LENS

Low-Energy Solar Neutrino Spectroscopy

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Science Goals:
Solar neutrino research offers an ideal opportunity for major advances in the detailed understanding of the nature of the neutrino (ν), in particular ν-flavor phenomena, and of stellar astrophysics. The Sun offers the greatest source flux of a pure ν_e flavor coupled with high matter density in neutrino transport, long baseline, and low ν-energies. The low-energy spectrum (≤2 MeV) offers a palette of fluxes at specific energies ideal for probing flavor physics via the energy dependence of ν-flavor survival. The low-energy ν-spectrum offers unique access to direct experimental proof for the still incomplete MSW-LMA ν-flavor conversion model, for new scanning of non-standard particle physics, and on an overall precision test of ν-physics and astrophysics using the fundamental equality of the ν-electroweak luminosity, L, to the precisely known photo-fluxes derived luminosity at the Sun L_S, (e.g. N. Bahcall, Phys. Rev. C., 65, 2002). Any inequality L ≠ L_S that survives at high precision, has epochal implications (current analysis - L/L_S< 1.00±0.14, Gonzalez-Garcia et al., JHEP 2010). This objective requires the measurement of not only pp ν-e but the complex set of pp, p, n, CNO ν-fluxes (which together make up 99.9% of the ν-luminosity) clearly resolved into individual fluxes with minimal uncertainty of background. Energy-specific CC-based ν-e survival is essential for this purpose. This is the mission of LENS.

Method:
Charged-Current capture of ν_e on 119Sn.

Challenges:

- Production of liquid-loaded liquid scintillator with high light yield, high transparency, good chemical stability and high content of Indium
- Discrimination of internal background from the 115In beta decay;
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The table below shows Indium background reduction in LENS and pp neutrino signal. Cuts from coincidence tag, shower characteristics, tag energy, and tag topology result in a background reduction of ~6-10^4.

Signal (pp)

Bkgd (Ba)

Prompt

Delayed Tag

(E=1±1.40keV)

(>4.76µs, E_p=613keV)

62.5

79 x 10

50

2.76 x 10

46

2.98 x 10

44

306

40

13 x 0.6

Results of the GEANT4 Monte Carlo simulation (cell size = 7.5cm, 5/6=3) (Raghavan and Grek 2005):

Indium β-Background Discrimination

A) T2-Depicts the signal spectrum from 4-100 day exposure from a 10 MCl source of 115In with the scaled solar spectrum included. The Cs signal has 1.3 x 10^12 events with ~0.1% background (from the 7Be line).

B) μLENS SL:

The central PMTs are installed on the opposite side, masking those channels, a light illuminates that side, and one can easily see the light channelling in the non-masked channels of the detector. C) Isotropic light is channelled along three Cartesian axes in a simulated SL.

LENS Beyond Solar Neutrinos:

LENS-Sterile

The LENS SL provides the unique ability to identify events of a single cell vs multiple cell events. This may be useful for a future large scale ββ-decay liquid scintillator detector.

MiniLENS:

- Staged approach
- Capable of shielding with 1.5m of water
- Capable of shielding against PMT backgrounds
- Fully test LENS technology for rare decays that may mimic delayed gamma tag