

Nuclear Physics Gamma-ray Imaging System for Real-Time Rare Isotope Harvesting, Monitoring and Radiochemical Separation – NP Imager

DE-SC0017245 5/21/2018 – 5/20/2021

Ethan Hull Ph.D PI, CEO and Technical Director

Matt Kiser, Ph.D. Director of Physics

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**A collaboration with: ORNL (Jared Johnson, Jon Garrison, Riley Hunley, Klaus Ziock)
MURR (Heather Hennkens and Alan Ketring)
NSCL (Greg Severin)**

- **PHDS Co. Introduction**
- **NP Imager Concept**
- **Continued NP Imager Prototype Development**
- ***Sales of NP Imager Products!!***

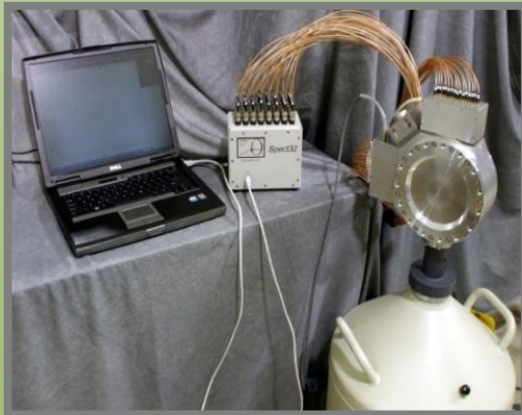
PHDS Co. History



- Est. Fall 2004 – Nuclear and Solid-State Physics Origin
 - History: Custom Nuclear-Physics Detectors (Lab)
 - Recently: Modular HPGe Systems (Lab and Field)
- Complete Germanium Manufacturing + R&D at PHDS Co.
 - Concept Design
 - Crystal Growth
 - Detector Fabrication
 - System Integration
 - Software application
 - Sales & Service

Enabling Capabilities
From rocks to software

Science Experiment



NPX (150 lbs.)
2008 Laboratory



Versatile Global Commercial Product



Versatile Global Commercial Product



Specialty Operations Product



GeGI (15 lbs.)
2016 Hand Portable Imager + Spectrometer
10x less size and weight



Fulcrum (7-9 lbs.)
2018 Hand Portable Spectrometer



LoPro (8-11 lbs.)
2020 Specialty Spectrometer

From **Frontiers** of Nuclear Physics
to **Frontlines** of Nuclear Security

PHDS Co. now manufactures and sells 4 HPGe products



GeGI

Germanium Gamma-Ray Imaging HPGe Spectrometer



HPGe Isotope Identification
Source Location Imaging
Source Distribution Imaging
Quantitative Imaging
SNM Capable
ANSI N42.42 Reachback



Fulcrum

Hand Portable HPGe Gamma Ray Spectrometer



HPGe Isotope Identification
Compact Form Factor
SNM Identification
Fully Integrated turnkey HPGe



LoPro

Low Profile Hand Portable HPGe Gamma Ray Spectrometer



Designed by operators
for operators

HPGe Isotope Identification
Compact Form Factor
SNM Identification
GADRAS Capable
Fully Integrated turnkey HPGe

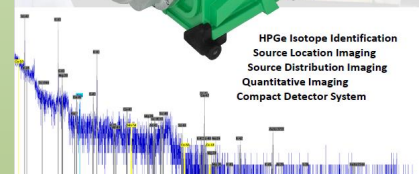
PHDS Co. 3011 Amherst Road, Knoxville, TN 37921 (865) 202 6253 www.phdco.com sales@phdco.com

NP Imager

Nuclear Physics - Radiochemistry Imaging Spectrometer



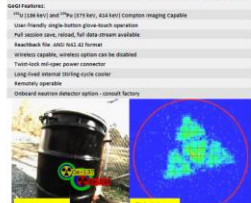
HPGe Isotope Identification
Source Location Imaging
Source Distribution Imaging
Quantitative Imaging
Compact Detector System



GeGI



Weight (detector)	33 lbs. (14.9 kg)
Dimensions (Detector)	13.5" x 9.4" x 5.5" (34 cm x 24 cm x 14 cm)
Battery life	3 hrs (normal) (not supported), 4 hrs (optional)
Power supply	100-240 VAC, 50-60 Hz
COOP maintenance	None
User resolution	FWHM @ 2.2 keV (0.3 keV @ 462 keV)
Scintillator/Compton imaging field of view	48 (180°)
Optical camera field of view	24 (180°)
Field-of-view imaging field of view	90°
Imaging Range	(100cm - 50' meters)
Scintillator (HPGe) 2" x 2" x 3" (5.1 cm x 5.1 cm x 7.6 cm)	
40 kV (specification)	3.7 keV @ 1.3 MeV (362 keV, 80)
Location (imaging) time	30 sec @ 1" x 1" (25 cm x 25 cm) (1000 counts)
Exposure rate capacity	200 kcps (10% dead time @ 15 mSv/hr ⁶⁰ Co)
Energy range Compton imaging	30 keV - 3 MeV (12 MeV option)
Energy range Particle Imaging	30 keV - 402 keV
Compton Library	400 (optional) (auto detect or user selected)
Isotope identification	57 frequently encountered isotopes
Isotope Catalogue	SNM, NORM, IAD, MED
HPGe detector crystal dimensions	90-mm diameter, 12 mm thick
Active detector volume / area	67 cm ³ / 63 cm ²
Cool-down time	2 hours
Detector startup time	2 minutes
Tablet	rugged / daylight-readable glow touch screen



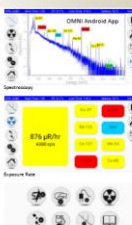
2500 300 W-hr External battery
20210129
Specifications subject to change

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Fulcrum



Fulcrum Specifications:	
Weight:	7.3 lbs. + 1.1 lbs. (internal battery)
Dimensions:	8" x 4" x 6" (20 cm x 13 cm x 15 cm)
Battery life (internal not supported):	15 min
Battery life (external):	5-6 hrs
Power supply:	100-240 VAC, 50/60 Hz
User maintenance:	None
Energy resolution:	FWHM @ 2.2 keV @ 1302 keV
Resolution 133 keV efficiency vs. 3" x 3" NaI:	10-15%
Maximum 133 keV dead time in 1.5 mSv/hr ⁶⁰ Co:	20 kcps (SNM dead time in 1.5 mSv/hr ⁶⁰ Co)
Energy range spectroscopy (133 keV):	40 keV - 3 MeV (12 MeV option)
Isotope identification:	50 user-selectable isotopes
Isotope Catalogue:	SNM, NORM, IAD, MED
HPGe detector crystal dimensions:	60-mm diameter, 12 mm thick
Cool-down time:	2 hours
Detector startup time:	2 minutes
User interface device:	Android Mobile Phone, OMAN App



Fulcrum Features:
Cool monitoring to ^{113m}In and ¹⁹⁸Au
Reachback for raw and cooled ANSI N42.42 format
Windows capable, windows option can be disabled
Touch-back anti-grip power connector
Long-life internal starting cycle center
Fast recovery operation



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LoPro



LoPro Specifications:	
Weight:	8.3 lbs. (3.6 kg) + battery
Dimensions:	8" x 4" x 7" (20 cm x 20 cm x 18 cm)
Battery life:	4-15 hrs (depends on battery configuration)
Power supply:	100-240 VAC, 50-60 Hz
User maintenance:	None
Energy resolution:	FWHM @ 2.2 keV @ 1302 keV
Resolution 133 keV efficiency vs. 3" x 3" NaI:	10-15%
Maximum 133 keV dead time in 1.5 mSv/hr ⁶⁰ Co:	20 kcps (SNM dead time in 1.5 mSv/hr ⁶⁰ Co)
Energy range spectroscopy (133 keV):	40 keV - 3 MeV (12 MeV option)
Isotope Library:	GADRAS
Isotope identification:	GADRAS
Isotope Catalogue:	SNM, NORM, IAD, MED
HPGe detector crystal dimensions:	60-mm diameter, 12 mm thick
Cool-down time:	2.5 hours
Detector startup time:	2 minutes
User interface device:	Android Mobile Phone, OMAN or TAB

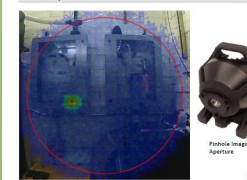


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NP Imager



NP Imager Specifications:	
Weight (Detector)	33 lbs. (14.9 kg)
Dimensions (Detector)	13.5" x 9.4" x 5.5" (34 cm x 24 cm x 14 cm)
Battery life	3 hrs (normal) (not supported), 4 hrs (optional)
Power supply:	100-240 VAC, 50-60 Hz
User maintenance:	None
User resolution	FWHM @ 2.2 keV @ 462 keV
Scintillator/Compton imaging field of view	48 (180°)
Optical camera field of view	24 (180°)
Field-of-view imaging field of view	90 to 90° (depends on configuration)
Imaging Range	(100cm - 50' meters)
Scintillator (HPGe) 2" x 2" x 3" (5.1 cm x 5.1 cm x 7.6 cm)	
40 kV (specification)	3.7 keV @ 1.3 MeV (362 keV, 80)
Location (imaging) time	30 sec @ 1" x 1" (25 cm x 25 cm) (1000 counts)
Exposure rate capacity	200 kcps (10% dead time @ 15 mSv/hr ⁶⁰ Co)
Energy range Compton imaging	30 keV - 3 MeV (12 MeV option)
Energy range Particle Imaging	30 keV - 402 keV
Compton Library	400 (optional) (auto detect or user selected)
Isotope identification	57 frequently encountered isotopes
Isotope Catalogue	SNM, NORM, IAD, MED
HPGe detector crystal dimensions	90-mm diameter, 12 mm thick
Active detector volume / area	67 cm ³ / 63 cm ²
Cool-down time	4 hours
Detector startup time:	2 minutes



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GeGI *Ge*
Gamma
Imager

GeGI User Manual

Version: 2019-07-03



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Fulcrum User Manual

Version: 2021-02-18



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LoPro User Manual

Version: 2020-10-29



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NP Imager
Nuclear
Physics
Imager

NP Imager User Manual

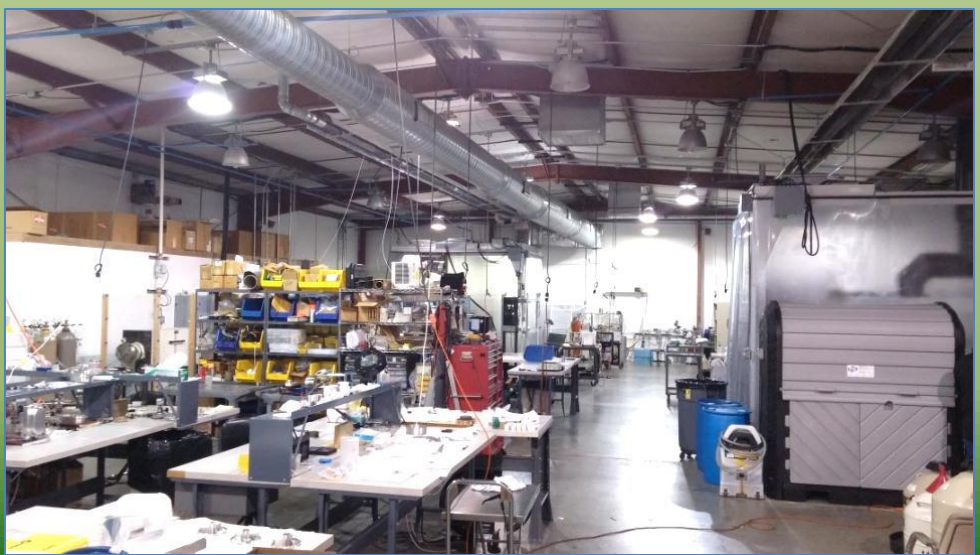
Version: 2020-07-29



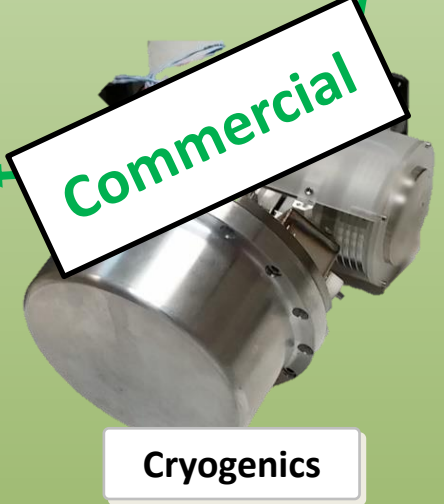
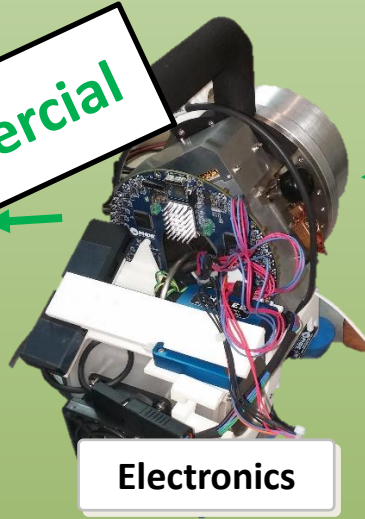
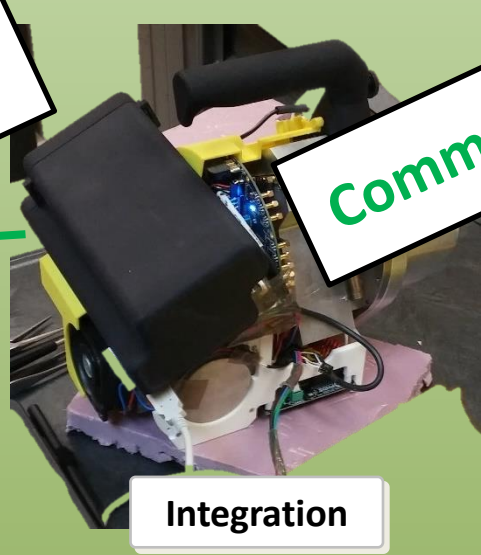
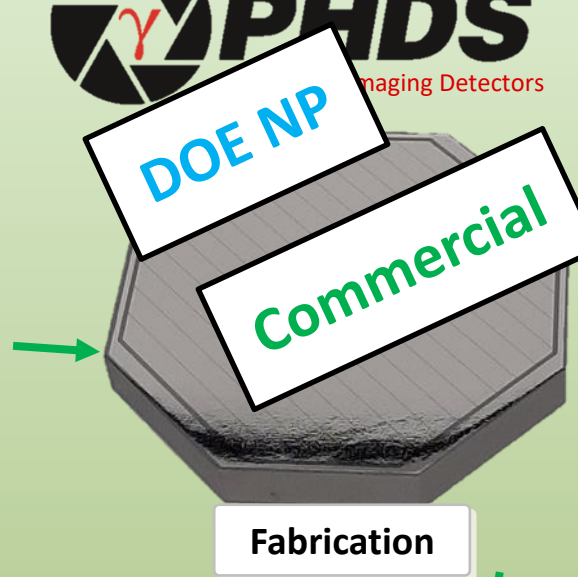
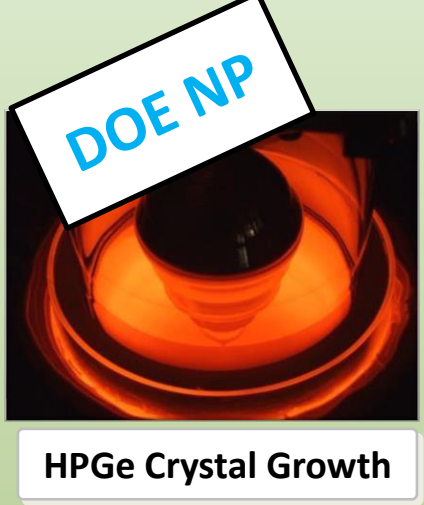
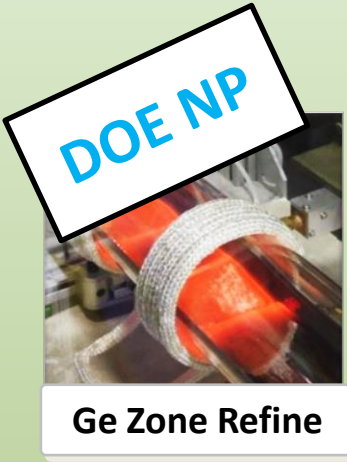
PHDS Co. now supports 4 products



**10,000 ft² Manufacturing
and R&D Facility in
Knoxville, TN**



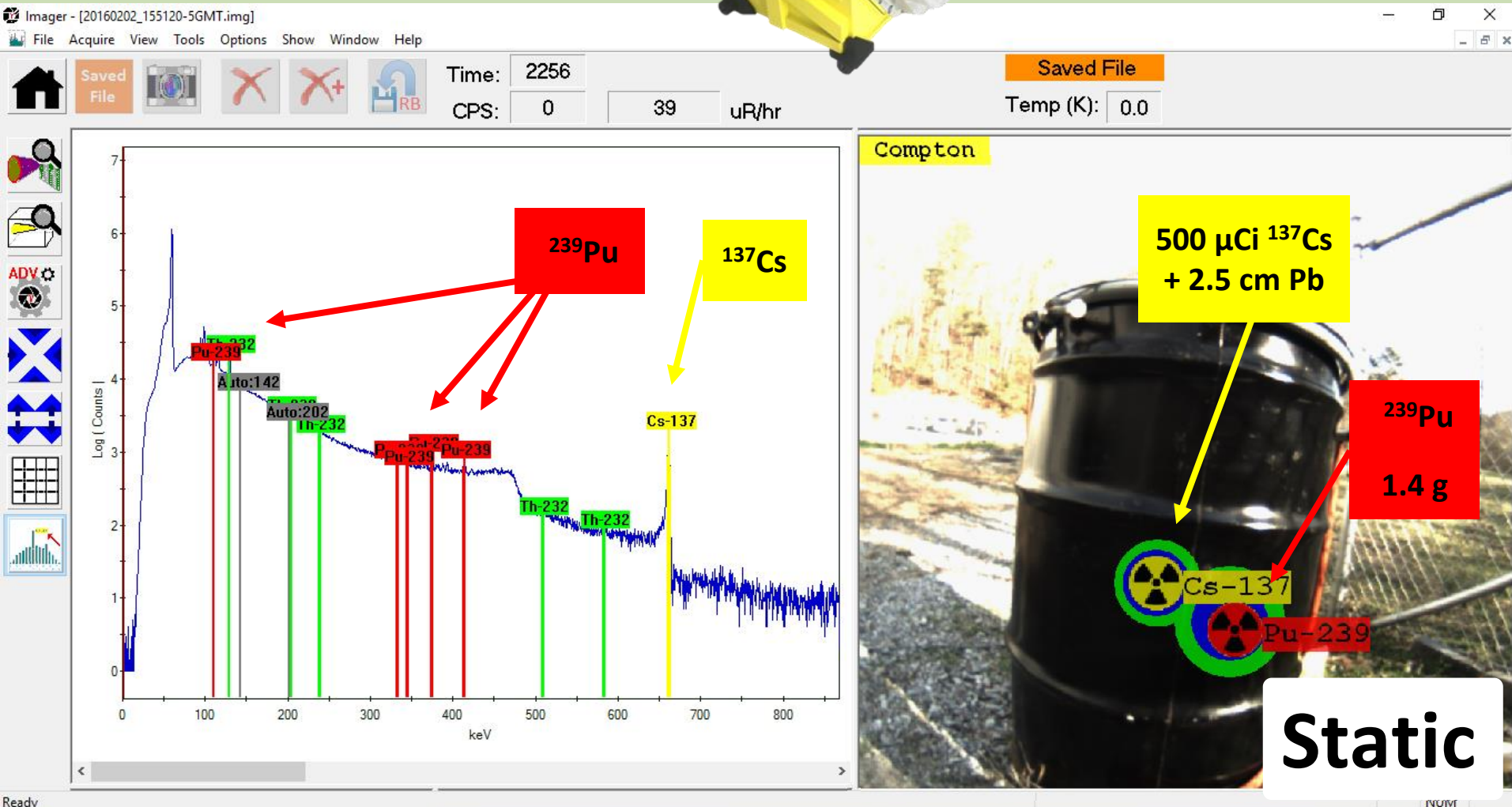
Vertical manufacturing at PHDS Co.



From rocks to software

Motivation CBRNE Team Training

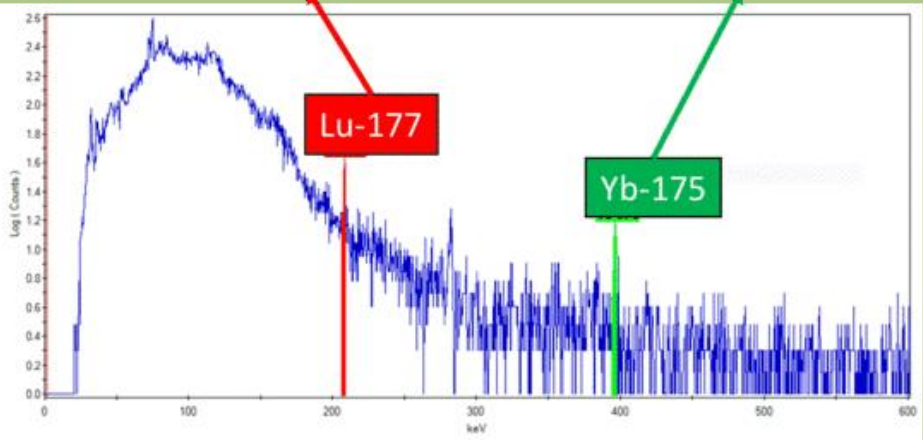
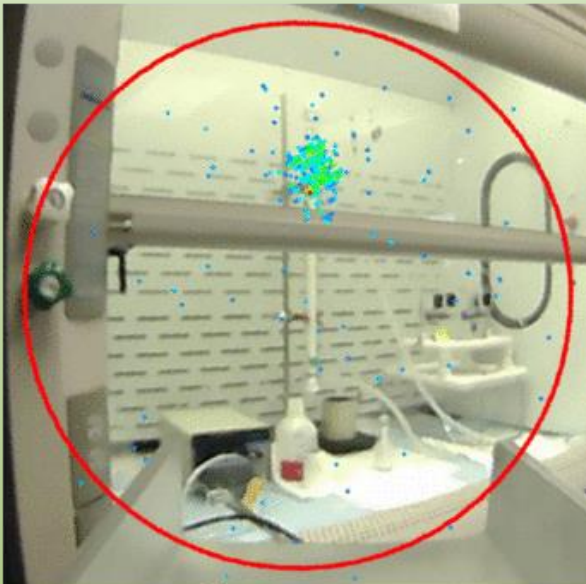
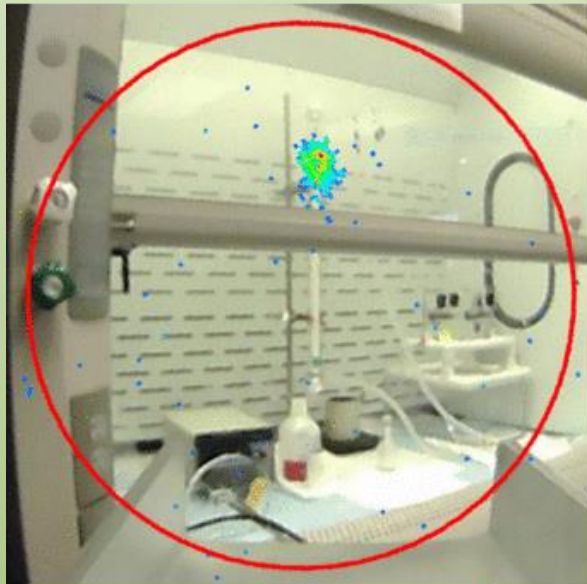
^{239}Pu ID and Location



Radiochemistry is Dynamic → Things necessarily move
NP Imager combines *Imaging, Spectroscopy and Time*.

$^{177}\text{Lu}/^{175}\text{Yb}$ Column Separation at MURR

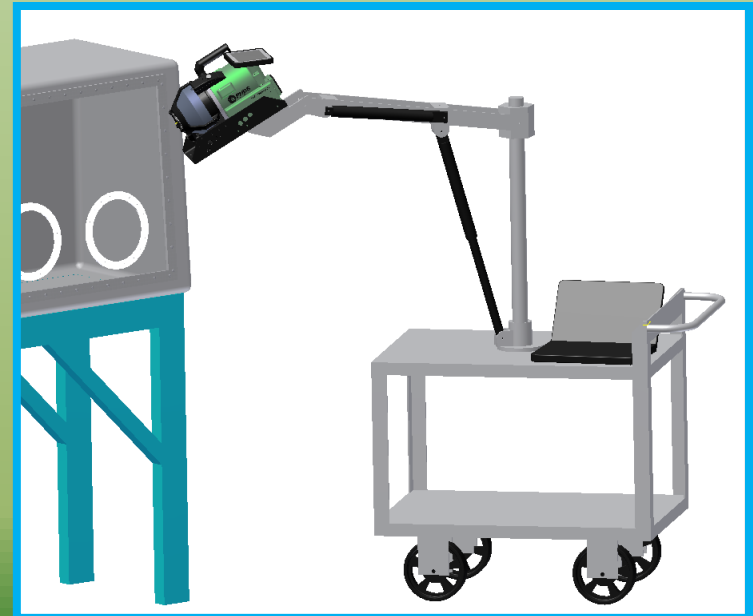
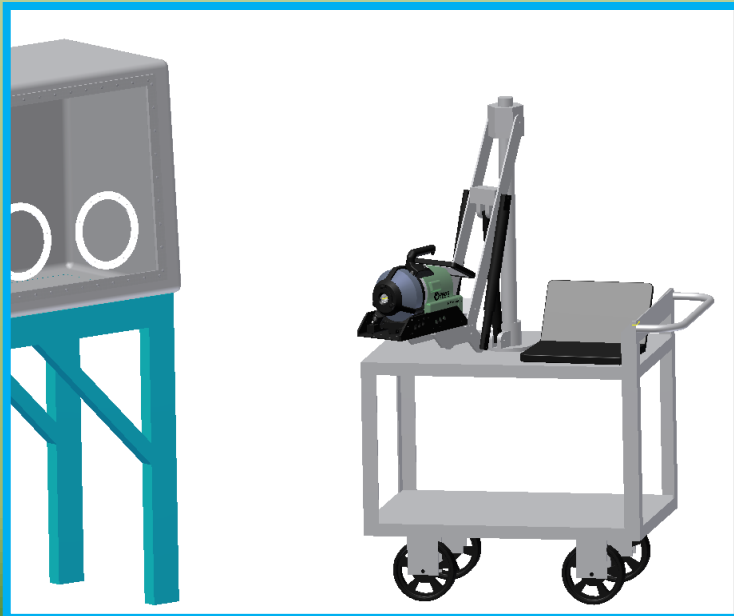
t = 0 - 10 minutes



NP Imager Technical Development Phase-II Prototypes



Concept Design



Summary of the NP Imager Phase II SBIR



Phase II prototypes were delivered to:

1. MURR – Heather Henkens
2. ORNL – Jared Johnson and Klauz Ziock
3. NSCL – Greg Severin

Multiple collaborative efforts took place at all 3 DOE sites.

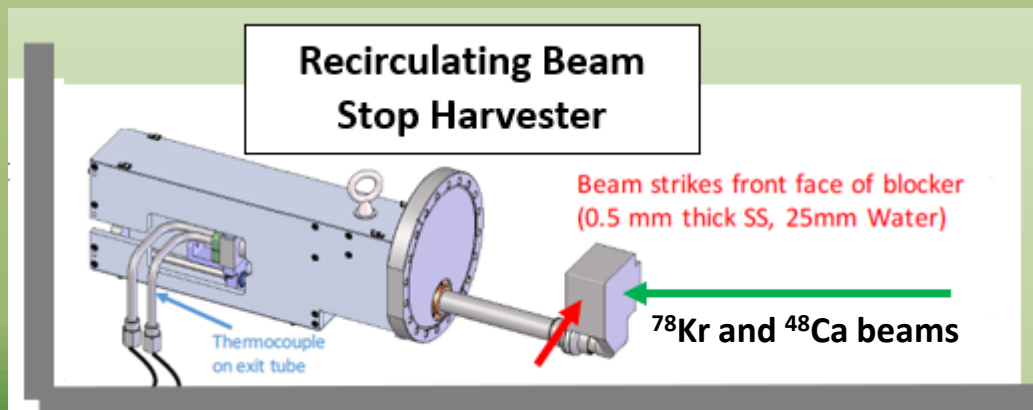
Throughout the program development with engineering units at PHDS Co.
(see recent coded aperture example later – slides)

The major result: The Phase II program has been able to build the products up to reasonable commercial readiness and sell some products for DOE applications.

Summary of the NP Imager Phase II SBIR



1. MURR – Heather Henkens and Alan Ketring
Wide variety of MURR-isotope separation images (prev slide)
Feedback regarding the need for shielding
1. ORNL – Jared Johnson and Klauz Ziock
Wide variety of ORNL isotope separation images
Value of the fusion of Compton imaging to recognize “other sources” (slides)
2. NSCL – Greg Severin
Novel measurements of production and harvesting (^{78}Kr and ^{48}Ca beams)
Recent mass transport calculation/NP Imager AGREEMENT (Greg’s slides)



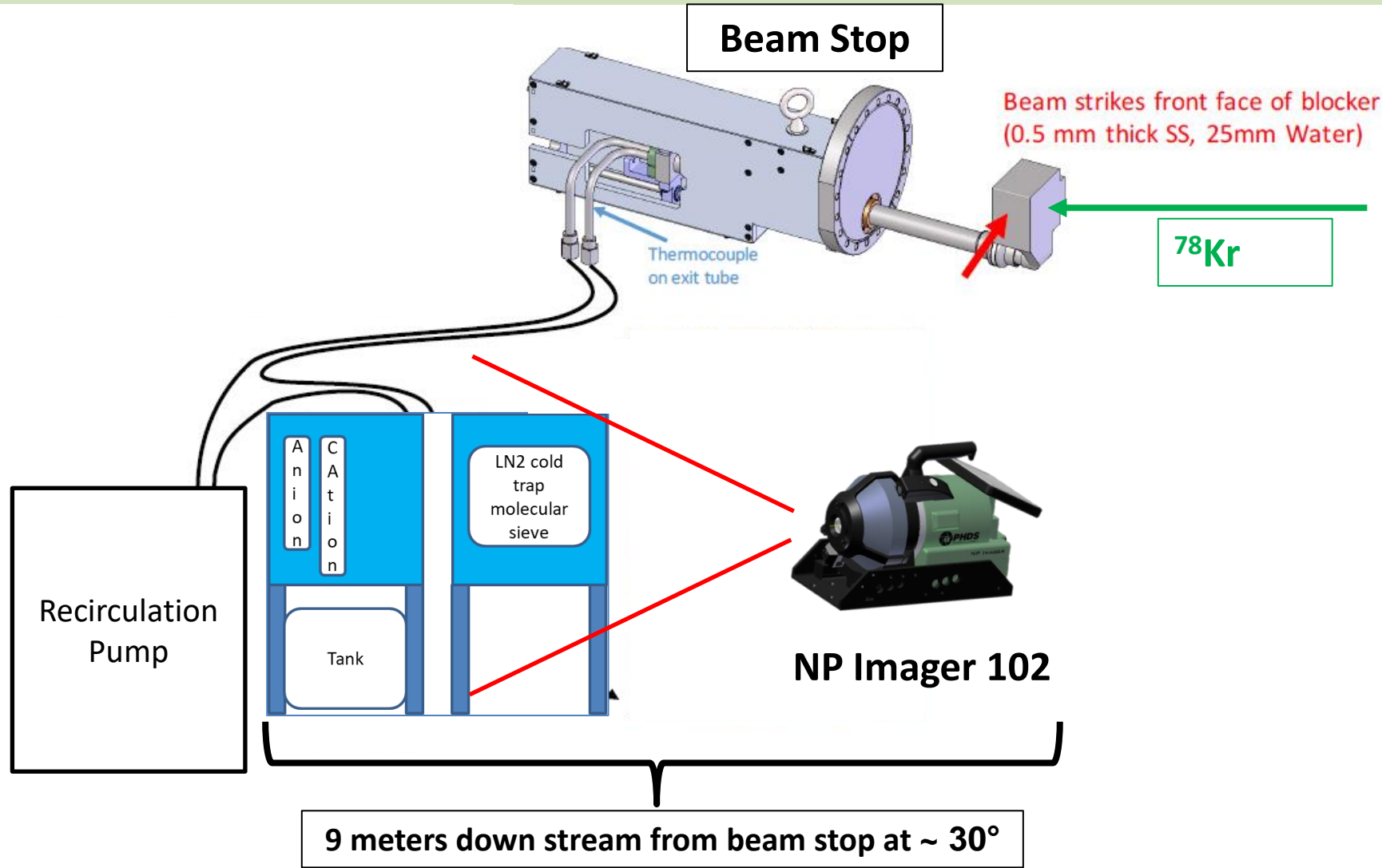
Recall how NP Imager is used

Beam Stop

Beam strikes front face of blocker
(0.5 mm thick SS, 25mm Water)

^{78}Kr

Thermocouple
on exit tube



Imager - [20190510_230705-4GMT-Kry77_129keV.img]

File Acquire View Tools Options Show Window Help

Time: 1003 Live: 0.964

Saved File

PC:0 SC:0 PU: 0
TC:0 RJ:0 F2: 0.00

CPS: 0 16 uR/hr

Temp(K): N/A

Threshold 0 - 100 % Distance(m) 1.700 +/-

Events 48080 Search Pixels Edit ROIs Switch to Polygon ROIs

Show All Energy Windows

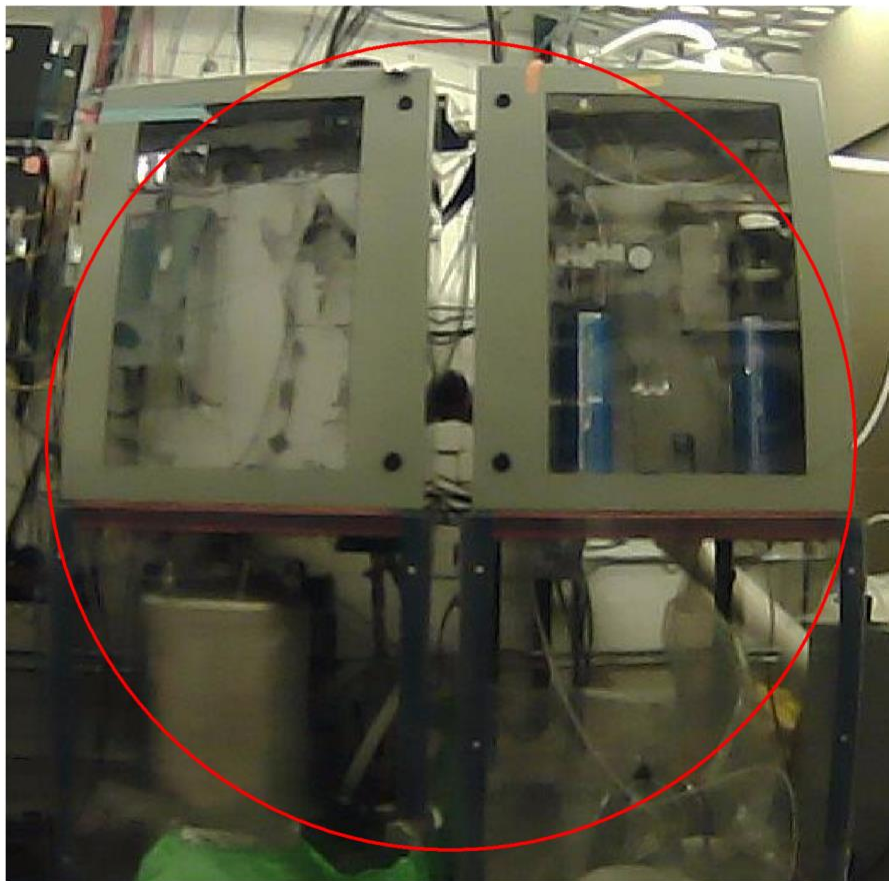
Isotope	Energy (keV)
<input type="checkbox"/> Th-232	57.8
<input type="checkbox"/> Th-232	72.8
<input type="checkbox"/> Auto:87	87.3
<input type="checkbox"/> Ann	511.0
<input checked="" type="checkbox"/> U-232	129.1
<input checked="" type="checkbox"/> U-232	35.4
<input type="checkbox"/> Auto:138	137.8
<input type="checkbox"/> NEU:847	845.9
<input type="checkbox"/> Auto:143	143.3
<input type="checkbox"/> Auto:286	286.0
<input type="checkbox"/> Auto:375	375.1
<input type="checkbox"/> Auto:417	417.1
<input type="checkbox"/> Auto:635	635.1
<input checked="" type="checkbox"/> Th-232	911.2
<input type="checkbox"/> Auto:820	819.7
<input type="checkbox"/> Auto:900	900.4
<input checked="" type="checkbox"/> Th-232	1501.6
<input type="checkbox"/> Auto:1041	1041.1
<input type="checkbox"/> Auto:1098	1097.7
<input type="checkbox"/> Auto:1294	1294.4

Intervening Materials

Material	Density(g... Thick(cm)

ROI Materials

ROI	Material	Density(g... Thick



Units Curies (Ci)

ROI Isotope Energy Count Activity (Ci) Radioactive Mass (g) Activity Conc. (Ci/g)

There are no items to show in this view.

Imager - [20190510_230705-4GMT-Kry77_129keV.img]

File Acquire View Tools Options Show Window Help

Time: 1003 Live: 0.964

Saved File

PC:0 SC:0 PU: 0
TC:0 RJ:0 F2: 0.00

CPS: 0 16 uR/hr

Temp(K): N/A

Events

48080

Search Pixels

Edit ROIs

Switch to Polygon ROIs

Threshold 0 - 100 % Distance(m) 1.700 +/- 0.000

Show All Energy Windows

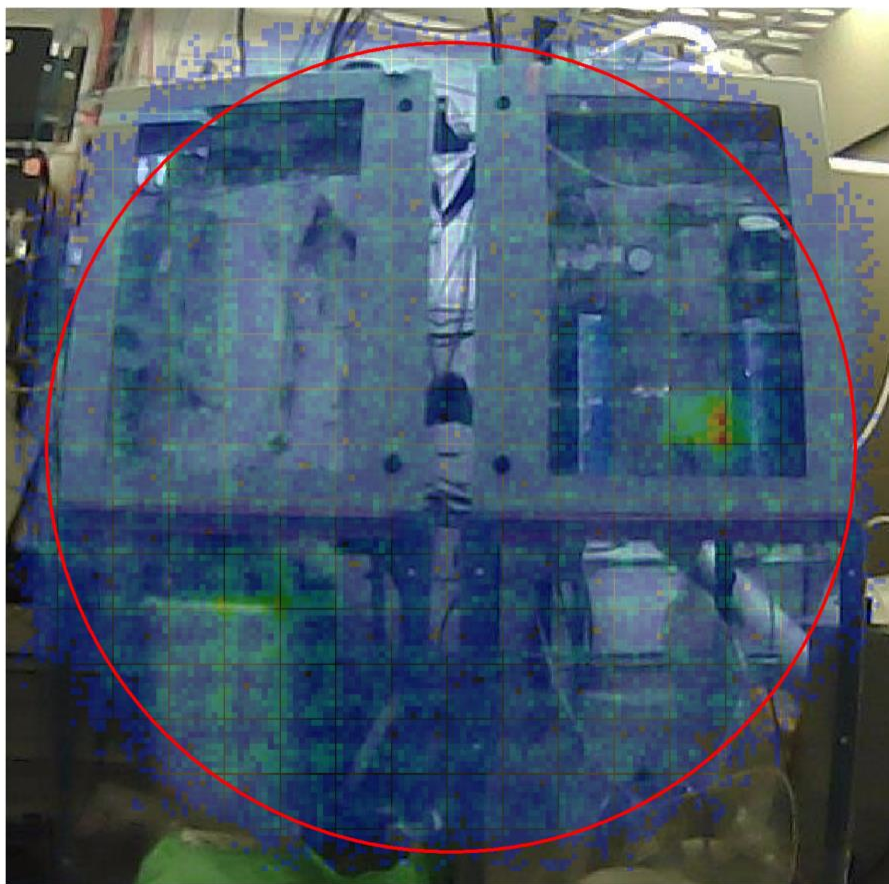
Isotope	Energy (keV)
<input type="checkbox"/> Th-232	57.8
<input type="checkbox"/> Th-232	72.8
<input type="checkbox"/> Auto:87	87.3
<input type="checkbox"/> Ann	511.0
<input checked="" type="checkbox"/> U-232	129.1
<input type="checkbox"/> U-232	35.4
<input type="checkbox"/> Auto:138	137.8
<input type="checkbox"/> NEU:847	845.9
<input type="checkbox"/> Auto:143	143.3
<input type="checkbox"/> Auto:286	286.0
<input type="checkbox"/> Auto:375	375.1
<input type="checkbox"/> Auto:417	417.1
<input type="checkbox"/> Auto:635	635.1
<input type="checkbox"/> Th-232	911.2
<input type="checkbox"/> Auto:820	819.7
<input type="checkbox"/> Auto:900	900.4
<input type="checkbox"/> Th-232	1501.6
<input type="checkbox"/> Auto:1041	1041.1
<input type="checkbox"/> Auto:1098	1097.7
<input type="checkbox"/> Auto:1294	1294.4

Intervening Materials

Material	Density(g... Thick(cm)
There are no items to show in this view.	

ROI Materials

ROI	Material	Density(g... Thick
There are no items to show in this view.		



Units Curies (Ci)

ROI Isotope Energy Count Activity (Ci) Radioactive Mass (g) Activity Conc. (Ci/g)

There are no items to show in this view.

Imager - [20190510_230705-4GMT-Kry77_129keV.img] PC:0 SC:0 PU:0
TC:0 RJ:0 F2: 0.00

File Acquire View Tools Options Show Window Help

Time: 1003 Live: 0.964 Saved File

CPS: 0 16 uR/hr ⚡ Temp(K): N/A

Threshold: 0 Distance(m): 1.700 +/- 0.000

Events: 48747 Search Pixels Edit ROIs Switch to Polygon ROIs

Show All Energy Windows

Isotope	Energy (keV)
<input type="checkbox"/> Th-232	57.6
<input type="checkbox"/> Th-232	72.8
<input type="checkbox"/> Auto:87	87.3
<input type="checkbox"/> Ann.	511.0
<input checked="" type="checkbox"/> Kr-77	129.1
<input checked="" type="checkbox"/> U-232	85.4
<input type="checkbox"/> Auto:138	137.8
<input type="checkbox"/> NEU:847	845.9
<input type="checkbox"/> Auto:143	143.3
<input type="checkbox"/> Auto:286	286.0
<input type="checkbox"/> Auto:375	375.1
<input type="checkbox"/> Auto:417	417.1
<input type="checkbox"/> Auto:635	635.1
<input checked="" type="checkbox"/> Th-232	911.2
<input type="checkbox"/> Auto:820	819.7
<input type="checkbox"/> Auto:900	900.4
<input checked="" type="checkbox"/> Th-232	1501.6
<input type="checkbox"/> Auto:1041	1041.1
<input type="checkbox"/> Auto:1098	1097.7
<input type="checkbox"/> Auto:1294	1294.4
<input type="checkbox"/> Auto:2019	2018.8

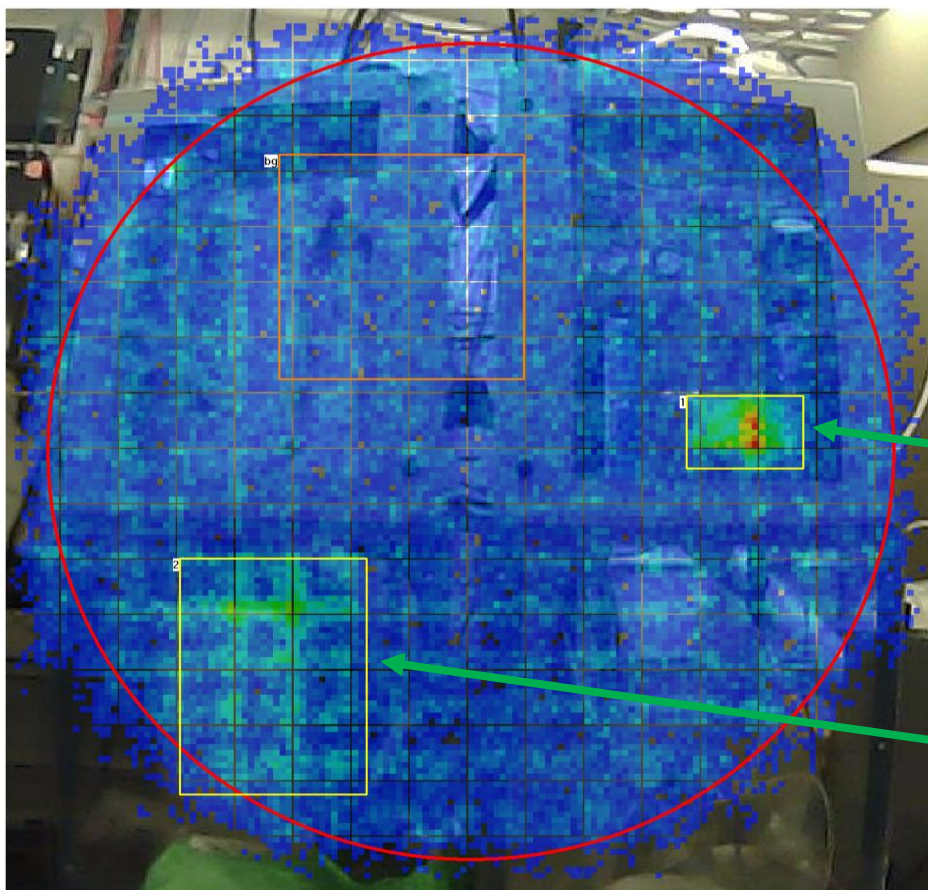
LOG

Intervening Materials

Material	Density(g...)	Thick(cm)

ROI Materials

ROI	Material	Density(g...)	Thick
1		0.0000	20.72
2		0.0000	45.95



ROI	Isotope	Energy	Count	Activity (Ci)	Units	Curies (Ci)	Radioactive Mass (g)	Activity Conc. (Ci/g)
1	Kr-77	129.1	1908	3.92e-03 +/- 9.24e-05		3.9	1.83e-04 +/- 4.32e-06	N/A
2	Kr-77	129.1	4718	8.74e-03 +/- 1.67e-04		8.7	4.09e-04 +/- 7.82e-06	N/A
BG	Kr-77	129.1	3088					

129 keV 77Kr 3.9 mCi

129 keV 77Kr 8.7 mCi

Uranium Imaging at ORNL REDC



Imager - [20210129_150722-5GMT-Th227m3 - Copy.img]

File Acquire View Tools Options Show Window Help

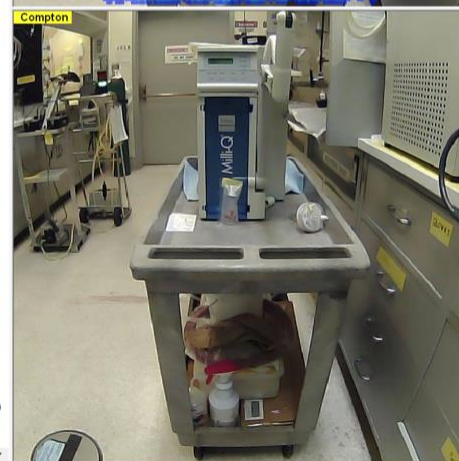
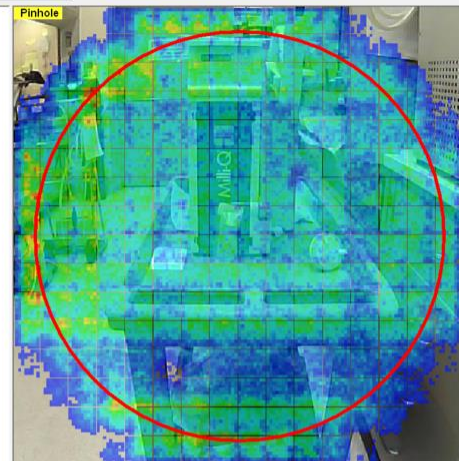
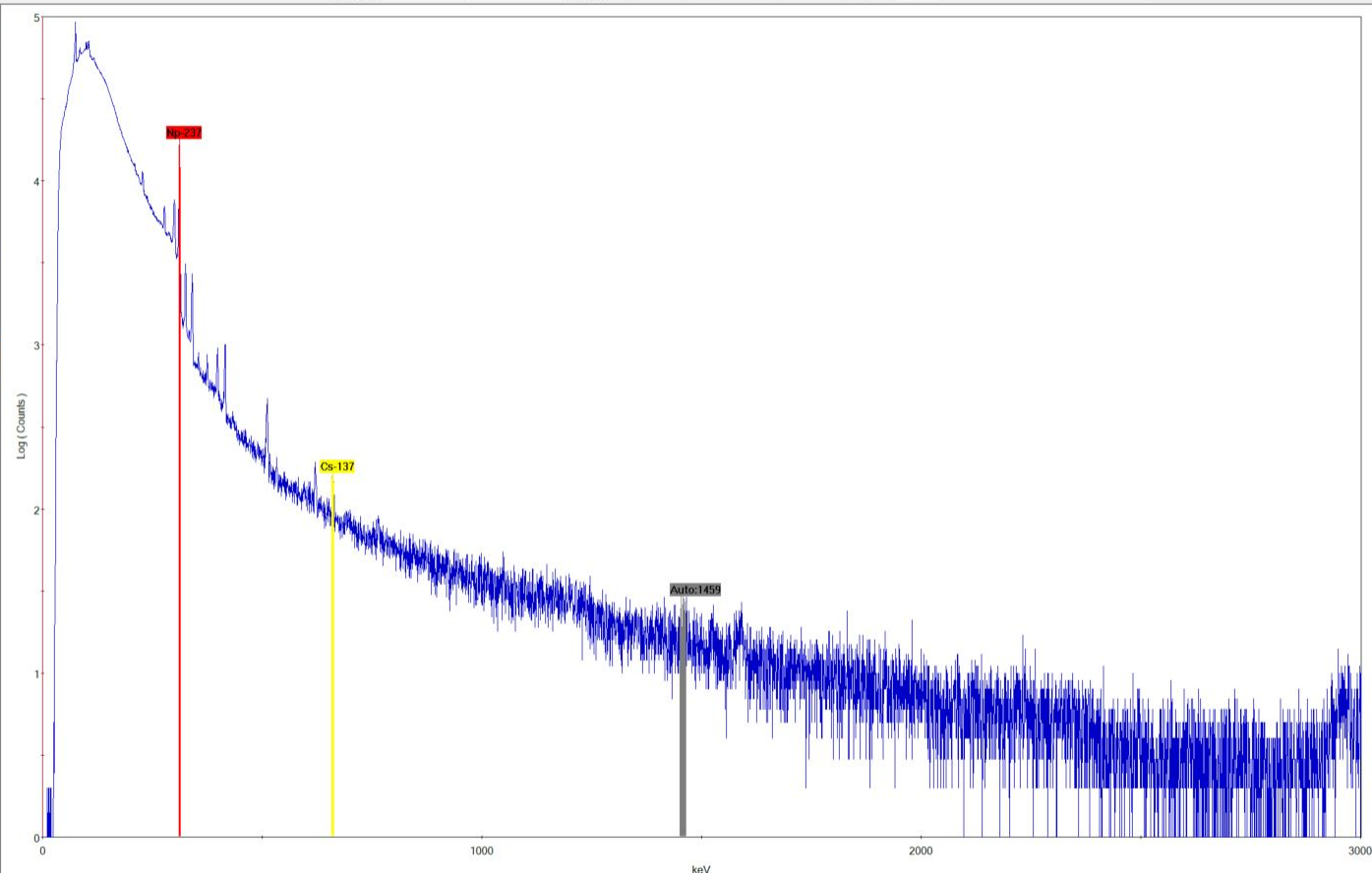
Home Save File Close Print RB

Time: 13666 Live: 0.987

Saved File

PC:0 SC:0 PU:0
TC:0 RJ:0 F2: 0.00

CPS: 0 11 uR/hr Temp(K): N/A



Windows taskbar icons including File Explorer, Chrome, Teams, Edge, PowerPoint, and Settings.

6:27 PM
8/4/2021

Uranium Imaging at ORNL REDC



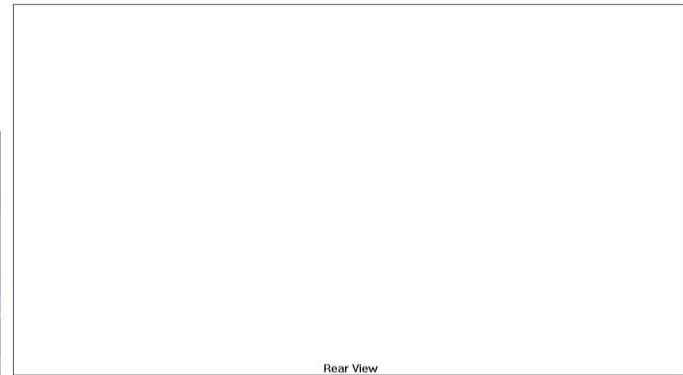
Imager - [20210129_150722-5GMT-Th227zm3 - Copy.img]

File Acquire View Tools Options Show Window Help

Time: 13666 Live: 0.987 **Saved File** PC:0 SC:0 PU:0
CPS: 0 11 uR/hr Temp(K): N/A TC:0 RJ:0 F2: 0.00

Custom Distance(m) 0.648 Events 0 Switch to Tactical View Width 30 %

Isotope	Energy (keV)	Events
<input checked="" type="checkbox"/> Np-237	112.7	15422
<input type="checkbox"/> Cs-137	661.7	0
<input type="checkbox"/> Auto:1459	1458.8	285



Rear View
Activity Units Curies (Ci)

ROI Isotope Energy Count Activity (Ci) Radioactive Mass (g) Activity Conc. (Ci/g)

There are no items to show in this view.

Intervening Materials

Material	Density(g...	Thick(cm)
----------	--------------	-----------

ROI Materials

ROI	Material	Density(g...	Thick
-----	----------	--------------	-------

There are no items to show in this view.

Uranium Imaging at ORNL REDC



Imager - [20210129_150722-5GMT-Th227zm3 - Copy.img]

File Acquire View Tools Options Show Window Help

Time: 13666 Live: 0.987
Saved File
PC:0 SC:0 PU:0 TC:0 RJ:0 F2: 0.00

CPS: 0 11 uR/hr
Temp(K): N/A

Custom
Distance(m) 0.648
Events 16422
Switch to Tactical View
Width 30%

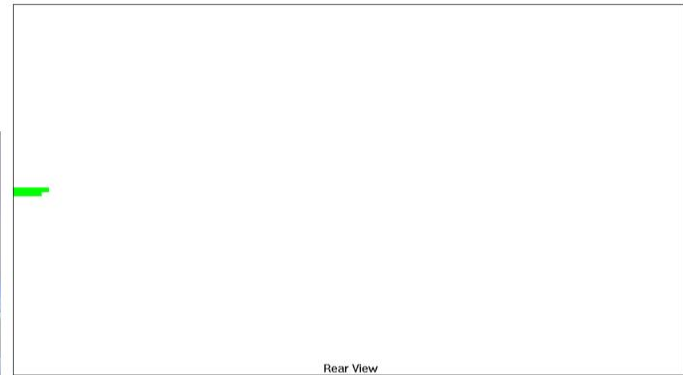
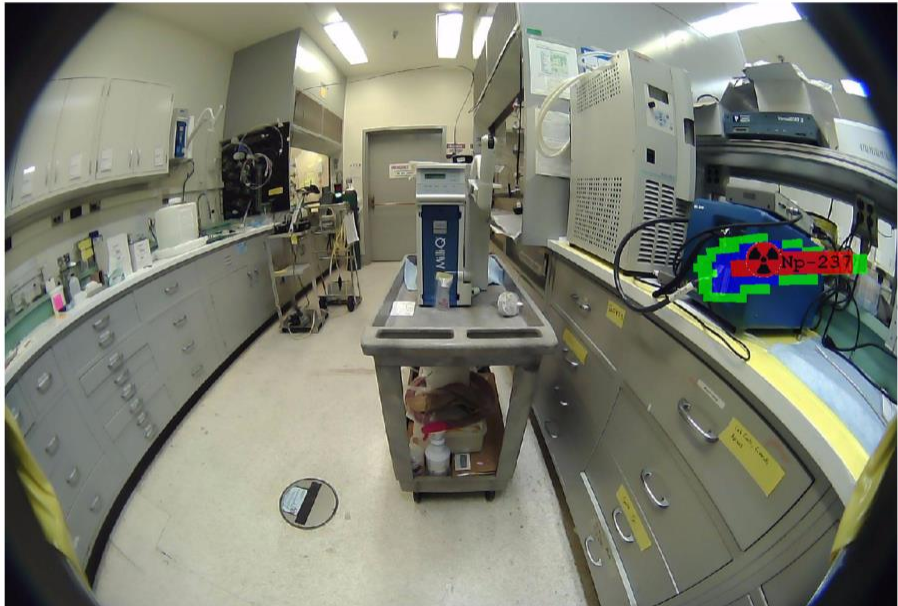
Isotope	Energy (keV)	Events
<input checked="" type="checkbox"/> Np-237	312.7	18422
<input checked="" type="checkbox"/> Cs-137	661.7	0
<input type="checkbox"/> Auto:1459	1458.8	285

Intervening Materials

Material	Density(g...	Thick(cm)

ROI Materials

ROI	Material	Density(g...	Thick
There are no items to show in this view.			



Activity Units: **Curies (Ci)**

ROI	Isotope	Energy	Count	Activity (Ci)	Radioactive Mass (g)	Activity Conc. (Ci/g)
	Np-237	312.6	1846...	1.20e-03 +/- 2.80e-06	3.87e-08 +/- 9.01e-011	N/A

NP Imager Coded Aperture Development
On the bench at PHDS with NP Imager Engineering Model
Collaborators at ORNL – Coded aperture expert – Klaus Ziock



**Primo Automated
Coded Aperture
System**

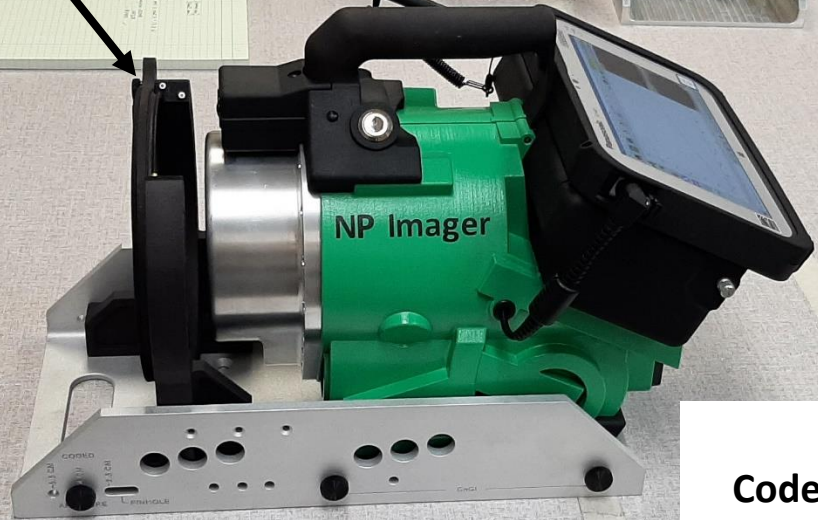
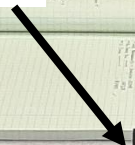
**Controls
Mech structure
Variable zoom
Auto rotate**

**Best of the Best
for imaging
quality**

77 lbs.!



**Mask-antimask
selected manually**



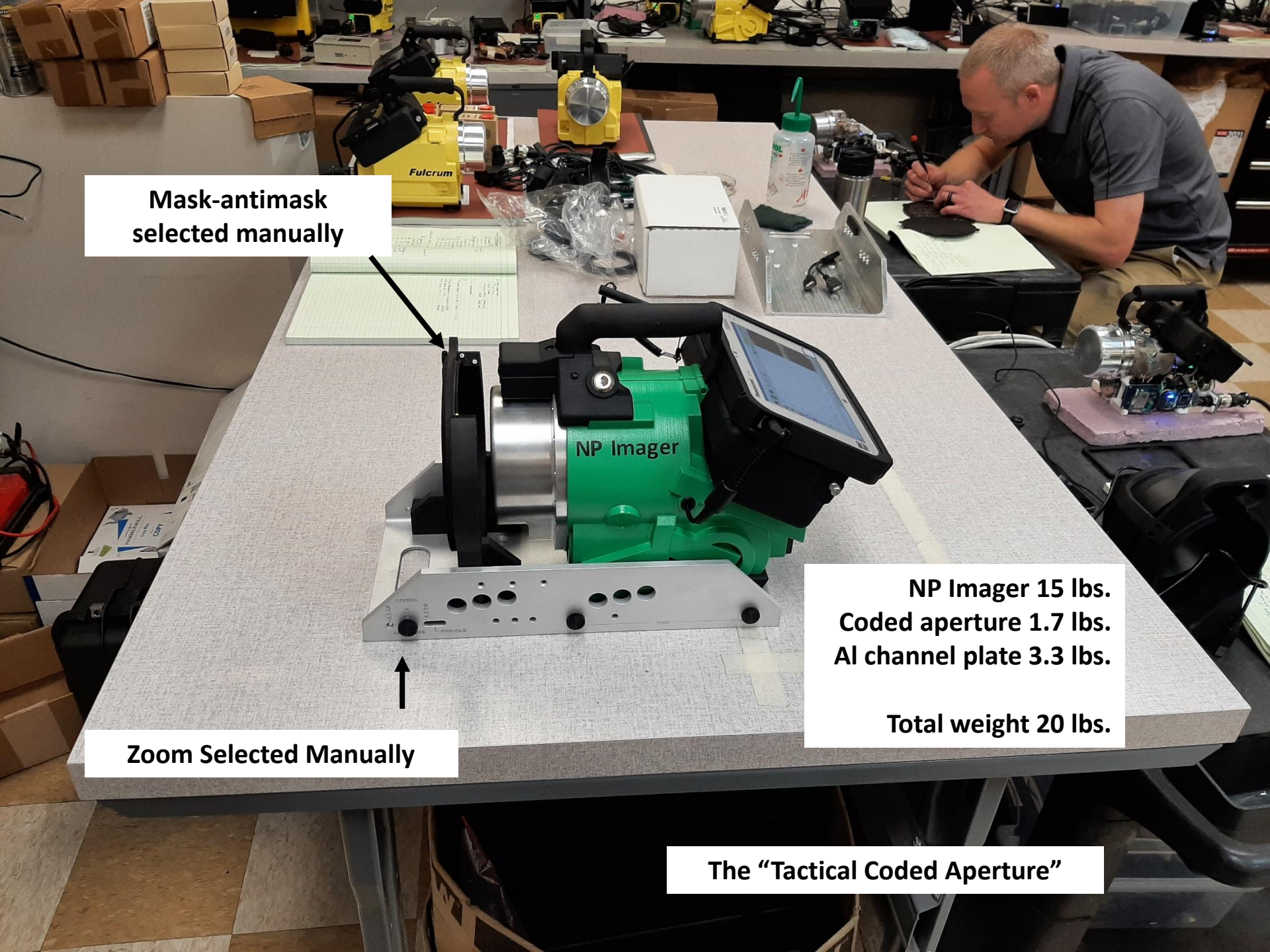
**NP Imager 15 lbs.
Coded aperture 1.7 lbs.
Al channel plate 3.3 lbs.**

Total weight 20 lbs.

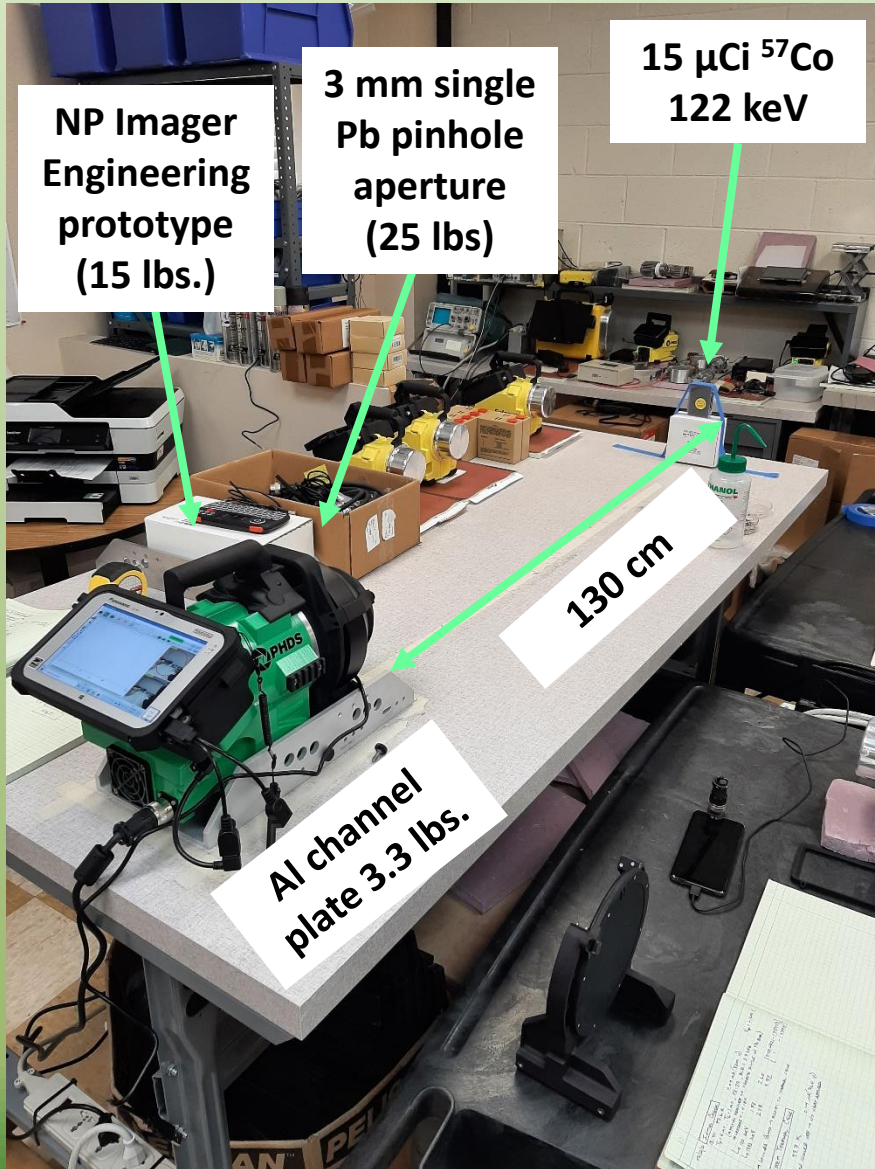
Zoom Selected Manually



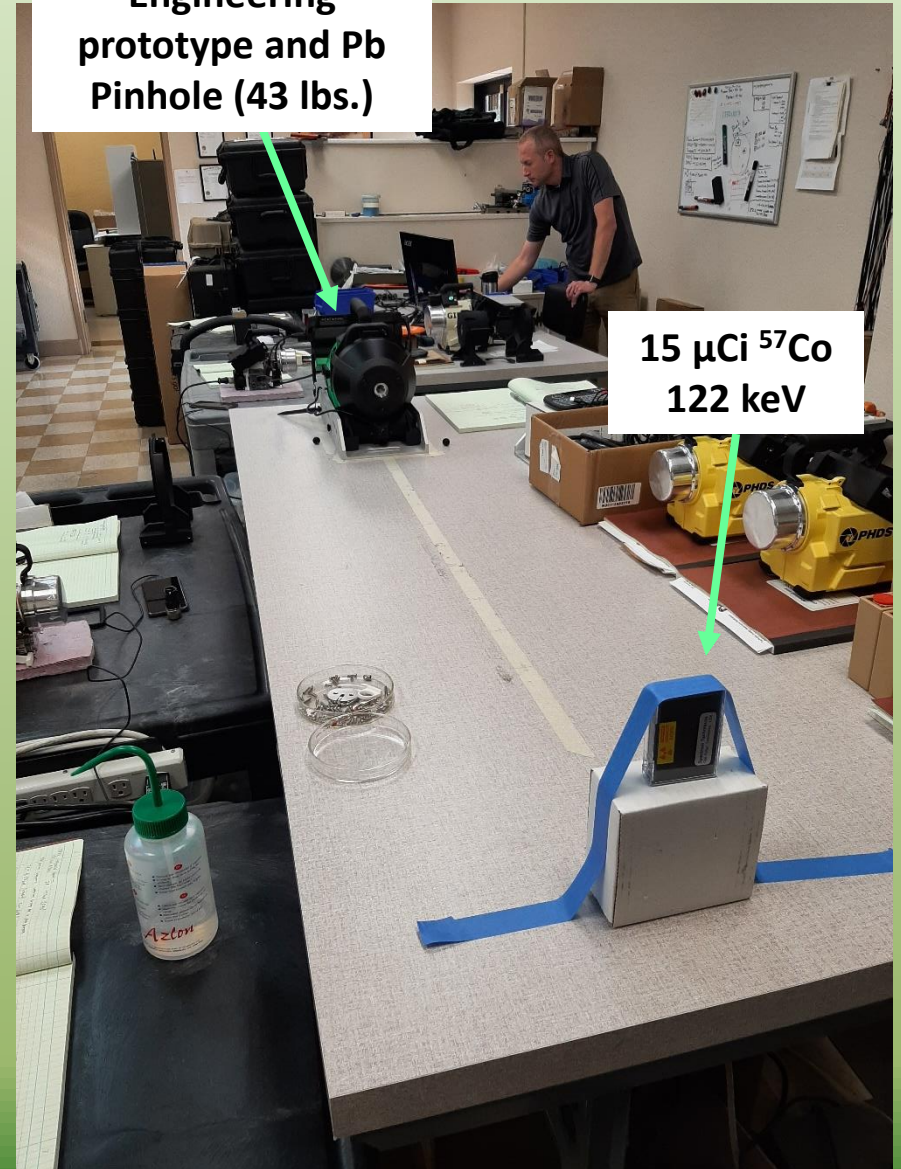
The "Tactical Coded Aperture"

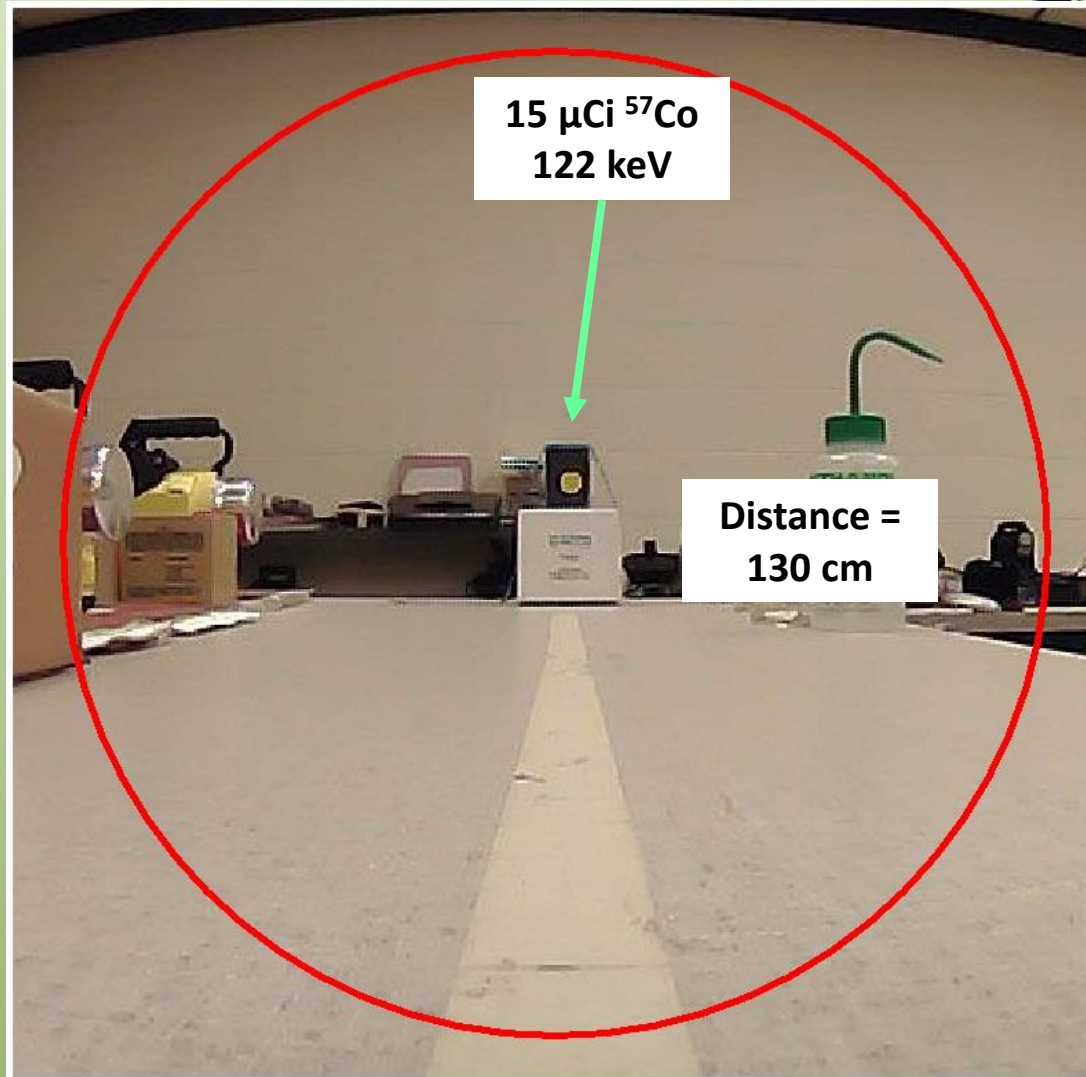


NP Imager Pinhole Imaging



NP Imager Engineering prototype and Pb Pinhole (43 lbs.)





0
min



1
min



**2
min**



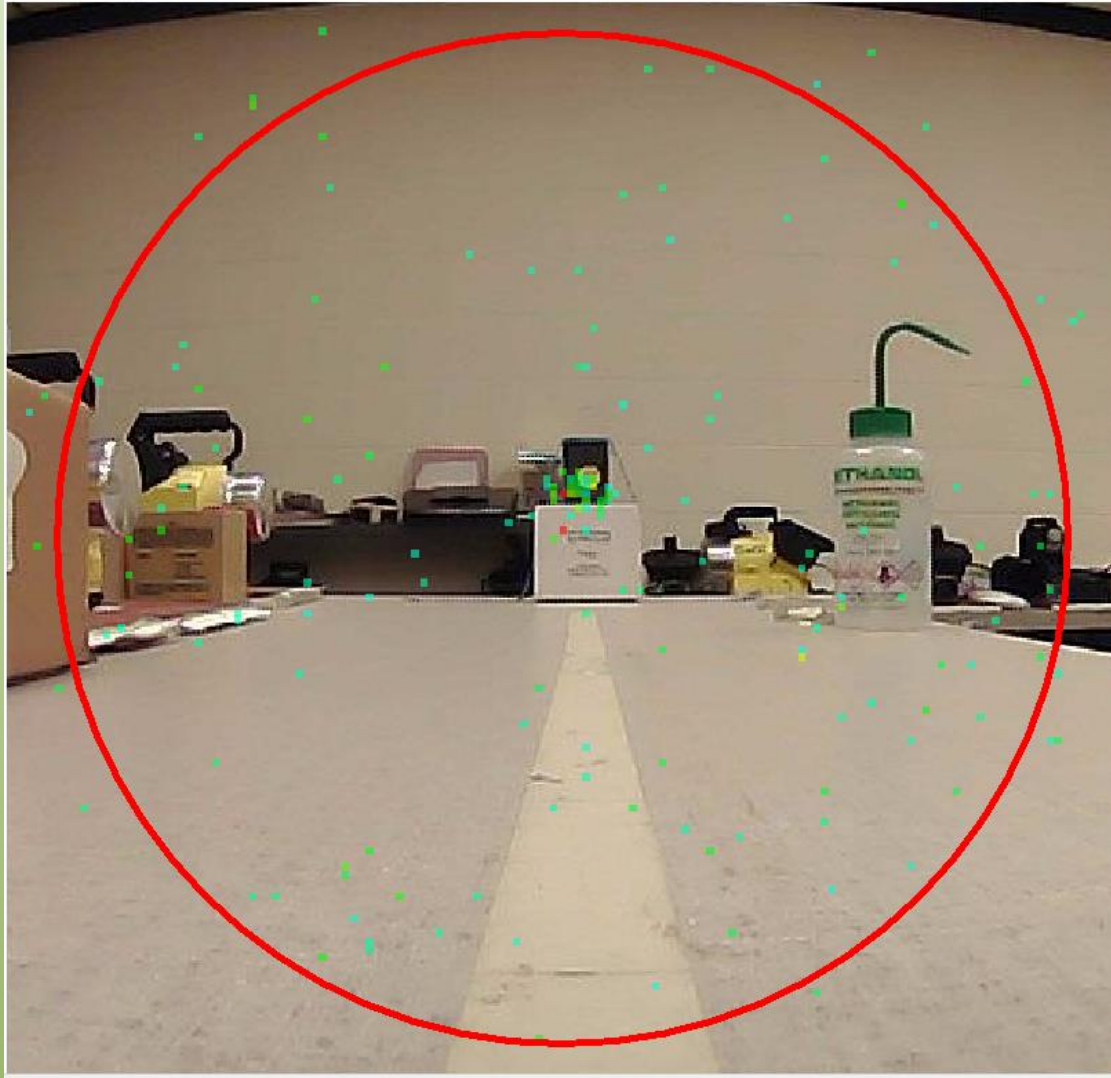
**3
min**



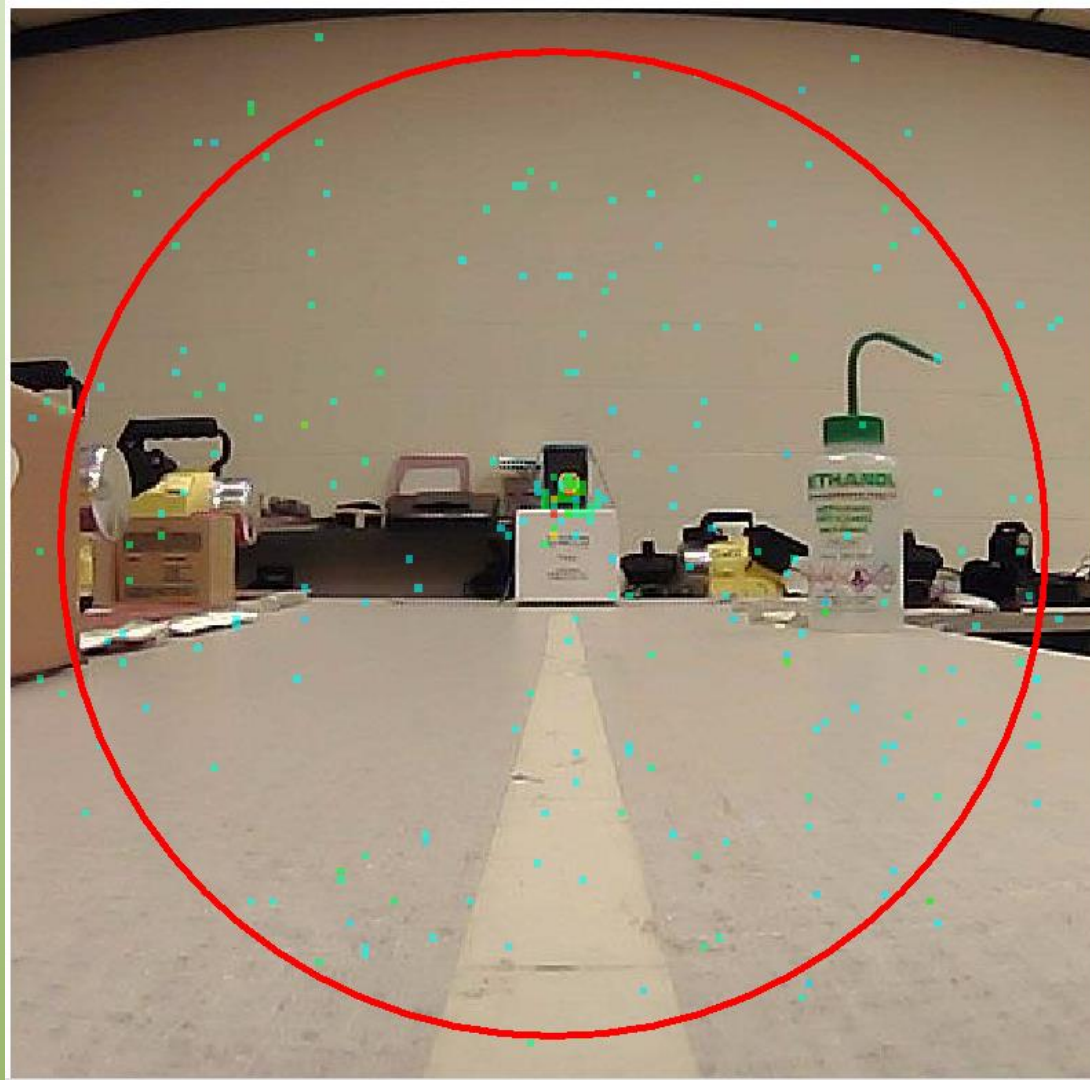
**4
min**



**5
min**



**6
min**



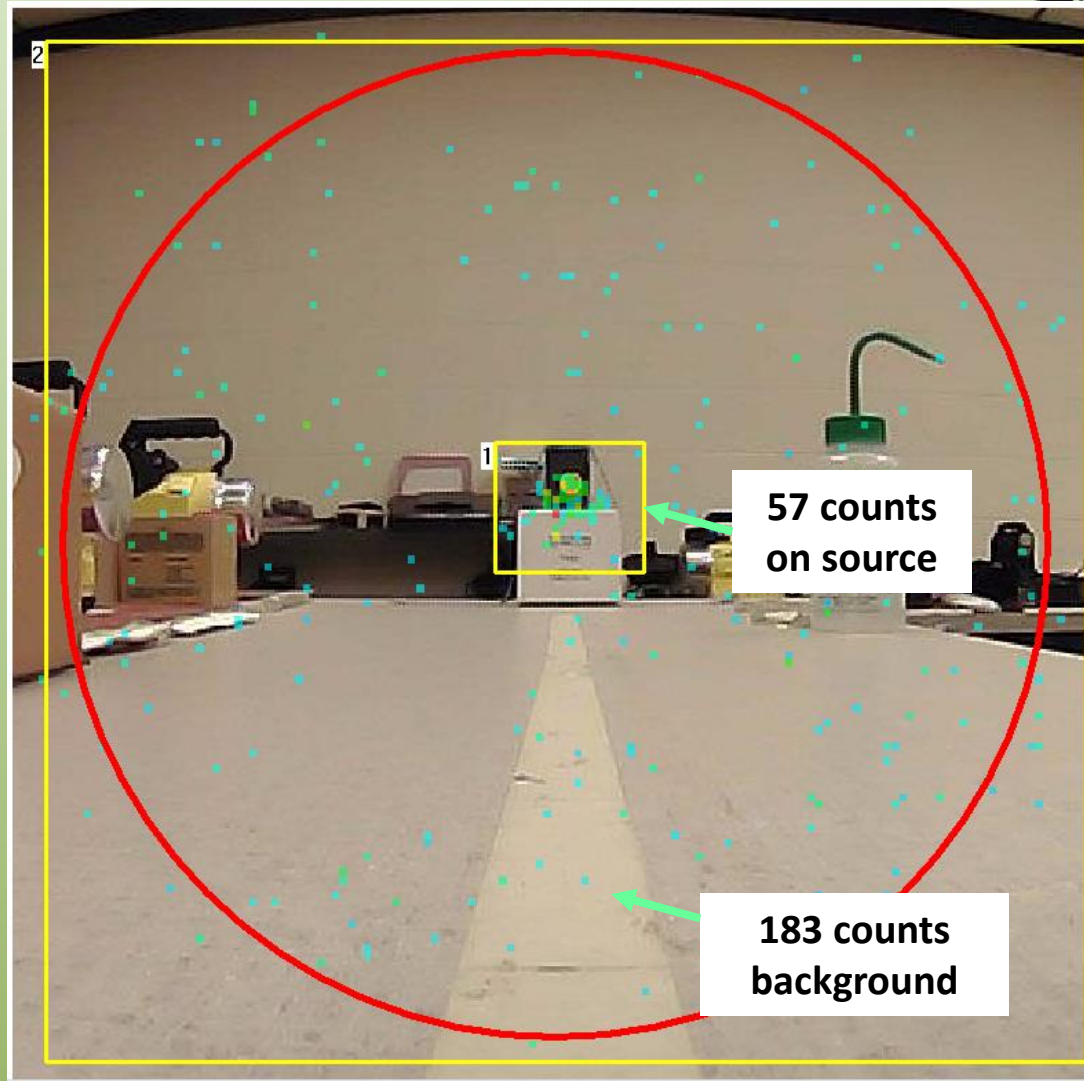
7
min



**8
min**



9
min



**9
min**

**57 counts
on source**

**183 counts
background**

**0.41 cps total
count rate**

**240 total
counts**

**All gated on
122 keV**

NP Imager Coded Aperture Image

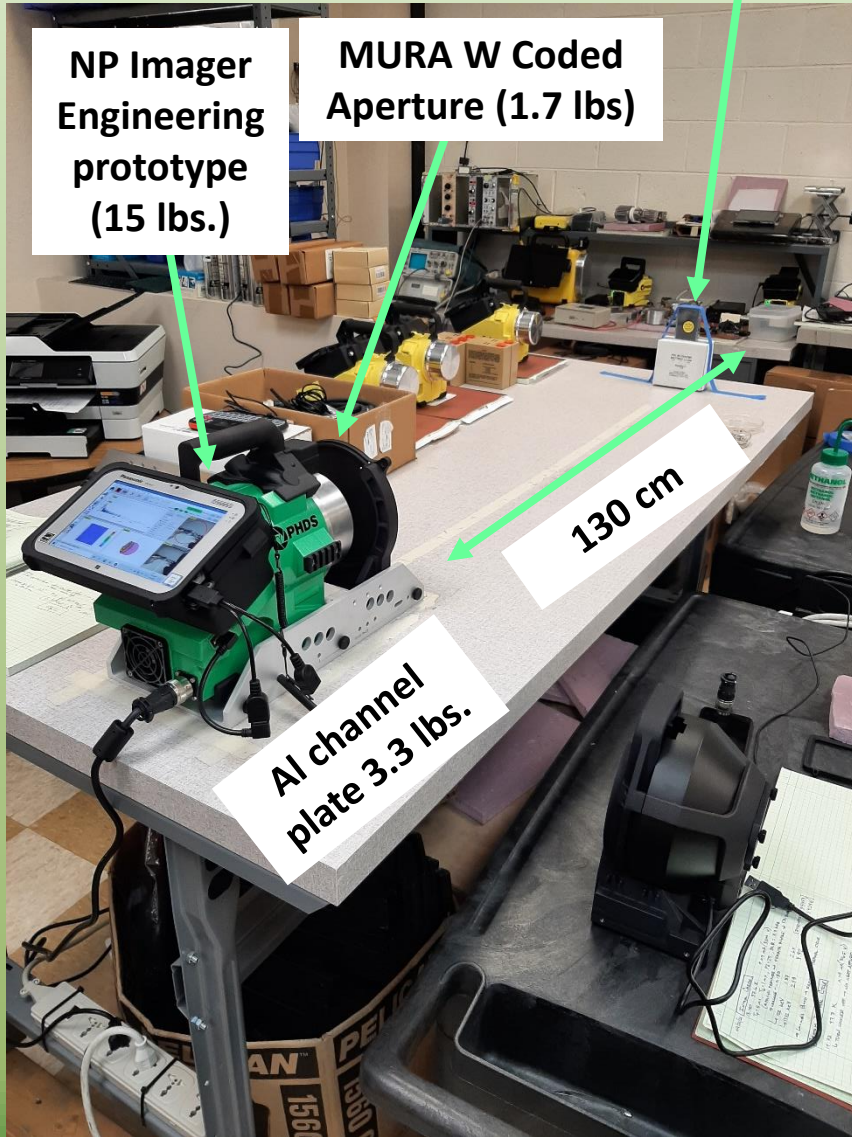
15 μCi ^{57}Co
122 keV

NP Imager Engineering prototype (15 lbs.)

MURA W Coded Aperture (1.7 lbs)

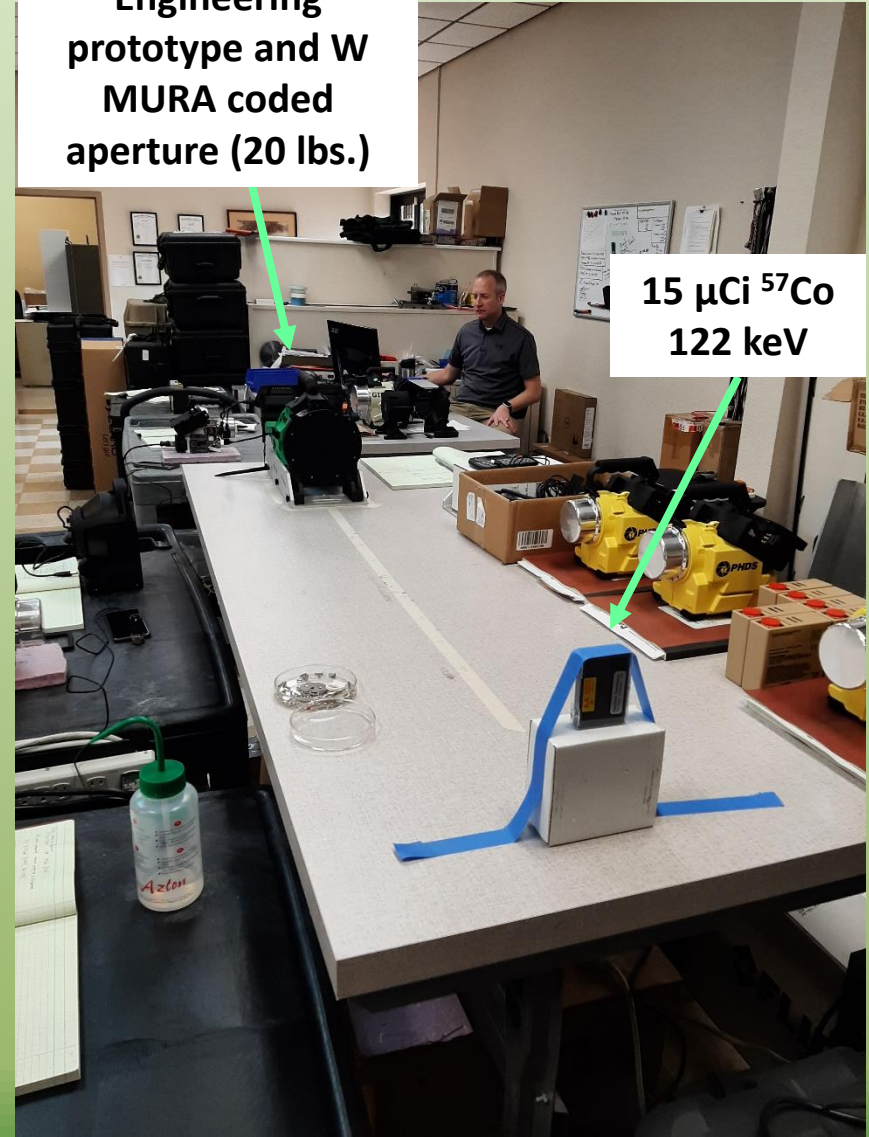
130 cm

Al channel plate 3.3 lbs.



NP Imager Engineering prototype and W MURA coded aperture (20 lbs.)

15 μCi ^{57}Co
122 keV



NP Imager Coded
Aperture Image

0
min



**NP Imager Coded
Aperture Data**

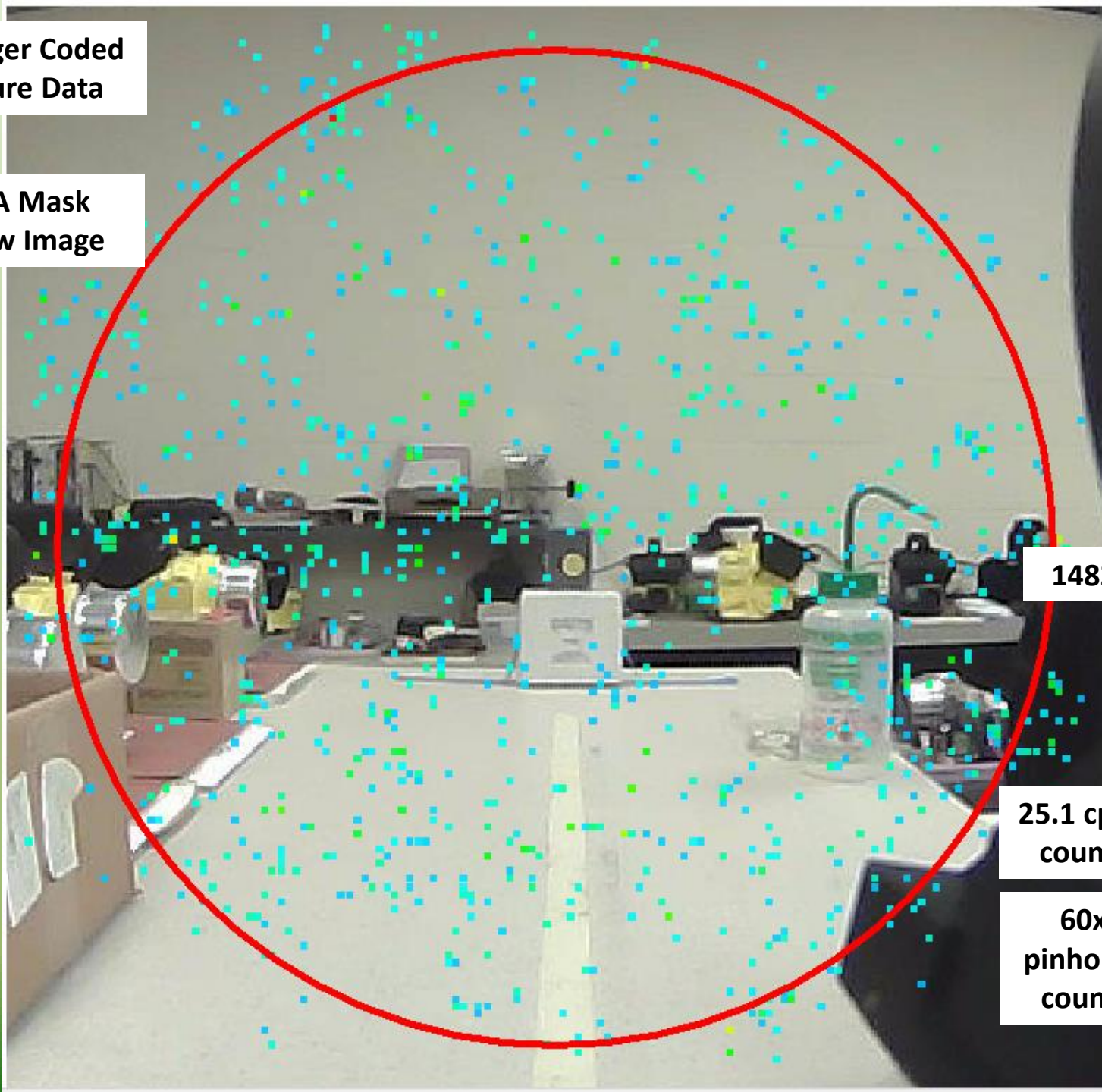
**MURA Mask
Shadow Image**

**1
min**

1482 counts

**25.1 cps total
count rate**

**60x the
pinhole total
count rate**

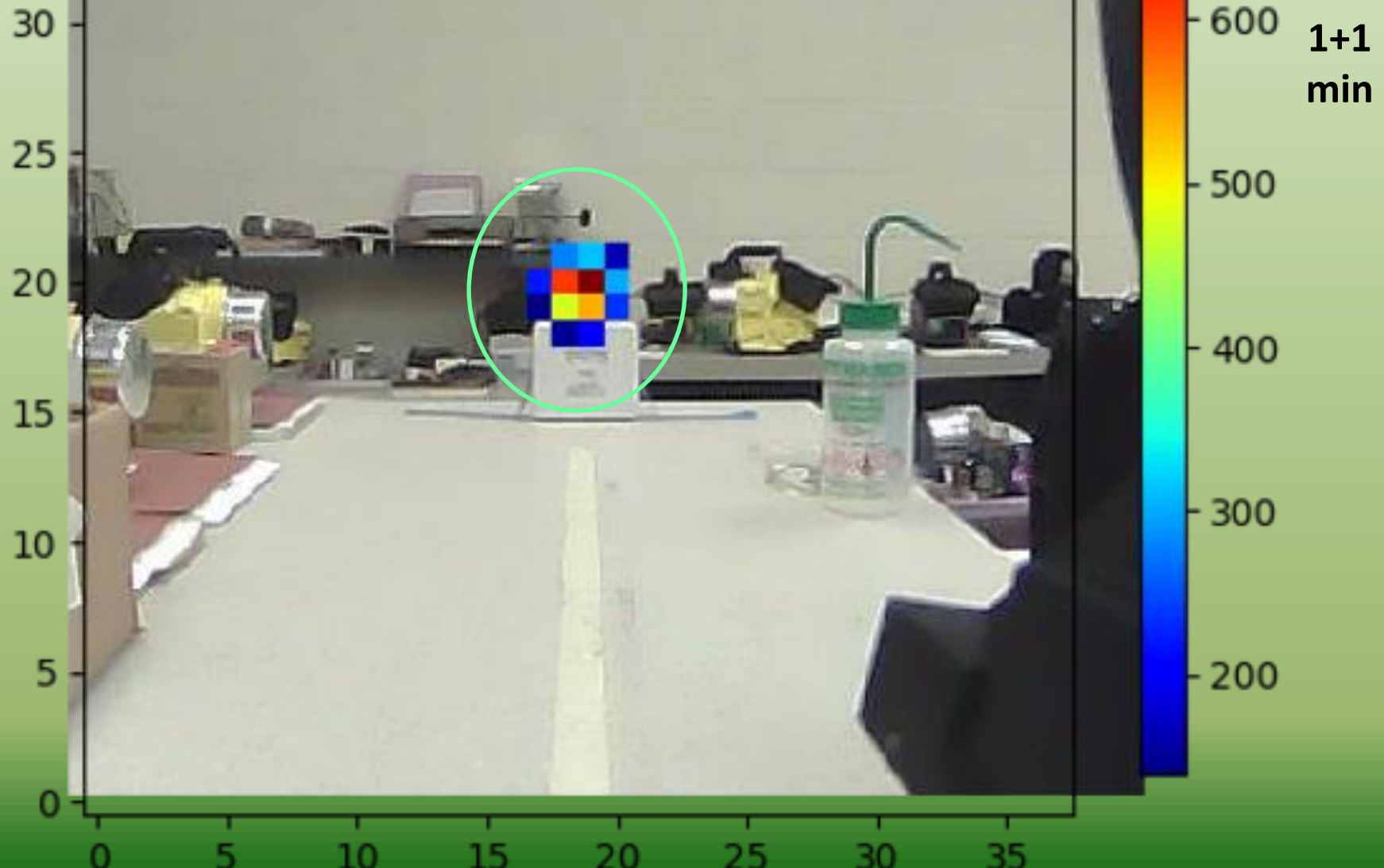


NP Imager Coded
Aperture Image

Mask/Antimask - Final Image

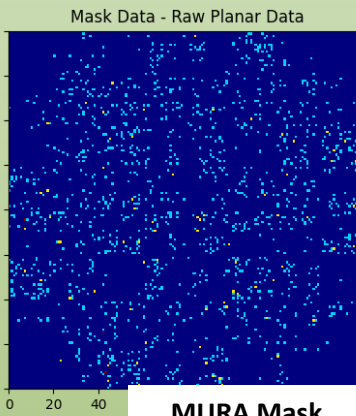
PHDS
Gamma Ray Imaging Detectors

Mask/Antimask

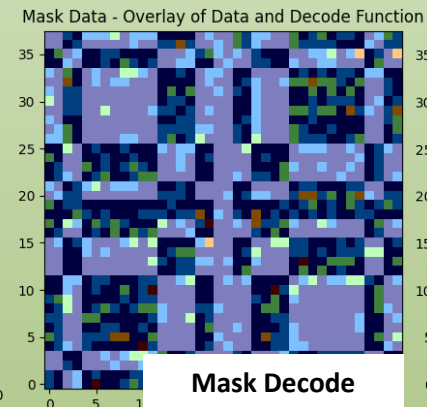




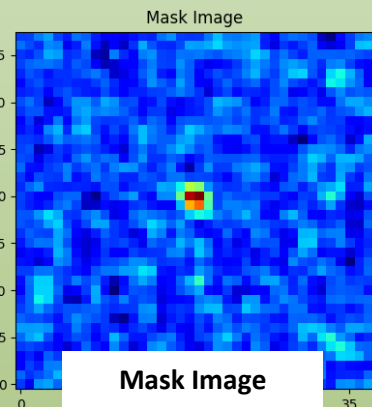
**MURA Mask
Shadow Image**



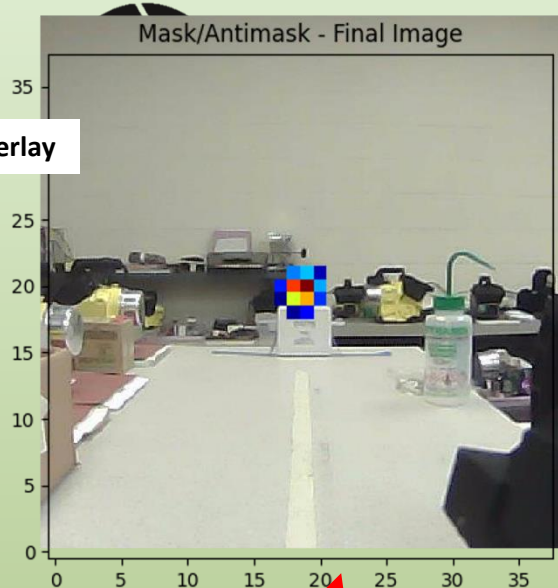
**MURA Mask
Shadow Image**



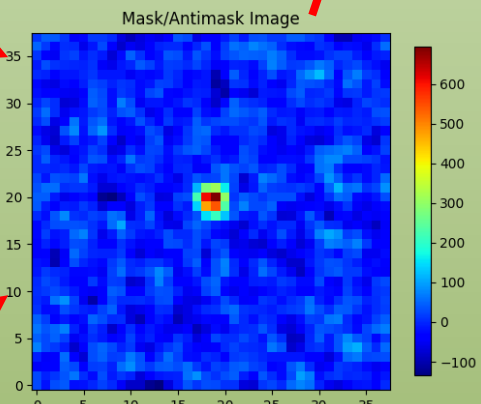
**Mask Decode
Function**



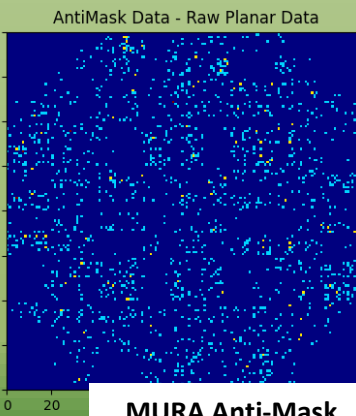
Mask Image



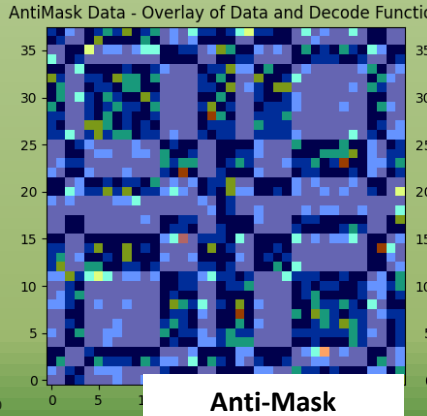
Optical Overlay



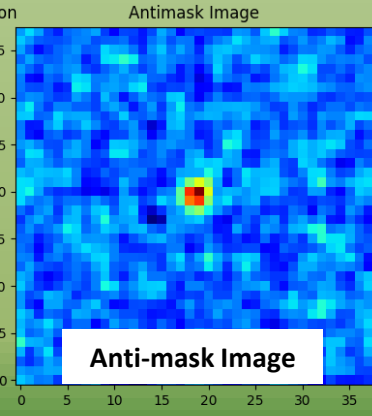
**Complete Mask/Anti-
mask Image**



**MURA Anti-Mask
Shadow Image**



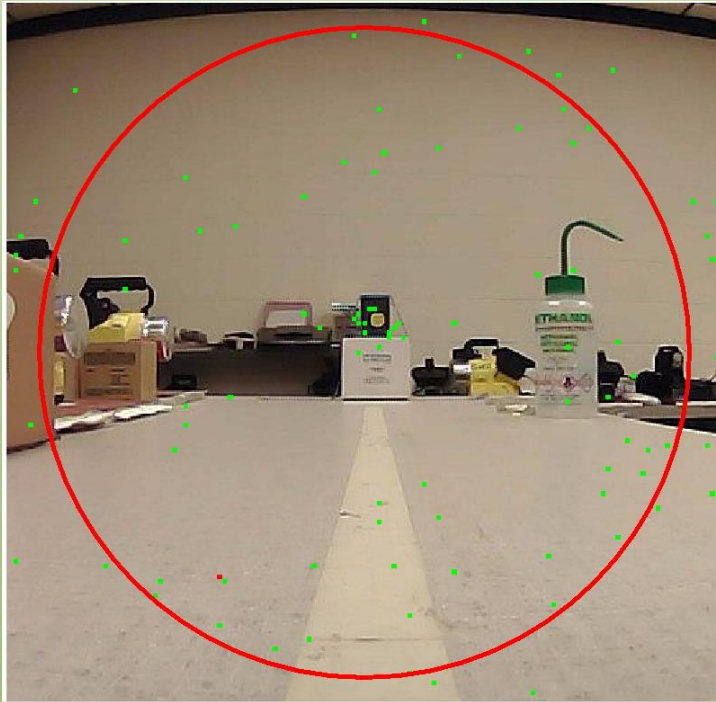
**Anti-Mask
Decode Function**



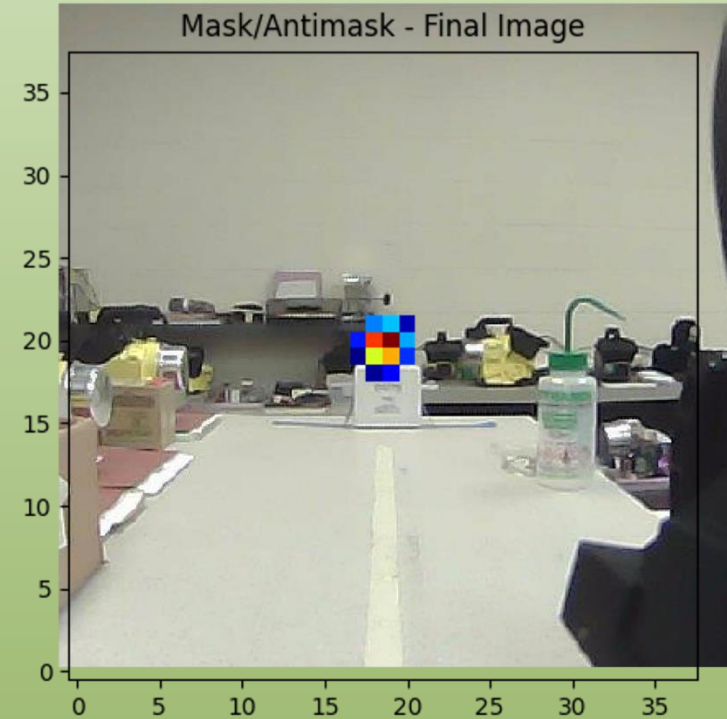
Anti-mask Image

Comparison Pinhole vs. Coded Aperture

Pinhole 2 min

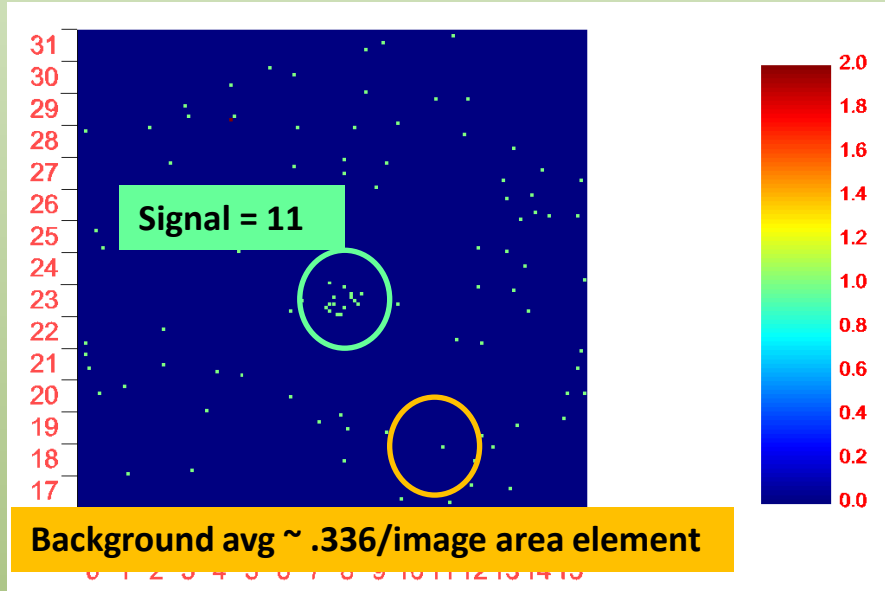


**Coded Aperture
1 min + 1 min = 2 min**



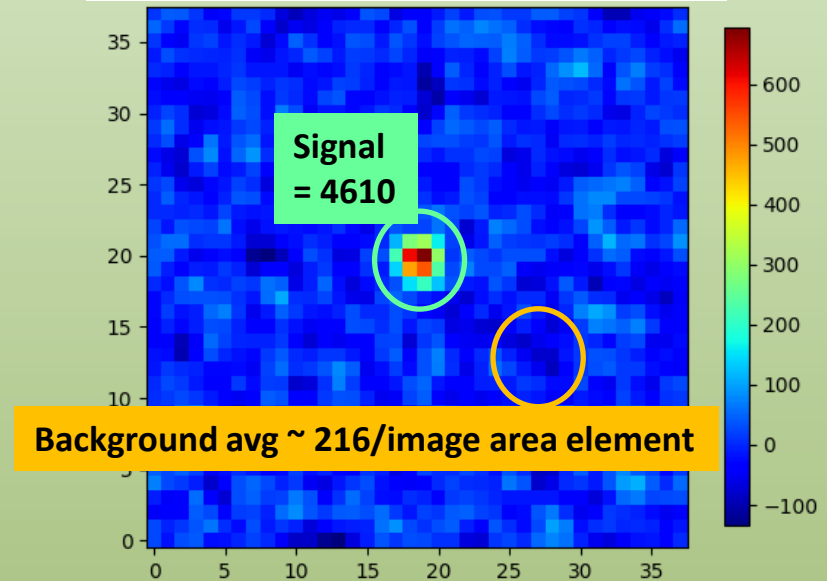
Comparison Pinhole vs. Coded Aperture

Pinhole 2 min



$$\text{Signal}/\text{SQRT}(\text{background}) = 19$$

Coded Aperture 1 min + 1 min = 2 min



$$\text{Signal}/\text{SQRT}(\text{background}) = 313$$

$$313/19 = 16.5$$

With a single point source

Remaining Coded Aperture Product Challenges

Quantitative Analysis

Additional sources decrease the signal to background in image space
nontrivial reconstruction of activity

Use at higher energies

Thicker aperture – sacrifices spatial resolution – pixel size
Compton imaging may take over here

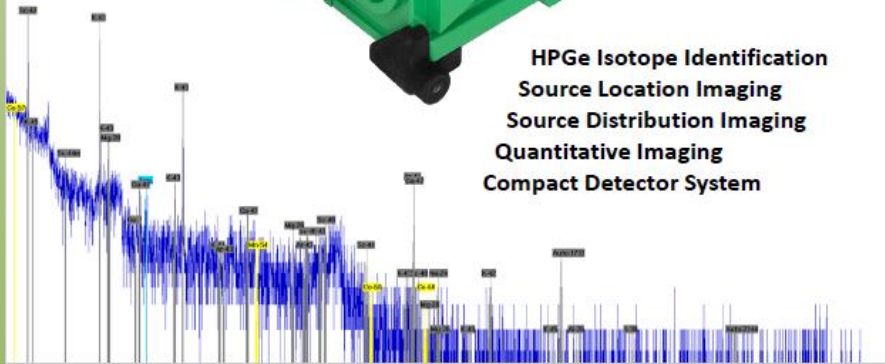
**Press on with the existing capability.
Go ahead and make a product!**

NP Imager

Nuclear Physics – Radiochemistry Imaging Spectrometer



HPGe Isotope Identification
Source Location Imaging
Source Distribution Imaging
Quantitative Imaging
Compact Detector System



NP Imager



NP Imager Specifications:

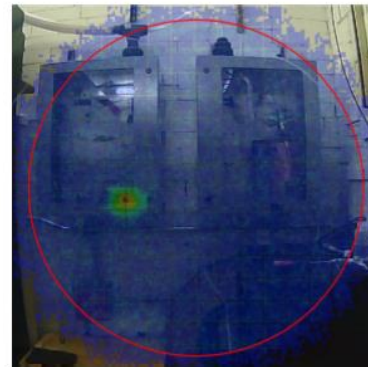
Weight (Detector):	15 lbs. (6.8 kg)
Dimensions (Detector):	10.5" x 8.0" x 5.5" (26 cm x 20 cm x 14 cm)
Battery life:	3 hrs internal (hot swappable), 6-8 hrs external
Power supply:	100-240 VAC, 50-60 Hz
User maintenance:	None
Energy resolution:	FWHM < 2.1 keV at 662 keV
Gamma-ray Compton imaging field of view:	4π (360°)
Optical camera field of view:	2π (180°)
Pinhole imaging field of view:	up to 60° (depends on Zoomfactor)
Zoomfactor Gamma-ray Image Magnification	x1 - x6
Imaging Range:	(10 cm - 50' meters)
At 10 μCi ¹³⁷ Cs at 1 meter (3.3 μR/hr, 33 nSv/hr)	
ID time (spectroscopy):	3.7 sec +/- 1 sec (662 keV, 8σ)
Location (imaging) time:	30 sec +/- 13 sec (Compton image)
Exposure rate capacity:	200 kcps (~10% Dead time in 15 mR/hr ⁶⁰ Co)
Energy range spectroscopy (16k ch):	30 keV - 3 MeV (12 MeV option)
Energy range Compton Imaging:	150 keV - 3 MeV
Energy range Pinhole Zoomfactor Imaging:	30 keV - 662 keV
Isotope Library:	400 isotopes (Auto detect or user selected)
Isotope Identification:	37 frequently encountered isotopes
Isotope Categories:	SNM, NORM, IND, MED
HPGe detector crystal dimensions:	90-mm diameter, 11-mm thick
Active detector volume / area:	67 cm ³ / 61 cm ²
Cool-down time:	4 hours
Detector startup time:	2 minutes



Heavy Duty Imaging Gantry



Tablet or Laptop operation



Radioisotope Harvesting Image



Pinhole Imaging Aperture



2590 300 W-hr External battery

20210129

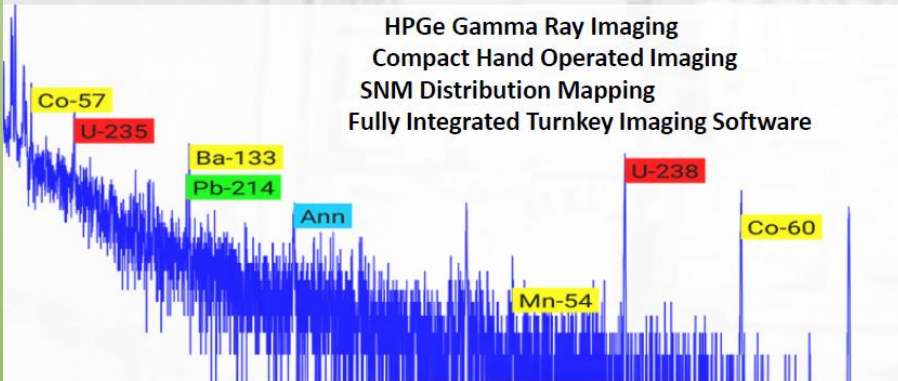
Specifications subject to change

Tactical Coded Aperture

High resolution fast-accumulation planar imaging mask for NP Imager and GeGI



HPGe Gamma Ray Imaging
Compact Hand Operated Imaging
SNM Distribution Mapping
Fully Integrated Turnkey Imaging Software



Releasing Tactical Coded Aperture Software with ImagerPro this fall

Tactical Coded Aperture



Tactical Coded Aperture

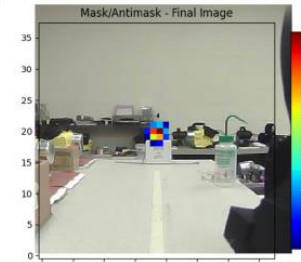
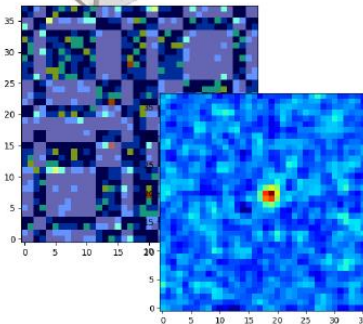
Specifications:

Weight:	1.7 lbs.
Dimensions:	4" x 7.5" x 8" (10 cm x 19 cm x 21 cm)
Battery life (internal hot swappable):	No battery or power required
User maintenance:	None
Spatial resolution:	FWHM < 2.2 degrees at 122 keV
Gamma-ray throughput	50%
W mask thickness	2 mm
Energy range:	40 keV - 662 keV
Point source sensitivity	1 second to locate 1 μCi ^{57}Co at 1 meter
Compatible Detector Systems	GeGI and NP Imager
Mask-Antimask Operation	Manual, prompted by app

Tactical Coded Aperture can be used with NP Imager OR GeGI



Lightweight Compact Form Factor



Integrated Gamma-Ray Imaging-Optical Overlay



20210805

Specifications subject to change

NP Imager Product Sales



As of August 13, 2021

NP Imager
Nuclear Physics – Radiochemistry Imaging Spectrometer



HPGe Isotope Identification
Source Location Imaging
Source Distribution Imaging
Quantitative Imaging
Compact Detector System



Tactical Coded Aperture
High resolution fast-accumulation planar imaging mask for NP Imager and GeI

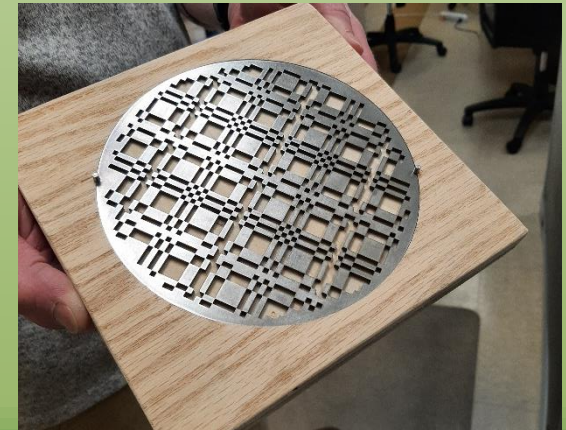


HPGe Gamma Ray Imaging
Compact Hand Operated Imaging
SNM Distribution Mapping
Fully Integrated Turnkey Imaging Software



NP Imager Item	Sold	Shipped	Pending
NP Imager HPGe Detector			
Fully Automated MURA			
Tactical Coded Aperture			

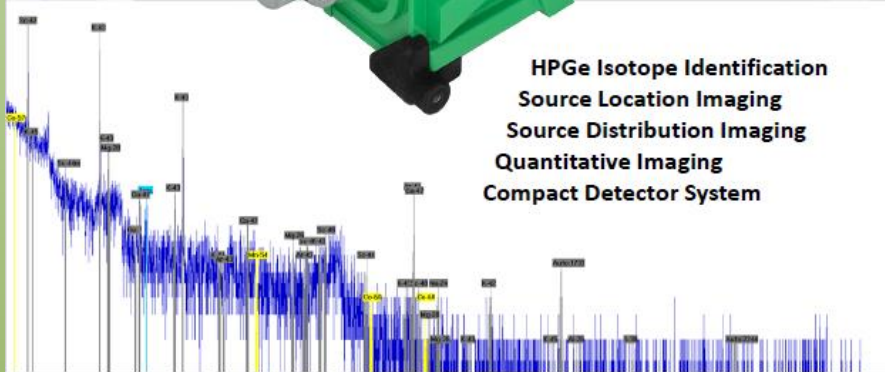
DOE National Labs
DOE NNSA
Private industry research



**Brock Roberts
Electrodynamic**

NP Imager

Nuclear Physics – Radiochemistry Imaging Spectrometer



Thank you, DOE NP, for the NP Imager



Tactical Coded Aperture

High resolution fast-accumulation planar
imaging mask for NP Imager and GeGI

