



# New CZT ALARA Tools Implemented at Cook Nuclear Plant

**David W. Miller, PhD**  
**North American Regional Director**  
**Information System on Occupational Exposure**  
**Cook Nuclear Plant, American Electric Power**

**2015 ISOE Asian ALARA Symposium**  
**September 9-10, 2015**  
**Tokyo, Japan**

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# OECD NEA Director Visits NATC

William Magwood presented lecture on OECD NEA nuclear energy programs on September 3 at College of Engineering, University of Illinois

Challenged F

aculty & NATC staff to conduct more research to support nuclear power operations for another 20 years



ISOE

NORTH AMERICAN REGIONAL TECHNICAL CENTER

100B

ILLINOIS  
David Miller  
Department of Nuclear, Plasma,  
and Retrievable Engineering

PROF D MI

# Two NATC Research Initiatives

**This presentation discusses two NATC occupational dose reduction & source term characterization projects:**

- 1. Removal of colloids from primary coolant by specialty resin**
- 2. Introduction of new CZT detector for temporary shielding adequacy verification and other uses**

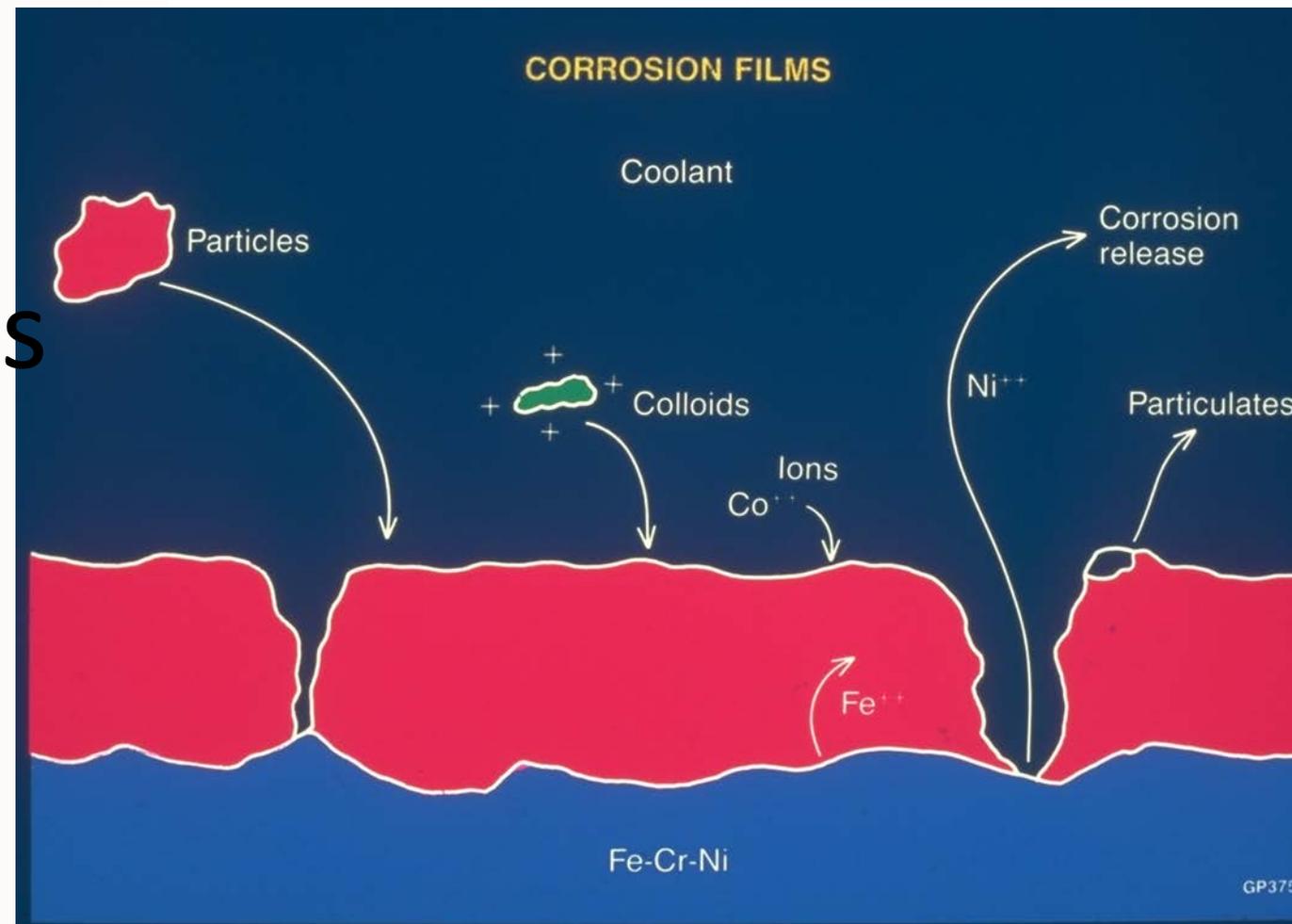
# Cook Units 1 & 2 Achieved Significant Source Term Reduction in Primary Coolant from 2002 - 2015

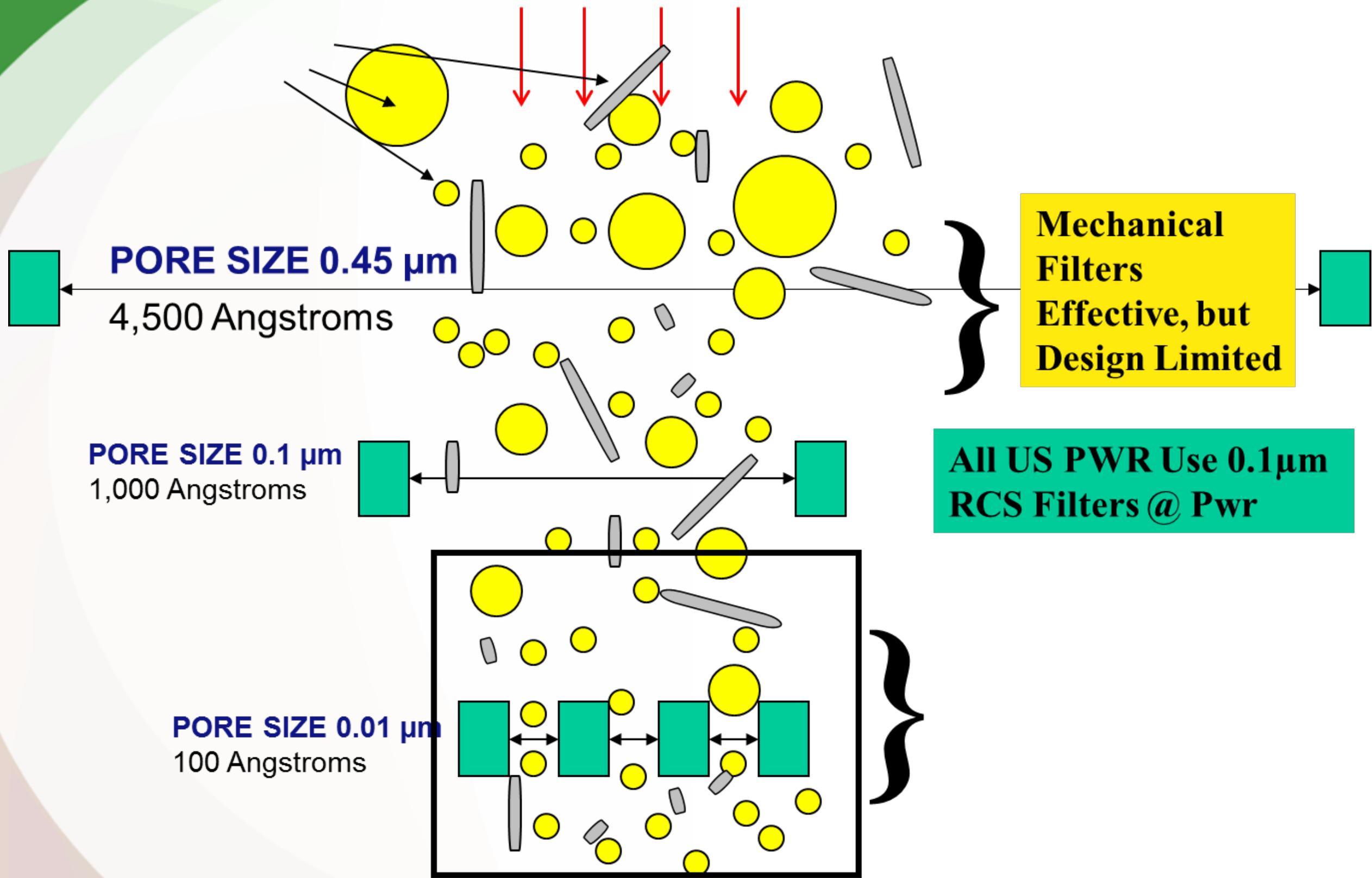
- **Highest US PWR annual dose for Cook 1,2 in 2001**
- **Implemented a new resin designed to remove colloids (Co-58 & Co-60)**
- **Achieved lowest PWR WANO 3 year rolling average for PWR in 2009**
- **Primary Coolant at 1 E -6 uCi/cc: most PWRs are at E-4 or E-5**
- **Low source term allowed entry to upper and lower containment soon after CRUD Burst**
- **High refueling water clarity, Very clean fuel assemblies**
- **Breaker to breaker run cycles with no Reactor Coolant Pump seal problems**

# What are Colloids?

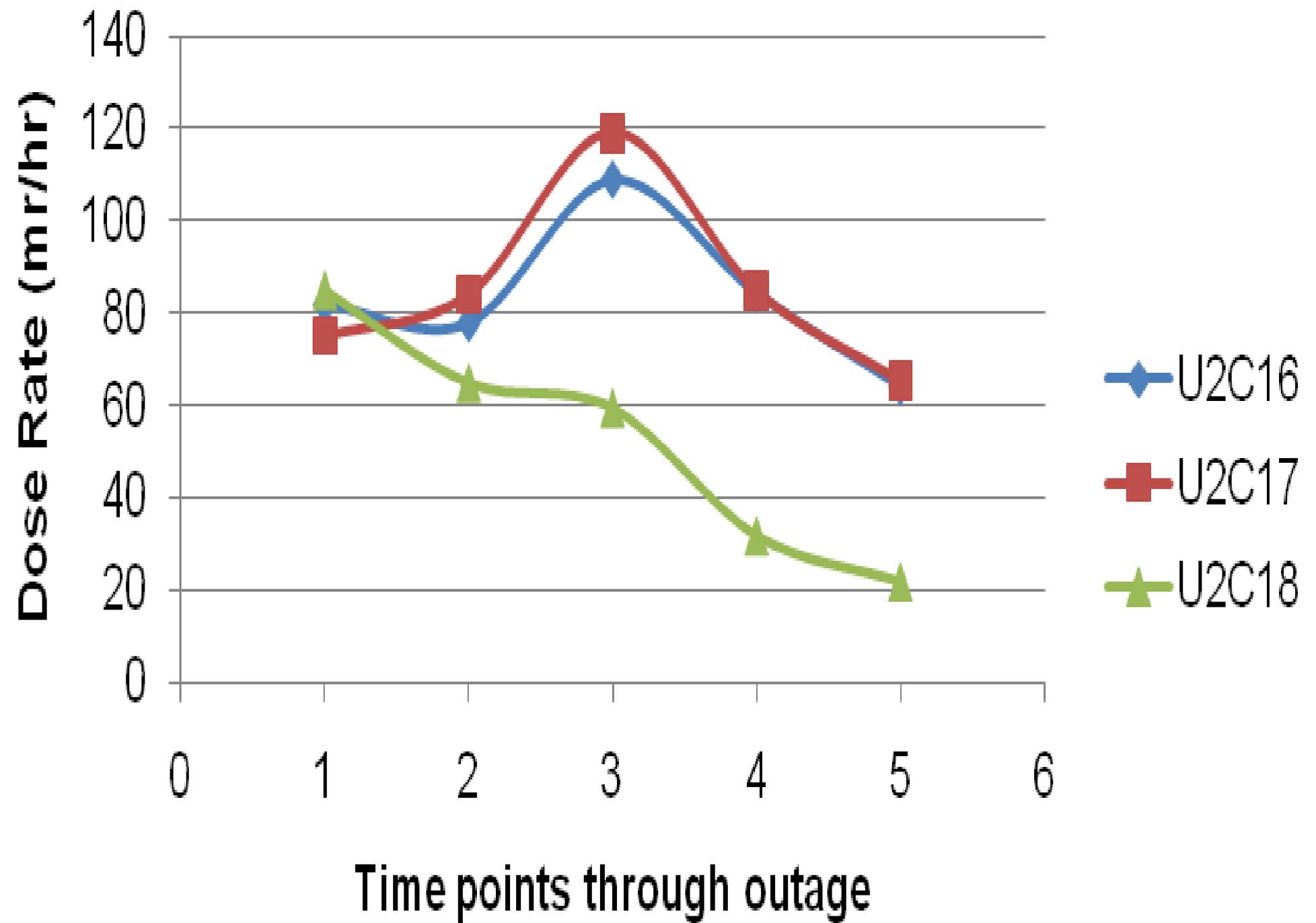
Iron Oxides  
Spinels

0.01 size





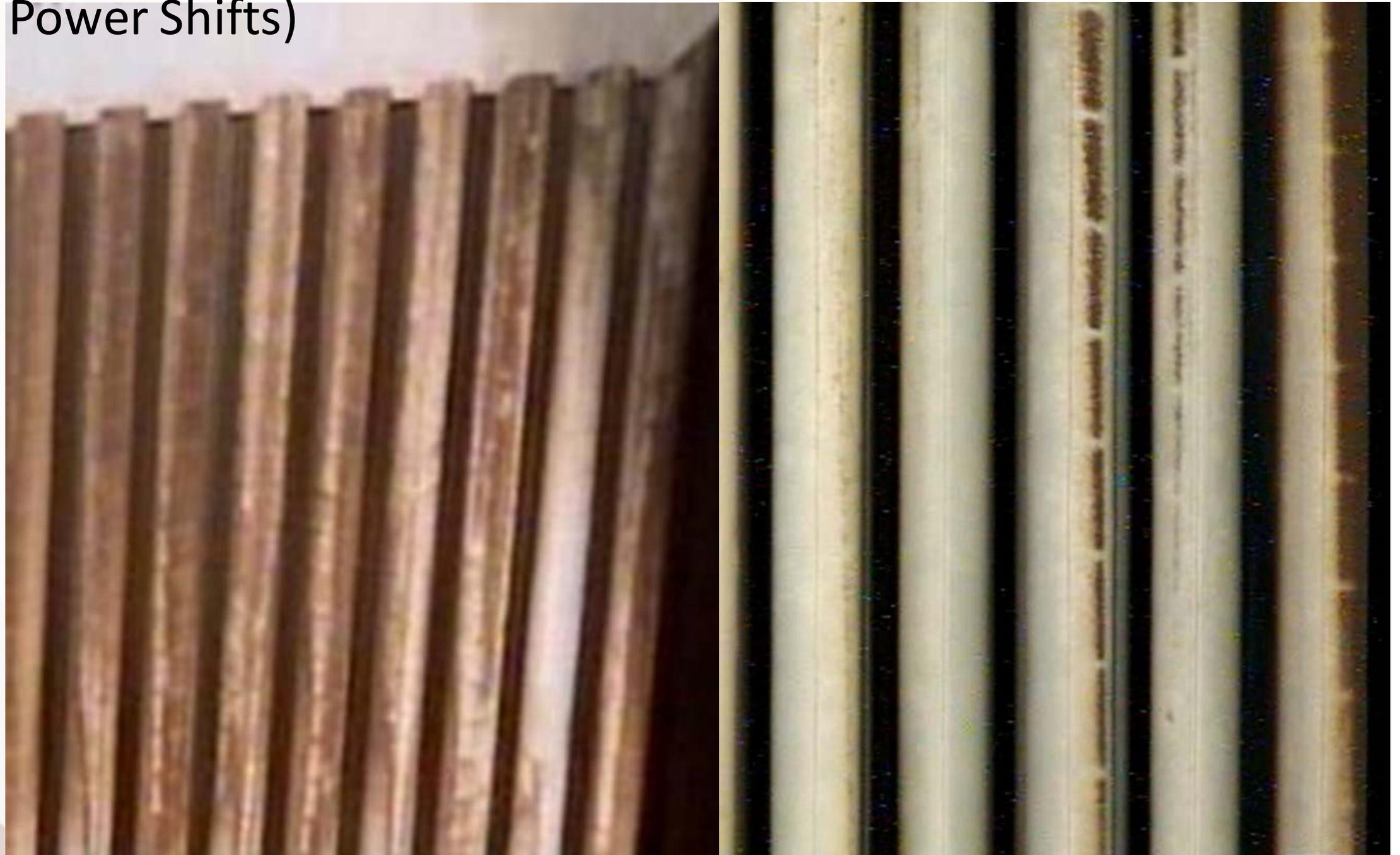
## Letdown HX Contact



# Fuel CRUD Photos Before/After

Photo on right shows pellet outline

Avoids need for fuel cleaning: AOA, CIPS (CRUD Induced Power Shifts)



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# Braidwood 1,2 & Byron 1,2

Four sister units vetted the Cook source term reduction strategy

Braidwood 1,2 implemented Cook protocol for 4 cycles

Byron 1,2 continued to use tradition protocol

Braidwood 1,2 achieved 16 personrem (160 person mSv) outage dose in spring 2015

# Results Favored Specialty Resin

Significant reduction in refueling PWR dose was achieved at all four sites using Los Alamos specialty resin

Saved \$5 million in cancelled fuel cleaning equipment costs

RP, Chemists, Operators and Plant Manager pleased with clean plant

# Low Co-60 Levels in Piping Create Health Physics Challenges & Discoveries

- Zr-95/Nb-95 ratio in CRUD increased from 2% to 40% in a decade
- Many isotopes previously masked by Co-60 are being detected
- The second part of the presentation discusses new technologies employed to assure proper and efficient characterization of isotopes in plant components & piping

# Cook Optimization Adjustments

- Realized a need to better measure dose fields to improve accuracy of ALARA job dose estimates
- reduce the number of temporary shielding packages due to lower doses
- validate the adequacy of temporary shielding packages using a new ALARA Tool – H3D
- RP Staff wanted to have isotopic identification in the field

# CZT a New ALARA Tool

Search for an instrument to provide isotopic identification in the field

High resolution

Light weight

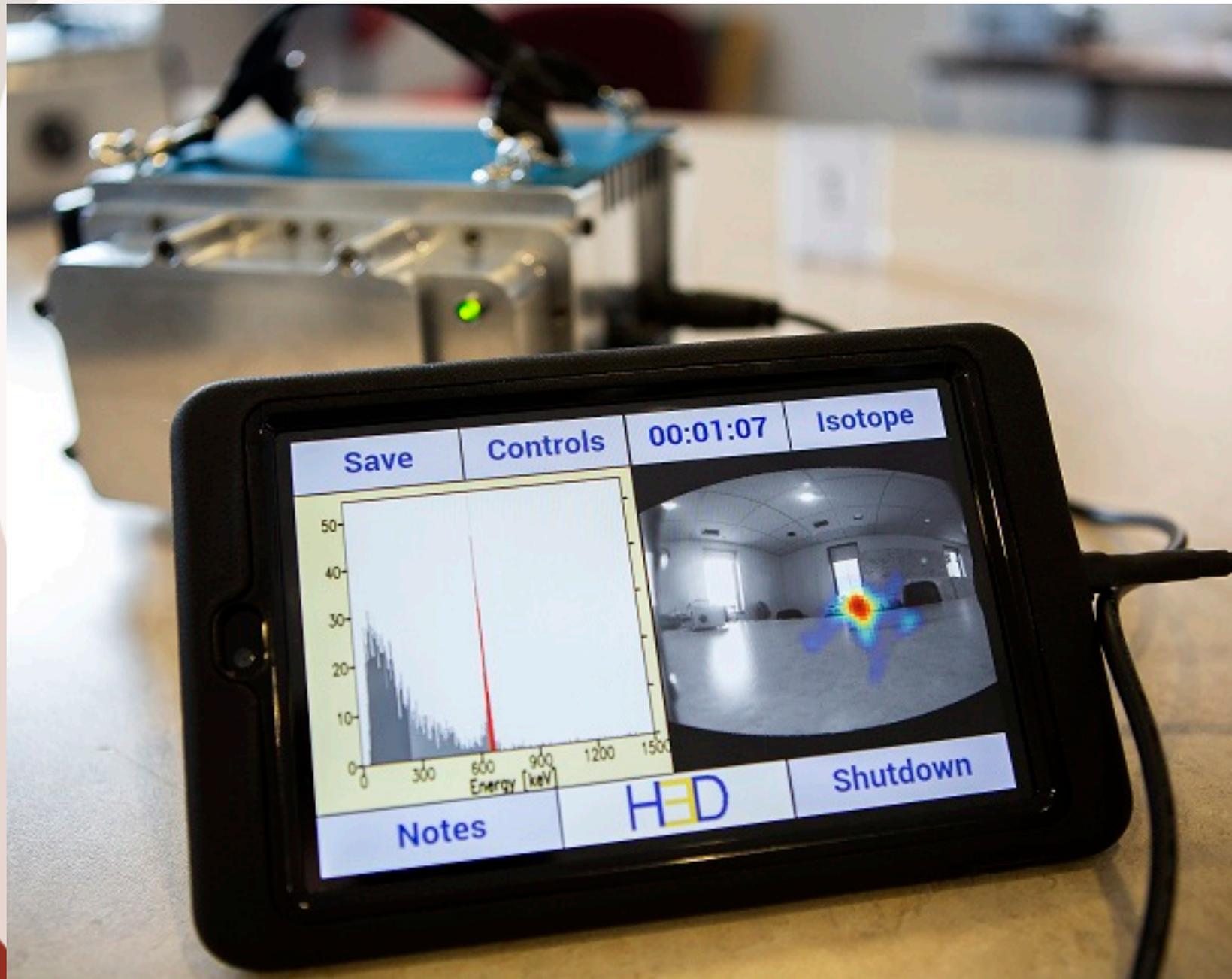
# Background on H3D

- **Developed at Un of Michigan 2002-2012**
- **Field tested in 2013 at Cook**
- **Introduced in 2014 as a new ALARA Tool for RP Analysis of Individual Isotopes in the field**
- **Initially used to verify adequacy of temporary shielding**

# Polaris-H

## Imaging Spectrometer for Nuclear Power Plants

Response to nuclear power plant need for **portable instrument to image in contaminated areas.**

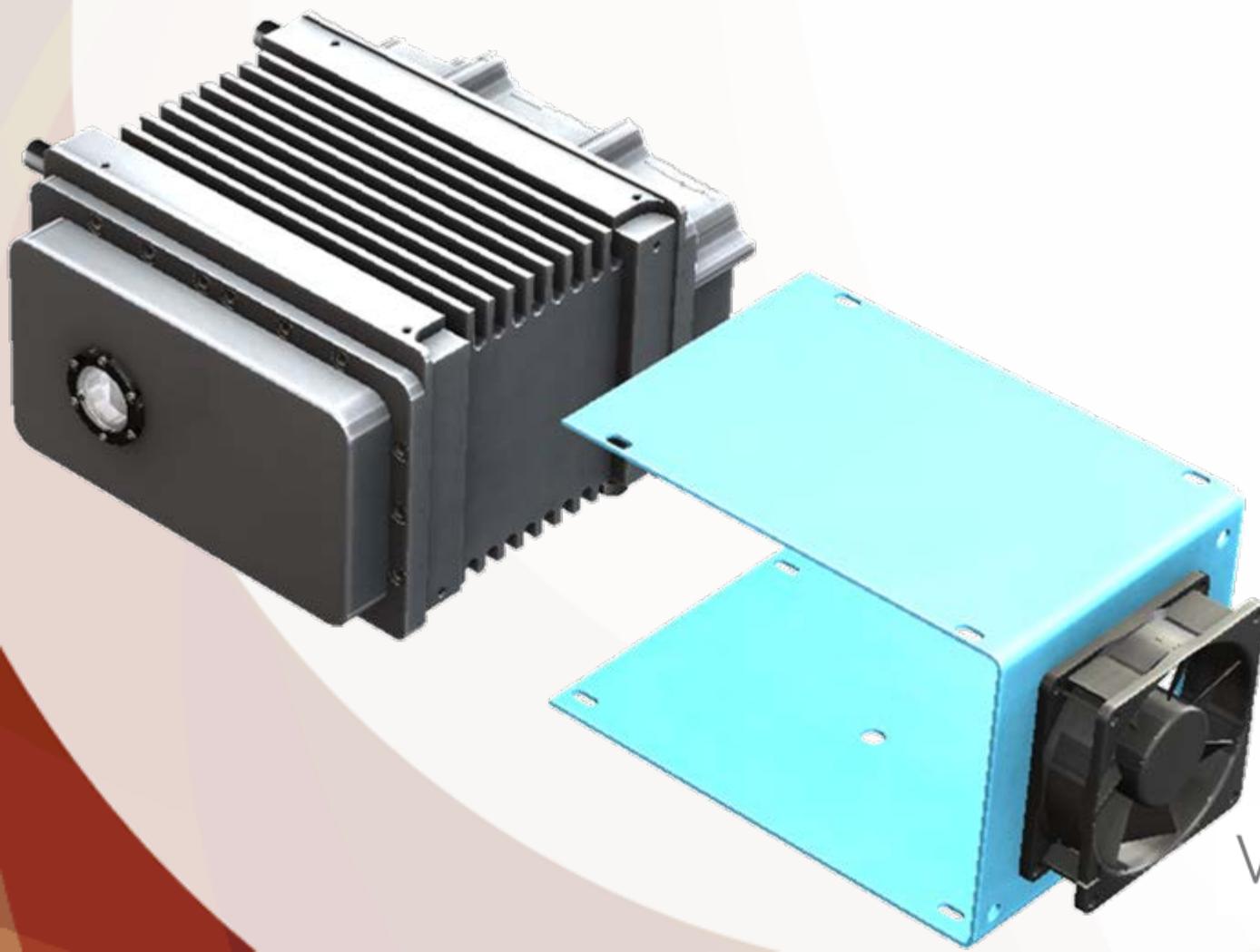
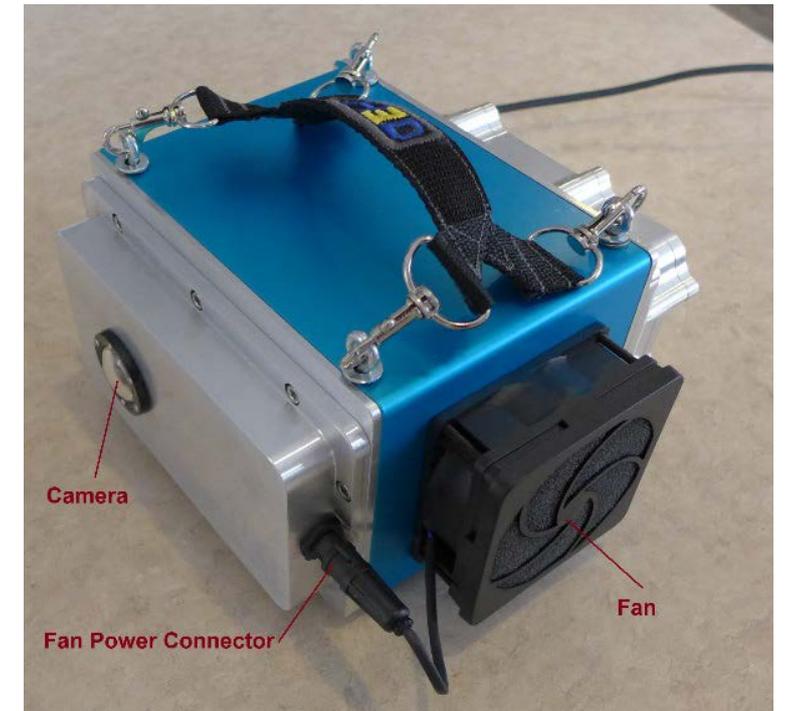


- 8.5 lbs
- Battery operated (5 hr)
- Washable for easy decontamination
- “Simple” user interface
- $\leq 1.1\%$  FWHM energy resolution at 662 keV
- Omnidirectional imaging

# Polaris-H

## Imaging Spectrometer for Nuclear Power Plants

- $\sim 2\pi$  optical camera for overlay of radiation image
- Compton imaging  $\sim 250$  keV to 3 MeV
- Communication with tablet display via Wi-Fi, Bluetooth, USB, or Ethernet to network
- Fan and external fins for temperature regulation



We

# Polaris-H

## Imaging Spectrometer for Nuclear Power Plants

- Real-time software on embedded CPU for isotope detection/ID, isotope-specific imaging, data logging, control and regulation.

The screenshot shows the real-time software interface. The top row contains buttons for 'Save', 'Controls', '00:02:20', and 'Isotope'. Below these are a spectrum plot on the left and a camera view on the right. The 'Back' panel shows system status: 'Thu Dec 19 16:04:58 2013', 'Elapsed Time: 00:05:21', 'Count Rate: 46 CPS', 'Storage Space: 11.1GB', 'On Wall Power', 'Battery Level: N/A%', 'High Voltage: OK', and 'Detector Temperature: 86°F'. The bottom row has 'Notes', '16 CPS', and 'Shutdown'. The rightmost panel is a grid of isotope detection results:

Cancel	None	All IDs	Submit
Cs-137 480(92%)	Co-60 57(100%)		
Cs-134 (No Peak)	Co-58 (No Peak)	Mn-54 (No Peak)	Fe-59 (No Peak)
511 keV (No Peak)	*Am-241 (No Peak)	K-40 (No Peak)	I-131 (No Peak)
*Ce-141 (No Peak)			

- Post-processing software for time analysis, high-resolution imaging, detailed studies.

The left screenshot shows the 'H3DVisualizer' post-processing software. It features a 'Filters' section with search criteria for 'Cs' and a table of measurements:

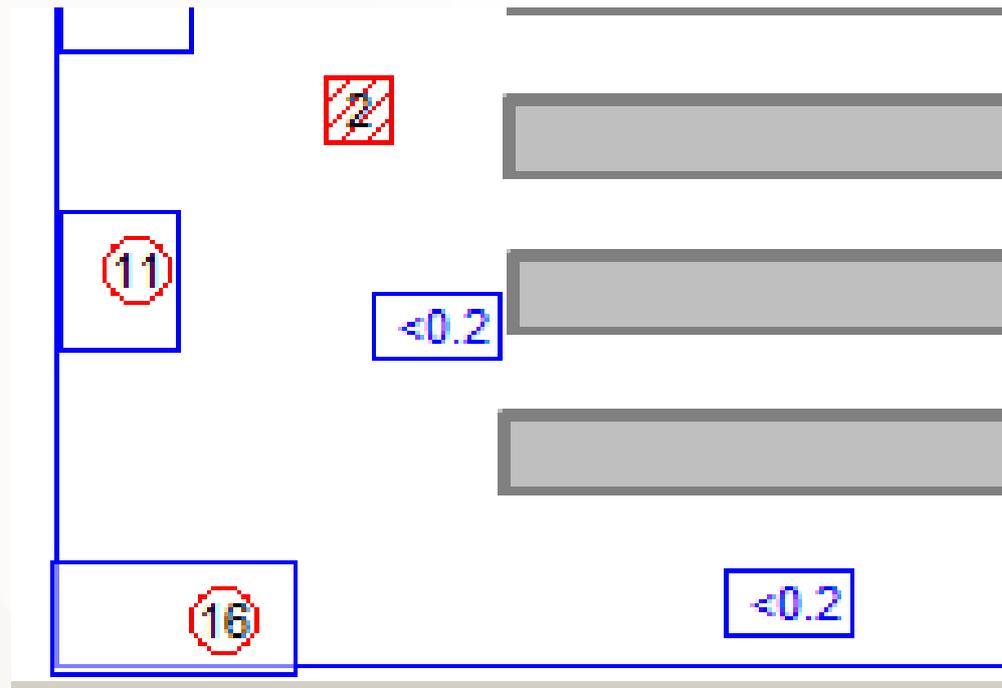
Name	Date	Time	Durati...	Detector
co60_cs137_location_1	2014-08-04	12:59:23	00:10:02	N0000010Hannah
cs	2014-07-29	14:05:10	00:00:24	N0101005Joanna
cs137res	2014-07-29	14:01:40	00:03:30	N0101005Joanna
Cs-137_Angular_Resolution	2014-06-30	15:34:15	02:04:48	N0100005Miriam
Cs-137_Angular_Resolution	2014-06-30	15:01:57	01:25:44	N0100005Miriam
Cs-137_Angular_Resolution	2014-06-30	12:28:51	02:57:30	N0100005Miriam

The right screenshot shows a detailed view of a measurement. It includes a 'Choose Measurements' list, a spectrum plot showing a peak at approximately 662 keV, and a camera view of the measurement area. The spectrum plot is labeled '3648 cts; Cs-137; Cs-137\_Angular\_Resolution'.

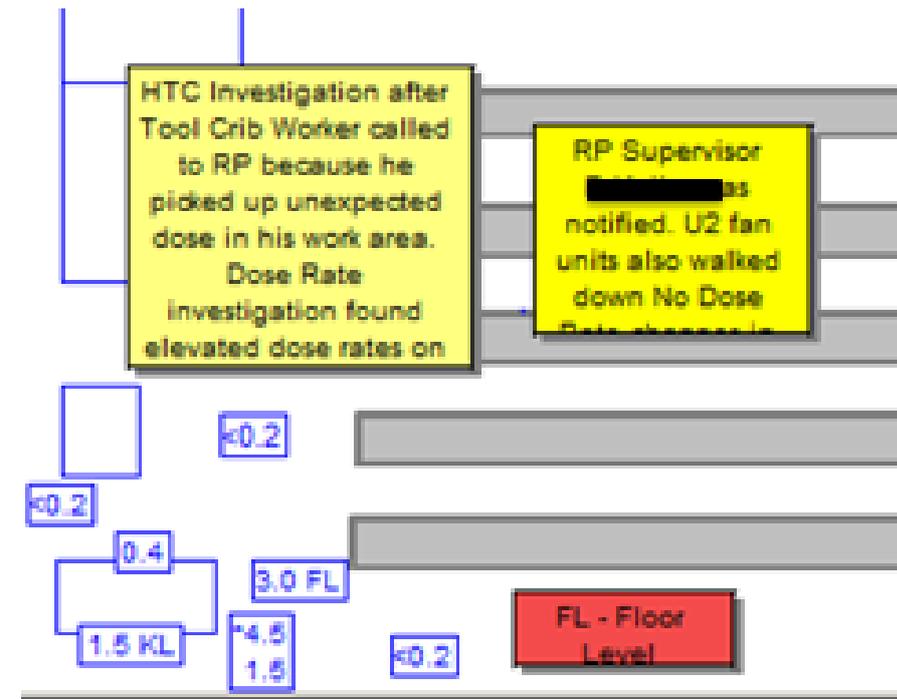
# Elevated Dose Rates in Hot Tool Crib

- On 9/10/14, a tool crib worker received an unexpected dose accumulation of 0.1 mRem while in the Hot Tool Crib (HTC).
- Dose was streaming through the floor plugs from a drained demin vessel.

# Elevated Dose Rates in Hot Tool Crib

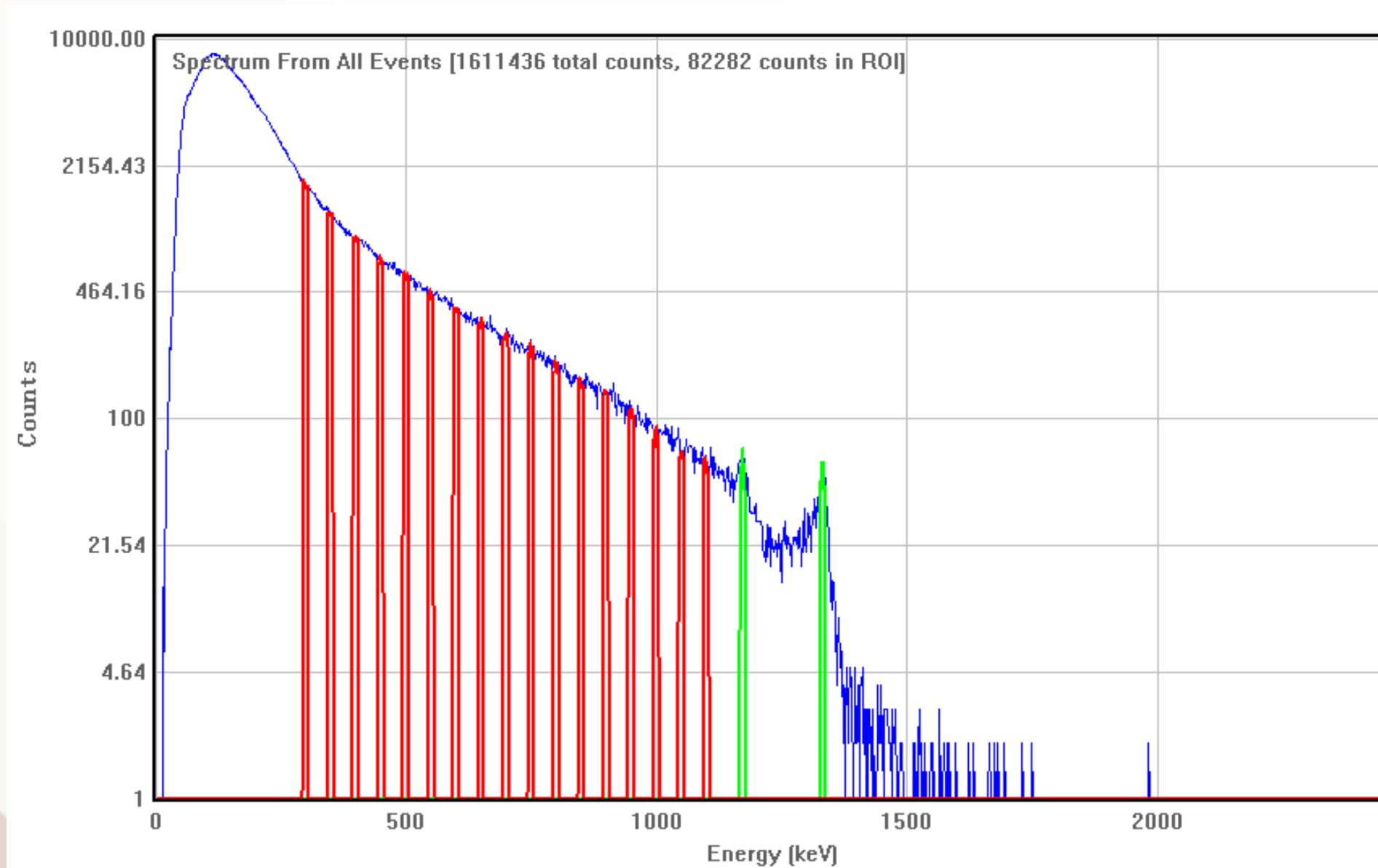


Typical Dose Rates



Elevated Dose Rates (9/10/14)

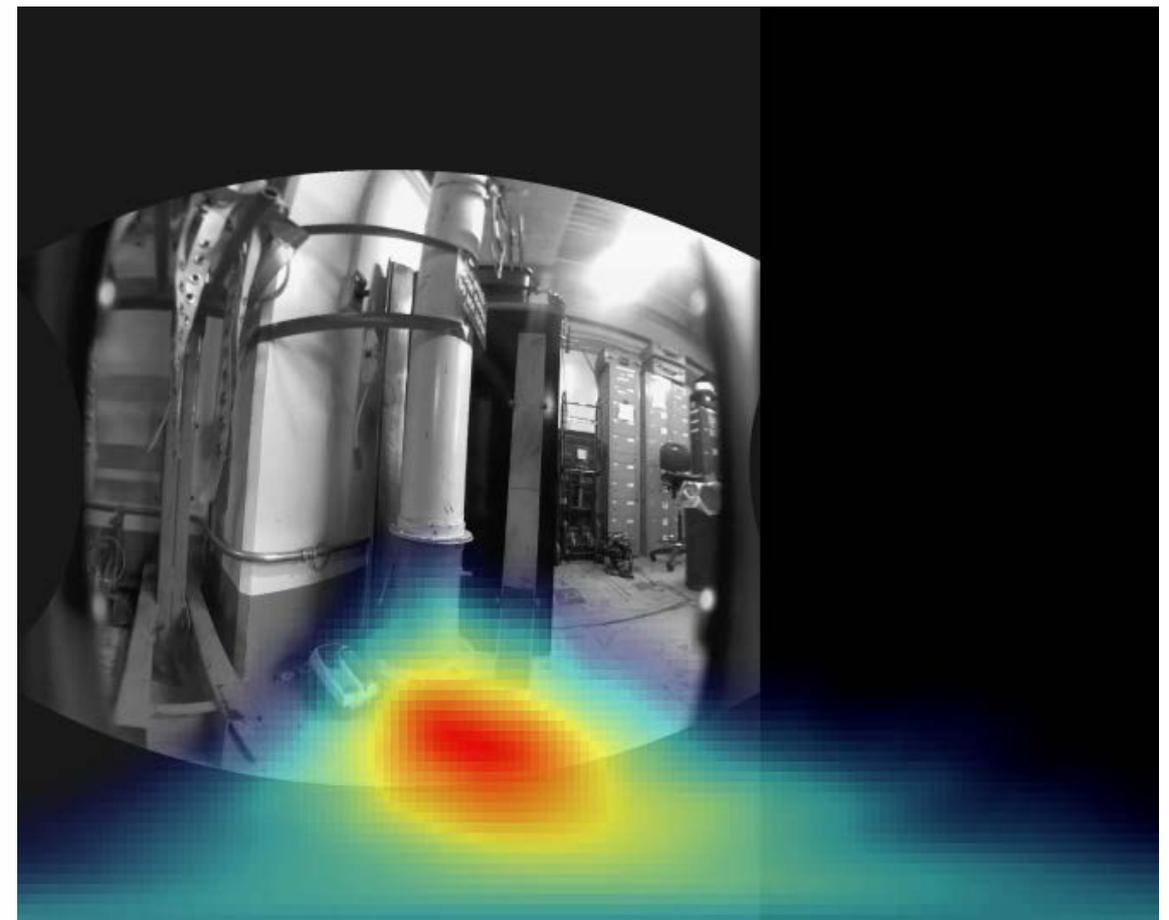
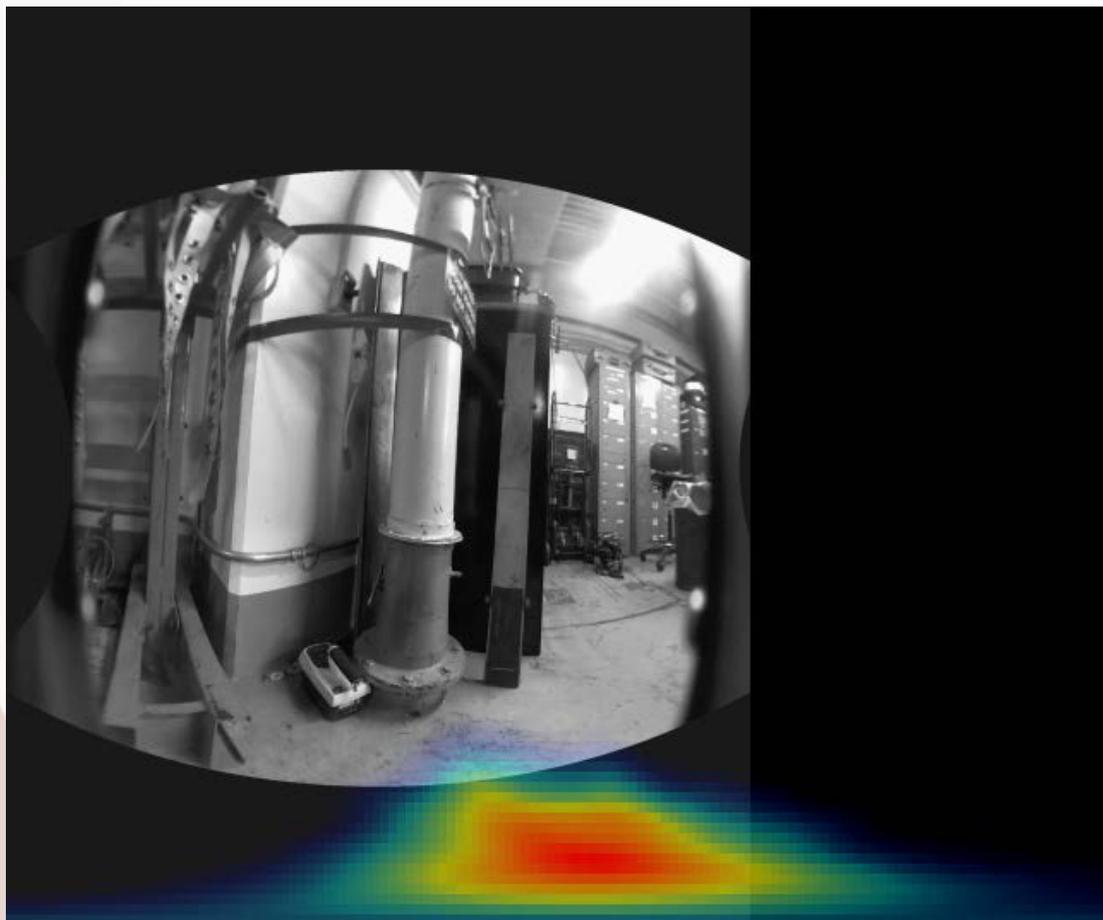
# Elevated Dose Rates in Hot Tool Crib



# Elevated Dose Rates in Hot Tool Crib

Image of Co-60:

Image of Scatter:



# Elevated Dose Rates in Hot Tool Crib

## Results of the Imaging:

- HTC Workers Instructed to avoid whole area near floor cover
- Increased Importance to Refill Demin prior to refueling outage
- Filled Demin decreased Dose Rates

# Elevated Dose Rates in Waste Gas System

- No air sample needed to get isotopic on waste gas
- Gamma Spectrum provided on next slide nearly matched composite sample of resin taken for resin characterization.

# Elevated Dose Rates in Waste Gas System

Comments:

0.2604 grams of resin from the SRST sluice performed on 12-10-2014.

Efficiency File: 8\_ResinVial\_1.Clb

Efficiency Desc: RP Detector #8 Resin Vial on Jig

Library: General.lib

Nuclide	Activity uCi/gm	Error %
Be-7	1.298E+00	2.35
Mn-54	1.275E+00	0.57
Co-57	7.185E-02	2.68
Co-58	1.689E+00	0.47
Co-60	5.123E+00	0.19
Zn-65	5.587E-02	16.54
Zr-95	7.471E-02	6.00
Nb-95	1.282E-01	2.53
Ag-110m	4.037E-02	11.78
Sn-113	3.673E-02	11.44
Sb-124	7.499E-03	16.32
Cs-134	3.872E+00	0.25
Cs-137	3.360E+00	0.29
Sb-125	6.310E-01	2.13

*H3 = 1.05 mCi/cc or  
1.311 mCi/g*

Total

1.766E+01

PAGEBREAK

1.766E+01

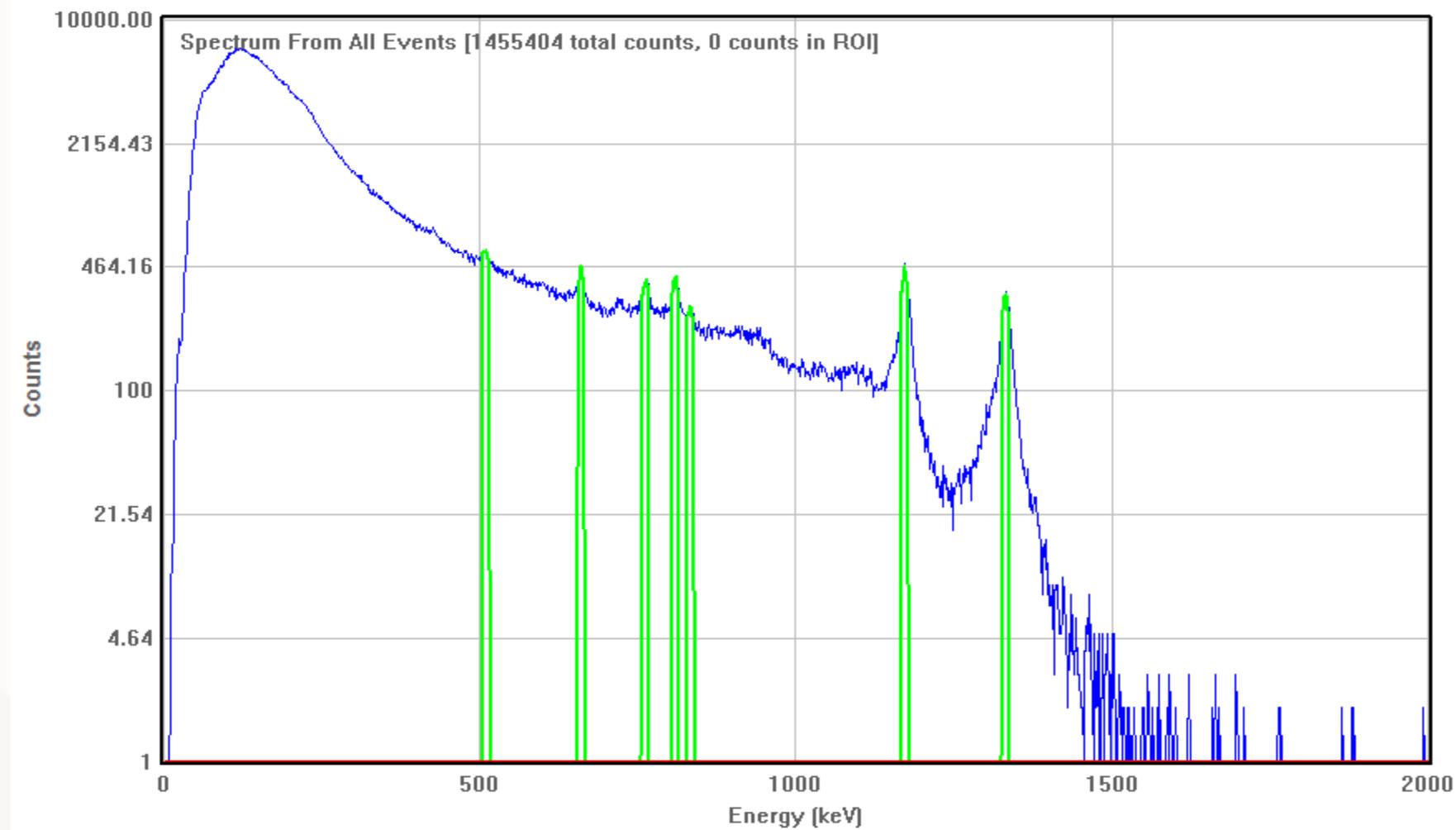
DC Cook Nuclear Power Plant

CHEM/RP/ENV Department

Description: Unit#12 SRST resin sample sluiced on 12-10-14

RWP: 2014-1012

# Elevated Dose Rates in Waste Gas System – S. Waste Gas Compressor

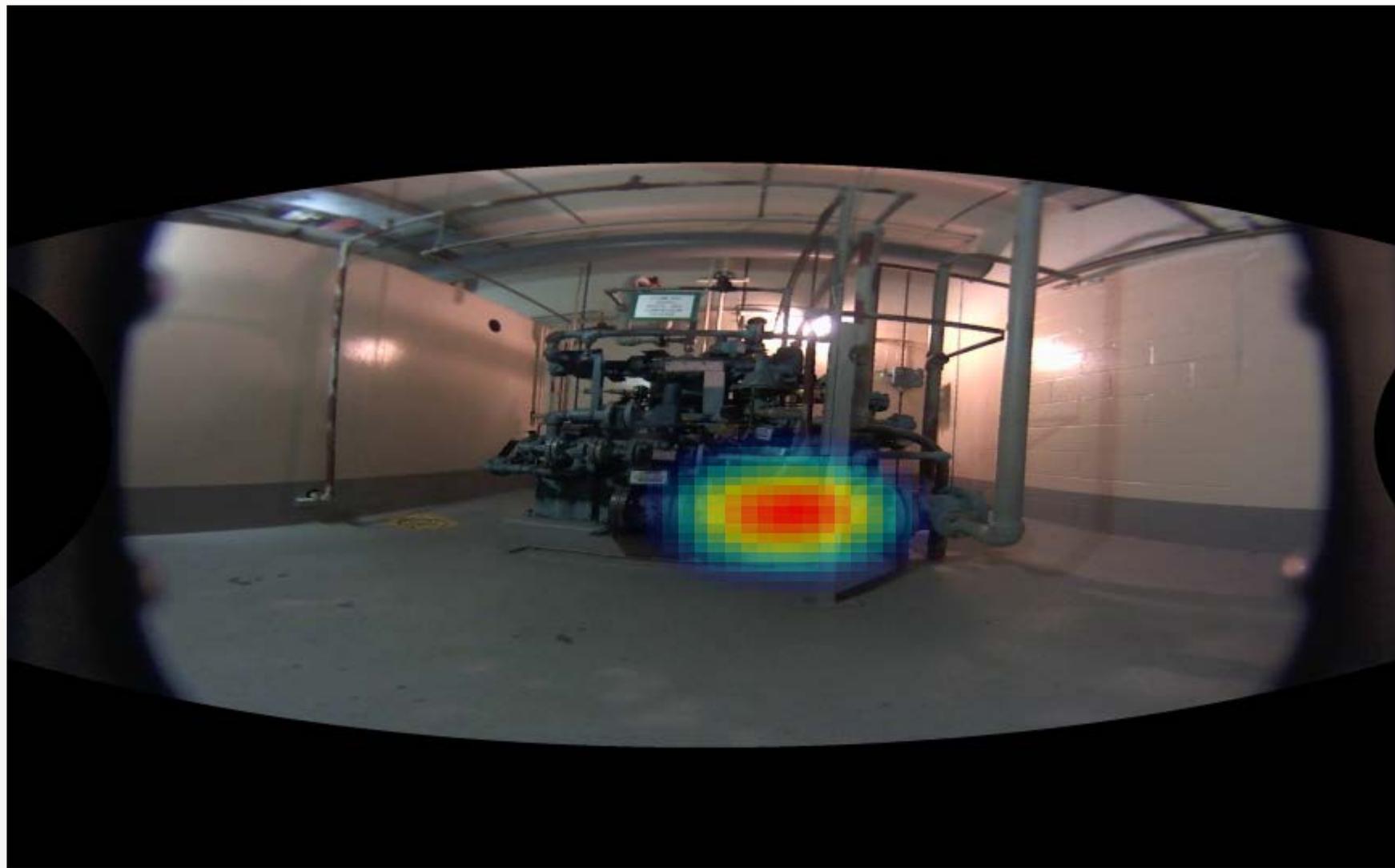


S. Waste Gas Compressor:  
Co-58, Co-60, Cs-137, Mn-54, Nb-95

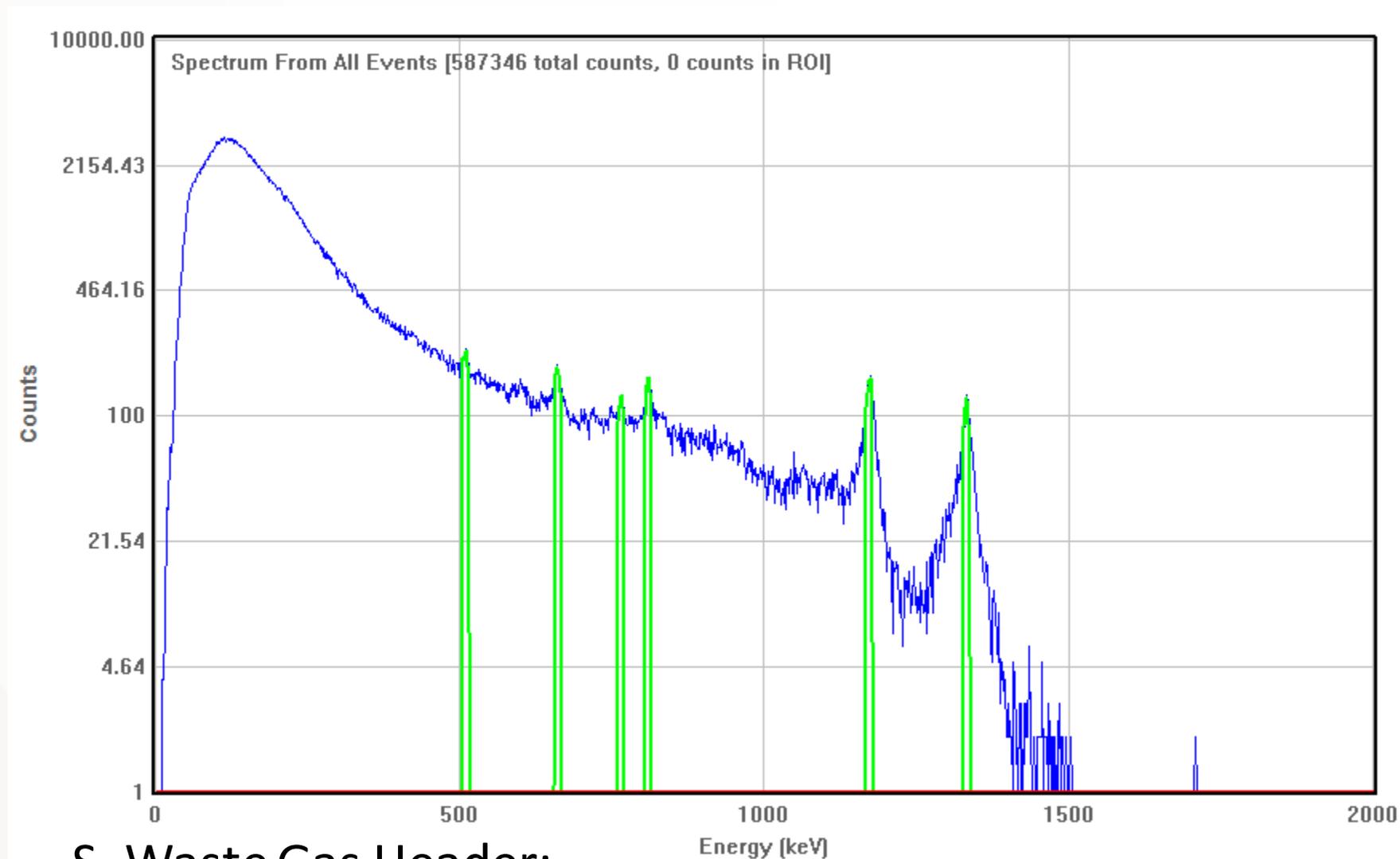
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# Elevated Dose Rates in Waste Gas System – S. Waste Gas Compressor

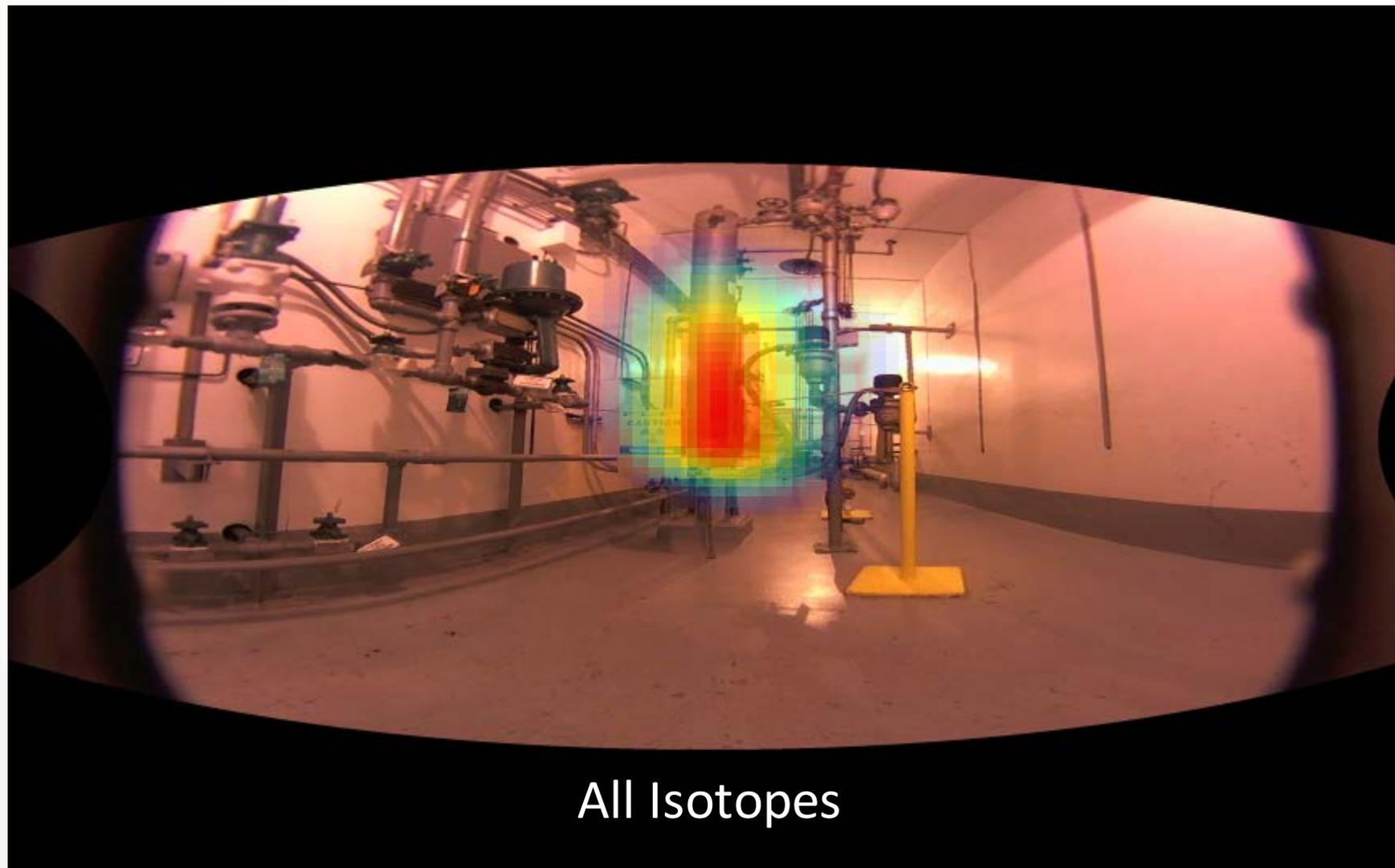


# Elevated Dose Rates in Waste Gas System – S. Waste Gas Header



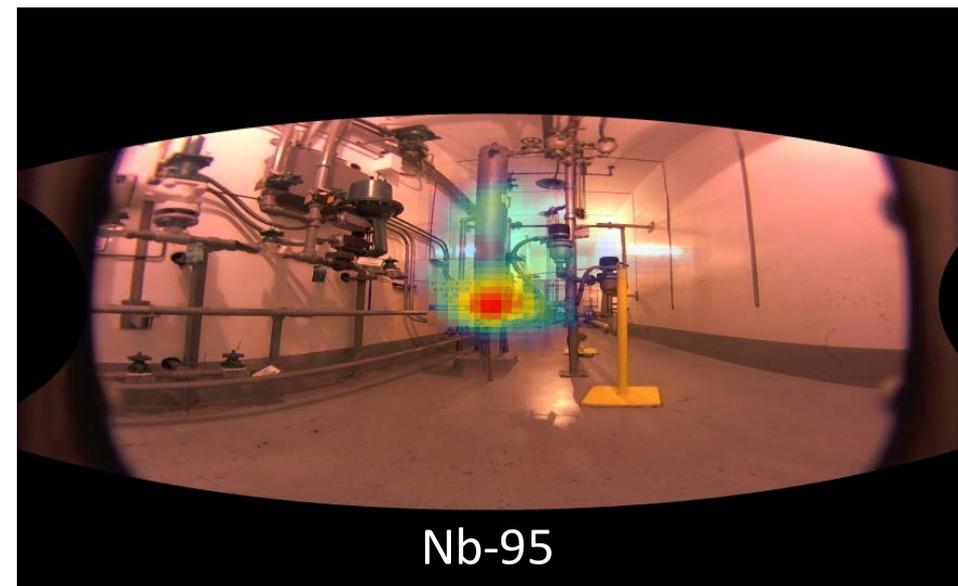
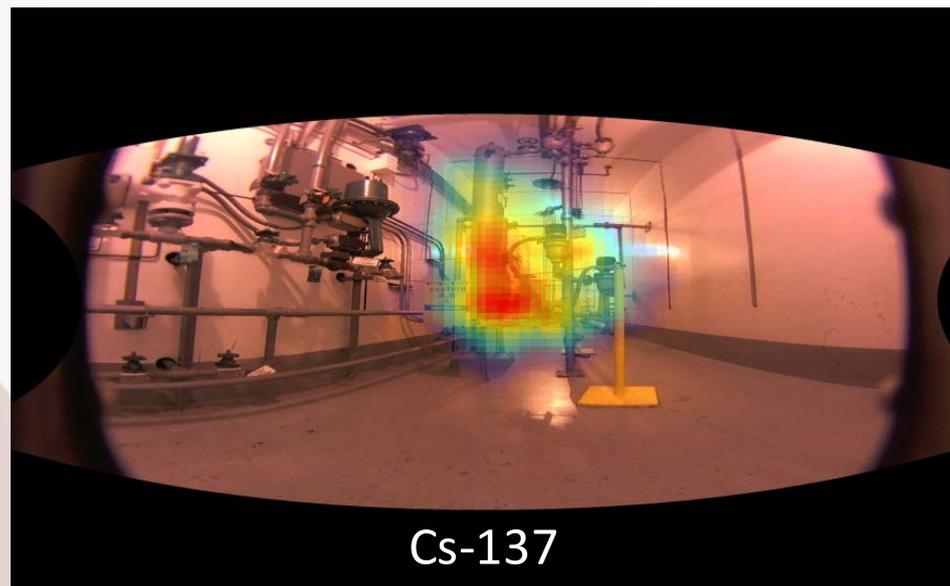
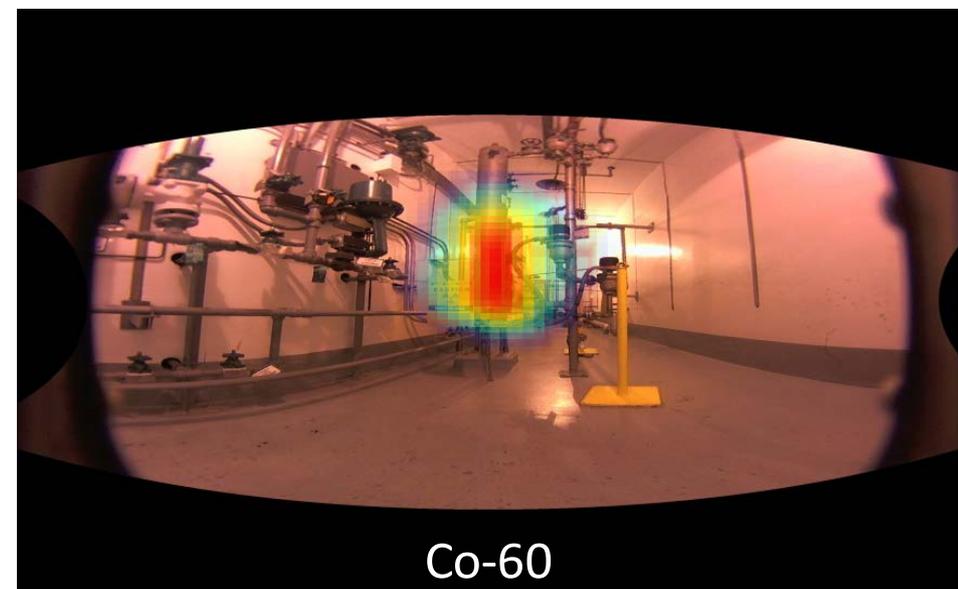
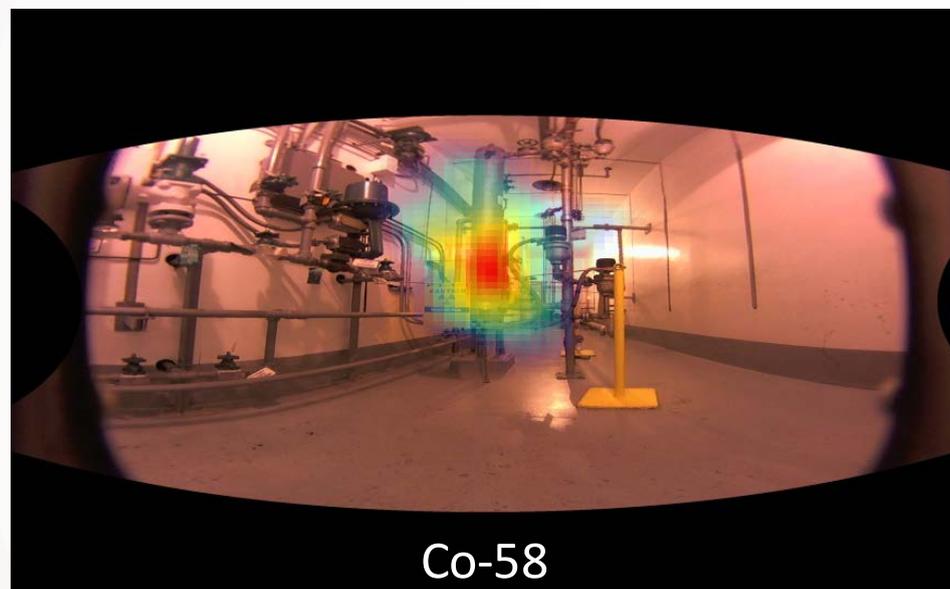
S. Waste Gas Header:  
Co-58, Co-60, Cs-137, Nb-95

# Elevated Dose Rates in Waste Gas System – S. Waste Gas Header



All Isotopes

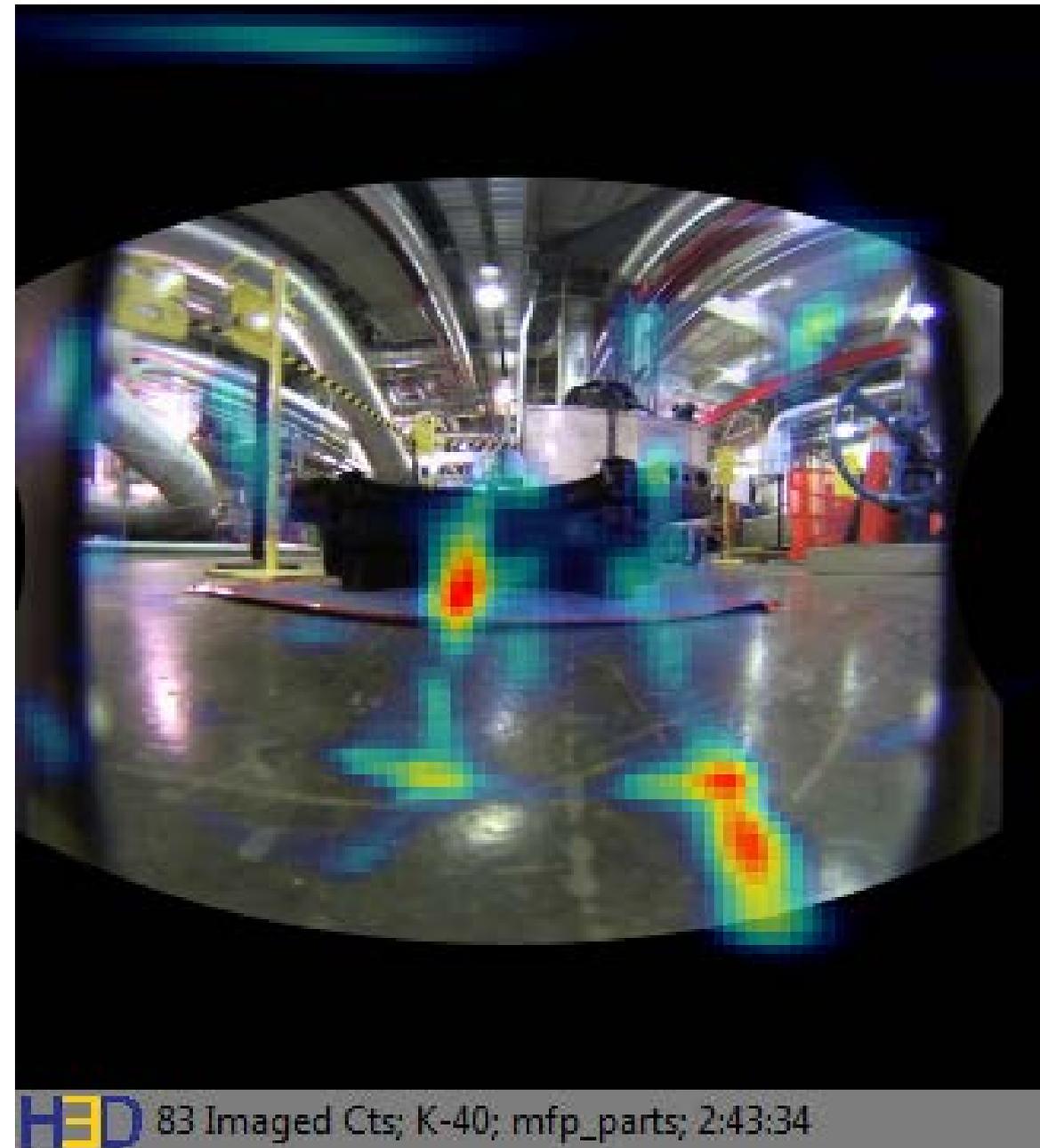
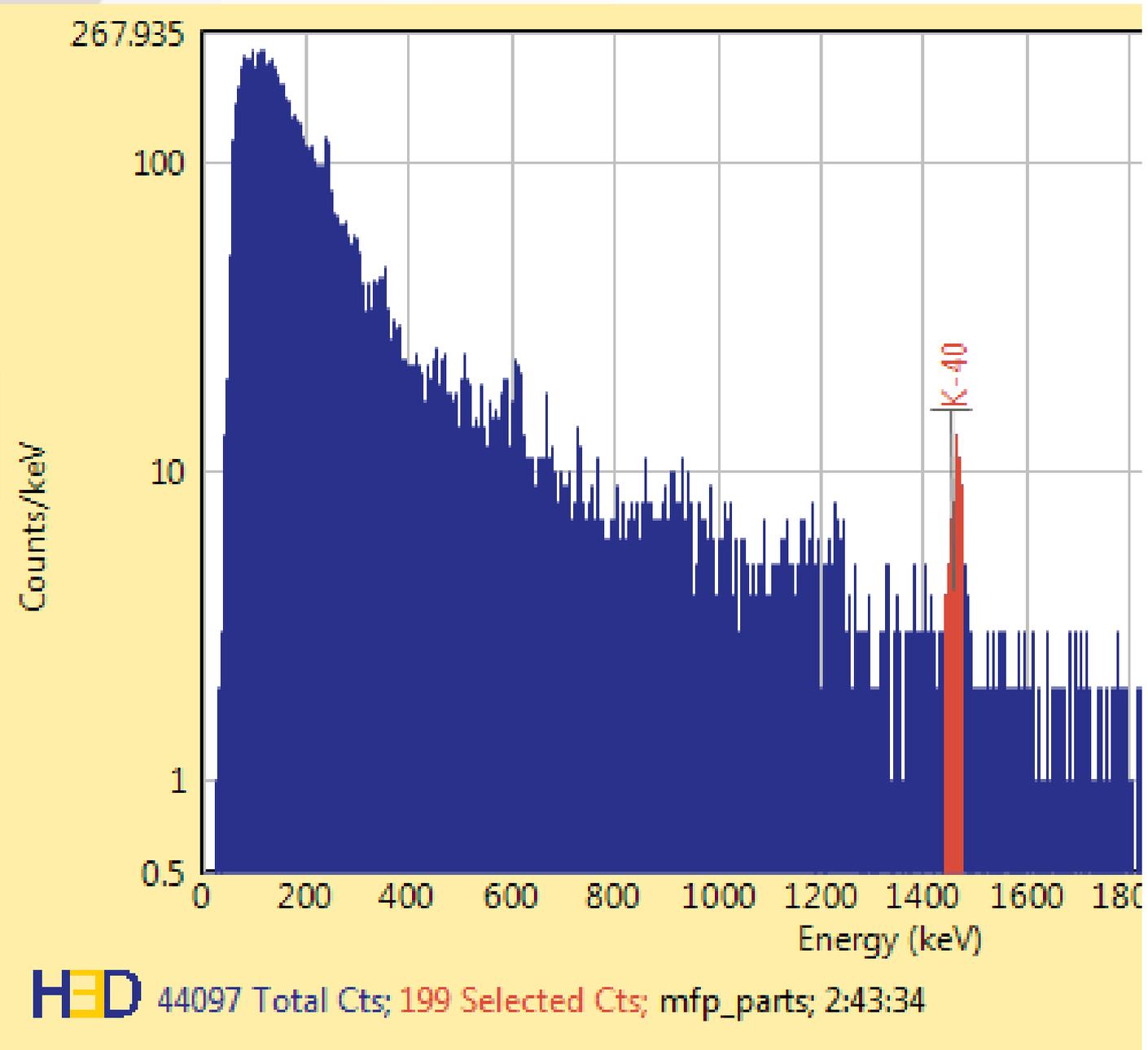
# Elevated Dose Rates in Waste Gas System – S. Waste Gas Header



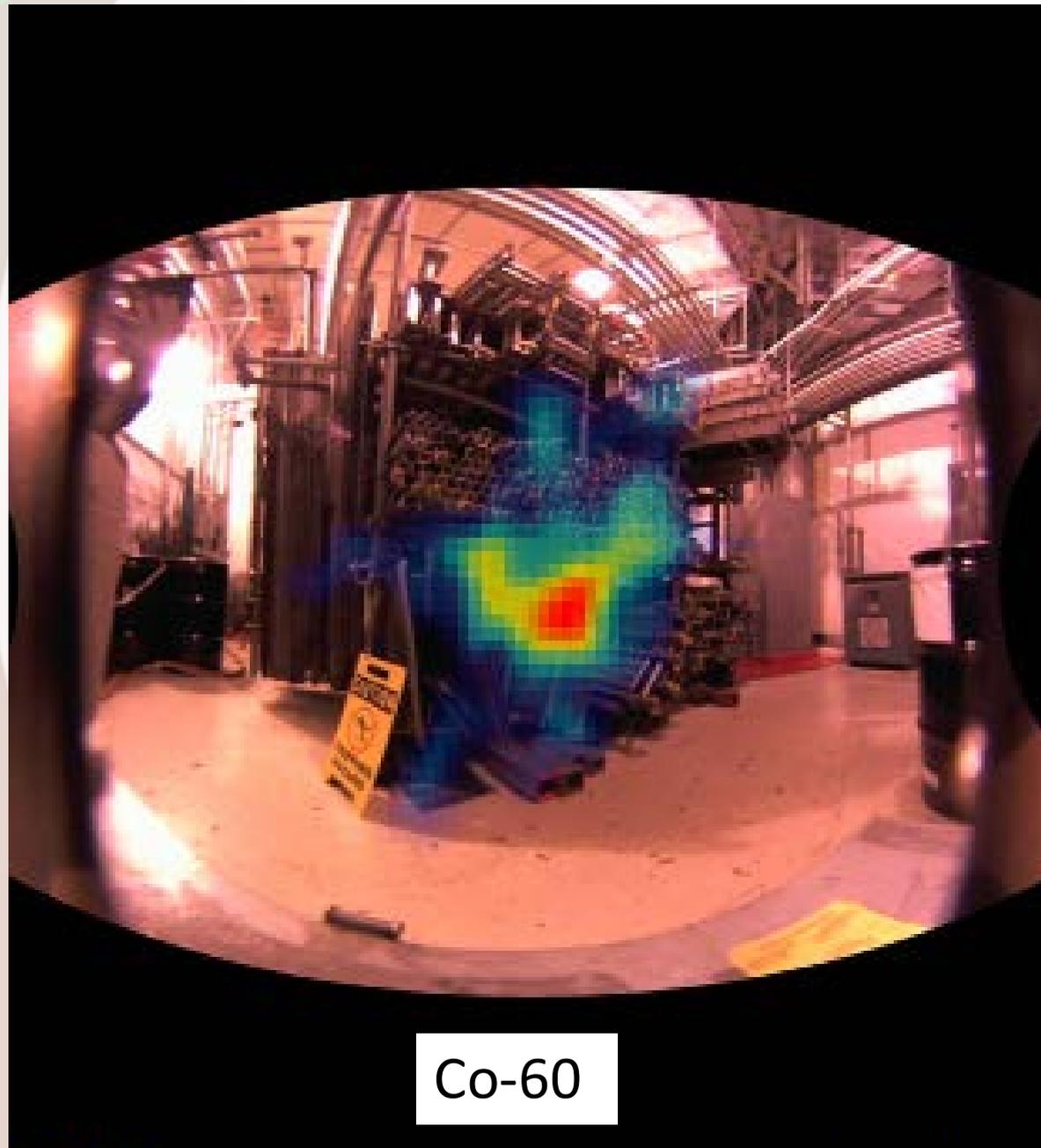
# Elevated Dose Rates in Waste Gas System

- When the spent resin storage tank was filled water solid, the vent path allowed water to enter the plant vent header.
- This water cleared out particles entrained in the piping and flowed down to the drain tank.
- The gas / vapor with the radioactive particles was drawn into the south compressor suction.

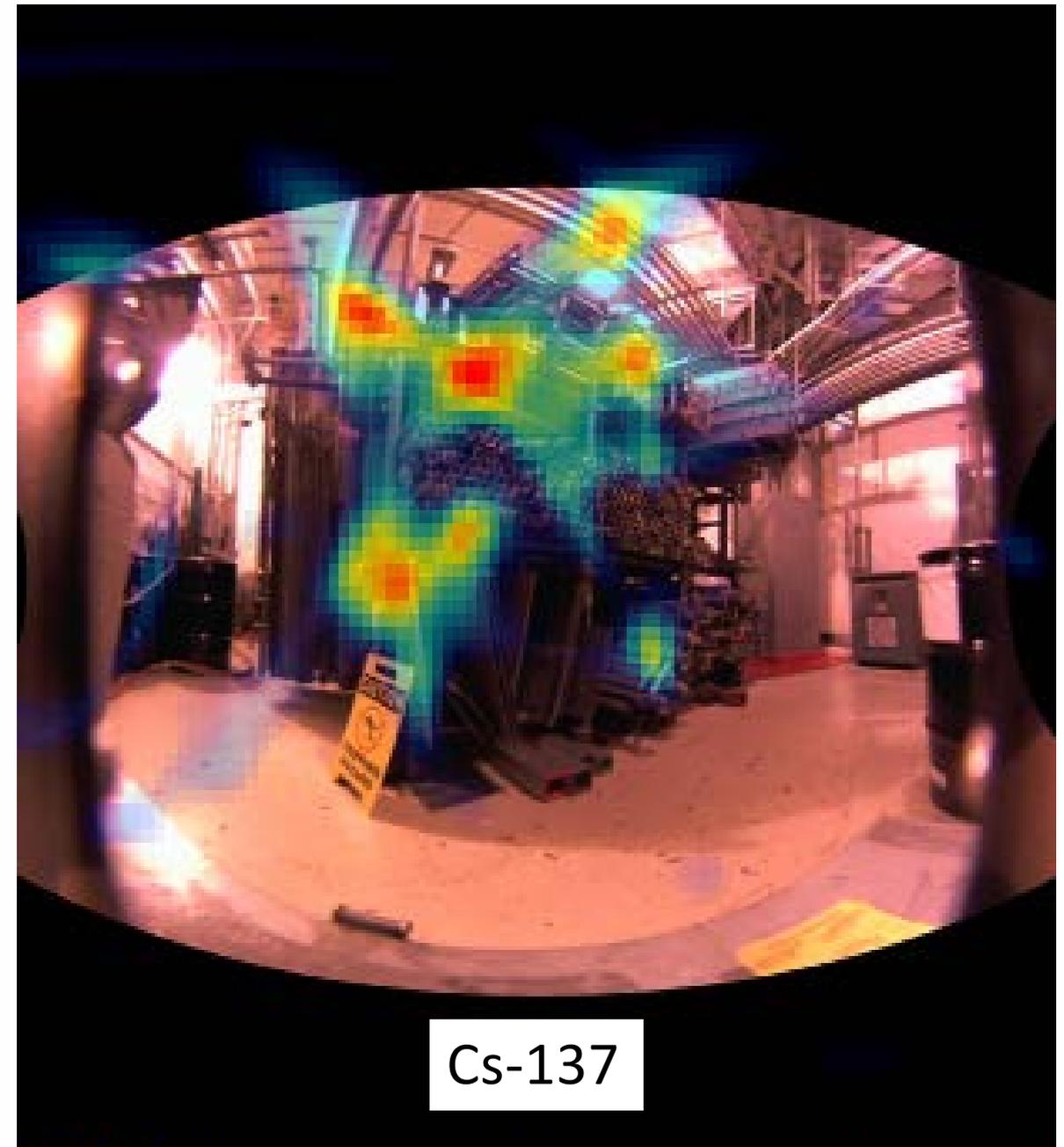
# Auxiliary Feedwater Pump Seal



# Scaffold Rack Contamination



HED 209 Imaged Cts; Co-60; cook\_unit\_2\_609\_scaffoldir

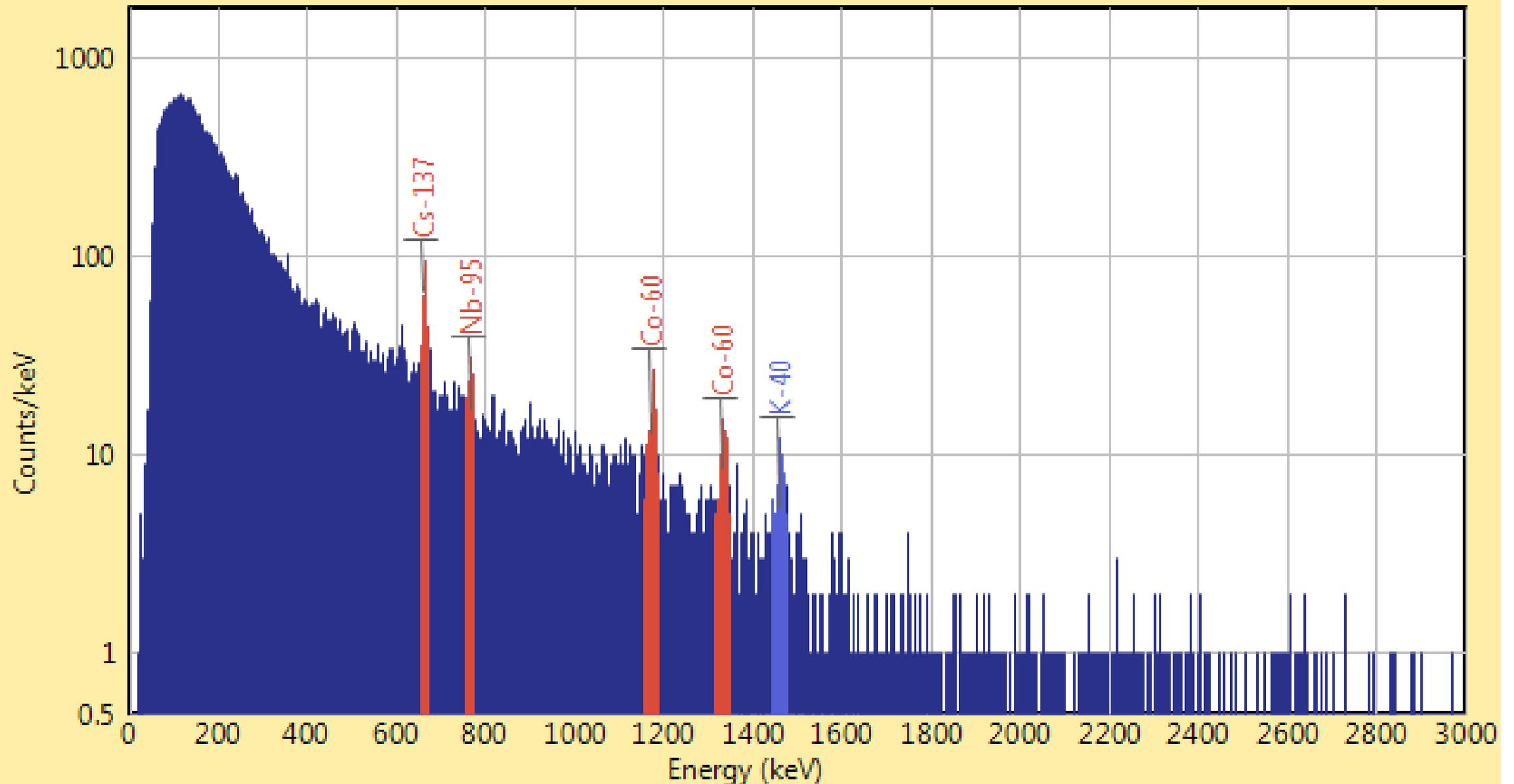


HED 249 Imaged Cts; Cs-137; cook\_unit\_2\_609\_scaffoldir

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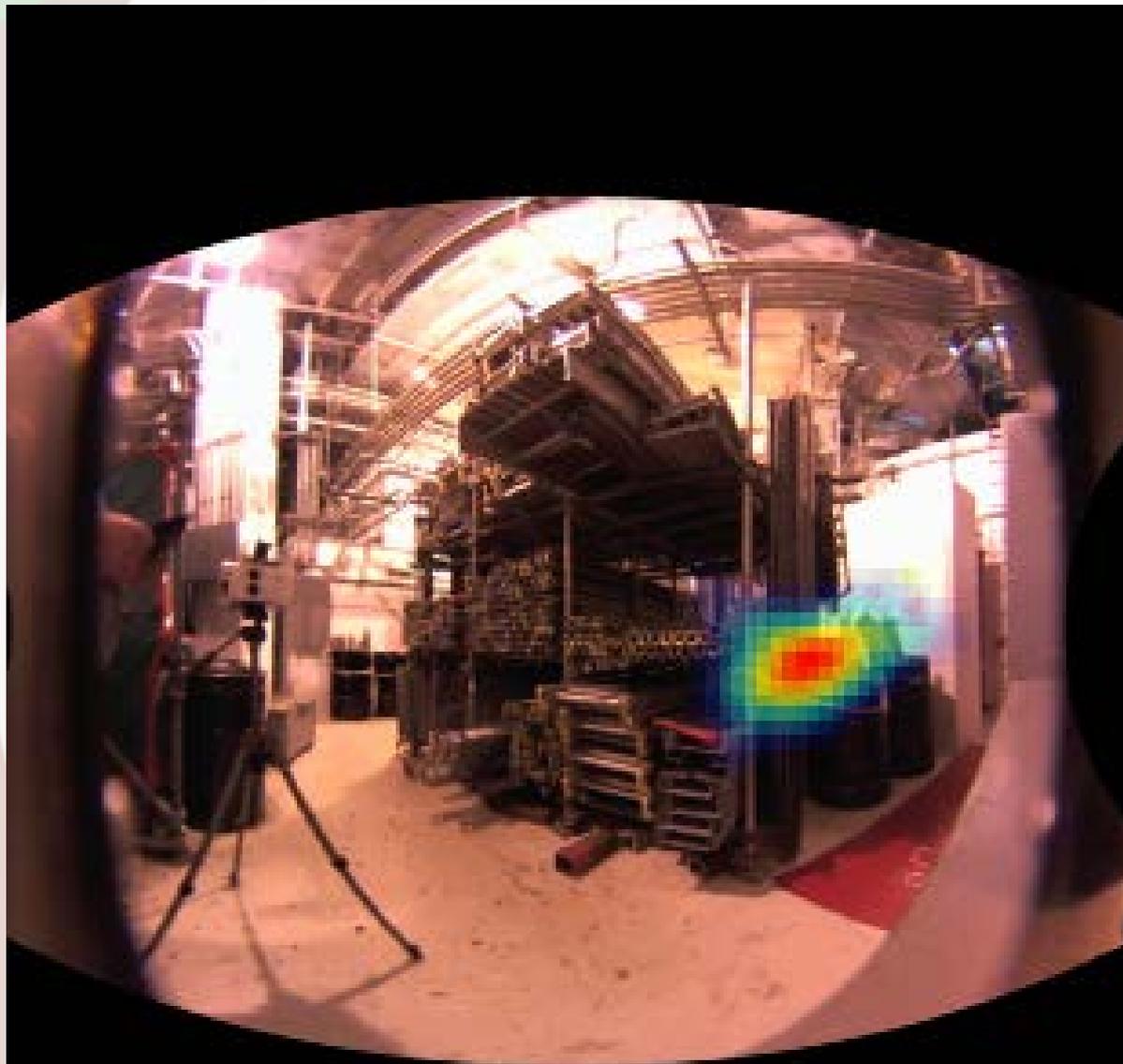
# Scaffold Rack Contamination



HED 116498 Total Cts; 1791 Selected Cts; cook\_unit\_2\_609\_scaffolding\_5; 2:55:00

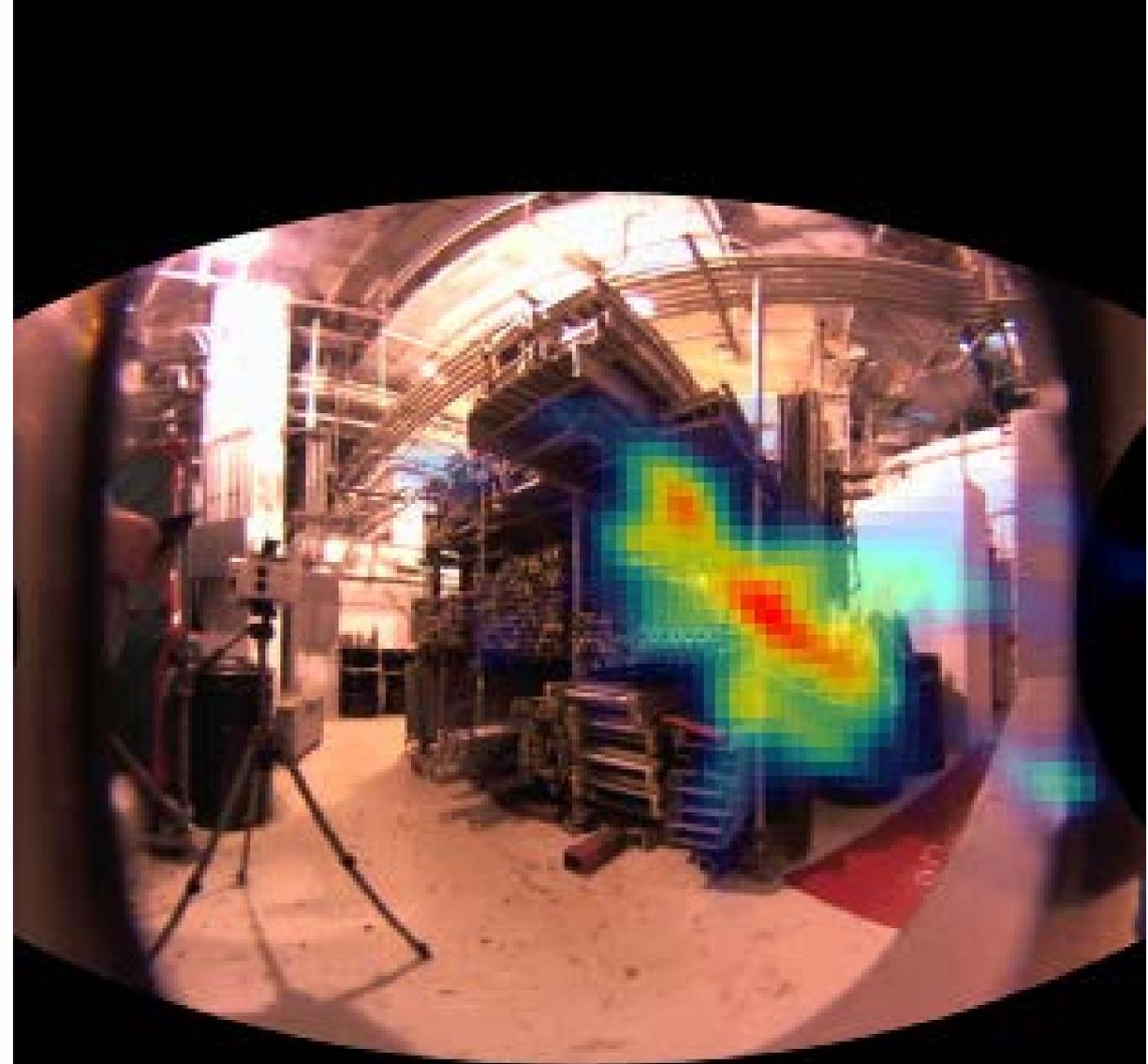
Detected Selected

# Scaffold Rack Contamination



Co-60

HED 369 Imaged Cts; Co-60; 603\_aux\_unit\_2\_scaffolding



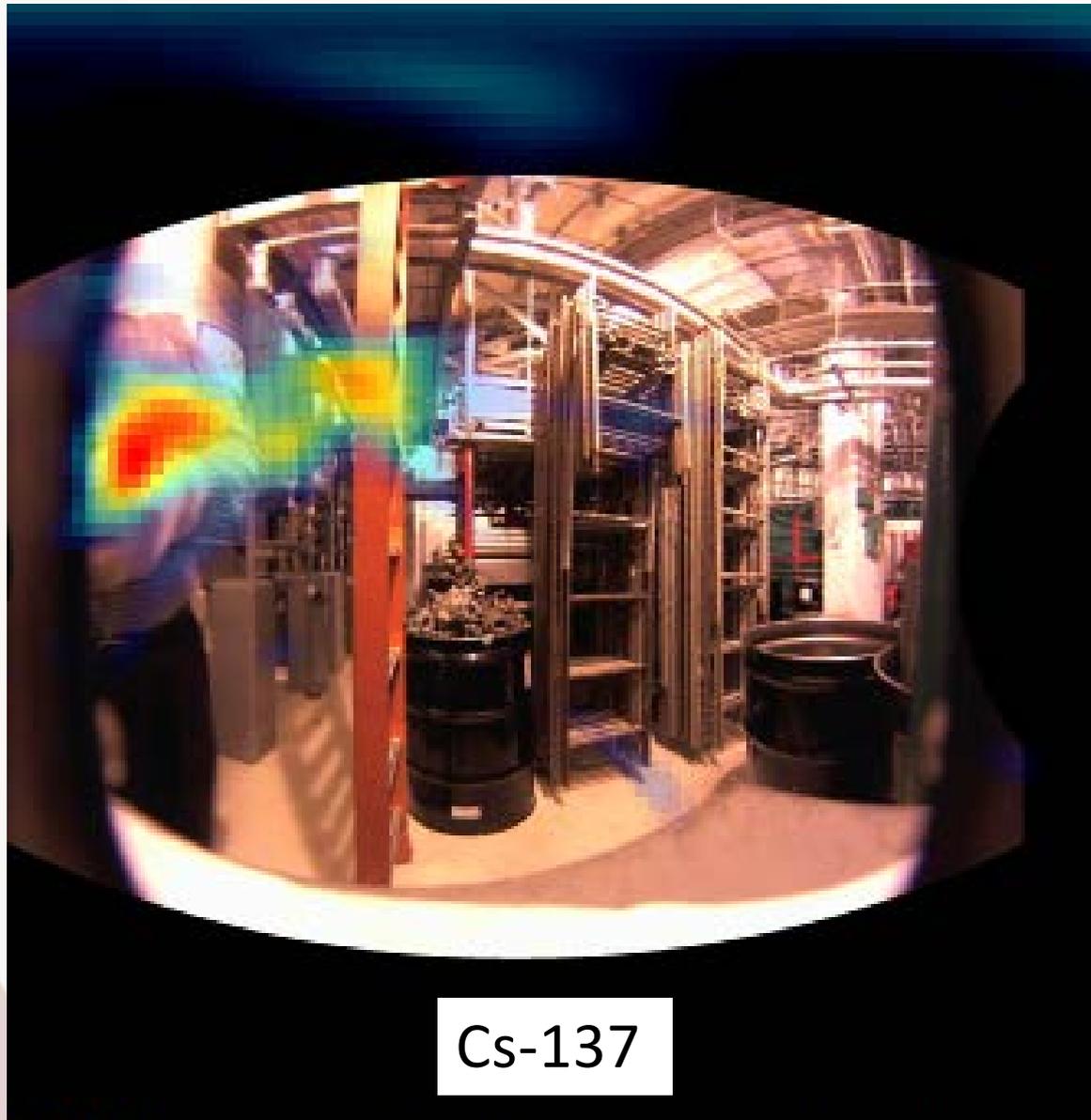
Cs-137

HED 217 Imaged Cts; Cs-137; 603\_aux\_unit\_2\_scaffolding

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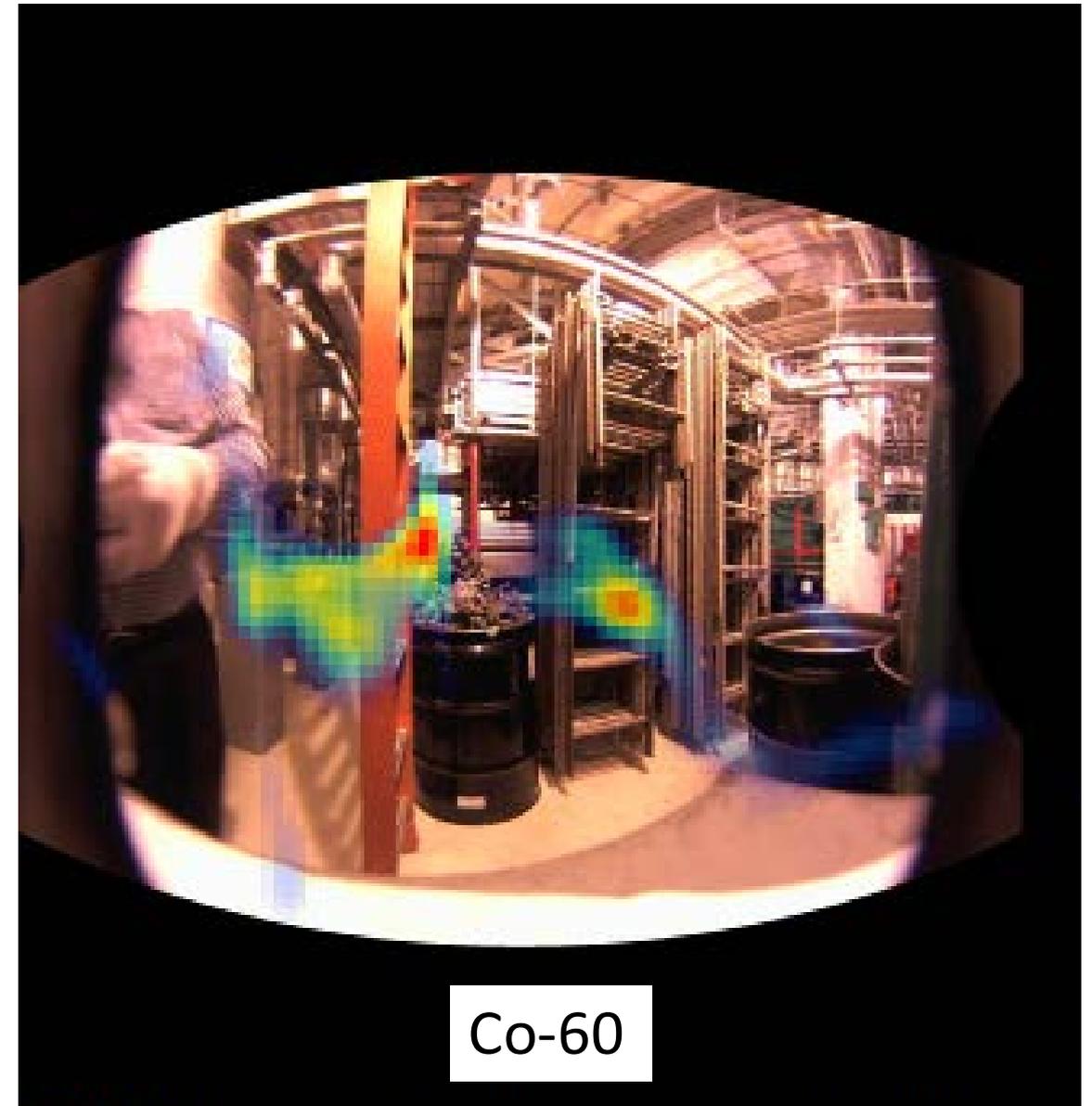


# Scaffold Rack Contamination – Behind Scaffold



Cs-137

HED 90 Imaged Cts; Cs-137; cook\_unit\_2\_609\_scaffolding\_st

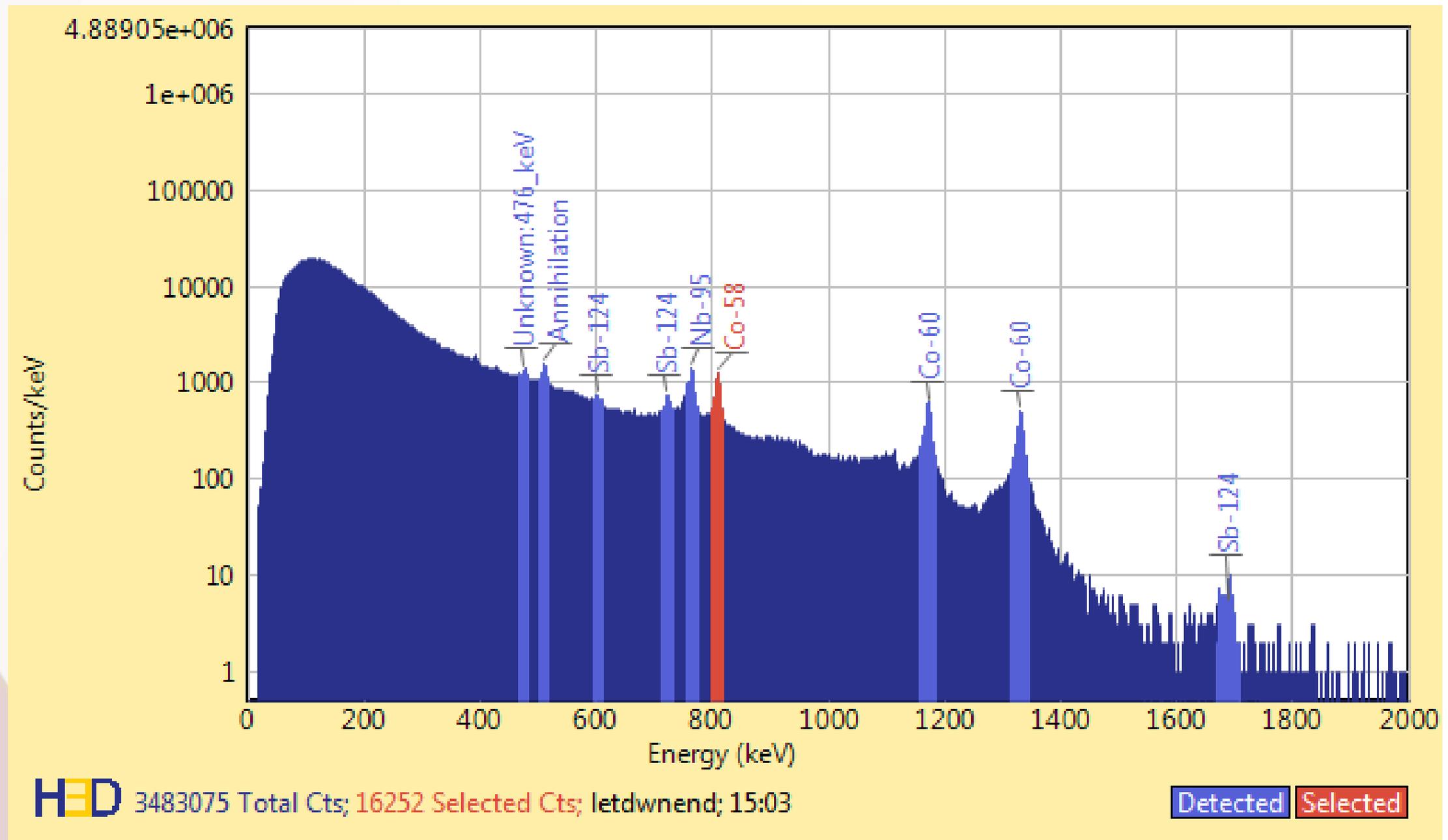


Co-60

HED 51 Imaged Cts; Co-60; cook\_unit\_2\_609\_scaffolding\_st

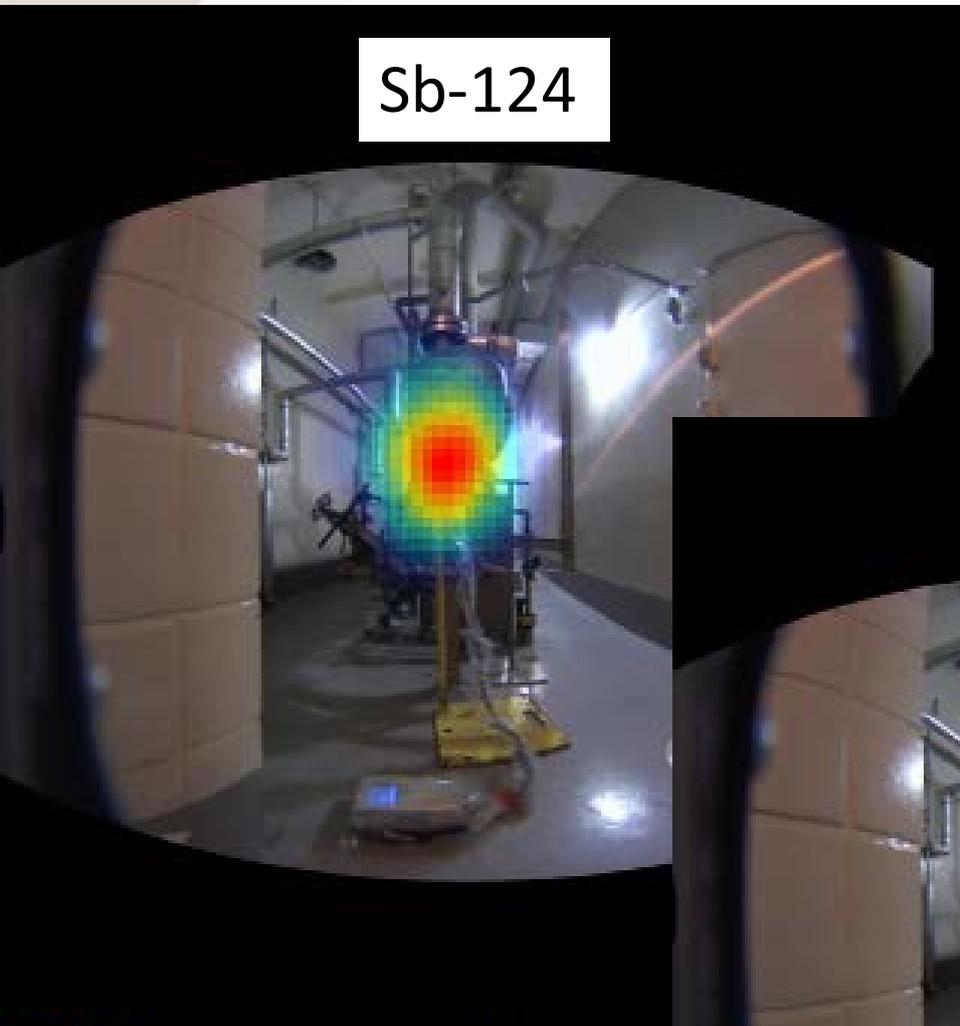
10.4 mR/hr contact w/Ion Chamber –  
Lowest recorded dose rate

# CRUD Location Isotopic – Letdown Hx Endbell

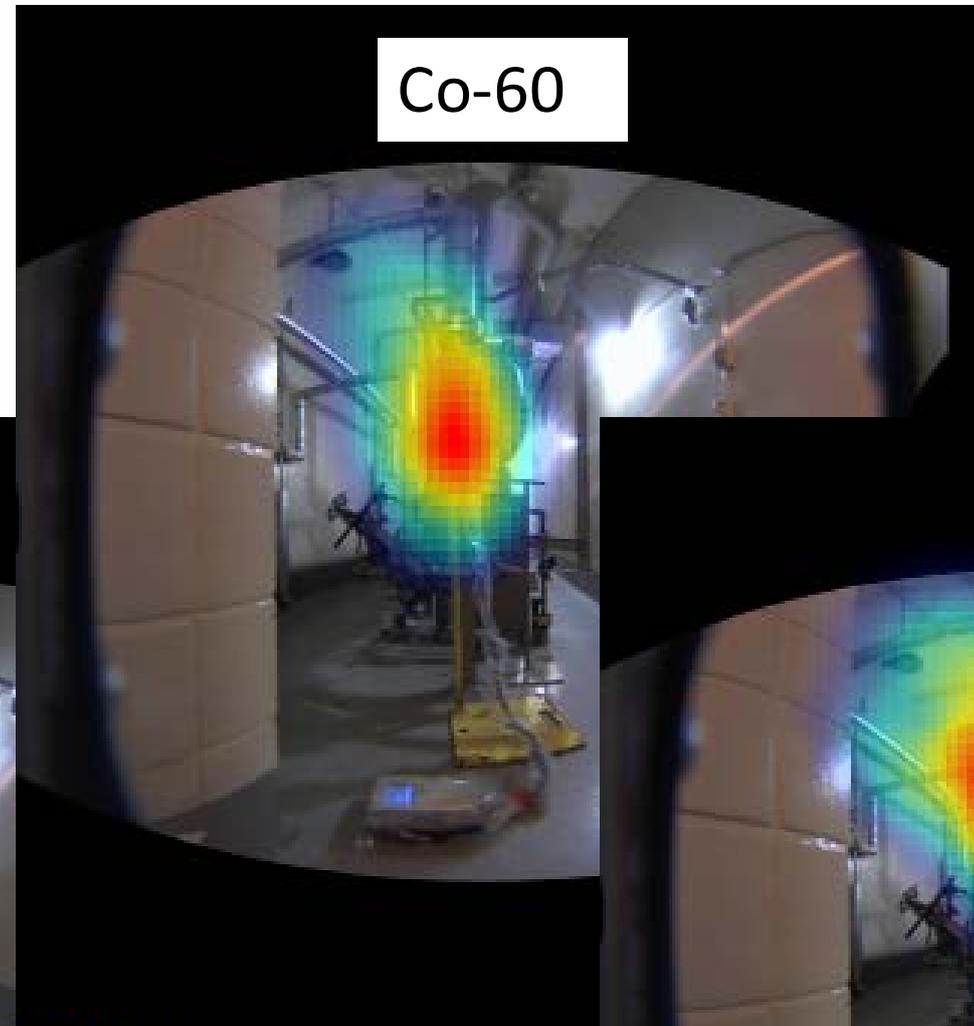


# CRUD Location Isotopic – Letdown Hx Endbell

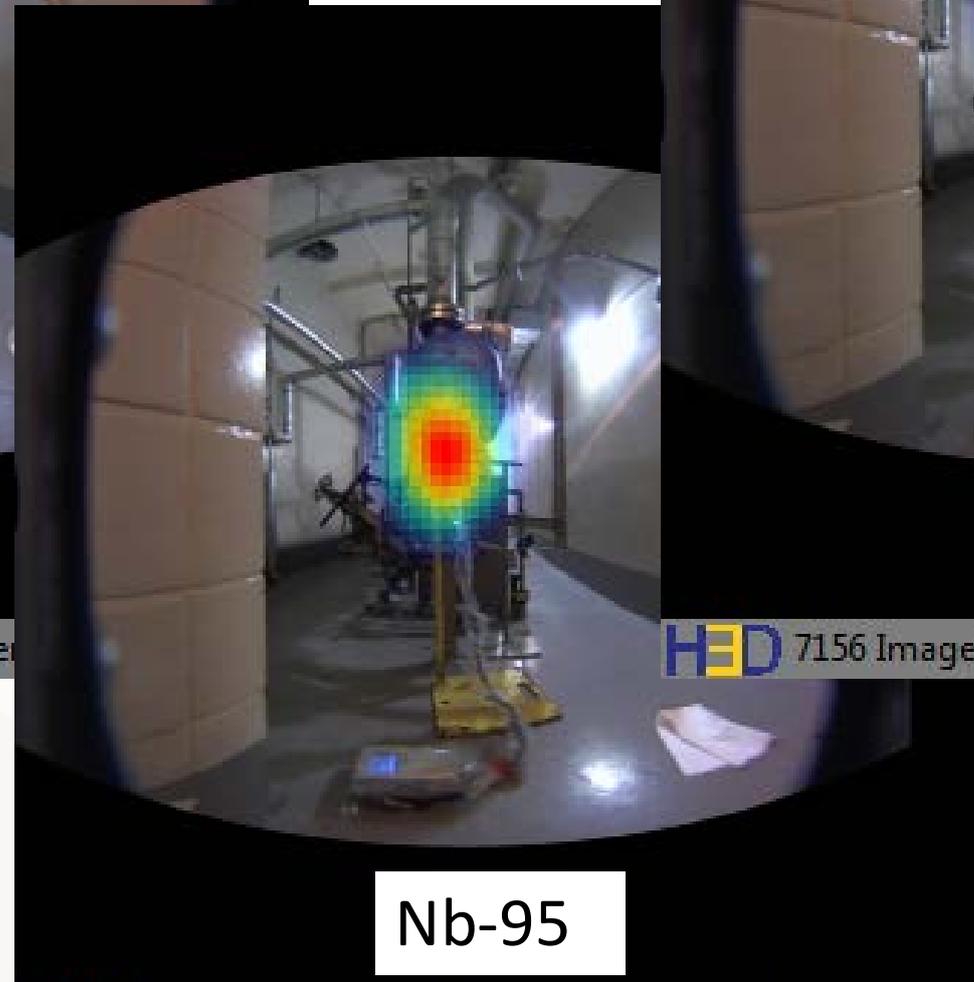
Sb-124



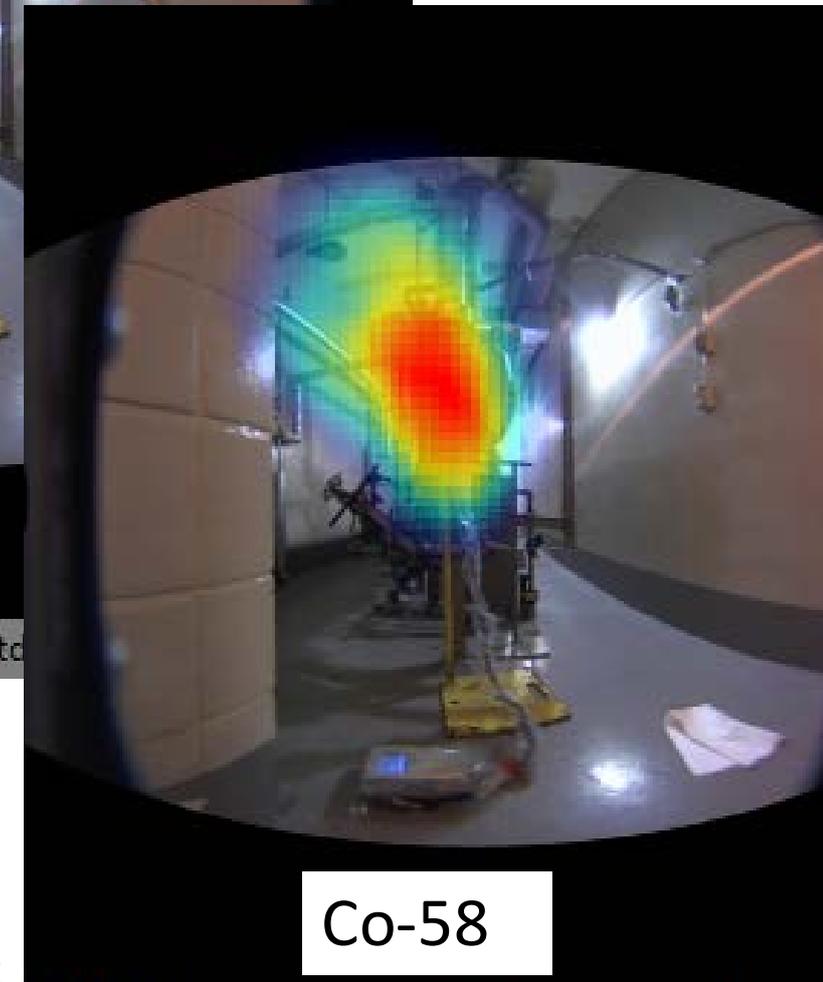
Co-60



Nb-95



Co-58



HED 6181 Imaged Cts; Sb-124; letdwnend

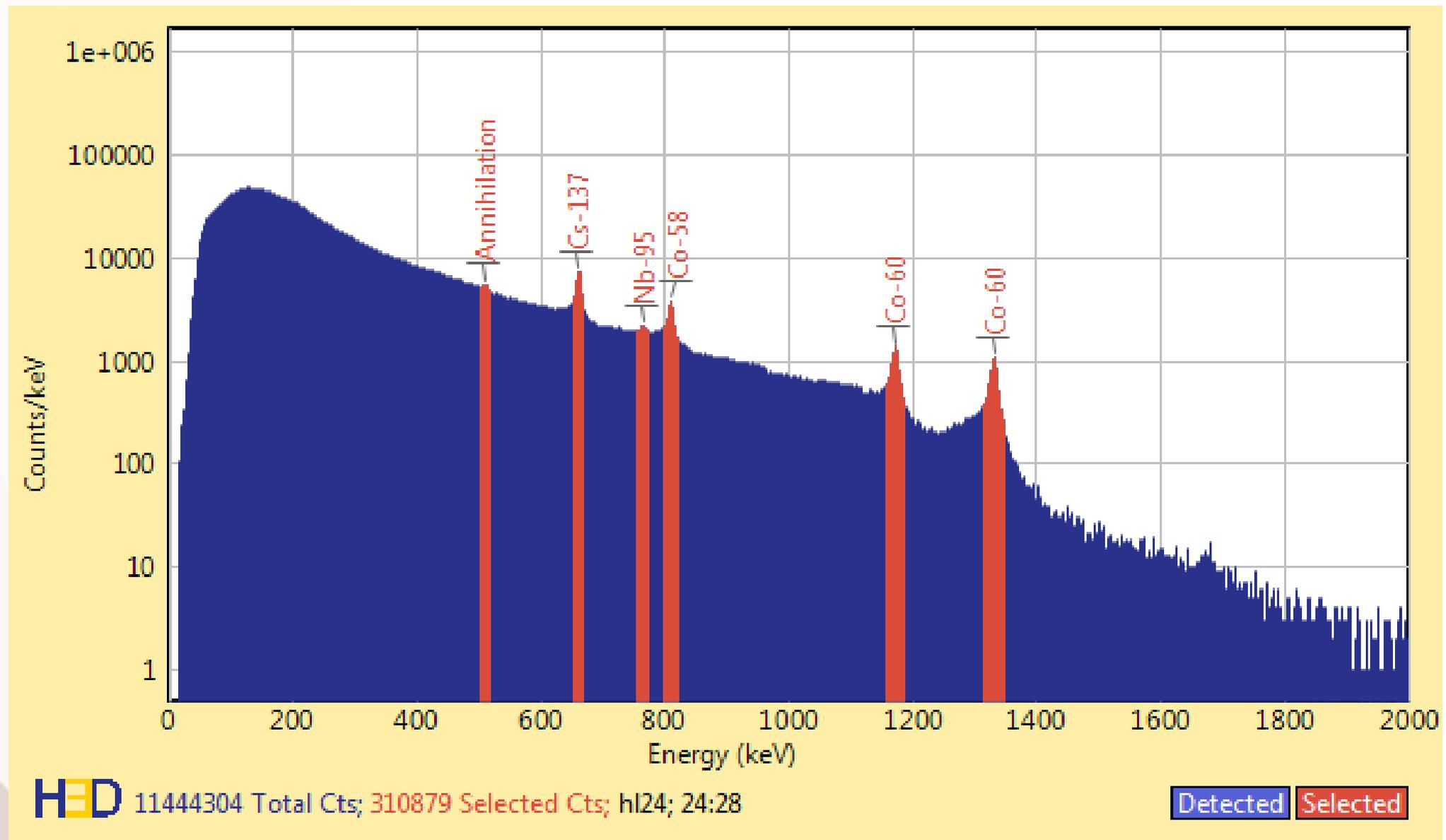
HED 7156 Imaged Cts; Co-60; letdwnend

HED 5998 Imaged Cts; Nb-95; letdwnend; 15:03

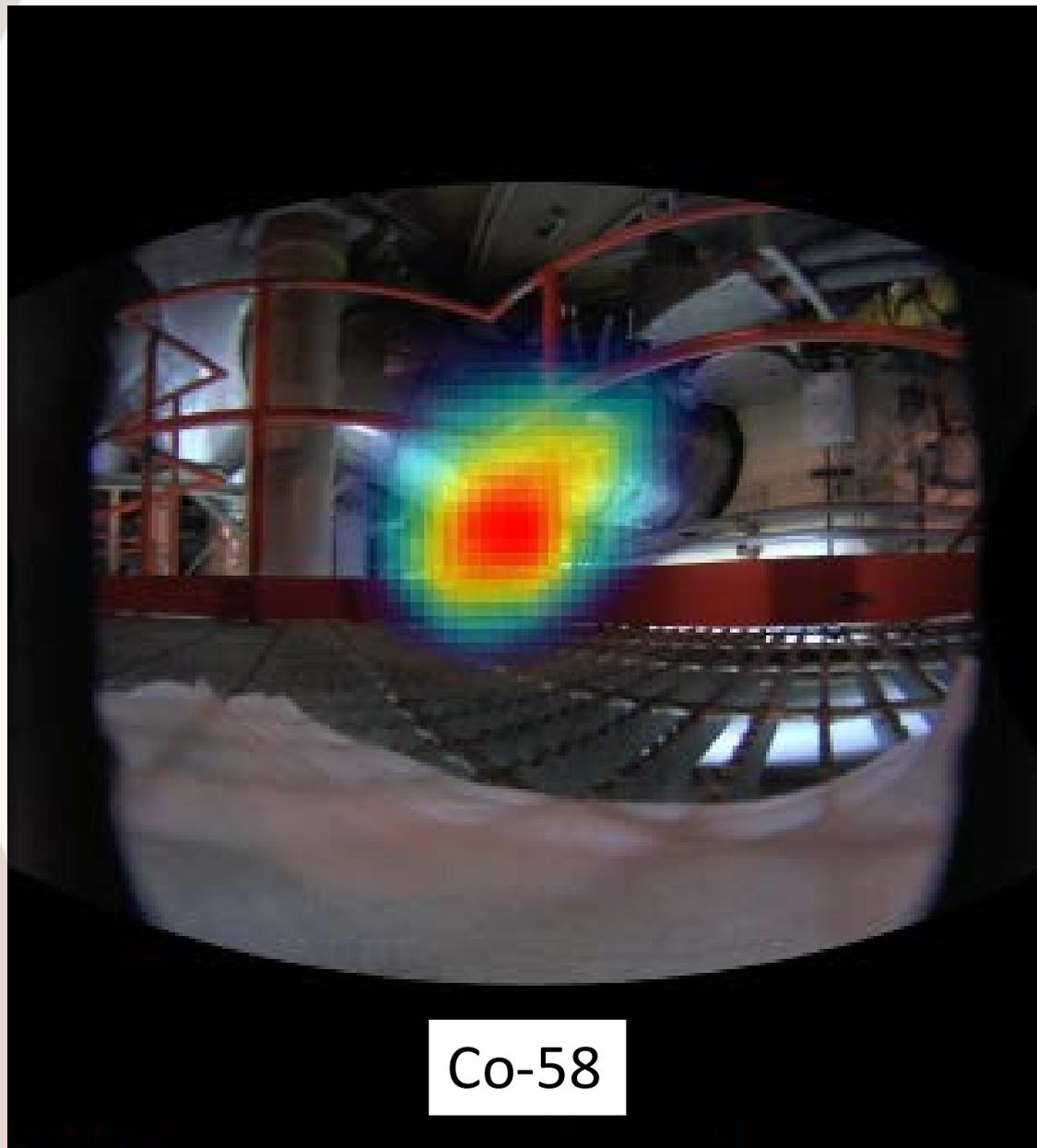
HED 4874 Imaged Cts; Co-58; letdwnend; 15:03

~10 mR/hr on platform, 28 mR/hr contact

# CRUD Location Isotopic – S/G Hot Leg Loop 2

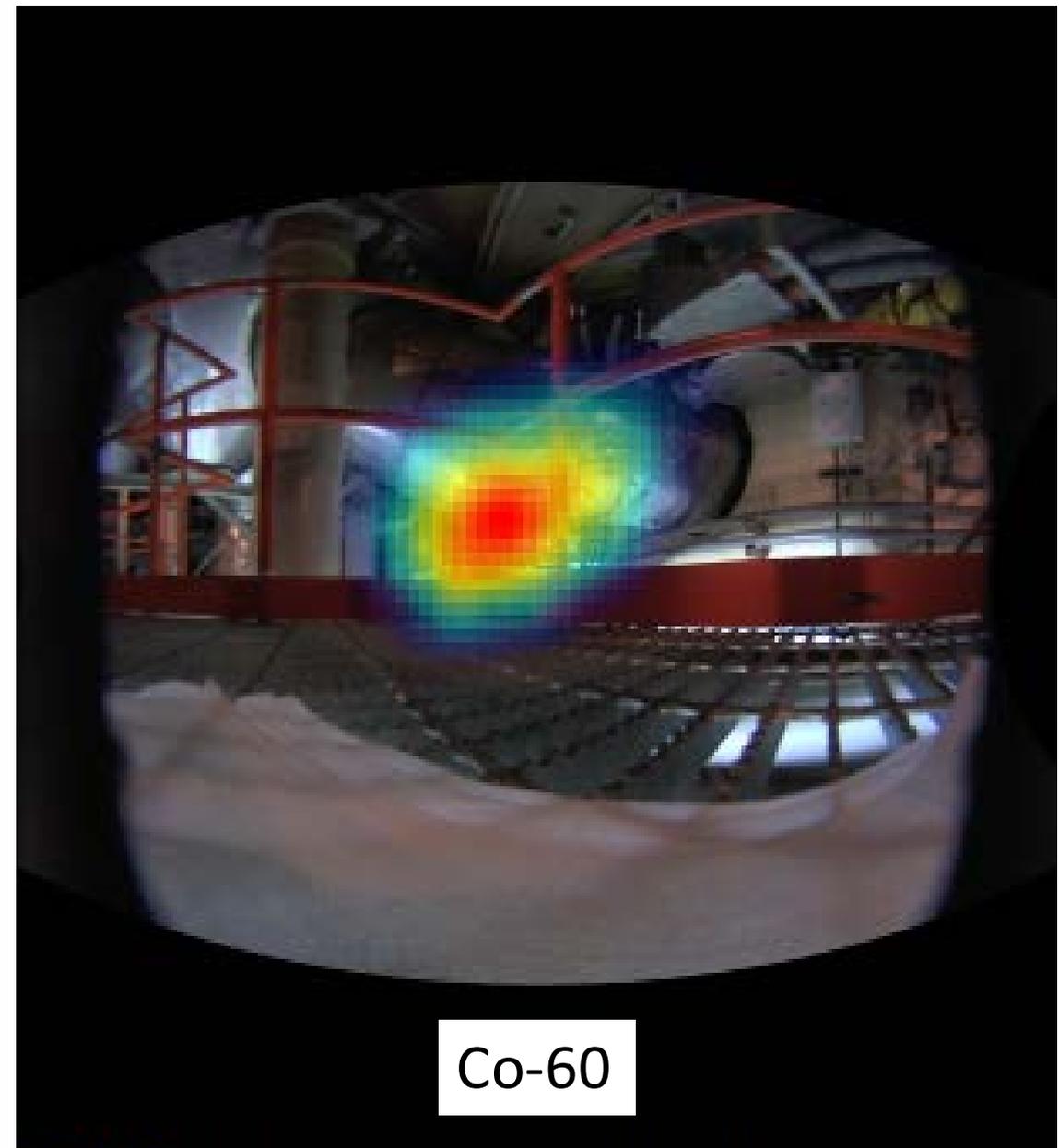


# CRUD Location Isotopic – S/G Hot Leg Loop 2



Co-58

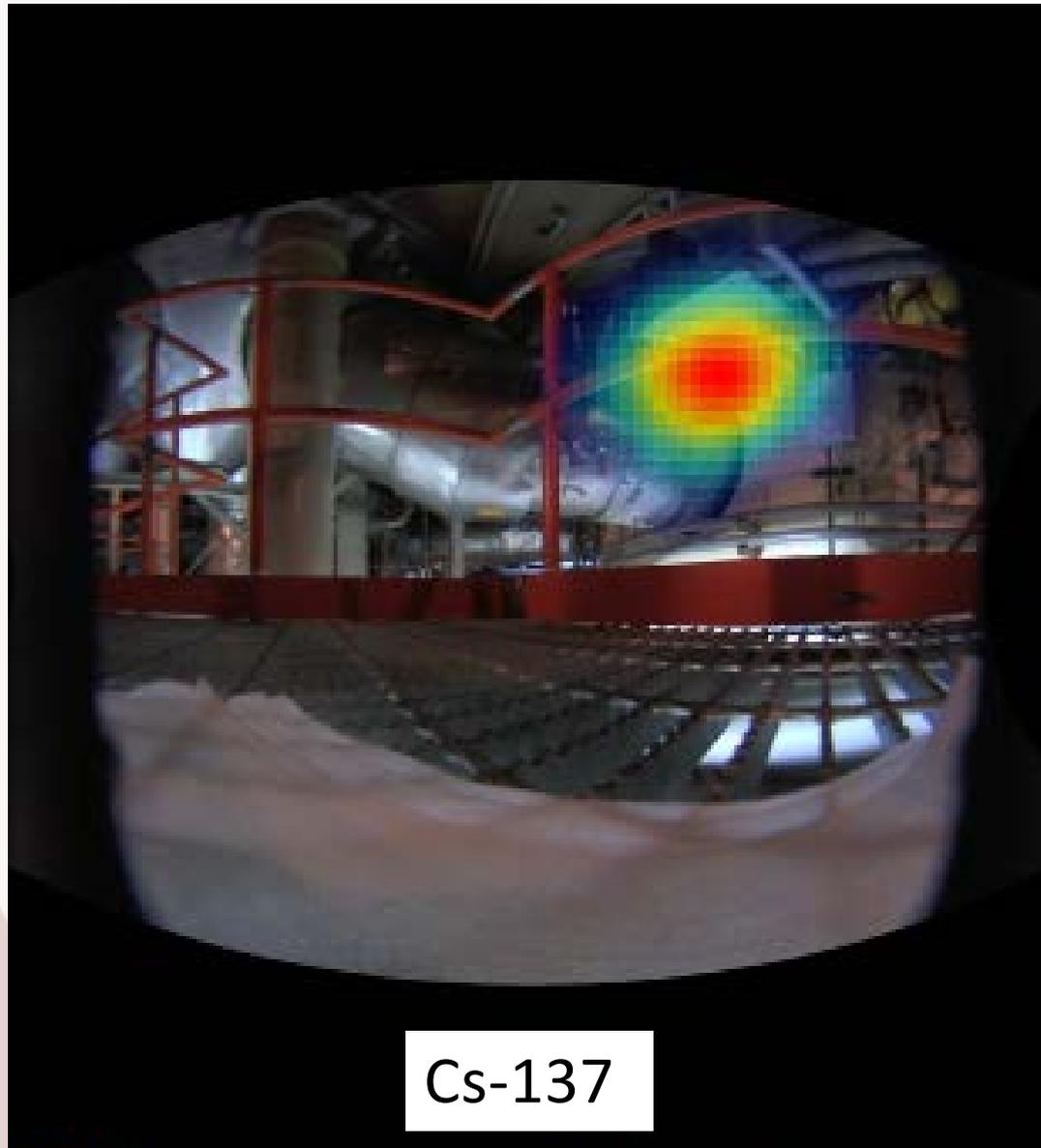
HED 18096 Imaged Cts; Co-58; h124; 24:28



Co-60

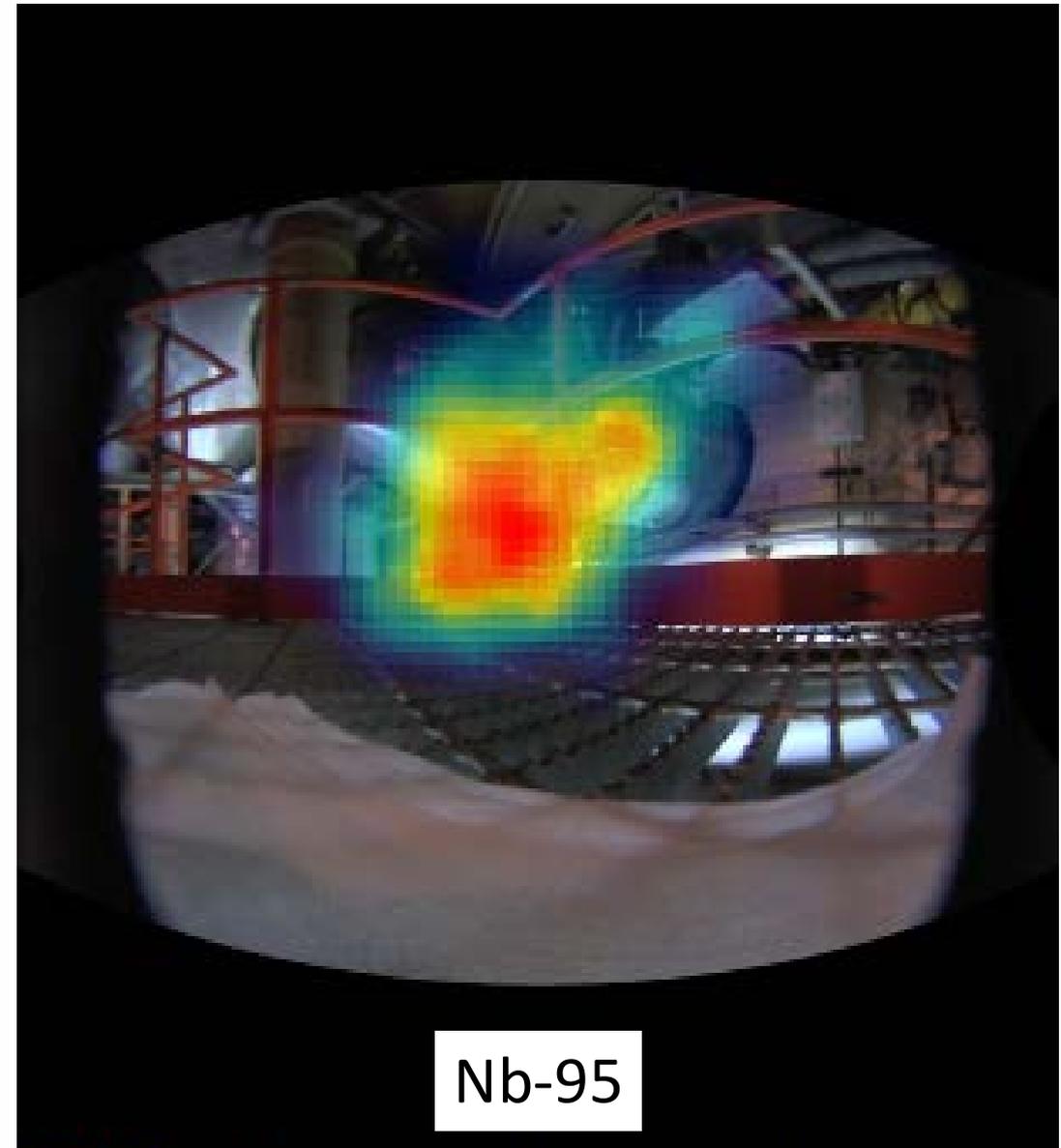
HED 18171 Imaged Cts; Co-60; h124; 24:28

# CRUD Location Isotopic – S/G Hot Leg Loop 2



Cs-137

HED 27870 Imaged Cts; Cs-137; h124; 24:28



Nb-95

HED 13207 Imaged Cts; Nb-95; h124; 24:28

# Senior NPP Managers Show High Interest in Project

Duke CNO and President observed  
Oconee results last month

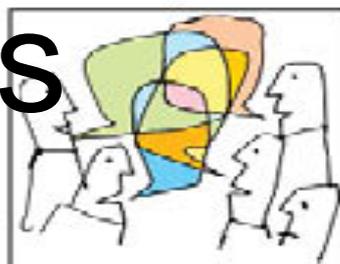
Cook Station ALARA Committee  
provides new ideas for component  
images

Dry Cask campaigns using tool to  
reduce worker dose

# Site News Shows CZT Uses to Workers

## Floor Painting

### *It's time for Nick's Network questions*



The next Nick's Network discussion panel with AEP President and CEO *Nick Akins* is scheduled for Wednesday, June 17. Our panel representative from Cook Plant is *Anna Doms*, and she's looking for your input -- questions, comments, concerns -- to take to this important employee forum.

If you have things you'd like Anna to share at this meeting, please e-mail your thoughts to her by no later than Friday, June 12. It's great to have a voice. Take advantage of it by lending yours to Anna for a day.

### *Congratulations to our May new hires and June service anniversaries*

If you haven't done so already please take a few moments to welcome the newest members of our Cook Team: *Arin Hejduk* – E-plan; *Charles McColley* – Maintenance;



*Dylan Rose* – Materials Management; *Glenn Richter* – IT Security; and *Andrew Gardner* – Training. Also, hired into the Site Protection group were: *David Adams*, *Patrick Fitch*, *Bruce Greer*, *David Krugh*, *Joseph Luthringer*, *Daniel Smith*, and *Bryan Waggoner*.

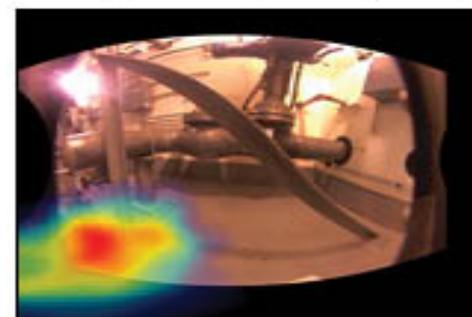
And don't forget to congratulate the following folks who are celebrating Service Anniversaries in June:

<i>Ron Sieber</i> - 40 years	<i>Dan Walter</i> - 25 years
<i>Brian Mutz</i> - 40 years	<i>Robbie Bates</i> - 20 years
<i>David Sudhoff</i> - 35 years	<i>Russ Stine</i> - 15 years
<i>Mark Michaelson</i> - 30 years	<i>Glen McCourtie</i> - 15 years
<i>Steve Watkins</i> - 25 years	<i>Dave Porter</i> - 15 years
<i>Martin Tallman</i> - 25 years	<i>Roberta Smith</i> - 10 years
<i>Jim Bachteal</i> - 25 years	<i>Karl Sell</i> - 5 years
<i>Tom Swihart</i> - 25 years	

**WEAR IT. SHARE IT.  
Peer Coaching Works!**



### *Look for temporary RP paint markings*



Beginning this week there are painting and resurfacing activities taking place in the Unit 1 and Unit 2 SI Pump and Charging Pump rooms in the Auxiliary Building. There has historically been fixed contamination painted over within those areas.

The photos to the left show what that fixed contamination looks like under imaging cameras, and also what kind of markings you might find out in the field that provide information about fixed contamination in the area.

To assist the work groups in mitigating the spread of contamination, RP has located fixed contamination in the floors and walls and marked it with small tri-foil symbols and other descriptors such as nuclide or counts on a frisker. The markings are temporary until they are painted over and are intended to notify painters and RP technicians of the fixed contamination in the area. Please contact *Derek Hultquist*, x2088 for more information.

### *It's "Movie Night" again at the Vickers*

The Employees Club is sponsoring another Movie Night at Vickers Theatre June 24, at 6:00 p.m. What movie? Glad you asked! It's *Woman in Gold*, starring Ryan Reynolds and Helen Mirren. It centers around a woman whose family art collection -- including a valuable painting titled "Woman in Gold" -- was stolen by the Nazis during the invasion of Austria.



The \$5 tickets for Employees Club members are limited to 4 per person and include hors d'oeuvres. Register now on the Employees Club website. Send payment by June 19 to *Maria Freed*, Mail Zone 12 or put payment into the drop box located outside of the HR offices across from the elevator.

# Oconee Component Results

We were recently able to image a 5 R/hr hot spot on a resin backwash line adjacent to some air handling unit piping slated for replacement. We were able to arrange a flush that got the spot down to 25 mR/hr.

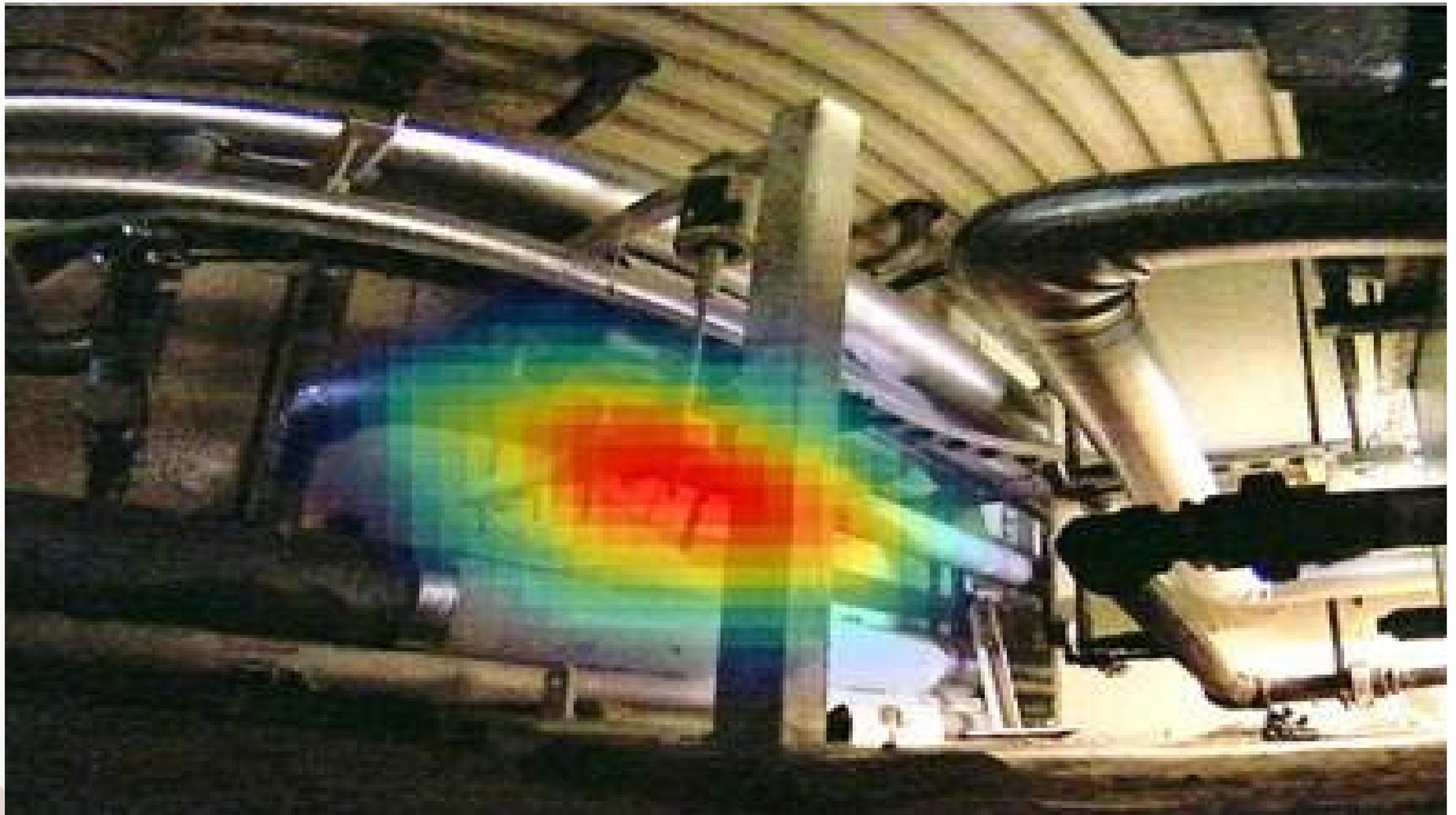


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# Oconee Hot Spot & Flush Imaging

## Photo of Resin Backwash Line



## Duke Feedback on Value of Data Analysis

“We had a recognition lunch last week attended by Duke’s President of Regulated Generation, the Chief Nuclear Officer, and several site VP’s that featured our use of the Polaris in making this spot go away. A good deal of positive interest was generated.”

**Bill Meldrum**

**Oconee Nuclear Station**

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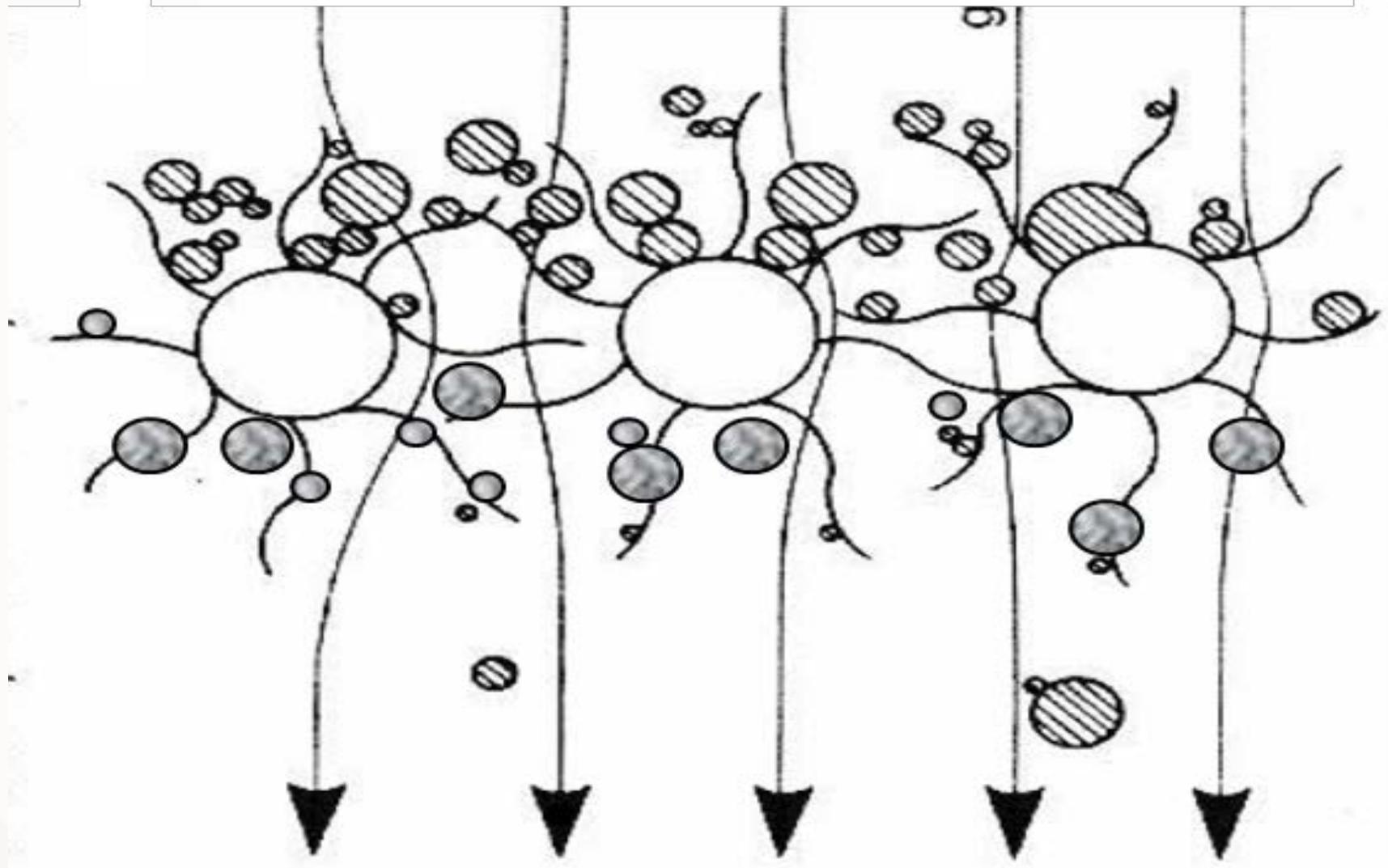


Questions?



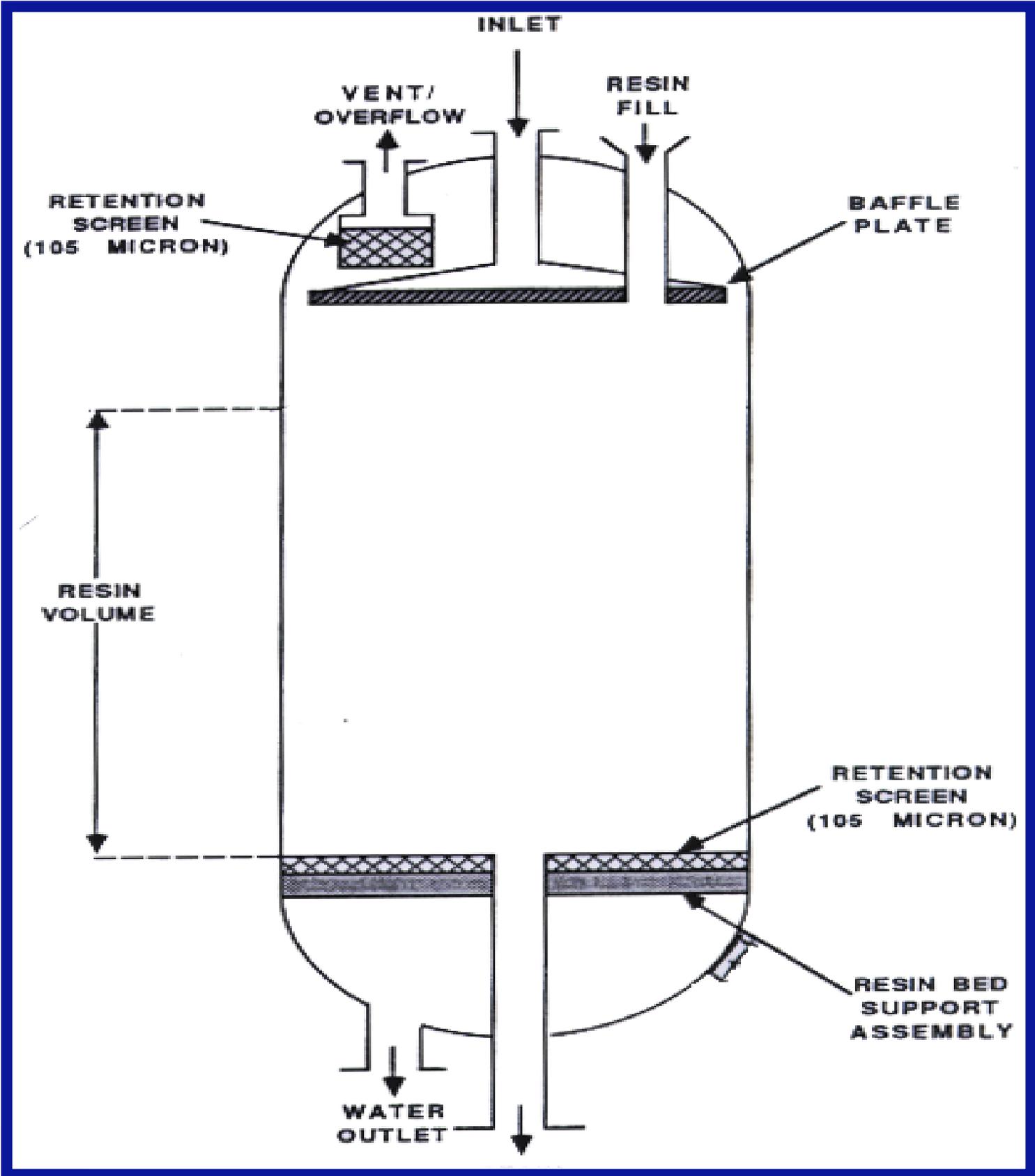
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We **power** life's possibilities<sup>SM</sup>





We **power** life's possibilities<sup>SM</sup>

