ReA3 Service level description

This document describes the level of support provided by the ReA Department to users of the ReA3 beams at the ReA3 experimental Hall and outlines user responsibilities with respect to the system. This information is presented in three sections:

1. Standard Configuration
2. Support Level
3. User Responsibilities

1. Standard configuration

The ReAccelerator facility ReA3 is a worldwide unique, state-of-the-art accelerator for rare isotope beams. The beams accelerated by ReA3 can be provided by a Colutron source, the EBIT, or by the gas Stopper in the N4 vault. After the sources, the main components of ReA3 are:

- Cooler-Buncher, where beams can be collected and prepared to injection into the EBIT breeder
- Electron Beam Ion Trap (EBIT) charge breeder, where singly-charged ions are bred to high charge states
- Room temperature Radio Frequency Quadrupole (RFQ), allowing beams to be accelerated from 12 keV/n to 600 keV/n
- Superconducting linac with independently phased cavities
- Beam distribution system with three beam lines.

Beams of rare isotopes are produced and separated in-flight at the NSCL Coupled Cyclotron Facility and subsequently thermalized in the linear gas cell at N4 vault. The rare isotopes are then continuously extracted as 1+ (or in a few cases as 2+) ions or molecular ions and transported through the Cooler/Buncher to the ReAccelerator charge breeder. In the EBIT charge breeder, the 1+ beam is captured in the ion trap, ionized to a charge consistent with the operation range of the SRF linac, extracted in a pulsed mode, mass analyzed and injected into the ReAccelerator. The beam, after extraction is bunched to the operation frequency of the RFQ and SRF linac of 80.5 MHz and accelerated to energies ranging from 300 keV/u up to 6 MeV/u, depending on the charge-to-mass ratio (q/A).

Alternatively, stable ions can be injected into the linac from the EBIT in off-line mode (by ionization of residual gas without injection from N4) or by the off-line injector source (Colutron source).
The minimum energy which can be delivered by ReA3 is 300 keV/u, when using selected resonators as decelerators.

The maximum energy varies with q/A of the accelerated ion according to the following relationship:

$$E\ (\mathrm{MeV/n}) = 12\ (q / M)$$

where q is the charge state of the ion and M is its atomic mass. The range of q/M accelerated by ReA3 is between 1/4 to 1/2.

The beam emittance in the experimental hall is usually better than 5 π mm mrad (4 RMS).
Due to the intrinsic batch-mode operation of the EBIT, all beams (with exception of those from the Colutron, e.g. H2+) have a macrostructure. The pulse length and duty-factor vary with the charge state and total power in the RFQ. Some flexibility with respect to the time structure exit is possible to adapt to the experimental requirements. This is an active area of development.

The ReA3 beam is delivered to one of three experimental points in the ReA3 experimental Hall. The beam sizes can vary from about 2 mm to about 2 cm depending on position.

The beams (particularly low-intensity rare ion beams) are likely to be contaminated by stable ions that are near-by in q/M. One is not expected to have rare ion contamination in the beams provided by ReA3, as they are first selected by the A1900 and then by range in the gas cell. An estimate of the stable-ion contamination level as well as the nature of the contamination will be provided by the ReA3 team for each experiment.

2. Support Level

Prospective users of ReA3 are required to follow instructions given in the NSCL User Guide (http://www.nscl.msu.edu/users/guide.html) and submit a proposal to the NSCL-PAC.

The ReA team will provide information needed for preparation of plausible proposals to the NSCL-PAC. This includes beam intensities, beam emittance, estimates of contaminants and timing structure. The supported beam list, updated periodically, is available at: http://www.nscl.msu.edu/users/beams.html. Beams not in the list require development and are not included in the base level of support. New beam requests and requirements should be sent by Letter of Intent to the NSCL Director (preferred) or by a full proposal. Collaboration with the gas cell and ReA teams on non-supported beam development is also possible.

The ReA team will provide feedback to the PAC on the feasibility of submitted proposals.
Prior to each experiment, the ReA contact person, the Manager for User relations and the User will establish one Experiment Service Description (ESD).

A certain number of diagnostic devices (all intercepting) are used for tuning the beam, like Faraday cups, beam profile monitors, etc. Users can have access, if needed, to the data from these devices.

One member of the ReA team will be designated to work with the spokesperson. Contact person: Antonio Villari (villari@frib.msu.edu).

Other than the beam, and if requested, ReA can provide a synchronous electronic signal with the beam pulse structure.

One ReA operator will be assigned per shift during the whole duration of the experiment.

The ReA team will strive to deliver the requested beam with the characteristics needed to complete the approved experiment.

3. User Responsibilities

The User (spokesperson or assigned by the spokesperson) must communicate with the ReA team during the preparation of the experiment.

The experimental setup must be compatible with one of the ReA3 beam lines. Special attention must be taken to maintain an excellent vacuum level in the beam lines. All beam lines of ReA3 operate on the 10-9 Torr level. If the experimental set-up has a higher vacuum level, special pumping between the experiment and the beam line must be installed. The ReA team can help design and test solutions to vacuum problems.

The User must provide a signal to ReA for monitoring the counting rate and for final tuning of the beam to the experiment.