100% Design Review

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

Presented by:
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Glenn Holland, NRL
Perry Bell, LLNL
Tina Back, LLNL

Presented to:

NIF Diagnostic review committee formed by the JCDT

8 November 2001

The 100% DR viewgraphs and other HENEX documents are available on the website:
spectroscopy.nrl.navy.mil

Agenda for the HENEX 100% Design Review

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No. of VGs

13 1. Overview (John Seely, john.seely@nrl.navy.mil)

10 2. Optical Design (Larry Hudson, larry.hudson@nist.gov)

9+ 3. Mechanical Design (Layne Marlin, lmarlin@ssd5.nrl.navy.mil)

23 4. Electronic Design (Rob Atkin,ratkin@tigerinnovations.com)

16 5. Interface/Sensor (Glenn Holland, gholland@ssd5.nrl.navy.mil)

7 6. Project (John Seely, john.seely@nrl.navy.mil)

Questions/comments: Please refer to presentation number 1.

78+ Total No. of Viewgraphs

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

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

Overview of the HENEX instrument

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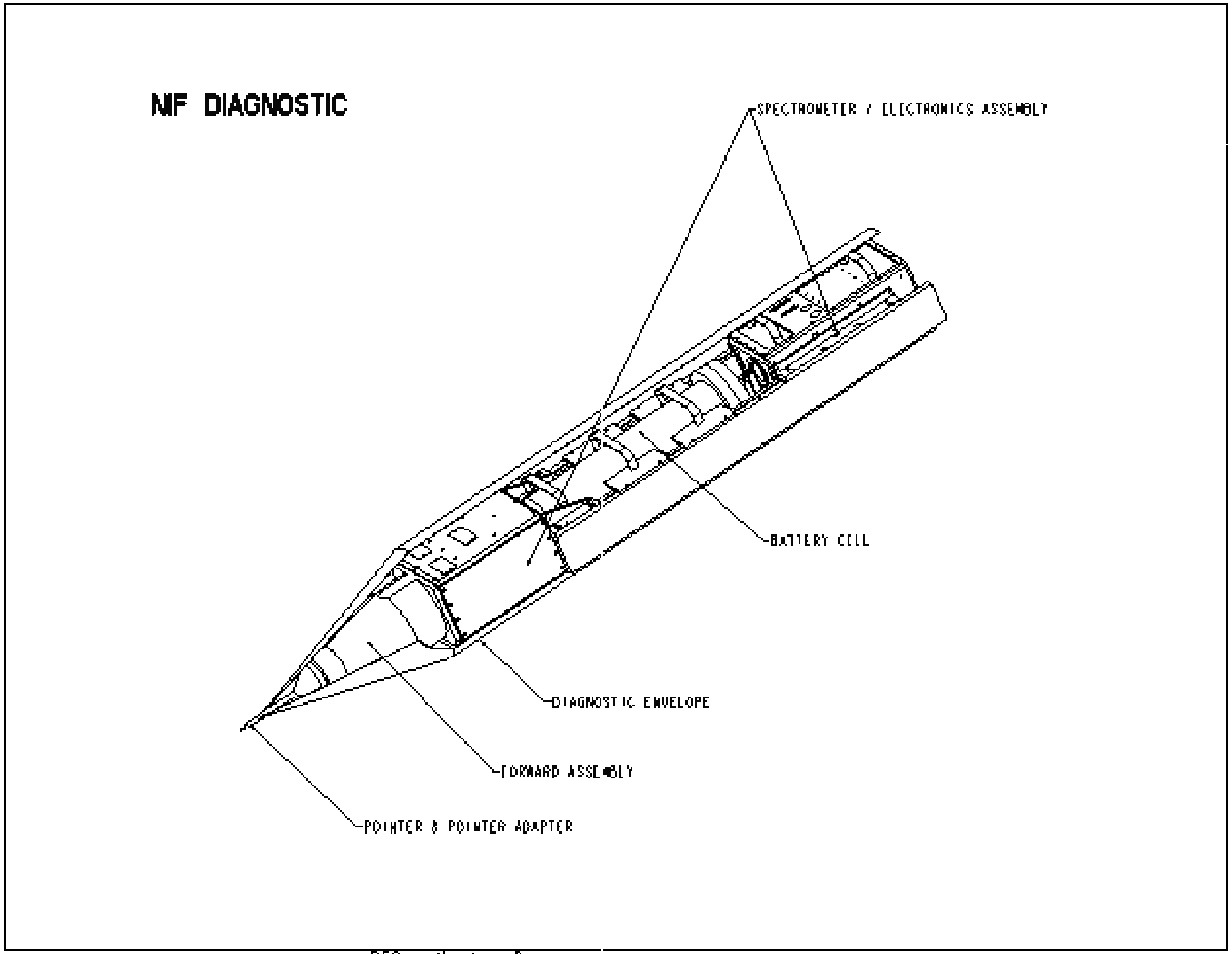


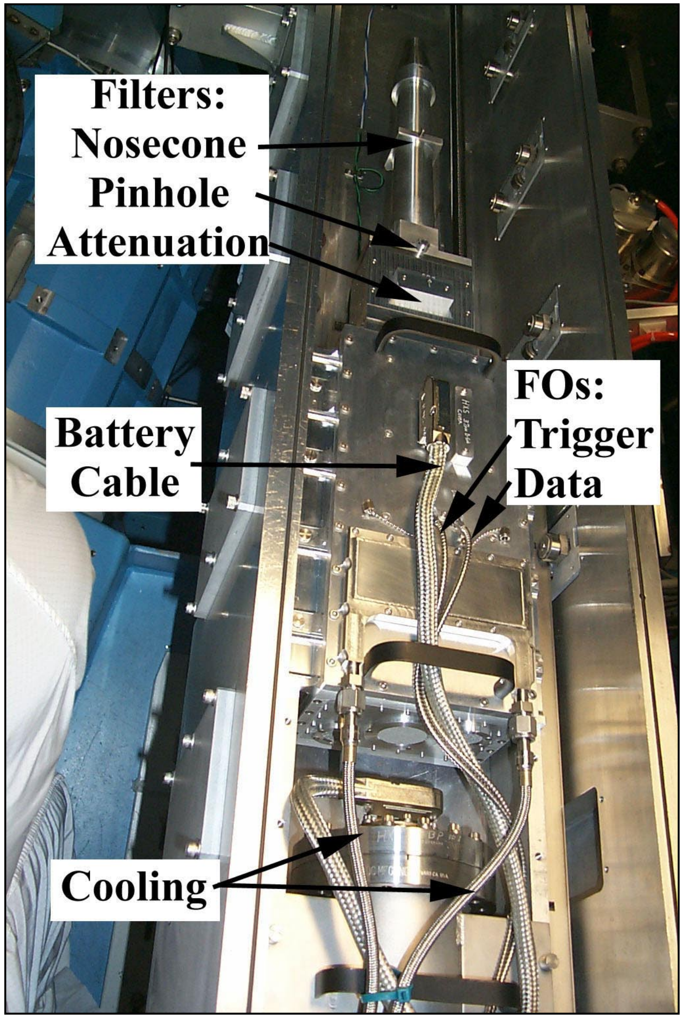
REP : Master Rep
SCALE : 0.167 TYPE : ASSEM NAME : HIFF SIZE : E

Description of HENEX instrument

- HENEX is designed to operate in the NIF DIM and the LLE TIM.
- The x-ray dispersive elements are five crystals used in reflection or transmission.
- The standoff distance from the target is changeable (0.5 m or 2.2 m).
- Two SMA 62.5 micron fibers handle triggering and data transmission.
- The baseline electronic detectors are 12 bit resolution and controlled by low-power custom built readout/drive electronics housed inside the Drive Electronics (DE) package in the rear of the instrument.
- The instrument is designed so that no data are retained when the power is disconnected.

Prototype Hard X-ray Spectrometer (HXS)

- **Prototype HENEX components:**
  - **Transmission crystal (covering 12 - 60 keV).**
  - **Electronic detection (CCD).**
  - **On-board computer and drive electronics.**
  - **Powered by an internal battery pack.**
  - **Command/control and data transmission via fiber optic links from the instrument to a remote computer/interface unit that is connected to the host facility network.**
  - **Upgrade to HENEX-based electronics.**



HXS Spectral Images from Krypton Targets

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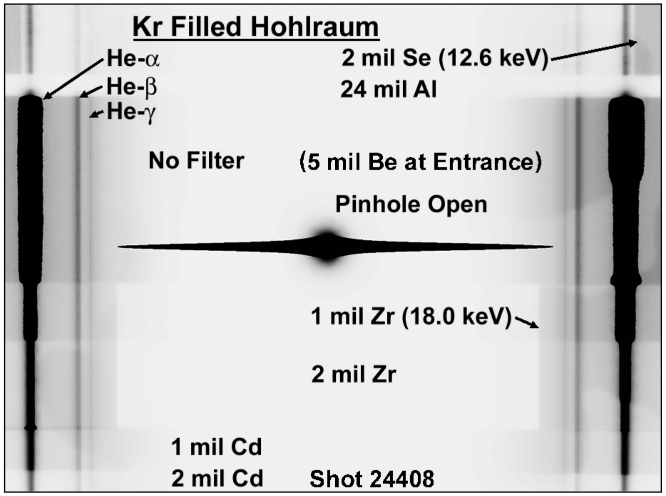
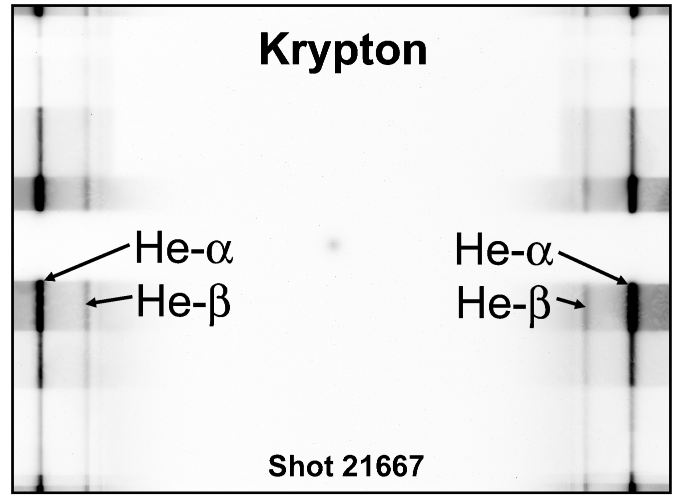
Kr-filled hohlraum on 8/30/01:



Kr-filled CH shell on 11/23/00:



100% Design Review Requirements

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The Engineering 100% design review is where the diagnostic detailed design will be reviewed by the National NIF Diagnostic Program or their nominees, the relevant expert group members, and the NIF user community. The review includes all work necessary to fabricate, assemble, offline test, and field the final diagnostic and will consist of the following sections:

1) Demonstrate compliance with design requirements *(Larry)*

2) Address comments and action items documented at the M2 - Engineering 65% design review *(John)*

3) Verification of compliance with interface control documents *(Glenn and Rob)*

4) Present RAM analysis - An estimate of the expected reliability and/or availability when operated on the NIF, based on experimental results *(John)*

5) Present final risk mitigation plans *(John)*

6) Present final safety analysis of the diagnostic and layout *(John and Glenn)*

7) Present calculations and analysis of design performance (electrical circuit evaluation, structural response, shielding, etc.) *(Rob, Layne, Glenn)*

8) Demonstrate that the design is complete:

- **Design models are complete and checked for form, fit, and function *(Layne)***
- **Drawing packages are complete *(Layne)***
- **Manufacturability of components *(Layne)***
- **List of control and monitor points *(Rob)***
- **Electronic designs, printed circuit board designs and cable layout details *(Rob)***
- **All detail drawings must be approved by the diagnostic project engineer, and placed into configuration management system per the NIF diagnostic standards and guidelines *(Layne)***
- **Present results of prototype and component testing *(Larry, Glenn, and Rob)***

100% Design Review Requirements (cont.)

9) Present the status of the software design, ready for coding - Software Requirement Specifications and Software Design Specifications - identify software manuals, Prototype SW demonstrating or evaluation design concepts (optional) *(Rob)*

10) Demonstrate compliance with the NIF Diagnostic Standards and Guidelines documents *(Glenn and Rob)*

11) Update the cost and schedule information *(John)*

12) Present the procurement plan:

•List of all components to be purchased *(Glenn)*

•Bid estimates to support procurement of all components *(Glenn)*

•Specifications written for all purchased components *(Glenn)*

•Suppliers of components identified *(Glenn)*

•Drafts of Statements of Work *(Glenn)*

13) Present drafts of the assembly and fabrication procedures *(Layne and Glenn)*

14) Present drafts of Off-line and On-line acceptance test procedures *(Rob and Glenn)*

15) Present drafts of calibration procedures *(Larry)*

16) Present drafts of the alignment procedures *(John and Glenn)*

17) Present drafts of installation procedures *(John and Glenn)*

18) Identification of operation plans *(Rob and Glenn)*

Comments and action items will be recorded, and addressed in the M4a - Fabrication and Assembly Complete Report.

The National NIF Diagnostic Program or their nominees will accept or decline milestone completion within 5 working days of presentation. This review will not be considered complete until the acceptance of the set of requirements. The completion criteria for this review are that all work has been done that is required to start the procurement, fabrication, and assembly tasks for the diagnostic.

Comments from the 65% Design Review

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The document is on the website spectroscopy.nrl.navy.mil:

The 65% Design Review Comments/Questions were emailed to NRL on May 4, 2001. A response is provided after each comment/question.

Comment/Question Impact Types:

1=If left unresolved, could result in a recommendation of "rejection of a specific aspect of design."

2=If left unresolved, could result in a recommendation of "acceptance of the design with comment."

3=Comments that provide information and suggestions to the design team.

Pages refer to the 65% Design Review presentation at the website

http://spectroscopy.nrl.navy.mil/HENEX/Reviews/65%25DR/65%25DR.html

A. Carl Pawley

A.1. (Type 2, Software) Work out the details of software ownership. Allow sufficient flexibility to allow rebuilds to another standard if LLNL requires it.

John Seely: Rob Atkin and Tiger Innovations Inc. (TI) are committed to supporting the HENEX software and making modifications to accommodate possible future changes. If for some unforeseen reason TI is unable to do this, TI has offered to place the software in escrow at NRL. The original NIF specifications and requirements did not address the disposition of the source code, and the HENEX budget and the agreement with TI does not cover the cost of providing the source code. A possible option is for LLNL to purchase the source code.

Risk Mitigation Plans

The document is on the website spectroscopy.nrl.navy.mil:

Component	Priority 1=Highest	Probability % in 1st Year	Event	Effect	Management	Comment
Nosecone	3	20	Misalignment of the DIM to the source position.	Shift of the spectra on the sensors.	Implement attenuation filters and compute new energy scale using absorption edge positions.	Analytic expressions for the energy scales have been derived.
Nosecone	2	20	Entrance filter bursts.	Additional x-ray flux and visible light reach the sensor. Filter must be replaced.	The filter supports are designed for easy filter replacement.	Most likely for the thin filter on the lowest energy channel.
Spectrometer	3	10	Crystal breaks.	Crystal must be replaced.	Spectrometer is detached from the instrument, disassembled, and the new crystal and mount are inserted.	The crystal thickness is chosen to accommodate the bending radius.
Sensor	3	5	Sensor filter bursts.	Additional x-ray flux and visible light reach the sensor. Filter must be replaced.	Sensor/filter module is designed to be easily withdrawn, and the filter is replaced.	Unlikely because the sensor's filter is protected by the crystal and the entrance filter.
Sensor	3	10	Sensor fails because of EMI.	Destruction of the sensor.	EMI shielding is implemented. Sensor module is easily withdrawn, and the sensor can be replaced.	EMI shielding was successful for HXS.
Sensor	2	20	Sensors are overexposed.	Dynamic range is reduced.	Filters are designed to be easily withdrawn, and additional attenuation is added.	HXS saturation occurred on hohlraum shots.
Battery	1	<<1	Battery pressure vessel fails.	Dispersal of contaminants into the target chamber.	Engineering analysis indicates the battery pressure vessel is structurally over designed by at least a factor of 100.	Tiny probability, huge consequences.

RAM Analysis

The document is on the website spectroscopy.nrl.navy.mil:

We assume that the time between NIF shots is sufficiently long so that at least one hour is available for corrective action. That is, if the failure can be corrected within one hour, then the failure does not impact the NIF shot schedule and is not significant with regard to the RAM analysis. Failures that take longer than one hour will delay the shot schedule and must be further considered in the RAM analysis.

The calculated parameter is the time to correct the failure minus one hour times the probability that the failure will occur during the first year of operations. By summing up these times for all of the relevant failure modes, the result is 0.1 hours. Thus based in these assumptions, HENEX is estimated to delay the NIF shot schedule by 0.1 hour during the first year of operation. This possible delay is expected to decrease in later years since reliability should increase with experience.

There are many assumptions that form the basis of the HENEX RAM analysis. These are grouped into several categories:

(1) The spare HENEX components listed in the last column of the table are available on site and can be quickly brought to the HENEX DIM. In some cases, such as the replacement electronics, the costs of these spare components are considerable and must be added to the budget for the construction of the HENEX instrument.

(2) We assume that the instrument can be withdrawn into the DIM, vented, evacuated after refurbishment, and re-deployed into the NIF chamber in less than one hour.

(3) Off-line NIF facilities are available for the set-up and complete testing of the instrument. This includes the availability of NIF DAS signals for testing the triggering of the instrument.

Installation Procedures

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The document is on the website spectroscopy.nrl.navy.mil:

<u>Contents:</u>

HENEX Components

Operating Modes

Off-Line Tests

Deployment in the Instrument Insertion Module

Instrument Start-Up