The role of LLNL's FAST calibration facility in diagnosing NIF fusion plasmas

J. G. Thompson[1], C. Scott[2], G. V. Brown[3]
[1]Cal Poly State University, San Luis Obispo, CA [2]California State University Chico, Chico, CA
[3]Lawrence Livermore National Laboratory, Livermore, CA

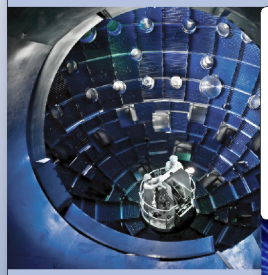
Abstract 1

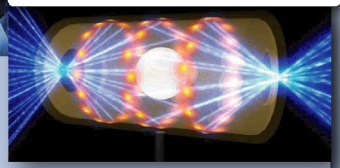
The Fusion and Astrophysics (FAST) Data and Diagnostic Calibration Facility at LLNL is being used to calibrate and characterize diagnsotics employed at the National Ignition Facility (NIF).

Background: NIF and Dante 2

Some facts about NIF:

- NIF is an experimental inertial confinement fusion device located at LLNL
- It consists of 192 lasers UV lasers
- The lasers focus >1 MJ of energy onto a hydrogen target to create fusion energy.



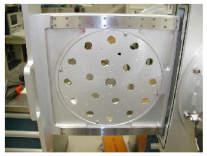


NIF target chamber and artists interpretation of the holhraum during a shot. NIF's lasers hit the inside of the hohlraum generating X-rays, which in turn compress the H-filled capsule until it fuses.

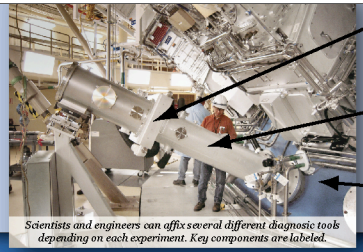
Lawrence Livermore National Laboratory, with NIF and FAST facilities.

The Dante Soft X-ray Spectrometer is used to determine the temperature of the implosion:

- Dante has 17 filtered channels each covering a different energy band.
- Accurate temperature determination requires well calibrated filters.
- Filters are calibrated at FAST.



Filter Wheel



Dante Soft X-ray Diagnostic

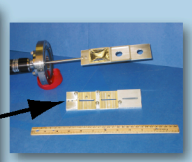
Target Chamber

Scientists and engineers can affix several different diagnostic tools depending on each experiment. Key components are labeled.

Background: FAST 3

The FAST facility...

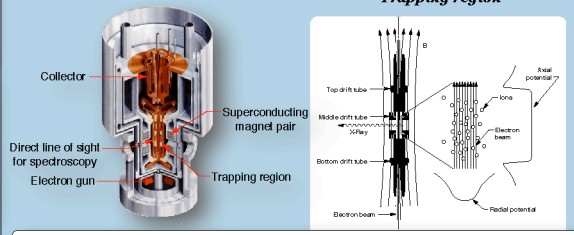
- covers the 0.1 to 100 keV energy range
- uses discrete line emission from highly charged ions
- can be used to calibrate:
  - filter transmission
  - spectrometer efficiency
  - instrument line profiles



X-ray filters being fitted onto the translator before testing.

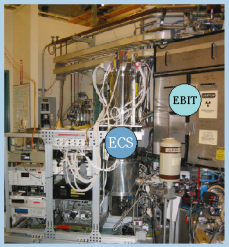
EBIT X-ray Source & Detector

EBIT-I *Close up of Trapping region*



The EBIT-I electron beam ion trap uses an electron beam to ionize, trap, and excite highly charged ions. Ions are trapped axially using three drift tube electrodes, each at a different electric potential.

The EBIT Calorimeter Spectrometer (ECS)



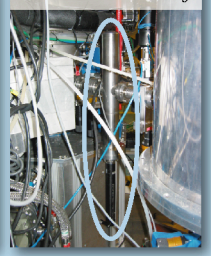
Characteristics of the ECS microcalorimeter instrument:

- ΔE ≈ 4.5-8 eV @ 0.1-12 keV band
- 32 channels
  - –18 optimized for 0.1 to 10 keV
  - –14 optimized for 0.5 to 100 keV
- 65 hour uninterrupted integration time
- 80 microsecond time resolution

Filter Calibration

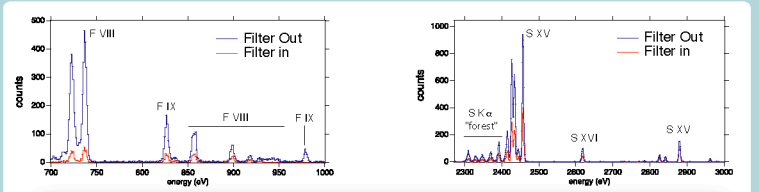
Filters are absolutely calibrated by measuring the x-ray emission from strong, discrete lines with the filter in the X-ray line of sight and then out of the line of sight. By dividing the "filter-in" signal by "filter-out" signal, the absolute transmission efficiency is determined. Above is a picture of the filter translator and to the right is the translator housing located between EBIT-I and the ECS.

Filter Translator Housing



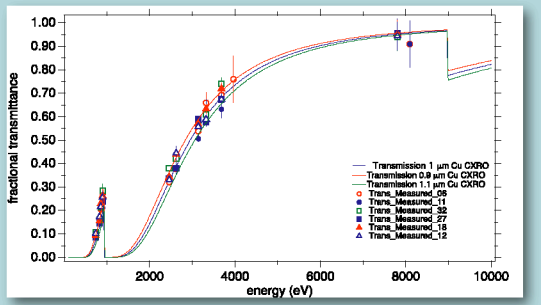
Results 4

Spectra measured with the filter in and out of the x-ray line of sight.



- **Each in-out cycle takes two hours, one each for in and out.**
- **A filter can be fully calibrated in one day.**

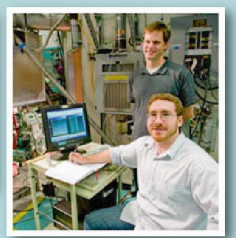
Measured Absolute Transmission Compared to Theory



Theoretical curve calculated from the Center For X-ray Optics (CXRO) website and based on thickness of 0.9, 1.0 and 1.1 micrometer thick Cu filters. Measured thickness of each filter fell in the 0.9 to 1.1 micrometer range.

The EBIT Facility is a regular host to...

- undergraduate students
- student teachers
- graduates students
- post-docs
- visiting scientists from all around the globe.



Dr. Greg Brown (behind), EBIT's mentor researcher, with a previous STAR intern.

Ties to the Classroom 5

EBIT-I is full of exotic and exciting physics that can be brought back to any science classroom. The utility of x-ray spectroscopy, a branch of spectroscopy that students may not usually be exposed to, is regularly unveiled in the EBIT lab. Experiments at EBIT have connections to high energy astrophysics, atomic physics, quantum mechanics, inertial confinement fusion, magnetic fusion, and high energy density physics. Also, EBIT's use of strong electric currents and magnetic fields can segue into any electromagnetism unit. Finally, NIF itself has its own classroom possibilities; bringing man's next step towards successful nuclear fusion into the classroom will create better student engagement with topics related to current scientific events.

This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.
This material is based upon work supported by the S.D. Bechtel, Jr. Foundation and by the National Science Foundation under Grant No. 0552043 and Grant No. 0833353. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the S.D. Bechtel, Jr. Foundation or the National Science Foundation.
LLNL-POST-410784