COS
Monthly Status Review
September 26, 2001
GSFC

Agenda

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BATC Presentation	R. Higgins
Financial Splinter	GSFC/Ball/CU

Progress Summary Since Last Monthly (8/28/01)

- Continued working DVA door recovery efforts.
- Prepared for DVA ETU Vibe tests.
- Continued working NUV grating issues.
- Renewed FUV grating tests.
- Took delivery of G230L gratings.
- Held COS Science Team Meeting.

Optics Development Status

- All FUV gratings are completed, coated, mounted, tested and meet specifications.
- G230L is at GSFC for coating and testing.
- JY has just completed several new G185M test pieces. Results are highly variable.
- Procurements with Coastal and Hitachi are 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).
- TA1 has been delivered and is within specification.

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

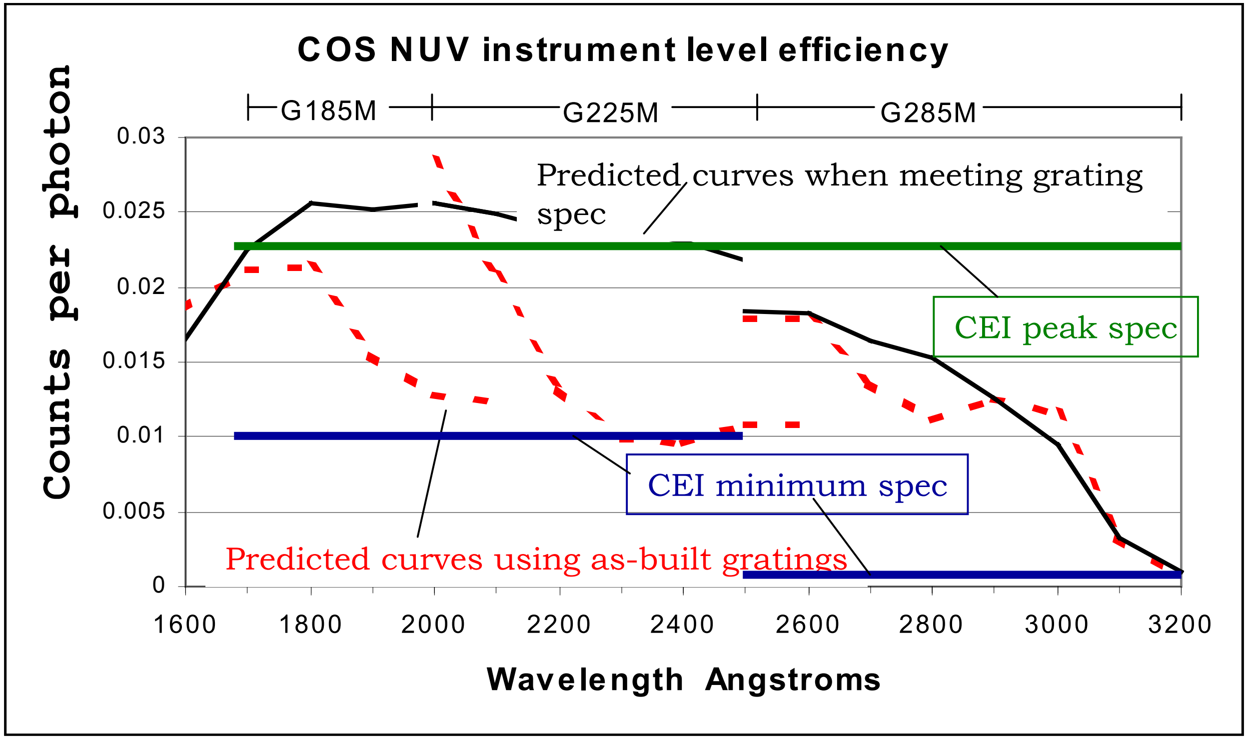


Figure 1: *Instrument throughput efficiencies across the COS NUV wavelengths (1700-3200Å). The thick black curve shows the predicted performance if the gratings were to meet their component level specifications. The dashed red curves show the predicted performance using the as-built G185M, G225M, and 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

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
  - 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
  - One test piece shows improved performance, one does not. Still trying to understand.

NUV Grating Resolution

- The COS team is committed to flying the best possible instrument *within the cost and schedule constraints of the program*
  - The project must decide to prioritize either cost or performance, or trust the PI to make that decision.
- We have a mitigation plan in place for each of the three NUV medium resolution gratings.

NUV Grating Issues

- The PI currently suspects that the NUV problem is generic to all three gratings, and represents a low-efficiency anomaly in the design.
- These anomalies occur when the periodic structure of the grating acts as a wave guide for certain wavelengths, and transmits energy along the length of the grooves, rather than reflecting it.
- This wave guide condition is met at a certain proportion of λ (wavelength) to line spacing (d), which is the same for all three NUV gratings (if it is a problem on one, it is a problem for all).
- When the grating has a metallic coating, the wave guide is defined at the metal/vacuum interface, and occurs at a certain wavelength.

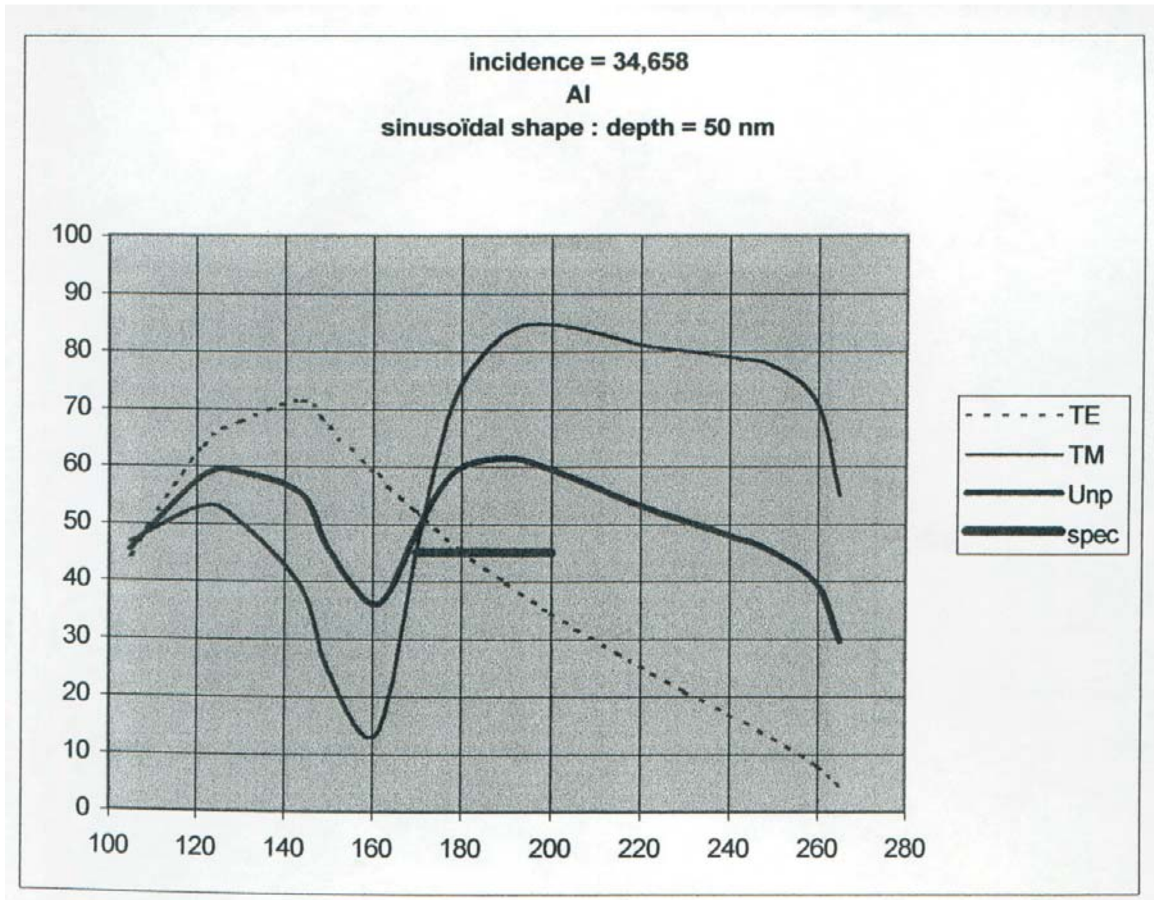
NUV Grating Issues

- The “un” efficiency of this wave guide is a function of its geometry, and thus, groove depth.
- J-Y simulations of the grating performance were performed in the design of the gratings, assuming an aluminum coating, and show the presence of the anomaly shortward of the operating band.
- Tests of aluminum gratings at J-Y were performed with matched the predictions reasonably well, and indicated performance that met specification. The gratings were accepted on this basis.
- Subsequent testing after the application of Al/MgF_2 coating showed the performance to be below specification.

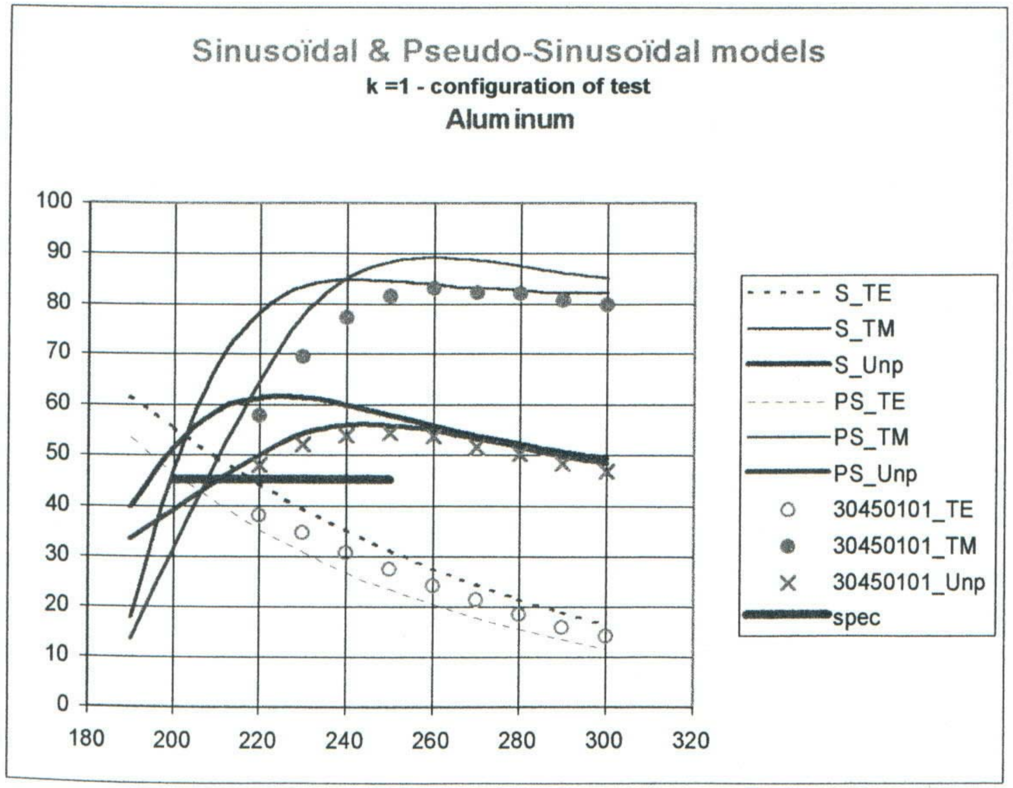
NUV Grating Issues

- The PI suspects that the application of the MgF2 coating has shifted the anomaly into the operating bandpass, resulting in the poor performance (but maintaining good performance outside of the bandpass - e.g. G225M).
  - "*a thin dielectric layer deposited over a metallic grating can shift the resonance anomalies in TM polarization and cause new anomalies both in TM and TE polarization*" - Diffraction Gratings and Applications, Loewen and Popov

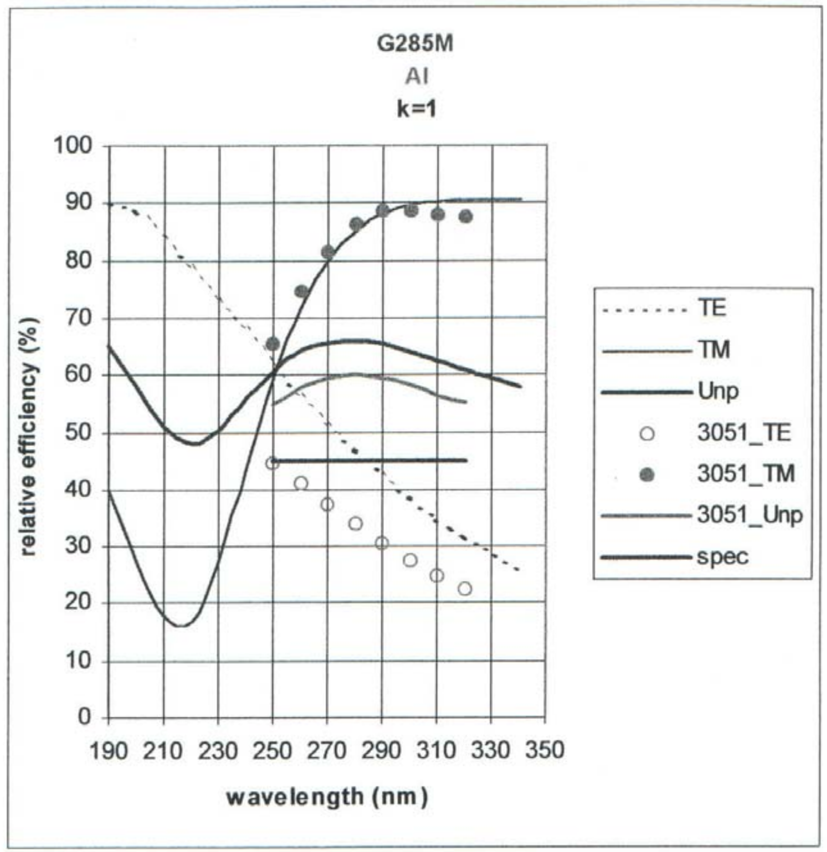
Grating Performance With Aluminum Coating G185M



Grating Performance With Aluminum Coating G225M



Grating Performance With Aluminum Coating G285M



NUV Grating Issues

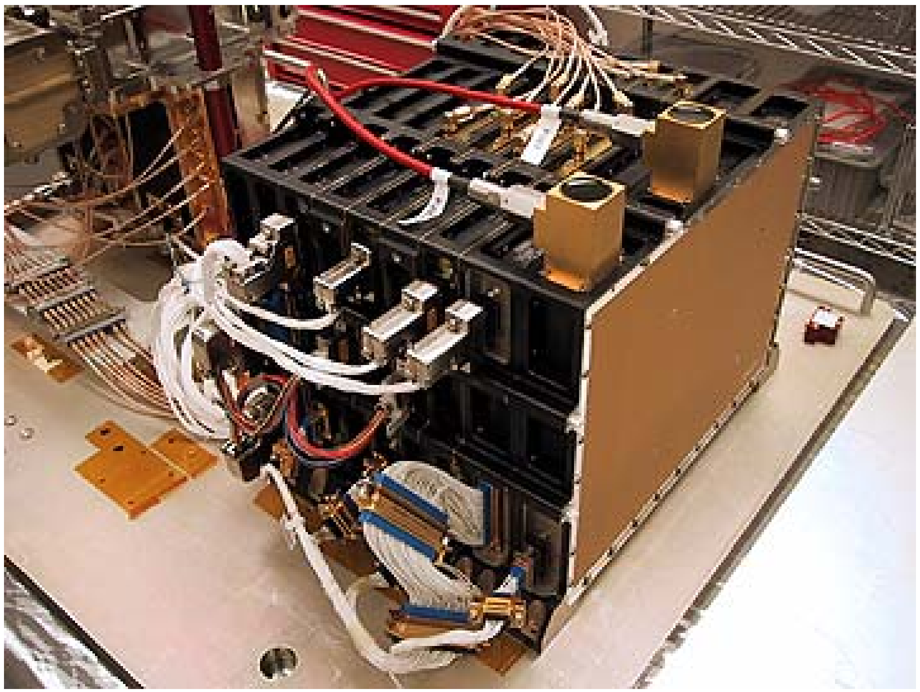
- The PI recommends that test pieces be replicated and coated only with aluminum for test at GSFC in flight configuration. Some test pieces in this configuration already exist.
- If these pieces are acceptable, we should produce flight replicas and fly bare aluminum gratings.
- This will impose certain handling and storage requirements on the instrument, but will restore full science capability.
- Bare aluminum has reasonable lifetime performance in the NUV longward of 1700 Å. We are getting more information on this.

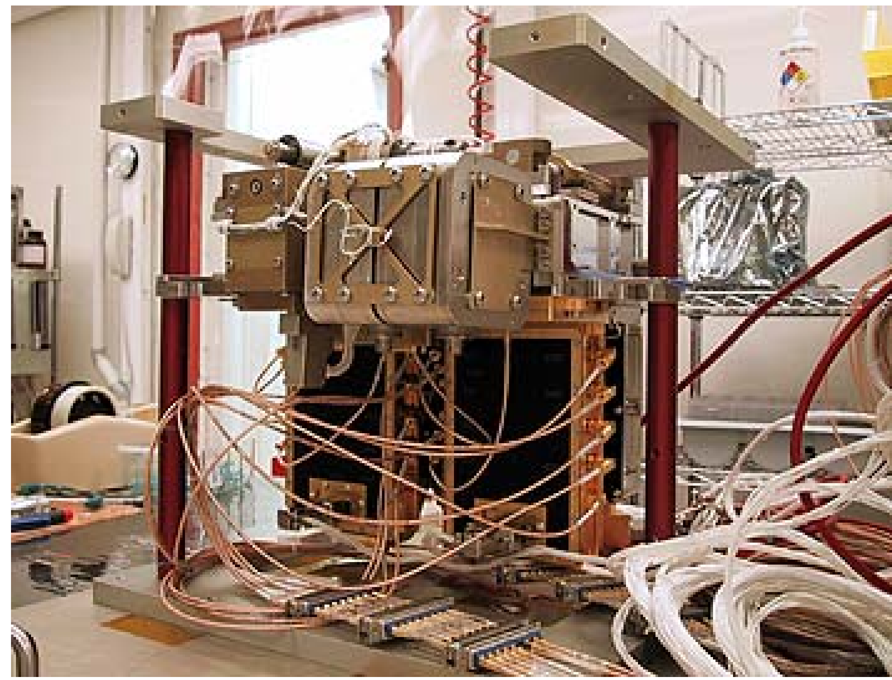
NUV Grating Issues

- If this technique is not successful, the PI recommends:
  - G185M: fly a deep groove replica if performance meets specification, otherwise, fly a 225M grating in its place.
  - G225M: fly the existing grating or the Hitachi grating, whichever is superior.
  - G285M: the Al/MgF2 coated G285M grating has no better performance than the Au coated G285M (quite a shock!). This has strengthened my belief that the MgF_2 is responsible for our problems - if bare Al coating does not solve the problem, fly the 225M grating in its place (gives higher spectral resolution).

COS FUV Detector Systems

- Detector DEB
- Detector Head





Flight FUV01 Detector System

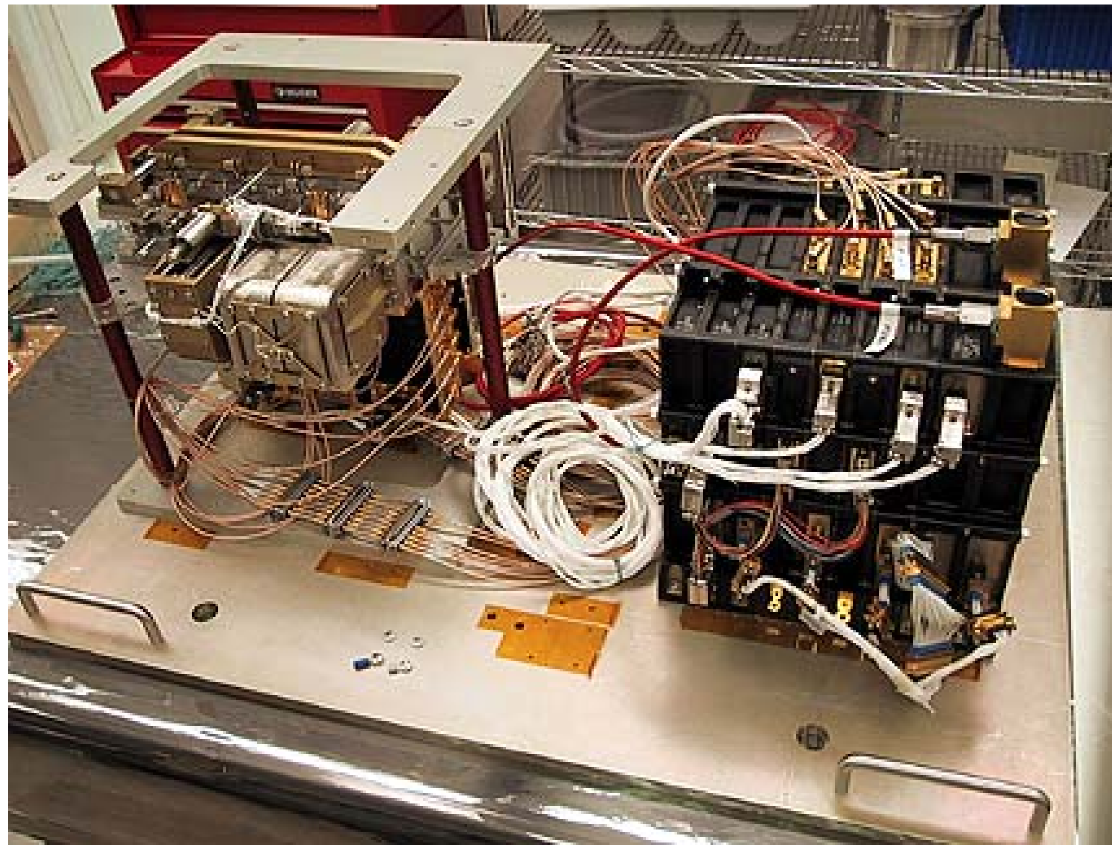
FUV01 Flight Unit

Detector system delivered to Ball in early September for alignment tests

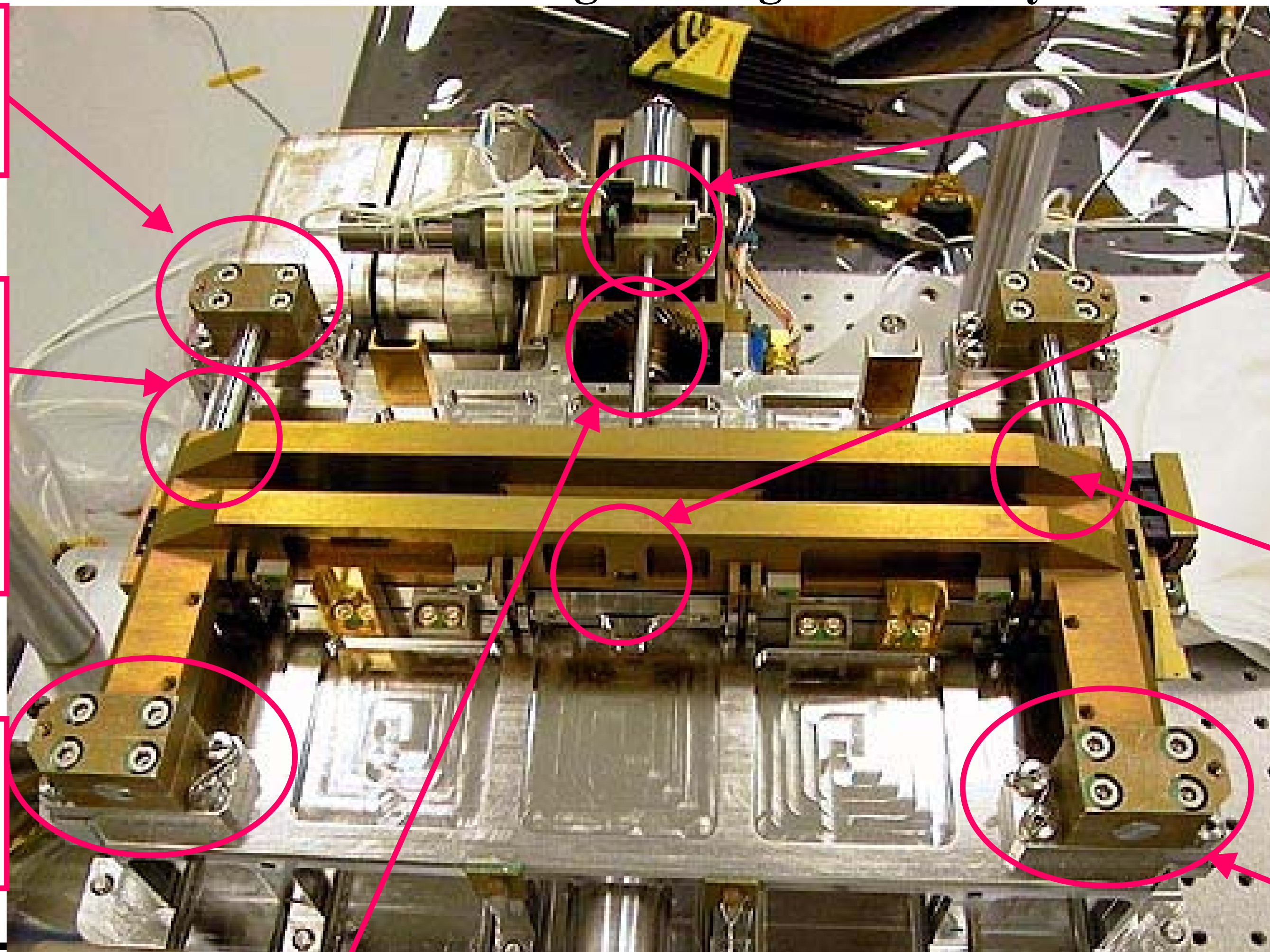
DEB in thermal vacuum chamber.

VHA has upper door & mechanism removed

Detector upper door & mechanism at UCB for rework



FUV01 Door Design Changes Summary



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 and allow rail to slide through the pillar blocks. Modify floating rail to have flats.
    - Rails made - need dowel pin drawing from SWALES.
  - Build new door carriage/modify old to pin one rail & change bearings for flat rail.
    - Bearings made, carriage made, mods in process.
  - Grease the rails with Braycote 602 to lower friction .
  - Hard mount all rail pillars and use bored rail holes instead of half clamps.
    - Rail pillars made - need dowel pin drawing from SWALES.
  - Change link for actuator drive shaft to monoball joint on farside of door carriage.
    - Ball and socket material in house, fab in progress, need dowel pin drawing.
  - Reduce actuator drive shaft diameter to allow flexture, and grease shaft.
    - Drive shafts made.
  - Replace actuator PEEK bushings with PEEK/PTFE (friction 0.15) & counterbore
    - Bushings made - need counterbore specs from SWALES.
  - Apply lower door motor current limit to ensure no stall condition occurs, in addition to existing sensor limit switches.

FUV01 Door Problem Resolution (cont)

New door drive shafts

New Door Rails

Plan of Action - Status and plan

- Have made most of the parts to be changed
- Most critical - drive shaft ball & socket - currently in fabrication
- Have been building parts as soon as the drawings are received/reviewed.
- Couple of drawings still needed, mostly dowels & counterbore spec
- 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).

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.

Flexture Mount - Detector VHA Vibration

- Concern that the detector will have problems when vibrated on the flexures.
- DVA & flexture models (GSFC & Ball) show high Q resonances at ~300Hz.
- Vibration test results on the detector VHA shows high Q for the ion pumps.
- Project decision to build up a vibration "simulator" to run a real test to assess the quantitative vibration test risk factors.
- We have assembled ETU components into a detector vibration VHA "simulator" that is representative of the true mass and configuration.
- The detector vibration "simulator" has been vacuum tested and successfully shipped to GSFC via UPS ground
- We will use Ball prototype flextures for vibration test
- A vibration test procedure has been defined for the test at GSFC
- UCB supporting vibration test with GSFC & Swales at GSFC this week.

Near Term Plan of Action

Detector Door/FUV02

- Complete fabrication of new door parts, complete last details
- Assemble and test FUV02 DVA with new door designs

FUV01

- Support alignment tests at Ball
- Refit door after design verification and complete Thermal Vac test

DVA Vibration

- 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 – Delivered
Cal/FF SS Optical Integration	Fall/winter '01
FUV-01 Delivery to Ball for Alignment	Delivered
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

- Assemble and test new DVA door mechanism on FUV-02.
- Complete surrogate DVA qual-level vibe testing.
- Support FUV alignment tests at Ball.
- Continue working NUV grating recovery.

Issues

- None