The High Energy Circular e+e- collider, CepC project

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IRFU-CEA, DPhP, January 20 2020

Disclaimer & acknowlegdments

- ✓ *The main focus is on the **Circular electron-positron Collider** project under development in China: **its current status and objectives.***
- ✓ *The aim is **indeed to inform** on this important project.*
- ✓ *Many thanks to a number of people for provided information and explanations:*

Especially to:

Angeles Faus-Golfe, Philip Bambade, from LAL, and

Profs J. Barreiro Guimaraes da Costa, Jie Gao, from IHEP, CAS

I am also indebted to a lot of people's presentations or documents to which I give credit (refs) in these slides.

Outline

- **Introductory Remarks**: why, since when China/IHEP is interested in the CepC?
- **The accelerator** towards TDR: current status, new developments and R&D objectives
- **The detectors** design and R&Ds
- A glimpse to **the Physics case and Physics reach**.
- **The SppC** as a foreseen second stage.
- **The CepC organization, timeline, funding scenarii and location**
- **The Industrial involvement in China**
- **Concluding remarks** including “internationalization”

Introductory remarks

The history of the CepC project in a nutshell

1973 HEP in China starts of IHEP

1988 Oct: First e+e- collisins at BEPC → 1988

1998 BEPCII: 1×10^{33} cm^{-2}s^{-1}, i.e. x100 higher Lum(BEPC)

2008 July, New BESIII detector starts running at BEPCII

2012 Higgs Discovery: **1st presentation of CepC @ HF2012 (FNAL)**

2014 **CepC @ HF2014** (Beijing) see Y.Wang with **Pre-CDR (03/2015) White Report**.

2017 CepC Progress Report (Yellow report)

2018-2020 **CDR (Sept 2018)** & Wkshps:

+ confs on Accelerators technology …

- **CepC Wkshp Nov 2017, IHEP**
- **EU-CepC Wkshp May 2018, Rome**
- **CepC Wkshp Nov 2018, IHEP**
- **EU-CepC Wkshp April 2019, Oxford**
- **EU Strategy, May 2019, Granada**
- **US-CepC Wkshp Oct 2019, Chicago**
- **CepC Wkshp Nov 2019, IHEP**
- **US-CepC Wkshp, Apri22-23Washington DC**
- **EU-CepC. 4-6 May 2020, Marseille…**

2021 **Accelerator TDR**

2023 *See specific timeline for the CepC/SppC programme (see later)*

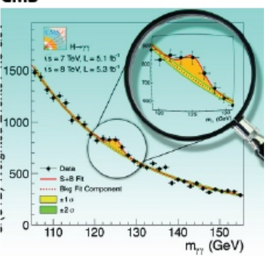
1988 – 2020: More than 30 years of e+e- Physics @IHEP

Towards CepC

BEPCII=2 ring e+e- collider running in the
Tau-charm Ecm: 2 to 4.6 GeV
Increase in luminosity by x
BEPC to BEPCII (1×10^{33} and
new BESIII detector design (trigger).
First collisions in BESIII (July 2008)

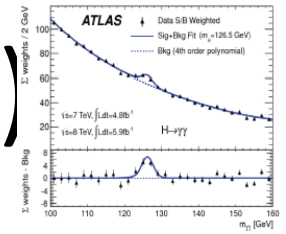
BEPC and BEPCII: 30 Years of e+e- light hadrons, Charm and Tau Physics
Large Chinese collab + large Nb of USA Universities (CLEO/BEPC Collab)
A few EU teams.
Collab also for the machine with KEK

10/1988: 1st collision at BEPC



HiggsFab-circular prehistory (2012)

a new particle was discovered today…



Patrick Janot: TLEP+VHE-LHC

$\sqrt{s} \leq 350$ GeV : Feasible by 2025 – 2035 ?

Factory	Example	$\sqrt{s}$	Benefits from	Extendable
e^+e^- (Linear)	ILC	Phase 1 Up to 350 GeV	20 years of R&D	500 Gev (1 TeV?) GigaZ
e^+e^- (Circular)	LEP3	Up to 240 GeV LHC tunnel	ILC, LHeC, LHC b Factories	HL/HE-LHC, 33 TeV TeraZ
	TLEP	Up to 350 GeV New 80km tunnel	ILC, LHeC b Factories	VHE-LHC, 100 TeV TeraZ
$\mu^+\mu^-$ (Circular)	LEMC	125 GeV Up to 350 GeV	MICE R&D ν Factory	5-15 TeV
γγ	CLICHE PLC SAPPHIRE	~125 GeV Up to 300 GeV	ILC, CLIC, LHeC	-

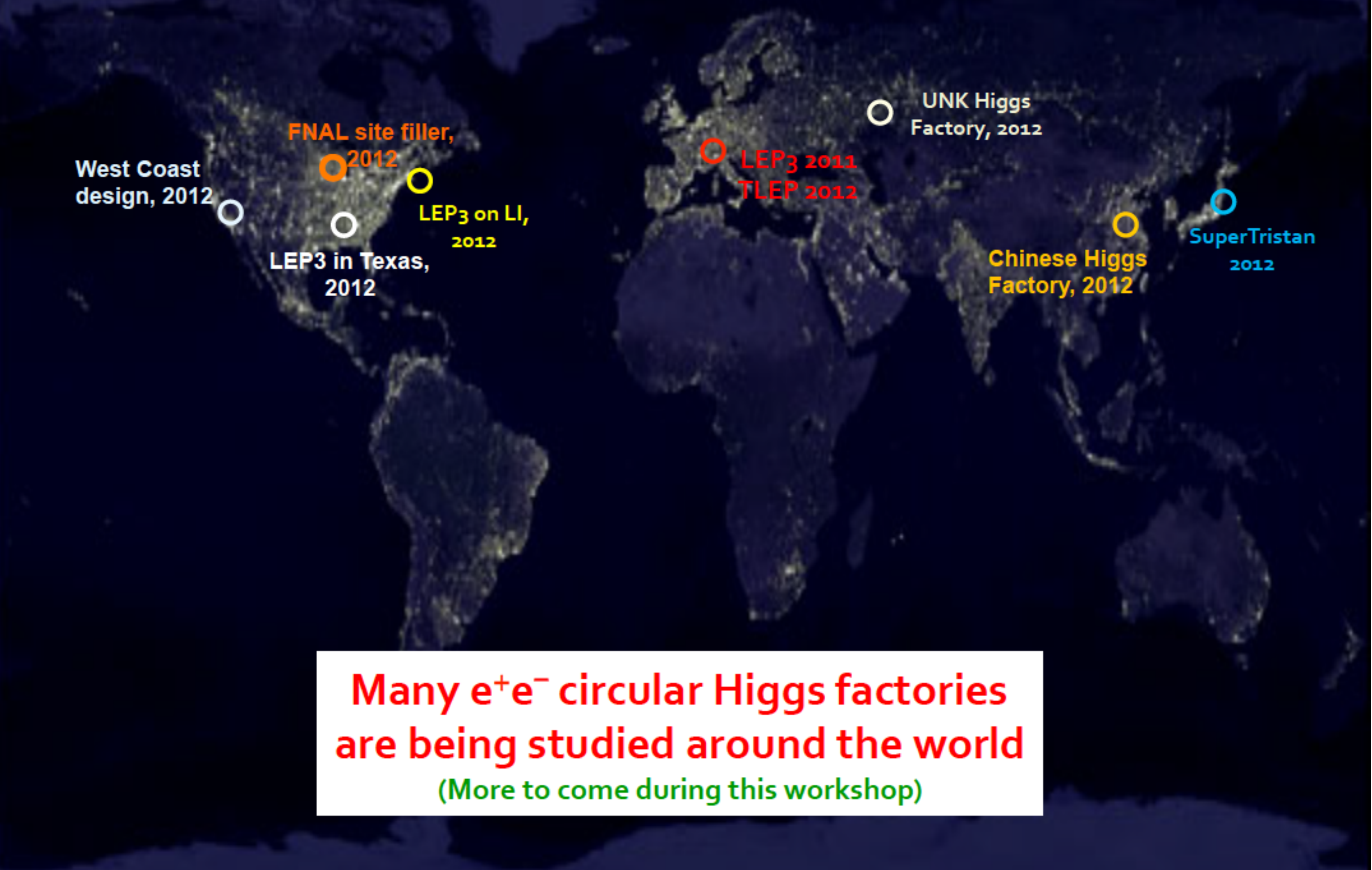
Q. Qin IHEP, CAS: CHF+SppC

Beam energy (GeV)	120	120
Circumference (km)	49,78	69,88
Number of Ips	2	1
SR loss/turn (GeV)	3	2,35
Ne/bunch (10^{12})	0,7	0,6
Bunch number	26	52
Beam current (mA)	17,5	21,3
L_0/IP ($10^{34}cm^{-2}s^{-1}$)	2,5	3.85

Beam energy (TeV)	25	65
Circumference (km)	49,78	59,88
Number of IPs	2	2
SR loss/turn (keV)	440	4090
N_p/bunch (10^{11})	1,3	0,98
Lum/IP ($10^{35}cm^{-2}s^{-1}$)	2,15	2,85

B=20T

From: Patrick Janot's talk at HF2012FNAL, Nov 2012.



Many e^+e^- circular Higgs factories are being studied around the world

(More to come during this workshop)

From: Patrick Janot's talk at HF2012FNAL, Nov 2012.

- **The LHC run at 13 TeV may revolutionize the current physics perspective**
  - New discoveries will strongly influence the strategy for future collider projects
    - And so will absence of new discoveries, possibly even more strongly
      - ➨ We will know much more in 2015

- **Future projects should therefore encompass**
  - A high-precision Higgs factory
    - Including high-statistics Z, W, and possibly top, factories
  - A high-energy-frontier facility able to study the new physics discovered at the LHC
    - And to probe much higher scales

- **It is probably too early (and maybe imprudent) to decide now**
  - The possibilities presented here should help provide strategic guidance
    - Meanwhile, studies of all Higgs factory concepts must be encouraged

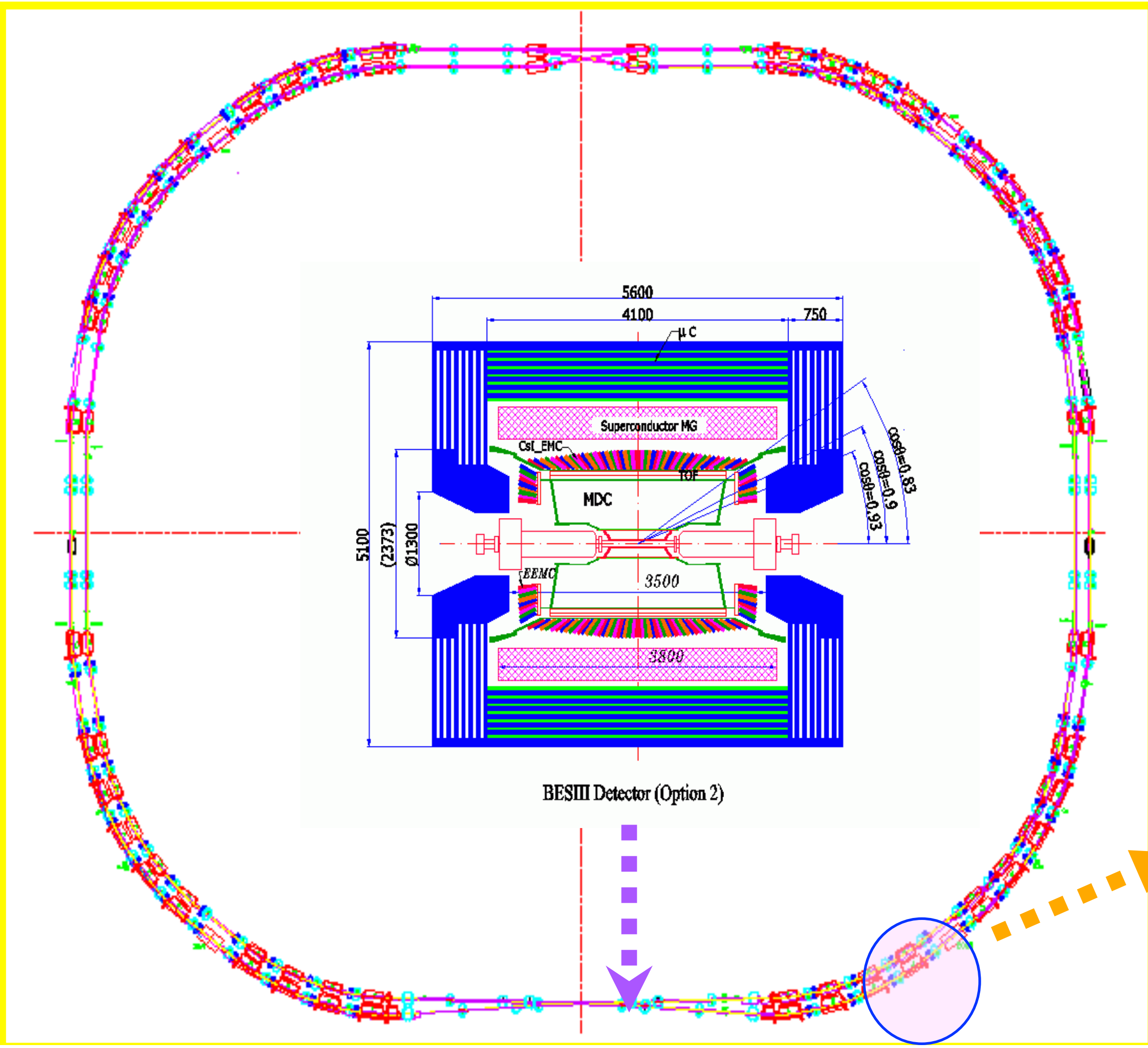
HEP: Current and Future Projects

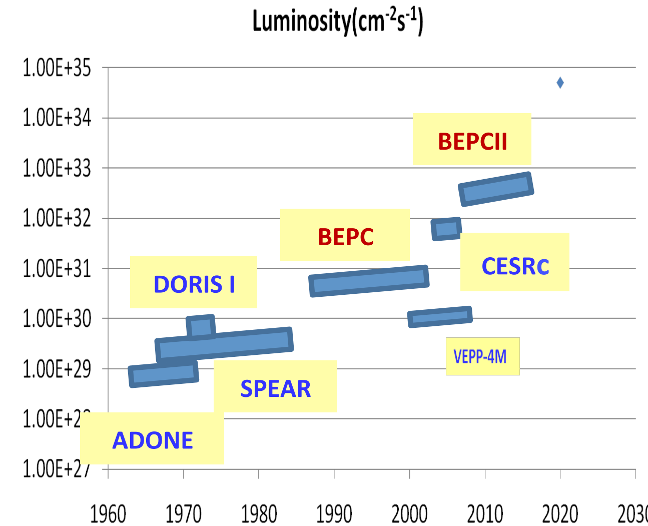
Yifang Wang, Institute of High Energy Physics, Oct. 9, 2014, Beijing, HF2014

		Current	Future
Accelerator-based	Precision frontier	BESIII	International: ILC CEPC → SppC
		International projects: Belle II、PANDA、COMET	
	Energy frontier	CMS、ATLAS	
Non-accelerator-based	underground	Daya Bay	JUNO
		EXO	
	surface	ASγ	LHASSO
	Space	AMS	HERD XTP
		HXMT	

BEPCII/BESIII: Operational since 2009

A high lumi. e^+e^- collider at the τ-c energy region



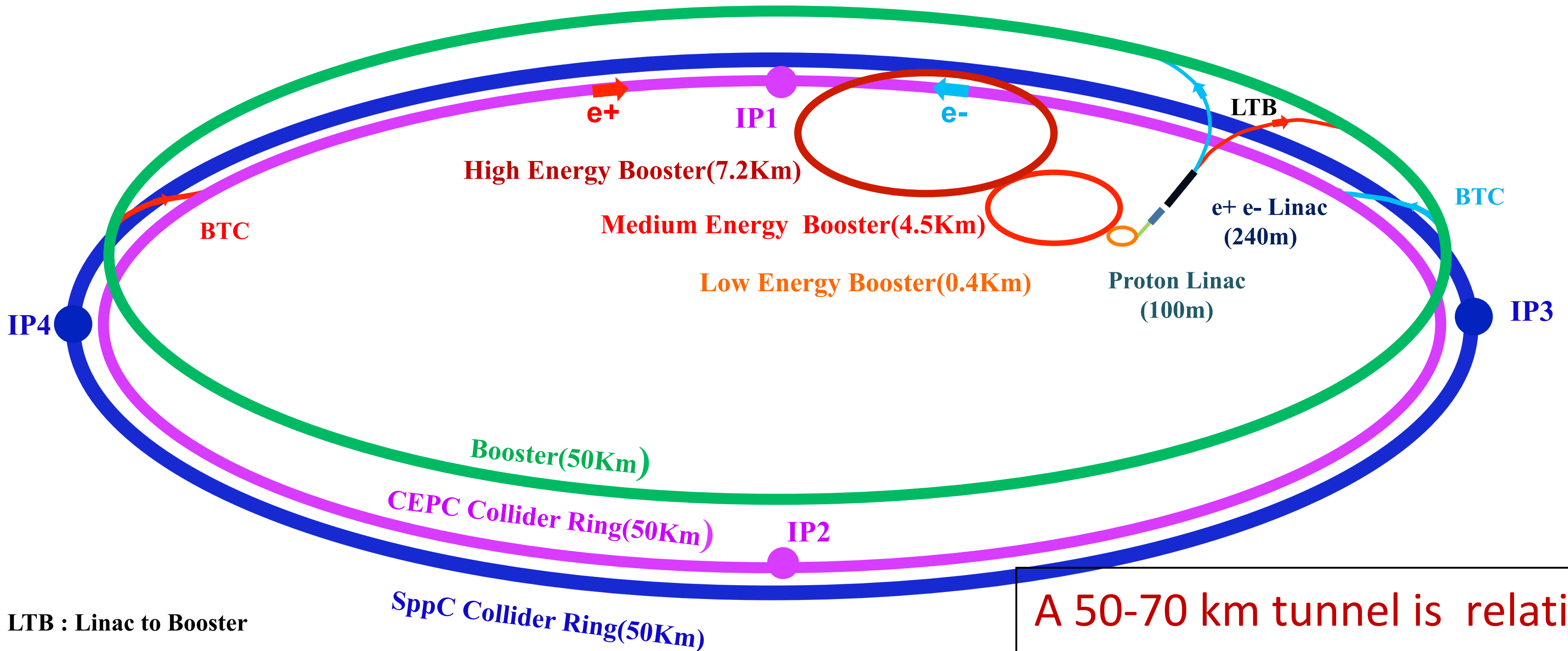


Yifang Wang, Institute of High Energy Physics, Oct. 9, 2014, Beijing, HF2014

Future: CEPC+SppC

Yifang Wang, Institute of High Energy Physics, Oct. 9, 2014, Beijing, HF2014

- Thanks to the discovery of the low mass Higgs boson, and stimulated by ideas of Circular Higgs Factories in the world, CEPC+SppC configuration was proposed in Sep. 2012



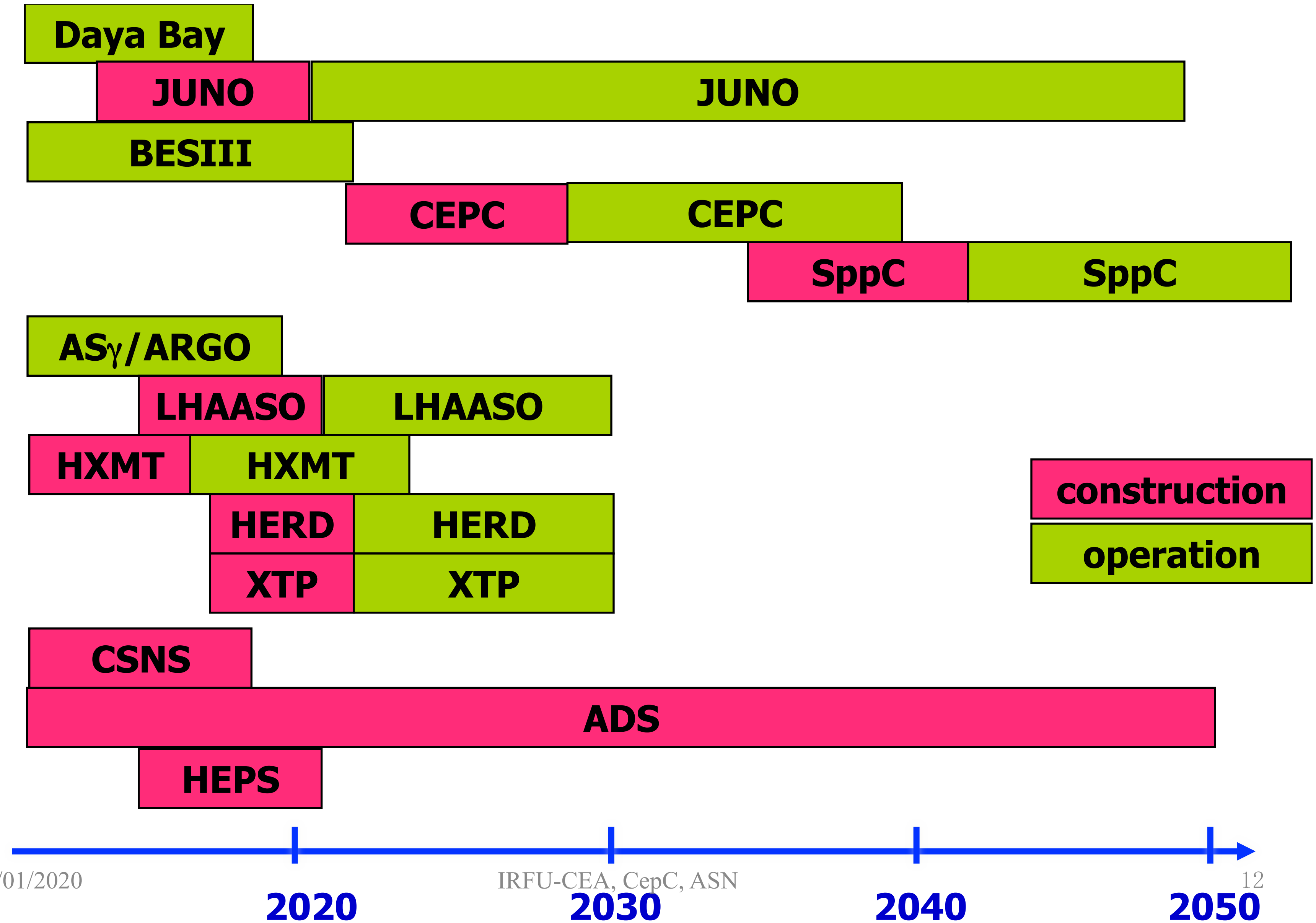
LTB : Linac to Booster

BTC : Booster to Collider Ring

A 50-70 km tunnel is relatively easier NOW in China

Large Projects at IHEP

Yifang Wang, Institute of High Energy Physics, Oct. 9, 2014, Beijing, HF2014



Summary

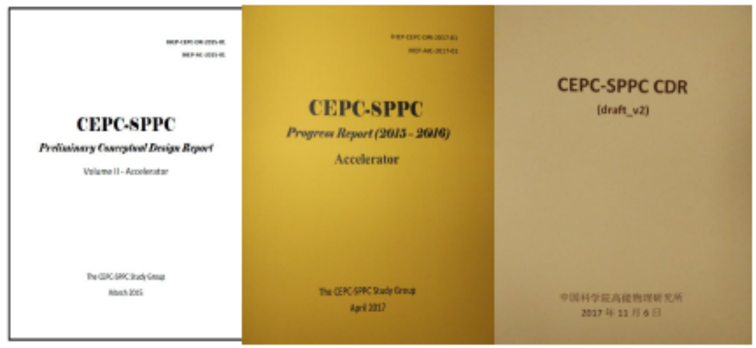
Yifang Wang, Institute of High Energy Physics, Oct. 9, 2014, Beijing, HF2014

- For the past 30 years, particle physics in China experienced an enormous growth, thanks to the economical growth of China.
- A lot more projects in the future.
- CEPC is the most important one and we will organize it as an international project.
- A new mode of international collaboration is needed. Welcome suggestions.

CEPC Accelerator from Pre-CDR, CDR towards TDR

CEPC accelerator CDR completed in June 2018 (to be printed in July 2018)

- – Executive Summary
- 1. Introduction
- 2. Machine Layout and Performance
- 3. Operation Scenarios
- 4. CEPC Collider
- 5. CEPC Booster
- 6. CEPC Linac
- 7. Systems Common to the CEPC Linac, Booster and Collider
- 8. Super Proton Proton Collider
- 9. Conventional Facilities
- 10. Environment, Health and Safety
- 11. R&D Program
- 12. Project Plan, Cost and Schedule
- – Appendix 1: CEPC Parameter List
- – Appendix 2: CEPC Technical Component List
- – Appendix 3: CEPC Electric Power Requirement
- – Appendix 4: Advanced Partial Double Ring
- – Appendix 5: CEPC Injector Based on Plasma Wakefield Accelerator
- – Appendix 6: Operation as a High Intensity γ-ray Source
- – Appendix 7: Operation for e-p, e-A and Heavy Ion Collision
- – Appendix 8: Opportunities for Polarization in the CEPC
- – Appendix 9: International Review Report



March 2015 | April 2017 | Draft CDR for Mini International Review in Nov. 2017

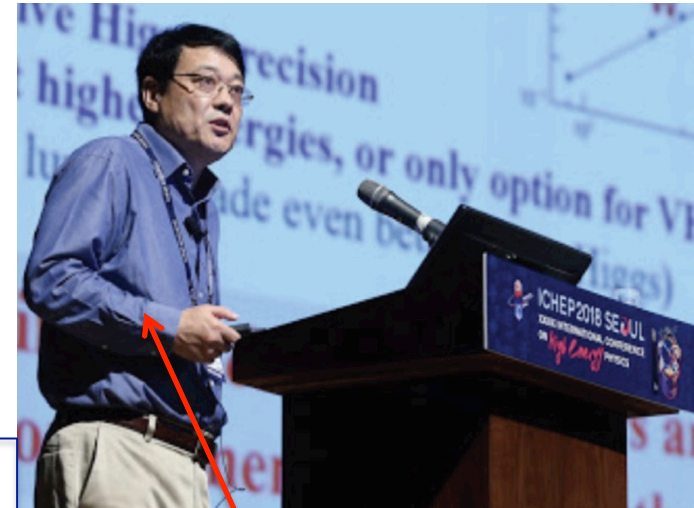
CEPC CDR Vol. I and II was publically released in Nov. 2018

CEPC Accelerator Submitted to European Strategy in 2019

1) CEPC accelerator: ArXiv: 1901.03169
2) CEPC Physics/Detector: 1901.02170

CDR Version for International Review June 2018
Formally relased on Sept. 2, 2018:arXiv: 1809.00285
http://cepc.ihep.ac.cn/CDR_v6_201808.pdf

CepC: 3 Key- people



Yifang WANG: Director of IHEP, CAS member; CepC/SppC project leader, Steering Com. Head: awarded:
Panofsky Prize in 2013,
20th Nikkei Asia Prize in 2015,
Breakthrough Prize in Fund. Physics in 2016
Bruno Pontecorvo Prize in 2016.
BsC in Nanjing U. (1984);
PhD in Firenze (1991)
Then: MIT & Stanford U.
Back in China in 2001.
L3, AMS, Palo Verde, KamLAND & BES expts.
Design & construction of BESIII det. (BEPC)
Daya Bay Reactor ν-expt (θ13 mixing angle).
Juno, CepC/SppC.

Jie GAO: Prof. CepC/SppC: Institution Board Deputy Steering Com. Member, Head Accelerator WG.
1978-1983 Tsinghua, CN, BsC
1983-1986 Tsinghua, Master
1986-1989 IHEP,CAS, Ph. D work
1992.4 Ph. D @Paris XI (J. Le Duff, Committee Chair: Davier)
1996.6 HDR-Paris XI (Davier)
Working experience:
1989-1992 Visitor LAL
1993-2004 permanent CNRS as Accelerator Physicist at LAL
2005-now IHEP, CAS, Professor, ILC-IHEP group leader, CepC/SppC

Xinchou LOU: Prof, CAS, Head of IHEP Experimental Physics Dept, CepC Project Director.
BsC: U. of Science and Techno, CAS, Hefei
1984-89: PhD at SUNY-Albany (CLEO)
Postdoc at Indiana U.(OPAL) and scientific Associate at CERN.
Since 1994- U. Texas at Dallas (UTD)
2004: Head of Physics Dept of UTD.
Back in China in 2012 (Thousand talents)
Prof. CAS, Head of the Exptal Physics Dept., At IHEP
B-Physics: CLEO, OPAL, Babar, ***currently in BESIII. Team leader ATLAS Higgs & Upgrade, CepC***

The CepC accelerator towards TDR:

Current status

New ongoing developments and R&D objectives

- ✓ Baseline Layout
- ✓ Main parameters
- ✓ Main components: injector, booster, SR cavities, MDI..
- ✓ Upgrades for the TDR and R&D’s for future improvements

The parameters of the CepC at the start of the project (pre-CDR), in 2012

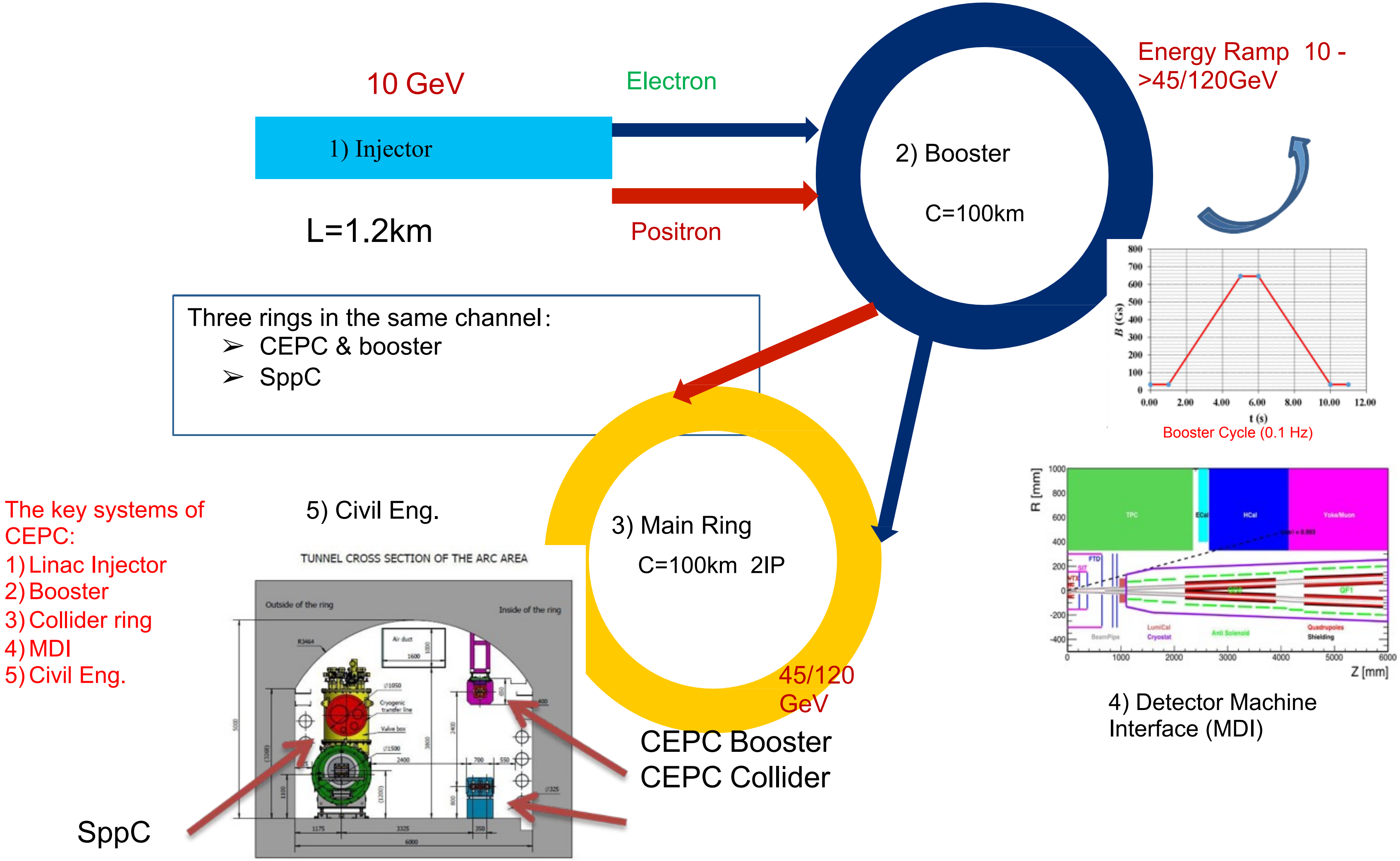
Table 1: Main Design Parameters of the CEPC Ring

Para.	Unit	Value	Para.	Unit	Value
Energy	GeV	120	Circum.	km	54.752
N_e	10^{11}	3.79	N_b/beam		50
Beam current	mA	16.6	SR power /beam	MW	51.7
ε (x/y)	nm	6.12/ 0.018	Bending radius	km	6.094
β_{IP} (x/y)	mm	200/1	σ_x/σ_y (@IP)	μm	70/0.15
$\xi_{x,y}$		0.118/ 0.083	SR loss /turn	GeV	3.11
α_p	10^{-4}	0.336	σ_z	mm	2.88
V_{rf}	GV	6.87	No. of IP		2
ν_s		0.181	f_{rf}	GHz	0.65
δ_{SR}		0.0013	Harm. No.		118712
δ_{BS}		0.0008	$\delta_{BS,\ tot}$		0.00177
n_γ		0.23	τ_{BS}	hr	12.2
F_H		0.692	L /IP	/cm^2/s	2.0×10^{34}

Comparison with the FCC-ee at same time

parameter	LEP-2	FCC-ee				
		Z	Z(c.w.)	W	H	t
E_{beam} [GeV]	104	45	45	80	120	175
circum-ference [km]	26.7	100	100	100	100	100
current [mA]	3.0	1450	1431	152	30	6.6
$P_{SR,tot}$ [MW]	22	100	100	100	100	100
# bunches	4	16700	29791	4490	1360	98
N_b [10^{11}]	4.2	1.8	1.0	0.7	0.46	1.4
L/IP [10^{34} cm^{-2}s^{-1}]	0.01	28	212	12	6	1.7

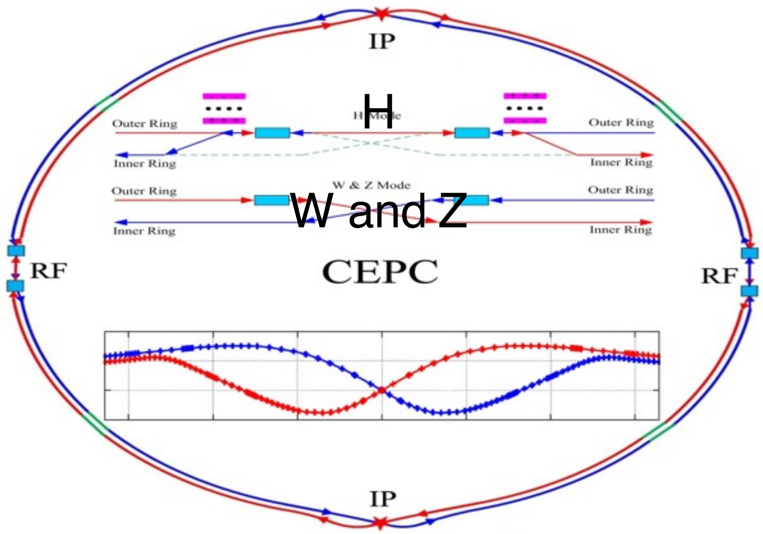
CEPC Accelerator Chain and Systems



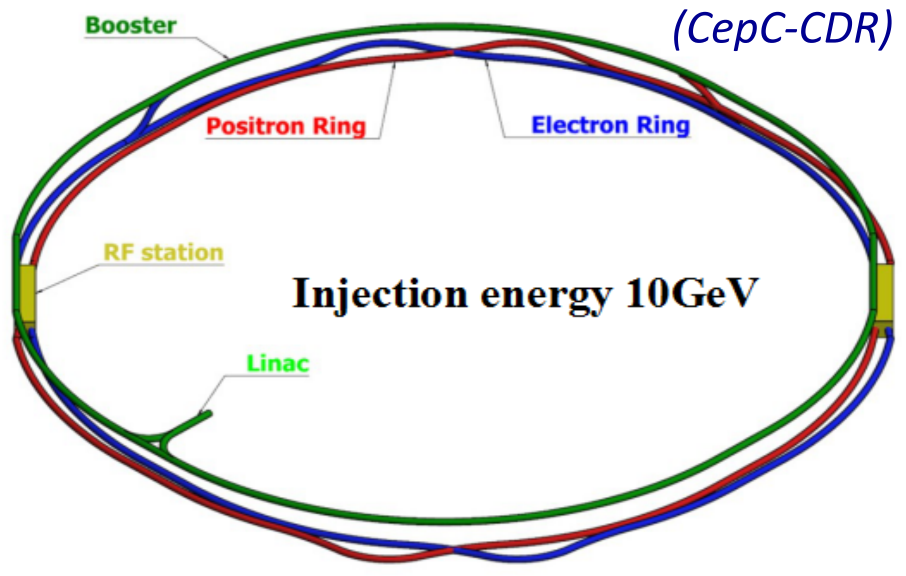
(CepC-CDR)

CepC CDR Baseline Layout

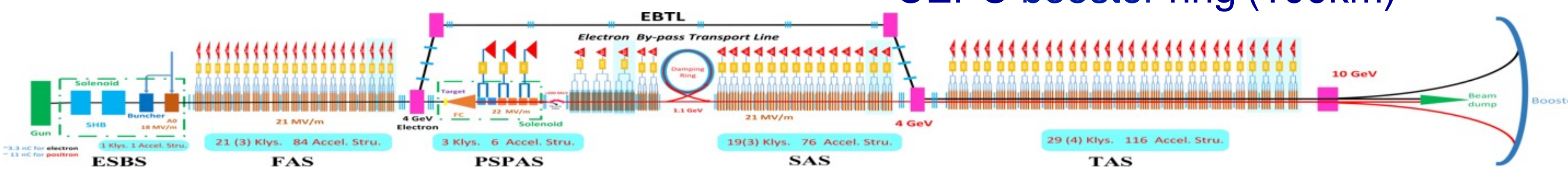
(CepC-CDR)



CEPC collider ring (100km)



CEPC booster ring (100km)



CEPC Linac injector (1.2km, 10GeV)

$$L[\mathrm{cm}^{-2}\mathrm{s}^{-1}] = 2.17\times10^{34}(1+r)\xi_y \frac{E[\mathrm{GeV}]I[\mathrm{A}]}{\beta_y[\mathrm{cm}]}$$

where

$$\xi_y = \frac{r_e N_e \beta_y}{2\pi\sigma_y(\sigma_x+\sigma_y)}$$

Max beam beam tune shift:

$$\xi_{y,\,\max} = \frac{2845}{2\pi}\sqrt{\frac{T_0}{\tau_y \gamma N_{IP}}}$$

r_e is electron radius

γ is normalized energy

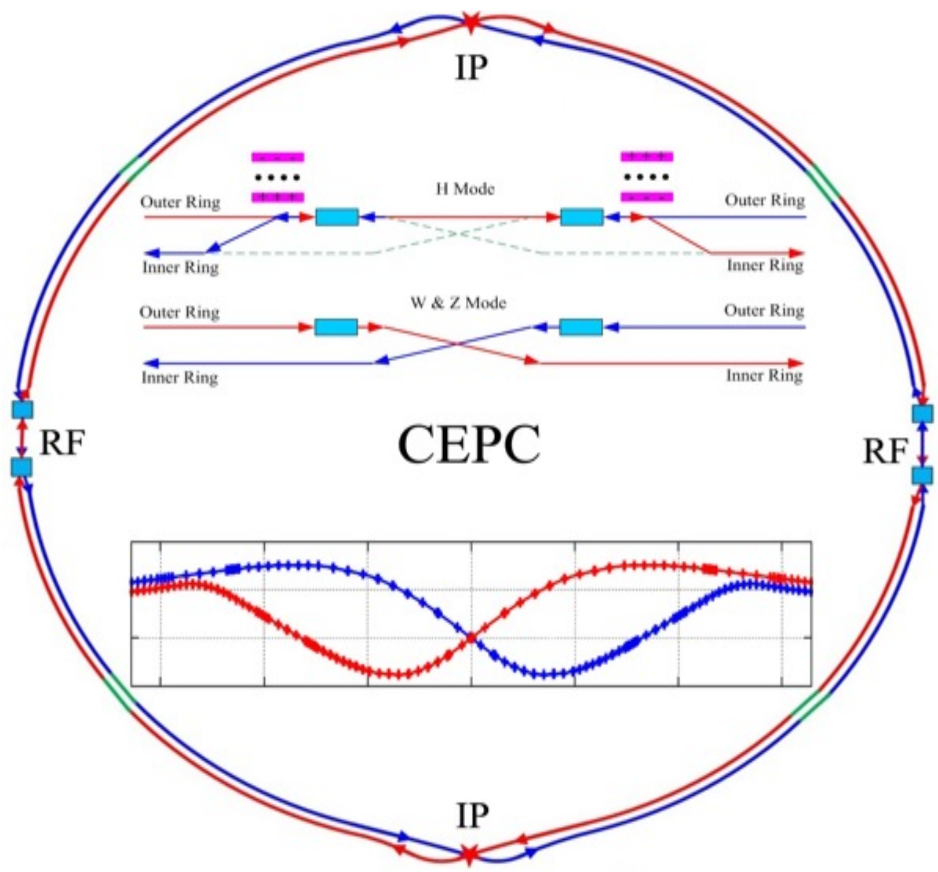
R is the dipole bending radius

N_{IP} is number of interaction points

J. Gao, NIM 2004

CepC basic design choices

Double ring e+e- collider ~100km
Follows footprint of SppC
except around IPs.
Asymmetric IR layout & optics
to limit synchroton radiation (SR)
towards the detector.
2 IPs, **large** horizontal crossing
angle **~ 30 mrad, crab-waist optics**
Synchroton radiation power 30-38
MW/beam at all beam energies;
tapering of arc magnet strenghts
to match local energy
Top-up injection scheme; **requires**
booster synchroton in collider tunnel



FCC-ee basic design choices

double ring e^+e^- collider ~100 km

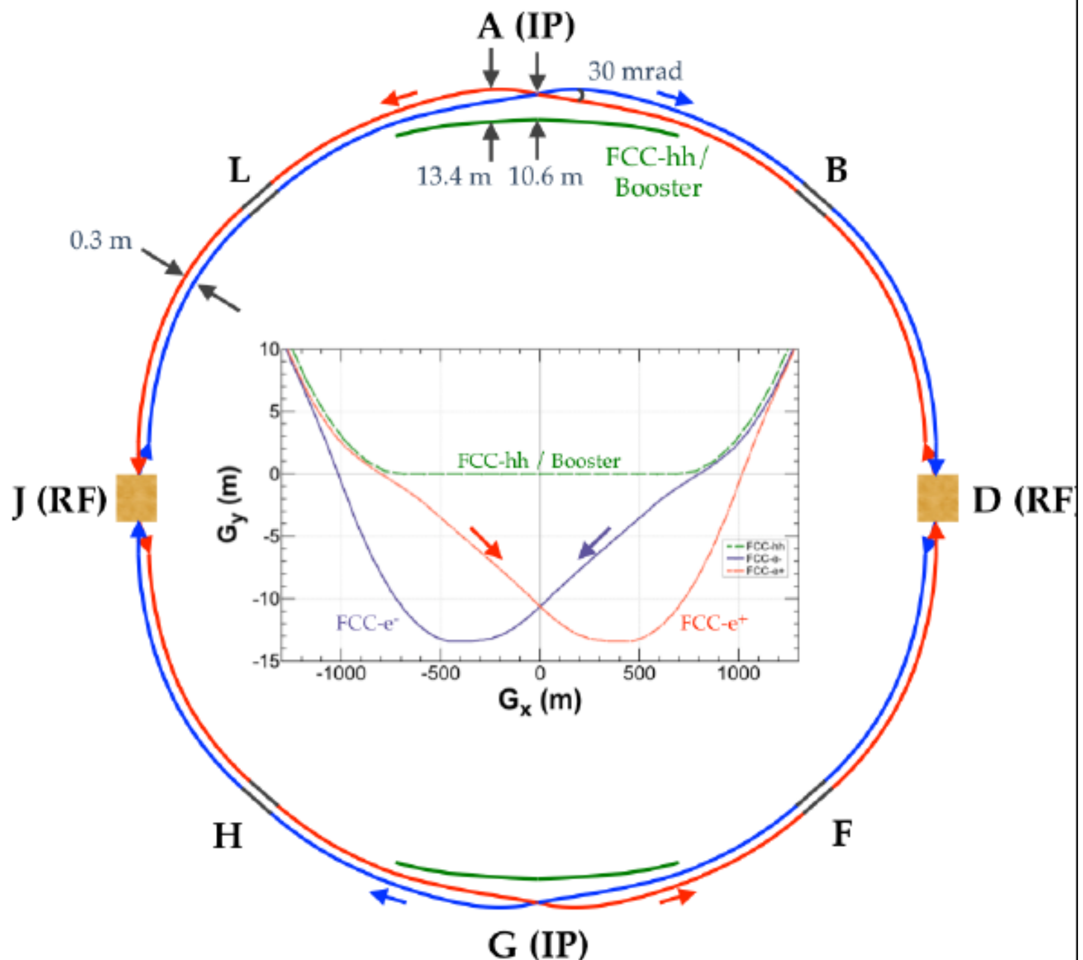
follows footprint of FCC-hh, except around IPs

asymmetric IR layout & optics to limit synchrotron radiation towards the detector

presently 2 IPs (alternative layouts with 3 or 4 IPs under study), **large** horizontal crossing angle **30 mrad, crab-waist optics**

synchrotron radiation power 50 MW/beam at all beam energies; tapering of arc magnet strengths to match local energy

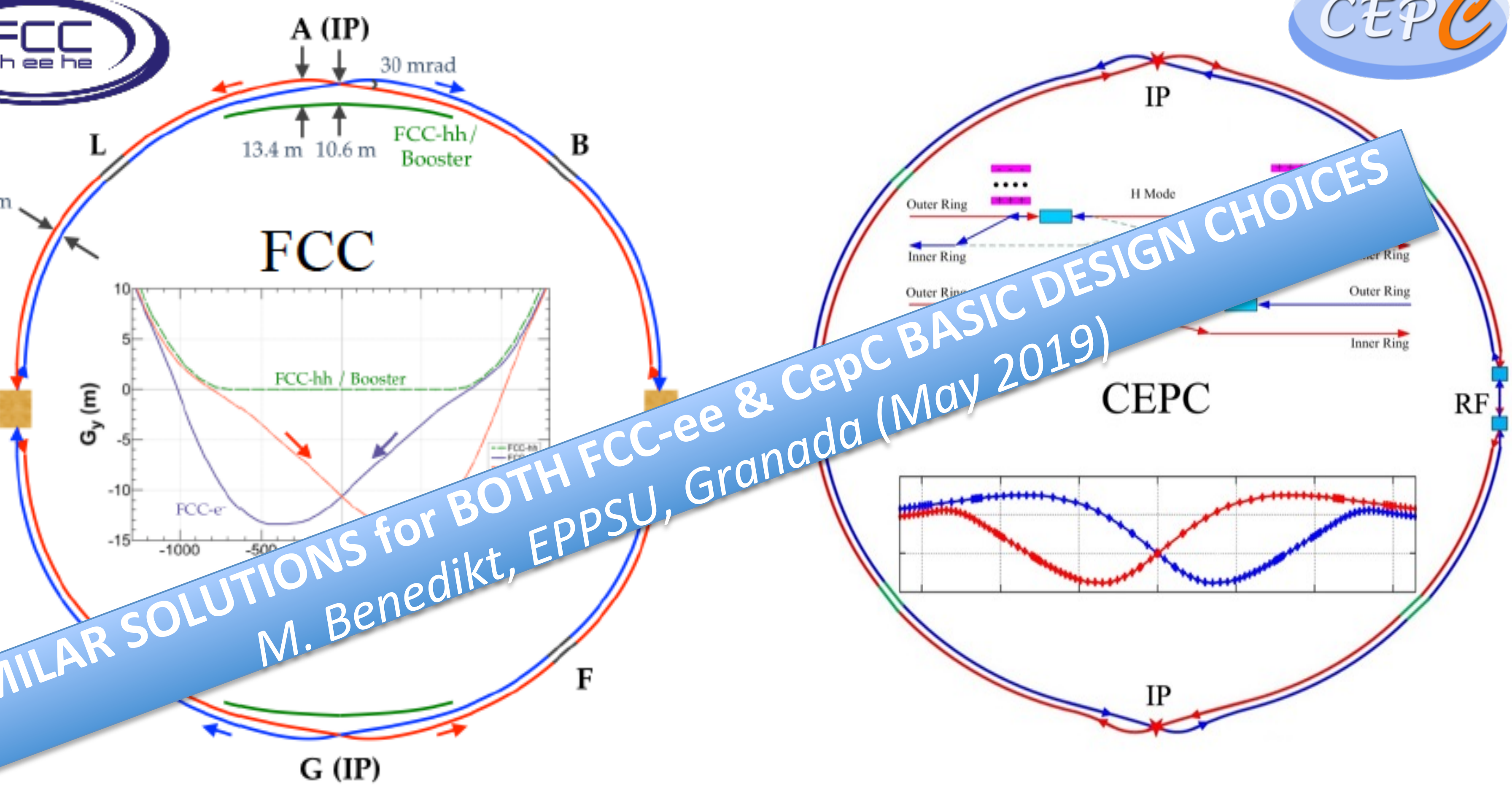
top-up injection scheme; requires **booster synchrotron in collider tunnel**



(Courtesy of Frank Zimmerman)

K. Oide et al.

CepC & FCC-ee basic design choices:



SIMILAR SOLUTIONS for BOTH FCC-ee & CepC BASIC DESIGN CHOICES

M. Benedikt, EPPSU, Granada (May 2019)

Similar yes but note some relevant differences in next slides on the CepC accelerator

CEPC towards TDR: new parameters for Higgs after CDR

Jie Gao, CERN FCC, 13/1/2020

	tt	Higgs	W	Z (3T)	Z (2T)
Number of IPs	2				
Beam energy (GeV)	**175**	**120**	**80**	**45.5**	
Circumference (km)	100				
Synchrotron radiation loss/turn (GeV)	7.61	1.68	0.33	0.035	
Crossing angle at IP (mrad)	16.5×2				
Piwinski angle	0.91	3.78	8.5	27.7	
Number of particles/bunch N_e (10^{10})	24.15	17.0	12.0	8.0	
Bunch number (bunch spacing)	**34 (4.9μs)**	**218 (0.76μs)**	**1568 (0.20μs)**	**12000 (25ns+10%gap)**	
Beam current (mA)	3.95	17.8	90.4	461.0	
Synchrotron radiation power /beam (MW)	**30**	**30**	**30**	**16.5**	
Bending radius (km)	10.7				
Momentum compact (10^{-5})	0.91				
β function at IP β_x^* / β_y^* (m)	1.2/0.0037	**0.33/0.001**	**0.33/0.001**	**0.2/0.001**	
Emittance $\varepsilon_x/\varepsilon_y$ (nm)	2.24/0.0068	0.89/0.0018	0.395/0.0012	0.13/0.003	0.13/0.00115
Beam size at IP σ_x/σ_y (μm)	51.8/0.16	17.1/0.042	11.4/0.035	5.1/0.054	5.1/0.034
Beam-beam parameters ξ_x/ξ_y	0.077/0.105	0.024/0.113	0.012/0.1	0.004/0.053	0.004/0.085
RF voltage V_{RF} (GV)	8.93	2.4	0.43	0.082	
RF frequency f_{RF} (MHz) (harmonic)	650 (216816)				
Natural bunch length σ_z (mm)	2.54	2.2	2.98	2.42	
Bunch length σ_z (mm)	2.87	3.93	5.9	8.5	
HOM power/cavity (kw)	0.53 (5cell)	0.58 (2 cell)	0.77 (2 cell)	**1.94** (2 cell)	
Energy spread (%)	0.14	0.19	0.098	0.080	
Energy acceptance requirement (%)	**1.57**	**1.7**	**0.90**	**0.49**	
Energy acceptance by RF (%)	2.67	3.0	1.27	1.55	
Photon number due to beamstrahlung	0.19	0.104	0.050	0.023	
Beamstruhlung lifetime /quantum lifetime* (min)	~ 60	30/50	>400		
Lifetime (hour)	**0.7**	**0.22**	**1.2**	**3.2**	**2.0**
F (hour glass)	0.89	0.85	0.92	0.98	
Luminosity/IP L (10^{34}cm^{-2}s^{-1})	**0.38**	**5.2**	**14.5**	**23.6**	**37.7**

*include beam-beam simulation and real lattice

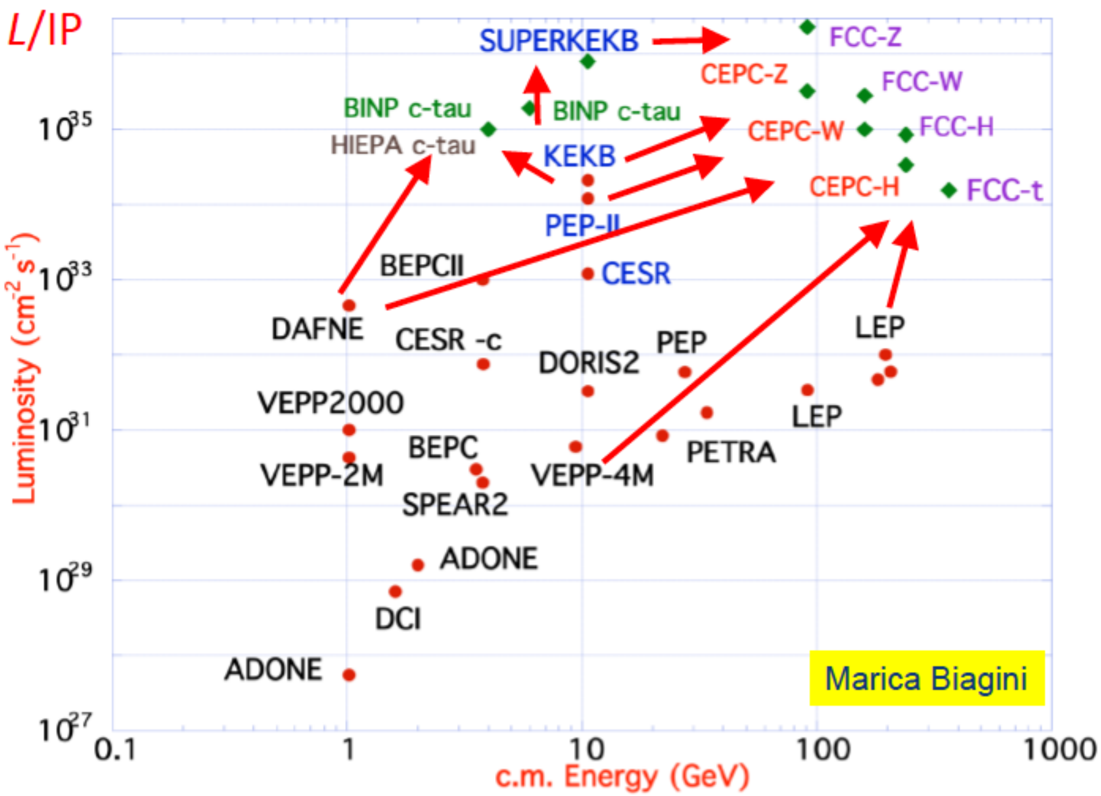
Jie Gao

CEPC vs FCC-ee @ Z (2T)

	CEPC-CDR	*CEPC-30MW*	*CEPC-38MW*	*FCC-ee*
Number of IPs	2	2	2	2
Energy (GeV)	45.5	**45.5**	**45.5**	45.6
Circumference (km)	100	100	100	100
SR loss/turn (GeV)	0.036	0.036	0.036	0.036
Half crossing angle (mrad)	16.5	16.5	16.5	15
Piwinski angle	23.8	27.9	33.0	28.5
N_e/bunch (10^{10})	8.0	12.0	15.0	17
Bunch number	12000	**14564 (20.6ns+10%gap)**	**15000**	16640
Beam current (mA)	461	839.9	1081.4	1390
SR power /beam (MW)	**16.5**	**30**	**38.6**	**50**
Bending radius (km)	10.7	10.7	10.7	10.76
Momentum compaction (10^{-5})	1.11	1.11	1.11	1.48
β_{IP} x/y (m)	0.2/0.001	**0.2/0.001**	**0.2/0.001**	0.15/0.0008
Emittance x/y (nm)	0.18/0.0016	0.18/0.0016	0.18/0.0016	0.27/0.001
Transverse σ_{IP} (um)	6.0/0.04	6.0/0.04	6.0/0.04	6.4/0.028
ξ_x/ξ_y/IP	0.004/0.079	0.004/0.093	0.004/0.098	0.004/0.133
V_{RF} (GV)	0.1	0.10	0.10	0.1
f_{RF} (MHz) (harmonic)	650	650	650	400
Nature bunch length σ_z (mm)	2.42	2.42	2.42	3.5
Bunch length σ_z (mm)	8.5	10.0	11.8	12.1
HOM power/cavity (kw)	1.94 (2cell)	**2.29 (1cell)**	**3.15 (1cell)**	?
Energy spread (%)	0.08	0.1	0.115	0.132
Energy acceptance (DA) (%)	1.5	**0.6**	**0.7**	1.3
Energy acceptance by RF (%)	1.7	1.7	1.7	1.9
Lifetime by rad. Bhabha scattering (hour)	2.9			1.13
Lifetime (hour)	2.5	**2.0**	1.8	1.0
L_{max}/IP ($10^{34}cm^{-2}s^{-1}$)	**32.1**	**74.5**	**101.6**	**230**

Z:1*10^36/cm^2/s now with single cell 650Mhz large grain cavity

CepC as FCC-ee exploits proven concepts & techniques from past/present colliders & light sources



B-factories: **KEKB & PEP-II:**
- **double-ring lepton colliders,**
- **high beam currents,**
- **top-up injection**

DAFNE: crab waist, double ring

Super B-factories, **S-KEKB: low β_y^***

LEP: high energy, SR effects

VEPP-4M, LEP: precision E calibration

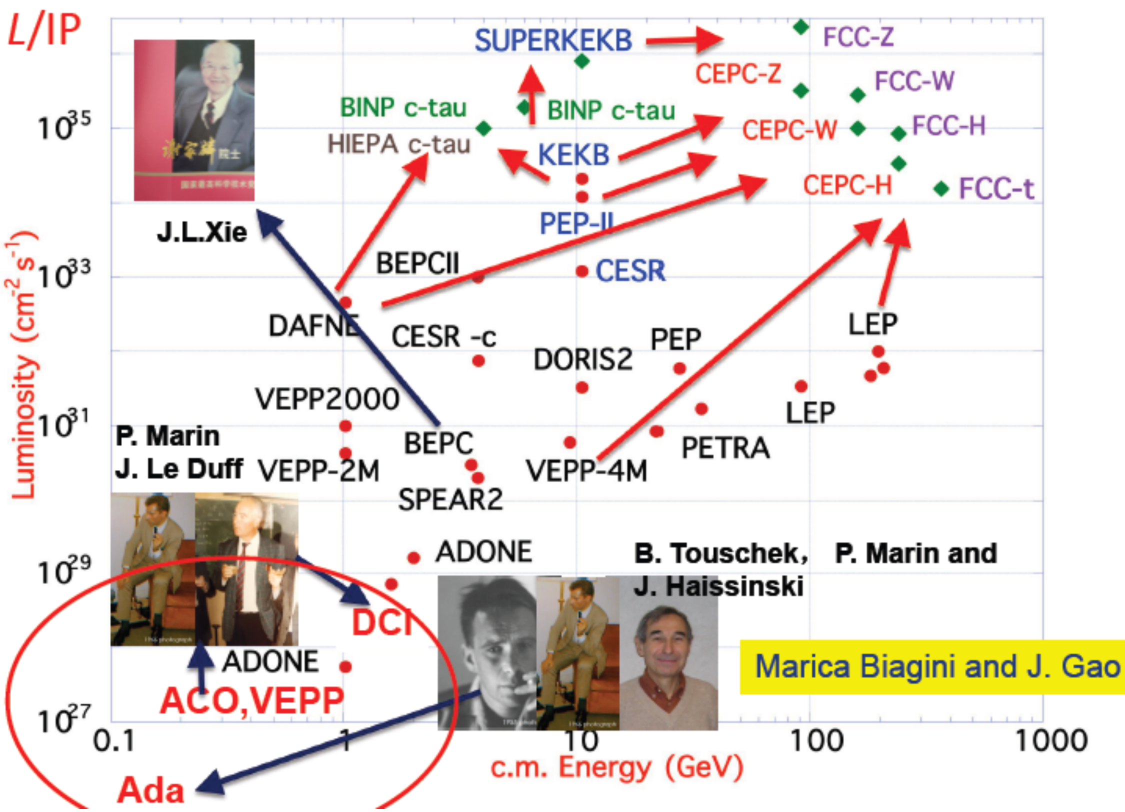
KEKB: *e^+* source

HERA, LEP, RHIC: spin gymnastics

It combines successful ingredients from several recent colliders => Highest Luminosity and Energy

Courtesy of Marica Biagini, at CepC Nov 2018 Workshop, repeated in all CepC and FCC talks.

CepC as FCC-ee exploits proven concepts & techniques from past/present colliders & light sources



B-factories: **KEKB & PEP-II:**
- **double-ring lepton colliders,**
- **high beam currents,**
- **top-up injection**

DAFNE: crab waist, double ring

Super B-factories, **S-KEKB: low β_y^***

LEP: high energy, SR effects

VEPP-4M, LEP: precision E calibration

KEKB: *e^+* source

HERA, LEP, RHIC: spin gymnastics

It combines successful ingredients from several recent colliders => Highest Luminosity and Energy

Courtesy of Marica Biagini, at CepC Nov 2018 Workshop, repeated in all CepC and FCC talks.

Main CepC items

- Z-pole polarization under design
- Dynamic aperture
- MDI
- Booster
- CepC self polarization
- Linac injector
- CepC R&D status on High Q and High gradient
- Klystron
- CepC collider & Booster Ring conventional magnets

CepC self-polarization at Z-pole, with asymmetric wigglers: 5% achieved.

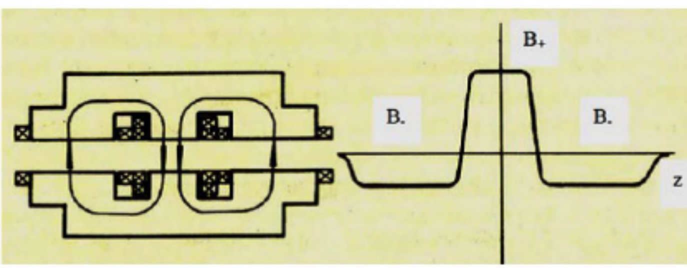
Inputs by J. Gao's talk FCC wkshp, Jan 13 2020 & refs therein + S. Nikitin at CepC Wkshp Nov 2019

- **Special wigglers to speed up self-polarization:**

N_w	B_+	L_+	B_-	L_-	$\frac{\tau_p}{\tau_p^w}$	u	$\frac{\Delta E_w}{\Delta E}$	$\frac{P_0^w}{P_0}$
10	0.6T	1m	0.15T	2m	13.4	0.34	3.2	0.99

In collaboration with Sergei Nikitin of BINP

u: Fraction of radiation energy loss enhancement. **:Factor of beam energy spread enhancement.**

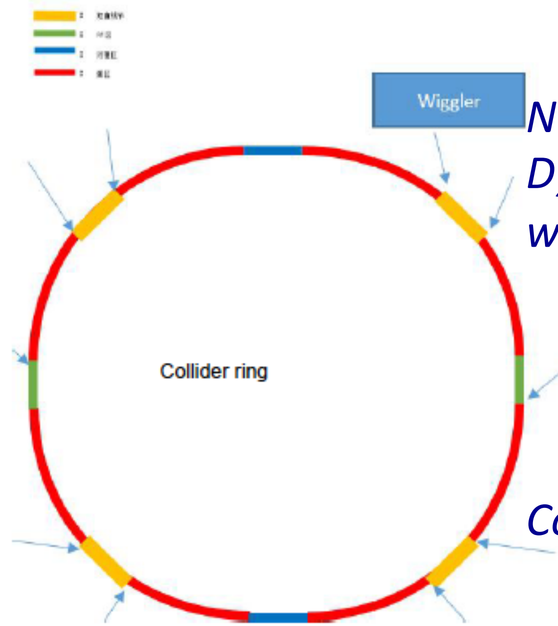


$$P(t) = P_0^w(1 - e^{\frac{-t}{\tau_p^w}})$$

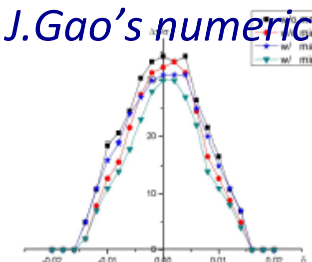
$$\tau_p^w = 19.6h,\ P(t) = 5\%,\ P_0^w = 0.913,$$

$$t = 1.10h$$

5% is enough for energy calibration.



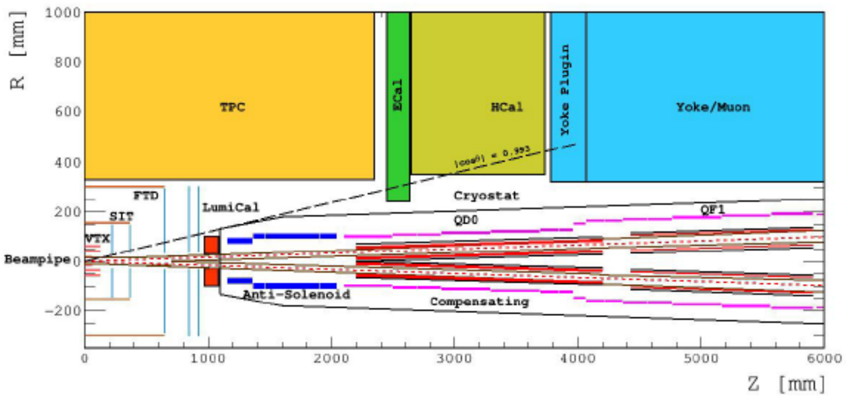
Numerical studies on Dynamic Aperture DA with J.Gao's numerical Computation/simulation DA



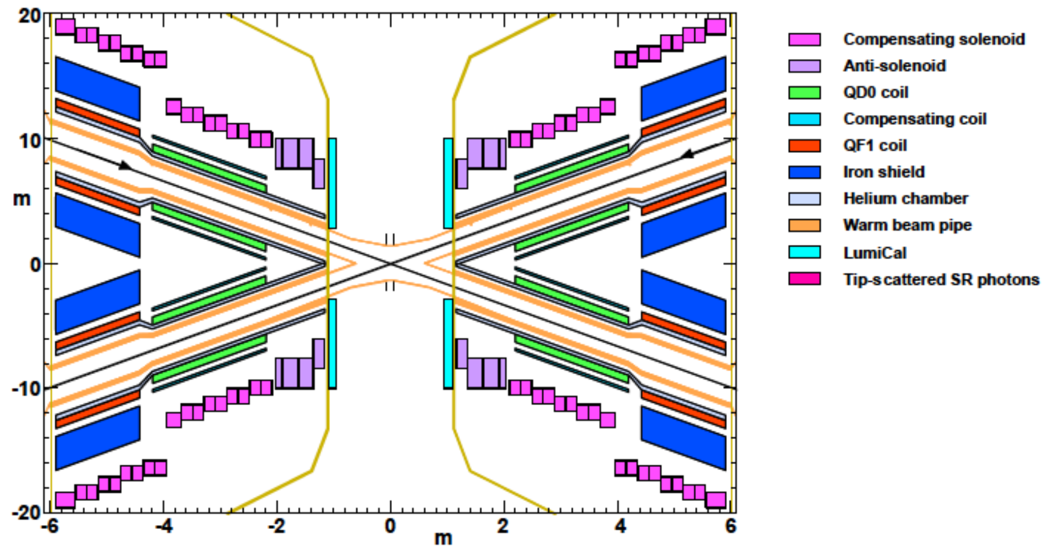
Longitudinal polarized beam position and full polarization injection scheme are under studies with strong contribution by BINP (S. Nikitin et al., see contribution at CepC Wkshp, Nov 2019)

MDI Layout and IR Design

With Detector solenoid



Without Detector solenoid
~cryostat in detail



- The accelerator components inside the detector without shielding are within a conical space with an opening angle of cosθ=0.993.
- The e+e- beams collide at the IP with a horizontal angle of 33mrad and the final focusing length is 2.2m
- Lumical will be installed in longitudinal 0.95~1.11m, with inner radius 28.5mm and outer radius 100mm.

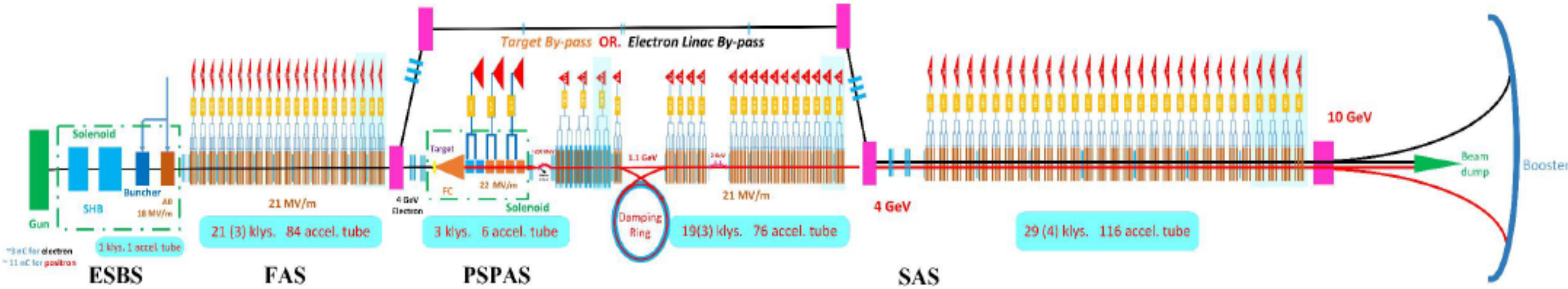
- The Machine Detector Interface (MDI) of CEPC double ring scheme is about ±7m long from the IP
- The CEPC detector superconducting solenoid with 3T magnetic field and the length of 7.6m.

New (/CDR) Booster design

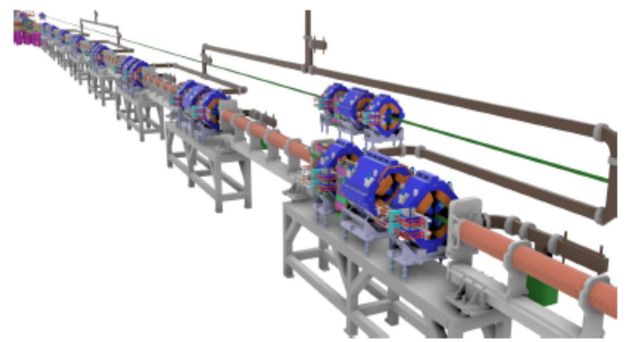
- ✓ *Emittance reduced from 3.6 to 1.2 nm*
- ✓ *Inner aperture of Vacuum chamber: 44 instead of 55 mm*

10 GeV injection	H	W	Z
Extraction beam energy [GeV]	120	80	45.5
Bunch number	242	1524	6000
Bunch charge [nC]	0.72	0.576	0.384
Beam current [mA]	0.52	**2.63**	**6.91**
Extraction RF voltage [GV]	1.97	0.585	0.287
Extraction bunch length [mm]	2.7	2.4	1.3
Cavity number in use (1.3 GHz TESLA 9-cell)	96	64	32
Gradient [MV/m]	19.8	8.8	8.6
Q_L	1E7	6.5E6	1E7
Cavity bandwidth [Hz]	130	200	130
Beam peak power / cavity [kW]	8.3	12.3	6.9
Input peak power per cavity [kW] (with detuning)	18.2	12.4	7.1
Input average power per cavity [kW] (with detuning)	0.7	0.3	0.5
SSA peak power [kW] (one cavity per SSA)	25	**25**	**25**
HOM average power per cavity [W]	0.2	0.7	**4.1**
Q_0 @ 2 K at operating gradient (long term)	1E10	1E10	1E10
Total average cavity wall loss @ 2 K eq. [kW]	0.2	0.01	0.02

CepC Linac Injector: baseline



Parameter	Symbol	Unit	Baseline	Design reached
e^-/e^+ beam energy	E_{e-}/E_{e+}	GeV	10	10
Repetition rate	f_{rep}	Hz	100	100
e^-/e^+ bunch population	N_{e-}/N_{e+}		$> 9.4\times10^{9}$	1.9×10^{10} / 1.9×10^{10}
		nC	> 1.5	3.0
Energy spread (e^-/e^+)	σ_e		$< 2\times10^{-3}$	1.5×10^{-3} / 1.6×10^{-3}
Emittance (e^-/e^+)	ε_r	nm· rad	< 120	5 / 40 ~120
Bunch length (e^-/e^+)	σ_l	mm		1 / 1
e^- beam energy on Target		GeV	4	4
e^- bunch charge on Target		nC	10	10



Why & How improving Linac injection?

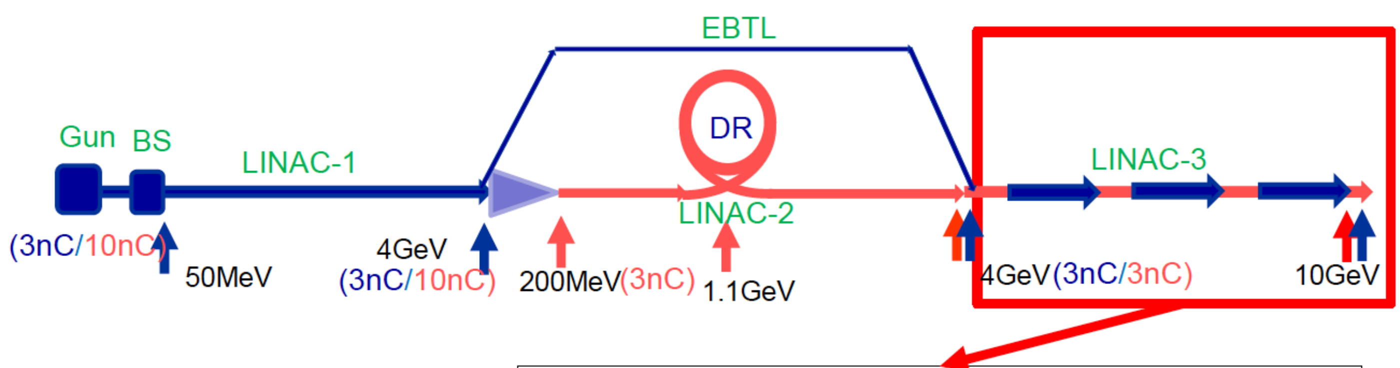
- Why?

  By increasing the Linac energy will:

  – Reduce the difficulty of the Booster design

  – Reduce the technical risk of low magnetic field magnets of the Booster

- How? Alternative: 10 GeV→20 GeV with S-band+C-band RF system
  – C-band start energy: 4GeV



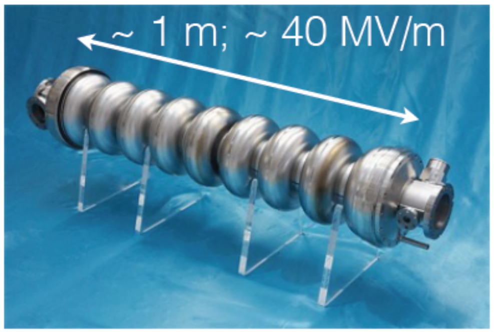
Baseline: S-band: **4**GeV → 10GeV
Alternative: C-band: **4**GeV → 20GeV

not really considered now

“Baseline” alternative: PWFA LINAC

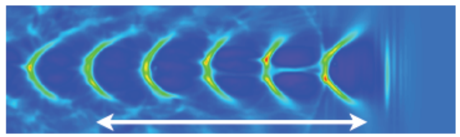
IHEP+TSINGHUA U. strong collaboration, joint group on advanced Accelerator Research since 03/2017, High Priority R&D (NSFC); 1st goal = in 5 years, feasibility study of plasma injector for 45 GeV. If feasible, they will present a detailed technological design (end 2022)

Introduction to plasma wakefield acceleration, Stuart Mangles, The John Adams Inst. for Accelerator Science, Imperial College



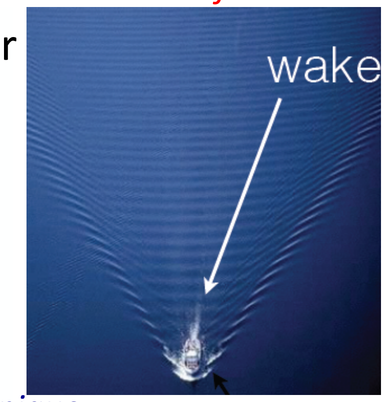
a section of RF cavity

Plasma as an accelerator



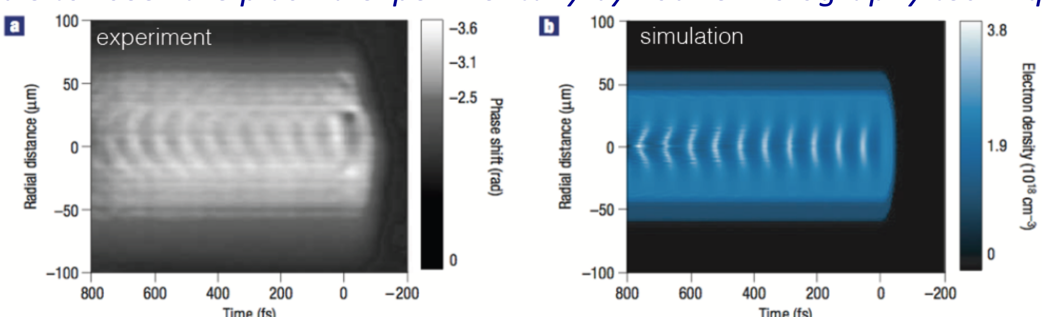
~ 50 μm; ~ 100 GV/m

a plasma wave

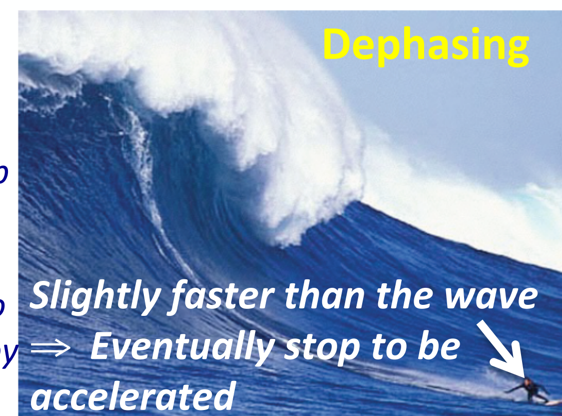


Wakefield acceleration: a boat travelling through water produces a wave behind it- a WAKE.
We can use a laser pulse travelling at close to c in a plasma to drive a strong wave behind it.

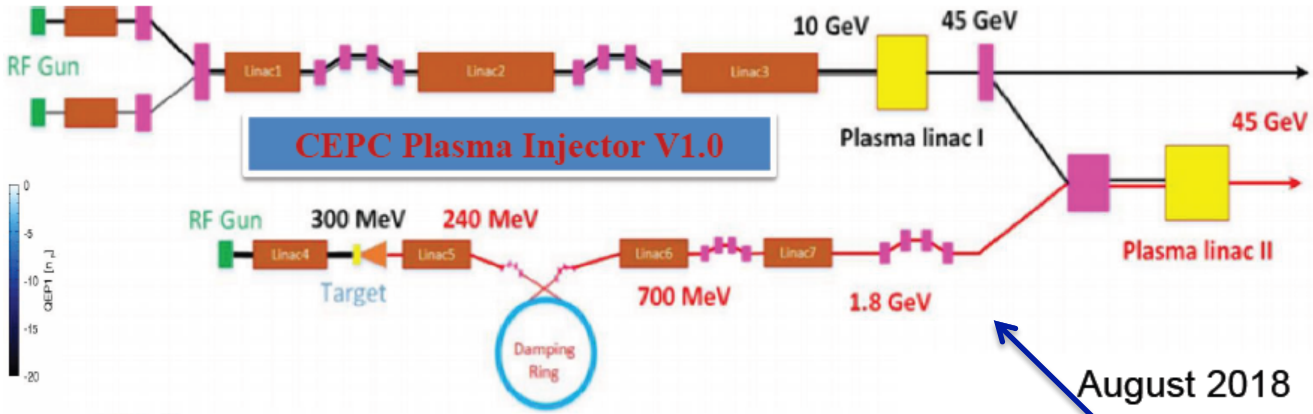
Possible to “see” the plasma experimentally by Fourier holography technique



To catch a wave surfer must swim to get up the speed before wave arrives.
If too slow the wave just pass over him
We must find a way to accelerate e-’s up to the correct speed for them to be trapped by the wave and accelerated.

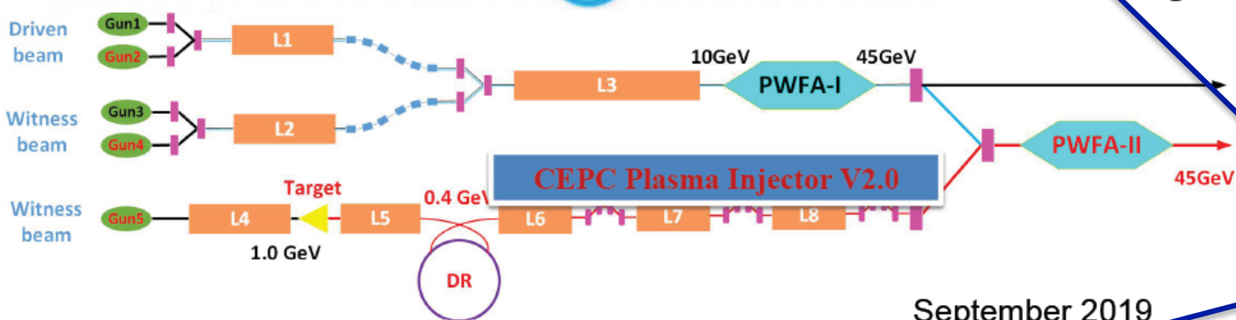


➢ Conceptual design for Plasma injector up to 45GeV, V1.0->V2.0 & tests workplan



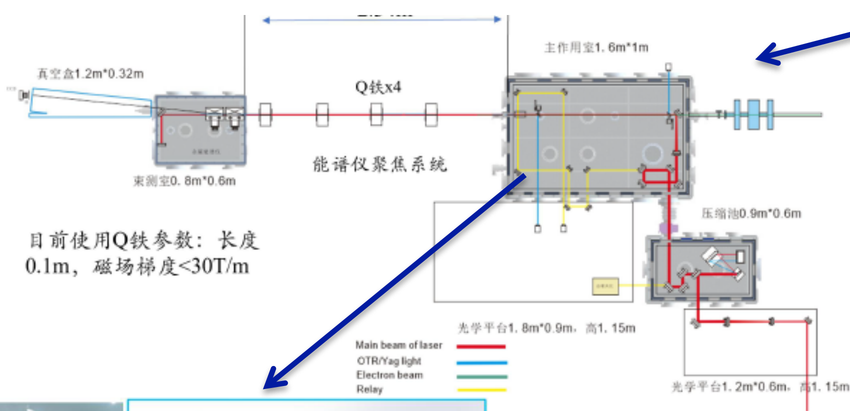
Technical design review has been done (August 22,2019)

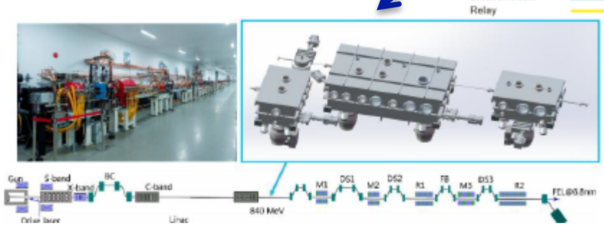
August 2018



Workplan
- Detailed simu, performances and feasibility studies.
- Prelim test at THU facility(next)
- e- plasma acceleration to be tested at Shanghai Soft XFEL
- e+ plasma acceleration might be tested at FACET II at SLAC

September 2019



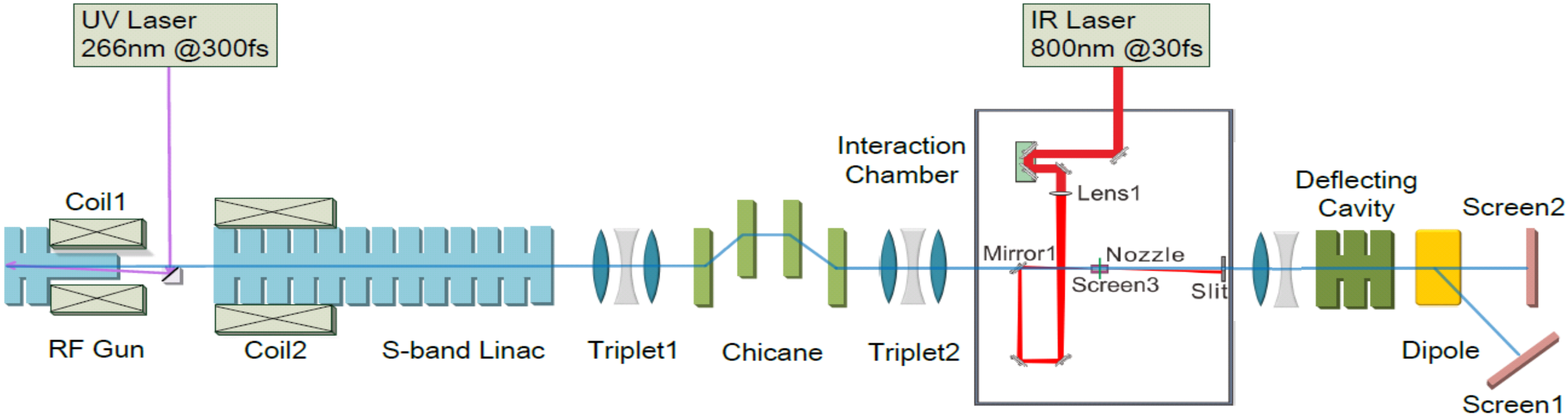


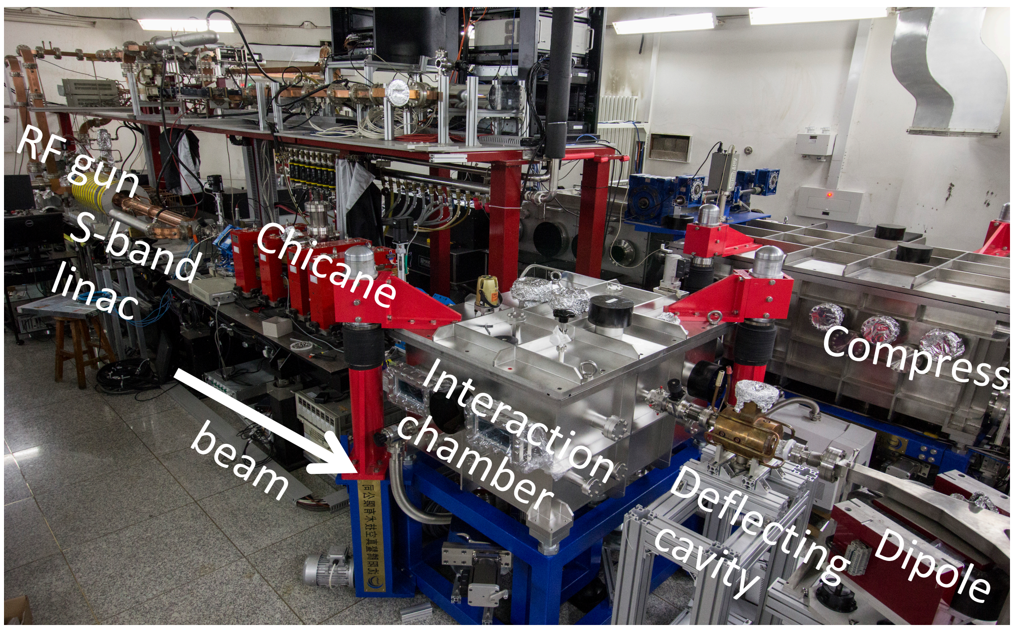
Dechirper experiment schedule

Parameter	Value
Energy	0.8GeV
Charge	50pC
Emittance	0.8μm
Beam size	10μm
Peak current	2.4kA
Energy Chirp	~8MeV

- First step: Obtaining a stable positively-chirped beam with few percent energy spread
- Second step: Post-processing the beam using a passive dechirper

➢ *Hollow Channel experiment preparation at THU Lab*





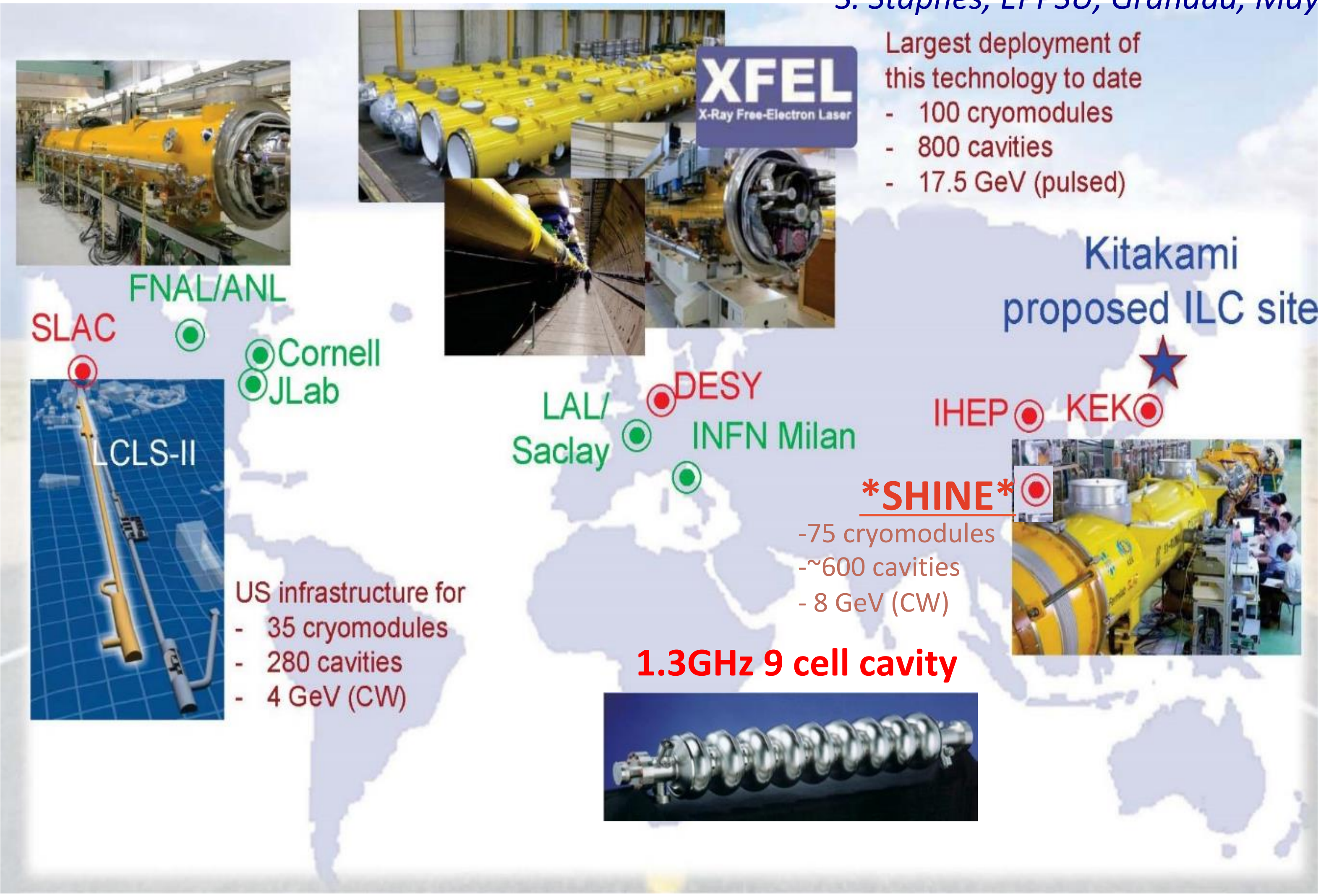
Wei Lu (THU) CepC workshop, Nov. 2019

Estimated Start Time: 2019.12

- Diagnostic system upgrade(1~2 weeks)
  - Assembling quadrupoles (1 week)
  - Online test (1 week)
- Offline test (4 weeks)
  - Optical layout (1 week)
  - Bessel beam profile measurement(1week)
  - Plasma density measurement(2 week)
- Dechirper experiment (8 weeks)
  - Optical layout (2 week)
  - Debugging (3 weeks)
  - Accessing data (3 weeks)

World wide Labs for RF systems

S. Stapnes, EPPSU, Granada, May 2019

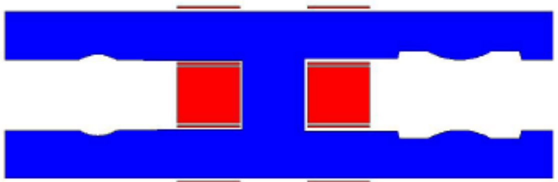


CepC: low-power magnets latest progress

JIE GAO, cepcws2019
Beijing, 20 Nov. 2019

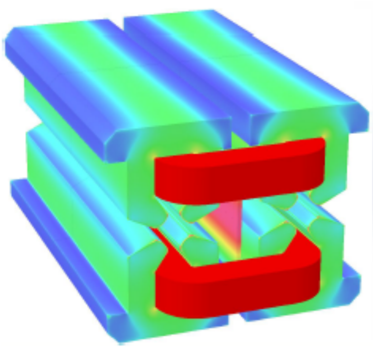
CEPC Collider Ring dual Aperture Dipole, Quadrupole and Sextupole Magnet Design Progress

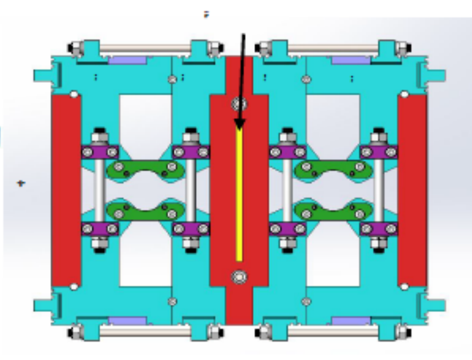
Technical design review has been done (May 5, 2019)

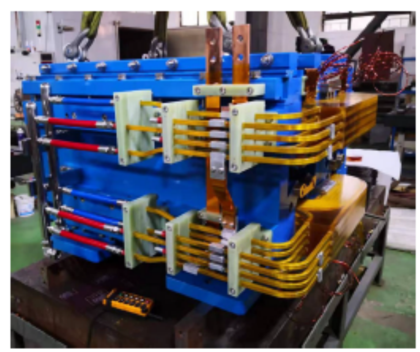


Single/dual aperture magnets: Power reduction by a factor 2

First dual aperture dipole test magnet of 1m long has been fnished in Nov, 2019







First dual aperture quadrupole magnet has been fnished in Nov, 2019

Low field booster dipole magnets: specs & challenges

JIE GAO, cepcws2019, Beijing, 20 Nov. 2019

	BST-63B
Quantity	16320
Minimum field (Gs)	28
Maximum field (Gs)	338
Gap (mm)	63
Magnetic Length (mm)	4700
Good field region (mm)	55
Field uniformity	0.1%
Field reproducibility	0.05%

10GeV injection enegy fromlinac to 100Km booster (→ Minimum field)

Challenges

- **Total length of the dipoles ~75km how to reduce cost**
- **Field error <29Gs*0.1%=0.029Gs how to design**
- **Field reproducibility<29Gs*0.05%=0.015Gs how to measure**
- **Magnet length ~4700mm how to fabricate**

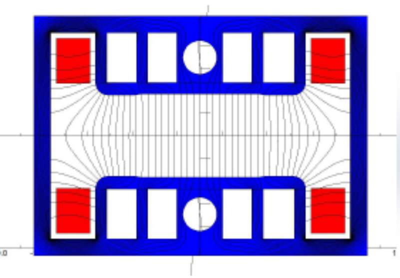
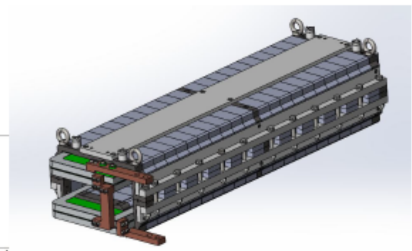
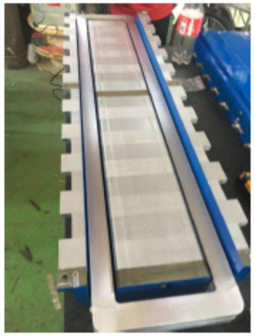
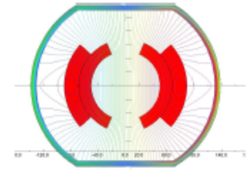
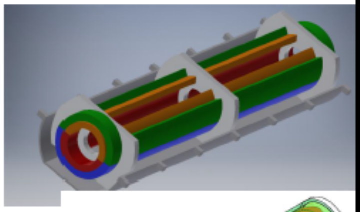
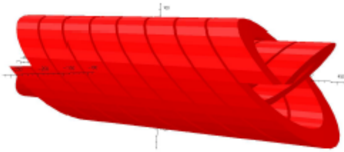
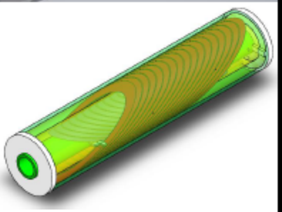
Booster high precision low field dipole magnets

JIE GAO, cepcws2019
Beijing, 20 Nov. 2019

Technical design review has been done (May 5, 2019)

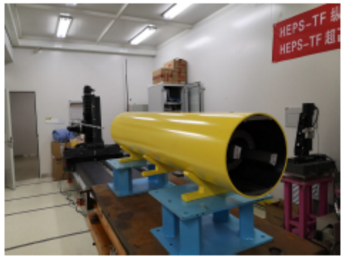
One kind of the dipole magnet with diluted iron cores is proposed and designed

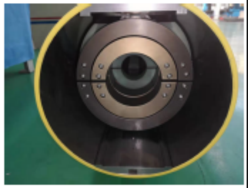
Two kinds of the dipole magnets without iron cores called Cos Theta (CT) and Canted Cos Theta (CCT) are proposed and designed

Baseline design

1m long test booster dipole magnet with iron core, completed in Nov. 2019





1m long test booster dipole magnet without iron core completed in Oct. 2019, under field measurement

Circular e+e- Colliders: RF systems

Angeles Faus-Golfe, LLR Perspectives Sept 2019

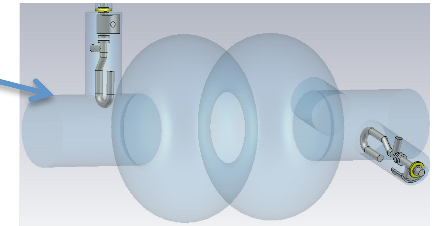
	f_{RF} [MHz]	#cavities	#cell/cavity	$V_{RF,tot}$ [MV]	acc. gradient [MV/m]	technology
SuperKEKB	509	30 (ARES) 8 (SCC)	1 1	15 12	2 6	warm Cu bulk Nb
charm-tau	500	1 / ring	1	2x1	6	bulk Nb
FCC-ee-H	400	136 / ring	4	2000	10	Nb/Cu
FCC-ee-t (addt'l)	800	372	5	6930	19.8	bulk Nb
CEPC	650	240	2	2200	19.7	bulk Nb

- All RF systems are between 400 and 800 MhZ, and based on various technologies
- Preference for SC cavities
- FCC-ee RF system will be optimized for each working point, while
- **CepC features a single RF system**

CepC: *RF R&D activities, High Q & High Gradient R&D (650 MHz)*

CEPC 650 MHz 2-cell cavity by HERT

HOM (Higher Order Mode) couplers for CepC cavities



- 650 MHz 2-cell cavity, buffered chemical polishing (BCP) without N doping, reached:

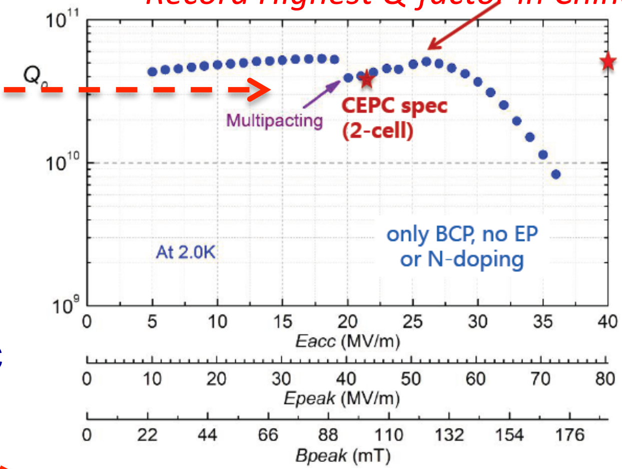
Q= 5.1x10^{10} at Eacc (accelerating gradient)= 26 MV/m

- Next step: N doping and Electro Polishing (EP) on 650 MHz cavity and

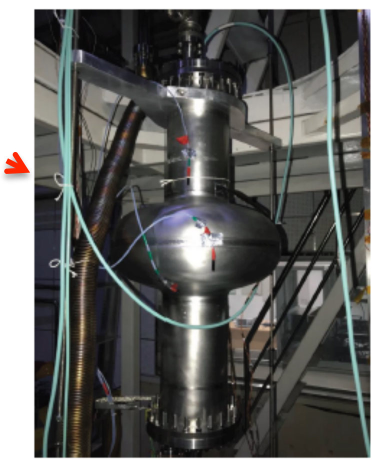
EP under commissioning, to increase Q & Eacc

to: 5x10^{10} at 42MV/m (vertical test)

Record Highest Q-factor in China

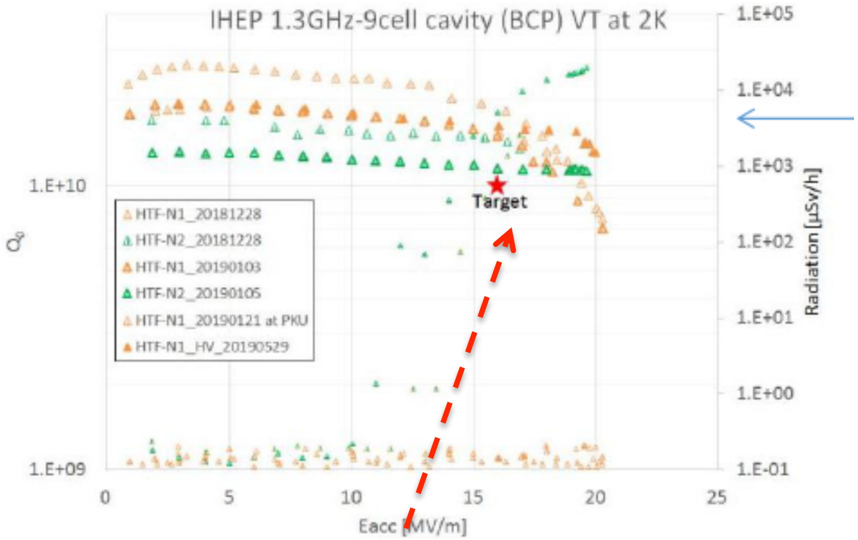


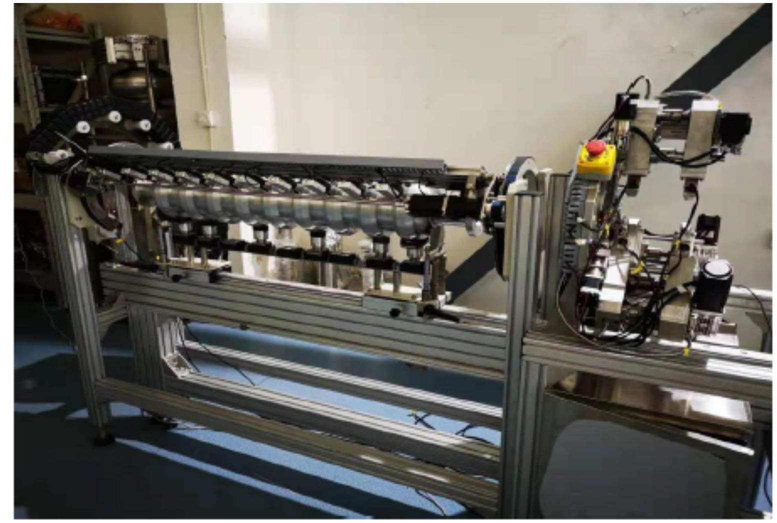
Bird view of IHEP New SC Lab under construction: 4500 m2



650 MHz 1-cell

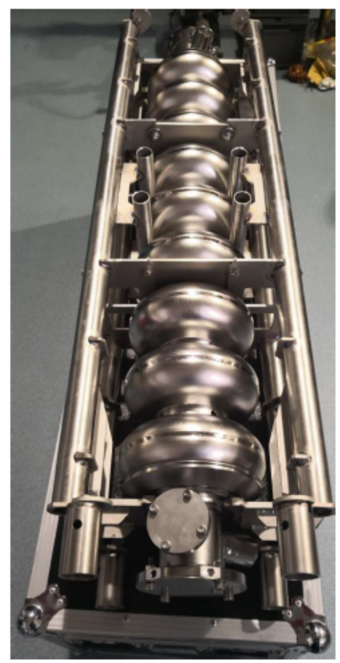
CepC *High Q & High Gradient R&D driven by SHINE-1.3GHz 9-cell cavities*



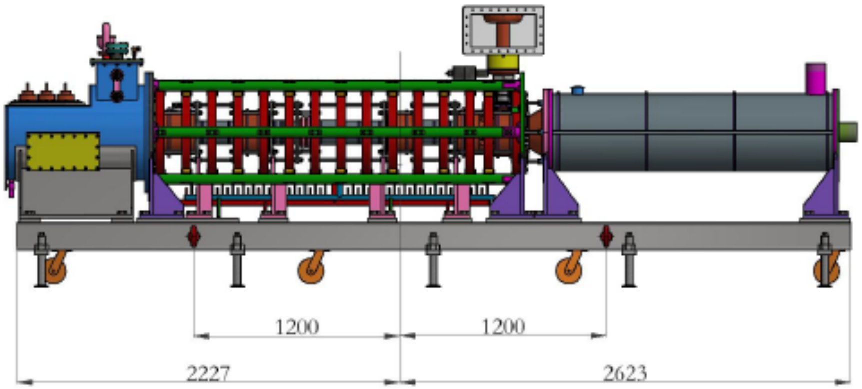


IHEP has made the 1.3GHz 9-cell cavity

that reaches the requested SHINE target.



CepC 650 MHz High Efficiency Klystron development

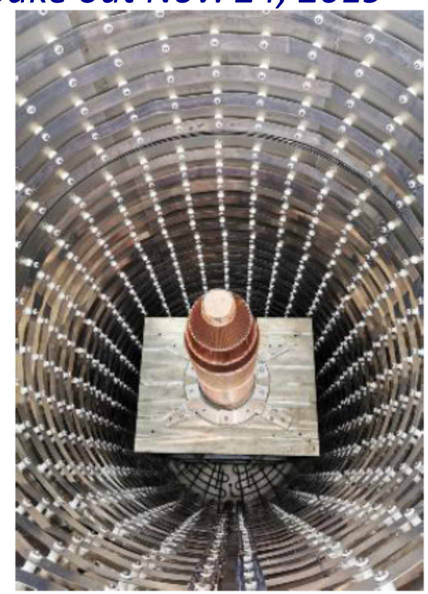


Mechanical design of conventional klystron

Parameters	Conventional efficiency	**High efficiency**
Centre frequency (MHz)	650+/-0.5	**650+/-0.5**
Output power (kW)	800	**800**
Beam voltage (kV)	80	-
Beam current (A)	16	-
Efficiency (%)	~ 65	> 80

Established High efficiency klystron collaboration consortium with IHEP, Institute of Electronics of CAS and Kunshan Guoli Science and Technology (GL company). 1st Proto installed Oct 26, bake out Nov. 24, 2019

Prototype installation



Top view

Packing and Transportation

Final state at factory

Packing

Loading

Leave factory on Dec.24, 2019

Arrived IHEP on Dec.25, 2019

In place at IHEP on Dec. 26, 2019

JIE GAO, FCC workshop, CERN, Jan 13, 2020

Major Technical Challenges

H. Abramovitch, Report from Granada, Ghent Meeting

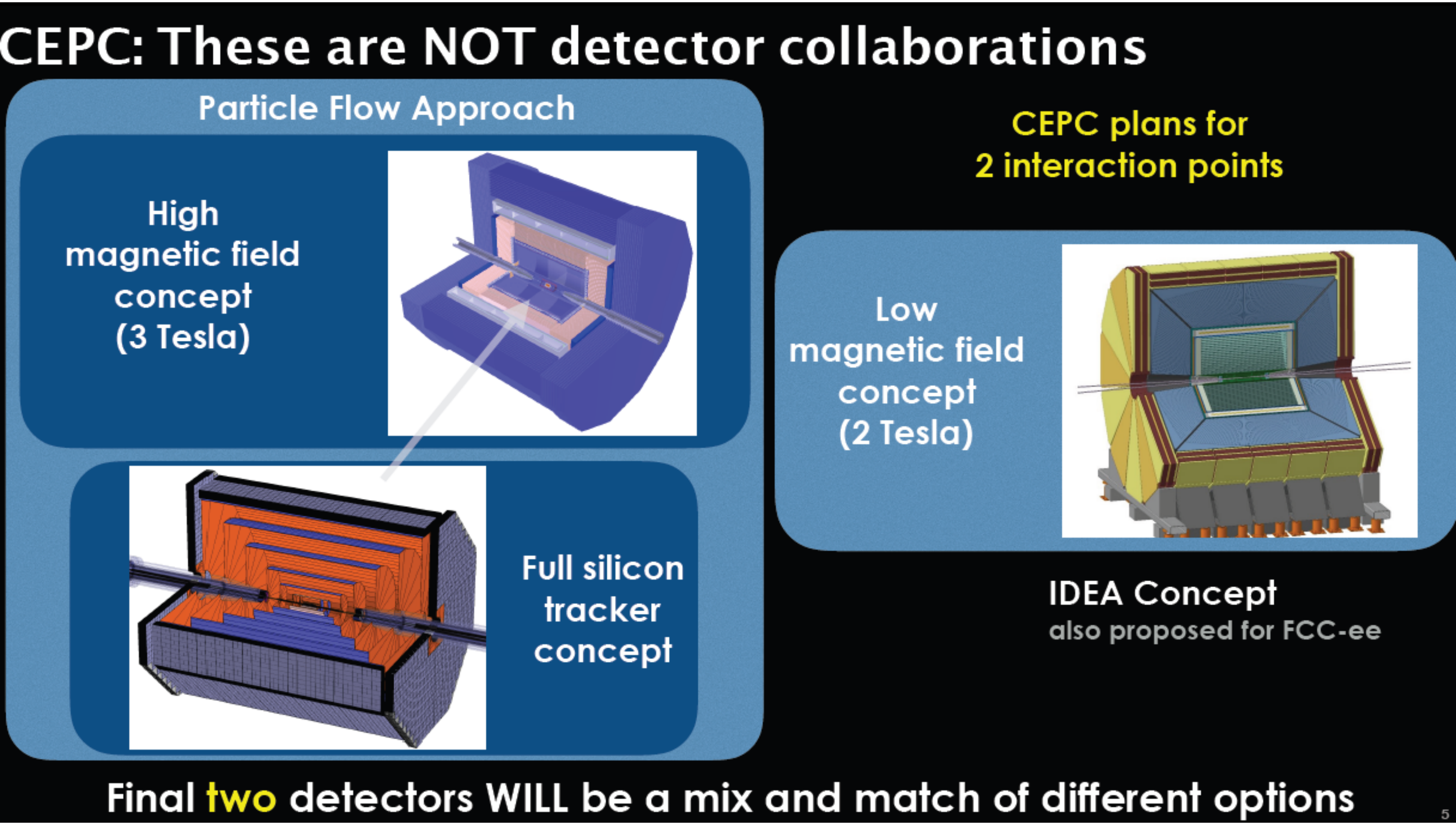
		Ref.	E (CM) [TeV]	Luminosity [10^{34}]	AC-Power [MW]	Cost-estimate Value* [Billion]	B [T]	E: [MV/m] (GHz)	Major Challenges in Technology
CC hh	FCC-hh	CDR	~ 100	< 30	580	24 or +17 (aft. ee) [BCHF]	~ 16		High-field SC magnet (SCM) - Nb3Sn: Jc and Mechanical stress Energy management
	SppC	(to be filled)	75 – 150	10	TBD	TBD	12 - 24		High-field SCM - IBS: Jc and Mechanical stress Energy management
CC ee	FCC-ee	CDR	0.18 - 0.37	460 – 31	260 – 350	10.5 +1.1 [BCHF]		10 – 20 (0.4 - 0.8)	High-Q SRF cavity at < GHz, Nb Thin-film Coating Synchrotron Radiation constraint Energy efficiency (RF efficiency)
	CepC	CDR	0.046 - 0.24 (0.37)	32~ 5	150 – 270	5 [B$]		20 – (40) (0.65)	High-Q SRF cavity at < GHz, LG Nb-bulk/Thin-film Synchrotron Radiation constraint High-precision Low-field magnet

*Cost estimates are commonly for "**Value**" (material) only.

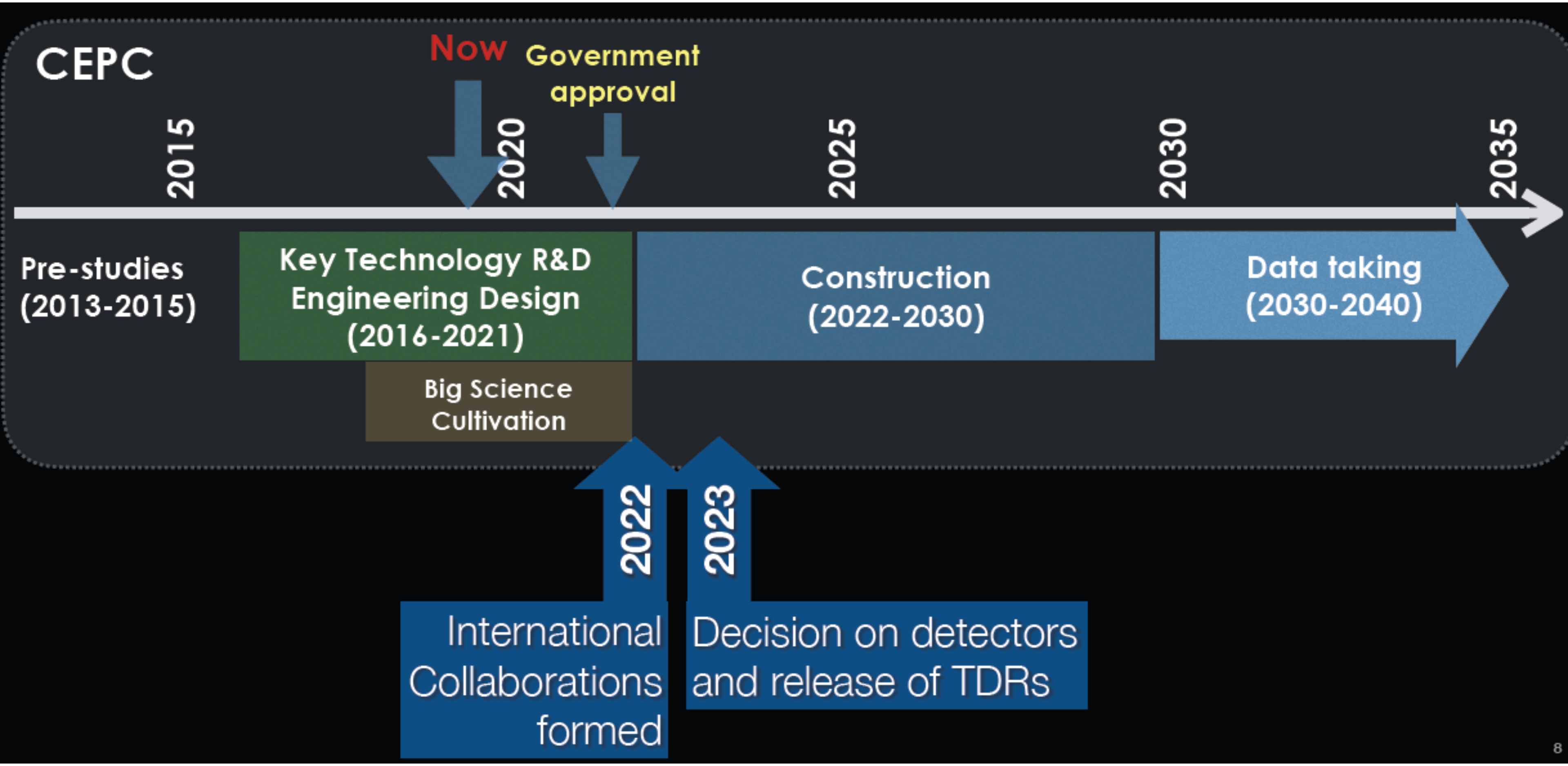
The CepC detectors design & R&D

Inputs from Joao Barreiro Guimaraes da Costa (IHEP, CAS) currently co-coordinator of the Physics & Detector CepC WG. Most of the following slides on this topic are from Joao.

Preparing for the TDR Detector Phase


CEPC: These are NOT detector collaborations
Particle Flow Approach
High magnetic field concept (3 Tesla)
Full silicon tracker concept
CEPC plans for 2 interaction points
Low magnetic field concept (2 Tesla)
IDEA Concept
also proposed for FCC-ee
Final two detectors WILL be a mix and match of different options
5

CepC Project Timeline for detectors



Updated Parameters of Collider Ring since CDR

	Higgs		Z (2T)	
	CDR	Updated	CDR	Updated
Beam energy (GeV)	120	-	45.5	-
Synchrotron radiation loss/turn (GeV)	1.73	1.68	0.036	-
Piwinski angle	2.58	3.78	23.8	33
Number of particles/bunch N_e (10^{10})	15.0	17	8.0	15
Bunch number (bunch spacing)	242 (0.68μs)	218 (0.68μs)	12000	15000
Beam current (mA)	17.4	17.8	461.0	1081.4
Synchrotron radiation power /beam (MW)	30	-	16.5	38.6
Cell number/cavity	2	-	2	1
β function at IP β_x^* / β_y^* (m)	0.36/0.0015	0.33/0.001	0.2/0.001	-
Emittance $\varepsilon_x/\varepsilon_y$ (nm)	1.21/0.0031	0.89/0.0018	0.18/0.0016	-
Beam size at IP σ_x/σ_y (μm)	20.9/0.068	17.1/0.042	6.0/0.04	-
Bunch length σ_z (mm)	3.26	3.93	8.5	11.8
Lifetime (hour)	0.67	0.22	2.1	1.8
Luminosity/IP L (10^{34} $cm^{-2}s^{-1}$)	2.93	5.2	32.1	101.6

Luminosity increase factor: × 1.8 × 3.2

formed

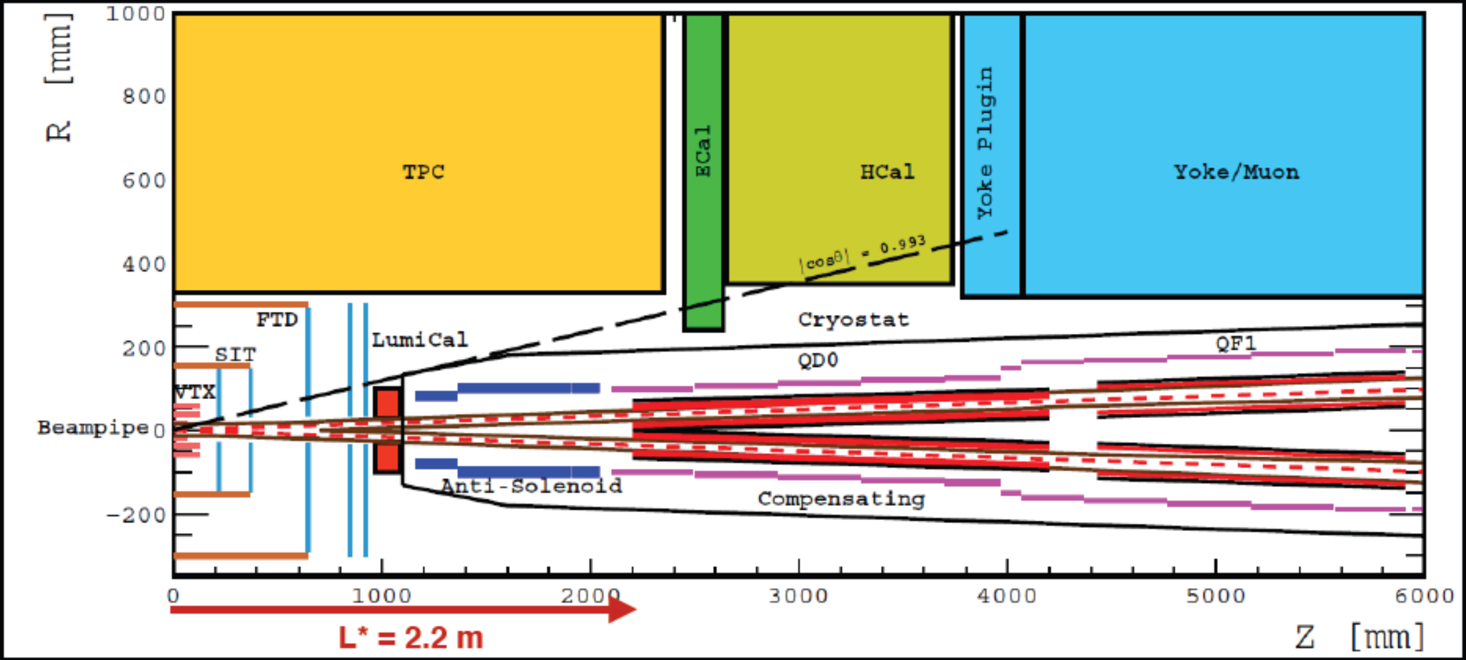
8

Machine-detector interface (MDI) in circular colliders

High luminosities → Final focusing quadrupoles (QD0) need to be very close to IP

Detector acceptance:
> ± 150 mrad

Head-on collision crossing angle: **33 mrad**



Cooling of beampipe needed → increases material budget near the interaction point (IP)

22

Final remarks

CEPC CDR: http://cepc.ihep.ac.cn/

CEPC Detector CDR completion was a major milestone for the CEPC project

Two significantly different detector concepts developed

High-magnetic field (3 Tesla)	Low-magnetic field (2 Tesla)
PFA-oriented — with TPC or full-silicon tracker	Drift chamber and dual readout calorimeter

Now is time to explore alternatives and test new ideas
Work needs however to be coherent and organized

From 2019 - 2022, R&D towards CEPC Detector Collaborations

Key accelerator and detector technologies R&D continues and are put to prototyping

Need to coordinate with engineers to study real detector feasibility

Need to expand international collaboration

Big Science Cultivation project starting —> Key technology demonstration

2023: Decision on Experimental Detectors and TDR

CEPC CDR: Particle Flow Conceptual Detector

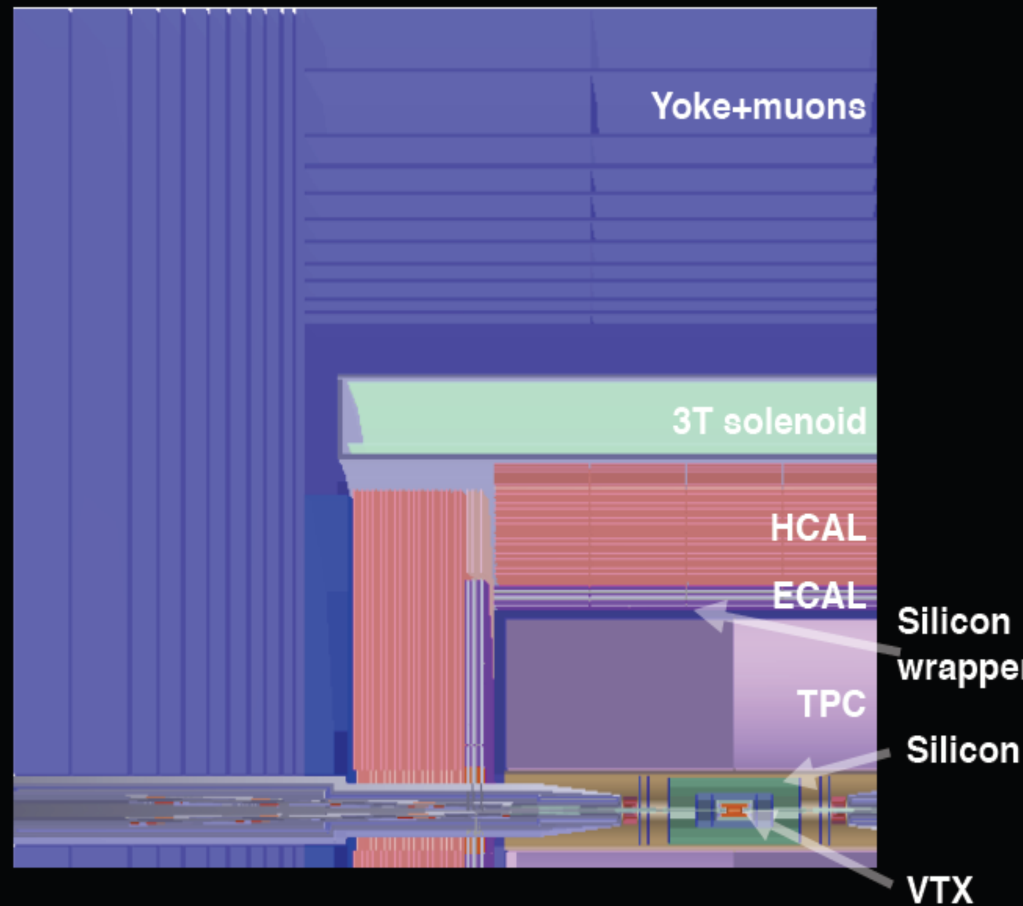
Major concerns being addressed

1. MDI region highly constrained
   L* = 2.2 m
   Compensating magnets

2. Low-material Inner Tracker design

3. TPC as tracker in high-luminosity Z-pole scenario

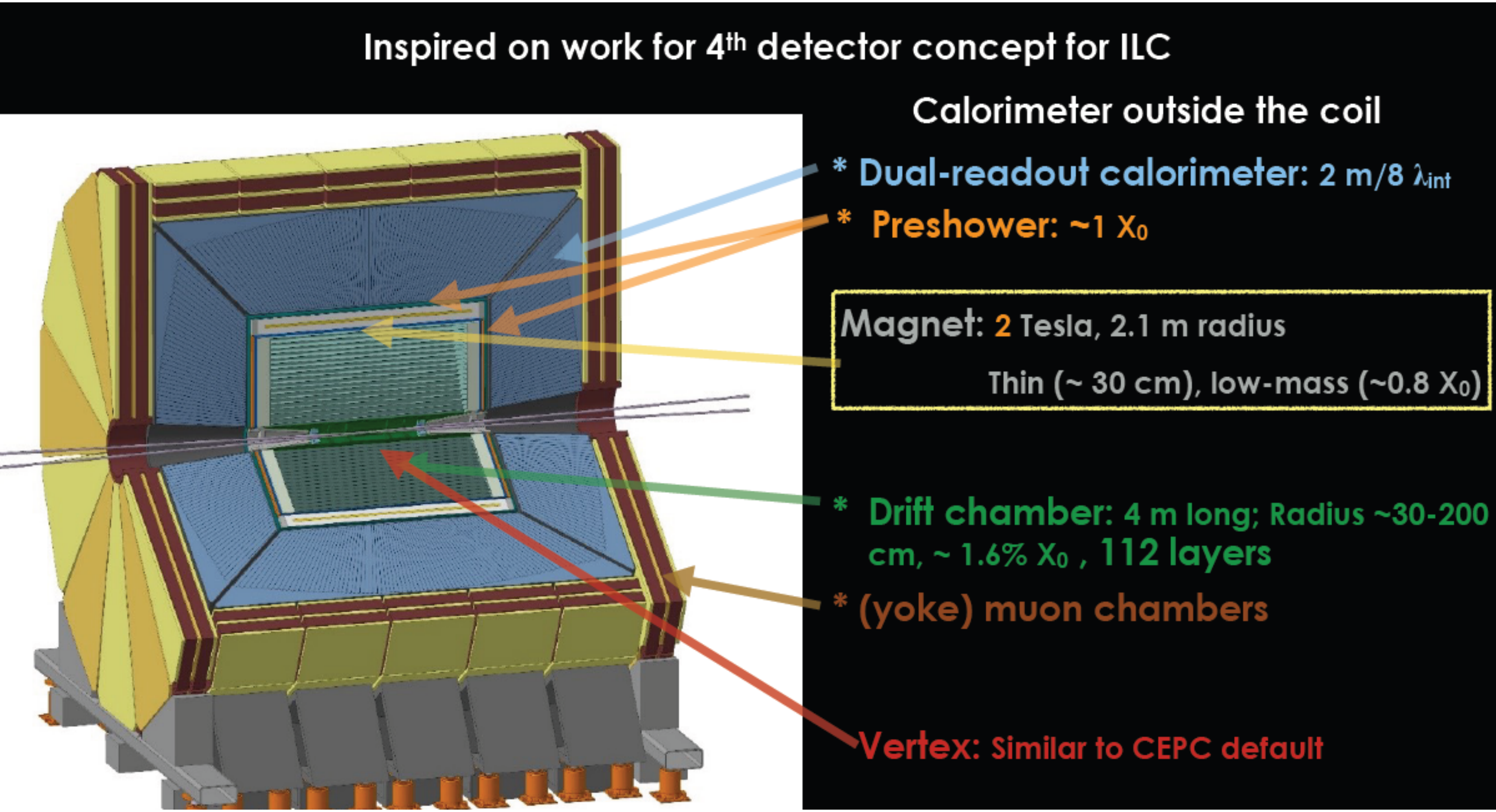
4. ECAL/HCAL granularity needs
   Passive versus active cooling
   Electromagnetic resolution



Magnetic Field: 3 Tesla

54

CEPC CDR: IDEA Conceptual Detector (CEPC + FCC-ee)



Integrated optimization effort needed

CEPC Detector Working Group Exists

Need to better integrate:

Detector and physics performance people

International Colleagues

Plenary meetings, Wednesday, 3 pm Beijing time

Aiming for a document sometime before collaborations are proposed is reasonable (end of 2021?)

Some glimpse on the Physics case & reach

Comparison with HL-LHC in terms of Physics reach and timescale

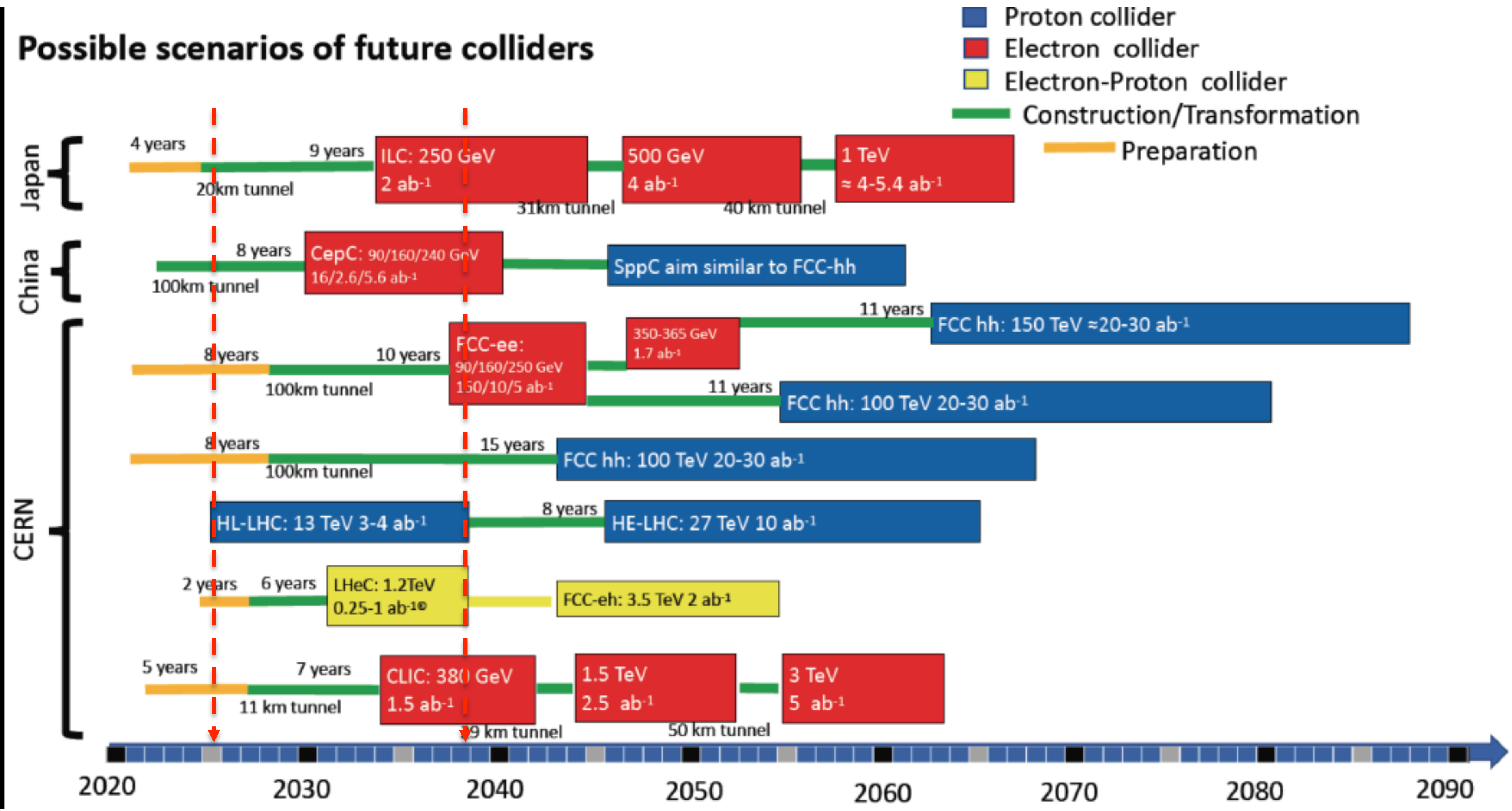
Here also emphasis is on the latest results/developments
Comparing mainly with the HL-LHC prospects that will may be running contemporarily a part of the time…

Operation mode	$\sqrt{s}$ (GeV)	L per IP (10^{34} cm^{-2}s^{-1})	Years	Total $\int L$ (ab^{-1}, 2 IPs)	Event yields
H	240	3	7	5.6	1×10^6
Z	91.2	32 (*)	2	16	7×10^{11}
W^+W^-	158–172	10	1	2.6	2×10^7 (†)

(CepC-CDR)

=> Goal: Collect over 1M of Higgs; 1 TeraZ; 100M WW events

Currently foreseen schedule for Future Machines in project



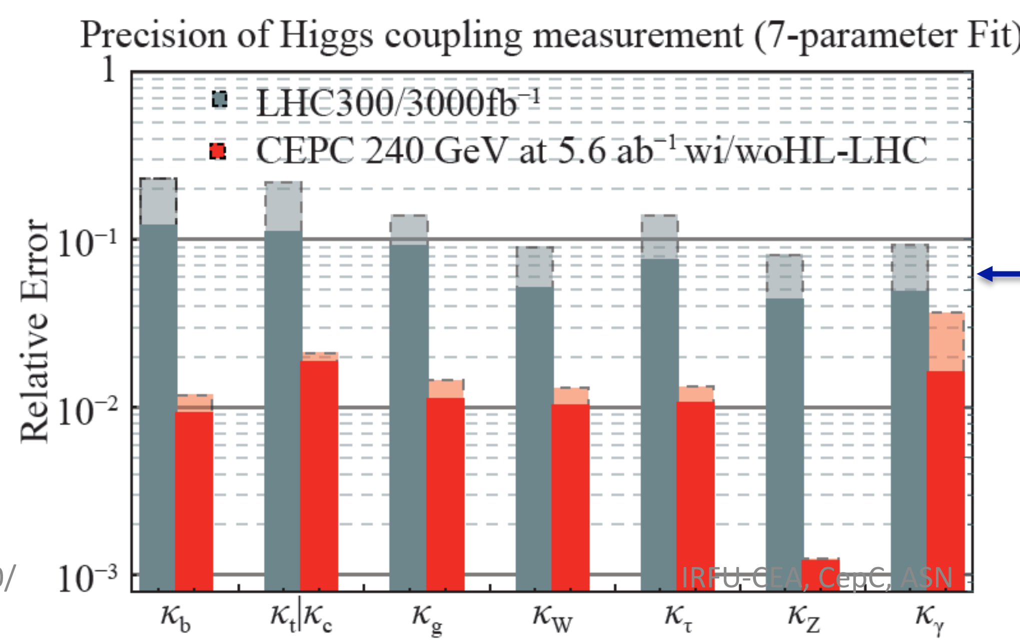
European strategy, Granada

$(240\text{GeV}, 5.6\text{ab}^{-1})$	CDR, (2018)	Current: 2019.11	Reports in this workshop
$\sigma(ZH)$	**0.50%**		
$\sigma(ZH) * \text{Br}(\text{H} \to \text{bb})$	**0.27%**		Yu Bai
$\sigma(ZH) * \text{Br}(\text{H} \to \text{cc})$	**3.3%**		
$\sigma(ZH) * \text{Br}(\text{H} \to \text{gg})$	**1.3%**		
$\sigma(ZH) * \text{Br}(\text{H} \to \text{WW})$	**1.0%**		
$\sigma(ZH) * \text{Br}(\text{H} \to \text{ZZ})$	**5.1%**		Ryuta Kiuchi
$\sigma(ZH) * \text{Br}(\text{H} \to \tau\tau)$	**0.8%**		Dan Yu
$\sigma(ZH) * \text{Br}(\text{H} \to \gamma\gamma)$	**6.8%**	**5.4%**	Fangyi Guo
$\sigma(ZH) * \text{Br}(\text{H} \to \mu\mu)$	**17%**	**12%**	
$\sigma(\text{vv}H) * \text{Br}(\text{H} \to \text{bb})$	**3.0%**		Hao Liang
$\text{Br}_{\text{upper}}(\text{H} \to \text{inv.})$	**0.41%**	**0.2%**	Ryuta Kiuchi
$\sigma(ZH) * \text{Br}(\text{H} \to Z\gamma)$	**16%**		
Width	**2.8%**		

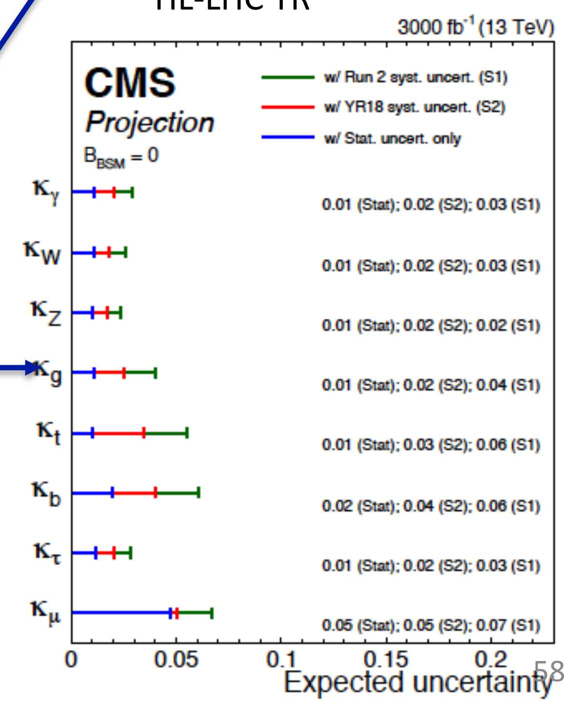
HIGGS as the 1st target

Kaili Zhang (IHEP CepC Workshop)
Results evolve/CDR. Only stat error
& assumed Theory syst.<1% in lept.coll.

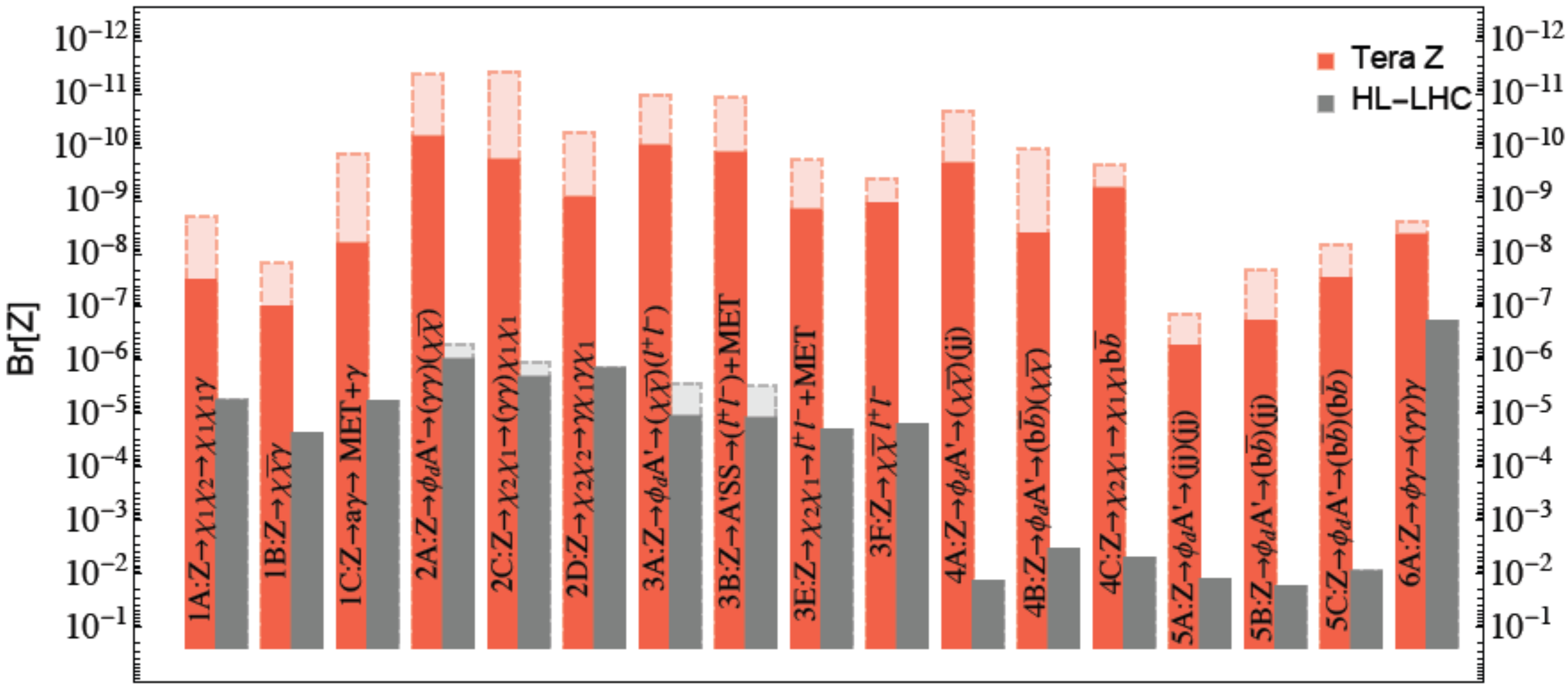
(Hao Zhang, IHEP,
CepCWorkshop, Nov 2019)



HL-LHC YR

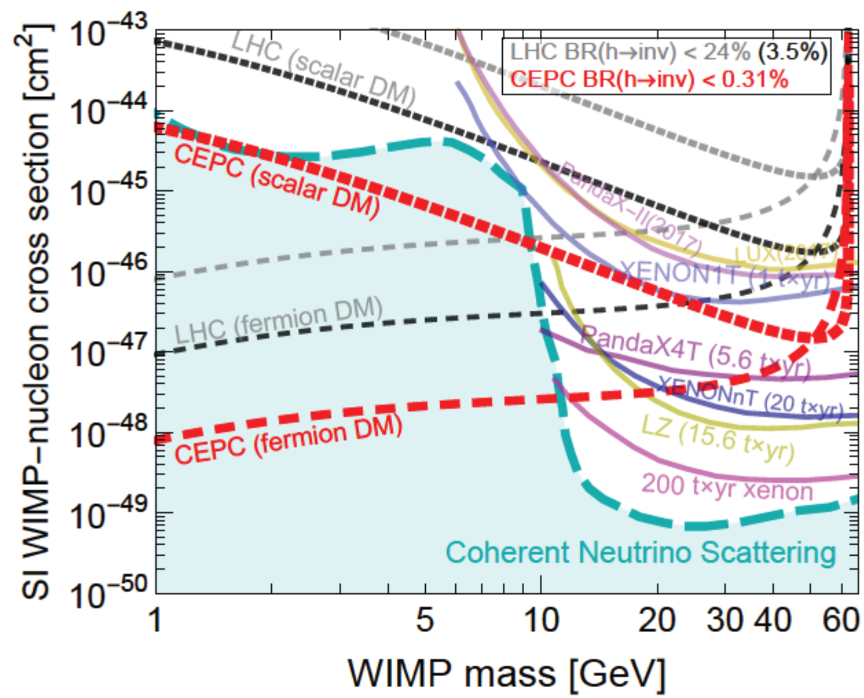


Sensitivity reach in the Z branching ratio for various exotic Z decay topologies at CepC(CDR) & HL-LHC

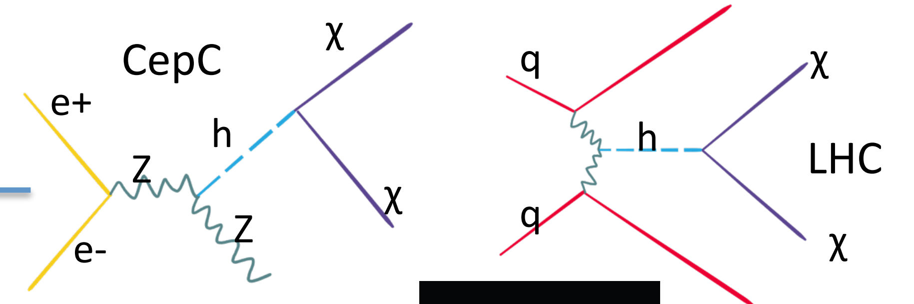


Assumed here: CepC: 1012 Z and Luminosity at HL-LHC = 3 ab-1, adapted from Ref: ArXiv.1712.07237v2 "*Exposing Dark Sector with Future Z-Factories*", Jia Liu (Uchicago) et al.

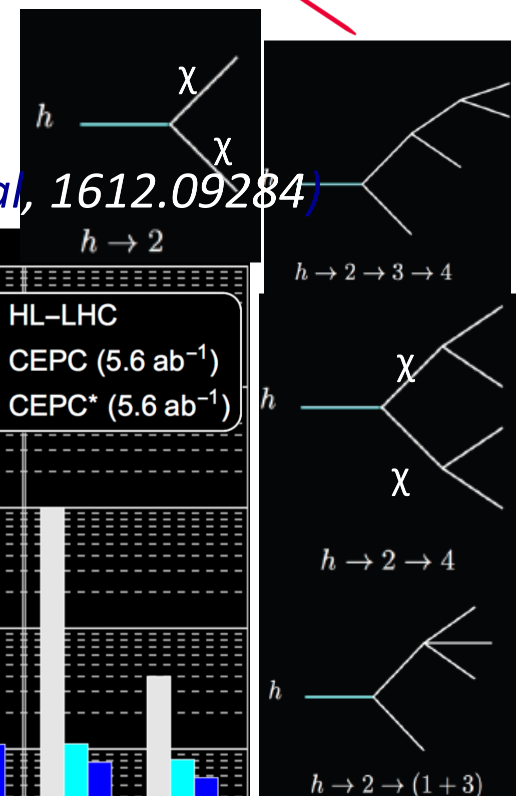
CepC/Dark Matter searches

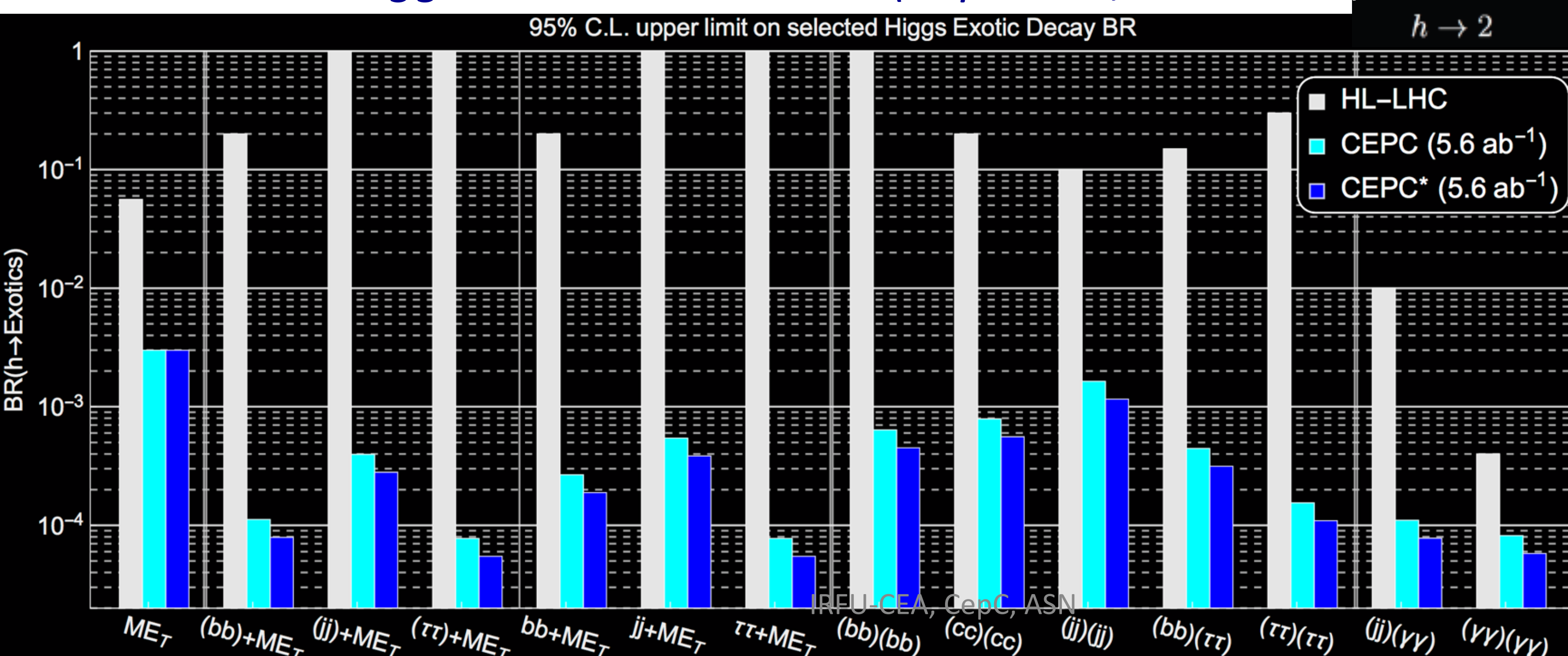


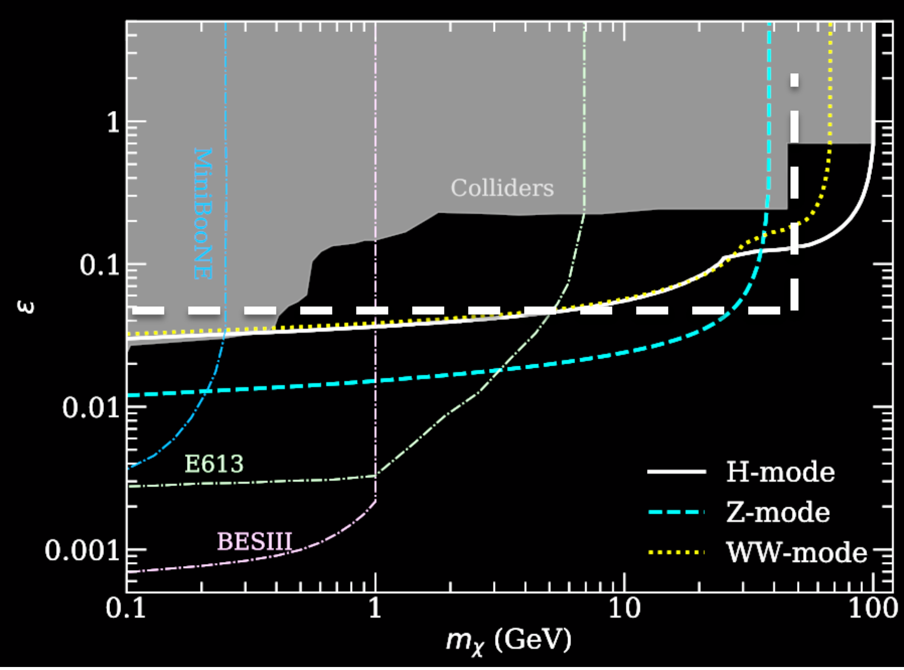
Example 1: D.M. interacting via the Higgs



Dark Sectors & Higgs->exotics & cascade (CepC CDR, Z. Liu et al, 1612.09284)



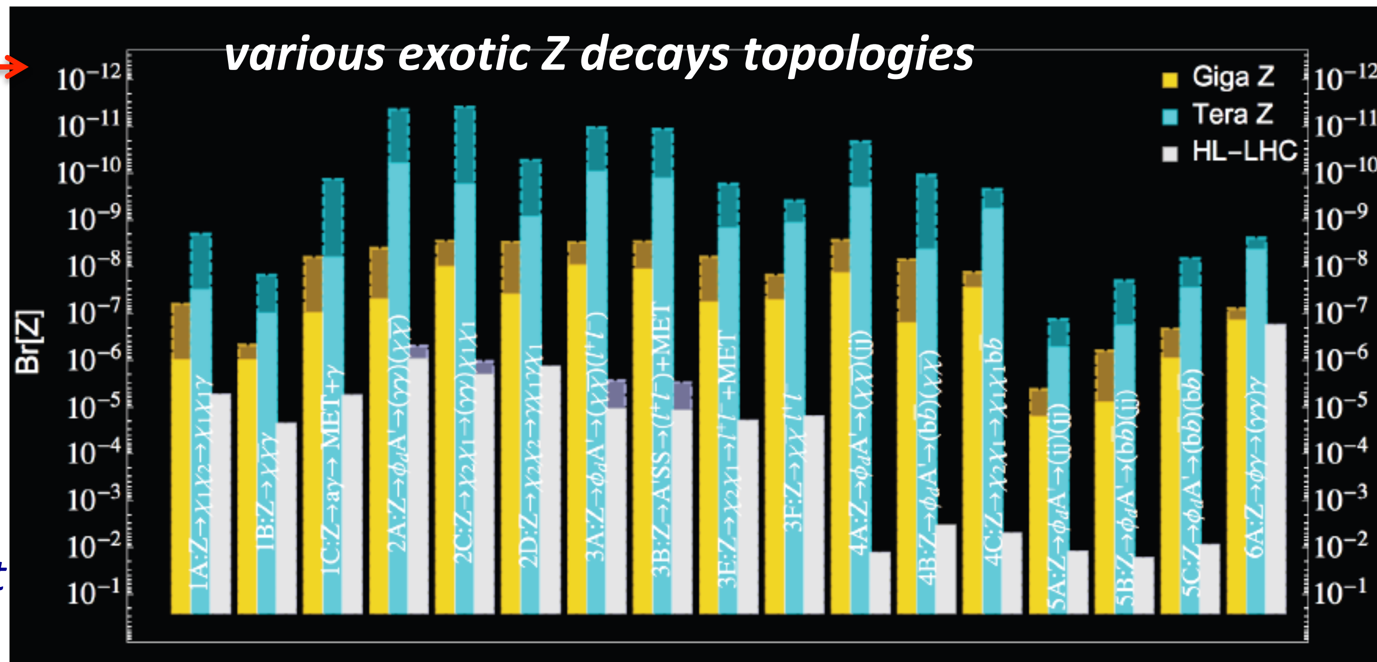




Dark Matter & Z

Indirect bound from improved Z width measurement; further improvements likely possible… (*Zuowei Liu, Zhijun Liang*)

Dark sector & Z: Sensitivity reach in Z-branching ratio for various exotic Z decays topologies @CepC & the HL-LHC (L=3ab^{-1}) (*CEPC CDR; J.Liu & al, ArXiv 1712.07237v2). Limitation for LHC: QCD &QCD induced Bkgd, but can still be improved.*



CepC vs Flavours

Particle	@ Tera-Z	@ Belle II		@ LHCb
b hadrons				
B^+	2×10^{10}	3×10^{10}	$(50\,\mathrm{ab}^{-1}$ on $\Upsilon(4S))$	3×10^{13}
B^0	2×10^{10}	3×10^{10}	$(50\,\mathrm{ab}^{-1}$ on $\Upsilon(4S))$	3×10^{13}
B_s	7×10^{9}	3×10^{8}	$(5\,\mathrm{ab}^{-1}$ on $\Upsilon(5S))$	8×10^{12}
b baryons	3×10^{9}			1×10^{13}
Λ_b	3×10^{9}			1×10^{13}

vs Belle II: b baryons, Λ_b, 100x B_s

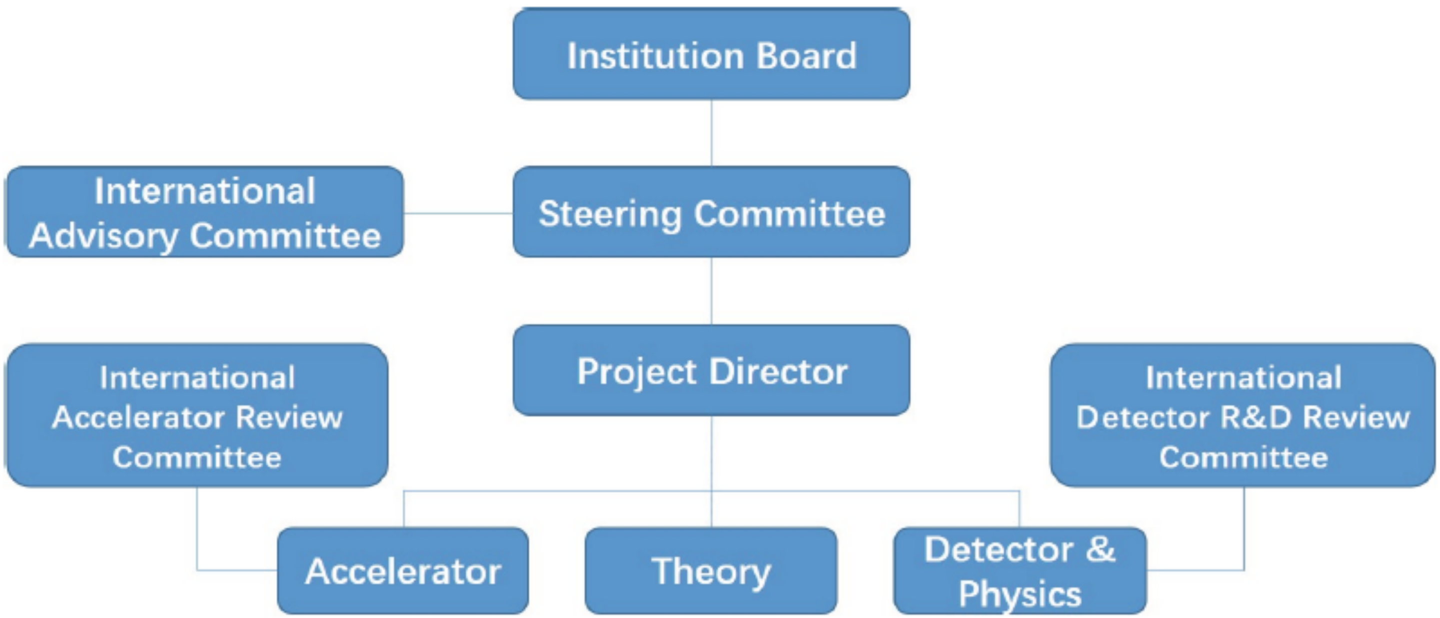
vs LHCb: low bkg→neutrals (γ, π_0,...)

Unique sensitivity to processes unavailable at LHCb or Belle II: flavor-violating Z decays*, lepton universality in Z decays*, rare b→sττ decays, rare b→sνν decays, B_c decays*, semi-tauonic b→cτν decays, τ decays, FCNC single top.

CepC Organization, Timeline, Funding and site locations

CepC Organization

The organization structure was officially formed in the kick-off meeting in September 2013. It consists of the Institute Board (IB) with representatives from each institution in the project; the Steering Committee (SC) with members appointed by the IB; the International Advisory Committee with experts from various fields providing consult to the SC; the Project Director appointed by the SC and in direct charge of the three working groups, Theory, Accelerator, and Detector & Physics. In 2019, the International Accelerator Review Committee and the International Detector R&D Review Committee were formed.



Institution Board		Yuanning Gao (PKU) Jie Gao (IHEP, Deputy)
Steering Committee		Yifang Wang (IHEP, Chair) Hongjian He (Tsinghua Univ) Xinchou Lou (IHEP) Shan Jin (NJU) Qing Qin (IHEP) Haijun Yang (SJTU) Meng Wang (SDU) Nu Xu (IMP, CAS) Yajun Mao (PKU) Jie Gao (IHEP) Yuanning Gao (PKU) Jianbei Liu (USTC) Qinghong Cao (PKU)
Project Director		Xinchou Lou (IHEP) Qing Qin (IHEP, Deputy) Nu Xu (IMP, CAS, Deputy)
Working Group	Theory	Hongjian He (Tsinghua Univ) Jianping Ma (ITP) Xiaogang He (SJTU)
	Accelerator	Jie Gao (IHEP) Jingyu Tang (IHEP) Yunlong Chi (IHEP)
	Physics & Detector	Joao Barreiro Guimaraes da Costa Shan Jian (NJU) Jianchun Wang (IHEP)

International Advisory Committee

- Barry Barish, Caltech
- Hesheng Chen, IHEP, Chinese Academy of Sciences
- Michel Davier, LAL
- Marcel Demarteau, ORNL
- Brian Foster, DESY/University of Hamburg & Oxford University
- Rohini Godbole, CHEP, Bangalore
- David Gross, University of California, Santa Barbara
- George Hou, Taiwan University
- Peter Jenni, CERN & Albert-Ludwigs-University Freiburg
- Young-Kee Kim (Chair), University of Chicago
- Eugene Levichev, BINP
- Lucie Linssen, CERN
- Joe Lykken, Fermilab
- Luciano Maiani, University of Rome
- Michelangelo Mangano, CERN
- Hitoshi Murayama, University of California, Berkeley & Kavli IPMU
- Tatsuya Nakada, EPFL
- Katsunobu Oide, CERN & KEK
- Robert Palmer, BNL
- John Seeman, SLAC
- Ian Shipsey, Oxford University
- Steinar Stapnes, CERN
- Geoffrey Tayler, University of Melbourne
- Henry Tye, IAS, Hong Kong University of Science and Technology

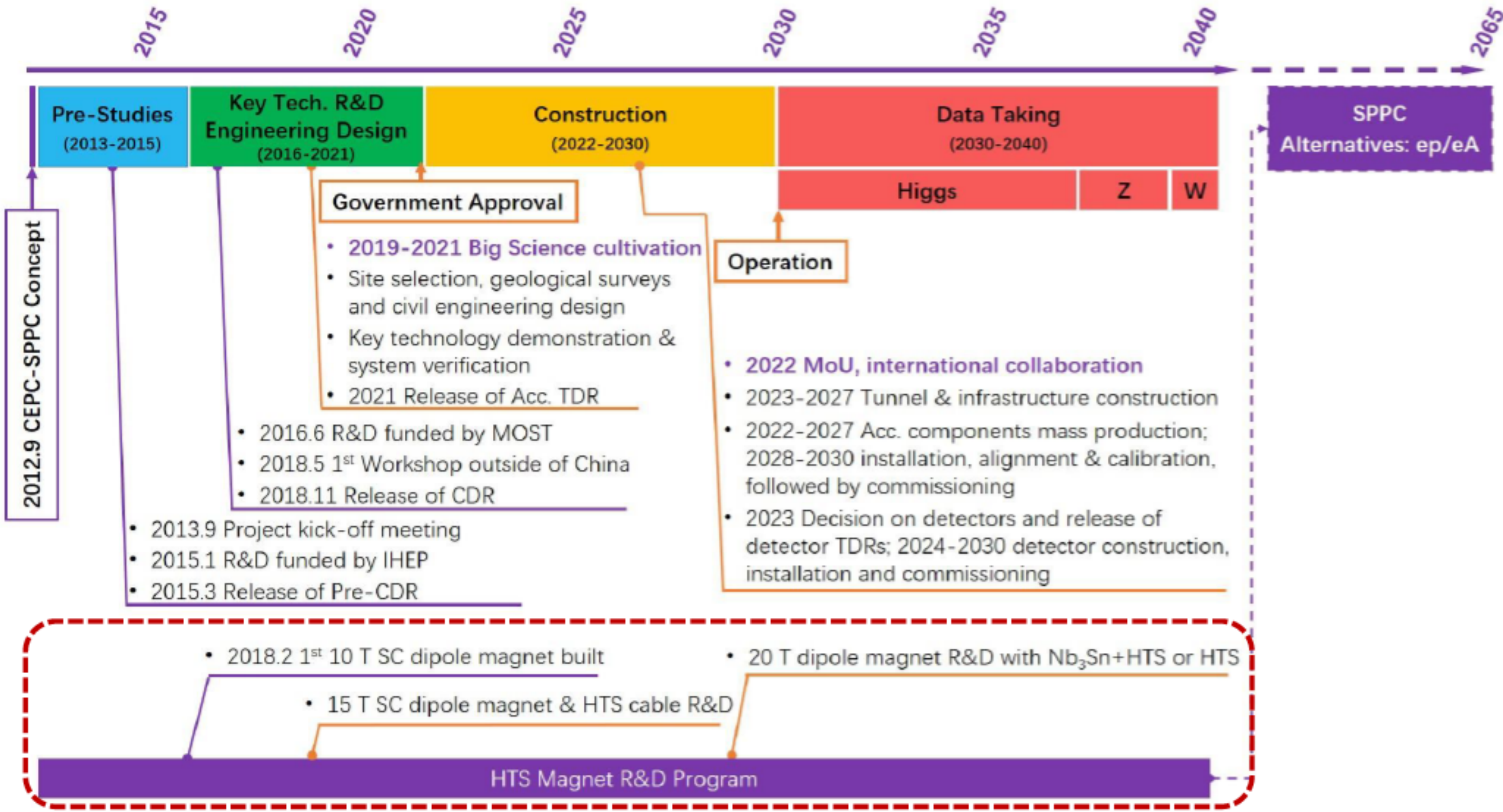
International Accelerator Review Committee

- Phillip Bambade, LAL
- Marica Enrica Biagini, INFN
- Brian Foster, DESY/University of Hamburg & Oxford University
- In-Soo Ko, POSTTECH
- Eugene Levichev, BINP
- Katsunobu Oide (Chair), CERN & KEK
- Anatolii Sidorin, JINR
- Steinar Stapnes, CERN
- Makoto Tobiyama, KEK
- Zhentang Zhao, SINAP

International Detector R&D Review Committee

- Jim Brau, USA, Oregon
- Valter Bonvicini, Italy, Trieste
- Ariella Cattai, CERN, CERN
- Cristinel Diaconu, France, Marseille
- Brian Foster, UK, Oxford
- Liang Han, China, USTC
- Dave Newbold, UK, RAL (chair)
- Andreas Schopper, CERN, CERN
- Abe Seiden, USA, UCSC
- Laurent Serin, France, LAL
- Steinar Stapnes, CERN, CERN
- Roberto Tenchini, Italy, INFN
- Ivan Villa Alvarez, Spain, Santader
- Hitoshi Yamamoto, Japan, Tohoku

CEPC Project Timeline



Scientific Policy and Funding Strategy

X. Lou, CepC Workshop, Nov 2019

Chinese Government： "actively initiating major-international science project…"
国发〔2018〕5号（2018.3.14）http://www.gov.cn/zhengce/content/2018-03/28/content_5278056.htm

See next Slide=>

- focuses on "**frontier science, large-fundamental science , global focus, international collaboration, …**"
- by year 2020， 3-5 projects will be chosen to go into "preparatory stage", among which 1-2 projects will be selected. More projects will be selected in later years.
- The task of selecting the projects, and develop them further falls on the Ministry of Science and Technology (MOST)
- MOST committees formed, are writing the guidelines
- **This is a likely path to realize CEPC. We are paying close attention to this opportunity**

- ➢ **CEPC team is in regular contact with MOST expert committee**
- ➢ **Selection criteria seem to be in place, but selection process is not clear, expect to be rather volatile**
- ➢ **CEPC is focusing on working, & making progress according to the roadmap-schedule**

Scientific Policy and Funding Strategy

Chinese Government: **"actively initiating major-international science project..."**
国发〔2018〕5号（2018.3.14）http://www.gov.cn/zhengce/content/2018-03/28/content_5278056.htm

23/1/2018 : Meeting of the China Reform and Development Committee (led by President J.P. Xi);
=> the plan of "Chinese Initiated International Large Scientific Plan & Large Scientific Project"
28/3/2018 : Chinese Government (led by Prime Minister Keqiang Li) made public details of the "Chinese Initiated International Large Scientific Plan & Large Scientific Project":….
Actively participate to the other country or multi-countries's initiated Large Scientific Projects ...
Actively participate to important international scientific organizations' scientific projects and activities...

(translated by J. Gao)

Funding scenarii

Xinchou Lou, CepC Workshop, Nov 18, 2019

Total cost of the CepC project: 36 B CNY ≈ 5 B $ ≈ 4.6 B €, under the assumption that the local government will provide the land and the necessary infrastructures.

Scenario	Cost sharing	Funding sources	comment
Option 1	32 B CNY≈ 4. 57B$ (4. 12B€) 4BB CNY≈ 0. 57B$ (0. 51B€)	Chinese Central Gov. International Contribution	Project submitted Nov. 13 2019, by IHEP, PI. Yifang Wang; waiting for results
Option 2	12 B CNY≈ 1. 71B$ (1. 55B€) 10 B CNY≈ 1. 43 B$ (1. 29 B€) 10 B CNY≈ 1. 43 B$ (1. 29 B€) 4B CNY≈ 0. 57 B$ (0. 51 B€)	Chinese Central Gov. From MOST International Science project From local government International Contribution	Work actively in parallel on this option=> Option 1 is not a show-stopper.

Under discussion: the funding breakdown across various 5 years-periods

CEPC Site Selections

Huanghe Company particitated

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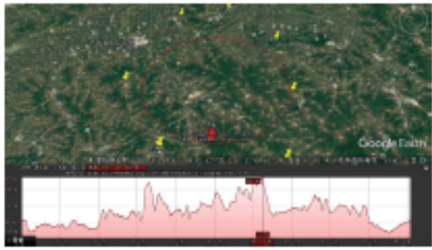

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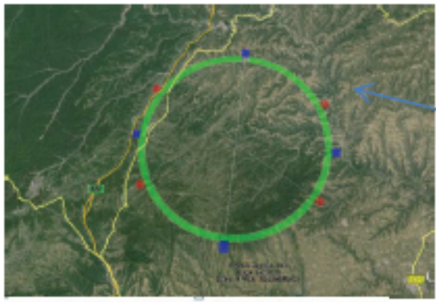

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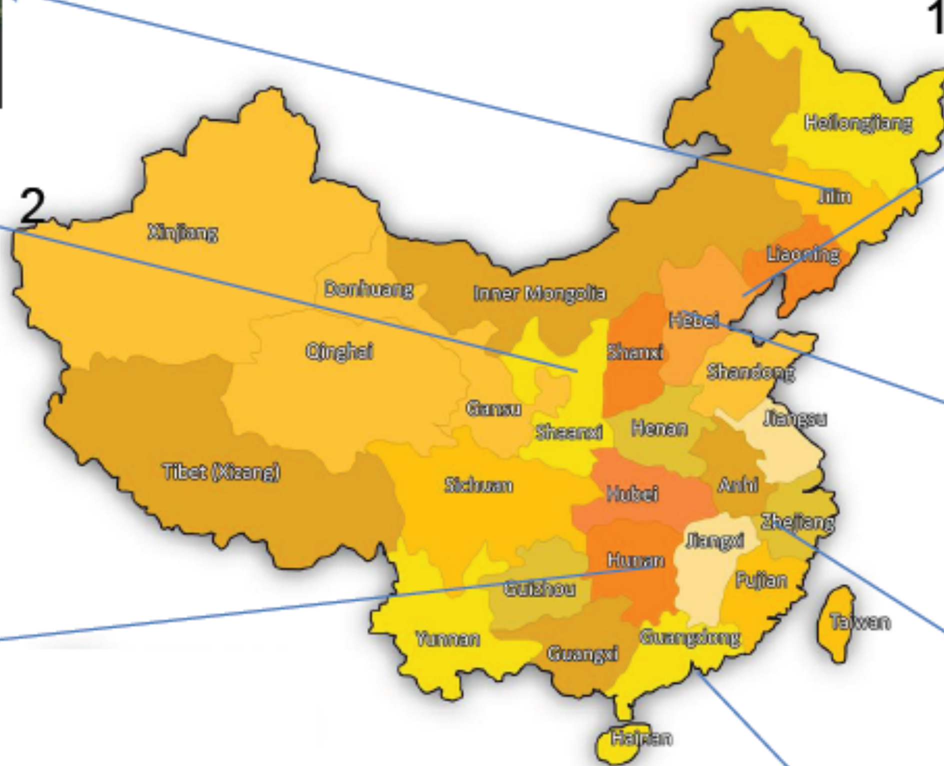

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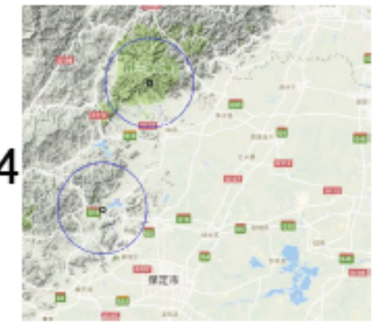

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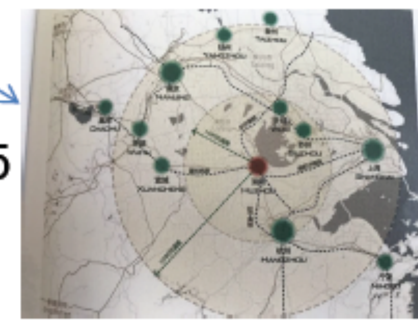

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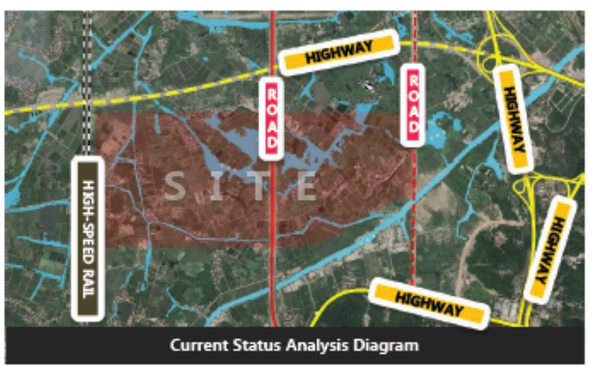
1) Qinhuangdao, Hebei Province（Completed in 2014）
2) Huangling, Shanxi Province（Completed in 2017)
3) Shenshan, Guangdong Province(Completed in 2016)
4) Baoding (Xiong an), Hebei Province (Started in August 2017)
5) Huzhou, Zhejiang Province (Started in March 2018)
6) Chuangchun, Jilin Province (Started in May 2018)
7) Changsha, Hunan Province (Started in Dec. 2018)

Science City Planning (Huzhou site as an example)

Science City is located in the southwest of Huzhou, south of Huzhou Scientific and Technological City, **5 kilometers** away from Huzhou High Speed Railway Station, **7 kilometers** away from CEPC, and the site area is about **3.92 square kilometers**.



CEPC Core Building

ARCHITECTURE

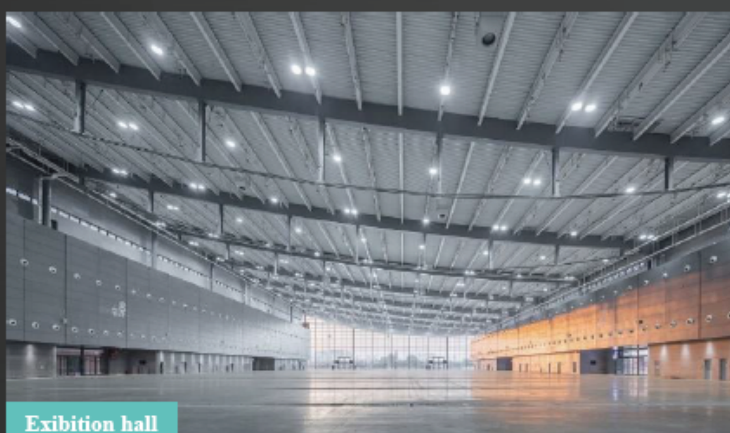
CEPC-SPPC项目国际科学城概念规划
CEPC-SPPC Project International Science City Concept Planning

Functional Area

xperimental labs

Experimental hall

Cafeteria

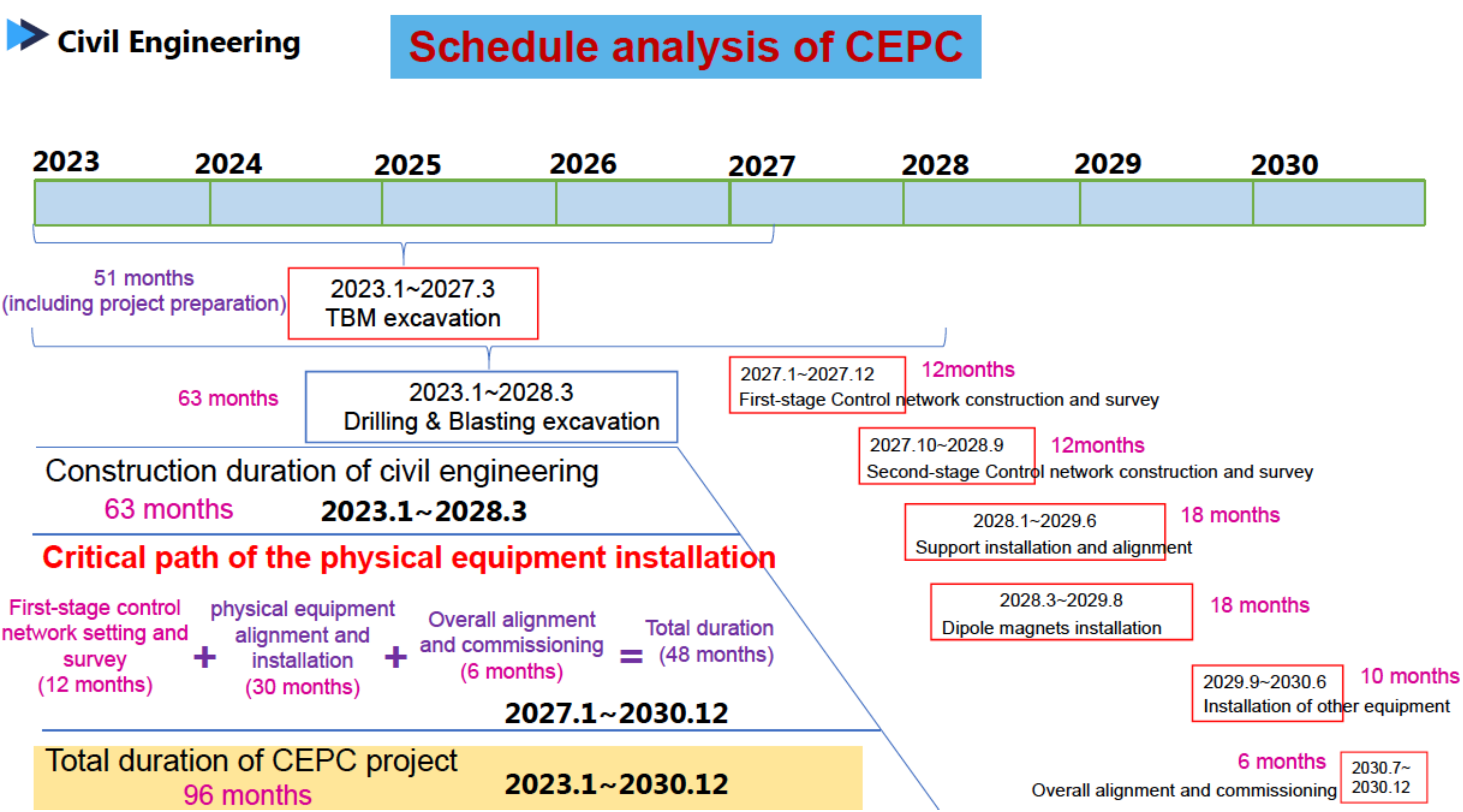


Exibition hall

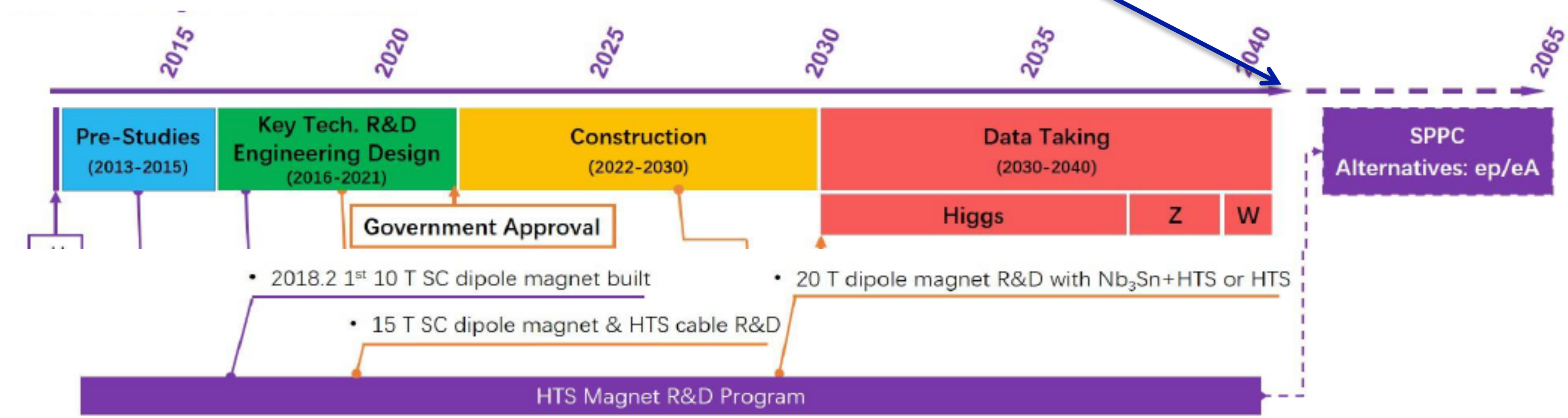
Sport facility

DETAILED & RELIABLE FLOW CHART FOR CepC CONSTRUCTION & CIVIL ENGINEERING

See Wang Xialong's talk at CepC Workshop at IHEP, Nov 2019, on behalf of the Installation & Alignment team



The SppC as a second stage of CepC



- ✓Updated parameters after CDR
- ✓Geometry compatibility study SppC/CepC
- ✓Proton injector chain
- ✓**HIGH FIELD MAGNETS R&D**: integrated in **National High priority effort for HT superconducting technology**; SppC project instead: only 2 small scale NSFC funds => only accelerator physics studies

SppC Main Parameters

Parameter	Unit	Value		
		PreCDR	CDR	Ultimate
Circumference	km	54.4	100	100
C.M. energy	TeV	70.6	75	125-150
Dipole field	T	20	12	20-24
Injection energy	TeV	2.1	2.1	4.2
Number of IPs		2	2	2
Nominal luminosity per IP	$cm^{-2}s^{-1}$	1.2e35	1.0e35	-
Beta function at collision	m	0.75	0.75	-
Circulating beam current	A	1.0	0.7	-
Bunch separation	ns	25	25	-
Bunch population		2.0e11	1.5e11	-
SR power per beam	MW	2.1	1.1	-
SR heat load per aperture @arc	W/m	45	13	-

Jie Gao:” *SppC 12 T OR OTHER field, depending the actual level at that time, not means first 12 and then 24. If 24 could be achieved then, we use 24*”.

Courtesy of Jingyu Tang for the SppC WG, CepC, workshop, Nov 2019

Geometry Compatibility Study of CepC & SppCY

Y. Wang, Y. Chen, D. Wang, C. Yu, J. Gao, J. Tang

at CepC Workshop Nov. 2019

– The SPPC will share the tunnel of CEPC as much as possible.
– The SPPC locates outside of CEPC
– In the 8 arc regions and 4 short straight sections, two machines share the tunnel (distance of machine centers=3.5m)
– In the 4 long straight sections, the SPPC will bypass the CEPC (distance of machine centers at IPs=23m as the big size of CEPC and SPPC detectors)
  - IP1 and IP3 for CEPC interaction and SPPC collimation
  - IP2 and IP4 for CEPC RF and SPPC interaction

Tunnel in the ARC

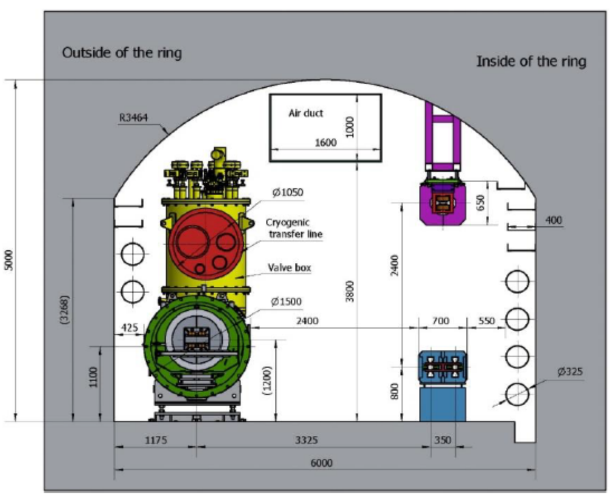
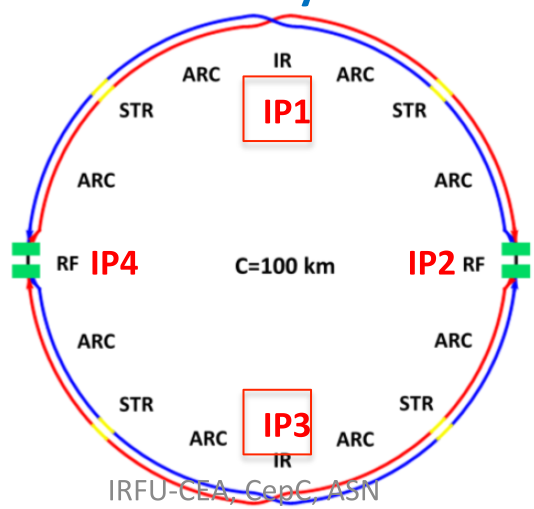
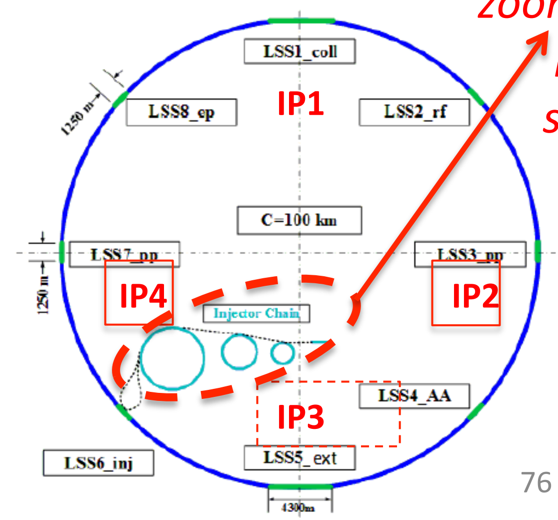


Figure 2.1: Tunnel cross section in the arc region

CEPC Layout

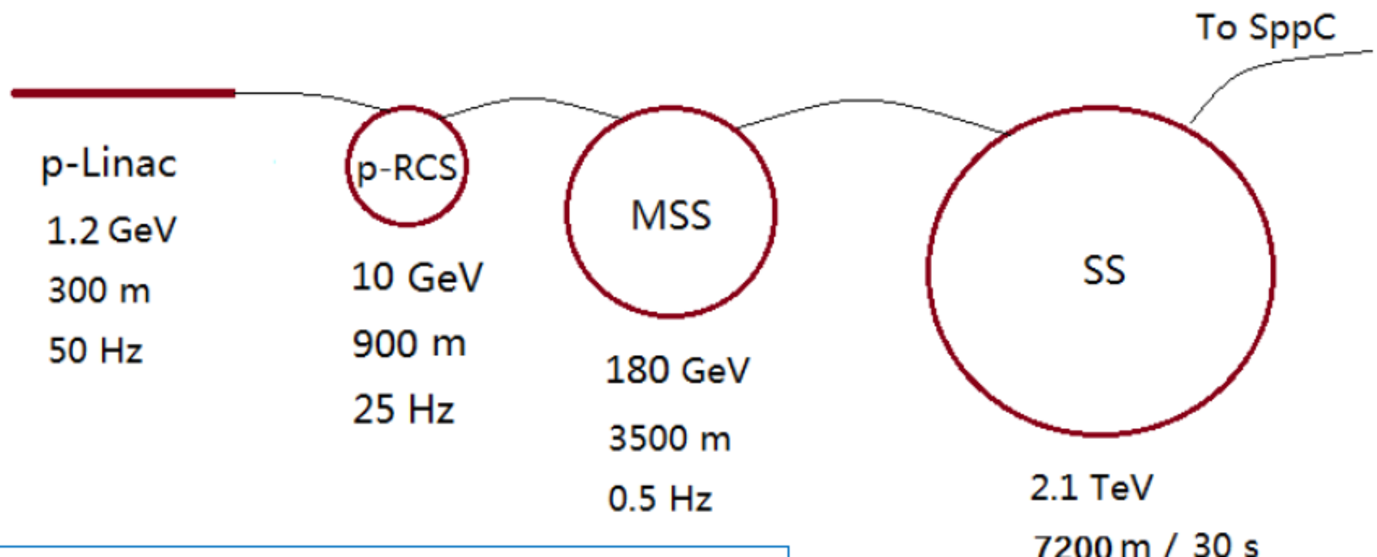


SPPC Layout



Injection: zoom on next slide

Zoom on: SppC injector chain



Now increased to 4.2 TeV

p-Linac: proton superconducting linac

p-RCS: proton rapid cycling synchrotron

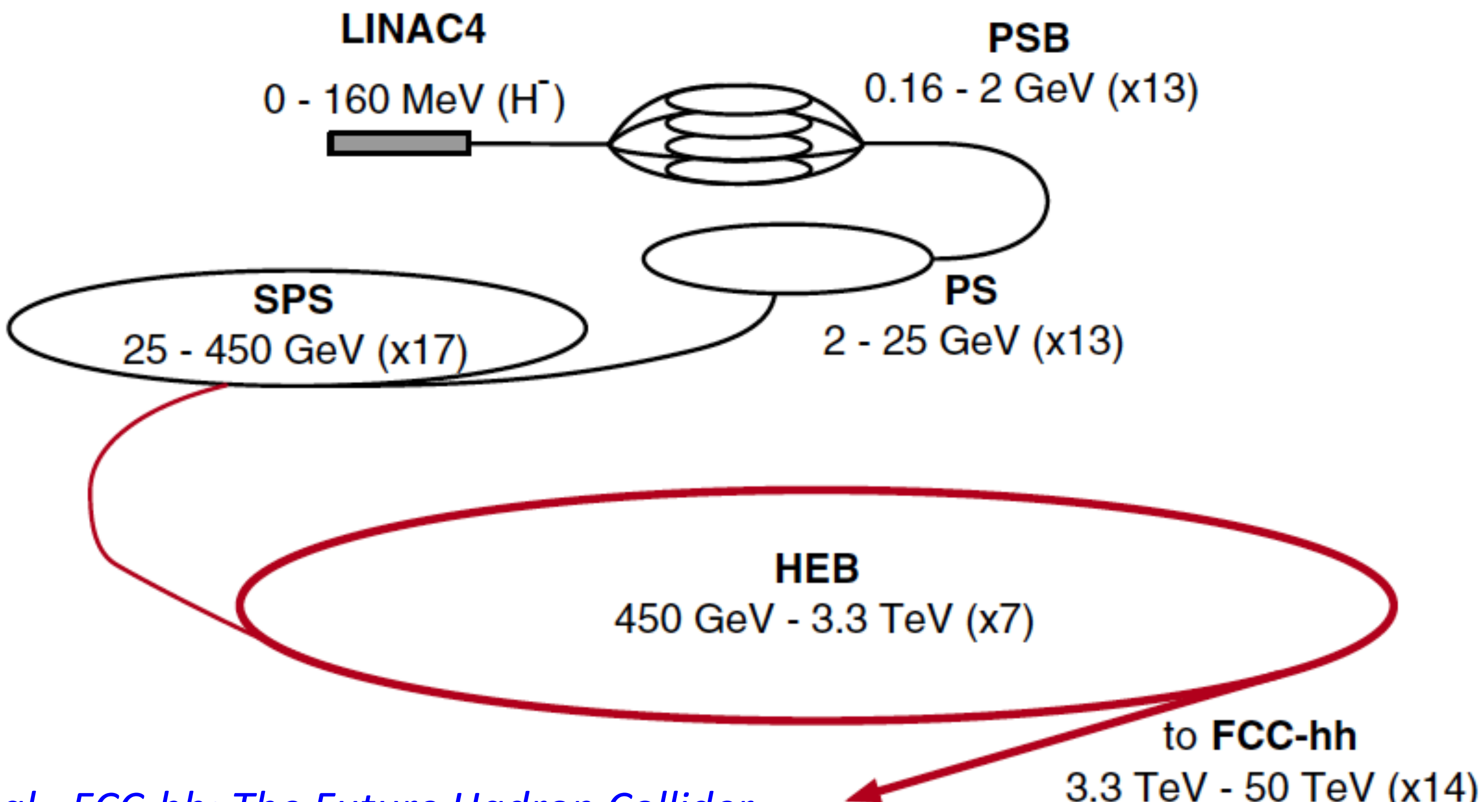
MSS: Medium-Stage Synchrotron

SS: Super Synchrotron

Courtesy of Jingyu Tang for the SppC WG, CepC, workshop, Nov 2019

Just for comparison…

*The FCC-hh injector chain, **based on the existing LHC injector chain** and a 3.3 TeV high energy booster, HEB*



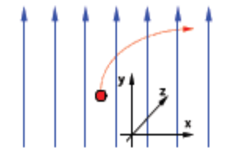
A. Abada et al., FCC-hh: The Future Hadron Collider

Eur. Phys. J. Special Topics **228**, 755–1107 (2019)

Some basic reminder on the need for High Fields

- Increase the collision/beam **energy** to possible generate new particles

Dipoles to bend the trajectory of the beam

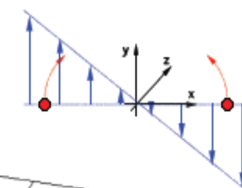


Beam energy — Bending radius — Dipole field

$$E[GeV] = 0.3\,B[T]\,\rho[m]$$

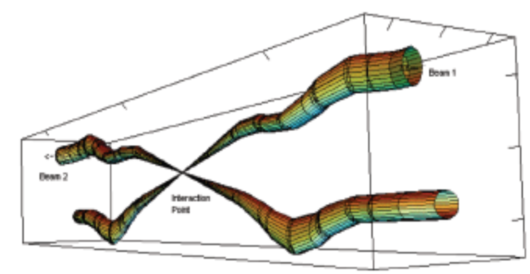
- Increase the number of particles collisions (**luminosity** at the experiment)

Final focus quadrupoles to reduce the beam dimension at the interaction point



Peak coil field — Quadrupole length — Beam size at the collision point

$$B\ell_q \approx \frac{1}{\sigma^*}$$



Relative beam sizes around IP1 (Atlas) in collision

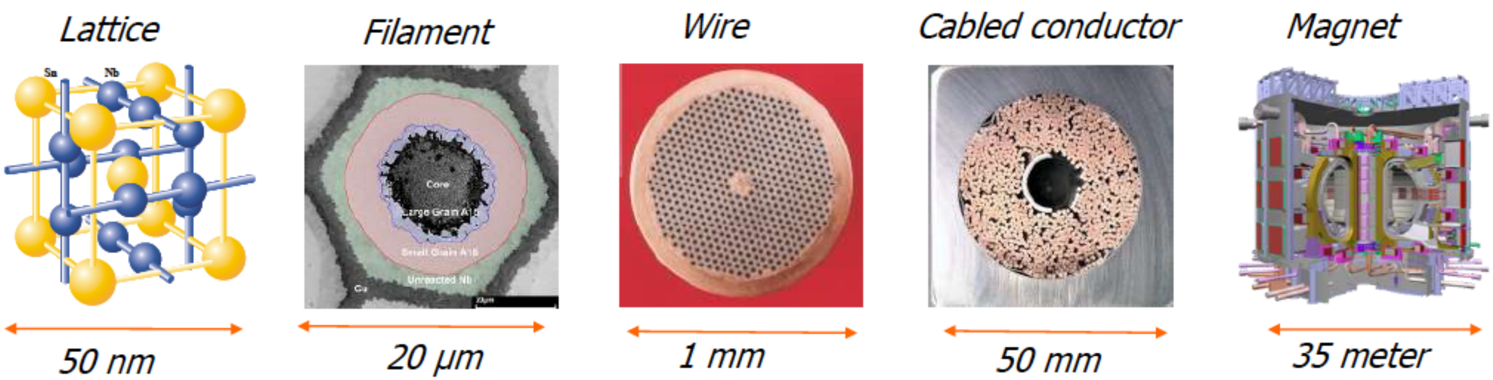
Courtesy of Bernardo Bordini, CERN, MT26 Conf. TRIUMF, Sept 2019

Bernardo Bordini | **High Field Accelerator Magnets** | MT 26 Conference, Vancouver

!!!!KEY ISSUE APART FROM THE TECHNOLOGICAL CHALLENGE: THE QUANTITY X THE PRICE!!!!!

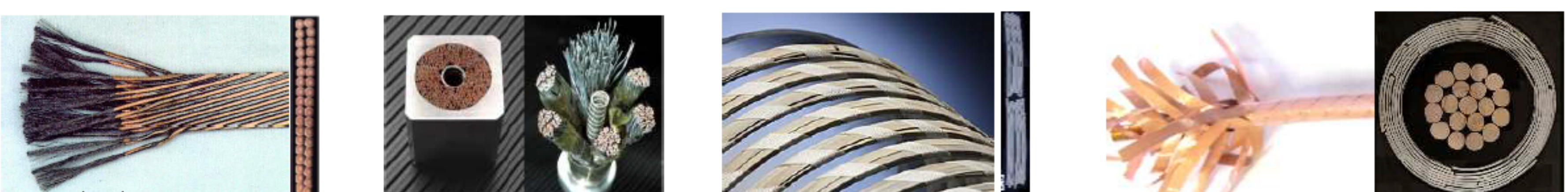
From material to magnet

Courtesy Herman Ten Kate, CERN, Seminar Twente



- How to make cabled conductors that guarantee the magnet not to quench or degrade ?
- Essential area of research, to avoid surprises and degraded magnets
- Need to understand and control the entire chain
- Striking examples exist of missing understanding putting large projects at risk !

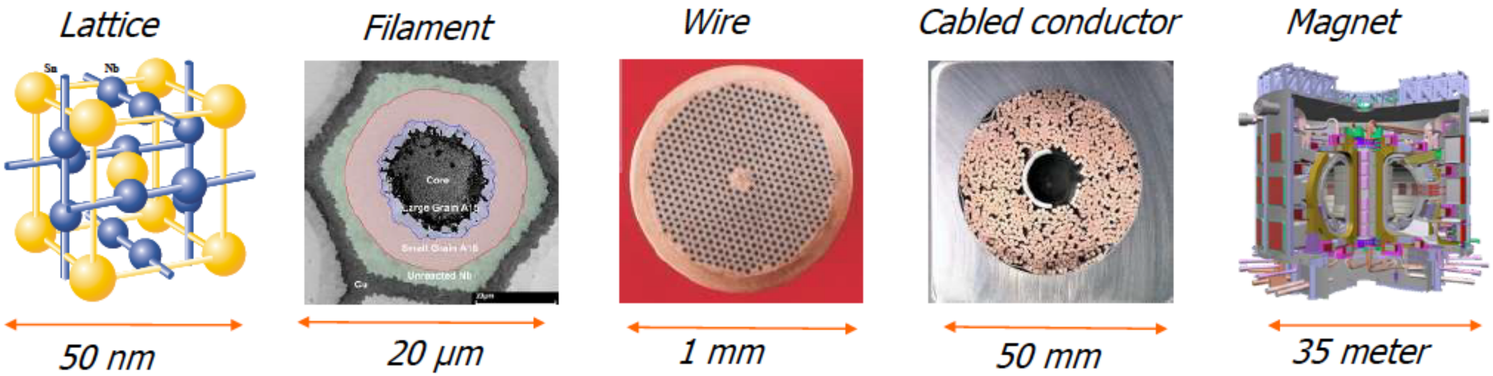
Understanding cables



Rutherford cable *CICC* *ReBCO-Roebel cable* *ReBCO-CORC*

From material to magnet

Courtesy Herman Ten Kate, CERN, Seminar Twente



At present, long superconducting wires are only produced from six superconductors: NbTi, Nb3Sn, MgB2, Bi2223, Bi2212 and REBCO. **Only wires of Nb compounds are used industrially, with intensive work on Nb3Sn optimization still under way**. The other materials are still considered in the R&D phase. (*Jan Jaroszynski, National High Magnetic Field Lab, Tallahassee, FL in Supercond. Sci. Technol. 32* **(***2019) 070501* **(***3pp***))** *and. B. Bordini slide in backup and talk at Magnet Techno 26 Conf, Sept 2019.*

Understanding cables

R. Aymar, H. Ten Kate, CERN, IEEE prize for contribution to Applied Supraconductivity, MT23, Boston (in backup)

High Fields for Accelerator Magnets

Based on Nb-Ti


RHIC
3.5 T


Tevatron
4.3 T


HERA
4.7 T


LHC
8.33 T

High Field Accelerator Magnets > ~ 10 T

China contributes to HL-LHC magnets

HiLumi HL-LHC PROJECT

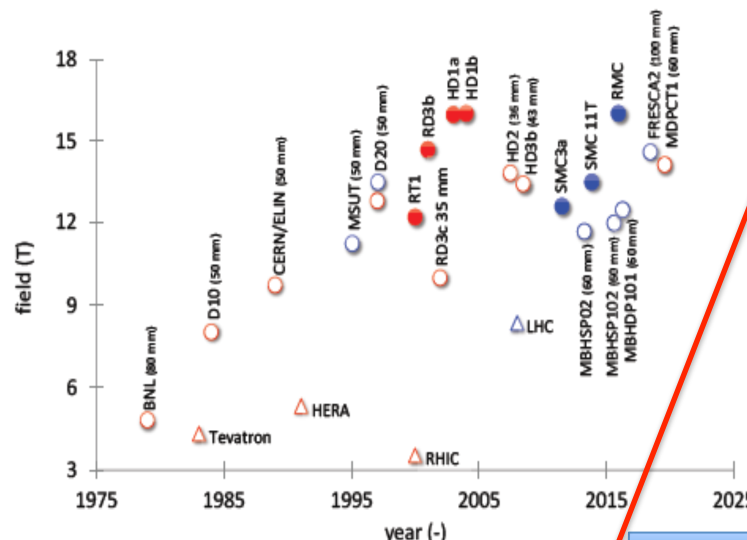
HL-LHC
~ 11 T (Nb_3Sn)

FCC hh ee he

FCC-HH
16 T (Nb_3Sn)

SPPC
12 T → 24 T (IBS)

- At present **Nb_3Sn** is the only **mature** technology for **HF Accelerator Magnets**
- The rest of the presentation will be focused on Nb_3Sn Magnets



Field in Accelerator Type **Nb_3Sn Dipoles**
vs
Field in the main **Nb-Ti dipoles** in accelerators (triangles)

Courtesy L. Bottura

N.B. For High Energy Frontier pp collider, China carries on actively the R&D on High Field magnet with IBS as main R&D stream and Nb3Sn as an option (cf Jie Gao)

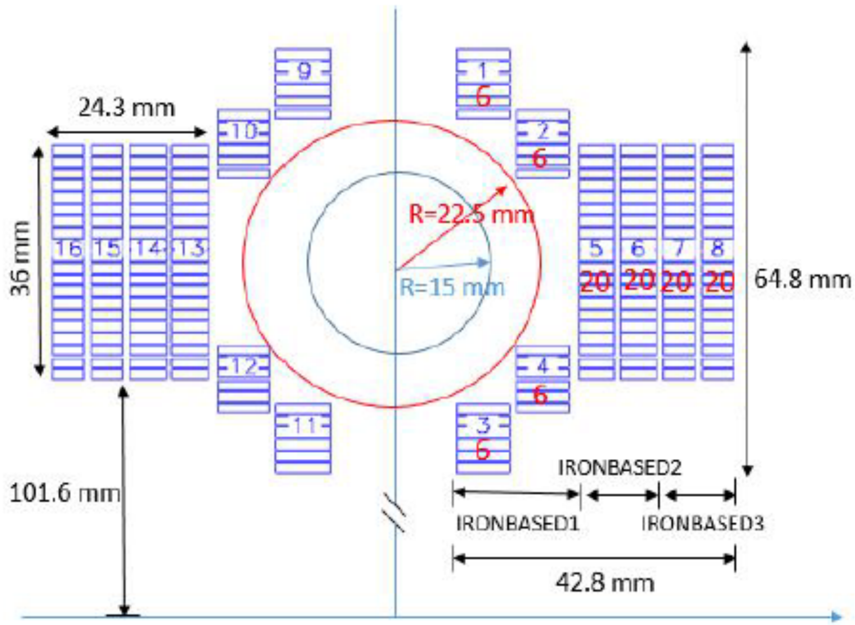
New different R&D line by China for HTS magnets IBS-conductor- based

Domestic Collaboration on HTS for SppC SC Dipole Magnet *(J. Gao, CepC Wksp, Nov 2019)*

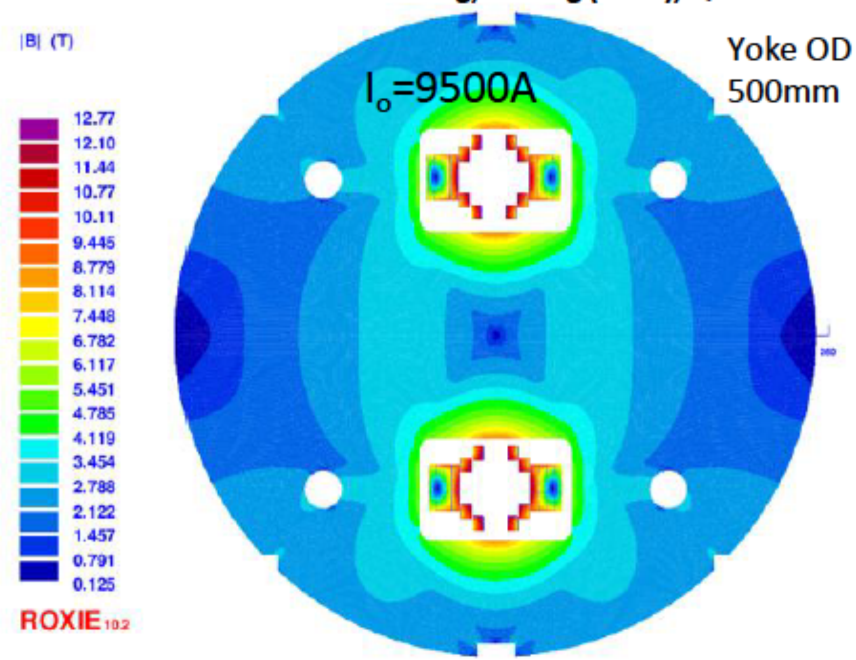
"Applied High Temperature Superconductor Collaboration" was established in Oct. 2016.

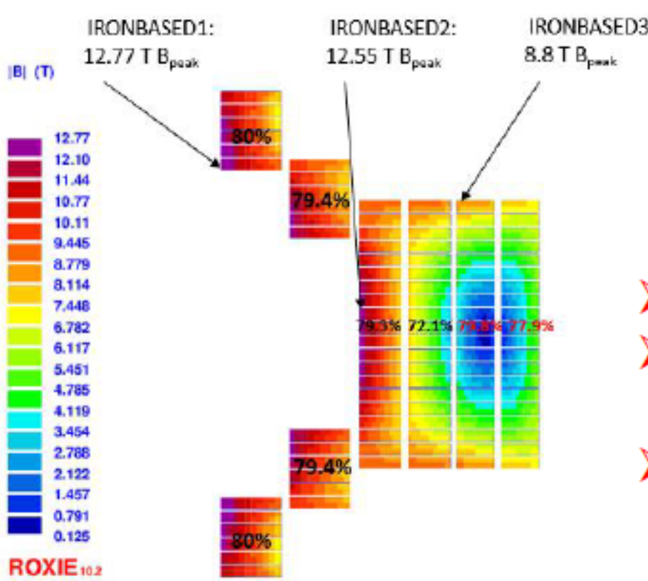
- **Goal:**
  1) To increase the J_c of **IBS** by 10 times, reduce the cost to **20 Rmb/kAm @ 12T & 4.2K**;
  2) To reduce the cost of **ReBCO and Bi-2212** conductors to 20 Rmb/kAm @ 12T & 4.2K;
  3) Realization and Industrialization of iron-based magnet and SRF technology.
- **Working groups:** 1) **Fundamental science** investigation; 2) **IBS** conductor R&D; 3) **ReBCO** conductor R&D; 4) **Bi-2212** conductor R&D; 5) **performance** evaluation; 6) **Magnet and SRF** technology.
- **Collaboration meetings:** every 3 months, to report the progress and discuss plan for next months.

The 12-T Fe-based Dipole Magnet



C. Wang, E. Kong (USTC), Q. Xu et al.





Design with expected J_e of IBS in 2025

Strand	diam.	cu/sc	RRR	Tref	Bref	Jc@ BrTr	dJc/dB
IBS	0.802	1	200	4.2	10	4000	111

- The required length of the 0.8 mm IBS is 6.1 Km/m
- For 100-km SPPC accelerator, 3000 tons of IBS is needed
- Target cost of IBS: 20 RMB (~2.6 Eur) /kAm @12 T

Latest results: Fabrication & Test of IBS solenoid coil at 24 T

IOP Publishing Superconductor Science and Technology
Supercond. Sci. Technol. 32 (2019) 04LT01 (5pp) https://doi.org/10.1088/1361-6668/ab09a4

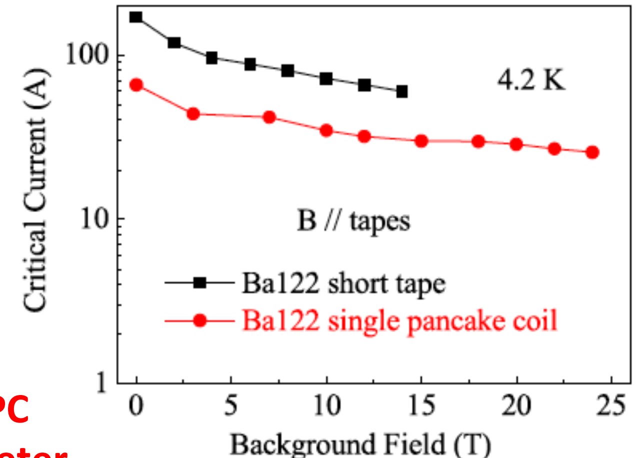
Letter

First performance test of a 30mm iron-based superconductor single pancake coil under a 24T background field

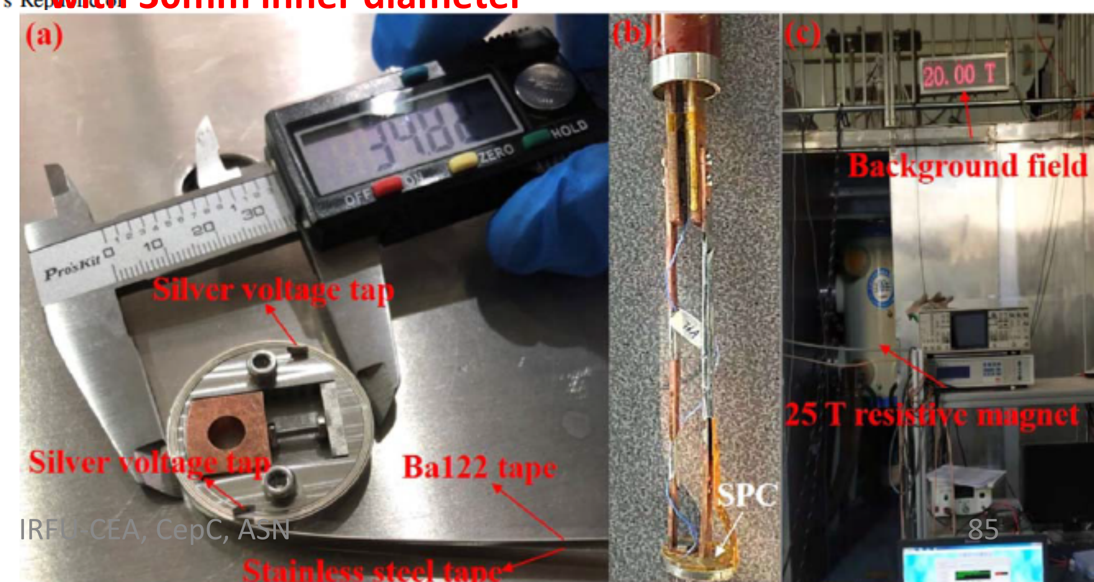
Dongliang Wang[1,2,5], Zhan Zhang[3,5], Xianping Zhang[1,2], Donghui Jiang[4], Chiheng Dong[1], He Huang[1,2], Wenge Chen[4], Qingjin Xu[3,6] and Yanwei Ma[1,2,6]

[1] Key Laboratory of Applied Superconductivity, Institute of Electrical Engineering, Chinese Academy of Sciences, Beijing 100190, People's Republic of China
[2] University of Chinese Academy of Sciences, Beijing 100049, People's Republic of China
[3] Institute of High Energy Physics, Chinese Academy of Sciences, Beijing 100049, People's Republic of China
[4] High Magnetic Field Laboratory, Chinese Academy of Sciences, Hefei 230031, People's Republic of China

Micrograph view of transverse cross-sectionof heat treated 7-filamentary Ba122/Ag/AgMn tape



Outer view of Ba122 SPC with 30mm inner diameter



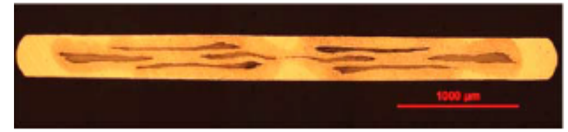
***Initiator of the IBS technology*:**
Kamihara Y, Watanabe T, Hirano M and Hosono H, 2008 Iron based layered superconductor La[O1-xFx]FeAs (x=0.05-0.12) with Tc=26K J.Am. Chem.Soc. 130 3296-7

Latest results: Fabrication & Test of IBS solenoid coil at 24 T

IOP Publishing Superconductor Science and Technology
Supercond. Sci. Technol. **32** (2019) 04LT01 (5pp) https://doi.org/10.1088/1361-6668/ab09a4

Letter

First performance test of a 30mm iron-based superconductor single pancake coil under a 24T background field



Viewpoint on the letter by D. Wang et al (2019 Supercond. Sci.Technol. 32 04LT01).

IOP Publishing Superconductor Science and Technology
Supercond. Sci. Technol. **32** (2019) 070501 (3pp) https://doi.org/10.1088/1361-6668/ab1fc9

CrossMark

Viewpoint

Constructing high field magnets is a real tour de force

Jan Jaroszynski
National High Magnetic Field, Laboratory, Tallahassee, FL, 32310, United States of America
E-mail: jaroszy@magnet.fsu.edu

This is a viewpoint on the letter by Dongliang Wang *et al* (2019 *Supercond. Sci. Technol.* **32** 04LT01).

Following the discovery of superconductivity in 1911, Heike Kamerlingh Onnes foresaw the generation of strong magnetic fields as its possible application. He designed a 10 T electromagnet made of lead–tin wire, citing only the difficulty

"From a practical point of view, IBS are ideal candidates for applications. Indeed, some of them have a high critical current density Jc, even in strong magnetic fields, and a low superconducting anisotropy.
Moreover, ***the cost of IBS wire can be 4 to 5 times lower than that of Nb3Sn****, making it more expensive than NbTi, but with much higher critical parameters/Nb3Sn"*

"The paper by Wang et al ***[16]*** *reports on the first test of a coil made of* $Ba_{0.6}K_{0.4}Fe_2As_2$ ***(****Ba122****)*** *wire at a very high field of 24 T. Ba112 is very brittle, similar to the six other useful superconductors, besides NbTi.*
To overcome this, the powdered elements Ba, K, As, and Fe, were chemically reacted, powdered, loaded into a silver tube, and drawn. Seven such tubes ***(****a natural number for the closest packing hexagonal geometry****)*** *were bundled into an AgMn tube and drawn again into a 1.65mm diameter wire. To increase Jc, the wire was rolled into a 0.33mm thick and 4.5mm wide tape. This 4.5m long tape was coiled and heat treated at 850 °C to sinter the powder….."*

Industrial involvement:

Chinese Industries involvement & support: a prerequisite for a successful financial support by Chinese Government and for achieving the important Technological challenges.

In order to overcome the CEPC Engineering Complexity;

In order to meet the CEPC Extremely High Technical Specs;

What China Industry should do NOW for CEPC?

Through the CEPC project

How to Stimulate the Development of Manufacturing, Technologies, and Engineering Process of China Industry?

Jinlin Gao, Beijing SinoscienceFullcryoTechnology Co., Ltd, Chairman CipC

CEPC Industrial Promotion Consortium (CIPC)

As the world's most advanced accelerator, CEPC put forward the following directions:

Established in Nov. 7 , 2017

(Jinlin Gao, Chairman CipC, CepC Wkshp, Nov 2019)

1) Superconduting materials (for cavity and for magnets)
2) Superconductiong cavities
3) Cryomodules
4) Cryogenics
5) Klystrons
6) Magnet technology
7)Vacuum technologies
7) Mechanical technologies
8)Electronics
9) SRF
10) Power sources
11) Civil engineering
12) Precise machinery

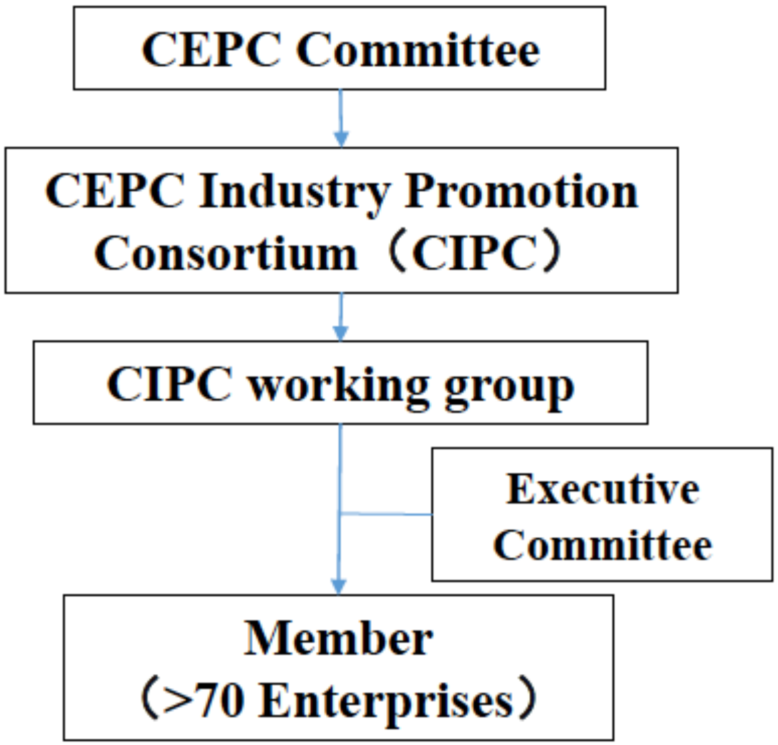
.....

More than 40 companies joined in first phase of CIPC,

and 70 companies now.

CIPC Organization

CIPC Working group meetings were held on Nov. 24,2017 and Mar. 14 2018. The Executive Committee was established, and the CIPC charter has been drafted and adopted.



CIPC Logo on the plaque

(Jinlin Gao, Chairman CipC, CepC Wkshp, Nov 2019)

CIPC Partial Member (No order)

(Jinlin Gao, Chairman CipC, CepC Wkshp, Nov 2019)

CIPC Partial Member (No order)

高能锐新 HE-RACING TECHNOLOGY

上海超导 SHANGHAI SUPERCONDUCTOR

爱科赛博 ACTIONPOWER

正机科技 GENTECH

中国电建 POWERCHINA

地矿建设 DIKUANG CONSTRUCTION

核工业井巷建设集团有限公司 HUZHOU CHINA

浙北地质矿产调查研究院 HUZHOU CHINA

黄河勘测规划设计研究院有限公司 Yellow River Engineering Consulting Co., Ltd.

中国电建 POWERCHINA 华东勘测设计研究院 HUADONG ENGINEERING CORPORATION

中国电建 POWERCHINA 中国电建集团昆明勘测设计研究院有限公司 KUNMING ENGINEERING CORPORATION LIMITED

海南展创光电技术有限公司 HZC PHOTONICS

(Jinlin Gao, Chairman CipC, CepC Wkshp, Nov 2019)

CIPC at this Workshop: 35 reports and about 80 attendee

Jinlin Gao, Chairman CipC, CepC Wkshp, Nov 2019

Monday 18 November 2019

14:00 - 16:05 CIPC
Convener: 浩 黄
Location: C305

- 14:00 **Klystron** *15′* — Speaker: 永明 李 (昆山国力大功率器件工业技术研究院)
- 14:15 **Klystron** *15′* — Speaker: 瑞 张 (电子所)
- 14:30 **Klystron** *15′* — Speaker: 修东 杨 (中科院空天信息研究院)
- 14:45 **Collider, booster and linac magnets** *15′* — Speaker: 旭文 戴 (所工厂)
- 15:00 **Collider magnets** *15′* — Speaker: 明涛 康 (上海普束科技有限公司)
- 15:15 **Linac magnet** *15′* — Speaker: 光亮 朱 (合肥科烨电物理设备制造有限公司)
- 15:30 **Electro-magnet seperator** *15′* — Speaker: 盘林 郭 (上海夯业真空设备科技有限公司)
- 15:45 **Electro-magnet seperator** *15′* — Speaker: 守平 王 (中信重工机械股份有限公司)

16:30 - 18:30 CIPC
Convener: 大炜 刘
Location: C305

- 16:30 **Linac structure and SCRF cavity fabrication** — Speaker: 旭文 戴 (北京高能锐新公司厂长戴旭文)
- 16:45 **NbTi超导卢瑟福电缆** *15′* — Speaker: 裕 赵 (无锡统力电工股份有限公司)
- 17:00 **0.5mm NbTi超导股线** *15′* — Speaker: 燕敏 朱 (西部超导材料科技股份有限公司)
- 17:15 **超导四极磁体QD0短样机制造** *15′* — Speaker: 海京 王 (合肥聚能电物理高技术开发有限公司)
- 17:30 **超导四极线圈加热固化系统** *15′* — Speaker: 艺 万 (合肥科烨电物理设备制造有限公司)
- 17:45 **CEPC MDI-1** *15′* — Speaker: 吕洪清 (无锡创新低温环模设备科技有限公司)
- 18:00 **CEPC MDI-2** *15′* — Speaker: 志华 刘 (沈阳慧宇真空技术有限公司)
- 18:15 **CEPC MDI-3** *15′* — Speaker: 绍栋 何 (北京空间机电研究所)

Tuesday 19 November 2019

08:30 - 10:10 CIPC
Convener: 明 李
Location: C305

- 08:30 **Vacuum** *15′* — Speaker: 东林 章 (上海真空阀门制造有限公司)
- 08:45 **Vacuum** *15′* — Speaker: 宇 蔺 (川北真空科技（北京）有限公司)
- 09:00 **Vacuum** *15′* — Speaker: 崇凌 赵 (中国科学院沈阳科学仪器股份有限公司)
- 09:15 **Vacuum** *15′* — Speaker: 奇 杨 (沈阳慧宇真空技术有限公司)
- 09:30 **Vacuum** *15′* — Speaker: 涛 陶 (合肥科烨电物理设备制造有限公司)
- 09:45 **SCRF** *15′* — Speaker: 领会 杜 (宁夏东方超导科技有限公司)

10:30 - 12:30 CIPC
Convener: 金林 高
Location: C305

- 10:30 **SCRF** *15′* — Speaker: 海根 邵 (安徽华东光电技术研究所有限公司)
- 10:45 **SCRF** *15′* — Speaker: 承业 郑 (上海三井真空设备有限公司)
- 11:00 **SCRF** *15′* — Speaker: 文清 李 (北京富斌盛世真空设备有限公司)
- 11:15 **cryogenics** *15′* — Speaker: 金林 高 (北京中科富海低温科技有限公司)
- 11:30 **Cryogenics** *15′* — Speaker: 学华 章 (安徽万瑞冷电科技有限公司)
- 11:45 **cryogenics** *15′* — Speaker: 森 蔡 (中船重工鹏力（南京）超低温技术有限公司)
- 12:00 **cryogenics** *15′* — Speaker: 洪清 吕 (无锡市创新低温环模设备科技有限公司)
- 12:15 **Cryogenics** *15′* — Speaker: 杰峰 吴 (合肥聚能电物理高技术开发有限公司)

SESSIONS DIFFICULT TO FOLLOW FOR NON-CHINESE SPEAKING PEOPLE

Tuesday 19 November 2019

14:00 - 16:10 CIPC
Convener: 大明 孙
Location: C305

- 14:00 **cryogenics** *15′* — Speaker: 大明 孙 (江苏克劳特低温技术有限公司)
- 14:15 **Instrumentation** *15′* — Speaker: 海根 邵 (华东光电研究院)
- 14:30 **Instrumentation** *15′* — Speaker: 子燕 谢 (浩德科仪真空技术有限公司)
- 14:45 **Instrumentation** *15′* — Speaker: 崇凌 赵 (沈阳科学仪器厂)
- 15:00 **radiation protection** *15′* — Speaker: 龙 张 (北京市射线应用研究中心)
- 15:15 **radiation protection** *15′* — Speaker: 泽学 郭 (天津市万木辐射防护工程有限公司)
- 15:30 **MDI远程真空连接设计** *15′* — Speaker: 志华 刘 (沈阳慧宇)
- 15:45 **超导铁支架设计** *15′* — Speaker: 宝瑞 刘 (航天508所)

16:30 - 19:00 CIPC
Convener: 豫 肖
Location: C305

- 16:30 **隧道磁铁、支架等设备运输车辆** *15′* — Speaker: 超 孙 (北车618所)
- 16:45 **100m参观模型设计，1:1mockup隧道设计** *15′* — Speaker: 育宏 郑 (中科高能科技有限公司)
- 17:00 **非接触式精密测量和智能视觉系统** *15′* — Speaker: 生宏 范 (北京普达迪泰科技有限公司)
- 17:15 **精密基准件研制** *15′* — Speaker: 长河 朱 (汉中远航精密机械制造有限公司)
- 17:30 **高分辨率对地观测系统、机械设计、系统集成** *15′* — Speaker: 兴泽 王 (中国空间技术研究院总体部)
- 17:45 **精密光电测量系统** *15′* — Speaker: 达宝 劳 (中国科学院微电子所)
- 18:00 **大地测量，工程测量** *15′* — Speaker: 进贵 邹 (武汉大学 测绘学院)
- 18:15 **CEPC地质研究** *15′* — Speaker: 保芝[illegible]

Wednesday, November 20, 2019

08:30 - 10:10 CIPC
Convener: 继东 孙
Location: C305

- 08:30 **Installation and store** *15′* — Speaker: 佳斌 王 (华侨大学)
- 08:45 **SppC magnet** *15′* — Speaker: 建伟 刘 (西部超导)
- 09:00 **SppC magnet** *15′* — Speaker: 跃 赵 (上海超导)
- 09:15 **SppC magnet** *15′* — Speaker: 传兵 蔡 (上海大学/上创超导)
- 09:30 **SppC magnet** *15′* — Speaker: 裕 赵 (统力电工)
- 09:45 **CIPC全体会议** *15′*

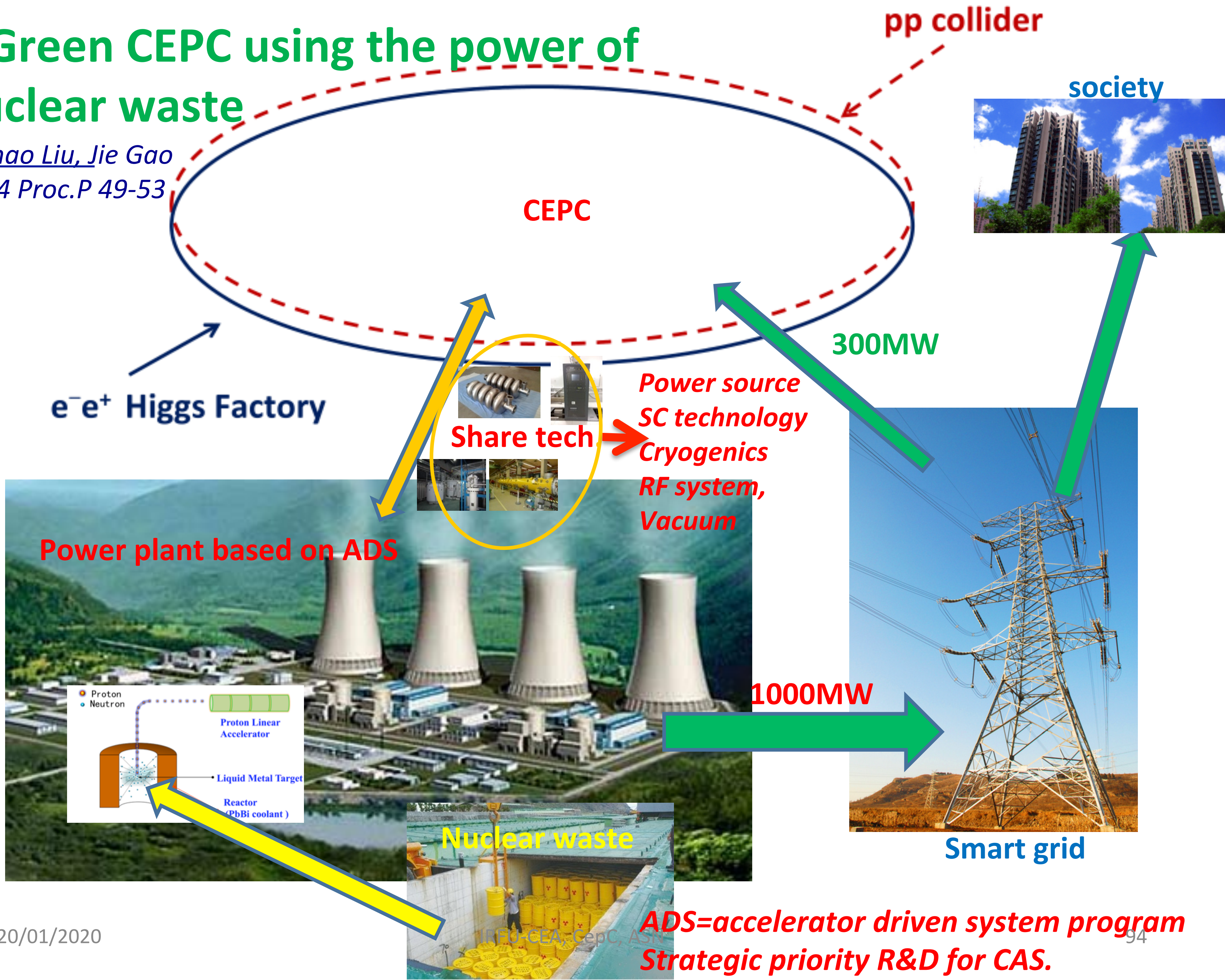
11:30 **CIPC report** *20′* — Speaker: Dr. Jinlin Gao (Fullcryo Technology Co.,Ltd)

Concluding remarks

- A green CepC
- Internationalization

A Green CEPC using the power of Nuclear waste

Zhenchao Liu, Jie Gao
HF2014 Proc.P 49-53



ADS=accelerator driven system program
Strategic priority R&D for CAS.

BESIII Collaboration

CEPC Accelerator International Collaboration Activities

Japan Super KEK B (e+e- circular collider, similar to CEPC) :

Since 2018, under the envelope of MoU between IHEP and KEK on Super KEK B and circular e+e- collider in general:

March 17, 2018 Jie Gao, Yiwei Wang(3) participated the first round Super KEK B commissioning and operation and collider ring collaboration for one week.

In May, Sha Bai visited Super KEK B on MDI for one month, Kanazawa-san provided RVC design materials of Super KEK B MDI for reference.

From June 10-17, Yuan Zhang visited Super KEK B for one week on beam beam study.

In June, 10-17, 2018, Yuan Zhang, visited Super KEK B on beam beam and dynamic apertures for one week.

In July 5,9-13 Jiyuan Zhai and Dianjun Gong visited Super KEK B on SCRF system of Super KEK B for one week.

From 2018.11.18-2019.1.12, Dr. Haoyu SHI at KEK, started to visit for three months under IHEP-KEK MoU with Hiroyuki Nakayama and Shuji Tanaka, on MDI detector part.

From Nov18-24. 2018. 2018, Jingru Zhang will visit KEK super B linac for one week.

From 2019.3.31-2019.5.21, Haoyu Shi visited KEK Super B on detector and MDI.

From 2019. 11.25 (two weeks), Dou Wang, visit KEK on damping ring and booster

From 2019. 11.25 (two weeks), Daheng Ji, visit KEK on operation and orbit correction

Russia Polarization :

In 2018 IHEP is working with BINP to form a new body of collaboration to be signed at the end of 2018, aiming at collaboration on key issues of e+e- colliders, such as lattice DA, polarization, SC magnets of MDI :

In 2019, since May 1, Wenhao Xia visited BINP for one month on polarization beam design.

From Nov. 4 2019, ,Ksenia Ryabchenko (MDI SC magnet), Ksenia Karyukina (numerical dynamic aperture optimization), Ivan Morozov (theorical study of nonlinear beam dynamics), Grigory Baranov (4th generation light source development) visit IHEP for one month under IHEP-BINP MoU.

USA Polarization :

In 2019, from Nov. 1, Wenhao Xia is visiting BNL for one month on polarization beam design.

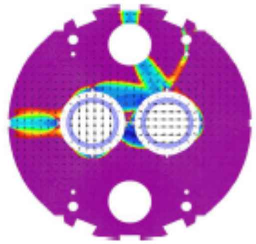
More than 20 MoUs have been signed, recenly, a new MoU has been Signed with Dubna

Jie Gao, CepC Workshop. Nov. 2019

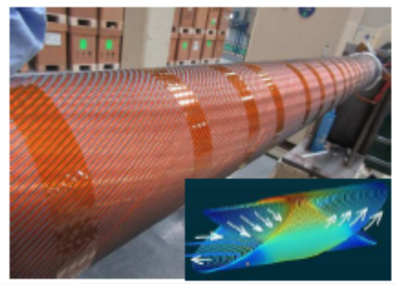
R&D of HL-LHC CCT Magnets

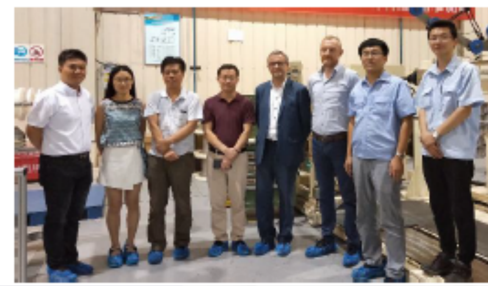
China provides 12+1 units CCT corrector magnets for HL-LHC before 2022

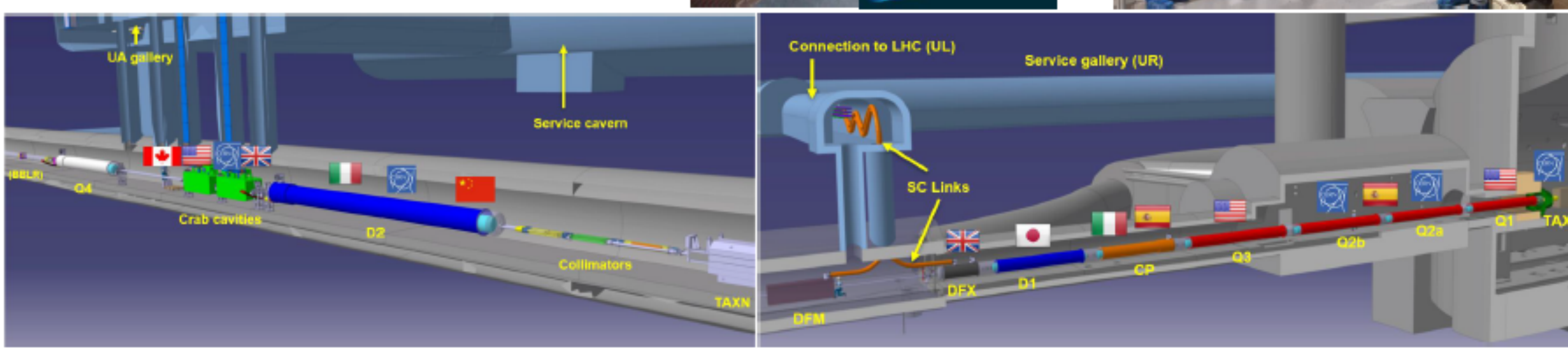
2*2.6T dipole field in the two apertures. 2.2m prototype being fabricated.



- ***0.5m prototype completed***
- ***2.2m prototype being fabricated.***
- ***Production started in 2020.***







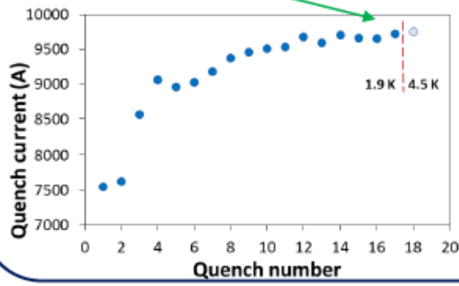
Jie Gao, FCC Workshop, CERN, Jan 2020

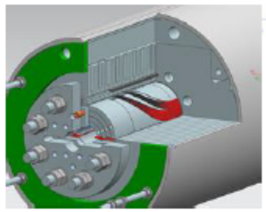
Models development toward 16 T magnets

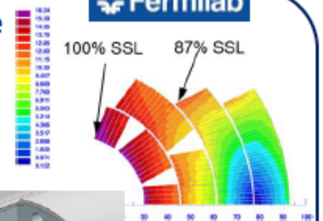
Key milestone: 15 T dipole

U.S. MAGNET DEVELOPMENT PROGRAM — Fermilab

- 4 layer graded magnet, 1-m long
- 1st step: 14.1 T performance

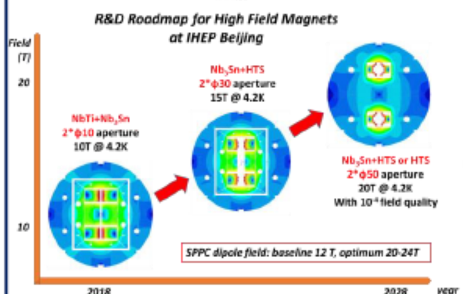


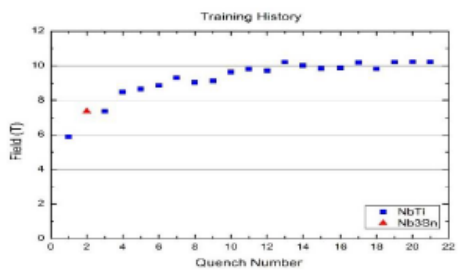




Courtesy of A. Zlobin, FNAL

Institute of High Energy Physics
Chinese Academy of Sciences



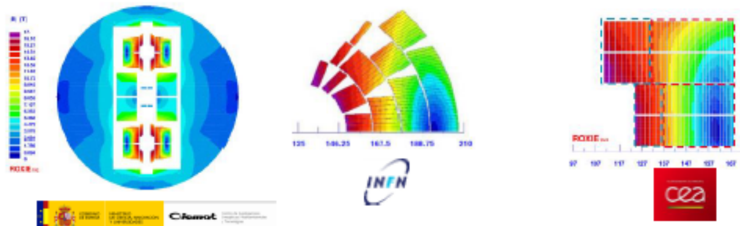


Courtesy of Q. Xu, IHEP

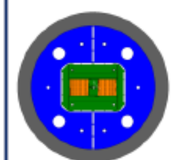
24/09/2019

10.2 T at 4.2 K in 2 apertures

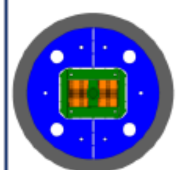
FCC 16 T Model Magnet Development



Nb_3Sn GRADING

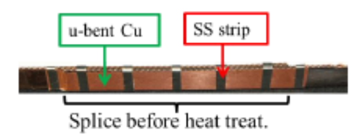


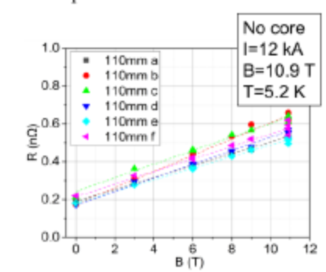
eRMC
No bore
16 T target



Racetrack Model Magnet = RMM
50 mm bore
16 T target

Nb_3Sn joints





Courtesy of V. D'Auria, EPFL

60

Helene Felice, 26th Magnet Technology Conference, TRIUMPH, Sept. 2019

Strenthening collaboration with CERN: Magnets for HL-LHC, participation to LHC Experiments etc…

Joined: CALICE collaboration, ILD TPC collab RD collabs..

Organized CepC Workshop in Europe and USA:

1st international Workshop on CepC in Europe: Rome May 2018

2nd international Workshop on CepC in Europe: Oxford April 15-17, 2019

3rd international Workshop on CepC in Europe: Marseille, May 4-6, 2020

https://indico.in2p3.fr/event/20053/

1st US workshop at Uchicago, September 16-18, 2019

2nd US Workshop at Catholic University in Washington DC, April 22-23, 2020

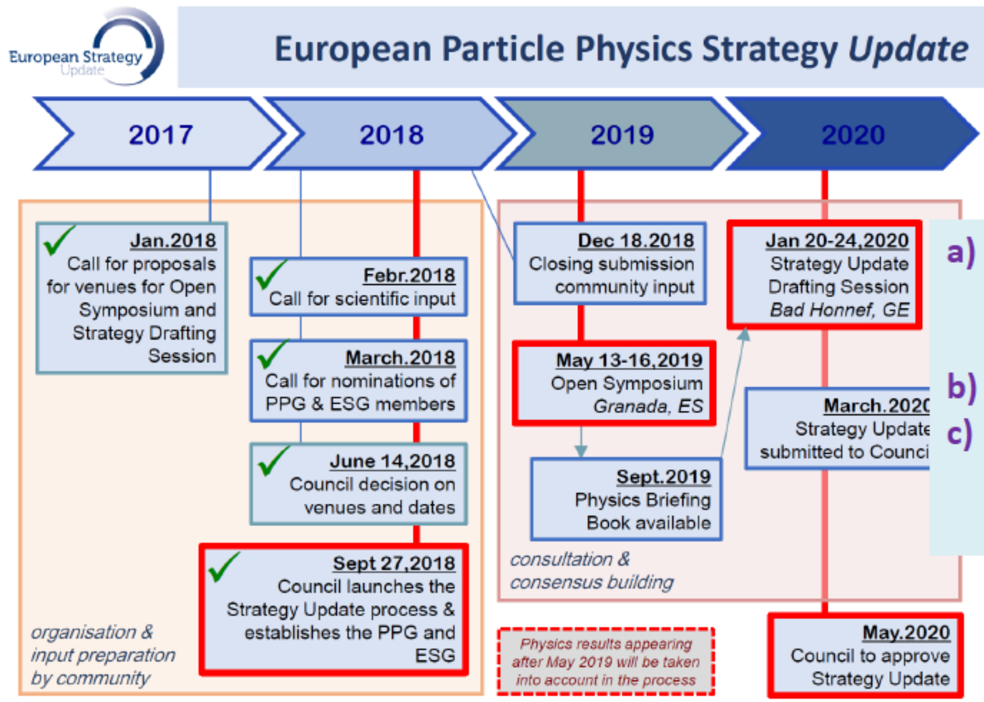
Xinchou Lou, CepC Workshop. Nov. 2019

ACTIVE CONTRIBUTION and PARTICIPATION to :

Preparation for European Strategy for Particle Physics update

Inputs (CEPC accelerator, physics-detector) have been submitted

CEPC accelerator: ArXiv: 1901.03169, CEPC Physics/Detector: 1901.02170



- **a) CEPC team submitted two input documents to the USPPU;**
- **b) Engaging with PPG and ESG;**
- **c) Many attend the Open Symposium in Granada, Spain.**

Xinchou Lou, CepC Workshop. Nov. 2019; should attend Bad Honhef this week

Granada sessions	Description	Conveners	
	Large experiments and projects	PPG/ESG	
	National road maps	ESG	
B1	Electroweak Physics (physics of the W, Z, H bosons, of the top quark, and QED)	Keith Ellis	Beate Heinemann
B2	Flavour Physics and CP violation (quarks, charged leptons and rare processes)	Belen Gavela	Antonio Zoccoli
B3	Dark matter and Dark Sector (accelerator and non-accelerator dark matter, dark photons, hidden sector, axions)	Marcela Carena	Shoji Asai
B4	Accelerator Science and Technology	Caterina Biscari	Lenny Rivkin
B5	Beyond the Standard Model at colliders (present and future)	Gian Giudice	Paris Sphicas
B6	Strong Interactions (perturbative and non-perturbative QCD, DIS, heavy ions)	Krzysztof Redlich	Jorgen D'Hondt
B7	Neutrino Physics (accelerator and non-accelerator)	Stan Bentvelsen	Marco Zito
B8	Instrumentation and Computing	Xinchou Lou	Brigitte Vachon
	Other (communication, outreach, strategy process, technology transfer, individual contributions,...)	ESG	