TWO Color Laser Ranging with the TIGO SLR System

Status and First Results

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Abstract

TIGO (See [1]) is an abbreviation for "Transportable Integrated Geodetic Observatory". TIGO is a Fundamental Reference and Calibration Station for Geodesy. It houses all relevant geodetic space techniques. The task of TIGO is to provide data for creating geodetic reference points, especially in the southern hemisphere, to improve and to maintain the reference frames.

At the moment TIGO is located at Wettzell. It has passed the first tests and demonstrated its functionality. Now it is necessary to improve some parts and finish the integration.

The following report is about the status of TIGO's Laser Ranging Module.

1. TIGO-SLR: Status

In the year 1992 the Bundesamt für Kartographie und Geodäsie (BKG) has started the TIGO-Project. The development, construction and manufacturing of the SLR module lasts until the end of 1997. In the first quarter of 1998 the system was set up and preliminary tested. In April a collocation with the WLRS was done. During May and June a few improvements and "bug fixing" were carried out. Between July and September, while WLRS was under maintenance, the TIGO SLR module took over the routinely measurements of WLRS. **Table 1** summarizes the workplan so far.

Table 1: "Summary of the Schedule of the SLR Module"

Time	Action
1993 - Oct 1997	Manufacturing of the SLR Module
Nov 1997 - Dec 1997	Setup of the system
Jan 1998 - Mar 1998	First tests
April 1998	Collocation with WLRS
May 1998 - June 1998	Improving of the system
July 1998 - September 1998	Routine measurements

2. TIGO-SLR: First Collocation Results

During a collocation between WLRS and TIGO-SLR in April 1998 the first reasonable results were achieved.

More than 130 passes were measured and evaluated. A pass summary with respect to the satellites is given in **table 2**.

Table 2: Measured passes during the collocation with WLRS

Satellite	Number of passes
Ajisai	30
Lageos1	34
Lageos2	5
Topex	2
Stella	16
Starlette	19
Resurs	4
ERS2	12
Fizeau	7
Glonass67	2
Etalon1	1
GFO1	4
Glonass71	1
Sum	137
Used for Collocation	95
Useful in infrared	80
Useful in blue	82
Useful in infrared and blue	66

The reasons for having not always results in both colors simultaneously, are mainly alignment errors and the higher attenuation of the blue light in the atmosphere.

The passes which had returns in the infrared as well as in the blue were analyzed with the simultaneous measurements done by WLRS. In **table 3** the rangebias between the two stations are listed.

Table 3: Calculated Rangebias of the Collocated Passes

		Rangebias (m)	
Satellite	Passe	Infrared	Blue
Ajisai	24	0.000	0.011
Lageos1	11	-0.015	0.003
Lageos2	3	0.010	0.024
Stella	6	-0.010	0.029
Starlette	9	-0.007	0.022
Resurs	1	0.034	0.055
ERS2	8	0.011	0.041
Fizeau	4	-0.002	0.031
Sum	66	-0.002	0.019

The comparison of the measurements between TIGO and WLRS delivered a mean rangebias of 2 mm with the infrared light and 2 cm with the blue light.

Table 4 is an extract of the Quicklook report of the University of Texas and certifies also respectable results.

Table 4: Extract of the Quicklook Residual Analysis Report of the University of Texas Austin/Centre for Space Research

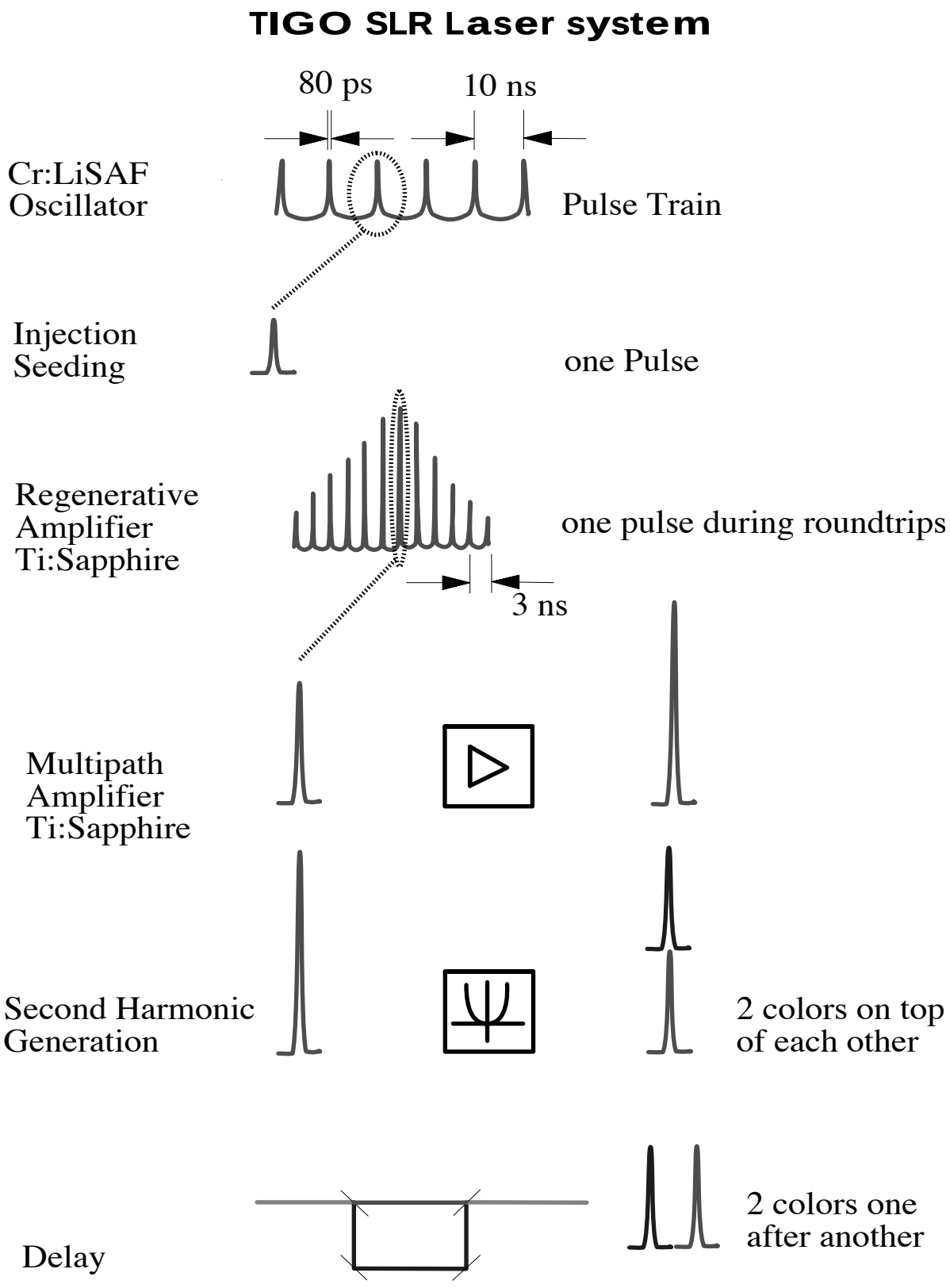
		Good OBS	Raw rms (mm)	Range bias (mm)
Satellite	Passe	Mean	Mean	Mean
Lageos1	32	15.3	17.5	-1.6
Lageos1	9	9.1	20.9	7.8

It turned out, that the most important factor for the quality of the data is the adjustment and the stability of the Titanium Sapphire laser system. If the laser is well tuned the results are pretty good.

The rough environment in the container and the "room saving" construction of the laser however, is the reason for the slightly decreasing quality of the laser adjustment, witch leads to inaccurate results.

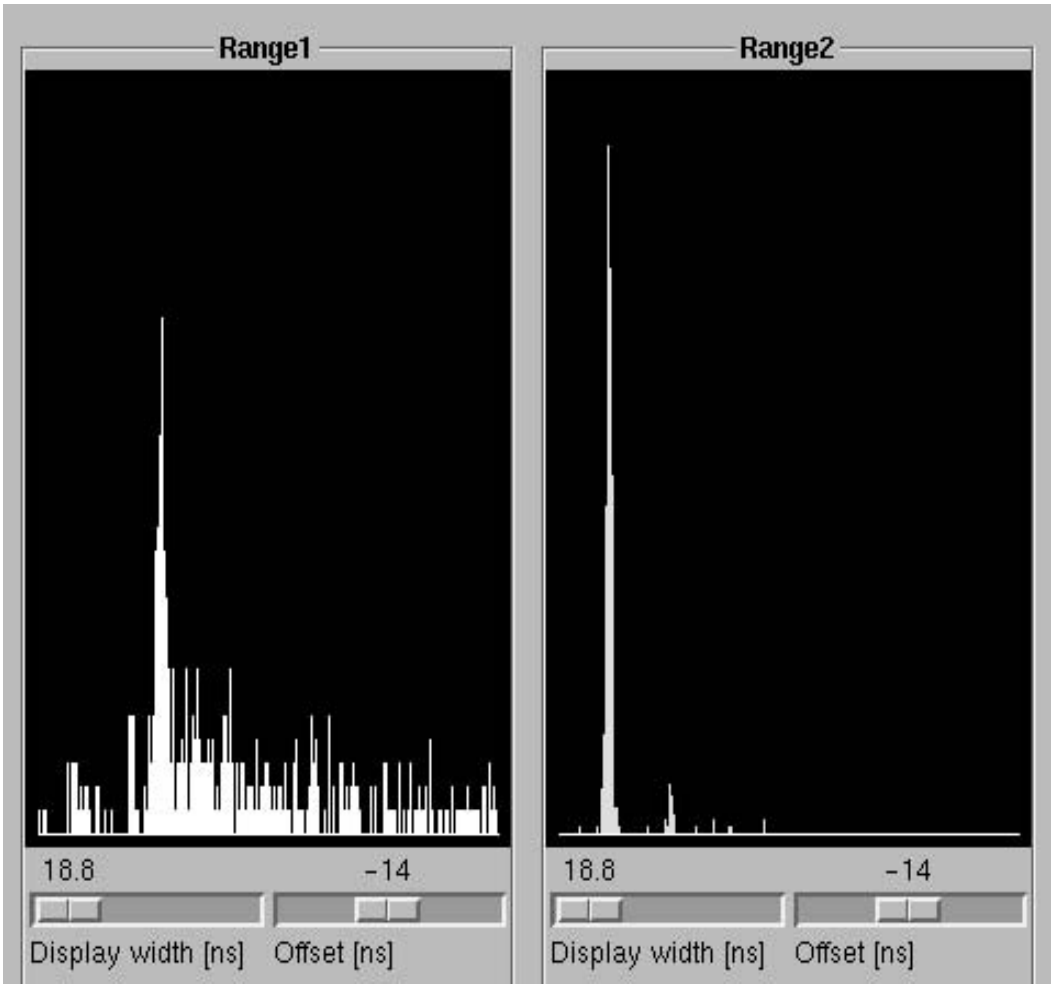
3. TIGO-SLR: Discussion of the results

Picture 1 shows the principle of the laser system. The Cr:LiSAF oscillator produces a pulse train with a pule rate of 100 MHz. Ten times a second one pulse out of that pulse train is coupled into the regenerative amplifier. The length of the cavity is about 0.9 m which leads to the time of one roundtrip of about 3 ns. When the laserpuls has reached it's maximum energy, it leaves the regenerative amplifier and passes two multipath amplifiers to gain energy. After the second harmonic generation, two dichroic mirrors delays the blue laser pulse to spread the laserpower over the time which should save the transmitting optics. The adjustments of the laser system is not easy, especially in the rough "container environment". A bad adjusted laser transmit not only one pulse, but a kind of pulse train, with all distances of pulses resulting from mixing 10 ns pulses with the cavitylength of 3 ns. That means the outgoing pulse is a mixture of pulses, or lets say the pulse gets very broad. This phenomena happened a few times during the collocation and produced unusable results.



Picture 1: Principle of the TIGO-SLR Laser system

A second attribute was also noticed while analyzing the results. The CSPAD detector, used in at the infrared wavelength, produces not a gaussian copy of the shape of the laser pulse, but contains a not deniable "tail" witch also has an effect on the accuracy of the measurement. In **picture 3** the histograms of a typical calibration is shown.



Picture 3: Histogram of the detected ranges during a calibration in infrared and blue light

4. TIGO-SLR: The near future

As the TIGO-SLR module should be easy to use and to maintain, especially under field conditions, it is necessary to achieve high compatibility with the WLRS Laser Ranging System. Therefore some adoptions in aspect to the controlling soft- and hardware have still to be done. Further it is necessary to gain more stability in the laser system to reduce the effort of man power to keep the laser running. Nevertheless the TIGO-SLR module is on the way to become a high accurate ranging data production instrument.

References

[1] W. Schlüter, et al.: **TIGO - Transportable Integrated Geodetic Observatory. A Fundamental Station for Geodynamic Research**, paper presented at, XXIII Brazilian Congress of Cartography, Scientific Assembly of the International Association of Geodesy, Rio de Janeiro, September 3-9, 1997