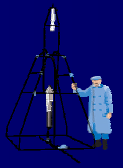

Sub-system and System Level Testing and Calibration of Space Altimeters and LIDARS.

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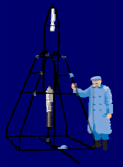
Overview

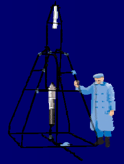


- Space LIDARs and Altimeters
- Testing Challenges
- Sub-system testing and qualification
- System testing and calibration
  - Radiometry
  - Time of Flight
  - Boresight Alignment

LIDARs in Space

- Laser Altimeters have been in space since since early 1970’s (Apollo program).
- Successful altimetry and atmospheric missions have mapped Mars and other planetary bodies and atmospheres.
- Primarily based on high peak power pulsed lasers (mostly YAG) and sensitive Si-based detectors.
- Future missions will almost certainly involve more complicated systems (transmitters, receivers, scanners, fiber lasers, etc.).

Testing Challenges



- Test Environments
- Test Configurations & Safety
- LIDAR Simulations (Atmospheric and Ground Echo Returns)
  - Radiometric Calibration.
    - Requires *absolute* knowledge of spectral radiances
  - Time of Flight Measurements (for Altimeters).
    - Requires *stable, coordinated* time bases
  - Boresight alignment.
    - Requires *stable, repeatable* alignment ground system.

Challenging Test Environments

Photo Courtesy of BATC

Clean Rooms

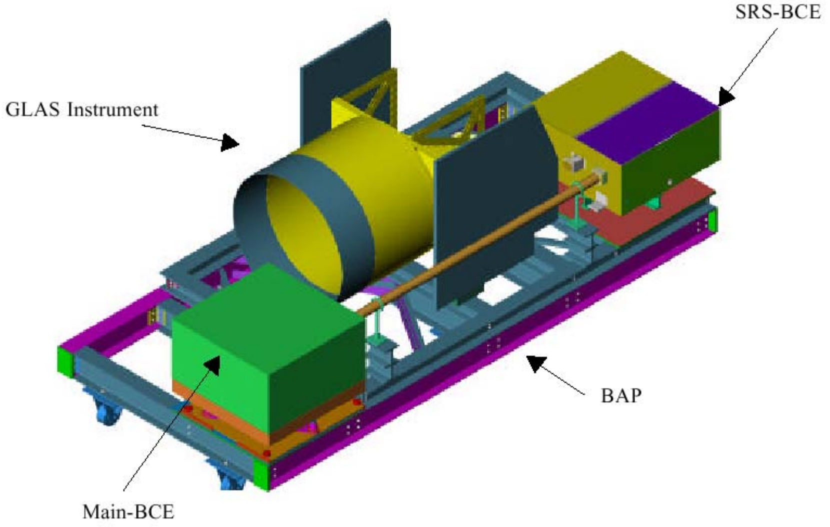
TVac Chambers

Photo Courtesy of Spaceflightnow

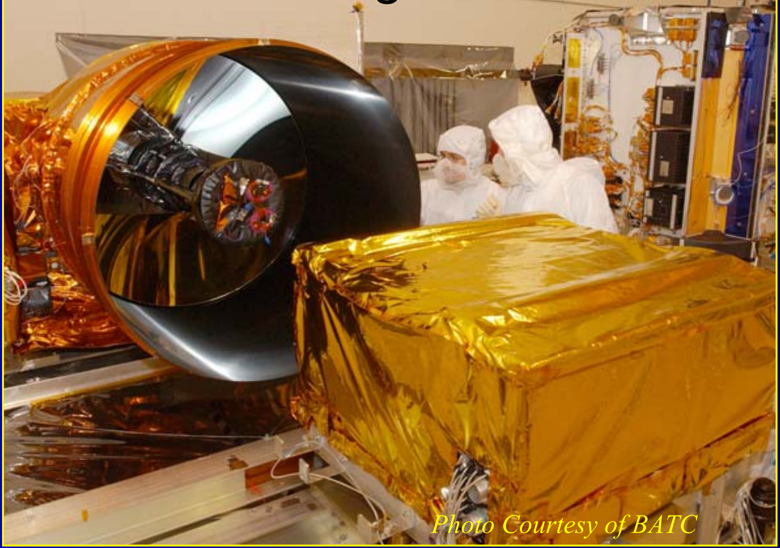
Launch Sites

Test Configurations

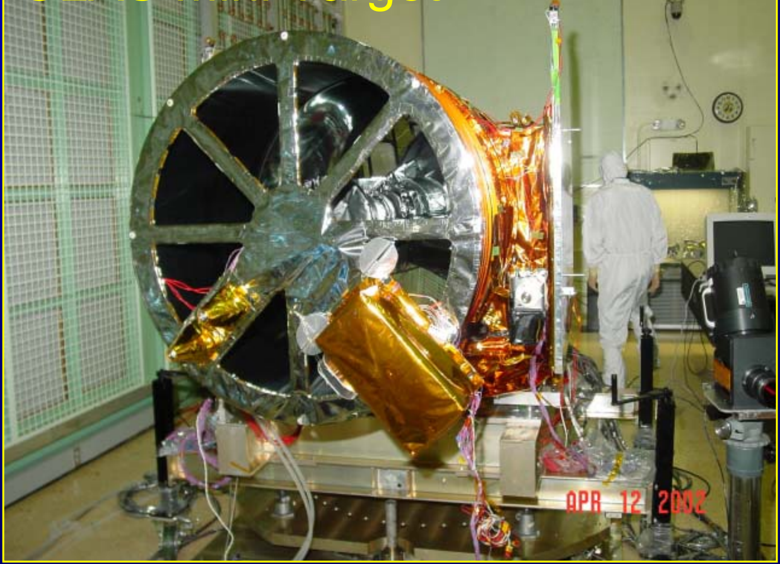
GLAS TVAC Test Configuration



GLAS Main Target



GLAS Mini Target



Test configurations will change.

Need for cross calibration between test setups.

Independent verification of test equipment.

Laser safety is an issue.

Sub System Testing

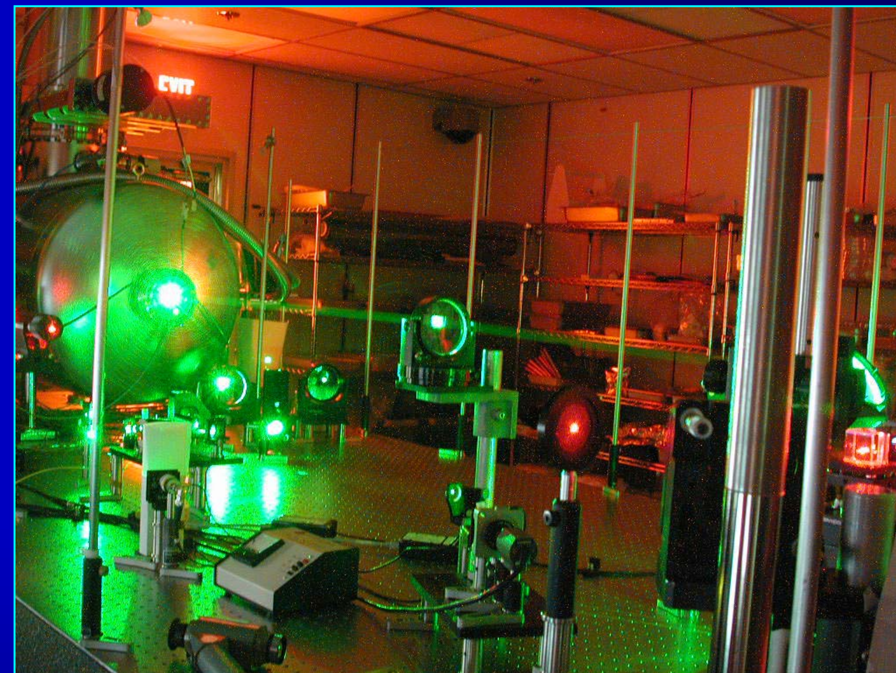
Sub system testing must verify all functional requirements of the subsystem.

Long term testing is a must

"Test as you fly" is desirable but is not always possible (some conditions, e.g. 0 g, can not be simulated).

Data connectivity (data rate, formats, etc) should with conform with system testing.

Calibrations necessary before system integration: Alignment, radiometry (receiver sensitivity), timing.



ICESat Description

Surface Altimetry:

- Range to ice, land, water, clouds
- Time of flight of 1064 nm laser pulse
- Laser beam attitude from star-trackers, laser camera & gyro

Atmospheric Lidar:

- Laser back-scatter profiles from clouds & aerosols at 1064 nm & 532 nm
- 75 m vertical resolution

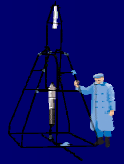
Laser Transmitter

- < 6 ns pulsewidth
- 40 Hz rep rate
- 75 mJ at 1064 nm & 35 mJ at 532 nm

Receiver

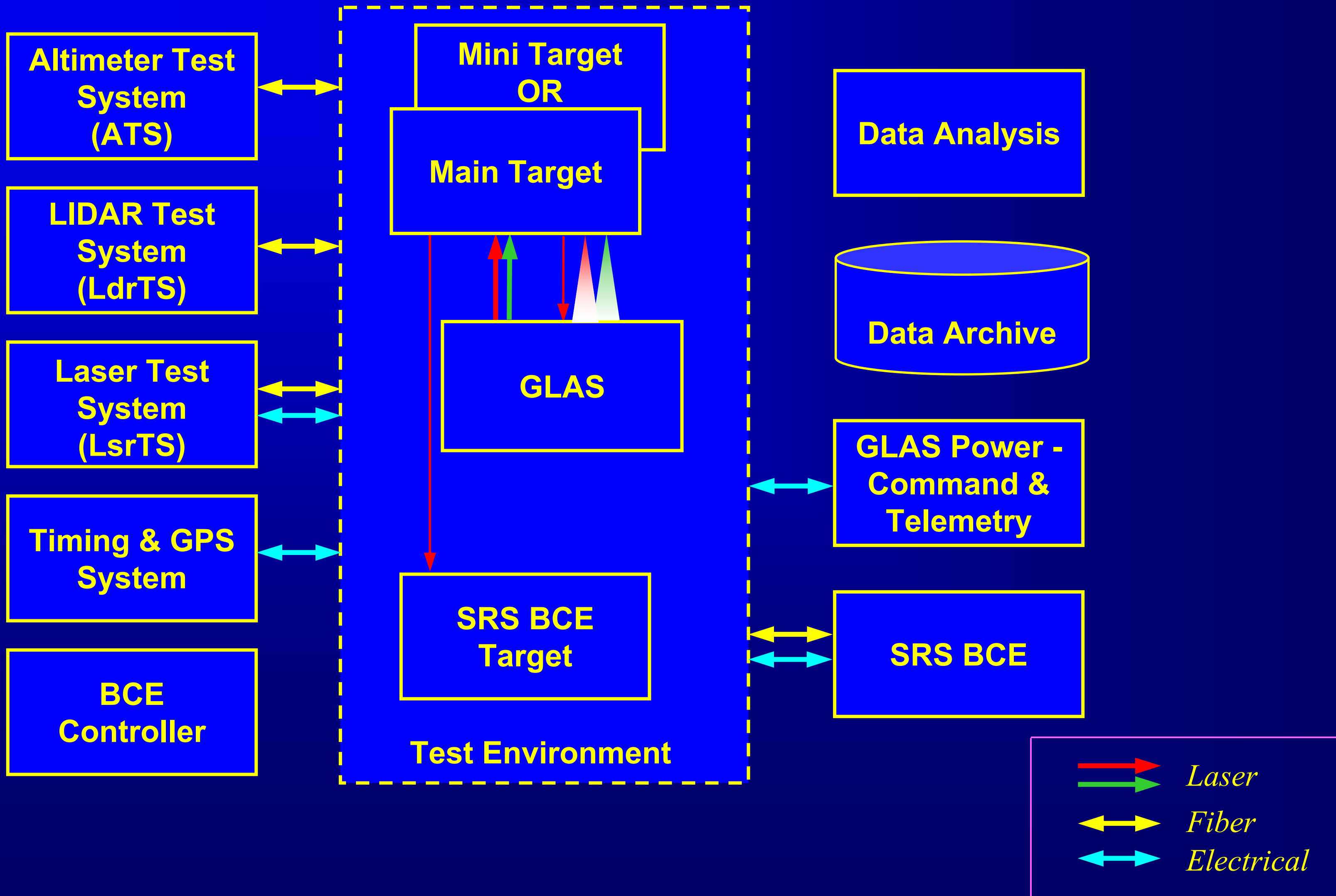
- 1 m Beryllium telescope (475 μrad FOV)
- APD with AGC at 1064 nm
- Photon Counters (SPCMS) at 532 nm

ICESat Test Systems



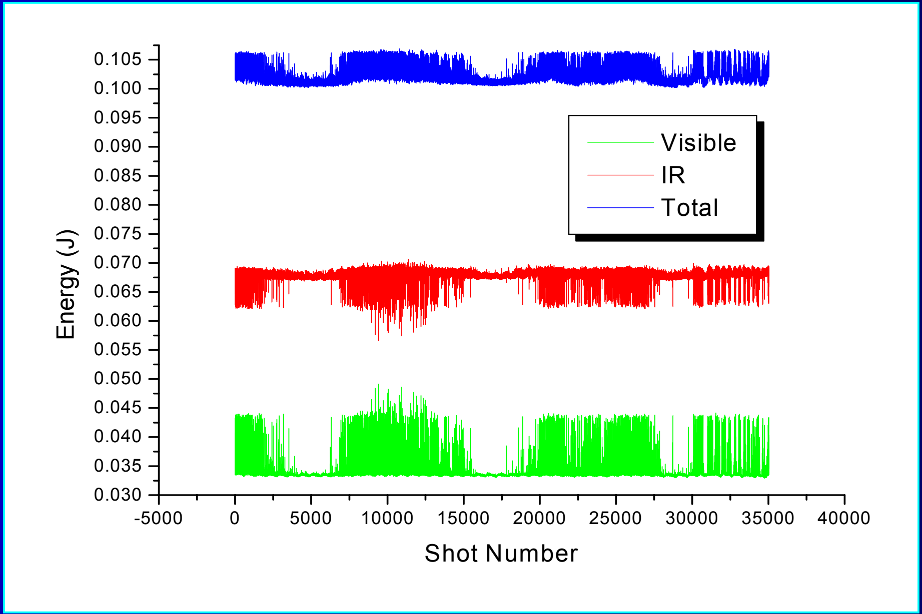
- Simulate and monitor ground echo, clouds and background signals at 1064 & 532 nm - all independently adjustable over several orders of magnitude in amplitude and width.
- Measure Time of Flight at 40 Hz, 24/7 using GLAS Start Pulse and BCE ground echo pulse.
- Simulate orbits and provide a ground echo based on a Digital Elevation Model (DEM).
- Monitor Laser parameters:
  - GLAS laser energy (1064 and 532 nm @ 40 Hz)
  - GLAS laser pressure
  - GLAS laser rep rate and shot count
  - GLAS laser wavelength at 532 nm
- Field of View sweep (Boresight alignment) - 1064 nm ONLY
- Monitors GLAS oscillator referenced to GPS.
- Synchronize and verify event timing for all subsystems based on GPS.
- Transfers GPS time to GLAS and BCE for data alignment.

System Testing – ICESat example

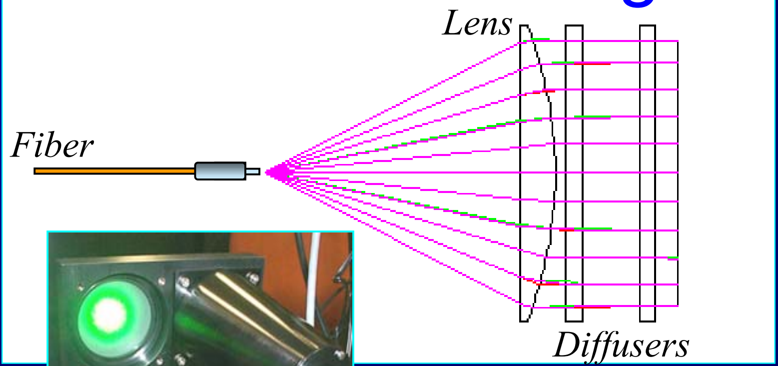


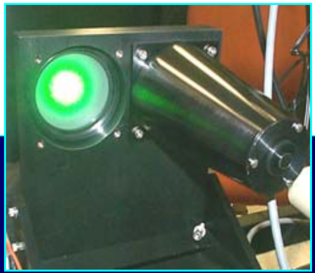
Radiometry and Laser Diagnostics

- Laser Diagnostics
  - Divergence and Absolute Laser Energy difficult to measure especially in TVAC.
  - Calibrate detectors!
- Receiver Radiometry very difficult to verify especially in TVAC
  - Showerhead used for radiometry (provides alignment insensitivity but hard to calibrate and monitor).



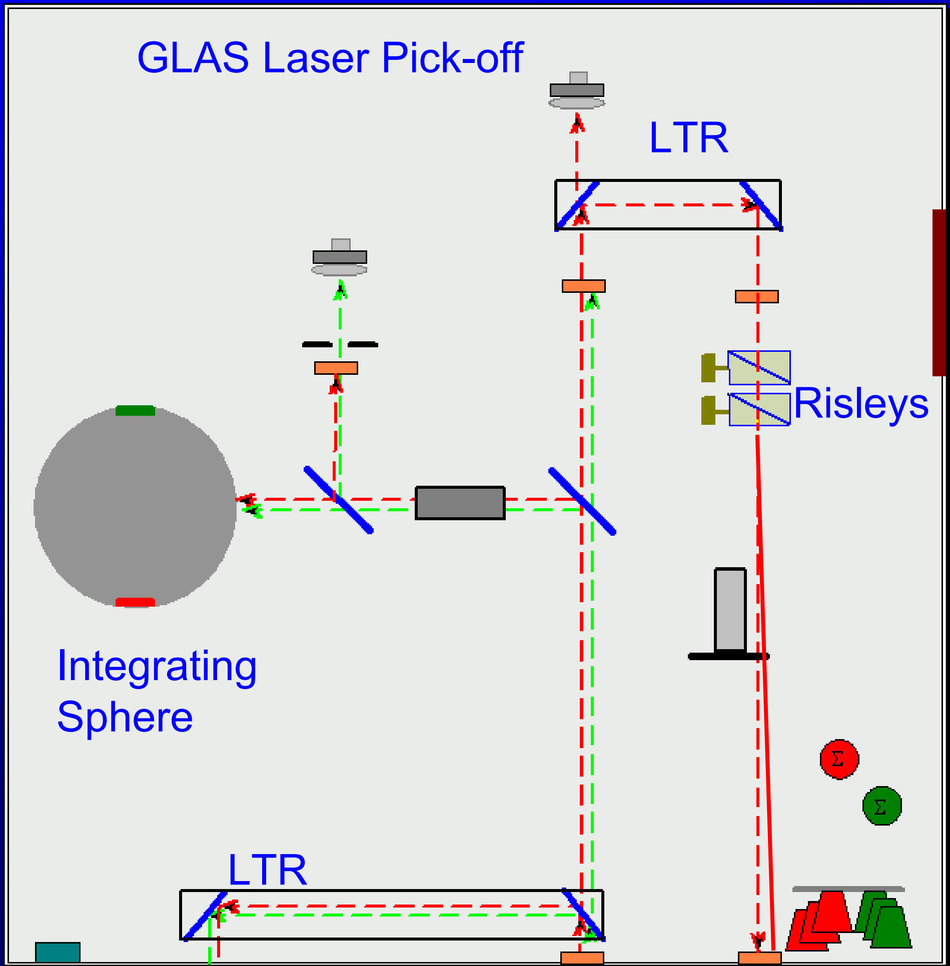
Showerhead Design



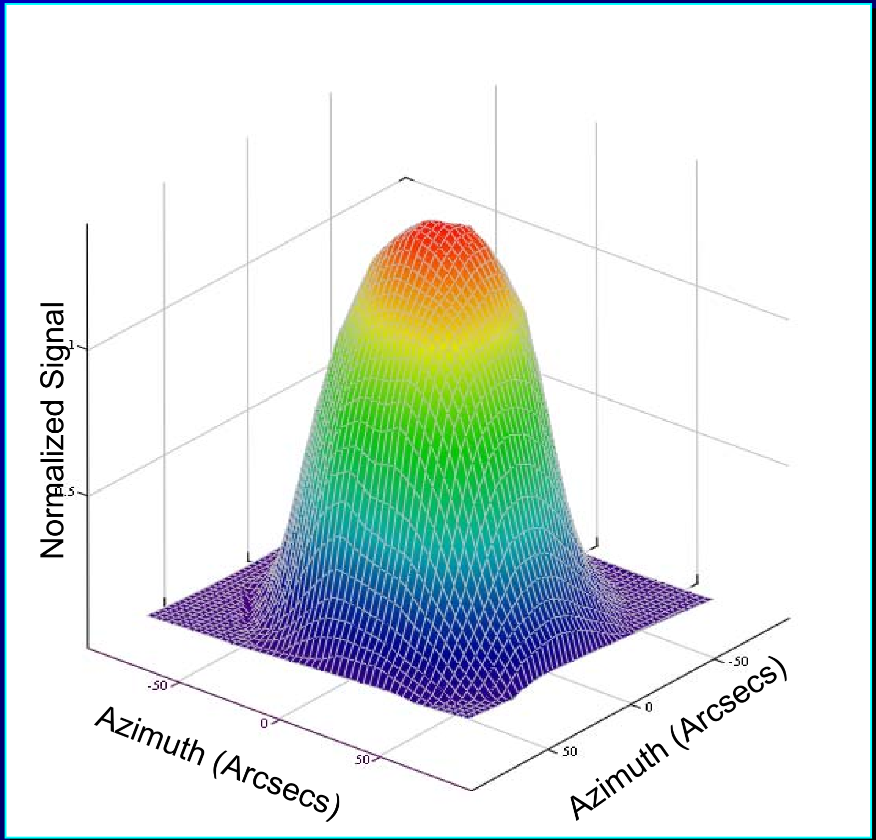


Boresight Alignment Check

- Field of view sweep using
  - Lateral Retroreflector (LTR)
  - Motorized Risley prisms

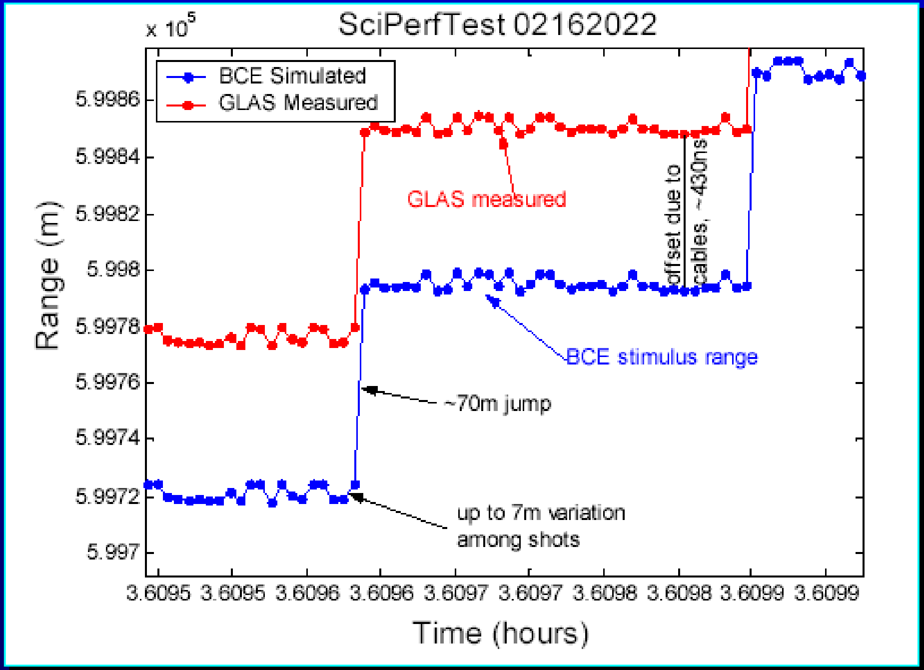


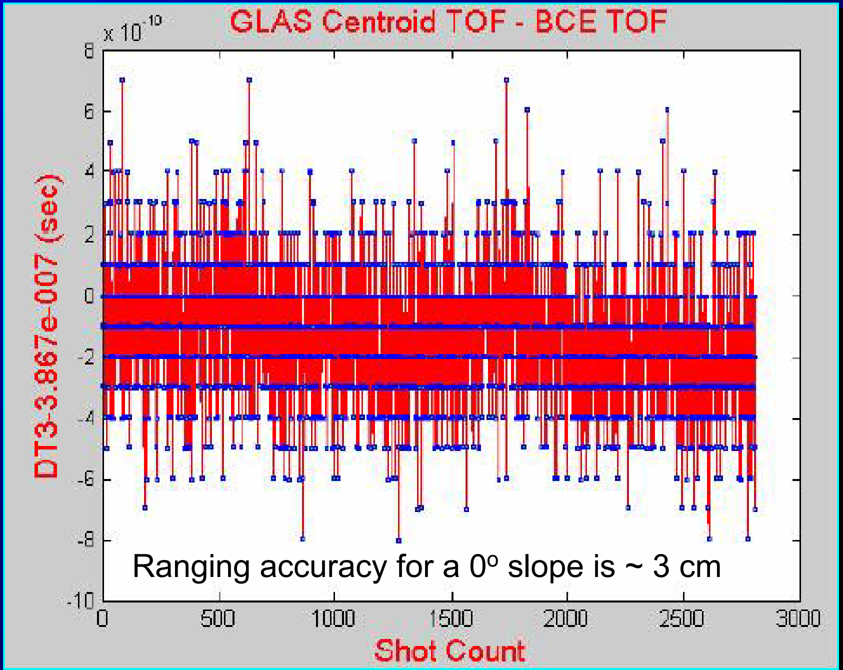
- Calibration of Risleys
- Time of scan
- Temperature issues in TVAC
- Repeatability



Time of Flight (TOF) Measurement

- Uses Time Interval Unit and High Speed Digitizers
- Accurate to 2.6 cm (= 85 ps)
- Uses Rb time base (referenced to GPS)
- Low drift - less than 15 cm (500 ps)/day
- TOF measurement @ 40 Hz 24/7 during testing
- Tested independently with a waveform generator and Time Interval Unit





ICESat Launch and On-orbit Data