Progress Toward Development of an IFE Power Plant Using Z-Pinch Technology*

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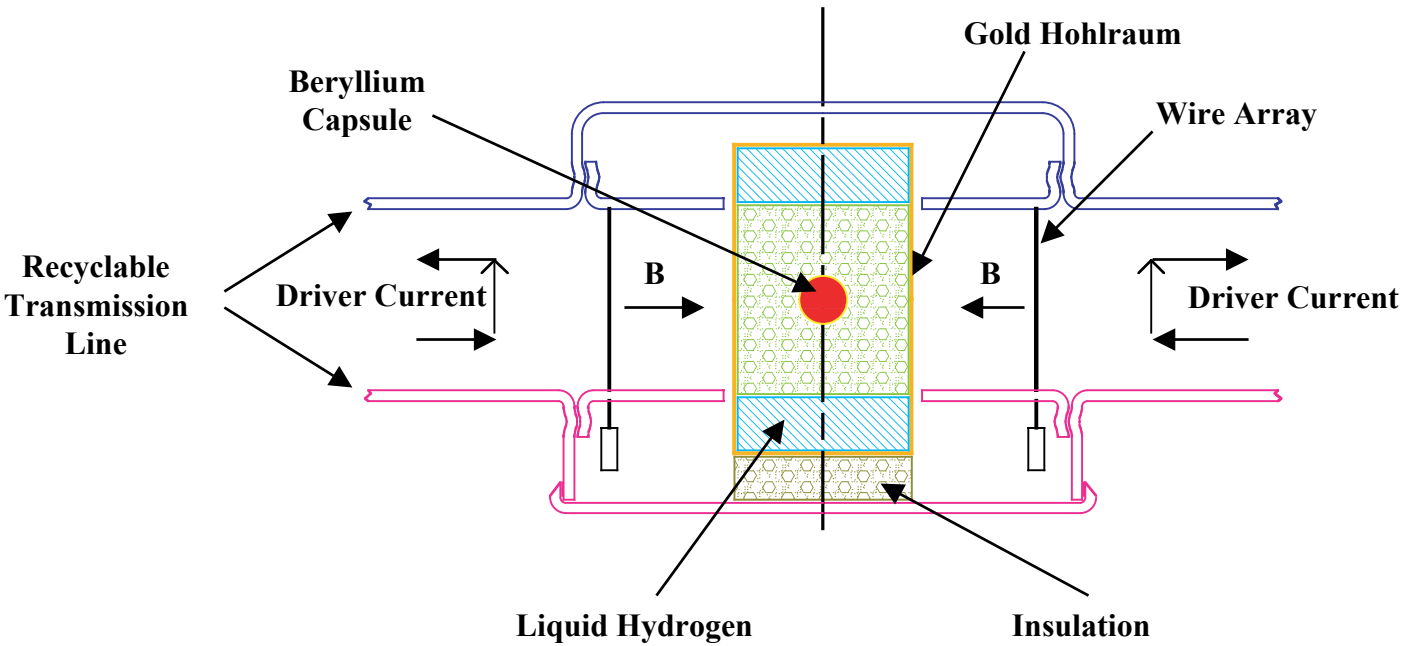
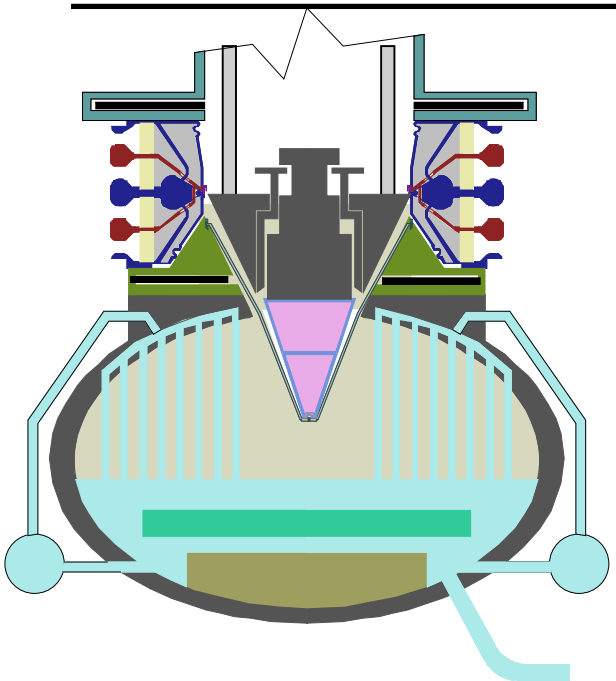
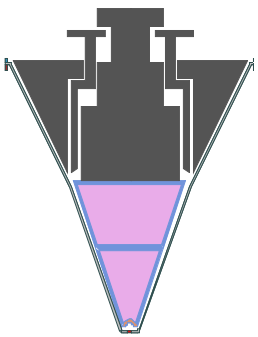
  - Kurchatov
  - Tomsk

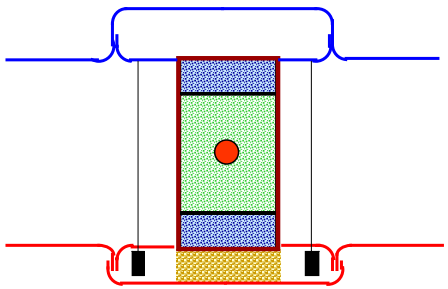
Z- Pinch Approach to ICF



Z-Pinch Power Plant General Concept



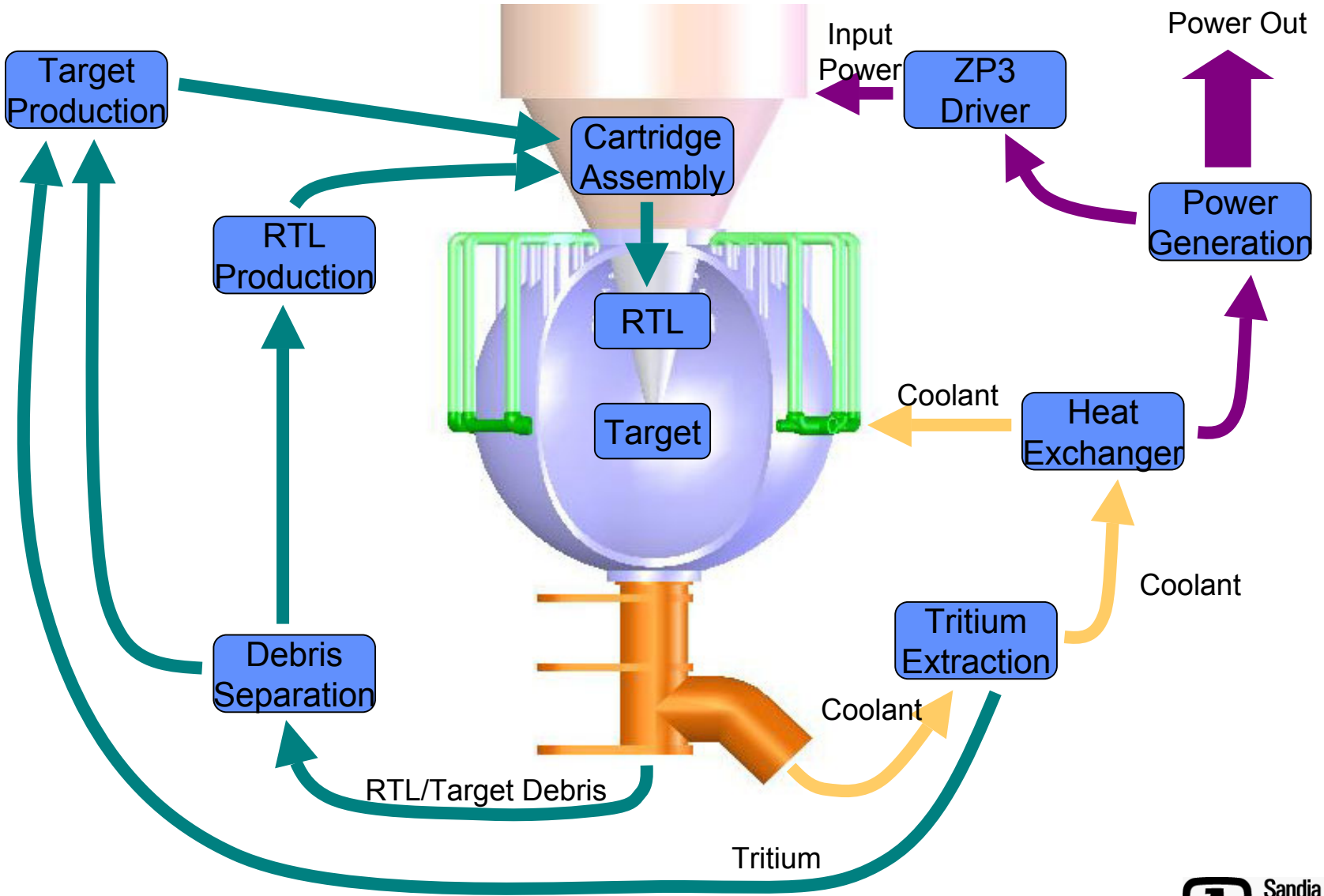




Cartridges containing fusion capsules are repetitively inserted, ignited and burned in a dynamic hohlraum driven by a shaped 150 ns rise time 60-100 MA pulse connected through a recyclable transmission line.

Current Objective:

Define a Power Plant Concept utilizing Inertial Fusion Energy driven by a pulsed power z-pinch x-ray source and define a development program.

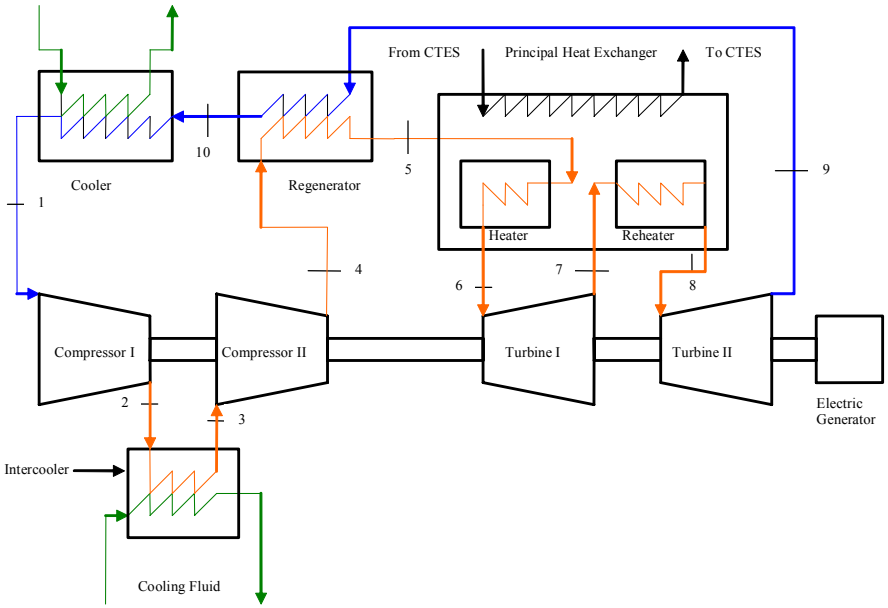


Proposed Z-Pinch Power Plant Operating Parameters

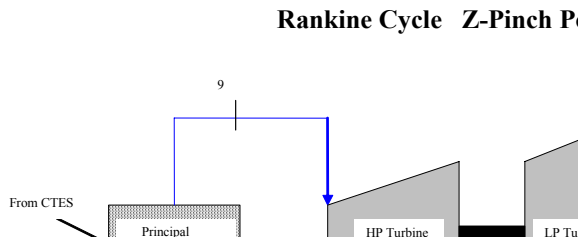
DESCRIPTION	BASELINE VALUES	RATE CHALLENGE VALUES	YIELD CHALLENGE VALUES	CONVERSION CHALLENGE VALUES
Nuclear Energy Released per Pulse (GJ)	3	3	20	3
Energy Recovery Factor	100%	100%	100%	110%
Thermal Energy Recovered per Pulse (GJ)	3	3	20	3.3
Pulse Frequency (Hz)	0.1	0.3	0.1	0.1
Thermal Power per Unit (GW)	0.3	0.9	2.0	0.3
Coolant Temperature (Kelvin)	817	817	817	1550
Thermal Conversion Process	Rankine	Rankine	Rankine	Brayton
Chamber Pressure (Torr)	20	20	20	200
Thermal Conversion Efficiency	34%	34%	34%	50%
Electrical Output Power per Unit (GW)	0.10	0.3	0.7	0.16
Number of Units per Plant	10	4	2	7
Plant Availability, Capacity Factor	80%	95%	95%	80%
Total Plant Power Output (GW)	1.0	1.2	1.4	1.2
Annual Power Sales (kWh)	7.1e9	9.9e9	11.3e9	8.1e9

A Z-Pinch Power Plant Energy Extraction

Brayton Cycle



Rankine Cycle



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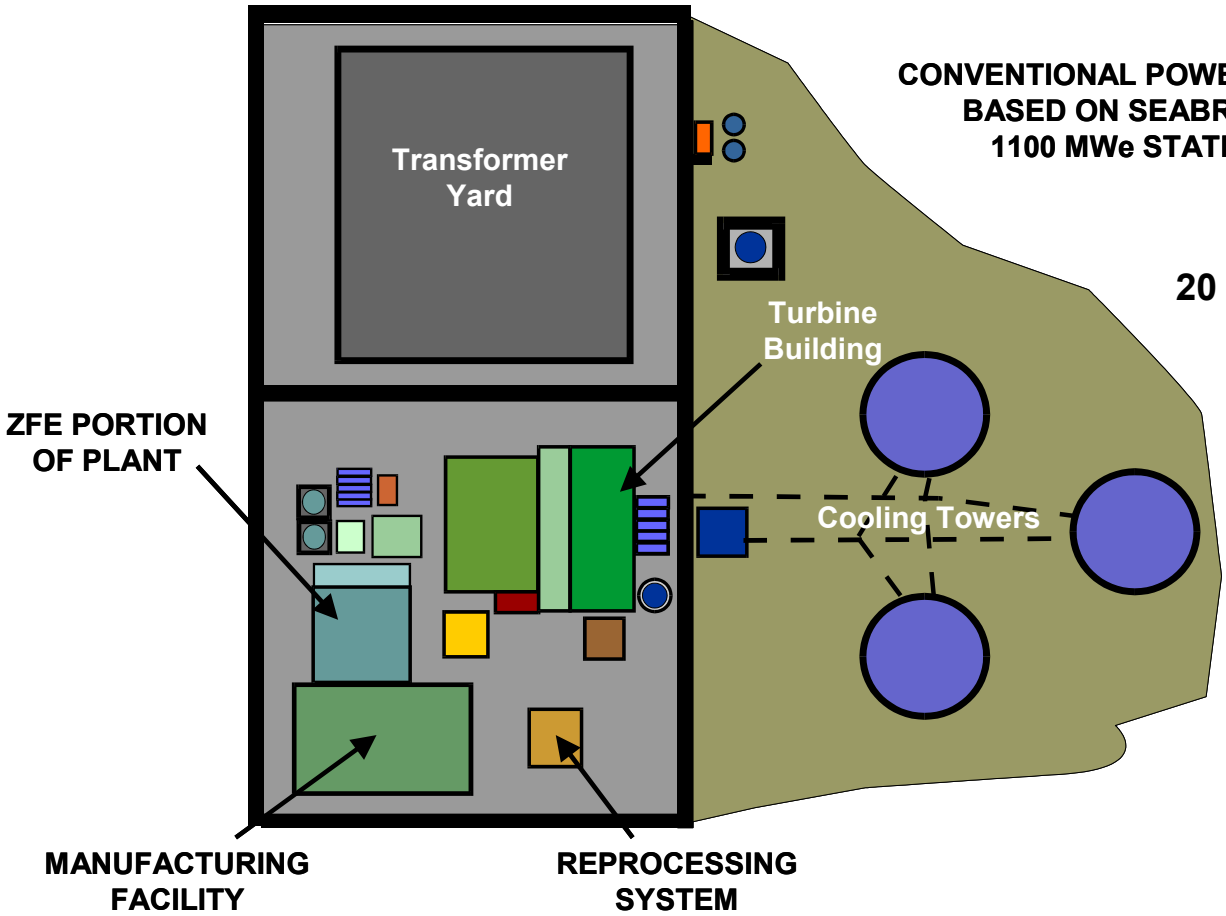
Z-Pinch Power Plant
Conceptual Plant Layout



CONVENTIONAL POWER PLANT
BASED ON SEABROOK
1100 MWe STATION

20 Gigajoules-Fusion @ 0.1 Hz

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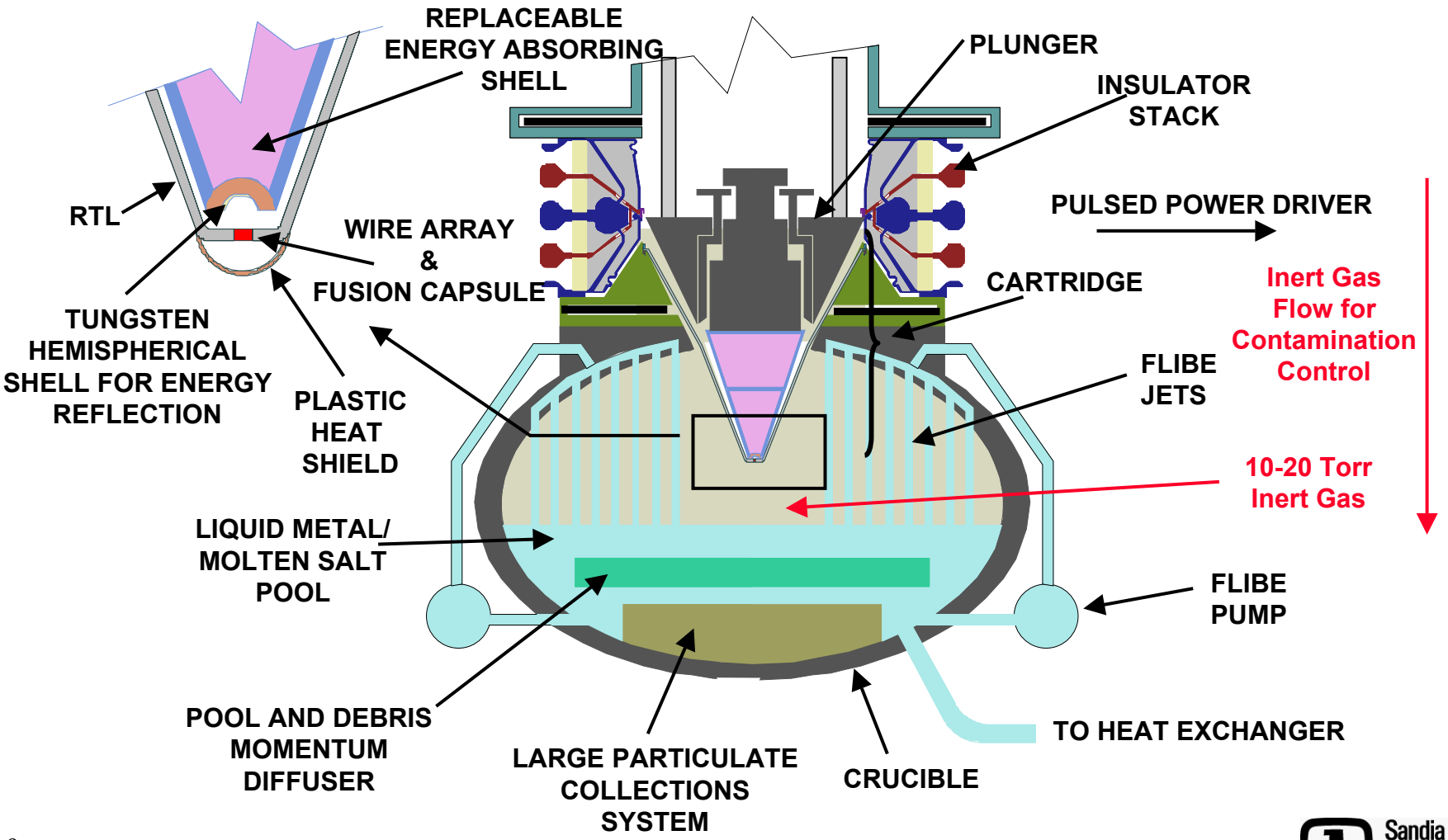
Z-Pinch Power Plant
Crucible Details



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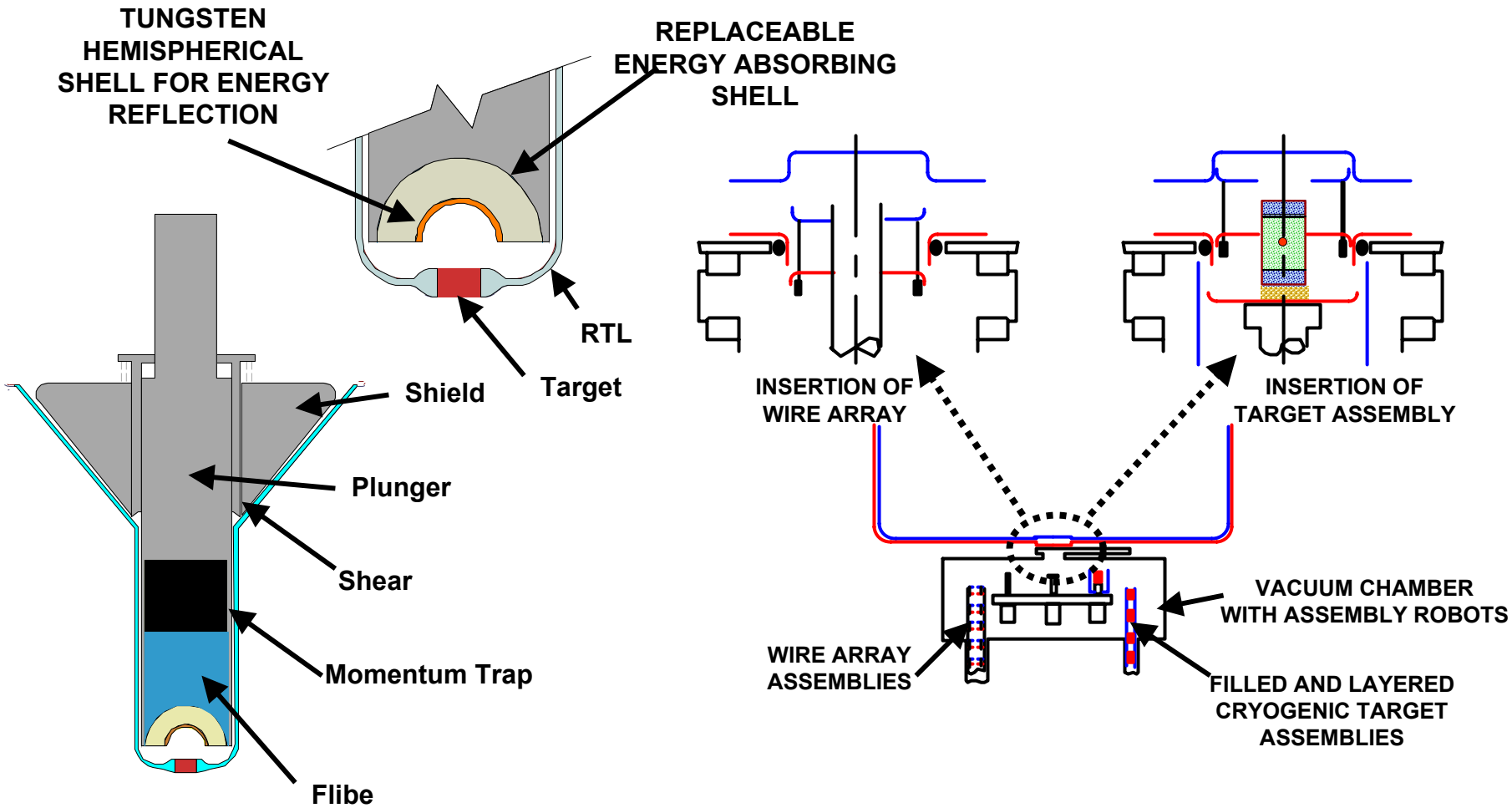
A Z-Pinch Power Plant Cartridge Details



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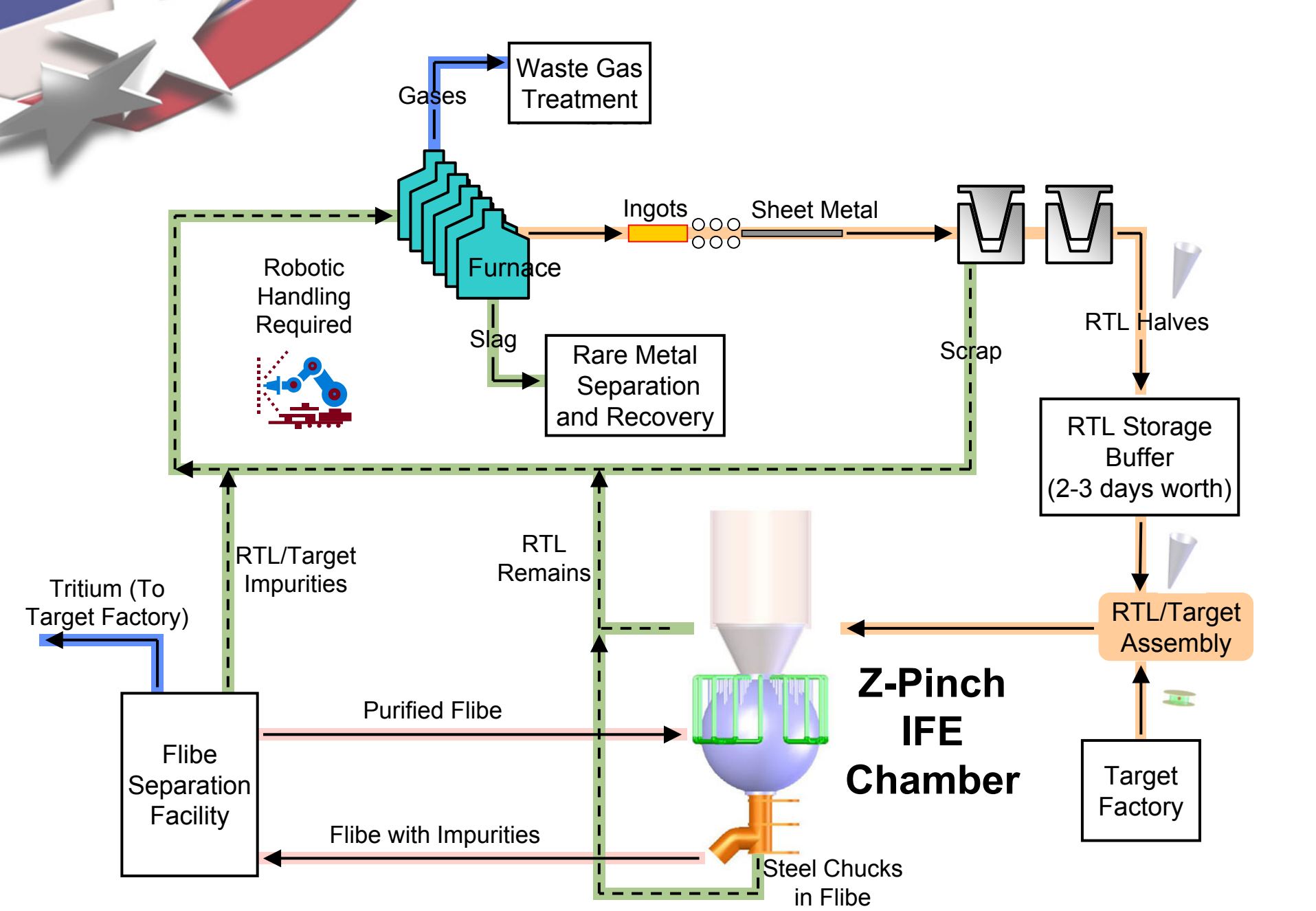

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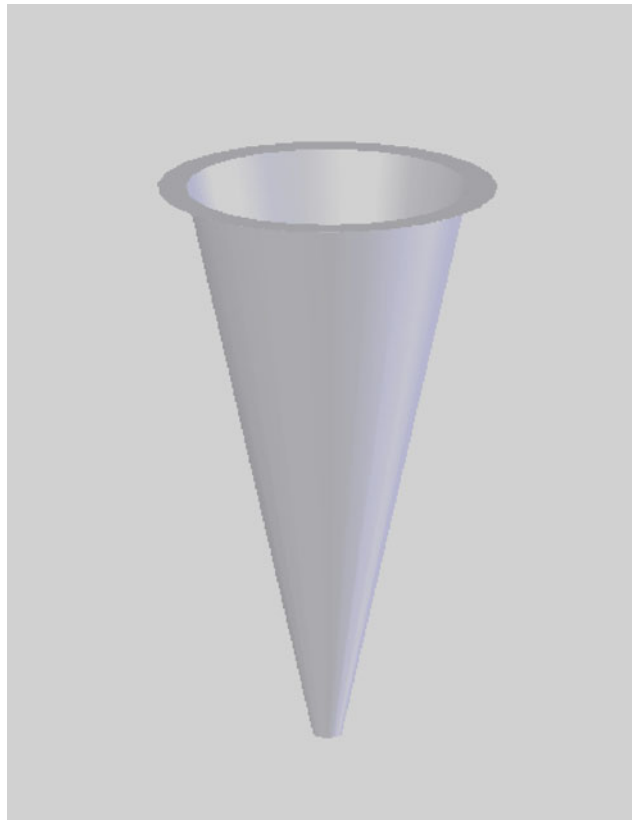
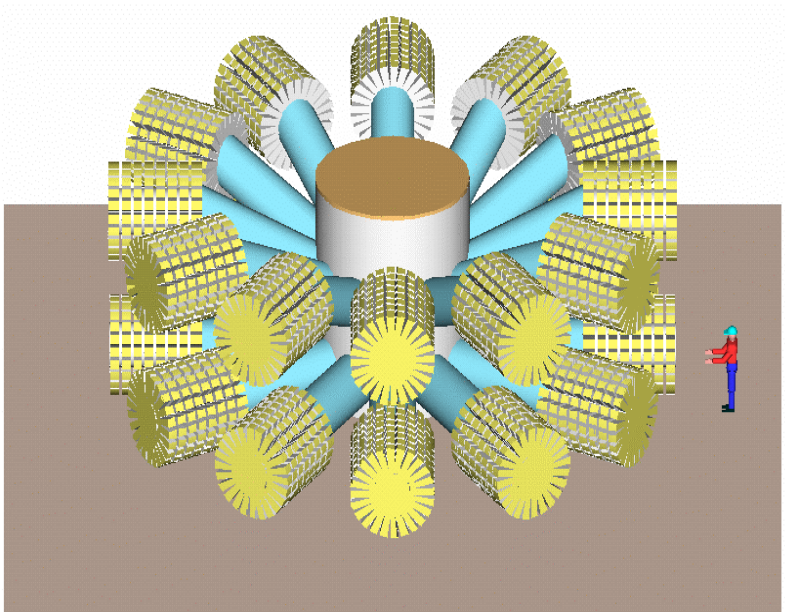
Mechanical Testing of A Full-Scale RTL has begun

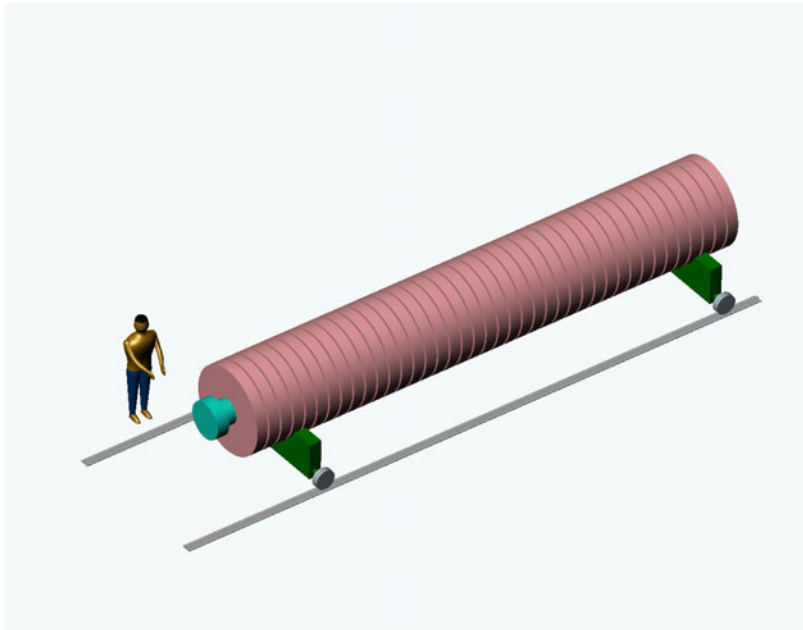
- Modeled by ANSYS and ABACUS and theory
- Constructed to a mass of 50 Kg
- Manufactured using a spinning process
- 8 constructed for testing of buckling
- 0.6 mm thick by 2 m long and 1 m in diameter
- Designed for 20 Torr differential pressure with 2.5 x below buckling limit



ZP3 Pulse Power Driver

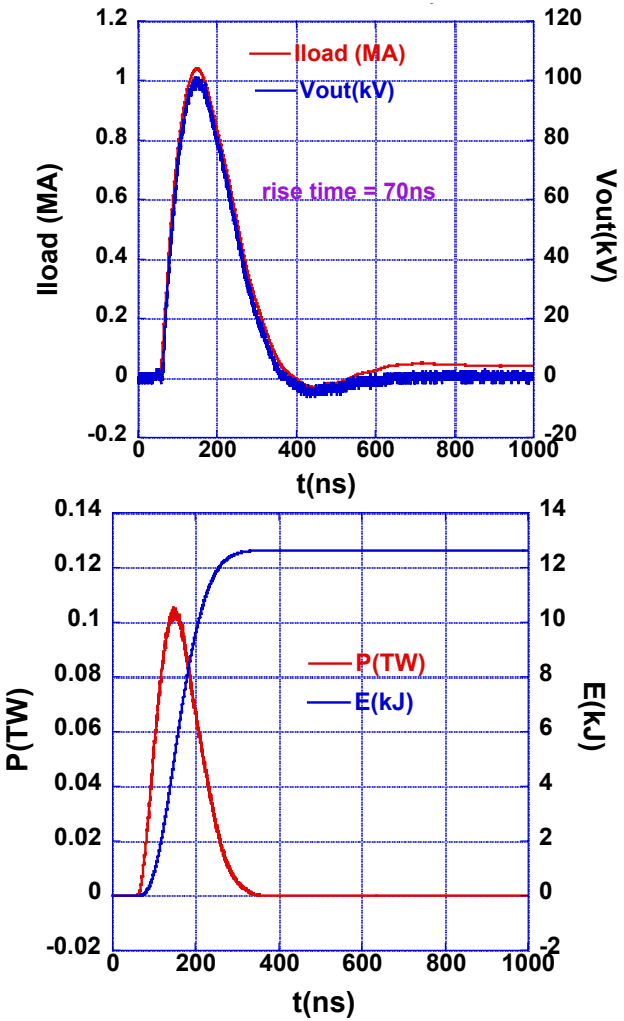


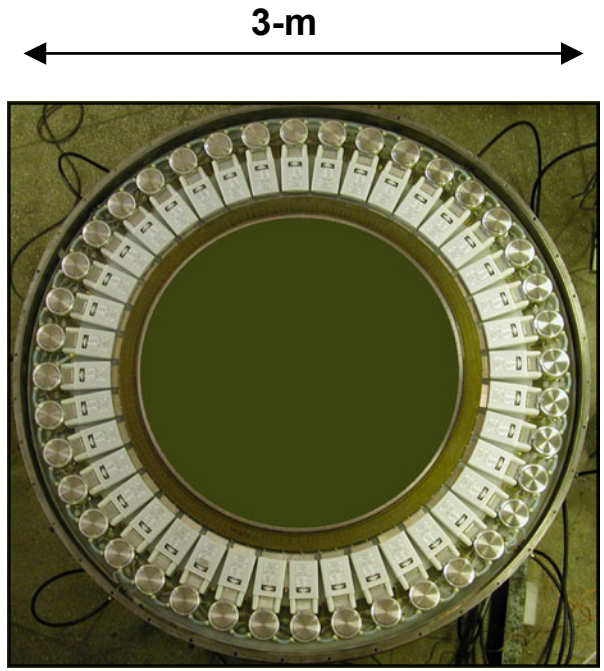
3 MV, 10 MA Driver



10 MV, 0.1 MA Driver

ZP3 Prototype Module Has Been Constructed and Tested





1-MA, 100kV, 70ns LTD cavity (top flange removed)

80 Maxwell 31165 caps,

40 switches, ±100 kV

0.1 Ohm load **0.1TW**

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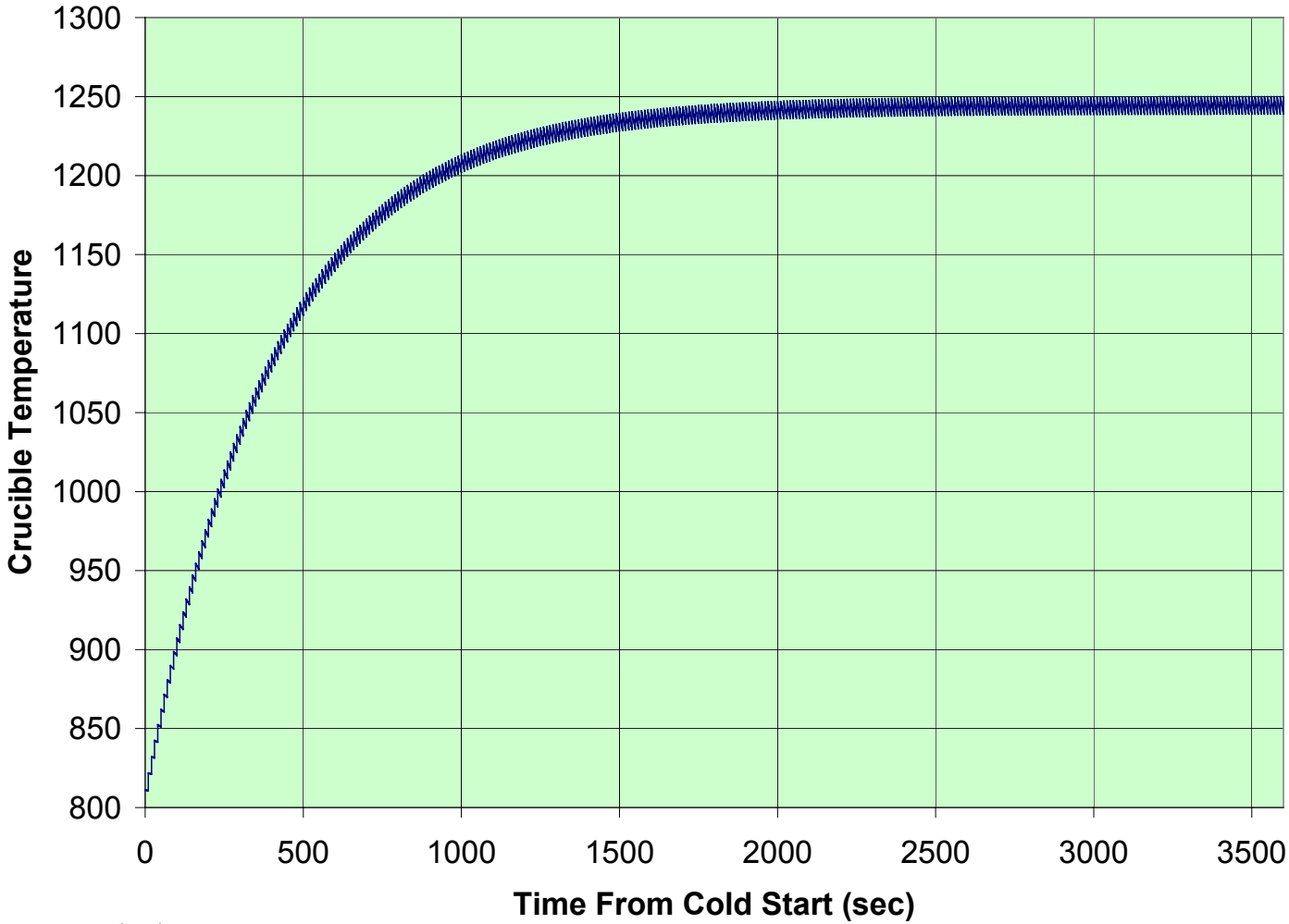
A Z-Pinch Power Plant Containment Details

- Flibe has good shielding characteristics
  - Concern for stability at high energy densities
- 0.4 m equivalent thickness of Flibe is needed to make steel crucible wall and driver components last the lifetime of the plant from radiation.
- Larger thickness of 1 m will be used to achieve Tritium Breeding Ratio of 1.1
- Overall energy multiplication is 1.1
- 10% of the energy is deposited in crucible wall
- Containing the shock is a major issue.

Crucible Warm-Up Curve



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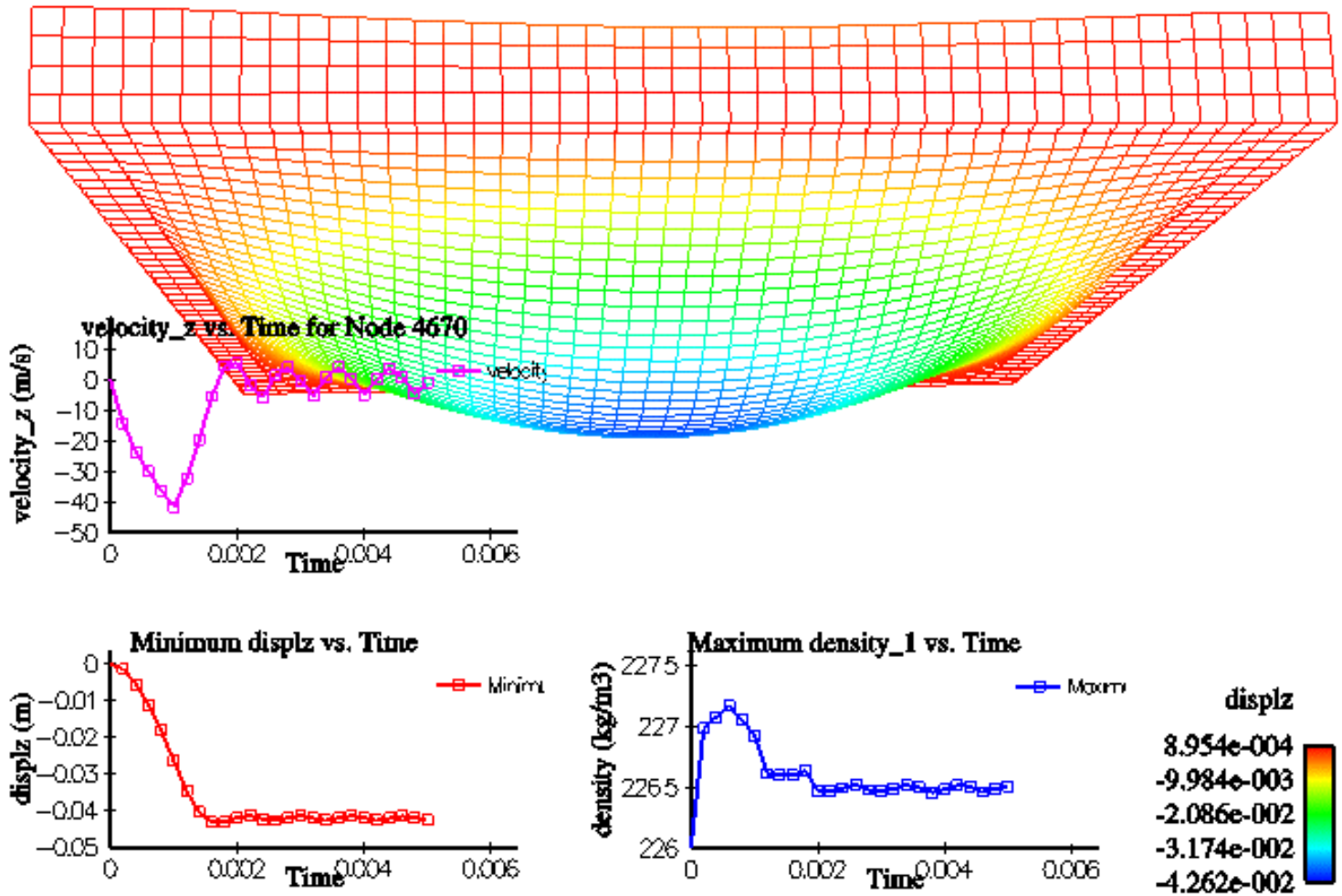
Preliminary ALEGRA Shock Tube Metal Foam Experiment Simulation



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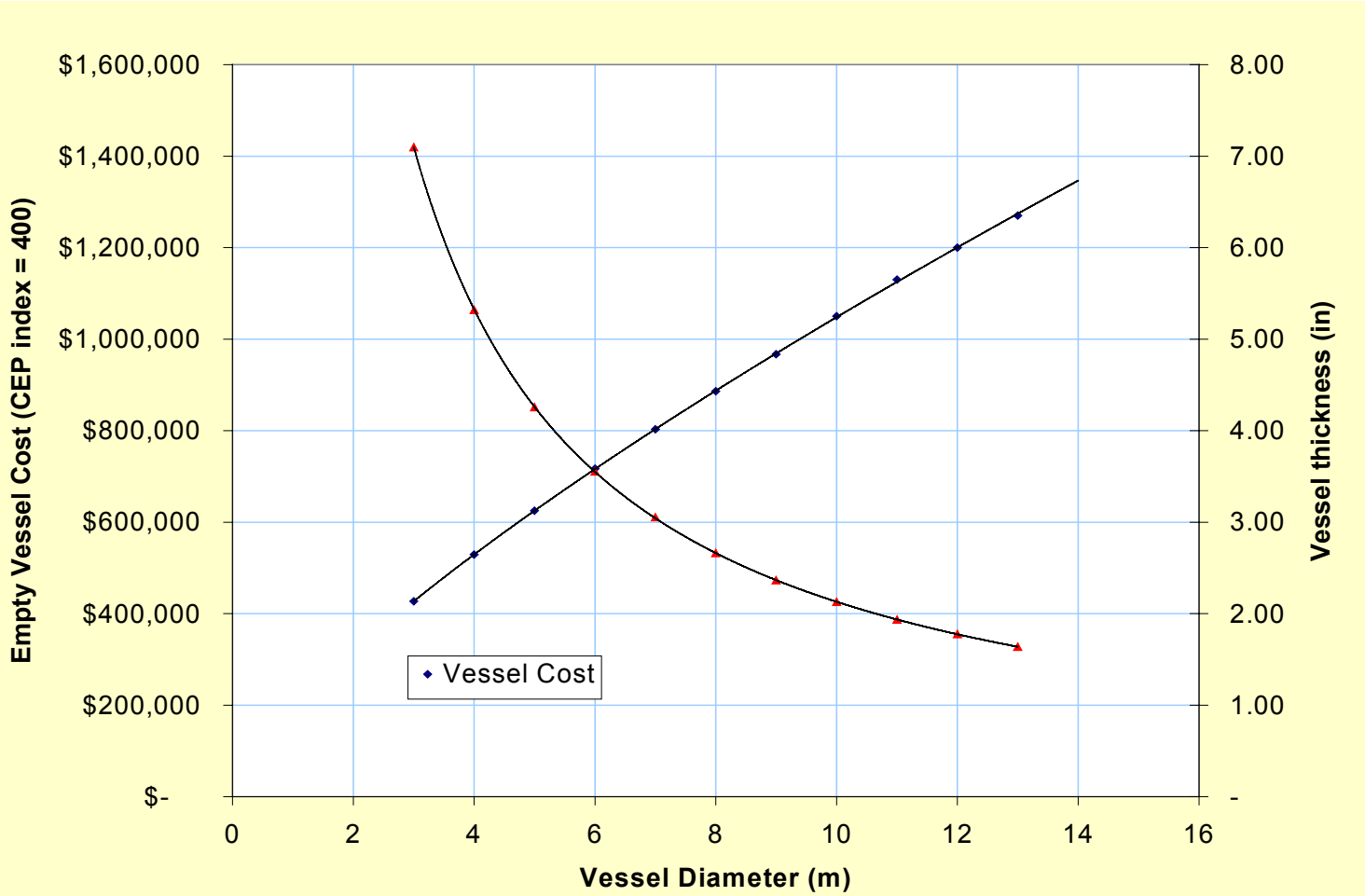
Crucible is on the order of a PWR PV



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ZP3 Path Forward

- Continue building a broad collaborative effort
- Continue to evolve the Conceptual Baseline
  - Identifying options to minimize development and capital cost
  - Minimize manufacturing requirements
- Refine concepts through modeling and experimentation.
  - Establish benchmarks for codes
  - Identify important scientific research

Status of Research on Z-Pinch Power Plant

- Concept Development
  - Conceptual Baseline in progress
  - Options list under development
- A large collaboration to evaluate the concept
  - identify scientific issues
  - propose research for resolution and technology development
- Working groups have been formed to define issues, set goals, determine costs, and make plans for the six PoP areas:
  - Full development and demonstration of the RTL concept
  - Rep-rated pulse power with an RTL at 1 MA
  - Energy and shock containment
  - Full RTL manufacturing cycle
  - Z-Pinch IFE target development
  - Z-Pinch Power Plant technology