# THE TWO-WAVELENGTH SATELLITE LASER RANGING EXPERIMENT AT SHANGHAI STATION

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## Abstract

*The paper presents multi-color ranging activities in Shanghai Observatory. An experimental two-wavelength SLR system with dual receiving channel is established at Shanghai station. Some LEO satellites have been observed successfully with a pair of 532nm/683nm.*

## Introduce

Several years ago, we were pleased to get an advance Raman cell from Dr. Gaignebet with which we began to work for multi-color ranging research. Two years ago, we cooperated well with Czech Technical University in researching the conversion efficiency of the Raman laser. We obtained fruitful results with Raman cell through an amount of the experiment: small wobbling of three wavelength beams and not low energy for Red/Blue color.
Last year, we got the support from national natural science foundation in China to research on two-wavelength SLR. During past year, we did a lot of improvements for routine system, including establishing two-SPAD receiver system, two counters recorded system, recoating all mirrors in the coude path etc. in order to work on multi-color satellite laser ranging.
An experimental two-wavelength SLR system with dual receiving channel and two-color transmitting simultaneously are established at Shanghai station. Some LEO satellites have been tracked with a pair of 532nm/683nm and over 20 passes were observed successfully.

## Raman laser and optical system

Routine laser at Shanghai station is self-filtering unstable resonator (SFUR) with output energy of 35mj and pulse width of 30-40ps at 8Hz repetitive rate. We adopt the laser output to pump Raman laser. Raman laser with the length of 1 meter is focused on the middle of cell and AR-coat on the both end of the cell. 18bar pressurized with hydrogen is optimum for our laser system according to Hamel, Hu conversion efficiency experiment result (fig.1). Under the pressure, red/green /blue energy is 4mj, 10mj, 0.4mj respectively.

Fig.2 is the two/three wavelength optical scheme. The upper right block is SFUR laser. M1 and M2 are high reflection mirrors for 0.532. The green beam is forced into the Raman cell. M3 to M8 mirrors are used to separate three beams. Three expander telescopes are put on optical pass to allow divergence adjusted. M9, M10, M11 are used to recombine the three beams to enter coude system. Due to low energy for blue color, in first stage, we select 532/683 pair wavelengths in the experiment. By blocking one out of three beams, two other colors are transmitted simultaneously to satellite target. Switching between routine ranging and two-color ranging is easily by moving M14 and M15 mirrors. We found output energy of

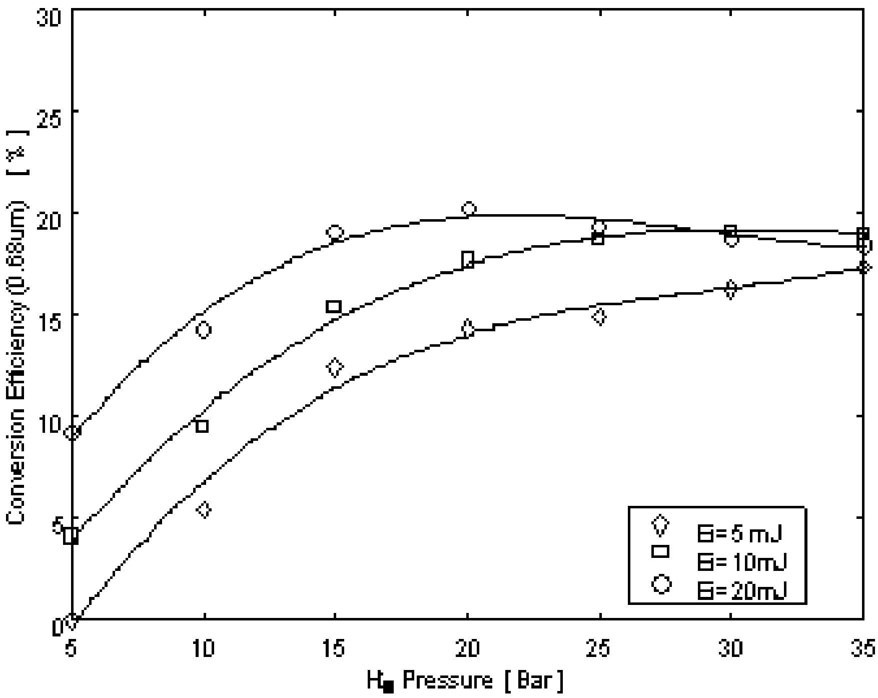


**Fig.1 Conversion efficiency vs. pressure**

Raman laser and ranging precision depended on the direction of laser on the both end of cell. It is necessary to adjust laser carefully before the experiment. Fig.3 is a laboratory for two-wavelength measurement.

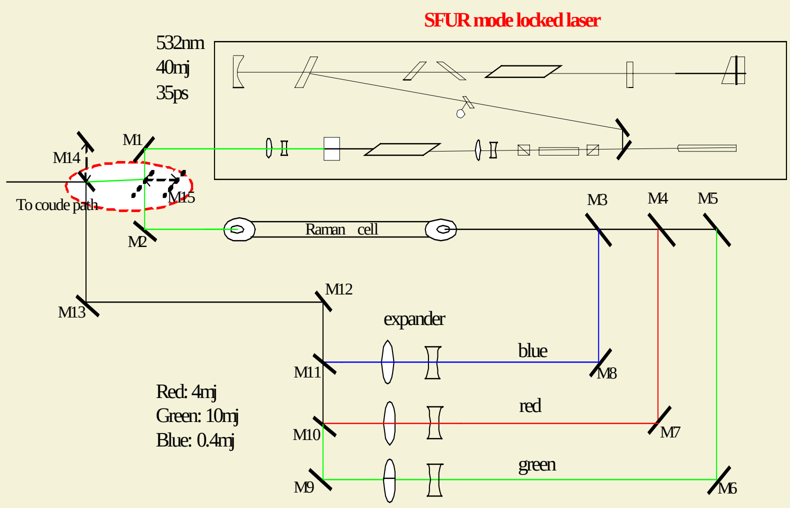


**Fig.2 Two/three wavelengths optical scheme**

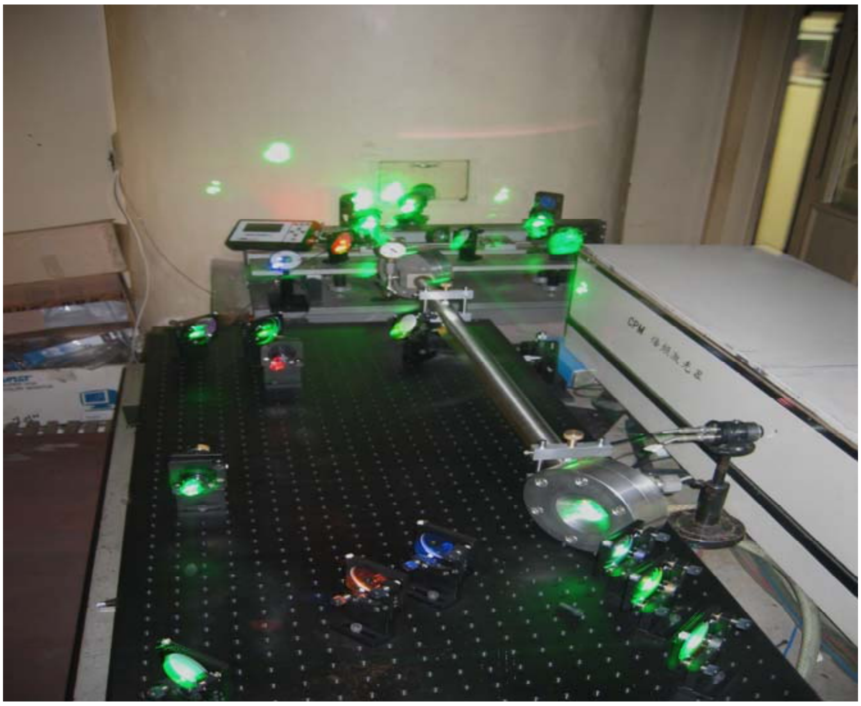

**Fig.3 Two-wavelength system setup**

In receiving system, two SPADs are used to receive signal of red/green color simultaneously. Two counters (SR620, HP5370) are adopted to record the two-wavelength return respectively. Independent calibration for two color /two SPADs is done at different receiving channel.

## Tracking surface

Range residual (O-C) from both colors displays on same display interface of tracking, a fixed range bias is added on the ranges of red color return for identifying two returns easily

## Ranging experiment and preliminary result

Only low earth orbit satellites are tracked due to low energy of 4mj at 683nm. It is important to adjust two beams to get better alignment before the experiment. After test to the near ground target, we started to range LEO satellites on July 27, 2003. More than 20 passes (including ERS-2, STARLETTE, TOPEX, JASON, AJISAI) were obtained for over two-month experiment Ranging precision is 0.8-1.2 cm for green color, 1.2-1.5cm for red color for most passes.

## Conclusion

1. An experimental two-wavelength SLR system with dual receiving channel was established at Shanghai station. Some LEO satellites have been tracked with a pair of 532nm/683nm.

2. But the present system has some drawbacks:

- The data from green color mixes with data from red one, it is difficulty for data preprocessing and degrades the ranging precision.
- Low energy at 683nm and 432nm.

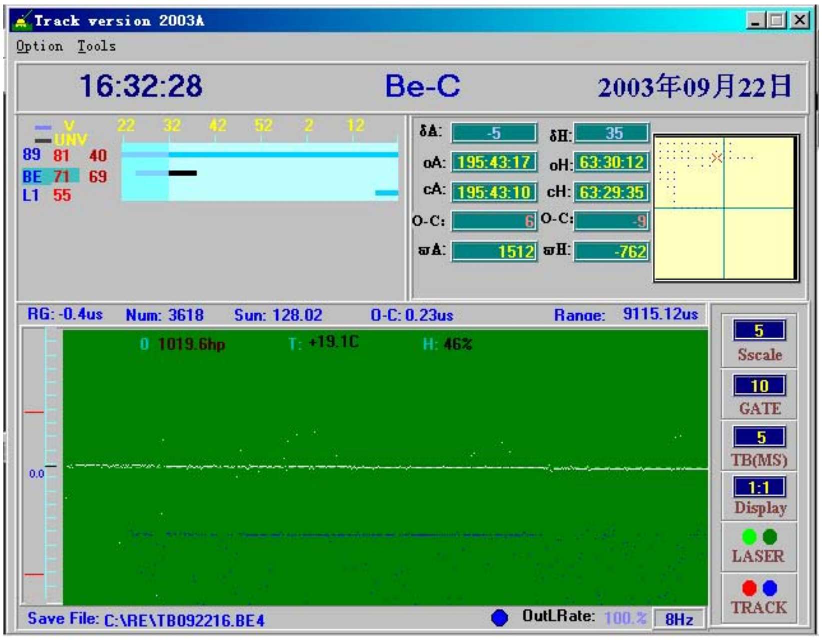


**Fig.4 Real-time track interface on BEC**

(An upper line in the figure is return signal from green beam, a down line from red beam)

**Acknowledge:**

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