Digisonde 4D Overview

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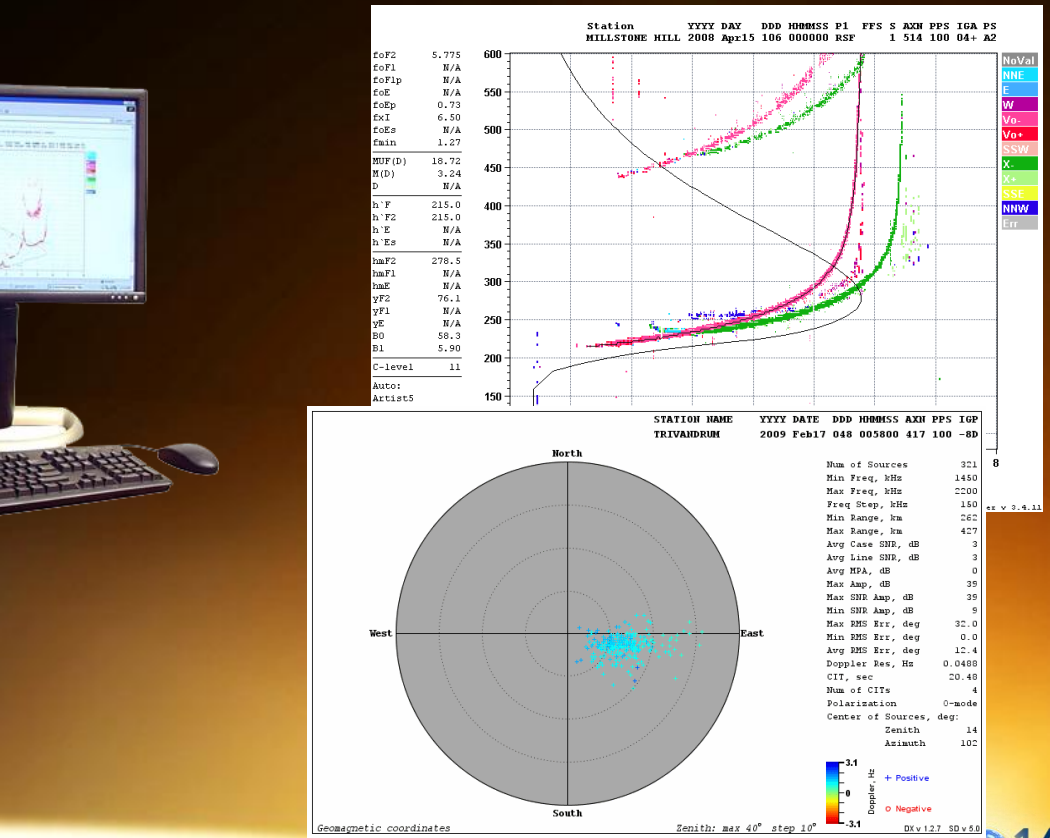
IGF 2014

XIV INTERNATIONAL GIRO FORUM · 20-23 MAY

Digisonde 4D



Outline

- Digisonde System Introduction
- Transceiver Hardware Overview
- Current Work and Future Digisonde Development

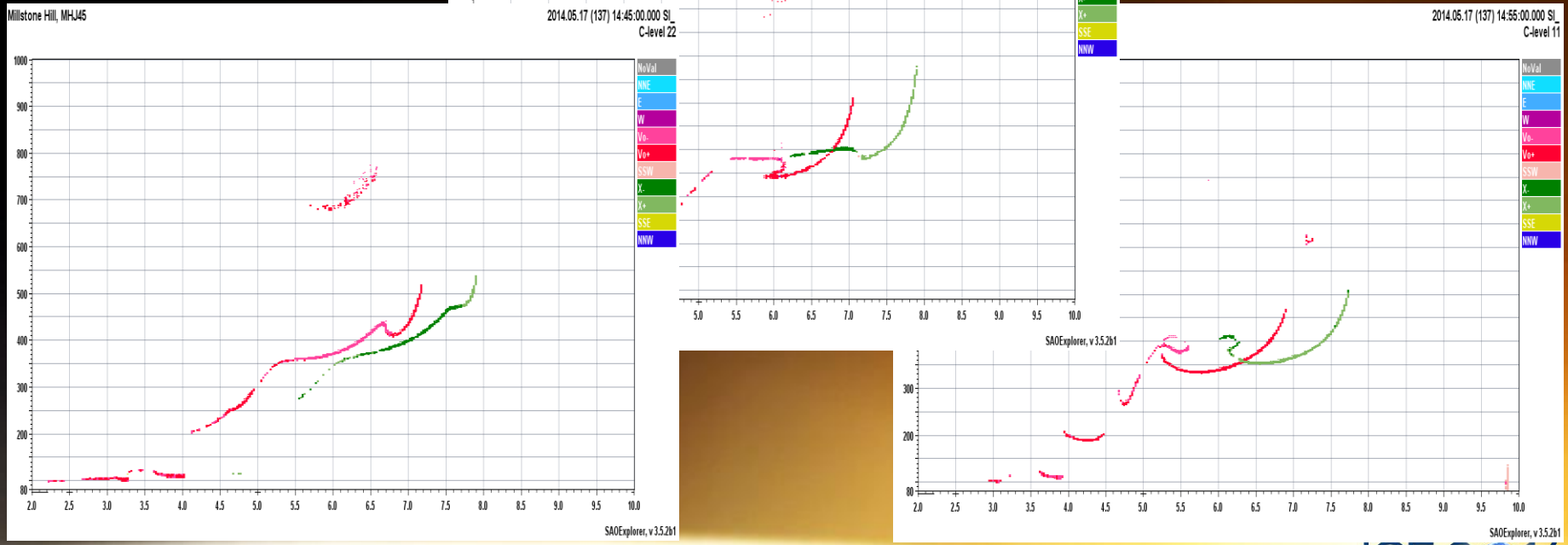
Key 4D Innovations

- **Digital Transceiver**
  - Superior accuracy, precision, and resolution of amplitude and phase measurements
    - Precision Echolocation for skymaps
    - Improved Ionogram fidelity
  - Simpler to build and maintain
- **Embedded platforms**
  - Faster processors and interfaces
  - Fast enough to record time domain raw data
  - No more pauses within a measurement

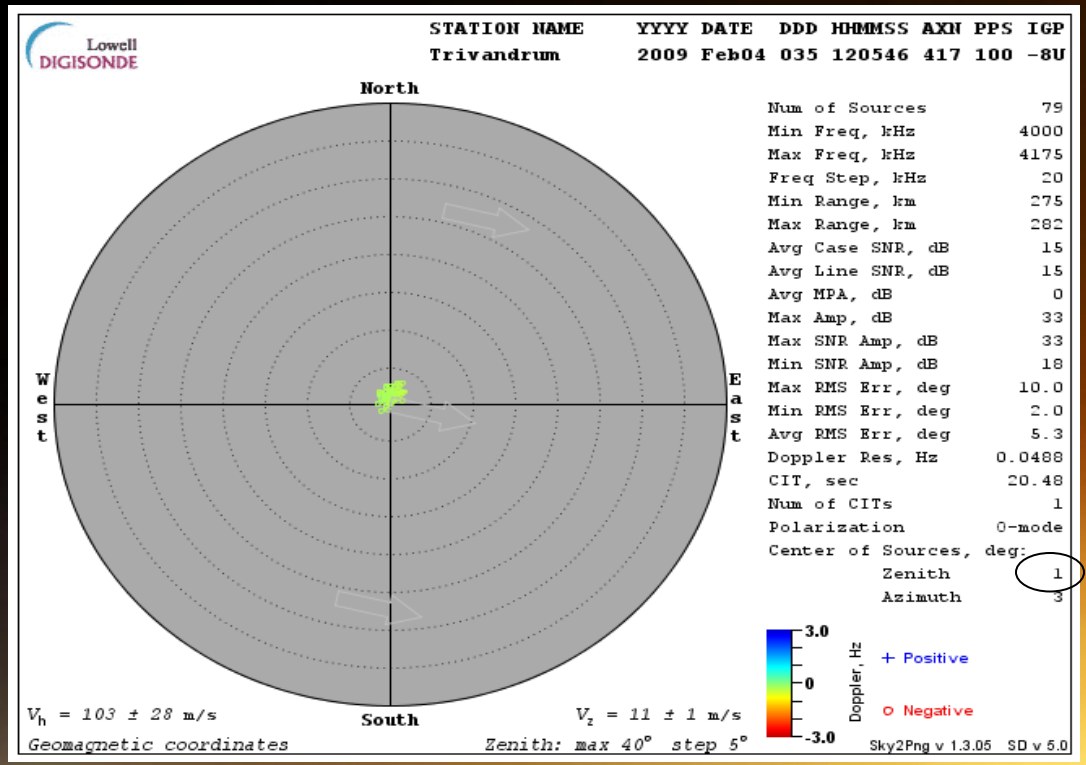
Key 4D Innovations (2)

- **New Signal Processing**
  - RFI Mitigation technique (~30 dB SNR improvement)
  - Faster measurements (2 sec ionograms)
- **Software and Data Analysis**
  - New DCART terminal for real-time data monitoring and processing, experiment planning and system commanding
  - New passive mode for reception of signals from transmitters-of-opportunity
  - Fault isolation to LRM with instructions to the engineer
- **Exact Reproducible Timing**
  - Automatic bi-static sounding

Improved Ionogram Fidelity

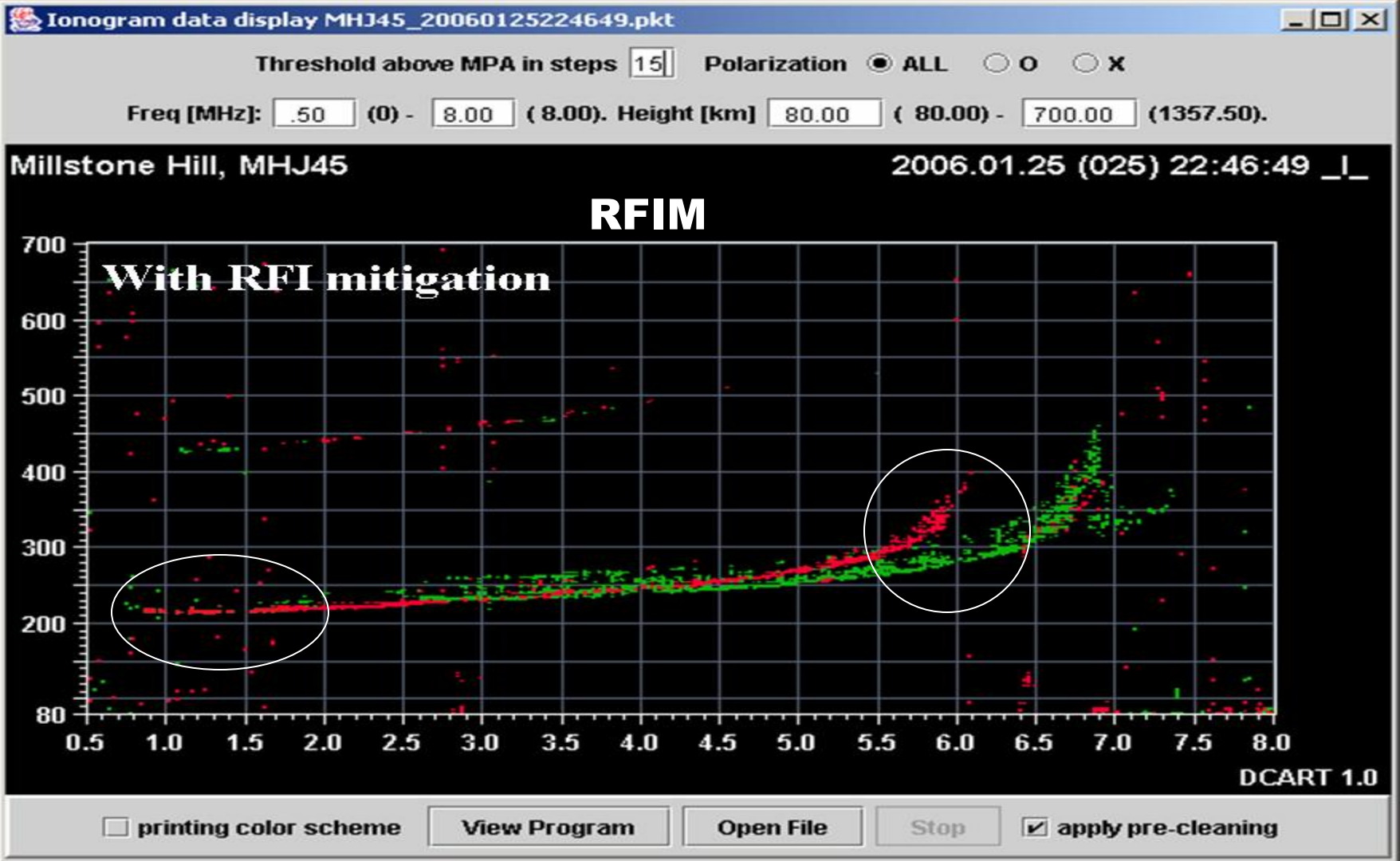


Precision Echolocation

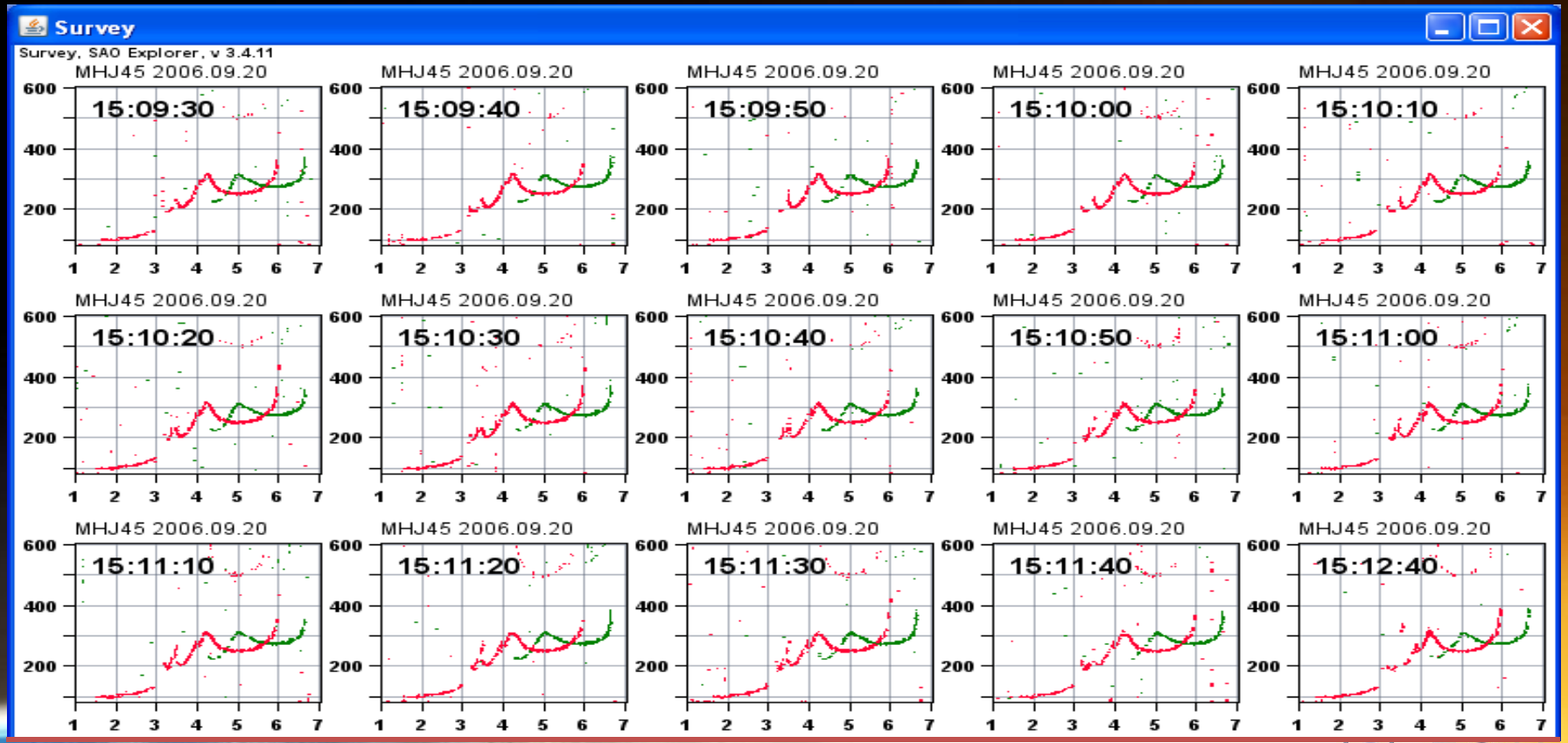


Echolocation with 4D at Trivandrum, India

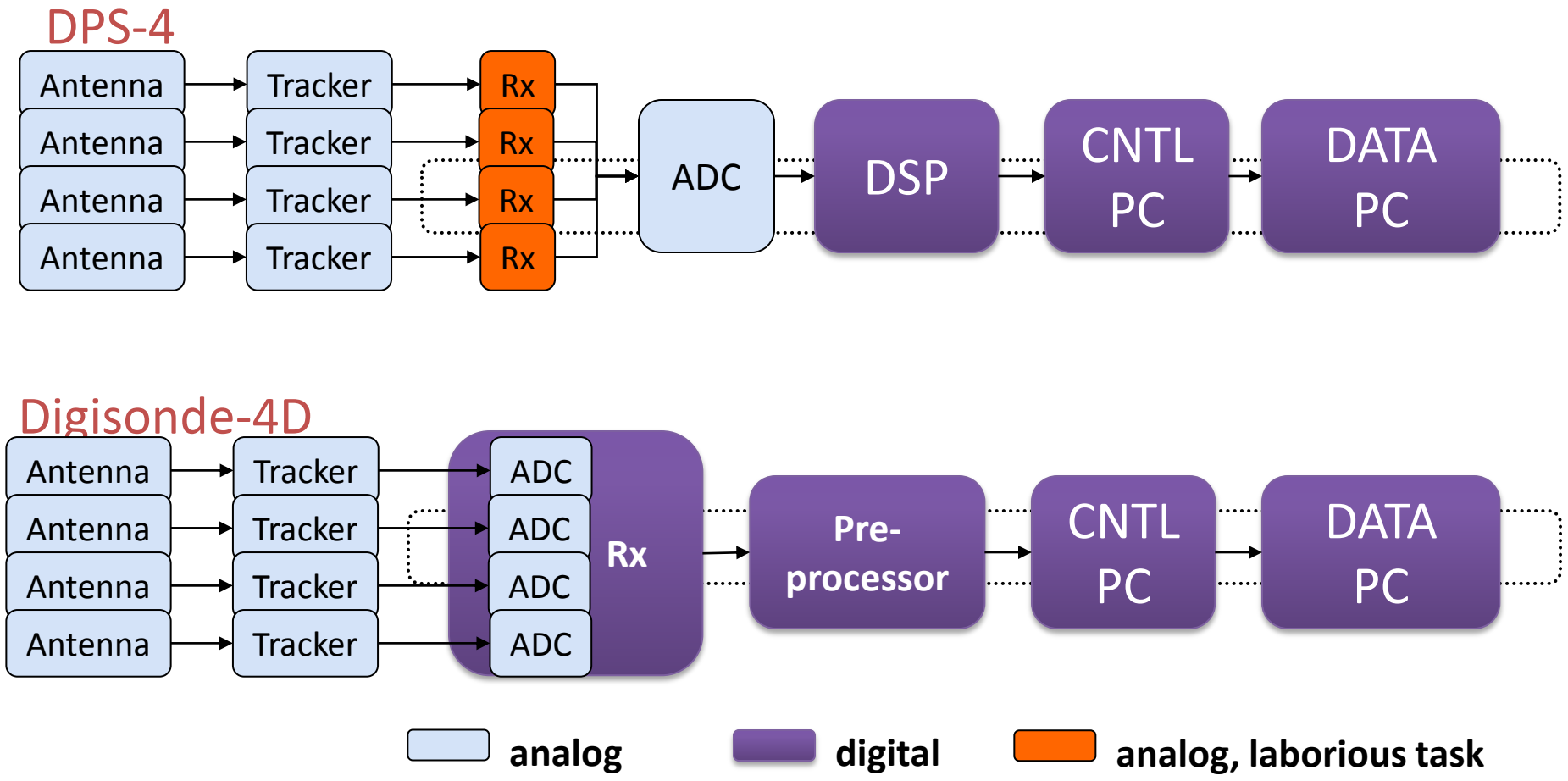
Real ionosphere, not a lab shelf calibration


Ionogram data display MHJ45_20060125224649.pkt
Threshold above MPA in steps 15
Polarization ALL O X
Freq [MHz]: .50 (0) - 8.00 (8.00). Height [km] 80.00 (80.00) - 700.00 (1357.50).
Millstone Hill, MHJ45
2006.01.25 (025) 22:46:49 _I_
RFIM
With RFI mitigation
700
600
500
400
300
200
80
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0
DCART 1.0
printing color scheme
View Program
Open File
Stop
apply pre-cleaning

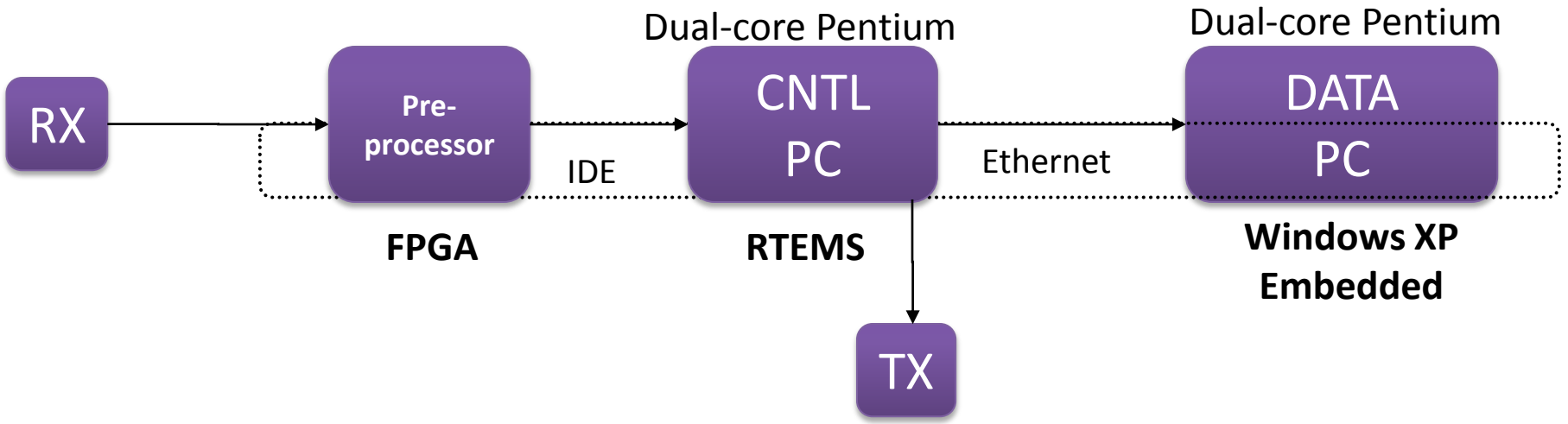
Rapid Ionograms



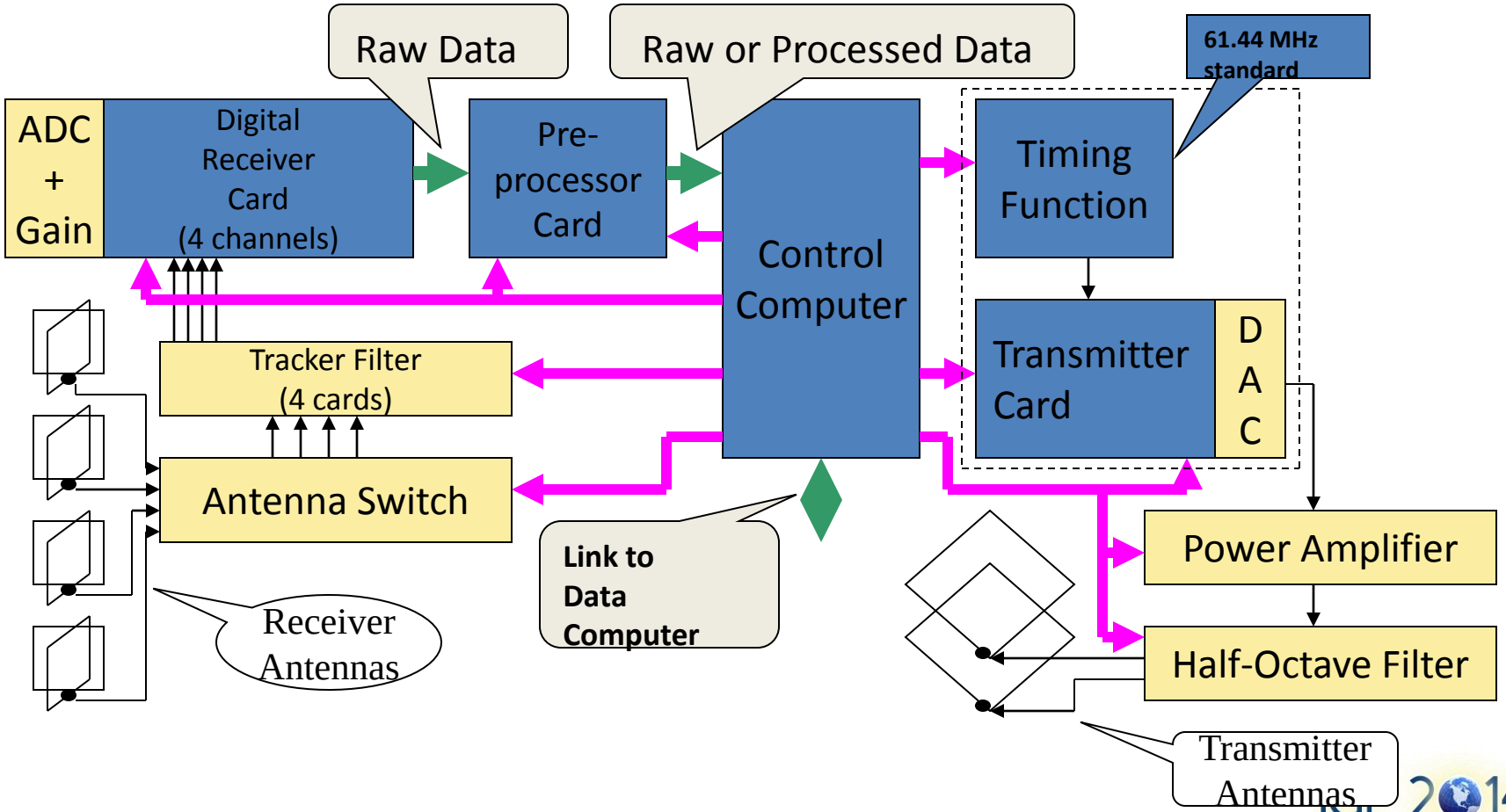
Simplified Architecture



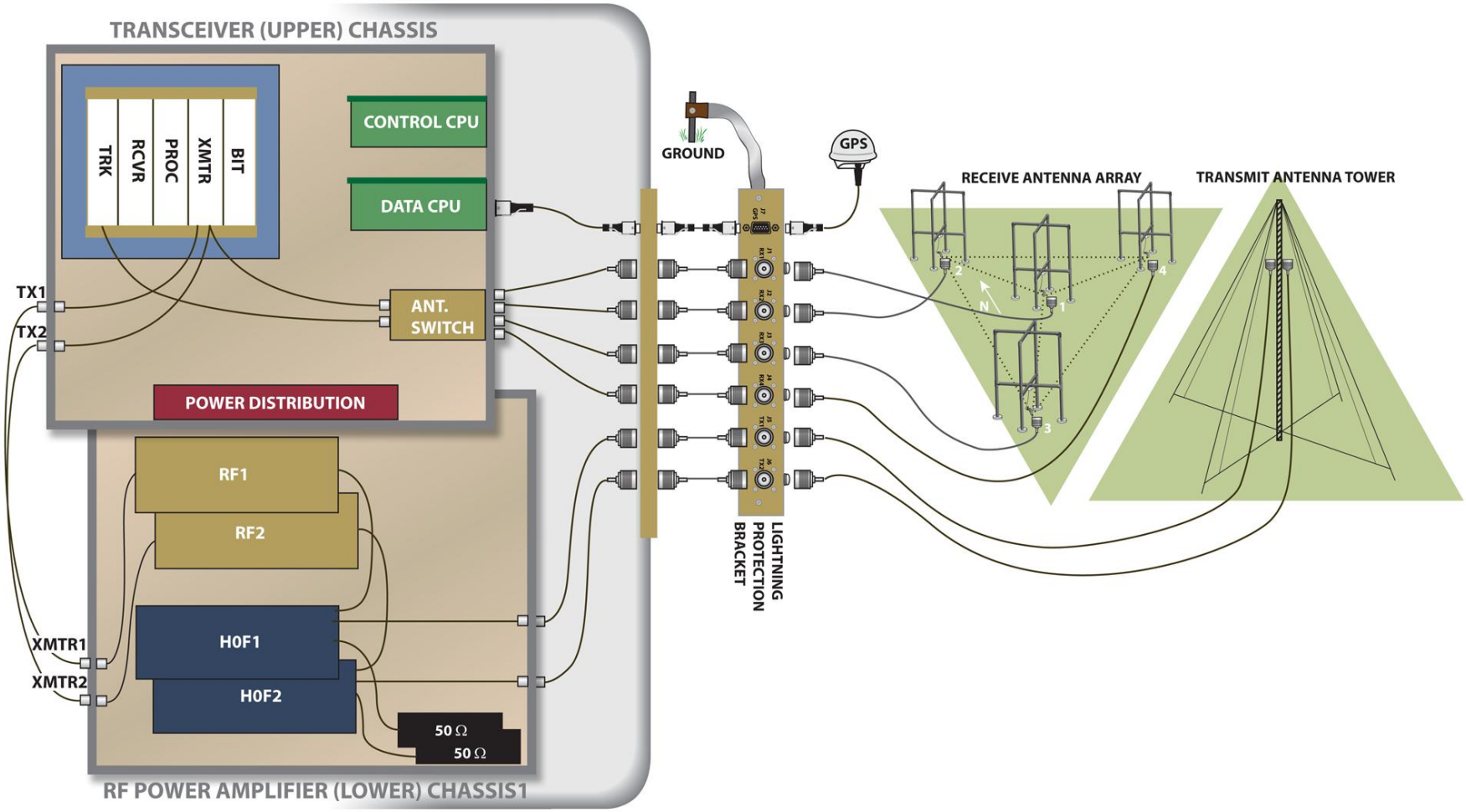
Embedded Systems



DPS-4D Digital Transceiver Block Diagram



Digisonde 4D General Layout



Development of Topside Sounder

- Much of the Digisonde 4D digital transceiver technology is applicable to a topside sounder
- Current transceiver hardware is unacceptable for space
- Implement a digital transceiver that is suitable for space (in FPGA)
- Use the development knowledge and apply it to the ground system

Field Programmable Gate Array (FPGA)

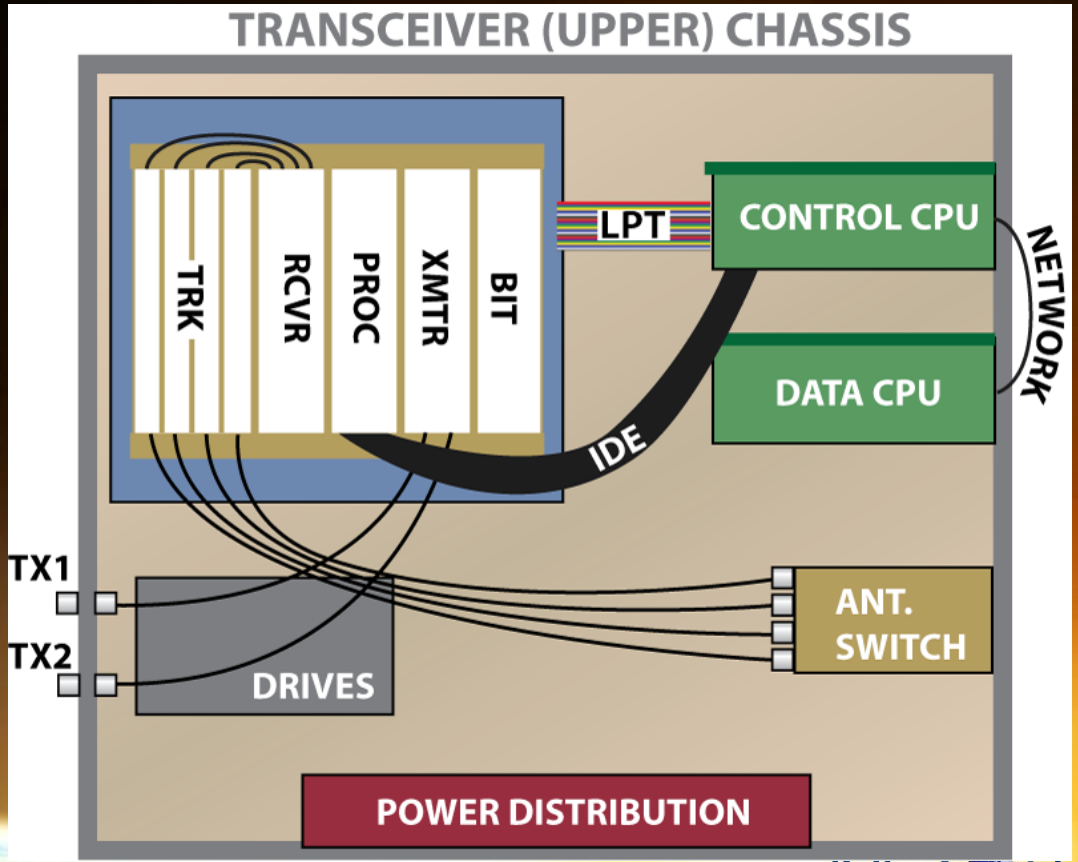
- An integrated circuit designed to be configured by a customer or a designer after manufacturing – hence “field programmable“
- Contemporary FPGAs have large resources of logic gates and RAM blocks to implement complex digital designs
- The FPGA configuration is specified using a hardware description language (HDL) code
- FPGAs can be used to implement any logical function that an ASIC could perform
- The ability to update the functionality after shipping, partial re-configuration of a portion of the design and the low non-recurring engineering offer advantages for many applications

Future Direction of Digisonde

- Implement transceiver in Field Programmable Gate Array (FPGA)
  - Consolidation of components (Transmitter / Receiver / Pre-Processor / BIT)
  - Functionality is implemented as firmware (code) and is more portable
  - Greater control over functionality
  - The resulting IP can be applied to different devices to suit various applications (space, for example)
- Replace RTEMS (Real Time Executive for Multiprocessor Systems) with Real Time Linux
  - Better Hardware support allows more flexibility in choosing future computers
  - Large support community
- Selected PCI as transceiver / computer interface (instead of IDE and LPT)
  - More than fast enough for our future needs
  - Good life expectancy

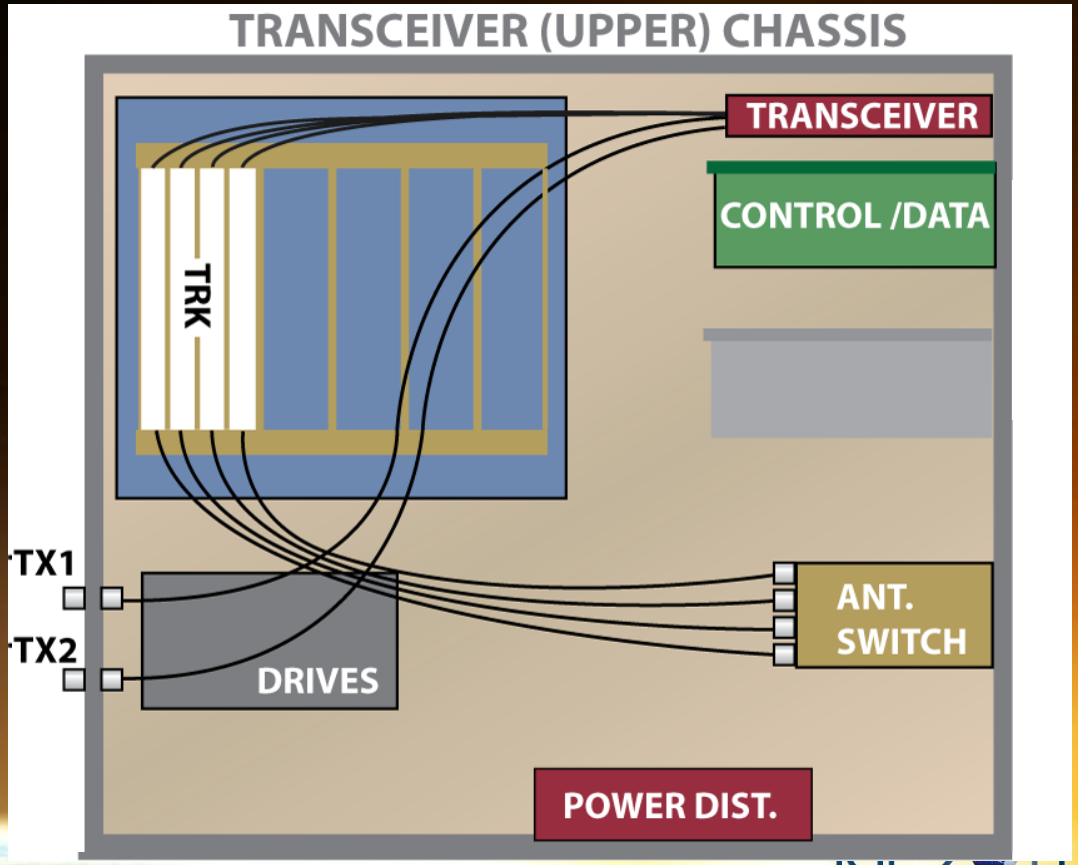
Digisonde 4D Transceiver Layout: Current System

- LPT for control of hardware in card cage
- IDE DMA delivery of receiver data
- RTEMS hardware support limits computer options



Digisonde 4D Layout: Fully Implemented Transceiver

- All transceiver functionality implemented as a single transceiver PCIe card
- Replace RTEMS with RTLinux
- Integrate function of Control and Data computer into a single platform



Benefits

- Single interface to computer means any computer with a PCIe bus is a candidate for our system
- Replacing ASIC components with firmware implemented on FPGA provides us greater development control
- All our technology on one device (ideally)
- Good platform to expand functionality of the Digisonde
- More flexible to keep up with technology as it evolves

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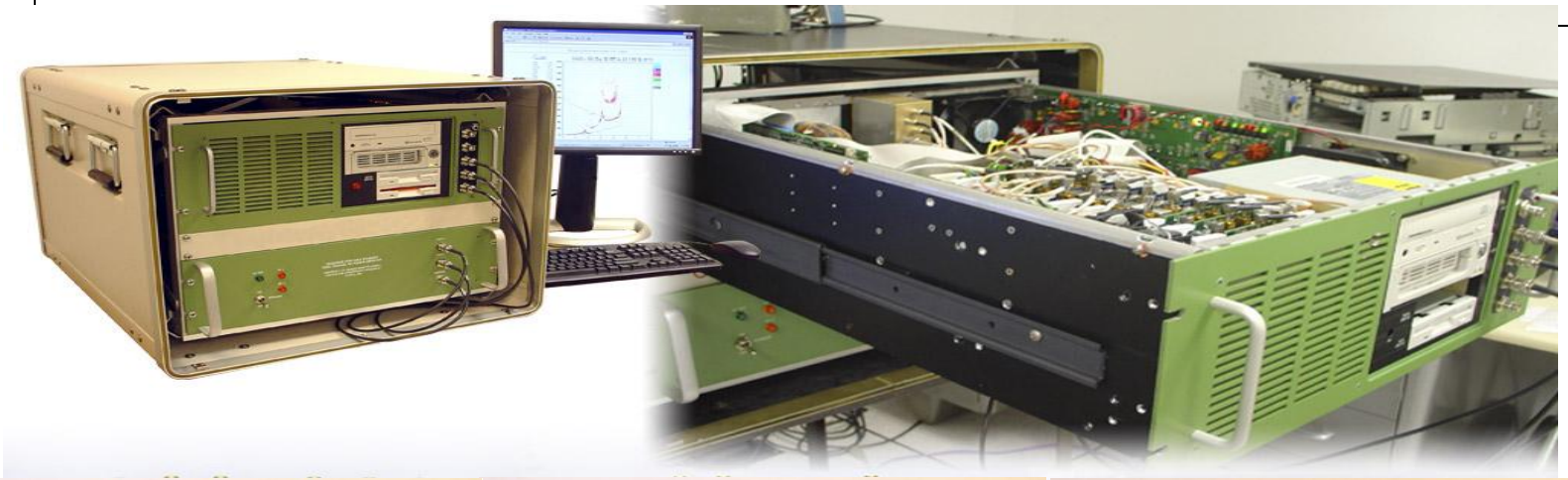
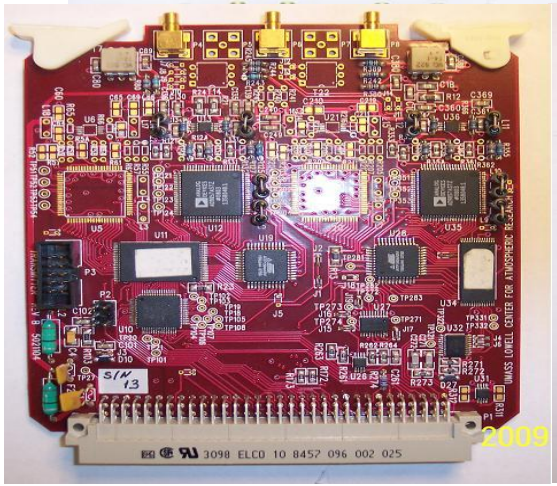
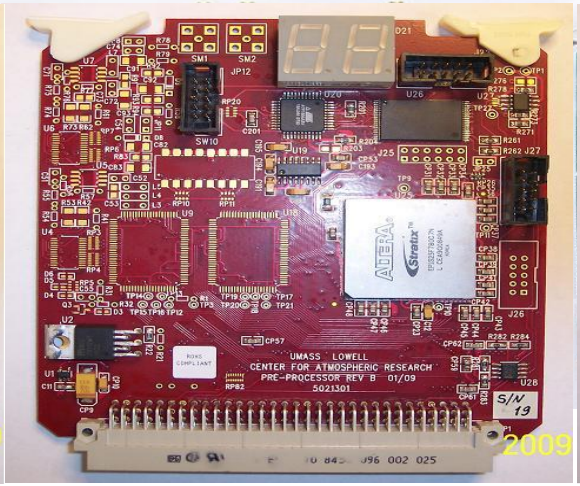
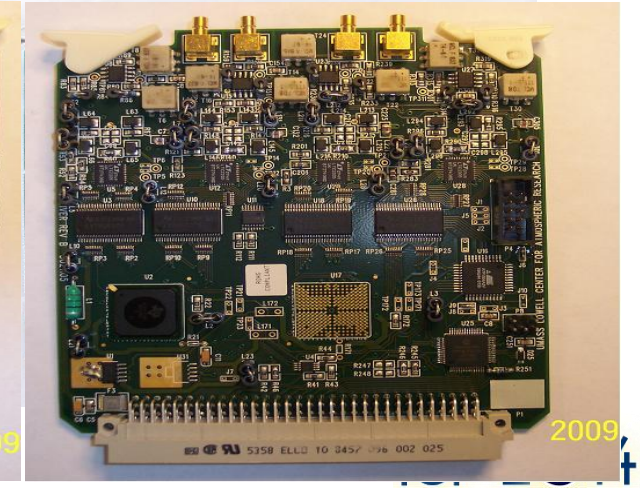
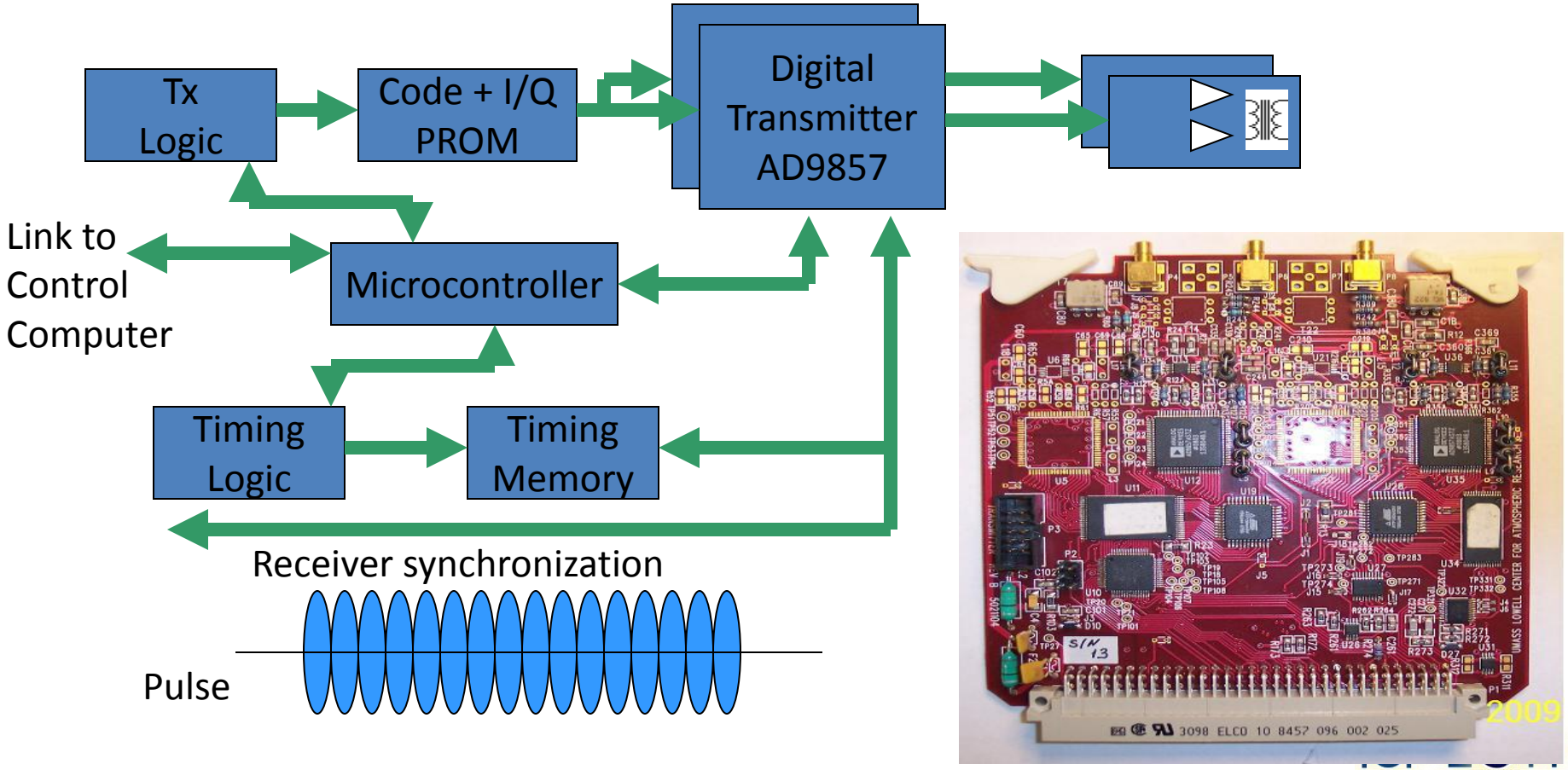






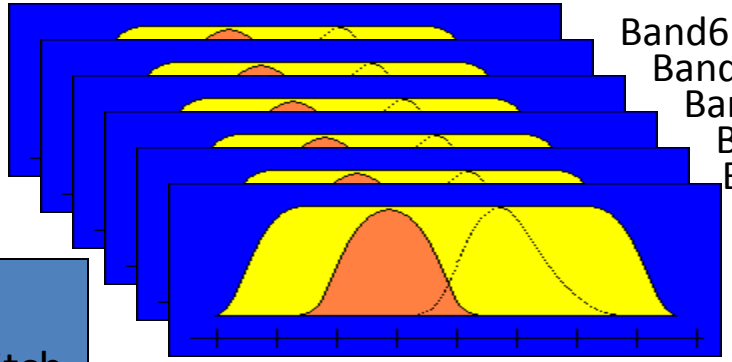


2-Channel Digital Transmitter



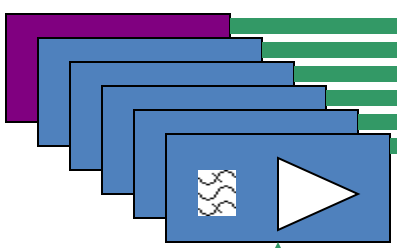
Tracker Filter

Prevent ADC saturation



Band6: 15 – 32MHz
Band5: 7 – 15MHz
Band4: 2.9 – 7MHz
Band3: 1.2 – 2.9MHz
Band2: 0.5 – 1.2MHz
Band1: 0.1 – 0.5MHz

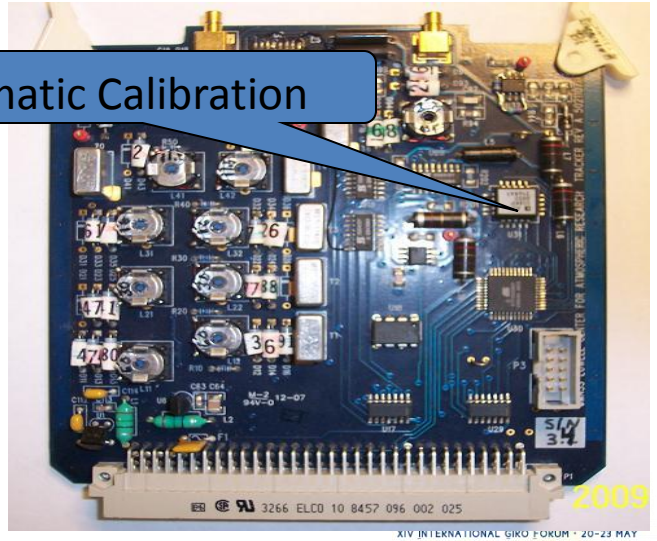
Band Filters



Switch

To Receiver

Automatic Calibration



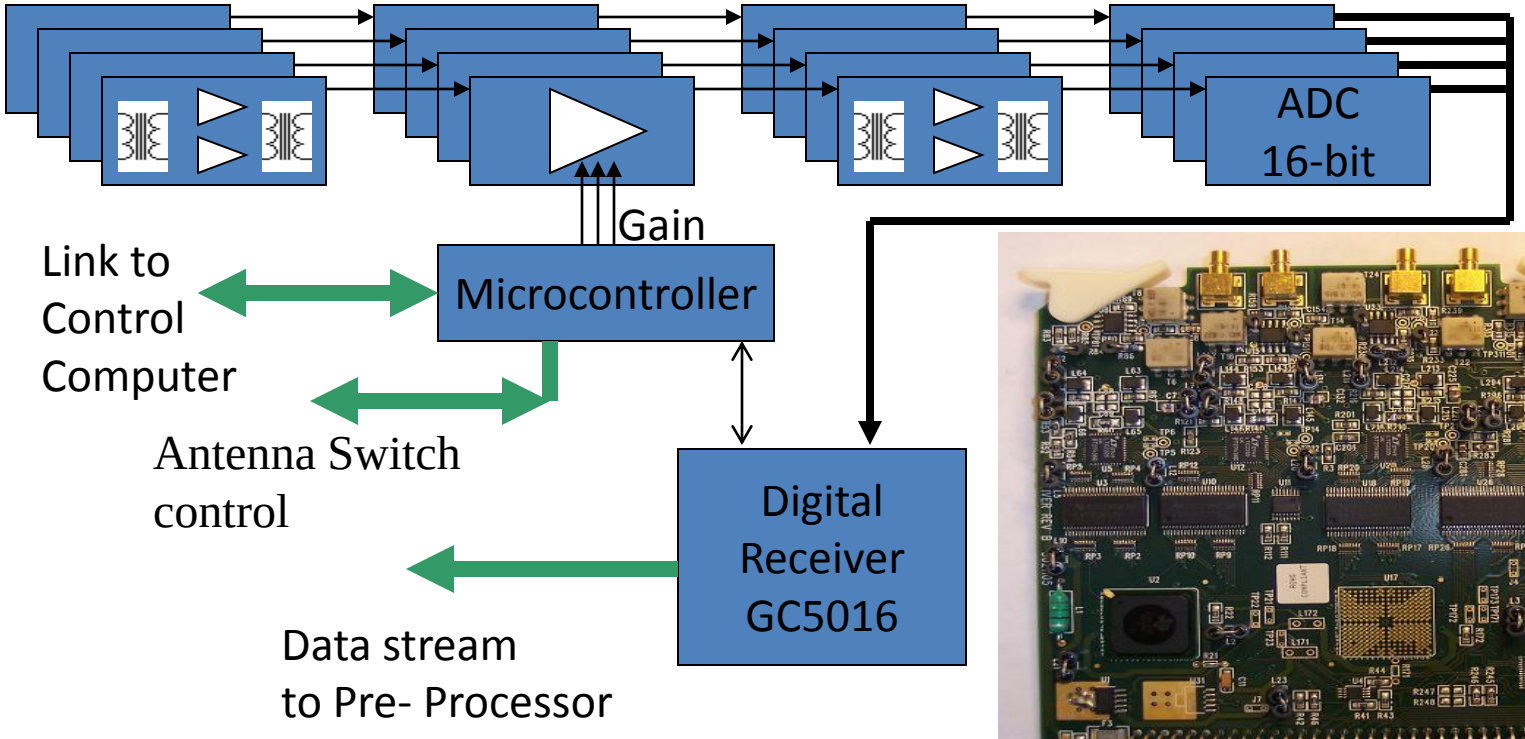
DC to Varicaps

DAC

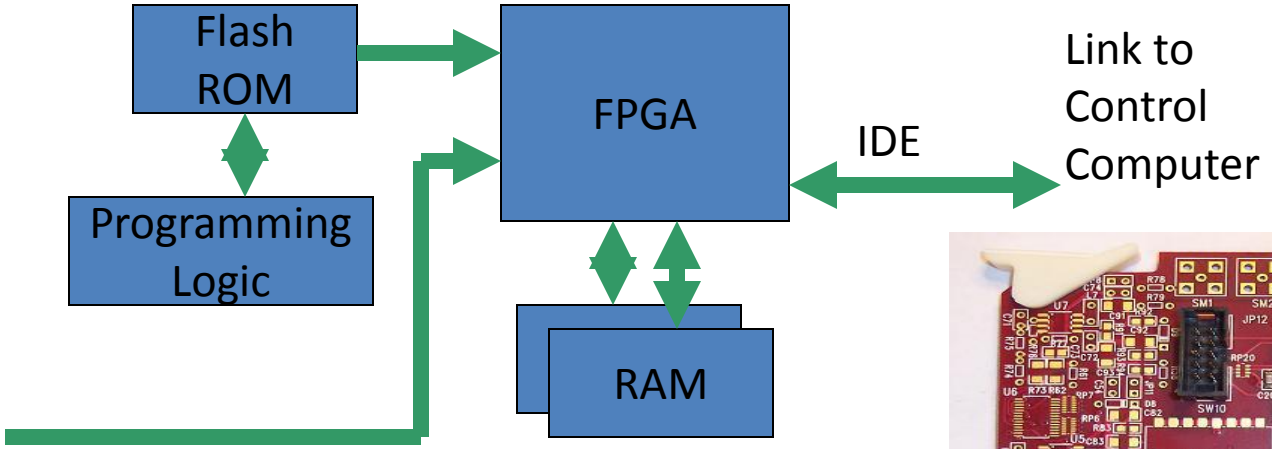
From Control Computer

Control Logic

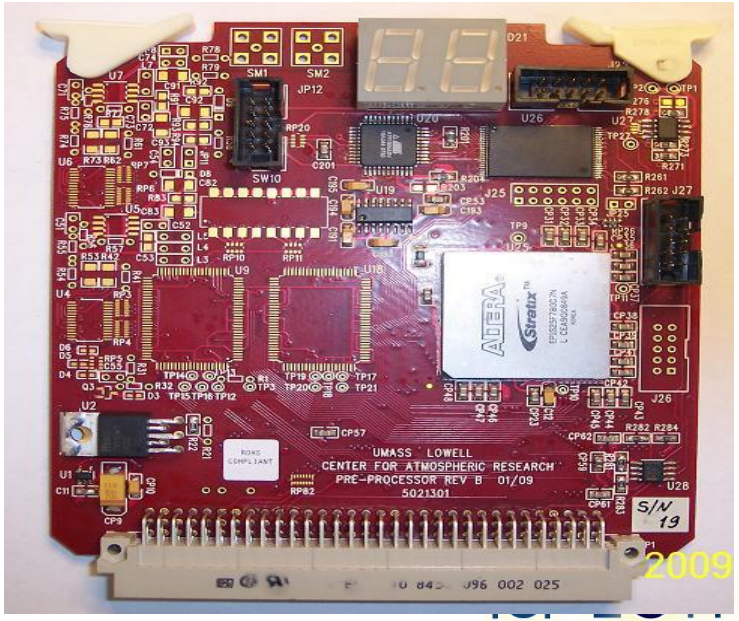
Digital Receiver



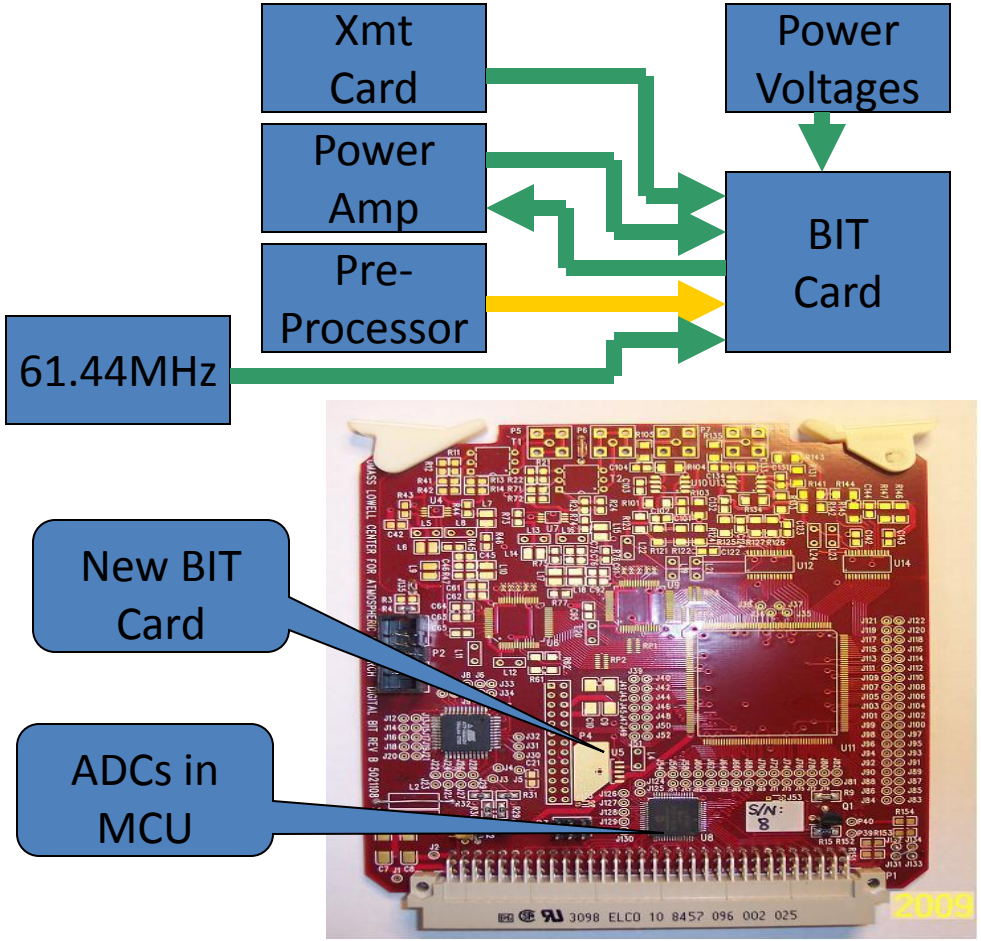
Preprocessor Card



- IDE Interface
- DMA support
- RFIM



BIT-Card


Xmt Card
Power Voltages
Power Amp
BIT Card
Pre-Processor
61.44MHz
New BIT Card
ADCs in MCU
2009

Power Distribution Card

+27V to +24V

+24V to +15V

BIT volt Sensors

+24V to +12V

+24V to -15V

+24V to - 5V

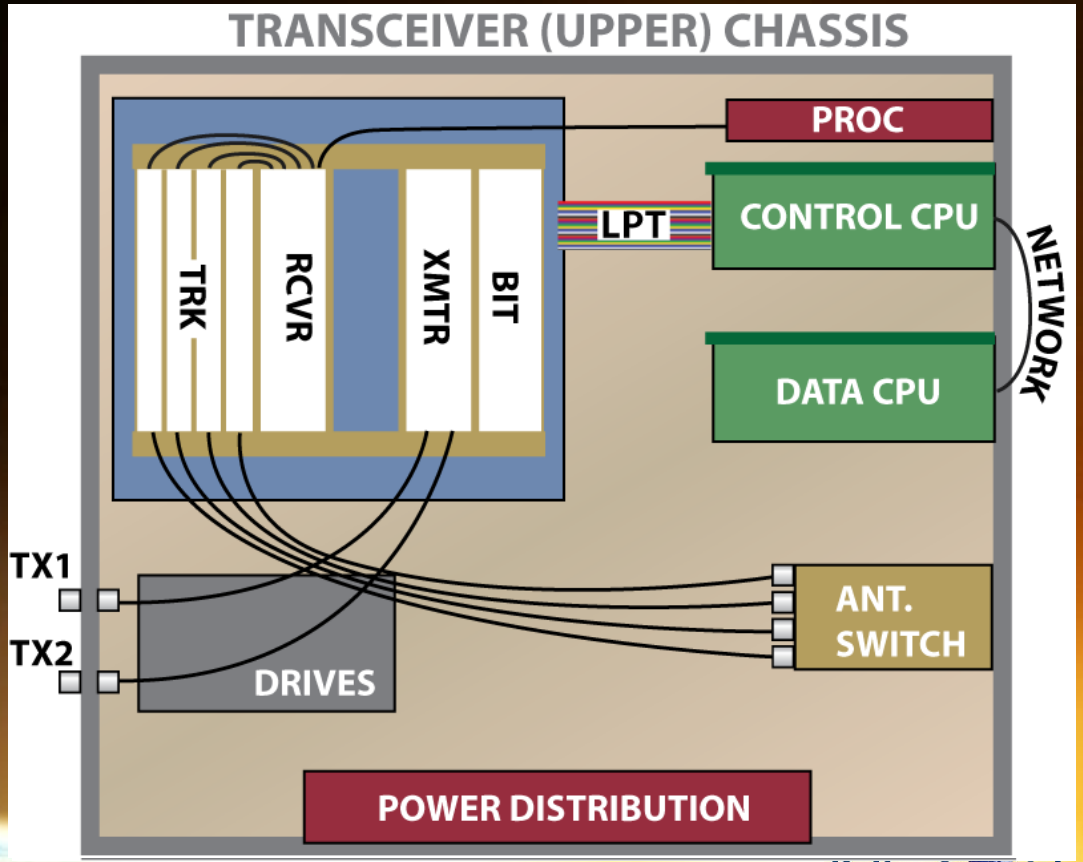
+24V to +5V

+24V to +17/22V

+24V to +3.3V

Digisonde 4D Transceiver Layout: Pre-Processor as PCIe Card

- Move Pre-Processor functionality to PCIe card on Control Computer bus



Change

- Initially implement Pre-Processor as PCIe card
  - Minimal changes to current system
- Eventually migrate the digital transceiver into a PCIe card