CEPC Accelerator EDR in Synergy with other Accelerator Projects in China

Jie Gao

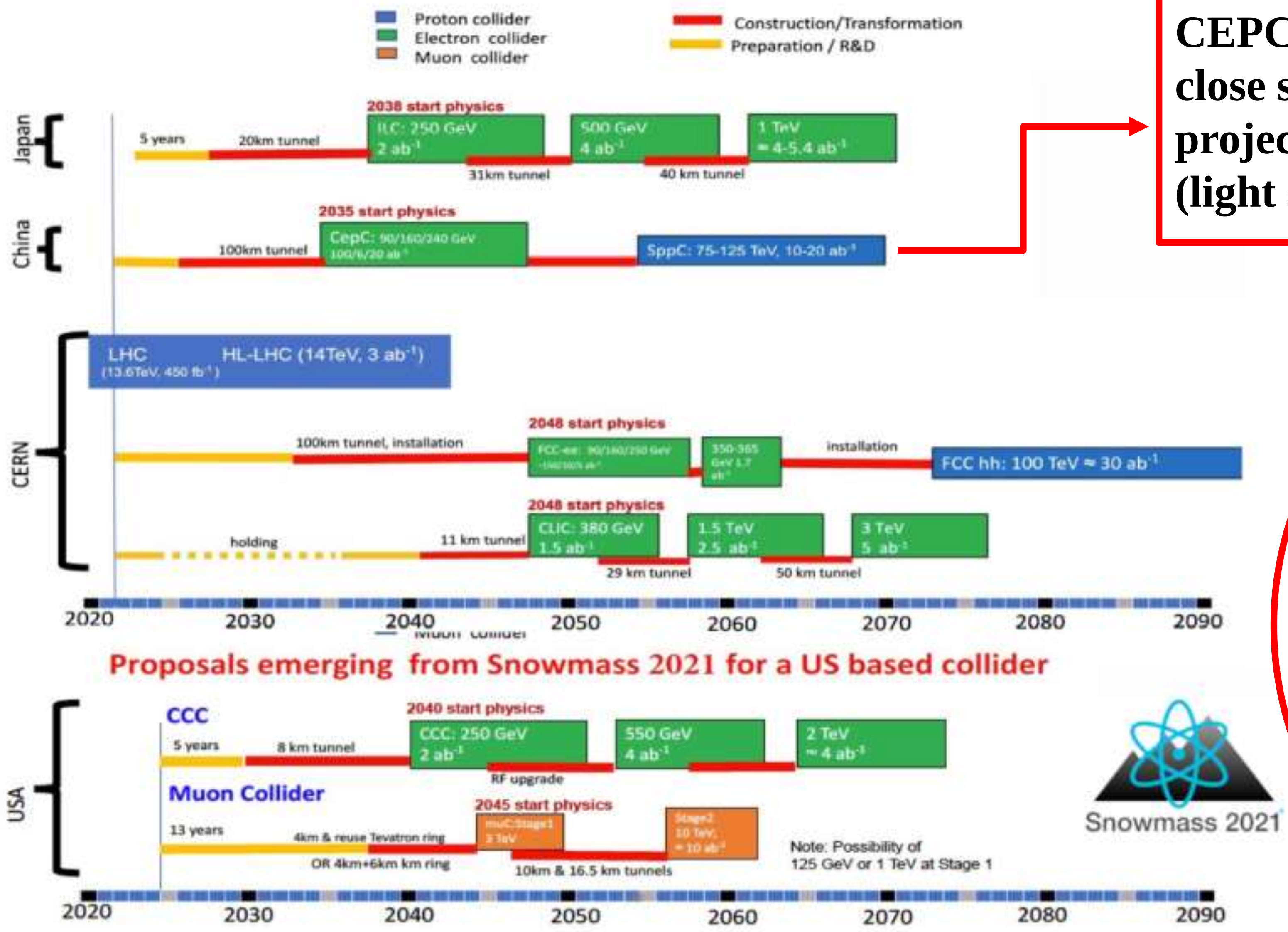
IHEP

CEPC Workshop EU Edition, April 8-11, 2024, Marseille, France

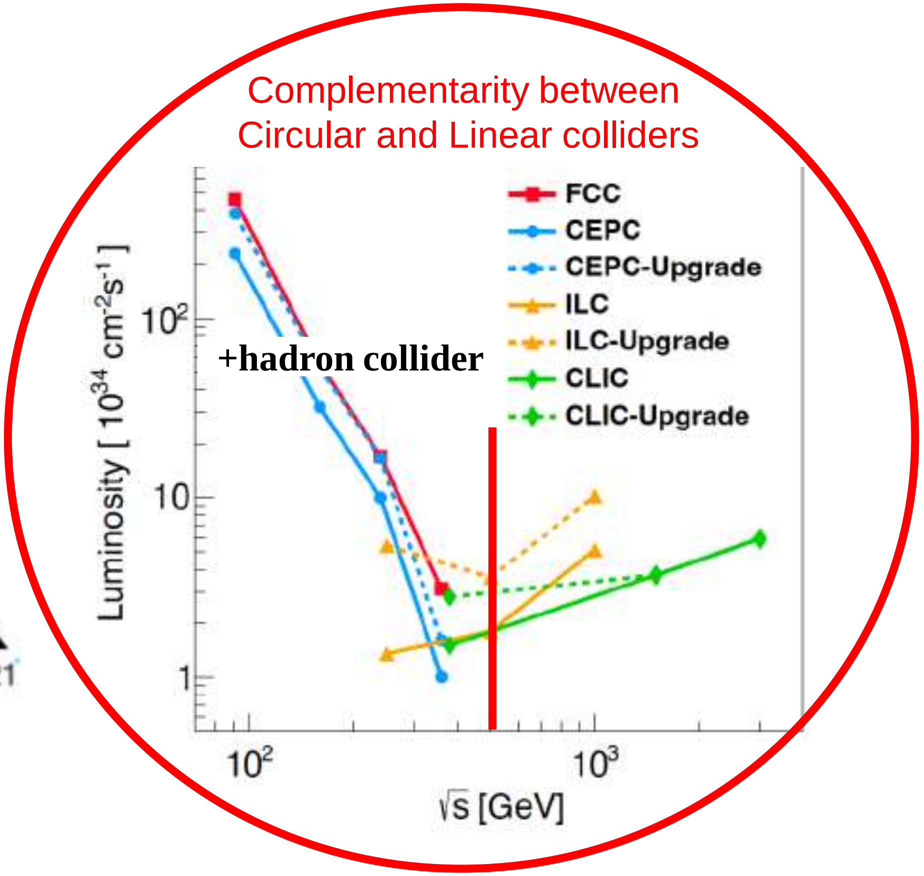
Contents

- **Introduction**
- **CEPC accelerator development in TDR and EDR**
- **Status of other accelerator projects under construction in China**
- **Synergies issues with CEPC**
- **Summary**

Timelines in Snowmass Energy Frontier Summary

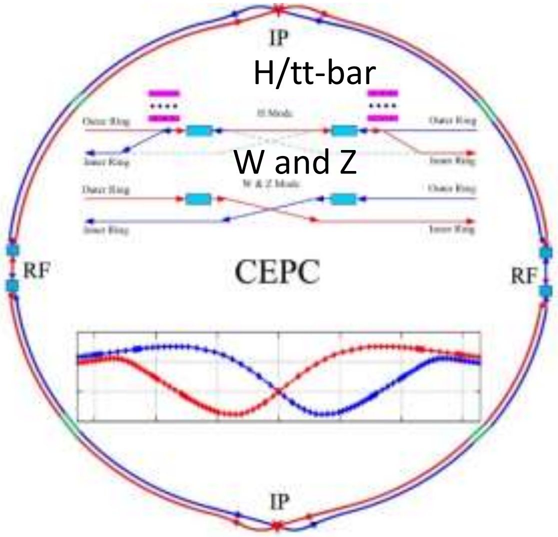


CEPC EDR and construction will be in close synergy with other accelerator projects under construction in China (light sources, XFEL, Nuclear physics, etc).

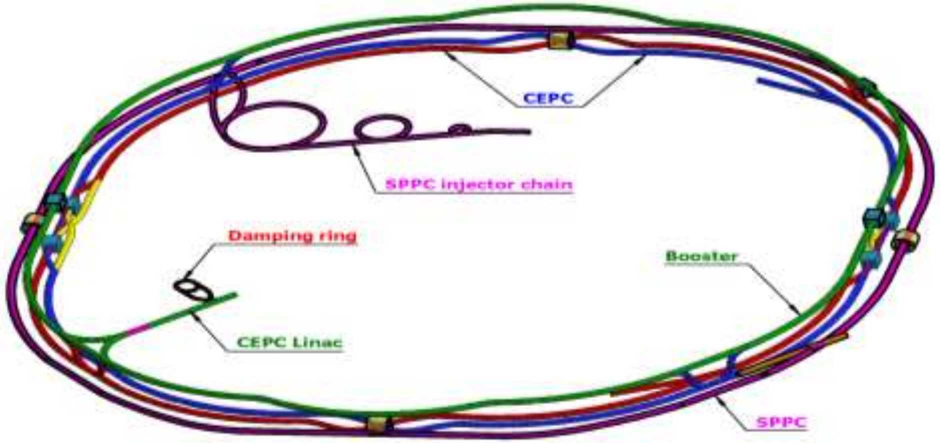


CEPC Higgs Factory and SppC Layout in TDR

CEPC as a Higgs Factory： H, W, Z, upgradable to ttbar, followed by a SppC (a Hadron collider) ~125TeV
30MW SR power per beam (upgradable to 50MW) , high energy gamma ray 100Kev~100MeV

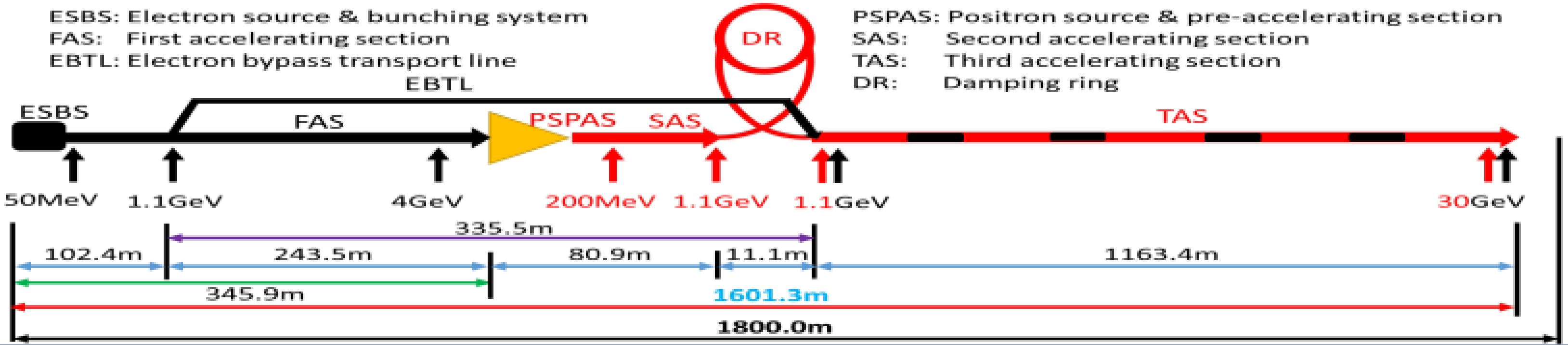


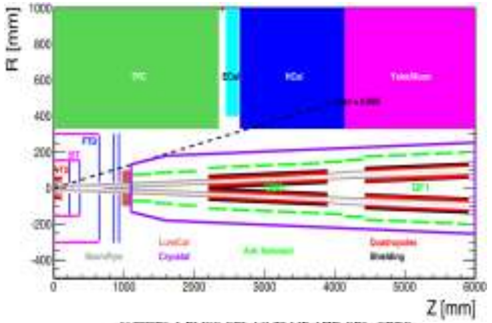
CEPC collider ring (100km)

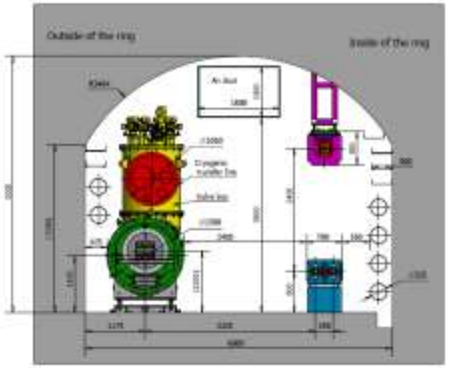


CEPC booster ring (100km)

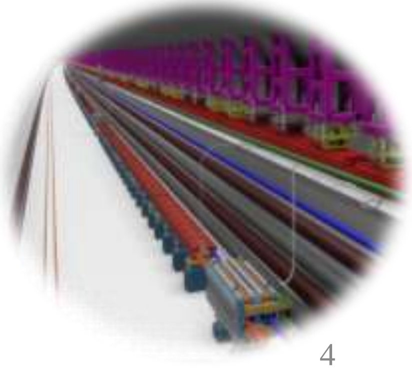
CEPC TDR S+C-band 30GeV linac injector







CEPC/SppC in the same tunnel



CEPC Accelerator System Parameters in TDR

Linac

Parameter	Symbol	Unit	Baseline
Energy	E_{e-}/E_{e+}	GeV	**30**
Repetition rate	f_{rep}	Hz	100
Bunch number per pulse			1 or 2
Bunch charge		nC	1.5 (3)
Energy spread	σ_E		1.5×10^{-3}
Emittance	ε_r	nm	6.5

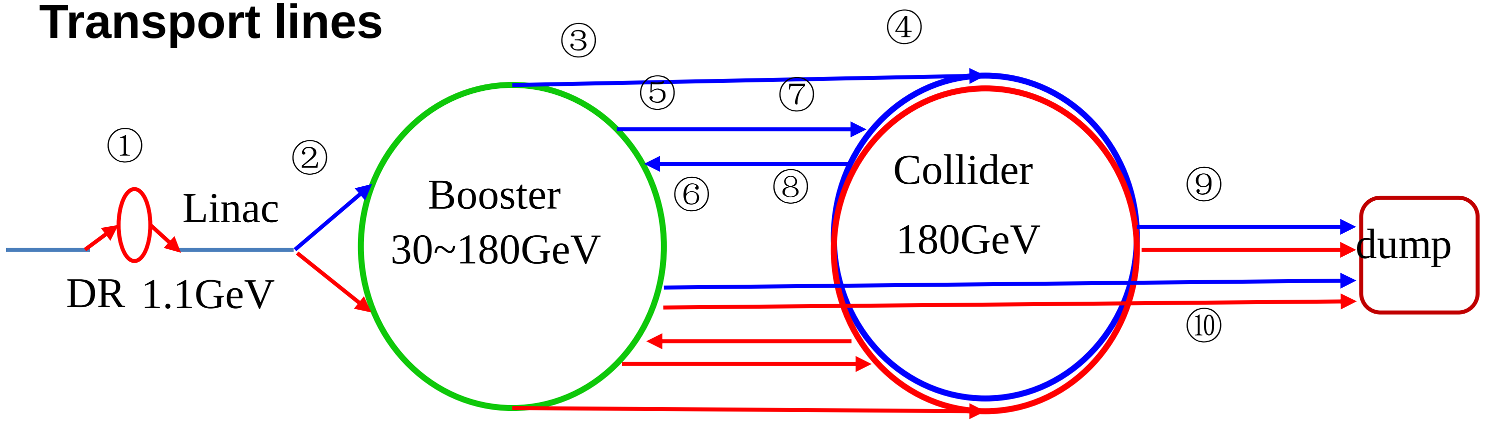
Booster

		tt	*H*		*W*	*Z*	
		Off axis injection	Off axis injection	On axis injection	Off axis injection	Off axis injection	
Circumfer.	km	**100**					
Injection energy	GeV	**30**					
Extraction energy	GeV	**180**	**120**		**80**	**45.5**	
Bunch number		35	268	261+7	1297	3978	5967
Maximum bunch charge	nC	0.99	0.7	20.3	0.73	0.8	0.81
Beam current	mA	0.11	0.94	0.98	2.85	9.5	14.4
SR power	MW	0.93	0.94	1.66	0.94	0.323	0.49
Emittance	nm	2.83	1.26		0.56	0.19	
RF frequency	GHz	1.3					
RF voltage	GV	9.7	2.17		0.87	0.46	
Full injection from empty	h	0.1	0.14	0.16	0.27	1.8	0.8

Collider

	Higgs	Z	W	$t\bar{t}$
Number of IPs	2			
Circumference (km)	**100.0**			
SR power per beam (MW)	**30**			
Energy (GeV)	**120**	**45.5**	**80**	**180**
Bunch number	268	11934	1297	35
Emittance $\varepsilon_x/\varepsilon_y$ (nm/pm)	0.64/1.3	0.27/1.4	0.87/1.7	1.4/4.7
Beam size at IP σ_x/σ_y (um/nm)	14/36	6/35	13/42	39/113
Bunch length (natural/total) (mm)	2.3/4.1	2.5/8.7	2.5/4.9	2.2/2.9
Beam-beam parameters ξ_x/ξ_y	0.015/0.11	0.004/0.127	0.012/0.113	0.071/0.1
RF frequency (MHz)	650			
Luminosity per IP (10^{34} cm^{-2} s^{-1})	**5.0**	**115**	**16**	**0.5**

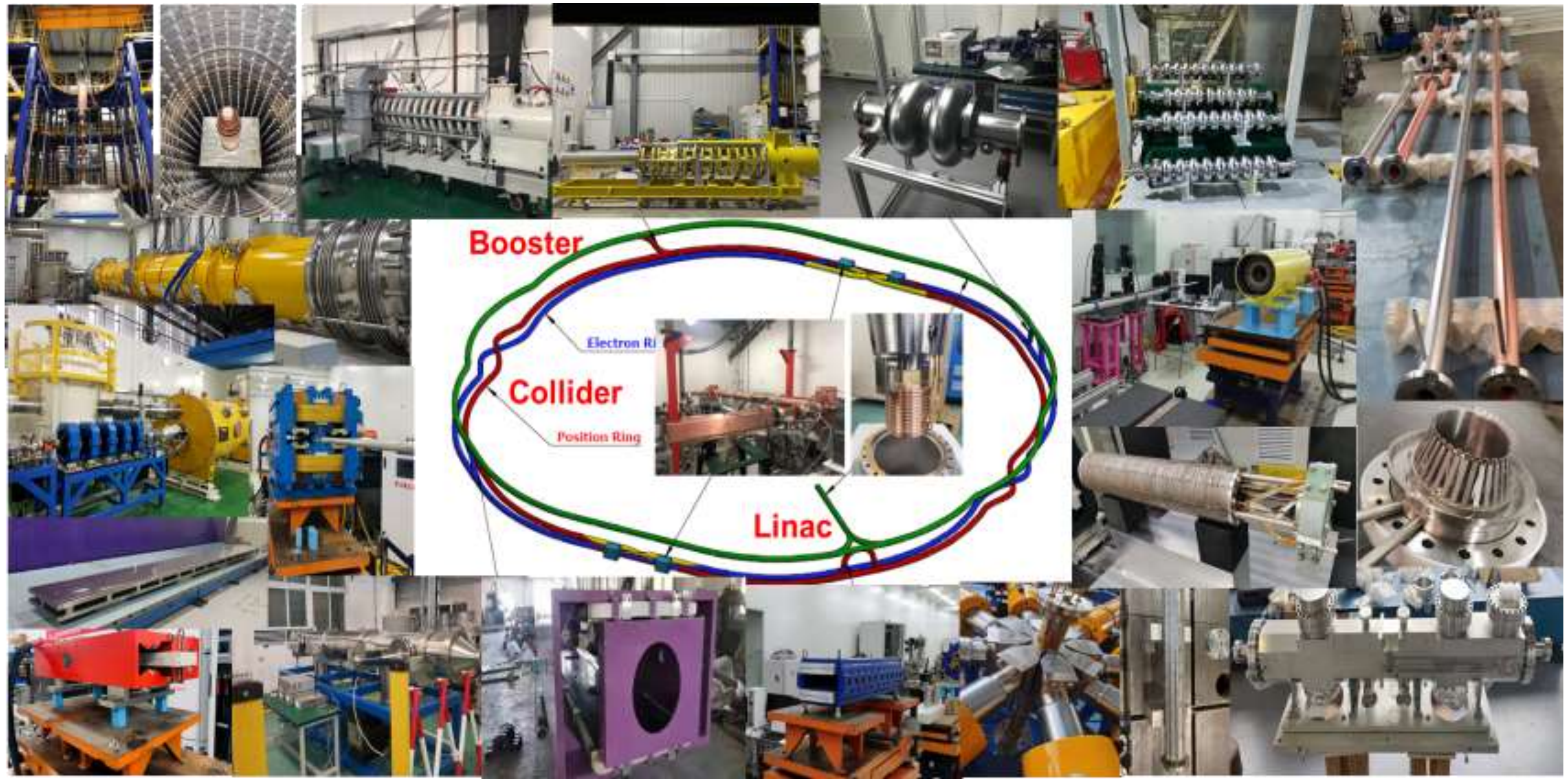
Transport lines



CEPC Technical Design Report (TDR) includes:
1) CEPC Accelerator TDR
2) CEPC Detector TDRrd (rd=reference design)
will be released by June 2025

CEPC Key Technology R&D Status in TDR

Specification Met ✓ Prototype Manufactured ✓



	Accelerator	Fraction
✓	Magnets	27.3%
✓	Vacuum	18.3%
✓	RF power source	9.1%
✓	Mechanics	7.6%
✓	Magnet power supplies	7.0%
✓	SC RF	7.1%
✓	Cryogenics	6.5%
✓	Linac and sources	5.5%
✓	Instrumentation	5.3%
✓	Control	2.4%
✓	Survey and alignment	2.4%
✓	Radiation protection	1.0%
✓	SC magnets	0.4%
✓	Damping ring	0.2%

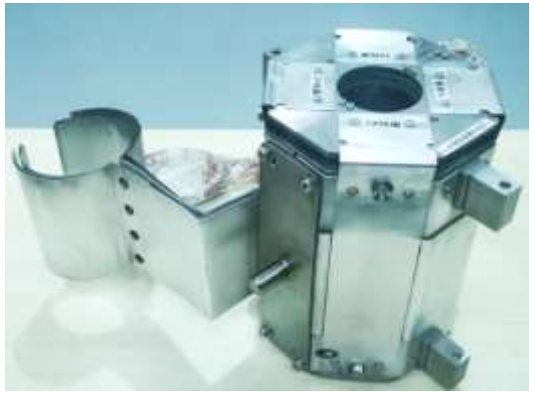
Key technology R&D in TDR spans all component lists in CEPC CDR

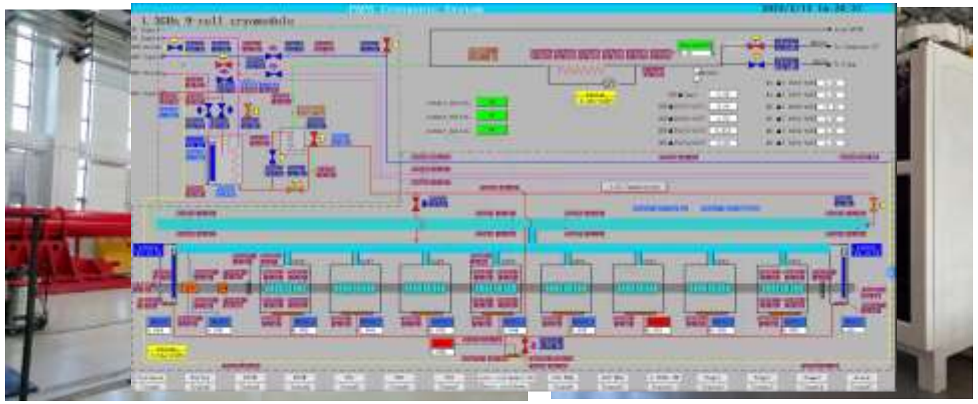
CEPC Booster 1.3 GHz 8 x 9-cell High Q Cryomodule

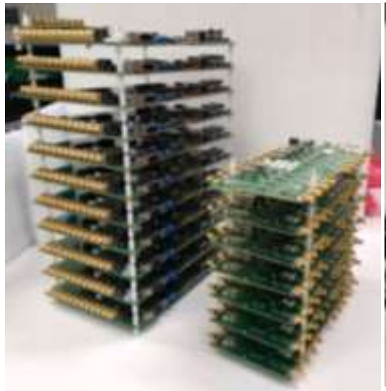
CEPC booster 1.3 GHz SRF R&D and industrialization in synergy with CW FEL projects.

Parameters	Horizontal test results	CEPC Booster Higgs Spec	LCLS-II, SHINE Spec	LCLS-II-HE Spec
Average usable CW E_{acc} (MV/m)	23.1	3.0×10^{10} @ 21.8 MV/m	2.7×10^{10} @ 16 MV/m	2.7×10^{10} @ 20.8 MV/m
Average Q_0 @ 21.8 MV/m	3.4×10^{10}			



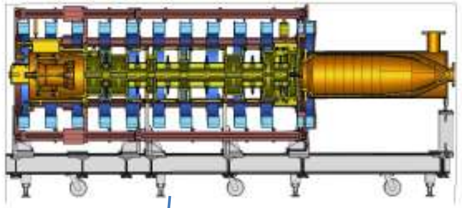



CEPC High Efficiency High Power Klystron Development and RF Power Distribution System

CEPC klystron R&D

Klystron No. 1
Efficiency 65%
(2020)

Klystron No. 2
Efficiency 77%
(2021)



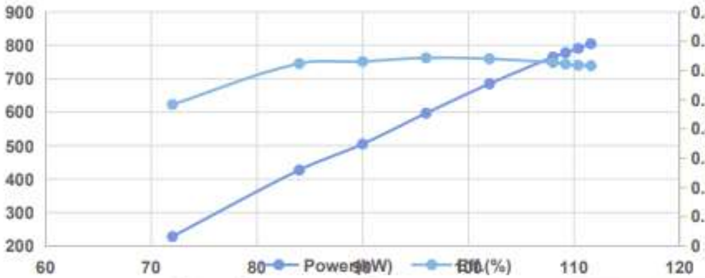
Klystron No. 3 （MBK
Efficiency 80.5%
(under fabrication)

77.2%@849kW pulsed in 2024

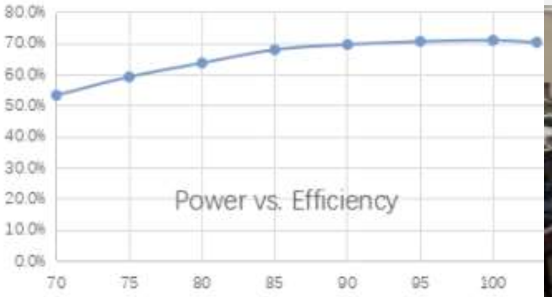
2022

Pulsed RF Mode (30% duty factor, 60ms/5Hz)

High Voltage vs. Power&Efficency

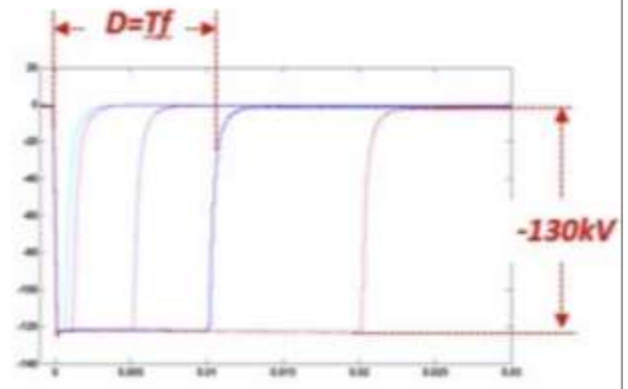


70.5% @ 630kW

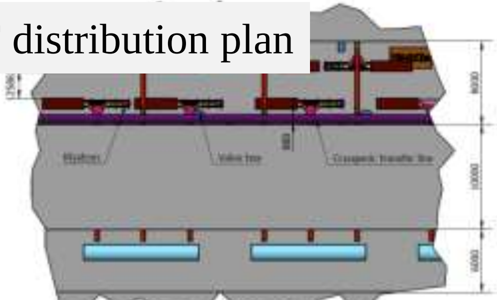


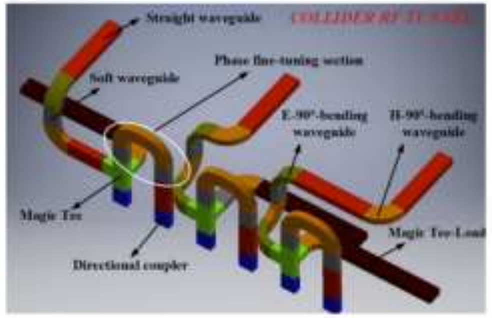
To be tested at the end of 2023

Power Supply Modulator



RF distribution plan



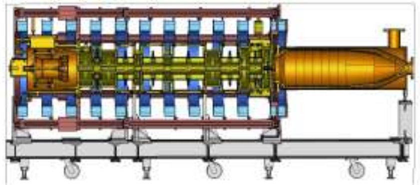


- Three prototypes of the **650MHz 800KW CW** klystrons are developed. The efficiency reaches 70%
- PSM is developed with the industrial collaboration
- RF tunnel distribution was planed

CEPC Accelerator Main EDR Development: Klystrons

Klystron R&D

Klystron No. 2
Efficiency 77%
(2021)



Klystron No. 1
Efficiency 65%
(2020)

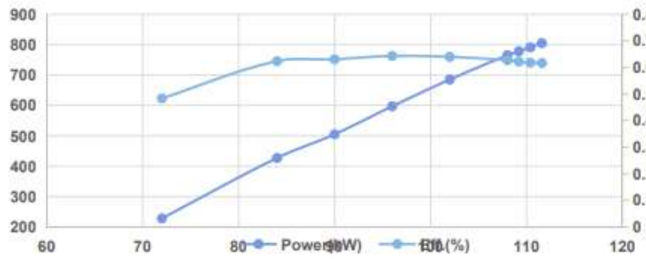
77.2%@849kW pulsed in 2024

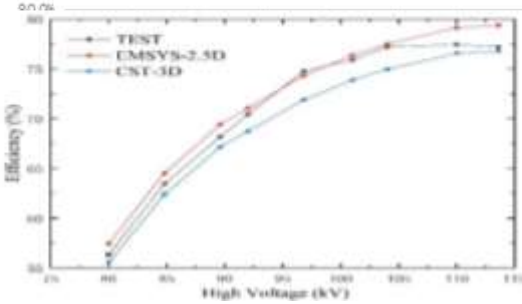
Klystron No. 3 （MBK
Efficiency 80.5%
(under fabrication)

Pulsed RF Mode (30% duty factor, 60ms/5Hz)

70.5% @ 630kW

High Voltage vs. Power&Efficency

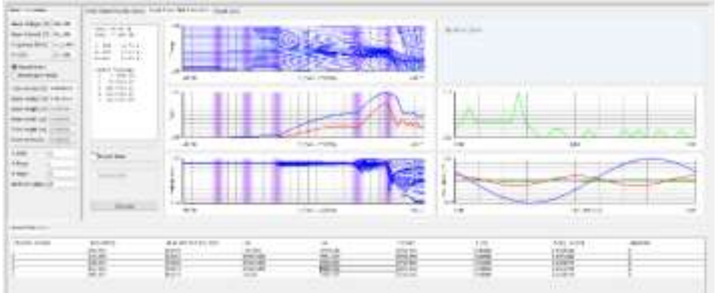


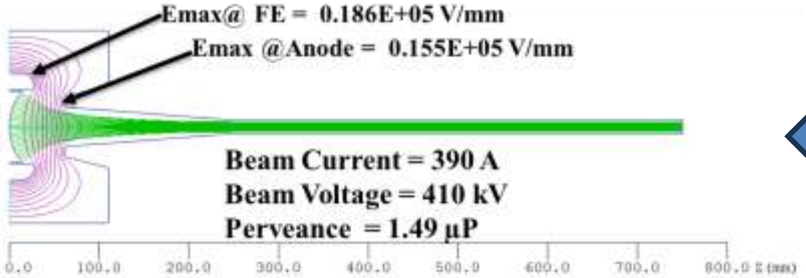


Parameters	Value
Frequency	5720 MHz
Output Power	80MW
Pulsed width	2.5us
Repetition rate	100Hz
Gain	54 dB
Efficiency	47%
3dB bandwith	±5MHz
Beam voltage	420 kV
Beam current	403 A
Focusing field	0.28 T

CEPC collider ring 650MHz klystron development in TDR phase

C band 5720MHz 80MW Klystron





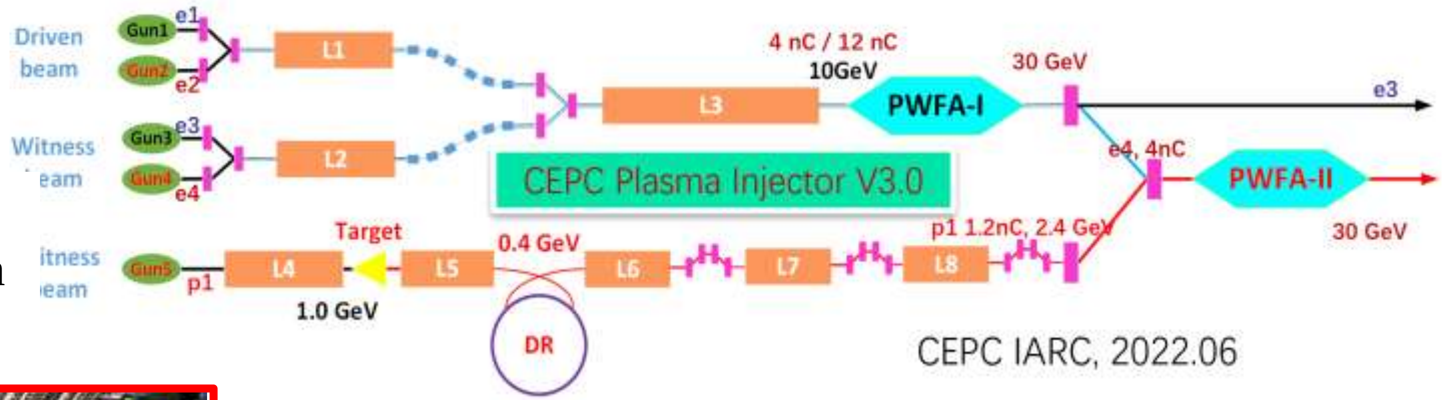
C band 5720MHz 80MW Klystron design progress

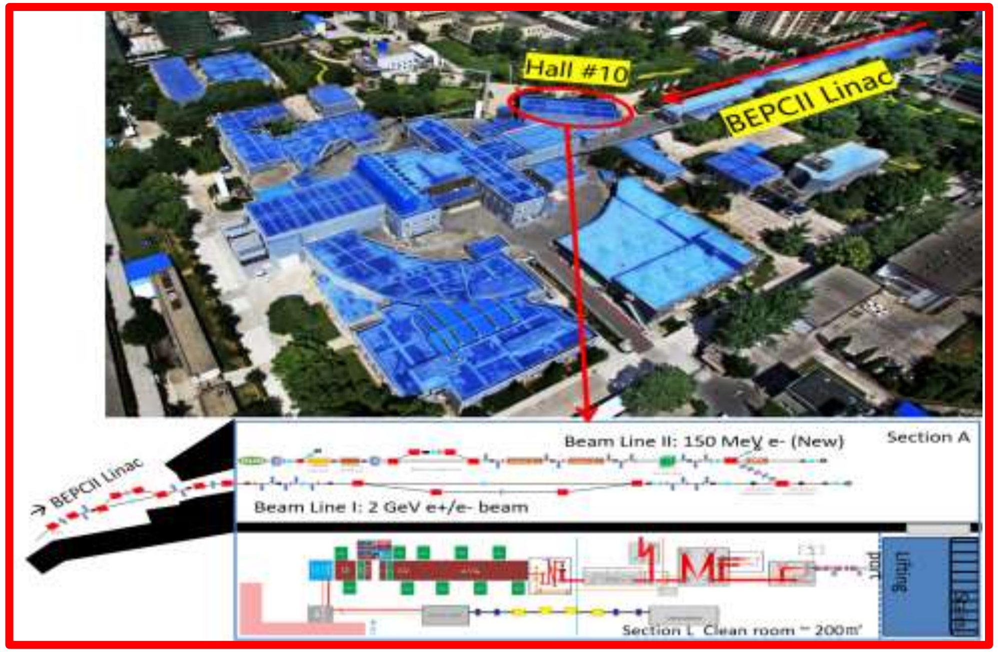
CEPC Plasma Injector (alternative option) and TF Plan

CEPC plasma injector scheme:

From 10 GeV → 30 GeV → **TR ≥ 2**

Simulation results show that it works on paper with reasonable error tolerances for both electron and positron beams injected to the booster





Phase I （Year0-Year2）

1. Re-design and install transport beamli... system, optimize the e- / e+ beam quality...
2. Clean room and high power l... TW) installation200TW
3. Beam instrumentati...
4. RF Gun platfor...
5. Commissio... systems

Phase II （Ye...

1. ... lines (1PW + 20/40 TW) ... rm and install it on the ...

Pl...

1. ... damping ring the bunch compression ... improve the e+ quality
2. ... used FEL studies

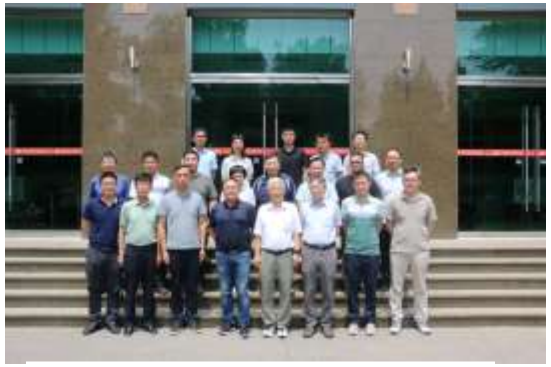
- Positron and electron acceleration
- Cascading acceleration
- Future linear collider technologies
- High energy beam for detector R&D (possible application)

PWFA/LWFA TF based on BEPC-II Linac and HPL has been founded by CAS 90M RMB in Sept. 2023

CEPC Accelerator International TDR Review and Cost Review
June 12-16, and Sept. 11-15, 2023, in HKUST-IAS, Hong Kong

CEPC Accelerator TDR Review
June 12-16, 2023, Hong Kong

CEPC Accelerator TDR Cost Review
Sept. 11-15, 2023, Hong Kong



Domestic Civil Engineering
Cost Review, June 26, 2023, IHEP

9th CEPC IAC 2023 Meeting
Oct. 30-31, 2023, IHEP

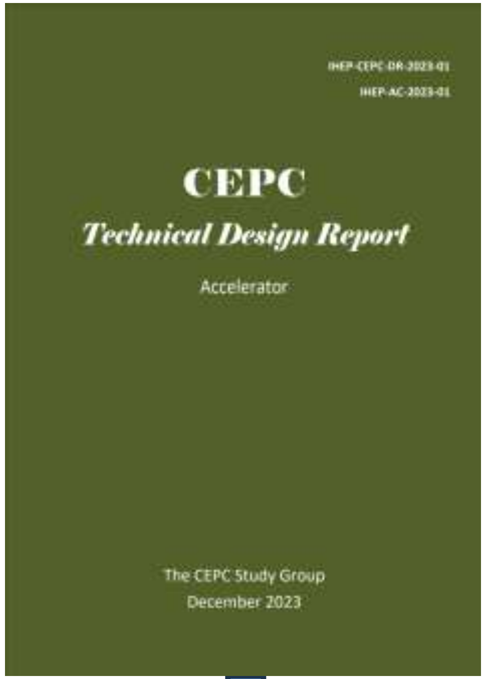
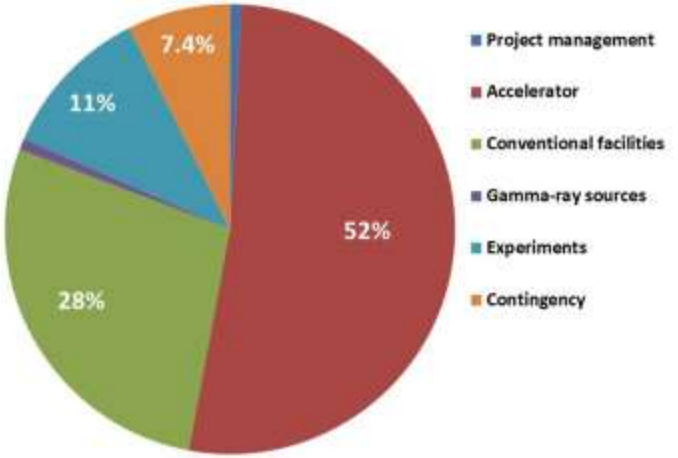


Table 12.1.2: CEPC project cost breakdown, (Unit: 100,000,000 yuan)

Total	**364**	**100%**
Project management	3	0.8%
~~Accelerator~~	~~190~~	~~52%~~
Conventional facilities	101	28%
Gamma-ray beam lines	3	0.8%
Experiments	40	11%
Contingency (8%)	27	7.4%



Distribution of CEPC Project total TDR cost of **36.4B RMB**

CEPC accelerator TDR has been completed and formally released on December 25, 2023

CEPC accelerator TDR link: （arXiv： 2312.14363）

CEPC accelerator TDR releasing news:
http://english.ihep.cas.cn/nw/han/y23/202312/t20231229_654555.html

CEPC Engineering Design Report (EDR) Goal

2012.9	2015.3	2018.11	2023.10	2025	2027	15th five year plan
CEPC proposed	Pre-CDR	CDR	TDR	CEPC Proposal CEPC Detector reference design	EDR	Start of construction

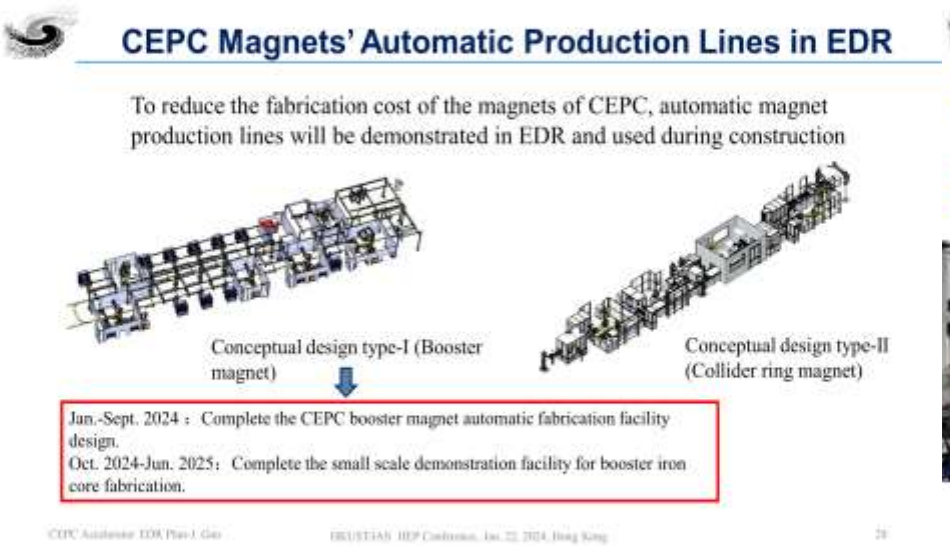
CEPC EDR Phase General Goal: 2024-2027

After completion CEPC accelerator TDR in 2023, CEPC accelerator will enter into the Engineering Design Report (EDR) phase (2024-2027), which is also the preparation phase with the aim for CEPC proposal to be presented to and selected by Chinese government around 2025 for the construction start during the ”15th five year plan (2026-2030)” (for example, around 2027) and completion around 2035 (the end of the 16th five year plan).

CEPC EDR includes accelerator and detector (TDRrd)
CEPC detector TDR reference design (rd) will be released by June 30, 2025

CEPC Accelerator EDR Phase goals, scope and the working plan (preliminary) of 35 WGs summarized in a documents of 20 pages to be reviewed by IARC in 2024

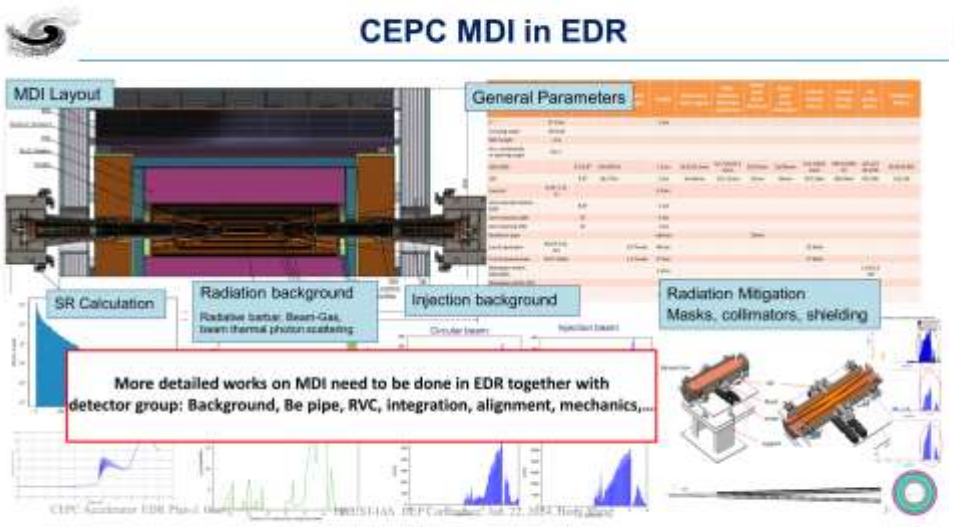
Some Key Issues in EDR (examples)-1

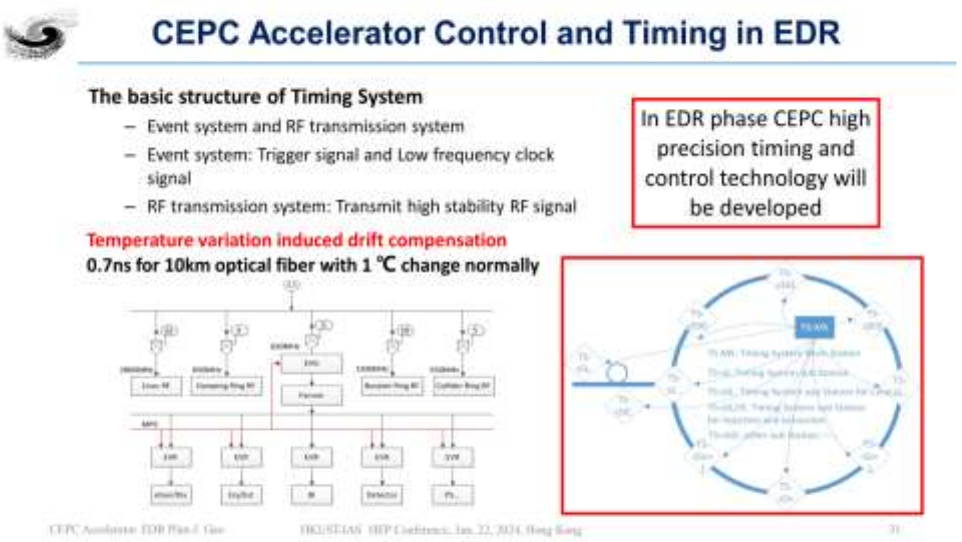


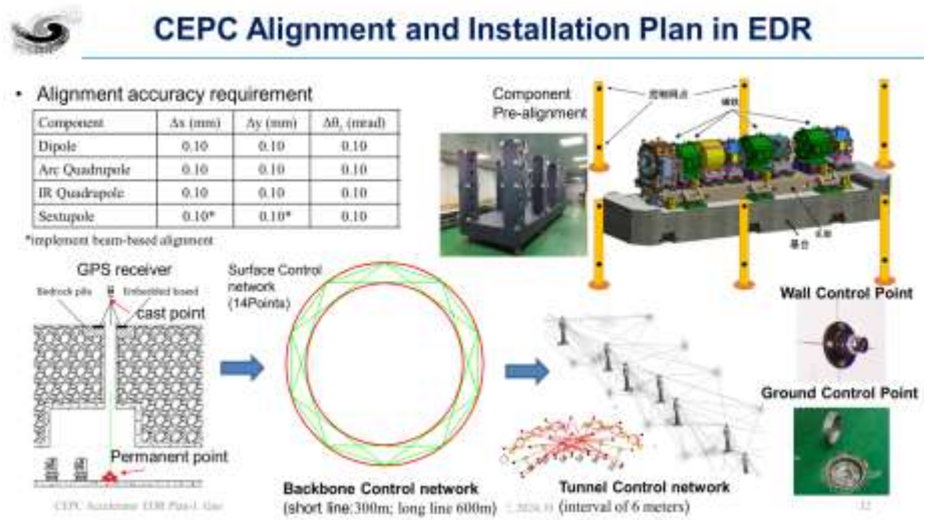
There are many common challenging issues for future Higgs factories, both circular and linear ones, such as MDI, control and timing, components industrial mass production and alignment/installation, etc.

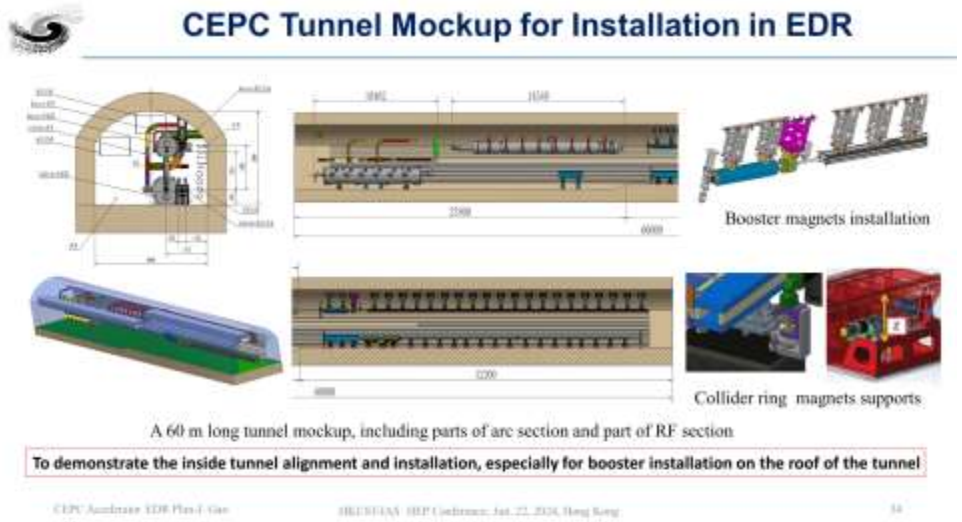
Dedicated topical international workshops and collaborations are very useful and welcome

Some Key Issues in EDR (examples)-2









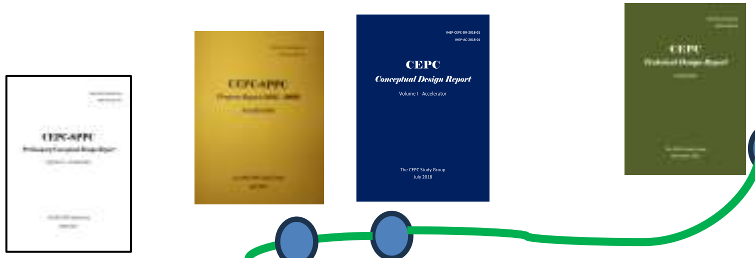
There are many common challenging issues for future Higgs factories, both circular and linear ones, such as MDI, control and timing, components industrial mass production and alignment/installation, etc.

Dedicated topical international workshops and collaborations are very useful and welcome

CEPC Evolution Milestones

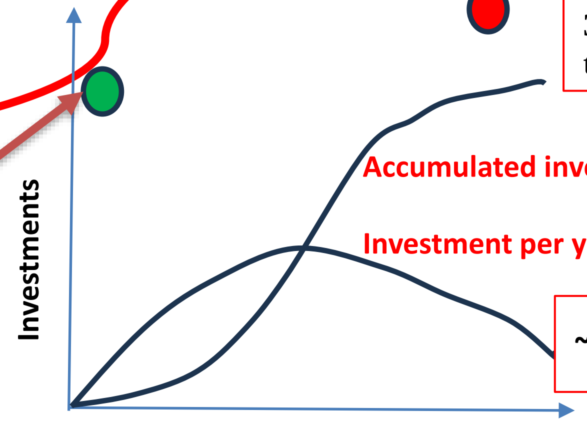
Year	2012	2013	2015	2017	2018	2023	2025	2027	2030	2035

CEPC kickoff meeting in Sept. 2013



Proposal (2025) for CEPC entering 15th five year plan

EDR is the critical path towards CEPC construction starting around 2027



36.4B RMB total

~2B RMB/year

2012.9	2013.9	2015.3	2017.4	2018.11	2023.12	2024 ~ 2027	~2035
CEPC proposed		Pre-CDR	Progress report	CDR	TDR	EDR start of construction	Completion

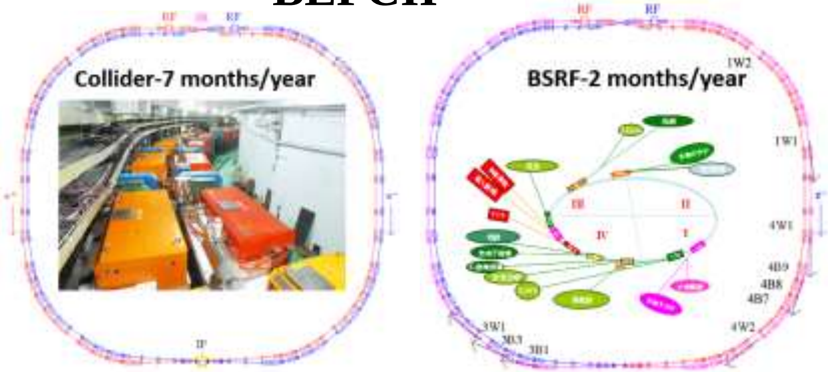
CEPC in Synergy with other Accelerator Projects in China

Project name	Machine type	Location	Cost (B RMB）	Completion time
CEPC	Higgs factory Upto ttar energy	Led by IHEP, China	**36.4 (where accelerator 19)**	2035 (starting time around 2027)
BEPCII-U	e+e-collider 2.8GeV/beam	IHEP (Beijing)	**0.15**	2025
HEPS	4th generation light source of 6GeV	IHEP (Huanrou)	**5**	2025
SAPS	4th generation light source of 3.5GeV	IHEP (Dongguan)	**3**	2031 (in R&D, to be approved)
HALF	4th generation light source of 2.2GeV	USTC (Hefei)	**2.8**	2028
SHINE	Hard XFEL of 8GeV	Shanghai-Tech Univ., SARI and SIOM of CAS (Shanghai)	**10**	2027
S3XFEL	S3XFEL of 2.5GeV	Shenzhen IASF	**11.4**	2031
DALS	FEL of 1GeV	Dalian DICP	**-**	(in R&D, to be approved,)
HIAF	High Intensity heavy ion Accelerator Facility	IMP, Huizhou	**2.8**	2025
CIADS	Nuclear waste transmutation	IMP, Huizhou	**4**	2027
CSNS-II	Spallation Neutron source proton injector of 300MeV	IHEP, Dongguan	**2.9**	2029

The total cost of the accelerator projects under construction:39B RMB more than CEPC cost of 36.4B RMB

BEPCII-Upgrage@IHEP

BEPCII



- HEP or collision

Design Goals of BEPCII

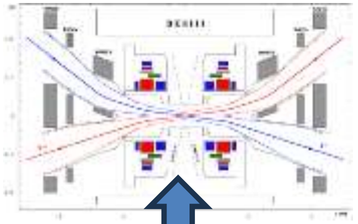
- Beam energy range 1-2.1 GeV
- Optimized beam energy 1.89 GeV
- Beam current 910 mA
- Luminosity $1\times10^{33}cm^{-2}s^{-1}$ @1.89 GeV

Beam Energy：2.35GeV

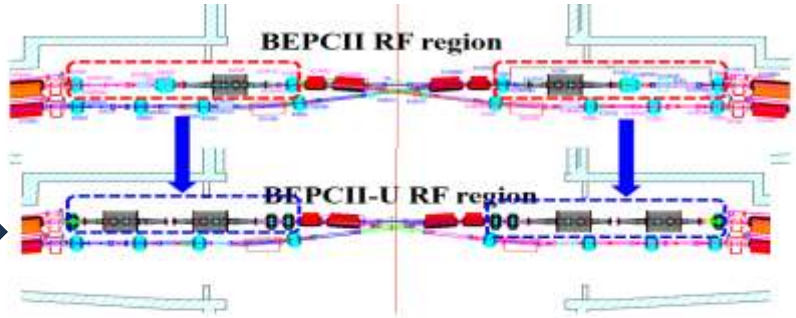
	BEPCII	BEPCII-U
Lum [$10^{32}cm^{-2}s^{-1}$]	3.5	11
β_y^* [cm]	1.5	1.3
Bunch Current [mA]	7.1	7.5
Bunch Num	56	120
SR Power [kW]	110	250
$\xi_{y,lum}$	0.029	0.036
Emittance [nmrad]	147	152
Coupling [%]	0.53	0.35
Bucket Height	0.0069	0.011
$\sigma_{z,0}$ [cm]	1.54	1.04
σ_z [cm]	1.69	1.3
RF Voltage	1.6 MV	3.3 MV

BEPCII-U

- Luminosity is increased by a factor of 3 @2.35GeV
- Maximum beam energy is increased from 2.1GeV to 2.8GeV.
- Conventional scheme: Squeeze bunch length and β_y^* by increasing RF voltage + Increase beam current (SR Power)
- **Cost: 0.15B RMB**
- **Complete in 2025**



BEPCII-U 500MHz SC cavity and cryomodule



BEPCII-U final focus SC quadupole of 25T/m

- 2020 White Paper of BESIII
- May. 2020 Internal Review of Accelerator
- Jun. 2021 Feasibility Study Report
- Jul. 2021 Project Approved
- *Apr. 2022 Design Finished*
- Jun. 2024 Procurement & Fabrication Finished
- Jul. 2024 Shutdown for Installation
- Jan. 2025 Restart

Photo taken in Dec. 2022

High Energy Photon Source (HEPS) of IHEP

The first high-energy synchrotron radiation light source in China

-Groundbreaking: **Jun. 29, 2019**
-Scheduled completion in **Dec., 2025**
-Cost: **~5B RMB ~750M USD**

Area	**650,658.21**	**m²**
Circumference	**1360.4**	**m**
Beam energy	**6**	**GeV**
Emittance	**≤0.06**	**nm•rad**
Brightness	**>1×10²²**	**phs/s/mm²/mrad²/0.1%BW**
Beamlines	**≥90**	**14 BLs in Phase I**
Photon energy range	**0.2-300**	**keV**

Location: Huairou Science City of Beijing , about 80km away from IHEP

HEPS Construction Schedule

The construction period was estimated to be six and a half years.

- Date of Groundbreaking ceremony: **Jun. 29, 2019**
- Project is scheduled to be completed in **Dec., 2025**

Dec. 11, 2023, the last magnet was installed in the storage ring.
Aug. 8, 2022, the installation in the booster tunnel began.
Jun. 28, 2021, HEPS Installs First Piece of Accelerator Equipment in Linac Tunnel.

HEPS Accelerators

Weimin Pan

By using the 7-Bending Achromatic (7BA) lattice, the horizontal emittance of the electron beam becomes better than 60pm·rad.

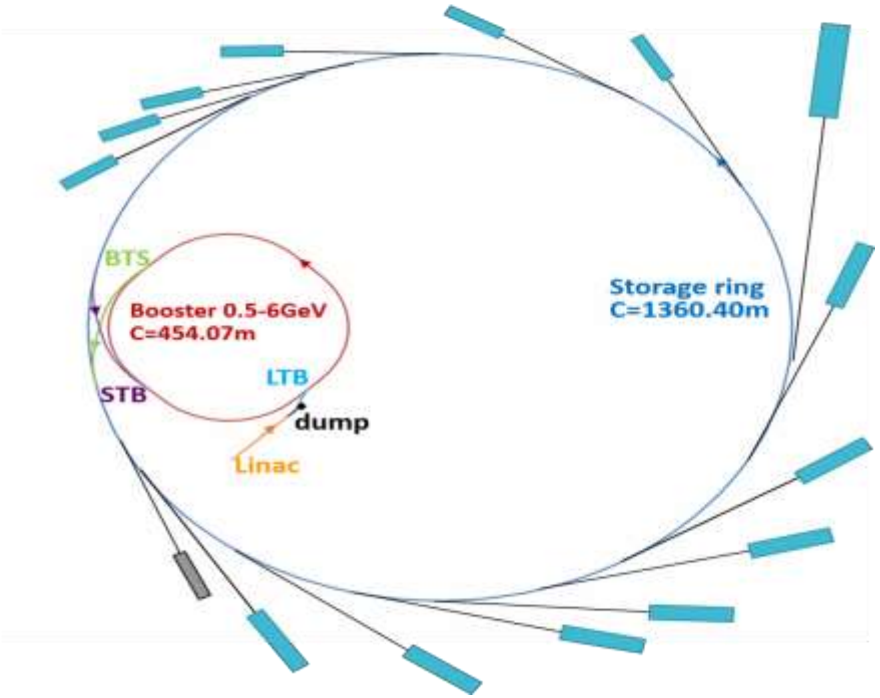
2400+ Magnets

700+ BPMs

~2000 vacuum chambers

Requirements of girder design

Resolution	Transverse	≤5μm
	Vertical	≤5μm
Adjusting range	Horizontal	±5mm
	Vertical	±9mm
Eigen frequency		≥54Hz



HEPS Booster

HEPS Linac

IHEP PAPS Infrastructure in Huairou, Beijing

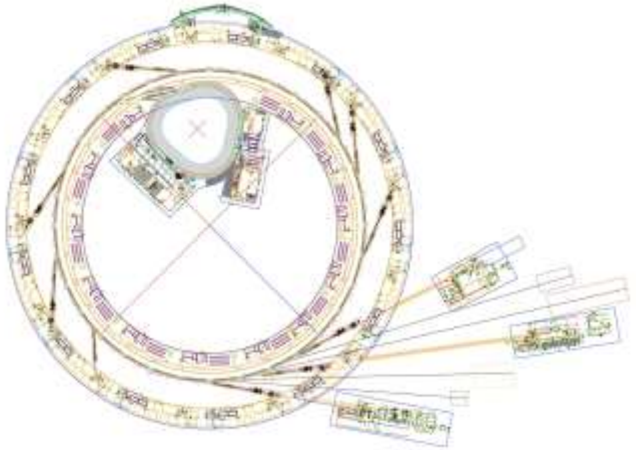
Accelerator key technology R&D and Testing platform:

- ➢ SRF cavity and module
- ➢ High precision magnet
- ➢ Vacuum assembly & coating
- ➢ High efficiency Klystron
- ➢ Mechanics and alignment
- ➢ Beam test facility

The Southern Advanced Photon Source (SAPS) of IHEP in Dongguan

Sheng Wang

- The **4th** generation (**3.5GeV**) diffraction-limited storage ring
- Brightness >10^{22}phs/s/mm^2/mrad^2/0.1%BW
- SAPS will be located adjacent to CSNS
- Planned to start construction around 2025
- Cost about 3B RMB ~450M USD



SAPS is located at IHEP, Dongguan campus, Guangdong Province, China

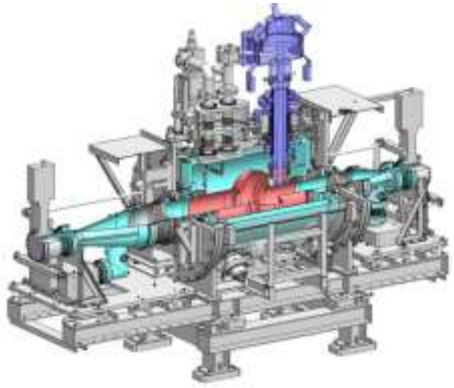
Accelerator Main Parameters

- Linac+Booster+Storage Ring
- Modified Hybrid-7BA
- 350mA high brightness mode
- 500mA high flux mode
- Swap-out / longitudinal injection
- Coherent attosecond radiation

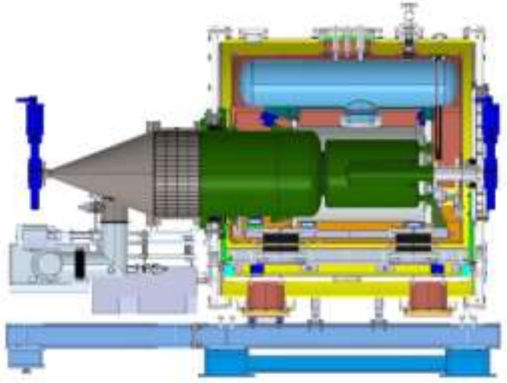
Parameters	Value	Unit
Beam energy E_0	3.5	GeV
Current	500	mA
Circumference	810	m
Nature emittance	33.4	pm·rad
Cell number	32	-
Long straight section	6	m

Test Facility Construction and R&D

RF gun research platform



499.8 MHz SC cavity



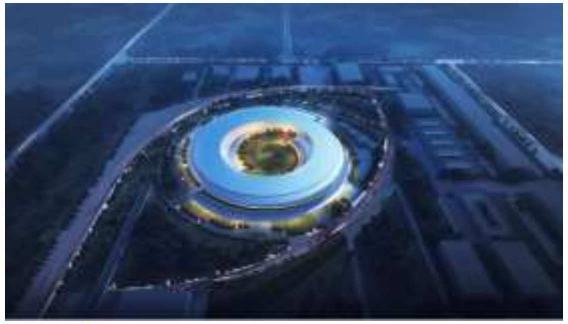
166.6 MHz SC cavity

IHEP Dongguan SRF Infrastructure

Advanced Light Facility (HALF@Hefei)

Guangyao Feng

On July 12, 2022, the NDRC approved the feasibility study report of HALF project

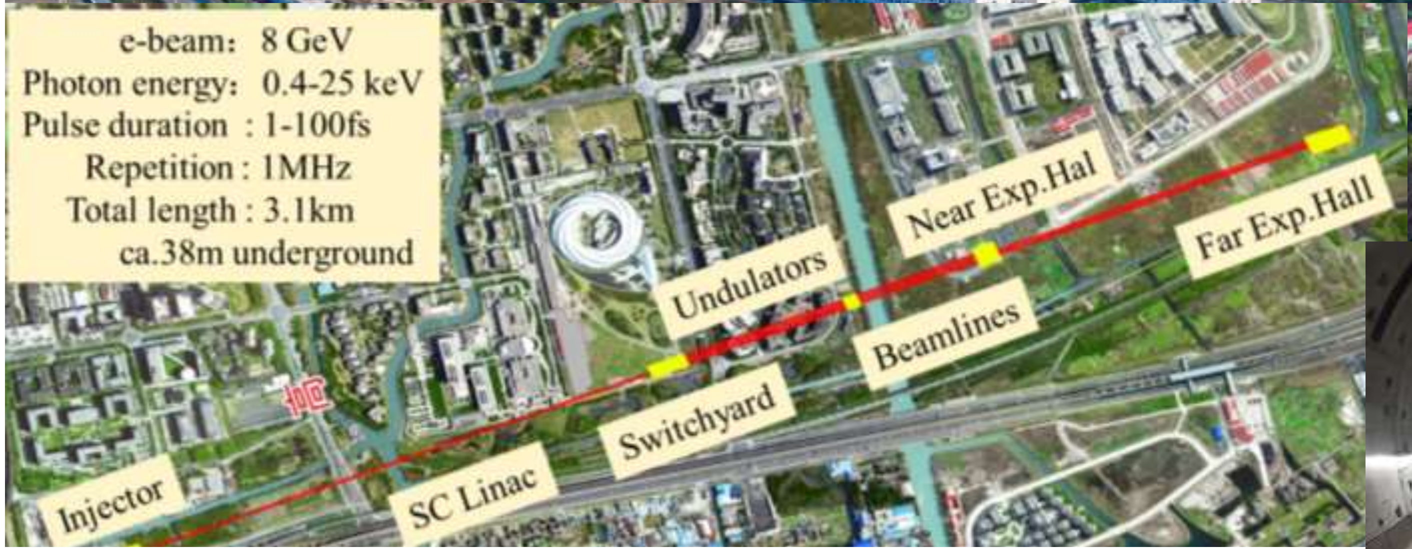


Parameter	Design Metrics
Energy [GeV]	2.2
Beam current [mA]	350
Circumference [m]	479.86
Natural emittance [pm·rad]	85.8
Lattice Structure	6BA
Number of straight sections	20×5.3 m+20×2.2 m
Maximum brightness [Flux/mm^{2}mrad^2]	1.15×10^{21}
Coherence ratio (@ 1 keV)	30%

- Project target: the 4th generation synchrotron radiation light source in the low-energy region in the world
- Ring parameters: 2.2 GeV, 480 meters, 85 pm·rad
- Beamline stations: 10 for phase I (at least 35 beamline totally)
- Scientific target: To enable accurate measurement of electronic/chemical/spin states of inhomogeneous complex systems
- Service areas: material science, life and health, new energy, new materials, aerospace technology, integrated circuits, etc.
- Building area: 68307 m^2
- Construction period: 64 months (start in 2023 and complete in 2028)
- Project investment: 2.718 billion RBM (tentatively)

Shanghai Hard X-ray FEL Facility (SHINE)

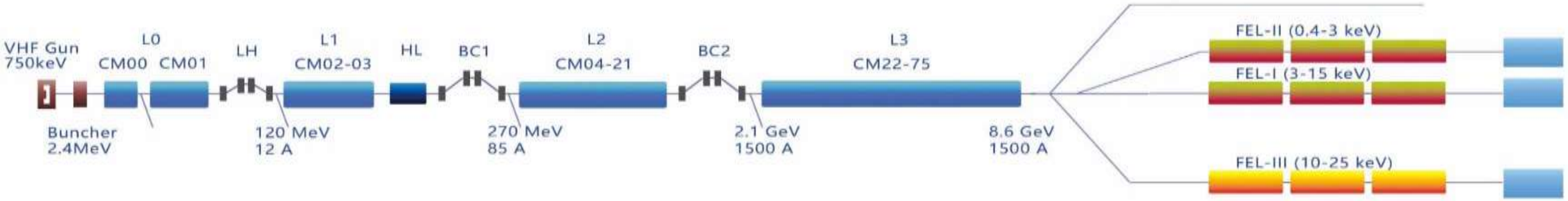
Zhentang Zhao



SHINE is based on 1.3GHz SC accelerator technology:

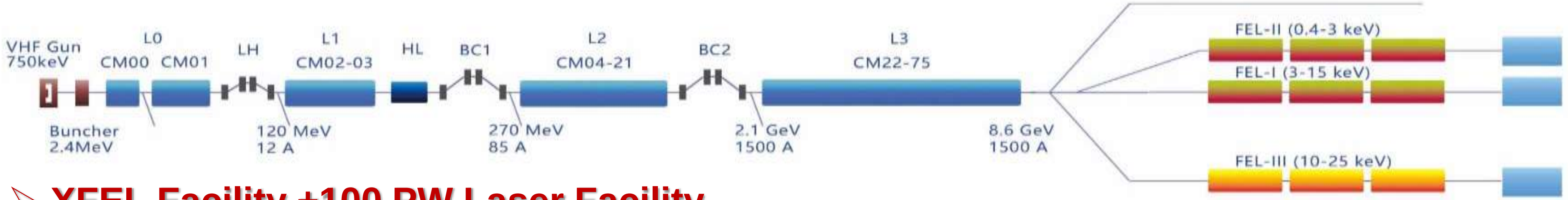
- 1.3GHz SRF cryomodules : 75
- 1.3GHz 9cell cavities: 600+16
- 3.9GHz SRF modules: 2

- SHINE groundbreaking in April, 2018, aiming at lasing in 2025.
- SHINE cost:~10B RMB or ~1.5B USD



This facility will be developed by Shanghai-Tech Univ., SARI and SIOM of CAS.

SHINE: A high-rep rate XFEL based on SCRF



- **XFEL Facility +100 PW Laser Facility**

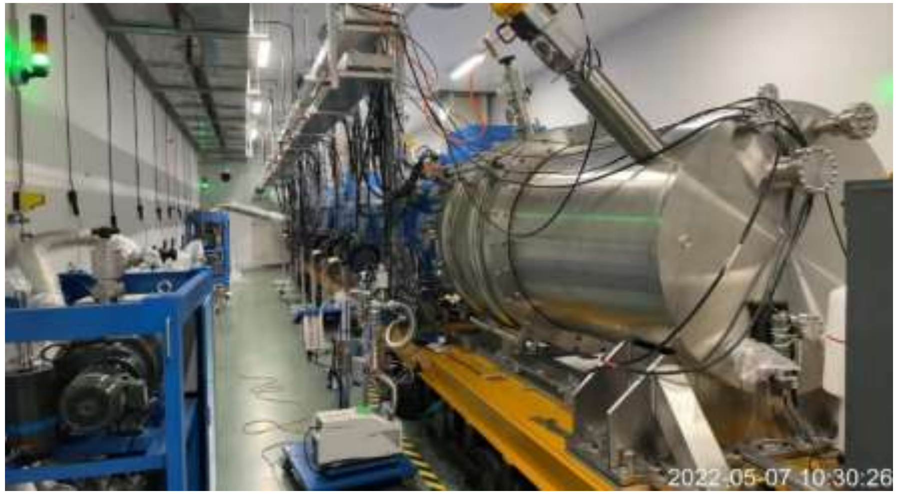
	Nominal	Range
Beam energy/GeV	8.0	4-8.6
Bunch charge/pC	100	10-300
Max rep-rate/MHz	1	up to 1
Beam power/MW	0.8	0 - 2.4
Photon energy/keV	0.4-25	0.4-25
Pulse length/fs	20-50	5-200
Peak brightness	5×10^{32}	1×10^{31}-1×10^{33}
Average brightness	5×10^{25}	1×10^{23}-1×10^{26}
Total facility length/km	3.1	3.1
Tunnel diameter/m	5.9	5.9
2K Cryogenic power/kW	12	12
RF Power/MW	2.28	3.6

FEL Line	Nominal	Objective
FEL-I		
Photon energy/keV	3-15	3-15
Photon number per pulse @12.4keV	$>10^{10}$	$>10^{11}$
Max pulse repetition rate/MHz	0.66	1
FEL-II		
Photon energy/keV	0.4-3	0.4-3
Photon number per pulse @1.24keV	$>10^{12}$	$>10^{13}$
Max pulse repetition rate/MHz	0.66	1
FEL-III		
Photon energy/keV	10-25	10-25
Photon number per pulse @15keV	$>10^{9}$	$>10^{10}$
Max pulse repetition rate/MHz	0.66	1

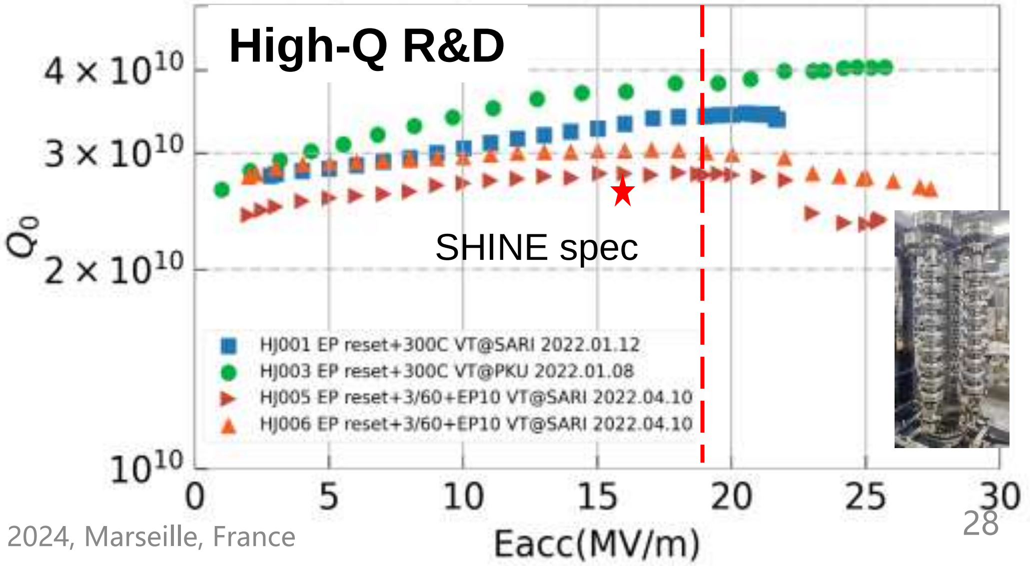
SHINE Key-Tech： SRF Accelerating Module

Zhentang Zhao

- **Prototypes & infrastructures built for R&D and production**
- **First standard 8-cavity (BCP refurbished) CM,** RF tested in June 2022, has reached its main goal (>128 MV, >1.0E+10, <1 nA).
- **First standard 8-cavity (High Q) CMs,** tested in December 2022, including midT-baked and N-doped cavities (>128 MV, >2.0E+10, <1 nA).
- **High-Q technologies** (N-doping& midT-baking) have been achieved on 1.3 GHz 9-cell cavities.



CM with 8 BCP'ed cavities under testing

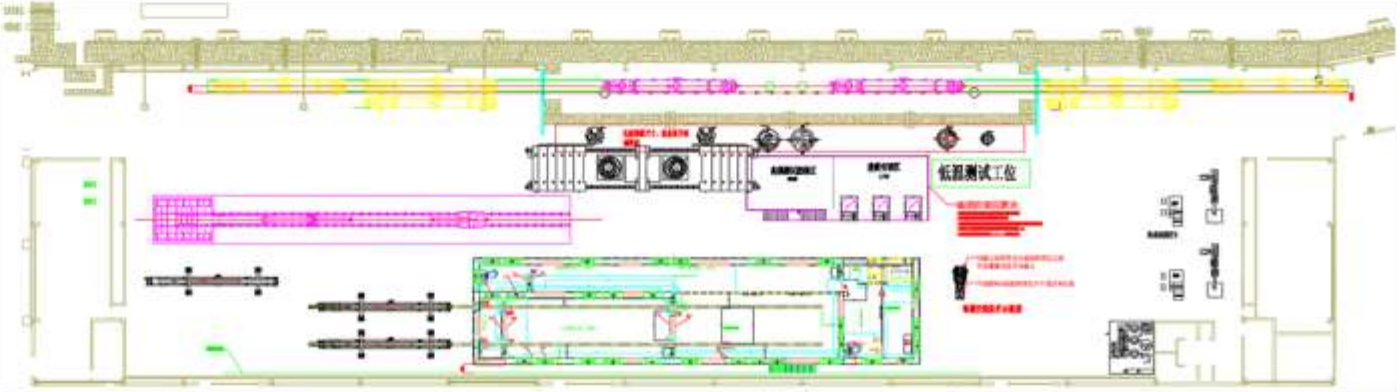


Infrastructure of Shanghai SARI SHINE

Infrastructure for CM assembly and test

S. Sun

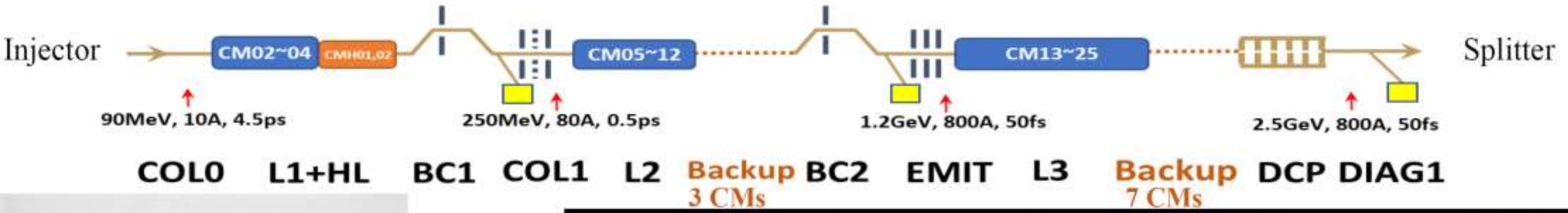
- Two 3000 m^2 for CM Assembly and Test Halls (ATH1 & ATH2)
- Commissioning and gradually put into operation since 2021
- 3 rounds of standard CM assembled and tested

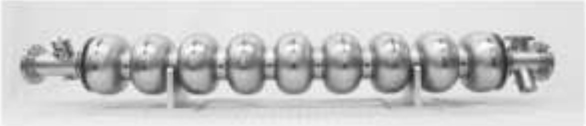


Shenzhen IASF S^3FEL

LINAC design

Function: accelerate the electron beam, compress the beam length and increase the peak current intensity





1.3 GHz cryomodule:
26 sets, energy acceleration

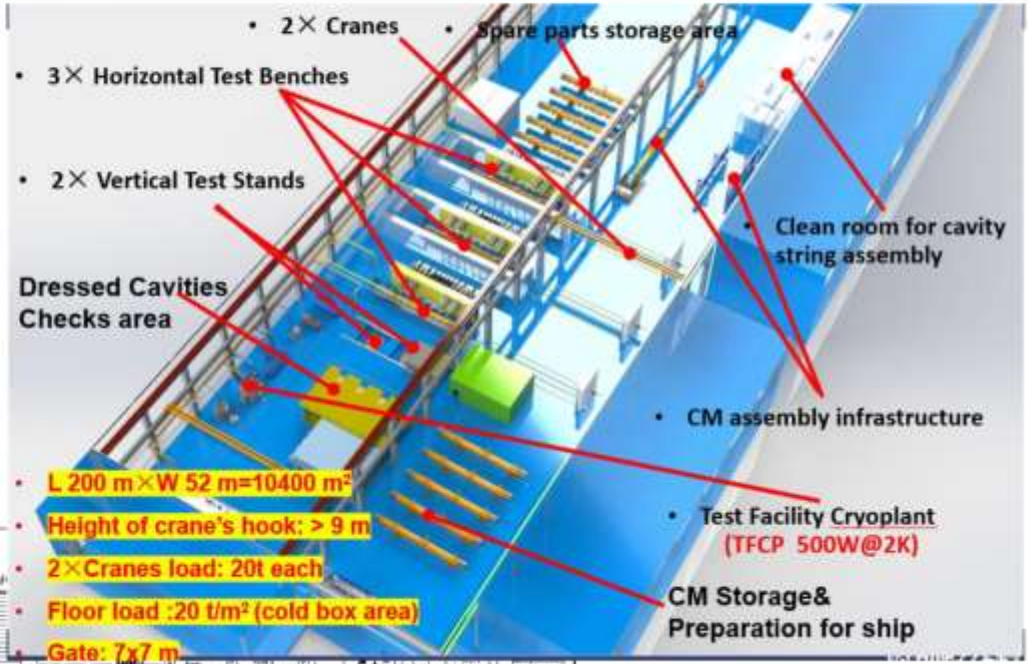
3.9 GHz cryomodule:
2 sets, linear compression compensation

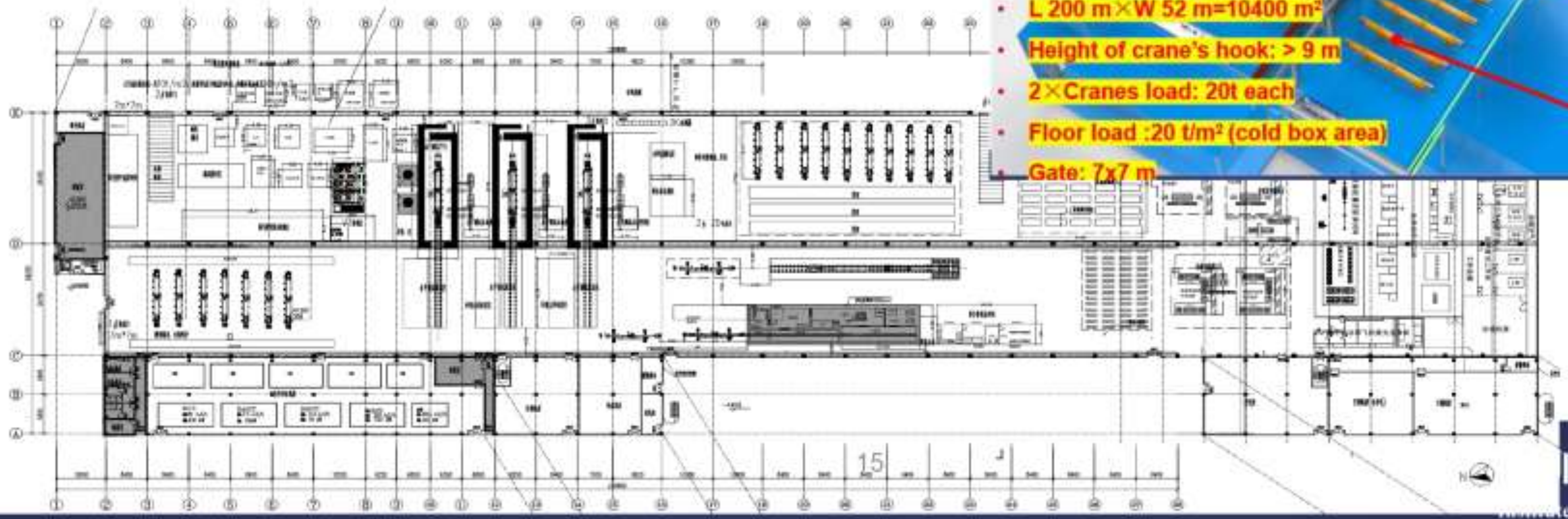
Parameter	Design	Range	Unit
energy	2.5	1.0-2.5	GeV
charge	100	10-300	pC
bunch length（rms）	50	10-100	fs
current	800	200-1000	A
emittance	0.5	0.2-1.0	mm·mrad
energy spread	400	250-500	keV
rep. rate	1	0-1	MHz

Shenzhen IASF S^3FEL

SRF Module Test Facility (SMTF)

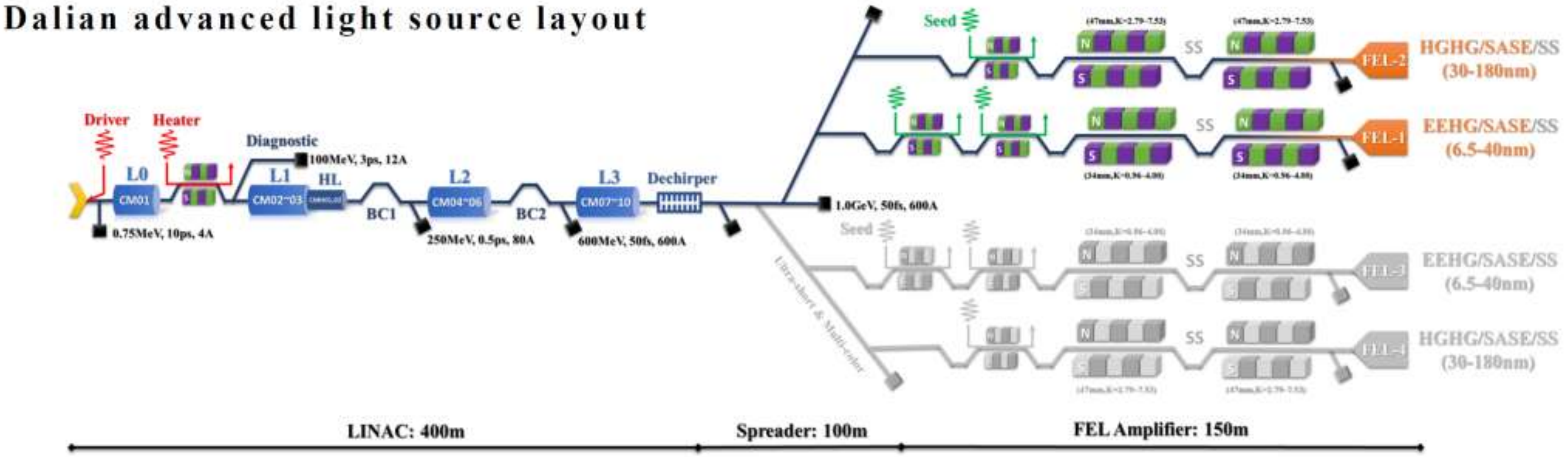
- 2 × Vertical Test Cryostats (VTC)
- 3 × Cryomodule Test Benches (CMTB)
- 1 × Magnet test bench
- 1 × Clean room infrastructure
- 1 × Multipurpose cryo-test Facility
- Cryomodule assembly and integration bench
- Dedicated RF test bench





Dalian DICP DALS

DALS Project overview

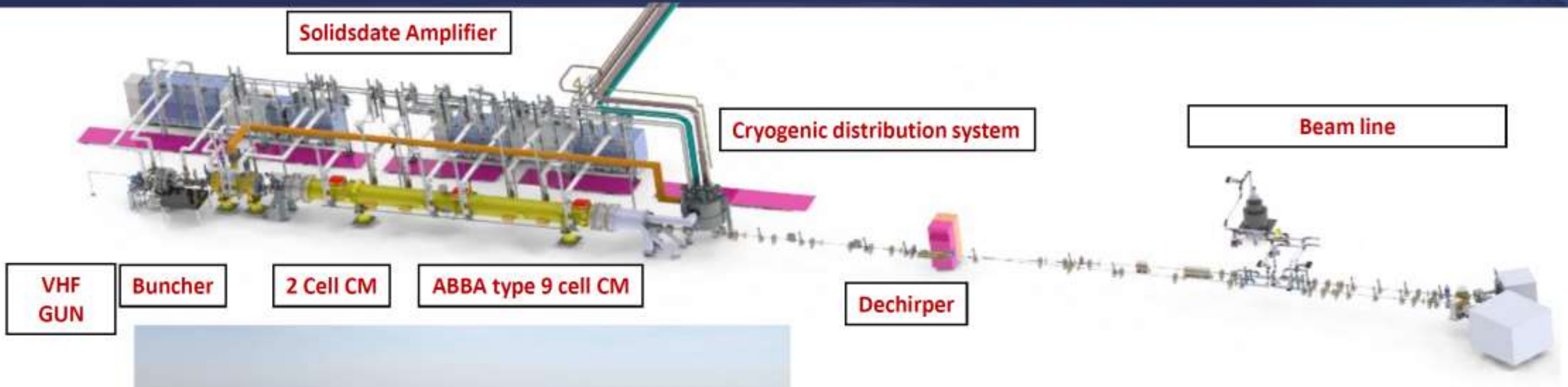


Parameter	design
beam energy/ GeV	1
charge/ pC	100
emittance/ mm-mrad	0.5
rep. rate/ MHz	1

CM type	Frequency [GHz]	Number of Cavities	Number of CM
9-cell cavity CM	1.3	80	10
9-cell cavity CM	3.9	16	2

Dalian DICP DALS

Current situation of injector test facility for DALS



Parameter	design
Beam energy/ MeV	90
Charge/ pC	100
Emittance/ mm-mrad	0.5-1.5
Rep. rate/ MHz	0.1-1
RMS pulse length/ps	4
Cooling capacity@ 2 K/W	370

HIAF& CiADS Projects in China

Hongwei Zhao

- **HIAF: High Intensity heavy ion Accelerator Facility**
- **CiADS: China Initiative Accelerator Driven System**
- **Being built by IMP in Huizhou of Guangdong Prov.**

- **Two of 16 large-scale scientific infrastructure facilities approved by China Government during the 12th 5-year-plan 2016-2020**

- **HIAF:** Nuclear physics research
- **Total budget:** 2.8 B CNY ¥ (424 M USD $)
- **Schedule:** 2018-2025
- Construction started officially Dec. 2018

- **CiADS:** Nuclear waste transmutation
- **Total budget:** 4.0 B CNY ¥ (606 M USD $)
- **Schedule:** 2021-2027
- Construction started officially July. 2021

HIAF Layout and Parameters with SC Technologies

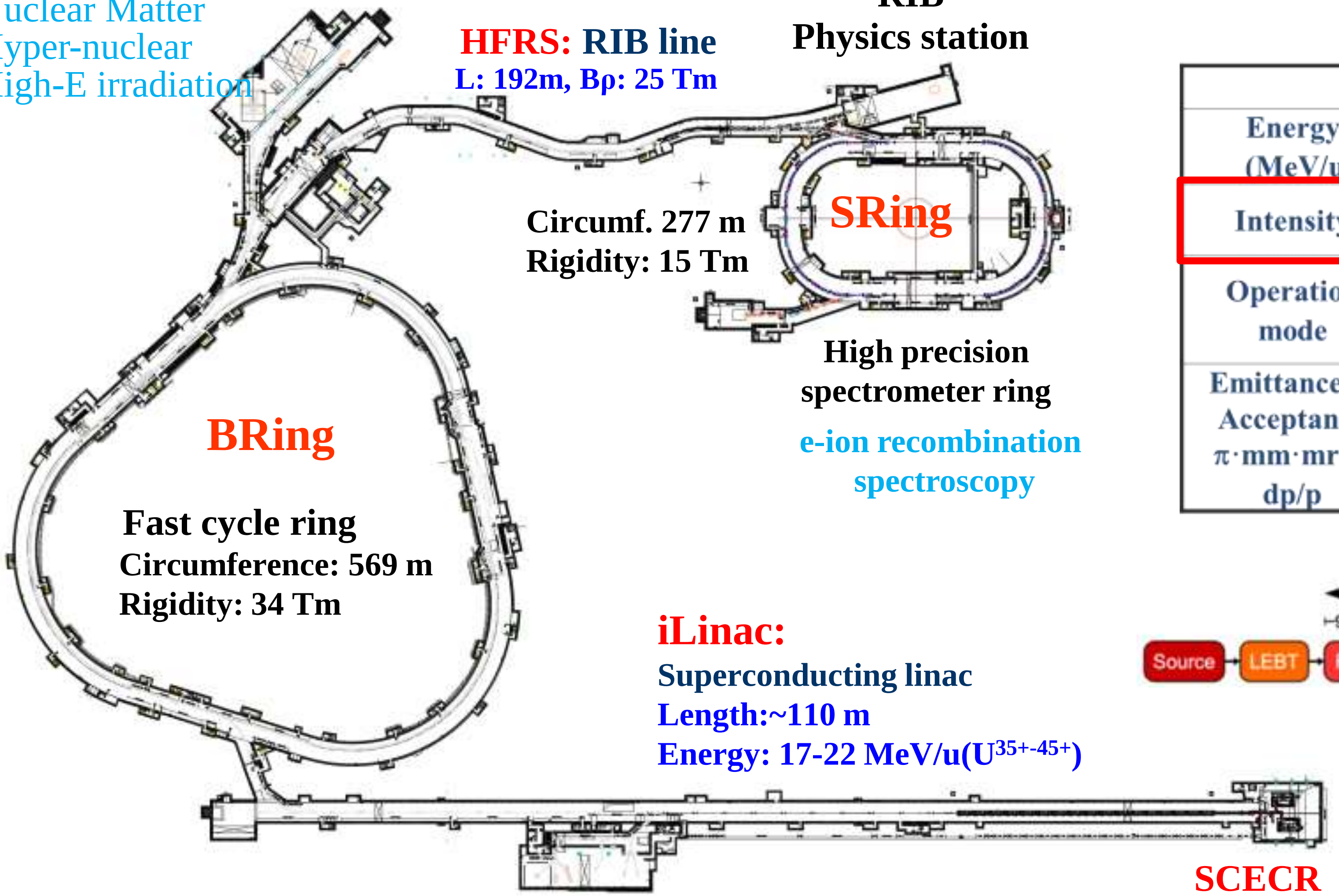
Hongwei Zhao

External target station

Nuclear Matter
Hyper-nuclear
High-E irradiation

HFRS: RIB line
L: 192m, Bρ: 25 Tm

RIB Physics station



SRing
Circumf. 277 m
Rigidity: 15 Tm

High precision spectrometer ring

e-ion recombination spectroscopy

BRing

Fast cycle ring
Circumference: 569 m
Rigidity: 34 Tm

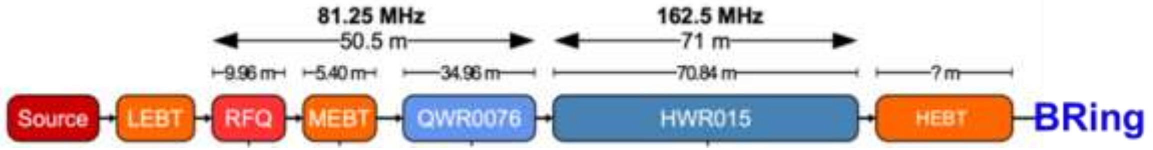
iLinac:
Superconducting linac
Length:~110 m
Energy: 17-22 MeV/u($U^{35+-45+}$)

SCECR
SECRAL II &FECR

Low energy nuclear structure and irradiation terminal

HIAF key parameters

	SECR	iLinac	BRing	HFRS	SRing
Energy (MeV/u)	0.014 (U^{35+})	17 (U^{35+})	835 (U^{35+})	800 (U^{92+})	800 (U^{92+})
Intensity	50 pμA (U^{35+})	28 pμA (U^{35+})	2×10^{11}ppp (U^{35+})	-------	10^{10}ppp (U^{92+})
Operation mode	DC	CW or pulse	fast ramping 12T/s 3Hz	Momentum -resolution 1100	DC, deceleration
Emittance or Acceptance π·mm·mrad dp/p		5 / 5	200/100 0.5%	±30/±15 ±2%	40/40 1.5%

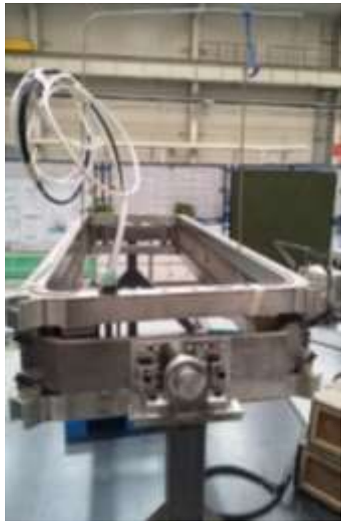


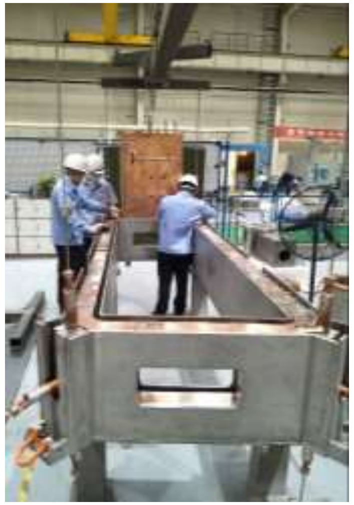
iLinac:
Superconducting linac injector

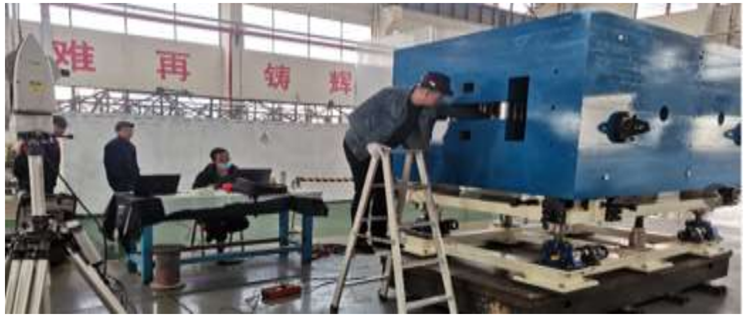
HIAF Components Fabrication

- **Most of the components are in mass production**

BRing dipole magnets







Components of HFRS superconducting magnets

iLinac HWR015 cavities

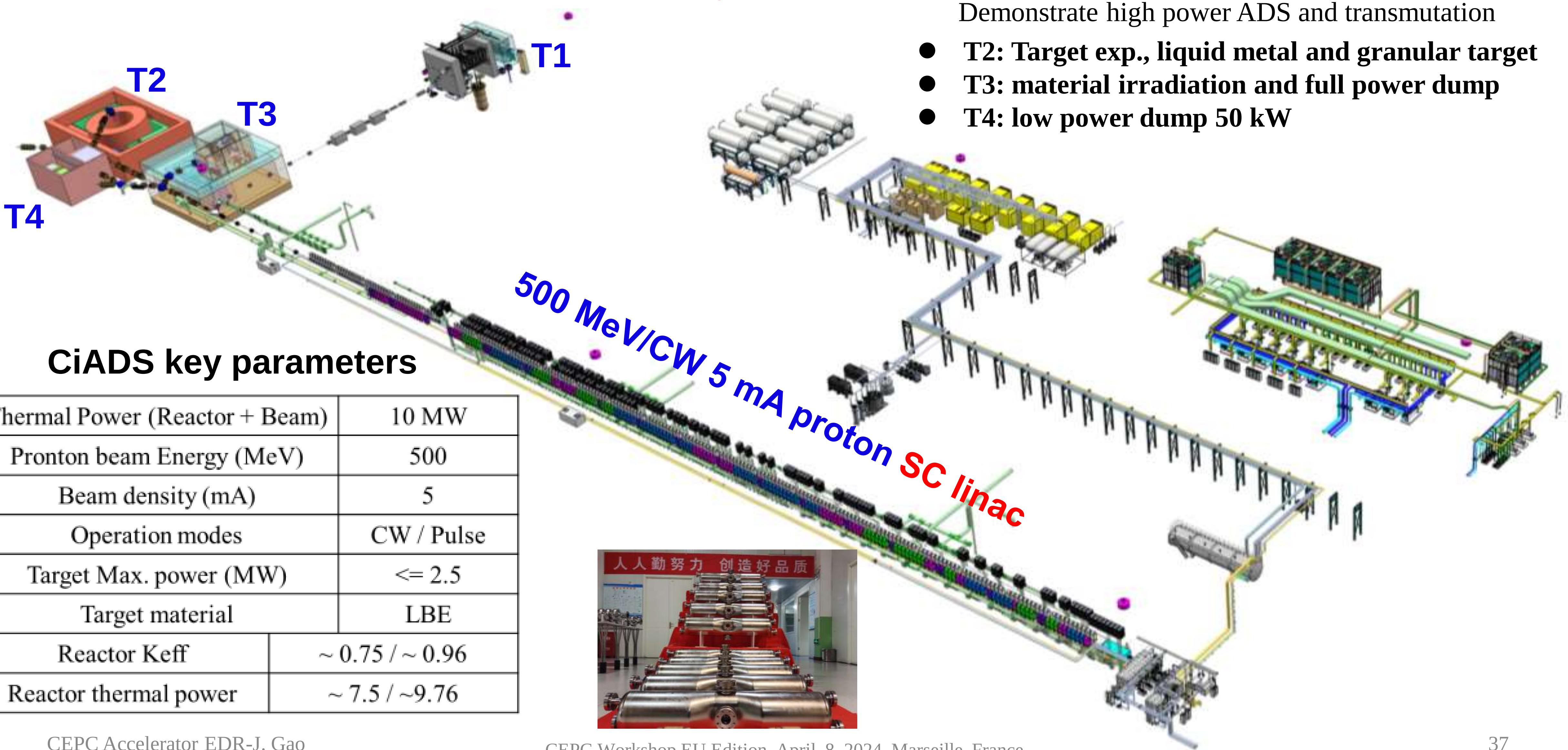
Components of SRing electron cooler

BRing collimator

CiADS Layout and Parameters with SC Technologies

CiADS could be the world first MW-level ADS facility

- **T1: Fast reactor, LBE target** Hongwei Zhao
  Demonstrate high power ADS and transmutation
- **T2: Target exp., liquid metal and granular target**
- **T3: material irradiation and full power dump**
- **T4: low power dump 50 kW**



CiADS key parameters

Thermal Power (Reactor + Beam)	10 MW
Pronton beam Energy (MeV)	500
Beam density (mA)	5
Operation modes	CW / Pulse
Target Max. power (MW)	<= 2.5
Target material	LBE
Reactor Keff	~ 0.75 / ~ 0.96
Reactor thermal power	~ 7.5 / ~9.76

CiADS Facility in Prototyping and Engineering

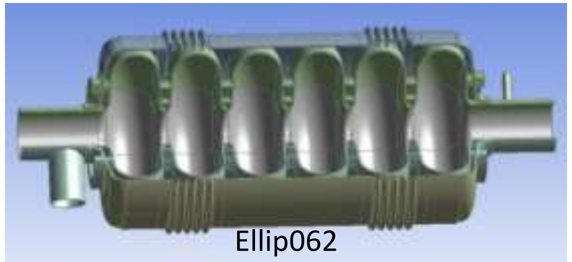
650 MHz SSAMP @ 150 kW


HWR010

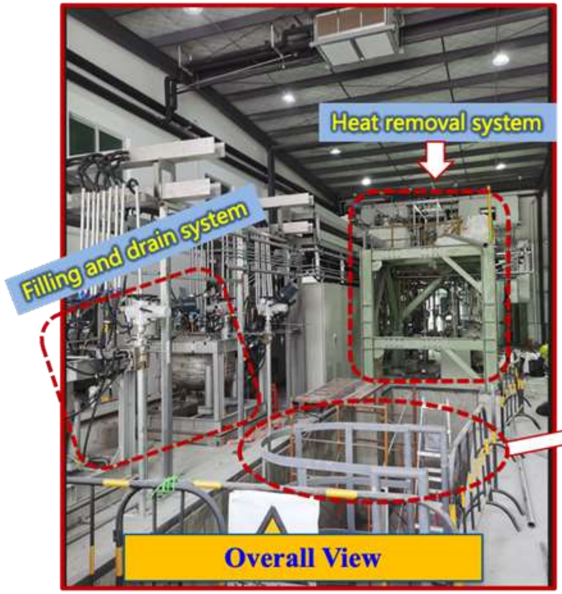

HWR015


HWR040


Ellip082

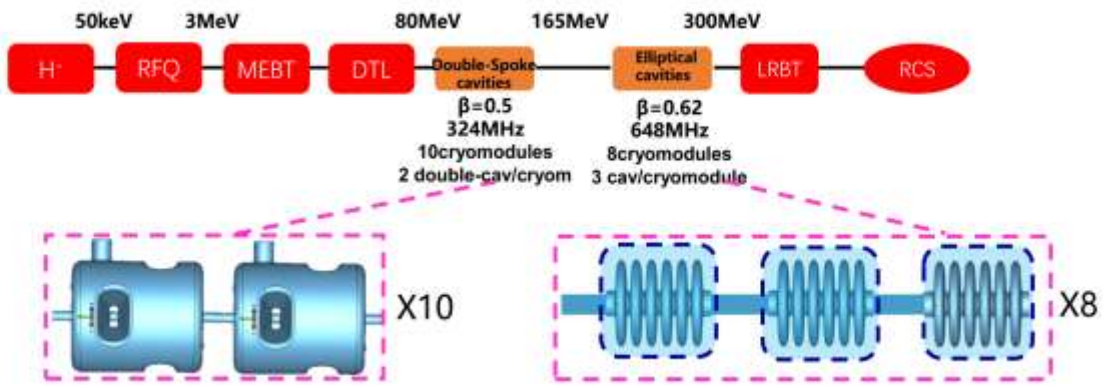

Ellip062

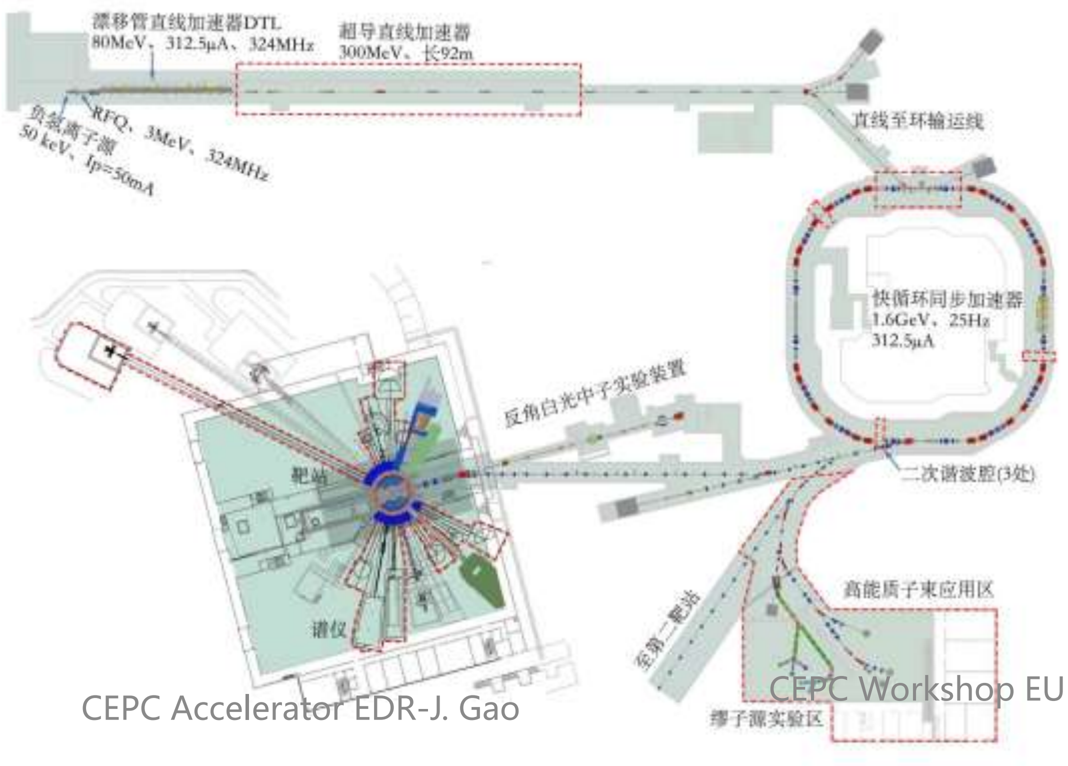
SRF cavities

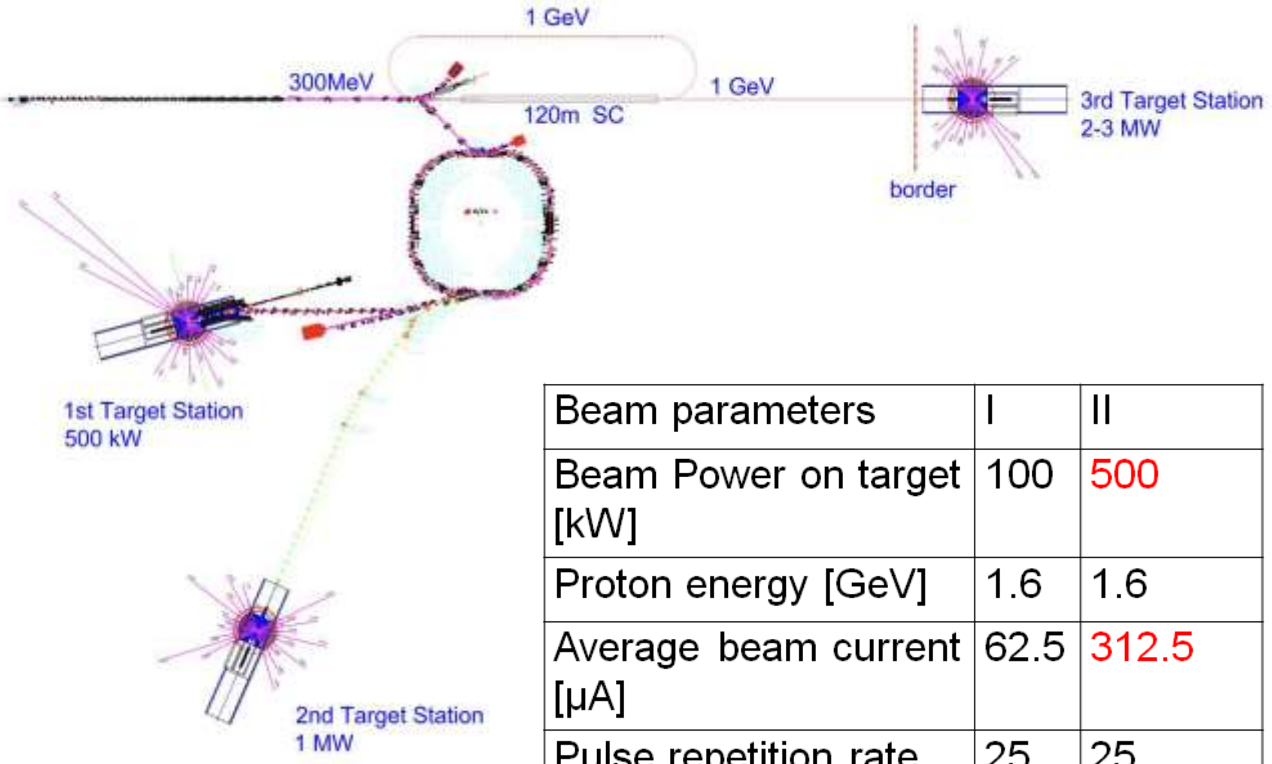


Target Prototype

CSNS-II@IHEP Dongguan







Beam parameters	I	II
Beam Power on target [kW]	100	500
Proton energy [GeV]	1.6	1.6
Average beam current [μA]	62.5	312.5
Pulse repetition rate [Hz]	25	25
Linac energy [MeV]	80	300
Macropulse. ave current [mA]	15	40
Linac RF frequency (MHz)	324	324/648
Linac beam width(μs)	400	600

CSNS-II Double-Spoke Module Prototype Assembly

Main Synergies with CEPC in Summary

- From **2018~2027** is the CEPC accelerator TDR +CEPC EDR phases before the construction
- During **2018~2027** there will be **more than 20B RMB** other accelerator projects will be completed in China (including IHEP) (**experiences related**)
- The project related experienced accelerator physicists, engineers, technicians, administration teams, etc. with wide range of expertise will have a significant increase to an unprecedented level (**human resource reservoir related**)
- The industrial sector's capability, capacity, availability, participation and contribution, etc. in accelerator related fields will have a significant increase to an unprecedented level (**industrial preparation related)**
- The accelerator R&D and industrial production facilities and platforms will have a significant increase to an unprecedented level (**R&D, test and industrial fabrication facilities related**)
- The international collaboration and participation (**including foreign industries**) will reach a new level (**International involvement related**)

Acknowledgements

Special thanks go to Hongwei Zhao, Zhentang Zhao, Weimin Pan, Guangyao Feng, Sheng Wang, Jiyuan Zhai, and Yuan Zhang for their kind helps in providing and collecting the materials and information during preparation of this presentation