IHEP PAPS SRF Facility Status

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IHEP

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PAPS- Platform of Advanced Photon Source Technology R&D

- Budget: 500M CNY funded by Beijing Gov., from 2017.5-2020.6

- 4500m^2 SRF Lab for Superconducting Accelerator Projects R&D
- Cryogenic system with a capacity of 2.5kW@4.5K/300W@2K
- Beam Test System
- Precision Magnet center for precision machining and measurement for HEPS magnets
- X-ray research center for advanced X-ray related technologies R&D

PAPS SRF facility Layout

① 4500m^2 SRF Lab for Superconducting Accelerator Projects R&D

② Beam Test System

③ Cryogenic system 2.5kW@4.5K/300W@2K

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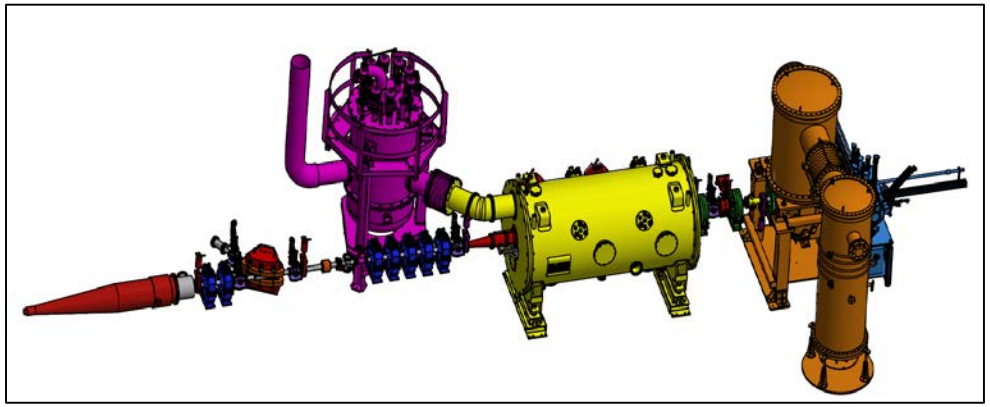

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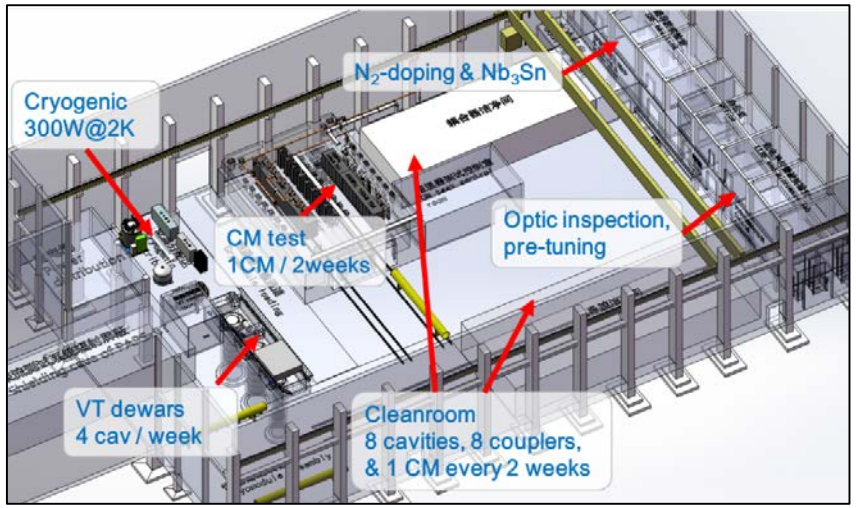

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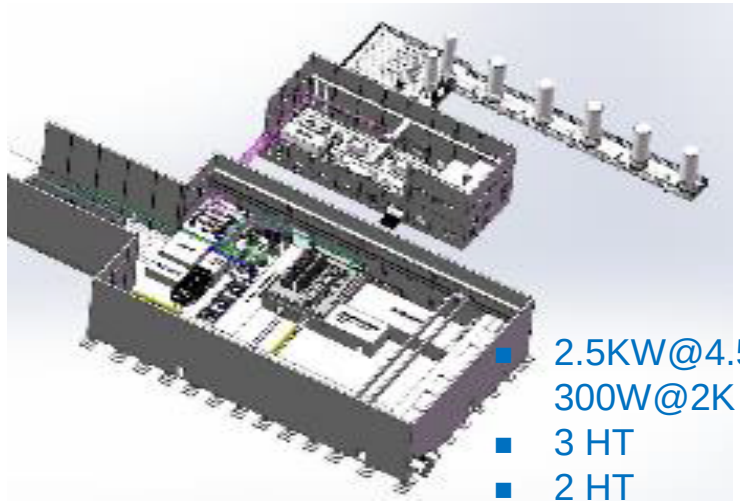
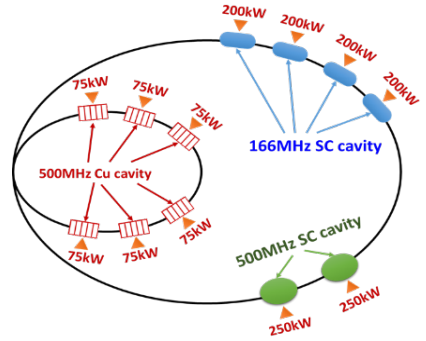
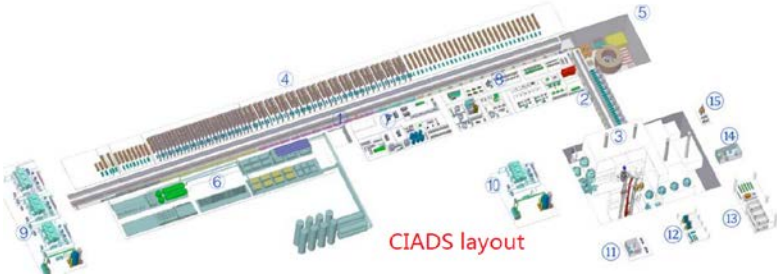


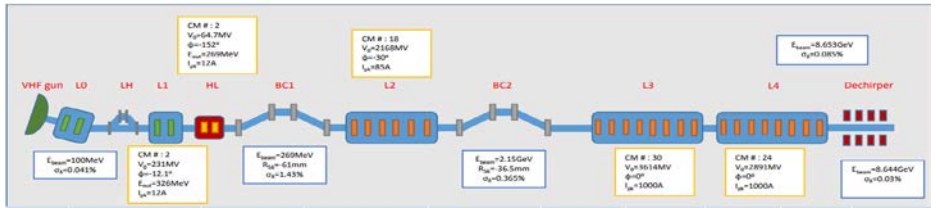
- 2.5KW@4.5K
  300W@2K
- 3 HT
- 2 HT

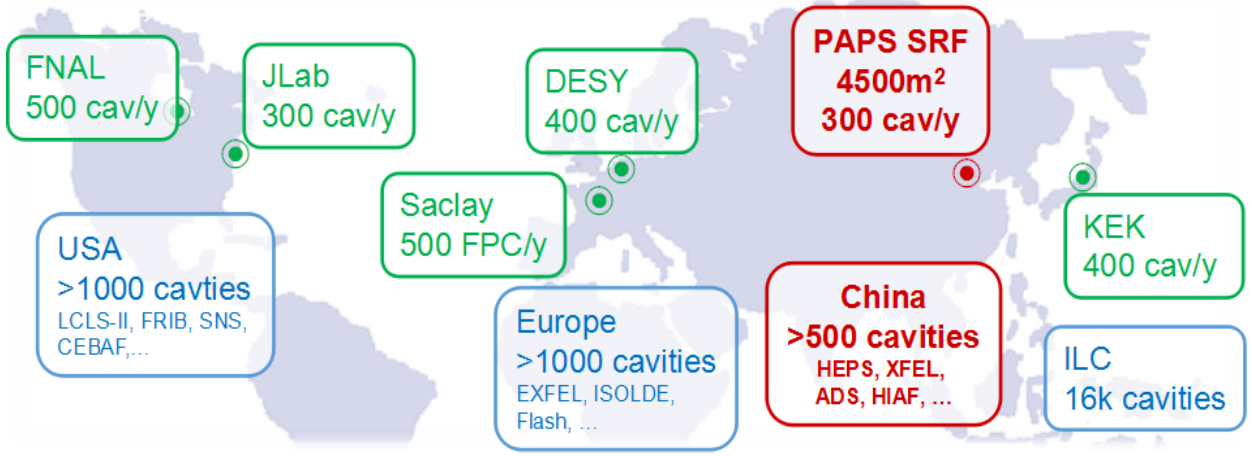
PAPS SRF Facility Capability

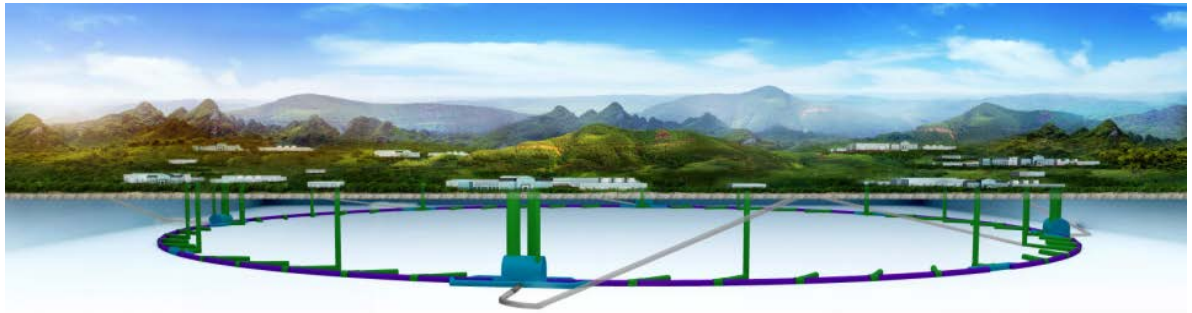


- 6 SRF cavities for the HEPS project
- >600 cavities and 75 cryomodules for SHINE
- >56 double spoke cavities for CiADS
- >38 spoke and elliptical cavities for CSNS-upgrade
- 336 650MHz-2cell and 1.3GHz-9cell cavities for CEPC



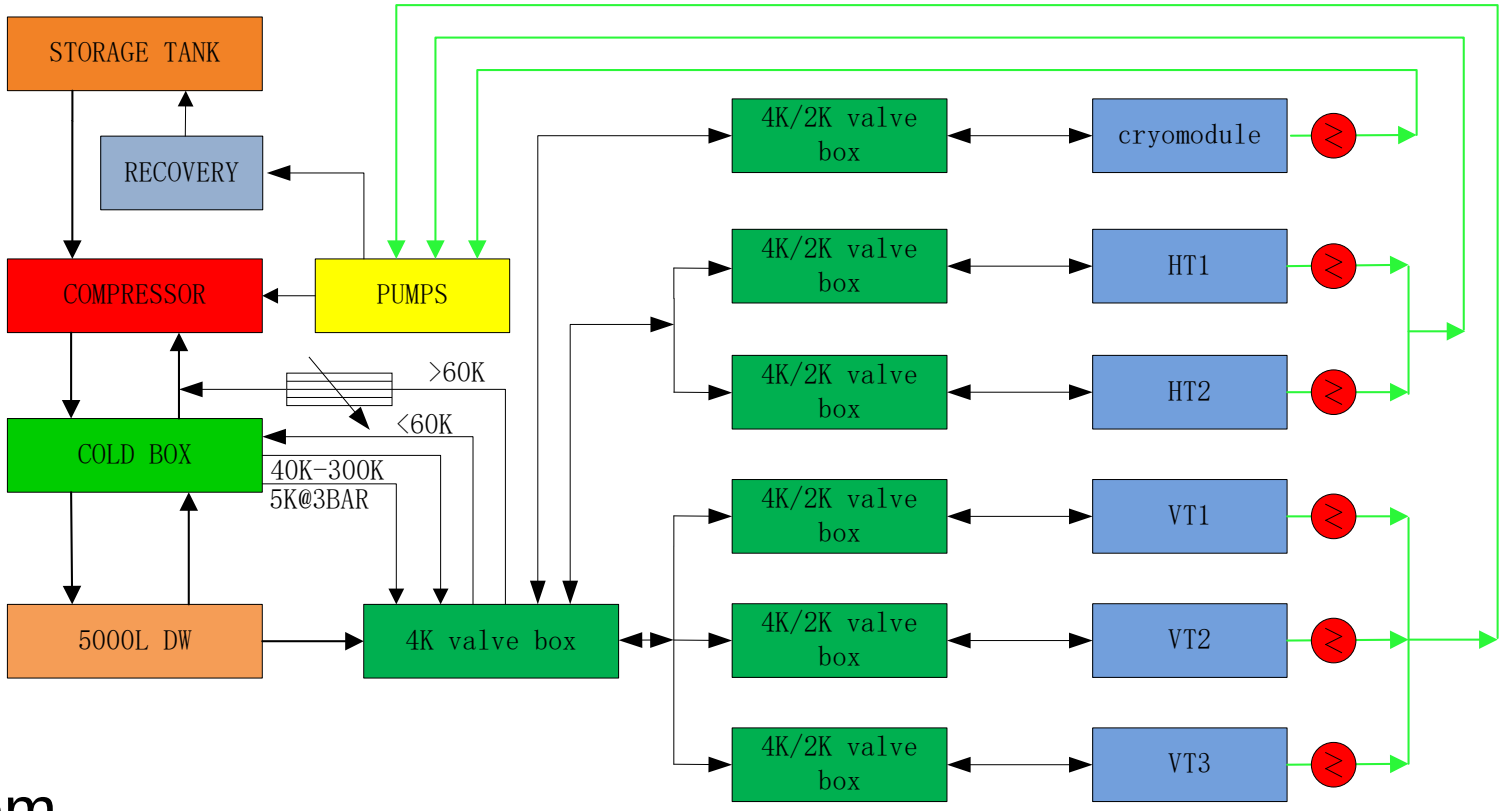






PAPS SRF Facility Cryogenics

- Refrigerator/liquefier
- Helium Storage
- Transfer and distribution
- 2K pump system
- 2K JT heat exchanger
- Vertical test Dewar
- Cryomodules
- LN2 system
- Recovery and purification system



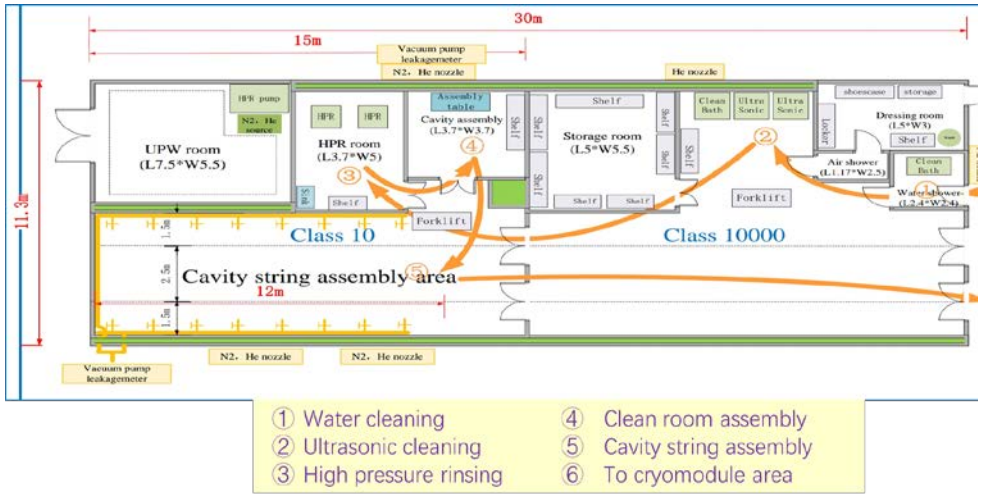
Cryogenics Flow chart

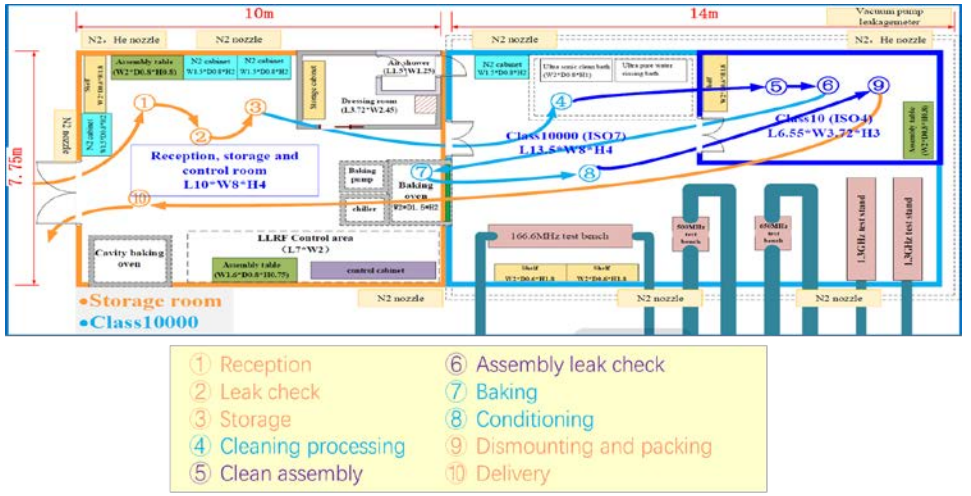
PAPS SRF Facility Cryogenics

- 2.5KW@4.5K Refrigerator ready for installation.
- The pipeline and control system of the dry pump group have been assembled and are being tested.
- Completed the assembly of high-pressure helium recovery compressor and oil separator.

PAPS SRF Facility implementation

- The cryomodule test caves will be finished at Feb. 2020.
- The clean-room will be finished at May. 2020.
- The N-doping system will be commissioned at March. 2020
- The Pre-tuning machine has been commissioned.
- Optical inspection machine will be functional at Feb. 2020.

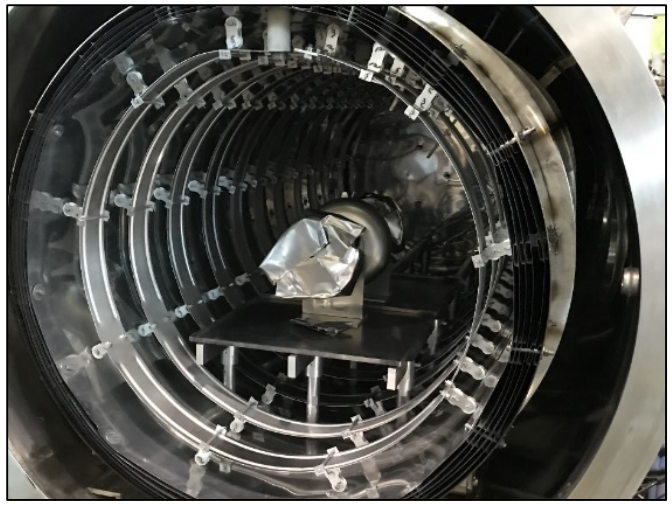




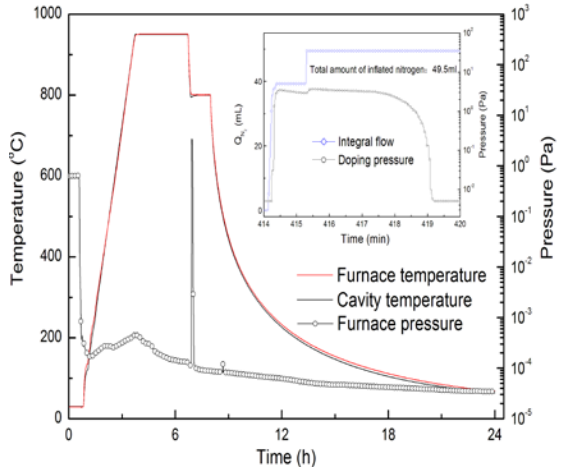
PAPS SRF Facility implementation

- N-doping system

- Large vacuum furnace completed : can be used for 1.3GHz 9-cell and 650MHz 2-cell cavities; the main performance reaches the design target, and will be transferred to the PAPS.
- Small vacuum furnace completed : mainly used for N-doping of 1-cell 1.3GHz cavity; a lot of N-doping experiments were done here, and the obvious "**Anti-Q-slope**" was observed, which lays the foundation for future development.



N-doping of 1.3GHz 1-cell cavity

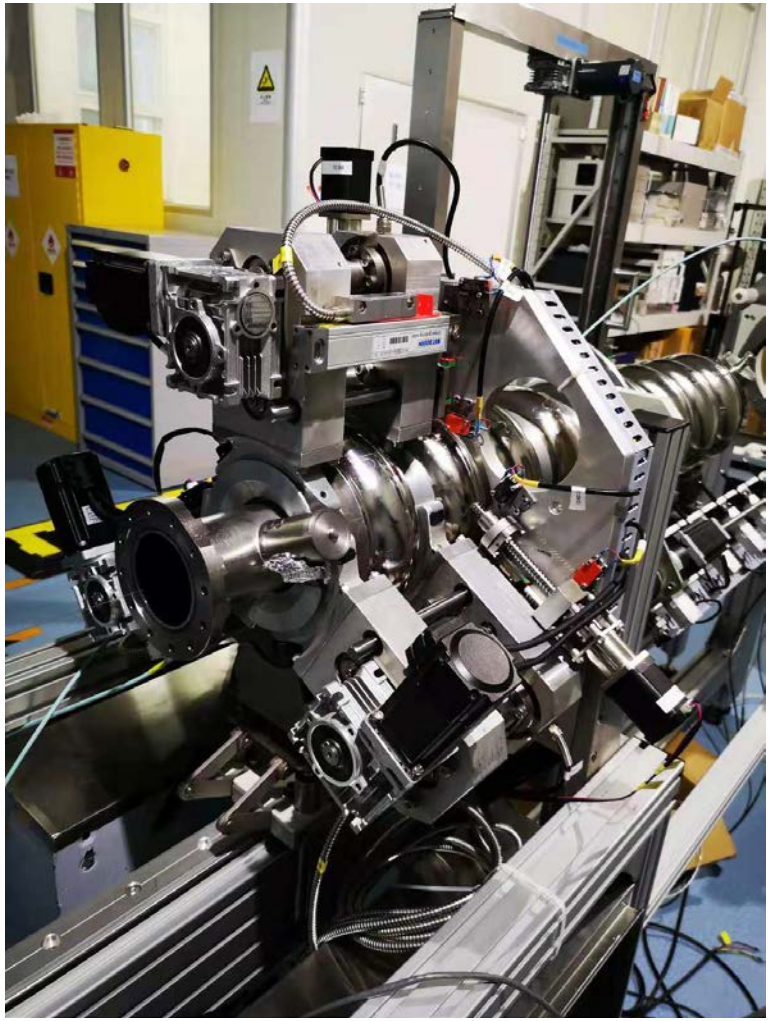


N-doping process curve

PAPS SRF Facility implementation

- Pre-tuning machine & Optical inspection machine

- The Pre-tuning machine has been commissioned
- Optical inspection machine will be functional at Feb. 2020.
- They will be switched to PAPS-SRF lab after the civil construction is finished



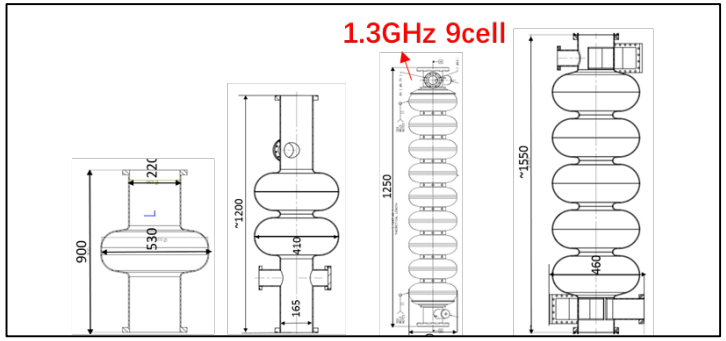
- Combined CavCam and Local-Grinding for 650 MHz up to 5-cell cavity.
- Extendable to 1.3 GHz 9-cell by changing camera head and grinder head
- At present, we also do some efforts for the 1.3GHz cavity.

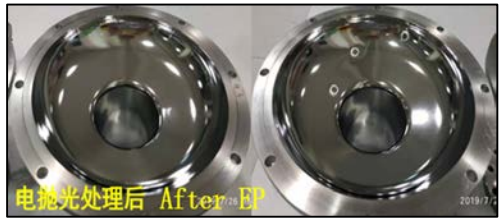
PAPS SRF Facility implementation

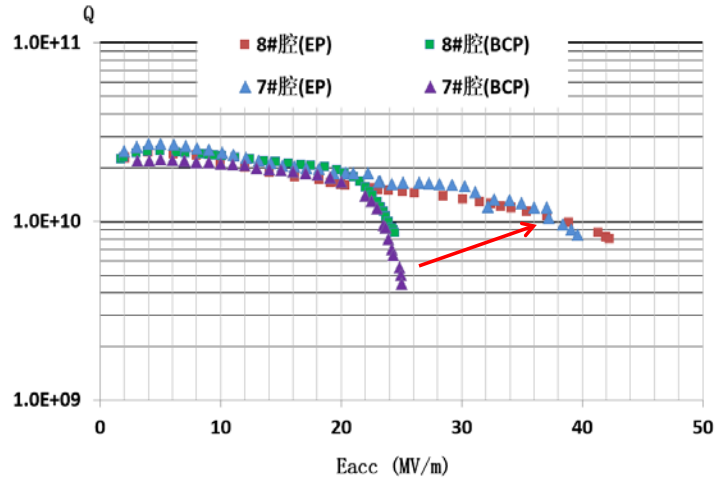
- EP machine

- R&D of the horizontal EP system completed.
- This is the first practical EP equipment put into use in China, which makes IHEP the fifth lab to have the ability of cavity EP after JLab, ANL, DESY and KEK.
- Commissioning was completed in May this year, and so far, more than 27 rounds EP finished.
- After EP, the Eacc of 1-cell 1.3 GHz cavity was stable (>35MV/m), which at the international advanced level.

- **For the Variable Cavity Post treatment**
  - R&D and mass production
  - Horizontal;
  - Compatible: 500MHz single cell, 1.3GHz up to 9 cell , 650MHz up to 5 cell

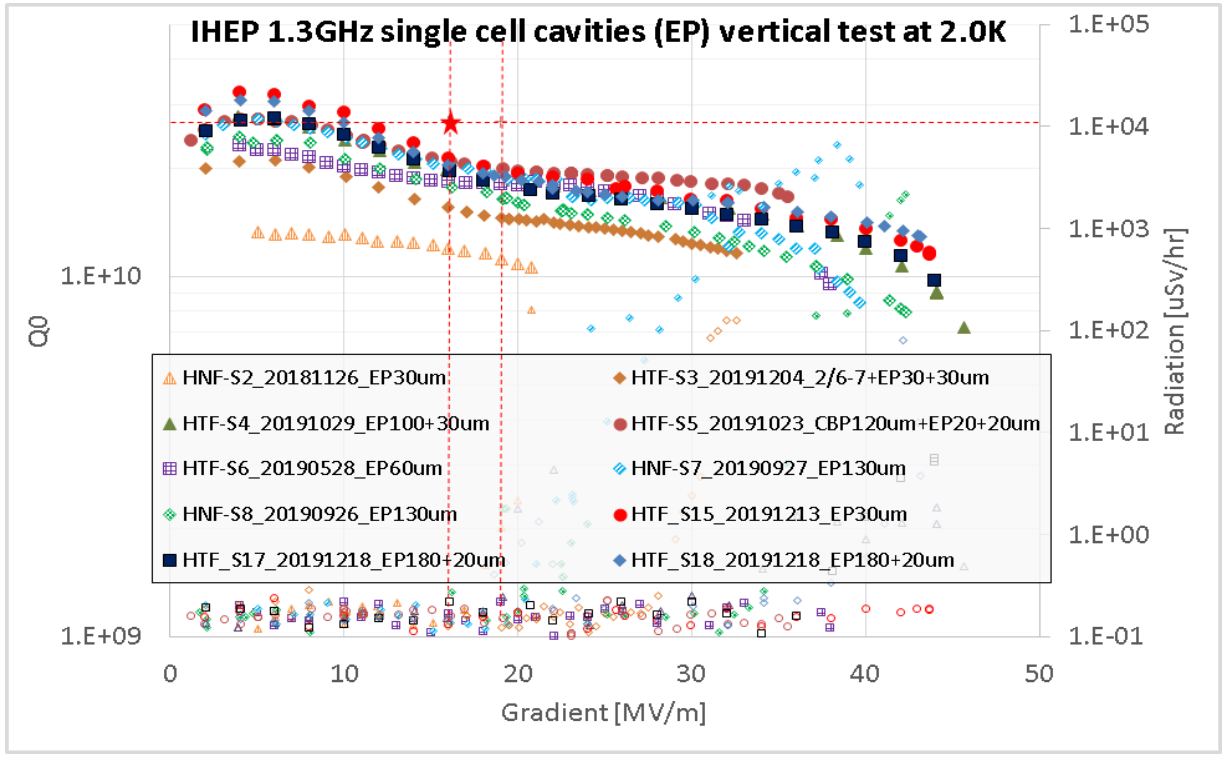






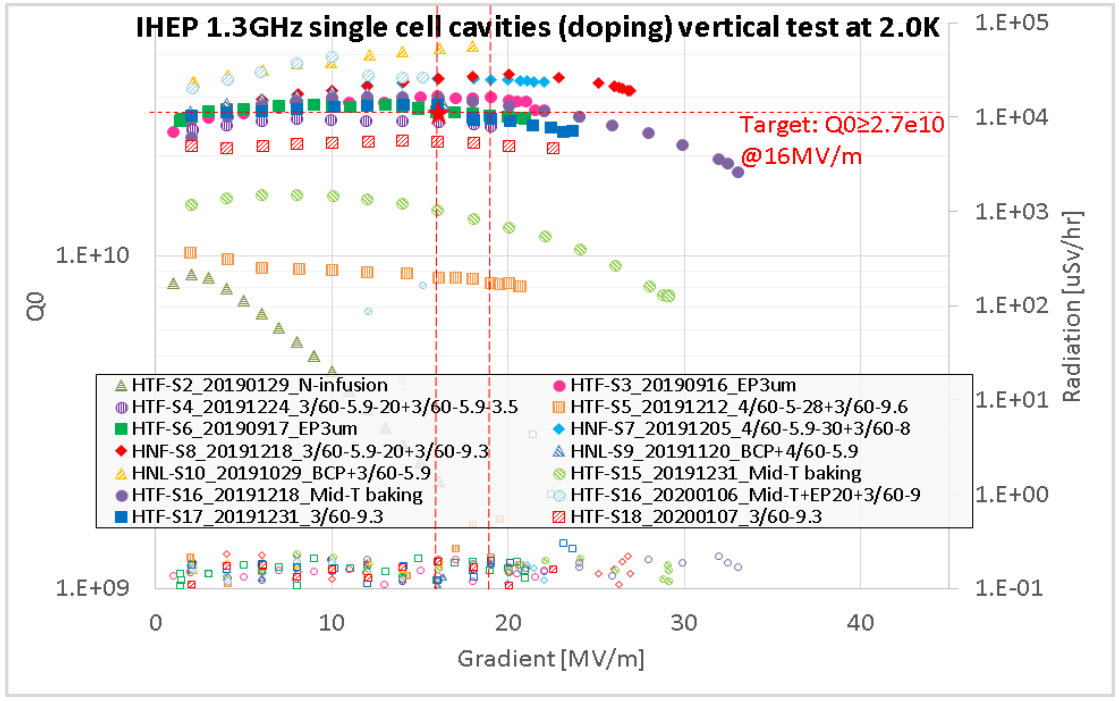
1.3GHz single cell cavity R&D

- With new EP machine and careful control of cavity inner surface, 1.3GHz single-cell cavities routinely reached 40MV/m.



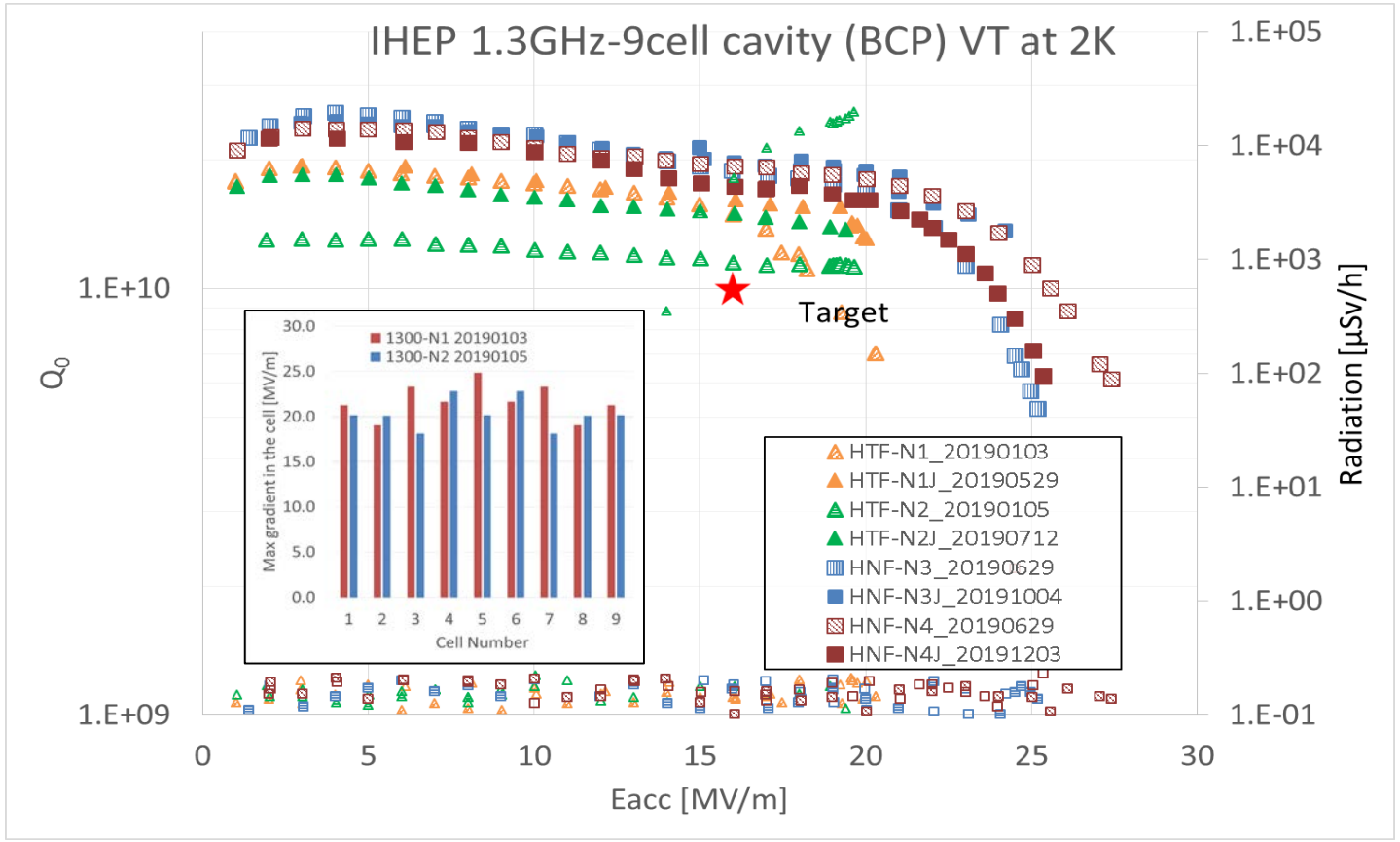
1.3GHz single cell cavity R&D cont.

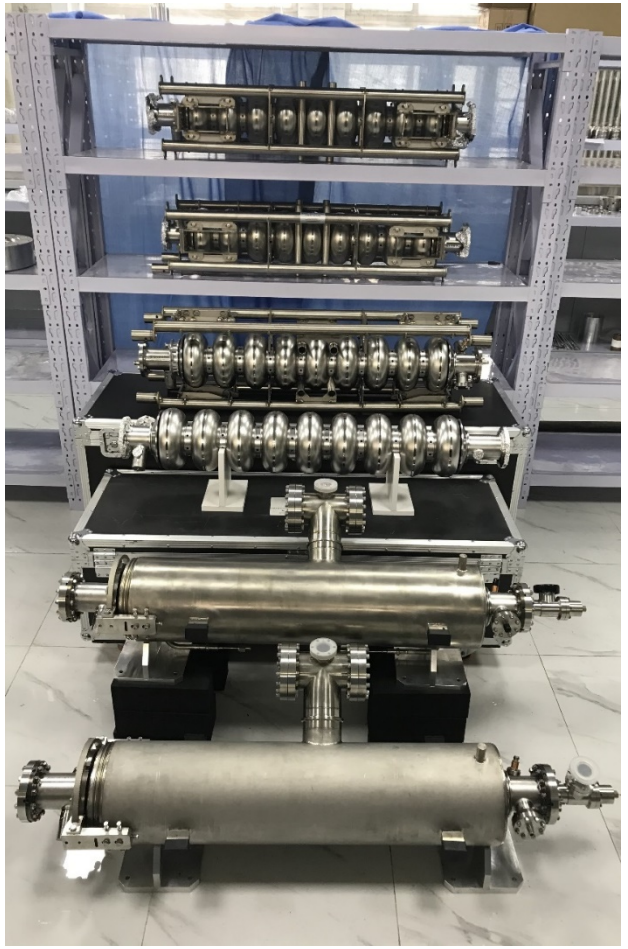
- Preliminary results on N-doping and Mid-T baking have been achieved.
- Efforts on cold-EP and cleaner furnace will be made.
- EP and N-doping on 9cell cavity is in the plan.



1.3GHz 9cell cavity prototypes

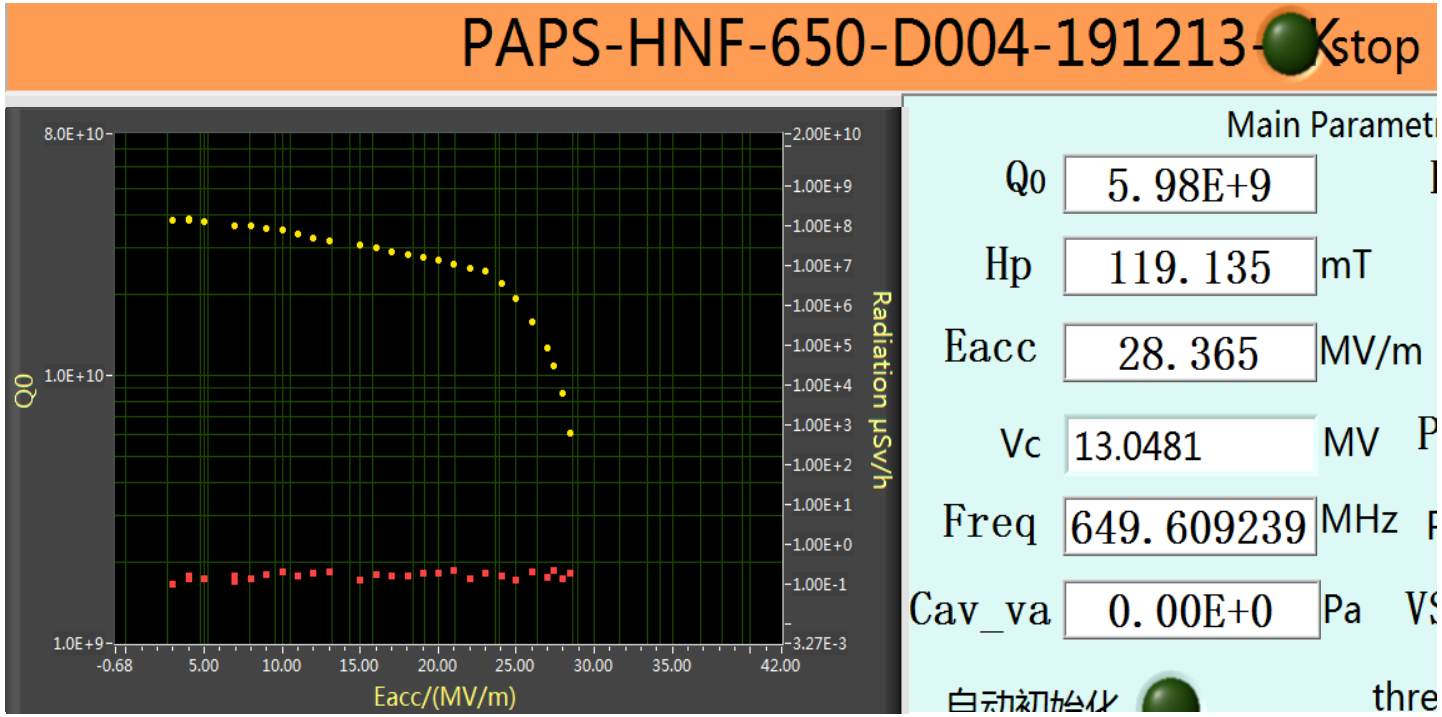
- Technique for mass production is well learned with 10 prototype cavities.
- 4 jacketed cavities reached BCP target of 19MV/m + Q0 1e10@16MV/m; the rests are for EP and doping study.





650MHz 2-cell cavity R&D

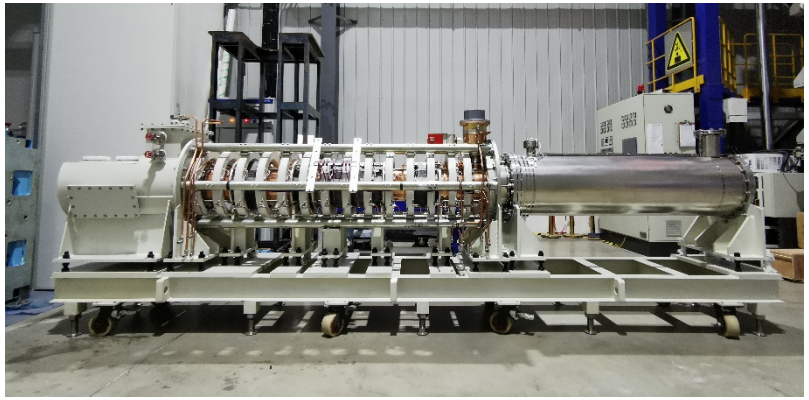
- The first 650-2cell cavity for the PAPS beam-test system reached design target at vertical test. The next step is helium vessel welding.
- The rest 2 bare cavities will be vertical tested at early 2020.

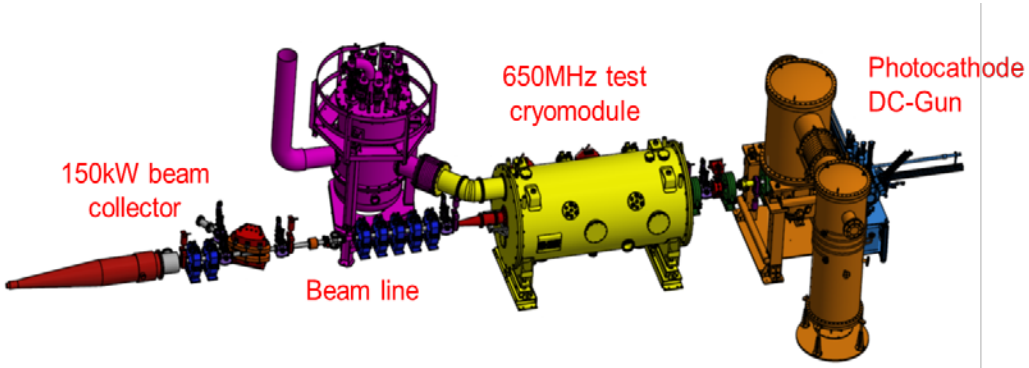


PAPS SRF Facility implementation
- Beam test system

- Beam test system is based on a photocathode DC-Gun.
- To test several key technologies of 650MHz SRF system, such as CW operation of high Q SRF cavity with beam at high gradient, low heat load and fast cooling down of the test module……
- To build up a high power test platform for high efficiency klystrons.
- For future R&D and beam experiment of other accelerator related devices and technologies.

Parameter	Value
HV of the gun	350-500kV
Bunch charge	15.4pC
Repetition rate	650MHz
Average current	1-10mA
Emittance	<2mm.mrad
Bunch length	1-3ps
Beam energy	10-15MeV

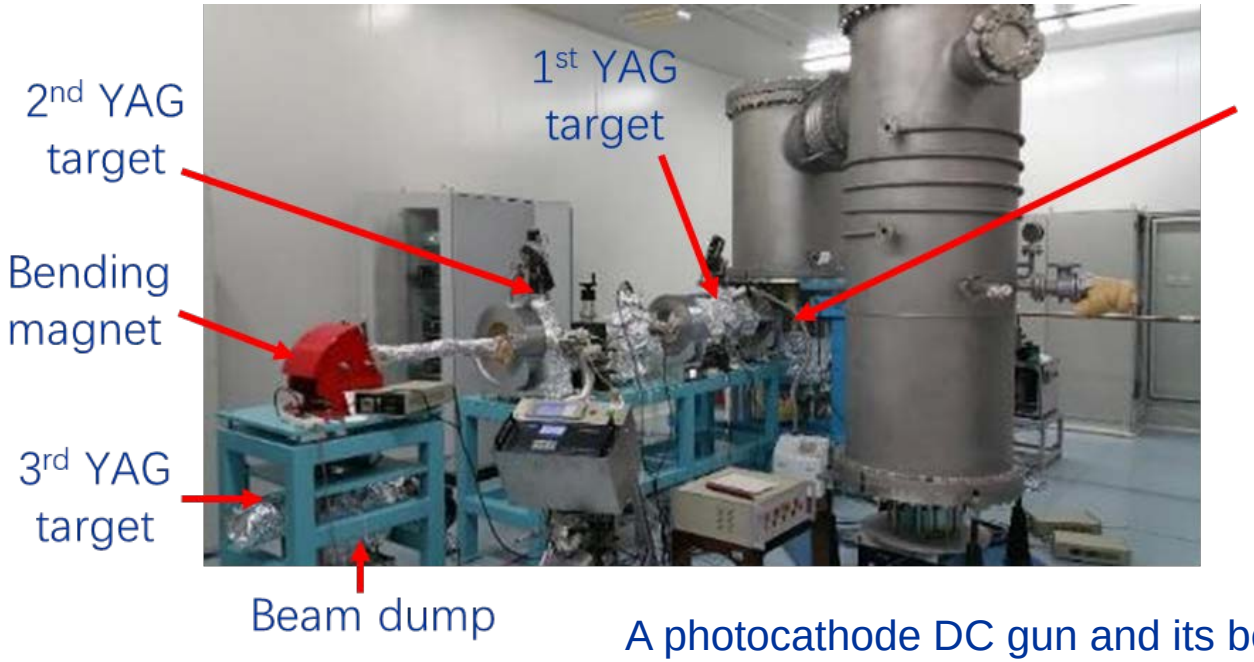


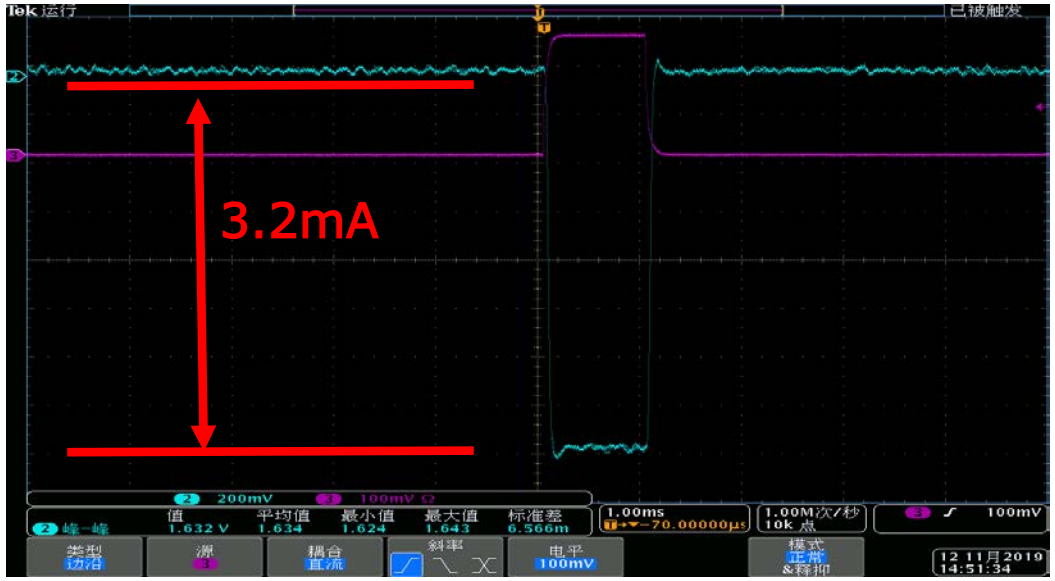


PAPS SRF Facility implementation

- Beam test system

- The photocathode dc electron gun was operating at a HV of 360kV, with a GaAs photocathode (Design HV : 500kV).
- Beam optic was optimized at a pulse operation mode with a 10Hz/1ms macro pulse.
- 3.2mA@Pulsed and 2.4mA@CW electron beam was obtained.
- Next, continue to increase beam current (Design current : 1~10mA).





A photocathode DC gun and its beam experiment

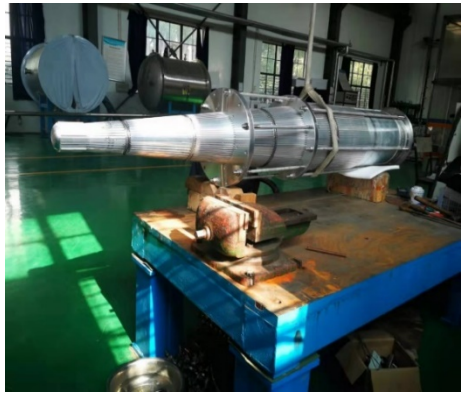
PAPS SRF Facility implementation

- Beam test system

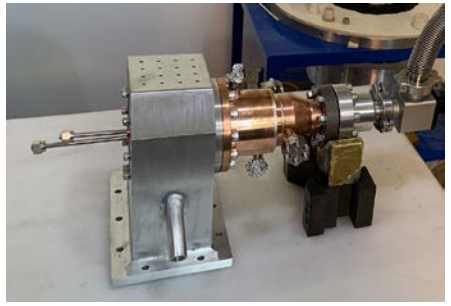
- Complete the development of a 650MHz test Cryomodule
- A 1.3GHz CW operation buncher, a 1.3GHz coupler and a 1.3GHz/10kW solid state amplifier have been developed
- A 150kW beam collector, magnets and vacuum boxes for beam line is ready

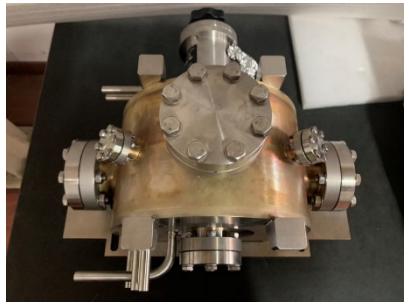
A 650MHz test cryomodule

1.3GHz/10kW amplifier

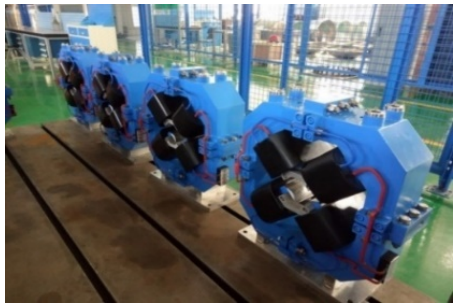


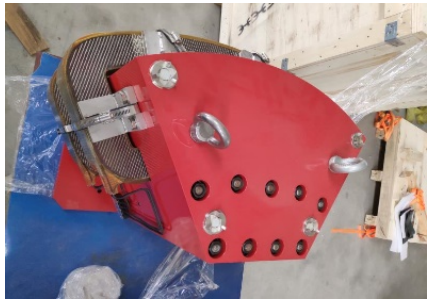
150kW beam collector





1.3GHz-CW buncher and coupler



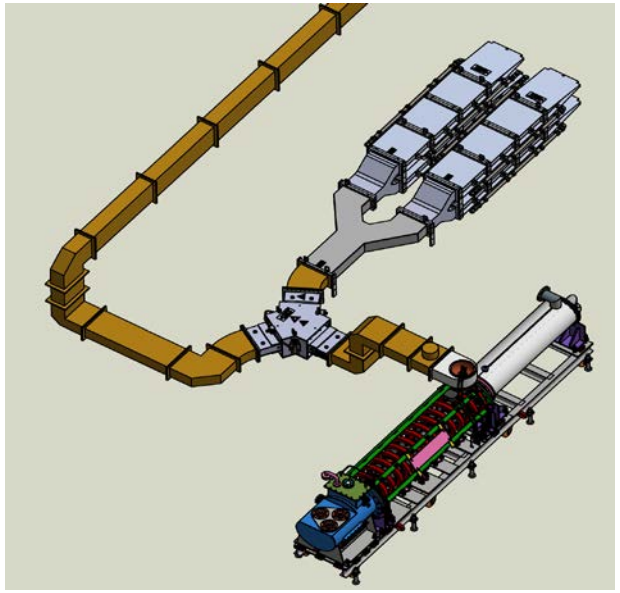


Magnets

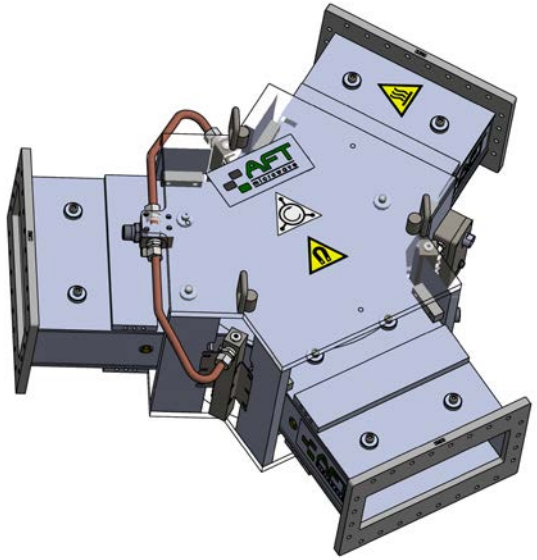
PAPS SRF Facility implementation

- Beam test system

- Complete the design of the core components including PSM power supply, high-power circulator and ferrite load, which are currently under development
- The capacity of the PSM power supply is designed to 130kV/16A, which can satisfy the high-power test of various high-efficiency klystrons in the future.



The high power test platform



High power circulator

130kV/16A PSM power supply

Summary

- New IHEP PAPS SRF facility were well designed and arranged mainly based on PAPS project.
- IHEP PAPS SRF facility can support variable SC cavity and High efficiency klystron as well as new accelerator technology research and development in near future.
- IHEP PAPS SRF facility has capability of cavity mass production for large scientific facilities such as HEPS, SHINE, CiADS, CEPC etc.

Thanks for your attention !