CIRMS 2026

Fusion Industry Needs

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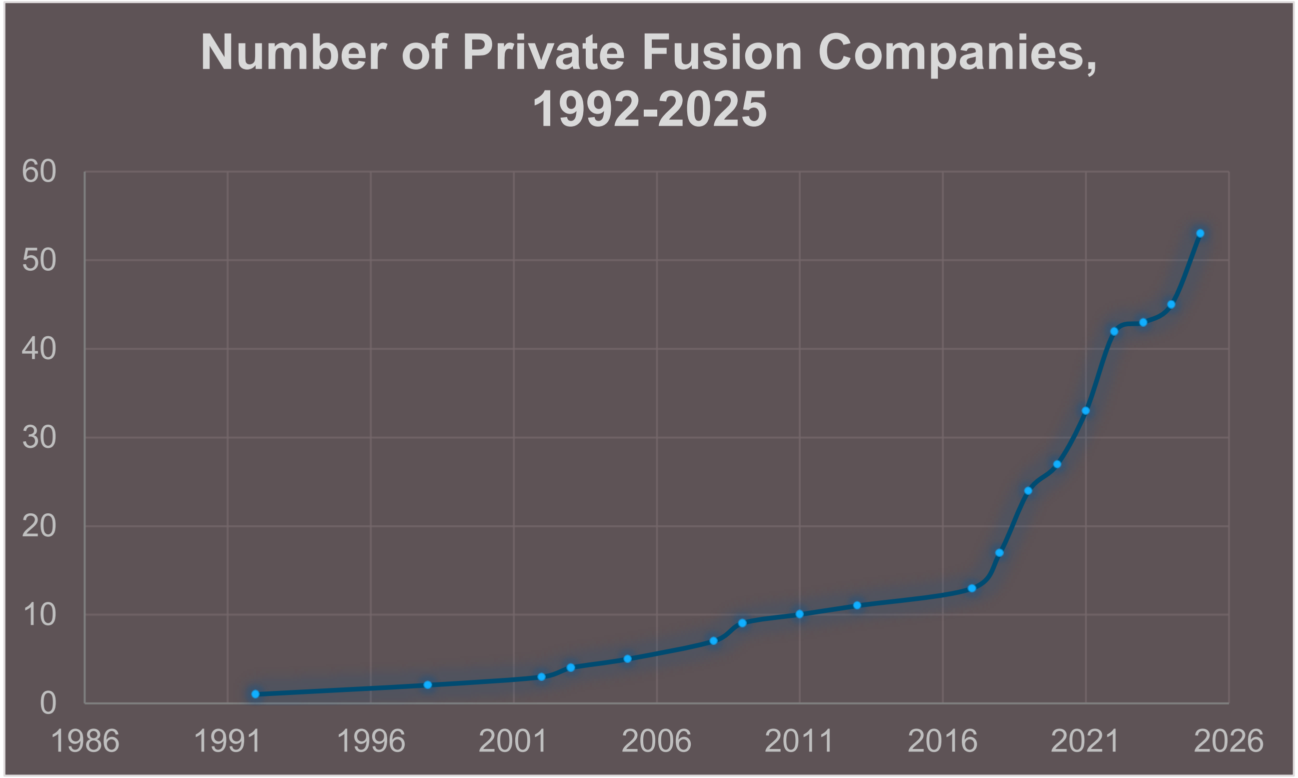
Commonwealth Fusion Systems

Agenda

1. Introduction – Commercial fusion industry and CFS
2. Context – Setting the stage for fusion challenges
3. Needs – Highest priority needs and gaps
4. Future – Audience impact and next steps

Fusion Commercial Industry



Commonwealth Fusion Systems

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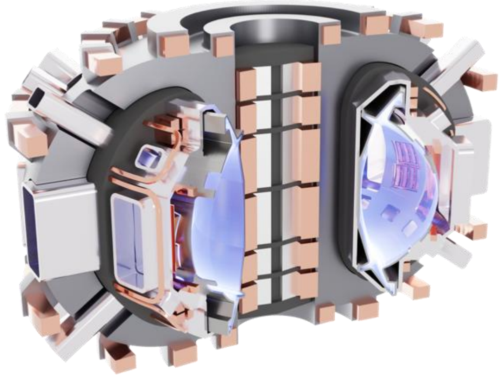
REALTA FUSION

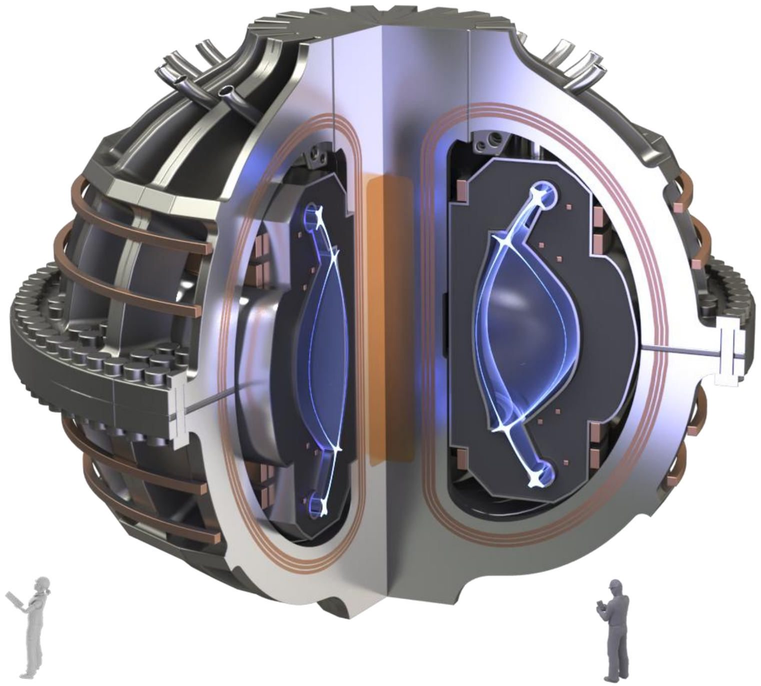
XCIMER

Commonwealth Fusion Systems

- Commonwealth Fusion Systems (CFS) is on track to bring fusion energy technology to market
- SPARC is a compact, high-magnetic-field tokamak that uses high temperature super conducting magnets.
- Following the SPARC demonstration, CFS is planning to construct ARC which will be the first fusion power plant



SPARC



ARC

Commonwealth Fusion Systems – SPARC Facility

Nuclear Engineering

- We are a company-level, analysis-focused team that provides neutronics analysis for any project at CFS
- 16 FTEs
- In Nuclear Engineering, we:
  - Deliver shielding solutions
  - Establish radiation environments
  - Advise all of CFS on Nuclear Engineering-related considerations

Radiation Protection

- Team who focuses on ensuring the radiological safety of the environment, people and facility
  - Regulatory compliance
  - Operation controls
  - Radiation monitoring systems
  - Work planning and radiological surveys
- 4 FTE

How we work together?

- Early integration in design:
  - Radiation protection requirements and nuclear engineering analysis are developed together so that radiation safety considerations inform design
- Coordination during operations:
  - Maintenance planning
  - Establish radiation boundaries
  - Validation through measurements
- Decommissioning:
  - Handling of radioactive byproduct material

Today's Presentation

What is Unique about Fusion?

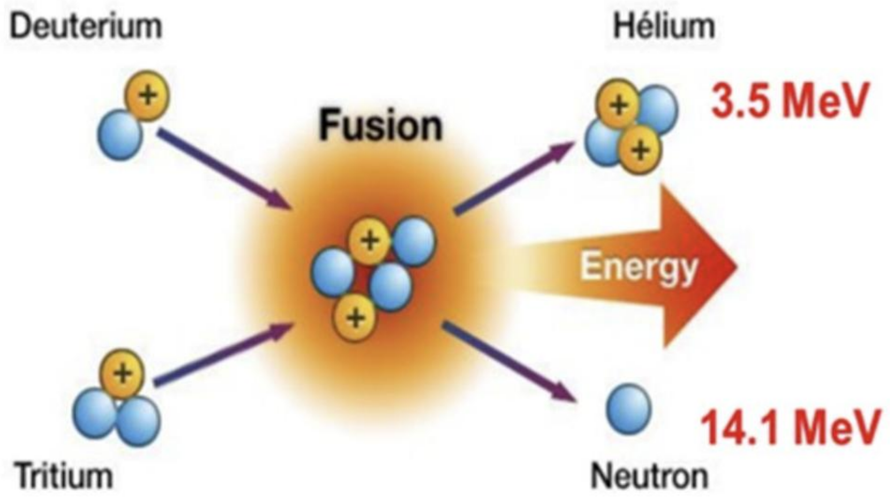
Power Plant

SPARC Specific

Summary of Challenges

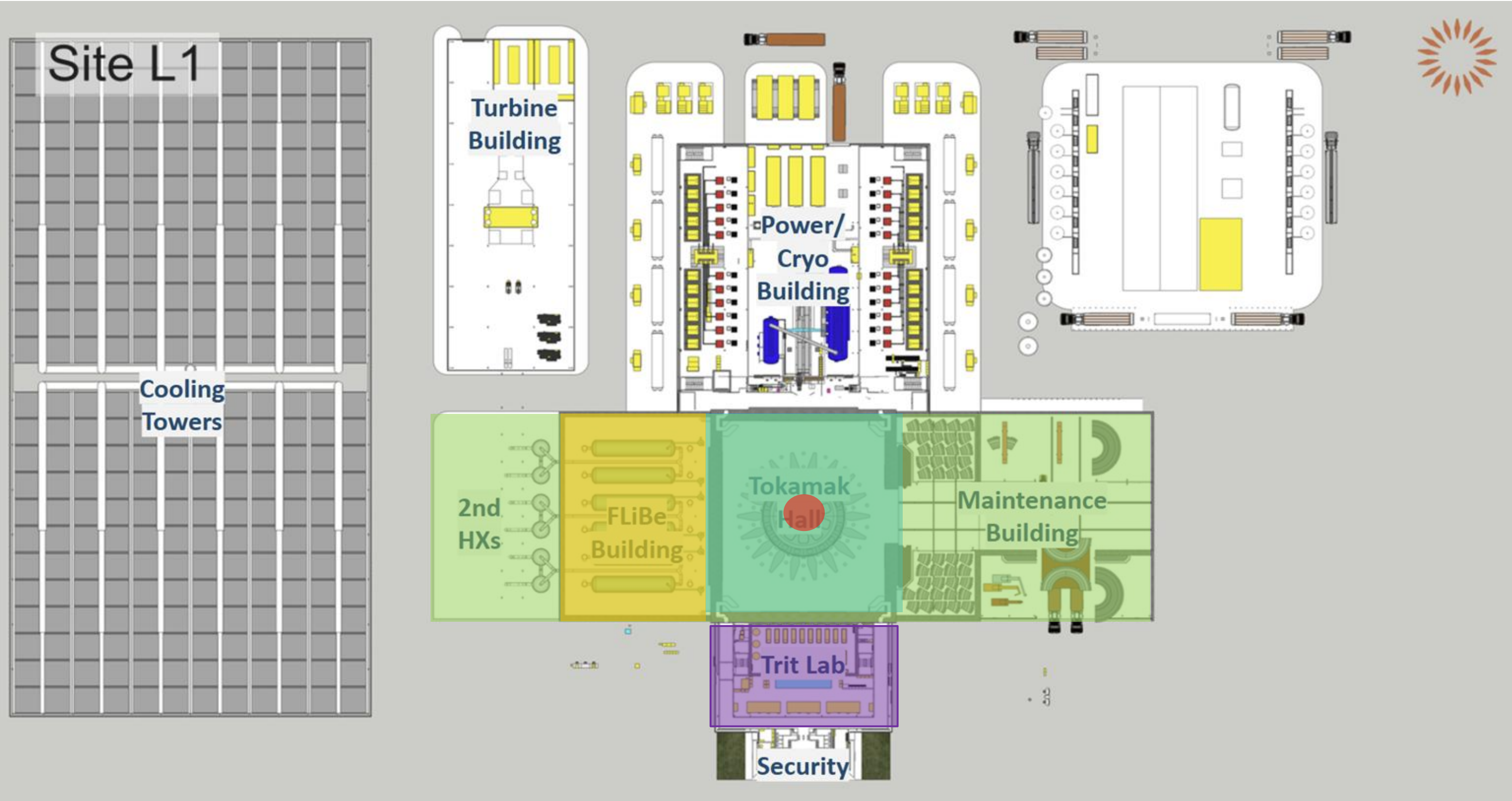
Fusion Power Plant Environment

- Neutron and gamma field
  - 14 MeV neutrons produced by the D–T fusion reaction
  - Primary photons produced in the plasma
  - Secondary photons created by n,g interaction with materials
  - Photoneutrons from runaway electrons and photon interactions with certain materials (e.g., Be)
- Activation products (APs)
  - Neutron interactions in materials create radioactive isotopes leading to gamma decay radiation fields
  - Different types: APs in structural materials, APs in coolants, gaseous APs
- Tritium
  - Main fuel for fusion reactions
  - Distributes in the tokamak (vacuum vessel, breeding blanket), tritium plant



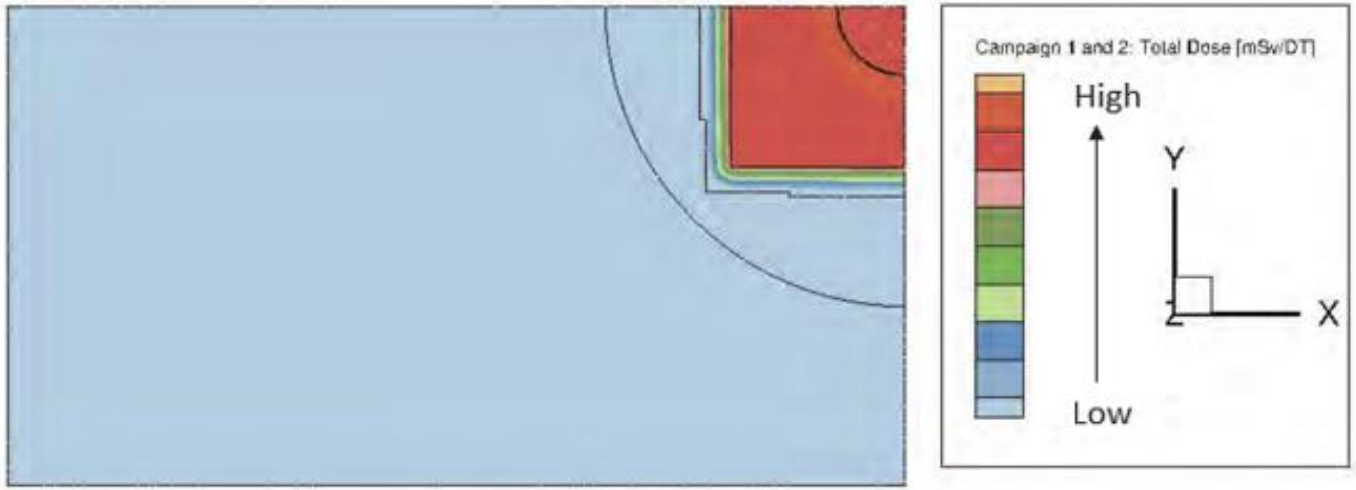
Fusion Reaction

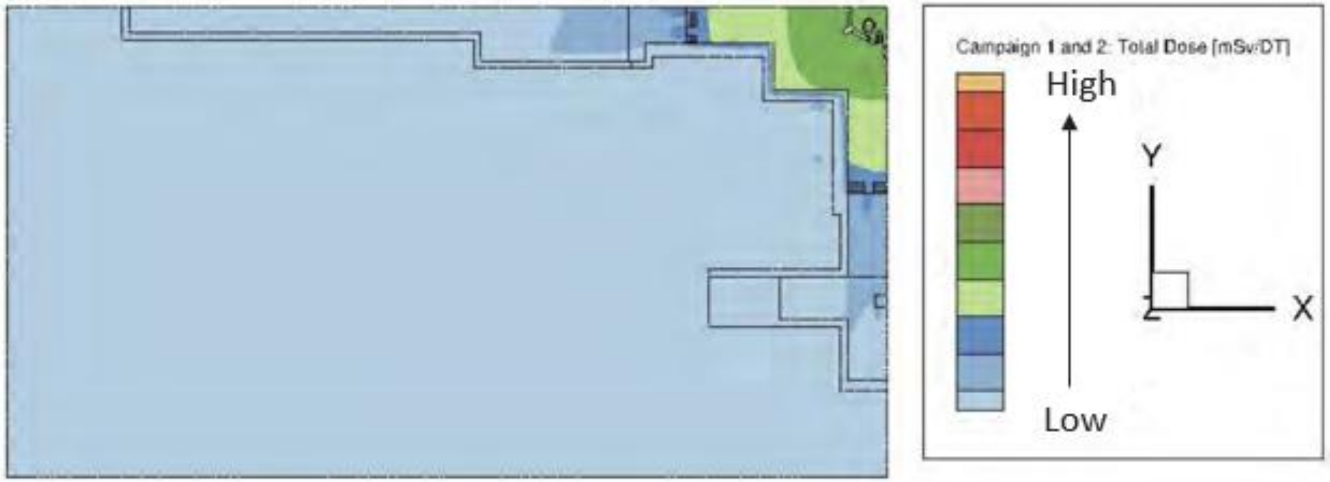
Examples of Environments



- Neutrons from Plasma
- Runaway electrons
- Photons from n,g interactions
- Working fluids
- Photoneutrons from FliBe
- Activated components
- Effluent

CFS SPARC Dose Fields

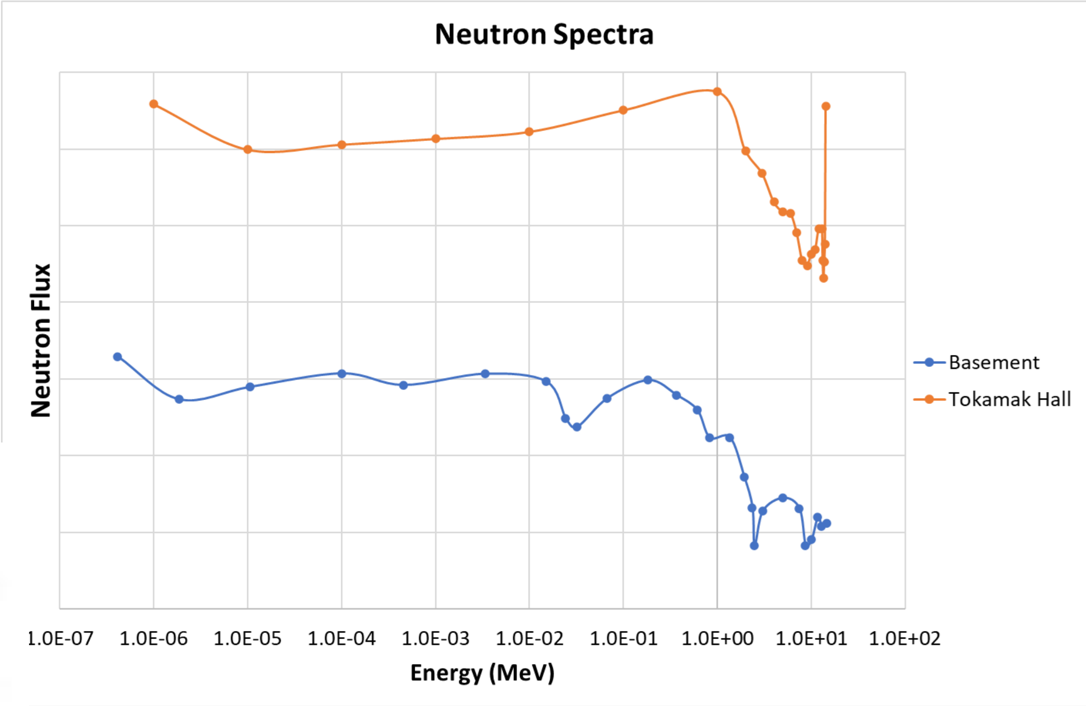


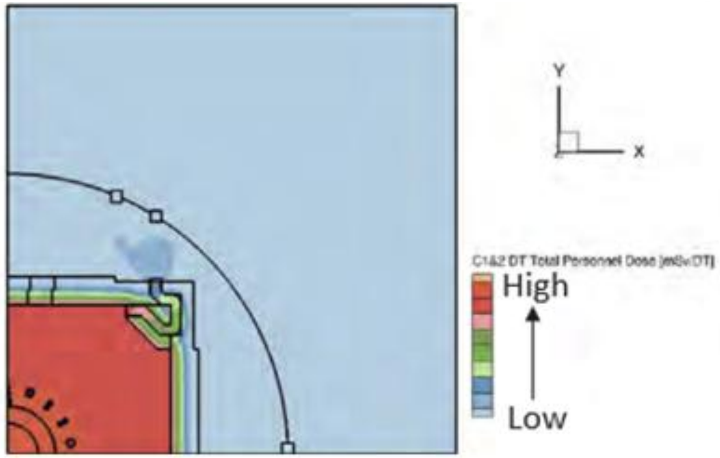


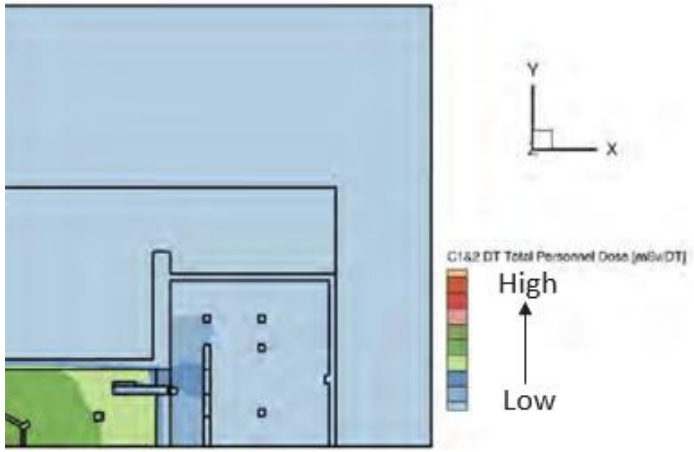
Highly spatially heterogeneous fields

- Thick tokamak building shield wall reduces the neutron flux by 6–10 orders of magnitude
- Penetration allows neutrons to stream out; local shielding needed
- Radiation intensity varies dramatically depending on location

Radiation Field in SPARC







Spectral variations across different locations

- Neutron spectra hardens or softens depending on the location

Summary of Challenges

- Broad neutron energy spectrum (thermal -> 14 MeV)
- Mixed radiation field (neutrons, photons)
- High fluxes and strong gradients
- Pulsed or time-varying operation
- Off-the-shelf detectors have not been tested sufficiently in fusion environments

Needs for standardization

Radiation protection and operational safety

Characterization of sources to calibrate fusion power diagnostics

Validation and benchmarks

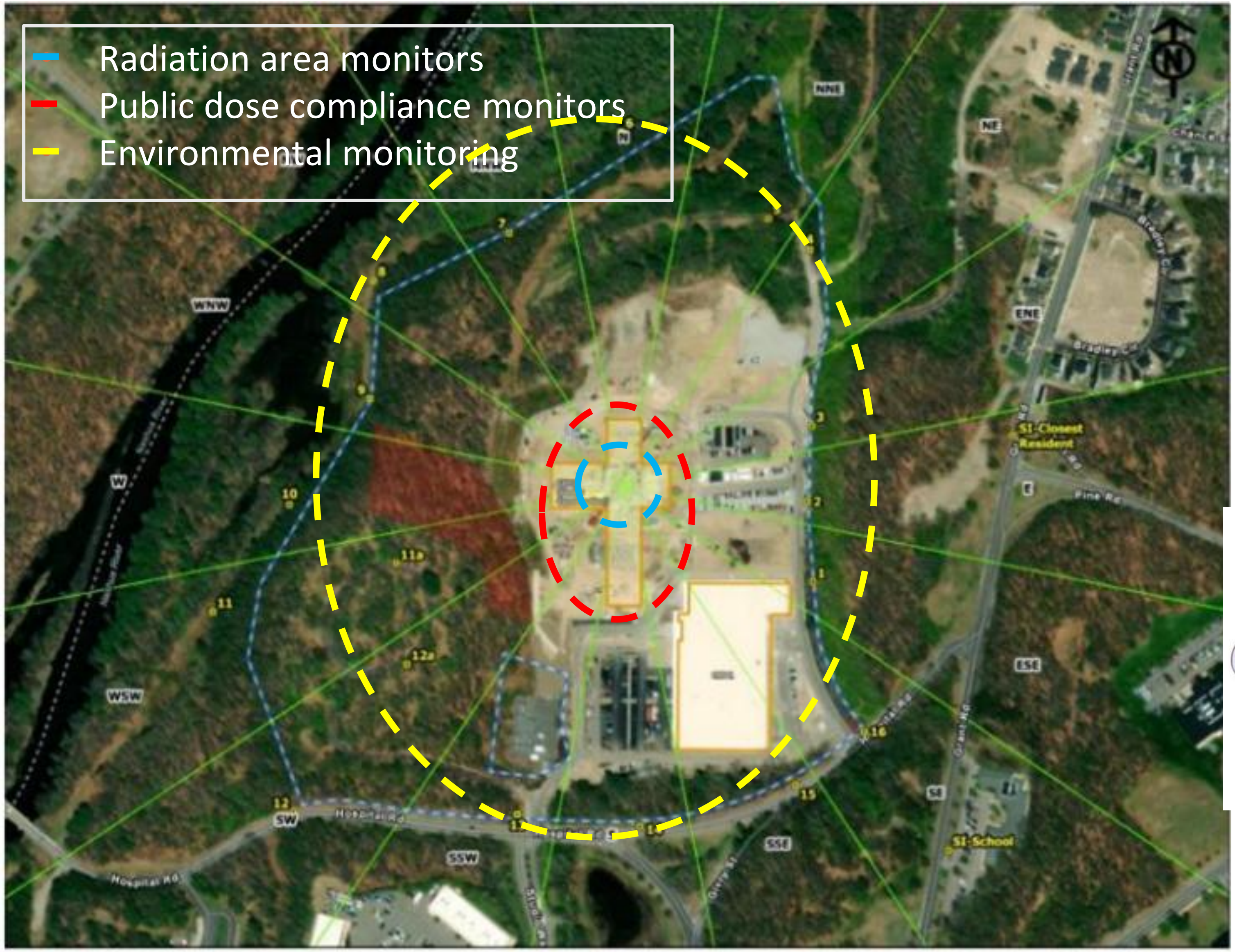
Radiation protection and operational safety

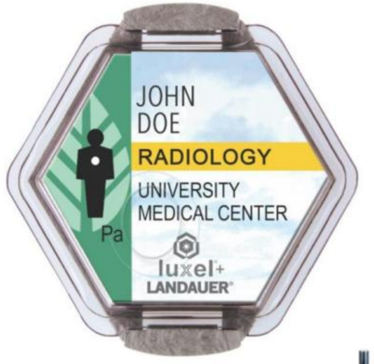
- Robust detection systems:
  - Work with the diversity of source terms and timescales
  - Reliable / repeatable performance
  - Work under magnetic fields

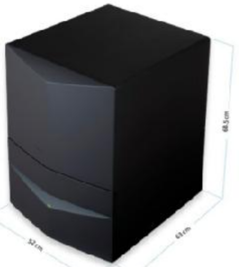
- Detection system calibration should adapt to fusion applications:
  - Traceable sources relevant to fusion (i.e., DT neutrons, broad spectrum)
  - Standardization of calibration process
    - Measurement procedure
    - Uncertainty quantification
    - Application of flux-to-dose conversion factors

Credit: PUBLIC HEALTH ENGLAND / SCIENCE PHOTO LIBRARY

SPARC Radiation Monitors

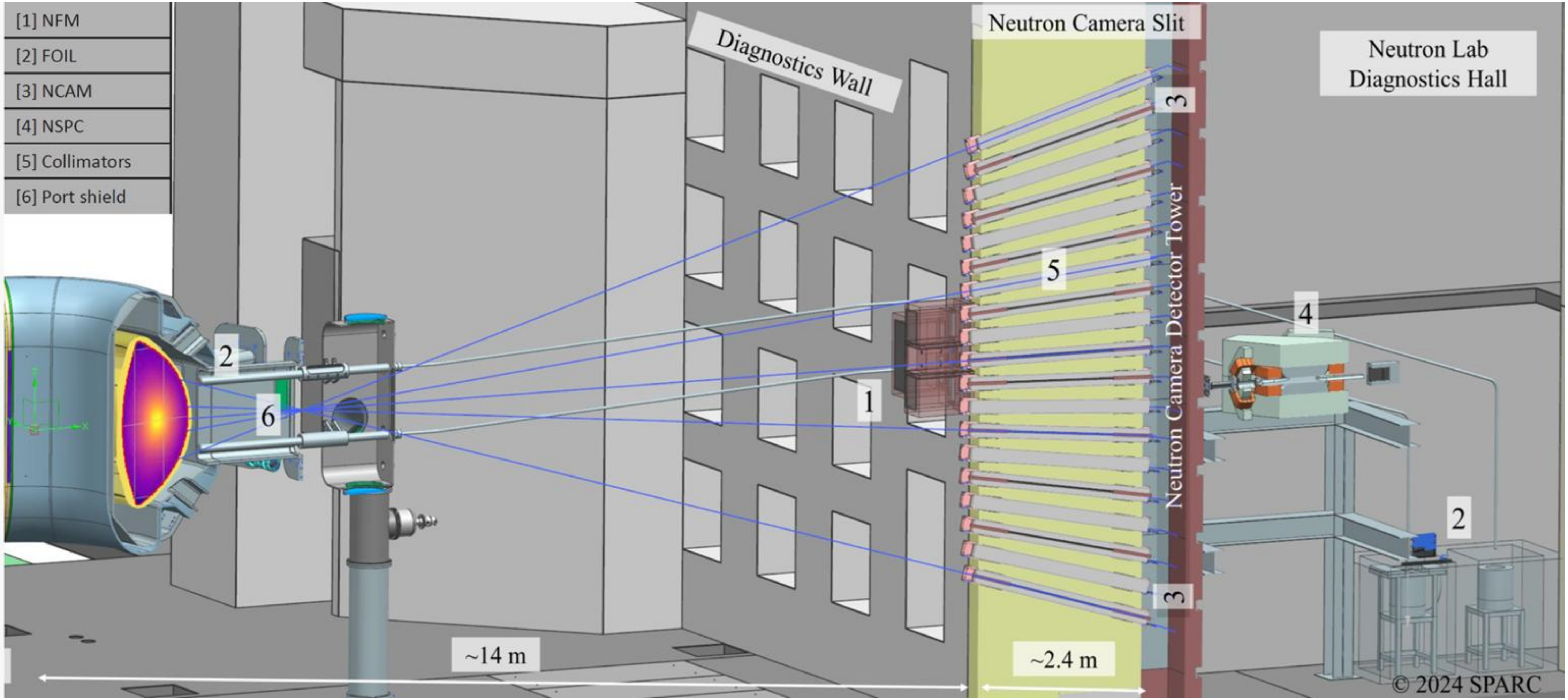






SPARC Neutron Diagnostics

Four neutron diagnostics systems will be installed for SPARC to measure neutron yield -> fusion power



Characterization of sources to calibrate fusion power diagnostics

Standardization of the characterization process:

- Measurement process
  - Robust reference detectors
- Calibration source yield calculation
  - Methods to measure total neutron yield
  - Methods to determine angular and energy distribution
- Uncertainty quantification

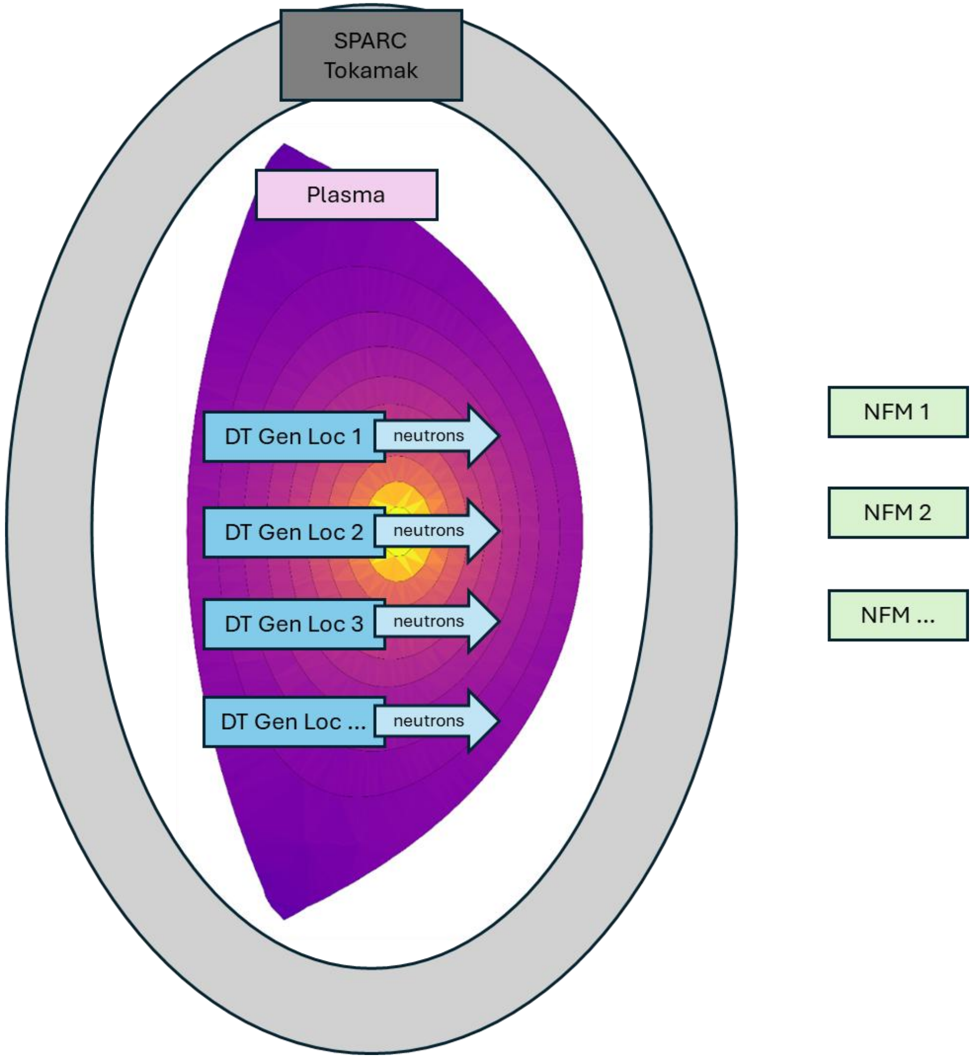
DT generator Thermofisher P383 Credit: https://www.lanph.mit.edu/dt-generator

Calibration strategy

- In-situ calibration:
  - DT generator inside plasma chamber
  - Systems: FOIL and NFM

- Ex-vessel calibration:
  - Detector specific position
  - Systems: NSPC and NCAM

Calibration requires well characterized and calibrated sources to minimize uncertainty in fusion power calculations



Validation and benchmarks

Need for detectors that can produce data to validate physics models and nuclear data:

- High quality responses
- Full characterization required (spectral sensitivity, efficiency, time resolution, etc)

Why this matters now?

- Fusion development is accelerating towards commercial deployment
- Radiation measurement capabilities must keep pace with industry needs
- We need tools and methods that are
  - Repeatable
  - Clear
  - Relevant

Where is early engagement between industry and standards organizations most critical?

Highest needs and impacts are for the detection systems calibration and source characterization

Development of standards to support them

Call to action

- Fusion brings new measurements and standards challenges at an unprecedented scale
- Addressing them will require collaboration across the community
- CIRMS can play a key role in:
  - Bridging critical gaps
  - Coordinating expertise
  - Defining priorities for the Needs Report

Potential technical session topics

Possible areas for deeper discussion:

- Characterization of fusion neutron sources
- Detector calibration for fusion environment
- Experimental benchmarks needs
- Standards for detector performance