P3.079

Geochemical Determination of the pp-Neutrino Flux with ^{205}Tl-LOREX: A Progress Report

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LOREX, the acronym for LORandite EXperiment, attempts to determine the solar neutrino flux by measuring the ^{205}Pb content in the thallium-bearing mineral lorandite $TlAsS_2$, from the mine of Allchar, FYR Macedonia, which is there formed via the neutrino-capture reaction $\mathbf{^{205}Tl + \nu_e \rightarrow {}^{205}Pb + e^-}$.This geochemical detector offers **the lowest threshold** among all the detectors of only **52 keV** (GALLEX 233 keV, LENS 144 keV) for solar pp-neutrinos and the ensuing quantitative determination of the ratio of ^{205}Pb / ^{205}Tl atoms would provide the product of solar neutrino flux, integrated over the age of lorandite of **4.31 · 10^6 yr**.

Recent advances in research on LOREX project allowed us to obtain the quantity of the order of 1 kg of 98% pure lorándite and to determine erosion rate, i.e. the content of ^{205}Pb in lorandite as a result of solar neutrinos capture by ^{205}Tl and cosmic radiation contribution (Table 1).

Key issues for further research 1. **Neutrino capture probability** into the 2.3 keV state of ^{205}Pb. The ratio ^{205}Pb/^{205}Tl provides only the product of solar neutrino flux and neutrino capture probability into the different nuclear states of ^{205}Pb. However, the capture of neutrinos should populate predominantly the first excited state at E* = 2.3 keV. Hence, to get the neutrino flux itself, one has to determine the capture probability into this low-lying state of ^{205}Pb. (Figure 1) 2. **Extraction and detection of ^{205}Pb trace concentration**. How can the expected ultra-low abundance of ^{205}Pb be reliably measured?

Table 1. Cosmic ray contribution N (^{205}Pb)$_{\text{fast muons}}$ and N (^{205}Pb)$_{\text{total}}$

Depth of location m	Erosion rate m/Ma	N (^{205}Pb)$_{\text{fast muons}}$ x10^3 (at 1 kg of lorandite)	N (^{205}Pb)$_{\text{total}}$ x10^3 (at 1 kg of lorandite)	N(^{205}Pb)$_\nu$ %	N (Pb^{205}) fast muons %
28	75*	8.1	10.3	21	79
28	387**	1.7	3.9	56	44

*) Min erosion rate (^{3}He i ^{21}Ne) **) Max erosion rate (^{26}Al i ^{36}Cl)

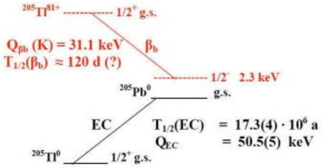

Fig.1. Decay scheme of neutral ^{205}Pb atoms (black) and of bare ^{205}Tl^{81+} ions (red).

Identification of the ^{205}Pb nuclei in the lead sample extracted from the lorandite mineral requires 10^{-10} to 10^{-11} overall detection sensitivity for ^{205}Pb/Pb and comparable suppression of the ^{205}Tl isobar. This is proposed by full stripping of ^{205}Pb at high energy (345MeV/u) at the **RIKEN-RIBF ion-beam facility**. ^{205}Tl isobar separation is in principle already largely achieved by chemical Pb-Tl separation by the overall sample preparation. Samples with a higher concentration (^{205}Tl/natPb = 1%) are necessary for a guide-beam and initial accelerator tuning. A sample with a considerably lower level of about 10^{-8} is needed for control of the beam analysis system with ^{205}Tl ions, in the presence ultimately of a lighter guide beam, to limit the in-beam production of ^{205}Pb by the (p,n) reaction on ^{205}Tl in the energy-loss and ion-stripping steps in the accelerator and the subsequent BigRIPS/Mass-Ring experimental apparatus. The relative cross sections between full stripping of ^{205}Pb and (p,n) on ^{205}Tl is estimated as 10^5. Test experiments to verify the various aspects of the proposed approach at the RIBF are under preparation.

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NEUTRINO 2016
SOUTH KENSINGTON, LONDON

Poster session 3: Wednesday 6 July

XXVII INTERNATIONAL CONFERENCE ON NEUTRINO PHYSICS AND ASTROPHYSICS
4–9 JULY 2016