



Charger-1: A Pulsed Fusion Propulsion Testbed

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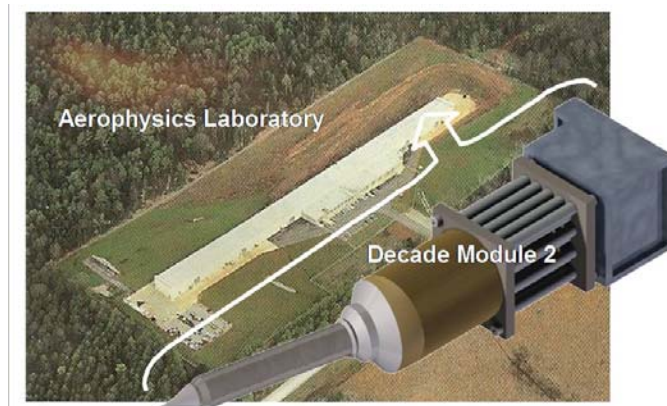
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1



What We're Building

- A test facility for high power and thermonuclear fusion propulsion concepts, astrophysics modeling, radiation physics
- Located in the UAH Aerophysics Lab at Redstone



2



What We're Building



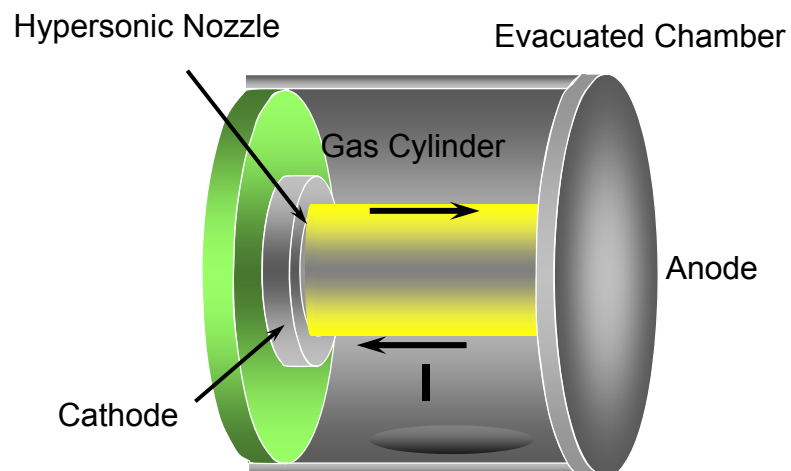
- The highest instantaneous pulsed power facility in academia – 572 kJ (1 TW at 100 ns)
- Main equipment donated by DTRA to UAHuntsville
- MSFC loaning experiment side equipment, expertise, other equipment



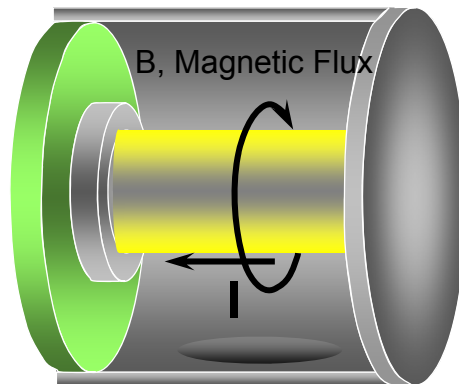
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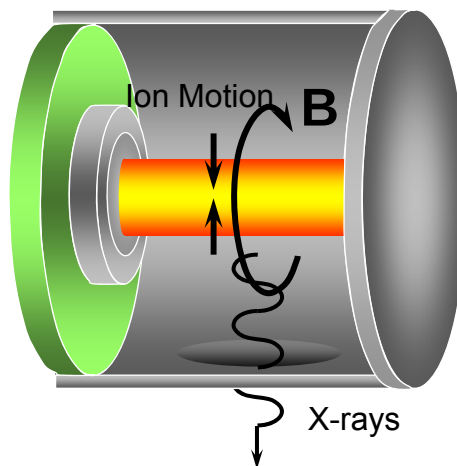
Operation of a Z Pinch



Operation of a Z Pinch

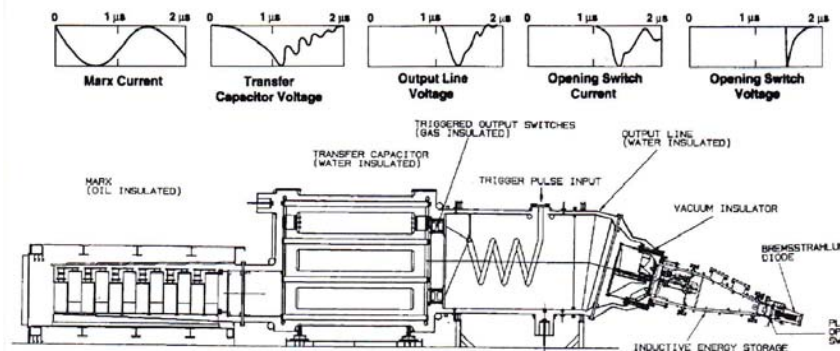


Operation of a Z Pinch



How It Works

- Successive systems compress and intensify pulse
 - 1.2 MV @ 1 MA over 100 ns



7

Marx Bank

- Full power: charged to ± 85 kV
- Aerovox capacitors, $C = 2.2 \mu\text{F}$, rated at 100 kV
- Once triggered, erected Marx looks more or less like a single capacitor with value $1.1 \mu\text{F}$, charged to 1.02 MV
- **Total stored energy: 572 kJ**



Transfer Capacitor

- Collection of 32 coaxial lines bussed together on either end
- Water filled
- Urethane diaphragm that separates oil in Marx tank from water in the TC
- Total capacitance $C = 0.43 \mu\text{F}$
- Divertor switches located on both upstream and downstream ends of TC
- Designed to remove 320 kJ immediately after forward pulse has passed



Output Line: Switches

- 6 switches control output from TC: these switches are fired simultaneously and are in parallel to share the output current equally
 - Pressurized with SF_6 to ~90 psig (variable depending on test)
 - Last triggered stage in pulsed power system
 - Peak voltage on switches: 1.2-1.4 MV
 - Total current carried: 1.6-1.8 MA
- Jitter in the firing of output switches is ~2-3 ns leading to an overall jitter in the arrival time of the current at the front end of 4-5 ns





Output Line



- Single line has impedance $Z \sim 0.5 \Omega$ and is 100 ns long
- Total insulator stack height is 35 cm
 - This design requires cleaning of the insulator surface after 20-30 full power discharges
- At the end of the water OL is an oil section isolated on the upstream side from water by a 1 inch thick polyurethane diaphragm and isolated on the downstream side from the vacuum components by a 16 gradient ring, polyurethane and Dendresist, high voltage insulator (see picture)



Test Stand



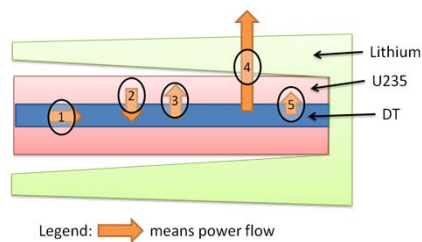
- Formerly GDM experiment in PRC – loaned to Aerojet
- 48" dia x 5 ft long vacuum chamber
 - 15 ports, large sight glass
 - Hinged end door
- Alcatel Pascal Series roughing pumps
- Alcatel turbopumps
- Miscellaneous valves, controllers, isolation gate, cables, etc.
- Larger roughing pumps acquired



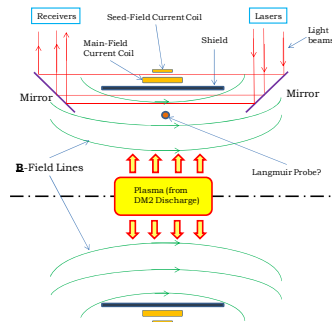
12

Planned Experiments

- Pulsed Fission-Fusion (PuFF)
(Subscale Thermonuclear Test)
 - Leverages legacy nuclear experience
 - Potential for nearer term thermonuclear fusion
 - Addresses plasma instability issues



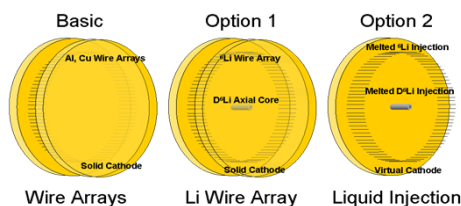
- Magnetic Nozzle Experiment
(Pulsed Plasma Propulsion)
 - Seed field propagation
 - Field line freezing
 - Scaling laws relating solar and laboratory scales
 - Test bed for space weather codes



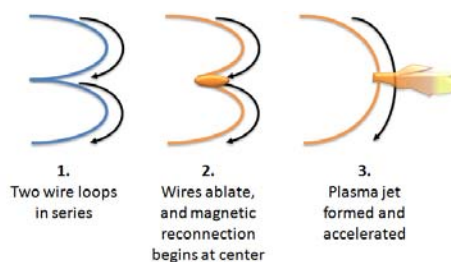
13

Planned Experiments

- LiD Wire Array Diode
(Subscale Thermonuclear Test)
 - Measure x-ray and neutron output
 - Estimate fusion energy output
 - Code validation
 - Optimization of diode design
 - Scaling for break even design



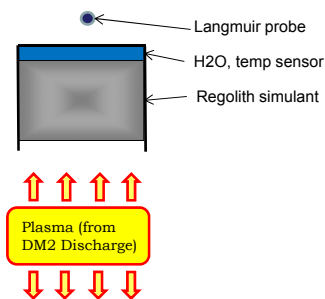
- Simulation of Coronal Mass Ejection (Space Weather Experiment)
 - Measure jet velocity
 - Magnetic reconnection physics
 - Scaling laws relating solar and laboratory scales
 - Test bed for space weather codes



14

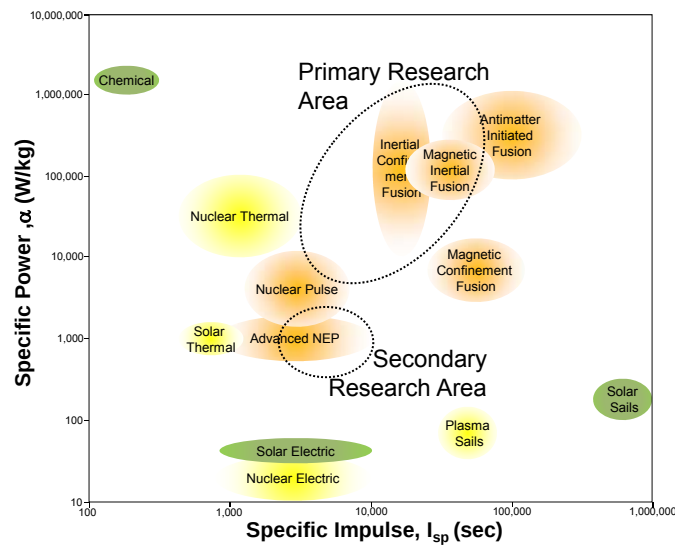
Planned Experiments

- Solar Wind Interaction with Lunar Regolith (Space Weather)
 - Tests possible depth of H₂O on Moon
 - Measures shielding capabilities of regolith
 - Improves understanding of plasma impingement physics
- Other Experiments
 - Ablative Z-pinch
 - Radiation shielding

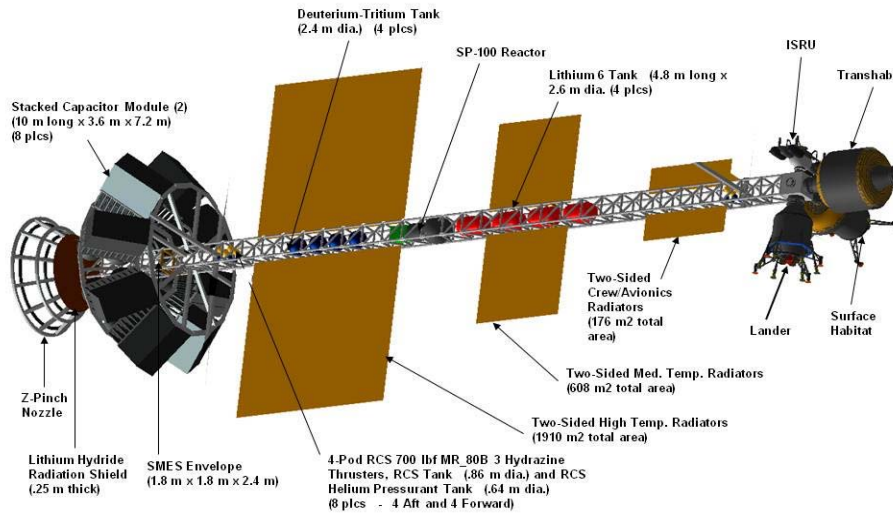


15

Propulsion Technologies



Propulsion Technologies



Status - Facility

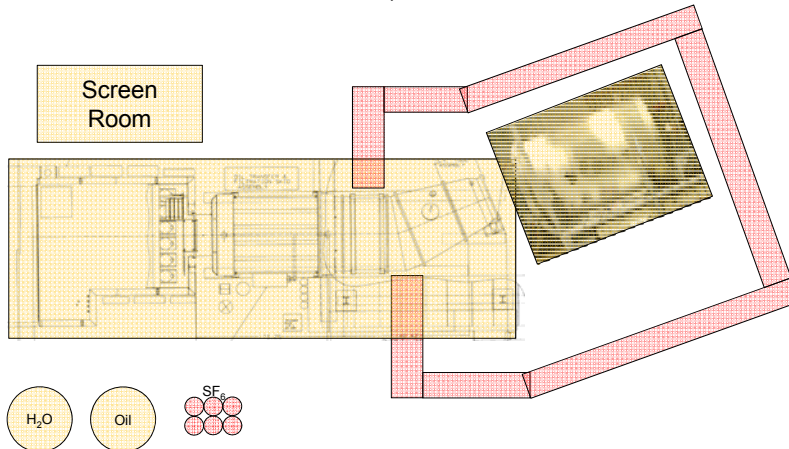
MDAS

EDAS

Not Available

Processing

Operational





Fluence



- Decade Quad designed to
 - Produce 20 krad over 2,500 cm² in a 45 sec pulse
 - Generate hot x-rays (30 keV to 2 MeV) using Bremsstrahlung Radiation Source (BRS)
- Charger – 1
 - Only stores 572 kJ
 - Does not include BRS
 - Could create multiple fluences by z-pinch of various fuels
- Target
 - 100-140 mrad outside wall per year

19

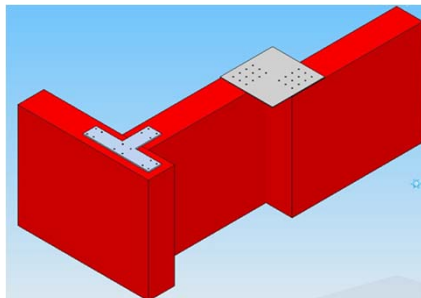


Concepts



Currently two major design concepts

- Polycarbonate/Acrylic shell with sand filler
- Concrete





Conclusions



- Target Date for low power testing is Spring 2013
- Other experimenters are welcome!
- Charger – 1 will enable research into multiple propulsion concepts, astrophysics and radiation protection.

