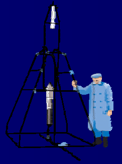

# Sub-system and System Level Testing and Calibration of Space Altimeters and LIDARS.

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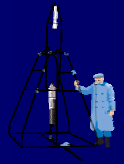
# Overview

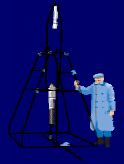
- Space LIDARs and Altimeters
- Testing Challenges
- Sub-system testing and qualification
- System testing and calibration
  - Radiometry
  - Time of Flight
  - Boresight Alignment

# 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

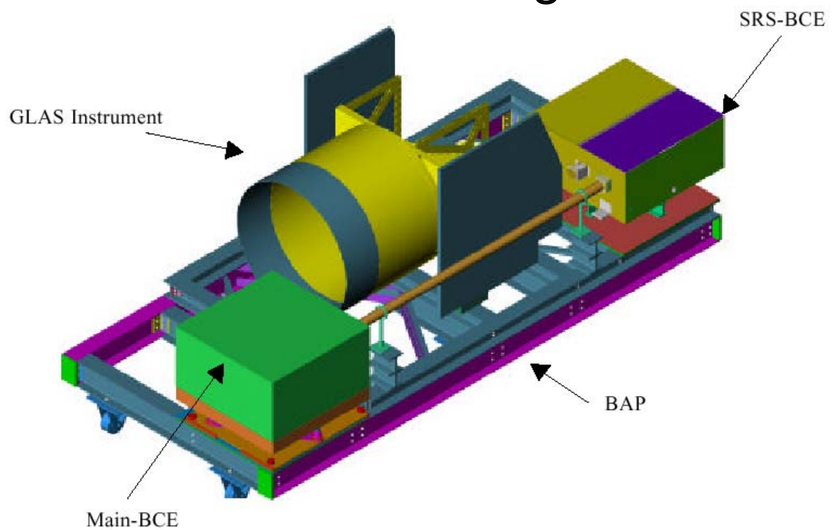
TVac Chambers

Photo Courtesy of Spaceflightnow

Launch Sites

# Test Configurations

GLAS TVAC Test Configuration






Test configurations will change.

Need for cross calibration between test setups.

Independent verification of test equipment.

Laser safety is an issue.

# Sub System Testing

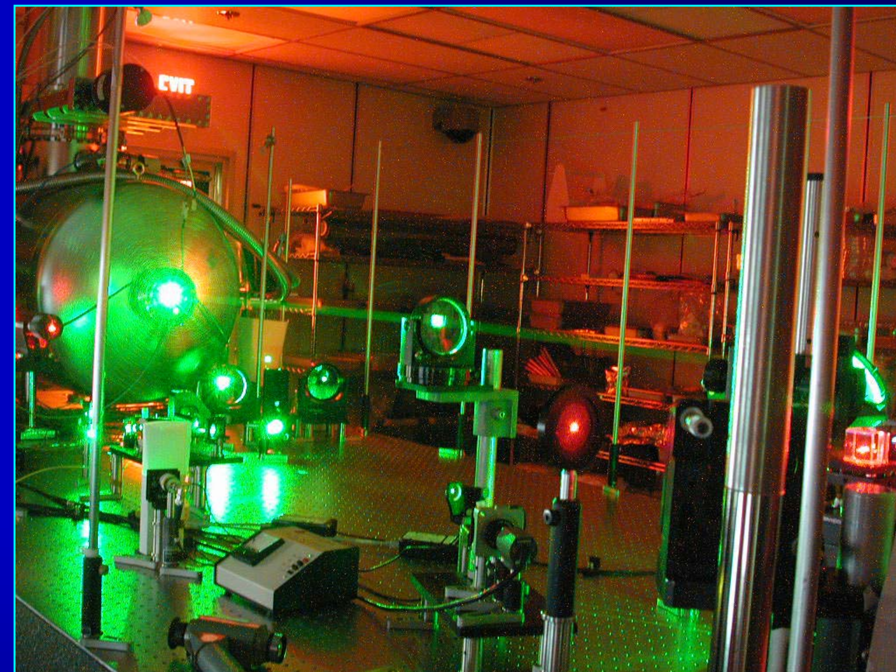
Sub system testing must verify all functional requirements of the subsystem.

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

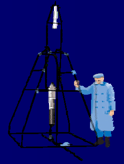
## Laser Transmitter

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

## Receiver

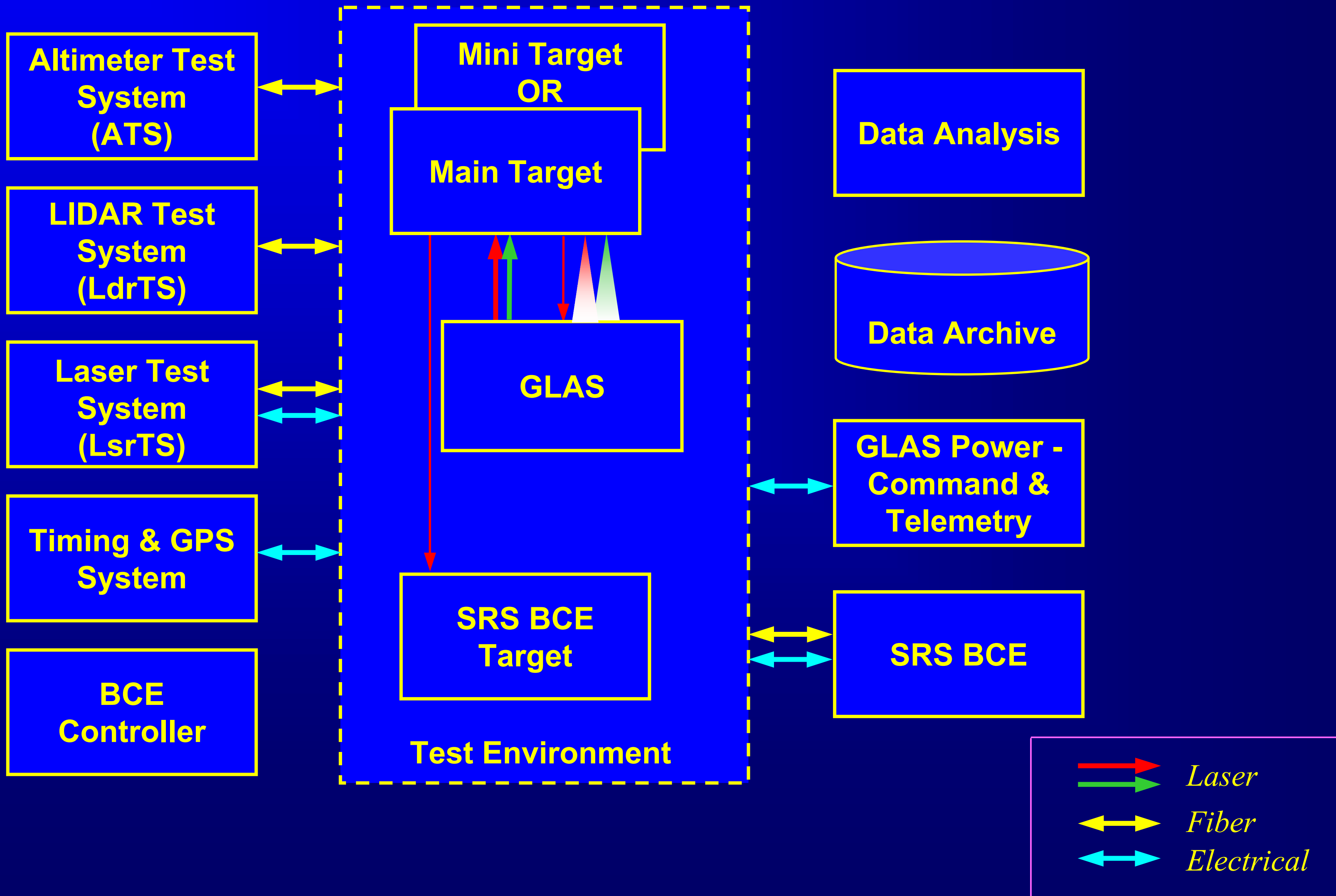
- 1 m Beryllium telescope (475 µrad FOV)
- APD with AGC at 1064 nm
- Photon Counters (SPCMS) at 532 nm

# ICESat Test Systems



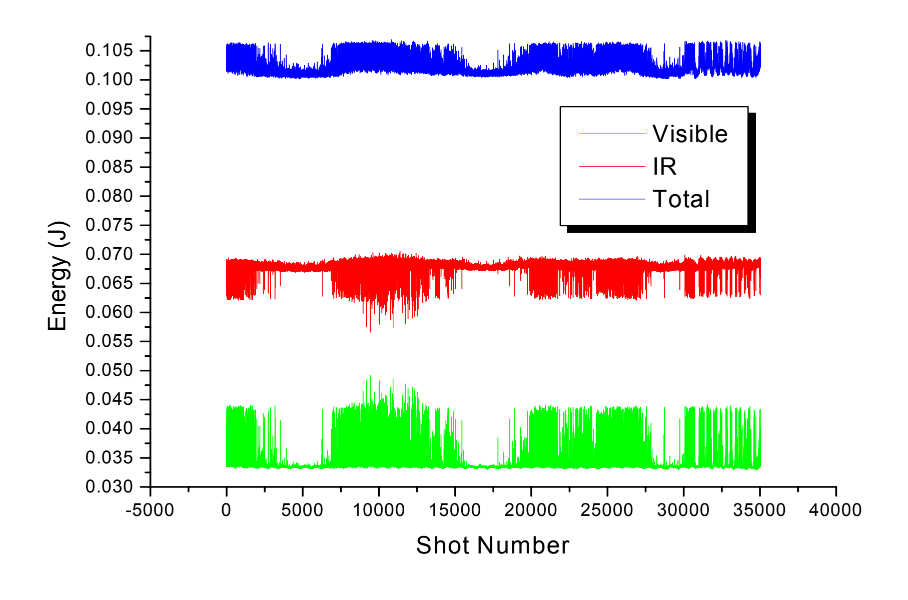
- Simulate and monitor ground echo, clouds and background signals at 1064 & 532 nm - all independently adjustable over several orders of magnitude in amplitude and width.
- Measure Time of Flight at 40 Hz, 24/7 using GLAS Start Pulse and BCE ground echo pulse.
- Simulate orbits and provide a ground echo 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

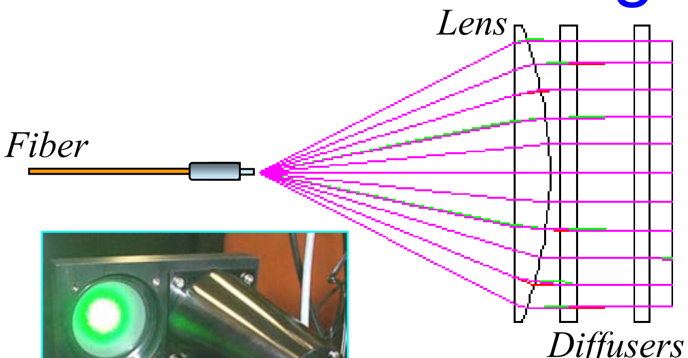


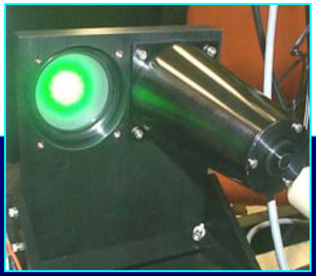
# Radiometry and Laser Diagnostics

- 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).



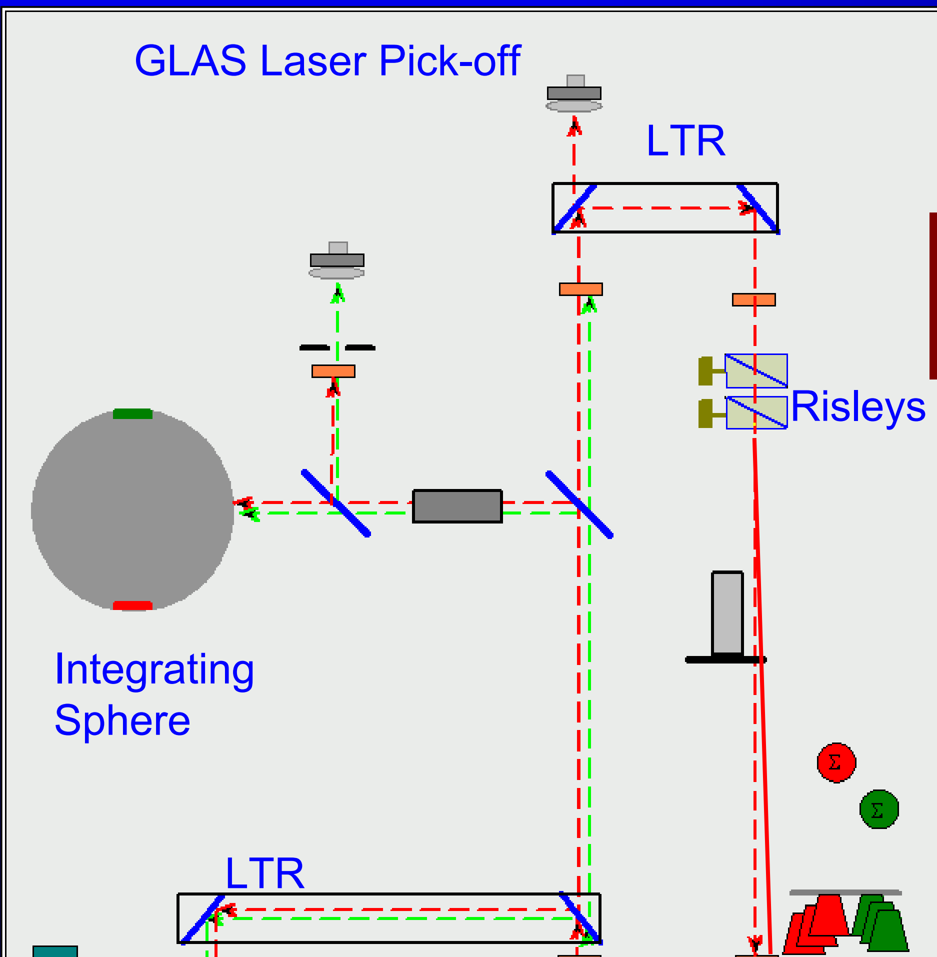

## Showerhead Design



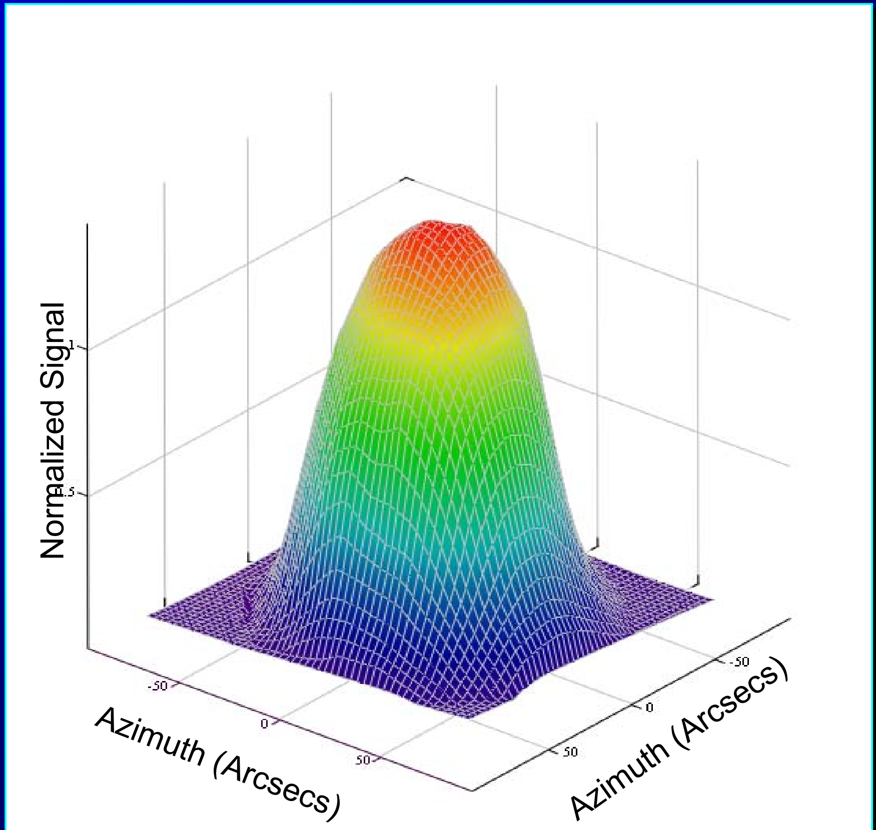



# Boresight Alignment Check

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

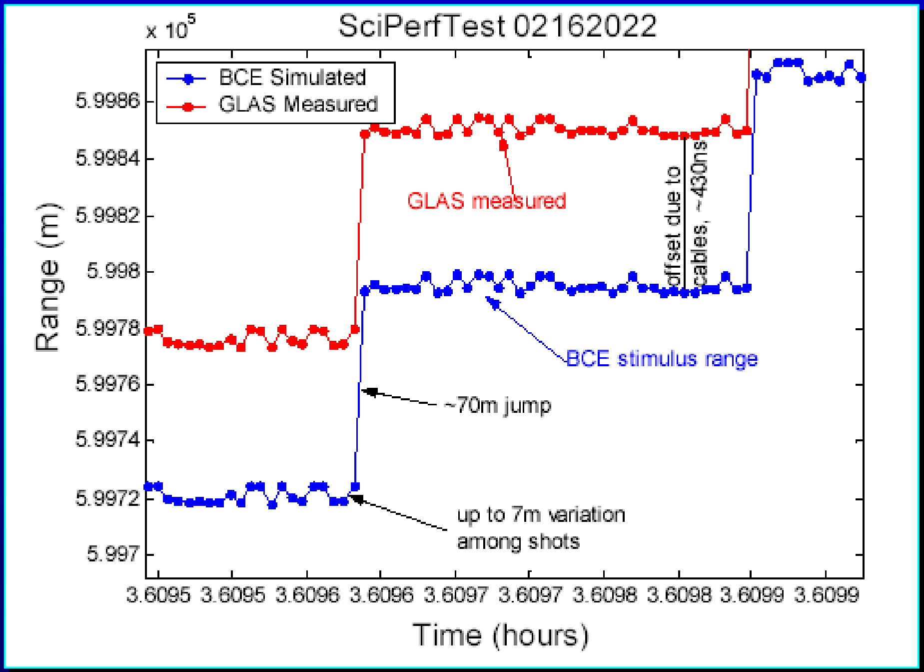


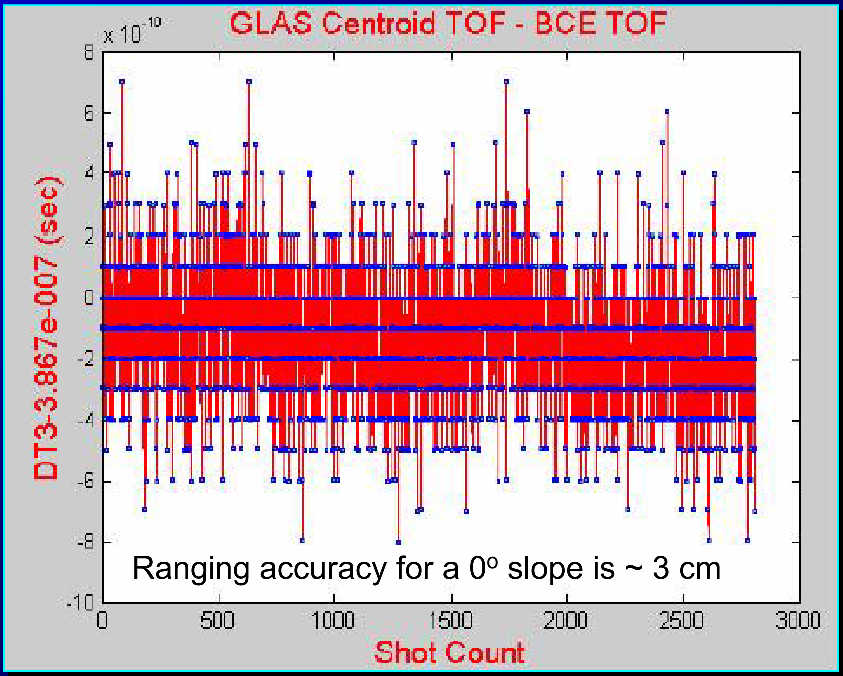

- **Calibration of Risleys**
- **Time of scan**
- **Temperature issues in TVAC**
- **Repeatability**



# 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