About Dan Werthimer

Dan Werthimer is Chief Scientist of the Berkeley SETI Research Center and principal investigator of SETI@home and CASPER, the Center for Astronomy Signal Processing and Electronics Research. CASPER instrumentation made the first image of a black hole, and discovered a planet made from solid diamond and many pulsars and fast radio bursts. Dan has testified to congress about SETI, holds the Drake Award for SETI research and the Carl Sagan award for science education, and published 250 papers in the fields of SETI, astronomy, and science education; he is editor of "BioAstronomy: Molecules, Microbes and Extraterrestrial Life" and "Astronomical and Biochemical Origins and the Search for Life in the Universe. Dan has been associate professor in the engineering and physics departments of San Francisco State University and a visiting professor at Beijing Normal University, the University of St. Charles in Marseille, and Eotvos University in Budapest. Working with Unesco, Dan taught science education at universities in Peru, Egypt, Ghana, Ethiopia, Zimbabwe, Uganda and Kenya. Dan was in the “Homebrew Computer Club” with Steve Jobs and Steve Wozniak; everyone in that club became ultra-rich, except Dan.

The New Landscape of Data Acquisition and Signal Processing for FRB Research and The PANOSETI IR/Visible Ultra-Wide Field Nanosecond Time Scale Transient Search

First I'll discuss new architectures and open source hardware, gateware, and software for FRB instrumentation**.** For those new to instrumentation, I'll quickly review the CASPER open source technologies for rapidly building radio astronomy instruments such as correlators, beamformers, spectrometers, pulsar, and FRB machines.

Radio telescope arrays produce high data rates; a 1000 element array with 1 GHz bandwidth produces ~ 50 Terabits/second. Even single dish telescopes, especially those with wide-band feeds, multi-beam receivers, or phased array receivers, produce such high data rates that their data cannot be recorded or transported over internet to a remote computing facility. Most raw radio astronomy data must be processed in-situ.

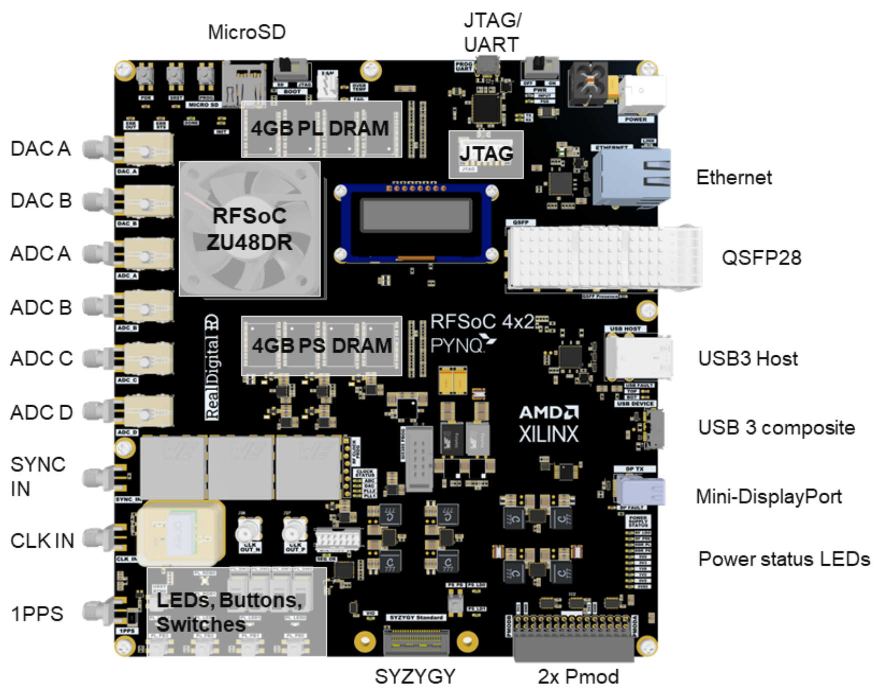
Early in-situ instruments developed by the Collaboration for Astronomy Signal Processing and Electronics Research (CASPER) were based largely on FPGAs (Field Programmable Gate Arrays). FPGA chips are good at signal processing, and more importantly, can handle very high data rates. FPGA chips handle ~1 Terabit/second. But FPGAs are hard to program and aren't good at floating point computation.

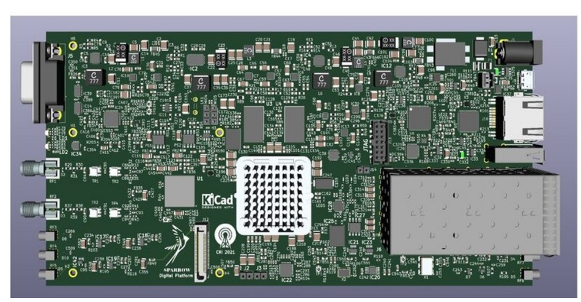
Today's radio astronomy instrumentation developers are shifting some or all signal processing computation to GPUs. GPUs are easier to program than FPGAs and are good at both floating point and integer signal processing. But GPUs have a bottleneck - getting high speed data in and out of the GPU can be very difficult. Almost all radio astronomy data processing applications on GPU's are I/O bound, not compute bound. Tensor cores on Nvidia GPU's are excellent at correlation, beamforming, and filtering; there are powerful codes for these radio astronomy applications, but we need to improve techniques to get high speed data into GPU. I'll talk about some of the new data transport techniques for getting high rate ethernet data into a GPU at rates to ~400 Gbit/second. By the way, tensor cores are not useful for FFT's, but more standard GPU processing elements can compute spectra and de-disperse efficiently, without tensor cores.

Since more radio astronomy signal processing computation is being shifted to accelerator boards (both FPGA and GPU accelerator boards), the CASPER collaboration has been working on inexpensive boards for digitizing signals, time stamping, and packetizing time domain ADC data. Some of these digitizer boards are pictured below.

For those new to radio astronomy instruments, the CASPER collaboration develops architectures and open source hardware, software, GPUware, FPGA gateware, tools, libraries, reference designs, tutorials, training videos, and workshops for radio astronomy instrumentation.
CASPER instrumentation is utilized mostly for radio astronomy, but also for physics, medicine, genomics, and engineering. More info at http://casper.berkeley.edu

The **PANOSETI** experiment searches a largely unexplored parameter space, observing a large field of view simultaneously (4,450 degrees) for nanosecond to second time scale transients at visible and near-IR wavelengths. The PANOSETI observatory employs two domes separated by ~1 km. Data from the two domes is cross-correlated to distinguish between astrophysical events and atmospheric phenomena (eg: Cherenkov radiation). Each PANOSETI dome contains ~45 telescopes; each telescope covers a 10 by 10 degree field. We have deployed a prototype PANOSETI observatory at Lick Observatory; we plan to build a full scale system at Lick or Palomar observatory. The small aperture, wide field-of-view, and low cost of the PANOSETI telescopes make them well-suited for high energy gamma-ray astronomy.





DIgitizer/Packetizer boards, which digitize signals, time stamp them, packetize, and transmit via ethernet. Left is $2,150 Xilinx RFSOC4x2 board, with four 5 Gsps 14 bit ADC's and 100Gbit ethernet. Lower left is low cost 10 watt dual 250 Msps 12 bit ADC Pika board developed by Lincoln Greenhill. Lower right is dual 500 Msps 12 bit ADC Sparrow board developed by Nima Razavi and Jack Hickish.