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

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

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 (CERO) website and based on thickness of 0.5, 1.0 and 1.5 micrometer thick Cu filters. Measured thickness of each filter fall in the 0.3 to 1.1 micrometer range.

The EBIT-1 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 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 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 the “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-1 and the ECS.

Ties to the Classroom

EBIT-1 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.