Development of In Gas Laser Ablation Source

Minya Bai, Laura Gonzalez Escudero

Supervisors: Thomas Brunner, Christopher Chambers

Neutrinos and Neutrinoless Double Beta Decay ($0\nu\beta\beta$)

Known

- Neutrinos are weakly interacting particles
- Neutrinos have mass

Postulated

- Are neutrinos their own antiparticle?
- Can neutrinos violate lepton number conservation?

Search for $0\nu\beta\beta \rightarrow$ lepton number violating decays

The nEXO Experiment

- A proposed neutrinoless double beta decay ($0\nu\beta\beta$) detector
  - 5 tonne LXe enriched with 90% ^{136}Xe
  - Time Projection Chamber (TPC) for 3D event reconstruction

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

Ba-Tagging

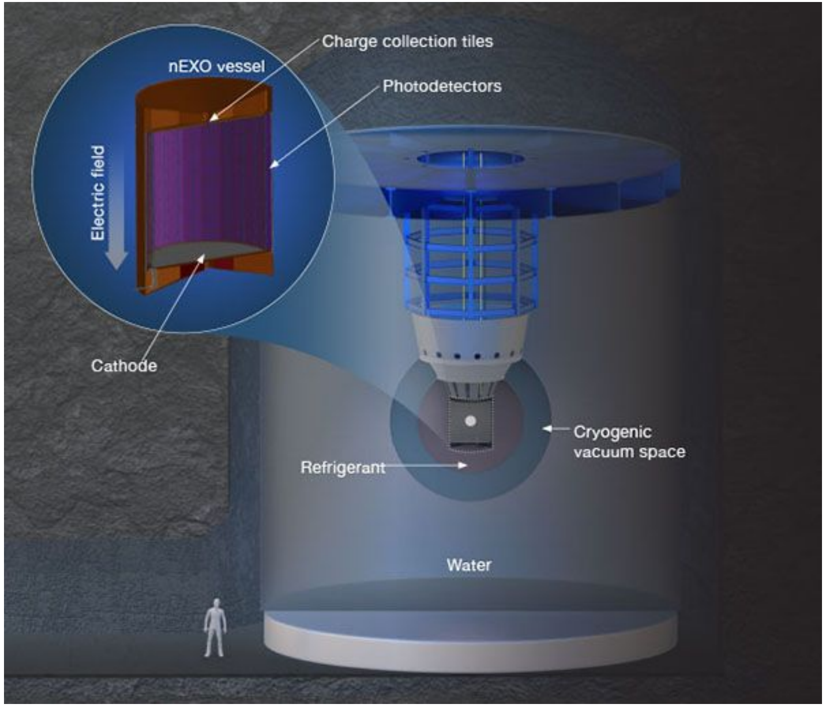


Image taken from https://nexo.llnl.gov/nexo-overview

Canadian Ba-Tagging Scheme

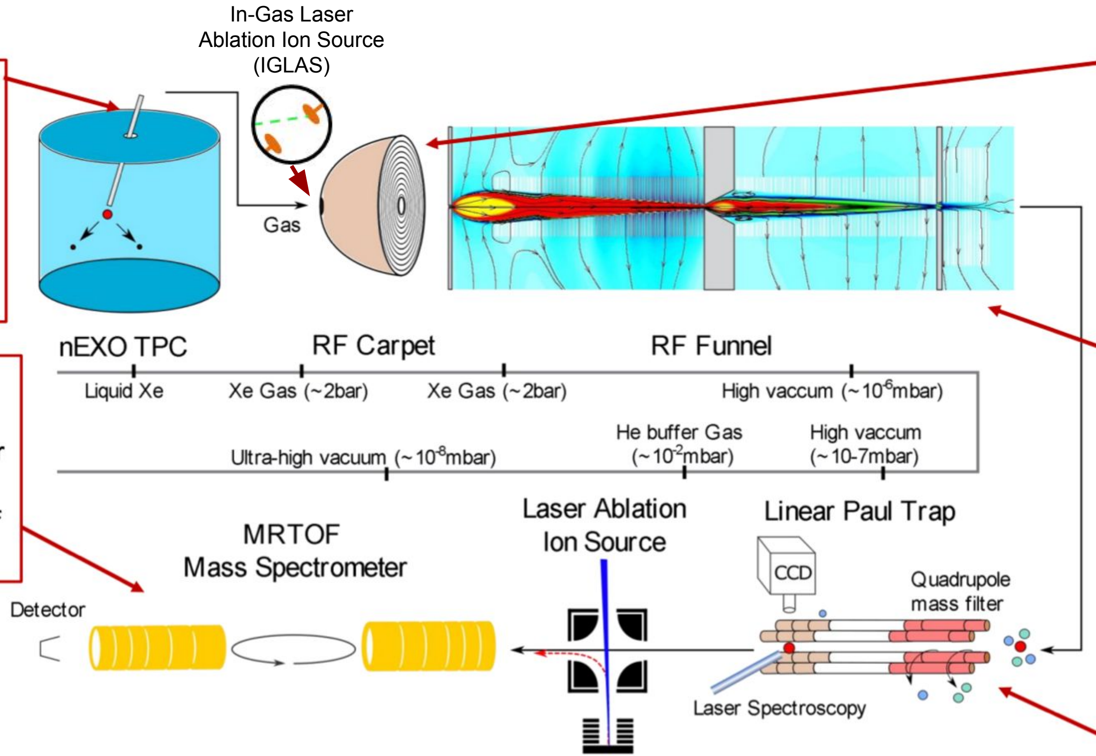
Stage1:
Extraction of detector volume around the location of the decay to gas phase using a capillary tube.

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.



CAP 2021; C. Chambers

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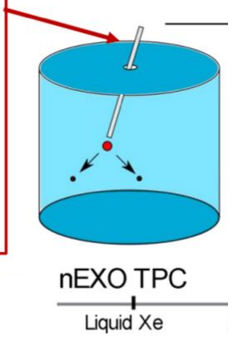

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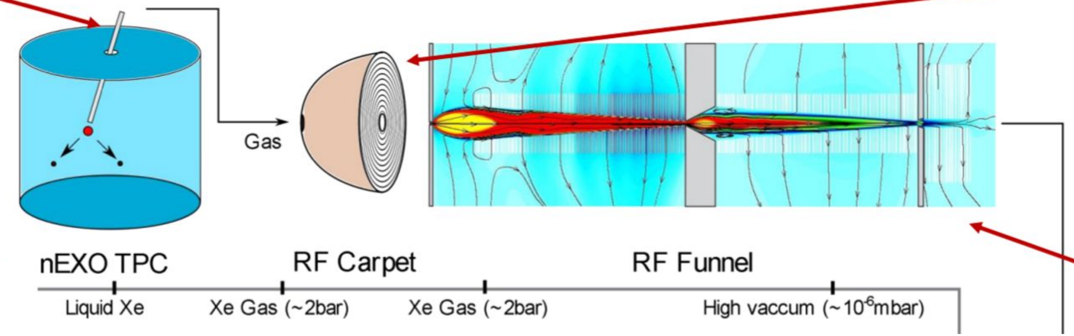

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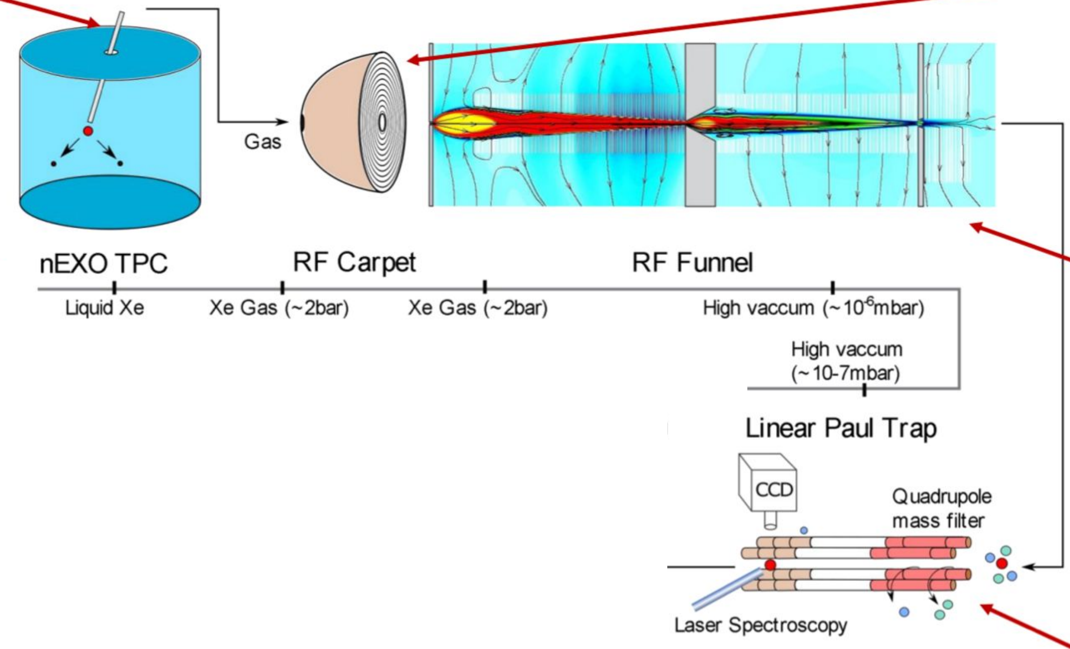

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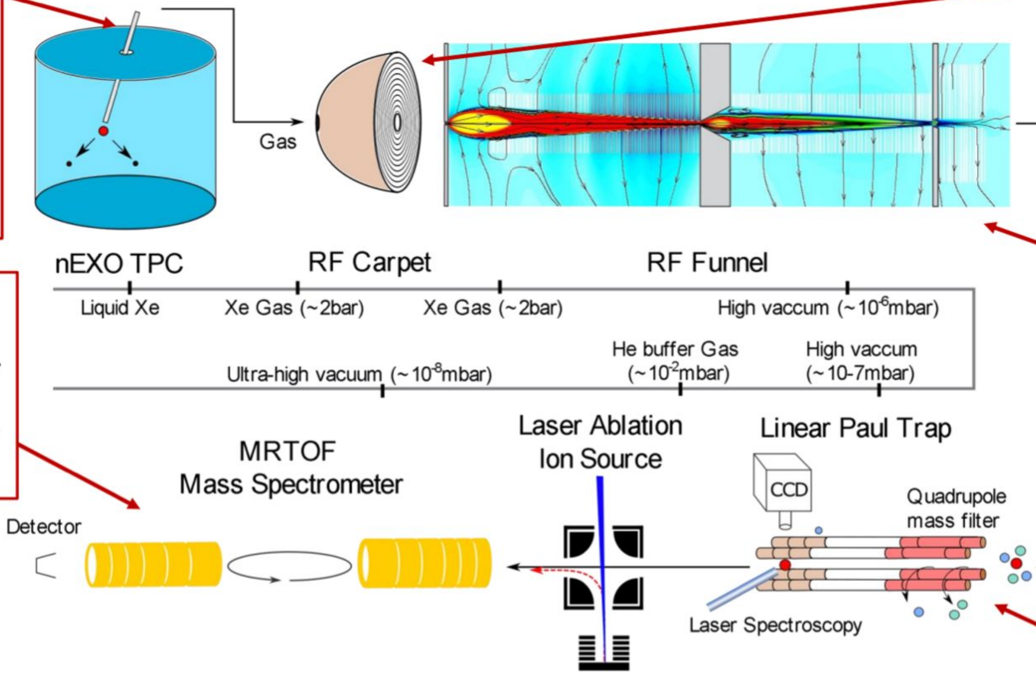

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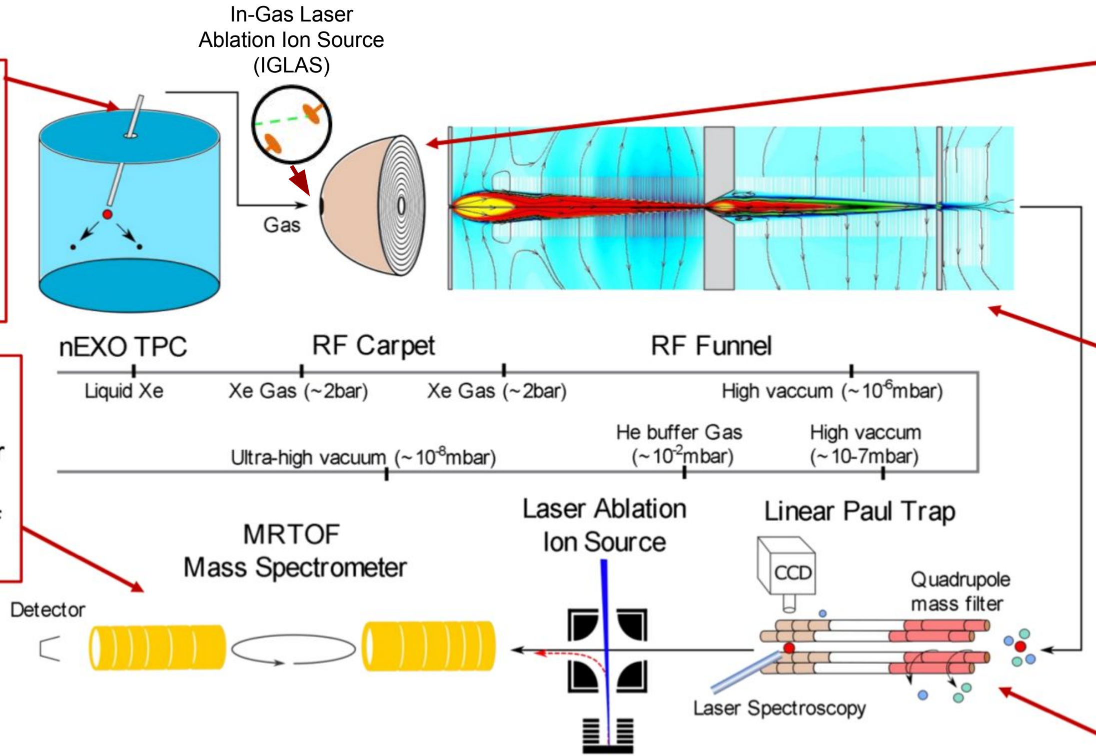

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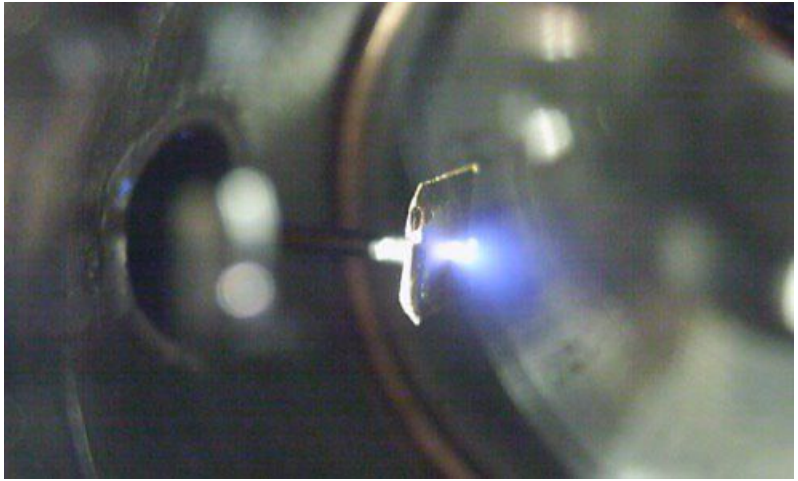
What is Laser Ablation?

- Focused laser to release ions from surface of target

Advantages?

- Provides a low-rate source of a specific ion
- Allows for synchronization with rest of ion optics
- We have experience with laser ablation in vacuum



Thesis, M.M.Peregrina

Set Up

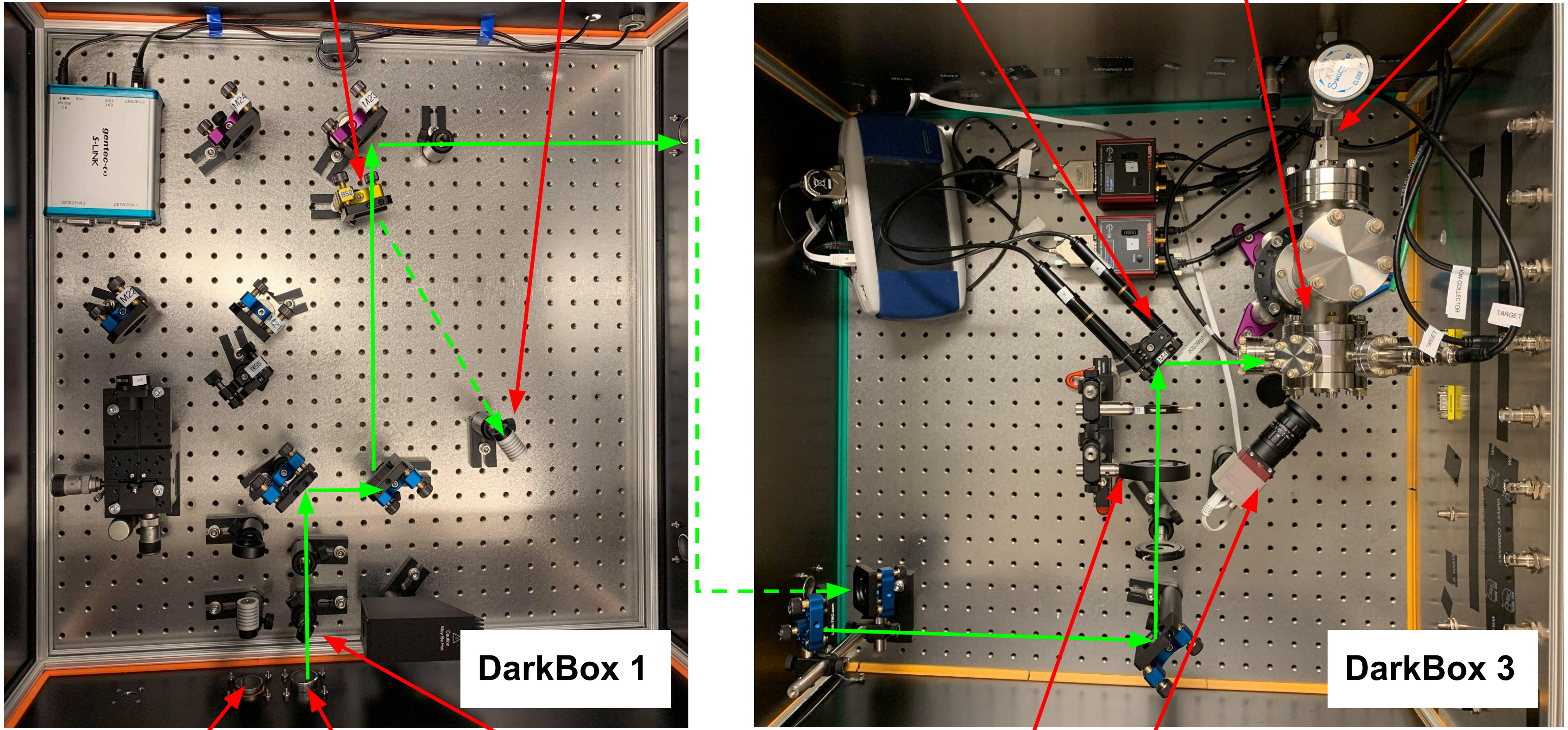
Beam Splitter

Beam Dump/
Energy Meter

Motorized Mirror

In-Gas LAS
Chamber

to Xe Gas
Cart



355 nm

532/1064 nm

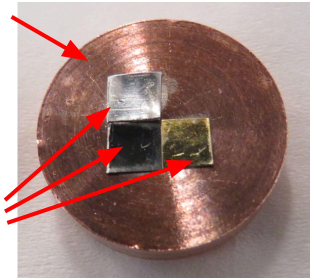
Dichroic Mirror

Focusing Lens

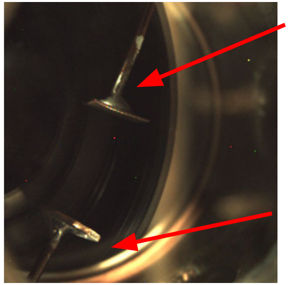
Camera (Joseph Torsiello - Aug 23, 18:00 EST)

IGLAS Chamber

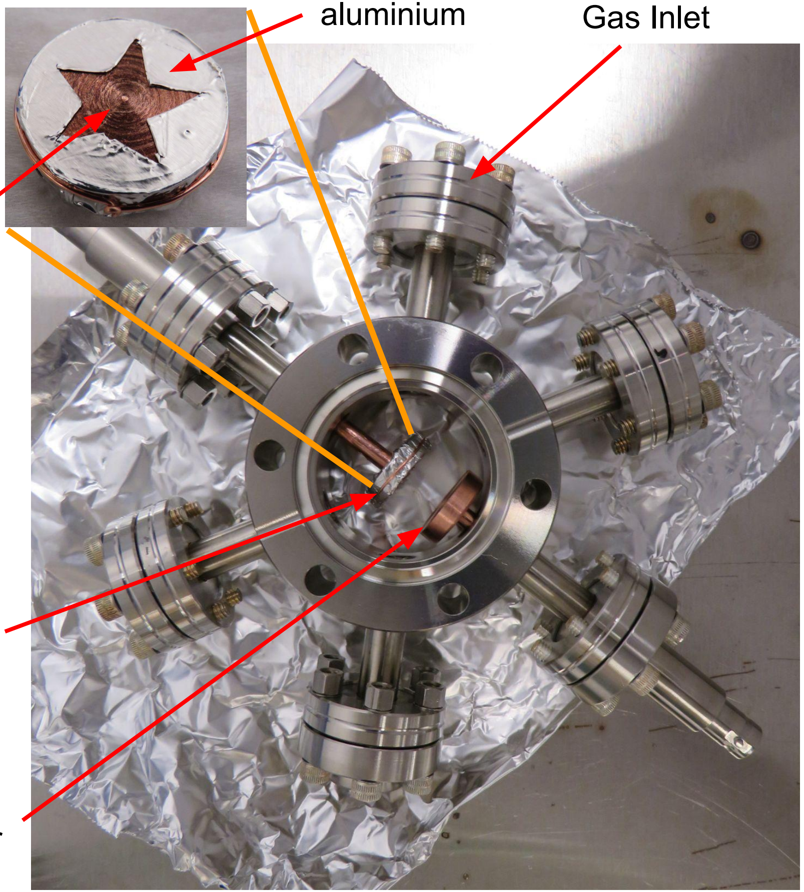
- Two parallel copper plates separated by ~ 0.8mm
- Chamber at vacuum or filled with gas
- Different metals for calibration



Multi-metal targets with new target design



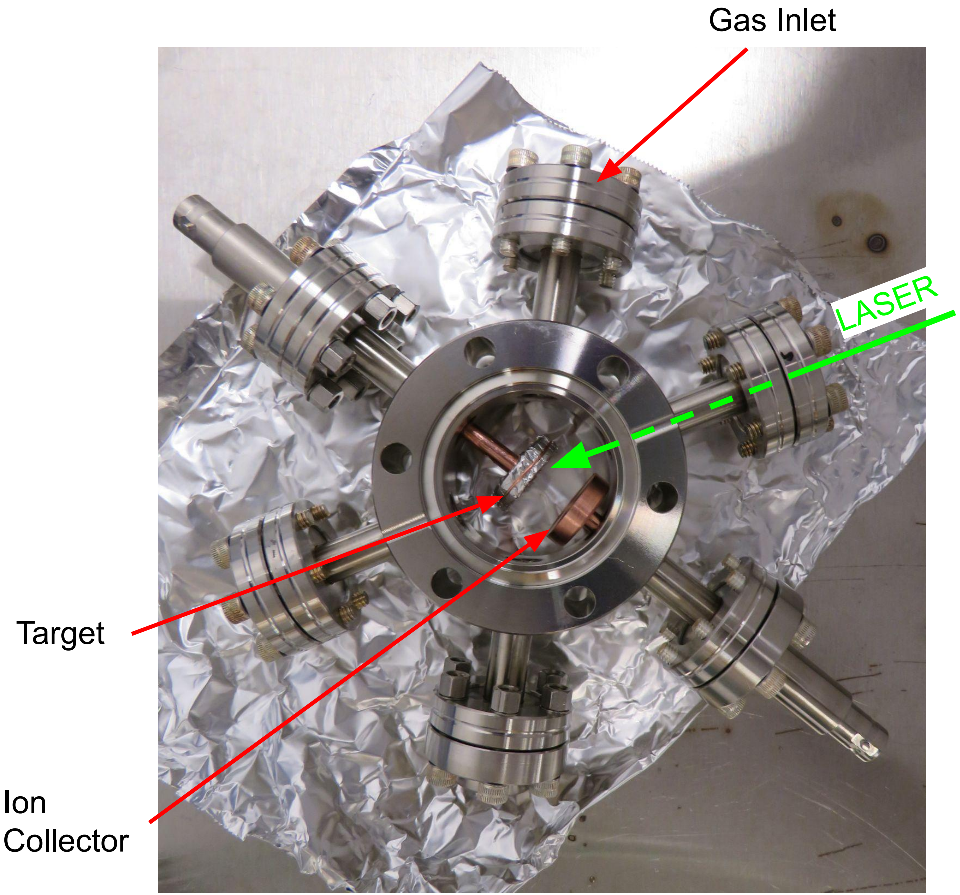
Old Targets Design



New Targets Design for In-Gas Laser Ablation Source (IGLAS)

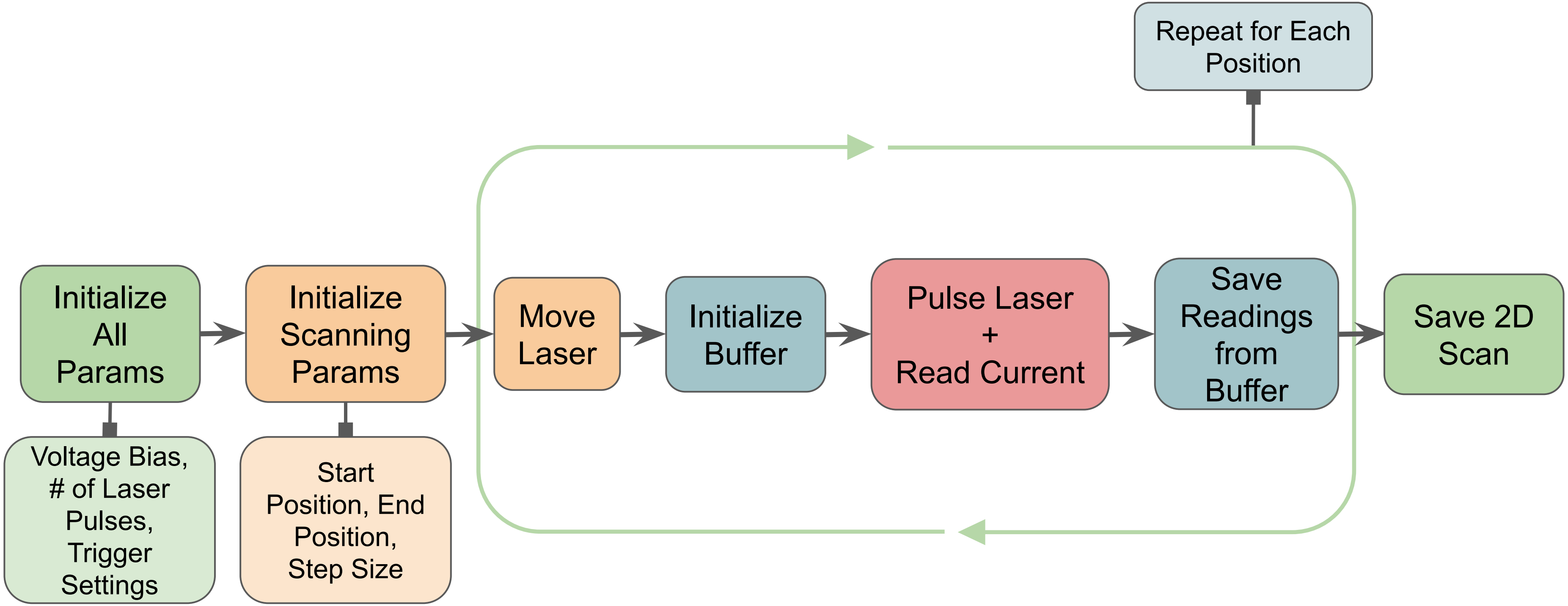
IGLAS - Measurement

1. Ions are ablated off the surface of the target
2. Apply voltage bias to drift ions from target to ion collector
3. Signal read as ion current on collector and target



IGLAS Chamber

Measurement Cycle

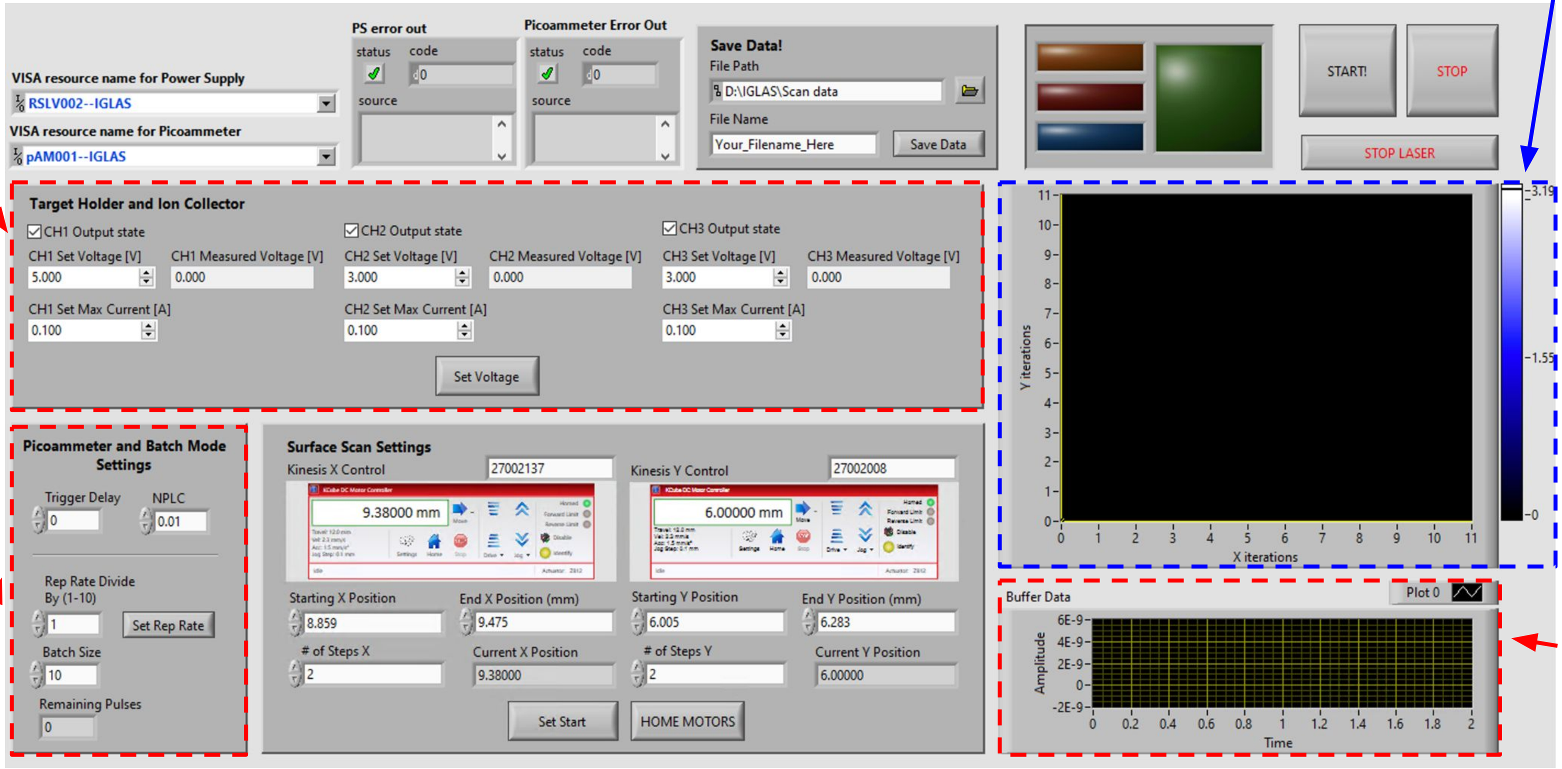


*Scanning Program: Laura Gonzalez Escudero - Aug 24, 14:45 EST

Data Acquisition - LabView Control Panel

Voltage Bias Settings

Intensity Plot of Current



Buffer Readings

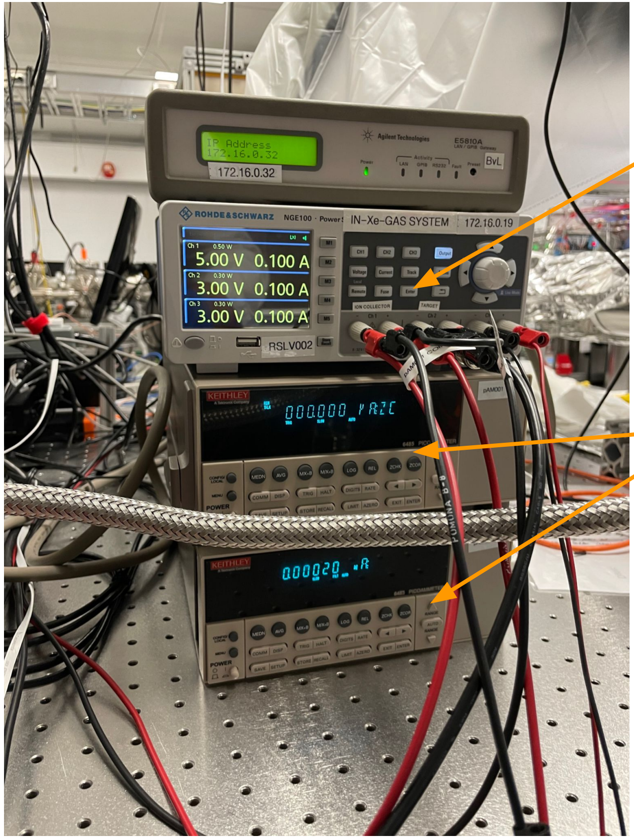
Picoammeter Settings

Triggering Measurements

- Readings from Keithley Picoammeter are triggered by TTL signal from Q1 laser

- At each position, laser is fired a set number of times and the readings are loaded into a buffer

- All readings in buffer are returned and buffer is cleared before moving to next position



Moving Forwards

Demonstrate in-vacuum operation works in new setup
(Scan multi-element targets for calibration)

↓

Increase pressure inside IGLAS chamber

↓

Test different gases (helium, argon, xenon)

↓

Barium ablation in xenon gas at 10bar pressure

Experimental Controls

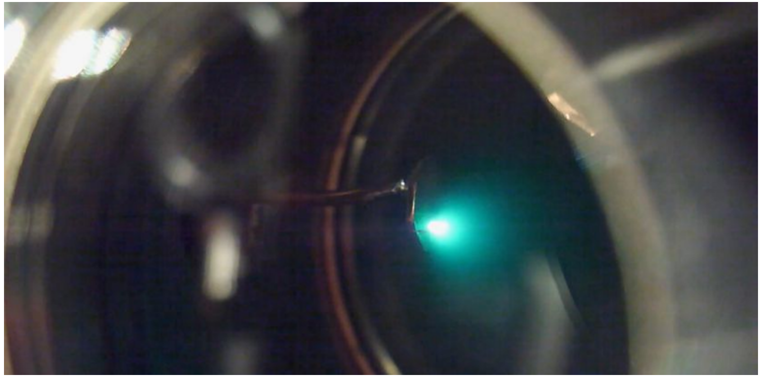
Measure ion current signals as a function of different parameters:

1) Pressure up to 10 bar
2) Different gas environments
3) Electric field dependence
4) Multi-material targets
5) Different laser wavelengths (266 nm, 355 nm, 532 nm, 1064 nm)
6) Laser energy and repetition rate up to 10 Hz
7) Laser spot size on target

} Laser Fluence (items 6–7)

Conclusion

- Laser ablation has been tested in vacuum in IGLAS and measured ion currents up to 80 nA
- Making progress towards scanning in an in-gas laser ablation source for the Ba-tagging setup



349nm laser on copper target in vacuum taken by Melissa Medina Peregrina.

Acknowledgements

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CRSNG

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nEXO

McGill UNIVERSITY

Fonds de recherche sur la nature et les technologies
Québec

BNL

Thank You for Listening!