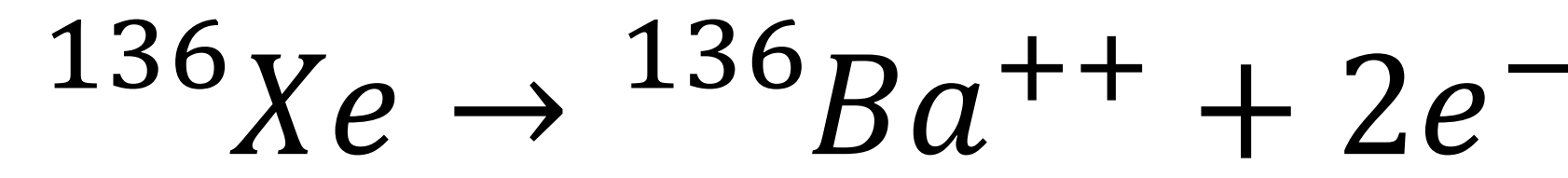
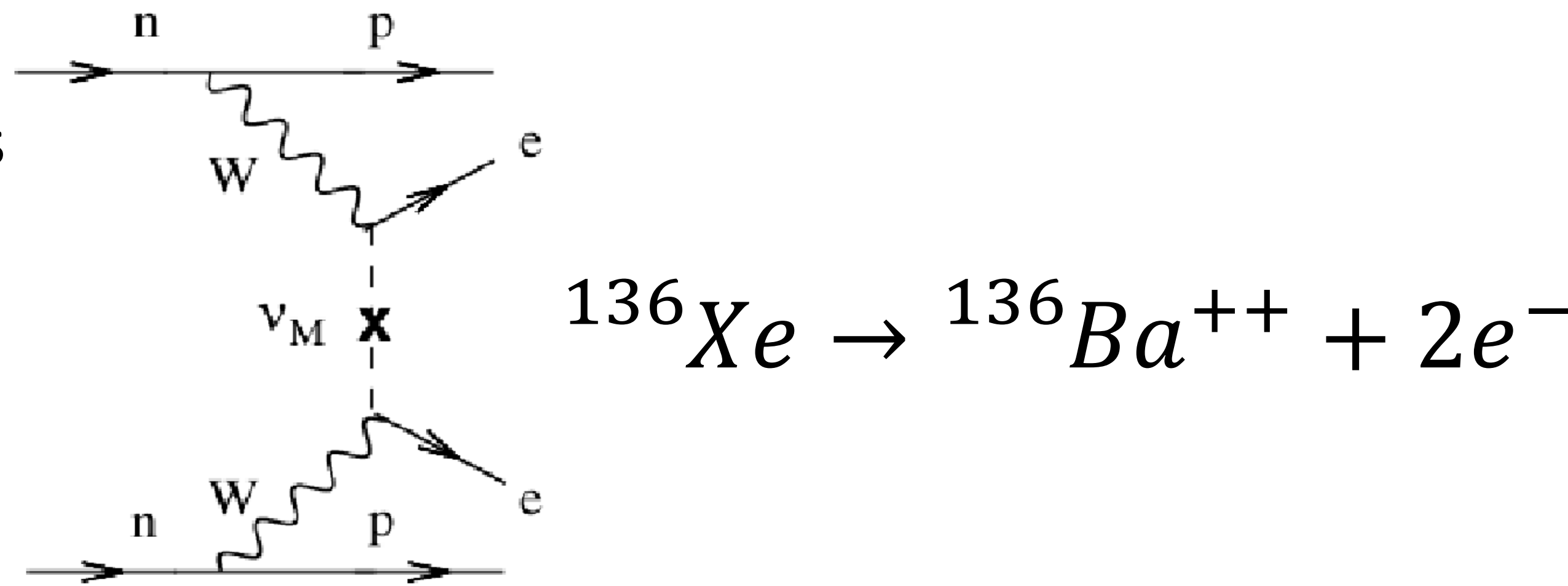


## Neutrinoless Double Beta Decay in the nEXO Detector

Discovery would demonstrate:

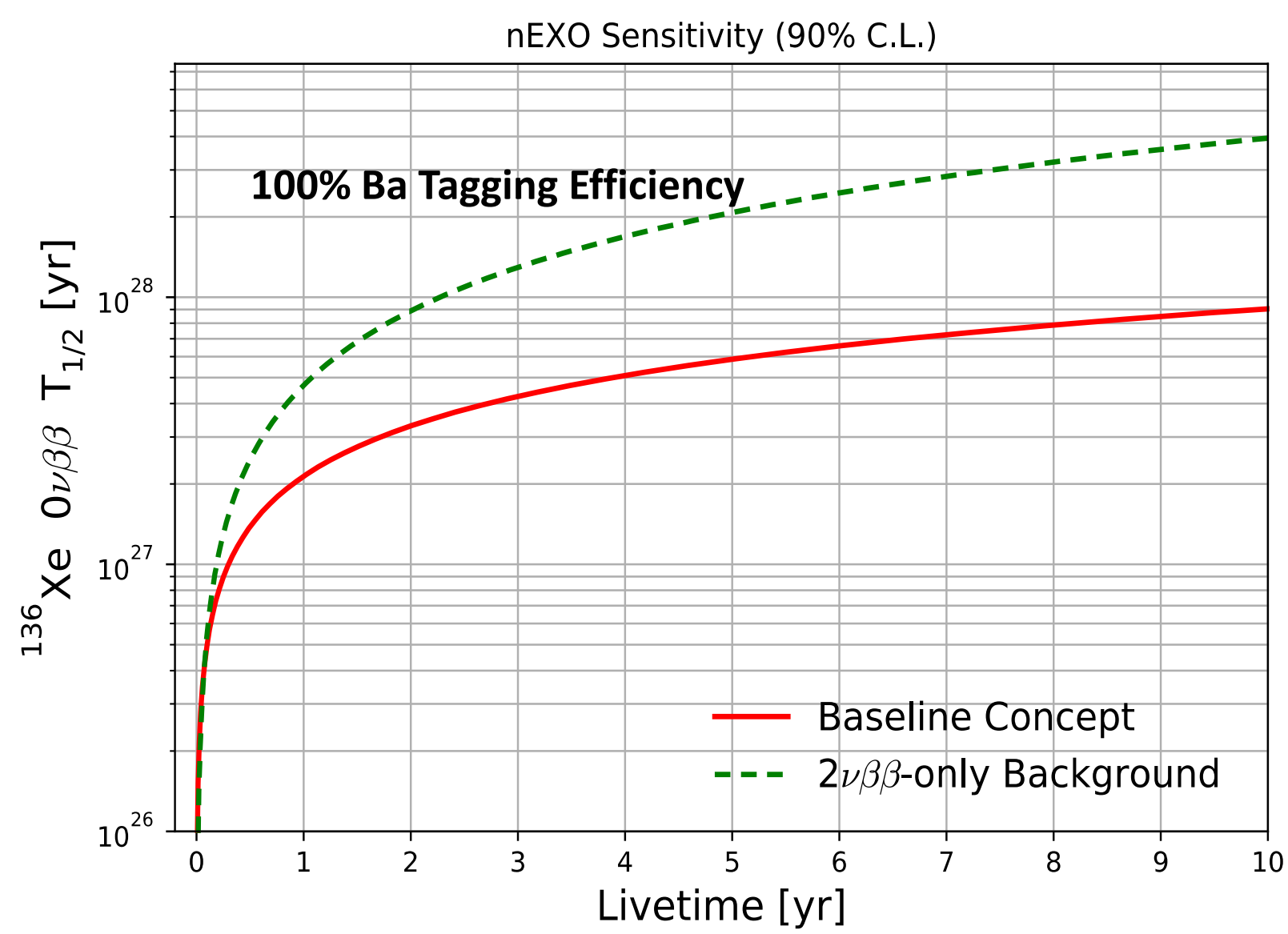
- Neutrinos are Majorana Particles
- Lepton Number Violation
- Neutrino Mass and Hierarchy



### Ba-Tagging Motivation

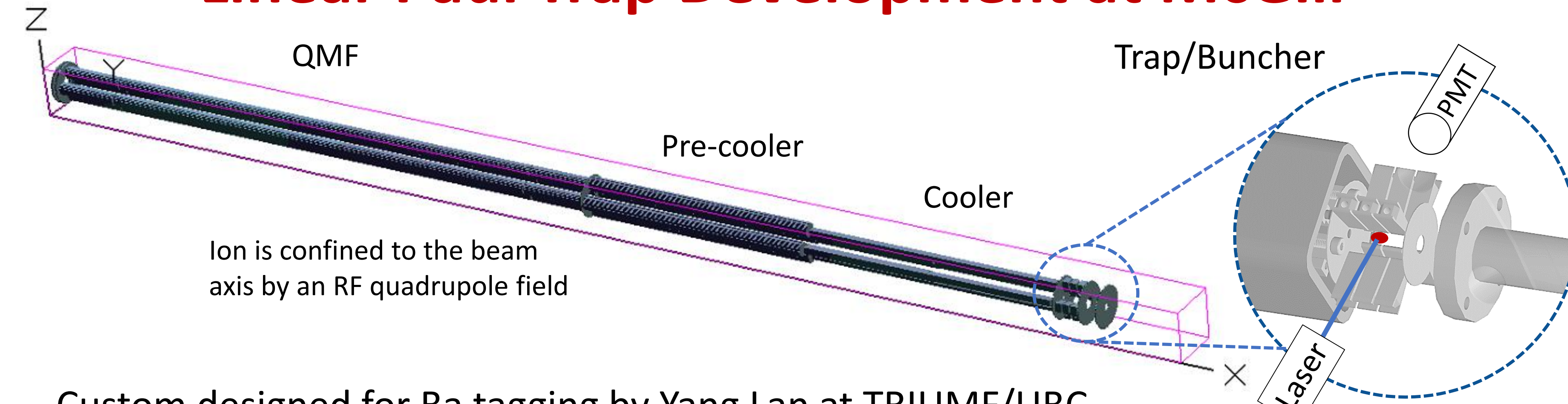
Background discrimination is crucial for  $0\nu\beta\beta$  searches

- Under development as potential upgrade for nEXO
- Ba daughter tagging rejects all but  $2\nu\beta\beta$  events
- Improves sensitivity of nEXO baseline design
- Gives positive confirmation of  $\beta\beta$  event



[1] More details on sensitivity of nEXO on poster by S. Sangiorgio at NEUTRINO 2020

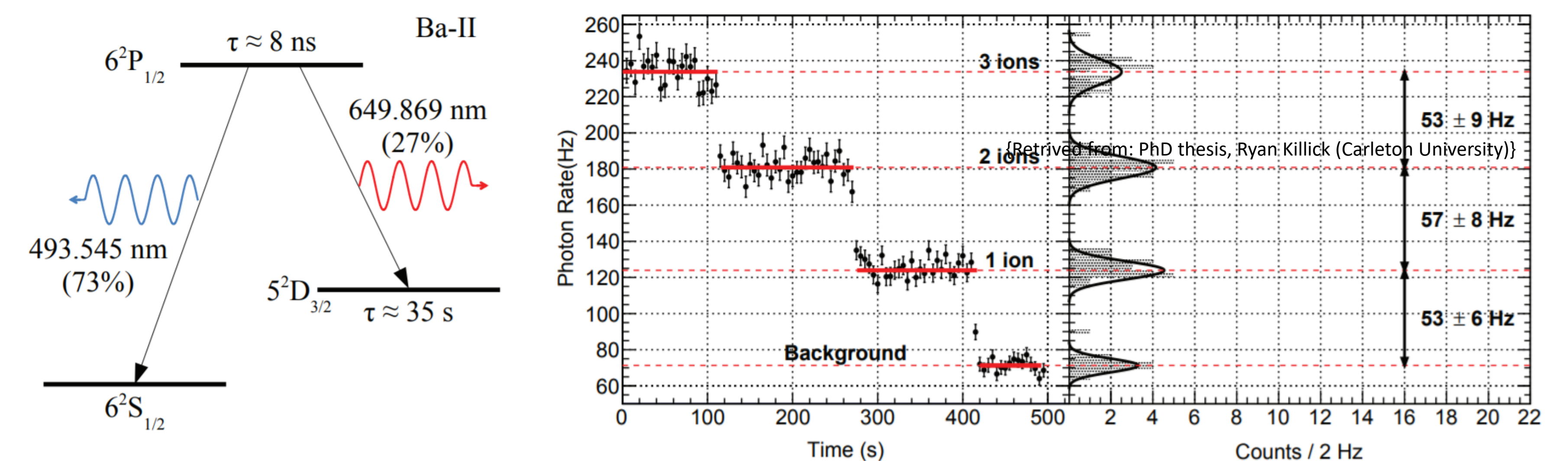
## Linear Paul Trap Development at McGill



Custom designed for Ba tagging by Yang Lan at TRIUMF/UBC

- Quadrupole Mass Filter is used to remove ions of incorrect charge to mass ratio
- He-buffer gas used to lower the energy of the Ba ions to allow for trapping
- Trap/Buncher region uses DC potential well to trap ions along the axis

## Ba Spectroscopy in a Linear Paul Trap at Carleton

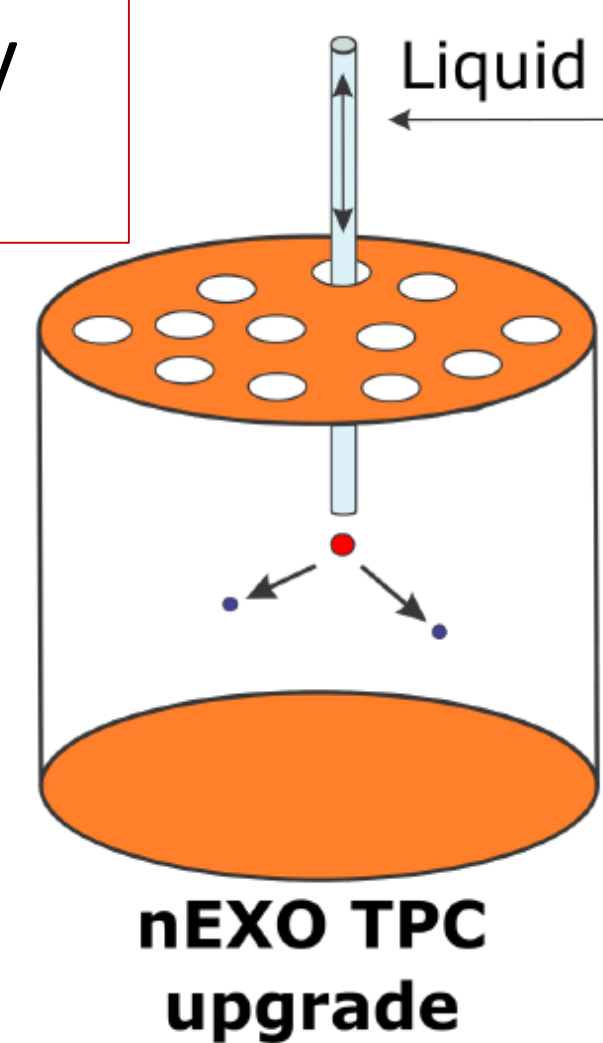


Single Ba<sup>+</sup> ions have been successfully observed in a linear ion trap

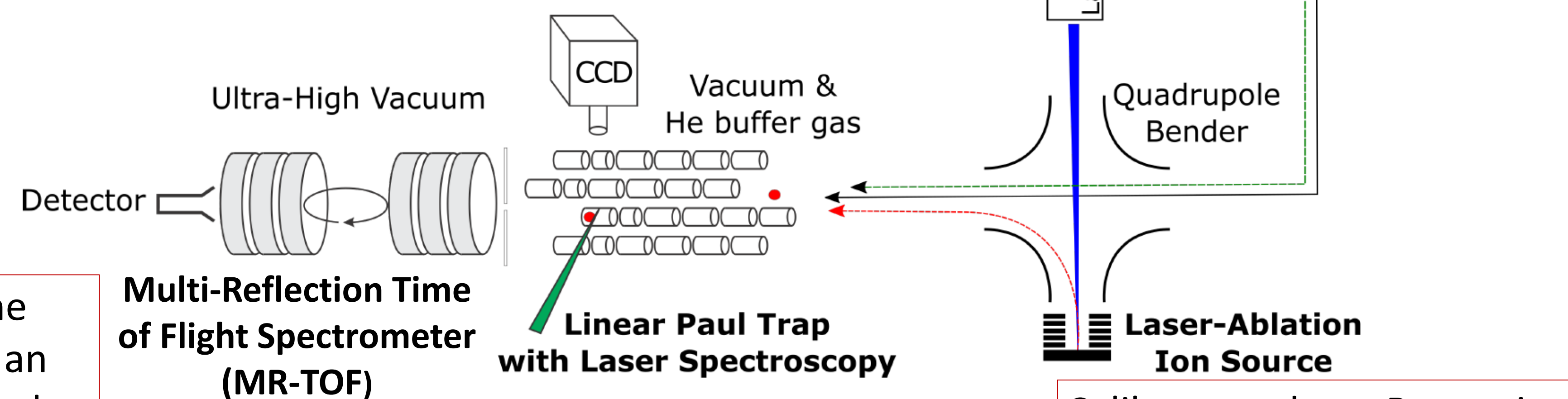
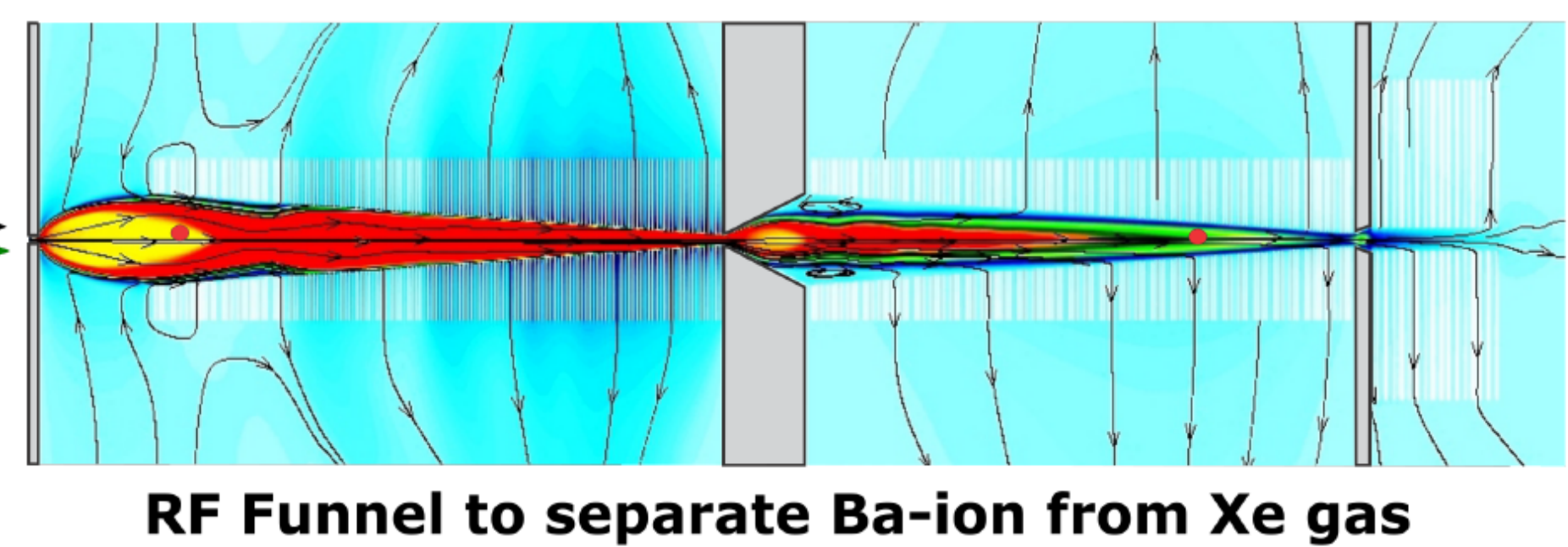
- Fluorescence transition at 493.5 nm
- Requires re-pumping out of metastable state at 649.9nm

## Scheme for Ba-Tagging from Xe Gas

**Stage 1:** Extract small volume of liquid Xe with the Ba daughter ion at a potential  $0\nu\beta\beta$  decay site into gas phase



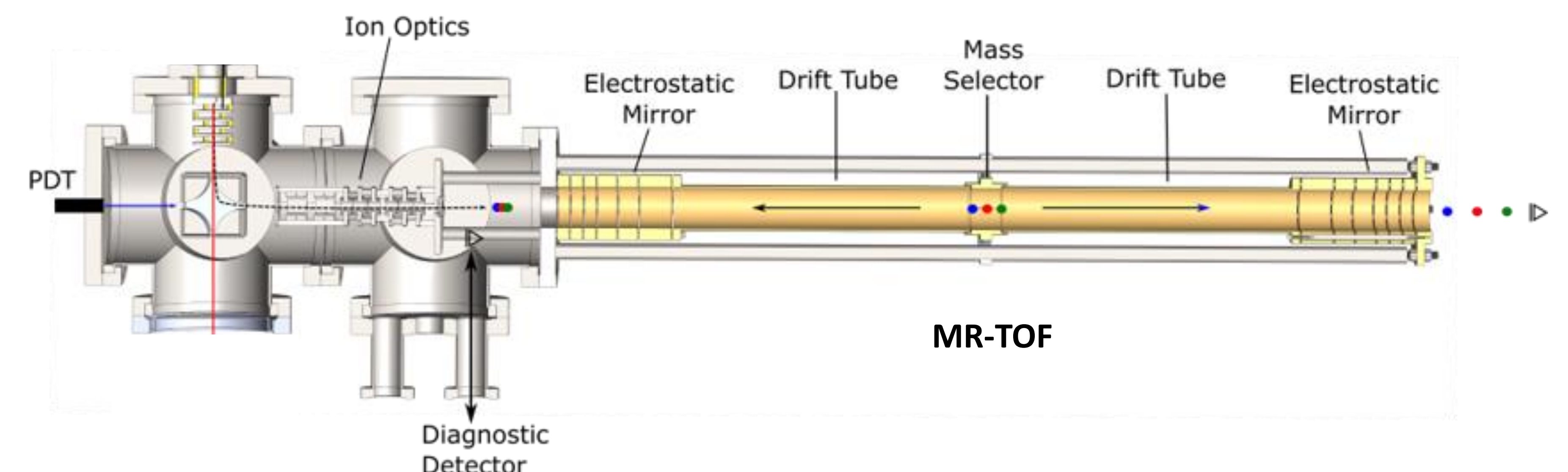
**Stage 2:** Pump out Xe gas to millibar level using a RF ion funnel to transport the Ba ion [2]



**Stage 4:** Measure the mass of Ba ion with an MR-TOF [4]. Also used for systematic studies of the extraction process

**Stage 3:** Confine Ba ion in a Linear Paul Trap and identify species using laser spectroscopy [3]

## MR-TOF Development at McGill



Multi-Reflection Time of Flight spectrometer is machined and soon to be assembled

- Ions are separated by mass through multiple passes through a drift tube
- Simulated mass resolving power of 50000 of ions from the LPT

### References:

- [1] nEXO Collaboration *Phys. Rev. C* **97**, 065503 (2018) [2] T. Brunner et al., *Int. J. Mass Spectrom.* **379**, 110-120 (2015)  
 [3] M. Green et al., *Phys. Rev. A* **76** 023404 (2007) [4] K. Murray et al. *Hyperfine Interact* **240**, 97 (2019)

### Current Status and Outlook

Developing upgraded RF ion funnel at McGill  
 LPT and MR-TOF are machined and being assembled at McGill  
 Single Ba<sup>+</sup> ions have been observed in a trap at Carleton