Conceptual Design of a High-Power LEU Research Reactor

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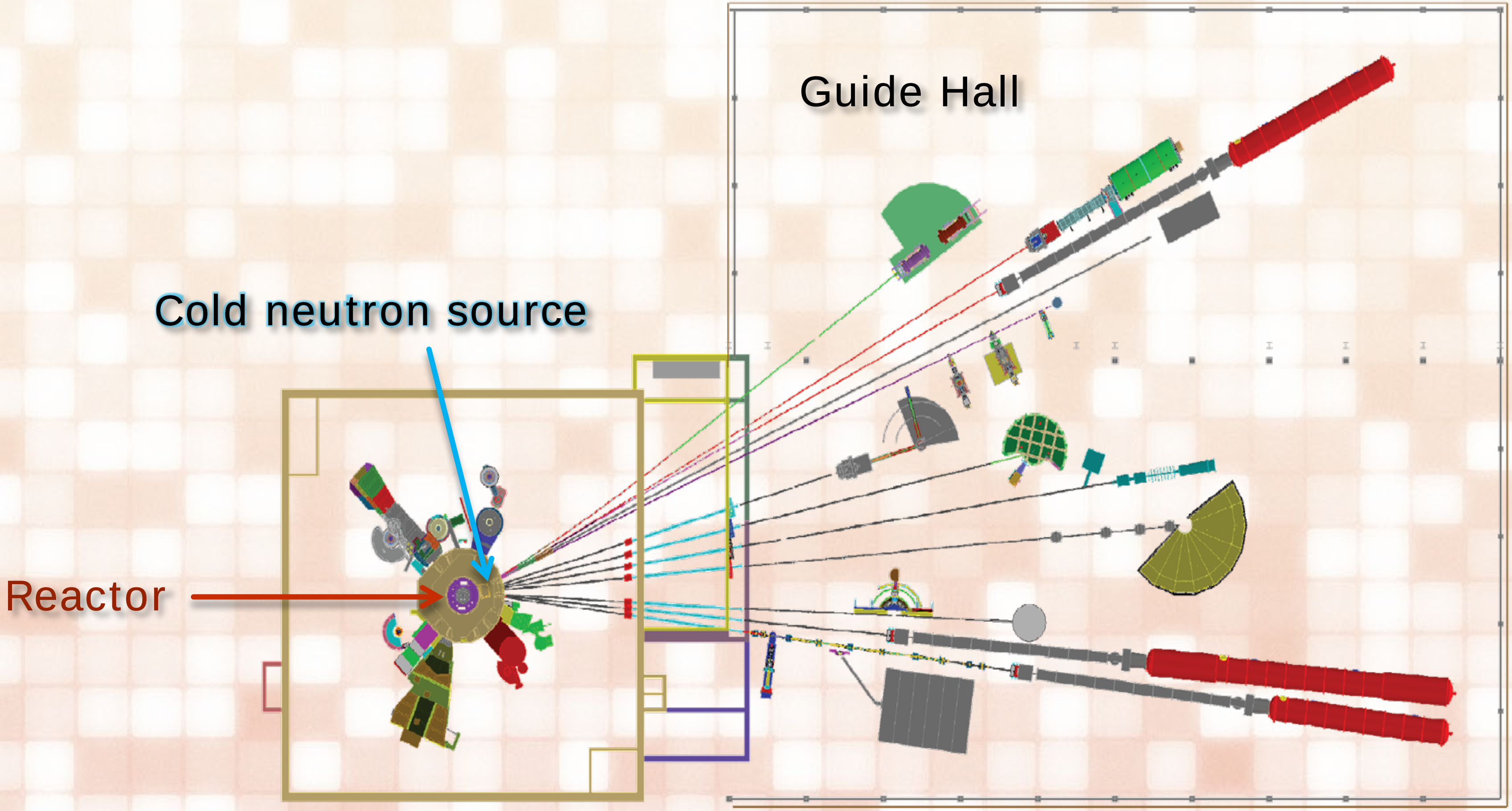
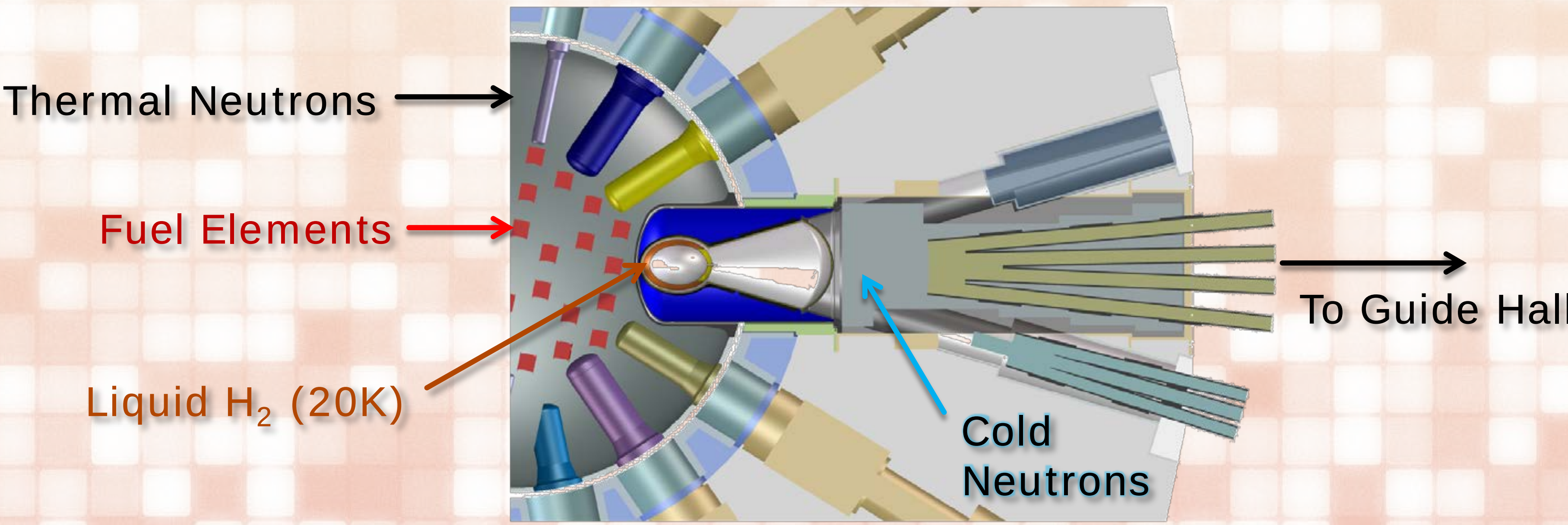


Neutrons

- Use as measurement tool
- ‘Temperature’ of a neutron
- Production in a research reactor

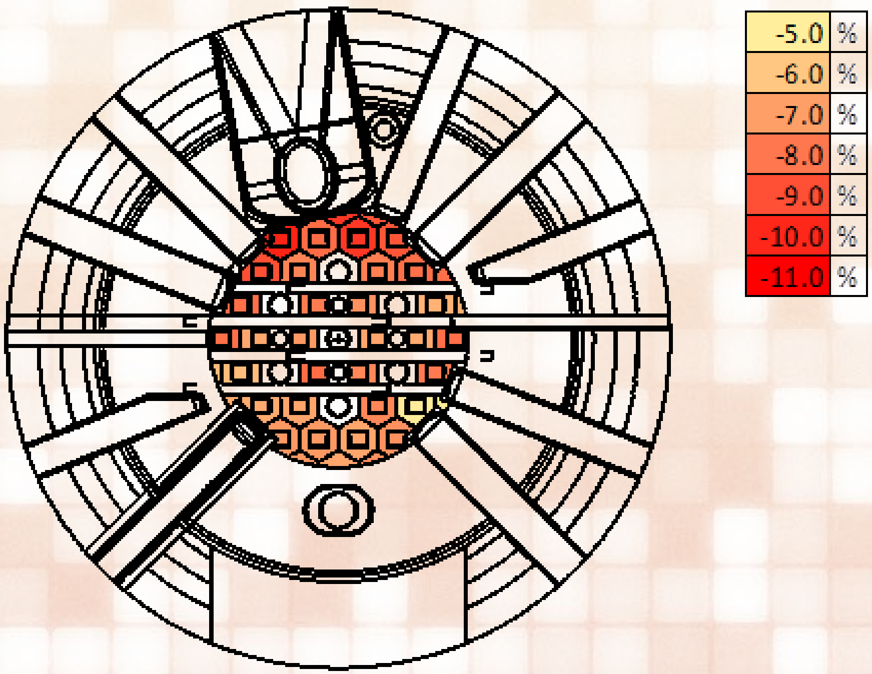


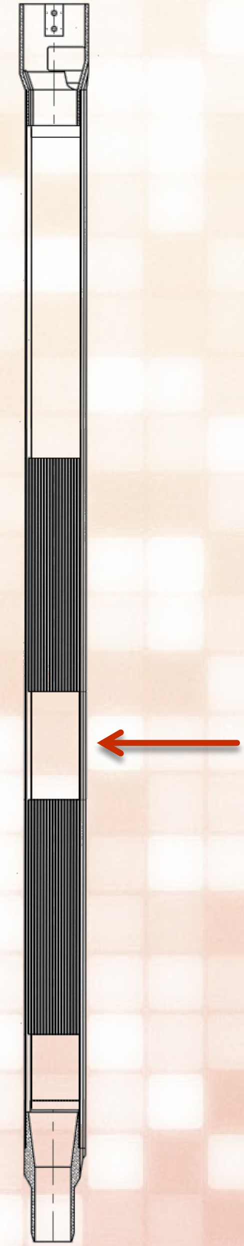
Need for LEU Reactor

- NBSR License expires in 2029
  - Built in 1960s
- Reactor source best suited for cold neutron production
  - Allow NCNR to maintain leadership in cold neutron research
- Low-Enriched Uranium (LEU) fuel
  - Political support and non-proliferation

LEU vs. HEU

% Change in thermal flux at reactor mid-plane





Figures based on “NBSR Conversion Safety Analysis Report”, Brookhaven National Laboratory

Improving Cold Source Performance

- Exposure to higher thermal neutron flux
- Where is highest flux in existing cores?

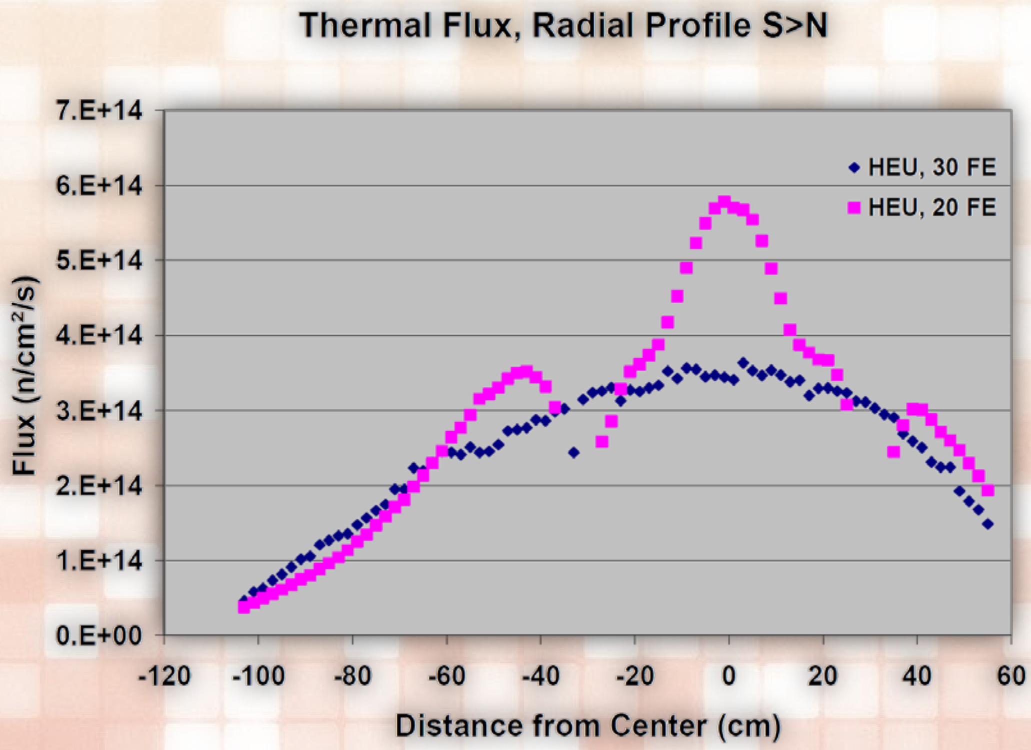


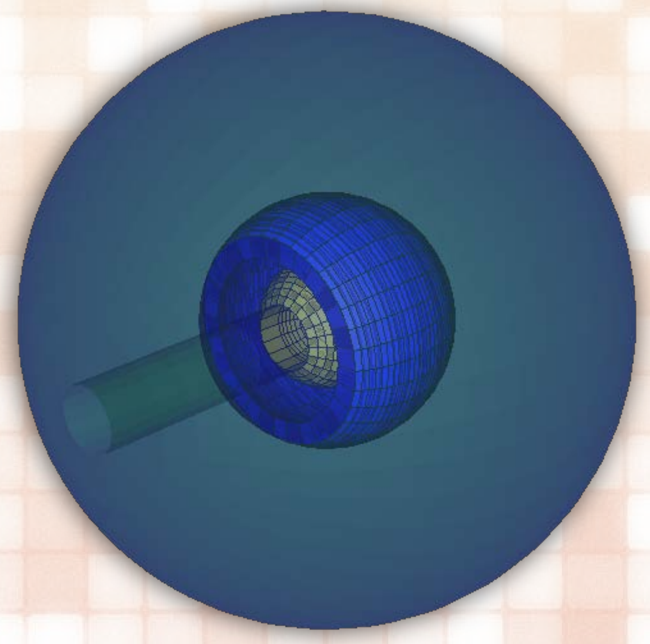
Figure: Bob Williams, Mike Rowe. NBSR Compact Core.

MCNP

- Monte Carlo N-Particle Transport Code
- Average of many random simulations
- Greater precision = more time to solve
  - Numerical and geometric precision

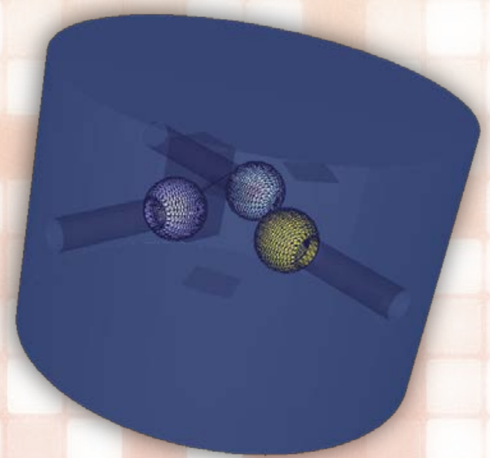
Ideal Geometry

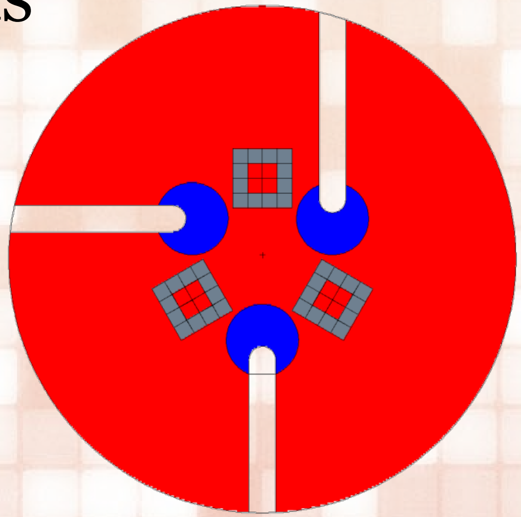
- Best achievable performance
  - Ignoring constraints
- Hollow sphere of fuel
  - Fuel composition
  - Inner and outer radii
  - Distance to cold source

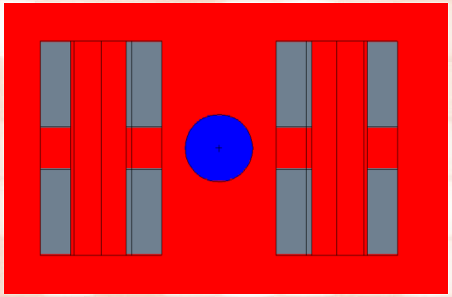


Optimized Geometry

- Fuel placement based on previous findings
- Three cold sources
- Symmetric arrangement
- 36 fuel elements







Results

- Acceptable power distribution
  - Max/average ratio of 16%
- Gain of 3 in neutron current density
- Does not have realistic guide size
- Cold source is not possible to manufacture as in model

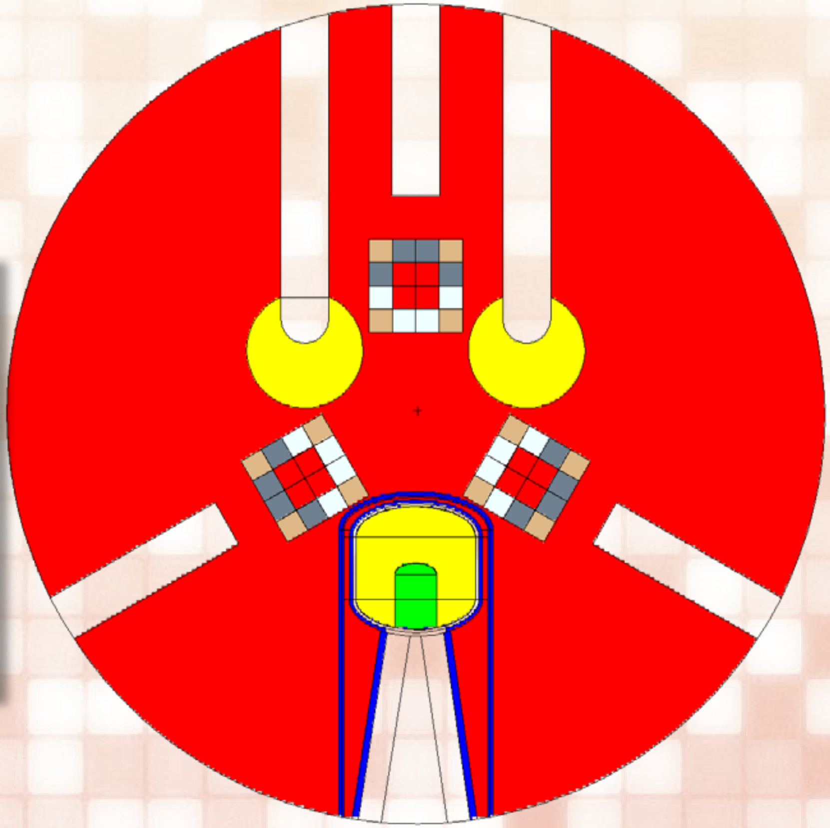
More Realistic Design

- Fuel burn-up
- Cold source aluminum vessel and vapor
- Angular spread on CS beam tube for guides
- Place fuel more effectively
- Increase power density
- Greater LD_2 volume in cold source

Latest Concept

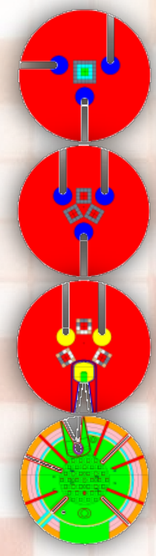
- Thermal beam tubes
- Large D_2 CNS
- Estimated fuel burn-up
- Smaller CNS solid angle

Core & CNS	Power	Current Density
NBSR LD_2	20MW	9.08×10^{11}
New Core LD_2	20MW	1.65×10^{12}
New Core LD_2	24MW	1.98×10^{12}
New Core LD_2	48MW	3.96×10^{12}



Core Comparison

- ❑ Cold neutron current
- ❑ Thermal concerns
- ❑ Cost to run
- ❑ Practicality



	CNS Current	Peak Power
Compact Core	2.07×10^{12}	50%
Semi-Compact Core	1.82×10^{12}	30%
Triple Core	1.98×10^{12}	30%
NBSR Expected	9.08×10^{11}	15%

Further Research

- Add control method
- Analyze fuel burn-up through multiple cycles
- Optimize CNS for instruments
- CNS heat load
- Shielding and structural components

Thank You

Robert Williams

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Dennis Nester

Michael Middleton

SURF Directors

Grant + Isaac

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