



Accelerator-based neutrino experiments

Towards a coherent proposal by the
neutrino community?

European Strategy for
Neutrino Oscillation Physics - II

http://indico.cern.ch/event/neutrino_town

A. Blondel Neutrino Town Meeting 14-05-2012

CERN, MAY 14-16 2012

NEUTRINO TOWN MEETING

[HTTP://INDICO.CERN.CH/EVENT/NEUTRINO_TOWN](http://indico.cern.ch/event/neutrino_town)



Program Committee

Sergio Bertolucci
Alain Blondel
Anselmo Cervera
Andrea Donini
Marçõs Dracõs
Dominique Duchesneau
Fanny Dufour
Rob Edgecock
Ilias Efthymiopoulos
Edda Gschwendtner
Yury Kudenko
Ken Long
Jukka Maalampi
Mauro Mezzetto
Silvia Pascoli
Vittorio Palladino
Ewa Rondiõ
André Rubbia
Carlo Rubbia
Achim Stahl
Jenny Thomas
David Wark
Elena Wildner
Marco Zito

Local organizing committee

Sergio Bertolucci
Alain Blondel (Chair)
Dominique Duchesneau
Fanny Dufour
Ilias Efthymiopoulos
Edda Gschwendtner
Patricia Mage
Federico Petrolò
Ewa Rondiò
André Rubbia
Elena Wildner





In 2006 the European Strategy for Particle Physics recommended:

"4. [...] it is vital to strengthen the advanced accelerator R&D programme; a coordinated programme should be intensified, to develop the CLIC technology and high performance magnets for future accelerators, and to play a significant role in the study and development of a high-intensity neutrino facility.

*6. Studies of the scientific case for future neutrino facilities and the R&D into associated technologies are required to be in a position to define the optimal neutrino programme based on the information available in around **2012**; Council will play an active role in promoting a coordinated European participation in a global neutrino programme.*

We are in 2012 - What do we know, and what do we propose?

If we do not have a COHERENT answer to this question...

is it predictable that NOTHING will happen in Europe in the next decade

- Scientific case
- Status of neutrino technologies
- A Neutrino programme



Massive neutrinos: THE NEW PHYSICS there is

Since neutrino oscillations have been demonstrated in 1998 ...

- SuperKamiokande atmospheric neutrinos 8σ

Neutrino masses constitute a new question which has **no unique answer in the Standard Model**

- while all other charged fermions receive 'Dirac' masses neutrinos are neutral and could *also* receive 'Majorana' masses which allow a transition between neutrinos and antineutrinos
i.e. matter and anti-matter

As a consequence, massive neutrinos could **quite naturally** have 'sterile' brothers ... and contribute to the solution of several well known observations

- baryon asymmetry of the universe
- dark matter
- ($N_{\nu}^{\text{eff}} \approx 4$ instead of 3) the apparent need for an additional degree of freedom in the early universe (CMB)

which have no explanation within the Standard Model.



1998

Atmospheric neutrinos

$$|\Delta m_{32}^2| = |m_3^2 - m_2^2|, \theta_{23}$$

2002

Solar neutrinos (SNO) reactor (KAMLAND)

$$\Delta m_{21}^2 = m_2^2 - m_1^2, \theta_{12}$$

2011-12

Accelerator (T2K (06/2011, MINOS 07/2011) and reactors (Dchooz 12/2011, DayaBay 03/2012, Reno 04/2012)

$$\theta_{13}$$

NOW

Do neutrinos follow the same *mass hierarchy* as all other fermions?

$$\text{sign}(\Delta m_{32}^2)$$

Do ν 's and $\bar{\nu}$'s oscillate the same? (CP violation)

$$\delta_{CP}$$

Do neutrinos have a Majorana mass term?

$$\beta\beta 0\nu > 0$$

Do sterile neutrinos exist?

Precision measts of all the above,

What are their masses? (anywhere from $\leq \sim eV$ to $\sim 10^{19} eV$!)

new oscillations or new neutral objects that interact only with gravity. except for small mixing with active ν 's

Depth =
exoticity
or
perhaps
time





$\sin^2 2\theta_{13} \sim 0.097 \pm 0.012$ is no longer 'unknown' and is LARGE

Next: **sensitivity to Mass Hierarchy (MH)**
 CP Violation (CPV)

This is a turning point for which we have been preparing since 1998

ECFA study groups,

BENE in CARE, (2004-2008)

NEU2012 in EUCARD, (2009-2013)

Beta-beam in EURISOL, (2005-2009)

superbeam, beta beam and neutrino factory in EURONU (2008-2012)


LAGUNA (detectors for astroparticle physics and beam experiments) (2008-2010)

LAGUNA-LBNO (focuses on beam experiments from CERN) (2011-2014)

HOW DO WE GO ABOUT IT ?

GLOBAL or EUROPEAN?

Small steps or a big step?



Neutrino Studies in Europe :
EUROnu, IDS-NF, Neutrino R&D experiments

Present neutrino beam: CNGS 500kW 730 km
-- the most 'super' of today's superbeams

Future neutrino beams

- EUROnu Superbeam: 4MW, to Fréjus**
Betabeam design and R&D experiments
Neutrino Factory design study
- R&D experiments: MERIT, MICE, EMMA, β beam...**

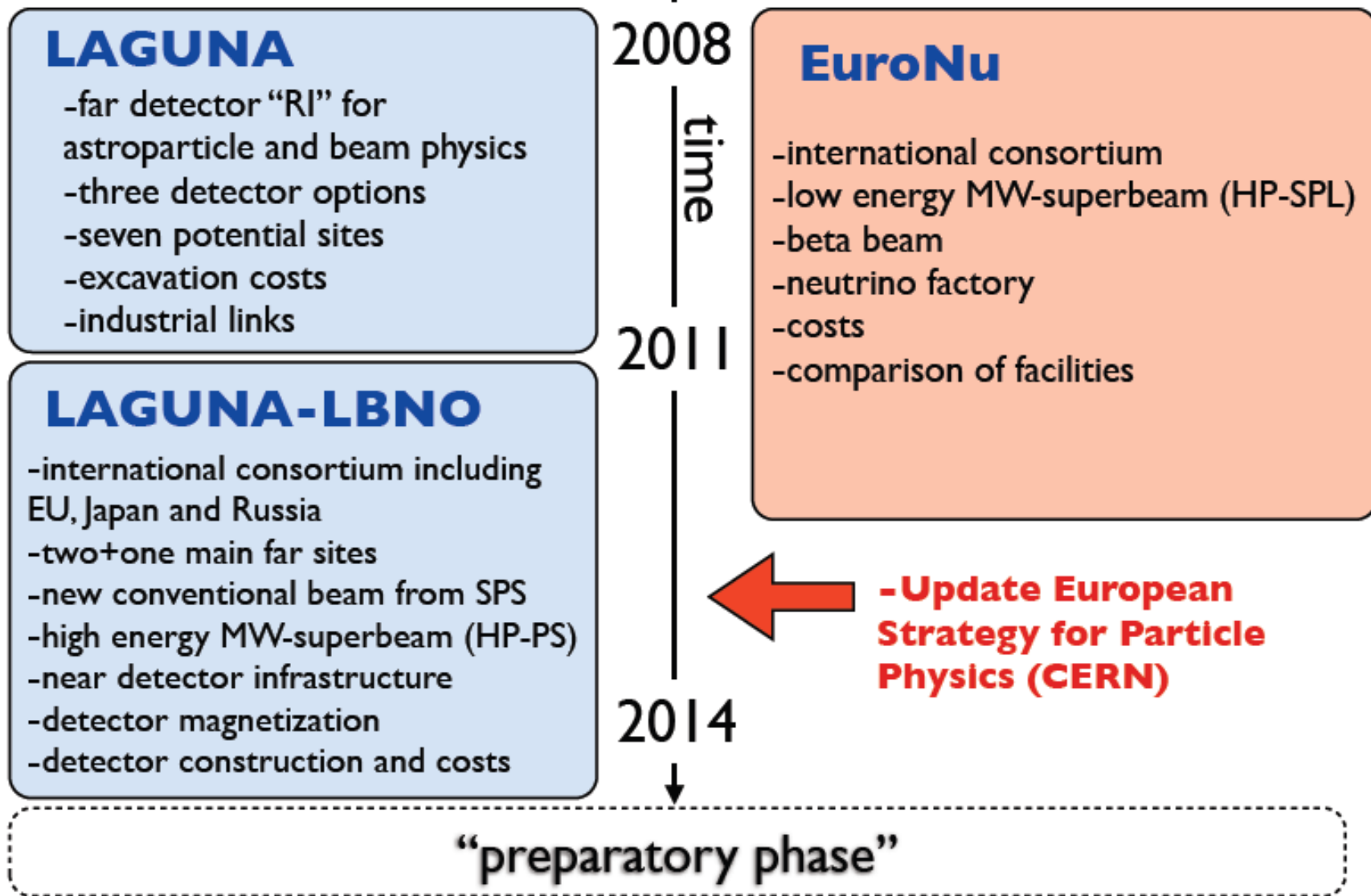
Neutrino detectors and underground labs:

- LAGUNA, LAGUNA-LBNO**

A coherent approach with a feasible first step?

- CN2PY**

The EU design study “menu”





From the invitation letter:

1. The European strategy process will consider the long term view, but will give guidelines for the next 5-6 years.
Neutrino oscillation physicists should come up with a vision in European neutrino oscillations physics that encompasses a concrete short term plan.
Are we in a position to propose such a vision and such a plan?
Can it lead to a realistic facility with top level objectives, yet broad use and long term possibilities of development?
- 2, CERN is the established world leader in the high energy investigation.
Europeans have unique strengths to offer in neutrino oscillation physics and the physics is important enough to be addressed in different ways and places.
In this context there should be space for a meaningful accelerator-based neutrino program in Europe.
Do we have something realistic to propose that would allow a practical realization?

The output of the workshop will be a 3-4 pages summary statement supported by a roadmap document.



AGENDA

Monday 14 May:

- neutrino physics (morning)
- review of present program (afternoon)

Tuesday 15 May:

- sterile neutrinos
- relation with astrophysics
- proposals for the future (afternoon and Wednesday morning)

Wednesday 16 May:

- international context
- comparison of proposals
- discussion and draft statement to strategy (afternoon)

Program is quite tight -
important that speakers stick to their time
which includes time for specific questions



Questions to the workshop

There is a full list of questions prepared by the program committee and posted on the meeting web site

http://indico.cern.ch/event/neutrino_town

A selected list follows



D Questions on physics

D.1 What is $\sin^2 2\theta_{13} = 0.1$ telling us?

D.2 What is the ultimate accuracy expected from ongoing experiments?

D.3 What is the likelihood of there being no interesting physics beyond measuring CP violation and mass hierarchy?

D.4 What is the relevance of neutrino masses for the cosmological and astrophysical observations (BAU, dark matter, N_{ν})

D.5 What is the precision at which the neutrino mixing parameters should be measured?

D.6 Can experiments reach those precisions?

D.7 Are there fundamental limitations that would prevent those measurements?

D.8 What is the theoretical interest in the mass hierarchy determination?

D.9 (How many theoretical papers would go in the bin if the hierarchy is inverted?)

D.10 What are the systematic limitations of the next generations of experiments?

D.11 In which way would **near detectors and precise flux determinations** reduce these systematics?

D.12 What is the concrete, prioritized program to this effect?

D.13 How important is it to measure the (anti)electron neutrino cross-sections

D.14 and with what precision?



A. Questions on ongoing efforts

A.1 What is the status of the ongoing CNGS experiments?

A.2 What has been learnt from CNGS operation (beam and experiments)?

A.3 What are the physics perspectives for the CNGS /LNGS facility in the near and longer term?

A.4 What is the precision required from hadro-production measurements and for cross-section measurements e.g. with a muon storage ring?

EUROnu:

A.5 What are the achievements of EUROnu?

A.6 will EUROnu be able to come up with a *prioritized* list of recommended R&Ds?

A.7 Based on technical limitations, what is the estimated time scale (from now to taking data) for various detector and accelerator technologies?

A.8 Ideas in EUROnu concerning a possible continuation?

A.9 Which of the proposed facilities can be housed by CERN, on which timescales, with what available machine time, what are the synergies with LHC?



B Questions on sterile neutrinos

B.1 What is the parameter space covered by the various proposals?

B.2 What roughly is the time scale and resources required for the various proposals?

Associated question from C. Vallée

C.22 Is a North Area short baseline neutrino facility in synergy with (or in the way of) a long baseline program?



Questions on next project (0):

C.0 Given the fact that $\sin^2(2\theta_{13})$ of the order of 0.1:
do we have in Europe, a real chance of
discovery (i.e. first and 5 sigma),
or just evidence (i.e. 3 sigma)
of the neutrino mass hierarchy and/or of the CPV phase?



Questions on next project (1)

1) Question for existing CNGS line:

- C.1 What physics reach does the 732 Km baseline permit and what effort that implies?
- C.2 Is it necessary/ possible/affordable to equip the line with a near detector site?
- C.3 Are the modifications necessary to lower the present very high energy of the beam feasible/affordable?
- C.4 How large a detector can be housed either in the existing lab or in possible extension?
- C.5 Is there a longer term prospective for this?
- C.6 Are there synergies with p decay and neutrino astrophysics?

- C.7 What is the estimated date at which 5 sigma (resp 3 sigma) will be reached for the mass hierarchy determination?
- C.7' Same as C.7 for CP violation



Questions on next project (2):

2) Questions for CN2PY

- C.1' What physics reach does the 2285 Km baseline permit and what effort that implies?
- C.7 What is the estimated date at which 5 sigma (resp 3 sigma) will be reached for the mass hierarchy determination?
- C.7' Same as C.7 for CP violation
- C.8 What could be the incremental steps in detector mass and beam intensity?
- C.9 When can a Liquid argon detector be built that would reach the goal?
- C.10 Is there an easier technology than LARG that would do it?
- C.11 Could we use a more conventional technology (like NOvA) as a first step?
- C.12 What is the added value of a large liquid scintillator detector?
- C.13 What is the performance of LENA for Mass Hierarchy/CP violation?
- C.14 What are the near detector proposals for the various superbeam/betabeam and neutrino factory proposals?
- C.15 Can the CN2PY baseline be used for a neutrino factory?
- C.16 Can the detectors foreseen for CN2PY be used for a neutrino Factory?
- C.17 Is there physics to be done at CN2PY Phase I with a large MIND?



Questions on next project (3):

3) questions on 'neutrino test area at CERN'

C.18 Can we see more concrete details on this (size, space)

C.19 Do we need this area and what would we do in it?

C.20 When can it be ready?

C.21 Is there physics one can do in the area?

C. 22 Is a North Area short baseline neutrino experiment in synergy with (or in the way of) a long baseline program?



For the discussion on Wednesday:

The discussion will be chaired by *Claude Vallée* (chair of CERN SPSC) after a presentation of a draft of a document to the CERN strategy process.

We welcome **SINGLE SLIDE** contributions to the discussion please submit them to *Claude Vallée* and myself by Wednesday 8:00 the latest.

Discussion should be lively ... and it will be important to make a mature effort to arrive to a **coherent proposal!**

NOW, LETS GO TO WORK!