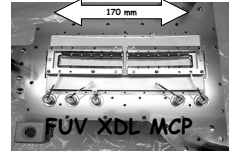
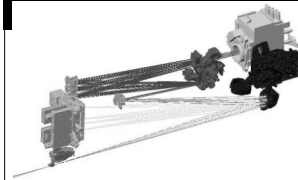
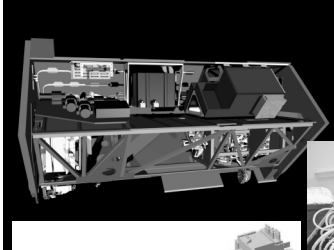


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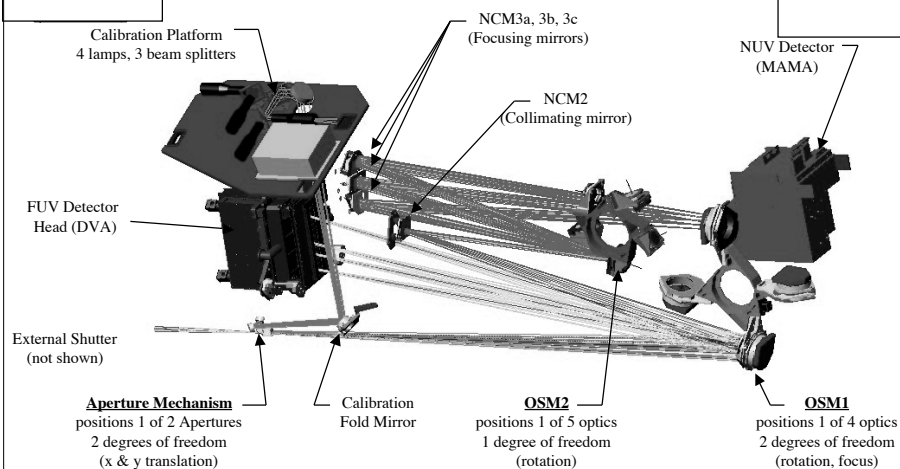
Agenda

- SI and Testing Status
- User Support and Ground System Status
- TAGFLASH
- Ground and On-orbit Calibration
- Supplementary Material (not presented)

assembly

Integrated SI

COS Optical Layout



*Cosmic Origins Spectrograph
Hubble Space Telescope*



Center for
Astrophysics and
Space
Astronomy

courtesy of
Ball Aerospace
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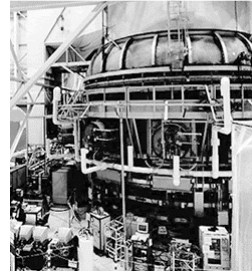
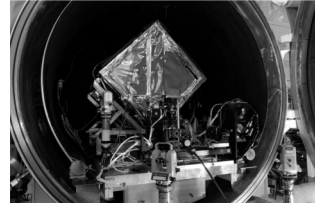
11



Summary of Test Program to Date



- Completed Environmental Test (TV I) in 2003
- Delivered COS to GSFC in April 2004
- Semi-annual Functional Testing (2004-present)
- Removed, Inspected, Reworked, & Tested MEB boards from August-September 2006 – including replacing all LVPS
- Integrated all boards back in the MEBs in September 2006.
- COS ready for Thermal-Vacuum Test (TV II) in October 2006



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User Support and Ground System Summary



- Astronomer Proposal Tools
 - Spectroscopic and Target acquisition ETCs – complete in Dec 2006
 - Bright Object Evaluation tool – Dec 2006
 - > Includes GALEX catalog to extend DSS
- COS Handbooks
 - Mini-handbook v. 3.0 : October 2006 (cycle 16 CP)
 - Instrument Handbook v. 1.0 : spring 2007 (cycle 17 CP)
- STScI COS Website
 - <http://www.stsci.edu/hst/cos/>
- Proposal and Scheduling System
 - All science exposure and calibration commanding is complete
- CALCOS (Pipeline) Development
 - Most pipeline steps tested against instrument data (screening, thermal distortion, geometrical correction, dead-time correction, flatfield, 1-d extraction, wavecal processing, etc)
 - TAGFLASH coded and partially tested - Final testing awaits TV II exposures

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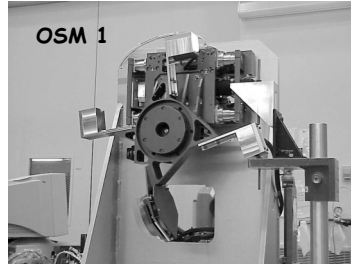


Ground Testing Status Summary



- All major performance requirements met in TV I in 2003

- Spectral resolution
- Sensitivity
- Flatfield quality
- Scattered light
- Wavelength coverage

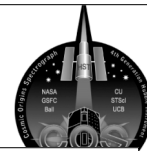


- TV I testing revealed spectrum drift caused by OSM motions
 - TAGFLASH Mode (OSM-drift operational correction)
 - > Test at Thermal-Vac II in November 2006

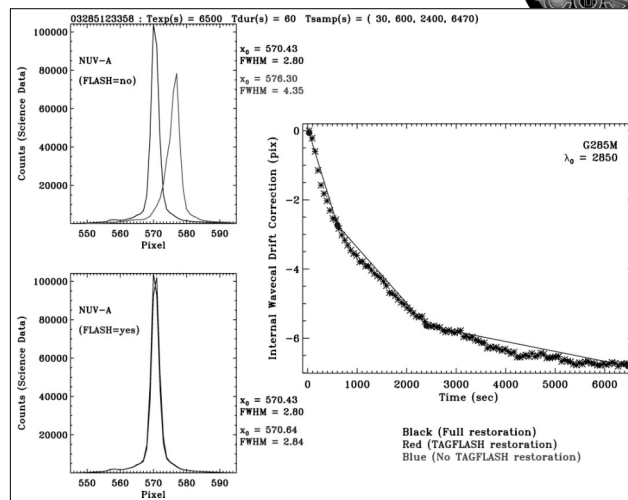
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Spectrum Drift Correction (TAGFLASH)



- Analysis of 2003 thermal vac data shows image motion can be corrected to <0.25 resel/hr
- STScI has implemented TAGFLASH as default observing mode for COS; will be used in 2006 TV
- Lamp flashed at beginning and at intervals during every TIME-TAG exposure (based on time since last mechanism motion)
- Projected lamp usage sufficient to support COS over projected lifetime



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TAGFLASH Testing



- Tests during Thermal-Vac II
- Lamp Lifetime Tests ongoing at NIST and CU
- SMOV tests
 - Determine drift character on-orbit for suite of OSM motions
 - Allows changes for on-orbit understanding of drift
 - Early pattern will be conservative (more flashes)

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Ground Science Calibration 2006



- Science calibration tests in November 2006 TV II test at GSFC
- Goals of 2006 test plan (“Appendix C”):
 - Demonstrate continued nominal performance of COS
 - Exercise new modes and capabilities: e.g., “TAGFLASH” observing mode
 - Obtain additional information needed to reduce and interpret science data: external FUV flat-field observations
- Will not repeat all tests from 2003; only those required to meet above goals
- Two-tiered test plan: required tests and optional tests to be executed only if questions arise about the current performance of COS
- Close STScI Thermal-Vac Coordination with IDT
 - Coordinated development of CALCOS via detailed AV-03 specifications and Calibration Working Group meetings
 - Coordinating Thermal-Vac staffing resources and schedules
 - FUV and NUV Thermal-Vac data processed by OPUS and ingested in MAST
 - Initial reference file delivery from IDT prior to SMGT in March 2006

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TV II Science Cal Tests



Required Tests

Test #	Activity
1111-1121	FUV spectra of PtNe lamp
1161-1191	NUV spectra of PtNe lamp
1210-1230	FUV sensitivity measurements
1250-1295	NUV sensitivity measurements
1300-1391	FUV external flat-field
2250	NUV spatial resolution
2300-2350	Grating stability, FUV & NUV
3300-3310	BOA transmission & resolution
3500-3550	OSM1 & OSM2 position checks
4000	FUV line spread function
5000	Tag-flash test

Contingency Tests

1410-1475	Target acquisition
1700-1750	Internal flat-fields
2745	FUV detector optimization
2805-2810	High local count rates
2950	NUV resolution at FUV PSA off

- Items in red are new tests for 2006.
- Total run time is at approximately 13 days for required tests and 21 days for required+contingency. Science calibration has 23 days in the schedule.

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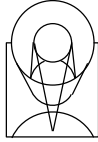


SMOV4 Timeline Summary



- SMOV4 requirements developed and reviewed in summer 2003.
- “Delta” concept/requirements review in December 2006
- SMOV activity planning (Jan-Mar 2007)
- SMOV Project Review: Apr 2007
- SMOV Program generation: Apr-Sep 2007

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On-orbit Calibration

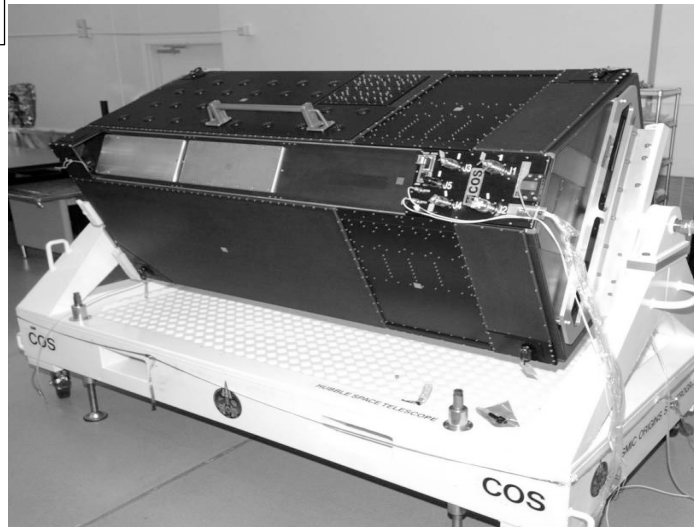


- Coordinated SMOV and C17 calibration programs to fully calibrate SI.
- Full set of SMOV requirements reviewed and approved in summer 2003 (“delta” review in Dec 2006)
 - e.g., basic aliveness and functional checkout; locate apertures, verify alignment and mechanism stability, verify TA, wavecalcs, spectral and spatial resolution, flatfields, sensitivity; LSF, drift characteristics
 - Full suite of requirements may be found at:
 - > <http://www.stsci.edu/smov/smov4webfolder/SMOV4REQUIREMENTS/smov4webpostings/smovcosrqmts.pdf>

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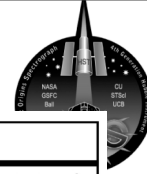
Cosmic Origins Spectrograph Supplementary Material



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Cosmic Origins Spectrograph



	FUV MCP	NUV MAMA
Photocathode	CsI (opaque)	Cs ₂ Te (semi-transparent)
Window	None	MgF ₂ (re-entrant)
Wavelength range	1150 – 2050 Å	1700 – 3200 Å
Active area	85 x 10 mm (two)	25.6 x 25.6 mm
Pixel format	16384 x 1024 (two)	1024 x 1024
Pixel size	6 x 24 µm	25 x 25 µm
Spectral resolution element size	6 x 10 pix	3 x 3 pix
Quantum efficiency	26% at 1335 Å 12% at 1560 Å	10% at 2200 Å 8% at 2800 Å
Dark count rate	~0.5 cnt s ⁻¹ cm ⁻² ~7.2x10 ⁻⁷ cnt s ⁻¹ pix ⁻¹ ~4.3x10 ⁻⁵ cnt s ⁻¹ resel ⁻¹	~34 cnt s ⁻¹ cm ⁻² ~2.1x10 ⁻⁴ cnt s ⁻¹ pix ⁻¹ ~1.9x10 ⁻³ cnt s ⁻¹ resel ⁻¹
Detector global count rate limit	TTAG	~21,000 cnt s ⁻¹
	ACCUM	~60,000 cnt s ⁻¹ segment ⁻¹
Local count rate limit	~100 cnt s ⁻¹ resel ⁻¹ ~1.67 cnt s ⁻¹ pix ⁻¹	~1800 cnt s ⁻¹ resel ⁻¹ ~200 cnt s ⁻¹ pix ⁻¹

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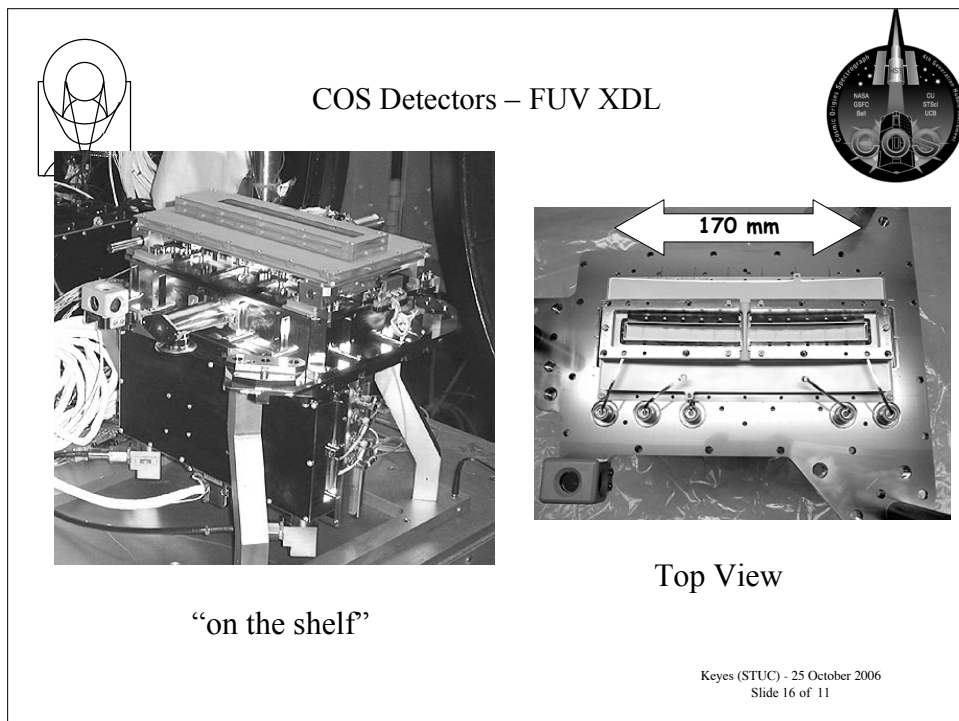
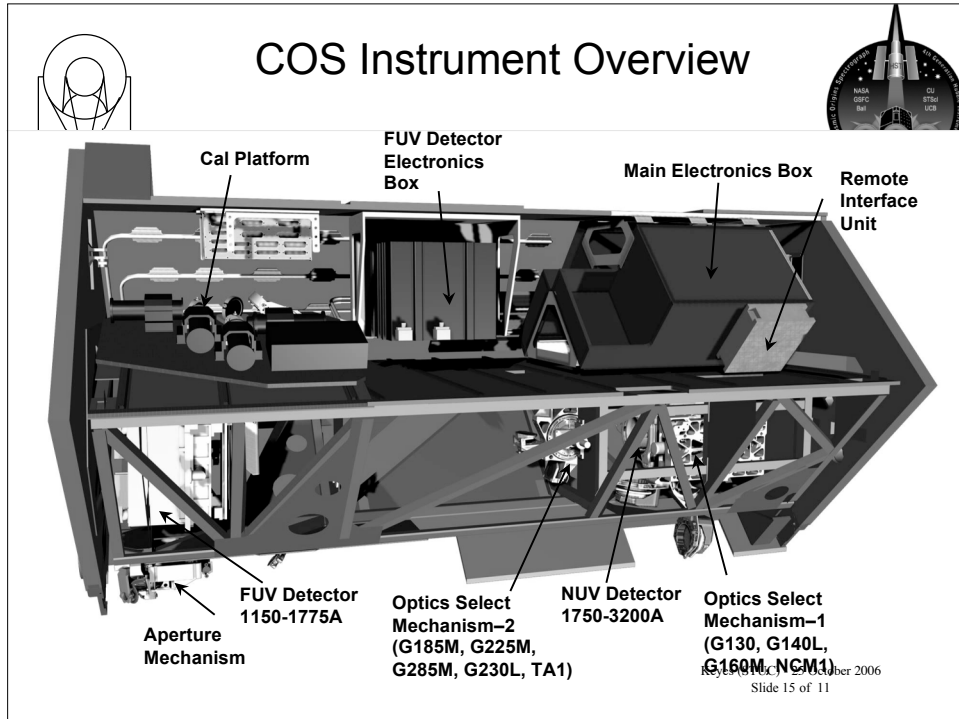


Spectral Resolution and Bandpass Summary



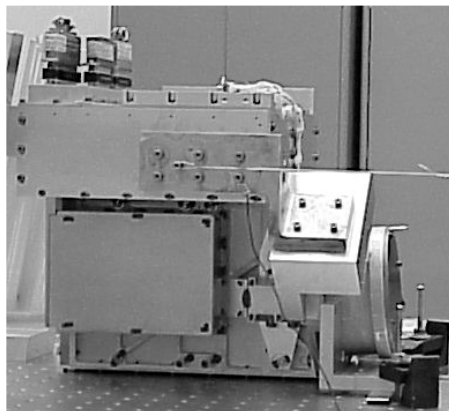
- FUV channel
 - G130M R > 20,000 λλ 1150-1450
 - G160M R > 20,000 1405-1775
 - G140L R > 2,000 1230-2050
- NUV channel
 - G185M R > 16,000 1700-2100 (3x35)
 - G225M R > 20,000 2100-2500 (3x35)
 - G285M R > 20,000 2500-3000 (3x41)
 - G230L R > 1,700 (most of bandpass) 1700-3200
- Bright Object Aperture (BOA) resolution degraded
 - Wedge in ND filter degrades resolution by factor of ~2.5 for FUV modes and ~4 for NUV modes.

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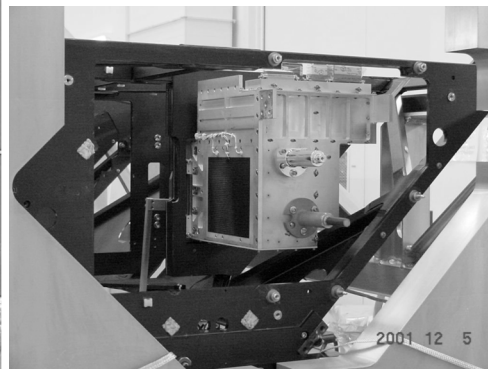




COS Detectors – NUV MAMA



“on the shelf”

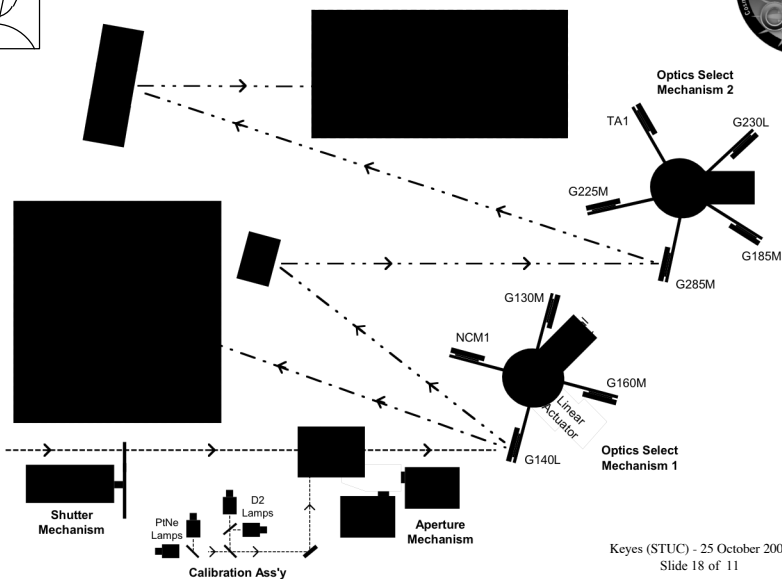


in the enclosure

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COS Optical Layout



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Spectral Drift Correction (TAGFLASH)



- Correction needed to meet Level 1 requirements
 - Spectral resolution (and perhaps more importantly, line shape)
 - Wavelength zero point
- Simple correction could be done with existing wavecal capabilities outside science exposures if necessary
 - Wavecal at beginning and/or end of science exposure
 - > Not satisfactory for long exposures
 - > Long exposures could be broken into shorter exposures with additional overhead (~4 min per wavecal, or about 8% observing efficiency loss *per wavecal* assuming 52 minute orbital visibility)
- TAGFLASH will embed wavecals in science time
 - TIME-TAG mode ONLY
 - No overhead for wavecals at all
 - CALCOS updated to correct for drifts

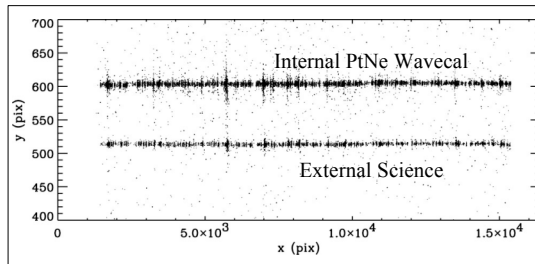
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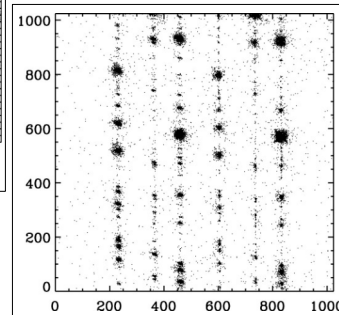
COS Spectral Layout for Simultaneous Internal Wavecals and Science Spectra



FUV MCP (1 of 2 segments)



NUV PtNe External
MAMA Wavecal Science
C B A C B A



- Obtain (continuous or flashed) internal PtNe spectra at same time as science exposure
- Track internal PtNe lines and apply shifts to science spectrum (all events time-tagged) in COS data pipeline
- Scattered light from internal wavecal at position of science spectrum is negligible (<1%); residual events can be removed from TIME-TAG list.

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