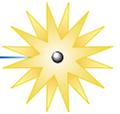


# Agenda for the HENEX 100% Design Review



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1. Overview (John Seely, [john.seely@nrl.navy.mil](mailto:john.seely@nrl.navy.mil))
2. Optical Design (Larry Hudson, [larry.hudson@nist.gov](mailto:larry.hudson@nist.gov))
3. Mechanical Design (Layne Marlin, [Imarlin@ssd5.nrl.navy.mil](mailto:Imarlin@ssd5.nrl.navy.mil))
4. Electronic Design (Rob Atkin, [ratkin@tigerinnovations.com](mailto:ratkin@tigerinnovations.com))
5. Interface/Sensor (Glenn Holland, [gholland@ssd5.nrl.navy.mil](mailto:gholland@ssd5.nrl.navy.mil))
6. Project (John Seely, [john.seely@nrl.navy.mil](mailto:john.seely@nrl.navy.mil))

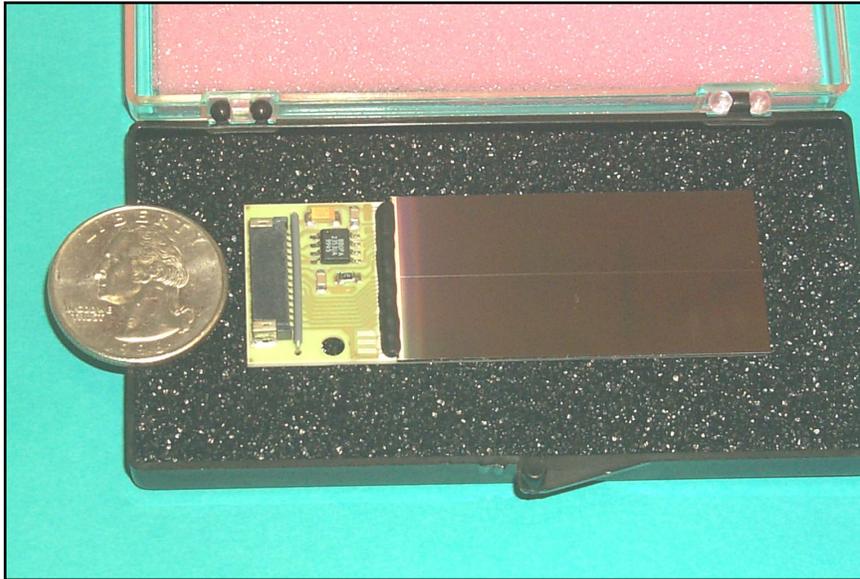
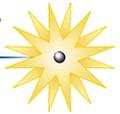
**Questions/comments: Please refer to presentation number 5.**

# Rad-icon CMOS Sensor



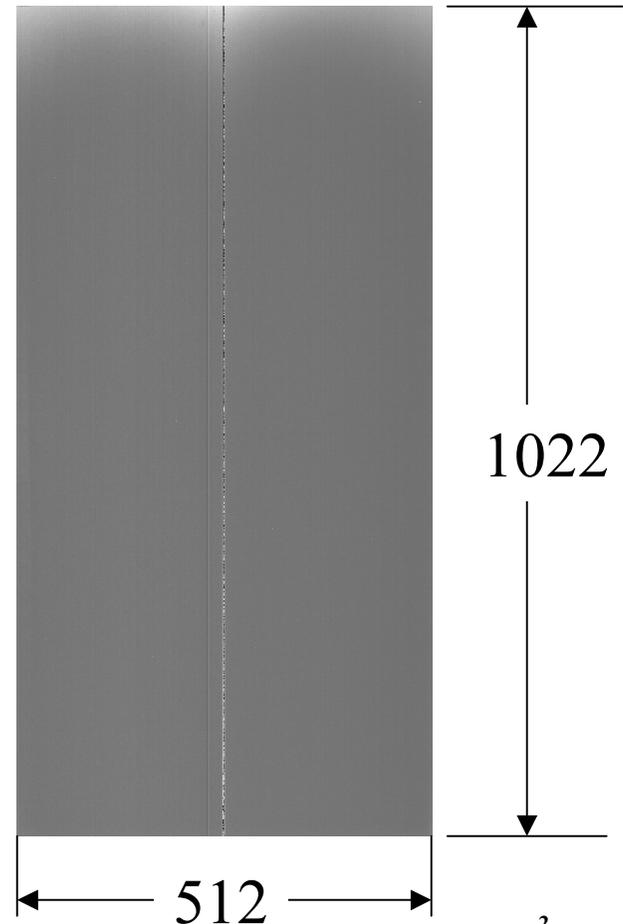
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RadEye 1 sensor cost \$2K ea.  
[www.radicon.com](http://www.radicon.com)

20 sec dark image



- 512 x 1022 array imager.
- 48 micron pixels.
- 24.6 x 49 mm active area.
- 95% fill factor, active pixels.
- Rad-hard to 100K rads.
- Low power, vacuum compatible.
- 12 bit depth pixels.

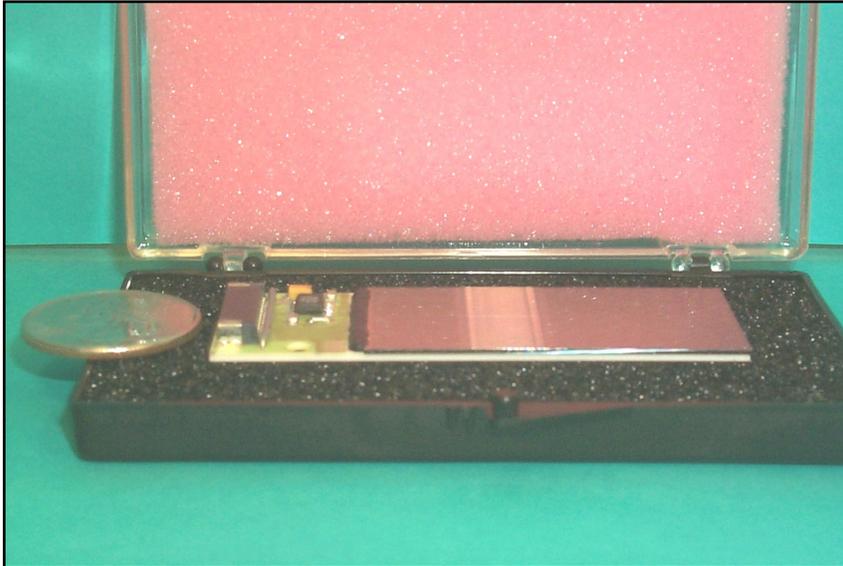
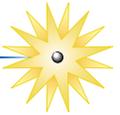
# Scintillator Coatings for Sensors



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**RadEye 1 sensors will be coated with scintillator ( $Gd_2O_2S;Tb$ ) to improve the x-ray detection.**

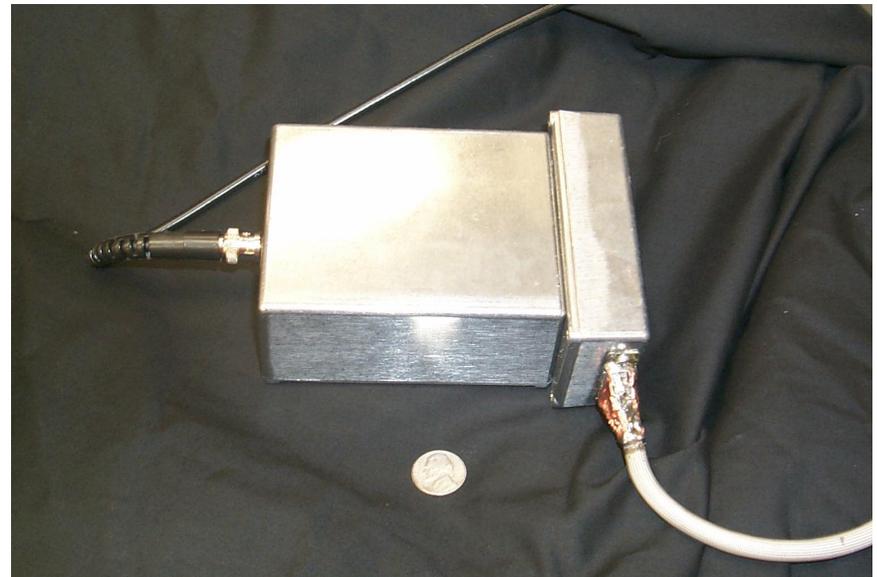
- **The scintillator will be applied directly on the top surface of the sensor.**
- **The coatings will be optimized for each energy channel.**
- **Applied Scintillation Technologies (AST) will supply the coatings.**

# CMOS Test Bed System

LED mounted on BNC connector

Commercial Radicon read-out system

Custom 60" long cable

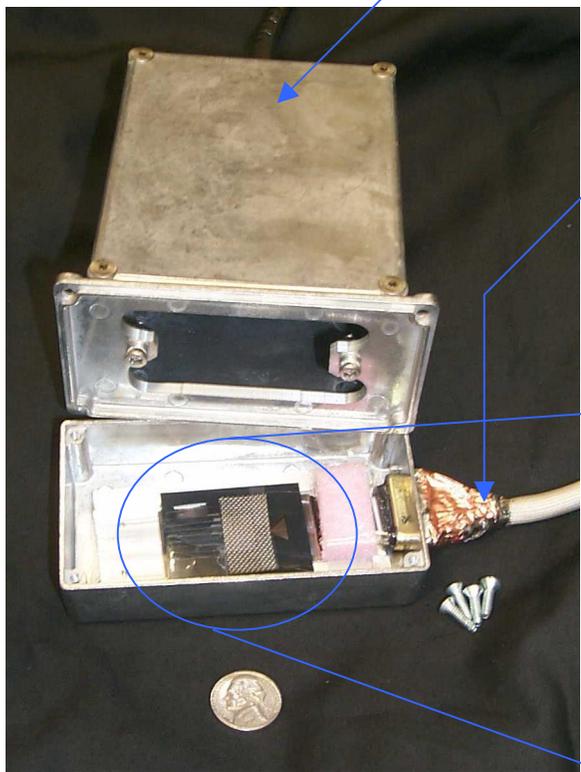
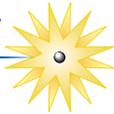


# CMOS Test Bed System (Continued)

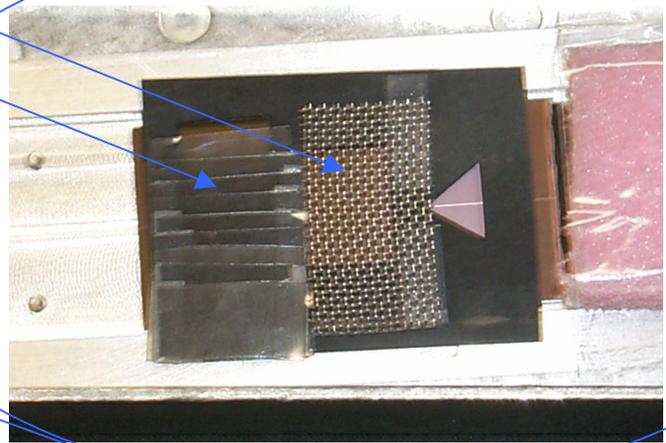


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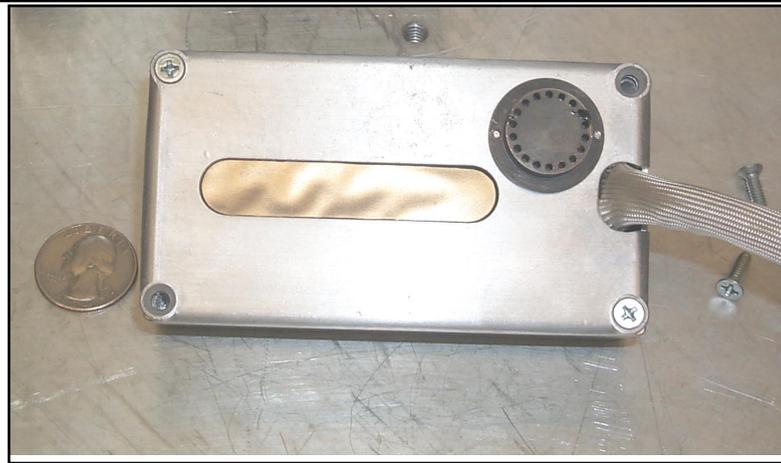
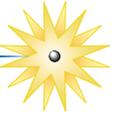
- LED mounted inside box on BNC connector. (not shown)
- Custom 60" long cable (details show on Cable Pin-out slide).
- Nine steps of ND filters.
- S.S. woven mesh, wire size  $\sim .006$ " dia.



# Prototype Remote Sensor Head



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**Prototype developed for RadEye 1  
CMOS sensor testing in vacuum at NRL:**

- **Sensor can drive a long cable (65").**
- **.001" thick Beryllium filter.**
- **Manson source with Aluminum anode in coffin vacuum system.**
- **RAP bent crystal.**

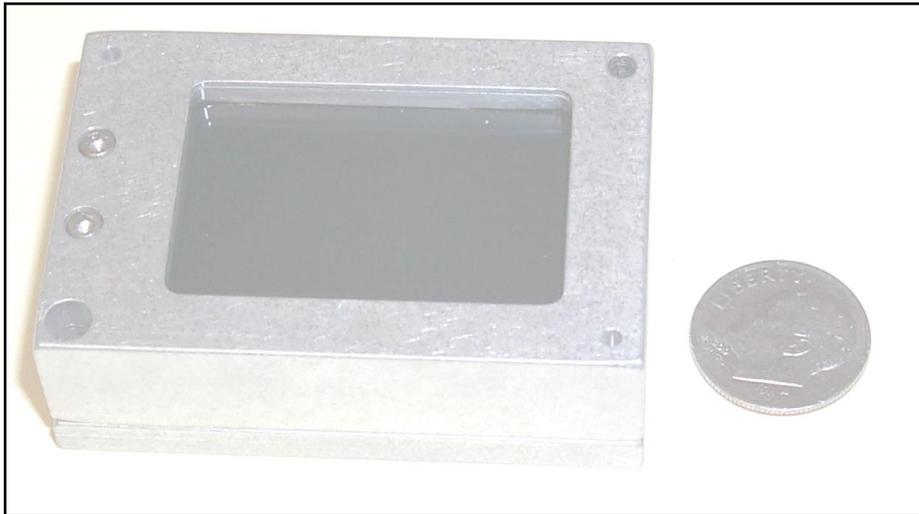
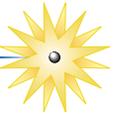


# EMP / EMI Protection



**NIF**

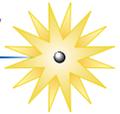
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**EMP/EMI shielded remote  
sensor head will be developed  
For the RadEye 1 sensor.  
(HXS CCD enclosure shown)**

- **EMP/EMI protection achieved with  
conductive metal filter material (beryllium)  
completing the Faraday cage enclosure with  
the cable shield tied to the diagnostic interface.**
- **Sensor module could be exchanged with film  
module (fabricated at additional project cost).**

# Safety Analysis



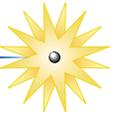
	<b>People</b>	<b>Facility</b>	<b>Diagnostic</b>
Battery Enclosure	-Low voltage >9VDC -100 times over rated pressure vessel -Fused output	Rechargeable unit Requires 110VAC/5amps	Required to allow operation in EMP/EMI Temperature range of -20C to +65C
Beryllium Filters	-Follow handling procedure's -Where gloves when handling it	-Follow handling procedure's -Contained with the diagnostic	Required to maintain visible light blocking and low energy light transmission as well as EMI shielding
Crystal Material	Follow handling procedures, material should not be ingested.	Follow handling procedure's All material are non-toxic	Required to obtain data
Lead Shielding	Where gloves when handling it, don't ingest All areas are covered with Aluminum	The Shielding is contained with the diagnostic	Required to protect sensors and electronics from direct exposure to X-rays.
Fiber optic cables	Not a safety concern - Use dust covers to protect fibers from particles.	Two standard 62.5 multimode with ST connectors	Required for command / control. Damage from shock or particles could reduce transmission
Drive Electronics	-Low voltage >24VDC Contained within diagnostic	No power need from DIM or TIM, only two fibers needed to command	Required for readout of the electronic detection CMOS sensors
CMOS Sensors	Coated with a converter screen coating which should not be ingested.	Contained with the diagnostic	Required to obtain data, Employ a converter screen to allow detection of x-rays.
Assembled HENEX Diagnostic	Will weigh ~ 75 LBS -Two people required to install / remove	Clean, dry storage space for offline storage. 1'x1' x 8.5'	Shock from improper handling could result in damage to crystal, sensor or electronic components.

# IBP engineering study indicates large safety factors



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The pressure enclosure provides protection from contamination released from the NiCad battery cells during discharge while under vacuum. The safety factor exceeds 4 times normal pressure. The enclosure also provides a tight RF shield to protect the control electronics of the diagnostic from EMI / EMP noise.

Type 304 SS Yield Strength = 30,000 PSI

$T = dp/2s \quad t = 4.5/2 - 4.26/2 = .12$  (wall thickness)

D=4.26 (inside diameter)

P=14.7 PSI

$.12 = (4.26) (14.7) / 2s$

S=261 PSI = Stress on cylinder, Factor of Safety =  $30,000/261 = 115$

$S = pr^2/t^2 = 14.7 (4.260/2)^2 / (.250)^2 = 1067$  PSI

S=1067 PSI = Stress on end cap, Factor of Safety =  $30,000/1067 = 28$

$S = P/A \quad A = .12 (4.26 + .12)(3.14) = 1.651$  in<sup>2</sup>

$P = 14.7 (4.260/2)^2 (3.14) = 209.5$  LBS

$S = 209.5 / 1.651 = 127$  PSI

S=127 PSI = Stress on welds, Factor of Safety =  $30,000/127 = 236$

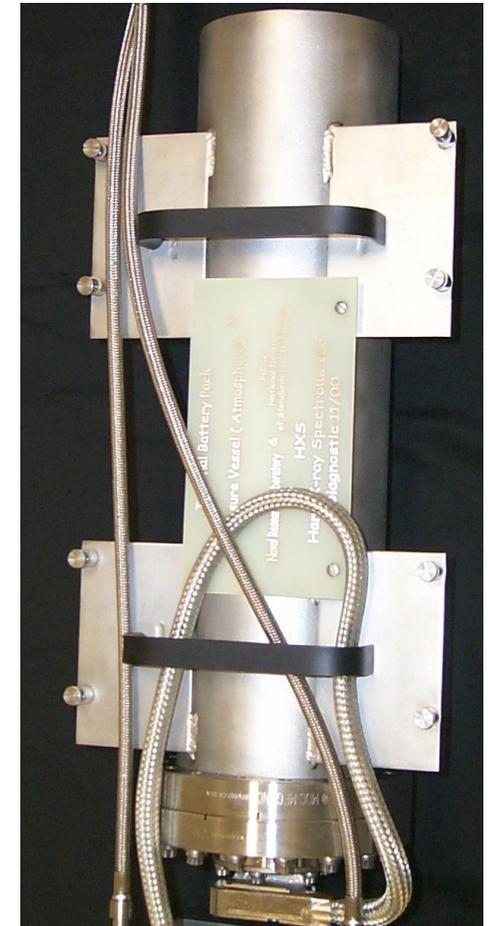
$S = P/A \quad A = .0580$  for 5/16-24 Bolts 16 bolts

$A = 16(.0580) = .928$  in<sup>2</sup>

$P = 14.7 (4.260/2)^2 (3.14) = 209.5$  LBS

$S = 209.5 / .928 = 225.8$  PSI

S=225.8 PSI = Stress on bolts, Factor of Safety =  $30,000/225.8 = 133$



# System Requirements



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- 1) **Water cooling of diagnostic while inside the DIM under vacuum.**
- 2) **Two fiber optic cables 62.5 /125 micron multi-mode with ST connections to be used under vacuum inside the DIM.**
- 3) **Two fiber optic cables 62.5 /125 micron multi-mode with ST connections to be used between the DIM and the Diagnostic Interface Unit (DIU) installed in the screen room near target chamber. (Two fibers are needed for each different DIM to be used.)**
- 4) **The DIU will interface with the NIF DAS through the diagnostic control Processor (DCP). The DIU & DCP will require 19" rack space, 3' high and 3' deep.**
- 5) **The DIU & DCP require one 15 amp 115 VAC circuit power ideally filtered with an Uninterrupted Power System (UPS).**
- 6) **The DCP requires an 10/100 Base-T network connection to the NIF Front-End-Processor (FEP) which will interface with the DAS.**
- 7) **A static IP address.**
- 8) **Clean storage for spare parts near target chamber, 2'x 2'x 1'.**
- 9) **Off line clean storage for the diagnostic, 8.5'x1'x1'.**
- 10) **Off-line charging of the battery pack, 115VAC, 2'x2'x1' table space.**

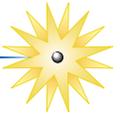
# We will comply with NIF guidelines



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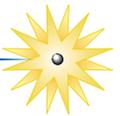
- 1) **Guideline on Cleanliness 300/A**  
1x10<sup>5</sup> 10 micron size particles to one 400 micron particle.  
NIF Vacuum\_Clean. Doc.  
We will deliver a clean, double-bagged instrument for testing.
- 2) **Guideline on diagnostic's out-gassing specification of less than or equal to 1x10<sup>-1</sup> torr liter/sec.**  
NIF Vacuum\_Clean. Doc, NIF 0019542.doc  
Use vacuum compatible components to fabricate the instrument where possible.  
Vent all blind-tapped holes.  
Clean and bake out the instrument before delivery.
- 3) **Guideline on Shielding**  
NIF doc# 0008324, NIF doc# 0018673, NIF doc# 0010463.doc, NIF doc# 0055778.doc, NIF 0055789.doc.  
N/A due to Internal Battery Powered Diagnostic.  
The Internal Battery Pack (IBP) floats inside the Faraday Cage and the ground of the battery is the single point ground.
- 4) **Guideline on the Triggering**  
NIF doc# 0018678, NIF doc# 5000034-0C, NIF5002565.doc  
We will interface to the NIF 'ITS' via a 50ohm BNC connection to our Diagnostic Interface Unit (DIU).
- 5) **Guideline on interface to the FEP**  
NIF doc# 0018678 (Appendix "C")  
We will provide a software hand-shake that follows the NIF doc# 0018678 Appendix "C" rules.
- 6) **Guideline on External Power Standard**  
NIF External Power Standard 28VDC.doc  
N/A due to Internal Battery Powered Diagnostic.

# Operation Procedures and Time Cost



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**The operation time costs will be directly affected by the amount of debris that the diagnostic is exposed to. Filters are placed forward of the crystal assemblies to add protection. These filters will also provide spectral fiducials to aid in data reduction. The filters are mounted in cassettes which are easily replaced.**

**We anticipate the following support from an Operation Technician:**

- 7 min. for pre-deployment hardware systems check, which includes inspection of filter packs and battery hook-up.**
- 5 min. for pre-deployment software system check, which includes full check of interface to DAS and diagnostic.**
- 5 min. for pointing of the instrument.**

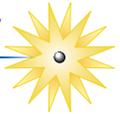
**Approximately 17 min. total time to prepare the instrument.**

# Operation Maintenance Schedules



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Items	Replaceable	Inspection cycle	Re-calibration required
Filter pack assembly	yes	Before each shot	No, pure material used.
Sensor assembly	yes	Before each shot	No, if tested before at NIST If damaged then a replacement can be inserted off-line.
Crystal assembly	yes	Every 5 <sup>th</sup> shot, TBD	No, if tested before at NIST If damaged then a replacement can be inserted off-line.
Battery pack	yes	Covered by DIU	No
Electronics (Sensor boards)	yes	Covered by DIU	No, each board has a known gain value.
Fiber optic cable	yes	Covered by DIU	No, just digital data lines.
Drive Electronics Boards	yes	Covered by DIU	No, TI will supply report.
Diagnostic Interface Unit (DIU)	yes	Covered by DIU self test	No
Diagnostic Control Processor (DCP)	yes	Covered by DCP self test	No, standard PC

# Major Component Suppliers/Costs



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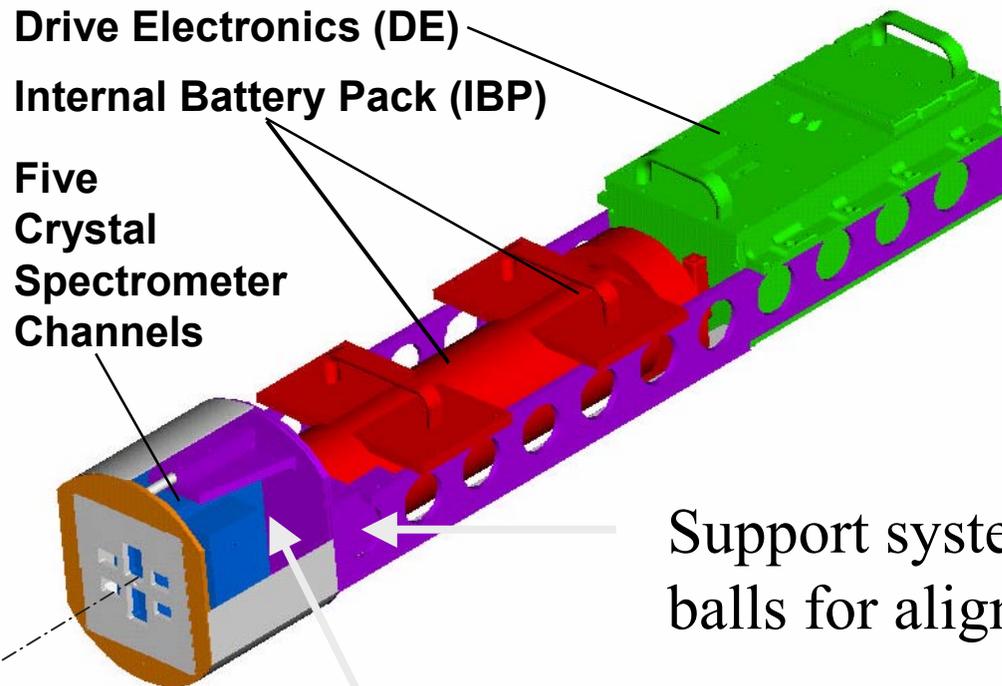
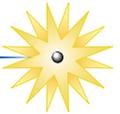
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Item	Description	Part Number	Cost	Vendor, address, phone
Neutron Shielding	Ultra High Density Polyethylene	Sheet PN. UHMWVNAT 2.0" 12"x12"	\$40.00	Read Plastics 12331 Wilkins Avenue Rockville, MD 20852 Phone 301-881-7900
X-ray Shielding	Tantalum sheet	.010" thick 24"wide ~85" long	453.25 per LB	Strategic Aerospace Materials 150 Park Avenue Hicksville, NY 11801 Phone 516-932-3322
X-ray Shielding	Lead sheet	.016" thick 48" x 25'	475.00 Lot	Strategic Aerospace Materials 150 Park Avenue Hicksville, NY 11801 Phone 516-932-3322
Beryllium Filters	99% pure foil	PF-60	792.00 ea	Brushwellman
CMOS Area Sensors From Rad-ikon	1022 x 512, 48 micron pixel size	RadEye 1	2000.00 ea	Rad-ikon Imaging Corp 3193 Belick Street, Unit 1 Santa Clara, CA 95054-2404 Phone 408-486-0886
Quartz Crystal	Transmission channel 11.4 – 28 keV	225mm thick x	1k ea	Sawyer Crystal Systems 1601 Airport Rd. Conroe, TX 77301
RAP 001 & ADP 101 Organic Crystals	Reflection channels RAP .9k- 2.1 keV ADP 2.0 –4.1keV	.250 mm thick x	1 –2 k ea	Saint-Gobain Cristaux BP 521 77994 Nemours CEDEX Phone (33) 164 45 10 10 Fax (33) 164 45 10 02 www.saint-gobain.com
Germanium Crystal (400)	10-20kev reflection channel, fused silica could be used as a substitute	.16 mm thick x	1k ea	Eagle-Picher Technologies, LLC PO Box 47, Joplin, Missouri 64802-0047 USA or C & Porter Streets, Joplin, Missouri 64801 USA Phone: (417)623-8000 Fax: (417)781-1910
Silicon Crystal (111)	Reflection channel 3.9 –9keV	.200 mm thick x	1k ea	Virginia Semiconductor, 1501 Powhatan Street Fredericksburg, VA 22401-4647 USA Phone: (540) 373-2900 Fax: (540) 371-0371 www.virginiasemi.com
Polishing of Quartz Crystal	For transmission channel	.225mm thick		Bond Optics, Inc. Etna Road, Box 422 Lebanon, NH 03766
Sinlilator / Phosphor converter	1-2 keV, 3-8keV,9-20 keV	Gadox screen	~600.00ea	Applied Scintillation Technologies 12 President Point Drive Annapolis, MD 21403 410-263-6005
K-Line filters	Pure Metal foils			Alfa
Sintered Breathers	Stainless Steel	Need for electronics box / EMP, EMI	.500 min order (get Samples!)	Mott Corporation 84 Spring Lane, Farnington, CT 06032 Phone 860-747-6333 Fax 860-747-8629
Cabling for sensors	15 pin connectors	Twisted pair shielded,		Custom made by NRL, interfacing with Samtec connectors jumpers (FJ-15-D-06.00-4)
Connectors for sensors	inside drive electronics on Sensor board		3.00 ea	Samtec USA P.O. Box 1147 New Albany, IN 47151-1147 Phone: 800-726-8329 Fax 812-948-5047
Connectors for sensors boards in drive electronics	Interface to Mother Board	On Mother Board = 84699-650 On Sensor Board = 87402-150	~\$5.00ea Min Qty (100)	FCI 5511 Capital Center Drive Suite P-120 Raleigh, NC 27606 phone 919-859-7200 Fax 919-859 7201 www.fciconnect.com
Fiber Optic connectors	SMA /ST bulkhead connectors	These are tressed into the top plate of the drive electronics at a 45° angle		Newark
Fiber Optic cable	SMA-ST cable / Tefzel jacket			Fiber Guide
Epoxy for potting cable connectors and other things		EPO-TEK 301	25.00 for A&B kit of small size	Epoxy Technology 14 Fortune Drive Billerica, MA 01821 Phone: 978-667-3805 Fax :978-663-9782
Vacuum Electrical Feed-through	HD D-sub 44 pin connector on 2-3/4CF	Needed for Battery enclosure that will power diagnostic during shot	800.00 ea	Douglas Engineering Company 14 Beach Street Rockaway, NJ 07866 Phone 973-627-8230 Fax 973-627-5798
Rechargeable NiCad batteries	4.4 A/hours at 1.2VDC Tabbed "D" cells	PN.P158T-ND	6.7245 ea /100	Digi-key 701 Brooks Ave. South Thief River Falls, MN 56701-0677 Phone (1-800) 344-4539 www.digikey.com
Drive & Support Electronics	EMP/EMI proof Fiber Optic Control	DCP, DIU, DE		Tiger Innovation 2404 –E South Walter Reed Drive Arlington VA 22206-1174 Sales@tigerinnovations.com Website: www.tigerinnovations.com Phone:703-578-3334 POC: Rob Atkin
Shipping cases	49.75" x 20" x 13.75" id PN. 1SKB-H5020W	Nose cone, Diagnostic	189.00	CPD Industries14020 Central Ave. Unit #530 Chino, CA 91710 USA Phone (800) 882-4730Fax (909)- 465-5598Website: www.casefoam.com

# Off-line Alignment of HENEX



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Drive Electronics (DE)  
Internal Battery Pack (IBP)  
Five  
Crystal  
Spectrometer  
Channels

For more information, see the  
“Alignment Procedure” document  
on the HENEX web site:

<http://spectroscopy.nrl.navy.mil>

Support system will have Tooling  
balls for alignment with TIM or DIM

Alignment mirror for optical axis will  
be mounted to the support system.

# Early Procurements/Cost Projections



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<b>Early procurements (included in the project budget):</b>	<b>\$K</b>		
Rad-icon sensors for sensitivity tests	10		
Scintillator test depositions optimized for each channel	5		
Electronics breadboard and sensor readout tests	100		
Crystals for bending tests (TAP and ADP)	10		
<b>Estimated operations/replacement costs (not included in the project budget):</b>	<b>\$K Each</b>	<b>Number</b>	<b>\$K Total</b>
Replacement frontend filters	1	5	5
Replacement pre-mounted crystal	10	5	50
Replacement fiber optic cables	2	2	2
Backup spare sensor assembly with scintillator & filter	20	5	100
Drive Electronics complete replacement	70	1	70
Diagnostic Interface Unit complete replacement	23	1	23
			250
<b>Possible add-ons (not included in the project budget):</b>			
Film assemblies (5 to mount on HENEX and 5 with pre-loaded film for the next shot)	6	10	60
Crystal characterizations (topographs,rocking curves,reflectivity)	3	5	15
Extend transmission crystal range to 60 keV	50	1	50
Implement additional CMOS sensors for x-ray & neutron dose measurements	50	2	100
Retrofit CMOS sensor electronics to have adjustable gain (software controlled)	20	1	20
Add Sleep Mode to Drive Electronics (would extend battery lifetime)	20	1	20
Upgrade battery capacity (would extend lifetime)	30	1	30
10-diode array for time-dependent flux measurements on transmission crystal channel	25	2	50
Imbedded fast digitizing electronics	200	1	200
Multi-channel fiber optic cable/feedthrough for diode channels	175	1	175
			720