COS
Monthly Status Review
August 28, 2001
GSFC

Agenda

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Progress Summary Since Last Monthly (7/25/01)

- Continued working DVA door recovery efforts.
- Supported DVA analysis efforts at MEGA.
- Continued working NUV grating issues.
- Renewed FUV grating tests.

Optics Development Status

- All FUV gratings are completed, coated, mounted, tested and meet specifications. G160M-c is being retested because Grover was slightly out of alignment when original image test was done.
- G230L is complete at JY and under final acceptance testing now. JY is optimistic this grating will meet its specification. Tests results due by end of week and if good the gratings can be picked up next week.
- JY has just completed two new G185M test pieces which are being sent to GSFC for coating and testing. Results of these tests will steer our decisions on G185M fixes.
- Procurements with Coastal and Hitachi are now underway for mechanically ruled G225M.

Instrument Performance Overview - Summary

- We have flight detectors for both channels which meet/exceed performance requirements (QE, resolution, flat-fields, etc.).
- We have flight acceptable FUV gratings for all channels (G130M, G160M, and G140L).
- We have NUV gratings for G185M, G225M and G285M which are below specification in absolute efficiency (44-76% of specification).
- We do not yet have G230L but expect it by the end of August. The master has been ion etched and we are awaiting replication and test.
- TA1 has been delivered and is within specification.

FUV Performance Status

Grating & Test λ	Grat Efficiency Meas/spec	Det QE Meas/spec	Channel Throughput Meas/Spec = %
G130M @1304Å	.45/.36	.33/.25	.15/.09 = **165%**
G160M @1560Å	.55/.36	.23/.17	.13/.06 = **207%**
G140L@1470Å	.33/.24	.25/.19	.082/.046 =**179%**

FUV Summary

- System throughput will be significantly above specification.
- G140L performance at level originally anticipated with triangular groove grating (due to high detector QE).
- If blazed G140L can be manufactured by JY and if we elect to incorporate it into the instrument the G140L performance will substantially (~50%) improve. A decision on cost/benefit of incorporation should await testing of a completed, blazed G140L.

NUV Gratings

- G185M gratings were accepted based on J-Y test data and analysis on un-coated gratings
- Initial efficiency test data were obtained at GSFC with the proper $Al+MgF_2$ coating and optical configuration
  - Subsequent measurements by CASA and J-Y concurred with GSFC and show that most of the in-band efficiency is substantially (~38%) below spec
  - Out-of-band measurements by GSFC show that the G185M blaze function peaks at ~1600Å then falls rapidly over the 1750-2000Å range
- While the G185M efficiency tests were on-going at GSFC, J-Y fabricated and delivered G225M and G285M gratings
  - Gratings were accepted based on vendor test data and model analysis
  - Efficiency test data from GSFC likewise show that these gratings fall substantially (as much as ~56% for G225M and ~24% for G285M) below spec at certain wavelengths in their nominal operating bands

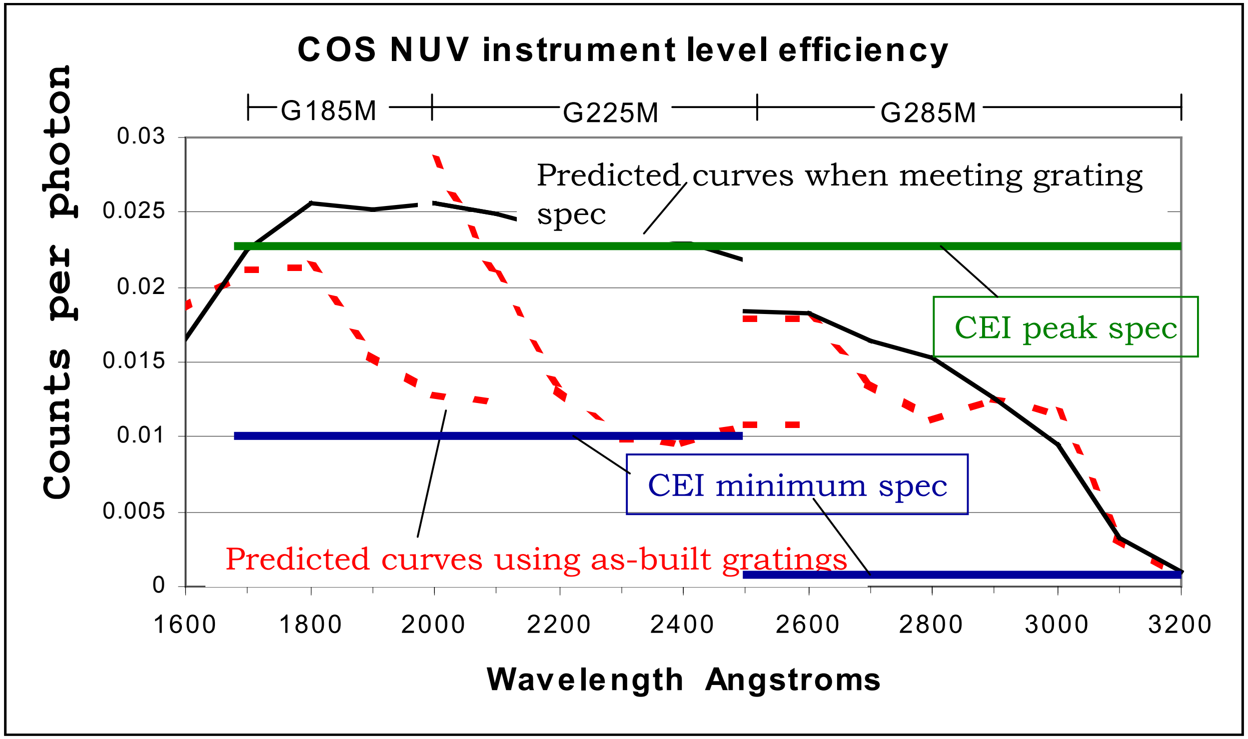


Figure 1: *Instrument throughput efficiencies across the COS NUV wavelengths (1700-3200Å). The thick black curve shows the predicted performance if the gratings were to meet their component level specifications. The dashed red curves show the predicted performance using the as-built G185M, G225M, and G285M gratings. The thick blue line is the CEI minimum spec and the thick green line is the CEI peak spec. For each grating,all points should exceed the minimum spec and at least one point should exceed the peak spec.*

NUV Gratings

- Science impact of "as-built" NUV M grating performance
  - Spectral resolution is preserved for all three grating modes
  - Low as-built grating efficiencies adversely affect <u>all</u> COS NUV science programs
    - For faint sources ($F_\lambda < 1\times10^{-14}$ ergs/s/cm^2/Å), net ~40% lower throughput efficiency across most NUV wavelengths results in need for ~60% longer exposure times to preserve signal-to-noise ratios for making accurate equivalent width measurements of absorption features
    - Largest effect is felt by programs that require complete λ coverage, such as Lyman α forest studies
      - 60% reduction in number of QSO sight-lines observed at NUV wavelengths reduces the science impact of statistical results to such an extent that the COS Science Team would largely *abandon* such complete λ coverage observations using GTO time, and instead would concentrate on the z = 1.3-1.5 range where the frequency of absorbers undergoes a significant change.
      - <u>Note:</u> Even with ~40% lower throughput efficiency, COS observing efficiency of faint sources in the NUV would still be several times better than STIS due to high background of STIS NUV MAMA

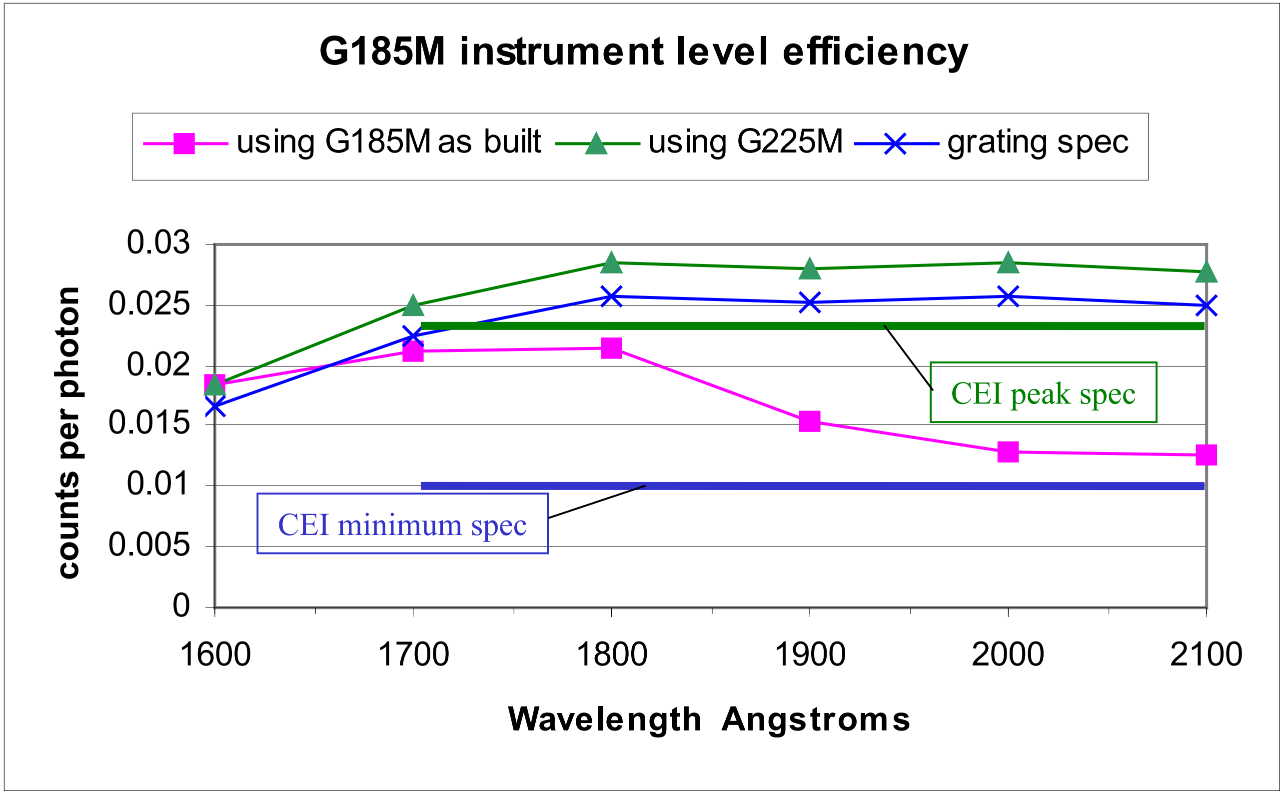


Figure 2: *Instrument throughput efficiency at the G185M wavelengths (1700-2000Å). The blue curve shows the specification, the magenta curve shows the predicted efficiencies using the as-built G185M grating, and the green curve shows the predicted efficiencies using the G225M grating at the G185M wavelengths.*

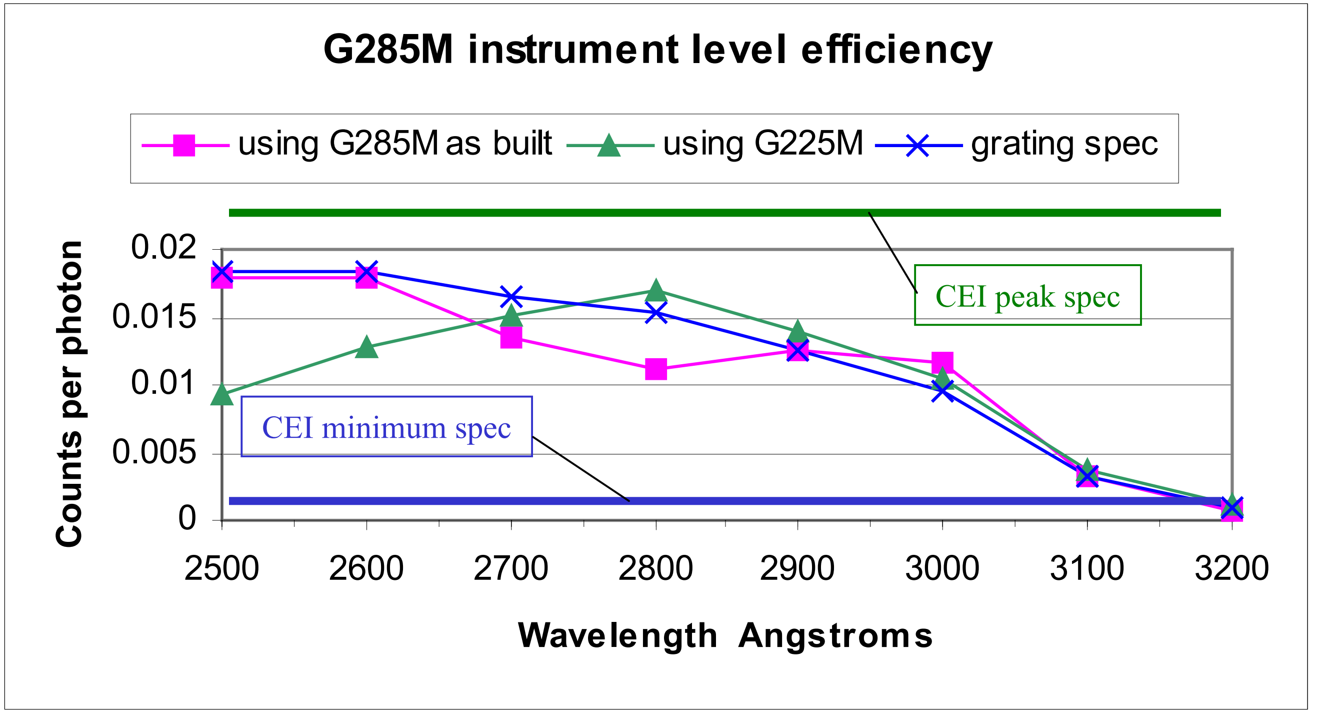


Figure 3: *Instrument throughput efficiency at the G285M wavelengths (2500-3200Å). The thin blue curve shows the specification, the magenta curve shows the predicted efficiencies using the as-built G285M grating, and the green curve shows the predicted efficiencies using the G225M grating at the G285M wavelengths.*

- NUV gratings:
  - During the past several months, the COS IDT has pursued a low-cost NUV grating "recovery" program
  - GSFC has experimented with varying the thickness of the MgF_2 coating
- Results:
  - Thicker MgF_2 coating results in only marginal improvement of G185M in-band efficiency
  - J-Y has successfully achieved deeper grooves on G185M sub-master
    - Groove depths increased from 65 nm to 110 nm
    - Will also attempt on G225M
- Results:
  - J-Y efficiency measurements of G185M sub-master with deeper grooves awaiting in-band testing
  - Solicited proposals from Coastal and Hitachi for fabricating substrates and mechanically ruled gratings to restore M grating efficiency performance orders in process
  - J-Y has successfully achieved ion-etching of shallow blaze angle (~3.3°) for G230L and J-Y efficiency measurements appear suitable for flight

NUV Gratings

The COS IDT and HST Project are considering a number of different options for bringing this issue to a satisfactory conclusion that take into account cost, schedule, and scientific capability.

Option 1: Fly the as-built gratings in their originally designated positions, with significantly decreased sensitivity compared to predicted performance if the gratings each met specification, but nominal (R = 20,000) spectral resolution for all three NUV grating modes is preserved.

Impacts:

- Schedule: No impact
- Cost: No additional cost
- Performance and science: Large decrease in observing efficiency (as previously discussed; see Fig. 1)

NUV Gratings

Option 2: Use as-built G225M gratings in the positions for G185M and G225M, and use the as-built G285M in its original position. G225M grating would need to be aligned for use with different α/β angles in the G185M slot.

Impacts:

- Schedule: Little impact. Two G225M gratings are in-hand, and one additional G225M replica (spare) would need to be fabricated at J-Y to provide spare to G225M & G185M.
- Cost: Small additional cost for gratings (< $10k). Also, STScI will need to modify existing ground system wavelength tables for G185M. Ball must modify bezel for G225M used at different α/β angles.
- Performance and science: Most science programs using G185M and G285M will be preserved with some differences in spectral resolution and observing efficiency. Sensitivity will exceed spec for G185M wavelengths with 20% lower spectral resolution than nominal. G225M and G285M wavelength regions will have nominal spectral resolution but with sensitivity below spec at some wavelengths. Composite COS NUV sensitivity curve will have a large trough over the G225M wavelength region. Spectral dispersion will be constant from 1700-2500Å, similar to the operation of STIS G230M (R ~ 9,110-13,500) but with ~1.8 times higher spectral resolution (R ~ 16,000-24,000), thus still preserving COS "uniqueness" at NUV wavelengths.

NUV Gratings

<u>Option 3:</u> Proceed with all work to enable Option 2, but also attempt to procure improved G225M and G185M (deep groove versions, already in existence) gratings to recover performance at these wavelengths. New G225M gratings are being procured at J-Y (higher groove depth as per G185M), and Hitachi (mechanically ruled).

Impacts:

- <u>Schedule:</u> Significant impact. In addition to impacts from Options 2, an Hitachi G225M flight grating would need to be installed into OSM2 several months after OSM2 had been integrated into the optical bench and the enclosure put in place. Delivery time for one G225M grating from Hitachi is 7.5 mos. plus time for cleaning, coating, testing, mounting, aligning, etc. (J-Y schedule is unknown, but should be before October 1.)
- <u>Cost:</u> Potential significant additional costs. Quote for one G225M grating from Hitachi is ~$110k (including Coastal substrates), plus significant "marching army" costs at Ball during <1 month needed to place new G225M into OSM2 in late-Spring 2002.
- <u>Performance and science:</u> Restores G225M performance and, combined with Option 2, enables essentially all COS GTO NUV science programs.

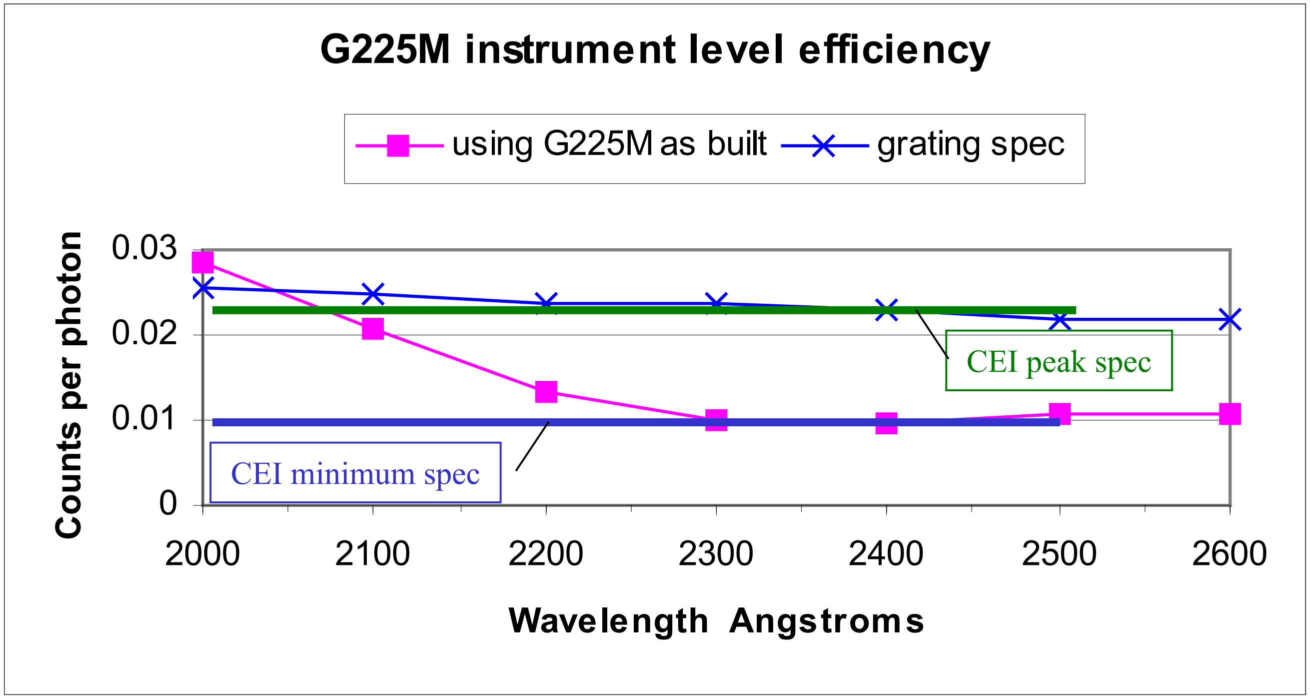


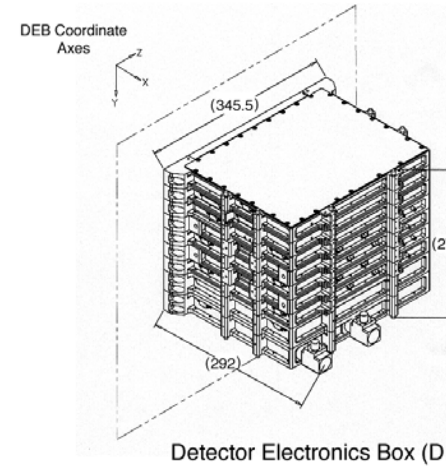
***Figure 4:** Instrument throughput efficiency at the G225M wavelengths (2000-2500Å) for the as-built gratings. The thin blue curve shows the specification, and the magenta curve shows the predicted efficiencies using the as-built G225M gratings. The efficiency of the as-built G225M grating is over a factor of two below the spec at some wavelengths.*

NUV Gratings

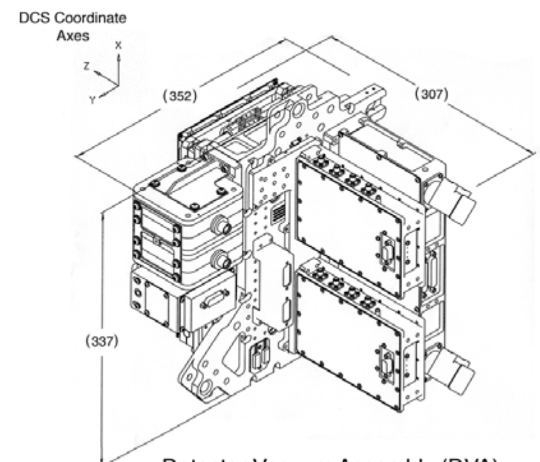
- Current plan:
  - If deep groove replicas from J-Y are successful, they will be flown (should know by Nov 1)
    - science impact: none
    - schedule impact: non-zero, but manageable
  - If deep groove gratings not successful, fly G225M as G185M and fly Hitachi G225M (assuming high performance)
    - science impact: reduction of spectral resolution in G185M (G225 may provide full resolution @ G185 if alignment is better than assumed tolerances)
    - schedule impact: 2 weeks to 1 month for late grating swap (only a guess at this time)

Overview of FUV Detector Assemblies

- **DEB** - (**D**etector **E**lectronics **B**ox)
  - **DCE** (**D**etector **C**ontrol **E**lectronics**)**)
  - **TDCs** (**T**ime**-to-D**igital **C**onverters)
  - **HVPS** (**H**igh **V**oltage **P**ower **S**upply)
  - **LVPC**(**L**ow **V**oltage **P**ower **C**onverter)
- **DVA** - (**D**etector **V**acuum **A**ssembly)
  - **VHA** (**V**acuum **H**ousing **A**ssembly)
    - Detector Door Mechanism
    - Ion Pump Assembly
  - **DBA** (**D**etector **B**ackplate **A**ssembly)
    - **Amplifiers**
    - **HVFM** (**H**igh **V**oltage **F**ilter **M**odule)



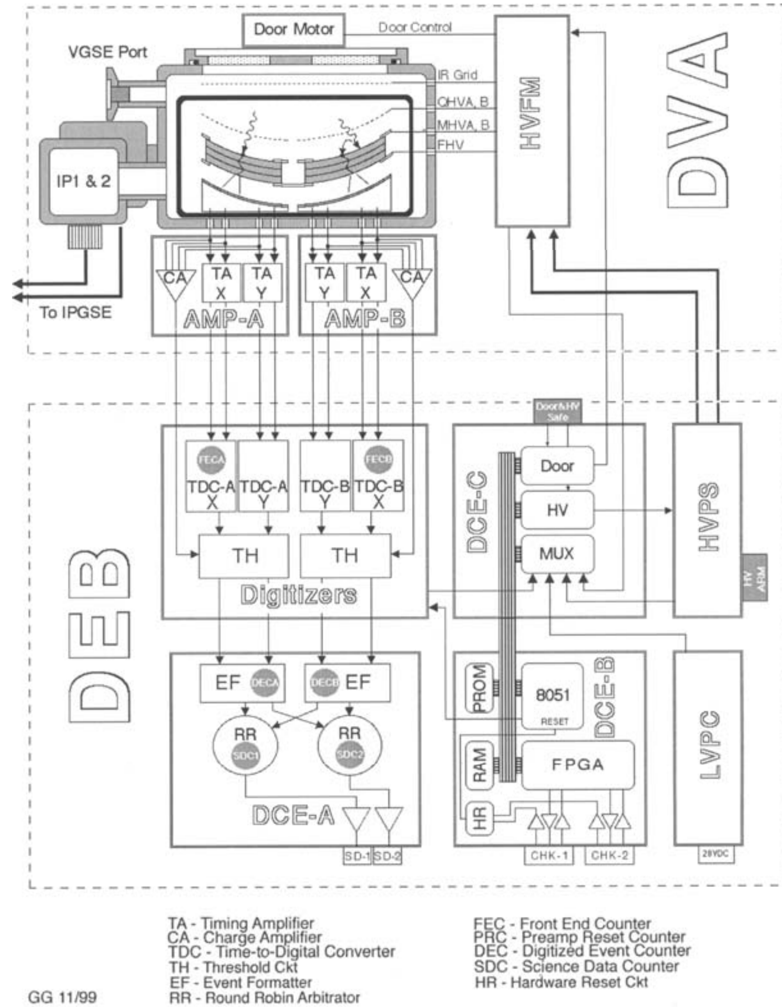
Detector Electronics Box (DEB)



Detector Vacuum Assembly (DVA)

FUV Detector Subsystem Block Diagram

- UCB is under contract to deliver 1 flight FUV detector subsystem (FUV-01) and 1 flight-spare detector subsystem (FUV-02).



UCB FUV Detector Status - Systems

- Documentation Update:
  - ICD Rev B reviewed and released in May.
- Mass and Power Updates (changes in red/bold):

	Mass (Kg)			Power (W)		
	Actuals	SoR Allocation (1)	Margin	Actuals	SoR Allocation (1)	Margin
DVA	20.43	21.5	5%	4.59	-	-
DEB	14.44	15.3	5.6%	47.42	-	-
Harness (est.)	2.7	3.4	20.5%	-	-	-
Total	37.57	40.2	6.5%	52.01	53.0	1.73%

Notes: (1) SoR Revision B allocations

- Latest UCB masss & power numbers are actuals measured on the flight system. The numbers come from Revision D of the UCB Mass & Power Budget Report (UCB-COS-RPT-1015, UCB-COS-RPT-1004).

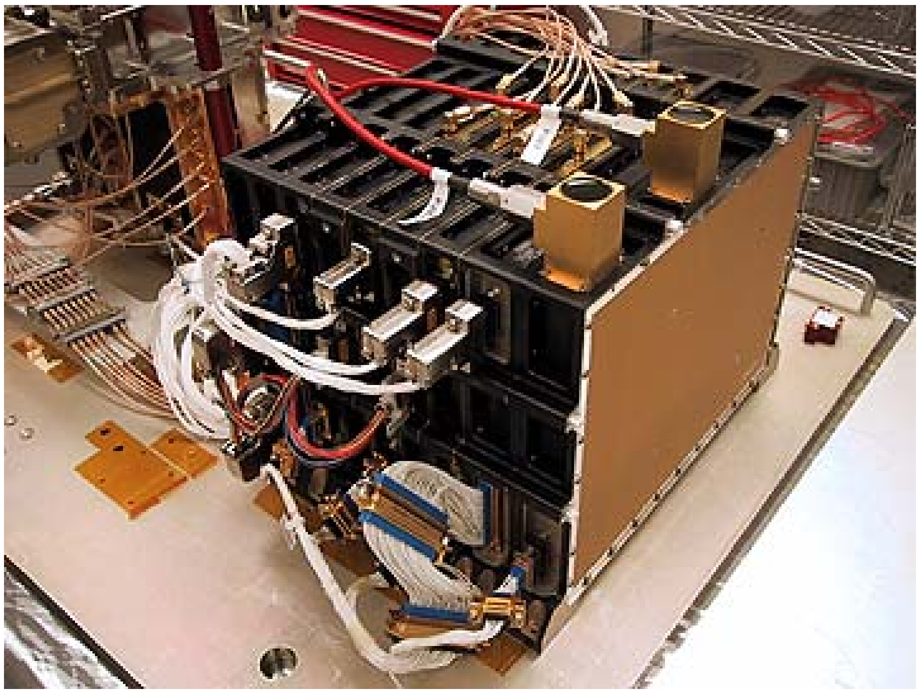
FUV Detector Verification Testing To-Date Summary

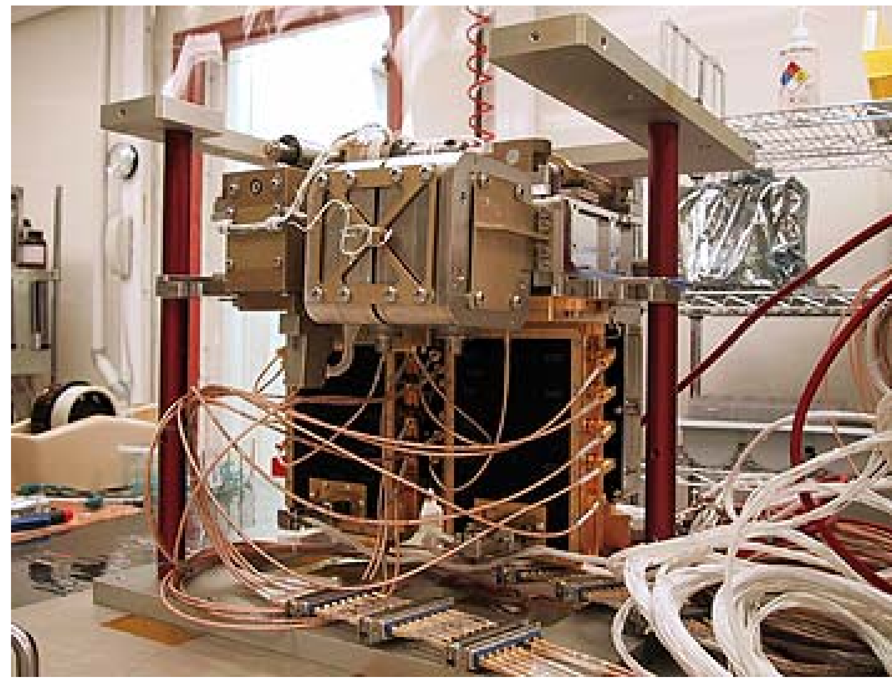
Unit	Functional Testing	Performance Testing	EMI/EMC	Sine Burst	Random Vibe	Thermal-Vac	Contamination Certification
FUV-01 DVA	C	C	@SS	A - C	A - C	@SS	@SS
FUV-01 DEB	C	C	@SS	Q - C	Q - C	@SS	@SS
FUV-01 SS	C	C	C	@Comp	@Comp	6-cycles	C
FUV-02 DVA	C	C	N/R	Q - P	Q - P	@SS	@SS
FUV-02 DEB	C	C	N/R	Q - P	Q - P	@SS	@SS
FUV-02 SS	P	P	N/R	@Comp	@Comp	8-cycles	P

C = Complete
@SS = At Subsystem
A = Acceptance Levels
Q = Qualification Levels
N/R = Not Required
P = Planned

COS FUV Detector Systems

- Detector DEB
- Detector Head





UCB FUV02, Flight Backup Detector, Status

- **DEB Electronics Boards**
  - All boards have been cleaned, coated, staked, and vacuum baked.
- **Harnesses**
  - Cleaned and vacuum baked/certified.
- **Detector Backplate Assembly**
  - Built up and awaiting integration with VHA for vibration testing.
- **Vacuum Housing Assembly**
  - Currently awaiting completion of new door mechanism parts.
- **Brazed Body Assembly**
  - Photocathodes deposited successfully and detector QDEs measured.
  - BBA currently in safe vacuum storage awaiting final FUV02 buildup.
- **ETU DEB**
  - ETU DEB delivered to Ball mid August.

Flight FUV01 Detector System

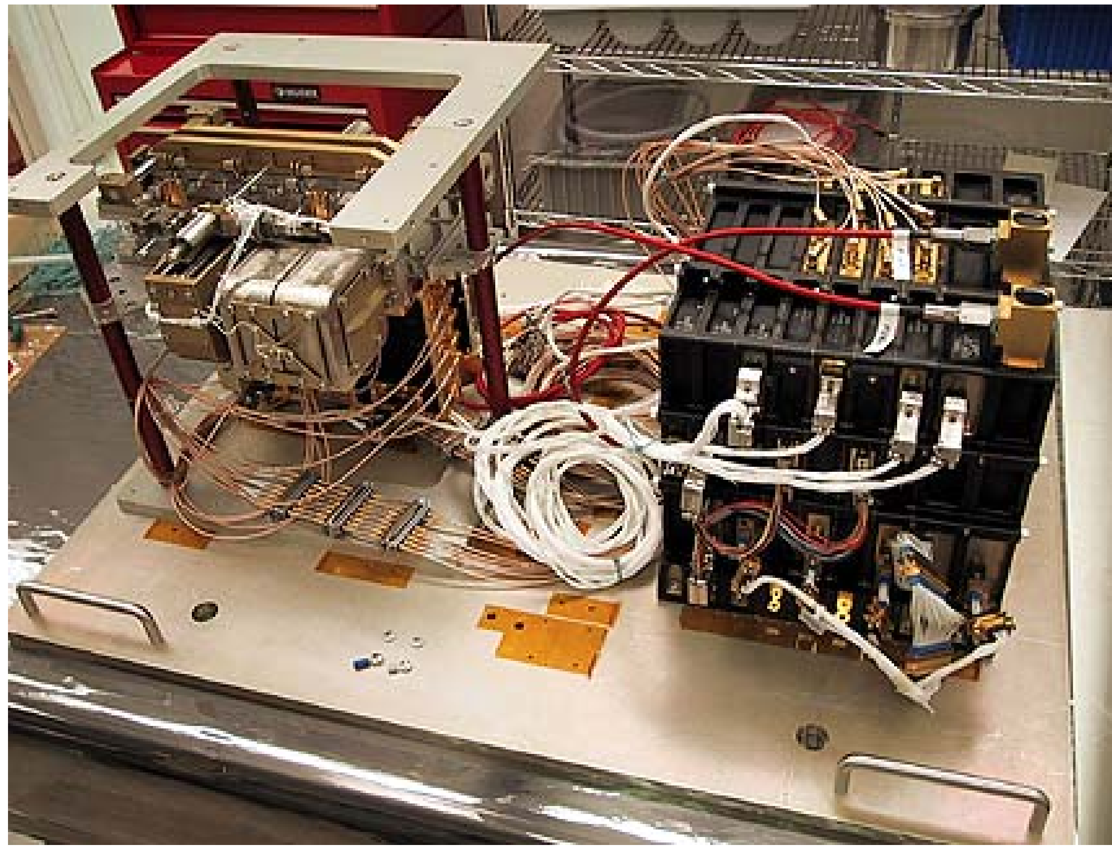
FUV01 Flight Unit

Detector system currently at CU – CASA

DEB in thermal vacuum chamber.

Detector on optics bench with upper door & mechanism removed

Detector upper door & mechanism at UCB for rework



FUV Detector Door Mechanism Summary

- Found the door redundant actuator only partially opens the door at any temp during the thermal vacuum test, even though motor operation works.
- Elevated door motor current during first operation after vibration implies door rail misalignment. Analysis shows high friction for small misalignments.
- Linear bearing protruding from FUV01 door carriage is consistent with door rail misalignment.
- Testing on FUV02/01 indicates that door rail misalignment, induced by a lateral force on the door rail mount block, is not fully released upon removal of the lateral force. Resistance to door travel remains even after successive operations of the door with the motor. The moving rail pillars have a tendency to stick when the mechanism is fully assembled.
- Stress induced by baffle installation, and door shaft translation only worsen the problem.
- Both detector doors have been successfully disassembled, without vacuum leaks, and show the same basic problem.

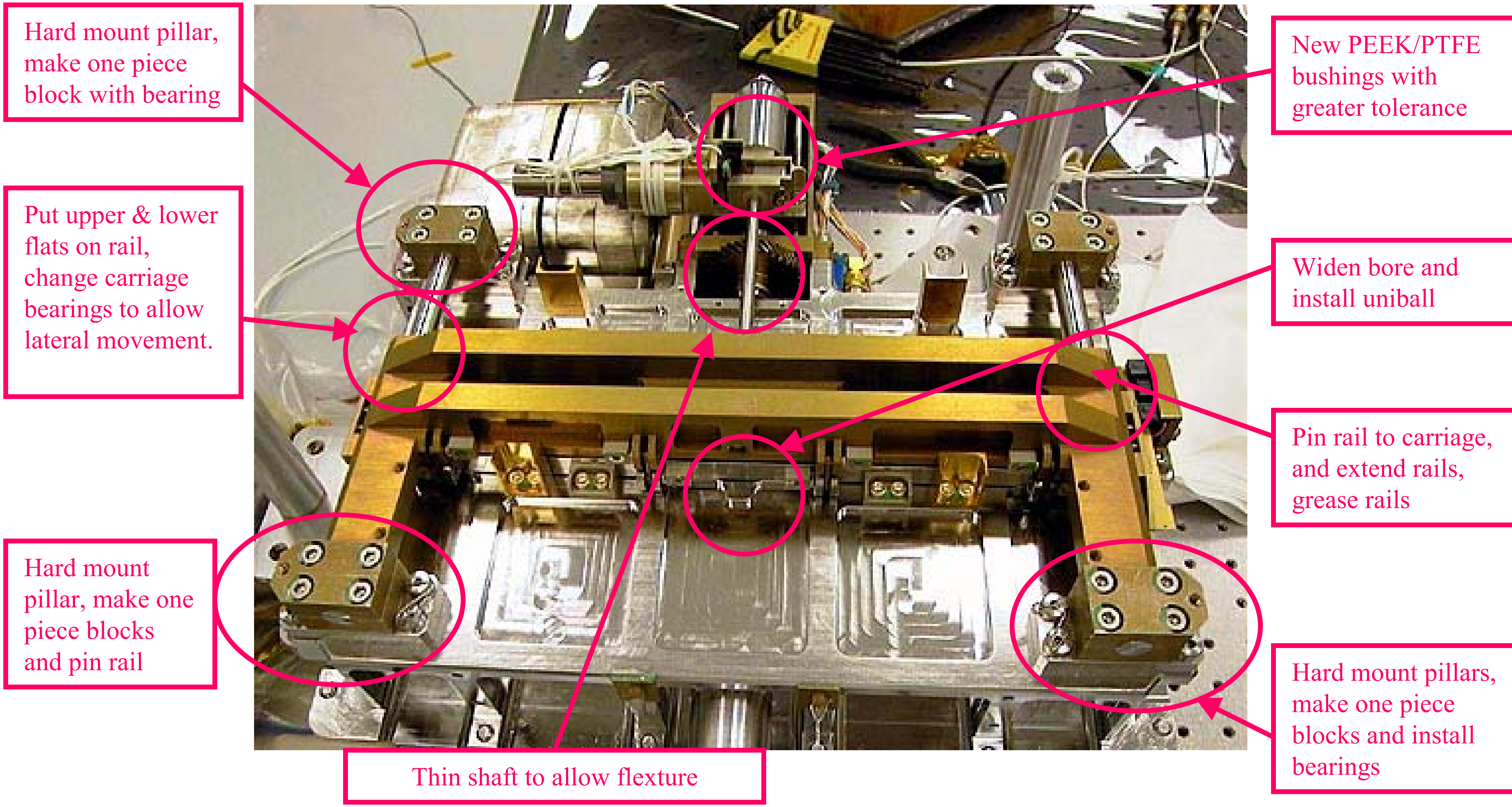
FUV01 Door Problem Resolution

- **UCB Approach and Philosophy**
  - Goddard/Swales/CU/UCB team doing drawings, fabrication, assembly, test.
  - Test selected solution on FUV02 before implementation on FUV01.
  - Address the root cause of the problem and make sure the implemented solution prevents future occurrence of problem.
- **Issues**
  - VHA vacuum break - we have vacuum GSE in place, both FUV01 and FUV02 have been disassembled successfully leaving the vacuum door in place.
  - Current door parts are shimmed for proper alignment as are position readouts. - We will have to repeat the shimming process on reassembly.
  - FUV02 is still considered a flight unit. - A well thought out approach will prevent damage to this hardware and validate our FUV01 processes.
  - Avoid delays with Ball detector alignment. - we have made a door clamps to hold the FUV01 vacuum door so that Ball can use FUV01 for alignment while the door scheme is modified and verified on FUV02.

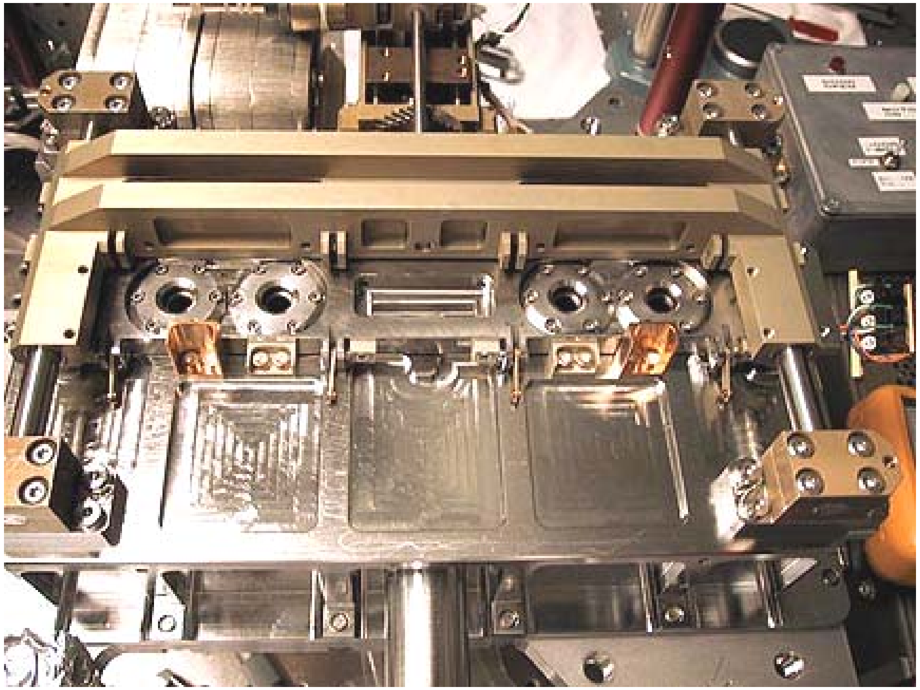
FUV01 Door Problem Resolution (cont)

- **In-situ repair of FUV01 and replace some door parts with new parts**
  - Replace fixed rail with longer rail, pin rail to door carriage, put bearings into support pillars and allow rail to slide through the pillar blocks.
  - Modify floating rail to have upper/lower flats to constrain height, but allow motion in X/Y to eliminate door carriage sticking.
  - Build new door carriage/modify old to pin one rail & change bearings for flat rail.
  - Grease the rails with Braycote 602 to lower friction .
  - Hard mount all rail pillars and use bored rail holes instead of half clamps.
  - Change link for actuator drive shaft to monoball joint on farside of door carriage.
  - Reduce actuator drive shaft diameter to allow flexture, and grease shaft.
  - Replace actuator PEEK bushings with PEEK/PTFE (friction 0.15) and counterbore to reduce friction and reduce angular constraint.
  - Apply lower door motor current limit to ensure no stall condition occurs, in addition to existing sensor limit switches.

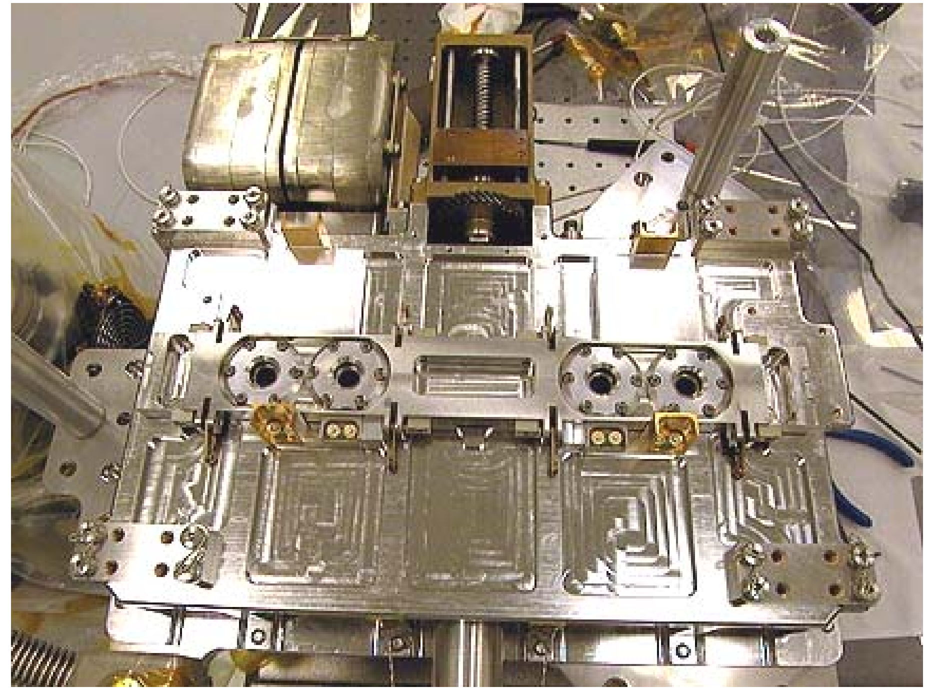
FUV01 Door Design Changes Summary



COS FUV Detector Door Disassembly



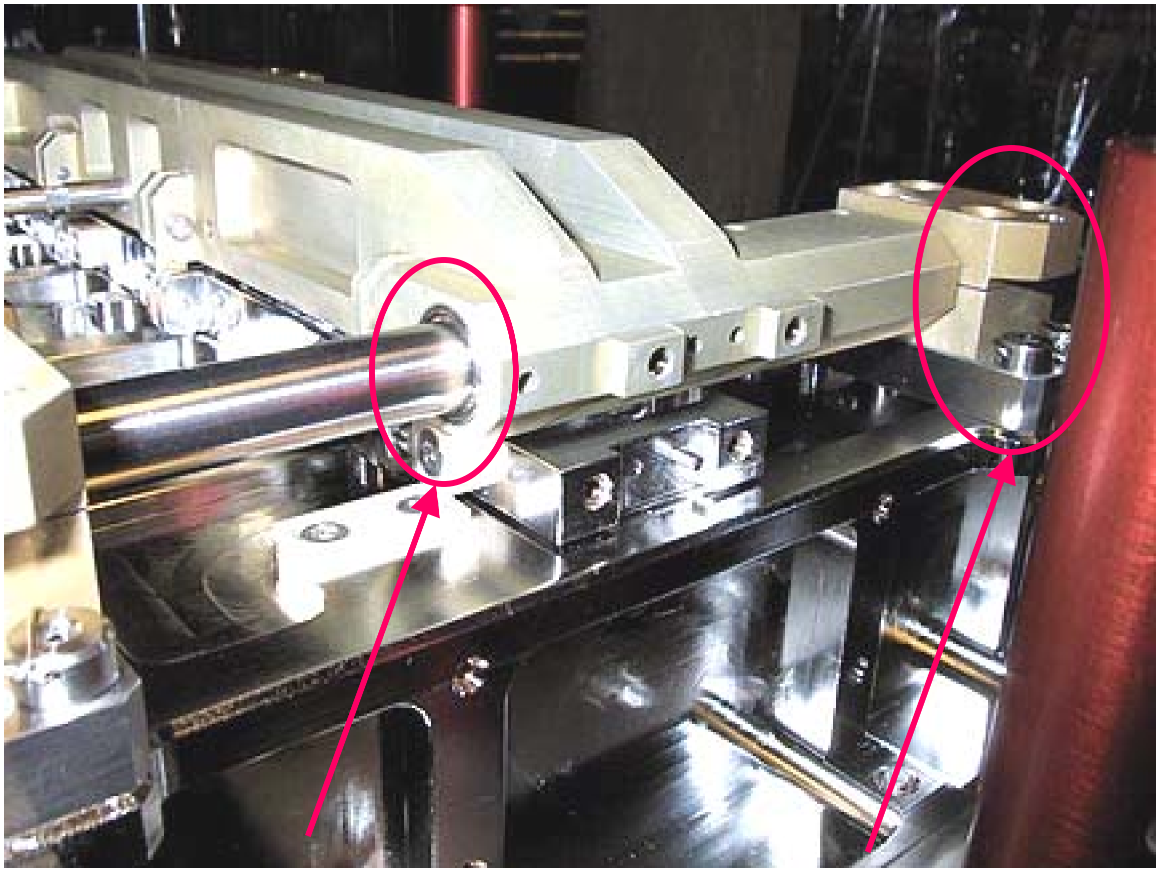
Carriage detached from lower door



Door system removed from DVA

Both FUV01 and FUV02 upper door assemblies were detached and removed while maintaining vacuum inside the DVA's. This allowed position and force measurements to be made. The door carriage could also slide along the rails permitting investigation of the problem.

COS FUV Detector Door Old Rail System



Carriage bearing   Rail post and split clamps

The door rails are mounted on four posts. Two fixed & two moving to accommodate expansion. It was found on both systems that the moving posts were sticking, allowing misalignment of the rails and increased friction (~75% of the redundant actuator force for the rails alone). Essentially the door is over-constrained, and does not allow the moving posts to slide freely in their oversize holes with shoulder bolts.

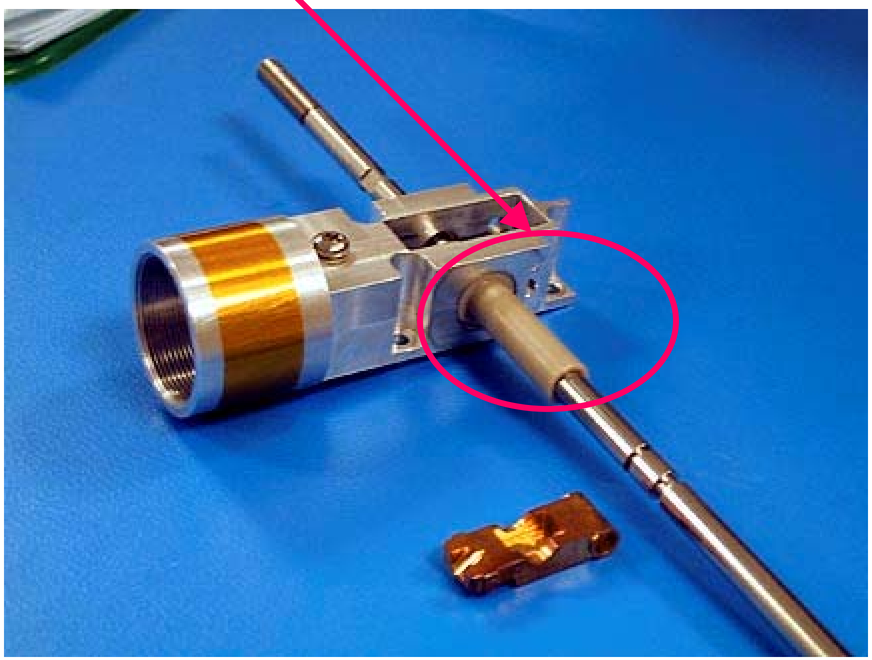
New Detector Door Parts

Rail Mounting blocks

Carriage sleeves and bearings

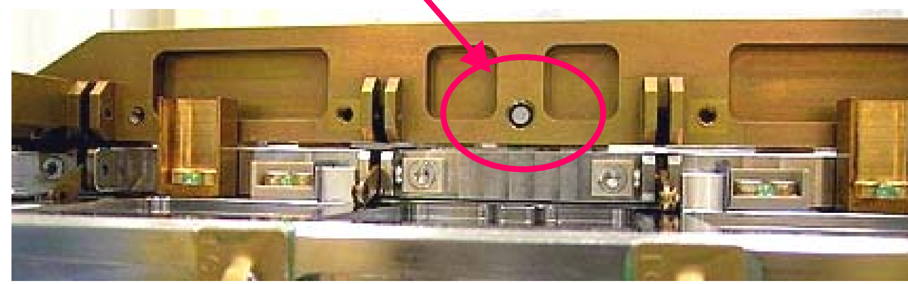
COS FUV Detector Door, Old Actuator Backup System

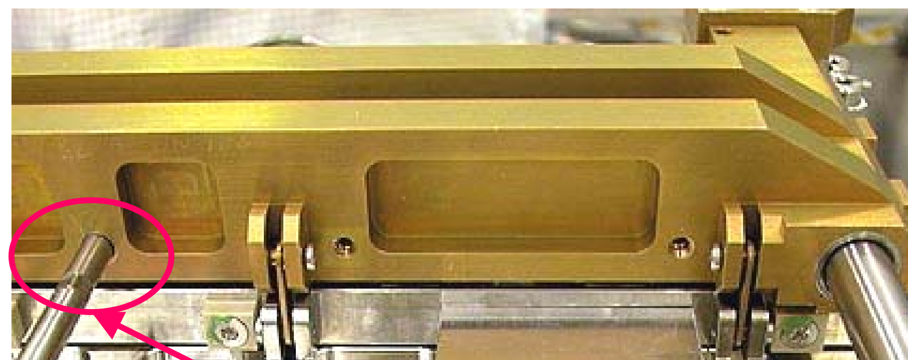
Door push rod actuator housing and PEEK bushings.



The PEEK bushings allow a very small range of angular displacement, and their coefficient of friction is high (0.4)

Door push rod screw thread on door far-side

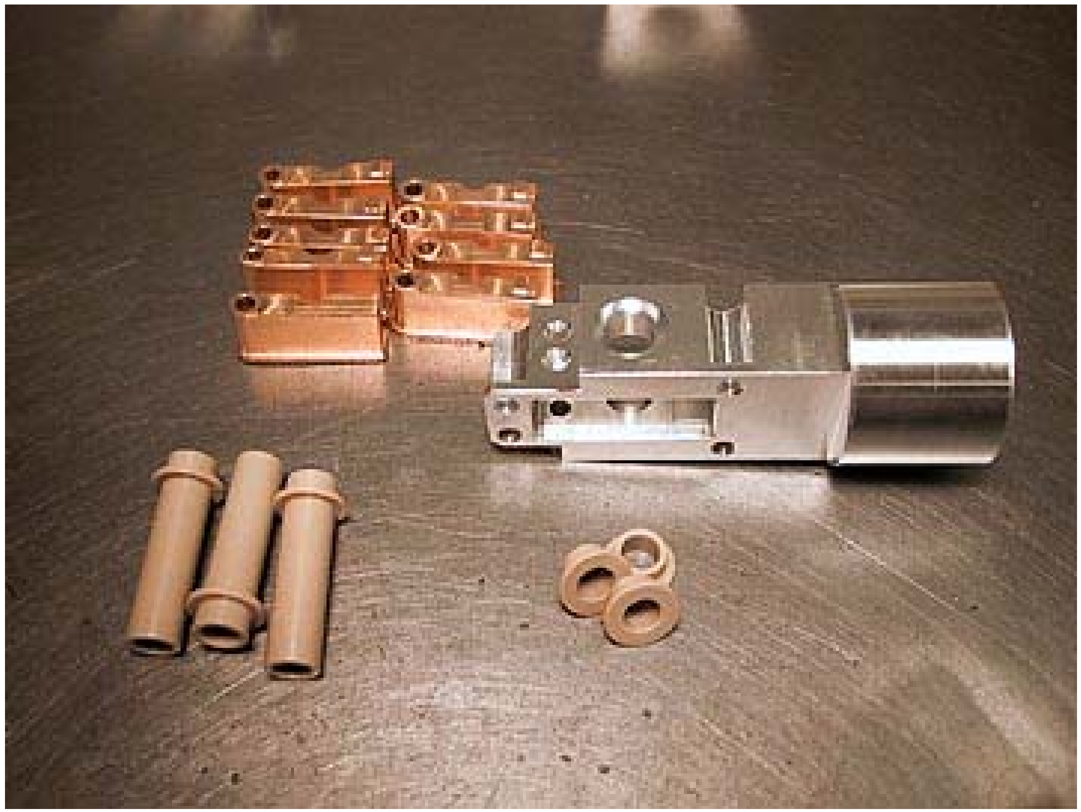




Door push rod on door near-side. The shaft-door attachment has no compensation for rotation or translation

New Detector Door Parts

Actuator housing PTFE/PEEK bushings and clamshells



Plan of Action - Status and plan

- Have defined the subset of parts to be changed and the design schemes.
- Have been building parts as soon as the drawings are received/reviewed.
- Received last batch of drawings last week, couple of mods still TBD
- Have fabricated most of the parts designed prior to last week.
- Reviewing/fabricating latest parts with highest machine shop priority.

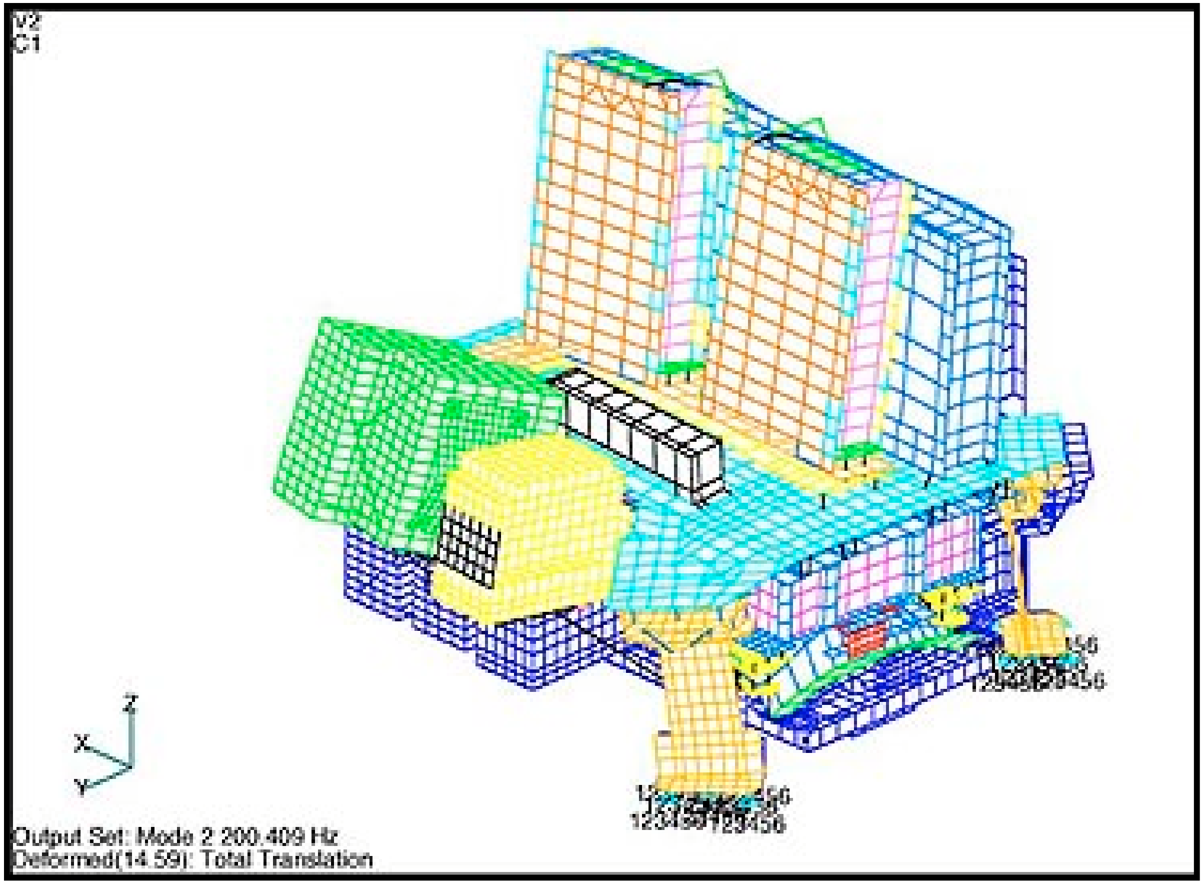
Test/Verification Plan

- Assemble and test solutions on FUV02 VHA.
- Perform qualification testing of corrected FUV02 VHA (inc. vibration).
- Apply corrective action to FUV01 door assembly/VHA.
- Complete/Re-iterate FUV01 thermal vacuum testing.
- Vibrate corrected FUV01 DVA to *TBD* levels.
- FUV02 final buildup.
- FUV02 environmental testing (qualification level vibration and thermal vacuum).

Flexture Mount - Detector Vibration Issues

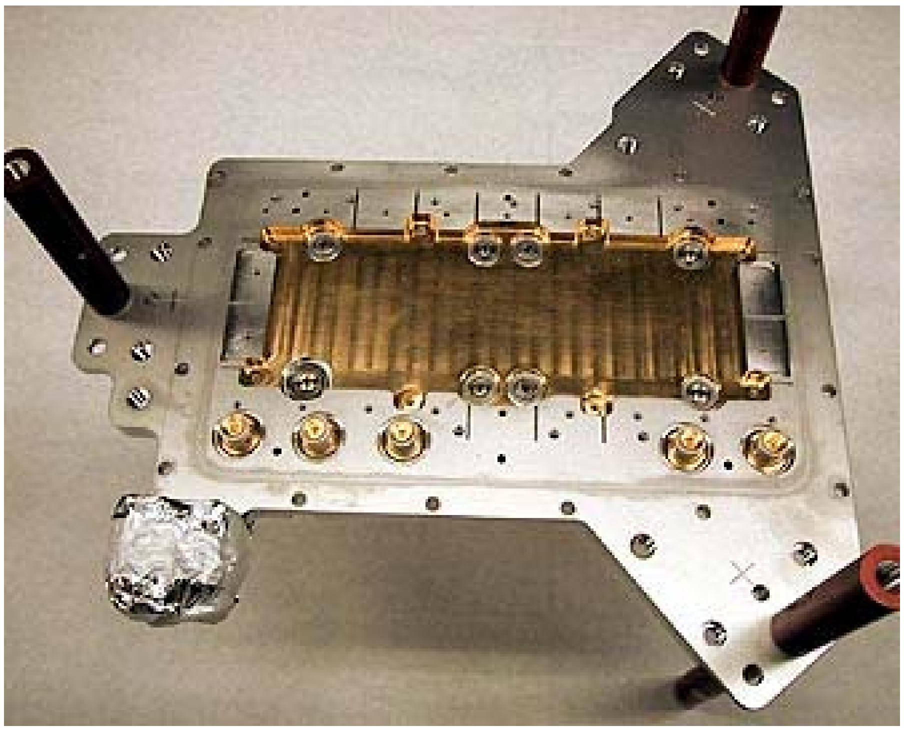
- The flexture mounts show high Q's at low frequencies.
- Vibration test results on the detector shows high Q for the ion pumps.
- Concern that the detector will have problems when vibrated on the flexures
- DVA & flexture models (GSFC & Ball) show high Q resonances at ~300Hz.
- Models are not able to predict the failure limits for DVA without extensive extra work. We do have COS acceptance & FUSE vibration test data.
- Project decision to build up a vibration "simulator" to run a real test to assess the quantitative vibration test risk factors.
- We have located all the necessary ETU components to assemble a detector vibration "simulator" that is representative of the true mass and configuration
- Will assemble the detector vibration "simulator" this week and vacuum test
- Use Ball prototype flextures for vibration test
- Define conditions and set up vibration test at GSFC in early September

Detector- Flexture Mount Vibration Model

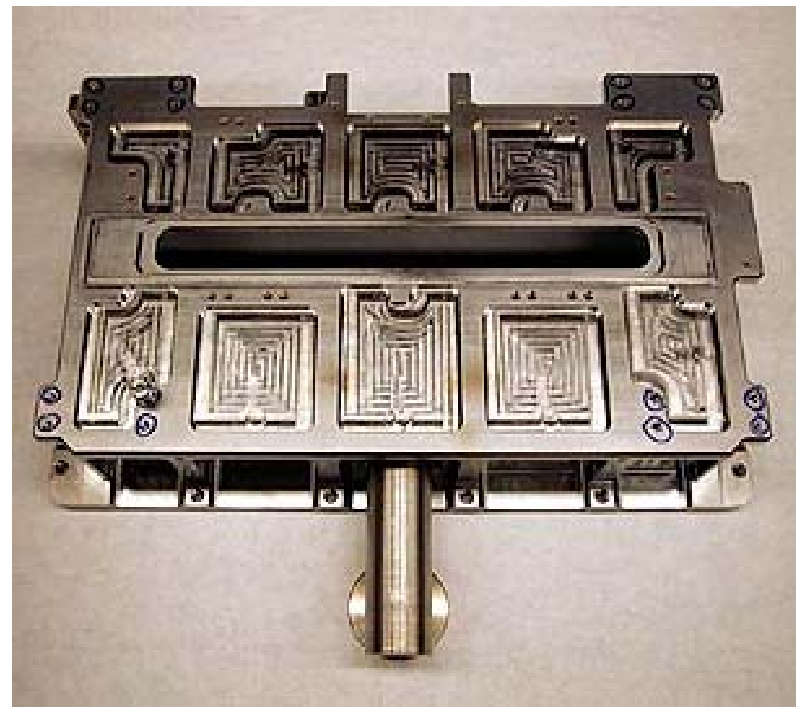


Hardware for Detector - Flexture Vibration Test

Detector backplate

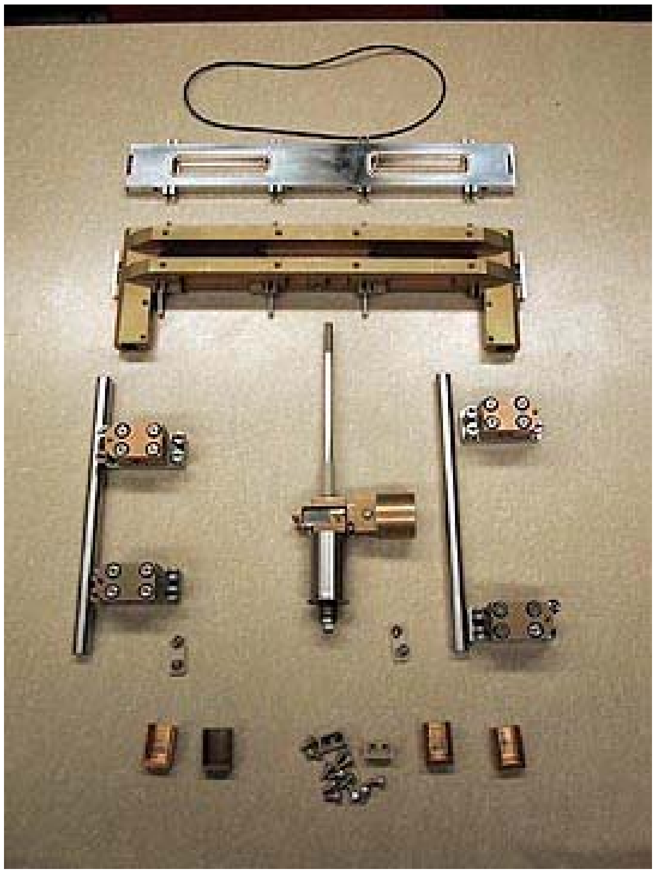


Detector vacuum housing



Hardware for Detector - Flexture Vibration Test

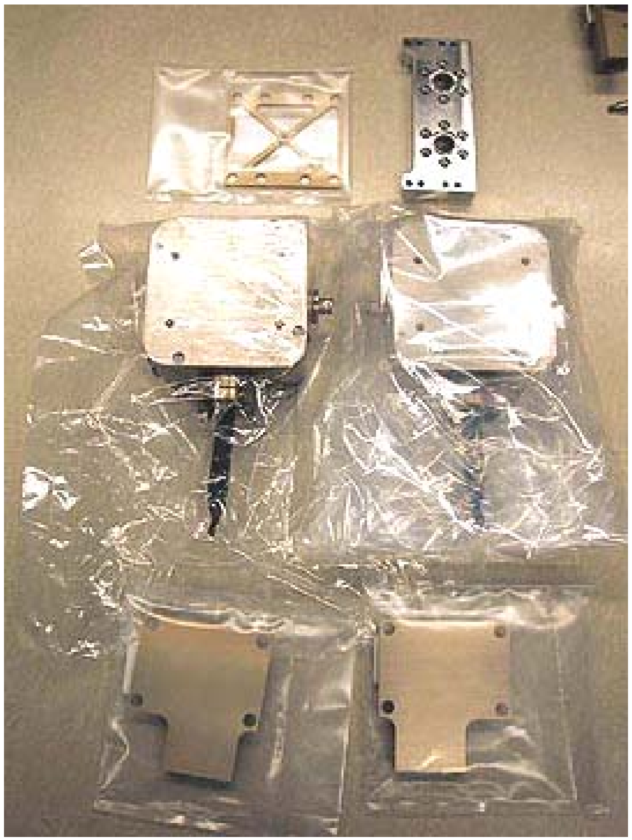
Door components



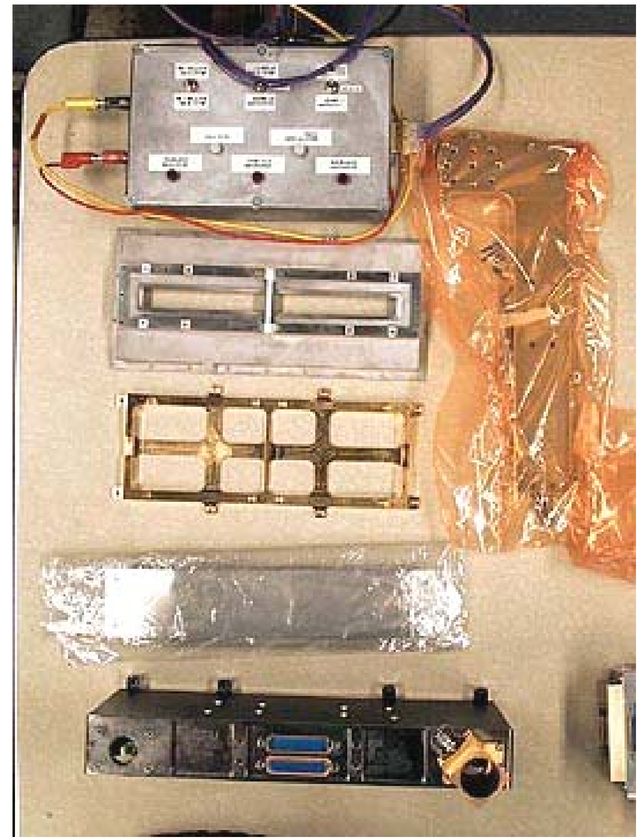
Door motor

Hardware for Detector - Flexture Vibration Test

Ion Pumps and brackets



Detector, HV filter, heatsink



Near Term Plan of Action

Detector Door/FUV02

- Complete parts drawings and fabrication of door design solution
- Assemble and test FUV02 DVA with new door designs

FUV01

- Attach FUV01 door clamps and deliver FUV01 to Ball for alignment tests
- Support alignment tests at Ball

DVA Vibration

- Assemble and vacuum test detector vibration "simulator"
- Perform vibration testing of detector "simulator" at GSFC

COS Schedule for CU/UCB

Task	**Status**
G160M/G140L – Blazed Grating Testing	G160M-c - repeat image tests now ongoing
G140L – Blazed Grating Testing	G140L-pending JY's successful delivery. No sooner than November '01.
CALCOS Software Development	On-going
JY Deliveries	G230L – August/01
Cal/FF SS Optical Integration	Fall/winter '01
FUV-01 Delivery to Ball for Alignment	9/7/01
FUV-02 Needed at Ball	~10/15/01
FUV-01 Available for Workmanship Tests	Oct-Nov '01

COS Descope Issues (No Changes Since Last MSR)

- The COS IDT has been asked to develop and track a descope plan which, if implemented, can be used to control future cost growth and/or schedule difficulties.
- At the beginning of the COS development effort, late CY97 and early CY98, we prepared and presented several descope options. At that time we descoped the following:
  - Reduced the MEB SRAM buffer memory
  - Fewer NUV/FVU optics/grating spares
  - No parallel technology path for NUV gratings
  - Reduced I&T/calibration effort
  - Baselined environmentals at GSFC

COS Descope Tracking List

Candidate De-Scope	Trigger Date	Resource Saved*	Impacts
Eliminate FUV Detector detailed resolution tests	**Implemented**	2 weeks	Knowledge of detector
Eliminate FUV Detector detailed QE tests	**Implemented**	2 weeks	Knowledge of detector
Eliminate FUV Detector deep FF tests	**Implemented**	3 weeks	Knowledge of detector
Make DCE Op Code non-uploadable	**Too late**	---	Higher risk, Ops
Early transition of FSW to Code 582	**Too late**	$	Ops
Remove Redundant Cal/FF Elements	**Too late**	$,t	Higher risk, Ops
Remove/reduce memory	**Too late**	---	Ops
Remove NUV gratings from OSM2	TBD	$,t	Degraded science
Drop NUV channel	TBD	$$$,tt	Degraded science
Remove NCM3 optics	**Too late**	$,t	Degraded science, Ops
Eliminate Aperture Mechanism	TBD	$,t	Ops, Obs. Efficiency, higher risk
Drop all Accum mode processing w/ Doppler	**Too late**	$,t	Degraded science
Drop spare FUV detector	**Too late**	$,t	Higher risk
Drop OSM1 capability (don't cover λ gap)	**Too late**	---	Degraded science
Reduce S/N requirement to 30 (no FF lamp)	TBD	$,t	Degraded science
Relax NUV resolution requirements below 20k	TBD	$,t	Degraded science
Remove on-orbit change-out capability	TBD	$,t	Higher risk
Drop dispersed light TA	**Too late**	$,t	Ops
No Ion Gauge	TBD	$,t	Higher risk, Ops
No external shutter	**Too late**	$,t	Ops
Change MSRs to QSRs	TBD	$	Save trees
Eliminate Mechanism Lifetime tests	TBD	$$	Higher risk
Reduce CDRLs	TBD	$	Unknown
Drop G140L blazed effort	TBD	$,t	Missed opportunity for improved science
Reduce G160M image testing	**Too late**	$,t	Higher risk

*The IPT has not yet done a detailed analysis to quantify actual $ or time saved.

Upcoming Events/Activities

- Continue DVA door recovery efforts.
- Continue build-up of surrogate DVA and vibe test @ GSFC.
- Support FUV-01 install and alignment work at Ball.
- Continue working NUV grating recovery.
- Submit January '04 Launch Delay Proposal.

Issues

- CU has had its first COS attrition
  - Dr. Ken Brownsberger, our COS FSW/OPS Sr. Scientist, has announced his resignation from CU effective 9/28/01.
  - We learned this last Thursday and have not yet had the team together to discuss the full impacts of Ken's departure and a recovery plan.