Virtual Laboratory for Technology Input to Budget Planning Meeting

Charles C. Baker
VLT Director

Rockville, Maryland
16 March 2004

NOTE: Detailed information for each VLT element on budgets, tasks and milestones is provided in the VLT PAC presentation materials (provided for OFES program managers).

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Outline

- VLT Mission, Organization, PAC
- Overview of FY05/06 Budget Situation
- For each element
  - summary of mission and highlights
  - FY05 tasks and funding
  - FY06 tasks and funding (-10% and flat cases)
- FY05 Incremental Requests
- FY06 Incremental Requests
- Special Issues — NSO/FIRE and IFE Technology

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The Enabling Technology Research Mission

To contribute to the national science and technology base by developing the enabling technology for existing and next-step experimental devices, by exploring and understanding key materials and technology feasibility issues for attractive fusion power sources, by conducting advanced design studies that integrate the wealth of our understanding to guide R&D priorities and by developing design solutions for next-step and future devices.

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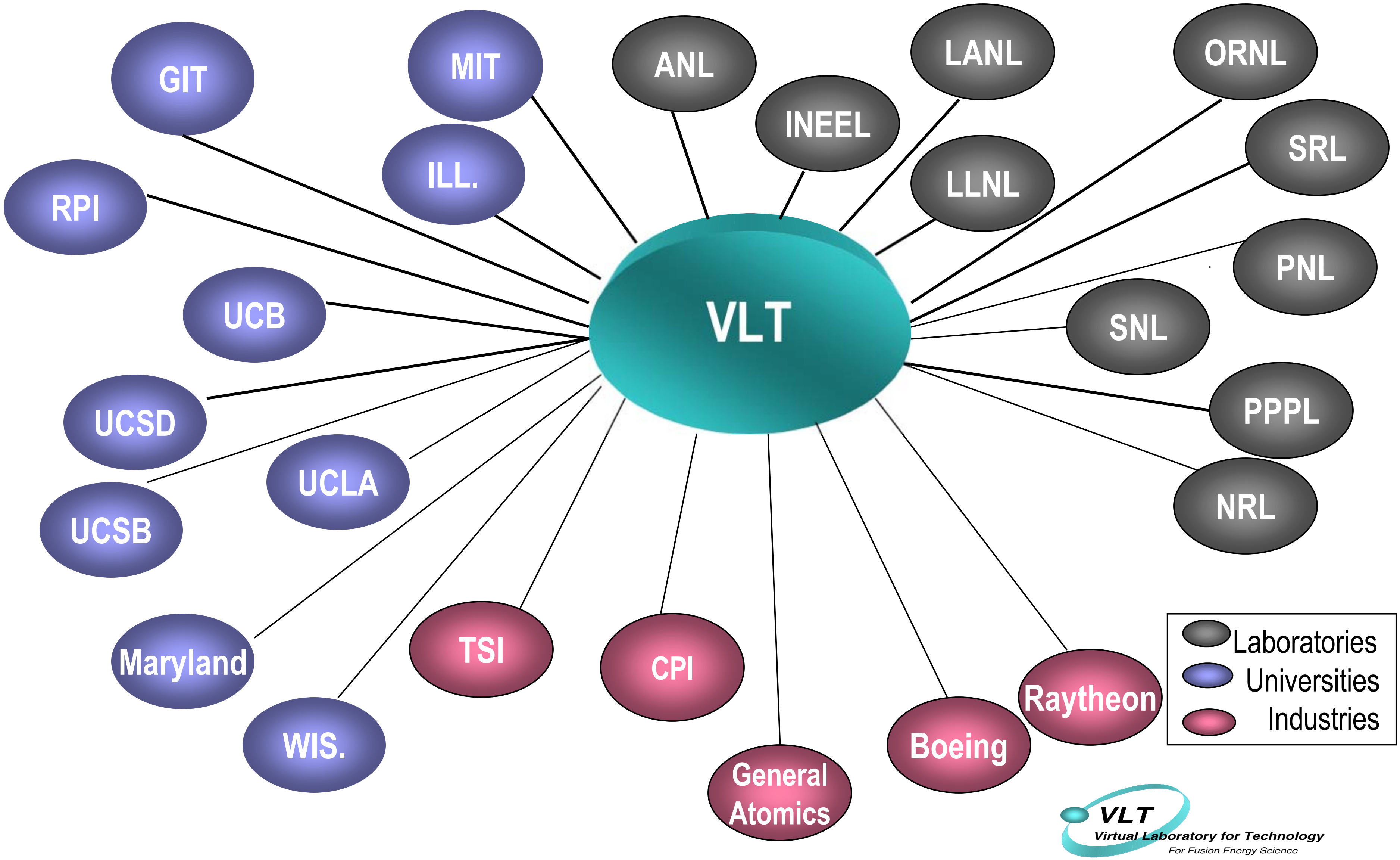
VLT Program Advisory Committee Members

PAC Member

J. Freidberg, Chair (*M. Porkolab)
*R. Hawryluk, Acting Chair
*D. Batchelor
J. Dahlburg
*B. Hooper
*T. Jarboe
*A. Kellman
*J. Kwan
P. Peterson
*K. Schoenberg
*J. Sethian

***** attended March 2-3, 2004 meeting*

The Technology Program is a Multi-institutional National Resource



VLT Program Element Leaders

Deputy Director	**S. Milora - *ORNL***
<u>Program Element</u>	**<u>Element Leader</u>**
Magnets	**J. Minervini - *MIT***
PFC	**M. Ulrickson - *SNL***
Chamber	**M. Abdou - *UCLA***
ICH	**D. Swain - *ORNL***
ECH	**R. Temkin - *MIT***
Fueling	**S. Combs - *ORNL***
Safety & Tritium Research	**D. Petti - *INEEL***
Tritium Processing	**S. Willms - *LANL***
NSO/FIRE	**D. Meade - *PPPL***
ARIES	**F. Najmabadi - *UCSD***
Socio-Economic	**J. Schmidt - *PPPL***
Materials	**S. Zinkle - *ORNL***
IFE Technology	**W. Meier - *LLNL***

Presentation Format
(for each area/element presenter)

- **Area/Element Overall Mission/Scope**

- **FY03/04 Technical Highlights/Accomplishments**

- **Proposed FY05 Tasks of President's Budget**
  1. list specific tasks with funding and deliverables (month/date)
  2. designate those tasks directly supporting ITER but not funded by ITER Project funds
  3. identify possible tasks (with funding) for incremental funds listed **in order of priority**

- **Proposed FY06 Tasks - Three Categories**
  1. list specific tasks with funding and deliverables of the FY05 President's Budget level MINUS 10%
  2. list additional tasks with funding **in priority order** with total funding at FY05 President's Budget level
  3. list proposed additional tasks above FY05 President's Budget level **in order of priority**

  For all three categories, identify those tasks directly supporting ITER, but not funded by ITER project funds.

- **List key concerns/issues**

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FY05/06 Budget Considerations

- "In planning for the FY2006 ongoing base program, institutions should increase their focus on burning plasmas and identify specific tasks, such as high-priority ITPA R&D, theory, and technology R&D..."

  → This is the major factor in planning the VLT program.
  Our planning assumes a positive ITER decision.

- The general approach used by Ned and Charlie regarding supporting R&D/design for ITER is to assume work to be done in national laboratories and universities, using existing people, will be funded through the base program. Industrial R&D/design will be funded by ITER project funds.

- The VLT program is thoroughly integrated into the IPPA Program Goals:
  - Lead on MFE Goal 4 (technology, materials, systems)
  - Major support on MFE Goal 3 (burning plasma)
  - Small support on MFE Goal 2 (innovative confinement concepts)
  - Activities supporting IFE Goal 2 (rep-rated systems) are to be eliminated.

- Support for the Plasma Technology area has been modestly increased, but most of the changes are due to moving elements into this area.

- The Fusion Technology area is to be eliminated in FY05.

  → Some MFE activity is retained under Plasma Chamber Systems and it is being re-directed to focus on ITER blanket test modules. The effort is severely budget limited.

  → All IFE chamber and target injection technology is to be eliminated.

- The FIRE design activity is to be concluded in FY04.

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FY 05 OFES Technology Program Budgets ($K) as of 2-02-04

Program Elements	FY03	FY 04 Jan.	FY 05 CBR	FY ITER Support
Plasma Facing Components	6550	5954	7054	2469
Magnet Systems	2103	2164	2248	1706
Plasma Chamber Systems	1000	0	1894	1894
ICH Systems	1764	1334	1611	960
Safety/Tritium Research	0	1933	2234	1650
ECH Systems	1126	1185	1418	650
Fueling Systems	910	930	1024	650
Neutronics	0	75	197	
Neutral Beam Systems	64	60	60	
TOTAL - Plasma Technologies	**13517**	**13635**	**17740**	
TSTA	2679	0	0	
MFE Chamber Technologies	2984	1840	0	
IFE Chamber Technologies	*2262*	*1038*	*0*	
MFE Safety and Environment	1330	0	0	
IFE Target Fabrication	*685*	*0*	*0*	
Tritium Research	745	0	0	
IFE Safety and Environment	*308*	*160*	*0*	
Remote Systems	110	0	0	
TOTAL - Fusion Technologies	**11103**	**3038**	**0**	
Next Step Option-FIRE	1893	600	0	
IFE System Studies	*1002*	*0*	*0*	
MFE System Studies	1068	1636	1636	
VLT Management	797	704	697	
Socio-economic Studies	217	30	150	
Burning Plasma Applications	179	120	98	
ITER Cost Estimating	733	0	0	
TOTAL - Advanced Design	**5889**	**3090**	**2581**	
Materials Science	**7741**	**7636**	7379	250
TOTAL	**38250**	**27399**	**27700**	**10229**
TOTAL IFE	***4257***	***1198***	*0*	

Magnet Technology Mission

Reduce the size and cost of superconducting magnets by higher fields, current densities, stress levels and operating temperatures. Develop high critical temperature superconductors. Develop improved conductors and components for a Burning Plasma Experiment and advanced magnet concepts to achieve better physics performance. Develop cost effective design and fabrication techniques for IFE-HIF focusing magnets.

- **Support of LDX**
  - **Low and High Temperature superconducting magnet design, fabrication and testing**
- **Support of IFE-HIFD**
  - **HCX magnet and cryostat design, fabrication and test**
- **Support of Next Step Options**
  - **FIRE and ITER magnets**
- **Basic R&D**
  - **Superconductors and magnet insulation and structural materials**
  - **Education and training of students**

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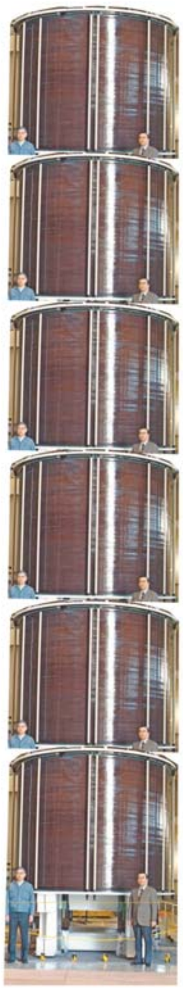
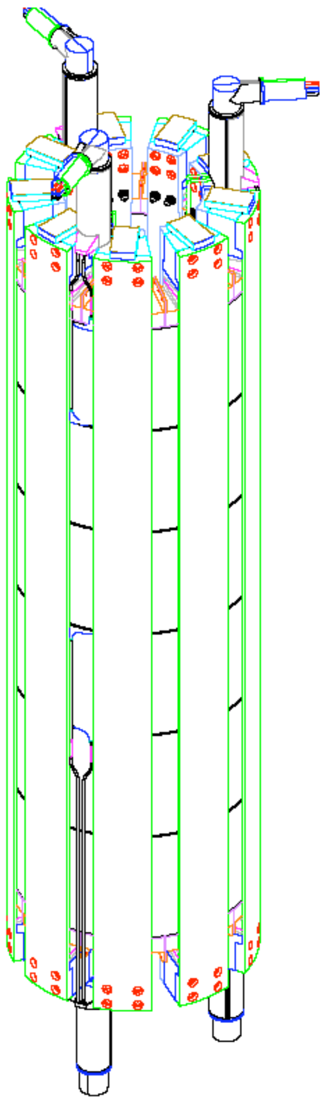
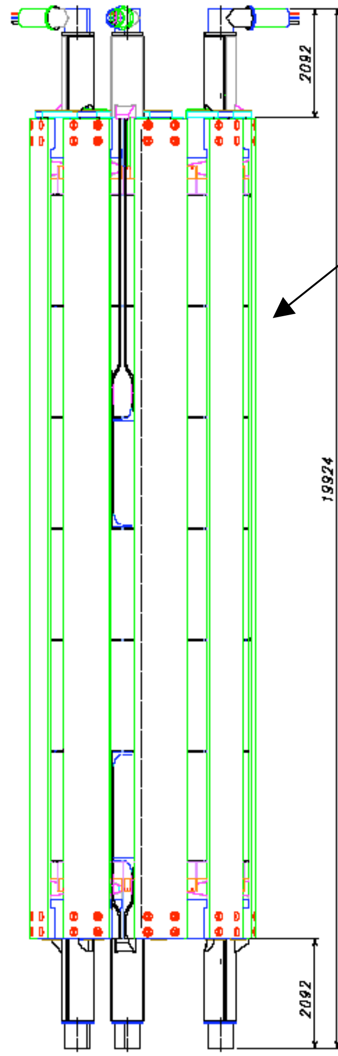
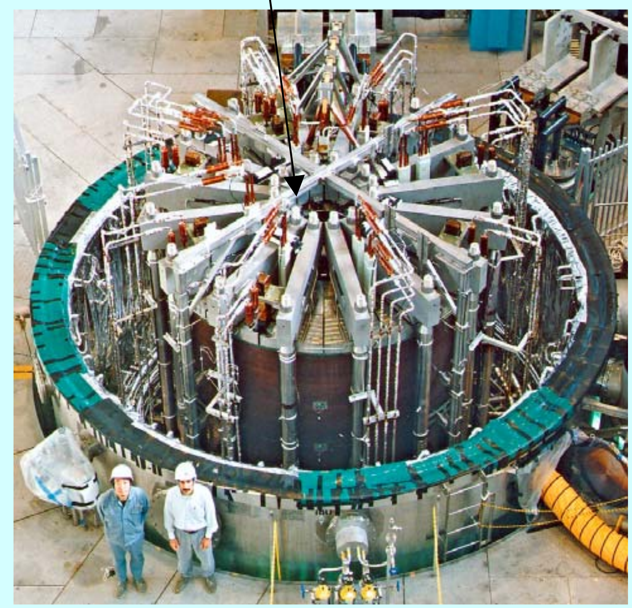
CS Coil is Composed of 6 Pancake Wound Modules







Each Module is slightly larger than the complete CS Model Coil



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VLT PROGRAM ELEMENT:	Magnet Systems					
	FY05 (K$)		**FY 06 (K$)**			
	CBR	(ITER)	-10%	(ITER)	Flat	(ITER)
Task Descriptions						
• Strand Development	396	(348)	172	—	172	—
• Jacket Material	240	(160)	256	(256)	256	(256)
• CS Specification, Procurement Development, Analysis and Tests	1198	(1198)	750	(750)	990	(990)
• Small-scale Tests and Graduate Research	414	—	574	—	574	—
• Quench Protection	—	—	256	(256)	256	(256)
TOTALS	2248	(1706)	2008	(1262)	2248	(1502)

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Mission and Goals for Plasma Facing Components

- **The PFC Program mission is the development of plasma facing component systems capable of interfacing with the extreme conditions at the boundary of fusion grade plasmas.**

- **There are three goals:**

  - Engineering and design of innovative PFC systems for present day and next generation fusion experiments including burning plasma experiments such as ITER

  - Advancing the scientific field of plasma materials interactions (PMI)

  - Developing the science and engineering foundation for the PFC system of DEMO.

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PFC Accomplishments

- **Injected 10 m/s flowing Li jet into NSTX like magnetic field and measured MHD effects (SNL).**
- **He and H retention and diffusivity measurements in flowing liquid lithium as a function of energy and lithium temperature in FLIRE (UIUC).**
- **A multiple-materials (C, Be, V, W) DiMES sample was exposed to 22 upper single null discharges to simulate chamber wall erosion. Erosions was measured by Ion beam analysis at SNL. (GA)**

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PFC Accomplishments (cont'd)

- **Experimentally demonstrated that depleted codeposited C layers do not refill with H after annealing. (SNL)**

- **Upgraded the science of integrated erosion and redeposition analysis of liquid lithium and other liquid metal and solid divertors. (MD, T dependent sputtering, fluid and kinetic code impurity transport SOL plasma. (ANL)**

- **PISCES experiments show carbon erosion suppressed by small amount of beryllium impurity in boundary plasma. (UCSD)**

- **Very clean liquid Li fill of limiter tray on CDXU. (UCSD)**

- **Molecular Dynamics modeling of D sputtering of liquid Li to calculate reflection coefficients and sputtering. (UIUC)**

- **Predict low intrusion of lithium to the core of NSTX (full coverage, with UEDGE utilizing WBC and vice versa). (LLNL)**

VLT PROGRAM ELEMENT: Plasma Facing Components

Task Descriptions	FY05 (K$) CBR	FY05 (K$) (ITER)	FY 06 (K$) -10%	FY 06 (K$) (ITER)	FY 06 (K$) Flat	FY 06 (K$) (ITER)
• Liquid Metal Research	2537	—	2359	—	2464	—
• Plasma Material Interactions	2322	(1094)	2032	(1282)	2322	(1282)
• Solid Surface PFC Research	1128	(920)	1087	(779)	1237	(779)
• PMI and SOL Modelling	1067	(455)	904	(368)	1031	(368)
TOTALS	7054	(2469)	6382	(2429)	7054	(2429)

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Scope of Plasma Chamber Systems Activities

1. ITER test blanket module (TBM) program

- Active participation in ITER test blanket working group (TBWG).
- Evaluate blanket options for DEMO and evaluate R&D results for key issues to select primary US blanket concepts for testing in ITER in collaboration with materials, PFC, and safety communities.
- Perform concurrently R&D on the most critical issues required (e.g., MHD flow and insulators, tritium recovery and control, SiC inserts, solid breeder/multiplier/structure/coolant interactions).
- Enhance and focus current international collaborative R&D to provide data for ITER TBM.
- Develop engineering scaling and design, in collaboration with ITER partners, for TBMs.

2. Support for the basic ITER device

- Provide more accurate prediction in the nuclear area for critical ITER components as we move toward construction (e.g. diagnostics damage, personnel access, activation to assess site specific safety issues)

3. Predictive capabilities and tools needed by elements of fusion program

- Improve our predictive capabilities in areas of neutronics, activation, neutron-material interactions, heat transfer, fluid mechanics, MHD, tritium recovery and control, fuel cycle dynamics, reliability and availability.

4. International collaboration: JUPITER-II (Funds from Japan), IEA

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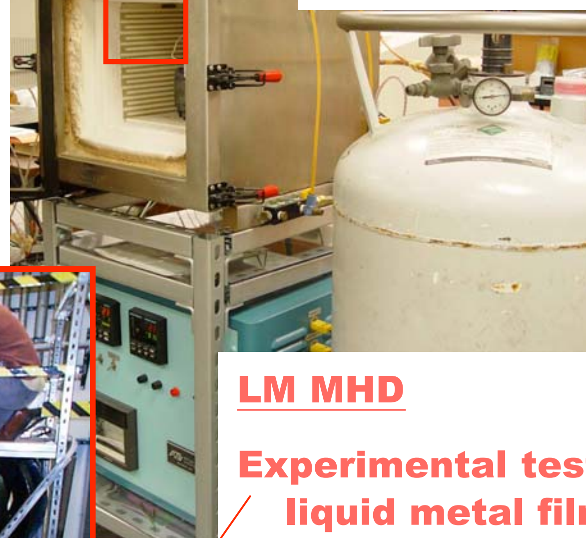
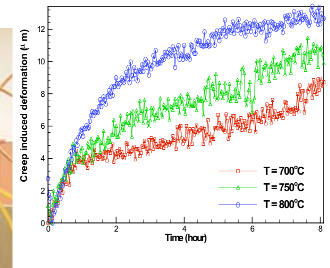
FY04 Experimental Accomplishments

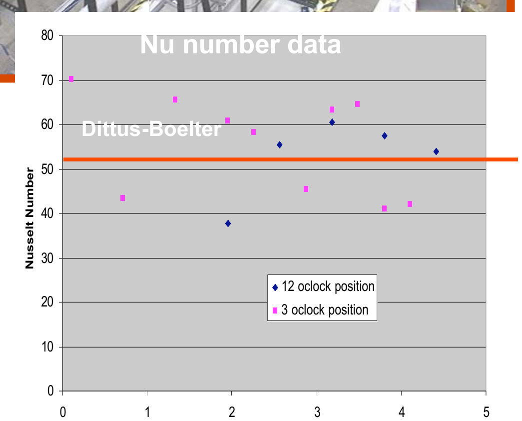
Understanding phenomena and producing data for code benchmarking





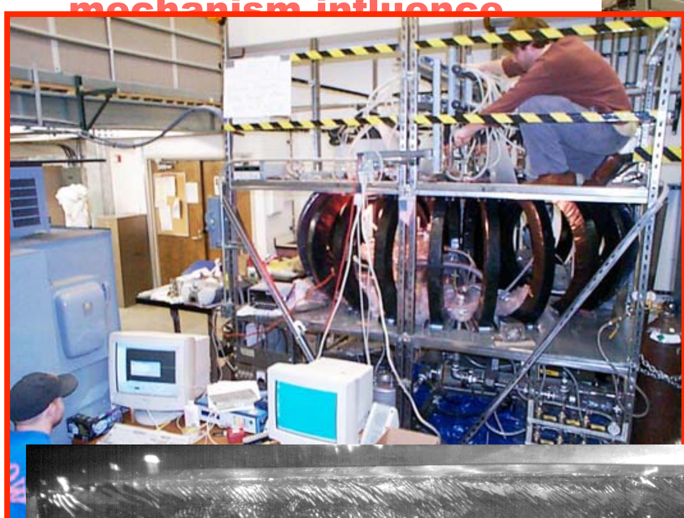
Jupiter-2 Flibe Thermofluid

7 m heat transfer test section constructed, detailed experiments underway with high Pr molten salt simulants



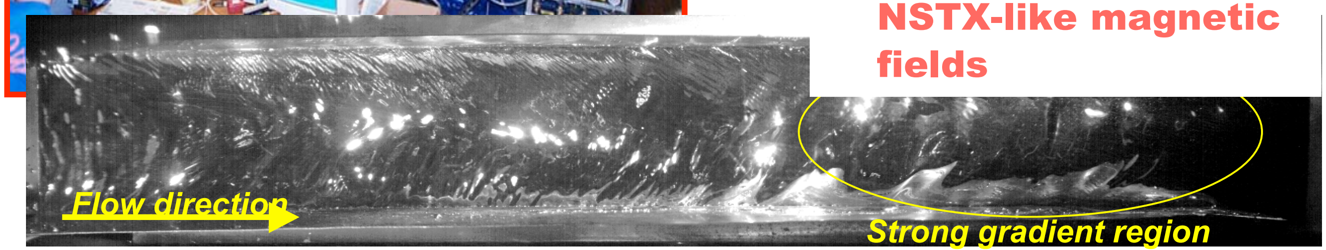
Solid Breeder Thermomechanics

Temperature experiments on pebble bed thermal creep shows creep mechanism influence



LM MHD

Experimental tests of liquid metal film flows show significant MHD drag effect in scaled NSTX-like magnetic fields



VLT PROGRAM ELEMENT:	Plasma Chamber Systems					
	FY05 (K$)		FY 06 (K$)			
	CBR	(ITER)	-10%	(ITER)	Flat	(ITER)
Task Descriptions						
• U.S. Contributions to Test Blanket DDD and Test Article Design	510	(510)	410	(410)	510	(510)
• Solid Breeder R&D	380	(380)	300	(300)	380	(380)
• Liquid Breeder Assessment	414	(414)	464	(464)	414	(414)
• Jupiter-II Collaboration	590	(590)	531	(531)	590	(590)
TOTALS	1894	(1894)	1705	(1705)	1894	(1894)

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Fusion Safety Program Mission

- Characterize and assess the safety and environmental issues associated with magnetic and inertial fusion. Assist the various design teams in improving the safety and environmental attributes of their design.
- Demonstrate the safety and environmental potential of fusion by (1) avoiding any need for off-site public evacuation during worst case accidents and (2) minimizing the amount of radioactive waste that would pose a burden for future generations.
- This is accomplished by:
  - Understanding the behavior of the largest sources of radioactive and hazardous materials in a D-T machine
  - Understanding how energy sources in a fusion facility could mobilize those materials
  - Developing integrated state of the art analytic tools to demonstrate the safety and environmental potential of fusion
  - Assessing/evaluating safety and environmental issues associated with emerging fusion concepts such as those studied in the MFE ARIES, ALPS, APEX, NSO projects, and the IFE program

Outstanding ITER safety issues

- Validate US safety analysis tools (calculations with quantified uncertainties with the level of detail to depend on regulatory requirements of the actual site) that underpin the ITER safety analysis
- Validate magnet safety codes against medium scale magnet and busbar arcing experiments to demonstrate that ITER can tolerate large internal and external arcs in the magnet systems without violating the integrity of the radioactive confinement barriers.
- Validate dust inventory estimates in ITER and develop a dust removal strategy that will demonstrate compliance against dust safety limits in ITER and not hamper operational flexibility of the machine
- Validate tritium inventory estimates in ITER mixed material PFCs and demonstrate that removal strategies are effective at the ITER scale to comply with safety limits

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VLT PROGRAM ELEMENT: **Safety and In-Vessel Tritium**

Task Descriptions

	FY05 (K$)		FY 06 (K$)			
	CBR	(ITER)	-10%	(ITER)	Flat	(ITER)
• Fusion Safety Codes	450	(450)	450	(450)	450	(450)
• Magnet Safety	150	(150)	150	(150)	150	(150)
• Dust Source Term	450	(450)	325	(325)	450	(450)
• In-vessel Tritium Source	600	(600)	600	(600)	600	(600)
• Jupiter II Participation	290	—	290	—	290	—
• Risk Assessment and Safety Support	300	—	200	—	300	—
TOTALS	2240	(1650)	2015	(1525)	2240	(1650)

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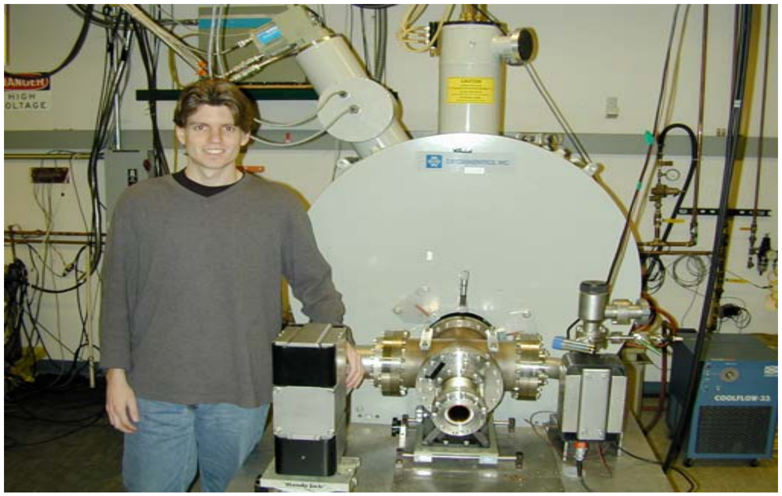
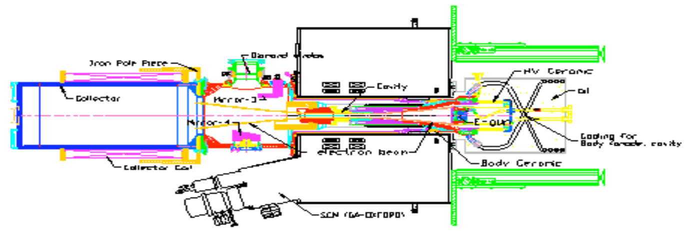
ECH Mission / Scope

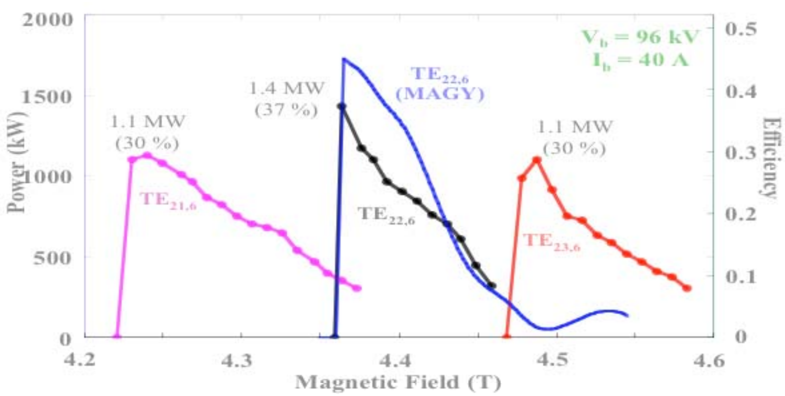
- Develop advanced, reliable technology for ECH, ECCD, EBW
  - Gyrotrons, Windows, Transmission Lines and Antennas.
- Support near term and burning plasma ECH experiments.
- Foster international collaboration.

- Increase the reliability, power and efficiency of gyrotrons.
  - Develop tunable gyrotrons for use at a range of B field values.
- Develop efficient mode converters to Gaussian beams.
- Increase the efficiency of transmission lines.
- Develop remote, steerable launchers.
- Develop the theory and design tools for the accurate design of new gyrotrons and transmission line components.
- Reduce the cost of all gyrotron system components.
- Develop a low cost gyrotron power supply system.

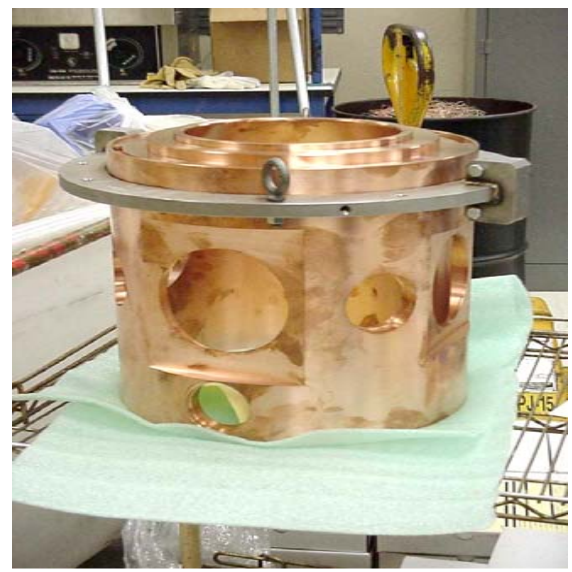
FY03 / FY04: 1.5 MW, 110 GHz Gyrotron







Demonstration of 1.4 MW at Short Pulse Lengths (MIT)



CW Tube will operate in 3/04 (CPI)

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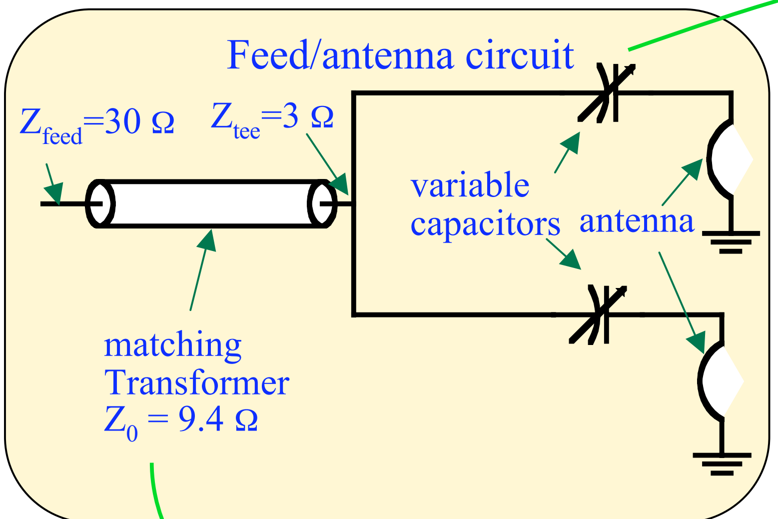
VLT PROGRAM ELEMENT: **ECH Systems**

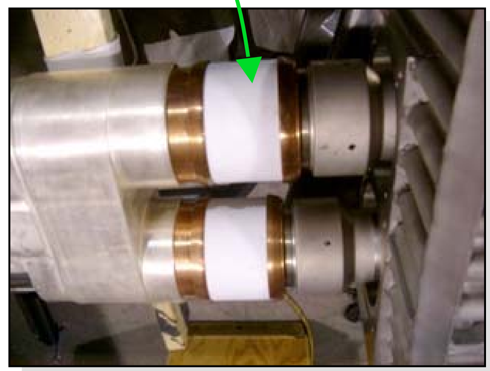
	FY05 (K$)		FY 06 (K$)			
	CBR	(ITER)	-10%	(ITER)	Flat	(ITER)
Task Descriptions						
• ITER 1MW, 120GHz Gyrotron	475	(475)	625	(625)	757	(757)
• 1.5MW, 110GHz, Depressed Collector Gyrotron	368	—	—	—	—	—
• ITER Transmission Line	75	(75)	50	(50)	50	(50)
• Remote Steerable Launch/Reflector	75	(50)	77	(55)	77	(55)
• ITER Reliability Studies, Loss Tangent and Space Charge Studies	—	—	185	(150)	195	(160)
• Next Step Gyrotron Research	195	—	200	—	200	—
• Modelling/Code Development	230	(50)	139	(70)	139	(70)
TOTALS	1418	(650)	1276	(950)	1418	(1092)

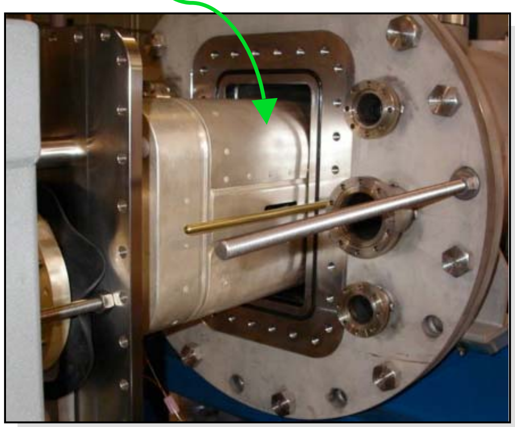
The long-term objectives are to develop reliable, advanced ICRF heating & current drive systems that:

- Operate routinely at their design power and voltage.
- Reduce the required port size - high power density launchers.
- Are robust - tolerant of rapidly varying plasma loads.
- Are flexible
  - Operate over a wide range of density and magnetic fields.
  - Heat either ions or electrons
  - Control plasma conditions via heating and current profile.
- Support long pulses - essentially steady-state.
- Work reliably in a reactor environment.

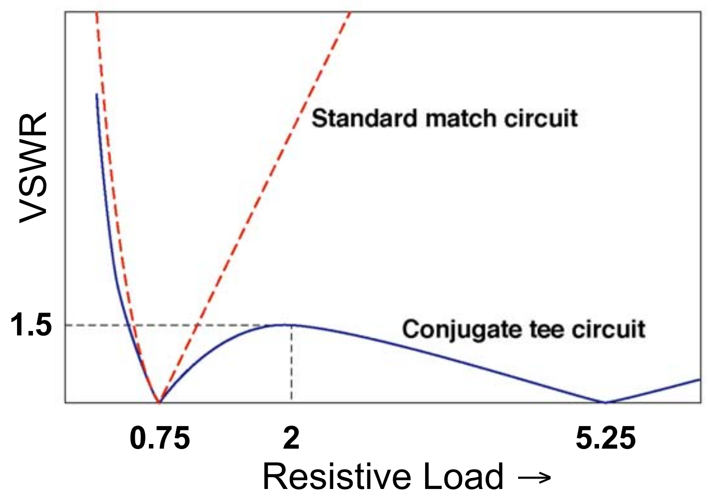
Load-tolerant antenna designs address the long standing plasma edge variability issue but also introduce some design challenges







RF match behavior with increasing resistive load



Load Tolerant Antennas:

Test

Tore Supra
JET-A2
JET-HPP
C-Mod external

Fabrication

JET-EP

Design

DIII-D replacement
C-Mod replacement
ITER

VLT PROGRAM ELEMENT:	ICH Systems					
	FY05 (K$)		**FY 06 (K$)**			
	CBR	(ITER)	-10%	(ITER)	Flat	(ITER)
Task Descriptions						
• ITER RF System Design	210	(210)	405	(405)	510	(510)
• Dual-tube Transmitter Tests	100	(100)	—	—	50	(50)
• RF Insulator Neutron Irradiations	150	(150)	—	—	—	—
• High Power Density Antenna Tests	300	(300)	100	(100)	100	(100)
• Antenna Component R&D	200	(200)	300	(300)	300	(300)
• RF/Edge Interaction Modelling, Breakdown and Improved Reliability	500	—	500	—	500	—
• Support for ICC Concepts	100	—	100	—	100	—
TOTALS	1560	(960)	1405	(805)	1560	(960)

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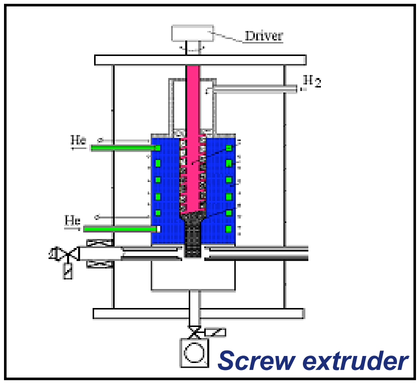
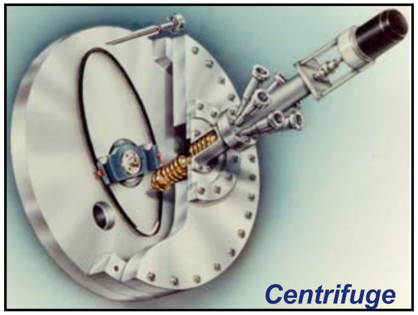
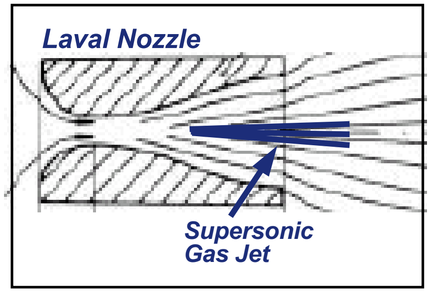
New Technical Challenges for ITER Fueling System

- ITER pellet injector baseline is a centrifuge fed by a continuous screw extruder
- High throughput and tritium compatibility
  - Continuous screw extruder rates are ~5-10 times lower than that required (Viniar, RF)
  - Highest ice flow rates to date are ~67% of ITER requirements using three batch extruders operating in sequence (Combs et al.)
  - Snail pump needed for excess extrusion material
- Centrifuges have not yet achieved the reliability objective (~100% intact pellets).
- Pneumatic injectors can more easily meet reliability requirements, but have a gas load issue.
- Significant R&D effort still required before final ITER design; development and testing program will be needed to validate the proposed design.
- Generic technology development may lead to supplemental approaches (supersonic gas jet, high-speed vertical injector, inner bore PI, etc.)







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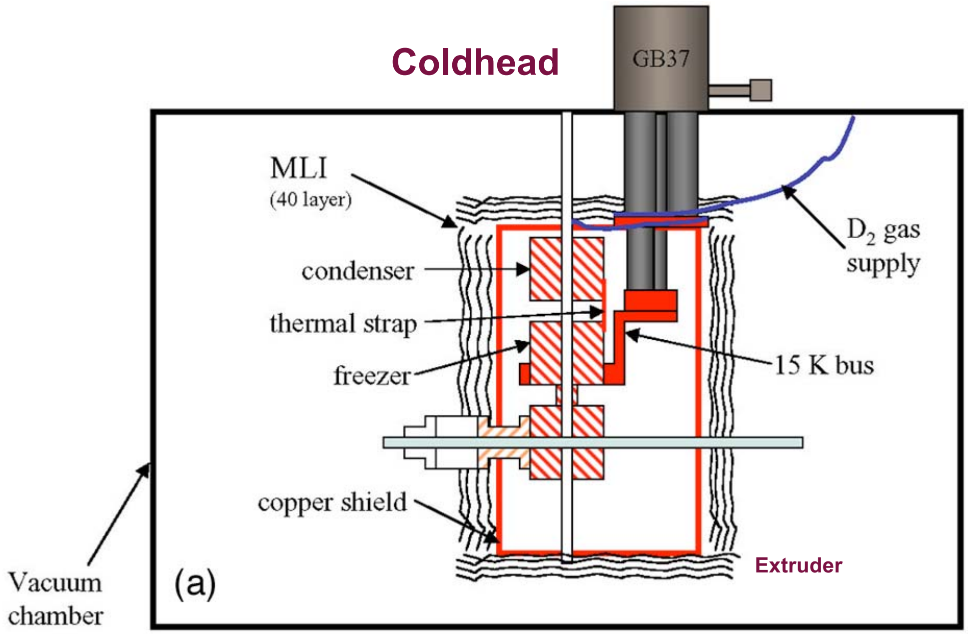
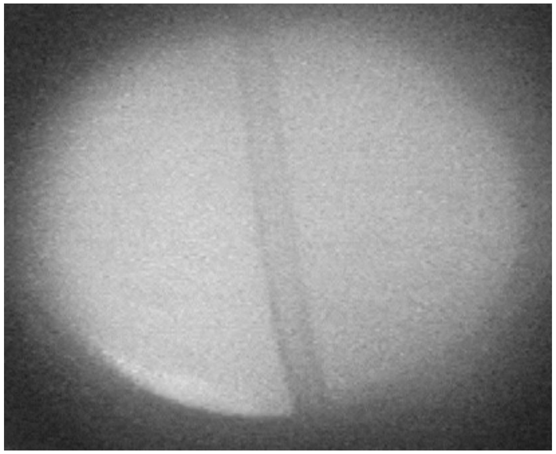
H2 Extrusions Achieved with Cryocooler Technology



H2 Ice Extrusion



- Work done in collaboration with Prof. J. Pfotenhauer at the UW
- Extruders for long-pulse pellet injectors are usually cooled with LHe (dewars or cryogenic plant)
- Pellet injector with cryocooler offers some advantages
  - low operating cost after initial investment (up to several $K per day for lab operations)
  - independent from LHe dewars or facility cryogenic systems

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VLT PROGRAM ELEMENT: **Fueling System**

Task Descriptions	FY05 (K$) CBR	FY05 (K$) (ITER)	FY 06 (K$) -10%	FY 06 (K$) (ITER)	FY 06 (K$) Flat	FY 06 (K$) (ITER)
• Multiple Pellet, High Throughput, Inner Wall Guide Tube Testing	150	(150)	50	(50)	50	(50)
• Prototype Centrifuge Development	200	(200)	250	(250)	250	(250)
• Continuous Extruder Development	100	(100)	100	(100)	100	(100)
• Pellet Injector System Design	200	(200)	250	(250)	250	(250)
• Compact Pellet Injector and Diagnostic Development	225	—	200	—	225	—
• Cryocooler Development	100	—	75	—	100	—
• Supersonic Cryogenic Gas Jet	50	—	—	—	50	—
TOTALS	1025	(650)	925	(650)	1025	(650)

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Fusion Materials Science Mission Statement

- Advance the materials science base for the development of innovative materials and fabrication methods that will establish the technological viability of fusion energy and enable improved performance, enhanced safety, and reduced overall fusion system costs so as to permit fusion to reach its full potential

- Assess facility needs for this development, including opportunities for international collaboration

- Support materials research needs for existing and near-term devices

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Principal FY03/04 Achievements

- ❑ State-of-the-art computational research and experimental studies have uncovered the physical mechanisms responsible for flow localization in metals irradiated at low temperatures (e.g. dislocation channeling). This can lead to the design of materials that are resistant to these radiation-induced flow localization processes.

- ❑ A Master Curve methodology was developed to treat constraint loss effects in fracture toughness specimens, and a critical stressed-volume model was established that successfully described the behavior in V alloys and ferritic-martensitic steels.

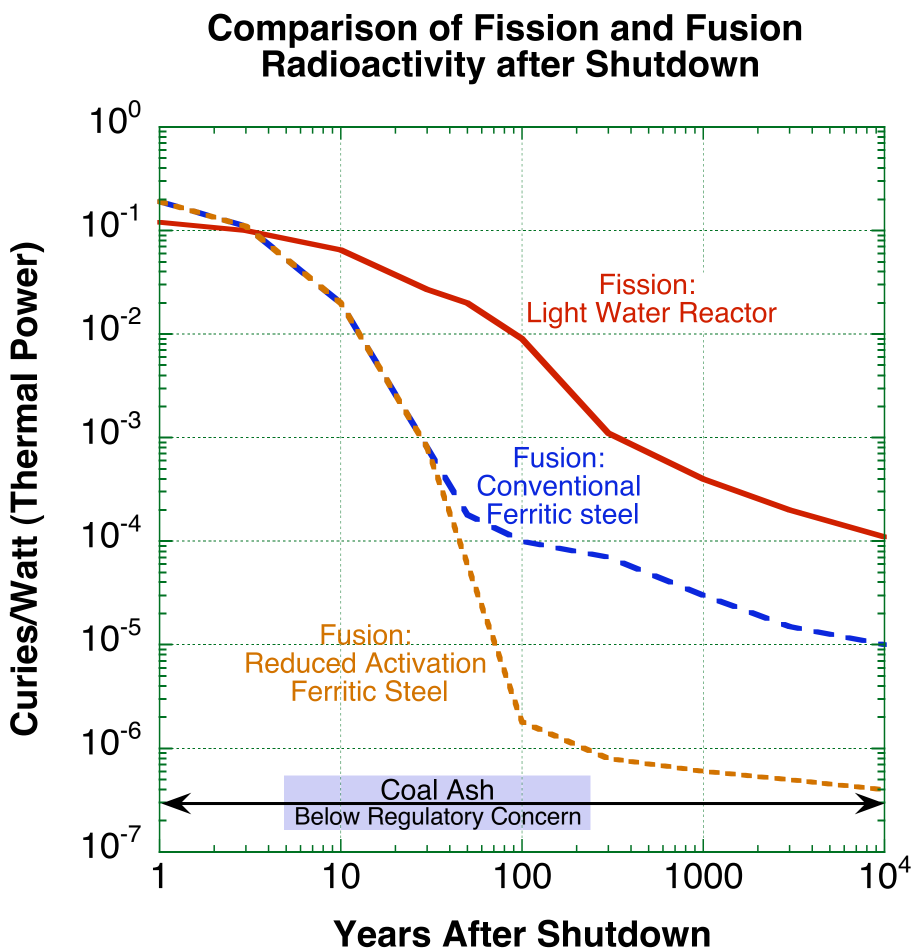
- ❑ Evidence for new thermodynamic processes at the nanoscale (e.g., dissolution of Y_2O_3 particles during processing) have been obtained in nanocomposited ferritic steel. The new alloys may increase the upper operating temperature limit of steels by ~200˚C.

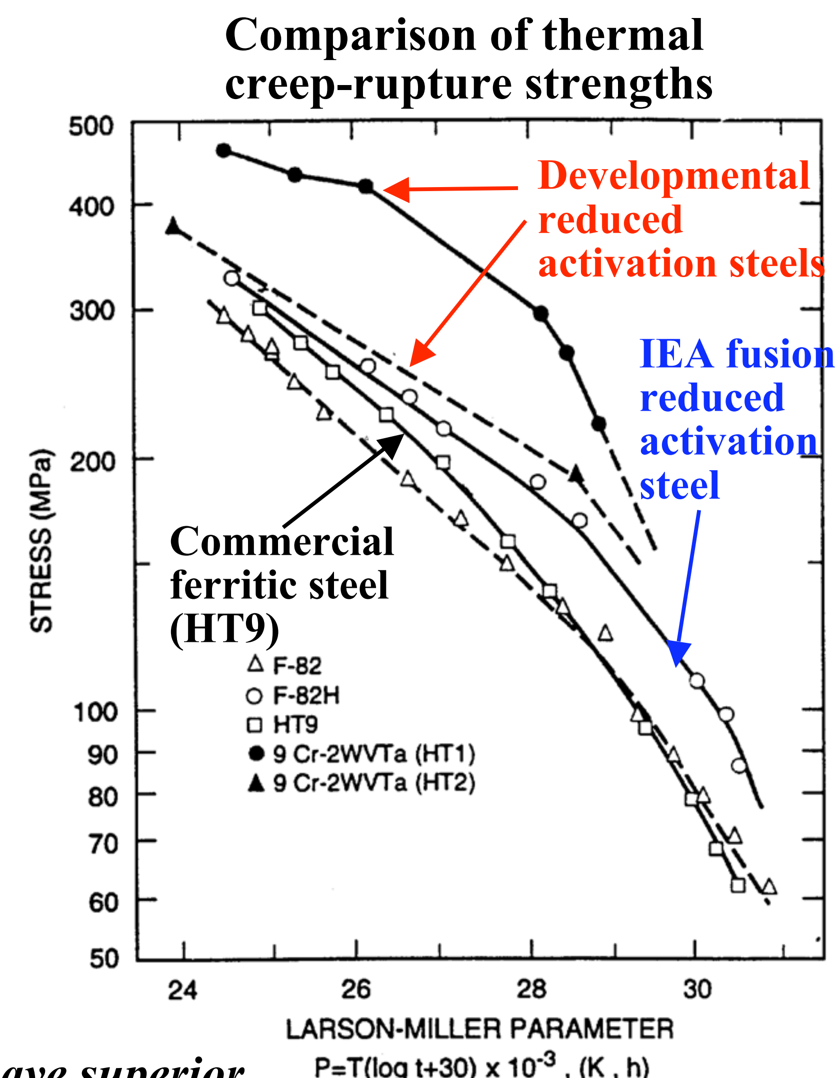
- ❑ A science-based program has led to the development of radiation-resistant SiC/SiC composites (for doses up to 10 dpa). These improved composites utilize 3rd-generation SiC-based fibers and tailored fiber/matrix interphase regions (e.g., SiC multilayer interphases). Work with Japanese colleagues (Jupiter-II program) has resulted in the first SiC/SiC composites that have sufficiently low bulk permeation constants for He gas.

- ❑ Scoping compatibility experiments for candidate V/Li MHD insulators have identified several candidates which may perform satisfactorily for temperatures up to 800˚C, including AlN, Y_2O_3 and Er_2O_3. Work is underway to expand their upper use temperatures by doping the Li with suitable concentrations of Ca, O, Al or N solutes.

- ❑New atomistic computational methods are revealing the mechanisms of transport and retention of helium in irradiated ferritics.

Ferritic/martensitic Steels with Reduced Radioactivity and Superior Properties Compared to Commercial Steels have been Developed by Fusion





Fusion-developed steels also have superior tensile strength, irradiated fracture toughness, and thermal conductivity

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VLT PROGRAM ELEMENT: **Materials Science**

Task Descriptions	FY05 (K$) CBR	FY05 (K$) (ITER)	FY 06 (K$) -10%	FY 06 (K$) (ITER)	FY 06 (K$) Flat	FY 06 (K$) (ITER)
• Cross-cutting Theory and Modelling	2020	—	2010	—	2020	—
• Structured Materials Including US/Japan Match	4500	—	4150	—	4500	—
• Functional Materials	480	—	450	—	500	—
• Neutron Source Assessments	150	—	—	—	50	—
• ITER Materials R&D	250	(250)	50	(50)	330	(330)
TOTALS	7400	(250)	6660	(50)	7400	(330)

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ARIES Research Bridges the Science and Energy Missions of the US Fusion Program

- Mission Statement:

  Perform advanced integrated design studies of the long-term fusion energy embodiments to identify key R&D directions and provide visions for the program.

- Commercial fusion energy is the most demanding of the program goals, and it provides the toughest standard to judge the usefulness of program elements.

- Knowledge base of fusion power plants involves subtle combinations of physics, technology, and engineering. Extensive systems studies are needed to identify not just the most effective experiments for the moment, but also the most cost-effective routes to the evolution of the experimental, scientific and technological program.

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ARIES Program charter was expanded in FY00 to include both IFE and MFE concepts

ARIES activities in FY03:

- **ARIES-IFE study was continued for another year (~50% of the effort):**
  - ✓ The ARIES-IFE study is now officially completed.
  - ✓ Work in FY03 was focused on thick-liquid wall concept (*i.e.*, HYLIFE)
  - ✓ Results from 2001 and 2002 research will appear in Journal of Fusion Science & Technology (pre-prints available on ARIES Web site).
- **ARIES compact stellarator (ARIES-CS) was started (~50% of the effort)**
  - ✓ This is a four-year study (because of budget reductions.)

> FY04 ARIES activity is entirely on compact stellarators.

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An Optimum ARIES-Compact Stellarator Program Plan is a ~$2M/year effort

<u>Possible Scenarios for ARIES Research:</u>

- $1.35M Level – Configuration Exploration
  - ✓ Limited examination and assessment of concepts. <u>No integrated assessment.</u>
- $1.65M Level – Entry Level for a Power Plant Study
  - ✓ Limited examination of configuration space. Designs will not be fully integrated or self-consistent. <u>Lack of thoroughness will degrade the credibility of the research substantially.</u>
- $2.0M Level – Comprehensive, integrated, and self-consistent study
  - ✓ Minimum level to support a single, self-consistent design study with thorough examination of configuration space. <u>Results will be credible and will have lasting impact on R&D.</u>
- $2.3M Level – Comprehensive, integrated, and self consistent study and an additional small scale, preparatory study
  - ✓ Such as H production and how fusion can provide transportation fuel (a contributor to all sectors of energy market).

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VLT Incremental Requests

- **Emphasis is placed on proposed design and R&D activities that will reduce risks in meeting ITER commitments.**
- **Emphasis is also placed on time-critical activities.**

FY05 Incremental Requests

<u>High Priority</u> (no particular order)

$190K • Upgrade NIST equipment to measure critical superconducting currents as function of magnetic field, stress and temperature.

$225K • Upgrades for PMTF (ELM testing), TPE (tritium retention) and DiMES (DIII-D).

$200K • Increased design effort and component testing on ICH system for ITER.

$200K • Increased support for ITER design work in neutronics, shielding and activation analysis.

FY05 Incremental Requests (cont'd)

<u>Medium Priority</u> (no particular order)

$330K • Increased effort on the ITER TBM design and R&D activities.

$350K • Enhanced materials engineering support for the ITER International Team and US TBM effort.

$190K • Enhanced modeling of PMI and SOL.

$125K • Initial development of a tritium system dynamic simulation code.

$358K • Increase Advanced Design (ARIES) effort to level of fully integrated, self-consistent design effort.

Total: $2160K (excluding IFE Technology and NSO/FIRE)

FY06 Incremental Requests

<u>High Priority</u> (no particular order)

$400K • Complete fabrication of prototype components for ECH, 1MW, 120GHz gyrotron.

$400K • Increased effort on ITER ICH and antenna component R&D.

$565K • Upgrades of e-beam power supply (ITER first wall testing) and complete upgrade of TPE (diagnostics) and DiMES.

$175K • Continued ITER design support in neutronics, shielding and activation analysis.

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FY06 Incremental Requests (cont'd)

<u>Medium Priority</u> (no particular order)

$500K • Increased effort on design and component development of the ITER pellet injector and continuous extruder.

$330K • Continued effort on the ITER TBM design and R&D.

$350K • Continued materials support for ITER design issues and TBM development.

$125K • Enhanced materials efforts on radiation design effects on ITER plasma diagnostic components.

$500K • Implementation of a medium scale (10MW) magnet arcing experiment.

$120K • Increased efforts on advanced sensors for superconducting magnets.

$250K • Continued development of a tritium systems dynamic code.

$350K • Increased Advanced Design (ARIES) effort to level of fully integrated, self-consistent design effort.

Total: $4065K (excluding IFE Technology and NSO/FIRE)

Next Step Options Studies/FIRE

- **Assuming that ITER proceeds, studies of Advanced Tokamak modes in ITER should continue. ($0.5M/year)**

- **If ITER does not proceed, then the FIRE project should continue.**

	FY05	FY06
Conceptual Design	$7M	$8M
Supporting R&D	$1M	$1M

- **In any event, some type of next-step option study should always be part of the program.**

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IFE Technology - Incremental Request

	FY05	FY06
• Continue effort on thick liquid wall R&D	$1.5M	$1.5M
• Continue effort on target fabrication and injection	$0.8M	$1.0M
• Continue safety, environmental and systems assessment	$0.5M	$0.5M

Summary

- The VLT is increasing its support of burning plasma issues--will be about 40% of the CRB budget in FY05 and FY06.

- Critical research activities aimed at realizing the potential of fusion energy continue (except for IFE technology tasks) but at very constrained levels--will be about 50% of the CRB budget.

- Selected activities in support of near-term experiments are maintained but also at constrained levels--will be about 10% of the CRB budget.

- There are important needs and opportunities for incremental budgets (over FY05 CBR)
  - $2.2M in FY05
  - $4.1M in FY06

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