

**BRIEFING ON FUSION NUCLEAR TECHNOLOGY ISSUES**

**TO**

**DR. JOHN V. DUGAN, JR.**

**STAFF DIRECTOR**

**SUBCOMMITTEE ON ENERGY RESEARCH AND PRODUCTION**

**HOUSE SCIENCE AND TECHNOLOGY COMMITTEE**

**BY**

**PROFESSOR MOHAMED A. ABDOU**

**SCHOOL OF ENGINEERING AND APPLIED SCIENCE**

**UNIVERSITY OF CALIFORNIA, LOS ANGELES**

**AND**

**DR. CHARLES C. BAKER**

**DIRECTOR, FUSION POWER PROGRAM**

**ARGONNE NATIONAL LABORATORY**

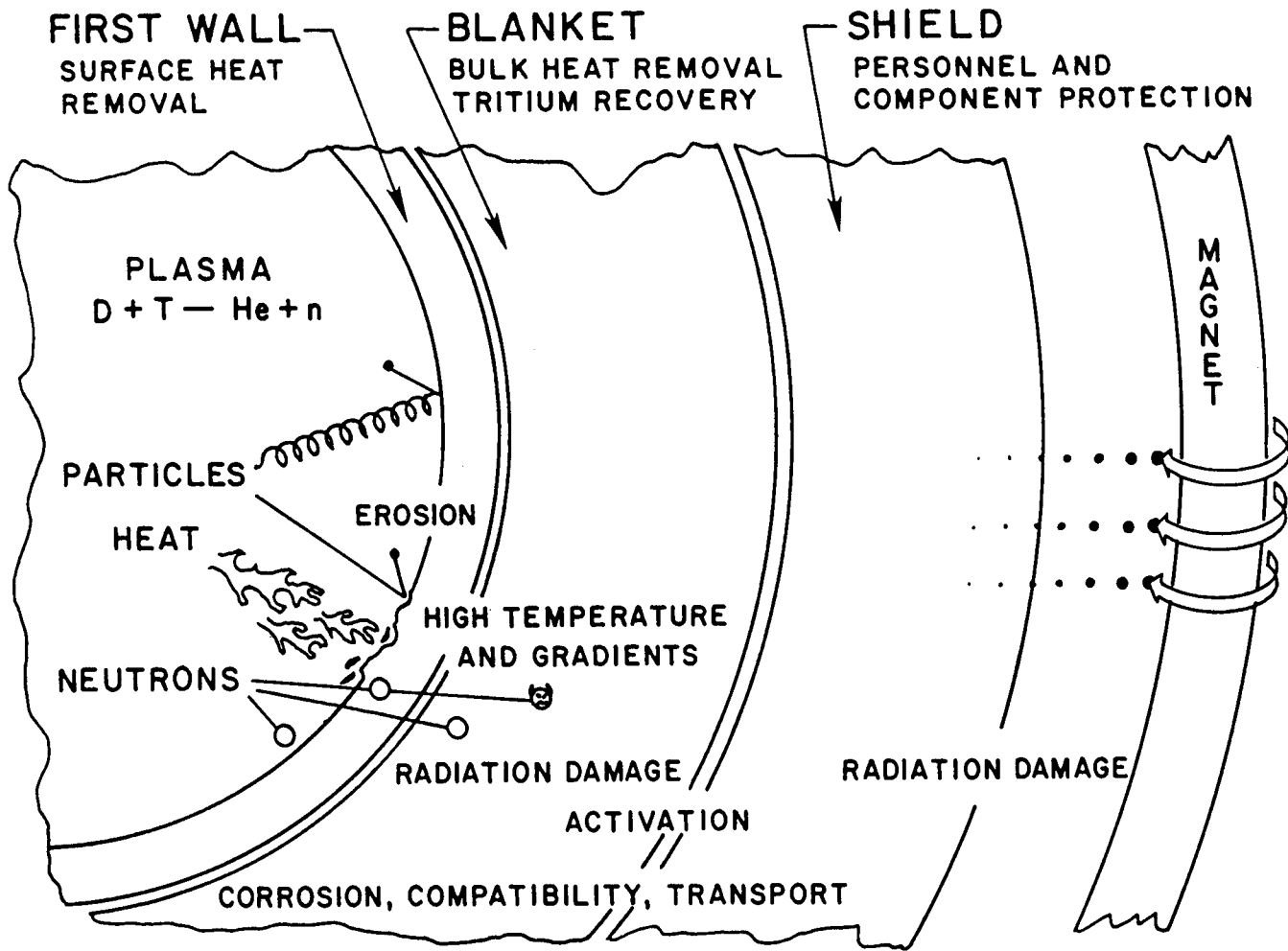
**DECEMBER 1, 1983**

## FUSION REACTOR ELEMENTS

- PLASMA
- ENGINEERING COMPONENTS
  - MAGNETS
  - PLASMA HEATING
  - NUCLEAR COMPONENTS

## NUCLEAR COMPONENTS

- HANDLING OF PLASMA PARTICLES AND ENERGY CONVERSION
  - PLASMA-INTERACTIVE COMPONENTS (FIRST WALL, LIMITER, DIVERTOR, ETC.)
  - BLANKET
  - SHIELD
  - TRITIUM SYSTEM



- OPERATIONAL CONSIDERATIONS**
- EFFICIENT REMOTE MAINTENANCE
  - FLOW TRANSIENTS
  - RAPID SHUTDOWN

## WHY SHOULD RESEARCH BE CARRIED OUT NOW ON BLANKET AND MATERIALS ISSUES?

- THE DEVELOPMENT OF A VIABLE FIRST WALL AND BLANKET CONCEPT REPRESENTS A MAJOR, UNRESOLVED FEASIBILITY ISSUE FOR FUSION.
- THE SELECTION OF A FIRST WALL AND BLANKET CONCEPT CAN SIGNIFICANTLY IMPACT PLASMA ENGINEERING ISSUES, AND VICE VERSA. EXAMPLES INCLUDE:
  - PLASMA CONTROL OPTIONS
  - IMPURITY CONTROL OPTIONS
  - ACCESS AND MAINTENANCE
- OPERATION OF ANY FUSION DEVICE THAT BURNS TRITIUM FOR A SIGNIFICANT PERIOD OF TIME WILL REQUIRE CONSTRUCTION OF A TRITIUM-PRODUCING BLANKET.
- THE PERCEPTION OF FUSION'S SAFETY AND ENVIRONMENTAL FEATURES IS LARGELY DETERMINED BY NUCLEAR/MATERIALS TECHNOLOGY CONSIDERATIONS.
- FUSION ECONOMICS WILL GREATLY DEPEND ON THE PERFORMANCE OF THE NUCLEAR SYSTEMS.
- THE TIME SCALE FOR THE DEVELOPMENT OF ADVANCED ALLOYS IS LONG.
- LESSONS LEARNED FROM OTHER TECHNOLOGY DEVELOPMENT STRONGLY SUGGEST WORKING ON LONG-LEAD ITEMS EARLY.

## WHAT WE NEED TO DO

MAINTAIN A STRONG AND STABLE R&D PROGRAM AIMED AT RESOLVING THE CRITICAL FEASIBILITY ISSUES OF THE FUSION NUCLEAR SYSTEM:

- PERFORM SEPARATE AND MULTIPLE EFFECTS TESTS IN NON-FUSION FACILITIES IN THE 1980's.
  
- PLAN FOR INTEGRAL TESTS IN FUSION FACILITIES IN THE 1990's.

## SUMMARY

- ONGOING ACTIVITIES IN FUSION NUCLEAR AND MATERIALS TECHNOLOGY ARE FOCUSED ON: (1) NEAR-TERM NEEDS FOR THE NEXT STEP AND, (2) MAJOR LONGER TERM FEASIBILITY ISSUES.
- MOST OF THE REQUIRED FACILITIES ARE IN PLACE TO SUPPORT NEAR-TERM NEEDS FOR IN-VESSEL AND FIRST WALL COMPONENT DEVELOPMENT AND TRITIUM FUEL HANDLING. THERE IS A NEED FOR A FACILITY FOR LARGE SCALE, CW PLASMA SIMULATION TESTS OF IMPURITY CONTROL COMPONENTS.
- THE FOUNDATION OF MATERIALS AND BLANKET DEVELOPMENT PROGRAM HAS BEEN ESTABLISHED. RECENT RESULTS ON SOLID BREEDER MATERIALS HAVE BEEN QUITE ENCOURAGING.
- THERE IS A NEED FOR ADDITIONAL TEST FACILITIES TO DEVELOP THE MATERIALS DATA BASE AND BLANKET TECHNOLOGY REQUIRED FOR FUSION REACTORS.
- IT IS CRITICAL FOR THE NATIONAL FUSION PROGRAM TO CONTINUE TO BE GOAL-ORIENTED. THIS REQUIRES MAINTAINING AN ADEQUATE PROGRAM TO DEMONSTRATE ENGINEERING FEASIBILITY IN THE 1990'S.

# FUTURE NUCLEAR SYSTEMS FACILITY REQUIREMENTS

## NON-FUSION FACILITIES (1980'S)

- UPGRADES OF EXISTING FACILITIES

- ASURF TO 1 MW
- FELIX TO 4T
- TSTA/BLANKET PROCESSING

- FIRST WALL/IN-VESSEL COMPONENTS

- LARGE (~ 1 MW) PLASMA SIMULATION TEST FACILITY
- COMBINED HIGH HEAT FLUX AND MAGNETIC FIELDS FOR DISRUPTION SIMULATION

- MATERIALS IRRADIATION - FMIT

- BREEDER NEUTRONICS TEST FACILITY

- NEUTRON SOURCE OF  $10^{11}$  +  $10^{12}$  n/SEC (USE RTNS-II, AND/OR OTHER FACILITIES)

- LIQUID METAL BREEDER BLANKET TEST FACILITY

- COMBINED TESTING OF CORROSION, MHD, THERMAL-HYDRAULICS, AND TRITIUM RECOVERY

## FUTURE NUCLEAR SYSTEMS FACILITY REQUIREMENTS (CONT.)

- SOLID BREEDER BLANKET TEST FACILITY
  - COMBINED TESTING OF THERMAL-HYDRAULIC/THERMAL-MECHANICAL, TRITIUM RELEASE & RECOVERY
    - NON-NUCLEAR SIMULATION OF BULK HEATING
    - FISSION REACTORS
  
- MAINTENANCE
  - MOCK-UP
  - COMPUTER GRAPHIC SIMULATION STUDIES

## FUSION FACILITIES (1990's)

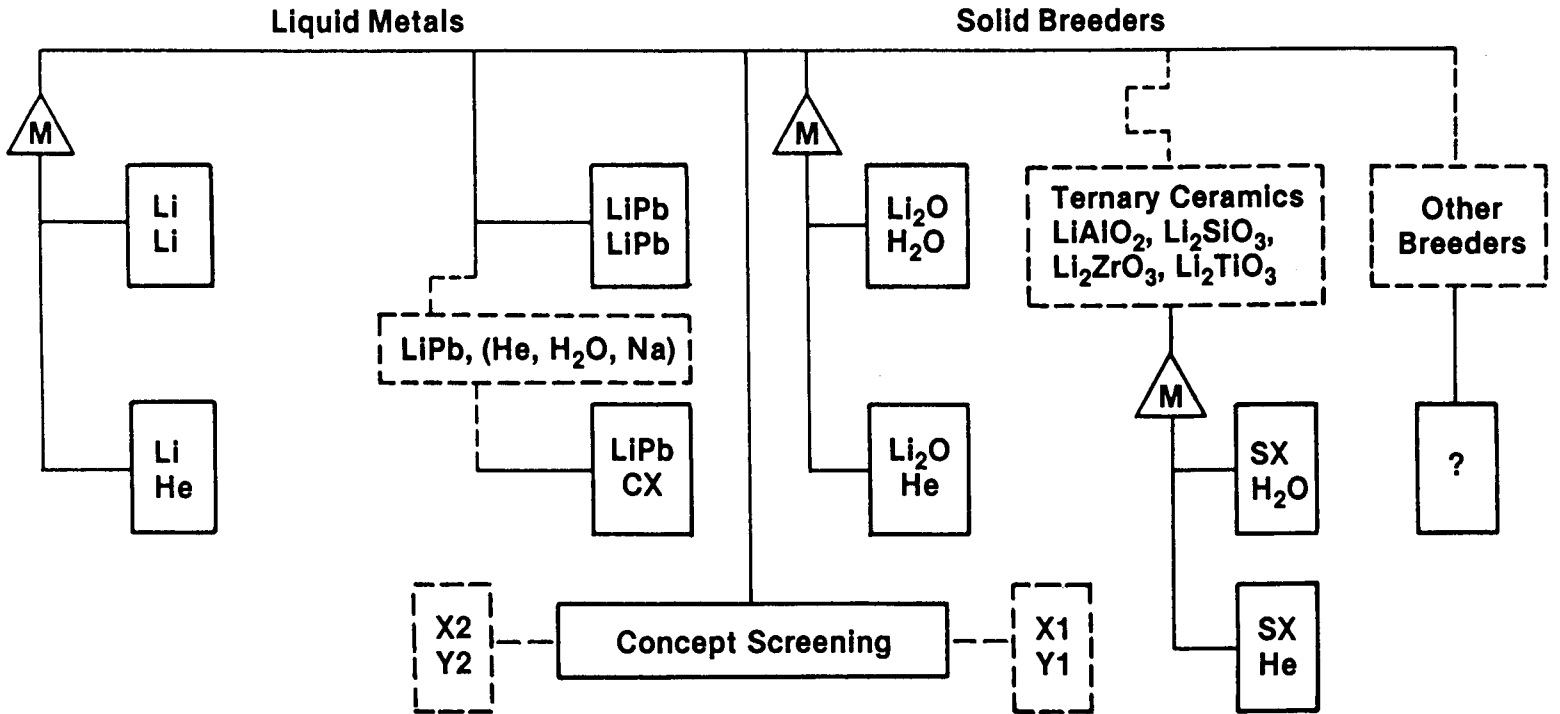
- FUSION BASED LARGE SCALE FIRST WALL/BLANKET/SHIELD COMPONENT AND MATERIALS TESTING FACILITY
  - LARGE TEST VOLUME/AREA ( $> 10 \text{ m}^2$ )
  - NEUTRON WALL LOADING  $\sim 2 \text{ MW/m}^2$
  - HIGH AVAILABILITY



KEY FEASIBILITY ISSUES FOR IN-VESSEL  
AND FIRST WALL COMPONENTS

<u>ISSUE</u>	<u>ACTIVITY/FACILITY</u>
• IMPURITY CONTROL	
-- PLASMA CONTAMINATION	PMTF, PISCES, TEXTOR LIMITER
-- HIGH HEAT FLUXES	ASURF/PMTF
-- PARTICLE PUMPING	PISCES
• COMPONENT LIFETIME	
-- EROSION/REDEPOSITION	PMTF, PISCES
-- DISRUPTIONS	ESURF, ASURF
-- ELECTROGMAGNETIC LOADS	FELIX
-- CORROSION/COMPATIBILITY	VARIOUS LOOPS
-- RADIATION EFFECTS	DUAL-ION IRRADIATIONS, FISSION REACTORS RTNS-II (FMIT)
• TRITIUM CONTAINMENT	SMALL LAB. EXPERIMENTS
• ENERGY RECOVERY	ASURF

# BLANKET OPTIONS



————— A concept for the detailed comparative study.

----- A study required to define a concept (within a class) for inclusion in the detailed comparative study.

## Structural Material

- Big difference in R&D
- Crucial for concept selection
  - (1) PCA
  - (2) Advanced alloy (FS or V or ?)

## M = Neutron Multiplier

- All breeders (except LiPb may require multiplier.
- Is beryllium the only choice?
- Beryllium assessment.

## KEY FEASIBILITY ISSUES FOR BLANKETS - GENERAL

<u>ISSUE</u>	<u>ACTIVITY/FACILITY</u>
• STRUCTURAL LIFETIME	- DUAL-ION IRRADIATIONS - FISSION REACTORS (ORR, HFIR) - RTNS-II (FMIT)
• ELECTROMAGNETIC EFFECTS (FIELD PENETRATION/DISTURBANCES)	- FELIX
• ASSEMBLY/MAINTENANCE	- TFTR - SMALL SCALE TESTS
• ACTIVATION, WASTE MANAGEMENT, REPROCESSING	- PANEL REPORT ON LOW ACTIVATION - SMALL SCALE STUDIES
• EFFICIENT HEAT EXTRACTION	

## ALLOY DEVELOPMENT FOR IRRADIATION PERFORMANCE

- NEAR TERM

PATH A      AUSTENITIC STAINLESS STEEL

PATH B      NICKEL-BASE ALLOYS (DROPPED)

PATH E      FERRITIC STEELS

- LONG TERM

PATH C      REACTIVE/REFRACTORY ALLOYS

PATH D      INNOVATIVE CONCEPTS

## KEY FEASIBILITY ISSUES FOR SOLID BREEDER BLANKETS

<u>ISSUE</u>	<u>ACTIVITY/FACILITY</u>
• TRITIUM BREEDING	- COOPERATIVE INTEGRAL BREEDER NEUTRONICS EXPERIMENTS AT JAERI
• TRITIUM RELEASE	
-- IN SITU RECOVERY	- TRIO/ORR
-- MATERIALS DATA	- FUBR/EBR-II, LAB. EXPERIMENTS
• THERMAL PERFORMANCE	- SMALL SCALE HEAT TRANSFER AND HE PURGE FLOW TESTS
• LIFETIME	
-- NEUTRON EFFECTS	- FUBR/EBR-II
-- CORROSION	- SMALL SCALE LAB. EXPERIMENTS

## KEY FEASIBILITY ISSUES FOR LIQUID BREEDER BLANKETS

<u>ISSUE</u>	<u>ACTIVITY/FACILITY</u>
• CORROSION/COMPATIBILITY	- LOOP EXPERIMENTS
• MHD	- PROGRAM STARTING IN FY 1984
• TRITIUM RECOVERY	- NO WORK AT PRESENT (PAST EXPERIMENTS WITH LI)

## KEY FEASIBILITY ISSUES FOR SHIELDING

<u>ISSUE</u>	<u>ACTIVITY/FACILITY</u>
• PREDICT RADIATION ATTENUATION	INTEGRAL SHIELDING FACILITY
• DEFINE RADIATION PROTECTION REQUIREMENTS FOR REACTOR COMPONENTS, ACCESS	IPNS, OTHER FACILITIES RTNS-II
• ELECTROMAGNETICS	FELIX
• COST	DESIGN STUDIES

# KEY FEASIBILITY ISSUES FOR TRITIUM FUEL CYCLE

<u>ISSUE</u>	<u>ACTIVITY/FACILITY</u>	
• TRITIUM REPROCESSING FROM VACUUM STREAM	}	
• TRITIUM ACCOUNTABILITY		TSTA
• TRITIUM CONTAINMENT		
• TRITIUM REPROCESSING FROM BLANKET	FUTURE UPGRADES OF TSTA	