Significance of the 2.3 keV isomer state in 205-Lead in determining its fate in the early solar system

Abstract ID : **69**

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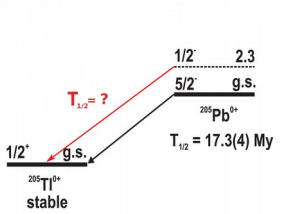
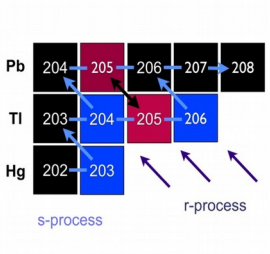
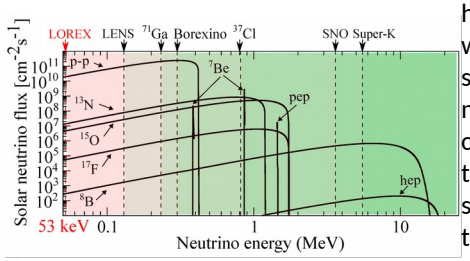
1. Introduction

1. ^{205}Pb is the only purely *s*-process SLR (10^7 yrs) alive in the early solar system.
2. Validity of ^{205}Pb as a chronometer can be strongly affected by the electron-capture (EC) from the first excited state of ^{205}Pb.
3. Due to availability of high charge state, β_b of ^{205}Tl could counter-balance ^{205}Pb abundance. Thus the experimental measurement is crucial.
4. In case of bound-state beta decay (β_b), an electron is created in one of the empty electronic orbitals and a monochromatic anti-neutrino is emitted into the continuum.



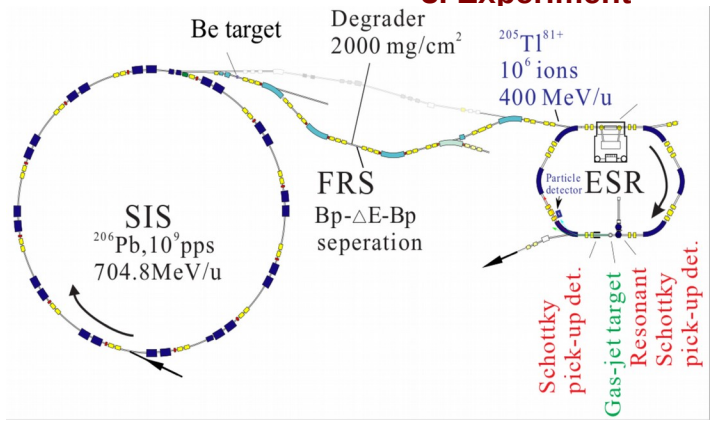
2. Physics motivation





There are two big physics cases attached with this experiment. One is linked with the LOREX project where the measurement is needed to determine the matrix element for the pp neutrino capture by the ground state of ^{205}Tl to the 2.3 keV excited state in ^{205}Pb. The second physics case is associated with the ^{205}Pb/^{205}Tl pair as a *s*-process cosmo-chronometer.

3. Experiment

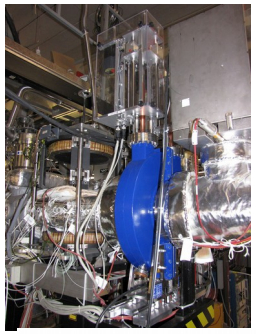


1. ^{206}Pb primary beam was bombarded on thin ^{9}Be target where ^{205}Tl^{81+} ions were produced.
2. ^{205}Tl^{81+} ions were well separated from the contaminants in the FRS and then were transferred to ESR where they were cooled and stored for different storage times.
3. At the end of storage time, Ar gas jet was switched on and the β_b daughter ions were detected by schottky cavity.

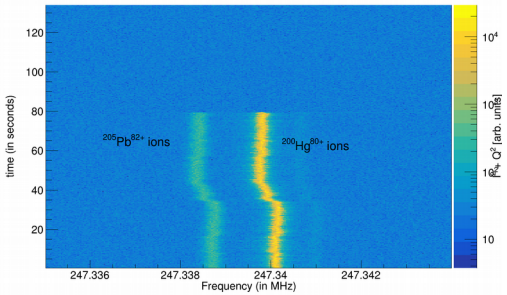
4. Results and outlook

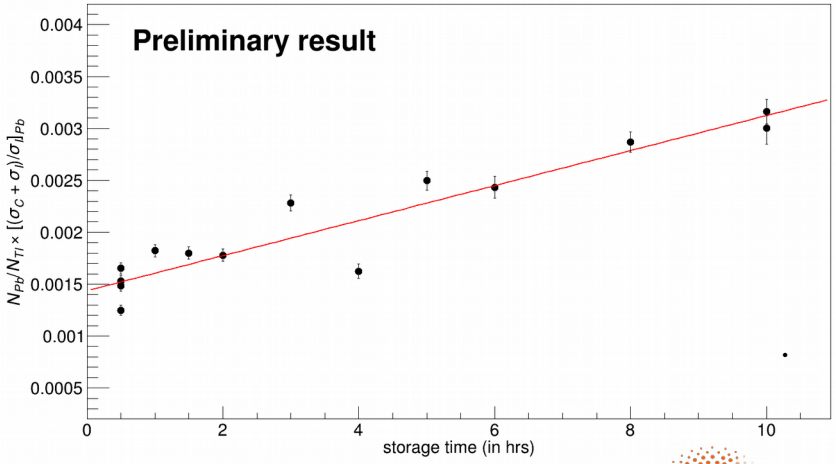
The principle for the half-life determination is given by the formula: where, λ_β is the decay constant, γ is the lorentz factor, N^*_{Pb} and N_{Tl} are the number of daughter and mother ions at the end of the storage time respectively.

$$\frac{N^*_{Pb}(t_s)}{N_{Tl}(t_s)} = \frac{\lambda_\beta}{\gamma} t_s \left[1 + \frac{1}{2}\left(\lambda^{cc}_{Tl} - \lambda^{cc}_{Pb}\right) t_s + \ldots\right]$$



On left is a picture of 245 MHz resonant Schottky non-destructive detector which was employed in the experiment. The integrated noise power is proportional to the number of stored ions. On right is the Schottky spectrum from one of the measurements where the daughter ions are counted after the gas jet target is switched off.





The adjacent figure shows the preliminary results from the first direct measurement of the half-life of bare ^{205}Tl ions. Longer measured half-life corresponds to a slower reduction of ^{205}Pb due to the electron capture from the 2.3 keV excited state. This is crucial for the understanding of the fate of ^{205}Pb in the early solar system.