# Nuclear Data Uncertainty Quantification for Reactor Physics Parameters in Fluorine-19-based Molten Salt Reactors

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**Abstract:** The use of the F-19 isotope in the nuclear fuel cycle is already well established for fuel enrichment, but future plans for Gen-IV reactors such as Molten Salt Reactors could utilize a fluorine-based salt as a basis for the fuel. It is therefore imperative that an understanding of the characteristics of F-19 is instituted, and one component of key interest is the quantification of reactor parameter uncertainties that arise from the uncertainties in the nuclear data. The results from such analyses can shed light on where experimentalists need to further improve nuclear data for F-19, as well as yielding critical information for developing and optimizing reactor designs thanks to greater knowledge in the uncertainties that result from nuclear data.

In this work, we analysed a molten salt reactor based on the designs made by Transatomic Power. Uncertainty quantification was performed for two operating modes of the reactor – a thermal mode, and an epithermal mode with a faster neutron spectrum compared to the thermal mode due to the use of less moderator rods. We generated nuclear data that was sampled from the covariance matrices in the JEFF-3.3 nuclear data library using SANDY and NJOY. By utilising the Total Monte Carlo-approach, we propagated the uncertainties from the samples to uncertainties in the neutron multiplication by simulating the reactor in OpenMC, a Monte Carlo-based neutron transport code. Individual reaction channels were perturbed while keeping others constant, allowing for quantification of how much a single reaction channel contributes to the overall uncertainty.

For the thermal reactor, the F-19 data sampling resulted in an uncertainty in reactivity of 61.5 pcm. The main contributors of the reactivity uncertainty for the thermal reactor are elastic scattering, neutron capture and alpha production. The epithermal reactor, with a reactivity uncertainty of 213.4 pcm, is mostly affected by elastic scattering, inelastic scattering, and alpha production. The alpha production channel had an unexpectedly large contribution, and it should be investigated further. Quantitatively, we observe that scattering plays a bigger role for the uncertainty in the epithermal system, a phenomenon which could be explained by the fact that with less moderation in the form of moderator rods, the role of F-19 in thermalization of neutrons is greater, and hence its contribution to the uncertainty is greater.