



**SARAO**  
South African Radio  
Astronomy Observatory

## **ON-SKY VERIFICATION TESTS FOR CORRELATOR RELEASE JULY 2020: IMAGING AND VISIBILITIES**

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## DOCUMENT APPROVALS

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## DOCUMENT HISTORY

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1	12 August 2020	V Krishan R Ramanujam S Legodi	

## DOCUMENT DISTRIBUTION

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## DOCUMENT SOFTWARE

Package	Version	Filename
Word Processor	Google drive	Original google doc link: <a href="https://docs.google.com/document/d/1IMoUWllhFDHZs7Mec4q3RuE6fE-gaUPgoJnpuAh--iM">https://docs.google.com/document/d/1IMoUWllhFDHZs7Mec4q3RuE6fE-gaUPgoJnpuAh--iM</a>

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## OBSERVATIONS

### Standard field

1. L band, 4K channels, wide band, 1596158164
2. UHF band, 4K channels, wide band, 1596163435

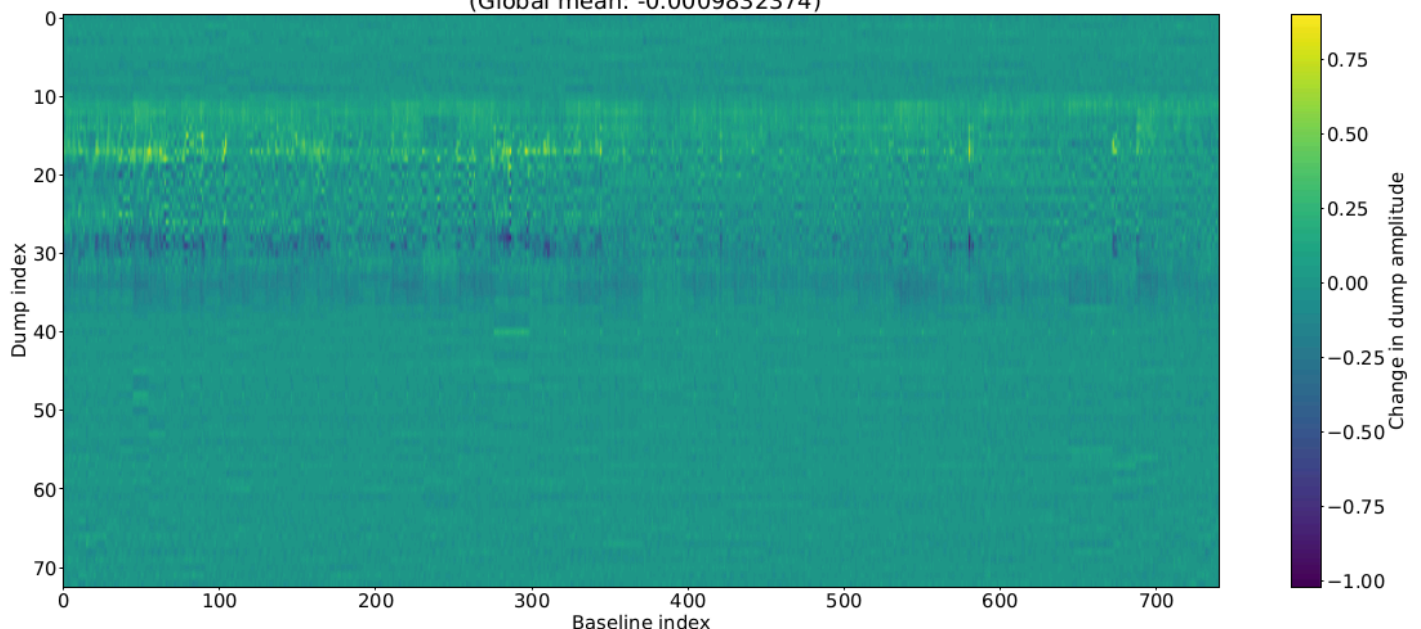
### Long tracks on calibrators

We undertook system stability-track observations on either J1939-6342 or J0408-6545 between 28 to 31 July 2020. Each of these lasted for approximately 2 hours. Previous observations to test the cmc2 version of the correlator have focused on the L band 1K and 4K modes. In the following list, the starred lines indicate the first instance that we observed in these modes for the purpose of verifying the correlator.

1. L band, 1K channels, wide band, 1595971406
2. L band, 4K channels, wide band, 1596017058
3. UHF band, 1K channels, wide band, 1596094172\*
4. UHF band, 4K channels, wide band, 1596172238\*
5. L band, 32K channels, narrow band, 1596017061\*

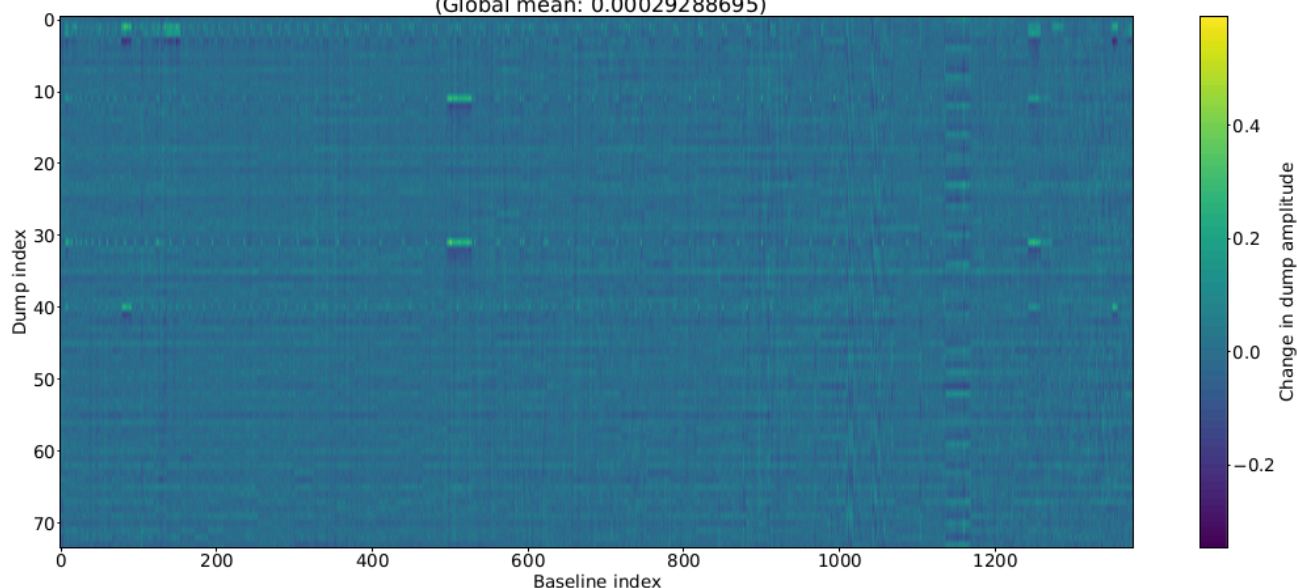
During the analysis, we found that the first scan of the L band 4k observation (1596017058) was corrupted with RFI:

5. Change in amplitude from one dump to the next for  
 1596017058\_sdp\_l0.full-scan-1-[980000000.0,1020000000.0]-h  
 (Global mean: -0.0009832374)

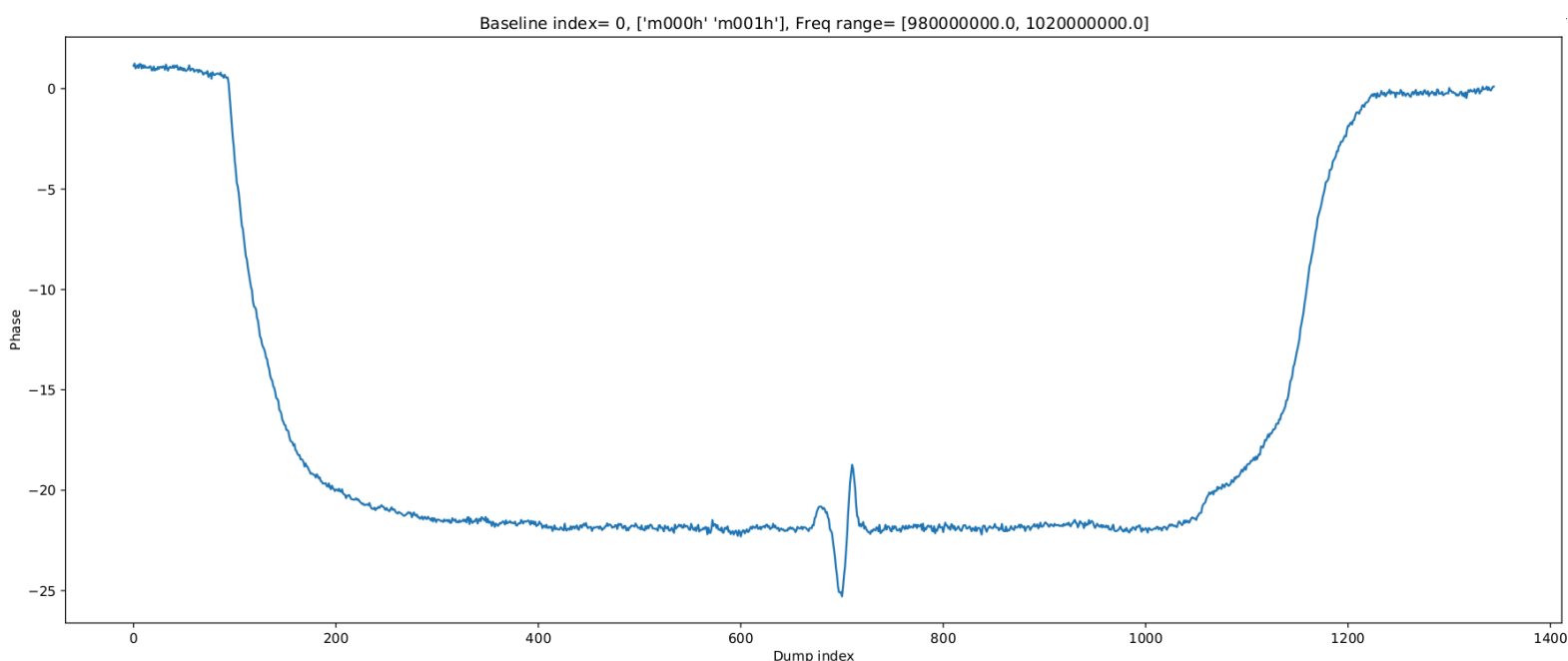


Even though we applied CAM flags, we encountered several antenna issues with some scans which affected our analysis. The UHF band observations were particularly hindered by this.

5. Change in amplitude from one dump to the next for  
1596094172\_sd\_p10.full-scan-4-[650000000.0,690000000.0]-h  
(Global mean: 0.00029288695)



There was a problem with m000 during the L-band 1k (1595971406) observations.



## SCAN AMPLITUDE

We summarise the average amplitude of the visibilities across all scans for the L-band 1k, 4k and 32k narrowband observations, as well as UHF 1k and 4k observations in the tables below.

## L-band

The bandpass amplitudes for c856M1k are consistent with those of the previous release ([Correlator release April 2020 tests - imaging](#)). While the amplitudes between both 1k and 4k modes are comparable across most of the band, this does not apply to the band in the range between 0.98 - 1.02 GHz.

Mean bandpass	h pol 1.46	v pol 1.46	v pol 1.33	v pol 1.33	h pol 0.98	v pol 0.98
amplitude	- 1.50 GHz	- 1.50 GHz	- 1.37 GHz	- 1.37 GHz	- 1.02 GHz	- 1.02 GHz
c856M1k, 8s	8.7	8.7	8.9	8.9	8.9	8.9
c856M4k, 8s	7.7	7.4	10.2	10.0	16.4	16.0

Mean bandpass amplitude		
1.4441735 to		
1.4448265 GHz	h pol	v pol
c856n107M, 8s	9.0	8.5

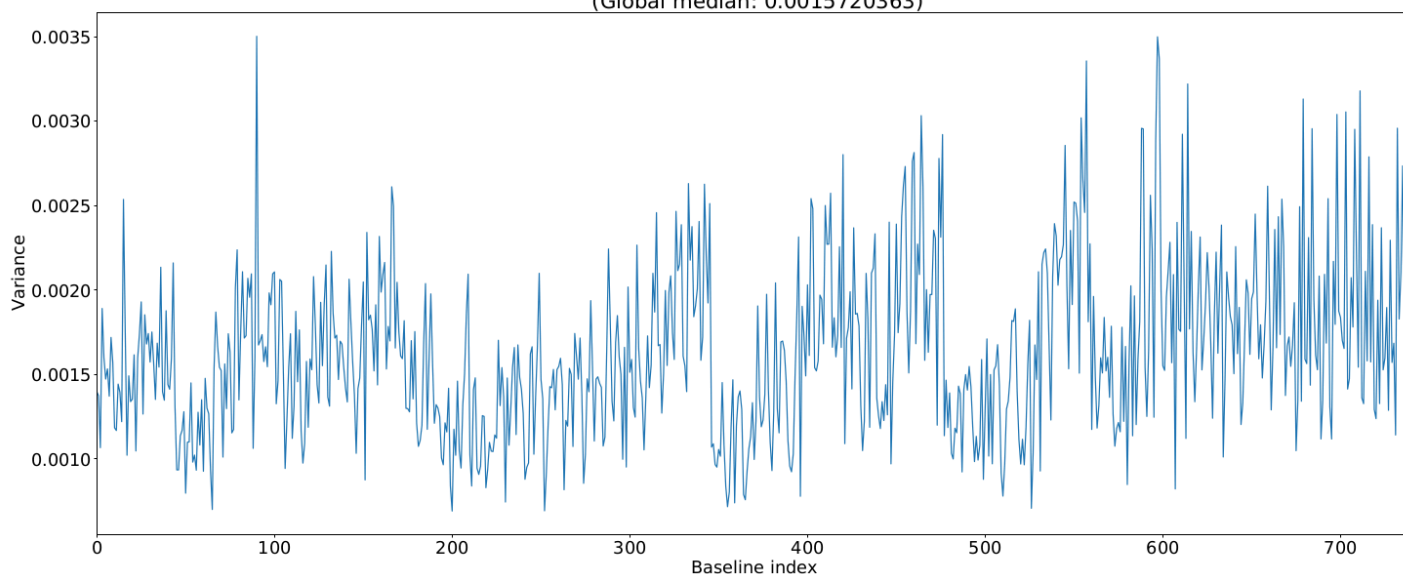
## UHF

Mean bandpass	h pol 0.65	v pol 0.65	h pol 0.80	v pol 0.80	h pol 0.97	v pol 0.97
amplitude	- 0.69 GHz	- 0.69 GHz	- 0.84 GHz	- 0.84 GHz	- 1.00 GHz	- 1.00 GHz
c544M1k, 8s	14.1	13.6	15.3	14.6	9.1	8.8
c544M4k, 8s	15.1	14.5	16.3	15.6	9.7	9.5

## CHANGES IN AMPLITUDE ACROSS SUCCESSIVE DUMPS

In order to detect sudden changes, we took the amplitude difference of successive dumps for each baseline. Several scans showed systematic "waves" with baseline index. This was observed in all of the L band modes, though most clearly in the 1k and 4k modes.

6. Dump amplitude variance for each baseline for  
1596017058\_sdp\_10.full-scan-2-[980000000.0,1020000000.0]-h  
(Global median: 0.0015720363)



## PHASE STABILITY

The plots of phase vs time still have the 2° to 5° variations in the raw phase, compared to previous correlator release. The ripples and periodicities particularly affect both 1k and 4k data in the UHF band, but are present in L band as well.

## OSCILLATIONS, RIPPLES AND PERIODICITIES

Automated detailed reports for each dataset [are in this folder](#).

### L band 1K mode (2330-0230 SAST; J1939)

Seems ok, except for ([see plots here](#))

Things to check

1. **Ripples in spectra. Lower baselines replicated by model. Higher bls - model does not account for all structure. But gain phases of ants of higher bls correlated weakly ~0.2.**
2. M000 amp decreased by 10% and phase changes in the middle 75% of observations. Need to check pointing. Not a correlator issue
3. Flags, mean, rms and gains are higher for central few scans - not a correlator issue

### L band 4K mode (1200-1400 SAST; J0408)

Seems ok except for ([see plots here](#))

Things to check

1. Gain phase ripples ~8-10 times more than model
2. Gain phases of ants in long baselines correlated ~0.3
3. **Possibly effect of ionosphere**

### L band narrow 32K mode (1200-1400 SAST; J0408)

Seems ok, except for

Things to check

1. Vis phases ~2 higher ripples than model. Amps are replicated by model.
2. Gain phases between long baseline ants correlated at ~0.3
3. **Evidence for some ionospheric effect**

### U band 1K mode (0930-1230 SAST; J0408)

Seems ok except

Things to check

1. Many ripples in high bl vis amp and gain phases
  - a. lower baseline ripples replicated by field structure for amp and phase

- b. higher baseline amplitude rippled replicated by field model but phase ripples are larger (by x4-5) than model for some bls.
- c. Can't be the Sun
- d. Correlation between gains phases of pairs of antennas is higher than expected for larger baselines ( $\sim 0.4$ ), so could be ionosphere
- e. No U band 1K long track in previous tests to compare
- f. Excess ripples in vis phases for higher baselines, maybe due to ionosphere

## U band 4K mode (0700-1000 SAST; J0408)

Seems ok except

Things to check

1. Lots of ripples in lower baselines - confirmed to be due to field structure.

## 64-CHANNEL DIPS

Unchanged in amplitude, is about 0.002 for long tracks on calibrator.

Not seen in narrowband (similar to may 20)

## IMAGE ANALYSIS

### Observations

4K channel modes were imaged, for the standard correlator imaging field, at UHF and L-band in the July 2020 correlator release testing. The UHF observation has CBID 1596163435 (labelled as "c544M4k8s-Jul" or something similar in figure(s) and table(s) that follow) while the same for L-band is 1596158164 (labelled as "c856M4k8s-Jul" or something similar in figure(s) and table(s) that follow) .

### Image Dimensions

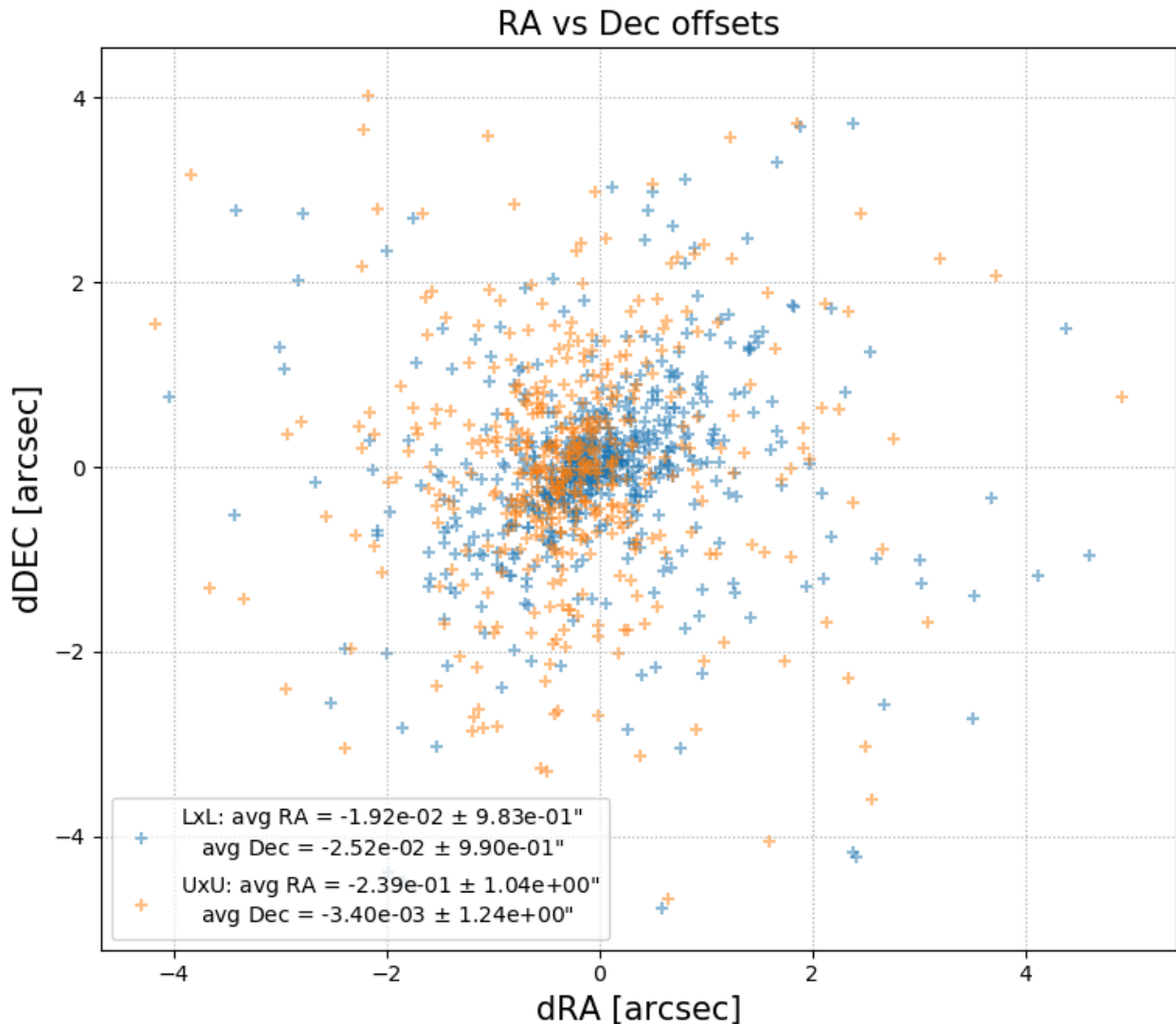
Mode	Pixels	cell size (asec)	Clean beam [arcsec]
c544M4k8s-Jul	3707 x 3707	1.94	22.60, 9.51
c856M4k8s-Jul	5803 x 5803	1.24	10.71, 7.55

### Position errors as compared to SUMSS

The five observations of the standard field were imaged and the sources in each MFS image were extracted using `badsf.process_image()`. The resulting source catalogues were then cross-matched with earlier May 2020 tests in the same modes and also the SUMMS catalog. The resulting angular separations in RA and

Dec are plotted below. The legend shows points for each mode and the average separations in RA and Dec between corresponding modes from July and May 2020, respectively. Overall the different modes produce similar positions of sources.

No significant offsets are seen as can be seen in the “IMAGE ROTATION” section below.



### Image Statistics

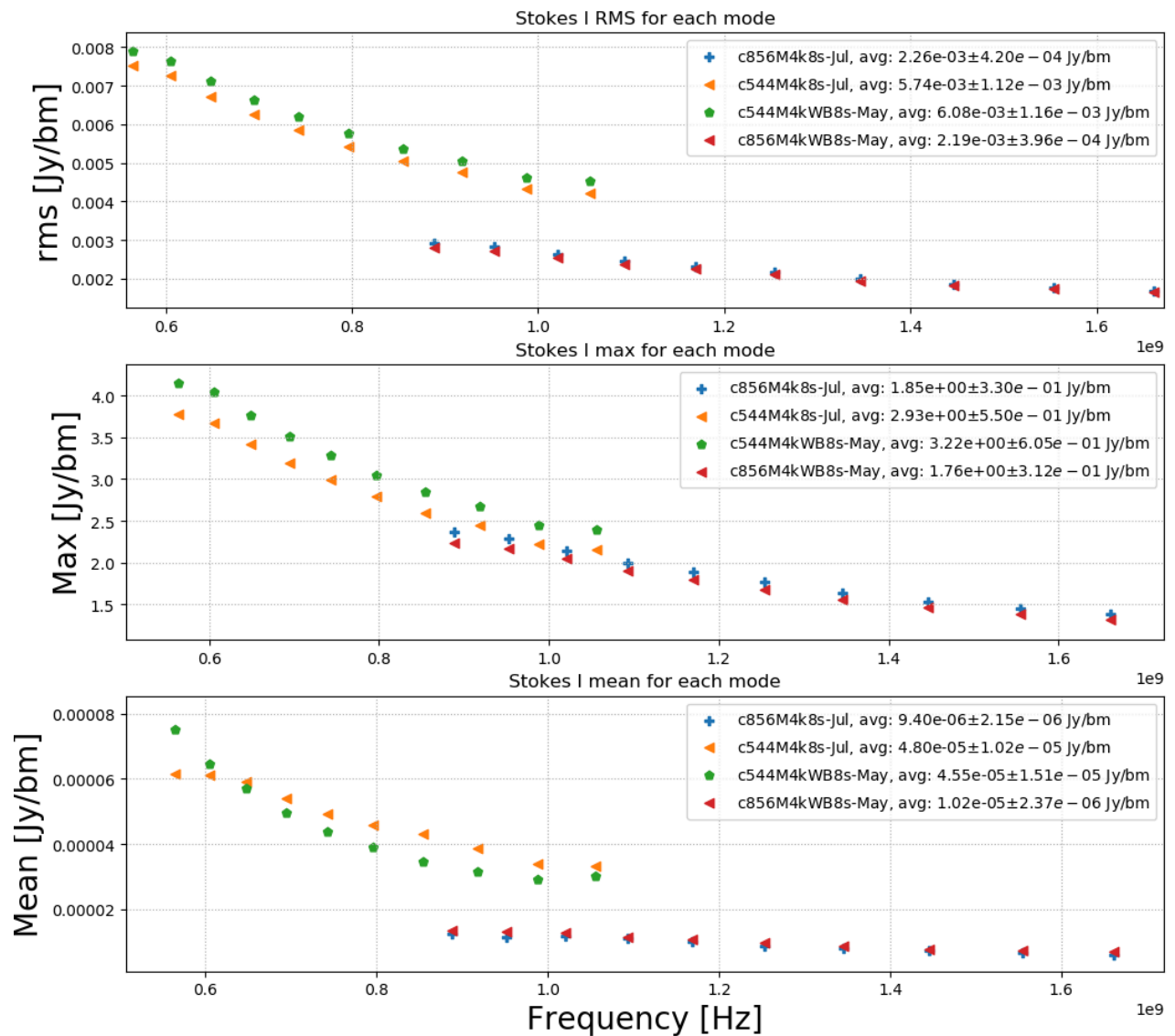
Below are the Stokes I statistics for the 4k July and corresponding modes from the May 2020 test. SED profiles for the image flux RMS, maximum and mean values for each imaging observation mode of the July 2020 correlator test observations and their May 2020 counterparts are also below. The table below shows the total flux of the central source and the fitted ellipse axes as given by PYBDSF’s “process\_image()” task. The RMS values are calculated across the band as can be seen in the SED plots below the table. The green rows in the table show the July 2020 values for the modes observed in the latest correlator test. The tabulated values are followed by plots showing the SEDs for each mode with the average values for each



mode printed in the plot legend. The error quoted for each average is the standard deviation of each distribution. The statistics are calculated via [CASA's imstat\(\)](#) task with the default “classic” algorithm used for calculations in the task.

No significant deviations between the two imaging tests are seen.

Mode	Central source total flux (Jy/beam)	Fitted source ellipse axes (arcsec)	integration time (s)	Ants	Scaled RMS (Jy/beam)
c544M4kWB8s, Jul	2.22	21.89 x 9.14	1920	58	2.28e-06
c856M4kWB8s, Jul	0.82	9.83 x 7.06	1920	61	8.53e-7
c544M4kWB8s, May	2.04	18.47 x, 8.14	4200	50	1.90e-6
c856M4kWB8s, May	1.52	12.80 x 6.76	1920	57	8.85e-7



## IMAGE ROTATION

No evidence for rotation wrt May 2020 L band 4K (no linear relationship seen - see [sec 5.2.3](#))

PA of src from centre (phi) vs angle of offset (theta)

