Potential Value of a Dedicated Fusion Technology Test Facility

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Related to
Volumetric Neutron Sources

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Component R&D Prior to DEMO

- We need to be concerned with the tasks that must be accomplished prior to the DEMO
- Some of these tasks can be performed in ITER
- Other tasks will have to be performed parallel to ITER

Components:

Plasma	Tritium Systems
Blanket	Magnets
PFC	Plasma Heating
Shield	Diagnostic

R&D Tasks:

1. Performance verification and concept validation
2. Failure modes and effects
3. Remote maintenance demonstration
4. System integration
5. Availability/reliability growth
6. Component lifetime

Facilities Need for Fusion Nuclear Technology R&D

1. Non-Fusion Facilities

   Fission Reactors, Non-Neutron Test Stands

2. Fusion Facilities

Conclusion of Technical Studies

A. Testing of nuclear components in fusion facilities is absolutely necessary prior to DEMO

B. The fusion environment must satisfy specific technical requirements in order to validate concepts for DEMO nuclear components.

Requirements for Nuclear Testing of Components Have Been Defined

- These requirements have been derived from several years of technical studies

- The technical requirements for the end goal they address (i.e., decision on DEMO) are not controversial

  - All international workshops, including ITER-CDA Test Program workshops

- But, because these requirements have major impact on device characteristics, they are often confused with the strategy debate

DEMO Characteristics

Neutron Wall Loading	2–3 MW/m^2
Availability *	> 50%
Fluence	5–10 MW-yr/m^2
Fuel Cycle	Self-sufficient, demonstrate doubling time requirements
Plasma Mode of Operation	Steady state (or very long burn, short dwell)

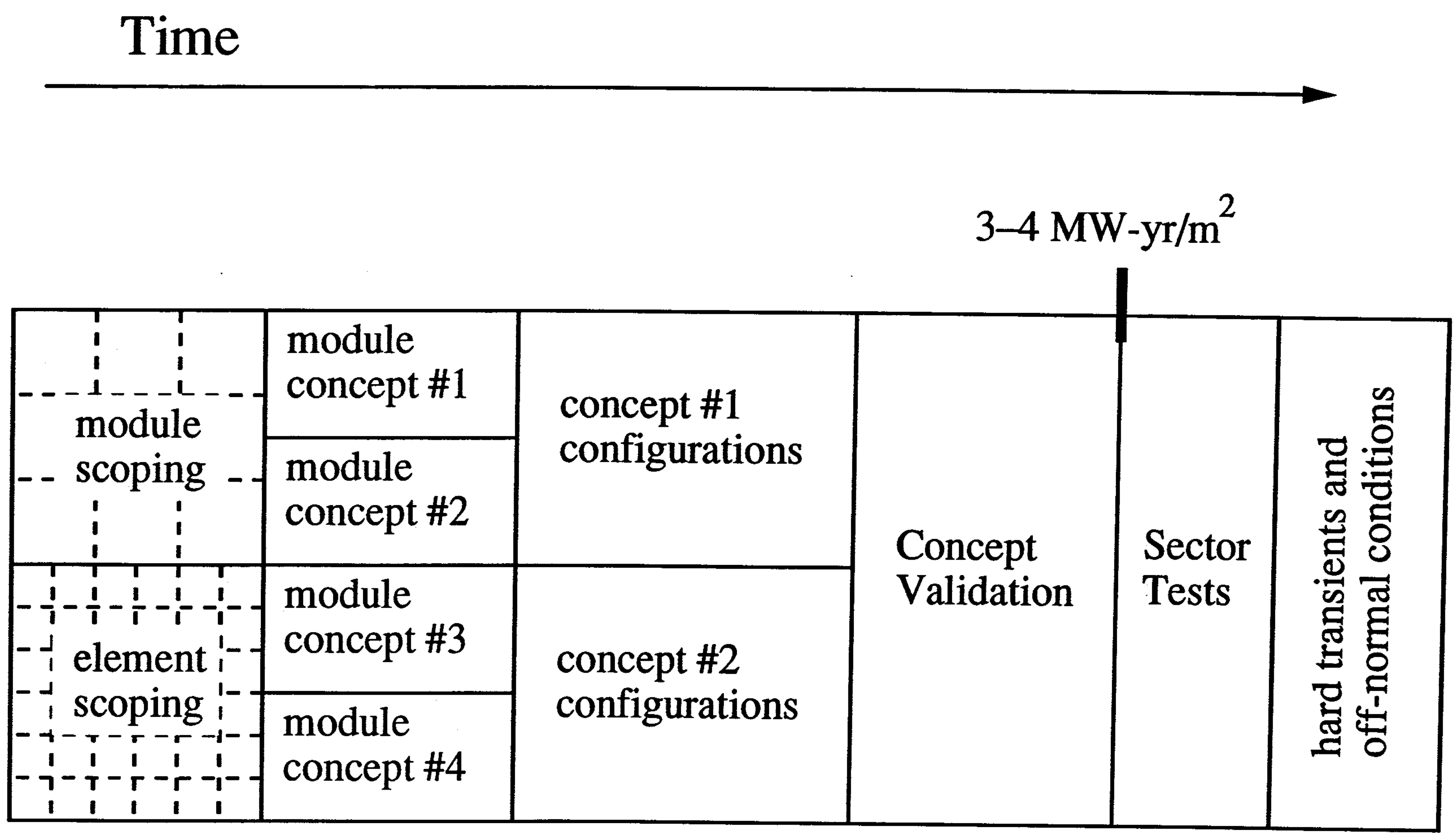
* To achieve machine availability of 50% means the availability per blanket module needs to be > 99%.

Nuclear Testing Requirements

	Minimum	Highly Desirable
Neutron Wall Load (MW/m^2)	1 *	2
Plasma Burn Time	> 1000 s	steady state (or long burn, hours)
Dwell Time	a	< 20 s
Continuous Test Duration (steady state or back-to-back cycle @100% availability)	> 1 week	2 weeks
Average Availability	10–15%	25–30%
Total Neutron Fluence ($MW\text{-}a/m^2$)	1.5	4–6
<u>Test Port Size</u> ($m^2 \times m$)		
Module	0.5×0.3	1×0.5
Outboard Sector	2×0.5	4×0.8
<u>Total Test Area</u> (m^2)		
Modules Only	5	10–20
Including Outboard Sectors	7	20–30

* lower wall load may be acceptable for screening tests if there is a big difference in the cost of the facility

Blanket Test Sequence



Physics and Technology Requirements for Testing Are Very Dissimilar

	Fusion Power	Integrated Burn Time	Tritium Consumption
Physics	1000 MW	15 days	0.7 kg
Technology (FNT)	20 MW	3 yr	1 kg
Combined e.g. ITER CDA	1000 MW	3 yr	50 kg

* Combining large power and high fluence leads to large tritium consumption requirements

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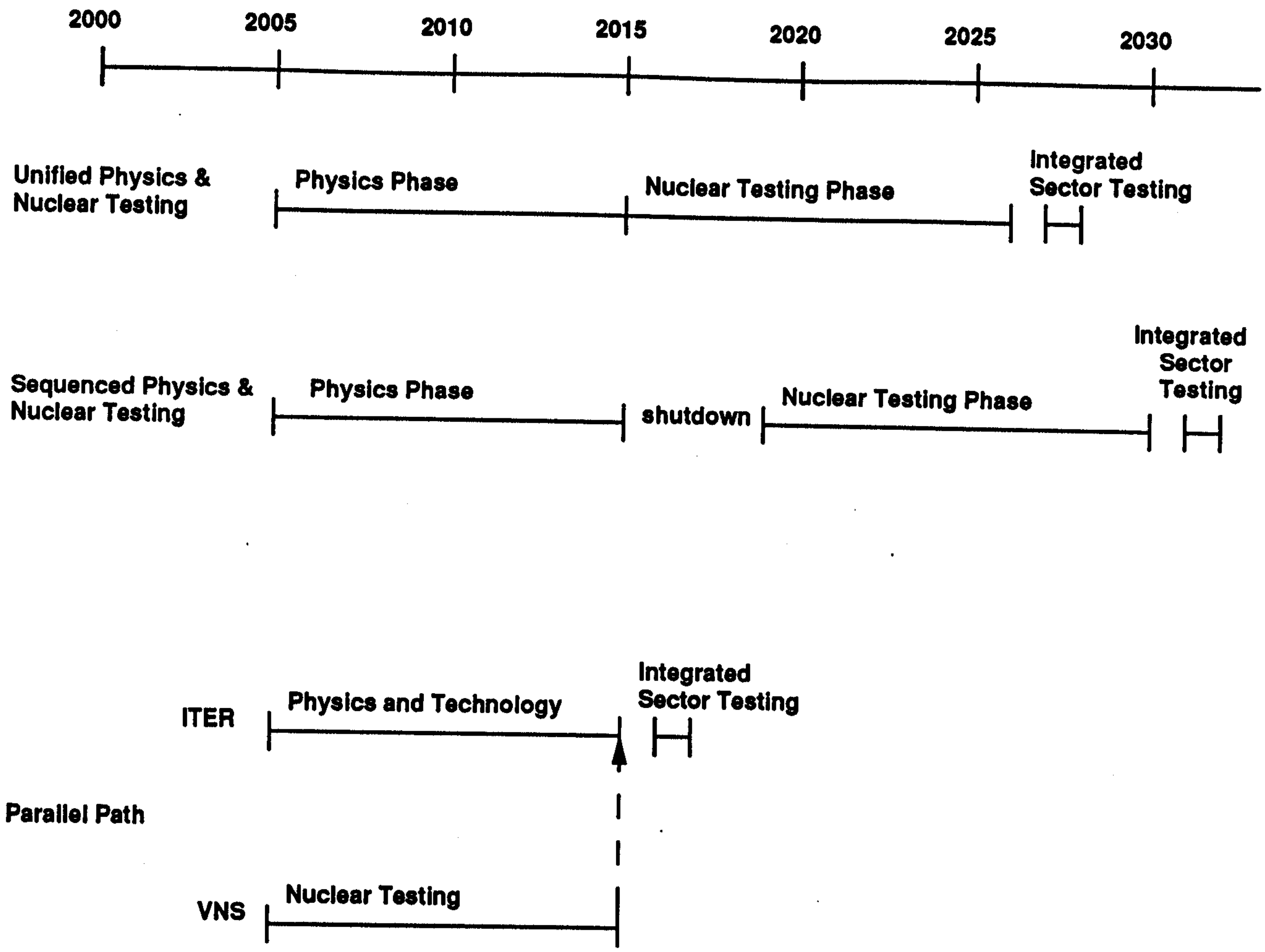

TIME-LINE FOR DEVELOPMENT SCENARIOS

Summary Observations

- Fusion Nuclear Technology (FNT) involves critical issues that must be resolved as part of demonstrating the potential of fusion as a practical energy source
- FNT R&D requires testing in non-fusion and fusion facilities
- Testing FNT in a fusion facility requires ~ 10 m^2 of surface area at ~ 1 MW/m^2 and a fluence > 3 $MW\text{-}yr/m^2$ <u>at the test module</u>
- FNT testing proceeds in stages:

  submodules → modules → sectors
- Performing the high fluence tests (~3 $MW\text{-}yr/m^2$) in <u>parallel</u> to ITER instead of <u>sequential</u> will help make fusion development more practical in terms of time scale and cost
- Therefore, if a fusion device can be constructed for ~$1B to test fusion nuclear technology, it will provide great momentum to the success of fusion development
- A study of the viability of a fusion facility for nuclear testing is very important for the world fusion program