



Power Upgrade Feasibility at the NC State University PULSTAR Reactor

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Outline

- Objective
- PULSTAR Reactor Overview
- Core Analysis
 - Neutronics
 - Thermal hydraulics
- Accident Analysis
- Equipment and Fuel Needs
- Future Work

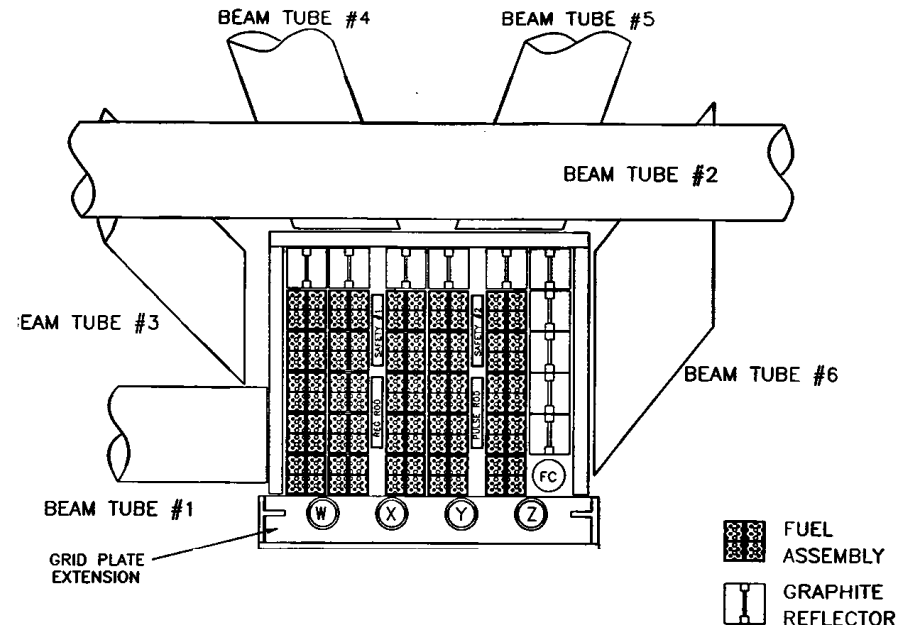
Objective

- Increase neutron flux at the experimental facilities
 - Intense Positron Beam
 - Neutron Imaging Facility
 - Powder Diffractometer
 - Ultra-Cold Neutron Source

- Achieve upgrade with a minimum amount of modification to the reactor.

PULSTAR Reactor

- ❑ 1-MW power
- ❑ 5 x 5 array of fuel assemblies
- ❑ 5 x 5 array of pins
- ❑ Sintered UO_2 pellets
- ❑ 4% enriched
- ❑ Open tank
- ❑ Light water moderated and cooled



PULSTAR NUCLEAR REACTOR
5 X 5 REFLECTED CORE # 3
(NOT TO SCALE)

FIGURE 3

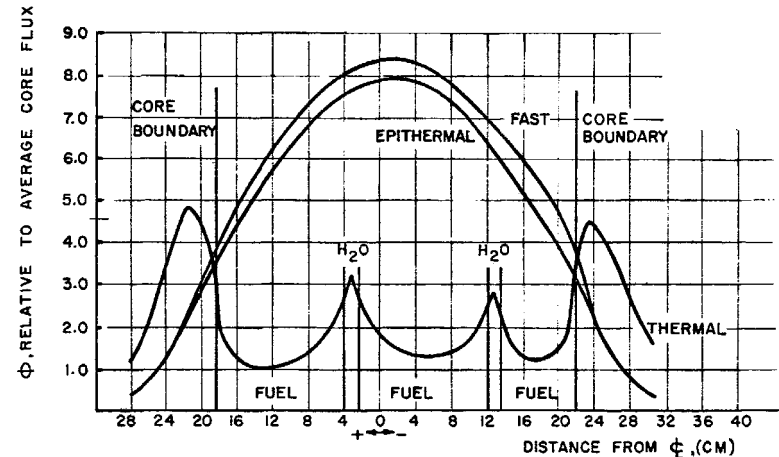
PULSTAR Attributes

□ Design

- Heavy loading of U-235
~12.5 kg
- Low Moderator-Fuel Ratio
- Thermal flux peak at core periphery

□ Benefits

- High fast-neutron leakage
- Thermal flux at core face
 1×10^{13} n/cm²/s
- Long core lifetime



Constraints

- Fuel
 - PULSTAR type to be maintained
 - Enrichment can be varied

- Core grid plate
 - Maximum core size 6 x 6

- Primary pipe size fixed at 10" Ø

- Control Rods
 - Maximum of four rods
 - Material – Silver/Indium/Cadmium

Core Neutronics

- Fuel Enrichment
 - 4.0% - 6.0%

- Preliminary design calculations showed that:
 - Flux scales linearly with no change in enrichment

 - Enrichment Increase, Flux Decreases

Thermal Hydraulics

□ CRITERION ONE

- No bulk boiling (i.e. two phase flow) at channel exit

□ CRITERION TWO

- No flow instabilities that lead to burnout

□ CRITERION THREE

- Minimum allowable DNB ratio (MDNBR) is 2.0

Accident Analysis

- Loss of Flow – Flow Reversal
 - Cladding Melting Temp. 3300 °F
 - 5 MW – max clad temp 625 °F

- Loss of Coolant
 - < 4 MW No ECCS required

- Fuel Pin Clad Failure
 - Radiation Doses to Public

Equipment Needs

- ❑ Core
 - Convert old Pulse Rod to Control Rod with SCRAM capabilities

- ❑ Instrumentation
 - Very little modifications

- ❑ Primary Side
 - N-16 Delay tank
 - Pump
 - Heat Exchanger

- ❑ Secondary Side
 - Larger Piping
 - Pump
 - Cooling Tower

Fuel Needs

- Core Lifetimes (4% U-235):
 - 1 MW – 25000 MW·hrs
 - 3 MW – 9500 MW·hrs
 - 5 MW – 3700 MW·hrs

- Increase enrichment
 - Increase core life
 - Decrease thermal flux at core edge (not favored)

- Fuel Management Program

Regulatory Aspects

- Licensing Changes
 - Technical Specifications
- Emergency Plan
- Physical Security Plan
- Increase in Inspection Periodicity

Future Work

- More in-depth analysis
 - Core optimization
 - Core thermal-hydraulics