



U.S. DEPARTMENT OF
ENERGY

OFFICE OF
**ENVIRONMENTAL
MANAGEMENT**



31st Annual Regulatory Information Conference
Technical Session TH37, “New and Innovative Technologies for
Decommissioning and Remediation of Nuclear Facilities”

Innovations for Nuclear Facility Decommissioning

Presented by
Rodrigo V. Rimando, Jr.

March 14, 2019

- ❖ **Introduction to Defense Environmental Cleanup**
 - **Office of Environmental Management**
- ❖ **Gaseous Diffusion Plant Decommissioning**
 - **Challenge of Assaying Residues of Enriched Uranium**
 - **Pipe Crawling Assay Measurement System**
- ❖ **Closing Remarks**



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Defense Environmental Cleanup

Addressing the Nuclear Weapons Legacy

MISSION OF OFFICE OF ENVIRONMENTAL MANAGEMENT

Safe cleanup of the environmental legacy created by the Manhattan Project, the ensuing Cold War nuclear arms race, and the early years of federal government-sponsored nuclear science research and technology development



The Hanford Reach
White Bluffs Overlooking the Columbia River

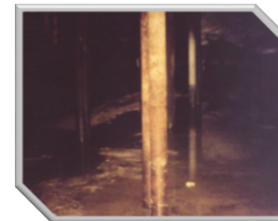
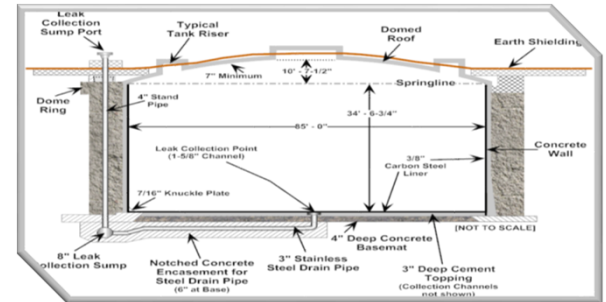
Nuclear Facility Decommissioning



Soil and Water Cleanup



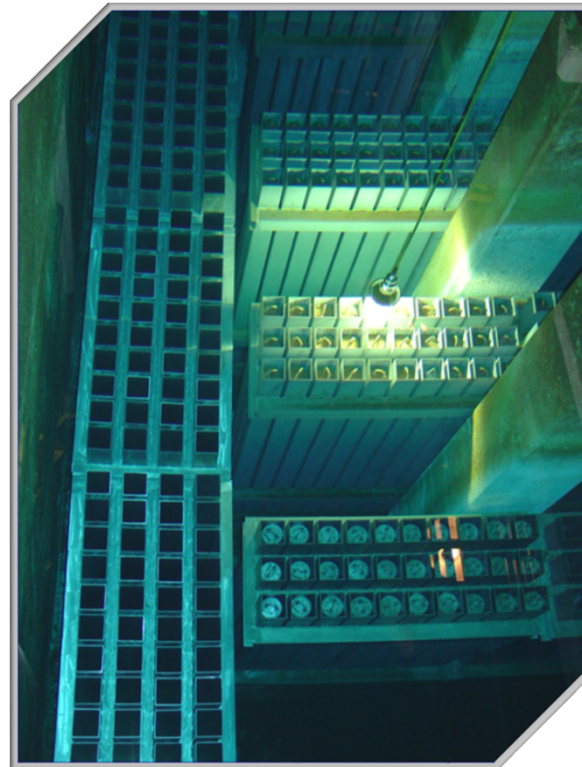
Liquid Radioactive Waste Processing & Disposition



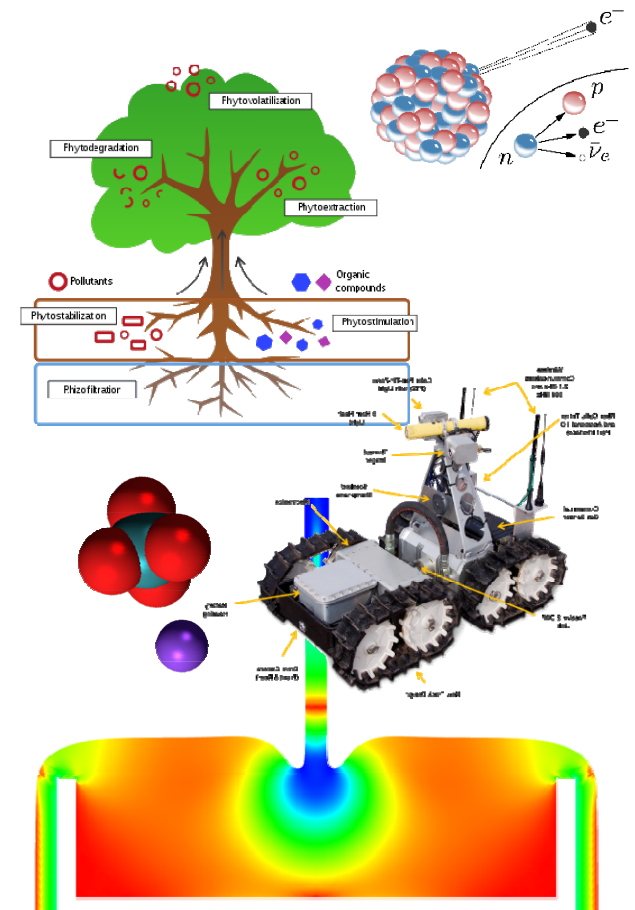
Solid Radioactive Waste Treatment, Storage & Disposal



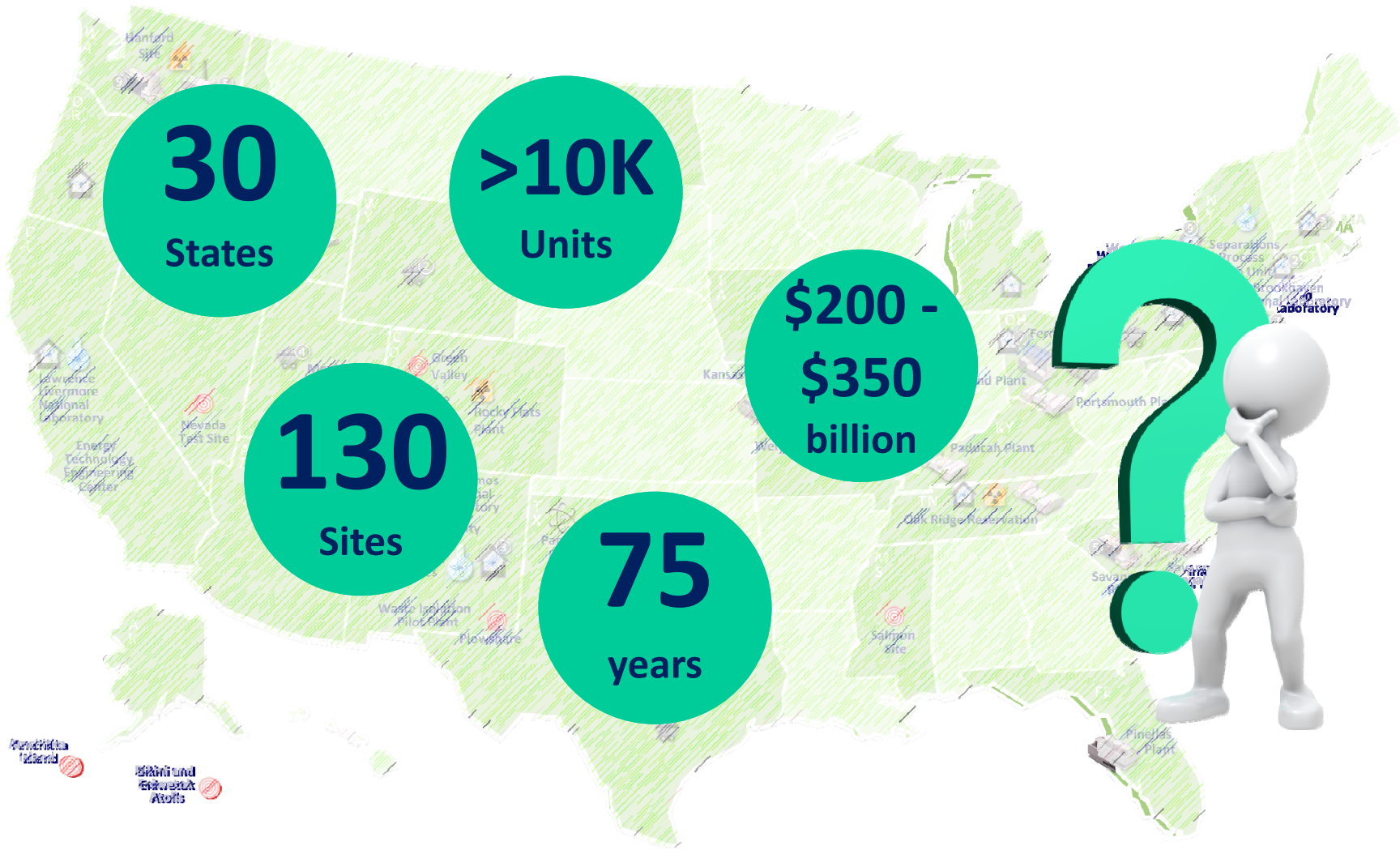
Nuclear Materials & Spent Nuclear Fuel Management



Science & Technology



Initial Scope of Legacy Cleanup



what's done?

30
years



91
of 107
sites

↓
risk

>\$170
billion

Decommissioning Successes: Hanford Site Production Reactors

6

of Hanford's nine production reactors have been placed in interim, safe storage allowing radioactive decay before final demolition



2

more reactors will be placed in safe storage in the next few years

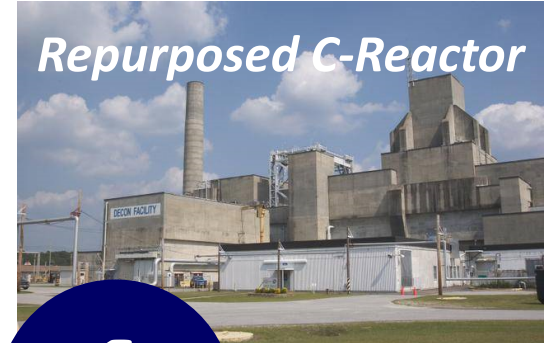
1

reactor was configured for public access because of its historical significance (world's first full-scale plutonium production reactor)

Decommissioning Successes: Savannah River Site Production Reactors

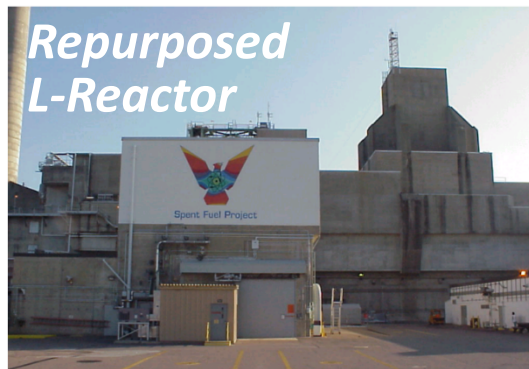
2

of Savannah River Site's five reactors are entombed



2

reactors are used for temporary storage of special nuclear materials and spent fuel



1

was converted to a decontamination facility

Decommissioning Successes: Test and Research Reactors

>75

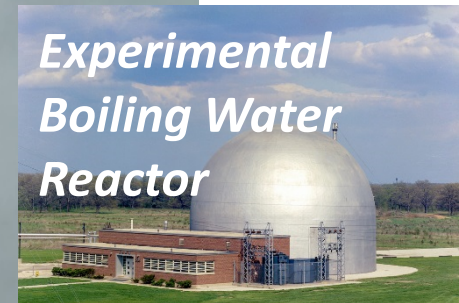
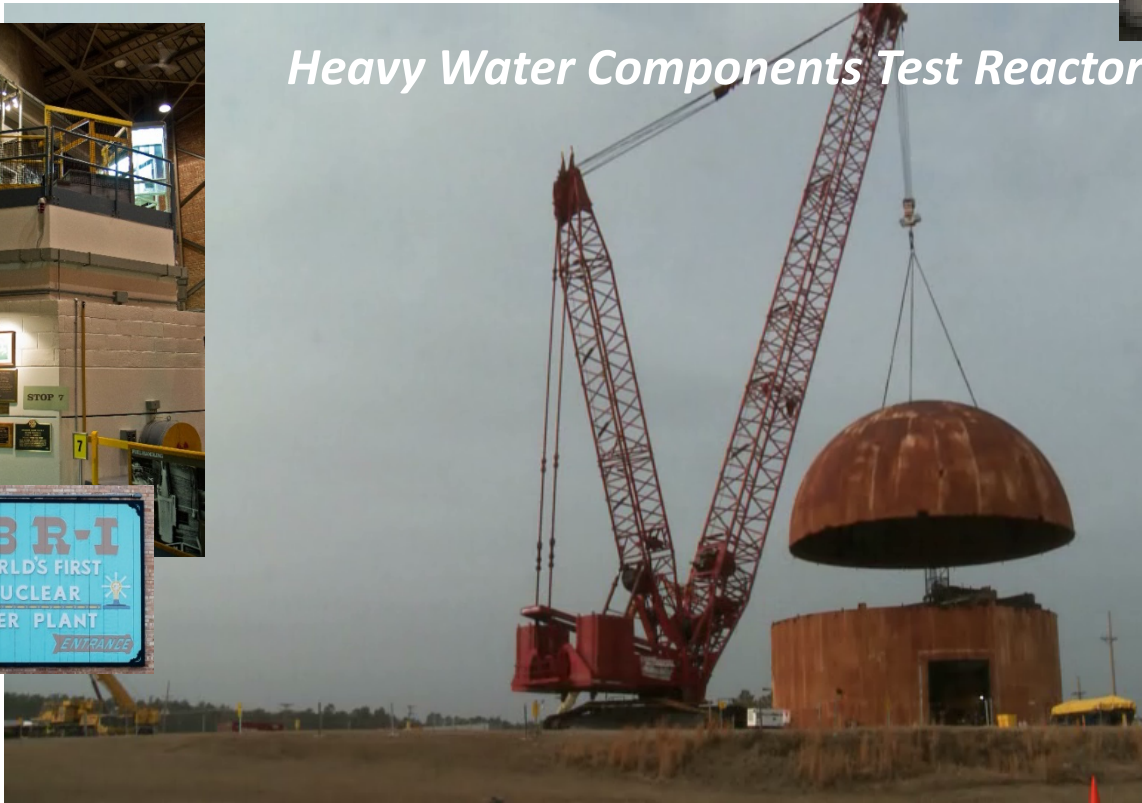
research reactors of various designs
across the DOE complex are in
various phases of decommissioning



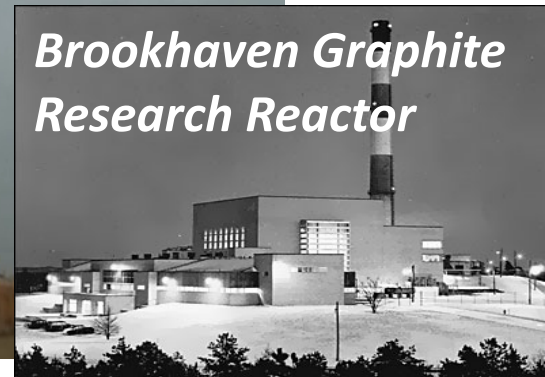
Chicago Pile 5



Heavy Water Components Test Reactor



*Experimental
Boiling Water
Reactor*



*Brookhaven Graphite
Research Reactor*

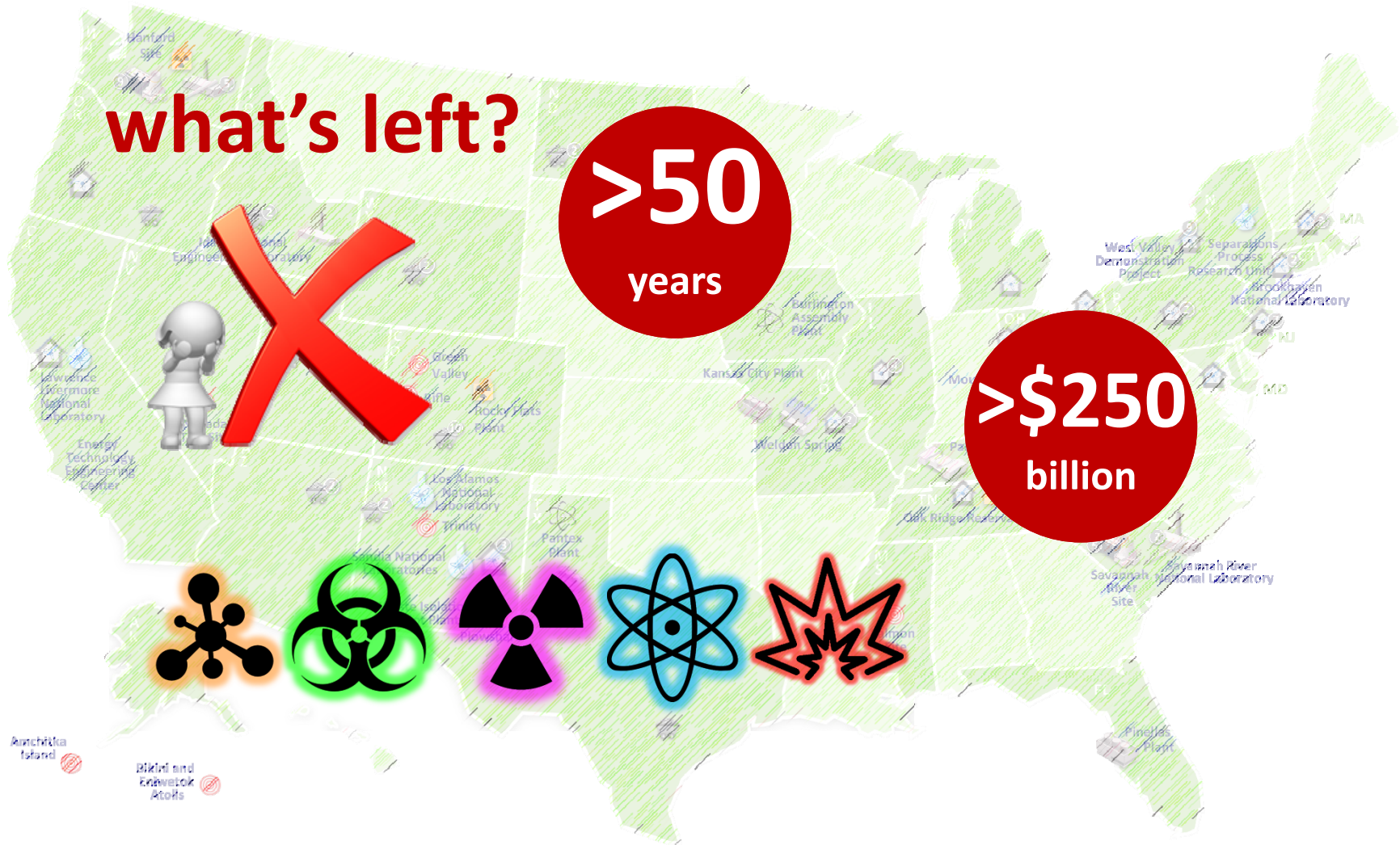
Decommissioning Successes: Other Nuclear Facilities



>715

other nuclear and
radioactive facilities
have been
decommissioned







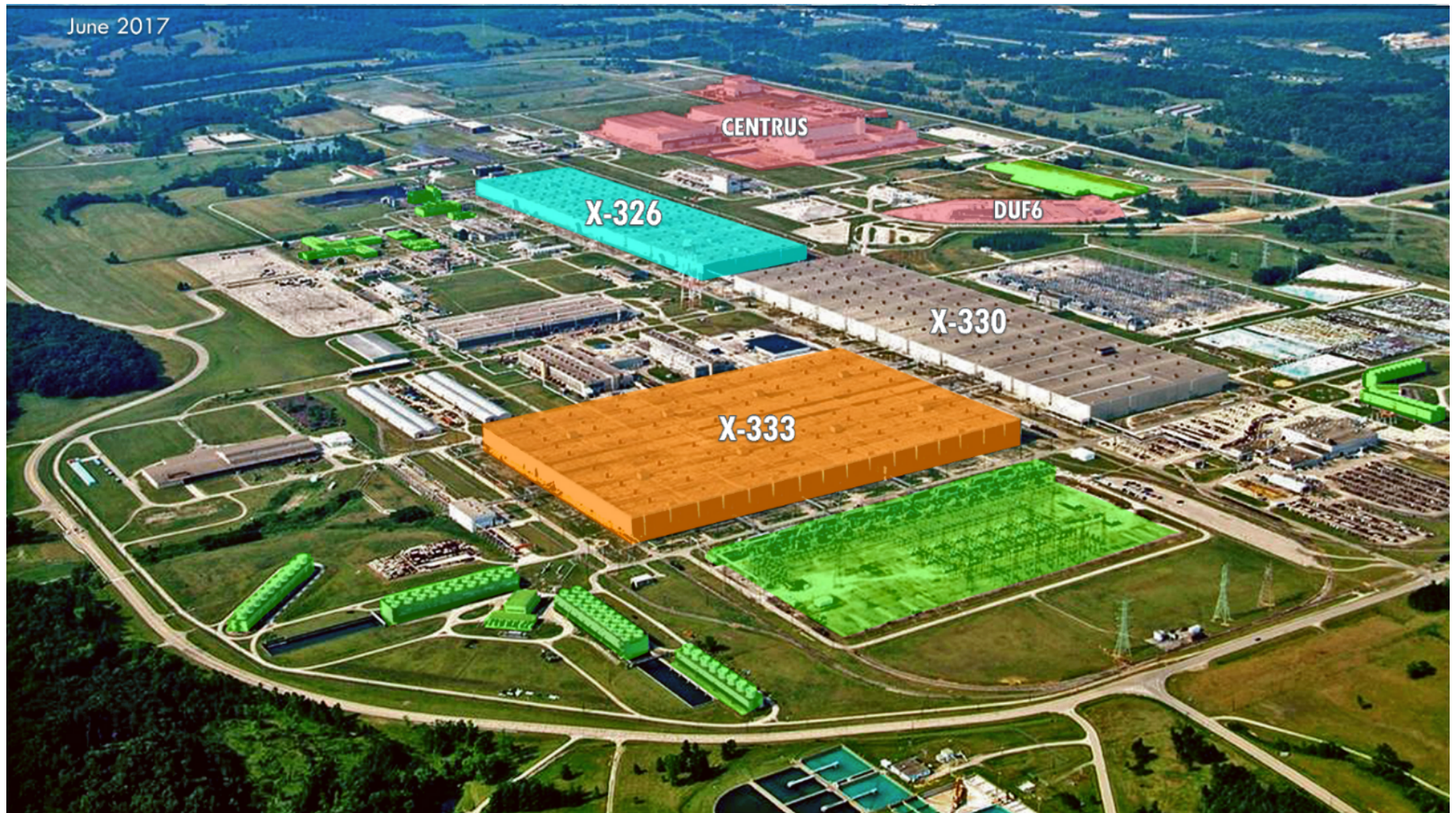
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Decommissioning Portsmouth Gaseous Diffusion Plant

*Innovative Solution to
Address Unique Challenges of
Uranium Enrichment Facilities*

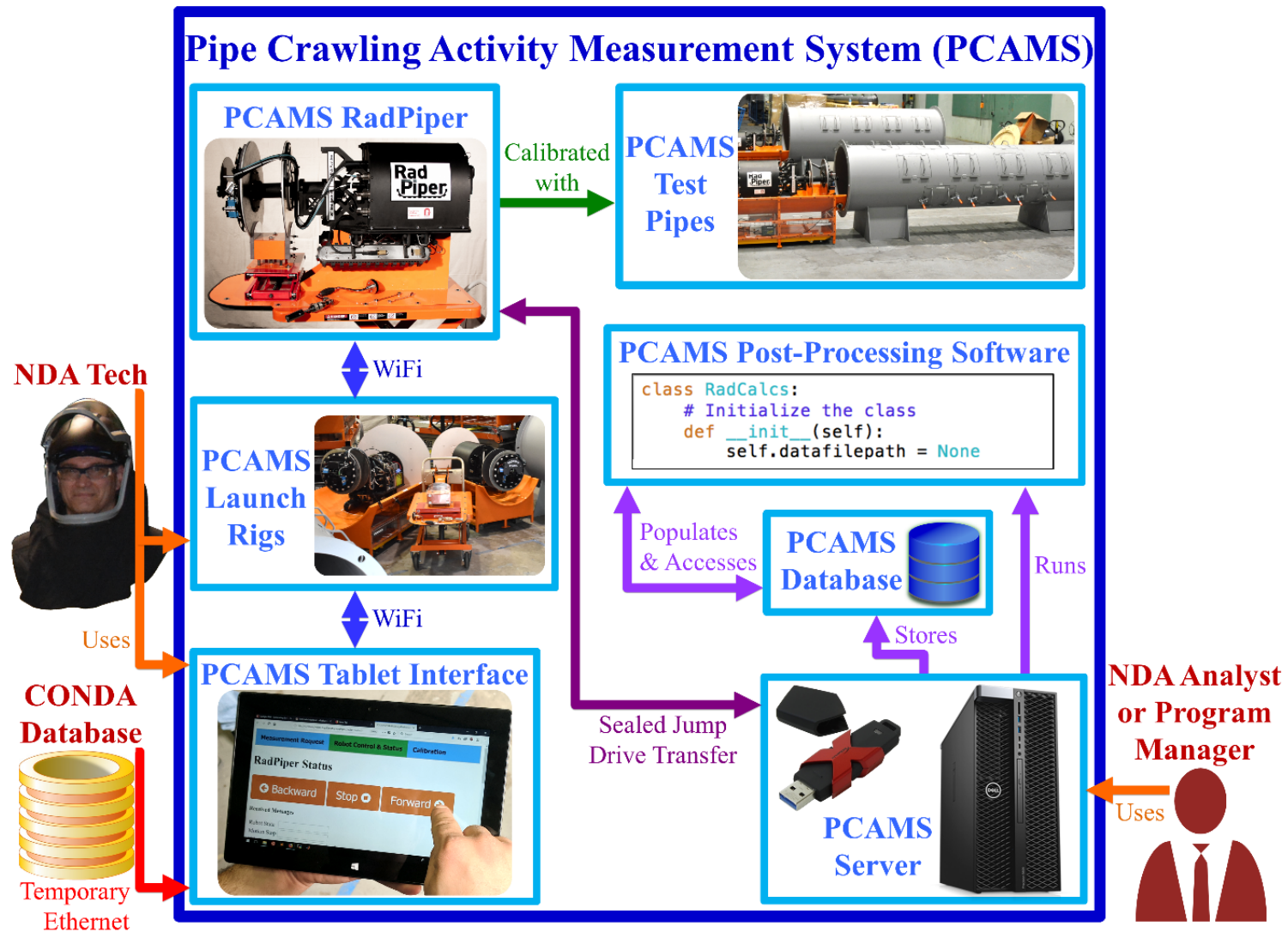
Portsmouth Gaseous Diffusion Plant Piketon, Ohio



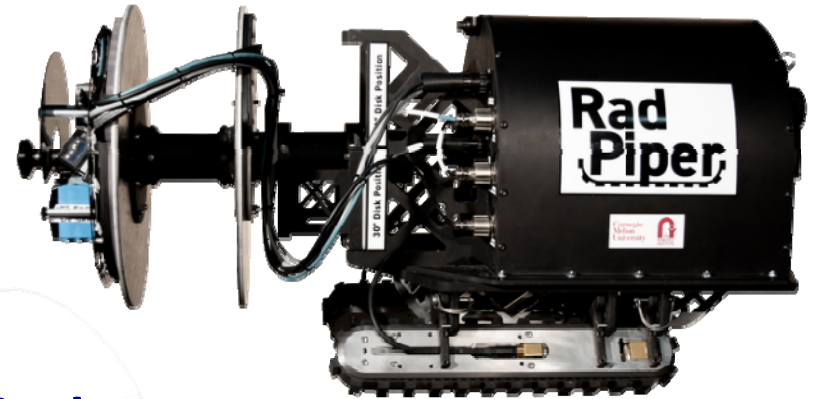
Over 15 miles of process piping to assay



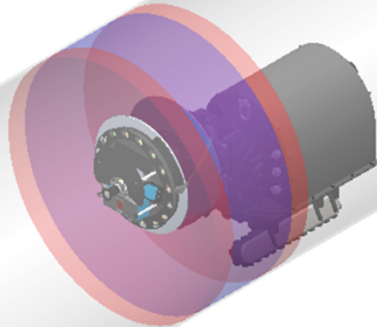
Pipe Crawling Activity Measurement System



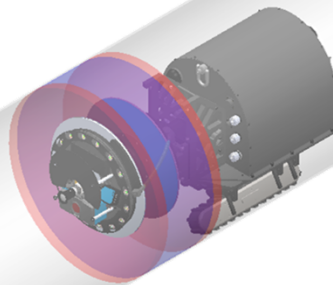
PCAMS RadPiper Robot



42-inch
piping



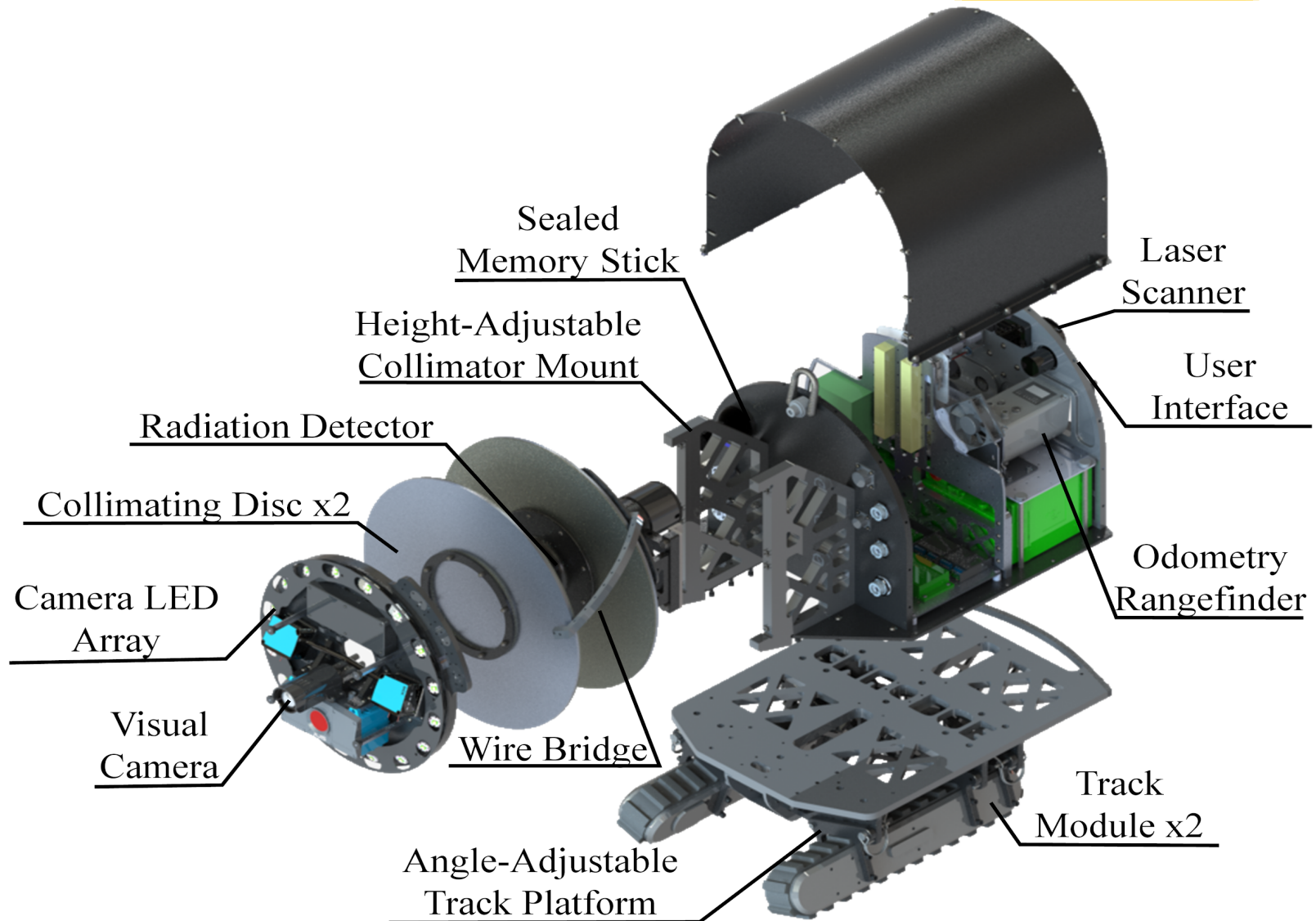
30-inch
piping



RadPiper During Mock-Up Testing

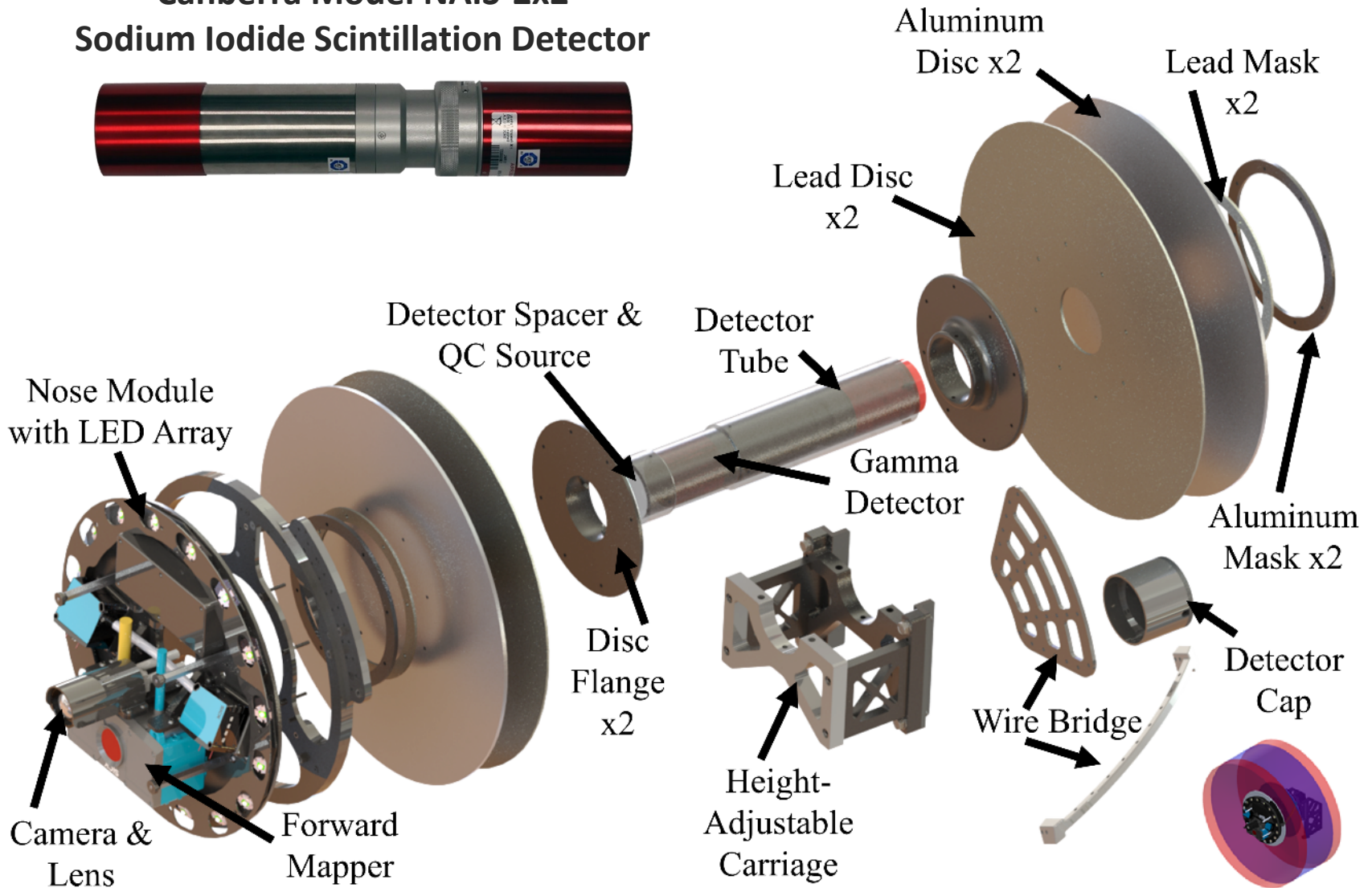


Exploded View of RadPiper

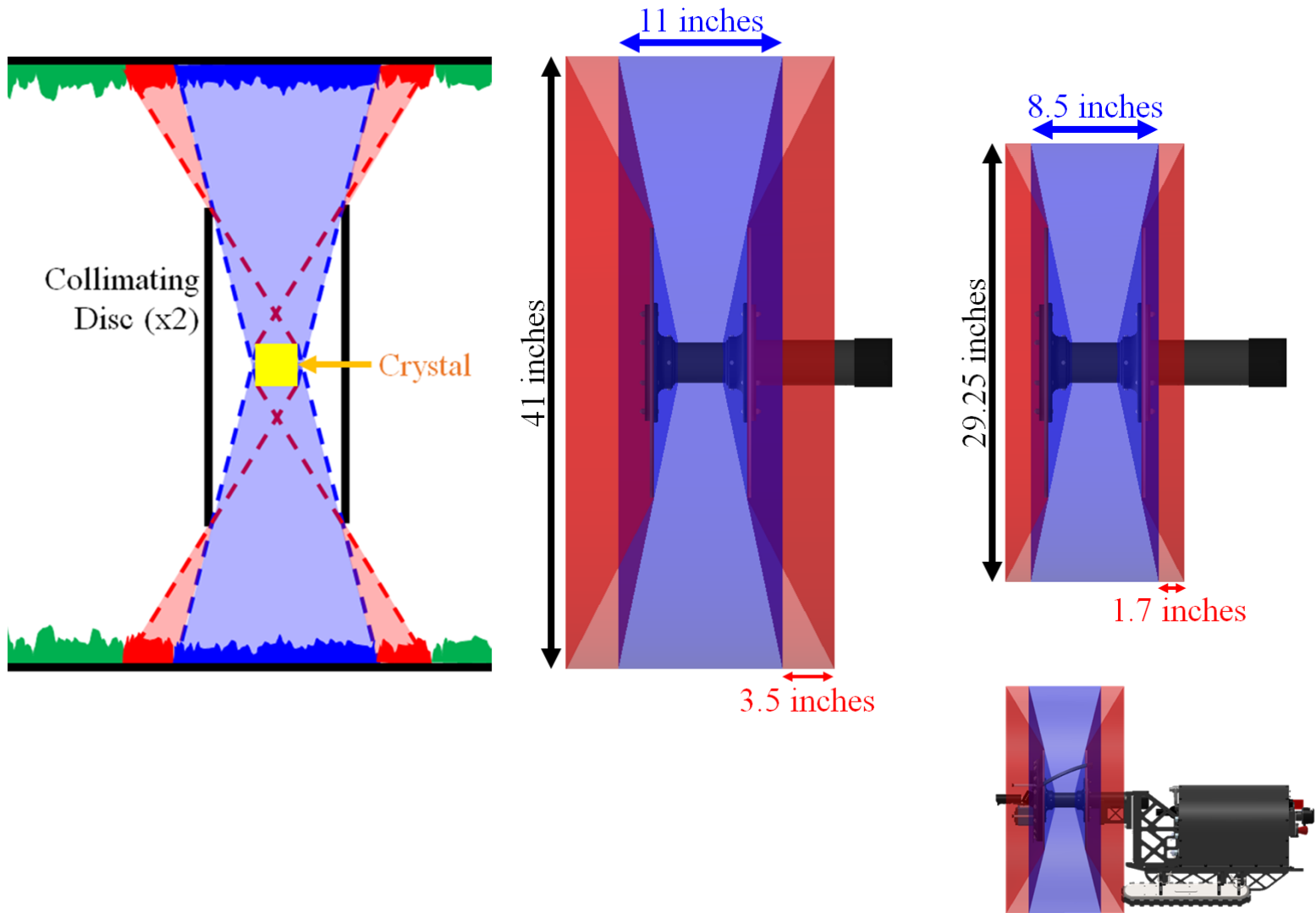


Disc-Collimated Detector Assembly

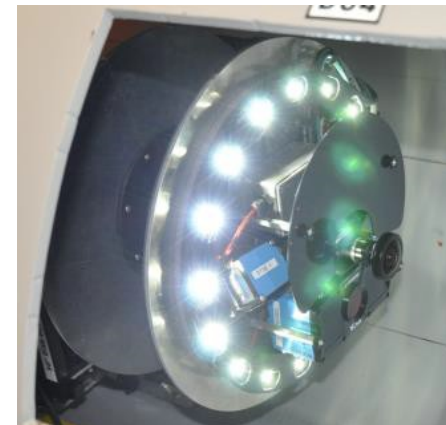
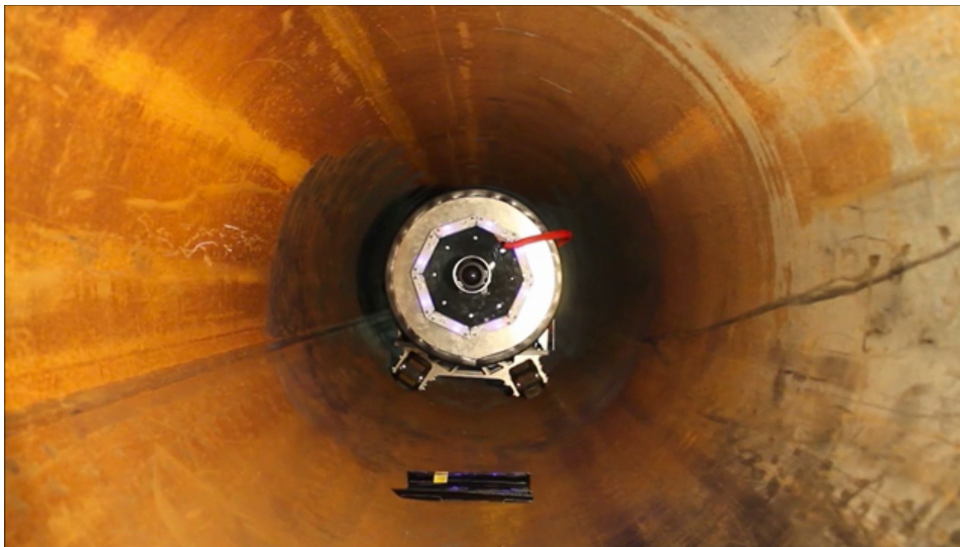
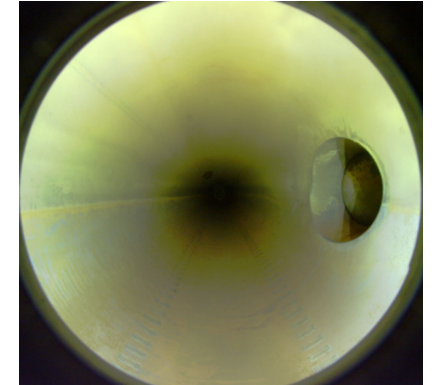
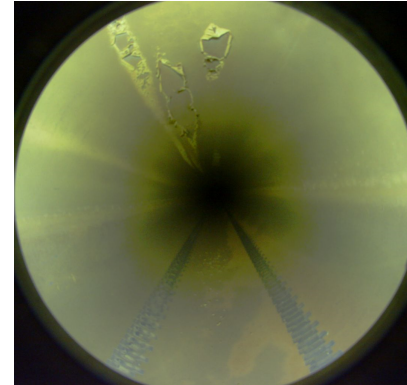
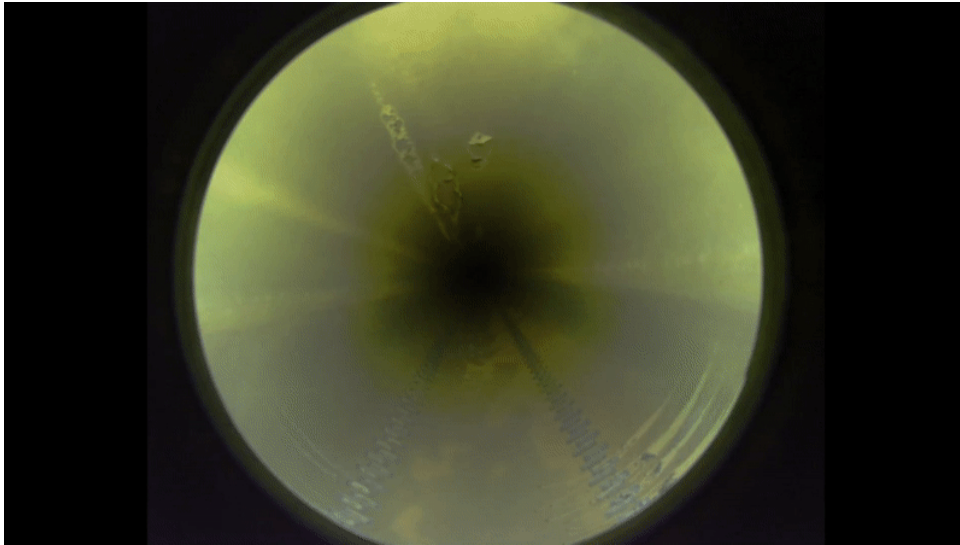
Canberra Model NAIS-2x2 Sodium Iodide Scintillation Detector



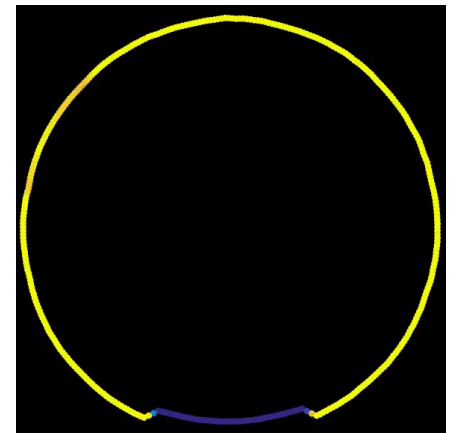
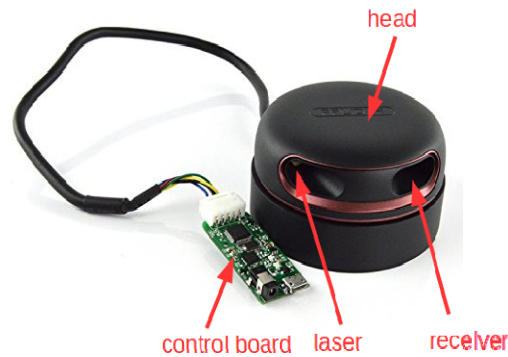
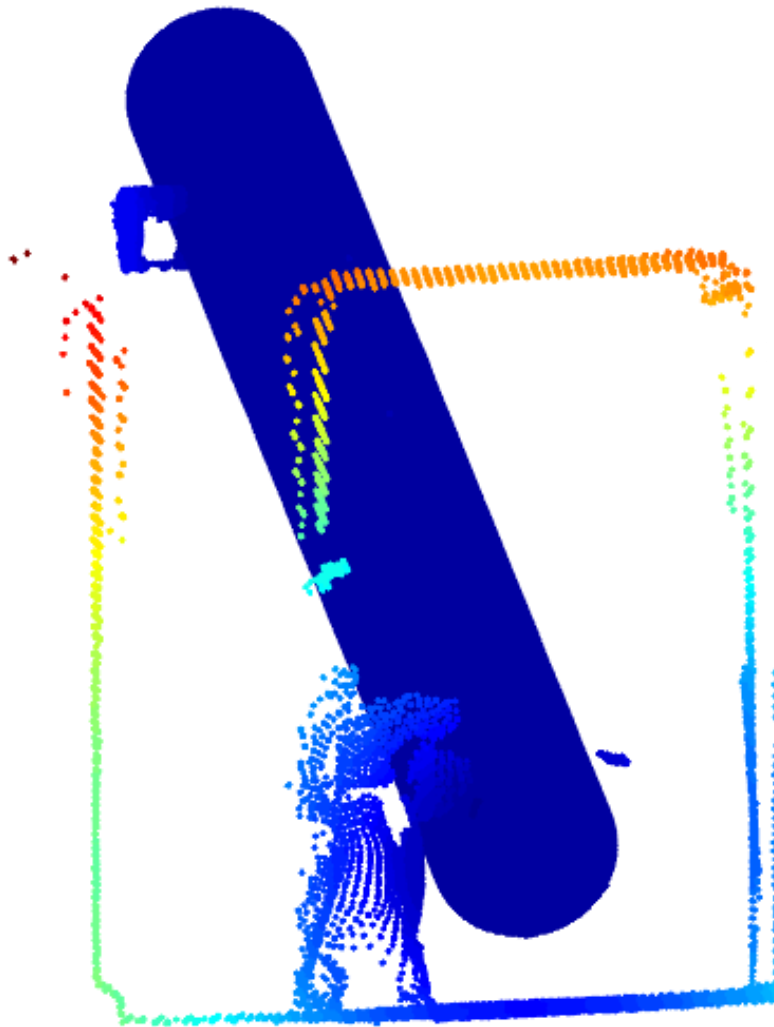
Gamma Counting Regions of View



Visual Camera with LED Array

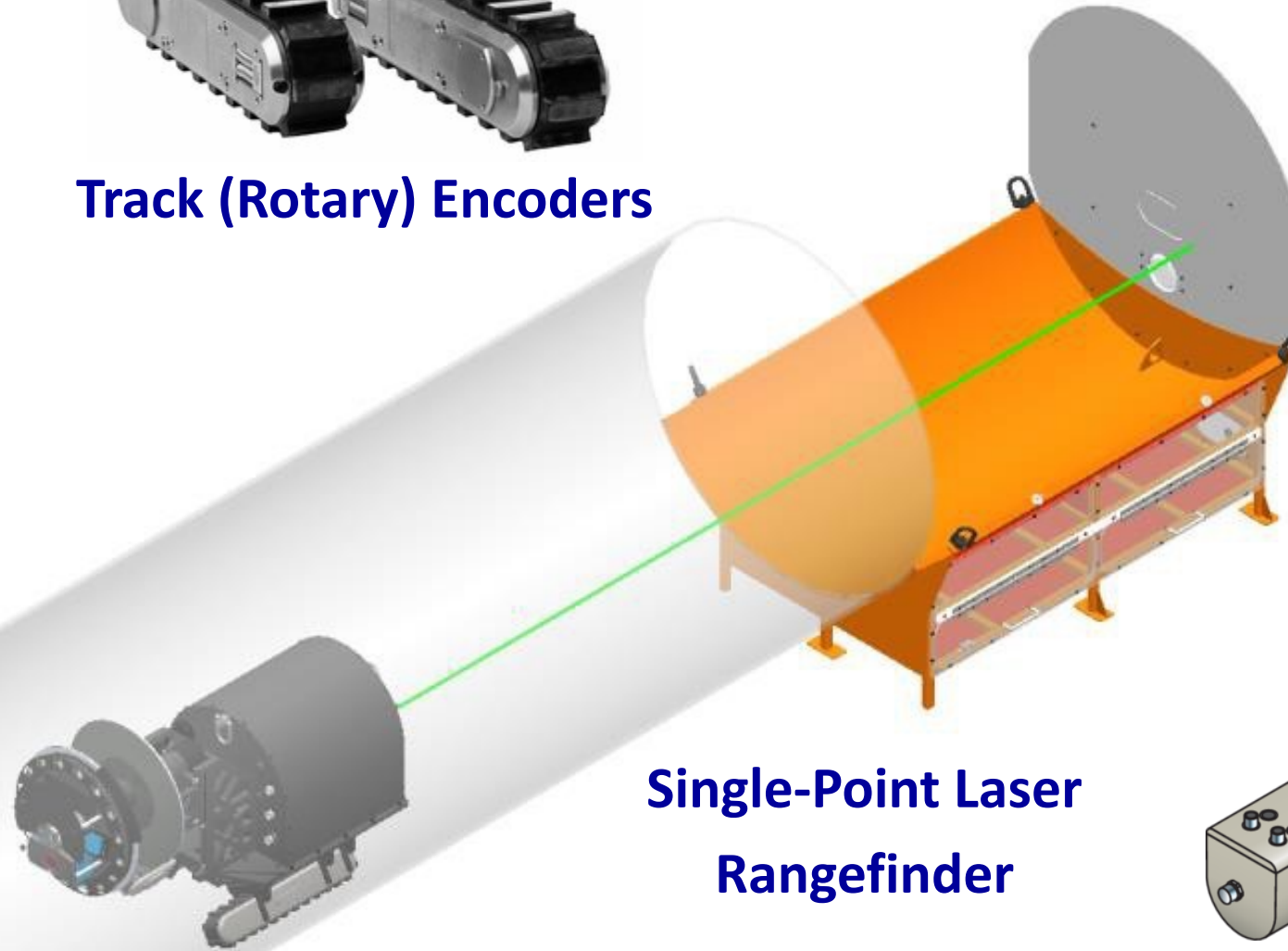


Geometry Profiler (LiDAR Mapping)

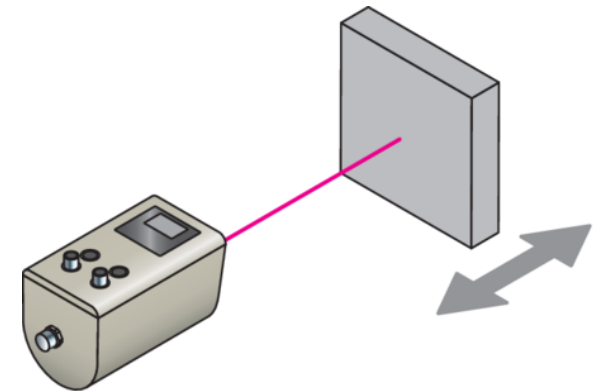




Track (Rotary) Encoders



**Single-Point Laser
Rangefinder**



User Interface (NDA Technician): Wireless Tablet

RadPiper Robot Control & Status Measurement Request Calibration QC Reports

Backward ⬅ Forward ➡

Robot State	Currently Idle
Motion Stop	Motion Enabled
Robot Displacement	0.5 Ft
Pitch	-0.68°
Voltage	26.5 V
Temperature	77.9°F

Abort! ⏹

3D Model

RadPiper Connection: [Connected](#) Robot ID: [RadPiper-01_0253](#) Version: 1.4

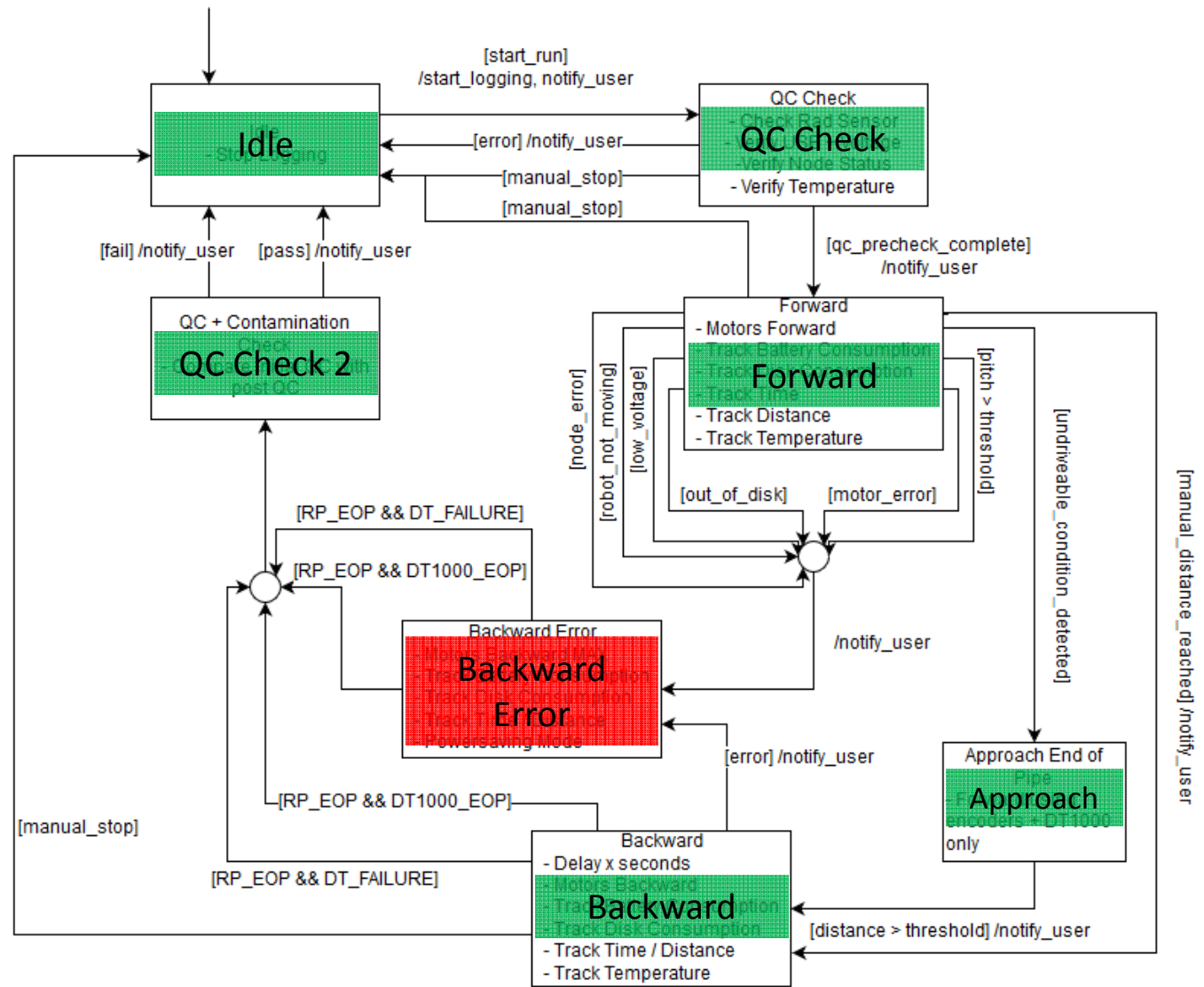
Tablet Display

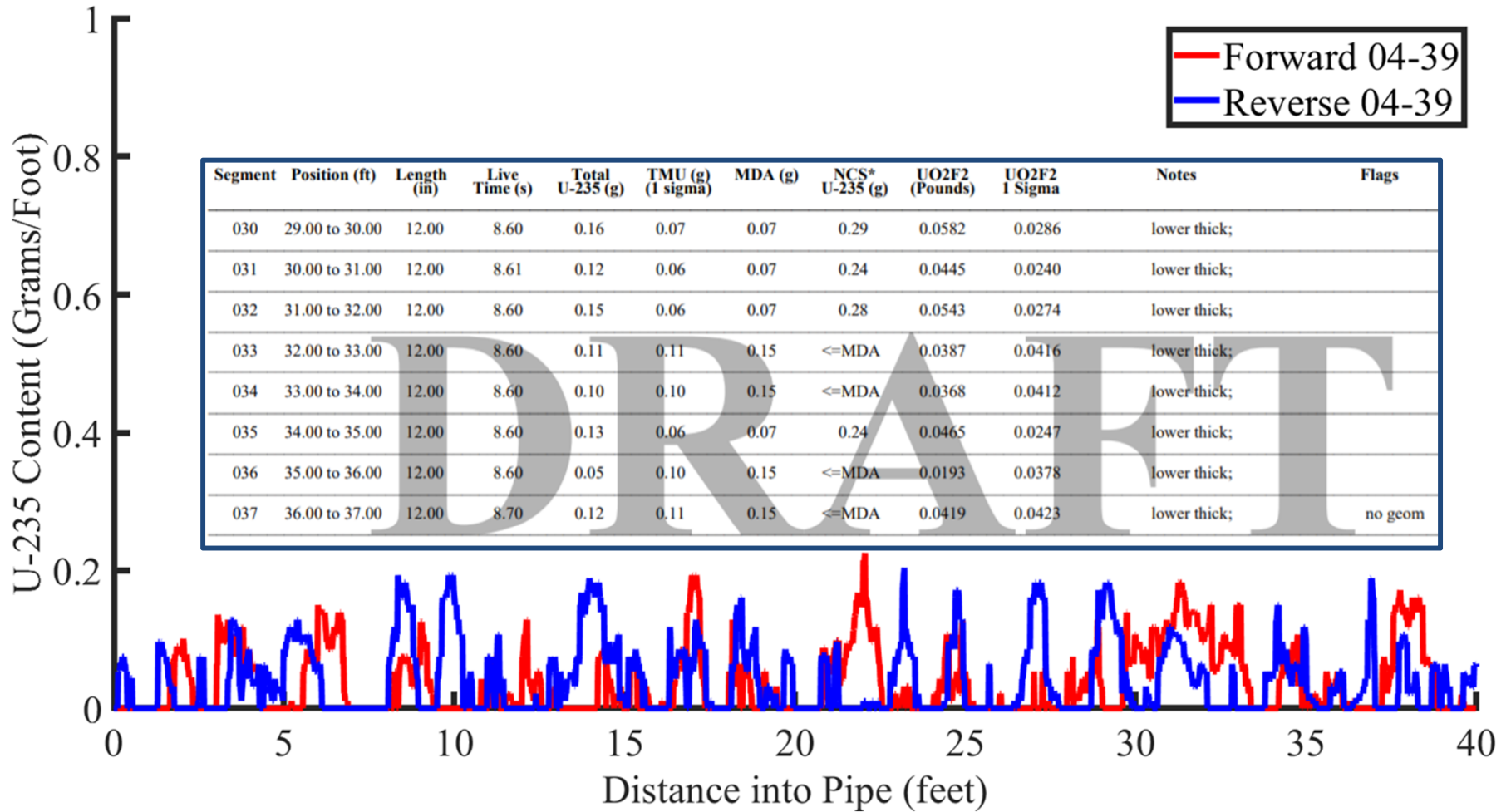
3D Model

❖ State machine

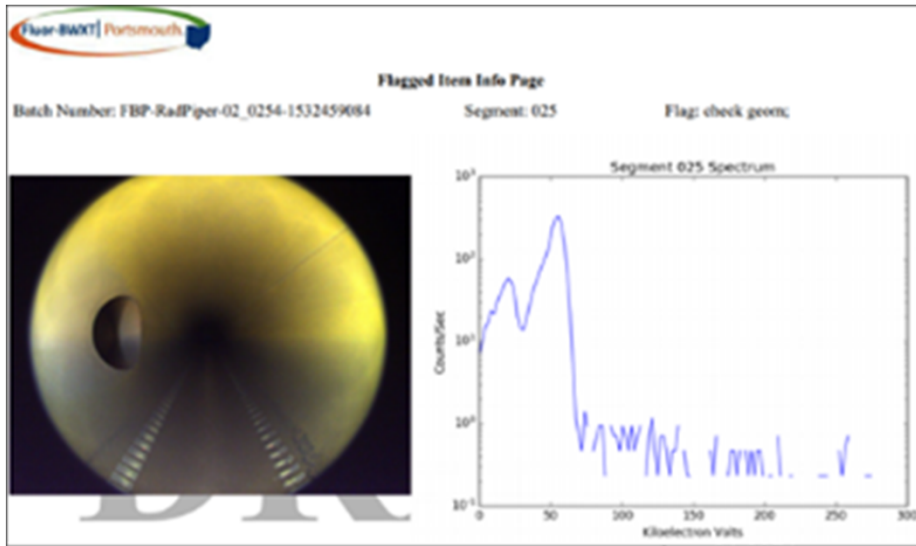
❖ Checks for errors

- Out of disk space
- Motor error
- Low battery
- High pitch





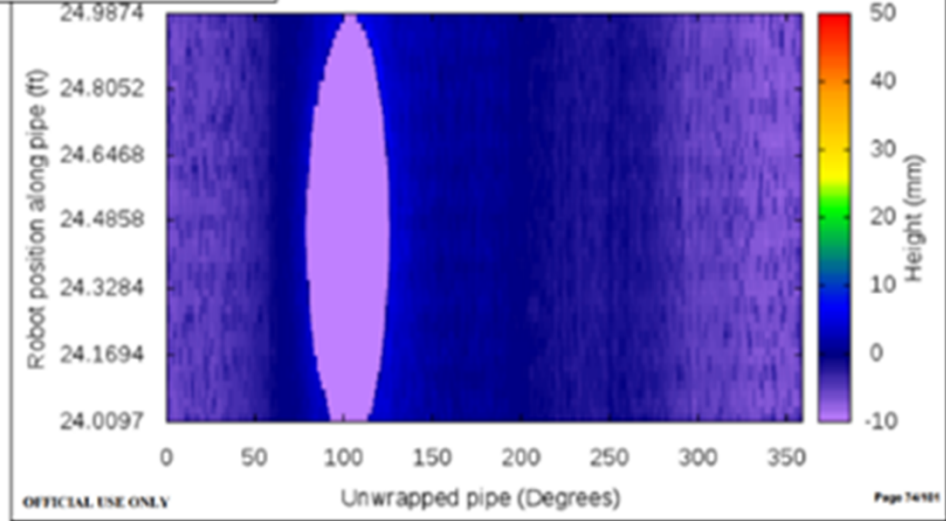
Interpreting Data Flags



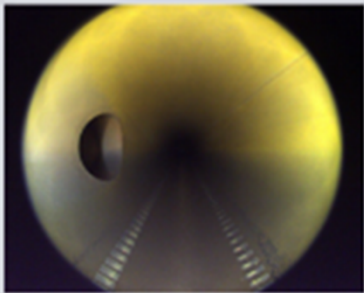
PCAMSPPS (Analyst)

Batch	Batch ID	Batch Name	Technician	Analyst	Proj Name	Batch St.
1	FDP-R-3	Barath_Vadha	Barath_Vadha	Barath_Vadha	Accepted	Accepted
2	FDP-R-3	Barath_Vadha	AKM	Barath_Vadha	Accepted	Accepted
3	FDP-R-3	Barath_Vadha	Barath_Vadha	Barath_Vadha	Submitted	Submitted

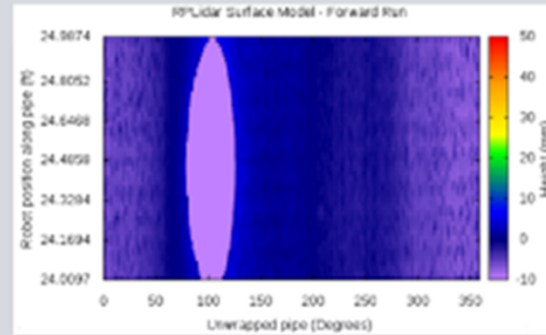
Position	Flags	Time	Length	Line Type	Forward	Backward	Forward	Backward	Forward	Backward	Forward	Backward	Accepted	Comments	
1		2018.0	12.000	8.000	3.241	3.204	0.844	0.457	0.857	0.910	3.029	2.206	0.132	0.132	new
2		2018.0	12.000	8.000	9.679	8.718	1.808	1.802	2.806	2.528	13.394	12.321	1.028	0.905	expected
3		2018.0	12.000	8.000	10.804	9.941	2.044	1.640	3.550	2.990	14.802	12.624	1.148	0.900	expected
4		2018.0	12.000	8.000	18.277	16.011	3.090	2.880	3.141	3.919	24.967	22.281	1.994	1.154	expected
5		2018.0	12.000	8.000	18.125	14.227	2.803	2.548	3.262	3.564	21.731	19.314	1.713	1.511	expected
6		2018.0	12.000	8.000	17.743	9.902	1.884	1.900	3.402	2.868	15.547	13.703	0.832	1.057	expected
7		2018.0	12.000	8.000	11.914	9.900	2.127	2.013	2.941	3.231	16.108	13.932	1.266	1.052	expected
8		2018.0	11.788	8.790	9.152	8.136	1.800	1.796	2.295	2.776	12.762	12.271	0.932	0.975	expected
9		2018.0	8.510	20.201	6.788	5.803	1.904	1.607	1.533	1.533	9.127	7.887	0.722	0.625	expected



Details: 12

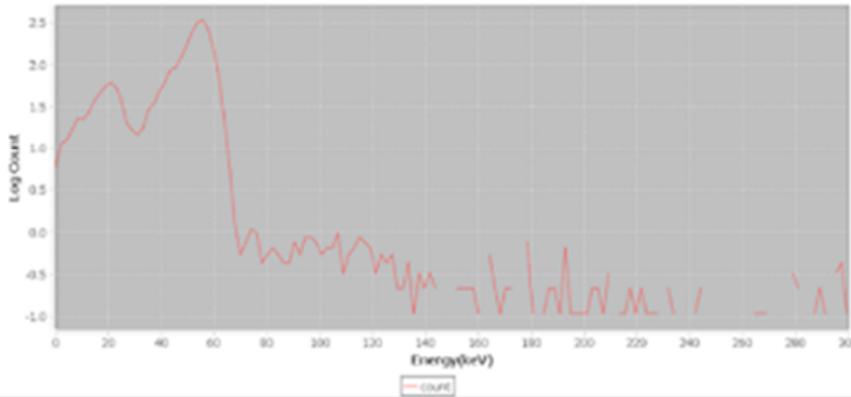


Position: 25
Distance: 24.119 ft

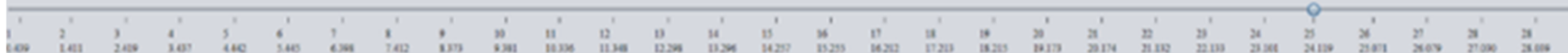
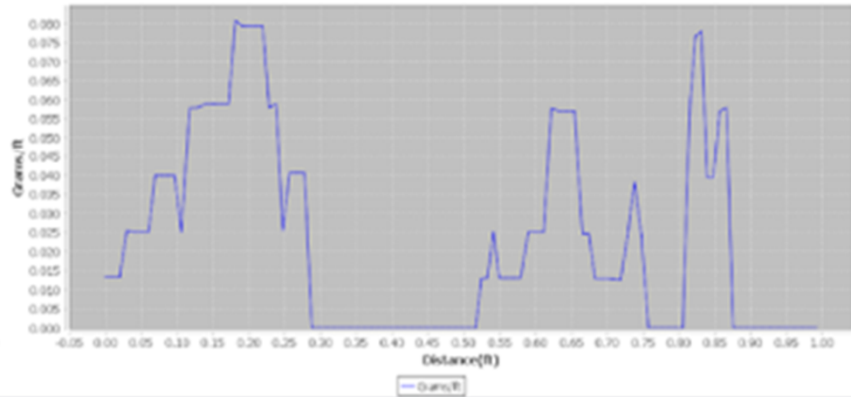


Position: 25

Spectrum



Deposit



Automatically Generated and Archived Quality NDA Reports

Batch Number: FBP-RadPiper-02_0253-1531104555

RadPiper NDA Batch Data Report

FLUOR-BWXT PORTSMOUTH

Project Name	Fluor/BWXT
Measurement Requester	John Lee
Measurements Performed By	C. M. F. B. Co.
Analyst Name	2018-07-14 15:56:57.345
Measurement Location (Building & Cell)	Building
Measurements Item Identification	1
RadPiper System ID	RadPiper-02_0253
Standard Operating and Calibration Procedures and Technical Basis Documents	<i>Linked into PCAMS - can be modified by administrator - Document names and numbers provided by FBP</i>
RadPiper Operating Software Title and Version Number	PCAMS RadPiper 4.0.0.0 (20180708) 4004.F321.0033.0129.040-
PCAMS Analysis and Reporting Software Title and Version Number	PCAMS Software 2.3 PCAMS Software 2.3
Method Description	<i>Linked into PCAMS - can be modified by administrator - Text provided by FBP</i>
QC Check Source	OSHA 48 CFR 1.1001 (a)(1)(IX) (2008-2-2)
Initial Calibration Filenames	RadPiper-01_0253_300CaCon_2018-07-23-11-44-43.bag, cal_eff_2018-07-26-09-26-28.bag, radpiper_bag_2018-06-19-18-29-36.bag, radpiper_bag_2018-06-19-21-45-47.bag, 2018-06-27_2018-07-26_2018-06-19_2018-06-19
Initial Calibration Dates	RadPiper-01_0253_300CaCon_2018-07-23-11-44-43.bag, RadPiper-01_0253_300CaCon_2018-07-23-12-49-23.bag, RadPiper-01_0253_300CaCon_2018-07-23-13-00-59.bag, RadPiper-01_0253_300CaCon_2018-07-23-13-10-56.bag, RadPiper-01_0253_300CaCon_2018-07-23-13-20-02.bag, RadPiper-01_0253_300CaCon_2018-07-23-13-29-22.bag, RadPiper-01_0253_42CaCon_2018-07-23-15-07-25.bag, RadPiper-01_0253_42CaCon_2018-07-23-15-18-21.bag, RadPiper-01_0253_42CaCon_2018-07-23-15-28-48.bag, RadPiper-01_0253_42CaCon_2018-07-23-16-06-58.bag, RadPiper-01_0253_42CaCon_2018-07-23-16-18-04.bag, RadPiper-01_0253_42CaCon_2018-07-23-16-29-05.bag
Calibration Confirmation Filenames	
Calibration Confirmation Dates	2018-07-23, 2018-07-23, 2018-07-23, 2018-07-23, 2018-07-23, 2018-07-23, 2018-07-23, 2018-07-23, 2018-07-23, 2018-07-23, 2018-07-23, 2018-07-23
Calibration Verification Filenames	radpiper_2018-07-14-15-56-57.bag
Calibration Verification Date	2018-07-14
Days Since Last Calibration Verification	204
Measurement	
Within Calibration Window	No
Data Acquisition Date	2018-07-08
Batch Number	FBP-RadPiper-02_0253-1531104555
Total Pipe Length	3.33 feet
Estimated Pipe Length	100.00 feet
Segments Measured	5



PCAMS NDA Measurement Data Report Version 8.8.8

Batch Number:	FBP-RadPiper-02_0253-1531104555	Location:	Highway
Pipe ID:	5	Pipe Diameter:	30
RadPiper ID:	RadPiper-02_0253	Speed (ft/min):	9.65
Measurement Date:	2018-07-08	Enrichment:	1.0

Segment Position (ft)	Time	Length (ft)	Live Time (s)	Total U-235 (g)	TMC (g)	MDA (g)	NC% U-235 (g)	UOP2 (pounds)	UOP2 Sigma 1	Notes	Flags	Comments	
001	0:00 to 1:00	22:50:44	12:00	12.10	20.97	3.97	1.48	31.91	0.0001	0.0032	Ca7,	Highway drive warning	No
002	1:00 to 2:00	22:50:38	12:00	12.10	1.77	0.46	0.43	2.72	0.0039	0.0011	Ca7,	no green drive warning	No
003	2:00 to 3:00	22:50:32	12:00	12.10	6.47	0.79	0.28	6.13	0.0010	0.0004	Ca7,	no green drive warning	No
004	3:00 to 4:00	22:50:26	12:00	12.40	6.25	0.34	0.25	6.00	0.0007	0.0003	Ca7,	no green	No

DRAFT

Robot Operator: CMU/FBC Secondary Operator: NJ Date: 2018-07-08 22:49:15
 NDA Specialist: Heather Date: 2018-07-14 15:56:57.345
 Program Manager: Date:

* "NC% U-235" is reported as the measured total grams plus 2 sigma or as "MDA" if MDA is greater than the measured total grams.

- ❖ **Quality Data (NDA-1) for**
 - **Nuclear Criticality Safety**
 - **Waste Characterization and Disposal**
- ❖ **Enhanced Safety**
 - **Construction**
 - **Occupational**
 - **Radiological → ALARA**
- ❖ **Schedule Acceleration**
 - **Faster Assay (4 inches/minute vs 9.8 feet/minute)**
 - **Automated quality data and reporting**
- ❖ **Cost Savings → \$10 million to \$50 million per facility**
- ❖ **Improved Data and Records Management**
- ❖ **Work Easier**



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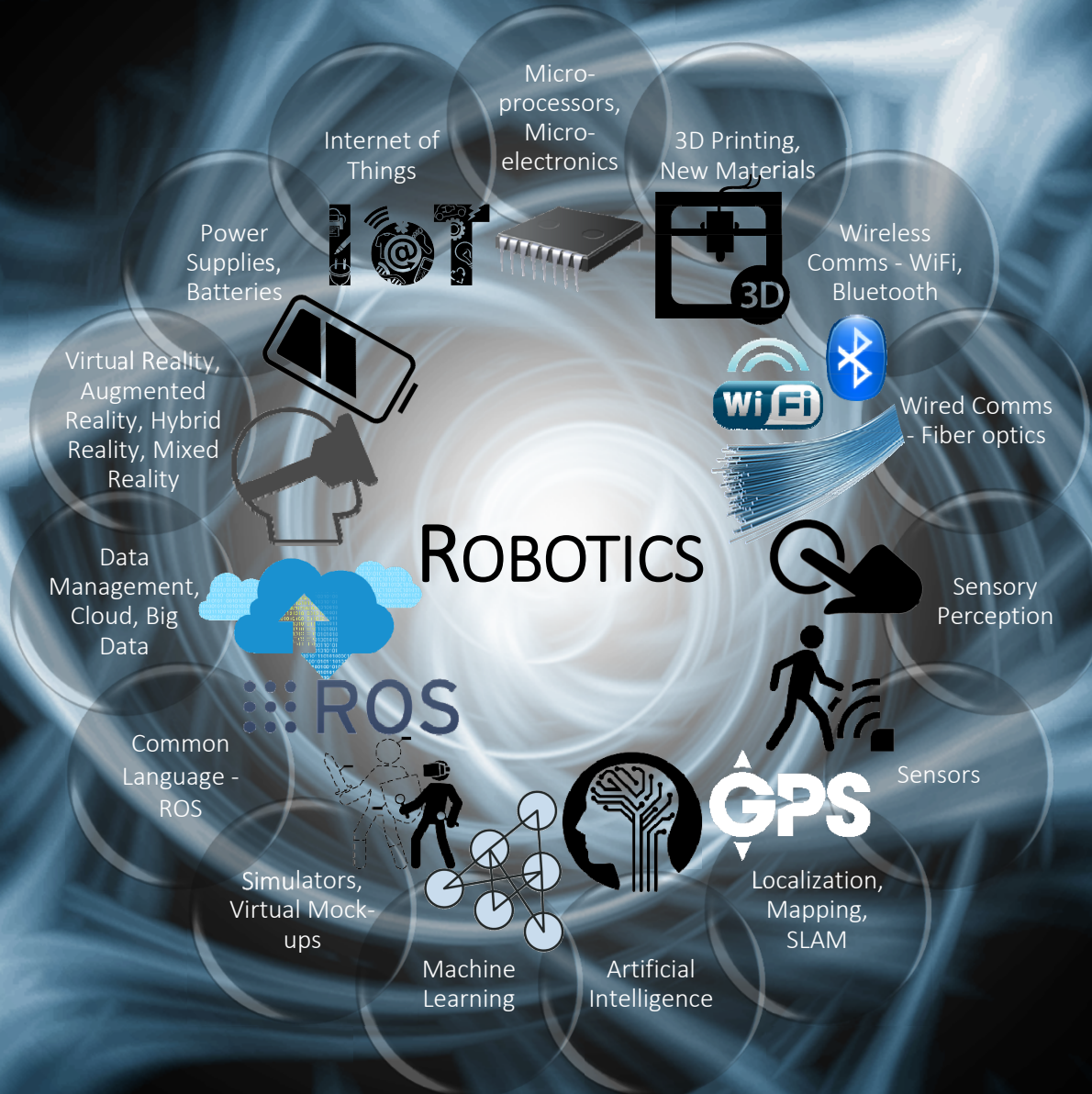
Final Remarks

❖ Designs are being investigated and/or developed

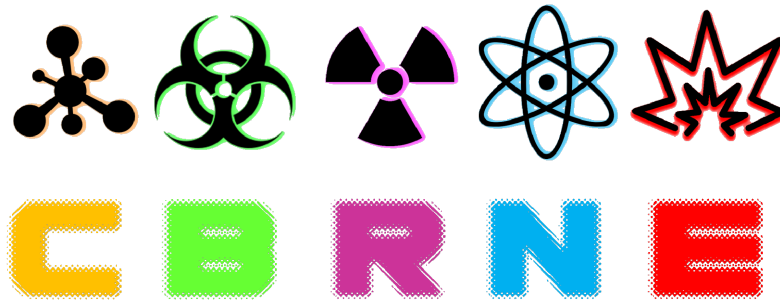
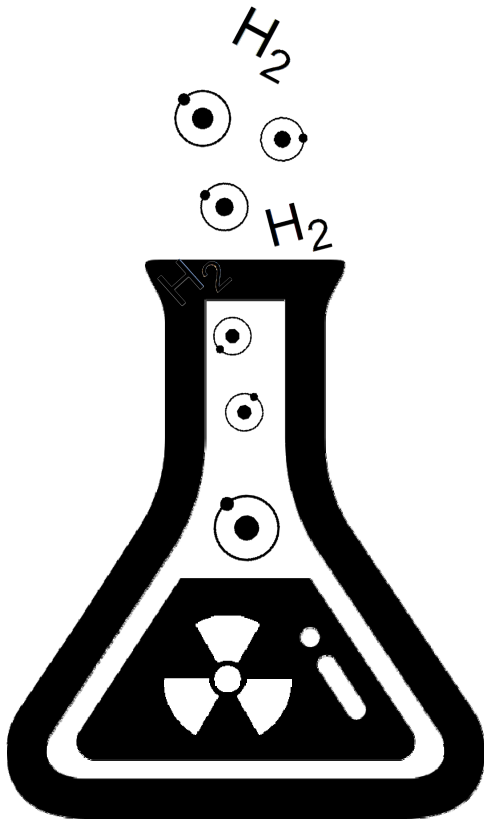
- 3- to 24-inch piping
- Pipe bends, elbows
- Vertical piping
- Process components



Technology Fusion



High-Hazard, High-Consequence, High-Risk Tasks



Broad Relevance and Utility



Dangerous

Dirty

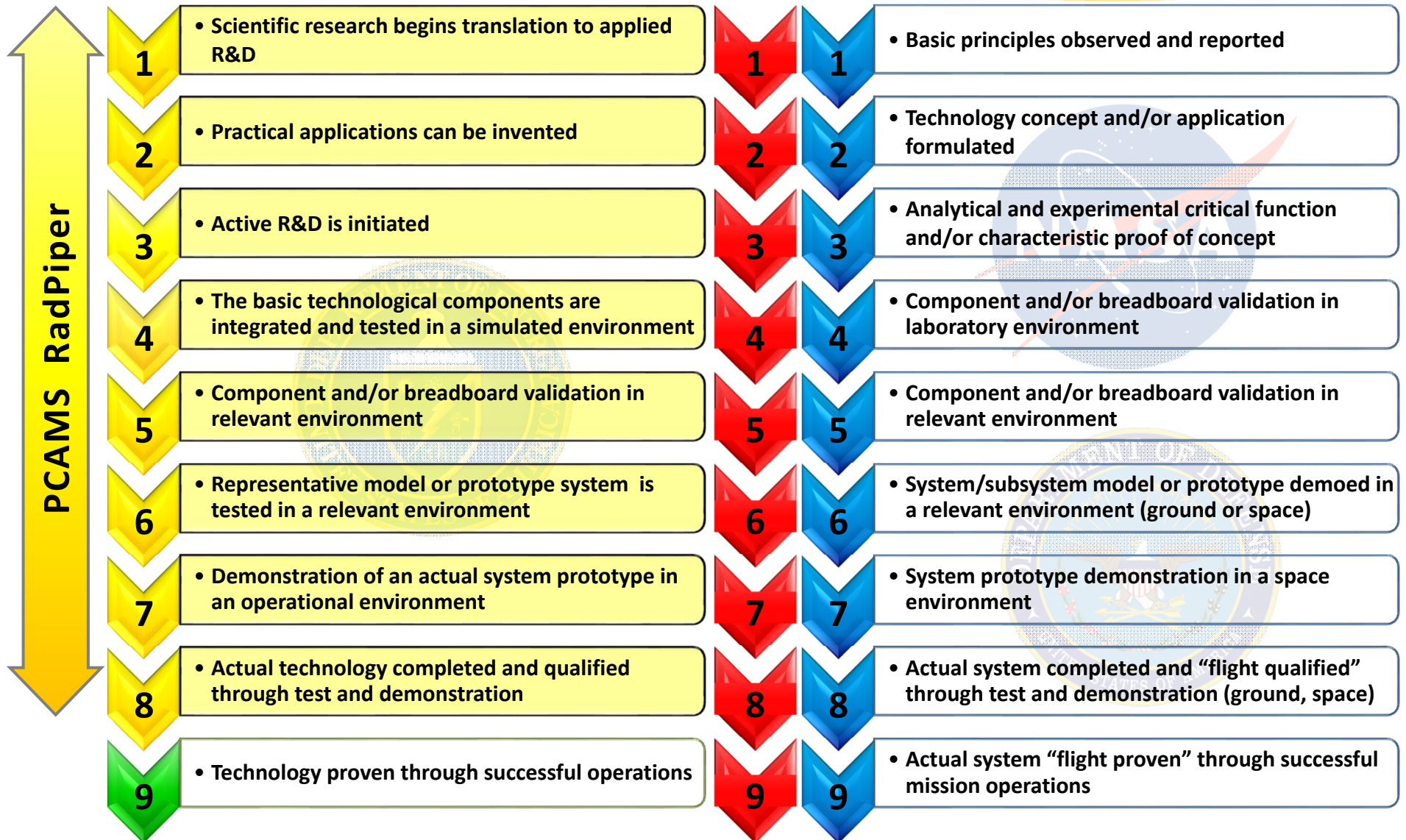
Dull

Difficult

- ❖ **Complex tasking**
- ❖ **Complex configurations**
- ❖ **Unknown, unstructured and/or changing environment**
- ❖ **Varying nature and extent of CBRNE**
- ❖ **Decision-making, reasoning**
- ❖ **Anticipation, prediction, reaction**
- ❖ **Maintain positive control**



Rapid Technology Maturation








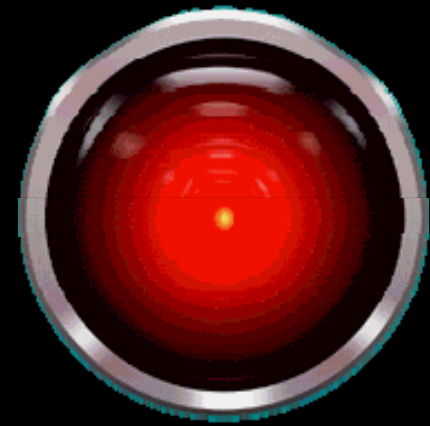


Rodrigo (Rod) V. Rimando, Jr.
rodrigo.rimando@em.doe.gov



Questions?

I'm sorry attendees.
I'm afraid this
briefing has just
been terminated.



2001: A Space Odyssey

HAL 9000 (Heuristically programmed Algorithmic computer)