# The High Flux Isotope Reactor (HFIR) – Past, Present, and Future

Presented to the
IGORR

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Director, Nuclear Operations

Oak Ridge, Tennessee
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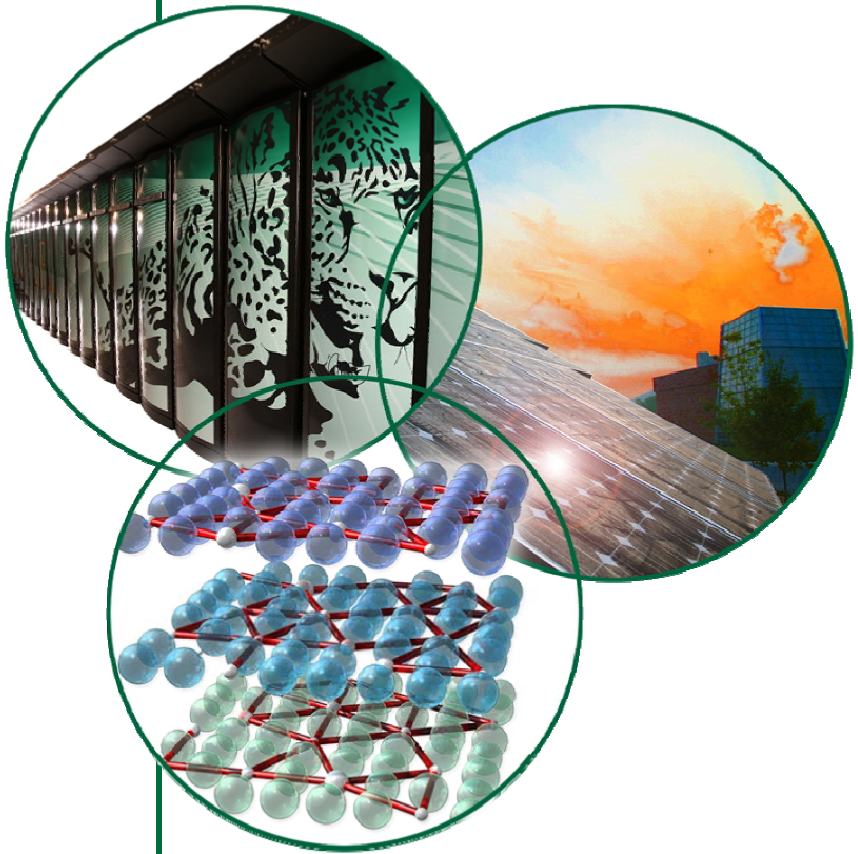

U.S. DEPARTMENT OF ENERGY

OAK RIDGE NATIONAL LABORATORY
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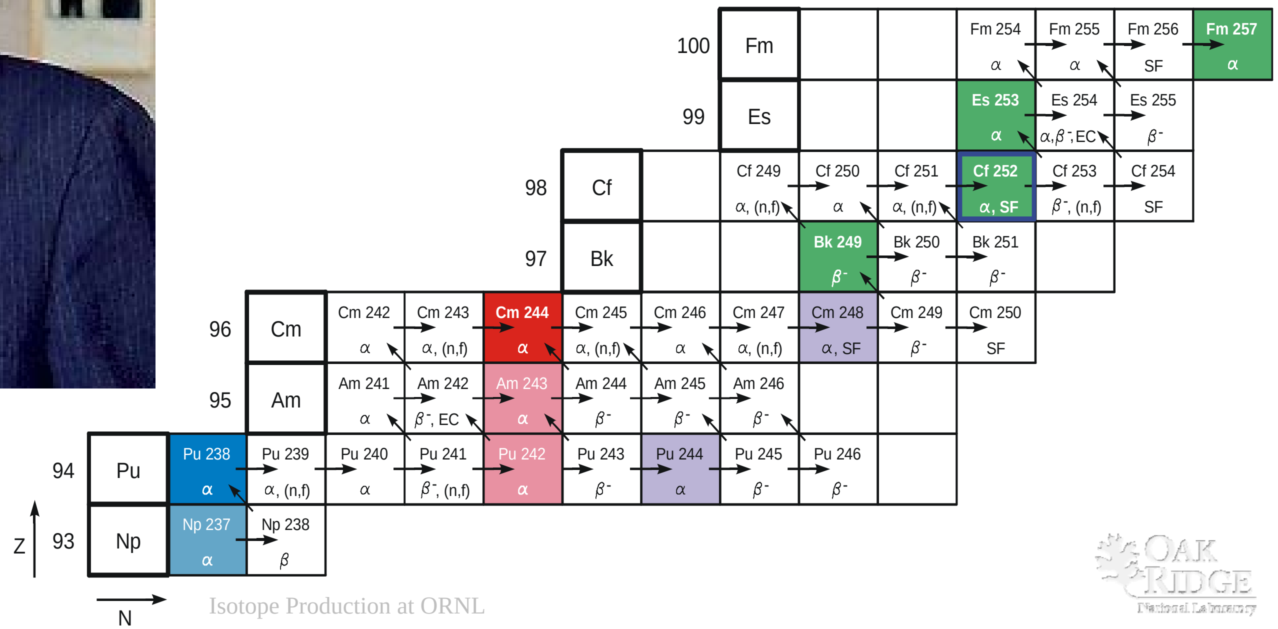
# The need for HFIR was expressed by Glenn Seaborg in 1957

*"The field of new transuranium elements is entering an era where the participating scientists in this country cannot go much further without some unified national effort... The future progress in this area depends on substantial weighable quantities (say milligrams) of berkelium, californium, and einsteinium..."*

G. T. Seaborg
Berkeley, October 24, 1957



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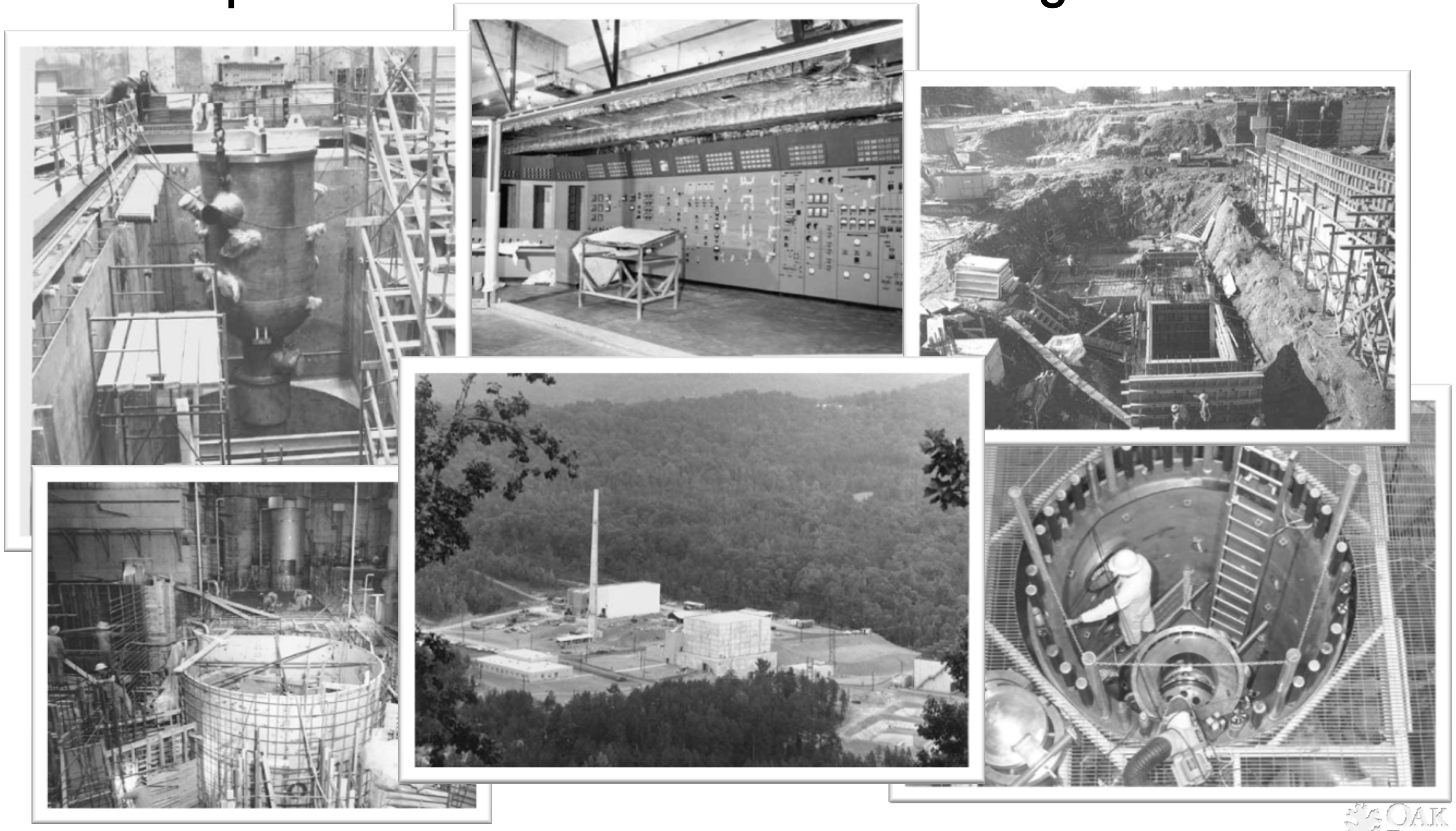
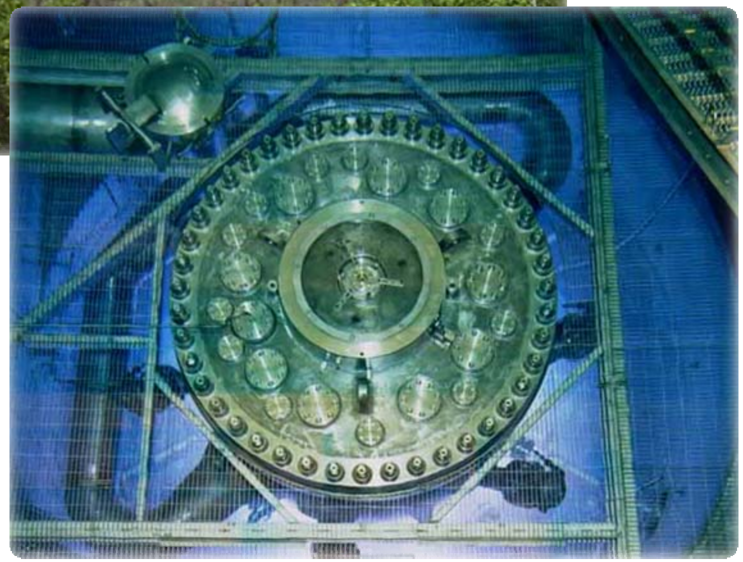
# The US Atomic Energy Commission (AEC) recommended HFIR construction in 1958

## The HFIR design proposed by ORNL was accepted in 1959 and construction began in 1961



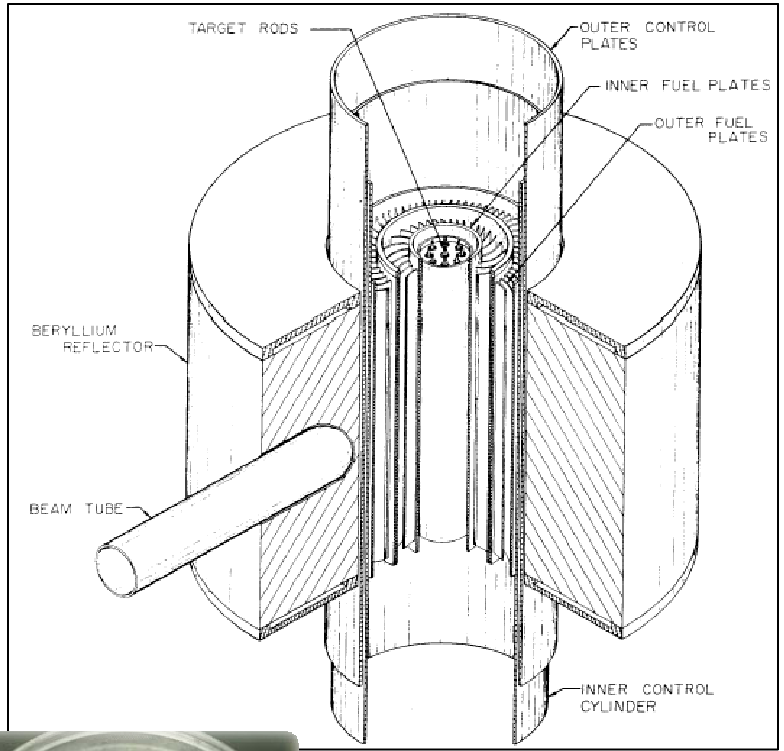
# Initial criticality – August 25, 1965
# Full power (100MW) – September 1966



$5.5 \times 10^{15}$ neutrons/$cm^2$/second
in the flux trap at 100 MW

# HFIR is a compact high-performance flux trap reactor

- Light water moderated and cooled
- Beryllium reflected
- Flux trap: 5 inch diameter
- Fuel: AL clad $U_3O_8$ plates
  - 9.4 Kg $^{235}U$
  - Active fuel length: 20 inches
- Reactivity Control
  - Concentric cylinders of EuO
- Pressure vessel
  - Carbon steel with stainless steel




# The Radiochemical Engineering Development Facility (REDC)

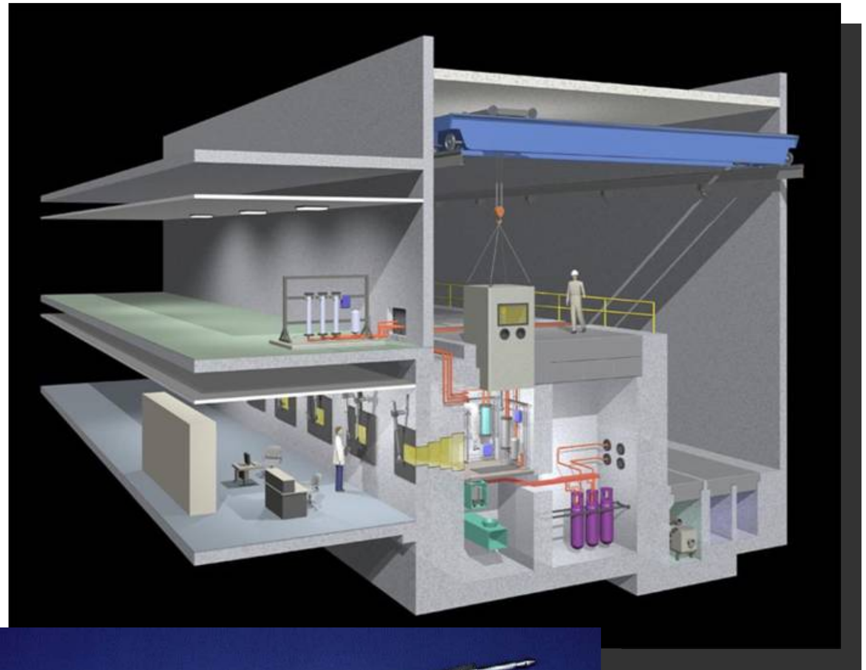
Built adjacent to HFIR, REDC completed Seaborg's vision

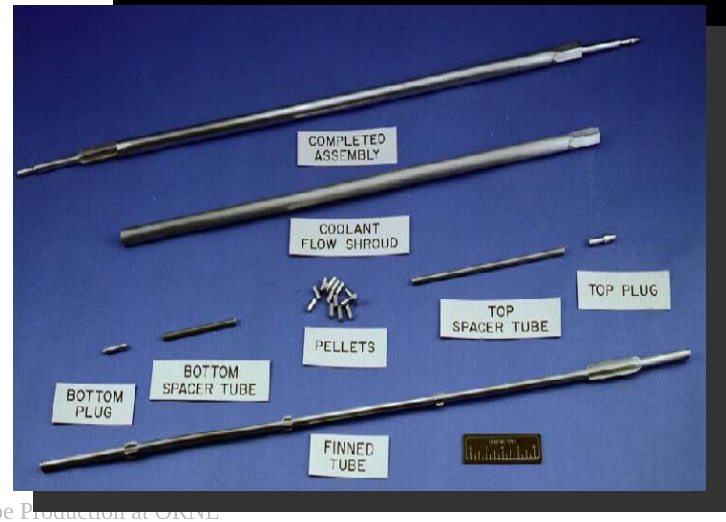
Previously available only in microscopic quantities, the milligrams of heavy elements produced at HFIR proved valuable for research

REDC, originally named the Transuranium Processing Plant (TRU), began operations in 1966

# REDC performs all transuranium target fabrication and processing

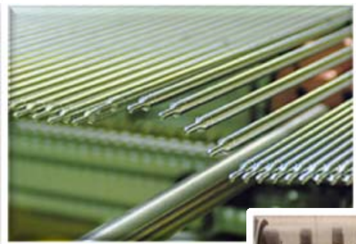
- Heavily shielded hot cells
  - Dedicated to pellet production and target fabrication
  - Chemical processing
  - Sample analysis
  - Waste handling
- Shielded caves and glovebox labs for product purification and R&D
- Radiochemical analytical labs





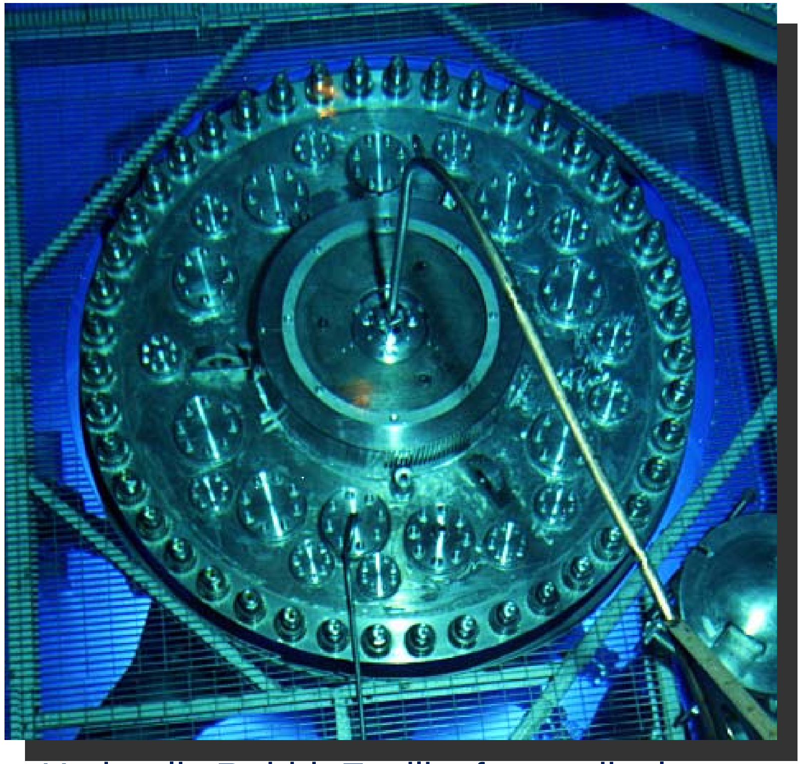
# HFIR/REDC continues to supply ~70% of $^{252}$Cf worldwide

- Applications
  - National security
  - Homeland security
  - Energy security
  - Civil infrastructure
  - Human health
  - Education

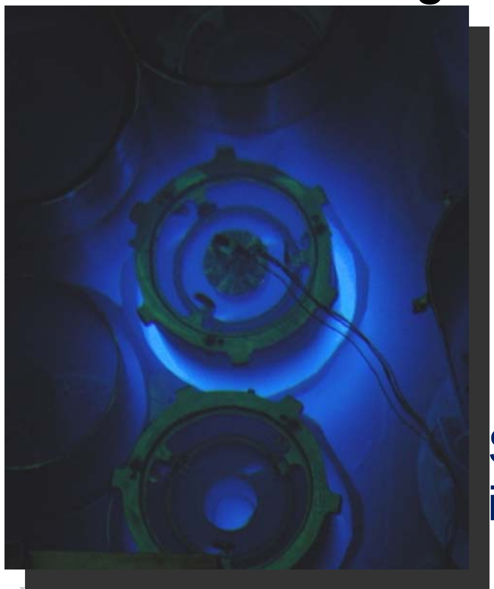



# The HFIR design is also very versatile supporting many other missions

- 67 total irradiation positions
  - Medical & industrial isotopes
  - Materials irradiation studies
  - Fuel irradiation studies
  - Neutron Activation Analysis (NAA)
  - Neutron scattering



Hydraulic Rabbit Facility for medical and industrial isotopes



Spent fuel is used for gamma irradiation experiments

# HFIR has supported neutron scattering science throughout its operation

ORNL Director, Alvin Weinberg, had the foresight to insist that HFIR include neutrons scattering facilities based on the seminal work of Clifford Shull

Cliff Schull & Ernie Wollan at the Graphite Reactor in 1949

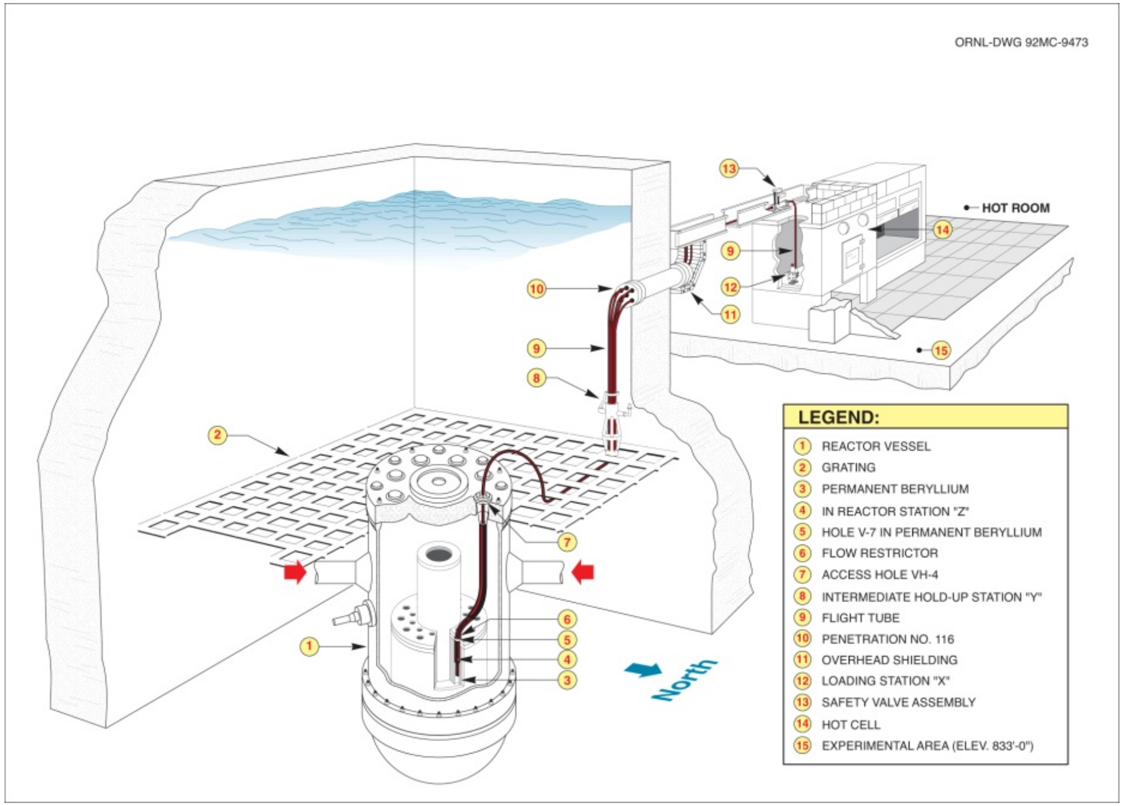

A triple-axis spectrometer on one of HFIR's four neutron beams

Scientists work on the original HFIR Small Angle Neutron Scattering instrument

# HFIR has two complimentary world-class Neutron Activation Analyses facilities

HFIR NAA has been used to solve numerous science and practical problems – environment, nuclear forensics, geology, biology…

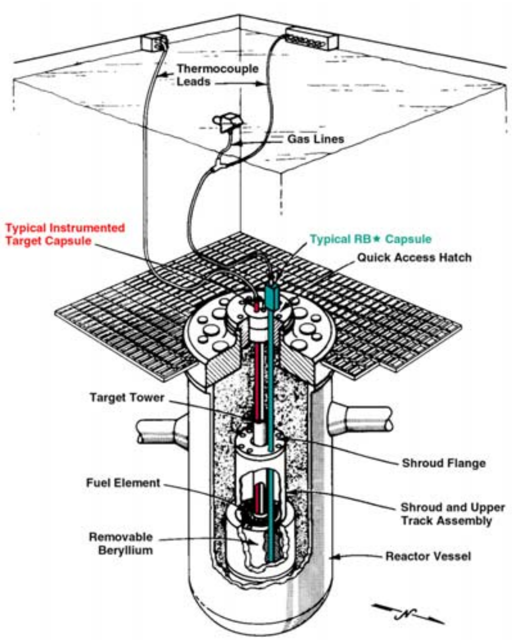
- Pneumatic Tube 1 (PT-1)
  - $2.8 \times 10^{14}$ neutrons/(cm²·s) with a thermal/epithermal ratio of 40
- Pneumatic Tube 2 (PT-2)
  - $5.9 \times 10^{13}$ neutrons/(cm²·s) with a thermal/epithermal ratio of 200
  - PT-2 has a special delayed neutron counter (DNC) for fissile nuclide analysis



# HFIR became recognized for its materials and fuels irradiation capabilities

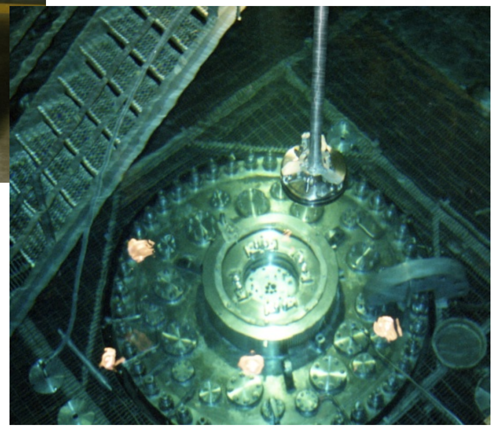
## Reactor internal modifications were made in the 1986 to enhance materials and fuels irradiations

- Larger capsule volume
- Gas cooling and temperature control
- On-line capsule instrumentation




Modified reactor components

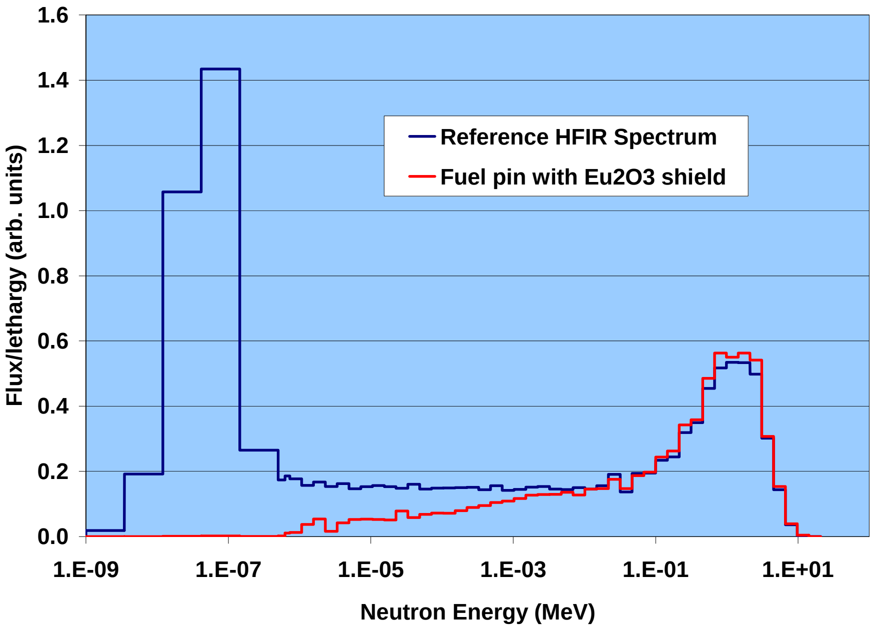

Materials Irradiation Facility Control Room



Reactor being assembled with new components

# HFIR's broad neutron spectrum can explore the behavior of fast reactor fuels and fusion reactor materials

Capsules covered by a $Eu_2O_3$ shield lead to a dramatic reduction in the thermal flux without significantly changing the fast flux




- Fast/thermal ratio is about 375
- Centerline temperatures can be very high – 2,000ºC



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# An upgrade in 2000 made HFIR neutron scattering facilities world-class

## Facility infrastructure improvements were made to support HFIR operation through 2040

- Neutrons on-target up by 300% for thermal neutron triple-axis spectrometers
- More neutron scattering instrument stations
- Provided for the installation of a cold neutron source

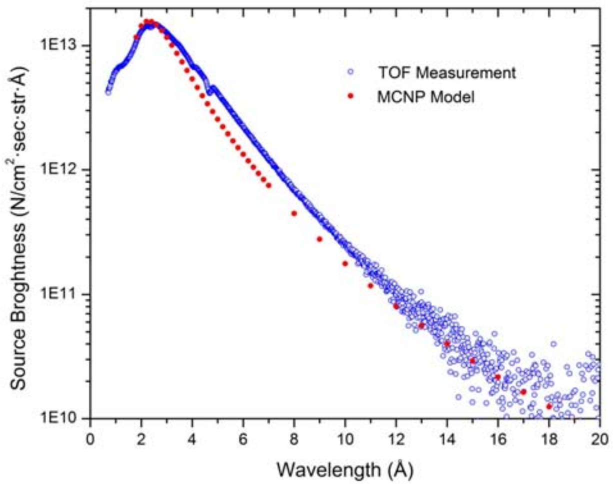
Reactor components upgraded for better neutron beams

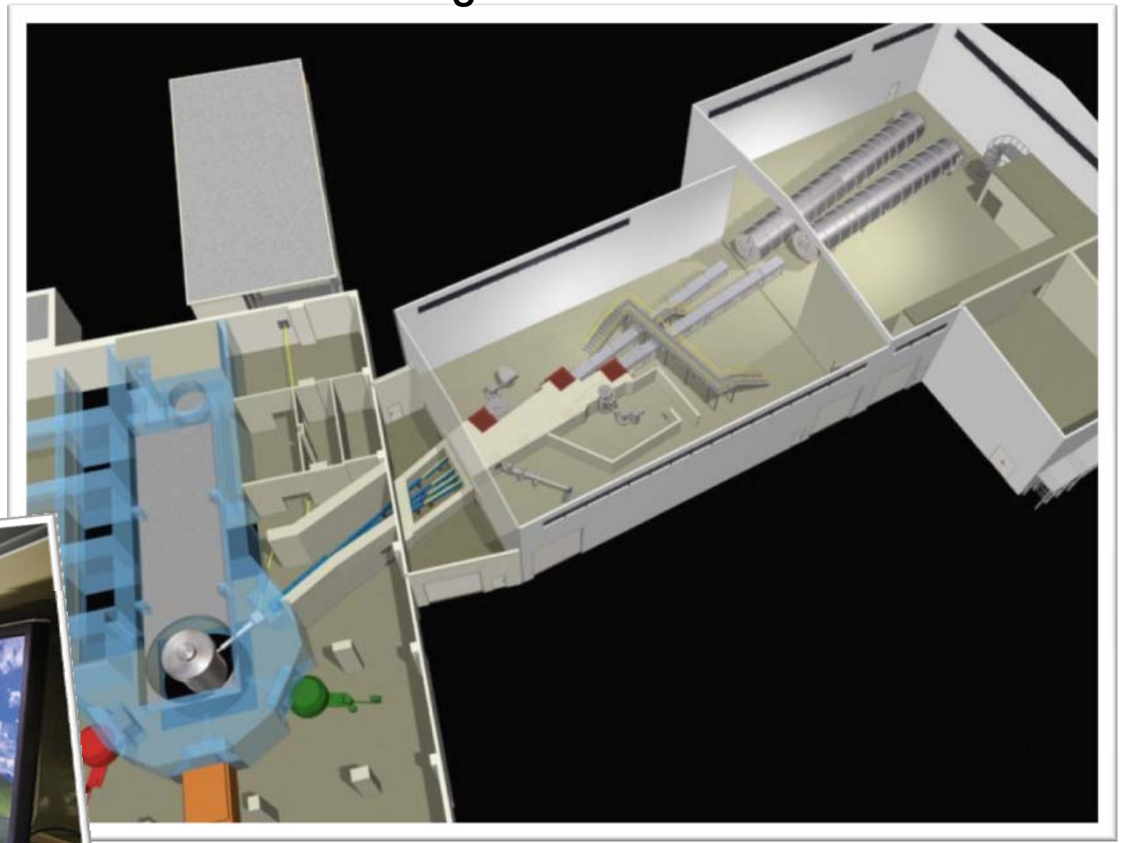
New cooling tower

# The HFIR Cold Source began operation in 2007

Measured to be the brightest reactor-based cold source in the world

Gain factors of 10 to 20 at neutron wavelengths from 4 to 12 Å





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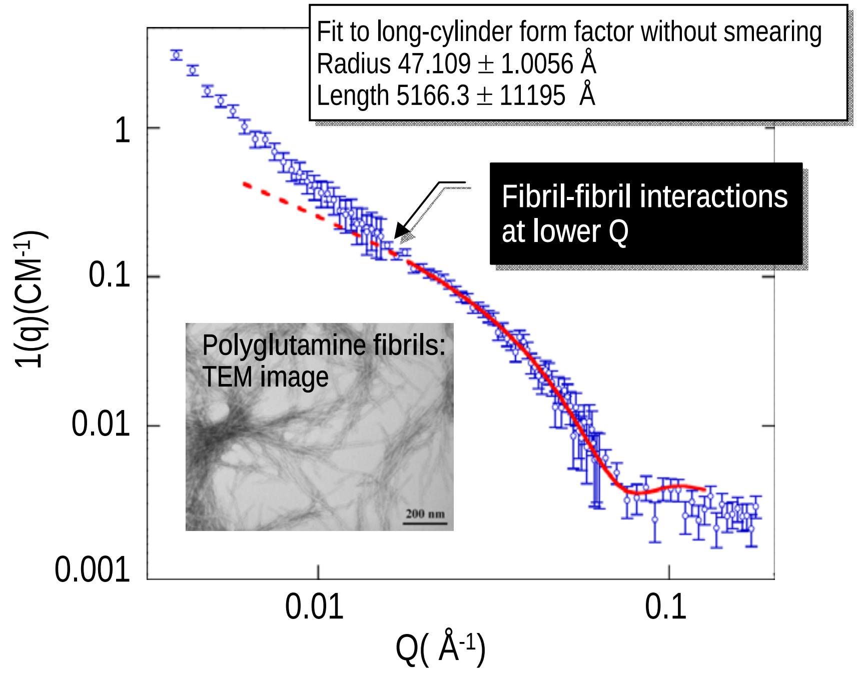
# Thermal and cold neutron scattering instruments at HFIR are at the forefront of science

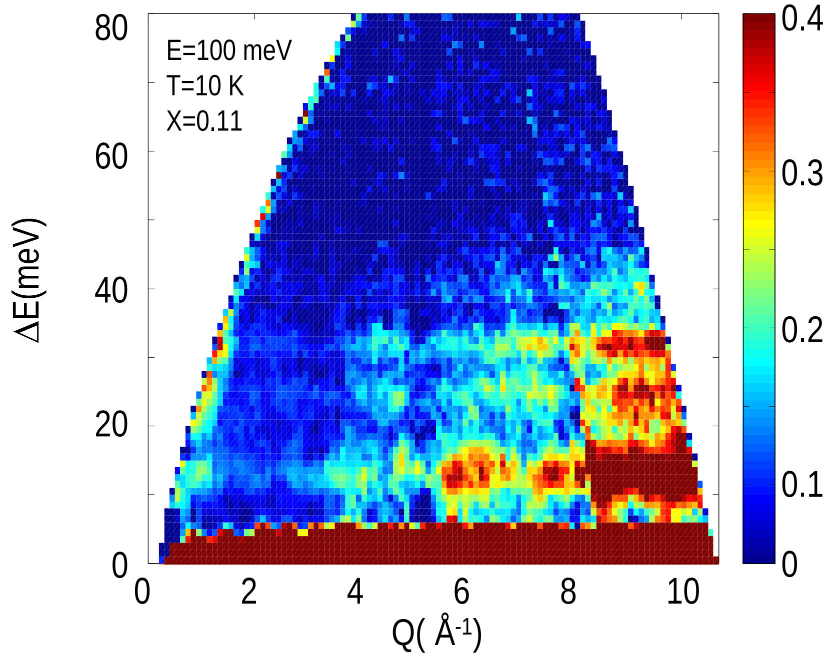
## Using SANS to understand polyglutamine aggregation in Huntington's disease




- Experiments on polyglutamine fibrils performed using BioSANS instrument at HFIR
- Results to be submitted to PNAS

Chris Stanley, Shull Fellow, ORNL, and Valerie Berthelier, Graduate School of Medicine, UT Medical Center

## Measuring lattice excitations in a new iron arsenide high $T_c$ superconductor



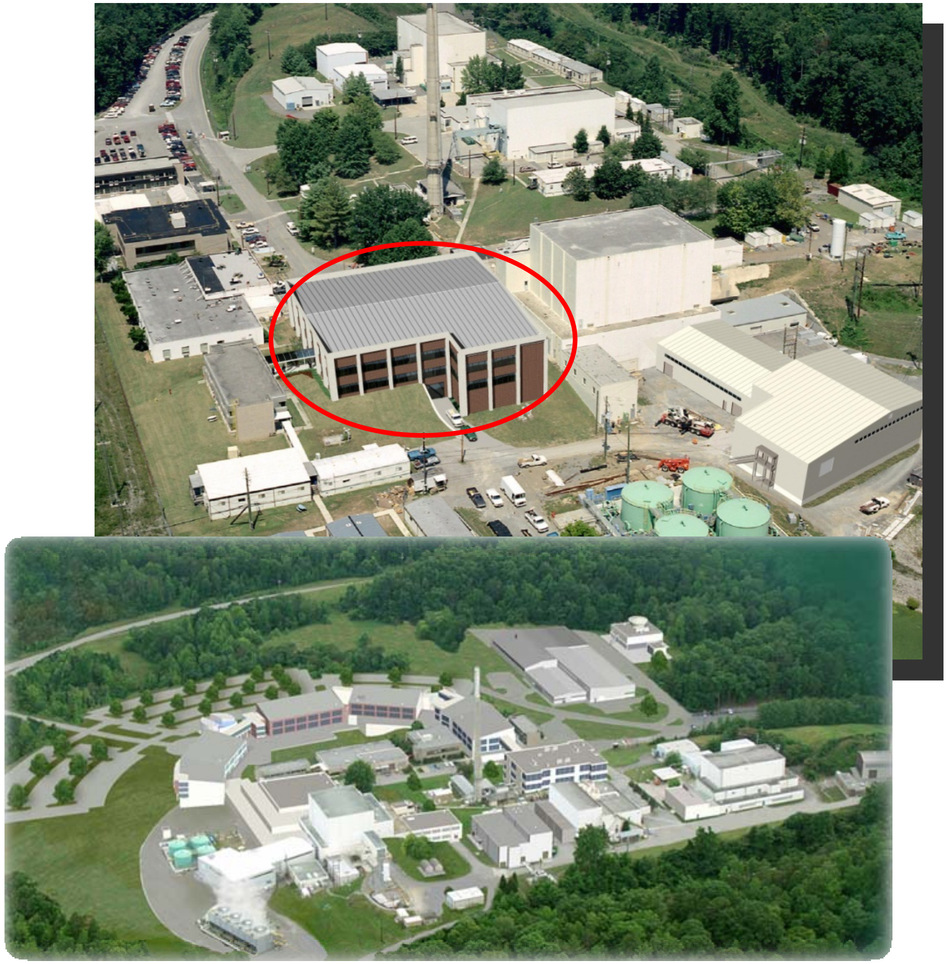

- First new high-temperature superconductor in ~20 years
- Results inconsistent with conventional superconductivity

A. D. Christianson and M.D. Lumsden at ORNL, CalTech, ISIS, Ames Lab, and Argonne collaborators, *PRL* (accepted for publication)

# Upgrades to the HFIR infrastructure are extending its availability through 2040

# Continued investments in scientific capabilities ensures HFIR remains a world-class facility


New world-class neutron scattering instruments continue to be added on existing HFIR neutron beams



A second cold source and neutron scattering guide hall are proposed



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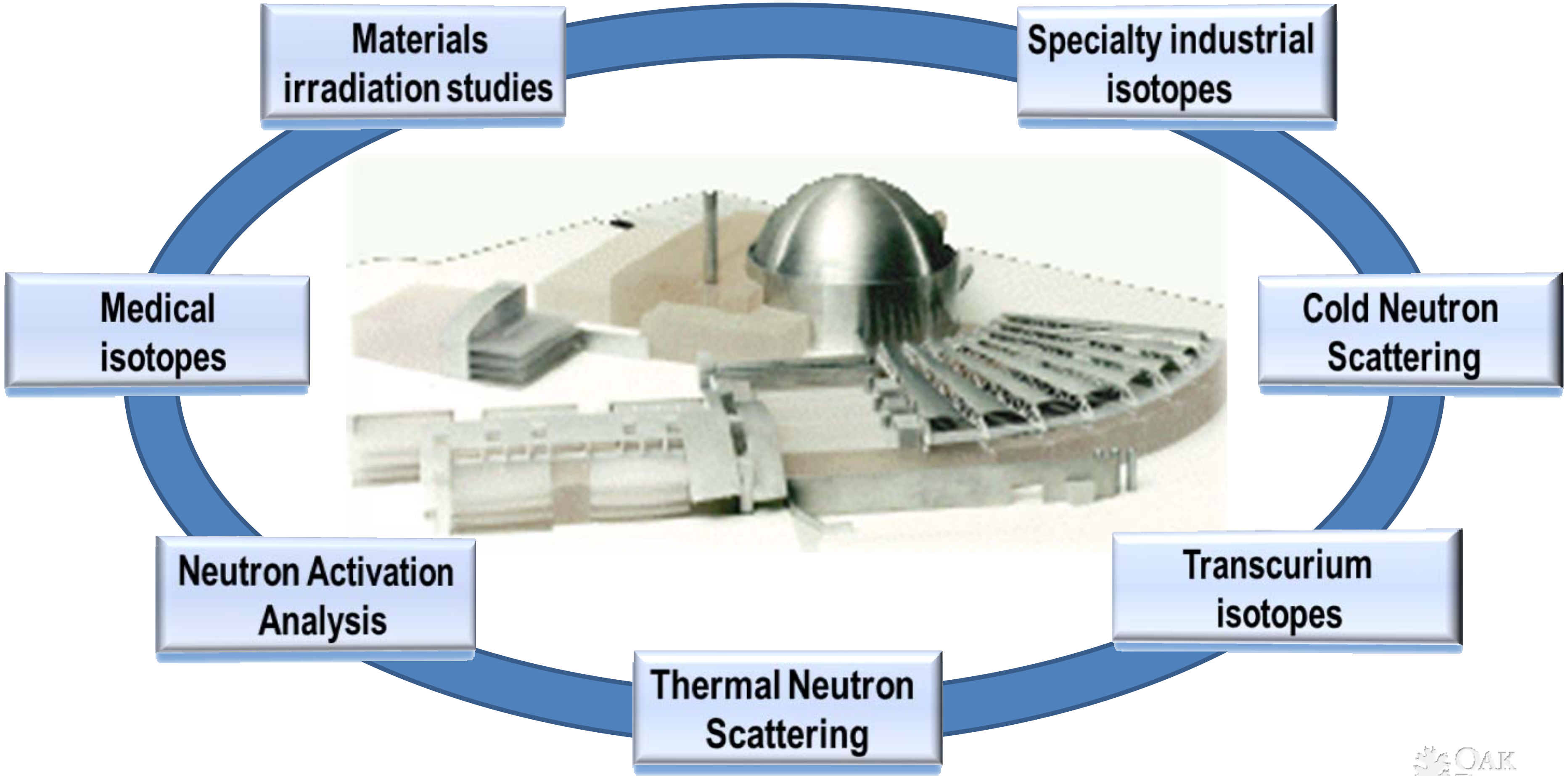
# There is resurgent interest in the US isotope program

- DOE's Office of Nuclear Physics (DOE-NP) has demonstrated committed leadership
  - Hosted a workshop to gather stakeholder input
  - Established Nuclear Science Advisory Committee (NSAC) Isotope Subcommittee
  - Established the National Isotope Data Center
- HFIR remains an important isotope production and research facility

# It’s time to begin planning the next generation reactor to succeed HFIR

HFIR staff are working to upgrade its infrastructure to support operations through 2040 if needed – Now is the time to begin a new generation of reactors to carry on its missions before HFIR is gone



# HFIR has served well and is poised to continue serving until the next generation of reactors arrive

*"If at some time a heavenly angel should ask what the laboratory in East Tennessee did to enlarge man's life and make it better, I daresay the production of radioisotopes for scientific research and medical treatment will surely rate as a candidate for the very first place."*

Alvin Weinberg

Former ORNL Director