Recommendations on Neutron Fluence Goals for ITER

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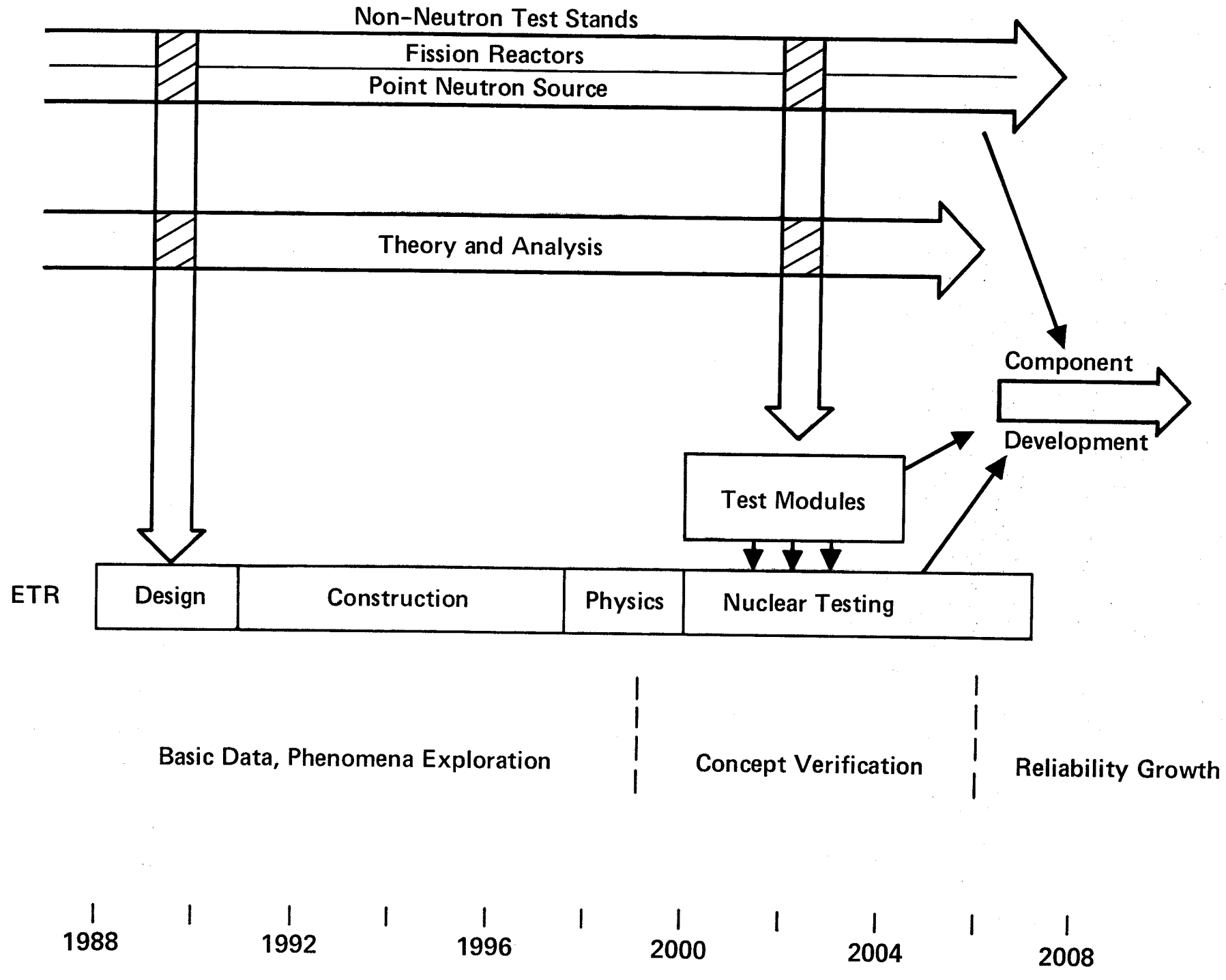
Minimum Technical Goal for Nuclear Testing in ITER

Provide definitive data to select with confidence concepts (particularly for blanket) which can operate with good performance and reasonable reliability in DEMO (device following ITER)

Framework For Fusion Nuclear Technology Development



ITER Nuclear Testing Sequence (Phases)

A. *Scoping/Screening Tests*

First Time Fusion Testing

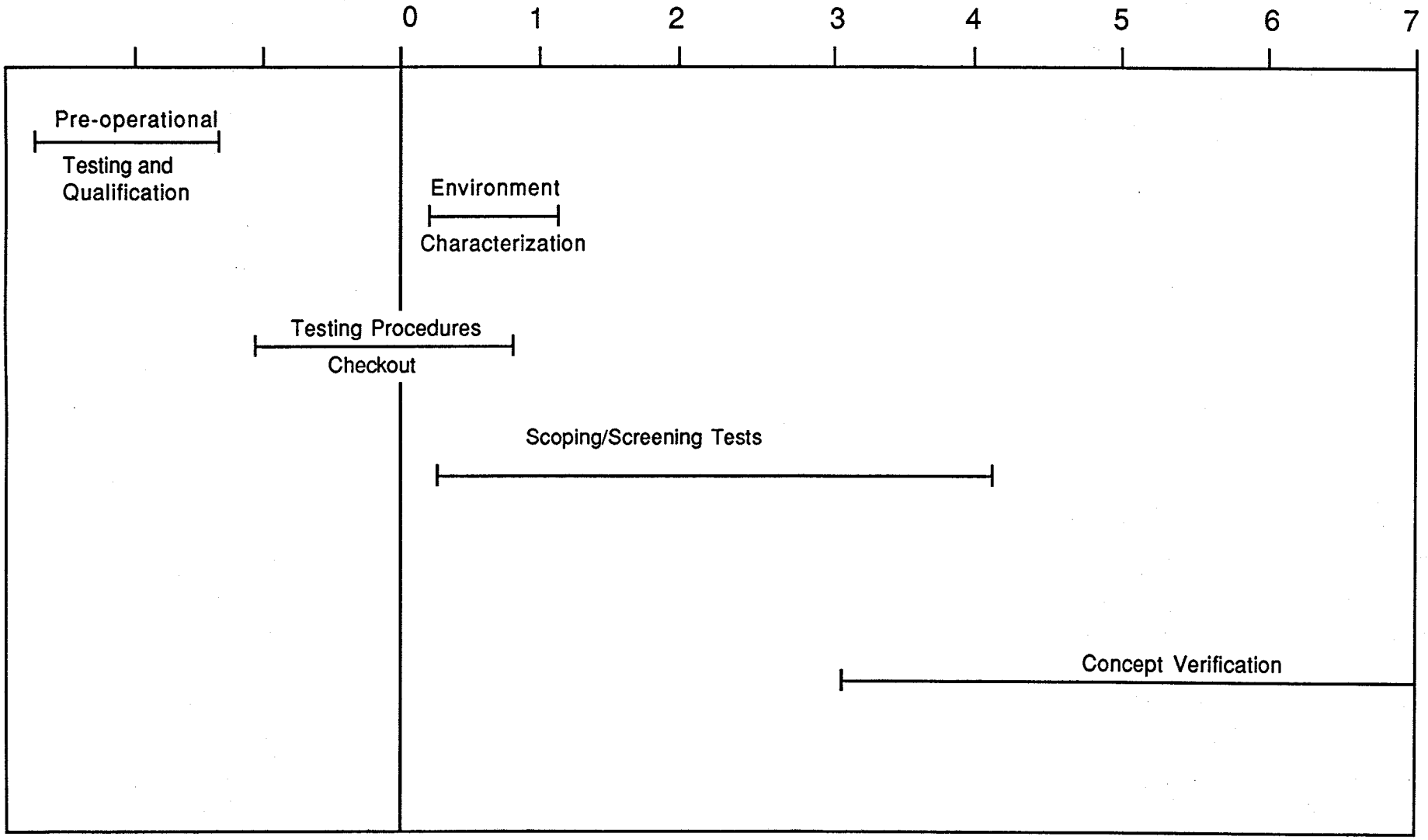
- Test a number of concepts (different materials, configurations, etc.) in test elements and submodules
- Results used to select a much smaller subset (e.g., 2 or 3 concepts) for the more comprehensive concept verification tests

B. Concept Verification Tests

- Integrated tests in modules, and possibly sectors, for very limited number of concepts
- Testing conditions (e.g., fluence) must provide definitive information for concept selection
  - Requires activation of mid-life radiation effects

STAGES OF BLANKET TESTING IN ITER PHASE III OF OPERATION

(PRELIMINARY)



Device Life Vs. Test Module Fluence

- Fluence achievable at test module $(\phi t)_m$

- Test facility "lifetime fluence" $(\phi t)_f$

$$(\phi t)_f > 2(\phi t)_m \text{ in general}$$

- Attenuation in device first wall and other in-vessel components reduces flux at test modules (most test modules must be isolated from the device "vacuum")

- There is inevitably a long period of fail/replace/fix for test module (remember: first time to test in fusion environment)

- Time for concept selection testing prior to concept verification testing

Fluence Regimes (for Blanket)

Power Reactor Goal: ~20 MW•y/m^2

Beginning of life: 0-1 MW•y/m^2

Mid-life: 1-10 MW•y/m^2

End-of-life: 10-20 MW•y/m^2

Testing Fluence

- Blanket Experiences Many Interactive Effects
- One of the Important Environmental Conditions is Neutron Irradiation
- True Concept Verification for Components Requires Fusion Testing Data on These Interactive Effects

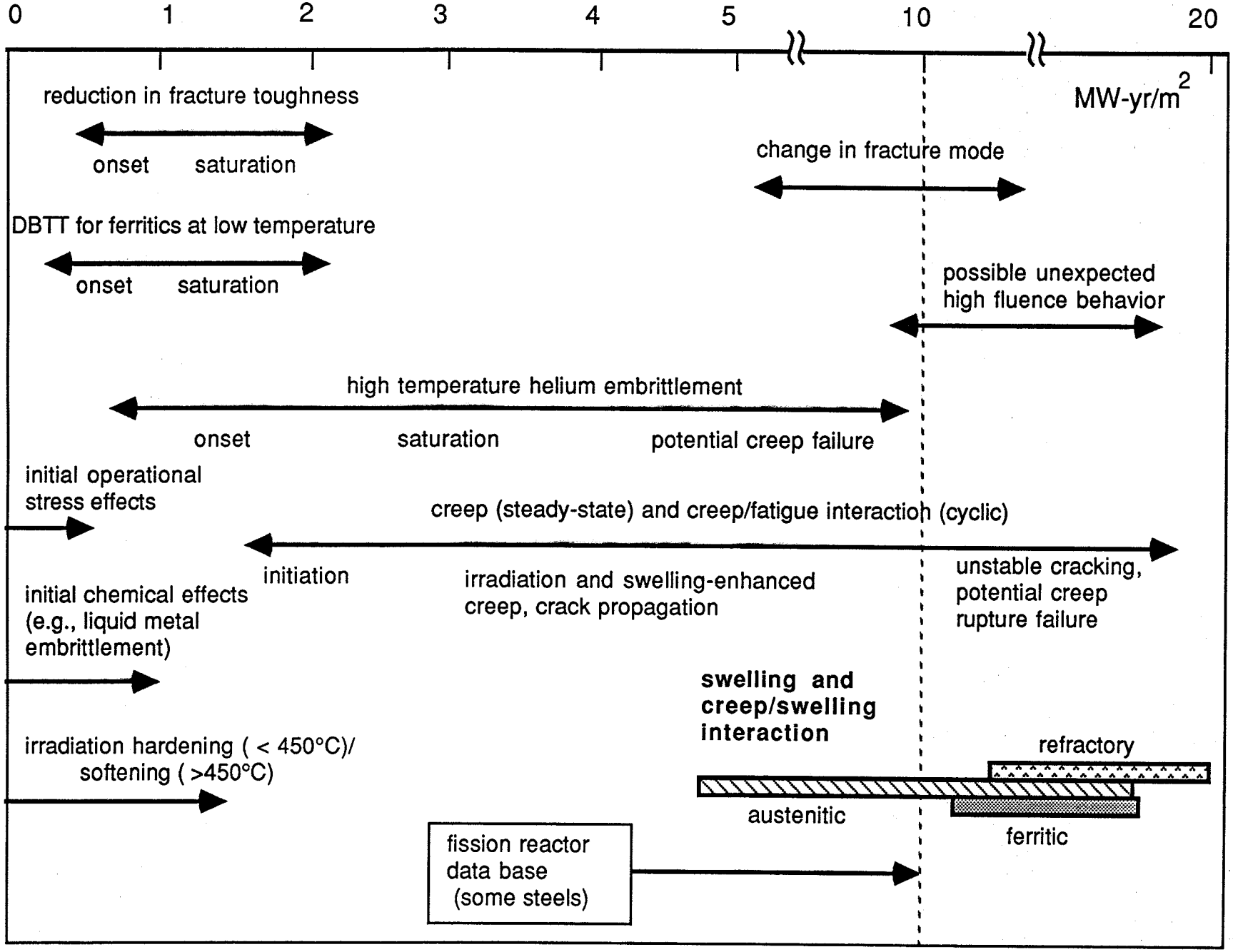
[Note: While "end-of-life" material irradiation is very useful, it is assumed to be beyond the capability of ITER]

- Suggested Fluence Goals (at Test Elements)

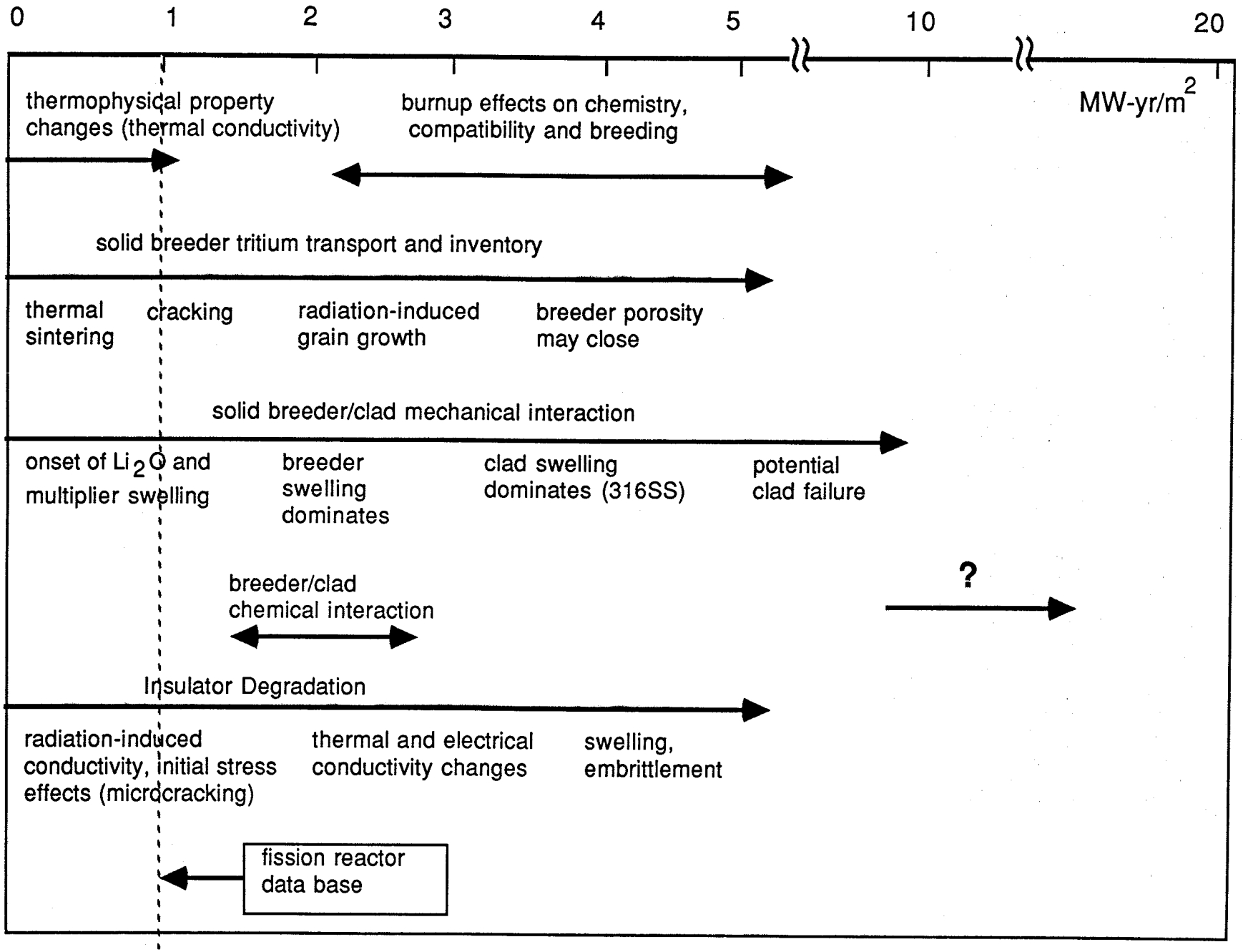
  Scoping/Screening Tests: 1-2 MW•y/m^2

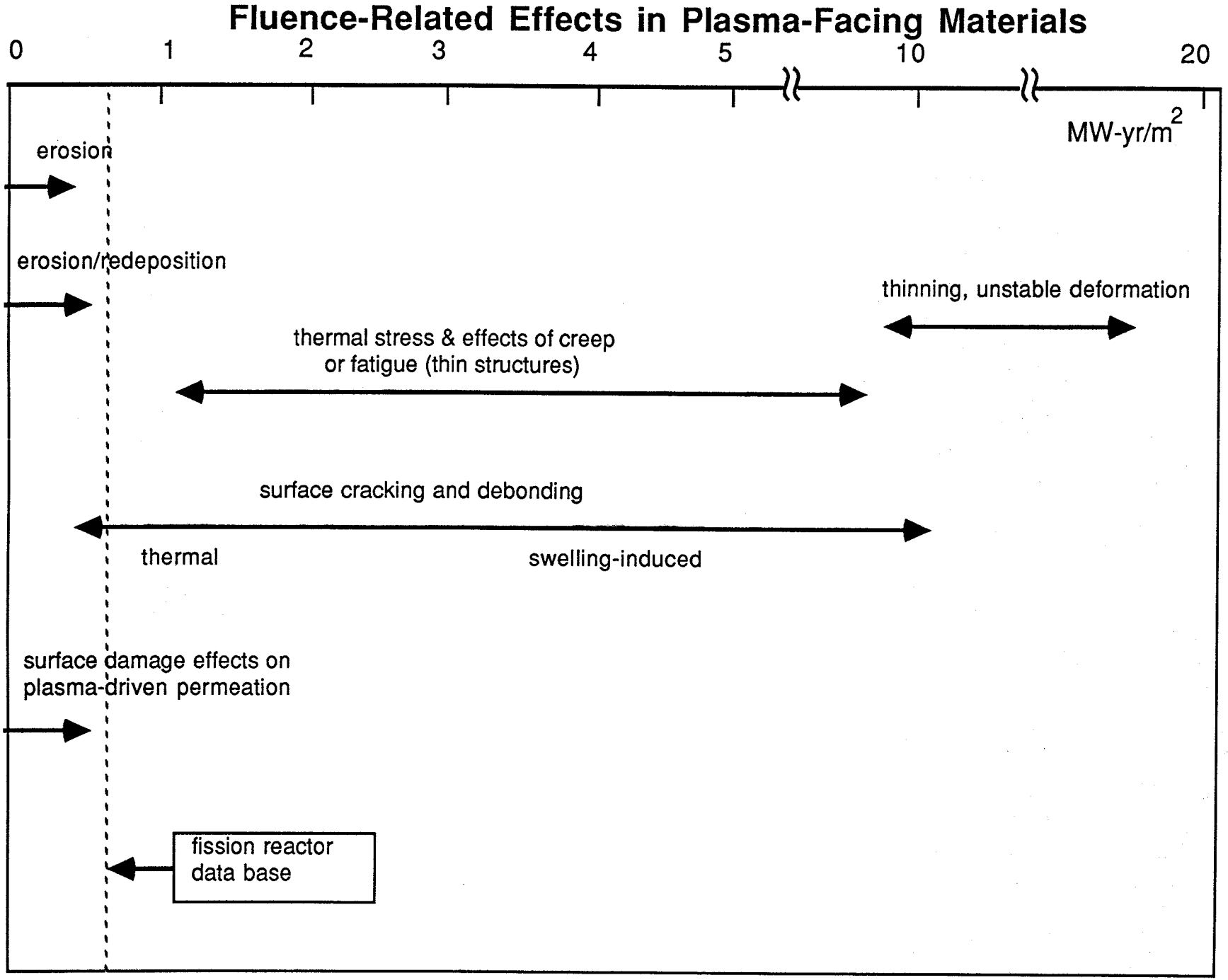
  Concept Verification Tests: 3-4 MW•y/m^2

Fluence-Related Effects in Blanket Structural Materials

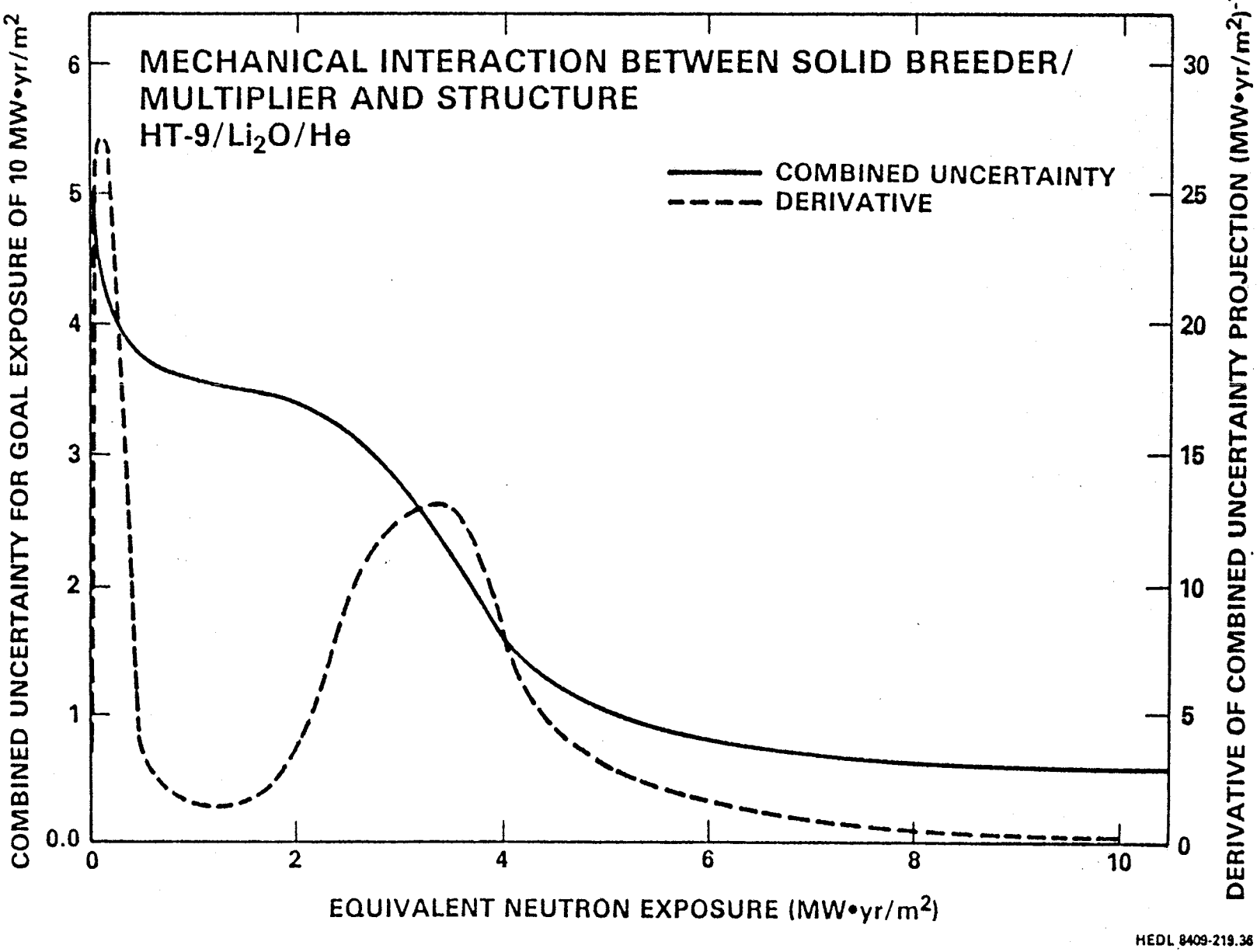


Fluence-Related Effects in Solid Breeders and Insulators




Fluence-Related Effects in Plasma-Facing Materials
0
1
2
3
4
5
10
20
MW-yr/m2
erosion
erosion/redeposition
thinning, unstable deformation
thermal stress & effects of creep
or fatigue (thin structures)
surface cracking and debonding
thermal
swelling-induced
surface damage effects on
plasma-driven permeation
fission reactor
data base

EXAMPLE OF BENEFIT Vs. FLUENCE



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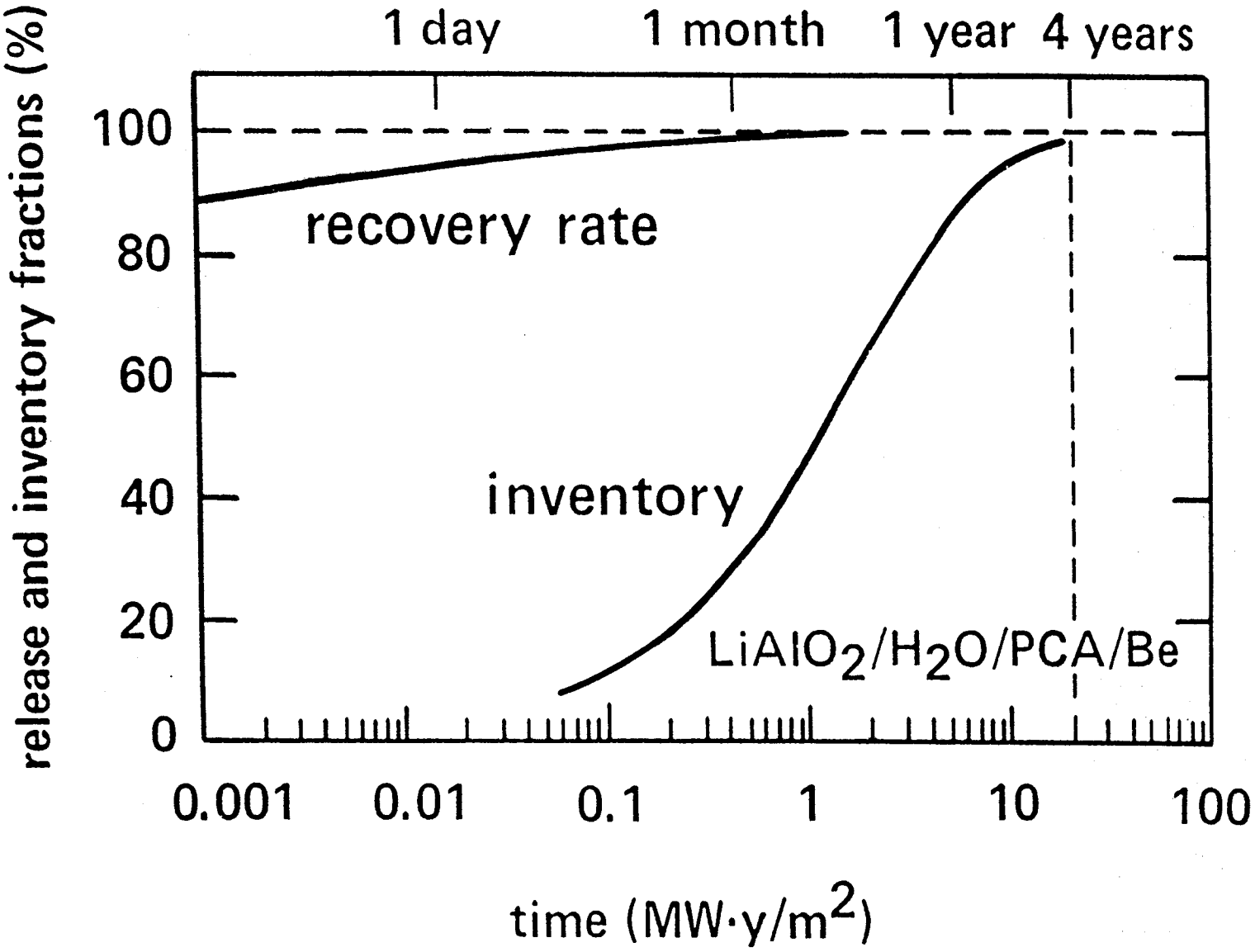
Reaching tritium inventory and recovery equilibrium may require long test times



Examples of Key FNT Issues Requiring Substantial Fluence

- Mechanical Interactions
  e.g., Solid Breeder/Clad Interactions
- Tritium Inventory in Solid Breeders
- Burnup Effects on Chemistry, Compatibility and Breeding
- Corrosion/Redeposition
- Failure Modes, Rates

Notes

- Substantial fluence needed based on:
  - long time constants for important processes
  - radiation effects
- Can not wait for DEMO: DEMO needs to operate reliably and safely. Reliability growth is the key in DEMO

Fluence Recommendations for ITER

	Approximate Fluence $MW \cdot y/m^2$
Checkout and Physics Testing	0.5
Nuclear: Scoping & Screening Tests	1 - 2
Nuclear: Concept Verification Tests	3 - 4
Allowance (for enclosure attenuation, failure/fix, etc.) = 0.3(4-6)	1 - 2

Recommended Neutron Fluence

for ITER:

5-6 $MW \cdot y/m^2$