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Simulations, design and commissioning of the debuncher prototype for the EMILIE project

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The goal of *WP2* of the *EMILIE* project was to simulate, design, build and commission a device which operates as a debuncher using high intensity *n+* bunched beams from *EBIS* charge breeders and which ejects continuous-wave (*CW*) ion beams.

The advantages of the *EBIS* breeding technique compared to the *ECR* method include formation of pure samples and very high charge states whereas the main disadvantage is related to lower intensities. In addition the *EBIS* is a pulsed device which provides all the statistics in relatively narrow time windows (typically in the order of several 10 µs and up to a few 100 µs in an extended extraction regime). The breeding time which is necessary for completion of the *EBIS* cycle can be as high as several 100 milliseconds. The ratio of the two characteristic times leads to the formation of very time-dense distributions which already at present intensities up to 10e+6 pps have started to be undesired due to large dead-times, pile-ups, and random coincidences at the experiments (e.g. beams from *REX-EBIS* at *ISOLDE*). With the planned increase of intensities in the future facilities this becomes a critical point for the utilization of EBIS breeders and need to be overcome.

The principle of operation of the debuncher is based on trapping of ion bunches using a linear radio frequency quadrupole (*RFQ*) structure and switching of *DC* potentials for radial and longitudinal confinement respectfully. The use of highly charged beams requires operation in very good vacuum conditions in order to avoid losses due to charge exchange processes which implies that only conservative forces are used in the debuncher operation, thus the beam emittance of the beam should be preserved. After the trapping of the beam bunches the ions are diffused in longitudinal direction within the debuncher structure and by slow ramping of selected *DC* potentials *CW* beams are formed through the exit electrodes of the device achieving a very narrow energy distribution compared to the incoming ion bunches.
The operation principles of the debuncher have been verified by extensive simulations at *GANIL* with *SIMION*. *RF* and *DC* potentials have been varied in order to determine the operational ranges for the device. The results from the simulations are promising –both high transmission (>85 % transmission for a 45 cm long debuncher and 50 microseconds incoming bunch length) and the desired flattened time structure have been achieved with many possibilities to improve both by increasing the length of the device and adjusting DC potentials/sequencing respectively.

The first results from the simulations allowed continuing with designing and building of the prototype debuncher in 2012 at *LPC Caen*. The required *RF* and *DC* electronics were built and tested soon after with the final step remaining the commissioning of the debuncher at a facility which could provide ion bunches with characteristics similar to the *EBIS* beams. The first tests of the debuncher operation were performed in 2015 at the *SHIRaC* test bench at *LPC Caen* where *1+* continuous stable ion beams were used. The results from these tests were sufficient for the qualitative confirmation of the operation principles but measurements of efficiencies of trapping and extraction were not achieved. The latter can be done eventually in a new set of measurements at an improved experimental setup which can allow for the formation of ion bunches at the input.

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