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PRESENTATION AT FTP/A REVIEW

OFE GERMANTOWN MARCH 25, 1987

BY

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ORNL PRESENTATIONS - AGENDA

* OVERVIEW	JOHN SHEFFIELD
* ATF CONSTRUCTION	TOM JERNIGAN
* EXPERIMENTAL PROGRAM	HUTCH NEILSON
* BUDGET/(MILESTONE) SUMMARY	MIKE SALTMARSH
* STELLARATOR PROGRAM - OPTIONS	JIM LYON

INTRODUCTION

* US CONFINEMENT PROGRAM

* ORNL ROLE

  1 - ATF

  2 - CIT/ETR

  3 - STX

  4 - THEORY

  5 - PLASMA TECHNOLOGY

* BUDGETS

* ENGINEERING

* STX

US CONFINEMENT PROGRAM

(MFPP, TPA, TRIVELPIECE/CLARKE TESTIMONY TO CONGRESS FEBRUARY 1987)

* MAGNETIC CONFINEMENT SYSTEMS

  - DEVELOP TOKAMAK
    - BASE
    - ADVANCED

  - PARTICIPATE IN INTERNATIONAL STELLARATOR AND RFP PROGRAMS

  - SMALL SCALE RESEARCH, STELLARATOR, RFP, COMPACT TORI

* BURNING PLASMA STUDIES

  - TFTR -> CIT -> ETR

ORNL ROLE IN CONFINEMENT PROGRAM - 1

* THE ADVANCED TOROIDAL FACILITY IS DESIGNED TO STUDY IMPORTANT TOROIDAL PHYSICS AREAS

  - SECOND STABLE REGION (Access at low beta)

  - ROLE OF WELL/HILL AND SHEAR (Externally controlled fields)

  - NON-AXISYMMETRIC TRANSPORT (Torsatron and Helical Axis)

  - ROLE OF ELECTRIC FIELD (Heavy Ion Beam Probe)

* ATF IS A COMPLEMENTARY PART OF THE WORLD STELLARATOR PROGRAM - INTEGRATED INTO A STRONG U.S. EFFORT

THE ATF PROJECT AND PROGRAM ARE PROGRESSING WELL THOUGH THERE ARE CONCERNS ABOUT DELAYS CAUSED BY LATE DELIVERY OF THE VACUUM VESSEL AND BUDGET LEVELS WHICH LIMIT TIMELY EXPLOITATION OF ATF

* THE ORIGINAL SCHEDULE FOR ATF SET IN JUNE 83 CALLED FOR MDF COMPLETION IN OCT 86 - FIRST PLASMAS IN DEC 86/JAN 87

* WE DELAYED PROJECT 2 MONTHS TO REFINE HELICAL COIL DESIGN

* THE REMAINING DELAYS ARE DUE TO LATE DELIVERY OF THE VACUUM VESSEL - COMPLIMENTS ARE DUE PDM FOR PERSERVERANCE

* **THE MDF COST IS STILL UNDER THE TEC**

* WHILE WE ARE SYMPATHETIC TO DOE-OFE'S DIFFICULTIES IN TIGHT BUDGET TIMES NEVERTHELESS AS ATF AFFICIONADOS WE MUST POINT OUT THAT BUDGET CUTS ARE HURTING OUR ABILITY

    - TO FULLY EXPLOIT ATF'S PRESENT CAPABILITIES

    - TO PREPARE FOR FULL PERFORMANCE

    - TO CONTINUE (EXTEND) OUR SUBSTANTIAL COLLABORATIONS

ORNL ROLE IN CONFINEMENT PROGRAM -2

* PROVIDING PHYSICS SUPPORT TO THE CIT AND THE ETR

  - ANALYSIS OF OPERATING SCENARIOS
    COMPARISON TO ALTERNATIVES

  - COMPUTER MODELLING OF CIT PERFORMANCE

  - ANALYSIS OF FUELING NEEDS

  - ANALYSIS OF RF HEATING, PARTICULARLY EDGE EFFECTS

  - ANALYSIS OF ALPHA INDUCED INSTABILITIES

  - COORDINATION AND SUPPORT OF THE IPSG

ORNL ROLE IN THE CONFINEMENT PROGRAM -3

* THE SPHERICAL TORUS EXPERIMENT HAS BEEN PROPOSED TO IMPROVE THE PHYSICS BASE FOR THE TOKAMAK, NOTABLY IN THE AREA OF ASPECT RATIO OPTIMIZATION

PHASE 1 -TRANSFORMER DRIVEN CURRENT

- TESTING OF BETA LIMITS
- CHANGE OF MHD BEHAVIOR WITH R/a
- TESTING OF TRANSPORT THEORY AND EMPIRICAL SCALINGS

PHASE 2

- STX HAS BEEN DESIGNED TO TEST OSCILLATING FIELD CURRENT DRIVE

OTHER ROLES OF ORNL IN THE CONFINEMENT PROGRAM

4 PLASMA TECHNOLOGY

- FUELING
- NEUTRAL BEAMS
- RF HEATING, ICRH/ECH
- PLASMA MATERIALS
- PUMPED LIMITER/DIVERTOR

5 THEORY

- FUNDAMENTAL THEORY
  - TRANSPORT
  - MHD
  - RF HEATING
  - FUELING
- WELL INTEGRATED WITH EXPERIMENTS
  - ANALYSIS CODE FOR ATF, HELIOTRON-E, WVII-AS
- CONCEPT IMPROVEMENT
  - ATF
  - SMALL R/a TORSATRON
  - SECOND STABLE HELIOTRON
  - SYMMOTRON
  - FLEXIBLE HELIAC
  - EBS
  - STX

ORNL EXPERIMENTAL BUDGET REQUESTS FY 87-89

(FTP/A REQUESTS SUMMARIES)

(PRESIDENTS BUDGET)

	FY1987			FY1988			FY1989		
	BA	BO	CAP	BA	BO	CAP	BA	BO	CAP
ATF RES	14984		1370	17700		1500	19700		1650
ATF HEAT	1800		130						
ATF MDF	706								
TOTAL	17490	17822	1500	17700	17700	1500	19700	19700	1650
(SUPPLEMENTAL BUDGET REQUESTS)									
ATF SUPPL.				1300	1300				
ATF EXT.				870	870		2000	2000	
STX OPS.	50	50		350	350		500	500	
STX MDF				1640	1150	490	3200	3485	1050

* THE PRESIDENTS BUDGET INCLUDES SUBSTANTIAL UNIVERSITY SUPPORT FOR AUBURN, GEORGIA TECH, RPI, U. TENNESSEE, U.WISCONSIN.

	490	490	300	600	600		630	630

* BUDGETS ARE LESS THAN THOSE ON ISX-B DURING A SIMILAR PHASE OF OPERATION (ALLOWING FOR INFLATION)

* THERE IS NO FUNDING IN THE PRESIDENTS BUDGET TO RETAIN KEY ATF DESIGN ENGINEERS

SUPPORT FOR ENGINEERS IN THE ORNL CONFINEMENT PROGRAM

* THE ENGINEERING DIVISION OF MARTIN MARIETTA ENERGY SYSTEMS HAS PLAYED A MAJOR ROLE IN THE SUCCESSES OF THE ORNL CONFINEMENT PROGRAM

* WE WILL CONTINUE TO EMPLOY ENGINEERS AND DRAUGHTSMEN IN SUPPORT OF ATF OPERATIONS

* **BUT WITHOUT SOME FUNDING FOR EXPERIMENT DESIGN WE WILL BE UNABLE TO RETAIN THE KEY ENGINEERS WHO DESIGNED AND BUILT ATF**

* ALERNATIVES WHICH REQUIRE ENGINEERING SUPPORT ARE

  - PREPARATION FOR LONG PULSE OPERATION OF ATF

  - STX

* **AT A MINIMUM LEVEL AN INCREMENTAL BUDGET OF ABOUT $500k IS REQUIRED**

STX IS AN INNOVATIVE EXPERIMENT WITH HIGH LEVERAGE TO STUDY KEY PHYSICS FACTORS WHICH ARE IMPORTANT TO THE OPTIMIZATION OF THE MAINLINE TOKAMAK

* THE SPHERICAL TORUS EXPERIMENT HAS BEEN DEVELOPED AT ORNL BASED UPON THE CONCEPT OF MARTIN PENG

* STX HAS RECEIVED THE ENTHUSIASTIC SUPPORT OF ORNL STAFF

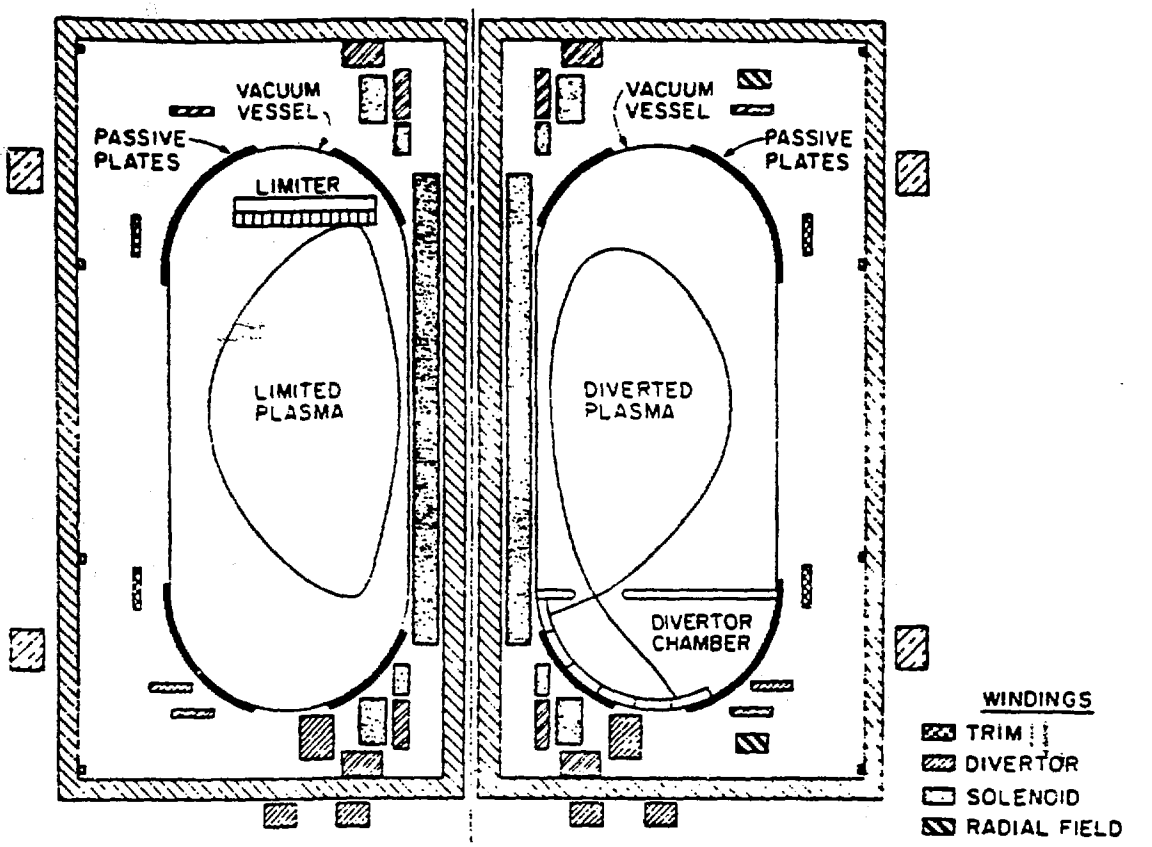
* FUNDING AND MORAL SUPPORT FROM THE OFFICE OF FUSION ENERGY HAS PERMITTED US TO IMPROVE THE THEORETICAL BASIS FOR STX

* STX STUDIES HAVE ALREADY CONTRIBUTED IMPORTANT PHYSICS INSIGHTS

ORNL MANAGEMENT HAS GIVEN SUBSTANTIAL SUPPORT
500K$ OF DISCRETIONARY FUNDING AND
ORNL WOULD LIKE TO BUILD STX

WE ARE LOOKING FOR PARTNERS
TO COLLABORATE WITH US ON THIS EXCITING EXPERIMENT

STX



PARAMETERS	PERFORMANCE
$R_0 = .45\ m$	$T_e(0) \approx 1\ keV$
$a_0 = .27\ m$	$T_i(0) \approx 1\ keV$
$\kappa \approx 2$	$\bar{n}_e \approx 1 \cdot 10^{20}\ m^{-3}$
$\delta \approx 0.4$	$\langle\beta\rangle \approx 20\ \%$
	(transport and stability)
$B_t = 0.5\ T$	$\beta_p \approx 0.36$
I_p *up to* 900 kA	$q_\psi = 3.5$
1.9 MW NBI	$\nu_{e_1} < 0.1$
$B_{sol} = 13.7\ T$	$\tau_E \approx 6\ ms$
$\Phi_{OH} = 1.2\ wb$	*(neo Alcator—*
XB divertor	*most pessimistic)*

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THE OFFSET LINEAR AND POWER LAW EMPIRICAL TRANSPORT SCALINGS LEAD TO DIFFERENT OPTIMIZATIONS FOR AN ETR

* OFFSET LINEAR (POST-KYOTO) FAVORS LOWER ASPECT RATIO

* POWER LAW (K-G) FAVORS LARGER ASPECT RATIO

IN PRESENT EXPERIMENTS DIFFICULT TO DISTINGUISH BETWEEN THEM

IN STX THERE IS A FACTOR OF 5 ->10 DIFFERENCE
IN THE PROJECTED CONFINEMENT FROM THE TWO SCALINGS

STUDIES FOR STX HAVE ALREADY LED TO IMPROVED UNDERSTANDING IN A NUMBER OF AREAS

* POLOIDAL CIRCUIT DESIGN - CIRCUS
* SOLENOID TECHNOLOGY TEST
* LOW R/a MHD
* LOW R/a DISRUPTIONS
* LOW R/a NEOCLASICAL TRANSPORT
* DIVERTOR CALCULATIONS
* OSCILLATING FIELD CURRENT DRIVE

A PROVISIONAL STX CONSTRUCTION BUDGET HAS BEEN PREPARED PENDING DEVELOPMENT OF A CONCEPTUAL DESIGN

	1988		1989		1990		
	BA	BO	BA	BO	BA	BO	
	EXPENSE FUNDING						
MDF BASE 1987$	1.4	0.9	2.2	2.7	1.4	1.4	5.0
CONTINGENCY (25%)	0.2	0.2	0.6	0.6	0.5	0.5	1.3
SUBTOTAL	1.6	1.1	2.8	3.3	1.9	1.9	6.3
ESCALATION (5%)	0.1	0.1	0.2	0.2	0.2	0.2	0.5
SUBTOTAL	1.7	1.2	3.0	3.5	2.1	2.1	6.8
	CAPITAL FUNDING (ESCALATED)						
POWER SUPP. ETC.	0.5	0.4	1.1	1.2	0.5	0.5	2.1
TOTAL	2.2	1.6	4.1	4.7	2.6	2.6	$8.9M ESCALATED

* THIS BUDGET INCLUDES A 1.5 MW BEAM SYSTEM. IT DOES NOT INCLUDE THE DIVERTOR POWER SUPPLY AND THE SECOND SHAPING SUPPLY.

* CONSTRUCTION TIME 30 MONTHS

* TOTAL ANNUAL BUDGET FOR OPERATION ≈ $5M (1988$)

ORNL IS INTERESTED IN MAINTAINING A STRONG ROLE IN THE TOKAMAK PROGRAM

* ORNL HAS MADE MAJOR INNOVATIVE INTEGRATED CONTRIBUTIONS TO
  - THEORY - MHD/TRANSPORT/HEATING/FUELING ...
  - SYSTEMS STUDIES - WHIST/FEDC
  - EXPERIMENT- ORMAK/ISX
  - TECHNOLOGY -NBI/RF/PELLETS/PMI/SC

* ORNL SUPPORTS NATIONAL AND INTERNATIONAL PROGRAM
  - TFTR/DIII-D/TEXT - CIT/ETR
  - TEXTOR/TORE SUPRA/JET

* IN THE FUTURE IT IS HOPED TO
  - CONTINUE INTEGRATED PHYSICS STUDIES ->CIT ->ETR
  - CONTINUE TO CONTRIBUTE TECHNOLOGY
  - BUILD STX AT ORNL