

INSTITUTE OF HIGH ENERGY PHYSICS CHINESE ACADEMY OF SCIENCES

CSNS-II SRF Linac R&D status

Wenzhong Zhou

Institute of High Energy Physics , Chinese academy of sciences China Spallation Neutron Source



The 11th IHEP-KEK SCRF Collaboration Meeting 2023.11.20—2023.11.21



Introduction for the China Spallation Neutron Source (CSNS)

The China Spallation Neutron Source (CSNS), located in Dongguan city, Guangdong Province, is the first pulsed neutron source facility in developing countries. It is composed of an 80 MeV H⁻ linac, a 1.6 GeV rapid cycling synchrotron (RCS) and a target station with three initial instruments. CSNS has passed national acceptance on August 23, 2018. In February 2020, the power of proton beam reached the design target of 100kW.

The user application increased dramatically. In the first half of 2021 the user applications have doubled, so CSNS faces an urgent need to increase neutron flux.





Upgrade design of the China Spallation Neutron Source phase II(CSNS-II)



The construction of the CSNS-II accelerator includes:

- > A new high-frequency ion sources
- > A superconducting linear

accelerator

- Increase RCS power with magnetic alloy cavities
- Increase 11 units of Experimental

terminal

Add Experimental terminal 11 units

The CSNS-II plans to complete construction in 69 months with a total investment of 2.956 billion yuan.



Upgrade scheme of linear accelerator for CSNS-II





CSNSII Block Diagram of Cryogenic System





324 MHz Double Spoke Cavity Unit



- > One valve box
- > One cryomodule
- > Two DSR
- \succ Two tuners
- > Two couplers
- > Two magnetic shield
- Some cryogenic pipeline



- \checkmark The design of the cryogenic system and cryomodule has been finalized.
- \checkmark the cryomodule was manufactured and delivered at PAPS in October.
- \checkmark The two DSR prototypes have been manufactured and vertical tested.
- \checkmark The high power couplers were finished a process of high power conditioning.
- ✓ The manufacturing and commissioning of both sets of tuners have been completed.



散裂中子源 China Spallation Neutron Source

324 MHz Double Spoke Cavity





EM design

散裂中子源 China Spallation Neutron Source





Process study

散裂中子源 China Spallation Neutron Source





Why dose the outer conductor need to be split in half for welding?



The first 325MHz DSR at IHEP

In this design, the both spoke bars need to be welded with the outer conductor at the same time to prevent significant deformation of the outer conductor and took over 12 days. The outer conductor cannot be splitted into halves because the two spoke bases overlap each other on the axle.



The first 324MHz DSR for CSNS

In order to improve the production efficiency for future mass production, We optimize the design and divide the outer conductor into two halves and weld them to the spoke bars one by one. It just takes 5 days. we also add four clean ports on the cavity for BCP 、 HPR and Pt.





Mechanical damage



Mechanical damage

Surface defect treatment



Weld metal spatter microscopic (bump)



Oxidation points or external contaminants

The surface defects should excite field emission which can degrade cavity's performance. So, in order to keep the microwave surface uniformity, the inner surface of all parts is inspected and polished to ensure that there are no spikes or pits.



Microwave-surface defect inspection with electron microscope • Page 11



Correlational research for the DSR



BCP Tool design and acid fluid simulation calculation

- special tool of BCP is designed for complex cavity to improve polishing uniformity.
- BCP exhaust ports with valves to control and regulate flow
- The fluid calculation shows that the acid disturbance introduced near the main acid outlet avoids the formation of local corrosion marks

BCP technical study



Cooling rate VS Q

In vertical measurement, we found that cooling speed is closely related to Q, slow cooling is conducive to the improvement of cavity 'Q, and the Q can be increased by 3-4 times compared with rapid cooling

Study on high Q performance



Vertical testing of DSR



10 11 12 13 14 15 16 9 1E1 Adiation(μsv)/h Q_a with vesse 1E10 1E9 9 10 11 12 13 14 E... (M B. (mT 60 72 96 132 84 108 120



Bare cavity and jacketed vacity

- ✓ The two double spoke cavity prototypes have been tested, the maximum Eacc reaches at 15 MV/m, and the Q is above 4E10 at 7.3MV/m. The Bpeak is 138mT and the Epeak is 61.5MV/m.
- ✓ Other key mechanical parameters were also tested, and the difference between the experimental and theoretical values is small.





散裂中子源 China Spallation Neutron Source

peremeter	value	unit		
Slow tuning				
Frequency range	100	kHz		
stroke	~0.93	mm		
resolution ratio	<5	Hz		
stiffness (2K)	>20	N/um		
Operate temperture	~5	Κ		
Fast tuning				
resolution ratio	>1000	Hz		
resolution ratio	<5	Hz		
Operate temperture	~5	K		
Respose time	~1	ms		

Tuner





Tuner model and object

High power coupler

Parameter	Value	
RF frequency	324 MHz	
Peak RF power	300 kW	
Pulse width	2.3 ms	
Pulse repetition frequency	25 Hz	
Qext	2.30E+05	
Interface to the cavity	Diameter 80 mm	
FPC position	Bottom to the cavity vertially	
Assembly	Clean assembly	
FPC type	Coaxial ,single window	
Window Type	Coaxial disk with choke	
Coupling type	Electric	



RF conditioning platform of coupler



Cavity string assembly

散裂中子源 China Spallation Neutron Source





Coupler installation



Cavity string assembly



Tuner installation



The whole core of cryomodule



Cavity string in the thermal shield



Lower thermal shield



multilayer thermal Insulation installaton



Magnetic shield

- > The cavity string has been assembled and vacuum leak detected in clean room.
- Outside the clean room, the cavities string is dressed with the magnetic shield, the cryogenic pipe, the cold tuning system and the thermal shield.
- The installation of cryomodule and valve box will be finished in two weeks and horizontal test will be finished in December.



The improved double spoke cavity

散裂中子源 China Spallation Neutron Source

nrototype

improved





prototype	mproved
324	324
0.5	0.5
4.1	3.44
9.2	8.86
410	401
120	118
50	50
7.3	9
-12.5	-4.56
	324 0.5 4.1 9.2 410 120 50 7.3 -12.5

narameter

- targets: mechanical structure of improved DSR
- ➢ Raise acceleration gradient to 9MV/m
- Reduce the coefficient of Lorentz force detuning

5-6



6-cell elliptical cavity unit

散裂中子源 **China Spallation Neutron Source**

• 648 MHz 6-cell Elliptical Cavity

parameter	design
Frequency(MHz)	648
TTF@β _g	0.7
β _g	0.62
E _p /E _{acc}	2.53
B _p /E _{acc} (mT/(MV/m)2	5.45
R/Q (Ω)	309
G (Ω)	177
Beam tube diameter (mm)	105/120
Cell-cell coupling (%)	1.35
E _{acc} (MV/m)	14

mechanical structure of ellipsoidal cavity



The mechanical design of coupler



The design of magnetic shield structure







The cryomodule structure Page 17

- \checkmark The design of the superconducting cavity, coupler, magnetic shield, and tuner has been completed.
- \checkmark The cryomodule is currently under design.
- \checkmark Now, the cavity \checkmark coupler and tuner are being manufactured.



Summary

- The installation of cryomodule and valve box will be finished in one week and horizontal test will be finished in December.
- > The two improved double spoke cavities are on going and will be finished in December.
- > The three 6-cell elliptical cavities are on going and well be finished in next year.



INSTITUTE OF HIGH ENERGY PHYSICS CHINESE ACADEMY OF SCIENCES

Thank you for your attention!

