SHINE project update

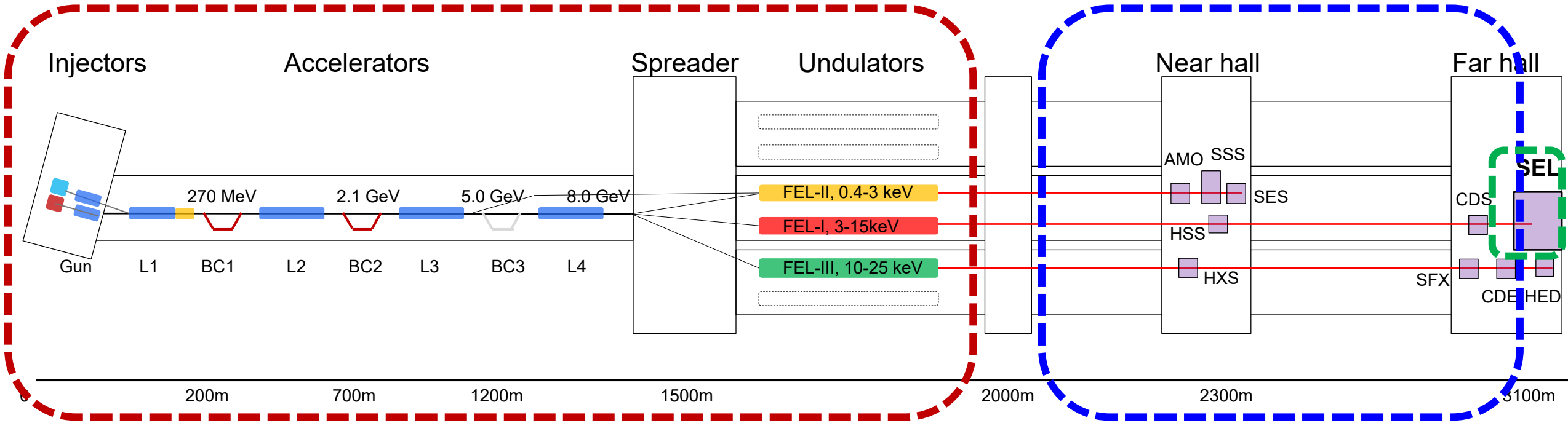
Dong Wang for SHINE Project team （STU, SARI, SIOM)

Future Light Sources 2023 ,　Lucerne, August 28

SHINE

SHINE project in brief

- **Civil construction:** 3.1km long, 5 shafts, 10 sectors of tunnels 30m underground
- **Accelerator/FEL:** 8 GeV, cw, 1MHz beam rep-rate, 3 FEL undulator lines
- **Photon beamlines:** one soft x-ray beamline, two hard x-ray beamlines
- **Experiment stations:** 10 end-stations for phase-I, including 100PW laser



SHINE

SARI/STU

STU/SARI

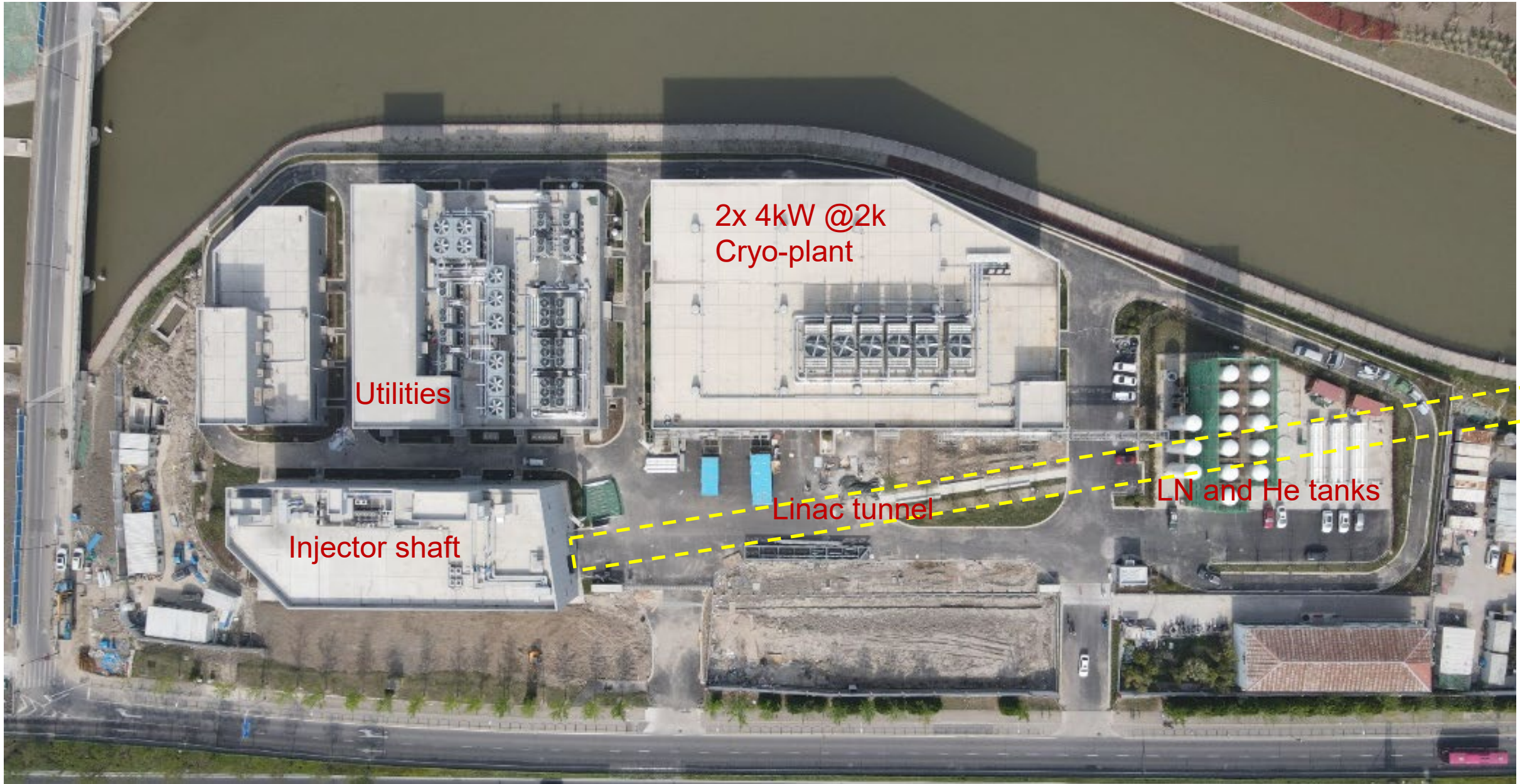
SIOM

SHINE: ~1.5B Euros cost, in 7 years

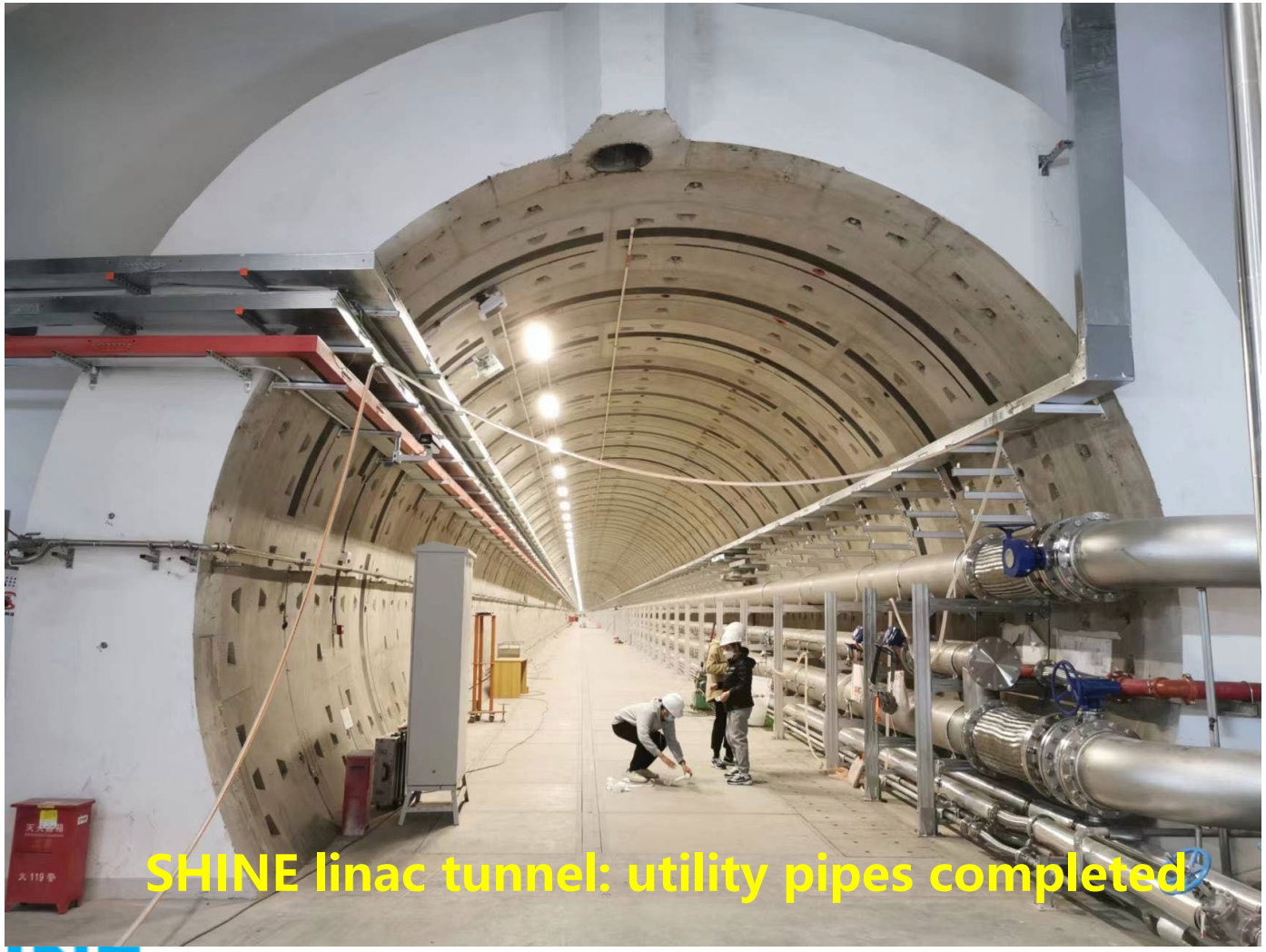
Year	2017				2018				2019				2020				2021				2022				2023				2024				2025				2026			
Quarter	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Civil construction	ground				SRF Hall												CP#1 Hall																							
	undergr				Injector shaft & linac tunnel: 2023.03 ★																				Others															
Cryogenic system					1kW@2K cryoplant for R&D																																			
											4kW @ 2K cryo-plant #1: 2024.01 ★																		CP#2 + #3										
Gun							217 MHz VHF gun R&D: tested OK																																		
																							deliver ★		Inst.															
LINAC					High-Q cavity/module infrastructure/R&D																																			
																					Mass product./test/install																		
																												Linac ramp up											
cw beam testbed																	Install.				Commis.																			
Undulators					Undulator R&D: 3 warm prototypes OK																				SCU R&D															
																					Mass production/install											SCU							
SHINE commiss.																																					1st Lasing 2025			

Shifting……

Civil constructions: shaft #1 area



Civil constructions: linac tunnel is handed over April



SHINE linac tunnel: utility pipes completed

2K Coldbox of 4kW cryo-plant #1: installed in injector shaft

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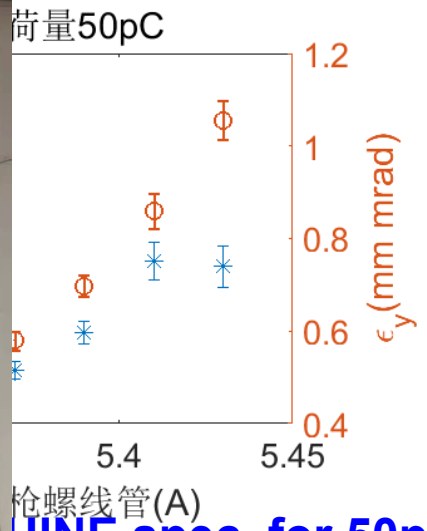
SHINE gun: 217MHz VHF gun(baseline) and more

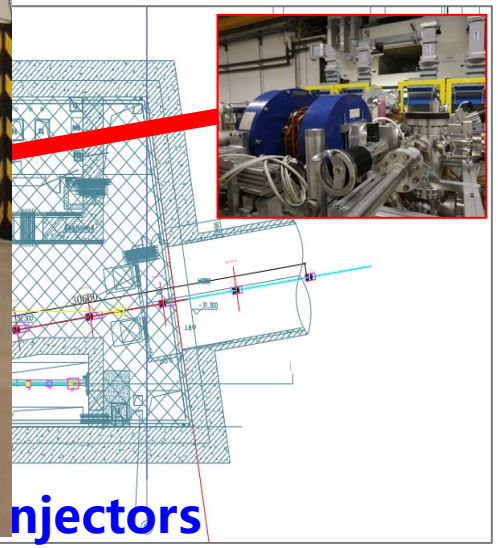
SHINE injector shaft

Main injector tunnel
VHF gun installed

Alternative injector tunnel
L-band (and DC-SRF) gun



HINE spec. for 50pC

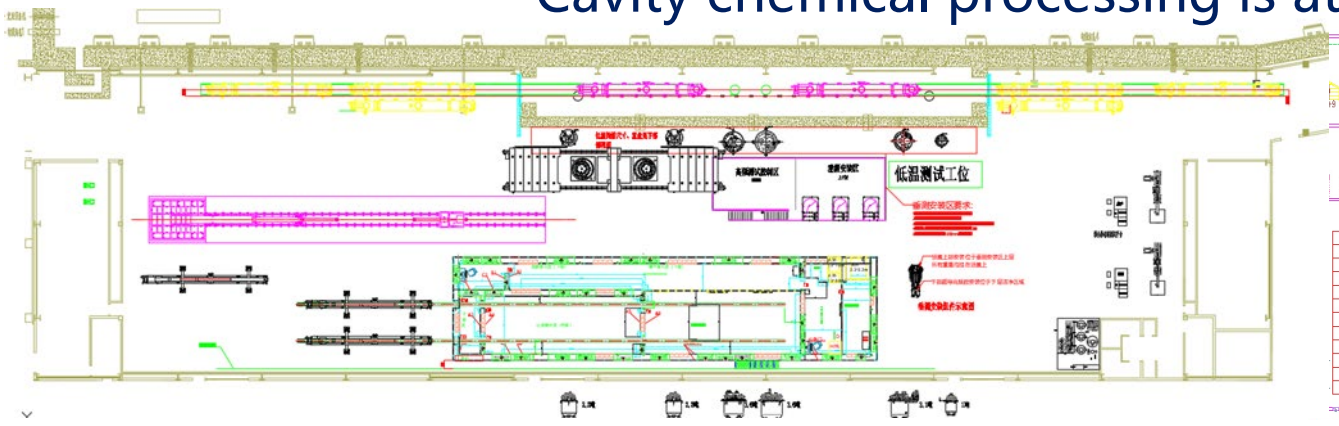


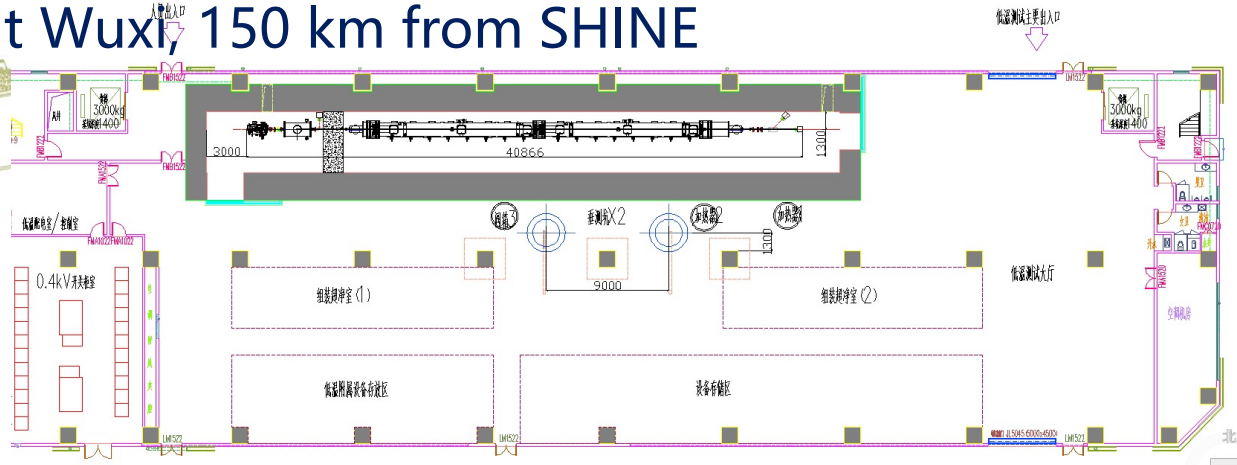
njectors

SHINE SRF Infrastructure at Shanghai

1, supporting intense R&D for SRF techs needed for SHINE and future
2, capacity for 600 cavities VT, 75 modules assembly & HT in 2~3 years
3, beam test with gun + 1-2 modules

Cavity chemical processing is at Wuxi, 150 km from SHINE





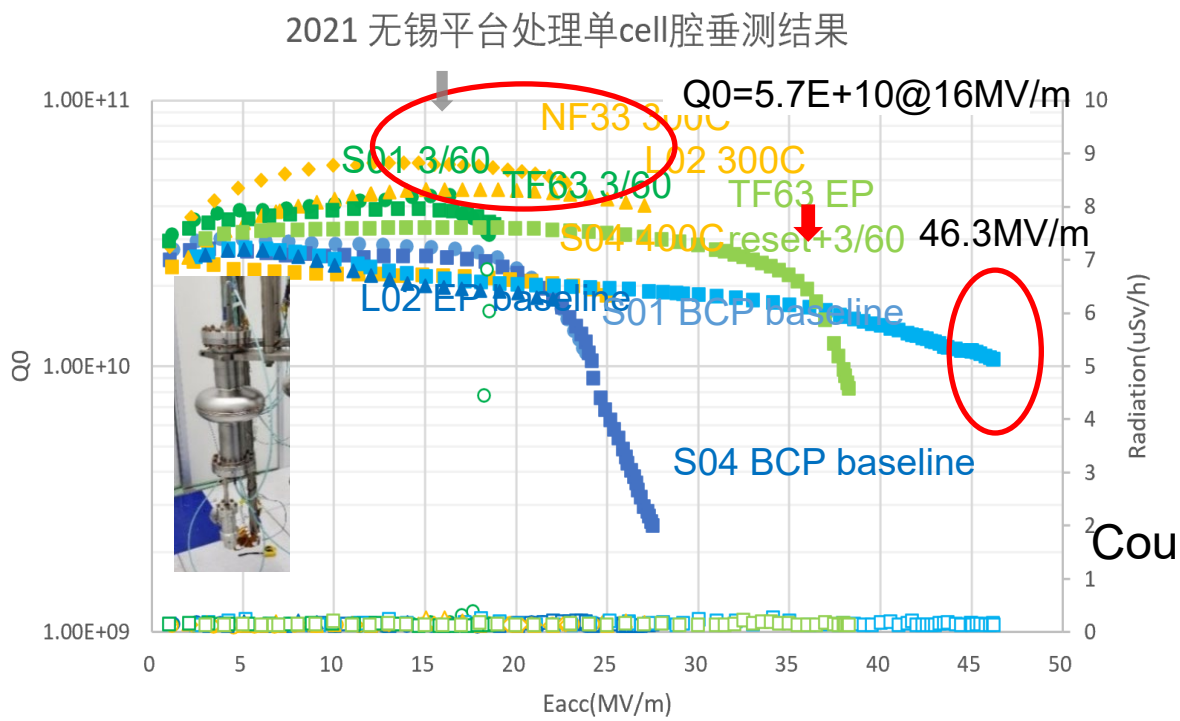
SHINE SRF Buildings
3 halls /w 8000m2

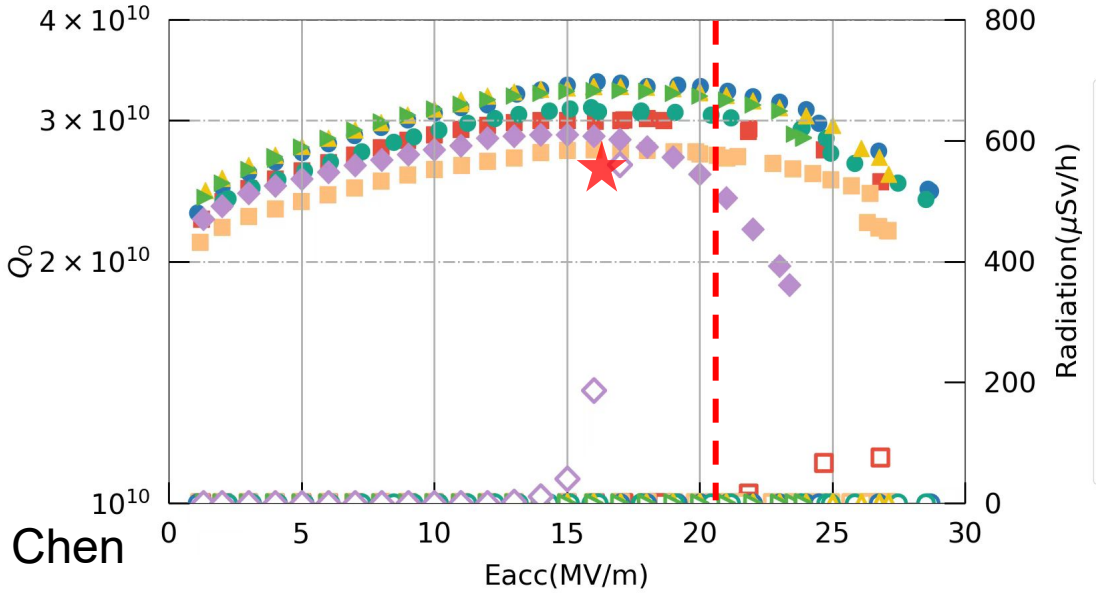
Hall #1: module assembly
2xVT caves 2xHT, in use

Hall #2: 2 x VT caves
2xHT/beam test, commi.

Cryoplant for RF test
1kW@2K reached 2021

SHINE new cavity R&D facility is really rewarding

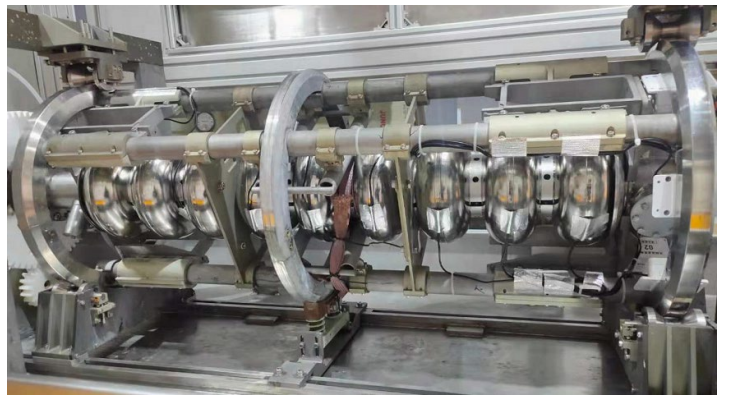




Courtesy: J. Chen

Performance of latest SHINE cavities by RI

SHINE new facility works great in finding various baking/doping recipes that are transferred to major vendors in China and Europe successfully. Both high Q and high gradients are achieved. Theoretical and experimental studies to explore mechanism and other new recipes.



Cryomodule assembly/test: SHINE + Industries

Three types of CMs are assembled and cooled down successfully. About 5 more standard CMs will be assembled/tested before series production starting 2024.


pM #0: cryo/mechanical properties


pM #1 standard CM


pM #2 short CM

Industry team on SHINE site for module assembly/tests.

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Courtesy: YIN Lixin, LIU Yiyong, SUN Sen, ZHAO Shenjie et al

Fundamental Power Couplers

- 30 sets of 1.3 GHz FPC prototypes have been manufactured and power conditioned with 14-kW traveling wave (TW) and 7-kW standing wave (SW) in continuous-wave (CW) mode. Even higher power levels have been demonstrated with **20-kW TW and 10-kW SW**, which indicates their robustness.
- 16 sets of 1.3 GHz FPC prototypes have been assembled into two cryomodules and been verified.
- Two 3.9 GHz FPC prototypes have been designed, manufactred and power conditioned with 2.2-kW TW and 2-kW SW in CW mode.

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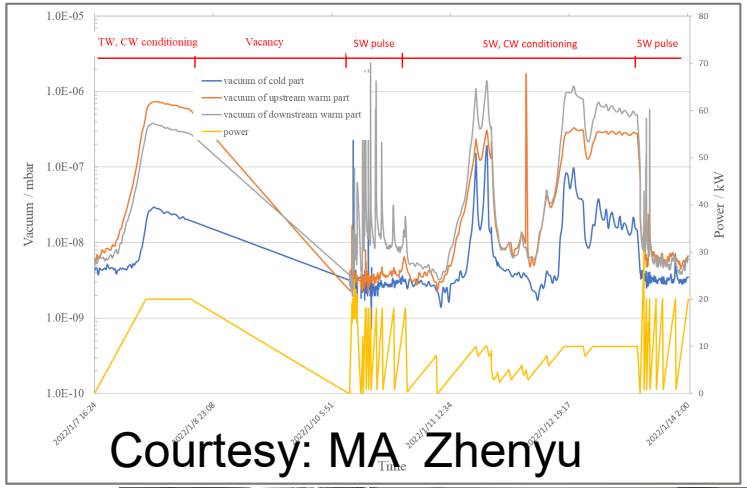
PHYSICAL REVIEW ACCELERATORS AND BEAMS **25,** 113501 (2022)

Manufacturing studies and rf test results of the 1.3 GHz fundamental power coupler prototypes

Zhen-Yu Ma,[1,*] Hong-Tao Hou,[1] Shen-Jie Zhao,[1] Xu-Ming Liu,[1] Yu-Bin Zhao,[1] Sen Sun,[1] Ye-Liang Zhao,[1] Xiang Zheng,[1] Qiang Chang,[1] Hong-Ru Jiang,[1] Zi-Gang Zhang,[1] Kai Xu,[1] Xue-Fang Huang,[1] Yue-Chao Yu,[1] Ya-Wei Huang,[2] Li-Jun Lu,[1] Yan Wang,[1] Jing Shi,[1] Xiao-Han OuYang,[1] Wen-Feng Yang,[1] Xin-Yu Li,[1] Qiang Huang,[1] Chen Luo,[1] Hong Wu,[1] Xiao-Yun Pu,[1] and Chang-Hao Cheng[1]
[1]*Shanghai Advanced Research Institute, Chinese Academy of Sciences, Shanghai 201204, People's Republic of China*
[2]*ShanghaiTech University, Shanghai 201210, People's Republic of China*



Courtesy: MA Zhenyu

SHINE 1.3 GHz FPC

SHINE 3.9 GHz FPC

FPC on 1.3 GHz Cryomodule

Solid State Amplifiers (SSA)

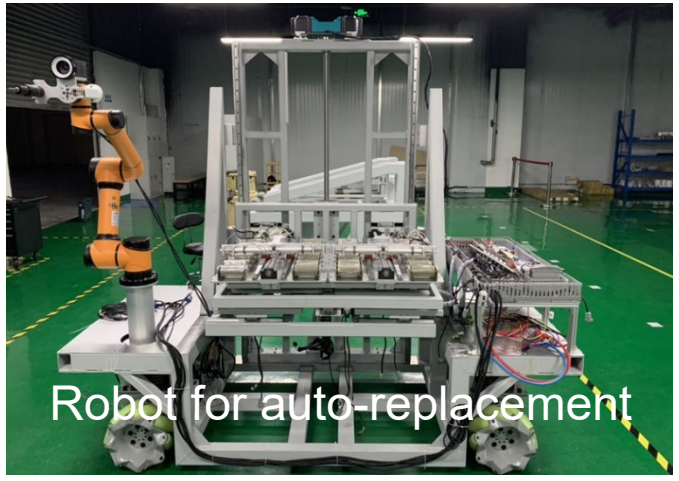
Courtesy: ZHAO Yubin

SHINE 1.3GHz SSA: 5.2 kW

- 100 uA beam at 16~20 MV/m with Qext = 4~6e7
- **required to accelerate the beam (i.e., $I_b \times V_c$)**
- input power required with no detuning or overhead
- input power with 10 Hz detuning
- source power for 10 Hz detuning
- **overhead for transport losses and gradient regulation margin**

	Requirement	Acceptance test result
Frequency	1.3GHz	1.3GHz
Delay of small signal	<300ns	44ns
1 dB compression	5.2kW @0dBm	5.5kW
Bandwidth(1dB)	1MHz	2MHz@0.1dB
Phase noise	80dBc/Hz(10Hz offset @1.3GHz)	89dBc/Hz
Amplitude stability	0.1% @ 1 second	<0.1%
Phase stability	0.1° @ 1 second	<0.1°
Spur	<-70dBc	<-70dBc
Noise	<10 dB	2dB (90-88)
Harmonic	<-30 dBc	-38 dBc@5th
Efficiency	>40% (at 5.2kW)	45%


More than 30 SSAs tested


Robot for auto-replacement

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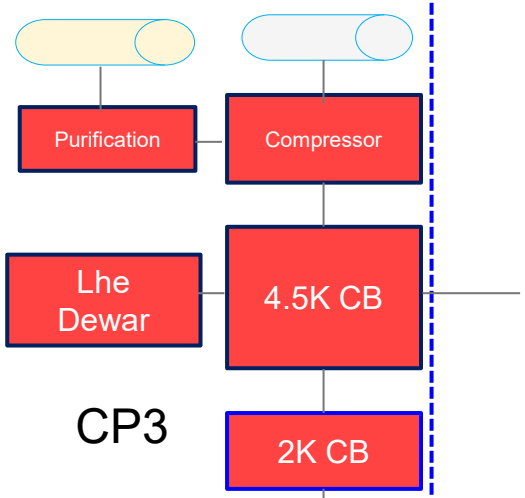
Cryogenic System for Cryomodules

1kW cryoplant in operation Spring 2021

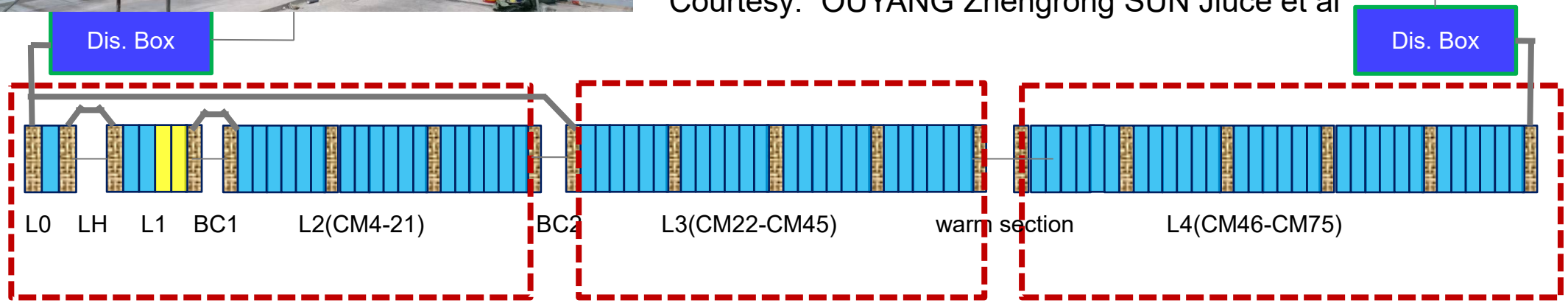
Shaft#2

1KW@2K CryoPlant



CP3

Courtesy: OUYANG Zhengrong SUN Jiuce et al



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SC linac: 75 x 1.3 GHz CMs, 2 x 3.9 GHz CMs

Cryo-plants: **3 x 4kW@2K** , plus **1kW@2K for SRF test**

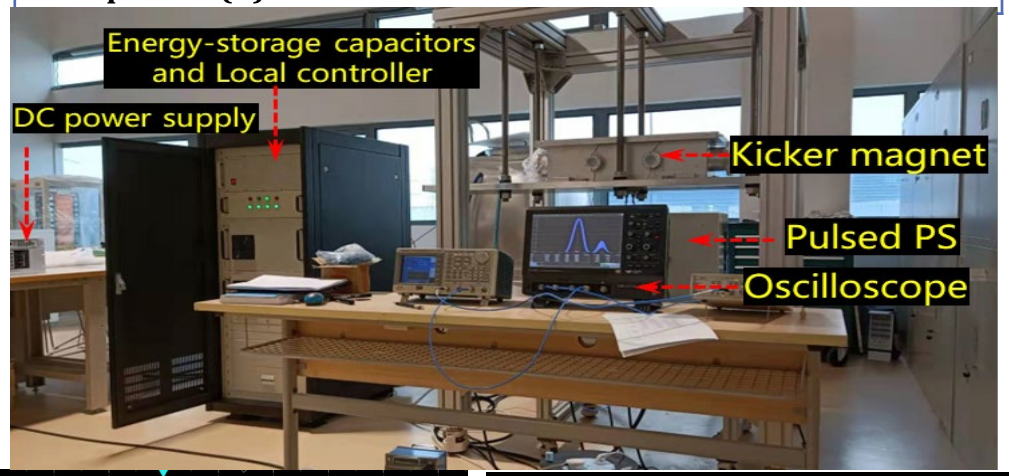
6CM

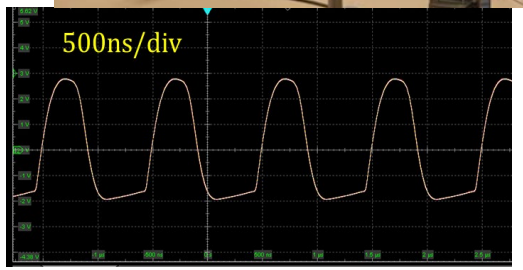
SHINE fast kicker for beam switchyard

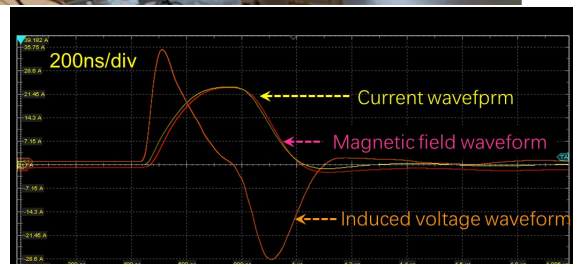
Courtesy: GU Ming, LIU Yongfang

Lumped-inductance Kicker

Key parameters of Lumped-inductance Kicker			
Beam energy	8 GeV	Bending angle	0.1 mrad
Effective length	0.5 m	Max. Rep. rate	1 MHz
Aperture(H)	10 mm	Field intensity	5.3 mT
Aperture(V)	16 mm	Peak current	50 A

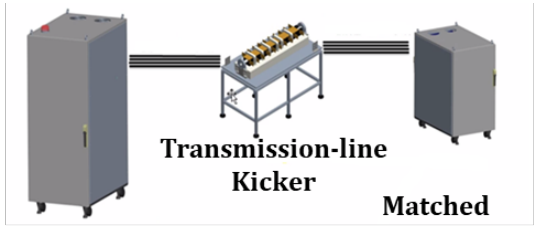


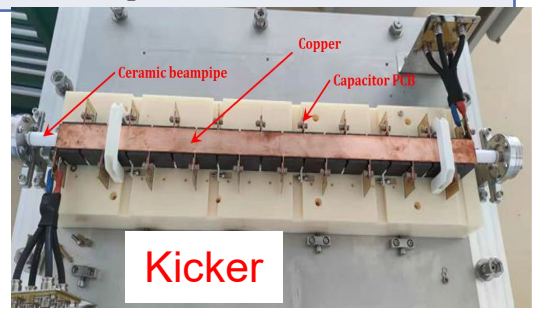


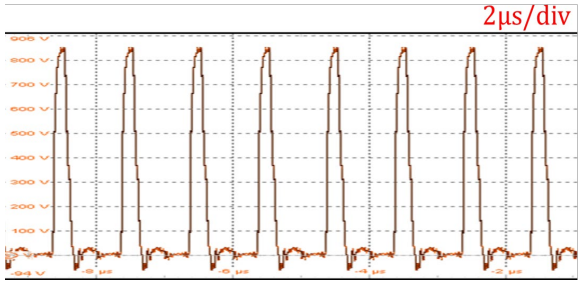


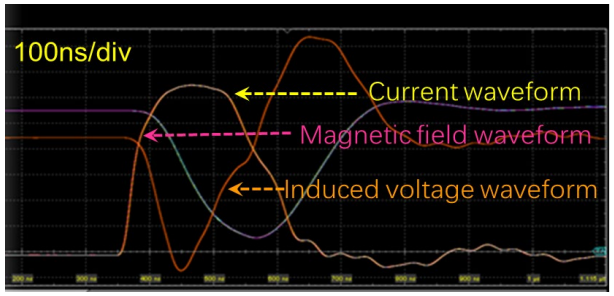
Transmission-line Kicker.

Key parameters of Transmission-line Kicker			
Beam energy	8 GeV	Bending angle	0.1 mrad
Effective length	0.8 m	Max. Rep. rate	1 MHz
Aperture(H)	25 mm	Field intensity	3.3 mT
Aperture(V)	25 mm	Peak current	67 A
Ceramic beampipe	Φ15 mm	Kicker impedance	12.5 Ω





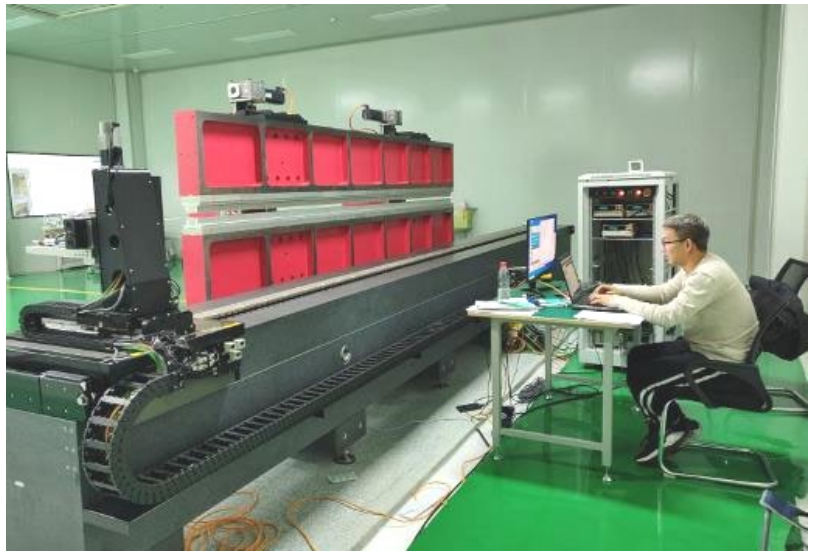




Two kinds of kicker prototypes are developed in SARI. Based on the advantages and disadvantages of the two prototypes and several compromises, lumped kicker, which is kept outside vacuum over a ceramic chamber, is chosen.

SHINE Warm Undulators : different types

Courtesy: ZHANG Wei

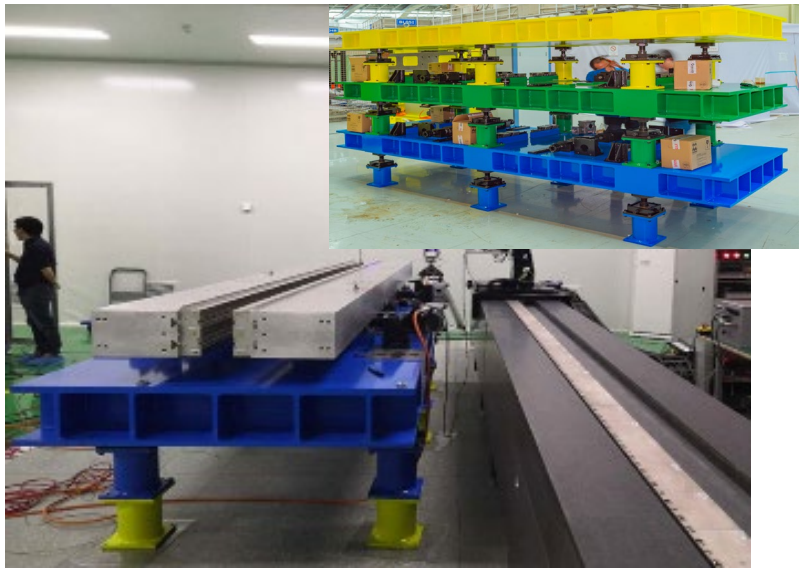


Conventional V-gap Undul.

All undulator are 4 m long.

26mm(FEL-I) and 55mm(FEL-II).

Series production now



H-gap Undulator

Anti-magnetic compensation.

Stackable, up to 3 layers,

Can work as EPU

Elliptical Polar. Undulator

Anti-magnetic compensations in all dimensions.

Ready for mass productions

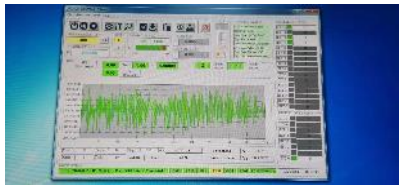
SHINE

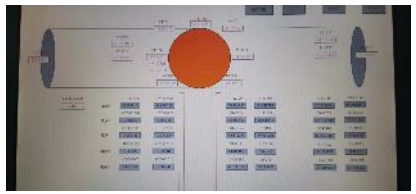
Superconducting undulator: nice but not easy

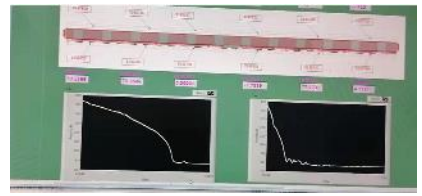
All components tested OK

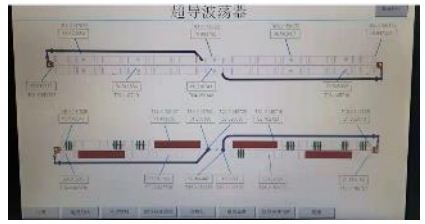
SCU cooldown is fine now

SC coils need more work.









Goals: 4m long, period length is 16mm, Bmax = 1.583T

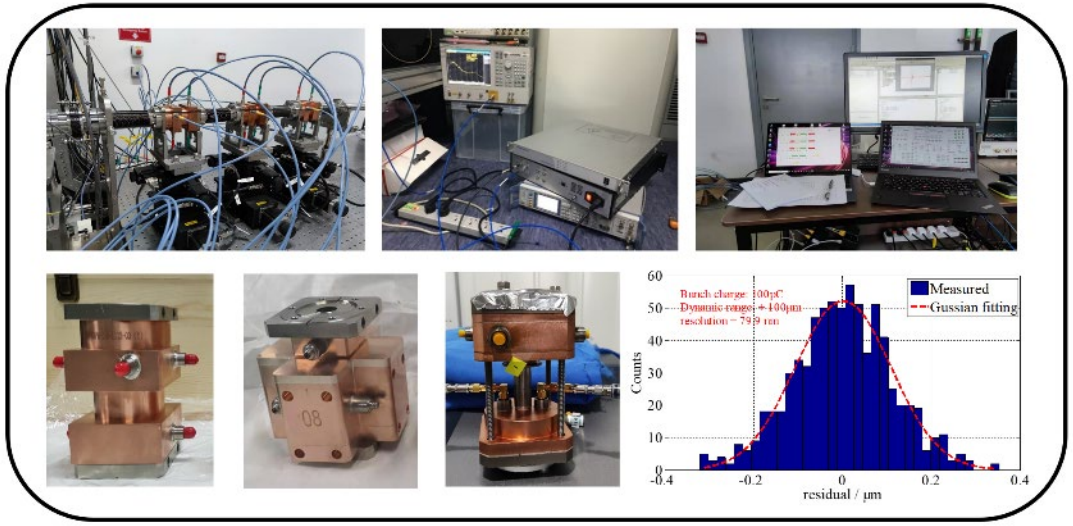
SHINE

Courtesy: Q. ZHOU et al.

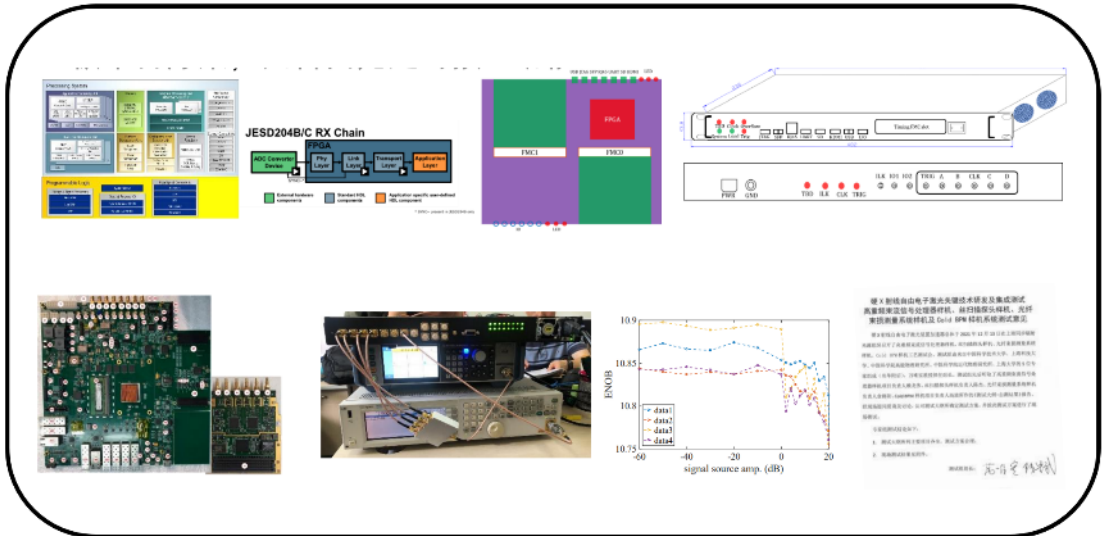
BI/control for high rep-rate beam:

Courtesy: Y. Leng, Y. Yan

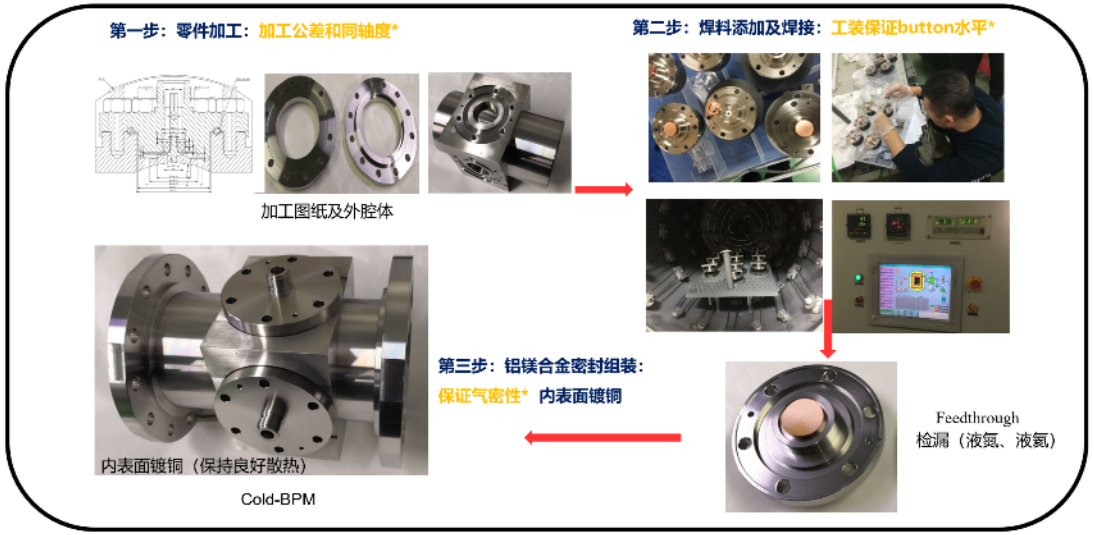
CBPM样机



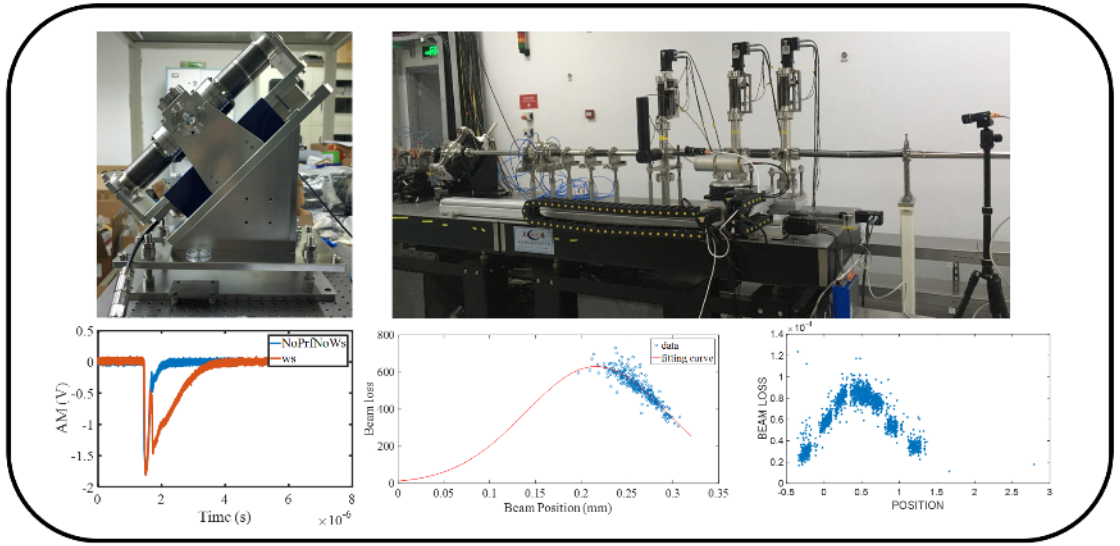
高重频束流信号处理器样机



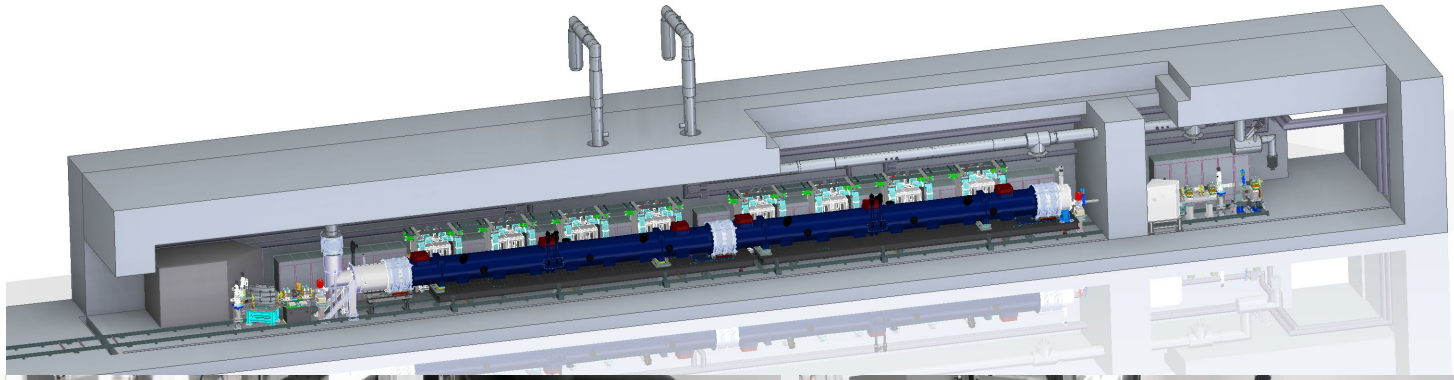
Cold-BPM样机



丝扫描样机



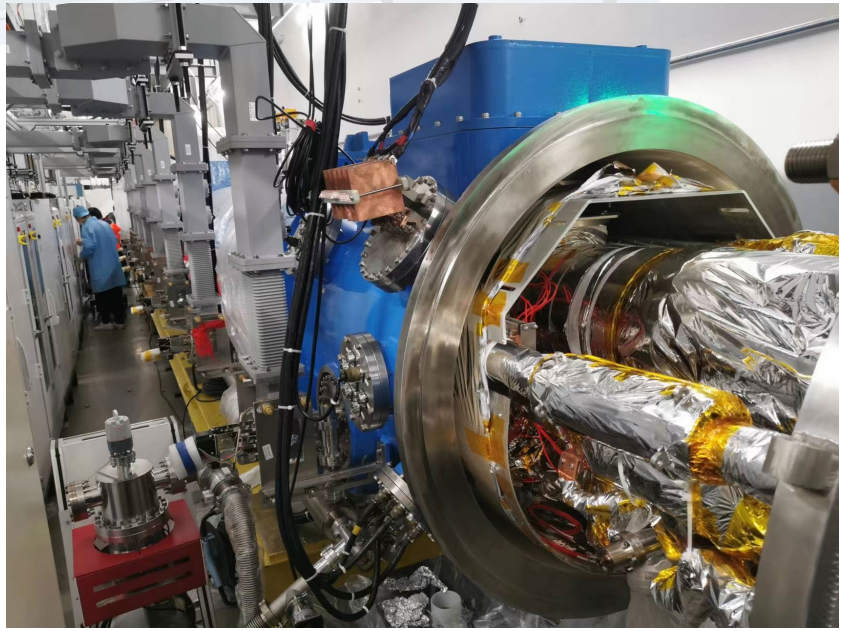
SHINE cw beam test facility



SHINE cw beam test facility:

- ~50m long bunker in SHINE site
- CW DC-SRF gun + 2 cryomodules
- Can also serve as two HT units

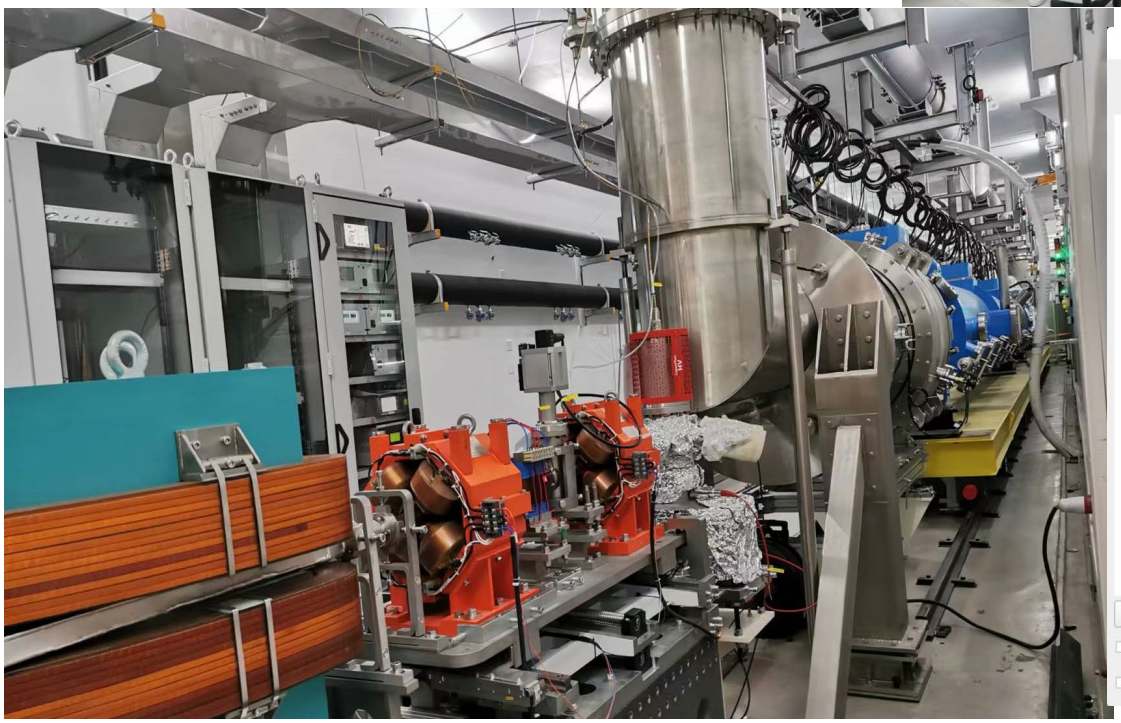
DC-SRF gun from PKU
Re-assembled by SHINE
Gun performed OK.

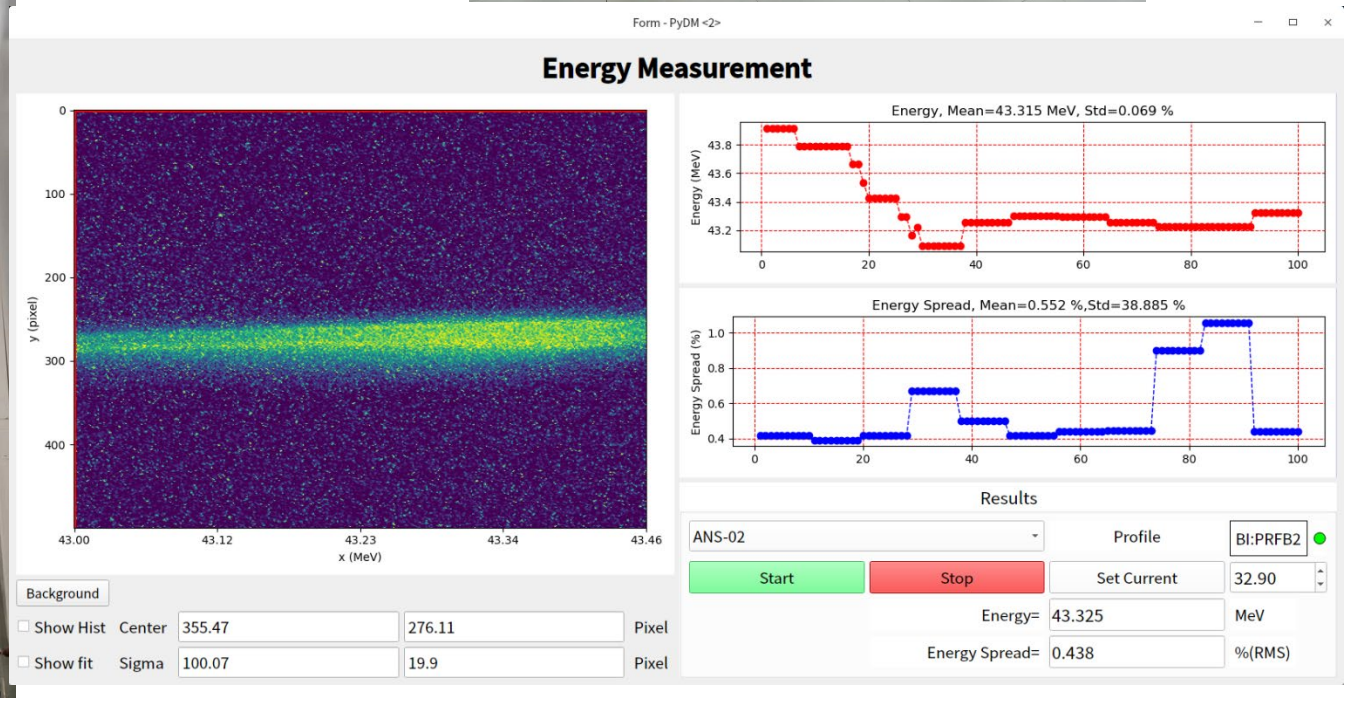


BCP cryomodule hori. tested.
Two-module welding completed
Already commissioned with beam.

Control/BI/power supplies
MHz drive laser
Beam dump(15kW)

CW testbed commissioning since 2022





Others: more tests, IR chamber at far hall

The single cavity module for injector is to be tested with beam before installed at shaft late 2023.

The Interaction Chamber was installed at shaft #5 (far exp. hall) , May 2023.

SHINE

Summary

- The challenges of SHINE project can not be overestimated. Despite of all kinds of difficulties the SHINE project has been advancing significantly in infrastructures on SRF/cryogenic, civil constructions, prototyping of (especially SRF) technologies.

- The R&D/prototyping for machine components are mostly completed. The 4m long SCU is still under development though there is backup warm solution. SHINE is now in the phase of series production of major parts of machine.

- The installations in underground tunnels/shafts started this April. Machine commissioning will begin from gun (2023) to linac (from 2024), then to FEL (from 2025 starting with first part of linac and FEL-II undulator line).


Thank you for your attention!
消防器材