EPIC Memo # 7

EPIC Data Assessment

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The EPIC commensal machine receives twelve streams of F-Engine data with 3.3 MHz with six each on two ports. Through the multicast capability in Bifrost we subscribe to one stream at a time which is processed by EPIC to produce images. The Advanced Digital Processor (ADP) handles the data flow from the F-Engine and how the streams are dispersed across the network to the commensal systems available at LWA-SV (refer Table 1). Since we run commensally, we do not have much control or choice over frequencies we process but only subscribe to an range of six IP's available on one port.This can result in abruptly changing the frequency band that is processed by EPIC.

Name	Description	Bandwidth	Data Rate	Address	Port(s)
F-Engine – Complex Spectra					
Sub-band 1	256 stands, dual pol.	2x 3.3 MHz	25 Gb/s	239.168.40.11	4015/4016
Sub-band 2	256 stands, dual pol.	2x 3.3 MHz	25 Gb/s	239.168.40.12	4015/4016
Sub-band 3	256 stands, dual pol.	2x 3.3 MHz	25 Gb/s	239.168.40.13	4015/4016
Sub-band 4	256 stands, dual pol.	2x 3.3 MHz	25 Gb/s	239.168.40.14	4015/4016
Sub-band 5	256 stands, dual pol.	2x 3.3 MHz	25 Gb/s	239.168.40.15	4015/4016
Sub-band 6	256 stands, dual pol.	2x 3.3 MHz	25 Gb/s	239.168.40.16	4015/4016
Beamformed – Complex Voltages					
Beam 1	2 tunings, dual pol.	19.6 MHz	600 Mb/s	239.168.40.41	10000
Beam 2	2 tunings, dual pol.	19.6 MHz	600 Mb/s	239.168.40.42	10000
Transient Buffer – Complex Voltages					
TBN	256 stands, dual pol.	100 kHz	800 Mb/s	239.168.40.44	10000

Table 1: Available commensal data sources at LWA-SV.

We have EPIC images for every 25 kHz at a cadence of 81.92 ms and one can extract light-curves (or dynamic spectra) for specific sources from the sequence of images generated with EPIC. It was noticed that such dynamic spectra displayed abrupt intensity jumps (refer Figure 2) that appeared to be stochastic.

This is now understood due to the unordered organization of the image file names making them not contiguous in time when read within the python environment. This is evident from the file ordering shown here and the images in Figure1 corresponding to different timestamps within a 5-minute window.

Unsorted files with frequency jumps

['/data5/LWA_SV_data/EPIC_data/Day_20210508/EPIC_401451.227200_45.188MHz.npz',
'/data5/LWA_SV_data/EPIC_data/Day_20210508/EPIC_654.608000_24.288MHz.npz',
'/data5/LWA_SV_data/EPIC_data/Day_20210508/EPIC_99629.163200_38.587MHz.npz',
'/data5/LWA_SV_data/EPIC_data/Day_20210508/EPIC_401988.849600_30.887MHz.npz',
'/data5/LWA_SV_data/EPIC_data/Day_20210508/EPIC_100615.480000_38.587MHz.npz',
'/data5/LWA_SV_data/EPIC_data/Day_20210508/EPIC_15979.268800_41.888MHz.npz',
'/data5/LWA_SV_data/EPIC_data/Day_20210508/EPIC_11355.704000_41.888MHz.npz',
'/data5/LWA_SV_data/EPIC_data/Day_20210508/EPIC_779.126400_24.288MHz.npz',
'/data5/LWA_SV_data/EPIC_data/Day_20210508/EPIC_102876.472000_38.587MHz.npz',
'/data5/LWA_SV_data/EPIC_data/Day_20210508/EPIC_9697.643200_41.888MHz.npz']

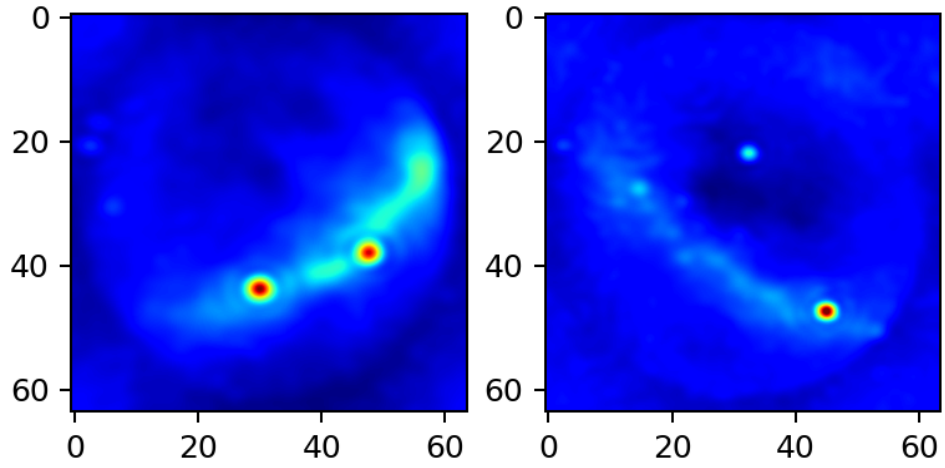

Figure 1 : Images corresponding to two different frequencies disordered within a 5-minute window

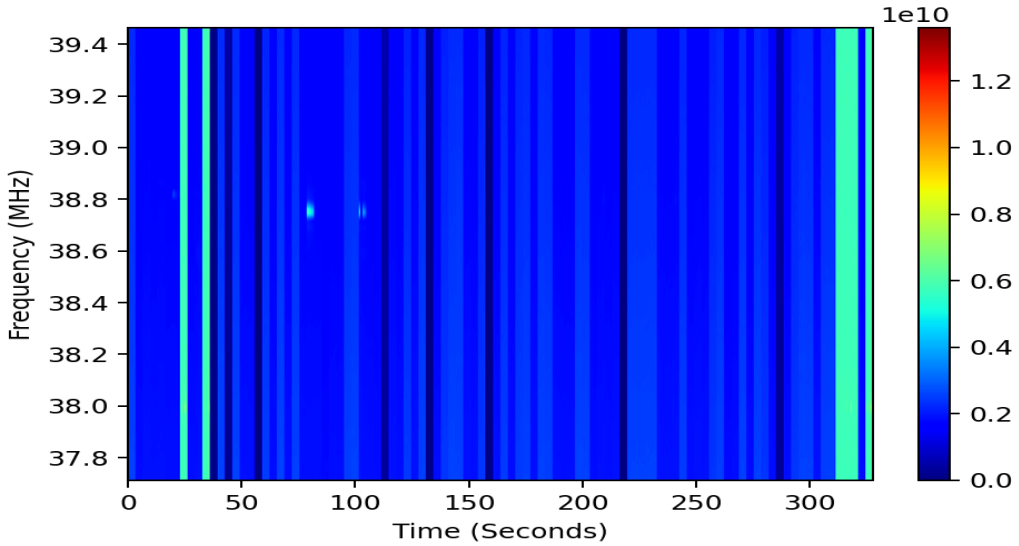

Figure 2 : Dynamic Spectrum from pixels corresponding to Cyg-A

While reading into the python environment, the files were sorted according to the time_tag and the file names. This eliminated the abrupt intensity jumps in the spectra as illustrated and the file ordering was made to be contiguous.

Files sorted by name and contiguous in time (without frequency switching)

['/data5/LWA_SV_data/EPIC_data/Day_20210508/EPIC_11545.758400_41.888MHz.npz'
'/data5/LWA_SV_data/EPIC_data/Day_20210508/EPIC_11549.035200_41.888MHz.npz'
'/data5/LWA_SV_data/EPIC_data/Day_20210508/EPIC_11552.312000_41.888MHz.npz'
'/data5/LWA_SV_data/EPIC_data/Day_20210508/EPIC_11555.588800_41.888MHz.npz'
'/data5/LWA_SV_data/EPIC_data/Day_20210508/EPIC_11558.865600_41.888MHz.npz'
'/data5/LWA_SV_data/EPIC_data/Day_20210508/EPIC_11562.142400_41.888MHz.npz'
'/data5/LWA_SV_data/EPIC_data/Day_20210508/EPIC_11565.419200_41.888MHz.npz'
'/data5/LWA_SV_data/EPIC_data/Day_20210508/EPIC_11568.696000_41.888MHz.npz'
'/data5/LWA_SV_data/EPIC_data/Day_20210508/EPIC_11571.972800_41.888MHz.npz'
'/data5/LWA_SV_data/EPIC_data/Day_20210508/EPIC_11575.249600_41.888MHz.npz']

Images at the beginning and end of a 5-minute window are compared in the two panels of Figure 3.

After sorting the files are read in order as per the time_tags in the file names

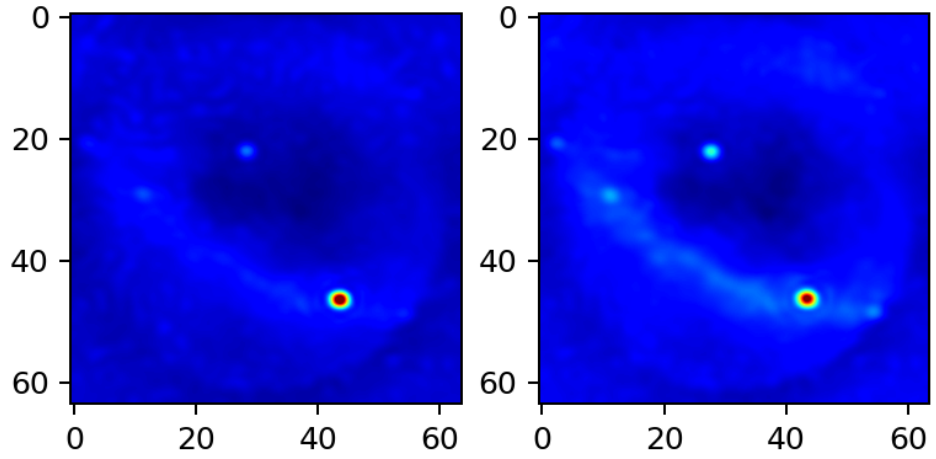

Figure 3 : Images at Beginning (left) and End (Right) of the 5-minute window at f = 41 MHz

Dynamic Spectrum :

The dynamic spectrum is extracted from the images for pixels corresponding to the Sun and Cyg-A locations. Both the spectra show a smooth spectrum (refer Figure 4). The Cygnus spectrum in the bottom panel of Figure 4 shows smooth variation in intensity most likely due to ionospheric scintillation and the solar spectrum shows sporadic radio bursts from the Sun.

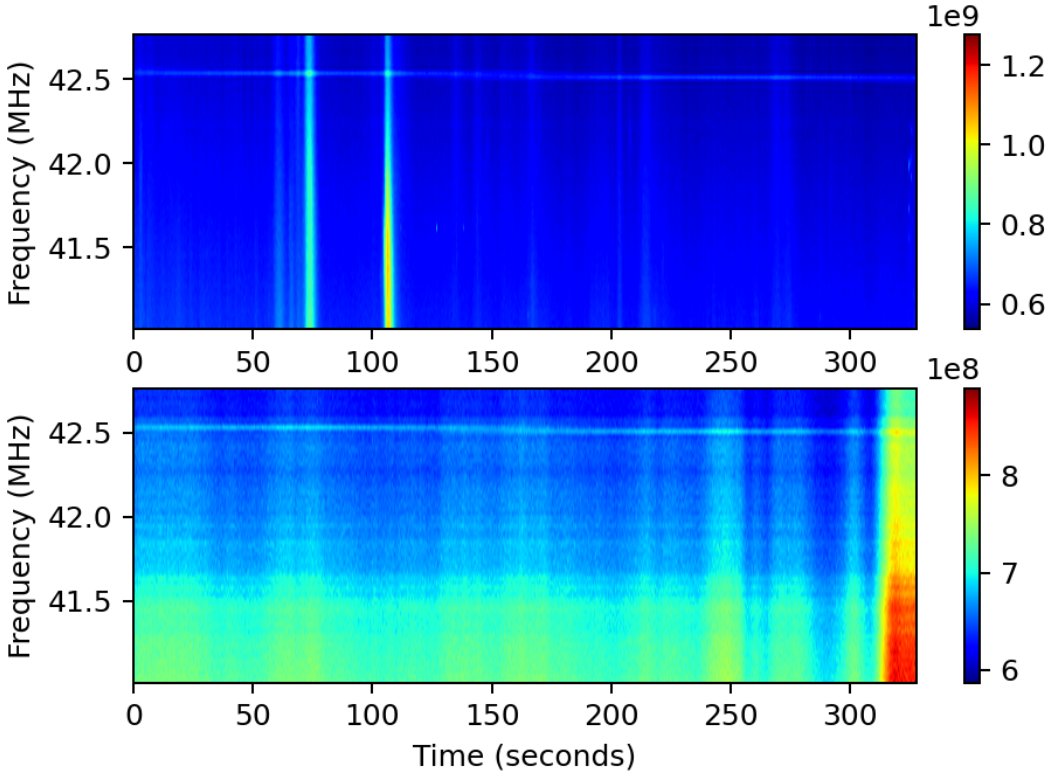

Figure 4 : Dynamic spectrum for Sun (Top panel) and Cyg-A (Bottom panel)

Files sorted by name and contiguous in time (with frequency switching)

As mentioned earlier, the EPIC commensal machine works independent of the ADP and only subscribes to the data streams available at the IP's of the two available ports listed in Table 1(Refer LWA Memo #217 https://leo.phys.unm.edu/~lwa/memos/memo/lwa0217.pdf). So, there can be switching in the frequency bands that are being processed. It is noticed that even though the above sorting eliminates the abrupt intensity jumps as shown in Figure 1, it cannot eliminate the frequency jumps that may happen during EPIC runs. The new frequency data, however, are arranged to be contiguous in time as shown below.

'/data5/LWA_SV_data/EPIC_data/Jupiter_20210803/EPIC_1610645786.170880_44.587MHz.npz'
'/data5/LWA_SV_data/EPIC_data/Jupiter_20210803/EPIC_1610645789.447680_44.587MHz.npz'
'/data5/LWA_SV_data/EPIC_data/Jupiter_20210803/EPIC_1610645792.724480_44.587MHz.npz'
'/data5/LWA_SV_data/EPIC_data/Jupiter_20210803/EPIC_1610645796.001280_44.587MHz.npz'
'/data5/LWA_SV_data/EPIC_data/Jupiter_20210803/EPIC_1610645799.278080_44.587MHz.npz'
'/data5/LWA_SV_data/EPIC_data/Jupiter_20210803/EPIC_1610645802.554880_44.587MHz.npz'
'/data5/LWA_SV_data/EPIC_data/Jupiter_20210803/EPIC_1610645805.831680_44.587MHz.npz'
'/data5/LWA_SV_data/EPIC_data/Jupiter_20210803/EPIC_1610645809.108480_44.587MHz.npz'
'/data5/LWA_SV_data/EPIC_data/Jupiter_20210803/EPIC_1610645812.385280_44.587MHz.npz'
'/data5/LWA_SV_data/EPIC_data/Jupiter_20210803/EPIC_1610645815.662080_44.587MHz.npz'

'/data5/LWA_SV_data/EPIC_data/Jupiter_20210803/EPIC_1610645820.126720_62.587MHz.npz'
'/data5/LWA_SV_data/EPIC_data/Jupiter_20210803/EPIC_1610645823.403520_62.587MHz.npz'
'/data5/LWA_SV_data/EPIC_data/Jupiter_20210803/EPIC_1610645826.680320_62.587MHz.npz'
'/data5/LWA_SV_data/EPIC_data/Jupiter_20210803/EPIC_1610645829.957120_62.587MHz.npz'
'/data5/LWA_SV_data/EPIC_data/Jupiter_20210803/EPIC_1610645833.233920_62.587MHz.npz'
'/data5/LWA_SV_data/EPIC_data/Jupiter_20210803/EPIC_1610645836.510720_62.587MHz.npz'
'/data5/LWA_SV_data/EPIC_data/Jupiter_20210803/EPIC_1610645839.787520_62.587MHz.npz'
'/data5/LWA_SV_data/EPIC_data/Jupiter_20210803/EPIC_1610645843.064320_62.587MHz.npz'
'/data5/LWA_SV_data/EPIC_data/Jupiter_20210803/EPIC_1610645846.341120_62.587MHz.npz'
'/data5/LWA_SV_data/EPIC_data/Jupiter_20210803/EPIC_1610645849.617920_62.587MHz.npz'
'/data5/LWA_SV_data/EPIC_data/Jupiter_20210803/EPIC_1610645852.894720_62.587MHz.npz'
'/data5/LWA_SV_data/EPIC_data/Jupiter_20210803/EPIC_1610645856.171520_62.587MHz.npz'
'/data5/LWA_SV_data/EPIC_data/Jupiter_20210803/EPIC_1610645859.448320_62.587MHz.npz'
'/data5/LWA_SV_data/EPIC_data/Jupiter_20210803/EPIC_1610645862.725120_62.587MHz.npz'
'/data5/LWA_SV_data/EPIC_data/Jupiter_20210803/EPIC_1610645866.001920_62.587MHz.npz'
'/data5/LWA_SV_data/EPIC_data/Jupiter_20210803/EPIC_1610645869.278720_62.587MHz.npz'
'/data5/LWA_SV_data/EPIC_data/Jupiter_20210803/EPIC_1610645872.555520_62.587MHz.npz'
'/data5/LWA_SV_data/EPIC_data/Jupiter_20210803/EPIC_1610645875.832320_62.587MHz.npz'
'/data5/LWA_SV_data/EPIC_data/Jupiter_20210803/EPIC_1610645879.109120_62.587MHz.npz'
'/data5/LWA_SV_data/EPIC_data/Jupiter_20210803/EPIC_1610645882.385920_62.587MHz.npz'
'/data5/LWA_SV_data/EPIC_data/Jupiter_20210803/EPIC_1610645887.014400_80.588MHz.npz'
'/data5/LWA_SV_data/EPIC_data/Jupiter_20210803/EPIC_1610645890.291200_80.588MHz.npz'
'/data5/LWA_SV_data/EPIC_data/Jupiter_20210803/EPIC_1610645893.568000_80.588MHz.npz

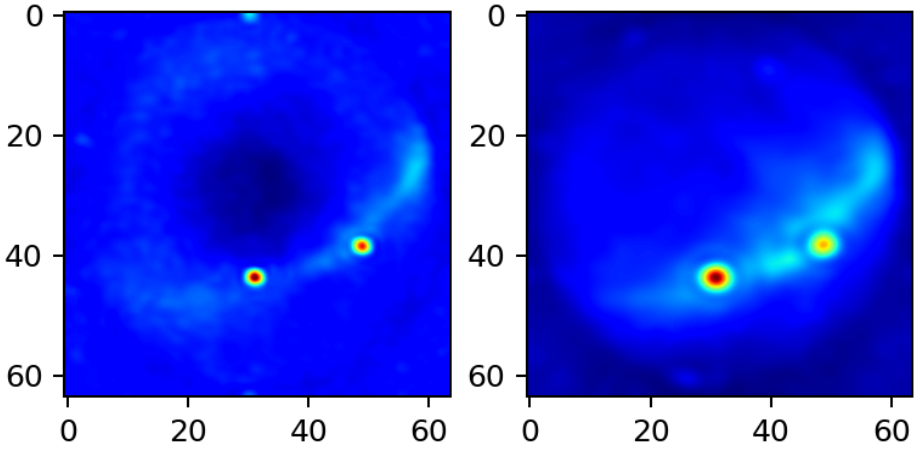

Figure 5 : Images at two different frequencies, 41 MHz (Left) and 27.5 MHz (right) during a 5-minute window

Note that the dynamic spectrum extracted for any source in the images shows the change in frequency as intensity jumps. But the spectra continue to remain smooth as long as the frequency stream remains stable, as illustrated in Figure 6.

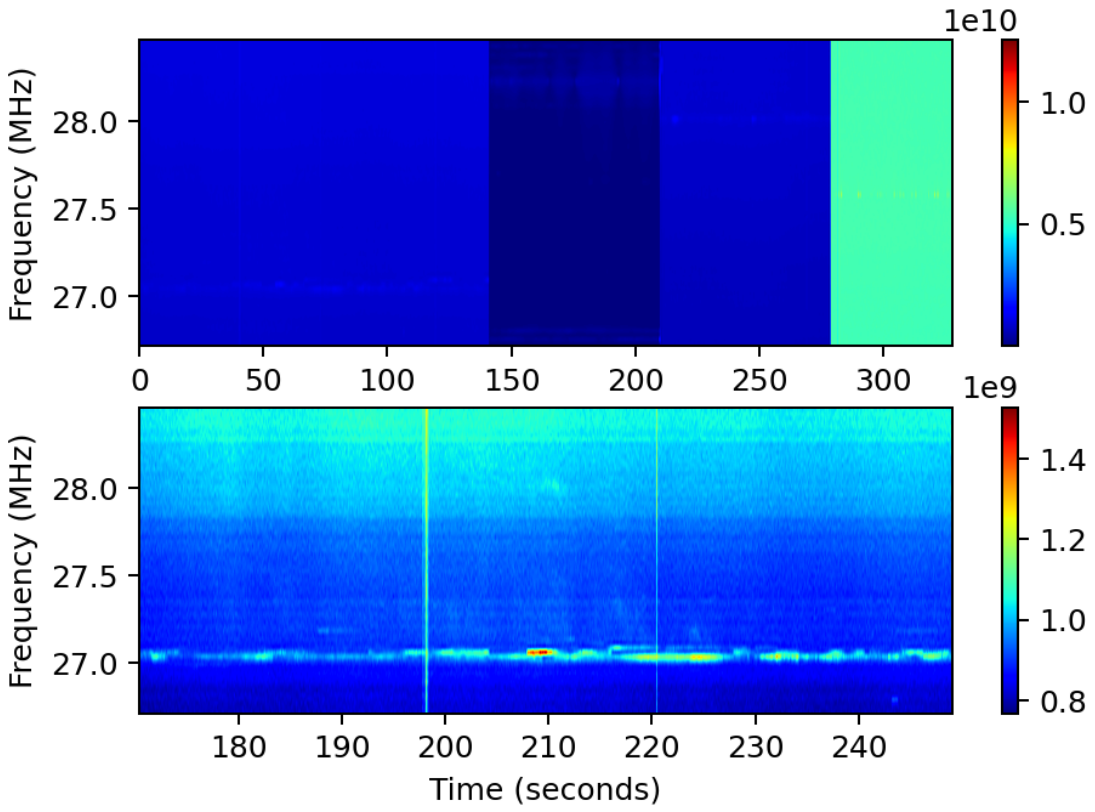

Figure 6 : Dynamic Spectrum for Cyg-A for full 5-minutes (Top panel) and for 1 minute stable frequency window (Bottom panel)