ν : WHERE WE STAND AND WHERE WE'RE HEADING TO

δm^2_{12} ✓ SOLARS+KAMLAND $\delta m^2_{12} = (7.9 \pm 0.7)\,10^{-5}\,eV^2$

θ_{12} ✓ SOLARS+KAMLAND $\sin^2(2\theta_{12}) = 0.82 \pm 0.055$

Addressed by accelerator neutrino experiments

δm^2_{23} ✓ ATMOSPHERICS $\delta m^2_{23} = (2.4 \pm 0.4)\,10^{-3}\,eV^2$

θ_{23} ✓ ATMOSPHERICS $\sin^2(2\theta_{23}) > 0.95$

θ_{13} ✓ $\sin^2 2\theta_{13} = 0.1$

LSND/Steriles ? ★

δ_{CP} ★★

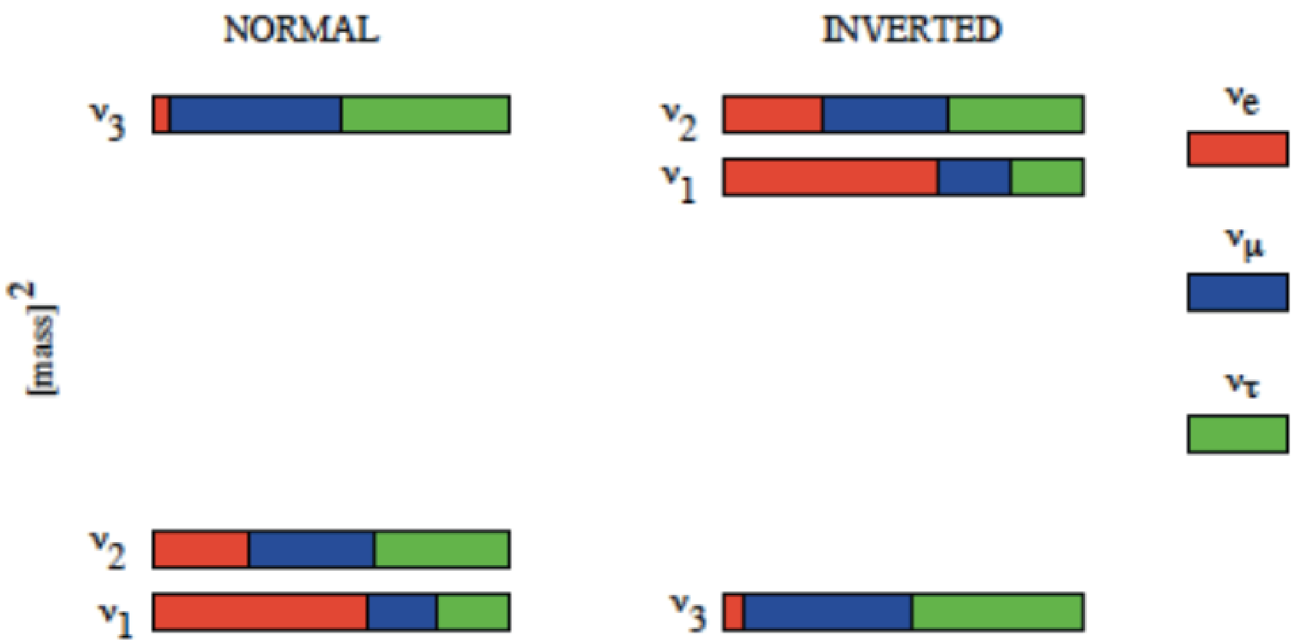
Mass hierarchy ★★

Σm_ν BETA DECAY END POINT $\Sigma m_\nu < 6.6$ eV ★★★

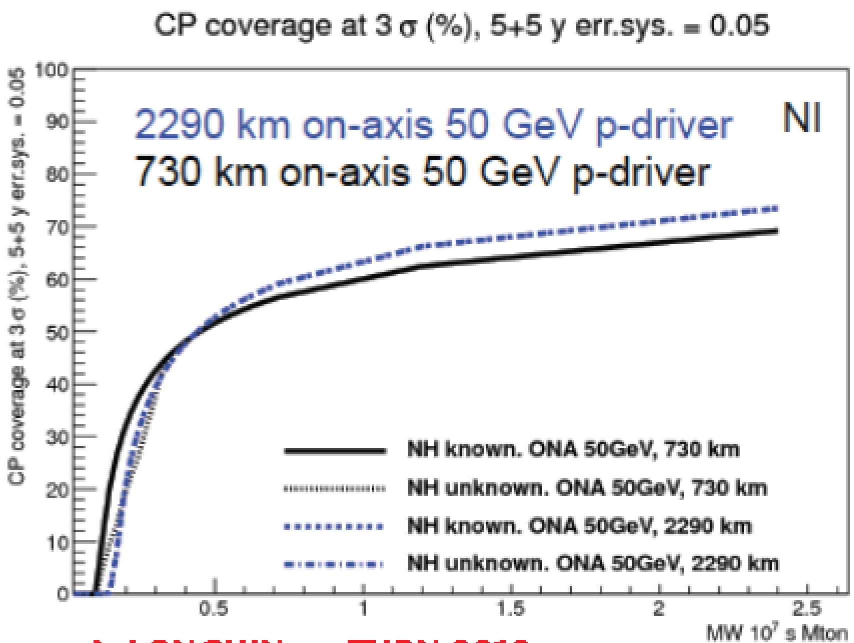
Dirac/Majorana ★★★★ ★

ACCORDING TO MY PERSONAL TASTE

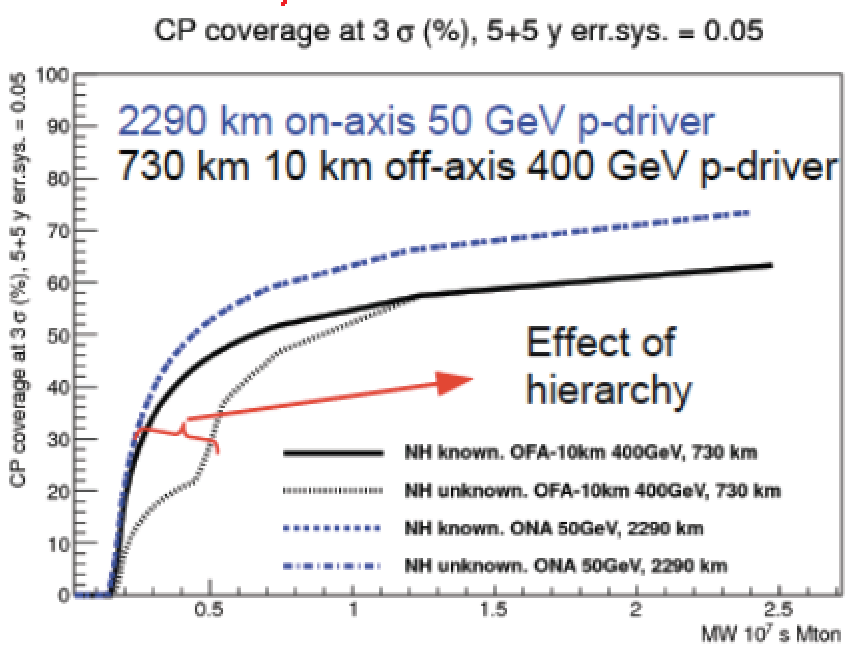
LARGE θ_{13} → NOT ONLY ACCELERATORS, BUT ALSO **REACTOR AND ATMOSPHERIC NEUTRINOS** CAN PLAY A ROLE IN THE **ν MASS HIERARCHY** GAME



INO+NOVA+T2K, ICE-CUBE with PINGU, DAYABAY, future Long BaseLine



A. LONGHIN, nuTURN 2012



LAGUNA-LBNO observatory at Pyhasalmi (-1400m.)

2x50 kton LAr + 50 kton LSc
879'000 m³ excavation
Design to be finalized within LAGUNA-LBNO by ≈2014

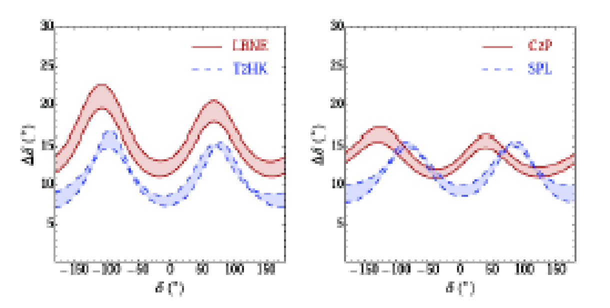
- Nominal beam power scenarios (700kW).
- For $\sin^2 2\theta_{13}=0.1$, approximately (at 90%C.L.):
  - MH: 100% coverage at >5σ in a few years of running
  - CPV: ≈60% coverage and evidence for maximal CP (π/2, 3π/2) at 2.9σ in 10 years

Long baseline projects

Project	Beam power MW	Fiducial Mass kt	Baseline km	MH	CPV 90%CL, (3σ)	Physics starts	Astrophysical program
LBNO	0.8	20->100	2300	Excellent	71 (44)	2023	Yes
T2HK	0.75	500	295	Little	86 (74)*	2023	Yes
LBNE	0.7	10	1300	OK	69 (43)	2022	No
Lund	5	440	365	Some	86 (70)	>2019	Yes
CERN-Canfranc	0.8-4	440	650	Some	80-88(80)	>2020	Yes

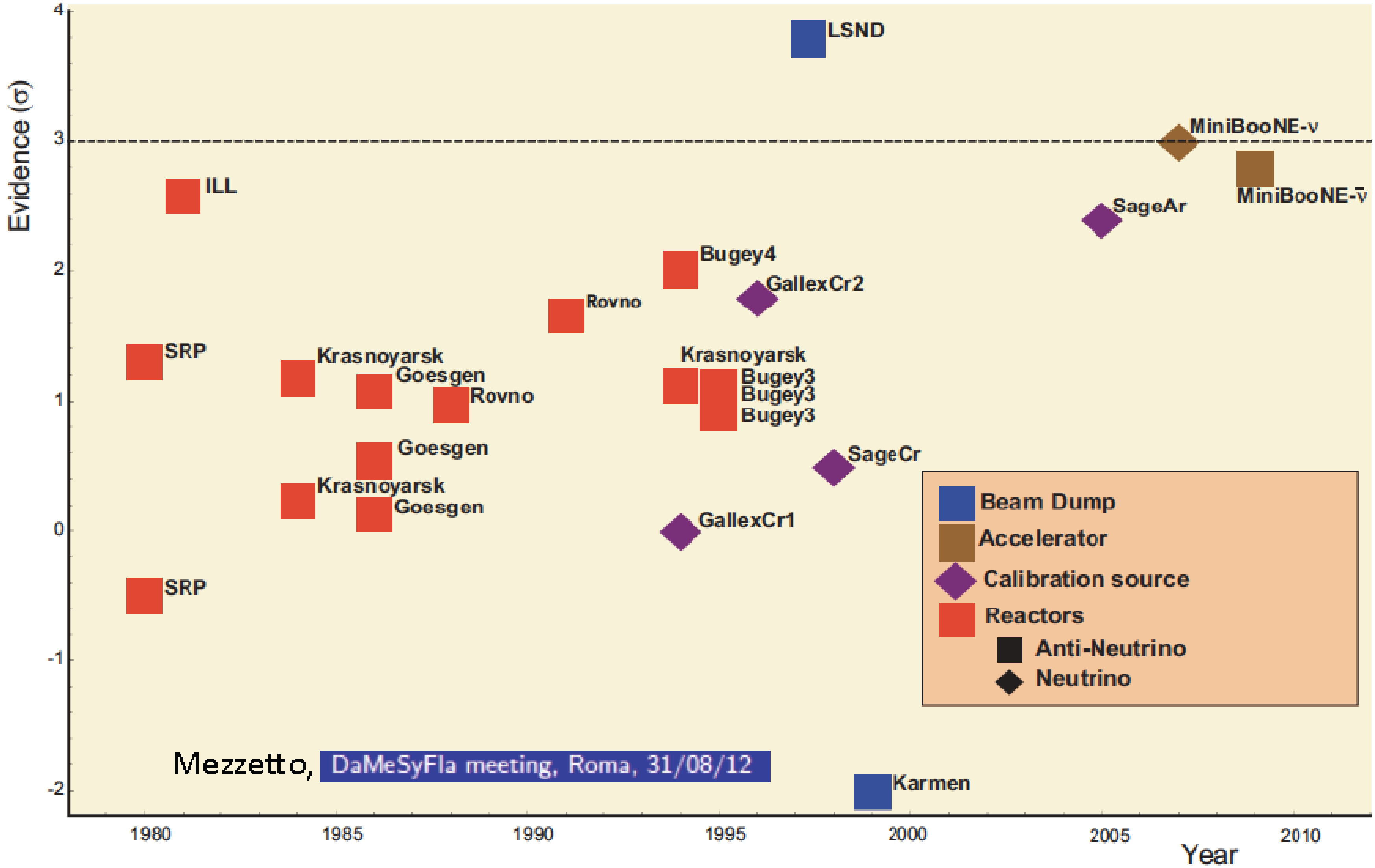
P. Coloma et al.hep-ph:1203.5651

*: if mass hierachy is known



T2HK: 4MW, 500 kt
LBNE: 0.8 MW,33 kt
C2P=LBNO : 0.8 MW, 100 kt

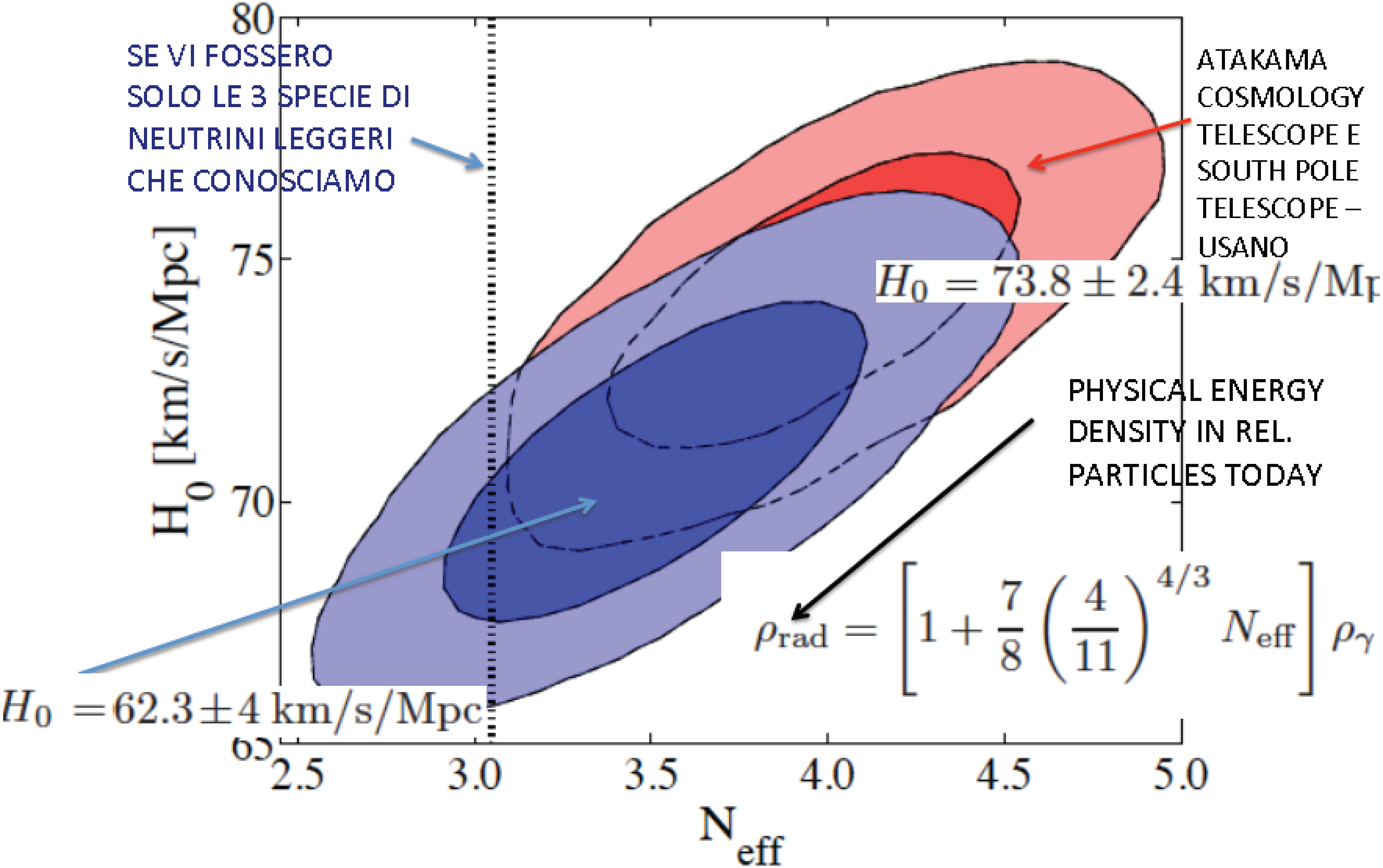
A long standing set of anomalies



Mezzetto, DaMeSyFla meeting, Roma, 31/08/12

INDICAZIONI DALLA COSMOLOGIA A FAVORE DI > 3 SPECIE DI NEUTRINI?

"DARK RADIATION"



CALABRESE, ARCHIDIACONA, MELCHIORRI, RATRA 2012

- The scientific impact of the search for sterile neutrinos has been highlighted: quoting Pilar Hernandez:

If there are other light sterile states we must know…

Our predictions/constraints on

1) matter-antimatter asymmetry

2) large-scale structure, CMB

3) nucleosynthesis

4) supernova explosions

5) the dark matter content of the Universe

4) supernova explosions

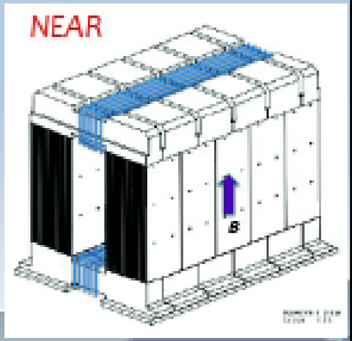
6) rate of neutrinoless double beta decay

depend on it !

Contribution ID38

SPSC-P-347 (Icarus-Nessie)

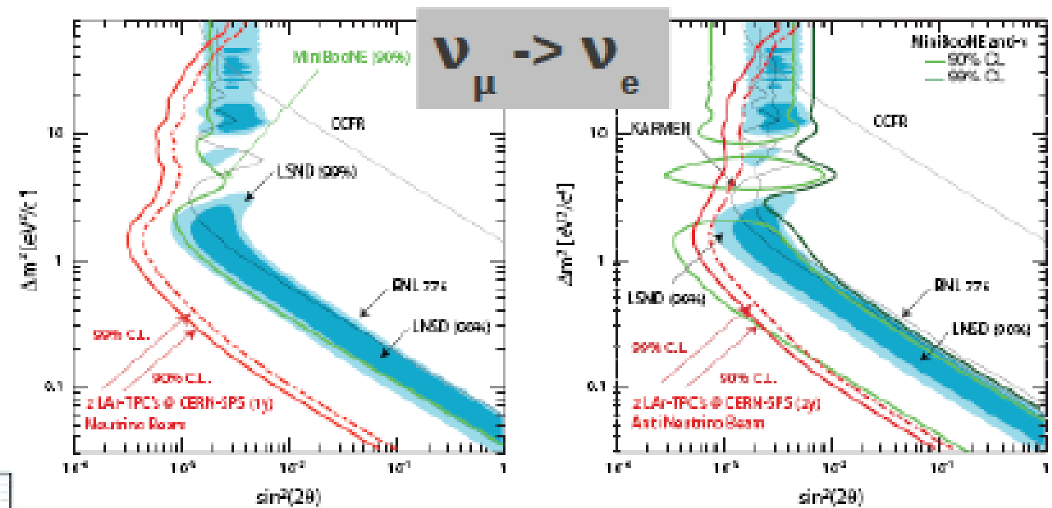
- Proposal (SPSC-P-347, 150 authors) of a comprehensive search for new neutrino states around $\Delta m^2 \sim 1 eV^2$ using a SPS 110 GeV proton beam in the NA
- with two LAr detectors, at 1600 m (ICARUS T600 now at Gran Sasso) and 300m (T150), supplemented by two spectrometers
- Method : two identical detectors, with imaging properties and complete final state reconstruction

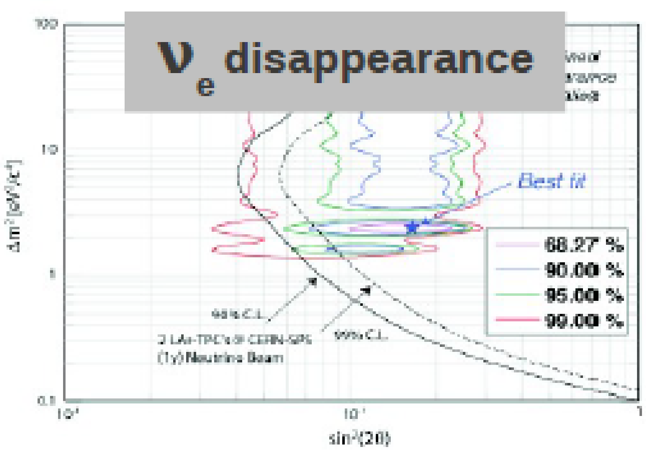


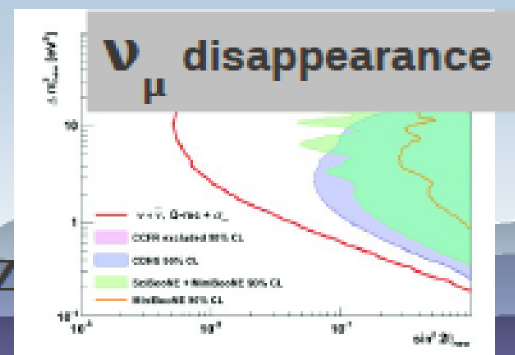
SPSC-P-347

- With two years negative and one year positive focusing, the following channels can be studied in neutrino and antineutrino modes. Very complete coverage of the region of the anomalies

- $\nu_\mu \rightarrow \nu_e$
- ν_e disappearance
- ν_μ disappearance







Summary of the ν session

- ν mass and mixings confirmed by many experiments and remain, with dark matter, the only present evidence of beyond the Standard Model physics.
- As the highest priority we should determine the unknown oscillation parameters and look for surprises. CP violation and the ν mass hierarchy could be keys to the matter/antimatter asymmetry of the Universe.
- A large and effective European community exists in this area.
- Long baselines are optimal for determining the mass hierarchy, real advantage of the CERN → Pyhäsalmi baseline and, to a lesser extent, LBNE.
- The CERN → Pyhäsalmi baseline is also near optimal for a Neutrino Factory.
- Shorter (~hundreds of kilometres) baselines with huge detectors would allow very high statistics measurements more helpful for CP violation, particularly if hierarchy is known. This is the case of T2HK (also European alternatives such as CERN → Frejus, CERN → Canfranc, or ESS-based ν beam)
- For best performance and synergy an experiment of each category is needed → Coherence with efforts in other regions. Coordination and cooperation with our international colleagues mandatory.
- Anomalies in a range of phenomena at lower energies perhaps point to sterile neutrinos, and a proposed experiment at CERN would be highly competitive.
- More sophisticated future projects, which EUROnu has concluded should be a Neutrino Factory, necessary to achieve the desired sensitivity to the CP phase and probe new physics.
- R&D including projects such as MICE and nuStorm (which may also offer a definitive test for sterile neutrinos) should be supported.
- Experiments in absolute neutrino mass, especially in neutrinoless double-beta decay, are also a top priority.
- Hadron production, neutrino cross-section, and other support measurements will be essential to reach the neutrino oscillation sensitivity goals.

My general comments for discussion II

- Small scale experiments should still be possible for some precision measurements. But, may be not for long…..
- e^+e^- colliders can now make a concrete physics programme on precision physics with "Higgs"-like particle and top (and some more)
- Concrete physics cases for both long and short baseline neutrino programme can be made. In principle, many of the technology seems to exist for those (i.e. more D than R needed). Long baseline facilities might be a concrete example of coordination between PP and APP.
- Projects to deepen our knowledge in Standard Model are being proposed
- Lets start the discussion, if anytime left….