NIST Center for Neutron Research

Feasibility Studies on a Hexagonal-Lattice Core for a World-Class Cold Neutron Source

Dylan Prévost (TAMU), Zeyun Wu, Robert E. Williams (NIST)

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NSF CHRNS CENTER FOR HIGH RESOLUTION NEUTRON SCATTERING NIST

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Outline of the Talk

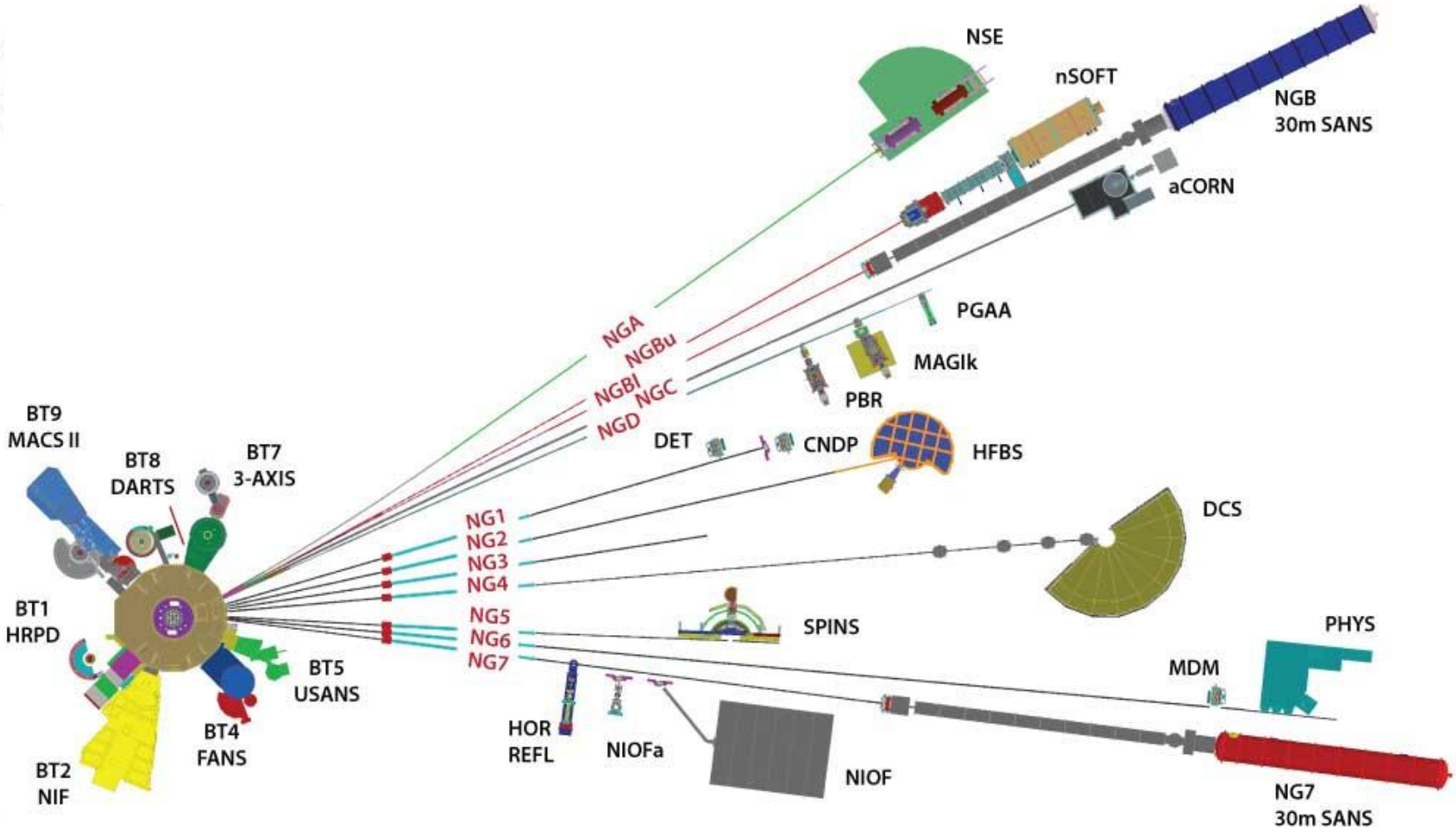
NIST's Cold Neutron (CN) Source

CESR: Cold-Energy-n Source Reactor

CESR design features and comparison

Summary of Successes

CNs → 2/3 of all NCNR Research



Project Inception

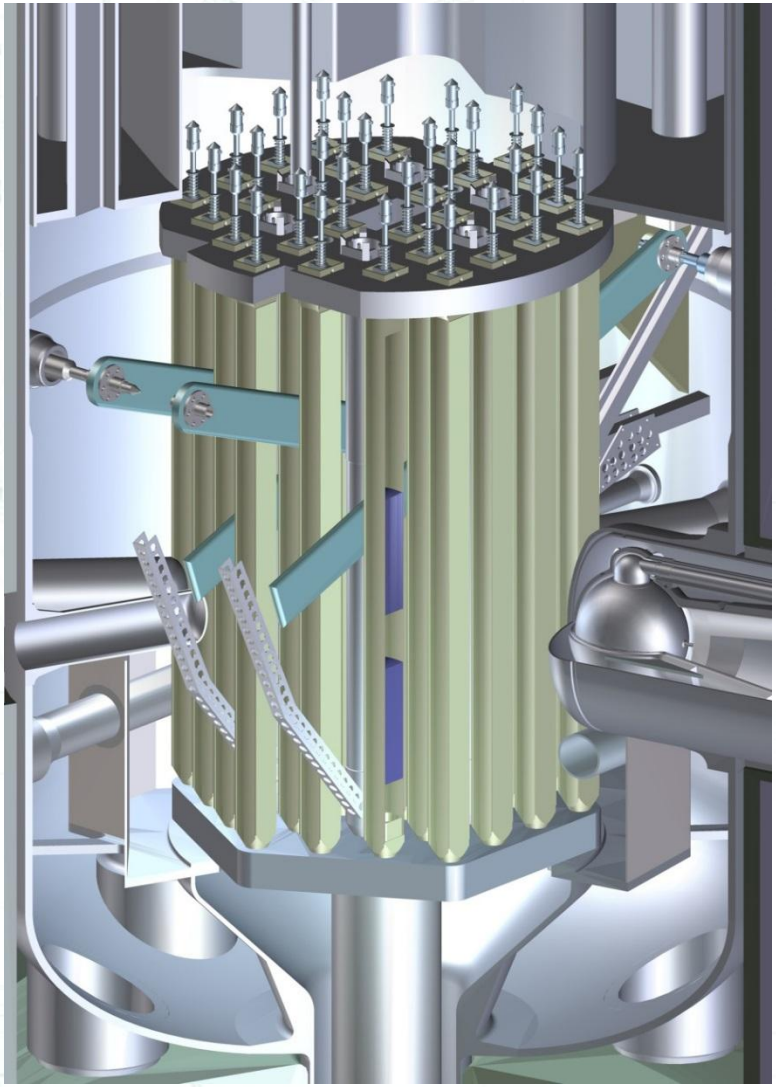
- 2000+ users annually, from industry to academia
- Finite reactor life – built in the 1960's!
- Politics – phasing out of highly-enriched fuels
- One of the greatest collections of instruments for CN experiments in the world

Task:

- ❑ Design a base conceptual model
- ❑ Optimize for CN production

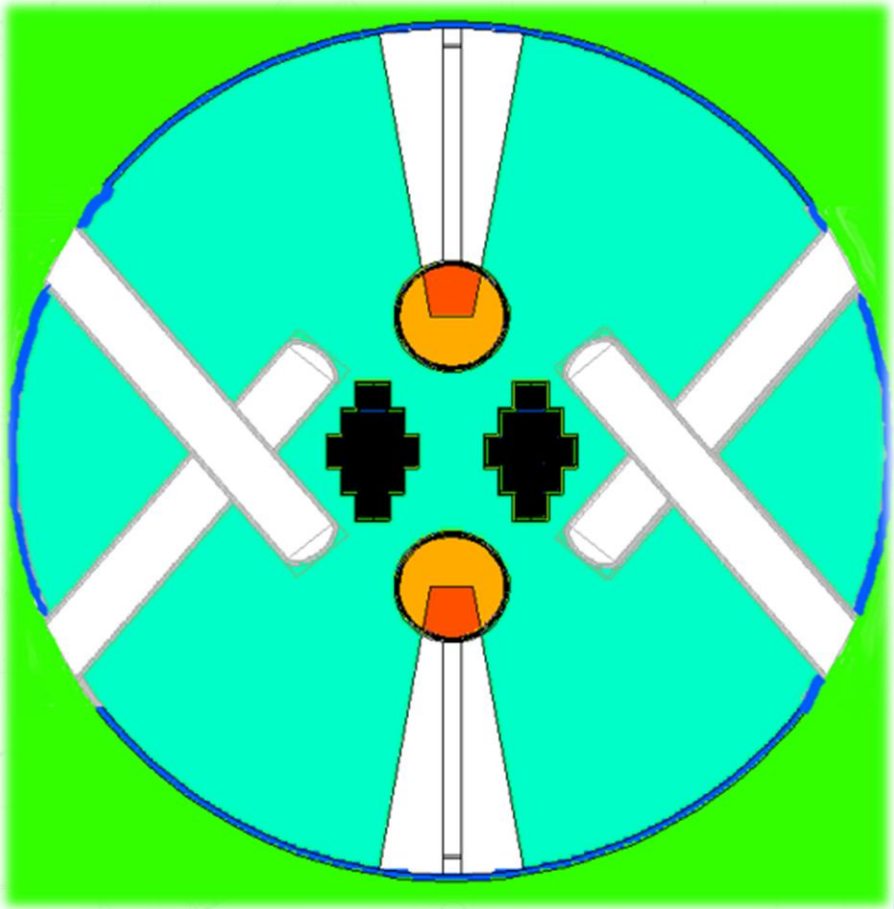
NBSR: Cut-away View

- Vertical flux trap
- Highly enriched uranium fuel
- ~1.2m in diameter
- Thermal flux peaks in center
- Fast flux is low near CNS

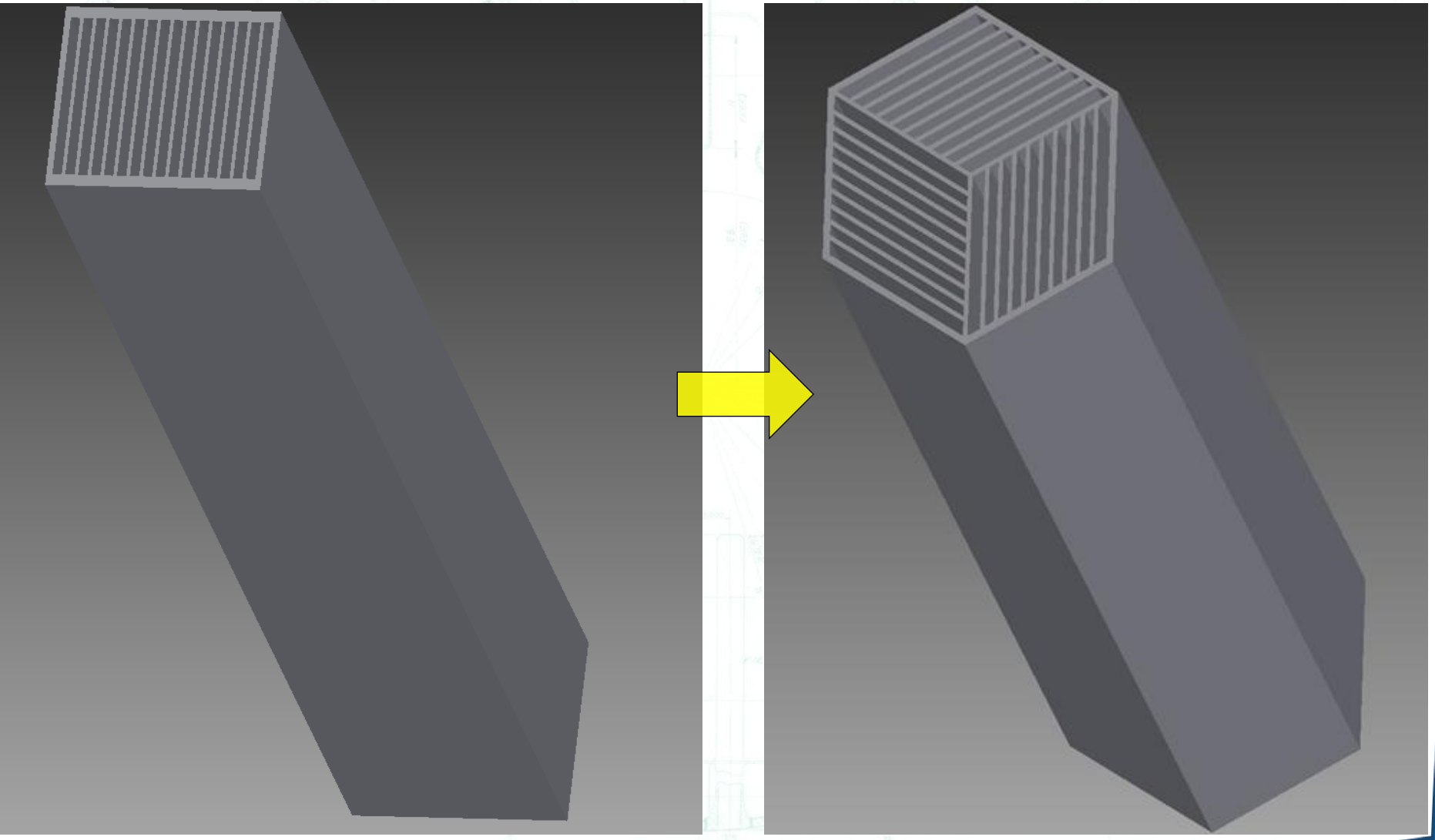


Split-core Design (NBSR-2)

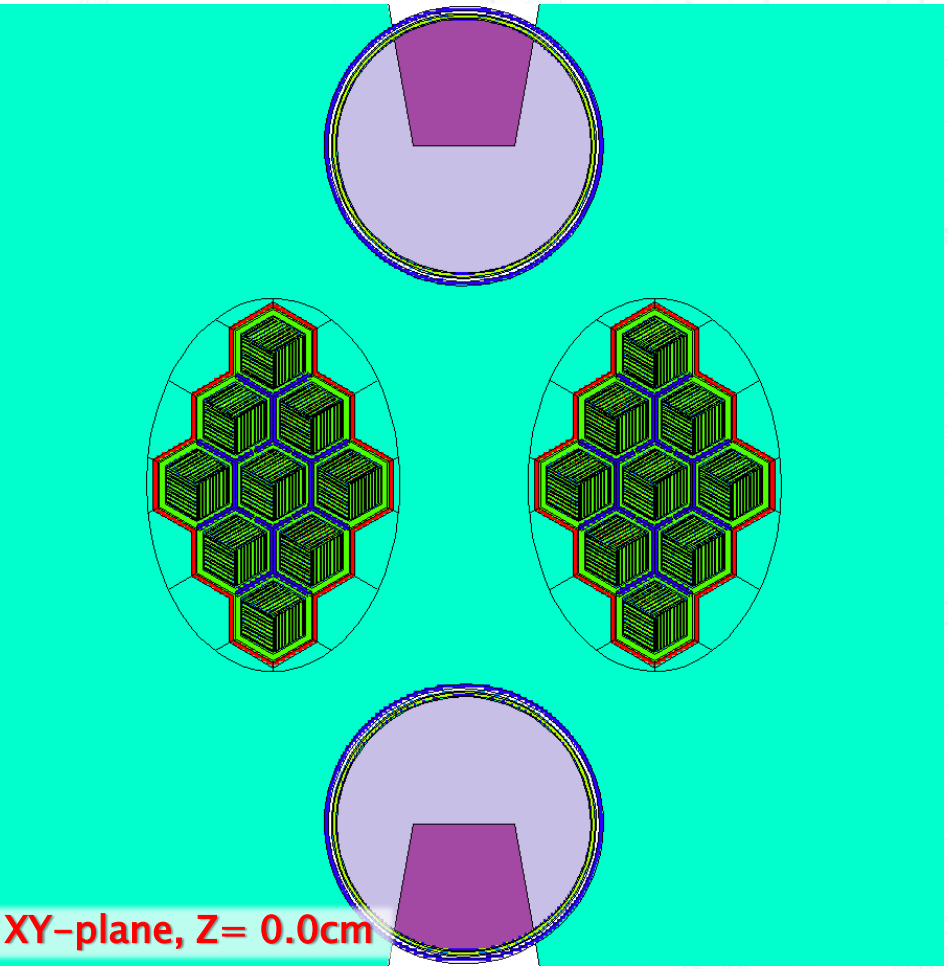
- Horizontal flux trap
- Low enriched uranium fuel
- <0.5m across both cores
- More efficient thermal flux trapping
- Reduction of fast flux at CNS tubes
- Approximately doubles capacity for CN facilities

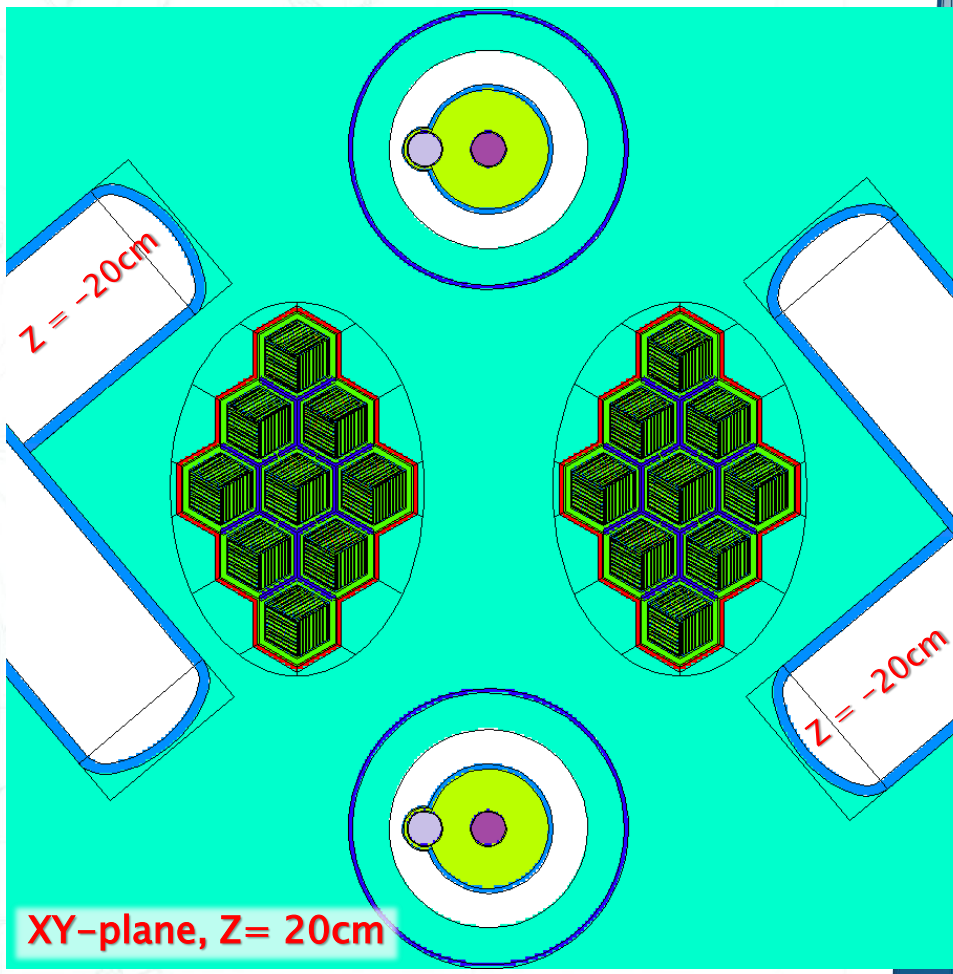


Proposition: Hexagonal Fuel Elements

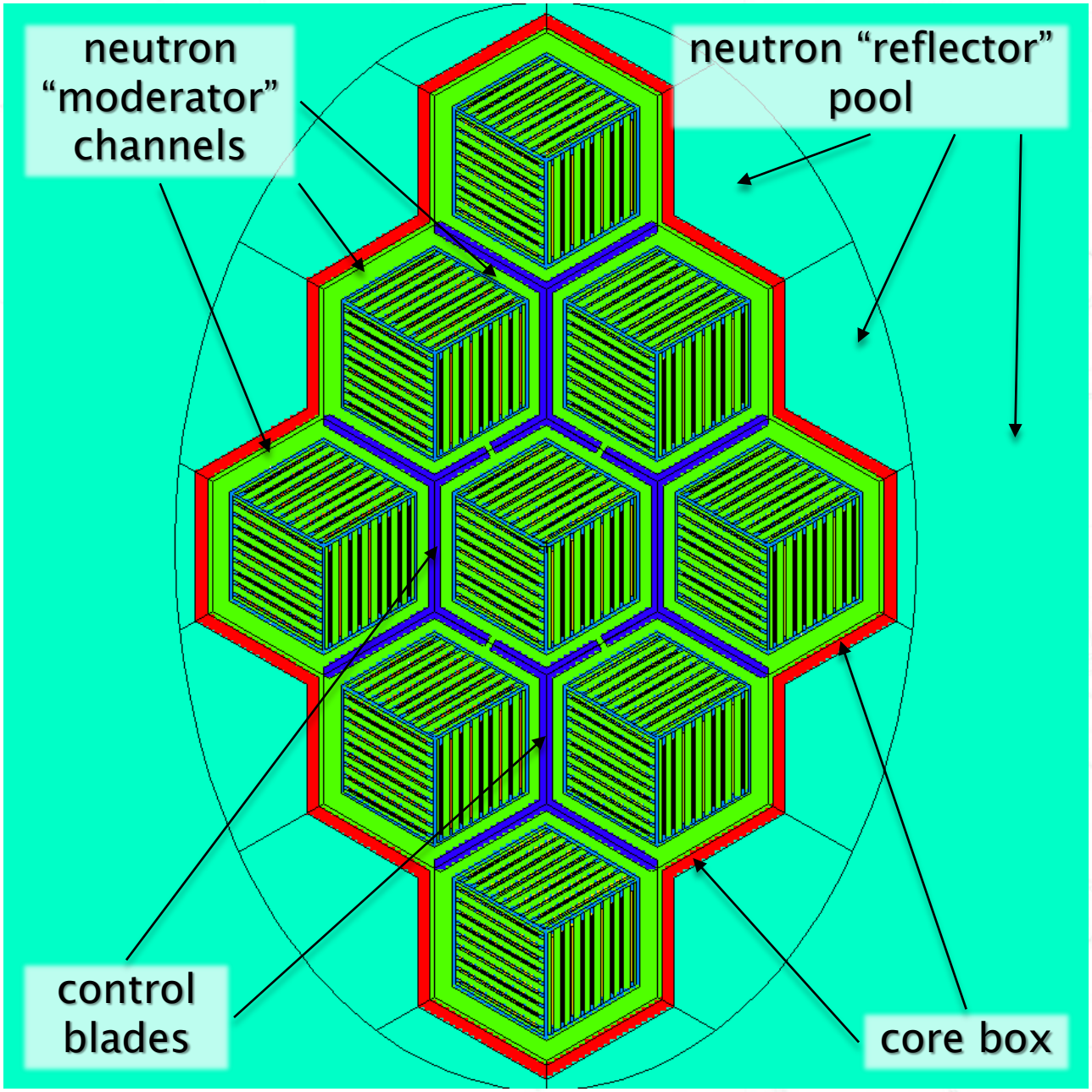


CESR Design – Inside the Reflector Barrel

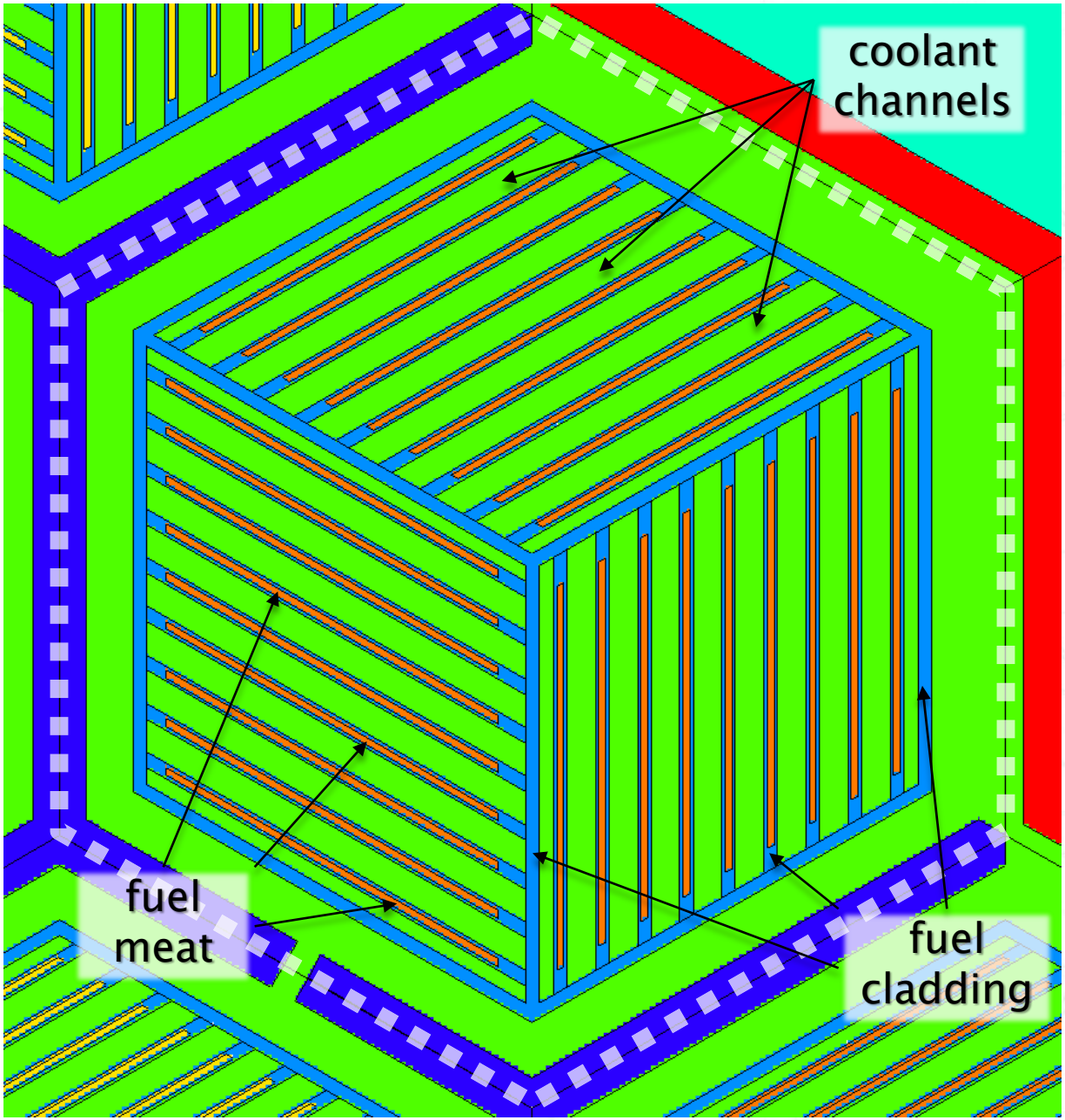




Rhombic Core-Half



- D_2O (heavy water)
- H_2O (light water)
- Zircaloy-4
- Natural Hafnium
- Aluminum-6061
- U_3Si_2 "meat" batches



Hexagonal Fuel Element

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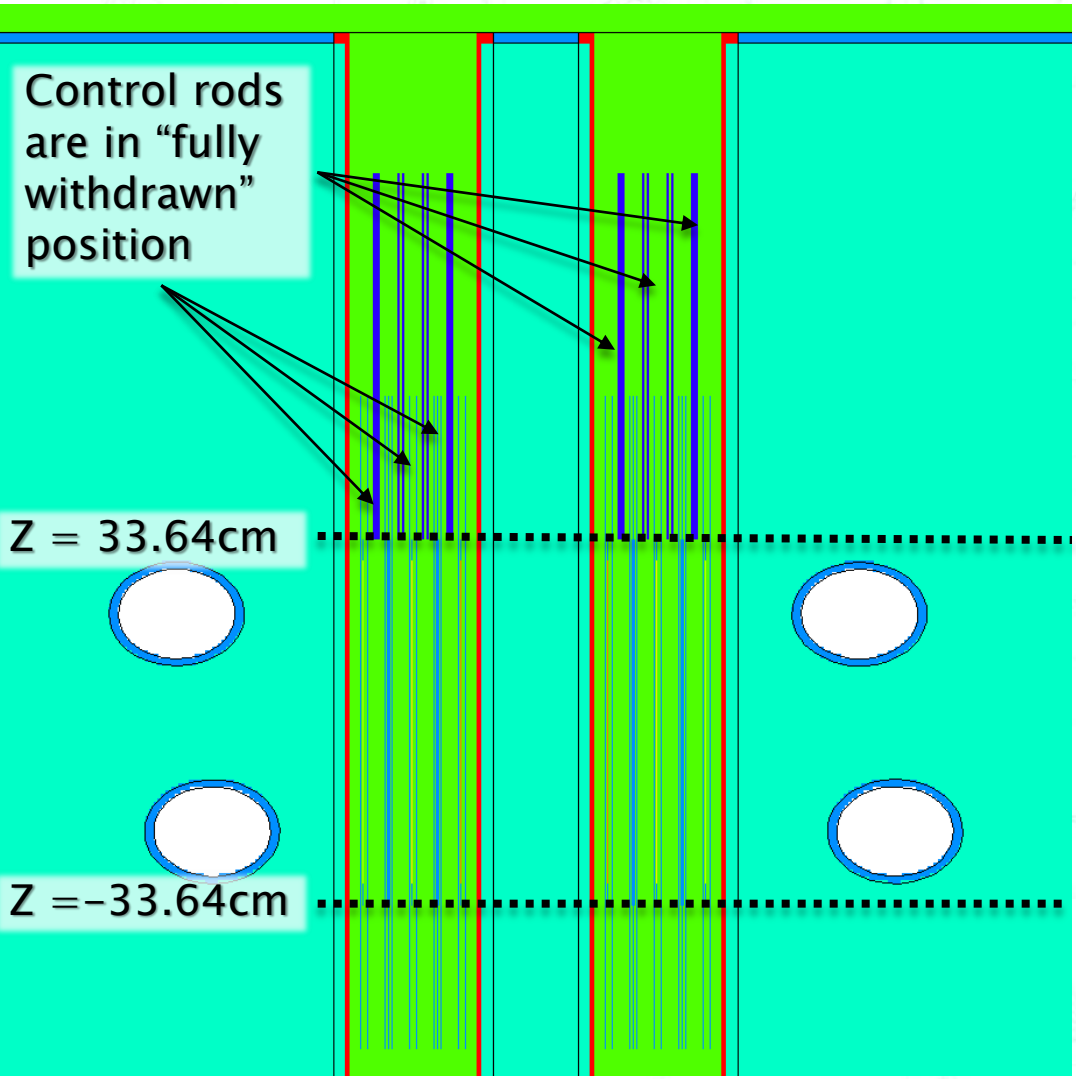
Control Rod Thickness Selection



1mm-thick rods:

32.1% Δk/k total worth at SU

35.0% Δk/k total worth at EOC

Above NRC standards for NBSR

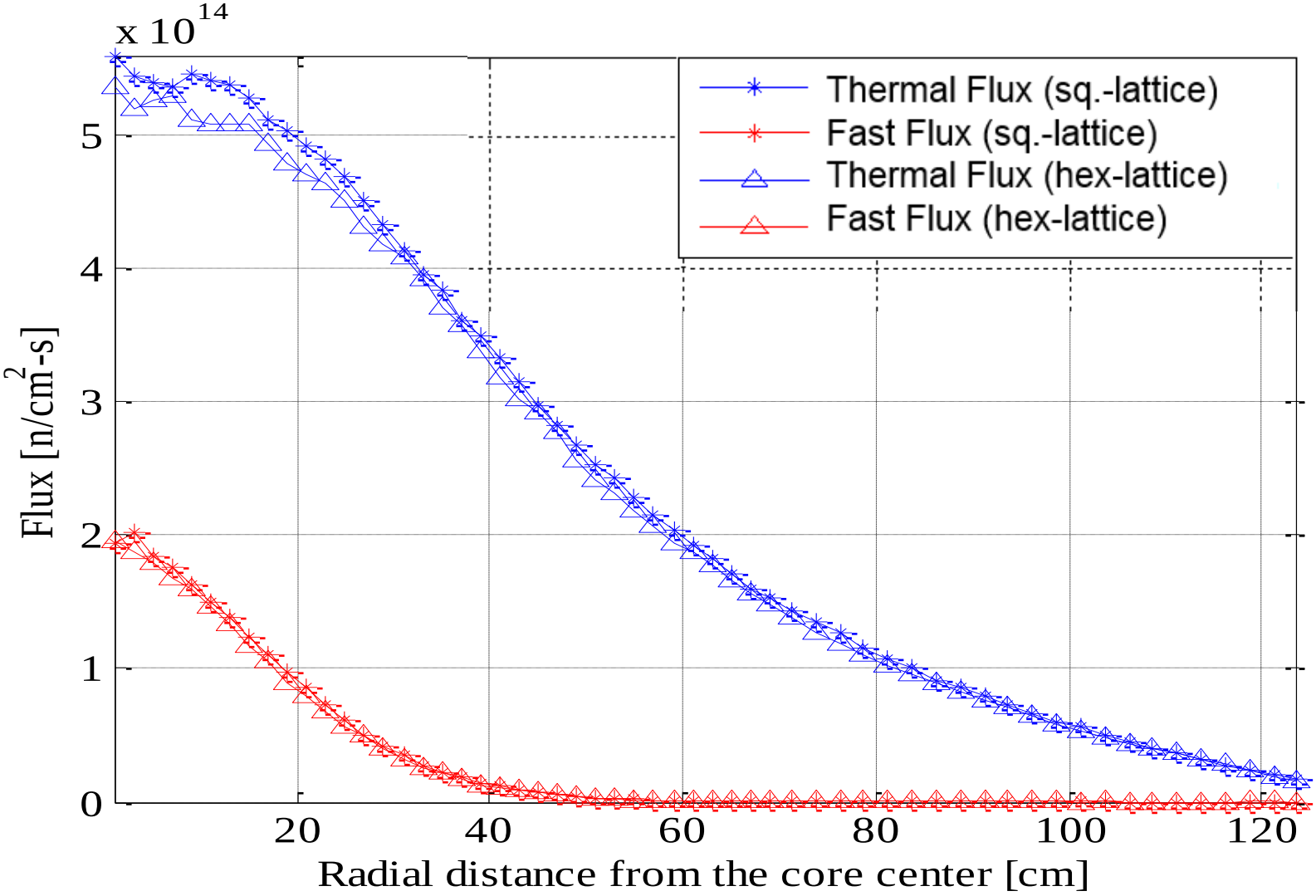
SU ρ_{ex} = 8.27% Δk/k

EOC ρ_{ex} = 1.58% Δk/k

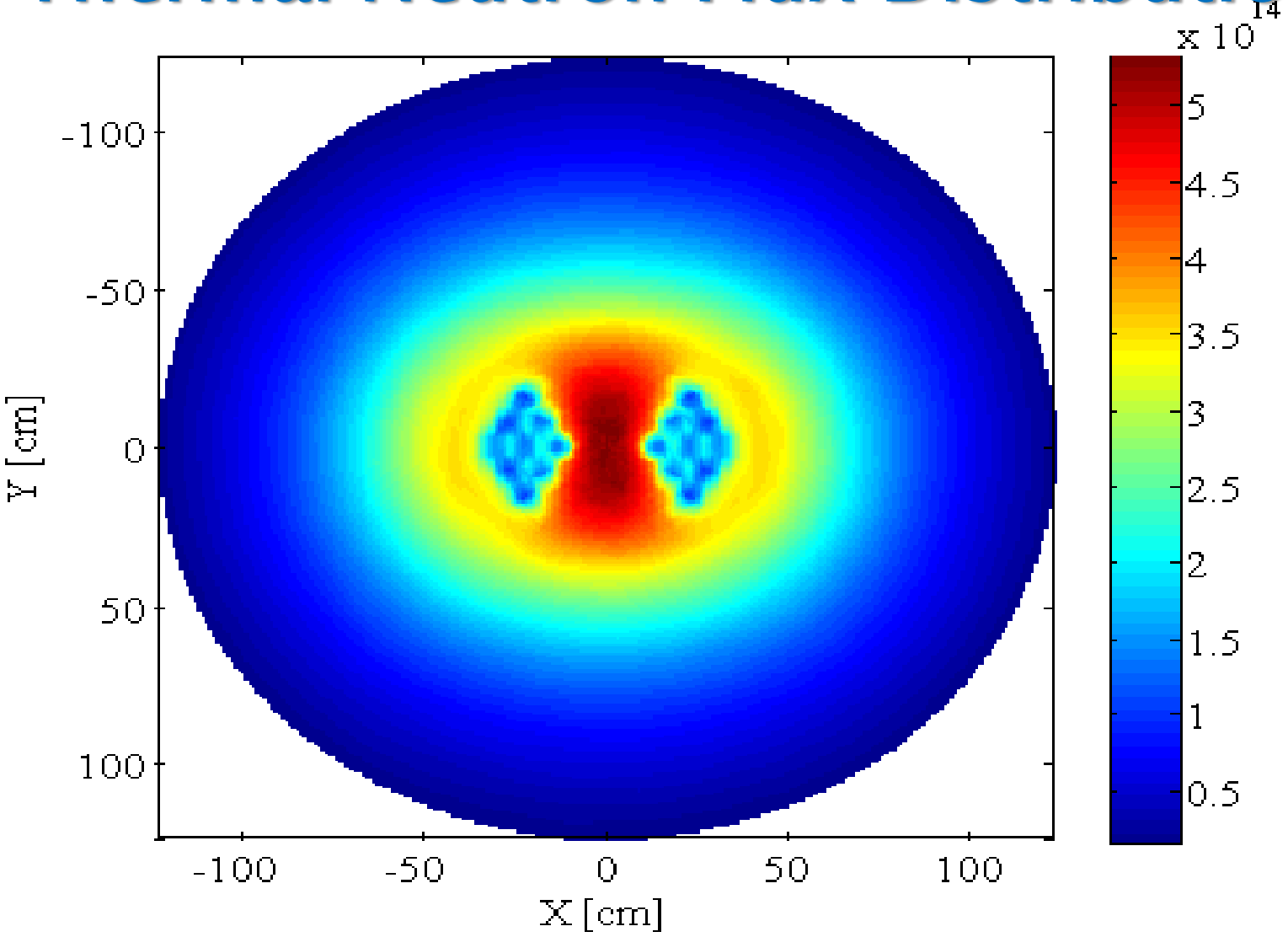
SU SDM = 19.63% Δk/k

EOC SDM = 25.04% Δk/k

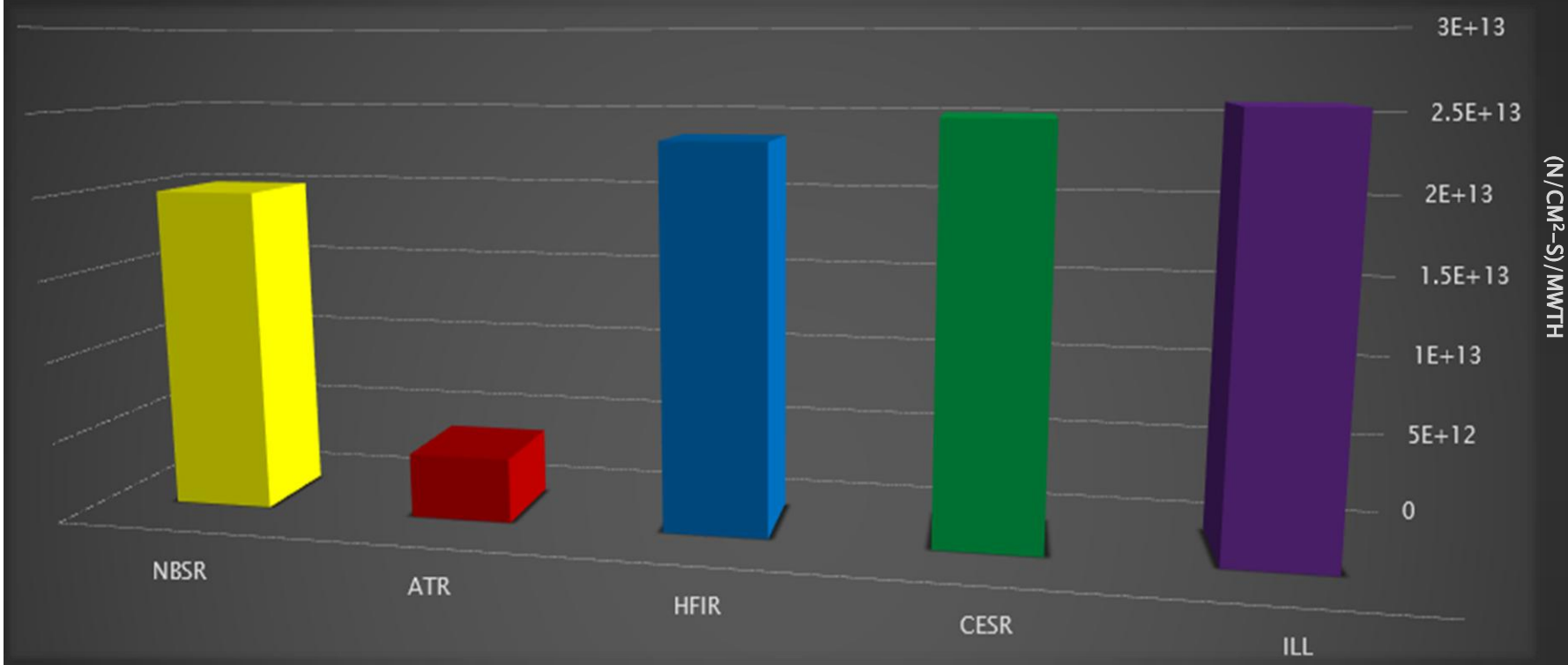
Flux Trap Comparison



Thermal Neutron Flux Distribution



Flux Heavyweight Champs



	Max thermal flux to operating power ratio
NBSR	2.00E+13
ATR	4.00E+12
HFIR	2.35E+13
CESR	2.50E+13
ILL	2.57E+13

All Hail CESR

- −5.5% fuel, and low-enriched $ ↓↓↓
- −13.1% FE size; compact but complex $ ↑
- −13.5% aluminum cladding mass $ ↓
- +0.23% neutron multiplication (K_{eff}) $ ↓
- **Room for control rods!**

Questions?

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