



nordion
SCIENCE ADVANCING HEALTH

Selective Gas Extraction: A transformational production technology being implemented by GA, MURR and Nordion

**Mo-99 2015 TOPICAL MEETING ON
MOLYBDENUM-99 TECHNOLOGICAL DEVELOPMENT**

Chris Critch, Nordion

John Saurwein, General Atomics

Ken Brooks, Missouri University Research Reactor

www.nordion.com

Mo-99 Production by Selective Gas Extraction (SGE)

Leveraging World-Class Capabilities and Existing Nuclear Infrastructure



About Nordion



Nordion is a health science company that provides market-leading products used for the prevention, diagnosis and treatment of disease.

We've been **delivering safe, high-quality products** to global customers for more than 60 years.

To best serve the diversity of our customers' requirements, we are organized into two business units—**Sterilization Technologies** and **Medical Isotopes**.

APPROXIMATELY

375 EMPLOYEES

SUPPLY OVER

500 CUSTOMERS

AROUND

30 PRODUCTS

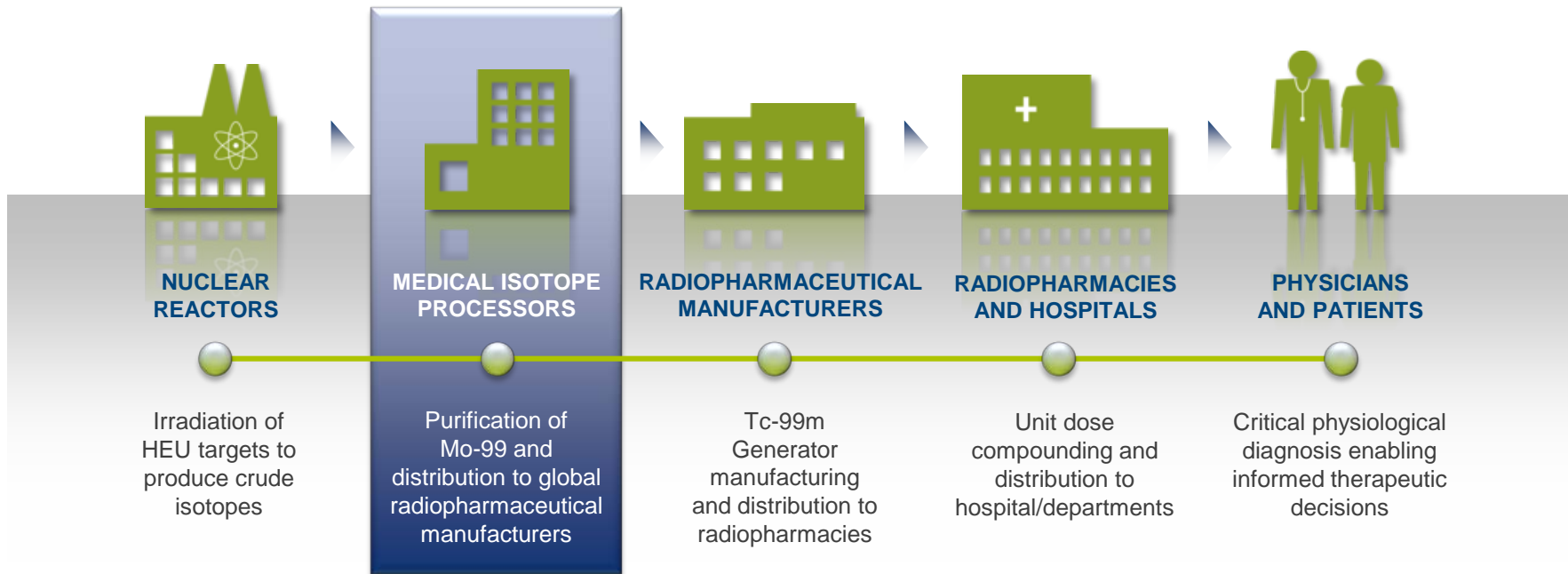
ACROSS MORE THAN

40 COUNTRIES



Medical Isotopes

Experts in the Critical Supply Chain (Mo-99)



- Established, reliable facilities providing high-quality isotopes to global customers
- Specialty skills in operations, regulatory affairs and global logistics
- Nordion has been manufacturing Mo-99 for over 40 years

Nordion Current Mo-99 Supply

- Nordion's current supply chain utilizes the National Research Universal (NRU) reactor operated by Canadian Nuclear Laboratories (CNL)
- The NRU is scheduled to cease routine production of Mo-99 in November 2016.
- Government of Canada announced on February 6, 2015 its support of the extension of the NRU operations until March 31, 2018 to help support global medical isotope demand in the unexpected circumstances of shortages during this time.
- Nordion supports the efforts of the Canadian Government to operate the NRU and provide a standby Mo-99 capability during the period of transition as new supply capacity comes online.



Since 2008 **Over 50** worldwide files/projects have been evaluated

- Both Reactor and Accelerator-Based

Supply Selection Criteria

1. Non HEU-based technology/targets
2. Credible Partners
3. Leverages existing infrastructure/capabilities to drive efficiency
4. Commercial feasibility – for Nordion and partners
5. Timeline - potential for commercialization in the near term



Partnership with General Atomics and the Missouri University Research Reactor (MURR)

- Mo-99 supply utilizing proprietary Selective Gaseous Extraction (SGE) technology
- Leverages existing reactor, processing facility and licensed shipping container infrastructure and capabilities
- Commercial supply by the end of 2017



Energy & Environment

New Nuclear

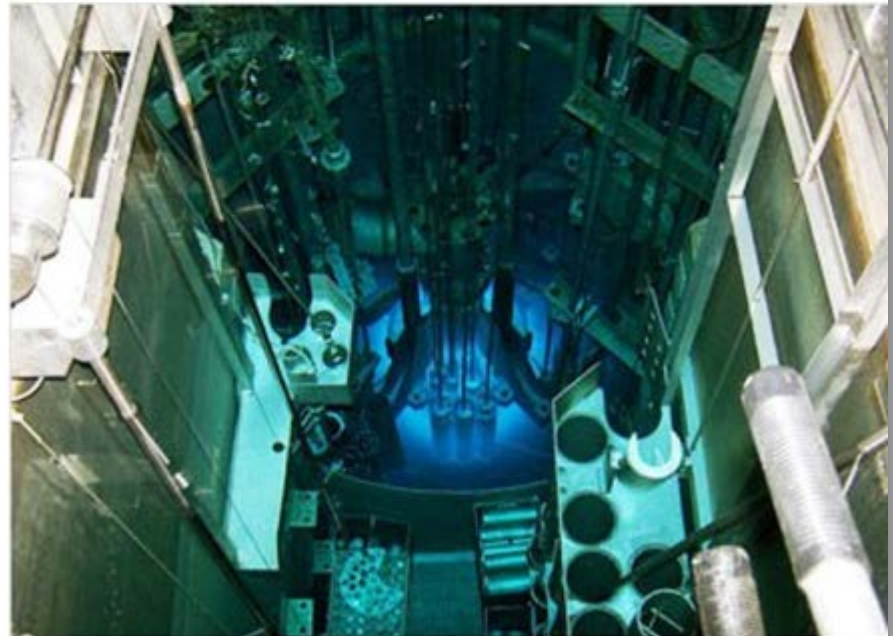
Regulation & Safety

Nuclear

US-Canadian partnership for isotopes

23 February 2015

A Canadian-US partnership has been announced to create a "new, reliable supply" of medical isotopes for use worldwide.



Highly Credible Partners



General Atomics

Target and reactor systems design and manufacturing

- Trusted resource of high-technology systems
- Experts in nuclear fuel cycle, including uranium mining and processing
- Experts in reactor design: GA TRIGA® research reactors in operations around the world for over 50 years
- Developer of LEU technology utilizing novel reusable target design

Missouri University Research Reactor (MURR)

Premium Reactor Operator and Research Center

- 10 megawatt facility; the largest university research reactor
- Operates 52 weeks a year
- 35+ years of successful and innovative radiopharmaceutical R&D and collaborations with industry
- Strong record of regulatory compliance (US NRC, US FDA)
- Experts in volume radiochemical processing and international shipping
- Nordion's partner in supply of TheraSphere for over 20 years

Nordion

Premier Isotope Producer and Distributor

- Experts in Mo-99 purification into medical grade product since 1975
- Strong record of regulatory compliance (US FDA, EMEA, Health Canada)
- cGMP/GLP - licensed facility
- Global leading supplier of Mo-99 with extensive marketing, sales & distribution expertise
- Global licensed transport container fleet

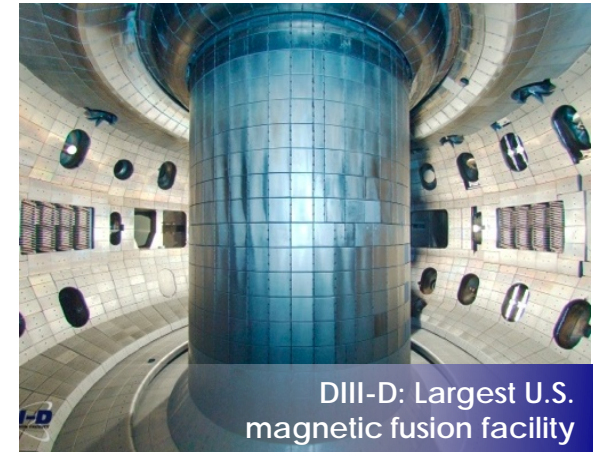
Nordion/General Atomics/MURR Mo-99 Program



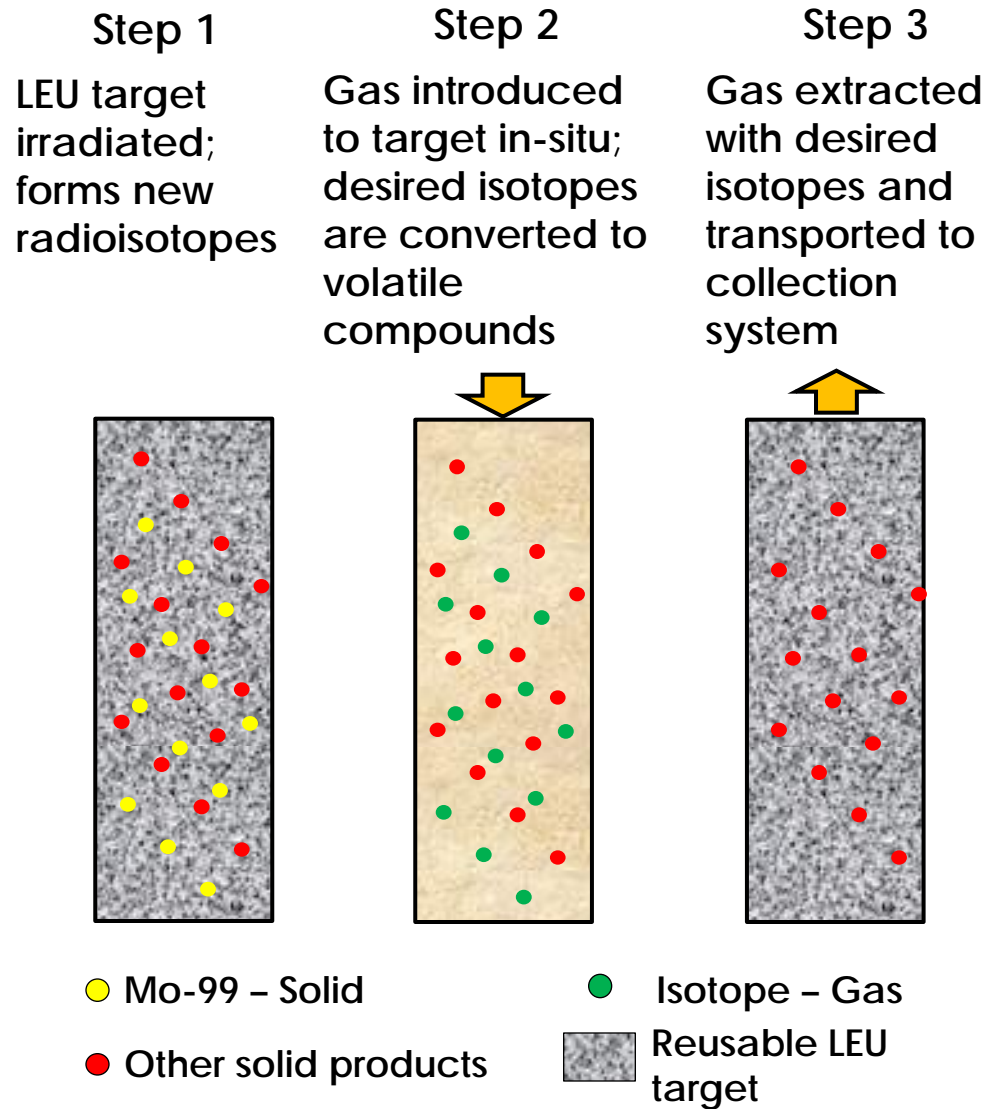
- Nordion has exclusively licensed GA's Selective Gaseous Extraction (SGE) Technology for Mo-99 production
- Nordion has agreed to provide funding for the implementation and commercialization of SGE Technology at MURR
- Nordion has executed a 20 year reactor services agreement with MURR
- MURR will supply a first-stage extract that will be processed and purified at existing cGMP Nordion facilities.
- Mo-99 produced by SGE will work seamlessly in all existing Tc-99m generators

General Atomics Specializes in Innovative R&D and Transforming Advanced Technology into Practical Systems

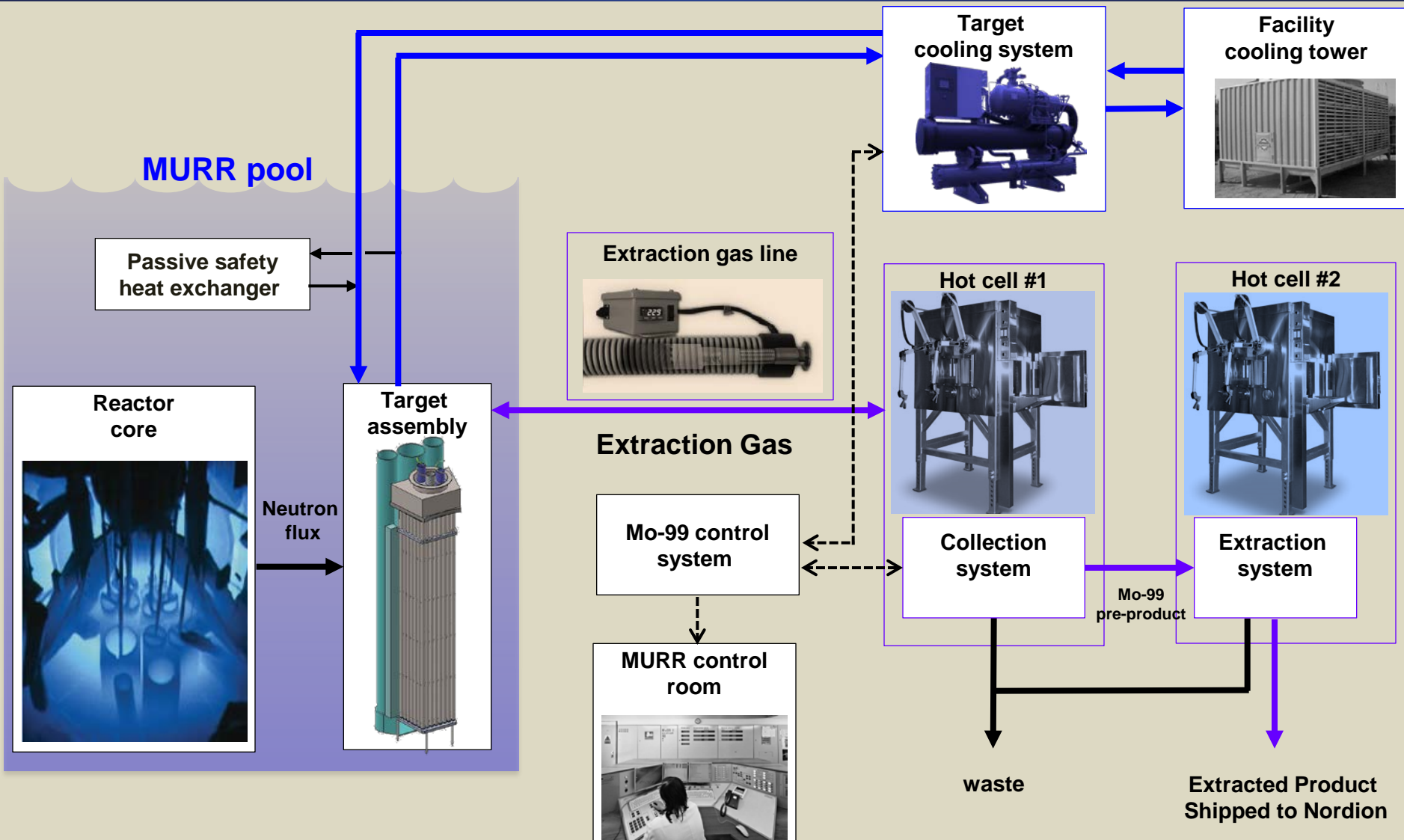
- **Innovative technology company headquartered in San Diego, CA**
 - Total staff >7000
 - 3 million sq. ft. engineering, laboratory, and manufacturing facilities in San Diego with expanded operations in U.S. and abroad
- **Over 50-year history developing high-technology solutions for energy, environmental, and defense challenges**



Selective Gas Extraction (SGE) Allows for Reuse of LEU Targets



Selective Gas Extraction Mo-99 Supply System Overview



Key Advantages of SGE Mo-99 Supply System

- High volume capacity – up to 4,200 6-day Ci per week
- 52 week-per-year availability
- LEU utilization vastly increased
- Uranium waste and liquid waste greatly reduced
- 100% compatible with all Tc-99m generators
- North America based – proximity to largest market
- Utilizes existing infrastructure – no new reactors, no new buildings, no new transport container fleet

Key Project Activities

- Complete target and auxiliary equipment design
- Conduct design verification testing
- Procure equipment and install at MURR
- Obtain MURR NRC license amendment
- Fabricate target assemblies
- Irradiate prototype target
- Validate Mo-99 purification process
- Obtain FDA approval for Tc-99m generators using SGE-produced Mo-99



Improving the Quality of Life

Distinct Subcultures *working together under the same roof*



Research
&
Development



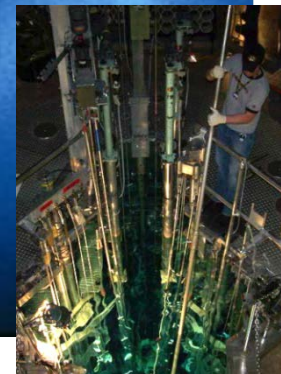
Education

Products
&
Services

Our core missions are Research & Education

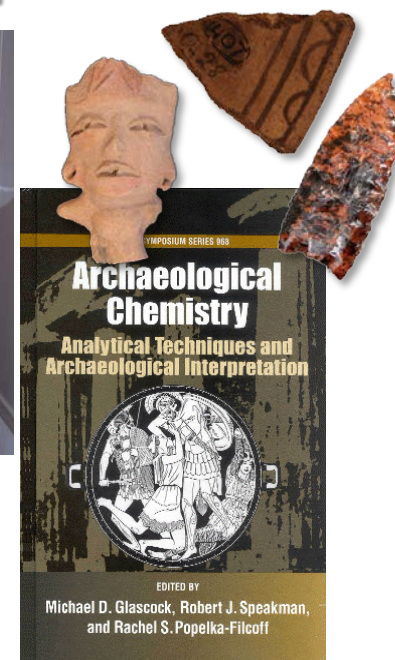
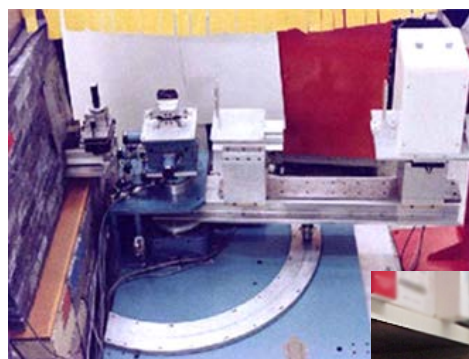


Reactor
Operations



Research and Development

- Life Sciences
 - ✓ Radiopharmaceutical Research
 - ✓ Trace Element Epidemiology
 - ✓ Boron Neutron Capture Therapy
 - ✓ Radioisotope Tracers
- Social Sciences
 - ✓ Archaeometry
- Material Sciences
 - ✓ Triple Axis Spectrometer
 - ✓ Neutron Reflectometer
 - ✓ Multi-detector Powder Diffractometer
 - ✓ High Resolution Powder Diffractometer

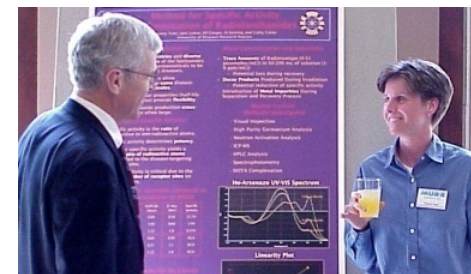




as an MU Crown Jewel and Unique National Resource



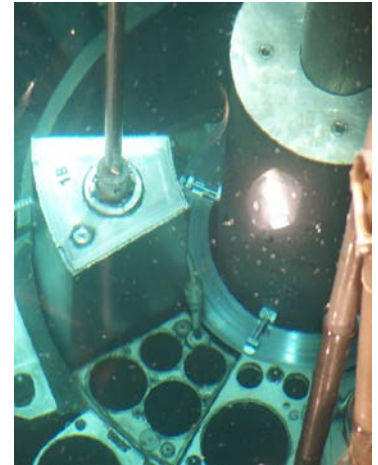
- October 1966 = First Reactor Start-up
- 1974 Facility upgraded from 5 to 10 megawatts (Largest University Reactor)
- **Facility operates 24 hours a day; 6 ½ days per week; 52 weeks a year – like none other!**
- ~200 Full & Part-time employees bring an all-encompassing expertise in research and development; reactor operations; regulatory compliance; instrument design, manufacture and maintenance; analytical services; irradiations and processing; shipping; IT support; fiscal services
- Students – Learning while helping!
 - Part-time student employees and other students with access to MURR – on average > 50



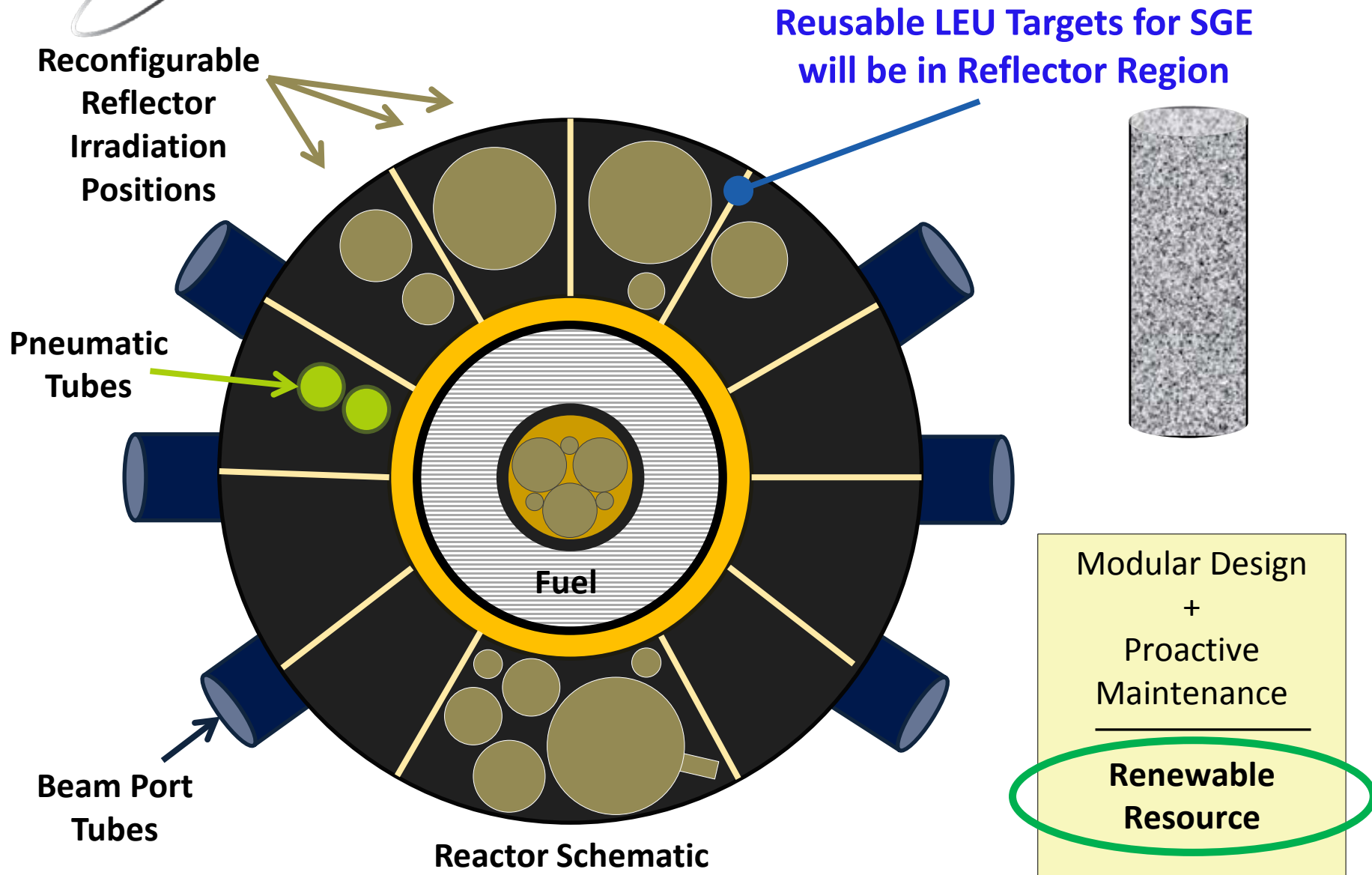


MURR's Modular Facilities: Refurbished for another 20+ Years

- Replacement of all Graphite Reflector Elements
- Radioactive Liquid Waste System Upgrades
- Installation of a Fire Protection System
- Replacement of the Primary & Pool Coolant System Heat Exchangers
- Replacement of the Reactor Plant Make-up Water Tanks
- Replacement of major facility Electrical Distribution Transformers and Motor Control Centers
- Replacement of the Cooling Tower & Increased Capacity

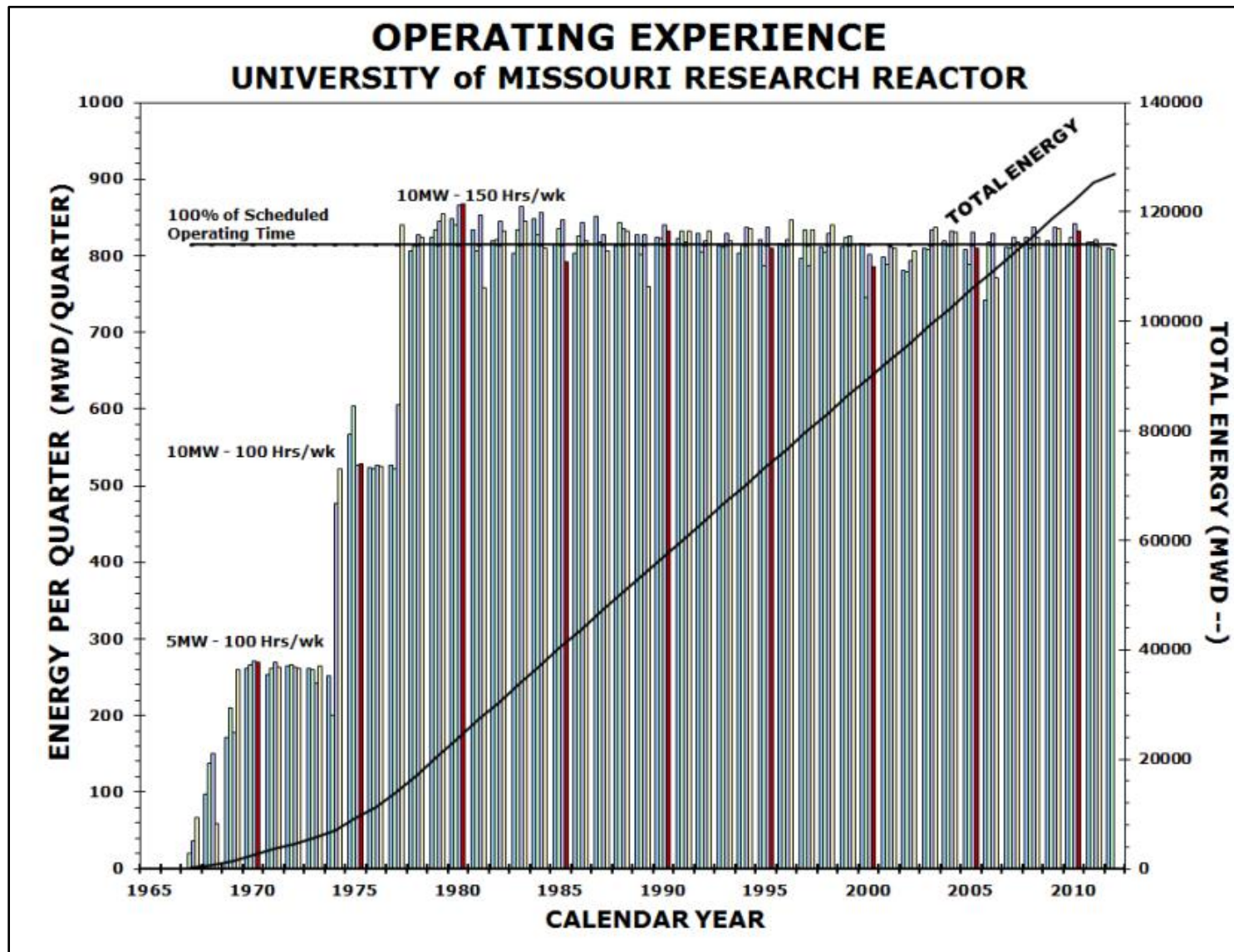


Custom Irradiations for Isotopes & Materials Testing



Reactor Operating Schedule

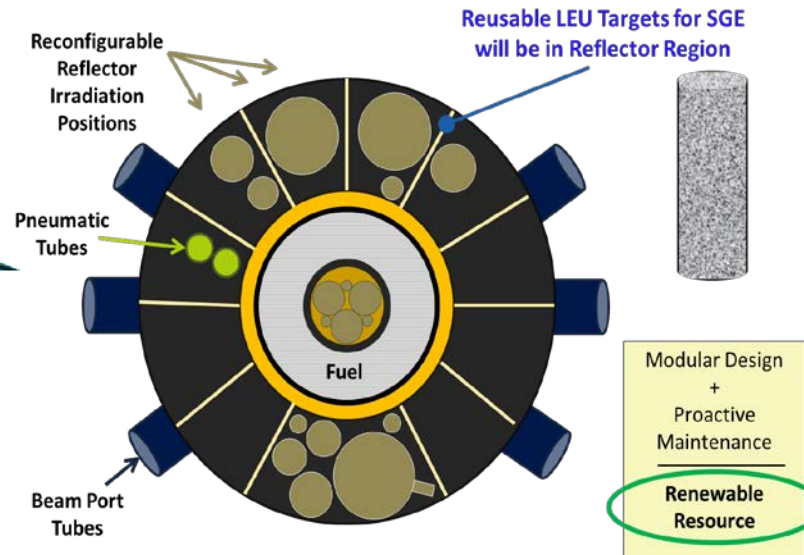
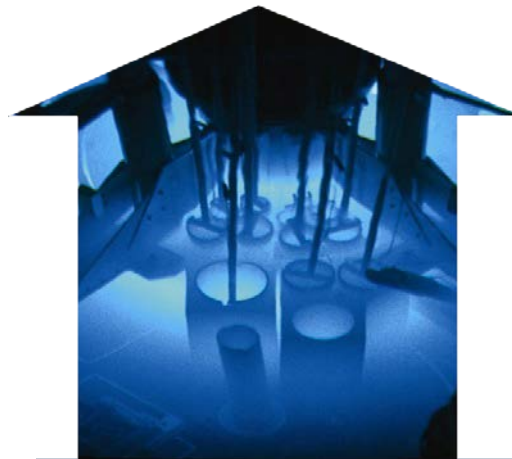
52 Weeks / Year; 150 Hours / Wk



The Conclusion: SGE Mo99 is a Great Fit

Project Evaluation Factors:

- ✓ *Competency*
- ✓ *Capacity*
- ✓ *Culture*
- ✓ *Complementary*



Research & Education: the reasons we exist

Summary



- Nordion remains committed to playing a critical role in the global supply of Mo-99 post NRU.
- Selective Gaseous Extraction technology is fully compatible with existing nuclear infrastructure at MURR and Nordion. No new reactors or accelerators, no new buildings, no new transport container fleet.
- Nordion's partnership with General Atomics and MURR will create a high capacity, reliable and efficient source of Mo-99 compatible with all Tc-99m generators.