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A 3-gap Booster Cavity to Match Ion Source Potential to RFQ Acceptance

Bob Laxdal, ZT Ang, T. Au, S. Kiy, S. Rädcl, O. Shelbaya, V. Zvyagintsev

TRIUMF

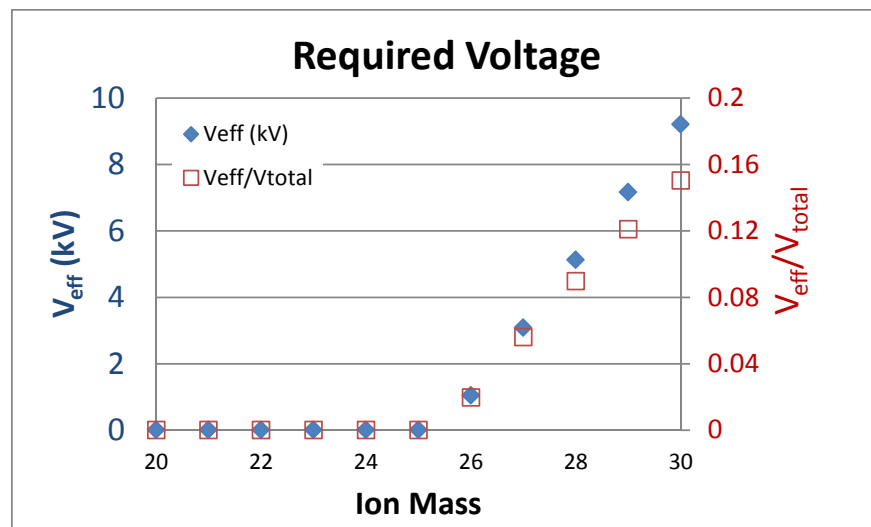
MOOP01, LINAC2018, Sept. 17, 2018



• Motivation

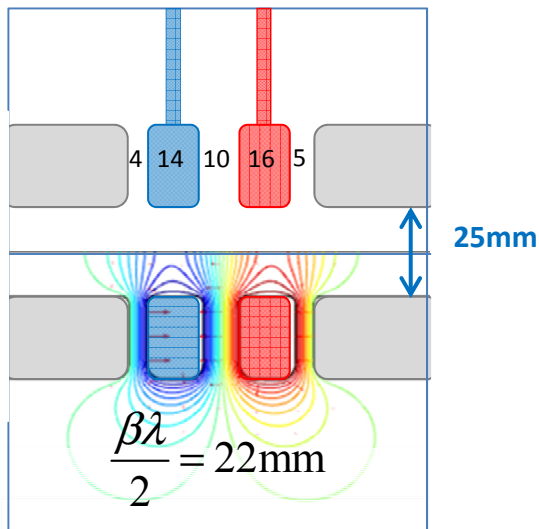
- The ISAC target modules have trouble holding voltages above 52kV
- RFQ can accelerate ions with $A/q \leq 30$
- RFQ acceleration demands $V_{\text{final}} = A * 2.04$ so masses > 25 require further voltage
- Goal is to add a small rf accelerating structure in front of the RFQ to augment the source bias when required

$$V_{\text{boost}} [\text{kV}] = 2.04 \frac{A}{Q} - V_{\text{source}} [\text{kV}]$$

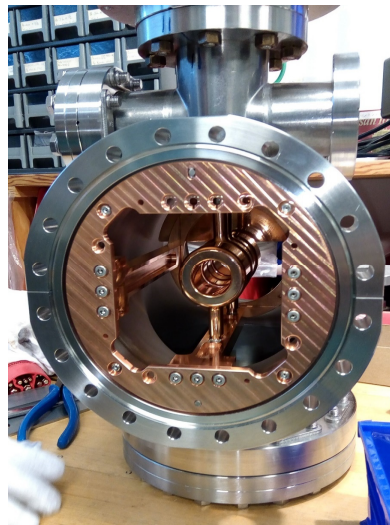


$$V_{eff} = 10\text{kV}, N_{gap} = 3, \text{ aperture} = 25\text{mm}$$

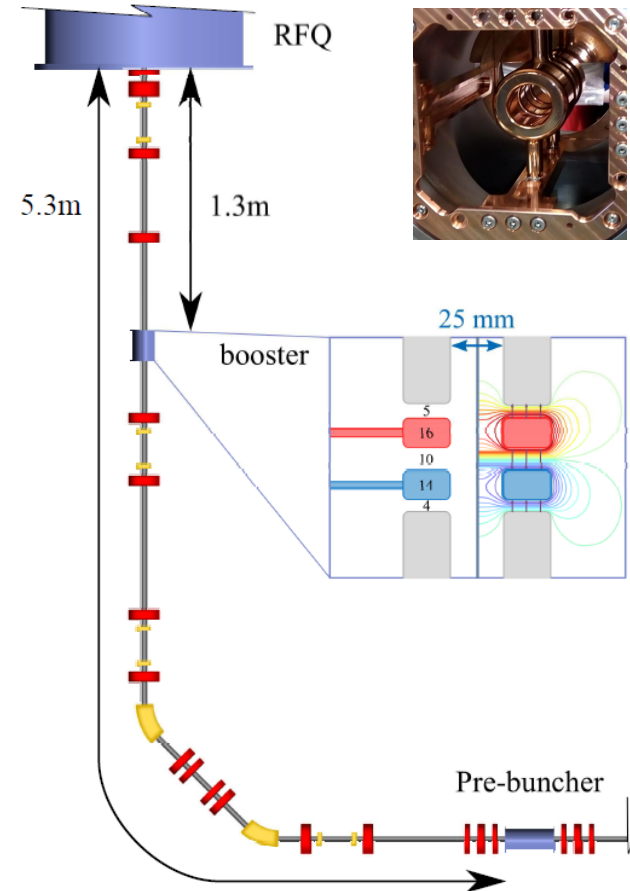
$$f = 11.8\text{MHz}, \beta = 0.17\%, \frac{\beta\lambda}{2} = 22\text{mm}$$

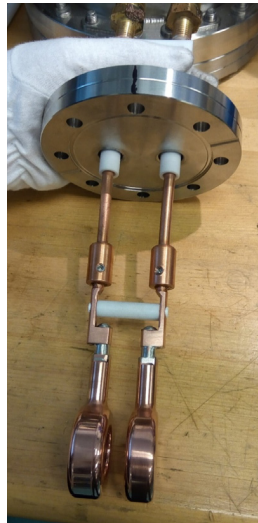
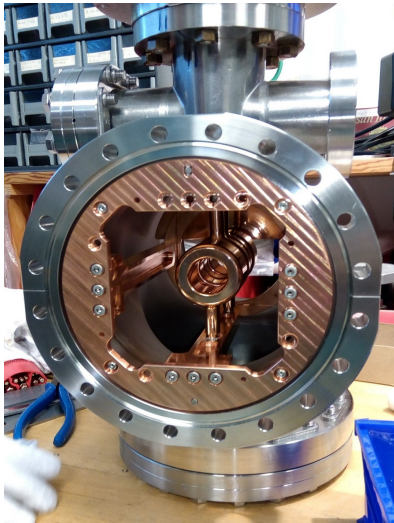


Drift tube geometry



Drift tube BL assembly

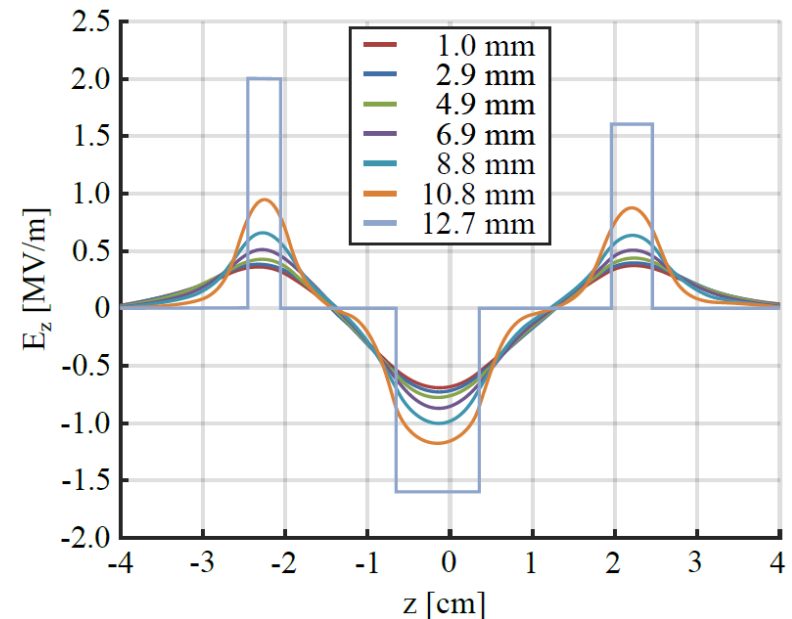




Attained $Q=1600$, $V_{\text{tube}}=4.7\text{kV}$ and $V_{\text{eff}}=9.8\text{kV}$

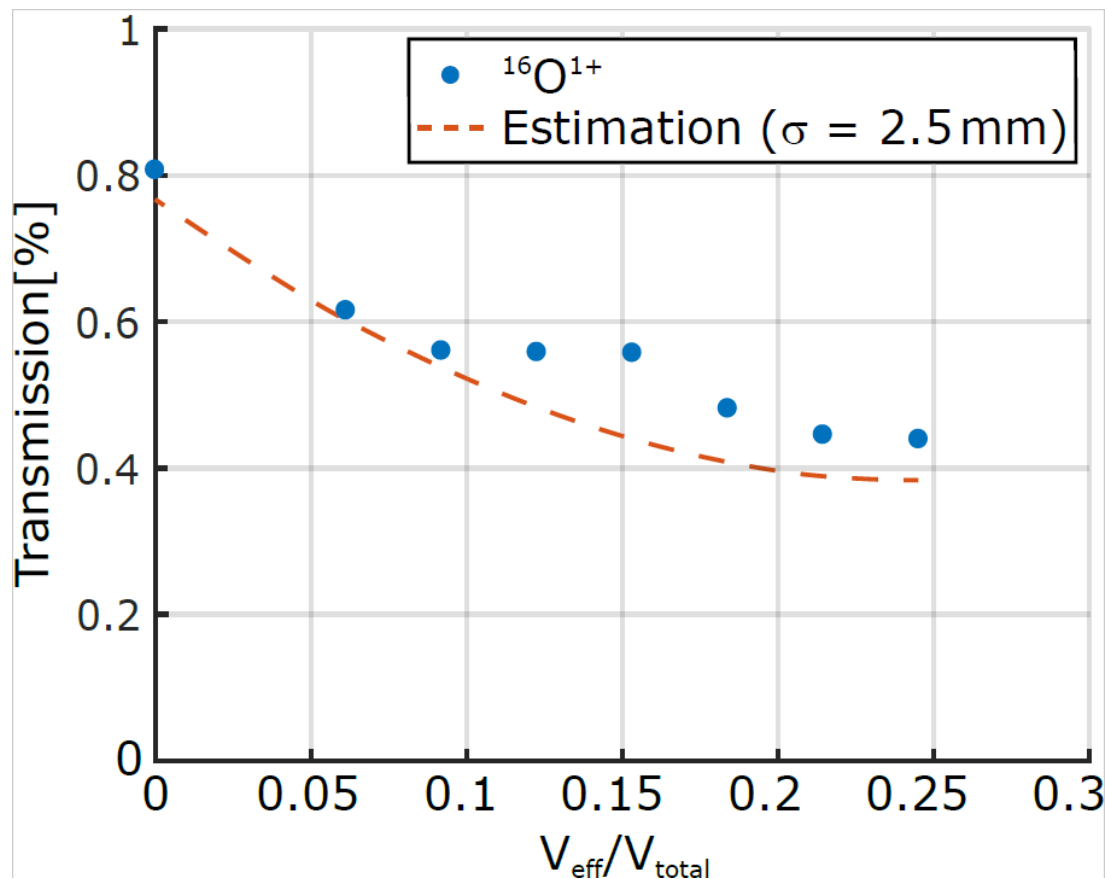
- Low velocity and large aperture creates strong dependence of the acceleration efficiency with radius
- Produces radial/longitudinal coupling that somewhat debunches the beam at the RFQ
- Reduces the RFQ transmission depending on the relative booster strength and beam size

$$\Delta W(r) = \frac{Q}{A} 4V_0 \xi(0) I_0(k_s r) \cos \phi_0 \approx 2 \frac{Q}{A} V_0 I_0(k_s r) \cos \phi_0$$

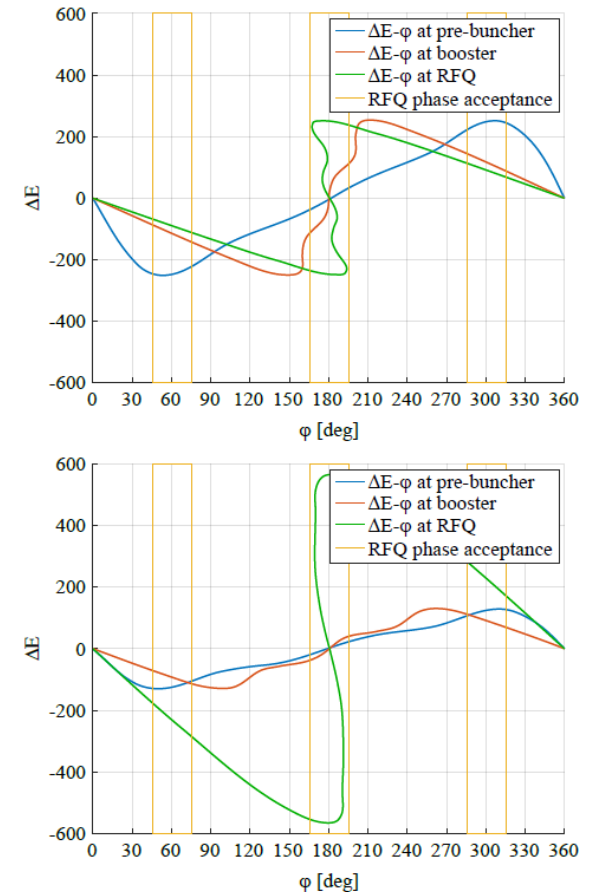


Demonstration

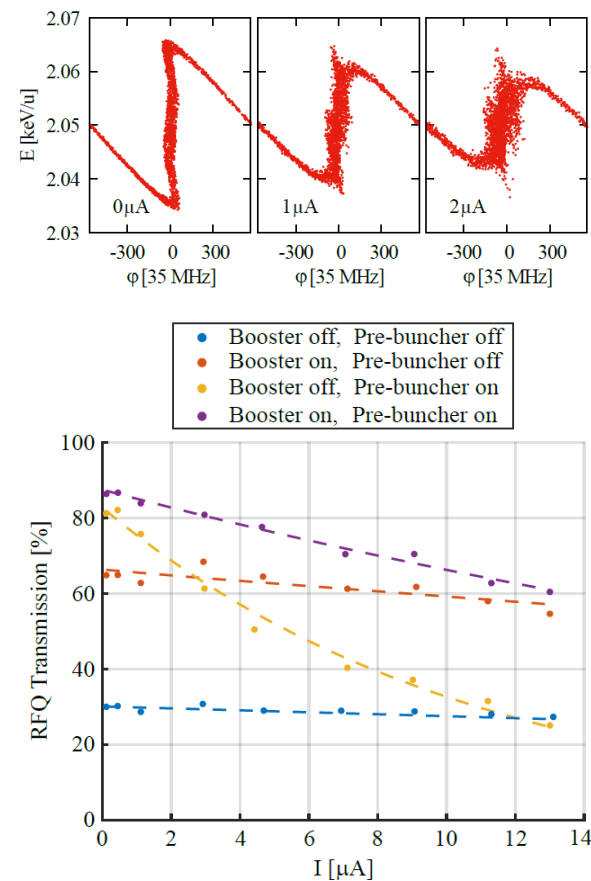
- Measured RFQ capture for $^{16}\text{O}^{1+}$ for various bias and booster values up to 8kV voltage added
- Reasonable transmission (>40%) for 25% voltage compensation



- The rf booster can also be used as a buncher.
- Bunching modes
 - Pre-buncher only: >75% capture
 - Booster only : >50% capture
 - Tandem: >80% capture



- Acceleration in the ISAC RFQ is space charge limited due to longitudinal debunching between the pre-buncher and the RFQ
- The debunching is dependent on A/q and the bunching drift length
- The space charge threshold can be increased by a factor of ~ 10 by using the booster as buncher
- This was demonstrated in beam tests





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