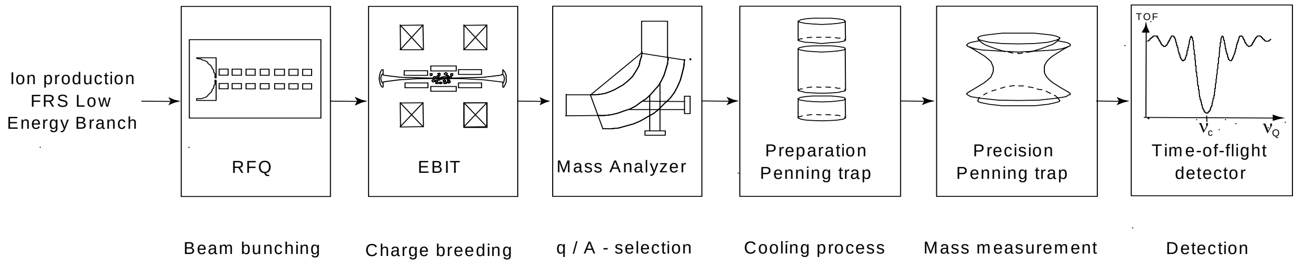
Executive Summary for *MATS*, an Advanced Trapping System



The mass is a unique property that distinguishes each nucleus. The binding energy, i.e. the difference between the total mass and the mass of the constituents, is the result of the strong force and the Coulomb force acting within the nucleus. Investigating nuclides with systematically varying numbers of protons and neutrons provides important insights. Precise mass measurements of all nuclei, especially short-lived radionuclides, provide a versatile testing ground for the understanding of complex nuclear structure such as shell closures, deformation, shape transitions, pairing, and isospin symmetry. Beyond nuclear structure physics, precise mass values are important for a variety of applications, ranging from nuclear-decay studies of the weak interaction and of the Standard Model to astrophysical models for X-ray bursts and the creation of heavy elements in stars.

Precise mass measurements combined with decay spectroscopy help to answer questions like: Is the nuclear shell structure concept applicable to very exotic nuclei? How does the deformation of the nucleus come about? Is the weak force sufficiently described in the Standard Model? How were the heavy elements created and distributed over the Universe?

The required relative uncertainty ranges from 10^{-5} to below 10^{-8} for radionuclides, which most often have half-lives well below 1 s. Substantial progress in Penning trap mass spectrometry has made this method a prime choice for precision mass measurements on rare isotopes. The technique has the potential to maintain high accuracy and sensitivity even for very short-lived nuclides. Furthermore, ion traps can be used and offer advantages for precision decay studies due to the well-defined storage conditions that are free of impurities.

With MATS (Precision Measurements of very short-lived nuclei using an Advanced Trapping System for highly-charged ions) at FAIR we aim for applying two techniques to very short-lived radionuclides: high-accuracy mass measurements and in-trap spectroscopy of conversion-electron and alpha decays. The experimental setup of MATS is a unique combination of an electron beam ion trap for charge breeding, Paul and Penning traps for beam preparation, and a high precision Penning trap system for mass measurements and decay studies.

MATS offers both high accuracy potential and high sensitivity. A relative mass uncertainty of 10^{-9} can be reached by employing highly-charged ions and non-destructive Fourier-Transform-Ion-Cyclotron-Resonance (FT-ICR) detection technique on a single stored ion. The high charge state of the ions can also be advantageously used to reduce the required storage time, hence making measurements on even shorter-lived isotopes possible.

Decay studies in ion traps will become possible with MATS. Novel spectroscopic tools for in-trap high-resolution conversion-electron and charged-particle spectroscopy from carrier-free sources will be developed, aiming *e.g.* at the measurements of quadrupole moments and *E0* strengths. With the possibility of both high-accuracy mass measurements of shortest-lived isotopes and decay studies, its high sensitivity and accuracy potential, MATS is ideally suited to for the study of very exotic nuclides that will only be produced at the FAIR facility.