SHINE Overview

Presenter: Christina Barrett

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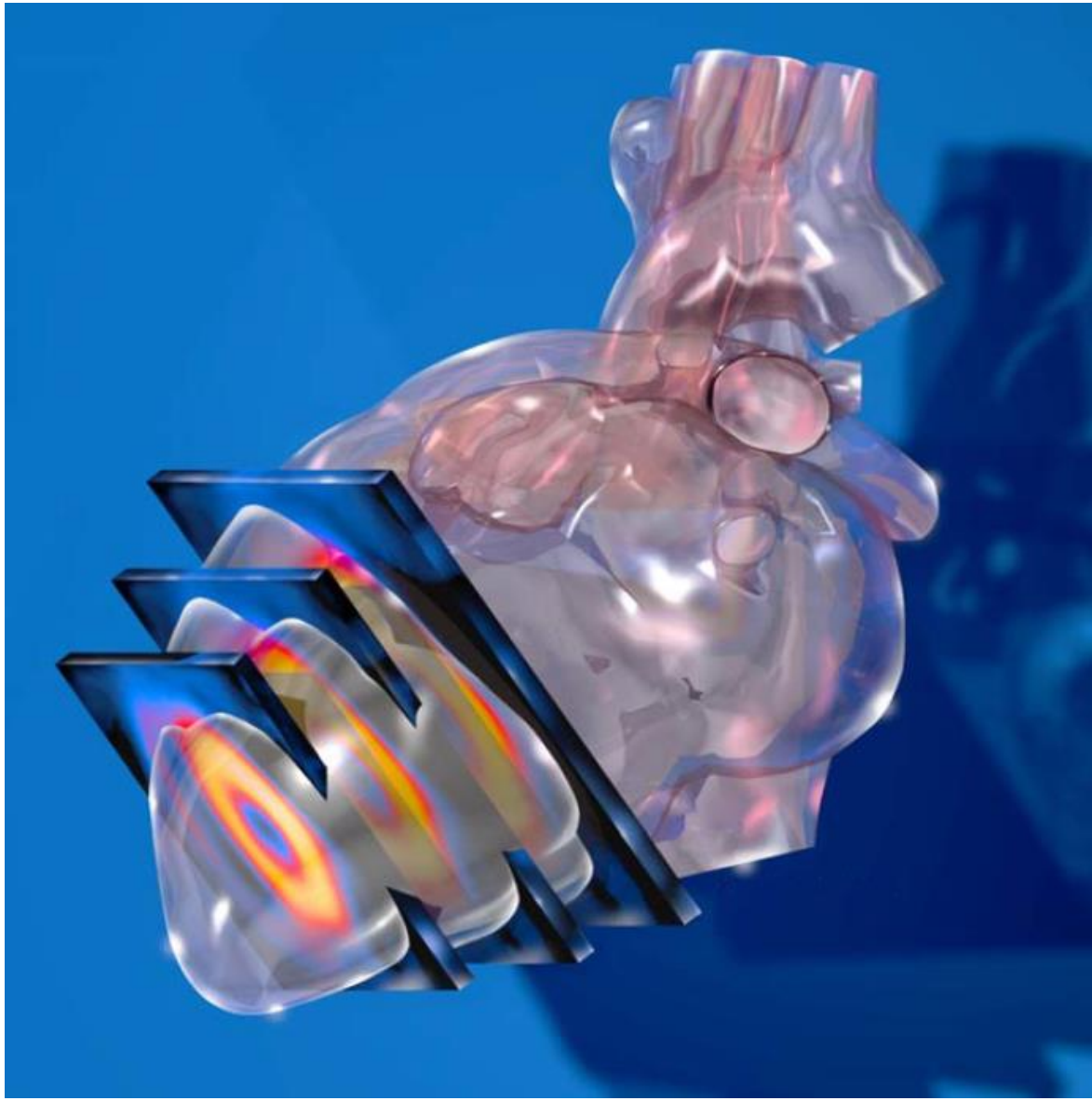
Mission

Dedicated to being the world leader in the safe, clean, affordable production of medical tracers and cancer treatment elements.



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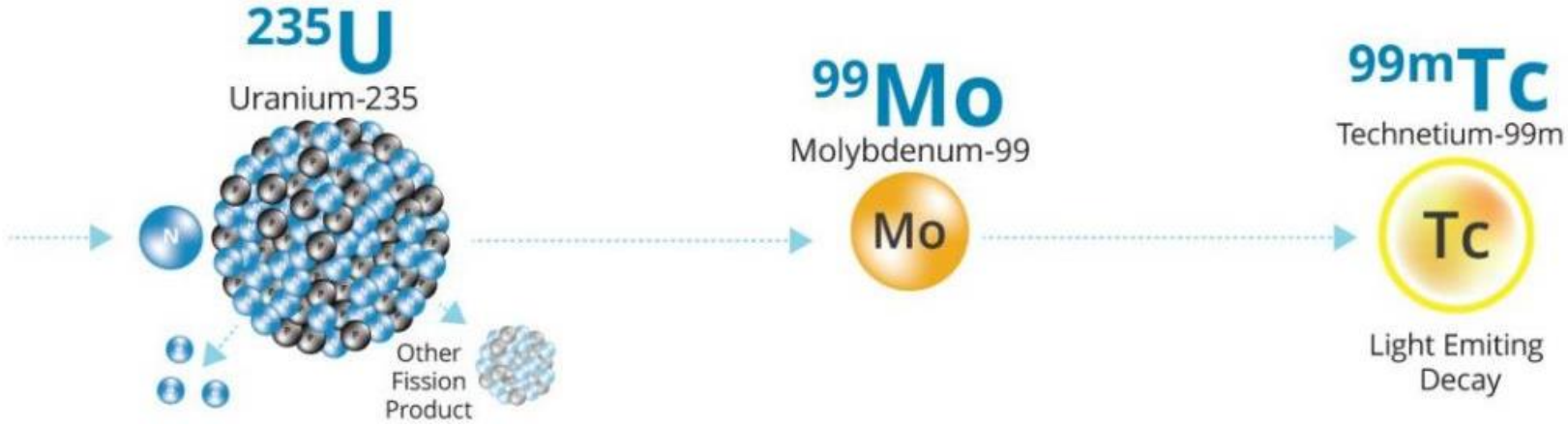
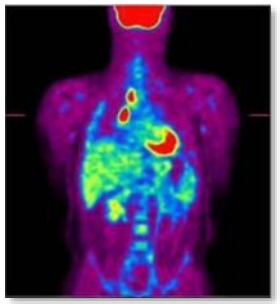
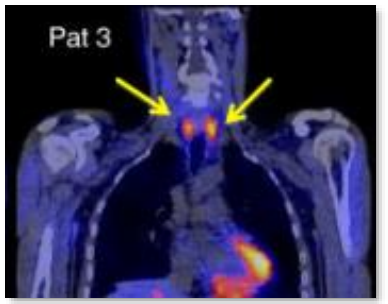
I. Mo-99 Overview and Market

Molybdenum-99 and Technetium-99m Refresher

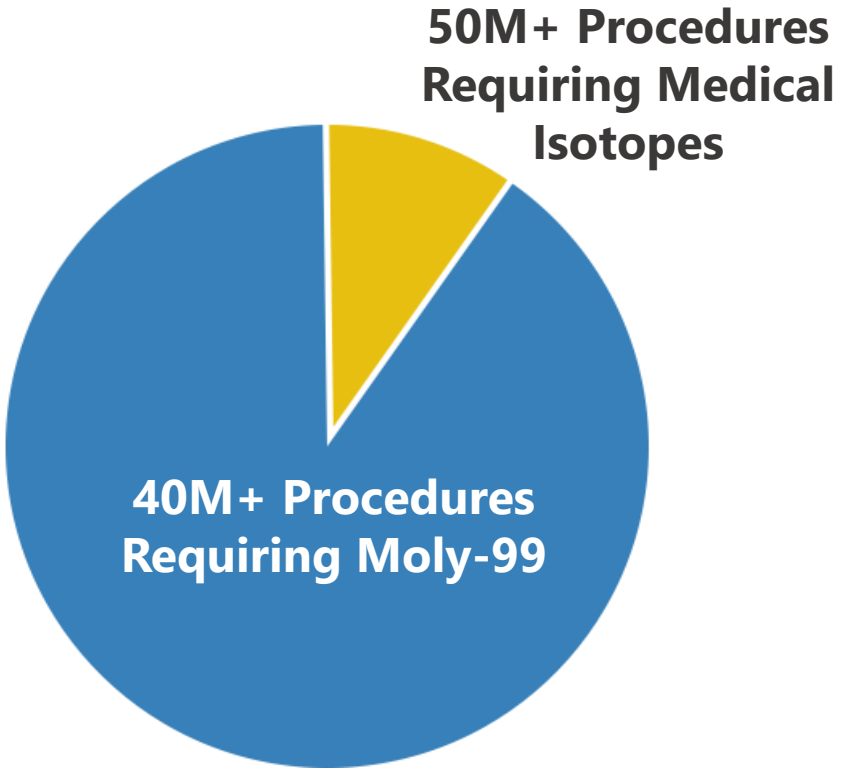


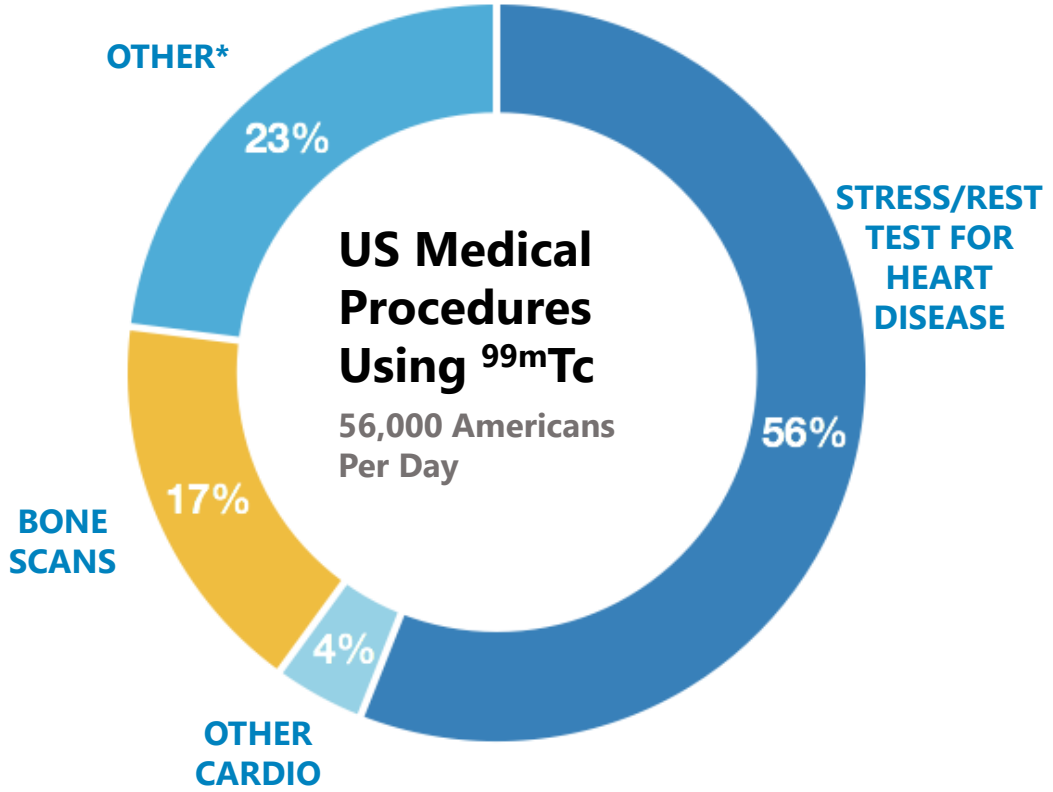
- Mo-99 decays into Tc-99m, which can then be extracted by radiopharmacy staff to deliver to physicians for use in patients
- Mo-99 decays at approximately 1% per hour, necessitating continuous supply
- Tc-99m decays about ten times faster





Medical isotopes enable doctors to diagnose and treat illnesses, such as heart disease and cancer





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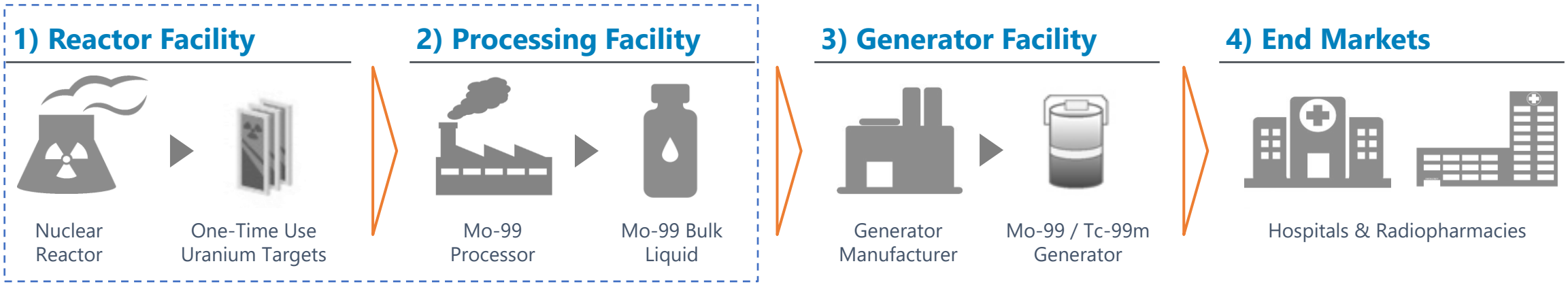
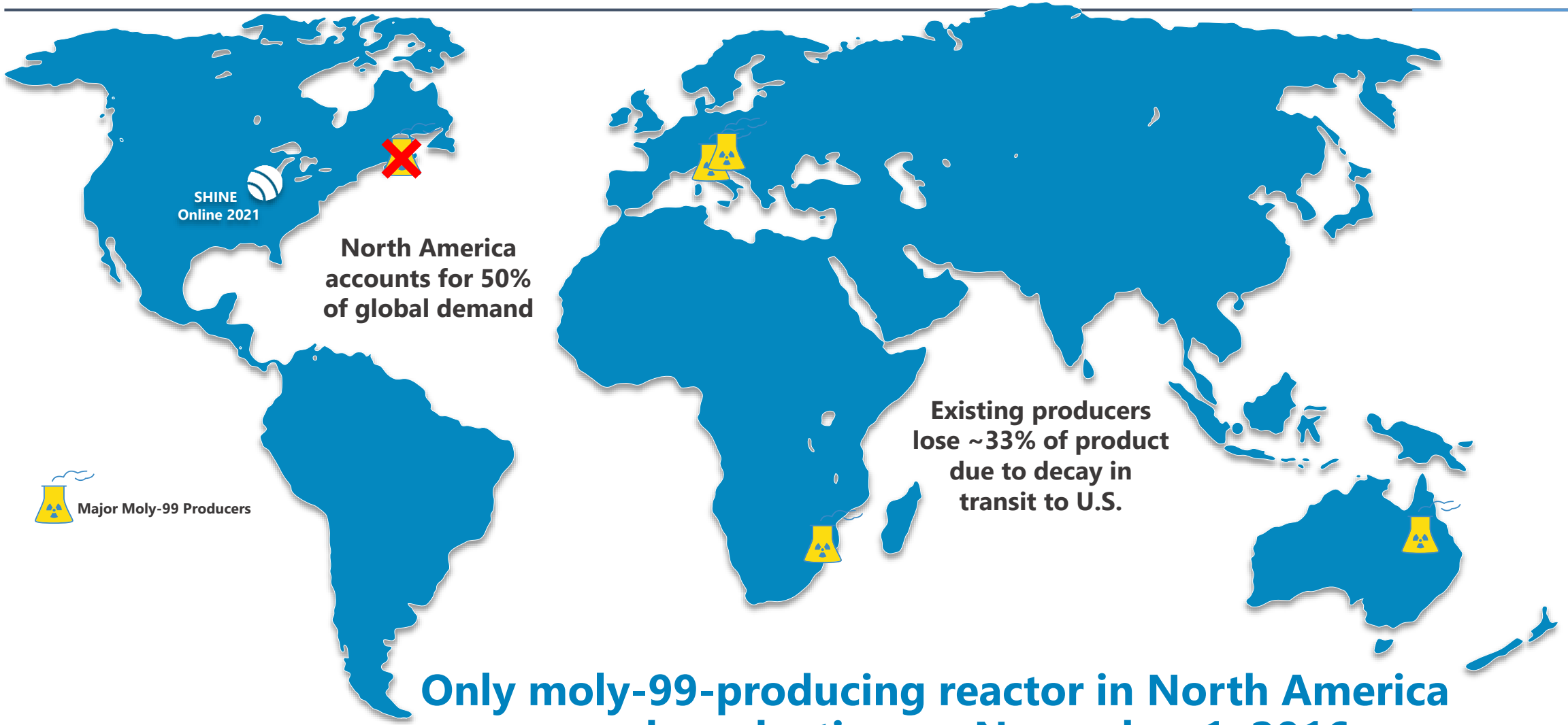
Current Mo-99 Supply Chain



1. **Reactor Facility**
   - U.S. government ships weapons-grade, highly-enriched uranium (HEU) to nuclear reactors around the globe
   - Reactors irradiate the solid targets to produce Mo-99
   - Targets containing Mo-99 are transported to Mo-99 processing facilities
2. **Processing Facility**
   - Processors dissolve the target, then chemically separate and purify the Mo-99
   - Non-reusable targets disposed of as nuclear waste
   - Purified Mo-99 packaged as bulk liquid and shipped overnight to generator facilities
3. **Generator Facility**
   - Bulk liquid packaged into Mo-99 generators and shipped to hospitals and radiopharmacies
4. **End Markets**
   - Healthcare professionals use the generators to dispense Tc-99m for patient use

Moly-99 decays at ~1% per hour, making proximity to patients critical



Only moly-99-producing reactor in North America ceased production on November 1, 2016

II. SHINE Technology

SHINE will replace Canadian production with proven technology at a fraction of today's cost

Technology proven by US National Laboratories and GE Healthcare

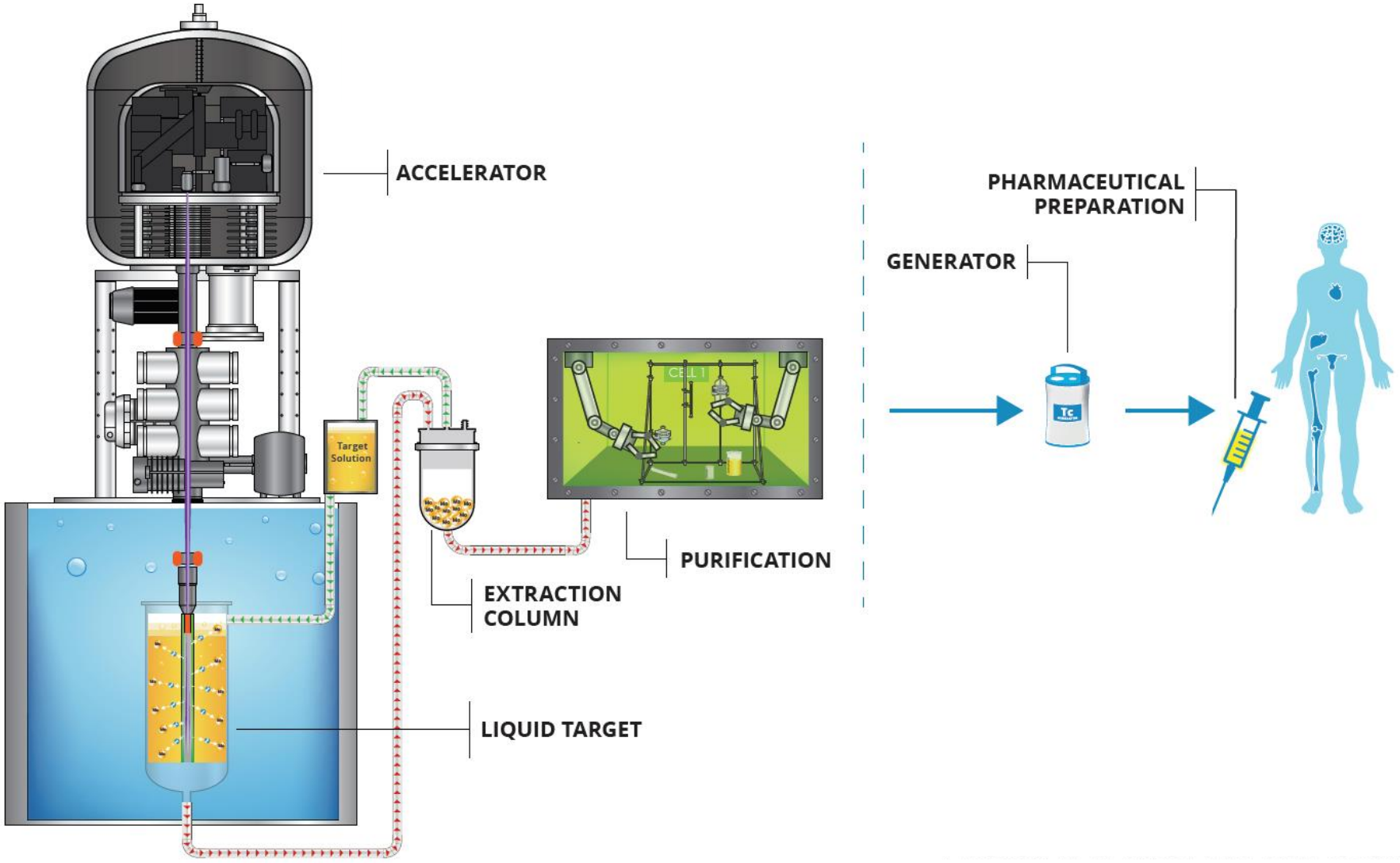
GE Healthcare

Argonne NATIONAL LABORATORY

SRNL

Los Alamos NATIONAL LABORATORY EST. 1943

OAK RIDGE National Laboratory



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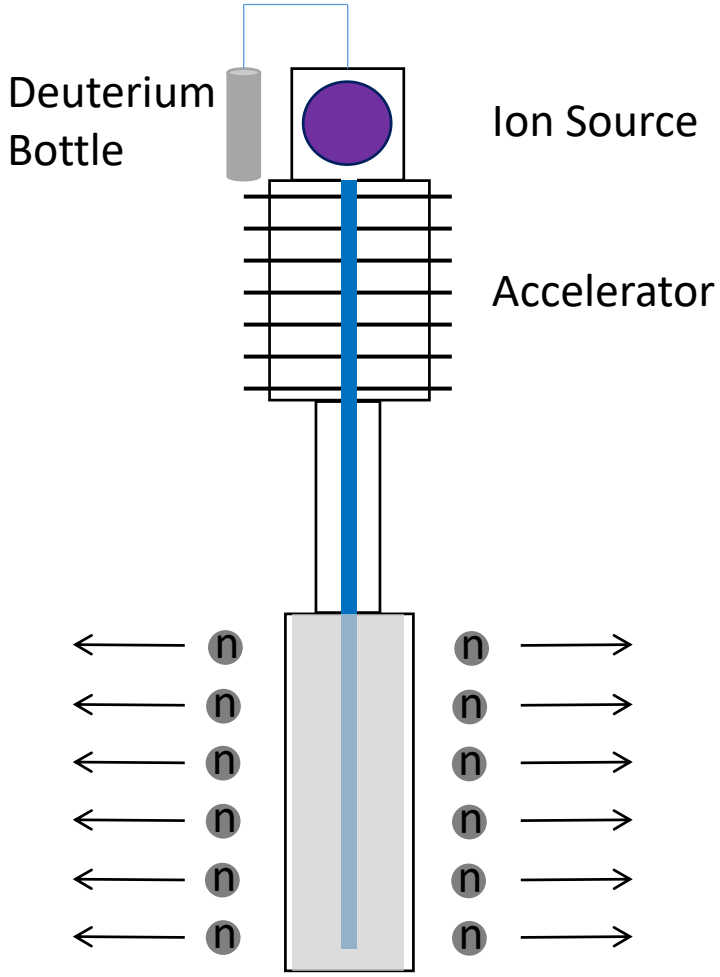
Fusion Neutron Source

- Step 1: Apply power to ion source
- Step 2: Apply power to accelerator
- Step 3: Introduce gas into target chamber—beam colliding with gas creates fusion reactions
- Step 4: Neutrons pass through target chamber wall and can be used to produce isotopes



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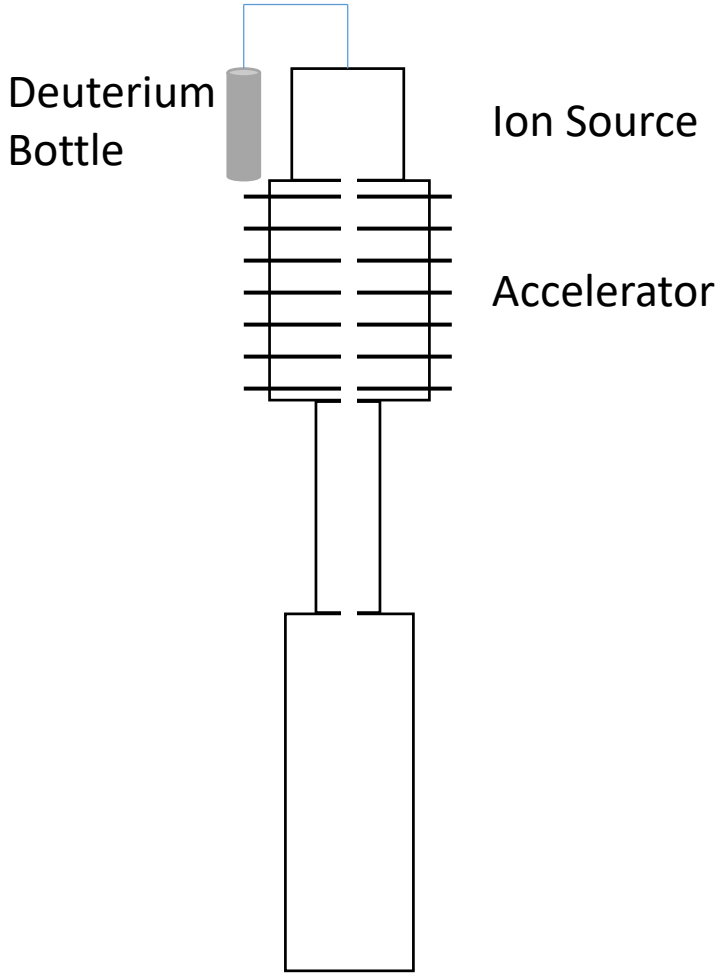
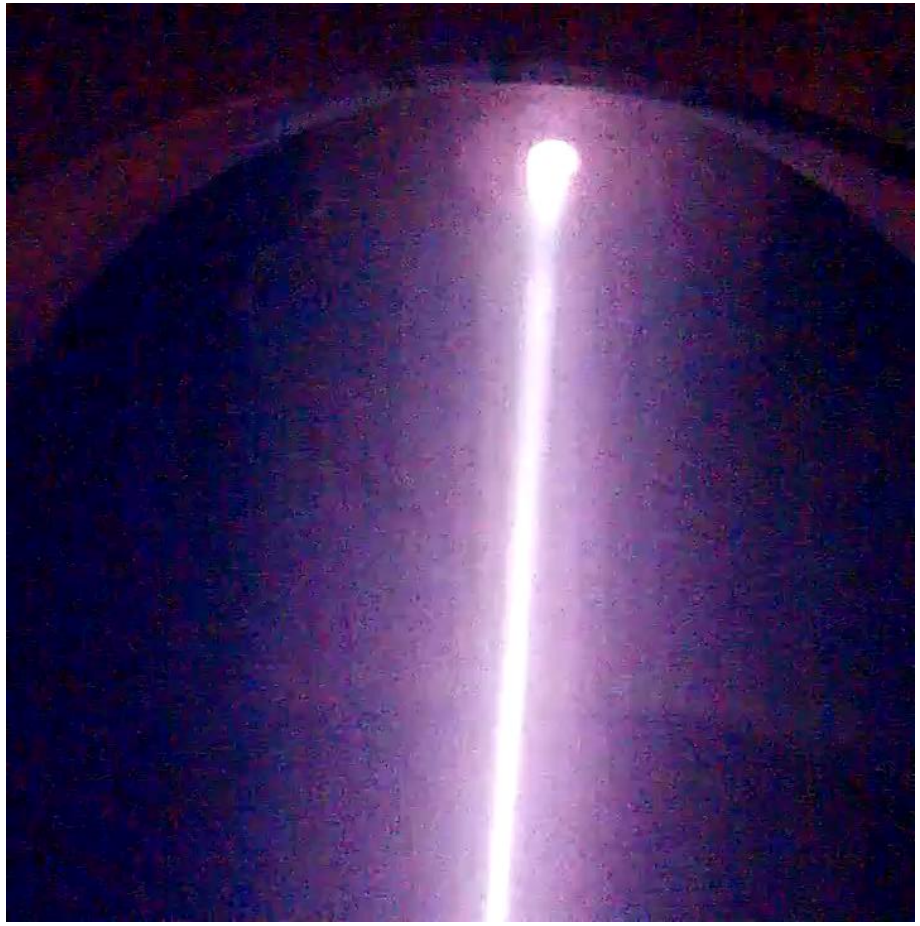
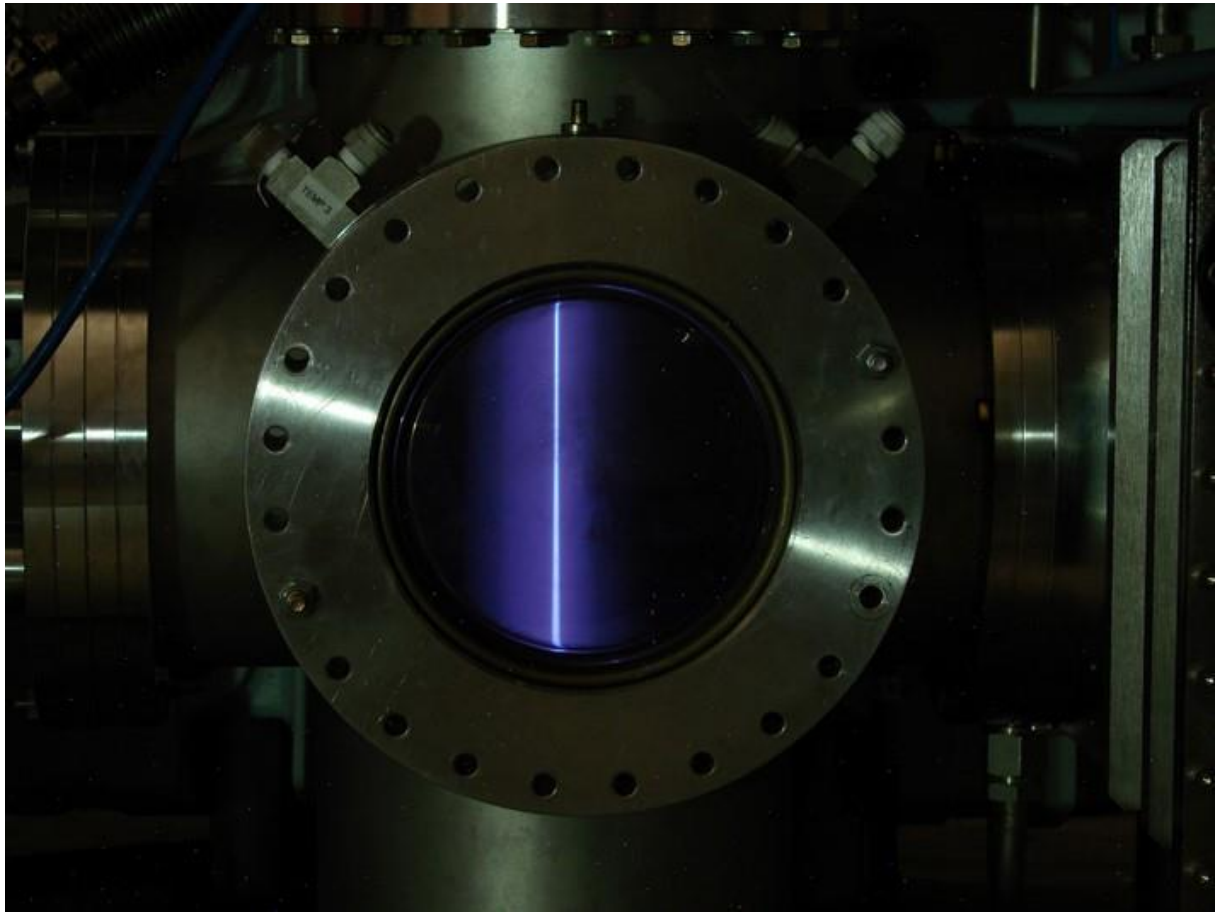
- Step 3: Introduce gas into target chamber—beam colliding with gas creates fusion reactions
- Step 4: Neutrons pass through target chamber wall and can be used to produce isotopes
- Step 5: Shut off power to source or accelerator and reaction stops



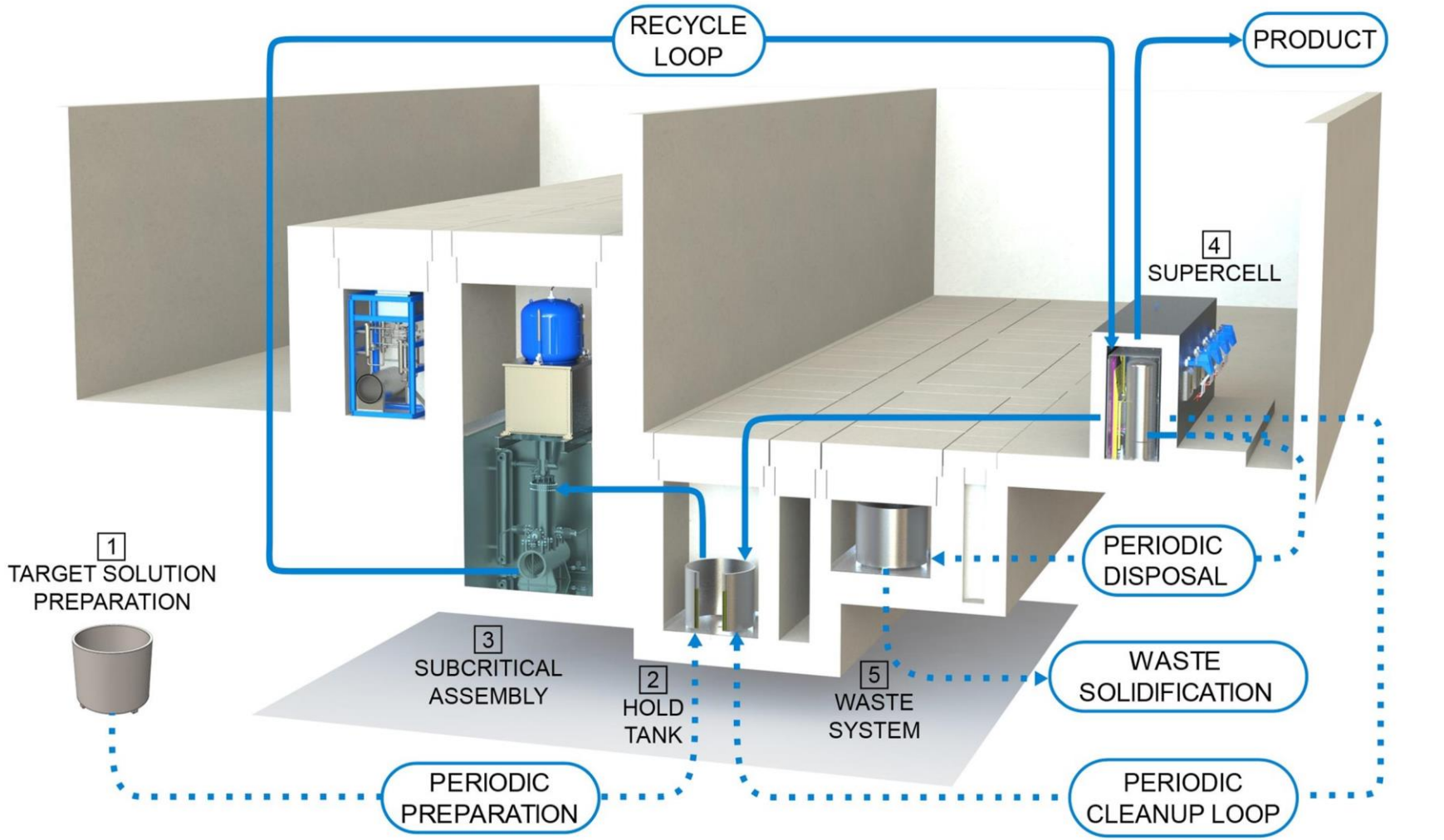
Beam Performance Demonstrated





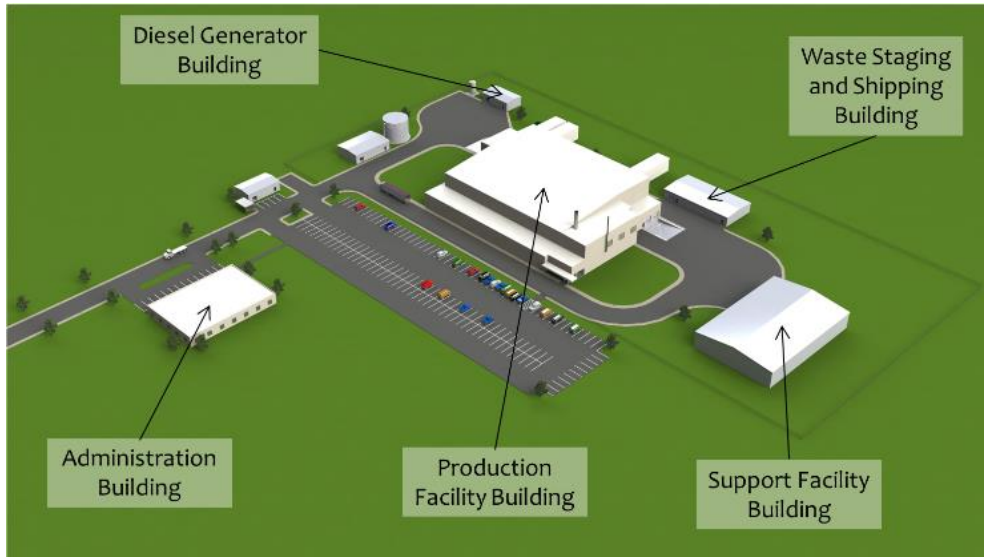
Process Steps

1. Periodic solution preparation
2. Staging to fill TSV
3. Irradiation
4. Extraction and purification
5. Periodic solution cleanup and disposal



Production Facility Design

- To be built in Janesville, Wisconsin, USA
- Will produce Mo-99, I-131, Xe-133, and others
- Plant capacity of 4,000 6-day Ci/week
- 8 independent irradiation units accelerators
  - High reliability
  - Flexible production schedule
- Independent hot cell chains further increase reliability and flexibility



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Square Feet	Accelerators	Hot Cells	Annual U.S. Demand Met*

Building One: First building on the SHINE campus

- Construction complete Q1 2018
- Full size equipment demo Q4 2018
- Future use for employee training and technology development

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III. Licensing Background and Update

The SHINE Licensing Process

Licensed under 10 CFR Part 50:

Utilization facility means:

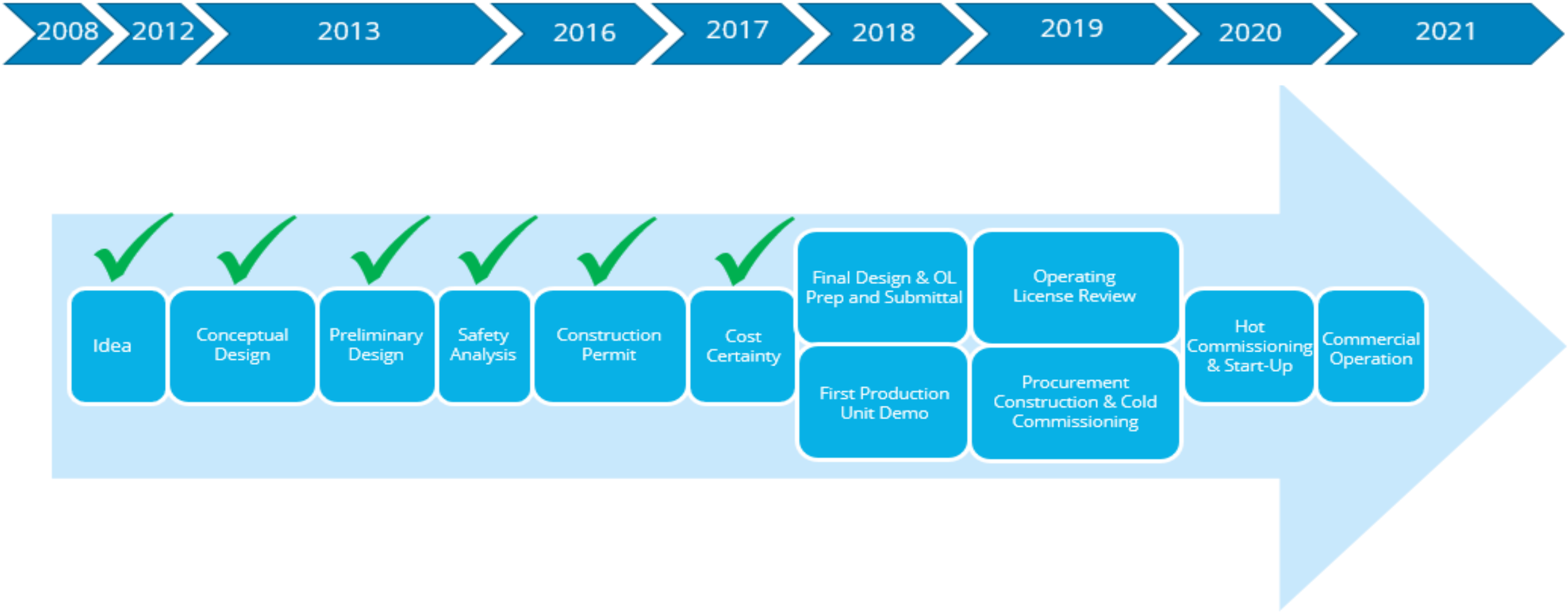
> (1) Any nuclear reactor other than one designed or used primarily for the formation of plutonium or U–233; or
>
> (2) An accelerator-driven subcritical operating assembly used for the irradiation of materials containing special nuclear material and described in the application assigned docket number 50–608.

The format and content requirements applicable to the SHINE license applications are described in the following:

- NUREG-1537, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors"
- FINAL Interim Staff Guidance Augmenting NUREG-1537 for Licensing Radioisotope Production Facilities and Aqueous Homogeneous Reactors

Class 103 License per 10 CFR 50.22, "Class 103 licenses; for commercial and industrial facilities"

Project Overview



Questions?

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THANK YOU.

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