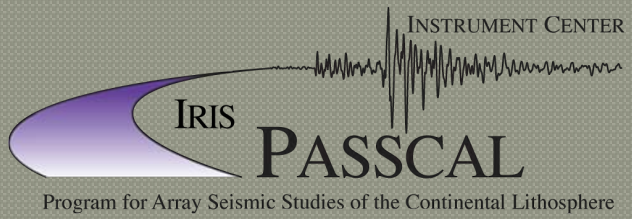
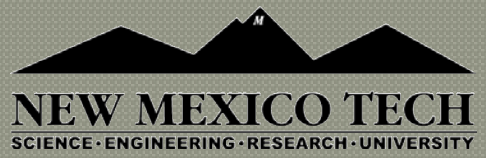
Design and Implementation of Cold-Hardened Seismic Stations

T. Parker, B. Beaudoin, B. Bonnett,
J. Fowler, and K. Anderson



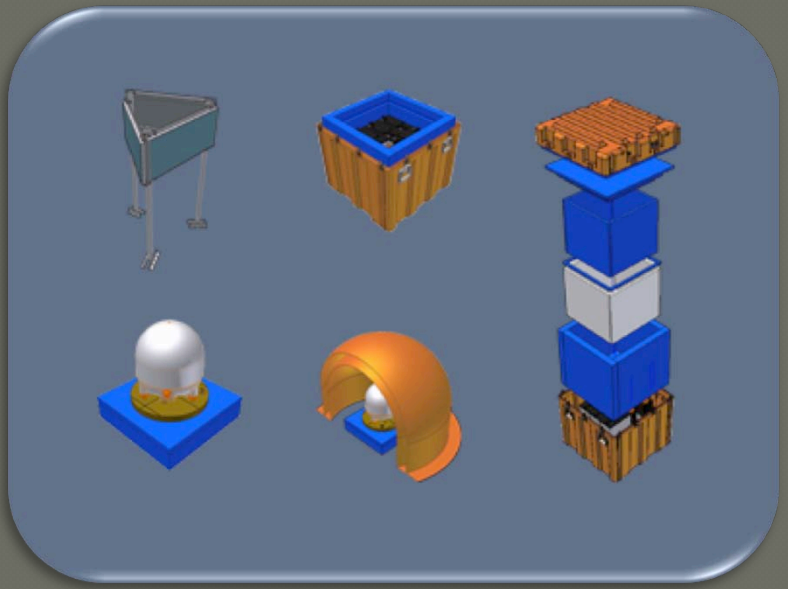


Development & IPY Support

- MRI – Development of a Power and Communications System for Remote Autonomous Polar Observations
  - Second year development deployed this winter
  - Leveraged development to support IPY science
- MRI – Acquisition of Broadband Seismic Stations for Polar Regions
  - Acquisition of 37 cold-hardened stations
  - 20 currently deployed at AGAP & POLENET

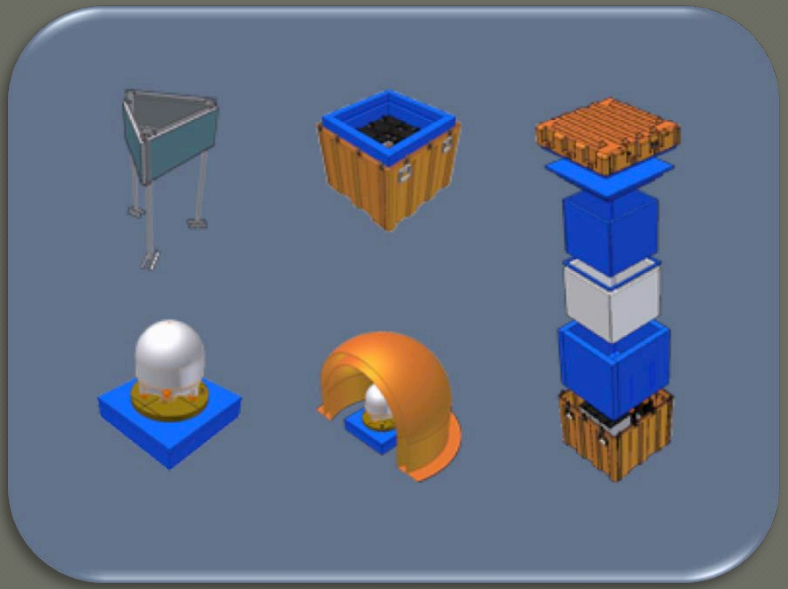
Current Development

- Motivation
  - Demand for year-round recording
  - Unify equipment pool
  - Simplify field logistics & support
  - NSF



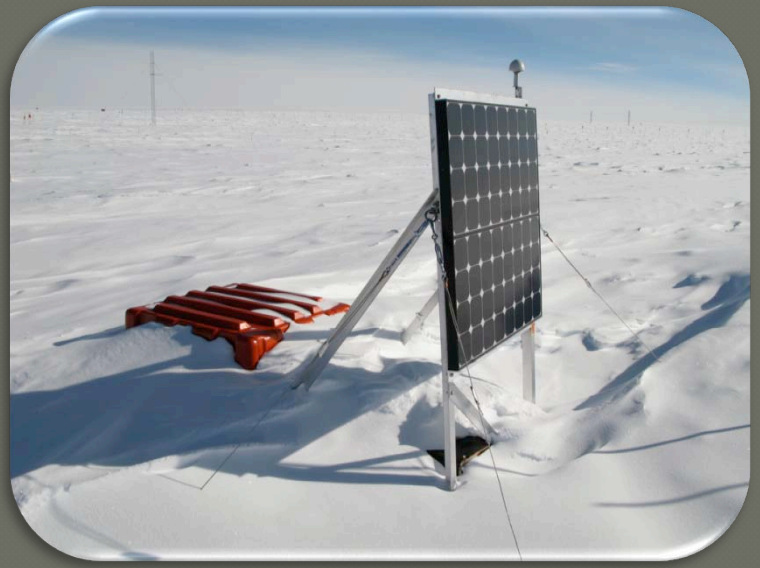
Current Development

- Reduce Power
  - Work with manufacturers
  - Low bandwidth SOH
- Harness DAS heat
  - Increase battery potential
  - Operate within specification
- Simplify deployment
  - Minimize ground time & payload
- Utilize Primary batteries
  - Simple
  - Dependable at extreme cold
  - Highest energy density



PASSCAL Polar Station

- Proven year round operation
- Low power (<1.5W)
- Leverage DAS heat to maintain station temperature ~20-25°C above ambient
- 275 kg total station weight (with Lithium)
- Easily deployed
  - AGAP stations installed on average 2 hours
- 2-way station communications
  - SOH
  - Command & control
- Power management



Colder rated Q330s

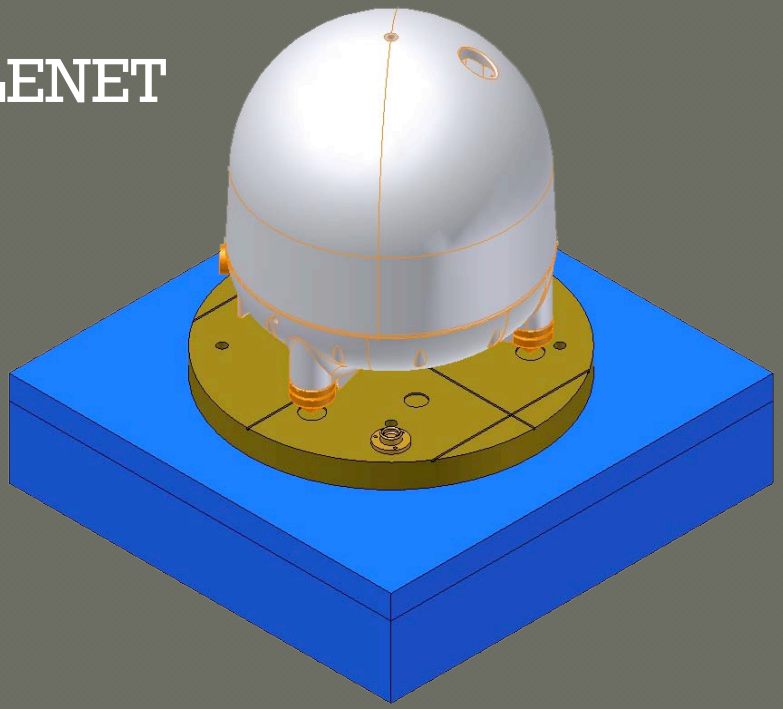
- Rated to -45°C, was -40°C
- 32MB of buffering allows longer time between baler cycles saving 2/3 of the baler power budget from last year
- 16GB of -45°C rated station storage device (media rated to -55°C)
- Power budget for Q330, 3 channels @ 40sps and continuous GPS is ~0.8 watts

Cold Rated Guralp 3T

- Leveraged GSN development of cold rated borehole seismometer
- Coldest rated and lowest powered broadband sensor
- 0.3 watts, -55°C rated, tested to -60°C

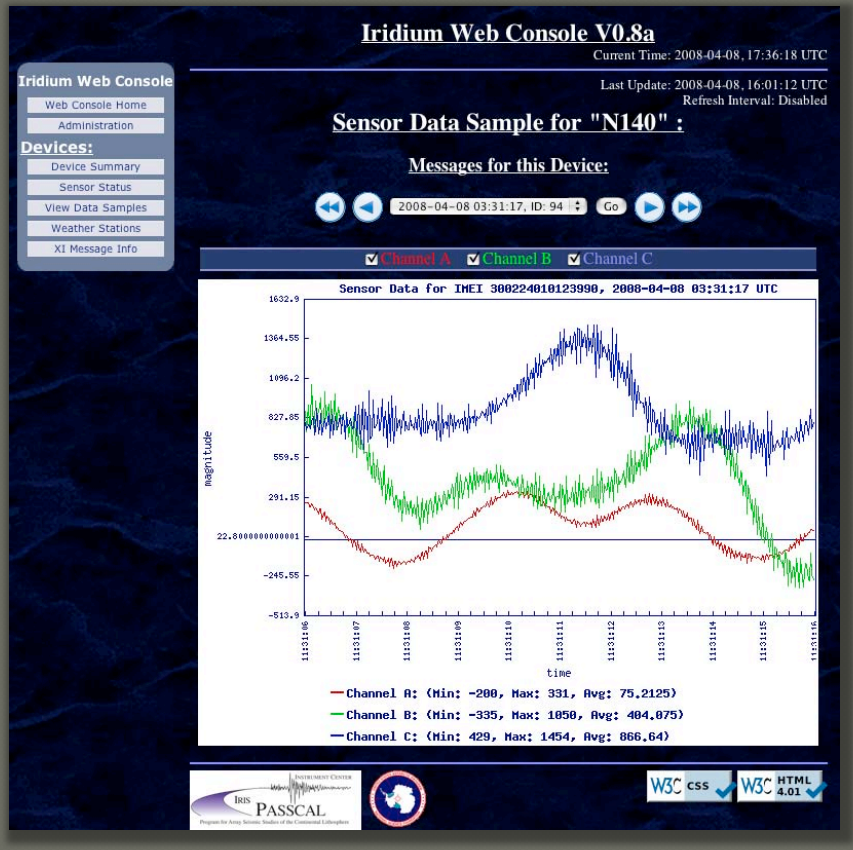
Nanometrics Trillium 240

- Successfully used for one season at South Pole
- 20 currently deployed for POLENET and AGAP
- 0.65 watts, -20°C rated



Development of SOH Iridium Telemetry

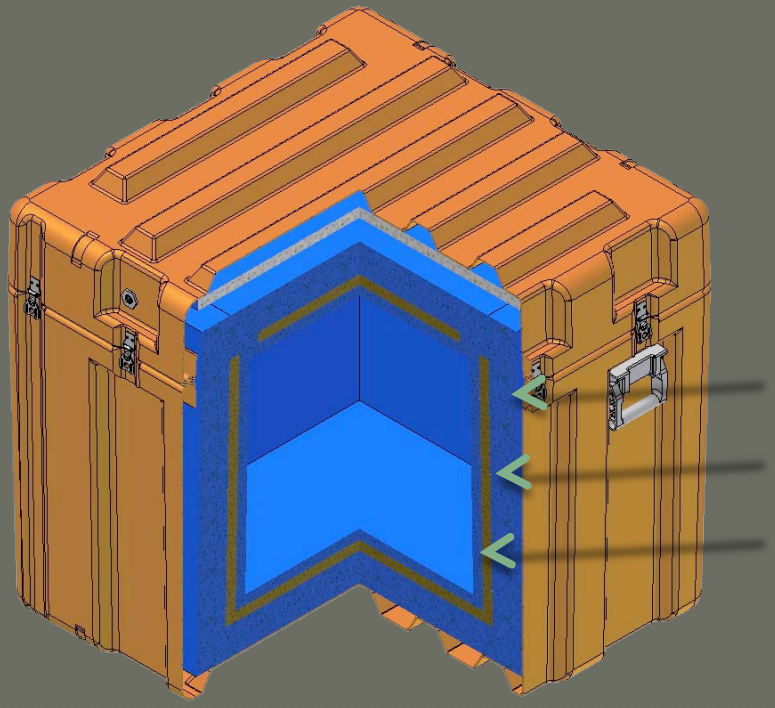
- Deployed but still in alpha testing of phase 1 of a two phase development
- Yearly power budget for once-a-day SOH, 5AH
- Data rate ~2Kb/s
- Status and data snippets
- Command and control of a subset of important station commands and reporting schedules
- Developed in collaboration with XEOS Technologies
- Integration of Vaisala weather station - data averaging, reporting and power control

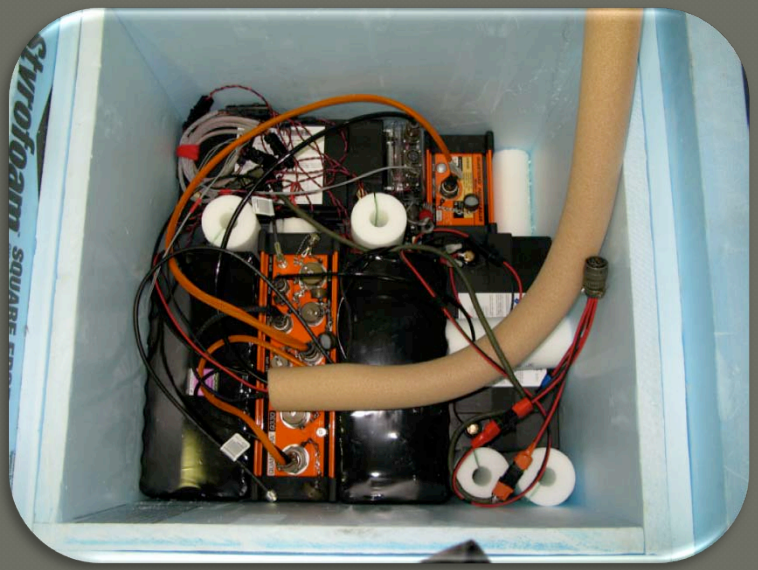


10s data snippet from Antarctica

Station Box

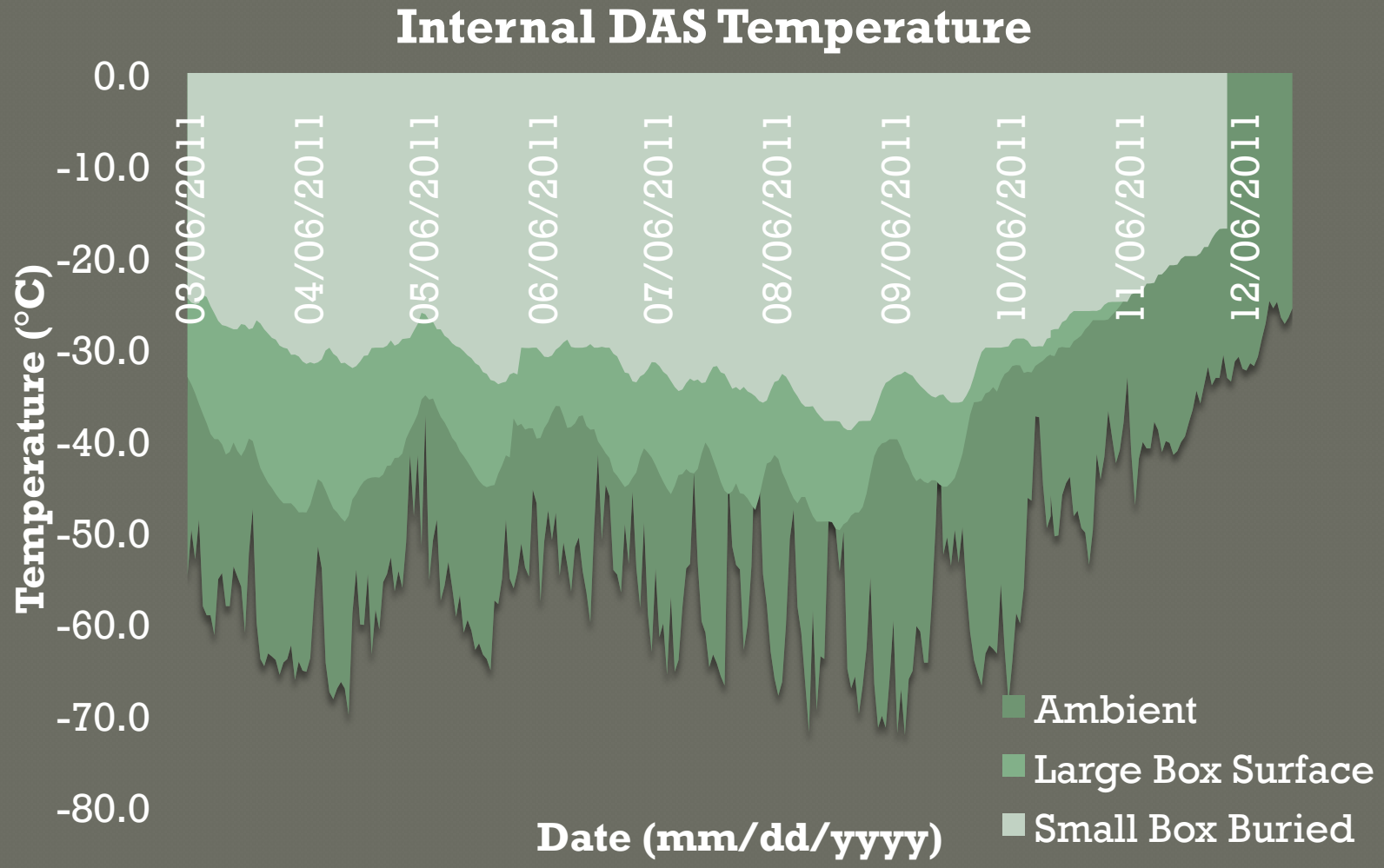
- Design
  - Hardigg Case
  - 94cm x 94cm x 94cm





- 7.6 cm Thick Foam Insulation
- 2.5 cm Thick Vacuum Panel
- 2.5 cm Thick Foam Insulation
- 1.9 cm Wall Cable Insulation

Station Box Performance



Sensor Vault: Rock Site

- Offield Mini-Vault
- Phenolic Sensor Base
- Double-Wall Insulated Dome
- Stretched Steel Dome-Retainer

Sensor Vault: Snow

- Phenolic Sensor Base
- Foam Base
- Sensor Insulation
- Double Wall Insulated Dome

Solar Panels: A-Frame

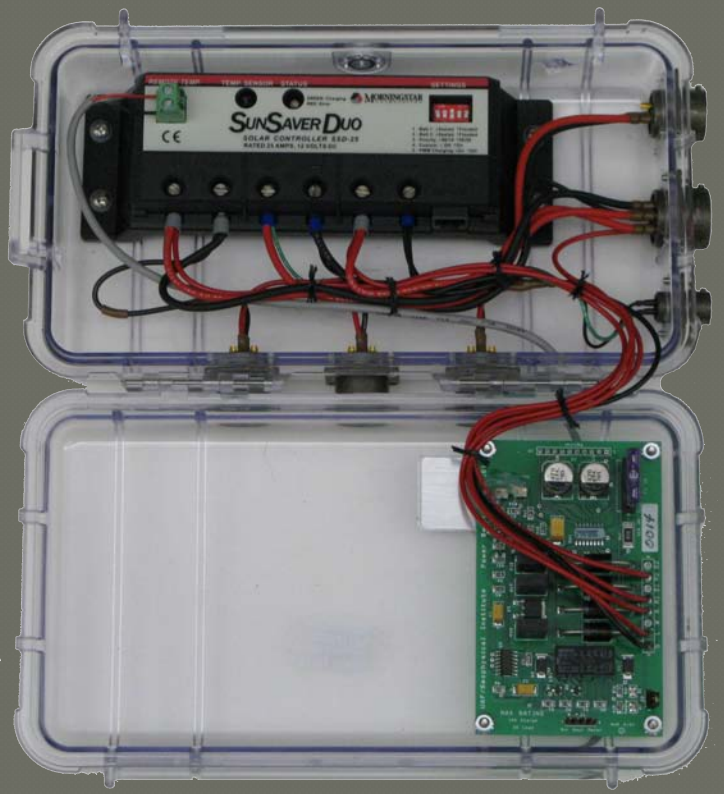
- Folded size: 203cm x 122cm x 15cm
- Weight: 57 kg
- Quickly Deployable
- Use on Rock or Snow
- 2x 80 Watt Sharp Solar Panels
- Integrated Enclosure Cradle
- Aluminum panel backing

Solar Panels: Tri-Panel

- Folded Size:
  213cm x 122cm x 15cm
- Weight: 68 kg
- Quickly Deployable
- 3x 80 Watt Sharp Solar Panels

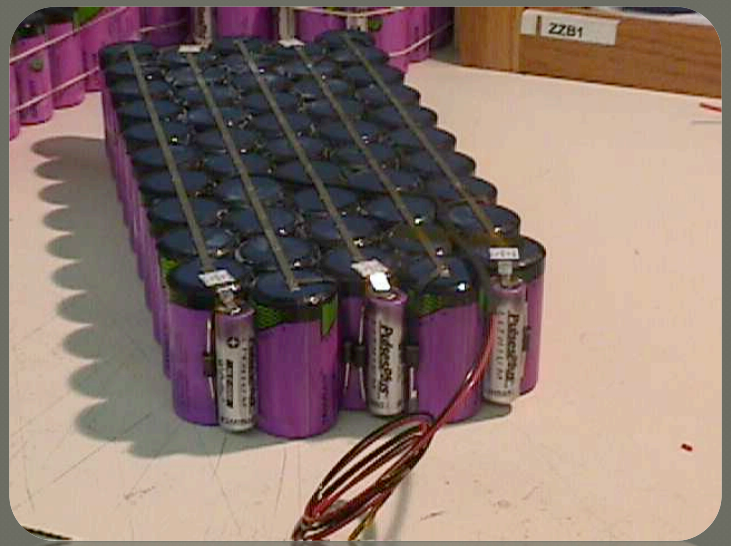
Power Management Box

- New power switching board, lower parasitic power
  - Switches between chargeable and primary batteries
- Charge controller, can use one charging source for two battery banks e.g. preferential charging
- LVD and HVR settable
- Cold culled to -50°C, 5 out of 30 fail because of charge controllers



Batteries

- Lithium Thionyl Chloride primary battery pack for winter operations
  - 190 A-h/unit between 18.5-15.5V
  - 10 unit pack
    - 30,000 W-h at room temperature
    - 23,000 W-h at -30°C
    - 16,500 W-h at -55°C
- AGM secondary, solar charged
  - 2x100 A-h

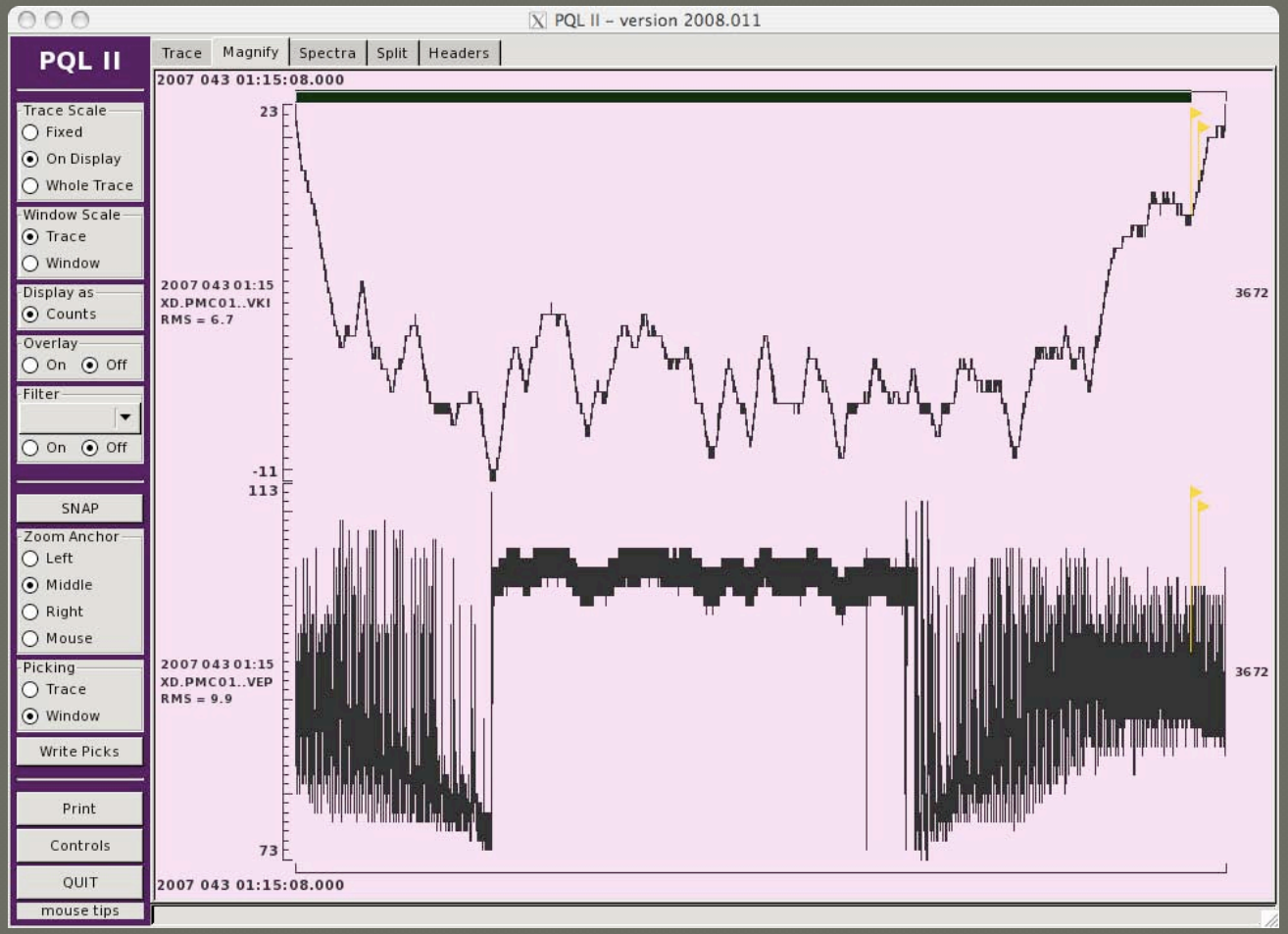


190 A-h unit prior to shrink wrap

Power Switching at PMC01

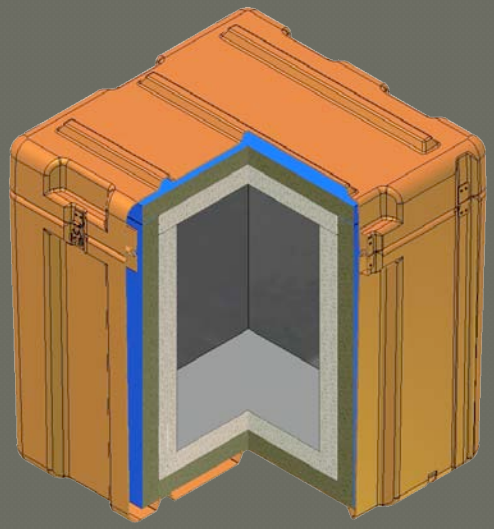
DAS Temperature

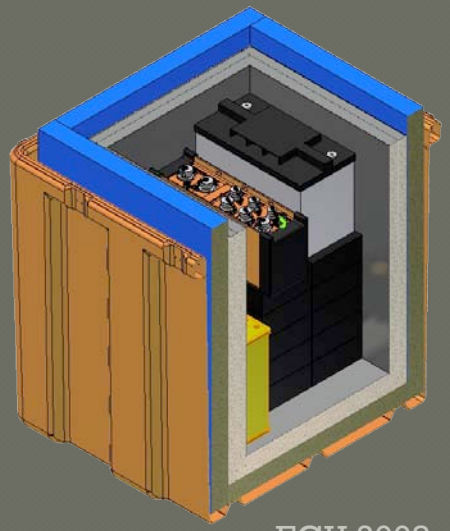
System Voltage

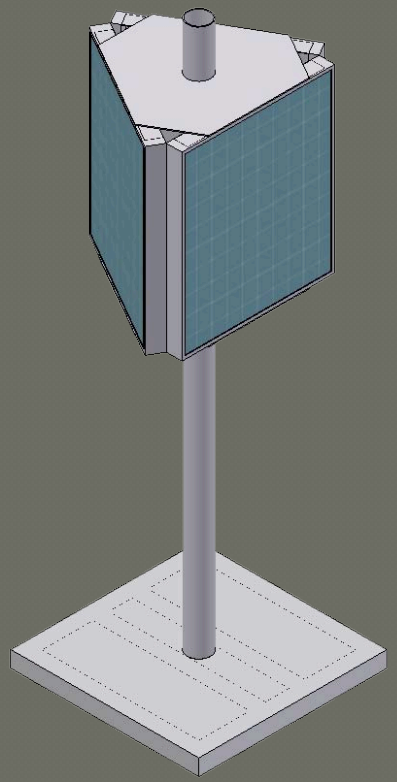


New Development

- New station box design
  - Better insulated
    - Double vacuum panel
    - Insulated cable harness
  - More durable
    - Hard liner
  - More easily fabricated
  - Smaller and lighter
    - 76cm x 76cm x 84cm
- New solar mount
  - Low wind, high-latitude environment
  - Single pole
  - 32kg
  - 3x30W panels







New Development

- New cold-rated solar charge controller development
- Iridium phase two
  - Request event data
  - Realtime low sample rate data (<10Hz)
- Parallel iridium development with Quanterra
- Alternate battery technologies
  - Lithium Ion

More Information & Design Docs