First Commissioning Results of the Multicusp Ion Source at MIT (MIST-1) for H_2^+

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IsoDAR is an experiment under development to search for sterile neutrinos using the isotope Decay-At-Rest (DAR) production mechanism, where protons impinging on ^{9}Be create neutrons which capture on ^{7}Li which then beta-decays producing $\bar{\nu}_e$. As this will be an isotropic source of $\bar{\nu}_e$, the primary driver current must be large (10 mA cw) for IsoDAR to have sufficient statistics to be conclusive within 5 years of running. H_2^+ was chosen as primary ion to overcome some of the space-charge limitations during low energy beam transport and injection into a compact cyclotron, to be stripped into protons before the target. At MIT, a multicusp ion source (MIST-1) was designed and built to produce a high intensity beam with a high H_2^+ fraction. MIST-1 is now operational at the Plasma Science and Fusion Center (PSFC) at MIT and under commissioning.

IsoDAR

- Definitive experiment to find sterile neutrinos
- Isotropic source of $\bar{\nu}_e$, detection through Inverse Beta Decay
- Detect surviving $\bar{\nu}_e$ as function of distance and energy
- ~45 M$ for driver, 5 years of running

need more H_2^+!

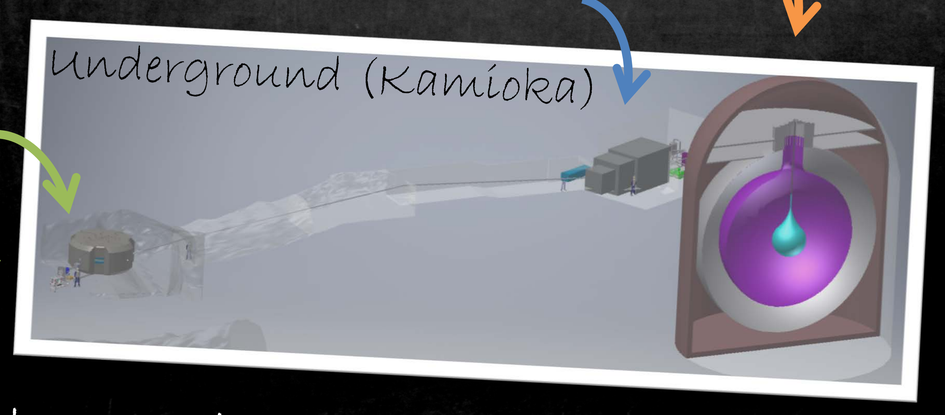
Ion Source Design

- Based on: Ehlers and Leung (saw 100 mA/cm^2): http://aip.scitation.org/doi/10.1063/1.1137452
- Multicusp, filament-driven, short plasma, modular

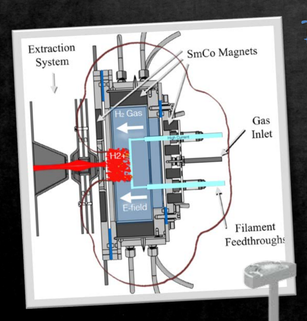
KamLAND (liquid scintillator)

Target (^{9}Be + 99.99% pure ^{7}Li)

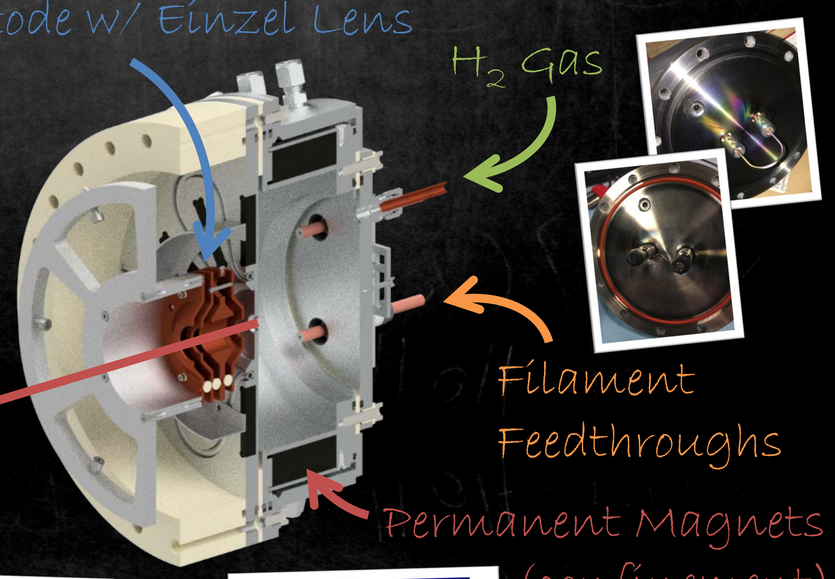
Driver
- Ion Source
- RFQ
- Cyclotron
- 5 mA H_2^+
- Stripped to p$^+$



Extraction System
Pentode w/ Einzel Lens



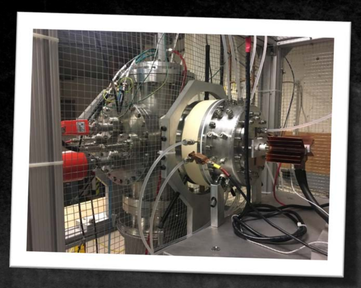
H_2 Gas

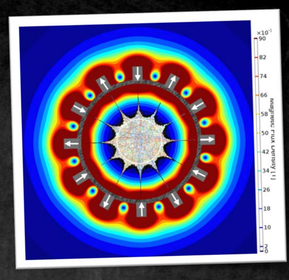


Filament Feedthroughs

Faraday Cup

Permanent Magnets (confinement)

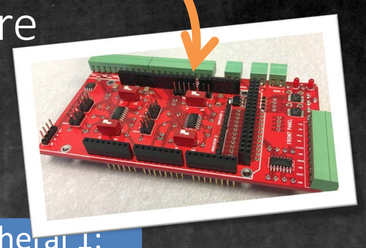


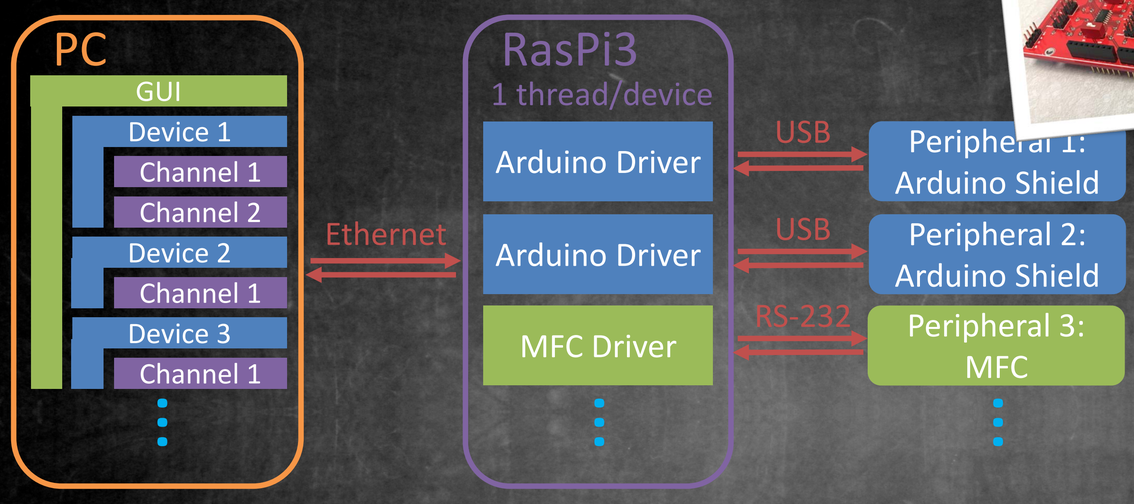


Control System

- Entirely open source, MIT license
- Based on python3 + QT5
- RasPi3 server controlling Arduino/Teensy/RS232
- Multiprocessing/Multithreading
- Drivers on RasPi3 translate PC ←→ Hardware

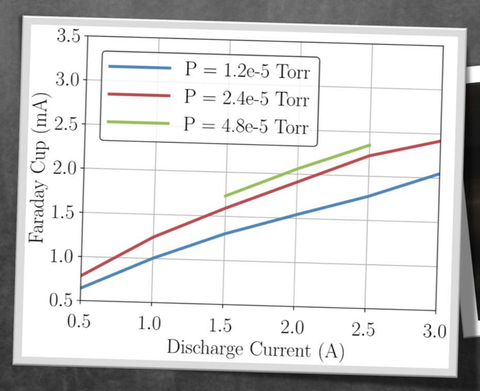
Arduino Shield

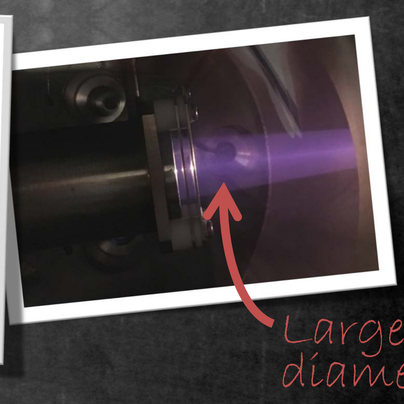




Commissioning

Best so far:
- 3.70 mA (or 7.36 mA/cm2) from ø 8 mm aperture
- 3.37 mA (or 11.9 mA/cm2) from ø 6 mm aperture
- Filament lifetimes: 4-10 h
- Total extracted current vs discharge:





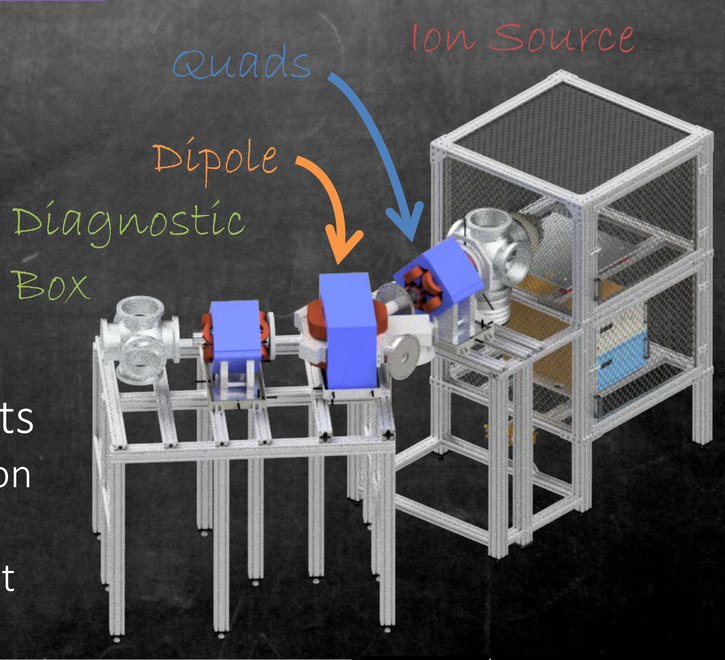
Large diameter

- Mainly limited by extraction system performance

Next Steps

- Improved Cooling
- Beamline extension
  - Analysis Magnet
  - Emittance Scanner
- Systematic measurements
  - Filament material, position
  - Gas inflow
  - Discharge voltage/current

Quads
Ion Source
Dipole
Diagnostic Box



...ask me what happened here :)

Multicusp Ion Source Technology @MIT

Massachusetts Institute of Technology

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