SAND2015-5716PE

Exceptional service in the national interest

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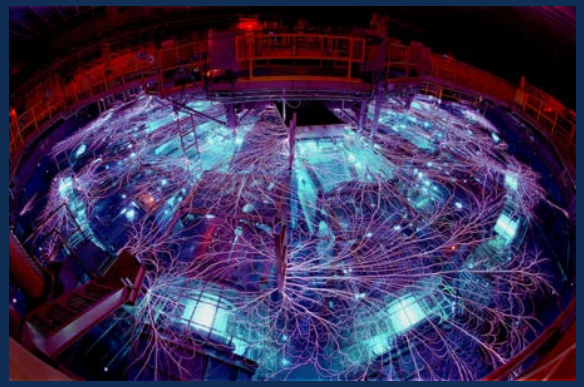

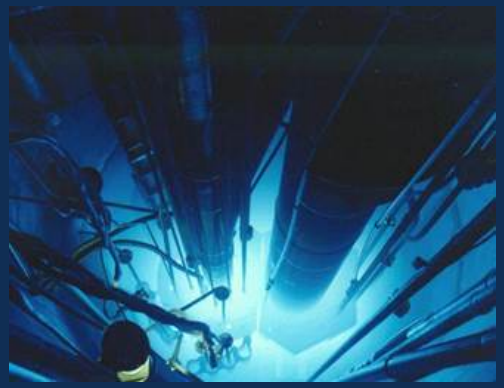

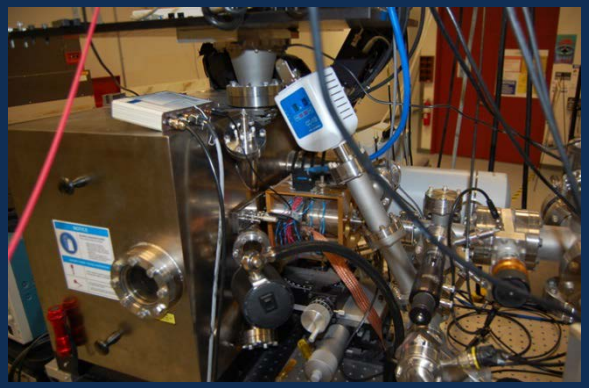

Z Facility Update and Future

Joel Lash

Senior Manager, Z Facility R&D

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

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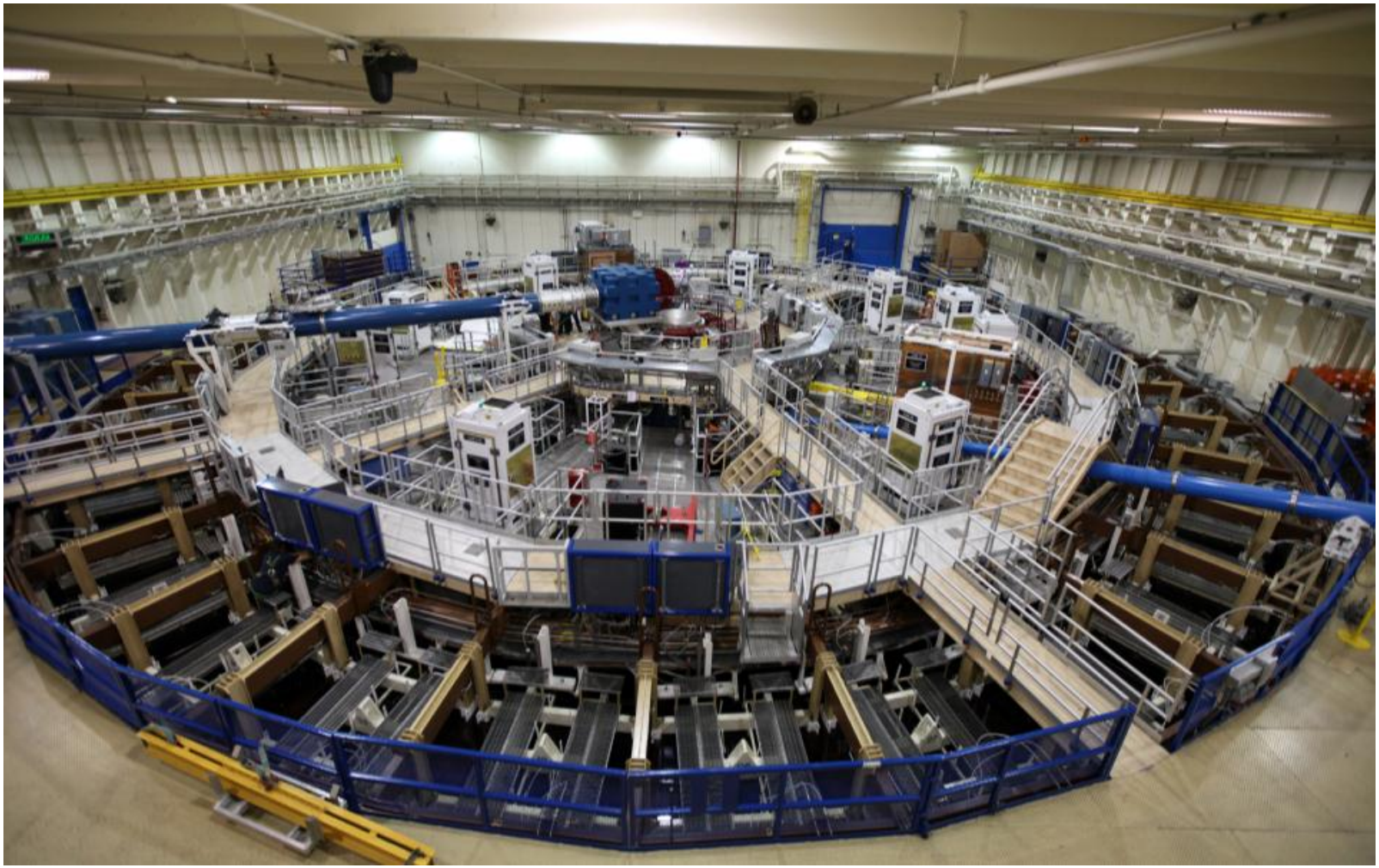
Outline

- Z shot data and visibility
- Safety and operational improvements
- Recent new capabilities
- Capabilities in development
- Beyond Z

Z is a unique world class pulsed power facility at Sandia National Laboratories

Sandia National Laboratories



Z is a unique world class pulsed power facility at Sandia National Laboratories

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Pulsed Power

22 MJ stored energy

3 MJ delivered to the load

26 MA peak current

1 - 100 Megabar

100 - 1000 ns pulse length

Diagnostics

Power & Energy

X-ray and Visible Spectrometers

Neutron TOF and Activation

Imaging (x-ray, visible, neutron)

Axial and LOS locations

Infrastructure

36 Marx generators

2160 capacitors

~ 1M gallons transformer oil

~ 0.5M gallons deionized water

100,000 liter vacuum vessel

Control and DAS

700 data channels per shot

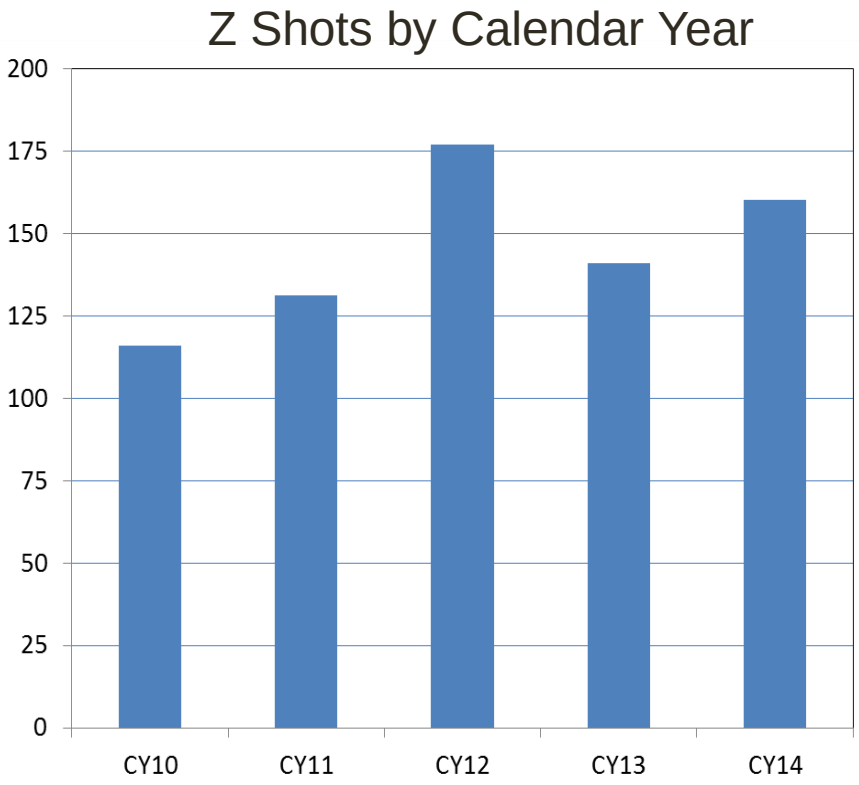
42 servers and 64 switches

~10,000 control points

~50,000 lines of code

5 – 6 different languages

Z is a unique world class pulsed power facility at Sandia National Laboratories



Z Shot Planning:

- Typically plan for 140 – 160 shots a year based on budget
- Single shift operation:
  - 6 am start
  - 5 pm shot window
- Nominally 1 shot per shot day
- CY16 will continue similar level of current FS shots (5 – 10%)
- External PIs work with internal PIs for planning and execution

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

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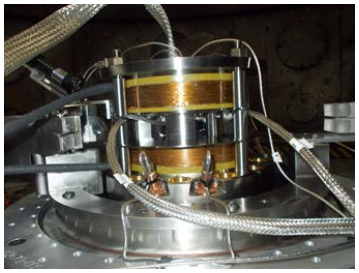
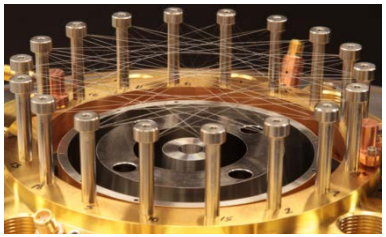
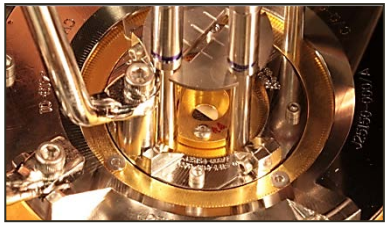
591 Shot Days have been requested by LANL, LLNL, and SNL for Stockpile Stewardship in CY15 – 3X more shot requests than available







CY14 statistics

	Shot Days	Shots	Fraction
Dynamic Materials	52	49	31%
Containment	29	7	4%
ICF	51	39	25%
Radiation Effects	45	30	19%
Secondary Assessment	23	22	14%
Primary Assessment	4	3	2%
Fundamental Science	3	3	2%
Facility/Maintenance	45	3	2%
	252	**156**	

20 planned shot days in CY15!

70% of Z shots are for Stockpile Stewardship experiments

The visibility of Z has increased both internally and externally

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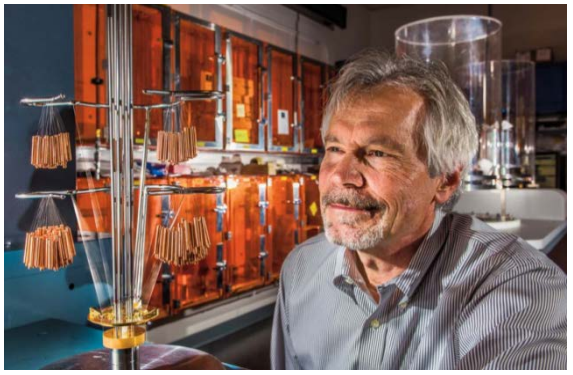
Tours:

- Secretary of the Air Force
- Chief of Naval Operations
- Nuclear Non-Proliferation Treaty Visit
- DOE OIG
- 10s of other visits; ~ 1 – 2 per week

Visibility:

- Hiroshima TV Documentary
- Center for Investigative Reports
- Nature, Nature Geosciences
- KOAT local news
- NPR/All Things Considered



Safety and Equipment Upgrades

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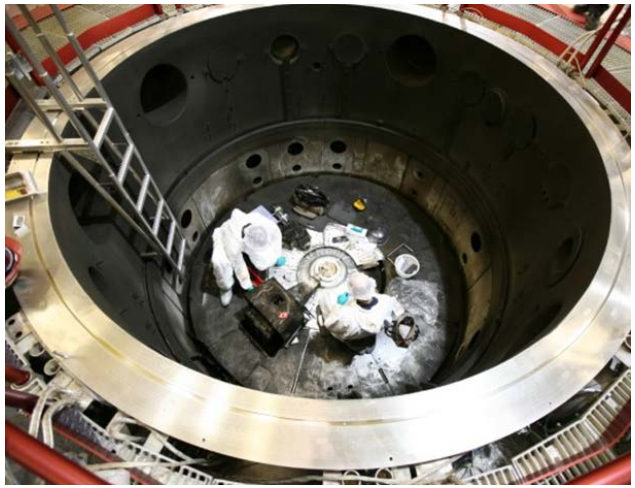
Vacuum Chamber Air Exchange



Replacing the MITL Refurbishment Tent

An engineered control for managing Be

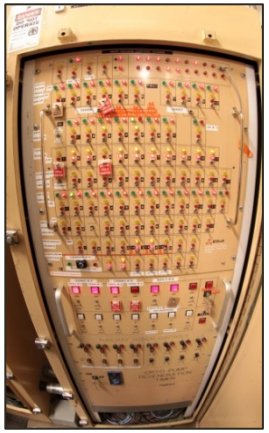
Removal of legacy waste and surplus equipment

- ~200,000 lbs. of Be contaminated waste
- ~400 chemicals and paint items disposed of
- 5 flatbeds of old and surplus equipment
- Over 100 blue barrels (potentially radioactive beryllium waste) have been properly disposed of
- Dismantled ~10 large machine shop tools

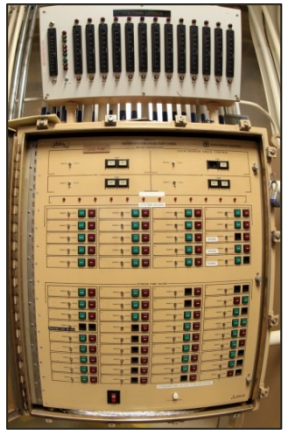
Working to replace aging/legacy equipment

- In the past few years many legacy control systems used within 1600 have been understood and upgraded. (ZBL, Mykonos, …)
- We are developing new systems to improve the capability, safety and reliability of control systems within 1600.

Z's control system computer. In place since 1993.



Z's vacuum control system In place since 1985.



Z's water drain/fill control system In place since 1985.

Information management improved through web-based applications

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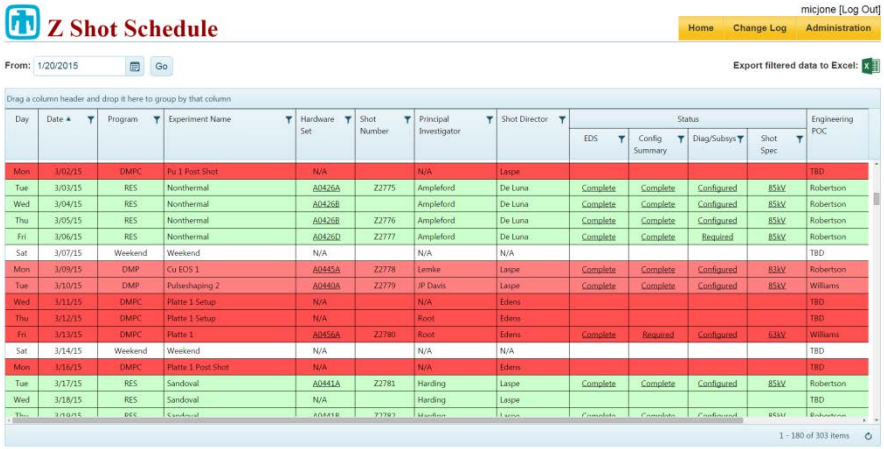
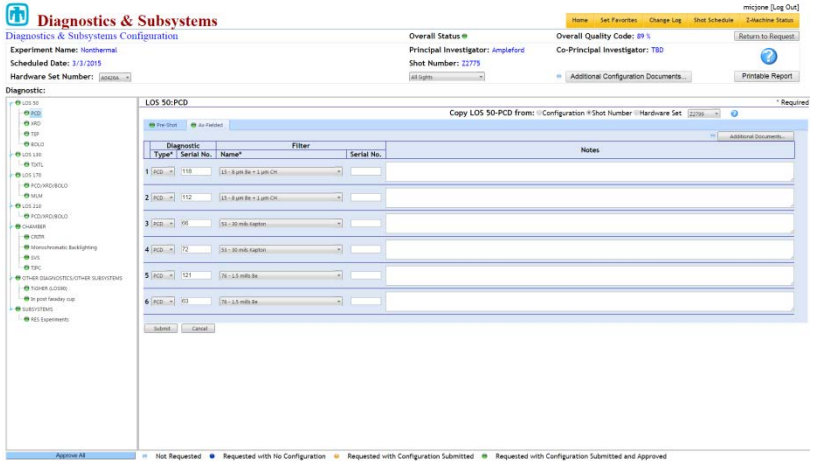
Z Shot Schedule



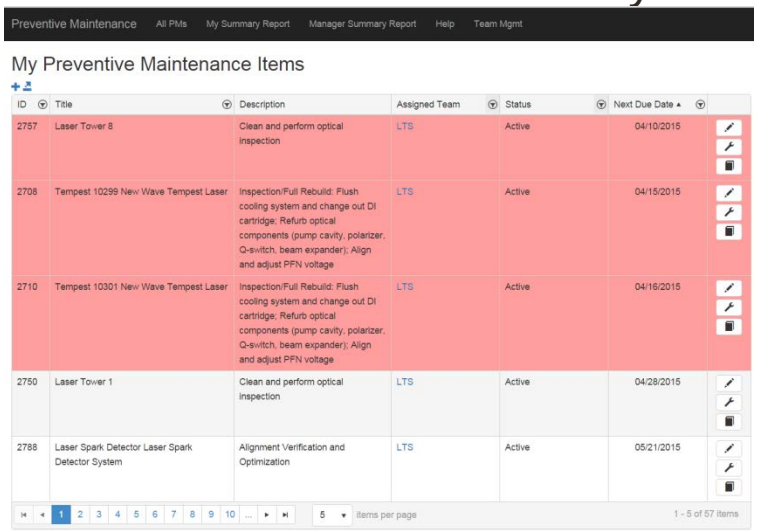
Z Diagnostic Request System



Z Shot Roster

	Mon 04/20/2015	Tues 04/21/2015	Wed 04/22/2015	Thurs 04/23/2015	Fri 04/24/2015
Experiment Name	**D2 Puff**	**D2 Puff**	**Hydroliquid**	**Union 2**	**Pulseshaping 3**
Shot Director	De Luna	De Luna	De Luna	De Luna	De Luna
Principal Investigator	Knapp	Knapp	Knudson	Lemke	JP Davis
Engineering POC	Reneker	TBD	Williams	Twyeffort	Williams
CM Operator	Baker	Baker	Radovich	Preston	Bock
CM Coordinator	Ploor	Ploor	Preston	Ploor	Preston
DAS Operator (CM POC)	Baker	Ploor	Preston	Ploor	Preston
Vacuum Shot Support	Bock	Bock	Bock	Bock	Bock
ESS Shot Support	Roznowski / Rakes	Divett / Jojola	Cortez / Speas	McCarthy / Avila	Cortez / Avila
LTS Shot Support	Potter	Potter	Potter	Potter	Potter
Access Evacuator (Top)	Roznowski / Potter	Jojola / De Luna	Speas / Potter	Avila / De Luna	Cortez / Potter
Access Evacuator (Bottom)	De Luna / Ploor	Divett / Baker	Cortez / De Luna	McCarthy / Potter	Avila / Bock
MiTL Refurb & Wipe	York / Citrin / White	York / Citrin / White	York / Citrin / White	York / Citrin / White	York / Citrin / White
Stack Refurb & Wipe	Justus / Roebuck / White	Justus / Roebuck / Macrunnels	Justus / Roebuck / Macrunnels	Justus / Roebuck / Macrunnels	Justus / Roebuck / Macrunnels
Lab 101	York / Olivas	York / Olivas	York / Olivas	York / Olivas	York / Olivas
Top Side Load	York / Citrin	Macrunnels / Citrin	Macrunnels / Citrin	Macrunnels / Citrin	Macrunnels / Citrin
Bottom Side Load	White / Roebuck	Roebuck / White	Roebuck / Olivas	Roebuck / Justus	Roebuck / White

Z Preventative Maintenance System



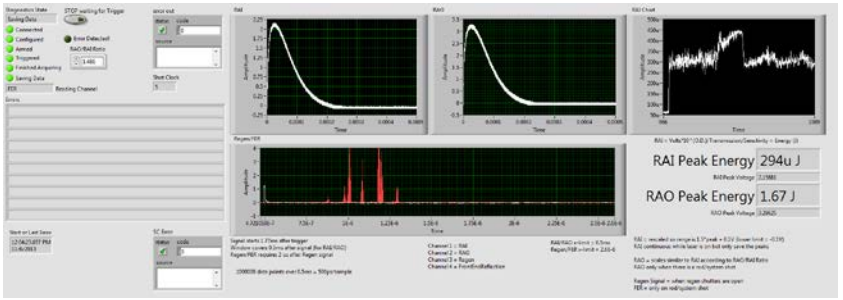
Improvements to Z's legacy systems are constantly being made

Z Gas Switch Pressure System

- Developed and deployed a system that improves the accuracy of the SF6 pressure in each LTGS and eliminated the need to manually check each line.
- Integrated status display into Z Status

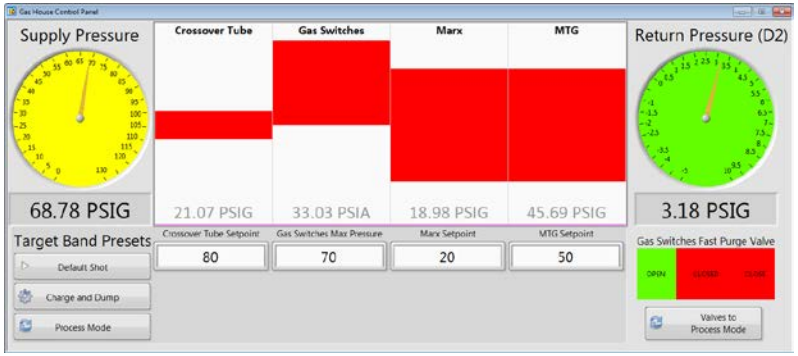
ZBL Shot Control & Z-ZBL Integration

- ZBL Shot Control was re-written and all subsystems (20) integrated into a new architecture
- The Z-ZBL integration was understood and upgraded. (~15% of integrated shots failed)
- No failures post these upgrades.



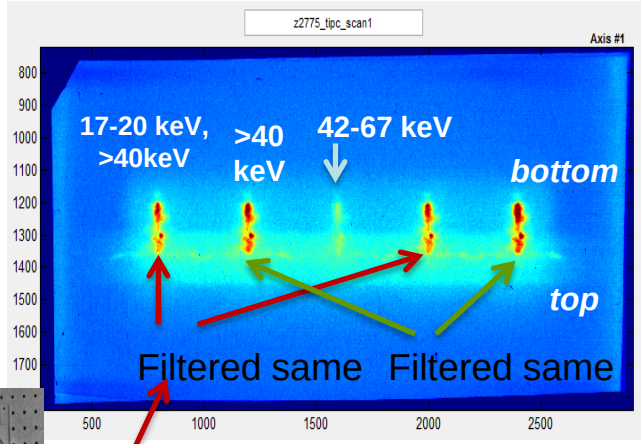
Z Gas House

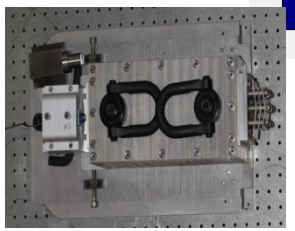
- More precise control over gas pressures in pulsed power components.
- Custom graphical user interface was developed to improve operator efficiency, allow easier training for new operators, and reduced operator error.

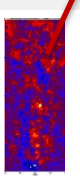


‘New’ diagnostics deployed on Z

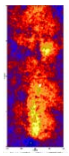
Time-Integrated Pinhole Camera (TIPC)







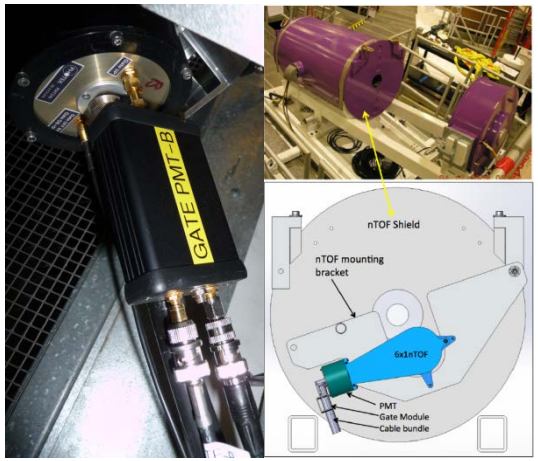
Subtracting images that are filtered the same



Subtracting different filtered images to get 17-20 keV window

- In-chamber pinhole camera designed for imaging warm x-rays (15-100 keV).
- 5 filtered pinhole images per experiment.
- Developed under hostile environments LDRD to identify where in the source warm x-rays are produced.
- Currently used broadly in ICF, RES programs.

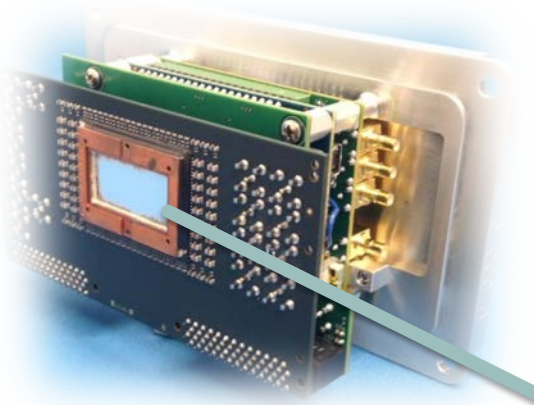
Gated nTOF detectors



- Collaboration with LLE based on Omega fielding experience (Glebov), and NSTec to implement Z detectors.
- Gating out brems pulse will allow higher signal-to-noise measurement of secondary DT spectrum.
- Improved BR measurement for MagLIF.
- Gate unit function has been demonstrated in Z electromagnetic environment.

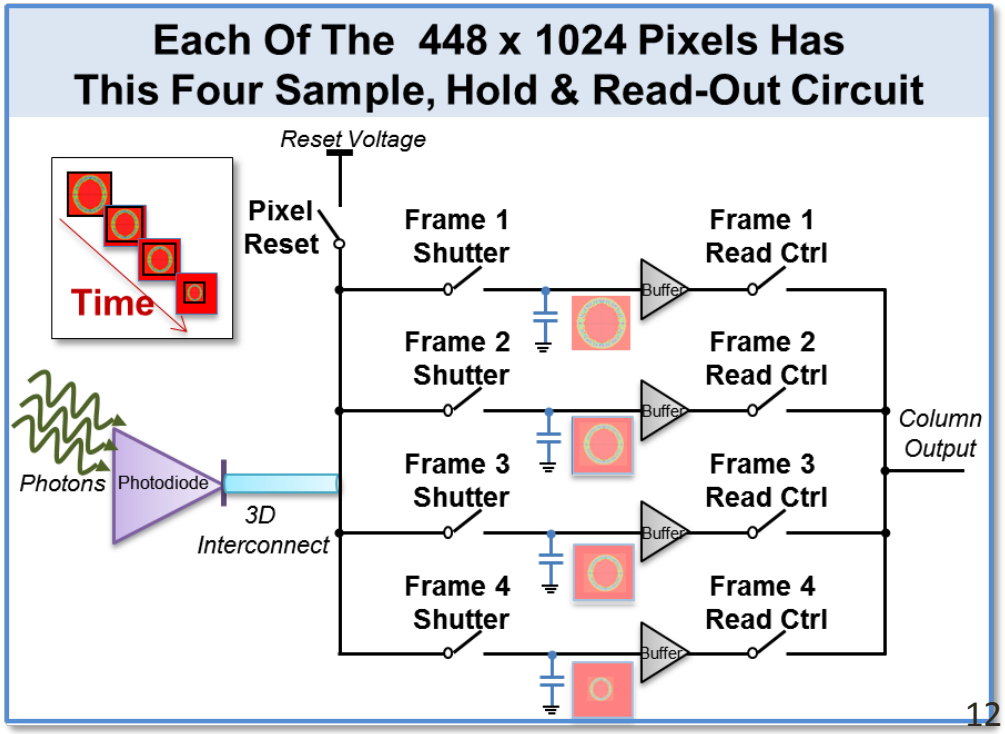
We've developed a high speed hybrid CMOS camera for multi-frame imaging, backlighting, and spectroscopy

hybrid CMOS camera



designed and built in collaboration with the MESA facility

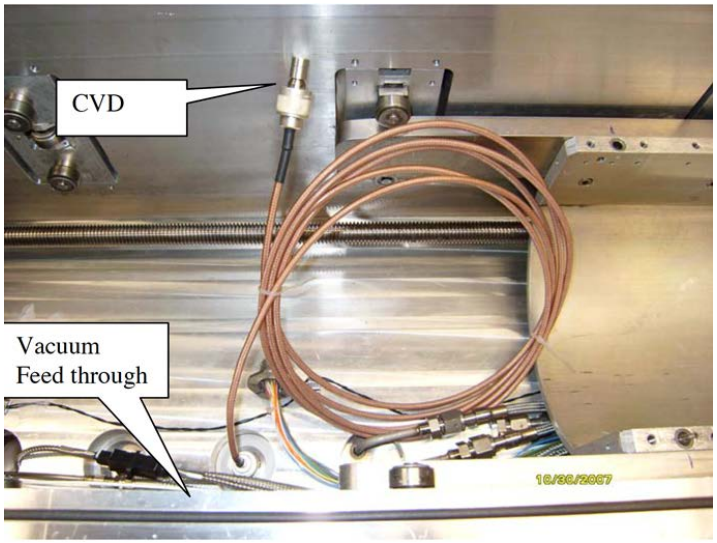
- Up to 4 frames of data on a single line-of-sight
- 1.5 ns minimum gate time
- 448 x 1024 pixel array
- 25 um x 25 um per pixel
- Sensitive to visible light and 0.7 - 6 keV x-rays



New diagnostics deployed on Z in collaboration with LLNL

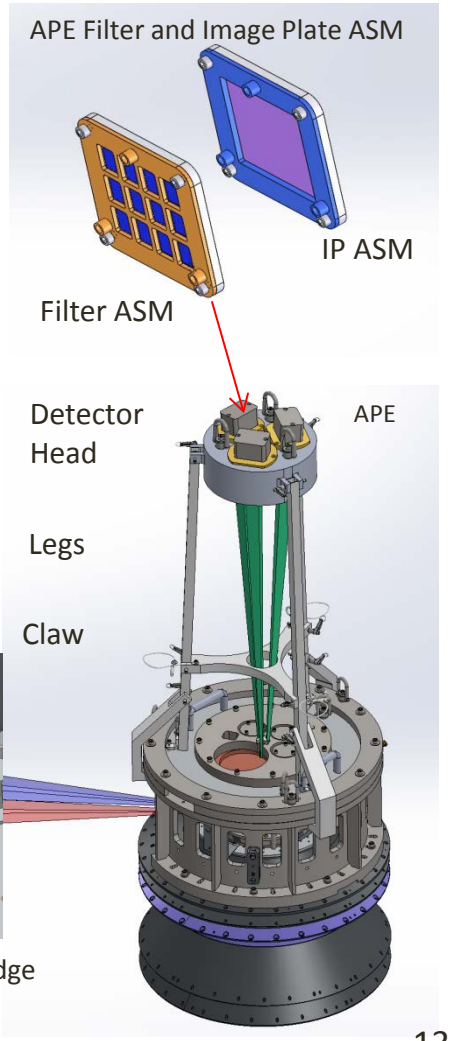
Diamond CVD

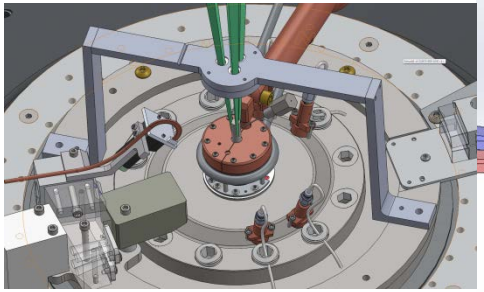
- Rapid response in fielding LLNL provided Diamond CVD x-ray detector with high temporal resolution beyond current Z PCD detectors



Axial Pinhole Imager (APE)

- Employs LANL-designed 1-micron pinhole arrays installed 10 cm from load
- 3 sets of 12 differentially-filtered data packets collected at head
- Time-integrated, resolution of ~12 µm, magnification ~10
- Initial use scheduled for July 2015

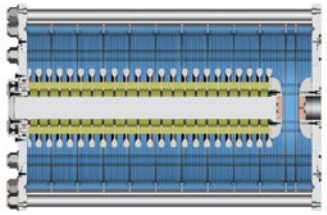


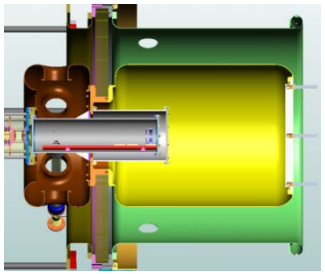


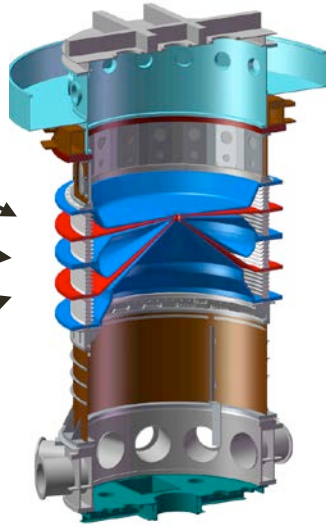
APE pinhole arrays: 3 arrays held in bridge 10 cm above load, inside of blast shield

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 – in progress**
  - 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%.

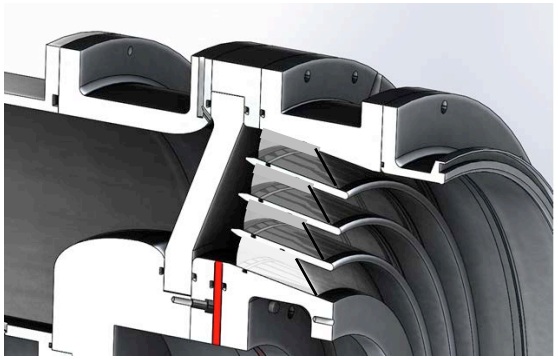


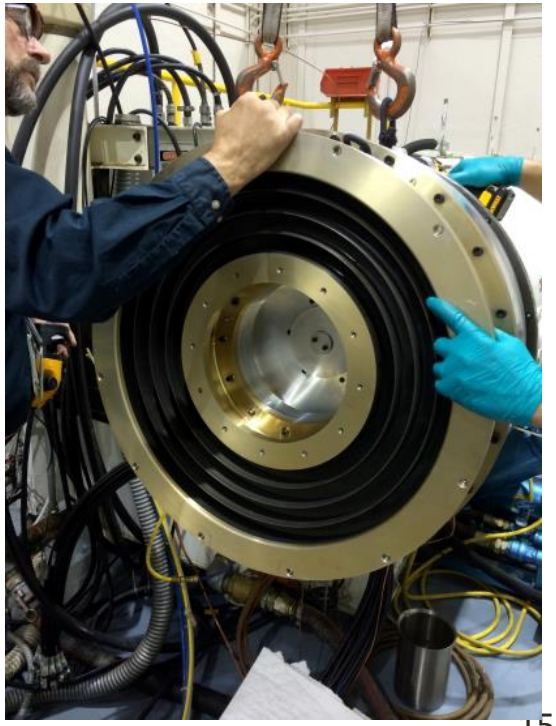


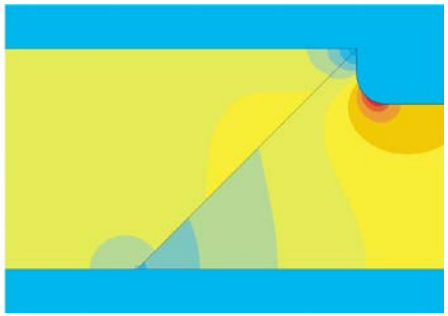


We are establishing a technical foundation for the design of a 95-kV insulator stack for Z

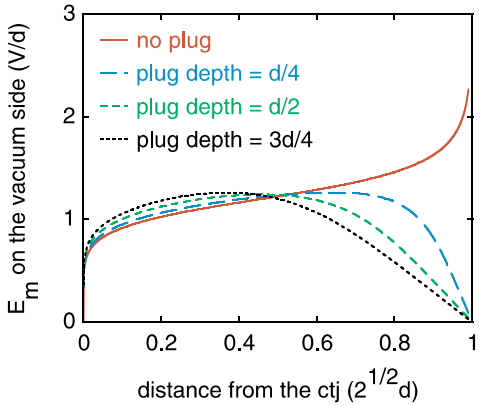
- We are conducting unprecedented insulator-flashover experiments on Sandia's Sphinx accelerator.
  - 50 consecutive shots at 184 kV/cm without a single total stack flashover.
  - 48 consecutive shots at 202 kV/cm without a single total stack flashover.
  - Results are consistent with previous experiments and are being performed with substantially improved statistics and diagnostics.
  - Results are also consistent with our insulator flashover model.
- We'll soon repeat these tests with an anode-plug geometry at ~250 kV/cm. Operation at this field on Sphinx will demonstrate that the next-generation insulator stack will work at 95 kV, and enable experiments on Z at 30 MA.



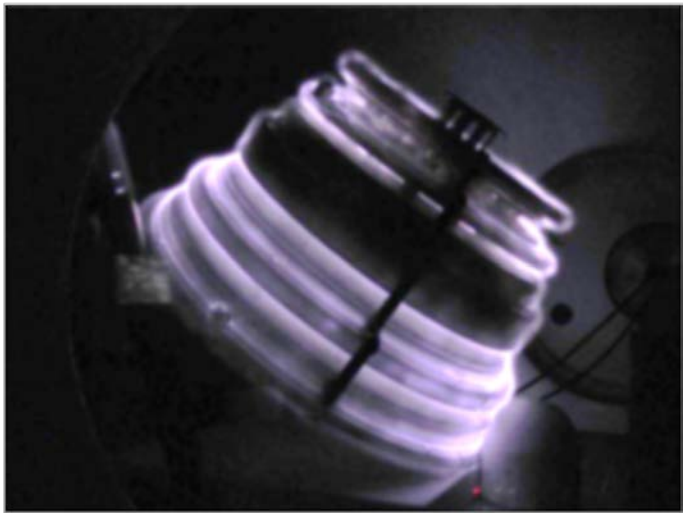




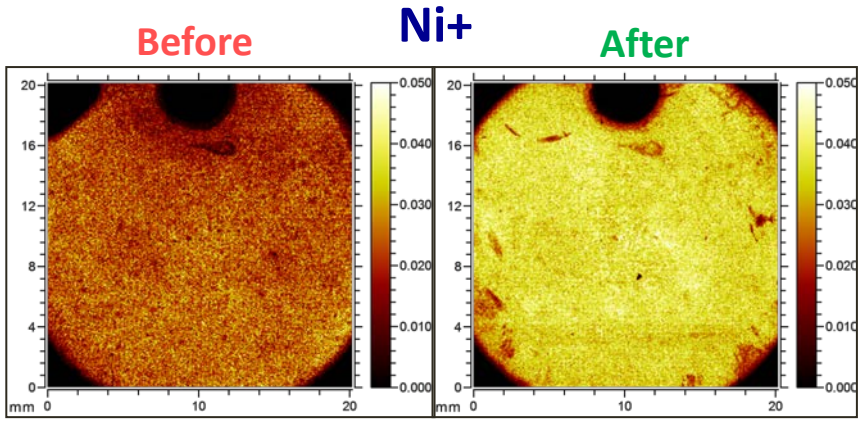
2D electric field of a 45° insulator with an anode plug



The GC LDRD is developing a plasma cleaning system to clean electrode surfaces and improve current delivery



Plasma cleaning development on Z Convolute hardware

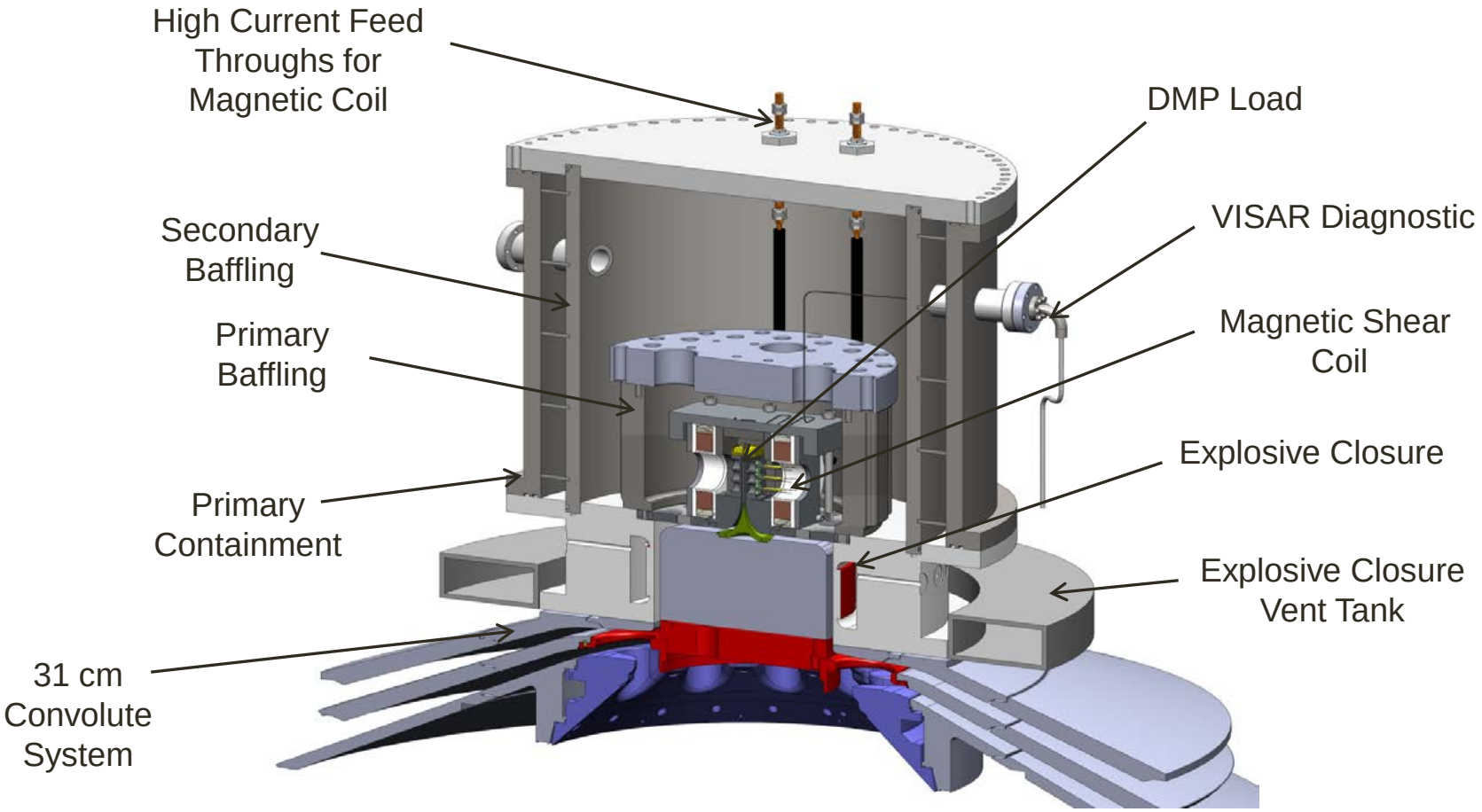


*Coupon with environmental exposure survey, shown **Before** and **After** plasma cleaning. Increase in detected bulk nickel indicates reduced surface contaminants on SS304 sample*

- Current loss in convolute negatively impacts nearly all Z experiments
  - Achievable pressure in dynamic materials experiments
  - Radiated power in wire array experiments
  - Fuel compression in MagLIF experiments
- An *in-situ* plasma cleaning system will remove surface contaminants from highest power density surfaces
  - Delay or mitigate creation, evolution of cathode and anode plasmas
  - Hydrocarbons and desorbed water likely culprits
  - Quantitative testing underway to evaluate removal rates for surface contamination materials
- The system is in the Conceptual Design phase
  - Goal is to be *integrated* and *commissioned* for inclusion of capability in CY16 shots

The next generation SNM containment system continues to evolve and mature.

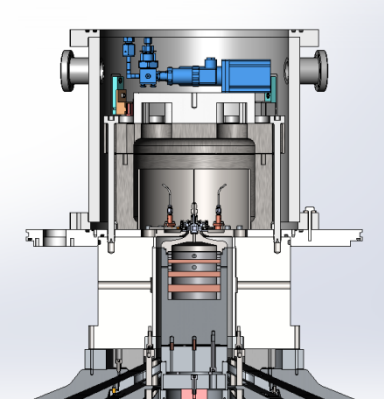
Conceptual design using the 31 cm convolute system.



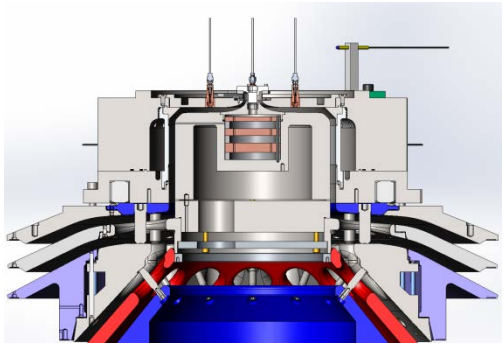
Conceptual DMP Load with Magnetic Shear Containment System

The GC LDRD tritium assessment is exploring the feasibility of using an explosive containment system

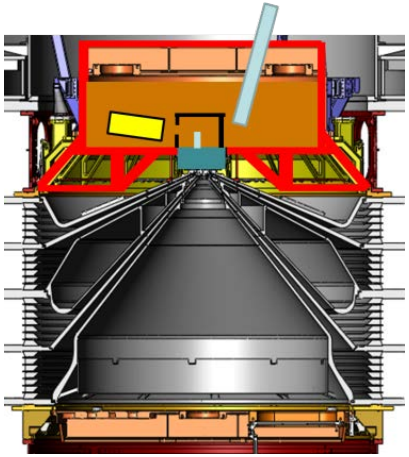
GC LDRD
T assessment with SNM containment system



Next Generation Containment (NGC)



Removable Target Chamber (RTC)



GC LDRD

- FY14 – 16
- Light gas surrogates
- Z-GTS
- Trace tritium in FY16

NGC

- FY17 – 19
- 1-10% T
- 31-cm convolute
- 23-cm UCV
- Low loss
- Faster closure

RTC

- FY19 +
- 50/50 DT
- In chamber diagnostics
- Closer placement of test objects

We are also thinking about systems required to conduct experiments without explosive containment

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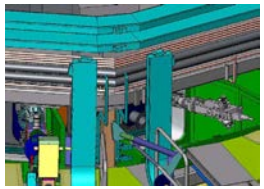
Shot Inventory, Throughput, Uncontained Shots

Time

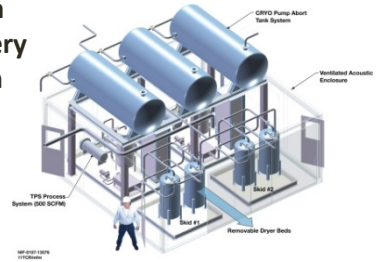
Surrogates | Trace T | 1% T | 10% T | 50% T

Tritium Diagnostics

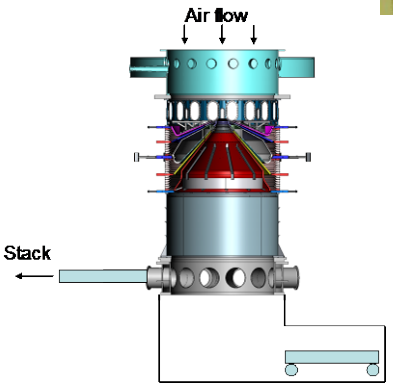
Diagnostic LOS Purge & Vacuum



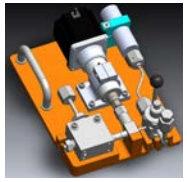
Tritium Recovery System



Center-Section Purge & Vent

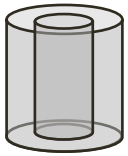


Tritium Gas Transfer System

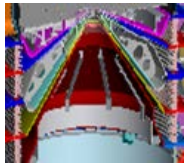


Tritium Capable MITL Refurbishment

983 HVAC Upgrade



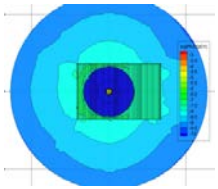
Shielding to Mitigate Dose for Personnel and Electronics



Additional MITLs/ Center Section

Tritium Ultrafast Closure Valve

Facility Neutron Environment Model

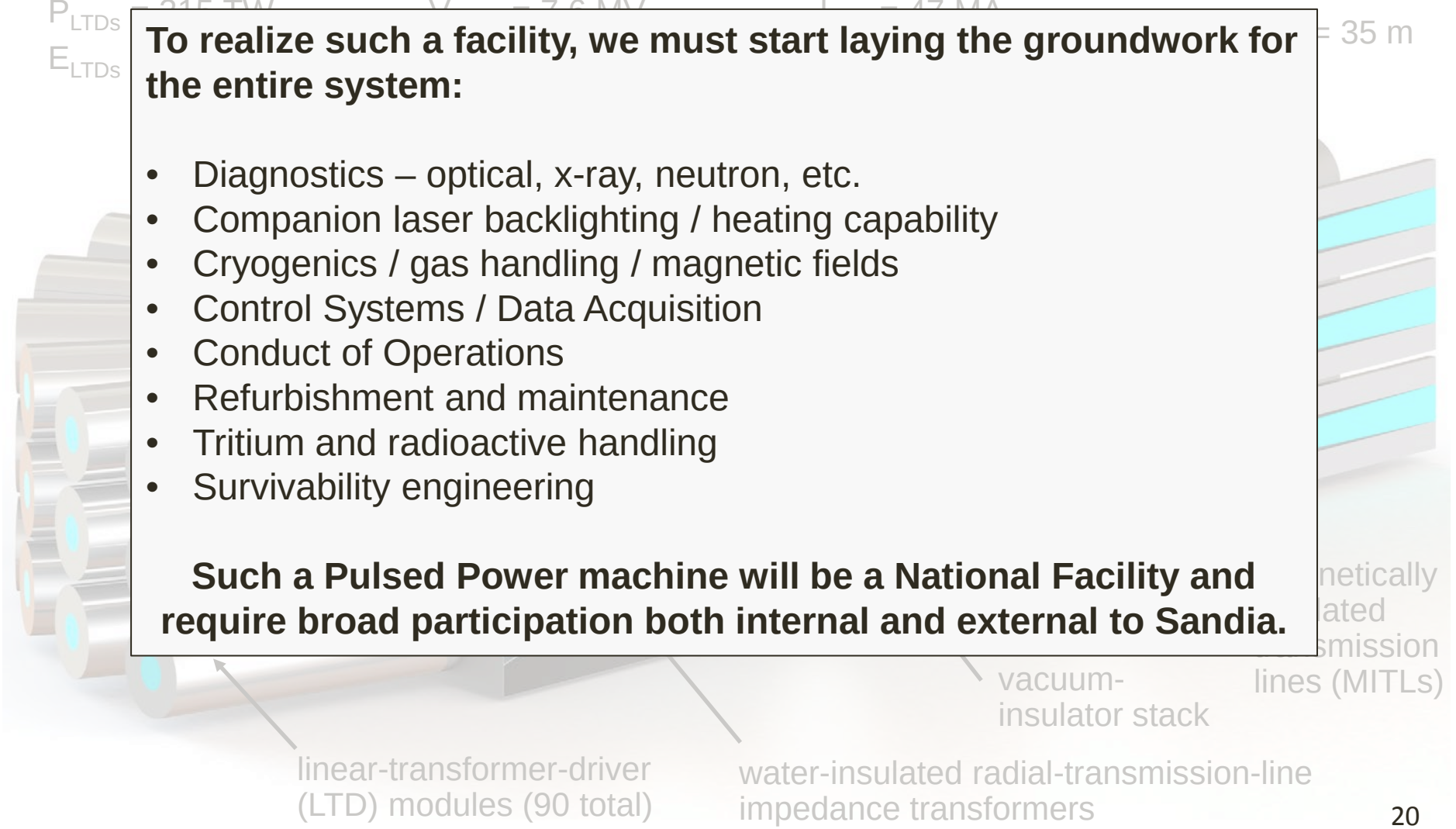


Z 300 can deliver 47 MA to a MagLIF load and fit within the existing Z building

To realize such a facility, we must start laying the groundwork for the entire system:

- Diagnostics – optical, x-ray, neutron, etc.
- Companion laser backlighting / heating capability
- Cryogenics / gas handling / magnetic fields
- Control Systems / Data Acquisition
- Conduct of Operations
- Refurbishment and maintenance
- Tritium and radioactive handling
- Survivability engineering

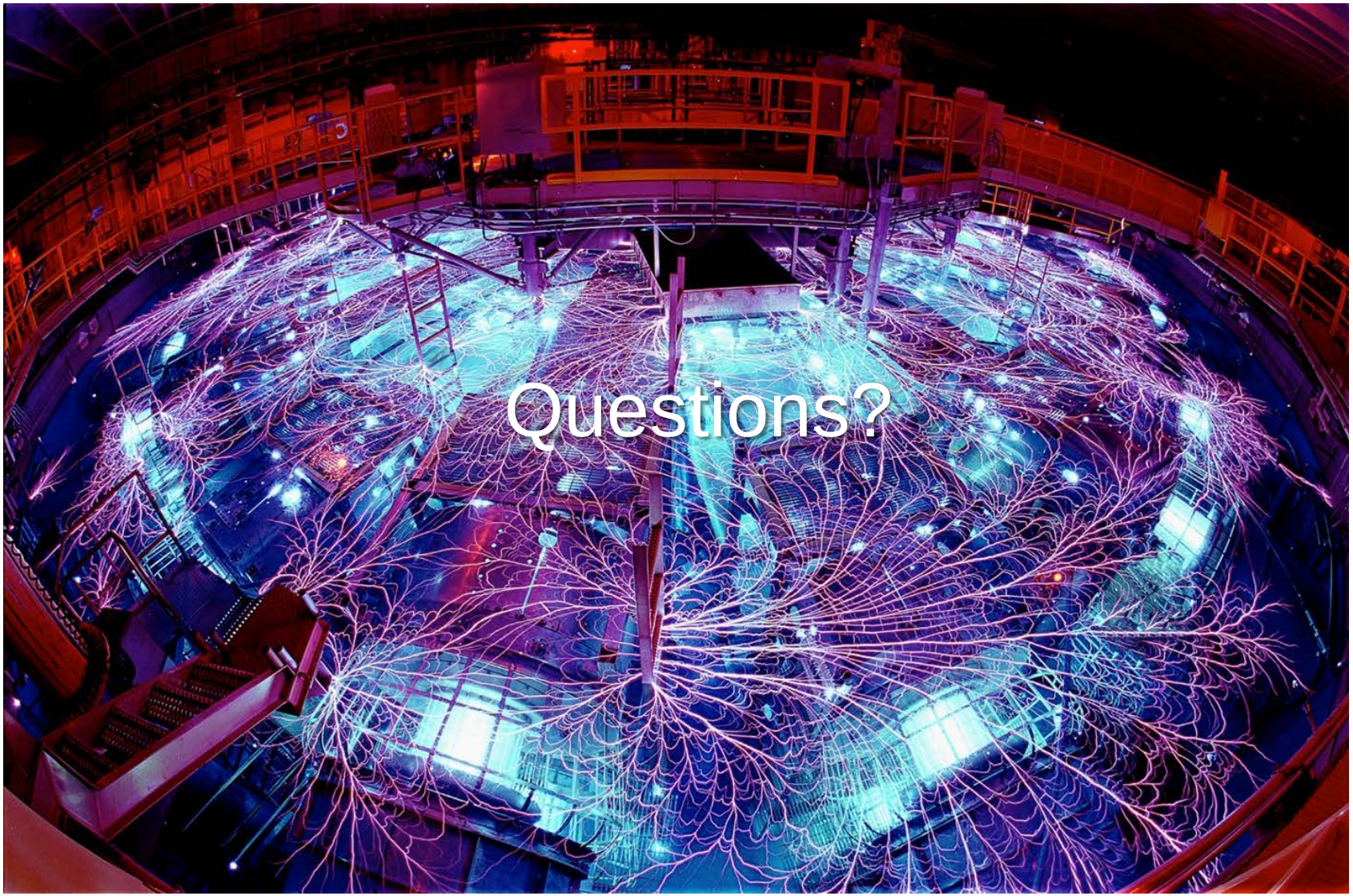
Such a Pulsed Power machine will be a National Facility and require broad participation both internal and external to Sandia.



Summary and thoughts on the future . . .

Sandia National Laboratories

- Z continues to be a unique and world-class facility for conducting HED science experiments with many visible impacts
- We have a roadmap for new and improved capabilities and the budget outlook appears favorable
- Beyond the dedicated Fundamental Science experiments, we're looking to build partnerships in pulsed power, diagnostics, targets, material, etc. that would benefit many other Z experiments
- The large Z vacuum chamber provides significant area/volume for ride-along experiments and diagnostic development – we want to work on realizing this opportunity for both the internal and external community
- Innovation and creativity are the foundation of our success – Z provides a wealth of technical challenges for the next generation of pulsed power and HED scientists – increased university partnering is a must
- All of the above are necessary to realize a future pulsed power machine for the nation; academia along with industry can play key roles in laying the technical foundation


Questions?