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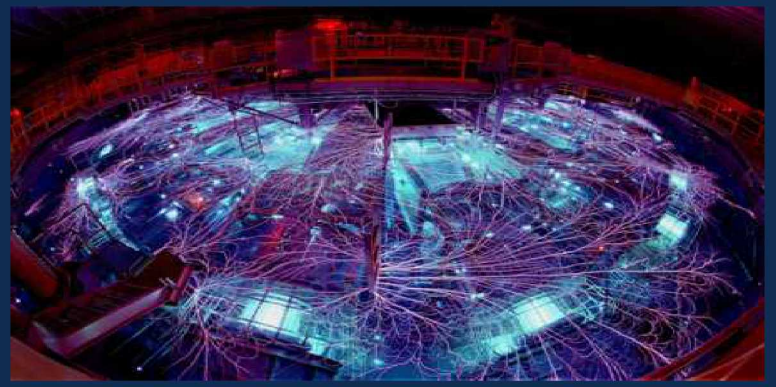

# Z Facility Strategy/Progress on Increasing Shot Rate

**Chris Bourdon**

**Radiation Effects and High Energy Density Sciences Research Foundation External Review, May 15-17, 2018**

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# Progress & Next Steps For Improving Shot Efficiency & Effectiveness

**Goals Support Program Needs**

Pulsed Power Science & Technology (PPS&T) Strategic Outlook (2016):

- Provide more Z shot opportunities, while maintaining opportunities for innovation and maintaining or improving data quality
- Pursue an increase in the capacity of the Z facility to 250 experiments per year

2016 ICF Program Framework:

- Double the number of Z magnetic direct drive experiments by 2019

Presentation Overview:

- **Z program environment**
- **Progress-to-date**
  - **Needs & constraints identified**
  - **Shot rate improvement realized**
  - **Z capabilities group re-structure completed**
  - **Budget and hiring plan progress**
  - **Implementing data-driven decisions**
  - **Planning tool improvement**
- **Path Forward**
  - **Continue next phase of studies and improvements**
  - **Continue development of tools (e.g., planning systems, measures, metrics)**

# Demand for Z Shots To Address Weapon Science Needs Remains High

**LLNL, LANL, SNL, and the Fundamental Science Community continue to have high demand for Z shots to address important questions**

(*All are critical stakeholders currently and in the future*)

**Requests for Z shots average over 3 times the shot capacity per calendar year**

**Includes Nuclear Counterterrorism requests** →

**CY18 Schedule Statistics**

| | Days Requested | Days Allocated | Day Fraction |
|---|---|---|---|
| **Dynamic Materials** | 123 | 43 | 17% |
| **Containment** | 49 | 32 | 13% |
| **ICF** | 232 | 74 | 30% |
| **SAT/RES** | 50 | 33 | 13% |
| **HEDP** | 18 | 12 | 5% |
| **Fundamental Science** | 68 | 15 | 6% |
| **Facility/Maintenance** | 15 | 15 | 6% |
| **Contingency** | 26 | 26 | 10% |
| **Total:** | **581** | **250** | |

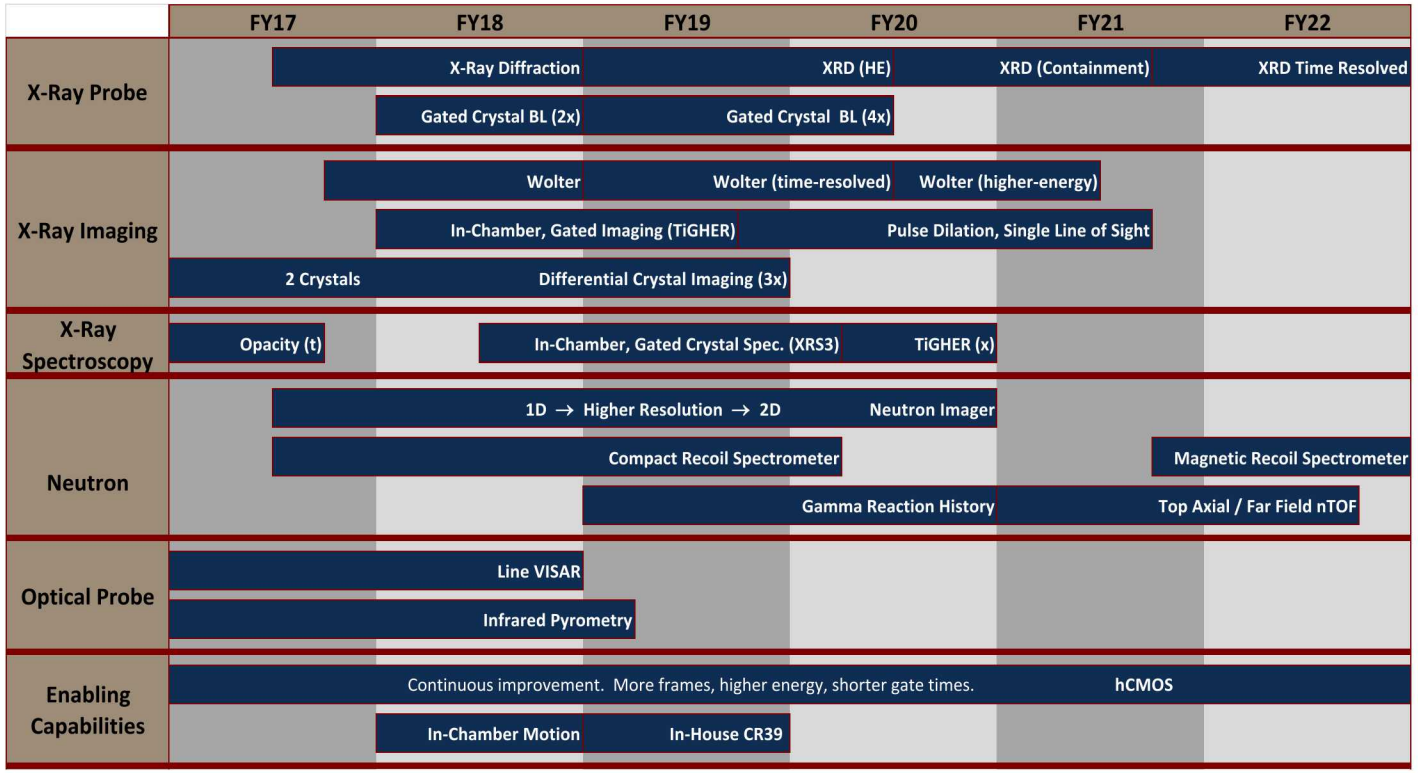
# Complexity of Shots is Increasing: Diagnostics are a great example

- Diagnostic fielding increasing; annual average number of diagnostics per experiment increased by **~250%** since 2013.
  - Each shot normally supports multiple experiments
  - ICF experiments still the most challenging – we routinely field over 20 diagnostics per shot
  - Multiple new diagnostic capabilities added to Z in 2016 and 2017
  - Extensive capabilities development planned for out-years

**New Capabilities Added in Last Two Years**

- High-resolution radiation flux: Avalanche Photo Diodes
- On axis measurement of x-ray flux from MagLIF targets: Spherical Crystal Imaging
- Advancing Power Flow measurements : CIDZ, mini-XRDs, MagSpec, FCAPs
- Neutron Imaging: One Dimensional Imager of Neutrons (ODIN)
- In-Chamber, gated pinhole imaging: TiGHER Pinhole Camera
- Time-resolved Opacity measurements: hCMOS convex crystal spectrometer
- Tritium: ZGTS, Tritium monitoring diagnostics
- Differential Crystal Imaging
- Warm X-ray imaging: Wolter Imager

**Plan for out-year diagnostics development**



# Progress-to-Date: Needs & Constraints Identified for Increasing Shot Rate

- An internal study evaluated investment options for increasing the shot rate and shot capacity
  - To increase shot rate: increase shot efficiency, increase machine maintenance and decrease non-shot operational days
  - To increase shot capacity: implement new operational model to increase operational days once the shot rate improvements have been realized
- Value is placed on maximizing learning in the Z operational model
  - Flexibility is encouraged to allow for emergent knowledge to influence our plans
  - Duplicate measurements, multiple configurations, flexible timelines employed to build resiliency into a shot/shot series
  - There is a balance (tension) between flexibility and efficiency
- Planning & risk management needs identified to improve shot rate:
  - Scheduling sufficient days for testing and commissioning activities
  - Dynamic allocation of people and building resilience onto operational teams
  - Better understanding and prediction of failure modes for Z pulsed power systems and subsystems
  - Stack damage mitigation through hardware design or mitigation features on MITLS
  - Investing early in the planning process in tools to manage timeline and risk

# Progress-to-Date: Shot Rate Improvement

| | CY14 | CY15 | CY16 | CY17 | CY18 |
|---|---|---|---|---|---|
| **# of Shots[1]** | 156 | 140 | 146 | 147 | **170[2]** |
| **Shot Efficiency[3]** | 0.77 | 0.70 | 0.71 | 0.76 | **0.82[4]** |

**Goal: SE > 0.85 annually by CY19**

1. Have average =146 shots per year for CY13 through CY17
2. Currently projecting ability to have 170 shots in CY18
3. Shot Efficiency= (Number of Shots)/(Number of days available to shoot)
4. Year to date

- Current operational model employs ~250 operational days per year
  - ~35 days used for scheduled non-shot activities (containment prep, maintenance, commissioning, 31-cm change-over)
  - Major maintenance activities (i.e., stack rebuild) may use ~15 operational days (typically bi-annually)
  - **Goal: Reduce non-shot activities to 40 or less days per year**
- Quarterly maintenance activities inserted into the annual Z shot schedule (~2 days per quarter) enabled scheduling of critical maintenance activities and improvement to shot efficiency
- Contingency added to the shot timeline by minimizing or eliminating activities (e.g., dive in water section)
- Tools developed and matured to better understand work flow/optimize resources

# Progress to Date: Completed Z Experimental Capability Management Group Restructure

1670
Z Experimental Capability Management
C. Bourdon

**1671: Z Mission Assurance, Execution, and Analytics (R. Kamm)**

- Systems Engineering and Shot Coordination
- Implementation and Facility Support
- Center Section Refurbishment
- Hardware Load

**1672: Z Pulsed Power and Data Systems (W. White acting)**

- Z Networks and Electronic Systems
- Control Monitoring and Data Acquisition Systems (CM/DAS)
- Laser Triggered Switches (LTS)
- Vacuum
- Energy Storage and Power Flow
- Z Mechanical Systems

**1676: Radiation and Fusion Diagnostics (C. Highstrete)**

- X-Ray and Neutron Diagnostic Science
- Implementation and Diagnostic Fielding Specialists
- Diagnostic Inventory and Data Processing

## Supporting Organizations

| | |
|---|---|
| 1691: Z/ZBL/ Diagnostics Engineering (M. Jones) | • Engineering Support for Operations<br>• New Capability Design and Engineering |
| 1692: Load and Diagnostic Engineering (E. Weinbrecht) | • Load Hardware<br>• Hardware Verification<br>• Target Fabrication<br>• Containment |
| 1650 : Pulsed Power Science | • Pulsed Power Systems Stewardship and Expertise |
| 1640, 1650, 1680: Embedded Diagnostic Capabilities | • Specialized Diagnostic Support (Stewardship and Operations) |

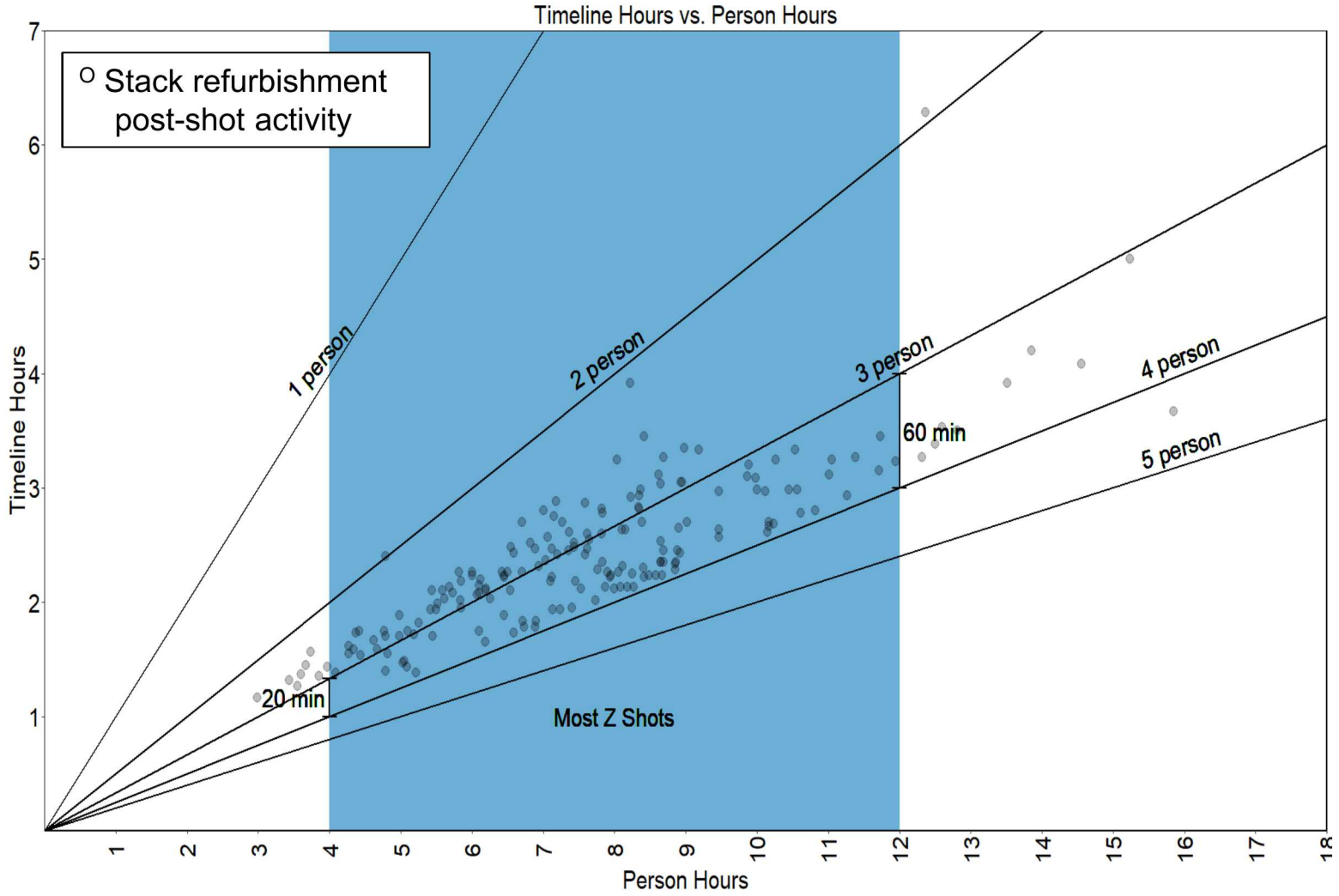
# Progress-to-date: Funding & Staffing Increases in Process

- FY18 funding for Z and operations increased 8% over FY17, targeted at shot efficiency
  - Will further address facility maintenance and deferred maintenance with Omnibus bill passing
- Staffing increases in progress on key teams
  - Hires to center section (+3) , systems/industrial engineering (+1), hardware design(+2) teams completed
  - Additional new hires authorized to systems/industrial engineering (+1), hardware design (+2), diagnostics (+2), web tools (+1) teams, to be completed this FY.
  - Staffing also in progress to increase operations robustness/resilience and resolve 1-deep challenges

# Progress to date: Implementing recommendations of internal study beginning to demonstrate results

Activity: Stack refurbishment post-shot

- Systems thinking was applied to re-assess task workflow and staffing
  - Increasing center section staffing to 12 enables dynamic staffing of activities
    - Also enables team to take scheduled breaks
  - Ops process indicators (e.g., cameras and task indicators) enabled accurate measurement of task duration and person-hours
- Process modifications improved workflow and timeline:
  - 20-40 minute timeline improvements attained for normal refurbishments
  - Hours of time savings are realized when there is heavy stack damage
- Goal: Drive data-driven decision making and process thinking throughout the facility



# Progress to date: Improving planning tools and data return

## Experiment Shot Reporting

Goal:

- Single-source, archivable, and searchable database
  - Progress this year: New application allows access to all shot related data
    - Configuration documents
    - As loaded pictures
    - Shot data
    - Post shot reports
    - Hazardous /RCRA materials
    - Diagnostic configurations
  - Next Steps:
    - Quality metrics post-shot for science objectives
    - Improving searchability

## Diagnostic Measurements

Goals:

- All needed information at the experimenter's fingertips
- Increase quality of diagnostic measurements
  - Progress this year:
    - Developed diagnostic responsibility matrix so roles can be better understood.
    - Adding detailed, online documentation for each of our diagnostic instruments.
    - Improving the fidelity of diagnostics fielded on Z.
      - Integration and commissioning
      - Developing measurement assurance plan
      - Quick look analysis of shot data
      - Reporting of diagnostic health

# Graded process for new capability integration implemented

- Established single point of contact for integrating new capabilities onto the facility/into an experiment
- Deployed graded approach for process rigor
- Developed tools to capture capability readiness
- Implemented appropriate level of rigor (“right-sized”) commissioning process for new diagnostic capabilities

A

Form: ADM_NEW_CAP_ACCEPT_FORM_REV.A
Date: 9/13/2017
Parent: ADM_REQMTSYS_ADPRO

| | |
|---|---|
| **System Name / Acronym:** | DMP Preheat System |
| **Responsible Individual:** | Justin Brown |
| **Description** | Need to re-commission the DMP preheat system. Currently the preheat shot is on the schedule for Nov. 3rd (might move to Nov. 20th). This experiment the plan is to preheat Cu and Zr. |

| **Screening** | **Notes** |
|---|---|
| | Electrical \| Laser \| Lifting \| Rad \| Pressure \| Thermal \| Other |
| Hazards | Electrical - Possibly 120V going into chamber \| Thermal - Heating target up to 300 Celcius \| Lifting - Screenbox cranted to mezzanine \| Be contamination **Center Tag Guide might need to be changed** |
| Operational Notes | Need local network to back of DAS. \| It appears the feedthru is for the radiation shield (maybe ABZ port can be used) \| Screenbox will need to craned onto mezzanine \| |
| New Materials in Center | ? - Should be captured by Configuration Summary |
| Security | NA |
| Other | Possible testing in west side BCCA<br>PI is requesting for center section to install cathode with thermocouples installed |

| **Interfaces** | | | | | |
|---|---|---|---|---|---|
| Electrical | <50 V | 110V | 220V | >220V | |
| Network | SRN | ZRN | Local | | |
| DAS | Trigger | High Speed | 0 | Low Speed | 0 |
| Crane | Yes | | | | |
| Vacuum Section | Bottom Lid | Bottom Spool | LOS Spool | Rad Shield | Top Lid |
| Location | Center | LOS Spool | Screenbox | Diagnostic Mezz | Other |
| | Yes | No / ? | Craned In | Yes | |
| Other | | | | | |

| **Resources Needed** | **Design** | **Installation** | **Ops.** | **Notes** |
|---|---|---|---|---|
| Mechanical \| Electrical \| ESH \| | | | | |

# Next Steps: Pursue Strategy for increasing shot rate and optimizing the use of Z as a center-wide effort

- Holistic approach: Look at the complete life-cycle of experiments and shots
- Focus on 4 areas:
  - Better planning/understanding of experiment & shot preparation and execution
  - More robust hardware and target design, manufacture and procurement processes, and staffing
  - More contingency built (or created) into the work day
  - Strategic activities to address Z systems maintenance needs
- Cross-functional Working Groups will study and make recommendations on:
  - Experiment planning and execution processes (idea to day of shot)
  - Z Sustainment (maintenance, legacy system improvements, Z capability enhancements)
  - Z operational model (for 5- day operations and 7-day operations)
- Aggressively address staffing and investments as budget becomes available
- Identify and pursue game-changing technologies that improve operations (e.g., elimination of debubble dive, automated MITL refurbishment, debris catching features in MITLs)