Exceptional service in the national interest

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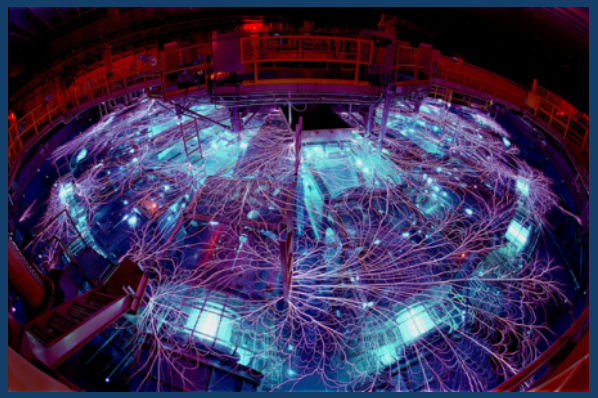
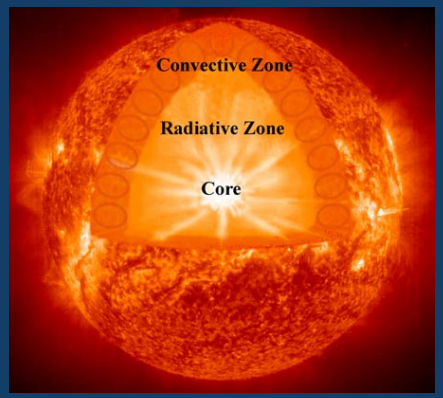
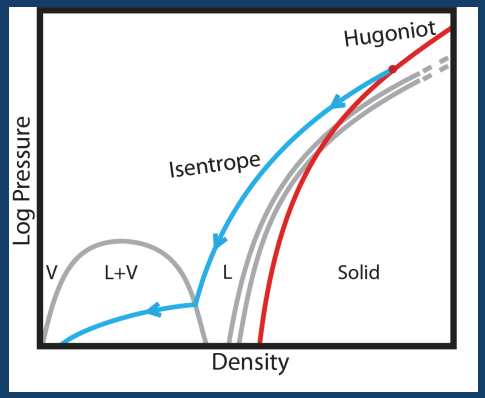






The Z Fundamental Science Program: status and future

SAND2015-5904 C

Thomas Mattsson

Manager, HEDP Theory

Fundamental Science with Pulsed Power: Research Opportunities and User Meeting
Albuquerque, NM July 19-22, 2015

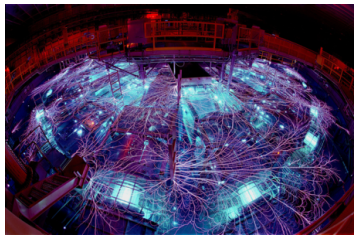
U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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.

We are enthusiastic to continue the series of workshops on fundamental science on Z

- **Workshops on fundamental science using pulsed power**
  - 2009 Hilton, Santa Fe
  - 2010 Eldorado, Santa Fe
  - 2011 Eldorado, Santa Fe
  - 2012 Andaluz, Albuquerque
  - 2014 Andaluz, Albuquerque
  - 2015 Hyatt, Albuquerque
- **Liner Fusion workshop**
  - 2012 Marriott, Albuquerque



- **Results from past workshops**
  - Launched and grew the Z Fundamental Science Program and university collaborations on liner fusion
  - New collaborations and projects
- **Objectives for 2015 workshop**
  - Forum for Z users and collaborators
  - Nucleate new collaborations and research ideas
  - Build a cohesive community for HED science that spans several areas
    - Astrophysics, planetary science, fusion, materials

The Z Fundamental Science Program engages a broad international community and has advanced HED science

- **Resources/shots on Z over 5 years**
  - 50+ dedicated ZFS shots (~5% of all Z shots)
  - Ride-along experiments on program shots
- **Science with far-reaching impact**
  - 1 Nature, 1 Nature Geoscience, 1 SCIENCE
  - 1 Phys. Rev. Lett, 3 Physics of Plasmas, 2 Physical Review (A,B) , 9 others
- **Popular outreach**
  - National Public Radio, “All things considered”, Joe Palca 3/6/2014
  - MIT Technology review, 10/4/2012
  - Discover Magazine, 9/16/2012
  - Local TV coverage (7-KOAT, 13-KRQE) in early 2015
- **New external funding won**
  - DOE/OFES/HEDLP
- **Students and postdocs**
  - 4 M.Sc. Exam, 2 Ph.D. exams
  - 5 postdocs

The Z Fundamental Science Program has made discoveries in iron (x2), water, and hydrogen

- **Resources/shots on Z since 2010**
  - 50+ dedicated ZFS shots (~5% of all Z shots)
  - Ride-along experiments on other shots
- **Science with far-reaching impact**
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LETTER RESEARCH

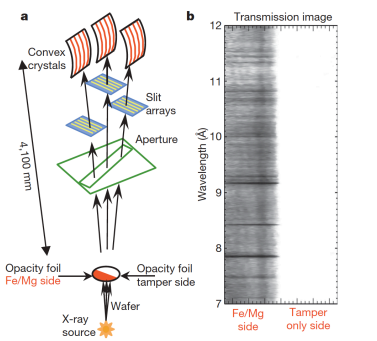


Figure 1 | Experiment diagram and example transmission image. a, Three to four spectrometers view the 'half-moon'-shaped tamped iron/magnesium sample (not to scale). Each uses multiple slits to project spatially resolved images onto a convex crystal that disperses the spectrum before recording

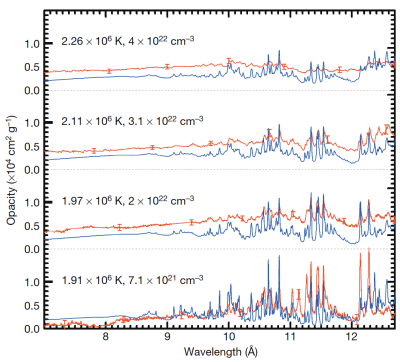


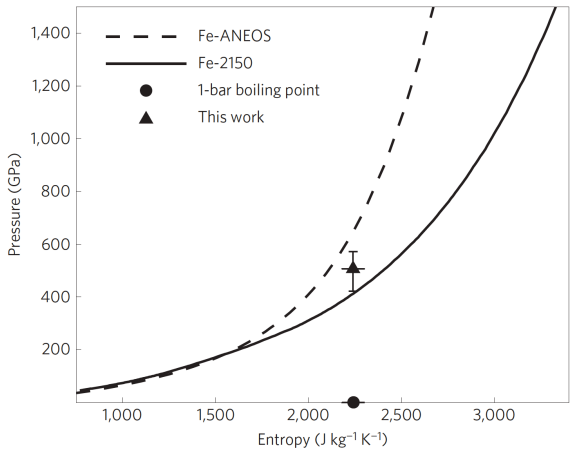
Figure 2 | Measured iron opacity spectra at four T_e/n_e values compared with calculations. The SCRAM[23] model calculations (blue lines) account for the instrument resolution. Red lines denote the measurements and the error bars

Solar opacity

Measured the iron opacity at solar conditions

Nature 2015

The Z Fundamental Science Program has made discoveries in iron (x2), water, and hydrogen



Earth and super earths
Determined iron vaporization
Nature Geoscience 2015

- **Resources/shots on Z since 2010**
  - 50+ dedicated ZFS shots (~5% of all Z shots)
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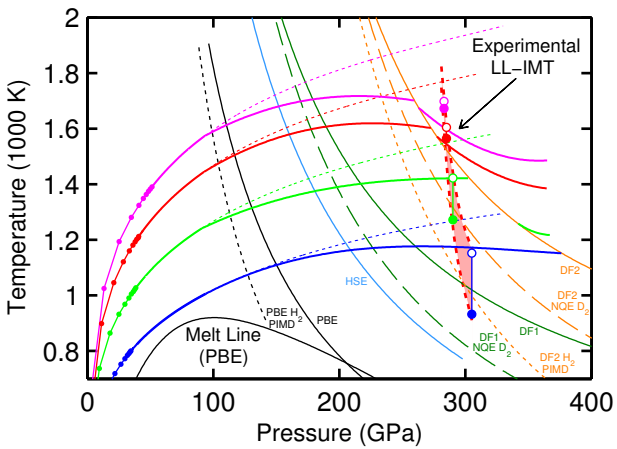
Gas Giants
Water and hydrogen
PRL 2012; SCIENCE 2015



The work behind the Z Fundamental Science Program started in 2008 with IHEDS (UT/SNL)

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ZFSP past and present

- IHEDS 2009-2010 workshops in SF
- 2010 – call for proposals and evaluation of an external international committee
- 2011 – 15 dedicated shots on Z
- 2012 – 20 dedicated shots on Z
- 2013 – NNSA/NA-11 pause
- 2014 – Restart of ZFSP
- 2014 – External review of the program and extension for CY15 shots
- 2015 – 18 shots on the schedule

The call for proposals is open and will close on 9/15/15

ZFSP call for proposals timeline

- June 15: call for proposals open
- July 20: workshop
- **September 15: call closes**
- October/November: evaluation and selection
  - Facility review: feasibility of experiments, safety, and diagnostics
  - Scientific review of international panel 11/10-11, 2015
  - December 11, distribution of shots
- 2016 & 2017
  - Shots scheduled for successful proposals

Sandia National Laboratories
Pulsed Power Sciences

Call for Proposals Package for the Z Facilities
Fundamental Science Experiments for the Period
April 1, 2016 to December 31, 2017

Date Issued: June 15, 2015

Applications Due: September 15, 2015

Point of Contact: Dr. Thomas Mattsson
Manager, High Energy Density Physics Theory
Sandia National Laboratories
P.O. Box 5800 MS 1189
Albuquerque, NM 87185-1189
(505) 844-9315
tmatts@sandia.gov

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NNSA

Purpose of the Z Fundamental Science Program

- The primary purpose of the Z-Facilities Fundamental Science Program is to provide access to NNSA's Z accelerator for HED experiments. The specific objectives of the program are to provide access to the Z accelerator and its diagnostics to a broad community of academic, industrial and national laboratory research interests, for use:
  - 1) as tools for conducting fundamental research in HED science, and
  - 2) in providing research experience necessary to maintain and grow the HED community, especially through involvement of researchers in academia

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NNSA

Merit review of the proposals will be done by an external international panel

- Applications will be technically evaluated based on the four general scientific/technical criteria listed:
  - Scientific and technical soundness and quality of the proposed method/approach, and the feasibility/likelihood of accomplishment of the stated objective
  - The overall scientific/technical merit of the project and its relevance and prospective contribution to its field of research
  - The competence, experience, and past performance of the applicant, principal investigator and/or key personnel
  - The demands of the project in terms of resource requirements (equipment, beam time, etc.) and/or other requirements (facility hardware modifications, component development, etc.) vis-à-vis competing demands.

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NNSA

The ZFSP greatly benefits Sandia's and NNSA mission on both short- and long term

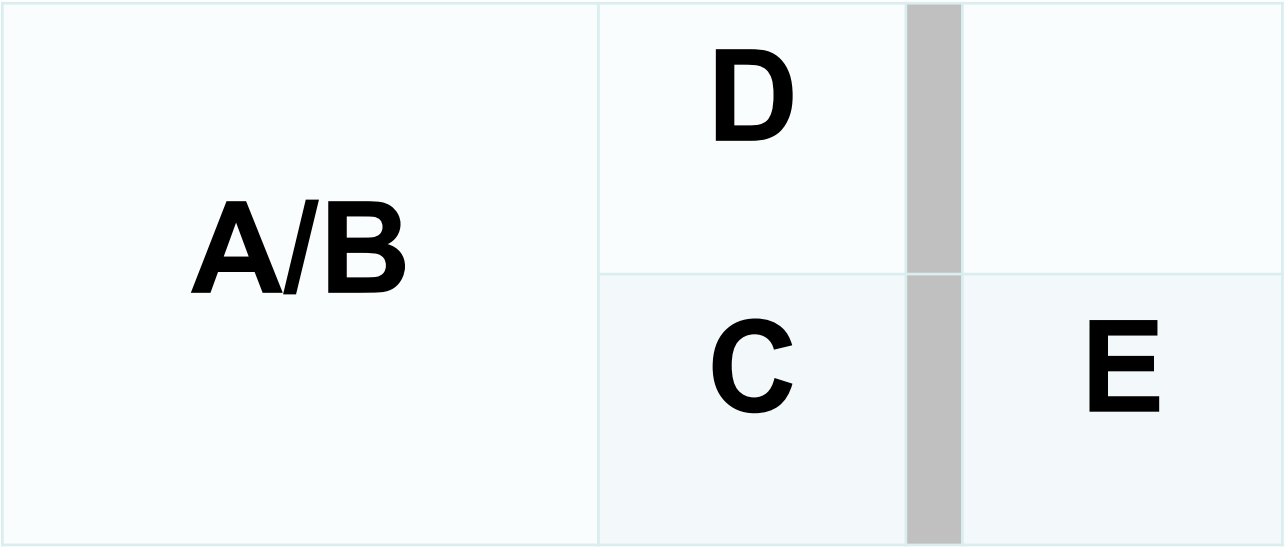
- **Supporting HED science – resulting in students and groups active in topics of importance to the national laboratories**

- **Growth in the HED science community**
  - New funding won by teams
  - Active participation in the academic community of HED science – attracting new academic partners
  - Scientific discoveries make the field attractive

- **Direct methods development**
  - The platform for shock experiments developed jointly with Harvard/UC Davis is now our standard setup for science campaign experiments
  - The work on Fe opacity has served an important role for platform development and provides international peer review

- **Development of technical staff**
  - An opportunity for Sandia staff to do leading research and participate fully in the international research community

One plenary room (Enchantment A/B) and three smaller rooms (C,D,E) each seating 20



Each room has a projector/screen, and flip chart (soon if not now)

4 plenary sessions and 5 topical break-out sessions

Monday	Tuesday	Wednesday
HED Science and the Z facility A/B	MagLIF Plenary A/B	Astrophysics A/B MagLIF: stagnation and burn measurements C MagLIF: Implosion instabilities E Planets/materials D
Planetary and Materials Science Plenary A/B	Astrophysics Plenary A/B AND MagLIF: target preconditioning experiments E	Summaries of breakout sessions and closing A/B

Goals for the break-out sessions

- **Future research directions**
  - New research directions/ideas, within existing fields - and suggestions for new topics/fields
  - Formation of new or extended collaborative teams

- **Identify key scientific development enabled by ZFSP to date (direction, capabilities, or momentum)**

- **How can we improve and support the ZFSP collaborative teams?**
  - Improvements on Z in terms of diagnostics or infrastructure or management?

- **Capture the discussions**
  - We plan to compile and release a workshop report – so expect small writing assignments!

Welcome to the ZFSP workshop 2015!

- **Many thanks to**
  - Tamar Armijo
  - Colin Hallahan

  - Alan Wootton
  - Dan Sinars
  - Don Winget
  - Jim Bailey

  - Hyatt Regency for patience with the long approval process