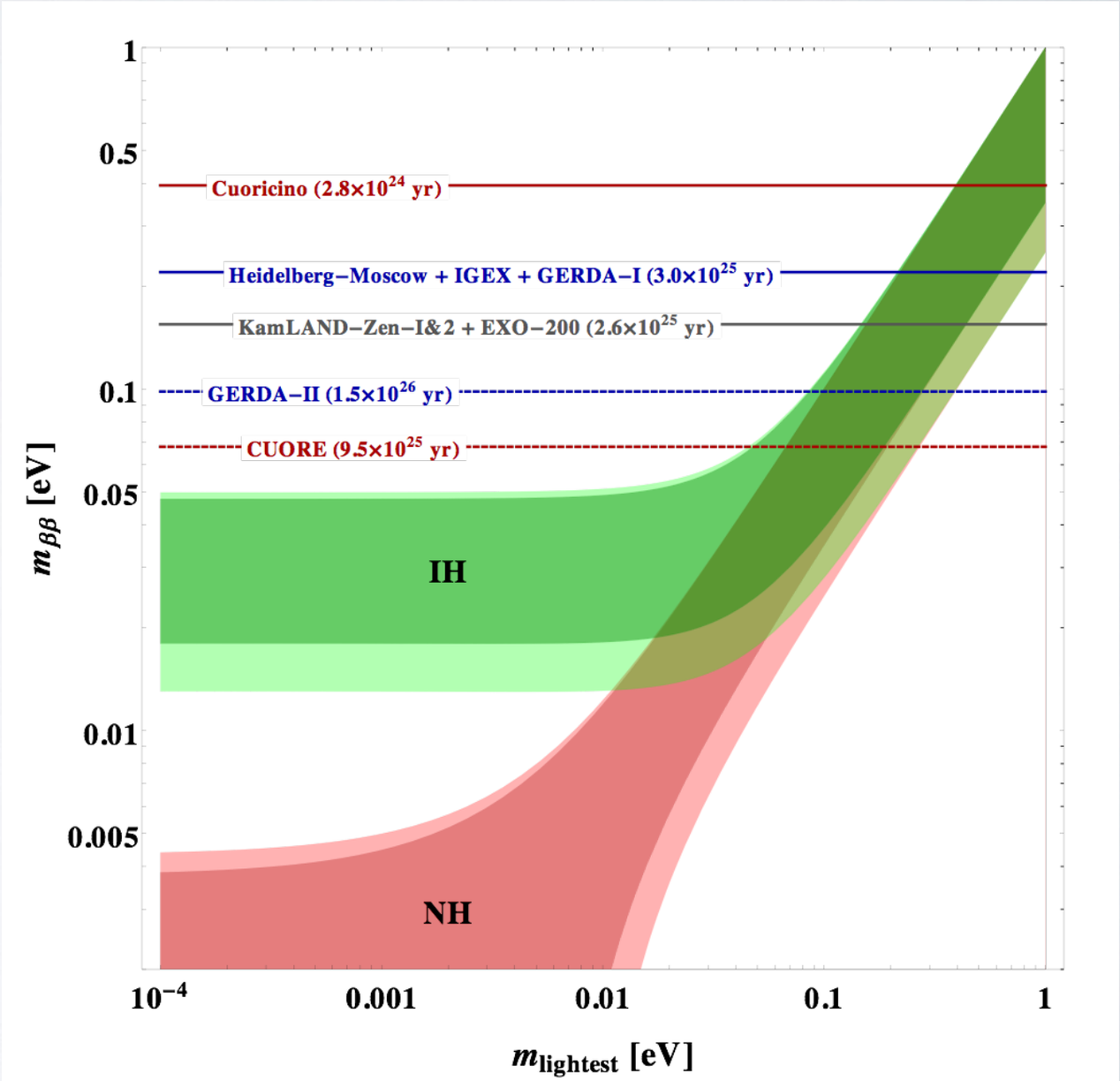
# SEARCH FOR MAJORANA NEUTRINOS WITH BOREXINO

S. Marcocci
Gran Sasso Science Institute

on behalf of the Borexino Collaboration

# THE NEED OF TON SCALE EXPERIMENTS

- Recent theoretical updates on *0νbb* worsen the expectations on new experiments sensitivities
- possibly, the IH won't be proved by next generation experiment
- ton scale is needed!




S.Dell'Oro, SM, F.Vissani, Phys. Rev. D 90, 033005 (2014)

# "XEBEX" IDEA IS OLD

VOLUME 72, NUMBER 10 PHYSICAL REVIEW LETTERS 7 MARCH 1994

## New Approach to the Search for Neutrinoless Double Beta Decay

R. S. Raghavan

*AT&T Bell Laboratories, Murray Hill, New Jersey 07974*

(Received 9 November 1993)

Sub-eV Majorana neutrino masses $\langle m_\nu \rangle$, can be explored by a new approach to neutrinoless double $\beta$ decay using $^{136}$Xe in a Xe gas-loaded, multiton liquid scintillator installed in a very low background detector such as the Kamiokande facility. With enriched $^{136}$Xe, a readily implementable, 10 ton detector experiment can establish an $\langle m_\nu \rangle = 0.45$ eV at $3\sigma$ in 1 yr (or exclude an $\langle m_\nu \rangle < 0.23$ eV in 2 yr). A 100 ton detector can extend the limit to $\langle m_\nu \rangle < 0.1$ eV, compared with the present limit of $\langle m_\nu \rangle < 1.3$ eV.

PACS numbers: 29.40.Mc, 14.60.Pq, 23.40.Bw

- Since the Borexino proposal in 1992, a neutrinoless double beta decay search with $^{136}$Xe in Borex has been considered !!
- This is where the idea of dissolving xenon in a liquid scintillator comes from

# FEATURES OF THE PROJECT

- Xenon solubility in pseudocumene is pretty high (2,2% wt at 900mbar)
- Thanks to Henry's law, solubility grows linearly with the pressure
- e.g at 5 bar solubility is more than 10% !
- Xe mass can be easily increased or reduced, no need of having all the isotope at the beginning, source in-source out possible
- and most importantly: Borexino is almost background free!
  Th< 9 $10^{-19}$ g/g 95% C.L., U< 8 $10^{-20}$ g/g 95% C.L., Kr< 7.1cpd/100tons 95% C.L.

# OTHER $^{136}$XE EXPERIMENTS

| Feature | EXO-200[1] | KamLAND Zen [2] | NEXT-100 (assumed) [3] | nEXO (from EXO-200) [4] | nEXO (assumed) [4] |
|---|---|---|---|---|---|
| Total Mass [kg] | 200 | 348 | 100 | 12000* | 12000* |
| Fiducial Mass [kg, $^{136}$Xe] | 76.5 | 87.8 | 80 | 4302 | 4302 |
| Enrichment [%] | 80.6 | 90.77 | 90 | 90 | 90 |
| FWHM Energy resolution[%] | 3.6 | 9.9 | 0.5 | 3.6 | 3.6 |
| 2v in ROI [c ton(136Xe)$^{-1}$ yr$^{-1}$] | 0.1 | 40 | <0.1 | 0.1 | <0.1 |
| Other bkg in ROI [c ton(136Xe)$^{-1}$ yr$^{-1}$] | 229 | 217 | 6.8 | 229 | 4.5-1.2 *** |
| Bkg in ROI [c ton(136Xe)$^{-1}$ yr$^{-1}$] | 229 | 255 | 6.8 | 229 | 4.5-1.2 *** |
| Total bkg in ROI 5 y [c] | 88 | 112 | 2.7 | 4934 | 97-16 *** |
| $^{0}T_{1/2}$ 90% c.l. limit [yr] | 1.1 $10^{25}$ | 1.3 $10^{25}$ * | - | - | - |
| $^{0}T_{1/2}$ 90% c.l. sensitivity [yr] computed by us (their live time or 5yr if new exp.) | 3.3 $10^{25}$ | 1.4 $10^{25}$ | 2.8 $10^{26}$ | 5.6 $10^{26}$ | 3.8-5 $10^{27}$ *** |


[1] Nature 510 (2014), 229–234
[2] KamLAND-Zen's talk at Neutrino2014
[3] J.J. Gomez Cadenas talk at Gran Sasso Summer Institute, LNGS, Sept. 2014
[4] G. Gratta talk at LNGS, 19th Feb. 2014


*assuming the same FV efficiency cut of EXO-200

**KamLAND-Zen's limit is much better (2.6 1025 yr, REF). We used only phaseII data (~110days exposure) to compare backgrounds

***The first number is computed using an assumed background of 6.1 $10^{4}$ c/yr/mol-136 and a fiducial mass of 4302kg, while the second one assumes 1.6 $10^{4}$ c/yr/mol-136 and a fiducial mass of 2700kg.

# BOREX-XE CONFIGURATIONS

| Feature | Current Borex * | Borex-Xe 4t ** | Borex-Xe 7t *** |
|---|---|---|---|
| Total Mass [kg] | 6200[a] | 18000[a] | 30000[a] |
| Fiducial Mass [kg, $^{136}$Xe] | 1174 | 4295 | 7158 |
| Enrichment [%] | 90 | 90 | 90 |
| FWHM Energy resolution[%] | 6.7 | 4.2 | 4.2 |
| 2v in ROI [c ton$(^{136}Xe)^{-1}$ yr$^{-1}$] | 4 | 0.25 | 0.25 |
| Other bkg in ROI [c ton$(^{136}Xe)^{-1}$ yr$^{-1}$] | 122 | 29 | 1.3 |
| Bkg in ROI [c ton$(^{136}Xe)^{-1}$ yr$^{-1}$] | 126 | 29 | 1.5 |
| Total bkg in ROI 5 y [c] | 1007 | 630 | 51 |
| $^{0}T_{1/2}$ 90% c.l. sensitivity [yr] computed by us (their live time or 5yr if new exp.) | $4.6\ 10^{26}$ | $1.5\ 10^{27}$ | $8\ 10^{27}$ |

[a]This number assumes that Borexino Geometry is not changed at all. With a modification of the project this number could be dramatically decreased.

*R=2.8m, p=1 bar
**R=2.7m, p=3 bar, current background, LY~doubled
***R=2.7m, p=3 bar, LY~doubled, background like current R<1m (should be easy, main contribution is $^{208}$Tl in light concentrators)