Progress Report on The Physics-Case Paper for LAGUNA

General Meeting – CERN

3 Mar 2011

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Physics paper (Editors: Pascoli, Rodejohann)

- **Nucleon decay** (Rodejohann, Fileviez Perez): 5 pages DONE
- **Theory of neutrinos** (Rodejohann, Pascoli, de Gouvea): 4 pages DONE
- **Solar neutrinos** (Gonzalez-Garcia, Akhmedov): 4 pages DONE
- **Atmospheric neutrinos** (Maltoni): 8 pages DONE
- **Reactor neutrinos** (Schwetz, Trzaska): 3 pages DONE
- **Geoneutrinos** (Mantovani): 3-4 pages in progress
- **Future opportunities** (LBL exp) (Mezzetto, Pascoli, Li, Coloma): 4-5 pages The LBL study is ongoing.
- **Supernova neutrinos** (Raffelt and Mirizzi): 4 pages in progress
- **Indirect dark matter searches** via neutrinos (Pascoli and Palomares-Ruiz): 3 pages nearly completed

Time scale

• Beginning of Sep 10: Contact about writing up. Done!

• Mid of February 10: deadline for provide first version of draft of the different sections Done!

• Mid of March 11: first draft of edited paper

• Mid of April 11: circulate the draft to LAGUNA consortium for comments

• Mid of May 11: Final version

• End of May 11: put on the arXiv and contact publisher.

The paper should be sufficiently short to be easily read but at the same time detailed enough to provide all the relevant information.

Typical structure for each section:

1- Theoretical introduction

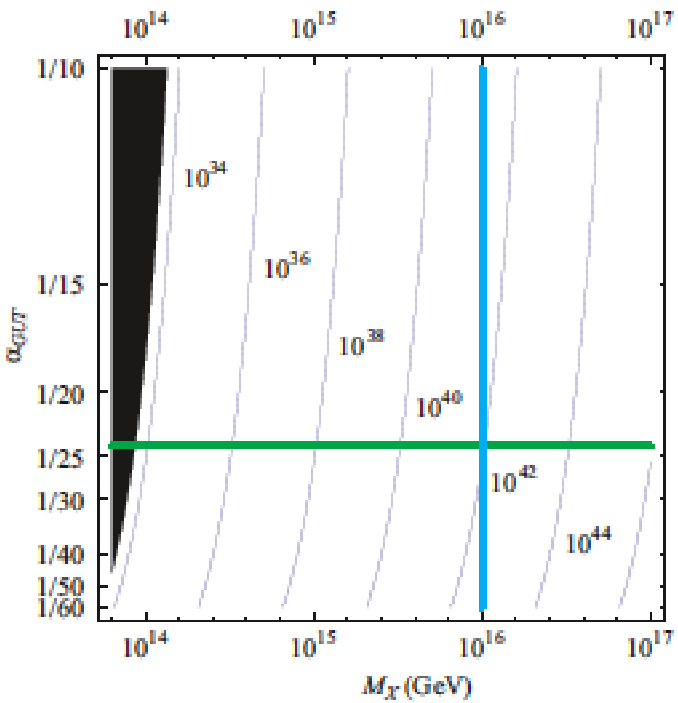
2- Review of present status of studies in the field

3- Specific sensitivity of MEMPHYS, GLACIER and LENA

Difficulty: not in all the areas the reach of the three detectors has been considered in great detail.

Nucleon decay
P. Fileviez-Perez

LAGUNA detectors can improve on the searches for proton decay in different channels.



	GLACIER	LENA	MEMPHYS
$p \to e^+ \pi^0$			
Typical predictions: 10^33-10^38 yr			
τ_p/B (90% C.L., 10 years)	0.4×10^{35}	-	1.0×10^{35}
$p \to \bar{\nu} K^+$			
Typical predictions: 10^32-10^36 yr			
τ_p/B (90% C.L., 10 years)	0.6×10^{35}	0.4×10^{35}	0.2×10^{35}

TABLE II: Expectations for GLACIER, LENA, and MEMPHYS.

Theoretical motivation for neutrino oscillation experiments

A. de Gouvea, W. Rodejohann

$$\Delta m^2_{12} = (7.59 \pm 0.2) \times 10^{-5}\ \mathrm{eV}^2, \qquad \sin^2\theta_{12} = 0.319 \pm 0.016,$$

$$\Delta m^2_{13} = \begin{cases} (-2.36 \pm 0.11) \times 10^{-3}\ \mathrm{eV}^2 \\ (+2.46 \pm 0.12) \times 10^{-3}\ \mathrm{eV}^2 \end{cases}, \quad \sin^2\theta_{23} = 0.478 \pm 0.067,$$

$$\delta \in [0, 2\pi\} \ \text{(unconstrained)}, \qquad \sin^2\theta_{13} < 0.047 \ (3\sigma \text{ upper bound}),$$

The need for precision in the measurements of the neutrino parameters (tri-bi-maximal mixing, leptogenesis).

From the point of view of completing our understanding of the neutrino oscillation parameters, the goals of future experiments are clear: precisely measure the currently known oscillation parameters, determine θ_{13} with good precision (or constrain it to be very small), establish whether the neutrino mass spectrum is normal or inverted, and observe CP-invariance violation in neutrino oscillations, thus measuring the CP-odd phase δ.

Solar neutrinos
C. Gonzalez-Garcia

Despite the progress of the theory, only neutrinos, with their extremely small interaction cross sections, can enable us to see into the interior of a star and thus verify directly our understanding of the Sun [6]. Indeed from

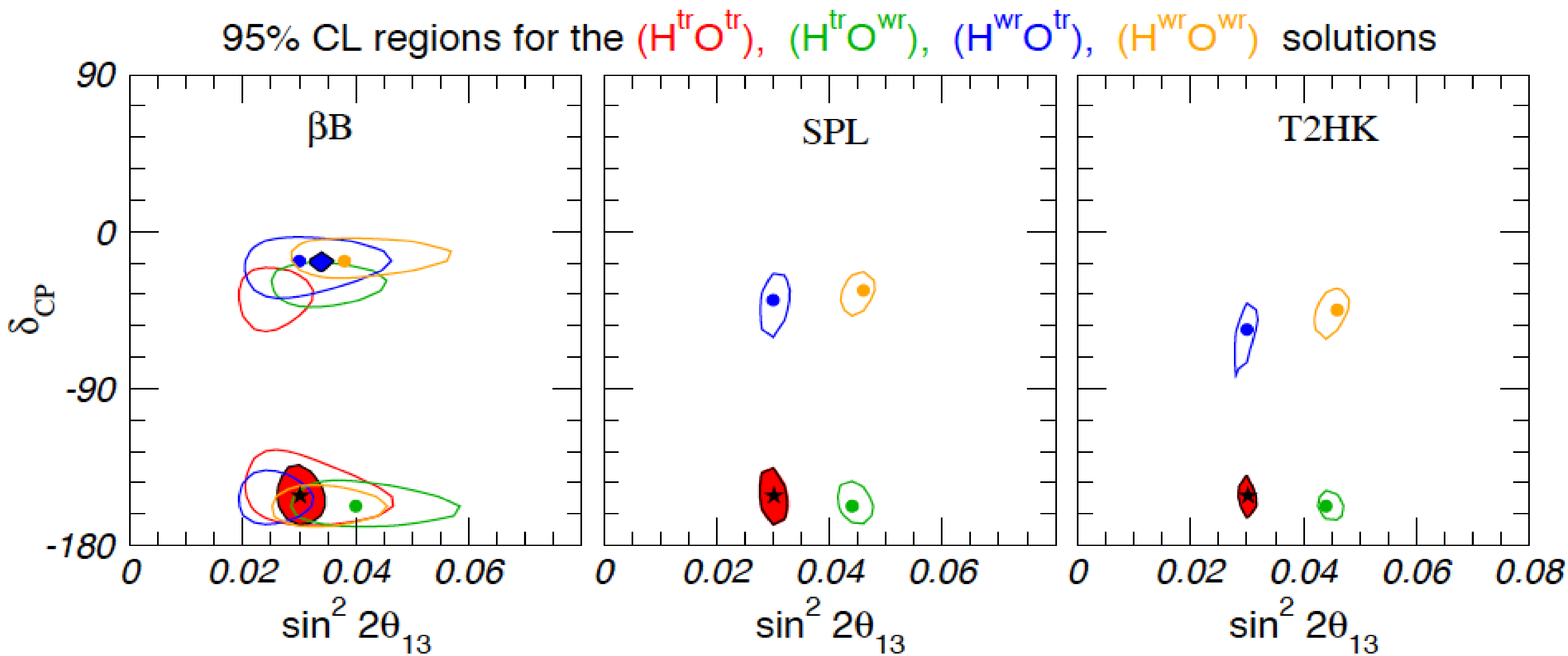
Flux cm^{-2} s^{-1}	GS98	AGSS09	Fit [13]
$pp/10^{10}$	$5.97\ (1 \pm 0.006)$	$6.03\ (1 \pm 0.005)$	$5.91^{+0.057}_{-0.063}$
$pep/10^{8}$	$1.41\ (1 \pm 0.011)$	$1.44\ (1 \pm 0.010)$	$1.41^{+0.019}_{-0.020}$
$hep/10^{3}$	$7.91 (1 \pm 0.15)$	$8.18\ (1 \pm 0.15)$	13 ± 10
$^{7}Be/10^{9}$	$5.08\ (1 \pm 0.06)$	$4.64\ (1 \pm 0.06)$	$5.08^{+0.52}_{-0.43}$
$^{8}B/10^{6}$	$5.88\ (1 \pm 0.11)$	$4.85\ (1 \pm 0.12)$	$5.02^{+0.18}_{-0.17}$
$^{13}N/10^{8}$	$2.82\ (1 \pm 0.14)$	$2.07 (1^{+0.14}_{-0.13})$	$7.8^{+5.0}_{-3.4}$
$^{15}O/10^{8}$	$2.09\ (1^{+0.16}_{-0.15})$	$1.47\ (1^{+0.16}_{-0.15})$	$4.0^{+1.8}_{-1.9}$
$^{17}F/10^{6}$	$5.65\ (1^{+0.17}_{-0.16})$	$3.48\ (1^{+0.17}_{-0.16})$	≤ 59

Table 1: The flux predictions of the models together with the results from the most up-to-day direct extraction of the solar neutrino fluxes from the solar neutrino data from Ref.[13] in the framework of three-neutrino oscillations.

Solar neutrinos can be used as a probe of the Sun.

Atmospheric neutrinos
M. Maltoni

- Determination of the neutrino mass hierarchy (for sufficient Mton/yrs)
- Synergy between atmospheric and LBL neutrinos (very relevant for short baselines, CERN-Frejus)



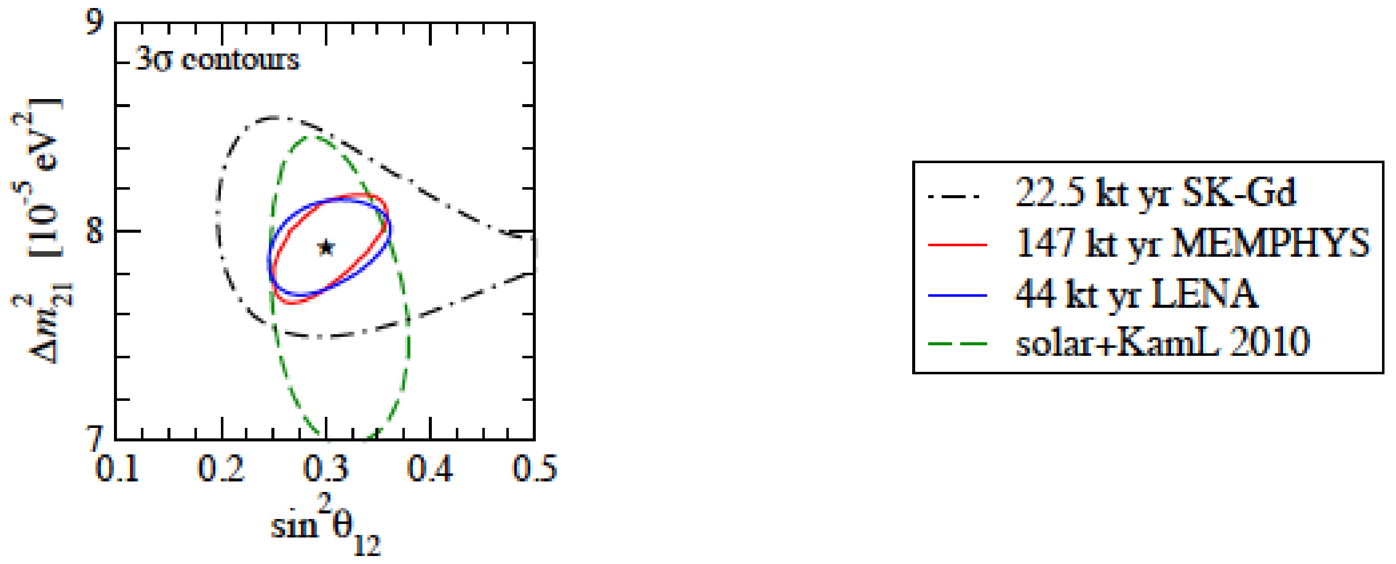
Reactor neutrinos

T. Schwetz

experiment	fid. mass	free protons	$E_{\rm thr}$	events/yr	energy resol.
MEMPHYS-Gd	147.0 kt	9.8×10^{33}	3.0 MeV	59 980	$44\%/\sqrt{E_p\,[\text{MeV}]}$
LENA	44.0 kt	2.3×10^{33}	2.6 MeV	16 670	$10\%/\sqrt{E_p\,[\text{MeV}]}$
SK-Gd	22.5 kt	1.5×10^{33}	3.0 MeV	8 000	$44\%/\sqrt{E_p\,[\text{MeV}]}$
KamLAND	0.41 kt	3.5×10^{31}	2.6 MeV	216	$7.5\%/\sqrt{E_p\,[\text{MeV}]}$

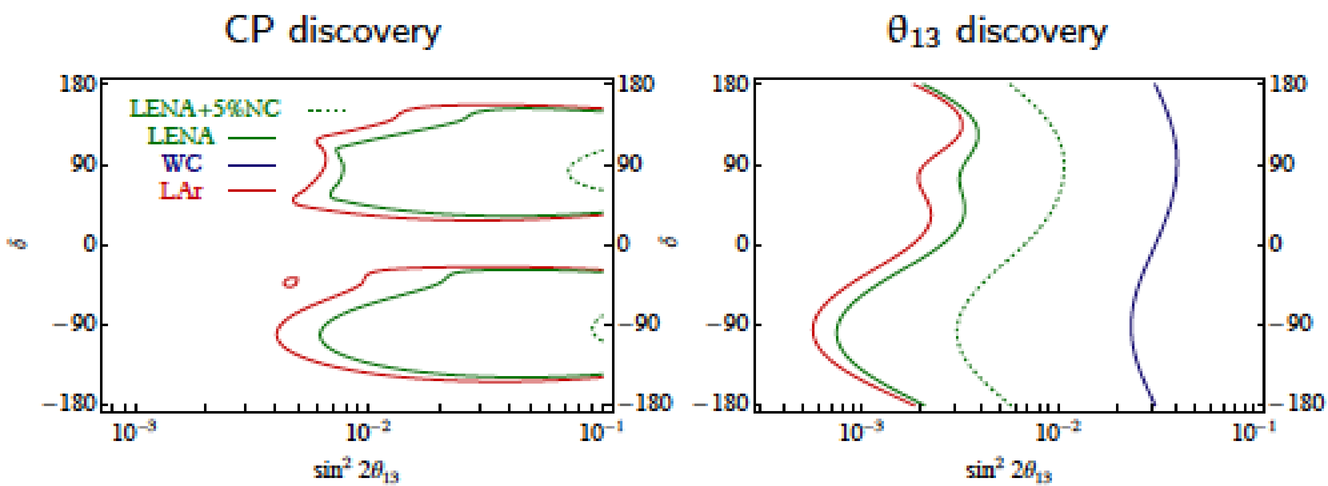
Table 1: Summary of the input characteristics of MEMPHYS-Gd, LENA, and SK-Gd. For comparison we show also the corresponding values for KamLAND. The number of events/yr is calculated for no oscillations and using the reactor flux at Frejus for MEMPHYS-Gd and LENA, and at Kamioka for SK-Gd.

Determination of the solar neutrino oscillation parameters



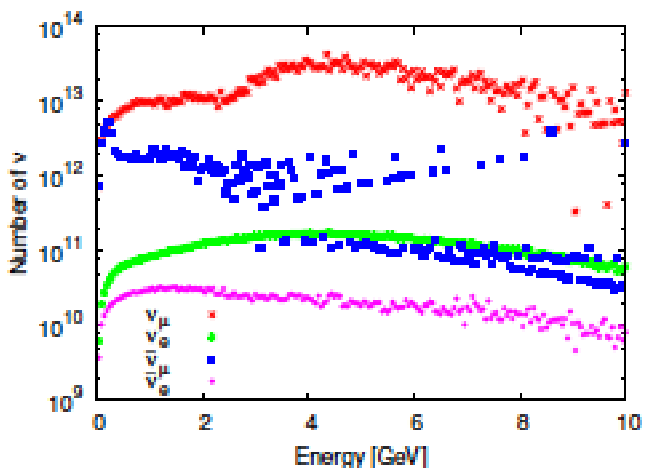
Future opportunities
P. Coloma, T. Li, SP; M. Mezzetto

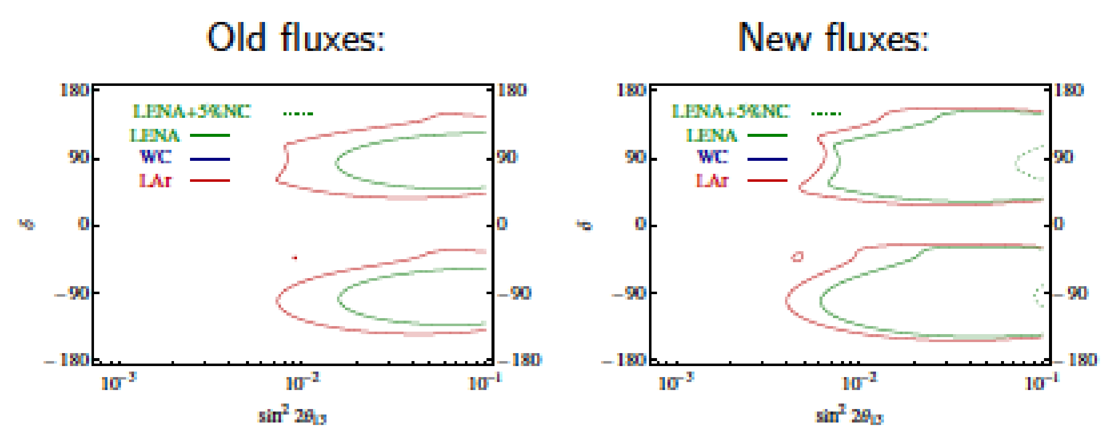
- **Analysis of the sensitivity w.r.t. NC backgrounds,**



- **The fluxes have been provided by A. Longhin:**

ν beam flux from A. Longhin:



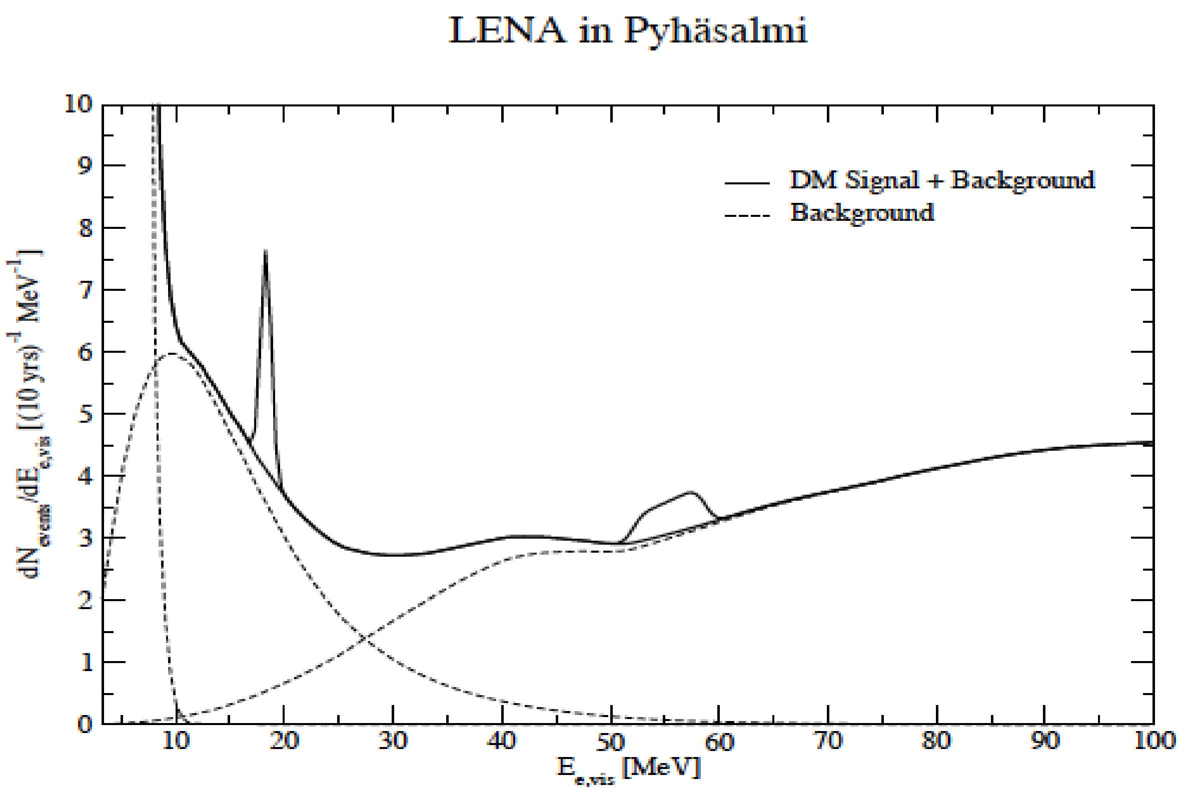


From T. Li's talk

Indirect DM searches
S. Palomares-Ruiz, SP

- **Searches for MeV DM at LENA and MEMPHYS**

- **Searches for WIMP DM annihilating in the Sun at MEMPHYS and GLACIER**



Conclusions and plans

• Most of the contributions have been received. All authors contacted have agreed. Remaining contributions are expected soon.

• A lot of work is being devoted to the study of LBL physics with LAGUNA sites (see Li's talk tomorrow) (Coloma and Li, with SP)

• Comments for discussion:

1) journal for publication
2) author list: which ordering?
3) involvement of the wider community