65% Design Review

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High Energy Electronic X-Ray (HENEX) Spectrometer
NIF Core Diagnostic

Presented by:

John Seely PI, Richard Deslattes, Lawrence Hudson, Albert Henins, Rob Atkin, Layne Marlin, Glenn Holland, Perry Bell, Christina Back

NRL, NIST and LLNL

Presented to:

NIF Diagnostic review committee formed by the JCDT

April 23, 2001

- The HENEX Conceptual Design Review was held on 12 December 2000.
- The CRD and the 65% DR viewgraphs and other HENEX documents are available on the website spectroscopy.nrl.navy.mil
- The conceptual design is detailed in the paper "Hard X-ray Spectrometers for NIF" (Review of Scientific Instrument, June 2001).

Agenda for the HENEX 65% Design Review

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1. Opening (Tina Back, tinaback@llnl.gov)
2. Design Overview (John Seely, john.seely@nrl.navy.mil)
3. Mechanical Design (Layne Marlin, lmarlin@ssd5.nrl.navy.mil)
4. Optical Design (Larry Hudson, larry.hudson@nist.gov)
5. Electronic Design (Rob Atkin,ratkin@tigerinnovations.com)
6. Interface/Sensor (Glenn Holland, gholland@ssd5.nrl.navy.mil)
7. Project Schedule (Perry Bell, e061547@popeye.llnl.gov)

Questions/comments: Please refer to the presentation number 1-7.

Contact the individual presenters for follow-up information.

This presentation and other HENEX documents are available on the website spectroscopy.nrl.navy.mil

The HENEX diagnostic is being developed to meet the NIF user community needs

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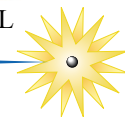

X-ray spectroscopy needs as identified by the NIF x-ray spectroscopy expert group

- Determination of the ion species present in the plasma by the identification of bound-bound emission features.
- Observation of the hard x-ray continuum and the electron energy distribution.
- Characterization of backlighter and hard x-ray (NWET) sources.
- Determination of the plasma temperature, density, optical depth.
- Target design and code validation.
- Basic research on the atomic structure of highly-charged ions.

Implementation of the many x-ray spectroscopic diagnostic techniques requires multiple diagnostics, the core diagnostic meets the most basic requirements

The NIF core spectroscopy diagnostic must provide data with sufficient spectral resolution

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- **Unique capabilities for the core diagnostic:**
  - Measure spectrally-resolved conversion efficiency
  - Unambiguously identify emission of highly-ionized high-Z x-ray sources and backlights
- **Additional applications may include:**
  - Characterization of plasma conditions - electron temperatures through line ratios or bound-free continuum measurements
  - Scoping or feasibility studies for more advanced research using x-ray spectroscopy

Intended applications of the core x-ray spectroscopy diagnostic

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- **Comprehensive survey instrument that covers a large spectral range**
  - identification of the presence of x-rays from the targets having emission in the 1.1 to 20 keV photon energy range
- **Verification of backlight materials**
- **Relative measurements of time-integrated line ratios and time-integrated bound free continuums**
  - n.b. the minimum spectral resolution is ~ 300. Although x-ray line ratio diagnostics may require higher resolution, this instrument is appropriate for a broad range of scoping studies to determine emissivity levels of spectroscopic signals of interest. This type of information enables proof of principle studies and is essential to enable better definition of higher resolution instruments tailored to the particular plasma conditions of interest.
- **Conversion efficiency measurements and quantification of multi-keV source characteristics (* pending funds for absolute calibration)**

NIF users have requested a survey spectrometer

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- The experimental campaigns that have requested this instrument come from two sources.
  - NIF diagnostic work sheets collated by Otto Landen at LLNL during the planning for diagnostics in 1997 (table below)
  - NIF integrated project schedule under the user module planed by Brian MacGowan of LLNL (next slide)

- The spectroscopy user group sets the instrument physics requirements

- The NIF facility sets the interface requirements

WBS 9.1	Backlighter Characterization	Kalantar LLNL
WBS 9.2	Plasma Spectra characterization	Chrien LANL
WBS 2.1, 2.2 WBS 3.2.3.4.2	Plasma Spectra & Emissivity	C. Back LLNL

The user module needs updated

Integrated Project schedule has the following experiments listed

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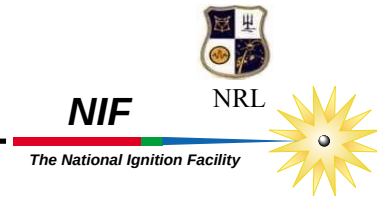
ID	line no.	WBS	M/S No.	evel	Task Name
499	454	9.7			ET0251 Source development - Ti disks
500	455	9.7			ET0252 Source development - Xe gasbags
503	458	9.7			ET0255 Source development - coupling
504	459	9.7			ET0256 Source development - coupling
509	464	9.7			ET0258 Source development - Xe-filled hohlraum
510	465	9.7			ET0259 Source development - higher energy solid with prepulse
511	466	9.7			ET0260 Source development - higher energy solid with prepulse
512	467	9.7			ET0261 Source development - coupling
513	468	9.7			ET0262 Source development - coupling
519	474	9.7			ET0271 Source development - long pulse demonstration
527	482	9.7			ET0264 Source development - higher energy targets
530	485	9.7			ET0265 Source development - distributed source preparation
531	486	9.7			ET0266 Source development - distributed source demonstration
533	488	9.7			ET0268 Source development - campaign 7 , output validation
540	495	9.7			ET0274 Source development - high power
542	497	9.7			ET0275 Source development - campaign 7 output validation
543	498	9.7			ET0276 NWET - user tests - preparation
544	499	9.7			ET0277 NWET - user tests
547	502	9.7			ET0279 Demonstration of 25 cm distributed source
548	503	9.7			ET0280 Demonstration of 25 cm distributed source
549	504	9.7			ET0281 Full distributed source demonstration preparation
550	505	9.7			ET0282 Full distributed source demonstration
553	508	9.7			ET0284 Campaign 7 follow-on
554	509	9.7			ET0285 Campaign 7 follow-on
555	510	9.7			ET0286 NWET - user tests
556	511	9.7			ET0287 NWET - user tests

REQUIREMENTS: NIF X-ray crystal spectrometer



As defined by expert user group

- **Energy range of operation** — **1.1 - 20.1 keV**
- **Temporal resolution** — **time-integrating**
- **Energy resolution E/ΔE** — **2000 (1 keV) - 300 (20 keV)**
- **Dynamic range** — **at least 100**
- **Signal-to-noise** — **~ 10 for significant spectral lines**
- **Field-of-view** — **5 mm with variable slit**
- **Detectable fluence** — **1×10^{-6} J/cm^2**
- **Data acquisition and analysis time** — **1 hour**