NLDBD SEARCHES

Current status for the white paper discussion

Valentina & Lindley

STATUS

- First draft of the NLDBD section of the white paper is available

- Updated RAT-PAC with THEIA 0nbb geometry, PMT and SNO+ LS properties (only locally available)

    - Under investigation: 136Xe (89.5% enr.) or 130Te (nat.)

- Initial simulation of key backgrounds

- Initial sensitivity studies

SIMULATION

Chris G. & Aobo

- Simple geometry with inner balloon of 6.4 or 8* m filled with 3% loaded scintillator

  - Scintillator model from SNO+ (LAB - PPO)

- PMT model with 5% coverage to speed up the simulation

  - Still very time consuming, with up to 24-48 hr per 5000 events

  - **Major MC work**: geometry, grey disk model, photo thinning, sim. speed

- 10% WbLS outside the balloon

- Simulation available at BU and MIT (ntuples and ratds)

BACKGROUNDS INCLUDED

Valentina

- Included only main backgrounds in the simulation

Table 1: Expected main background sources for the search of neutrinoless double-beta decay with THEIA. Shown are the target levels and the expected events/yr. The values are obtained considering a ballon with 6.4 m and 8 m radius and a density of 0.86 g/cm^3. It is assumed that the Te or Xe isotopes are directly loaded at a level of 3% in the LAB+PPO scintillator cocktail, for a total mass of 28.3 tonnes (6 m radius) or 55 tonnes (8 m radius).

Source	Target levels	Expected events/yr for r = 6.4 m	Expected events/yr for r = 8 m
^{10}C balloon		$250 - 800$	$500 - 1600$
^{8}B-neutrinos		1650	3200
^{130}I (Te target)		48 (9 from ^{8}B)	93 (18 from ^{8}B)
^{136}Cs (Xe target)		24 (3 from ^{8}B)	47 (6 from ^{8}B)
^{136}Cs (89.5% enriched Xe target)		245 (35 from ^{8}B)	478 (68 from ^{8}B)
$2\nu\beta\beta$ (Te target)		3.8×10^7	7.4×10^7
$2\nu\beta\beta$ (Xe target)		3.6×10^6	7.0×10^6
$2\nu\beta\beta$ (89.5% enriched Xe target)		3.6×10^7	7.1×10^7
Liquid scintillator	^{214}Bi: $10^{-16} g_U/g$	37000	73000
	^{208}Tl: $10^{-16} g_{Th}/g$	4400	9000
Nylon Vessel	^{214}Bi: $1.1< \times10^{-12} g_U/g$	7.7×10^4	1.2×10^5
	^{208}Tl: $1.6< \times10^{-12} g_{Th}/g$	1.3×10^4	2.1×10^4
PMTs	^{214}Bi: $10^{-6} g_U$/PMT		
	^{208}Tl: $10^{-6} g_{Th}$/PMT		

4

BACKGROUNDS INCLUDED

Valentina

- Define the required background reduction from sensitivity studies

Table 1: Expected main background sources for the search of neutrinoless double-beta decay with THEIA. Shown are the target levels and the expected events/yr. The values are obtained considering a ballon with $6.4\,$m and $8\,$m radius and a density of $0.86\,$g/cm^3. It is assumed that the Te or Xe isotopes are directly loaded at a level of 3% in the LAB+PPO scintillator cocktail, for a total mass of 28.3 tonnes (6 m radius) or 55 tonnes (8 m radius).

Source	Target levels	Expected events/yr for r = 6.4 m	Expected events/yr for r = 8 m
^{10}C balloon		250 − 800	500 − 1600
^{8}B-neutrinos		1650	3200
^{130}I (Te target)		48 (9 from ^{8}B)	93 (18 from ^{8}B)
^{136}Cs (Xe target)		24 (3 from ^{8}B)	47 (6 from ^{8}B)
^{136}Cs (89.5% enriched Xe target)		245 (35 from ^{8}B)	478 (68 from ^{8}B)
$2\nu\beta\beta$ (Te target)		3.8×10^7	7.4×10^7
$2\nu\beta\beta$ (Xe target)		3.6×10^6	7.0×10^6
$2\nu\beta\beta$ (89.5% enriched Xe target)		3.6×10^7	7.1×10^7
Liquid scintillator	^{214}Bi: $10^{-16}g_U/g$	37000	73000
	^{208}Tl: $10^{-16}g_{Th}/g$	4400	9000
Nylon Vessel	^{214}Bi: $1.1< \times10^{-12}g_U/g$	7.7×10^4	1.2×10^5
	^{208}Tl: $1.6< \times10^{-12}g_{Th}/g$	1.3×10^4	2.1×10^4
PMTs	^{214}Bi: $10^{-6}g_U/$PMT		
	^{208}Tl: $10^{-6}g_{Th}/$PMT		

Three fold coincidence

Delayed coincidence
Alpha/beta discrimination

FV cut, time distribution

5

BACKGROUNDS: LAB-PPO

Valentina

- Purity level of 10^{-18} in both U and Th has been demonstrated by Borexino:

    - U-238: $< 9.7 \times 10^{-19}$ g/g (95% CL from 214Bi-Po)

    - Th-232: $< 1.2 \times 10^{-18}$ g/g (95% CL from 212Bi-Po)

- Reduction:

    - Assumed 100% reduction of Bi-Po events in ROI. This is true for delayed coincidences, but need to verify the fraction that falls in the same trigger window

- Adding the isotope will probably worsen the purity. Purity can be reduced by a factor 100 (10^{-16} g/g)

BACKGROUNDS: C-10

Valentina

- One of the dangerous isotopes for the NLDBD study are the C-10 atoms.

    - Expected 500 - 1600 events/yr in THEIA inner balloon.

    - Demonstrated by KamLAND/Borexino 60% reduction of muon induced background by triple coincidence

BACKGROUNDS: B8-NEUTRINOS

Valentina

- The most dominant background in the ROI is due to 8B interactions.

    - Reduction using directionality?

SENSITIVITY STUDIES

Andy & Chris J.

- Goals are the following plots:

  - Background reduction requirements (X axis background reduction, Y sensitivity)

    - one curve for the 28 tonnes isotope loading (1 kt balloon with 3% loading)

      - ~10 t of 130Te, 25 t of Xe at 89.5% enr.

    - one curve for the 55 tonnes loading (1.8 kt balloon with 3% loading)

      - ~19 t of 130Te, 50 t of Xe at 89.5% enr.

  - Energy resolution requirements: plot with 6% and 3%.

SENSITIVITY STUDIES

Andy & Chris J.

- Presentation from Andy