ID: **P3.2-325** Type: **E-poster**

Impact Analysis of Hypothetical Space Reactor Re-Entry Using HotSpot Code

The development of space reactors represents a crucial advancement in exploration, providing sustainable energy for extended missions and emergency scenarios. This study focuses on the radiological impacts of a hypothetical space reactor accident during atmospheric re-entry at an altitude of 70 km, where aerodynamic and thermal stresses increase the risk of structural disintegration and radionuclide release. Utilizing the HotSpot code for radionuclide dispersion simulations, the research predicts dose distributions up to a distance of 200 km. The HotSpot simulations indicate that the Total Effective Dose Equivalent (TEDE) at a distance of 0.03 km was 130 Sv on the first day, rising to 710 Sv after 55 years, reflecting the long-term environmental radiation exposure. Organ-specific analysis using HotSpot showed that the liver absorbed 130 Sv on the first day, with a cumulative dose of 1300 Sv over 55 years. Persistent contamination was observed up to 80 km, where TEDE values were still measurable at 0.036 Sv after 55 years. These results emphasize the need to mitigate both immediate and long-term radiological risks, supporting enhanced safety protocols and environmental monitoring for space reactor operations.

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Session Classification: P3.2 Radionuclide Technologies and Applications

Track Classification: Theme 3. Monitoring and On-Site Inspection Technologies and Techniques: T3.2 Radionuclide Technologies and Applications