A high precision method for obtaining Large Scale Instrument Height

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SNS CHINESE ACADEMY OF SCIENCES

Outline

1. Introduction of CSNS
2. Introduction of CSNS ground network
3. Design of plumbing device
4. The method to obtain instrument height
5. Program implementation and summary

1. Introduction of CSNS

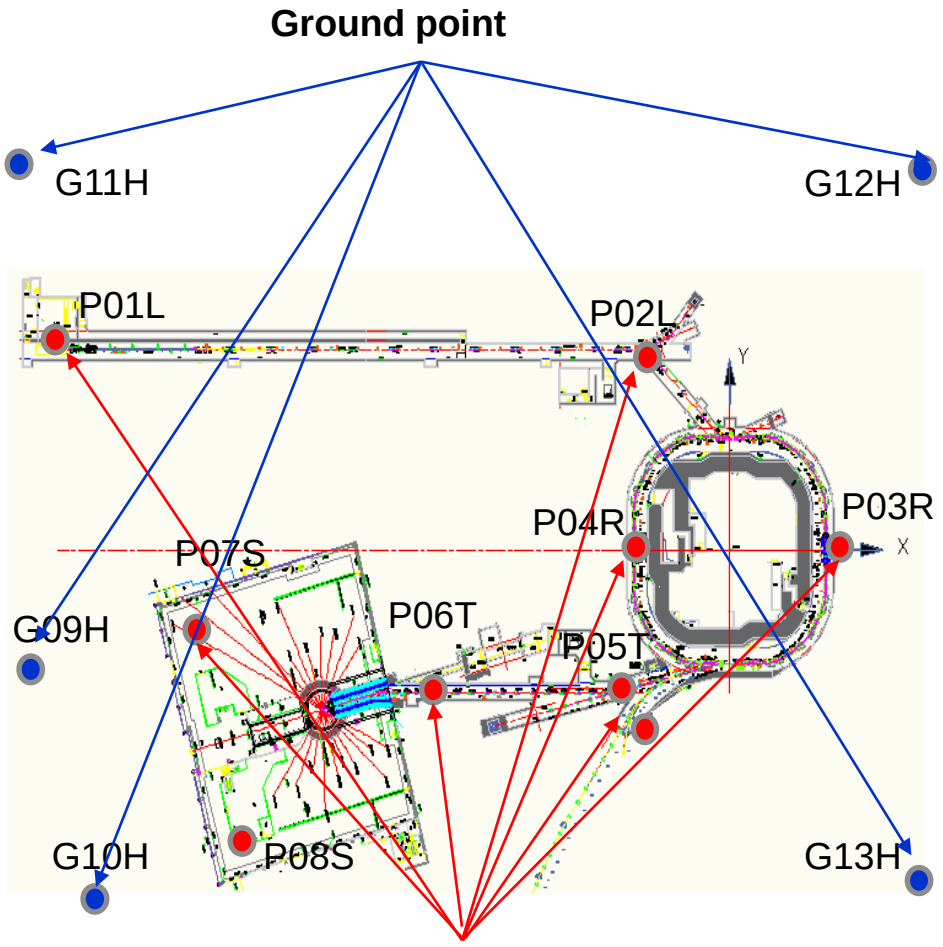
The China Spallation Neutron Source (CSNS) is a large scientific facility located in Guangdong, China. On August 28, 2017， the first neutron beam was obtained from the tungsten target. CSNS passed national acceptance on August 23, 2018, which signified that the facility was officially open to worldwide users in various disciplines.。

Bird view of CSNS in 2017. Numbering indicates as follows: (1) linear accelerator ; (2) rapid cycling synchrotron; (3) the first target building and experimental hall; (4) main substation; (5) future site of the second target station; (6) office building; (7) service building.

2. Ground control network

2. 1 Distribution and structure of control point

The control network contains 13 points. Eight points numbered P01-P08 located at the device area : Line, RCS, RTBT and target station . Other five points G09-G13 located at the campus ground . These points form a global control for the device.



2. 1 Distribution and structure of control point

For ground point , the pile is 3m deep, 1m in diameter . Point mark and tribrach are installed on the pile.

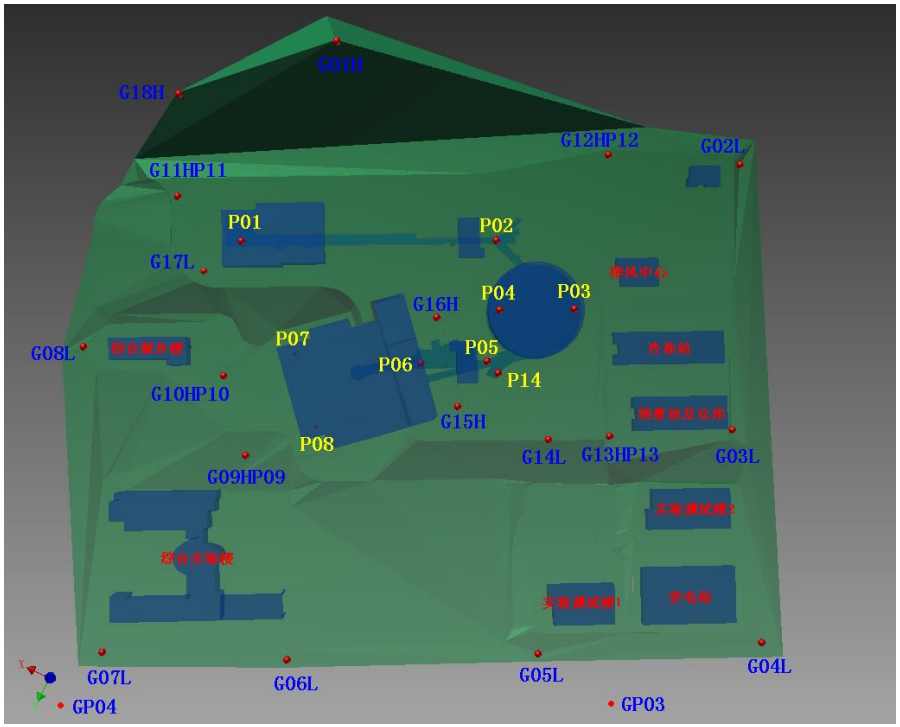
For device permanent point , the pile is located on the bedrock. Piles are casted with reinforced concrete and protected by steel barrel , on which point marks that could place 1.5 inch reflector are installed . There is a gap of 5cm between the Piles and the protect barrel, so piles are not affected by tunnel deformation and ground subsidence, which leads to good stability.

park permanent point

device permanent point

2. 2 Ground observation method

To use total station for ground observation , the measurement accuracy would be greatly affected due to the topography of the campus and the building distribution. Therefore , we use GPS for horizontal direction observation and the baselines are checked with total station. Level is used for height.



Topography of the campus

GPS observation

Level observation

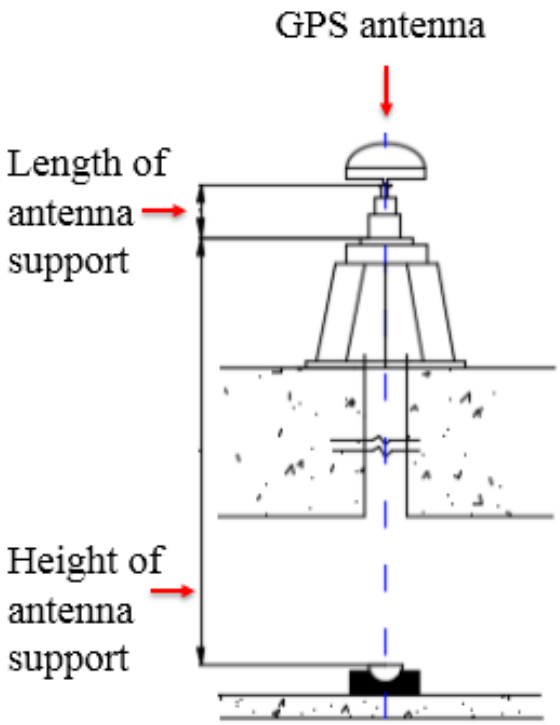
Ground level observation

Stair leveling

•2. 3 Observation schemes and some problems

Observation schemes：

Place the instrument support and GPS antenna on the roof or ground directly above the control point，then plumb, measure the height and make GPS observation.



Observation diagram

Some problems need to be solved with GPS：

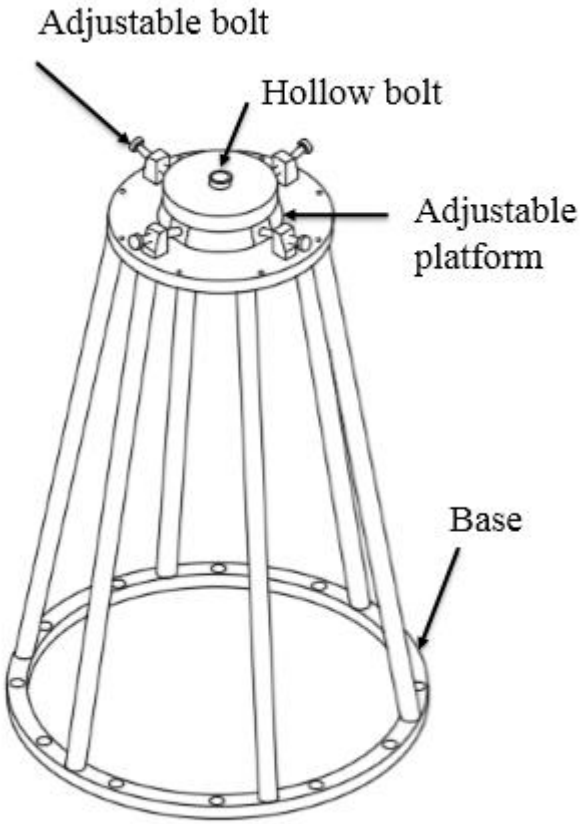
1. How to make high precision plumbing and ensure instrument stabilization；

2. How to obtain precision instrument height；

3. Design of plumbing device

•3. 1 Stable and adjustable roof support

The roof support is composed of base and adjustable platform . The base is fixed directly to the ground with bolts . Tribrach and zenith instrument are installed on the adjustable platform; adjustable bolts are used pluming.



3. 2、 Plumbing target and plumbing instrument

High precision plumbing target is designed with a diameter of 1.5 inch; the hemispheric surface is caved with 1mm dot and three concentric circular lines for plumbing with processing accuracy of 0.05mm;

Use Wild NL zenith instrument, the plumbing error is less than 0.5mm with the target range within 100 meters.

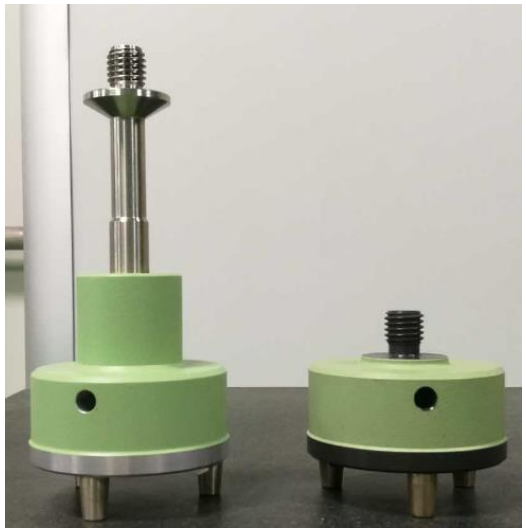
Hemispherical plumbing target

Wild NL zenith instrument

4、 The method to obtain instrument height

As shown below in Figure 2 , instrument height = length of the antenna support (value 1, distance from the antenna reference surface to the subface of the antenna support) + height of the antenna support (value 2, distance from the subface of the antenna to the tunnel point)

The value 1 is a constant that is available from the manufacturer,the problem is how to get a value 2?



antenna support

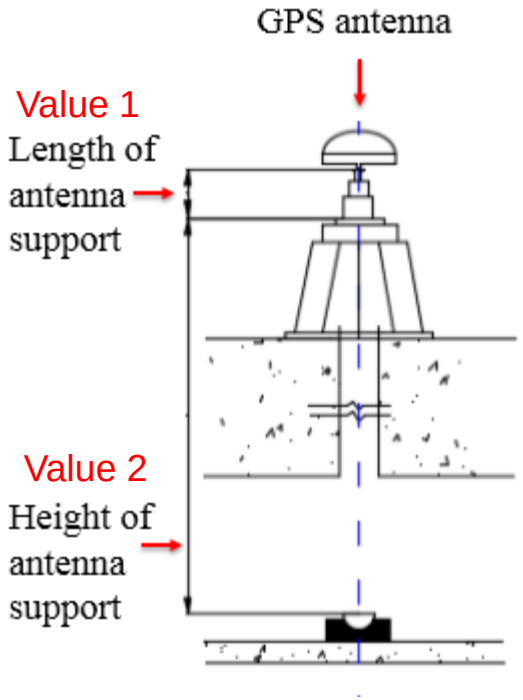


Figure 2

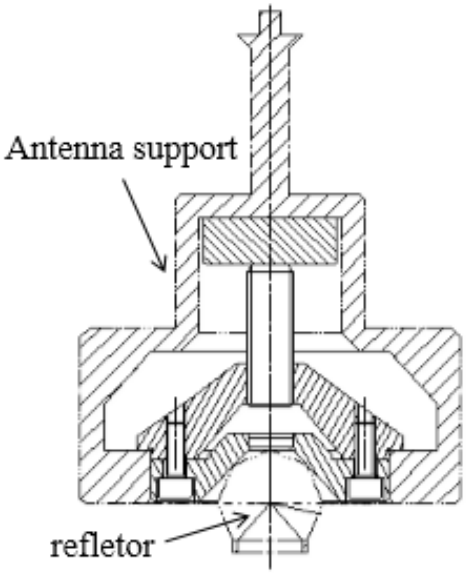
4. 1、Reform the antenna support

The support is modified through a series of designs which has the following characteristics:

1. A 0.875 inch reflector can be placed at the bottom;

2. The spherical center of the reflector is coincident with the vertical shaft of the antenna support,with accuracy of 0.05mm ;

3. The spherical center of the reflector is on the subface of the antenna support ,with accuracy of 0.05mm ;



•4. 2、Selection of laser tracker

To observe the reflector at the bottom of the antenna support above the roof，the laser tracker must be able to observe the zenith direction. Some types of Laser tracker could be used, such as LEICA AT401 and FARO vantage of which the handle can be removed for zenith observation.

LEICA AT401

FARO vantage

4. 3、 measure scheme of instrument height

As shown in the figure, GC01 is a permanent point, GC01_T is on the roof, 2 stations of measurements are conducted in the tunnel:

Station 1: setup station near GC01, measuring tunnel control point and GC01;

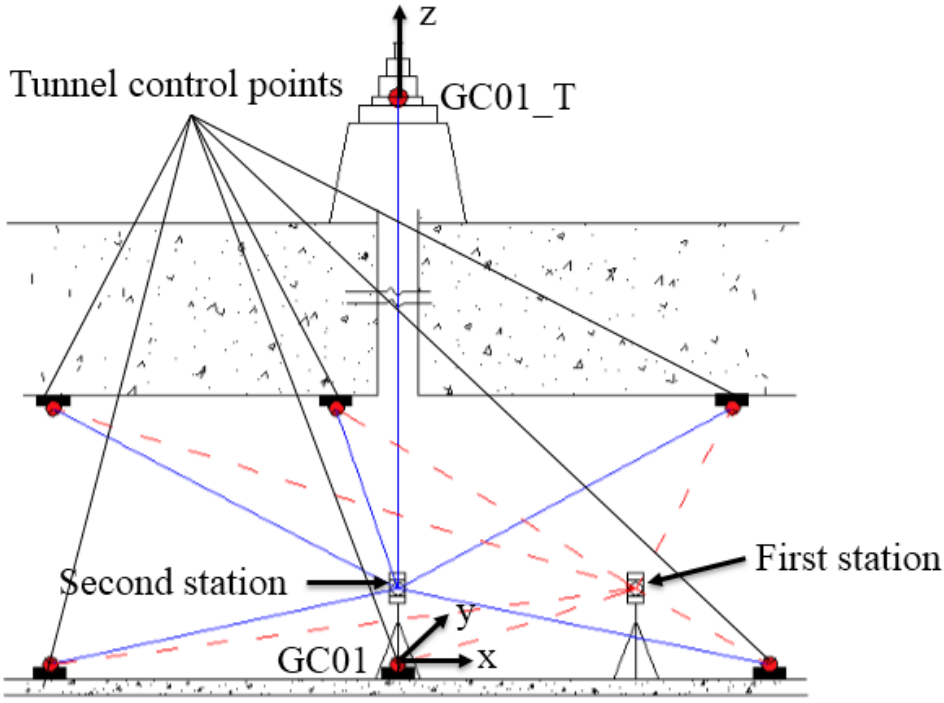
Station 2: Setup station above GC01, measuring tunnel control point and GC01_T;

Establish a horizontal coordinate system：

origin： GC01

Z axis： zenith direction

The Z value of GC01_T is the height of antenna support(value 2), X and Y values indicate the plumbing error.



5、Program implementation and summary

Using this method, plumbing and survey height for 6 permanent points that 30 meters under roof, the results are as follows (unit: mm) :

name	X/ tracker	Y/ tracker	Z1/ tracker	Z2/ tracker	Z1-Z2 / tracker	tapeline	tapeline -tracker
L01B_T	-0.04	-0.45	26454.90	26454.91	-0.01	26452.70	-2.21
L30B_T	-0.31	-0.19	14709.01	14709.11	-0.10	14707.20	-1.86
R01B_T	0.03	-0.07	29177.82	29177.80	0.02	29175.70	-2.11
R21B_T	0.21	0.12	29170.87	29170.85	0.02	29170.70	-0.16
T04B_T	-0.24	-0.30	13195.31	13195.34	-0.03	13193.70	-1.62
T12B_T	0.22	0.17	11470.03	11470.01	0.02	11468.70	-1.32

X and Y values are less than 0.45mm;The difference value of z1-z2 of the tracking elevation measurement is within 0.1mm; The tape measure results are all less than the values of the tracker.

5、Program implementation and summary

Summary：

- 1. Considering the reform error of the antenna support in horizontal is 0.05mm, the precision of the plumbing error is less than 0.5mm;
- 2. Considering the reform error of the antenna support in height is 0.05mm, the precision of height survey error can reach 0.2mm.
- 3. This method can be used for the height transmission between underground and roof and avoid error accumulation in leveling.

Thank you for attention!