

SOP for real-time coherent dedispersion mode of GSB

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A fully real-time Coherent Dedispersion mode has been developed for the GSB. This CD mode operates on the PA voltage beam data that is generated by running the standard voltage beam mode of the GSB. It reads the dual polarization voltage beam data from the shared memory to which it is written by the original GSB code and performs the following operations in real-time to generate coherently dedispersed intensity time series data for the two polarisations : (i) inverse Fourier Transform on the voltage beam data to get back the full bandwidth voltage time series (ii) coherent dedispersion on the full band time series (iii) square law detection followed by integration to the desired time constant (iv) recording of the intensity time series to disk¹. It also has the option to run a simple time domain folding program on the integrated intensity data to display folded profiles in real time (reading from an intermediate shared memory). The CD pipeline runs in a manner such that the data from both the polarisations is synchronized without any relative time delay between the final output time sequences. Since the CD pipeline does all the computations in real-time, it utilises an auxiliary set of compute nodes (any 2 out of 4 GPU equipped machines : nodes 51 to 54) that are attached to the GSB cluster (as compared to nodes 33 and 34 which are the default nodes used for most of the other beam modes of operation).

The current release of the CD pipeline has been tested fairly extensively, including fairly long observing runs of about 1 hour or so, and has been found to run quite stably. Further improvements that are in the pipeline are modes to (i) have the dedispersion done over multiple narrower sub-bands (to allow larger DMs to be done using the same hardware, at the cost of reduction of the best time resolution); (ii) include option of filtering out bad channels in the spectra before the inverse fourier transform stage; (iii) option of bringing together of the dedispersed data from both polarisations for computing Stokes parameters; (iv) extension of the scheme to the uGMRT systems.

The basic SOP for using the current version of the CD pipeline is as below :

1. Login to gsbm1. Go to `/mnt/code/gsbuser/bin/released/` ; check file `test_nodes_voltage`. For voltage beam recording mode, the last two entries should be node33 and node34. Change the last two entries to node51 and node53 for coherent dedispersion mode. (Remember to revert changes after the end of observations with the CD pipeline !)

¹ For further details on the algorithms used, refer to De & Gupta, ExA (2015), at <http://arxiv.org/abs/1509.00186>

2. Login to node51 and node53 and remove all shared memory segments.
3. Initialise the GSB in voltage beam mode, do power equalisation & phasing as required.
4. Login to gsbm1 as gsbuser. Go to the directory

```
/mnt/code/gsbuser/source_code/dvl.6/  
pa-voltage_analysis_pipeline/run_cd_realtime/gsbNodes/cdInitialize/(16MHz or 32MHz)
```

use 16MHz or 32MHz above, depending on the bandwidth being used. Edit the file `cd_nodes_2pols` so that the entries are node51 and node53.

5. Run the CD pipeline script in the folder, with the following syntax :

```
./startCD.csh <bandwidth> <sideband> <NumChans> <Frequency> <DM>  
<Window> <Integration>
```

Usage :

bandwidth = 1 for 16MHz and 2 for 32 MHz of voltage beam

sideband = 1 for positive band and -1 for negative band

NumChans = 256 for 256 channel mode and 512 for 512 channel mode of voltage beam

Frequency = Lower edge for positive band; upper edge for negative band

DM = DM of pulsar (see note at end for range of supported DMs)

Window = Window function to be used for CD transform : 1 for rectangular, 2 for Hanning, 3 for Welch and 4 for Butterworth

Integration = Number of samples to integrate for output intensity time series

This script will login into nodes 51 & 53, initialise the GPUs to start coherent dedispersion on these nodes, and start the MPI synchronised voltage inverse transform routine on gsbm1. A total of 6 windows will be launched by this script, which should be closed at the end of the scan. The mode will run till the process is killed. Monitor the output on gsbm1. Ensure that there are no buffer losses being reported on the main window.

6. Once the coherent dedispersion mode is initialised, one can initialise synchronised intensity recording on identical directories on node51 and node53.

7. Login to gsbm1 and go to the directory :

```
/mnt/code/gsbuser/source_code/dvl.6/pa-  
voltage_analysis_pipeline/run_cd_realtime/gsbNodes/fileWrite/
```

Edit the file `cd_nodes_2pols` so that the entries are node51 and node53.

8. Start the recording script with the following syntax :

```
./record_CDpipeline.sh <bandwidth> <Integration> <Duration (sec)> <Output file path>
```

Ensure that the input parameters <bandwidth> and <Integration> are the same as those used when initialising the CD pipeline. Note : <Duration> is the duration of recording in seconds; <Output file path> is full pathname of the data file to be recorded.

Make sure that the output file path is a valid location on both node51 and node53.

9. The output of the coherent dedispersion is in the form of power recorded for each of the two polarisations (node51 receives R pol and node53 receives L pol). The data is recorded in the files in <OutputFilePath>.

10. The data is recorded as consecutive time samples (time resolution depends on the integration used) stored as 2 byte short integers. Original resolution for 16 MHz mode is 30 ns, hence recorded time resolution is (30 x Integration) ns. Similarly, for 32 MHz mode, original resolution is 15 ns, recorded time resolution is (15 x Integration) ns.

11. The timestamps corresponding to each block are recorded on node51 as <Output File Path>.timestamp. A block is a sequence of 512 x 1024 integrated samples.

12. Before beginning another scan, close the windows launched by the CD script on gsbm1, node51 & node53. Remember to do the same at the end of the observing run.

Notes :

1. The maximum DMs currently supported for each observing frequency and bandwidth are given below. Ensure that the DM used is smaller than the maximum DM.

Frequency (MHz)	Bandwidth (MHz)	Maximum DM (pc/cc)
156	16	8
235	16	45
325	16	120
	32	30
610	16	800
	32	200
1000 – 1400	16 / 32	Upto ~ 3000

2. The above SOP is written with node 51 and node 53 as the two nodes to be used, but these can be any combination of nodes 51 to 54. All instructions in the SOP to be modified according to the change of nodes. Note however, as mentioned earlier, that there are some issues with long-term stability when using node 52, and hence it is recommended to NOT use this node at present.

3. Sample data : shown below is a sample real-time folded profile for a single polarisation, from an observation of the pulsar B0329+54 at 325 MHz with the coherent dedispersion pipeline. The upper panel is the cumulative folded profile for a duration of ~ 5 minutes. The lower panel is the instantaneous folded profile folded over a duration of ~ 4 seconds.

