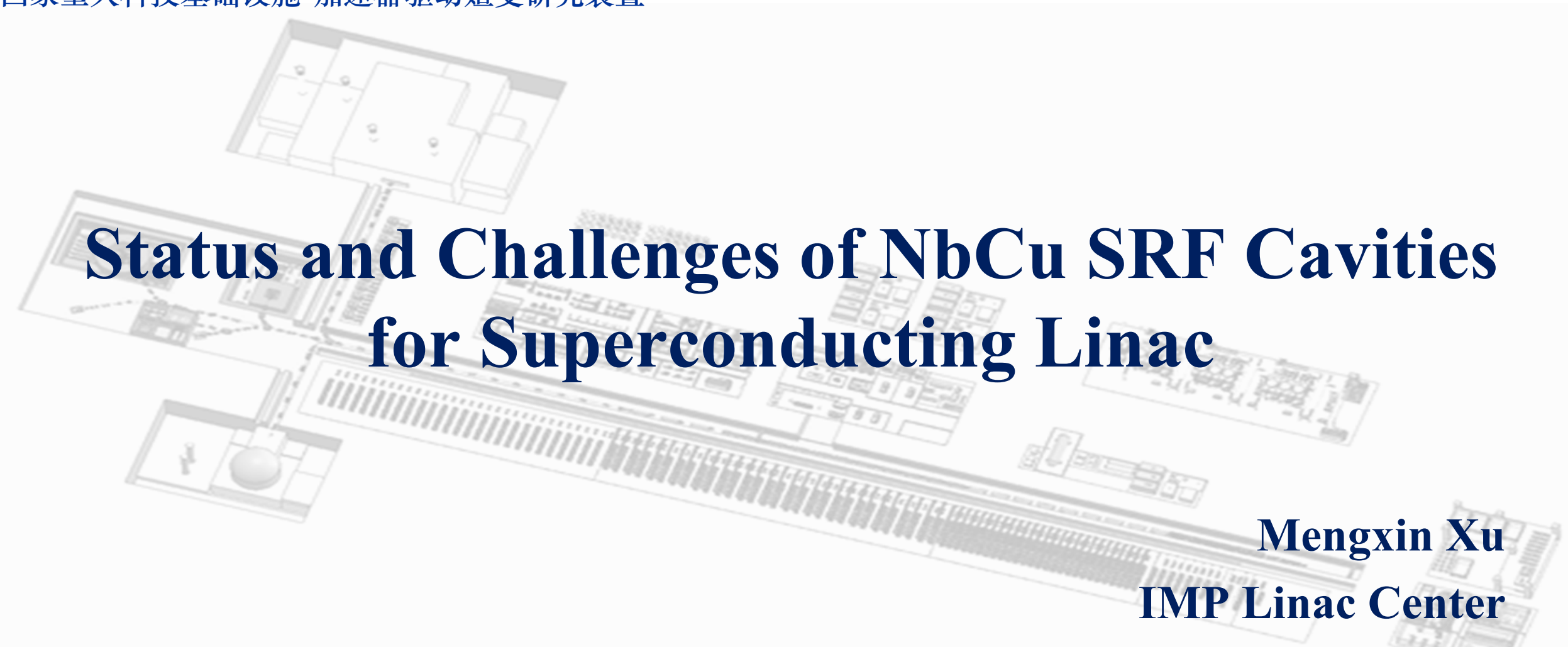

Status and Challenges of NbCu SRF Cavities for Superconducting Linac

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Aug 30 2022

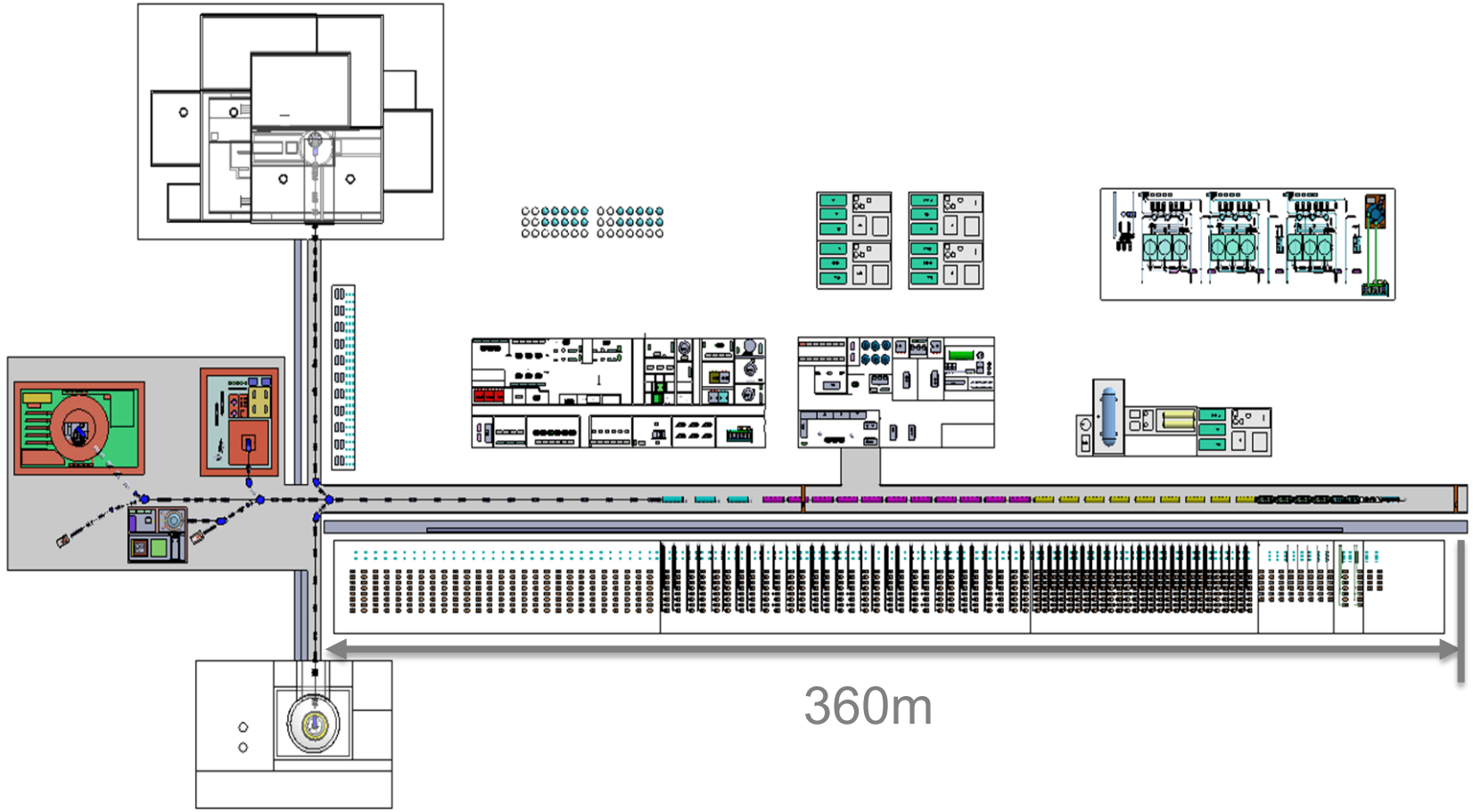
Outline

- 1. Introduction
- 2. Copper Niobium Cavity
- 3. Summary and Outlook

Introduction

China initiative Accelerator Driven System(CiADS)

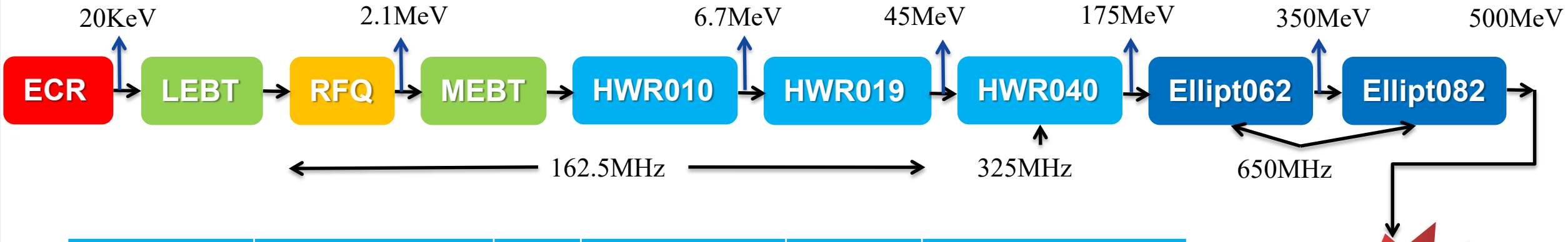
- For nuclear waste transmutation and energy production
- Main structure
  - Superconducting drive linac
    - 500MeV, 5mA
  - Spallation target
    - Pb-Bi, 2.5MW
  - Subcritical reactor
    - 10MW
- Total Budget about 400M $
- Schedule:2021~2027



Introduction

Introduction

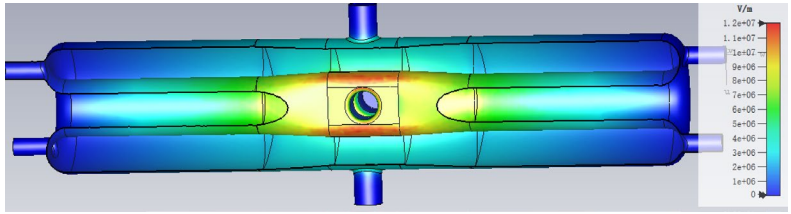
CiADS Linac Design

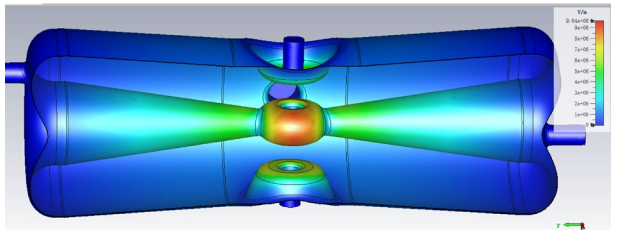


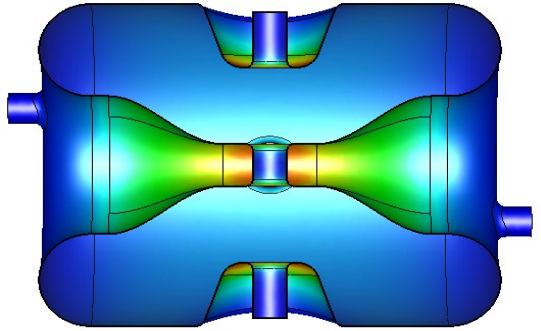
Sections	Frequency(MHz)	beta	Cryomodules	Cavities	Solenoids
HWR010	162.5	0.1	1	9	9
HWR019	162.5	0.19	4	24	24
HWR040	325	0.4	10	60	20
Ellipt062	650	0.62	10	30	0
Ellipt082	650	0.82	7	28	0
Totals			32	151	53

Introduction

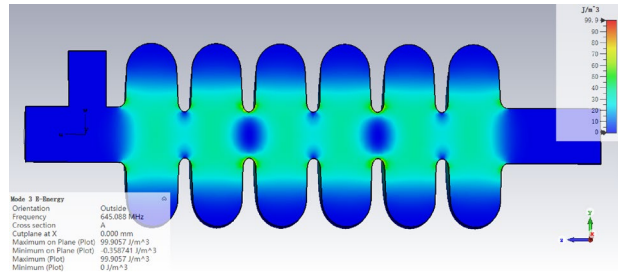
Cavities Parameters

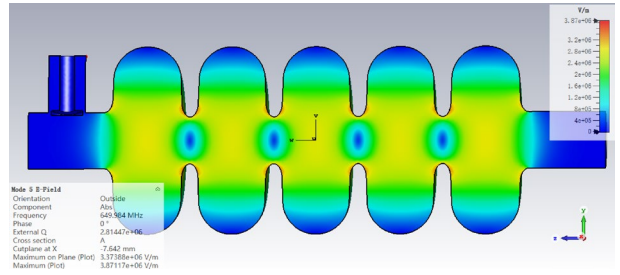






Parameters	Unit	HWR010	HWR019	HWR040	Elliptical062-6cell	Elliptical082-5cell
Beta		0.10	0.19	0.40	0.62	0.82
frequency	MHz	162.50	162.50	325.00	650.00	650.00
Beam Aperture	mm	40.00	40.00	50.00	100.00	100.00
Leff	m	0.185	0.351	0.369	0.821	0.896
L_{ftof}(flange to flange)	m	0.2100	0.4700	0.4500	1.2200	1.2200
Ep/Eacc		5.71	4.24	3.83	2.78	2.14
Bp/Eacc	mT/MV/m	12.52	6.21	7.35	4.83	4.04
Ep(operation)	**MV/m**	**26.00**	**28.00**	**28.00**	**29.00**	**29.00**
Bp @Ep	mT	57.01	41.01	53.73	50.38	54.75
TTF		0.83	0. 8871	0.82	0.73	0.73
Veff @Ep	[MV]	0.84	2.32	2.70	8.56	12.15
V0 @Ep	[MV]	1.01	2.61	3.29	11.73	16.64
Eacc @Ep	[MV/m]	4.55	6.60	7.31	10.43	13.55
U @Ep	J	4.54	15.68	13.02	54.34	73.61
G	Ohm	28.00	66. 43	106.80	188.00	229.00
R/Q	Ohm	158.33	337.22	244.60	330.00	501.00





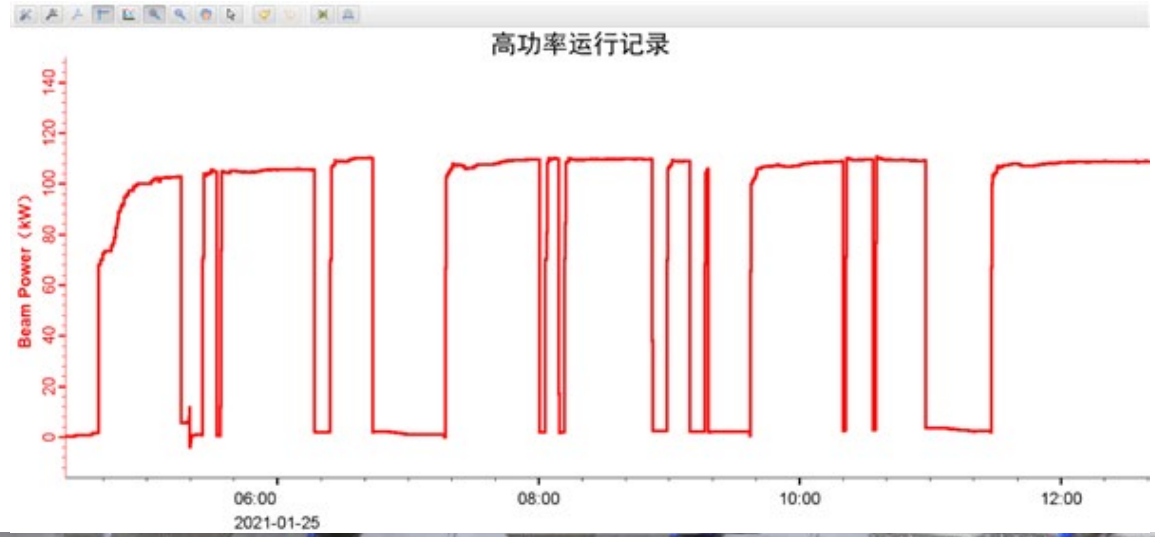
Top Level Requirement

Reliability of CiADS facility: beam trips is emphasized

- Electricity on the external grid, less than 3/y (beam trip time >5min)
- Thermal shock on the beam window, less than 25000/y(beam trip time <1s)
- Thermal shock on the reactor, less than 2500/y(1s<beam trip time <10s),less than 250/y(10s<beam trip time <5min)

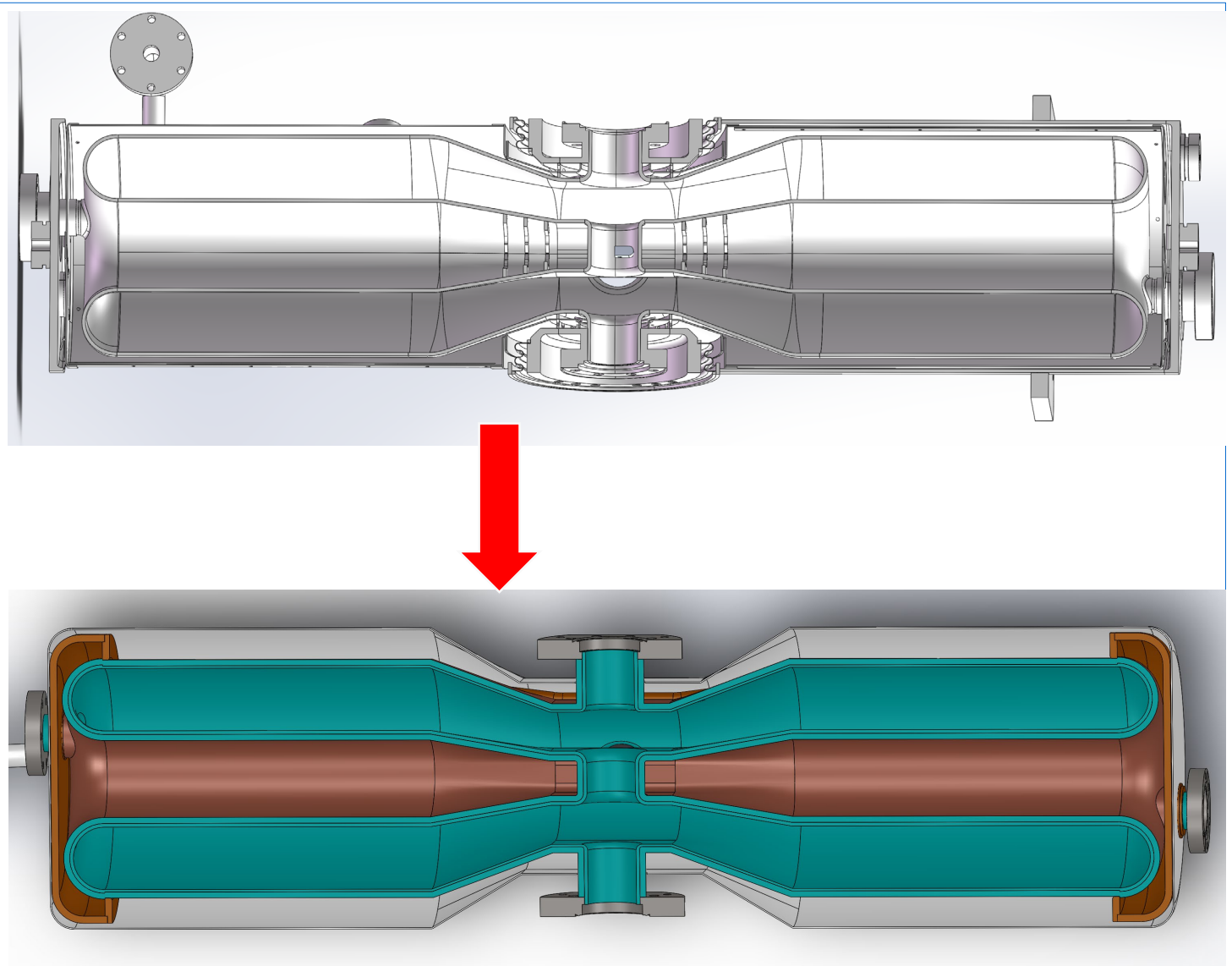
Status of CaFe linac

- 4 cryomodules
- 4K operation
- Trip about 1 time per hour



Robust Superconducting Cavity

- Thicker cavity wall
- Local helium contacted with cavity
- Shield the external vibrations



Copper Niobium Cavity

Cu/Nb Cavity

- **Save niobium cost**
- **High thermal stability**
- **High mechanical stability**
- **Previous two major technology**
  - Sputtering niobium on copper cavity(micro niobium): CERN's LEP, 274 cavities, 4cell, 352MHz; INFN's 54 QWR cavities
  - Cu/Nb Explosive sheet(2mm niobium+8mm copper):JAERI's QWR cavities
- **IMP's Cu/Nb Cavity development**
  - Developing sputteing niobium on copper since 2015
  - Cu/Nb sheet fabrication :Explosive, HIP
  - Coating Copper on Nb cavity
  - Casting Copper on Nb cavity

Thin-shell cavity

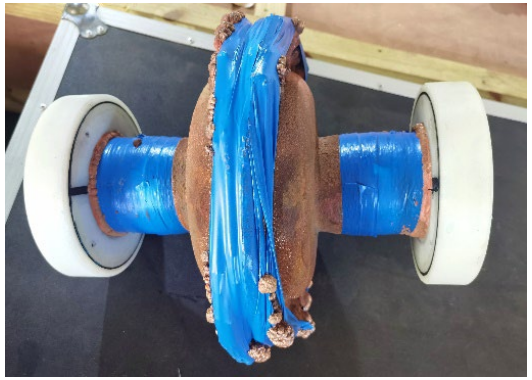
Fabrication cavity with 1mm thickness niobium

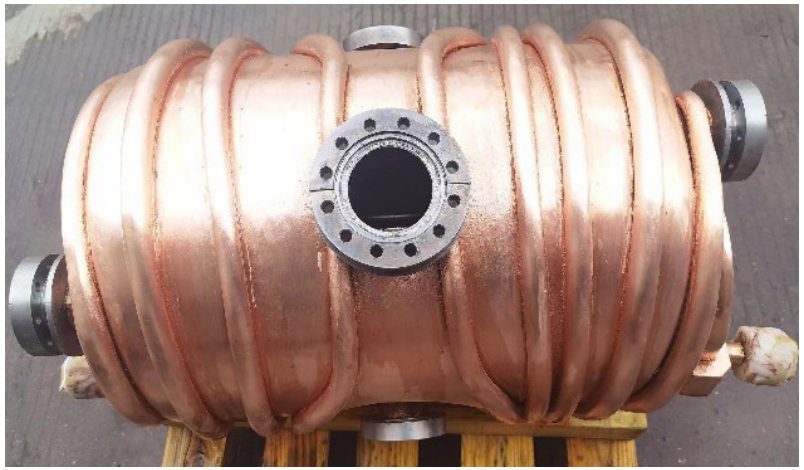
- **1/3 material cost**
- **Fabrication processing not change much**
- **Improved heat exchange**
- **Niobium cavity's surface processing still can be used**
- **4 single cell cavity have been completed and two of them be tested**
- **Now, fabricating 1mm HWR cavity are developing**

Coating Copper on niobium cavity

Coating 4~5mm copper on the outside of thin niobium cavity

- **Improved mechanical stability**
- **Enhanced the thermal performance for using local cooling**

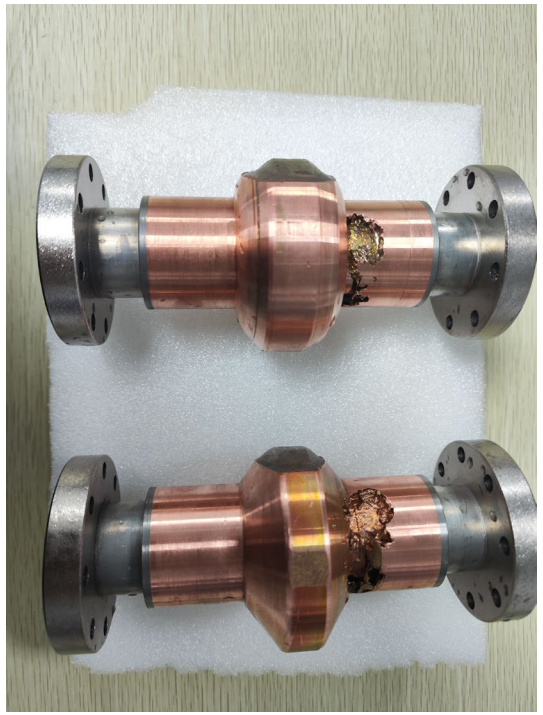


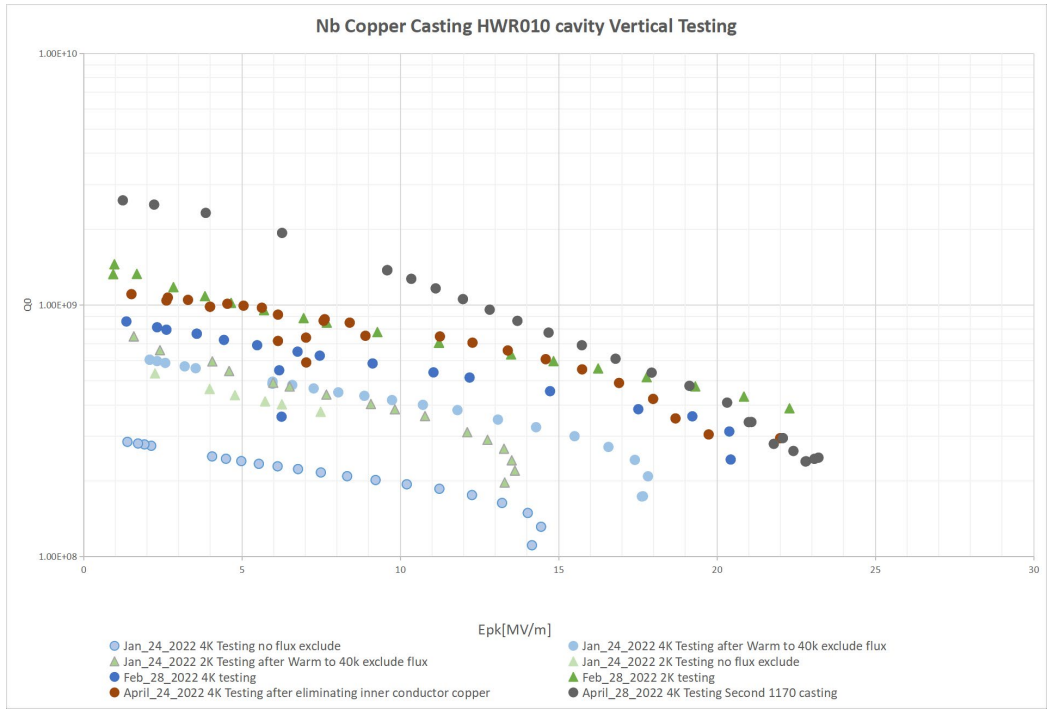


Casting Copper on niobium cavity

Comparing to coating copper

- Casting copper shows impressive higher thermal conductivity
- Shorter fabrication time
- There is some issues still work on

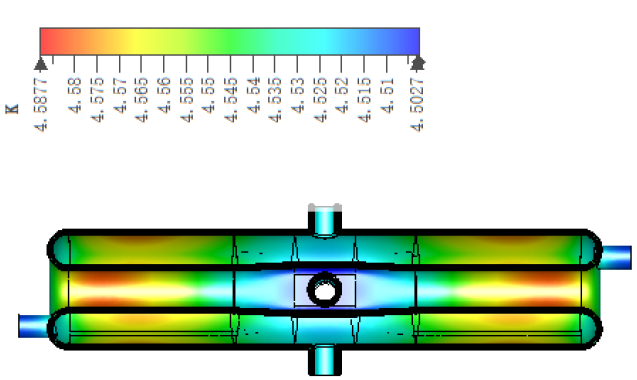


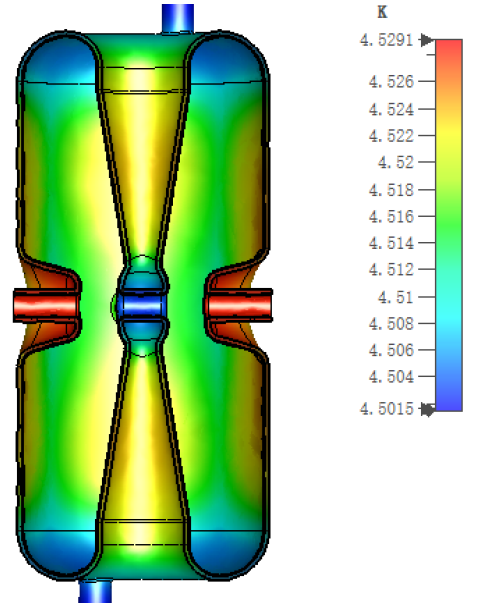


Cavity Simulation

Thermal Simulation

- Local helium cooling
- 0.2 K temperature arising

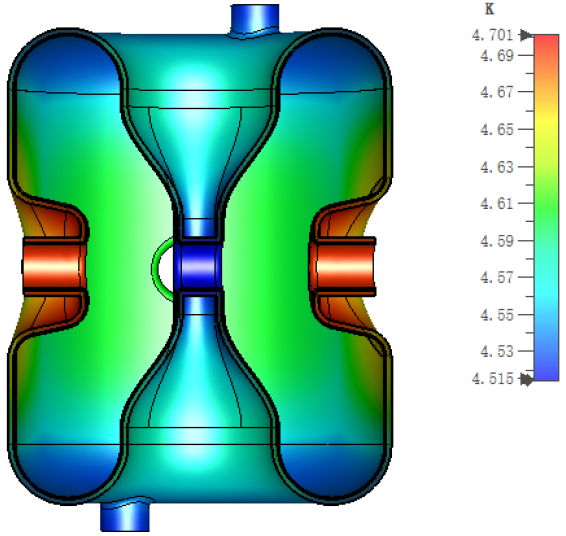




Mechanical Simulation

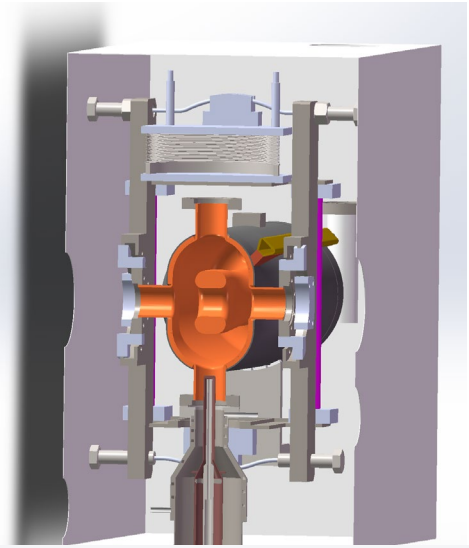
- Stiffness 10KN/mm
- Adjusting the thickness of cavity is flexible for optimizing mechanical stability

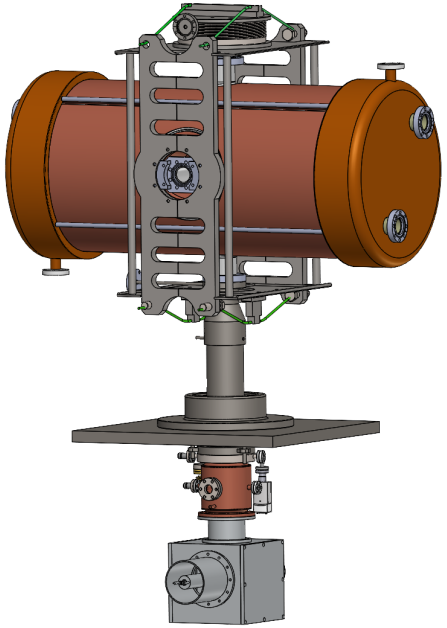
		HWR010	HWR019	HWR040
3mm niobium	LFD [Hz/(MV/m)^2]	-5.5	-5	-7
	df/dp [Hz/mbar]	-10.5	-1	-35
6mm(Cu/Nb)	LFD [Hz/(MV/m)^2]	-4	-0.92	1.23
	df/dp [Hz/mbar]	-0.08	0.71	2.28

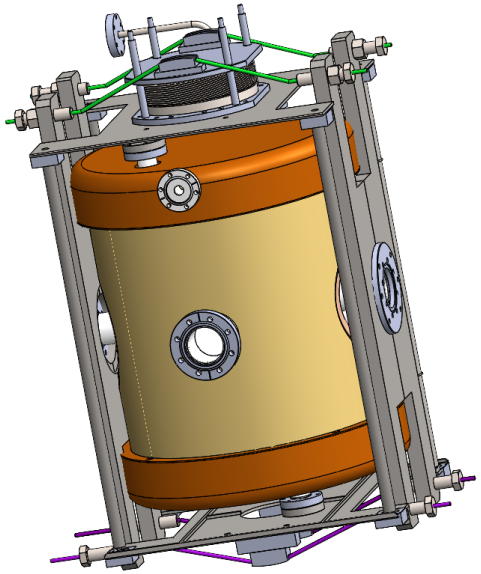


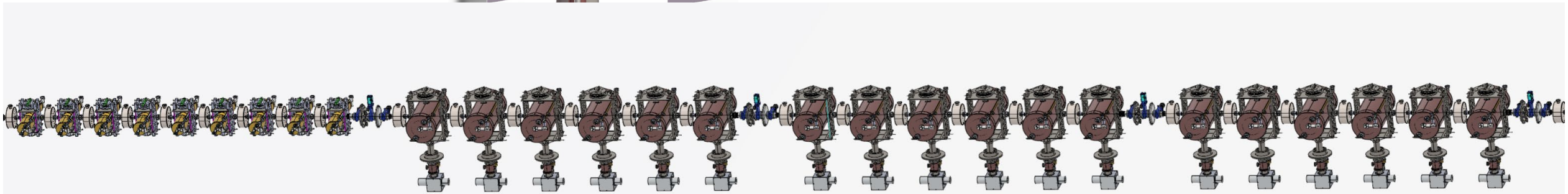
Engneering Design

- HWR section's design have been completed
- Ellipitical section's design still going on









Niobium cavity fabrication

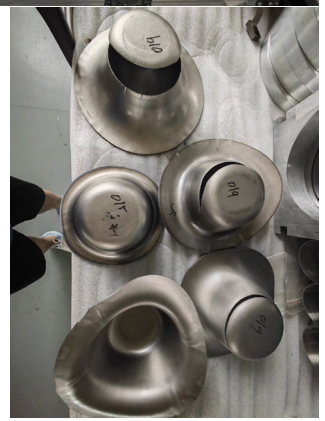
9 HWR010

5 deliver to lanzhou

4 final EBW

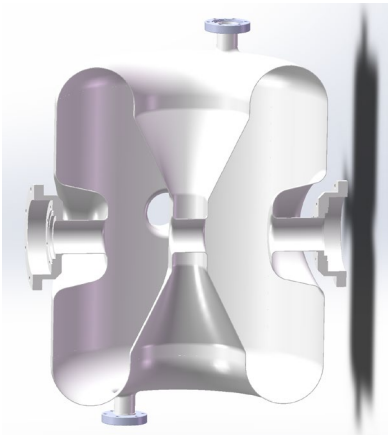
24 HWR019

6 are preparing for final EBW



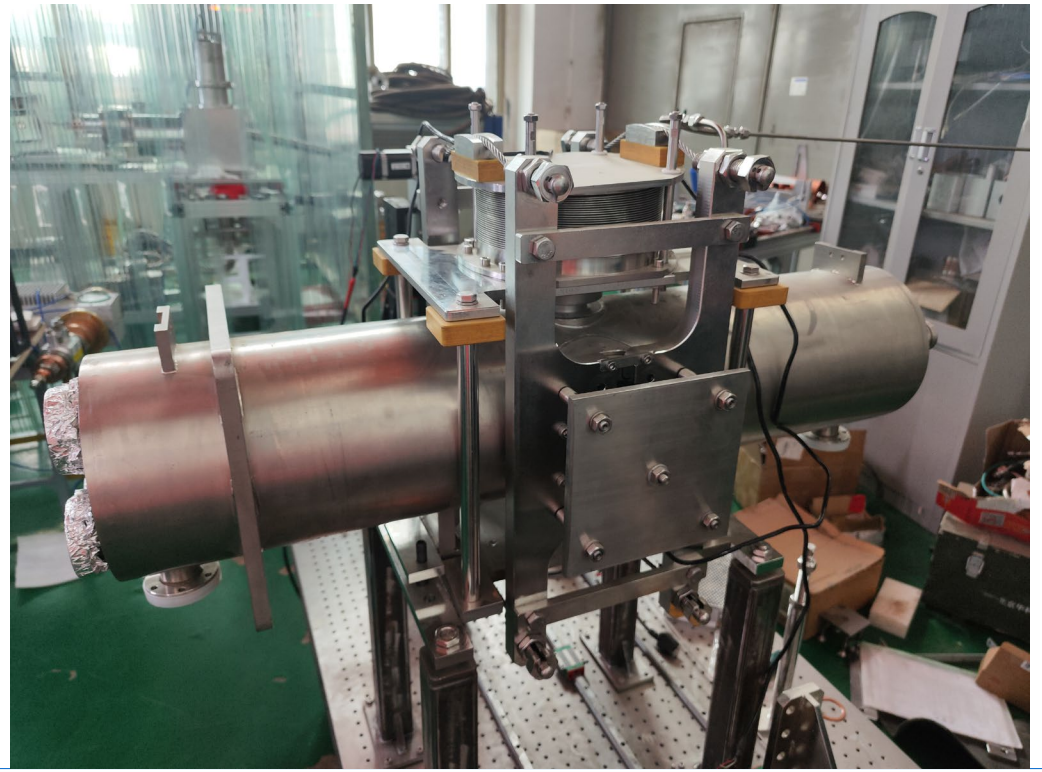
HWR040(1mm)

part fabrication



Prototype integration testing

- The coupler have been delivered two for testing
- Tuner are under testing
- Integration testing vessel have been ready
- Cavity is doing final coating processing



Summary and Outlook

- Appling Cu/Nb cavity technology in CiADS is a critical decision
- Different type of Cu/Nb cavity are developing
- New engineering design have been conducted to cooperate with the Cu/Nb cavity technology
- HWR010 cryomodule is planed assembly in the end of this year

Thank you for your attentions!