Increasing the HIFR fuel cycle length through the use of Be internal reflector

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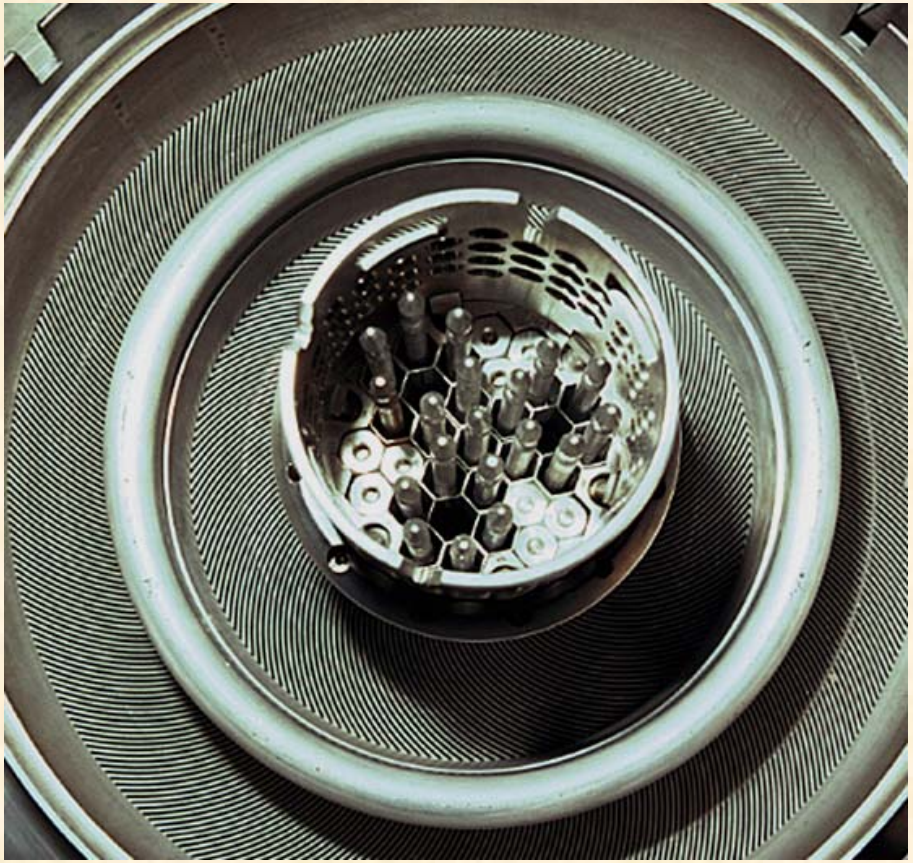
Presented July 23, 2004

Oak Ridge National Laboratory , Oak Ridge , Tennessee

Project Goal

- **Investigate the use of beryllium rods in the target region to increase the reactivity of the HFIR**
- **Consequently increase the fuel cycle length**
- **Currently "dummy" Aluminum rods fill most of the target positions**



Target Basket in Fuel Element

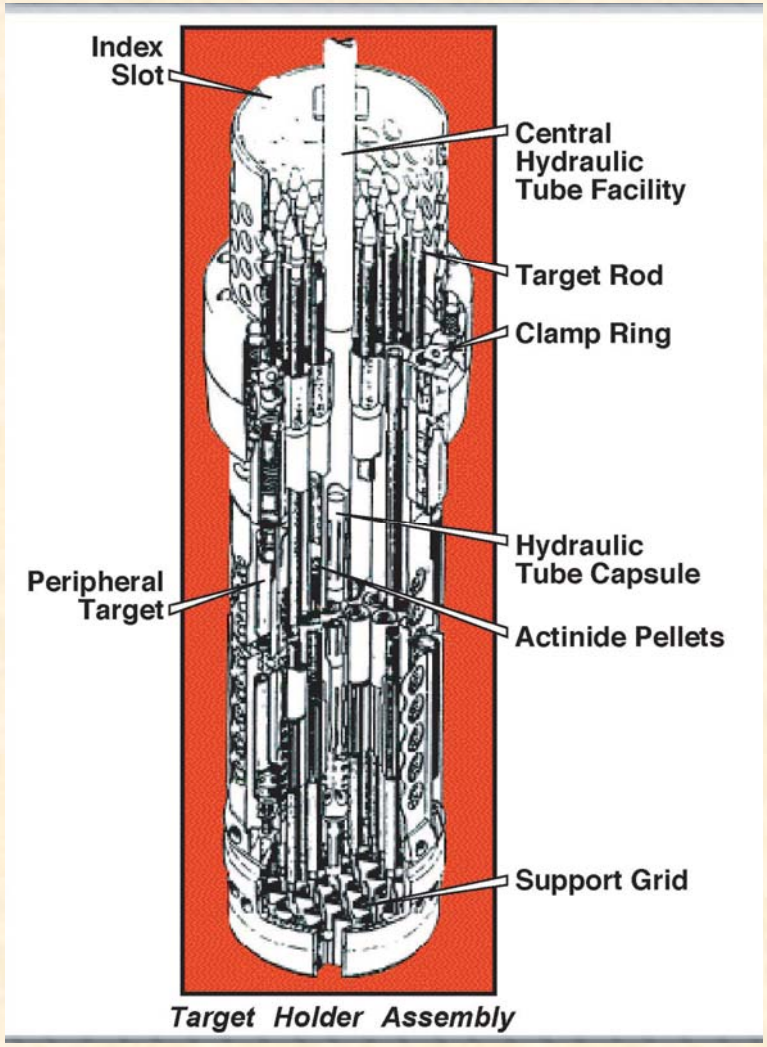
High Flux Isotope Reactor

- **100-MW (currently operating at 85 MW)**
  - **Highest thermal flux in world**
  - **LW moderated and cooled**
- **Beryllium reflected**
- **Fuel: AL clad U_3O_8 plates**
  -9.4 Kg ^{235}U
- **Fuel cycle:**
  - 21 days (@ 100 MW)
  - 26 days (@85 MW)
  - 7 days outage

Transplutonium Isotope Production

- **HFIR was designed and built to produce research quantities of transplutonium isotopes (isotopes with higher atomic number than plutonium)**
- **HFIR is the western world's only supplier of transplutonium isotopes – ^{252}Cf, ^{253}Es, and ^{259}Bk**
- **Used in basic research of the behavior of transcurium isotopes**
  - **basic research on chemical and physical behavior**
  - **target material for synthesis of still heavier isotopes in accelerators**
- **^{252}Cf has many medical, defense, and industrial applications**
  - **treatment of cervical cancer**
  - **neutron radiography of aircrafts for Air Force**
  - **startup source in nuclear reactors**
- **Only small quantities of these isotopes are produced each year**

Experiment Facilities in the Target Region Flux Trap

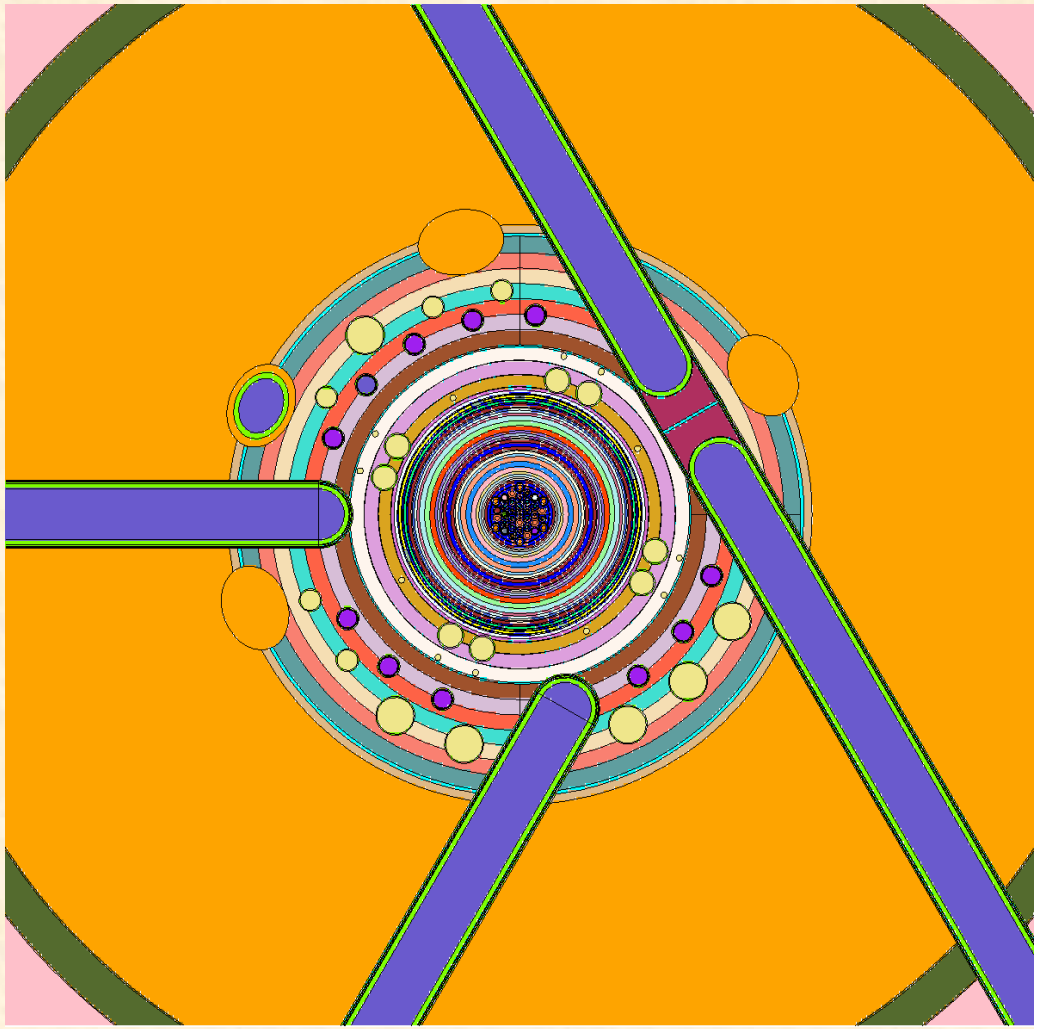


- **31 Sites in interior of basket**
- **6 Sites on periphery of basket**
- **Decrease in demand for ^{252}Cf**
- **Most of the target tubes are not being used**
- **They are currently solid Aluminum dummies**

MCNP model of the HFIR core

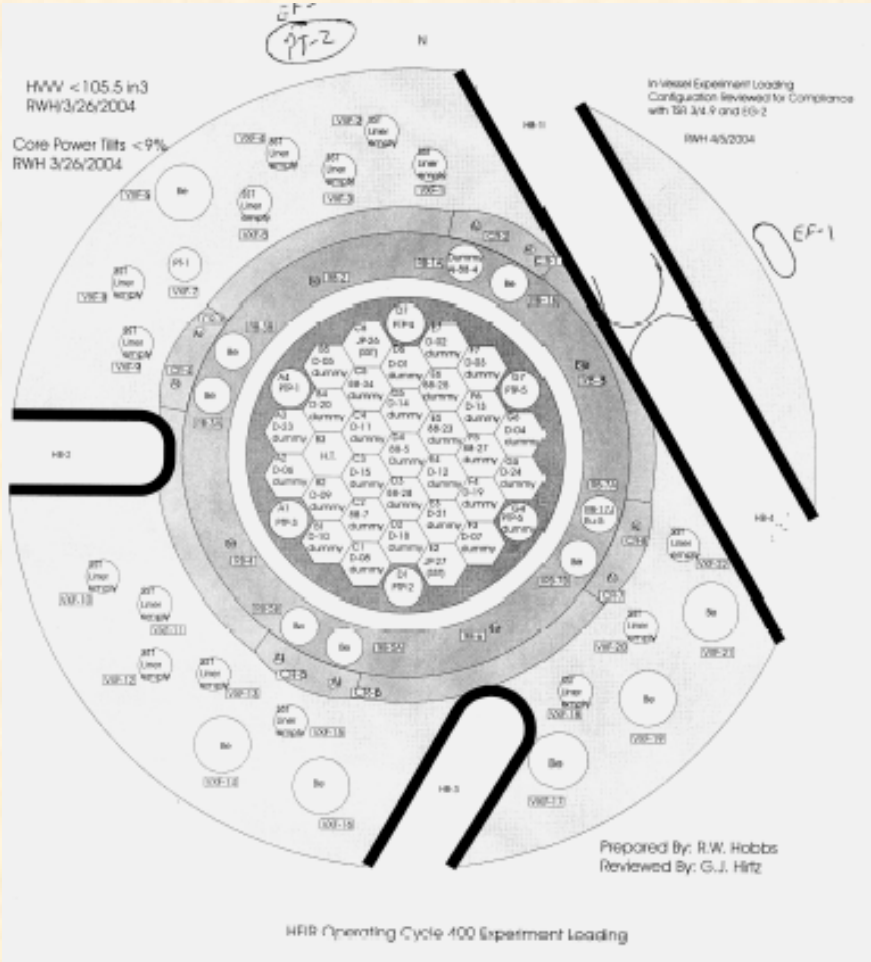
- **The MCNP model for the HFIR is divided into six regions (parts)**
  - **Target Rgn**
  - **IFE**
  - **OFE**
  - **Control Rgn**
  - **Removable Reflector**
  - **Permanent Reflector Rgn**

- **Study, modify, and document an existing MCNP model of the HFIR core**



Updated Model for the Target Region

- **Update the MCNP model to reflect the current physical status of the target region**
- **Modify, and document this new MCNP model of the HFIR core**

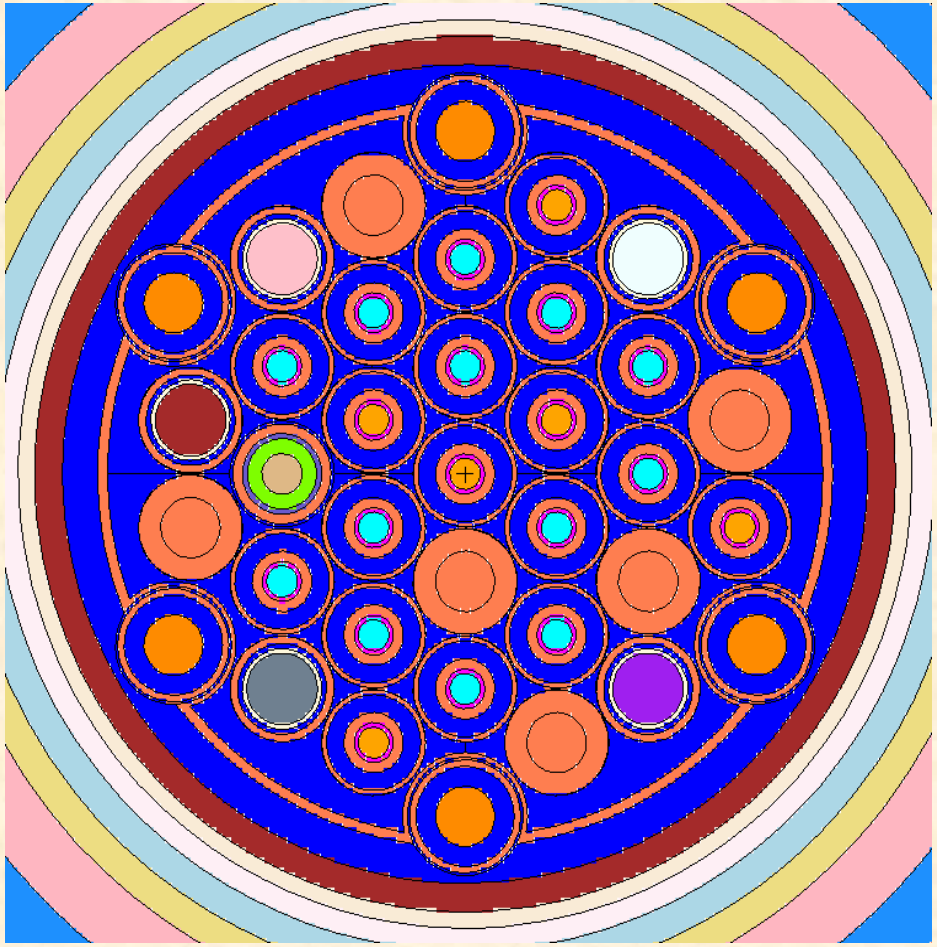


Benchmarking Cycle-400

- **The overall picture here is that we are going to make this MCNP model to be as close to cycle 400 as possible**
- **Cycle 400 will become our new benchmark**
- **Then from this new benchmark, we will calculate what the addition of Be rods gains in terms of cycle length.**

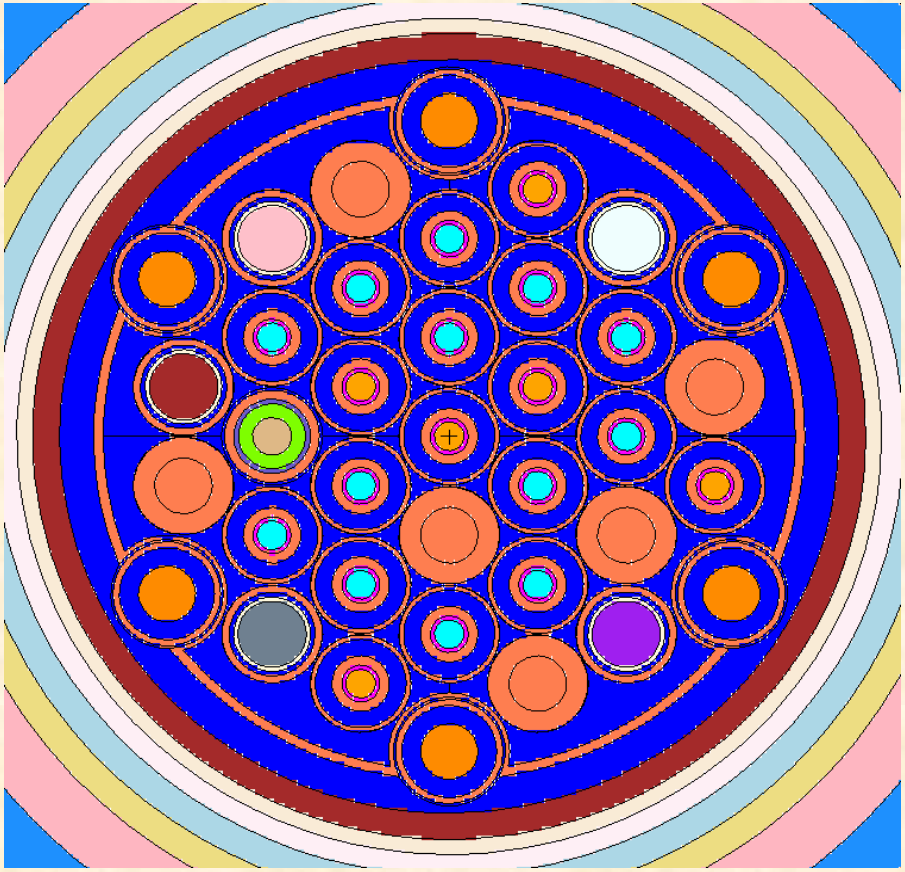
Be Rods

- Install the Be Rods
- Look at three options, 6, 12, and 18 Be rods
- To optimize the best location, investigate several cases
- Modify MCNP model to study the impact of using Be rods.
- MCNP for each case



Reactivity Increase

- **Modify the input to study the perturbations in reactivity and power distribution caused by various Be rod loadings**
- **Run the code**
- **Calculate K for each case**
- **The case with the highest K, is the optimum location for the Be Rod**



Document studies

- **Calculate needed physics parameters for the safety analyses**
- **Compare the K for the best case, with our benchmark (cycle-400) K**
- **This will be the increase in reactivity due to the use of Be Internal reflector**
- **Document studies in an ORNL/TM**

Economic Benefits

- **The study will be used to quantify the economic benefits of using Be rods in the HFIR target region**
- **We are expecting a 4% - 5% increase in life of fuel cycle**
- **This means a saving of $40,000 per fuel cycle**
- **Annual savings of approximately**
    - **$300,000- $400,000**