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Sandia National Laboratories

COMPARISON OF DIAGNOSTIC CAPABILITIES AT SPHINX AND RKA PULSED POWER FACILITIES

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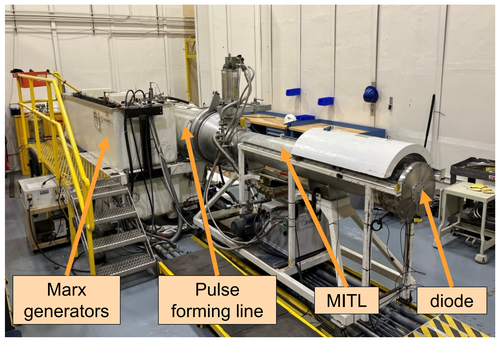
Overview

- Validating plasma codes like EMPIRE (SNL) and GAZEL (CEA) requires performing uncertainty quantification comparing simulation results and experimental data
- Collaboration between Sandia and CEA provides data collection for validation of codes for different geometries across a range of machine parameters
- Goal: develop synergistic capabilities and diagnostics to access a span of parameters within the plasma physics regime of interest, for more robust code validation
- Parameters of interest: endpoint voltage, beam current, fill gas, gas pressure, beam imaging, diagnostics that have simulation equivalents

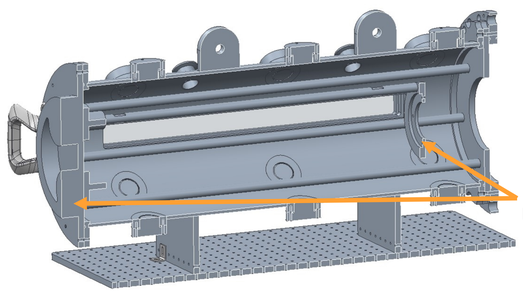
SPHINX: Short Pulse, High Intensity Nanosecond X-radiator



- 1.5 MV endpoint voltage
- Up to 40 kA beam current
- Variable pulse width, nominally 10 ns full width at half maximum (FWHM)

- 2 modes:
  - brems (5-mil tantalum converter)
  - e-beam (1-mil titanium converter) into gas cell

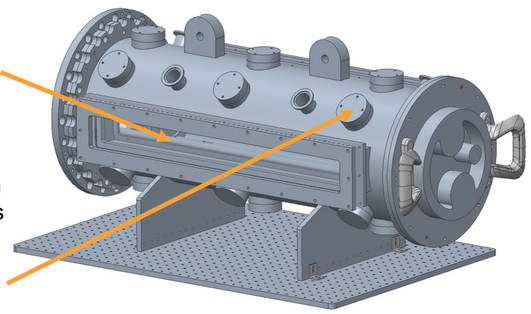
SPHINX Gas Cell Redesign: Expanding Diagnostic Capabilities



Windows for through-beam diagnostics (one on each side)

Customizable sample plates, with matched end plates

Diagnostic ports

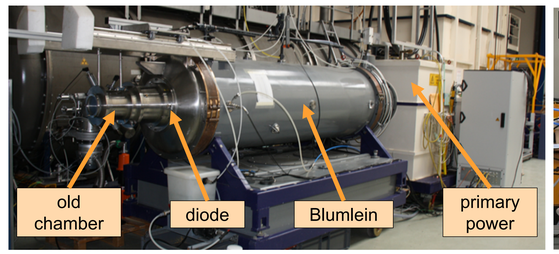


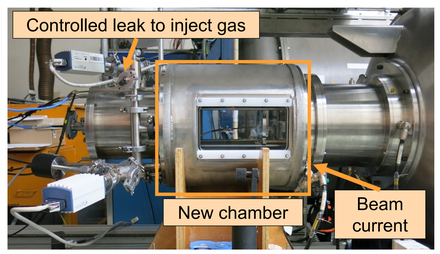
Diagnostic capabilities that are being planned for use with the new gas cell:

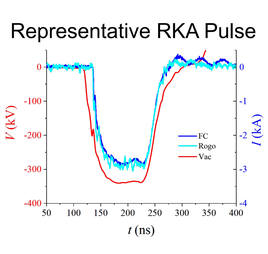
- Through-beam diagnostics like spectrometry and interferometry
- B-dot, V-dot, Electro-optical sensors (EOS), Magneto-optical sensors (MOS)
- Current-viewing resistors on return current rods
- Beam imaging of generated plasma
- Interchangeable sample plates, including but not limited to:
  - Calorimetry
  - Cerenkov plate
  - Faraday cup

RKA: Relativistic Klystron Accelerator

RKA is a 500 kV, 30 kA, 100 ns FWHM generator for electron beam studies

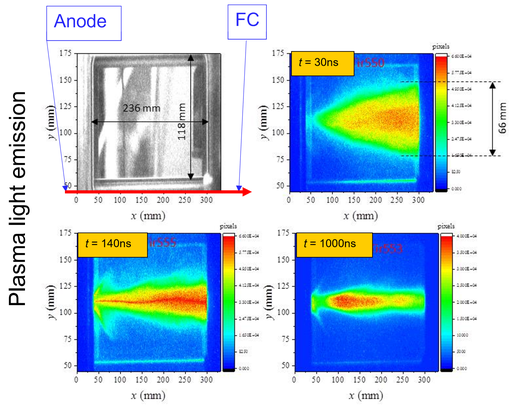


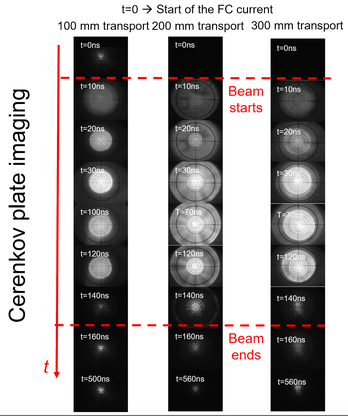




Diagnostics:

- Capacitive dividers: diode and gap voltage
- B-dots: diode current
- Rogowski coil: emitted current
- Cerenkov target: time-dependent beam imaging along z-axis
- Faraday cup (FC): beam current along z-axis
- Beam imaging: plasma light emission
- Smith-Purcell radiation diagnostic: axial velocity





Comparison

- Comparable diagnostic capabilities include B-dots, Faraday cup, Cerenkov plate, and beam imaging
- Capability differences include calorimetry at SPHINX and Smith-Purcell diagnostic at RKA
- Machine pulse differences
  - SPHINX: 1.5 MV, ~32 kA, 10 ns FWHM
  - RKA: 500 kV, 30 kA, 100 ns FWHM
- Gas cell lengths: SPHINX is 91 cm; RKA is ~40cm

Advantages

- Robust code validation to establish higher confidence in EMPIRE and GAZEL transport codes requires gathering validation data across a variety of gas cell geometries and machine pulse characteristics
  - Example: initial EMPIRE simulations of SPHINX indicate a higher pressure regime may be needed to get full beam transport across the cell
- Implementing diagnostics in simulation is more streamlined with comparable experimental capabilities

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