Experiences with the design and construction of wideband spectral line and pulsar instrumentation with CASPER hardware and software: The Digital Backend System

John Ford[1], Marty Bloss[1], Joe Brandt[1], Ramon Creager[1], Paul Demorest[1], Glenn Jones[2], Jintao Luo[1], Randy McCullough[1], Richard Prestage[1], Scott Ransom[1], Jason Ray[1], Galen Watts[1], and Mark Whitehead[1]

[1] National Radio Astronomy Observatory, Green Bank, WV, 24944, http://www.nrao.edu

[2] NRAO-PIRE Researcher, Columbia University, New York, NY, 10027, http://casper.berkeley.edu

NRAO recently designed and built a universal backend system for the Shanghai Astronomical Observatory's (SHAO) 65 meter radio telescope which was constructed near the city of Shanghai, China. The machine, called the Digital Backend System (DIBAS), was created from the design of the VErsatile GBT Astronomical Spectrometer (VEGAS) by adding nine incoherent pulsar search modes and eight coherent dedispersion timing modes to complement the 29 VEGAS spectral line modes. Together these modes cover all of the anticipated science requirements for the 65 meter except for VLBI.

The VEGAS multi-beam spectrometer was recently designed and built for the Green Bank Telescope (GBT) through a partnership between the National Radio Astronomy Observatory (NRAO) and the University of California at Berkeley. The VEGAS spectrometer is based on a Field Programmable Gate Array (FPGA) frontend and a heterogeneous computing backend comprised of Graphical Processing Units (GPUs) and x86-64 CPUs. Working together, the hardware in this system provides processing power to analyse up to 8 dual-polarization or 16 single-polarization inputs, at bandwidths of up to 1.25 GHz per input. An aggregate of up to 10 GHz of bandwidth, dual polarization, may be simultaneously processed with the VEGAS spectrometer.

As capable as this spectrometer is, it has no advanced pulsar capabilities such as were needed for DIBAS. There was no funding in the VEGAS project for fast dump search modes or coherent dedispersion modes. To create DIBAS, VEGAS was augmented with new FPGA designs based on those built for the Green Bank Ultimate Pulsar Processing Instrument (GUPPI) some five years ago. GUPPI was built on earlier generations of FPGA hardware designed by the CASPER project at Berkeley. Porting the old GUPPI designs to modern hardware and wider bandwidths was a good test case to determine the portability of the FPGA designs and the utility of the toolset to help move designs between generations of FPGA chips, as well as the degree of reuse that could be obtained from the VEGAS project.

This talk will explore the unique aspects of the DIBAS project, including the extremely high level of reuse of existing FPGA designs, the challenges of an aggressive schedule for the project, and the unique technical designs needed for the system, including the Python-based portable control system and GPU software.