SolPol Dark Tests

ΕΘΝΙΚΟΝ ΑΣΤΕΡΟΣΚΟΠΕΙΟΝ ΑΘΗΝΩΝ
NATIONAL OBSERVATORY ATHENS

University of Hertfordshire UH

Contents

HEADER file details:

SOLAR POLARIMETER

1. Polarimeter Position [deg]
2. Rotator Position [deg]
3. PEM Setting [nm]
4. Retardation [waves]
5. Wavelength Filter (Wavelength-Bandwidth)
6. ND-Filter
7. Time (UTC)
8. Bias Voltage on Diode
9. LabJack, mean DC (AIN0)
10. LabJack, other
11. Lock-in, 1w
12. Lock-in, 2w

MEASUREMENT details:

- Measurement starts when **PEM** is @0° and **Polarizer** @41° (must always check on **solpol.exe** status board)
- File naming:
  pol_DDMMYYYY_HHMM_LOC_DURATION.txt
- where HHMM is the PC time, LOC is one of "antik", "ath" or "cy" for Antikythera, Athens and Cyprus data, respectively, and DURATION is the measurement duration as either "onehour", "twohours" or "sixteenmin".
- 5 measurements per polarizer position (~41°, 131°,221° and 311°) per PEM position (0° & 45°)
- Each measurement (4 Polarizer pos. – 1 PEM pos.) last ~4mins
- Ends ALWAYS @PEM in **45°**
- Total **2hrs file length** 8334 lines, where 160 hits should account for each polarizer position, size 91-92 Kb. The ½ goes for 1hr measurements.
- Full day measurement starts @6 UTC ends @16 to 16:15 UTC
- Dark measurements with shutter closed and instrument either in **Tracking** mode -> **poldarkT**, or **Non-Tracking** mode → **poldarkNT**
- Darks available only during Aug. – Sept. 2020 datasets
- PEM aperture 23mm @ 90% efficiency
- Instrument FOV ~1° solid angle

MEASUREMENT sequence:

- Open **solpol.exe**, **picoscope.exe** and **opticstarview.exe** CCD camera program
- Hit the **Find** button in solpol.exe → wait for **"All peripherals found"** reading in the program screen
- Select in solpol.exe the **550nm** filter option and wait for Filter Wheel to operate (Picoscope indication varies)
- If sun appears on camera, polar alignment and parking positions are OK
- Slightly move the tracker to **N-S** & **E-W** directions through EQtab in order to target directly the Sun → maximization of the intensity signal in Picoscope voltage reading (reach at least 2.5 V & above if morning set-up)
- Hit track rate "Solar" (Sun icon) in EQtab and minimize tab
- Hit Initialize and wait for parameters
- Hit **Start** sequence → choose appropriate duration → save file and start (*wait for PEM to turn after 4'*)

SUN TRACKER Initialization & Tracking sequence:

Type: **EQ3 – SynScan** (lightweight, max. load of 10Kgs, less accurate in prolonged tracking) + **EQmod** direct PC control

- Open **CartesduCeil.exe** → Choose the appropriate observatory site, then → Telescope → Connect (Telescope EQtab opens)
- in EQmod tab → **Unpark** (co-ordinates scenario should be set to the specific instrument location)
- in **CartesduCeil.exe** search tab → Sun (Enter) → pointer on Sun (left click) → Telescope → Slew, tracker moves

Supplementary Material

Dark Tracking & Non-Tracking tests

There were two setups when conducting dark measurements (dark plastic cap adjusted to the front of the PEM every time, so that no light reaches the crystal, there is no internal mechanic shutter in the instrument & the dome is closed when performing dark measurements):

i. the EQ mount tracks the Sun, when the Sun is above the horizon
ii. the EQ mount is parked and does not track the Sun

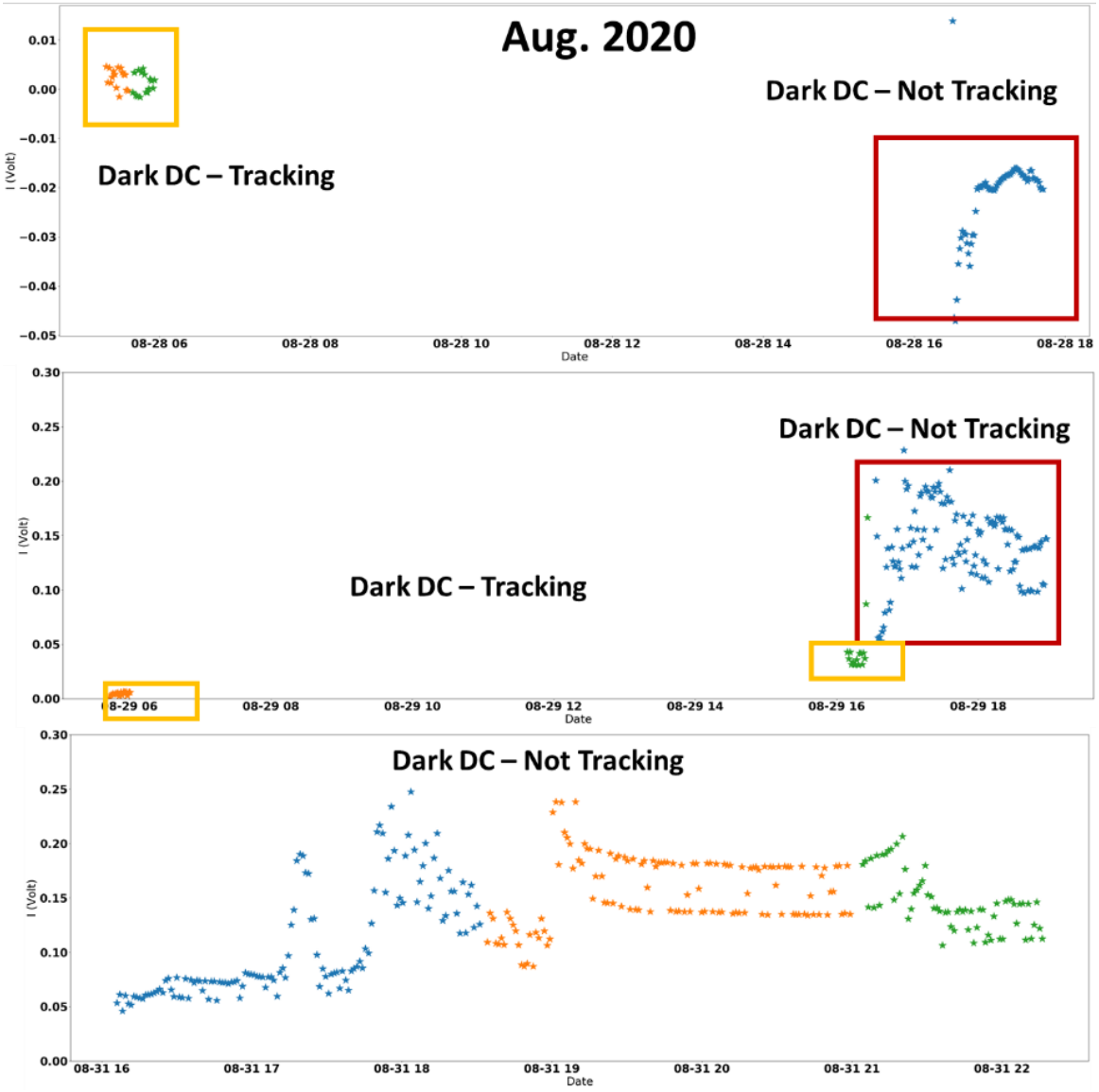
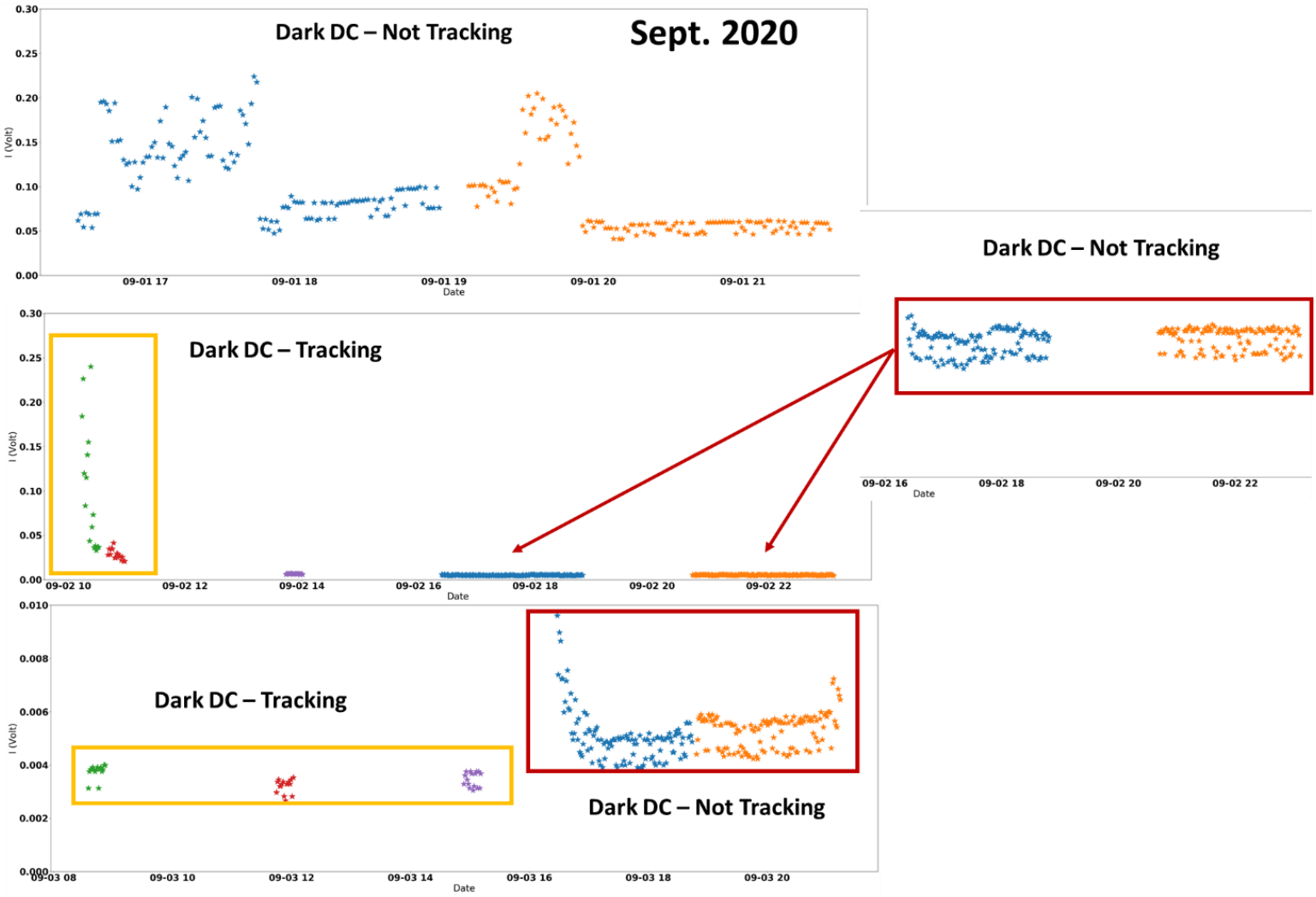


Fig. SM 1: DC voltage output (I) during August 2020 (28, 27 & 31/08) dark measurements. Different colours are used for each measurement set within the same day and may vary with the number of sets. Tracking mode dark outputs are highlighted with the yellow frames, while Not Tracking sets are highlighted with the red frames, Date is in UTC. Negative I values in the 28th are likely due to power leakage in the system, fixed the next day Not Tracking voltage is larger than in the tracking case.

 Instrument: ***courtesy of the University of Hertfordshire***

Dark measurements were performed during August – September – October 2020 periods, either in brief time-windows between regular measurements, in order not to lose much of the daylight, either during nighttime without tracking due to the unfavorable position of the tracker. The 17 - 18/10/2020 are total days with dark measurements. If we exploit only the mean DC voltage (I in Volts) from the dark measurements and later subtract it from the respective DC output of the regular measurement (Kemp and Barbour, 1981), then the tracking mode doesn't seem to significantly and persistently affect the mean DC value. As seen in **Fig. SM 1**-**Fig. SM 3**, it not clear which of the two modes DC current is dominant at each measurement day, therefore we are using both setups when feasible. The DC Not Tracking current appears to be larger than the Tracking DC current in most of the cases.

We should note here that we avoided moving the hosting dome during any of these sequences, as we have observed some spikes (electronic noise due to dome shutter/rotation motor) in the Picoscope reading.



(a)

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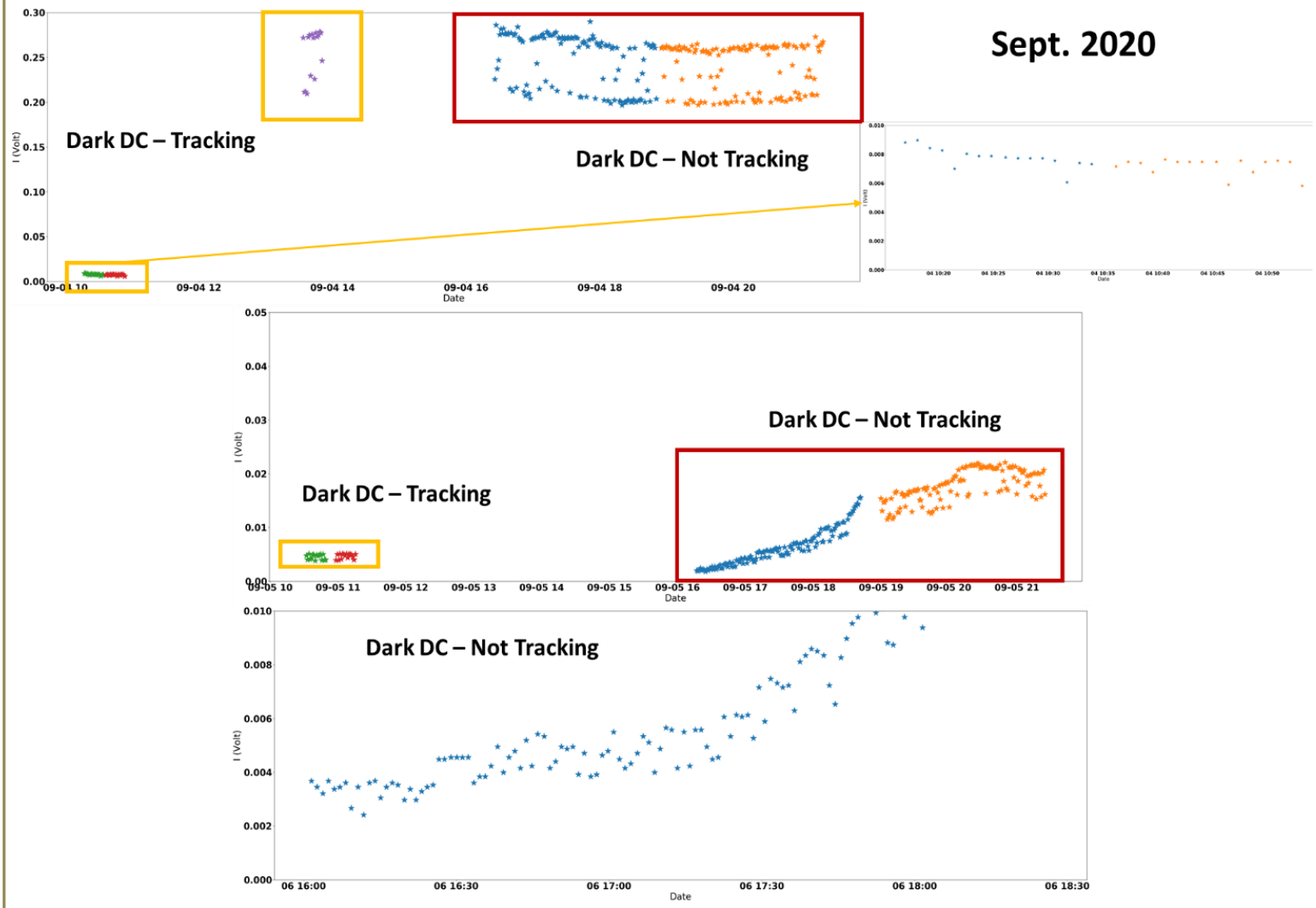


(b)

Fig. SM 2: (a) & (b) DC voltage output (I) during September 2020 (01-06/09) dark measurements. Again, Not Tracking outputs are larger than the Tracking outputs in most cases.

 Instrument: *courtesy of the University of Hertfordshire*

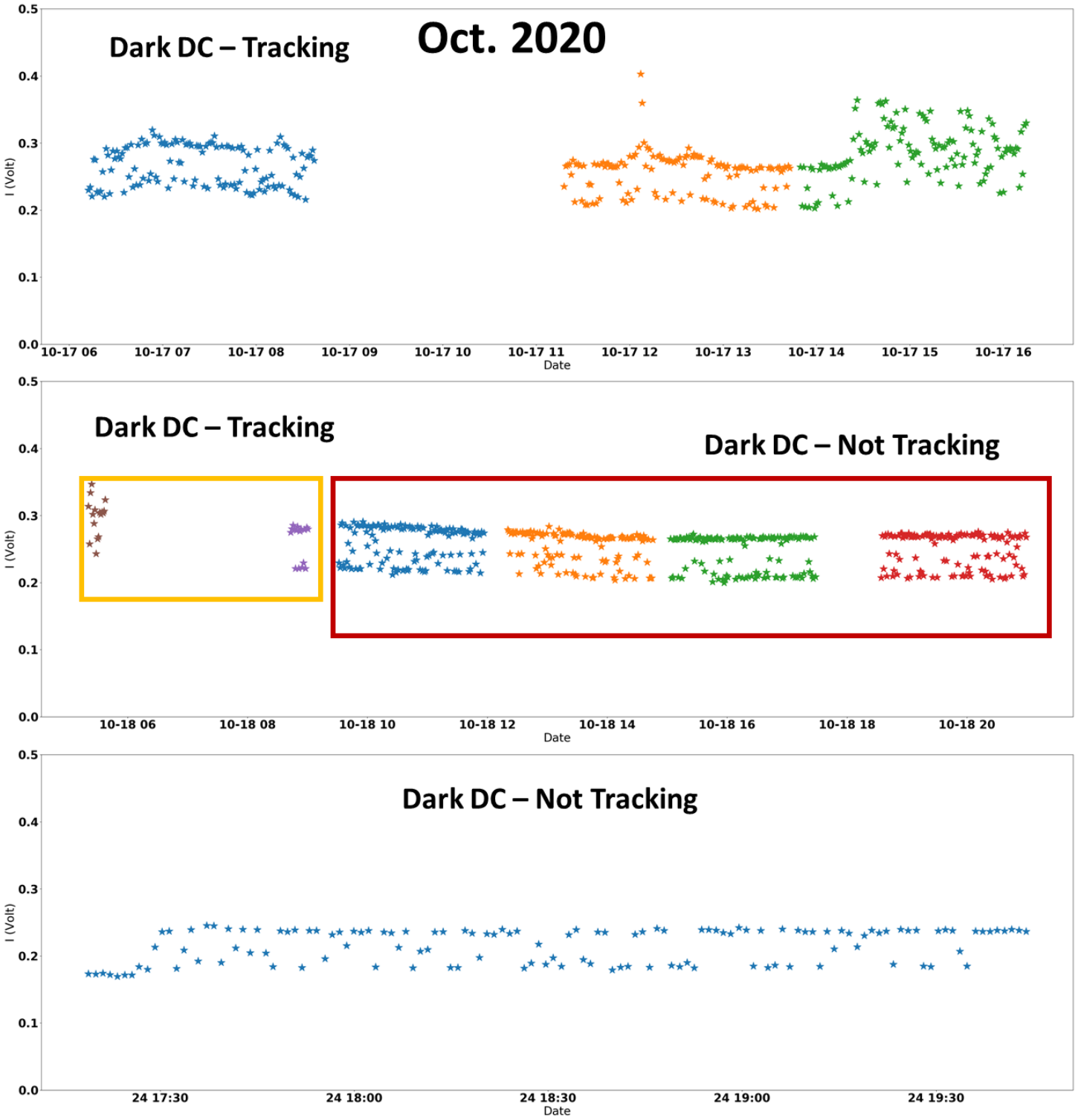


Fig. SM 3: DC voltage output (I) during October 2020 (17, 18 & 24/10) dark measurements. The 17th was a total dark measurements day scheduled with tracking and closed dome due to cloudy conditions and the 18th was a total dark measurements day with Not Tracking/closed dome so as to compare with the previous day. Data from both the 17th and 18th are of the same magnitude, with the Tracking measurements exhibiting a wavelike behavior and becoming randomized during late afternoon (green), while the Not Tracking measurements have an almost constant upper threshold.

Dark data fitting

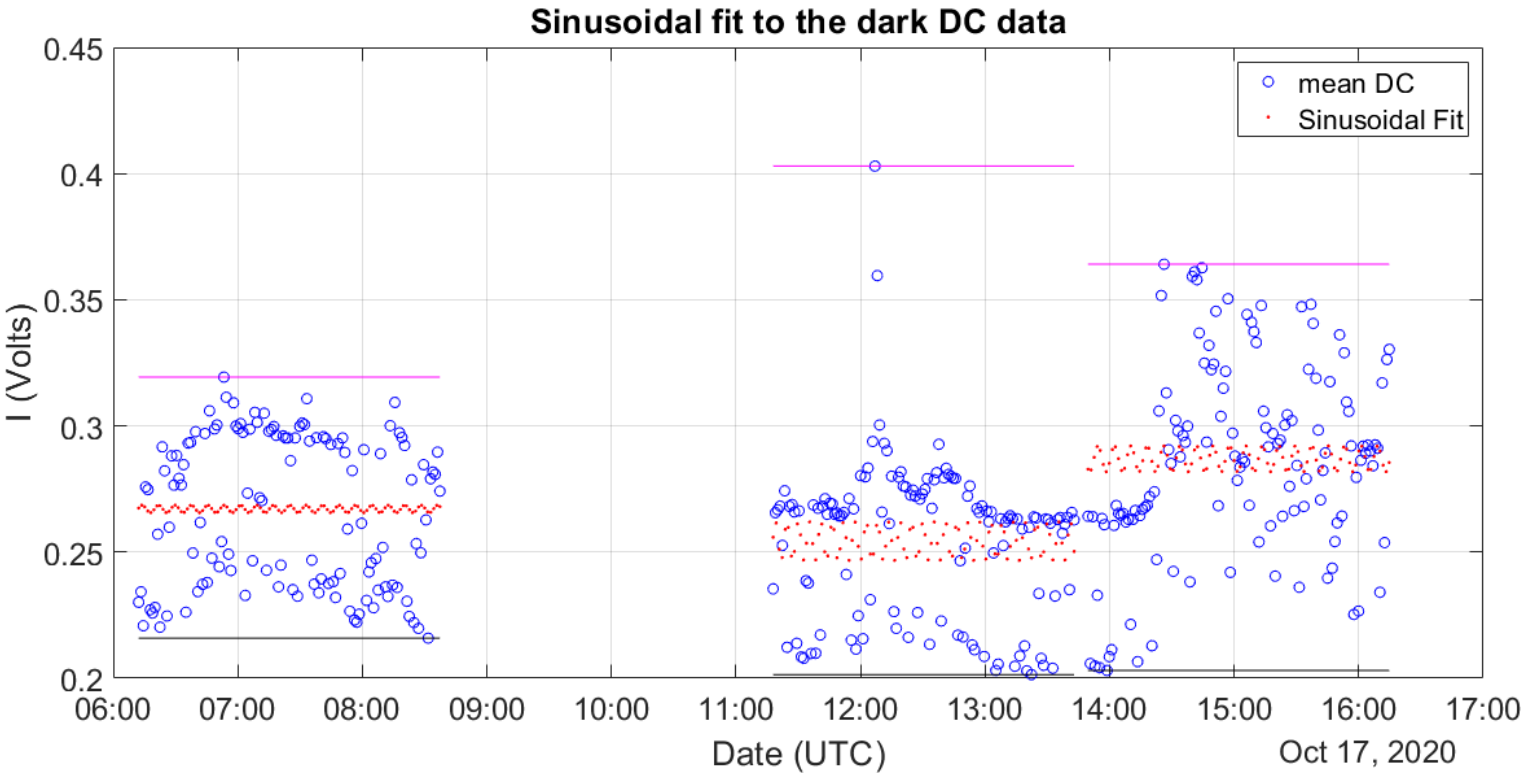


Fig. SM 4: Attempted fit with a sinusoidal function to the October 17th dark data in order to simulate dark current contribution. I_{dark} values vary within the day, while inner dome temperature would vary at most 1-2° C, since it was kept closed for the entire sequence.

Total intensity & raw lock-in outputs

For the extensive measurements period between 29/08/2020 and 07/09/2020 in Antikythera, we depict the variation of the DC current (total intensity I in Volts) as opposed to the total intensity recorded over the dark measurement sequences (I_{dark} in Volts). A difference of 1 order of magnitude is observed.

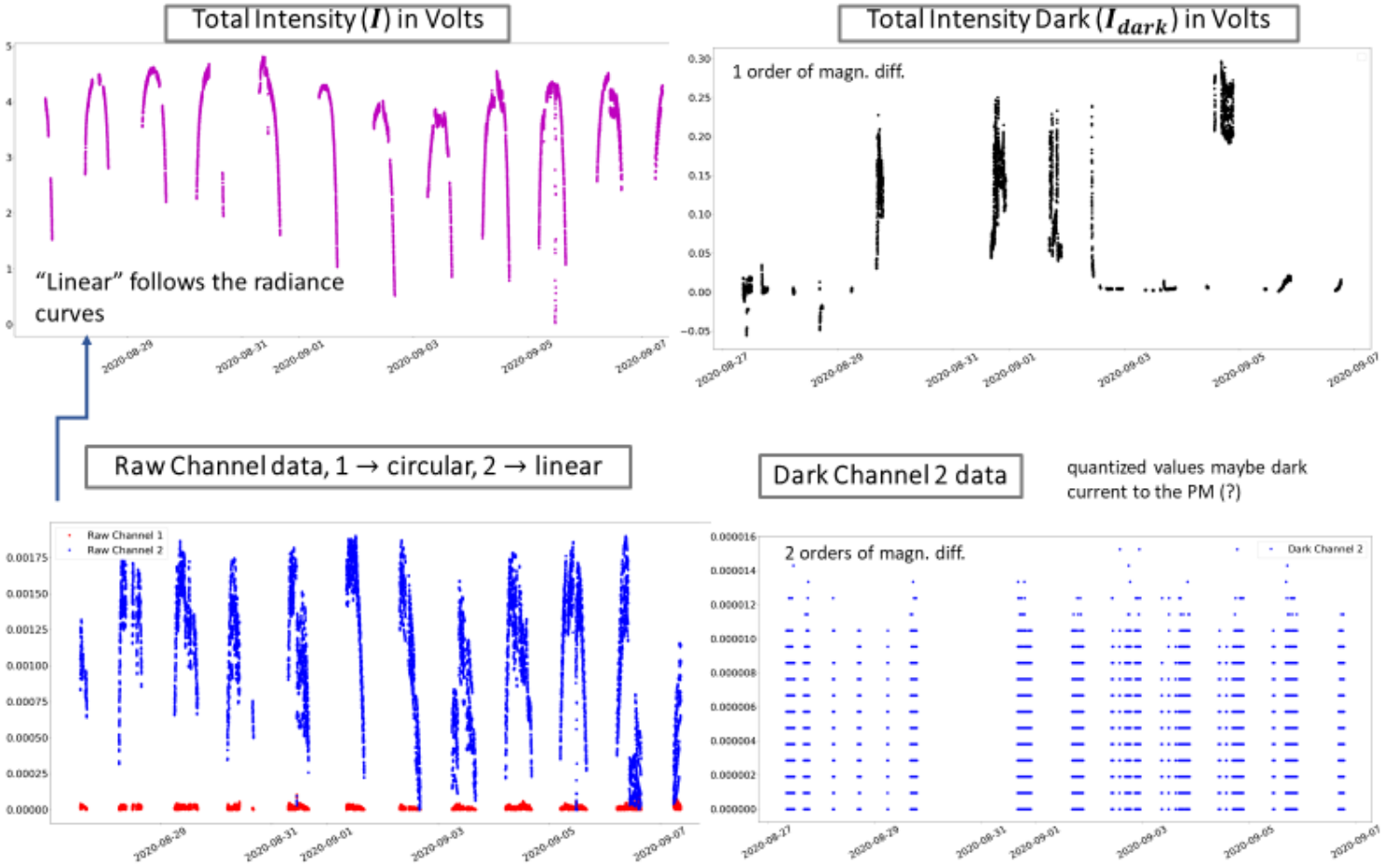


Fig. SM 5: Top panel: variation of I within each measurement day between August 29th and September 7th observations as opposed to I_{dark}. Bottom panel: Lock-in amplifier channel 1 (gives circular polarization) and channel 2 (gives linear polarization) raw signals compared to the dark channel 2 data for the same days.

Smaller Iris tests

During the 24/10/2020 measurements (**Fig. SM 6**), we experimented with a smaller iris in the front aperture of the instrument, in order to restrict the FOV in a smaller area of the Sun disk. The regular SolPol iris is of **5.5mm** in diameter, whilst the smaller one created from black cardboard paper was of **4mm** in diameter. Crude paper edges could impose non-quantifiable polarization effects, hence the non-zero circular polarization. The test will be repeated with an adjustable metallic diaphragm iris from Thorlabs.

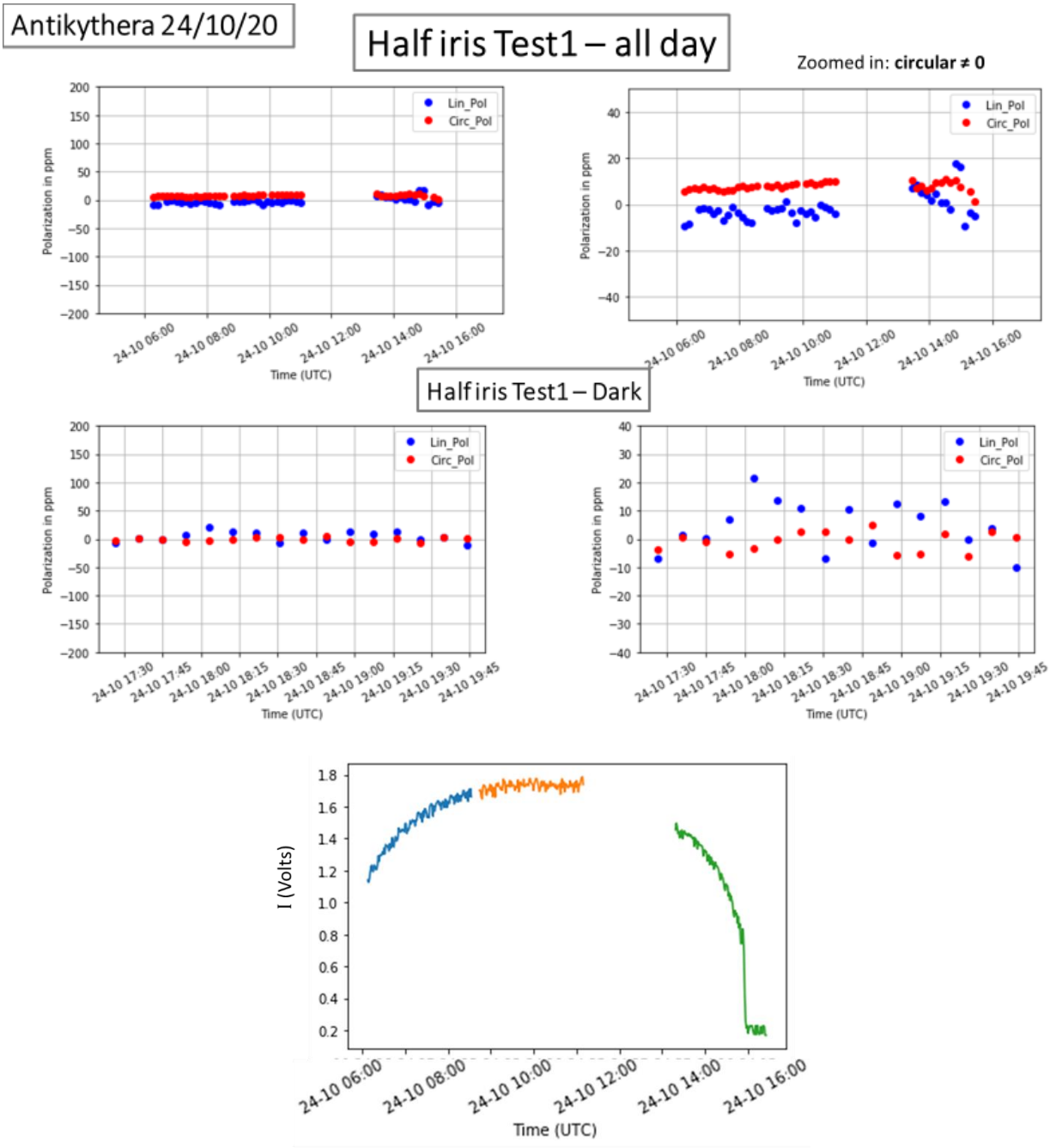


Fig. SM 6: Full-day measurement with a smaller handcrafted iris mounted below the existing aperture.

Sky – reading

For the preparation of these tests, we ensured that the initial sun tracking position maximized the recorded voltage in the oscilloscope (recorded each time through the EQmod po-up window) and then consecutively calculated the right ascension (RA) and declination (DEC) for 0.5, 1 and 2° incremental steps away from the sun disk (**Fig. SM *7***). The direction of the polarimeter was constrained only for changes in the local elevation, therefore a complete set of a cross-like sky reading test will be attempted during May 2021.

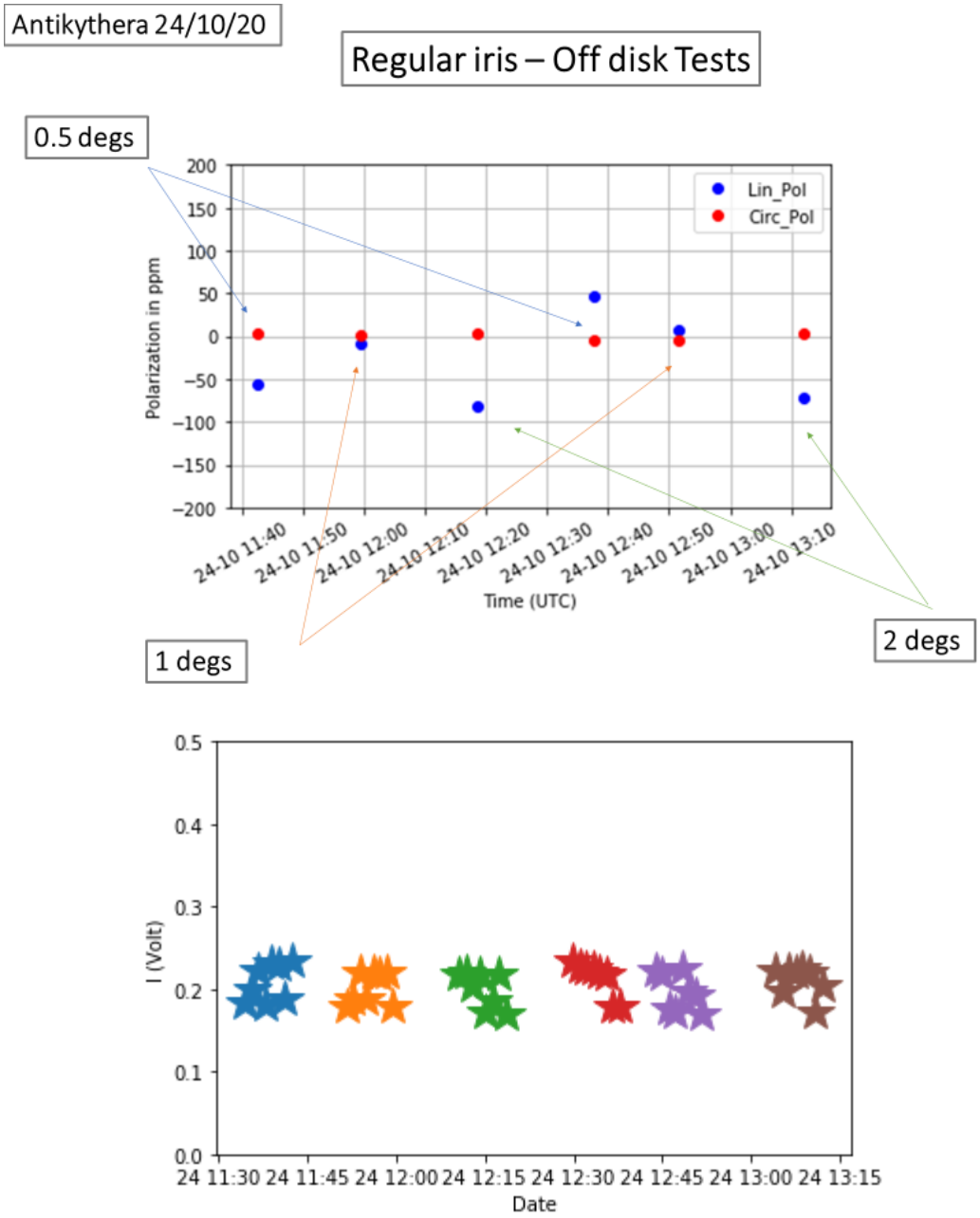
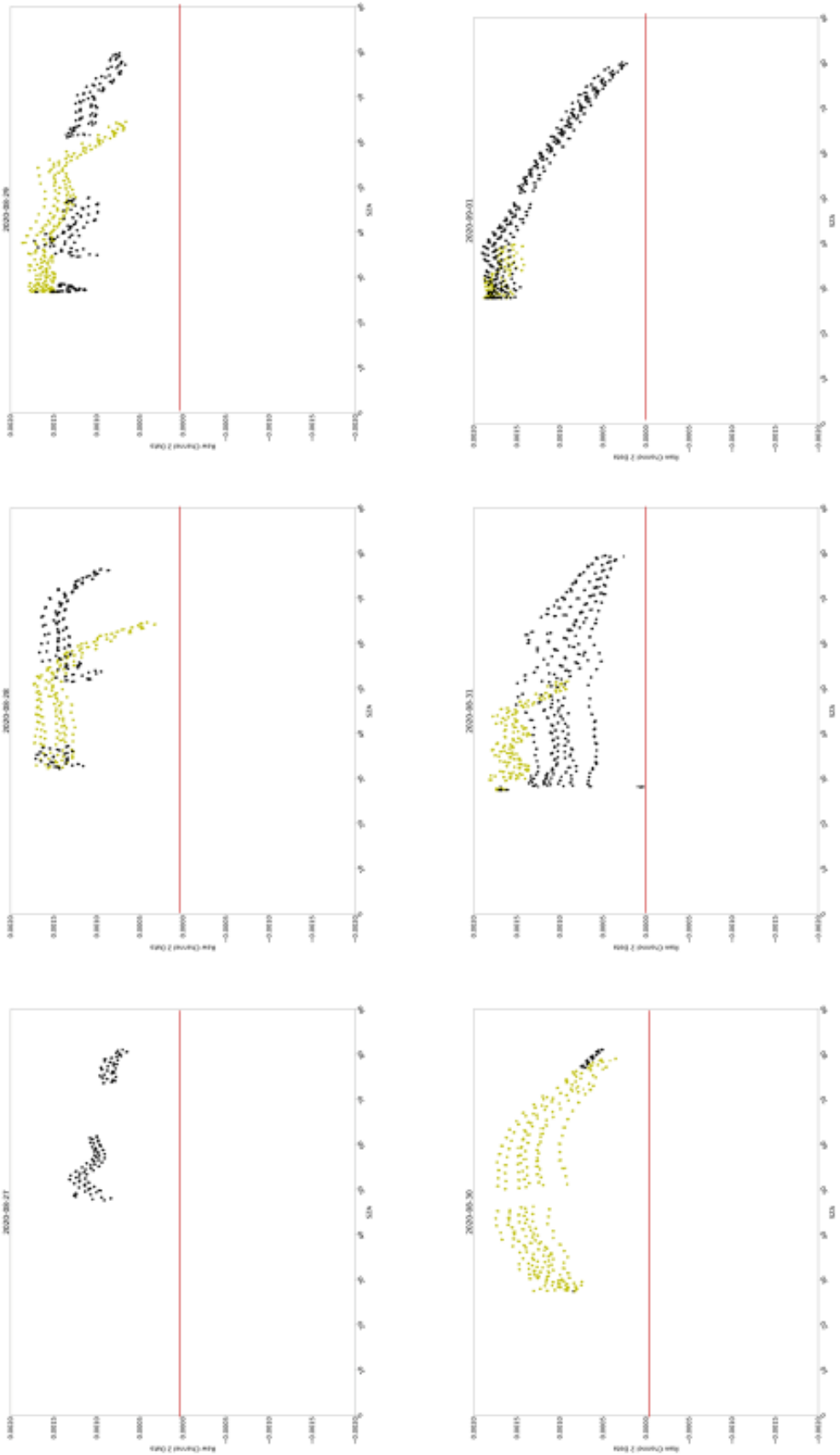


Fig. SM 7: Top panel: attempted sky-reading at 0.5, 1 and 2 degrees away from the central Sun's disk position that we assume under each measurement initialization with the tracker. Offset angles were calculated for the current day Sun position and manipulated through the Right Ascension and Declination commands in the EQ ASCOM control software. Bottom panel: light intensity during the off-disk measurements.

Morning vs Evening distinction

RAW data vs SZA (morning/evening)



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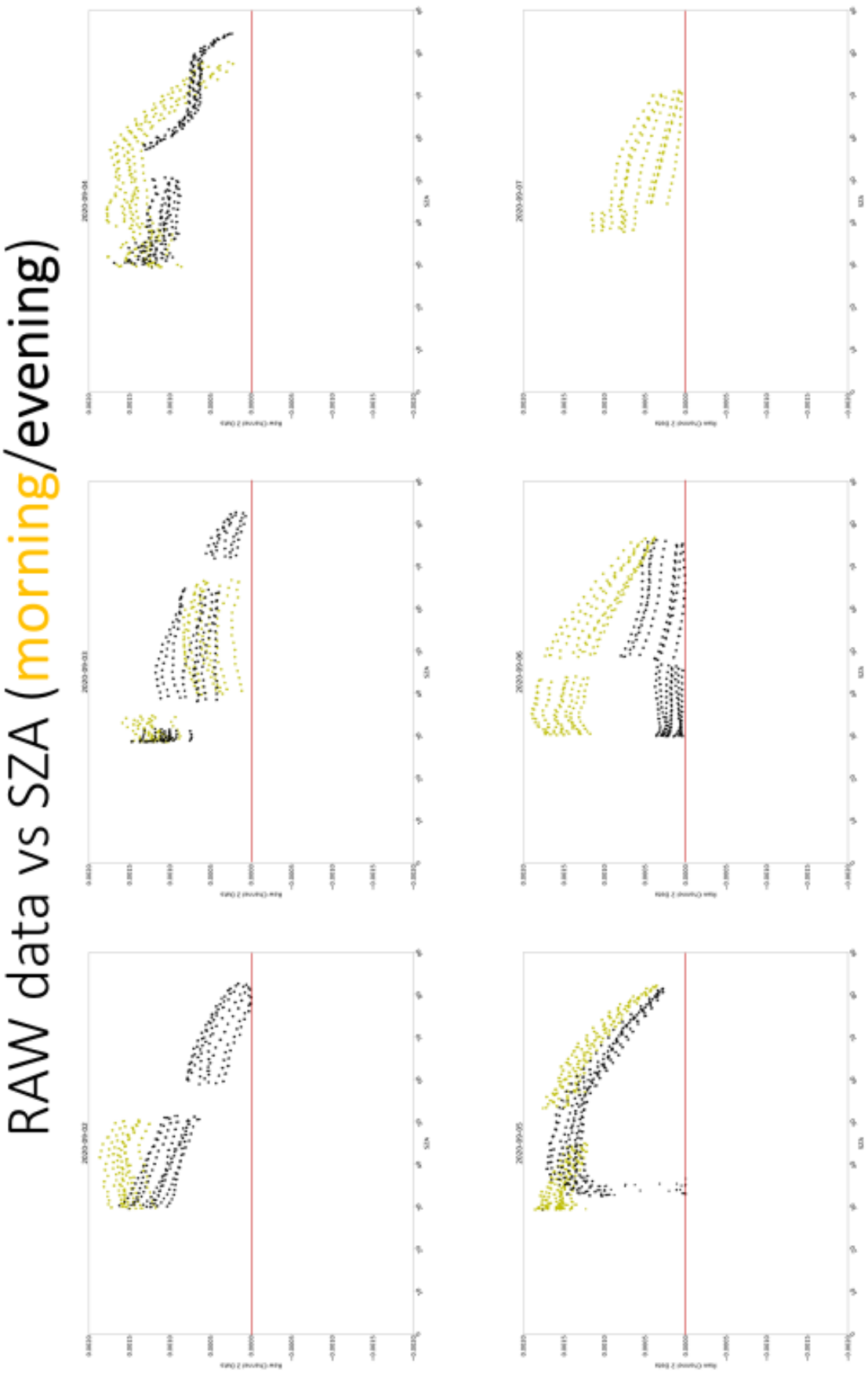

 Instrument: *courtesy of the University of Hertfordshire*