Results from Mike Kehoe's "Fiber Optic Stability Experiments: Part 1"
file: \data\2018\HI-2018-02\doc\FiberOpticStabilityExpPart1_Results(20181004,MF).pptx
(date: 18-Sep-2018, rev: 04-Oct-2018, MF)

On 06-Sep-2018 M.Feinholz did receive from M.Yarbrough the (un-dated) document from Mike Kehoe "Fiber Optic Stability Experiments.docx" = Fiber Optic Stability Experiments: Part 1. A MLML experiment, **HI-2018-02**, to address this was performed at the U.H. Marine Centre @ Pier 35, Room 124, between 11 and 19-Sep-2018 (GMT). Stephanie's data processing can be found at http://data.moby.mlml.calstate.edu/mobyrefresh/timeseries/characterizations/inital_testing/intial_html.html under H18-02-BS02 (on the left-side navigation bar).

Summary of Experimental Setup:

Lenses: Mark Y. bought 2 each of the 2x lenses shown in Mike K.'s Fig.2 "Experimental Setup".
Lens #1 = Thorlabs **ACL2520U-A**, Aspheric Condenser Lens, 25 mm dia., focal length EFL = 20.1 mm ± 8%, back focal length (REF) = 12 mm, centre thickness = 12.0 mm, edge thickness = 2.8 mm , AR coated 350-700 nm – flat side of lens toward light source.
Lens #2 = Thorlabs **LA1484-A**, N-BK7 Plano-Convex Lens, 1 in dia., focal length f = 299.0 mm ± 1%, centre thickness = 2.5 mm, edge thickness = 2.0 mm, AR coated 350-700 nm - collimated light incident on curved surface … to focus a collimated beam at the back focus.

Fiber Optic: Polymicro 600 µm, PN: 1068022382, Desc = FDP 600 660710 10,10,1, batch = AUKL02A, ~23 ft length = end of spool from Dec-2016 MOBY262 BS01 LuBot. Fiber termination was standard MOBY-refresh polishing with collett-and-end-piece at both ends of the fiber. There was no black rubber jacket over the fiber for these measurements.

Integrating sphere: Thorlabs 2 in diameter integrating sphere IS200, SN: M00423992

Light Source: Thorlabs SLS201L Stabilized Tungsten Light Source, with optional filter or attenuator. Attenuator = variable knife edge Thorlabs CFH2-V. Optional filter: Thorlabs FB510-10 = green, 510 nm, 10 nm FWHM. Source was coupled to integrating sphere via fiber optic = Thorlabs UM22-600, 600 µm, 0.22 NA, SN: TPO1245978, ~2 m long.

CCD Camera: Andor CCD-16345, from BS02, with factory shutter & AR Coated ½° wedge window, data acquisition via Andor SOLIS software @ -40 °C TEC, 4x gain.

Data Collection Approach:
The 23' FO was arranged either 1.) uncoiled = extended between camera & sphere with one broad 90° bend, or 2.) coiled onto a 14 in diameter fiber spool with approximately 6x loops. The 23' FO was disconnected from the sphere before coil/uncoiling by rotating the sphere to thread/unthread from FO tip so as not to twist the FO. The lamp&sphere were moved with the input FO tip between coiled & uncoiled FO positions. Room lights were off during measurements. Source was operated as either "bare lamp" = with or without knife-edge attenuator, or filtered. 1 "scan set" = 3x pairs of Signal & Background CCD images, and processed to "average net signal" = avg(sig – bac) (ADU).

HI-2018-02 Measurement Summary:

Day01: 11-Sep-2018 GMT, "**Step#1**" = bare FO output tip toward camera. FO tip ~10 in from camera face. Source= bare lamp, filter green = FB510-10, red = FES0900. 23ft FO uncoiled & coiled. "**Step#2**" = Aspheric condenser lens. FO tip to lens flat face = 13 mm, tip-o-lens to camera ~20+ mm. Source= bare, green. FO coiled & uncoiled. Check room lights on vs off.
Note: Day01 data = junk! ***Step#1 setup = bad – need closer FO-to-camera distance.***
Step#2 setup had incorrect back focal distance – should be 12 mm (was 13 mm) – see Day03!

Day02: 14-Sep-2018 GMT, **Step#1 rev.2** = get FO tip as close as possible to camera window. Camera shutter to window ~2.8 mm. Set FO tip ~0.5 mm to shutter = ~3.3 mm to window. Source= bare, green. FO= coiled, uncoiled. **Step#2 rev.2** = visually check aspheric collimation & check/re-set 13mm back focal length, get closest aspheric tip-o-lens to camera window ~22.3 mm.
Day02 Step#1 rev.2 data = OK (?)
Step#2 setup had incorrect back focal distance – should be 12 mm (was 13 mm) – see Day03!

Day03: 15-Sep-2018 GMT, **Step#2 rev.3** = re-set lens#1 aspheric back focal length = 12 mm = FO tip to lens flat face (clean dirty lens), lamp bare&green, FO straight&coiled. **Step#3** = add lens#2 = plano-convex N-BK7, set distance aspheric tip to plano flat = 297.3 mm, set distance plano round to camera window ~301.8 mm.
Day03 Step#2 rev.3 data = OK (?)
Step#3 setup incorrect – lens#2 plano-convex round face should be toward collimated light!

Day04: 19-Sep-2018 GMT, **Step#3** rev.2= set lens#2 plano-convex round face toward lens#1 aspheric. Try to get plano-convex back focal length = 297.3 mm = distance plano flat face to camera window. Total distance FO tip to plano flat face ~302 mm.
Day04 Step#3 rev.2 data = OK (?)

Day05: 22-Sep2018 GMT, K.Voss Q: is coil/uncoiling stable? First, MF **Q: is FO-to-sphere coupling repeatable?** I.E. need to couple/uncouple 2x FO's from sphere to coil/uncoil long FO. Same 2x lens setup as day4 = Step#3 , FO= coiled, kept lamp pwr ON while twist sphere on/off the input end of FO. Sphere uncoupled/coupled 3x times.

Day06: 25-Sep-2018 GMT, MF **Q: how long warmup until lamp is stable?** Same setup as day4,5 = 2x lenses = Step#3, FO=coiled, 10x Sig/Bac scans @ ~2min intervals during 20 min lamp warmup.
KV **Q: is coil/uncoiling long FO stable?** Coiled scan-set, un-coiled scan-set – repeat 3x times.
MY **Q: try change back focal distance @ apsheric lens#1.** @ Day3 I set FO-to-aspheric(flat face) @ 12mm via Thorlabs retaining ring wrench/gauge SPW602 (but did not measure this via calipers) = scan-set#1, uncoiled FO. SS#2= 0.5mm closer via SPW602 & measure via calipers = 11.54mm. #3= 0.5mm closer = 11.05mm. #4= 12mm target distance = 12.04mm. #5= 0.5mm further = 12.56mm. #6= 0.5mm further = 13.09mm.

Note: 20-Sep Ken asked to measure output of different number of FO coils – I forgot to try this…

Figure 1 below shows Mike Kehoe's Fig.2 "Experimental Setup Overview", marked here in **red** with locations **#1**, **#2**, **#3** = where images were collected via the Andor camera.

#1 = Closest possible to Fiber Optic Output Face, which was approx. 0.5 mm between FO tip and camera shutter, or approx. 3.3 mm to the camera window - see ***Day02 Step#1 rev.2 data.***

#2 = Closest possible to focal length of the Aspheric Lens ACL2520U-A. Day03 was approx. 21.7mm between the lens' flat face and camera window – note: ACL25020U-A EFL = 20.1 mm ± 8%, or 8.49 to 21.71 mm - see ***Day03 Step#2 rev.3 data.***

#3 = Closest possible to the back focal length of the plano convex lens LA1484-A, which was approx. 297.3 mm between lens' flat face and camera window – note: LA1484-A bf = 297.3 mm – see ***Day04 Step#3 rev.2 data.***

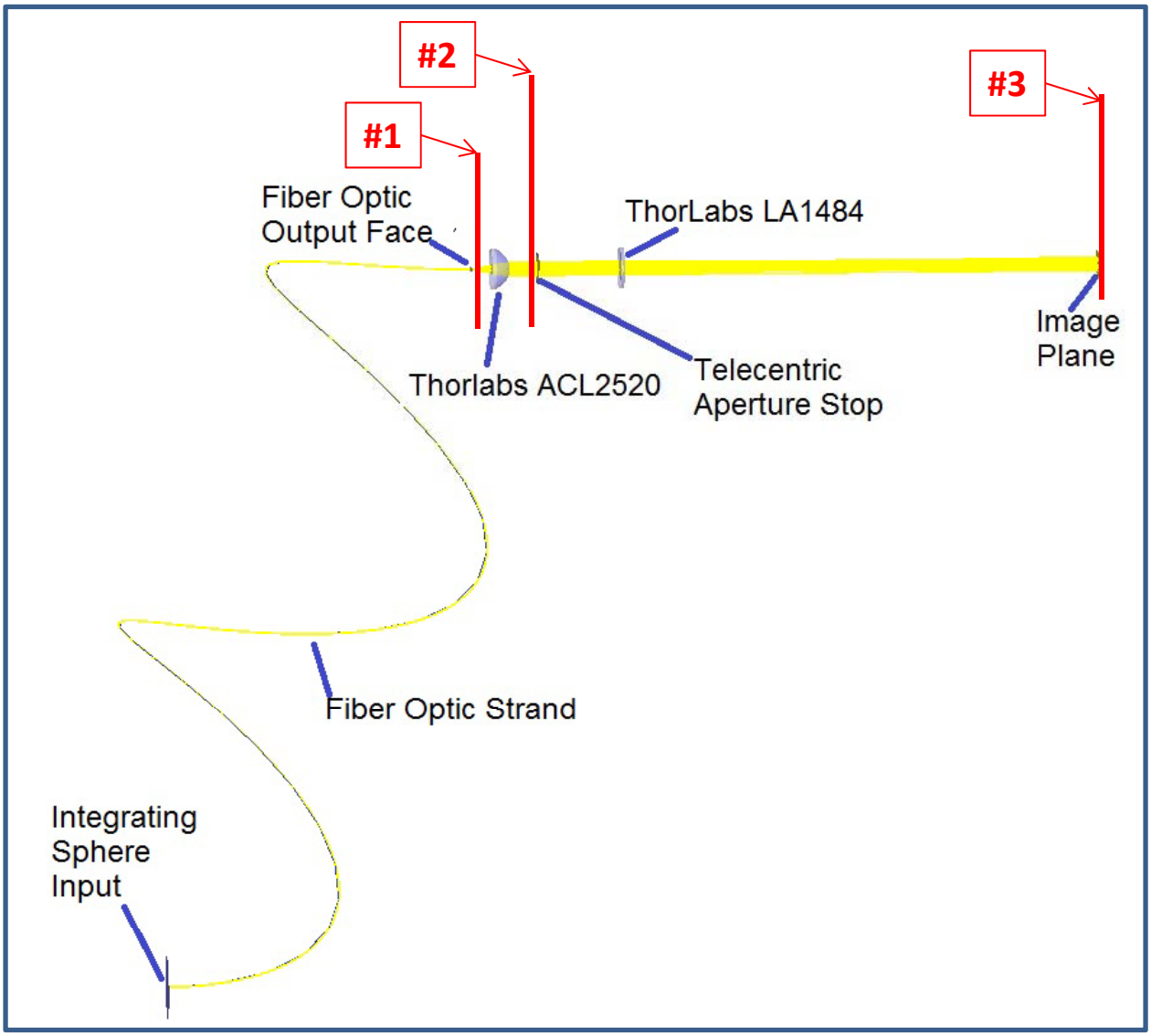


Figure 1, Mike K's "Experimental Setup Overview" with CCD positions in red

Results:

Figure 2 = **Step#1**: outptut FO tip 3.3 mm to camera, FO straight & coiled, lamp bare & green filter

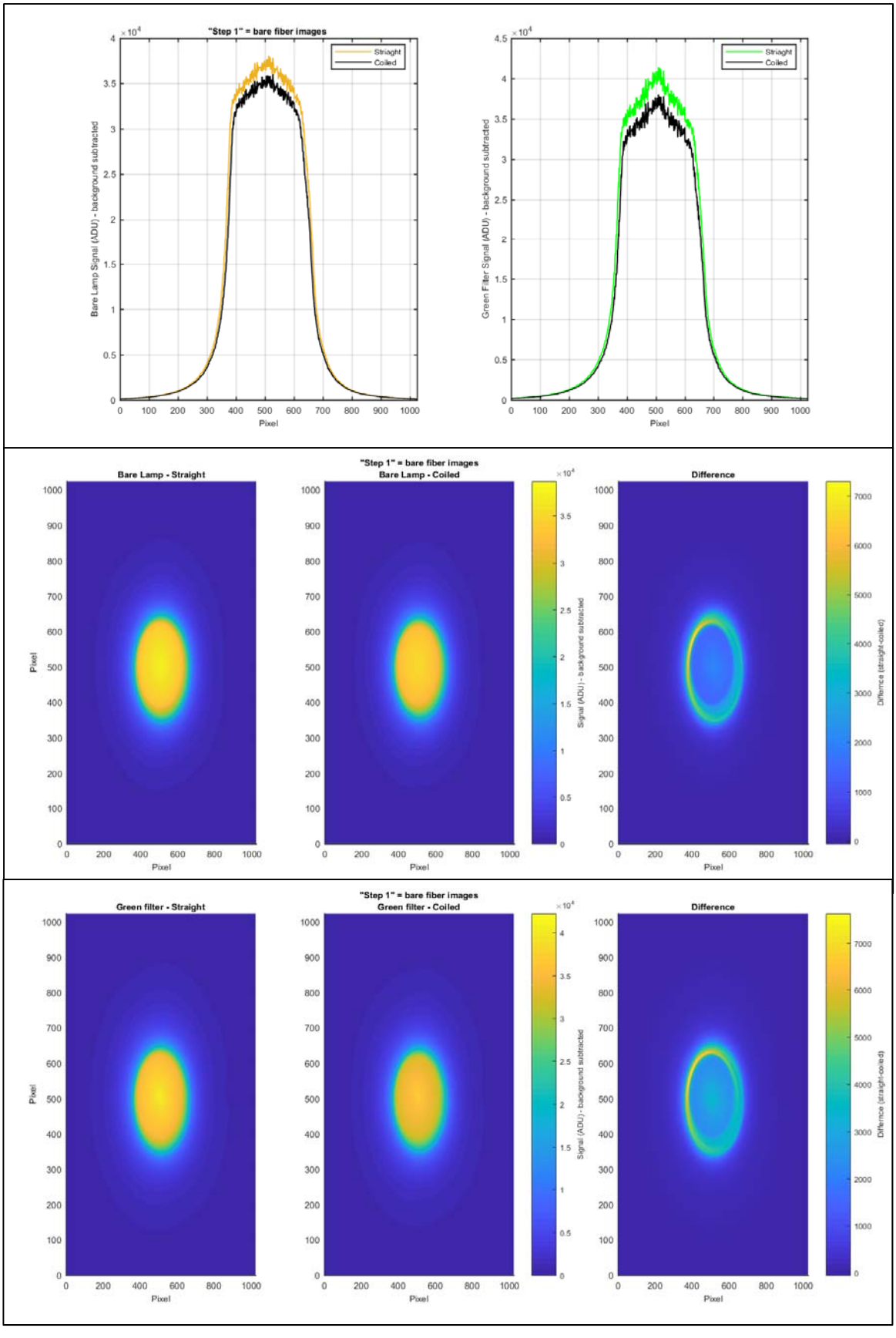


Figure 3 = **Step#2**: lens#1 flat face 21.7 mm to camera, FO straight & coiled, lamp bare & green filter

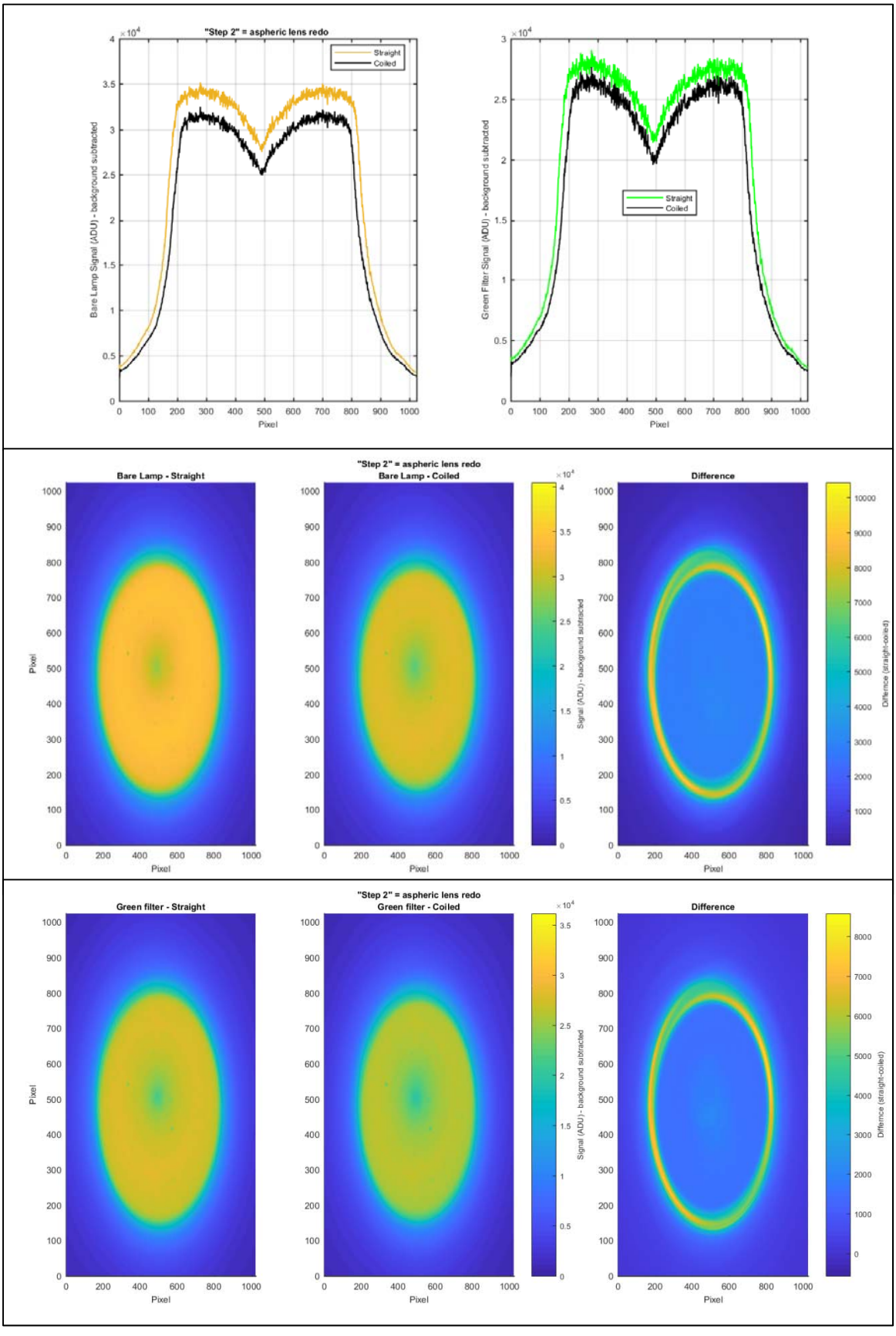


Figure 4 = **Step#3**: lens#2 flat face 297.3mm to camera, FO straight & coiled, lamp bare & green filter

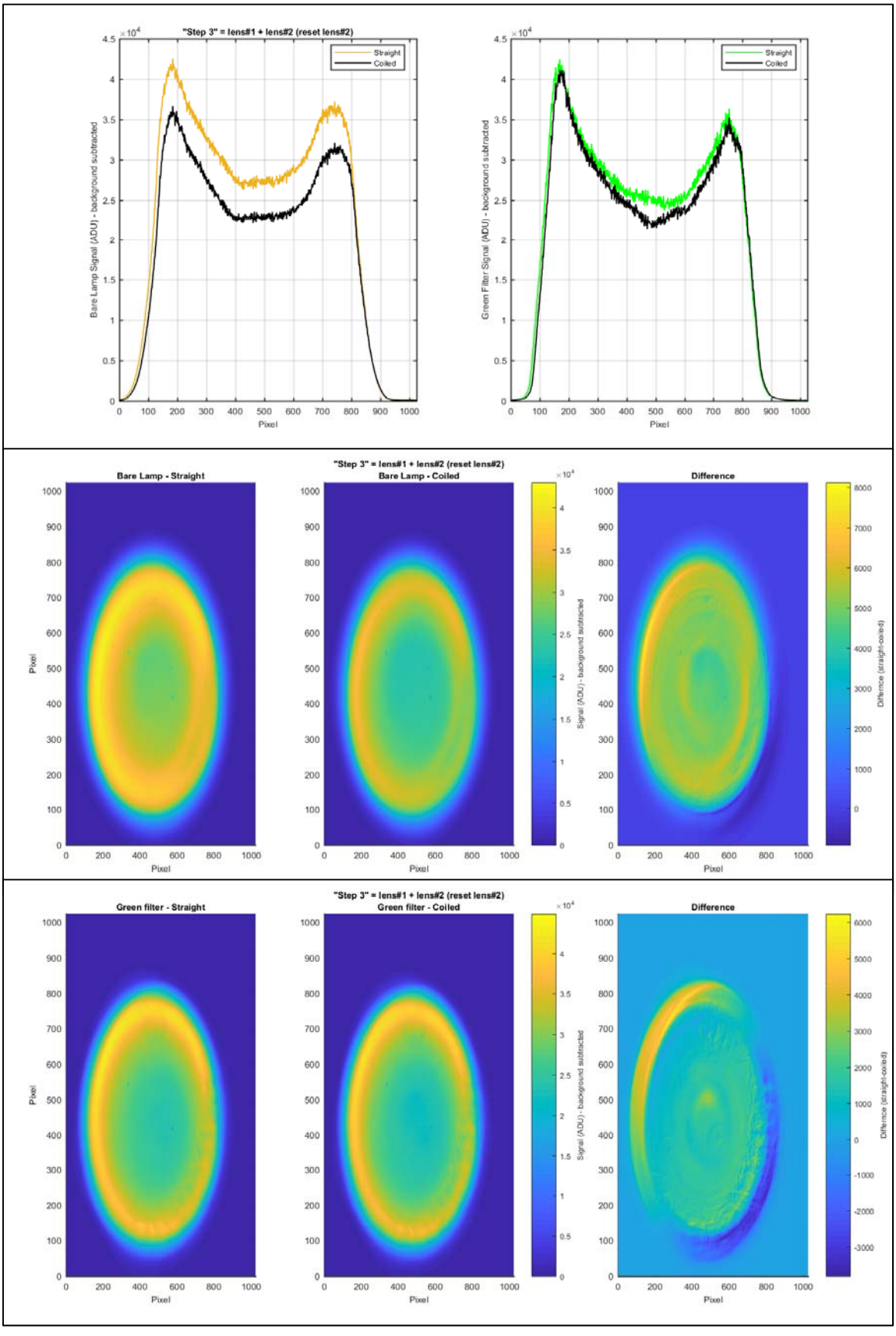


Figure 5 = **Day05**: Q: is FO-to-sphere coupling repeatable? I.E. need to couple/uncouple 2x FO's from sphere to coil/uncoil long FO. Setup = 2x lenses (Step#3), FO coiled.

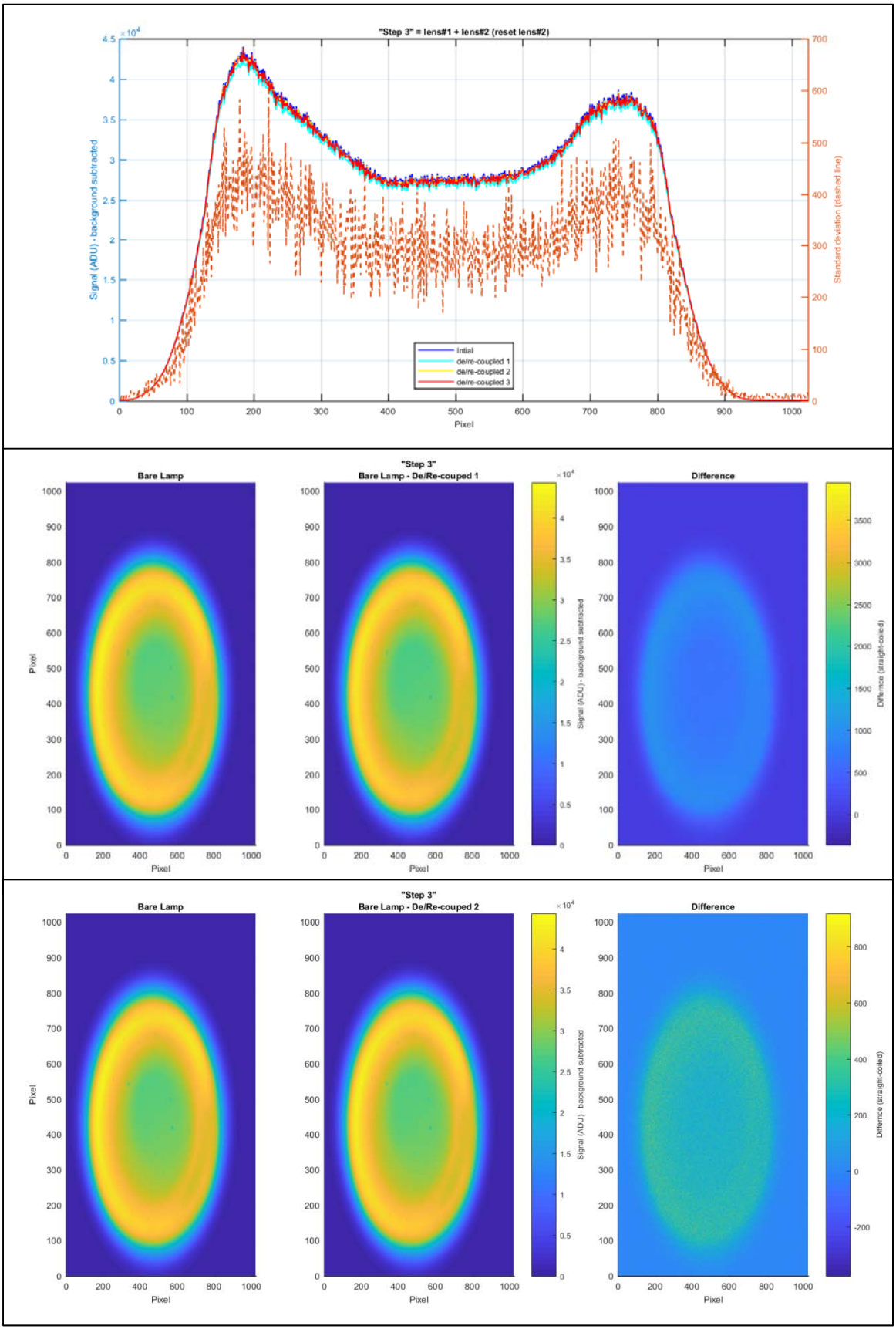


Figure 6 = **Day06**: Q: how long warmup until lamp is stable? Setup = 2x lenses (Step#3), FO coiled, 10x Sig/Bac scans @ ~2min intervals during 20 min lamp warmup

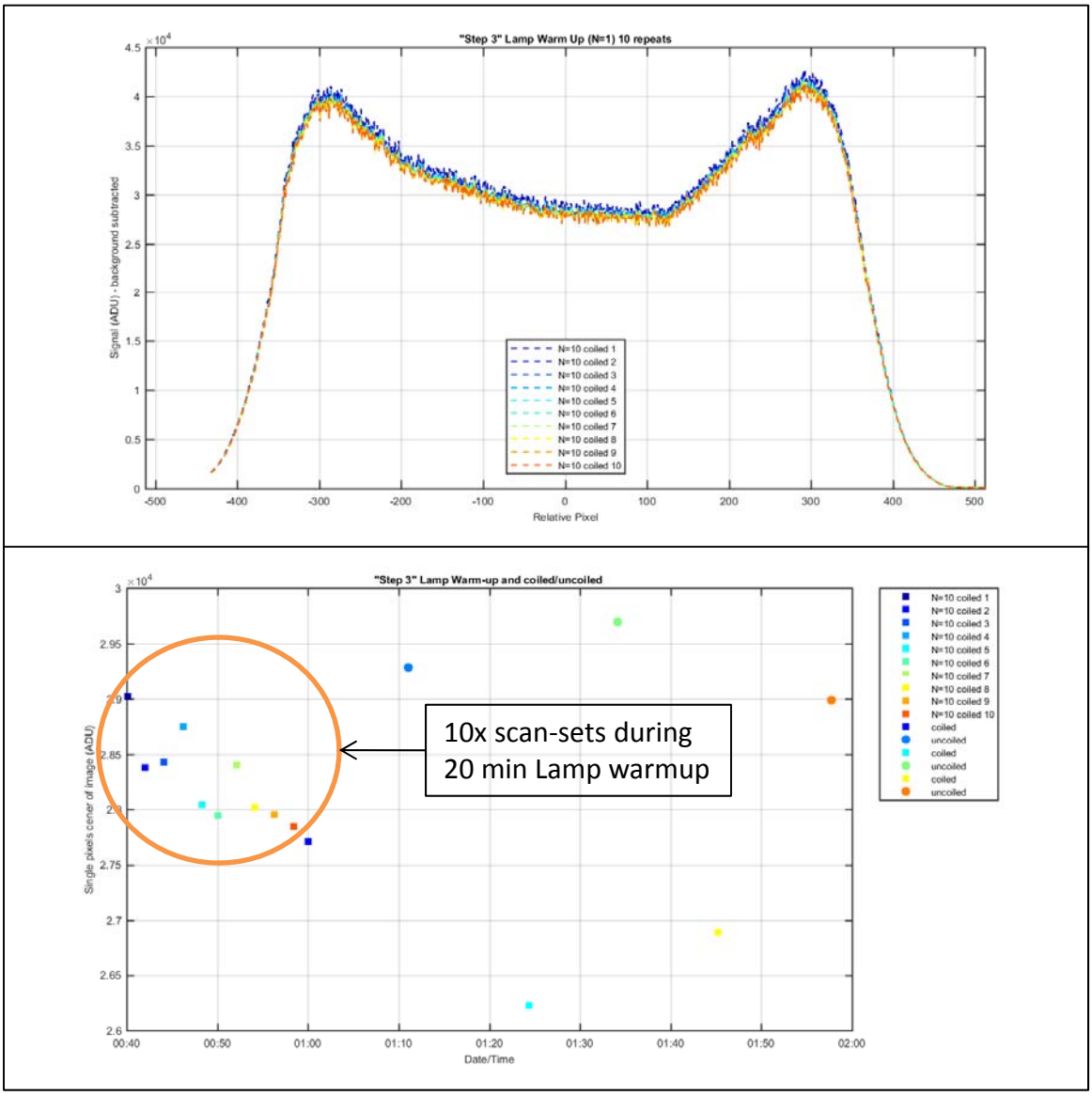


Figure 7 = **Day06**: Q: is coil/uncoiling long FO stable? Coiled scan-set, then un-coiled scan-set – repeat 3x times.

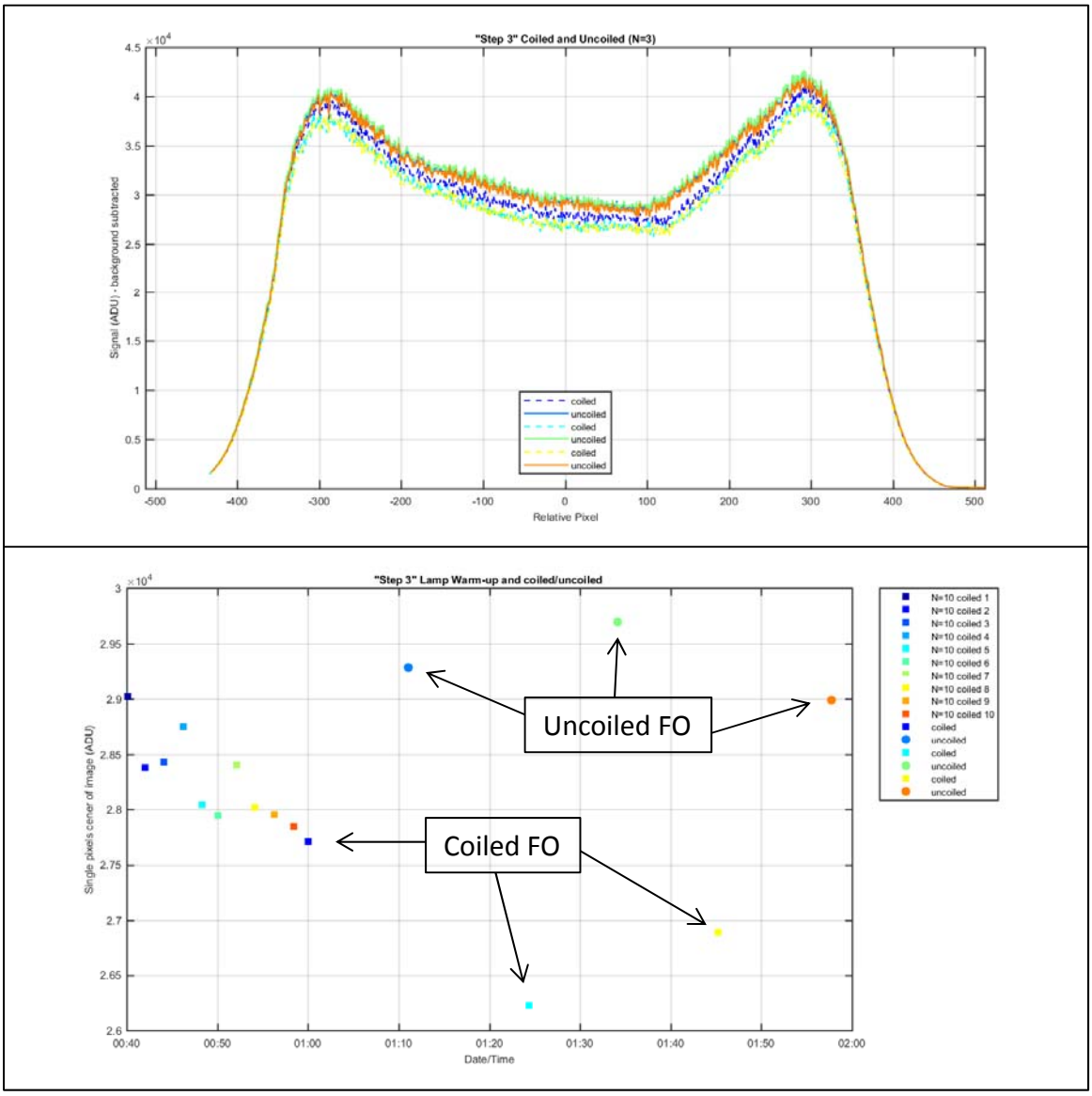
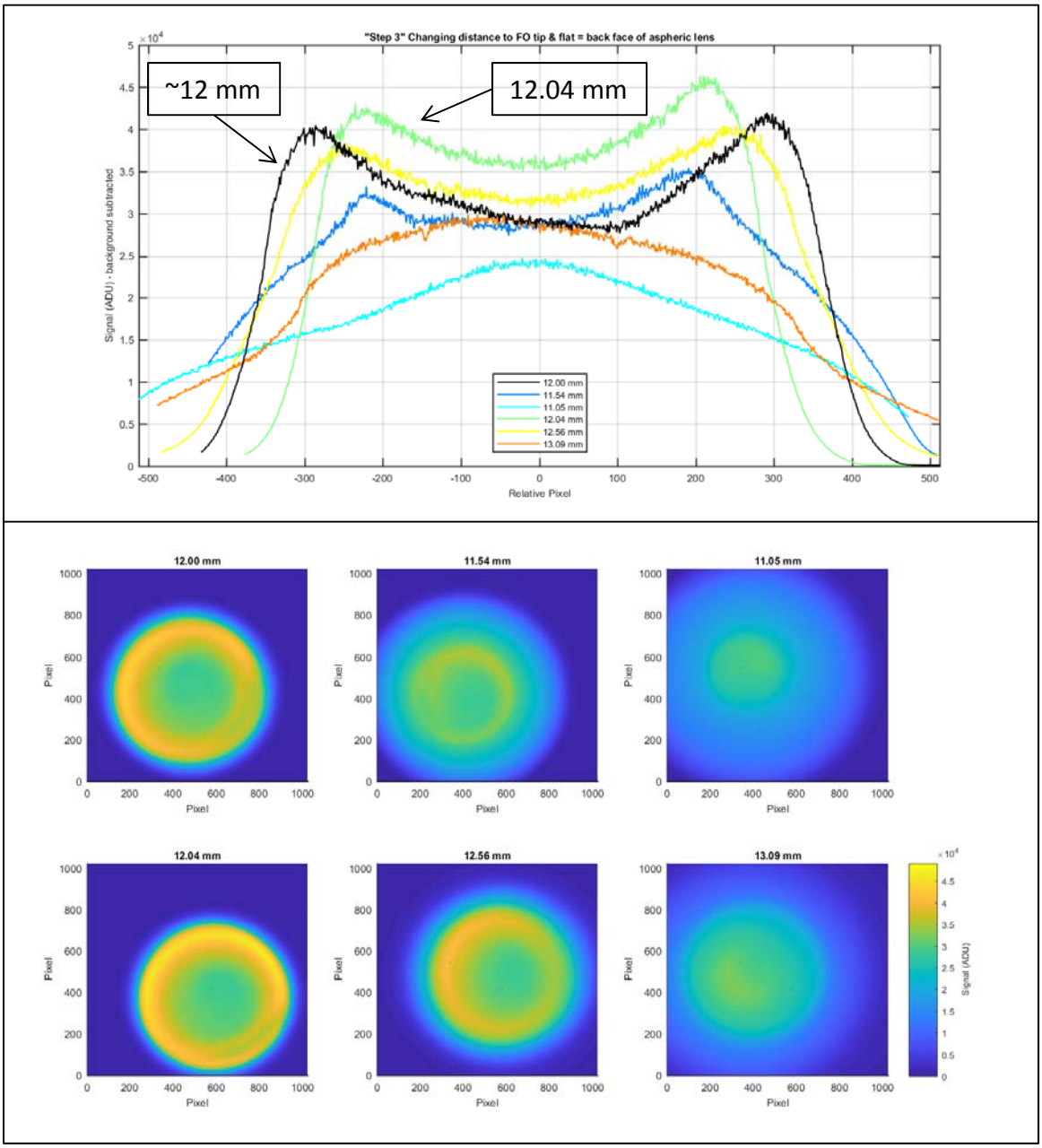


Figure 8 = **Day06**: Q: try change back focal distance @ apsheric lens#1. Uncoiled FO.



Note: Top panel = after S.F's centering of images shown in Bottom panel = raw from camera.