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Precision High Energy Liner Implosion Experiments – PHELIX

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Outline

- System Description
- Pulse Power Electrical
- Modeling Results
- Marx Configuration
- P-rad Facility
- Transformer Design
- System Configuration
- Conclusion

System Description

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• PHELIX is a megajoule sized transformer coupled pulse power system
    • 8 marx modules

• System to drive hydrodynamic liner experiments with a nominal current capability of 10 megamperes
    • Will drive liners to 4 km/s
    • Present budget limits us to ½ size for start up (5 megamperes, 480 kJ)
    • Multi-framing capability with proton radiography at “LANSCE” accelerator
    • Radial xradiograhy

• Marx banks utilize the “Atlas” plastic cased 60 kV, 60 kJ capacitors and railgaps

• 4:1 multi-filar toroidal air-core transformer is mechanically part of a circular disc line
    • Results in an attractive inductance budget

•Small reusable system very economical

Pulse Power Designs to be Conservative

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- System to use proven Atlas Capacitors and Railgaps
  - Resistive damping to limit fault currents
- 120 kV operation in air was proven in Atlas test fixture
  - Many thousands (50,000) of successful shots
- System to interconnect with RG-217 cable and integral part of transformer
- Bank damping to use Reticulated Vitreous Carbon (RVC) Foam Resistors
    - Tested to 850 kA, 17 kA / cm2
    - Tested to 120 kV and 130 J/cc
- Capacitor Lifetime ~500 Shots with 55% reversal
  - System to operate ~40% reversal

RAVEN MODELING

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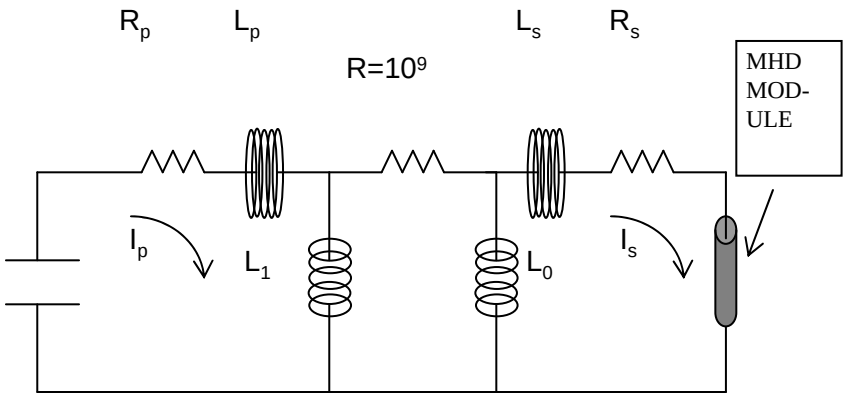

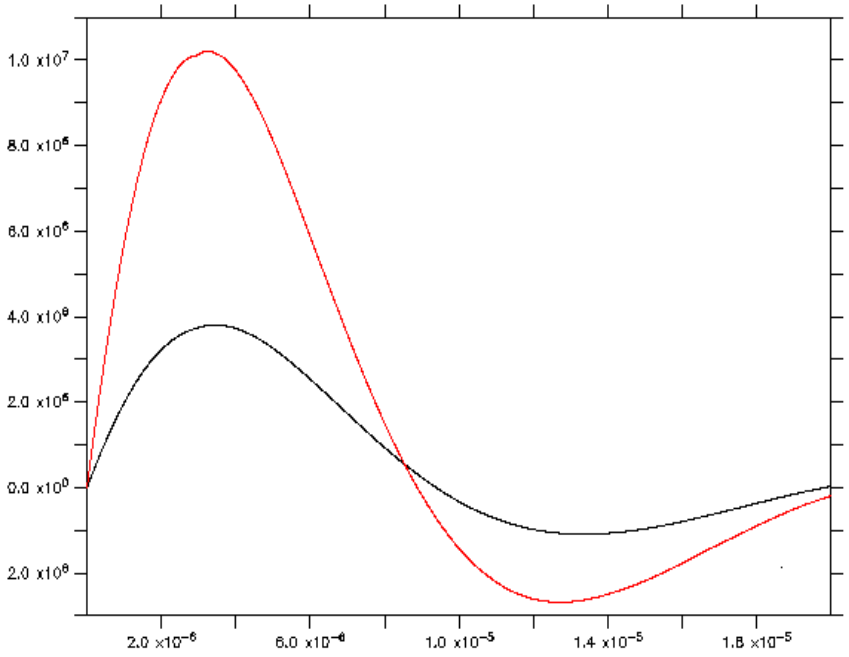

- Spice like network input file
- Couples to MHD module optimized for cylindrical hydrodynamics
- Lp and Ls are transformer inductances
  - includes coupling and leakage
- Li and Lo are uncoupled inductances

- Better than 10 MA to "liner" for 960 kJ
  - For 8 parallel marx modules
  - 120 kJ / 120 kV / module
  - ~30% reversal

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Extensive Capacitor Test Program Proved Lifetimes Better Than Predicted

LANL Qualification Life Test Data				
No. of Units	Failed/ Good	Normal C/D Cycles	Fault C/D Cycles	Normalized Total
1	Failed	8150		8150
1	Good	7600		7600
1	Failed	6200		6200
2	Good	4000	300	4653
5	Good	4000		4000

- Nominal life is 2,400 shots @15% reversal

8 Marx Model Results Indicated Physics Goals Achieved with Adequate Damping

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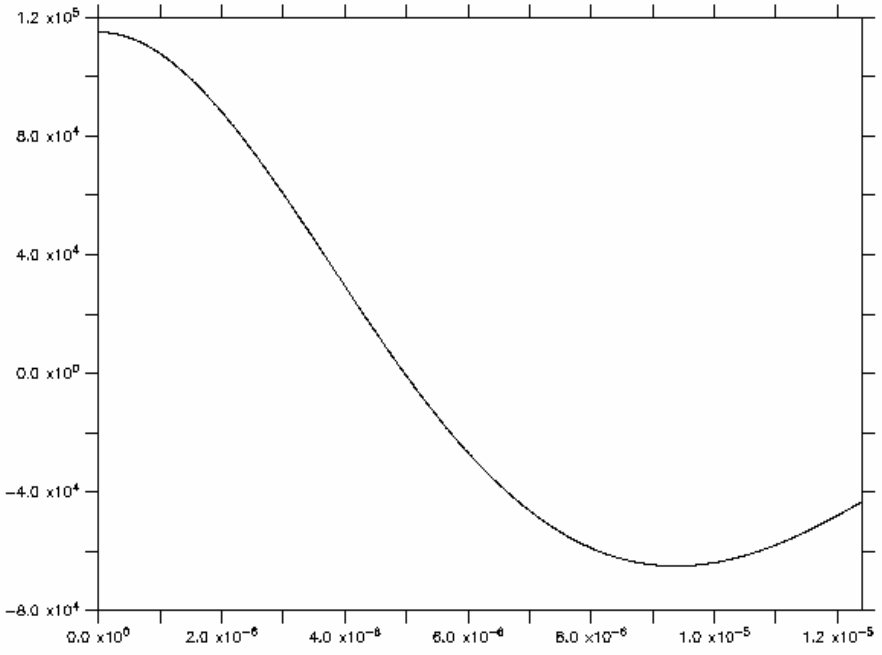
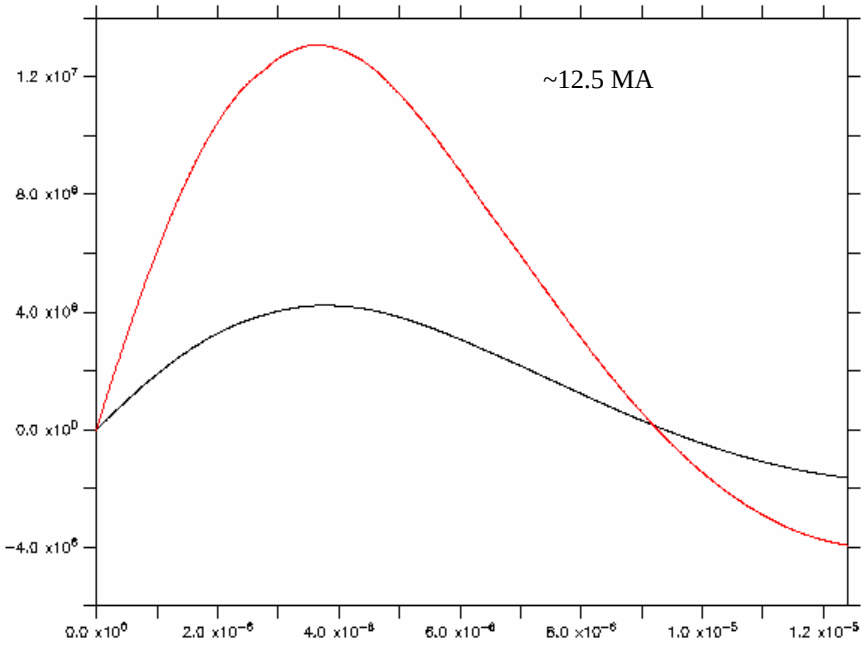


Bank Voltage (~55% reversal)



Primary and Secondary Current (MA)
500 kA module current, 50 kA cable

VIEW OF DUAL MARX RACK

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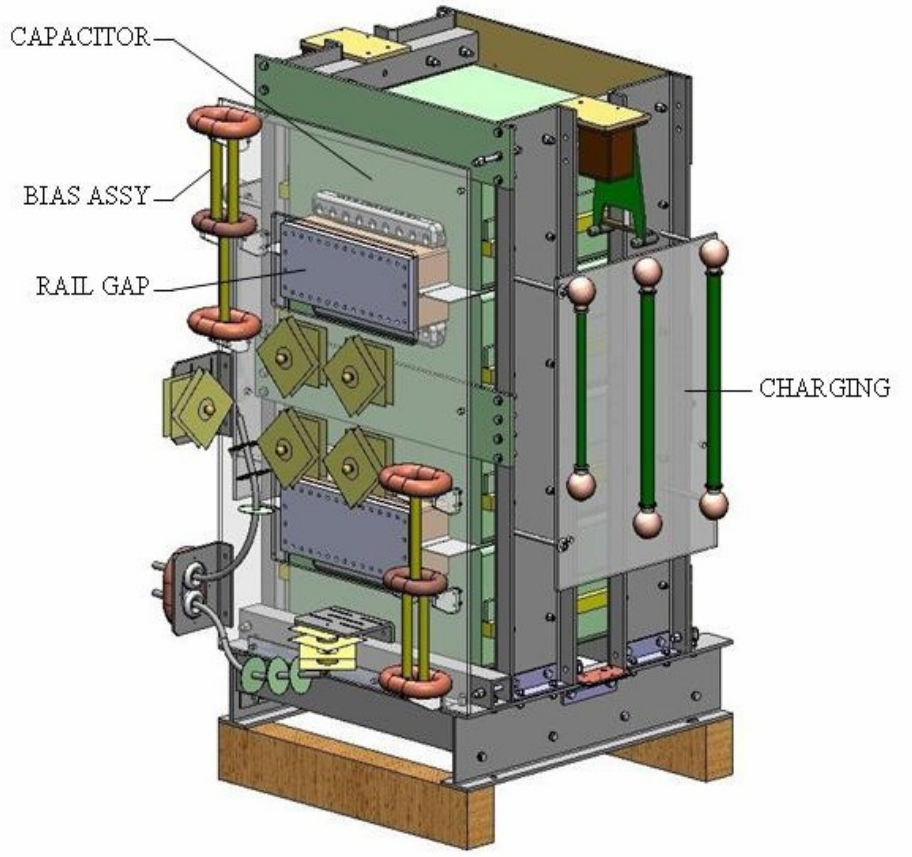
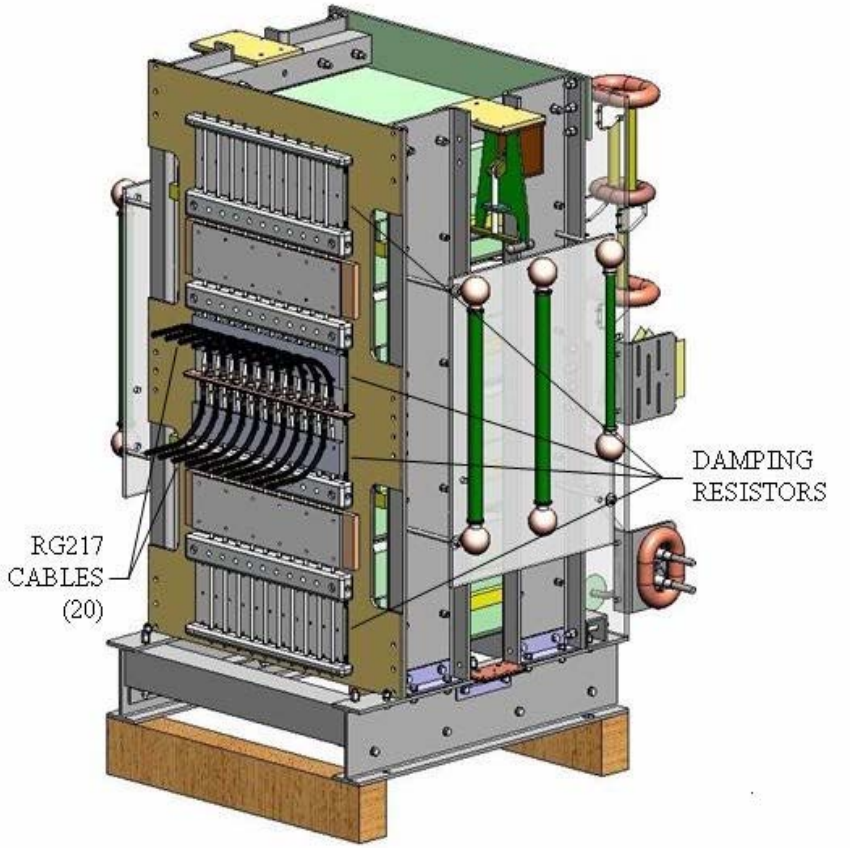


Switching / Charging Assemblies



Output / Damping Resistor Assemblies

VIEW OF TRANSFORMER

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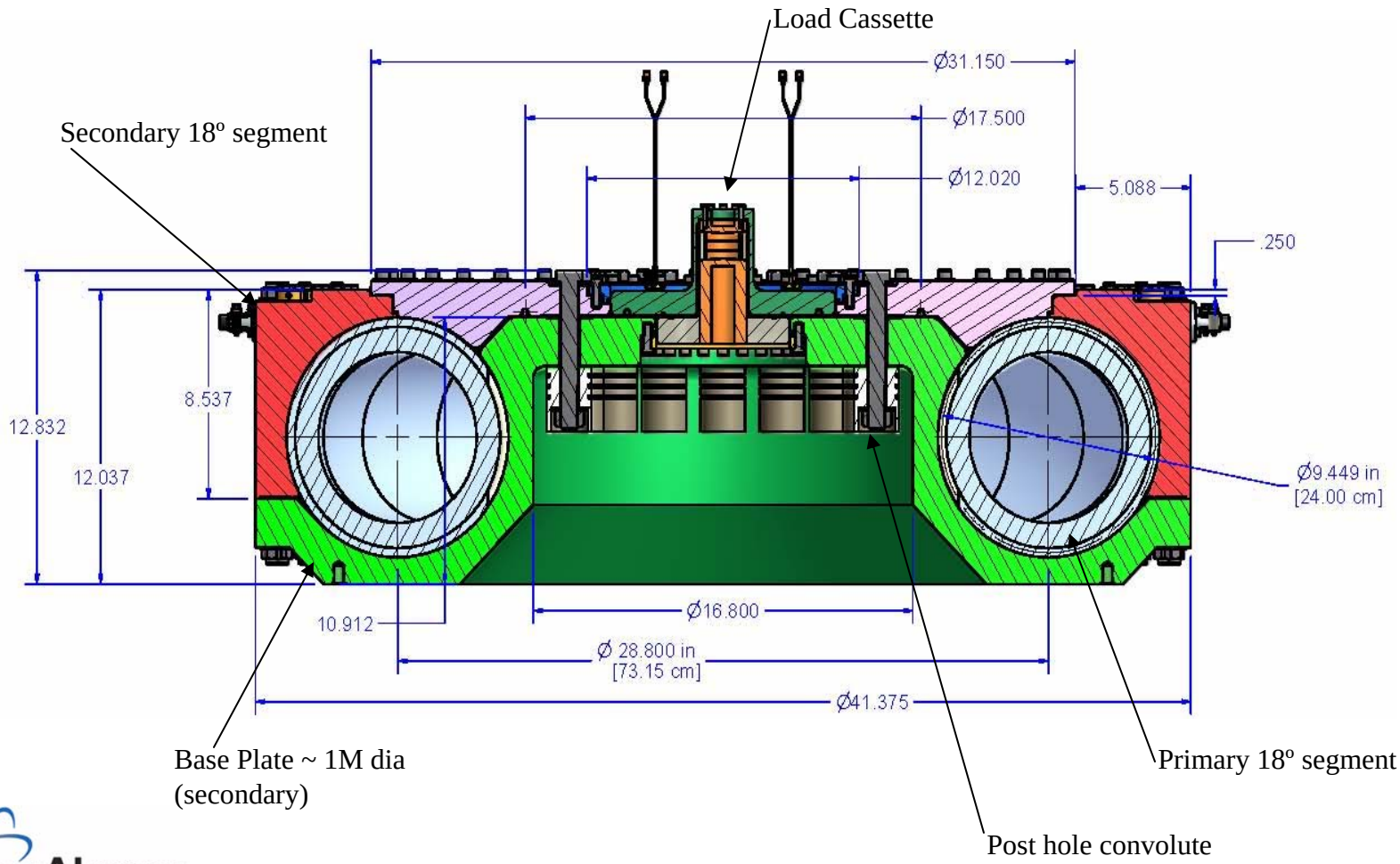

VIEW OF TRANSFORMER PRIMARY AND SECONDARY WINDING SEGMENTS

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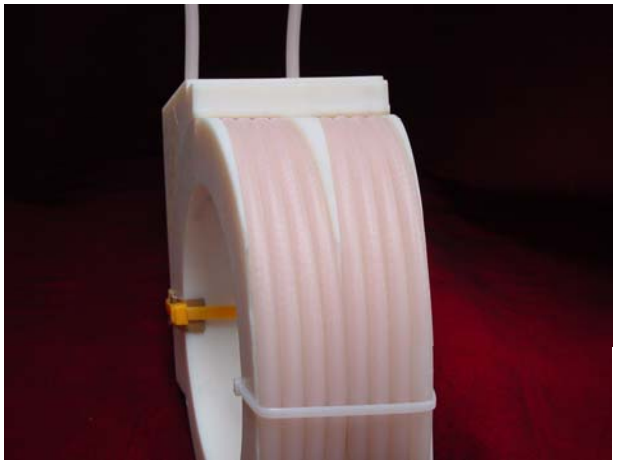
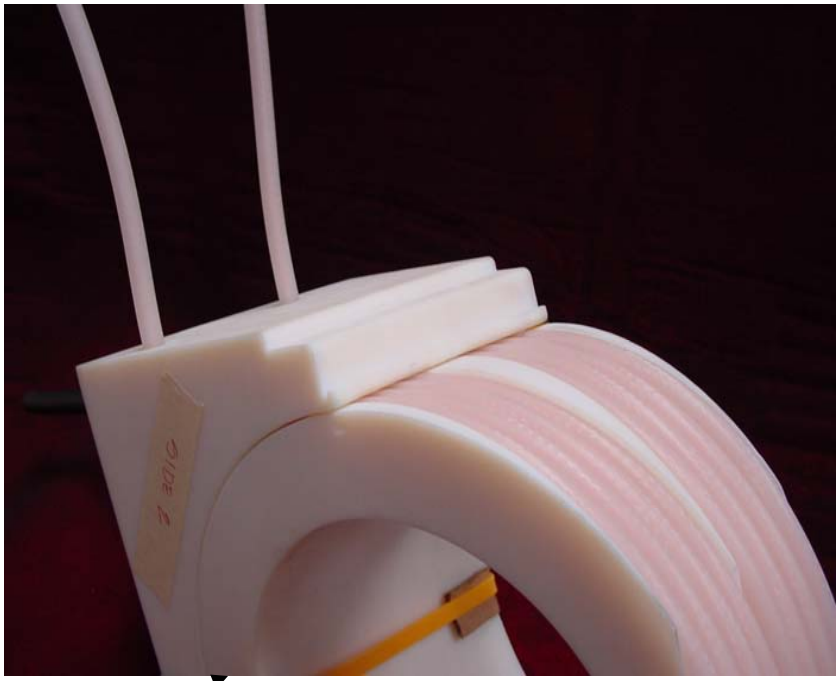


"Printed" Winding (Test) Assembly



"Printed" primary 18º segment

Secondary 18º segment

Contact lands

TRANSFORMER SUBASSEMBLIES

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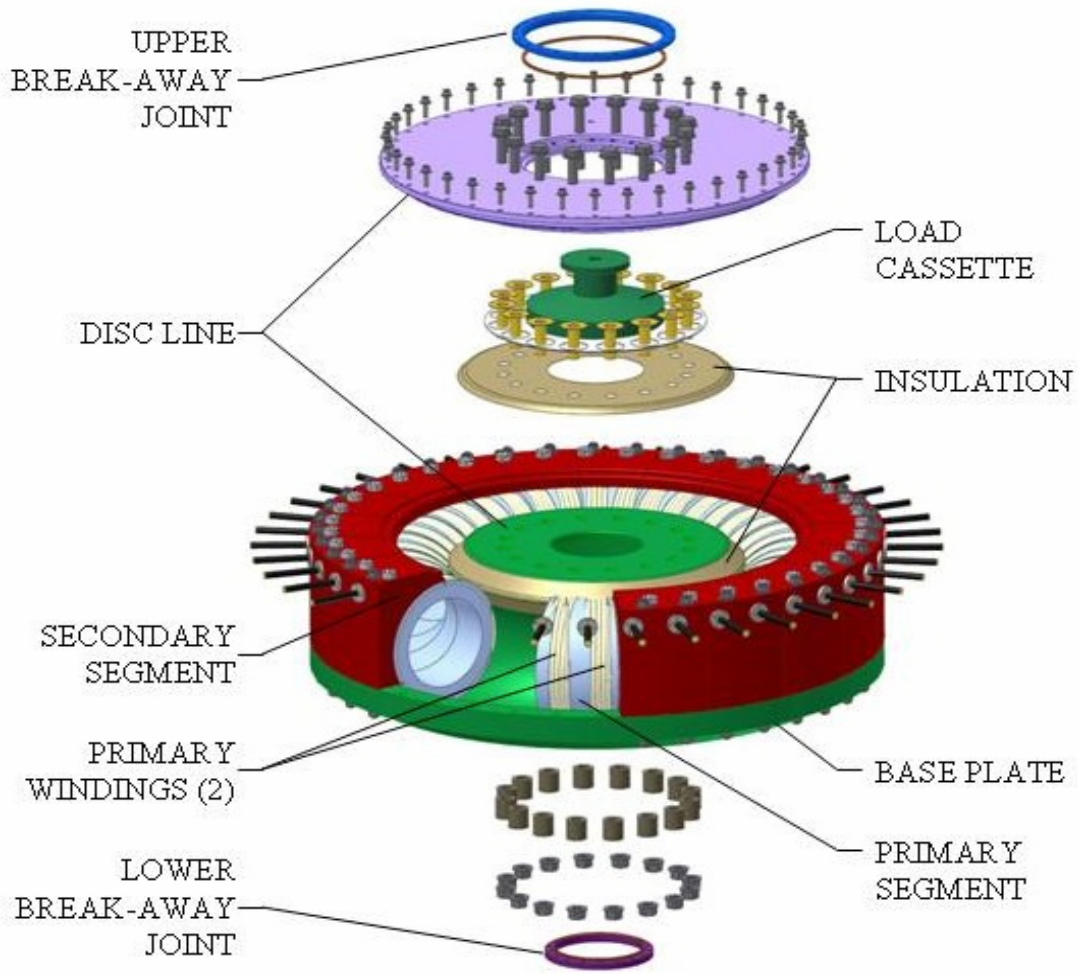

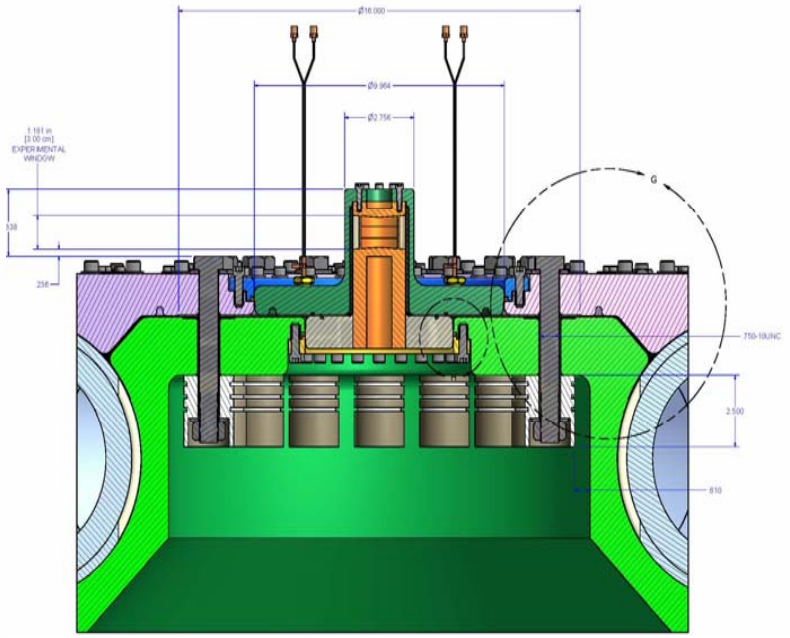

Detail of Power Flow Region

BUNKER TEST AREA

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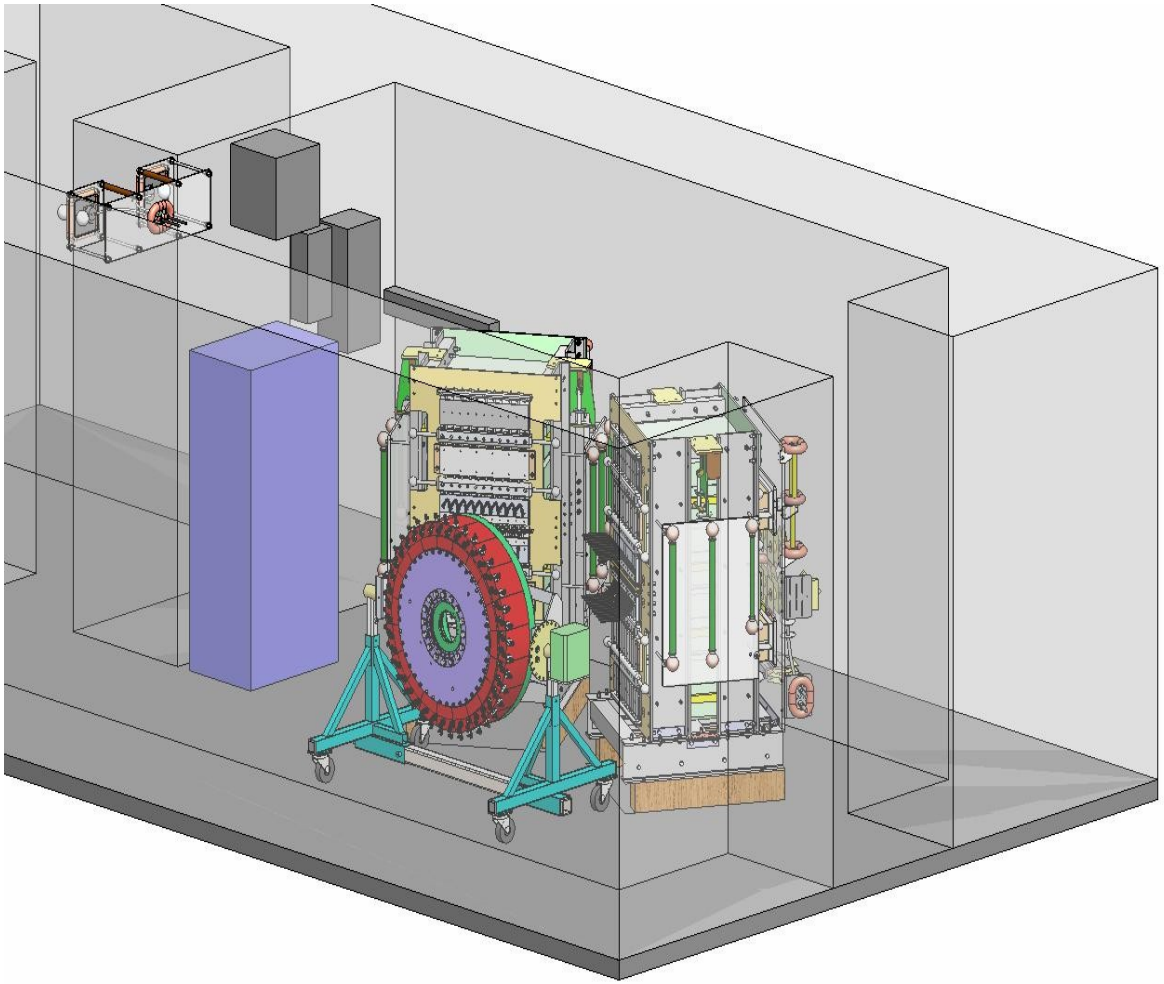

Compact Mechanical Design Accommodates P-rad Operational Requirements

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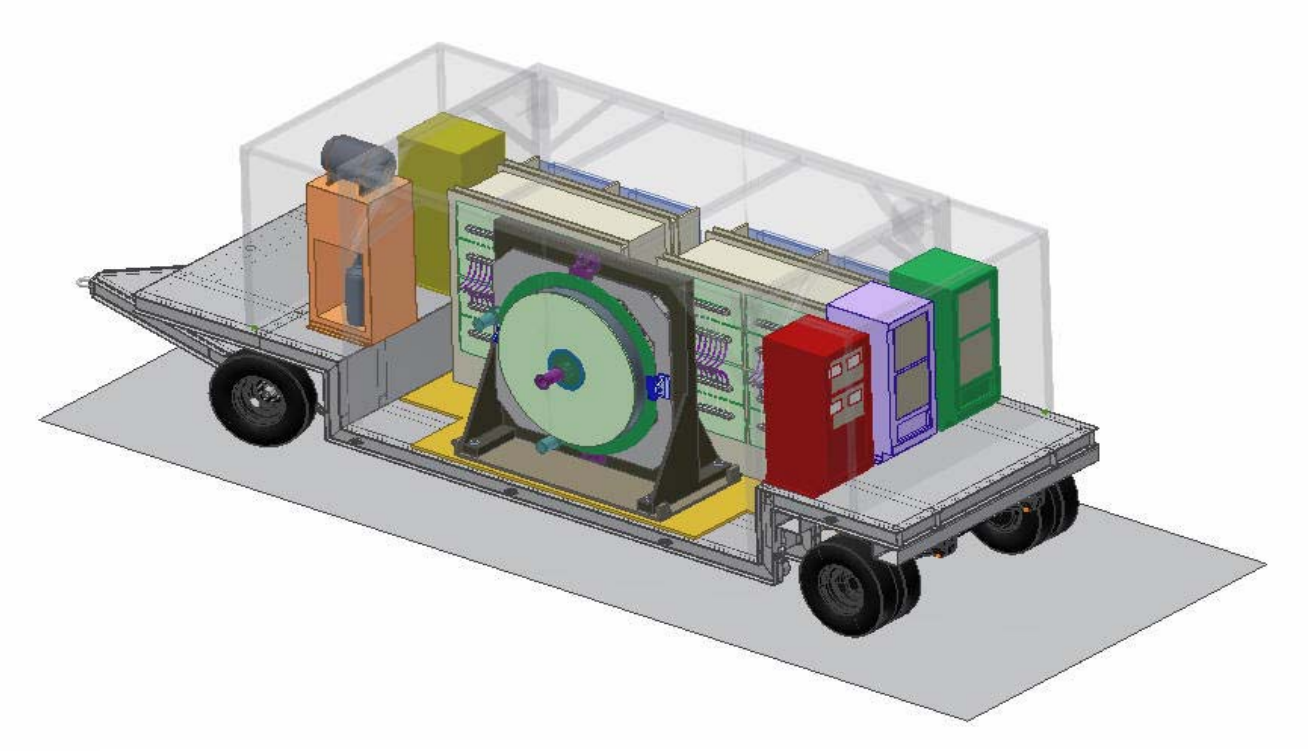
- Capacitor bank, charging system, gas handling system, trigger system, control I/O, and hydrodynamic load on transportable trolley
- Supports for torus alignment to concrete floor
- P-rad beam-line installation when required



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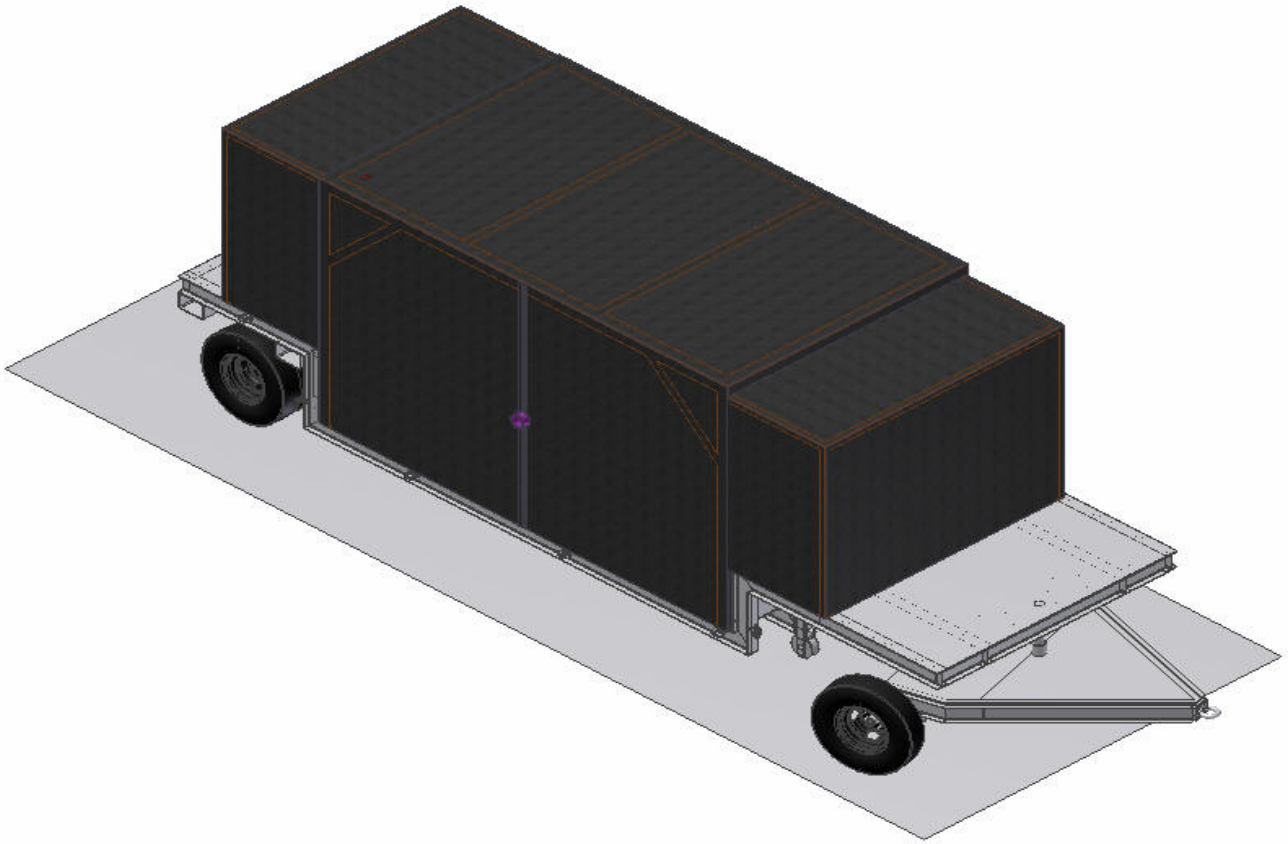
Aluminum Mechanical Enclosure Gives Required Electrical and Mechanical Safety



Entrance to LANSCE P-rad Facility

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Remote Control

- Interface and remote I/O (All Fiber Optic)
  - Accelerator timing hand-shake
  - Machine control / diagnostic hand-shake
    - Trigger system
    - Charging system
    - Gas handling system
  - Experimental diagnostics handshake
  - Personnel protection interlocks
- Utility input power well filtered

Conclusion

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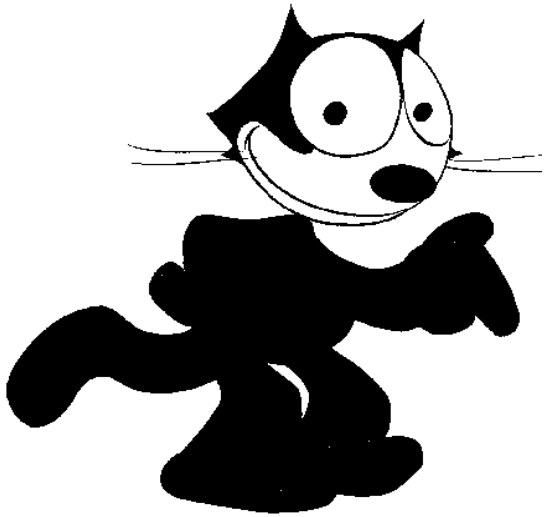

- Engineering and physics goals can be readily accomplished
- Systems fabricated with proven hardware and technique
- Design can meet all safety requirements
- Low operational costs will permit high shot rates
- With high shot rates and P-rad multi-framing capability, design tools can be more easily verified and validated
- PHELIX design is high performance, produces 10MA/MJ vs. 1MA/MJ for bigger machines such as ATLAS, SHIVA STAR, and PEGASUS
- Experimentation to start this year