Charger–1: A Pulsed Fusion Propulsion Testbed

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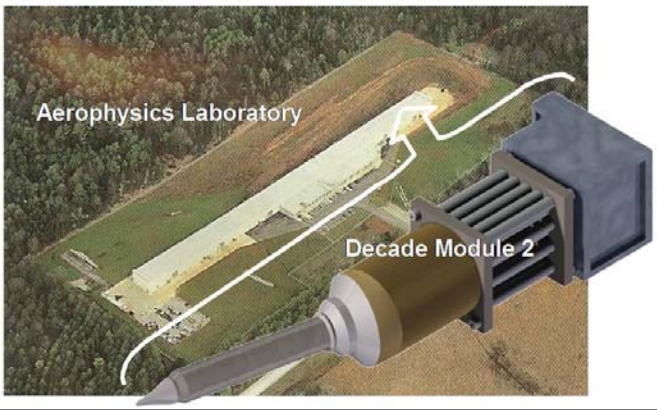
What We're Building

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



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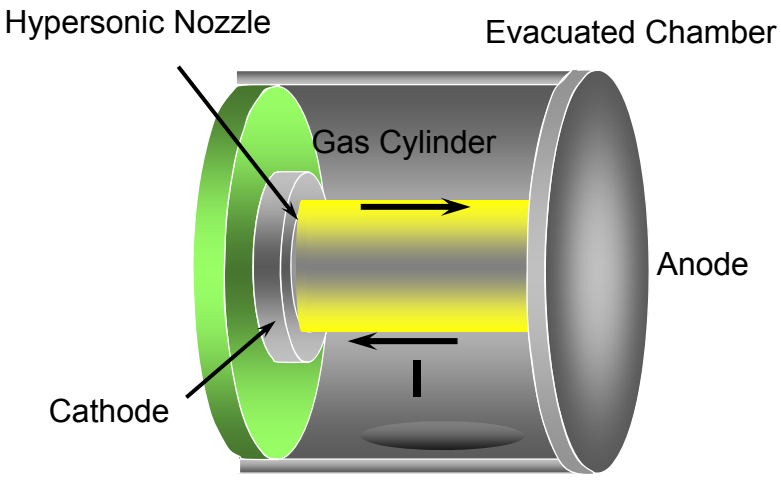
What We're Building

- 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

Operation of a Z Pinch



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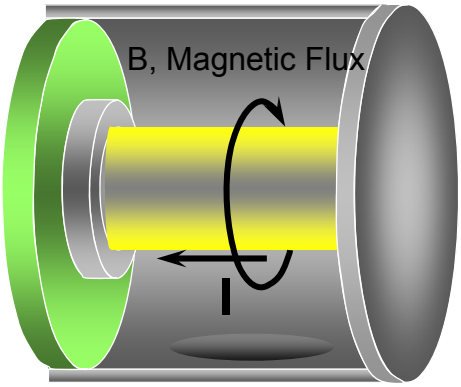

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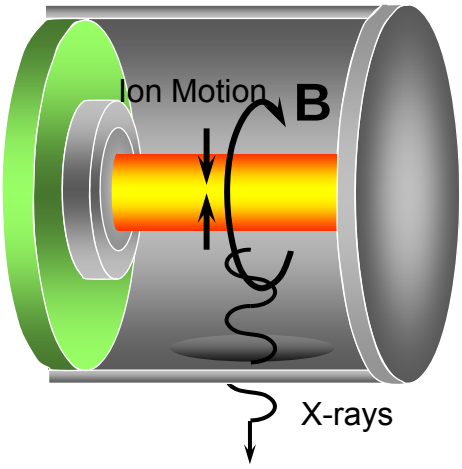
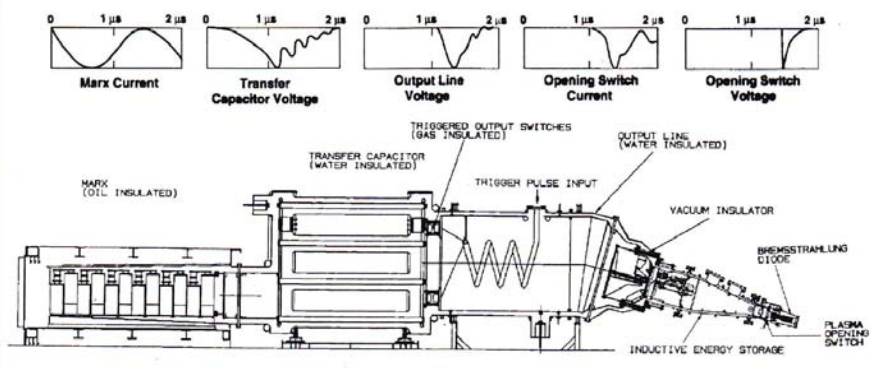


How It Works

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



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Marx Bank

- Full power: charged to ±85 kV
- Aerovox capacitors, C = 2.2 μF, rated at 100 kV
- Once triggered, erected Marx looks more or less like a single capacitor with value 1.1 μF, 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 μF
- 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 ~ 0.5 Ω 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

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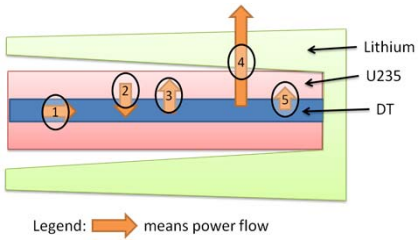
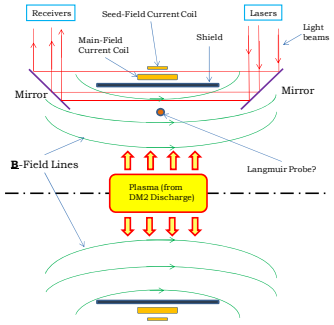
Planned Experiments

- 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



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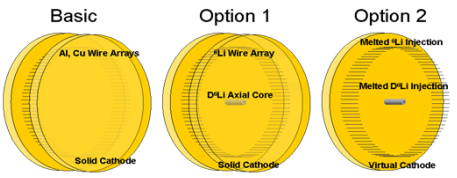
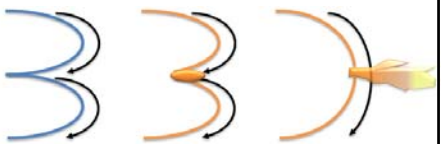
Planned Experiments

- 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



1. Two wire loops in series
2. Wires ablate, and magnetic reconnection begins at center
3. Plasma jet formed and accelerated

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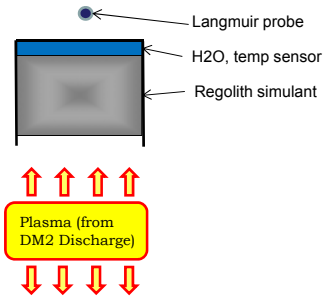
Planned Experiments

- 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



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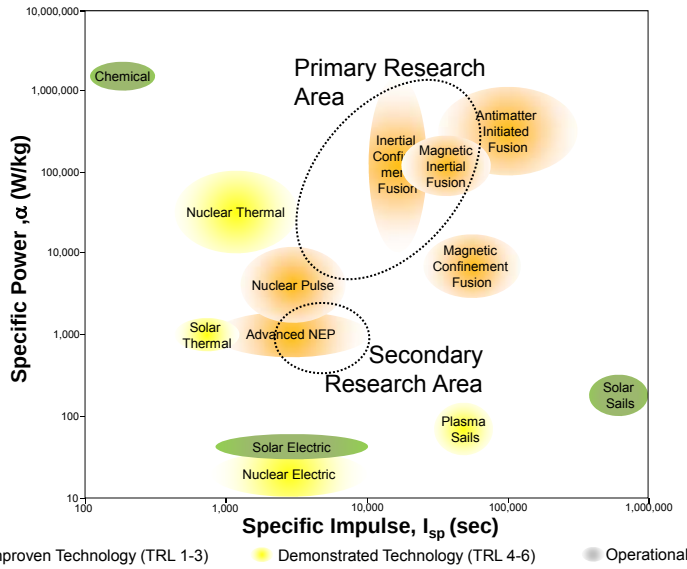
Propulsion Technologies



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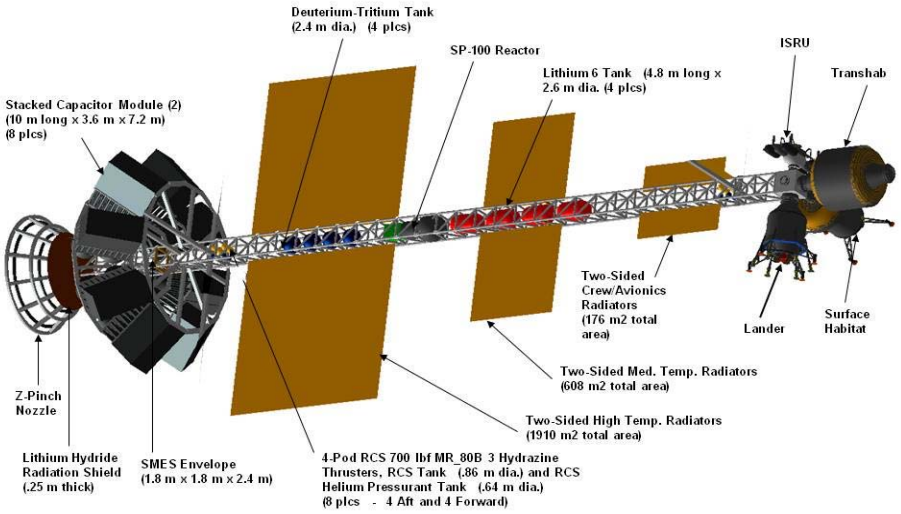
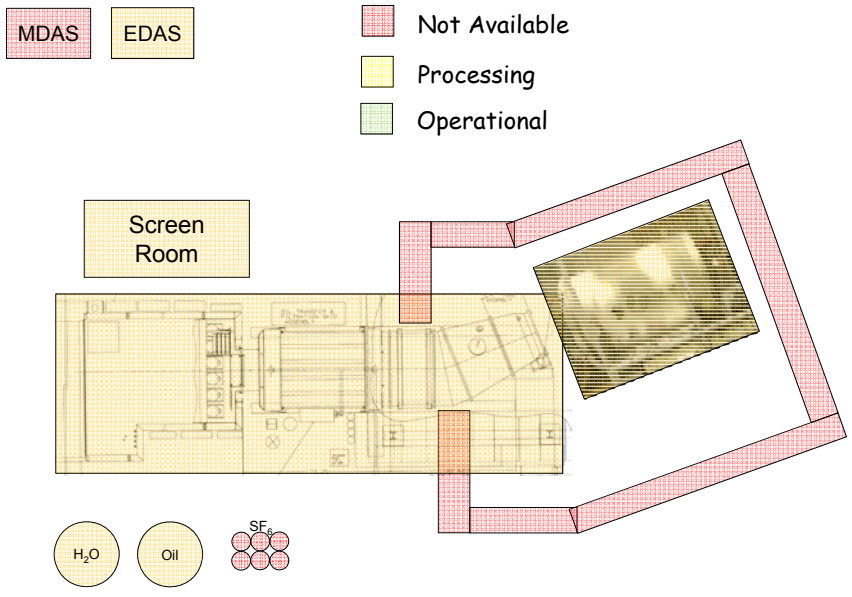


Status - Facility



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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

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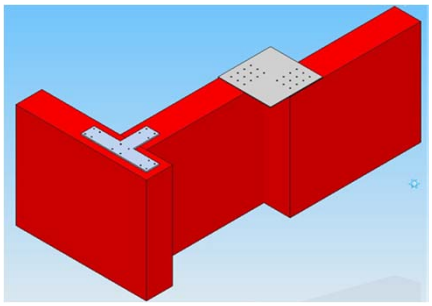
Concepts

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.

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