SAND2014-17517D

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Sandia National Laboratories

Diagnostics on Z

What can you measure during a Z pinch?

- For a very short period of time after the Z machine fires (billionths of a second), the pinch is as hot as the surface of the sun!
- When this happens, an incredible amount of energy (appx. 2 sticks of dynamite) is released, mostly as high energy x-ray or visible-wavelength photons. Sometimes we do experiments that also generate neutrons.
  - 15% of wall-plug electrical energy is converted to radiated x-ray energy for wire array implosions
- We use multiple diagnostics to measure the X-rays, visible light, and neutrons, and image the progress of Z experiments.
- One of the biggest challenges is designing diagnostics that will survive the Z environment and produce quality scientific data.

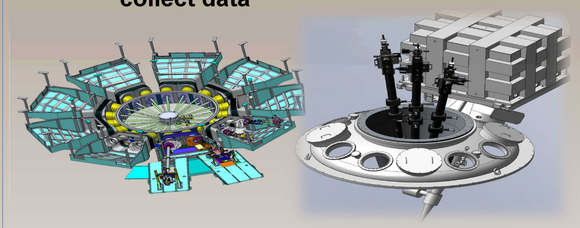
Pre-shot photo Post-shot photo

Images of the load hardware pre- and post-shot

- High levels of mechanical shock, EMP (electromagnetic pulse) and x-ray and neutron emission all occur when Z fires.

Diagnostic access on Z

- Ports are positioned around the z test chamber for mounting diagnostics
  - For tests when we want to measure above the pinch, we can use an axial diagnostic package
  - Other diagnostics have to be placed inside the test chamber to efficiently collect data

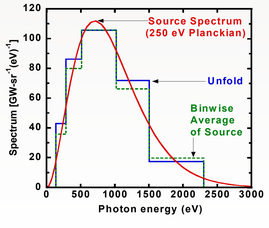


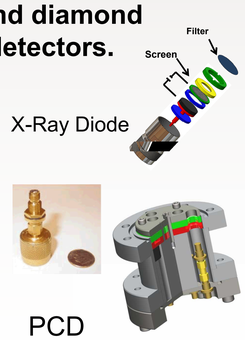
Radial lines of sight and axial diagnostic package

- Other diagnostics are coupled to the chamber with fiber optics to keep sensitive equipment out of harm's way.

Power and energy

- A suite of sensors are situated around the Z machine to measure X-ray power and energy. These sensors include carbon photo-cathodes, silicon diodes, nickel and gold bolometers, and diamond photo conducting detectors.

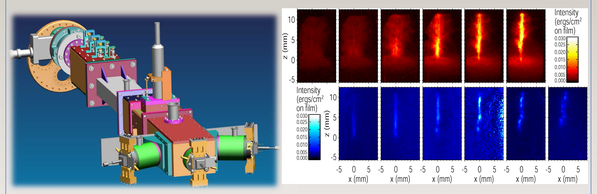




Resolving X-ray emission

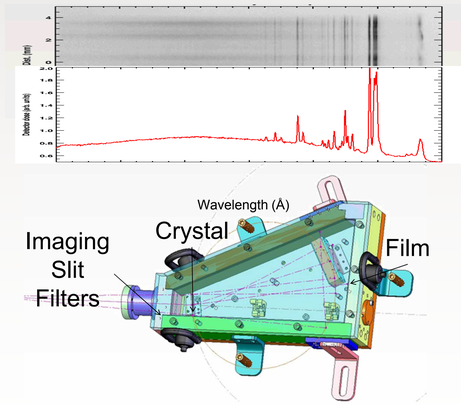
- Because the Z pinch creates an intensely hot, very dense plasma, most of the energy from the implosion gets released as X-rays.
- We image the X-ray emission of the plasma, measure its energy content, and when it gets released.
- We have multiple unique instruments that we use which mount in different places on the machine– on the radial lines of sight, in the chamber, or in the axial package.
- Below are 2 example X-ray diagnostics

Multi-Layer Mirror X-Ray Camera



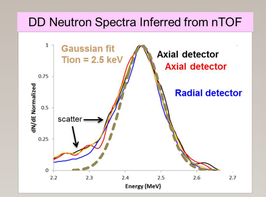
CRITR in-Chamber Spectrometer

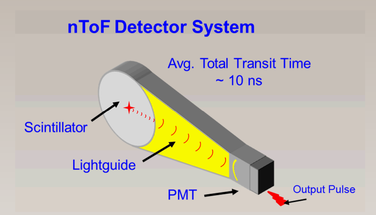
Space-resolved stainless steel emission spectra



Measuring neutrons

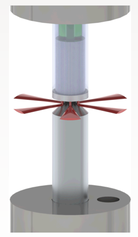
- Z conducts experiments in support of the inertial confinement fusion (ICF) program to develop fusion as a future energy source.
- Fusion experiments produce many neutrons, which we need to measure to diagnose the experiment's success.
- To do this, we use samples that activate when exposed to neutrons, and use neutron-sensitive diagnostics like the neutron time-of-flight detector.

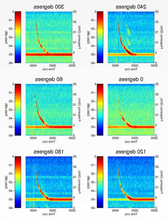




HED material studies diagnostics

- To support the nuclear weapons program, we study the behavior of materials at high energy and density (HED) conditions.
- To study material response to HED environments, we use several diagnostics to measure shock wave propagation, changes in material state, and changes in opacity. PDV is one of these diagnostics.





Photonic Doppler Velocimetry (PDV)