COS
Status Update

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for the COS Team

Overview

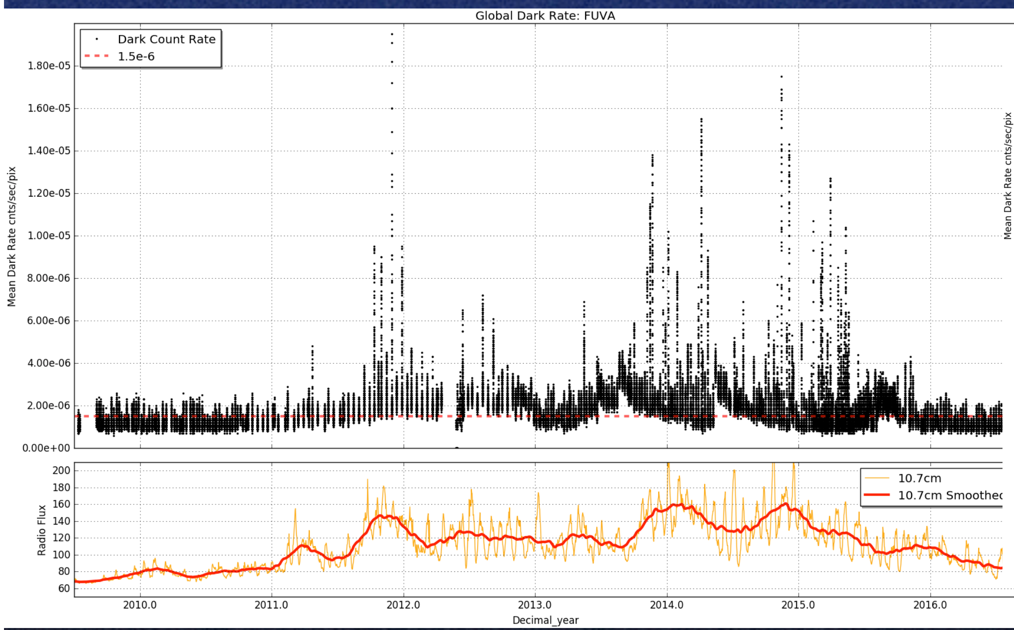
- COS Cycle 24 Calibration Plan – Overview

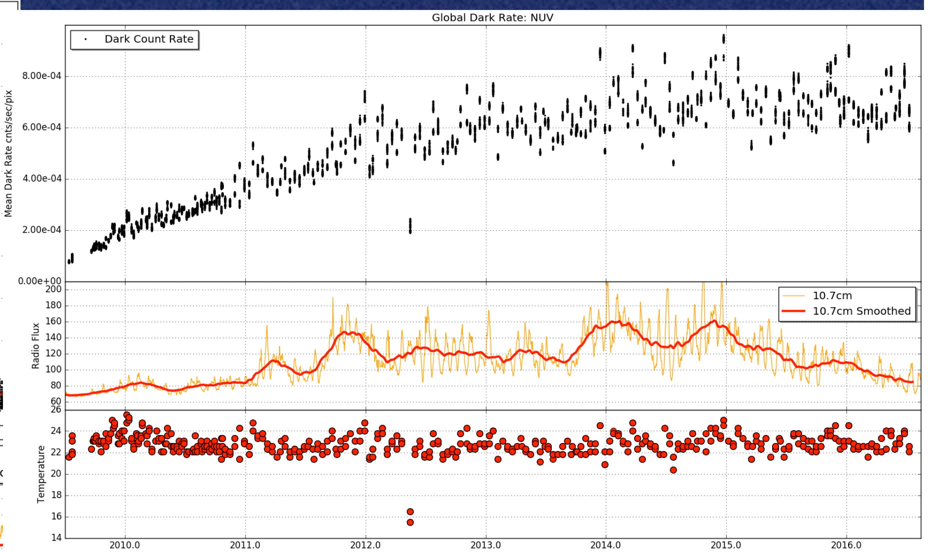
- COS/FUV Gain Sag Management
  - Move to LP4
    - Update (resolution, wavecorr, etc.)
    - Impact on remaining Cycle 24 programs
    - Changes to dispersed light TA at LP4
  - Cenwave management
    - Cycle 24
    - Changes for Cycle 25

- COS Wavelength Calibration
  - NUV
    - Update
  - FUV
    - Update

COS Operations

- **COS is operating nominally at this time**
- COS/FUV dark rate continues to be lower than in 2015
- COS/NUV dark rate continues to follow previous trend





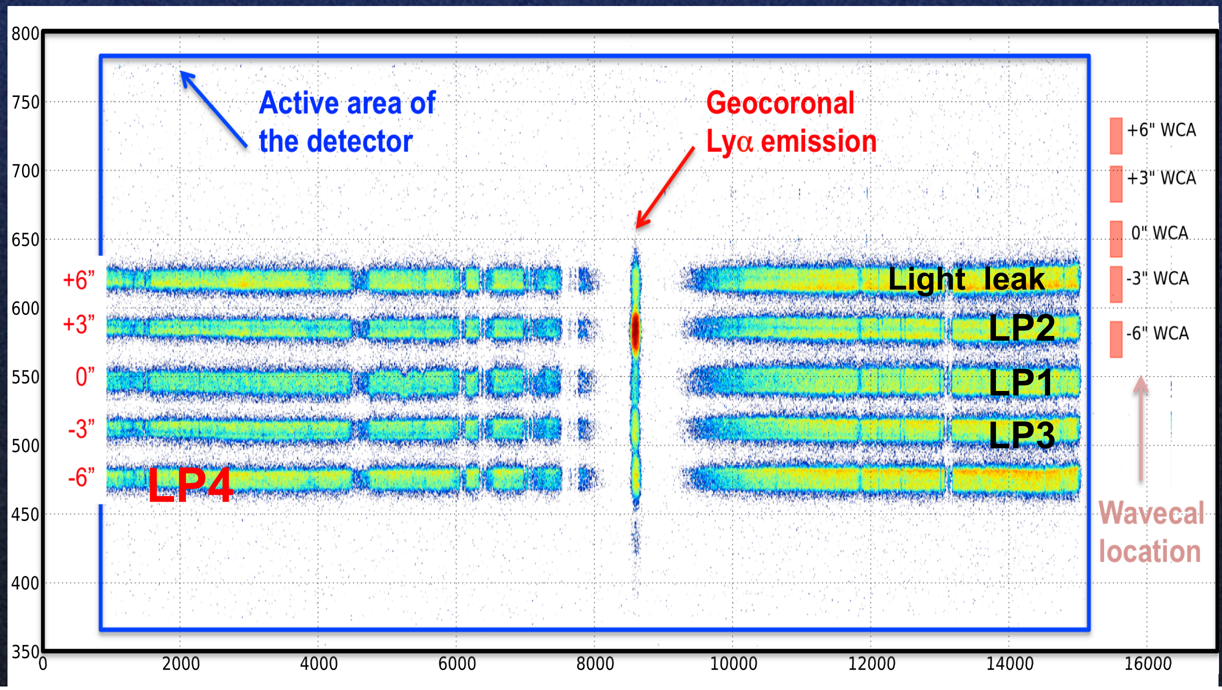
- COS FUV and NUV TDS follow previous trends overall

Cycle 24 Calibration Plan

Activity	# Ext orbs	# Int orbs	Program ID
FUV Monitors			
FUV Spectroscopic Sensitivity Monitor	26		14854
FUV Detector Dark Monitor		260	14520
FUV Internal/External Wavelength Scale Monitor	3		14855
Pure Parallel Observations of Geocoronal Ly α	3		14833
FUV Gain Maps after HV changes		5	14519
COS FUV Lamp Template at LP3		15	14856
NUV Monitors			
COS Target Acquisition Monitor	2		14857
NUV Spectroscopic Sensitivity Monitor	6		14858
NUV Detector Dark Monitor		52	14521
NUV Internal/External Wavelength Scale Monitor	2		14859
NUV MAMA Fold Distribution		1	14526
TOTAL Cycle 24 Request	39 + 3 (parallel)	333	

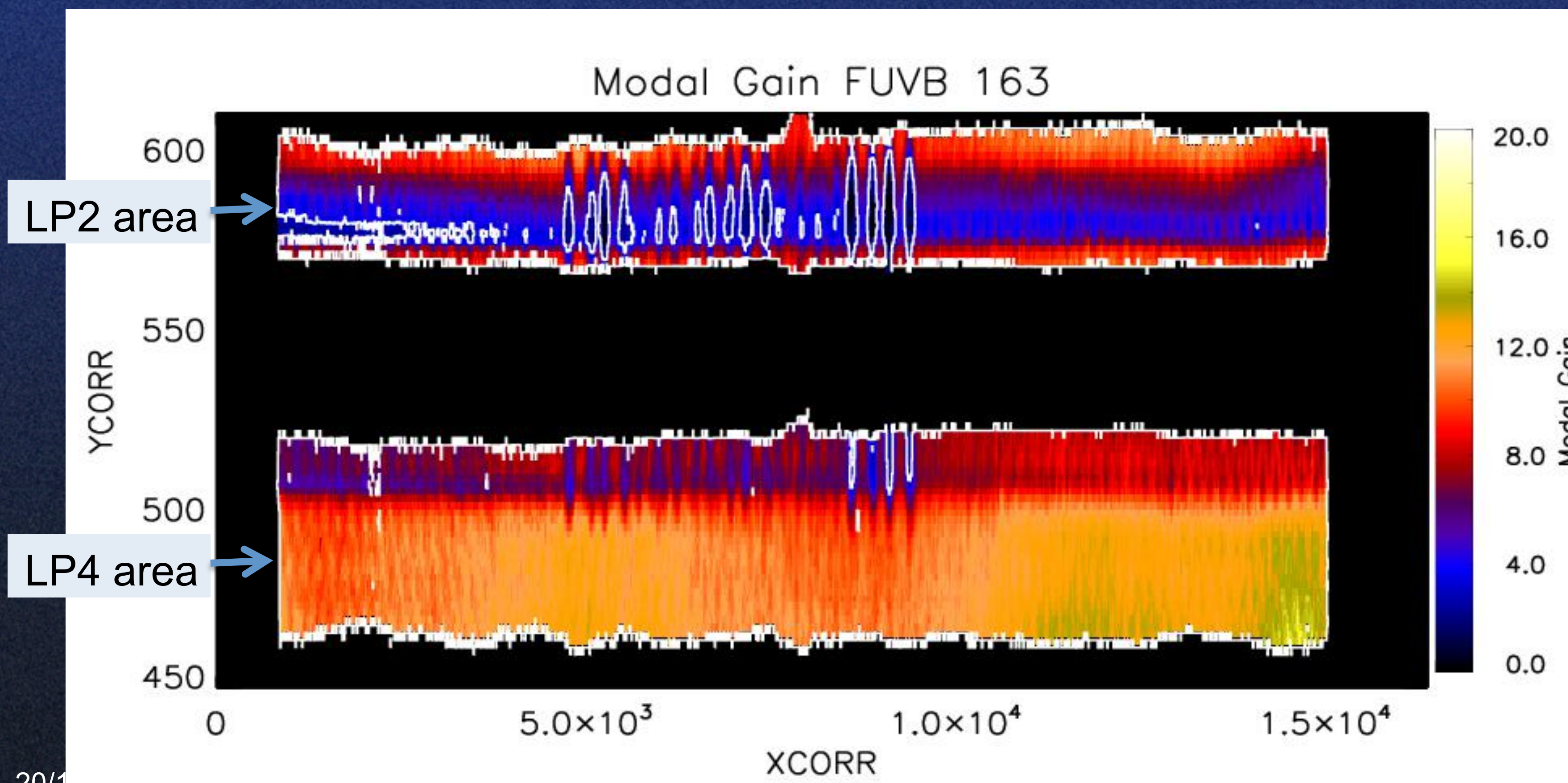
COS/FUV Move to LP4

- Move to COS/FUV Lifetime Position 4 scheduled for July 2017
- Programs executed over the summer ("exploratory phase") to evaluate
  - Exact LP4 location: -2.5" below LP3, i.e., -5" below original LP (LP1)
  - Optimal focus for G130M grating
  - Resolution degradation at LP4 (G130M): ~ 15% relative to LP3
  - Impact of sagged LP2 region on WAVECORR
  - Starting HV values that maximize LP4 lifetime while maximizing science quality



WAVECORR at LP4

- WAVECORR: CalCOS determines zero point of λ scales and drift correction
  - compares lamp flash with lamp template
- At LP4 most of lamp flash spectrum falls in LP2 sagged region w/ gain < 3 at HV = 163
- Simulations indicate can get zero point within +/- 2 pix with some changes (trim xcorr<10,000)
- Planning to obtain on-orbit data in near future to verify accuracy of WAVECORR at LP4



COS/FUV LP4 Move Exploratory Phase

Activity	Activity Name	Description	Dependencies	Phase II submitted by	Date range to obtain data	Final results due by	Program ID	Status
Exploratory								
1	**Gain maps at LP2 and LP3/LP4**	Obtain D lamp data to build gain maps that allow us to evaluate underlying gain and determine starting LP4 HV + evaluate gain at LP2 location where wavecal data will fall at LP4	**None**	Jun 17 2016	Jun 30 - Jul 15 2016	**Aug 10 2016**	14525 - 6 visits executed on Jul 4 2016	**COMPLETED**
2	**Mini focus sweep at LP4**	To determine best focus for G130M at LP4, which will be used in mini-resolution check program	**None**	Jun 17 2016	Jun 30 - Jul 20 2016	**Aug 10 2016**	14527 - vis 01 on Jul 12/13, vis 02on Jul 13	**COMPLETED**
3	**Wavecorr at LP4**	1) Determine potential impact of sagged LP2 regions on wavecorr at LP4 using simulations. 2) Obtain WCA data at final LP4 position and final HV values. These data will be used to evaluate impact on wavecal spectrum and then impact on wavecorr step of CalCOS. Determine if changes to CalCOS and/or tagflash times are needed	**None for part 1), 1, 4 for part 2)**	**Aug 10** for results of simulations, **Oct 15 2016** for phase II for data at correct Y and HV	Oct 30 - Nov 15 2016	**Aug 10 2016 for simulations, Dec 1 2016 for ana of data, May 1 2017 for implementation of changes in pipeline if needed**		**IN PROGRESS, Additional data to be obtained**
4	**Optimization of LP4 Y detector location**	Evaluate effect of LP3 sagged regions on the LP4 location, particularly on top portion of LP4 spectra. Use simulations to predict LP3 sag at the LP4 move date and LP4 starting HV	**1, 2**	Aug 10 2016	by Sep 5 2016	**Sep 30 2016**	14841 SMS of Aug 29	**DATA OBTAINED; ANALYSIS COMPLETED**
5	**Mini LP4 resolution check**	Perform a quick check of the resolution close to the final LP4 position, with the correct focus and HV. Obtain data also to evaluate geocorr at edge of detector (from TV data)	**1, 2**	Aug 10 2016	by Sep 10 2016	**Sep 30 2016**	14842 SMS of Aug 29	**DATA OBTAINED; ANALYSIS IN PROGRESS**
6	**Geometric correction at the edge of detector**	Use TV data to determine X and Y geocorr at edge of detector; evaluate this correction using data from 5; if needed obtain extra data to perform geometric correction. Phase II dates are only in case extra data is needed	**1, 2, 4**	Oct 30 2016	by Dec 30 2016	**October 10 for evaluation of correction using data from 5. April 1 2017 for template profles**	Uses data from 14842	**IN PROGRESS**

COS/FUV LP4 Move Enabling Phase

Enabling	Activity Name	Description	Dependencies	Phase II submitted by	Date range to obtain data	Final results due by	Program ID	Status
7	**LP4 Aperture placement**	Scan aperture in disp and xdisp directions to evaluate optimal placement	**4**	Nov 15 2016	by Jan 1 2017	**Feb 1 2017**		
8	**LP4 Focus sweep**	Determine optimal focus for the modes not used in activity 2.	**1, 6 (both minor)**	Nov 15 2016	by Dec 30 2016	**Feb 1 2017 (to use in 10)**		
9	**LP4 Target acquisition parameters**	Data taken during 4 visits to optimize TA parameters. Vis 01:ACQ/SEARCH, used to better define TA sub-arrays, vis 02: PEAKD, vis 03: PEAKXD (NUM-POS>1) used to verify TA subarrays and make adjustements, vis 04: After LP4 move to verify whole TA sequence	**1, 2, 4, 7, 8**	Vis 01 and 02 and 03 by Feb 15. Vis 04 by Jun 1	Vis 01 by Mar 15 2017 Vis 02 and 03 by April 15. Vis 04 after move	**Vis 01 by Mar 30 2017, Vis 02 and 03 by May 1 2017. Vis 04, 2 weeks after move**		

COS/FUV LP4 Move Calibration Phase

Calibration	Activity Name	Description	Dependencies	Phase II submitted by	Date range to obtain data	Final results due by	Program ID	Status
10	**Template profiles for spectral extraction**	Extraction templates are needed to extract LP4 data, similarly to LP3	**1, 2, 3, 4, 6, 7, 8, 9**	Feb 20 2017	Mar 1 - April 15 2017	**Jun 15 2017**		
11	**Flux and flat calibration of LP4**	Obtain data for flux, l-flat, p-flat calibration of LP4 data	**1, 2, 3, 4, 6, 7, 8, 9**	Feb 20 2017	Mar 1 - April 15 2017	**Oct 1 2017**		
12	**Wavelength scales at LP4**	Cursory check of the wavelength scales at LP4 to evaluate need to adjust zero points	**1, 2, 3, 4, 6, 7, 8, (9 ?)**	Jun 15 2017	Jul 1 - Aug 30 2017	**Oct 1 2017**		
13	**Spectral and spatial resolution at LP4**	Obtain data to determine the spectral and spatial resolution at LP4	**1, 2, 3, 4, 6, 7, 8, (9 ?)**	Jun 15 2017	Jul 1 - Aug 30 2017	**Oct 1 2017**		
14	**BOA performance at LP4**	Demonstrate that data can be obtained throught the BOA aperture at LP4	**1, 2, 3, 4, 6, 7, 8, (9 ?)**	Jun 15 2017	Jul 1 - Aug 30 2017	**Oct 1 2017**		

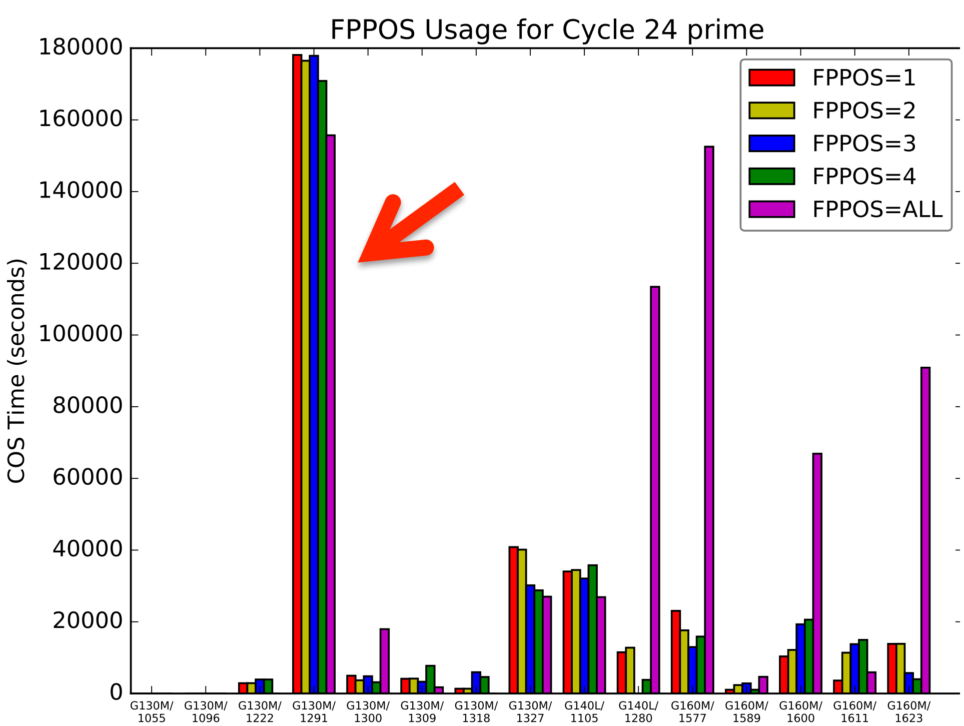
COS/FUV Move to LP4
Impact on Cycle 24 Programs

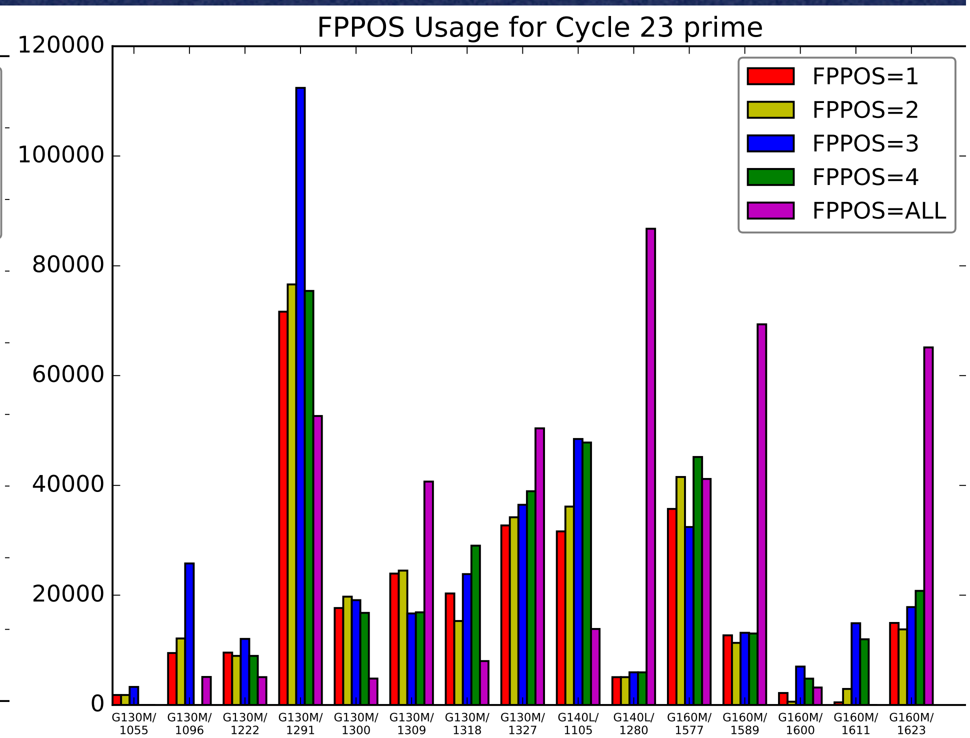
- **Working to minimize potential impact of move to LP4 on Cycle 24 programs**
  - While doing CS reviews checking if resolution is a critical need of program
  - Checking also for programs that cannot be split across LP (due to need to coadd or compare data, etc.)
    - Example is transit program 14767 (“The Panchromatic Comparative Exoplanetary Treasury Program”) where a single target is observed in 3 different visits

- **After move to LP4 FUV dispersed light TA (PEAKXD) will change**
    - TAs in dispersion and cross-dispersion (PEAKXD) directions will be identical, with target observed at several dwell points and then centroid determined from distribution of counts
    - Cross-dispersion TA will have # structure in phase II and might have slightly different overheads
    - Working with schedulers to ensure that Cycle 24 programs with FUV dispersed light TA execute before Jul 2017

COS/FUV Cenwave Management

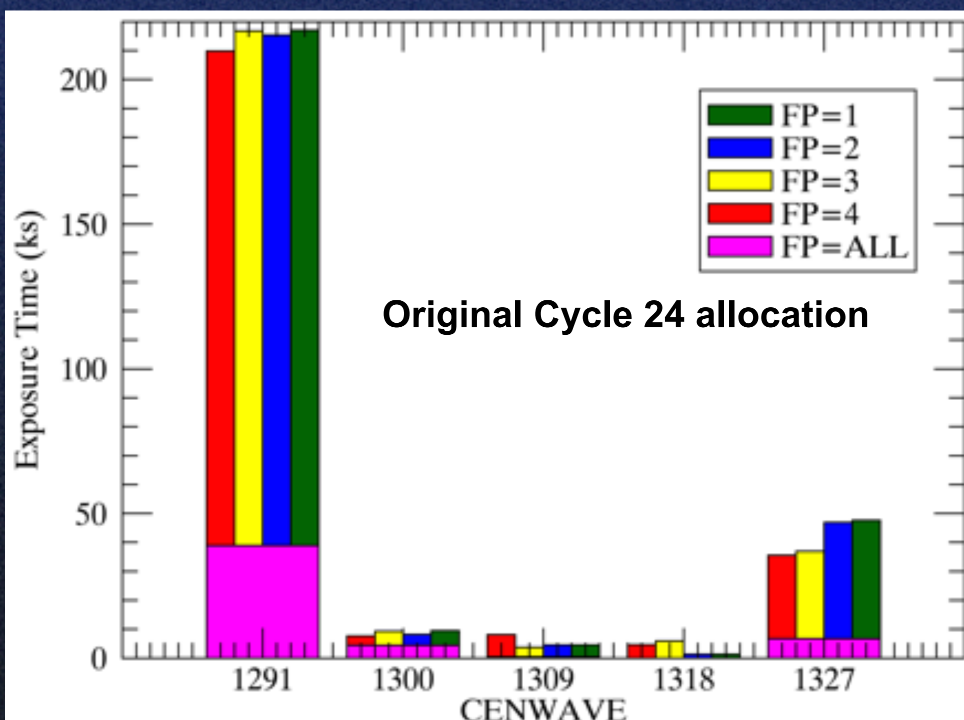
- LP moves and HV increases to minimize gain sag typically triggered by gain sag at the G130M/1291 location
- In Cycle 24 usage of G130M/1291 is factor 2- 3 larger than in Cycle 23
- If not changed, gain sag holes would appear before Jul 2017 and impact science data (there is also 80 orbit SNAP, 14633, not shown using G130M/1291)

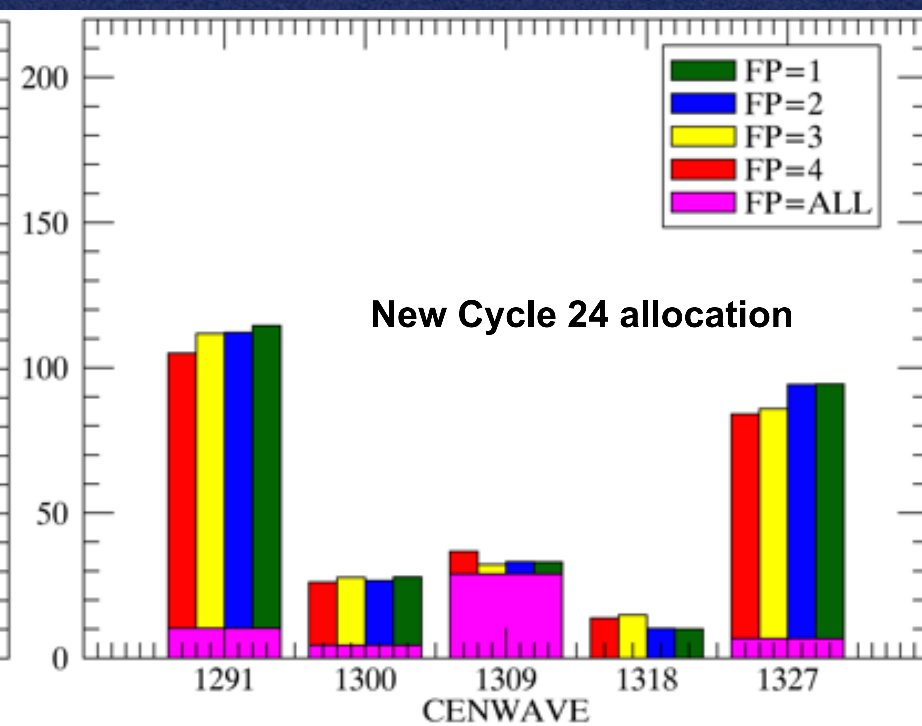




G130M Cenwave Management

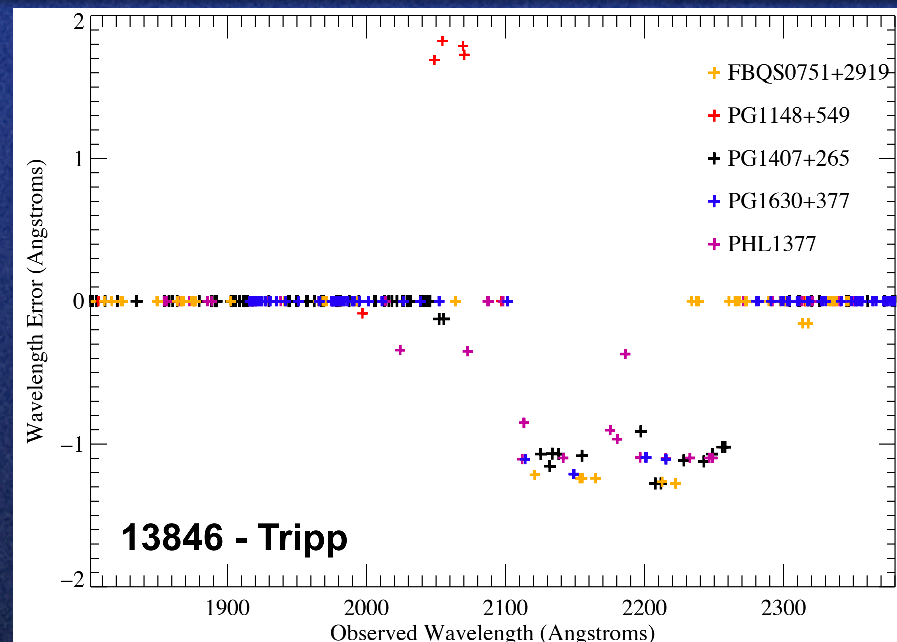
- Identified several programs that can be moved to other G130M cenwaves without impacting the science goal
- PIs have been contacted; working with them to select optimal cenwave that prolongs life of LP3 and does not affect science goal
- New text inserted in Cycle 25 Primer and CP: cenwave selection must be justified or STScI can allocate different cenwave if need be



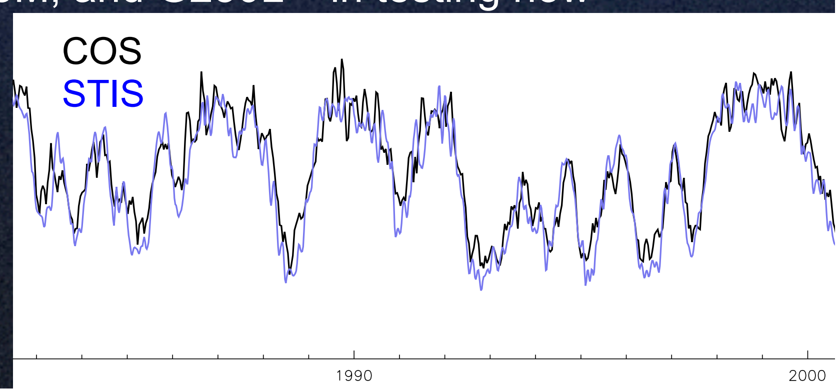


COS NUV Wavelength Calibration

- Triggered by help desk call earlier in the year we realized in the Spring 2016 that zero points of dispersion solution had not been updated on-orbit for some NUV settings
  - Offsets up to ~ +2 Å & -1.5 Å
  - All of G185M settings and some G225M/ G285M, and G230L stripes
- An intermediate ref. file was delivered in the summer to minimize issue

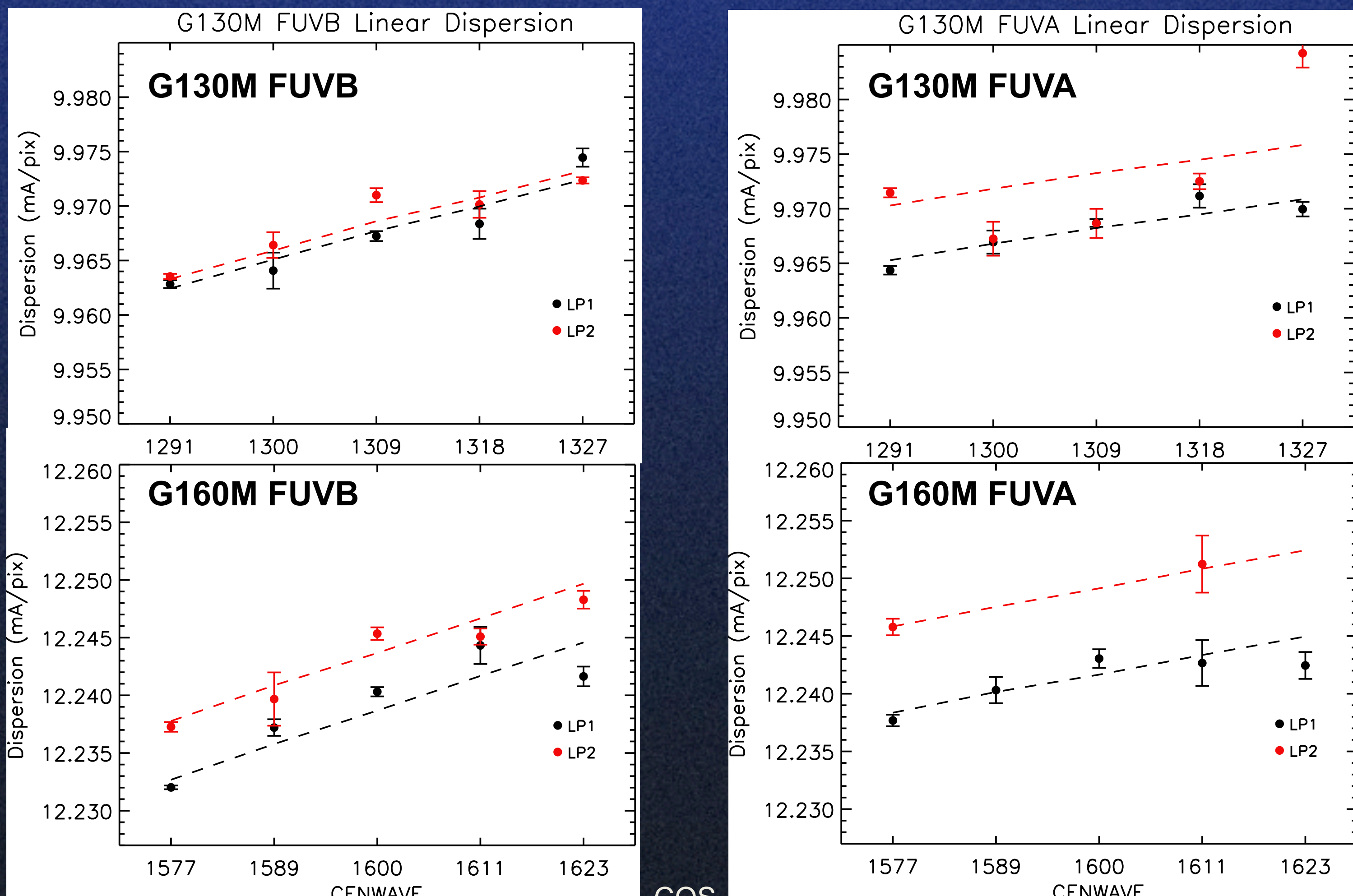


- Three special calibration programs executed during summer
  - Obtained COS for G185M, STIS data for other gratings
  - Offsets have been determined for G225M, G285M, and G230L – in testing now
  - In the process of determining offsets for G185M
    - Initial analysis shows that offsets not as large as for other gratings (3 – 4 pix)
  - Updated ref. files to be released in the next couple of months, STAN will inform community

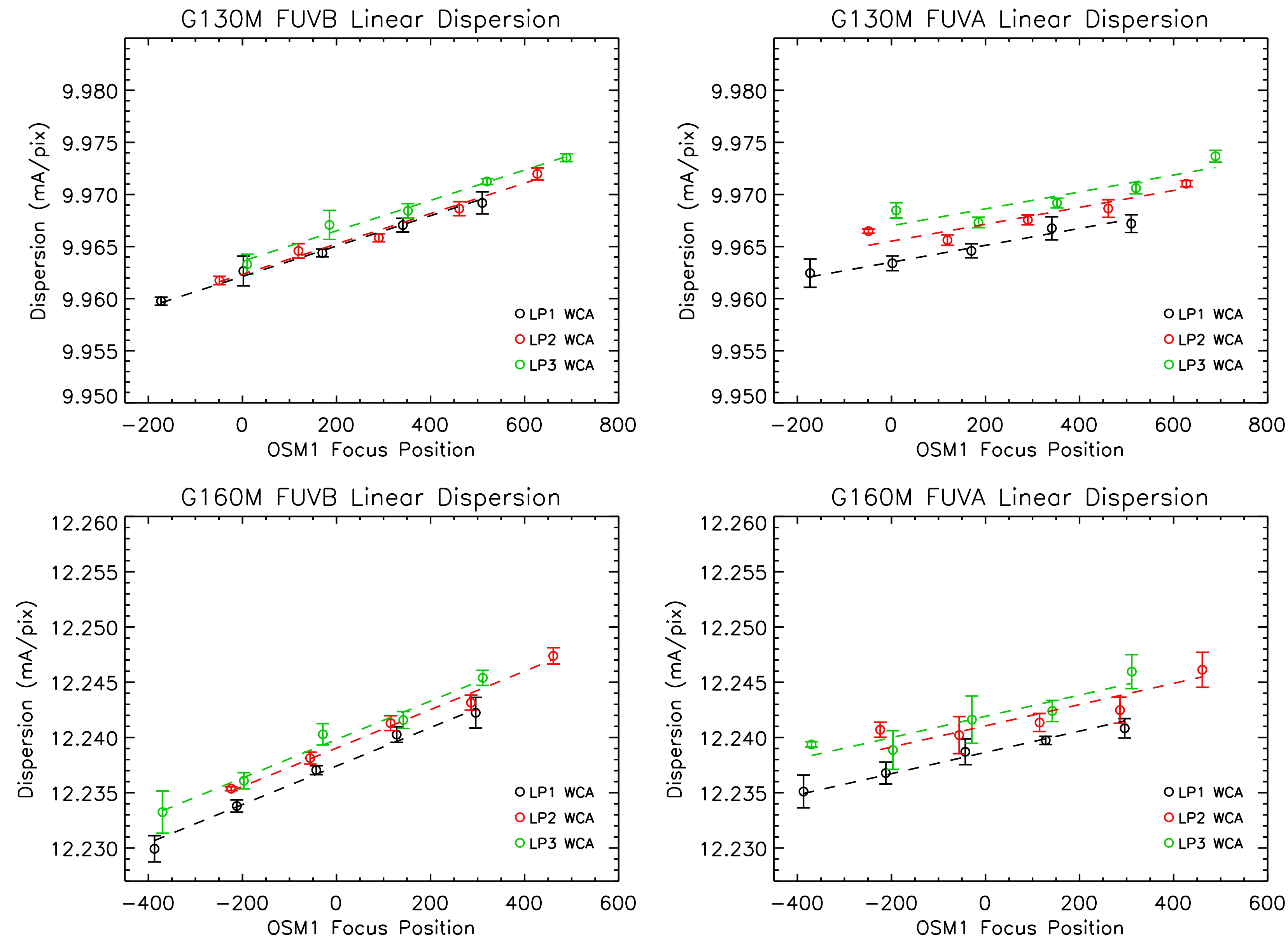


COS/FUV Wavelength Calibration

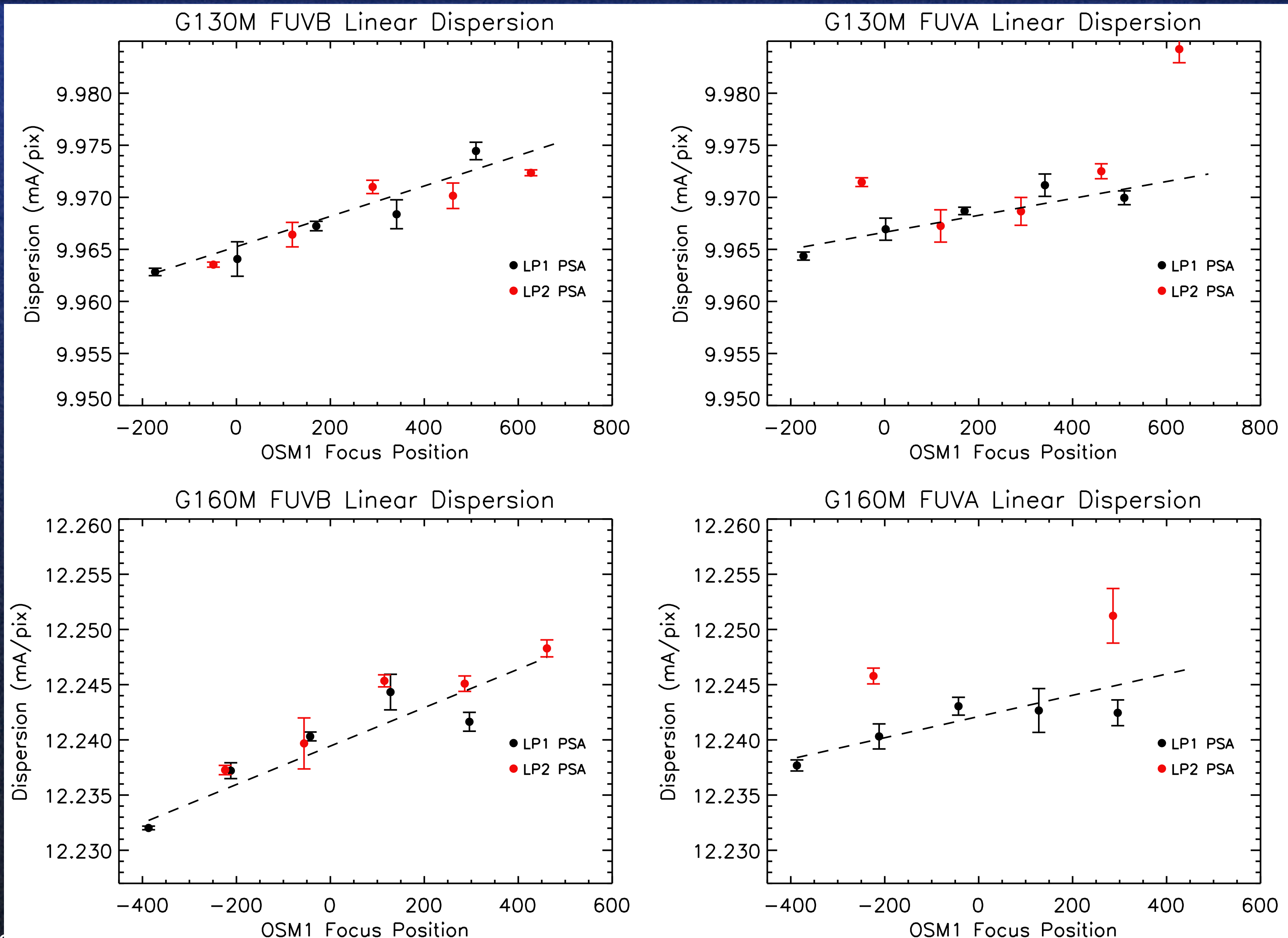
- LP1 dispersion solutions derived by cross-correlating COS and STIS data for same target + scaling ray-trace models; updated ref file delivered in May 2016
- For LP2 and LP3 lack of COS+STIS data led us to explore other possibilities



WCA Dispersion Solutions vs. Focus



PSA Dispersion Solutions vs. Focus



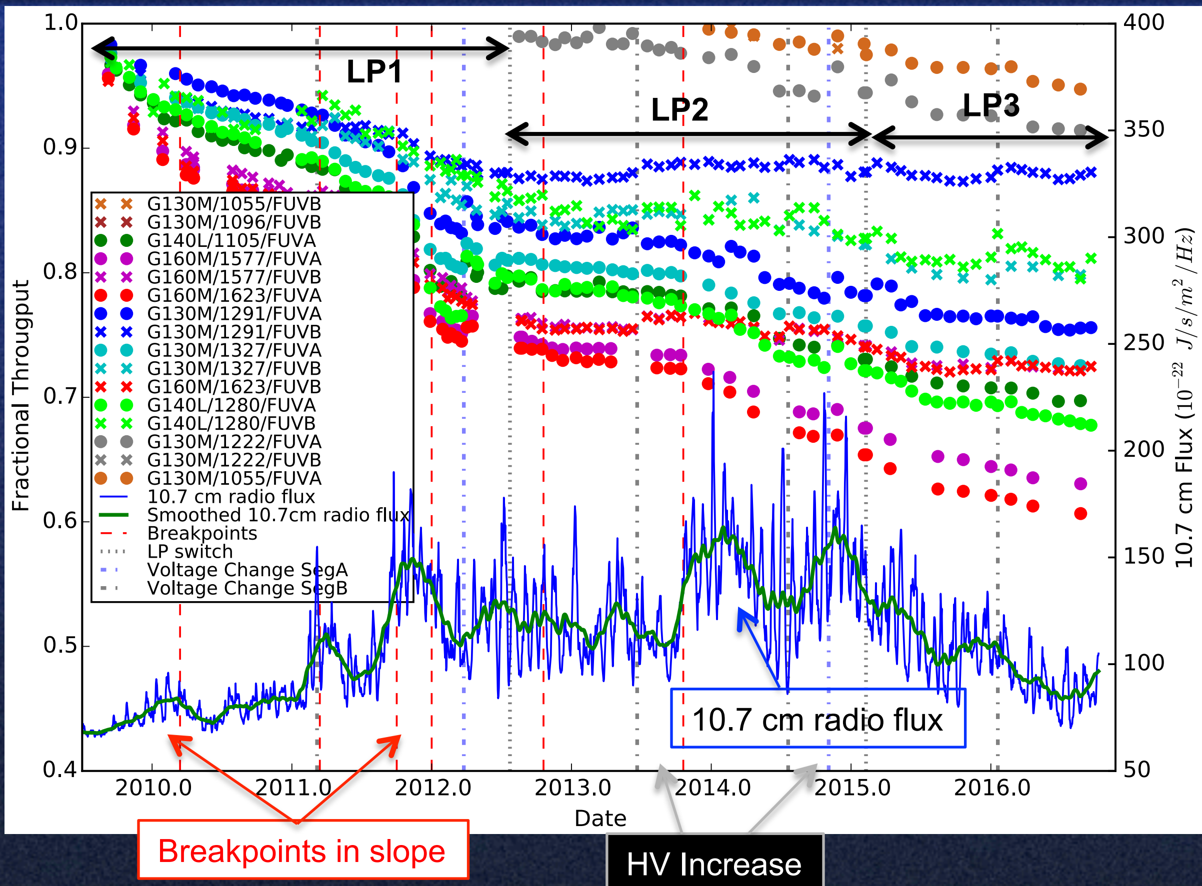
FUV Dispersion Solutions
Path Forward

- WCA analysis seems to indicate that dispersion solutions vary with LP and focus
  - But...large error bars due to low S/N of coadded flashes used for analysis (error bar plotted comes from avg of different FP-POS)
  - New calibration program that obtains LP3 lamp templates will allow us to compare WCA dispersion solutions vs. focus using two sets of deep lamp spectra

- For now adopt dispersion coefficients from scaling ray-trace to LP1+LP2 PSA data together (previous slide)
  - Use solutions for LP2 and LP3 testing – should improve over what is currently used
  - Can then potentially apply same method to LP4 and release updated dispersion solutions before move to LP4
  - Using updated dispersion solutions with lamp template obtained at each LP should also improve accuracy of λ calibration
    - And should help with WAVECORR issue at LP4

BACK-UP SLIDES

COS/FUV TDS Update



- Rate of decline of COS FUV Time Dependent Sensitivity (TDS) varies with time, detector, and λ
- Steeper TDS slopes in periods of increased solar activity – likely due to atomic O at HST's orbit reacting with CsI photocatode of open-faced COS FUV detector
- Increase in sensitivity with HV is under study

- Slopes have become flatter overall since late 2014/early 2015
- Investigating adding another break point during 2015

Data up to September 2016 included

COS NUV Zero Point Offsets

- NUV dispersion solutions in use were derived in TV03 (1^{st} order poly)
- Zero points, to place TV03 solutions in on-orbit frame of reference derived during SMOV (2009)
  - "d (pixel)" in DISPTAB - cenwave + stripe dependent (Oliveira et al. 2010, COS ISR 2010-05)
  - Derived by using STIS data of same target
  - For some settings zero points never derived
    - All cenwaves of G185M
    - G225M: 2186/2217/2233/2250 – A,B
    - G225M: 2268/2283/2306/2325/2339 – A
    - G285M: 2996/3035/30573074/3094 – C
    - G230L: 2635/2950/3000 – A, B, 3360 – B, C
  - Due to lack of overlap with STIS data or low S/N
  - Unsuitable target (G185M: Feige 48 – pulsating binary)

Grating	Cenwave	d (pixel)
G225M	2186	$\cdots$, $\cdots$, -25.798
	2217	$\cdots$, $\cdots$, -21.873
	2233	$\cdots$, $\cdots$, -21.359
	2250	$\cdots$, $\cdots$, -24.069
	2268	$\cdots$, -23.694, -23.324
	2283	$\cdots$, -19.864, -16.895
	2306	$\cdots$, -19.223, -15.621
	2325	$\cdots$, -18.477, -15.735
	2339	$\cdots$, -21.028, -19.789
	2357	-20.366, -19.090, -15.920
	2373	-23.128, -20.386, -16.533
	2390	-22.338, -20.363, -16.340
	2410	-17.735, -15.621, -11.394

- Why has problem has not surfaced before?
  - NUV has very low usage
  - Tripp had FUV data which allowed him to predicted expected NUV data (Ly series at z ~ 1)

What are we doing to fix NUV λ issue?

- G225M/2217/A/B/C offsets derived using AG DRA data (E230M)
- Missing offsets: use value from the nearest stripe for the same cenwave (except for G185M, not perfect but reduces offset)
- Updated NUV DISPTAB has been produced and delivered
- STAN is being prepared to warn all COS users as well as PIs of all COS NUV programs that used settings not updated on-orbit

- Tripp's data has been reprocessed by COS team, and PI was given access to it

➢ Special NUV wavelength calibration program do update zero points has been created and approved for execution by HSTMO
  - 3 special calibration programs (1 COS + 2 STIS, for a total of 5 orbits)
    - COS/G185M/NGC330-B37, STIS/E230M + G430M/HD187691 to update G225M + G285M zero points, STIS/G230MB + G230M/HD6655 to update G285M + G230L zero points
  - Program expected to execute over the next couple of months time frame
  - Once data analyzed and updated file delivered, STAN will be released

COS/FUV Wavelength Calibration

- Current requirement for wavelength calibration is 1 resolution element (~6 pixels, 1 σ)

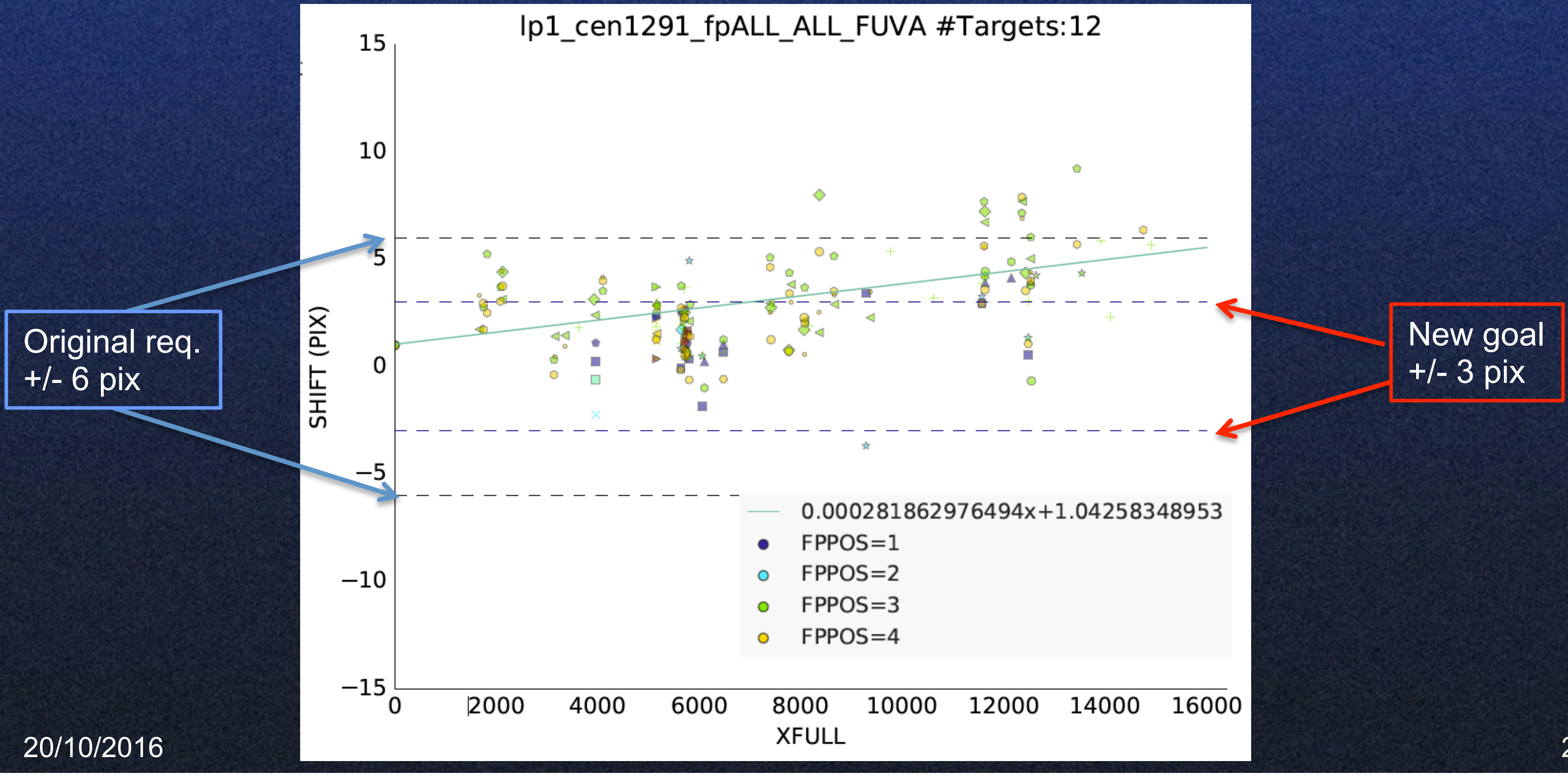
- Can be improved to 3 pixels RMS by revising dispersion solutions
  - Working ongoing also to improve walk correction and geometric correction

- Dispersion solutions are given by polynomials that transform pixels to wavelengths using a **zero point** and a **linear coefficient (slope)**

- Next slides walk us through different steps adopted to determine updated zero-points and slopes for dispersion solutions
  - Examples shown are all for LP1 data (G130M + G160M)

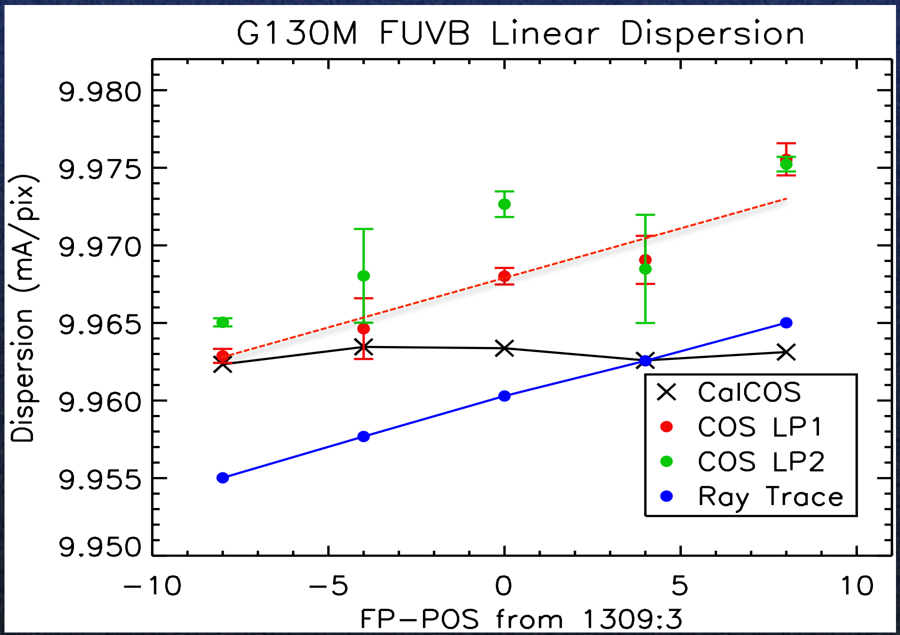
Steps to Improve λ dispersion Solutions - I

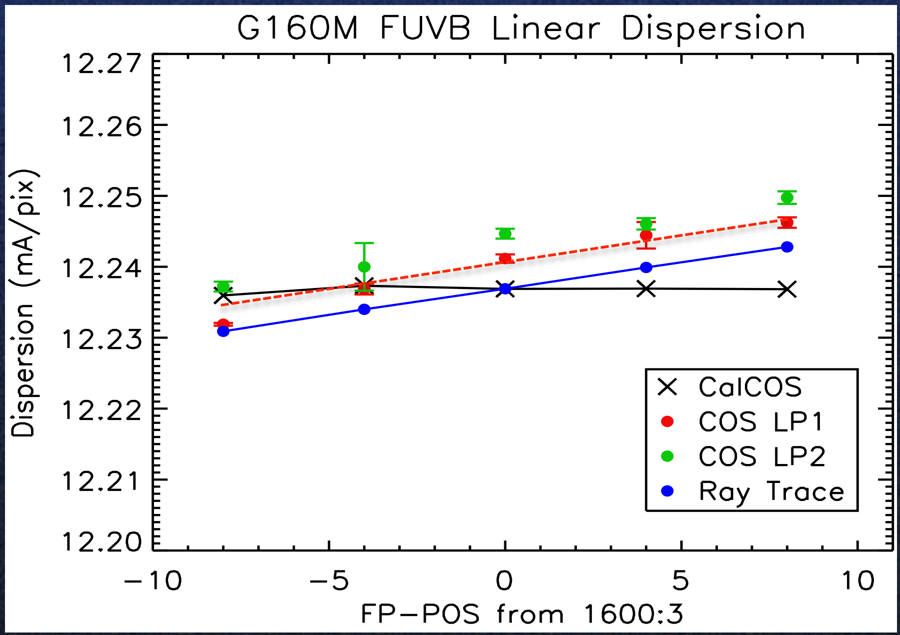
1 Cross-correlate COS spectra with STIS spectra, used as a reference wavelength, and derive wavelength offsets in pre-defined spectral windows where ISM lines are identified with good S/N. Fit the COS-STIS offsets vs XFULL to a linear solution (green line) to derive new dispersion solutions. This allows us to derive updated slopes and zero-points.



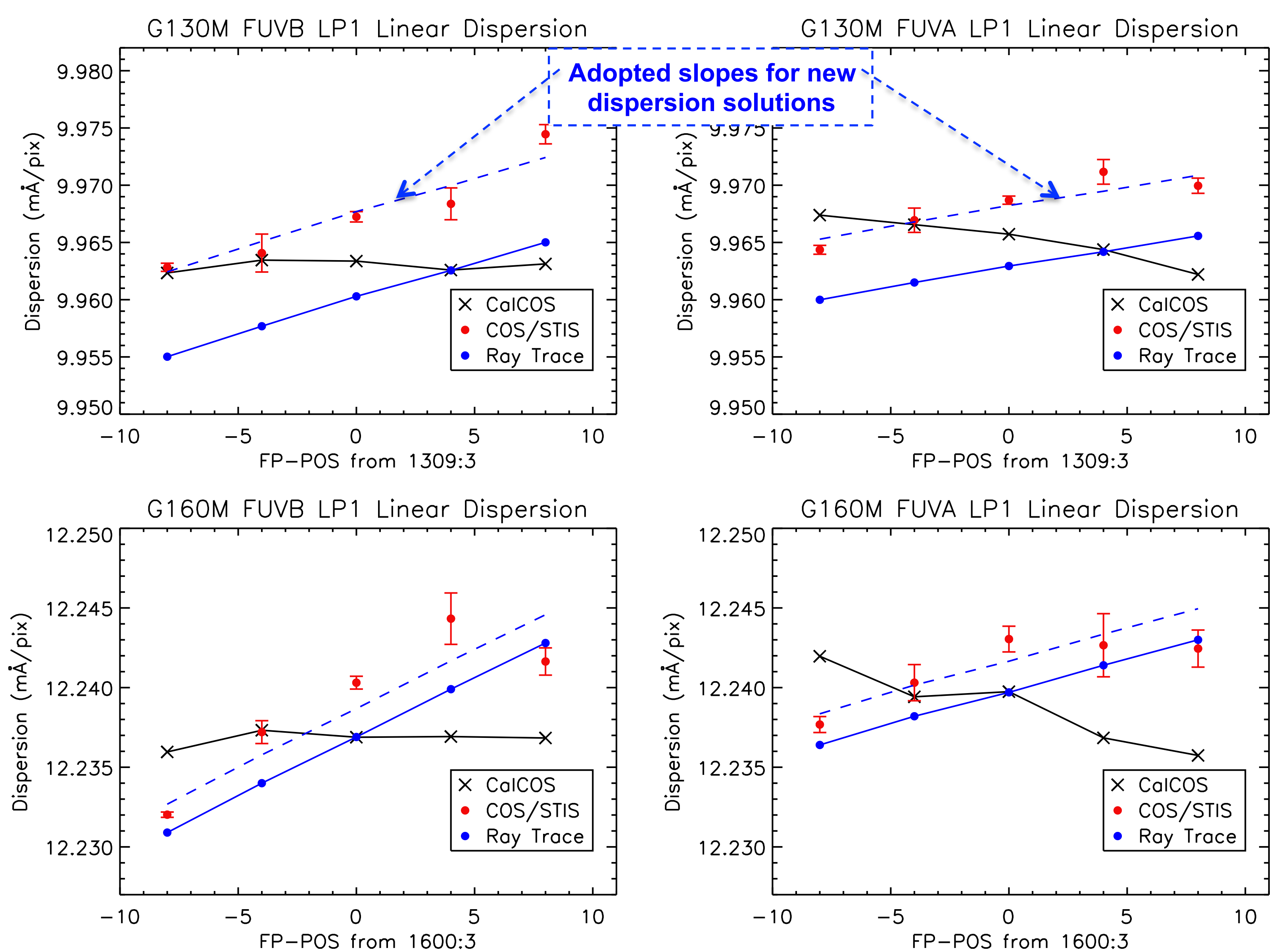
Steps to improve λ dispersion solution - II

2 New dispersion slopes are consistent with ray-trace models when plotted vs. OSM position. Ray-trace models have arbitrary focus reference, resulting in arbitrary vertical offset. χ^2 minimization performed between ray-trace slopes and COS-STIS dispersion slopes vs. OSM position allows us to determine vertical offset. Provides us with set of robust dispersion slopes (red dotted line) based on both COS-STIS cross-correlation and ray-trace modeling.



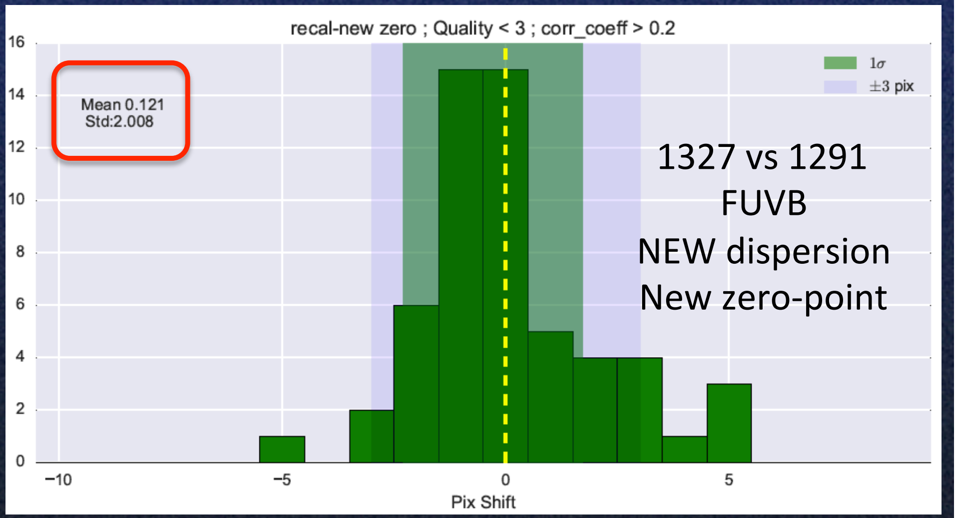


LP1 Dispersion Solutions (Slopes)



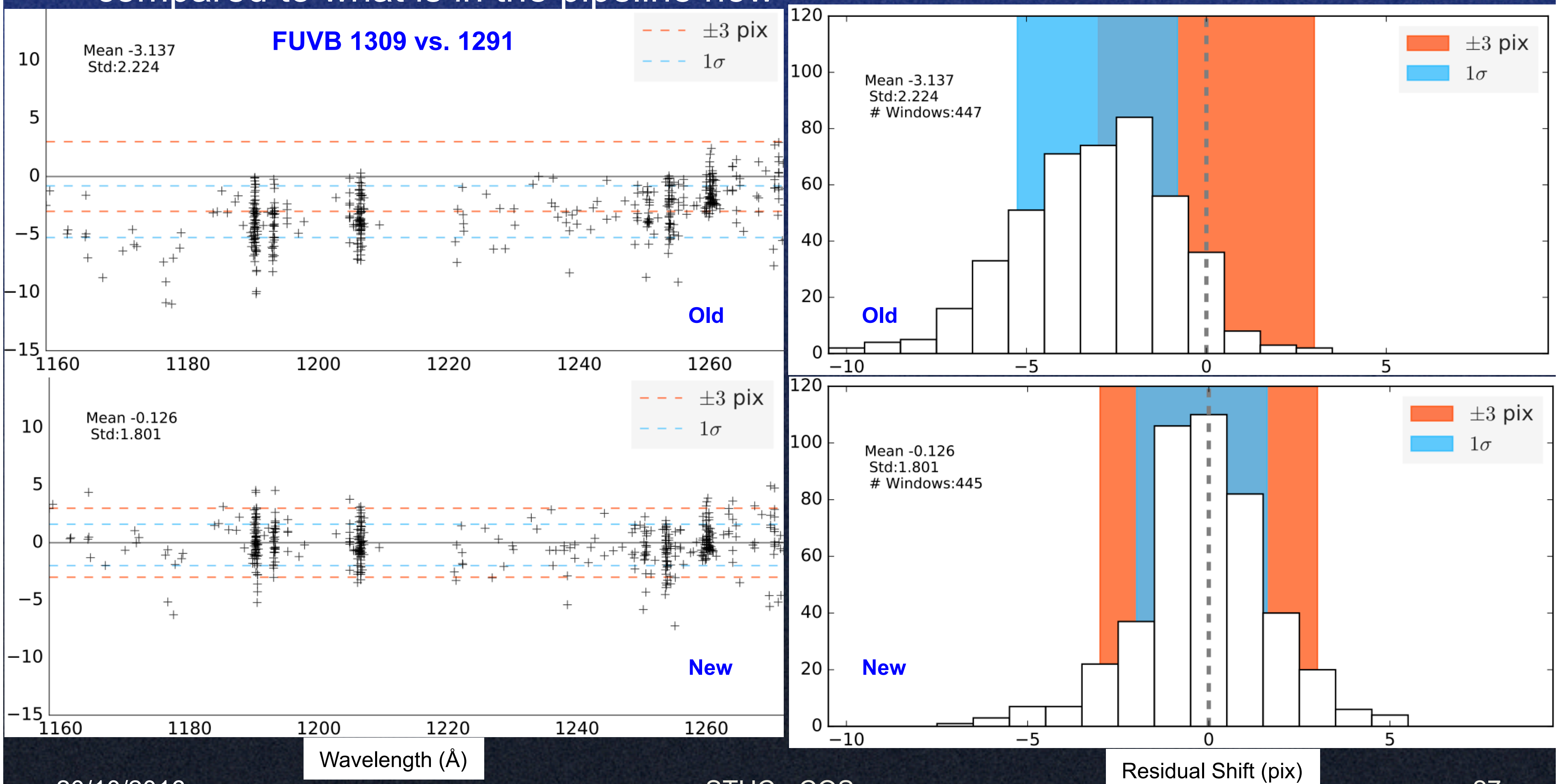
Steps to improve λ dispersion solution - III

3 Because of TA uncertainties in COS spectra, the zero-points derived from COS-STIS cross-correlations are only accurate to +/- 3 pix. (ray-trace model does not predict zero points). To correct for this, we perform cross-correlations between COS spectra obtained within single visits with different cenwaves. We adjust the COS-STIS derived zero-points so that the mean cross-correlation offsets between different cenwaves become zero.

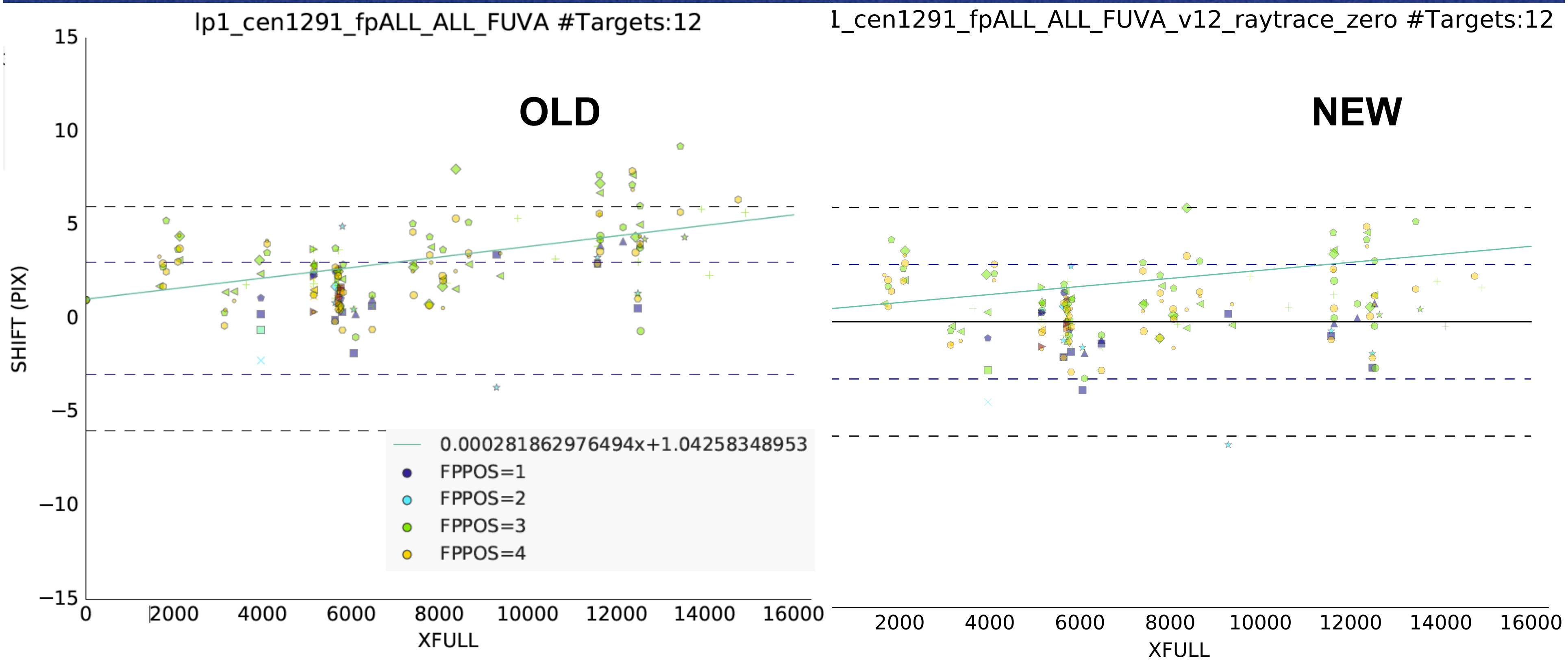


Steps to improve λ dispersion solution - IV

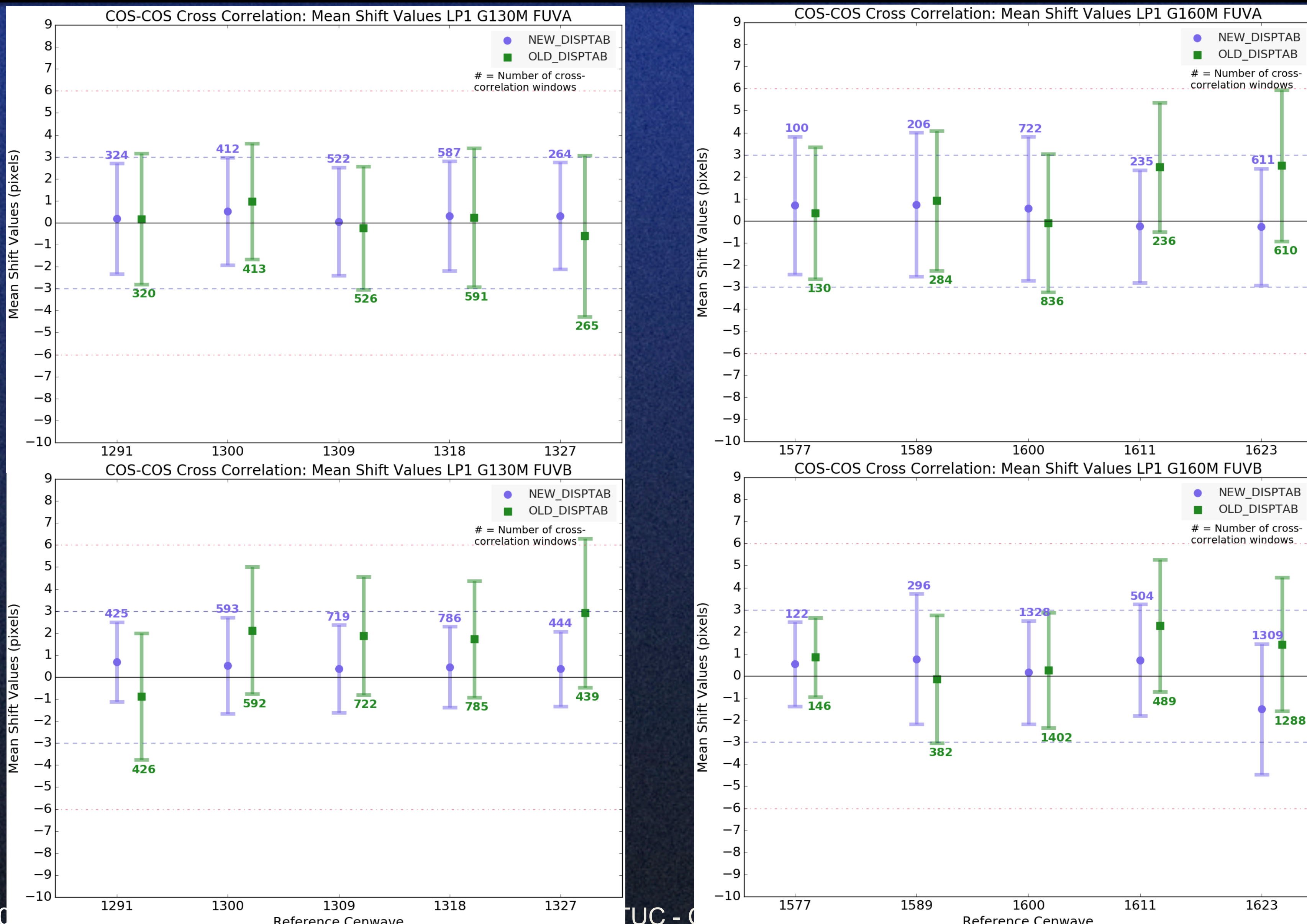
4 Re-run the COS-COS cross-correlations with the COS-STIS + ray-trace based dispersion slopes, and the zero-points adjusted to align cenwaves together (from step 3). Mean and RMS offsets in the COS-COS cross-correlations are improved compared to what is in the pipeline now



COS-STIS Comparison: Old vs. New



COS-COS Comparison – Summary



WCA Dispersion Solutions vs. Cenwave