Evolution of Clearance Standards and Implications for Radwaste Management of Fusion Power Plants

L. El-Guebaly, P. Wilson, D. Paige

and the ARIES and Z-Pinch Teams

Fusion Technology Institute

University of Wisconsin - Madison

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Objectives

- Highlight:
  - Rationale for clearance standards
  - US market for cleared solids
  - Industry opposition for clearance
  - ANS support for clearance.
- Compare IAEA and EU clearance standards to newly developed US-NRC'.
- Apply three clearance standards to representative MFE and IFE designs.
- Recommend changes to US-NRC clearance standards.

Radwaste Management Options

- **Disposal** in repositories
- **Recycling** – reuse in nuclear facilities
- **Clearing** – release to commercial market, if CI < 1.

- Main goal of clearing and recycling is to minimize volume of radwaste assigned for geological burial in repositories.

- For all three options, interim storage period could range from 0-100 y after plant decommissioning.

Clearance

- Solids containing traces of radioactive isotopes can be cleared from regulatory control and released to commercial market for reuse if CI < 1
  - materials are no longer radioactive.
- **CI** is ratio of activity / limit summed over all radioisotopes.
- US clearance standards existed for liquids and gases, but not for solids.
- In 2002, US-NRC issued clearance guidelines for **solids**.
- **Dose limit**: annual dose from releases should be 10 μSv/yr (1 mrem/yr) or less (< 1% of radiation received each year from natural background sources).

Several Organizations have Developed Clearance Guidelines

Organization	Year of Evaluation	Fission or Fusion Applications?	# of Elements
IAEA	1992	Both	1,650
EURATOM	1996	Both	300
US-NRC	2002	Fission	67

US Commercial Market for Slightly Radioactive Materials

- At present, US market does not exist.
- Steel and concrete industries and labor unions are opposing converting these materials into consumer products (cars, chairs, toys, spoons, etc) because of potential risk, health, and **economic** impacts.
- Advocates claim huge savings can be made by clearing slightly radioactive materials (such as concrete, furniture, etc).
- DOE is studying release of these materials to DOE nuclear recycling facilities only.
- National policy may change in future years and market may exit.

ANS Position on Clearance*

- ANS **supports release** of slightly radioactive materials, stating:
  - Absolutely prohibiting release of all solid materials that manifest small amount of radioactivity is not reasonable
  - Release of these materials can be accomplished with negligible or no risk to public health and safety.
  - 10 μSv/yr dose criterion is small fraction of existing standards for safe exposure from non-medical radiation sources.

* ANS News - March/April 2003.

Key MFE & IFE Design Parameters

	ARIES-CS	Z-Pinch
Net Electric Power	1000 MW_e	1000 MW_e
Target Yield	---	3000 MJ
Rep Rate	---	0.1 Hz
# of Shots per FPY	---	38 million
Average FW Radius	1.85 m	5 m
Neutron Wall Loading	2 MW/m^2	---
Availability	85%	85%
Plant Lifetime	40 FPY (47 y)	40 FPY (47 y)

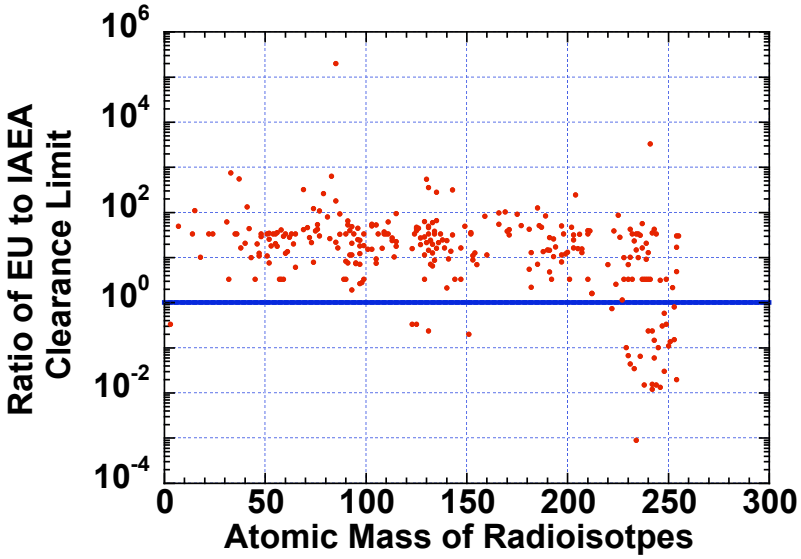
Codes and Data

- **DANTSYS** neutral-particle transport code

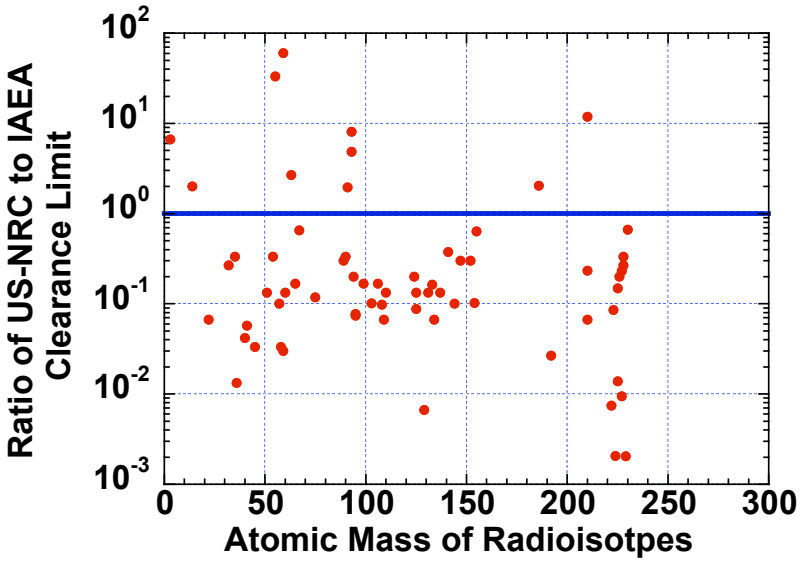
- **ALARA** **pulsed activation code**:
  - Explicit modeling of 85% availability
  - Exact modeling of Z pulses (~10,000)

- **FENDL-2** **nuclear data**:
  175 neutron and 42 gamma group structure.

Comparison of Clearance Limits

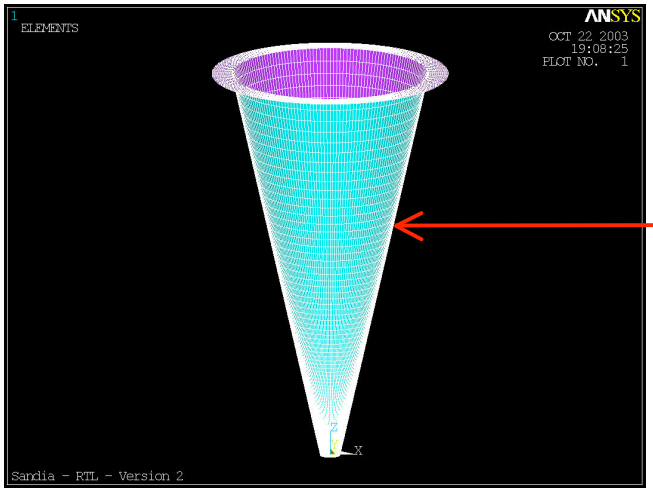


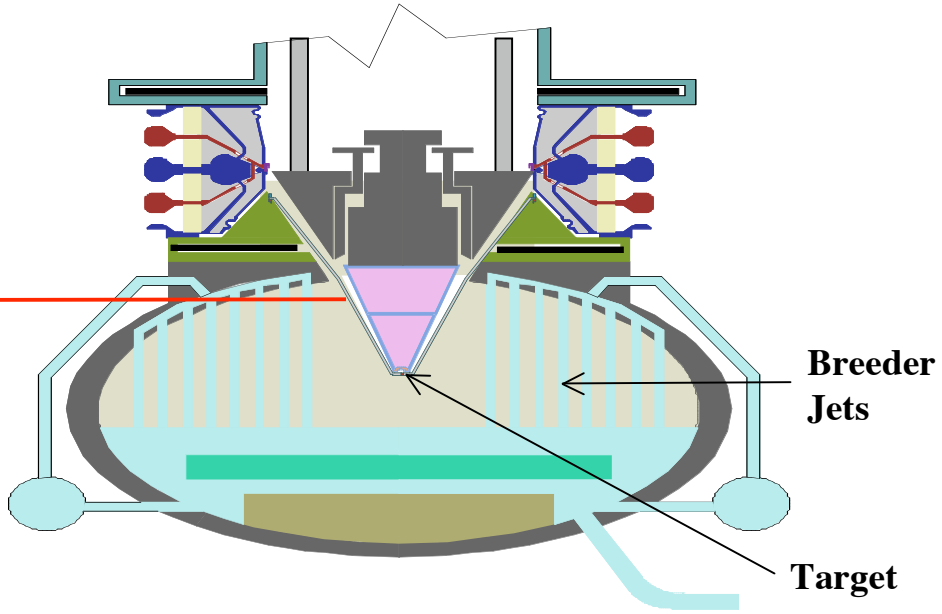
EU / IAEA



US-NRC / IAEA

Representative IFE Power Plant



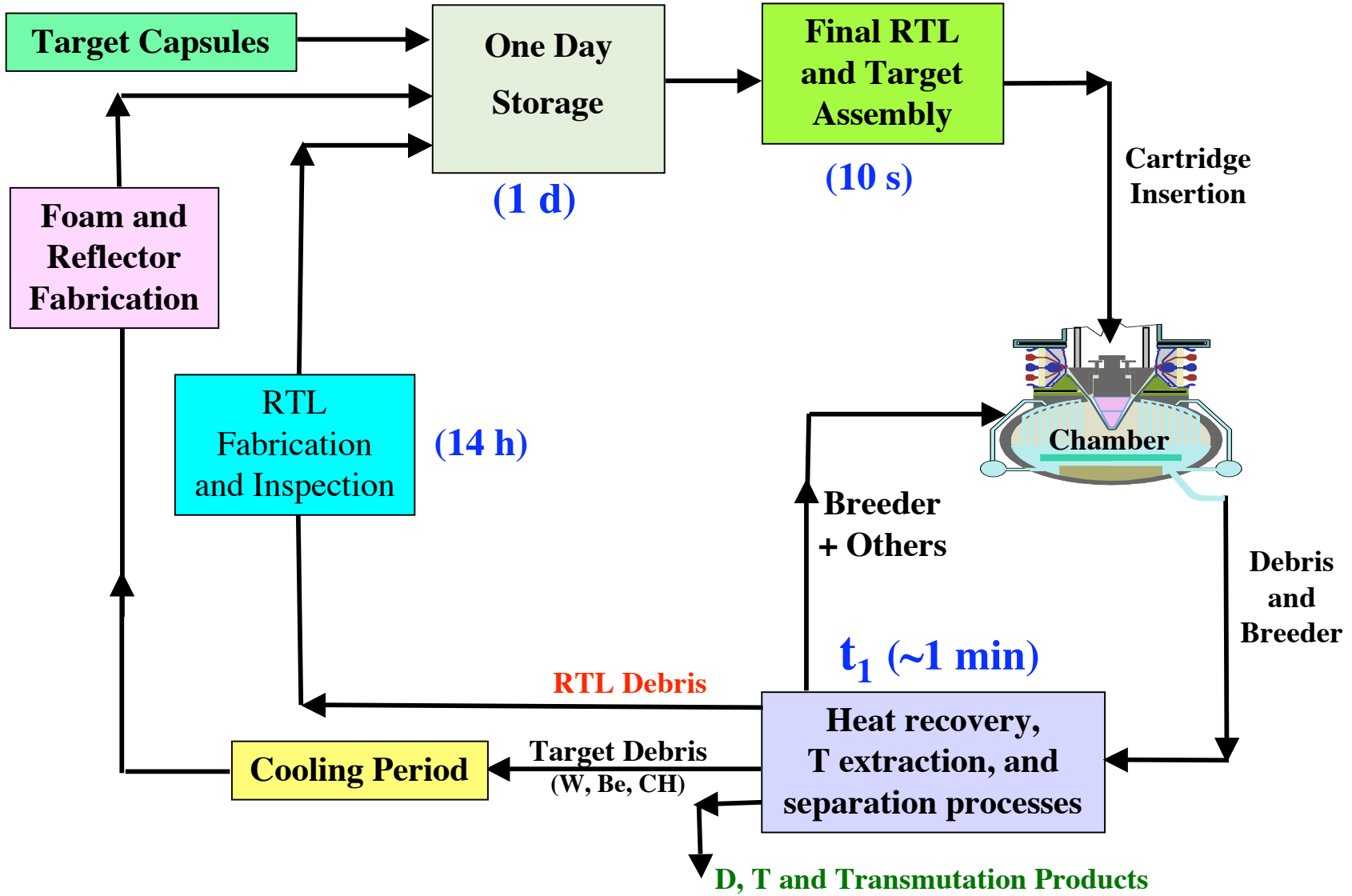


Recyclable Transmission Lines (RTL)

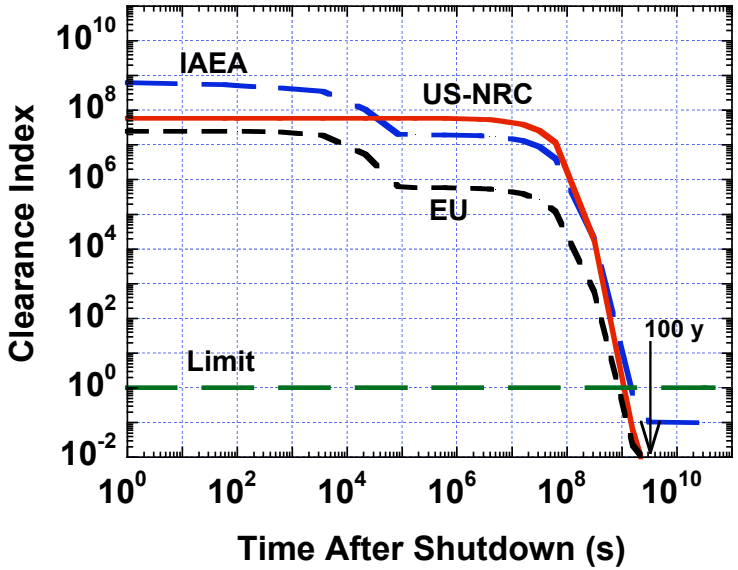
Carbon Steel
~ 0.6 mm thick
50 kg / RTL

Z-Pinch

RTL Recycling Process



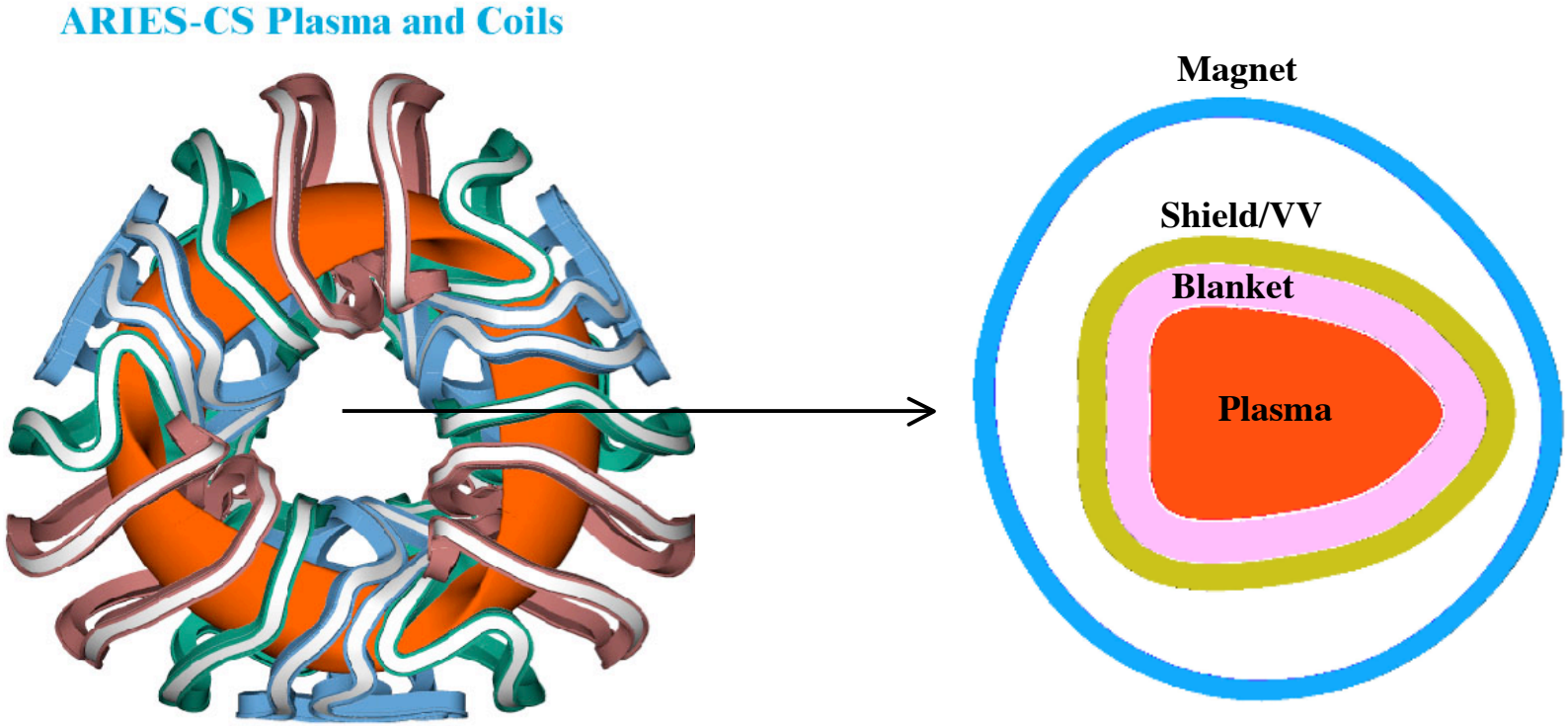
IFE Results
(Z-Pinch - RTL)



	Storage Period for CI=1		
	EU	**IAEA**	**US-NRC**
Carbon Steel	**30 y** (Mn-54)	**50 y** (Fe-55)	**35 y** (Co-60)

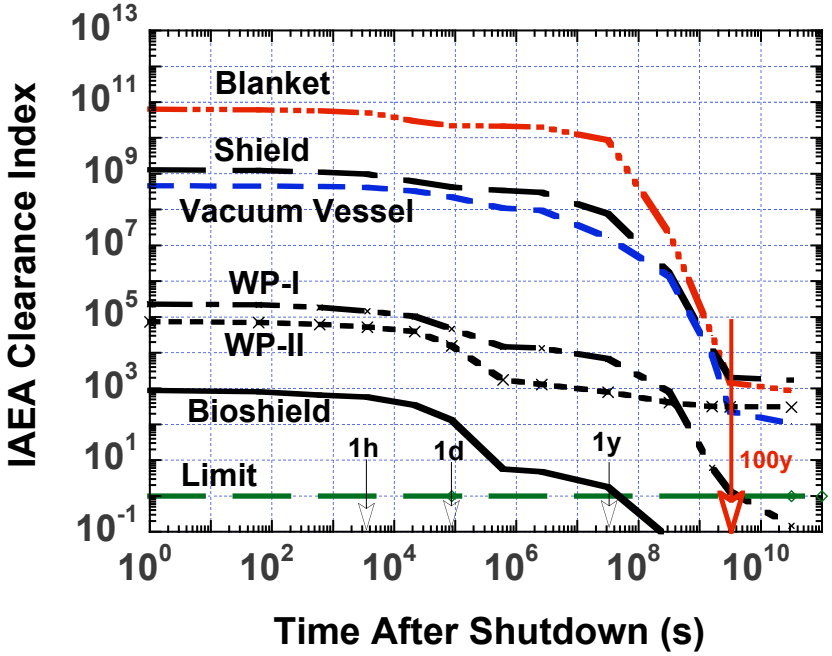
- IAEA standards call for longest storage period.
- Based on US-NRC guidelines, RTLs can be cleared after 35 y.

Representative MFE Power Plant



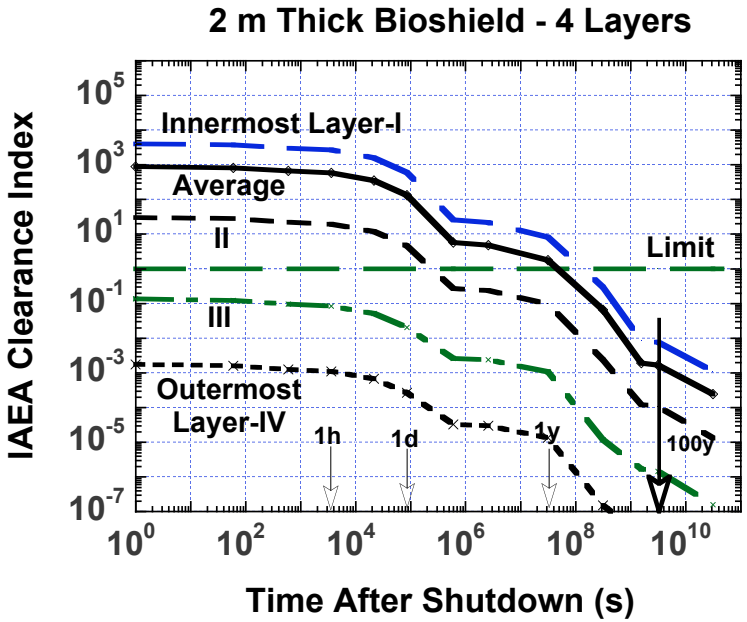
ARIES-CS Compact Stellarator

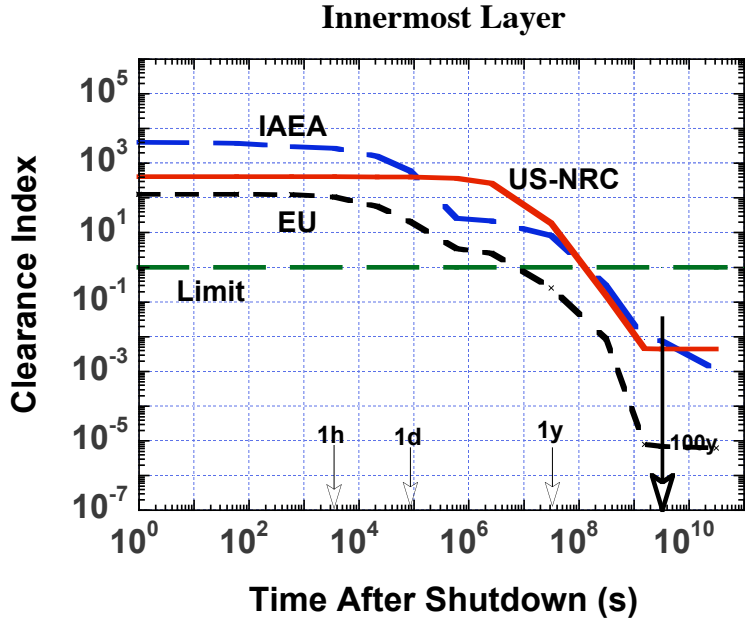
MFE Results
(ARIES-CS LiPb/FS/He System)



- None of the internal components can be cleared. All internals should be disposed of in repositories.
- Only building (or bio-shield) can be released after specific storage period.

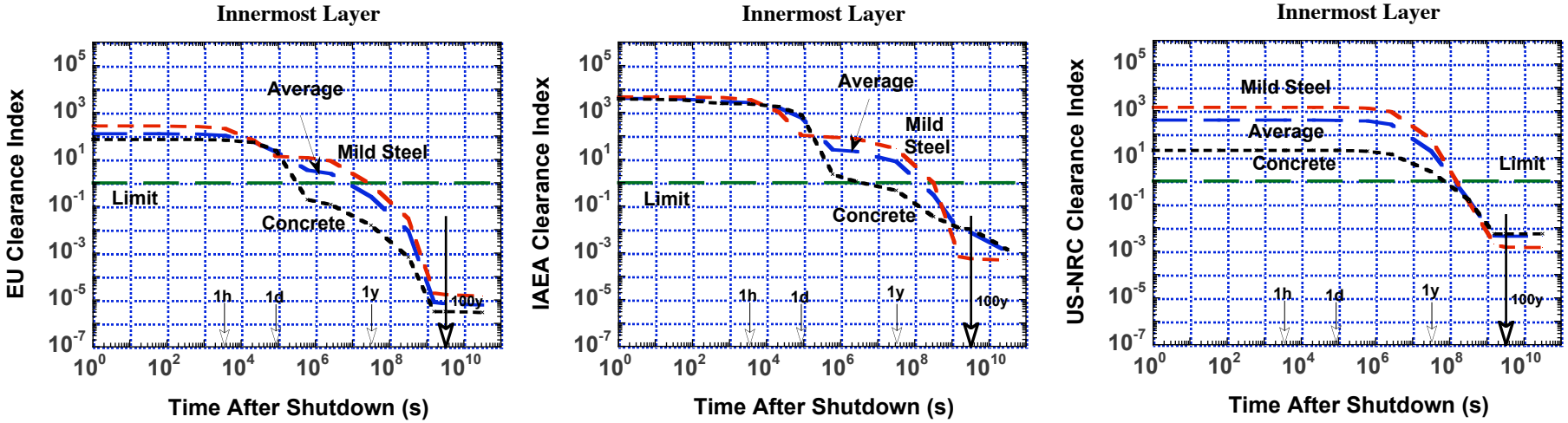
MFE Results (Cont.)
(ARIES-CS LiPb/FS/He System)





Segregate building into constituents
(10% mild-steel & 85% concrete)

MFE Results (Cont.)
(ARIES-CS LiPb/FS/He System)

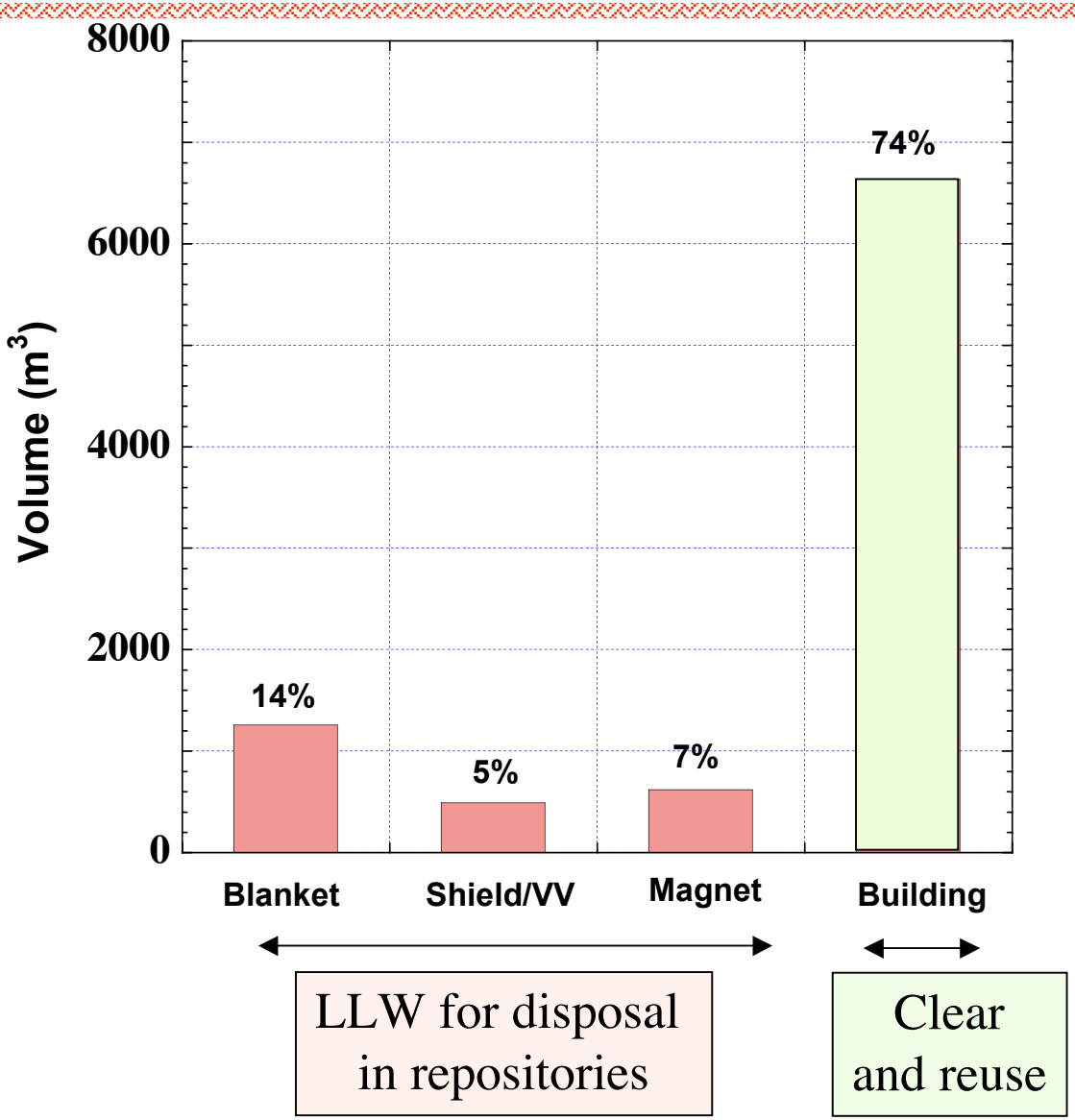


Storage Period for CI=1

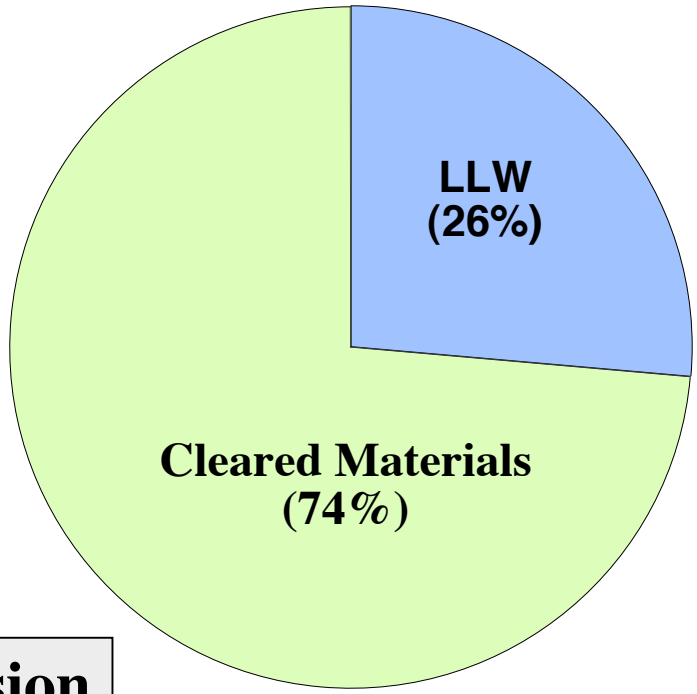
	EU	IAEA	US-NRC
Mild Steel	**1 y** (Fe-55)	**10 y** (Mn-54, Fe-55)	**5 y** (Co-60, Mn-54)
Concrete	**5 d** (Fe-55, Na-22)	**1 mo** (Fe-55, Na-22, Ar-39)	**2.5 y** (Na-22)

EU standards call for shortest storage period

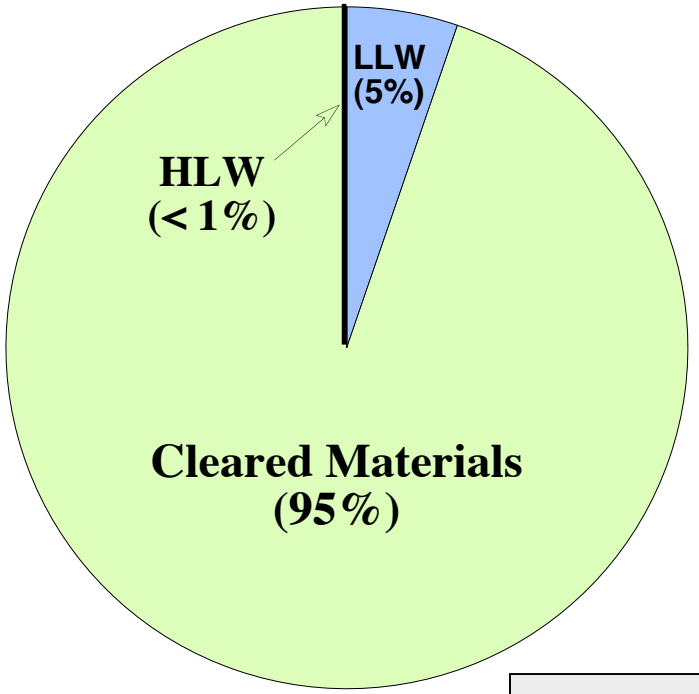
Building Dominates LLW Stream (MFE Concept)



Breakdown of Waste - Fusion / Fission Comparison



Fusion



Fission

More than 70% of waste can be released from nuclear facilities, providing strong incentive for supporting clearance.

Conclusions

- Buildings generate majority of fusion waste (> 70%) and contain traces of radioisotopes.
- Clearance is desirable as it frees ample space in repositories for HL and LL wastes, saving disposal cost for sizable buildings.
- At present, clearance market does not exit in US, but national policy may change in future years.
- Recently, US-NRC issued clearance guidelines for 76 elements of interest to fission, not fusion.
- **Recommendations**:
  - US-NRC should expand list of elements to cover all radionuclides of interest to fusion applications.
  - Continue monitoring clearance index for fusion designs using all three standards until US-NRC issues fusion-specific guidelines.

Companion Presentations

Oral on Wednesday @ 10:30 - 12 AM:

Benefits of Radial Build Minimization and Requirements Imposed on ARIES Compact Stellarator Design

L. El-Guebaly, R. Raffray, S, Malang, J. Lyon, L.P. Ku and the ARIES Team

Poster on Wednesday @ 1:30 - 3:30 PM:

Initial Activation Assessment for ARIES Compact Stellarator Power Plant

L. El-Guebaly, P. Wilson, D. Paige and the ARIES Team

Oral on Wednesday @ 3:30 - 5:30 PM:

Development Path for Z Pinch IFE

C. Olson