Demonstrating Capability for Radiochemical Analysis of Gaseous Samples at NIF

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Outline

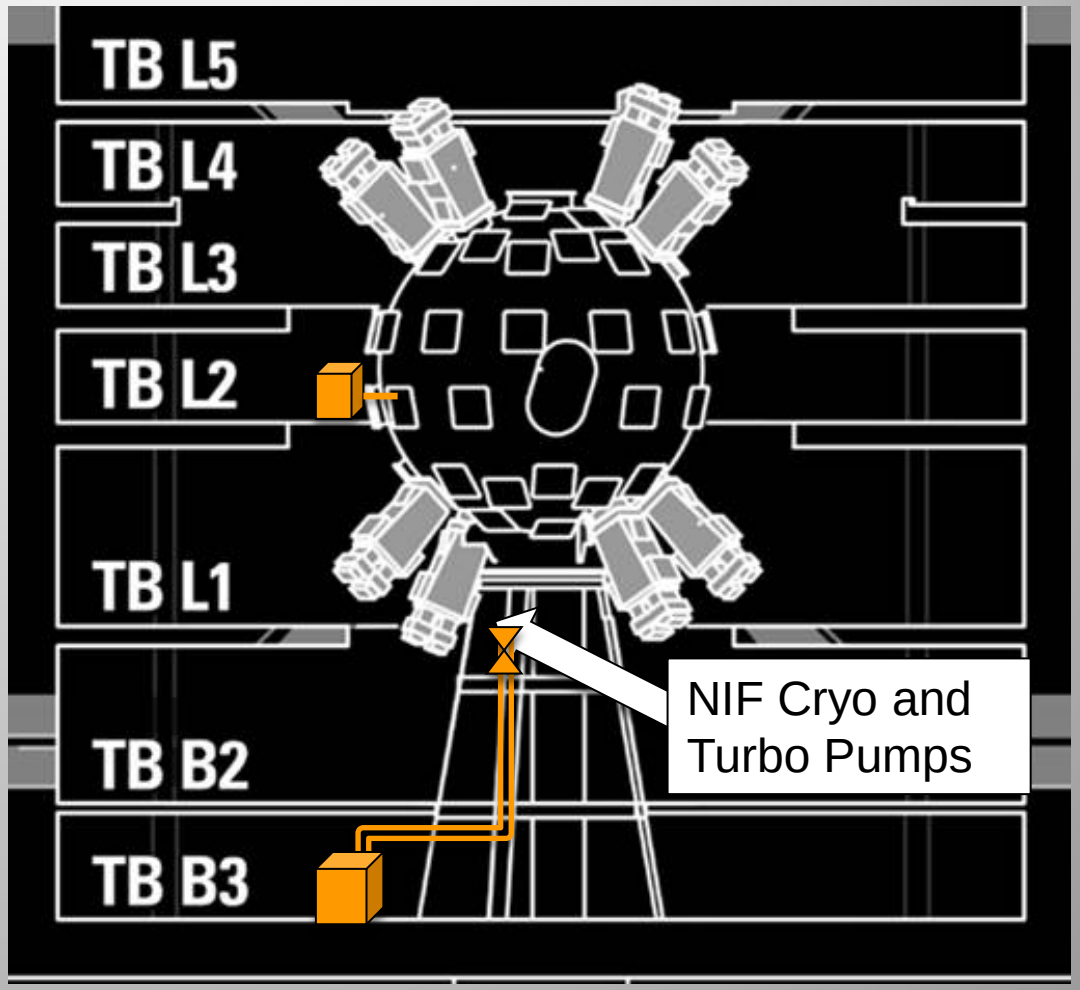
- Radiochemical Analysis of Gaseous Samples (RAGS) Description
- Results from participation on NIF shots
- RAGS performance
- Future Plans

RAGS has equipment on many levels of NIF Target Bay

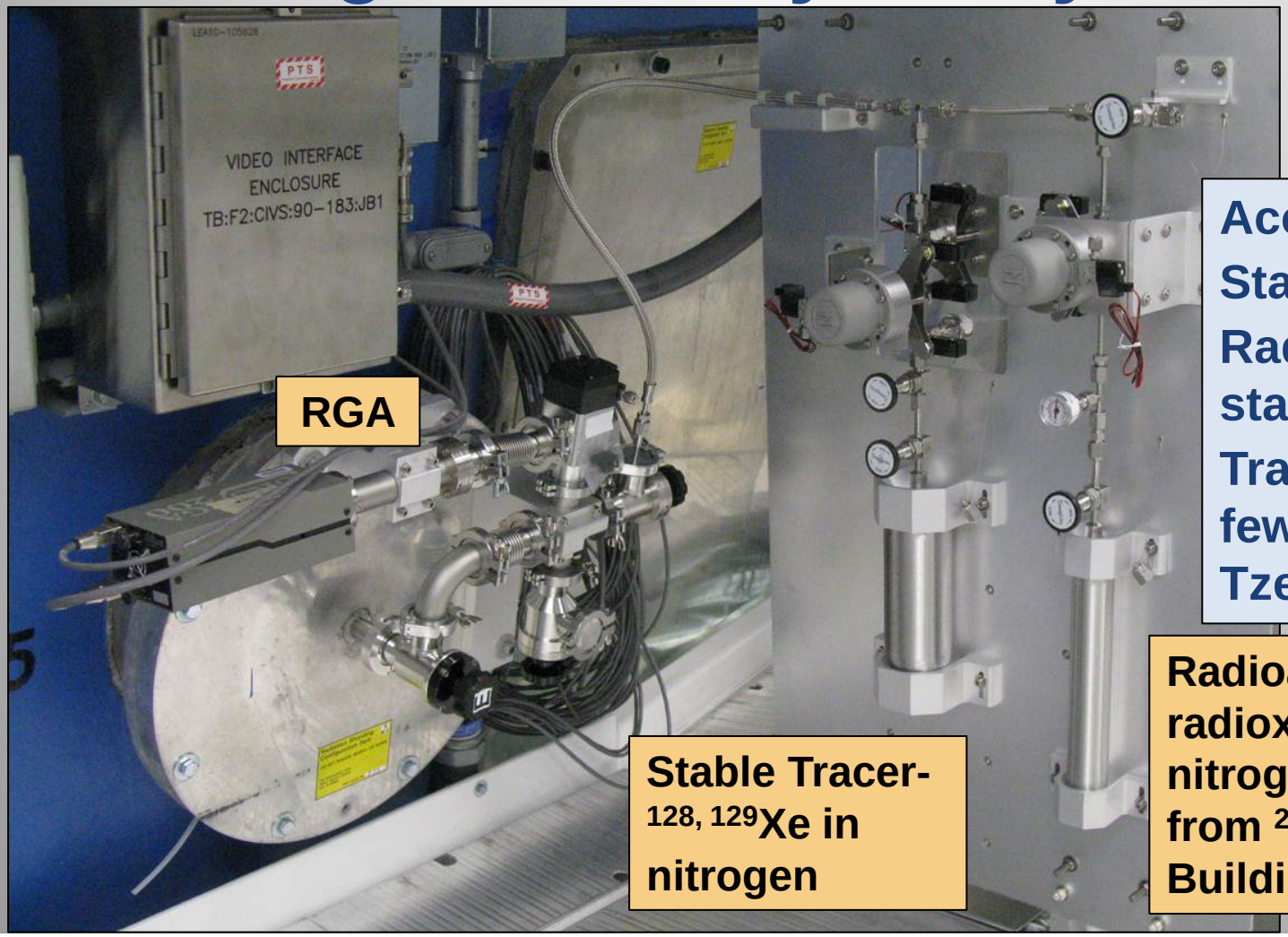
RAGS Tracer Injector on L2

RAGS Transfer line runs from L1 turbo exhaust to B3

RAGS Room on B3



Tracer injector allows high precision and high accuracy assays



Accuracy:

Stable - 1%

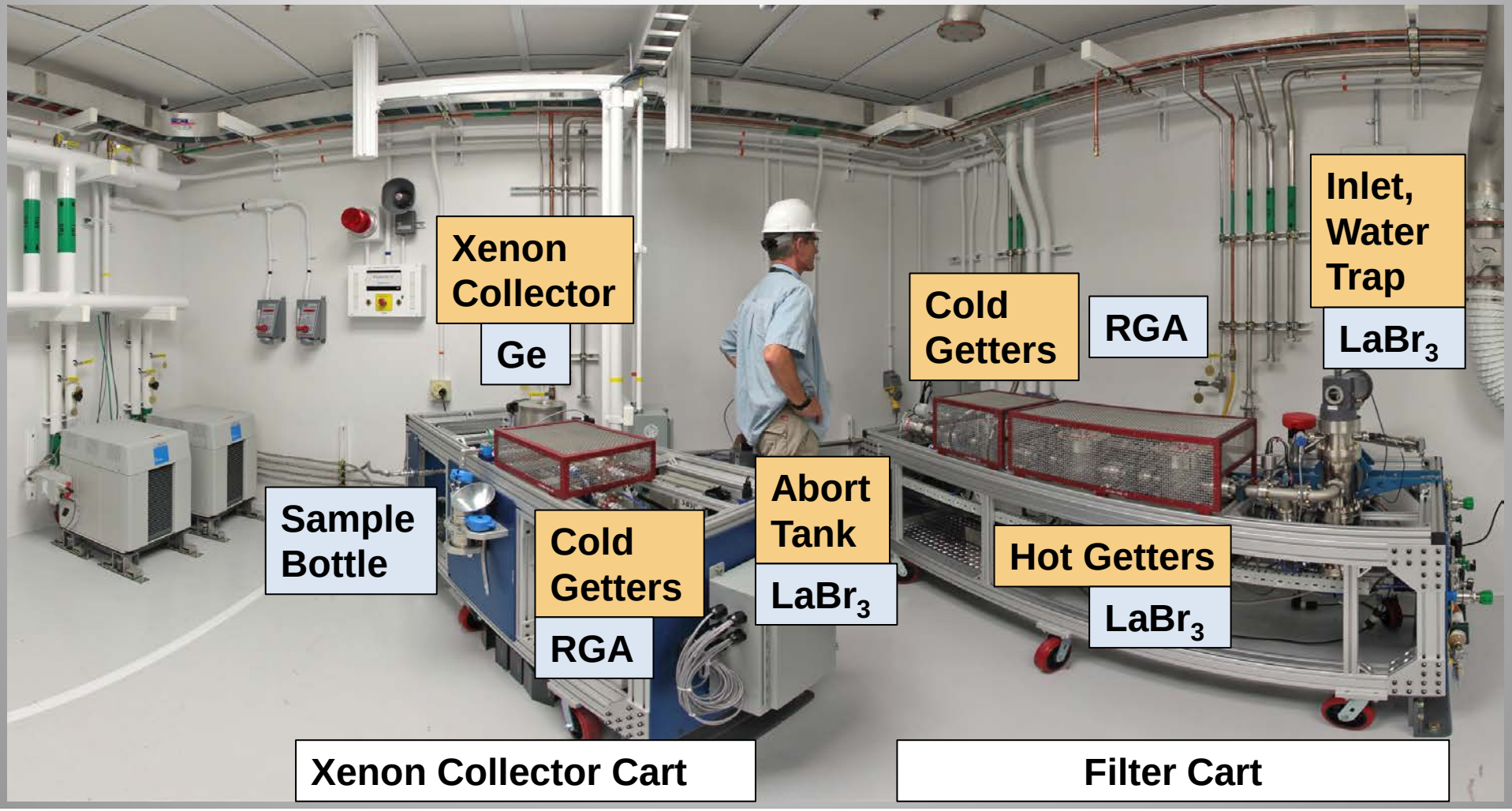
Rad - counting statistics

Tracers injected a few seconds after Tzero

Stable Tracer- $^{128, 129}$Xe in nitrogen

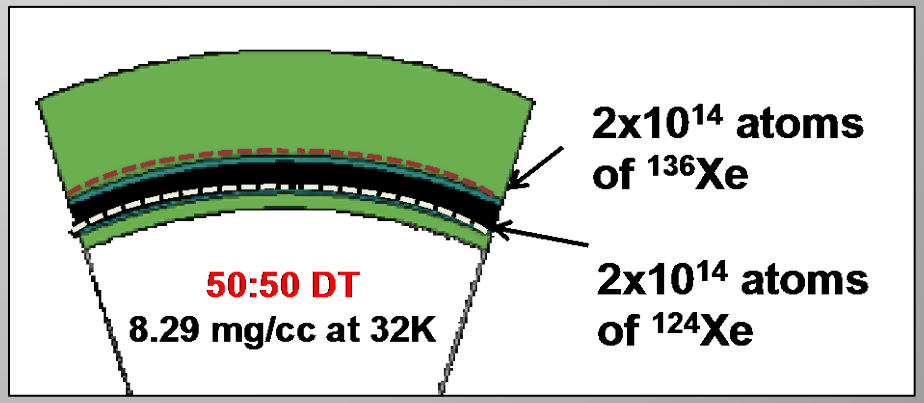
Radioactive Tracer- radioxenons in nitrogen transferred from ^{252}Cf source in Building 151

RAGS room processes shot gas for *in situ* and off-line measurements

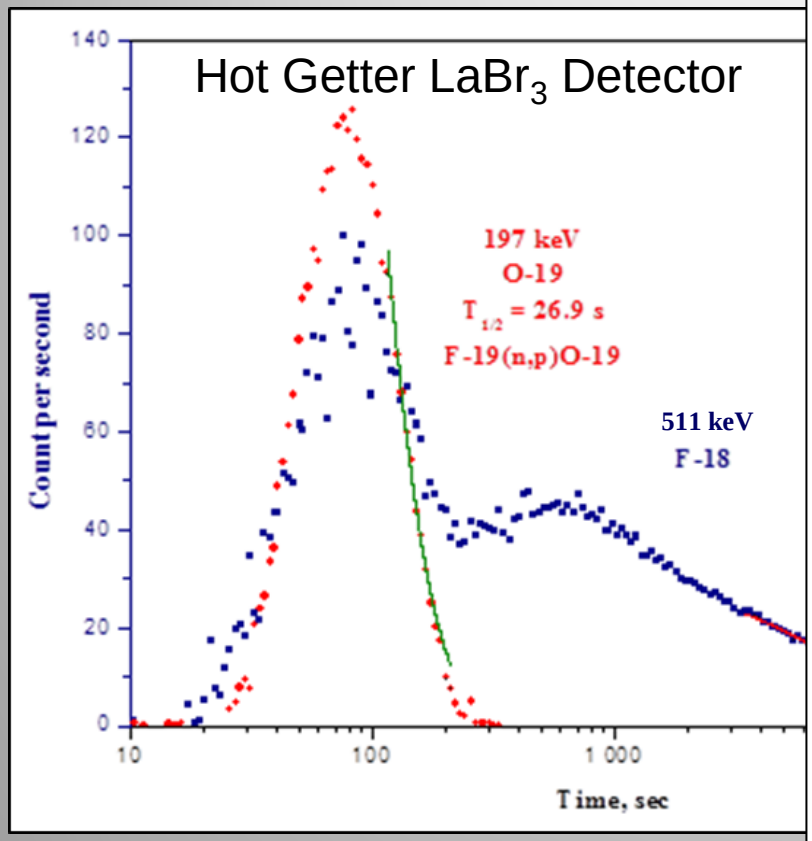


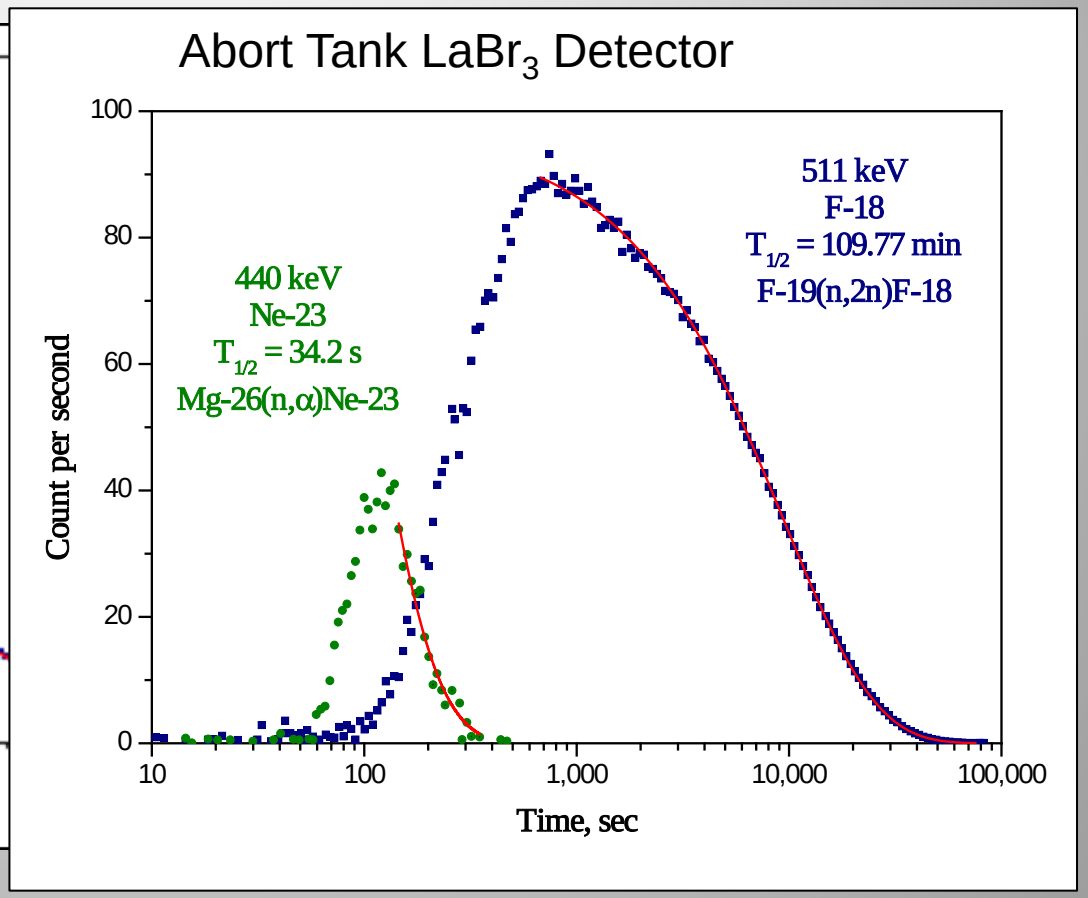
RAGS capabilities

- ρr studies via n,γ and n,2n reactions
  - Xenon-loaded DT Exploding Pusher capsule ready
- Mix studies with n,2n and/or charged particle reactions
  - Xenon-implanted Symcap capsules ready
- Cross sections
- Fission products



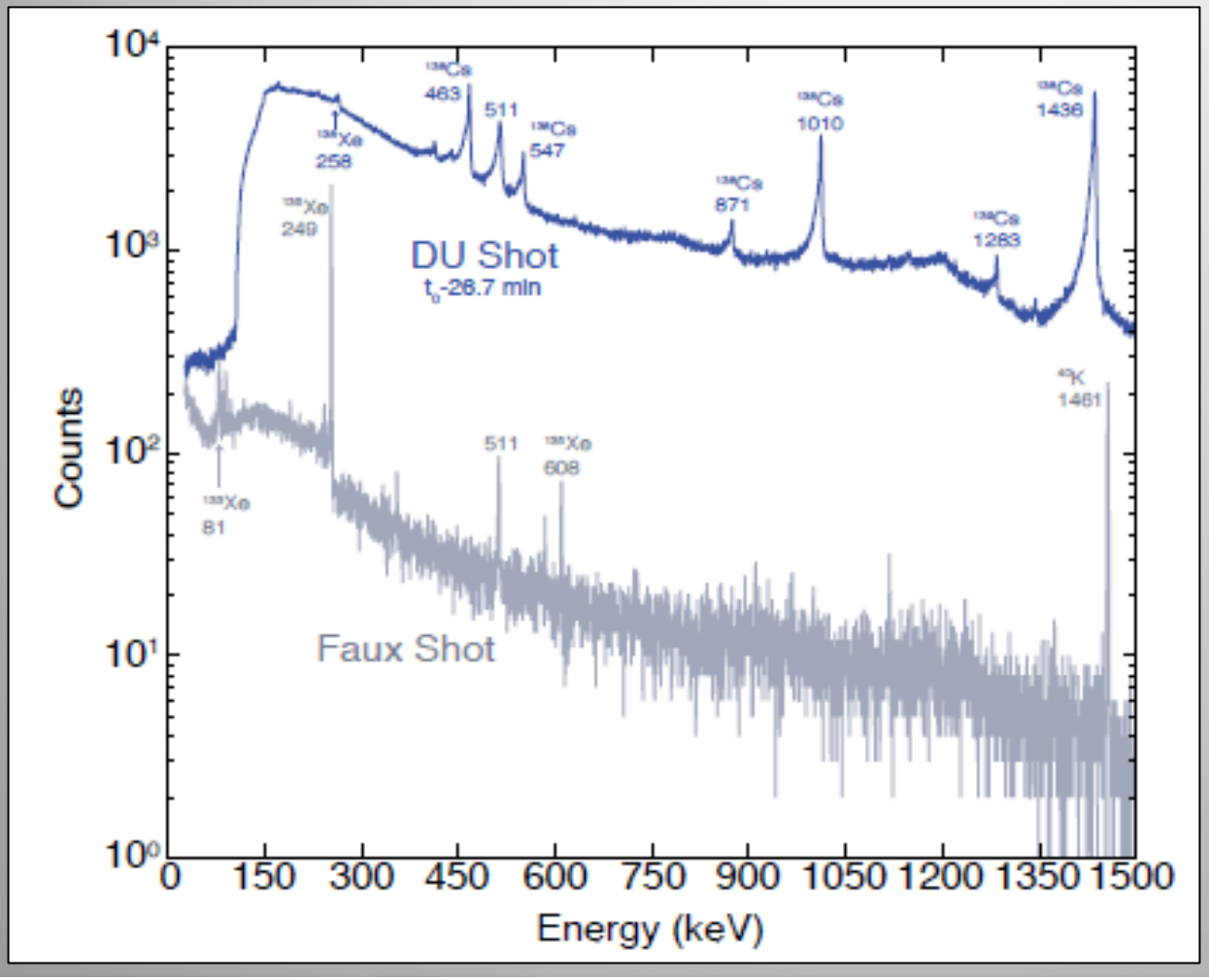
RAGS has identified short-lived products at all detector locations





We use energy and half-life for identification.

In situ Ge detector on Collector Cart comparing signals from a DU hohlraum shot to a RAGS Faux test



N140120 (DT w/DU Hohlraum)

Germanium Detector:

Short-lived fission products

^{91}Kr ($t_{1/2}$ = 8.57 sec.)

^{140}Xe ($t_{1/2}$ = 13.6 sec.)

^{139}Xe ($t_{1/2}$ = 39.7 sec.)

^{138}Xe ($t_{1/2}$ = 14.1 min.)

^{138}Cs ($t_{1/2}$ = 32.2 min.)

RAGS Faux

^{133}Xe ($t_{1/2}$ = 5.24 day)

^{133m}Xe ($t_{1/2}$ = 2.19 day)

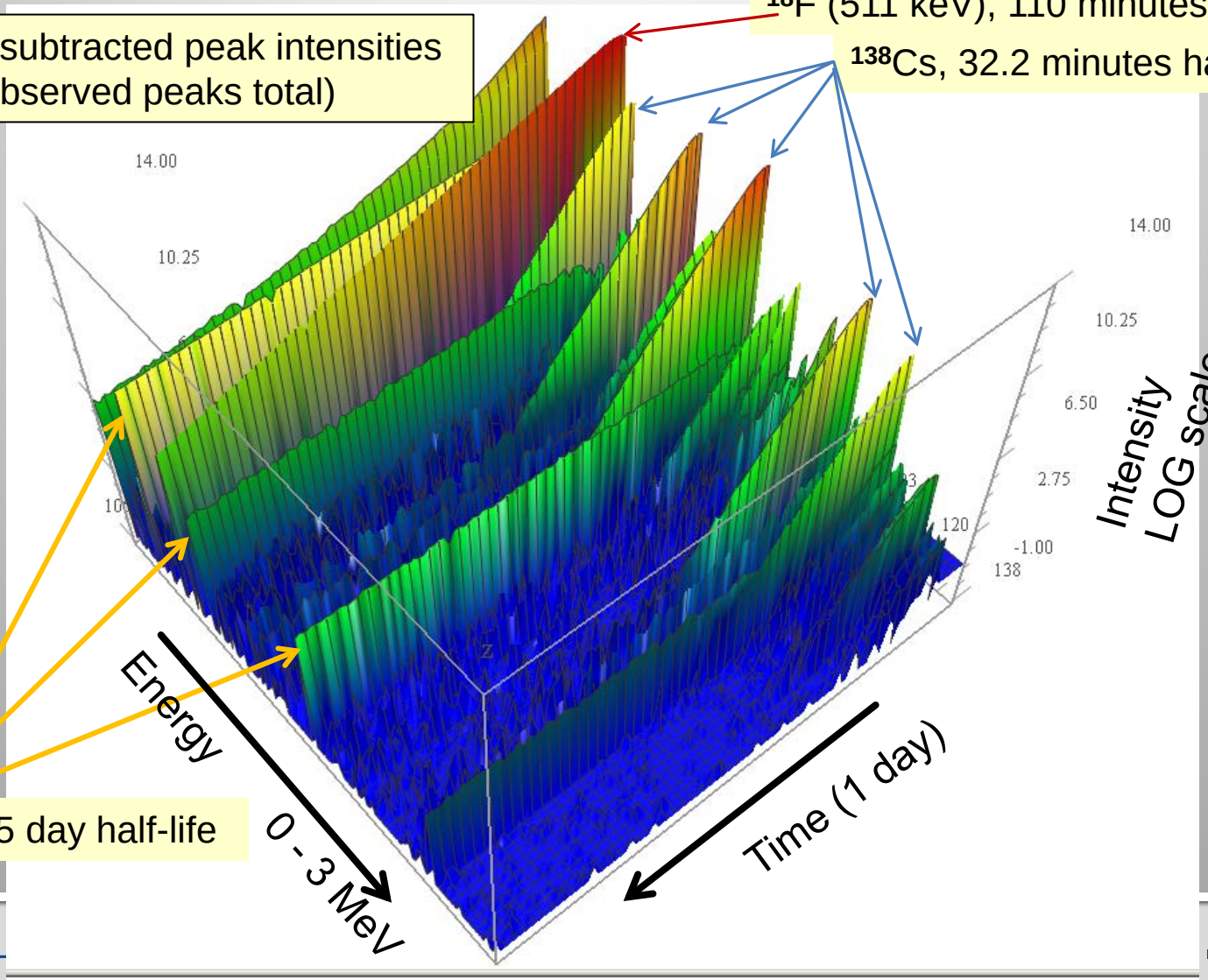
^{135}Xe ($t_{1/2}$ = 9.1 hour)

We extract the time history of peaks on the Ge detector

Background subtracted peak intensities (about 200 observed peaks total)

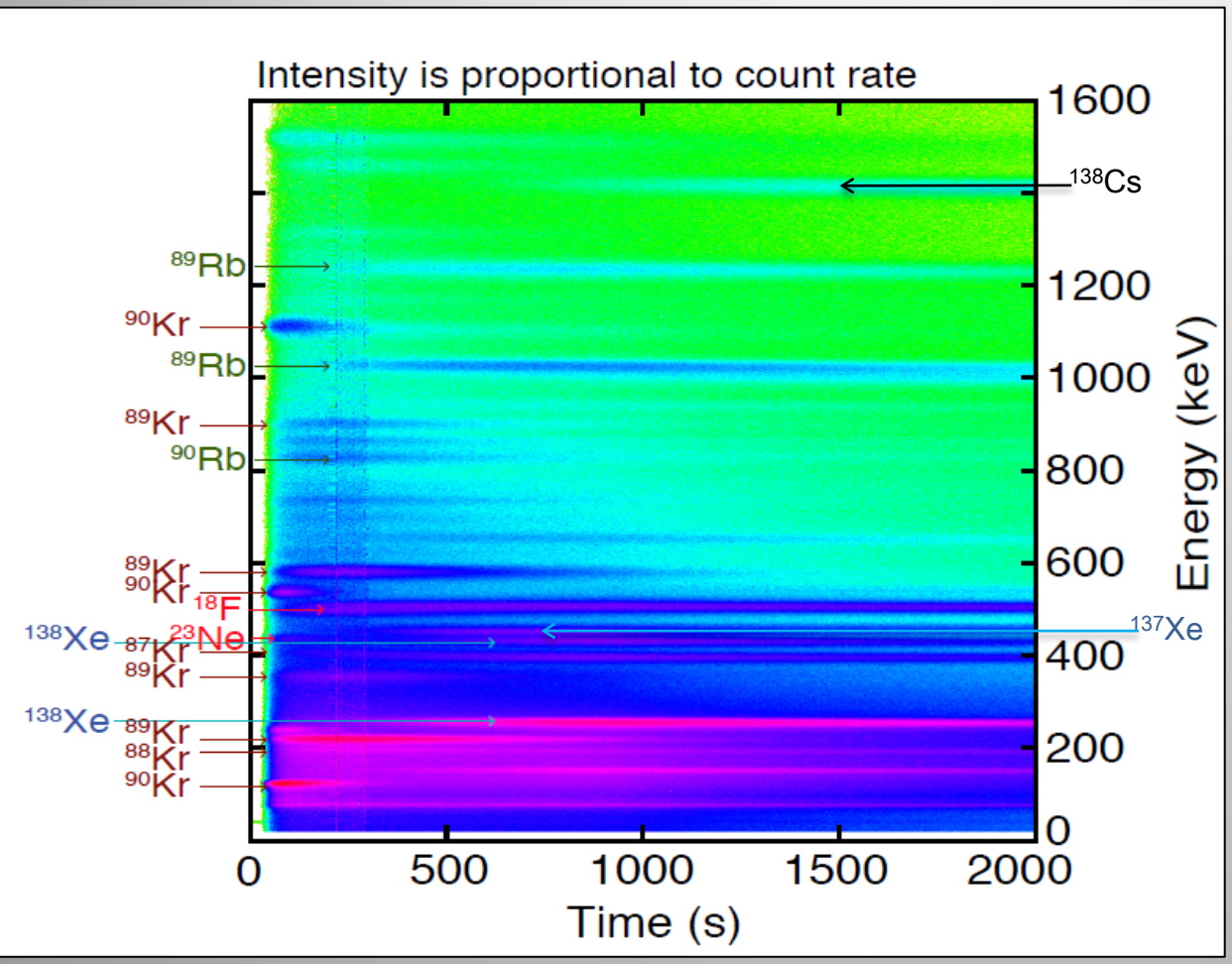
^{18}F (511 keV), 110 minutes half-life

^{138}Cs, 32.2 minutes half-life



^{140}Ba, 12.75 day half-life

We see fission and activation products in the abort tank ($LaBr_3$ detector)



N140120 (DT w/DU Hohlraum)

Short-lived fission products

- ^{90}Kr ($t_{1/2}$ = 32.3 sec.)
- ^{89}Kr ($t_{1/2}$ = 3.15 min.)
- ^{88}Kr ($t_{1/2}$ = 2.84 hour)
- ^{87}Kr ($t_{1/2}$ = 76.2 min.)
- ^{90}Rb ($t_{1/2}$ = 2.6 min.)
- ^{89}Rb ($t_{1/2}$ = 15.4 min.)

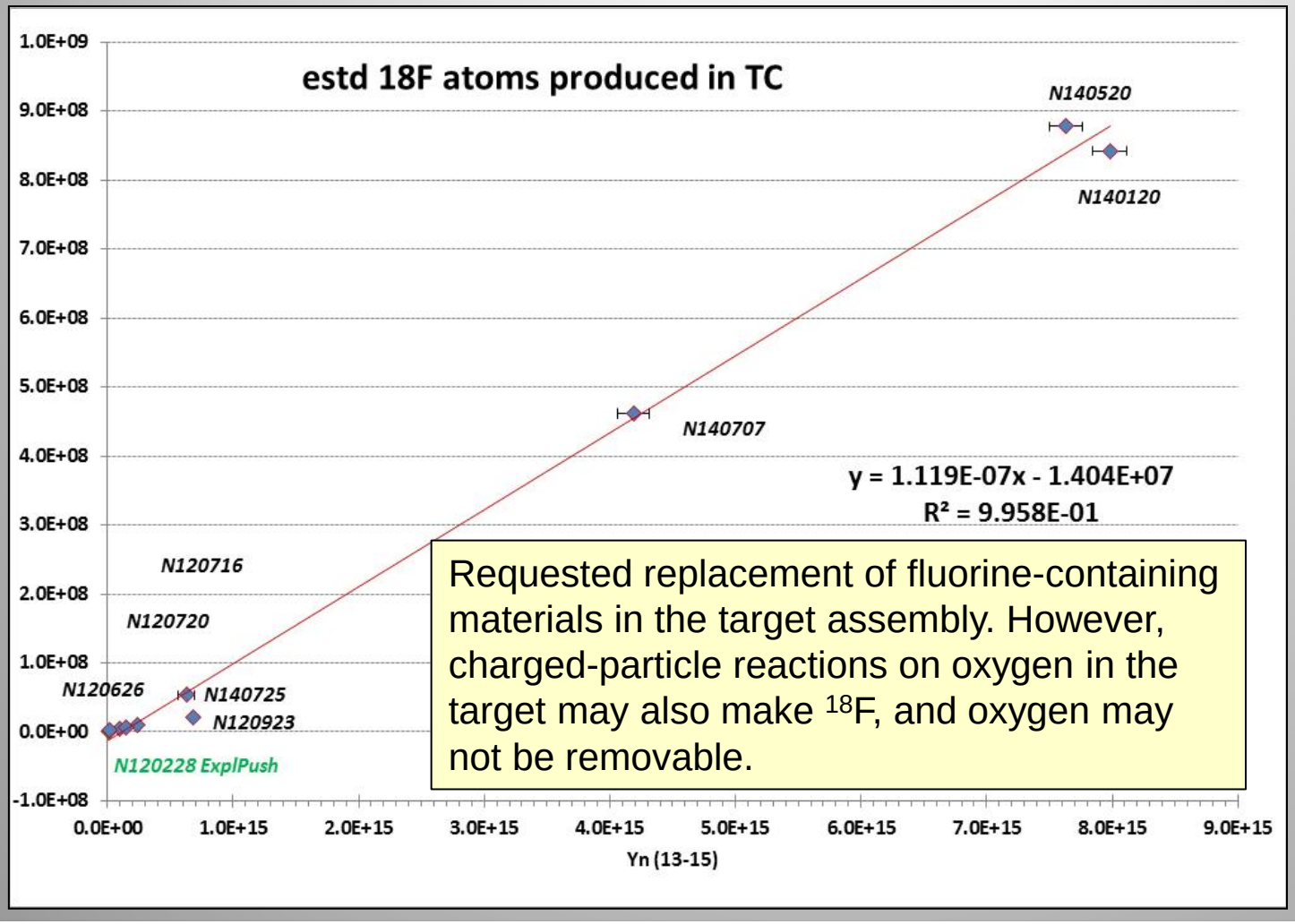
- ^{138}Xe ($t_{1/2}$ = 14.08 min.)
- ^{137}Xe ($t_{1/2}$ = 3.82 min.)

- ^{138}Cs ($t_{1/2}$ = 32.2 min.)

Activation products

- ^{18}F 511keV ($t_{1/2}$ = 110 min.)
- ^{23}Ne ($t_{1/2}$ = 37.2 sec.)

^{18}F scales linearly with 14 MeV neutron yield and impacts other signals



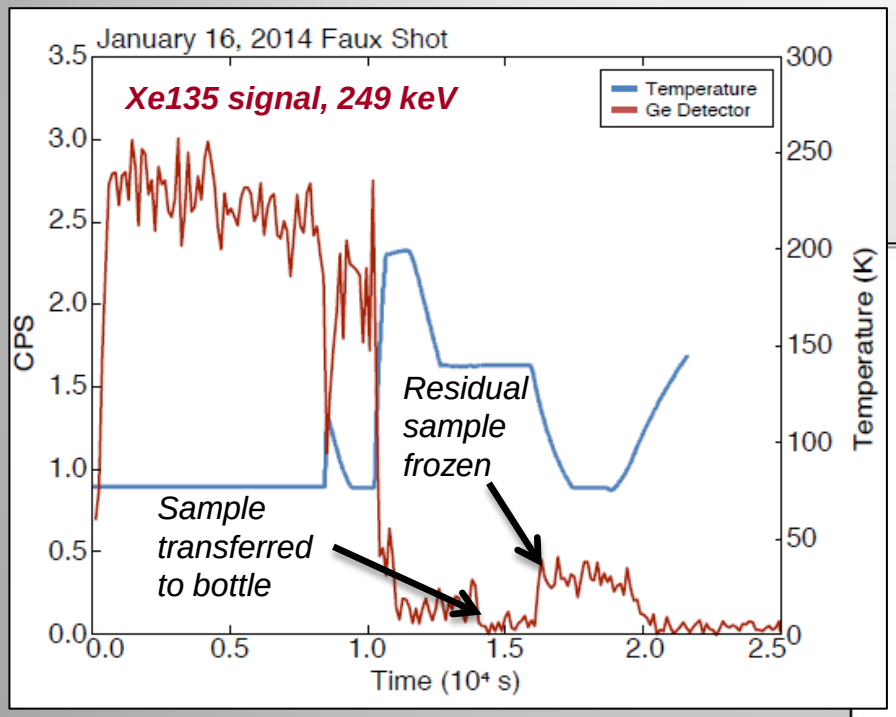
High levels of ^{18}F could obscure lower-energy gamma signals on the *in situ* Ge detector, losing diagnostic data.

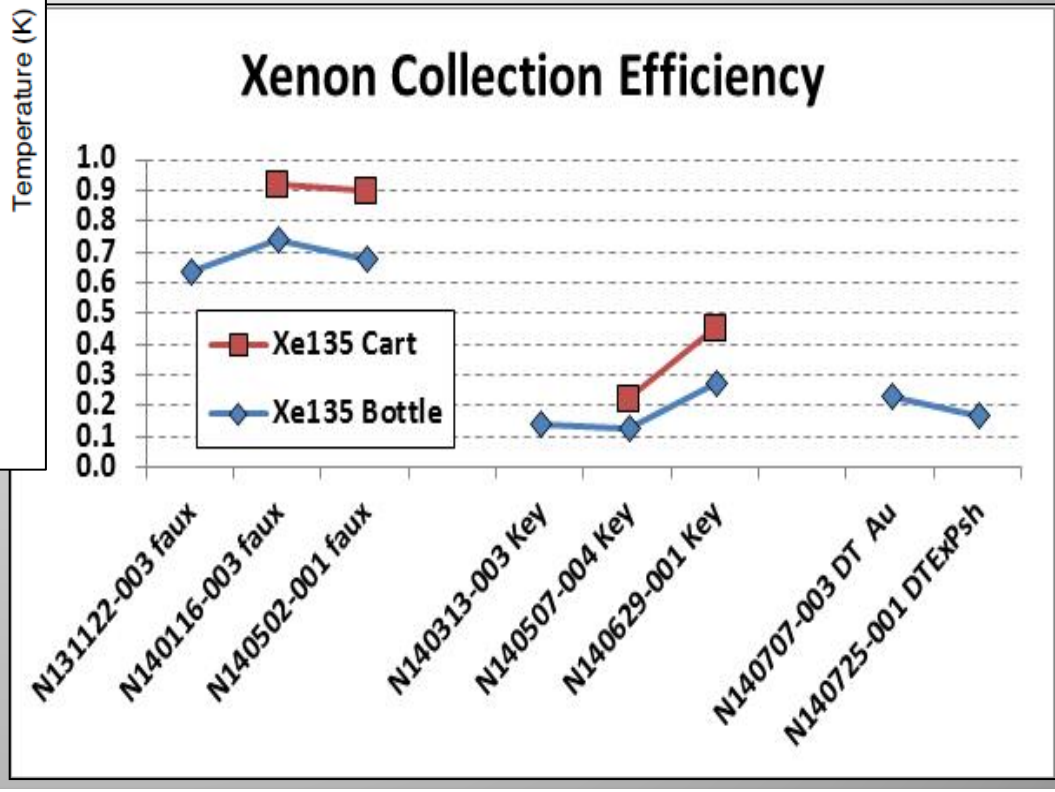
For offline counting with high ^{18}F, precision of short-lived xenons is 5-10x poorer than samples with low ^{18}F.

Characterizing RAGS Xenon Collection

- Use stable and radioactive isotope tracers injected into the target chamber a few seconds after Tzero
- Run faux tests with tracers
  - RAGS, no lasers, no target, no nuclear yield
- Participate on Keyhole shots, use tracers
  - RAGS, lasers fire, modified target and hohlraum, no nuclear yield
- Participate on shots with nuclear yield, use tracers
  - RAGS, lasers fire, targets with DT fill

On faux tests, 90% of radioxenon tracer is trapped in collector cart and 60-75% is transferred to the sample bottle. Shots with lasers and targets collect and transfer lower xenon amounts.

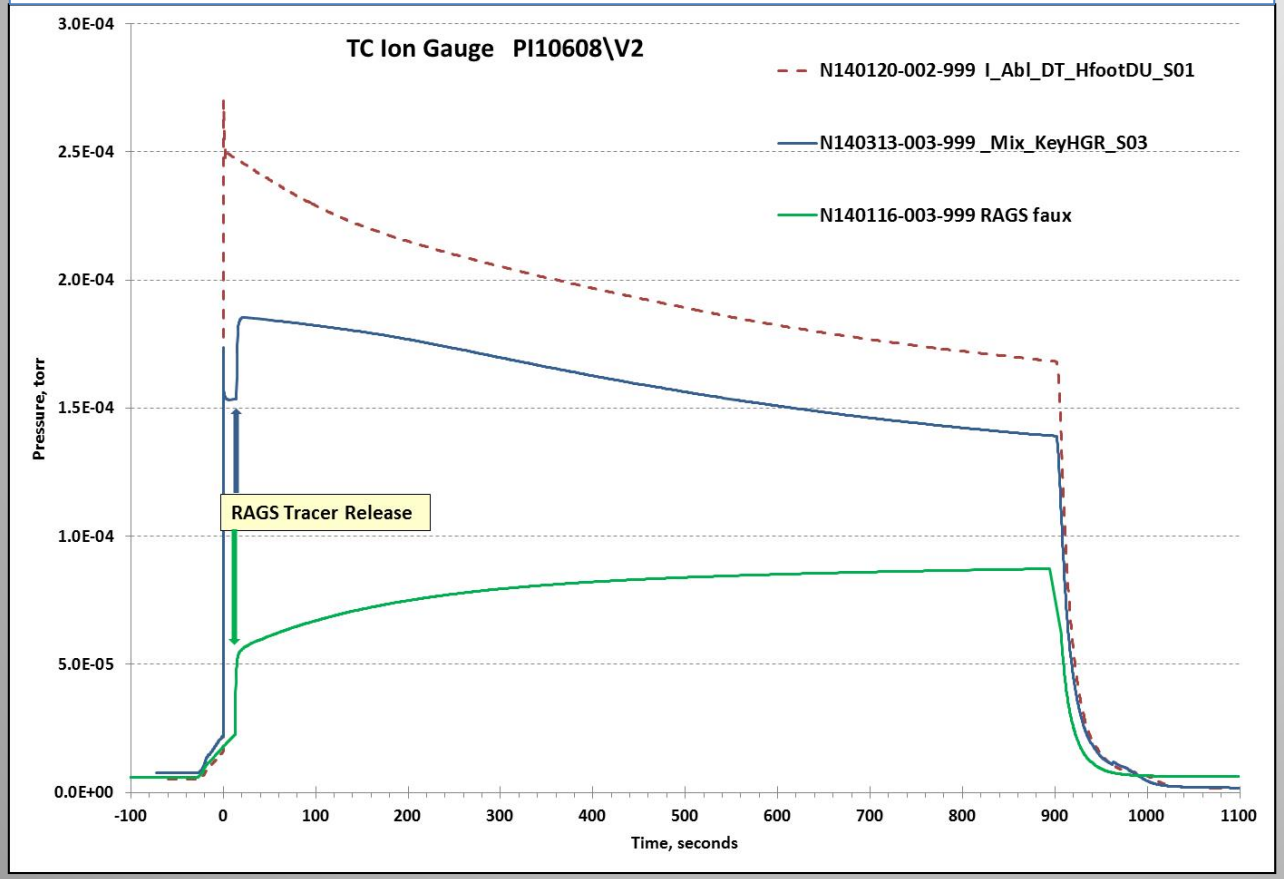




Fraction of tracer in Collector cart is calculated from RAGS sample bottle fraction and time history of Xe135 signal on Ge detector.

Target chamber and RAGS pressures are higher on shots, and gas composition is different, compared to RAGS faux tests.

Target Chamber Pressure during RAGS collections



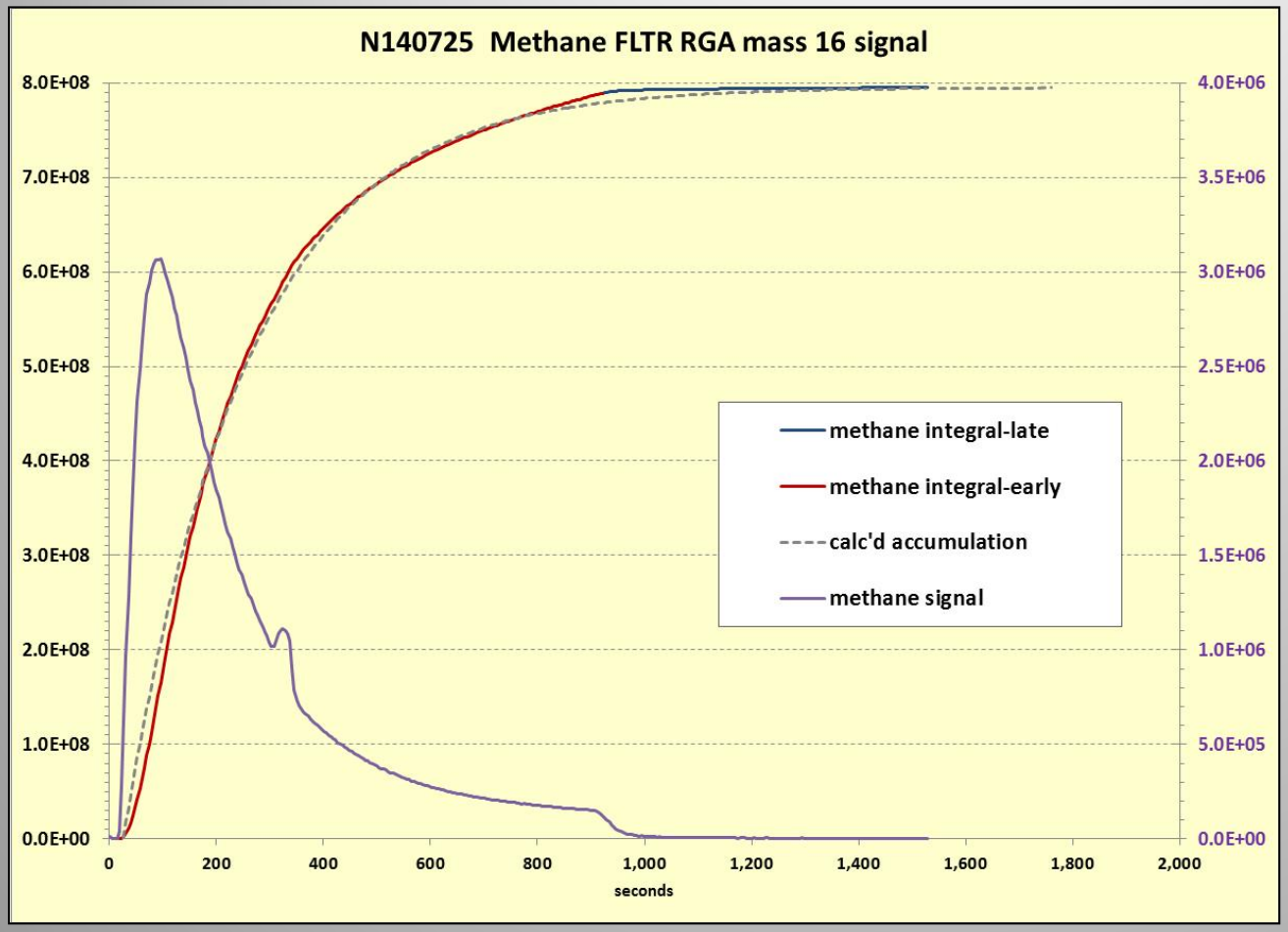
Shot Gases Produced:
- Carbon Monoxide
- Carbon Dioxide
- Methane

Shot Gases from Target & Hohlraum:
- Hydrogen
- Helium

Shot Gases released from TC Surfaces:
- Water

Chamber Air leak on shot and RAGS faux:
- Nitrogen
- Oxygen
- Argon

RAGS collects >90% of methane from target chamber

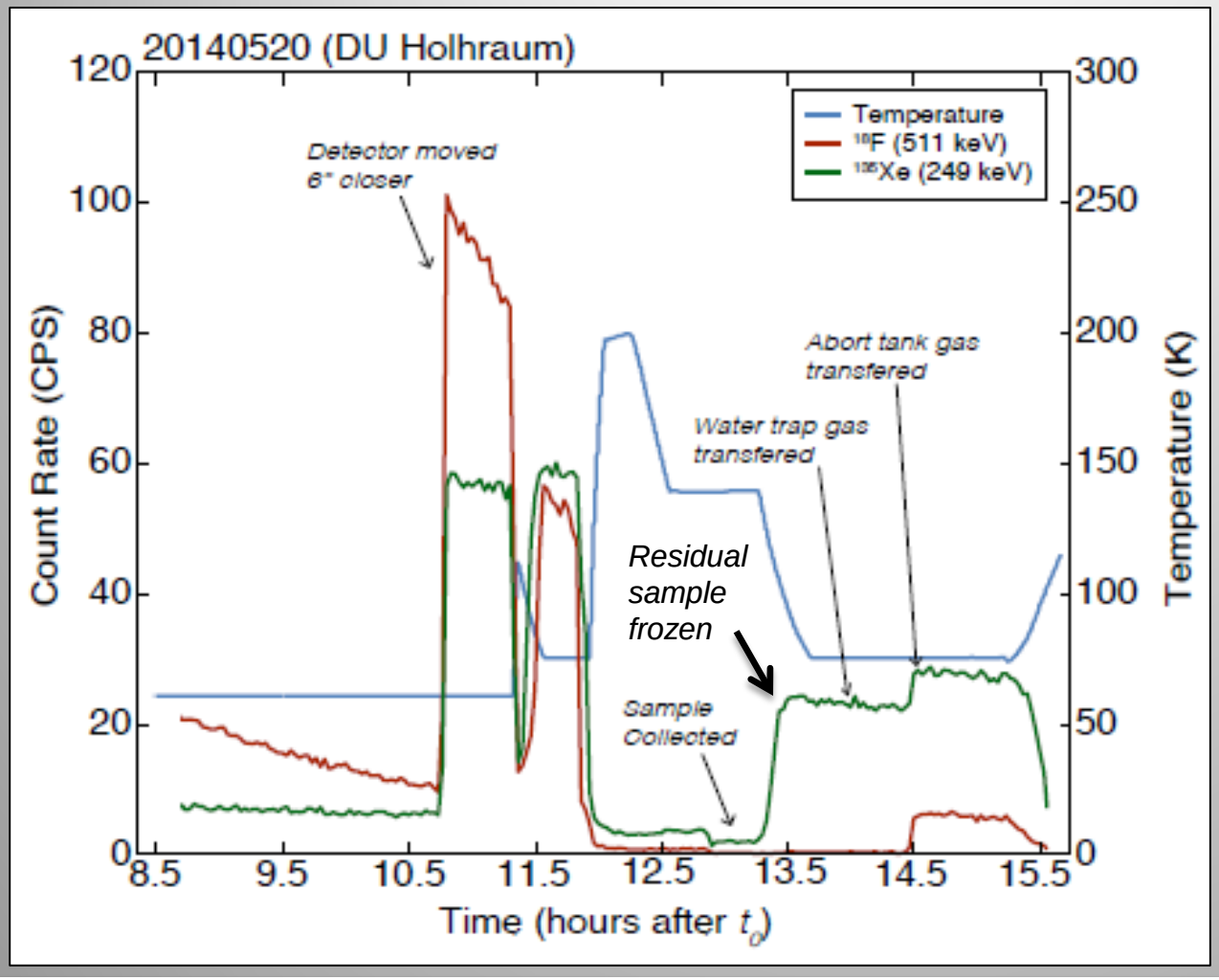


RAGS pumping model predicts 120 second time interval for half of the shot gas to be removed from the target chamber.

Methane measurements for 50% signal reduction range from 140-170 seconds (Filter Cart RGA).

Expect xenon acts like methane due to similar physical properties.

Gases may be passing through the xenon collector into the abort tank



Presence of radioxenon and ^{18}F in the abort tank suggest that more collector capacity is needed on shots compared to faux tests. New collector design and fab are planned for FY15.

Some xenon is co-trapped with water in the Filter Cart; increasing trap temperature may mitigate losses here.

Plans for FY15

- New collector
  - Higher capacity
  - Lower temperature - extend to krypton
- Calibrate ^{124}Xe n,2n cross section relative to ^{136}Xe
  - ^{124}Xe and ^{136}Xe in DT-filled exploding pusher
- Execute xenon-doped ablator mix experiment
  - ^{124}Xe at 45 microns from inner surface, ^{136}Xe at 70 microns
- Improve precisions of independent yield fission product measurements

Acknowledgments

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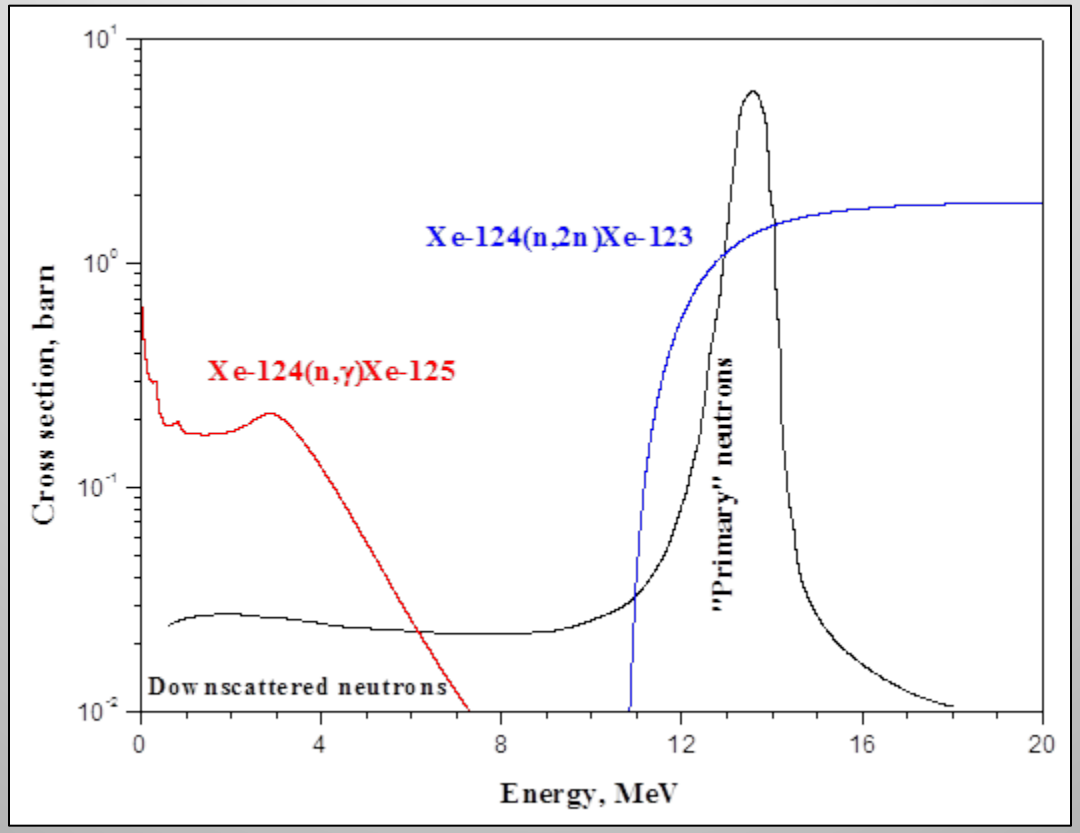
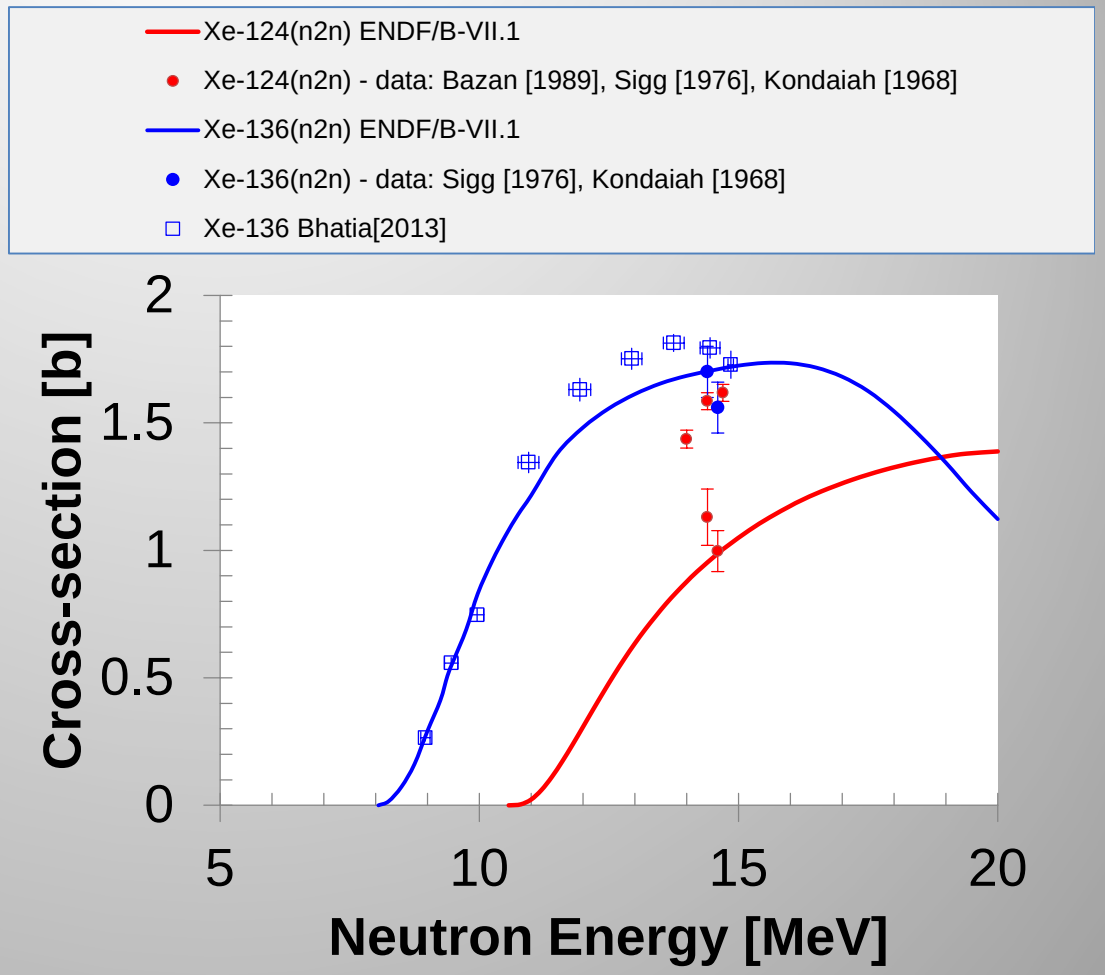
Questions?

Cross sections of n,γ and n,2n reactions on Xe-124 superimposed on the schematic NIF neutron spectrum, which is based on typical neutron time-of-flight spectra



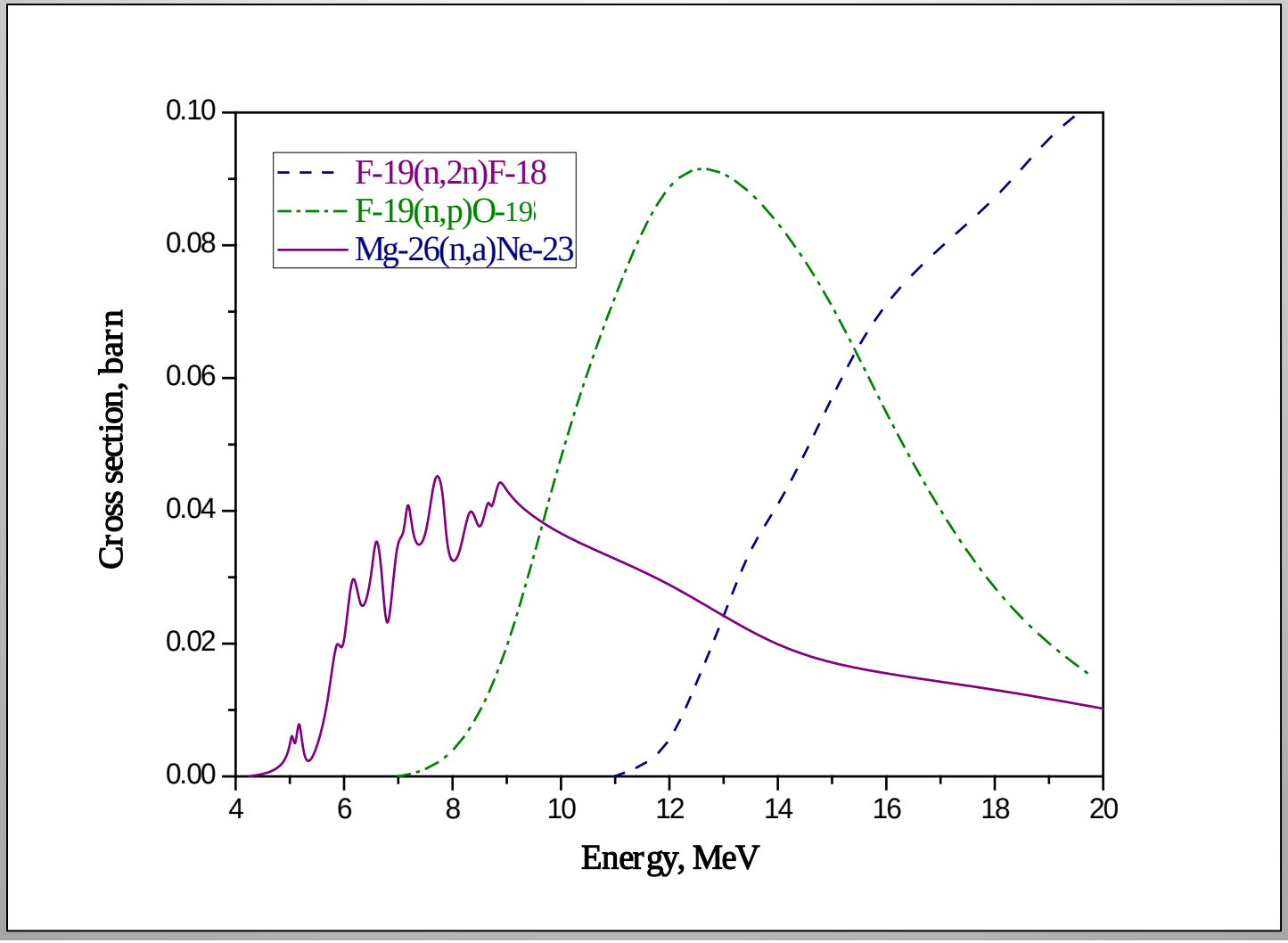
Relevant cross-sections for Xe activation

Large differences between measured Xe-124 n,2n cross section values can be evaluated at NIF by measurements relative to Xe-136 using targets loaded with both isotopes.



*Bhatia Phys. Rev. C 87, 011601(R) (2013)

Cross sections of neutron induced reactions for background gases observed during a NIF shot



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