The Cosmic Origins Spectrograph:
On Orbit Performance Update

Steve Osterman
Steve Penton
Stéphane Béland

Agenda

- COS overview
- COS sensitivity and sensitivity trends
- Blue Modes
- FUV gain sag, Y walk and lifetime moves
- NUV detector backgrounds
- CALCOS and Reference Files

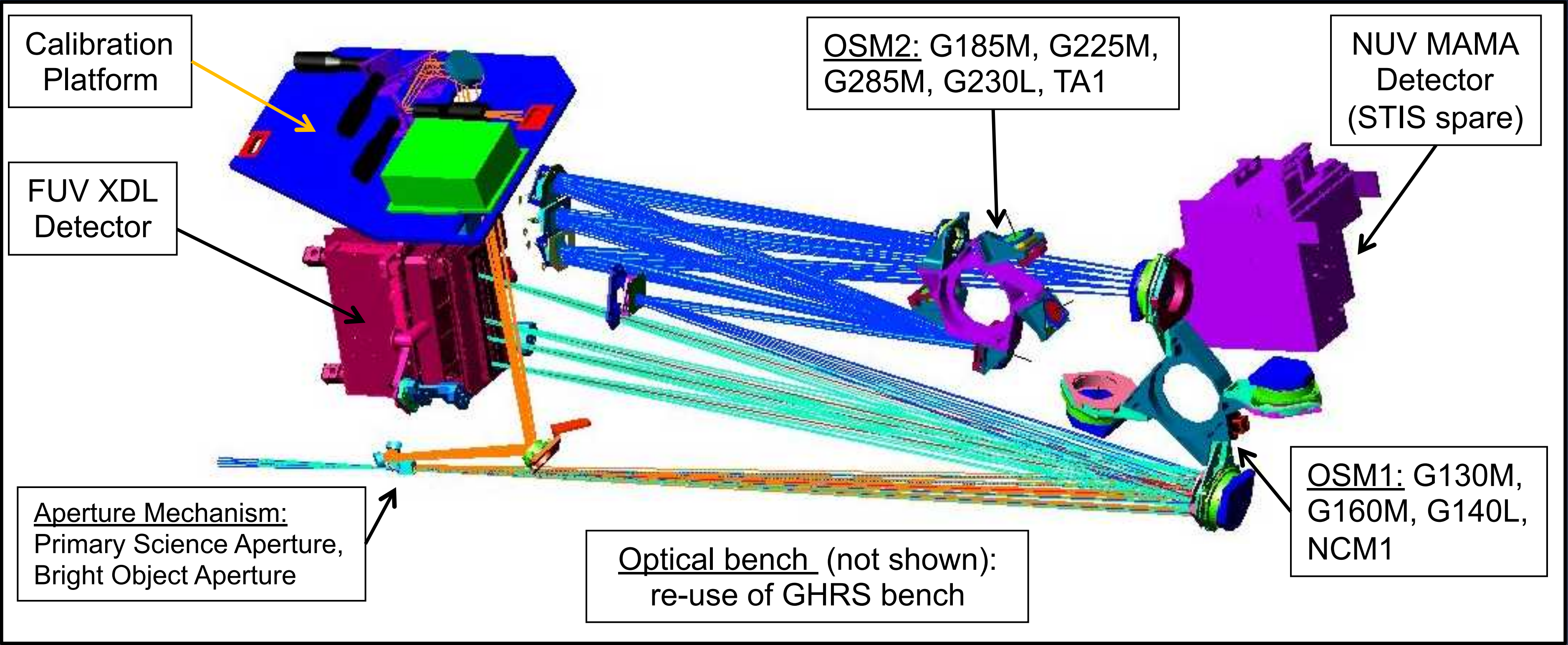
COS Performance Analysis Team

Thomas Ake (STScI), Alesandra Aloisi (STScI), Stéphane Béland (CU), Eric Burgh (CU), Charles Danforth (CU), Kevin France (CU), Cynthia Froning (CU), Parviz Ghavamian (STScI), Paul Goudfrooij (STScI), James Green (CU), George Hartig (STScI), Brian Keeney (CU), Tony Keyes (STScI), Daniel Lennon (STScI), Derck Massa (STScI), Jason McPhate (UCB), Christina Oliveira (STScI), Rachel Osten (STScI), Steve Osterman (CU), Steve Penton (CU), Dave Shanow (JHU), Ed Smith (STScI)

COS FUV Sensitivity Anomaly Review Board

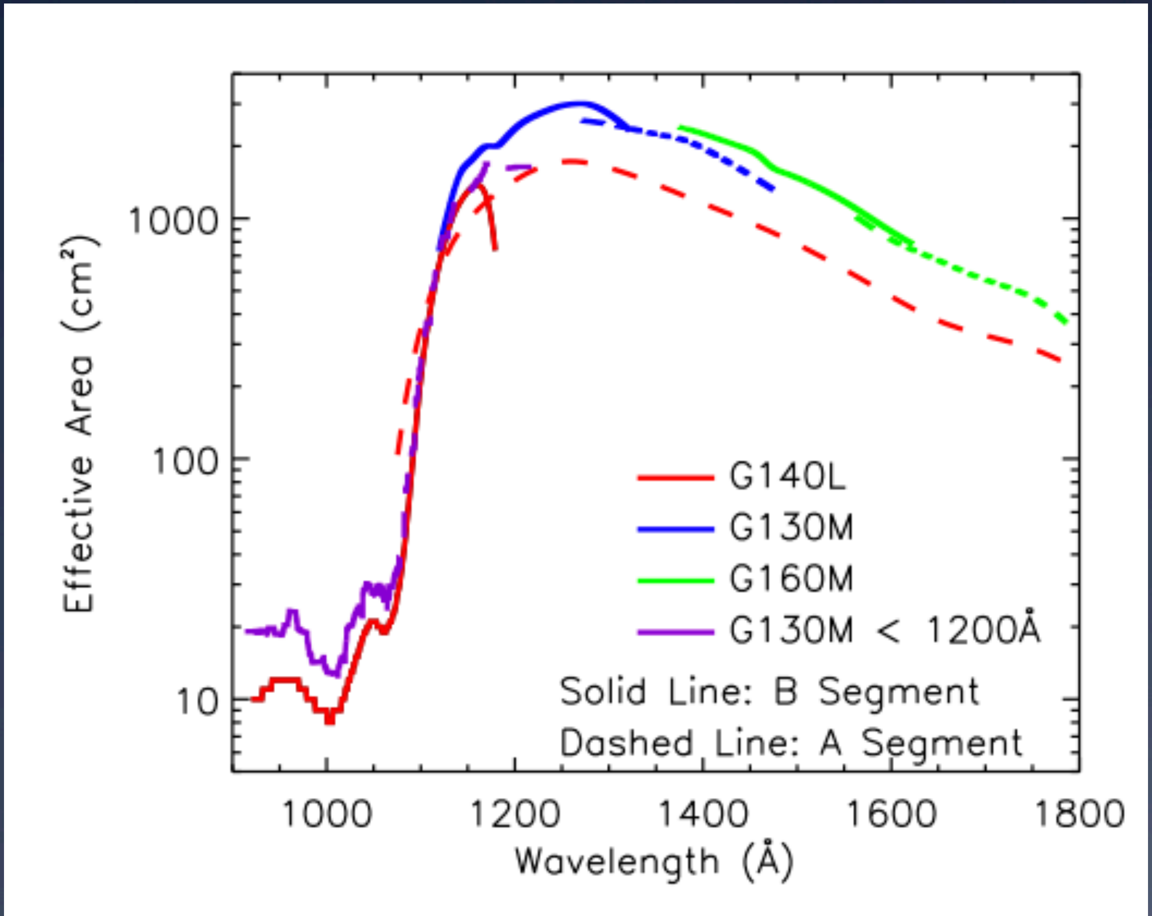
Randy Kimble, chair	David Hughes
Olivia Lupie, secretary	Jason McPhate
John Bacinski	Mal Niedner
Bruce Banks	Steve Osterman
Carey Cates	Charles Proffitt
Larry Dunham	Betsy Pugel
Eric Graham	Tom Wheeler
Additional key contributors: Joshi Anne, Paul Christensen, Brett Cruden, John Emmert, Rachel Osten, Aaron Paterson, Steve Penton, Marjorie Sovinsky	

COS Instrument Overview



- COS has 2 channels to provide medium and low resolution UV spectroscopy ($\lambda/\Delta\lambda$~20,000 and ~1500)
- **FUV gratings**: < 1150-1775Å, G130M, G160M, G140L
- **NUV gratings**: 1700-3200Å, G185M, G225M, G285M, G230L

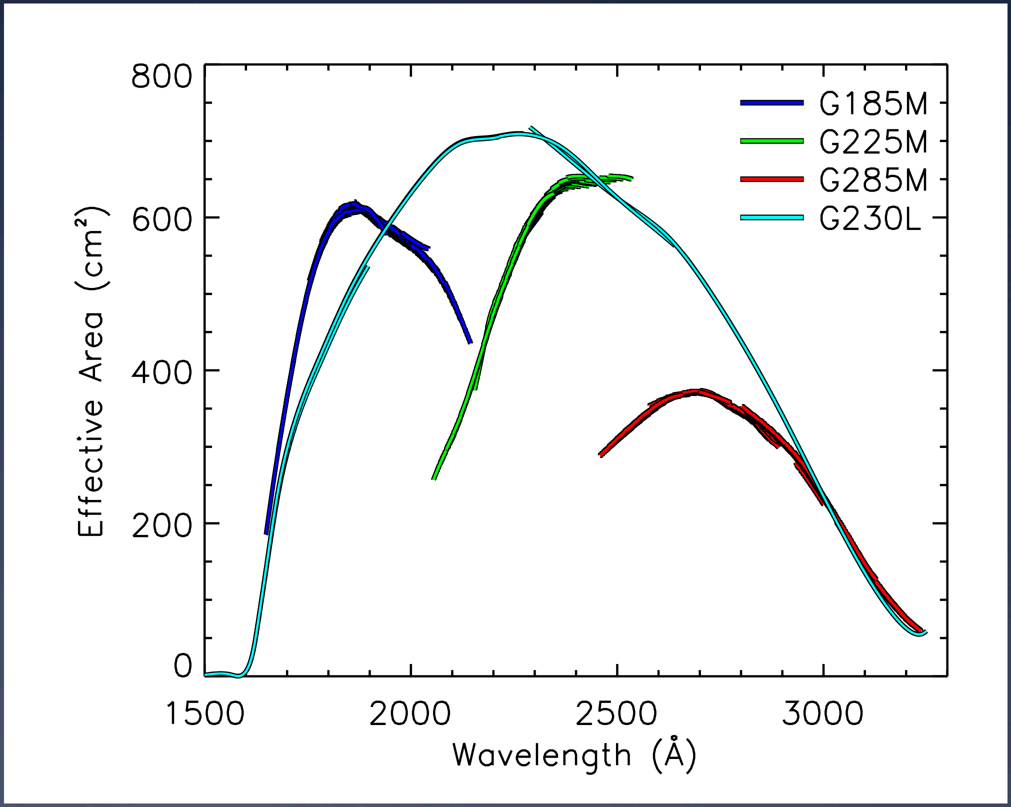
FUV Sensitivity



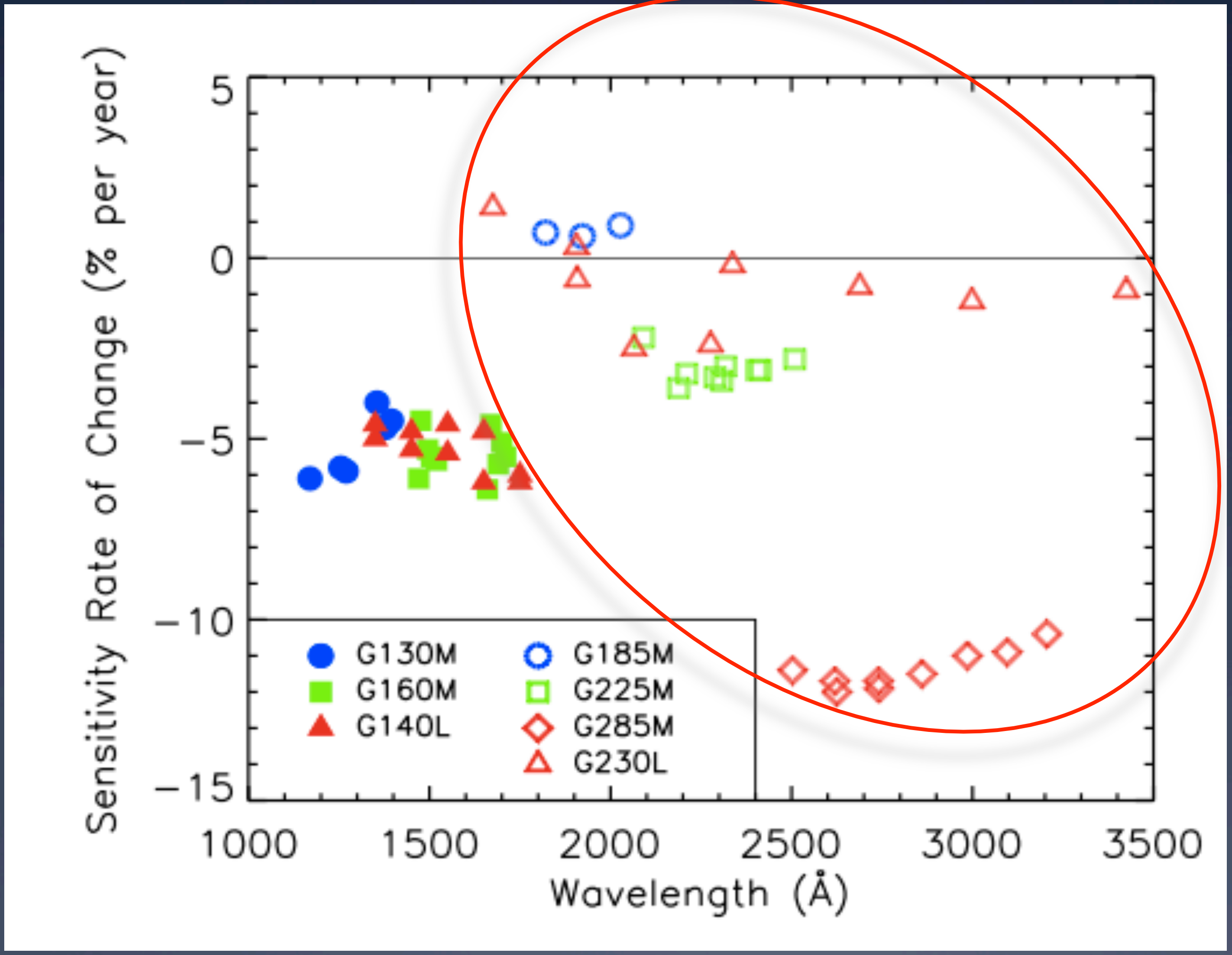
- FUV Sensitivity consistent with pre-launch calibration
- Exceeds CEI, proposal
- FUV gains >10 in sensitivity, 70 in observing speed
- COS gains: faint targets (discovery), observing times (survey)

NUV Effective Area

- G230L performance exceeds prelaunch predictions (black dotted line)
- Second order light in C strip clearly identified
- Second order light seen in B stripe above 3200Å not easily separated from first order



COS Time Dependent Sensitivity



COS Time Dependent Sensitivity: NUV gratings

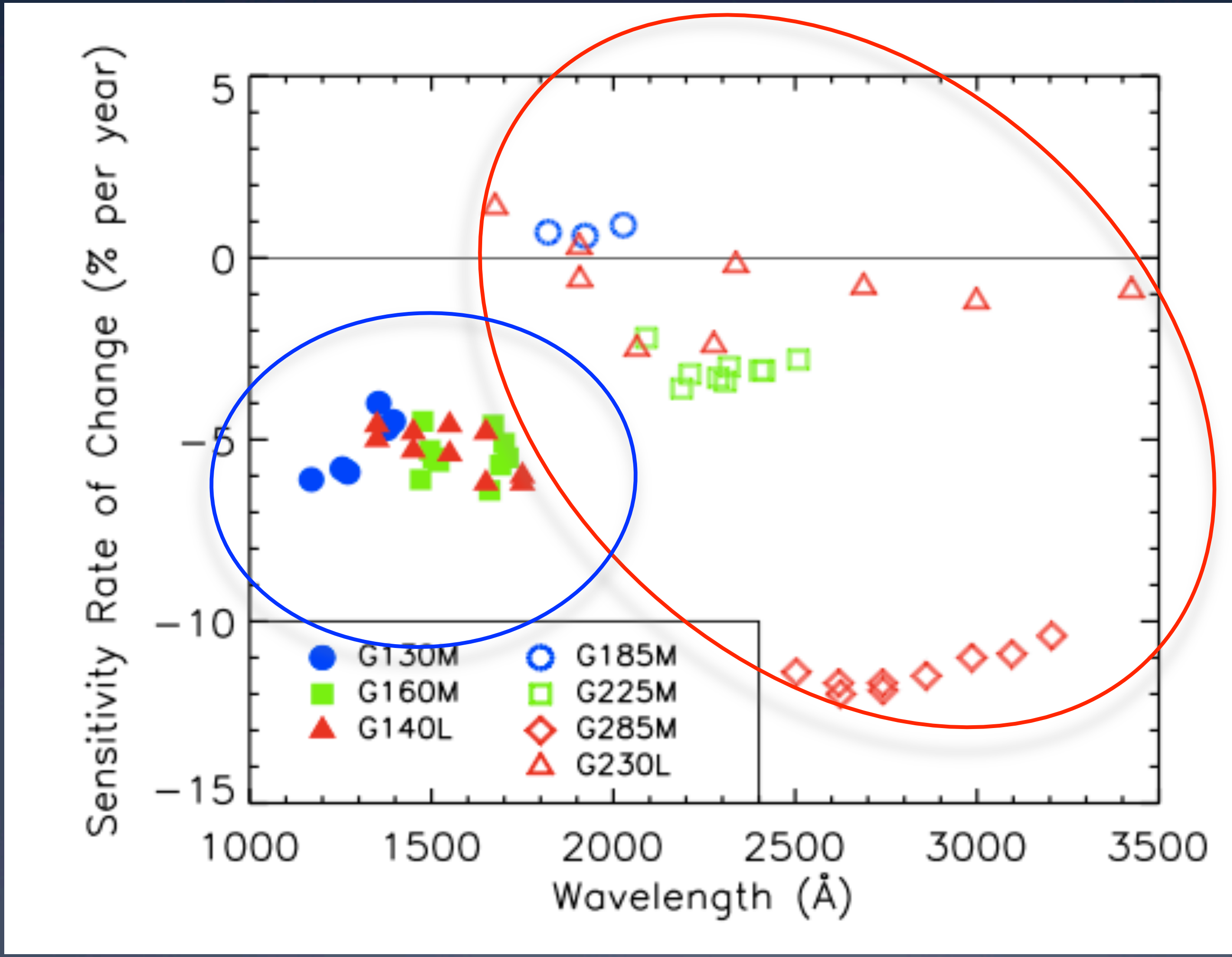
- Original NUV grating design:
  - G185M: MgF_2/Al, 5870 lines/mm (170nm/line)
  - G225M: MgF_2/Al, 4800 lines/mm (208nm/line)
  - G285M: MgF_2/Al, 4000 lines/mm (250nm/line)
  - G230L: MgF_2/Al, 500 lines/mm (2.0 μm/line)
- -M gratings performance below expectation in band
- Solution:
  - Use G225M in G185M position
  - G225M, G285M gratings coated with bare aluminum

COS Time Dependent Sensitivity: NUV gratings

Explanation:

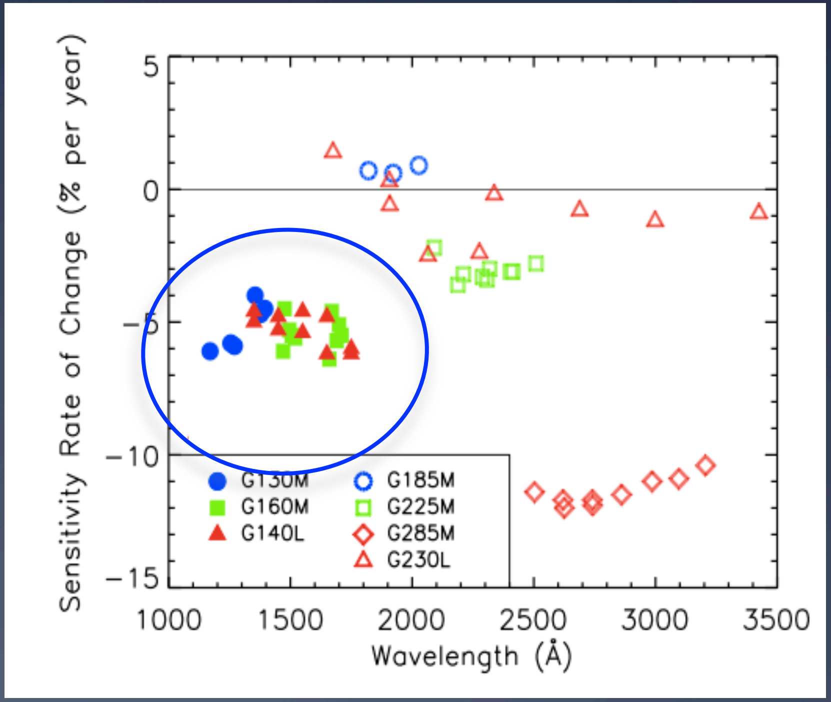
- Small changes in the Al_2O_3 thickness can move the TM minimum to longer wavelengths, dropping the mean efficiency.
- This might also be caused if the structure (and index of refraction) of the existing layer evolved with time.
- Continued decline in vacuum was unexpected
- Since launch t he trend shows no change with time

COS Time Dependent Sensitivity

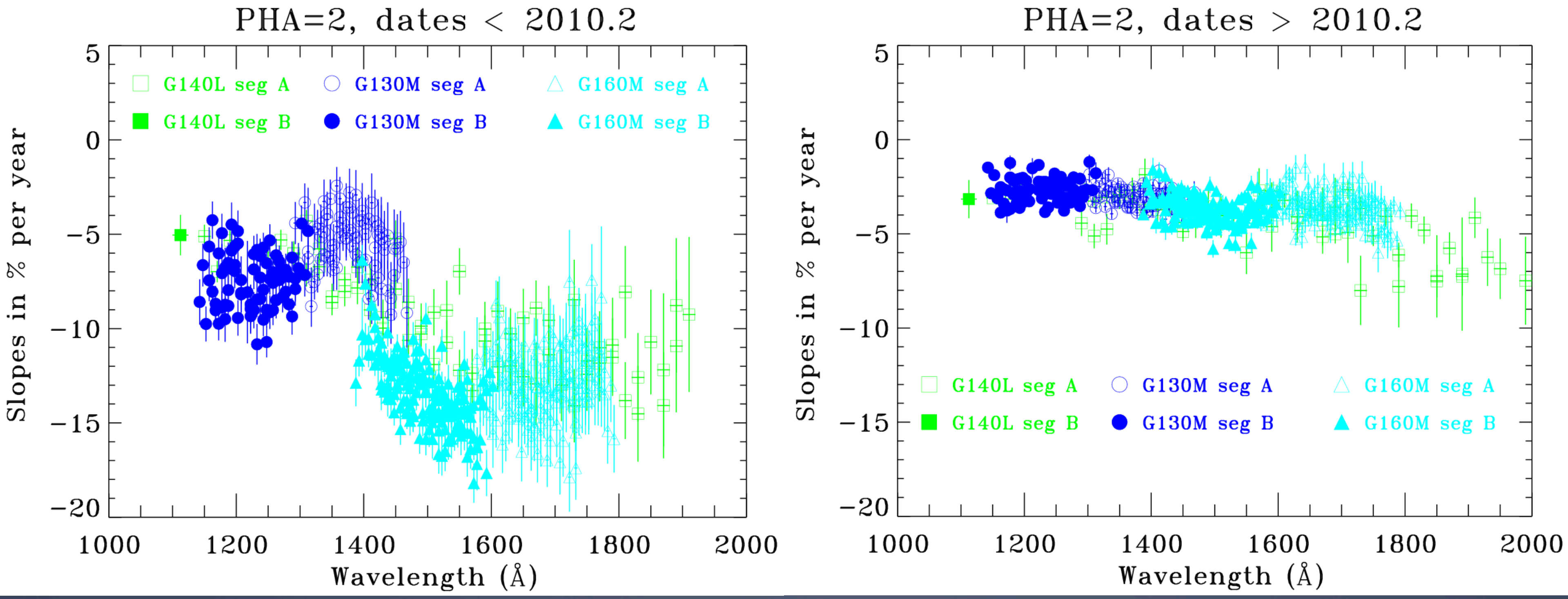


COS Time Dependent Sensitivity: FUV detector

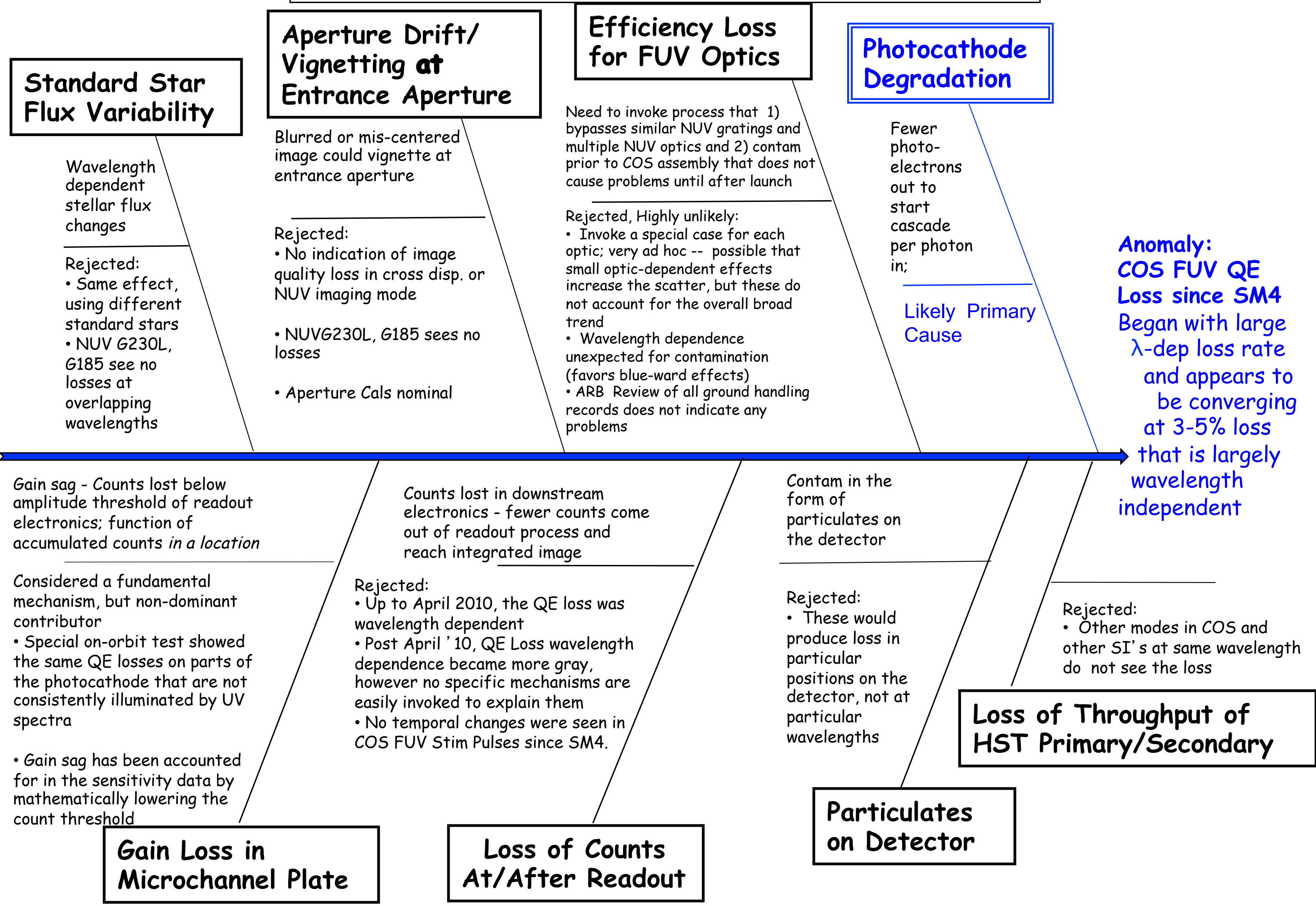
- NUV/FUV overlap – the G230L, G185M modes show no decline, despite many more surfaces ⇒ not optical contamination
- Not traceable to pointing, pipeline
- Not explained by MCP gain sag
- Sensitivity decrease initially more severe at longer wavelengths, now ‘gray.’
- Principal candidate: Atomic oxygen or AO+water vapor



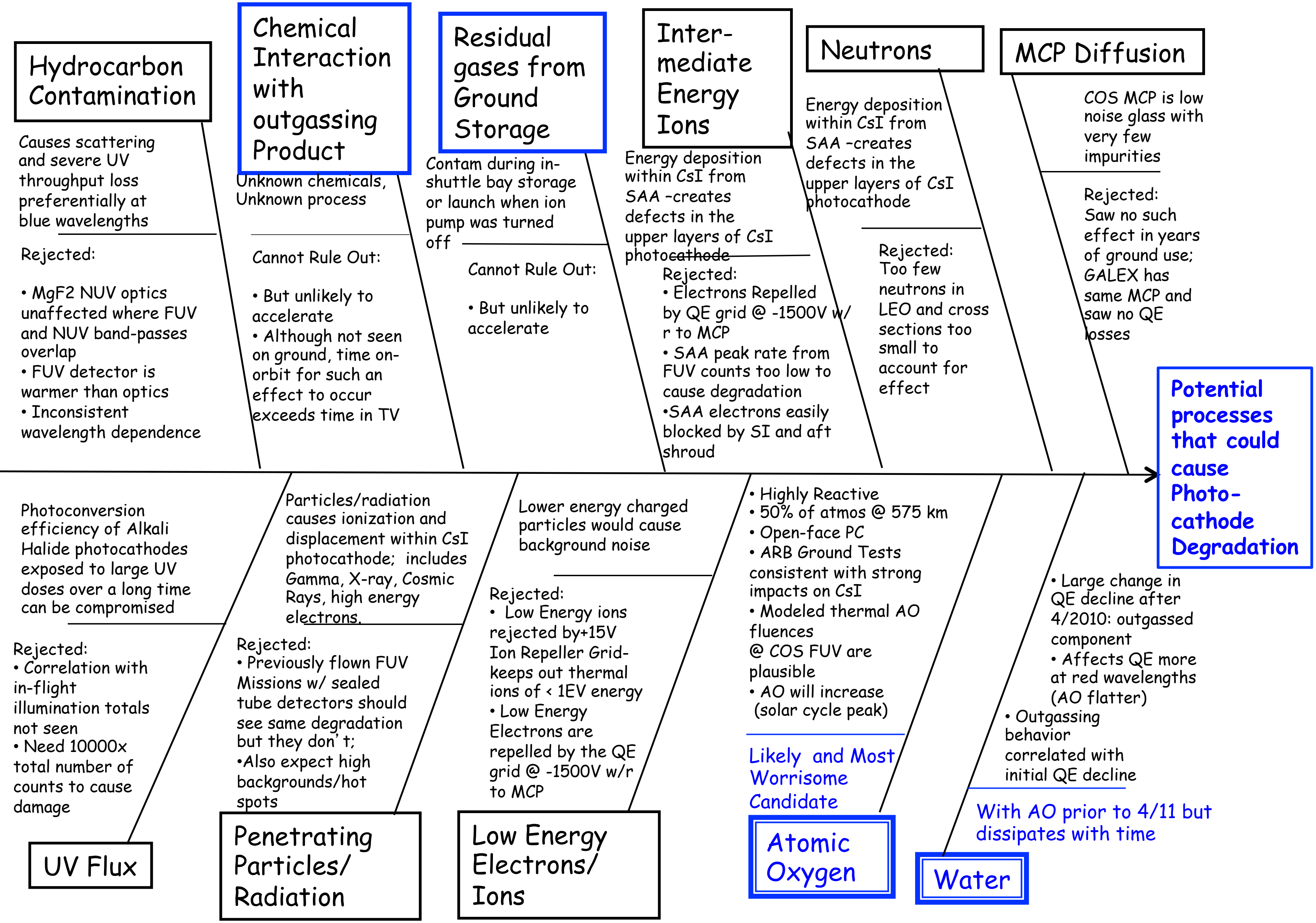
COS Time Dependent Sensitivity: FUV detector



Fault Tree Diagram for Sensitivity Loss

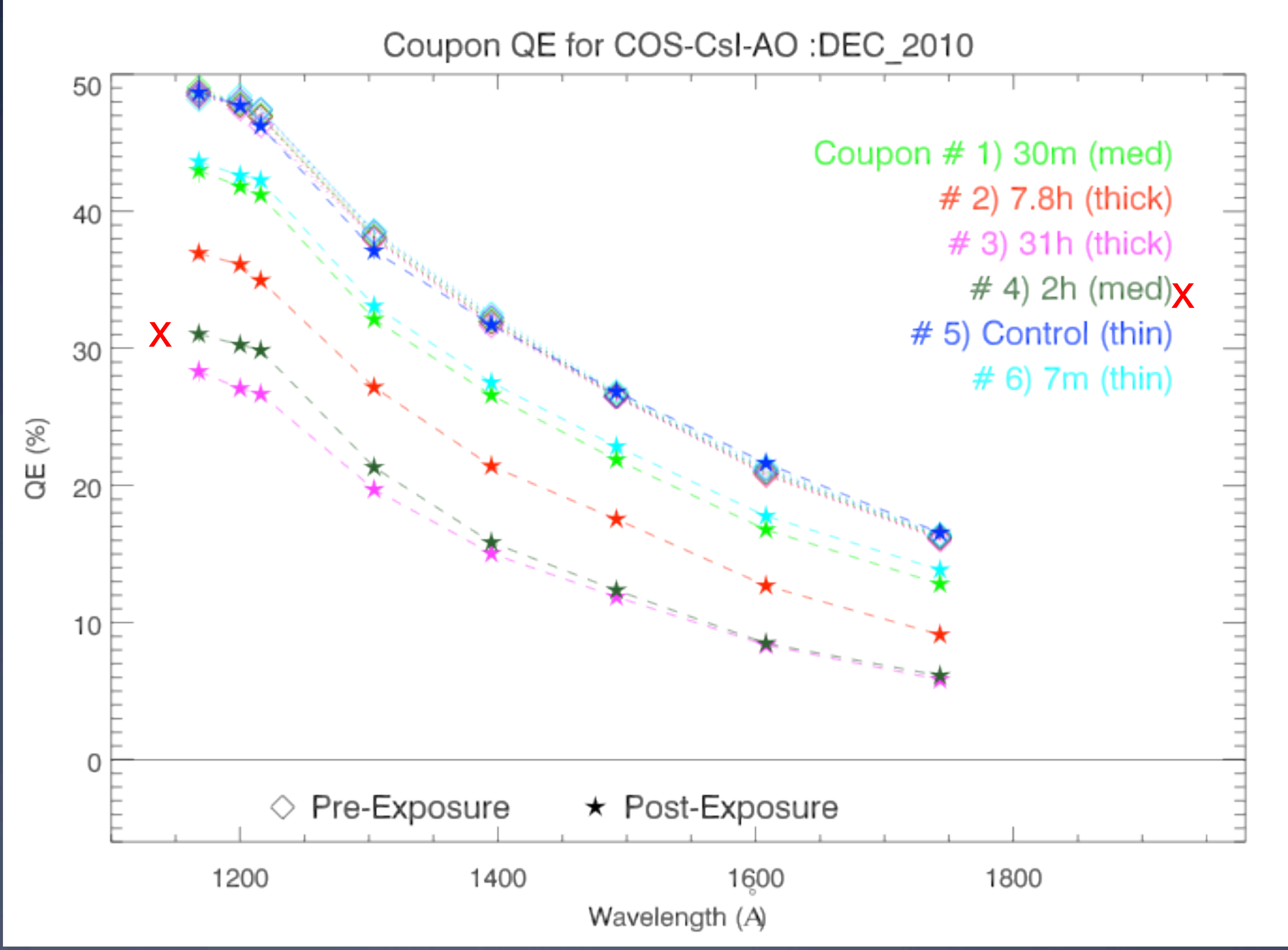


Fault Tree Diagram for Photocathode Degradation



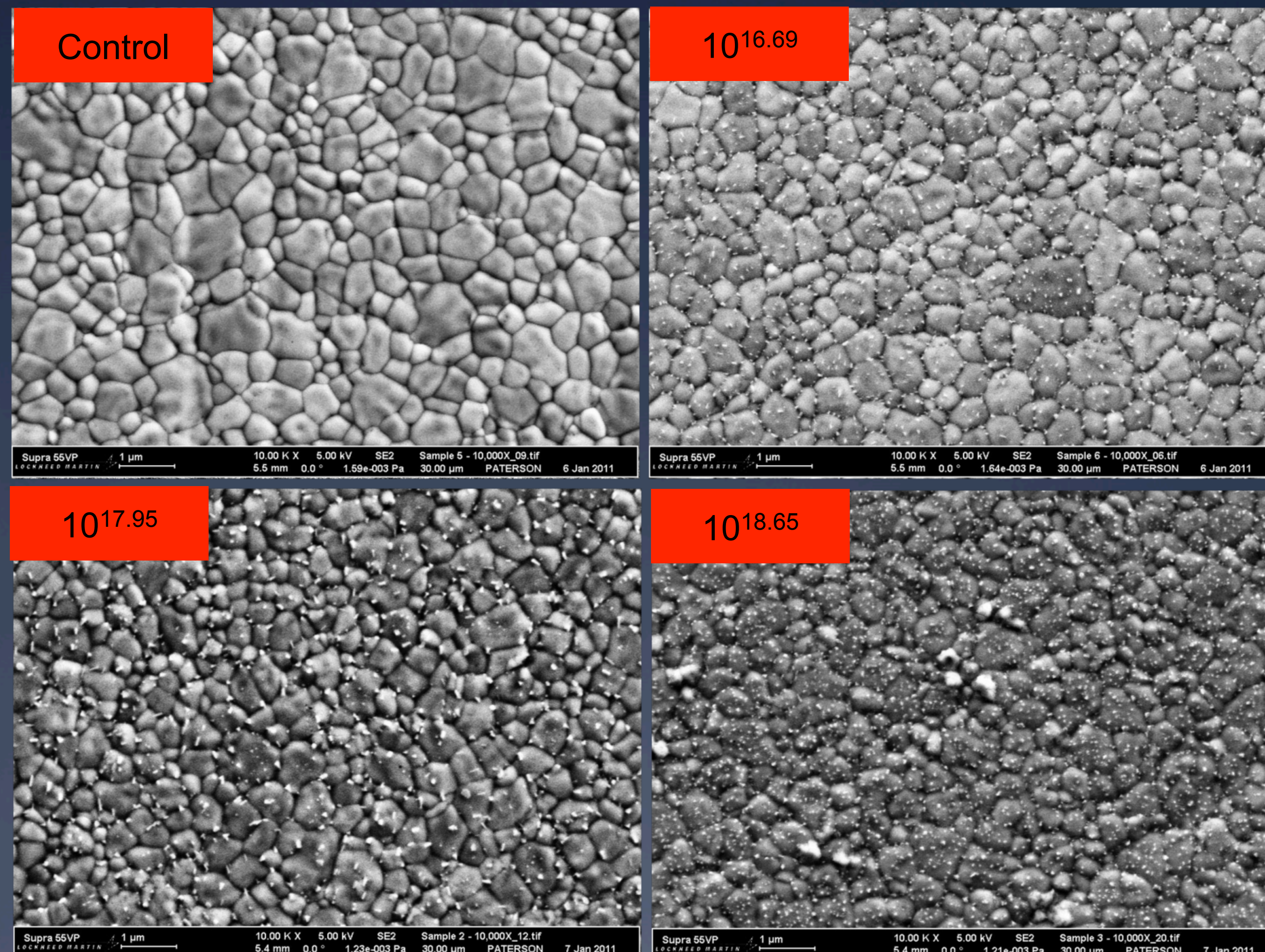
COS Time Dependent Sensitivity: AO Testing

- CsI samples exposed to AO in controlled environment at UCB
- Does impact performance
- Roughly gray shape (slightly worse at long wavelengths



COS Time Dependent Sensitivity: AO Testing

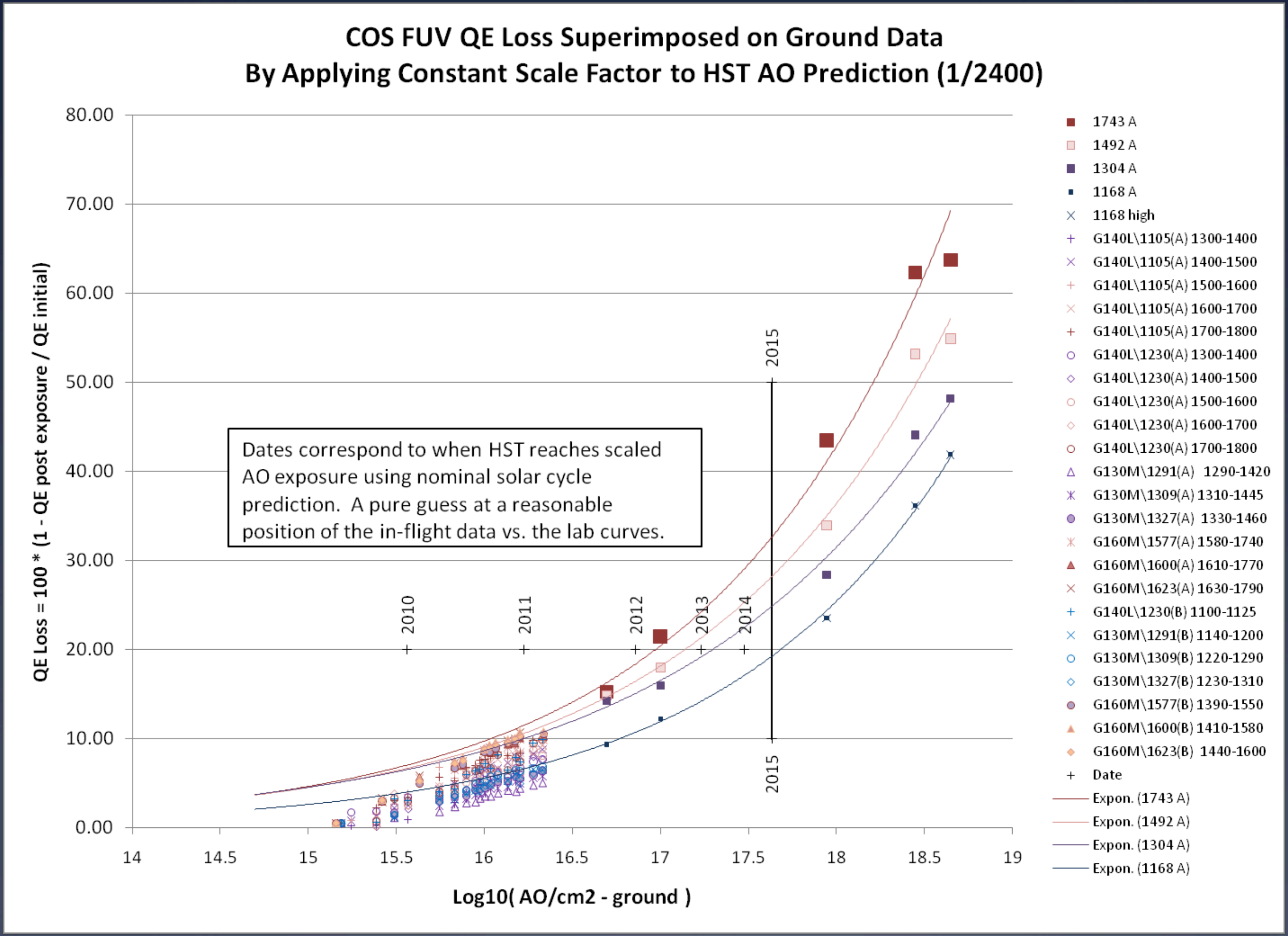
SEM reveals morphological changes – erosion of grain boundaries at high fluences – and growth of insulating nodules



COS Time Dependent Sensitivity: AO Testing

- QE loss appears to go as integrated exposure ^0.3 or ^0.5 - as we are exposed to more AO the rate of degradation should drop
- But – we're entering solar max, so more AO exposure expected
- The QE loss for the lowest fluence test point is greater than has been observed to date for COS in flight.
- At ~90x estimated exposure to date the QE loss is ~50% (the projected solar cycle predicts 20x current fluence by 2015.)

FUV Projections



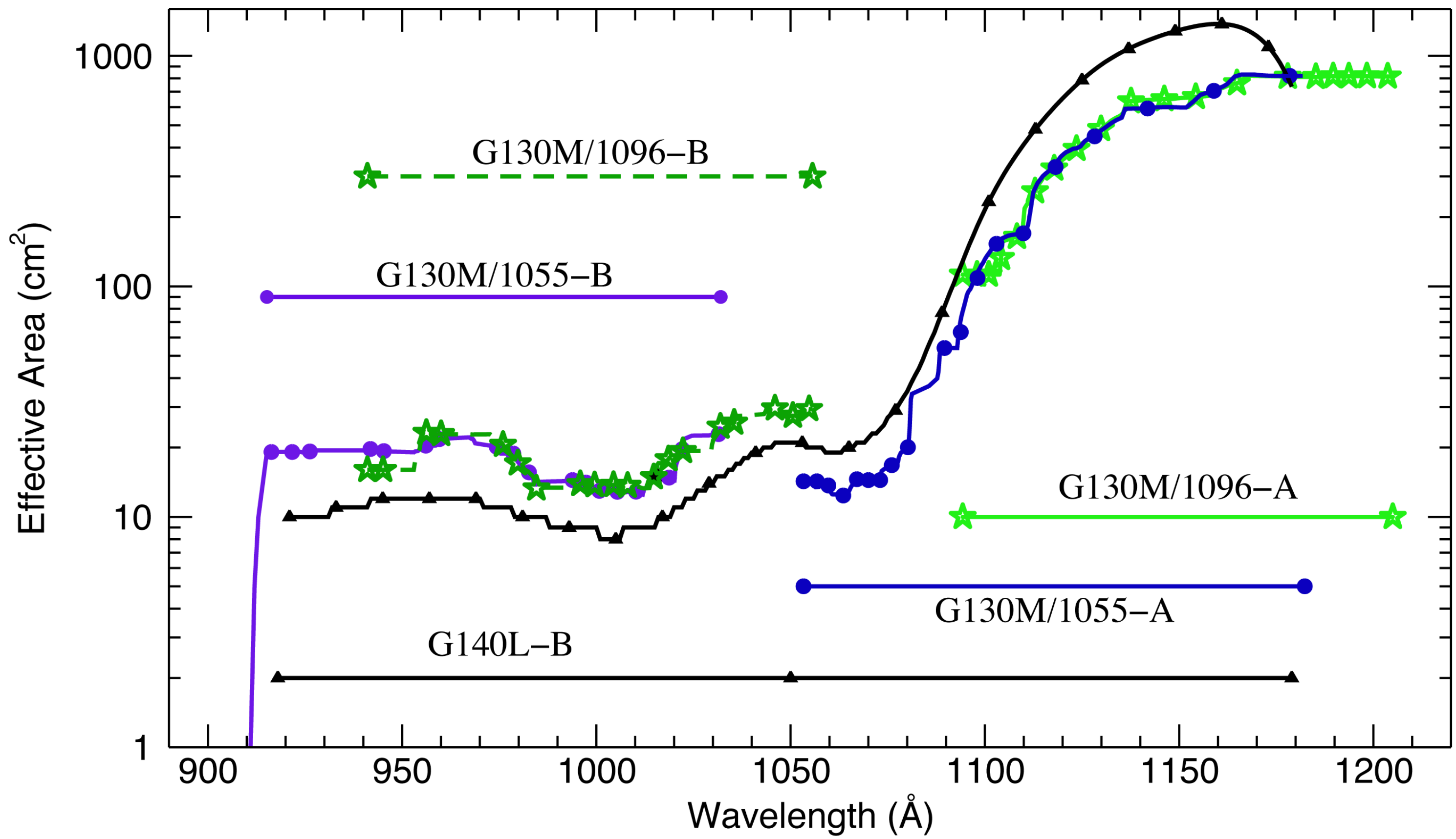
ARB Conclusions

- QE loss is expected to continue but should not rise linearly with AO density
- No action recommended for now – ram avoidance, etc. will not reduce exposure
- Loss of performance is not sufficient to front load COS observations
  - Other instruments are either single string (STIS, ACS) or are seeing loss of performance from other modes

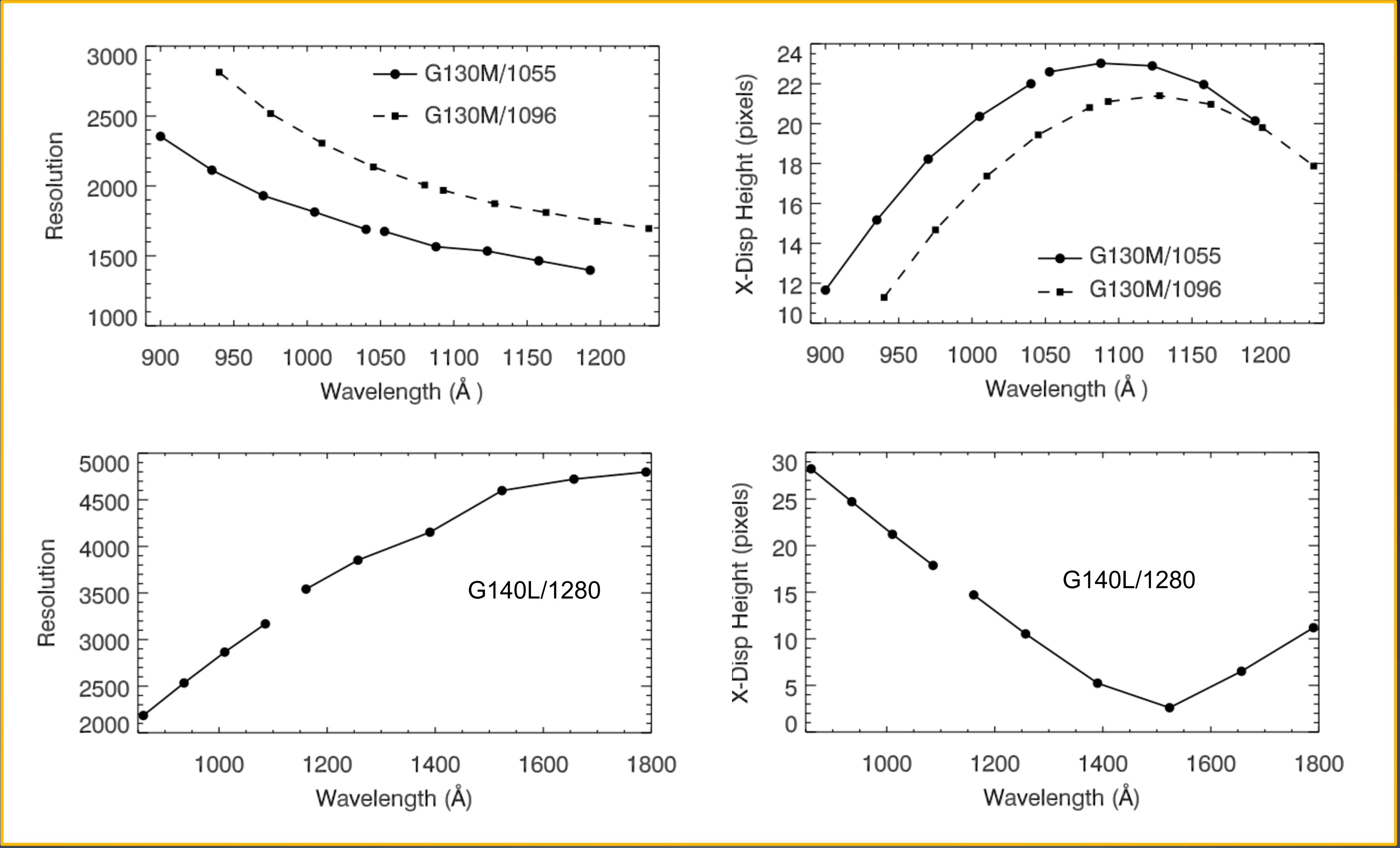
FUV Blue Modes

- Several sub-1150Å observing modes have been identified:
- G140L-1280, B segment (Verified in SMOV, available to observers)
- G130M -1055 and -1096 (Verified in 2010, in IHB, not currently supported for cycle 19)
- G130M -1222 (Proposed, CU)
- G140L-800 (G140L gapless, Proposed, JHU/CU)

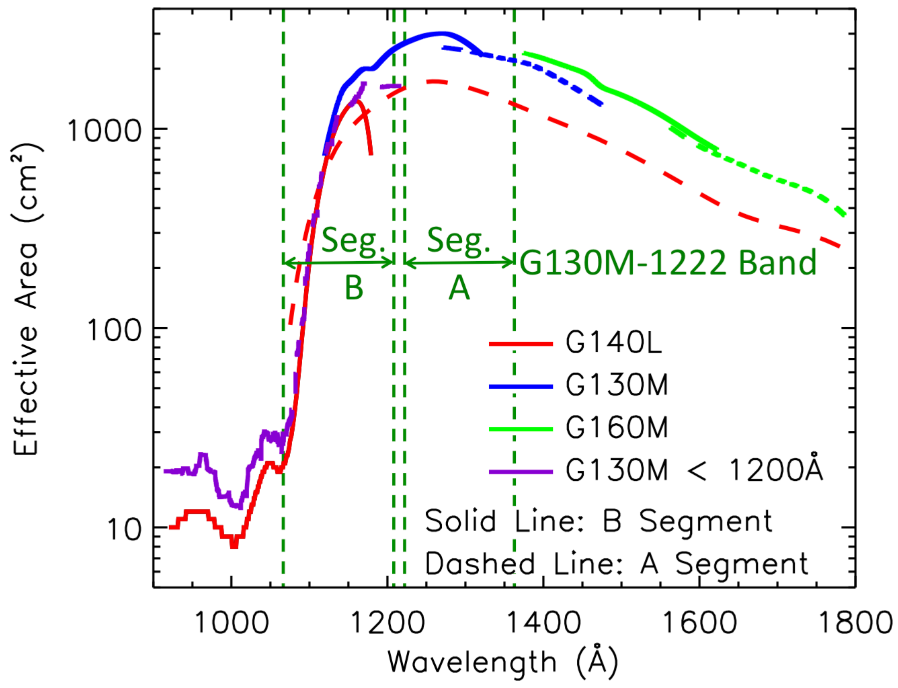
FUV Blue Modes

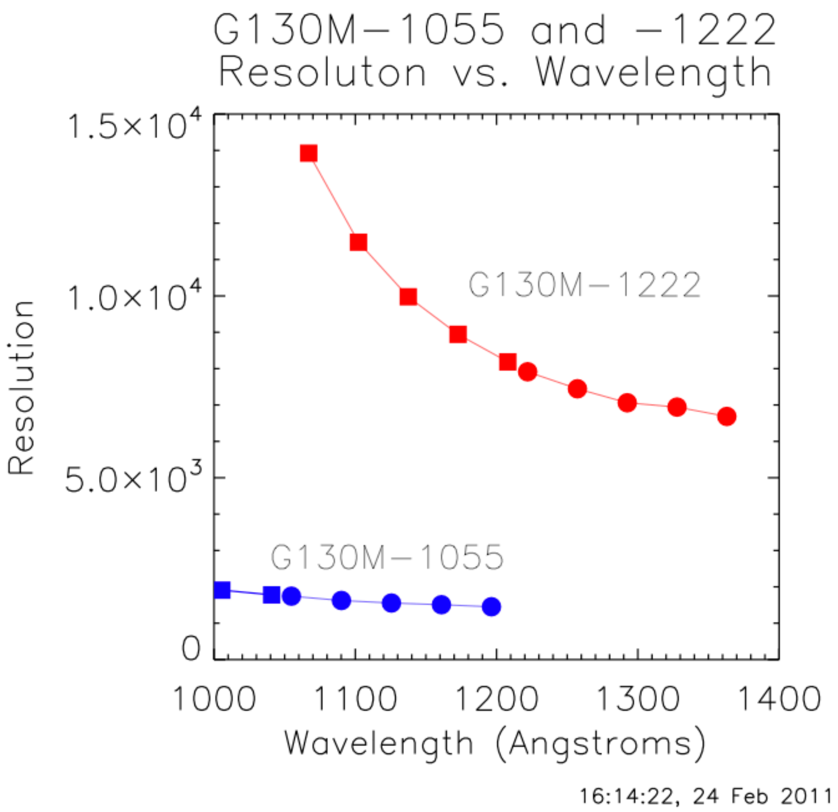


FUV Blue Modes

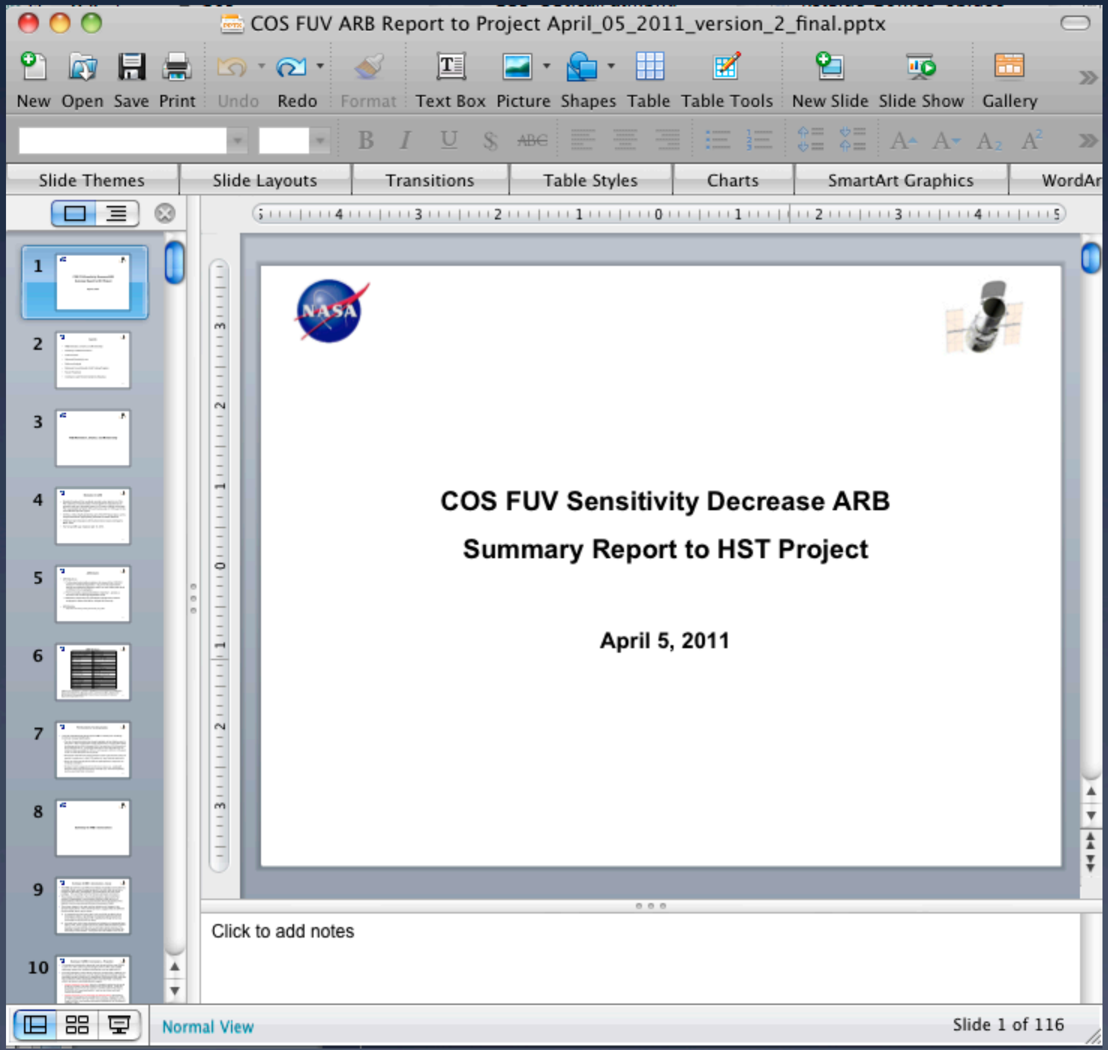


FUV Blue Modes: G130M-1222





Questions?



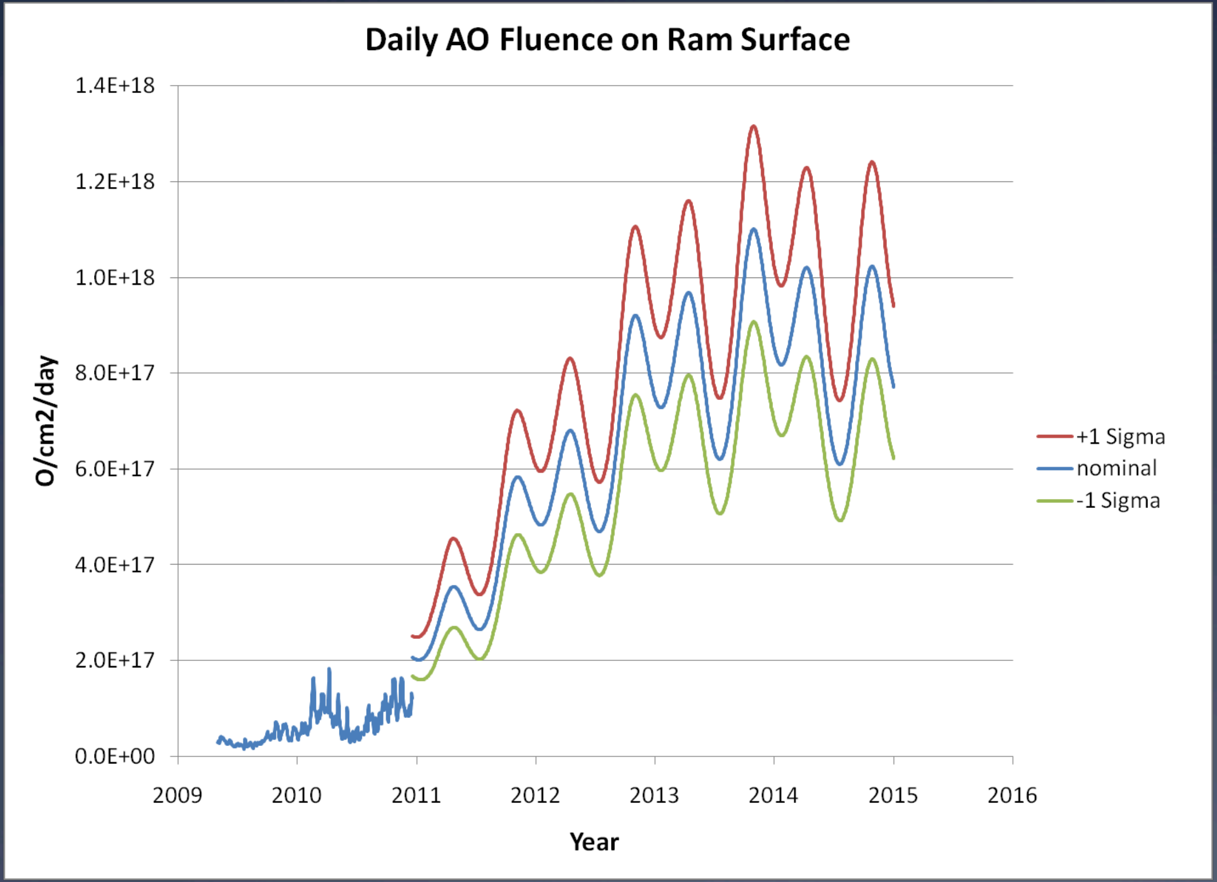
COS FUV ARB Report to Project April_05_2011_version_2_final.pptx
New Open Save Print Undo Redo Format Text Box Picture Shapes Table Table Tools New Slide Slide Show Gallery
Slide Themes Slide Layouts Transitions Table Styles Charts SmartArt Graphics WordAr
NASA
COS FUV Sensitivity Decrease ARB
Summary Report to HST Project
April 5, 2011
Click to add notes
Normal View
Slide 1 of 116


NASA
Atlantis
J.B. McPhate

Bonus Slides

AO Fluence Models

NRL (J. Emmert) has provided models of atmospheric density to date (normalized to satellite drag data) based on NOAA projections for the coming solar cycle. Note that while this prediction is for a weak solar cycle, the actual data through 2011.0 are still running below it.

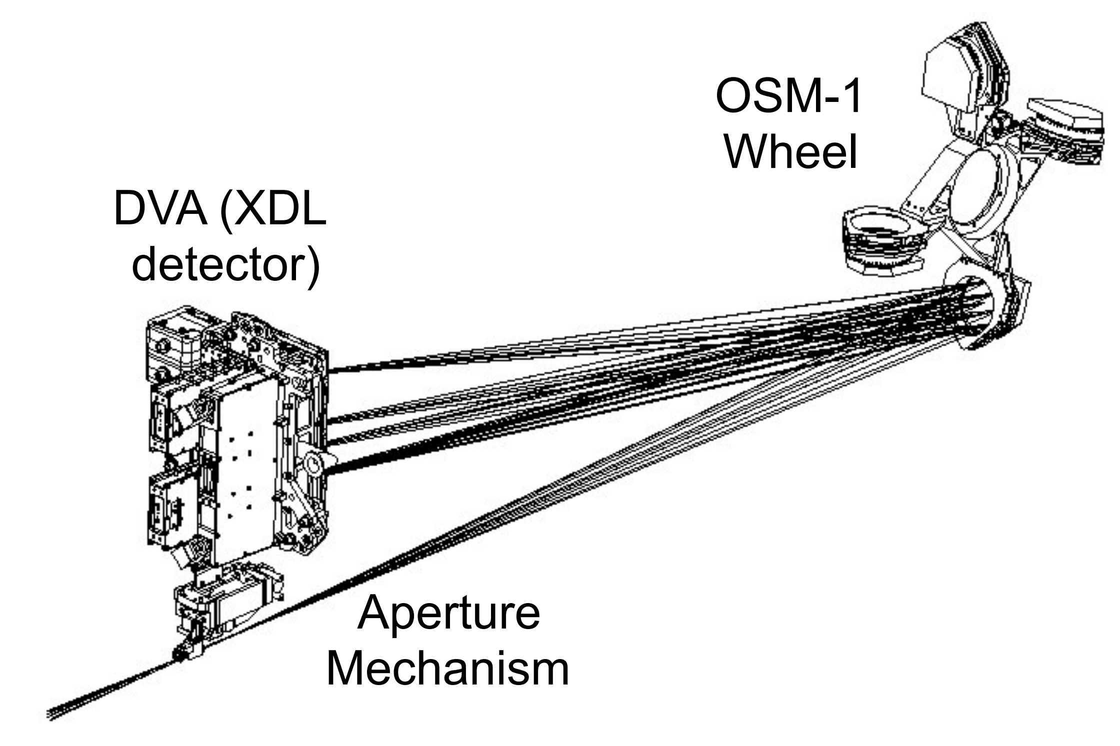


- These are *external* fluences, proportional to, but not equal to the fluences in our lab test.
- Note the increase in daily fluence by a factor of ~40 vs. the period immediately after SM4.
- Includes recent correction to HST altitude projection (now conservative).

COS FUV Channel

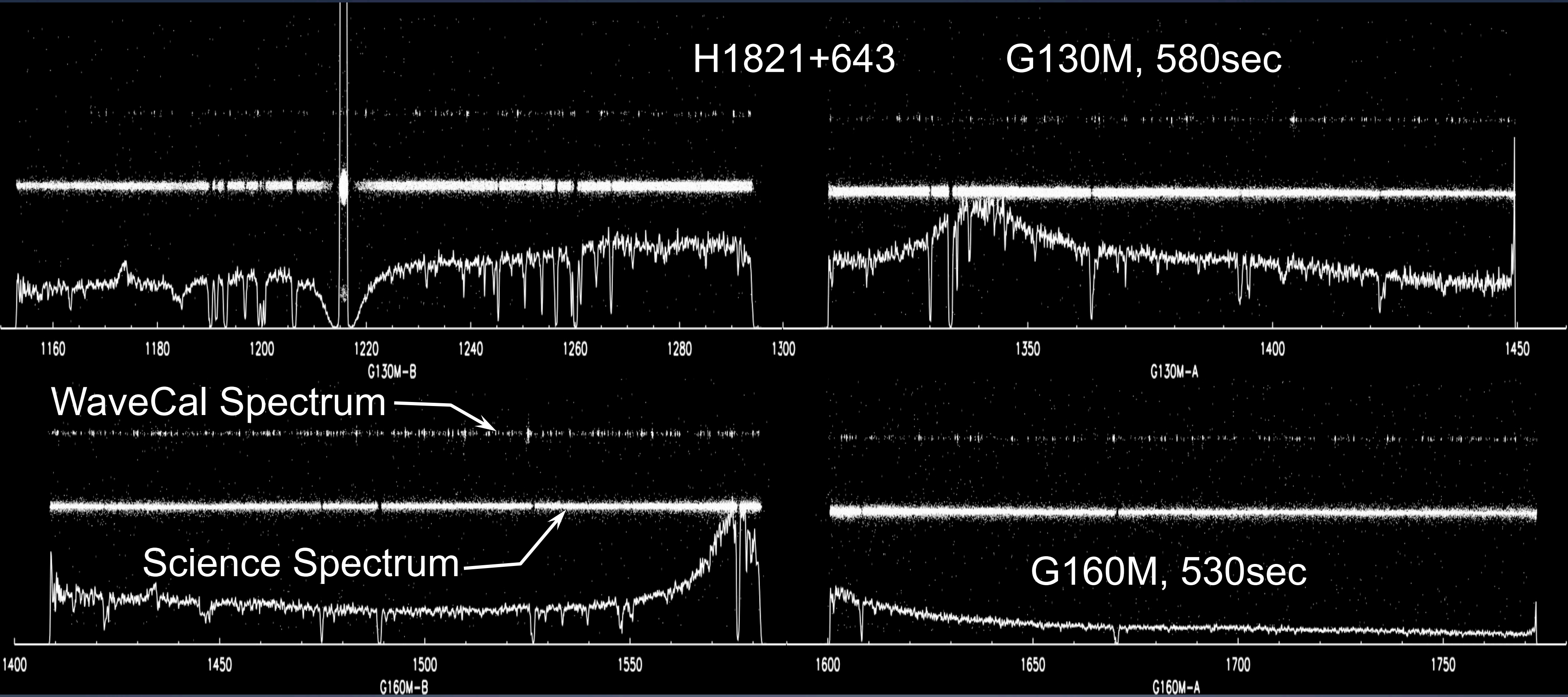
FUV Channel: Holograpically corrected off-Rowland

- Single reflection provides correction for HST aberration, diffraction and grating astigmatism correction
- Low scatter, holographcially ruled gratings with ~ 4880l/mm provide 16,000 - 21,000 Resolution from <1150-1800Å (300-370Å per grating position) in medium resolution modes
- Two segment (2 x 85x10 mm) XDL detector, ~36 μ m resolution



COS FUV Channel

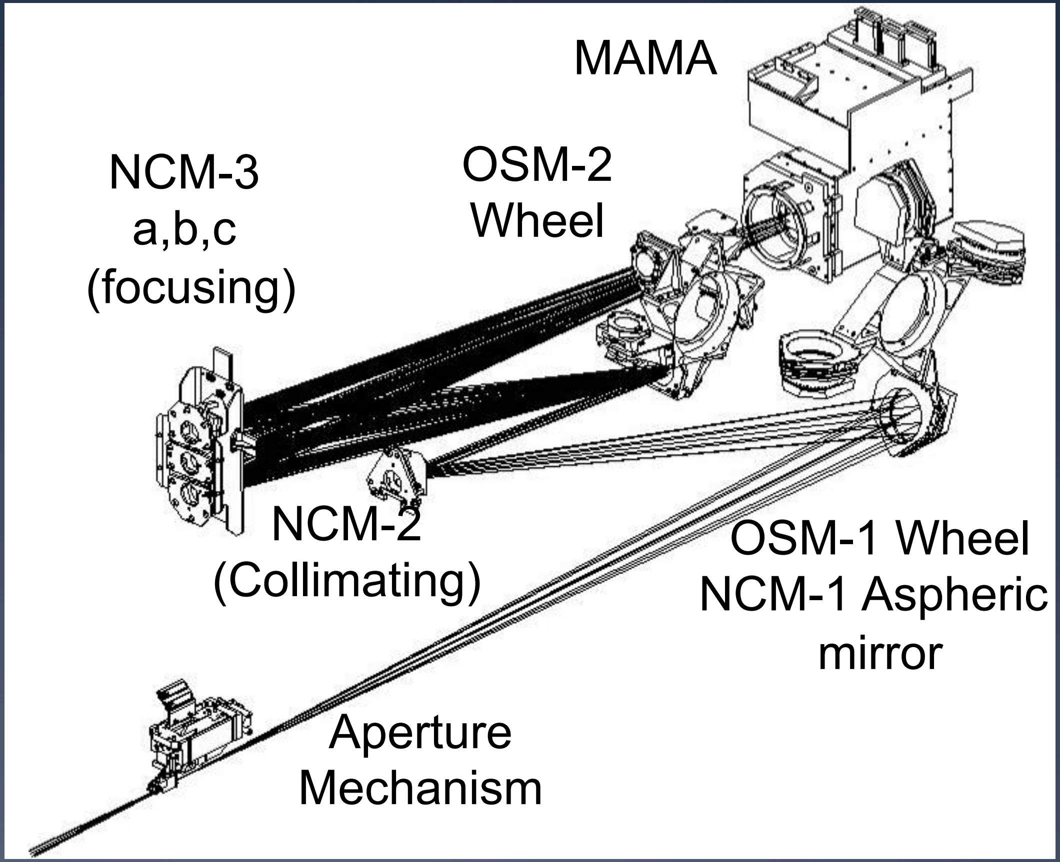
- Two detector segments, 15384x1024 pixels per segment
- Note background (~14 cts/sec/segment)



COS NUV Channel

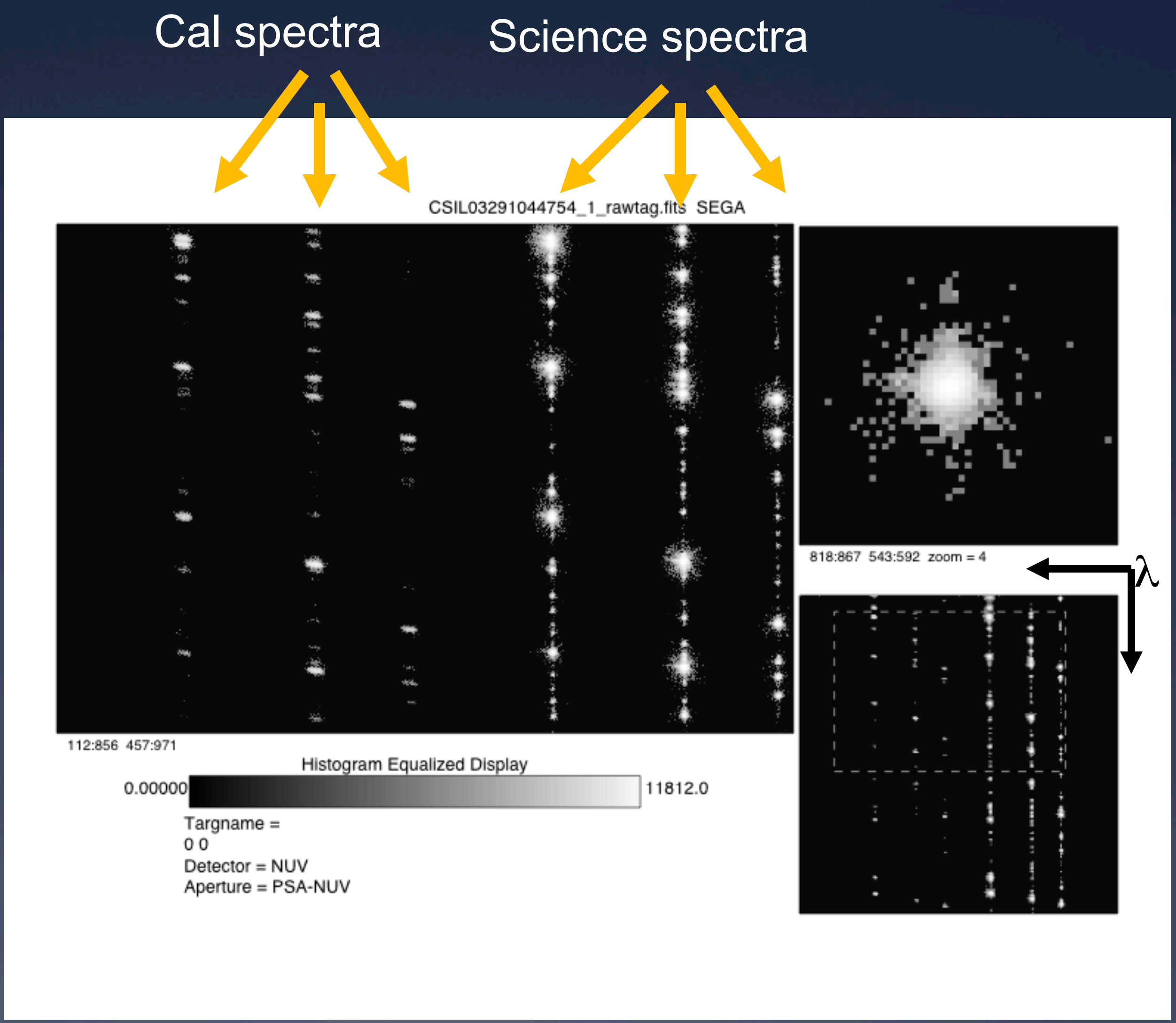
NUV Channel: Modified Czerny Turner spectrograph

- Holographically ruled gratings with ~ 4000-4800l/mm provide 20,000 - > 24,000 Resolution from1700-3200Å in medium resolution modes
- 34-40Å per stripe, 3 stripes per grating position with 65-70 Å gaps
- 25x25mm MAMA detector (STIS spare) with 25 micron pixels



COS NUV Channel

- Note that calibration lamp lines are not in focus
- Background on orbit is ~1/10 STIS NUV
- Target acquisition mode with ~ 45mArcsec resolution across ~1 arc sec unvignetted FOV



COS Performance Summary

Channel	Wavelength Range	Resolution ($\lambda / \Delta \lambda$)	Limiting V_{mag}* (S/N 10 in 10 Ksec)
G130M (FUV)	>1150-1450Å	16,000-21,000	19.1 *[16.3]*
G160M (FUV)	1405-1775Å	16,000-21,000	16.7 *[14.1]*
G140L (FUV)	>900-2050Å	1500-4000	20.6 *[17.8]*
G185M (NUV)	1700-2100Å	22,000-28,000	17.8 *[15.7]*
G225M (NUV)	2100-2500Å	>25,000	17.5 *[15.8]*
G285M (NUV)	2500-3200Å	>25,000	16.9 *[15.6]*
G240L (NUV)	1650-3200Å	2100-3900	20.4 *[18.7]*
TA1 (NUV)	1700-3200Å	0.05″ (Targ.Acq.)	

* S/N 10 per resl in 10Ksec at central λ, assuming B5V star (Castelli-Kurucz model) *[V_{mag} assuming a flat (F_λ) continuum]*

COS Time Dependent Sensitivity: NUV gratings

Spectrograph ground testing showed G285, G225 TM minimum had moved into Band