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MIRROR PROGRAM PLANNING NOTES

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Introduction

The charts reproduced herein represent a compilation of present thinking about Mirror Program Planning. This is not a plan as yet and is in fact intended to help stimulate discussion of plans.

The general theme here is building up by high current injection on a laser-induced target plasma column as small in diameter as possible in order to minimize the volume to be filled; namely, a diameter equal to the focal spot of convergent neutral beams (order of 6 to 10 cm). The concept is to build up to $\varepsilon_e = \omega_{pe}^2/\omega_{ce}^2 > 1$ in a few hundred microseconds starting from a target with containment $n\tau = 10^{10} cm^{-3}$ sec, followed by further buildup from the initial core to fill the full machine, and then followed by steady-state beams. The 2XIIB experiment will stimulate these processes (except steady state) and Baseball II will be utilized to develop laser-target plasmas and, later, to demonstrate steady state. The MX-1 (now shortened to MX) will embody these ideas in a larger device.

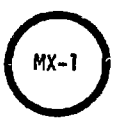
LAWRENCE LIVERMORE LABORATORY CTR PROGRAM

MIRROR EXPERIMENTS

GOALS
$n\tau\alpha E3/2$
STARTUP

SCALING
PHYSICS, TECHNOLOGY

REACTOR
TECHNOLOGY



FERF 10^{14} Neutral Flux

EPR Zero Power Li Blanket

HYBRID 50 MW Fission/Fusion

DEVELOPMENT

Neutral Beams

- Pulsed $\geq$ 1MW, 20 → 100 KV
- Efficient D.C. (Neg. Ion) 200 KV

Superconductivity

- Fil. NbSn 120 KG

MATERIALS

- RTNS 10^{13} Neutral Flux

COMPUTATION

- Mirror Program

CTR COMPUTER CENTER

MX - 1

GOALS

- BL Scaling
- Physics, technology (Vac. etc.)
- DT Option
- Operation by 1978

CONCEPT

- Minimum-B Mirror, Neutral Injection
- Pulsed Beam Startup, Laser Target

PARAMETERS (Preliminary)

- Yin-Yang Pulsed Aluminum Coil
  B = 20 Kg(Central) R = 2:1
  L = 340 cm
  On time = 1 sec (or more)
  Power: 500 MW pulse from Grid
- Startup
  1000 A, programmed 20 KV → 100 KV
  Start from Laser-Plasma core with diameter = focused beam
  1-2 KJ CO_2 laser
- Injection: 15A, 100 KV steady state

SITE

LLL Bldg. 431, Shielded Main Pit

ESTIMATED COST (in 1974 $, Without DT)

Operating	$ 20M
Equipment	15M
	$ 35M (very preliminary)

NO BUILDING REQUIRED

MX-1 DESIGN ISSUES

PROBLEM	APPROACH	DATE
$E^{3/2}$ Scaling	2XIIB	>Jan. 1975
Startup:		
Principles	2XIIB	>Jan. 1975
Laser Technology	BBII-T	FY 76 (preliminary data, 30j laser, >Jan. 1975)
Adiabaticity, at $\beta \geq .5$	Computation	Fall 1974
Neutron activation	Computation	Fall 1974

MIRROR PHYSICS PROGRAM

MAIN LINE	2XIIB	BBII	(2XC)	(MX-1)
1. $E^{3/2}$ Scaling	Yes - FY 75	Late FY 76		
2. Startup				
A. Main Line - Pulsed Beam (100 A/ℓ), Hot Ion Target ($n\tau = 10^{13}$)	Simulated, Gun & Compress	CO_2 Laser Target		
B. Backup - Pulsed Beam, Cold Target	Gun, no trapping			
C. Buildup from Core diam = beam focus	??	FY 76		
3. β Scaling	Yes			
4. BL Scaling				(FY 79)
5. Vacuum Technology				
A. Pulsed Beam Startup	Yes			
B. Steady State		Up to <.5MM 50-60 KV		(FY 79)
6. High Mirror Ratio			(Yes)	
7. Beam Access, Very High β			(Yes)	
8. Simple Mirror (geometry improvements)				

ALTERNATIVE MIRROR CONCEPTS

Higher Q

- Two-Component Mirror ✓
- Field Reversal by Neutral Beams ✓
- MIRICLE
  Electron containment by toroidal return
- Multiple mirror

(✓ : partially test in 2XIIB)

SIMPLER, CHEAPER COIL

- Simple mirror
- Average Min-B

ALTERNATIVE STARTUP

- 1 - 10 KA/ℓ Pulsed Beam, very short pulse (μsec's)

ALTERNATIVE STEPS TO DT MIRRORS

	E Injec.	Mirror Ratio	BL (X2XIIB)	$P_{into\ Plasma}$	$P_{in\ Neutrals}$	β	Classical Q_{DT}	Equivalent P_{nuc}/P_{waste}
Pulsed, Limited Shots MX-1	150KV	2	5	~0.5MW	1.5MW	.6	.5	<.1
DT-FTR FERF Design, NbT:	150	2	10	1MW	2.5MW	.5	.5	<.1
FERF Design, NbSn	150	2	13	2	2.4	.65	.5	few 0.1's
FERF NbT:	75	2	10	8	10	.65	.3	--
FERF NbSn	75	2	13	25	30	.65	.3	--
EPR[1] NbT:	75	3	15	9	11	.7	.7	.8
EPR NbSn	150	3	20	6	7	.65	1	~1 Zero Power
Hybrid				8	10		.3	1.2 (at 10X Neutron multiplication in Fission blanket - i.e. 20% overall efficient)

(1) Inj. Energy dropped to increase n and hence trapping efficiency.

TABLE I. Main Elements of LLL/LBL Neutral Beam Program

	FY 75	FY 76	FY 77
Pulsed Beams	40 KV, 10 msec (Jan. 1975)	60 - 80 KV (July, 1975) 40 - 80 KV, > 20 msec (Jan. 1976)	100 - 120 KV (Jan. 1977)
Efficient 150 - 200 KV Beams			
Low Voltage D^+ Injector	Test LBL 10 sec source 5 grids accel-decel	Begin scale up	D^+ Injector for the MW Negative Ion Beam
Negative Ion Beams	Test Negative Ion generation by Double Charge Exchange with Pulsed "10A" Injector	Complete tests with Pulsed Beam; further develop Double cx Cell	Tests of 200 KV Negative Ion Beam (1 MW neutrals) (begin Jan. 1977)
200 KV Test Stand	Design, long lead purchases	Major purchases and fabrication	D.C. 200 KV Test capability at >MW neutrals (Jan. 1977)