Challenge of multi-laboratories and industries collaboration: SHINE experience

Dong Wang

SARI/SINAP, CAS / SHINE Project

TTC meeting, 2022.01.25

SHINE

Introduction

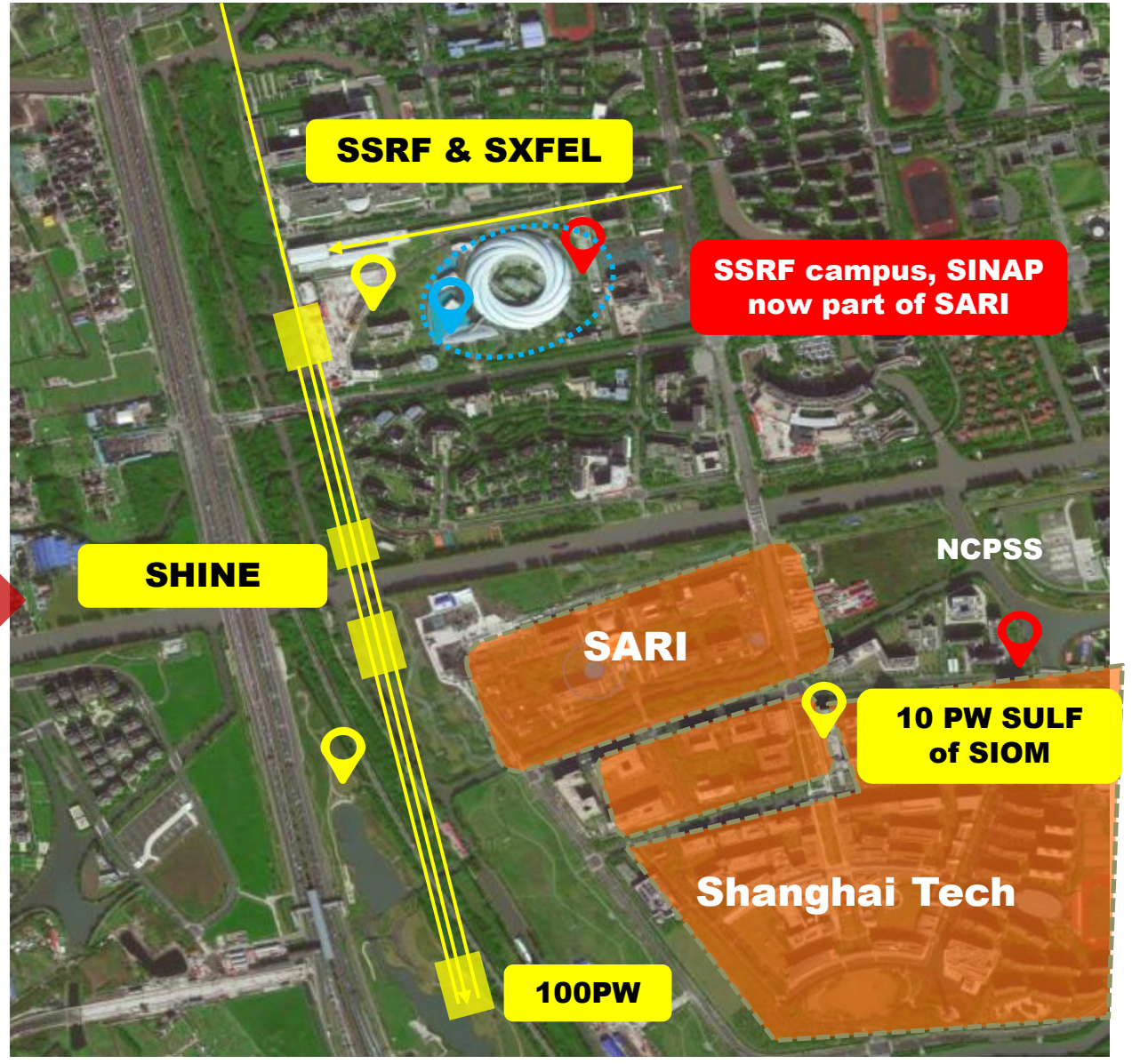
- As a matter of fact SHINE project was greatly inspired by the success of European XFEL and others.
- Although SHINE is not yet an international project (instead it is rather regional), it is indeed the part of global efforts on superconducting and XFEL technology in which TTC plays key role.
- Collaborations with multi-institutions / industries (domestic and international) are great challenges everywhere. SHINE is no exception, if not worse.

EuXFEL, LCLS-II-HE and SHINE

05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Great R&D				EXFEL，2009 to 2017-19 3 FELs											15 European countries, collaboration tradition										
CEBAF/FNAL/Cornell experiences									LCLS-II，4GeV + 2 FELs at 5keV										5 DOE labs + Cornell						
														LCLS-II-HE 8GeV											
				insufficient R&D/infrastructure									SHINE，8 GeV in 7 years								Sh. Tech/SARI/SIOM				

SHINE

SHINE: by STU, SINAP(now SARI), SIOM



Zhangjiang: 15 km to central Shanghai,
National center for large photon facilities

SHINE

SHINE: multi-inst./admin./funding agency

Government/ Administration	National/Central			Regional/Local	
	Others	**EDU**	**CAS**	**Shanghai city**	**Shenzhen city**
Institution		PKU	IHEP		SUST
		THU	IMP		IASF
		USTC	SINAP		…
		……	SIOM	SHINE project team	
			SARI	**ShanghaiTech**	
Project			BEPC(100%national funding)		
			SSRF(national:local, 2:1)		
			SXFEL(1:3)		
				SHINE(1:4)	SZ-XFEL
			SHINE funding source, 80% local		100% local
Funding agency	NSF	MOST	**NDRC**	**Shanghai city**	**Shenzhen city**

SHINE

NDRC: National Development and Reform Commission, major funding source for large facilities

What's special for SHINE on institution collaboration?

Unprecedented situation:

- Major funding source for a large scientific user facility is a local government (Shanghai), instead of national funding agency
- Host institution who is legally responsible for the project is a municipal university (ShanghaiTech) , instead of institute of CAS in the past.
- ShanghaiTech and SARI/SIOM follow different regulations, and do not share a common administration/headquarter who could coordinate 3 institutions (not to mention other CAS institutions or universities).

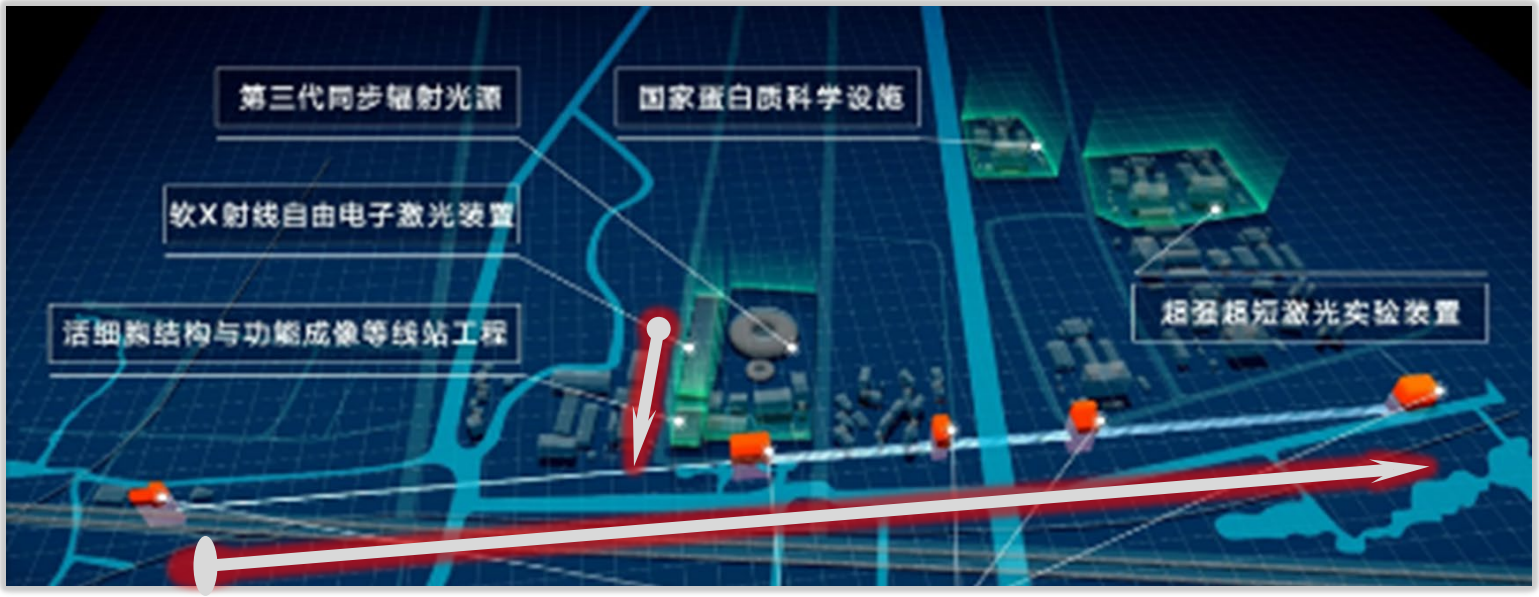
ShanghaiTech Overview

- *ShanghaiTech University was jointly established by Shanghai Municipal Government and Chinese Academy of Sciences (CAS) and approved by Ministry of Education in Sept. 2013.*

Center for Transformative Science(CTS), STU

Challenges in FEL: Big organization + Big Machine + Big Politics

Still Path Finding. Needs a new Institute in ShanghaiTech University



- **SXFEL: soft X-ray facility 2016-2021**
- **SHINE: High repetition FEL 2018-2025**

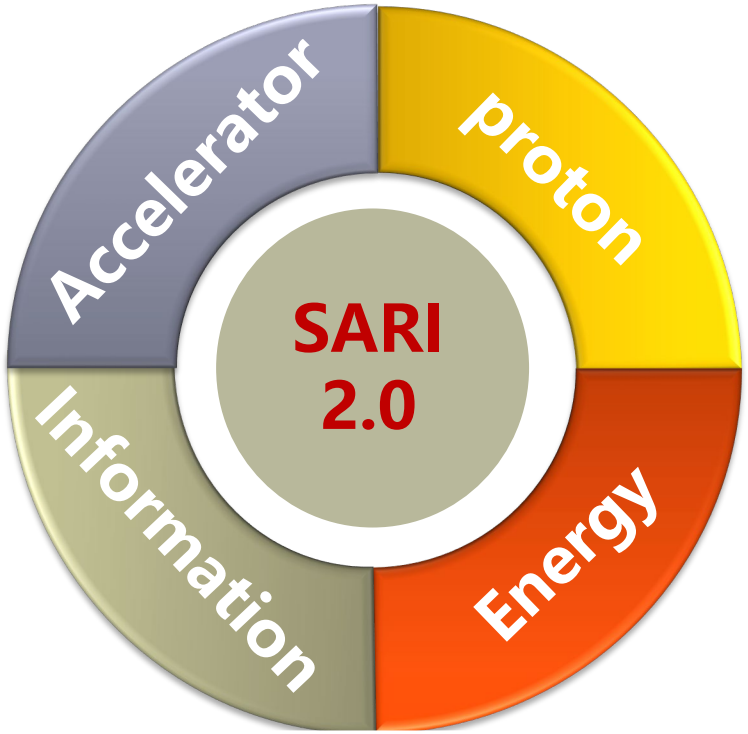
Center for Transformative Science

"Cultivating leadership, innovations, and breakthroughs in Big Science."

SHINE

SARI at a glance

In 2019, SARI went through structural reform. SSRF (originally affiliated to SINAP) and NFPSS (Originally affiliated to Shanghai Institutes for Biological Sciences) were merged with SARI.



7 Research Divisions

Shanghai Synchrotron Radiation Facility (SSRF)

National Facility for Protein Science Shanghai (NFPSS)

- Center for Low-Carbon Conversion Science and Engineering
- Center for Advanced Energy and Equipment Research
- Center for Green Chemical Engineering Technology
- Center for Intelligent Information & Communications
- Center for Research and Interdisciplinary

Basic Research → Application → Industrialization

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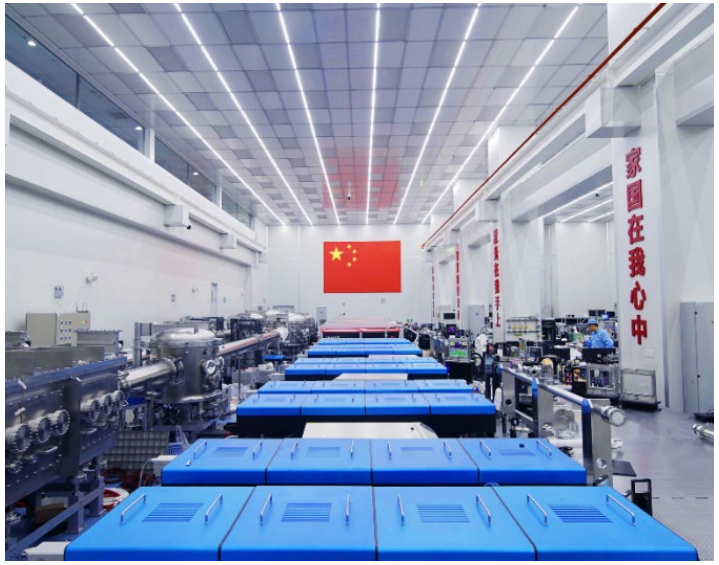
SULF of SIOM: Shanghai Superintense Ultrafast Laser Facility

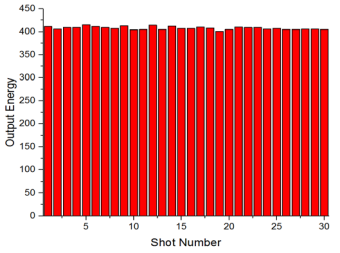
SULF facility, located in Zhangjiang comprehensive national scientific center, has 2 laser beamlines and 3 user platforms.

- **2 ultra-intense laser beamlines**
  - **A 10 PW beamline (1 shot/min)**
  - **An 1 PW beamline (0.1Hz)**

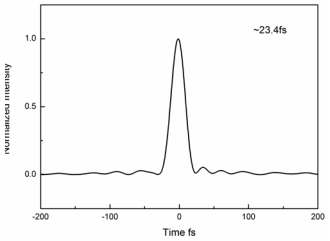
- **And 3 platforms for users**
  - **DMEC**: **D**ynamic of **M**aterials under **E**xtreme **C**onditions
  - **USAP**: **U**ltrafast **S**ub-**a**tomic **P**hysics
  - **MODEC**: Big **Mo**lecule **D**ynamics and **E**xtreme-fast **C**hemistry



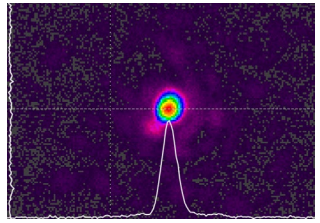
10PW laser system	
Wavelength	800nm
Peak power	10PW
Pulse duration	1 shot/min
Intensity	≥10^{22}W/cm^2
Pulse contrast	10^{-10} (before 100ps)
1PW laser system	0.1Hz/ 1PW



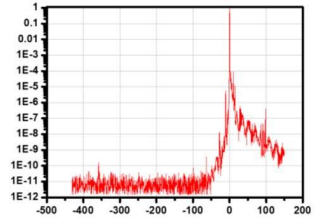
Stability



Pulse width



Focal spot



Laser contrast

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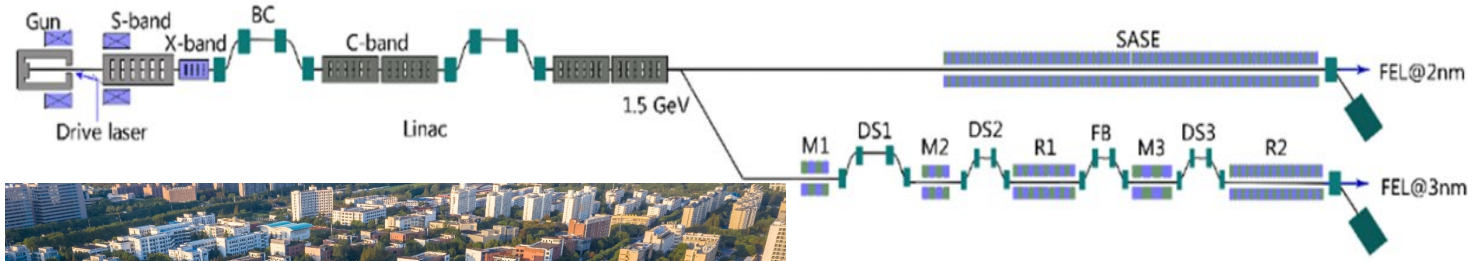
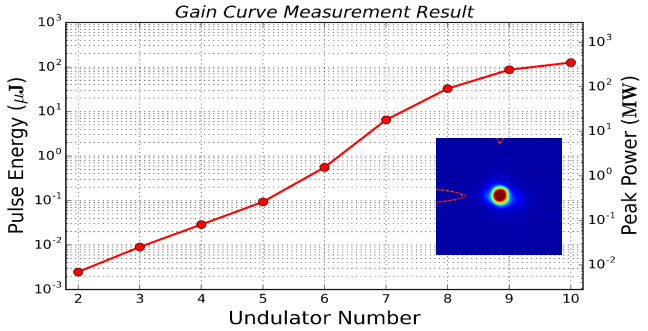
Multi-projects issues: SSRF upgrade & Soft X-ray FEL

SXFEL Facility, located at the SSRF campus, is being developed in two steps:

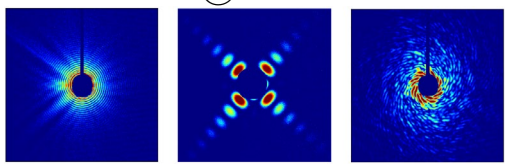
- **SXFEL-TF** was initiated in 2006 and funded in 2014, its 0.84GeV linac and main undulators started to be installed in 2016, the commissioning of SXFEL-TF is finished in 2020;
- **SXFEL-UF (+SBP)** was funded to upgrade the linac energy to 1.5 GeV for building two undulator lines with 5 experimental stations in the water window region.



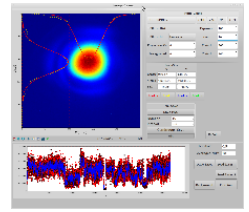
Total length	532m
Photon energy	0.2 – 0.6 keV
Pulse length	~100 fs
Repetition rate	10 - 50 Hz
Peak photon power	1 GW
Electron energy	0.8 - 1.5 GeV



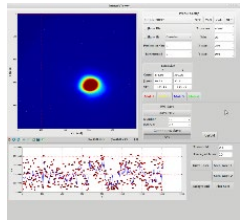
2nm FEL @ SASE line



Diffraction with 2.4nm FEL @ SASE line



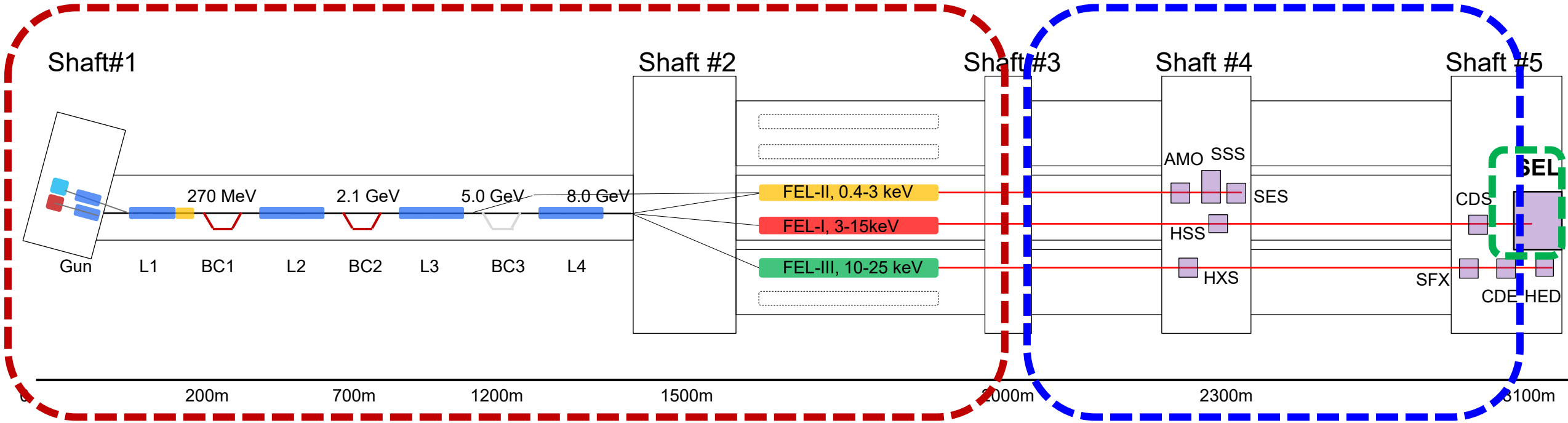
5.6nm HLSS



3nm SASE @Seeding line

SHINE project task breakdown

- Civil construction: ShanghaiTech University (STU)
- Machine/FEL: SARI(former SINAP) + STU (mainly at new cryogenic team)
- Photon beamlines: ShanghaiTech U / SARI
- Experiment stations: ShanghaiTech U / SARI, SIOM (100PW laser mainly)



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Issues(a lot) and advantages(little)

- Complexities at management/administrative level.
- Different financial/accounting systems/rules.
- Different cultures (Education vs. research, science vs. engineering)

- Support from fundamental sciences(e.g. High-Q/G mechanism, etc.)
- More grad students
- Adjunct professorships
- more choice on coffee/restaurant, pre/primary schools……

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SHINE Civil Construction: near completion

Tunneling machine reaches shaft #2 on August 5, 2021.

On the floor of SHINE linac tunnel, Bart and Yuhui, who once worked for DESY and EU-XFEL， Nov.24, 2021.

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Key techs for large SC-based XFEL projects

EXFEL

LCLS-II

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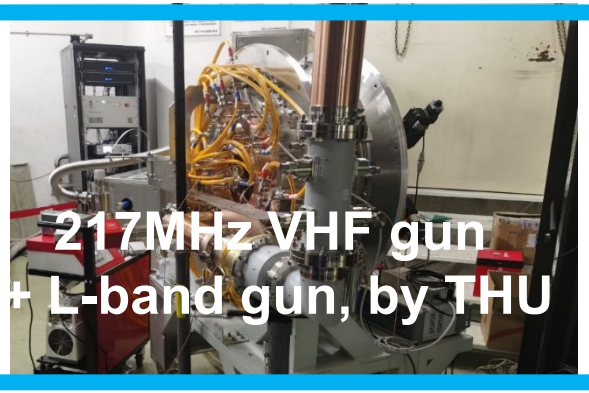


And Now Comes SHINE

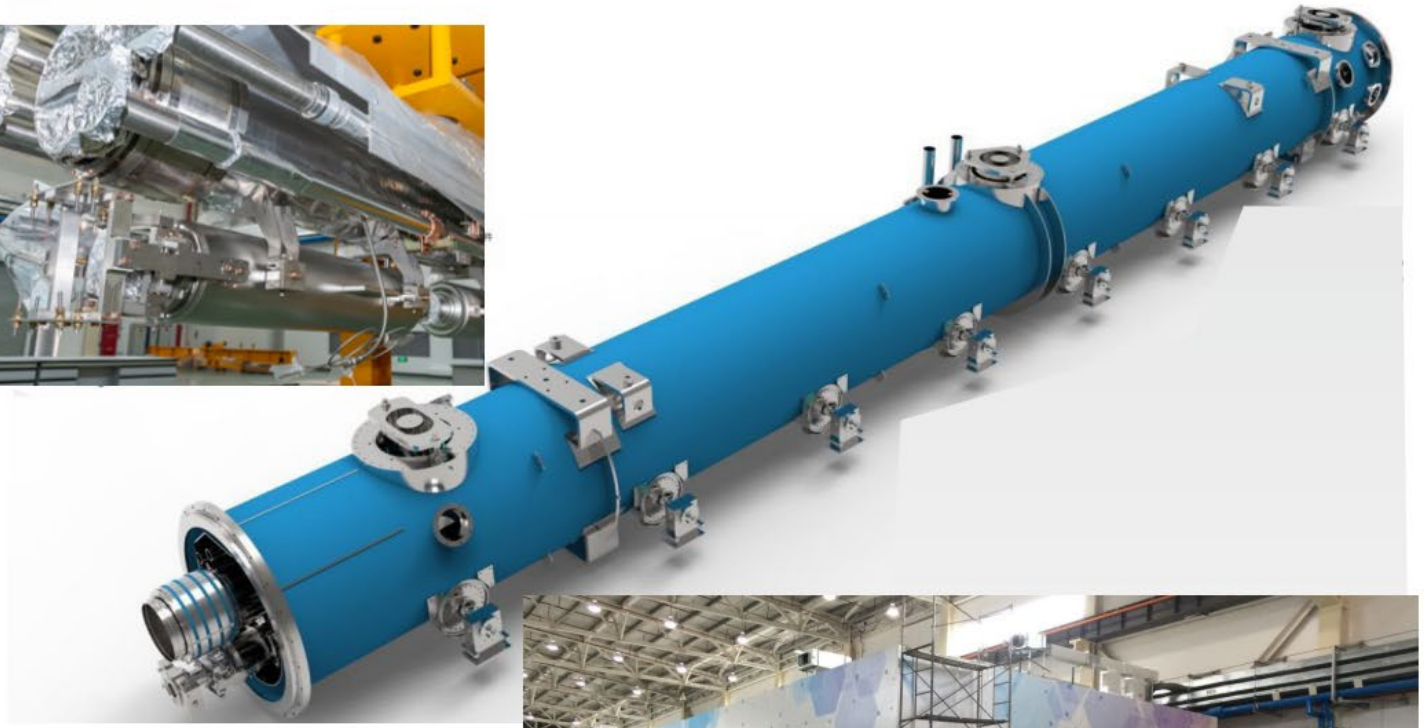
H. Weise, FEL2019

Chinese institutes are well known TESLA partners

SHINE activities profit from

- Published XFEL and LCLS-II R&D results
- Published TESLA / ILC R&D results
- Longtime TTC membership of several Chinese institutes (**IHEP, PKU, Tsinghua, IMP**)
- **IHEP Beijing** qualified a vendor (CX / WUXI) by building an XFEL prototype cryomodule
- IHEP was contracted to build 58 of the 103 **European XFEL cryostats**, with execution at WUXI
- Meanwhile WUXI activities include fabrication of all **LCLS-II cryomodules**, and also **FRIB cryostats and transfer lines**.
- Last BUT NOT LEAST: a large fraction of the Nb sheets used are coming from **OTIC Ningxia**.

More about several years of industrialization at Chinese vendors see e.g. J. Gao, ICHEP2018.

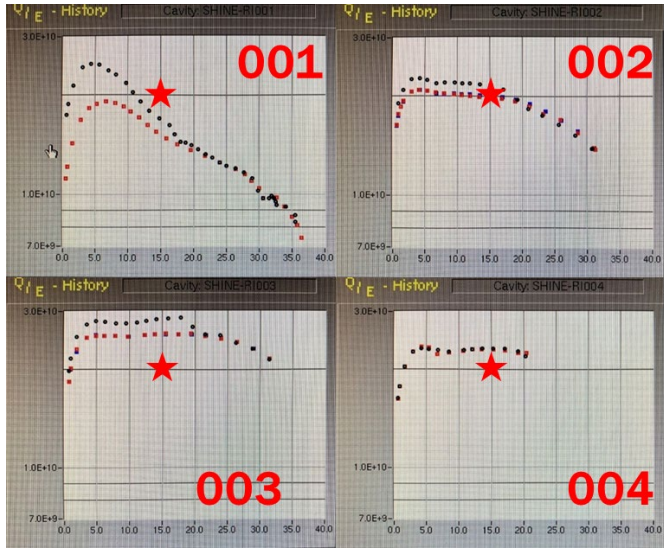


International collaborations

SHINE-RI 001-004
(9-Cell large grain cavities)
first turn of vertical test at DESY
for all the four SHINE-RI 9-cell
large grain cavities
has been successfully done

- Very important
- Hard in pandemic
- Still productive:

DESY, LASA, KEK, ESS, etc



Two visiting young scientists,
Yuefeng LIU and Chen LUO,
Stayed at DESY for 3 years

SHINE

SRF R&D Infrastructures: next

Talk in TTC2018, Milan

General information of SRF R&D programs

	IMP	IHEP	PKU	SINAP
Driven project	HIAF/ADS	HEPS/CEPC R&D	XFEL	XFEL
Infrastructure locations	HIAF site Huizhou	HEPS site Huairou	Same location	XFEL site Zhangjiang
SRF R&D fund	TBD	~50M$	~10M$	~100M$

All working well now

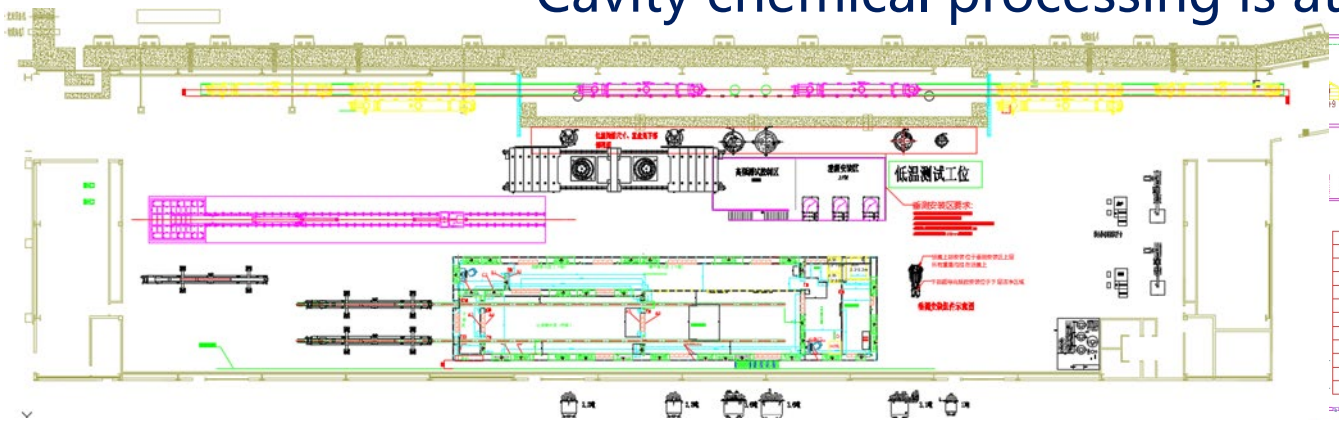
SRF Infrastructures in major institutions

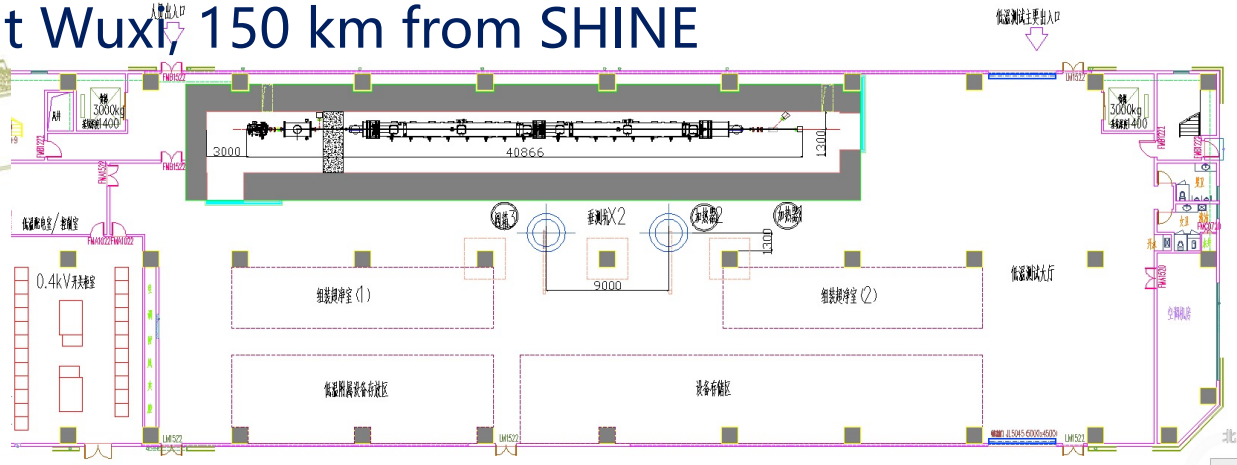
	Cryoplant-T	VTS	Space	CM-int./HTS	EP/N_doping
PKU	70W@2K	1x2cav	~2000m^2	2-cav CM	Yes/9-cell
IHEP-HR	300W@2K	3x4cav	~5000m^2	8-cavCM/2HT	Yes/9-cell
IMP-GD	TBD	yes	~TBD m^2	Yes	yes
SINAP	1000W@2K	4x4 cav	~8000m^2	8-cavCM/4HT	Yes/9-cell

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

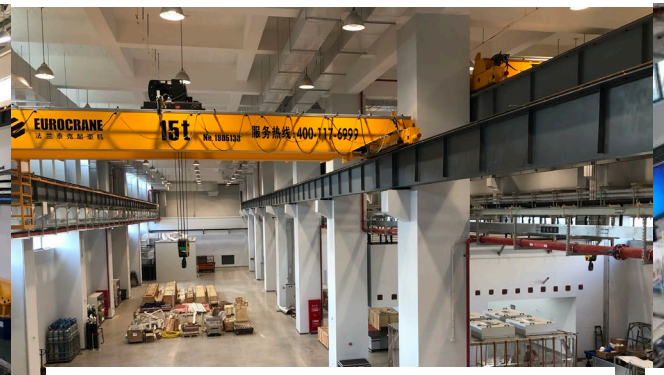
Cavity chemical processing is at Wuxi, 150 km from SHINE





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, install

Cryoplant for RF test
1kW@2K reached 2021

SHINE Progress: Cryogenic and SRF Testing

1kW@2K Cryoplant:
the largest superfluid helium cryogenic system in China with 1kW@2K has turned into operation to support the continuous cryogenic test.

The largest superfluid helium cryogenic system in China with 1kW@2K has finished the SAT （site acceptance test) in July , and has already supported six test benches among the HTB (Horizontal test BENCH),VTC(vertical test cryostat), MTC (multi functional test cryostat) to achieve 2K.

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First 4kW cryoplant installations start spring 2022, commissioning late 2023.

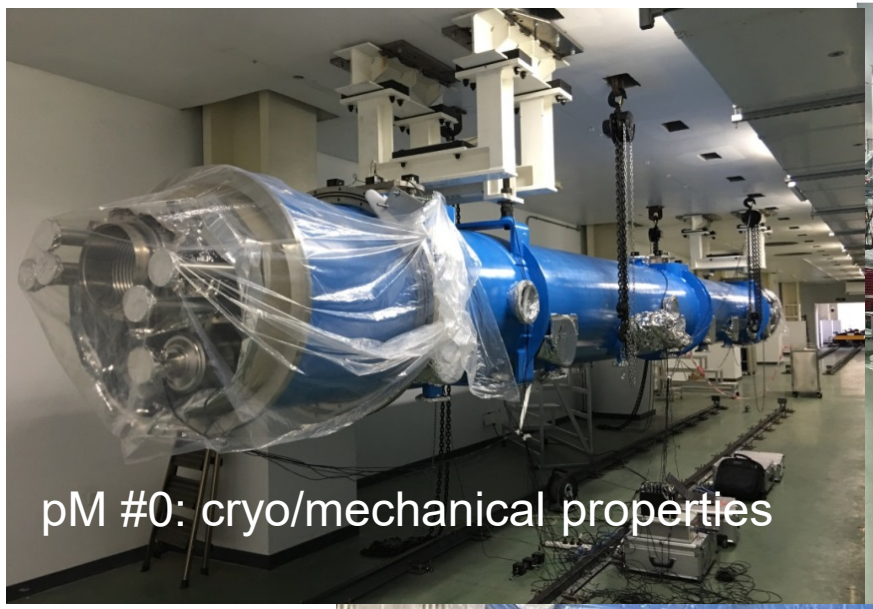
Collaborations with industries: pleasant and efficient

- Module assembly: 40 industry people involved, doubled soon
- Cryo-plant: cooperations with ALAT team very efficient
- Cavity treatment: build new facility at Wuxi, work perfectly
- Cavity/module test team: work jointly with industry
- Strengthen supply chain: for all key parts/components, domestic and international.

SHINE

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 2023.


pM #0: cryo/mechanical properties


pM #1 standard CM


pM #2 short CM

Industry team on SHINE site for module assembly/tests will double next year for series production.

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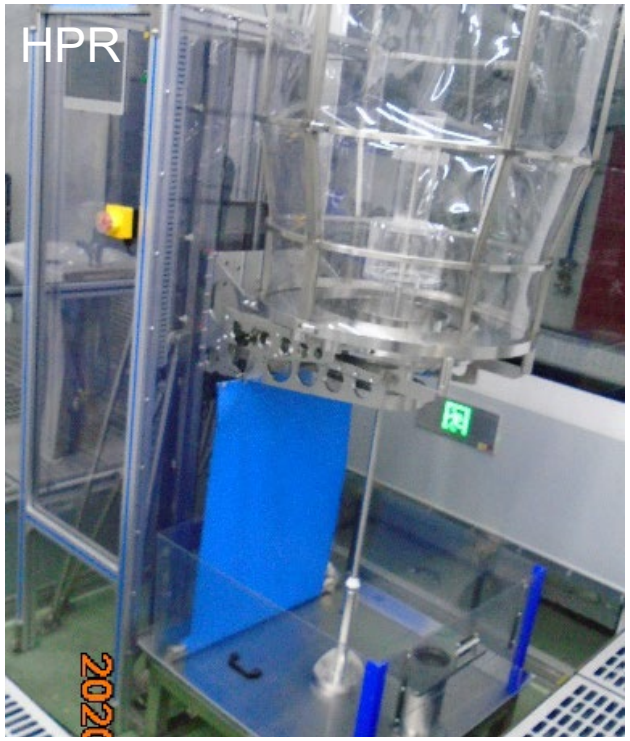
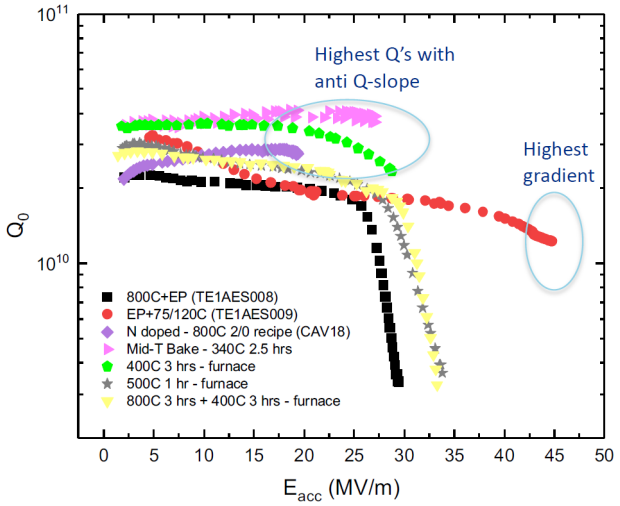
SHINE cavity treatment facility at Wuxi Creative



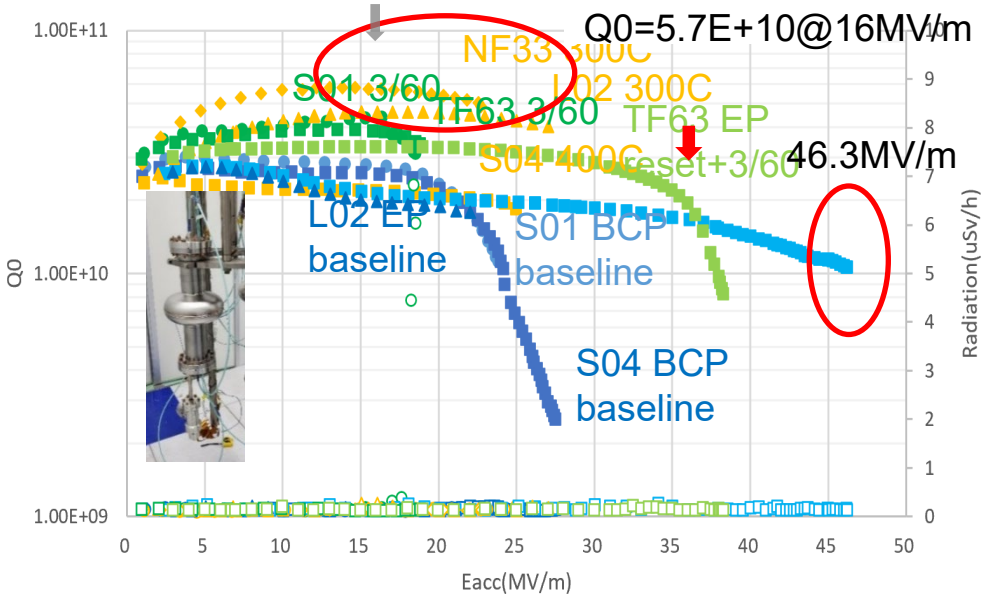
SHINE built a dedicated cavity facility at Wuxi

State-of-the-art treatments studied



4 6/29/2021 A. Romanenko I SRF'2021

2021 无锡平台处理单cell腔垂测结果

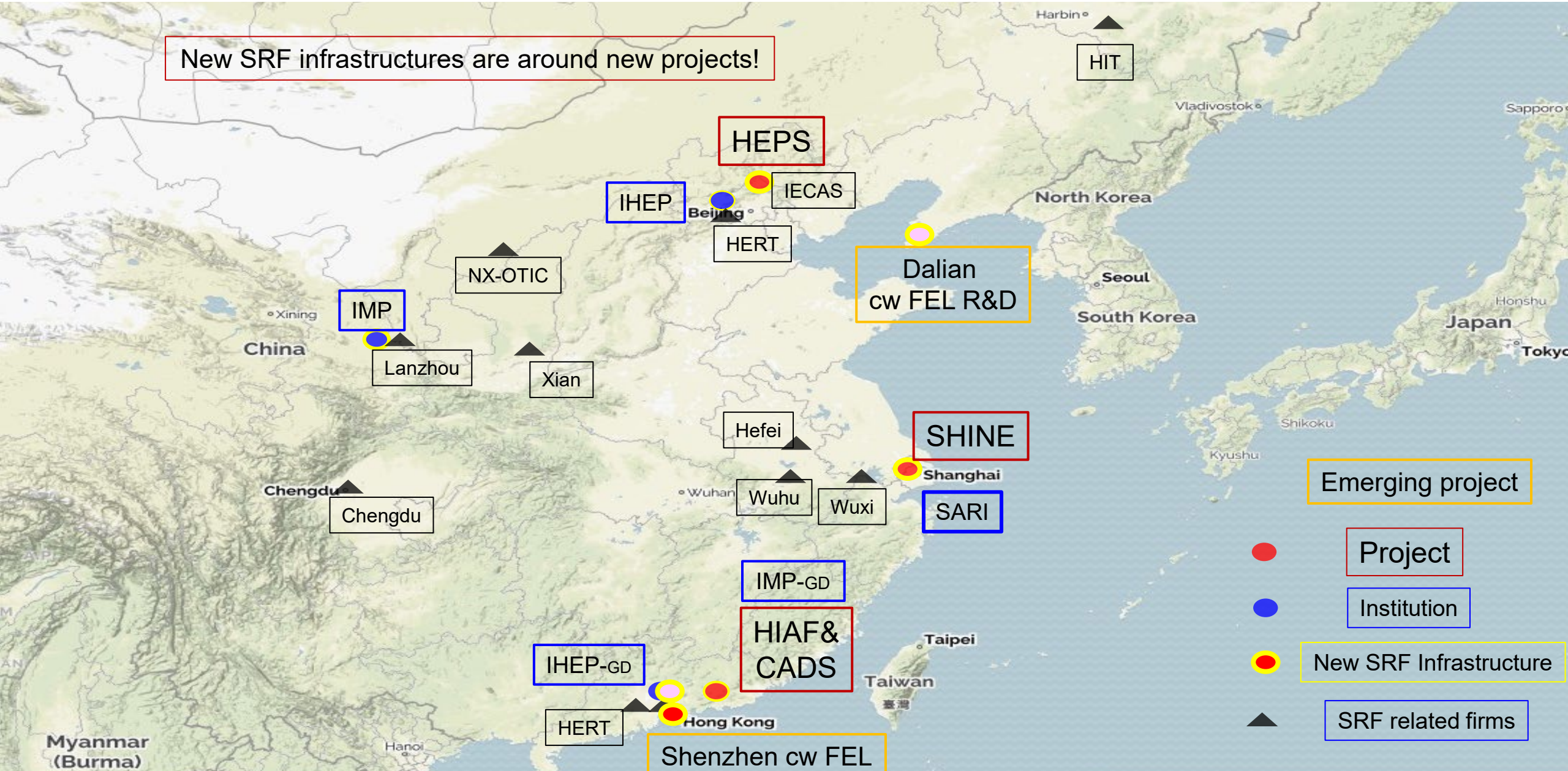


Details see Talk by J.Chen WG2 at same time

DESY team visit WXCX 2019.11

SHINE facility works great. 2021.12

SRF map in China: Facilities/Infrastructure/Industry



Major industry partners and suppliers for SHINE

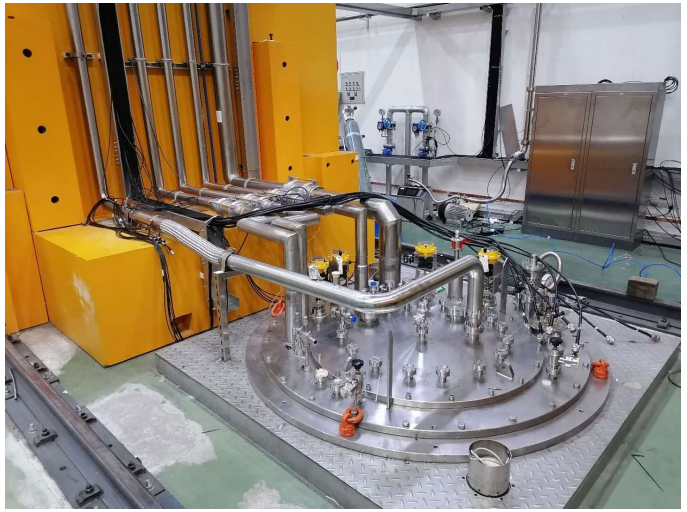
(Up to early 2022)

		Domestic			International	
Cryogenic system	**2K system**	Fuhaicryo			ALAT	Linde
	Distributions	SHINE				
Electron gun	**High rep-rate gun**	THU	PKU			
	Cathode	SHINE			LASA	
Linac	**Nb materials**	NX-OTIC	emerging		TD	
	1.3 GHz Cavity fabrication	NX-OTIC	HE-Racing	HIT	RI/DESY	Zanon
	Cavity-processing	NX site		Wuxi site	RI	Zanon
	VT	PKU	IHEP	SHINE+Wuxi	DESY/SHINE	SHINE
	1.3GHz FPC	HE-Racing	ECPE	IOE	CPI	RI-Tales
	SSA	KT	Wattsine	Tongfang		
	Assembly	SHINE+SI				
	HT	SHINE+Wuxi				
SC undulator	**SC coils**	Western-SC	Eight-horses			
Others	**e.g. Cavity BPM**	ECPE	Andesun	SKY		

Main testing facilities at SHINE site

Clean room tools

Cryogenic test for components



VT dewar

Assembly tool

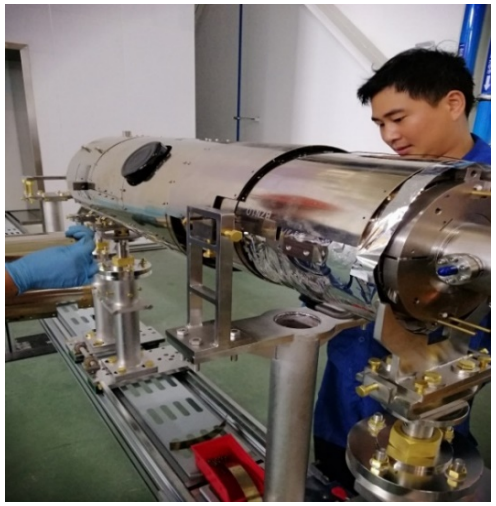
FPC conditioning device

HT feed-cup

Components assembly

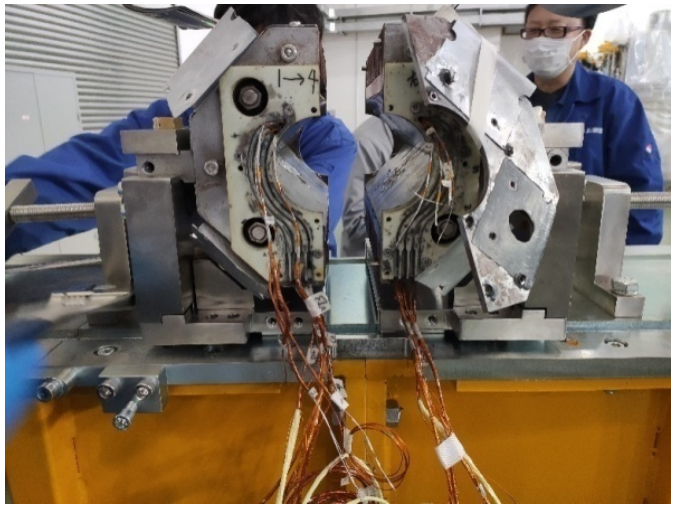
Bellows

Cold mass

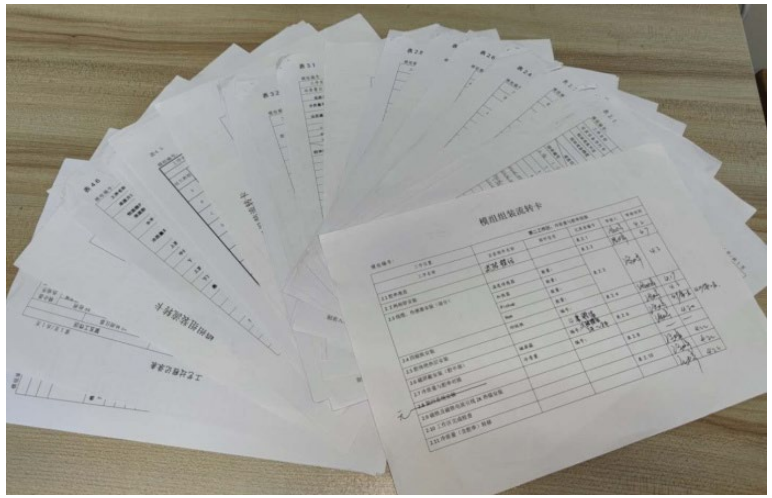


Magnetic shielding

FPC warm part



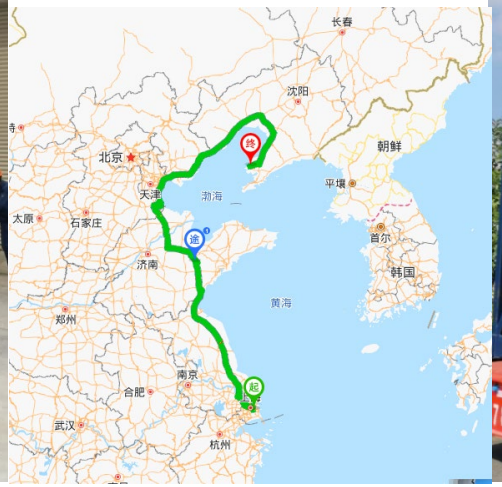
Magnet



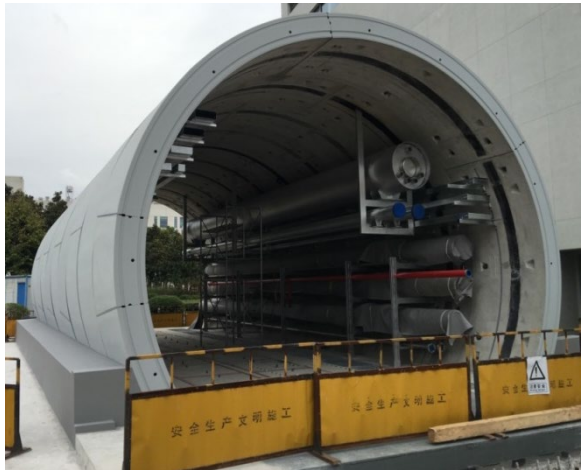
QA documents

CM installation & transportation test and so on

Tools for CM installation



Loading for CM (Shanghai)



Mock-up tunnel

CM test after transportation (Dalian)

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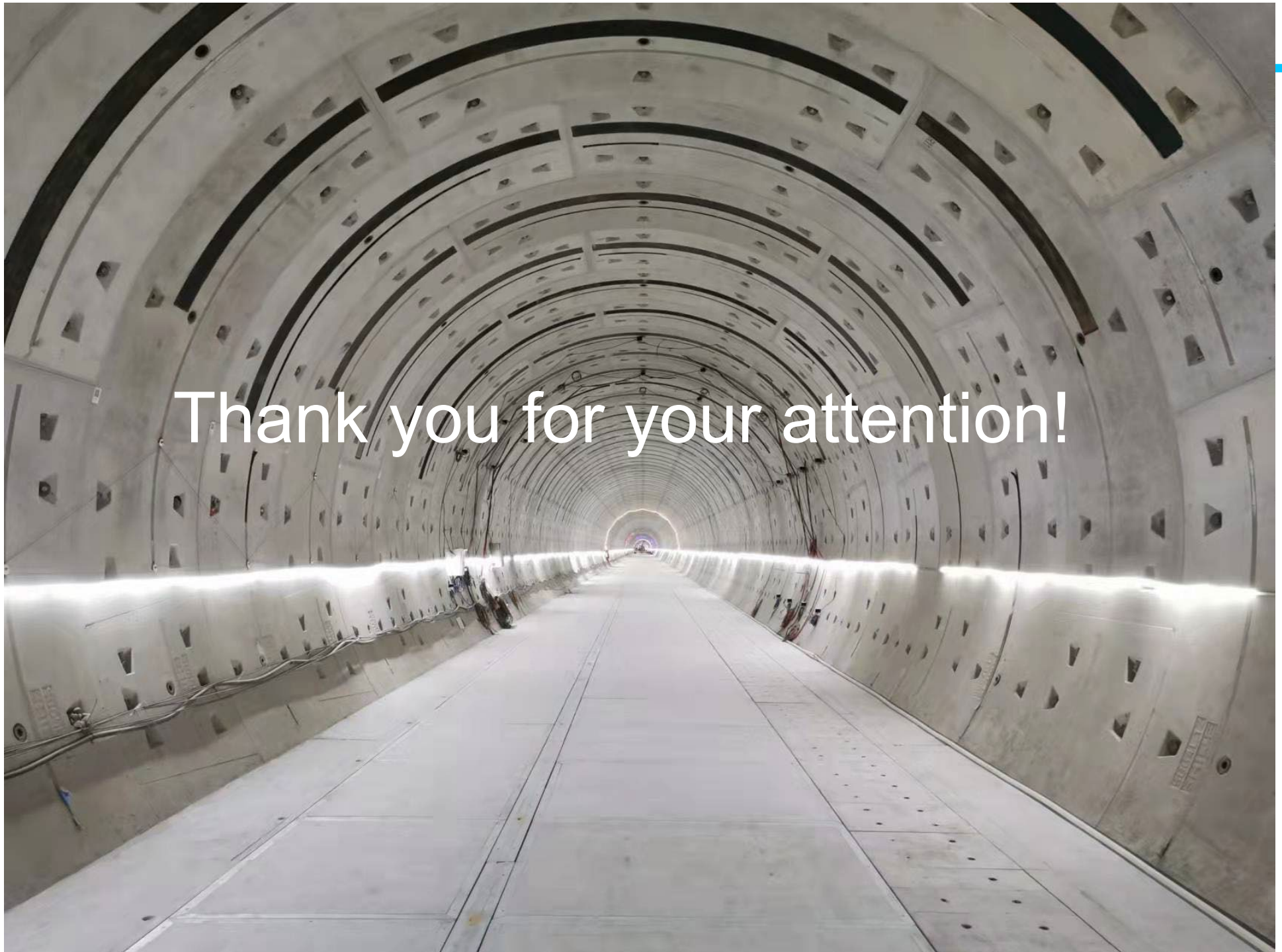
Summary

- The challenge of multi-labs collaboration is always huge. This is especially true for SHINE project since three major institutions are quite different. Despite of all kinds of difficulties the SHINE project has been advancing significantly.
- Collaborations with multi-industries (domestic and international) are important and generally fine, up to now.
- International collaborations face some real challenges. It is believed our community will find the way. TTC is of great spirit and practice.

We are willing to contribute as much as we can.

SHINE


Thank you for your attention!