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Responses to the HENEX CDR Comments/Questions
Compiled by John Seely

The CDR Comments/Questions were emailed to NRL on January 19, 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 CDR presentation at the website
http://spectroscopy.nrl.navy.mil/HENEX/Reviews/CDR viewgraphs.pdf

A. Brian MacGowan

A.1. (Type 1, Pages 20/21) The issue of triggering of the CCD readout of the HENEX was discussed. The engineers working on the HENEX were designing their system so that at t-10 sec you were committed to acquiring data between t-0.5 and t+0.5 sec. I believe that this is consistent with the way Omega operates. This may not be consistent with the way NIF will be controlled as the shot approaches. There may be holds that would upset this plan. All of that needs to be looked into and that comment was mentioned at the review. However, afterwards, I realized that this is a generic problem for multiple diagnostics and that we shouldn't be spending money designing a unique solution to this problem for HENEX or any other diagnostic. The diagnostics group should have a generic solution to synchronizing CCDs to the NIF shot sequence. That solution (possibly with a simple modification to make it compatible with Omega) should be provided to the HENEX designers.

Perry Bell: I have followed up on this issue with the integrated command and controls group. They have up-dated their plans and have established the sequencing of the shot cycle. It basically boils down to software to hardware handoff a t-2 sec. Diagnostic builders can not start any process that requires better than 15 sec resolution during the software controls phase. After the software to hardware handoff, the system is accurate to 30 ps rms.

A.2. (Type 1, Page 15) What is the origin of the neutron shielding requirement? Is it compatible with all of the experiments that need the HENEX? If neutron imaging is done at the same time would the higher yields and/or DT neutrons cause CCD damage. Are we sure that there is no requirement for HENEX operation with higher than 10^9 DD yield. If there were a need could we operate the device with film?

Tina Back: For experiments that require backlight verification and x-ray conversion efficiency measurements of low-convergence implosion targets (Nova/Omega-type) or other non-implosion targets, i.e. typical disk or gas-filled targets, this level of neutron shielding is sufficient. For a limited number of NIF high-conversion implosion experiments, survival in a 10^{14} - 10^{16} neutron yield may be of interest for spectroscopy of capsule tracer layers. However, it is not clear how to shield any diagnostics from 14.1 MeV neutrons and consequently, x-ray diagnostics are not expected to be run on high yield shots. The present shielding requirement is based on tests of a prototype in the Omega chamber where we are able to test the operation of the instrument with lead shielding. Higher fluxes for testing are not accessible with present sources. If necessary, we could operate with a film pack.

A.3. (Type 2, Page 20) Orientation – there may be some advantage to being able to orient the HENEX with its dispersion direction at other angles relative to the DIM. The expert group should review the value of this capability and change the requirements if necessary to allow other angles. A choice of two orientations e.g. horizontal or vertical may be appropriate and easily worked into the design.

John Seely: The normal orientation of the dispersion planes of the HENEX crystals is vertical. When deployed in a DIM, the spectrometer package can be rotated so the dispersion planes are horizontal. This is accomplished by unbolting the spectrometer package, rotating it by 90^{o}. Owing to space constraints, the spectrometer package cannot be rotated in a TIM.

A.4. (Type 2, Page 18) The vacuum outgasing/leak specification of 0.01 torr liter per sec may be the total budget for all diagnostics that are in the chamber on a particular shot. Someone should check this and if necessary allocate the HENEX an appropriate share of the leak budget.

Perry Bell: The out-gassing specification per the guideline in “The National Ignition Facility target chamber cleanliness, material compatibility and vacuum out-gassing specifications and guidelines “ states the following: "Target diagnostic vacuum specification. Each diagnostic system shall have a maximum out-gassing rate of 1 $x10^{-2}$ torr liters/sec after 2 hours of high vacuum pumping. All diagnostics in aggregate will have a total out-gassing rate equal to or less than 1e-1 torr liter/sec after 2 hours of high vacuum pumping." We are meeting the "each diagnostic system" maximum out-gassing rate. We anticipate that we will be well below this specification but can not quote the rate until it has been measured.

A.5. (Type 2, Page 23) The alignment requirement needs to be consistent with the field of view and any spatial discrimination that is necessary to avoid background and fluorescence. The strategy for alignment needs to be better defined. The idea of a 2.2 metre long pointer attached to the HENEX is worrying. Ideas such as laser pointers need something at chamber center to reflect the light. Moving things into and out of chamber center with the target positioner will take time. Chamber center time at NIF will be at a premium. We are trying to develop a shot “microschedule” that will show how much time is available to do things like align diagnostics. The first indications are that there won't be much time available. We need to have quick, non-invasive ways of aligning things.

John Seely: The pointing of the Hard X-Ray Spectrometer deployed in a TIM at LLE was accomplished using a pointer and TIM xyz motions. The pointing was done at the beginning of the shot campaign. The pinhole images recorded on subsequent shots indicated that the pointing was stable to within a few pixels over a number of days and instrument retractions into the TIM. Thus we expect that the HENEX pointing will be accomplished once at the beginning of the shot campaign, and the pointing would be stable over a number of days and perhaps weeks.

B. Jeff Koch

B.1. (Type 2, Page 23) The stated alignment pointing accuracy requirements, 500 µm in x and y and 250 µm in z, do not appear to be justified, especially in light of the required 5 mm field of view (pg. 10) and the statement by the presenters that spectral resolution of 300 can be attained for source sizes as large as 5 mm. The investigators should consider what the actual pointing requirements are, and how these requirements might impact the alignment procedure.

John Seely: The pointing accuracy of 500 µm in x and y and 250 µm in z are well within the DIM capabilities. The actual pointing should be more accurate. It is instrumental resolution of 300 that can be attained with source sizes as large as 5 mm. Spectral resolution can not. Both of these comments are true for all HENEX channels and energies.

B.2. (Type 2, Page 21) The alignment procedures for the instrument needs to be worked out in more detail, in conjunction with the Diagnostic Alignment Working Group, so that the investigators can demonstrate the diagnostic can be aligned within reasonable requirements.

Perry Bell: The current plan is to utilize a mechanical pointer during the LLE testing phase. We will then move to an opposing port DIM alignment system in the NIF design. We will align the instrument on an off-chamber alignment system (provided by the LLNL target experimental systems group), then move the instrument to the target chamber for final alignment. Z will be referenced from the DIM Z positioner. If the DIM is as repeatable as advertised, we can do dead reckoning from the initial co-axial line of sight positioning once a reference is established.

B.3. (Type 3, Page 19) A 12-16 hour battery lifetime seems short if this is wall clock-time - this would require daily removal and battery replacement if the instrument were used frequently. The design might be changed so that the detector electronics could be powered off between shots.

John Seely: The battery lifetime, if the instrument were operated continuously in the Ready-for-Shot Mode or the Data Retrieval Mode, would be approximately 12-16 hours.

However, these modes are activated only for short periods of time just before and after the shot. During the longer periods between shots, the instrument is in Standby Mode, where the battery lifetime under continuous operation is estimated to be at least 42 to 56 hours. The instrument is normally powered off overnight and during long shot delays.

C. Jonathan Workman

C.1. (Type 2) Filters: I did not see a specification as to where the filters are placed. This has been a significant issue on the Henway with much of the instrument needing to be disassembled. Is there a filter pack that can be slid in and out easily in front of the crystals/individual crystal. In addition, is there provision for filters directly in front of the CCDs.

John Seely: Filters will be mounded in front of the crystals on an easily removable frame. An additional light-tight filter will cover each sensor, and this filter can be replaced by disassembling the sensor module.

C.2. (Type 2) Fluorescence: This is a big issue. I do not believe that slits are absolutely necessary to eliminate fluorescence, however, appropriate materials inside the box will be important, e.g. any aluminum fluorescence from the box can be controlled with a Be filter in front of the CCD. Also, is there any provision for magnets or plastic coatings at the entrance to reduce hot-electron interactions? These issues should be directly addressed in the signal to noise ratio specification.

Larry Hudson: We do plan to use primarily lead and aluminum in construction of the spectrometer boxes and crystal mounts. Each detector holder will have a Be entrance window which will control Al fluorescence. To cause fluorescence, hot electrons would also have to penetrate metallic step wedge filters of at least 25 to 50 micrometer thickness. This becomes probable for electrons above about 100 keV. If needed, the inner spectrometer walls could be lined with plastic. Direct 'fogging' of the sensor by hot electrons will not be a problem given the shielding and orientation of the sensor edge on to the entrance window.

C.3. (Type 2) Crystals: Are the crystals chosen in the review the only crystals that will be used on the instrument? Interchangeable crystals would be desirable. In particular, MICA has relatively high reflectivity in many orders (up to 15th). This may be an issue when trying to look at low Z tracers and materials with higher energy backgrounds.

Larry Hudson: The spectrometers are modular in design and it will be possible to remove a mounted crystal and holder. This should be done with some thought since the sensor position, due to space constraints, has only millimeters of adjustment. This cluster of spectrometers was designed to cover the energy range required, not accommodate any crystal. That said, it is entirely possible to introduce crystals of different lattice spacings and radii of curvature in order to capture different ranges of spectral coverage with different sensitivities. In addition, these new plate functions are easily calculable. The crystals listed at the CDR were the baseline crystal selections at that time. Alternative crystals for each channel are continuing to be evaluated. The final crystal selection will be presented at the 65% Design Review.

C.4. (Type 2) Calibration: This, as was stated, is an important issue. Although NIST may do the initial calibrations (in particular reflectivity) crystals will degrade with time and may be damaged and need to be replaced. I know that anyone doing conversion efficiency measurements will consider the upkeep of calibrations important.

John Seely: The sensitivity calibration of HENEX is not part of the present project. Calibration is considered important by almost all potential HENEX uses. A project for NIST calibrations is under discussion.

C.5. (Type 2) Sensitivity/Dynamic Range: What are the phosphors/scintillators to be used on the CCDs for the 5 channels and what are their characteristics in terms of sensitivity vs energy. Overall, what will be the dynamic range as a function of energy. Will the dynamic range be 2500 at 20 keV? Also, will the x-ray converters be part of the NIST calibration?

John Seely: The phosphor/scintillator for each energy channel will be optimized in consultation with Applied Scintillation Technologies (formerly Levi-Hill). This is presently under study. We plan an early test of the lowest energy channel sensitivity using an AST recommended phosphor coating. The end-to-end sensitivity would be part of the future NIST calibration (not part of the present HENEX project).

C.6. (Type 2) Are the Bragg channels pointed toward the target (towed in) for the 0.5 m and 2.2 m distances or are they all parallel?

John Seely: As delivered, the individual spectrometer boxes are tilted in for the 0.5 m standoff appropriate for the LLE tests. Wedges will be provided for tilting in the boxes for the 2.2 m NIF standoff. For the NIF standoff, the side channels are towed in by 1.3 degrees; for LLE, 5.6 degrees.

D. Barukh Yaakobi and David Meyerhofer

D.1. (Type 2, Page 5) "Ion temperatures by line width": this presumably refers to Doppler width. It is virtually certain that the instrument will not have nearly sufficient resolution to measure Doppler widths (for very high temperatures we need to employ heavier atoms which reduces the Doppler width and to use high-energy lines where the resolution in this instrument is low).

John Seely: This was mentioned under "Additional applications may include" and referred to possible future measurements that would be carried out by an instrument with much higher resolving power. The HENEX resolving power specification is 300 which is much lower than needed to observe Doppler widths.

D.2. (Type 2, Page 10) Sensitivity should be estimated. It should be pointed out that the crystals listed here are low sensitivity. Since the resolution is geometry limited the question is why not employ higher-sensitivity crystals.

Larry Hudson: The flat crystal sensitivies are available in the literature and will be presented in tabular form at the 65% design review. Their sensitivity upon bending is altered due to geometrical factors as well as changes in mosaicity, extinction, and, in the case of quartz, the anisotropy of the inelastic stress tensor. We will choose crystals of higher sensitivity if they are available with the thin dimension needed for bending to 5 inches radius of curvature. TAP is the choice for the lowest energy channel; it is desirable due to its relatively high reflectivity, low fluorescence, and relatively good suppression of higher orders. ADP is the choice for the next energy channel since it is more than twice as sensitive as KDP. The surfaces of these large-d crystals are vulnerable to attack by atmospheric water and will be projected by a very thin layer of polystyrene. The crystal materials for the higher-energy channels, Si, Ge, and Qz, have acceptable sensitivity and are desirable because of their ease of acquisition, preparation, and stability.

D.3. (Type 2, Page 10) The instrument should greatly benefit from the ability to have (variable-width) slits in front of the instrument. Benefits: (a) spatial resolution with narrow slits, (b) fluorescence-background discrimination with wider slits (but still narrower than the crystal width).

John Seely: HENEX will have a slit/aperture module on the front end that will permit slit/aperture changes.

E. Dean Lee

E.1. Alignment of the HENEX needs to be coordinated with the Diagnostic Alignment Working Group.

Perry Bell: See B2 response.

E.2. Triggering requirements are not compatible with the NIF ITS. Need to review this with ITS and or change the HENEX requirements.

Perry Bell: See A1 response.

E.3. Is the raw data ever classified?

John Seely: The electronics are designed so that image data are lost from dynamic memory when the instrument is powered off.