HLS Used at *BEPCII*, *SSRF* and *NSRL*

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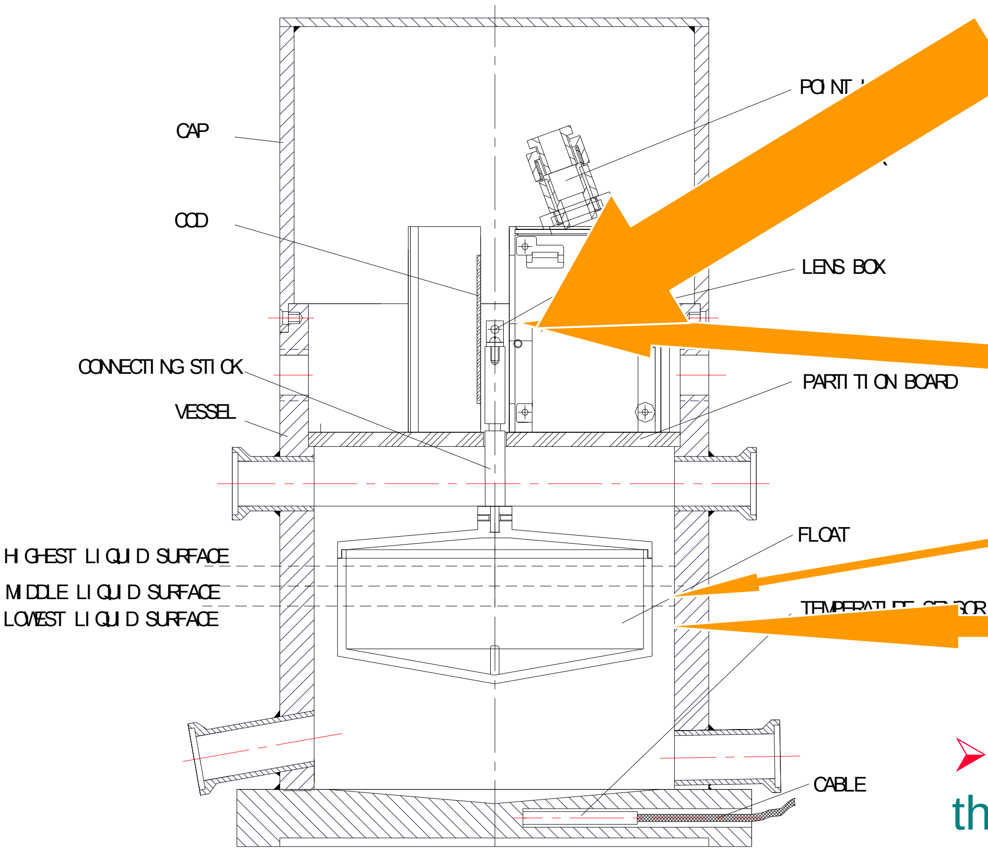
HLS Used at *BEPCII*, *SSRF* and *NSRL*

- ★ Sensors of HLS used at BEPCII,SSRF and NSRL
- ★ Calibration of the sensors
- ★ HLS at SSRF, the most complicated in China so far
- ★ Some questions followed with interest

1. Sensors of HLS used at BEPCII,SSRF and NSRL

- They are all based on the same technology--Charged Coupled Device (CCD)
- Their structures have been changed
- Water is chosen as the working liquid.
- The influent factor of the temperature difference between vessels must be adjusted in the altimetric measurement

1.1 sensor used at BEPCII (Intruduced at IWAA2004)



A bundle of parallel light shines on the bar and it will produce a shadow band on the acceptance widows of CCD.

- The mark bar moves up and down along with the float connected through connecting stick.
- The distance between the highest and lowest liquid surface determines the measurement range. The measurement rang of this type of HLS is 10 mm.
- The float moves up and down with the height of the surface of liquid.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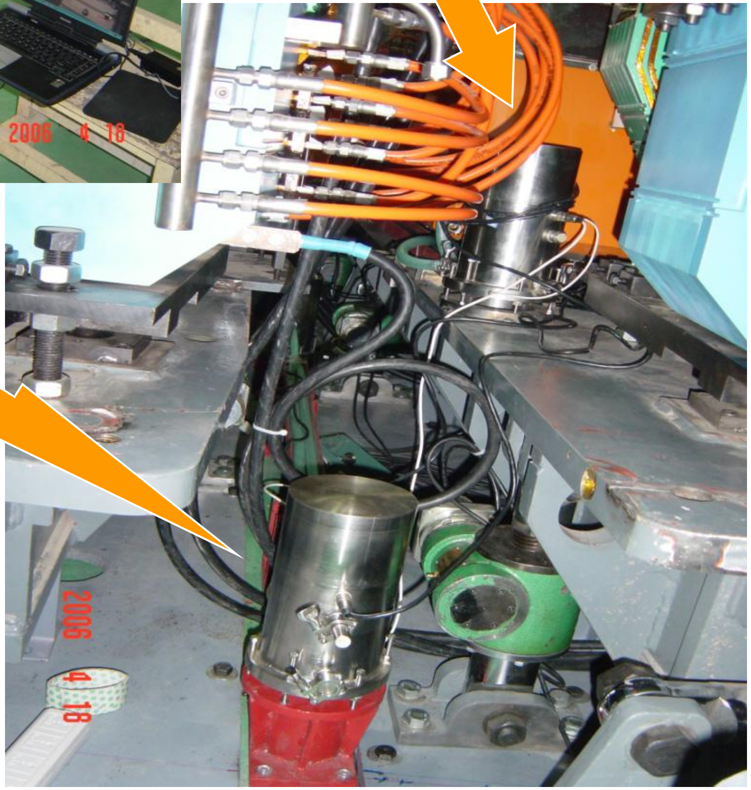
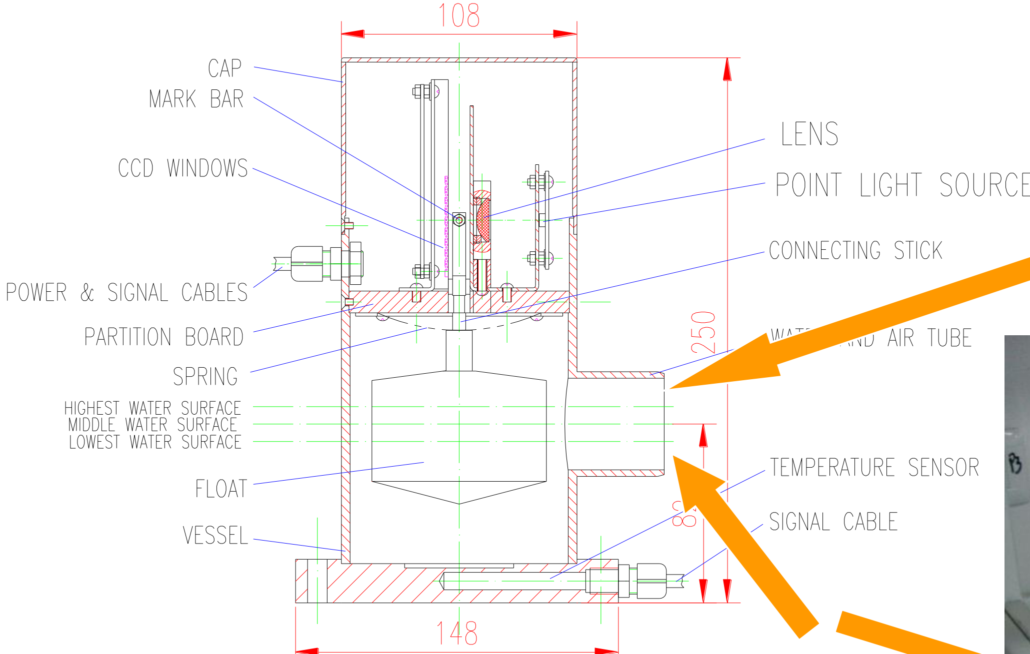


HLS

HLS

Because the ring is crowded and have no place to install a large set of HLS. The nine sensors were used in two set of system, one with 4 sensors and the other with 5 ones, to monitor one gird upper plane and the ground around it in the ring.

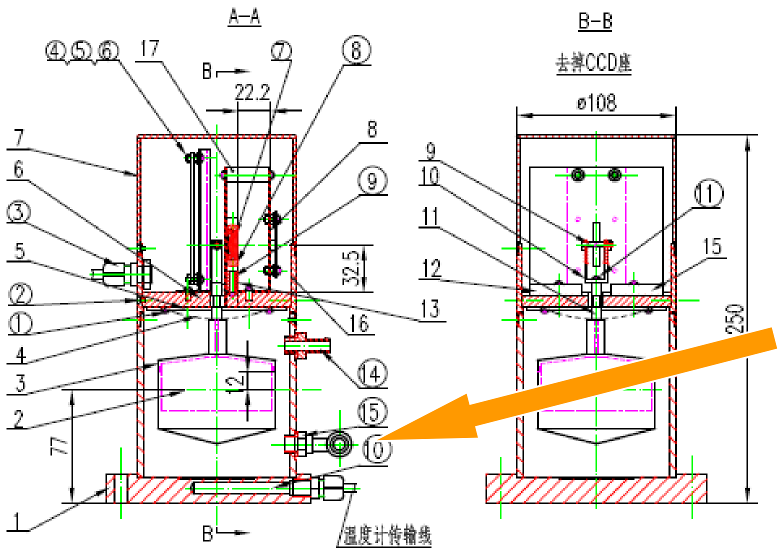
1.2 sensor used at SSRF (Intruduced at IWAA2008)



The sensor developed for BEPCII was the kind of full-filled one, but the one for SSRF is a half-filled one. The basic principle is the same.

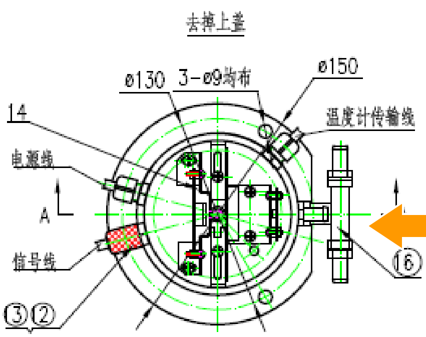
Because the geological condition of the SSRF site is more unstable than the BEPCII site, the HLS must have larger measuring range. Meanwhile, in order to get shorter time for HLS to stabilizing, the system uses circuit through stainless steel pipe with inner diameter 40 mm.

1.3 sensor used at NSRL



The air tube and the water tube are seperated again.But different from the one used at BEPCII, there are only one air tube and one water tube.

For the sensor, it is the full-filled type,but for the system, it is a half-filled one.



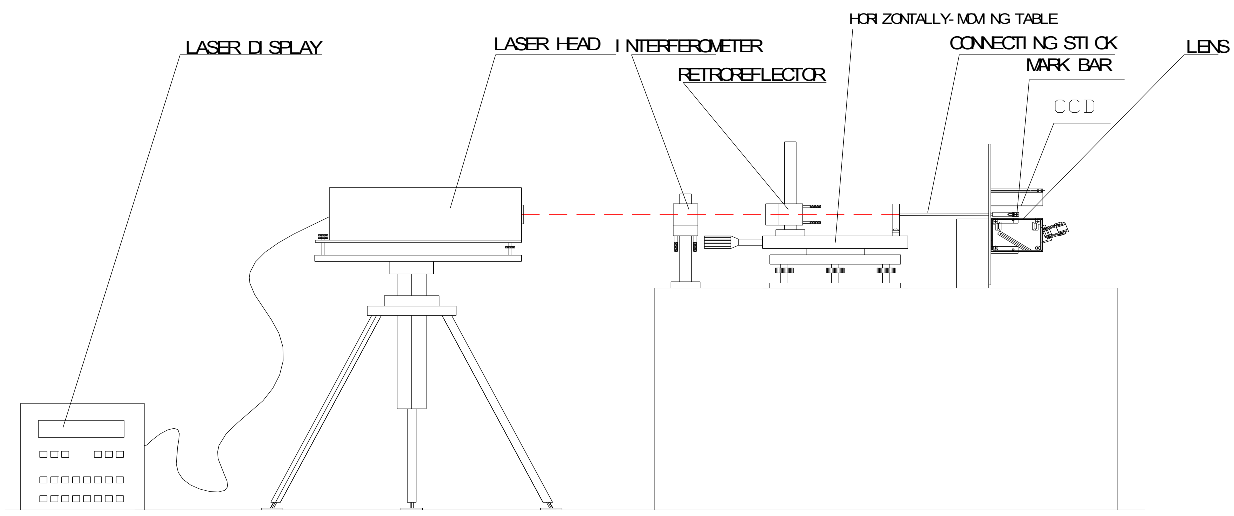
The new structure of the water tube joint make it easier for the vessel sensors to be seriatim connected in the system

2 Calibration of the sensors

Calibration includes the CCD ,vessel sensor and system test before used on-the spot.

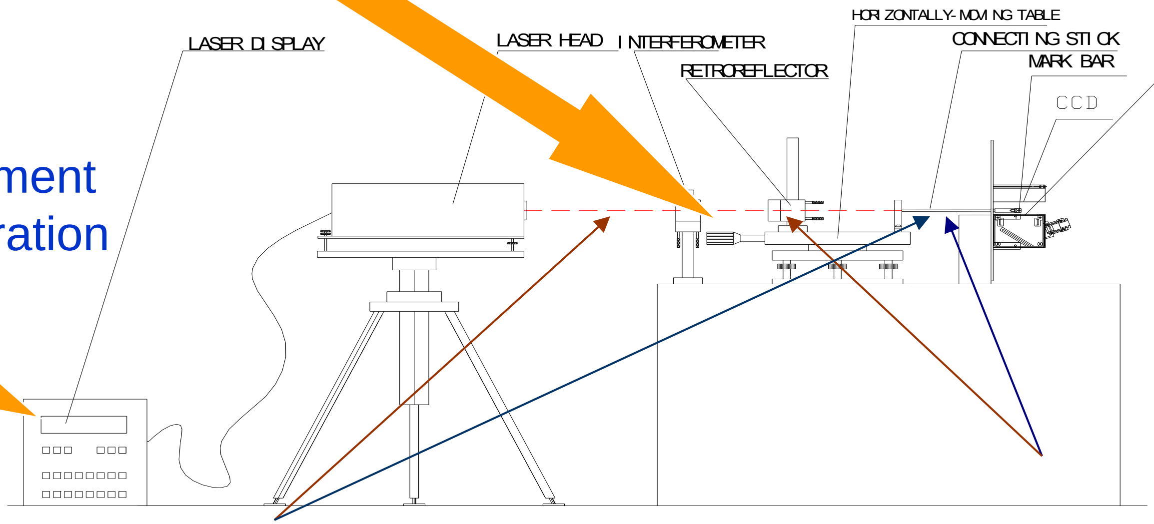
2.1. Calibration of CCD

Measurement Laser System is used to calibrate the CCD, which was inruduced at IWAA2004



Moving the table forth and back, we get the readings of the laser system and the signs from the CCD.

The laser measurement reading is the calibration datum.



The axle of the connecting stick and the laser beam are on the same line so as to eliminate the Abbe error during measuring.

The connecting stick and retroflector are fixed on the horizontally moving table by screws and connecting spare parts.

Laser head

Horinzontally-moving table

Connecting stick

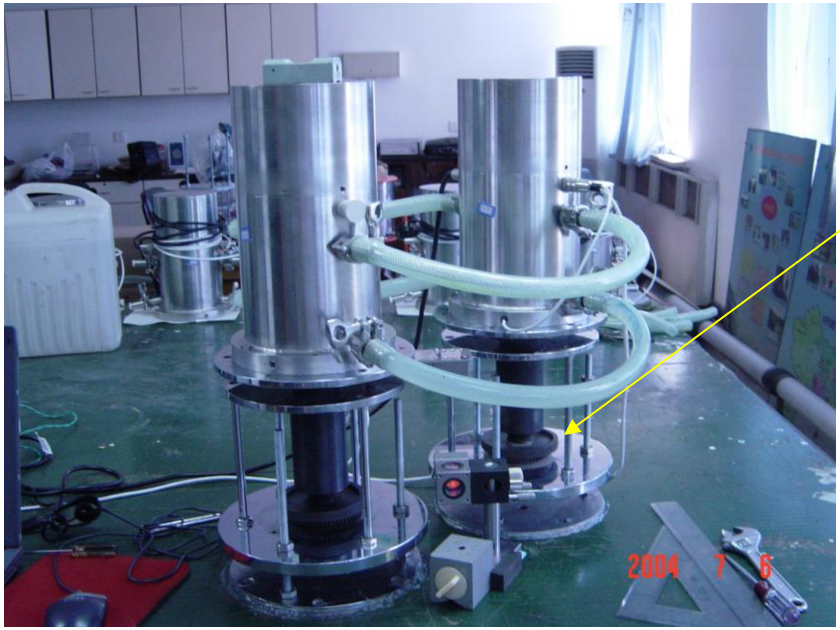
Interferometer

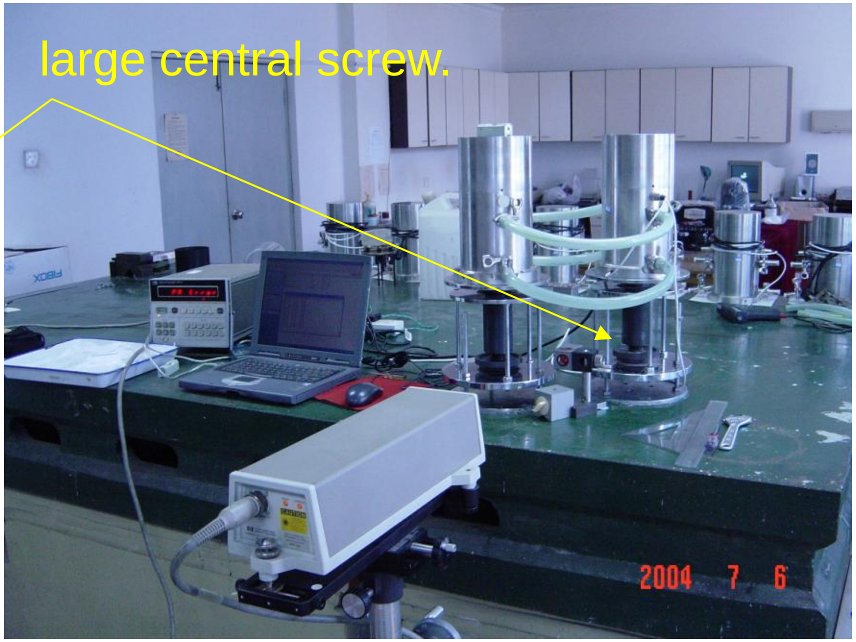
Retroreflector

2.2 Calibration of vessel sensor

2.2.1 Calibration of vessel sensor for the BEPCII (introduced at IWAA2004)

✓First method: by controlling the elevation of one vessel in a system of two vessels. HP 5528A Laser Measurement System is used to measure the change of the elevation, which is changed by turning the large central screw.



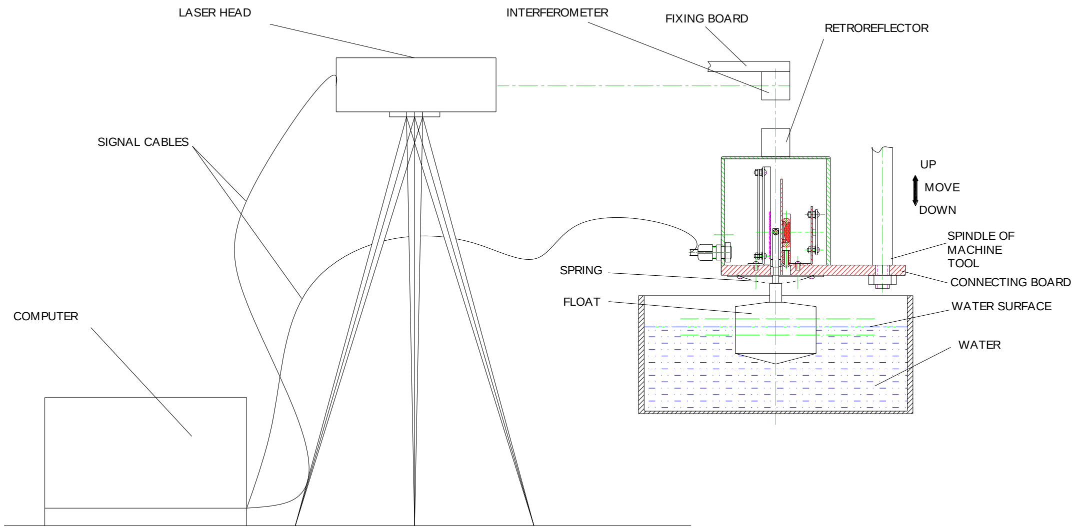


- The uneven screw pitch made the HP readings do not reflect the true change of the elevation of the vessel.
- So we use the second method instead of the first one, which is by adding a known volume steel lump.
- The steel lump is a cylinder of Φ21mm×10mm. And the inner diameter of the vessel is 126mm.So in a system of two vessels, one of the steel lump is added in the water of a vessel will make the water level raise about 138.89μm.We added five lumps one time and the water level would raise 694.445μm in each vessel.
- After linear fitting of the data we got standard deviation of the fit is 27.28μm.In order to correct the non-linearity of the sensor output over the range of 10mm(the readings of output of the sensor from 17 mm to 28 mm), we used a third degree polynomial curve to fit the measurement curve. And the result of SD is better then 0.02 mm.

steel lump

2.2.2 Calibration of vessel sensor for the SSRF (introduced at IWAA2008)

✓But the above methods always using two or more vessel sensors to establish a system, and the system factors often influence the calibration result.
✓Here we designed a system which can calibrate just one vessel sensor by comparing the read of laser measurement system and the output of the sensor.

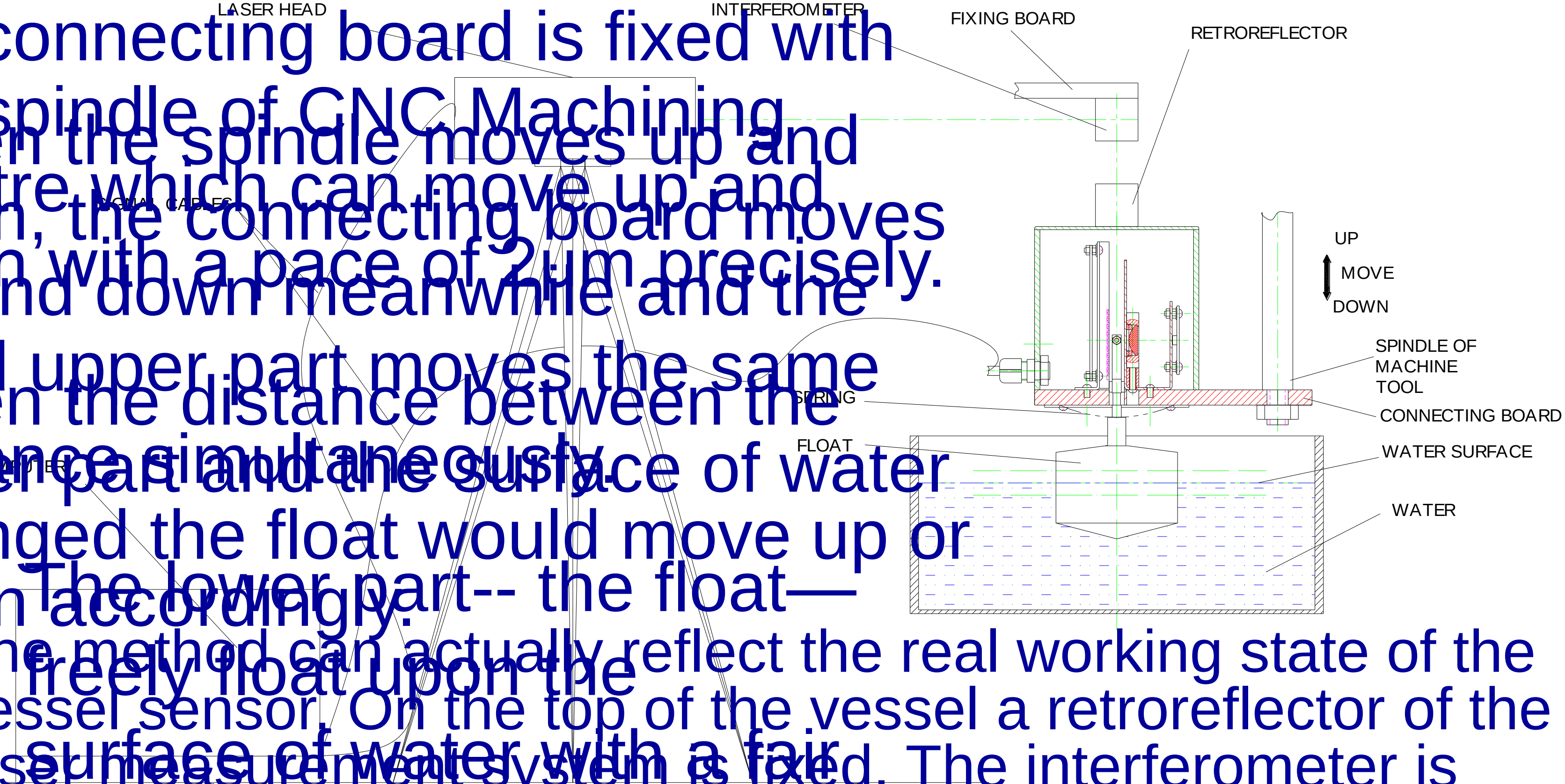


The upper part of the vessel sensor is fixed on a connecting board, and the connecting board is fixed with the spindle of CNC Machining Centre which can move up and down with a pace of 2 μm precisely.

When the spindle moves up and down, the connecting board moves up and down meanwhile and the fixed upper part moves the same distance simultaneously.

When the distance between the upper part and the surface of water changed the float would move up or down accordingly.

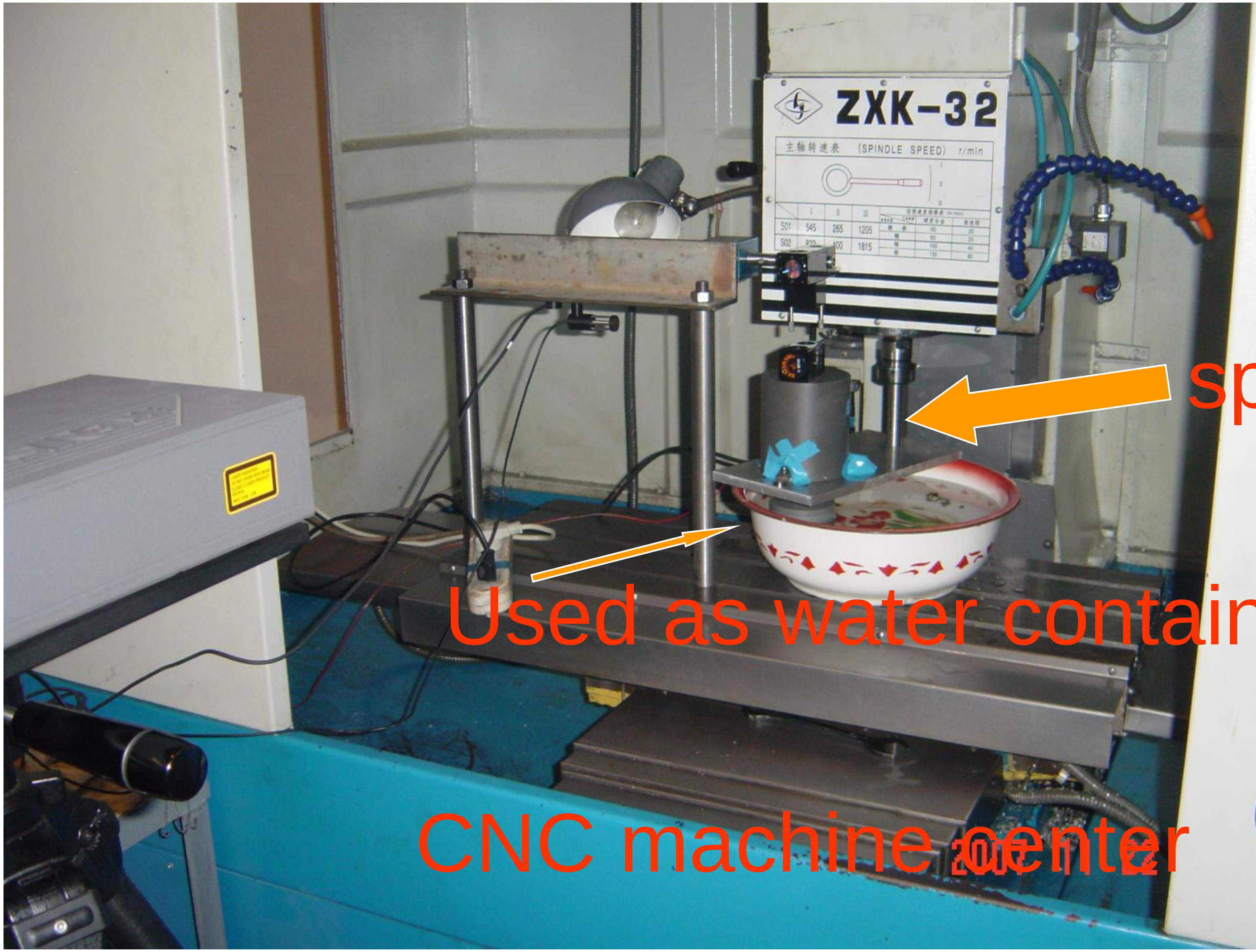
The lower part-- the float—freely float upon the surface of water with a fair depth in a container.

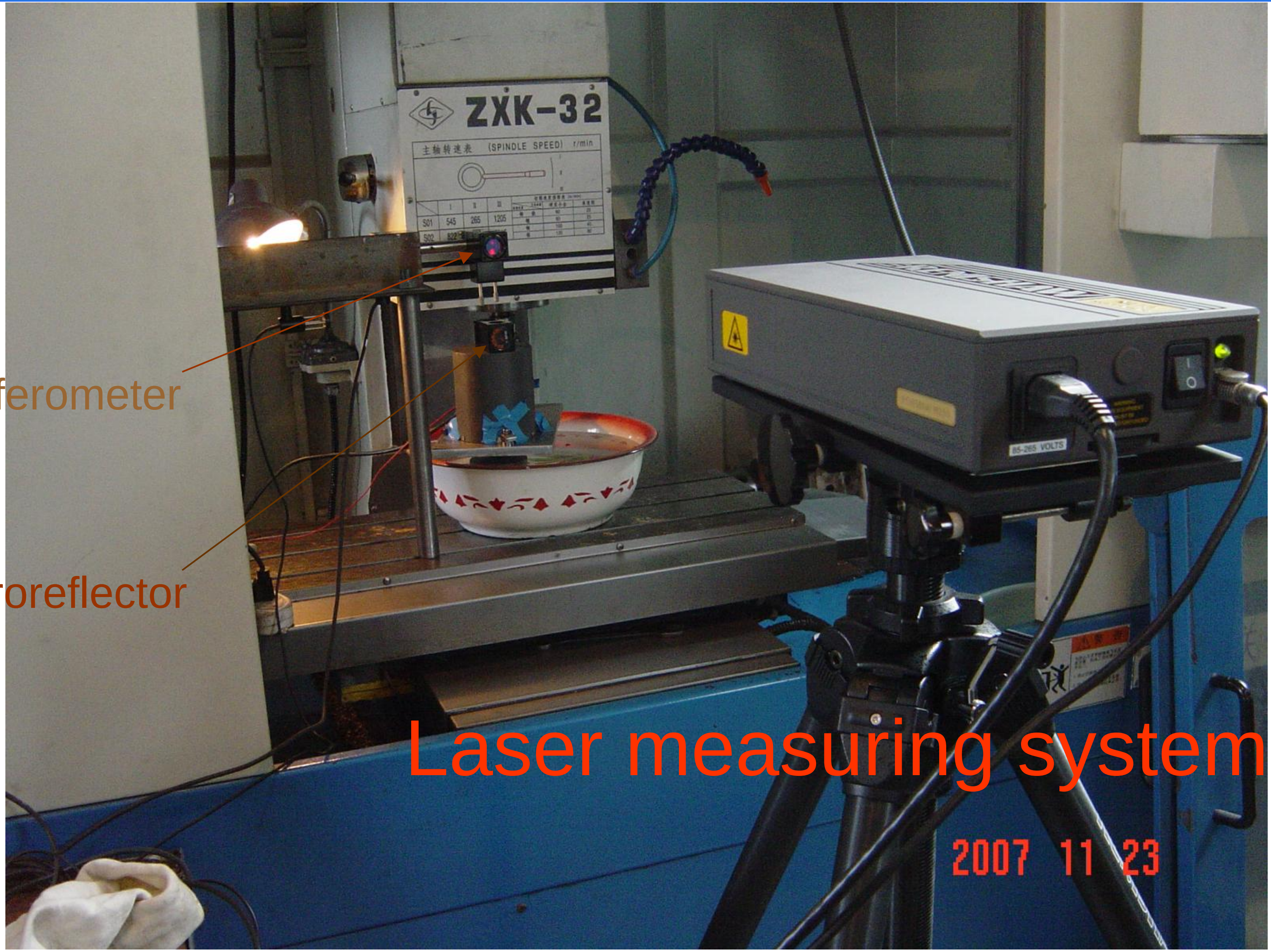


The method can actually reflect the real working state of the vessel sensor. On the top of the vessel a retroreflector of the laser measurement system is fixed. The interferometer is fixed on a fixing board, and use the laser measurement system to measure the moving distance of the vessel.

Calibration system for one vessel

★Using the laser system as the reference and by comparing the readings the laser system and the outputs of the vessel sensor, the vessel sensor is calibrated.


ZXK-32
spindle
Used as water container
CNC machine center


interferometer
Retroreflector
Laser measuring system
ZXK-32
(SPINDLE SPEED)
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2.2.3 Calibration of vessel sensor for the NSRL

✓In order to make the calibration process more efficient, and to get the results which could actually reflect the real working state of the vessel sensor. A calibration system which can calibrate more sensors was used at the calibration of vessel sensor for the NSRL

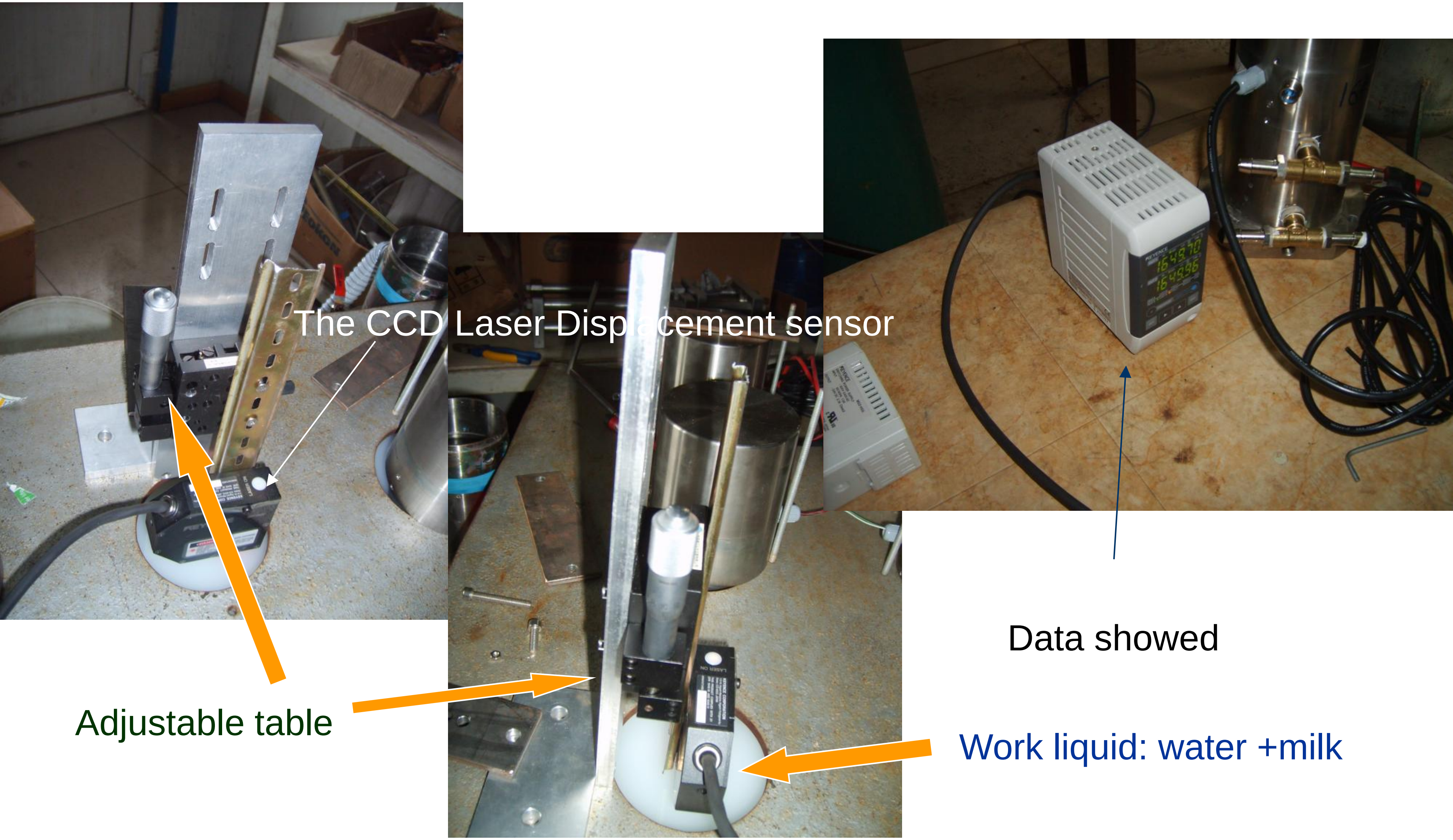
✓The CCD Laser Displacement sensor, product of Keyence Copporation, was used.

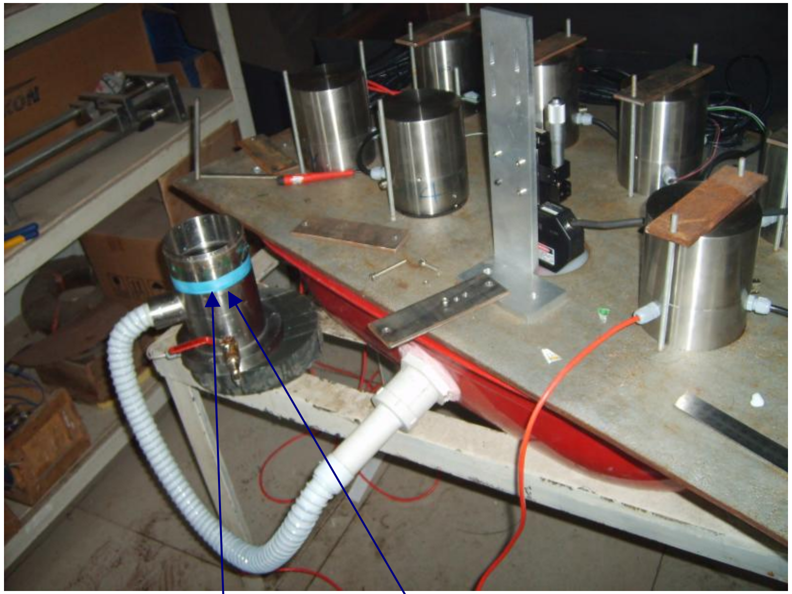
✓Main specifications of the Model LK-G30

Measurement range:	±5mm
Repeatability:	0.05μm
Linearity:	±0.05% of F.S.
Temperature characteristic:	0.01% of F.S./°C


Upper parts of HLS sensors


The CCD Laser Displacement sensor
KEYENCE


The CCD Laser Displacement sensor
Adjustable table
Data showed
Work liquid: water +milk



To pour into or draw off water here

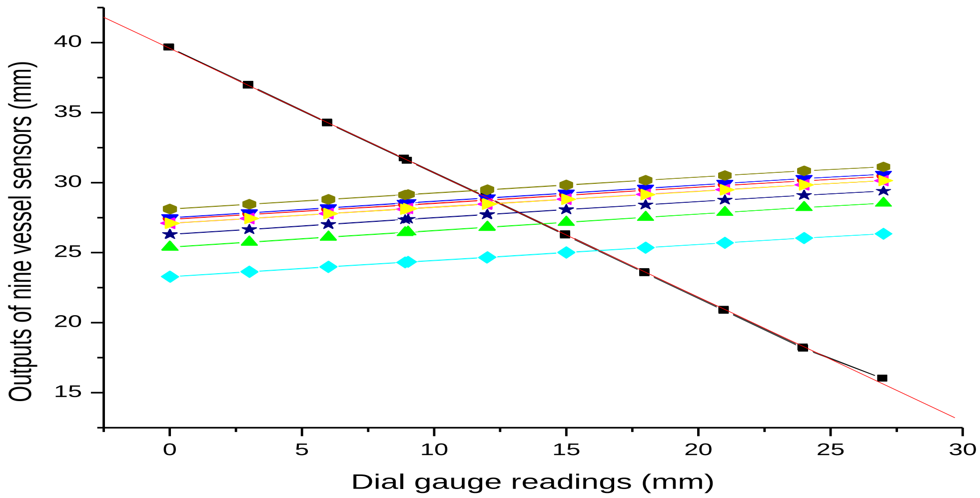
As plan, a test HLS system will be established at NSRL in May 2009,and in the Linac a HLS with seven sensors will be installed during the shut-down period, July to augest 2009.

2.3 Test of the a small system before used on-site

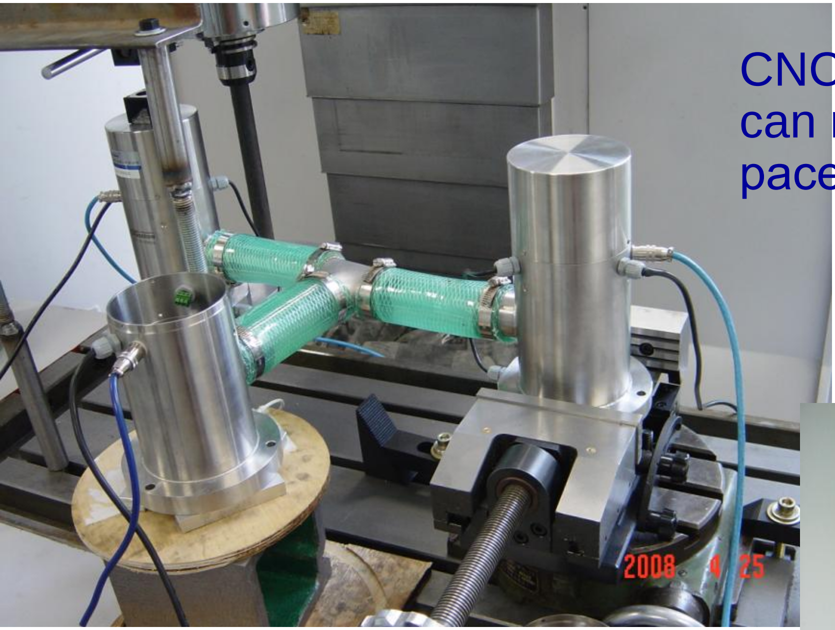
- Test of a nine-vessel HLS system for BEPCII

- In this system we raised and lowed the No.1 vessel by 3 mm increments. Then the water level of No.1 vessel would go down or up of 3*(9-1)/9=2.6667 mm a step. Otherwise the water level in other vessels would go up or down of 3/9=0.3333mm a step.
- Here we used dial gauge instead of HP Laser Measurement System to directly measure the elevation change of the No.1 vessel.

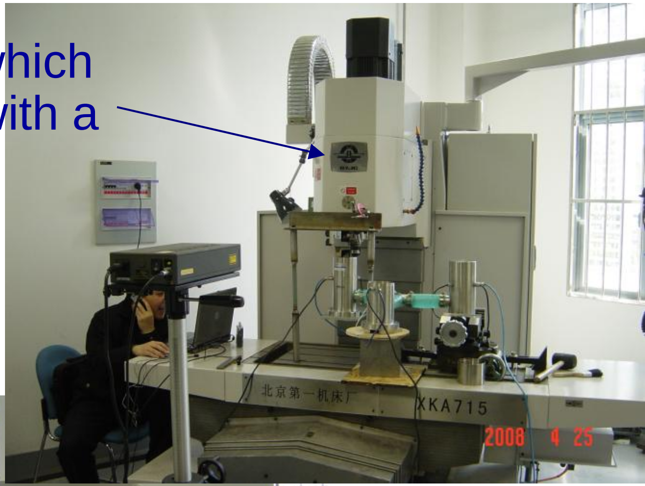
the test result is



➢Test of a three-vessel HLS system for SSRF



CNC Machining Centre which can move up and down with a pace of 2μm precisely.



a vessel sensor is fixed on a connecting board, and the connecting board is fixed with the spindle of CNC Machining Centre

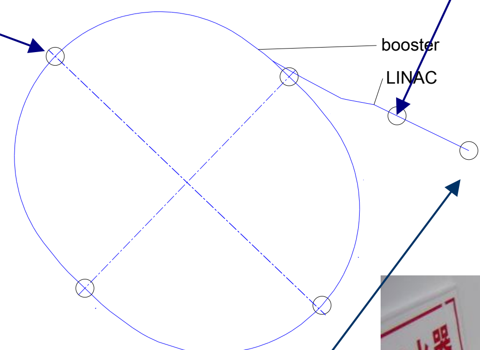
The laser measurement system measures the movement meanwhile

序号	干涉仪读数	步长1	传感器28	传感器32	读数差	步长2	*步长差*
0		-0.993					
1	-0.993	-0.995	5.62	7.947	-2.327	-1.016	***0.021***
2	-1.988	-0.994	4.958	8.301	-3.343	-0.999	***0.005***
3	-2.982	-0.996	4.302	8.644	-4.342	-0.995	***-0.001***
4	-3.978	-0.997	3.661	8.998	-5.337	-0.981	***-0.016***
5	-4.975	-0.996	3.032	9.35	-6.318	-1.002	***0.006***
6	-5.971	-0.994	2.395	9.715	-7.32	-0.981	***-0.013***
7	-6.965	-0.996	1.771	10.072	-8.301	-0.999	***0.003***
8	-7.961	2.957	1.108	10.408	-9.3	2.95	***0.007***
9	-5.004	2.986	3.025	9.375	-6.35	2.975	***0.011***
10	0.994	2.962	6.951	7.23	-0.279	3.009	***-0.047***
11	1.0022		6.96	7.232	-0.272		

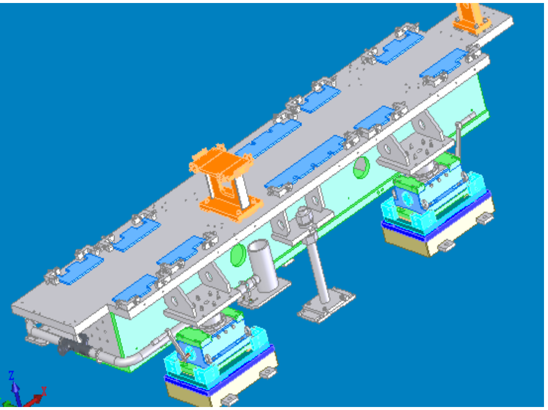
3 HLS at SSRF, the most complicated in China so far

HLS sensor along the Booster

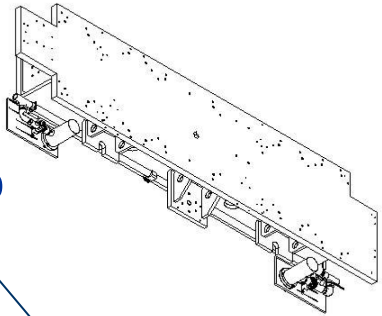
HLS sensor along the Linac



The first sensor in LINAC

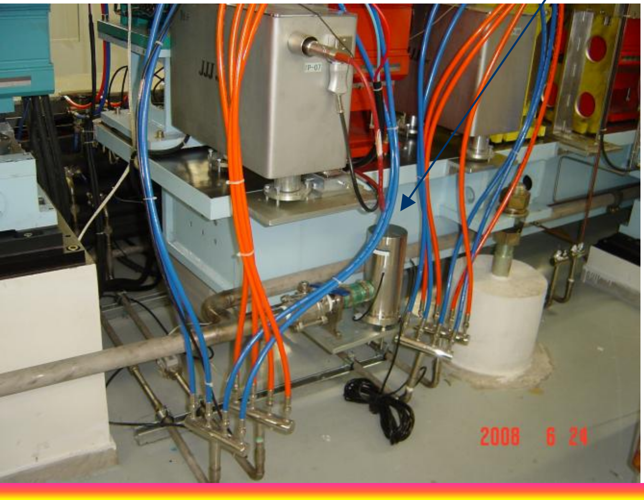


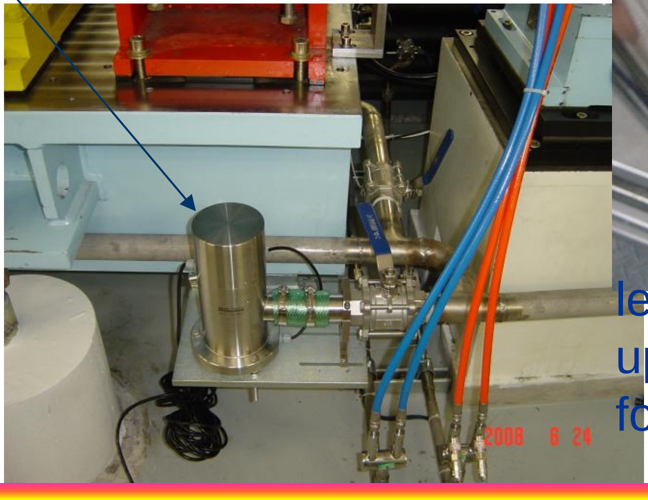
on the inner side of th egird a sensor was installed



on the outside of th egird two sensors were installed

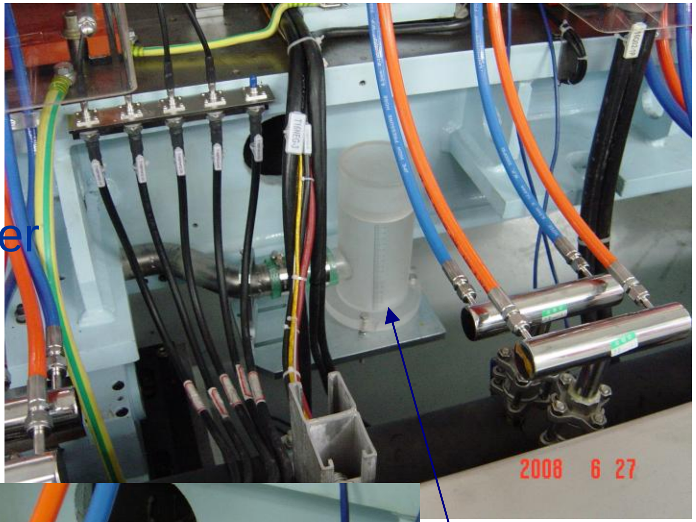
lead caps are put on the upper parts of the sensors for radiation protection

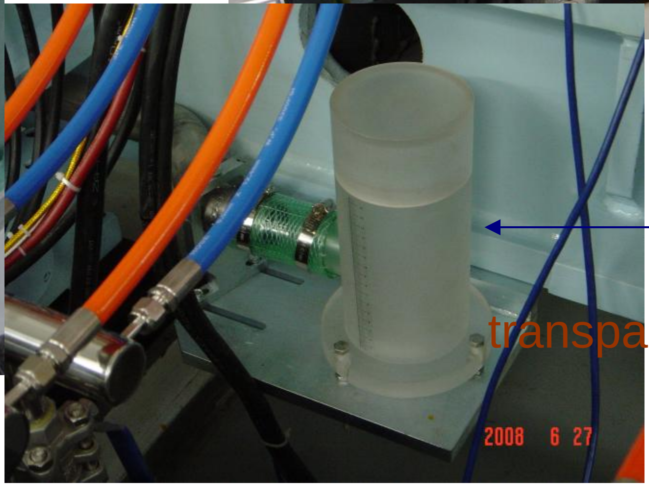




transparent vessels in Linac

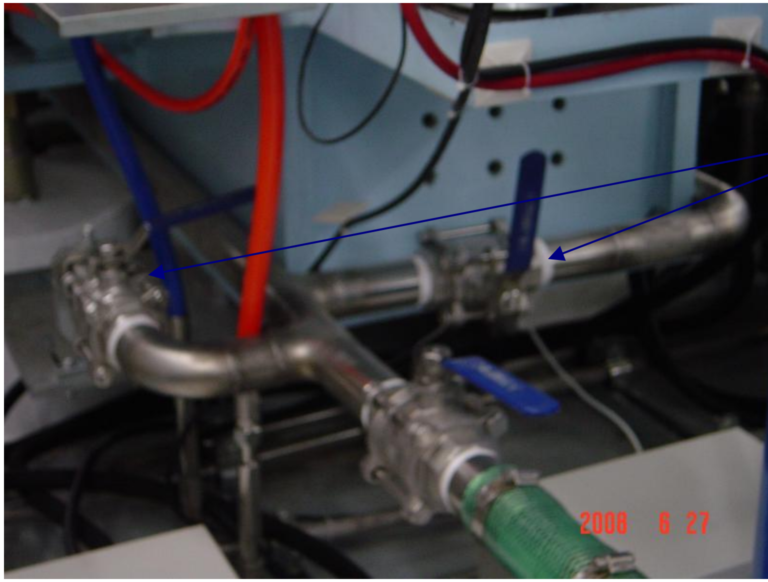
transparent vessels in booster



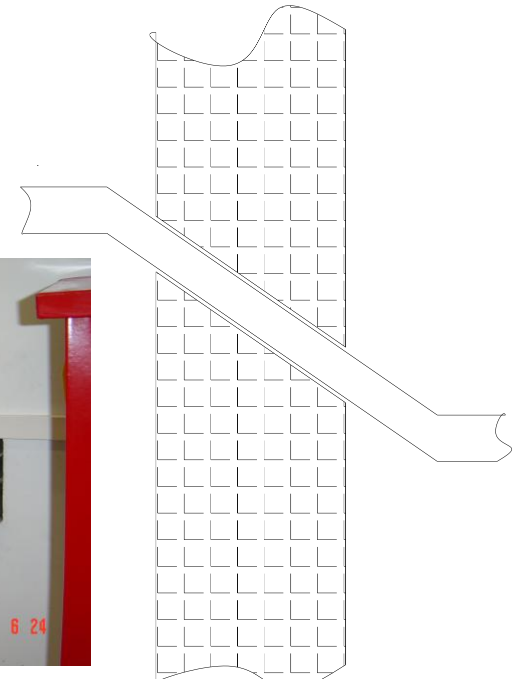


transparent vessels

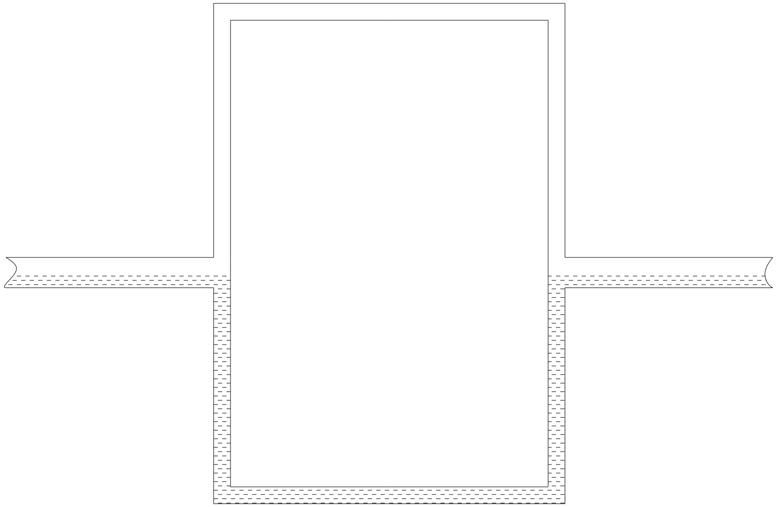
During pouring water into the system we could monitor the water height by the transparent vessels installed in the system



A ball valve is emplaced ahead of every vessel sensor along the pipe.

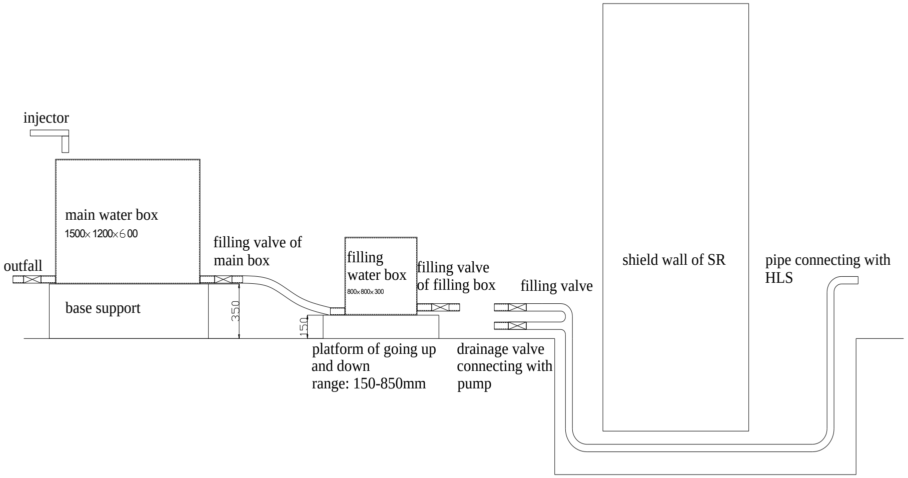


When the pipe passes through the wall between the Linac and Booster, Booster and the Storage Ring,this structure would be better for the radiation pretection



A gate shape of pipe when it pass a special part along the tunel

A soft pipe is used as the air-pipe where the main pipe have to be lowered



Filling and draining system

The installment of HLS at SSRF was finished in June 2008. After six months of work, the system was passed the appraisal organized by the engineering committee

4 Some questions followed with interest

- Accuracy of sensor and accuracy of the system

Measuring accuracy of HLS is not only determined by that of sensors.It is influenced by many factors.

Main influencing factors are:

1. Temperature, (which has been studied and solved on the whole)
2. Pressure, (which has been studied and solved on the whole)
3. Effect of the tides, (which has been studied)
4. Influence of the geoid and gravity on the measurements,(which has been studied)

- Different calibration method used on different type of sensors

Can the above calibration method be used at the calibration of non-contact sensor?

THANKS