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IRRADIATION RESEARCH CAPABILITIES AT HFIR AND ANS*

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EXTENDED ABSTRACT

A variety of materials irradiation facilities exist in the High Flux Isotope Reactor (HFIR) and are planned for the Advanced Neutron Source (ANS) reactor. The HFIR, while designed primarily for transuranium isotope production, has since 1970 been utilized for various materials irradiation programs. Approximately 80 uninstrumented capsules have been irradiated in the target region for the Magnetic Fusion Energy (MFE) and High Temperature Gas-cooled Reactor (HTGR) programs. Additionally, 20 instrumented capsules have been irradiated in the removable beryllium (RB) region for the HTGR program.

In 1986 the HFIR Irradiation Facilities Improvement (HIFI) project began modifications to the HFIR which now permit the operation of two instrumented capsules in the target region and eight capsules of 46-mm OD in the RB region. Thus, it is now possible to perform instrumented irradiation experiments in the highest continuous flux of thermal neutrons available in the western world. The new RB facilities are now large enough to permit neutron spectral tailoring of experiments and the modified method of access to these facilities permit rotation of experiments thereby reducing fluence gradients in specimens. A summary of characteristics of irradiation facilities in HFIR is presented in Table 1.

The ANS is being designed to provide the highest thermal neutron flux for beam facilities in the world. Additional design goals include providing materials irradiation and transplutonium isotope production facilities as good, or better than, HFIR. The reference conceptual core design consists of two annular fuel elements positioned one above the other instead of concentrically as in the HFIR. Each element will be 507-mm long providing an overall core height of slightly more than 1 meter.

A variety of materials irradiation facilities with unprecedented fluxes are being incorporated into the design of the ANS. These will include fast neutron irradiation facilities in the central hole of the upper fuel element, epithermal facilities surrounding the lower fuel element, and thermal facilities in the reflector tank. A summary of characteristics of irradiation facilities presently planned for the ANS is presented in Table 2.

Table 1. Characteristics of some irradiation facilities in HFIR

Characteristics	Target	RB*	Small VXF	Large VXF
Fast flux, E > 0.1 MeV (10^{18} neutrons m^{-2} s^{-1})	12	6	0.6	0.2
Maximum displacements per calendar year, stainless steel	25	8		
Thermal flux (10^{18} neutrons m^{-2} s^{-1})	24	14	9	5
Gamma heating (W/g SS)	46	16	3.5	1.9
Typical capsule diameter (mm)	16	46	37	69
Number of available positions	36	8	16	6

Table 2. Characteristics of materials irradiation facilities in ANS

Characteristics	Inside CPBT		In reflector tank			
	Central positions	Transuranium production positions	Slant tubes	Vertical holes	Hydraulic tubes	Pneumatic tubes
Fast flux, E > 0.1 MeV (10^{18} neutrons $m^{-2}s^{-1}$			5			
Thermal flux (10^{18} neutrons $m^{-2}s^{-1}$)			63	4-10	20-80	4
Nuclear heating (W/g SS)						
Typical capsule diameter (mm)	16-46	16				
Number of positions	10		2	7	4	3

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MAJOR MATERIALS IRRADIATION FACILITIES

HFIR

- Target region
- RB* facilities
- Permanent beryllium

ANS

- Central (fast)
- Reflector (thermal)

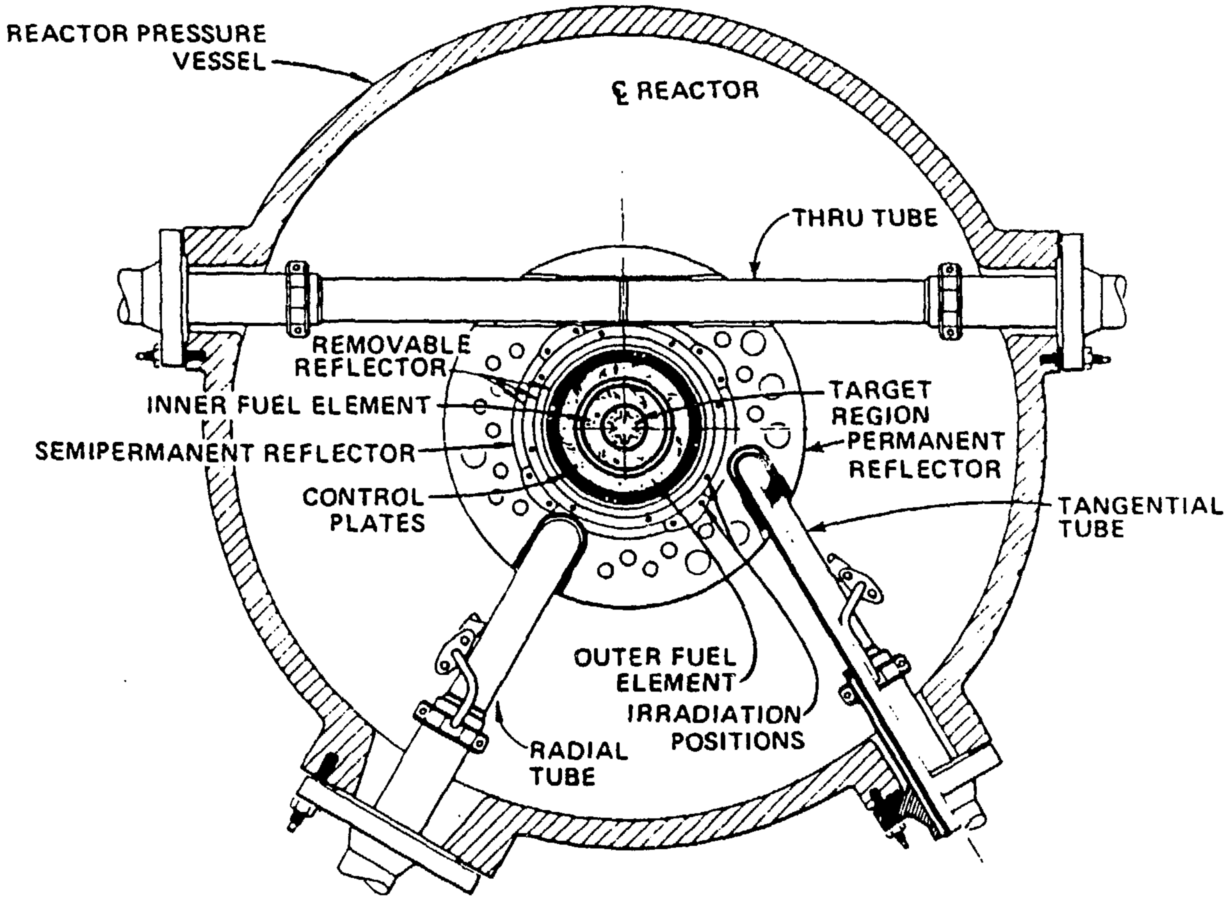
THE OAK RIDGE HIGH-FLUX ISOTOPE REACTOR (HFIR)

- A pressurized, light-water-cooled, beryllium-reflected, 85-MW research reactor
- Specifically designed and built for the production of transuranium isotopes
  - The highest continuous flux of thermal neutrons in the western world
- Also used for neutron-beam scattering experiments
- Also used for engineering materials irradiations
  - Fusion materials
  - HTGR fuel and graphite
  - Pressure vessel steel samples
- Low coolant water temperature - Inlet 49°C and Outlet 73°C
- Typical fuel cycle length of 25 days

A VARIETY OF IRRADIATION FACILITIES ARE AVAILABLE IN HFIR

- Target Region
    - Uninstrumented
    - Instrumented
    - Hydraulic tube
- RB*
- Vertical Experimental Facilities in Reflector
    - Small
    - Large
    - Pneumatic tube

PLAN VIEW OF THE HFIR SHOWING REACTOR COMPONENTS, FUEL, AND BEAM TUBES



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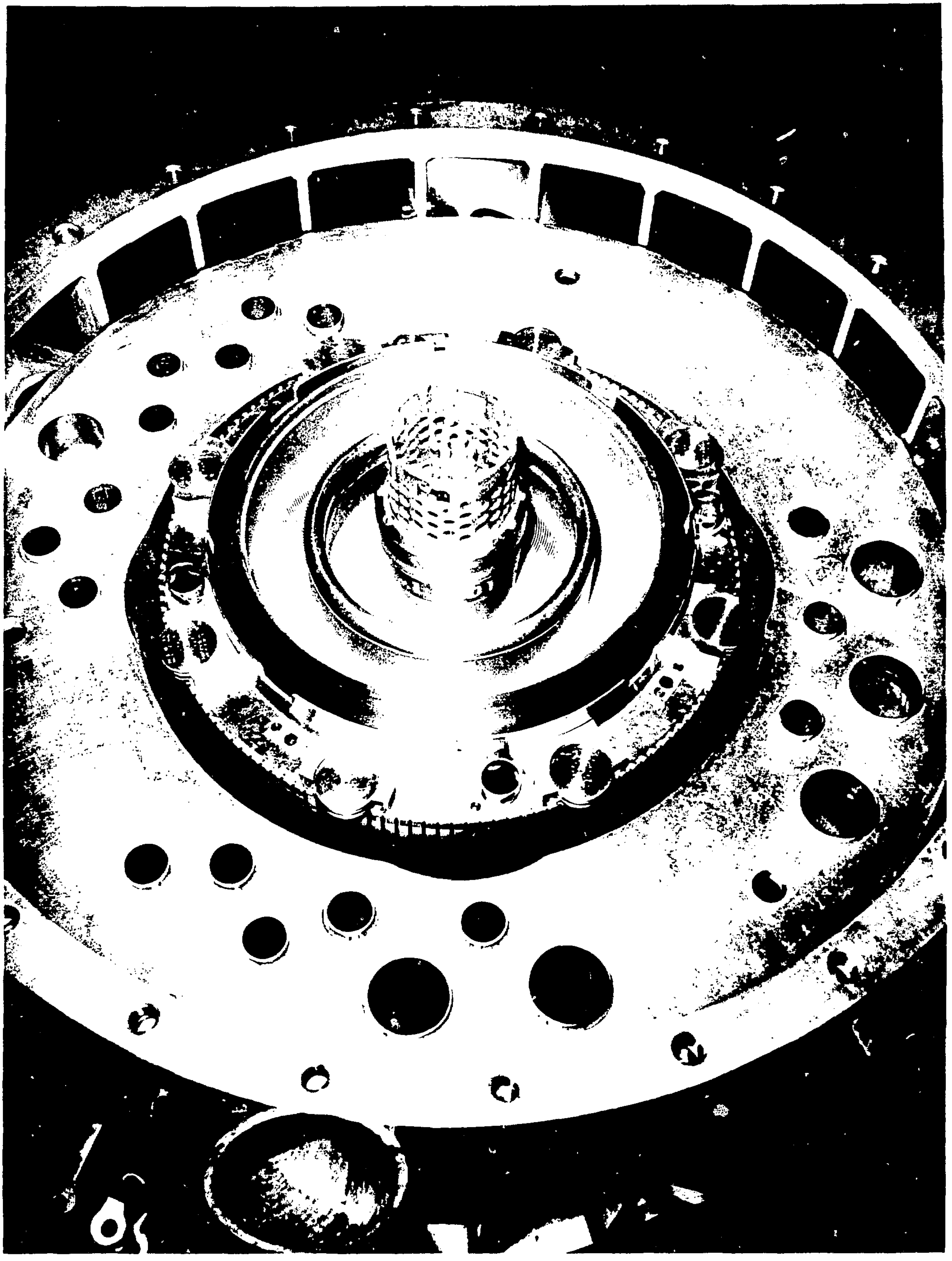

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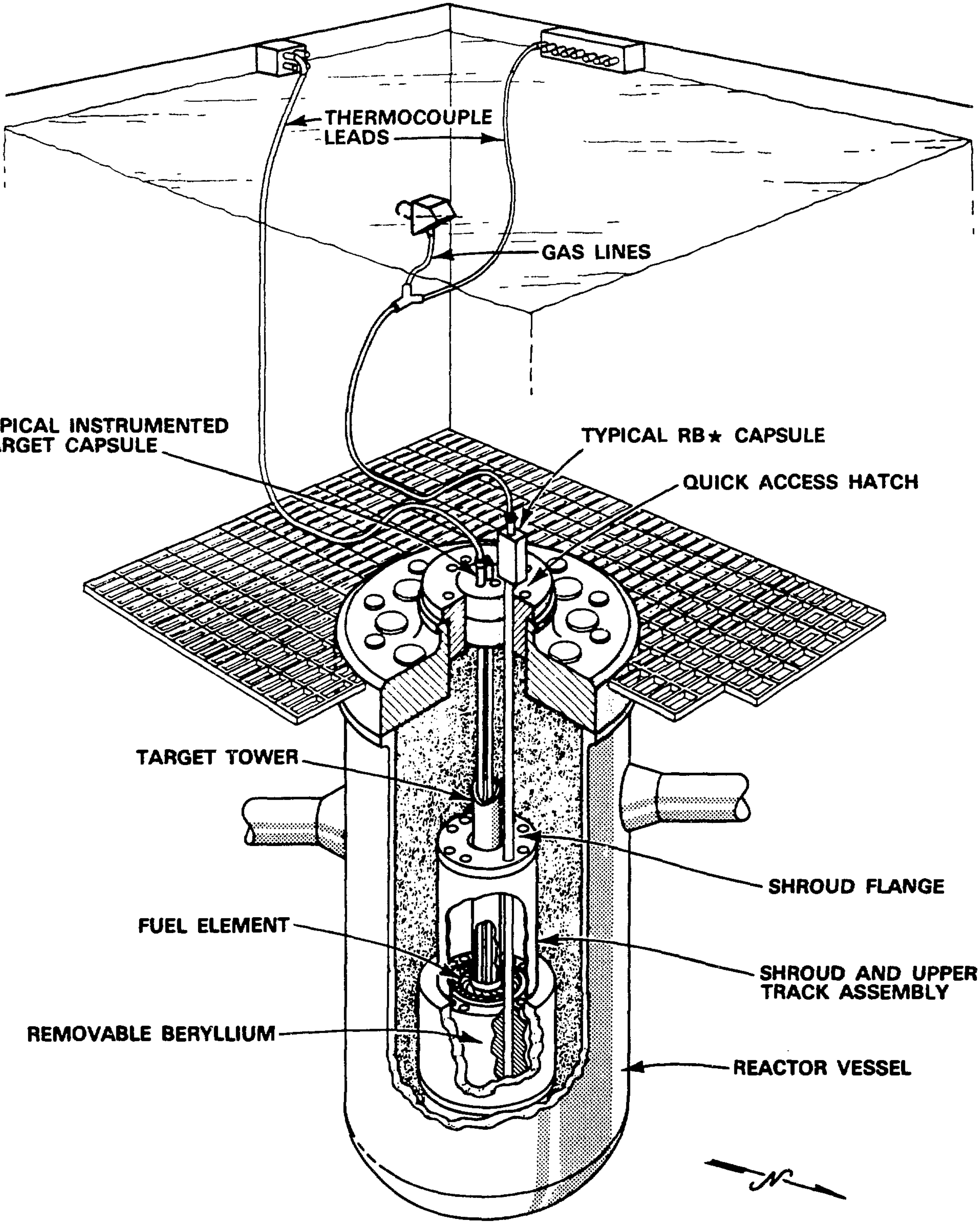
NEW EXPERIMENTAL FACILITIES IN HFIR



Characteristics of some irradiation facilities in HFIR

Characteristics	Target	RB*	Small VXF	Large VXF
Fast flux, E > 0.1 MeV (10^{18} neutrons m^{-2} s^{-1})	12	6	0.6	0.2
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Typical capsule diameter (mm)	16	46	37	69
Number of available positions	36	8	16	6

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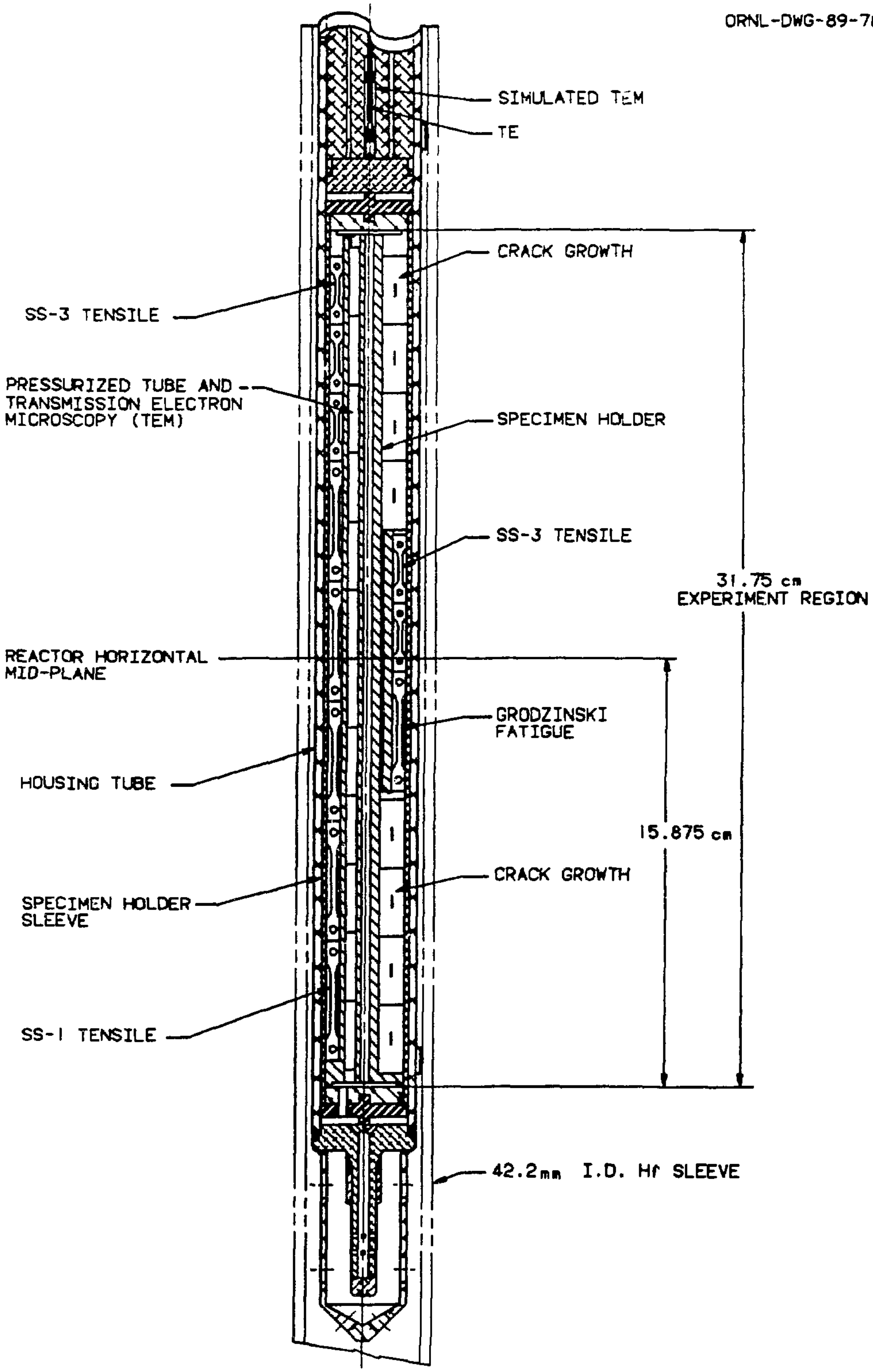


VERTICAL SECTION THROUGH HFIR-MFE 200J-1 CAPSULE

THE ADVANCED NEUTRON SOURCE PROJECT TECHNICAL OBJECTIVES

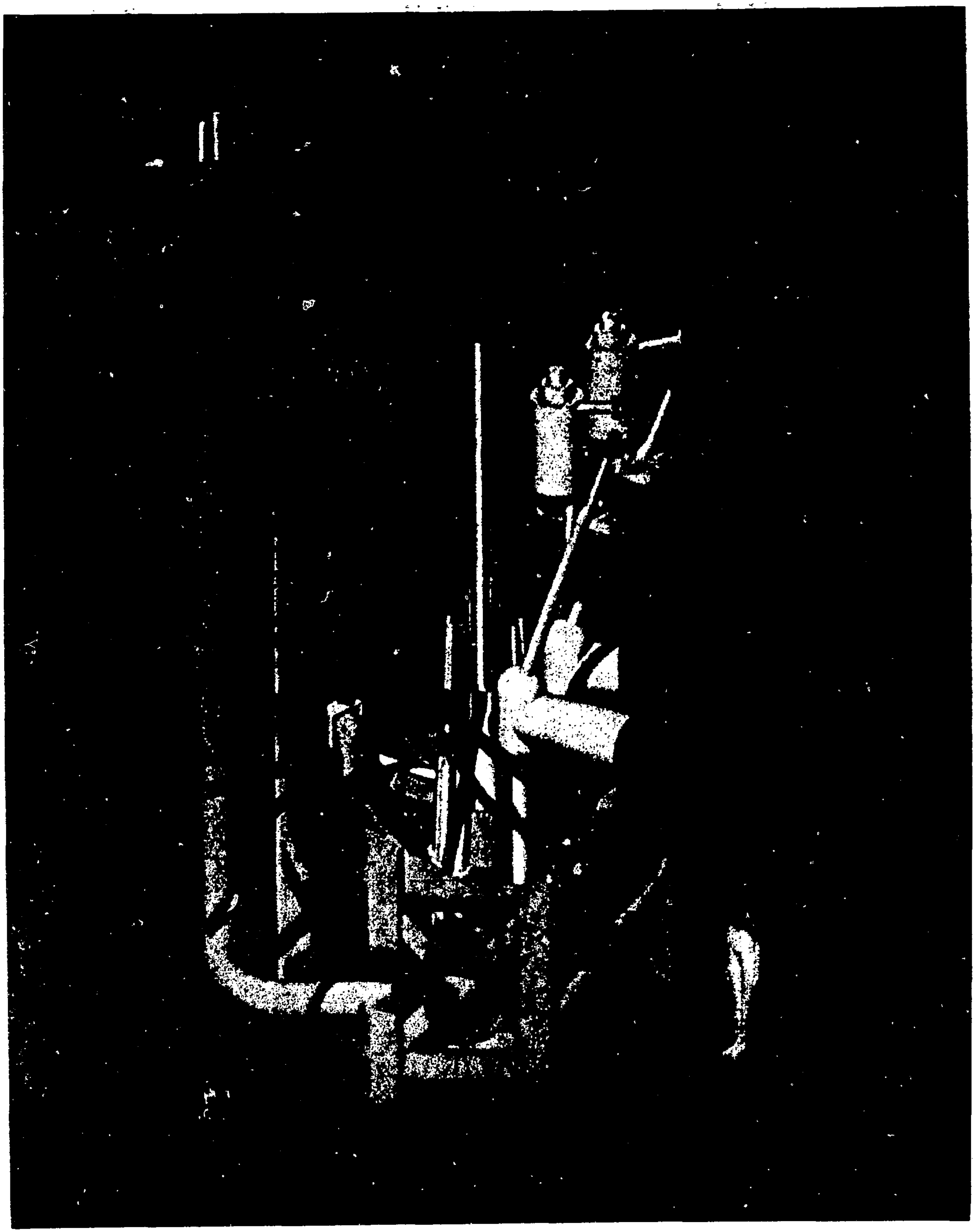
- To design and construct the worlds highest flux research reactor for neutron scattering

- To provide isotope production facilities that are as good, or better than, HFIR

- To provide materials irradiation facilities that are as good, or better than, HFIR

THE ADVANCED NEUTRON SOURCE (ANS) REACTOR

- Heavy-water - cooled and reflected
- 364 MW power
- Low coolant water temperature - Inlet 49°C and Outlet 84°C
- Typical fuel cycle length of 14 days



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A VARIETY OF MATERIALS IRRADIATION FACILITIES WILL BE AVAILABLE IN ANS (1)

- Fast Neutron Irradiation

  - 5 instrumented and 5 non-instrumented capsule positions are located just inside the upper fuel element

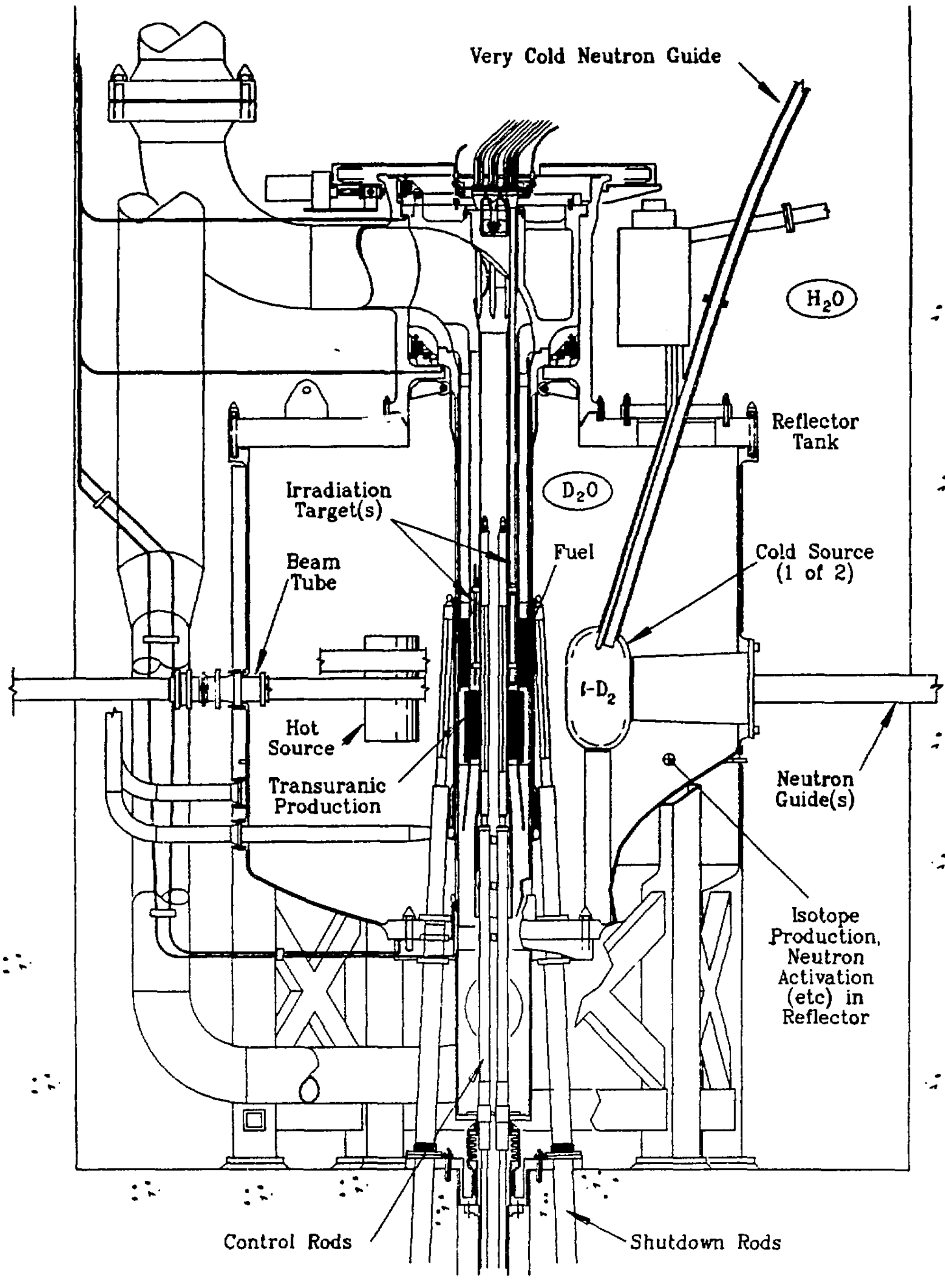
  - The Fast:Thermal ratio may be tuned by about a factor of 3 by selecting different radial positions within the global boundaries of the fast irradiation positions

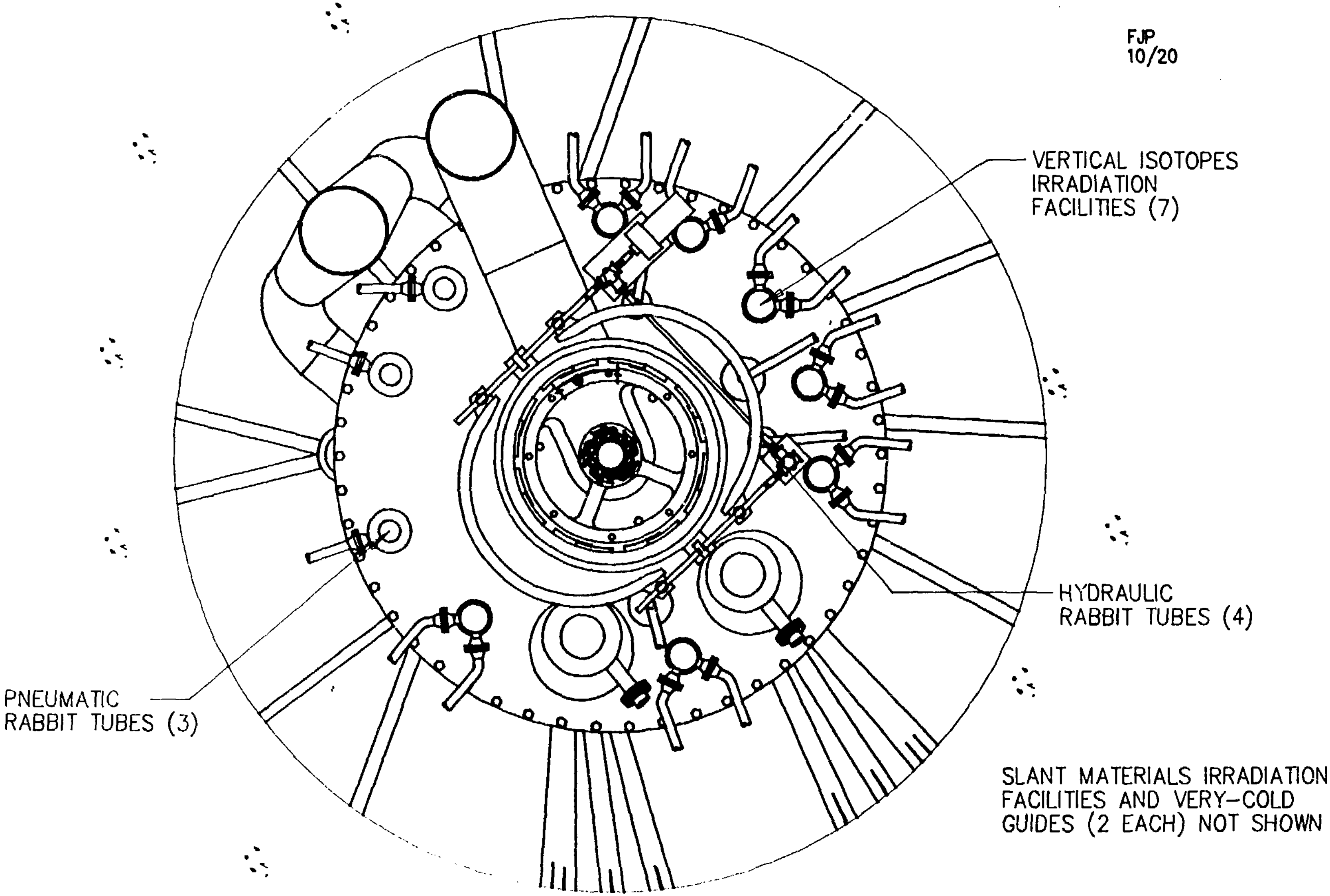
  - Absolute fast flux increases during burnup as the poison burns and the control rods move, but the absolute value of the Fast:Thermal ratio decreases concurrently.

A VARIETY OF MATERIALS IRRADIATION FACILITIES WILL BE AVAILABLE IN ANS (2)

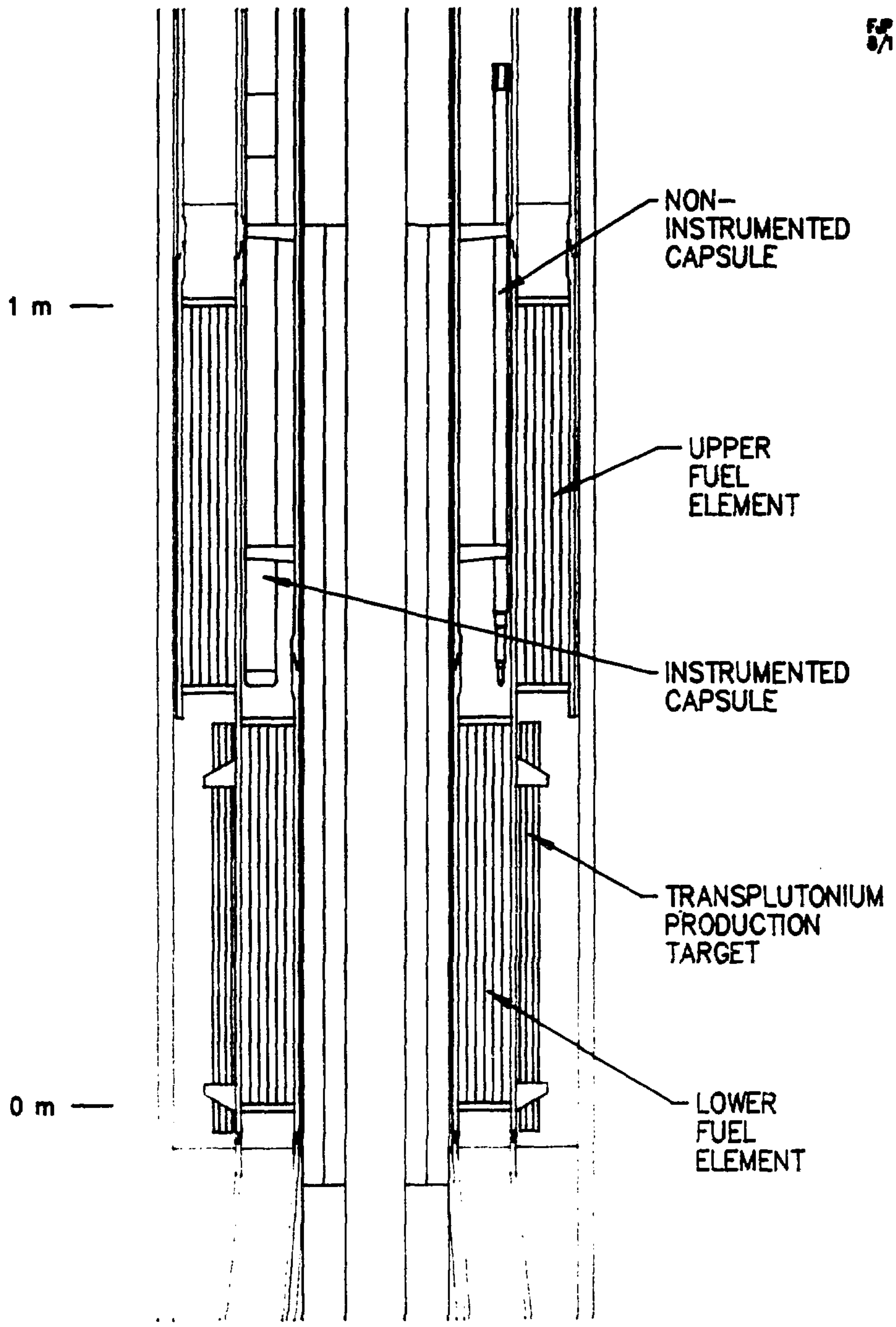
- Fast/Epithermal Neutron Irradiation
  - Capsules are interchangeable with the transuranium production rods (outside the lower fuel element)
- High Thermal Flux Irradiation
  - Provided primarily by the 2 slant facilities just outside the CPBT in the reflector tank
  - Other in-tank positions are available

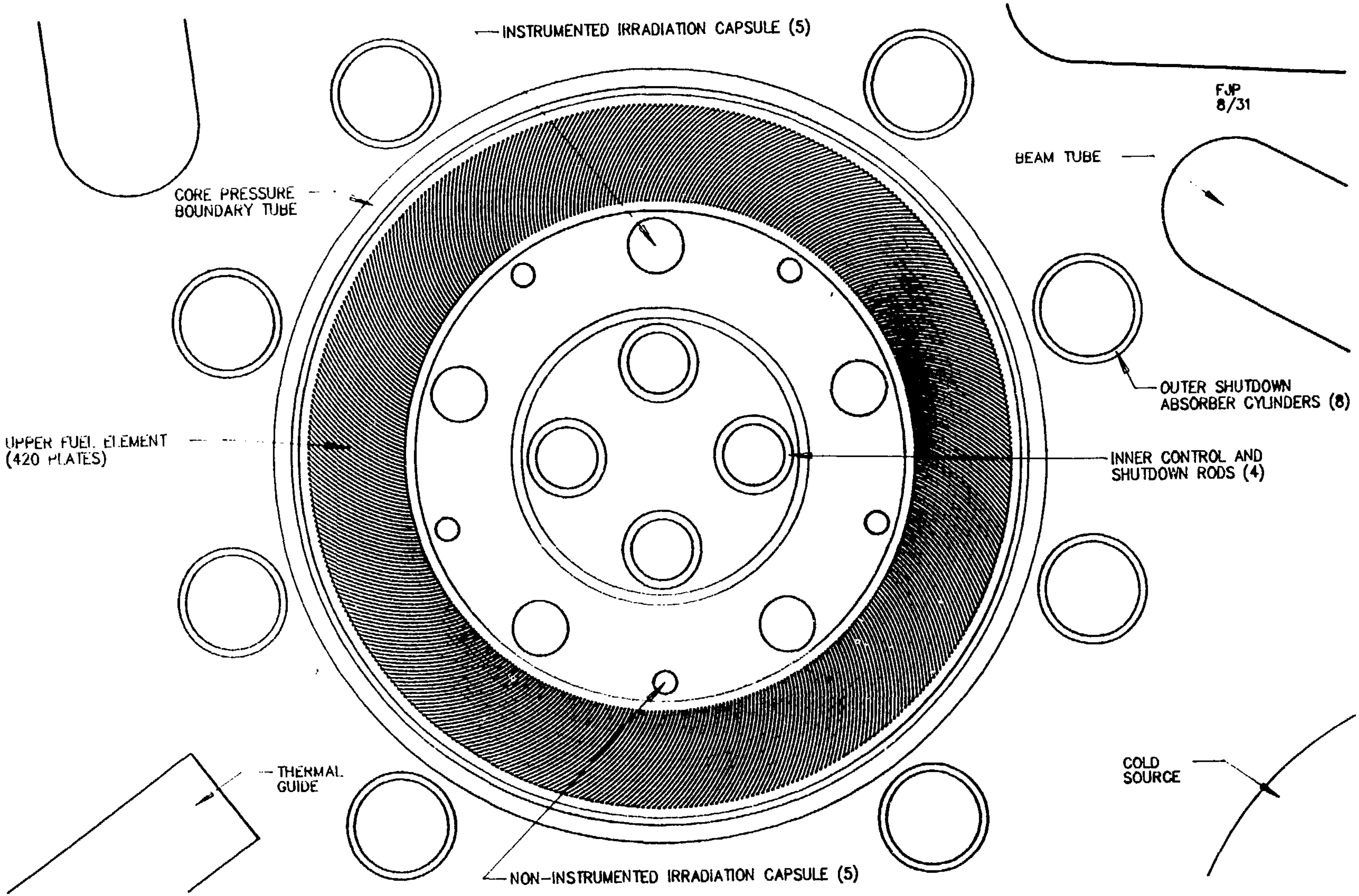
ANS REACTOR ASSEMBLY

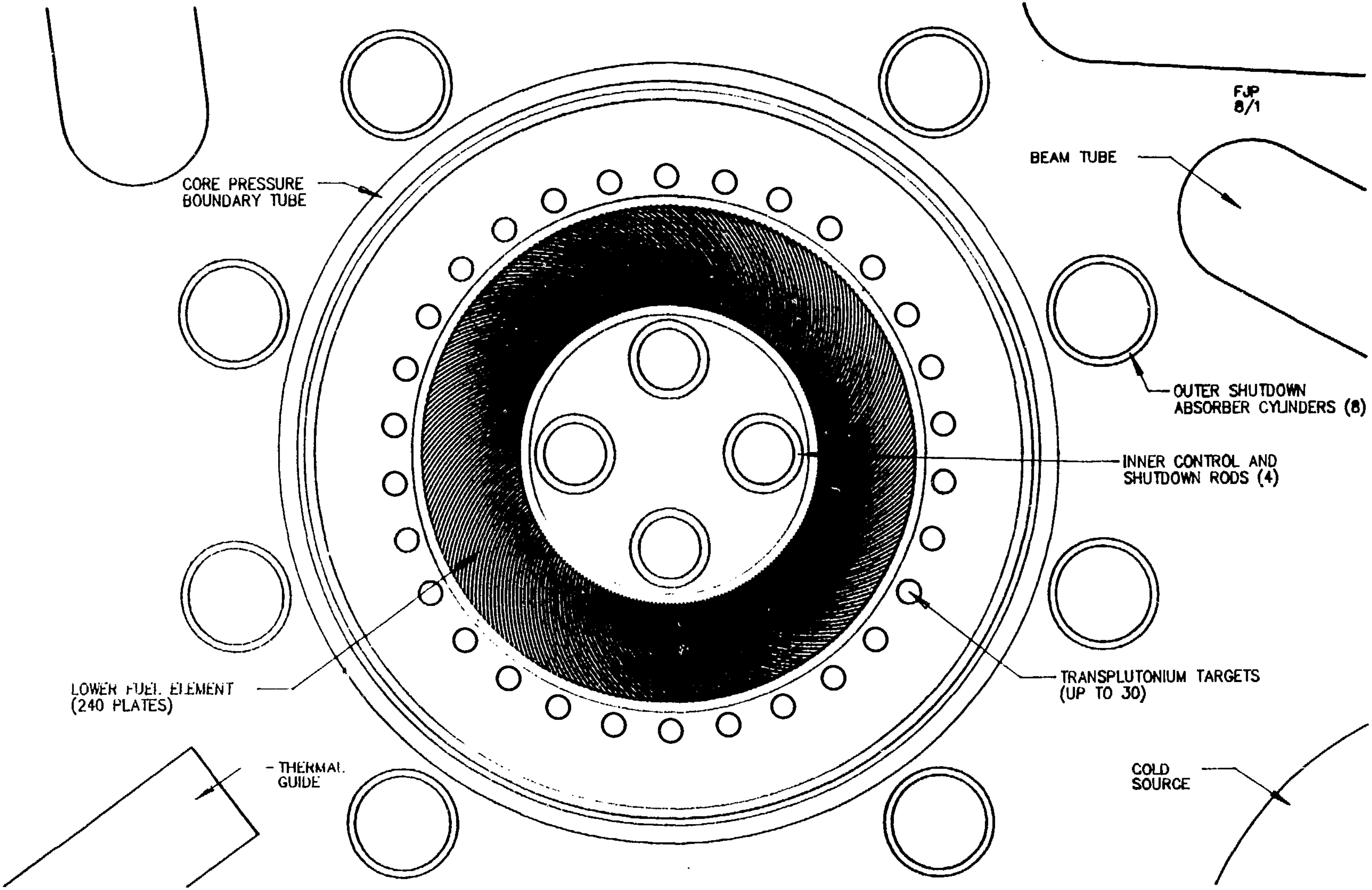


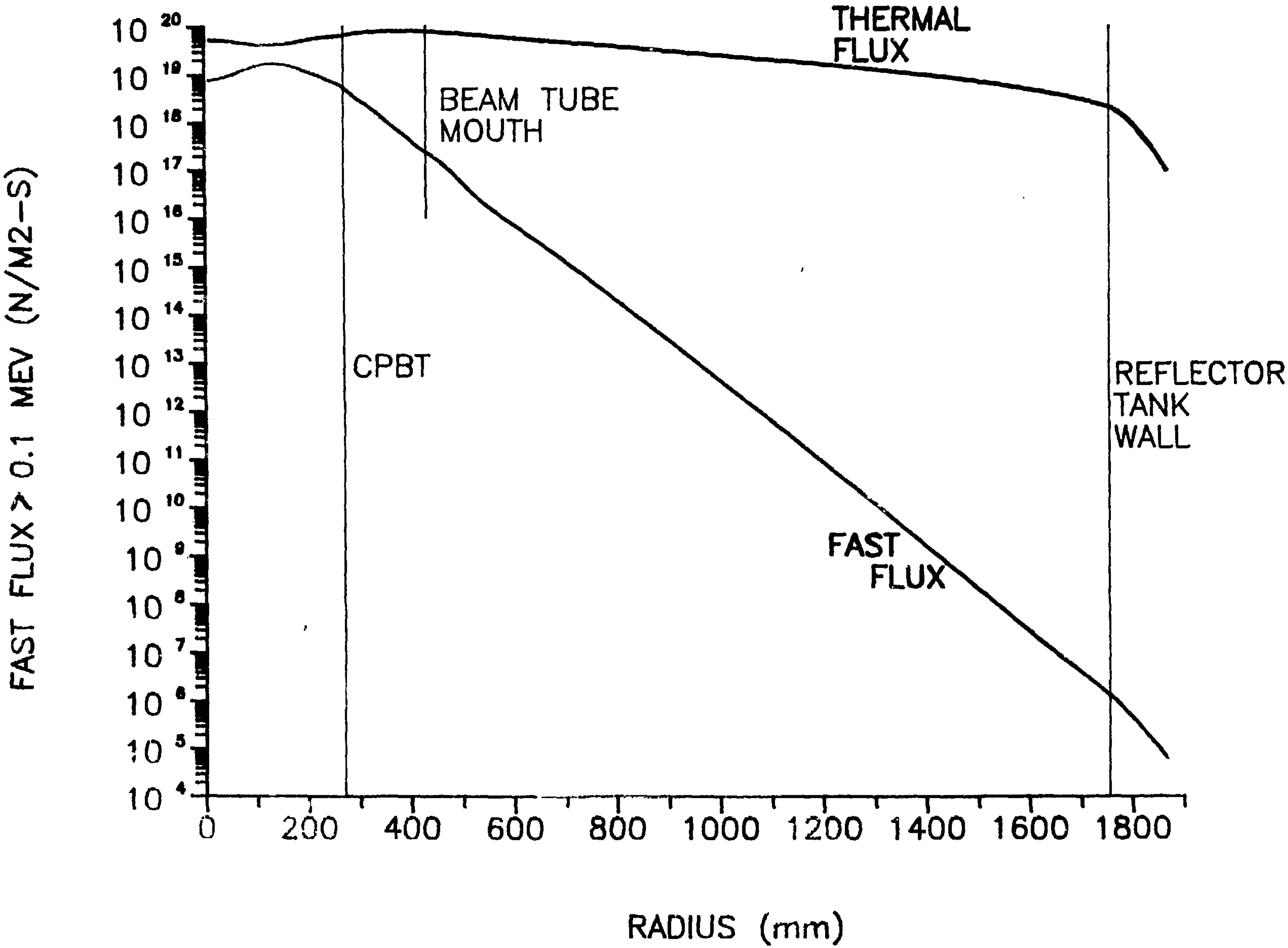

FJP
10/20
VERTICAL ISOTOPES
IRRADIATION
FACILITIES (7)
HYDRAULIC
RABBIT TUBES (4)
PNEUMATIC
RABBIT TUBES (3)
SLANT MATERIALS IRRADIATION
FACILITIES AND VERY-COLD
GUIDES (2 EACH) NOT SHOWN

CORE AND IRRADIATION FACILITIES

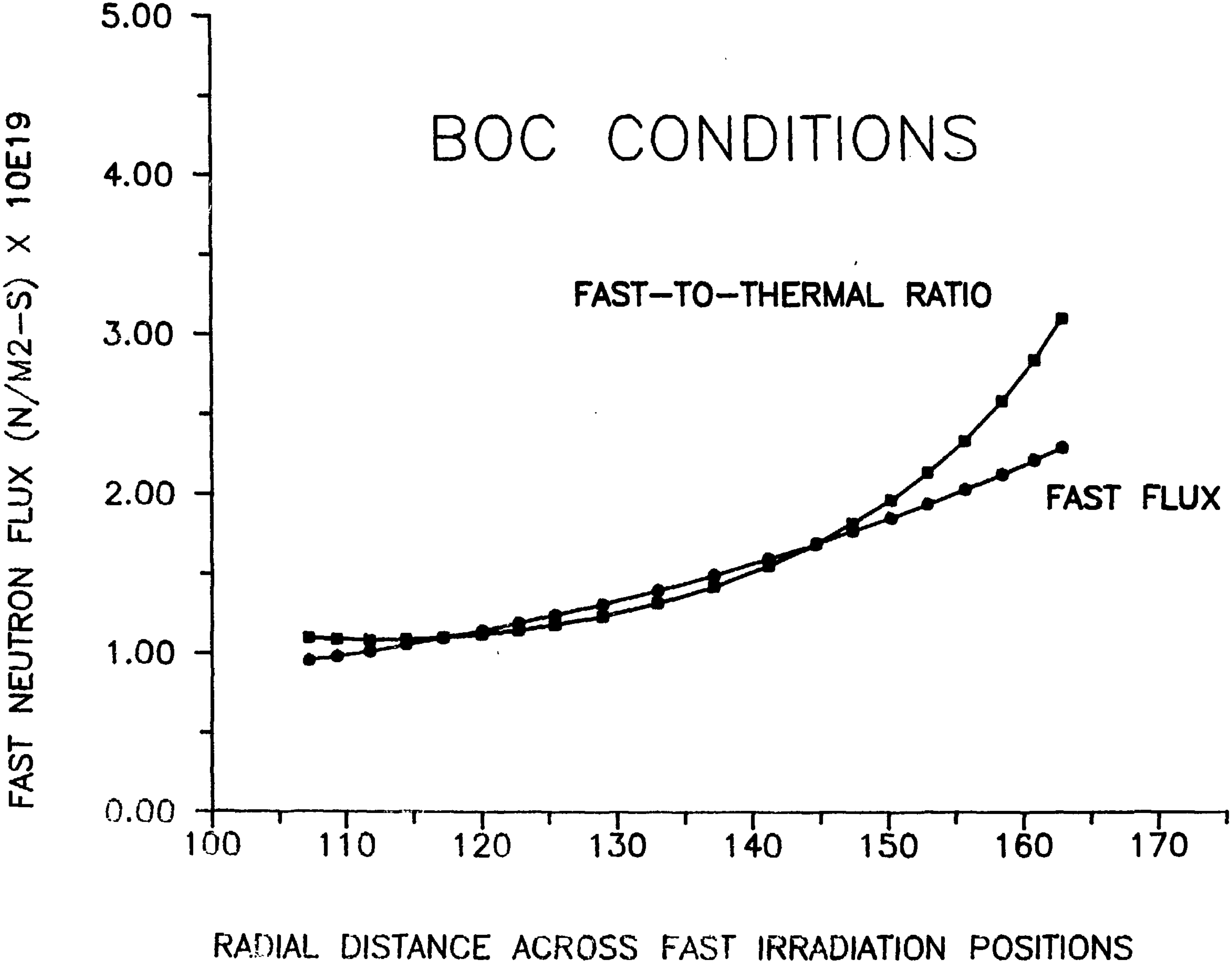



INSTRUMENTED IRRADIATION CAPSULE (5)
FJP
8/31
BEAM TUBE
CORE PRESSURE
BOUNDARY TUBE
OUTER SHUTDOWN
ABSORBER CYLINDERS (8)
UPPER FUEL ELEMENT
(420 PLATES)
INNER CONTROL AND
SHUTDOWN RODS (4)
THERMAL
GUIDE
COLD
SOURCE
NON-INSTRUMENTED IRRADIATION CAPSULE (5)

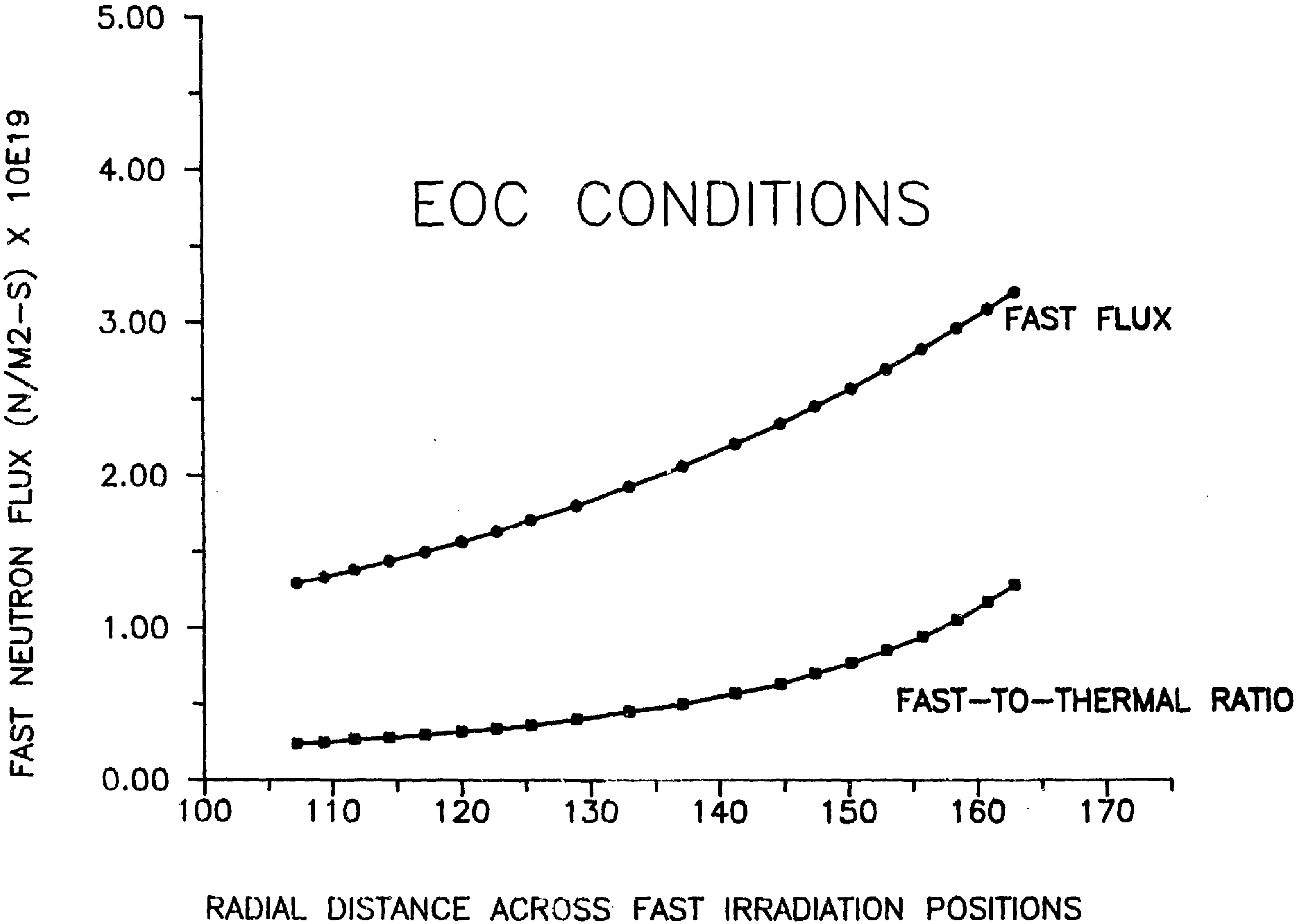

FJP
8/1
BEAM TUBE
CORE PRESSURE
BOUNDARY TUBE
OUTER SHUTDOWN
ABSORBER CYLINDERS (8)
INNER CONTROL AND
SHUTDOWN RODS (4)
LOWER FUEL ELEMENT
(240 PLATES)
TRANSPLUTONIUM TARGETS
(UP TO 30)
THERMAL
GUIDE
COLD
SOURCE

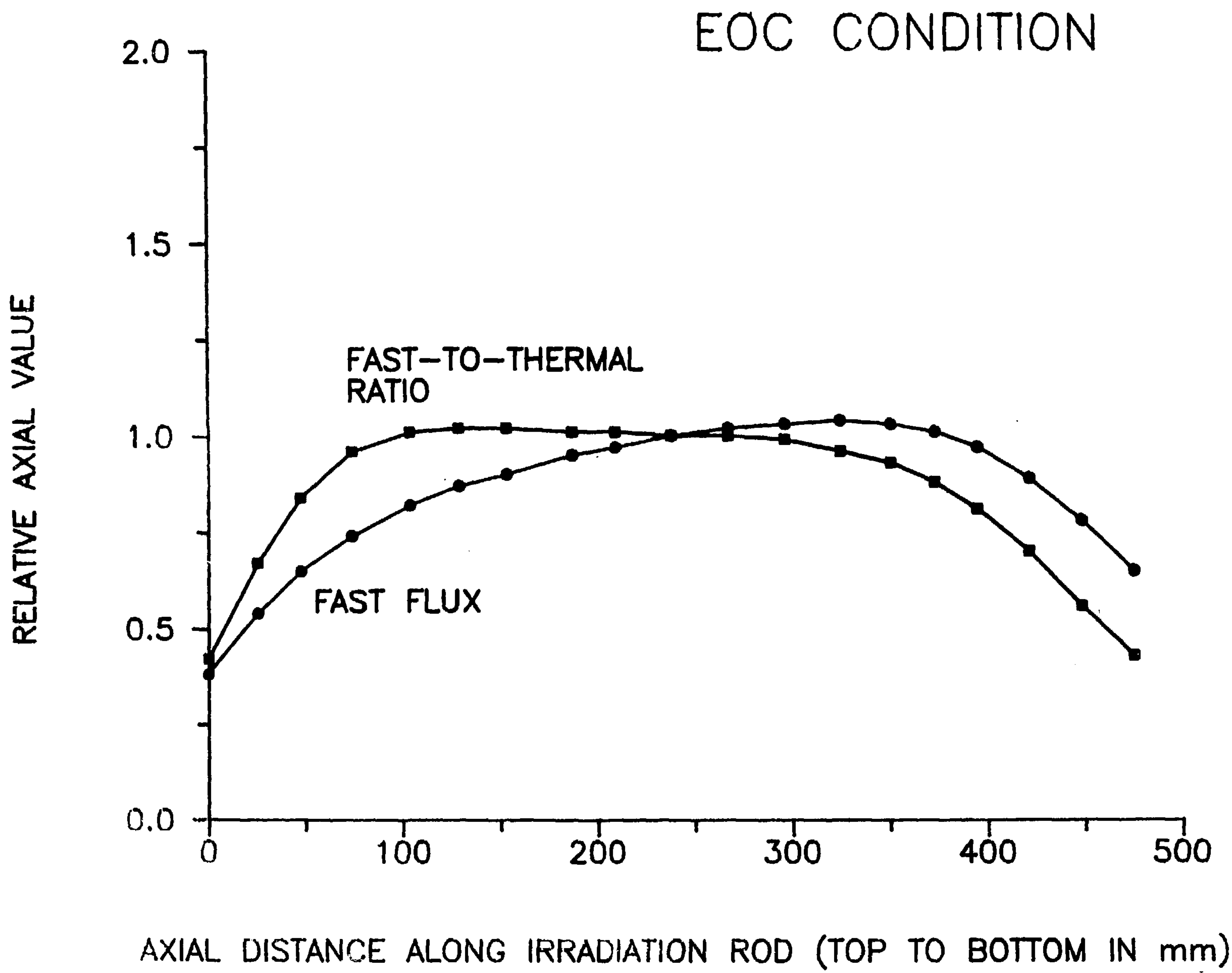


THERMAL FLUX
BEAM TUBE MOUTH
CPBT
REFLECTOR TANK WALL
FAST FLUX
FAST FLUX > 0.1 MEV (N/M2-S)
10 20
10 19
10 18
10 17
10 16
10 15
10 14
10 13
10 12
10 11
10 10
10 9
10 8
10 7
10 6
10 5
10 4
0
200
400
600
800
1000
1200
1400
1600
1800
RADIUS (mm)



BOC CONDITIONS
FAST-TO-THERMAL RATIO
FAST FLUX
FAST NEUTRON FLUX (N/M2-S) X 10E19
0.00
1.00
2.00
3.00
4.00
5.00
100
110
120
130
140
150
160
170
RADIAL DISTANCE ACROSS FAST IRRADIATION POSITIONS


EOC CONDITIONS
FAST NEUTRON FLUX (N/M2-S) X 10E19
5.00
4.00
3.00
2.00
1.00
0.00
100
110
120
130
140
150
160
170
FAST FLUX
FAST-TO-THERMAL RATIO
RADIAL DISTANCE ACROSS FAST IRRADIATION POSITIONS


EOC CONDITION
2.0
1.5
1.0
0.5
0.0
RELATIVE AXIAL VALUE
FAST-TO-THERMAL
RATIO
FAST FLUX
0
100
200
300
400
500
AXIAL DISTANCE ALONG IRRADIATION ROD (TOP TO BOTTOM IN mm)

Characteristics of materials irradiation facilities in ANS

Characteristics	Inside CPBT		In reflector tank			
	Central positions	Transuranium production positions	Slant tubes	Vertical holes	Hydraulic tubes	Pneumatic tubes
Fast flux, E > 0.1 MeV (10^{18} neutrons $m^{-2}s^{-1}$			5			
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Nuclear heating (W/g SS)						
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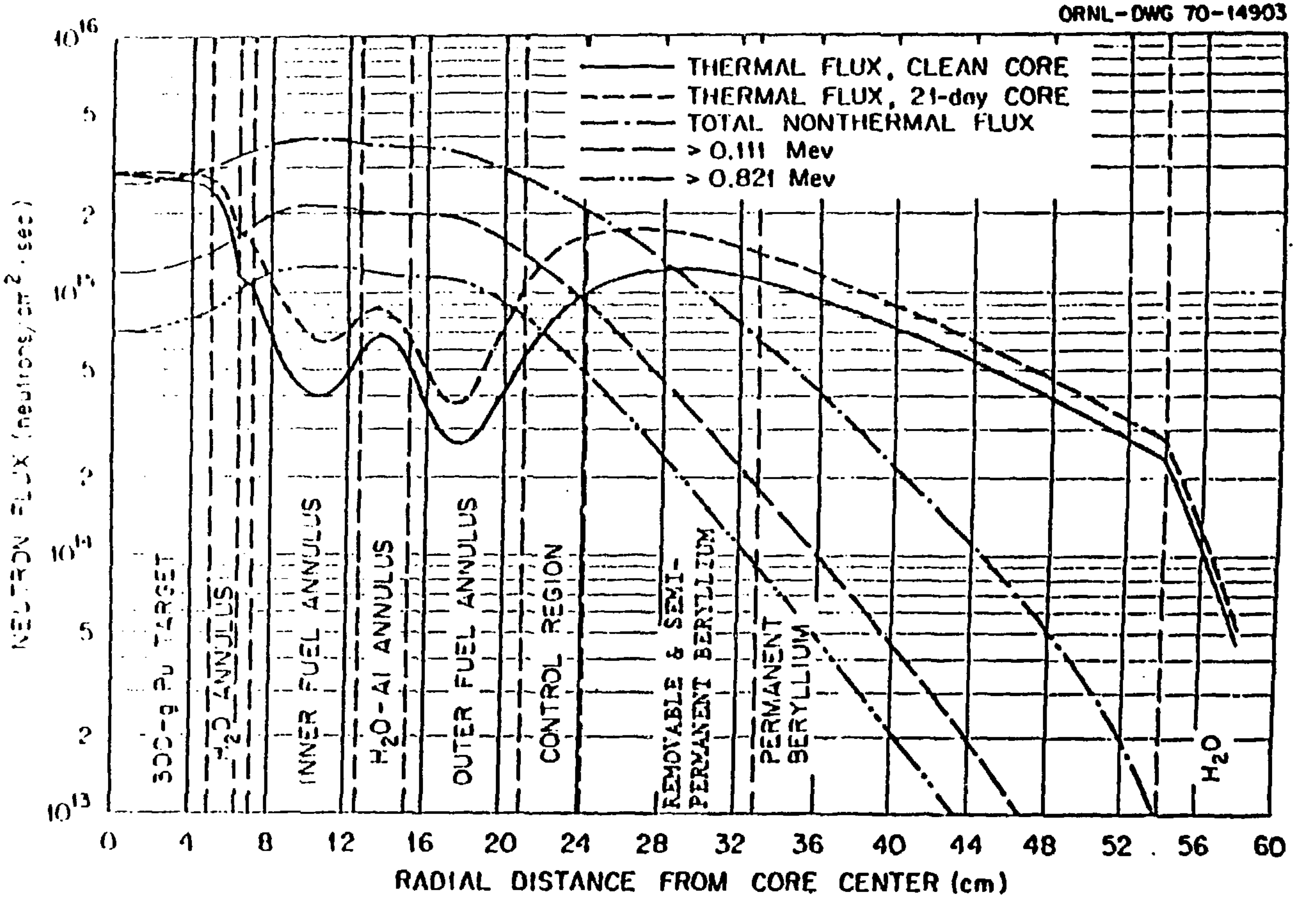

Fig. 10. Typical Radial Neutron Flux Distributions at Core Horizontal Midplane with Reactor Operating at 100 MW