

Mass Spectrometry of UF_6 in a Micro Ion Trap

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Why UF₆ MS?

²³⁵U

- Only naturally occurring isotope of reasonable abundance that can sustain a fission chain reaction
- Independent route to nuclear power
 - Electrical
 - Military
 - Political
- Relative abundance 0.7%
- Need ~4% for reactor, much more for weapons

Why UF₆ MS ?

- UF₆ is used in several enrichment schemes
 - Gaseous diffusion
 - Gas centrifuge
 - Molecular laser isotope separation
- ²³⁵U/²³⁸U is the metric
- Methods of analysis
 - Mass spectrometry
 - Optical spectrometry
 - Nuclear/physical methods

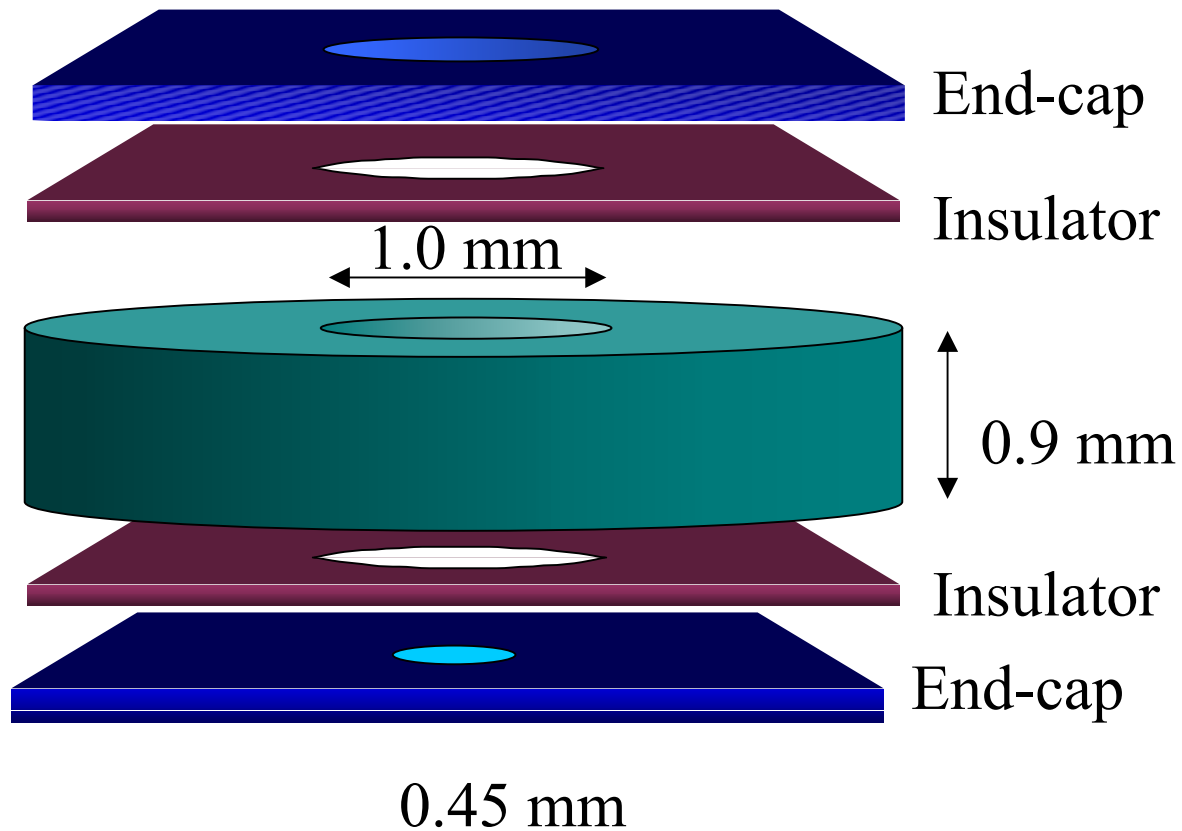
Tanks of depleted UF₆ at the former K-25 site, Oak Ridge



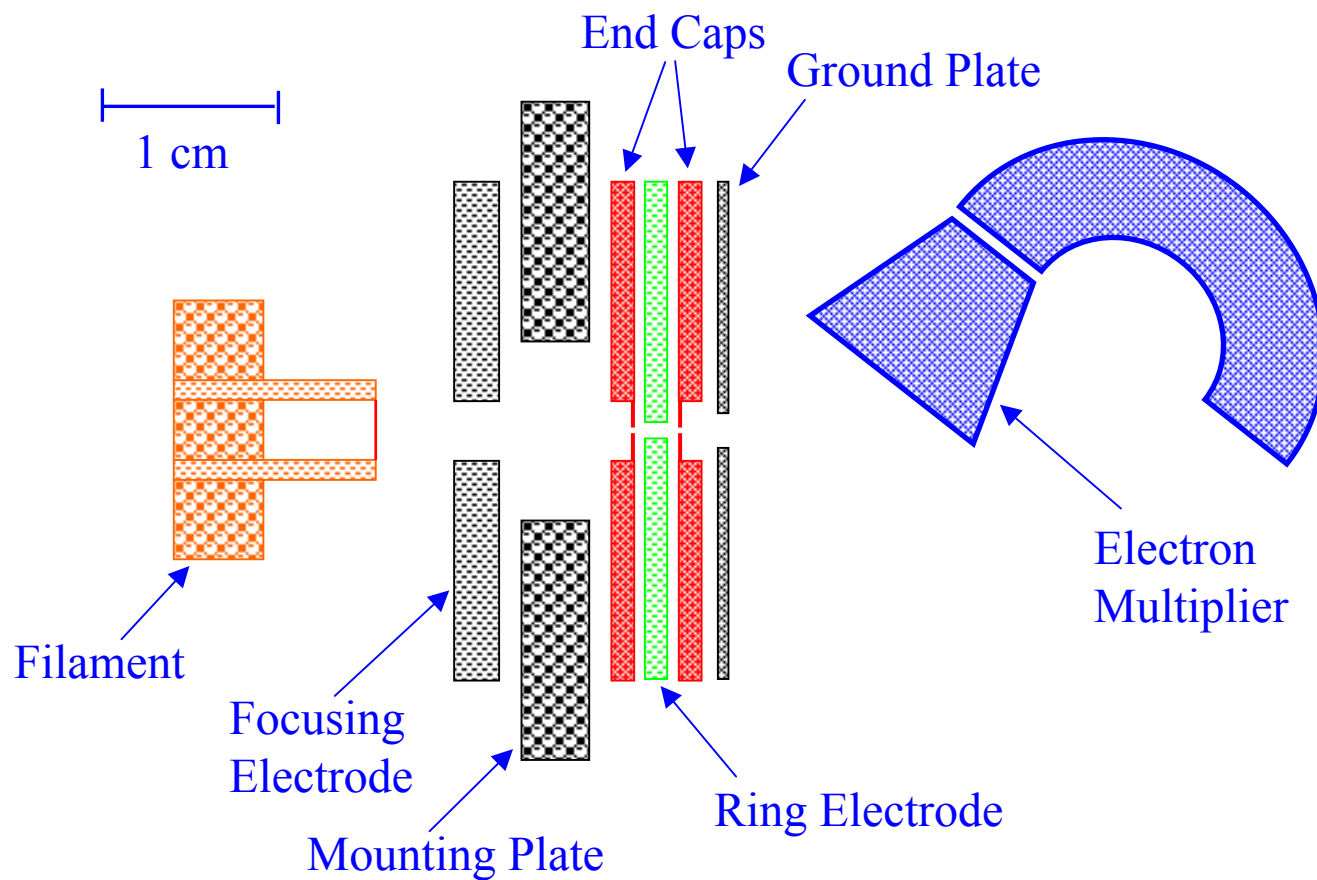
Tanks of depleted UF₆ at Paducah, KY



1-mm Cylindrical Ion Trap



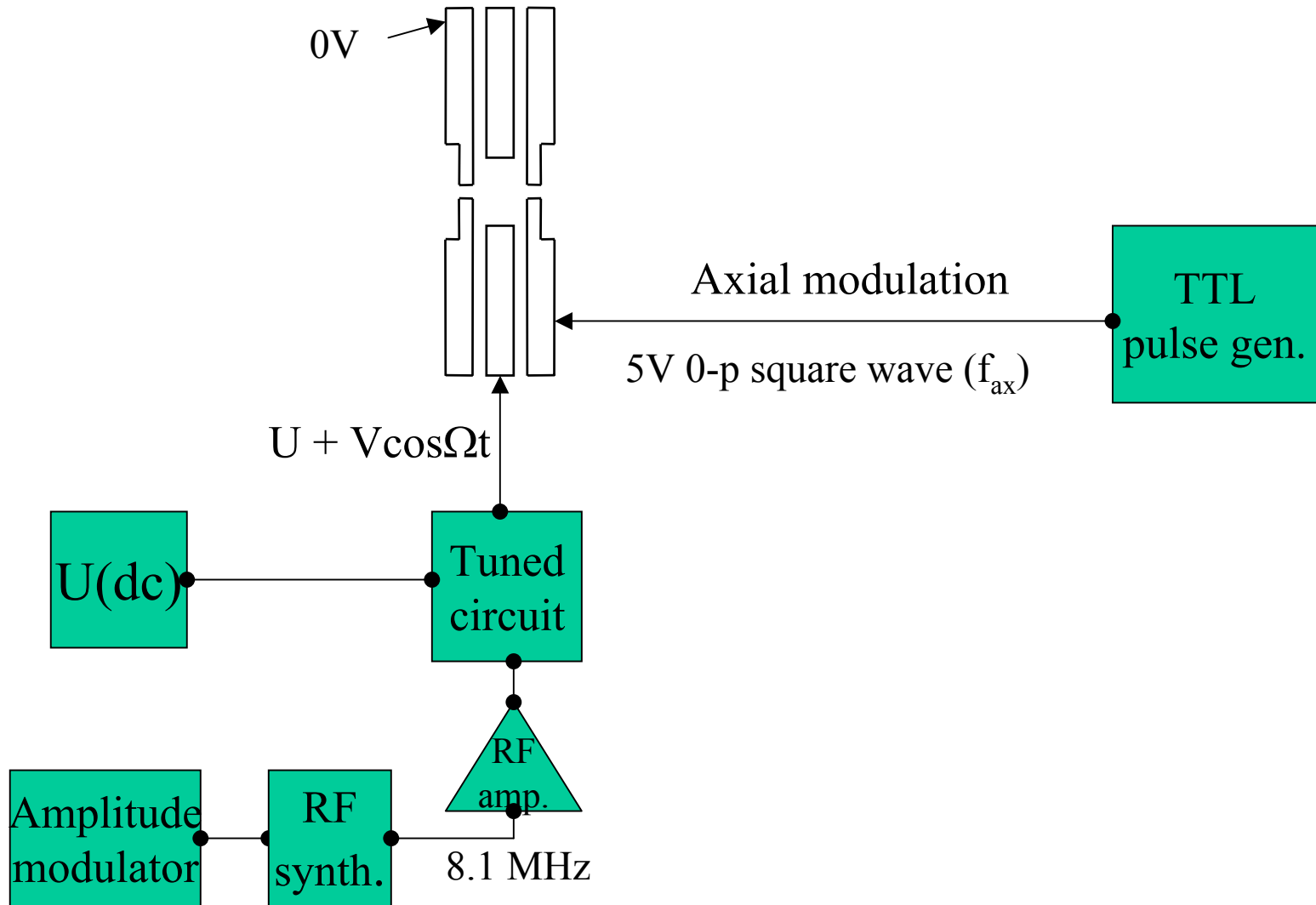
Micro Ion Trap, Ionization Source And Detector



Nonlinear resonances, double resonance ejection

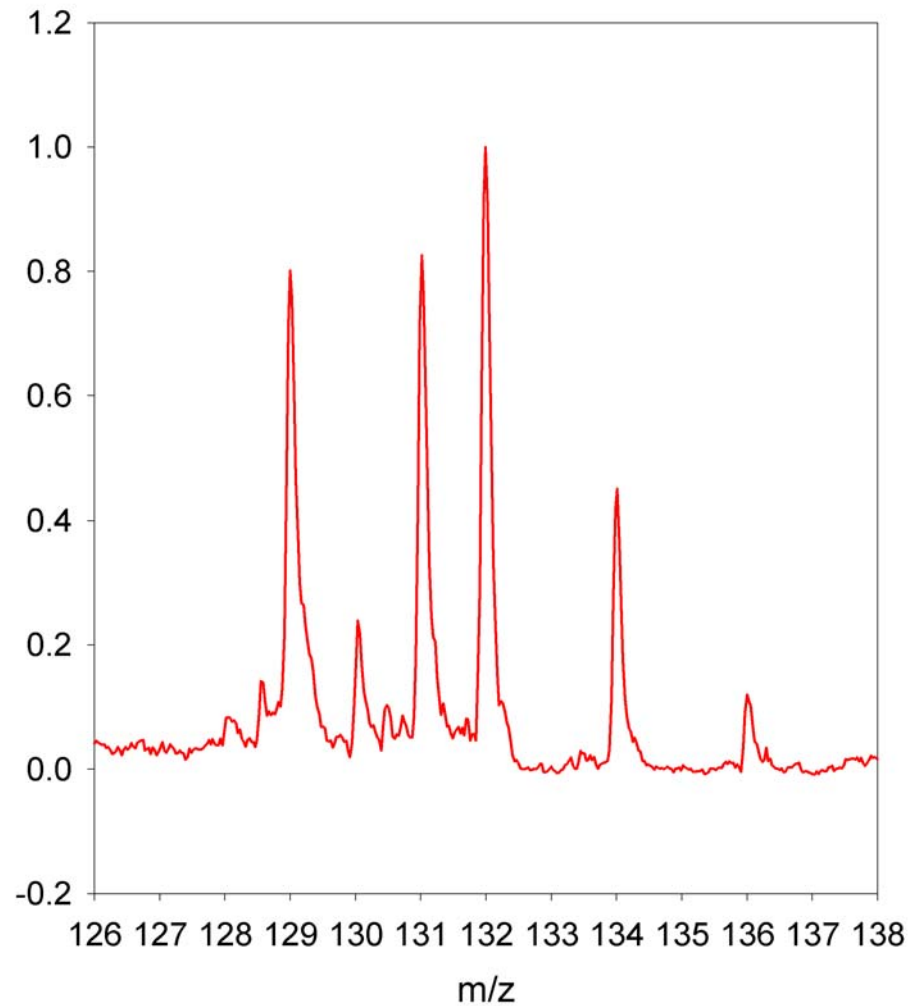
- Our trap geometry has fields of higher order than quadrupolar, e.g., octopolar.
- The secular motion becomes distorted, with higher frequency harmonics
- If a harmonic matches half the drive frequency, the ion can absorb power from the radiofrequency drive voltage and be ejected
- We apply axial modulation at a subharmonic of the drive frequency and ramp the rf voltage
- Ions are ejected when the secular frequency comes in resonance with the axial modulation

Setup for Double Resonance Ejection Studies



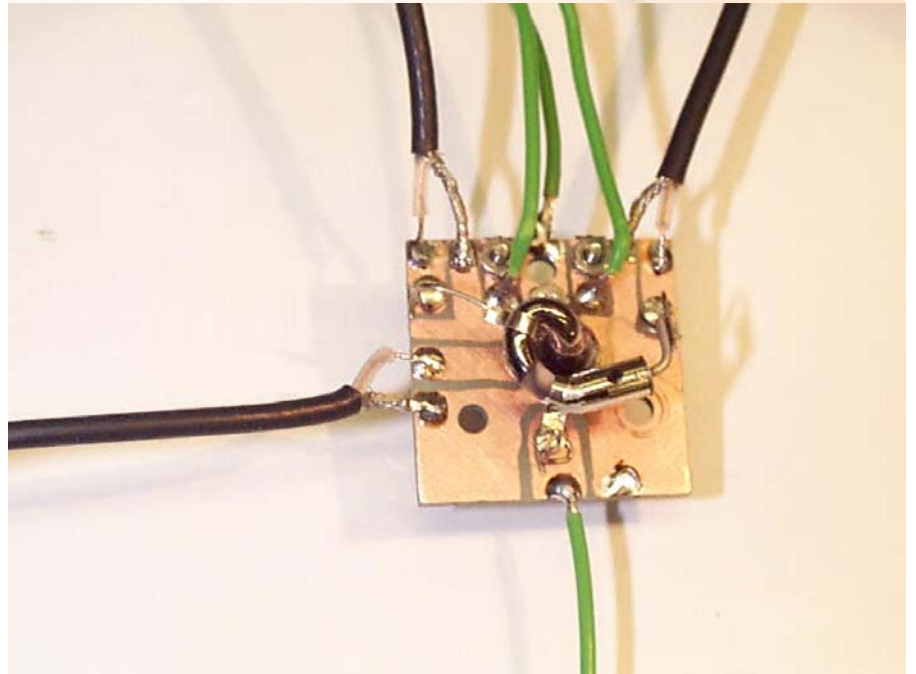
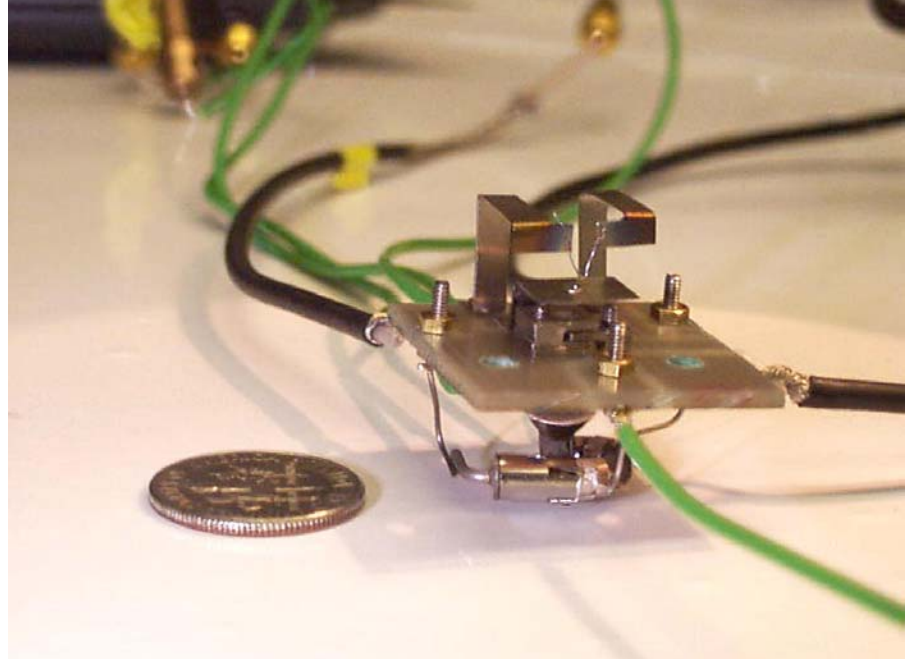
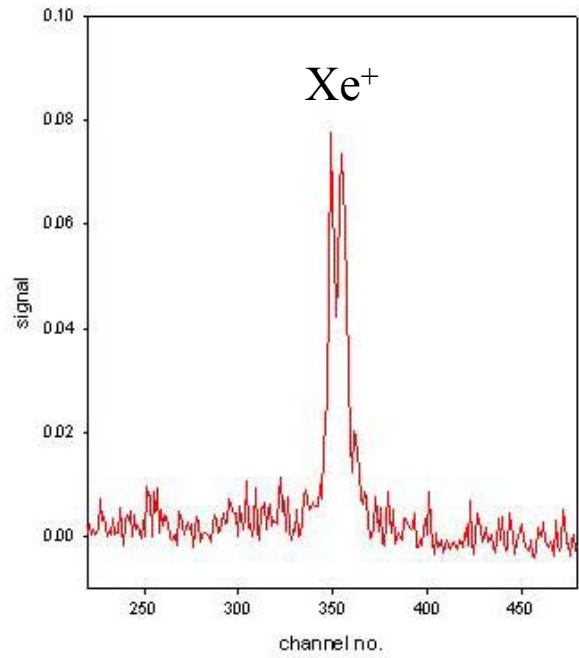
Mass Spectrum of Xenon isotopes, 1-mm Trap

$\Omega/2\pi = 6.8$ MHz $f_{ax} = 1.7$ MHz





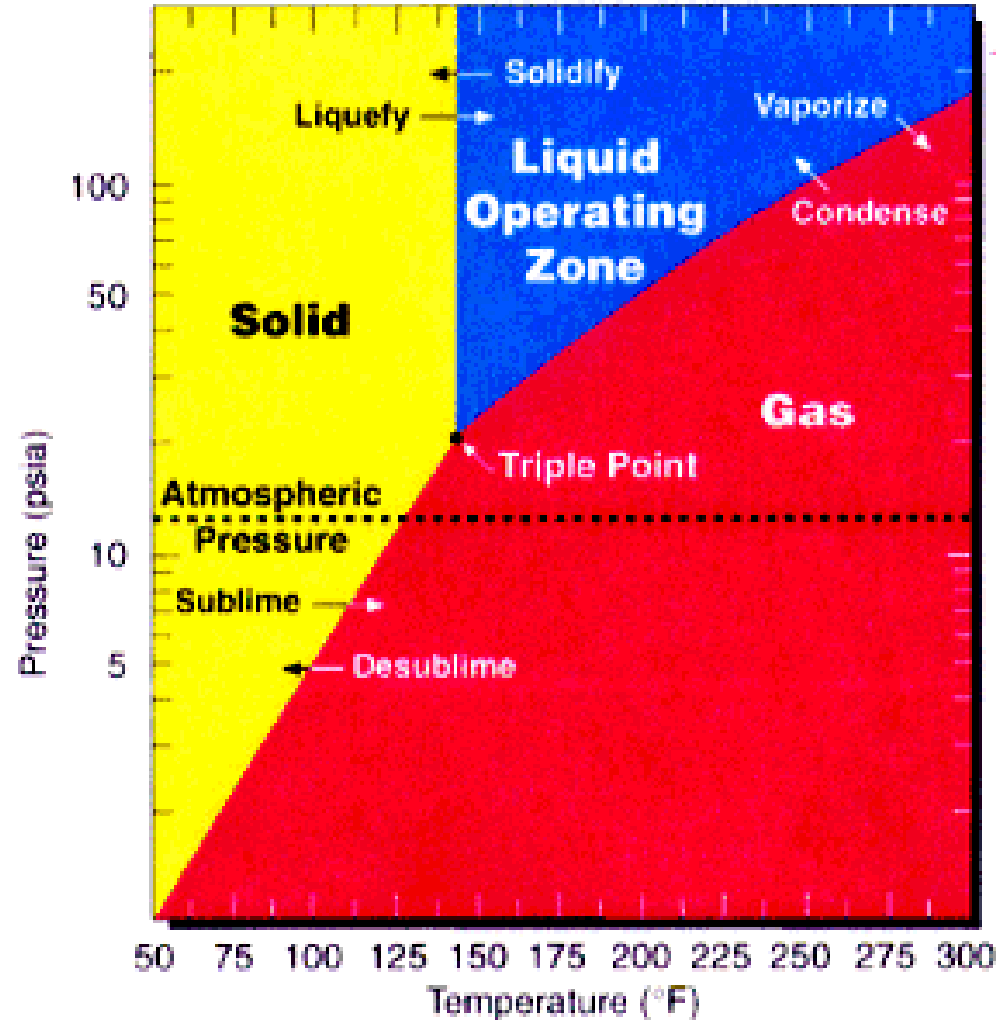
Micro Ion Trap on PC-Board



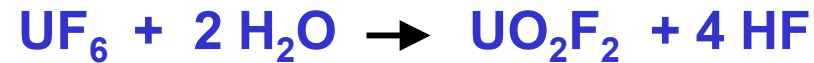
Battery-powered vacuum system with micro ion trap



UF₆ Phase Diagram



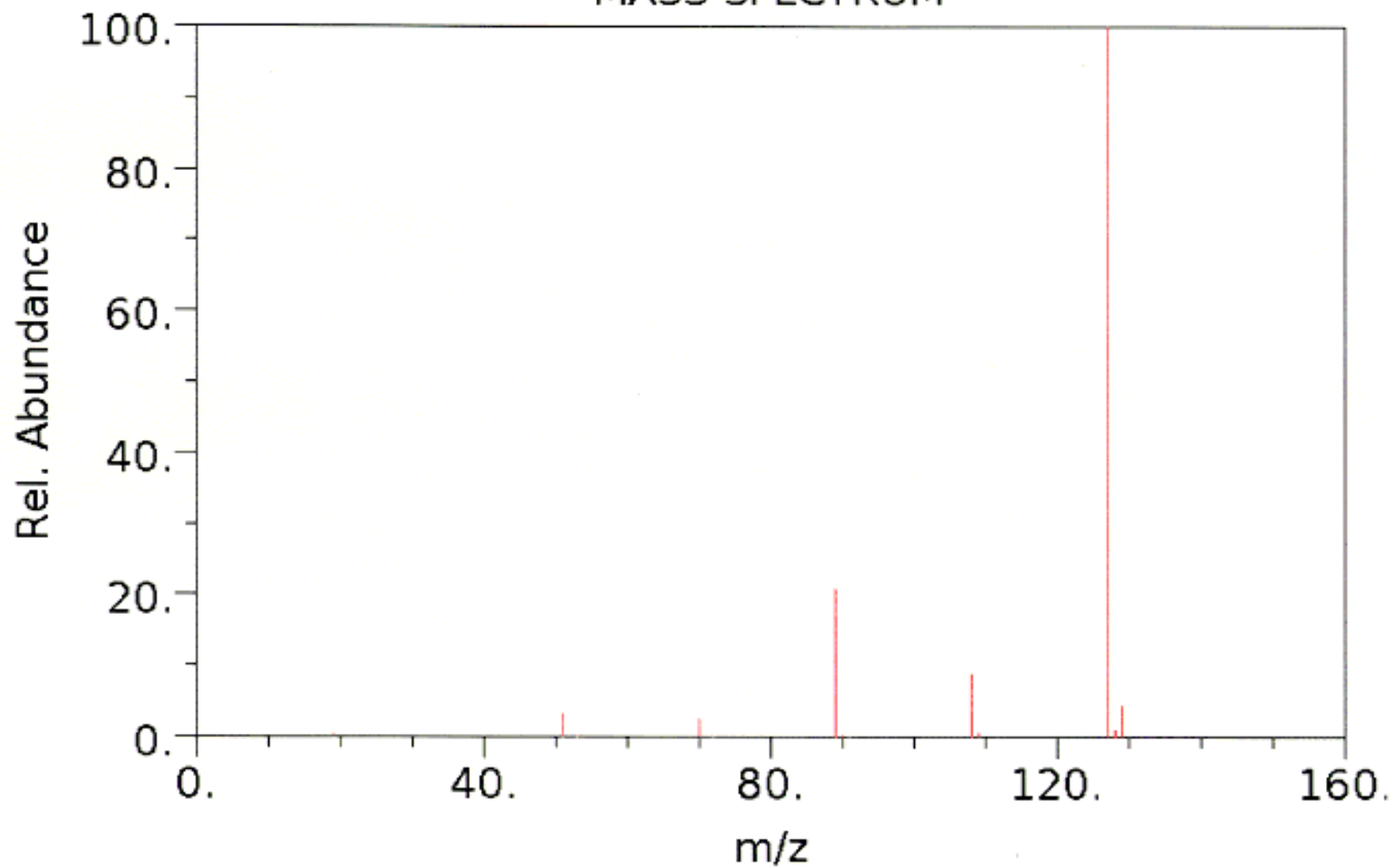
Chemical Properties of UF₆



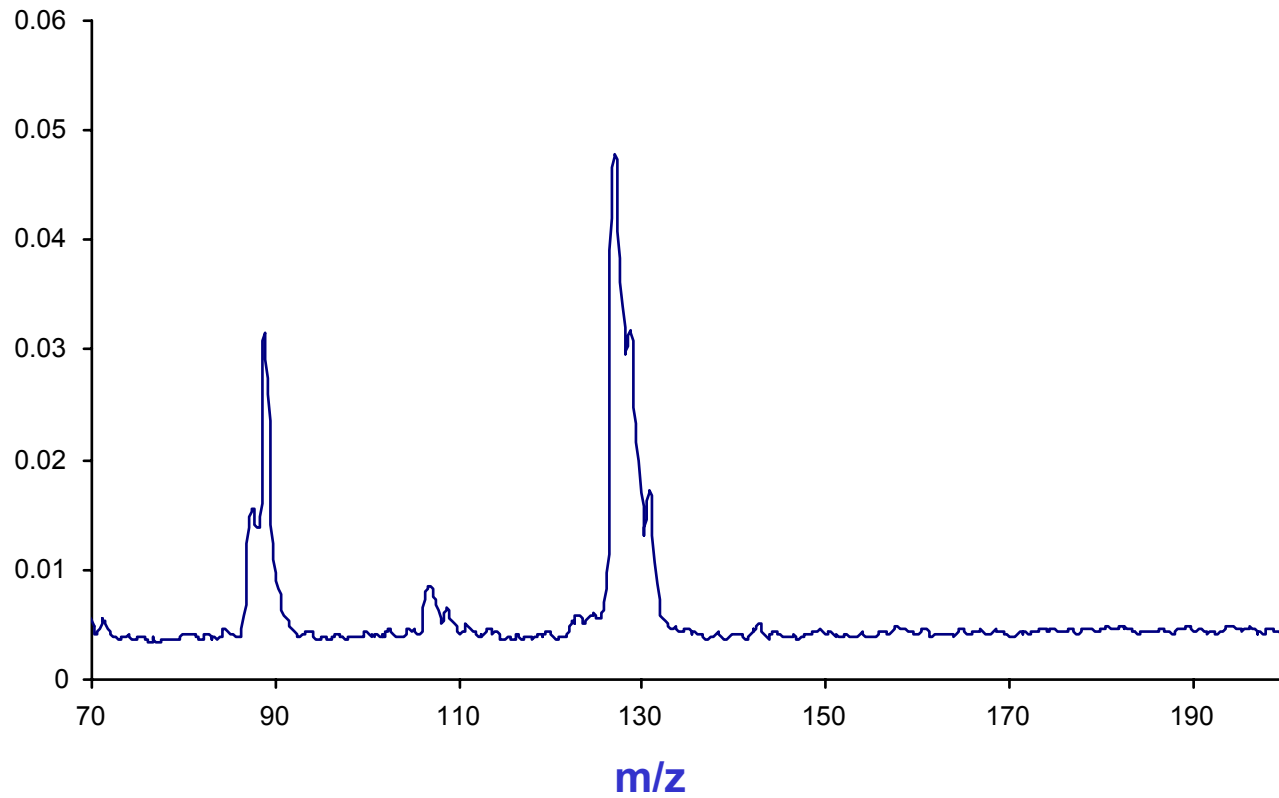
Nickel, aluminum, Al₂O₃, Teflon are relatively stable

What happens to detector, filament?

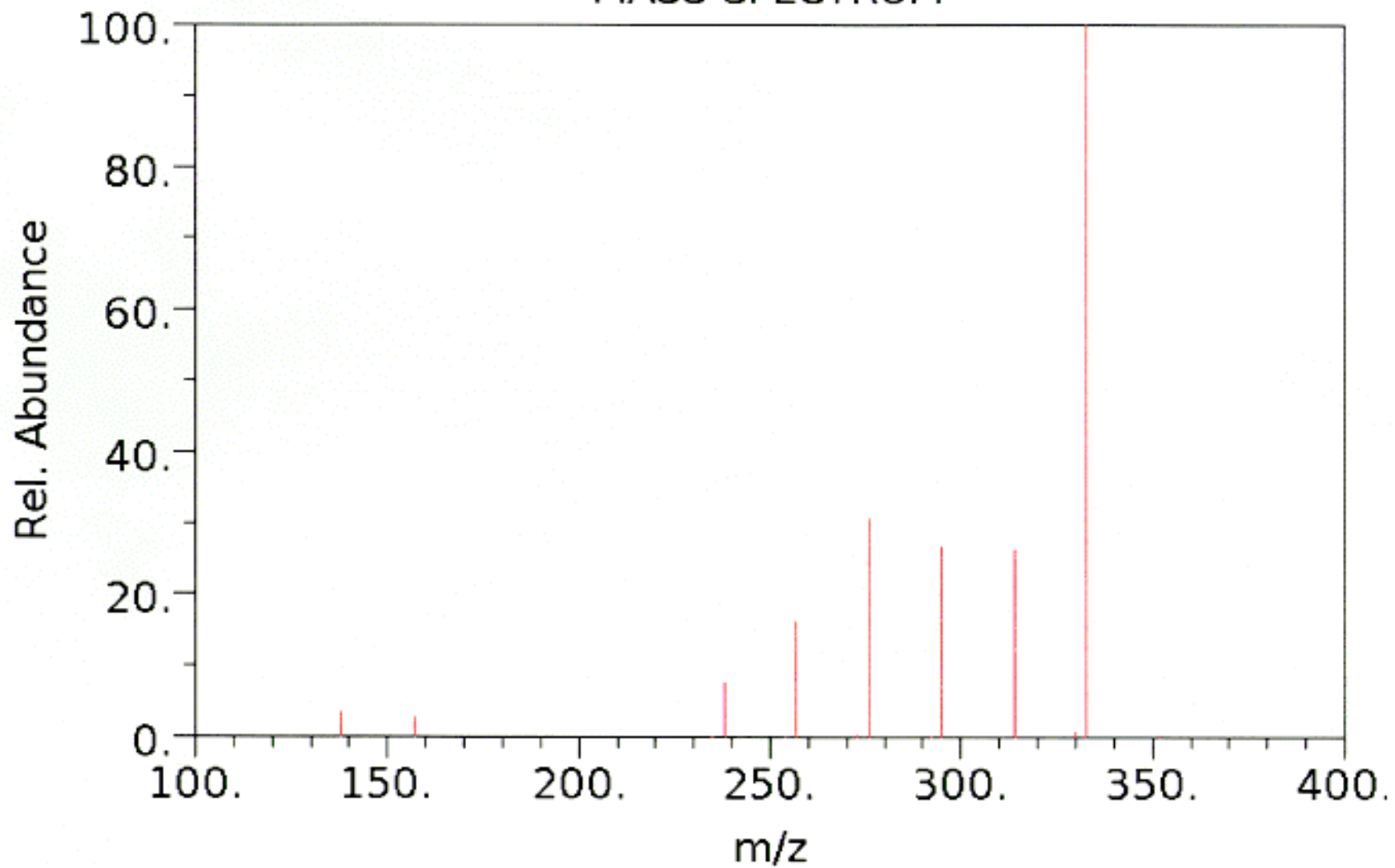
Sulfur hexafluoride
MASS SPECTRUM



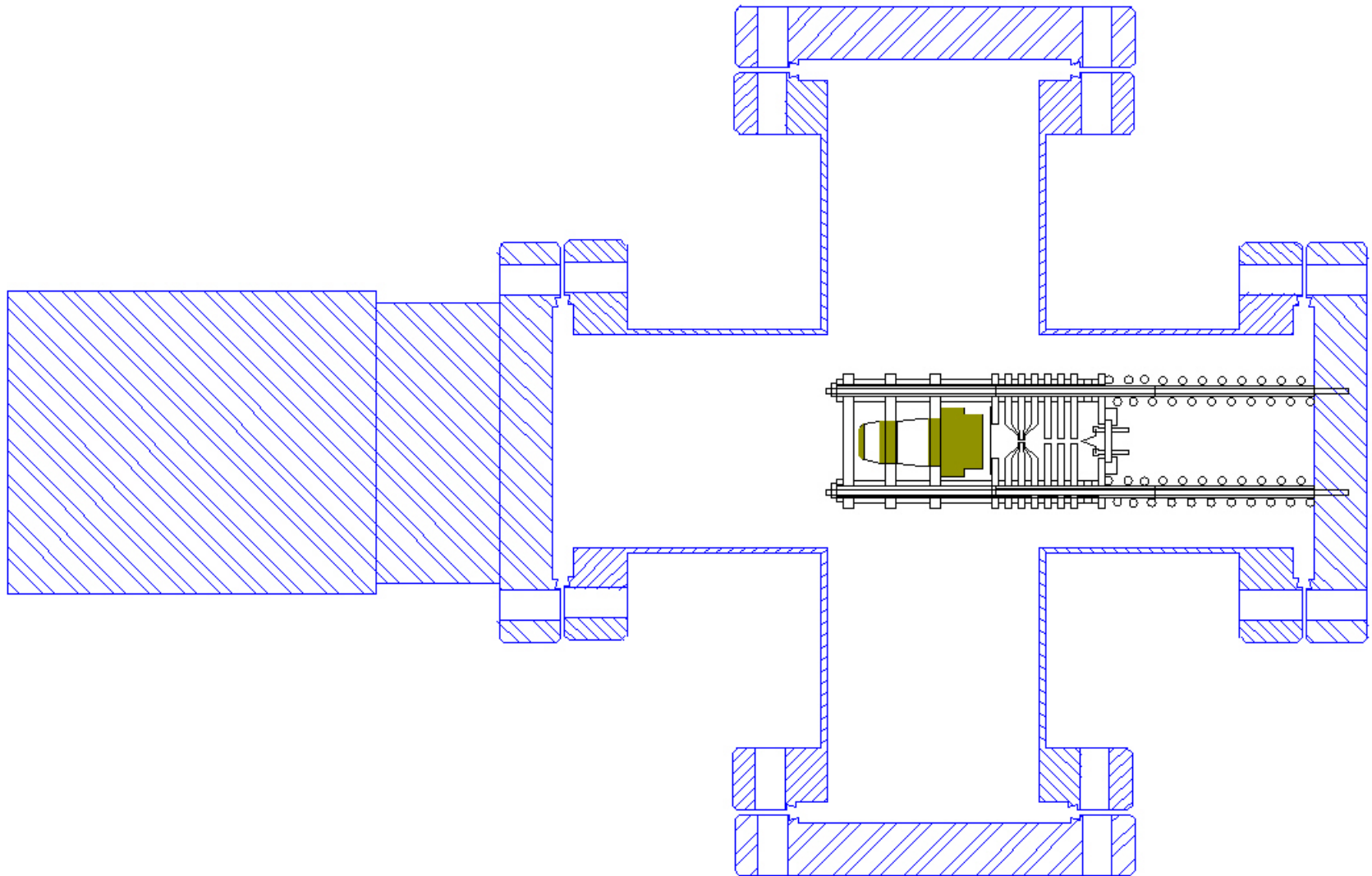
SF₆ Mass Spectrum



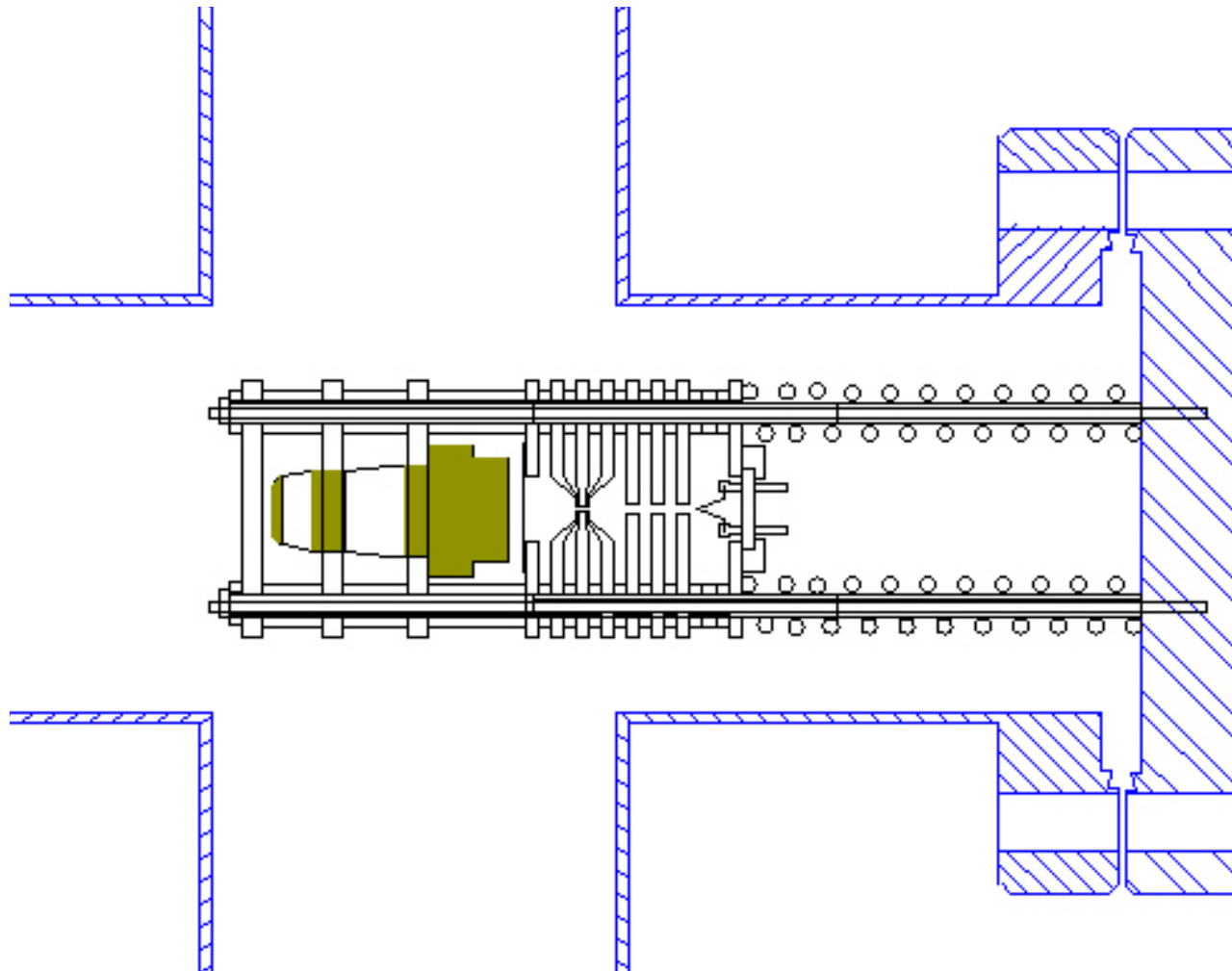
Uranium hexafluoride MASS SPECTRUM



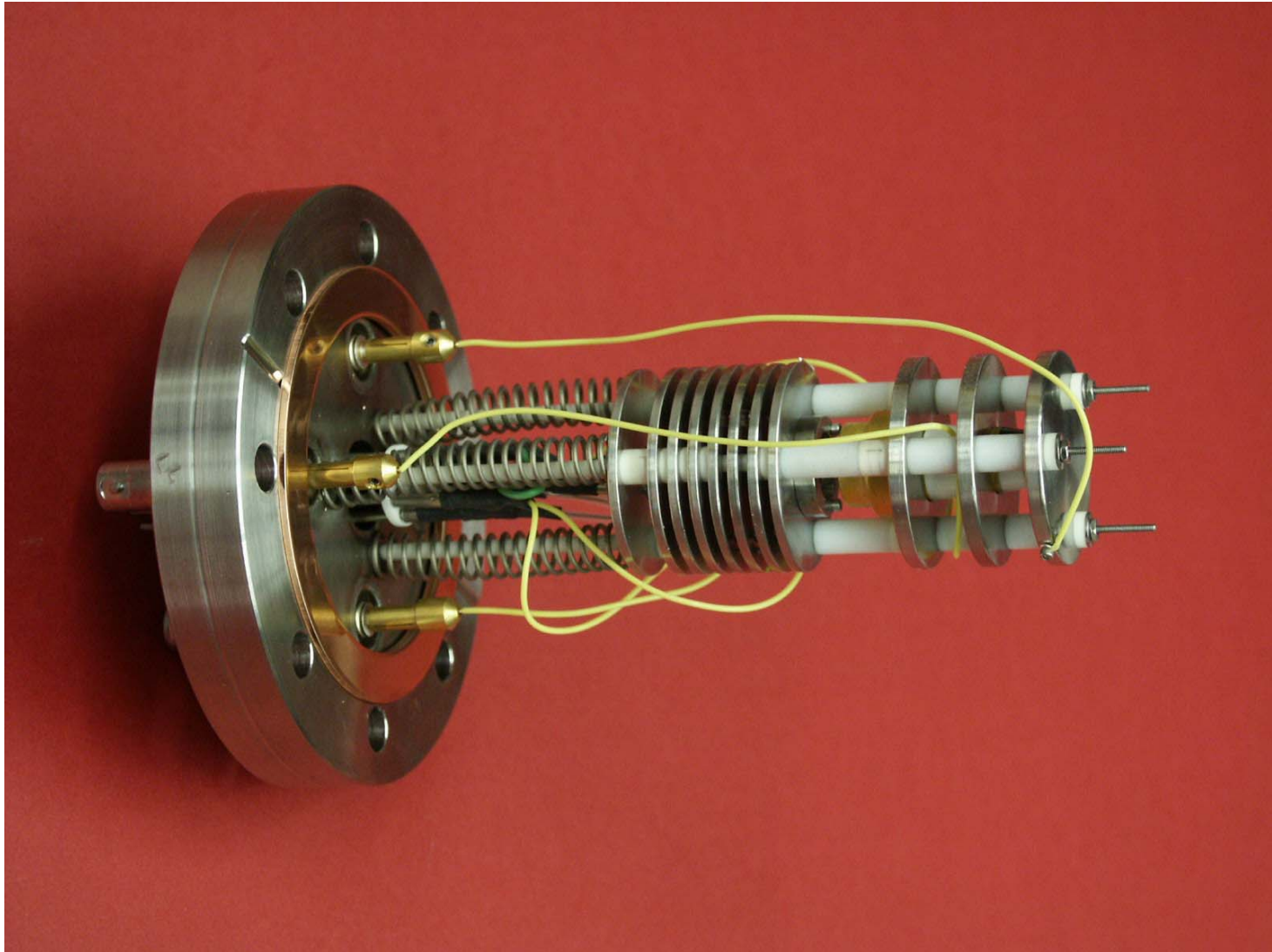
UF₆ Micro Ion Trap Test Assembly



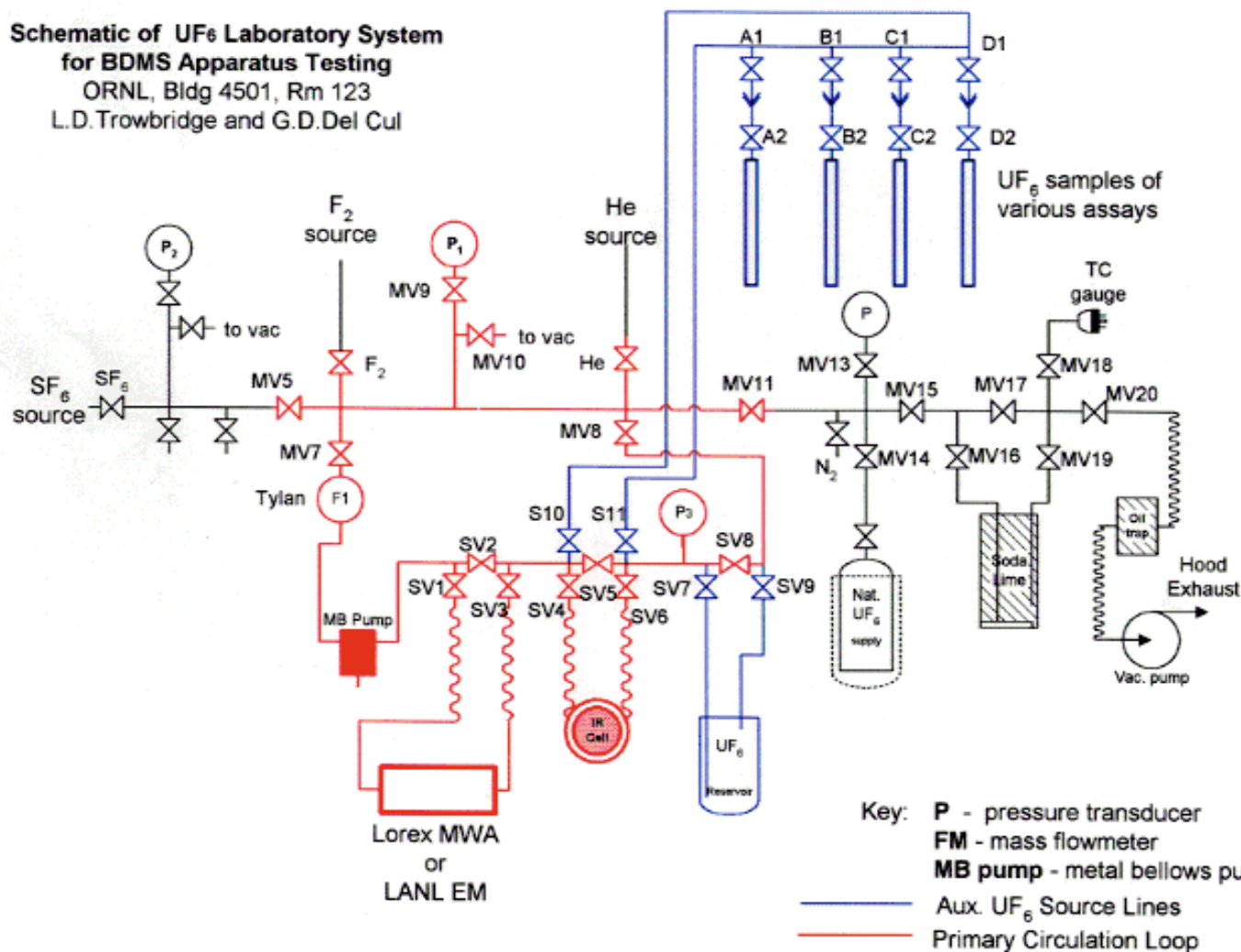
UF₆ Micro Ion Trap Test Assembly



Micro Ion Trap Mass Analyzer for UF_6 Measurements



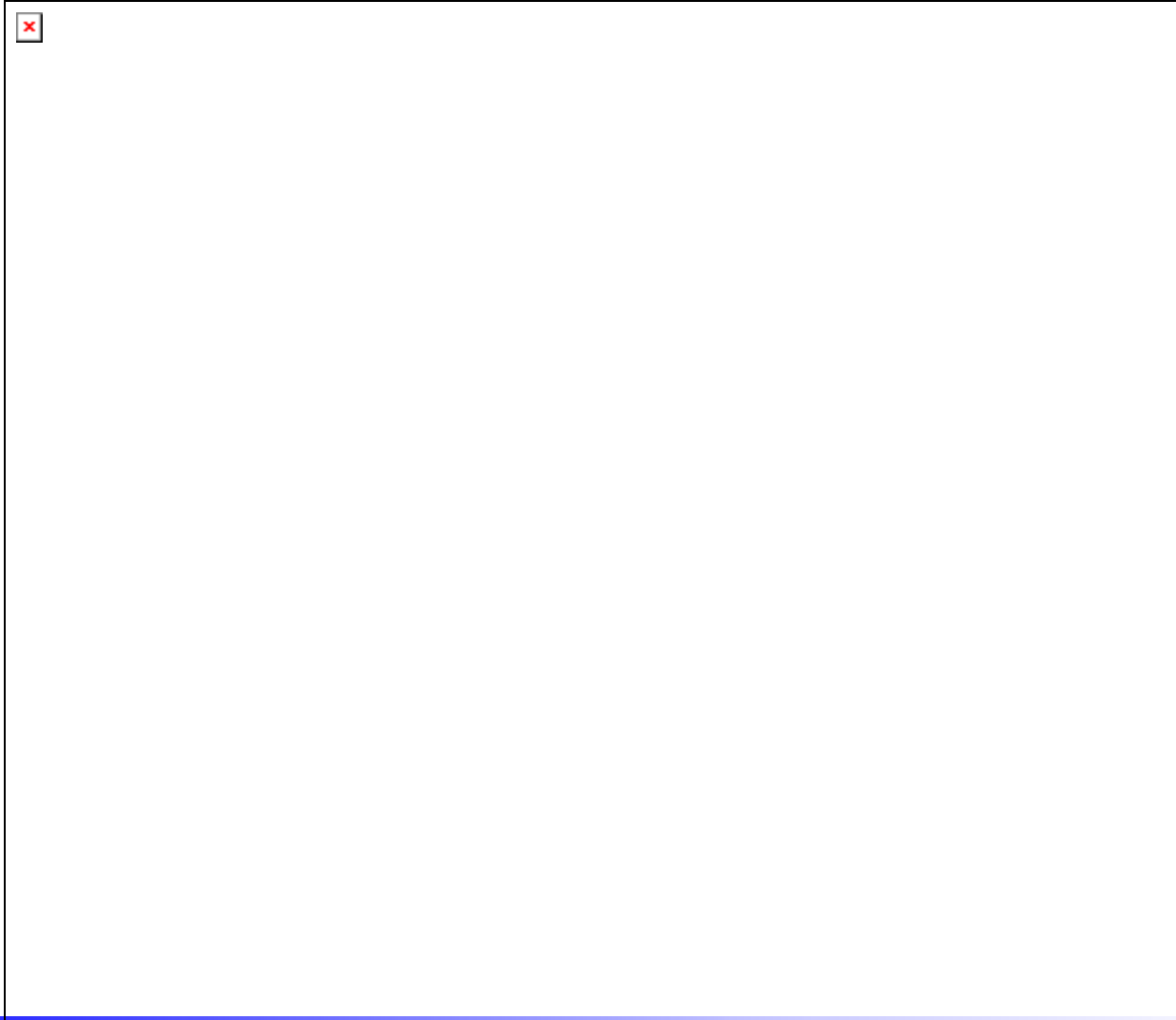
**Schematic of UF₆ Laboratory System
for BDMS Apparatus Testing**
ORNL, Bldg 4501, Rm 123
L.D.Trowbridge and G.D.Del Cul



Detector current vs time, UF_6 pressure 1×10^{-5} torr



Detector current vs UF_6 pressure



Summary

- Mass spectrometry with ion traps of submillimeter dimension is feasible
- Mass resolution is comparable to or better than from conventional ion traps
- Lower voltage, higher frequency favors smaller instrumentation
- Higher pressure operation reduces vacuum system requirements
- Reactivity of UF_6 does not appear to be a showstopper

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