# Waste Disposal Assessment for the Final Focusing Magnets in the RPD-2002*

by

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ARIES Project Meeting

May 5-6, 2003

*Work performed under the auspices of the U. S. Department of Energy by Lawrence Livermore National Laboratory under Contract W-7405-Eng-48.

# General requirements for the final focusing magnet shielding design

- Shielding design consistent with target beam requirements (e.g., half-angle of array <30º)
- Magnets don't quench on a per-shot basis (limits energy deposition in superconductor regions to ~100 mJ/cc/shot)
- Recirculating power for magnet cooling doesn't cause unacceptably large economic hit
- Magnets have reasonable radiation damage lifetime:
  - 100 MGy for insulators (dominated by gamma-rays)
  - Fast neutron fluence of $10^{19}$ n/cm$^2$ for NbTi superconductor (room temp anneal at $3 \times 10^{18}$ with 70% recovery)
- Avoid generation of above Class C waste, if possible

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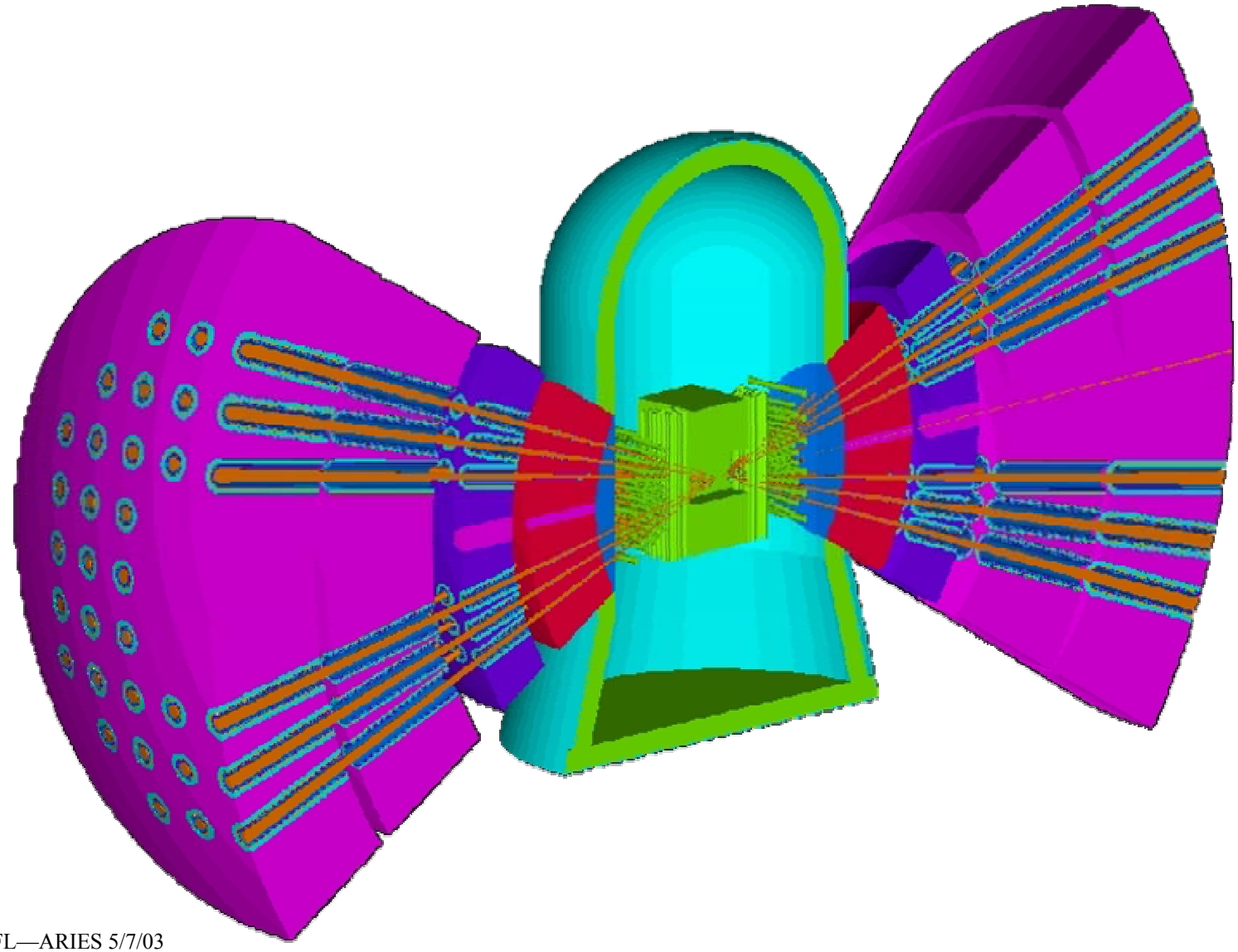
# Neutronics modeling for the new HIF point design is quite detailed



# Results: Magnet lifetimes and waste disposal rating (WDR)

- Last magnet:
  - Insulator lifetime = 230 full-power-years (FPY)
  - Superconductor lifetime = 260 FPY — WDR = 1.68
- 2nd-to-last magnet:
  - Insulator lifetime = 410 FPY
  - Superconductor lifetime = 1580 FPY — WDR = 0.42
- 3rd-to-last magnet:
  - Insulator lifetime = 100 FPY
  - Superconductor lifetime = 610 FPY — WDR = 0.48

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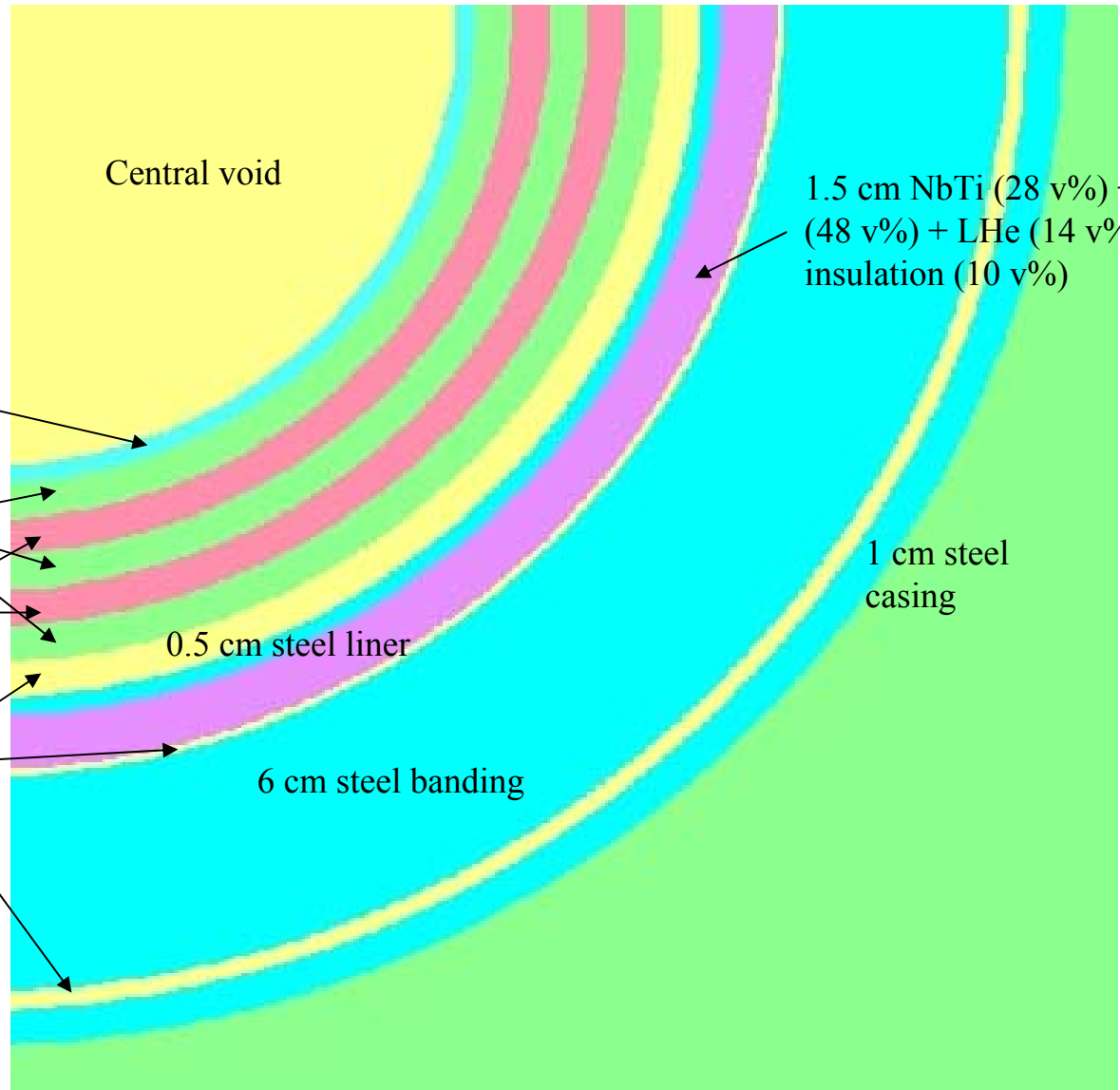
**This is waste disposal rating for the NbTi coil. What is the value for the magnet as a whole?**

- 3rd-to-last magnet:
  - Insulator lifetime = 100 FPY
  - Superconductor lifetime = 610 FPY

WDR = 0.48

# Magnet radial build




* Reactor Experiments, Inc.

# WDR for average magnet

| Description | Material | Cumulative Volume ($m^3$) | WDR | Dominant Radionuclide |
|---|---|---|---|---|
| Beampipe | SS#304 | | | |
| $n^0$ shield | Ti-poly | | | |
| $\gamma$ shield | W-poly | | | |
| $n^0$ shield | Ti-poly | | | |
| $\gamma$ shield | W-poly | | | |
| $n^0$ shield | Ti-poly | | | |
| Shield liner | SS#304 | | | |
| Coil Clamp | SS#304 | | | |
| Magnet liner | SS#304 | | | |
| Coil | NbTi+Cu+LHe | | | |

SS #304 composition includes 0.005 wt% Nb and 0.33 wt% Mo

# WDR for average magnet

| Description | Material | Cumulative Volume ($m^3$) | WDR | Dominant Radionuclide |
|---|---|---|---|---|
| Beampipe | SS#304 | 0.28 | | |
| $n^0$ shield | Ti-poly | 1.46 | | |
| $\gamma$ shield | W-poly | 1.57 | | |
| $n^0$ shield | Ti-poly | 1.68 | | |
| $\gamma$ shield | W-poly | 1.79 | | |
| $n^0$ shield | Ti-poly | 1.90 | | |
| Shield liner | SS#304 | 1.05 | | |
| Coil Clamp | SS#304 | 15.93 | | |
| Magnet liner | SS#304 | 3.10 | | |
| Coil | NbTi+Cu+LHe | 3.35 | | |

**Total volume = 32.1 $m^3$**

# WDR for average magnet

| Description | Material | Cumulative Volume ($m^3$) | WDR | Dominant Radionuclide |
|---|---|---|---|---|
| Beampipe | SS#304 | 0.28 | 8.60E-03 | $^{94}Nb$ |
| $n^0$ shield | Ti-poly | 1.46 | 5.03E-08 | $^{14}C$ |
| $\gamma$ shield | W-poly | 1.57 | 2.99E-05 | $^{99}Tc$ |
| $n^0$ shield | Ti-poly | 1.68 | 2.80E-08 | $^{14}C$ |
| $\gamma$ shield | W-poly | 1.79 | 2.75E-05 | $^{99}Tc$ |
| $n^0$ shield | Ti-poly | 1.90 | 2.28E-08 | $^{14}C$ |
| Shield liner | SS#304 | 1.05 | 2.70E-03 | $^{99}Tc$ |
| Coil Clamp | SS#304 | 15.93 | 2.15E-03 | $^{99}Tc$ |
| Magnet liner | SS#304 | 3.10 | 1.93E-03 | $^{99}Tc$ |
| Coil | NbTi+Cu+LHe | 3.35 | 1.68E+00 | $^{94}Nb$ |

**Total volume = 32.1 $m^3$**

**Mixed WDR = 0.18**

# Magnet waste disposal ratings are low enough to meet Class C requirements

- Last set of magnets would have average WDR of 0.18 → should qualify as Class C even with increased beam-to-structure stand-off distance (present results all assume 1 mm clearance; move to 5 mm clearance gives ~2x increase in activation & doses)
- Even coil regions of 2nd-to-last and 3rd-to-last magnets have WDR<1
- Variability between magnets is relatively small – certainly not 5× about average → **no individual magnets should exceed WDR=1**
- Have not included impurities in shielding materials from R/X, Inc.:
  - Impurities are unlikely to be bad enough to change classification
  - Will perform study to determine impurity limits in W-poly and Ti-poly
- As designs progress, should continue to monitor magnet lifetime, waste disposal rating, etc.