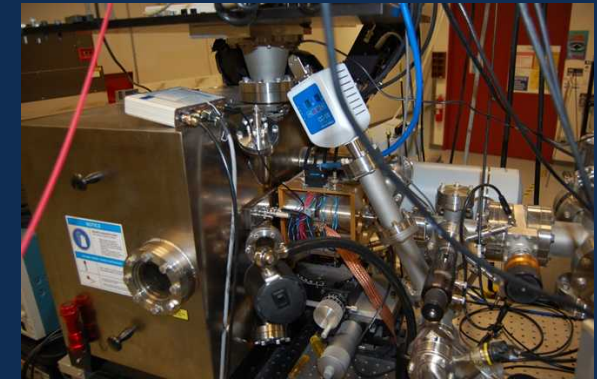
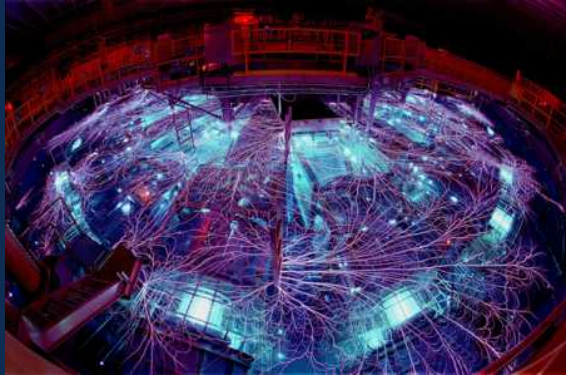


Exceptional service in the national interest



Z Facility Update and Future

Joel Lash

Senior Manager, Z Facility R&D

**Radiation Effects and High Energy Density Sciences
Research Foundation External Review, May 20-22, 2014**



Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Outline

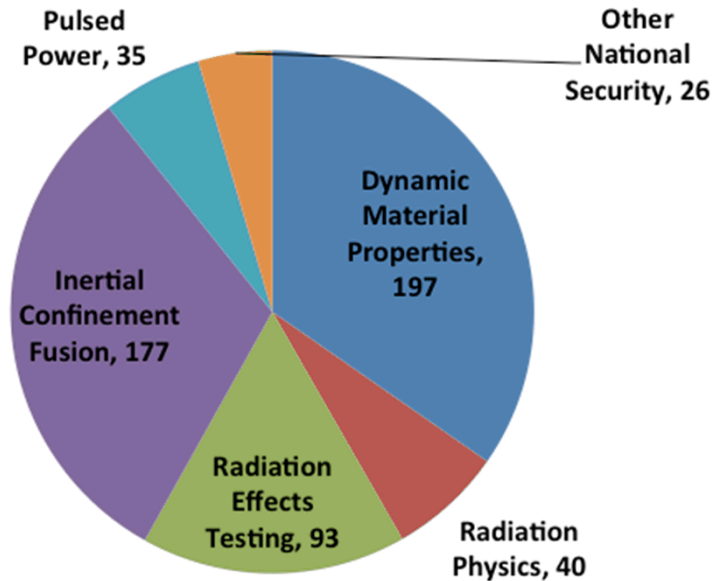
- Z shot data
- Visibility
- Recent new capabilities
- Operational improvements
- Future capabilities
- Beyond Z

Z continues to focus on key weapons science and is in great demand

568 Shot Days have been requested by LANL, LLNL, and SNL for Stockpile Stewardship in CY14 – 3X more shot requests than available

Address key stockpile issues:

- Understanding of Pu needed for reuse
- Pu Aging
- Boost
- Advanced safety concepts
- Non-nuclear component Nuclear Survivability

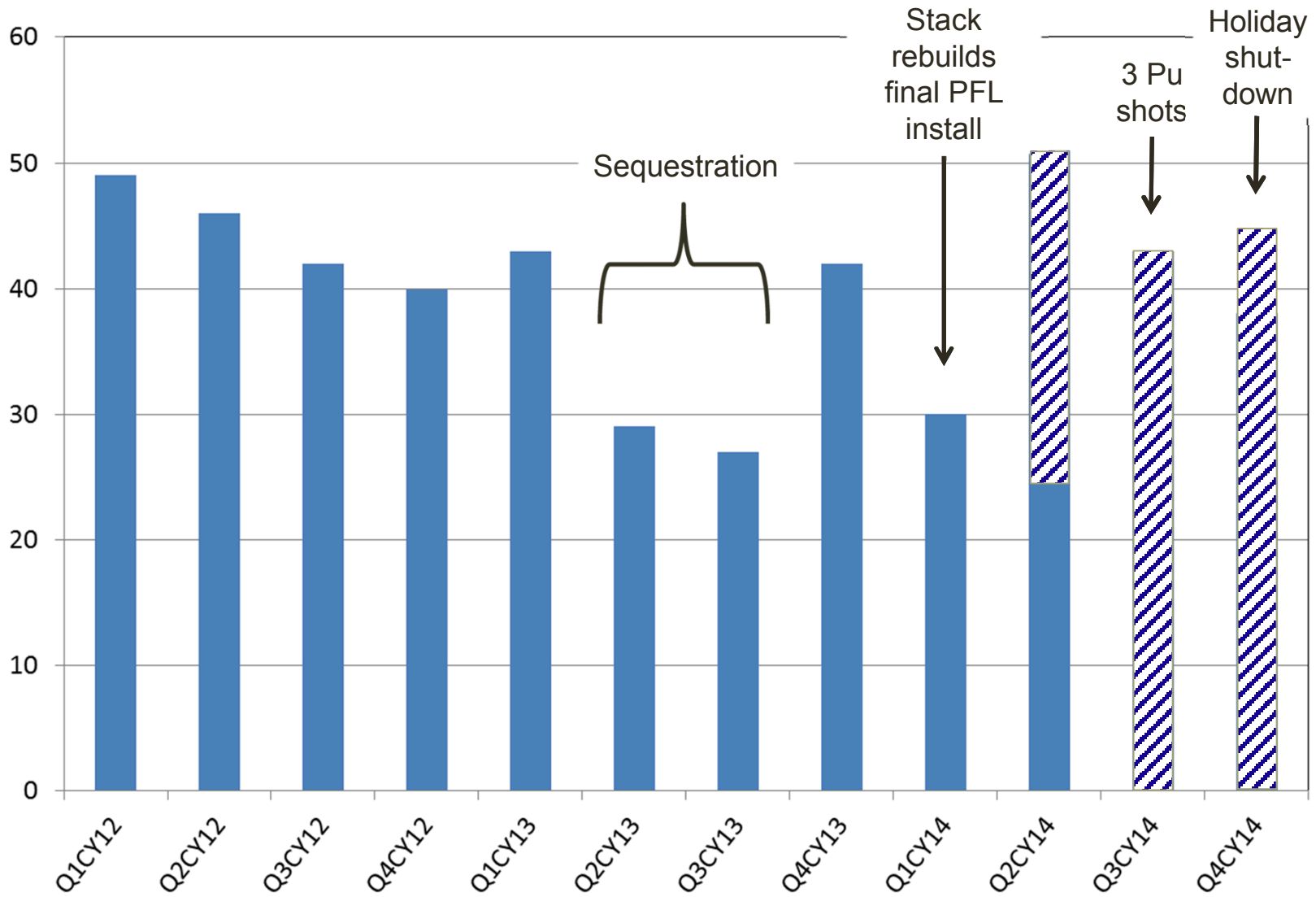


Current CY14 statistics

	Shot Days	Shots	Fraction
Dynamic Materials	47	46	28%
Containment	33	10	6%
ICF	57	44	27%
Radiation Effects	41	31	19%
Secondary Assessment	22	22	14%
Primary Assessment	4	4	2%
Fundamental Science	4	4	2%
Facility/Maintenance	43	1	1%
	251	162	

70% of Z shots are for Stockpile Stewardship experiments

Z shot data by quarter



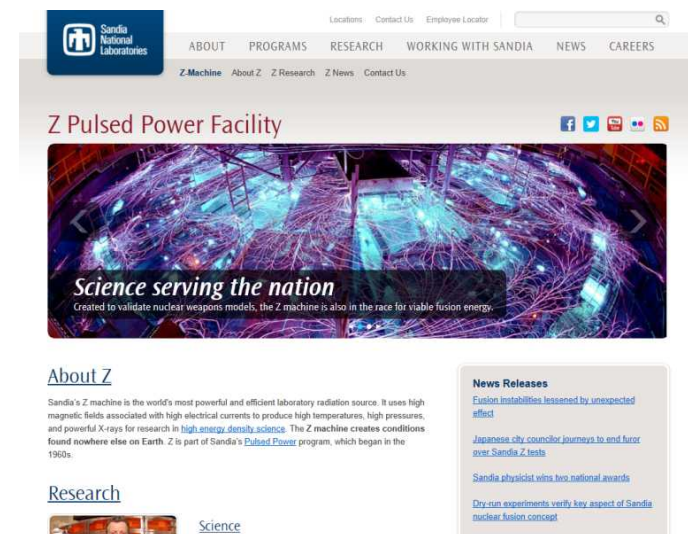
The visibility of Z has increased both internally and externally

Tours:

- Secretary of Defense visit to KAFB/SNL
- General Finan staff from Air Force Nuclear Weapons Center
- Sandia Division 2000 new hires
- Sandia Weapon Intern Program
- 10s of other visits; ~ 1 – 2 per week

Visibility:

- New external website
- New internal website
- NPR All Things Considered
- Nature News / Physics Today / etc.



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ABOUT PROGRAMS RESEARCH WORKING WITH SANDIA NEWS CAREERS

[Z Machine](#) [About Z](#) [Z Research](#) [Z News](#) [Contact Us](#)

Z Pulsed Power Facility

[f](#) [t](#) [v](#) [p](#) [s](#)

Science serving the nation
Created to validate nuclear weapons models, the Z machine is also in the race for viable fusion energy.

About Z

Sandia's Z machine is the world's most powerful and efficient laboratory radiation source. It uses high magnetic fields associated with high electrical currents to produce high temperatures, high pressures, and powerful X-rays for research in [high energy density science](#). The Z machine creates conditions found nowhere else on Earth. Z is part of Sandia's [Pulsed Power](#) program, which began in the 1960s.

Research

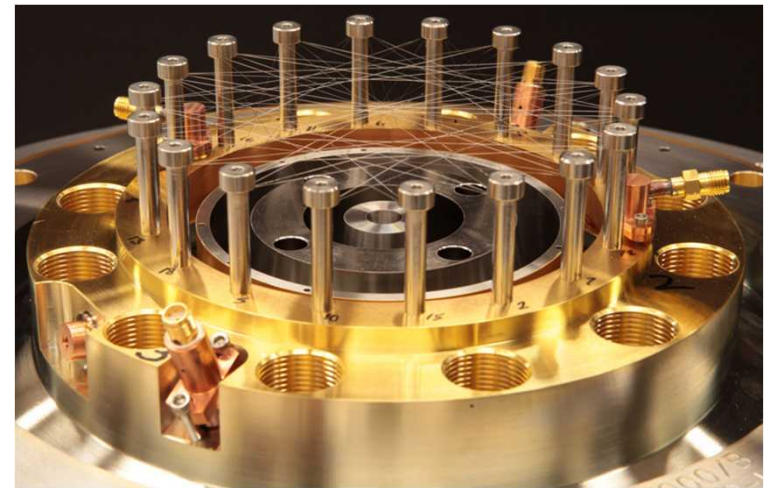
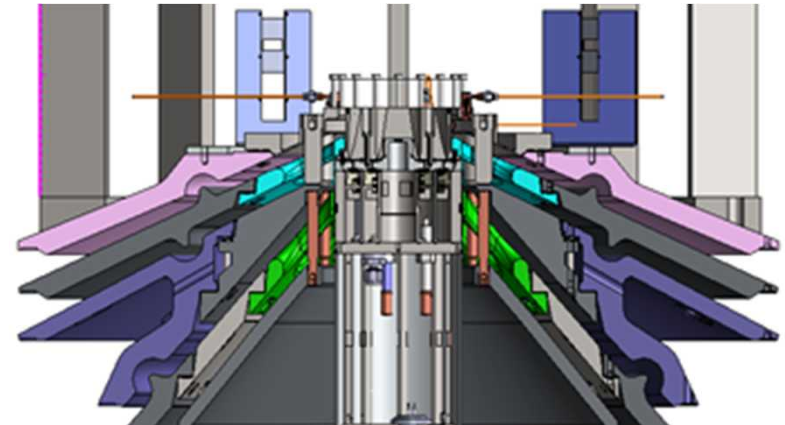
[Science](#)

News Releases

- [Emission instabilities lessened by unexpected effect](#)
- [Japanese city councilor journeys to end furor over Sandia Z tests](#)
- [Sandia physicist wins two national awards](#)
- [Dry-run experiments verify key aspect of Sandia nuclear fusion concept](#)

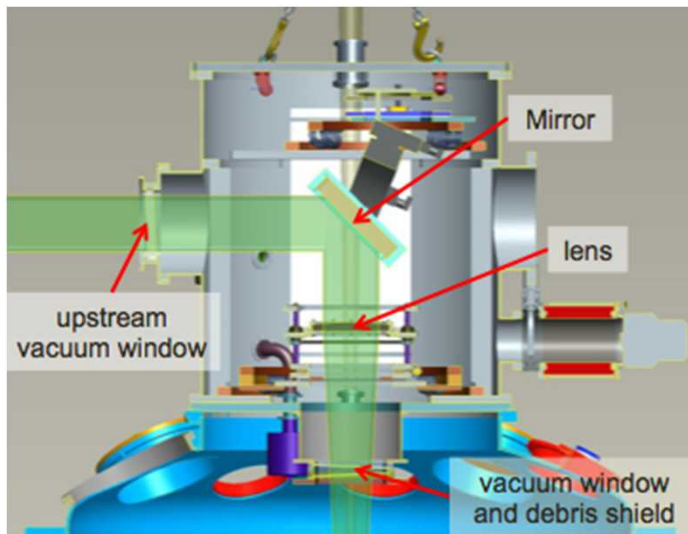
The Gas Puff capability produces the brightest AGT x-ray sources at >3 keV

- Argon gas-puff implosions demonstrated 330 kJ of Ar K-shell yield above 3 keV photon energy with $\pm 9\%$ reproducibility between tests.
- First krypton gas-puff implosions on Z, designed using 3-D rad-hydro simulations, produced a record 5 kJ of Kr K-shell yield above 10 keV photon energy.
- Complex engineering challenge to develop gas nozzles and gas delivery system as well as ensure gas present prior to Z firing.



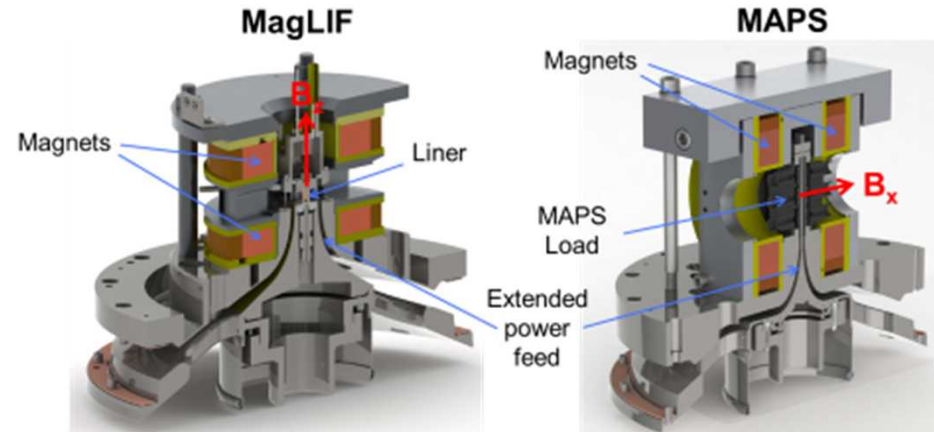
A new Z vacuum Final Optics Assembly has been commissioned

- Mitigate failure of vacuum window due to impact of on-axis fragment
- Increase mechanical integrity of structure
- Allow for automated lens and mirror alignment
- Designed along with new mezzanine to facilitate pre-shot alignments



Applied Magnetic Field (B) on Z [ABZ] capability key to fusion research

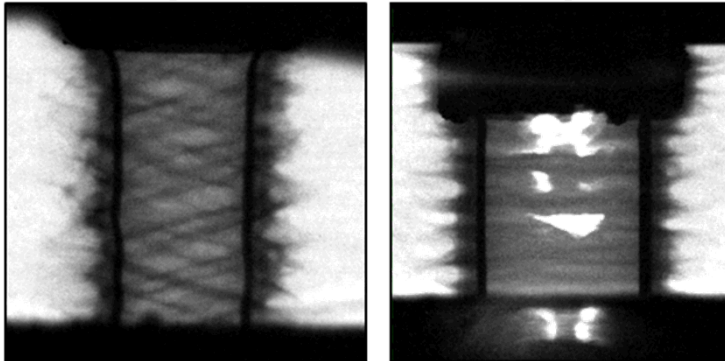
- The ABZ capacitor bank driver, coil system commissioned in February 2013
 - 900kJ capacitor bank sufficient to enable 10-30T+
- Axial magnetic field improves pinch performance, altered nature of MRT instability
- ABZ has been fielded on over 25 shots in FY13, FY14
 - A key component for exploring MIF with MagLIF integrated shots
 - Provides initial magnetic field for Magnetically-Applied Pressure Shear (MAPS) for materials



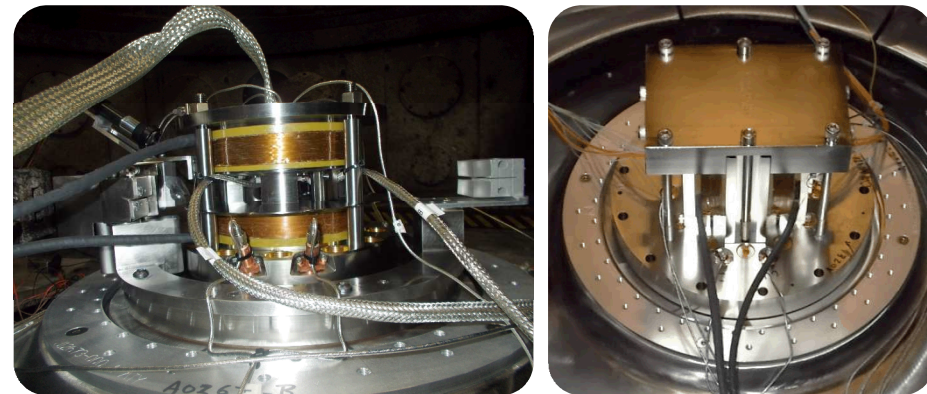
Applied Magnetic Field Coils magnetize load hardware targets prior to Z Machine downline shot

With Magnetic Field

Without Magnetic Field



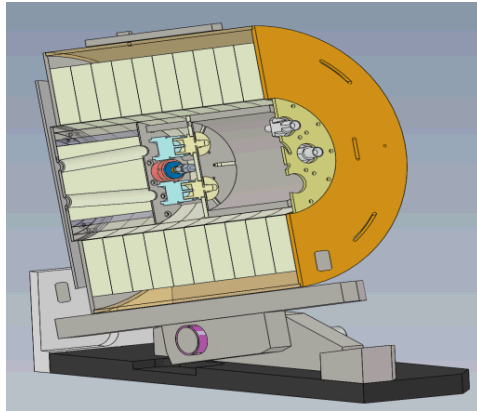
Radiographs of metal liner implosions with and without applied magnetic field



Z Shot hardware for MagLIF- (left) and MAPS-configured (right) ABZ coil loads

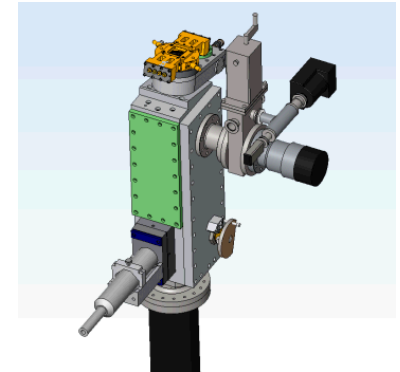
'New' diagnostics deployed on Z

Differential Absorption Hard X-ray (DAHX)



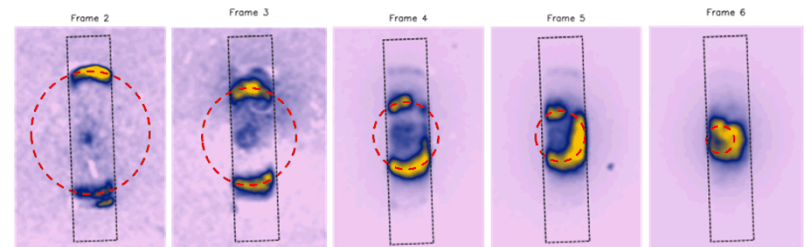
- Fielded on Z many years ago
- Provides a much needed diagnostic for photon energies above ~ 25 keV
- Time-resolved x-rays between 20 – 100 keV with ns resolution
- Uses an array of seven collimated Si PIN diodes with varying filters in a 2 to 4 inch thick tungsten housing

Glancing Mirror Pinhole Camera (GMPC)



- Time-gated axial pinhole camera used on Z prior to 2007 re-commissioned.
- Provides data on radiating shock in dynamic hohlraum implosions; used to constrain rad-hydro simulations of the Z opacity experiments.

Z2325 Dynamic Hohlraum Shock Implosion



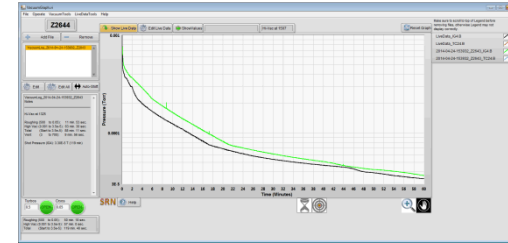
A number of improvements have been made to Z's vacuum system

Rough Pump Upgrade

- 15% increase in roughing speed
- Quieter operation
- Reduced power consumption of ~\$64,000 annually
- Remote operation capabilities

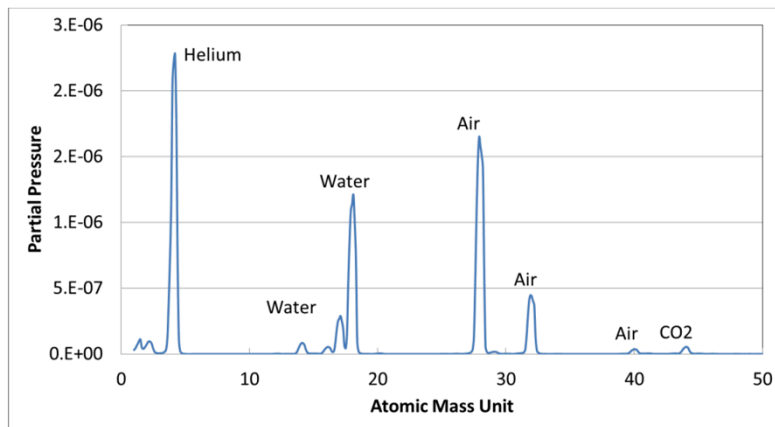


Automated Recording of Pump downs



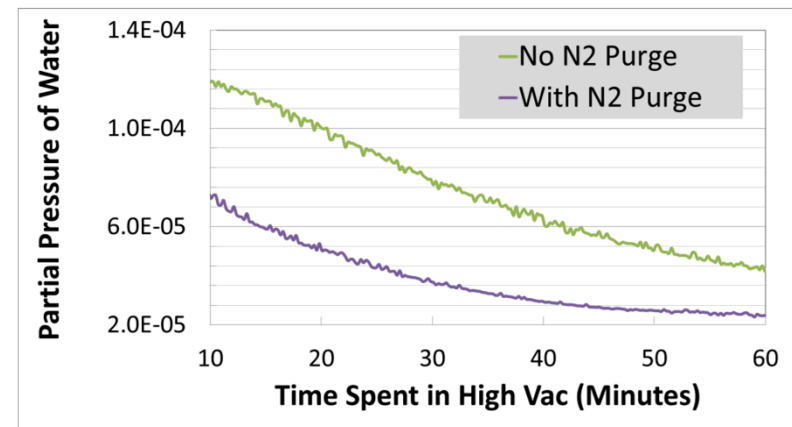
- Curves were hand recorded by hand every 5 minutes.
- Records all vacuum gages every second with information is pushed out
- Can identify vacuum issues much earlier

Diagnostic Improvements



We now utilize a RGA on each shot to help understand the state of Z's vacuum system.

N2 Purge Capability



New system developed and deployed to reduce water contamination in Z's vacuum chamber 10

Information management improved through web-based applications

Z Shot Schedule

The screenshot displays the 'Shot Schedule' web application. It features a header with the Sandia logo and 'Shot Schedule' title. Below the header, there are filters for 'From' and 'To' dates, and an 'Export Filtered Data to Excel Spreadsheet' button. The main content is a large table with columns for Shot ID, Shot, Program, Experiment Name, Shot Director, Configuration Engineer, Lead Hardware Designer, Storage Investigator, Hardware Set, Shot Number, Shot Type, Category, Subcategory, Machine, Status, and Notes. The table contains multiple rows of data, with some rows highlighted in red and others in green. At the bottom, there are navigation links for 'Shot Schedule', 'Z-Machine Status', and 'Z Program Sharepoint'.

Z Diagnostic Request System

The screenshot shows the 'Diagnostics' web application. It has a header with the Sandia logo and 'Diagnostics' title. The main area is divided into several sections: 'Diagnostics Request' with fields for 'Experiment Name', 'Principal Investigator', 'Scheduled Date', and 'Shot Number'; 'Overall Status' and 'Overall Quality Code'; and a grid of diagnostic requests. The grid is organized into columns for different diagnostic categories like 'LOS 50', 'LOS 270', 'LOS 310', 'LOS 330', 'LOS 130', 'LOS 150', 'LOS 170', 'LOS 190', and 'LOS 210'. Each request entry includes a name, a status (e.g., 'N/A'), and a 'Details' link. There are also sections for 'Request Approval', 'Configuration Approval', and 'OTHER DIAGNOSTICS'.

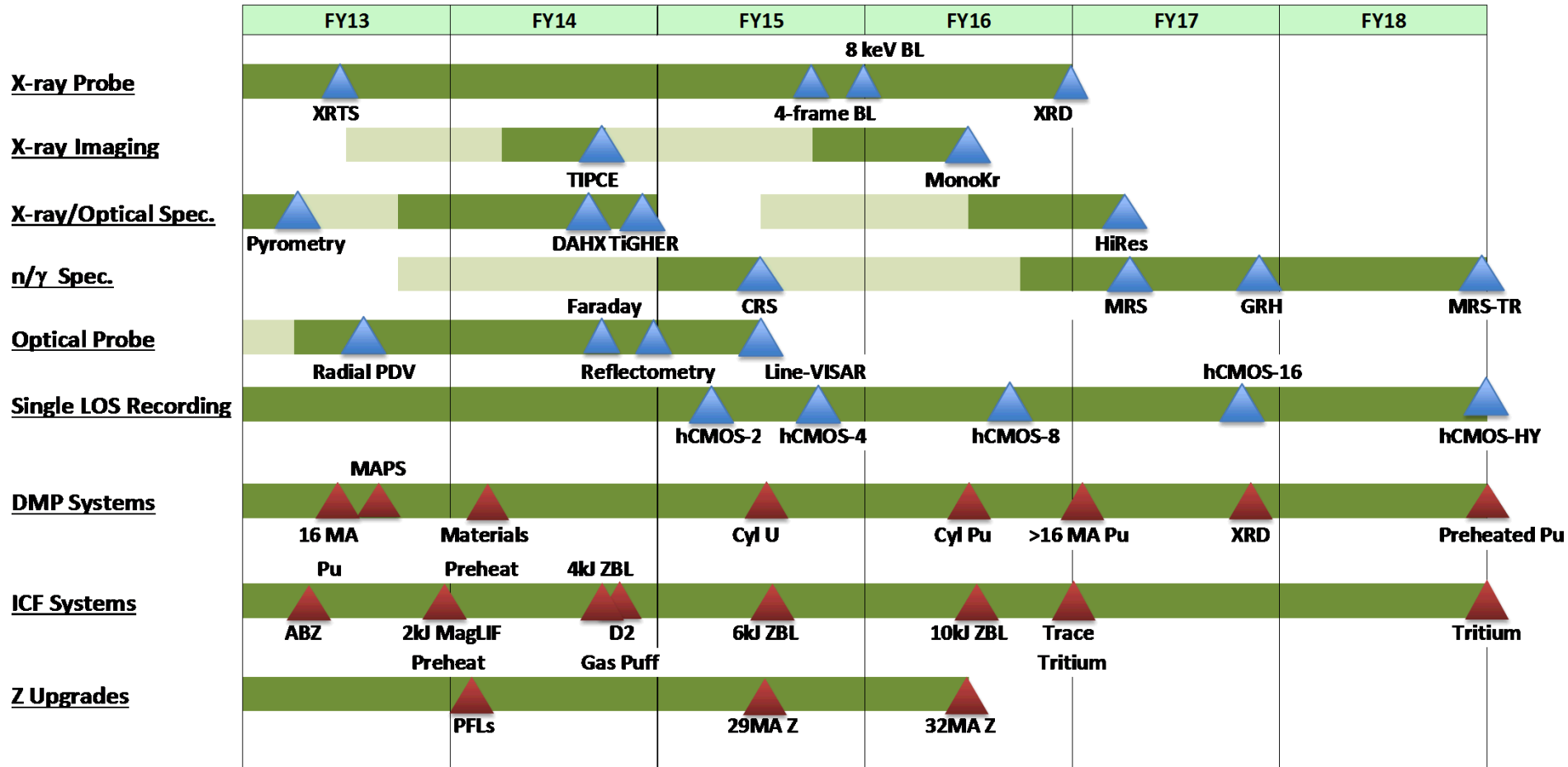
Z Machine Configuration

The screenshot displays the 'Z Shot Specification' web application. It features a header with the Sandia logo and 'Z Shot Specification' title. The main content shows details for a specific shot: 'A0359A - 31-cm Convolute (New Development)'. It includes fields for 'Shot Number' (Z344), 'Principal Investigator' (Krudson Edens), 'Shot Director' (Edens), and 'Shot Date' (4/25/14 (Friday)). There are also fields for 'Marx Charge' (85kV) and 'Upload Date' (4/24/14 03:54:05 PM (Thursday)). Below this, there are sections for 'Shot Specification' with a 'Shot Spec File' and 'Upload Date', and 'Actions' like 'Delete Shot Spec' and 'Update Shot Spec'. At the bottom, there are navigation links for 'Home', 'Z Web Applications', 'Z Program Sharepoint', and 'Z Operations'.

Z Training and Access System

The screenshot shows the 'Z Training and Access' web application. It has a header with the Sandia logo and 'Z Training and Access' title. The main content includes a 'Home' section with a 'To Do List (Next 30 Days)' and a 'News' section with a 'New Post'. There is a 'Document Quick Search (Advanced)' section with a search bar and 'Submit' button. Below that, there are sections for 'Common Documents and Forms (Table)' with links to 'Authorization Checklist', 'Badge Contract', 'Berkeley HSG', 'Escort Rules and Safety Briefing', 'Workshop Access Form', and 'Z Accelerator Implementation Plan'. At the bottom, there are navigation links for 'Home', 'Z Training', 'Search', 'Reporting', and 'Administration'.

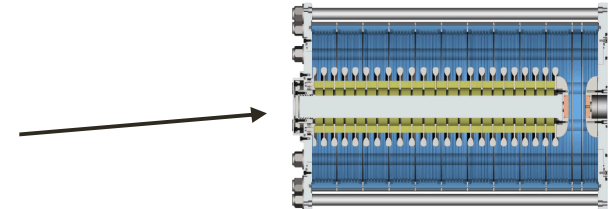
We have an integrated roadmap for future Z diagnostics and capabilities



We are increasing the peak current available on Z from 26 to 32 MA

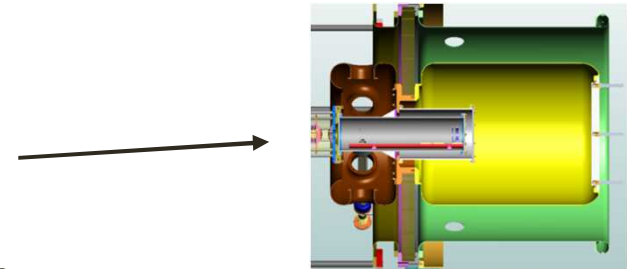
- **6.7-MV laser-triggered gas switches – done!**

- The new switches allow increasing the Marx voltage from 85 to 95 kV, double the precision of the pulse shape, increase the shot rate by reducing maintenance, and improve worker safety.



- **6.7-MV pulse-forming lines – done!**

- The new PFLs will allow us to increase the Marx voltage from 85 to 95 kV, and improve worker safety.



- **Next-generation vacuum-insulator stack**

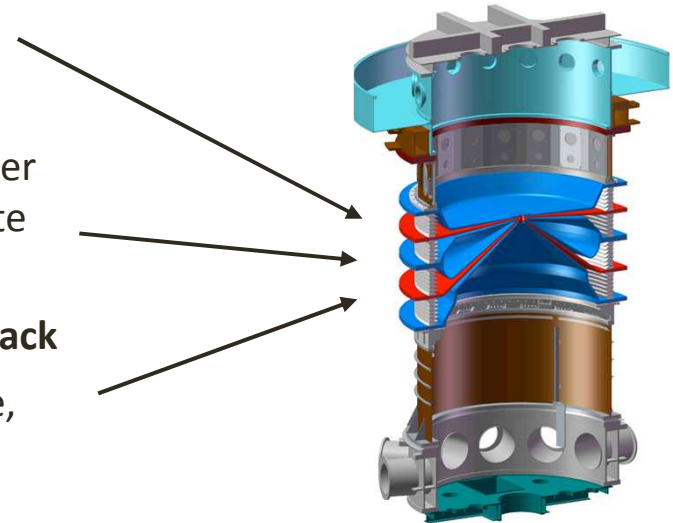
- The new stack will allow operation at 95 kV, and eliminate flashovers that can affect the pulse shape.

- **Lower-inductance MITL-convolute system**

- A new system would increase the peak current 5%, lower convolute costs by \$1M each year, increase the shot rate by 5%, and improve worker safety.

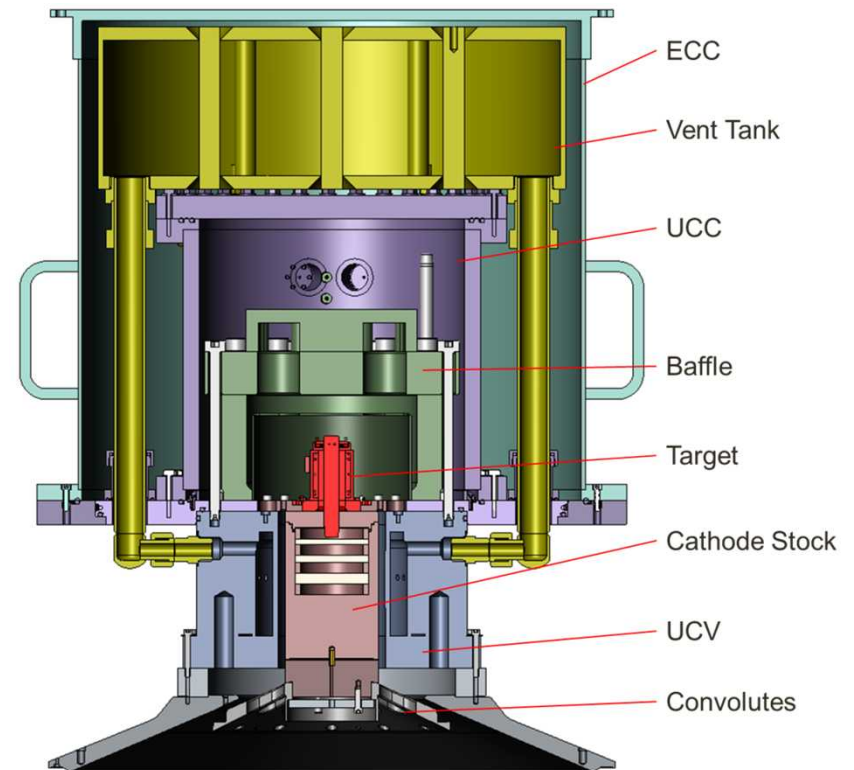
- **Horizontal water triplates that connect the PFLs to the stack**

- The new triplates will eliminate the 3D water convolute, which will increase the current by 7%.



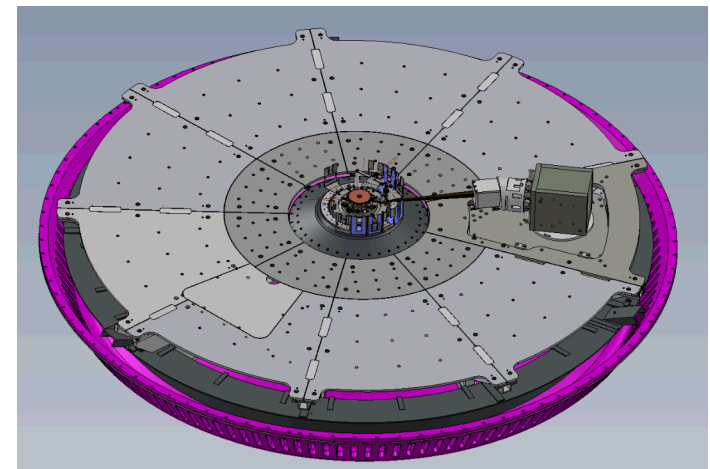
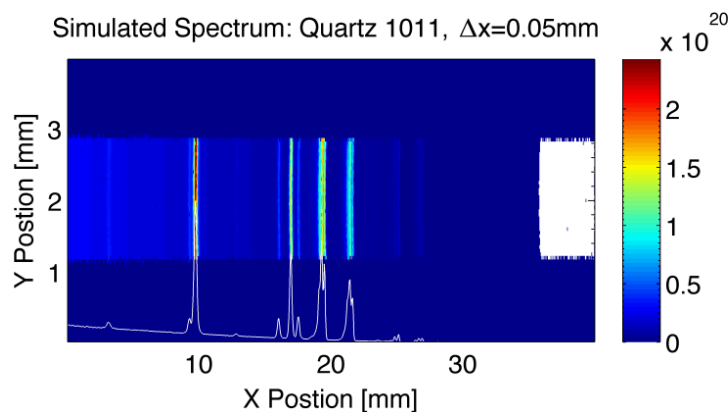
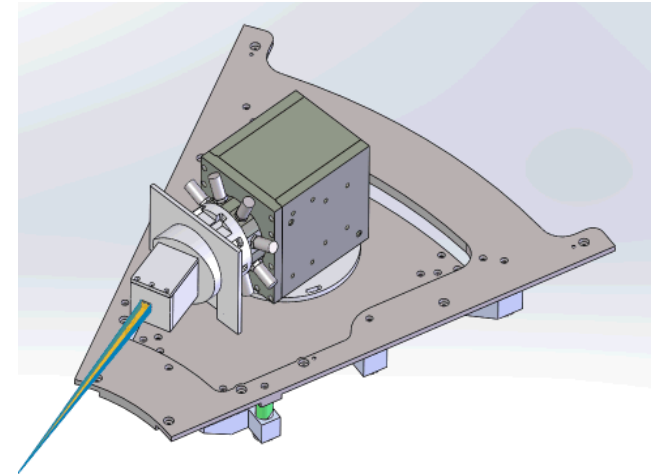
A next-generation containment system is being developed for use in FY16

- Leverage database of 50+ containment experiments
- Created 2 teams focused on power flow and system engineering
- Current delivery in containment geometry is a significant challenge
 - Investigating vacuum conditions inside the system
 - Exploring capabilities to reduce surface inventory that contributes to A-K plasma formation
 - Recent shots have identified positive load hardware geometry changes
 - Larger 31-cm convolutes may be needed
- Investigating design options for improved ultrafast closure valve (UCV) sealing



A new Time-Gated High-Energy Radiation Spectrometer (TiGHER) is in development

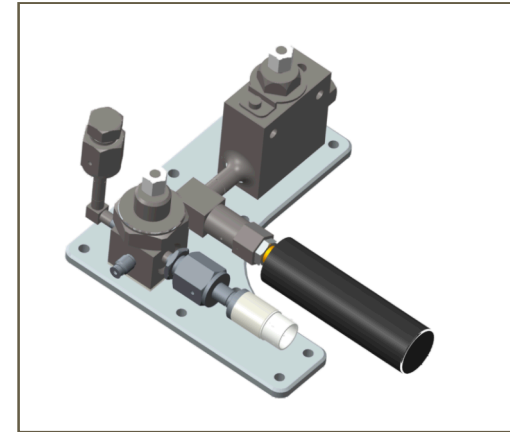
- In-chamber diagnostic for 1D time-resolved spectra
 - axially resolved; option for radially resolved
 - uses Gen-II NSTEC MCP
- Designed for measurement of Kr He- α and Br He- α
- 8-25 keV (0.5-1.55 Angstroms)
- Spectral: $I/DI \sim 700$; spatial $\sim 100 \mu\text{m}$
- 8 frames, 250 ps gate width
- Commissioning planned for August 2014



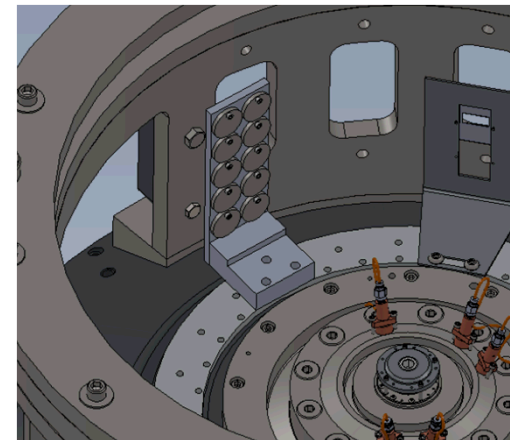
The GC LDRD is exploring the feasibility of implementing tritium on Z

- exploit the synergy with ongoing containment system development
- design and develop a gas transfer system (in-situ gas delivery system)
- model and measure tritium transport and containment with low mass surrogates
- measure uptake and retention of tritium (and tritium surrogates) in relevant Z center section materials
- develop an operational plan for inherently-safe levels or trace amounts of tritium (fielded in FY16)
- baseline current tritium levels as consequence of deuterium use
- explore tritium uncontained tritium management

Low-profile version of gas transfer system

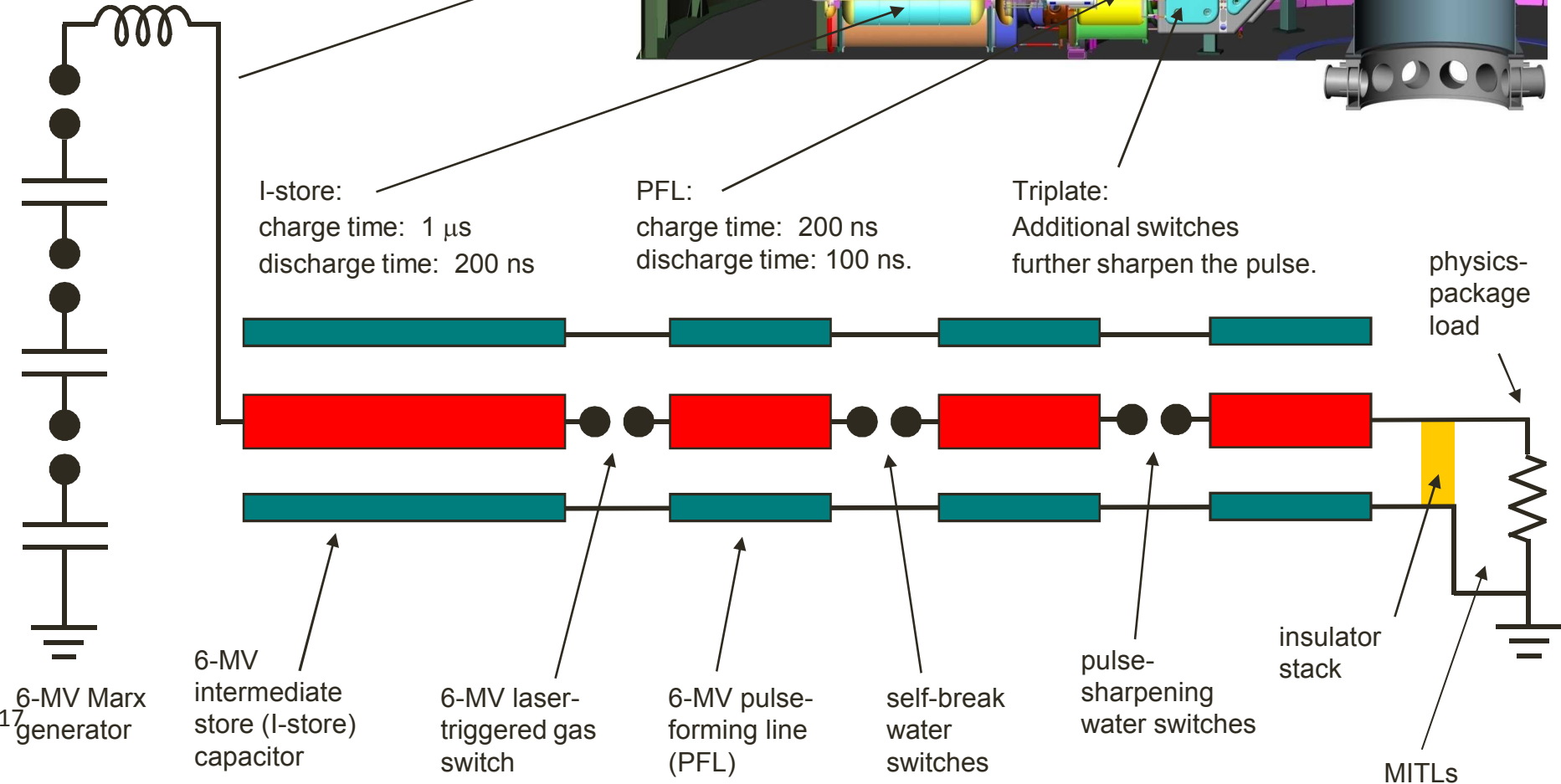
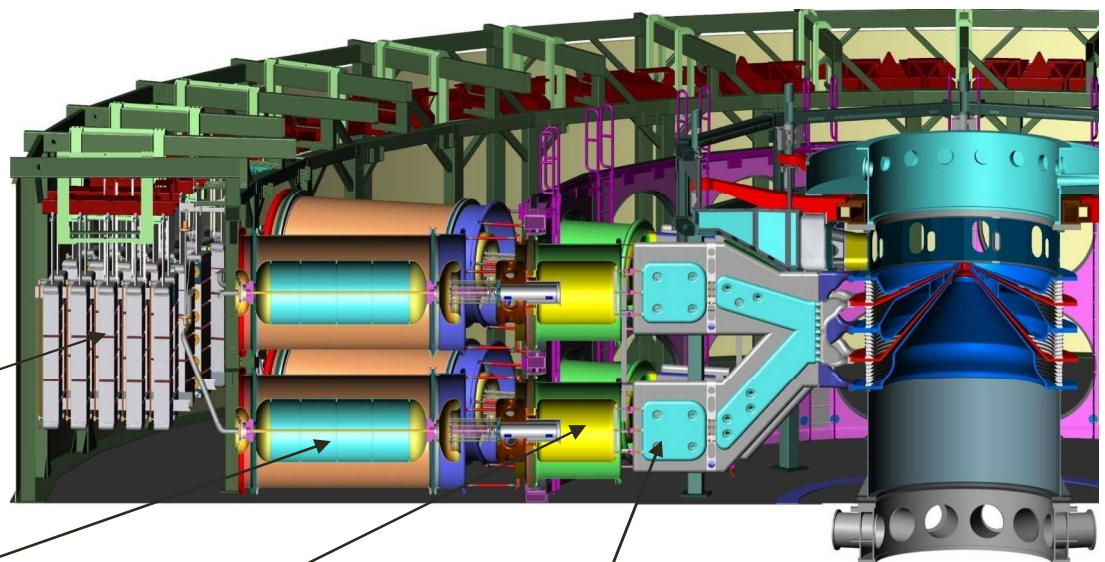


Recent Z coupon testing

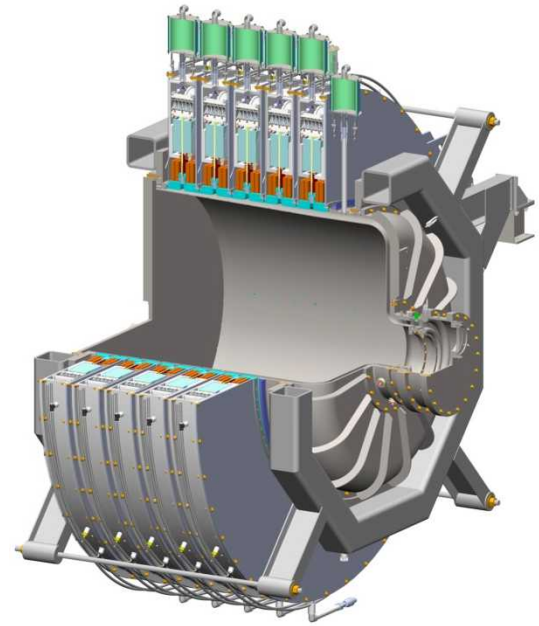
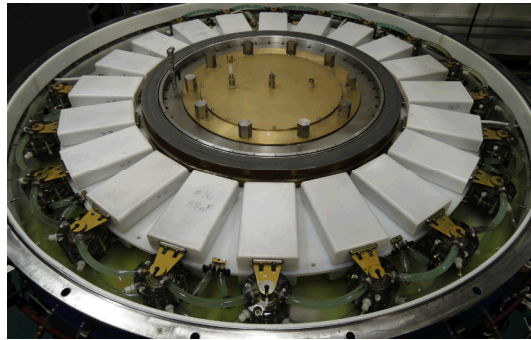
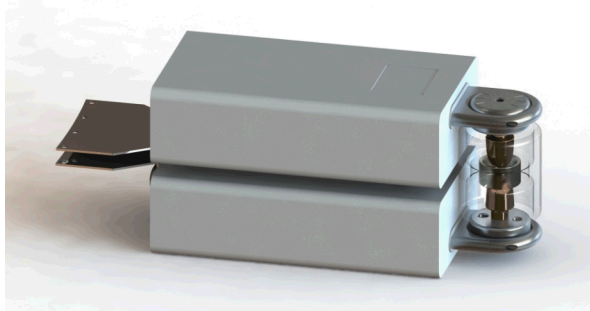


Each Z module performs four stages of pulse compression

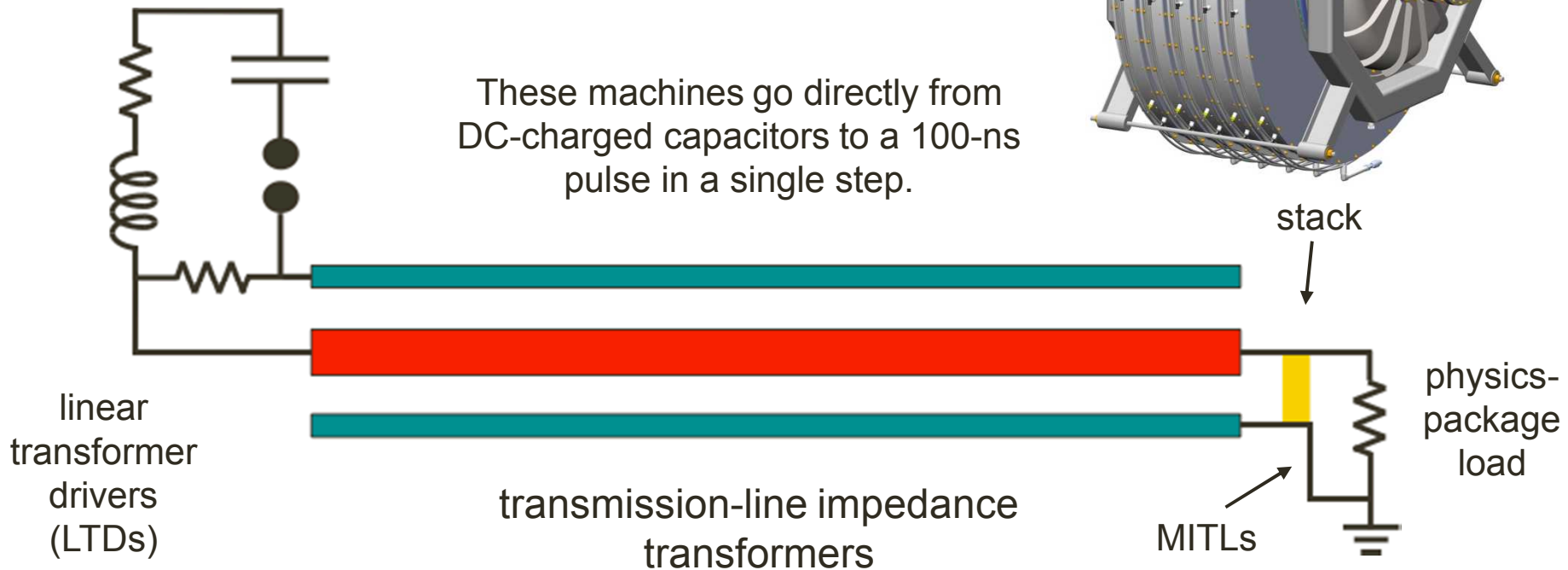
Marx generator:
 charge time: 100 s
 discharge time: 1 μ s.



Z 300 and future pulsed power machines will use single-stage pulse compression



These machines go directly from DC-charged capacitors to a 100-ns pulse in a single step.



Z 300 can deliver 47 MA to a MagLIF load and fit within the existing Z building

$P_{LTDs} = 315 \text{ TW}$
 $E_{LTDs} = 47 \text{ MJ}$

$V_{stack} = 7.6 \text{ MV}$
 $L_{vacuum} = 16 \text{ nH}$

$I_{load} = 47 \text{ MA}$
 $\tau_{implosion} = 133 \text{ ns}$

diameter = 35 m

