

Preliminary Results of Laser Ranging to Un-cooperative Targets at Shanghai SLR Station

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Goals

- **Investigation of the key techniques of un-cooperative target laser ranging**
- **Experimental laser ranging to un-cooperative targets**

Estimate of the returned signal strength

The returned signal strength of laser ranging on un-cooperative targets can be estimated by:

$$n_0 = \frac{\lambda \eta_q}{hc} \times \frac{E_t A_r \rho S \cos(\theta)}{\pi \theta_t^2 R^4} \times T^2 \times K_t \times K_r \times \alpha$$

Where

n_0 : Average number of photoelectrons received by detector

λ : Wavelength of laser, 532nm

η_q : Quantum efficiency of the **C-SPAD detector**, 0.2

h : Planck constant, 6.624×10^{-34} J·S

c : Light speed, 2.998×10^8 m/s

E_t : Energy of laser pulse, 2J

A_r : Effective area of receive telescope, 0.245m^2

ρ : Reflectivity of the target's surface

r : Equivalent radius of the target, 1m

$\cos(\theta)$: Suppose the targets are spherical, $\cos(\theta)=1$

θ_t : Divergency of laser beam from telescope, 12 arcsec

R: Range of the targets, 800Km

T: Atmospheric transmission, $T^2=0.6$

K_t : Eff. of transmitting optics, 0.60

K_r : Eff. of receiving optics, 0.60

α : Attenuation factor, 13dB

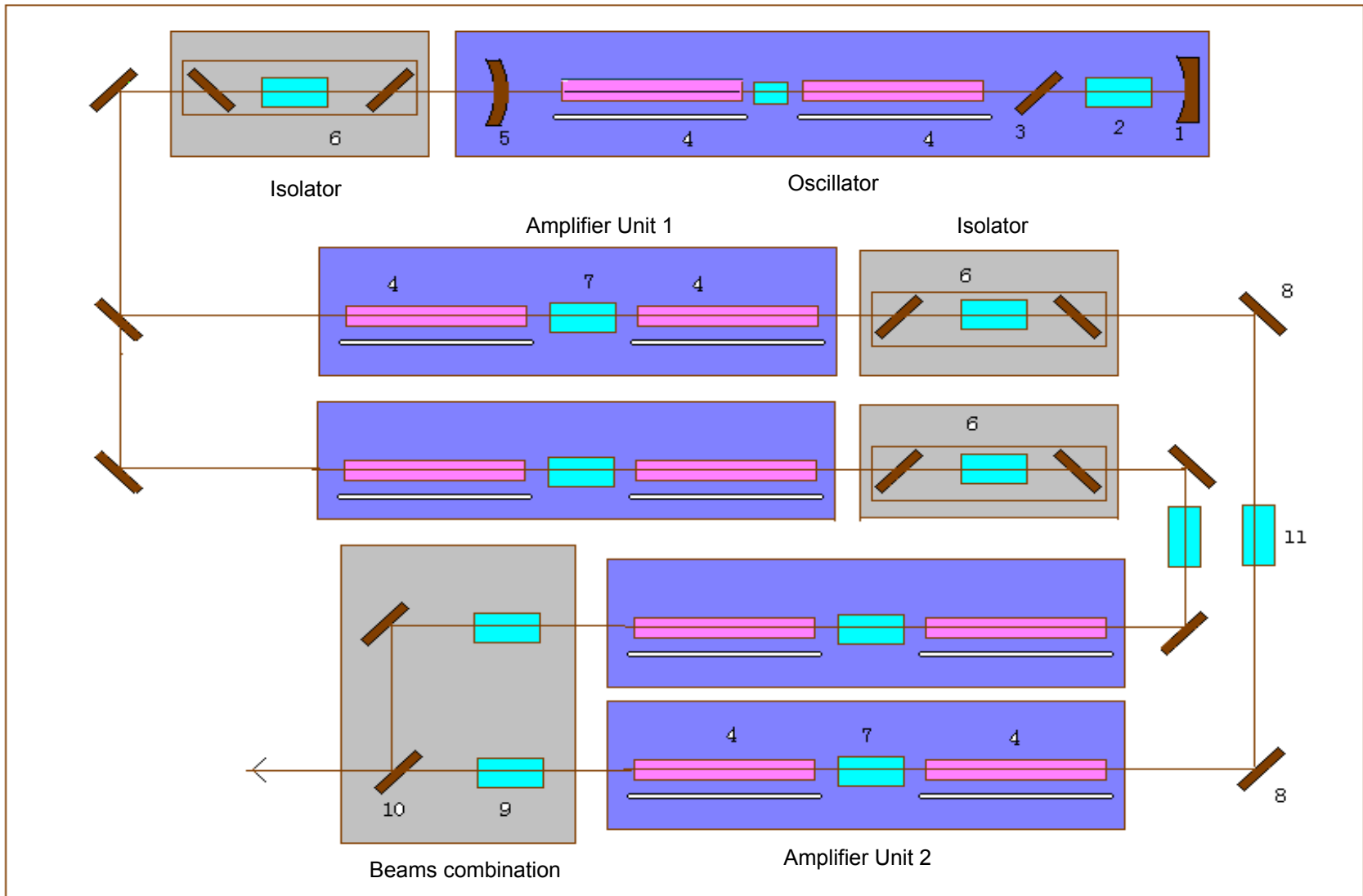
We have,

$$n_0=0.198 \text{ (Photoelectron)}$$

The probability of detection can be estimated:

$$P = 1 - e^{-n_0} = 1 - e^{-0.198} = 0.18$$

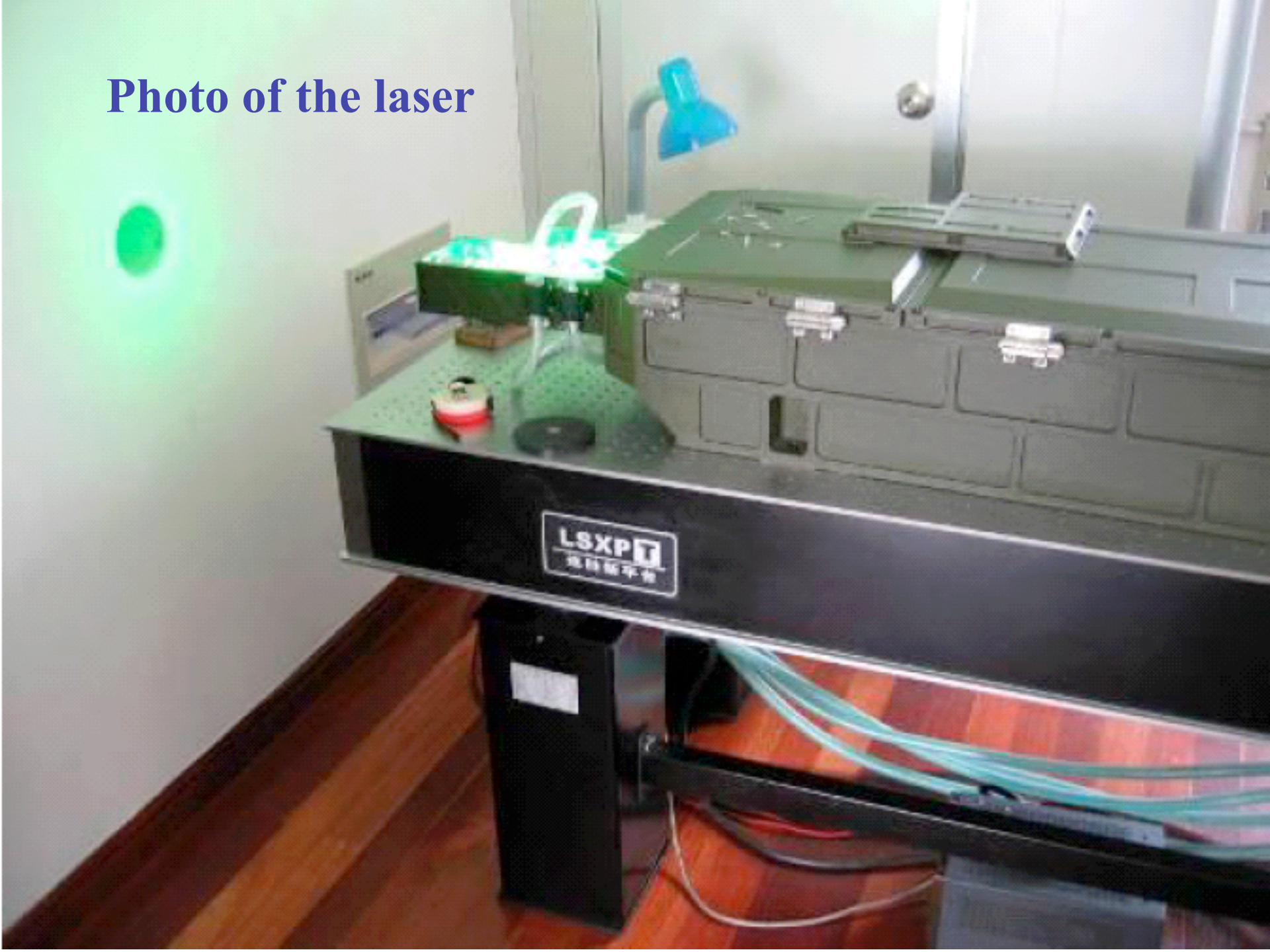
So we can get 18 return signals in 5 second by the laser with 20Hz repetition.

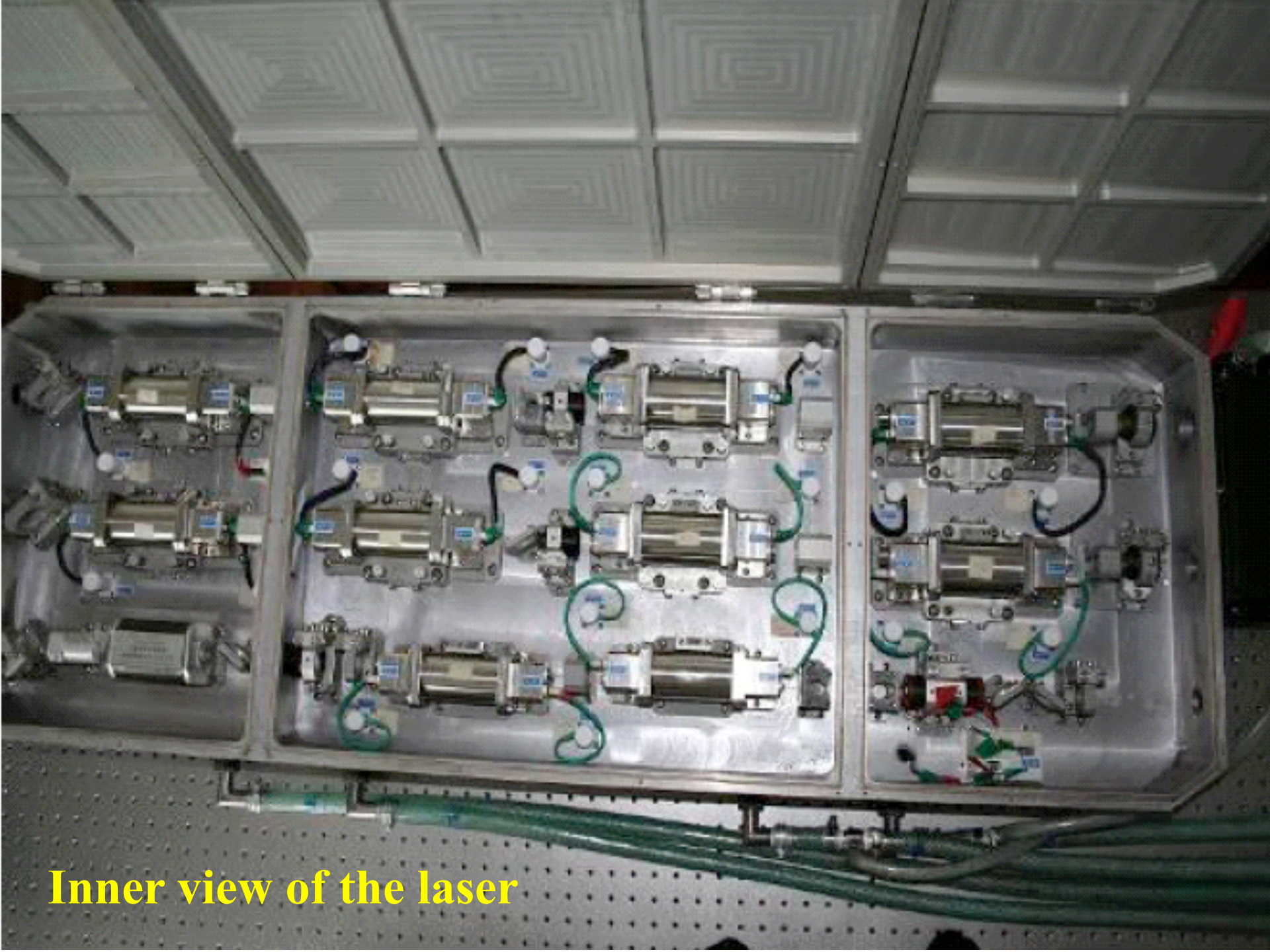


1: HR mirror 2: E-Q Switch 3: Polarizer 4: YAG rod 5: Output mirror 6: Isolator 7: Compensator
 8: Reflect mirror 9: Frequency doubler 10: Optical coupler 11: Imaging lens

Diagram of the 40W laser (2J, 20Hz, 10ns)

Photo of the laser



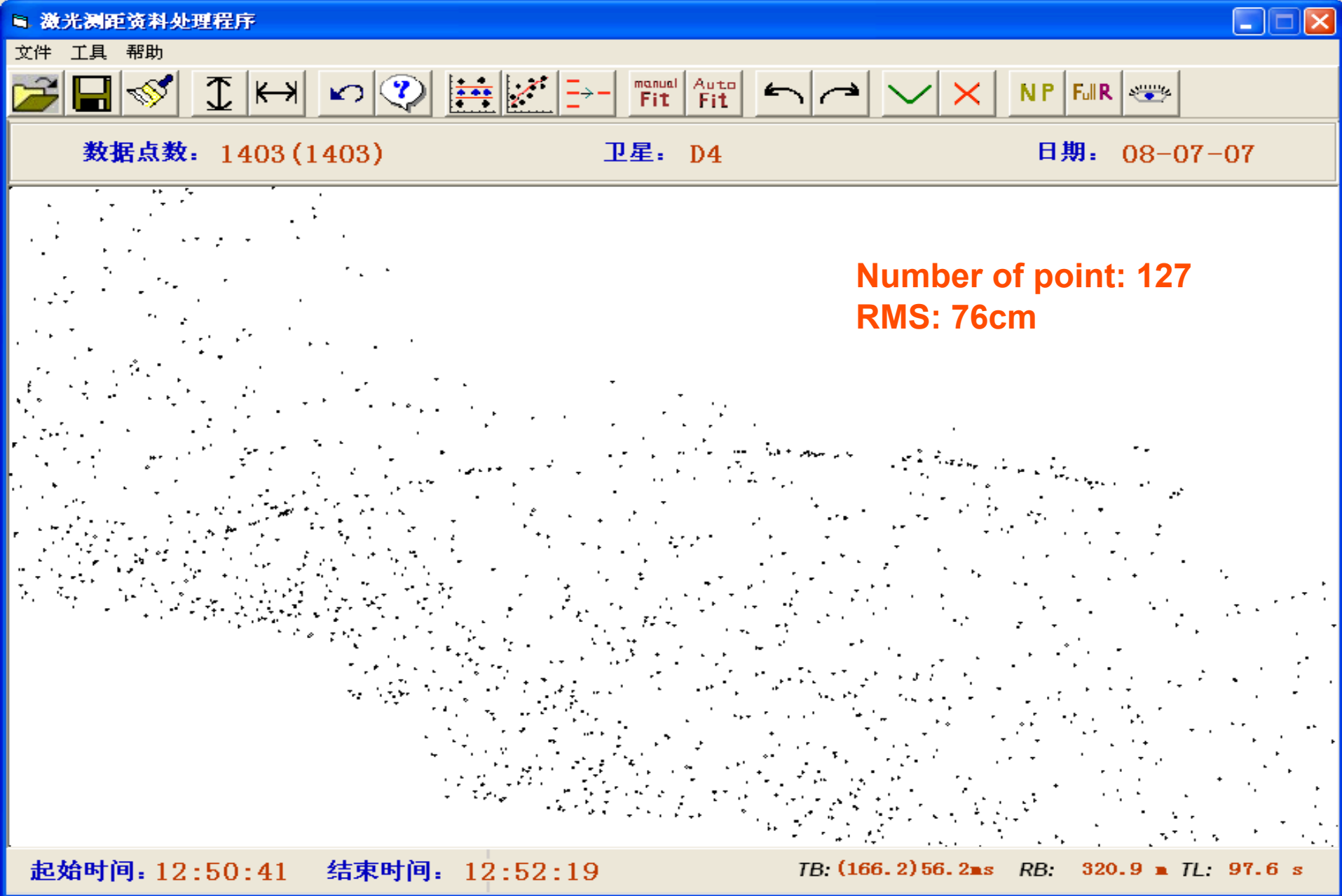


Inner view of the laser

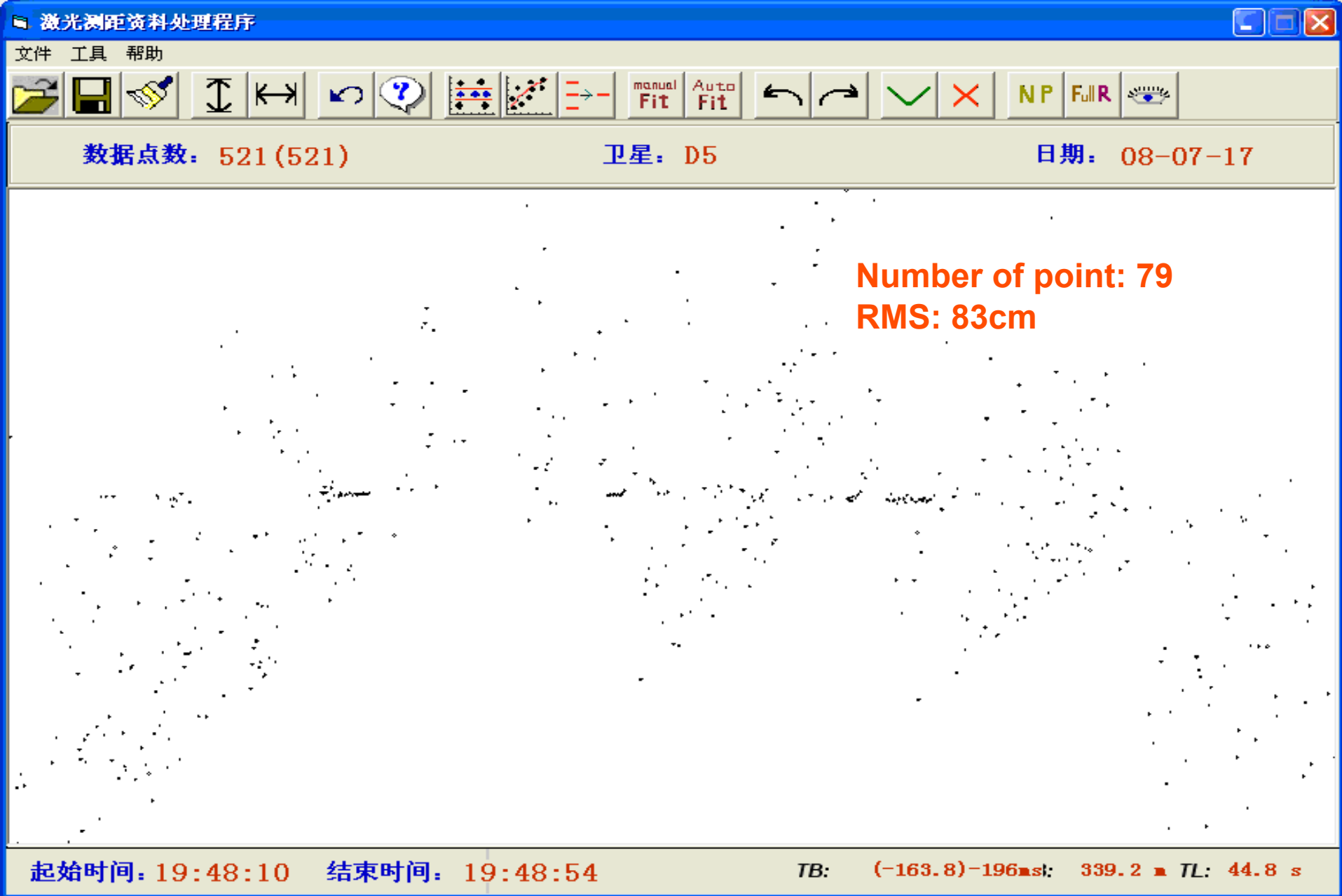


**Laser firing
at Shanghai**

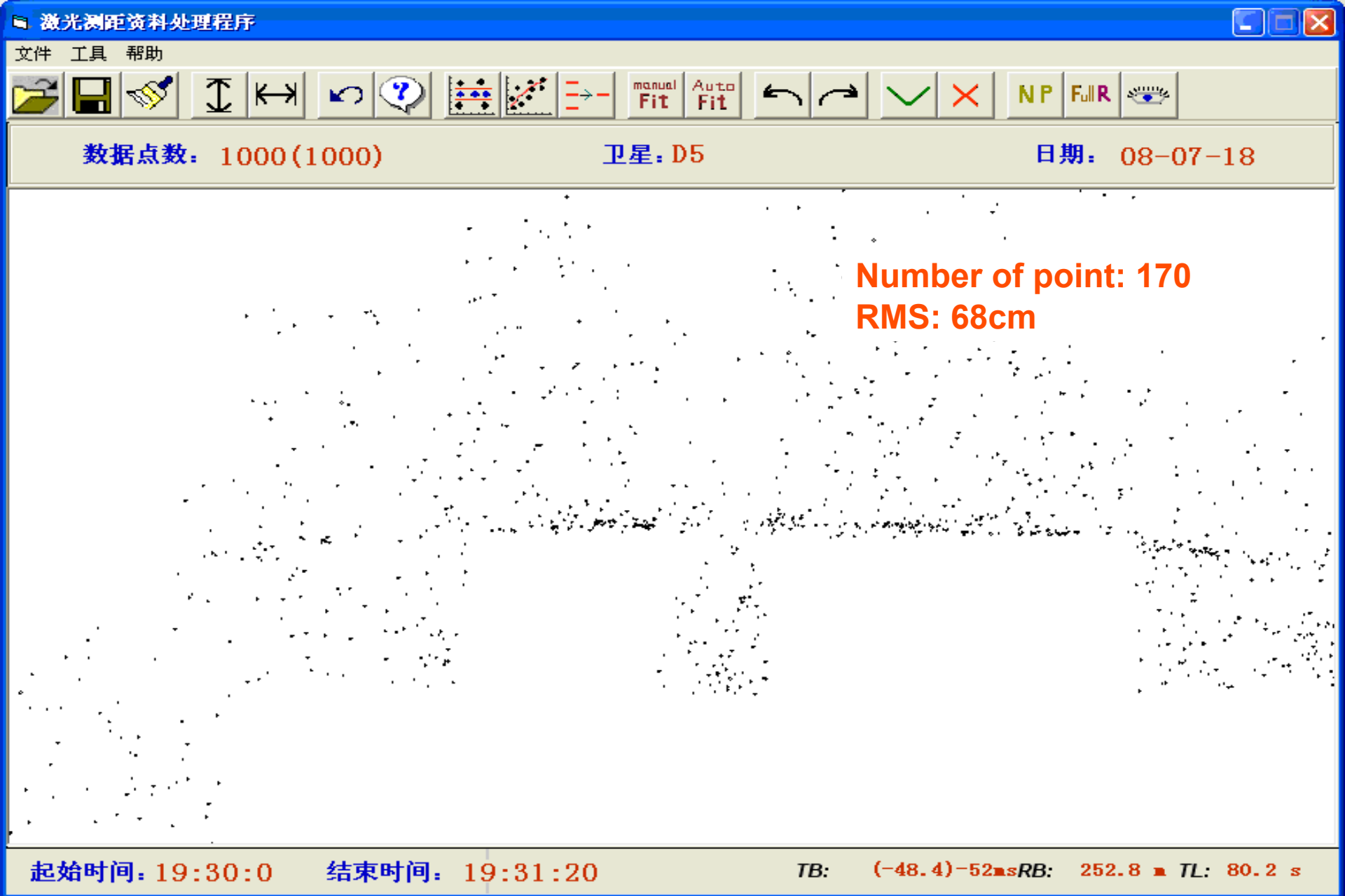
**Some results of
un-cooperative target laser ranging
at the Shanghai SLR station**



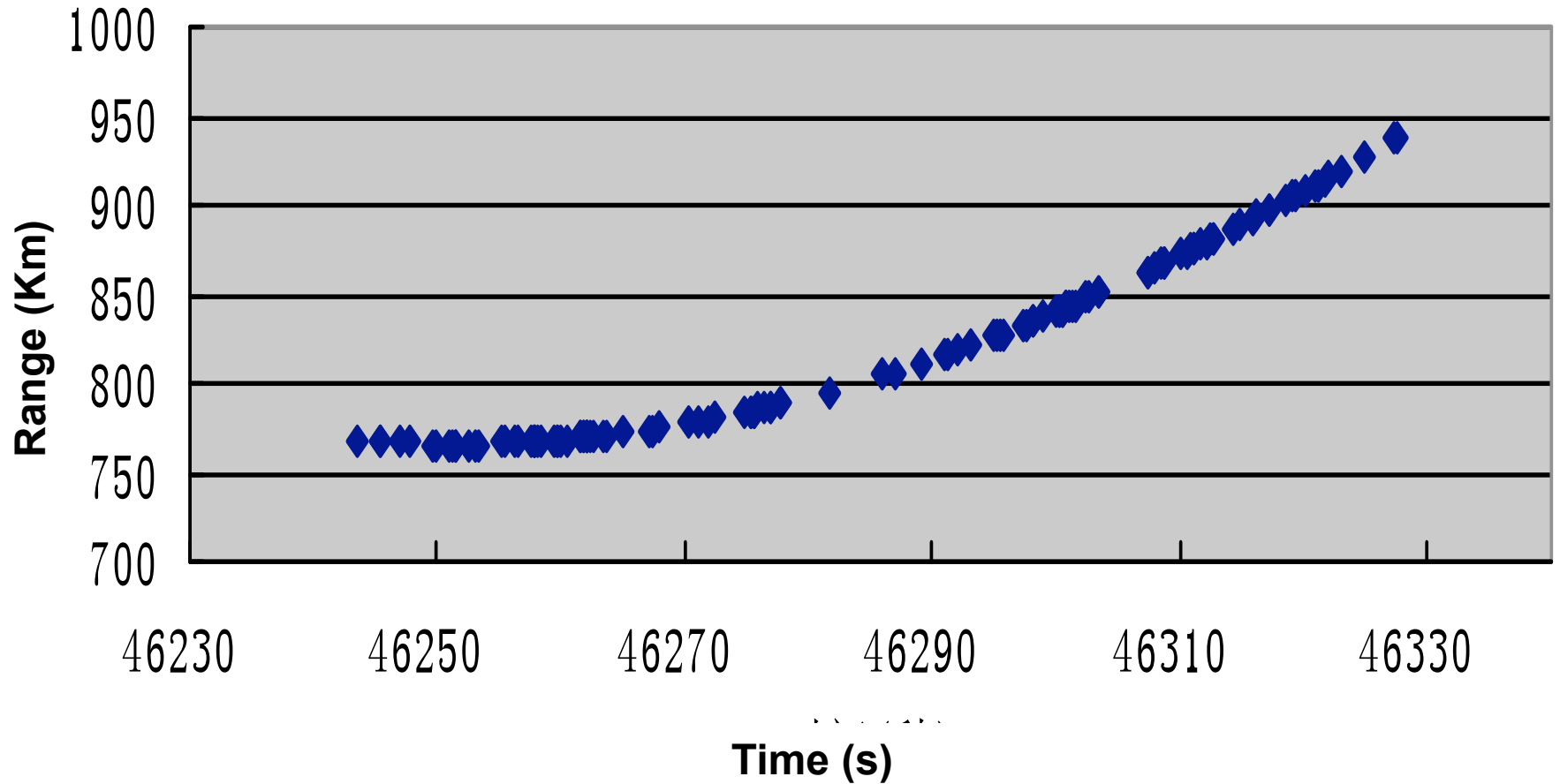
Returns from the discard Soviet rocket (ID 1987-38B) on July 7, 2008



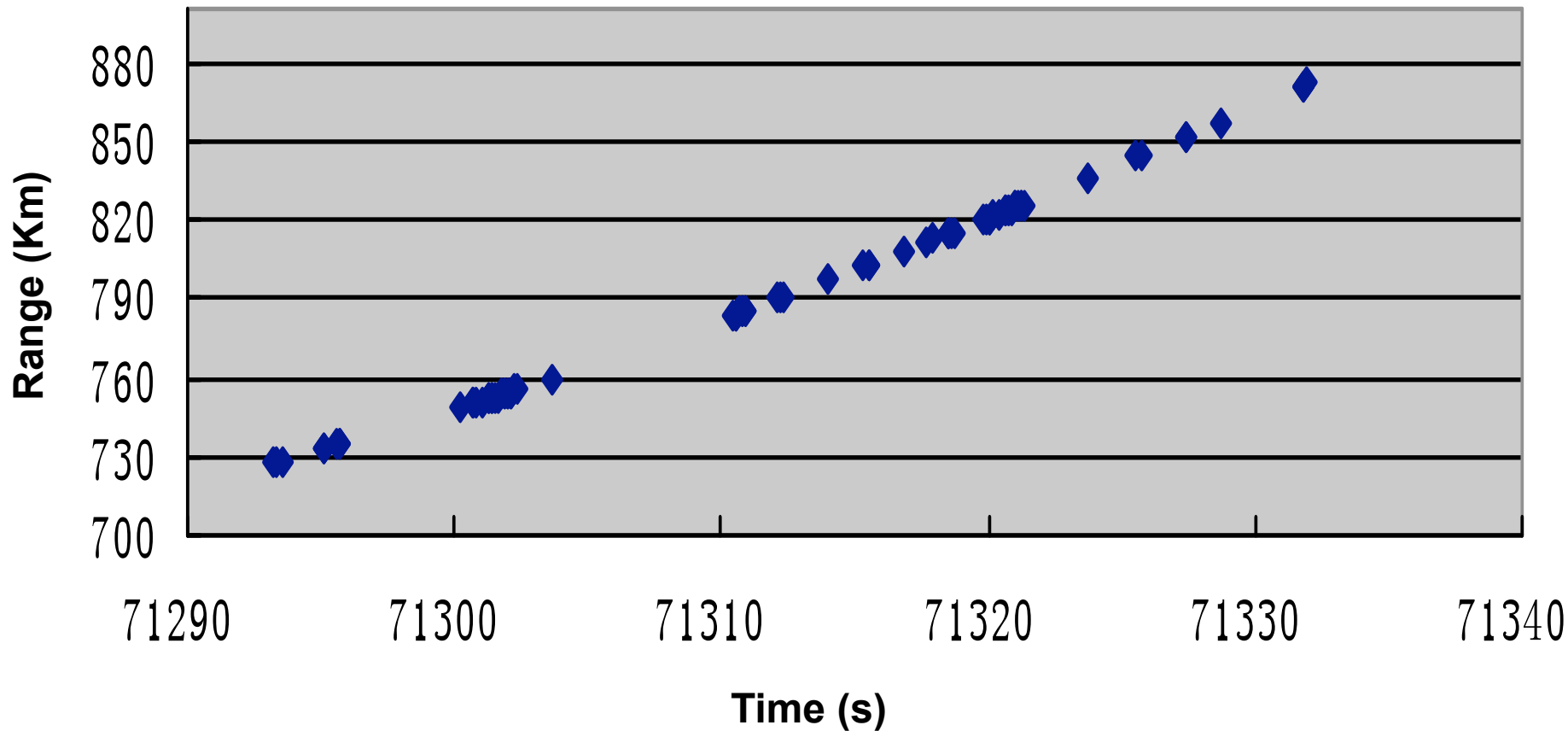
Returns from the discard US rocket (ID 2007-006G) on July 17, 2008



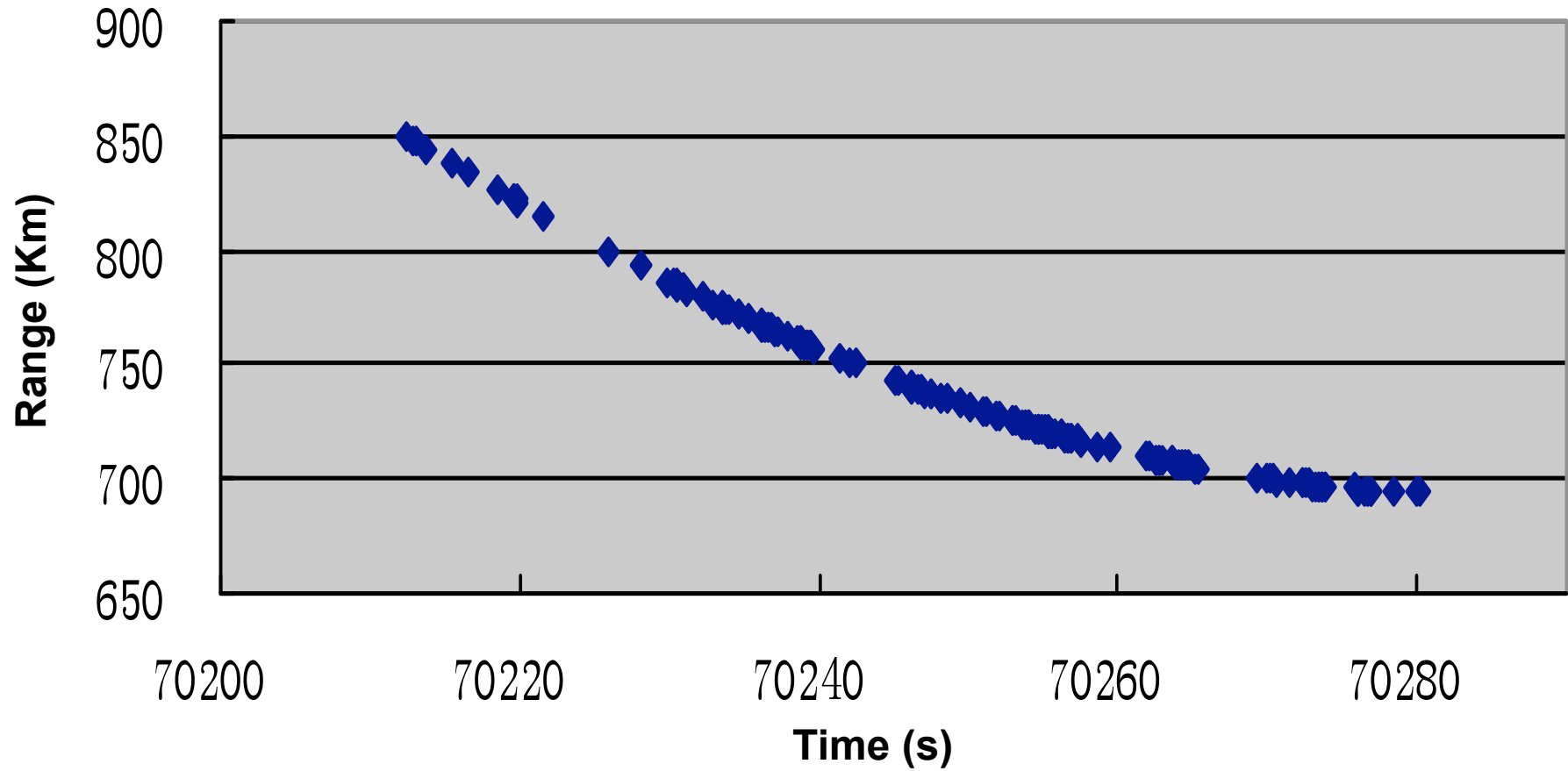
Returns from the discard US rocket (ID 2007-006G) on July 18, 2008



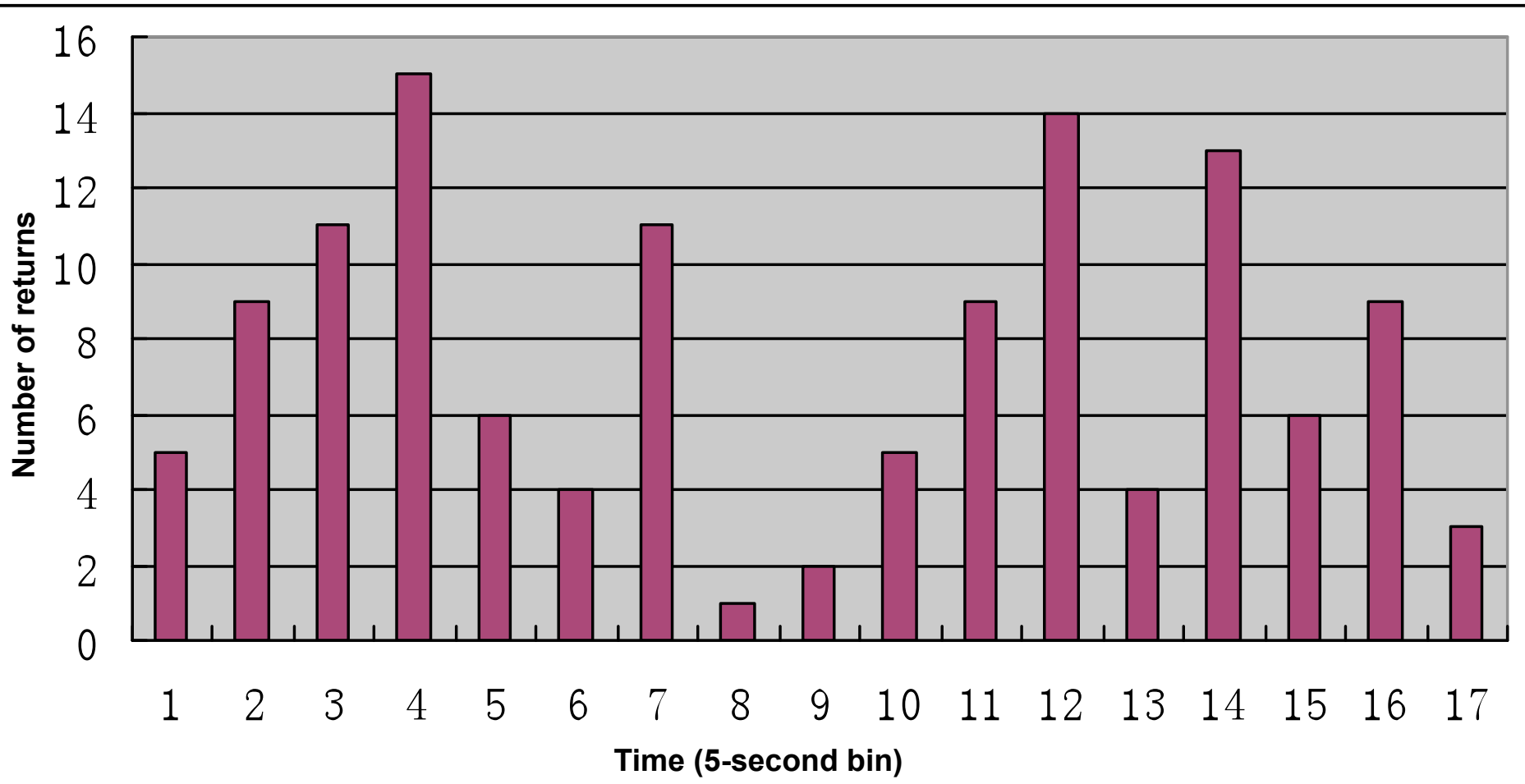
Ranging data of ID 1987-38B on July 7, 2008



Ranging data of ID 2007-006G on July 17, 2008



Ranging data of ID 2007-006G on July 18, 2008



Statistics of returns (5-second bin) on July 7, 2008

- 12-14 returns in 5 seconds were obtained when tracking well, and roughly coincide with the estimation of the returns signal strength.

Future Plan

- **Upgrading of the prediction of the targets (now the error of range prediction is about 1km, too difficult to obtain the returns)**
- **Automatically scanning of range gate and rapidly identify the return signals**
- **To track smaller targets and assessing the ranging capability of the system**

Summary

- **The laser returns from the un-cooperative targets have been obtained at the Shanghai SLR Station in July 2008.**
- **These targets are the discard Soviet and US rockets with the ID 1987-38B and 2007-006G respectively.**
- **The return signals from the targets with the range of 900km were quite strong.**

Thank You!