New SLR Station Running in San Juan of Argentina

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Abstract

The new SLR station in San Juan of Argentina is the result of a kind of cooperation of science and technology between China and Argentina and it was running by the twenty second of February of 2006. The whole SLR system in the station was designed and developed by Chinese Academy of Surveying and Mapping (CASM) and National Astronomical Observatories (NAO) of Chinese Academy of Sciences in the years of 2000 to 2003. The investor for the SLR system is the Ministry of Science and Technology of China. The new station building including the dome in the field of Observatorio Astronomico Felix Aguilar(FELIX), Astronomical Observatories of San Juan National University of Argentina, was designed and constructed by San Juan National University of Argentina. The approximate site position of the station is 31°30´31".050S, 68°37´23".377W and the height is 727.22m. The new SLR facility in San Juan station features a good accurate and prolific SLR system according to the data reports of ILRS data analysis centers. The current status, the future update and some questions for the SLR system in San Juan station are also mentioned in this paper

Background

The new SLR system in San Juan of Argentina is based on the Science and Technology cooperation between National Astronomical Observatories (NAO), Chinese Academy of Sciences and San Juan National University of Argentina. The supporter and investor for the project are the Ministries of Science and Technology of the two countries. In fact, for more than 10 years the Felix Aguilar Astronomical Observatory of San Juan National University of Argentina (OAFA) and National Astronomical Observatories (NAO), Chinese Academy of Sciences have developed friendly cooperation on astronomical research and observation. Under the efforts of the both Observatories the cooperation on cataloguing the Southern Parts of the Earth and astronomy geodynamics using the photoelectric astrolabe MARK II (PA II) has been successful and got lot of interesting results.

At November of 2000, National Astronomical Observatories (NAO), Chinese Academy of Sciences and Felix Aguilar Astronomical Observatory of San Juan National University of Argentina (OAFA) subscribed a cooperation agreement on satellite laser ranging (SLR) to extend the relationship between the two observatories for astronomical observation and research. It is very beneficial to set up a new fixed SLR station in Argentina of South America, which located in the southern parts of the Earth, as the distribution of the SLR stations in the world will be improved better.

According to the agreements of the cooperation the Chinese Academy of Surveying and Mapping (CASM) is responsible for design, developing, installing and debugging of whole SLR system and technical training to the persons from National Astronomical Observatories (NAO) of Chinese Academy of Science and Felix Aguilar Astronomical Observatory of San Juan National University of Argentina (OAFA).The National

Astronomical Observatories (NAO) of Chinese Academy of Science is in charge of packaging of whole SLR system and to ship it to Argentina. And San Juan National University of Argentina with its Felix Aguilar Astronomical Observatory takes charge for whole constructions and decorations of the SLR room including the mobile roof of the building.

The whole SLR system was designed and developed by Chinese Academy of Surveying and Mapping (CASM) and National Astronomical Observatories (NAO) of Chinese Academy of Science in the years of 2000 to 2003 and checked and accepted by China Ministries of Science and Technology at 12th of January, 2004. The main body of the new station building in Felix Aguilar Astronomical Observatory of San Juan National University of Argentina (OAFA) was completed in August of 2005 by San Juan National University of Argentina.

So there are three layers for the scientific and technical cooperation between China and Argentina. The first and top layer, the government layer, is between the two Scientific and Technical Ministries of the two countries and this is on the layer of policy. The second layer is between National Astronomical Observatories (NAO) of Chinese Academy of Sciences and San Juan National University of Argentina and this is on the layer of administration. The third layer is between Chinese Academy of Surveying and Mapping (CASM) and National Astronomical Observatories (NAO) of Chinese Academy of Science and this is on the layer of putting in practice.

Figure 1: *San Juan SLR Station*

Figure 2: *SLR Telescope*

Site Installation

The San Juan SLR station is located in the site of Felix Aguilar Astronomical Observatory in San Juan. San Juan city is 1300km Northwest from Buenos Aires the Capital of Argentina and it is the capital city of San Juan province. San Juan is No.12 of biggest city in Argentina with its population of 20,000 citizens in downtown area. The weather in San Juan region can go up to 50º in summer with very dry character of desert Climate and it is not cold in winter time with the lowest temperature of 5º. There are plenty of fruits and melons in harvest seasons especially the grape. So San Juan is very famous for its good quality and high productivity of the wine.

Felix Aguilar Astronomical Observatory has two observation stations, the Felix Aguilar station and Leonato station. The Felix Aguilar station is about 10 km from the city center of San Juan and the office building of the Observatory is there as well as the

SLR station. The Leonato station near Andes Mountains is 200 km from San Juan city and some astronomical instruments from Germany, America and Spain in use for science and technology cooperation.

So the San Juan SLR station not far from the city San Juan and with 300 good days for SLR observations is a excellent site for astronomical observations. The geographic positions of the site are 31°30´31".050S, 68°37´23".377W and 727.22m. There is an another astronomical device in use for nearly 10 years long the photoelectric astrolabe MARK II (PA II) also cooperated with National Astronomical Observatories of China. The groundwork for the SLR telescope is not good with its screen and sand underground and no base stones within 100 meters in deep.

Installation Time Table

The whole set of the SLR device reached San Juan of Argentina on 6th of Aug., 2005. Then we were waiting for the inspecting from Argentina customs for a month and opened the cargo container on 24th of Sep. From this date to about 20th of Nov., 2005 we were waiting for the decoration of the SLR buildings and for modifying the base pillar of the telescope and the bottom of the laser. On 28th of Nov., 2005 the installing started and the installing ended on 23rd of Feb., 2006 with the first Lageos pass of data returns received last night of the date before. That means we got the first SLR pass of satellites data in San Juan Station on the night of twenty second of Feb., 2006 and sent the data to ILRS and running the station on 23rd of Feb., 2006.

Installation Difficulties

The first difficulty is insufficient for the space of installing. For safety of the transportation from China to Argentina we packaged the whole SLR systems separately to the minimum units. And we needed the base pillar of the telescope and the whole second floor under the dome that must be strong enough and stable enough to the work to do the main mirror and second mirror installing and debugging. But the base pillar still needed to repair and the second floor under the dome was made of thin wood board

Figure 3*: Installing and debugging*

so the mirrors installing and debugging have to be in a big storage. It was not easy to do such a kind of working in a storage so it takes our nearly a month.

The second thing is the Base pillar of the telescope not fit with the telescope in height and orientation. So we have to change the height of concrete base pillar and some holes in positions and sizes. And that is very hard to do. Base for laser platform is too high and we spend lot of energy to cut the base by electric drilling machine.

Figure 4: *Base of laser platform and Base pillar of the telescope modifying*

Decoration for whole laser building not finished. So we have to do the installing and debugging for the SLR system and the decorating for the SLR building at same time. The mobile roof of the telescope we call it “dome” moves unreasonable. That repeatedly made problems with us and not safe as well.

Installation Personnel

Professor T. Wang from Chinese Academy of Surveying and Mapping (CASM) is responsible for whole installing and debugging and in charge of optics and telescope star calibrations. Professor T. Guo from Institute of Seismology, China Earthquake Administrations is responsible for electronics design and installing. Senior engineer W. Liu from National Astronomical Observatories of China is responsible for electronics and laser installing, debugging and daily maintain. Senior engineer D. Huang also from National Astronomical Observatories of China is responsible for installing and daily observations. Engineer Q. Xiang from Chinese Academy of Surveying and Mapping (CASM) is responsible for installing and daily observations. Senior engineer A. Gonzalez from Felix Aguilar Astronomical Observatory of San Juan National University of Argentina (OAFA) is responsible for electronics installing and The daily observation and maintains. Senior engineer R. Podesta from Felix Aguilar Astronomical Observatory of San Juan National University of Argentina (OAFA) is responsible for daily observations and maintains. Senior engineer E. L. Actis from Felix Aguilar Astronomical Observatory of San Juan National University of Argentina (OAFA) is responsible for daily observations and maintains. Senior engineer E. Alonso from Felix Aguilar Astronomical Observatory of San Juan National University of Argentina (OAFA) is responsible for daily observations and maintains. Senior engineer

Figure 5*: The San Juan SLR Station Team*

A. M. Pacheco from Felix Aguilar Astronomical Observatory of San Juan National University of Argentina (OAFA) is responsible for daily observations and maintains.

Daily Observations and Maintenance

To Argentina side: Monday through Wednesday 4 persons are shift on duty for observations but every day a Chinese people must be present at beginning.
To China side: Thursday to Sunday 3 persons are shift on duty and every day the free person in china side is in charge of cleaning, cooking and shopping for their living. So the work is heavy for every one.

Hope:

We hope getting 6000 passes of satellite data from all SLR satellites a year including 1200 passes from satellites Lageos-1 and Lageos-2 each year. And we hope the all data we get will have good quality.

Figure 6: *Daily Observations and review*

Problems and Questions:

The San Juan SLR station can get 6000 passes of satellite data from all laser satellites per year and they are all night productivities. That means the SLR system in San Juan station has no daytime ability now. This question refers to the laser system itself and we need a stable laser to finish the daytime ability to the SLR system.

In San Juan station the Laser is not only unstable and the spare parts damaged badly. Maybe in the laser system there are some designs unreasonable and we need to adjust the laser system every 3 or 4 days. We have only 3 sets of spare mirrors for the laser and short time after they are all damaged. So recently we have to change the positions of the damaged mirrors maintaining the laser beam output with very unstable some times. This is the second problem in San Juan station.

Some times different persons produce different quality for the data due to laser instability. Not every person can be in control of the laser adjusting so different data quality was produced in the people's shift of on duty from time to time. Dome moves difficulty and not safety are the problems and questions also. At beginning the data have big range bias due to the damaged chip in timing circuit board and now it is ok by change the chip. Running is more difficult compare to in China due to the delay of time for the spare parts transportation from China to Argentina.

Future Plan

The National Astronomical Observatories (NAO) of Chinese Academy of Sciences and Felix Aguilar Astronomical Observatory of San Juan National University of Argentina (OAFA) and Chinese Academy of Surveying and Mapping (CASM) will continue cooperate to the updating of SLR system in San Juan in the near future. The upgrading in first step is to change the SLR system to a new generation system that means we will have KHz and daytime ranging ability of course the semiconductor pumped laser as well.

But it is not soon due to the three layers cooperation and time is needed for finance support from the government and also the performance and the development of the new system need lot of time to do lot of things from China to Argentina.

The Instrumentation

The System Profiles:

The telescope was mostly rebuilt in a storage in San Juan station. It consisted of a Cassegrain receiving telescope of 60 cm aperture and a separated Galilei Telescope which collimated the laser beam with a factor of about 4.

The control computer is a common PC, even a notebook can be also, under windows operating system. All programs like satellite predictions, tracking the targets, ranging the data, data preprocessing and send the data to ILRS etc. are running on the same machine. The control computer is connected to the control interface box by parallel line and the servo system accessed to the control interface box by serial communications.

- Laser system is a Nd:YAG passive mod-locked dye laser with 30ps pulse width and single pulse energy of 30mj in green light.
- The detector is Compensated Single Photon Avalanche Diode (C-SPAD) from Czech Technical University.
- Stanford Counter SR-620

- TV system is Image Intensifier plus CCD and it collect the star and laser beam image by the main receiving telescope.
- Timing and frequency is by HP58503A GPS time and frequency receiver.
- Calibration short distance target, out-install, inside the dome.

The frame diagram of profiles for the whole system is shown as following diagram.

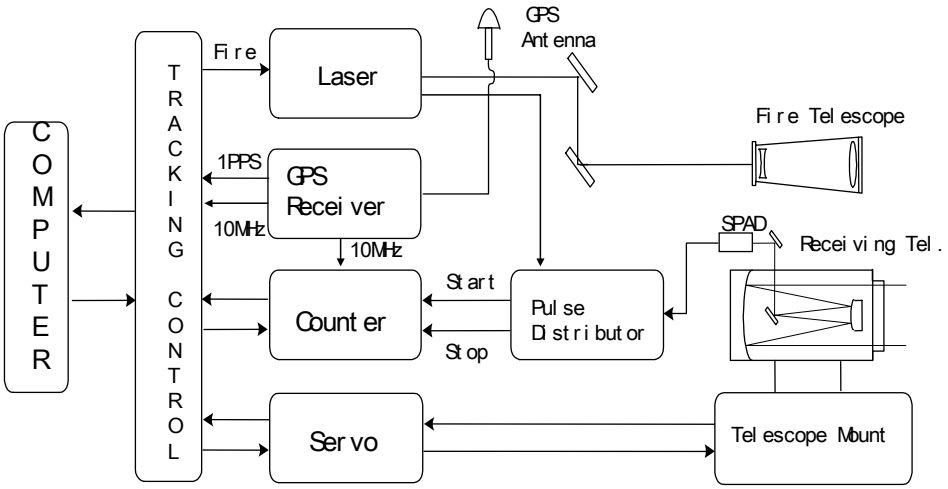

Figure 7: The frame diagram of profiles for the system

***Figure 8**: Control Room for SLR*

***Figure 9:** The Laser System*

***Figure 10**: The short distance Ground Target*

***Figure 11**: Monitoring Screen*

Optical System:

The optical receiving system has a microcrystalline glass main mirror (weight 80kg) with the diameter of 630mm and a microcrystalline glass secondary mirror with the diameter of 200mm. Also there are a spectroscope, an adjustable set of pinhole, an autocollimator and a broadband filter of 10nm in the optical receiving system. The optical receiving system is able to receive both visible light for ICCD and green laser for ranging detector without any additional adjustment due to the spectroscope.

For the transmitting path the laser beam can be guided to the Coude path via 2 reflecting mirrors and a beam expander of 2 times from the laser platform. The Coude path has 6 reflecting mirrors and from the Coude path the laser beam is guided to 16 cm diameter transmitting telescope and to the satellites.

The optical receiving and transmitting path can be shown as following drawing:

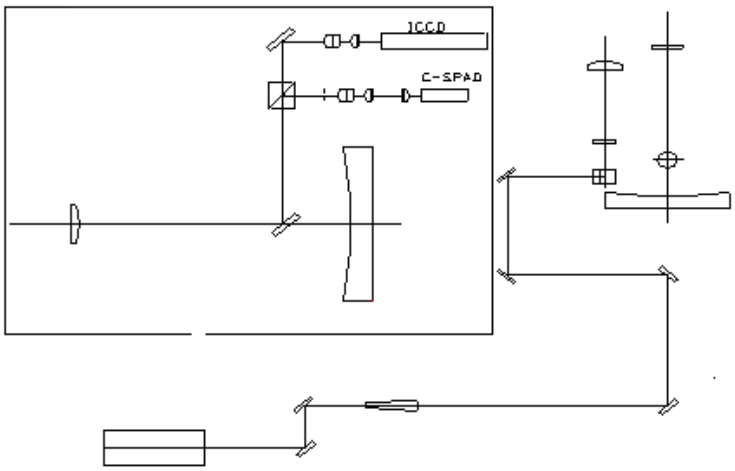

Figure 12: *Optical TR path.*

Laser System:

The computer controlled passive mode-locked laser (Nd: YAG) firing rate up to 10Hz has the pulse width of 30ps and pulse energy of 30mj for wavelength 532nm laser. It is produced by Shanghai Optics and Electronics Institute. The principle diagram of the laser is shown as following diagram:

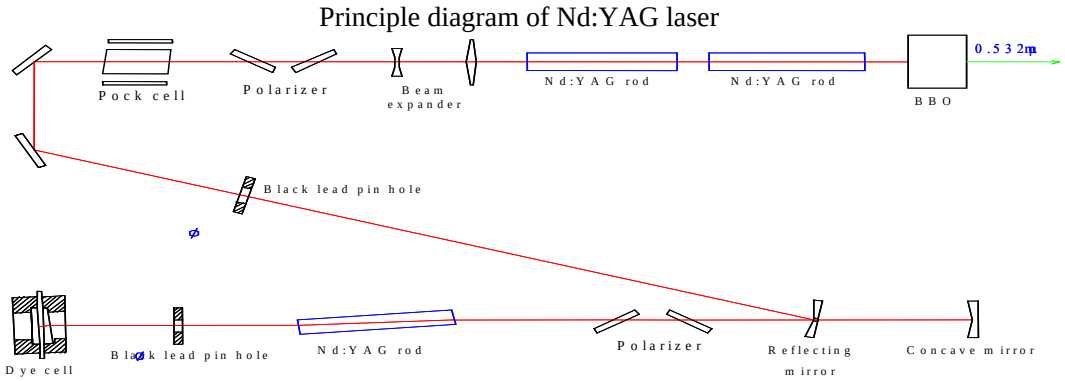

Figure 13: *Laser System.*

Tracking Control and Servo:

A common PC computer is used for telescope control, range gate setting, laser firing and data acquisition etc. All software including satellite predictions and data pretreatment is running in windows operation system and all things can be done just by the computer mouse.

Summaries

The New SLR station in San Juan of Argentina has being running since 23rd of Feb. 2006 and up to 30th of Sep. 2006 nearly 4000 passes of SLR data were sent to the analysis centers of ILRS including 799 Lageos passes and 509 high satellite passes in about 7 months (220 days) from the 2006 3rd quarter report of SLR Global Performance Report Card. That means the San Juan station has the possibility to get 6450 passes for all SLR satellites including 1325 Lageos passes and 844 high satellite passes.

Especially for the Galileo satellite GIOVE-A the San Juan station got 36 passes and it is the number 2 in the quantity line of GIOVE-A satellite by stations only following the station 7090 Yarragadee in Australia which got 45 passes.

The data quality is also very good with the calibration, satellite and Lageos precisions (RMS) of 12.4, 11.0 and 13.3 mm also from from the 2006 3rd quarter report of SLR Global Performance Report Card.

The fact above can prove the cooperation of science and technology between China and Argentina in the field of Satellite Laser Ranging is excellent successful. The SLR system in San Juan station developed by the scientists of China and Argentina has fine capability and stability although the laser is not stable and needs lot of work to maintain. The weather in San Juan station is very good we can say and be reassurance about it.

There are lots of acknowledgments to Professor Guo Tangyong from Institute of Seismology of China Earthquake Administrations and the people from Shanghai SLR station and other stations in China Laser Tracking Network for their efforts in the project.