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Overfocusing of the MEBT Bunch Rotator

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Abstract: During model-coupled accelerator tuning development, it was observed that for low A/q values ($\leq$ 4.5), an overfocus condition exists in the ISAC-MEBT section. This document is a record of this measurement.

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The first RF component in the ISAC linac medium energy beam transport (MEBT) section, shown in Figure 1, consists of a 3-gap, 106 MHz cavity[1]. The device is of identical exterior design as the three bunching cavities of the ISAC-DTL. It is intended to allow for the establishment of a time-focus at the stripping foil[2] and is referred to as the Bunch Rotator. The original design tune of the MEBT section (documented in [3]) calls for an (x, y, z) waist at the foil for a beam of A/q = 30 at E/A = 0.153 MeV/u, shown in Figure 2. This choice traces its history to the DRAGON experiment at ISAC-I, whose beams of interest were influential in the design of the ISAC-RFQ.

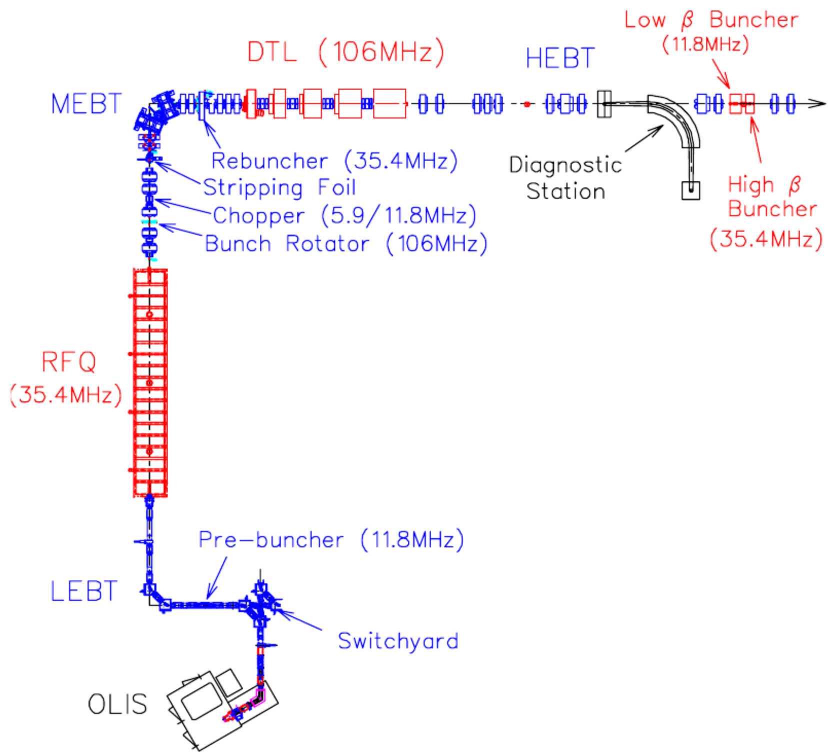

Figure 1: Overview of the ISAC-I linear accelerator.

Beyond the MEBT corner, all RF cavities are designed to accept a maximum A/q of 6. Should out-of-RFQ beams exceed this, the stripping foil in MEBT is used. This means that, of the room temperature cavities in the linac, excluding the RFQ, the Bunch Rotator has the highest maximum A/q rating. As a consequence, a correspondingly more powerful power supply unit is used for its operation.

This note presents an observation made in the ISAC-MEBT section, using an $^{18}O^{4+}$ beam (A/q = 4.5) that the ISAC Bunch Rotator is incapable of performing a time-focus at the location of the MEBT stripping foil. This is done by measuring the time spread of RFQ accelerated beam, using a time-sensitive Fast Faraday Cup, MEBT:FFC5. Figure 3 shows measured 2rms timespread for this beam, measured on 2021-05-21.

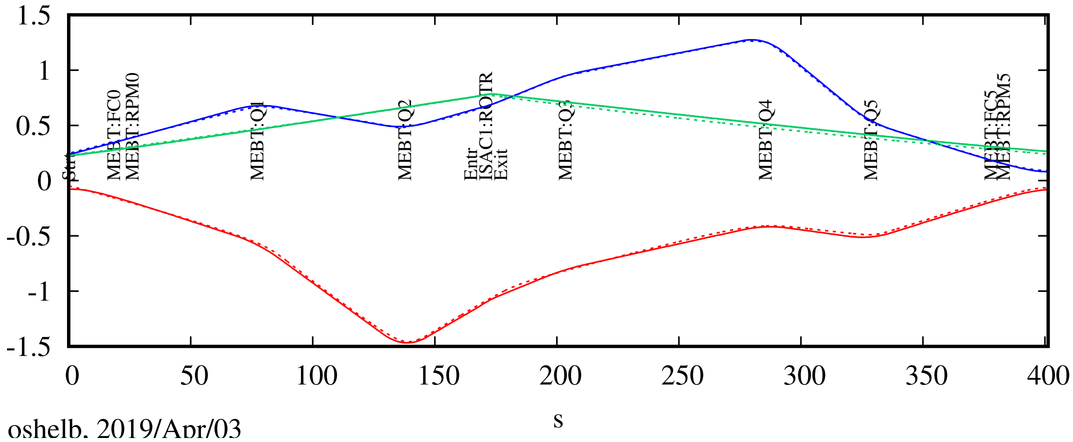

Figure 2: Comparison between `TRANSOPTR` model of ISAC-MEBT section and original `trace3D` 2rms envelopes for an A/q = 30/1, E/A = 0.153 MeV/u beam. The Bunch Rotator's effect upon the z (time) envelope of the beam can be seen at the rough midpoint of the simulation.

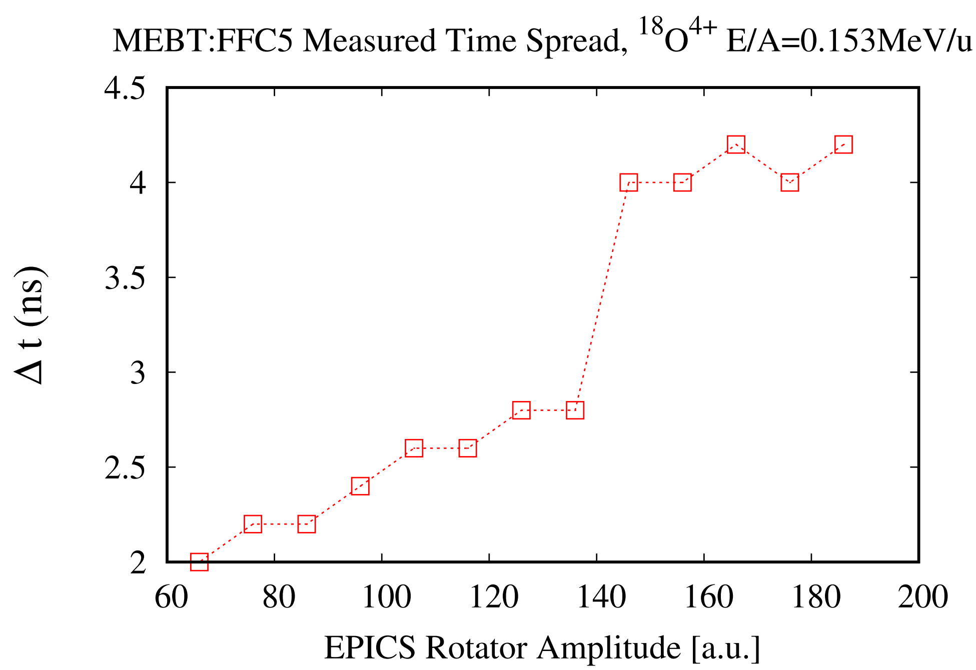

Figure 3: Measured MEBT:FFC5 time spread, defined as the peak width above the rms noise level for each acquired dataset. Decreasing Bunch Rotator field amplitude produces a narrowing of the observable time structure of the beam. This trend continues until the power supply amplitude is too low for stable operation, tripping either on rf interlocks or vacuum.

Would a time focus exist at the location of the Fast Faraday cup, one would expect to achieve a minimum time-spread in the beam distribution at a given rotator amplitude setting. This would correspond to a configuration similar to what is shown in Figure 2 for the z-envelope. At such a condition, either lowering or raising the amplitude of the Bunch Rotator should cause an increase in the measured time structure. However, the collected data from Fig. 3 suggests that for any Bunch Rotator amplitude setting, no such minimum can be achieved. This condition has existed for the lifetime of machine operation, meaning any beam with A/q at or below 4.5 was overfocused, with consequences downstream.

References

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[2] M Marchetto and RE Laxdal. High energy beam lines. In *ISAC and ARIEL: The TRIUMF Radioactive Beam Facilities and the Scientific Program*, pages 99–109. Springer, 2013.

[3] Olivier Shelbaya. TRANSOPTR Implementation of the MEBT Beamline. Technical Report TRI-BN-19-02, TRIUMF, 2019.