Francium sources and traps for fundamental interaction studies

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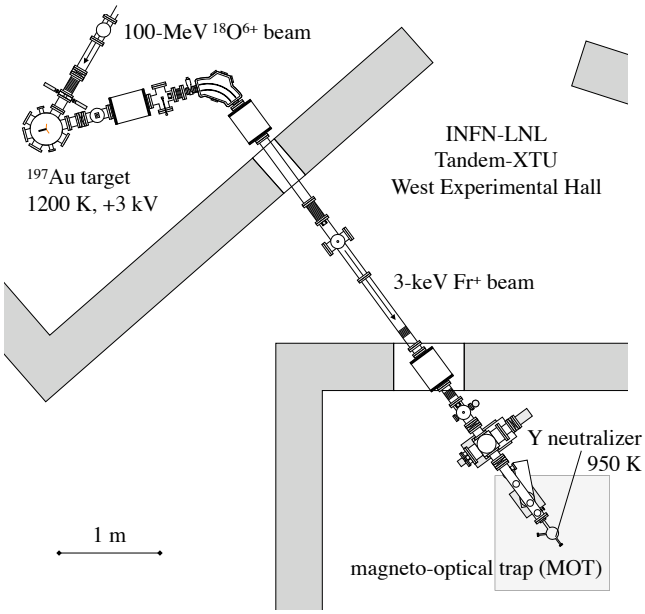
Francium is one of the best candidates for atomic parity nonconservation (APNC) [1,2] and for the search of permanent electric dipole moments (EDMs) [3,4]. APNC measurements test the weak force between electrons and nucleons at very low momentum transfers. They also represent a unique way to detect weak nucleon-nucleon interactions. EDMs are instead related to the time-reversal symmetry. Preliminary to these fundamental measurements are precision studies in atomic spectroscopy and the development of magneto-optical traps (MOT), which partially compensate for the lack of stable Fr isotopes. At LNL Legnaro, francium is produced by fusion of 100-MeV ^{18}O with ^{197}Au in a thick target, followed by evaporation of neutrons from the compound nucleus. Francium diffuses inside the hot target (1200 K) and is surface ionized for injection at 3 keV in an electrostatic beamline. Typically, we produce 1×10^6 (^{210}Fr ions)/s for a primary flux of 1.5×10^{12} particles/s. We have studied Fr yields as a function of primary beam energy, intensity, and target temperature. Information on the efficiency of bulk diffusion, surface desorption and ionization is deduced. The beam then enters a Dryfilm-coated cell, where it is neutralized on a heated yttrium plate. The escape time of neutral Fr (diffusion + desorption) is approximately 10 s at 950 K, as measured with a dedicated setup. In the MOT, we use 6 orthogonal Ti:sapphire laser beams for the main pumping transition and 6 beams from a stabilized diode repumper. Fluorescence from trapped atoms is observed with a cooled CCD camera, in order to reach background levels from stray light equivalent to approximately 40 atoms. Systematic tests are being done to improve the trapping efficiency. We plan to further develop Fr traps at LNL; in parallel, we will study APNC and EDM techniques and systematics with stable alkalis at Pisa, Siena, and Ferrara.



Layout of the experimental apparatus.

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