GLAS Instrument Status

GLAS Science Team Meeting

6/24/04

> 544 M shots !

GLAS Instrument Team

Contact:

James.Abshire@gsfc.nasa.gov

301-614-6081

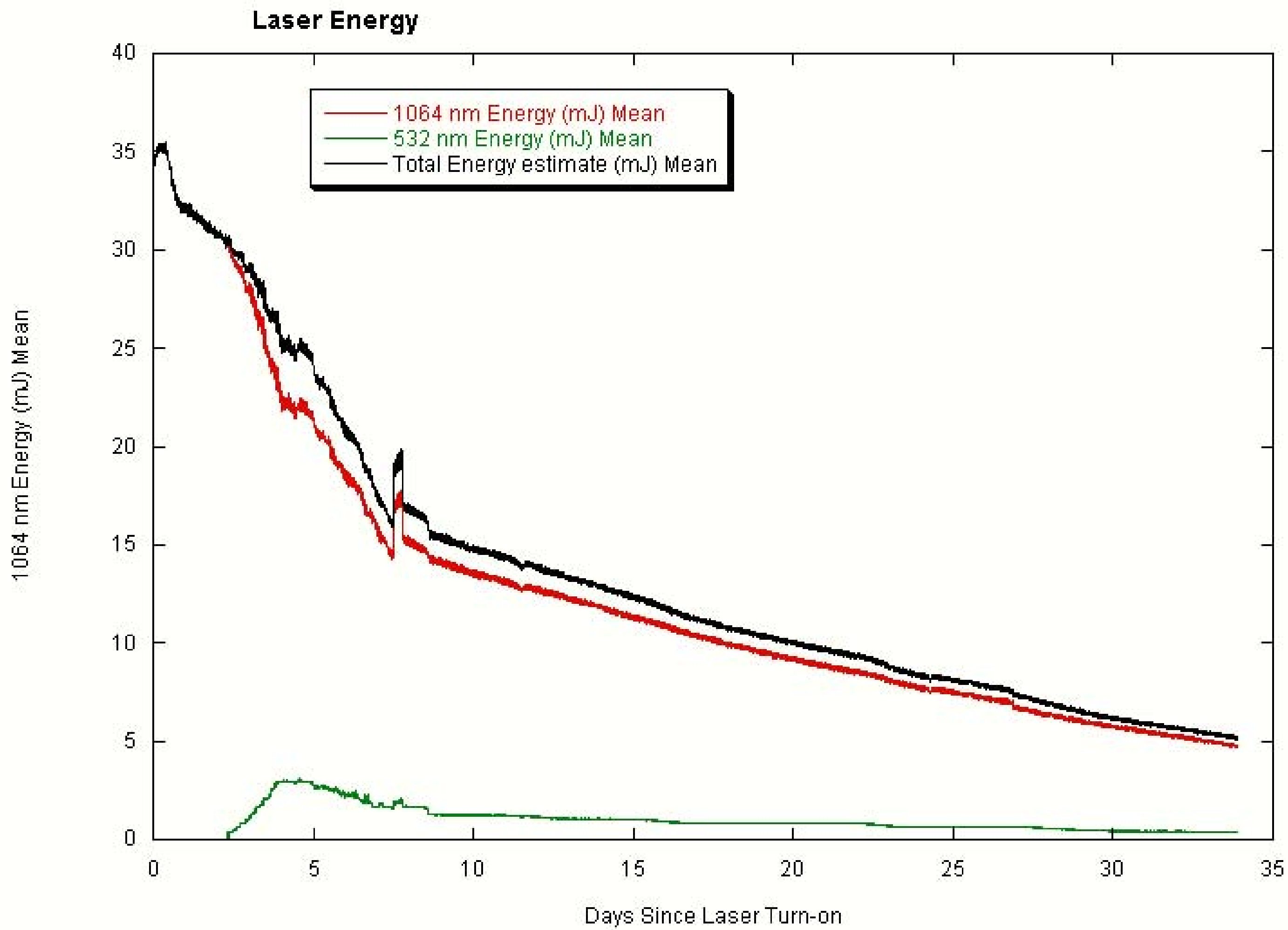
Outline

- Instrument update - Eleanor
- Glas Instrument Publications - Applied Optics special issue
- Laser Performance during Campaign 2C - Jim A.
    - Laser GARB2 work - a snapshot - Jim A.
    - ETU test plan overview - Haris Riris
- SRS measurement update - Marcos Sirota
- Altimetry echo pulse saturation correction algorithm - update - Xiaoli Sun
- Altimetry measurements during campaign 2C
    - Donghui's echo pulse energies & coverage over Antarctica -Jim A.
    - Later:
        - Ocean scans with reduced echo pulse energy- Scott Luthcke
        - Measurement coverage vs time - John DiMarzio

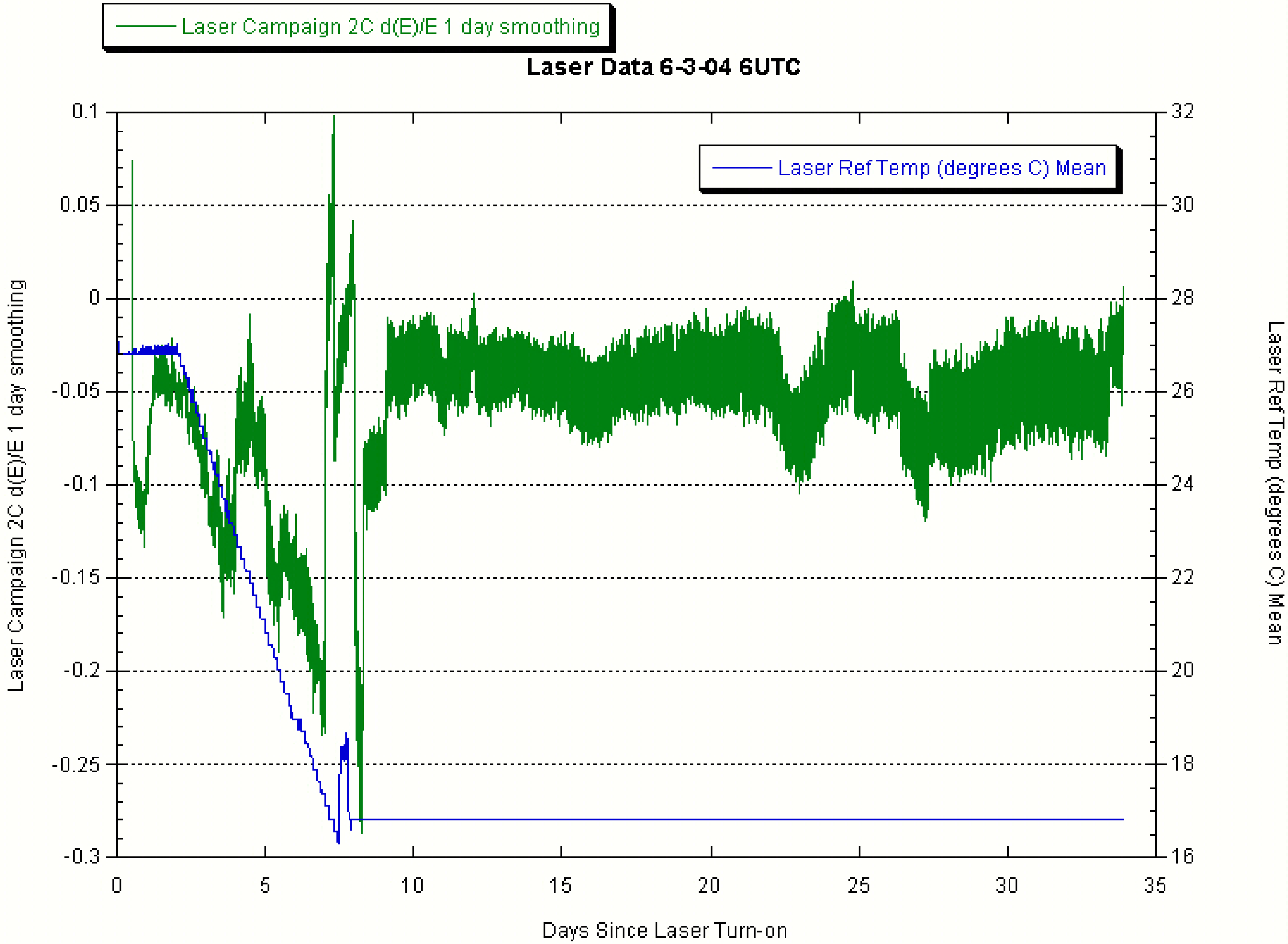
Campaign 2C – GLAS status
Eleanor Ketchum

- Quiet campaign for GLAS
- Component Loop Heat Pipes
  - Performed nominally at set point 6.5C, resulting in a telescope bench of 15C, as measured at the fiber delay line housing.
  - Safe maintenance is planned for off season
- Laser thermal environment
  - Took laser as cold as possible – reference temp of 16.8C, set point of 6.5C
  - At attempt to take laser colder, the survival heater came on
    - This cycling on the survival heater induced an approximate 1 deg slow variation at the laser (14.5C – 15.5C)
    - Laser thermal environment was soon re-stabilized at 16.8C for remainder of campaign.

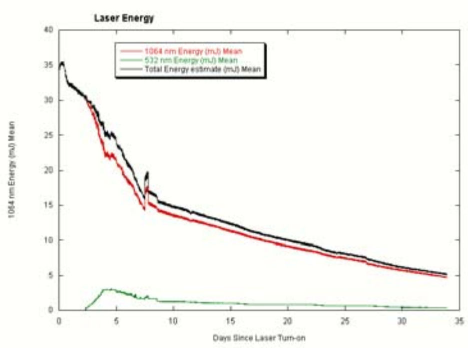
GLAS Laser 2C - Energy History

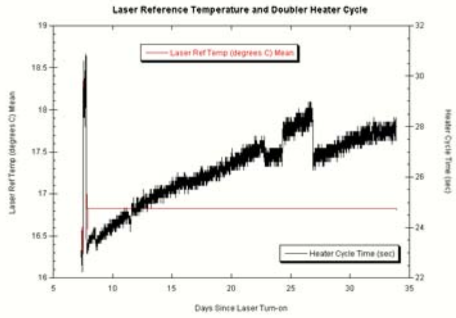


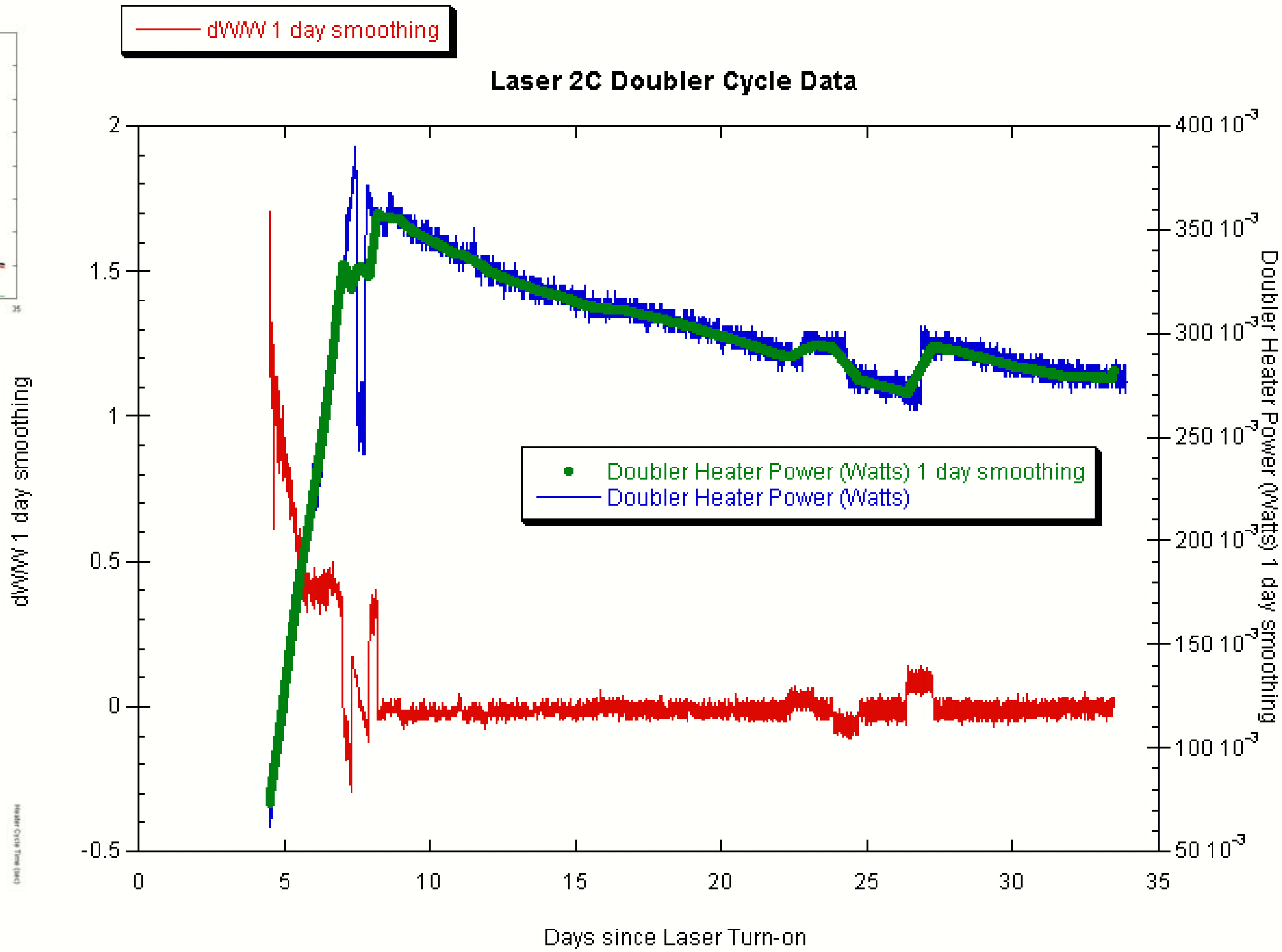
GLAS Laser 2C - relative energy decline rate & temp histories



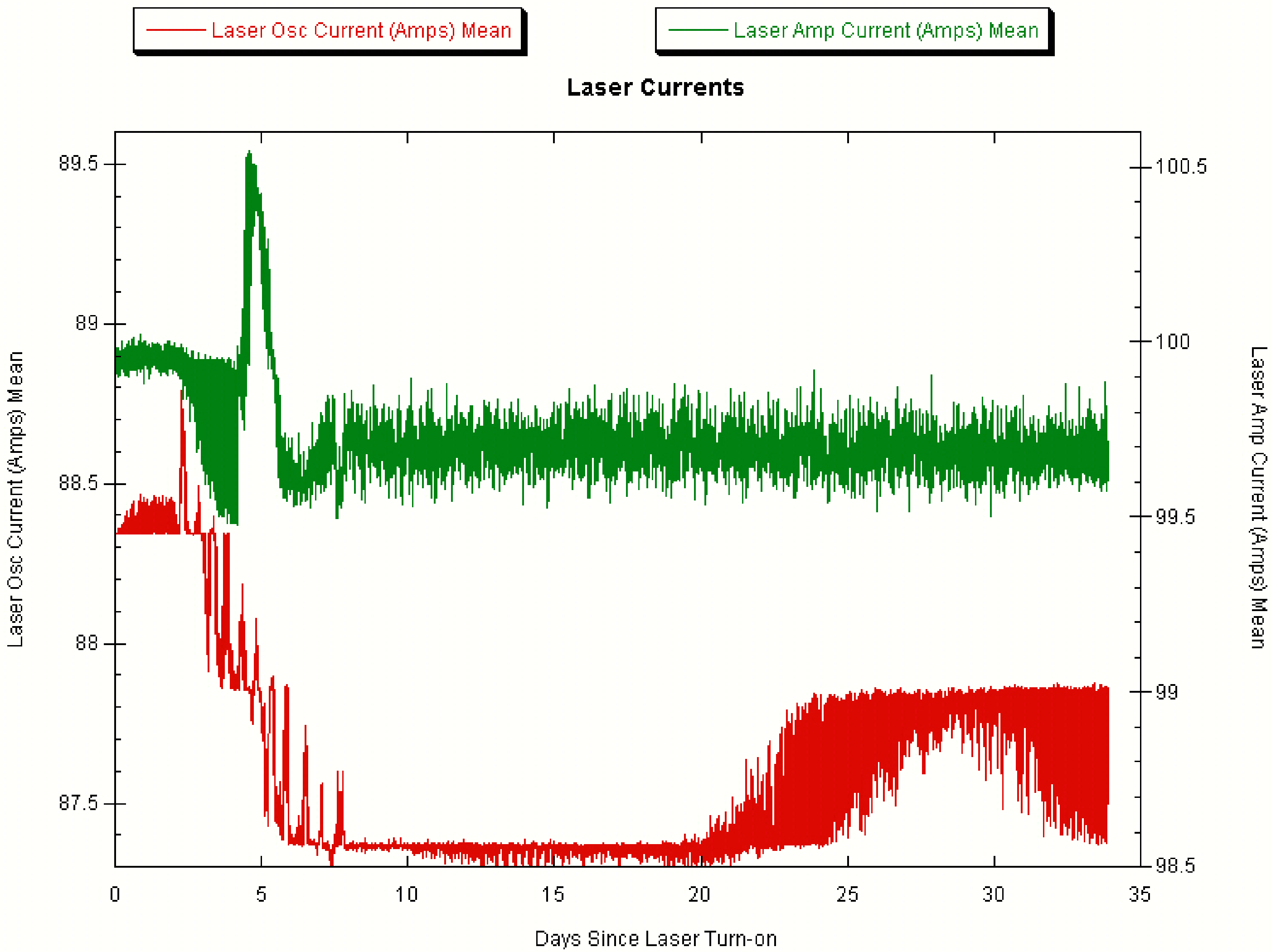
GLAS Laser 2C - Doubler heater history



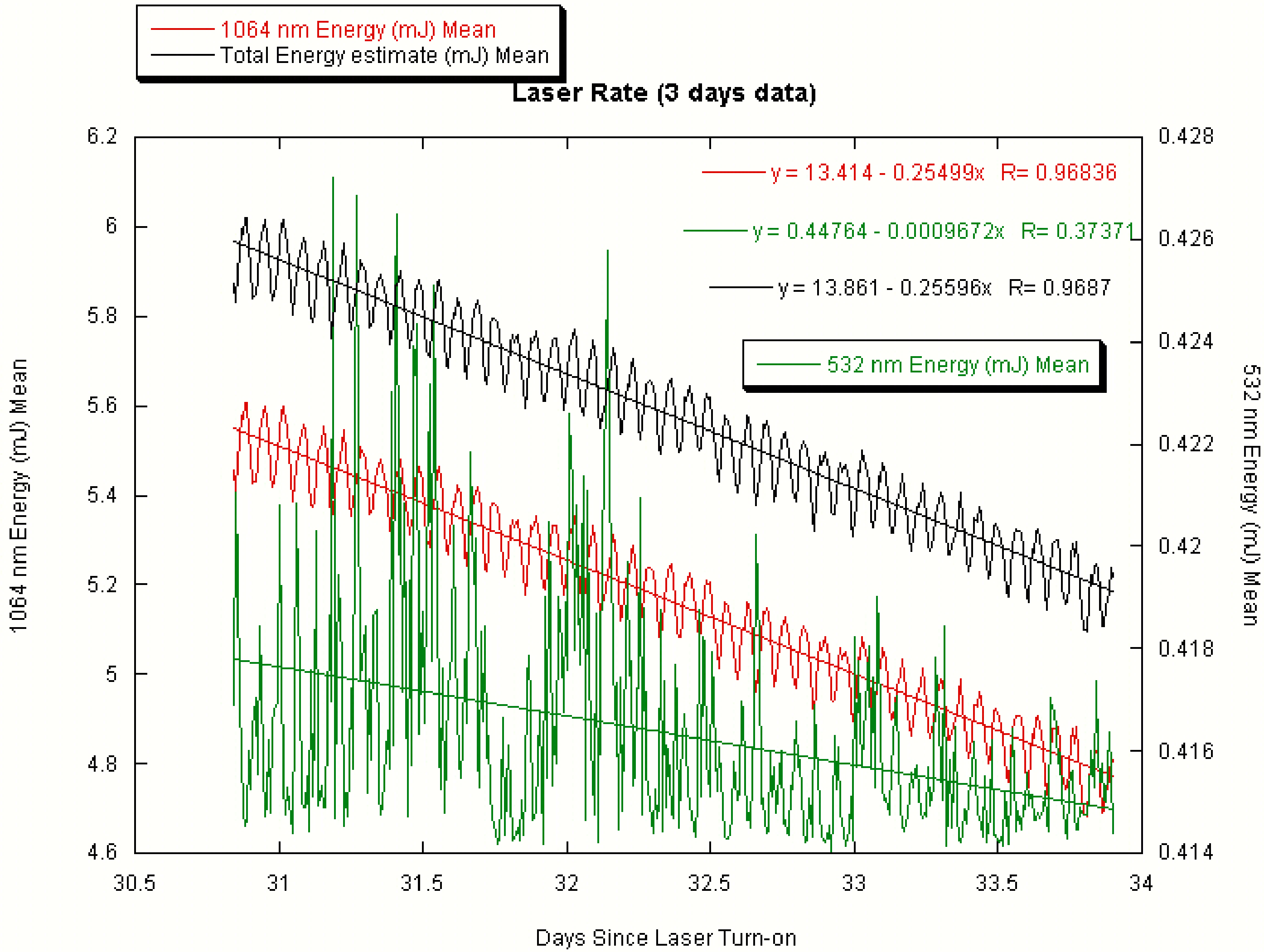




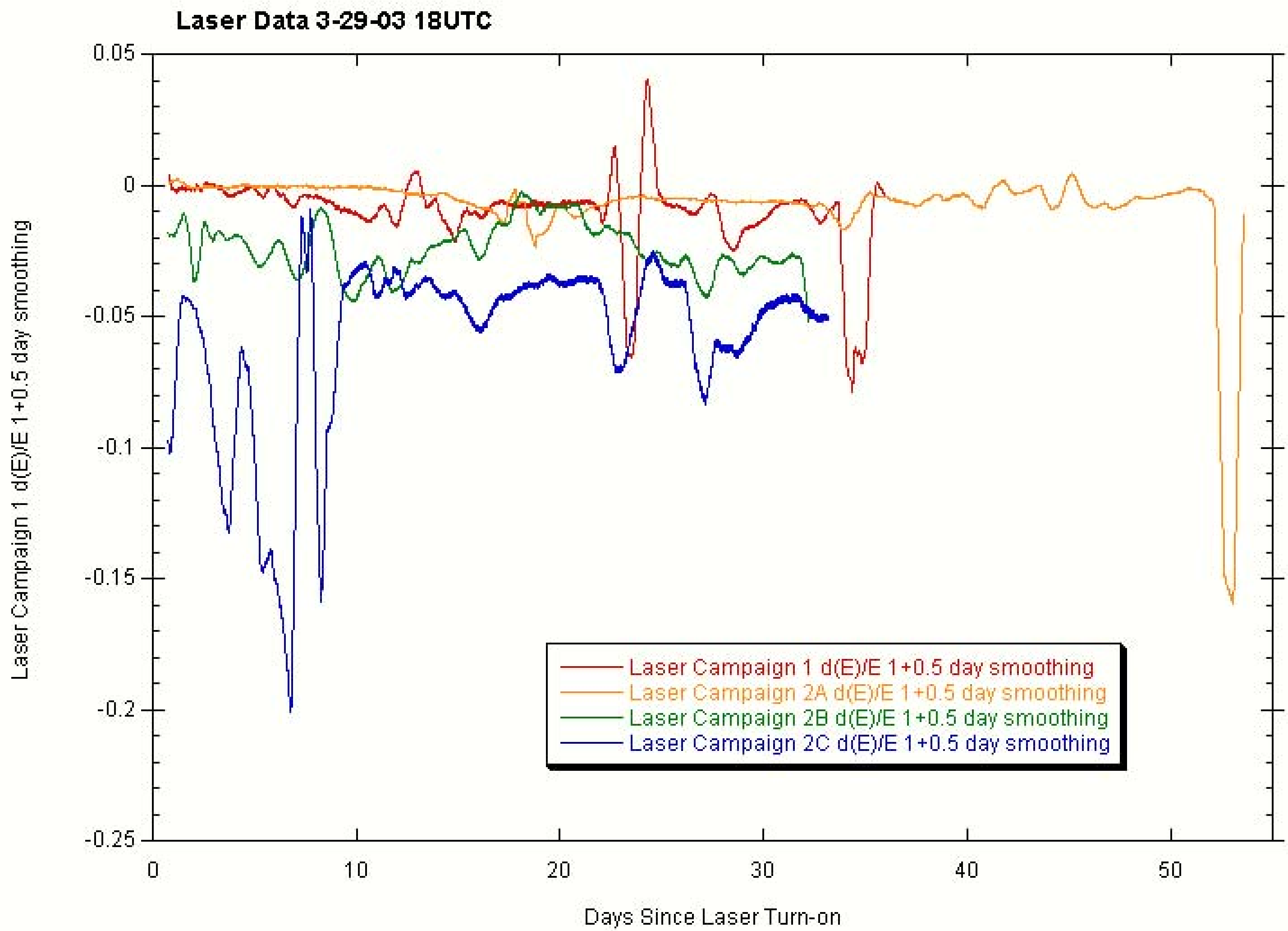
GLAS Laser2C - osc and amplifier currents



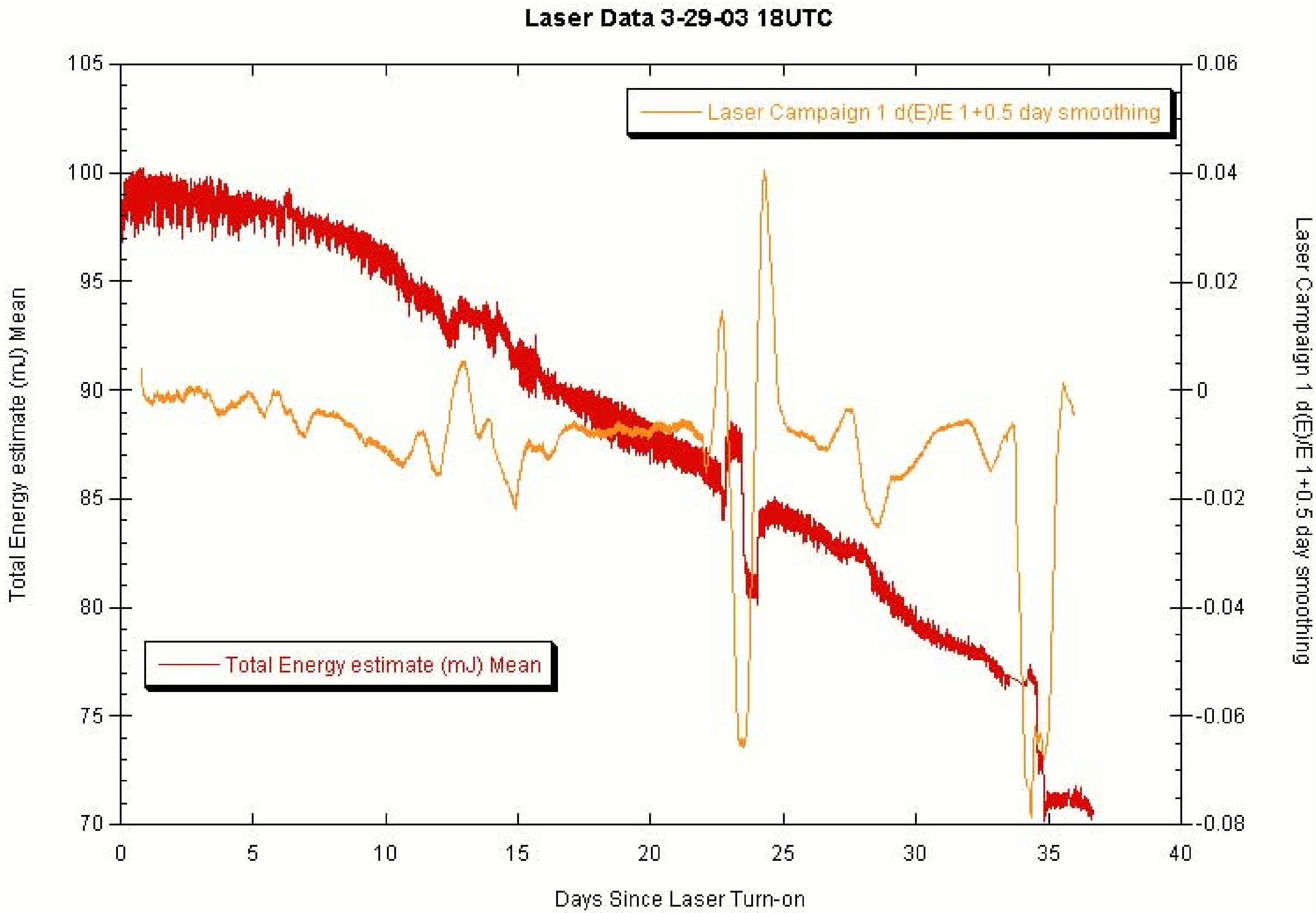
GLAS Laser 2C - 3 day rates



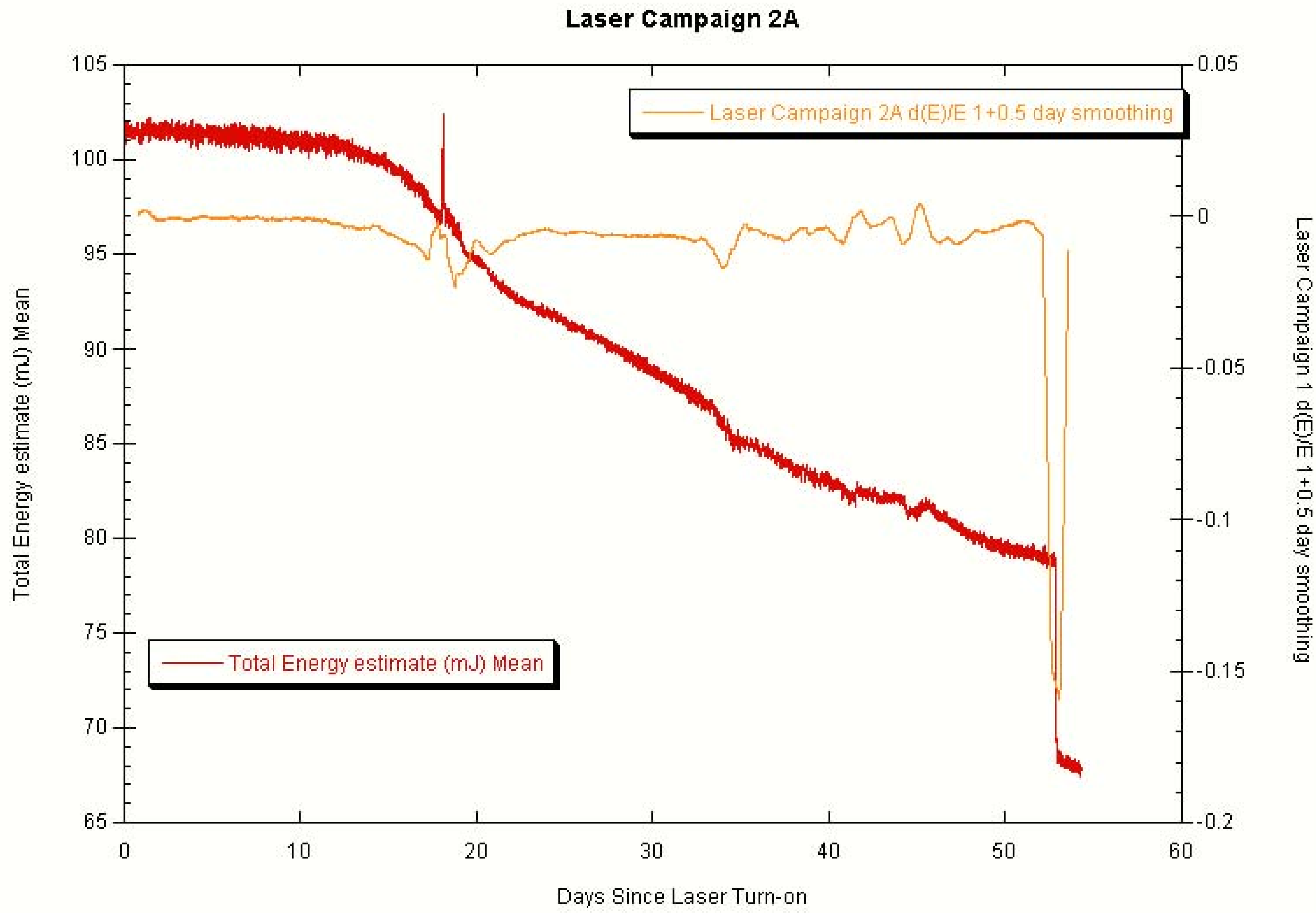
GLAS Lasers to date - relative energy decline rates



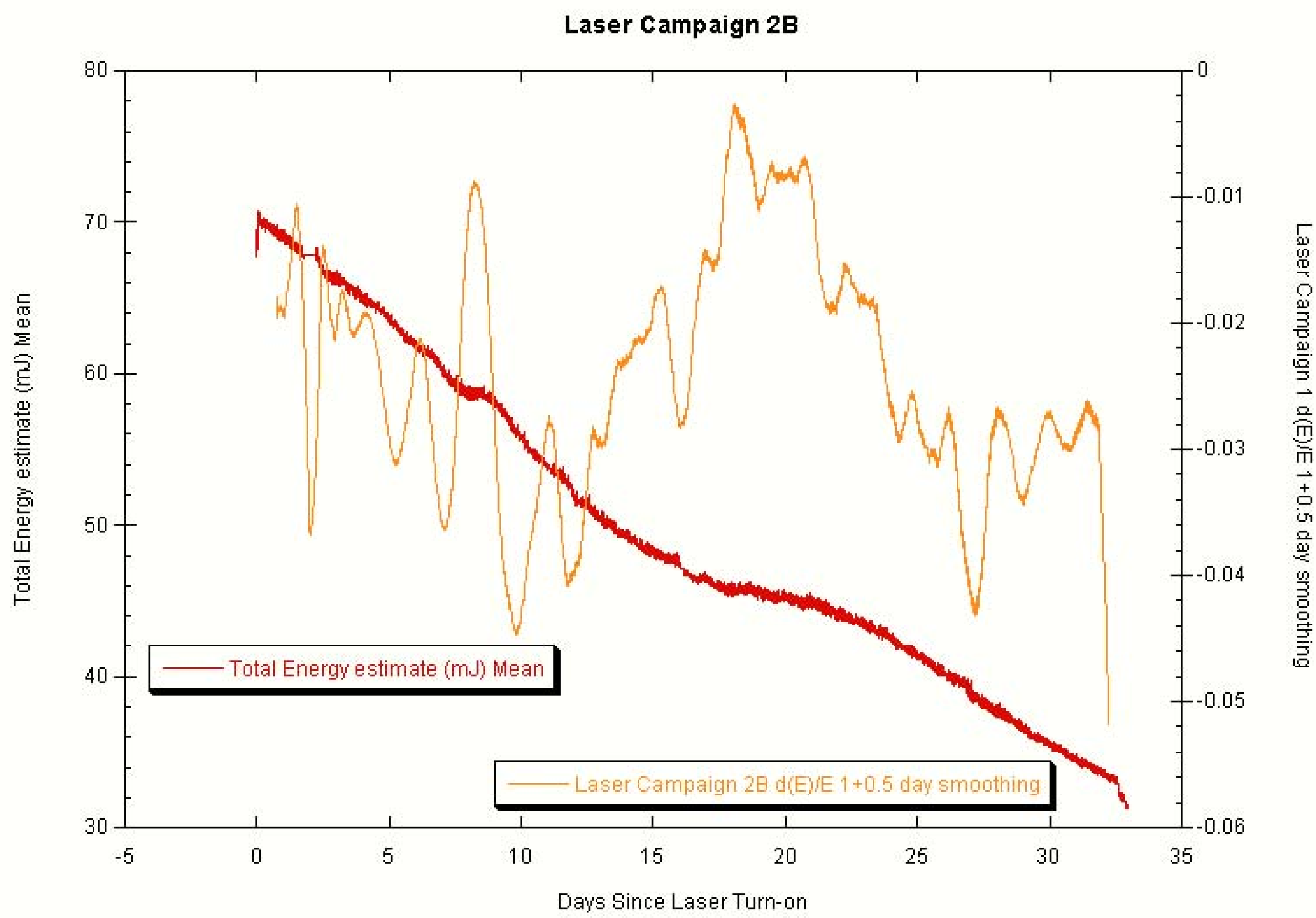
Laser 1 history



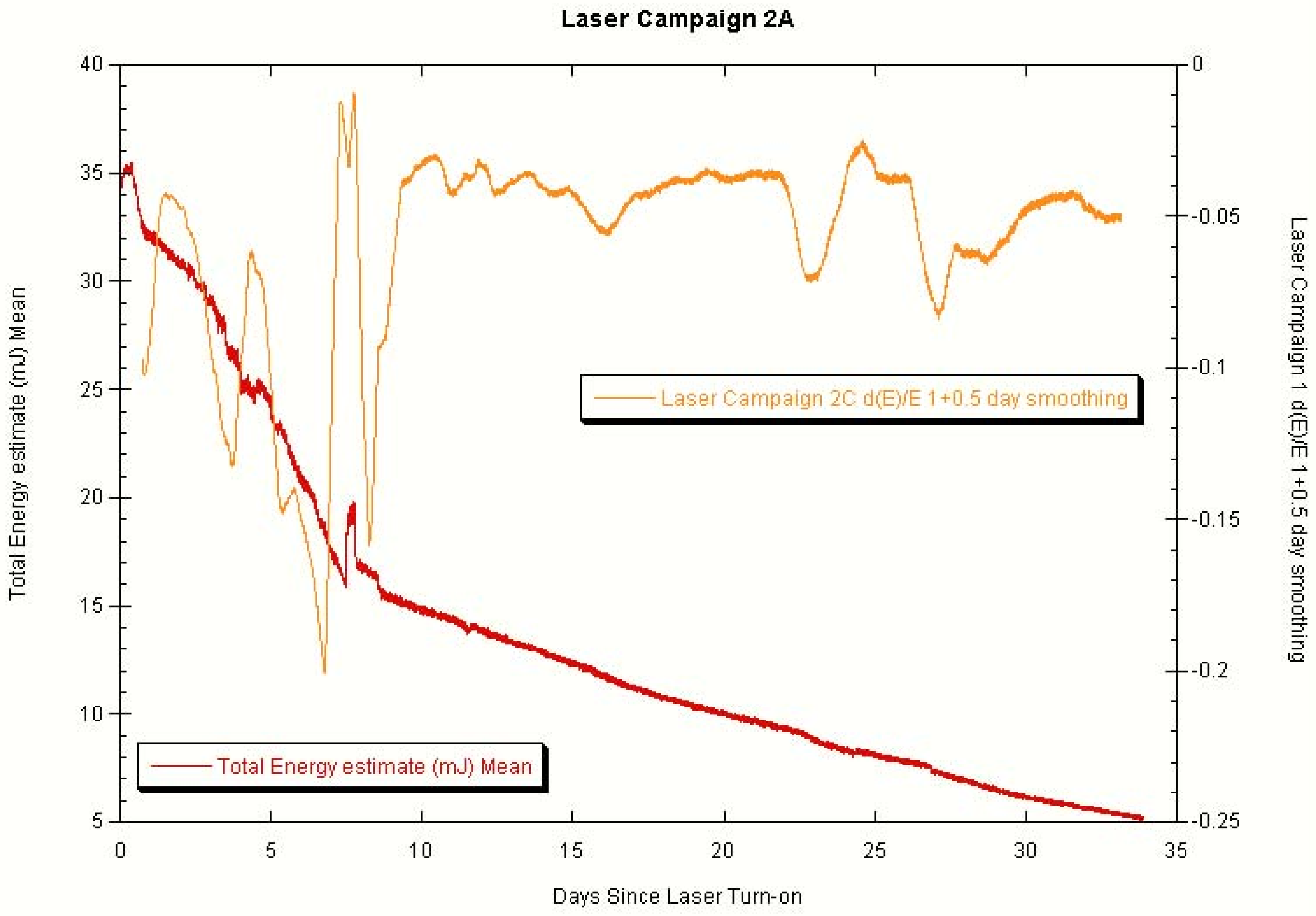
Laser 2A history



Laser 2B history



Laser 2C history

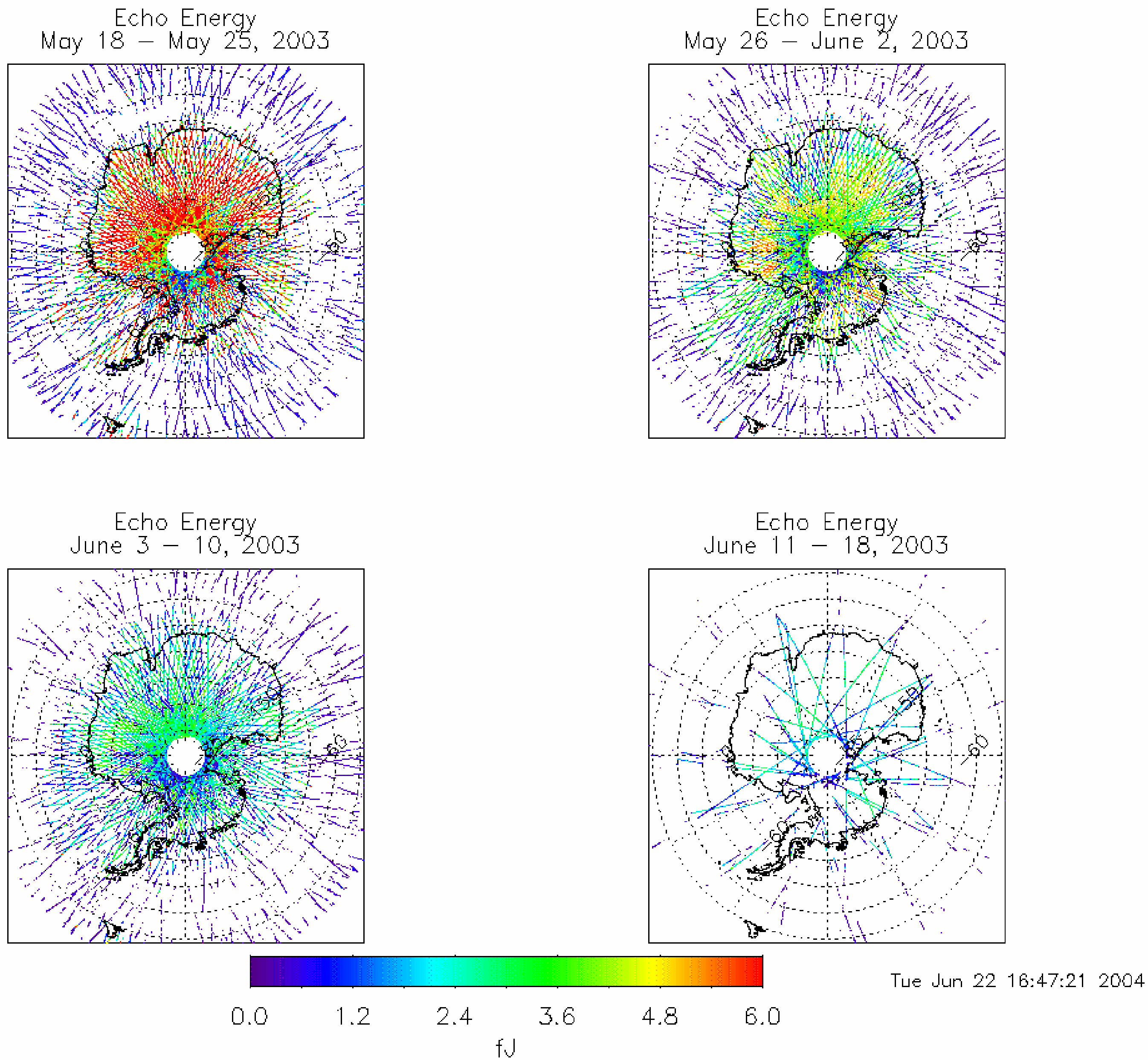


GLAS Laser 2 - GARB update

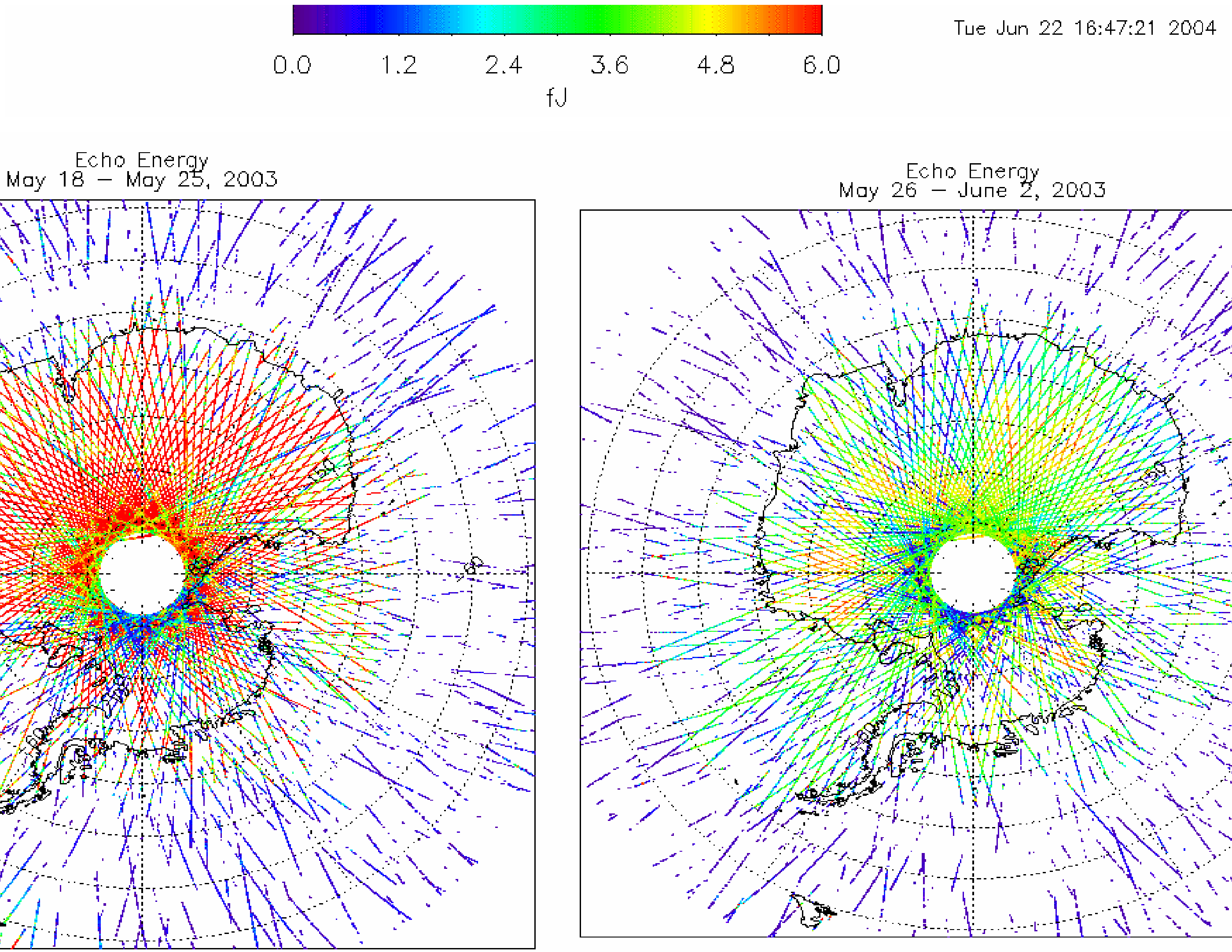
- GARB2 next activities - a detailed comparison of all data against fault tree
- Haven't seen the "diode signatures", as before the (likely) failure of Laser 1
- Do see gradual energy loss, relative rate of loss has increased from 2A, 2B, 2C
- Several observations seem to support a common hypothesis:
    - Slow build up of some kind of molecular contaminant near doubler crystal
    - Possibly out-gassing or materials migration
    - Contaminant is being slowly photo-darkened by laser light
    - Extra heating of doubler in most cases seems caused by laser light
    - Extra heating of doubler cannot explain all loss - other optics must be involved (also darkening)
    - Doubler analysis shows rapid increase in heating after Laser 2 temp spike
    - Suspects are one of the bonding agents used inside the laser
        - Either a bad actor, or just "too much" used for GLAS energy levels
- Oscillator stages in both Lasers 1 & 2 have worked fine - very little degradation

Laser 2C Echo Pulse Energies over Antarctica

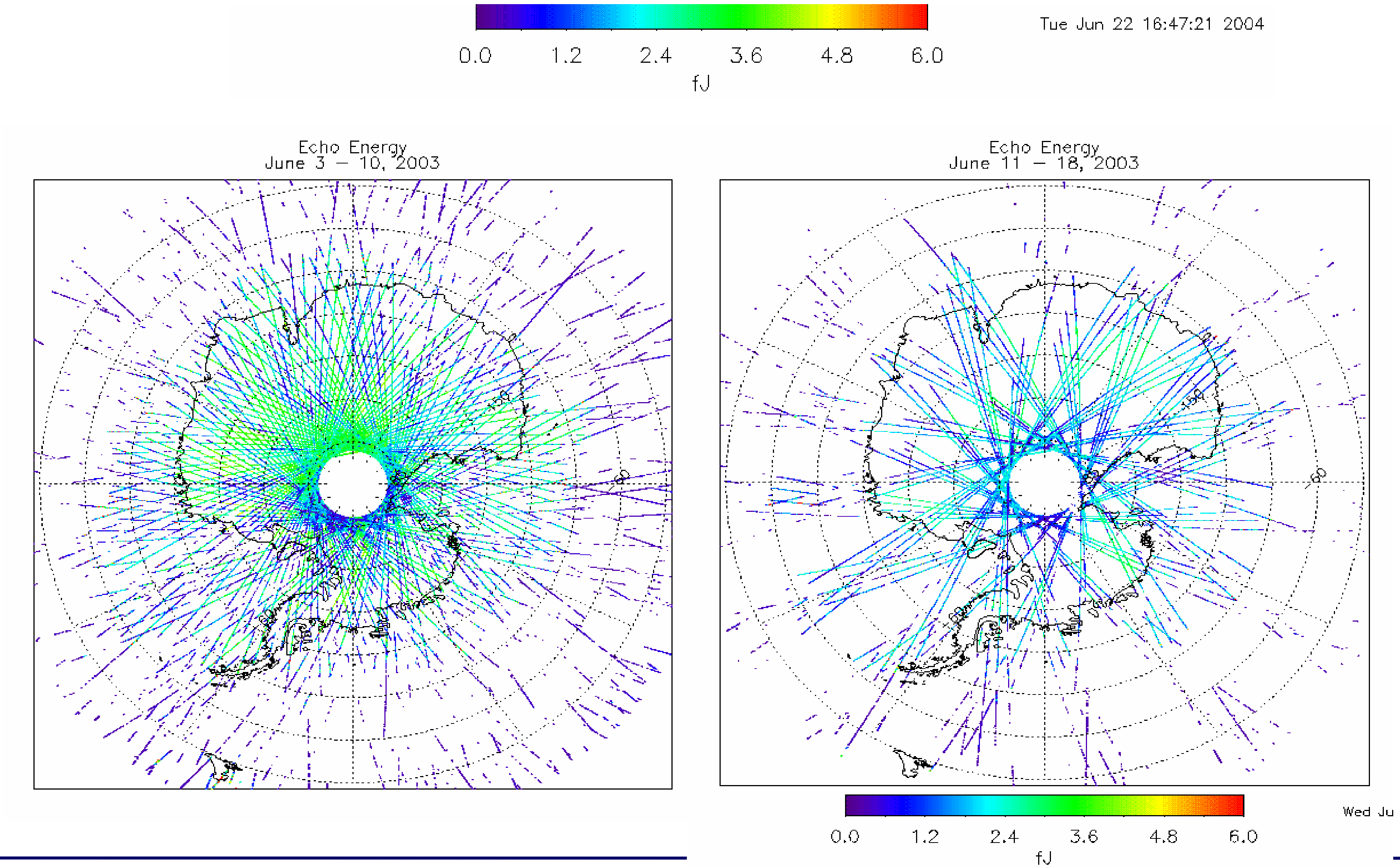
Donghui Yi



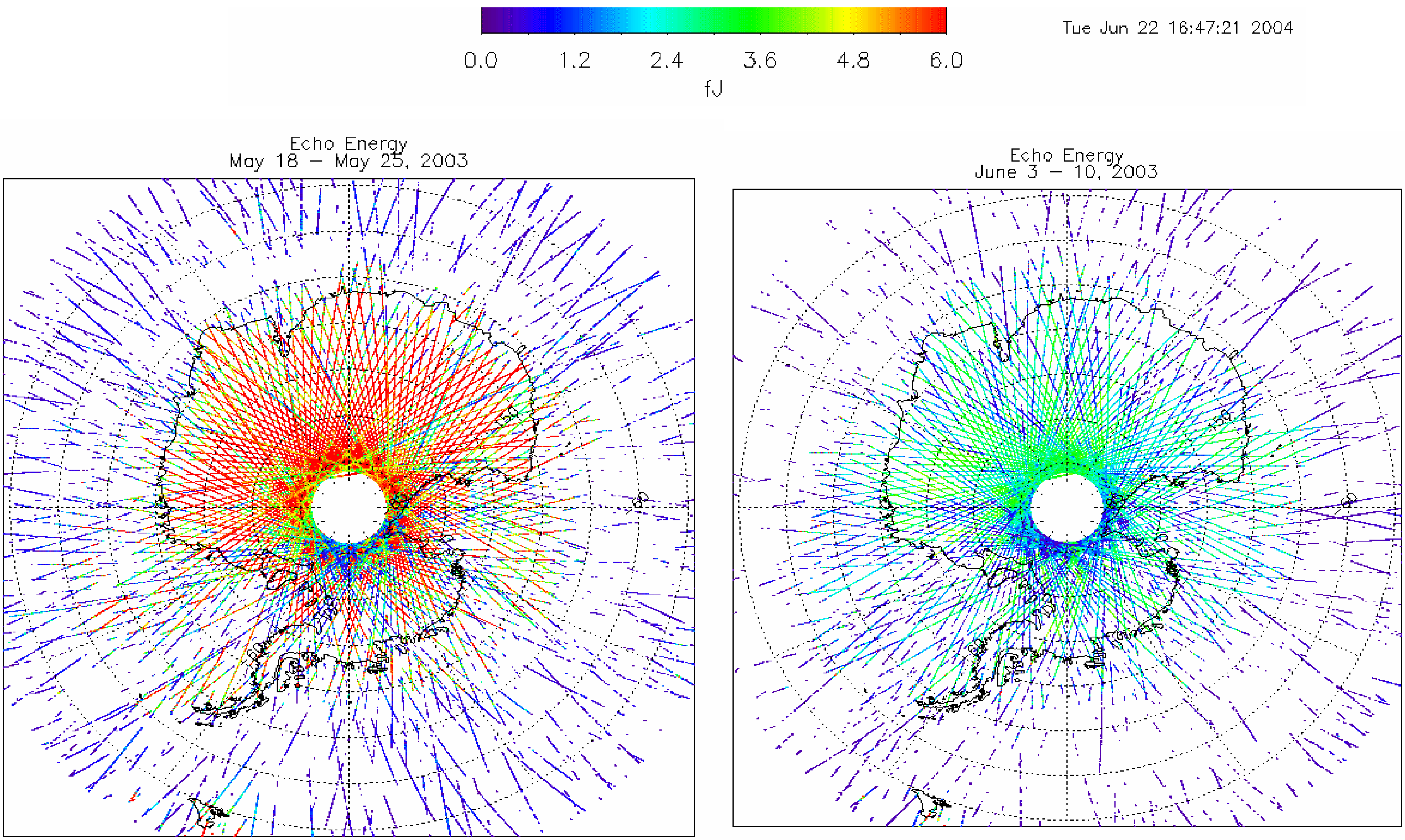
Laser 2C Echo Pulse Energies over Antarctica
Donghui Yi



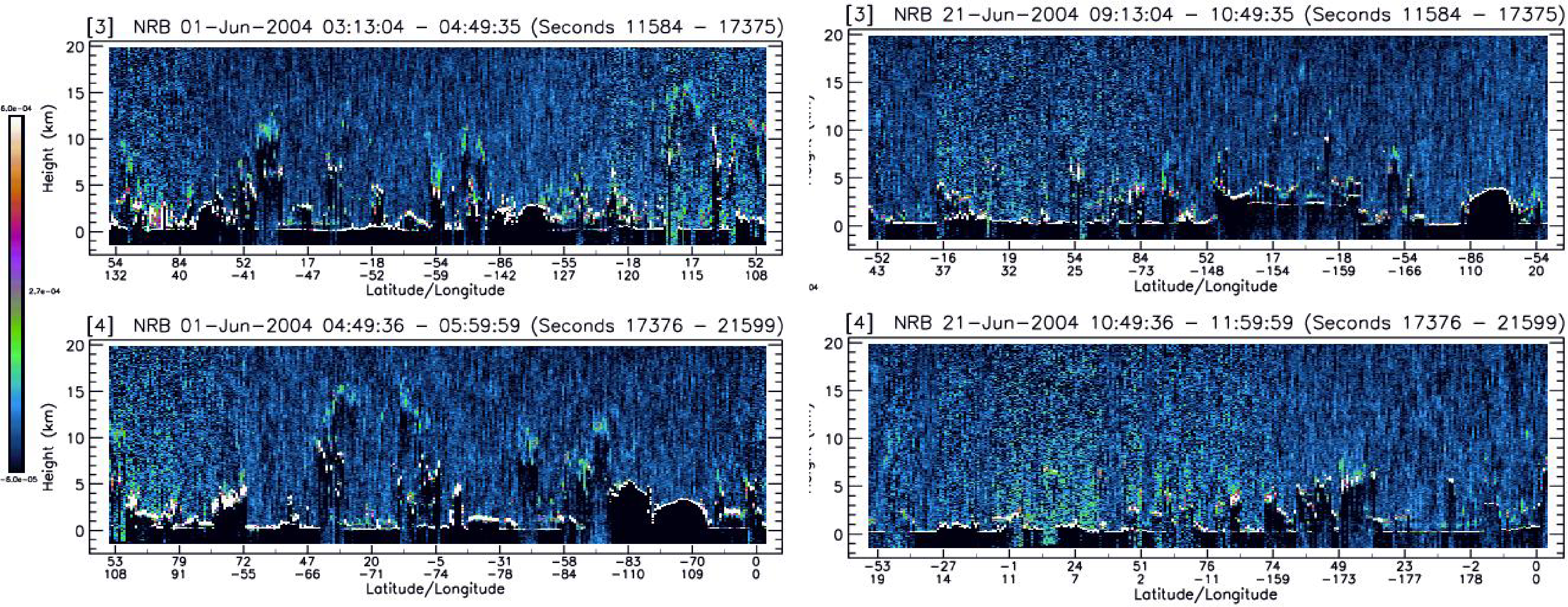
Laser 2C Echo Pulse Energies over Antarctica
Donghui Yi



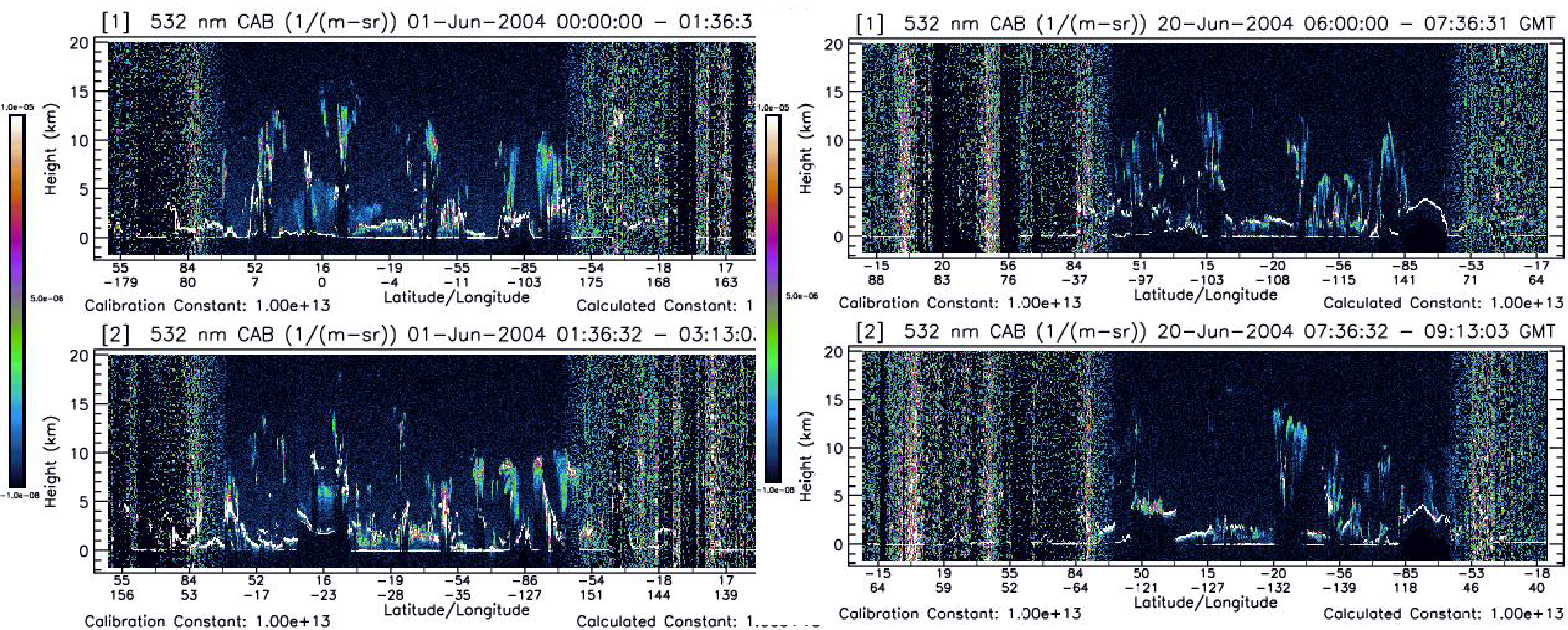
Laser 2C Echo Pulse Energies over Antarctica
Donghui Yi



GLAS Lasers- 1064 nm atm measurements 6/1 & 6/21/04



GLAS Lasers -532 nm atm measurements - 6/1 & 6/21/04



GLAS ETU Laser
Extended Vacuum Operation Performance Characterization

Haris Riris

6/4/2004

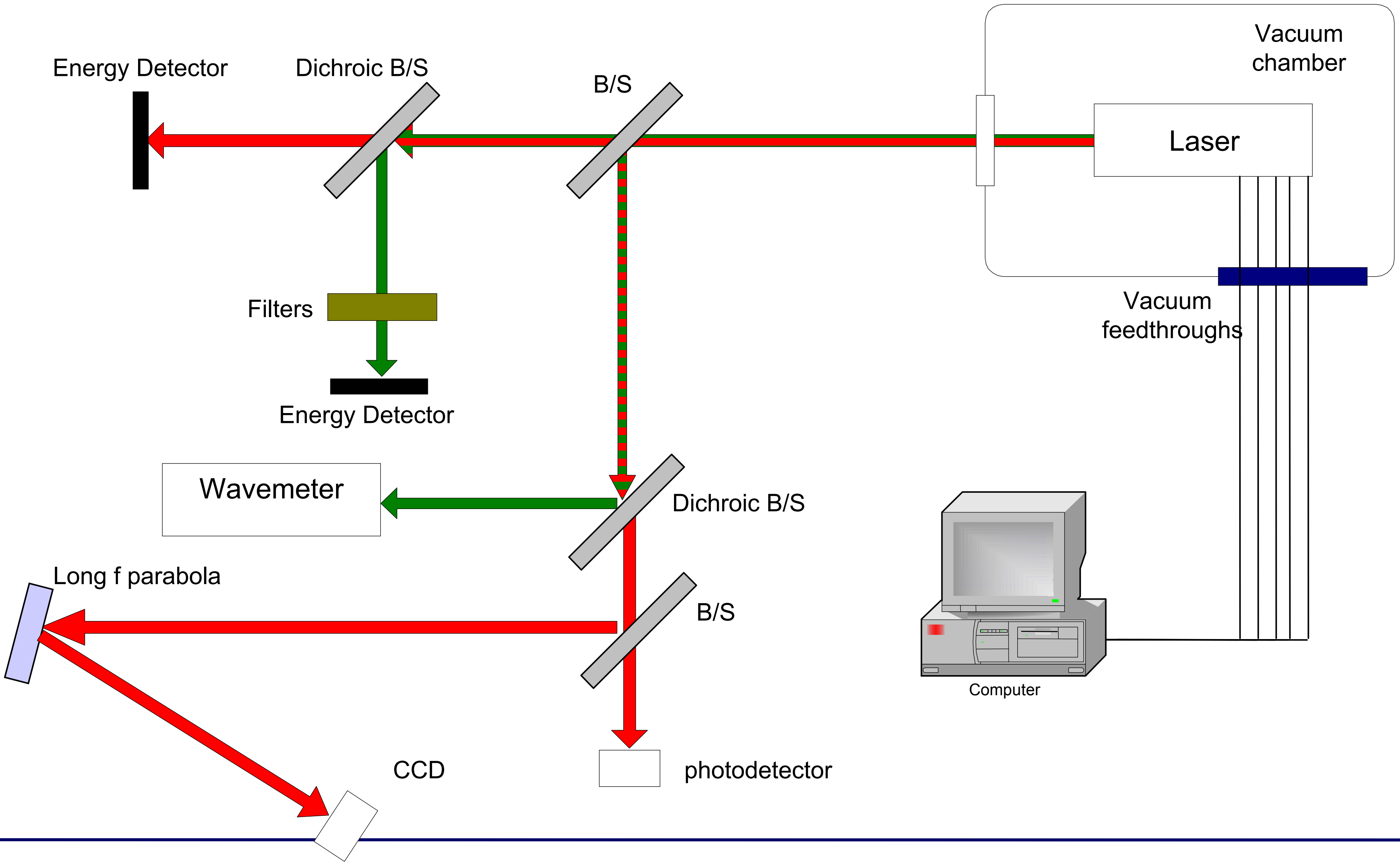
- Objectives:
  - –Expose GLAS ETU laser to continuous operation in vacuum
  - – Monitor, archive, and trend most important laser parameters
  - – Perform “autopsy” on laser to better understand effects of vacuum & likely cause of GLAS “faster than predicted” laser energy decline

GLAS Laser2 -GARB supported test

- Vacuum test of ETU laser (the pre-flight unit) should provide much better data
  - Plan written
  - Proposed to & supported by E□SMO & Code Y
  - Laser and test setup are being prepared in Laser lab (H017) in B33
  - Laser lab & TVAC chamber being re-setup from equipment moved from SLTC
- Performed a visual inspection (from outside the box) of the doubler crystal

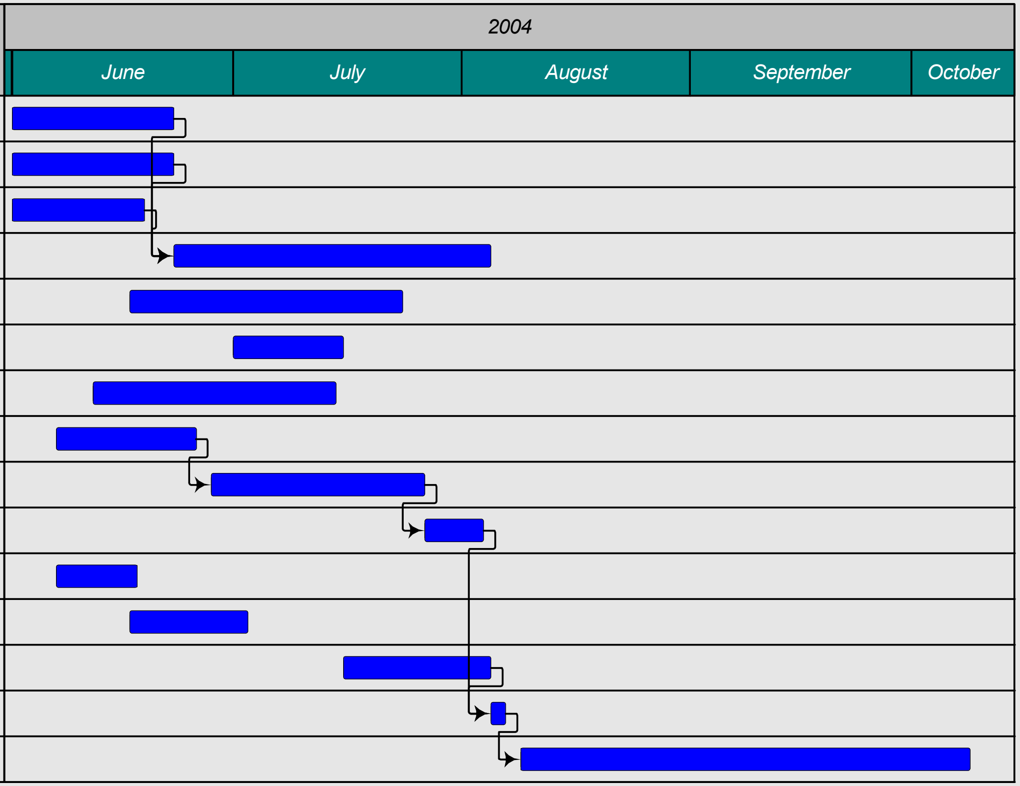
Approach

- (Lids on) inspect ETU laser prior to vacuum operation
- Operate laser in air-air for limited time to ascertain current energy levels status and get a baseline
- Set up chamber in B33 lab (H017) and qualify chamber and facilities
- Set-up and maintain a "clean area" around chamber
- Use existing SLTC and GLAS BCE equipment and software whenever possible
- Minimize software development/revisions
- Acquire 40 Hz energy data (whenever possible)
- Archive data and maintain archive and back-ups
- 24/7 Unattended operation after initial setup
- Fail-safe mechanisms for laser, chamber, power but not for data acquisition
- Anticipate vacuum test duration ~ 30 days
- Detailed Inspect/analysis of the laser optics after the test. Details of these are being worked


Vacuum chamber
Energy Detector
Dichroic B/S
B/S
Laser
Filters
Vacuum feedthroughs
Energy Detector
Wavemeter
Dichroic B/S
Long f parabola
B/S
Computer
CCD
photodetector

Draft Schedule

ID	Task Name	Start Date	End Date	Duration
1	Power Setup	6/1/2004	6/22/2004	16d
2	Wall penetrations and modifcations	6/1/2004	6/22/2004	16d
3	Pulmbing installation	6/1/2004	6/18/2004	14d
4	Chamber Qualification (cleaning certification etc)	6/23/2004	8/4/2004	31d
5	Clean tent installation and certification	6/17/2004	7/23/2004	27d
6	Misc facilities (LN2, Safety cert. etc.)	7/1/2004	7/15/2004	11d
7	Harnessing	6/12/2004	7/14/2004	23d
8	Software set upwith simulated signals	6/7/2004	6/25/2004	15d
9	Software tests with HW but w/oETU laser	6/28/2004	7/26/2004	21d
10	Software Tests with ETU laser	7/27/2004	8/3/2004	6d
11	Optical Test Setup	6/7/2004	6/17/2004	9d
12	Optical Test Checkoutw/o ETU laser	6/17/2004	7/2/2004	12d
13	Optical Test Checkoutwith ETU laser	7/16/2004	8/4/2004	14d
14	Baseline ETU in Air	8/5/2004	8/6/2004	2d
15	Vacuum Test	8/9/2004	10/8/2004	45d



Note: The schedule does not cover post vacuum test inspection

GLAS Instrument

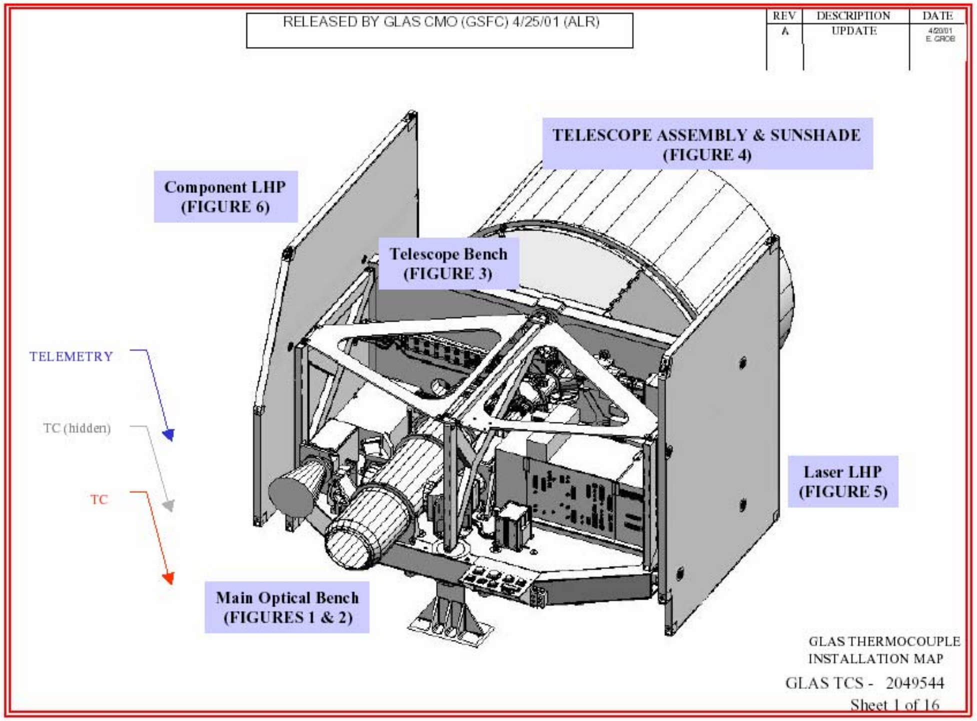
Orbital dependence of boresight ranging errors and their apparent effect on "pointing"

Presentation to

GLAS Science Team Meeting - 6/23/04

Marcos Sirota

(borrowing slides from former Scott's presentations, with permission)



Introduction

The main pointing calibration method for GLAS, i.e. ocean sweeps, yields only an "effective pointing bias ", formed by the SRS bias (very much a constant) and a FOV shadowing pointing bias (ranging-error originated) , which has strong orbital and long term variability.
The FOV shadowing bias is directly related to boresight alignment. Boresight alignment variations can be accounted for by considering the variations of the transmitter and receiver pointing vectors w.r.t. GLAS coordinates.

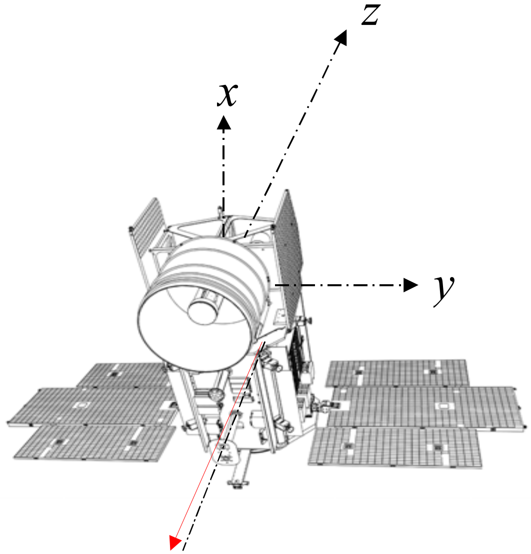


Figure 2. GLAS Coordinate System (GCS) summary. Direction of laser pointing shown in red.

Introduction (cont.)

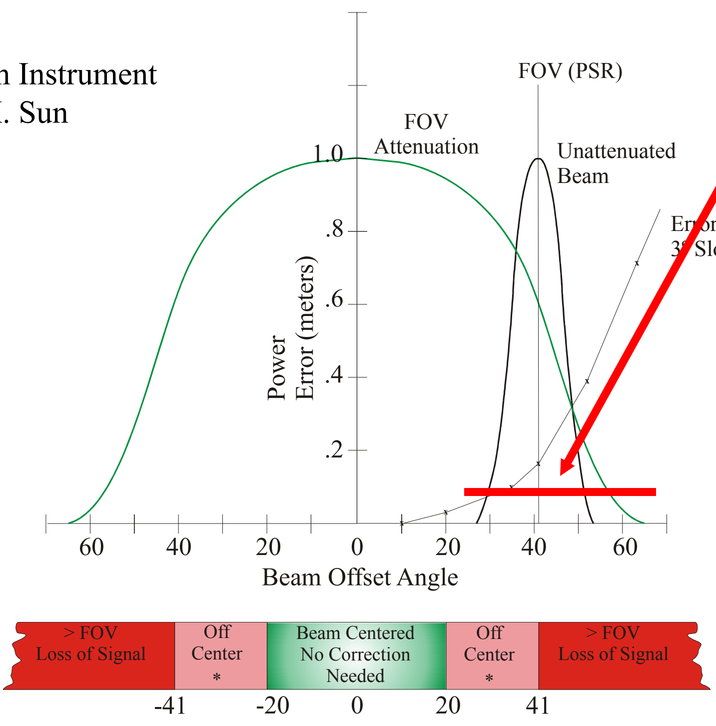
It is shown here that transmitter pointing has a very clear and predictable dependence on bench and laser temperatures. Furthermore, transmitter pointing is measured with high accuracy by the SRS.

However, receiver pointing orbital temperature dependence has not yet been analyzed quantitatively and may yield the strongest signature to predict effective pointing for every point along the orbit. Ocean sweeps produce effective pointing information along only two "points" in the orbit. World scans produce orbital results but may be biased by slopes of non-ocean areas used in the calibration. Only a combination of ocean/world sweep and instrument temperature modeling could yield a boresight orbital dependence model

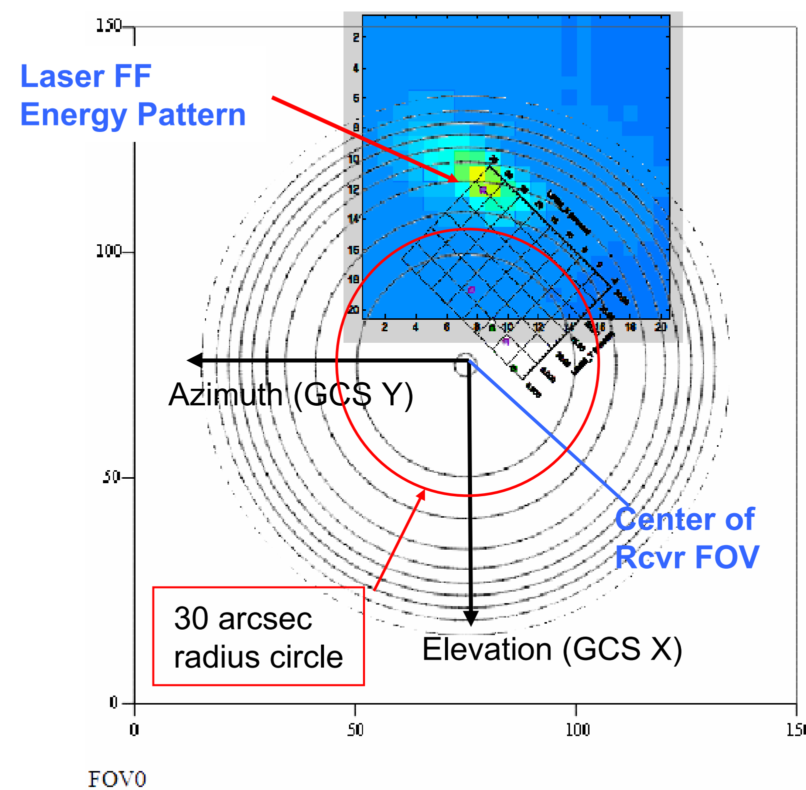
There may be a strong association between some ICEsat temperatures and the remaining error from ocean sweeps. The incorporation of these temperatures into pointing models shall yield a substantially more accurate ranging model.

- *If transmitter/receiver alignment “oscillates” in this region about +- 10 arcsec per axis on a per orbit basis it may lead to perceived “pointing” errors equivalent to +- 2.5 arcsec per axis over a 3 deg slope. Gets quickly worst with larger “permanent” boresight misalignment or larger orbital receiver oscillations.*

Figures from Instrument Team and X. Sun



* Elevation Correction Requires:
- Misalignment offset angle & azimuth
- Local slope & azimuth



The boresight missalignment was estimated at about 40 arcsec (or larger) at the beginning of Laser2A, with significant improvement afterwards due to both the BBQ event and the bench temperature changes.

Given the small variation of transmitter pointing, all the variations after the BBQ event were obviously due to receiver pointing changes.

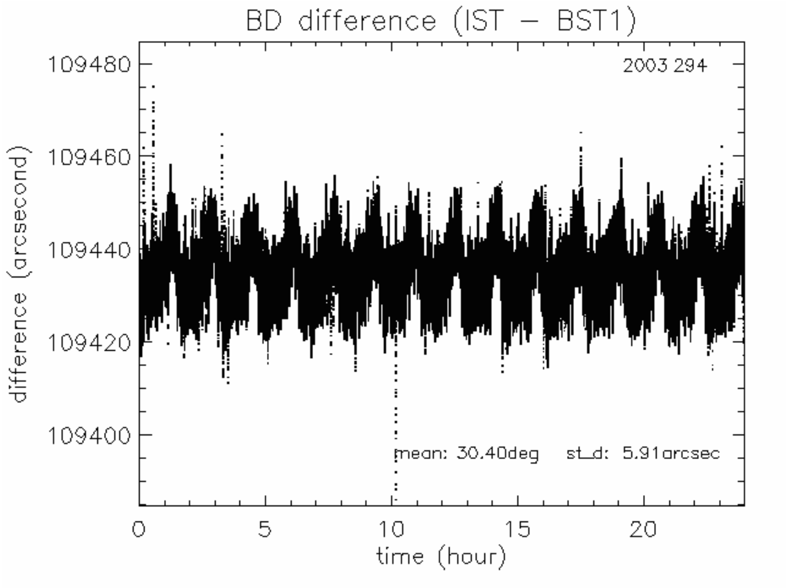
So far, receiver pointing has only been associated to bench temperature, and considered relatively constant for long periods. However, the orbital variation can be even larger than the long term bench-temperature dependent variation.

Heat pipes are suspected to be the main cause of the ubiquitous IST bracket motion, as shown by correlations between IST motion and Component Loop Heat Pipe temperatures.

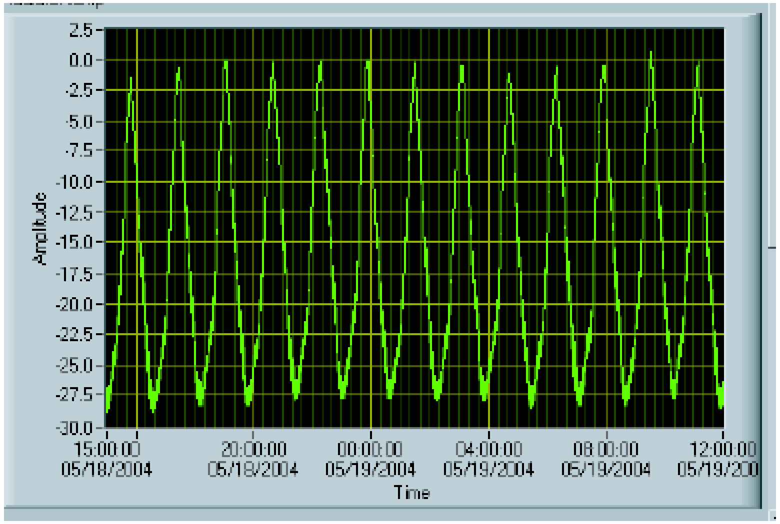
By the same effect, receiver components, including telescope bench, may be being stressed by heat pipes and their associated components (evaporators, etc). In addition, radiator and telescope shield thermal variations (both on the 10's of C per orbit) may be strong drivers on receiver pointing.

Thermo-mechanical clearly drives the IST motion

Heat pipes are suspected to be the main cause of the ubiquitous IST bracket motion shown by the CRS. The IST motion has been corroborated by observing IST to BST motion as shown below. This motion is of 15-20 arcsec per orbit per axis, and suspected to be caused by heat pipe expansion. as shown by correlations between IST motion and Component Loop Heat Pipe temperatures.



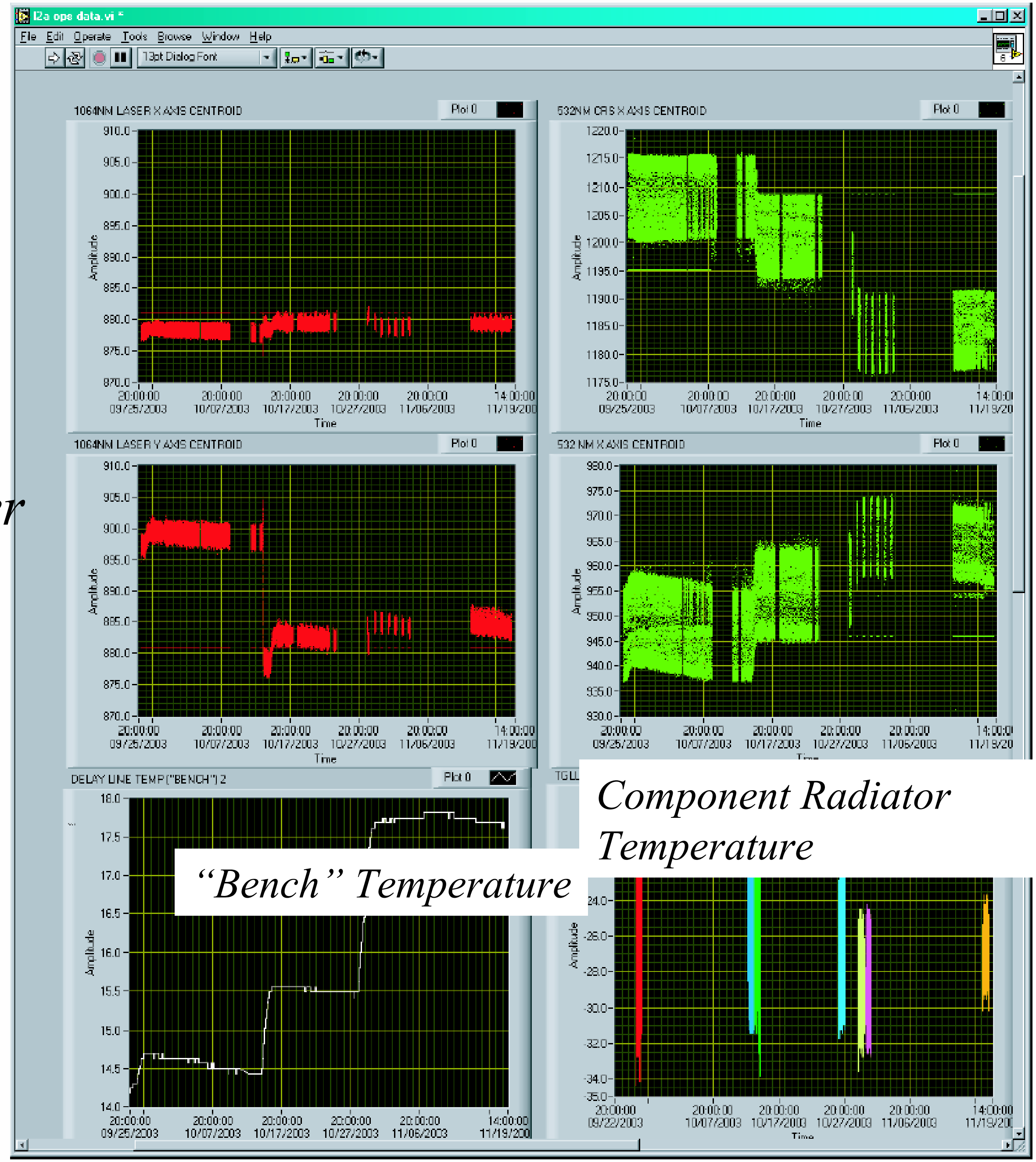
Radiator Temperature



Transmitter temperature dependences

The next slide shows the variation in pointing on the transmitter side during Laser2A operations.
For a variation in temperature of 3.5 C in Bench temperature there was effectively a very small variation on laser pointing as registered by the LRS. The only large variation was that associated with the "BBQ" event.

Laser 2A



Laser in LRS

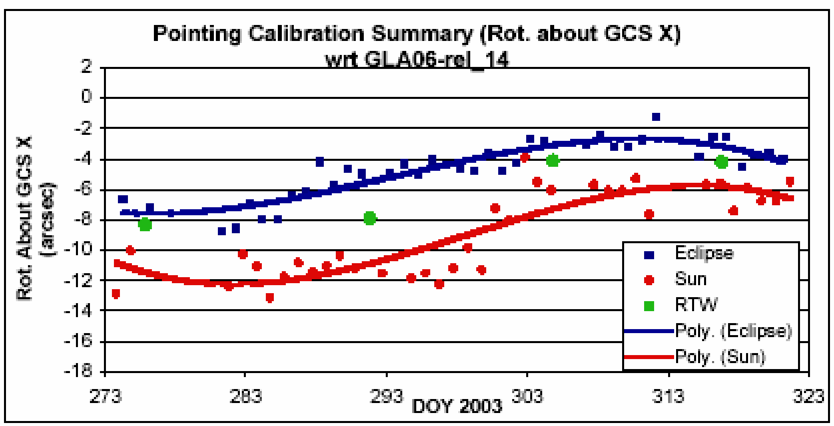
Receiver Pointing Temperature Dependence

At the bottom right of the slide the orbital variation for one of the radiators is shown. Each color bar corresponds to about a day of data. The length of the bar represents the peak to peak temperature variation. (The "triangular wave" variation on a per orbit basis can not be seen in this time scale)

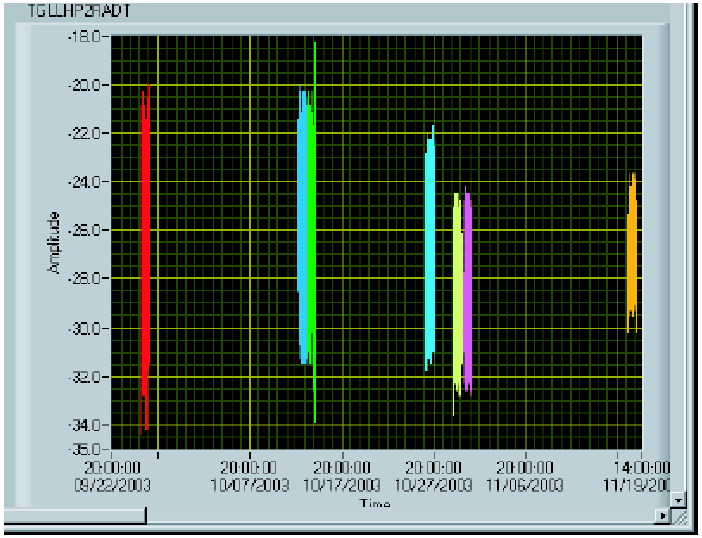
It is interesting to notice the variation in amplitude as the L2A period progresses. That variation was mostly due to β-angle.

Let's now look at the remaining pointing error as shown at left as calculated by Scott from ocean sweeps from release 14. A remaining bias error exists between night and day side of the orbits (blue and red dots). However, it is clear that it diminished towards the end of L2A (at least on this axis). This has been associated with better permanent boresight alignment due to change of bench temperature. However it may also be caused by a smaller orbital receiver pointing variation associated with instrument termo-mechanical variations.

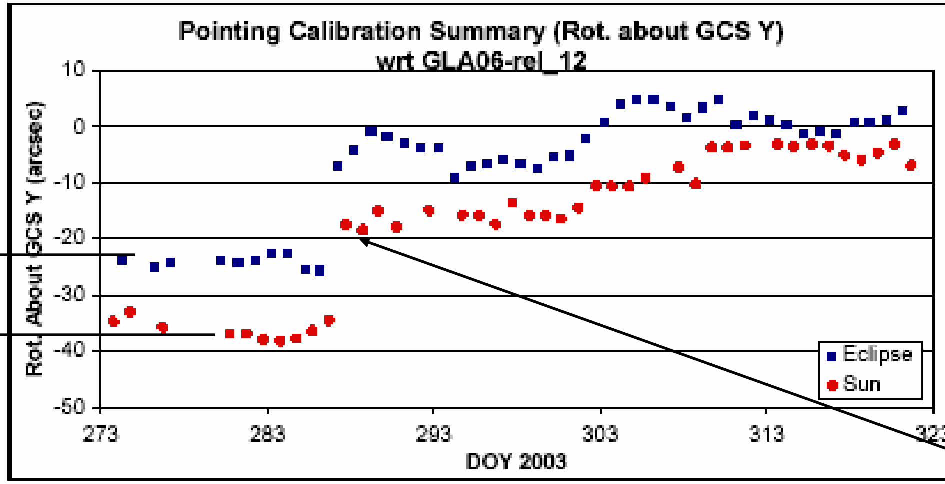
Remaining "pointing" error



Component Radiator Temperature ptp during L2A period



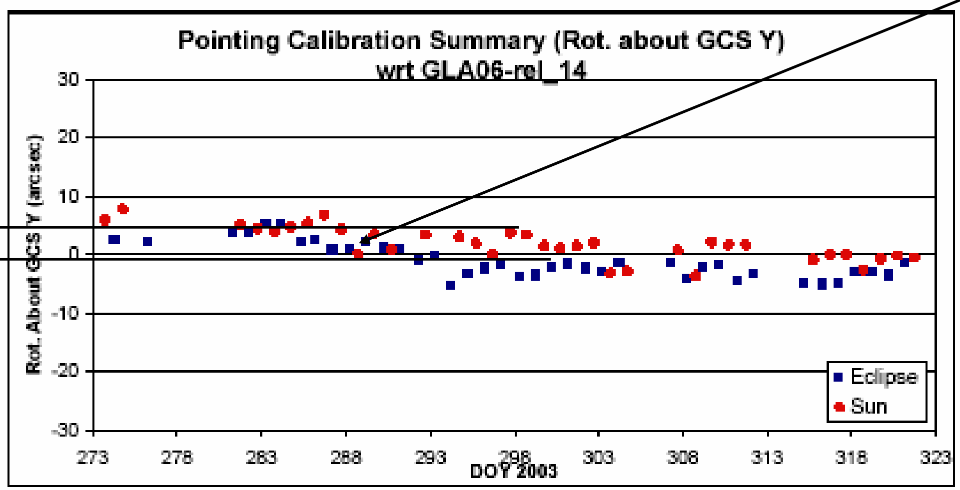
~ 16 arcsec
Clearly measured
by SRS CRS



No SRS

"BBQ" event (~ 20 arcsec) fully dissapears by simply using SRS transmitter pointing data

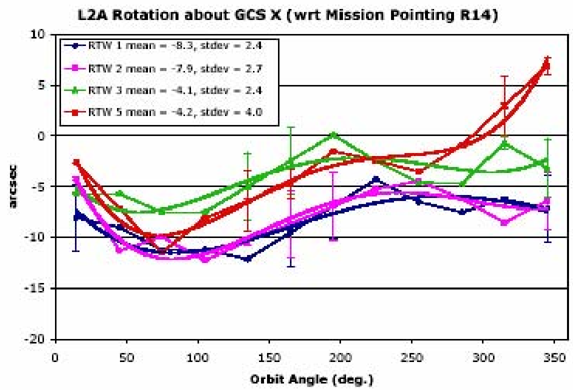
Remining orbital variation
Probably due to orbital receiver shifts and long term receiver shifts

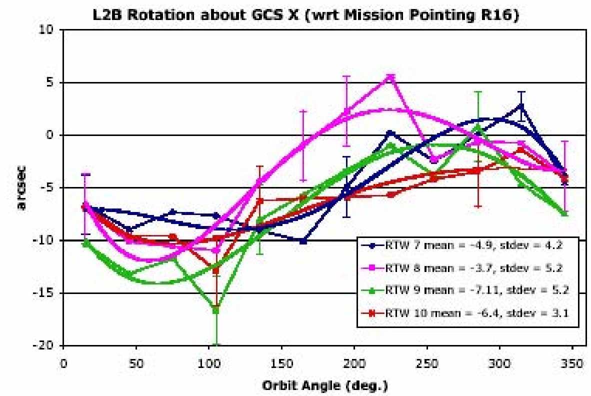


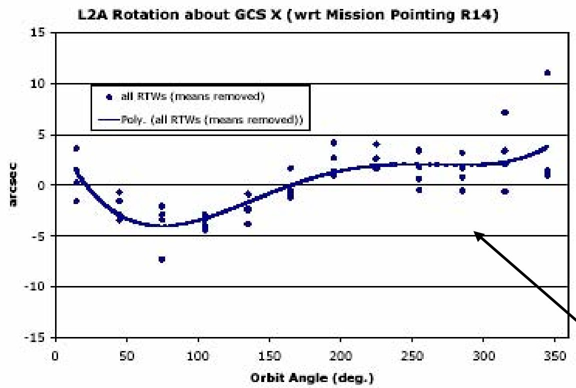
With SRS

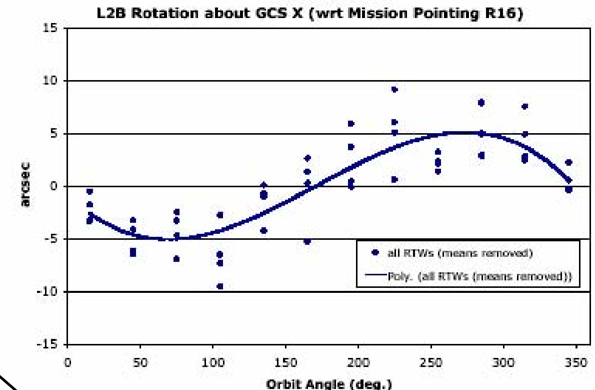
Orbit Variation Calibration from RTWs (GCS X)

L2A *L2B*

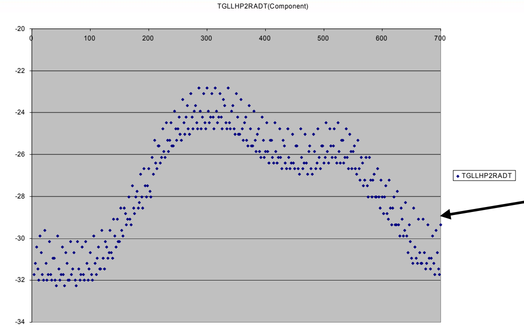








Component Rad. Temp.



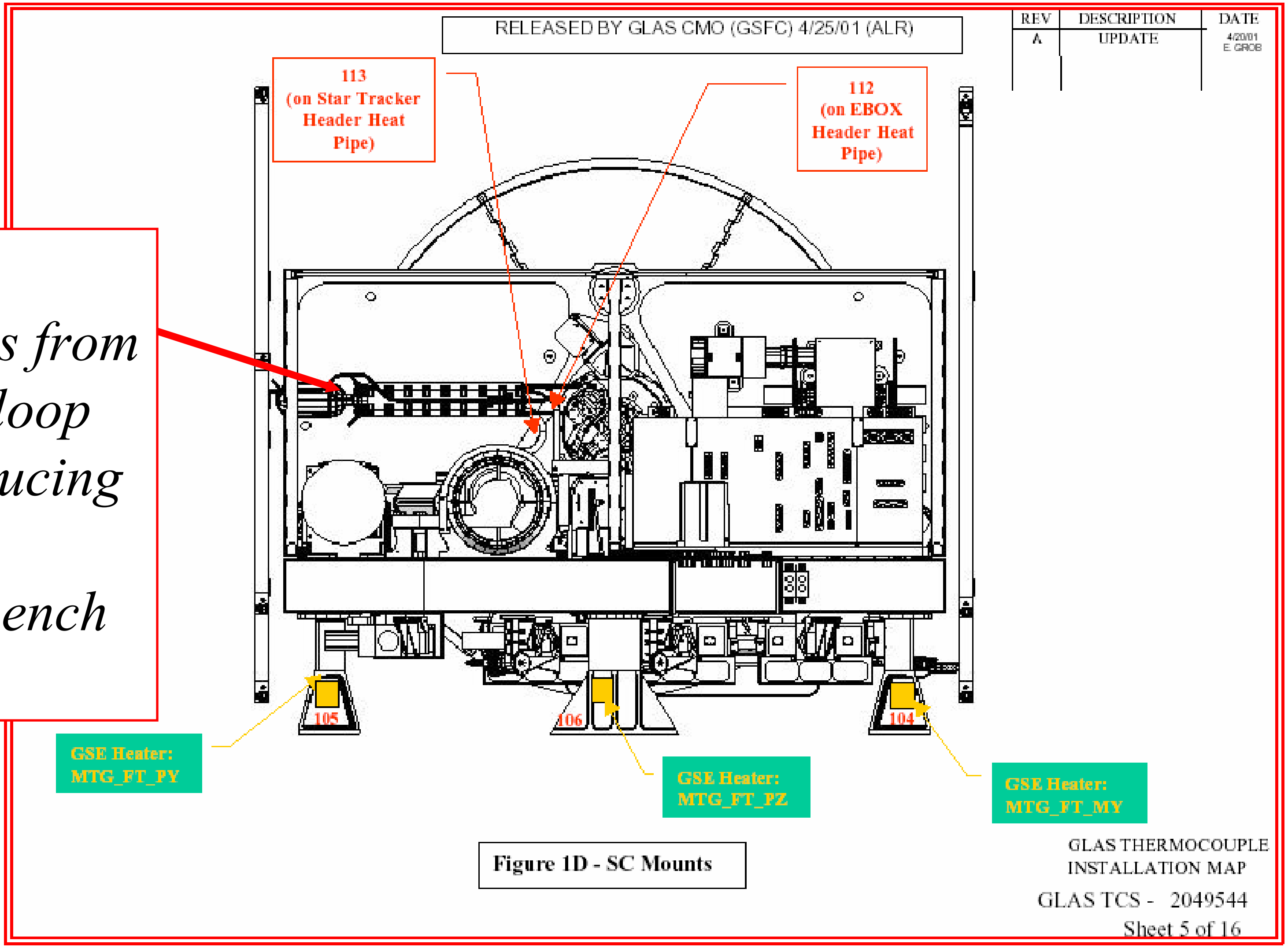
Correlations (if any) should be analyzed in amplitude and phase, even at an orbit by orbit basis.

List of temperatures of likely influence

GHKTELMTT	Telescope Mount Temp., PRT, Ch 22	
GHKTELBFT	Telescope Baffle Temp., PRT, Ch 23	
GHKFBOXT	Fiber Box Temp., PRT, Ch 29	
GTMPMIRHTR	GLAS TCM Telescope Primary Mirror Heater	
GTMPMIRTSP	GLAS TCM Telescope Primary	
Thermistors		
TGLLHP1RADT	Temp., GLAS 1, Laser LPH1 Radiator [type B]	
TGLLHP2RADT	Temp., GLAS 2, Component LPH2 Radiator [type B]	
TGLLHP1VLT	Temp., GLAS 8, Laser LHP1 Vapor Line	
TGLLHP2VLT	Temp., GLAS 9, Component LHP2 Vapor Line	
TGLLHP1EVAPT	Temp., GLAS 12, Laser LPH1 Evaporator	
TGLLHP2EVAPT	Temp., GLAS 13, Component LPH2 Evaporator	
TGLLHP1LLCCT	Temp., GLAS 14, Laser LHP1 Liquid Line (@CC)	
TGLLHP2LLCCT	Temp., GLAS 15, Component LHP2 Liquid Line (@CC)	

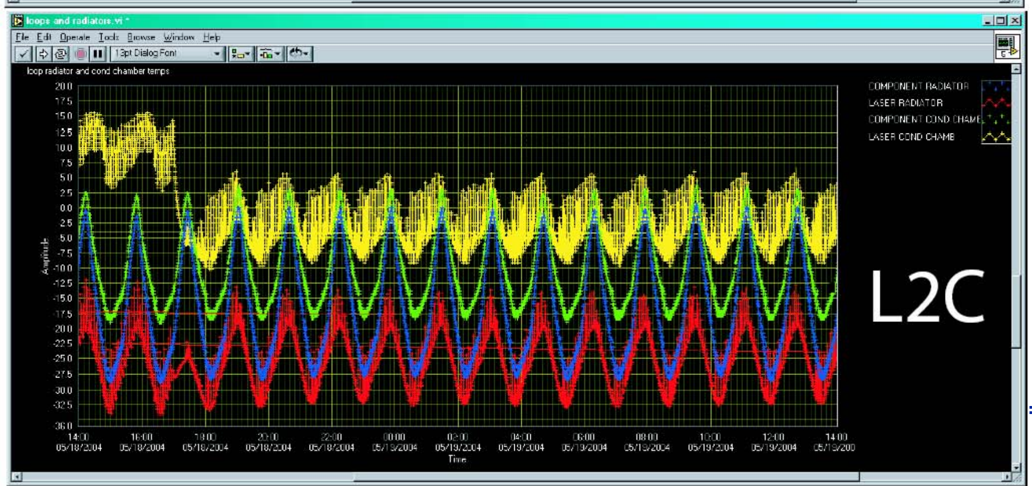
Files of these temperatures for the mission lifetime are being compiled by D.Hancock et al.

I have added a few slides with thermal structure of GLAS for further discussion.



These components from the CLHP loop may be inducing stress on telescope bench (?)

Radiator and evaporator temp. samples for three L2 campaigns



Note difference in shape, amplitude, and gradients.
Very likely to influence boresight differently for all three campaigns.
(Scan down the slide to see all three)

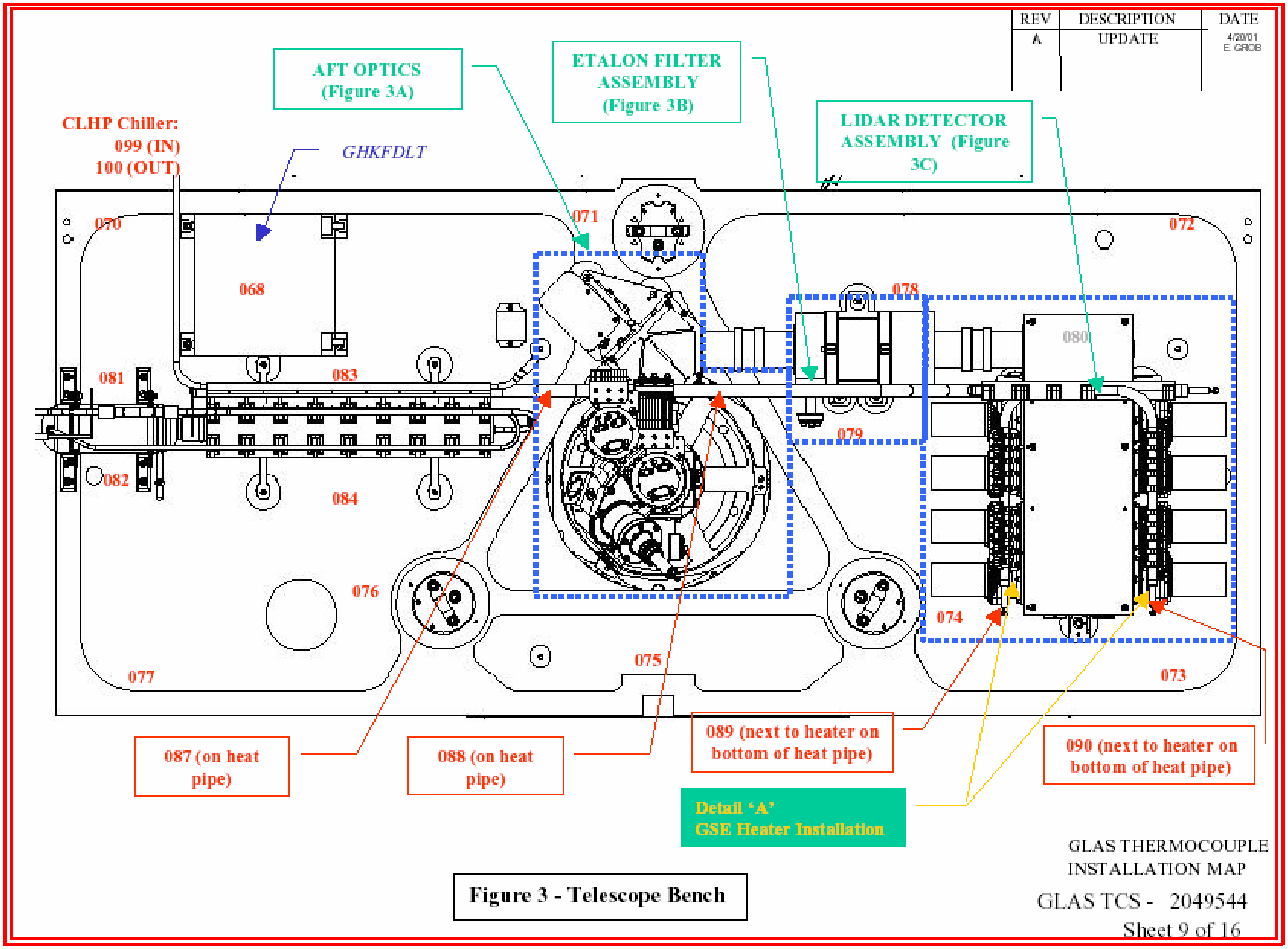


Figure 3 - Telescope Bench

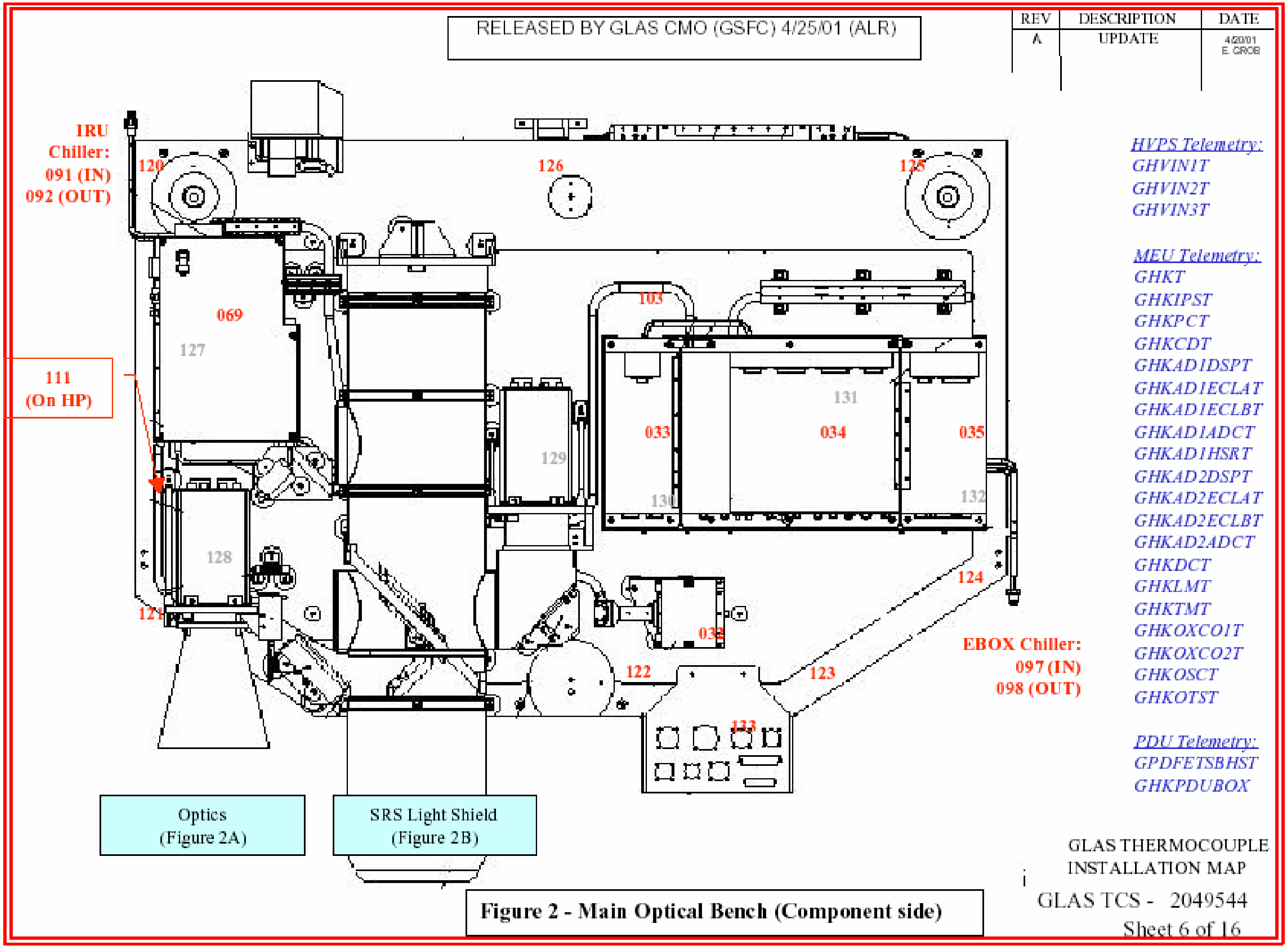


Figure 2 - Main Optical Bench (Component side)

Summary

- Thermo-mechanical motion of components (IST) has been clearly observed and measured by SRS and can be correlated to cooling component temperatures.
- Same effect is very likely to induce motion of receiver of 10's of arcsec per orbit. (About 28 arcsec was estimated by JBA pre-launch from T-Vac data).
  - Note that in T-Vac gradients were not induced, but they are present in orbit, adding thermo-mechanical stress.
- Receiver motion is biasing ocean sweep calibrations, as clearly stated by Scott. In fact, ocean sweeps are the "CRS" for the receiver !!
- Receiver motion produces a ranging error via moving the boresight shadowing function. However, it can be modeled through an "effective pointing" method.
- While receiver motion can be recovered from ocean sweep data, correlations with temperatures and gradients should be carried independently, at least as physical sanity check.
- Semantics: The term "pointing" should be reserved for transmitter pointing, to avoid confusion for the team and external users.
  - If "effective pointing" GLA06's are created, I propose "receiver biased pointing" instead as a definition.

GLAS Receiver Performance Assessment Update

Xiaoli Sun *et al.*
GLAS Instrument Science Team

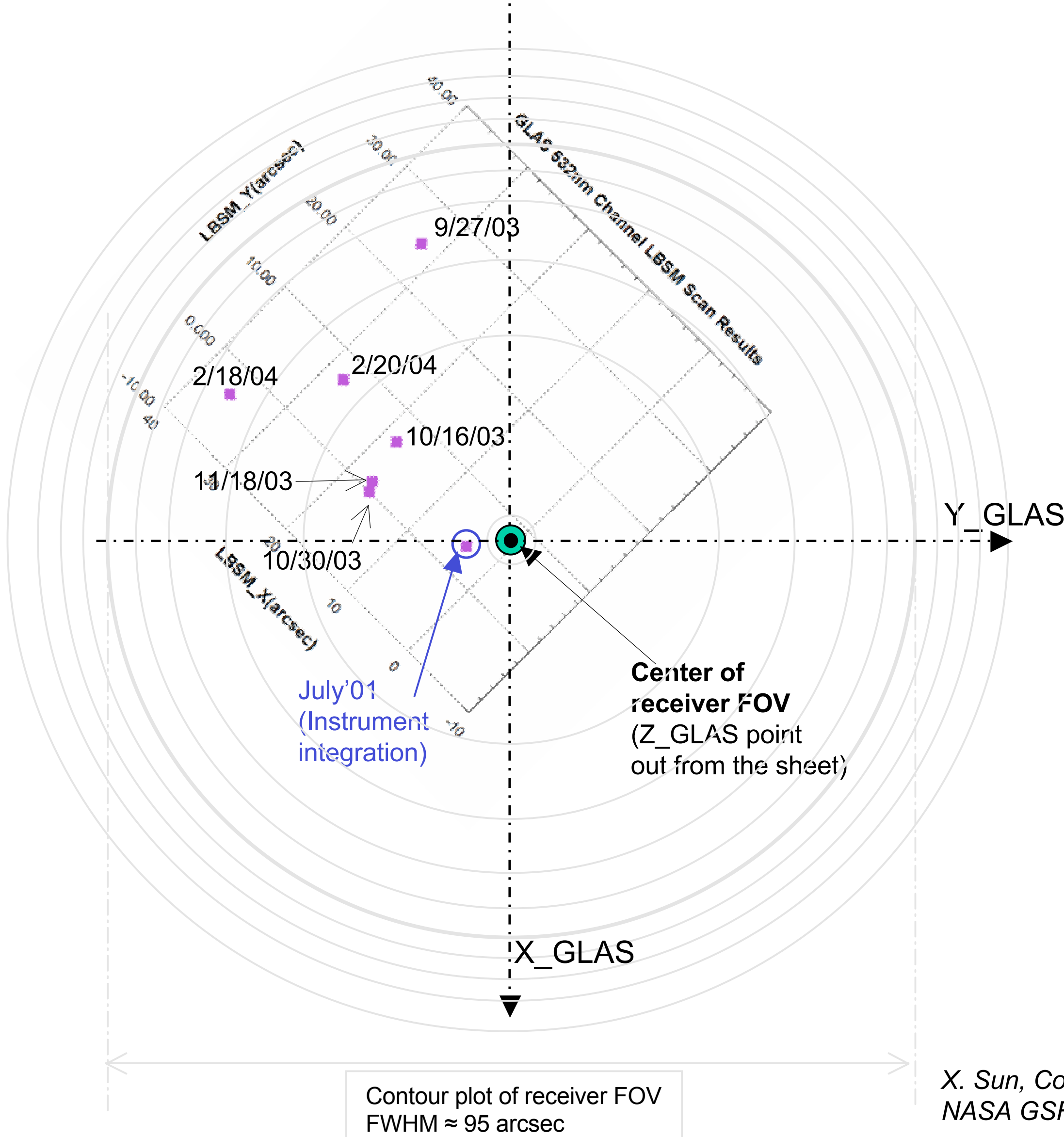
6-24-2004

Outline

- 1064 nm Bore sight assessment
- 532nm channel detectors (SPCM) status
- 1064nm altimeter channel range bias correction due to echo pulse saturation
- 1064nm altimeter channel minimum detectable signal

GLAS 1064nm Channel Bore Sight Shifts Summary as indicated by the 532nm Channel LBSM Scan Results

– Rev 3, 5/12/2004



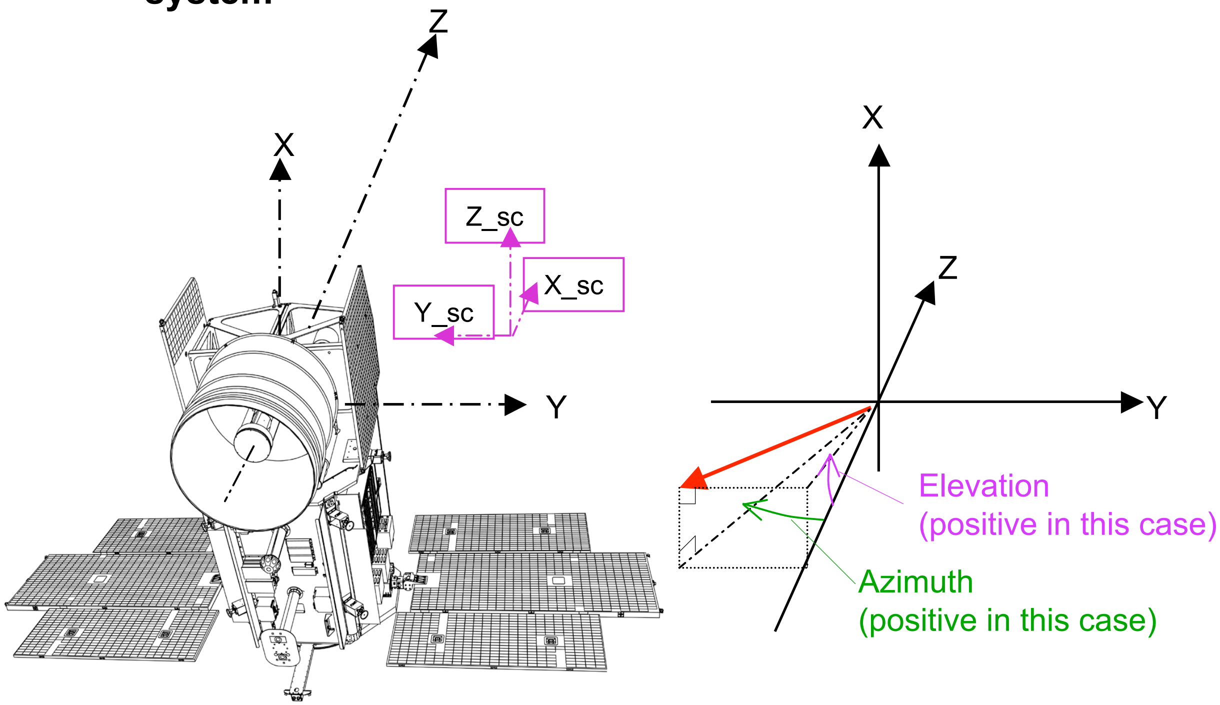
X. Sun, Code 924
NASA GSFC

ICESat/GLAS Angular Reference System – Rev. 3

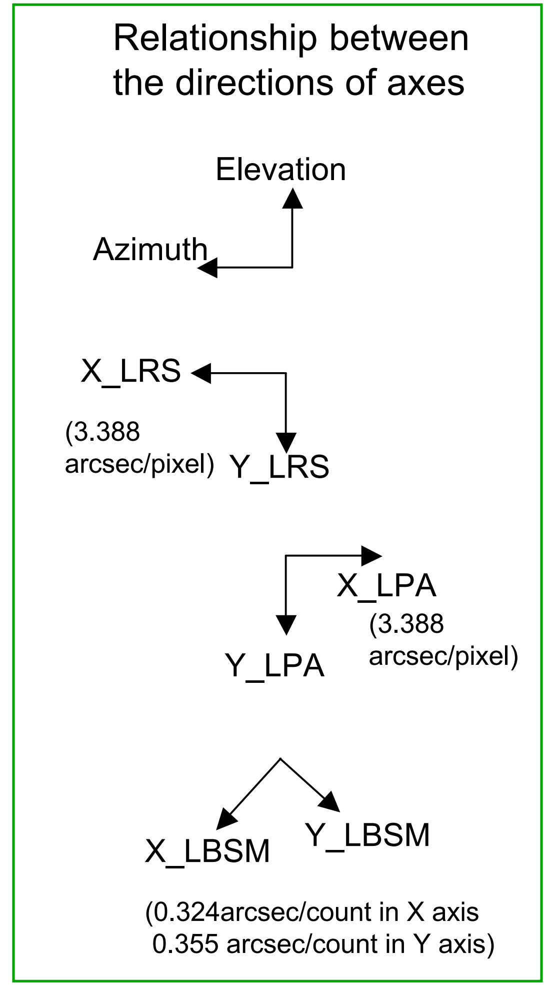
Xiaoli Sun, Marcos Sirota, Haris Riris, Steve Palm - 10-23-2003

The reference system we released earlier stays unchanged

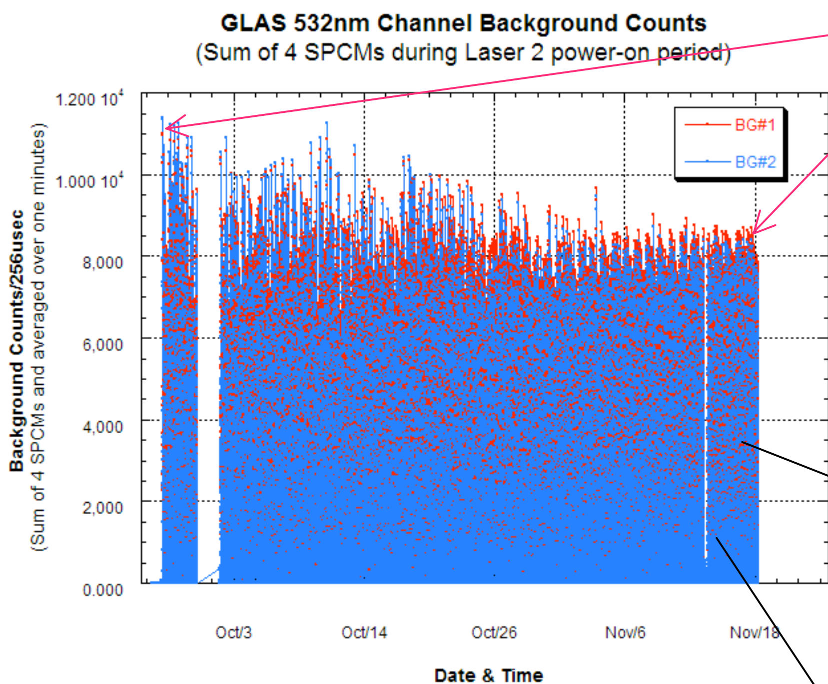
- **Definition of the angles and their relationship to the GLAS coordinate system**



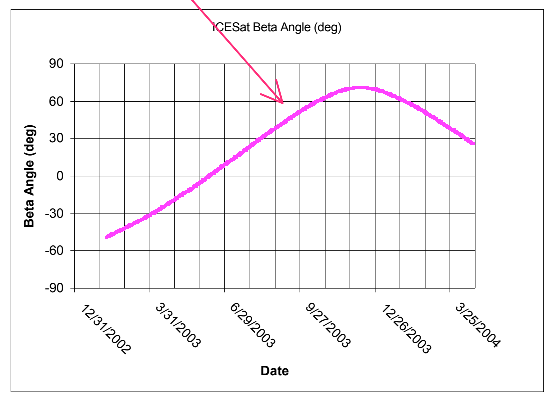
Front view

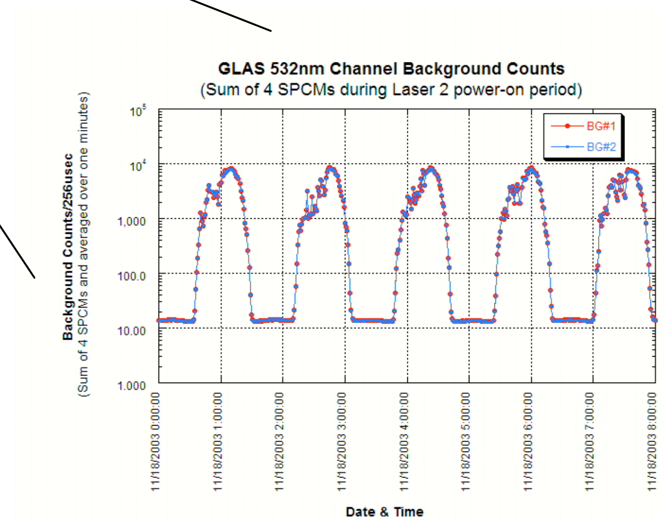


GLAS SPCM Background Counts - during Laser 2 Power on Period



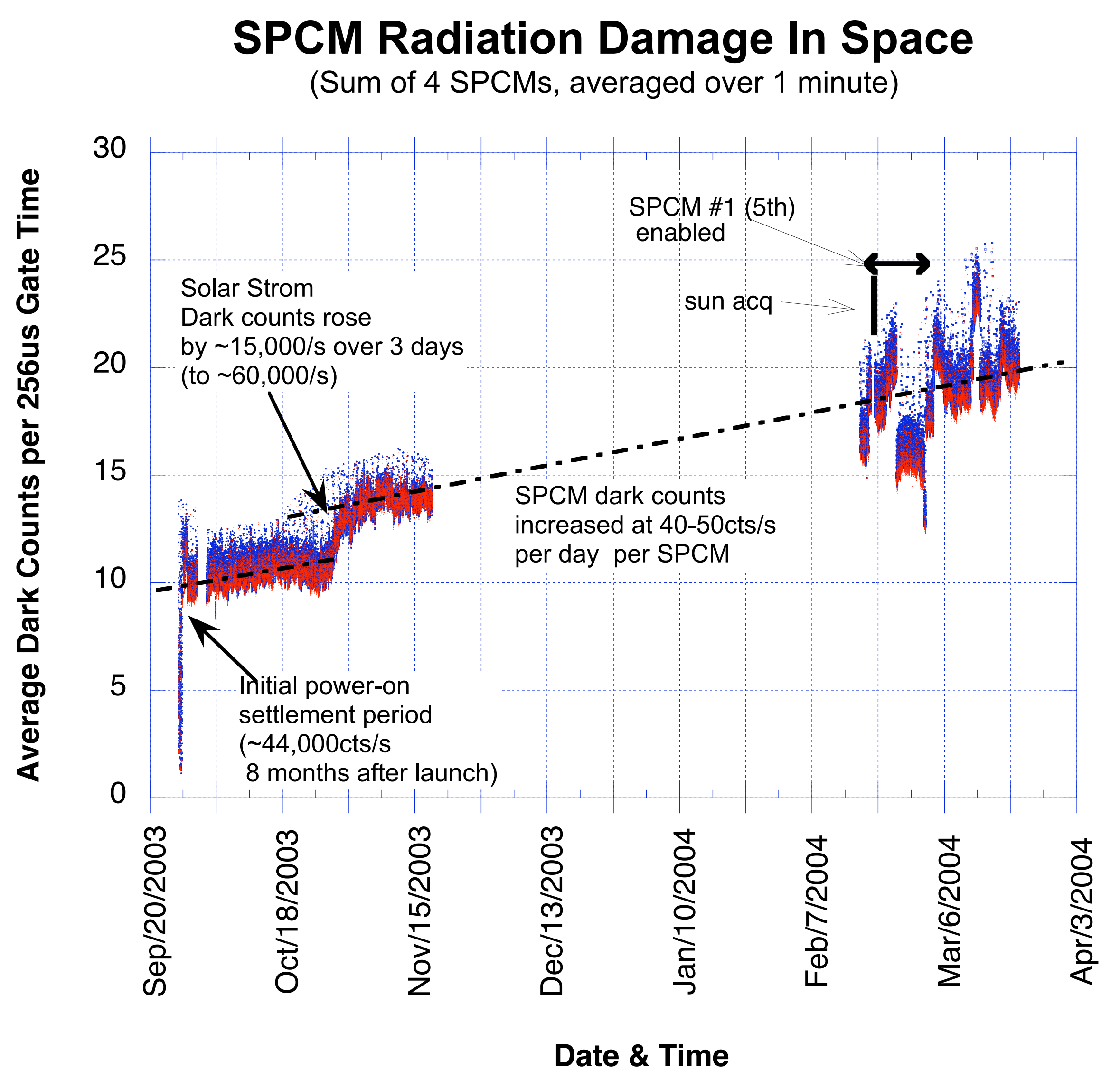
Peak daytime background light decreased slightly due to the slow rise of the beta angle (phase angle)





- Counts over 256 microseconds over the regions well before and after the laser pass through the atmosphere;
- Peak values represent maximum daytime background from sun lit earth surface;
- Minimum values represent SPCM dark counts

GLAS SPCM Background Counts
- during Laser 2 Power on Period (cont'ed)



GLAS Detector Saturation Characterization - Update

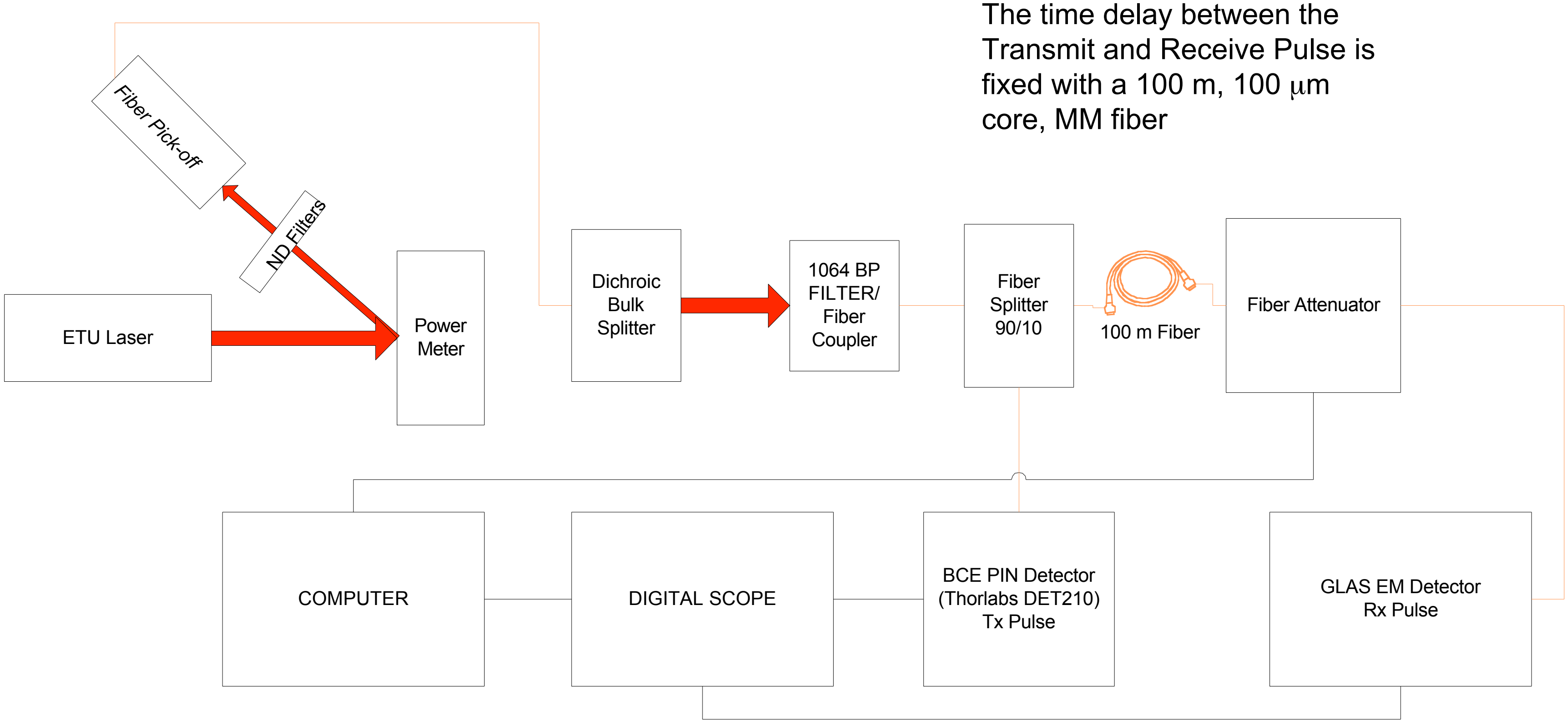
Haris Riris, Pete Liiva, Xiaoli Sun

6/24/2004

Experimental Setup

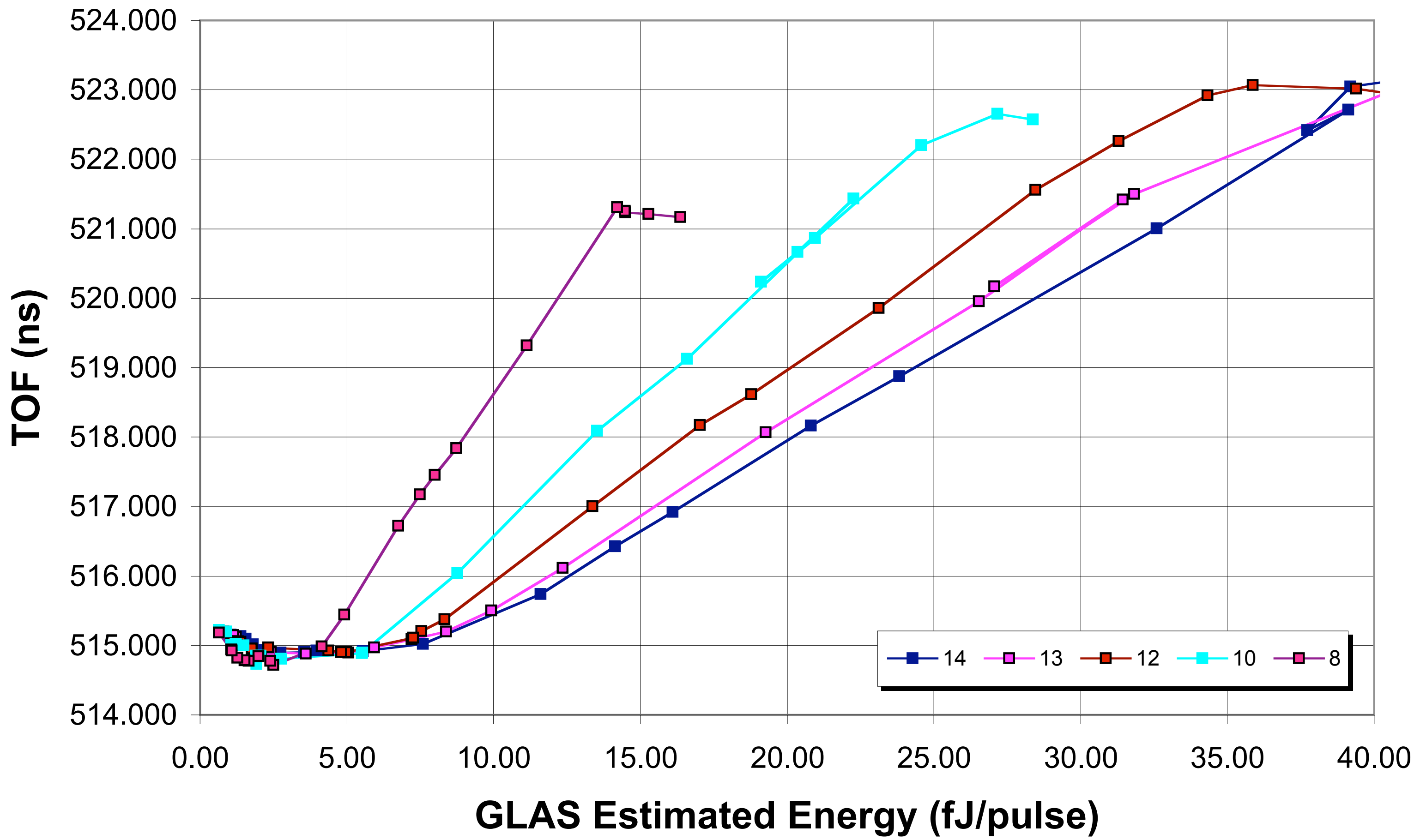
(Test conducted at SLTC before moving to GSFC)

The time delay between the Transmit and Receive Pulse is fixed with a 100 m, 100 μm core, MM fiber



Time-of-Flight Biases
vs. Measured Echo Pulse Energy

Data taken on 9/29/2003 (data from 11/25/03 show similar behavior)

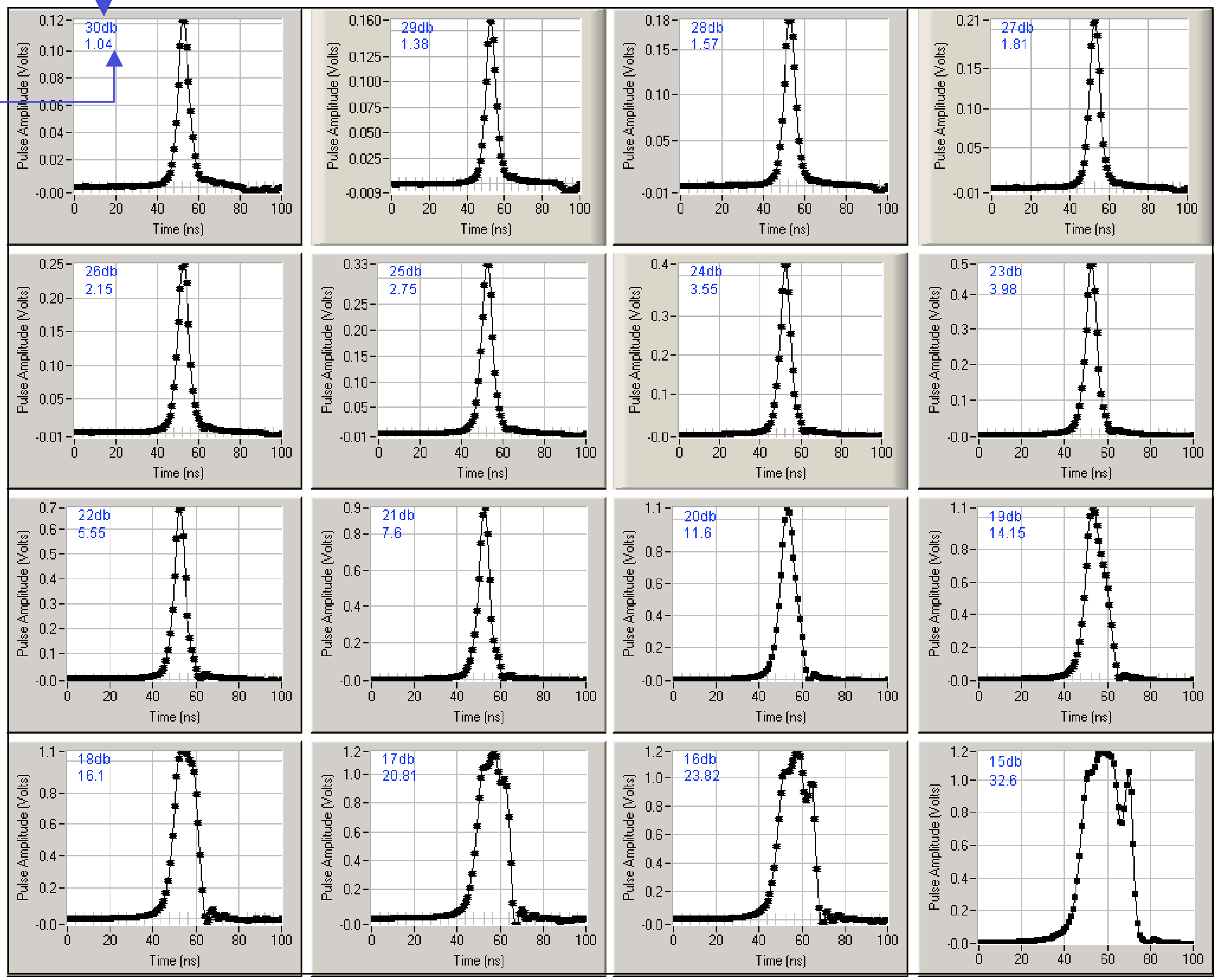


GLAS Waveform Samples – 9/29/2004 Test Data

Attenuator Setting (db)

Voltage Setting –0.890 Volts → Gain = 14; No of Averages = 1000

1.5 x GLAS
GLAS Energy
Estimate (fJ)



Saturation Corrections

- Measured echo pulse energy appears linear with the actual received pulse energy even under saturation;
- Time of flight biases appear to be linear with the measured echo pulse energy above a threshold - A piecewise linear correction algorithm may be applied;
- Correction coefficients vary with the gain setting;
- A minimum gain setting of 13-14 counts appears to give the optimal receiver dynamic range (linear + nonlinear-but-correctable);
- The correction coefficients may differ greatly between the flight spare detector used in the ground testing and the actual detector in GLAS (largely due to the difficulties in calibrating the input signal during the ground testing);
- Correction algorithm only applies to range measurement of flat and smooth surface with the detector gain at the minimum value;
- Saturation correction of other type of echo pulses may not be possible
  - Saturation at high detector gain due to the limited gain control loop response time
  - Specular reflection off water surface.

1064 nm Echo Pulse Saturation Correction Algorithm

- Applicable conditions:
  - Apply the correction algorithm when:
    - Peak echo pulse waveform ≥ N_{sat} (optimal value TBD, current best guess = 220)
    - AND detector gain = minimum (13);
    - AND surface slope < 0.5 degrees (based on DE or the along track slope measured by GLAS, or both)
    - AND echo pulse energy reported from GLAS ≥ E_{SAT}, with E_{SAT}= *TBD* (9- 13fJ/pulse)
- Correction to apply (to be added to the raw time of measurement)

  Delta Time-of-flight = - $alpha_{TOF}.(E_{echo} - E_{SAT})$

  With $alpha_{TOF}$ = TBD

  Current best guess for $alpha_{TOF}$ = 0.14 to 0.26 nsec/fJ

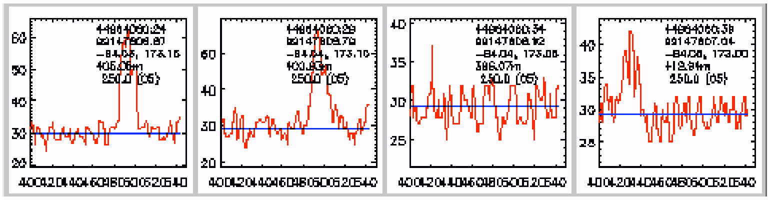
  - Notes:

    The flight GLAS detector characteristics may differ from the flight spare used in deriving the best guess coefficient values, E_{SAT}, and $alpha_{TOF}$. The flight coefficients need to be optimized with actual GLAS data via cross-over analysis or comparison with the ground truth.

Minimum Detectable Signal Level - 1064nm Channel

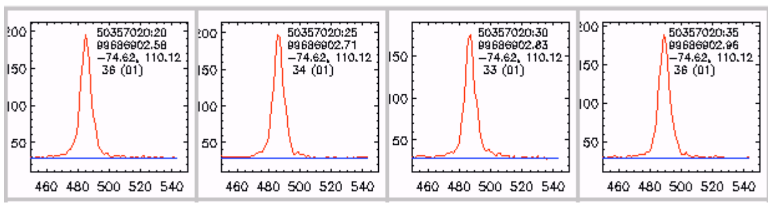
Sample Received Echo Waveforms

~0.05 fJ/pulse (minimum detectable)

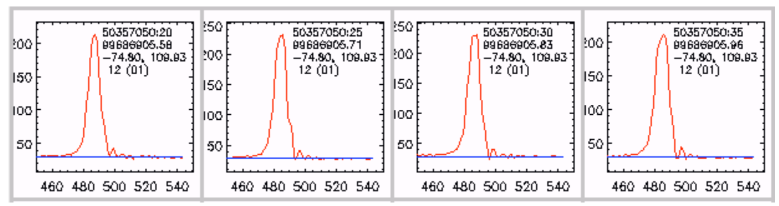


. . .

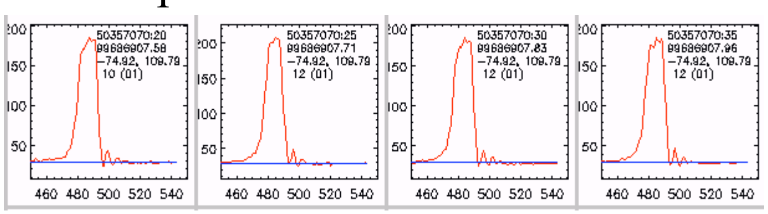
~5 fJ/pulse



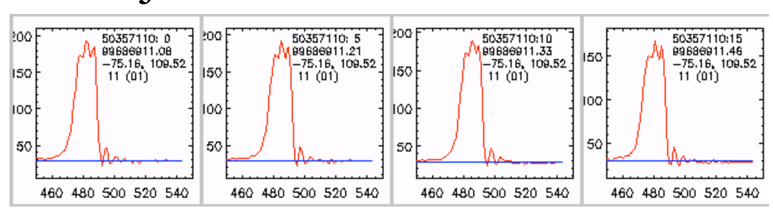
~13 fJ/pulse (just saturated)



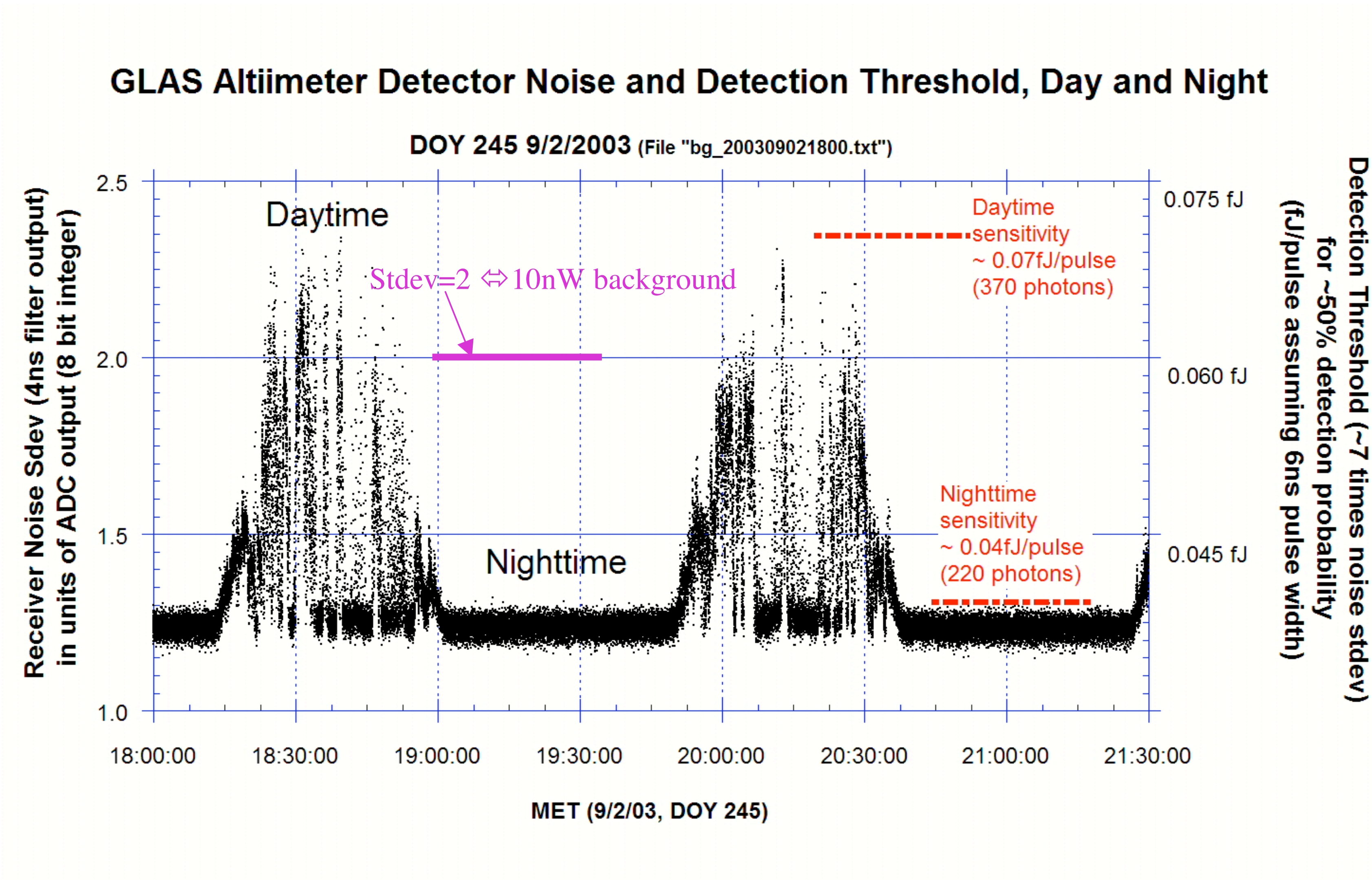
~18 fJ/pulse



~ 20 fjoules



Receiver Noise and Minimum Detectable Signal Pulse Energy



GLAS 1064nm Altimeter Receiver Sensitivity

- Minimum detectable signal level at 50% probability of detection: ~ 0.05fJ (270 photons);
- Minimum signal to achieve <0.1m ranging accuracy is about 5x the minimum detectable signal level or, 0.25 fJ/pulse;
- Average echo pulse energy over Antarctic is about 20 fJ/pulse at a transmitted laser pulse energy of 70mJ/pulse;
- The minimum laser pulse energy to achieve <0.1m ranging accuracy: (0.25fJ/20fJ) * 70mJ = 0.88mJ/pulse