Enabling LWA Science with Bifrost

Jayce Dowell

LWA Users Meeting

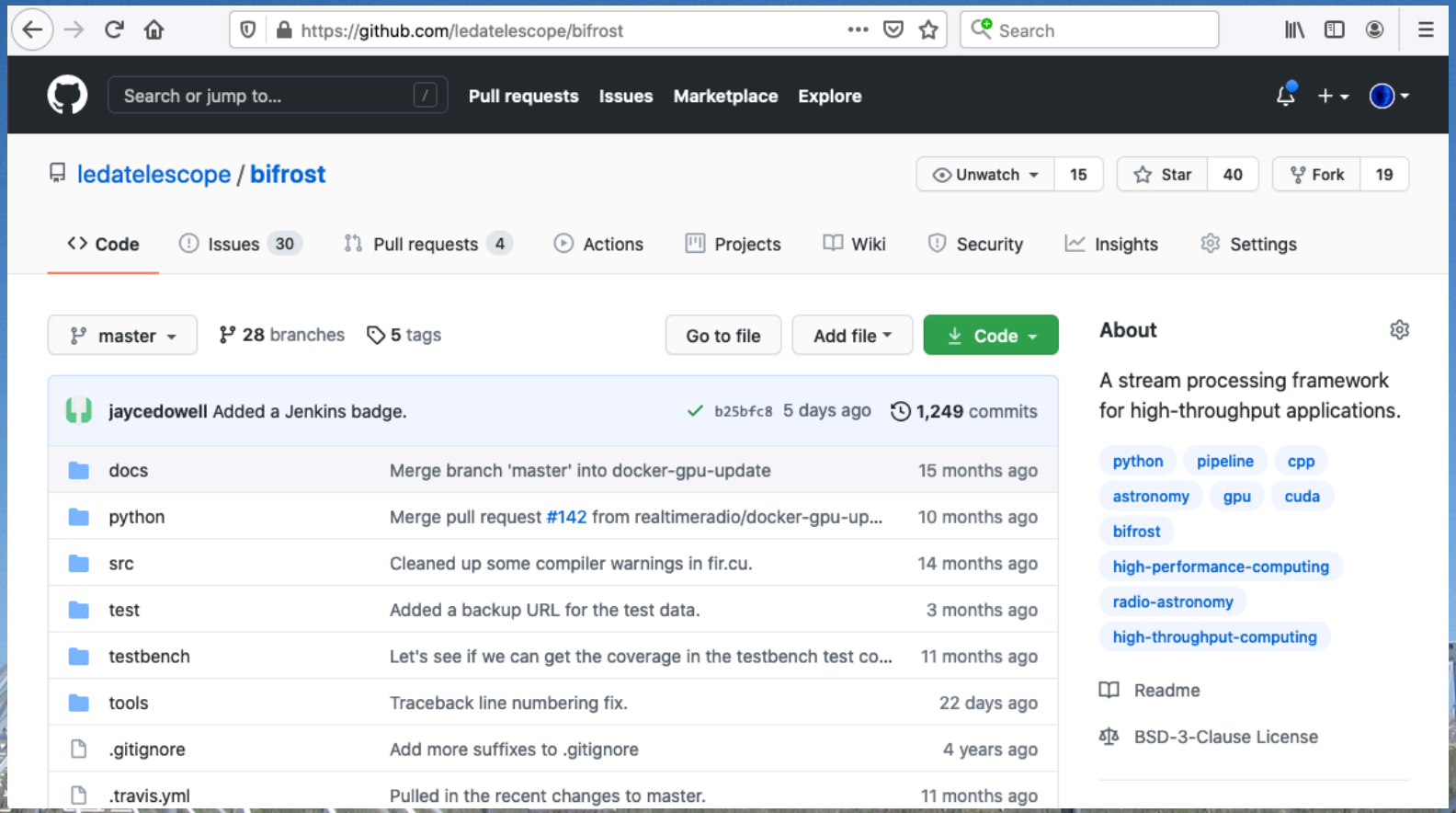
August 16, 2021

What is Bifrost

- C++/Python framework for building CPU and GPU-based pipelines
  - Used for building hybrid FPGA/GPU systems or stand-alone pipelines
  - GPU support through the CUDA API
  - Cranmer et al. (2017, JAI, 1750007)

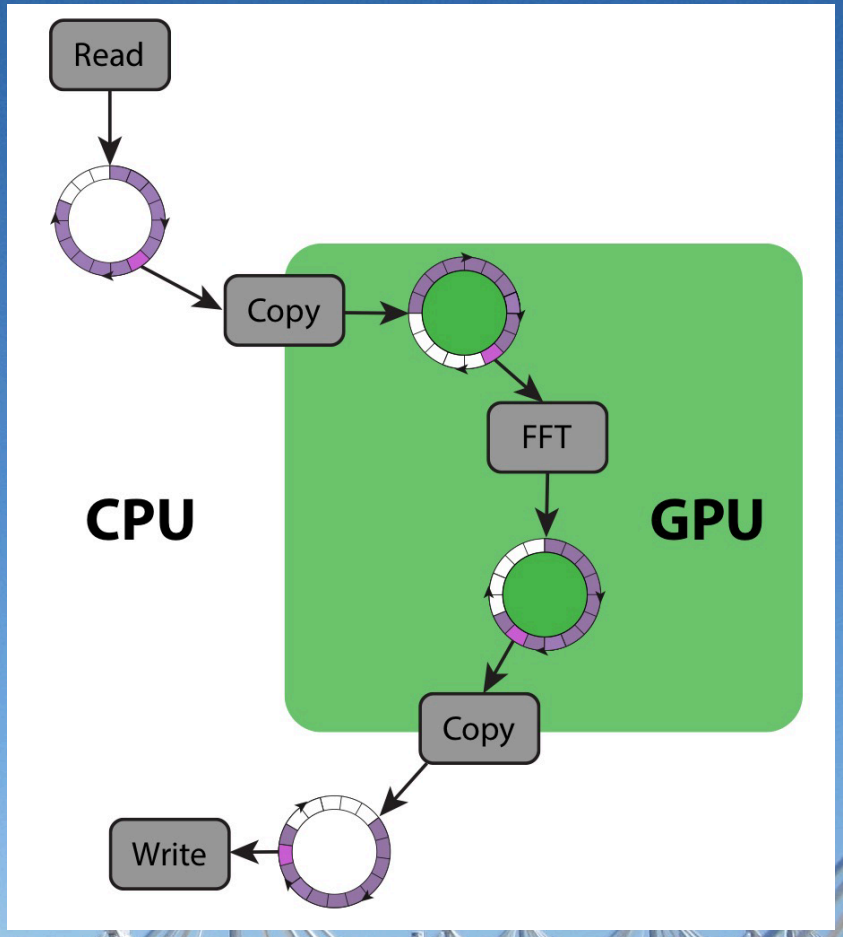
What is Bifrost

https://github.com/ledatelescope/bifrost
Or search for “leda telescope bifrost”



Bifrost Concepts

- Blocks
  - "Atomic unit" of processing
  - Independent thread
- Ring Buffers (Rings)
  - Emulates wrap-around in memory
  - Assigned to a specific "space"
- Pipelines
  - Combination of the above



Bifrost Design

- Python frontend wraps fast C++/CUDA backend
- Backend:
  - "Ring buffer" used for inter—block communication
  - Common type definitions and "BFarray" generic data structure
  - Several common modules implemented
    - FFT, matrix-matrix multiplication, FIR filters

Bifrost Design

- Python frontend wraps fast C++/CUDA backend
- Frontend:
  - Blocks and Pipelines are Python object abstractions for the backend
  - ctypes wraps all C calls
  - ndarray object for memory management (span of ring buffer)
    - Compatibility with many numpy functions, matplotlib, etc.

Bifrost Advantages

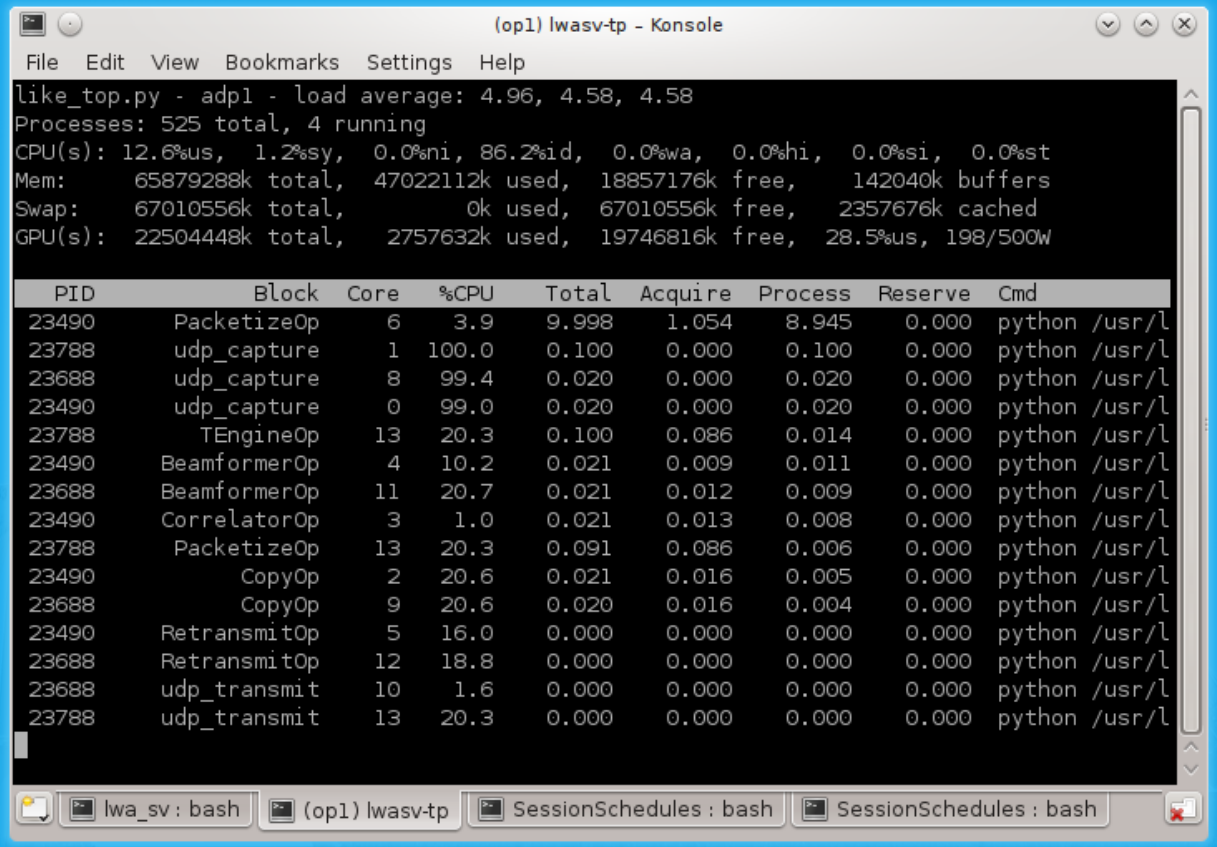
- Metadata describes the units of ring buffer dimensions; used in algorithms (e.g., dedispersion)
- Multi-sequence ring buffers, useful for different observations
  - The metadata will propagate down the pipeline

Bifrost Advantages

- Time-tagged sequences in ring buffers
  - Can dump section of data to disk based on time range, observation name
    - Useful for detections of transient phenomena
- Many astronomy and general processing blocks already built

Bifrost Advantages

- Built-in logging and performance benchmarking



How LWA is Using Bifrost

LWA-SV

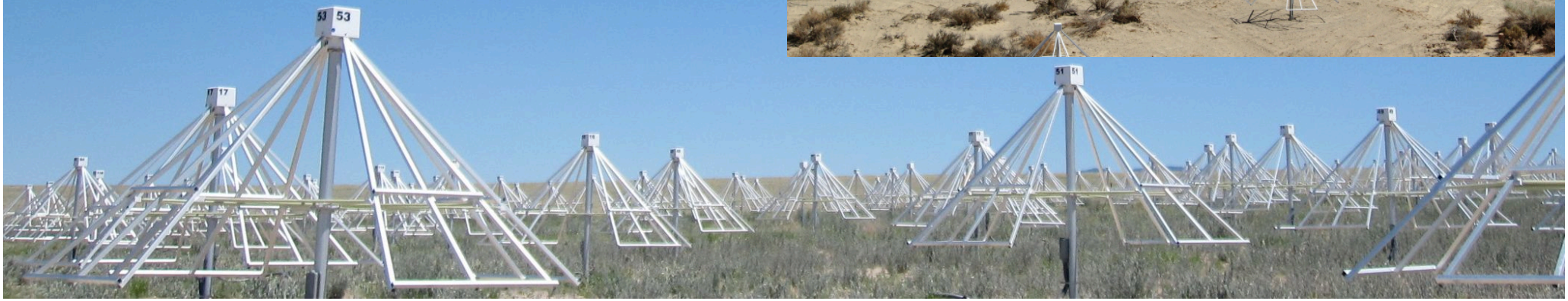
- ADP used for the backend – hybrid FPGA/GPU architecture
- Four data products:
  - TBF – 4+4-bit complex spectra, two tunings, up to a few seconds
  - TBN – same as LWA1
  - DRX – same as LWA1
  - COR – correlator visibility output

LWA-SV

- Up to 19.6 MHz per tuning
  - TBF and wide band correlator running at 19.8 MHz
- Two Beams
  - Not fully independent; tunings are tied together
- Orville Wideband Imager
  - Provides LWA-TV 2

OVRO-LWA

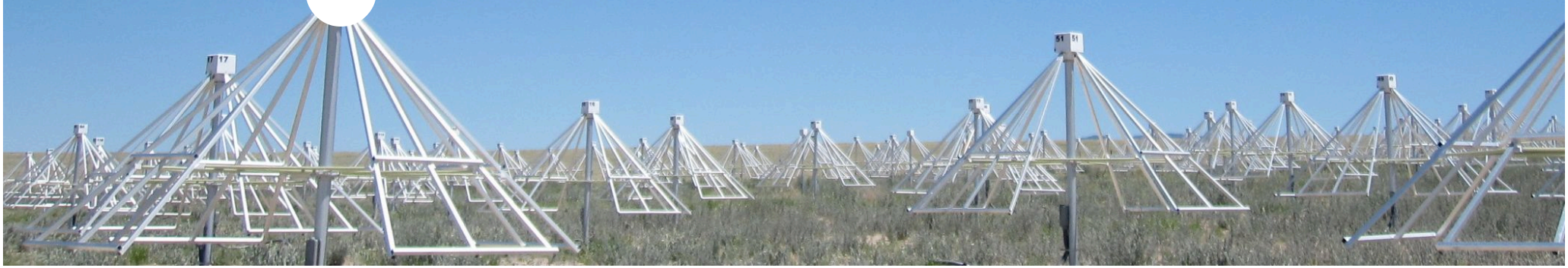
- 352 dipoles
- Next generation LWA hardware
- See Marin's talk



LWA-NA

?

- Prototype LWA mini station for the swarm
  - 64 dipoles
- Builds off OVRO-LWA hardware/software



Progress and Plans

- Current development focused on packet capture
  - New packet capture framework to make it easier to add new formats – both input and output
  - Support for InfiniBand Verbs
- Also want to add an interface for plugins and improve usability

Progress and Plans

- Work funded through NSF Cyberinfrastructure for Sustained Scientific Innovation grant
- Will support development as well as help for users wanting to get started with Bifrost
  - Initially focused on radio astronomy but interested in applications from other domains
  - Includes funding for a postdoc

For More Information

- Bifrost
  - https://github.com/ledatelescope/bifrost
  - https://ledatelescope.github.io/bifrost/
  - https://github.com/ledatelescope/bifrost_tutorial
  - https://arxiv.org/abs/1708.00720