



## **Double Beta Decay and CARIBU**

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#### **Double Beta Decay**

Observable if single beta decay is forbidden



#### **Observation of** $0v\beta\beta$ :

- Majorana neutrino
- Neutrino mass scale
- Lepton number violation

#### Two neutrino double beta decay



#### Neutrinoless double beta decay



#### **Double Beta Decay Energy Spectrum**



## EXO-200 and nEXO Sensitivity



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## **Barium Tagging for Background Rejection**



 $^{136}_{54}Xe \rightarrow ^{136}_{56}Ba^{++} + 2e^{-} + 2v_e$ 

 In-situ identification of decay daughter nucleus Ba can be used to eliminate all radioactivity induced background.

- Ba ions have nice laser
  spectroscopy signatures
- Difficult problem to detect a single ion inside few tonnes of liquid xenon.



One proposed barium tagging scheme

# Barium Ion Trapping in Buffer Gas Environment



• Have developed techniques for detecting single barium ion in a buffer gas filled ion trap ( $\sim 10^{-3}$  torr He, some Xe).

• ~ 9 $\sigma$  observation at 25s storage time.

• R&D efforts currently focus on develop a suitable probe to take barium from the liquid xenon bath and deliver it into the ion trap.

#### Study Barium Ion Transport at CARIBU



#### Ba Desorption from Solid Xe Surface



During CARIBU beam tests, we tried various heating methods to sublimate solid xenon. However, no Ba was desorbed from the SXe surface. We conclude that solid xenon is not a good probe material.

## Barium Desorption from Refractory Metal Surfaces



Saw 30% transport of Ba ion from Ta surface at 1250 K. Would like to go to 1500 – 1700 K and study different materials



Building a new apparatus to study Ba desorption from high temperature surfaces.

### Barium Desorption from Graphene Surface?

- Calculations of adsorption of Ba on graphene show: E<sub>des</sub> = 0.67 eV (compare to Ba on W: 3.31 eV)
- Electron transfer from the atom to the graphene is 0.86 electrons.
- Laser resonant ionization spectroscopy shows tantalizing results, but is hampered by bulk Ba contamination.
- Radioactive Ba Ion beam will be a good way to study Ba and graphene surface interaction.



# Measuring Ba Tagging Total Efficiency



# Summary

- The proposed nEXO detector is a next generation tonne scale detector, capable of probing a large fraction of the phase space of the inverted hierarchy.
- Barium tagging is an upgrade path for nEXO detector to become a background free detector, that can probe the normal hierarchy region.
- Radioactive ion beam from CARIBU can be used to study barium ion transport properties for developing a suitable probe for barium catching and releasing. (This technique can be used to study atom/ion surface interactions.)
- Accelerated beam can be used as a taggable barium source for measuring the total efficiency of a barium tagging technique.