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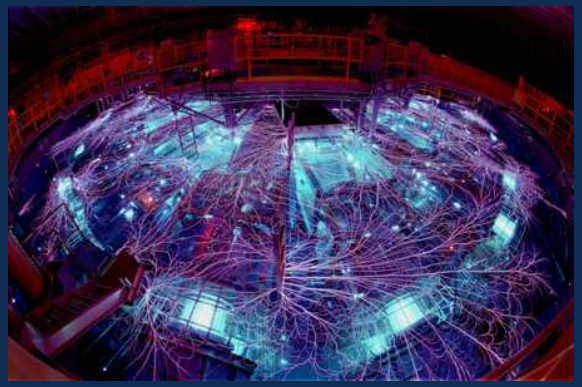

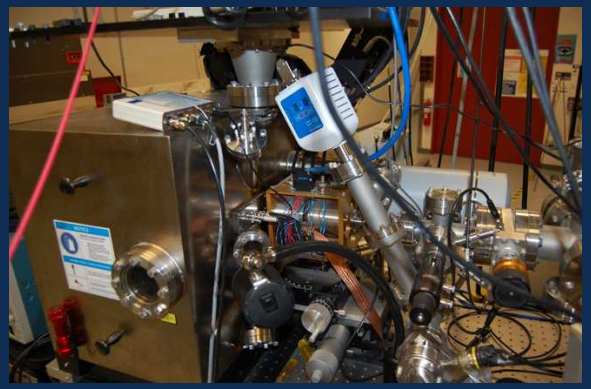

Z Facility Update and Future

Joel Lash

Senior Manager, Z Facility R&D

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

U.S. DEPARTMENT OF ENERGY | NNSA National Nuclear Security Administration

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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

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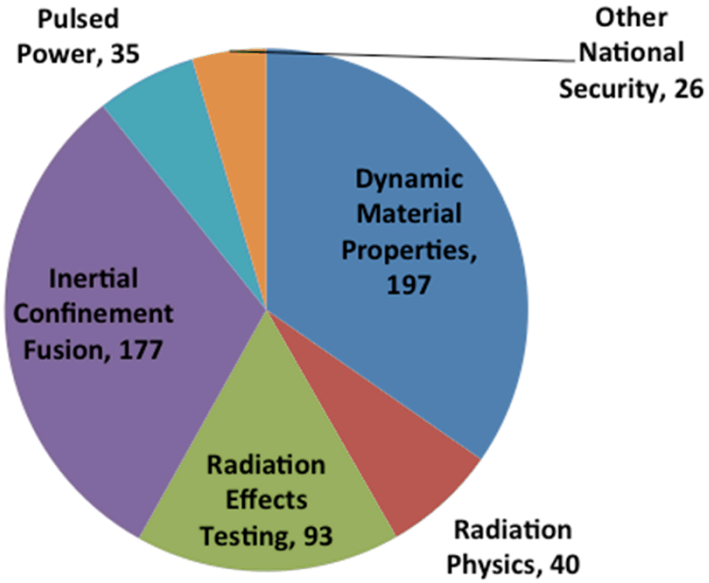
568 Shot Days have been requested by LANL, LLNL, and SNL for Stockpile Stewardship in CY14 – 3X more shot requests than available

Address key stockpile issues:

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

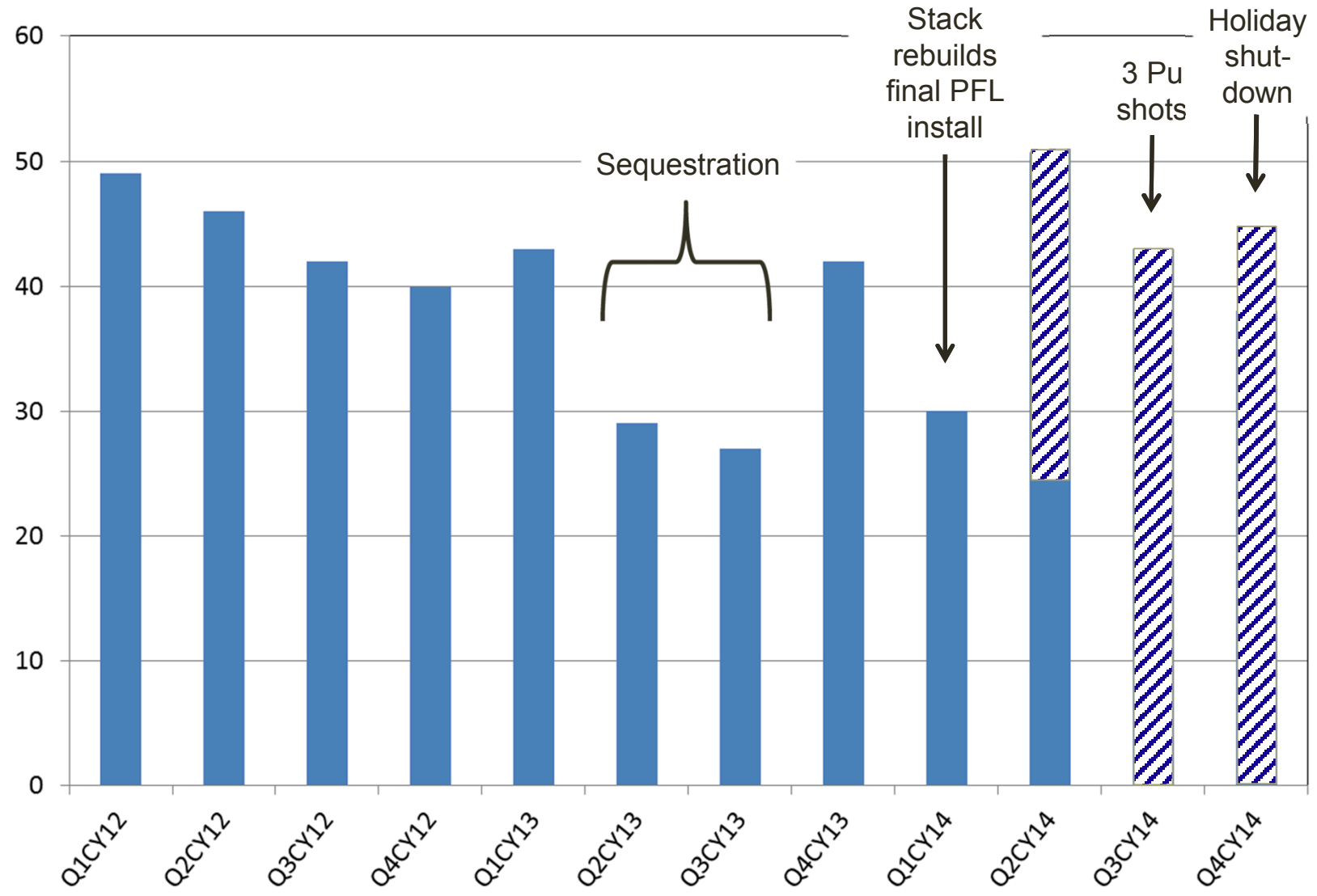


Current CY14 statistics

	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



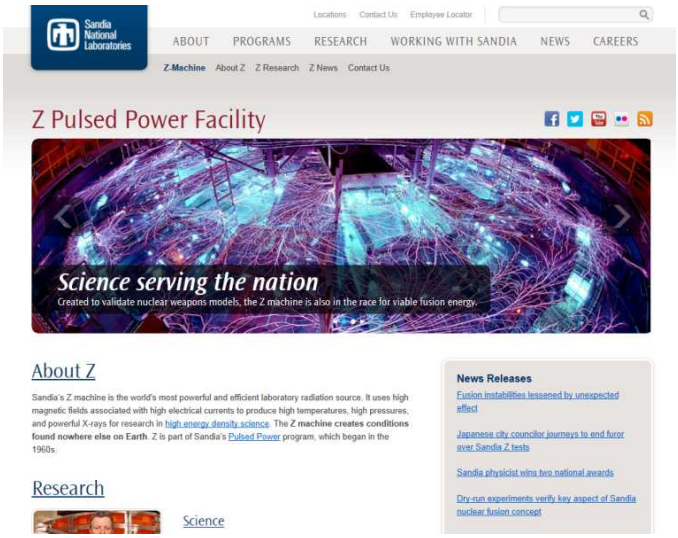
The visibility of Z has increased both internally and externally

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

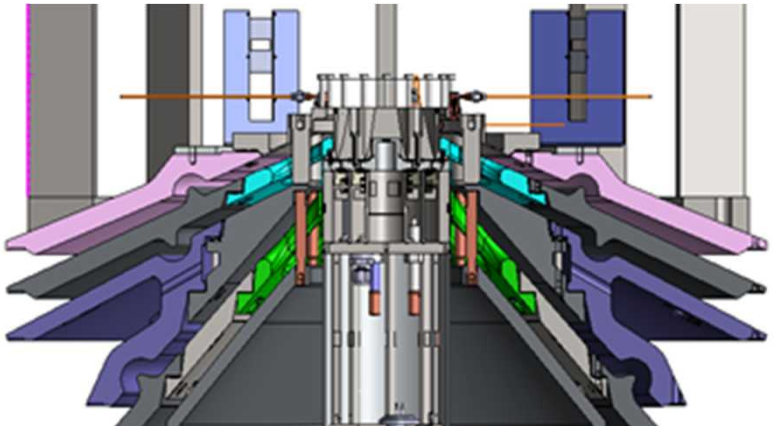
Visibility:

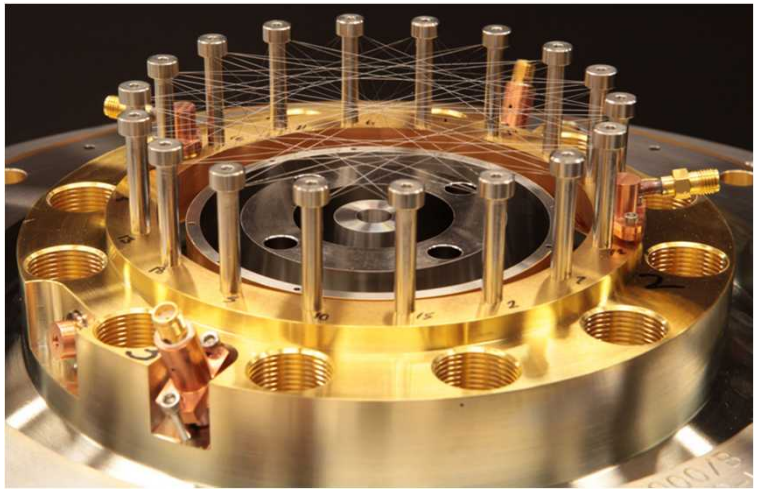
- New external website
- New internal website
- NPR All Things Considered
- Nature News / Physics Today / etc.



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

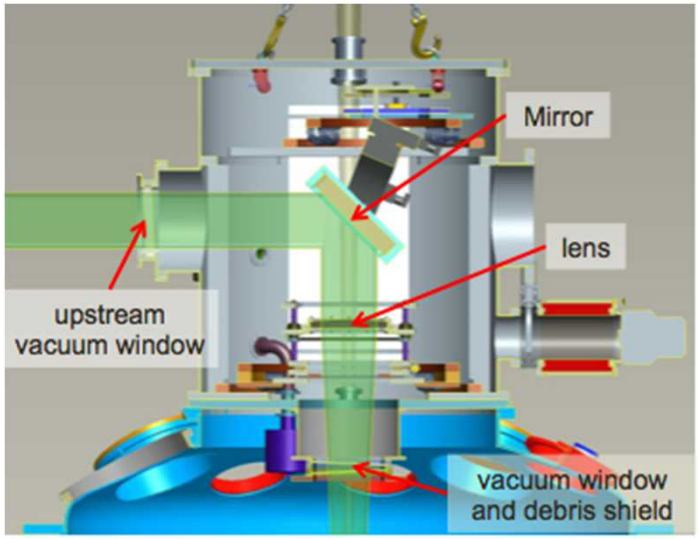
- Argon gas-puff implosions demonstrated 330 kJ of Ar K-shell yield above 3 keV photon energy with ±9% reproducibility between tests.
- First krypton gas-puff implosions on Z, designed using 3-D rad-hydro simulations, produced a record 5 kJ of Kr K-shell yield above 10 keV photon energy.
- Complex engineering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





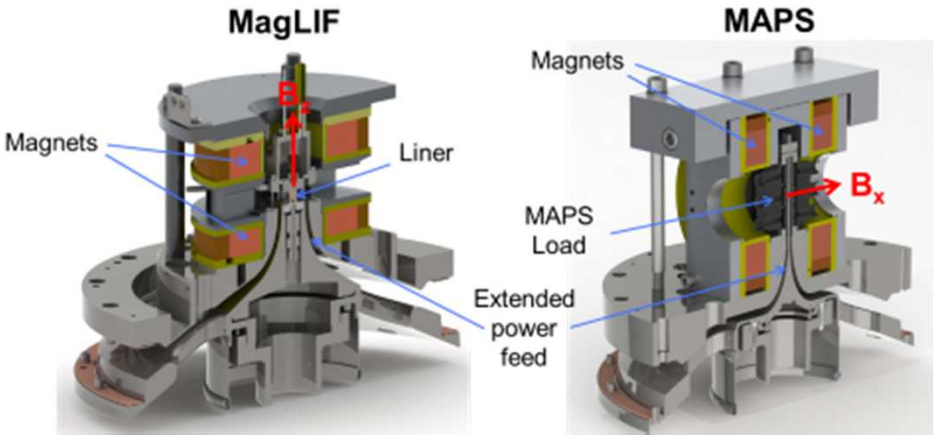
A new Z vacuum Final Optics Assembly has been commissioned

- 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

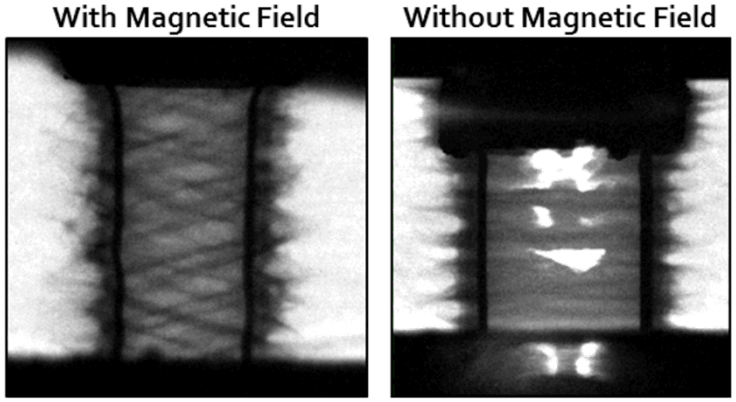


Applied Magnetic Field (B) on Z [ABZ] capability key to fusion research

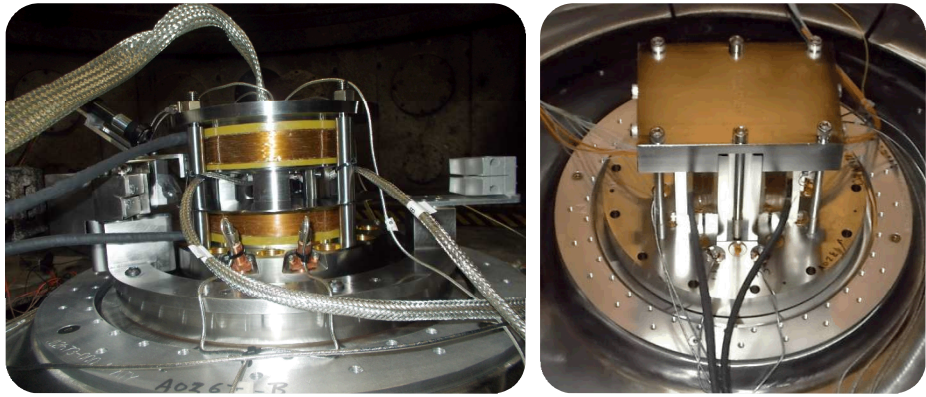
- The ABZ capacitor bank driver, coil system commissioned in February 2013
  - 900kJ capacitor bank sufficient to enable 10-30T+
- Axial magnetic field improves pinch performance, altered nature of MRT instability
- ABZ has been fielded on over 25 shots in FY13, FY14
  - A key component for exploring 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



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

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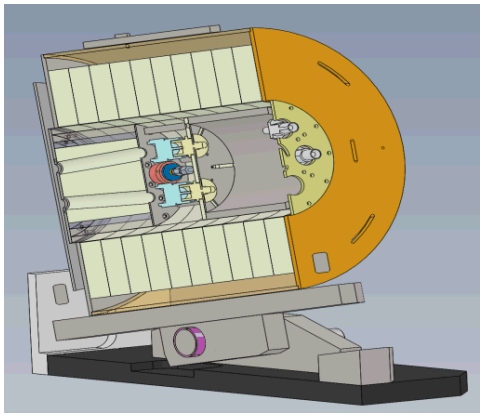
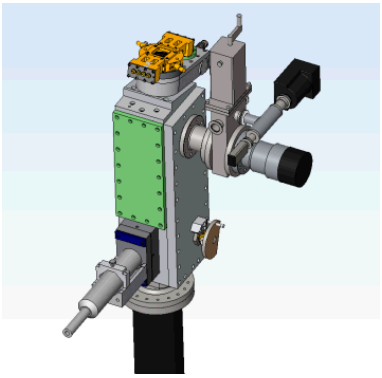
Differential Absorption Hard X-ray (DAHX)



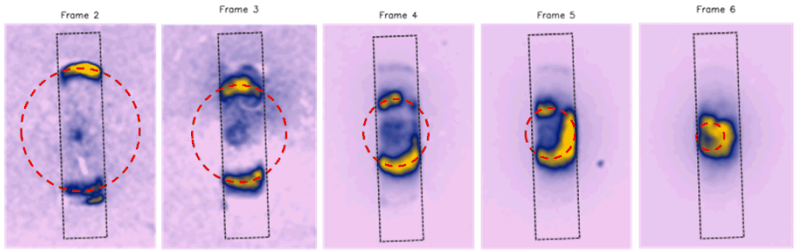
- Fielded on Z many years ago
- Provides a much needed diagnostic for photon energies above ~25 keV
- Time-resolved x-rays between 20 – 100 keV with ns resolution
- Uses an array of seven collimated Si PIN diodes with varying filters in a 2 to 4 inch thick tungsten housing

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

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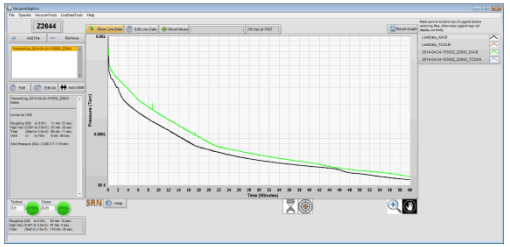
Rough Pump Upgrade

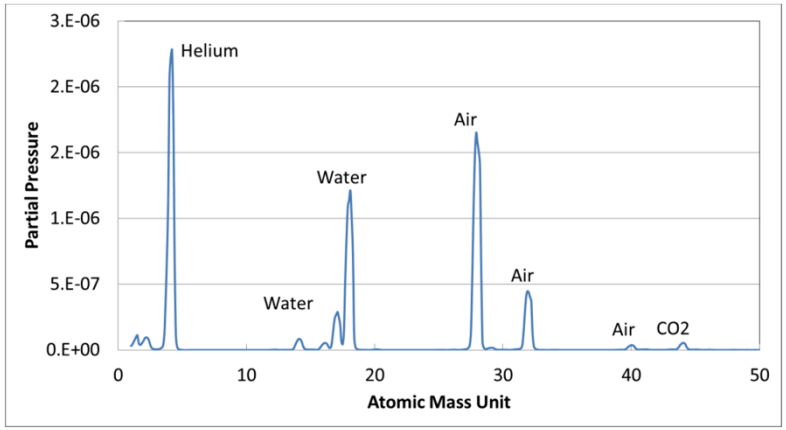
- 15% increase in roughing speed
- Quieter operation
- Reduced power consumption of ~$64,000 annually
- Remote operation capabilities

Automated Recording of Pump downs



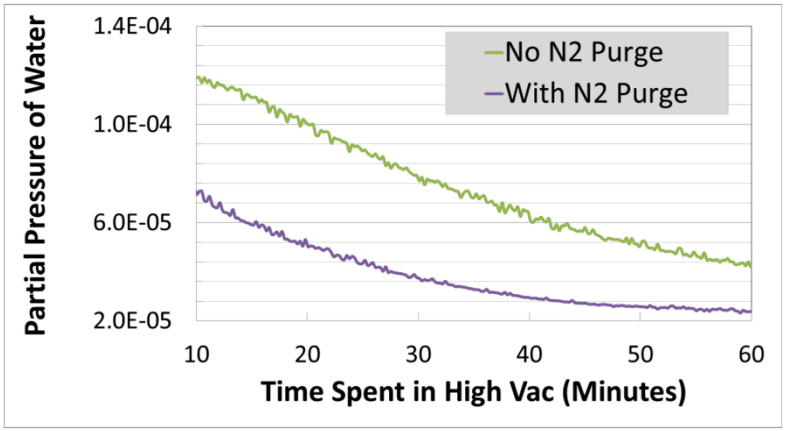
- Curves were hand recorded by hand every 5 minutes.
- Records all vacuum gages every second with information is pushed out
- Can identify vacuum issues much earlier

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

Information management improved through web-based applications

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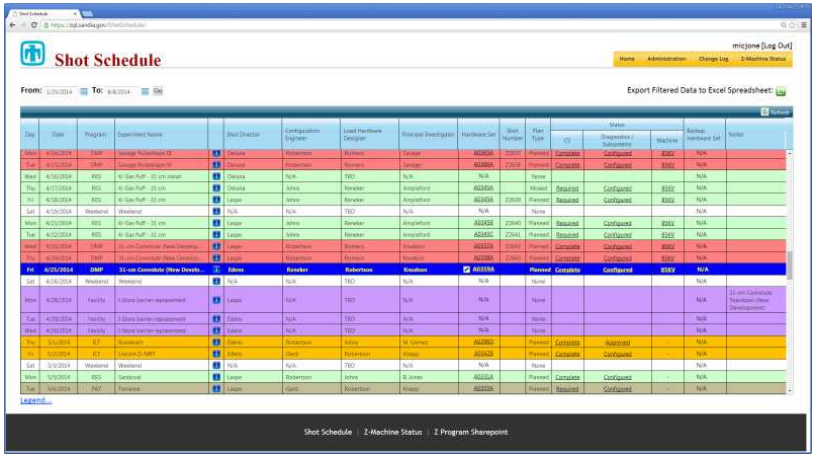
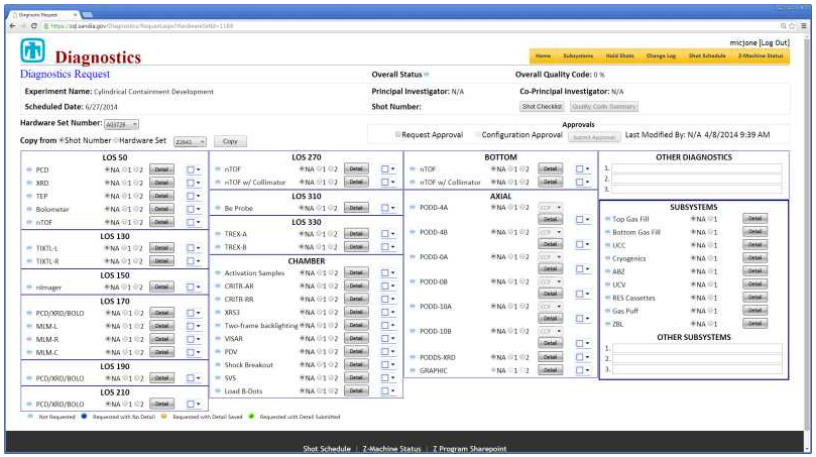
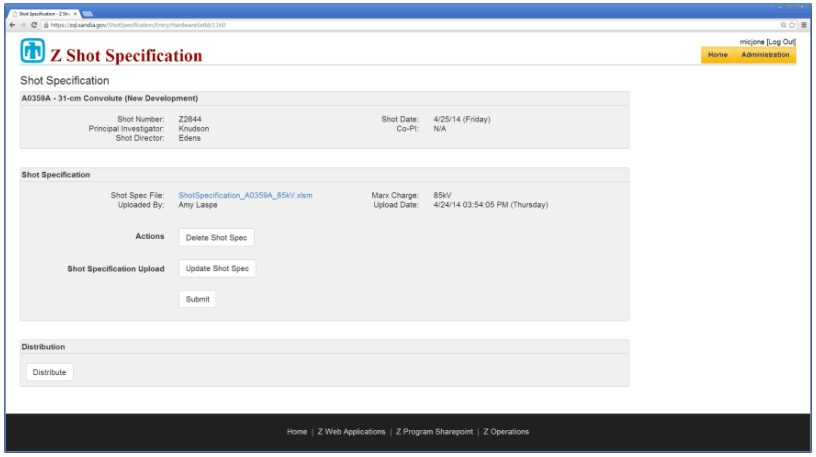
Z Shot Schedule



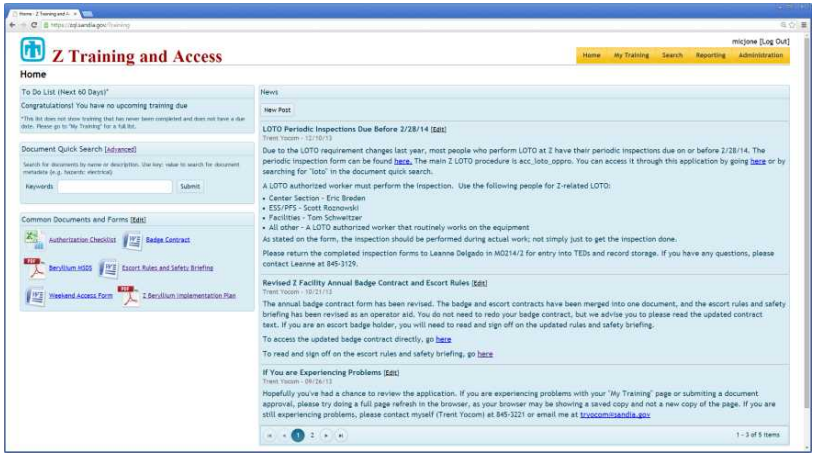
Z Diagnostic Request System



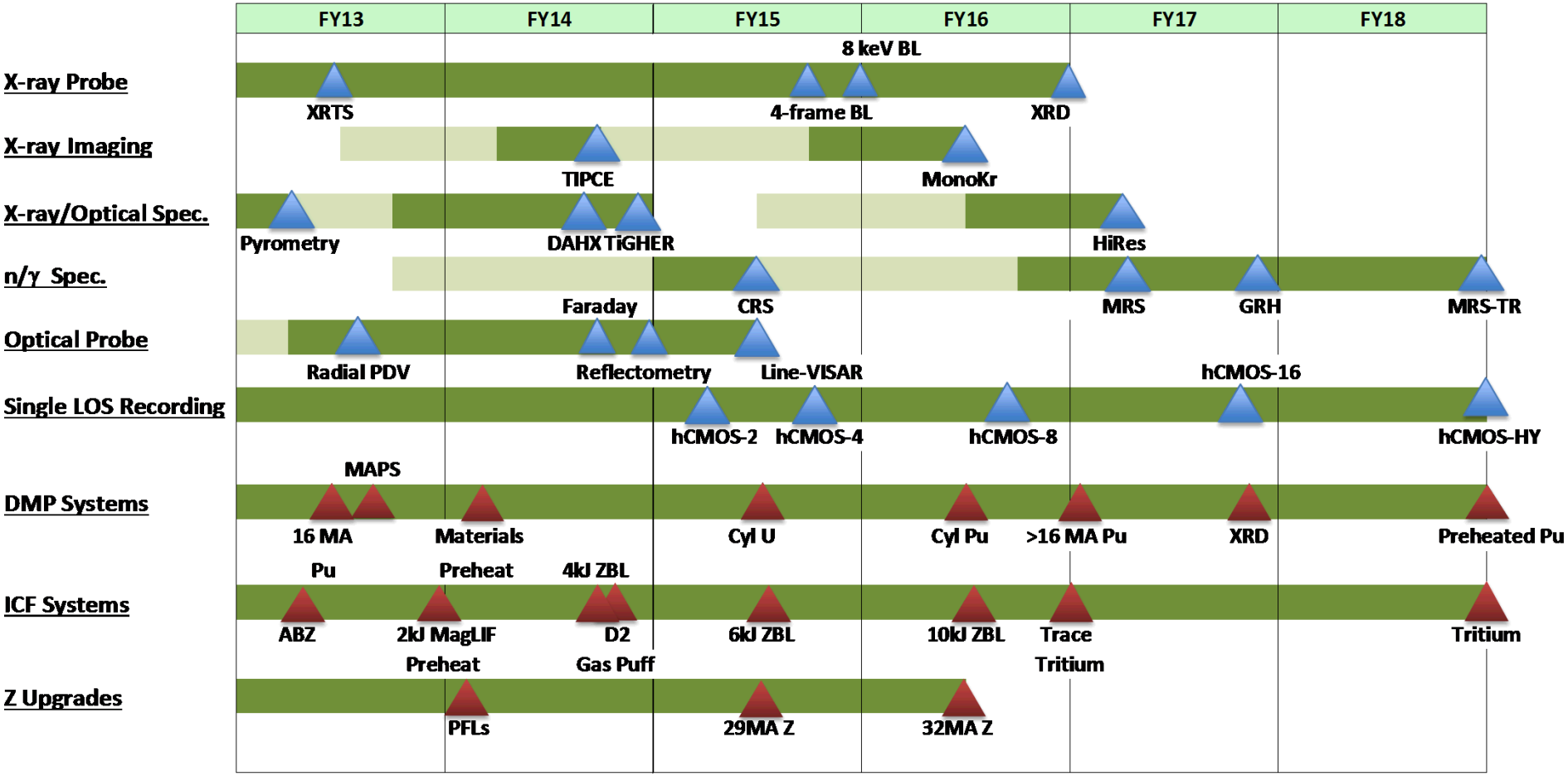
Z Machine Configuration



Z Training and Access System



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

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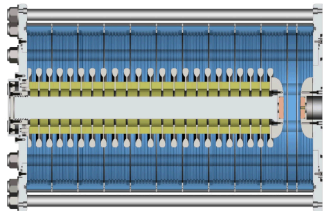
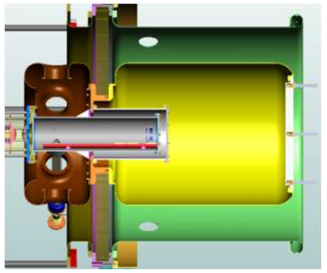
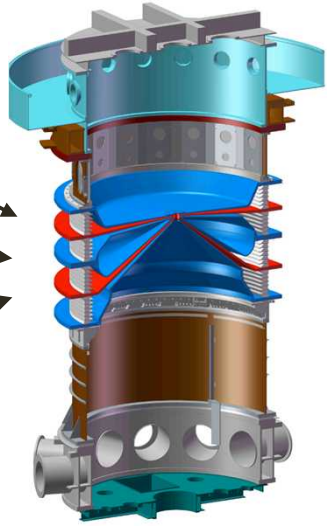
- **6.7-MV laser-triggered gas switches – done!**
  - The new switches allow increasing the Marx voltage from 85 to 95 kV, double the precision of the pulse shape, increase the shot rate by reducing maintenance, and improve worker safety.
- **6.7-MV pulse-forming lines – done!**
  - The new PFLs will 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%.

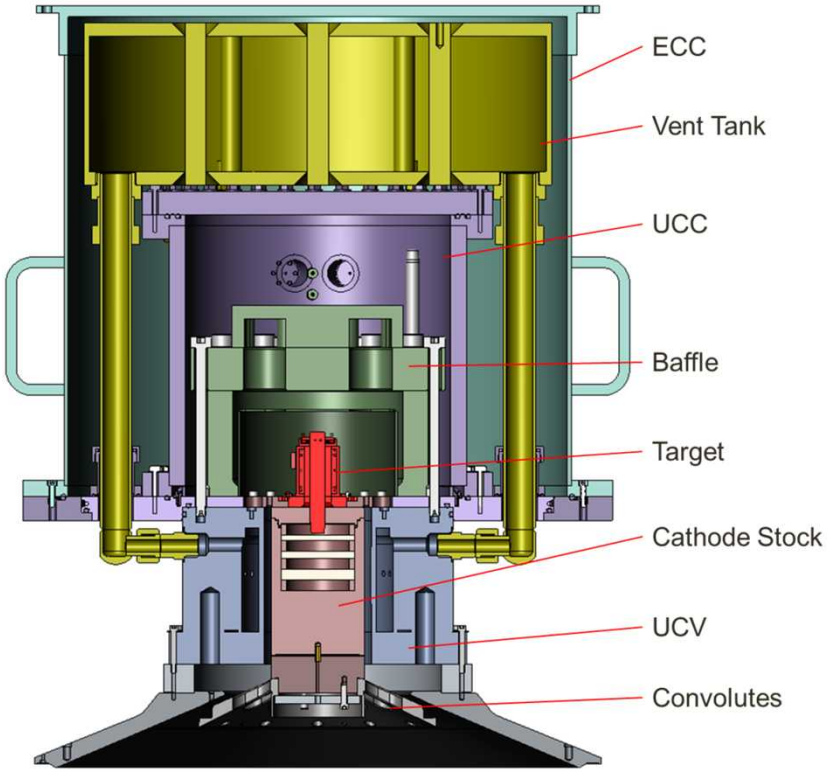






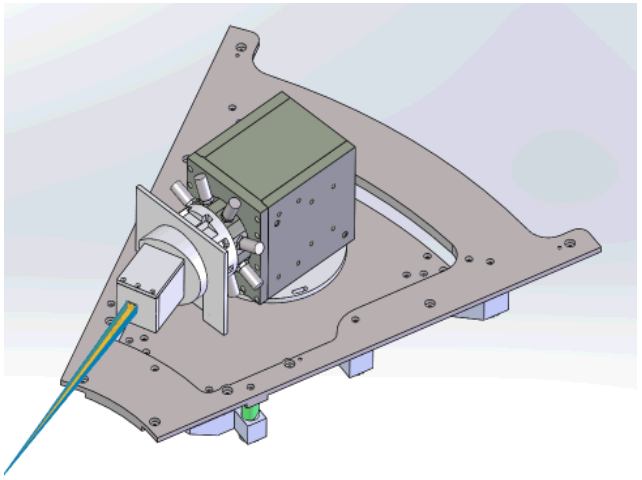
A next-generation containment system is being developed for use in FY16

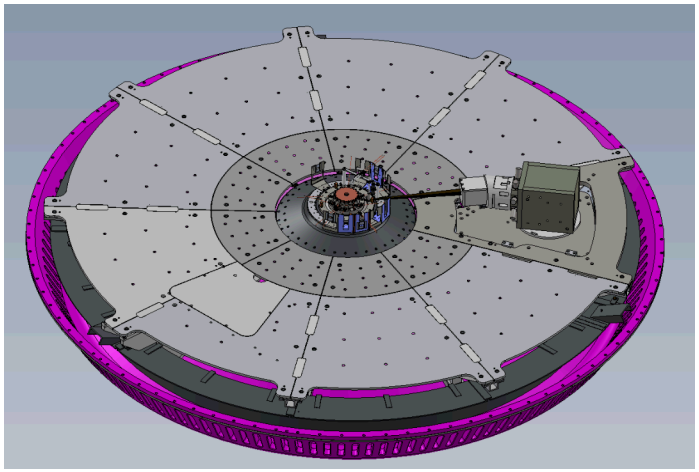
- Leverage database of 50+ containment experiments
- Created 2 teams focused on power flow and system engineering
- Current delivery in containment geometry is a significant challenge
  - Investigating vacuum conditions inside the system
  - Exploring capabilities to reduce surface inventory that contributes 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

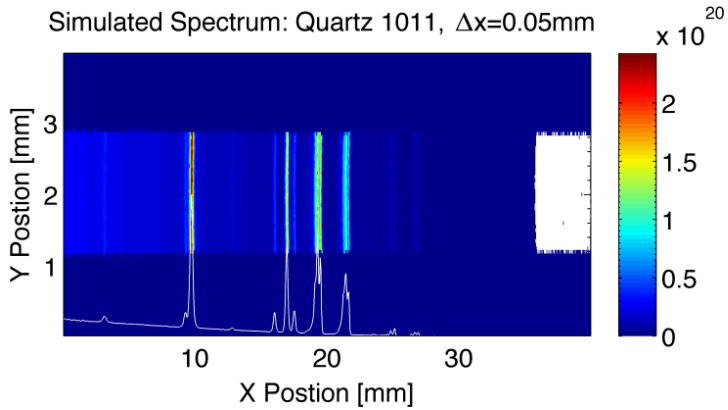


A new Time-Gated High-Energy Radiation Spectrometer (TiGHER) is in development

- 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: l/Dl~700; spatial ~100µm
- 8 frames, 250 ps gate width
- Commissioning planned for August 2014



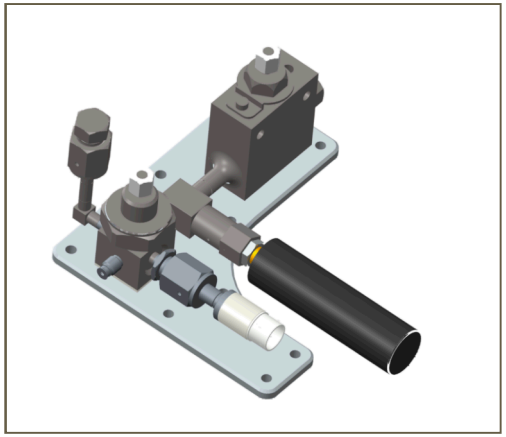




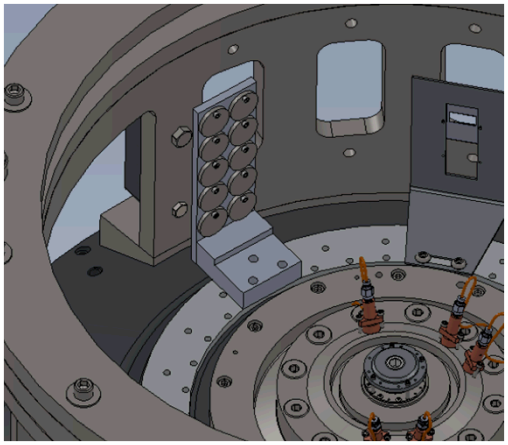
The GC LDRD is exploring the feasibility of implementing tritium on Z

- 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

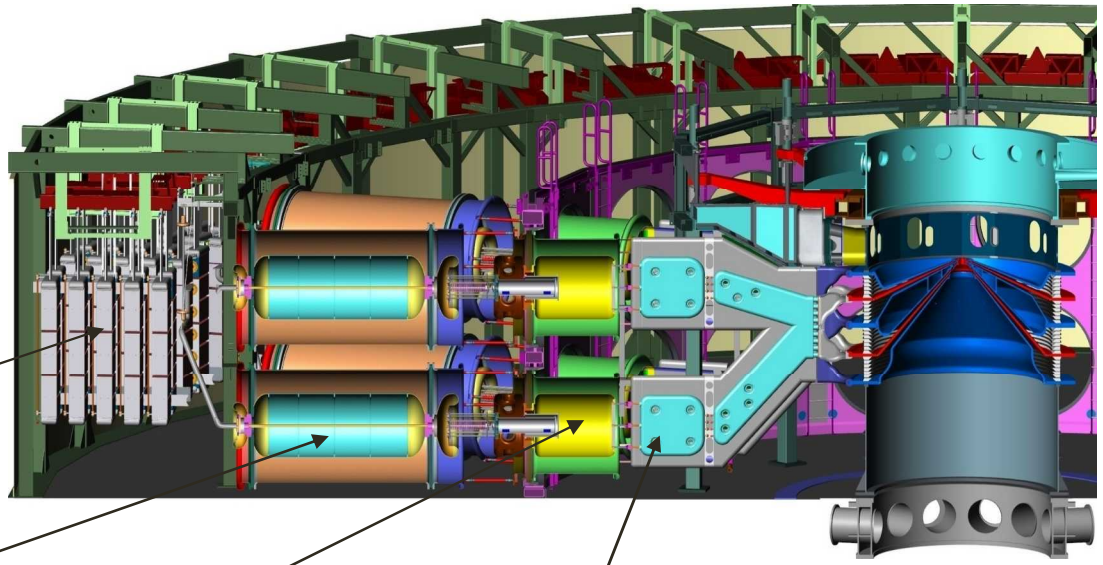
Low-profile version of gas transfer system



Recent Z coupon testing



Each Z module performs four stages of pulse compression



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

I-store:
charge time: 1 μs
discharge time: 200 ns

PFL:
charge time: 200 ns
discharge time: 100 ns.

Triplate:
Additional switches
further sharpen the pulse.

physics-package load

6-MV Marx generator

6-MV intermediate store (I-store) capacitor

6-MV laser-triggered gas switch

6-MV pulse-forming line (PFL)

self-break water switches

pulse-sharpening water switches

insulator stack

MITLs

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

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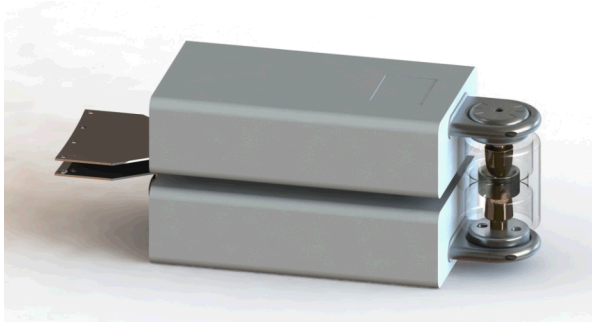

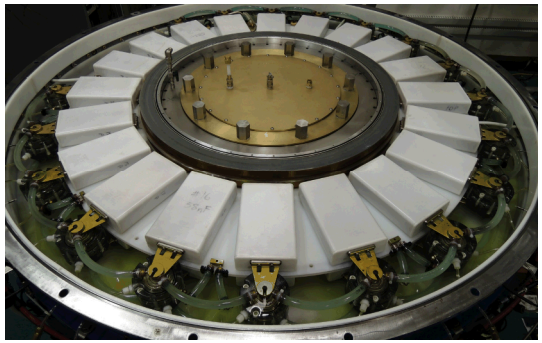

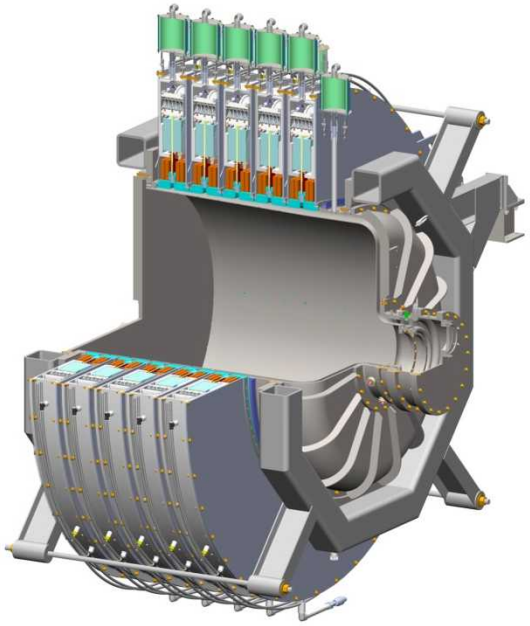

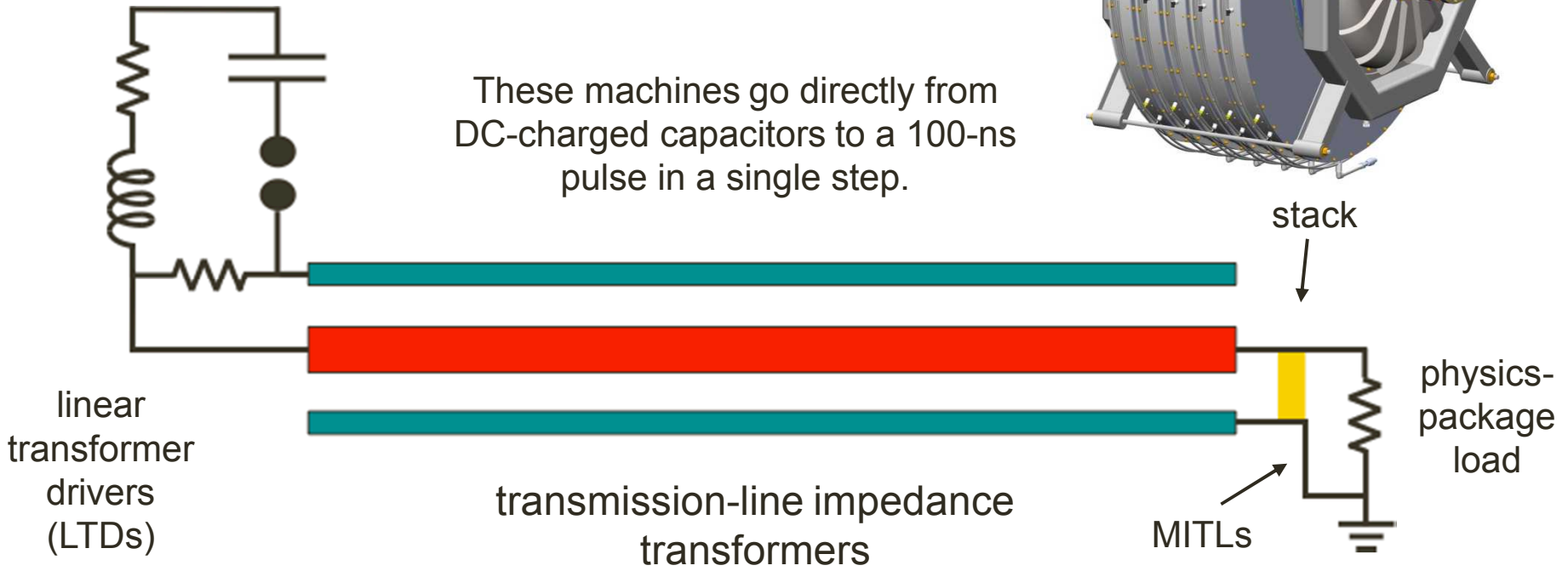

Z 300 can deliver 47 MA to a MagLIF load and fit within the existing Z building

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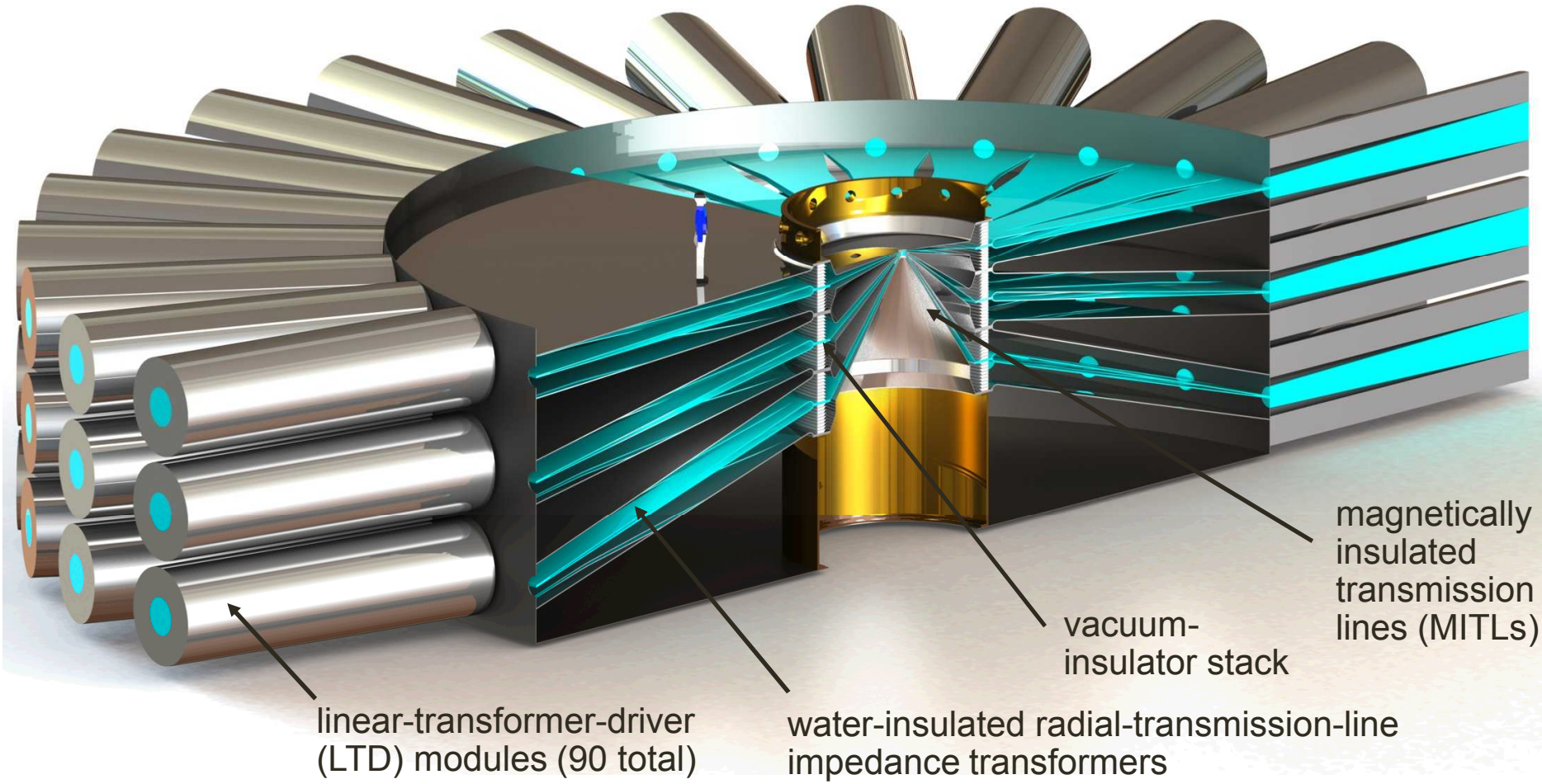
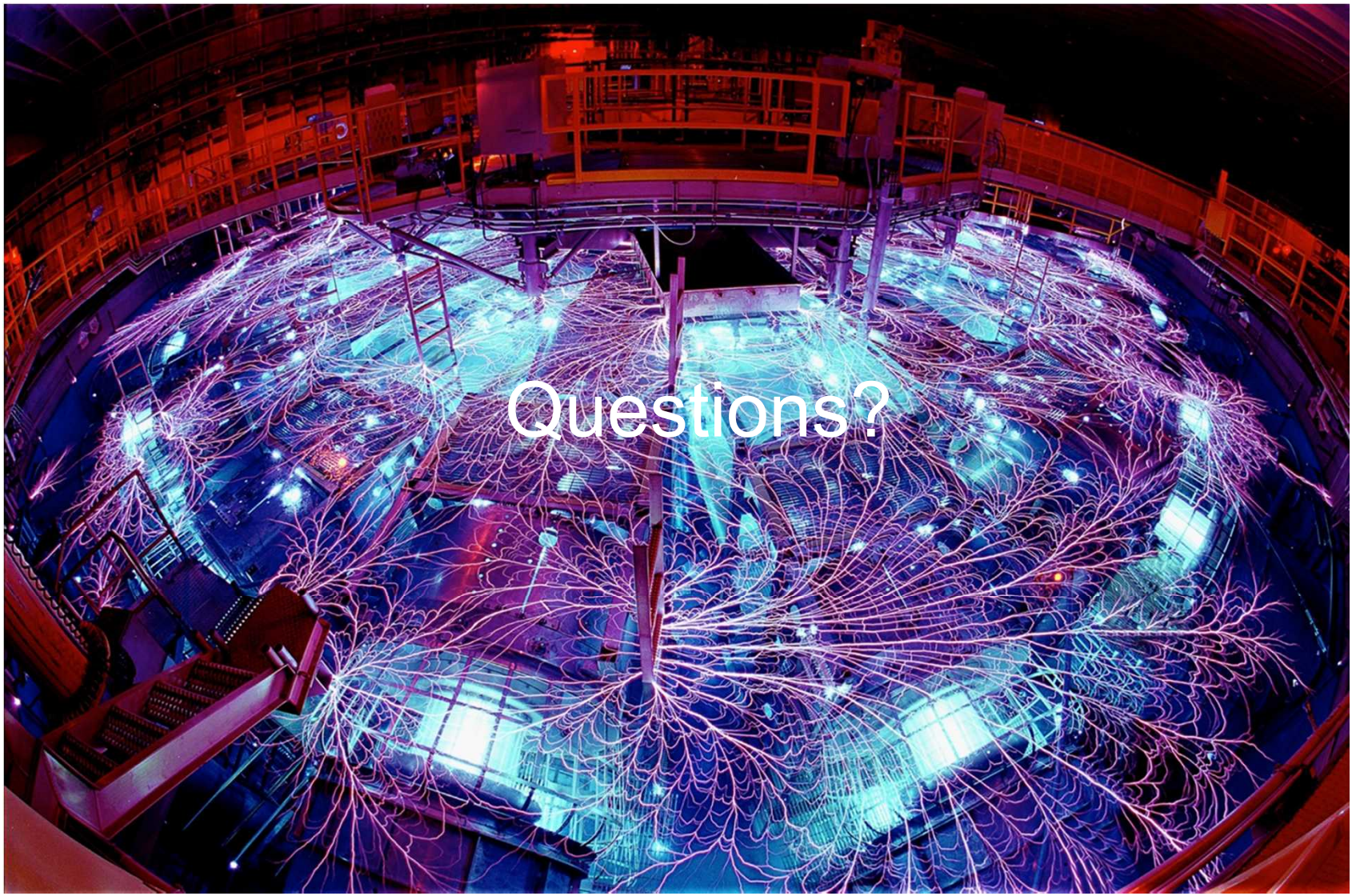
P_{LTDs} = 315 TW
E_{LTDs} = 47 MJ

V_{stack} = 7.6 MV
L_{vacuum} = 16 nH

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

diameter = 35 m




Questions?