CEPC/SPPC Accelerator summary

M. Biagini, INFN-Frascati

2018 Int. Workshop on the High Energy CEPC, IHEP, Nov. 14th 2018

Accelerator talks

CEPC accelerator physics *20'*
Speaker: Mr. Chenghui Yu (IHEP)

CEPC parameter optimization and lattice design *20'*
Speaker: Dr. Dou Wang (IHEP)

CEPC lattice design and DA optimization with error *20'*
Speaker: Mr. Yiwei Wang (IHEP)

CEPC beam-beam study and dynamic aperture study with errors
Speaker: Dr. Yuan Zhang (IHEP)

Coherent beam-beam instability in SuperKEKB and CEPC (KEK) *2*
Speaker: Prof. Kazuhito Ohmi (KEK, Japan)

CEPC orbit control *20'*
Speaker: Yuanyuan Wei (IHEP)

CEPC Injection/extraction and timing *20'*
Speaker: Dr. Xiaohao Cui (IHEP)

CEPC collective instabilities *20'*
Speaker: Yadong Liu

CEPC MDI *20'*
Speaker: Dr. Sha Bai (IHEP)

CEPC injector Linac beam dynamics *20'*
Speaker: Meng Cai (IHEP)

CEPC injector based on plasma based accelerator
Speaker: Wei Lu (Tsinghua University)

"CEPC polarization" *20'*
Speaker: Sergei Nikitin (BINP, Russia)

CEPC linac injector R&D *20'*
Speaker: Prof. Jingru Zhang (IHEP)

CEPC SRF system *20'*
Speaker: Mr. Jiyuan Zhai (IHEP)

CEPC SCRF cavity R&D *20'*
Speaker: Dr. Peng SHA (ihep)

CEPC RF power source *20'*
Speaker: Dr. Zusheng Zhou (IHEP)

CEPC Cryogenic system *20'*
Speaker: Jianqian zhang (IHEP)

CEPC Vaccum chamber system *20'*
Speaker: Mr. Haiyi Dong (Accelerator Center, IHEP)

CEPC booster magnets *20'*
Speaker: Dr. Wen Kang (Magnet Group, Accelerator Centor, IHEP)

CEPC collider magnets *20'*
Speaker: Dr. Fusan Chen (Institute of High Energy Physics, CAS)

CEPC power source and electrostatic separator *20'*
Speaker: Prof. Bin Chen (IHEP)

CEPC final focus SC magnets and anti solenoid designs *20'*
Speaker: Prof. Yingshun Zhu (IHEP)

Radiation and shielding *20'*
Speaker: Dr. Yadong Ding (IHEP)

CEPC mechanics *20'*
Speaker: Ms. Haijing Wang (IHEP)

Accelerator sessions

CEPC instrumentation *20′*
Speaker: Dr. Yanfeng Sui (IHEP)

CEPC control system *20′*
Speaker: Gang Li (IHEP)

CEPC survey syetem *20′*
Speaker: Mr. Xiaolong Wang (高能所)

CEPC tunnel design and Conventional facility *2*
Speaker: Prof. Jinshu Huang (IHEP)

CEPC SCRF R&D Infrastructure 10′ and EP 10′
Speaker: Dr. Song Jin (IHEP)

Green CEPC *20′*
Speaker: Dr. Zhenchao LIU (IHEP)

SuperKEKB interaction region (25′+3′) *28′*
Speaker: Zhanguo Zong (KEK, Japan)

SuperKEKB online luminosity monitoring (15′+3′) *18′*
Speaker: Chengguo Pang (LAL, France)

CEPC LumiCal design and R&D progress (15′+3′) *18′*
Speaker: Suen Hou (SINICA)

Physics background in luminosity measurement at CEPC (15'+3')
Speaker: Prof. Ivanka Bozovic (Vinca Institute of Nuclear Sciences)

Beam-monitor instrumentation for ILC (15′+3′) *18′*
Speaker: Konstantin Afanaciev (BSU, Belarus)

CEPC detector backgrounds (15'+3') *18′*
Speaker: Wei Xu (IHEP)

SPPC review *20′*
Speaker: Prof. Jingyu Tang (IHEP)

SPPC Lattice design *20′*
Speaker: Yukai Chen (IHEP)

SPPC longitudinal daynamics *20′*
Speaker: Dr. Linhao Zhang (IHEP)

SPPC Collimationdesign (Vidyo) *20′*
Speaker: Dr. Jianquan Yang (IHEP)

Collimator *20′*
Speaker: Maria de los Angeles Faus Golfe (Orsay, France)

SPPC high field magnets *20′*
Speaker: Dr. Qingjin XU (IHEP)

Total 42 talks

Personal remarks

- I was impressed by the huge and high quality work
- All talks were well prepared, clear and on time
- All sides of the complicated chain of accelerators, which will in the end result in the powerful CEPC collider, were carefully studied
- A plan for the TDR in just 3 years has been done
- A massive R&D work is undergoing or is ready to start as soon as budget/manpower allows for
- A lot of new (also for China) technology is being studied for the first time "in-house"
- All this work can guarantee success as far as the realization of the project is concerned (*luminosity is never guaranteed*...)
- *For lack of time this summary will cover just some of the topics presented at the workshop → Sorry!*

CEPC TD Timeline

TDR from 2018-2022

CEPC

2015 | 2020 | 2025 | 2030 | 2035

Pre-studies (2013-2015)	R&D Engineering Design (2016-2022)	Construction (2022-2030)	Data taking (2030-2040)

1st Milestone: Pre-CDR (by 2015) ;2nd Milestone: R&D funding from MOST (in Mid 2016);
3rd Milestone: CEPC CDR Progress Report (April 2017); 4th Milestone: CEPC CDR Report (publsih in July, 2018);5th Milestone: CEPC TDR Report and Proto R&D (by the end of 2021);6th Milestone: CEPC construction start (2022);

SPPC

2020 | 2030 | 2040

CDR and R&D (2014-2035)	Engineering Design (2035-2040)	Construction (2040-2045)	Data taking (2045-2060)

J. Gao

Lattice, beam dynamics, beam-beam, instabilities

CEPC collider lattice

- Linear optics of the CEPC collider ring fulfills requirements of the parameters list, geometry, photon background and key hardware
- Further optimization of Dynamic Aperture udergoing
- For Higgs mode, dynamic aperture with the errors currently considered fulfills the requirements of on-axis injection
- Further study with larger tolerance of misalignment is undergoing and the goal for Δx and Δy is 100 μm

- **Plan for TDR:**
  - Interaction Region design: optimization with progress of MDI study
  - RF region design: scheme with septum magnet to reduce number of electrostatic separators
  - Dynamic Aperture optimization: further optimization to get more margin for reduction due to error, longer QD0, more tuning knobs…
  - Error tolerance: study of looser tolerances
  - Lattice optimization for the polarization at Z energy

Y. Wang

Beam-beam

- Coherent beam-beam instability in head-tail mode has been predicted in strong-strong beam-beam simulation.
- Understanding this instability is very important for future colliders (CEPC/FCCee) based on crab waist scheme.
- The instability was observed in SuperKEKB commissioning as is predicted.
- Horizontal beam size blow-up has been observed depending on horizontal tunes of two beams.
- Bunch oscillation was detected, but streak camera did not show the signals of instability.
- Simulation in the experimental condition shows reasonable agreement. Probably mode coupling between +1(e^-) and -5(e^+) modes.
- More systematic tune scan, identify peak position.

Importance of benchmarking simulations on a real machine

K. Ohmi

Impedance and instabilities

- Impedance budget for all components estimated
- No showstopper shown for the current design. Parameters at Z show the most critical instability requirements
- Single bunch intensity mainly restricted by the Transverse Mode Coupling instability. Bunch lengthening is expected with the design bunch intensities
- Impedance of the electro-separator needs to be further optimized in order to avoid coupled bunch instability and to decrease the parasitic power loss
- Coupled bunch instabilities due to RF HOMs and resistive wall instability can be damped by feedback systems
- Fast beam ion instability and electron cloud instability need to be damped by transverse feedback system
- The electron cloud requires a minimum bunch spacing of 25 ns

Y. Liu

Injectors

Linac, Sources and Damping Ring design

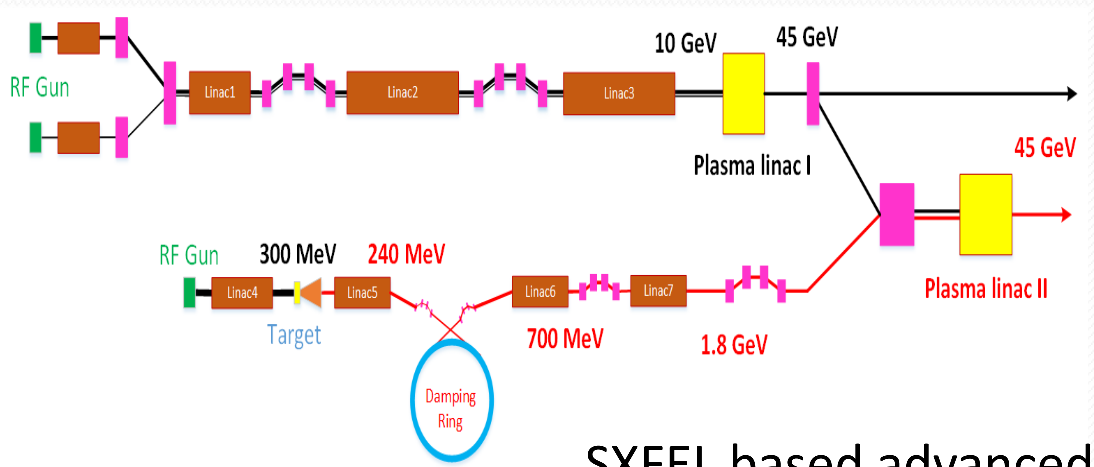
- Design meets requirements of Booster, beam dynamics and error study
- **Needs high reliability and availability**
- Linac can be upgraded for future
- Plan towards TRD:
  - Installation space
    - The lattice of CDR Linac design have included accelerating structures, quadrupoles, dipoles (EBTL+AMs), correctors, BPMs, ICTs, PRs; **have provide the first version survey data.**
    - The install space have been considered, but need to check with the "actual" element;
    - Parameters of magnets maybe have some modification, especially the aperture of quadrupoles at the low energy part of positron linac;
    - Solenoids and waveguide installation space of positron source part
    - Maybe more PRs …
  - Positron source
    - Target and supporting thermal stress and mechanical analysis
  - Damping Ring
    - IBS && CSR consideration
    - ECS && BCS design
  - Error study
    - Start-to-end simulation
    - Including more errors

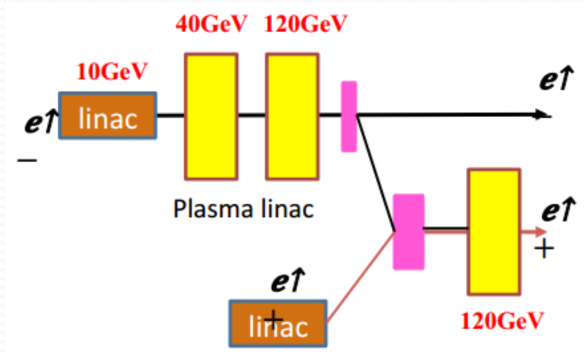
C. Meng

NEW

Experimental Verification Plan in SXFEL-TF for CEPC Plasma Injector

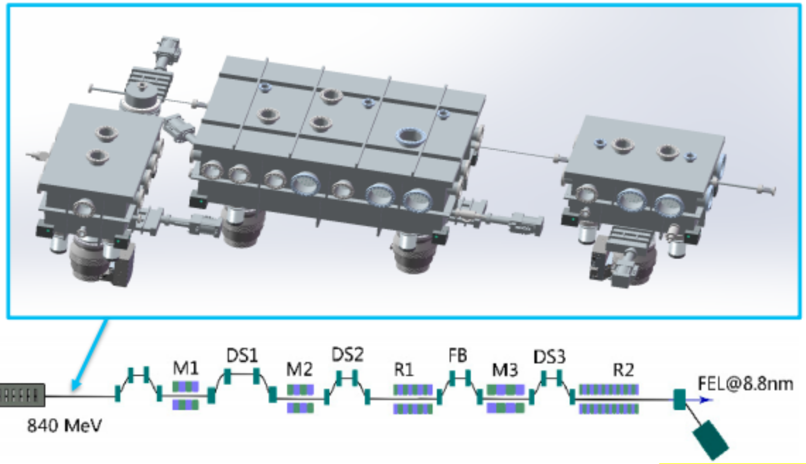
A dedicated budget of 10 Million has been allocated by IHEP





SXFEL based advanced accelerator research platform

Electron (SXFEL-TF)	
Energy	840MeV
Energy spread(rms)	≤0.1%
Norm. Emittance(rms)	≤1.5mmmrad
Length(FWHM)	≤1ps
Charge	0.5nC
Repetition rate	10Hz



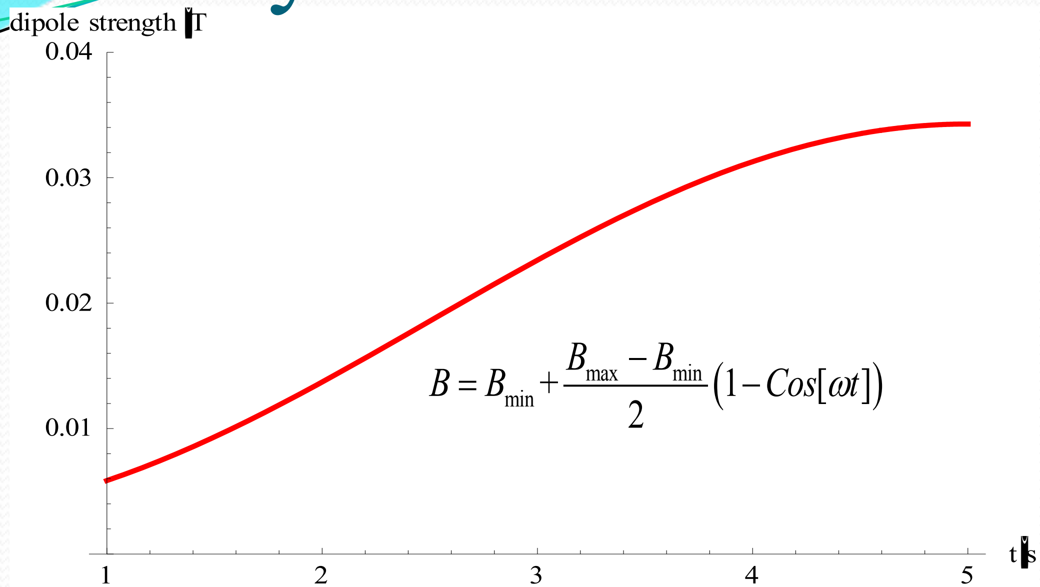
W. Lu

Booster design

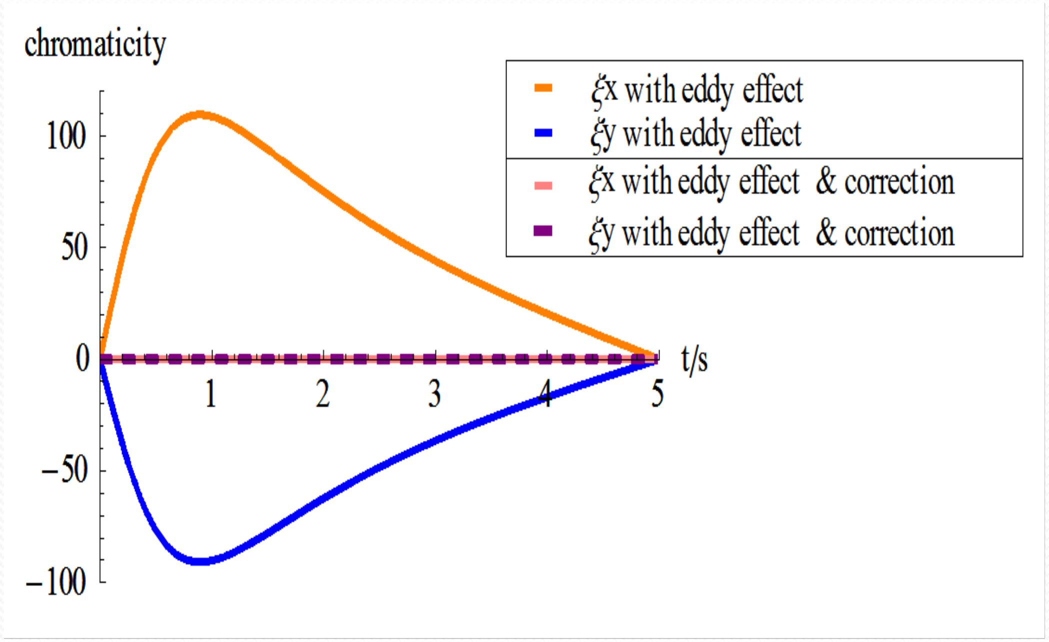
- Booster design meets injection requirements at three energy modes
- Accelerator physics design satisfies requirements of geometry, beam dynamics and key hardware
- Effect of errors studied → tolerable
- DA reduction due to eddy current effect is serious and local correction with extra sextupolar coils was designed
- Low B field is still a challenge. Both technical and physical solutions are studied continuously
- Plan towards TDR:
  - Eddy current correction
  - DA optimization
  - Simulation of the entire period from injection to extraction – beam loss rate
  - Effect of detector leak field & shielding design
  - Table ramping design & simulation

D. Wang

Eddy current effect



- During ramping, parasitic sextupole field is induced on beam pipe inside dipoles due to eddy current
- Ramping rate is limited by eddy current effect
- Dedicated ramping curve to control the maximum K2



- Chromaticity distortion is corrected by 2 sext. families (SF, SD) during ramping.
- K2 reach maximum at 20GeV
- K2 curve is checked by dynamic magnetic 3D simulation

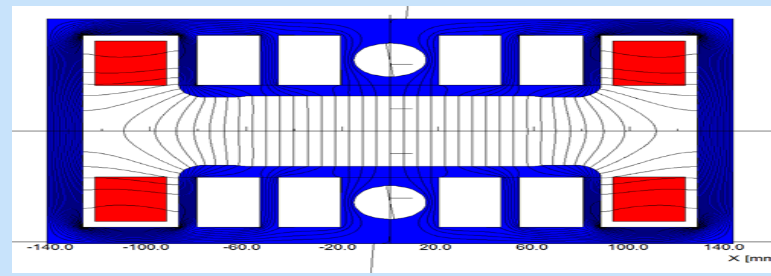
Low field dipole magnets

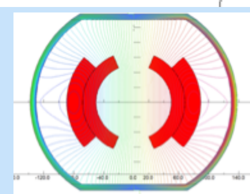
- Challenges:
  - Field error <29Gs*0.1%=0.029Gs
  - Field reproducibility <29Gs*0.05%=0.015Gs
  - The Earth field ~0.2-0.5 Gs, the remnant field of silicon steel lamination ~ 4-6 Gs

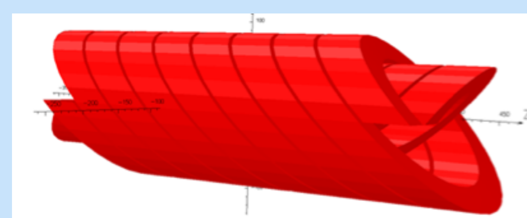
- Thinking beyond CDR
  - Wiggler dipole scheme
  - Combine the magnets with core and without core
  - Combine CCT dipole with sextupole coils
  - …

- Solutions by technical way
  - With magnetic core - dilution (better material)
  - Without magnetic core (higher power)

    a) CT   b) CCT





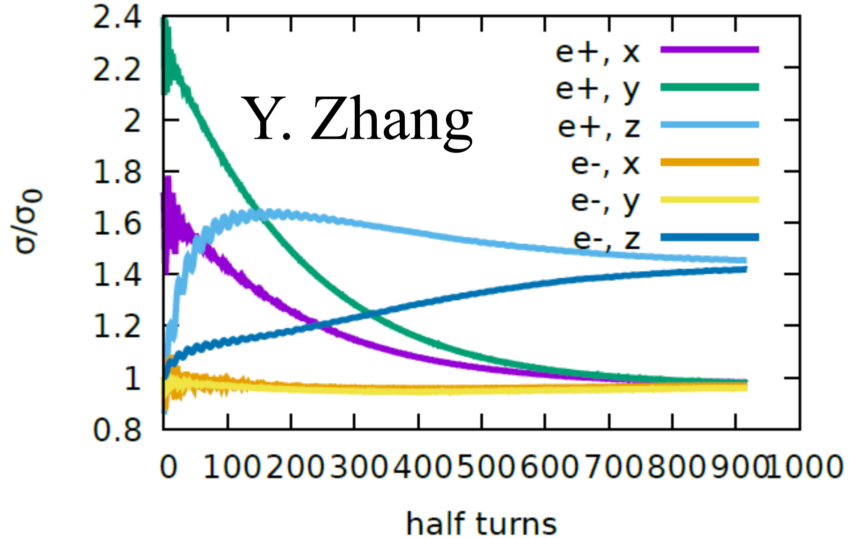


Key parameters for injection

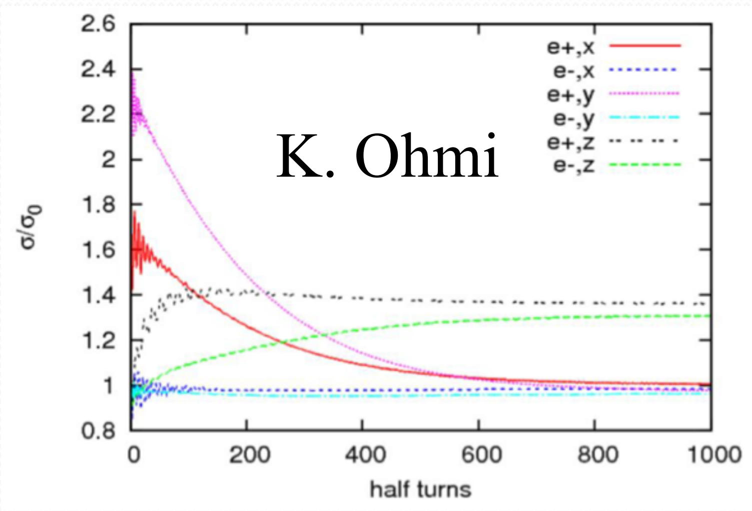
	Higgs	W	Z
Energy (GeV)	120	80	45.5
Bunch number	242	1524	12000
Bunch Charge (nC)	24	19.2	12.8
Bunch Current (mA)	17.4	87.9	461
Revolution Period (ms)	0.3336	0.3336	0.3336
Emittance x/y (nm)	1.21/0.0031	0.54/0.0016	0.17/0.004
Life time (Hour)	0.67	1.4	4
Full injection from empty (min)	10	15	130
Injection	ON-axis (DA=8σ_x)	OFF-axis (DA=13σ_x)	OFF-axis (DA=13σ_x)

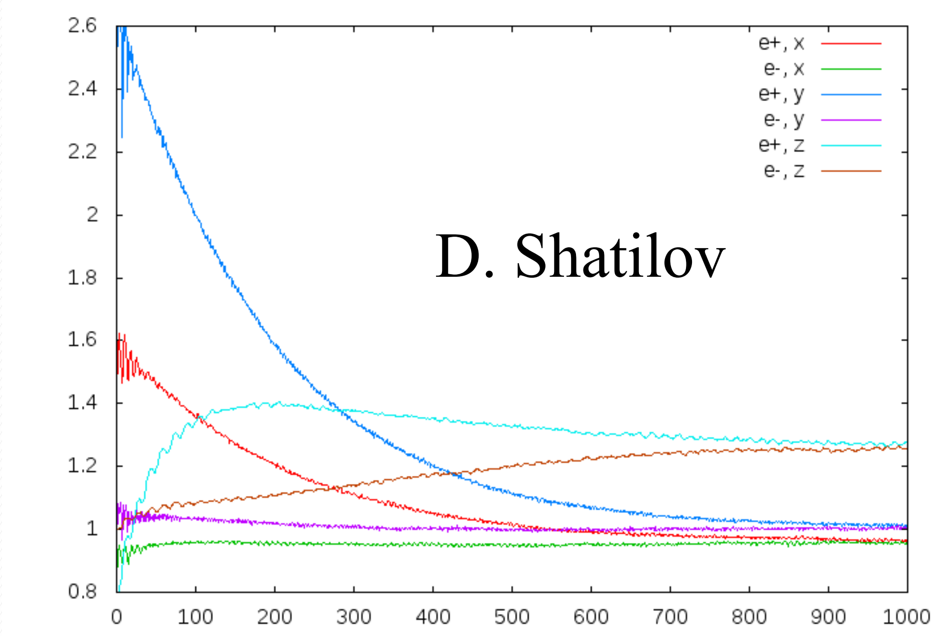
C. Xiaohao

On-axis injection @ Higgs



- **Different codes agree well**
- **There is no flip-flop instability**
- **Collision is stable**





Collaboration is the key to understand!

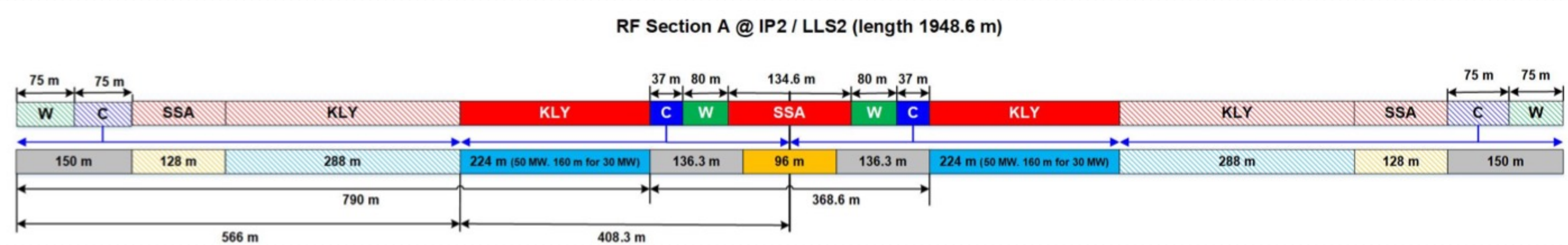
Technological systems

SRF

- CDR design of SRF system completed with considerations on various operational requirements & scenarios and particular beam-cavity interactions and technical issues
- SRF key components and test cryomodule design and R&D progress well, especially the world leading high Q cavity and high power SRF components
- More resources needed to complete TDR R&D in 2019-2023
- Eager for international collaboration and synergy with other SRF projects

J. Zhai

SRF Layout

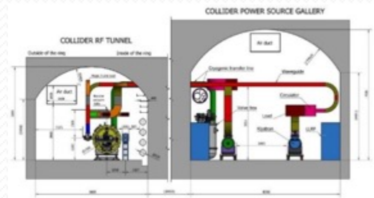


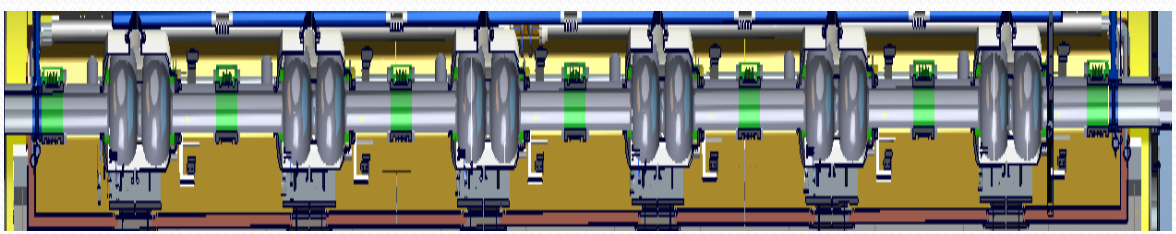
30 MW Higgs:

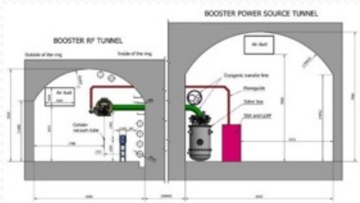
Collider: **240** 650 MHz 2-cell cavities in 40 cryomodules (6 cav./ module)

Booster: **96** 1.3 GHz 9-cell cavities in 12 cryomodules (8 cav. / module)

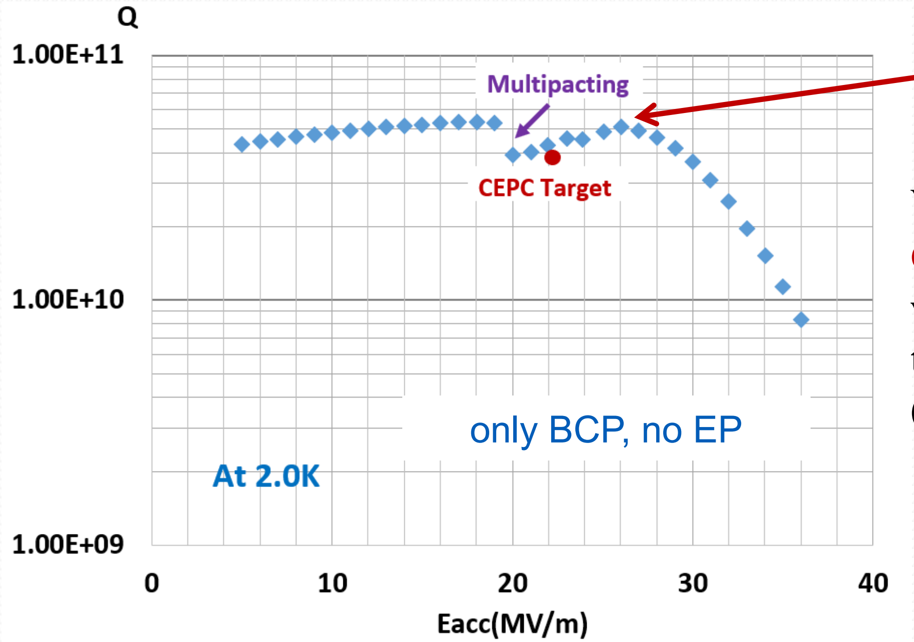
50 MW Higgs upgrade: add 16 Collider modules







Vertical test of 650 MHz 1-cell cavity



High Q & High gradient!

Vertical test result:
Q_0=5.1E10@26.0MV/m,
which exceed the CEPC target
(Q_0=4.0E10@22.0MV/m)

Helmholtz coil for degassing

中国科学院高能物理研究所
Institute of High Energy Physics
Chinese Academy of Sciences

P. Sha

SRF goals

- Research on N-doping/N-infusion, increase the Q value (650 MHz, 1.3 GHz) by N-doping/N-infusion and EP further
- Complete eight 1.3 GHz 9-cell cavities for SHINE: 2.7E10@16MV/m. Besides, Complete 8 couplers for these cavities: 14kW (traveling wave)

1 y

- **2021**: Exceed CEPC target (650MHz 2-cell: 4E10@22MV/m, 1.3GHz 9-cell: 3E10@24MV/m）； Transfer N-doping/N-infusion technology to HE-RACING TECHNOLOGY (HERT). Meanwhile: 600 cavities for SHINE start batch production
- **2023**: Master Nb_3Sn coating technology. Complete coating with 1.3 GHz cavity. Goal: $Q=1.0\times10^{10}$@E_{acc}=5~10MV/m (at 4.2K)

3-5 y

TDR plan for SRF System

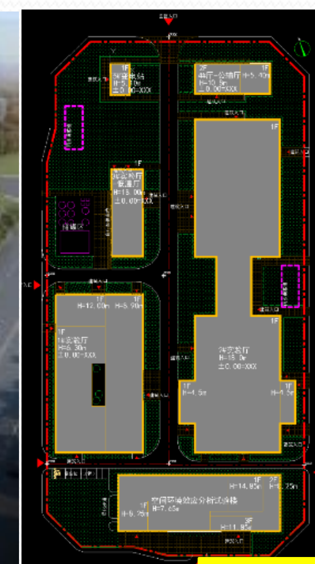
Time	TDR R&D Plan	Resources (in CNY)
2018-2020	• System design and optimization • Key technology R&D • 650 MHz test cryomodule	• MOST CEPC 7 M (650 MHz, IHEP & PKU) • PAPS 20 M (650 MHz & 1.3 GHz) • SHINE R&D 13 M (1.3 GHz cavity and coupler) • 4 FTEs now, 2 more FTEs needed
2020-2022	• Cryomodule prototyping	• 80 M (one 650 MHz & one 1.3 GHz module with power sources) • SHINE pre- and mass production ? M (1.3 GHz) • 12 FTEs
2022-2023	• Industrialization and pre-production • Cryomodule beam test	• 90 M (three 650 MHz modules + two 1.3 GHz modules) • SHINE mass production ? M (1.3 GHz) • 18 FTEs

SRF facility

- SCRF R&D Infrastructure will be built before 2020: including cleanrooms, VT and HT test stands, N-doping and Nb3Sn furniture, Cu-Nb sputtering system, Optical inspection, Pre-tuning machine, and so on
- An EP facility for both R&D and mass production was developed and finished main functional test at IHEP. It will be transferred to Ningxia soon

SCRF R&D Infrastructure

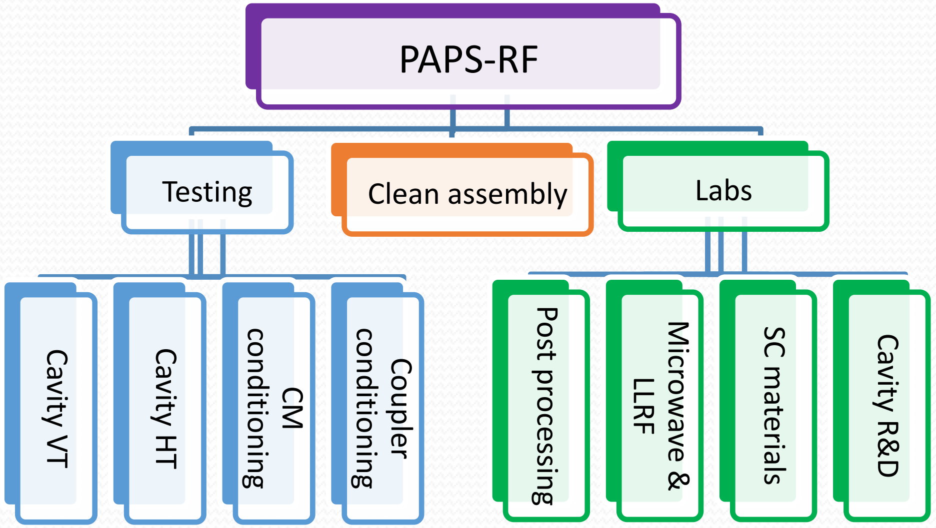
- SCRF R&D infrastructure mainly based on Platform of Advanced Photon Source Technology R&D project (PAPS)
- Budget: 500M CNY funded by Beijing Gov, from 2017.5-2020.6
- Construction: Consist of 7 systems:
  - **RF system**
  - Cryogenic system
  - Magnet technology
  - Beam test
  - X-ray optics
  -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



S. Jin

PAPS-RF system

- 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
  - Post-processing, clean assembly, VT/HT/conditioning of cavities, couplers, and cryomodules
  - 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
  - Total area of 4500 m^2
- Cryogenic system: 300W @ 2K



High efficiency klystrons design

- Increasing the klystrons efficiency is one key to energy saving!
- 3 designs currently considered:
  - Scheme 1: Optimize cavity chain by using the same gun as 1st tube
  - Scheme 2: With high voltage gun (110 kV/9.1 A), low perveance
  - Scheme 3: MBK, 54 kV/20 A electron gun

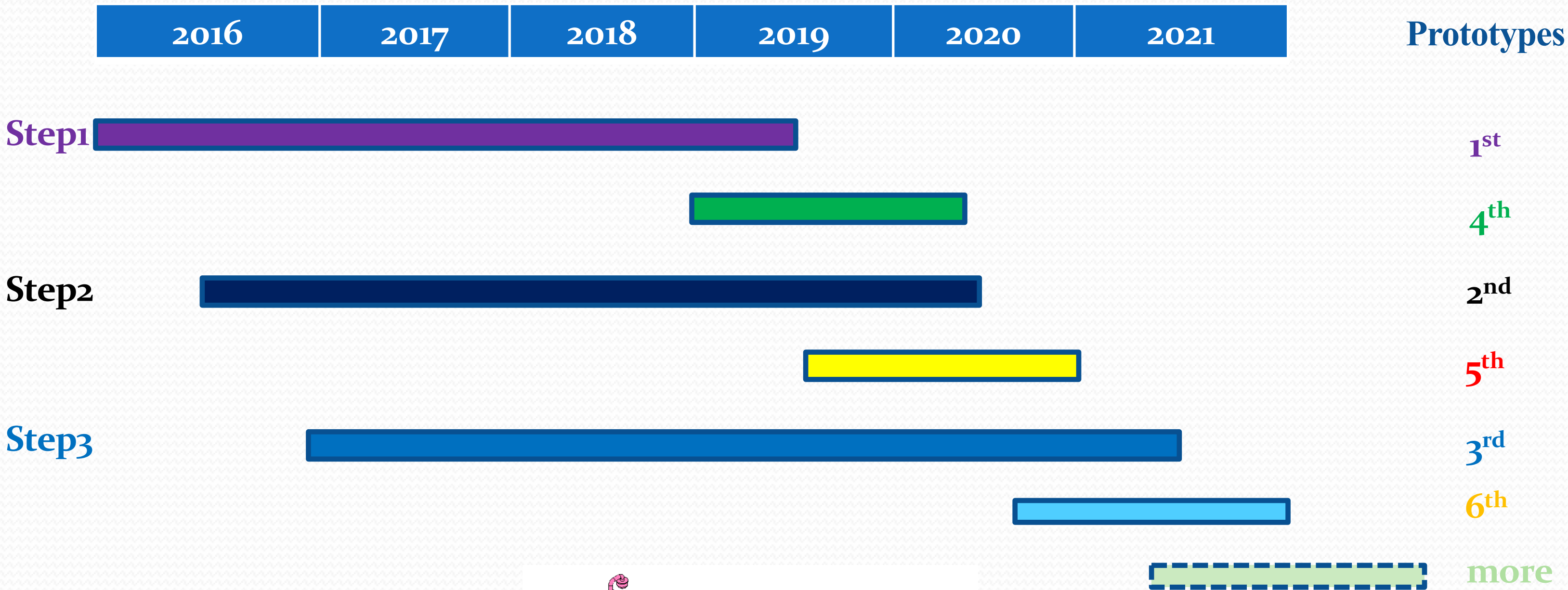
Parameter	Scheme1	Scheme2	Scheme3
Freq. (MHz)	650	650	650
Voltage (kV)	81.5	110	54
Current (A)	15.1	9.1	20(2.5×8)
Beam No.	1	1	8
Perveance (μP)	0.65	0.25	1.6(0.2×8)
Efficency (%)	>70	~80	>80
Power(kW)	800	800	800(100×8)

The three different schemes for the high efficiency klystron design are ongoing simultaneously and more prototypes will be manufactured in the near future

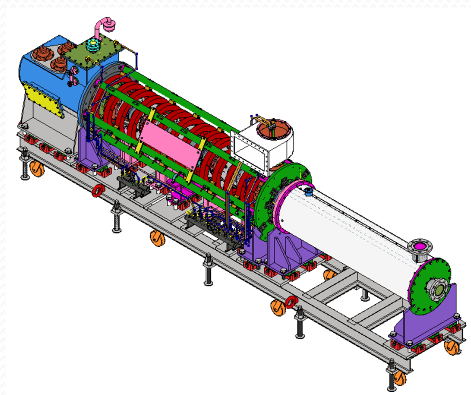
Z. Zhou

Strategy and plan (2016 to 2021)

3 or *more* klystron prototypes



1st tube: All drawings of the 1st prototype finished and it has been processed and manufactured in the machine shop



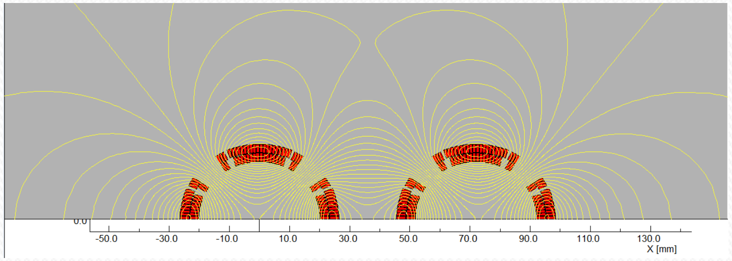
The manufacturing of the 2nd prototype will be started based on the most mature scheme as soon as possible

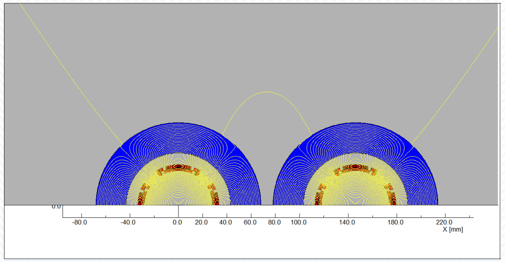
Similar efforts in US and EU → collaboration ?

IR magnets R&D

- SC magnets in IR are key devices for CEPC. Conceptual design is finished
- Field cross talk effect between two apertures in QD0 and QF1 can be acceptable
- TDR plan is ready
- Prototypes superconducting magnets are proposed, and R&D has started
- In the R&D stage prototype SC magnets will be developed in 3 steps:
  1. Development of double aperture SC quadrupole prototype magnet QD0
  2. Development of short combined function SC prototype magnet including QD0 and anti-solenoid
  3. Development of long combined function SC prototype magnet including QD0, QF1 and anti-solenoid

➢ **R&D Step 1 has started:** Development of double aperture SC quadrupole prototype QD0

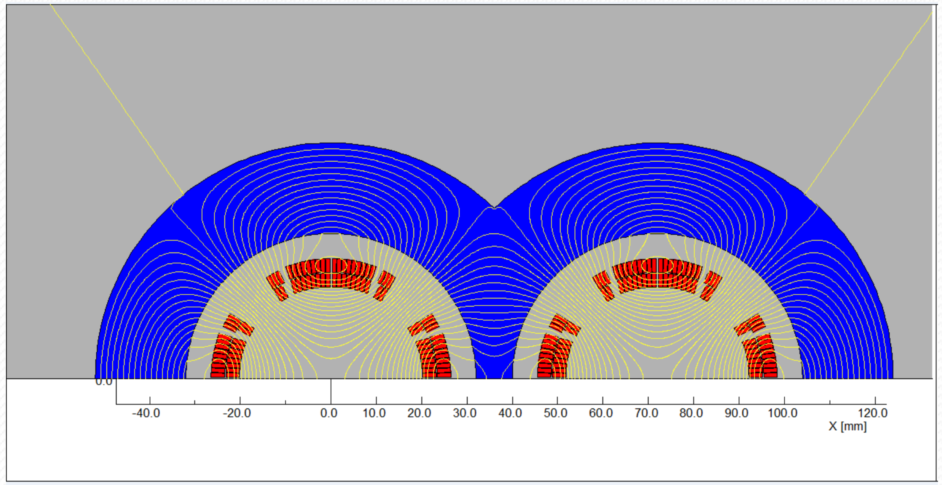


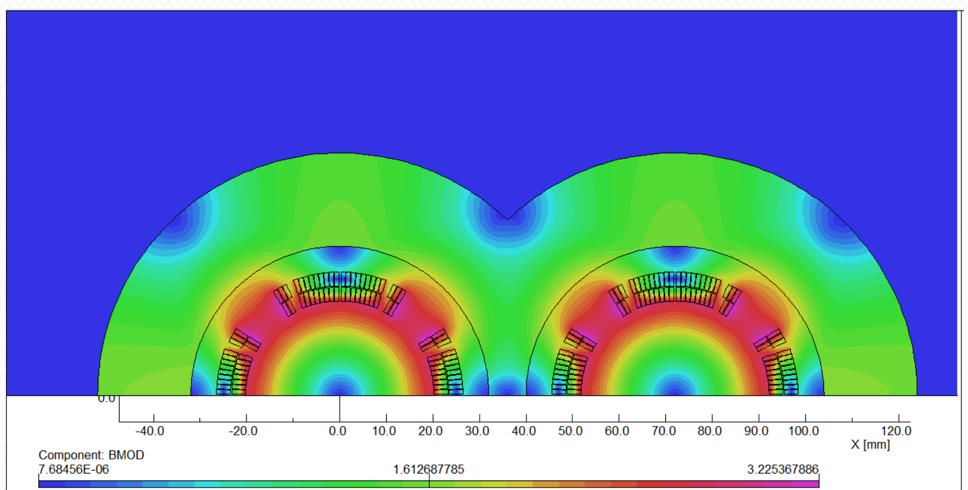


Y. Zhu

QD0 design option with iron yoke

- An alternative design option for QD0 with iron yoke is under investigation





Nearest to the IP point

IR SC magnets TDR plan

- **2018**
- Complete conceptual design of SC magnets in Interaction Region
- Preliminary design of short prototype of double aperture quadrupole QD0
- **2019**
- Complete physical design, mechanical design, stress and quench analysis of short prototype double aperture quadrupole QD0
- Fabrication of short prototype of double aperture quadrupole QD0
- Development of rotating coil magnetic field measurement system
- Development of quench protection system
- Preliminary design of the cryostat for combined function magnet
- **2020**
- Finish physical design, mechanical design, stress and quench analysis of superconducting quadrupole magnet QD0, QF1 and anti-solenoid
- Complete cryogenic vertical test of short prototype of QD0
- Fabrication of short combined function SC magnet prototype
- Complete design of cryostat for combined function SC magnet

- **2021**
- Complete cryogenic vertical test of short prototype of combined SC magnet
- Complete fabrication of cryostat for combined function SC magnet prototype
- Fabrication of long prototype of combined function SC magnet

- **2022**
- Complete cryogenic test of long prototype of combined SC magnet
- Summary of the R&D prototype magnets
- Complete the Technical Design Report (TDR) of IR SC magnets

Booster magnets TDR plan

2018：

- ✓ Study on the high precision low field dipole magnets.
- ✓ Complete designs of several subscale prototype dipole magnets.

2019:

- ✓ Produce all kinds of subscale prototype dipole magnets.
- ✓ Complete design of the prototype quadrupole magnet with hollow aluminum conductor coils.

2020:

- ✓ Based on the test results of subscale prototype dipole magnets, complete design of the full-scale prototype dipole magnet.
- ✓ Complete production of the prototype quadrupole magnet.

2021:

- ✓ Complete production and test of full-scale prototype dipole magnet.
- ✓ Complete test of prototype quadrupole magnet.

2022:

- ✓ Complete TDR of the booster ring magnets

W. Kang

Collider magnets

- Over 80% of collider ring is covered by conventional magnets

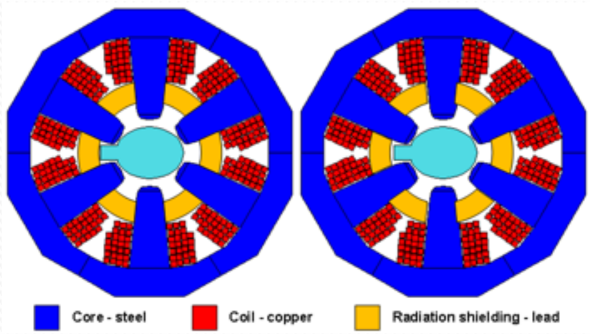
	Dipole	Quad.	Sext.	Corrector	Total
Dual aperture	2384	2392	-	-	13742
Single aperture	80*2+2	480*2+172	932*2	2904*2	
Total length [km]	71.5	5.9	1.0	2.5	80.8
Power [MW]	7.0	20.2	4.6	2.2	34

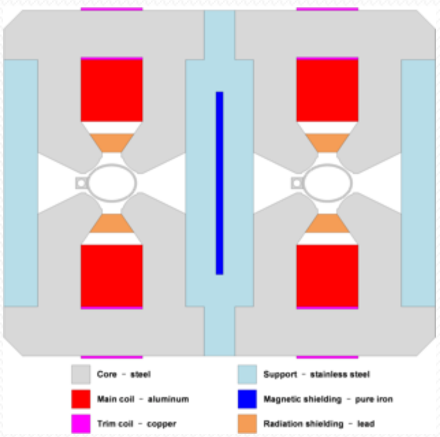
- The most important issues are Cost & Power Consumption
  - Make the magnets compact and simple
  - Use Aluminum for the coils
  - Dual aperture magnets save nearly 50% power
  - Consider the combined function magnets
  - Increase the coil cross section and decrease the operating current

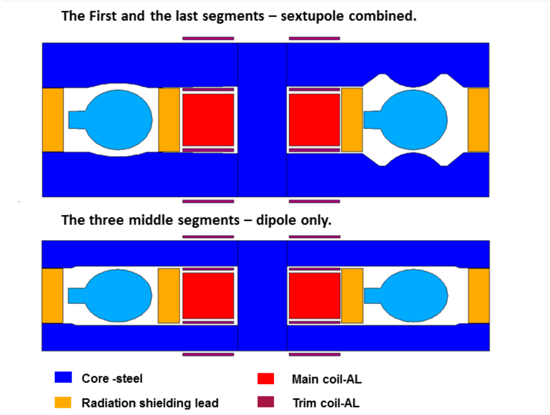
F. Chen

Magnet prototypes

- Prototypes of dual aperture dipole and dual aperture quadrupole are under development
- Dual aperture dipole prototype research goals:
  - Pure iron solid core instead of laminations
  - Dipole/Sextupole combined field quality
  - Step-like pole surface for low cost easy machining
- Dual aperture quadrupole prototype research goals:
  - Field cross talk between two apertures while changing trim current
  - Compensation effect of the middle iron plate with different shape
  - Coils made of aluminum hollow conductor
- Try to reduce the cost







CEPC power budget: green option

- Some power can use the renewable power such as wind, water, solar…
- 20% of wind power is wasted in China each year, price of wind power is the same as coal power at 2020

	System for Higgs 30MW	Location and electrical demand(MW)						Total (MW)
		Ring	Booster	LINAC	BTL	IR	Surface building	
1	RF Power Source	103.8	0.15	5.8				109.75
2	Cryogenic System	11.62	0.68			1.72		14.02
3	Vacuum System	9.784	3.792	0.646				14.222
4	Magnet Power Supplies	47.21	11.62	1.75	1.06	0.26		61.9
5	Instrumentation	0.9	0.6	0.2				1.7
6	Radiation Protection	0.25		0.1				0.35
7	Control System	1	0.6	0.2	0.005	0.005		1.81
8	Experimental devices					4		4
9	Utilities	31.79	3.53	1.38	0.63	1.2		38.53
10	General services	7.2		0.2	0.15	0.2	12	19.75
	Total	213.554	20.972	10.276	1.845	7.385	12	266.032 (86.522, 32.5%)

Z. Liu

SPPC

- Long term project with limited resources: need manpower and funding
- One SPPC chapter and one HFM R&D section in the CEPC CDR report
- Low-level efforts on accelerator physics will continue
- Challenging R&D as high field SC magnets, are being addressed and well supported
- SPPC high field magnet R&D:
  - Phase I: 12 T, all-HTS (iron-based conductors)
  - Phase II: 20-24 T, all-HTS

J. Tang, Q. Xu

R&D on SC magnets

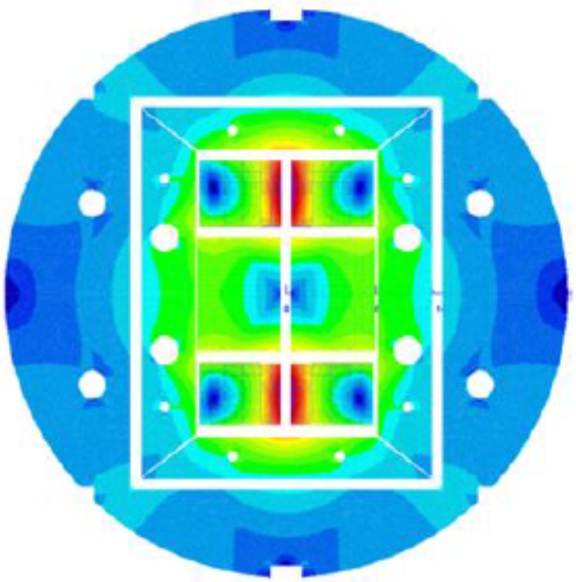
- ***SPPC design scope:*** *12 T IBS magnets to reach 70TeV with 100 km circumference. Upgrading phase: 20~24 T IBS magnets to reach 125~150 TeV.*
- *Strong domestic collaboration for the advanced HTS conductor R&D: Make IBS the High-T_c and High-Field "NbTi" conductor in 10 years!*
- ***R&D of high field magnet technology:*** *the 1st twin-aperture model dipole ($NbTi+Nb_3Sn$) reached 10.2 T @ 4.2 K; the 2nd model dipole ($Nb_3Sn+IBS$) is being tested. 15 T twin-aperture model dipole and 12 T twin-aperture model dipole with field quality to be developed.*
- ***CERN & China Collaboration:*** *Fabricating 12 units CCT corrector magnets for HL-LHC before 2022， and expecting more in future…*

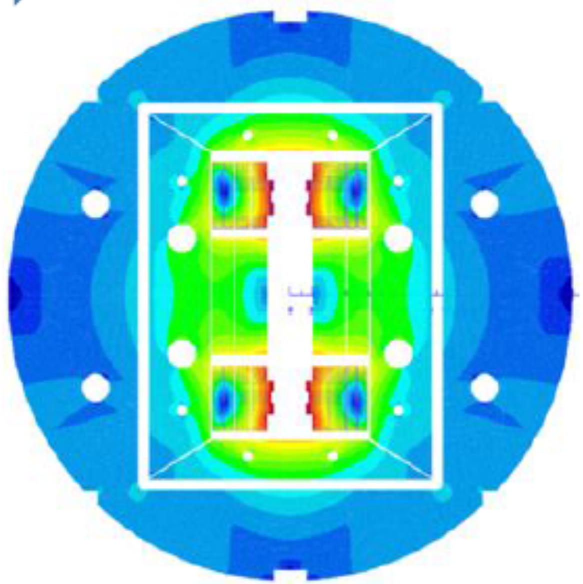
Q. Xu

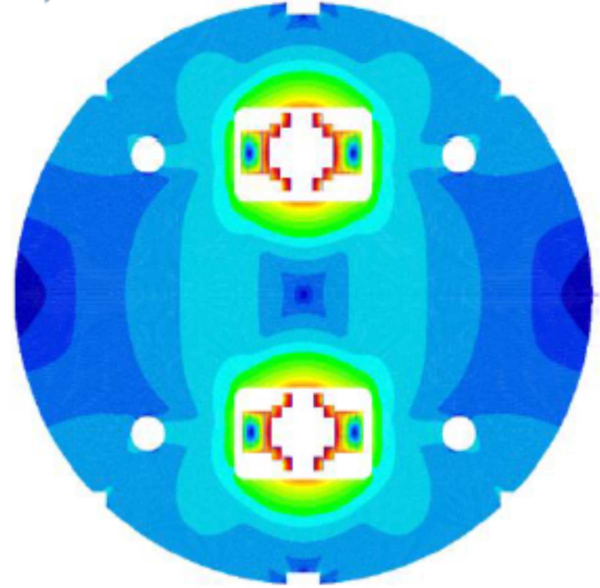
R&D of High Field Dipole Magnets

R&D Roadmap for the next 10~15 years

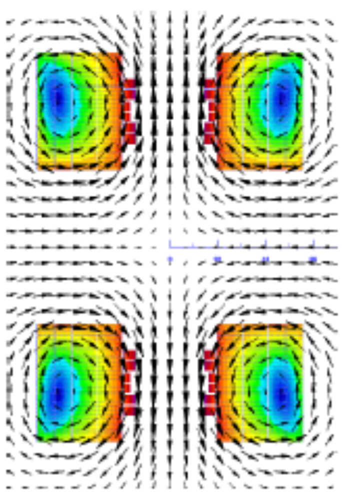
$NbTi+Nb_3Sn$, 2*ϕ10 aperture → **Nb_3Sn+HTS, 2*ϕ20 aperture** → **All HTS, 2*ϕ40 aperture**



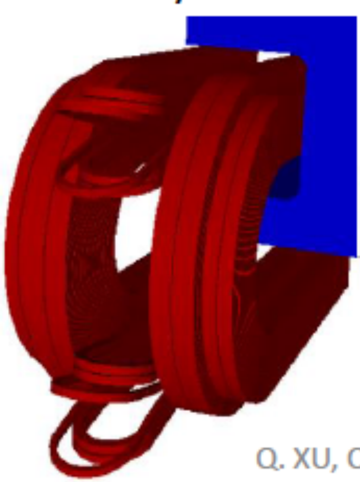




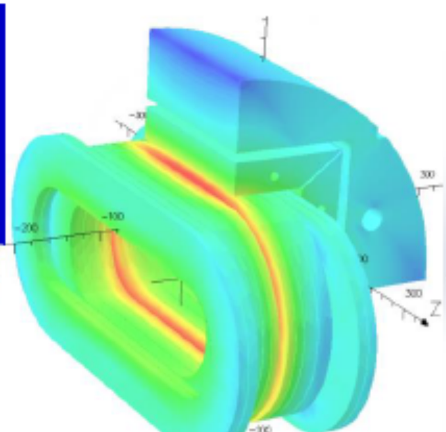
Magnetic flux distribution



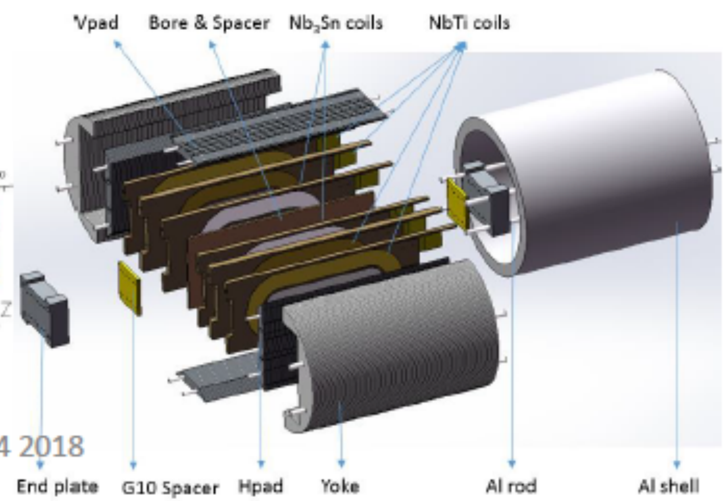
3d coil layout



3D magnetic field distribution

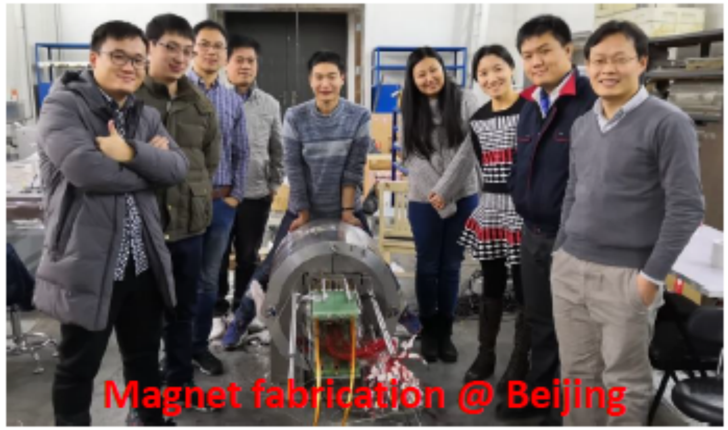


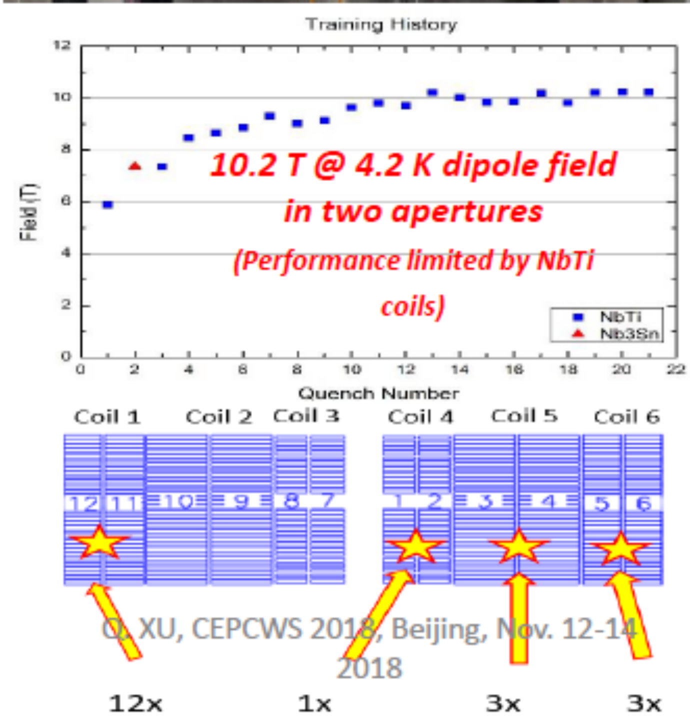
Components and assembly

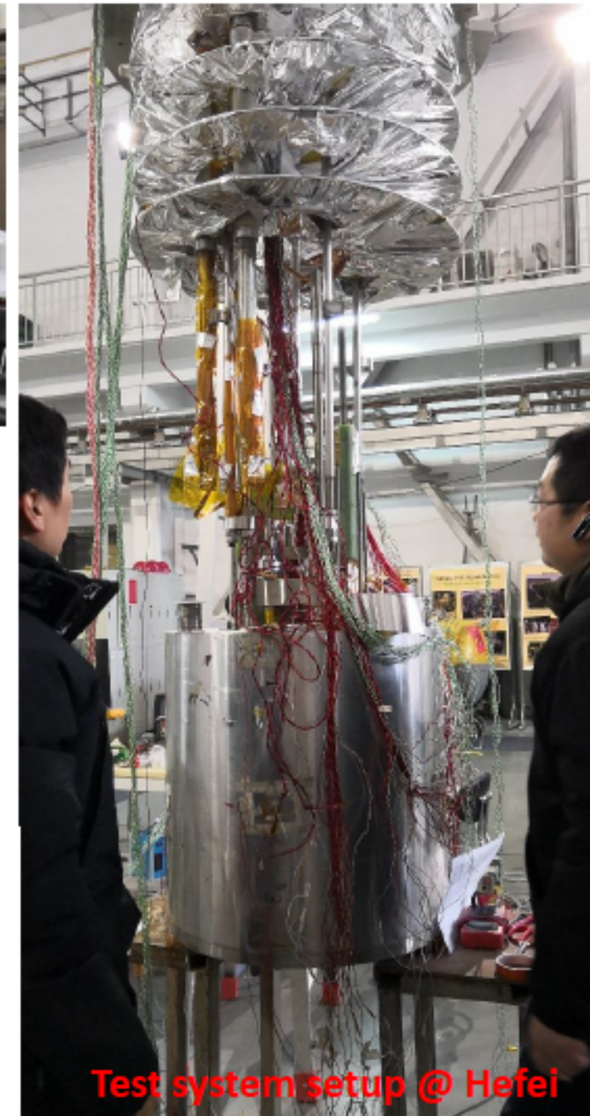


R&D of High Field Dipole Magnets

Test results of the 1st high-field dipole magnet in China Feb. 2018



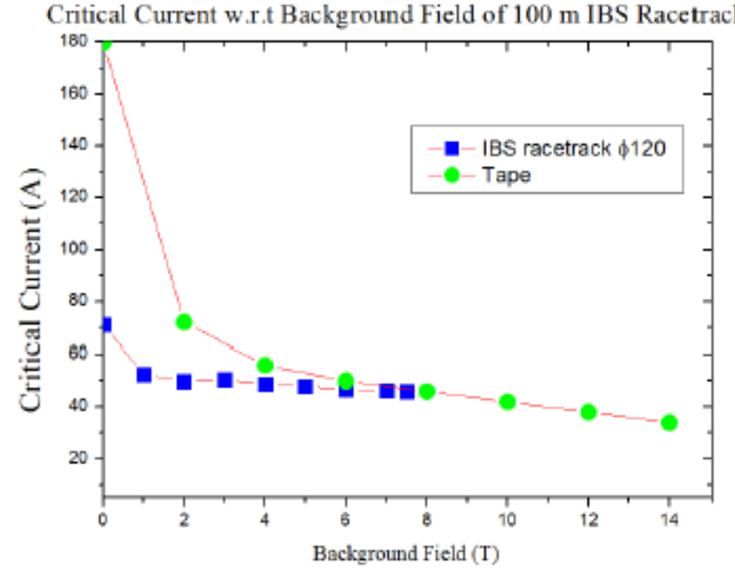


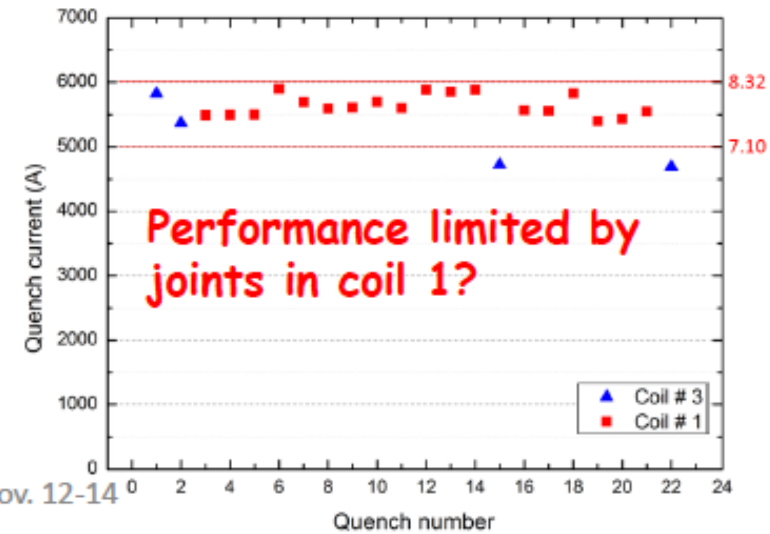


R&D of High Field Dipole Magnets

Performance of the LPF2 (Nb_3Sn with IBS)

Test stopped due to problems of joints? To be verified

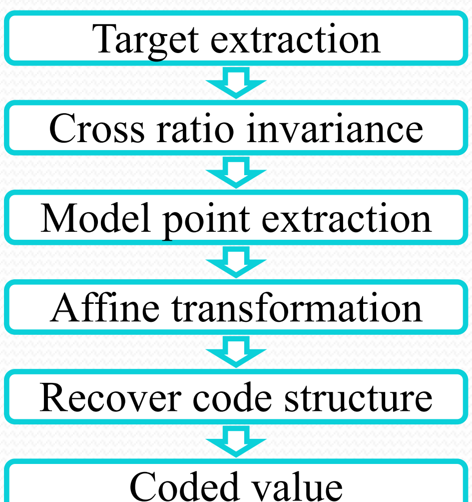


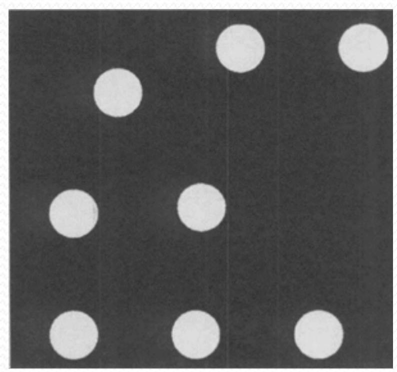


Survey and Alignment R&D Status

- Temperature & Humidity laboratory(constructed)
- 3D Calibration Field for instrument parameters calibration
- 3μm+3ppm photogrammetry camera
- One million capacity coded target has been developed and the recognition software has been tested.

3D Calibration Field



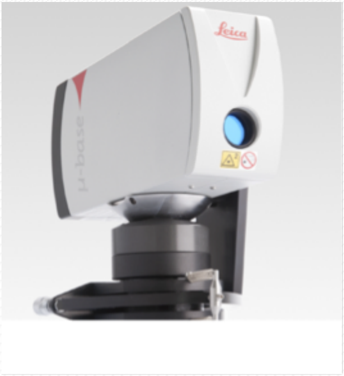


Coded target

X. Wang

3μm+3ppm Camera

- Five-face target
- High precision retro-reflective coating technology
- Vision instrument model integrated with a camera, a distance meter and a 2D-turnable
- High precision bearing system is under research
- Detailed structure is under research.
- Purchased a distance meter



Distance meter

Five-face target

Photogrammetry experiment

Conclusions

- A lot of work was done for the CDR release this Fall: congratulations!
- Plans for TDR completion in 3 years are ready
- R&D is on-going on all "hot" topics
- New R&D infrastructure is being built
- SPPC SC magnets R&D plans well defined, prototypes are being manufactured and tested
- CEPC design is mature for prototyping phase
- There are no showstoppers for the project success
- International collaboration is needed (*my opinion*)
- CEPC (*as well as its twin FCCee*) will be a major step forward in accelerator science & technology
- *Wish you Good Luck!*

福

我支持你

祝你顺利

祝你马到成功

我相信你

祝你成功

祝你工作顺利

你肯定会成功的