



Xenon Quality Control Materials Production

April 2023

Changing the World's Energy Future

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Gas Standards Team Lead

Xenon Quality Control Materials Production

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Martinez

Battelle Energy Alliance manages INL for the
U.S. Department of Energy's Office of Nuclear Energy



Idaho National Laboratory

Xenon Quality Control Materials Production

- Isolate Isotope of Interest
- Quantify the Activity
- Mix to Desired Specific Activity
- Fill Individual Lab Containers
- Conduct Internal Quality Control
- Ship
- Report

Routine Xenon Isotope Isolation and Mixing

- Individual Isotopes
- Mixed Isotopes

Cs131 ^{5/+} 9.69 d ϵ no γ E .35	Cs132 ²⁺ 6.48 d ϵ β^+ 40, ... γ 667.7, ... β^- , γ 464.6, ... $\sigma_\alpha < .15$ E 2.119 E -1.25	Cs133 ^{7/+} 100 σ_γ (2.6 + 27), (31 + 3.9E2) 132.905447	Cs134 ⁴⁺ 2.90 h IT 127.5, ... γ 11.2, e- β^- 14E1, ... E 2.0587 E +1.22	Cs135 ^{7/+} 53 m IT 846.1 β^- 21 γ 787.2 no γ σ_γ ~8.7, 9E1 E .269	Cs136 ⁵⁺ 19 s IT β^- ? γ 818.5, 1048.1, 340.5, ... E 2.548	Cs137 ^{7/+} 30.07 a β^- 514, ... γ 661.7D, 283.4 v σ_γ .25, ~0.4 E 1.1756
Xe130 4.08 σ_γ (.4+?), (16+?) 129.903507	Xe131 ^{3/+} 11.9 d IT 163.9, e- σ_γ 9E1, 9E2 130.905082	Xe132 26.89 σ_γ .05 + .4), (.9 + 4) 131.904154	Xe133 ^{3/+} 2.19 d IT 233.2 β^- 346, ... γ 80.99, ... β^- 2E2 E 427	Xe134 10.44 σ_γ 3.0 mb + .26) 133.905394	Xe135 ^{3/+} 15.3 m IT 526.6 β^- .91, ... γ 786.9, ... σ_γ 2.6E6, ~7.6E3 E 1.17	Xe136 8.87 σ_γ 26, .7 135.90722
I129 ^{7/+} 1.57E7 a β^- .15 γ 39.6, e- σ_γ (20+10), 5E1 E .194	I130 ²⁺ 9.0 m IT 39.96, e- β^- 2.5, ... γ 536.1, ... E 2.949	I131 ^{7/+} 8.020 d β^- 606, ... γ 364.5, ... σ_γ 0.7, 8 E .971	I132 ⁸ 1.39 h IT 98, e- γ ~22 β^- 1.47, γ 599.8, 667.7, 772.6, ... E 3.58	I133 ^{7/+} 9 s IT 74.0, β^- 1.24, e- γ 647.4, 912.6, ... E 1.757	I134 ⁴ 3.7 m IT 271.9 β^- 1.2, ... γ 44.4 β^- 847.0, 884.1, γ 847.0, 884.1, ... E 4.05	I135 ^{7/+} 52.6 m β^- 1.3, .9, ... γ 1260.4, 1131.5, 526.6D, ... E 2.63

Two Dimensions of “Purity” for Isotopes

Radioactively Pure – *Only one radioactive isotope / isomer present in a gas population*

Carrier Free – *Radioactive isotope not in the presence of stable xenon many orders of magnitude more abundant.*

The Goal of INL Noble Gas Laboratory is to have available Radioactively and Isotopically Pure Xenon for use in supplying quality control and test samples.

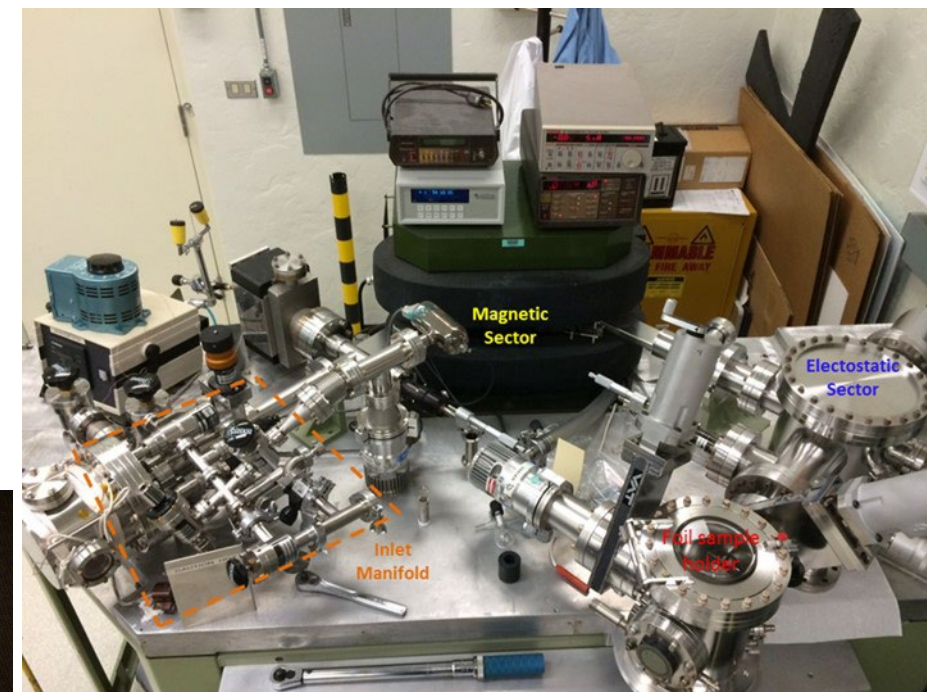
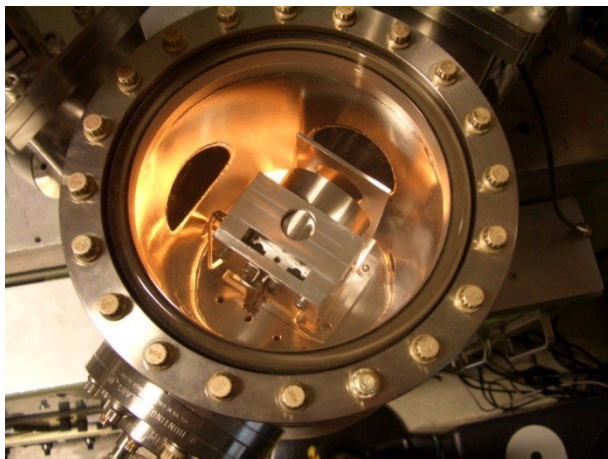
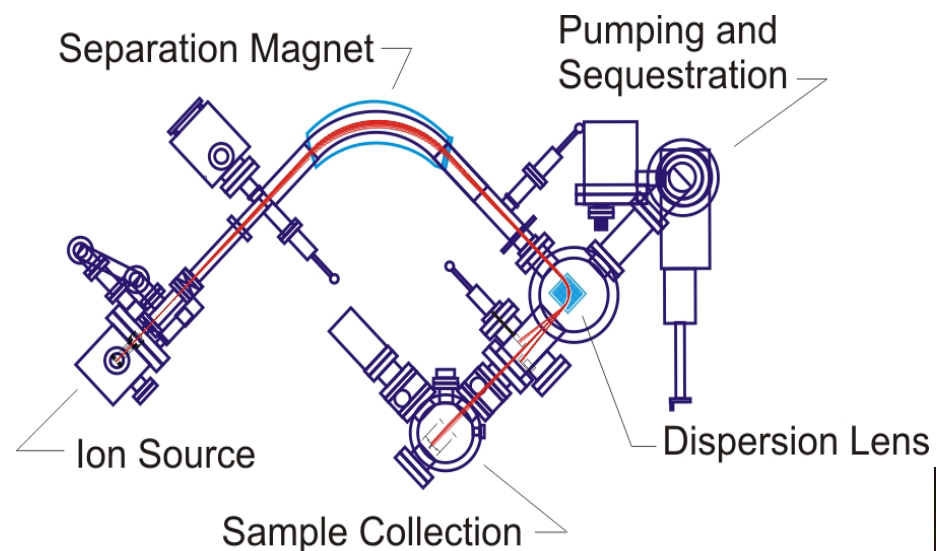


Two Dimensions of Purity - Status

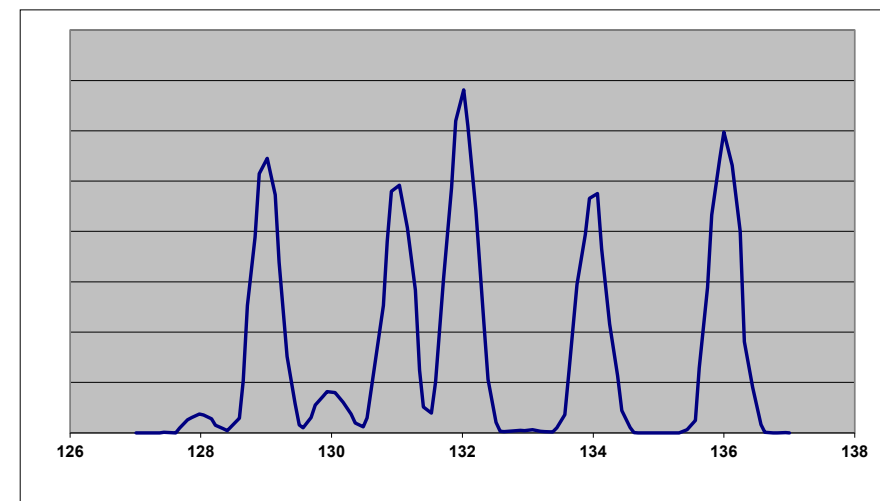
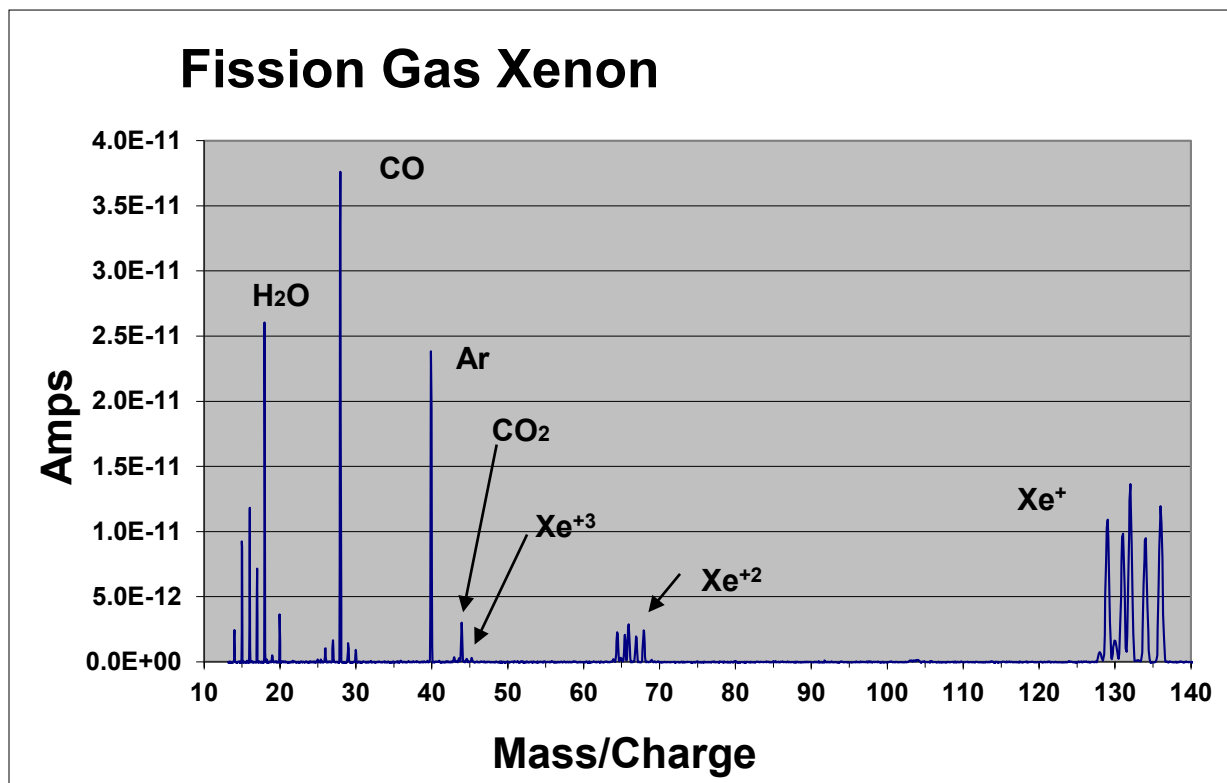
		Isotopic Purity	
		No Carrier Xenon	Carrier Xenon
Radioactive Isotopes / Isomers	Single	$^{131\text{m}}\text{Xe}$ ^{133}Xe	$^{131\text{m}}\text{Xe}$ ^{133}Xe $[^{127}\text{Xe}]$
	Multiple		^{135}Xe $^{133\text{m}}\text{Xe}$

Isolate ^{133}Xe from Fission Gas

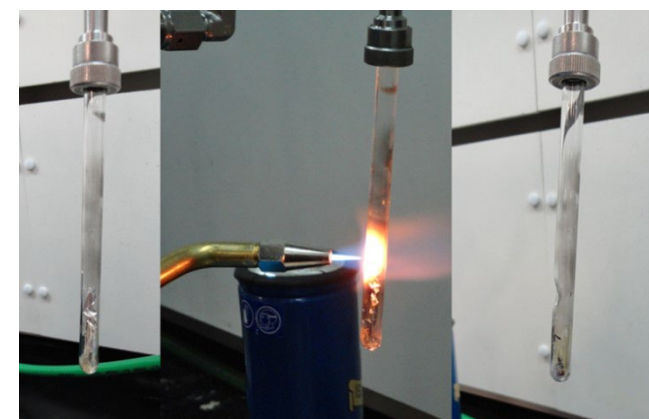
-- Xenon separator designed and built at INL



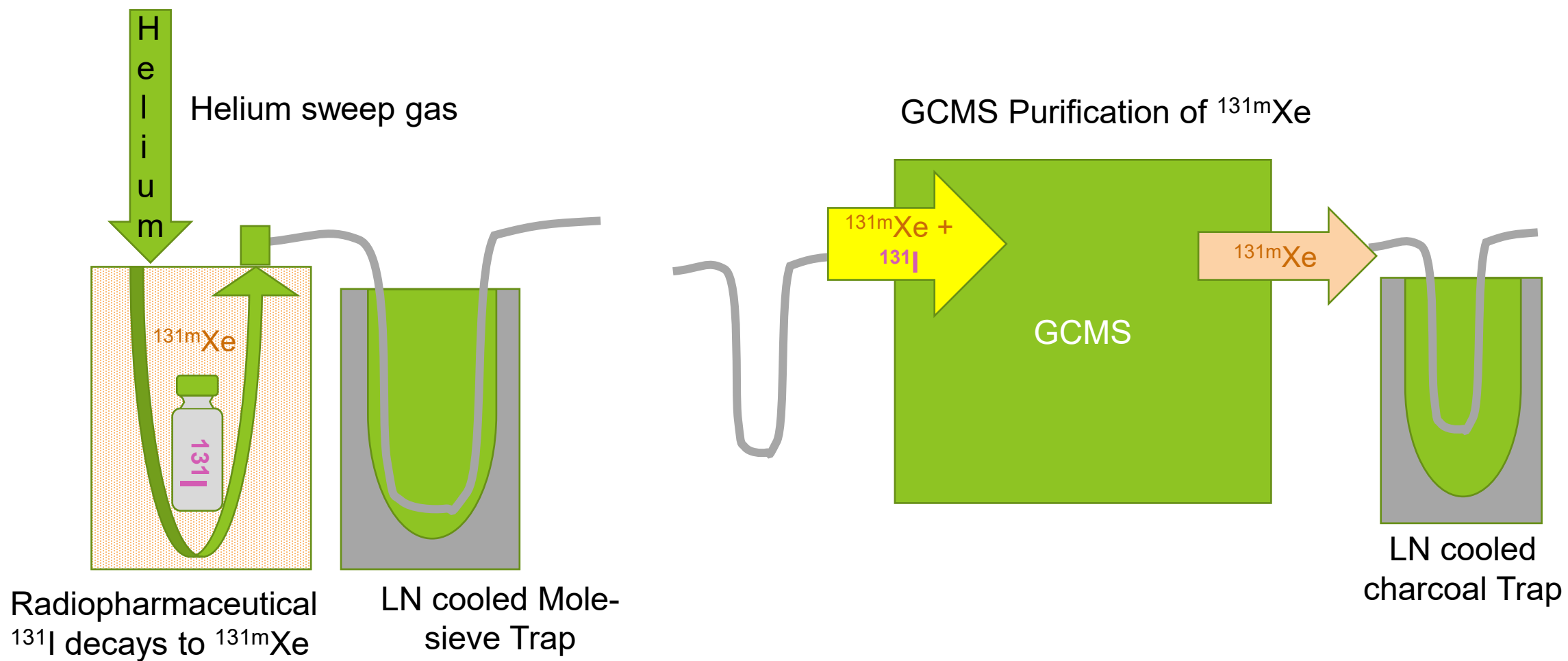
Starting material for ^{133}Xe standard is fission product xenon



Starting Material: 20.0 mCi ^{133}Xe
Product Material: 0.02 mCi ^{133}Xe



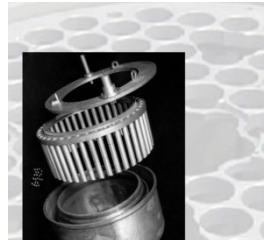
Preparation of Carrier Free ^{131m}Xe



[127], 131m, 133, 133m, 135 Xenon by Neutron Activation

NEUTRONS →

	11/-Xe131 3/+ 11.9 d IT 163.9, e ⁻	Xe132 26.89	11/-Xe133 3/+ 2.19 d 5.243 d IT 233.2 β ⁻ .346, γ 80.99, σ _γ 2E2	Xe134 10.44	11/-Xe135 3/+ 15.3 m 9.10 h IT 526.6 β ⁻ .91, γ 249.8, γ 786.9, σ _γ 2.6E6, ~7.6E3
	σ _γ 9E1, 9E2	σ _γ (.05 + .4), (.9 + 4)		σ _γ (3.0 mb + .26)	
	129.903507	130.905082	131.904154	133.905394	



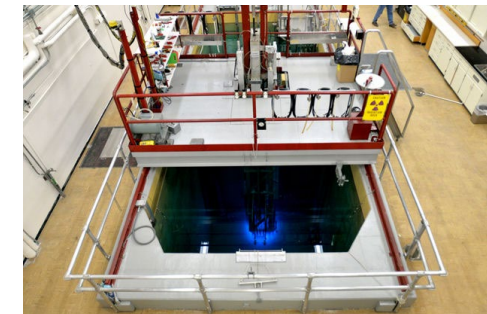
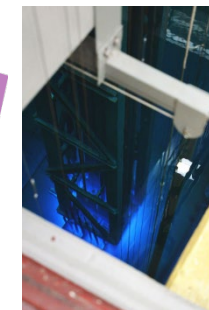
Nuclear Engineering Teaching Laboratory

at the University of Texas in Austin
Pickle Research Campus



WASHINGTON STATE UNIVERSITY

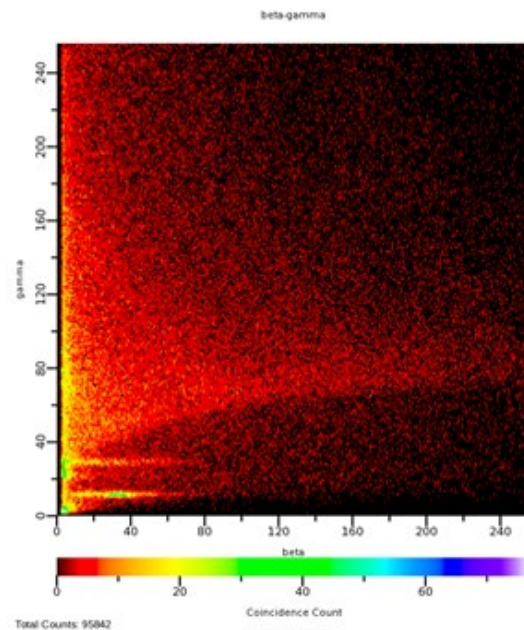
Nuclear Science Center



IDAHO NATIONAL LABORATORY

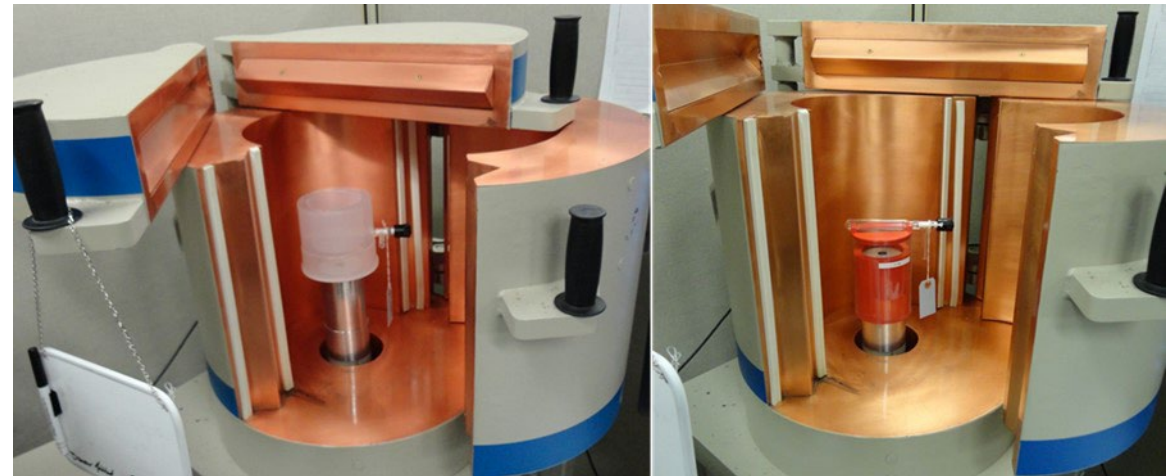
Detection Capabilities

- Germanium Detectors
- Beta-Gamma Coincident



Cell "3" was started on the day after the t-zero day. The spectrum contains less ^{135}Xe , ^{133}Xe ($^{133\text{m}}\text{Xe}$, and $^{131\text{m}}\text{Xe}$?).

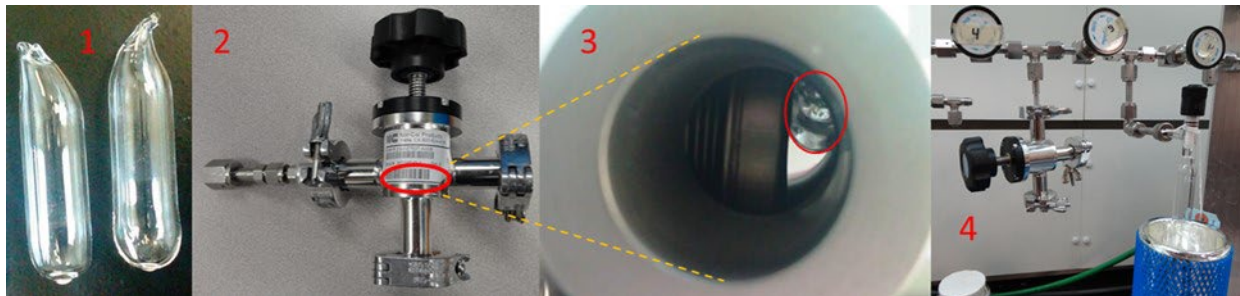
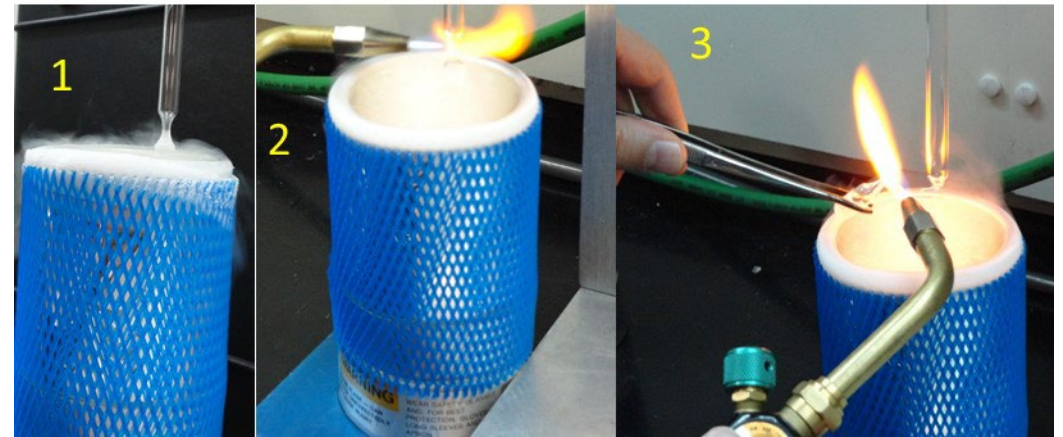
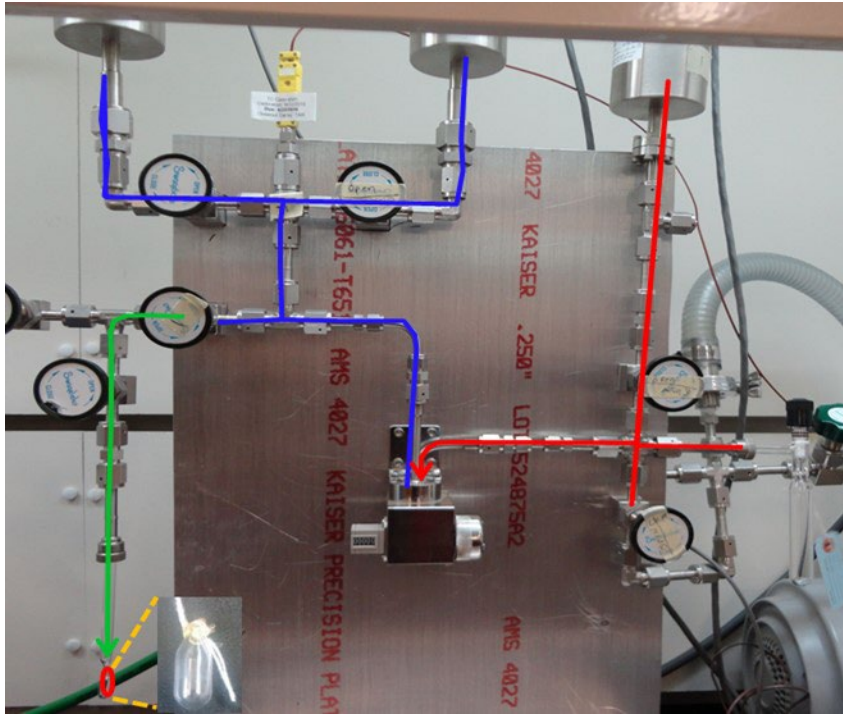
CountStart: 12/18/2018 14:48
CountEnd: 1/4/2019 12:01



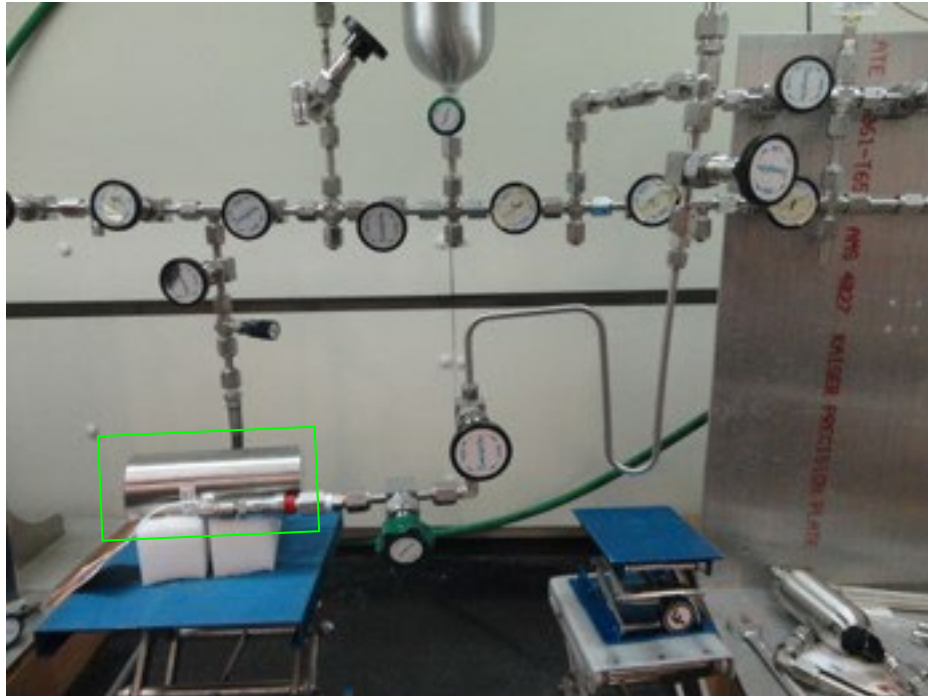
Mixing in Various Matrices

- Air
- Xenon
- Helium/Xenon
- Nitrogen/Xenon

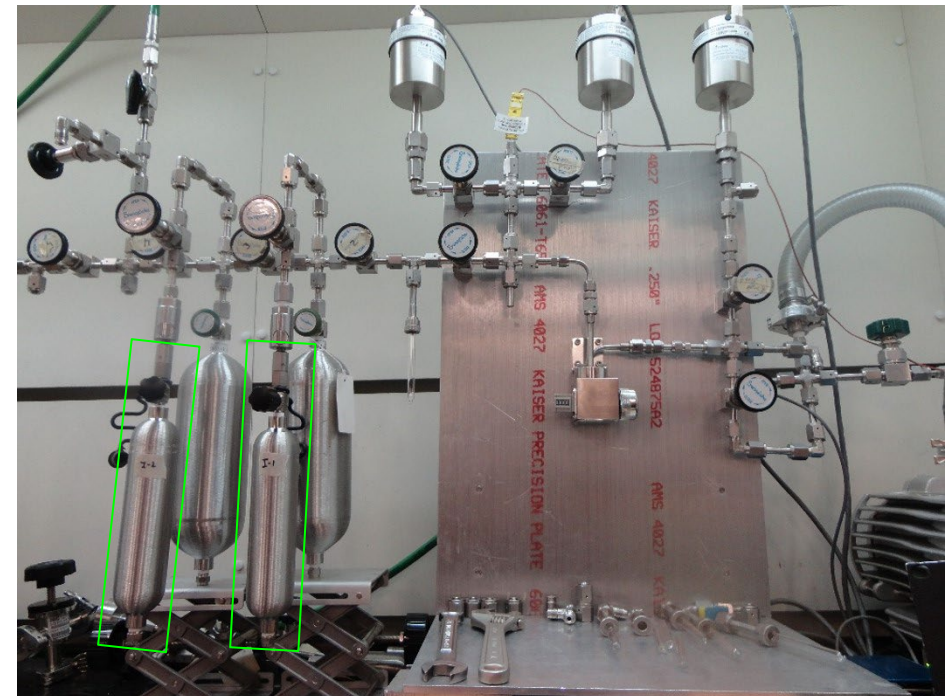
Small Volume Mixing & Dilution



Filling Exercise Bottles



New filling procedure **does not** include freezing the SAUNA bottle



Filling procedure **does** include freezing the SPALAX bottle

SAUNA Bottle Configuration Change



Old SAUNA bottle



Manual valve Added



SPALAX already has manual valve

New Packaging Protocol to Discourage Tampering with Sample in Transit

- Measurement lab in PTE reported odd sample properties
 - Air impurity
 - Moisture content
- After analyzing filling procedures and consulting with other labs, it was theorized that samples were tampered with in transit
- New packaging and bottle design implemented to discourage tampering
 - Shrink-wrap to discourage removal of stem protectors, operating manual valves
 - Stem protectors in place to prevent operation of quick-disconnect valves



Shipment

- Rugged case shipments were initially performed in the hope of reusing shipping materials would reduce waste
 - Smaller shipments not efficient use of large case capacity
 - Cardboard boxes adopted for smaller shipments to save weight and size in shipping
- New shrink-wrap packaging is incompatible with custom foam insulation
 - Cardboard boxes are used for shipments with shrink-wrapped samples



Conclusion

- Isolate Isotope of Interest
- Quantify the Activity
- Mix to Desired Specific Activity
- Fill Individual Lab Containers
- Conduct Internal Quality Control
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Battelle Energy Alliance manages INL for the U.S. Department of Energy's Office of Nuclear Energy. INL is the nation's center for nuclear energy research and development, and also performs research in each of DOE's strategic goal areas: energy, national security, science and the environment.

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