22nd International Workshop on Laser Ranging, Guadalajara (Spain), 10 Nov 2022

System design and concept of small-size, low-cost, multi-purpose Omni-SLR System

Ongoing project.
SLR not tested yet.

Just a toy? Or?

This work is supported by JSPS KAKENHI Grant Number 20H01993 and joint research with Softbank.

Toshimichi Otsubo (1), Hiroshi Araki (2), Yusuke Yokota (3), Takehiro Matsumoto (4), Mihoko Kobayashi (1), Kenji Kouno (3), Koichiro Doi (5), Yuichi Aoyama (5), Tetsu Takashima (6) and Noritomo Yanagimoto (7)

(1) Hitotsubashi University, Kunitachi, Japan, (2) NAOJ, Mitaka, Japan
(3) Institute of Industrial Science, University of Tokyo, Japan, (4) JAXA, Tsukuba, Japan,
(5) NIPR, Tachikawa, Japan, (6) Vixen Co., Ltd., Tokorozawa, Japan, (7) Softbank Corp, Tokyo, Japan

Omni-SLR: Background

- **Why has the number of SLR stations stayed almost the same?**

  ⇔ The number of satellite has boosted. > 100 now.

  A good global coverage will improve various global geodetic parameters.

- **What are needed for a "minimum" SLR station?**

  Affordable for univ people and new countries.

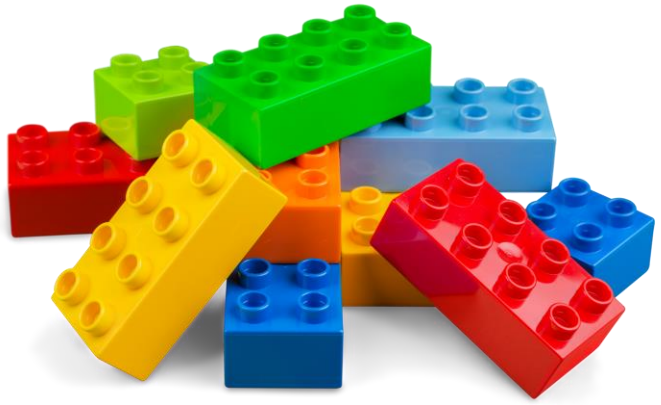
  Encouraged by the success of DLR MiniSLR. Even smaller? Even more economical?

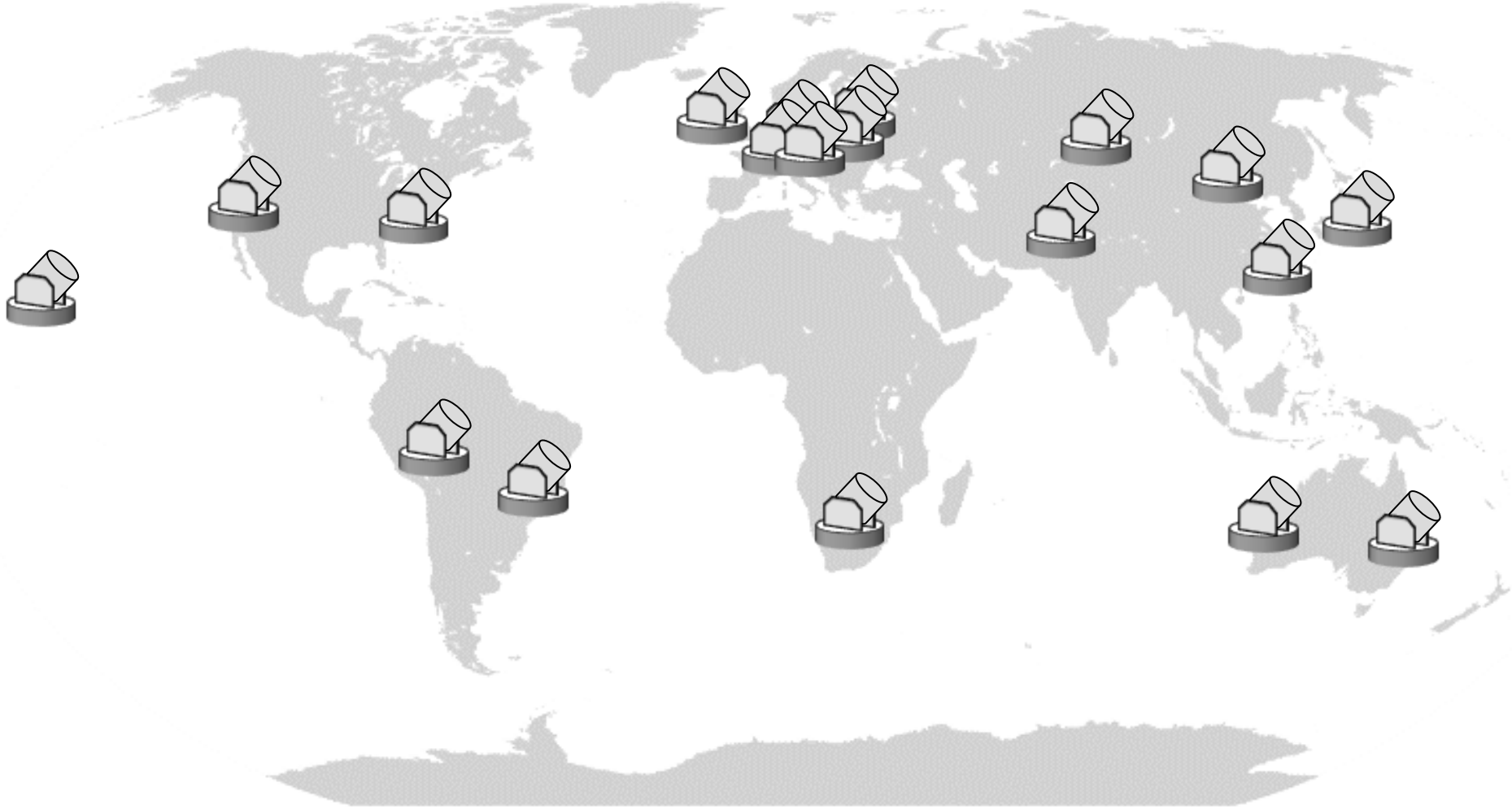
  What can such stations contribute?

- **Challenge: We can fail.**

  Trial-and-error approach. (Beauty of being a univ professor.)

  Component parts useful for others?





Omni-SLR: Concept

Compactness

High mobility.

Conveyable by a small car.

Low-cost

COTS products only.

Current set: ~ JPY 6M (EUR 45k)

- Swabian Timer
- CryLAS ns pulse laser
- Vixen mount and telescope
- Vaisala Barometer
- Hamamatsu SPAD
- ZWO/QHY Camera
- :
- :

Multi-purpose

Primary: SLR.

Aircraft tracking (for 6G communications ↓).

Space Comm.

Possibly applicable to:

- Photometry
- Space Debris/SSA
- :

https://www.hapsmobile.com/ja/

Omni-SLR: Technical approaches

No coudé path, on-mount laser & detector

Up to 20 kg for Vixen AXJ Mount

Expandable to a multi-mount system (ex. 1 transmission, N reception)

ns pulse-width laser

Lightweight. No additional cooling system.

1.3 ns FWHM → 7-8 cm RMS one-way. NP precision $\propto 1/\sqrt{N}$.

Gate-less detection/timing

No gate signal required. Burst laser transmission (N ms On→ N ms Off →…).

Distributed system

Small tasks dispatched to Raspberry Pis.

Green

Low-energy consumption < 100 W.

Open

Almost all the details will be disclosed (not now; when completed). Also available by part.

Omni-SLR: team & progress

HITOTSUBASHI UNIVERSITY

JAXA 宇宙航空研究開発機構 Japan Aerospace Exploration Agency

極地研 National Institute of Polar Research

東京大学 THE UNIVERSITY OF TOKYO

NICT National Institute of Information and Communications Technology

Management, Tracking system,
Raspberry Pis with sensors, etc.

Timing devices, Software, etc.

Optics, Laser, etc.

国立天文台 NAOJ National Astronomical Observatory of Japan

Vixen

SoftBank

JCG

now

FY2020 System design

FY2021 Parts test

FY2022 Small assembling test

FY2023 Whole assembling test → SLR

Easy link budget simulation

Comparison to Herstmonceux

Laser

Hx: 1 W (1 kHz, 1 mJ) vs Omni-SLR: 0.06 W (10 kHz, 6 μJ)

RX Telescope

Hx: 50 cm ϕ vs Omni-SLR 15 cm or 26 cm ϕ

Others

No major difference

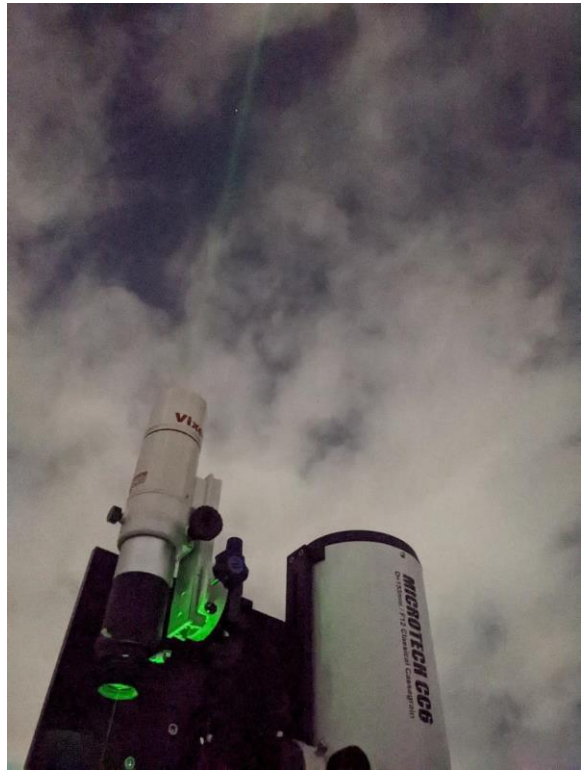
→ 1/200 (15 cm ϕ) to 1/66 (26 cm ϕ) of Herstmonceux

→ 1500-4500 returns/NP for Ajisai (30 s bin)

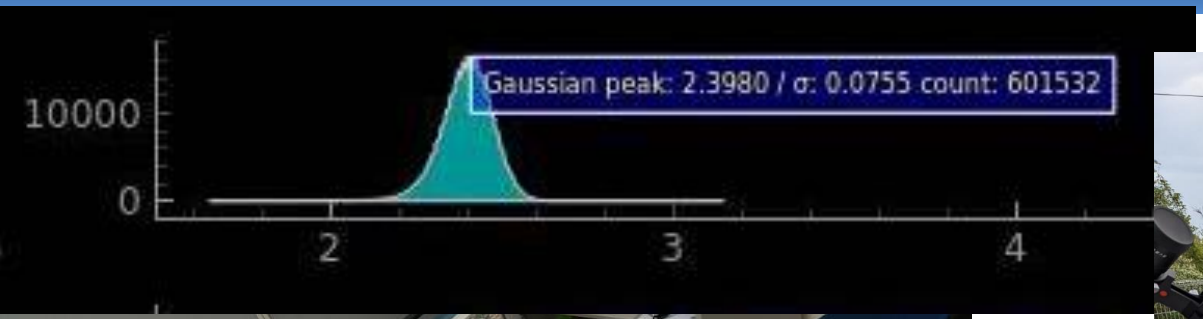
→ 8 cm single shot RMS / √ 1500 = 2 mm (!!) ← NP precision

→ 25-75 returns/NP for LAGEOS (120 s bin)

→ 8 cm single shot RMS / √ 25 = 1.5 cm ← NP precision



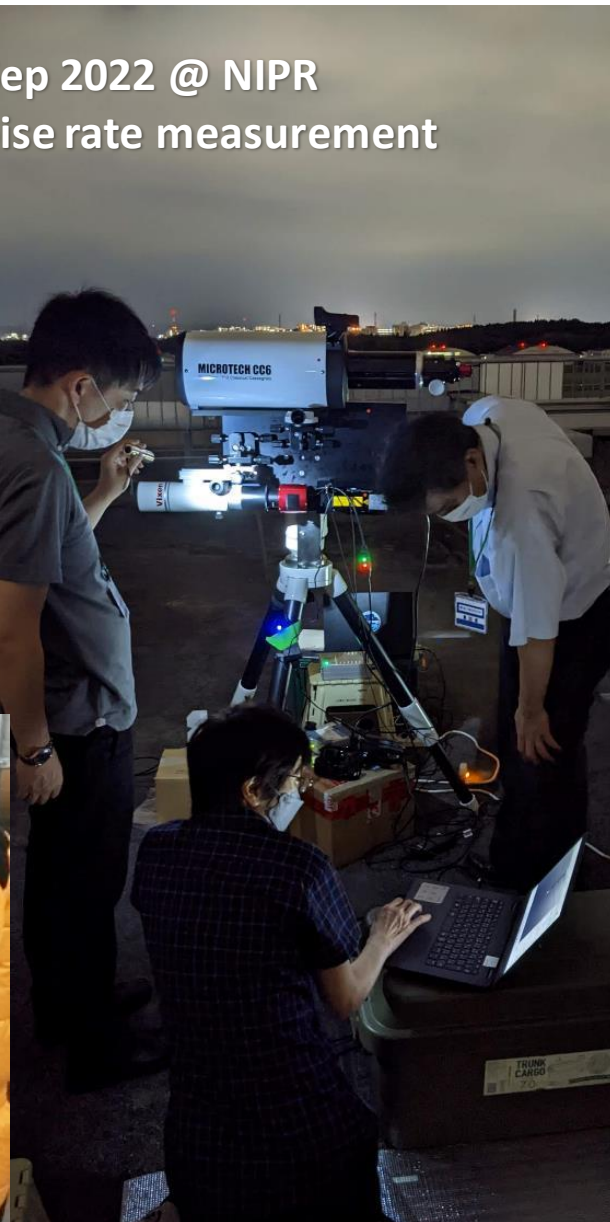
Assembly test: ongoing



10 Feb 2022 @ NAOJ
In-room ranging test

19-21 Apr 2022 @ Simosato
Alignment test etc

8 Sep 2022 @ NIPR
Noise rate measurement



9-11 May 2022 @ NIPR
Low Temp Test (-15 degC and -30 degC)


Cryosat-2 2022-09-30 19:43 JST @ Hitotsubashi Univ
Exp 0.5 s → Realtime animation
FOV 3.6 deg x 2.5 deg


ANA759 (HND to KMQ) 2022-09-26 20:59-21:00 JST @Hitotsubashi Univ
Exp 0.45 ms → Realtime animation
FOV 3.6 deg x 2.5 deg

Conclusions and future studies

Omni-SLR: Just started.

Small-size, Low-cost, Multi-purpose system.

Visit our 3 posters. (1) Optics, (2) Tracking and (3) Timing/software.

Still a lot of things to do.

SLR test in a year or so.

→ More reports in Arequipa or Kunming!