Kunming Station New Satellite Laser Ranging System

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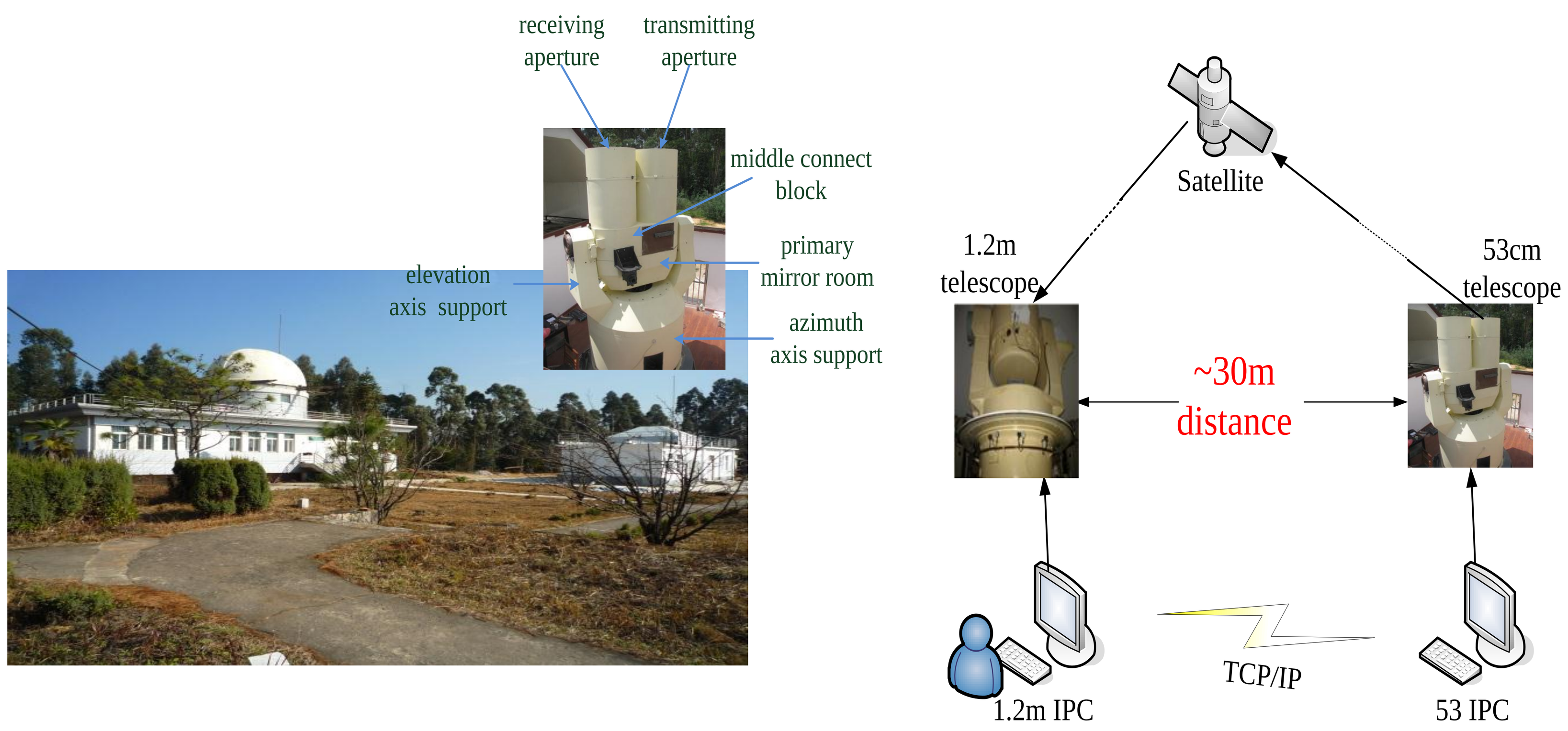

Figure 1: 53cm binocular SLR system

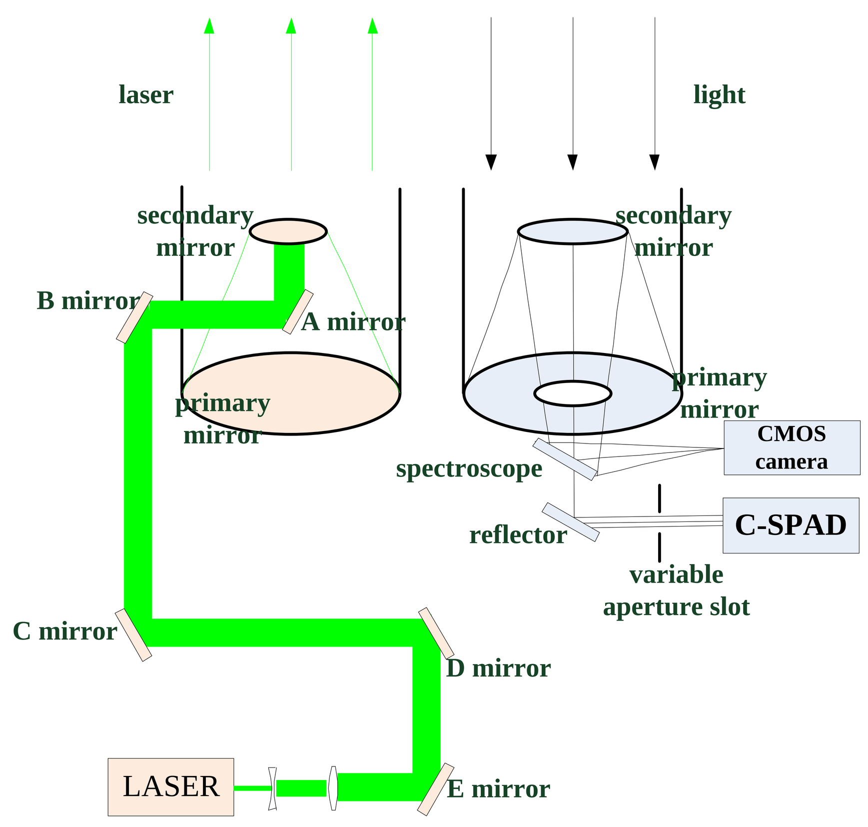

Figure 2: Optical Path

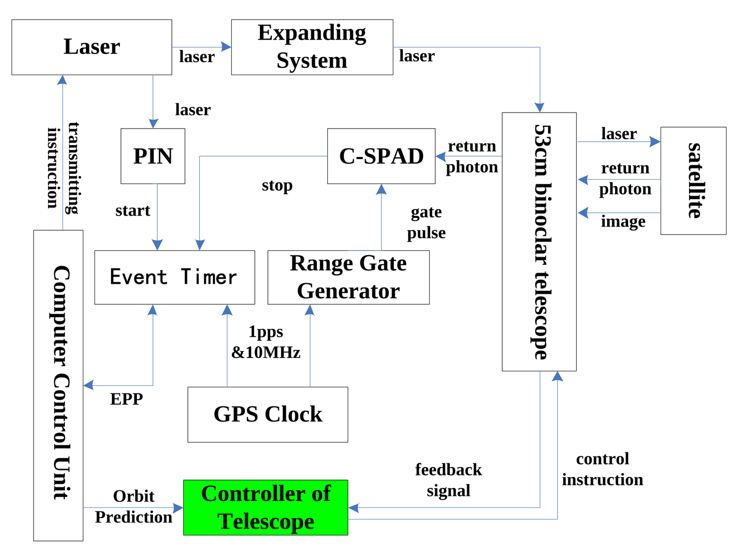

Figure 3: Computer Control System

Year/ Month	LEO pass Total	LAGEOS pass Tot	Heo pass Total	Total pass	LEO NP Total	LAGEOS NP Total	HEO NP Total	Total NP	Minutes	Cal.RMS mm	Star RMS mm	LAG RMS mm
2017.11	1186	188	557	1931	15931	854	1603	18388	9209	4.6	14.6	12.5
2017.12	1373	210	642	2225	18895	971	1822	21688	10848	4.6	14.6	12.6
2018.01	1603	251	758	2612	22342	1183	2174	25699	12904	5.8	14	12.3
2018.02	1495	232	653	2380	20967	1113	1884	23964	12255	6.8	13.3	11.9
2018.03	1813	308	1065	3186	25316	1475	3070	29861	15562	7.3	12.9	12
2018.04	2122	369	1446	3937	29388	1731	4046	35165	18027	6.5	12.6	12.1
2018.05	2397	409	1835	4641	32269	1877	5021	39167	19921	6.1	12.3	12.1

Table 1: Statistics of Measuring Data

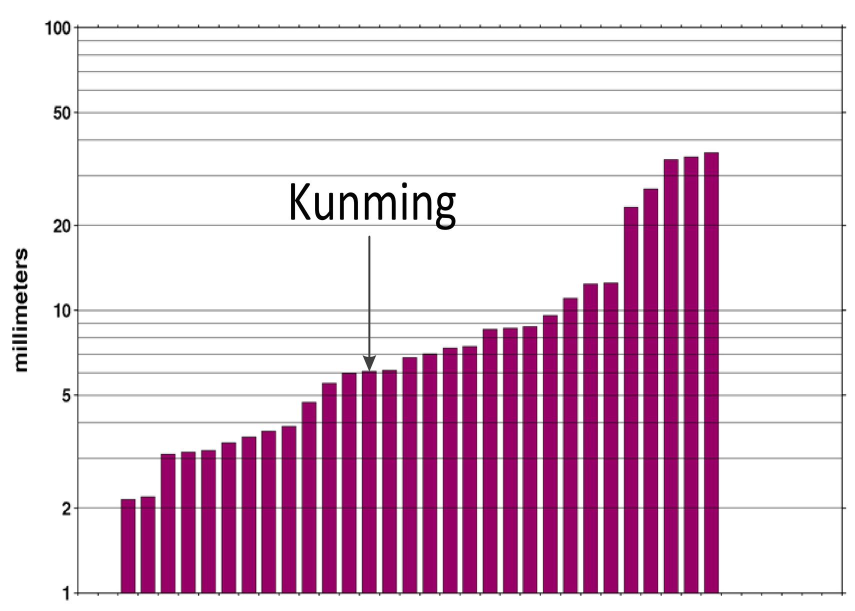

Figure 4:calibration RMS from March 1,2018 through May 31,2018

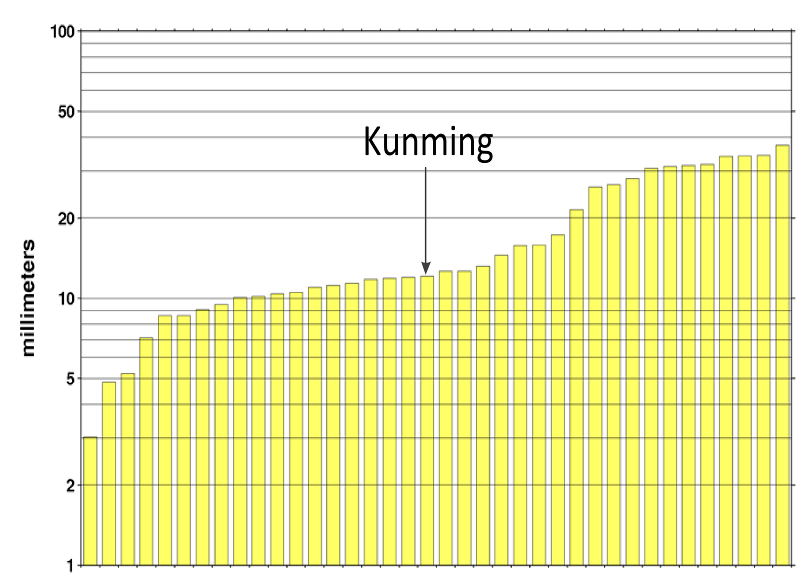

Figure 5:LAGEOS RMS from March 1,2018 through May 31,2018

Abstract

Kunming Station established a new satellites laser ranging system which is about 30m distance from the 1.2m telescope in 2017 year, that the figure 1 is their pictures. From then on, it is doing regular satellites laser ranging every day except for rainy or cloudy case. System, observing data and data’s quality are analyzed and described here.

System

Optical Subsystem: Figure 2 shows a schematic diagram of the laser ranging lighting path of the 53cm binoculars.

During ranging: the laser output from the laser passes through the 1-stage beam expander system, and is then reflected by the five mirrors such as E-mirror, D-mirror, C-mirror, B-mirror, and A-mirror into the sub-mirror of the telescope, and then into the main mirror of the telescope, finally completing the 2nd stage expansion and aiming at the laser ranging satellite; after the laser reaches the satellite, a small part of the photons are reflected back to the ground station by the retroreflector on the satellite. These photon signals enter the receiving main mirror of the 53cm binoculars, and then the secondary mirror is reflected into the beam splitter, the mirror (spectroscope, reflector in Figure 2), and the beam-shrinking system into a single-photon echo detector (C-SPAD in Figure 2).Another function of the beam splitter in the receiving path is to reflect the natural light to the CMOS camera, the ranging satellite used to monitor the tracking and the laser tip.

Calculated by losing 10% of the energy per mirror, the laser transmission efficiency of the transmitting optical system is about 0.39, and the laser transmission efficiency of the receiving optical system is about 0.66.

Control Subsystem:53cm binoculars laser ranging computer control system shown in Figure 3, the background color of the unit to complete 53cm binoculars servo control, can be more than 400km space target fast and smooth tracking, tracking accuracy is better than 5" (RMS value is less than 3").When laser ranging, the telescope tracks the laser ranging satellite according to the orbit prediction. The orbit prediction data is the cpf format data provided by the international laser ranging network. The laser emits light according to the external system trigger mode. The wavelength is 532 nm, and the single pulse energy is about 1mJ, frequency is 1000Hz, pulse width is better than 100ps; PIN detector will detect the laser signal emitted every time and output the main pulse (Laser pulse) to the event timer (ET) and the ranging control computer; once received the laser signal , the control computer will calculate the echo arrival time to Range Gate Generator according to the observation satellite orbit distance prediction information, and Range Gate Generator will send a gating signal to the single photon detector(C-SPAD) before the echo time epoch. C-SPAD detects the echo signal and sends it to record the echo time; the control computer will collect the event timer measurement data and perform real-time identification and display of the signal.

Performance: On November 7, 2017, the observation data was validated by the international laser ranging network, that is, the observation data sent daily to the international laser ranging data is available. Table 1 shows the statistics of regular laser ranging measurements after validation (November 2017) to May 2018, as Kunming entered the rainy season in June and will continue until the end of October. The observation time is very limited, so it is not counted here.

It can be seen from table 1 that the low-orbit satellite can measure more than 1,000 pass, the Lageos satellite can measure more than 200 pass, and the high-orbit satellite can measure nearly 1,300 pass until May 2018. The accuracy of the ground target is better than 7.3mm, the satellite measurement accuracy is better than 14.6mm, and the Lageos measurement accuracy is better than 12.6mm.

Summary

In 2016, the Yunnan Astronomical Observatory Applied Astronomical Research Group established a new 53cm binoculars laser ranging system with splitting path ranging mode. One lens barrel emits laser light and the other lens tube receives the echo signals reflected by the satellite. It officially joined in International laser ranging network, codenamed 7819,from Nov 2017. In addition to performing routine laser ranging, the system can also perform space debris laser ranging with a 1.2m telescope.

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