

Advancements in Analysis & Instrumentation @ R3B

The R3B (Reactions with Relativistic Radioactive ion Beams) experiment, a key component of the NUSTAR collaboration at FAIR, enables high-precision investigations of radioactive nuclei in inverse kinematics through its large acceptance and complete kinematic reconstruction. As such it offers the unique possibility for understanding the dynamics of nuclear reactions under extreme conditions. This contribution presents recent progress in two central analysis fields:

- (i) benchmark measurements of the total interaction cross section of $^{12}\text{C} + ^{12}\text{C}$ for equation-of-state studies at R3B, and
- (ii) quasi-free scattering reactions, including the pilot experiment *fission via quasi-free scattering*.

In addition, recent instrumental developments are highlighted, with a particular focus on the CALIFA calorimeter. The TUM group plays a leading role in its development and operation, contributing to hardware upgrades, software improvements, and the application of machine-learning techniques for enhanced cluster reconstruction. All these advancements contribute significantly to the promising experimental campaigns planned for the Early-Science program at FAIR, scheduled to begin in 2028.