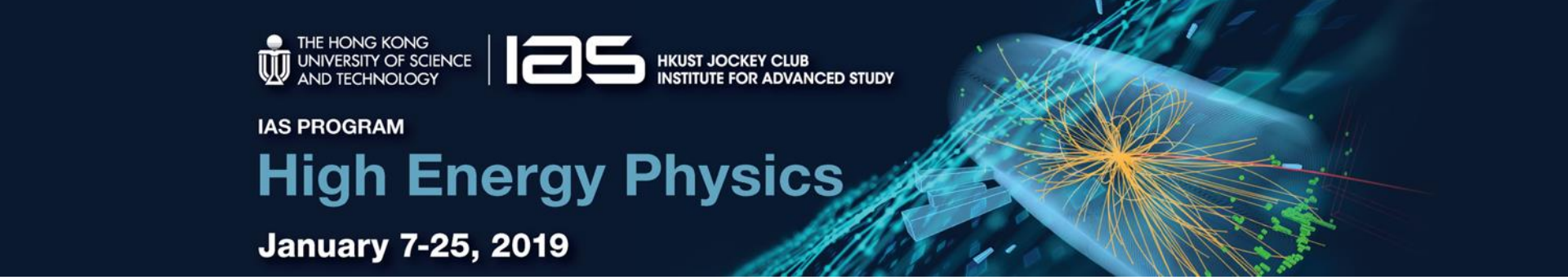


SCRF Infrastructure Development

Song Jin

On behalf of colleagues of RF group at IHEP

HKUST IAS HEP Conference, Hong Kong,

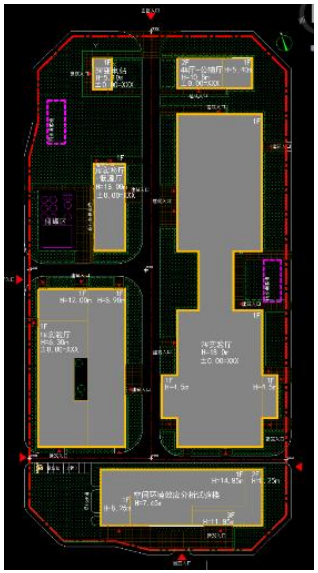
January 21 - 24, 2019

Content

- Introduction
- Infrastructures
- EP system development
- Summary

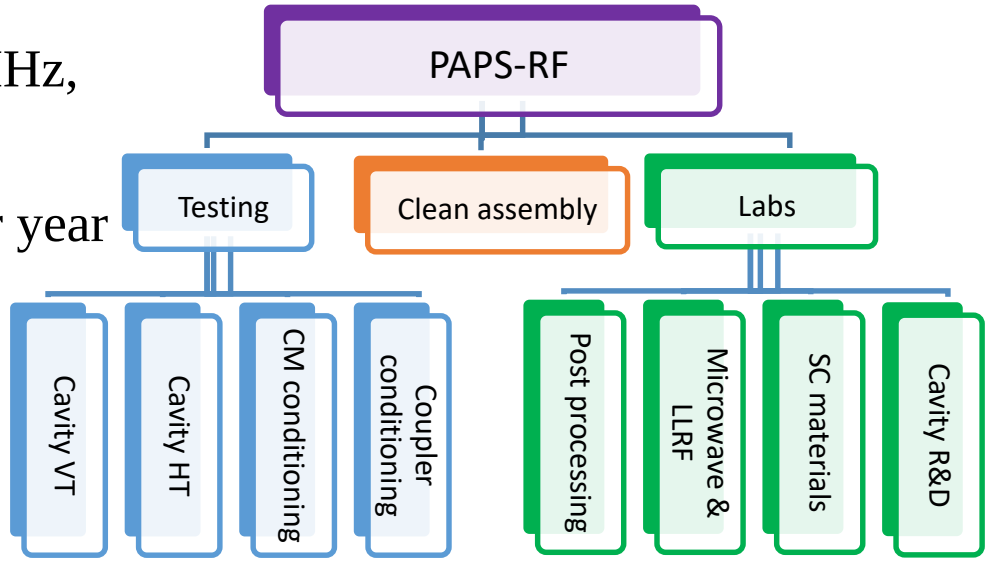
Introduction

- **SCRF infrastructure development mainly based on the program of Platform of Advanced Photon Source Technology R&D project (PAPS)**
- **Budget: 500M CNY funded by Beijing Gov., from 2017.5-2020.6**
- **Construction: Consist of 7 systems:**
  - RF system
  - Cryogenic system
  - Magnet technology
  - Beam test
  - X-ray optics
  - X-ray detection
  - X-ray application



Introduction

- **The PAPS-RF system has two targets :**
  - Build a SRF facility
  - Conduct R&D on cavities and ancillaries
- **The SRF facility is biased on mass production for SRF projects**
  - Total area of 4500 m^2
  - Compatible of 166MHz, 325MHz, 500MHz, 650MHz, and 1.3GHz
  - 200-400 cavities (couplers) per year
  - ~20 cryomodules per year
  - Support R&D on new material and new technology
- **Cryogenic system: 300W @ 2K**



Content

- Introduction
- **Infrastructures**
- EP system development
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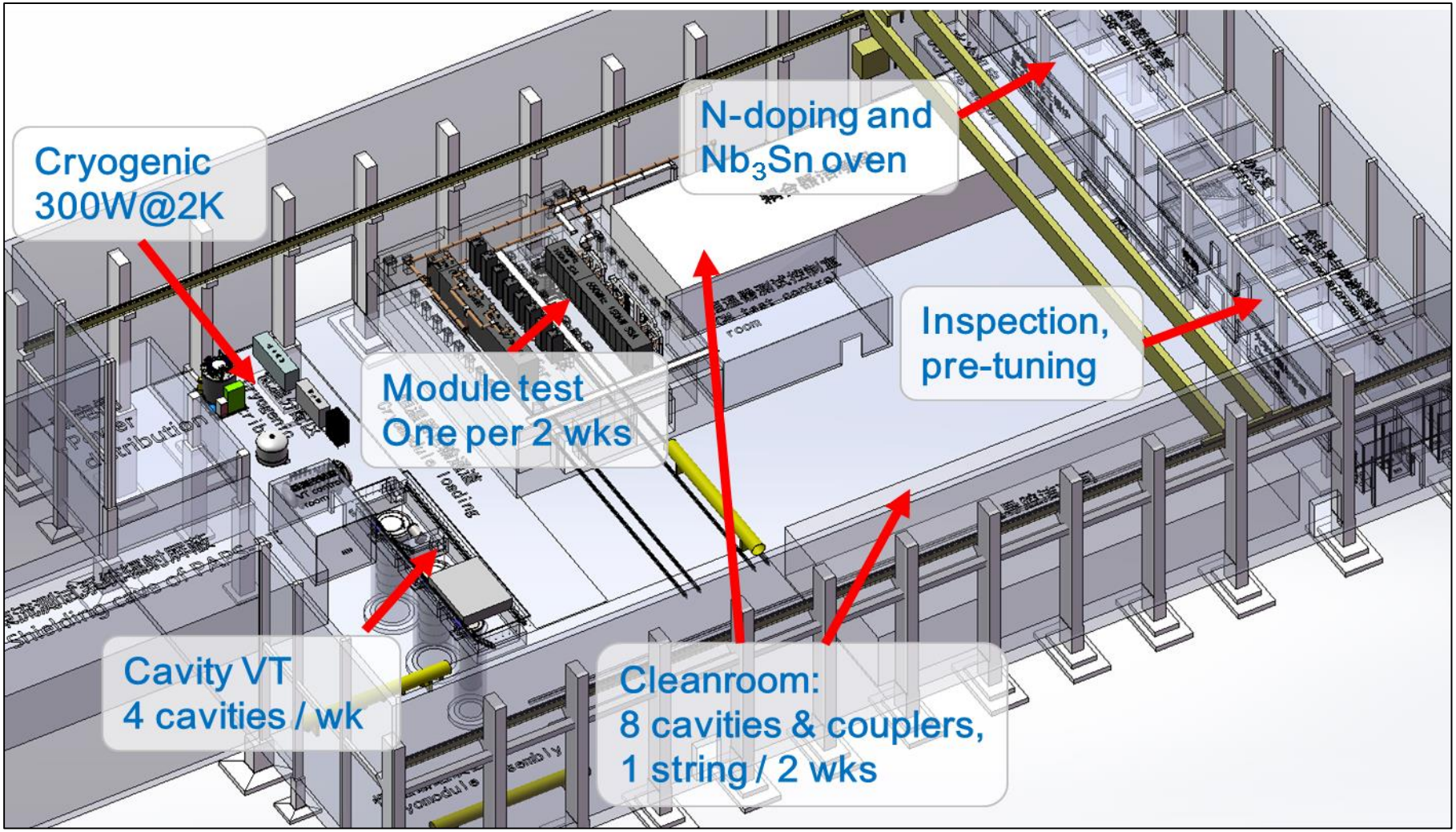
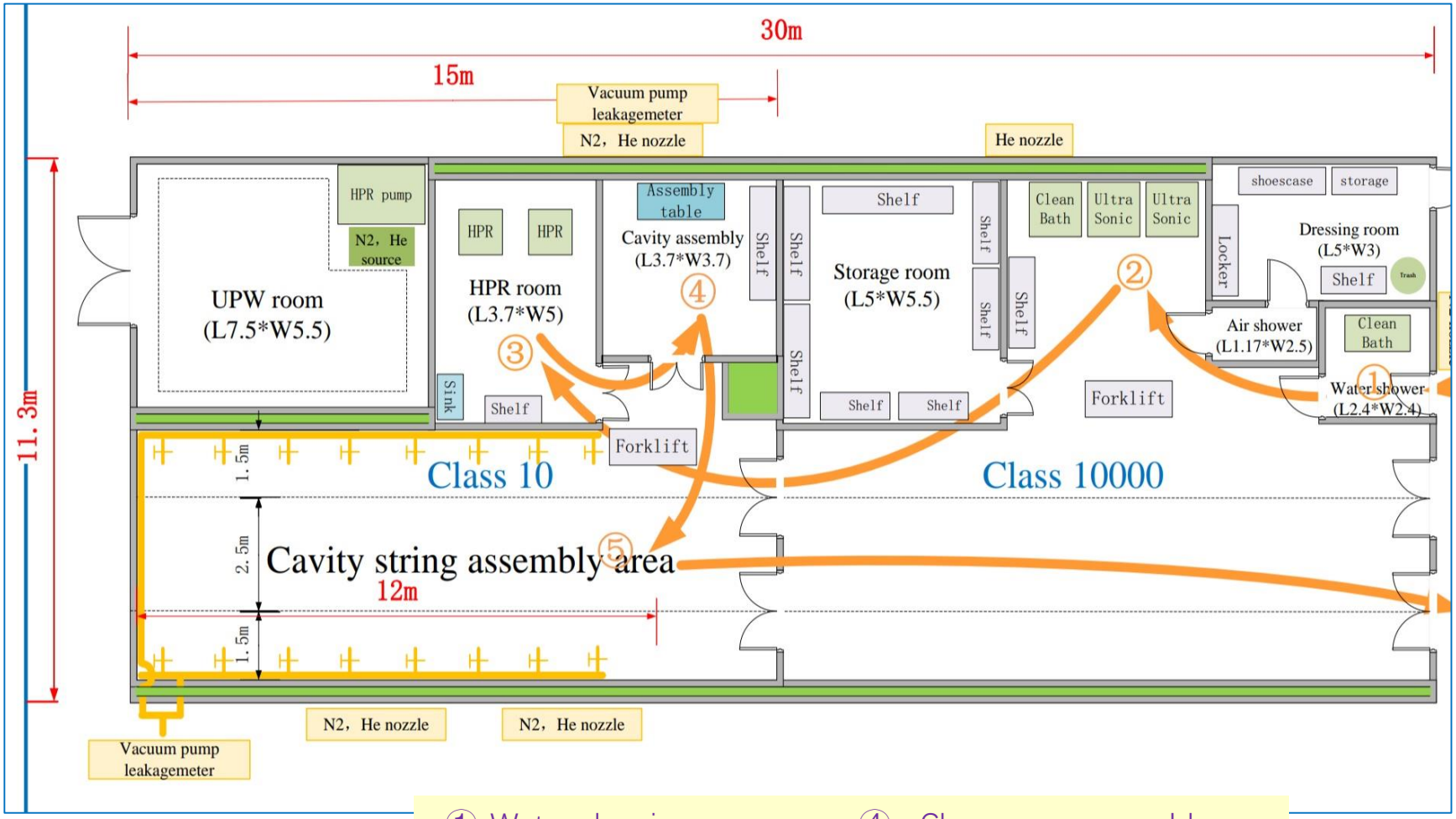
Layout for the infrastructures

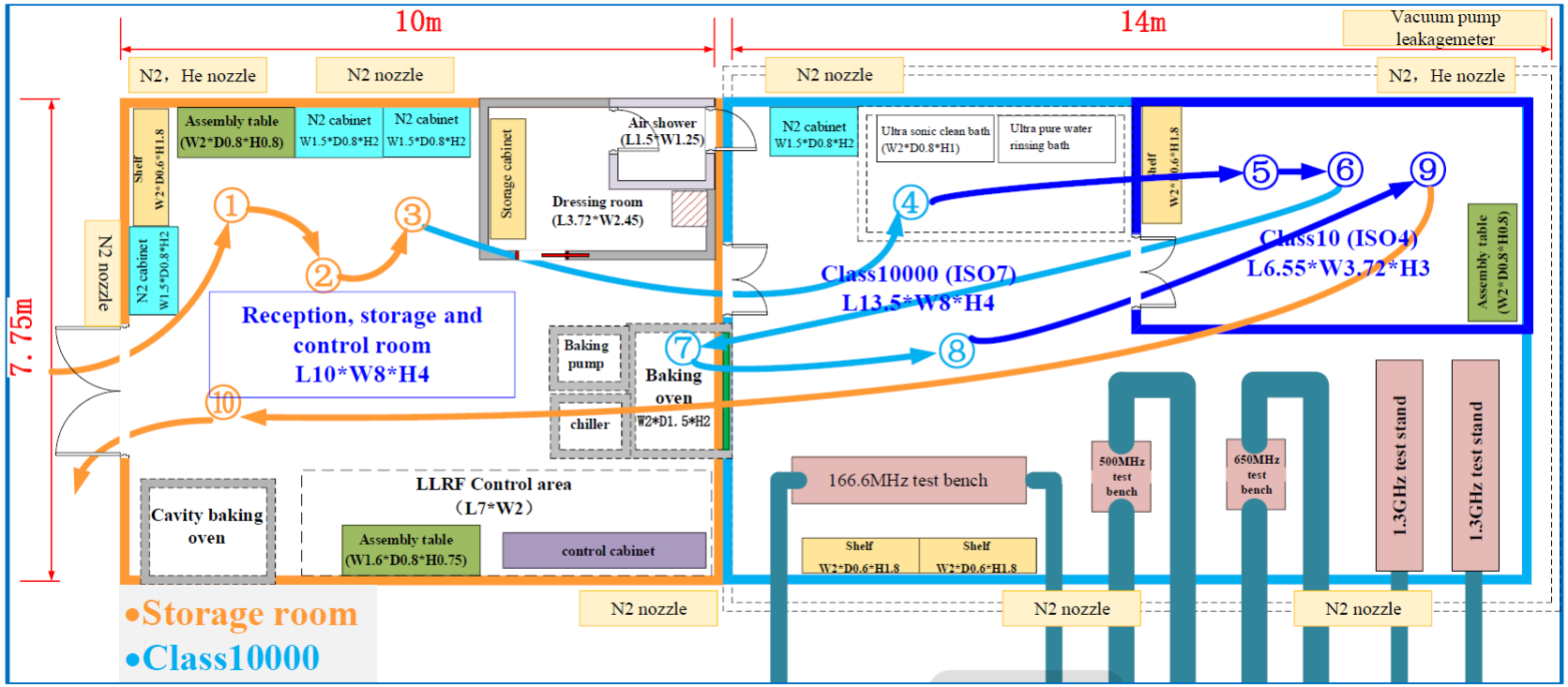


Cleanroom for cavities



① Water cleaning
② Ultrasonic cleaning
③ High pressure rinsing
④ Clean room assembly
⑤ Cavity string assembly
⑥ To cryomodule area

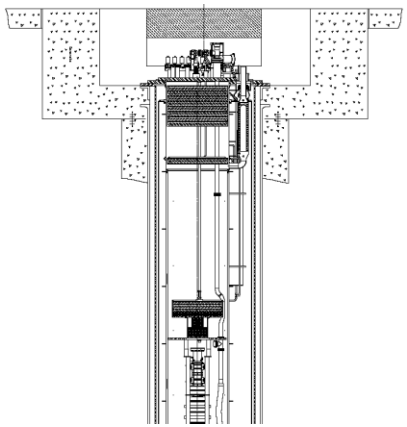
Cleanroom for FPC

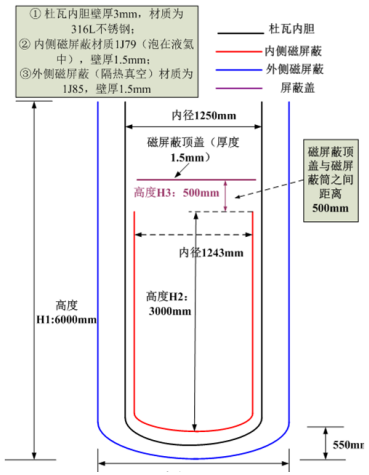


① Reception
② Leak check
③ Storage
④ Cleaning processing
⑤ Clean assembly
⑥ Assembly leak check
⑦ Baking
⑧ Conditioning
⑨ Dismounting and packing
⑩ Delivery

Vertical Test Area

- 2 large dewars of ID=1.25m, 4 of 1.3GHz cavities could be tested for one time in each dewars;
- 1 small dewar of ID=0.8m for R&D;
- Two-layer magnetic shielding are applied for each dewars;
- T-mapping for 650-2cell and 1.3-9cell were also developed;
- Second sound equipment is also under development;
- 8~10 of 1.3GHz 9-cell cavity tests per week.

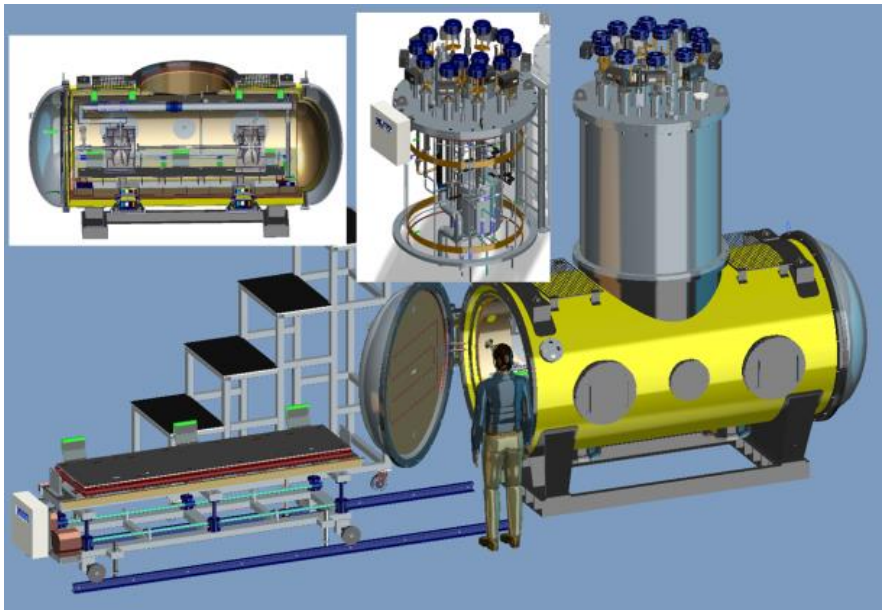


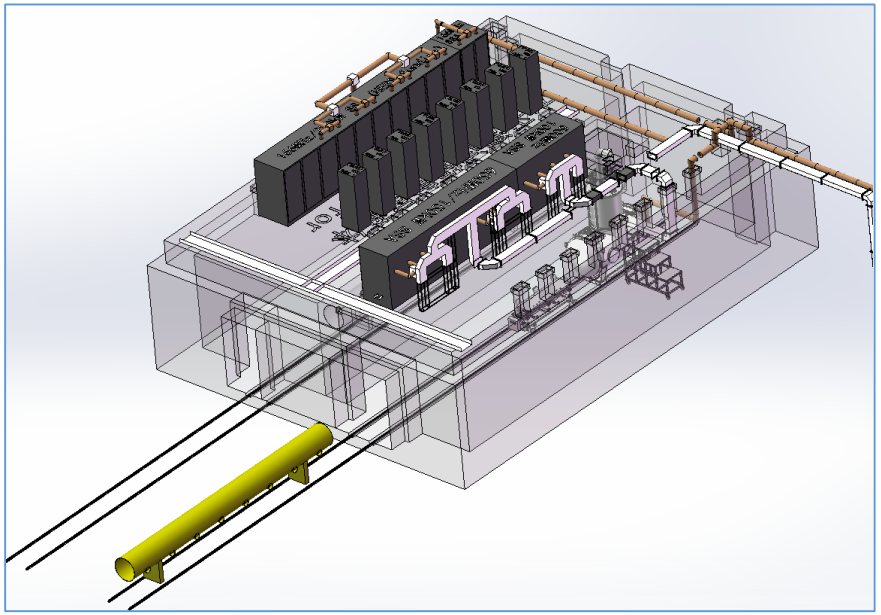


Magnetic shields

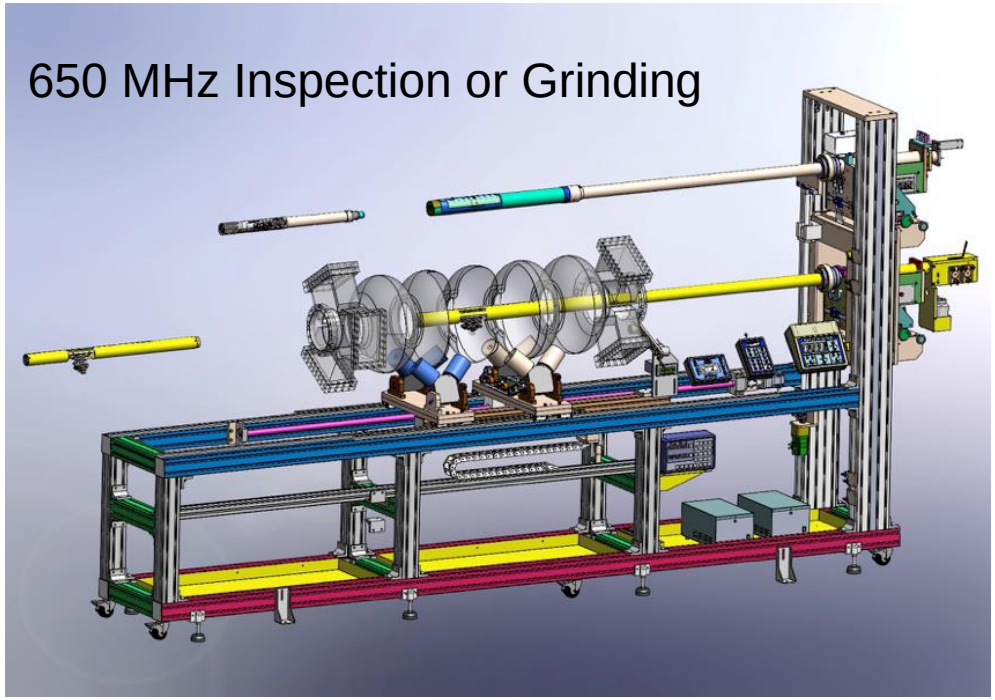
Horizontal Test Area

- A test cryomodule for horizontal test of cavity, coupler, and tuners is in fabrication.
- The radiation shielding bunker will be installed at March 2019.





Optical inspection equipment



Main Features:

- Inspection and grinding of the equator and iris area
- Automated inspection
- Resolution: < 5 μm / pixel
- Independent brightness control of each illumination LED

- 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.

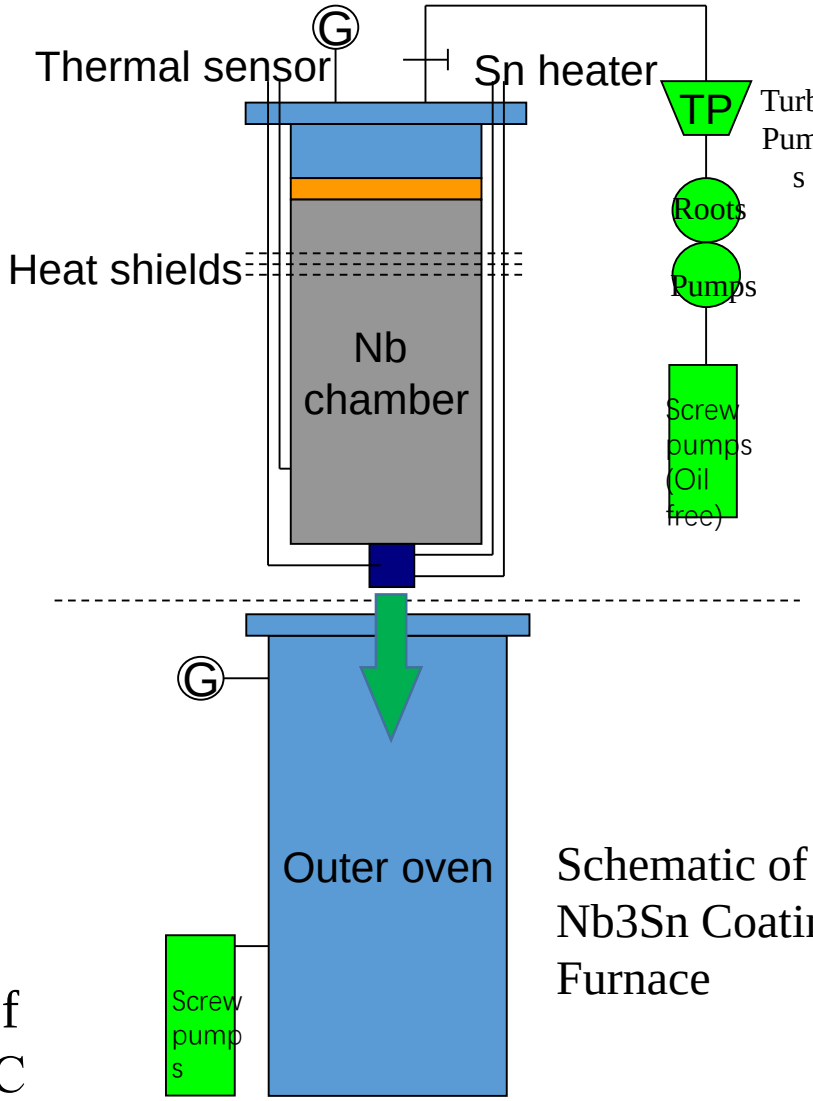
N-doping furnace

- Uniform temperature zone：1500*600*600 mm
- Max temperature： 1200 °C
- Ultra vacuum： <1e-5 Pa (@R.T.) and 1e-4 Pa (@900C)
- Cooling： Natural cooling with protective gas
- Gas Injection : 4 ports for N_2, Ar, air and RGA
- Mass flow controller: 0.1-100Pa (120-900C)

N-doping Furnace at OTIC (similar as ours)

Nb_3Sn Furnace

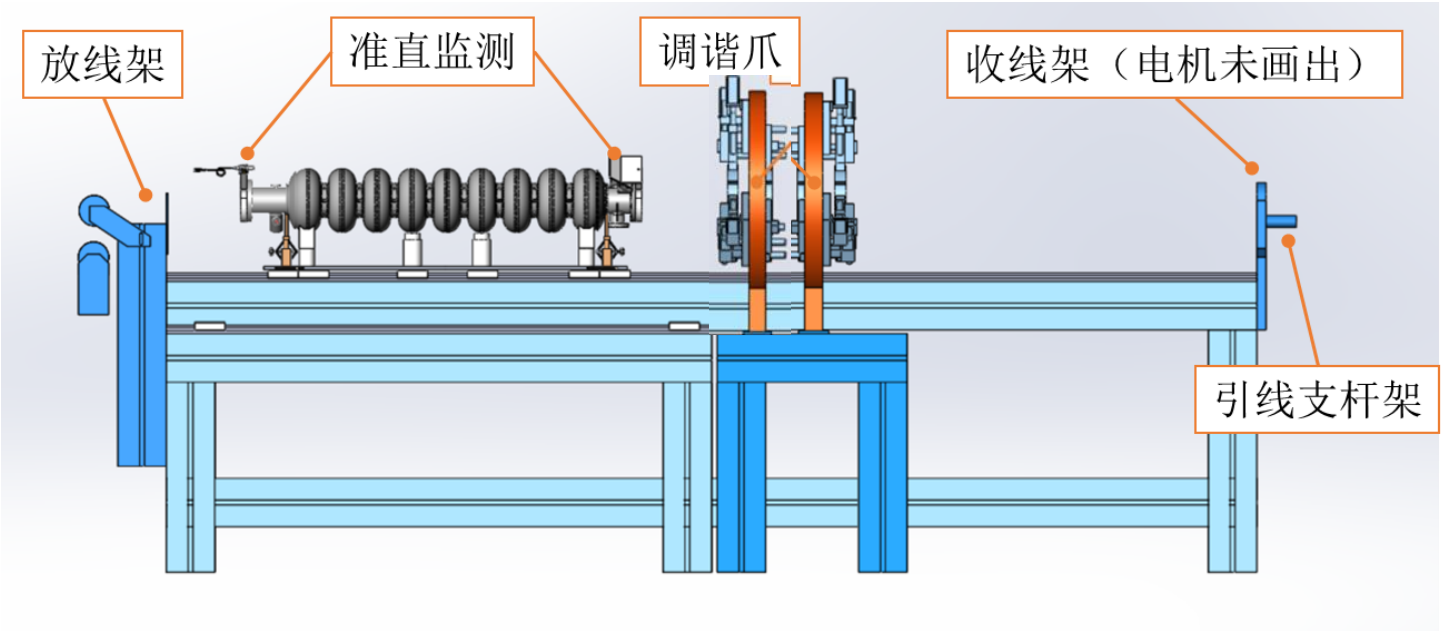
- Furnace
  - Working area:1000 × Φ 600 mm
  - Maximum temperature
    - Furnace area:1200℃
    - Crucible:1300℃
- Vacuum
  - Nb chamber
  - Crucible material: Tungsten
  - Oil free pumping system
  - Ultimate vacuum：<1×10^{-5} Pa （@R.T.）
- Temperature control
  - The temperature at Nb chamber can be precisely controlled in the range of 1000~1300℃ with accuracy of ±1℃



Schematic of Nb3Sn Coating Furnace

Pre-tuning machine

- A pre-tuning machine was developed in collabration with Peking university.
- Beside pre-tuning, it can also measure the coaxiality.
- However, the machine is not automatic, and can not adjust coaxiality.



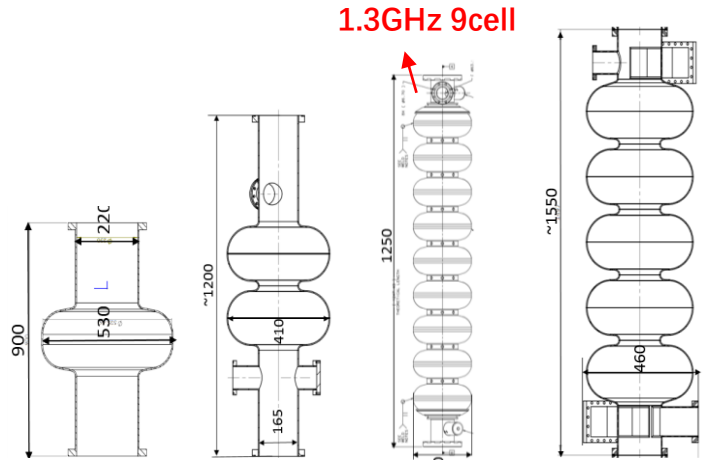
Pre-tuning machine

Content

- Introduction
- Infrastructures
- **EP system development**
- Summary

EP system development

- **For the Post treatment, we developed an EP system at IHEP.**
  - R&D and mass production
  - Horizontal;
  - Compatible: 500MHz single cell, 1.3GHz up to 9 cell , 650MHz up to 5 cell



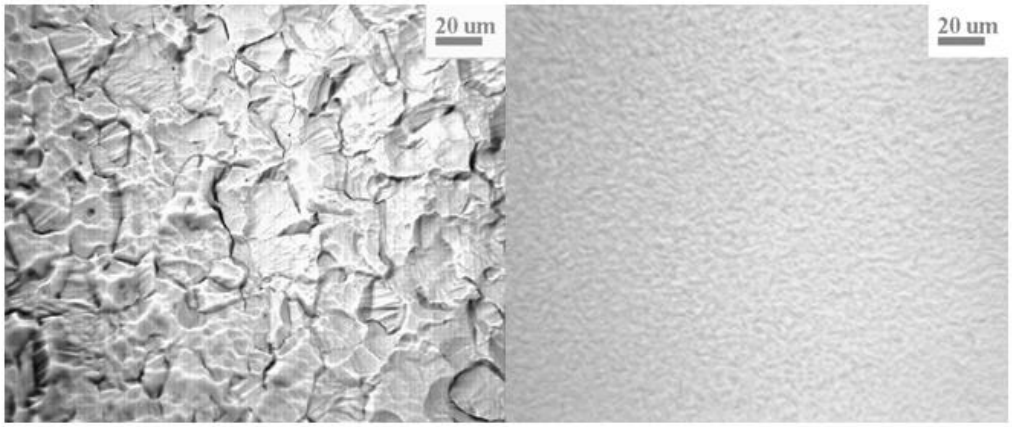
- EP system is expensive, e.g. ANL, KEK, several million dollars were cost;
- For this system, totally it is about 4M CNY (Cost of EP lab construction is not included)

- **EP facility R&D was started by several supporting as HEPS-TF, PAPS, CEPC and Beijing Municipal Science &Technology Commission**

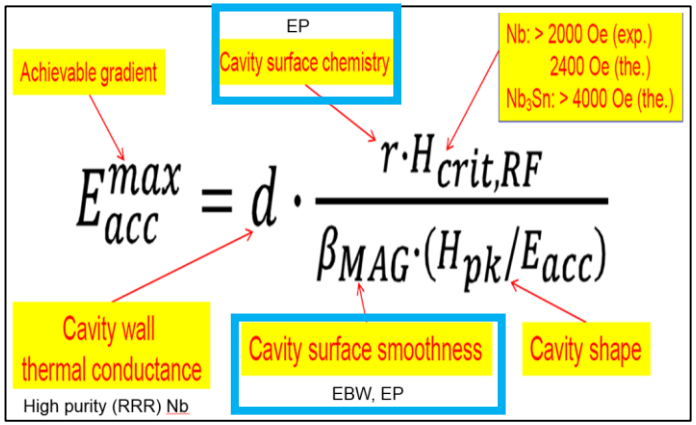
- **Also a part of effort of the collaboration of IHEP-KEK**

Brief background

- **For the high performance cavities, it is necessary.**
  - High gradient cavity, like ILC 1.3GHz cavities
  - For high quality factor cavities (N-doping）, like LCLS II, Shanghai hard X-ray FEL, CEPC.
- **However, there is still no operational EP system in China**



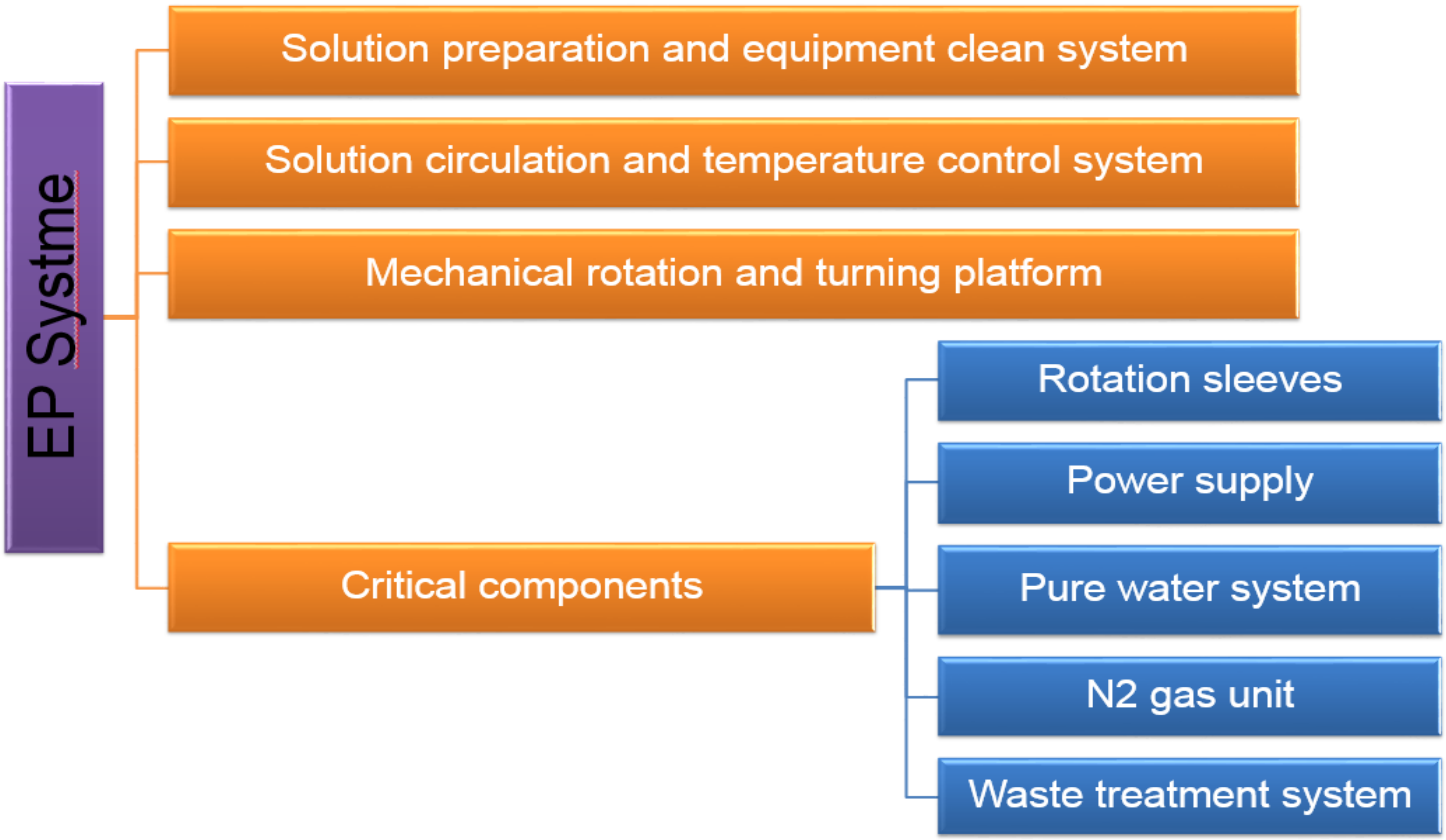
Niobium surface after BCP Niobium surface after EP



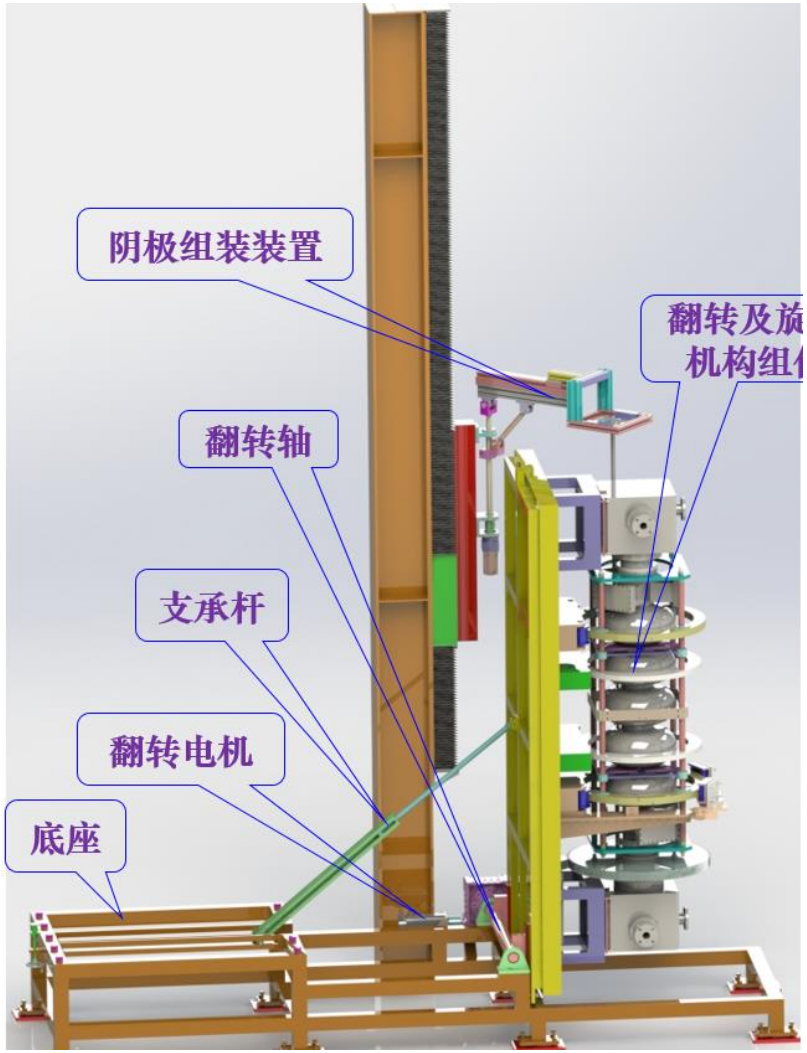
*Rongli Geng, Low-Surface-Field (LSF) Shape Cavity Development, LCWS2012, Dresden, Germany.

EP Facility overview

■ Main components



Mechanical unit

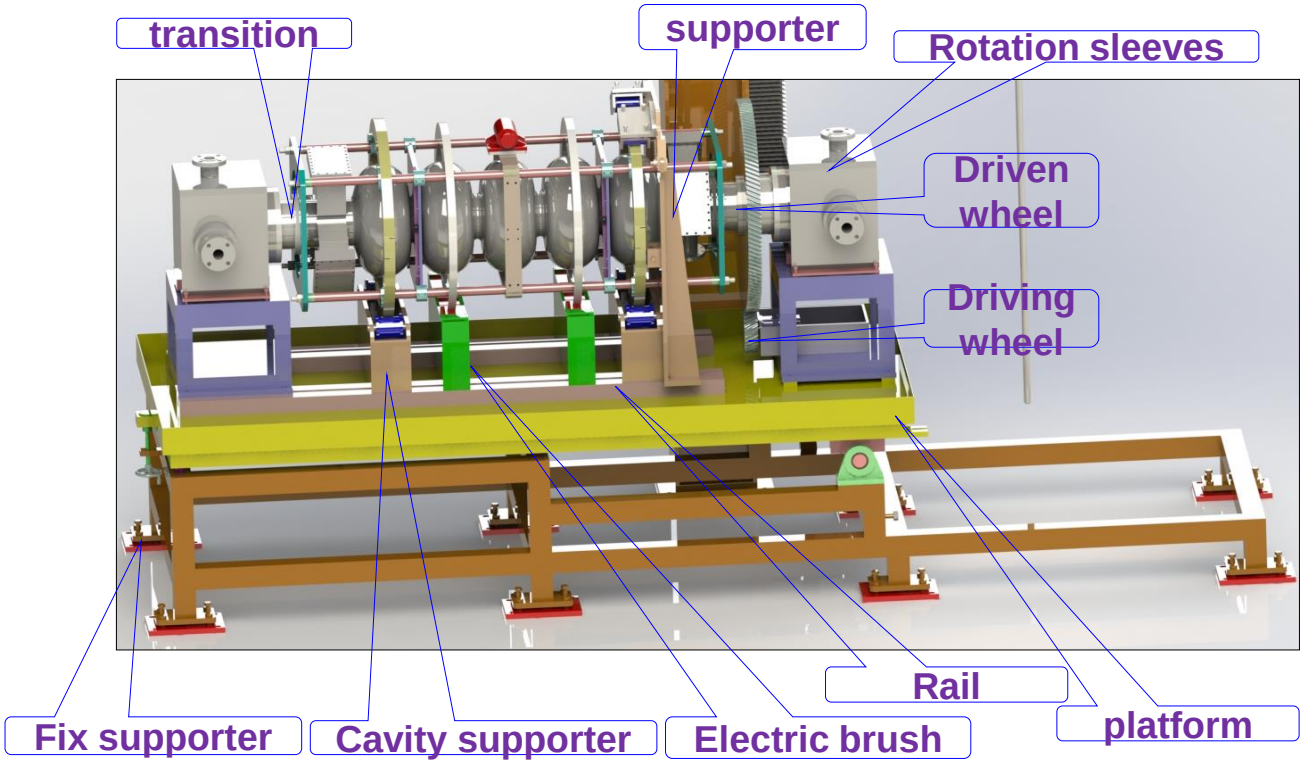


Functions

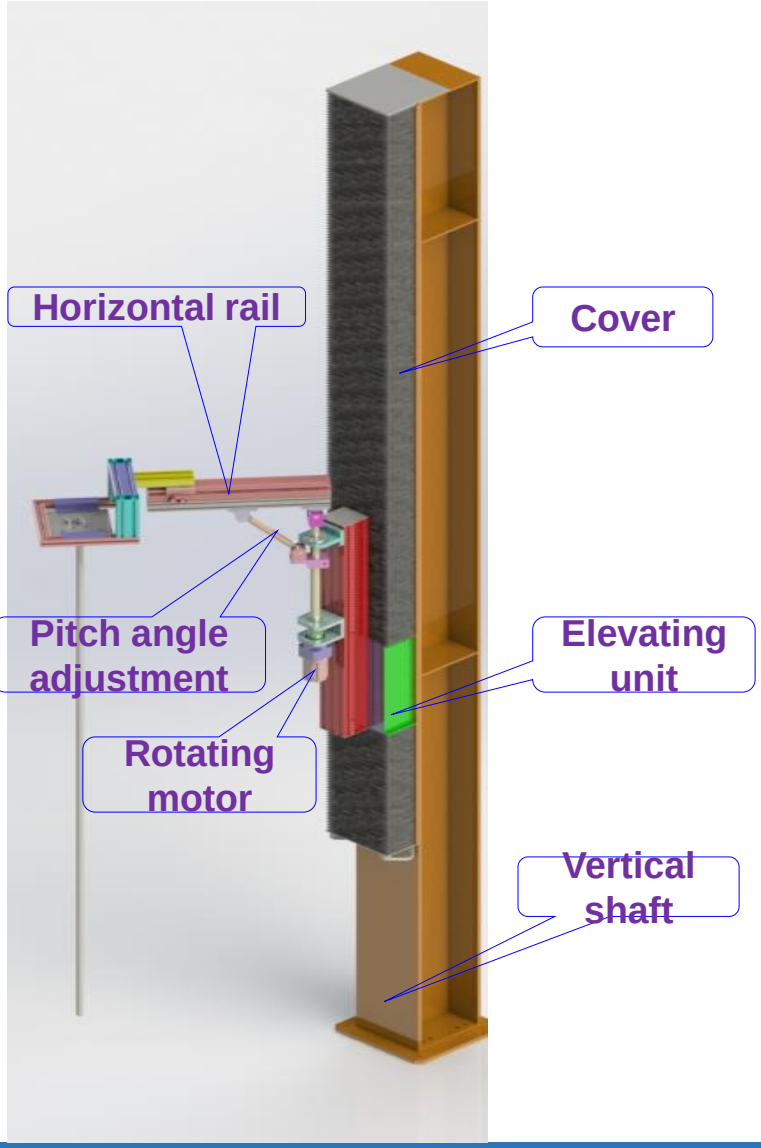
- Rotation when cavity at horizontal;
- Switchable between horizontal and vertical;
- Cathode assembly in vertical direction;
- Power connections;
- Automatic Control;
- Rotation sleeves
- Others

◆ Components of the mechanical platform

It contains a platform, cavity supporters, rotation sleeves, wheel gears, motors, gearbox, electric brushes. The turning of the platform powered a motor and gearbox . Material of most parts are stainless steel.



- **Cathode assembly equipment**
  - The maximum height is 5.5m
  - Maximum loading is 50kg
  - Can be adjusted in 8 direction; 6 is automatically controlled; 2 is by manual operation
  - A laser assembled in one of the end to monitor the assembly progress



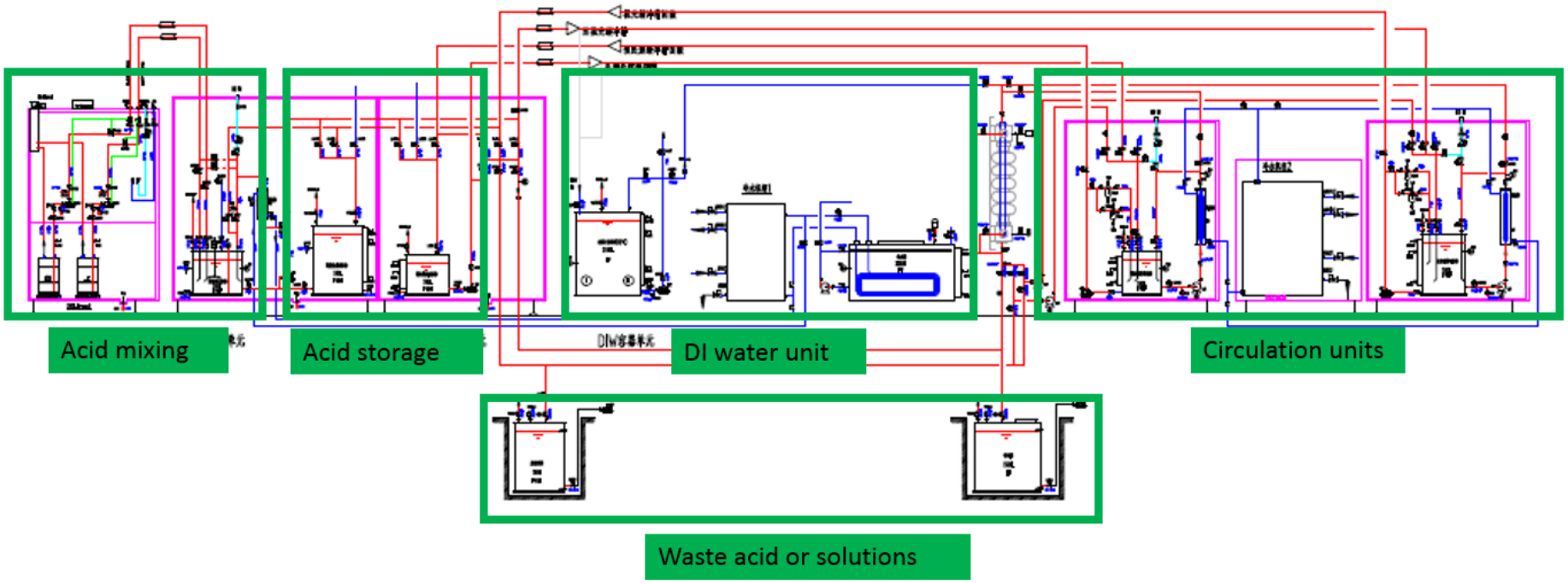
Mechanical Performance

- The working area is 1700mm ×600mm
- The maximum weight for support is 1000kg
- Material for most mechanical part is stainless steel (SUS304)
- Most controls and data lodging can be automatically operated.
- Maximum rotation speed is 10RPM, with a step of 0.01RMP adjustable
- The tuning from horizontal to vertical is 0-95^{o}
- Cathode can be adjusted in 8 direction
- 18 temperature sensors are prepared for surface temperature measurement for various cavities

Solutions units

- **Electrolyte Preparation and Equipment Cleaning Unit**
  - Acid mixing
  - Acid storage
  - DI water cleaning
- **Solution Circulation and Temperature Control Unit**
  - Acid circulation
  - Acid lever control
  - Acid cooling
  - Cavity cooling
  - Acid draining
  - DI Water rinsing
  - Hydrogen gas exhaust

Piping and Instruments Diagram



Acid mixing, Acid storage, DI water cleaning, Acid circulation, Acid lever control, Acid cooling , Cavity cooling, Acid draining, DI Water rinsing, Hydrogen gas exhaust

Main Circulations

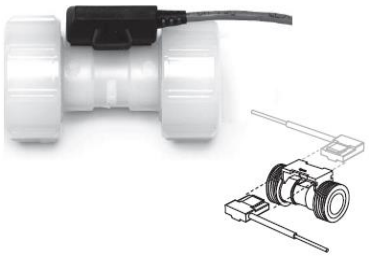
- Acid mixing-providing
- Acid mixing-cooling
- New acid to bulk EP
- New acid to pre-EP
- New acid to waste
- New acid to disposal
- New acid to EP buffer
- Old acid to pre-EP
- Old acid to EP buffer
- Old acid to waste
- Old acid to disposal
- Pre-EP to pre-EP buffer
- Pre-EP to waste
- Pre-EP to disposal
- DI water to cavity
- DI water self-circulation and heating
- DI water（to bulk EP, pre-EP, mixing）
- Pre-EP/Bulk EP to cavity
- EP buffer to waste/bulk EP/ mixing/disposal
- Pre-EP buffer to waste/pre-EP/disposal
- Leaking check diagrams

Main equipment

PP/PVDF valves

pneumatic diaphragm pump

magnetic drive pump



PVDF wheel flowmeter

PFA Pressure sensor

PVDF temperature sensor

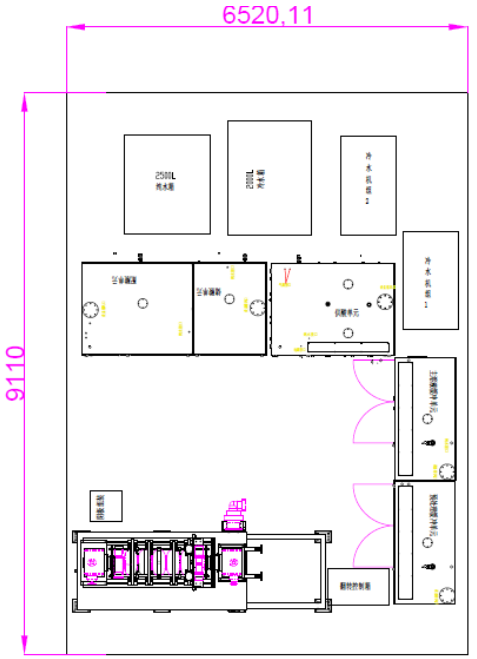
Performance of solution units

- Tens of circulations can be achieved for the EP process
- Material used in most of this part is PTFE, PVDF and PFA.
- The mixing rate for electrolyte mixing will be as high as 50L/hour, with an accuracy of ±1%
- The flow rate can be as high as 70L/min for both acid and DI water
- We have two 15kW chiller for the system for cooling
- The DI water can be cooled to 10C for outside cooling of the cavity, and also can be heated to 50C for cavity rinsing.

Characteristics of the EP system

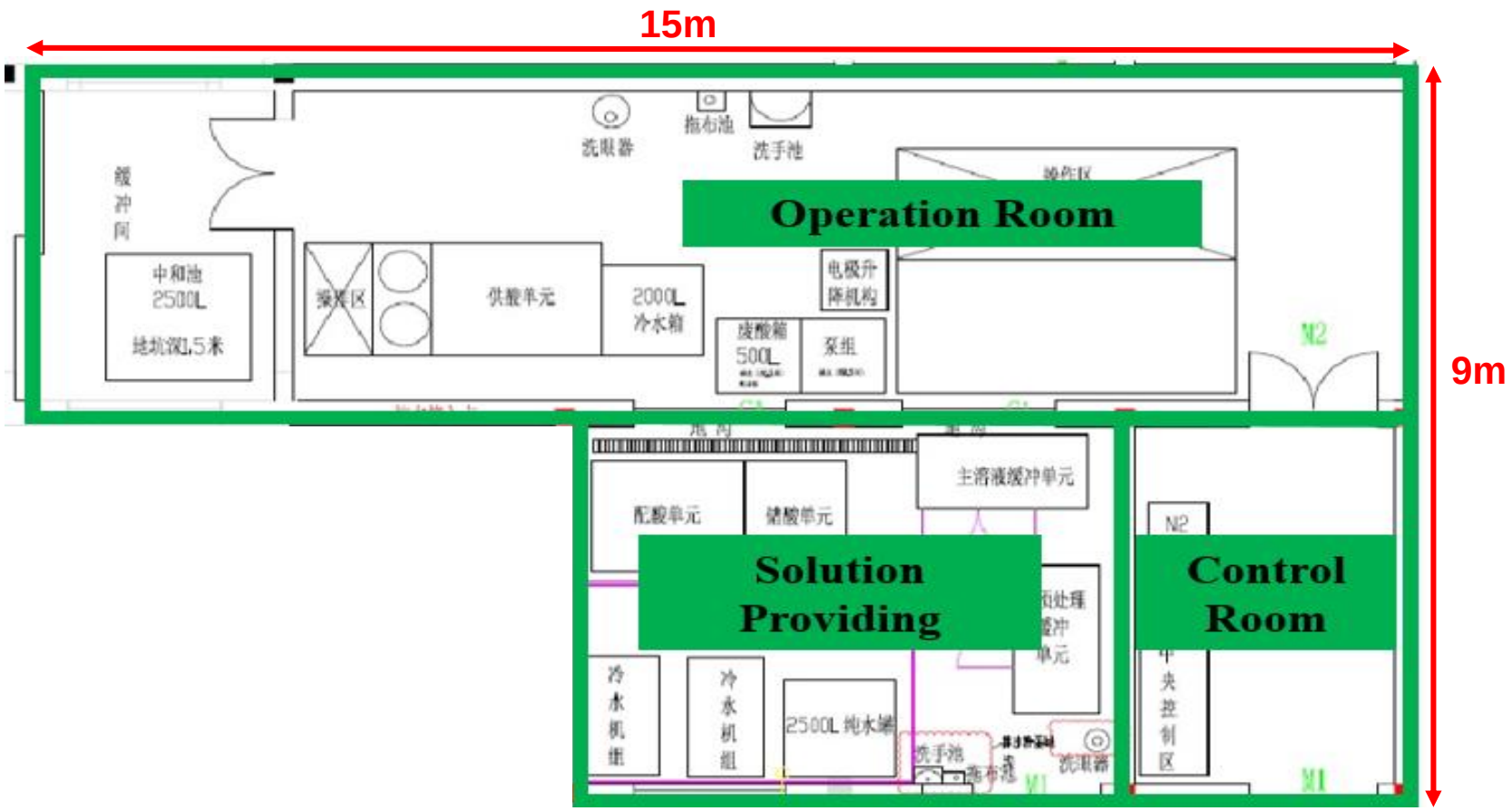
	Characteristics	IHEP	KEK	DESY	JLab	ANL
1	1.3GHz up to 9-cell	√	√	√	√	√
2	650MHz up to 5-cell	√	×	×	×	√
3	500MHz 1-cell	√	√	×	×	√
4	Electrolyte Preparation	√	×	×	×	×
5	Cavity outside water cooling	√	×	×	√	√
6	Vertical cathode assembly	√	√	?	×	√
7	New and old acid separation	√	×	√	√	√
8	Pre-EP unit	√	√	×	×	×

Function test at IHEP by water



Function test at IHEP in Sept. 2018

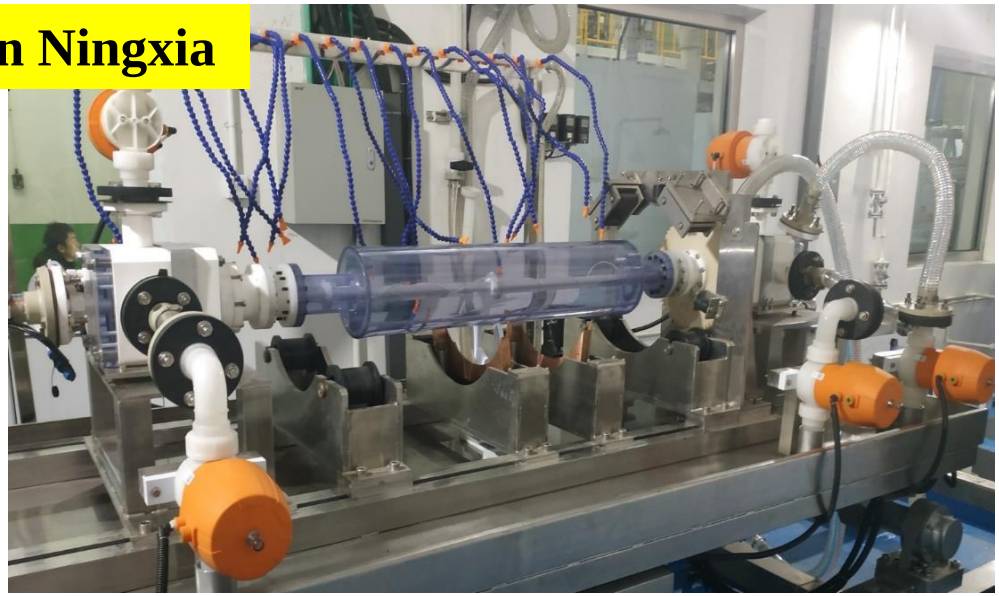
EP Lab at Ningxia



- Components distribution, Electricity, Water, UP water, Cooling water, Air exhaust, Waster water, Gas providing

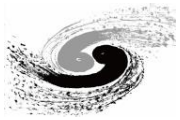
Status of EP system

EP system commissioning in Ningxia



Summary

- **The SCRF infrastructures were well arranged mainly basing on PAPS program and will be completed before 2020, including cleanrooms, VT/HT test stands, N-doping and Nb3Sn furnaces, Cu-Nb sputtering system, Optical inspection, Pre-tuning machine, and so on.**
- **An EP system for both R&D and mass production purposes was also developed and finished main functional test at IHEP. At present, it has been assembled at Ningxia, and is under commissioning.**



Thanks for your attentions!