Progress on the implementation of two-color high count rate laser ranging at Grasse

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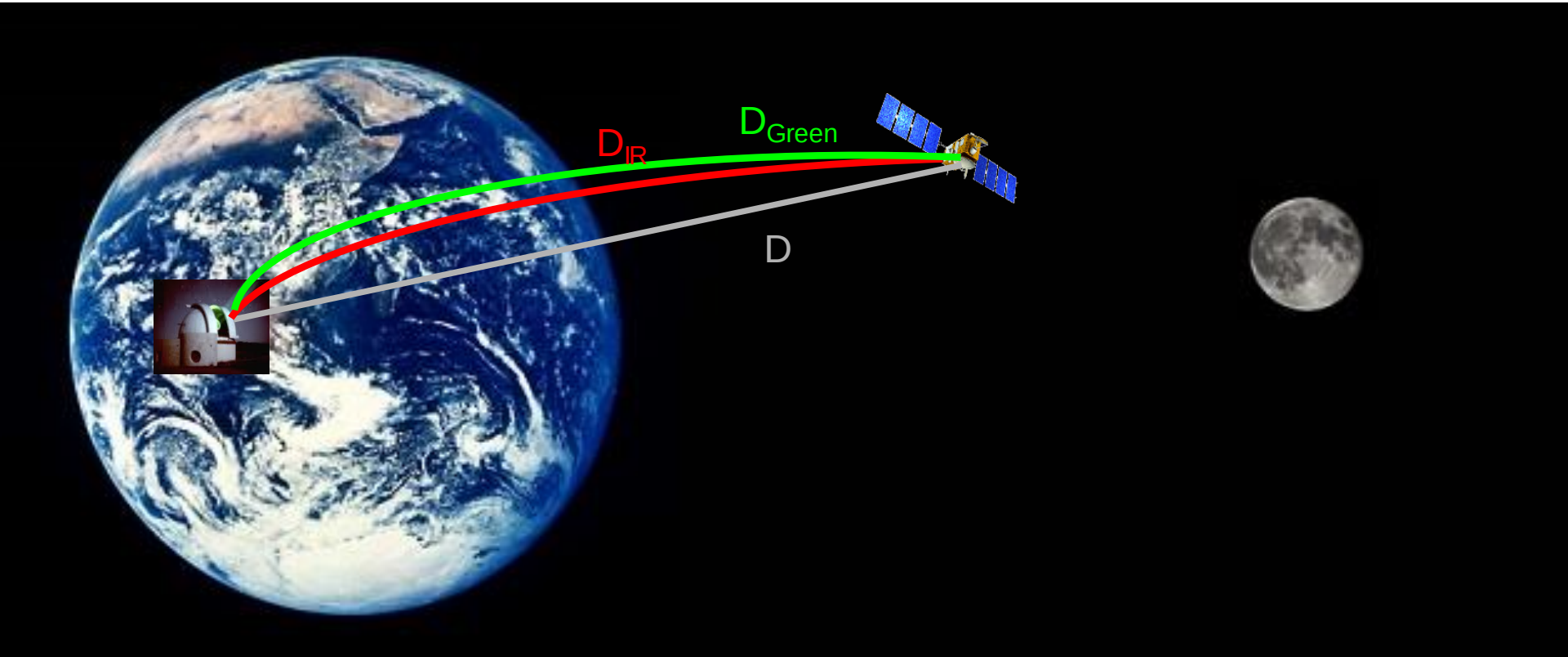
Our motivation:

2 colors measurement at the mm level

$$D = D_{Green} + A\,(D_{Green} - D_{IR})$$

=>

Requires an high improvement of the time-of-flight measurement on the both wavelength.



What is it necessary to implemented ?

High repetition rate SPAD

Collaboration in 2014 with

And with the help of the

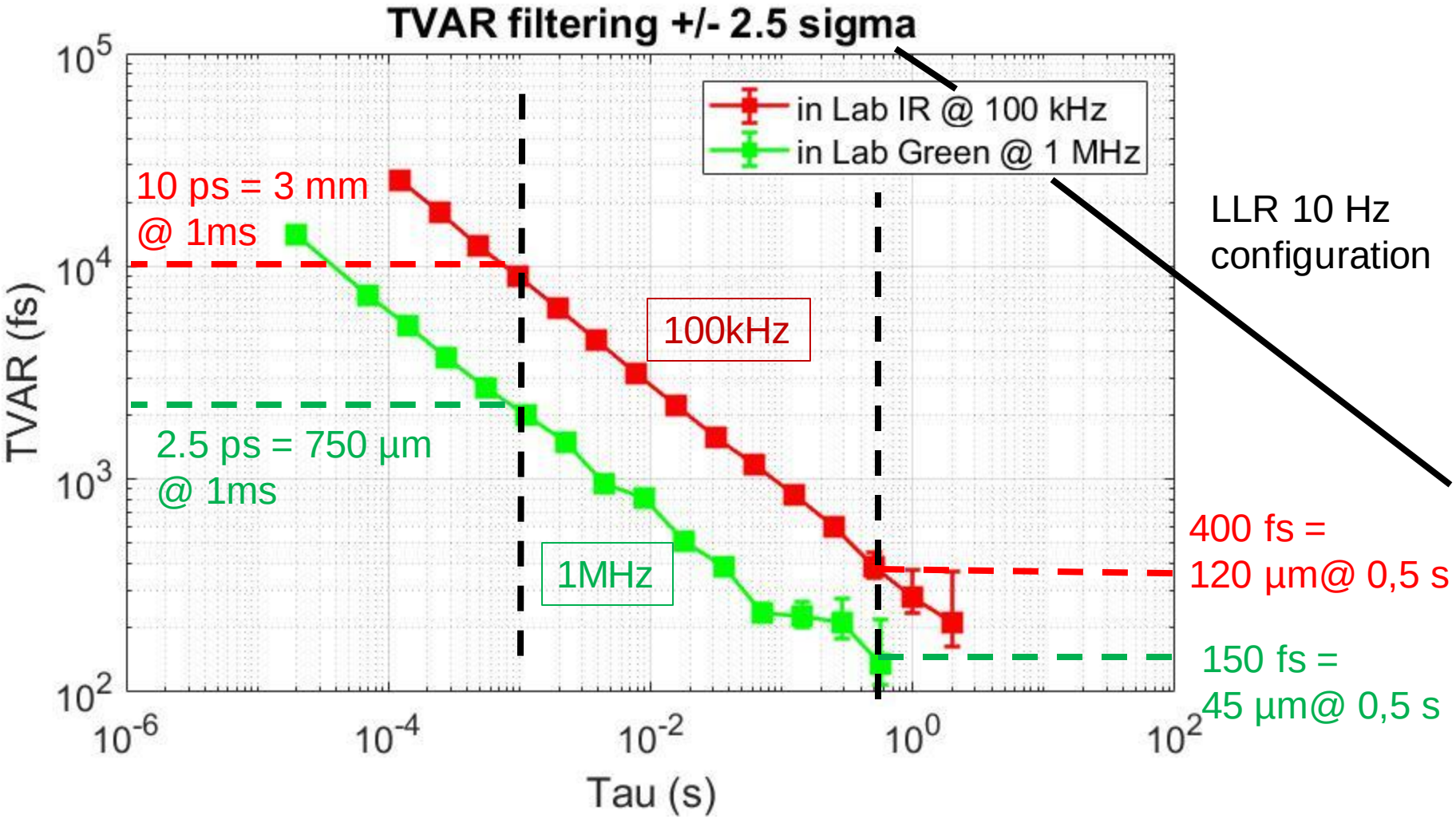
Development of two high repetition rate SPAD detections

Si-SPAD	
Active area diameter	100 µm
Max repetition rate	1 MHz
Timing jitter	33 ps FWHM
DCR @ 7 V	74 Hz
Quantum efficiency	53% @ 532 nm

InGaAs-SPAD	
Active area diameter	50 µm
Max repetition rate	100 kHz
Timing jitter	76 ps FWHM
DCR @ 7 V	200 kHz
Quantum efficiency	47% @ 1064 nm

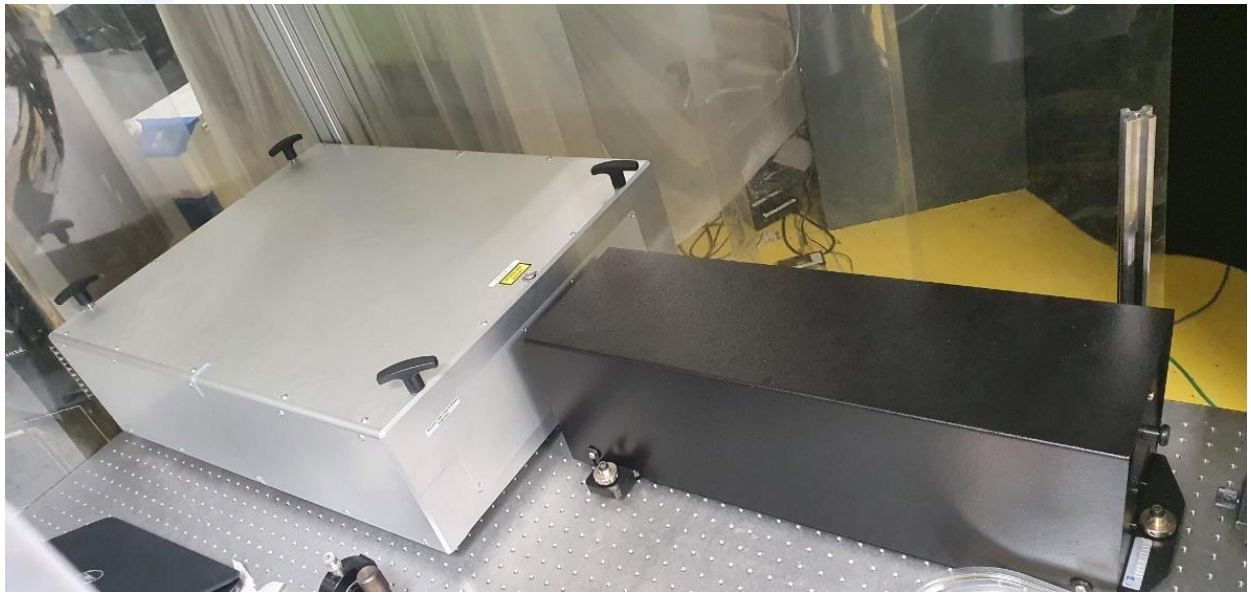
Characterization in Lab

Calibration on corner cube



Works in progress at GRSM

Reception of a Coherent HyperRapid laser in 2020 + beam expander



With the support of

10 ps FWHM

100 W @ 400 kHz

Adjustable pulse repetition rate between 100 Hz to 4 MHz

Works in progress at GRSM

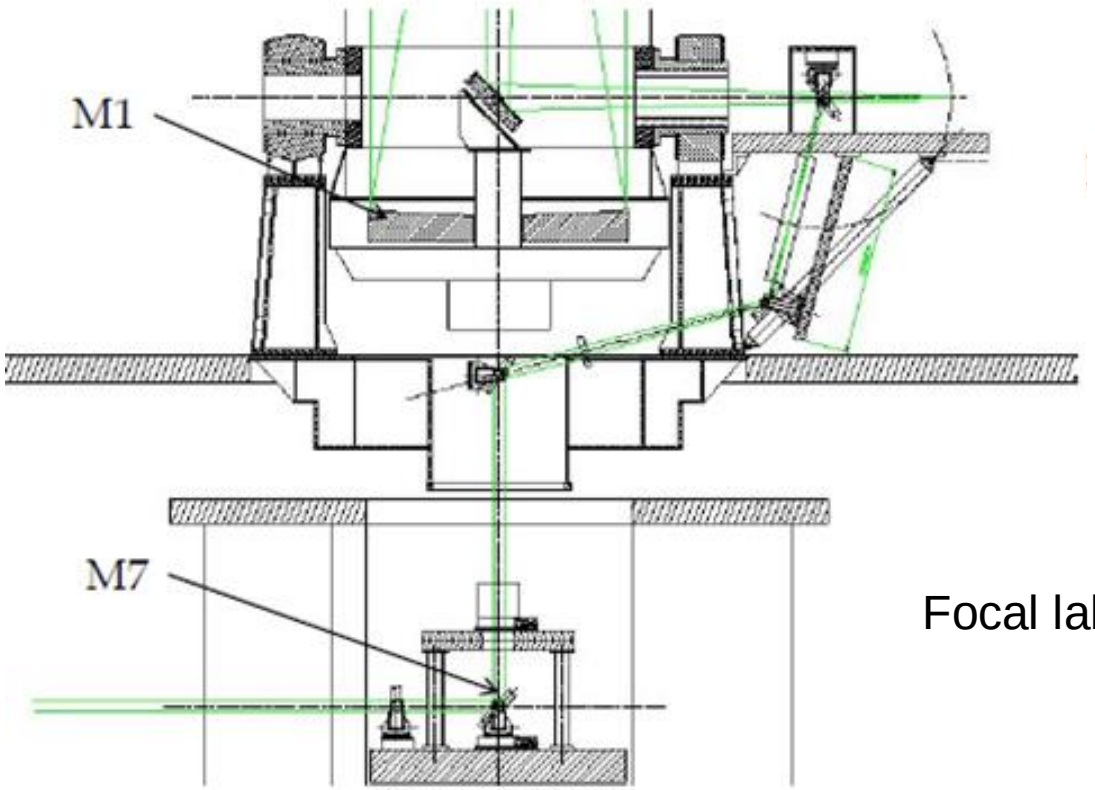
	Specification	Measurement
Beam Quality Parameter M^2	≤ 1.3	1.11
Beam divergence, full angle (mrad)	≤ 1	0.72
Beam diameter, 1 m in front of laser (mm)	N/A	2.4
Beam circularity, 1 m in front of laser (%)	≥ 85	97.9
Average power (W)	100W	101.0
Average power stability over 8 hours, within +/- 1°C, RMS 1σ (%)	≤ 1%	0.48
Pulse energy max (µJ)	250µJ	252
Pulse-to-pulse energy stability over 1000 pulses, RMS 1σ (%)	≤2%	0.90
Pulse length, IR (ps)	≤ 15	10.3
Central Wavelength @ 1064 nm [nm]	1064	1064.1
Spectral Emission bandwidth @ 1064 nm	N/A	205pm
Temperature max Power 1064nm	N/A	42.5

	Specification	Measurement
Beam Quality Parameter M^2	≤ 1.3	1.05
Beam divergence, full angle (mrad)	≤ 1	0.39
Beam diameter, 1 m in front of laser (mm)	N/A	1.9
Beam circularity, 1 m in front of laser (%)	≥ 85	99.5
Average power (W)	50W	68.5
Average power stability over 8 hours, within +/- 1°C, RMS 1σ (%)	≤ 1%	0.60
Pulse energy max (µJ)	125µJ	171
Pulse-to-pulse energy stability over 1000 pulses, RMS 1σ (%)	≤2%	0.81
Central Wavelength @ 532 nm [nm]	532	532
Spectral Emission bandwidth @ 532 nm	N/A	72pm
Temperature max Power 532nm	N/A	59.8

Works in progress at GRSM

From rotating mirror @10 Hz to aperture sharing for 400 kHz

First implementation of the G & IR SPADs in the focal lab



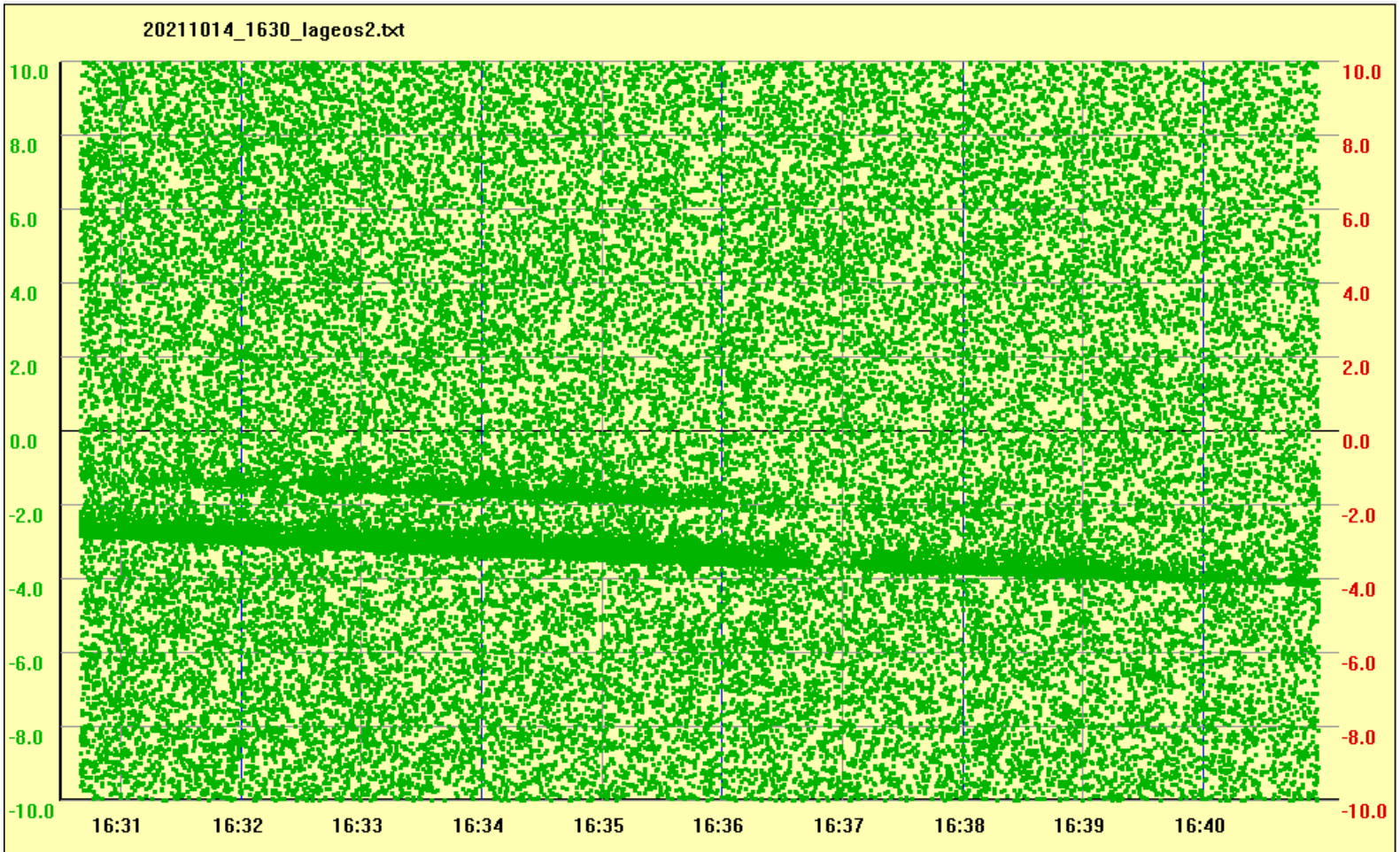
Nasmyth table

Focal lab

September 2021: green SPAD implementation in the Nasmyth table

Works in progress at GRSM

October 2021 :
First measurements on Ajisai, Lares, Lageos, Galileo during night/day light @ 4kHz in green

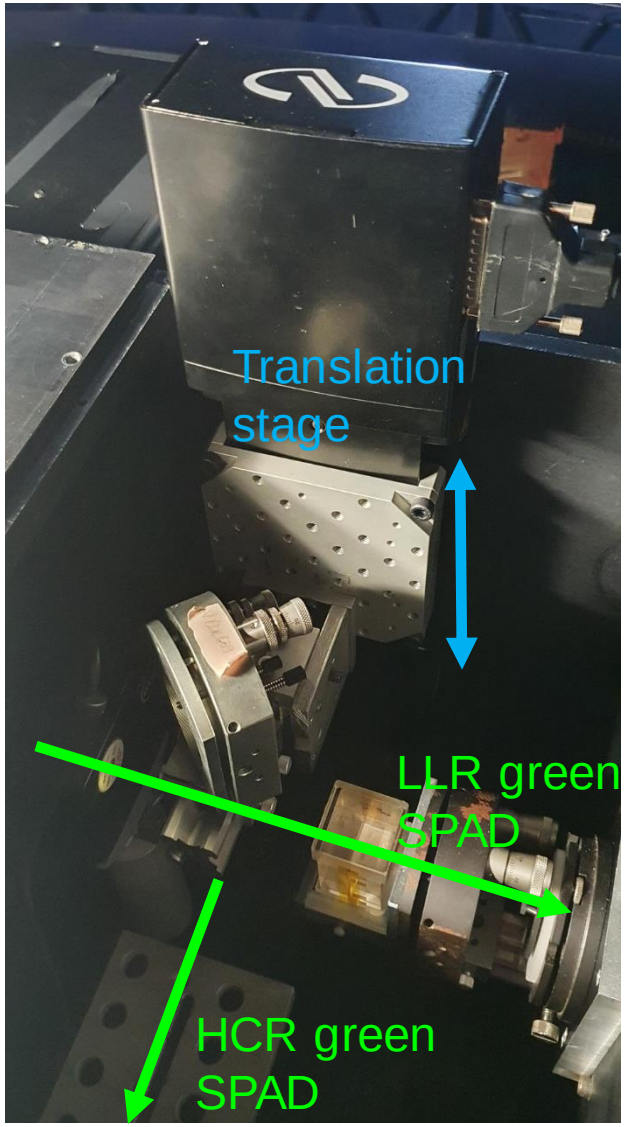


Works in progress at GRSM

Measurement stopped => too strong backscattering
Detection triggered without apply the voltage above the breakdown.

We decided to implement burst mode operation like in Graz with the addition of a chopper wheel to physically block the backscattering during firing.

July-August 2022: implementation of the IR SPAD in the Nasmyth table + translation stages to switch quickly between « LLR setup » to « HCR SLR setup »



And in september 2022, we have our first campaign with this setup:
=> **Metrological validation of the new instrumentation on ground**

Geometre project: first results

The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

Objectives:

Compare the Arpent long range distance meter developed by LNE-CNAM (sub-mm accuracy) to the new two-color SLR setup at GRSM and to the tie done by IGN

2587.402 meters

Close corner cube

Distant corner cube

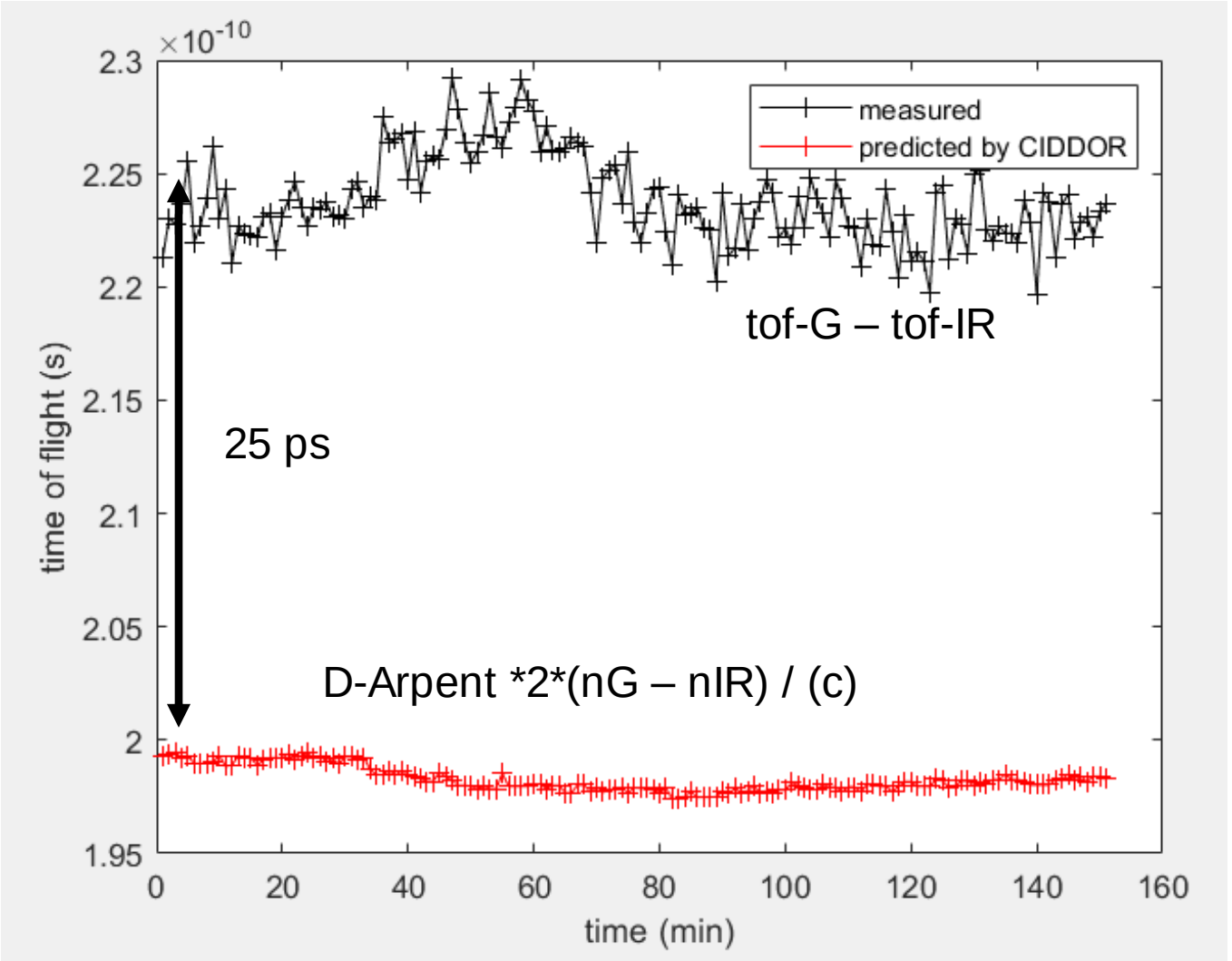
ARPENT laser telemeter in front of the GRSM telescope

2 experiments in september 2022:

1) Relative distance measurement between two corner cubes with 2 different 2-color instruments

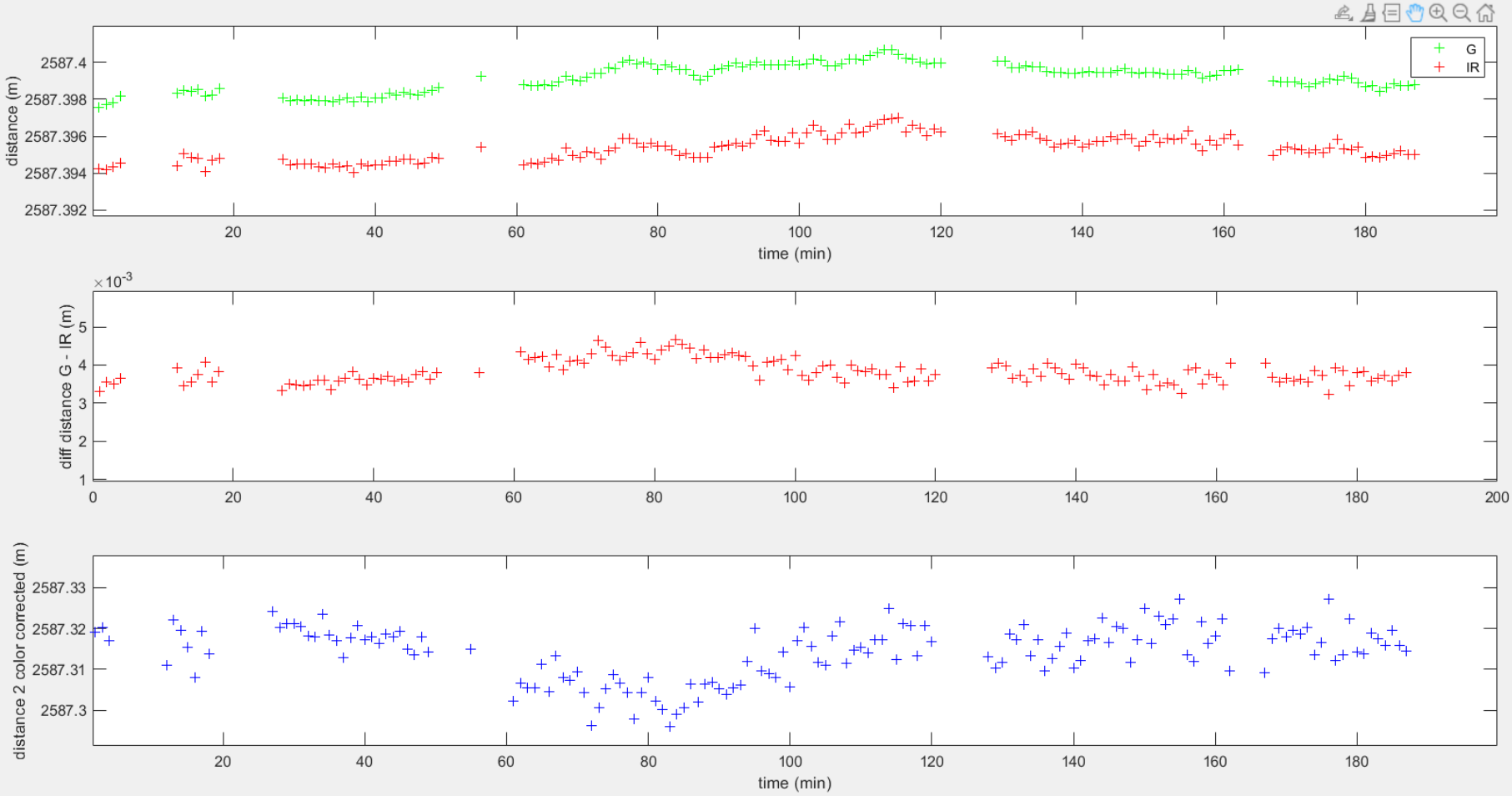
2) Displacement over 1 cm and back with mm steps

Geometre project: first results



Geometre project: first results

1st experiment @ 10 kHz
Atmospheric model used : CIDDOR



Geometre project: first results

Sampling (1 min)	A (Ciddor)	diff_Distance_G	diff_Distance_IR	D_2color
Mean (m)	21.1845	2587.3992	2587.3954	**2587.314**
Std (m)	15.294e-003	0.7E-3	0.7E-3	**6.6E-3**

In G, concordance with CNAM&IGN @ 2 mm

In IR, concordance with CNAM&IGN @ 5.5 mm

2color not good in absolute & the correction doesn't reach mm level.

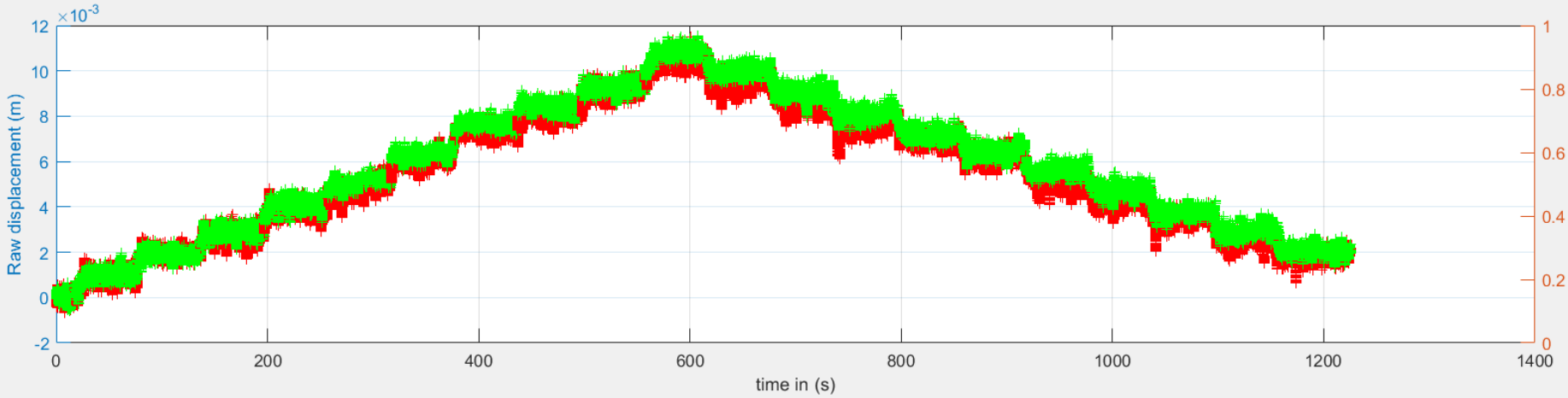
Under investigation

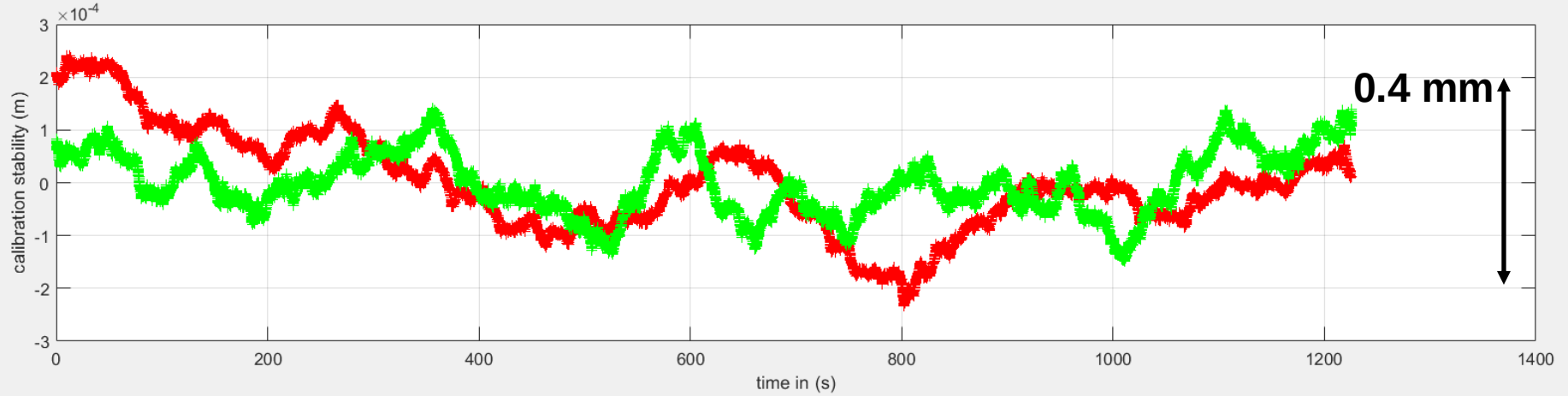
Geometre project: first results

2nd experiment: Displacement over 1 cm and back with mm steps

Geometre project: first results

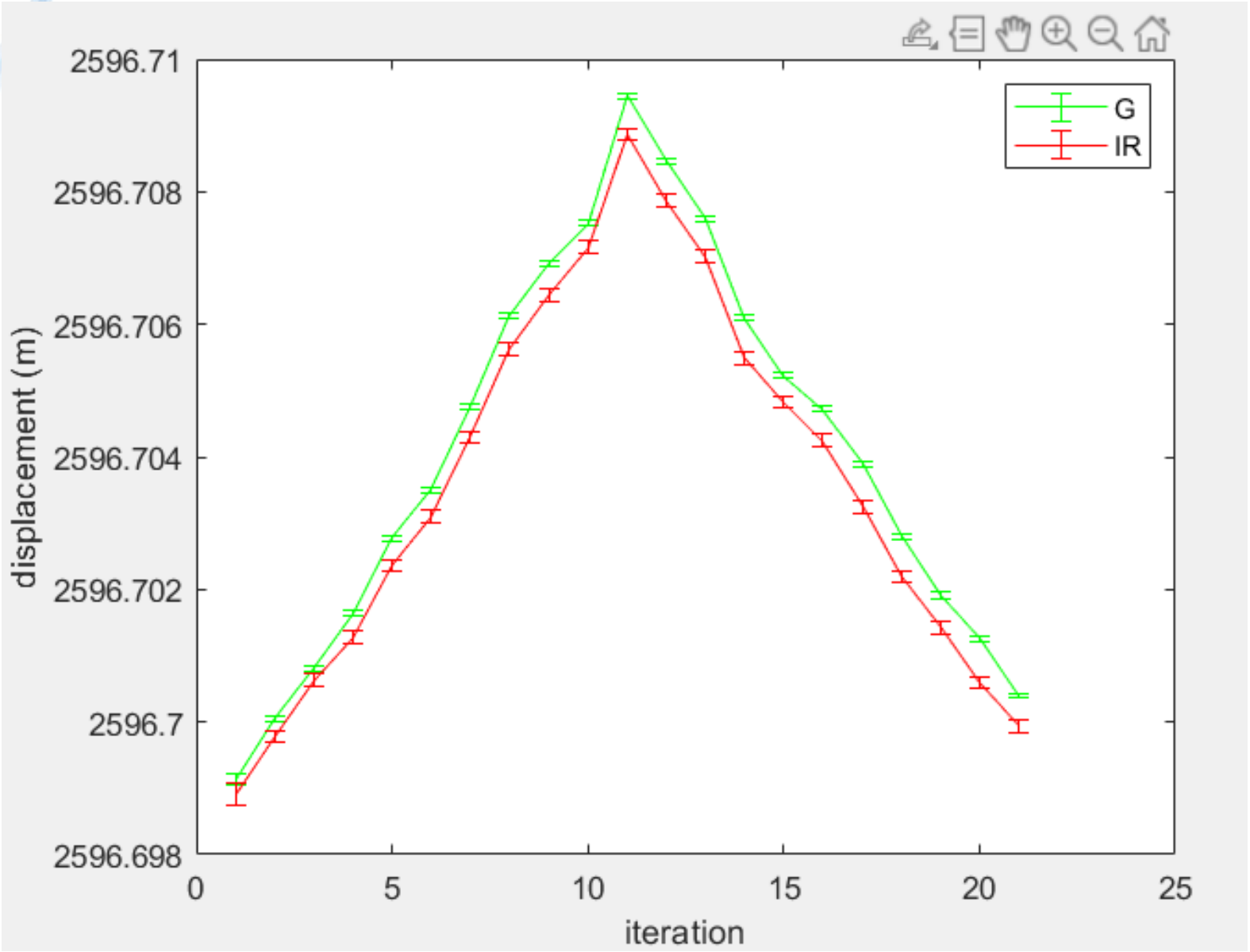
2nd experiment:
Raw displacement + calibration, with integration time of 60s





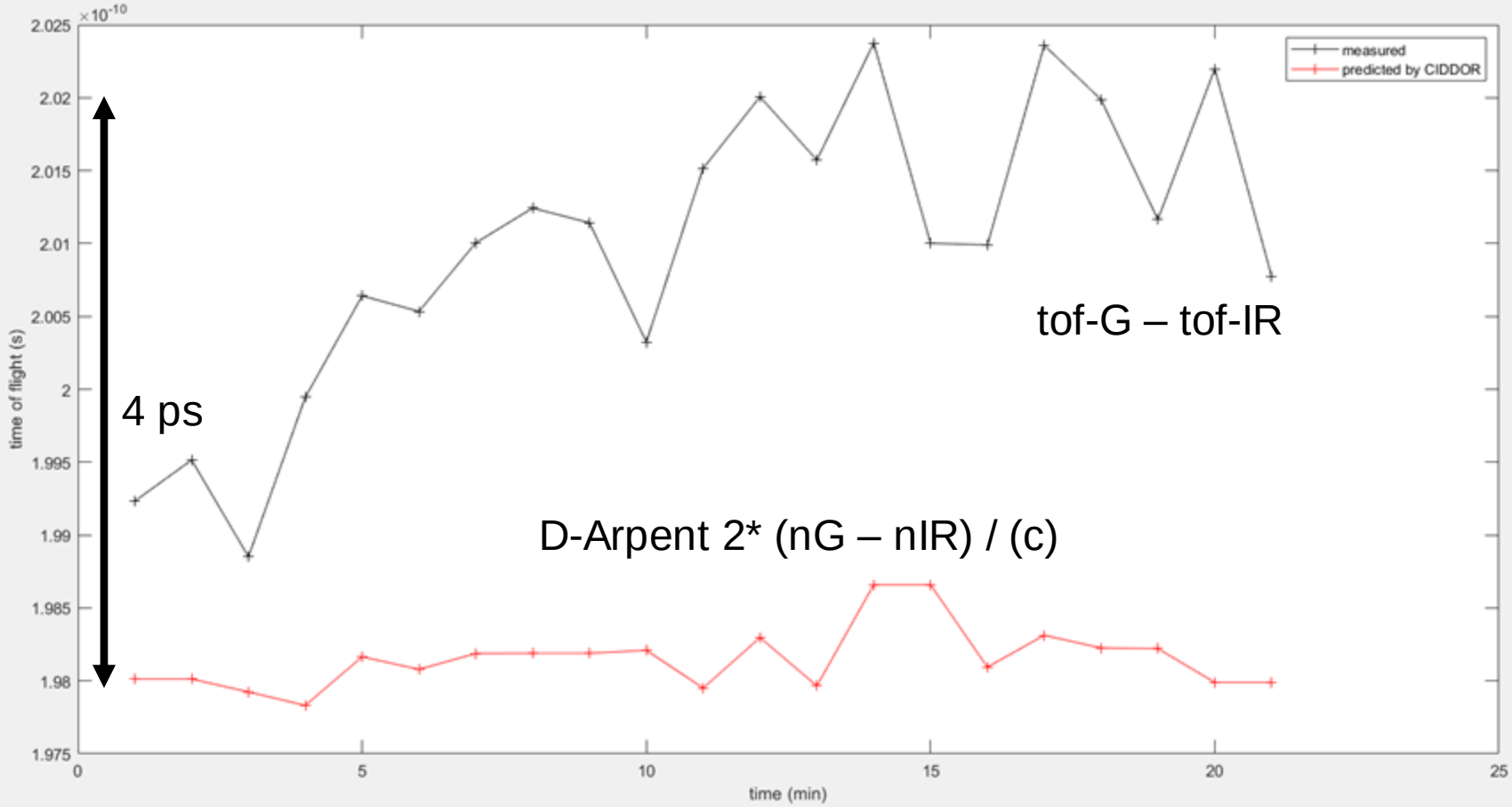
Geometre project: first results

2nd experiment : with the substraction of the calibration



Geometre project: first results

2nd experiment :
comparison of the tof difference measured with the predicted tof from CIDDOR



Works in progress at GRSM

Future works:

Implementation of the laser in a more secure zone.

We are waiting for an event timer who can measure up to 1 MHz in continuous mode (hopefully before the end of this year)

We have several designs for the calibration of this new system that need to be tested

Lot of work on the Geometre data analysis

And lot of work for the whole team on the data acquisition and treatment @ 400 kHz

Thanks for your attention