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IOTA rf cavity for 171Yb+ ions

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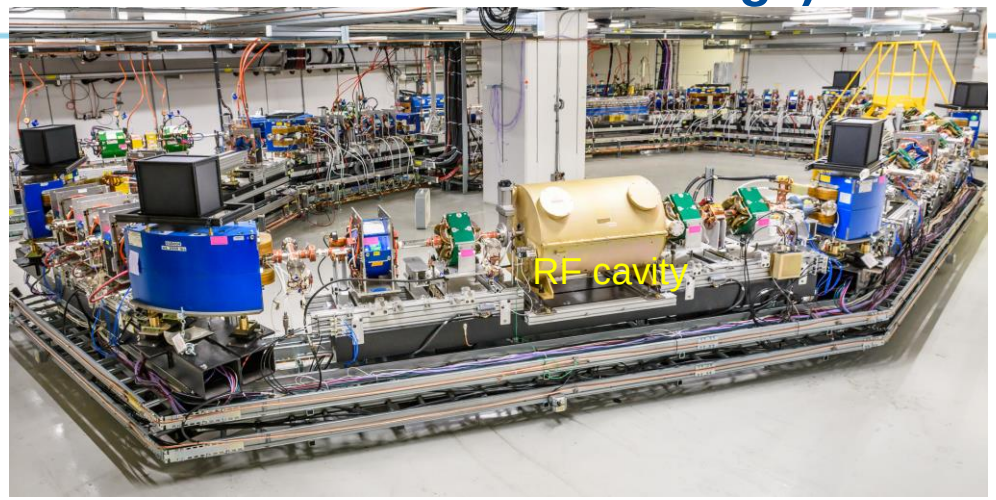
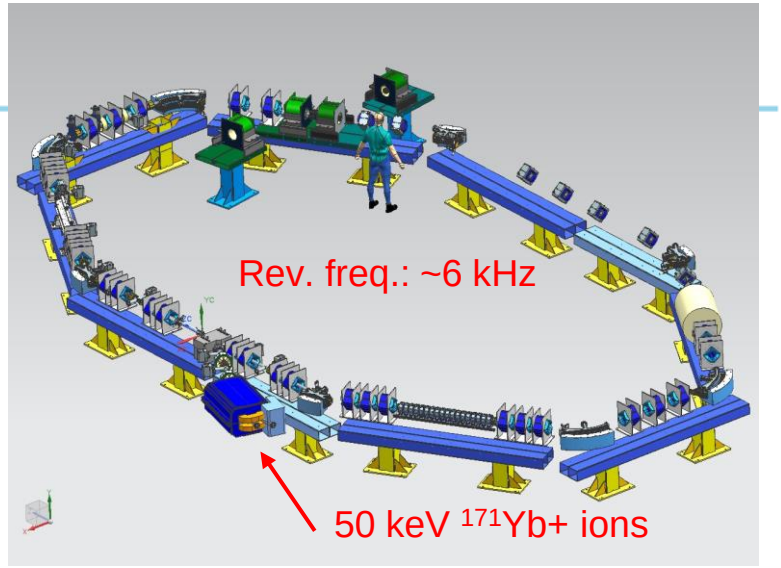
Fermilab IOTA ring (40-m circumference, 50 – 150 MeV/c momentum range)

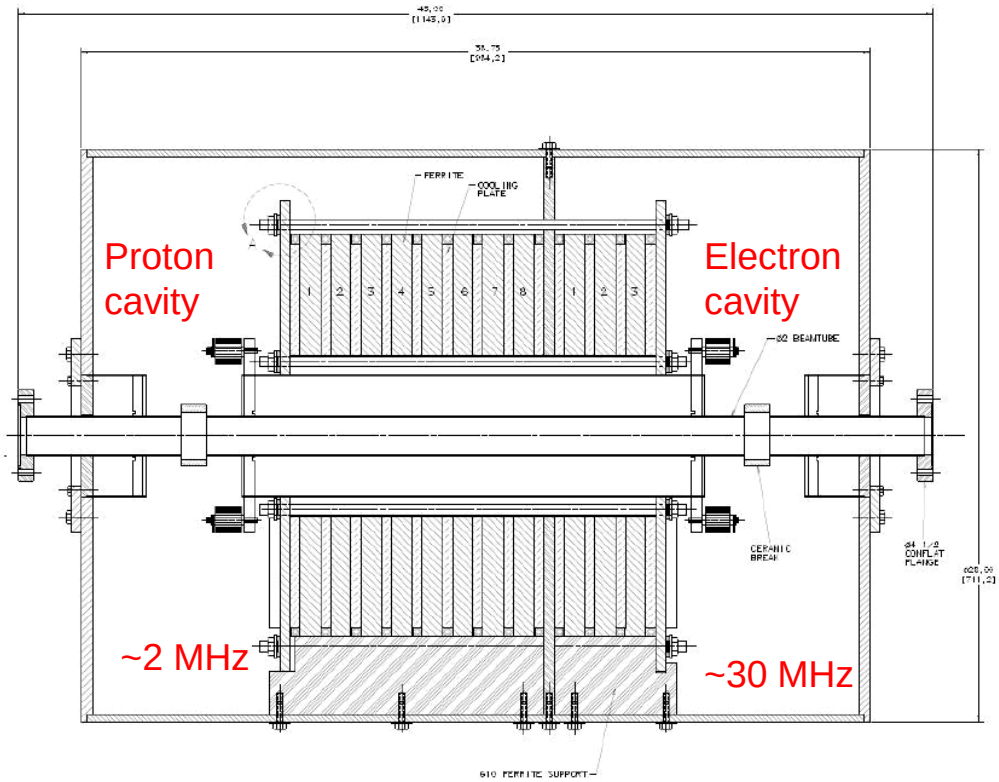




- Present status: operating with relativistic electrons (~100-150 MeV)
- **This proposal:** add a 50-keV (120-MeV/c momentum) ^{171}Yb+ ion source, install counter-propagating lasers for Doppler laser cooling and extra ion diagnostics.
- Let's assume that we can achieve +/- 50 eV energy spread

$$\frac{\Delta v}{v} = \frac{\Delta p}{p} = \frac{2\Delta E}{E} = \pm 2 \times 10^{-3}$$

Existing IOTA rf cavity



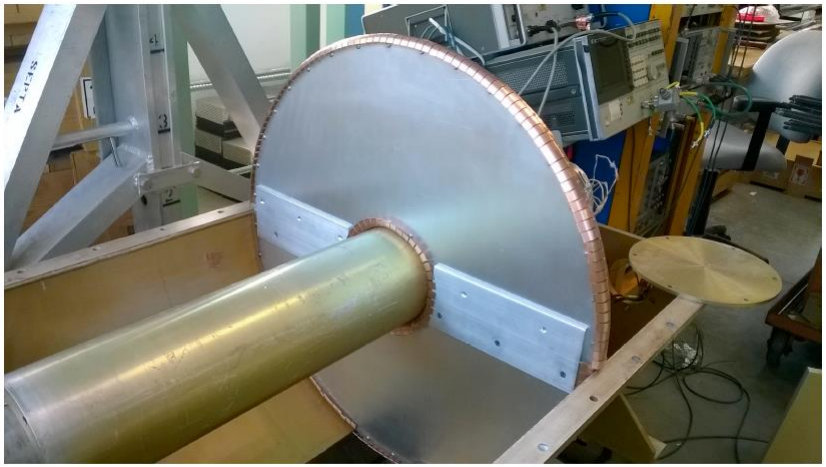
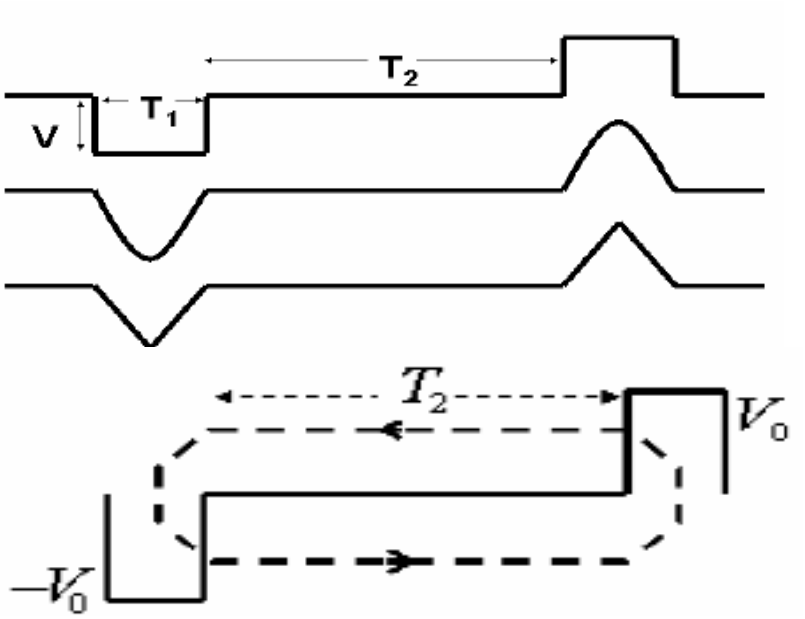


Fig. 6. The separator decoupling the 2 MHz and 30 MHz cavities

- The IOTA already has a dual-purpose rf cavity (ferrite loaded) for protons (2.5 MeV) and electrons (150 MeV)
- Both cavities are designed to operate at harmonic 4 of the revolution frequency

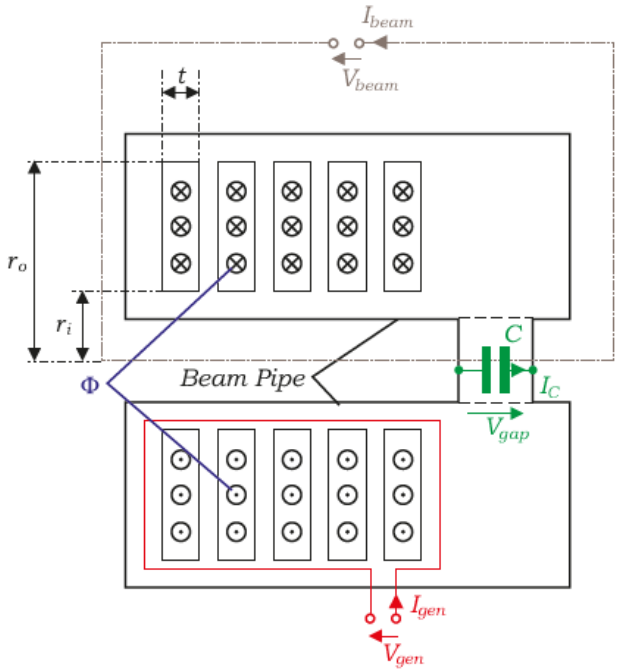
RF cavity for 171Yb+ ions

- At 50 keV the revolution frequency is 5.9 kHz (~168 μsec).
- Ideally, we would like to have a barrier-bucket rf system
  - ~5 V, 10 μsec rf barriers



- Need to investigate if the existing rf cavity is capable of operating as a barrier cavity…

Ferrite-loaded cavity



$$\oint_{\partial S} \vec{E} \cdot d\vec{l} = -\int_{S} \dot{\vec{B}} \cdot d\vec{S}$$

- In general, a ferrite-loaded cavity is a single-turn transformer

$$V_{gap} = \frac{1}{c}\frac{d\Phi}{dt} \approx \frac{2\mu t}{c^2}\ln\left(\frac{r_0}{r_i}\right)\frac{dI_{gen}}{dt}$$

- If μ ~ 100, t = 10 cm, we can get ~5 V for 1 A/μsec