Center for Astrophysics and Space Astronomy

COS
Monthly Status Review
July 25, 2001
GSFC

Cosmic Origins Spectrograph
Hubble Space Telescope

July 25, 2001

Agenda

Progress Summary Since Last Monthly	J. Andrews
Optics Development Status	J. Andrews
Instrument Performance Overview	J. Andrews
UCB FUV Detector Programmatic Status	J. Andrews
UCB FUV Detector Technical Status	O. Siegmund
CU Software Activities Status	K. Brownsberger
Cal/FF Subsystem Activities at CU	J. Andrews
Schedules	J. Andrews
Descope Report	J. Andrews
Upcoming Events/Activities	J. Andrews
CU Issues & Resolution Plan	J. Andrews
STScI Presentation	T. Keyes
BATC Presentation	R. Higgins
Financial Splinter	GSFC/Ball/CU

Progress Summary Since Last Monthly (6/28/01)

- Supported initial integration of FUV-01 at Ball.
- Met with J-Y to discuss NUV grating recovery plan.
- Continued testing existing NUV gratings for use in alternative configurations.
- Worked FUV-01 door mechanism failure evaluation and implemented repair and recovery plan
- Continued FUV-02 final build-up and preparations for qual-level testing.

Optics Development Status - Gratings

- Present grating delivery plan (changes since last month in red/bold):

Item	Delivery Date	Coating Dates at GSFC	Test Dates	Test Location	Status
G130M	Done	Done	Done	CU	Exceeds spec
G140L	Done	Done	Done	CU	Exceeds spec
G160M	Done	Done	Done	CU	Exceeds spec
G140L-Blazed	TBD	TBD	TBD	CU	In development at JY
G185M	Delivered	Done	<Specification	GSFC/CU/JY	Use G225M
G225M	Delivered	Done	<Specification	GSFC/CU	Resolve problem
G285M	Delivered	On hold	<Specification	GSFC	Use G225M
G230L	8/01	8/01	9/01	GSFC	Awaiting delivery

Instrument Performance Status - 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 Recommendations

- The G225M gratings have low efficiency at their design wavelengths, but high efficiency at the G185 and G285 wavelengths (shown by tests at CU and GSFC).
- Replace the G185M and G285M gratings with existing G225M gratings.
- This changes the resolution and bandpass of the G185M and G285M channels.

Modified NUV Performance

- G185M
  - Specification: 0.36 absolute efficiency
  - With existing grating: 0.224 eff (62% of spec)
  - With G225 as G185: 0.356 eff (99% of spec)
  - New resolution of G185: 16,000 (spec=20,000)
  - Simultaneous bandpass increases by 25%
  - “Detectability” (Aeff * R) increases by 27%
  - “Completeness” (Aeff*bandpass) up 98%

Modified NUV Performance

- G285M
  - Specification: 0.36 absolute efficiency
  - With existing grating: 0.274 eff (76% of spec)
  - With G225 as G285: 0.44 eff (122% of spec)
  - New resolution of G285: 24,000 (spec=20,000)
  - Simultaneous bandpass decreases by 17%
  - “Detectability” (Aeff * R) increases by 92%
  - “Completeness” (Aeff*bandpass) up 34%

Modified NUV Performance

- G225M
  - Not yet identified a superior substitute for G225M.
  - Should order 2 additional replicas of G225M from J-Y.
  - Should proceed with Coastal/Hitachi on G225M only.

NUV Performance

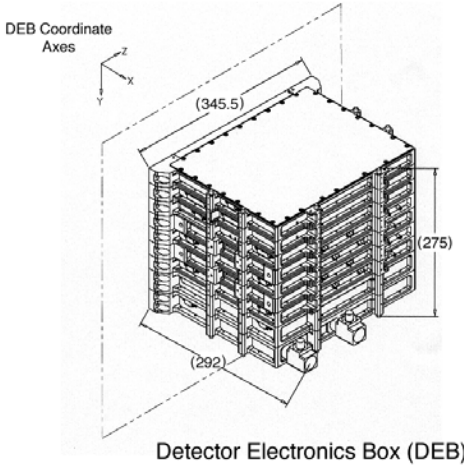
- G230L
  - Expect in spec grating by end of August.
- G185M
  - Some hope that a new G185M with higher efficiency will be available from JY before October 1.

Late Gratings

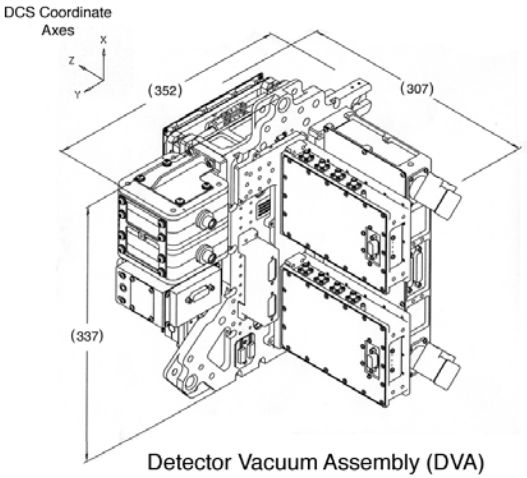
- Should higher quality gratings become available from J-Y and/or Hitachi after installation of OSM2 (Jan '02) there will be significant flow impact to incorporate them.
- Decision to install should await existence of tested, superior gratings so that performance/cost/schedule trades can be made at that time.
- At this time, it appears that the schedule impact is independent of the exact time that the swap out is implemented: we have already passed point at which any Hitachi grating can be easily incorporated.
  - We should decide soon if we want to at least proceed with a $27K effort at Coastal for substrate production.

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)



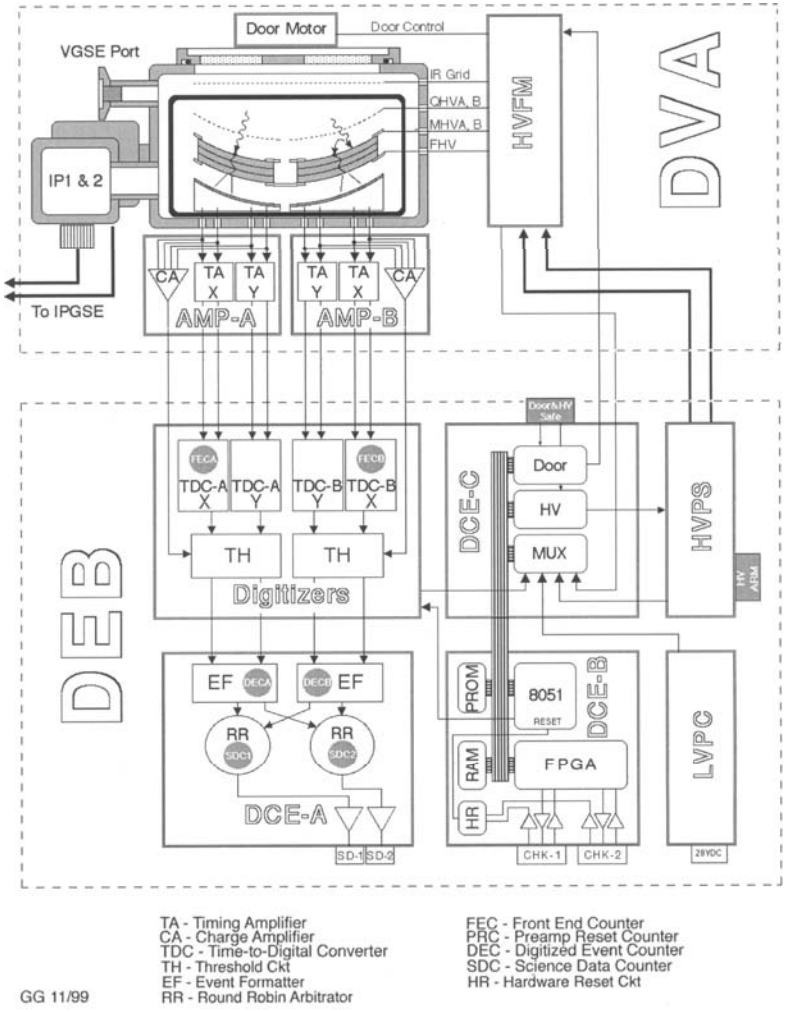
Detector Electronics Box (DEB)



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

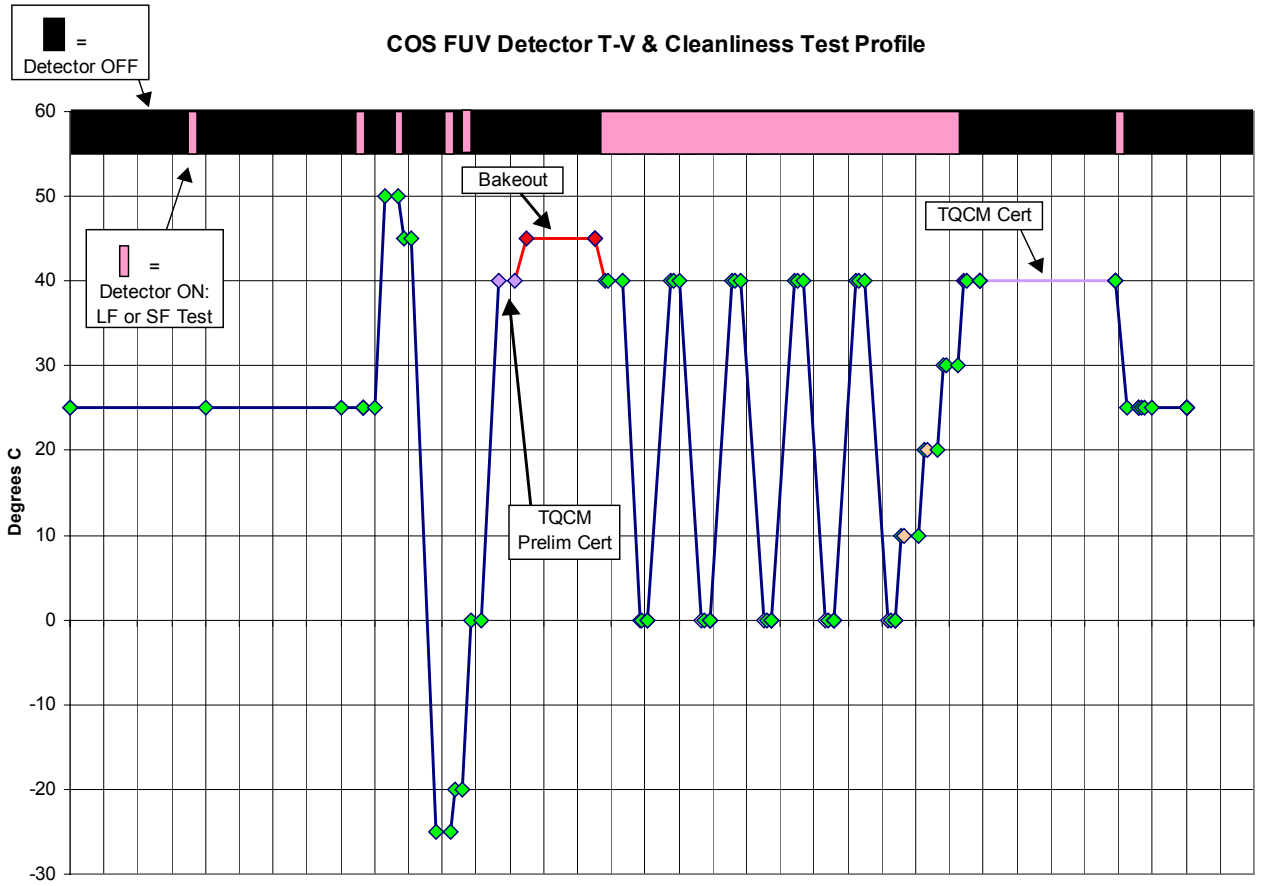
- Latest UCB masss & power numbers are actuals measured on the flight system. The numbers come from Revision D of the UCB Mass & Power Budget Report (UCB-COS-RPT-1015, UCB-COS-RPT-1004).

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
N/R	C	C	N/R	Q - P	Q - P	@SS	@SS
FUV-02 SS	P	P	N/R	@Comp	@Comp	8-cycles	P

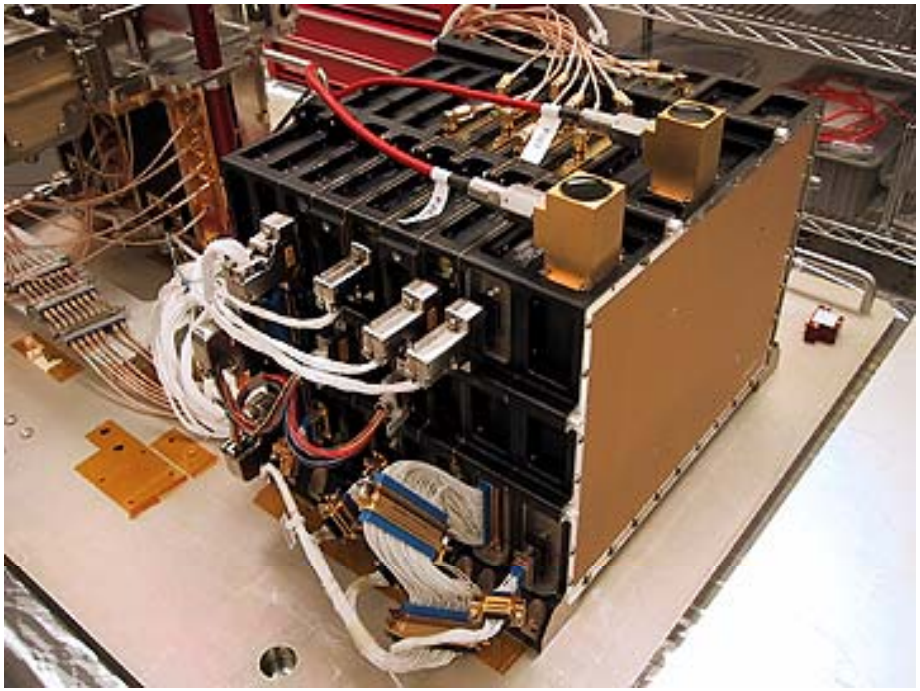
C = Complete
@SS = At Subsystem
A = Acceptance Levels
Q = Qualification Levels
N/R = Not Required
P = Planned

COS FUV Detector T-V & Cleanliness Test Profile - As Run

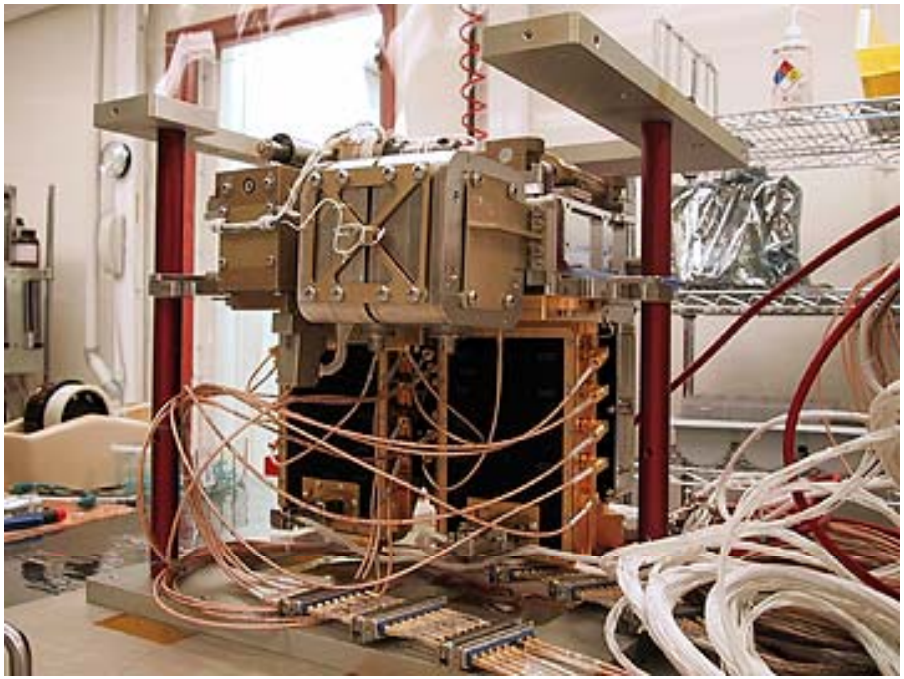


COS FUV Detector Systems

- 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 in vacuum bake.
- **Detector Backplate Assembly**
  - Built up and awaiting integration with VHA for vibration testing.
- **Vacuum Housing Assembly**
  - Currently testing solutions to the FUV01 door mechanism problem.
- **Brazed Body Assembly**
  - Photocathodes deposited successfully and detector QDEs measured.
  - BBA currently in safe vacuum storage awaiting final FUV02 buildup.
- **ETU DEB**
  - Will finish FUV02 cables, release DEB cables and send ETU DEB to Ball.

Flight FUV01 Detector System

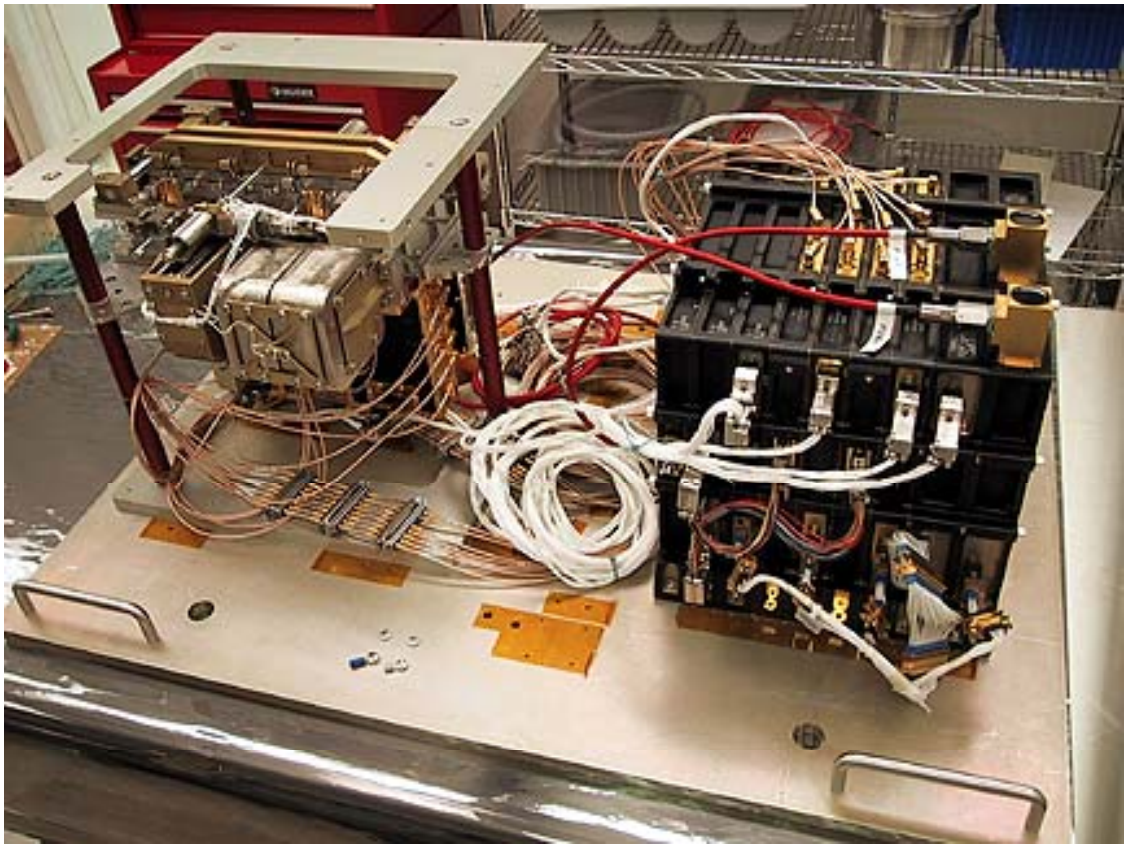
FUV01 Flight Unit

Detector system currently at CU – CASA

DEB in purged thermal vacuum chamber.

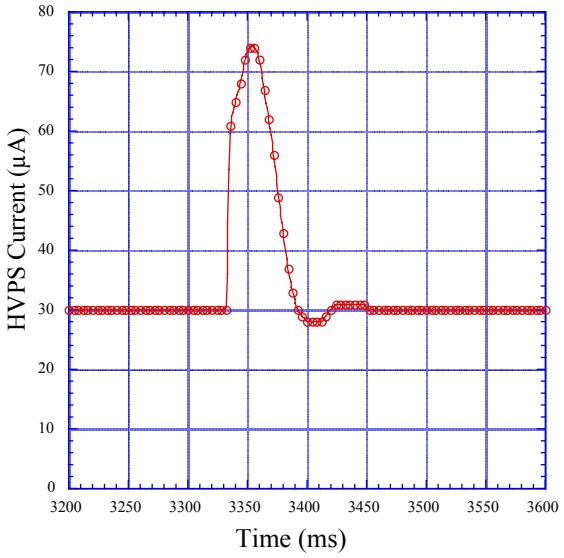
Detector on optics bench with upper door & mechanism removed

Detector upper door & mechanism at UCB for rework



UCB FUV01 Detector Post Thermal Vacuum Issues

- **High Voltage Current Transient (Study presented at March 01 monthly)**
  - Newly released flight software (v. 1041) uses a 60 ms (from 20 ms) persistence for the HV current limit task. This will significantly reduce the occurrence of HVI shutdowns, as 20 ms is the characteristic time of most transients. This should eliminate shutdowns from harmless transients while maintaining protection against real HV overcurrents.



COS non-trip HVI transient (threshold = 120), event spontaneously decays away

HVI transient

QuickTime™ and a TIFF (Uncompressed) decompressor are needed to see this picture.

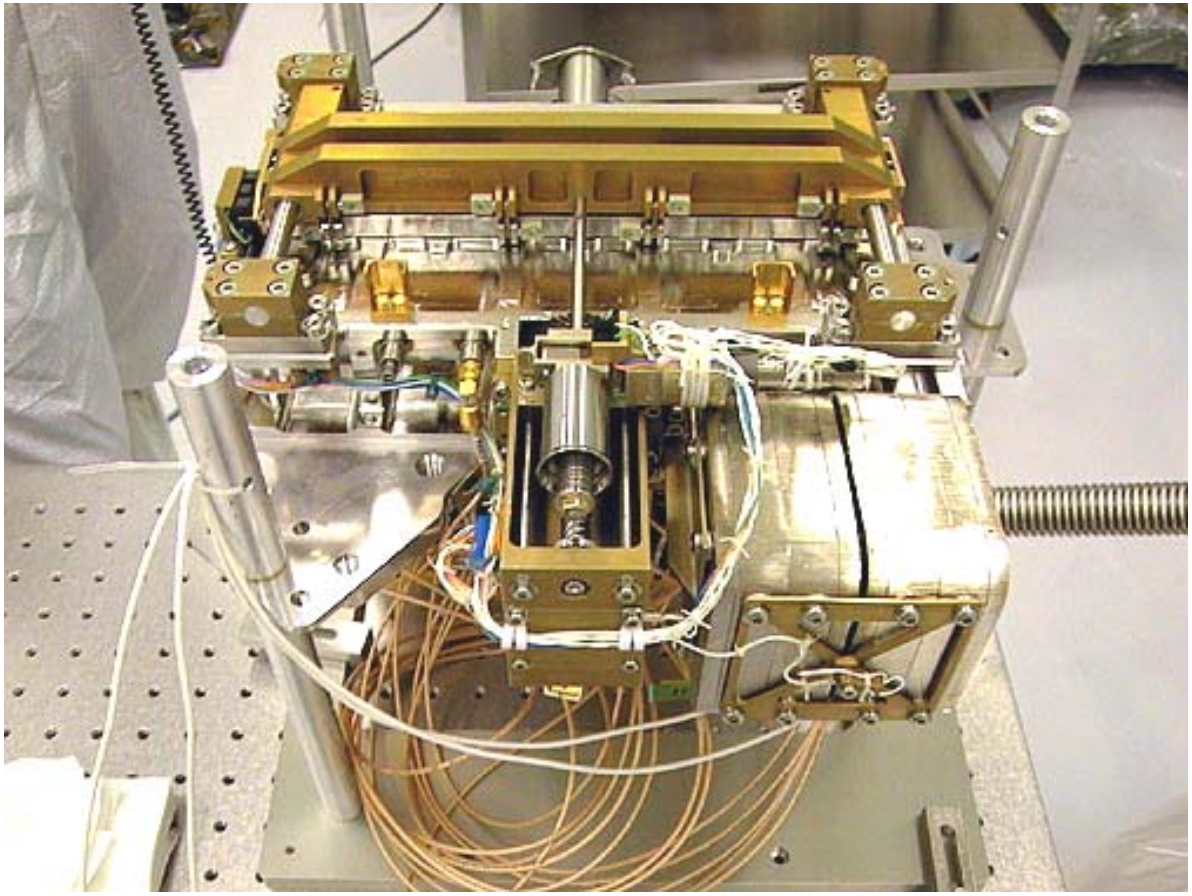
Large event

Lab study - HV transient example
Large saturated event and HVI transient

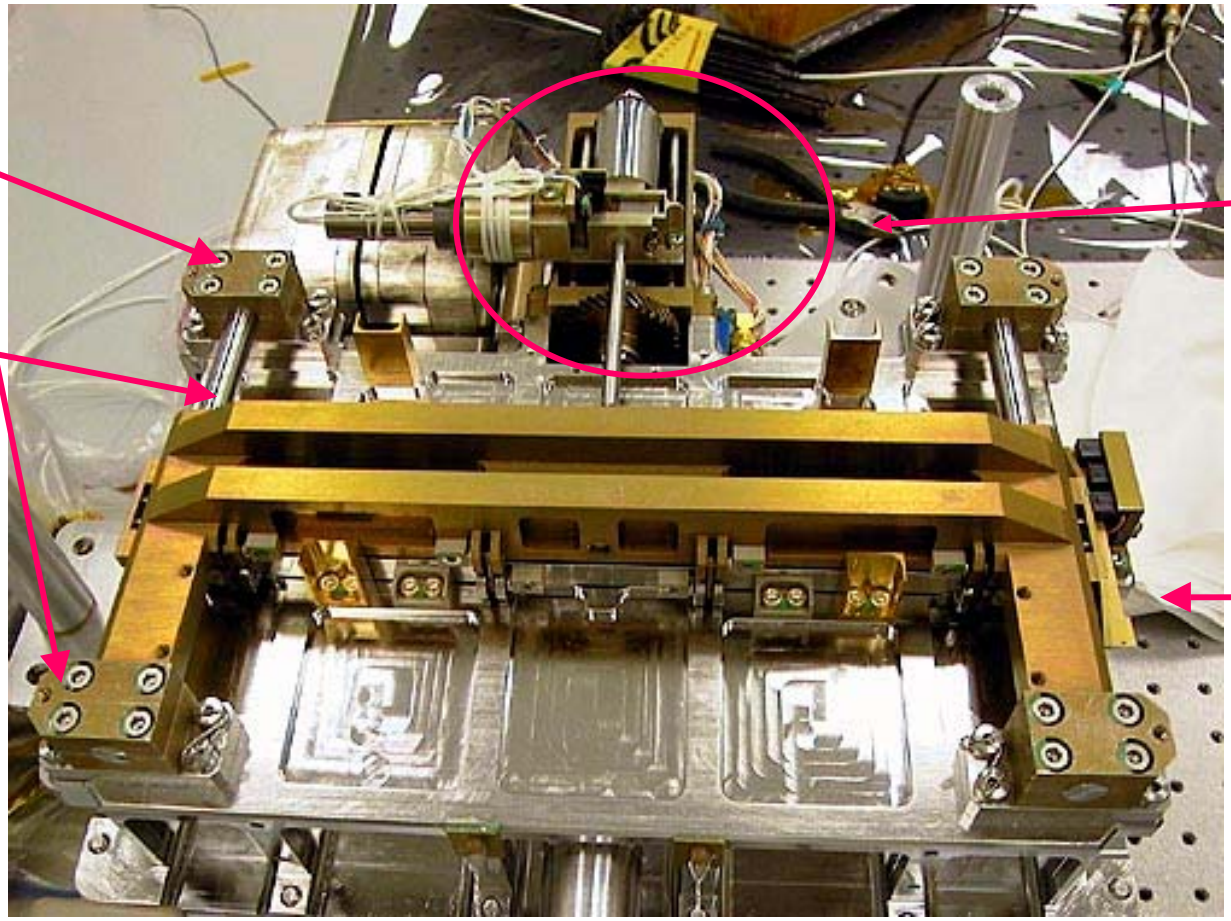
UCB FUV01 Detector Post Thermal Vacuum Issues

- **Ball optical alignment/DVA shim measurement (June)**
  - Very successful, 0.020” out of focus and 2 arcmin tip/tilt with nominal shims.
  - New shims cut to optimal values gave 0.010” focus and < 40 arcsec tip/tilt
  - Same process to be used used for FUV02 (only 17μm different to FUV01).
- **Door Mechanism**
  - Found the door redundant actuator only partially opens the door at any temp.
  - Analysis of FUV01 door operations shows a potential door rail misalignment.
  - FUV02 door was disassembled from VHA while VHA under vacuum.
  - Door disassembly procedure developed to allow FUV01 in-situ removal.
  - FUV01 door was disassembled while VHA under vacuum - successfully.
  - FUV01 shows similar results to FUV02 that indicate door friction as a result of rail misalignment.
  - Have developed tentative plan with GSFC/Swales and CU to modify some of the door components to resolve the problems.

COS FUV01 Detector Assembly



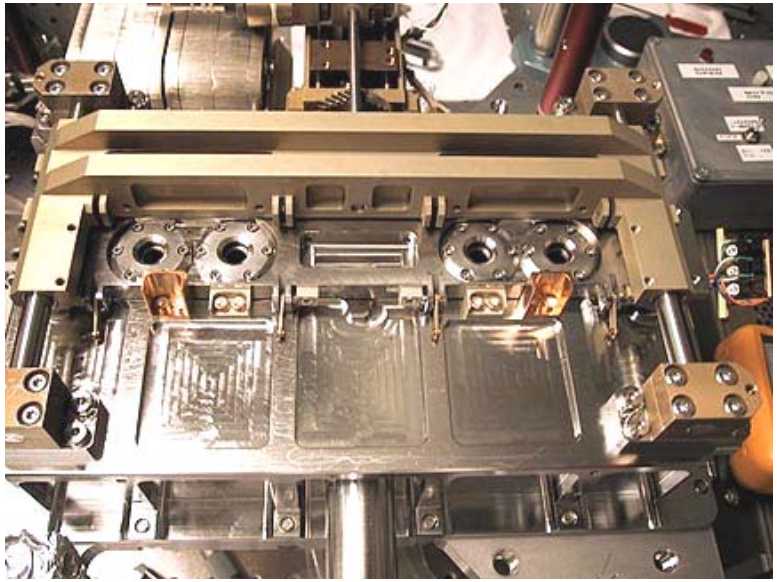
COS FUV01 Detector Door Assembly



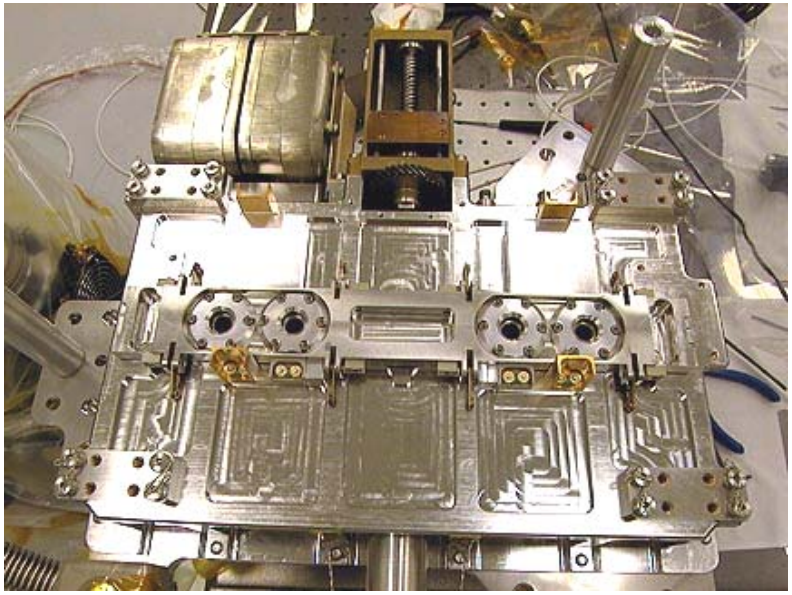
COS FUV01 Detector Door Disassembly Measurements

Many measurements of position and friction were made during disassembly. These show that the friction was too great for the backup system to open the door.

COS FUV Detector Door Disassembly



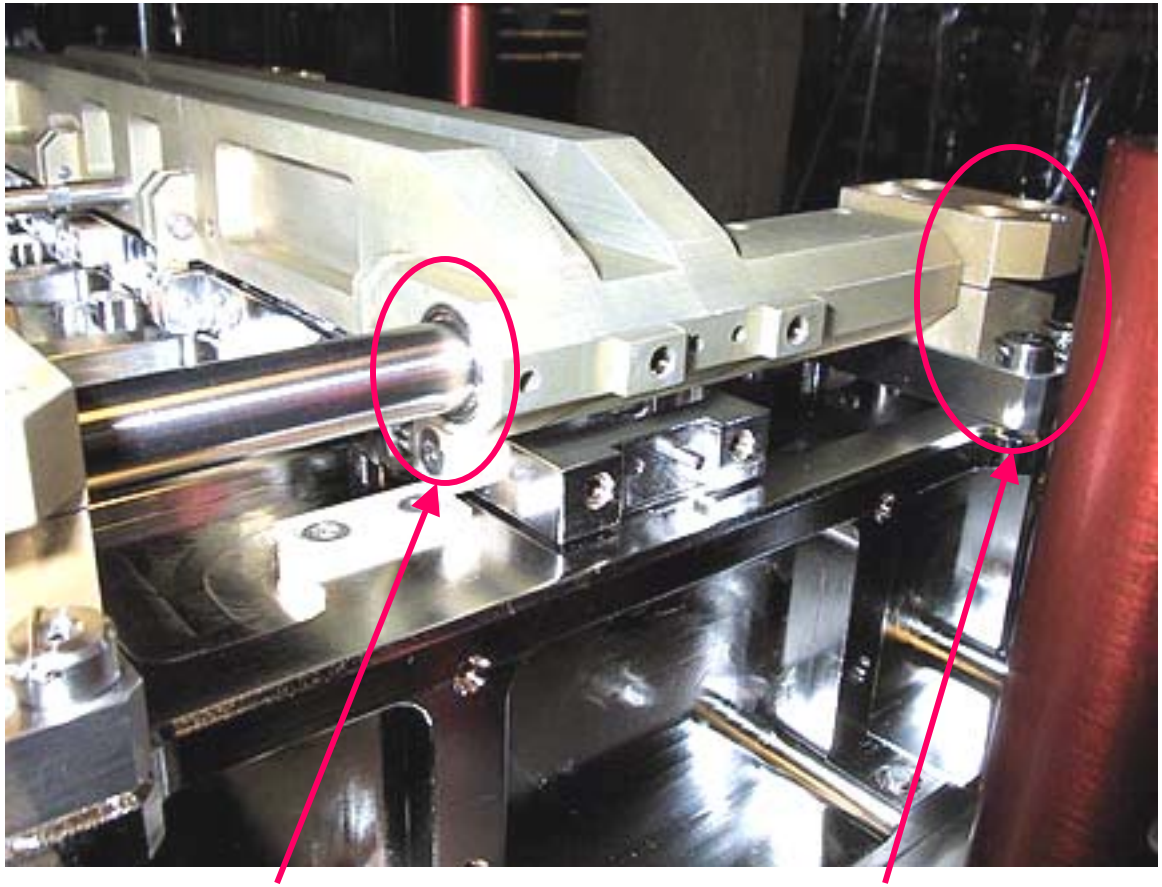
Carriage detached from lower door



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.

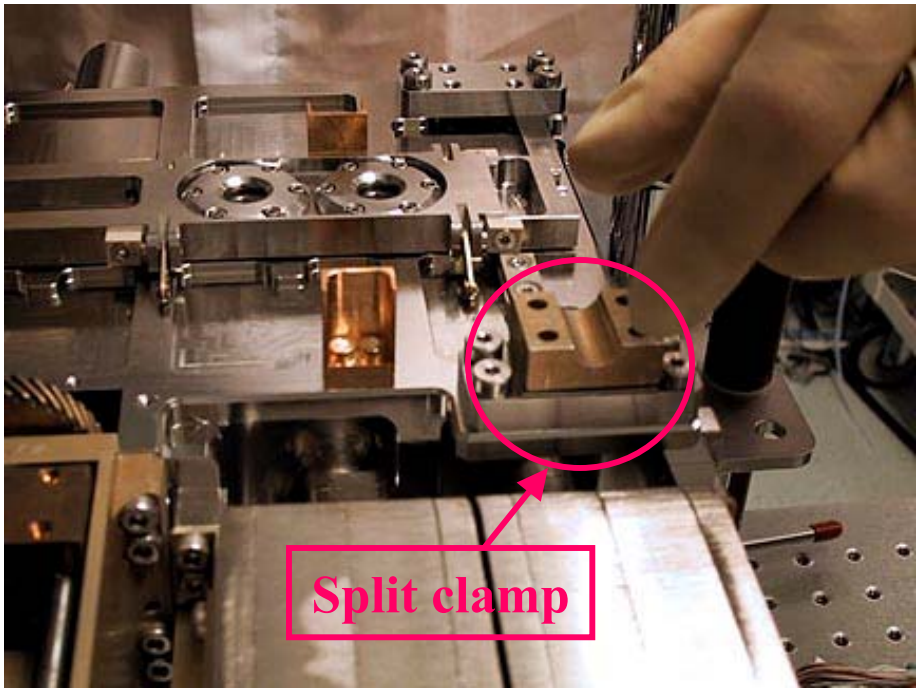
COS FUV Detector Door Rail System

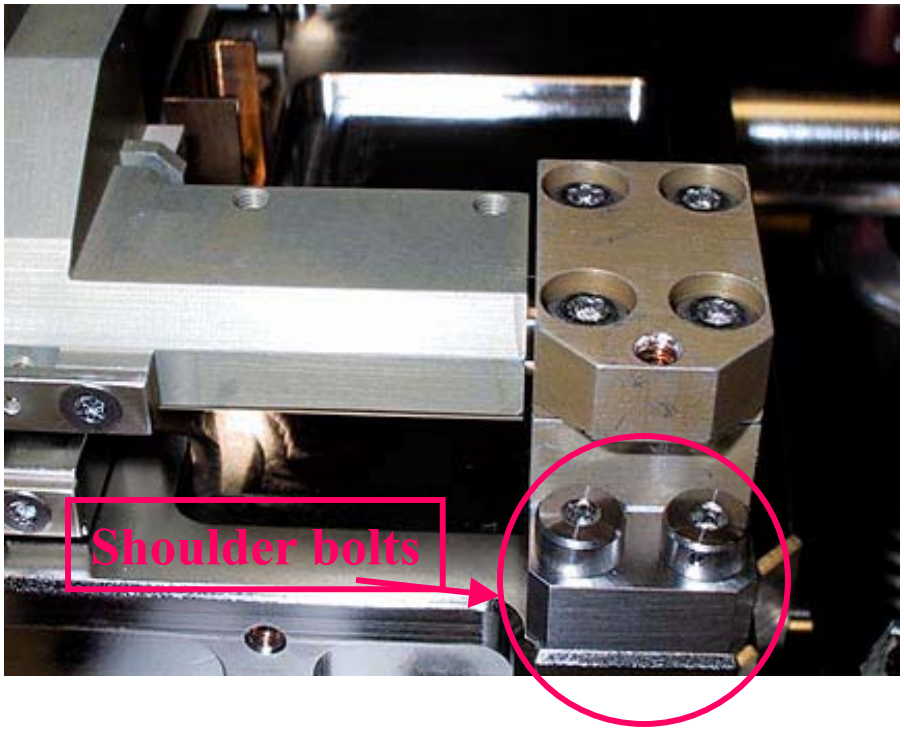


Carriage bearing **Rail post and split clamps**

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.

COS FUV Detector Door Rail and Pillar Mounts

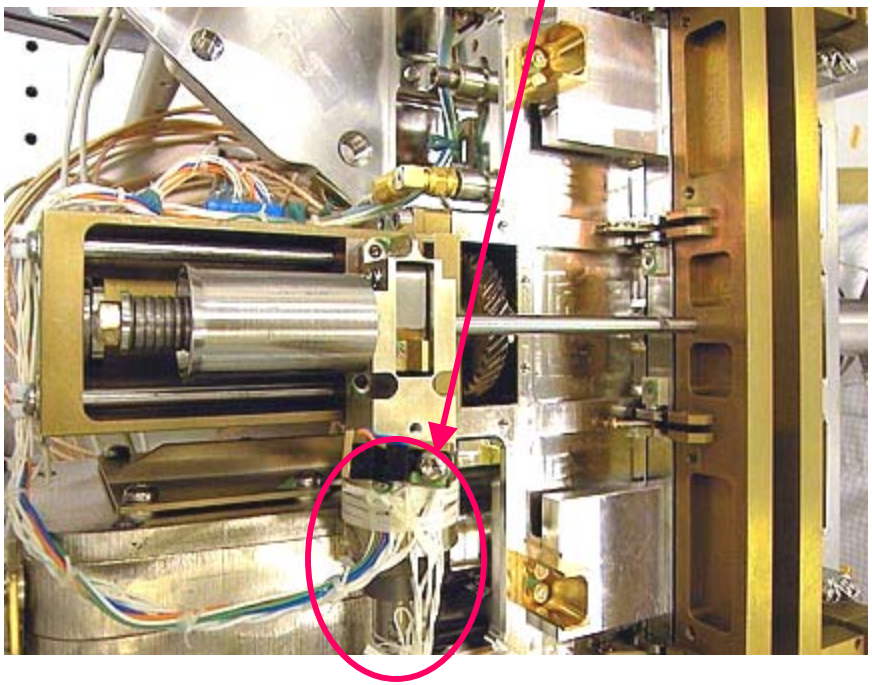




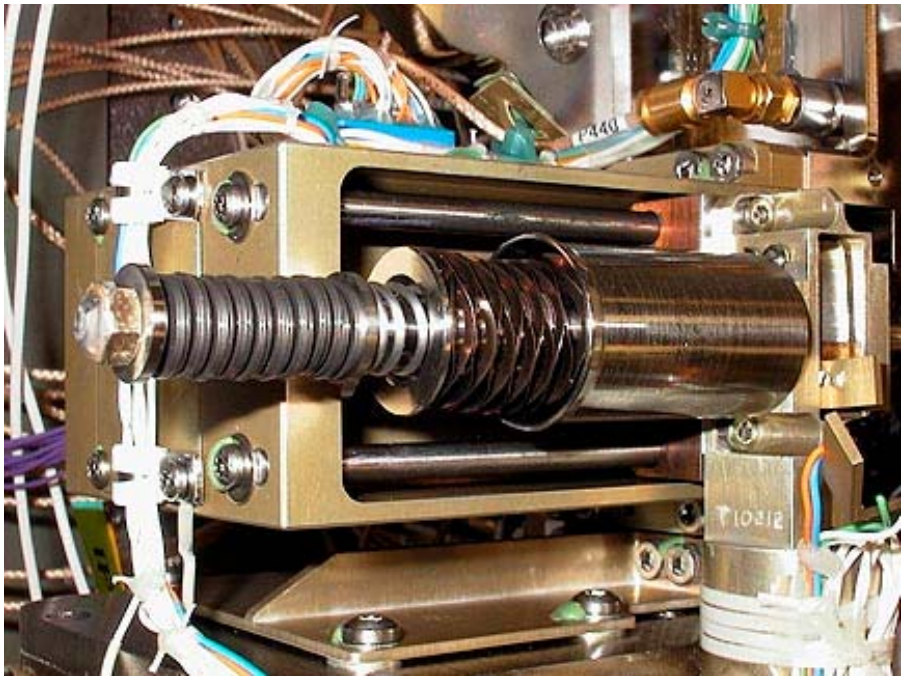
A number of factors can exacerbate the rail misalignment, baffle mounting stresses on the posts, and axis errors on the split clamp rail bores. Rail misalignment can also affect the backup door HOP mechanism, forcing the push rod to be misaligned and increasing the friction on the PEEK bushings.

COS FUV01 Detector Door Backup Actuator System

Door push shaft and HOP assembly



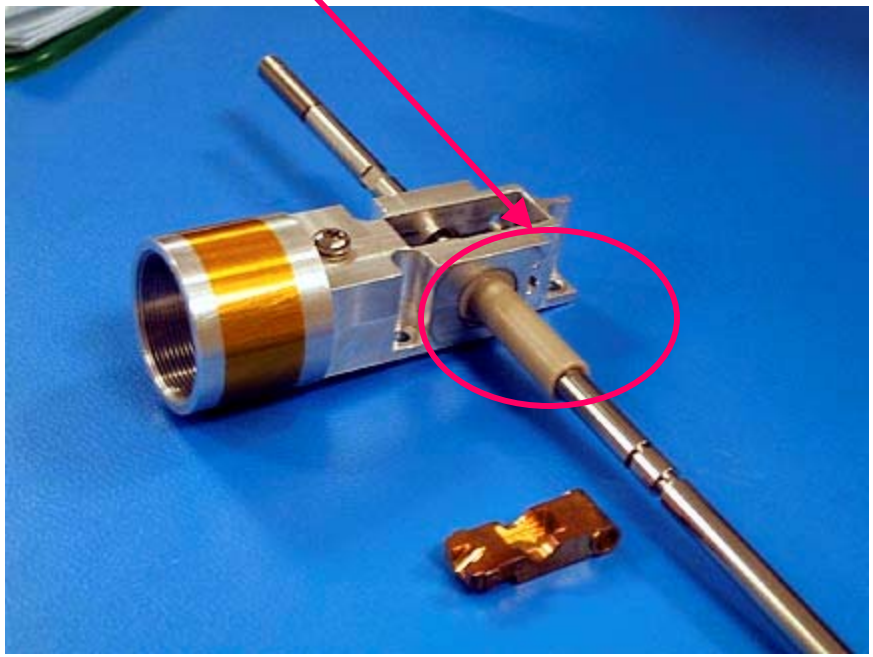
Redundant actuator spring pack



The spring packs on FUV01 and FUV02 are both nominal. However, analysis and practice show that the door push shaft is displaced by door carriage misalignment, the friction in the PEEK bushings becomes considerable. The shaft hard mount to the door carriage and the HOP carrier over-constrain it.

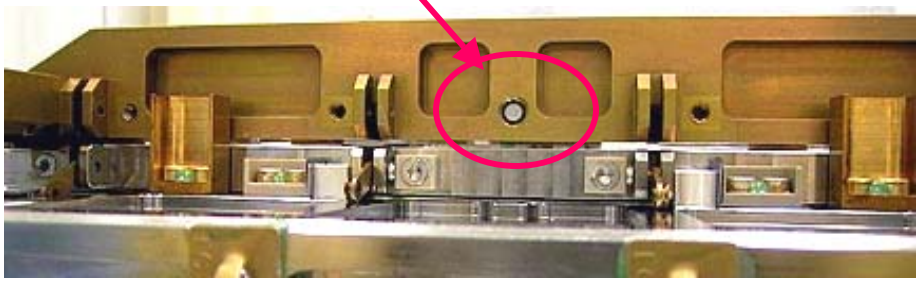
COS FUV Detector Door Actuator Backup System

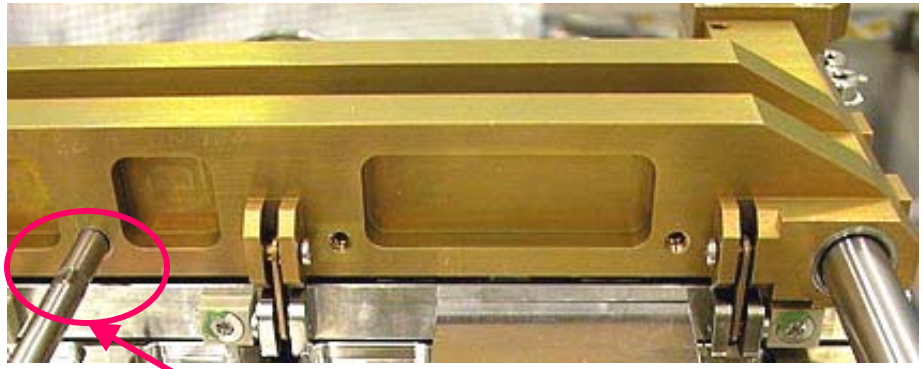
Door push rod actuator housing and PEEK bushings.



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

FUV Detector Door Mechanism Summary

- 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 and show the same basic problem.

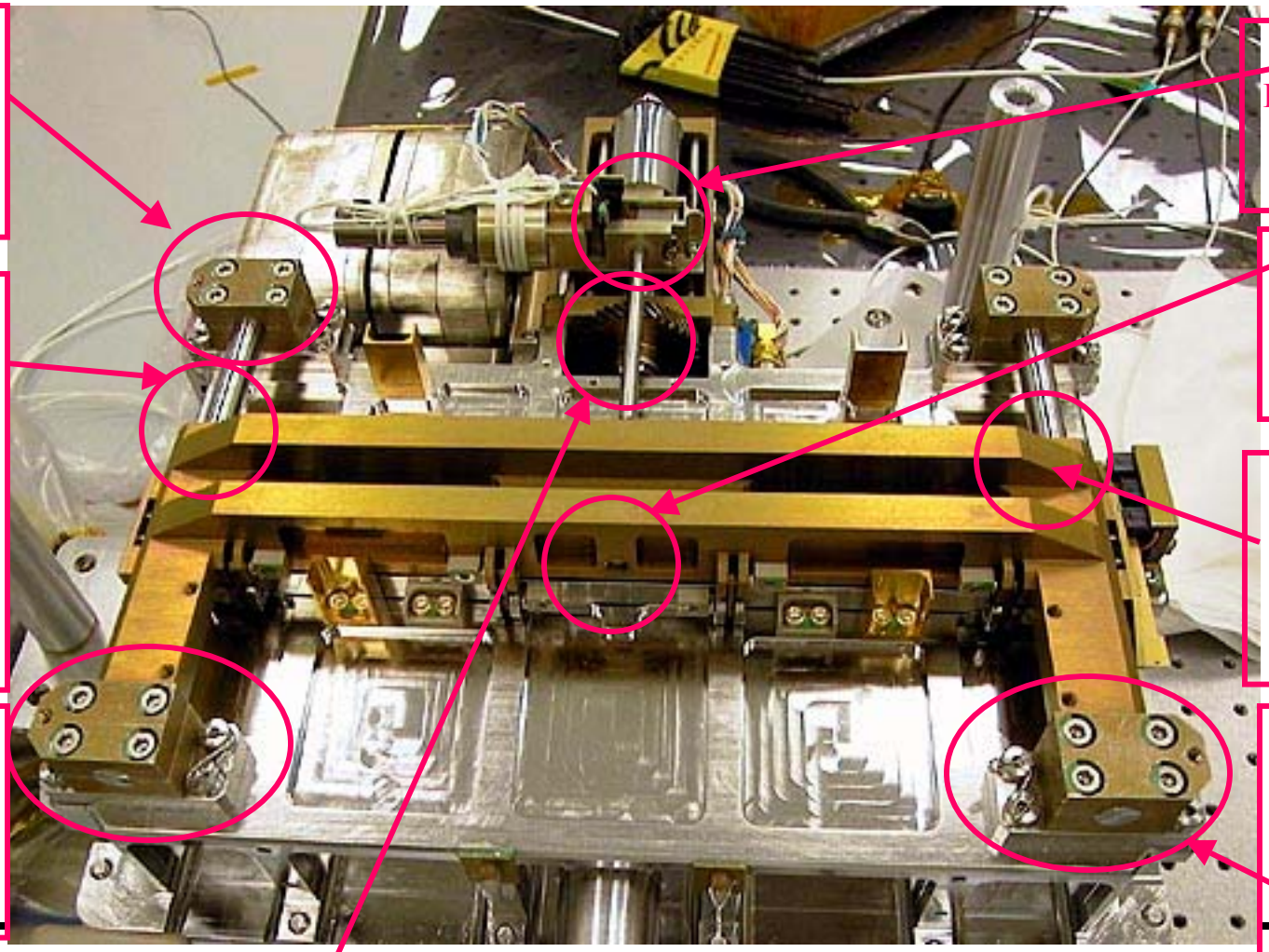
FUV01 Door Problem Resolution

- **UCB Approach and Philosophy**
  - We are very happy with Goddard/Swales/CU/UCB team approach.
  - Investigate all viable options before implementation on the flight unit.
  - 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.
- **Concerns**
  - 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 are investigating a door clamp scheme 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.(needs clearances to be verified).
  - 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 Redundant Actuator Mechanism



Proposed Plan of Action

- Finalize solution path for FUV01 door problem and build/modify parts.
- Test solution scenario 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 FUV Detector Status - Schedule Overview

OBJECTIVE: Minimal Impact to Ball's I&T Schedule

- Flight Unit - FUV-01:
  - Ball needs FUV-01 for RasCal alignment work starting 9/4/01.
    - Functionality of door is non-issue for this work.
    - UCB has plan for clamping door to protect vacuum seal.
  - Between now and 9/4/01 we will work on implementing door recovery plan.
  - There is a 3 week window in October when FUV-01 DVA will be removed from bench and available for door mechanism installation, test, vibe, and acceptance T-V tests.
  - By late October/early November FUV-01 DVA needed back at Ball.
- Spare Unit - FUV-02:
  - Further build-up pending door mechanism mods.
  - Want to mod door and conduct qual-level vibe before modifying FUV-01 door.
  - Once successfully through qual-vibe unit can be thermal-vacuum tested at CU either before or after alignment tests at Ball in October.

GSE Software Development

CEDAR, TAACOS, Spectral Simulator, CALCOS-GSE

http://cos-arl.colorado.edu/CEDAR/
http://cos-arl.colorado.edu/TAACOS/
http://cos-arl.colorado.edu/CALCOS/
http://cos.colorado.edu/ (Click on Link for Spectral Simulator)

Highlights:

- Cedar
  - Work started to implement new features (SDF to FITS converter, hooks for modules to provide interactive TC and GC corrections, etc.)
- TAACOS
  - No Change – All presently defined TAACOS efforts have been completed.

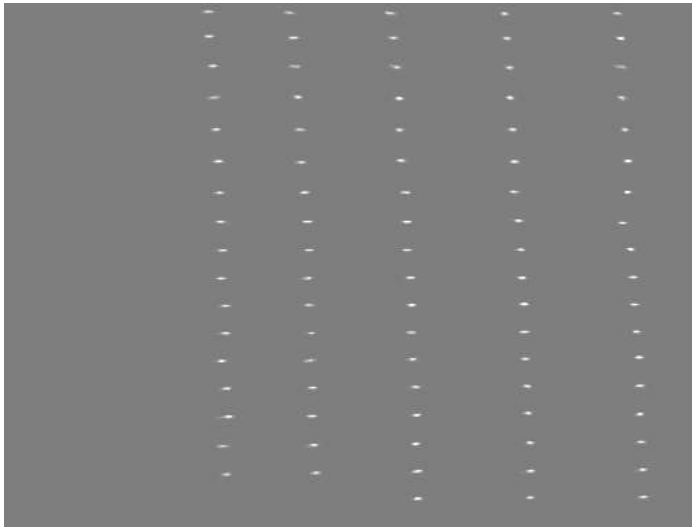
GSE Software Development

Highlights:

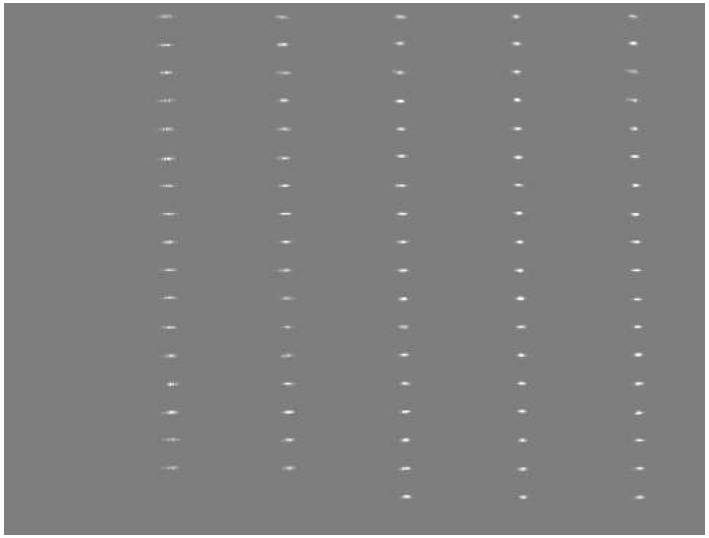
- CALCOS - GSE
  - Thermal Correction (TC)
  - Defined new Stim Pulse locations for expected in-orbit operating temperature from Thermal Vac.
  - Geometric Correction (GC)
  - Completed INL maps for both segment A and B.
  - Look up table is fastest approach (corrections as an image).
  - Requires interpolation at edges, where changes in correction values are large, to prevent aliasing.
- COS Spectral Simulator
  - Enhanced with multiple input spectra and ALL available COS spectroscopic modes. Beta version made available to science team from the COS web page.

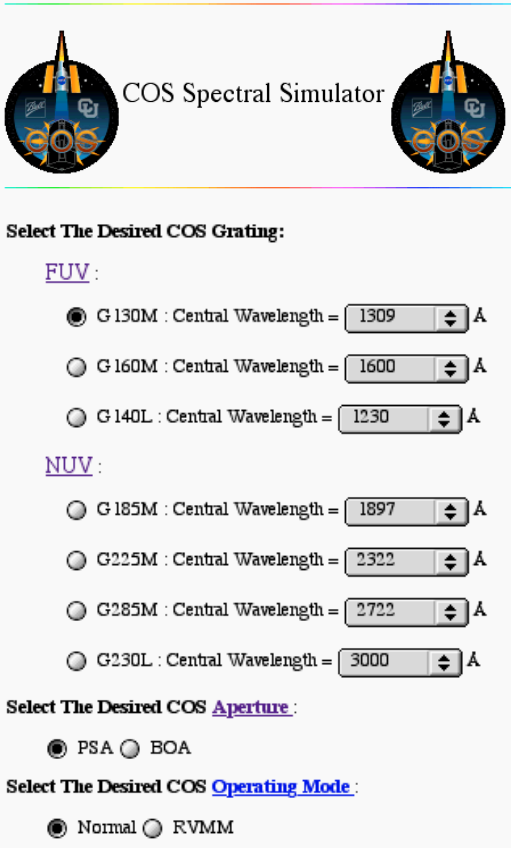
Geometric Correction of Pinhole Mask (Segment A)

Before Correction:

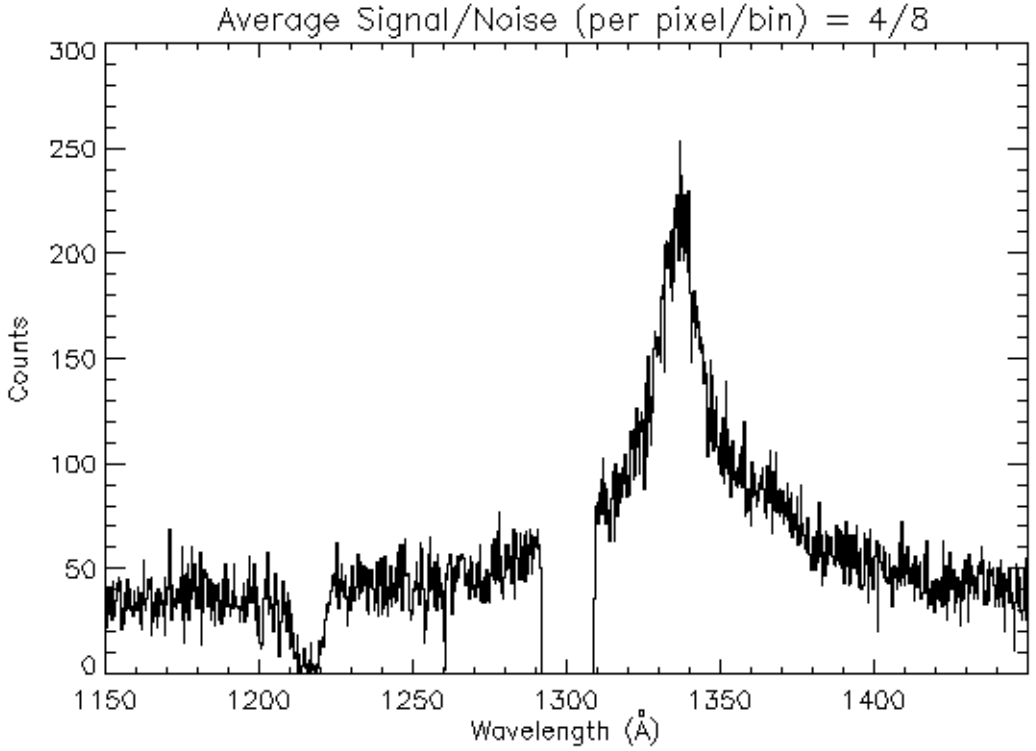


After Correction:




COS Spectral Simulator
Select The Desired COS Grating:
FUV :
G130M : Central Wavelength = 1309 Å
G160M : Central Wavelength = 1600 Å
G140L : Central Wavelength = 1230 Å
NUV :
G185M : Central Wavelength = 1897 Å
G225M : Central Wavelength = 2322 Å
G285M : Central Wavelength = 2722 Å
G230L : Central Wavelength = 3000 Å
Select The Desired COS Aperture :
PSA BOA
Select The Desired COS Operating Mode :
Normal RVMM
Target:
QSO at z = 0.10
Power Law with $F_\lambda = F_0$ (λ/1250.0 Å) -1.0
Black Body with T= 10000. K
Kurucz Model Spectra :
A1V
Other :
AGK_81D266
Pt-Ne Wavelength Calibration Lamp (Exposure Time is limited to 20s)
Flat Field Lamp
Target Flux :
1E-15 ergs/s/cm²/Å at 1250 Å
V magnitude = 16.0
No Normalization (default for Flat Field and Pt-Ne Lamps)
Exposure Time : 1000.0 seconds
Number of simulated absorption features : 0
Add Simulated Galactic absorption features ? Yes No
Number of pixels per bin : 5 (FUV is 5 pixels/RE, NUV is 3 pixels/RE)
Add Simulated Detector Noise ? Yes No
Color Scheme: White on Black Black on White
Image Type: PNG JPEG TEXT
Generate Simulated Spectrum
Generate S/N Spectrum
Show Input Spectrum
Reset Form

COS Simulated Spectrum



COS GRATING = **g130m** : Central λ = **1309 Å**
Exposure Time = **1000.0** seconds
Target is a **QSO (z = 0.10)**
Pixels per bin = **5**

FUV Detector FSW Development

DCE Flight Software Development and Test

http://cos-arl.colorado.edu/DCE/

Highlights:

- No Change. No known issues with Operate FSW v1041.

COS Schedule for CU/UCB

Task	Status
G160M/G140L – Blazed Grating Testing	G160M complete except repeat of image testing on G160M-b, which is on-going
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	9/4/01
FUV-02 Needed at Ball	~10/1/01
FUV-01 Available for Workmanship Tests	3 weeks in 10/01

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

- Complete G225M testing on G185/G285 configurations.
- Take delivery of flight G230L gratings from JY.
- Implement detector door mechanism recovery plan.
  - Complete analysis
  - Update designs
  - Fab new parts
  - Prepare door for alignment work at Ball
  - Modify FUV-02 and test to qual-levels
  - Modify FUV-01 and test to acceptance levels
- Work G225M replacement plan.
- Support Ball's I&T activities and RasCal alignment.