Aperture Array Radio Transient Imaging SysTem (AARTIST)

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One of the key scientific objectives of modern radio telescopes is the observational study of radio transient phenomena like radio counterparts of Gamma Ray Bursts /gravitational wave events, Meteor Radio Afterglows, Giant Pulse emission from pulsars, Fast Radio Bursts and flares/Coronal Mass Ejections from active/solar-type stars. Real-time imaging at high temporal resolution is considered an essential requirement which along with the need for high sensitivity, wide field-of-view and high angular resolution, are pushing the limits on the size and performance of modern radio interferometers. We present a generic solution with our E-field Parallel Imaging Corrlelator (EPIC) based on the Modular Optimal Frequency Fourier (MOFF) mathematical formalism for direct Fourier imaging, which images directly from the voltages measured by individual antennas without the expensive cross-correlation operation in the aperture-plane. EPIC is now implemented on a GPU-accelerated architecture and integrated with a python/C++ based high-performance streaming framework, Bifrost. It was successfully deployed and tested on the Long Wavelength Array (LWA) station located at the Sevilleta National Wildlife Refuge (LWA-SV) in New Mexico, USA. The LWA-SV is a compact array consisting of 256 dual-polarization active dipole antennas arranged in a pseudo-random pattern with an effective aperture of $\approx$ 100 m diameter operating in the frequency range of 10-88 MHz. The GPU implementation of EPIC is composed of multiple kernels/modules that perform the various functions of voltage gridding, spatial Fourier transform and the pixel-wise squaring of voltages on the image, making use of some of the standard signal processing blocks of Bifrost.

The instantaneous bandwidth achieved with the initial deployment of EPIC on LWA-SV was limited to $\approx$ 400 kHz per GPU. We are currently developing the Aperture Array Radio Transient Imaging SysTem (AARTIST) which will include optimizing the EPIC for increased bandwidth performance and additional capabilities for transient detection. AARTIST will make use of the fast dispersion measure transform (FDMT) module in Bifrost to implement search and/or targeted observing modes with additional RFI mitigation strategies included. LWA is one of the very few instruments uniquely capable of exploring fast transients through imaging at frequencies below 100 MHz. To enable the real-time detection and follow-up of transient sources within the sensitivity limit of LWA-SV, we plan to incorporate a rapid-response system to VOEvent based-alerts and external triggers from other space-borne and ground-based observatories/telescopes that include Swift, the Canadian Hydrogen Intensity Mapping Experiment and the Very Large Array, to name a few. In this talk, we will present details of the planned commensal system and the architecture of AARTIST, highlighting its potential future deployment on the LWA station at Owens Valley Radio Observatory and other similar arrays.