

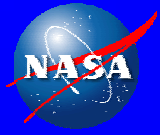
# Sub-system and System Level Testing and Calibration of Space Altimeters and LIDARS.

**Haris Riris, Pete Liiva, Xiaoli Sun, James  
Abshire**

*Laser Remote Sensing Branch*

*Goddard Space Flight Center,*

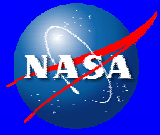
*Greenbelt, MD 20771*



# Overview



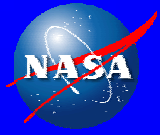
- Space LIDARs and Altimeters
- Testing Challenges
- Sub-system testing and qualification
- System testing and calibration
  - Radiometry
  - Time of Flight
  - Boresight Alignment



# 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**

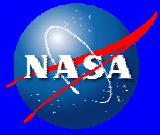


**TVac Chambers**



*Photo Courtesy of Spaceflightnow*

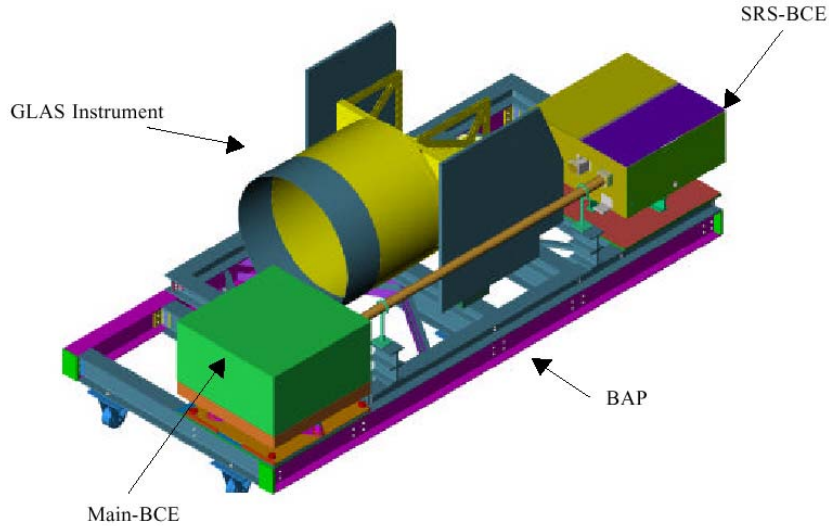
**Launch Sites**



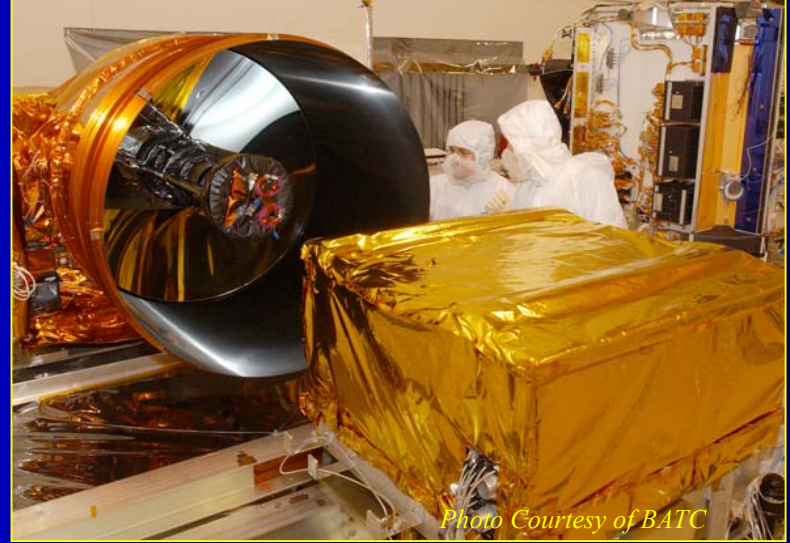
# Test Configurations



## GLAS TVAC Test Configuration



## GLAS Main Target



*Photo Courtesy of BATC*

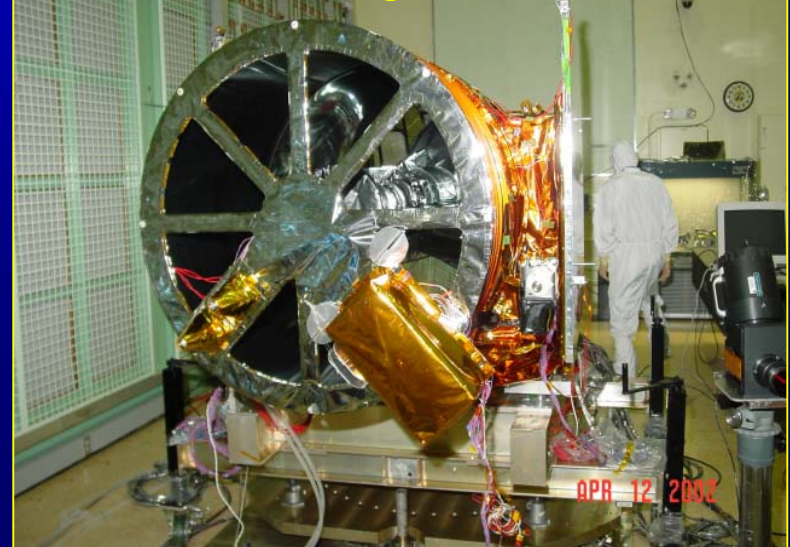
Test configurations will change.

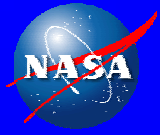
Need for cross calibration between test setups.

Independent verification of test equipment.

Laser safety is an issue.

## GLAS Mini Target





# Sub System Testing



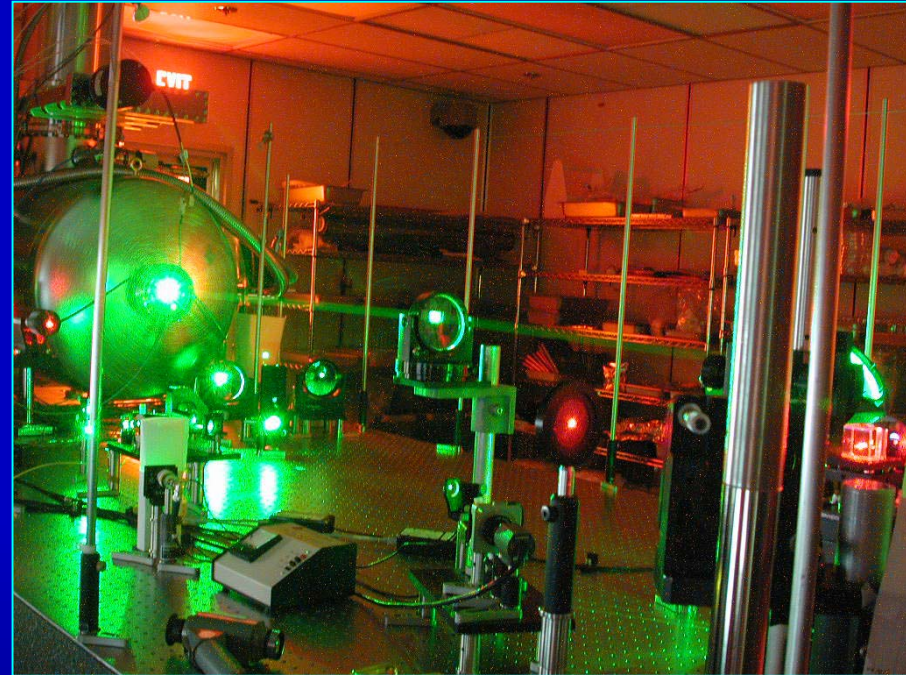
Sub system testing must verify all functional requirements of the subsystem.

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.



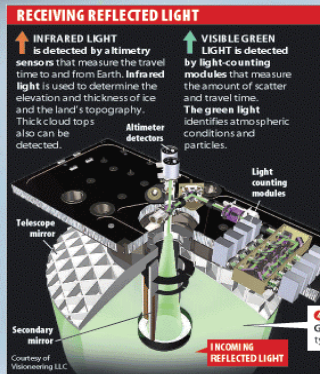
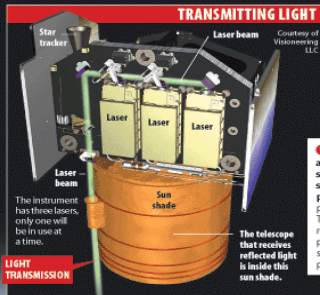
NASA's satellite ICESat is scheduled to launch Wednesday on a mission to study Earth's atmosphere and polar ice sheets. Scientists will use this new tool to answer questions on global warming and to record melting of polar ice.

# Laser light show

The heart of ICESat is an instrument that uses sophisticated lasers to measure features in the atmosphere and on Earth's surface.

## Laser measures air and land

The Geoscience Laser Altimeter System (GLAS) is the sole instrument aboard ICESat.



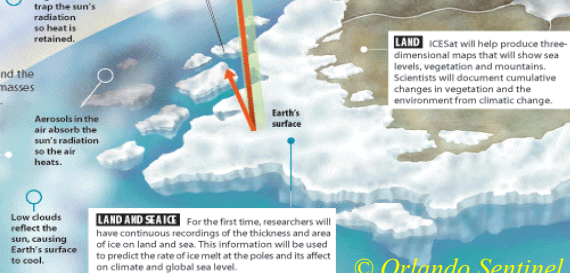
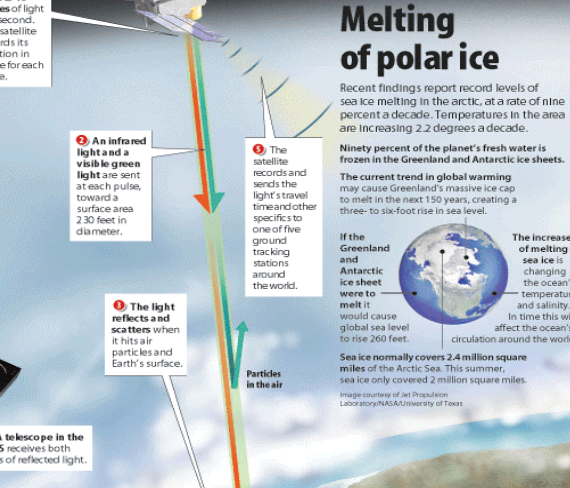
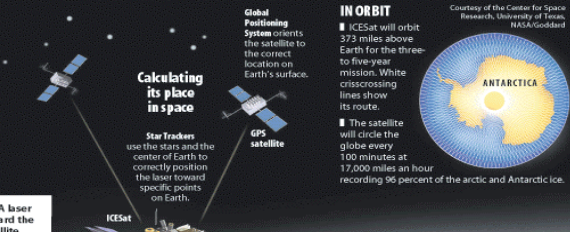
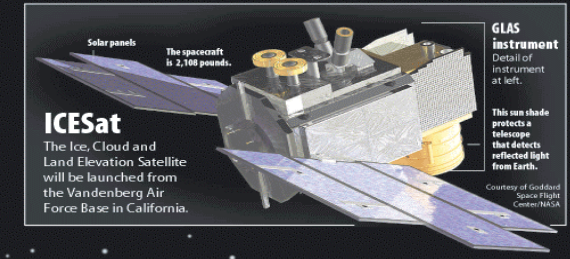
## ICESat contributions

This satellite will help scientists understand the relationship between changing polar ice masses, global warming and changing sea levels.

**ATMOSPHERE** ICESat will measure the height, thickness and vertical structure of clouds and analyze particles in the air. These factors show the warming and cooling of the air, which is key to accurate weather predictions.

**WATER** Researchers will compare changes in polar ice and coastlines to sea levels.

**For more information**  
Learn about the complex creation of snowflakes and see our special online section for holiday games and graphics. [sun.santinel.com/theedge](http://sun.santinel.com/theedge)



# 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

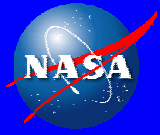




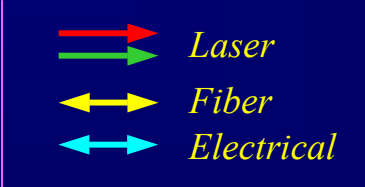
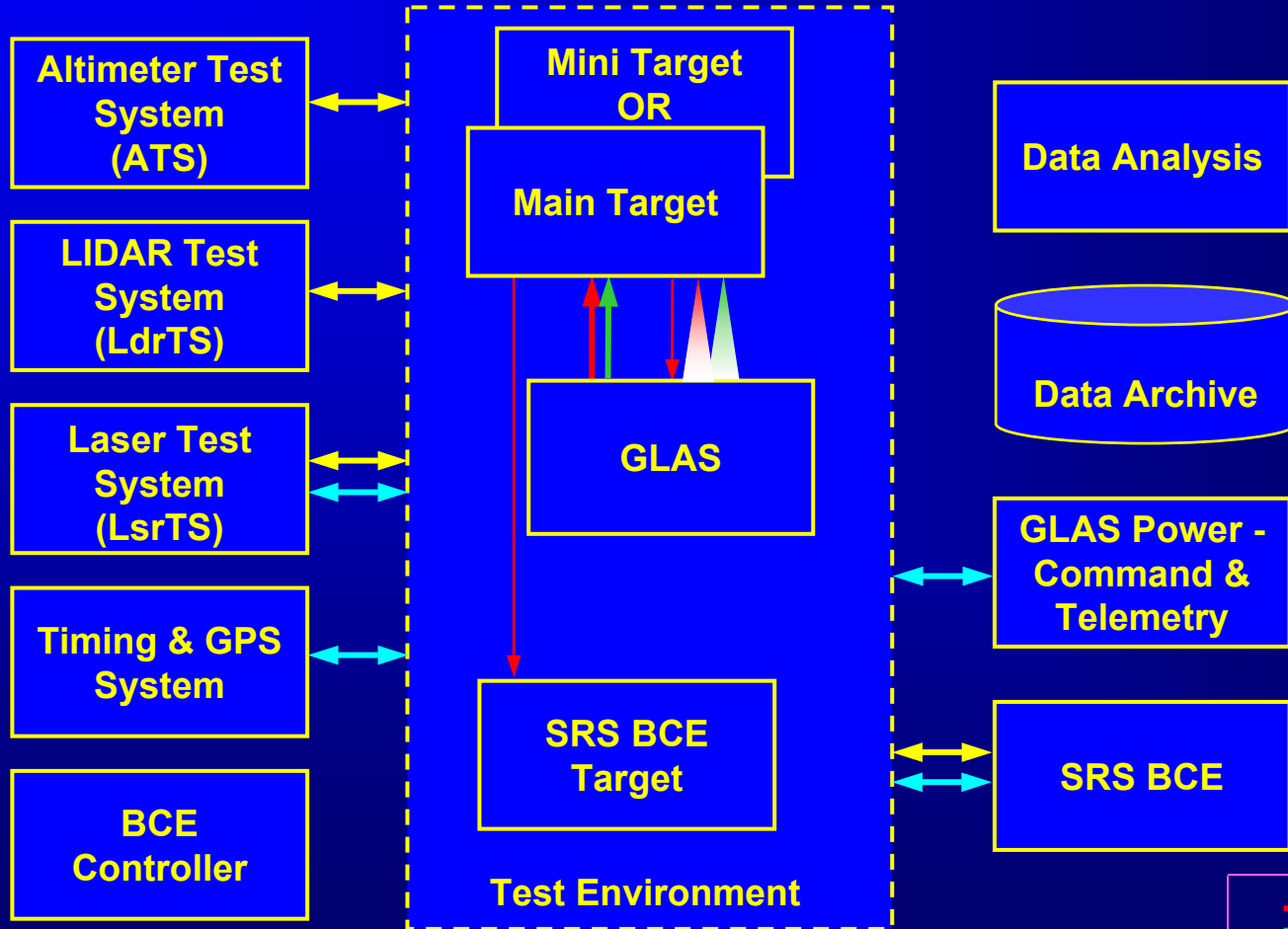
# ICESat Test Systems



- 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

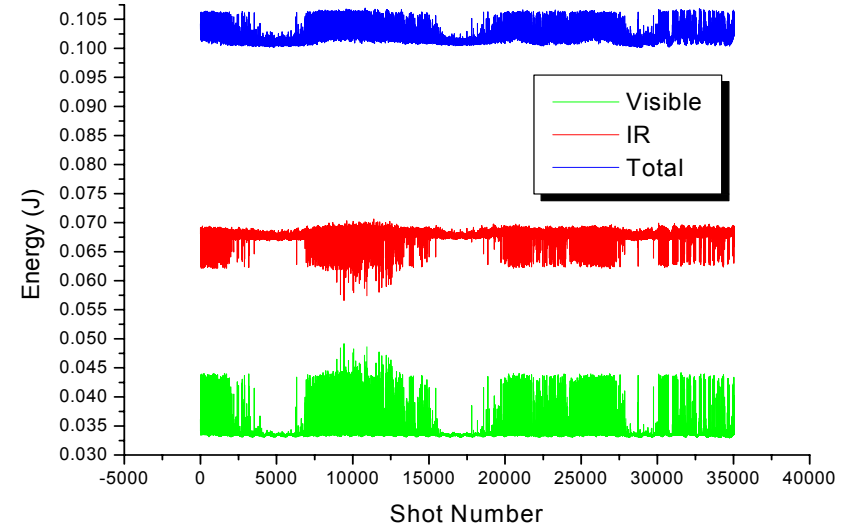


- **Laser Diagnostics**

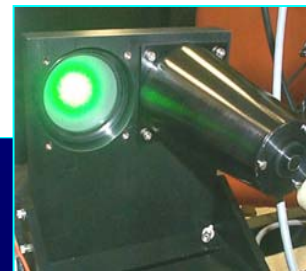
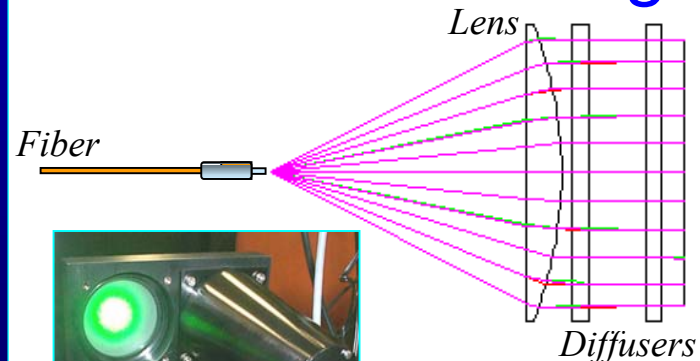
- Divergence and Absolute Laser Energy difficult to measure especially in TVAC.
- Calibrate detectors!

- **Receiver Radiometry very difficult to verify especially in TVAC**

- Showerhead used for radiometry (provides alignment insensitivity but hard to calibrate and monitor).



## Showerhead Design



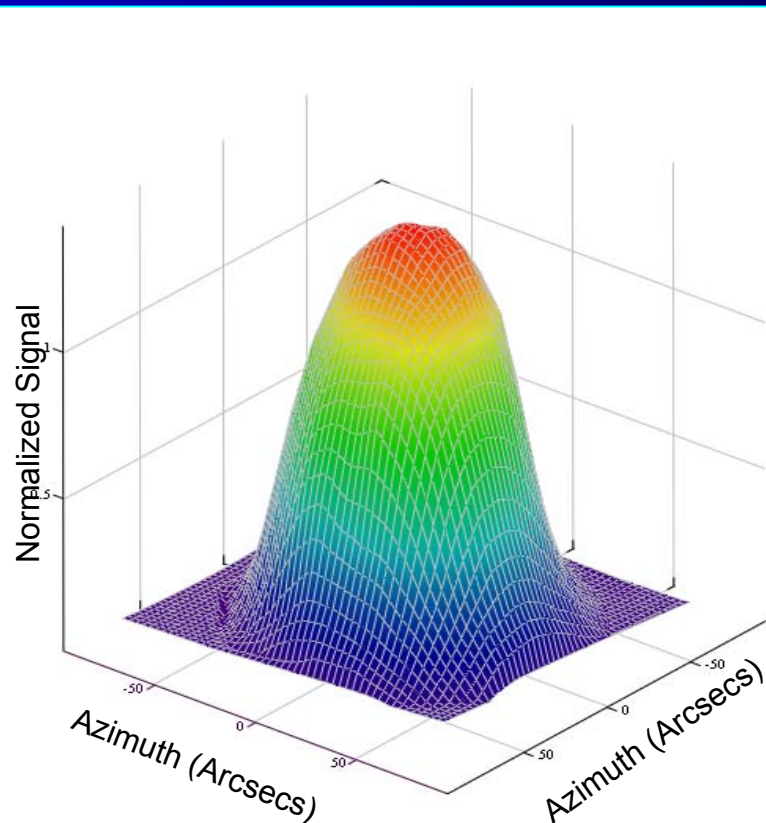
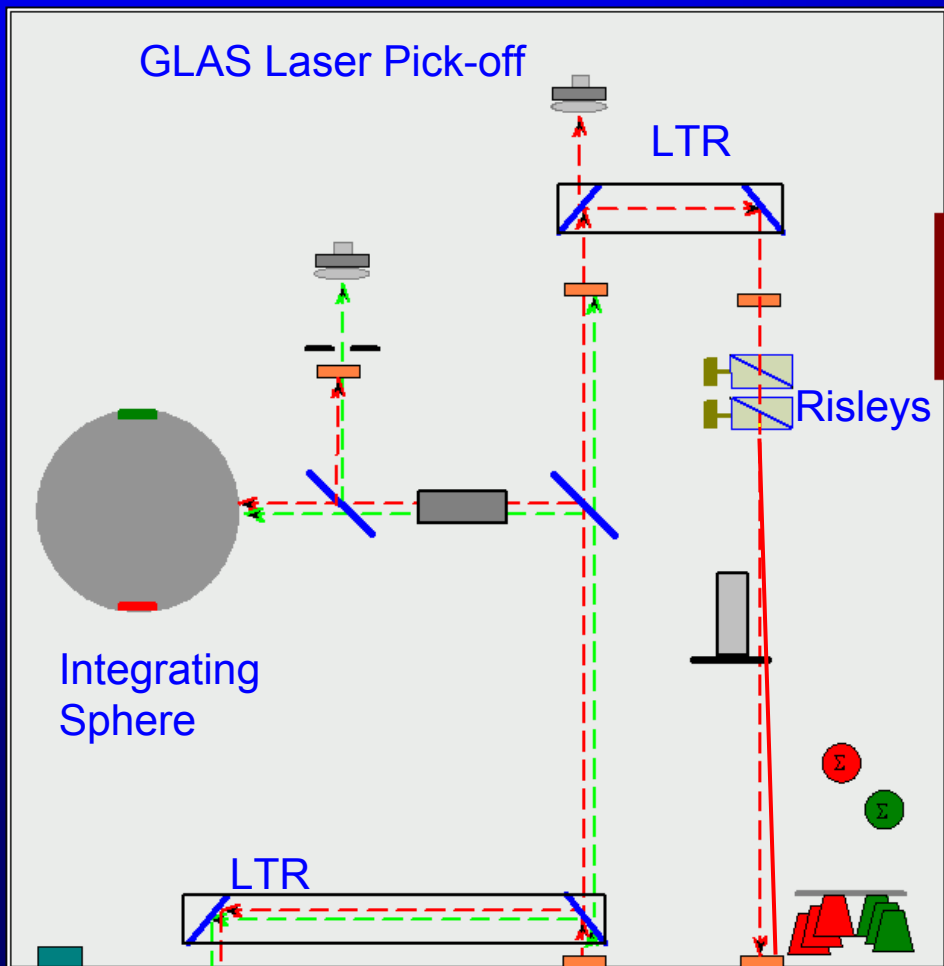


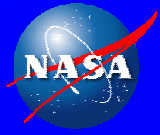
# Boresight Alignment Check



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

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

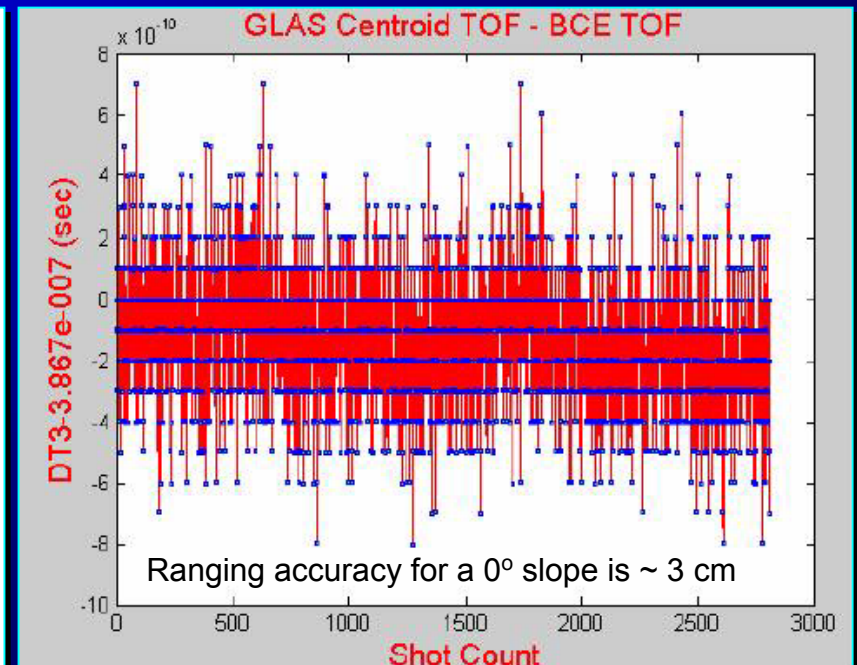
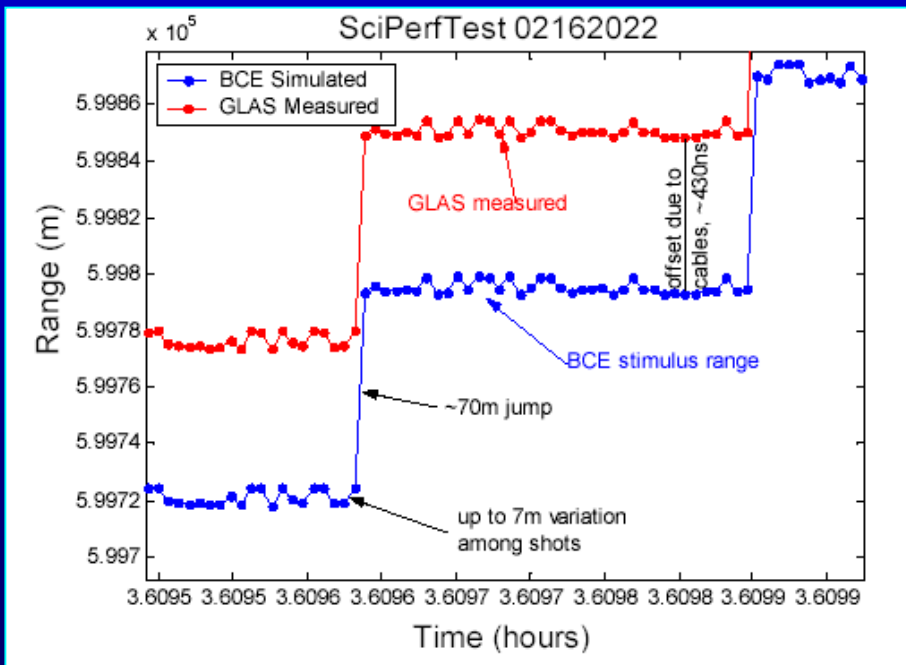




# Time of Flight (TOF) Measurement



- 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

