Pulsar Data Reduction

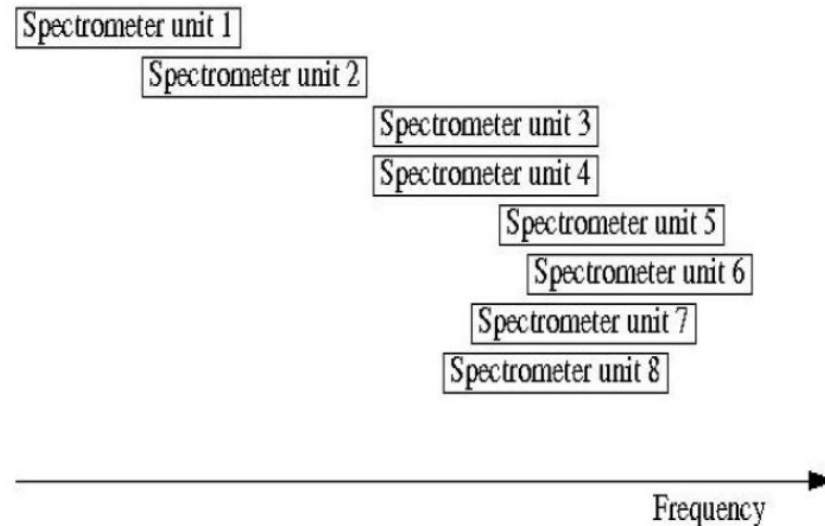Andrew Seymour

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Overview

- PSRFITS format used for all standard pulsar observing modes

    – Slightly different data structure depending on online processing mode ("search" vs "fold" vs "cal" modes)

    – Baseband recording modes available upon special request and coordination; we will not cover these here

- GBO does not maintain an independent pulsar data reduction package

- All GBO pulsar data can be analyzed using community-supported packages

    – PRESTO (especially good for searching for pulsars)

    – PSRCHIVE (especially good for fold-mode data)

    – PSRFITS UTILS (useful for search mode → fold mode)

    – DSPSR (useful for search mode → fold mode; also for processing baseband data)

PSRFITS Overview

- Conforms to FITS standard; compatible with astropy (though other packages provide more functionality)

- "Search" mode, aka filterbank mode

  - High time resolution spectra

  - Can record 1 (summed) or 4 (self/cross product) polarizations

  - Organized into "sub-integrations"

- "Fold" mode

  - Use a pulsar ephemeris to calculate precise rotational phase for each sample

  - Results in data cube of pulse phase vs freq. vs time

  - Must record 4 polarization products

- "Cal" mode

 - Specialized fold-mode for observing pulsed noise diode

Merging VEGAS Data

- Depending on observing mode, data from VEGAS may need to be "merged"

- In coherent dedispersion modes, one sampler is connected to 1, 2, or 8 processing computers (depending on bandwidth)

  – Each computer processes full, ½, 1/8th total bandwidth

  – Data written to subdirectories by bank (A, B, C, D, E, F, G H)

Spectrometer unit 1
Spectrometer unit 2
Spectrometer unit 3
Spectrometer unit 4
Spectrometer unit 5
Spectrometer unit 6
Spectrometer unit 7
Spectrometer unit 8

Frequency

Merging VEGAS Data

- Depending on observing mode, data from VEGAS may need to be "merged"

- In incoherent dedispersion mode, multiple samplers can be used to cover up to 6 GHz (depends on receiver and IF system limits)

  - Data still written to sub-directories by bank
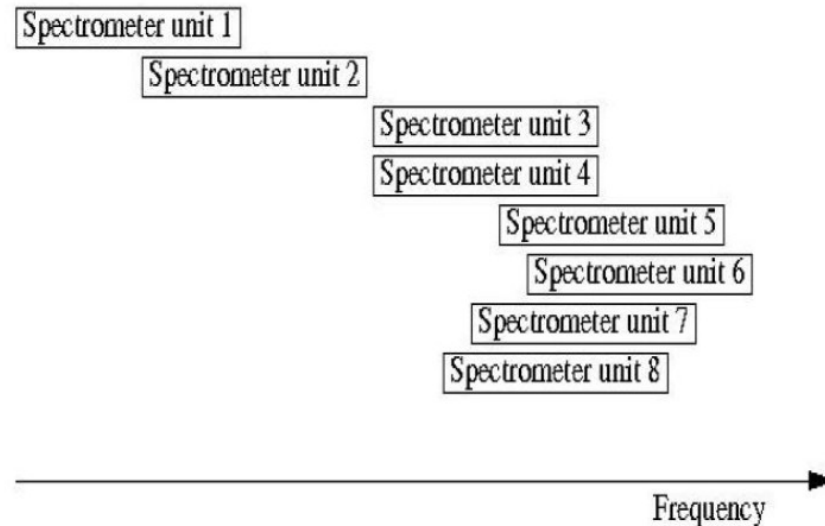
Merging VEGAS Data

- Depending on observing mode, data from VEGAS may need to be "merged"

- Data will be merged for you within ~24 hours

  – You can still do spot-checks of data from each bank (they are all valid PSRFITS files in and of themselves, just with a fraction of the total bandwidth)

- Search-mode data merged manually

  – Data volumes are large, so per-bank data needs to be deleted after manual checks for data integrity

  – Only fully merged data will be left

  – If you don't see it within 24 hours, email your project friend

GBO Pulsar Data

- All data are written to a mass file store (/lustre/gbtdata)
- Data further organized by project code and session number
  - e.g. /lustre/gbtdata/TGT21A_501_05
- Data further organized by mode (VEGAS for incoherent dedispersion, VEGAS_CODD for coherent dedisersion)
  - e.g. /lustre/gbtdata/TGBT21A_501_05/VEGAS_CODD

- Please do not analyze your data in these directories!!
  - These areas are archived
  - Create symlinks *to files* in /home/scratch/<username> or /lustre/pulsar/<username>

Getting Set Up

- To access pulsar data analysis tools, run the following command

  source /home/pulsar_rhel7/pulsar.presto3.bash

- You can wrap this in a function in your .bash_profile. Just add the following lines

  ```
  psrenv() {
      source /home/pulsar_rhel7/pulsar.presto3.bash
  }
  ```

- Then just type 'psrenv' when you open a new terminal
  - Must be done every time you open a new Linux terminal
- Wrapping in a function is necessary to prevent problems with VNC (remote desktop viewer)

PRESTO

- C and Python-based data reduction package
- Lots of functionality for searching for, finding, folding, and timing pulsars
  - Limited flux calibration routines
  - No polarization calibration
- Lots of additional Python utilities for pulsar astronomy
- https://www.cv.nrao.edu/~sransom/presto/
- Help menus for tools are fairly complete
- Tutorial available from Scott Ransom
- https://www.cv.nrao.edu/~sransom/PRESTO_search_tutorial.pdf
- Another tutorial available from Ryan Lynch
  - Just ask!

Common PRESTO Commands

- rfifind – Identify and "mask" RFI based on statistical outliers

- prepdata – Dedisperse, sum frequencies, and create time series

- prepsubband – Similar to prepdata; make lots of time series at once

- accelsearch – Find pulsars (including binaries)

- single_pulse_search.py – Find pulsars, RRATs, FRBs through single pulses

- prepfold – Fold a candidate or known pulsar

- get_TOAs.py – Get pulse times of arrival

PSRCHIVE

- C++ tools for working with fold-mode data

- Tools for viewing, editing, RFI-zapping, flux/polarization calibration, extracting TOAs

- http://psrchive.sourceforge.net/

- Online documentation is only partially complete

- Help menus for each program can answer common questions

- Some user-generated recipes for things like calibration

- Python wrapper available for some basic analysis

    - http://ipta.phys.wvu.edu/files/student-week-2018/demorest_ipta_psrchivepython_20180613.pdf

Common PSRCHIVE Commands

- pav – Lots of different ways to plot data

- paz and pazi – Automatic and interactive RFI removal

- pam – Lots of ways to manipulate data (e.g. downsample)

- psredit – View/edit header information

- vap – Another way to view header information

- fluxcal – Make flux calibration solutions

- pac – Flux/polarization calibration

- pat – Extract TOAs

- pas – Work with standard timing templates

- psrsmooth – De-noise standard timing templates

- psrplot – Advanced plotting

PSRFITS UTILS

- Mostly used to fold or reduce search-mode data

- https://github.com/demorest/psrfits_utils

- Two main useful commands
  - fold_psrfits – Folding search-mode data (then it can be analyzed with PSRCHIVE)
  - psrfits_subband – Reduce time/frequency/polarization resolution (useful for decreasing data volume)

DSPSR

- Useful for folding search-mode data and working with baseband data

    – Can also make search-mode data in PSRFITS and SIGPROC filterbank format from baseband data

    – Can also connect to data buffer for online observing (e.g. VLA)

- http://dspsr.sourceforge.net/

- Help menu is pretty descriptive

- After folding, use PSRCHIVE

Support

- GBT pulsar support scientists have many years of experience working with pulsar data

- We can answer most questions about data reduction, and the third-party packages

- Can answer **some** questions about installing on your own computer

- Package-maintainers are also very helpful and responsive

GREEN BANK
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