Poster 1839

SLR Station 1884 Riga
Upgrading the Station Calibration Procedures

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General Background

The SLR station 1884, Riga uses a calibration optical path which is different from the tracking optical path.
A small fraction of the outgoing laser beam is extracted, feed to an optical fiber with sufficient length (>25m) to avoid ET "dead time", and injected into receiver path using a small prism just before the FOV diaphragm.

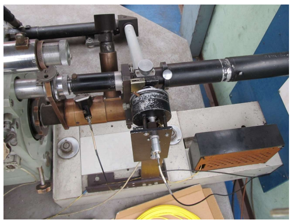
In order to measure and apply the system delay correction when the calibration laser pulse pass through the SLR telescope, only the distance between the SLR Invariant Point to the calibration target ($\mathbf{D_{IP-LRR}}$) has to be known.

In our configuration, we need to know only the length difference between the calibration path ($\mathbf{d}_{CP}$) and the Invariant Point distance correction ($\mathbf{IP}_{DC}$).

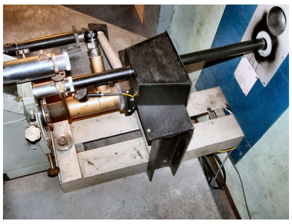
The length difference $(\mathbf{IP_{DC} - d_{CP}})$ can be determined experimentally.

The goal was to improve calibration accuracy and stability, improve station workflow and to introduce additional QC procedures.

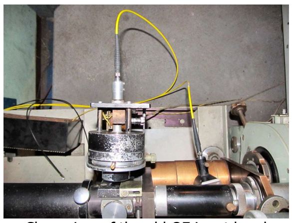
Before | **After**



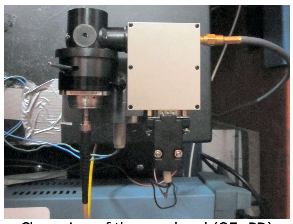
Output prism & old OF input head



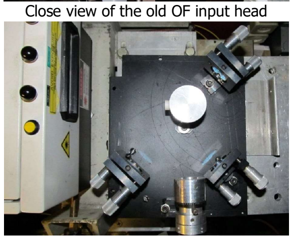
Output prism & new optical path selector



Close view of the old OF input head



Close view of the new head (OF+PD)



Beam mirrors & Start PD on IR channel

laser, laser beam directing mirror
and combined OF input head + start PD head
the OF Thermal Box below (white)

Hardware Upgrades

- •A single-mode calibration optical fiber (**OF**) in place of the old multi-mode fiber.
- •Hamamatsu H11901-20 PMT + Hamamatsu C5594 Amplifier for the stop channel.
- •Hamamatsu APD module C5658 PD for the start channel.
- •Optimized parameters for the start and stop channels like delay cable length, CFD parameters and filter settings.
- •A new optical head shared by the Start PD and the OF optics.
- •The Start PD signal moved from the IR laser beam to the green laser beam.
- •Using the green "leak" from the laser beam directing mirror as the source for the OF and the Start PD.
- •By eliminating the old OF head beam-splitter, the laser beam tracking power increased by ~4%
- •The laser, laser beam directing mirror and optical head are installed on a new optical bench.
- •Improved laser room thermal control, almost all of the OF length (23/25 m.) stored in a thermal box.
- •A new switch allows remotely selecting between the tracking and calibration paths.

Software Upgrades

- •Amplitude compensation to a fixed amplitude reference value for all the TOF data (calibration and ranging).
- •Observer's biases are eliminated by using calibration data automatic filtering.
- •The calibration drift is applied now, using pre-and post-pass calibrations done in a 1-hour time window.
- •All the generated data is archived automatically for further analysis.
- •Several software applications are used to monitor the system stability.

Determining The Riga System Delay Parameters: The Theory

If we define as:

Δt_{OF} time of flight using the optical fiber path.
Δt_{LRR} time of flight using the LRR @ SLR Telescope path.
Δt_{EPP} the electronic processing time.
$\mathbf{D_{IP-LRR}}$ the ***known*** distance Invariant Point-LRR prism.
$\mathbf{d}_{CP}$ the **C**alibration **P**ath Length.
$\mathbf{IP}_{DC}$ the **I**nvariant **P**oint distance correction.

Assuming that Δt_{EPP} and it's drift are the same for both paths:

$\Delta t_{LRR} = \Delta t_{EPP} + D_{IP-LRR} + IP_{DC}$
$\Delta t_{OF} = \Delta t_{EPP} + d_{CP}$

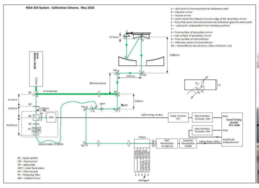
then, the Riga system delay correction parameter can be found as:

$(\mathbf{IP_{DC} - d_{CP}}) = (\Delta t_{LRR} - \Delta t_{OF}) - \mathbf{D_{IP-LRR}}$

Alternating calibrations runs between the OF and LRR configurations, the Δt_{OF} and Δt_{LRR} values can be interpolated to a common epoch in order to determine the value $(\mathbf{IP_{DC} - d_{CP}})$.

Each data set was amplitude compensated to the fixed amplitude reference value used in regular tracking, and filtered using 2.5σ.
Typical RMS for each set ~56ps.
The Station meteorological data was interpolated to each data set point epoch for the n_{air} evaluation used in the $\mathbf{D_{IP-LRR}}$ correction.

Determining The Riga System Delay Parameters: The Experimental Setup



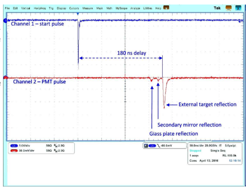
Calibration General Scheme

LRR measurement setup

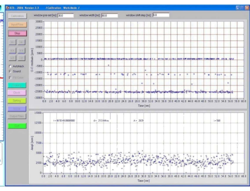
To isolate the LRR return signal:

- •A glass plate used as a beam splitter is installed in place of the transmitting path rotating mirror.
- •The laser beam is attenuated using neutral filters.
- •Masks are used on the transmitting path and a the center of the secondary mirror.

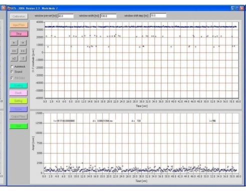
1.- Laser Beam Attenuating Filter.
2.- LRR on the secondary mirror.
3.- Secondary Mirror Central Mask.
4.- Laser Beam Splitter.
5.- Mask on the laser beam path.



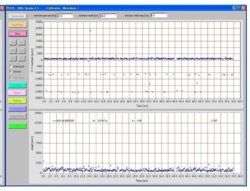
Signals using the unmasked LRR



LRR signals with the unmasked setup

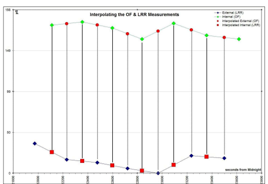


Optical Fiber signal



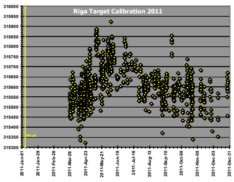
LRR signals with the masked setup

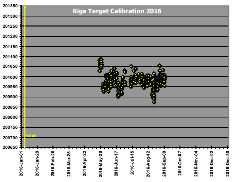
Determining The Riga System Delay Parameters: Results

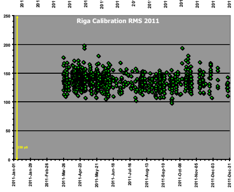


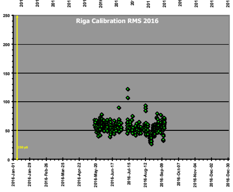
2.5 RMS	Ext interpolated	Int interpolated	Mean 2 Sets	Diff	All
	90854.046	90864.917			90854.046
	90868.819	90866.952			90868.819
	90866.873	90863.568			90866.873
	90859.658	90872.504			90859.658
	90871.970	90852.727			90871.970
	90847.364	90846.569			90847.364
					90864.917
					90866.952
					90863.568
					90872.504
					90852.727
					90846.569
Mean:	90861.455	90861.206	90861.330	0.249	**90861.330**
Sigma:	9.496	9.655	9.576	0.160	**9.131**
Max	90871.970	90872.504	90872.237	0.534	**90872.504**
Min	90847.364	90846.569	90846.966	0.795	**90846.569**
Range	24.607	25.935	25.271	1.329	**25.935**

Experimental Results

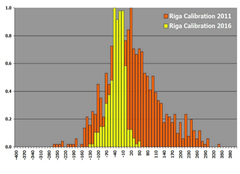


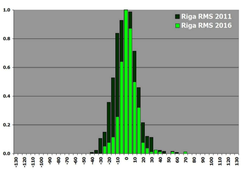




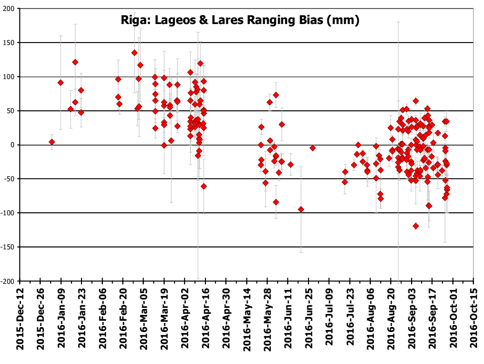


Same laser, same Event Timer



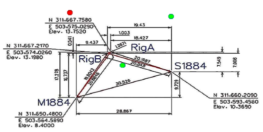


Normalized to mean and max bin



Range bias after implementing the April 2016 $(\mathbf{IP_{DC} - d_{CP}})$ value.

Determining The Riga System Delay Parameters: The Next Steps



In 2016, the potential new sites for additional three geodetic reference points were surveyed, marked as a green and red dots in the plan.

The places marked as green dots, will serve also as new external calibration targets.

Once the new external targets will be available and new $\mathbf{D_{IP-LRR}}$ values will be known, we will compare the results with the previous calibration results.

Acknowledgements:

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