Barium Extraction from Xe Gas and Identification for nEXO

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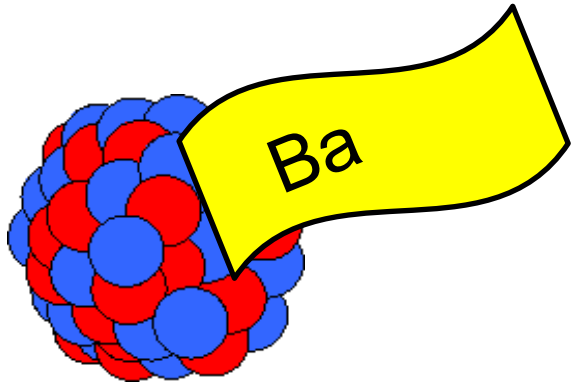


McGill

nEXO

Barium Tagging as an upgrade to nEXO Experiment

nEXO is a 0νββ search using a 5000kg liquid Xe TPC

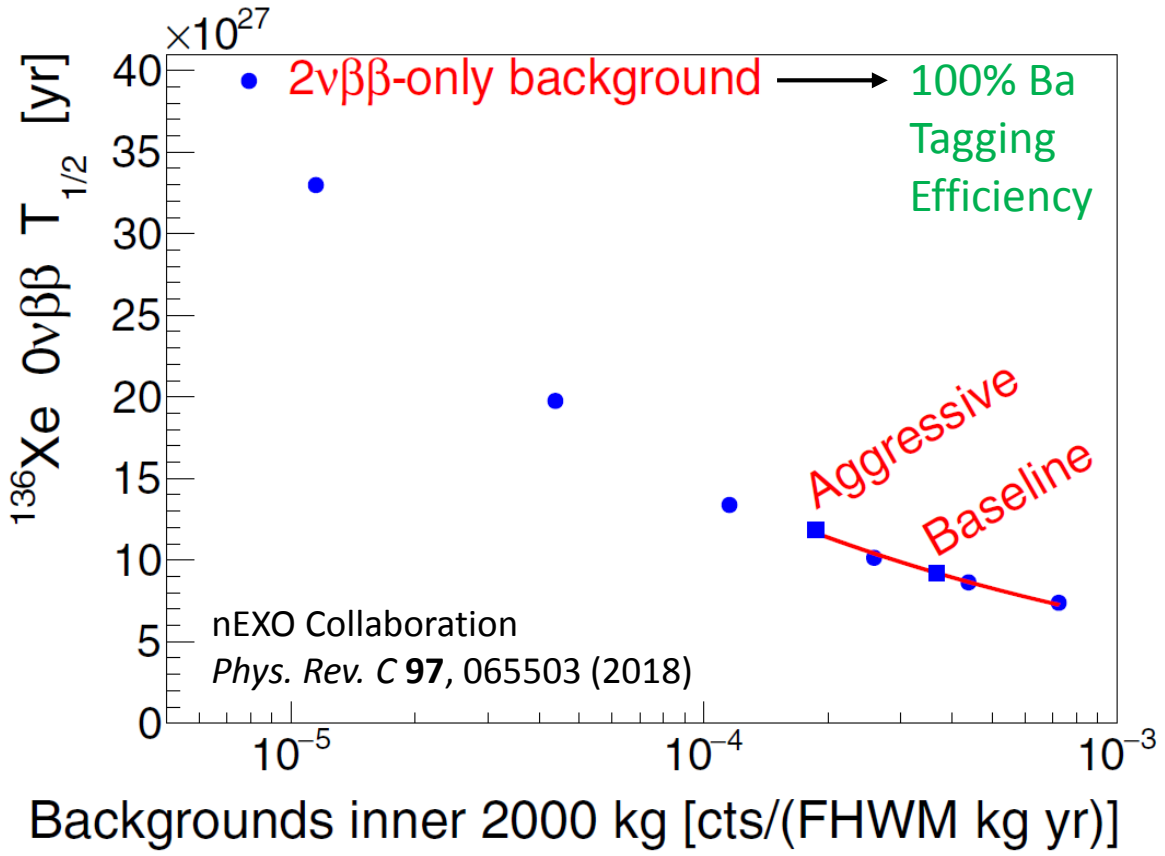
$$^{136}Xe \rightarrow {}^{136}Ba^{++} + 2e^{-}$$

Barium Tagging: identify barium daughter at 0νββ decay site for **complete** background elimination

Advantages of Ba-Tagging:

- Increases the projected sensitivity by factor of 3-4
- Provides POSTITIVE signal of ββ decay

nEXO Overview: Erica Caden, Session **TS4-2**



Requires counting of ***single*** Ba daughter in macroscopic amount of Xe

Canadian Ba Extraction and Tagging from Gas Xe

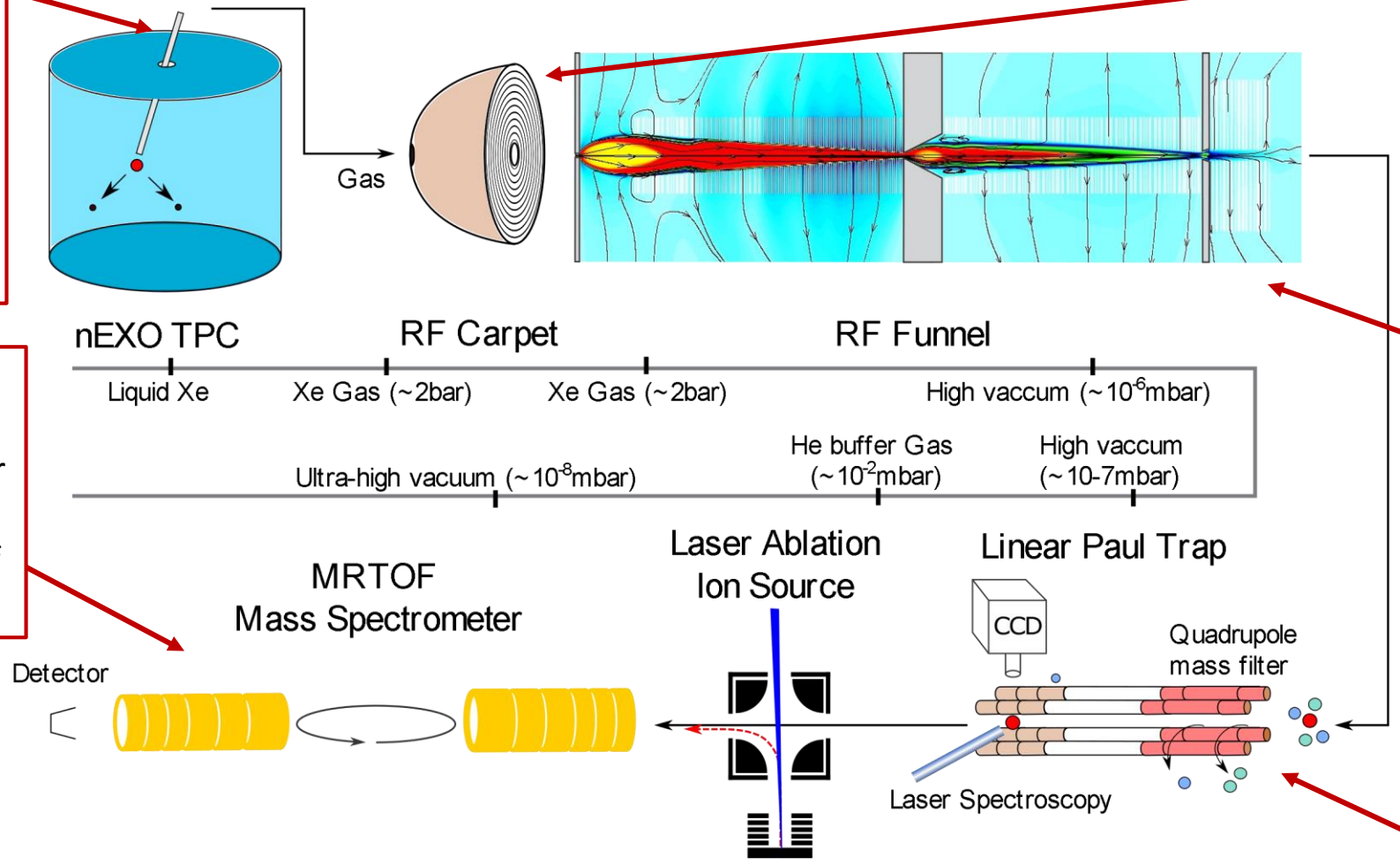
Stage1:
Extraction of detector volume around the location of the decay to gas phase using a capillary tube.

Stage2:
RF carpet for efficient transfer of ion from capillary to RF funnel

Stage3:
RF funnel facilitates separation of xenon accompanying the Barium ion.

Stage4:
The Linear Paul trap for detection of barium ion via laser fluorescence spectroscopy.

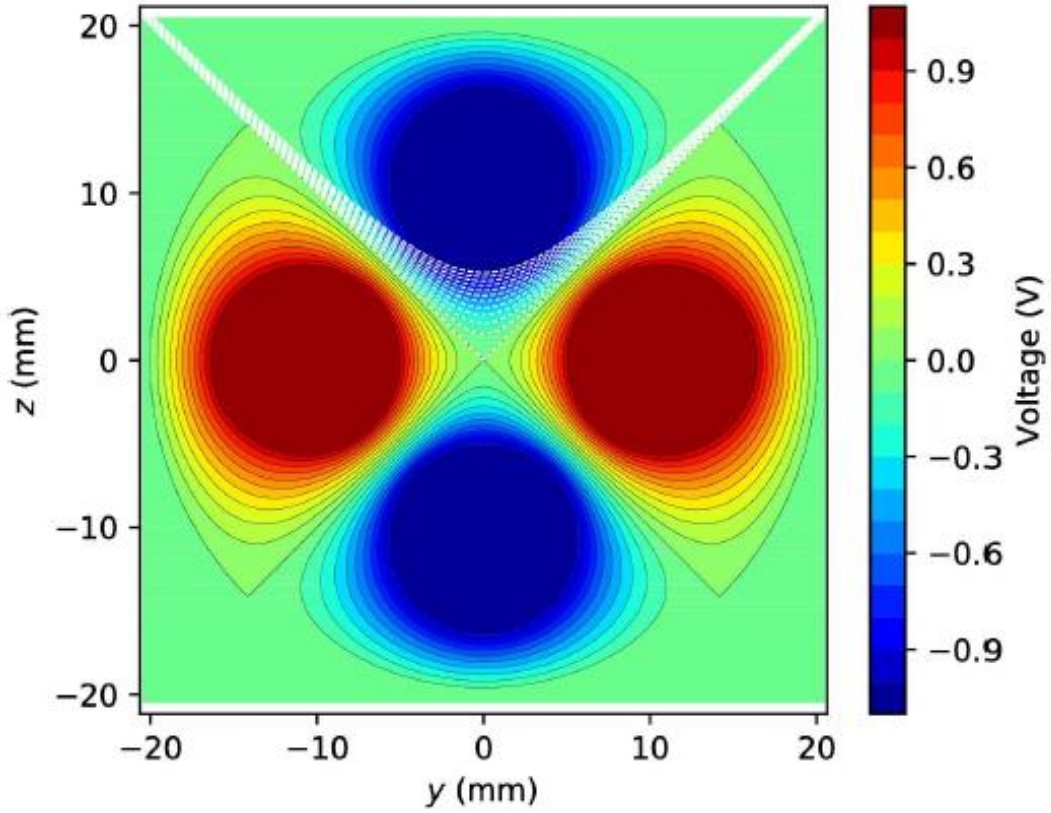
Stage5:
Multiple Reflection TOF Spectrometer for systematic studies and determination of ion mass.



What is a Linear Paul Trap?

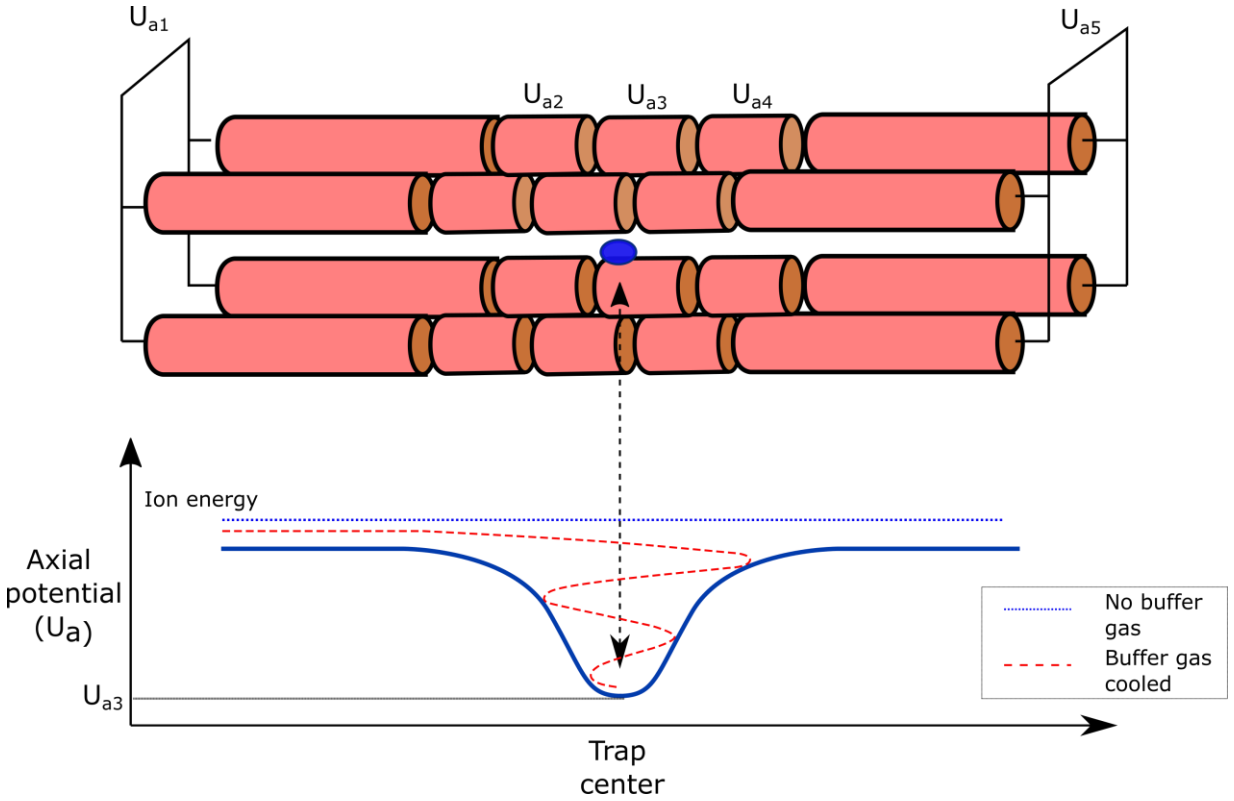
Design by Yang Lan @ TRIUMF
Construction by Hussain Rasiwala @ McGill

Retrieved from: PhD thesis, Y. Lan



Quadrupolar potential

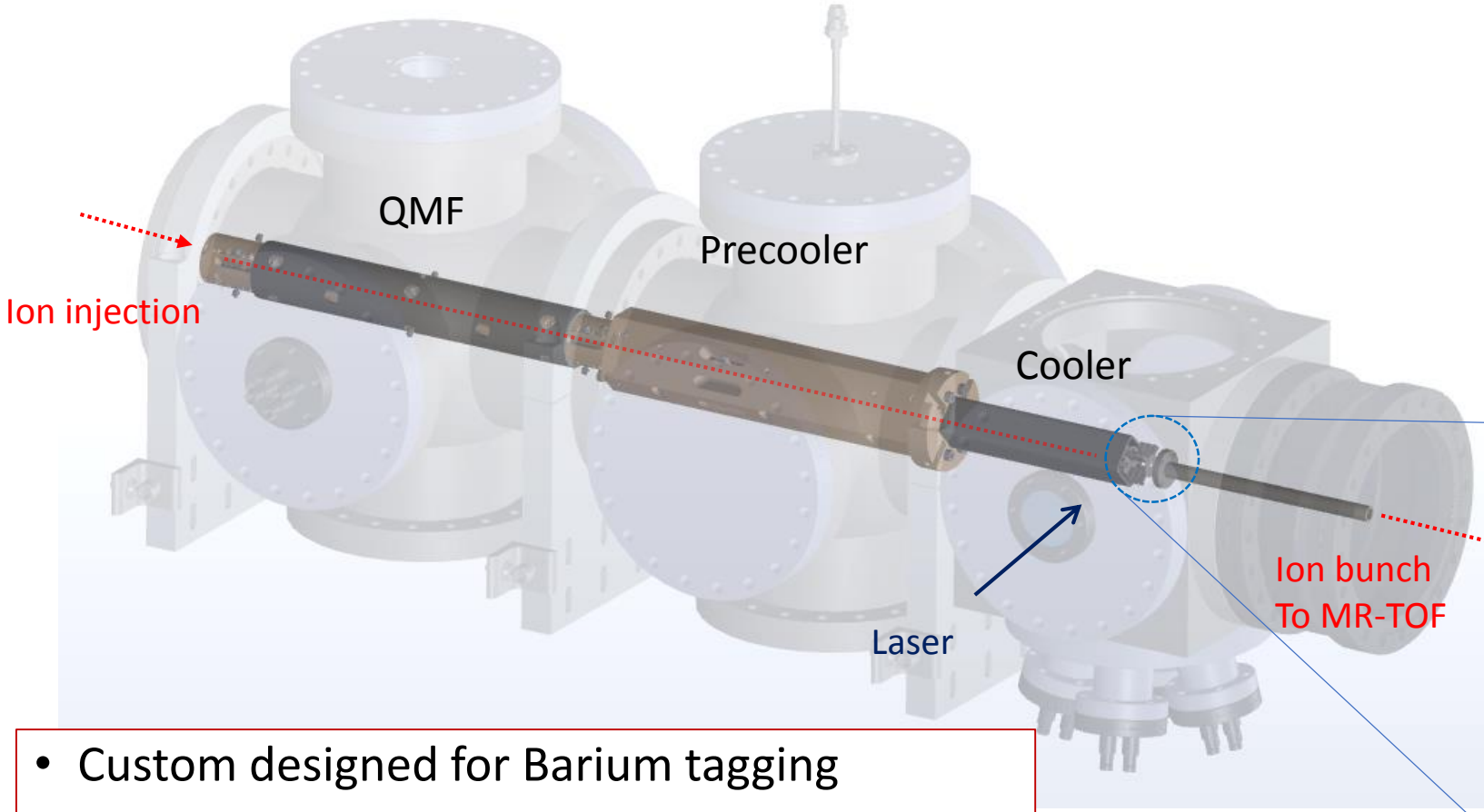
DC electric field for directing and confining axial motion.

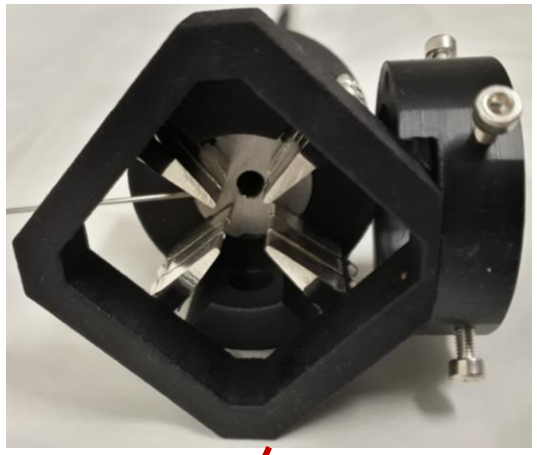


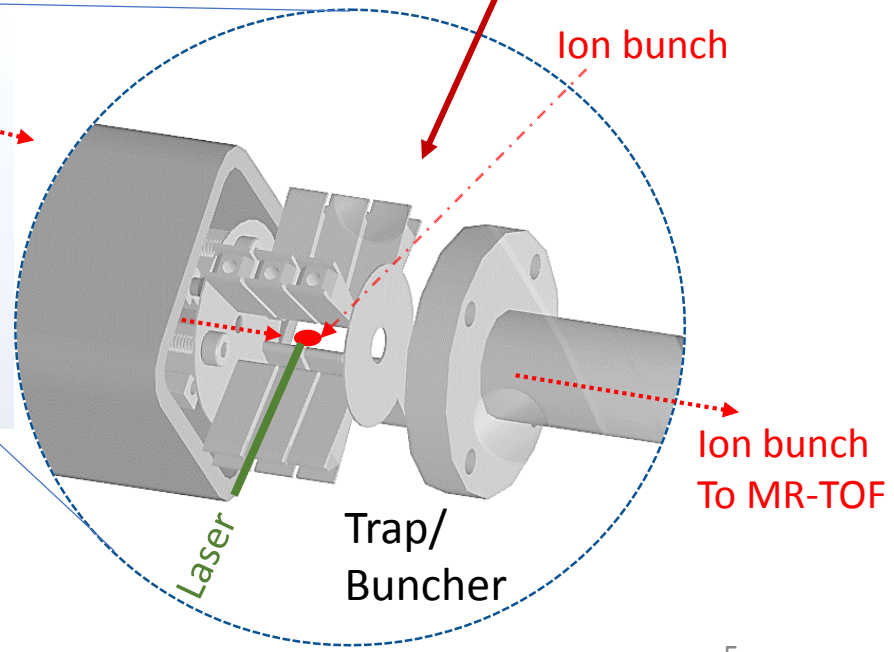
Radial confinement using radio-frequency (RF) potentials

Linear Paul trap for Ba-tagging

Design by Yang Lan @ TRIUMF
Construction by Hussain Rasiwala @ McGill



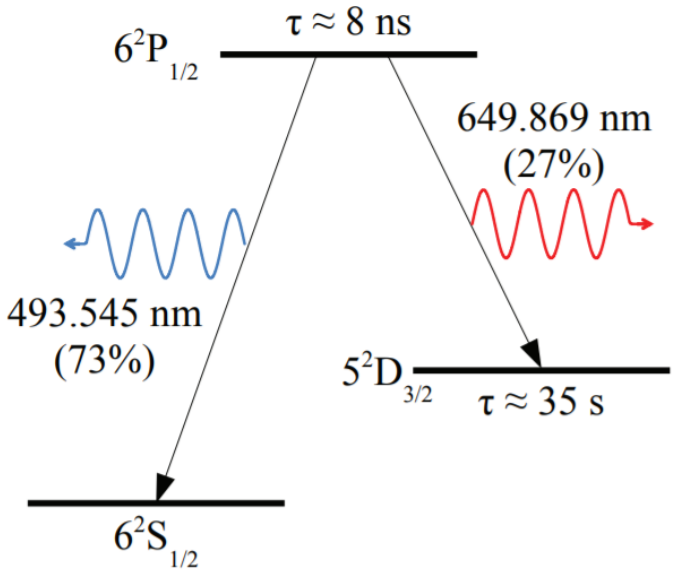




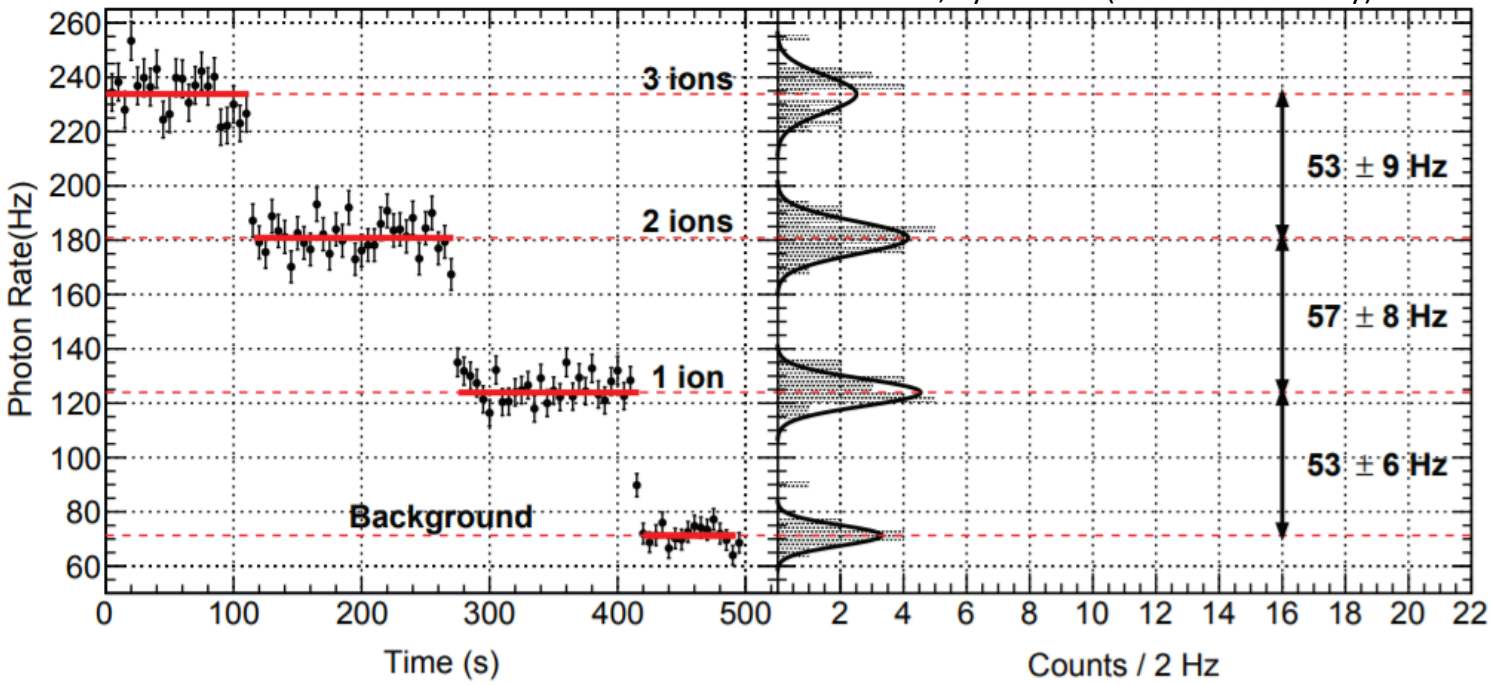
- Custom designed for Barium tagging
- Composed of a quadrupole mass filter (QMF), precooler, cooler and an ion buncher.

Matthew Green @ Stanford
Ryan Killick @ Carleton University

Single Barium ion detection



Retrieved from: PhD thesis, Ryan Killick (Carleton University)



- Uses ion trap for confining ions and laser induced fluorescence for barium ion detection.
- Single ion detection has been demonstrated by collaborators at Carleton University.
- Demonstrated first by M. Green et. al by studying 493nm florescence intensity from single barium ion.

M.Green, et al., Phys.Rev.A 76 (2007) 023404

What is an MRTOF?

Design and Construction by Kevin Murray @ McGill

Operating Principle

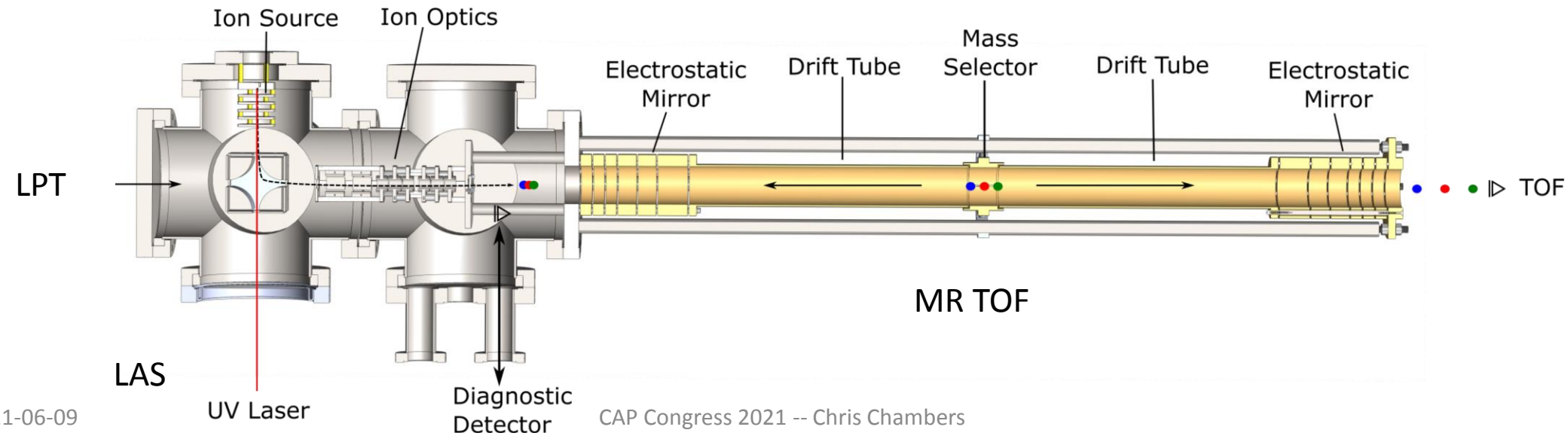
- Ions accelerated by potential gain kinetic energy
- Ions with different mass-to-charge separate in time, and can be resolved

Design

- Consists of central drift-tube and 2 electrostatic mirrors formed by 6 cylindrical electrodes.
- Ions are reflected between the mirrors to dramatically increase the MRP.

Goals

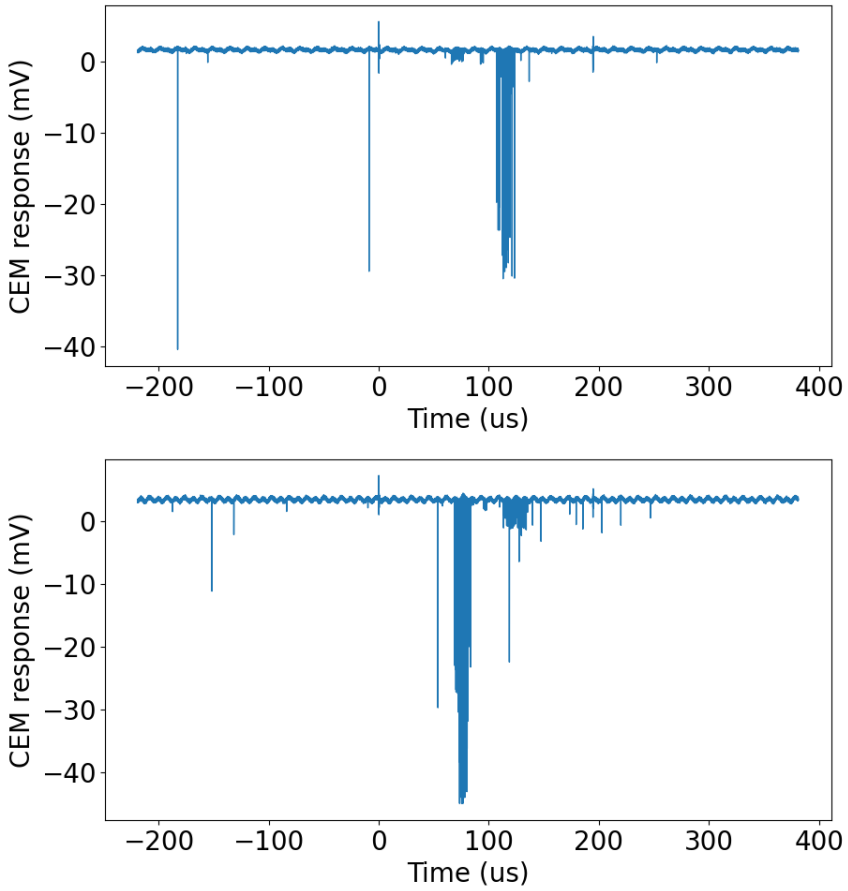
- Perform systematic studies of the Ba-tagging extraction technique. (What ion species are present in the LPT?)
- Confirm the isotope of barium identified in the LPT. (Was it really ^{136}Ba in the LPT?)



MRTOF First Ions – No Reflections

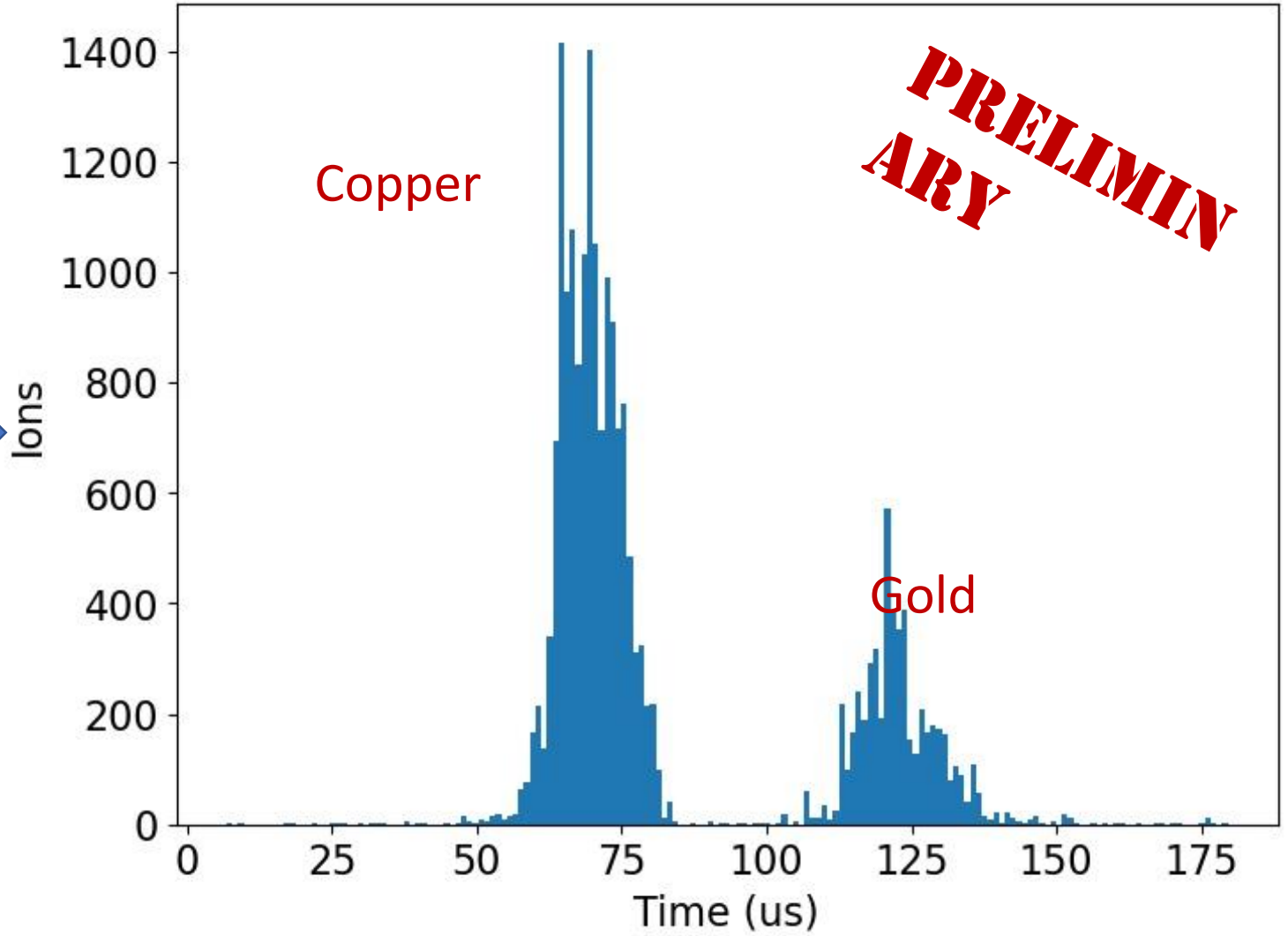
Data by Kevin Murray
@ McGill

Example Raw Waveforms

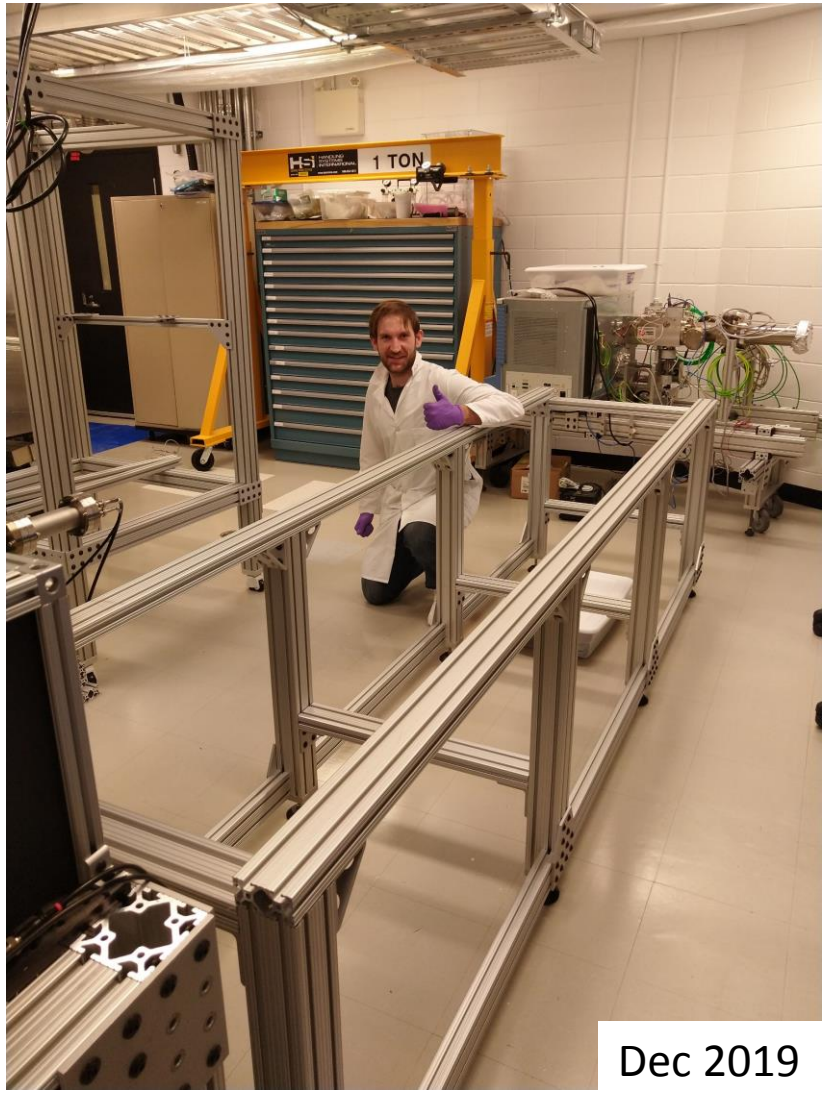


Single ion signal is approx. 2 mV

Time of Flight Spectrum



Lab Progress



Dec 2019

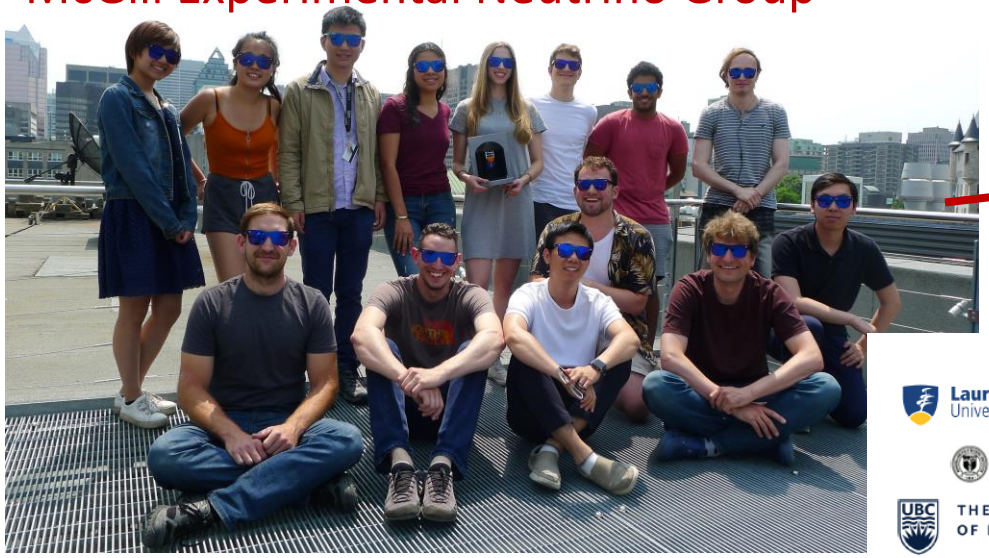
18 months

Jun 2021

The nEXO Collaboration

> 200 scientists worldwide!

McGill Experimental Neutrino Group



Summer 2019