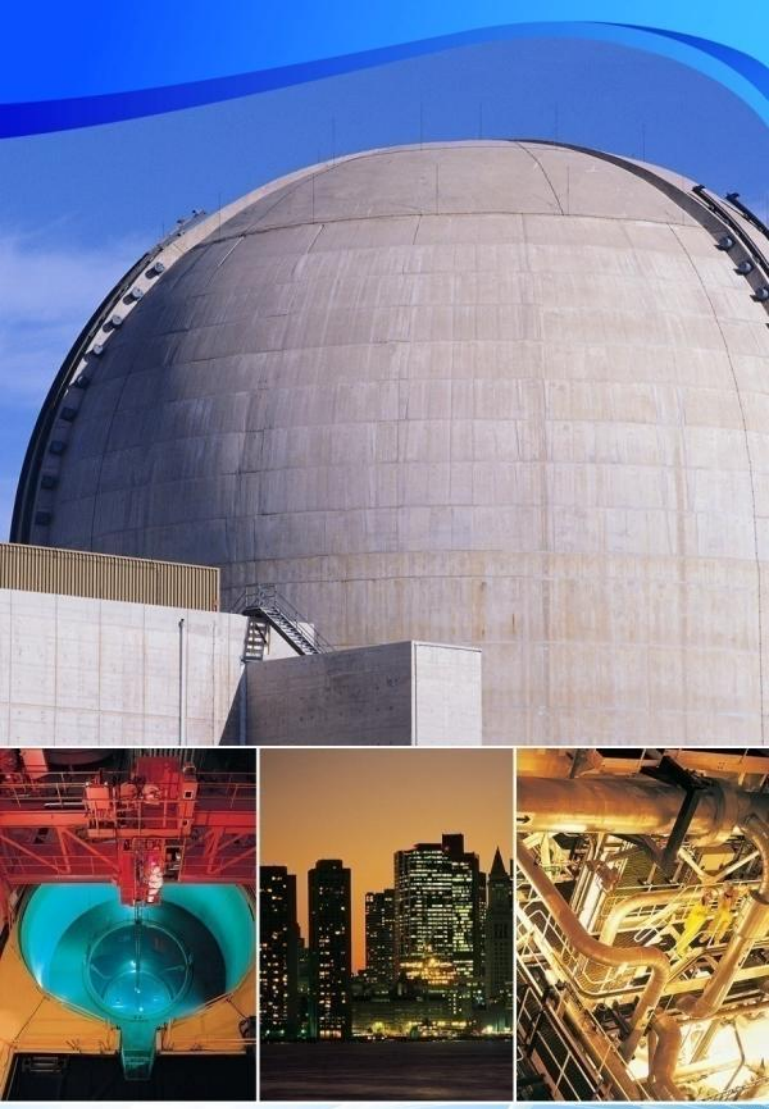


ELECTRIC POWER RESEARCH INSTITUTE

EPRI Radiation Management Program: Review of Radiation Field Reduction Strategies

ISOE Asian Technical Center ALARA Symposium
September 8th, 2009

Dennis Hussey, Ph.D.
Sr. Project Manager

Radiation Management, Chemistry, LLW, Fuel Reliability

Overview

EPRI Support of RP2020

Boiling Water Reactor Highlights

- Elemental cobalt measurements
- BWR Shutdown Calculations

Pressurized Water Reactor Highlights

- Dose Rate Trends

Radiation Protection Technology Demonstrations

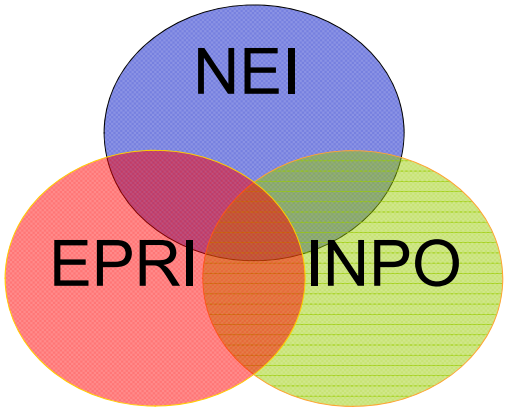
RP2020 Mission

Reshape radiological protection at nuclear power plants to achieve significant improvements in safety performance and cost-effectiveness.

Partners in Creating RP 2020

Radiation Protection Managers

Chief Nuclear Officers



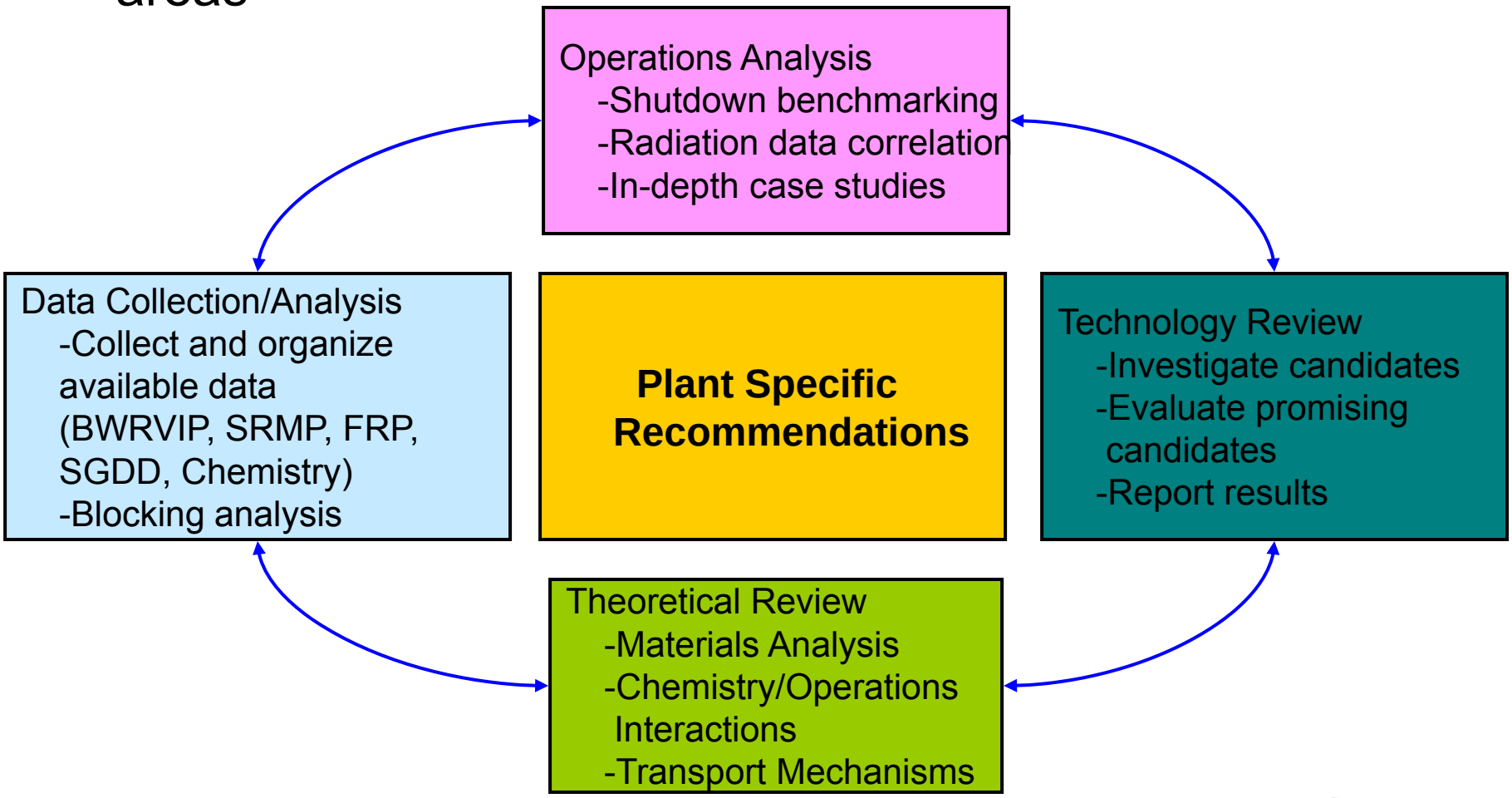
NEI = Policy
INPO = Performance
EPRI = Research

RP2020 Strategies and EPRI Status

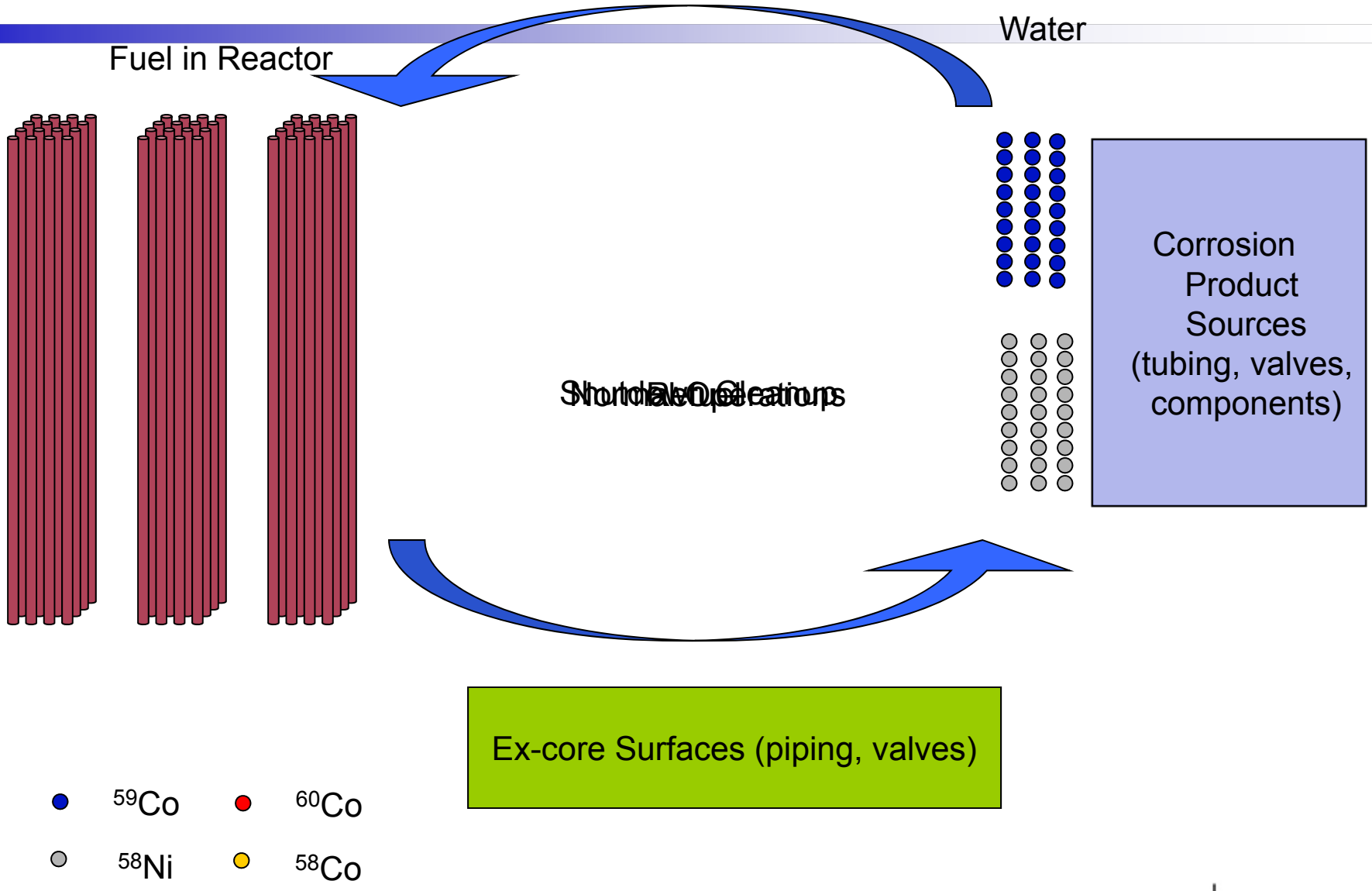
- **Reduce radiation fields—EPRI**
- **Improve technologies utilization—EPRI**
- Standardize RP criteria & practices—ALL
- Redefine RP roles/responsibilities—NEI/INPO/EPRI
- Influence RP regulations—NEI

Source Term Reduction Program Strategy

- EPRI Source Term Reduction Program focuses on four areas



Source Term Activation and Transport



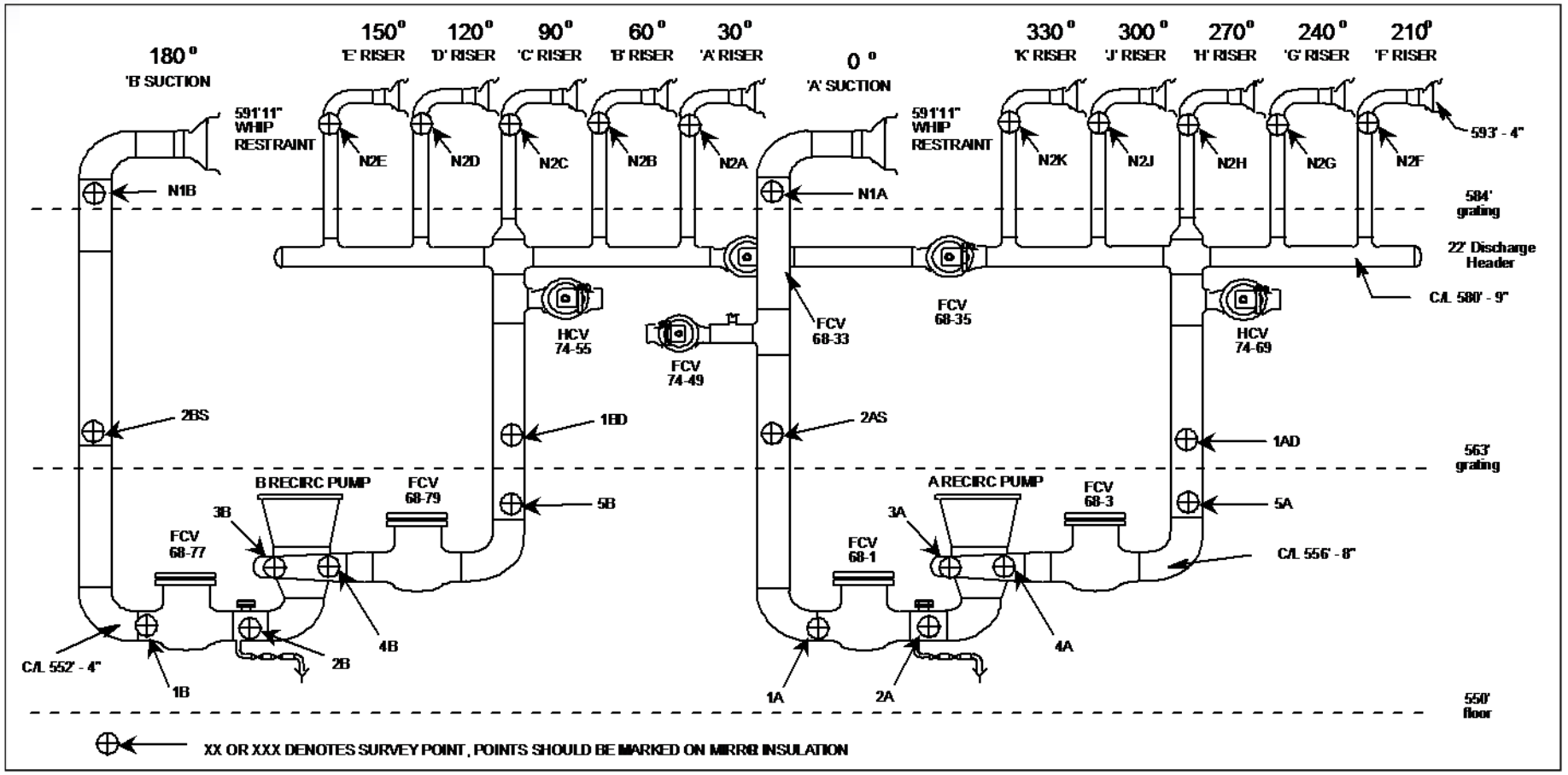
Source Term Magnitude By Location
PWR Example

Location	Surface Loading (uCi/cm^2)	Total Curies
Fuel	Co-58 = 250 Co-60 = 12	~10,000-15,000 Ci Co-58 ~500-750 Ci Co-60
Removal During Shutdown	N/A	500-5000 Ci Co-58 5-50 Ci Co-60
Ex-core Surfaces (including tubing, piping, channel heads)	Co-58 = 8 Co-60 = 3	~150-200 Ci Co-58 ~ 70 Ci Co-60

BWR Source Term Reduction Project

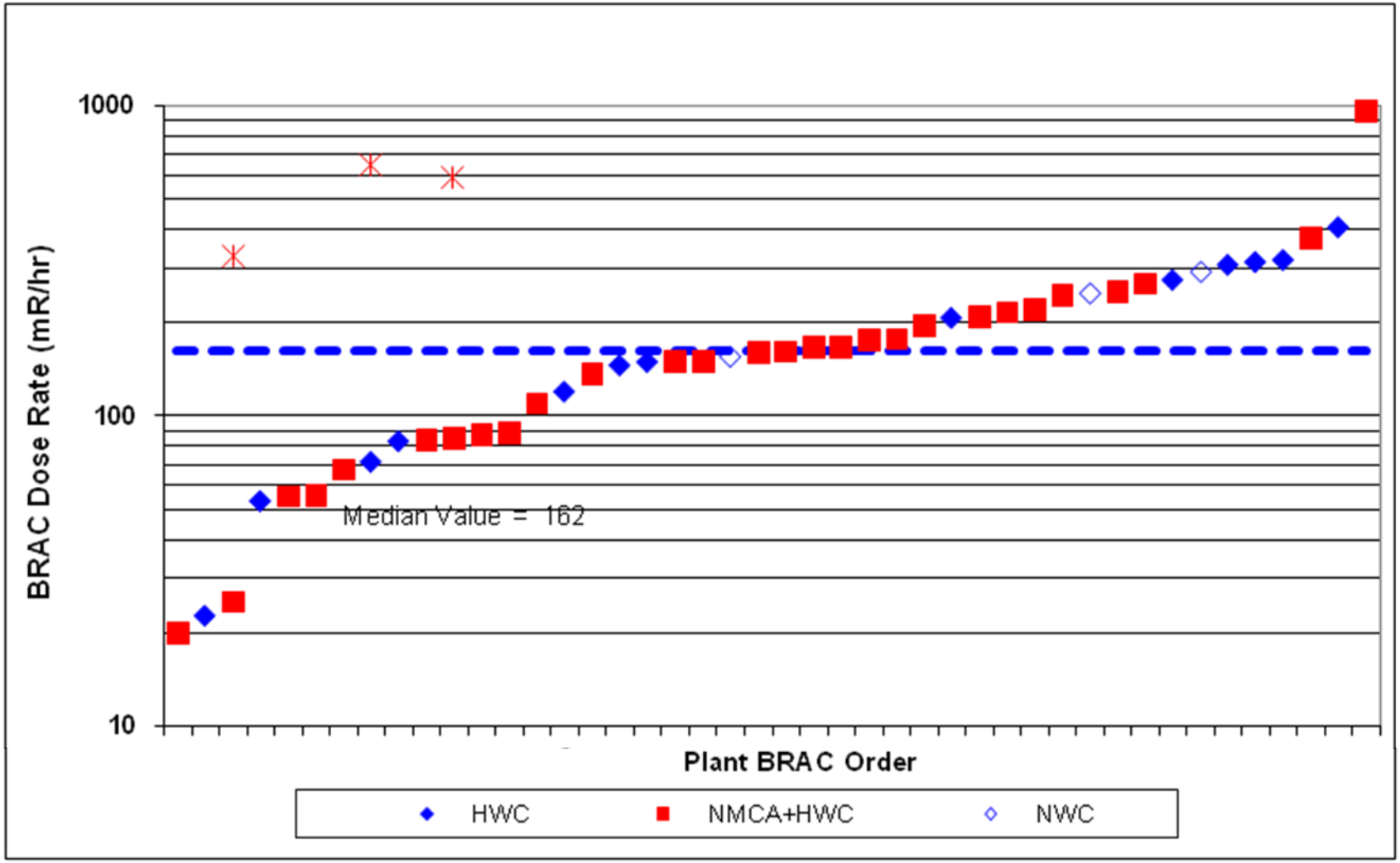
- BWR Source Term Reduction – Estimating Cobalt Transport to the Reactor (Report #1018371)
- Goals of Project
  - Identify how plants measure cobalt
  - Target cobalt sources
  - Benchmark cobalt transport to reactor
  - Quantify removal and releases during shutdown and normal operations

BRAC Measurement Points



BRAC Radiation Fields (June 2008)

Mitigation Strategy



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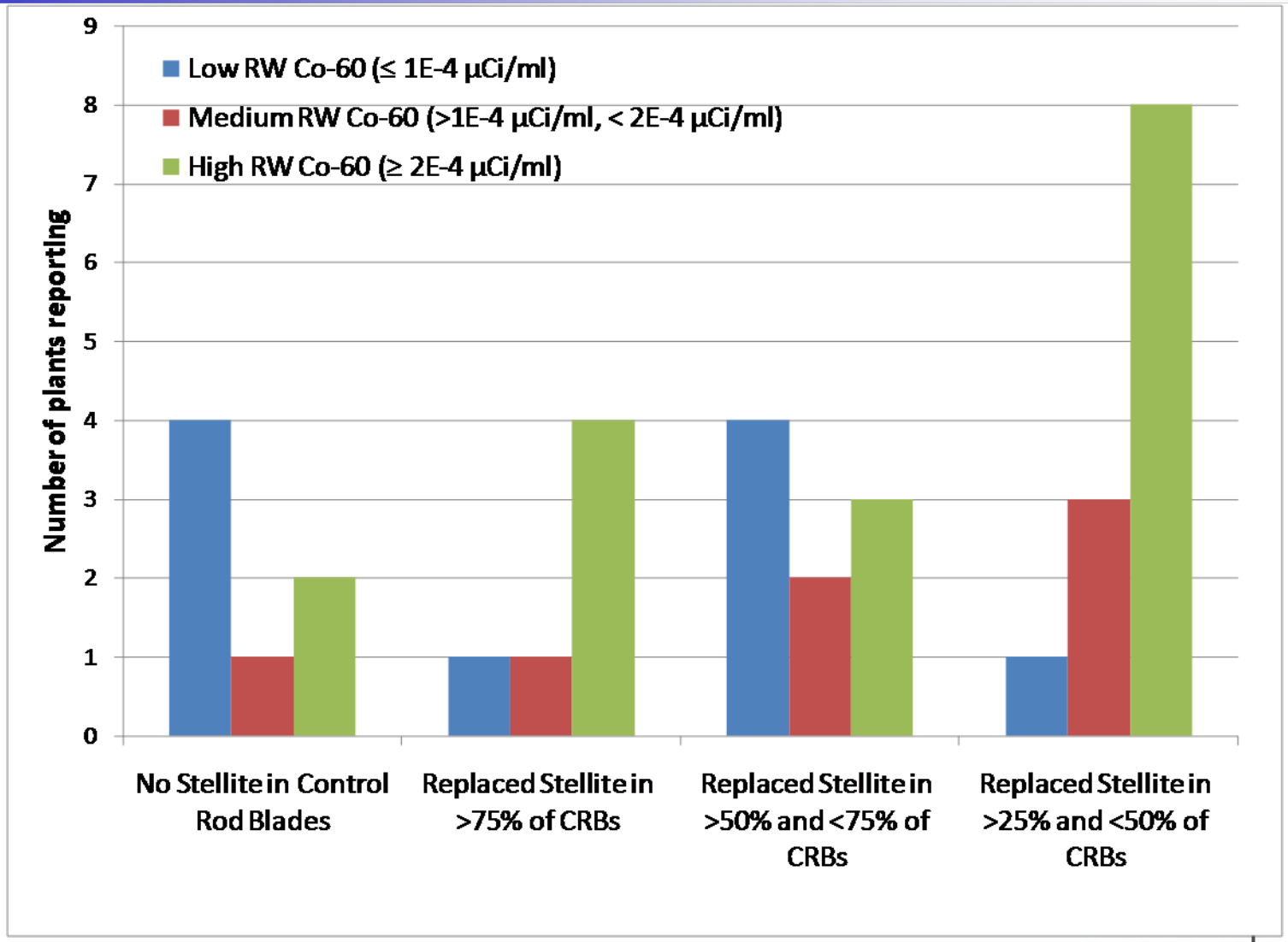
BWR Benchmarking/Source Term Ranking

- Co-60 Categories and BRAC

Parameter	Low Rxtor Water Co-60 Plants (≤ 1E-4 µCi/ml)	Moderate Reactor Water Co-60 Plants (>1E-4 µCi/ml, < 2E-4 µCi/ml)	High Reactor Water Co-60 Plants (≥ 2E-4 µCi/ml)
Average Co-60; µCi/ml	7.95E-5	1.38E-4	4.13E-4
Median Co-60; µCi/ml	6.48E-5	1.40E-4	2.79E-4
Co-60 Range; µCi/ml	1.94E-5 to 2.74E-4	5.98E-5 to 3.29E-4	9.42E-5 to 1.83E-3
Average BRAC; mR/hr	130	251	262
Median BRAC; mR/hr	89	261	168
BRAC Range; mR/hr	23-406	150-375	20-965

Impact of Control Rod Blade Replacement on Reactor Water Cobalt



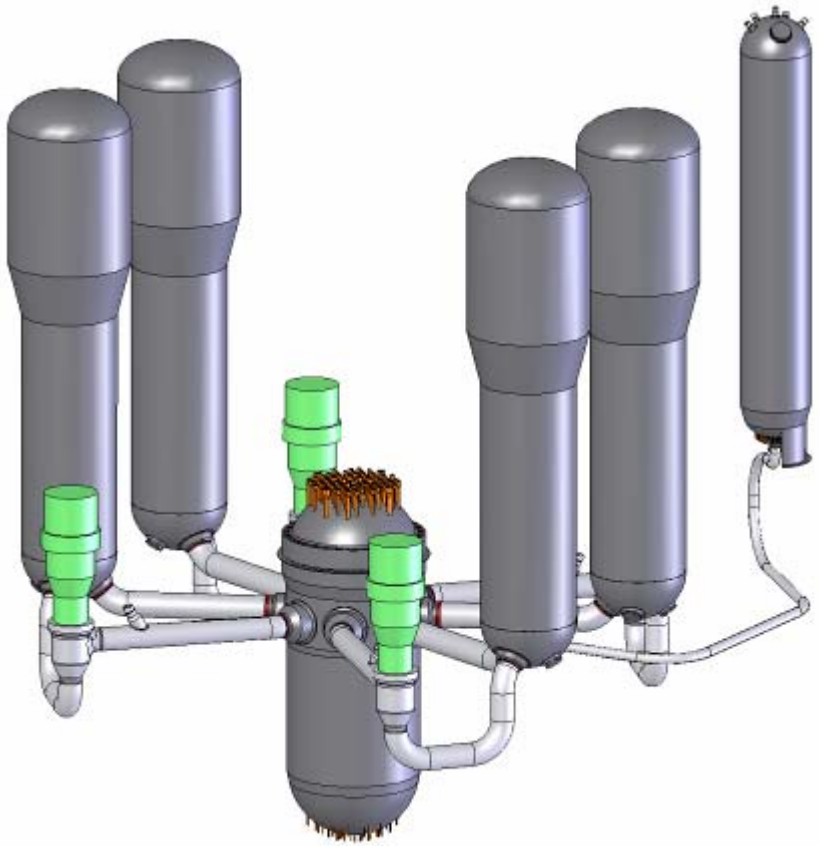
BWR Summary and Recommendations

- Recommendations
  1. Plants should update cobalt source term reduction status (CRBs, turbine components, valves, etc.)
  2. Conduct industry survey to see if plants have performed NP-2263 source identification evaluations
  3. Conduct a further evaluation on elemental cobalt sampling with focus on sample collection, preparation and analytical methods

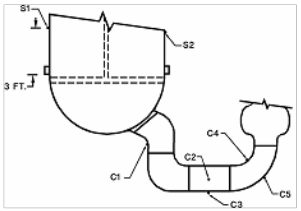
PWR Source Term Reduction
Technology Evaluations—Report 1016767

- Key Results
  - Zinc continues to show significant radiation benefits
  - pH effects noticed when comparing before and after PWR Primary Guidelines
    - Ringhals, San Onofre report benefits of elevated pH
    - Comanche Peak 1 and 2 do not show clear benefits
  - Long term benefits of electropolishing are noted

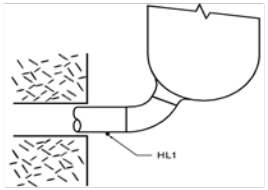
Westinghouse SRMP Monitoring Points



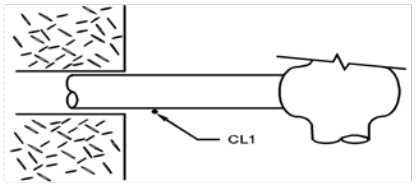
Loop piping



Crossover piping and SG

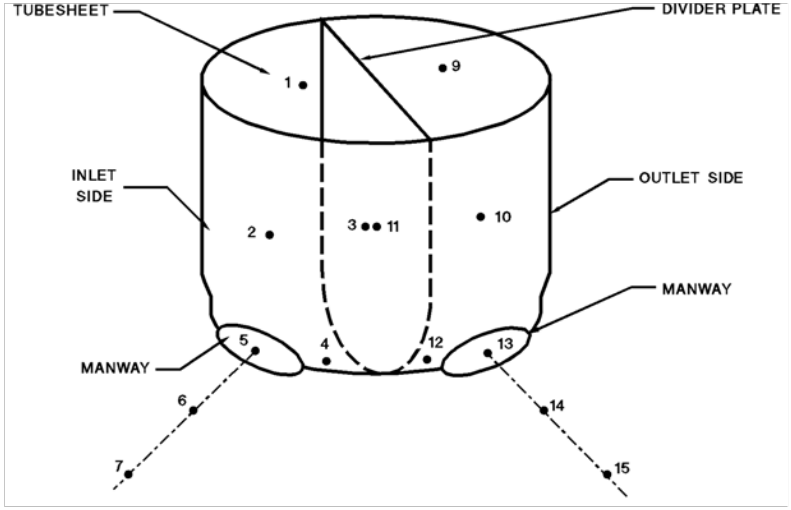


Hot leg piping



Cold leg piping

Steam Generator Channel Head



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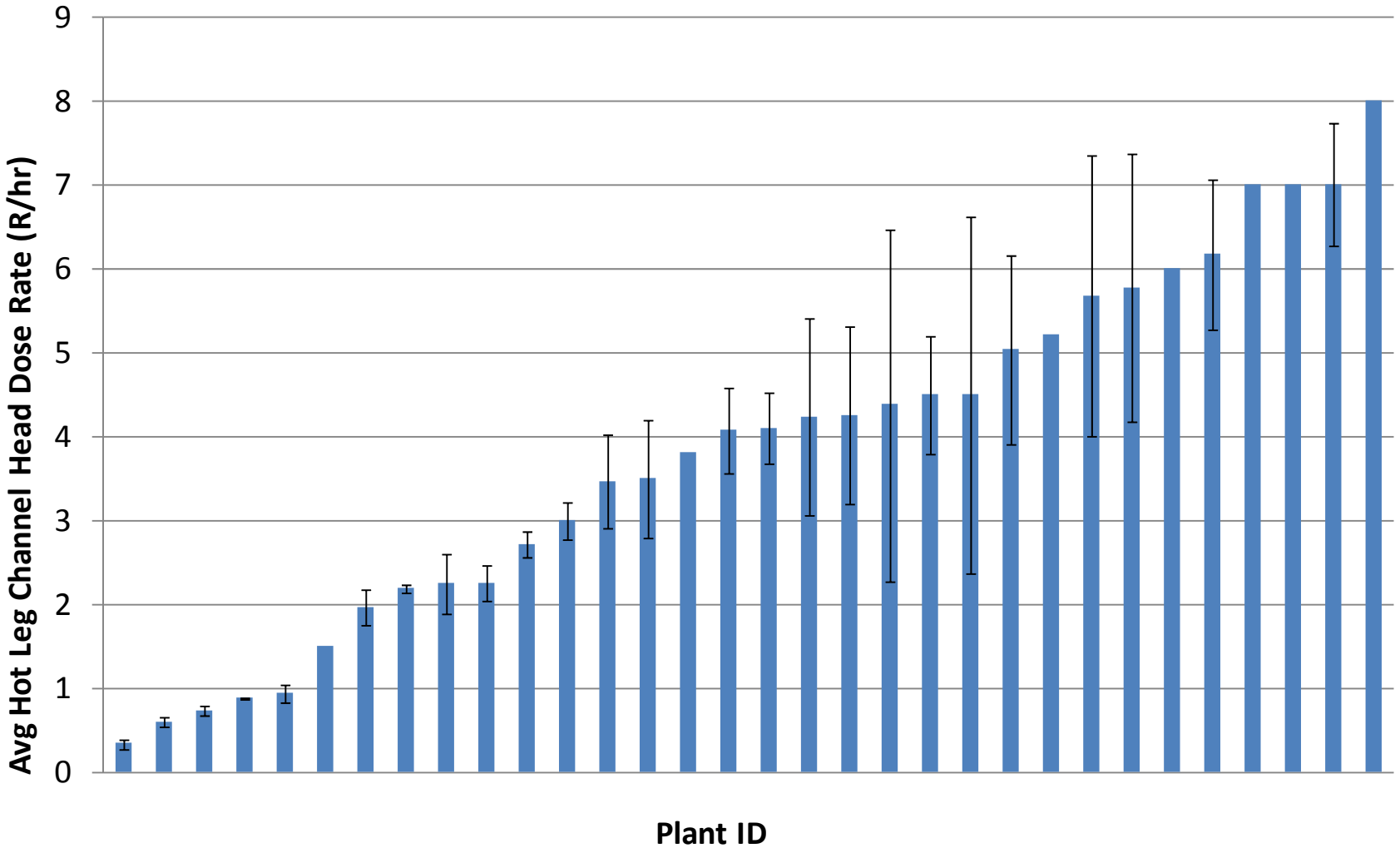
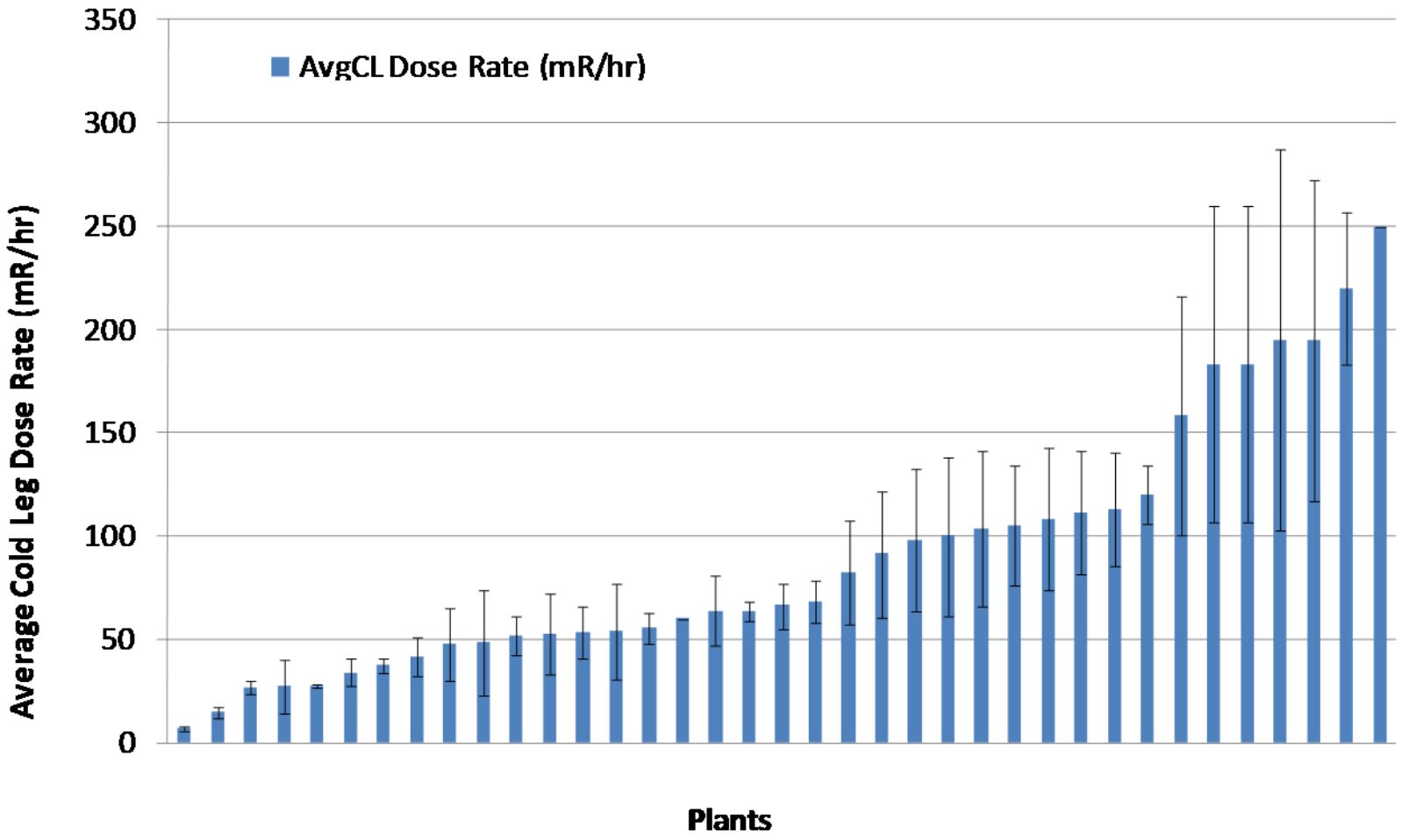
SRMP: PWR Center Channel Head Hot Leg

Most Recent Available Cycle



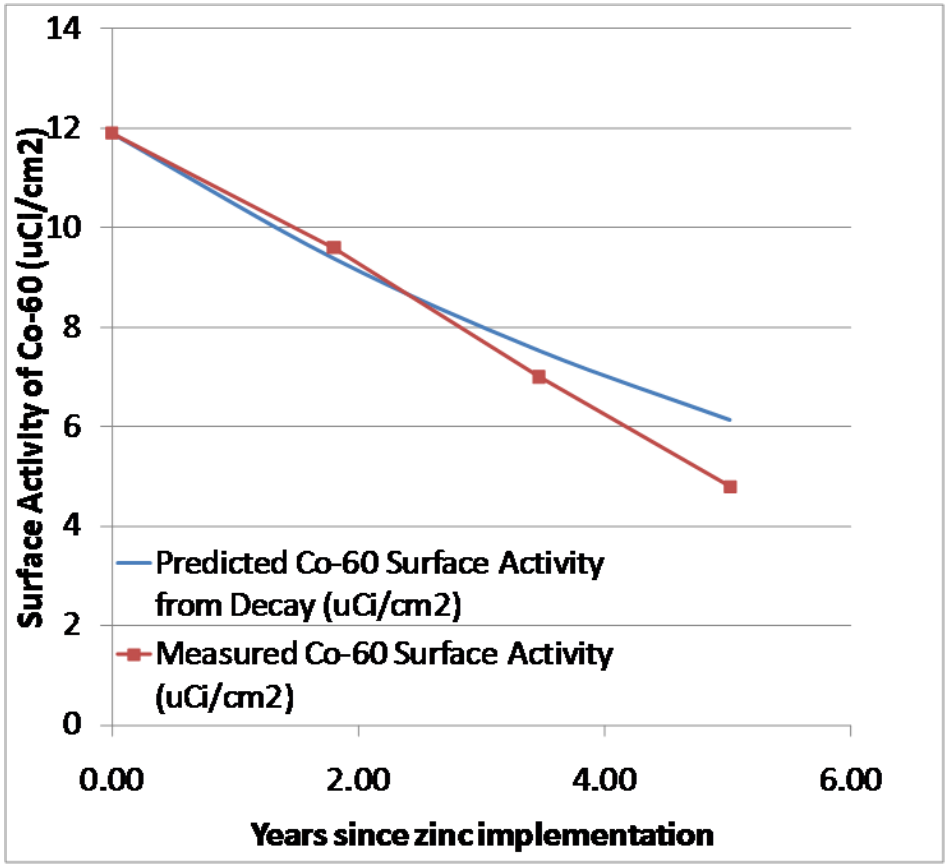
SRMP: PWR Loop Piping Cold Leg

Most Recent Available Cycle



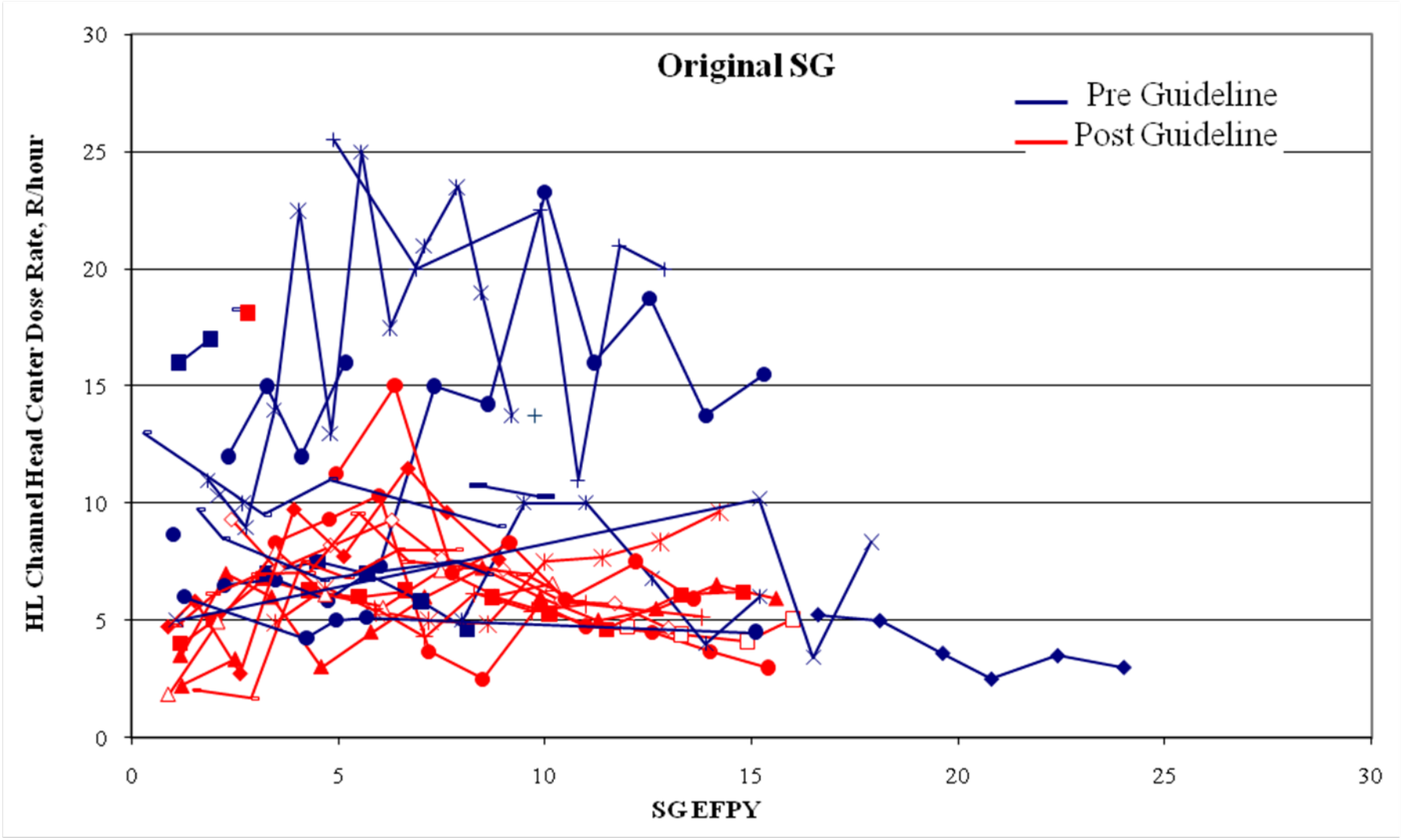
Zinc Injection Impact on Radiation Fields

- Several examples of positive impact of zinc
- Diablo Canyon 1 is most striking
  - Cobalt-60 decay curve is followed
  - Implies no additional activity deposition



For Diablo Canyon 1, since zinc injection, Cobalt-60 surface loading follows Co-60 decay curve at Diablo Canyon 1

Impacts of PWR Primary Chemistry Guidelines on Dose Rates



PWR Summary/Conclusions

- Zinc appears to be the strongest option to reduce ex-core dose rates
- pH has an impact, but mechanism is under investigation

RP 2020 Technology Program

Objective:

- Support of RP2020 Initiative to Improve RP Technology Implementation
- Identify plant tasks for high individual and cumulative dose, use technologies to improve dose performance

Description:

- Multi-year project focusing task analysis, technology search and development for high individual dose tasks

Results to Date:

- Outage reports collected, tasks separated

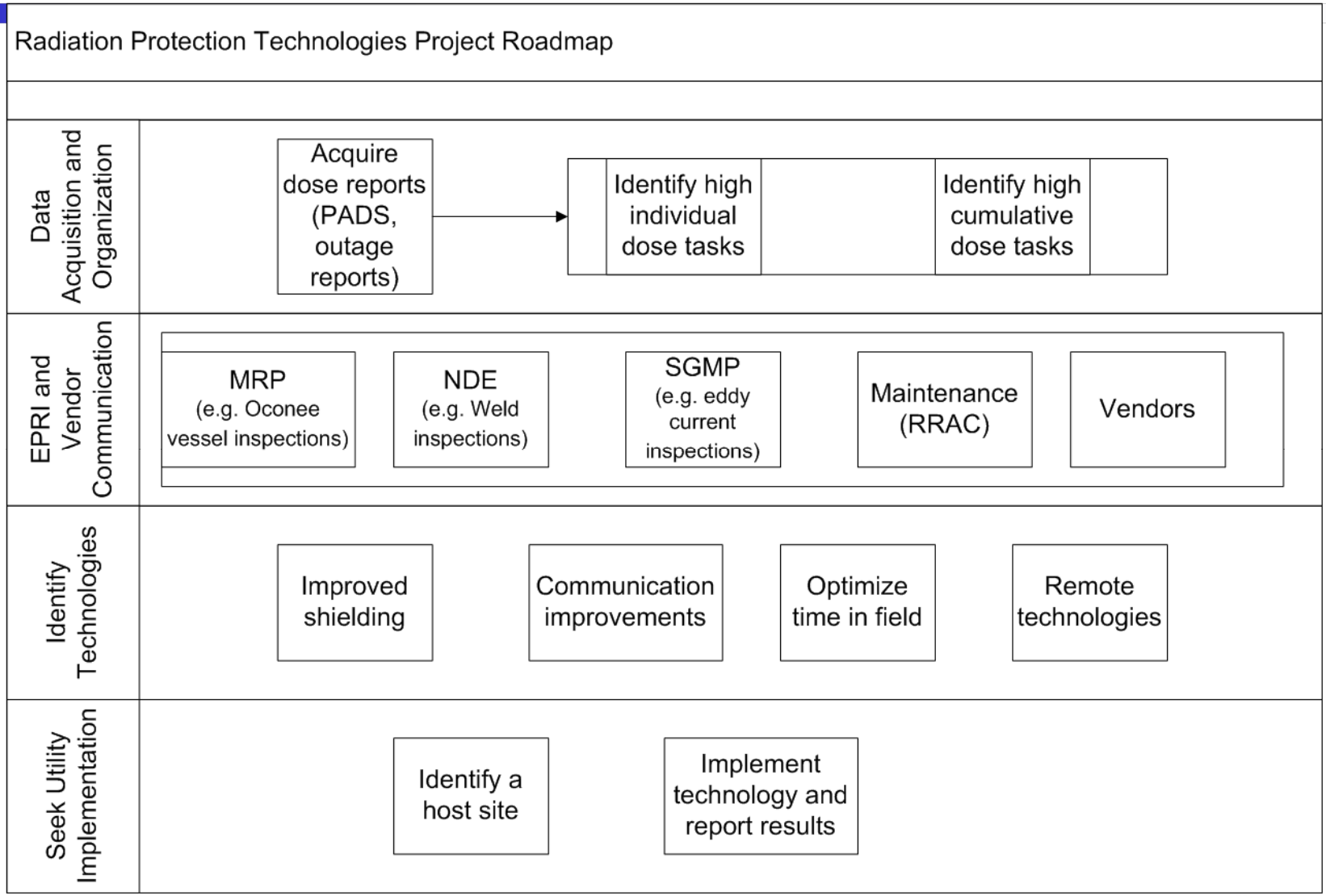
Benefits:

- Reduction of radiation fields allows planning of plant operations to minimize dose rates and reduce crud burst time

RP 2020 Technologies

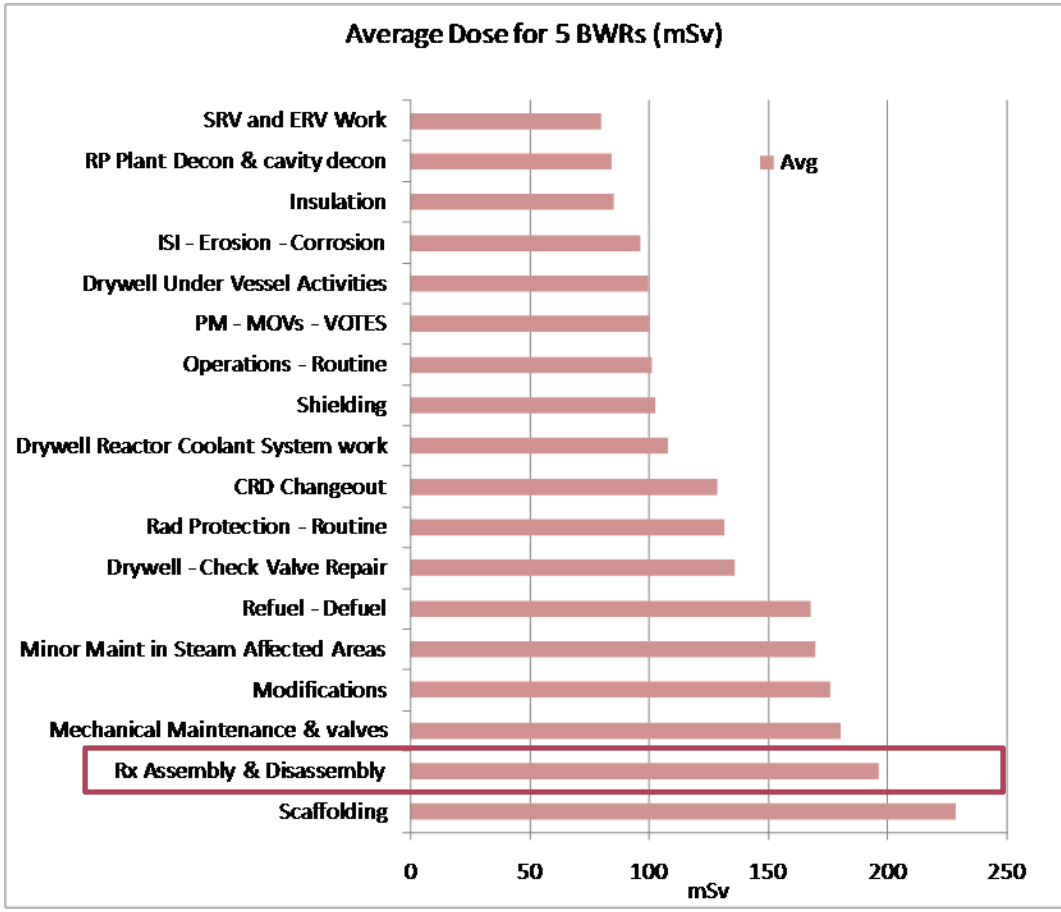
- Project has strategic and tactical parallel paths
  - Task Dose Benchmarking
  - Technology Identification and Demonstrations

RP Technology Implementation Roadmap



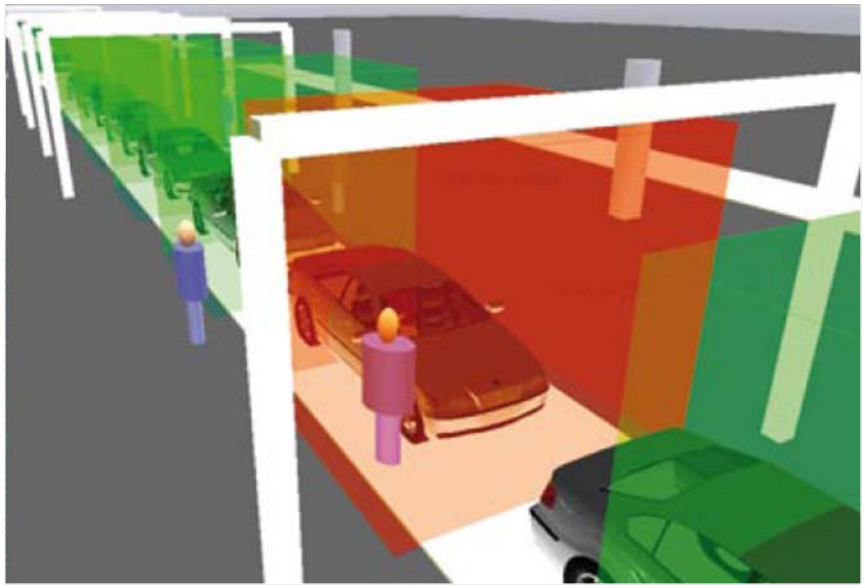
Technology Implementation Example
Identify the Task/Individuals

- Reactor Assembly/ Disassembly is a high dose task
  - High dose rates
  - Many tasks
    - stud tensioners
    - CRD work
  - Shielding difficulties
- Preliminary results show high effective dose rates
  - cumulative dose/work hours



Technology Implementation Example
Select Candidate Technology

- Real Time Location Sensors to assess efficiency
  - Reports 3-D position to 3 cm resolution
  - Use it to
    - Determine work flow path
    - Identify unnecessary personnel exposure
    - Identify possible parallel tasks



Technology Implementation Example
Identify Host Site

- Determine plants that may be interested in demo during outage
  - Communicated with two utilities
- Identify utility/vendor co-funding opportunities

RP 2020 Technology Implementation
Part II: Technology Demonstrations

- Utilities are already trying new technologies
- Technology list is in development
- For viable candidates, goal is to co-fund demonstration

Remote Technologies
Remote welding and sanding
Remote monitoring (fiber penetration)
Wireless remote monitoring
Bluetooth communications technology

Decontamination
Local system decontaminations
Control Rod Drive Flushing Tool
Cavity decontamination with peroxide
Dry vacuuming of vaults

Shielding
Shielding mats for refuel bridge
Permanent shielding on aux building systems
Moldable shielding

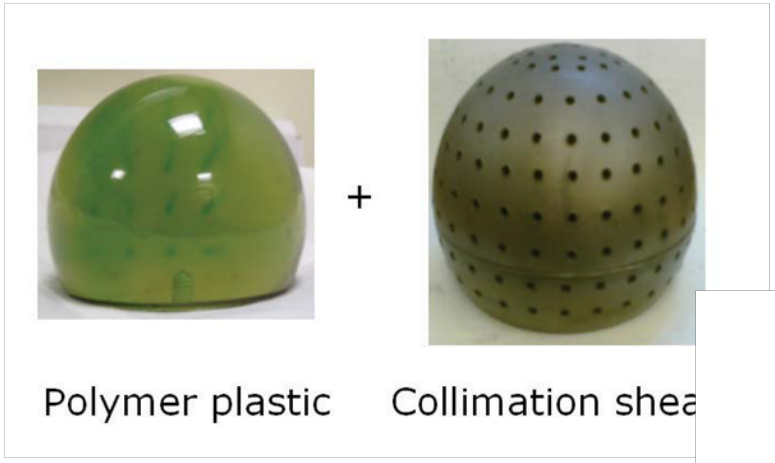
Novel Technologies
RadBall ™
Valve seat replacements
Replacement fiber insulation with reflective insulation
Location Tracking

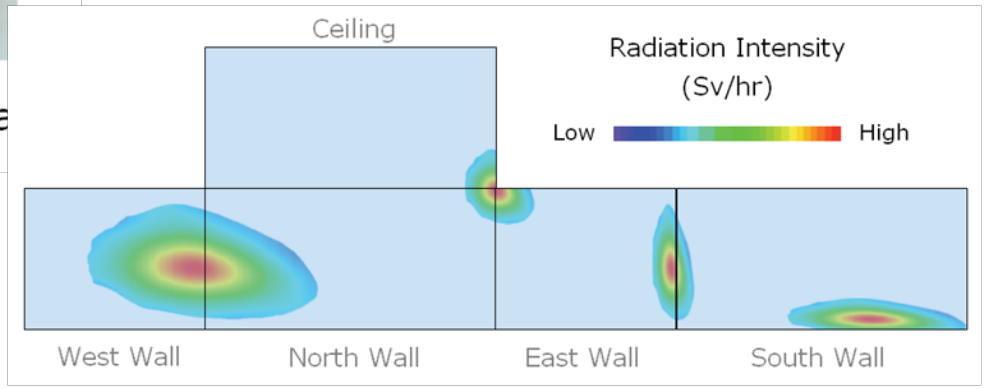
RP 2020 Technology Demonstrations
Advanced Shielding

- Customizable shielding for high dose applications
  - E.g Nozzle inspection
- Engineering qualification for permanent installation
  - Physical properties
    - Hardness variation
    - Linear weight
  - Environment limitations
    - Temperature
    - Radiation
- **Seeking utility support for installation**

RP 2020 Technology Demonstrations
RadBall

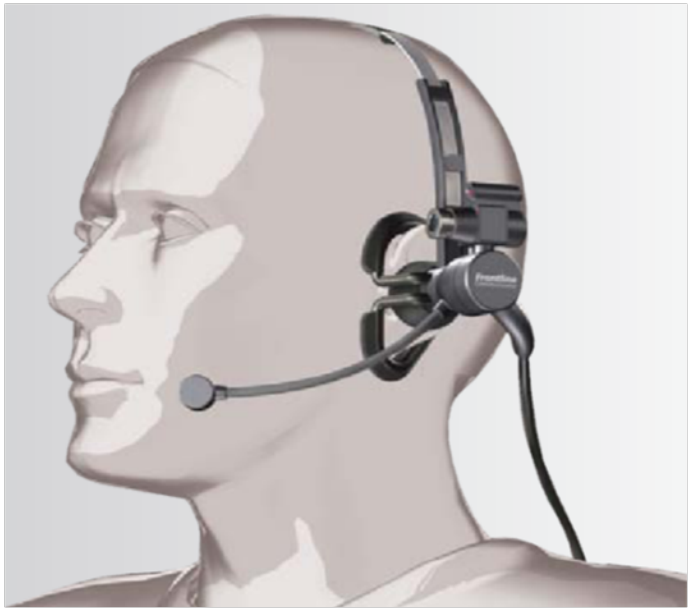
- Radiation sensitive polymer based radiation mapping device
- Locate, quantify and characterize radiation





RP 2020 Technology Demonstrations
Frontline Headset-Camera

- Wireless and wearable communication tool that transmits video images
- On and off-site communication



Technology Conclusions

- EPRI is actively seeking new technology demonstrations
  - International collaboration is welcome
  - Please contact Dennis Hussey, dhussey@epri.com