ON THE NEED OF CONSTRAINING THE $^{244}$Pu CONTENT OF THE EARLY SOLAR SYSTEM.

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The increasing knowledge of both stable and short-lived radioactive isotope systems allows us to study the origin and early evolution of matter in the Solar System (SS) [1-3]. Technological advances over the last decade have led to a highly improved characterization of nucleosynthetic components (carrier phases) and their variability in meteorites [4], and the results have been used to model nucleosynthesis in different stellar environments [e.g. 5]. Using the short-lived radionuclides we can now investigate temporal constraints on the last astrophysical events that added freshly synthesized material to the matter in the interstellar medium that ended up in the SS and constrain the isolation time of the star-forming cloud where the Sun was born [6]. We can trace processes (e.g., production of $^{26}$Al) in massive stars within this stellar nursery and constrain the pre-solar history of the SS matter. Importantly, short-lived isotope systems may constrain the timing of element fractionation during the first few hundred million years following the formation of the first condensed mineral assemblages from the hot solar nebula, the material processing in the proto-planetary disk, as well as early planetary differentiation events such as core formation, large scale silicate melting, and major volatile depletion events [7].

However, in order to obtain a consistent picture of the earliest processes shaping our SS, the initial abundance of each short-lived radionuclide at the time of the formation of the Sun has to be inferred with very high accuracy. Specifically, we plan to improve the current estimates of the initial $^{244}$Pu abundance of the SS and to apply the Pu-Xe system to both pre-solar and terrestrial chronometry.

$^{244}$Pu is an extinct actinide with a half-life of 81 Ma produced exclusively by the rapid neutron-capture ($r$) process, and whose presence is recorded in the xenon isotope spectrum of early-formed solids [7]. Due to the atmophile nature of noble gases, the $^{244}$Pu-Xe chronometer has a great potential to date early volatile depletion events, however, the initial $^{244}$Pu abundances estimated from equilibrated ordinary chondrites and angrites vary by almost a factor of two [8,9]. Further, the two estimates have complementary caveats: i) The direct approach [8] involved analysis of neutron irradiated samples of the St Severin equilibrated ordinary chondrite (LL6). The induced fission of $^{235}$U produces fissionogenic Xe isotopes in different proportions to Pu. With this method an initial ($^{244}$Pu/$^{238}$U)$_{o,SS}$ ratio of 0.007±0.001 (2σ) at 4567 Ma was obtained directly from Xe measurements of stepwise heating experiments (and the ($^{235}$U/$^{238}$U)$_{o,SS}$ value). However, St Severine has a complicated and heterogeneous lithology, and may not be representative of the bulk SS composition ii) The indirect approach [9] involved analysis of pyroxene and whitlockite phases of the Angra dos Reis angrite using $^{150}$Nd as a reference isotope. This resulted in a significantly lower value of the initial ($^{244}$Pu/$^{238}$U)$_{o,SS}$ ratio of 0.0044±0.001 (2σ) at 4567 Ma. This approach, however, measured the absolute abundances of Nd on aliquots separate from the Xe analysis.

We show that current noble gas, REE and absolute age data on different volatile depleted meteorites do not improve the current estimate of the initial ($^{244}$Pu/$^{238}$U)$_{o,SS}$ ratio, but calls for a new comprehensive set of experiments. We outline our new approach that should establish reproducible differences, if any, between volatile depleted mineral separates, igneous differentiated meteorites, ordinary chondrites, and CAIs. We present simple volatile degassing models that consider recent findings in solid Earth noble gas geochemistry [10,11,12,13] and highlight the importance and the several implications of an updated estimate of the initial value: from constraints on the r-process site, to the birth of the Sun and the timing of the Moon Forming Giant Impact.