US/JAPAN PCM MEETING

- Fusion Systems Analysis
- Neutronics (FNS) - ANNEX II
- Tritium - ANNEX III
- New Areas: PMI/HHF

Mohamed A. Abdou

Tokyo, 17-18 March 1987

FUSION SYSTEMS ANALYSIS
STATUS

- ETR
  - US PROPOSAL FOR JOINT US/JAPAN/EC/USSR DESIGN AND VALIDATING R&D NOW UNDER CONSIDERATION
  - TIBER DESIGN CONTINUING

- CIT IS NOW A PROJECT

- TITAN RFP STUDY IS CONTINUING - COMPLETED DECEMBER 1987

FUSION SYSTEMS ANALYSIS
RECENT US/JAPANESE EXCHANGES

- NEXT STEP MACHINE DESIGN
  - PERSONNEL

    J. HAINES (FEDC), S. DEVOTO (LLNL) TO JAERI
    M. SUGIHARA, T. HORIE TO PPPL/FEDC
    B. RIEMER (G/FEDC) AT JAERI

  - WORKSHOPS

JAERI	AUGUST	1983	FER/FED
FEDC	MARCH	1984	FER/TFCX
JAERI	MARCH	1985	FER/CIT
LLNL	FEBRUARY	1987	FER/TIBER

- CONCEPTUAL DESIGN OF A REVERSE FIELD PINCH FUSION REACTOR

  WORKSHOP AT TOKAI-MURA ON TITAN/REPUTER AUGUST 1986

FUSION SYSTEMS ANALYSIS
FUTURE PLANS

- CONCEPTUAL DESIGN OF A REVERSE FIELD PINCH FUSION REACTOR
  WORKSHOP PLANNED FOR JULY/AUGUST 1987 AT UCLA

- ETR DESIGN PENDING INTERNATIONAL COOPERATION AGREEMENT

- NEXT STEP MACHINE DESIGN
  CONTINUE PERSONNEL EXCHANGE

Annex II: US-JAERI Collaboration on Fusion Neutronics (Experiments in FNS)

Excellent Program Because of:

1. Focus on Critical Issues for Fusion

2. Remarkable Technical Achievements

3. Excellent Example of Successful (Ideal) International Cooperation
   - Equitable cost/benefit to both sides
   - Effectiveness and harmony in:
     - joint planning
     - performing the experiments
     - post-experiment analysis and interpretation
     - joint reports

ANNEX II: FUSION NEUTRONICS COLLABORATION (FNS)

Program Objectives

1. Contribute to resolving tritium self-sufficiency issue

Provide estimate of overall uncertainty in achievable tritium breeding ratio arising from uncertainties in basic data, calculational methods and modelling (Proceeding from simple geometry toward more prototypical blanket assemblies)

2. Develop the Neutronics Technology Necessary for FER/ETR

- To construct device
- To successfully perform neutronics tests in device
- To successfully perform blanket tests in which neutronics parameters are important (e.g., tritium recovery and thermomechanics tests require TPR and Nuclear heating)
- Neutronics Technology: Engineering Scaling, Experimental Measuring Techniques, Codes, Data, etc.

ANNEX II: Fusion Neutronics Collaboration (FNS)

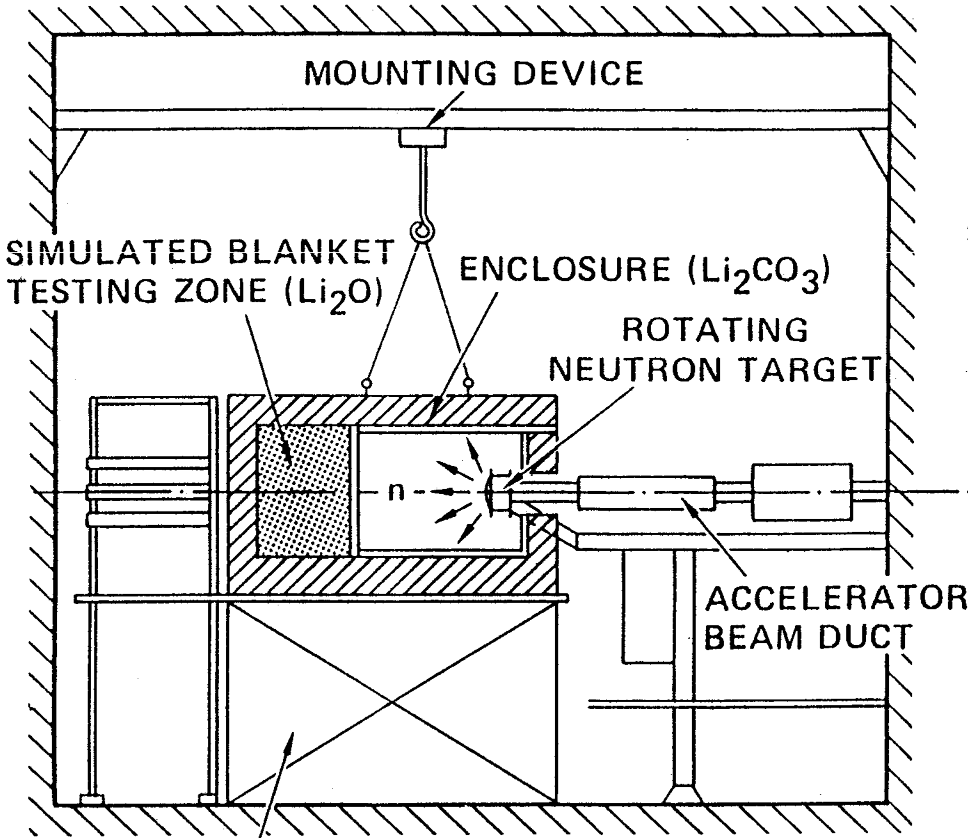
History

ANNEX II was signed 23 October 1984

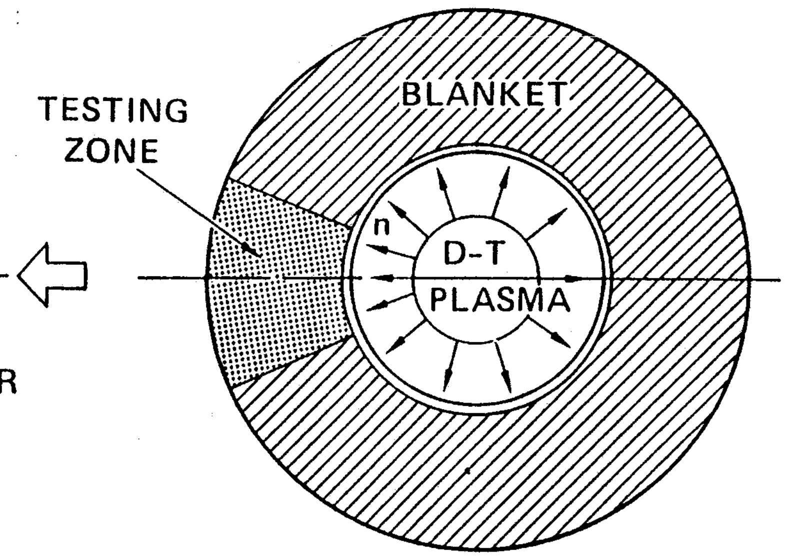
- Phase I Experiments
  - October 1984 to March 1986
  - Open Geometry
    - Li_2O assembly/first wall/coolant
    - Beryllium added later

- Phase II Experiments
  - Started August 1986
  - Closed Geometry
    - Li_2O assembly/Li_2Co_3 container
    - Be multiplier

EXPERIMENTAL SYSTEM FOR PHASE-2 OF US/JAERI PROGRAM
ON BLANKET NEUTRONICS



SCHEMATIC OF REACTOR MODEL



ANNEX II: Fusion Neutronics Collaboration (FNS)

- Personnel Exchange (April 86-March 87)

  US → JAERI
  - Two US Scientists participated in final Phase I experiment
  - One US Scientist participated in Phase II

  JAERI → US
  - One JAERI Scientist participated in calibration of TLD and design/fabrication of reduced size proton recoil counter

- Meetings

  Steering Committee Meeting and Technical Workshop were held in US in June 1986

ANNEX II: Fusion Neutronics Collaboration (FNS)

Technical Achievements (April 86-March 87)

- Constructed Geometrical Arrangement for Phase II Experiments
- Performed Experiment with Li_2O Reference Assembly, August 1986
- Experiment with Be Underway
- Developed and Successfully Applied New Technique for Zonal Tritium Production Measurements
- Improved Energy Measuring Range of Neutron Spectra by a Combination of NE 213 and Proton Recoil Spectrometer
- Several Technical Papers Published
  Joint Report No. 2 of Phase I Experiments near completion
- **Results Show Remarkable Progress in Reducing TBR Uncertainties & Advancing Analysis & Experimental Techniques**

ANNEX II: Fusion Neutronics Collaboration (FNS)
Recommendations for Period April 87-March 88

- Extend Annex II for Another 3-yr Period from Oct. 87
  General agreement on both sides on
  - Benefits of extending Annex II
  - Specific details of type of experiments and analysis

- Personnel Exchange

  US → JAERI
  - One Analyst for post analysis (2 weeks, May 87)
  - One Experimentalist to participate in Phase II experiments (1-2 months, Sept./Oct. 87)

  JAERI → US
  - One Experimentalist to participate in technique development (3 months)

ANNEX III: DOE-JAERI COLLABORATIVE PROGRAM IN DEVELOPMENT OF IMPROVED COMPONENTS FOR TSTA

- TWO SMALL-SCALE COMPONENTS (CERAMIC ELECTROLYSIS CELL AND PALLADIUM DIFFUSER) HAVE COMPLETED SUCCESSFUL TRITIUM TESTING AT LANL IN 1986 UNDER AN "EXCHANGE OF LETTERS" ON TRITIUM COOPERATION
- DOE AND JAERI MUTUALLY AGREED LARGER VERSIONS (PROCESS-READY) OF THE SAME COMPONENTS SHOULD ALSO BE TRITIUM TESTED AT LANL
- ANNEX III WAS SIGNED ON 10 NOVEMBER 1986
- BOTH COMPONENTS ARE EXPECTED TO BE DELIVERED TO LANL DURING THE WEEK OF 1 MARCH 1987
- TRITIUM TESTING SHOULD BEGIN IN LATE MARCH/APRIL 1987

PLASMA/MATERIALS INTERACTION
AND
HIGH HEAT FLUX MATERIALS AND COMPONENTS

- US/JAPAN WORKSHOPS
  - 1986 - DATA NEEDS FOR A BURNING CORE EXPERIMENT
  - 1987 - DATA NEEDS FOR STEADY STATE AND NEXT STEP DEVICES
- 1986-1987 PERSONAL EXCHANGES IN PMI, TRITIUM BEHAVIOR IN MATERIALS

- FUTURE
  - CANDIDATE GRAPHITIC MATERIALS EXCHANGES
  - CONTINUE PERSONNEL EXCHANGES
    - TRITIUM BEHAVIOR IN MATERIALS
    - RADIATION DAMAGE TO PMI/HHF MATERIALS
    - LONG PULSE EFFECTS IN HHF MATERIALS
    - IMPROVED ION SOURCE FOR PMTF
  - CONTINUE WORKSHOPS:
    - 1988 - DATA NEEDS FOR NEXT STEP DEVICE

SUMMARY OF EXISTING U.S. PMI/HHF LABORATORY FACILITIES

NAME	LOCATION	STATUS
PLASMA MATERIALS TEST FACILITY E-BEAM, ION-BEAM (PMTF)	SNLA	OPERATING
PLASMA-SURFACE INTER-ACTION EXPERIMENT (PISCES)	UCLA	OPERATING
TRITIUM PLASMA EXPERIMENT (TPX)	SNLL	OPERATING
HOT-CELL ELECTRON BEAM FACILITY (NEUTRON IRRADITION) (HEBF)	HEDL	OPERATING

NAME	LOCATION	STATUS
CONTINUOUS CURRENT DRIVE TOKAMAK (CCT)	UCLA	OPERATING/FUNDED FOR RF HEATING AND CURRENT DRIVE
ELECTROMAGNETIC FORCES (FELIX)	ANL	NOT OPERATING - WORKSHOPS ON EDDY CURRENT MODELLING

U.S. FACILITIES THAT IMPACT KEY PMI / HHF ISSUES

ISSUE	FACILITY			
	TPX	PISCES	CCT	PMTF
1. PLASMA CONTROL				
A. EXHAUST EFFICIENCY		*	*	
B. HEATING / FUELING			*	
C. DIAGNOSTICS	*	*		
D. EDGE CONTROL		*	*	
E. IMPURITY TRANSPORT		*	*	
2. SURFACE PHYSICS				
A. EROSION / REDEPOSITION		*	*	
B. SURFACE CONDITIONING	*	*	*	
C. H REFLECTION / DESORPTION	*	*		
D. TRITIUM PERMEATION / INVENTORY	*			

U.S. FACILITIES THAT IMPACT KEY PMI / HHF ISSUES

ISSUE	FACILITY: TPX	PISCES	CCT	PMTF
3. COATING / MATERIAL BEHAVIOR				
A. FABRICATION		*		*
B. BOND MECH. INTEGRITY				*
C. HEAT TRANSFER				*
D. THERMAL STRESS / FATIGUE				*
E. PLASMA FLUENCE EFFECTS		*	*	
F. PLASMA FLUX EFFECTS		*	*	
4. ACTIVE COOLI NG				
A. HEAT TRANSFER LIMITS				*
B. FLOW STABILITY				*
5. DISRUPTION AND EM				
A. EDDY CURRENT FORCES				
B. MELT LAYER BEHAVIOR				*
6. SYSTEM INTEGRATION				
A. REPLACEMENT / MAINTENANCE	*			
B. TRITIUM BREEDING				

U.S. PMI/HHF EXPERIMENTAL FACILITIES

I. PLASMA MATERIALS TEST FACILITY (PMTF) - SANDIA - ALBUQUERQUE

FEATURES	CHARACTERISTICS
A. ELECTRON BEAM TEST SYSTEM	30 KeV, 30 kW
TARGET AREA	1 - 100 cm^2
PULSE DURATION	0.05 SEC - CONTINUOUS
COOLING	CLOSED LOOP WATER
MAXIMUM HEAT FLUX	UP TO 30 kW/cm^2
B. ION BEAM TEST SYSTEM	
STEADY-STATE HEAT SOURCE	40 KeV, 1.6 MW H-BEAM
TARGET AREA	800 cm^2
PULSE DURATION	CONTINUOUS
COOLING	CLOSED LOOP WATER
MAXIMUM HEAT FLUX	2 kW/cm^2

U.S. PMI/HHF EXPERIMENTAL FACILITIES

II. PLASMA-SURFACE INTERACTIONS FACILITY (PISCES) - UCLA

FEATURES	CHARACTERISTICS
PLASMA	$n = 5 \times 10^{11} - 2 \times 10^{13} cm^{-3}$; $T_e = 3 - 25$ eV
TARGET AREA	100 - 400 cm^2
OPERATING MODE	CONTINUOUS
ION ENERGY	30 - 500 eV (BIAS)
COMPONENT COOLING	AIR OR WATER
MAXIMUM HEAT FLUX	200 W/cm^2
PLASMA FLUX	$10^{17} - 2 \times 10^{19}/cm^2 - s$

PISCES is a continuously operating plasma facility using a plasma generator and an axial magnetic field to produce plasma that is characteristic of the edge region in tokamaks and other confinement devices. One device exists, PISCES-A, and a second facility, PISCES-B, is under construction. Both devices are dedicated to surface materials and coating behavior under continuous high flux plasma bombardment. In addition, plasma experimental simulations of pump limiter and divertor behavior are an objective of the program.

OBJECTIVES OF PISCES

1. MATERIALS BEHAVIOR DURING CONTINUOUS BOMBARDMENT USING PLASMA WITH PARAMETERS OF THE SCRAPE-OFF LAYER

   EXAMPLE

   EROSION VERSUS EROSION/ REDEPOSITION OF PIC MATERIALS AND COMPONENTS

2. PLASMA EDGE SIMULATION EXPERIMENTS

   EXAMPLE

   PUMP LIMITER AND DIVERTOR PHYSICS SIMULATION EXPERIMENTS

3. RELATION/COMPARISON OF RESULTS IN CONFINEMENT EXPERIMENTS AND IN PISCES

U.S. PMI/HHF EXPERIMENTAL FACILITIES

III. TRITIUM PLASMA EXPERIMENT (TPX) - SANDIA - LIVERMORE

FEATURES	CHARACTERISTICS
RF GLOW DISCHARGE TRITIUM PLASMA (200W RF)	$n < 10^{11} cm^{-3}$; $T_e < 7$ eV
OPERATING MODE	CONTINUOUS
ION ENERGY	15 - 300 eV (BIAS)
PLASMA FLUX	$10^{17}/cm^2$-s

TPX is a low density discharge facility dedicated to surface materials investigations with tritium. Experiments relating to tritium recycling, permeability, and tritium inventory are a major focus of work.

U.S. FACILITY WITH PARTIALLY DEDICATED PMI/HHF ACTIVITY

CONTINUOUS CURRENT TOKAMAK (CCT) - UCLA

FEATURES	CHARACTERISTICS
PLASMA	5×10^{12} cm^{-3}; $T_i = T_e$ = 10 - 100 eV (TOKAMAK CONFINED)
TARGET AREA	TEST COMPONENTS > 1000 cm^2
PULSE DURATION	.3 SEC. @ I_p = 100 kA CONTINUOUS @ I_p = 10 kA
COOLING	WATER
AVERAGE HEAT FLUX	10 - 100 W/cm^2
PRIMARY MISSION	ICRF / FAST WAVE CURRENT DRIVE, COUPLING AND HEATING IN TOKAMAKS, WALL CONDITIONING AND BEHAVIOR

The CCT is a new tokamak operating at UCLA with the physical size of PLT, but operating at low field (1=7kG). The primary objective of CCT is ICRF heating and current drive with the intermediate goal of achieving steady-state operation at 10kA (pulsed up to 100kA for 0.3 s and return to 10kA). The plasma edge density in such a device is expected to be around 5 x 10^{11} cm^{-3} with $\tau_i=\tau_e$-10-30eV in the edge. Plans call for investigation of phenomena such as erosion and redeposition to compare with results from continuously operating simulation experiments such as PISCES.