-baseline neutrino programme exploring CP violation and the mass hierarchy in the neutrino sector. CERN should develop a neutrino programme to pave the way for a substantial European role in future long-baseline experiments. **Europe should explore the possibility of major participation in leading longbaseline neutrino projects in the US and Japan.***

j) *A range of important non-accelerator experiments take place at the overlap of particle and astroparticle physics, such as searches for proton decay, neutrinoless double beta decay and dark matter, and the study of high energy cosmic-rays. These experiments address fundamental questions beyond the Standard Model of particle physics. The exchange of information between CERN and ApPEC has progressed since 2006. In the coming years, **CERN should seek a closer collaboration with ApPEC on detector R&D** with a view to maintaining the community's capability for unique projects in this field.*

Reminder: UK input (December)

Long-baseline Neutrino Physics

Recommendation:

*The European particle physics community should continue to **support the engagement of European physicists in the worldwide neutrino programme**. Furthermore, we recommend that CERN continues to support the neutrino programme, both in terms of worldwide participation and through the neutrino platform facility at CERN.*

Neutrinoless Double-Beta Decay Physics

Recommendation:

*We recommend that the European Strategy includes the **further development of an overall programme of $0\nu\beta\beta$ experiments**. Such a programme should include at least one major experiment at a European underground laboratory and major involvement in other international projects. The programme should also include R&D for technologies that have the potential to eventually lead to a practical experiment capable of exploring the non-degenerate normal neutrino mass hierarchy.*

Reminder: UK input (December)

Underground laboratories

Recommendation:

*Europe possesses a number of underground laboratories, such as the Boulby underground laboratory in the UK, with important capabilities for DM and neutrinoless double-beta decay experiments. **We recommend that these laboratories be well supported** to benefit this type of experiment.*

Granada meeting

Neutrino oscillations

- Vibrant programme.
- Neutrino experiments need cutting edge detectors and %-precision on the flux and cross sections.
- Long term future for high-precision LBL measurements – time to prepare for it!

Understanding the neutrino mass

- The absolute mass is still unknown. Laboratory and cosmology missions ongoing.
- Is the neutrino a Dirac or Majorana fermion?
 - Mentioned LEGEND, not SuperNEMO / SNO+
- Neutrino mass might require new neutral fermions with masses between eV and GUT scale
 - Clarify eV scale anomalies
 - CERN could have a leading role for the search of new states at the GeV-EW scale (beam dump and colliders)

Comments from the community

- Ensure the LBL experiments fulfil their potential. Europe should build on this position of leadership and plan for the long-term future of high-precision LBL physics.
- Neutrino platform - strongly supported, should continue.
- Establish a systematic cross-section measurement programme:
 - NA61, new facilities such as nuSTORM
 - Nuclear physics theory to be integrated into generators - active engagement with nuclear physicists (CERN yellow report).
 - Theory support for neutrino – nucleus cross section
- Neutrinoless double-beta decay:
 - Covered by APPEC (more unified definition of astroparticle physics).
 - Theory support for nuclear matrix elements for $0\nu\beta\beta$.
- A broader programme (solar, reactor) to test oscillation physics in detail.
- SHiP motivation appears relatively weak, could jeopardise other project in CERN North area.
- Theory: Information found needs to be used to find a guiding principle and explore models.

Questions

Anything to add?

- How should the long-baseline programme be supported?
 - *Theory*
 - *Neutrino platform*
 - *Detector development*
 - *Cross section measurements*
- How should the neutrinoless double-beta decay programme be supported?
 - *Theory*
 - *Detector development*
 - *APPEC*
- How should other aspects be supported?
 - *Solar, reactor*
 - *SHiP*
 - *Wider strategy*