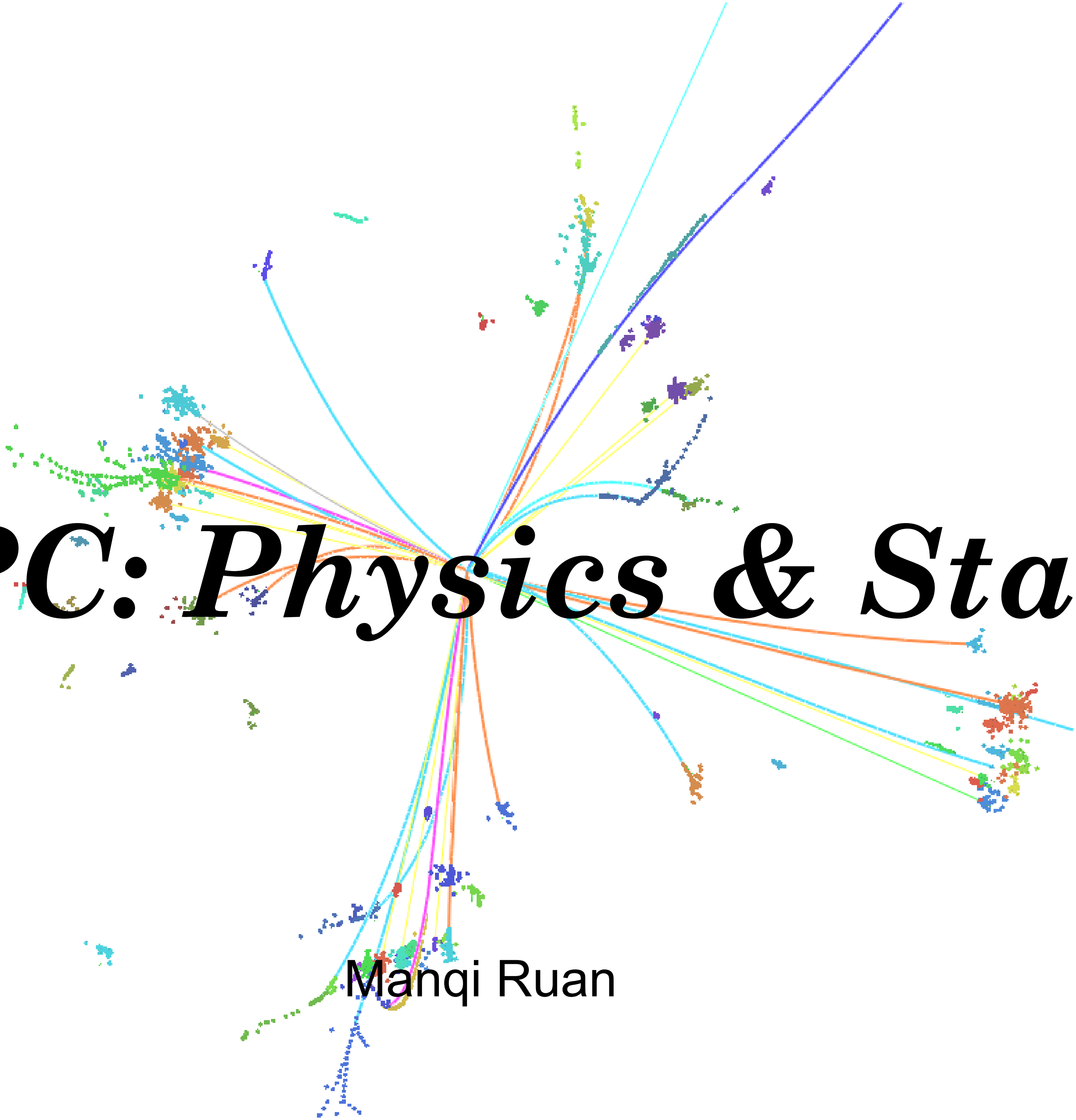
CEPC: Physics & Status



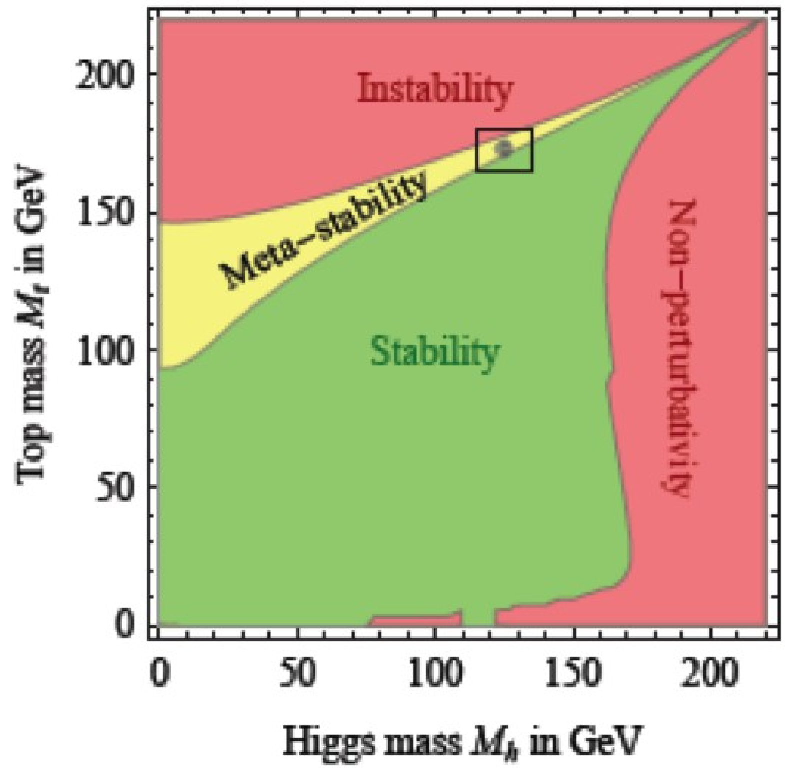
Manqi Ruan

SM is **NOT** the end of story...

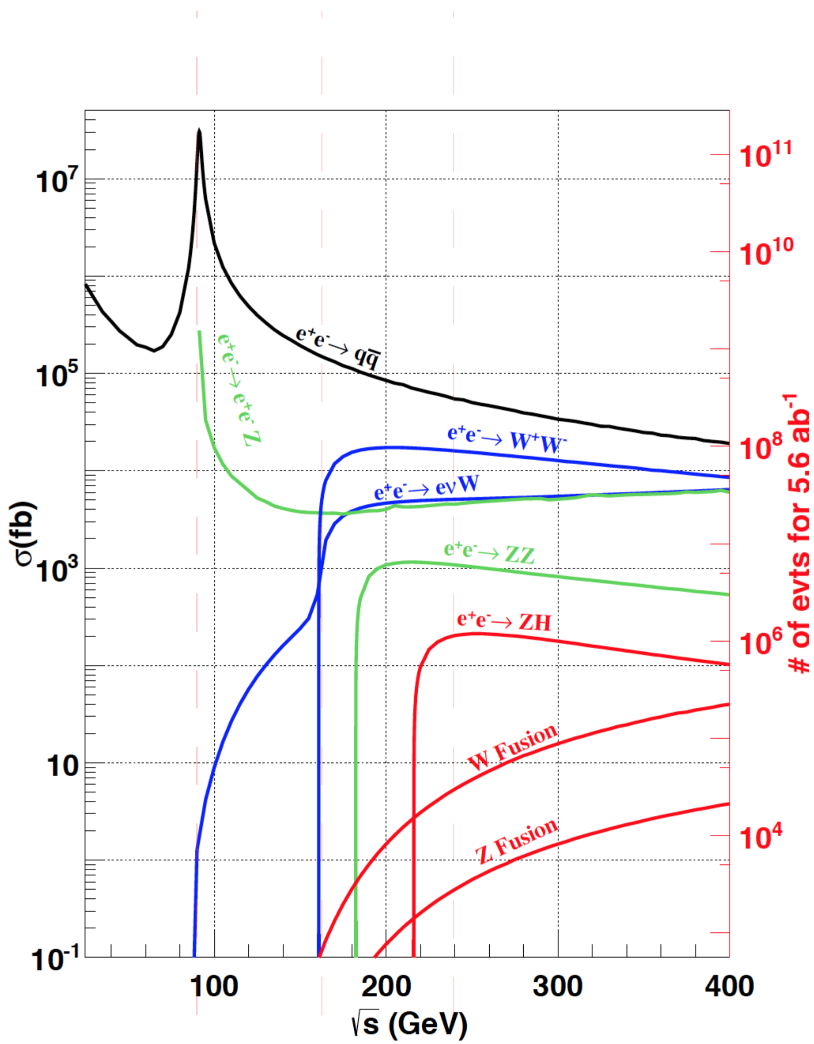
- **Naturalness?**
  - Fine tuning of the Higgs mass
- **Vacuum Stability?**
  - Masses of Higgs and top quark
- **Hierarchy?**
  - From neutrinos to the top mass, masses differs by 13 orders of magnitude
- **Unification?**
- **Dark matter?**
- **Baryogenisis?**

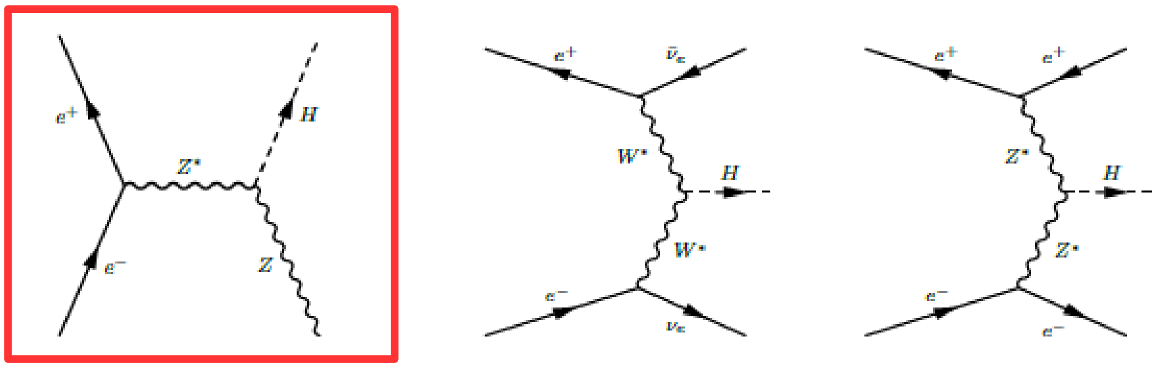
- **Most issues related to Higgs**

$$m_H^2 = 36{,}127{,}890{,}984{,}789{,}307{,}394{,}520{,}932{,}878{,}928{,}933{,}023$$
$$-36{,}127{,}890{,}984{,}789{,}307{,}394{,}520{,}932{,}878{,}928{,}917{,}398$$
$$= (125\ \mathrm{GeV})^2\ !\ ?$$



Higgs @ electron positron collider





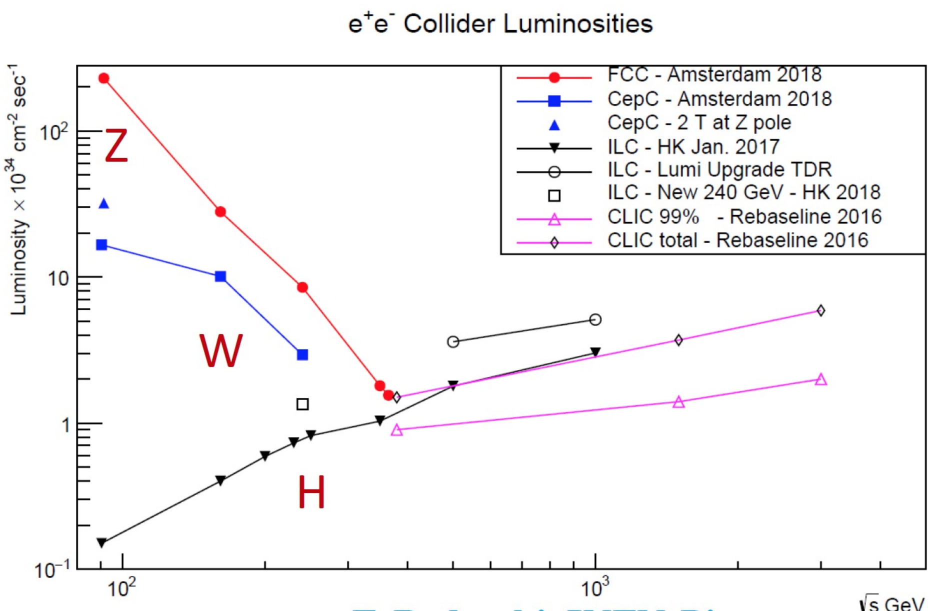
S/B ~ 1:100 – 1000

(7 orders of magnitudes better than HL-LHC)

Observables: Higgs mass, CP, σ(ZH), event rates (σ(ZH, ννH)*Br(H→X)), Diff. distributions

Derive: Absolute Higgs width, branching ratios, couplings

CEPC



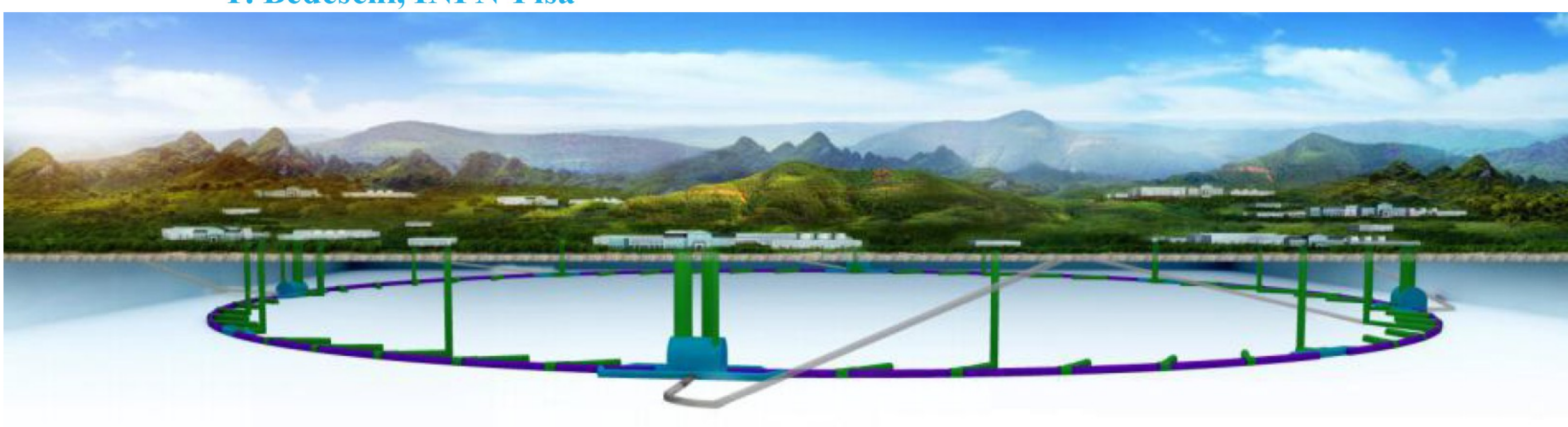
F. Bedeschi, INFN-Pisa

SR Power ~ 30 MW/beam

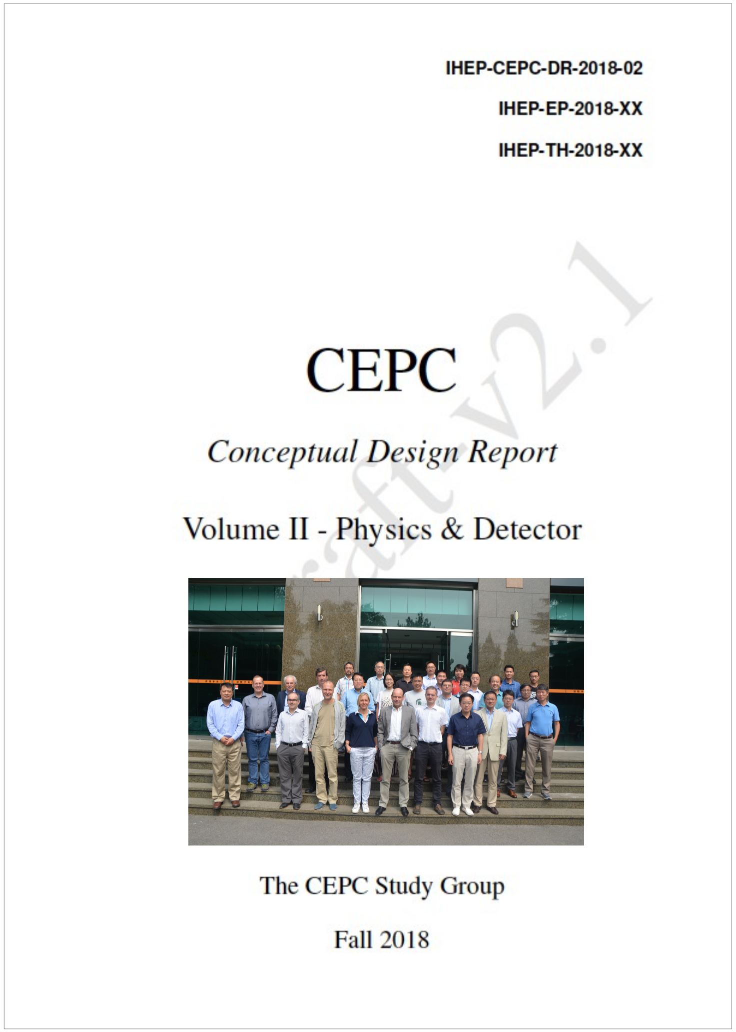
No change of accelerator elements at Z, W and H

Operation mode	Z factory	W threshold scan	Higgs factory
$\sqrt{s}$ (GeV)	91.2	158 - 172	240
L ($10^{34}\text{cm}^{-2}\text{s}^{-1}$)	16-32	10	3
Running time (years)	2	1	7
Integrated Luminosity (ab^{-1})	8 - 16	2.6	5.6
Higgs yield	-	-	10^6
W yield	-	10^7	10^8
Z yield	10^{11-12}	10^9	10^9

Table 3.2: Instantaneous and integrated luminosities at different values of center-of-mass energy ($\sqrt{s}$) and anticipated corresponding boson yields at the CEPC. The range of luminosities for the Z factory correspond to the two possible solenoidal magnetic fields, 3 or 2 Tesla.



Baseline geometry & reconstruction


IHEP-CEPC-DR-2018-02

IHEP-EP-2018-XX

IHEP-TH-2018-XX

draft v2.1

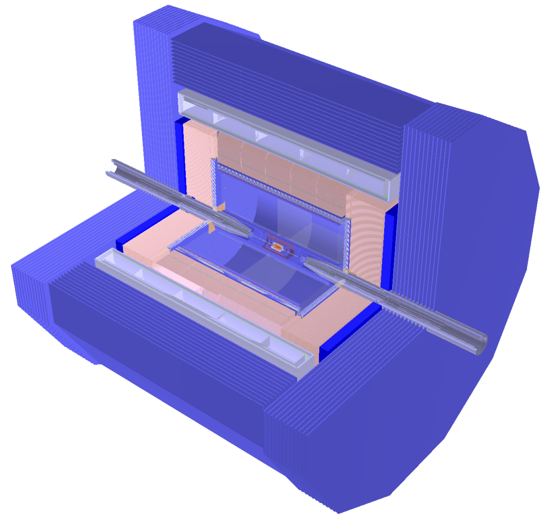
CEPC

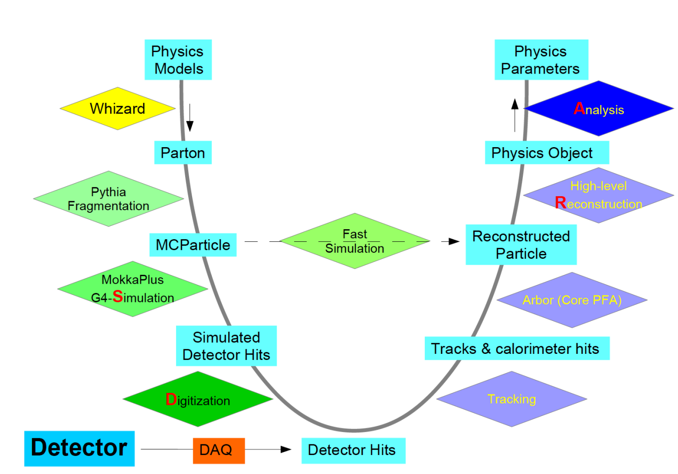
Conceptual Design Report

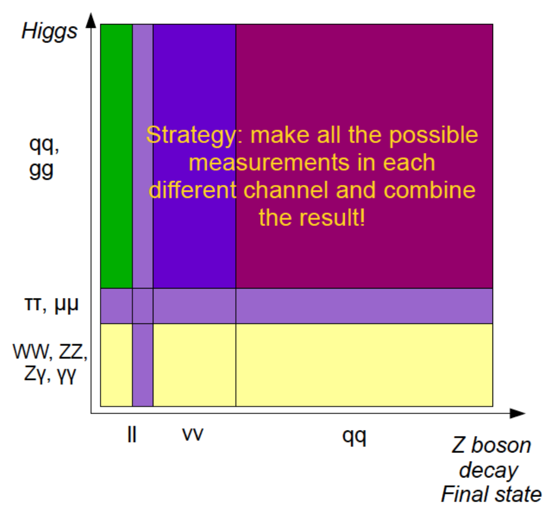
Volume II - Physics & Detector

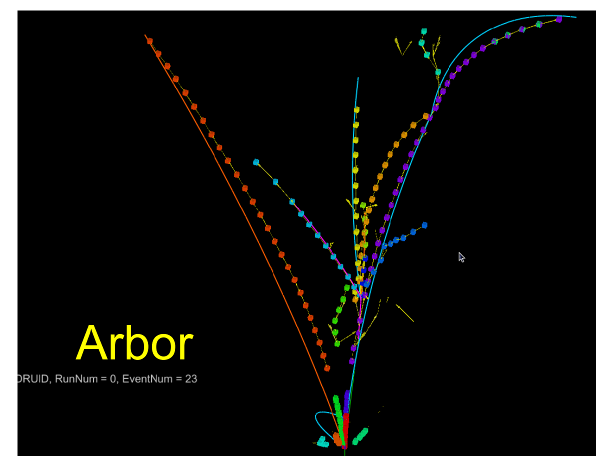
The CEPC Study Group

Fall 2018



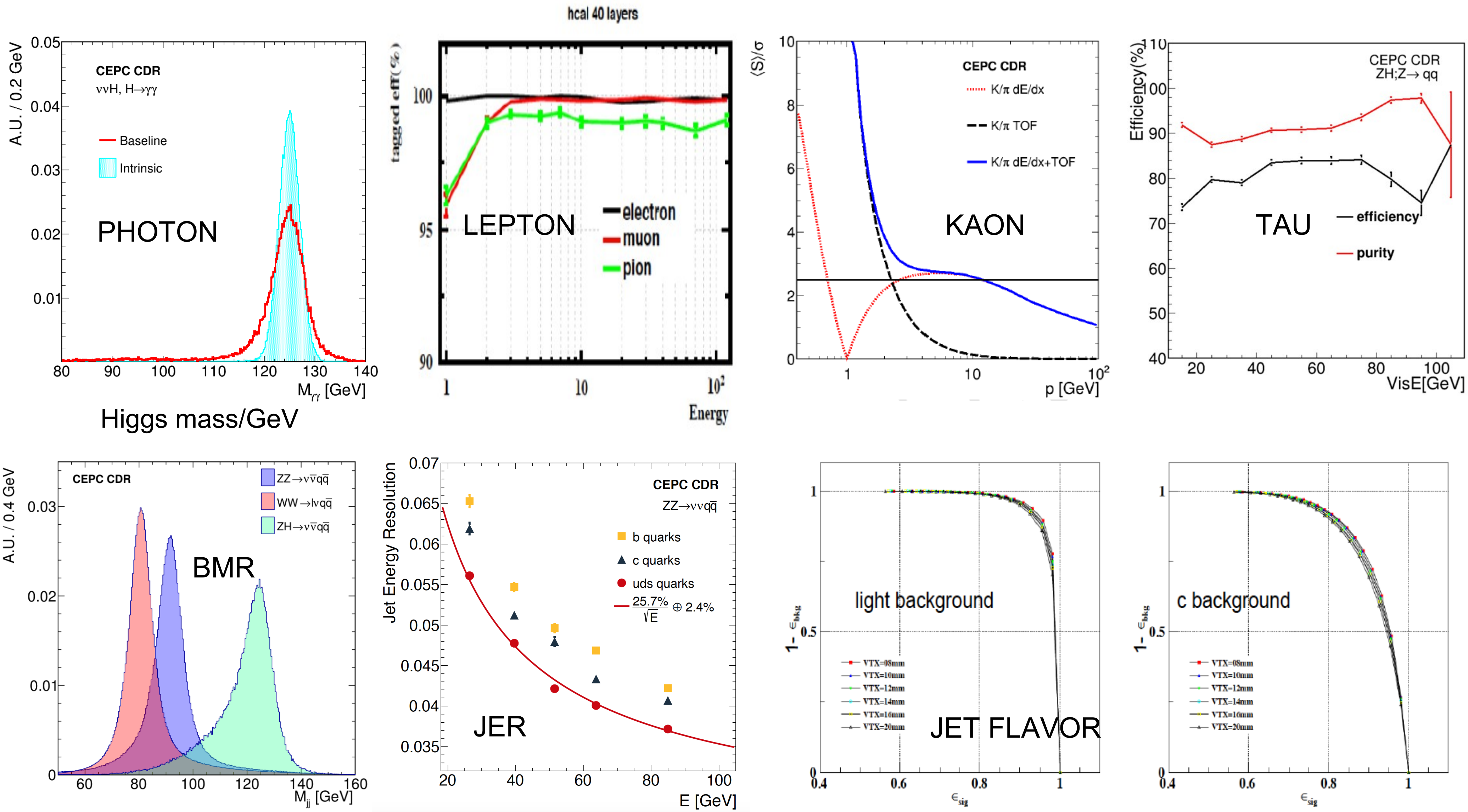




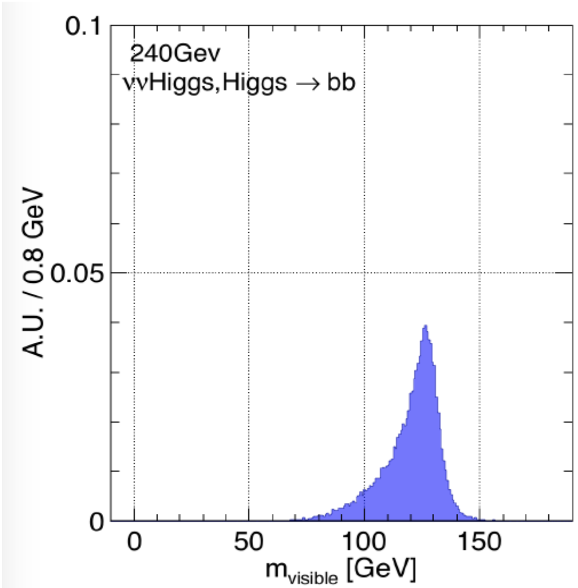


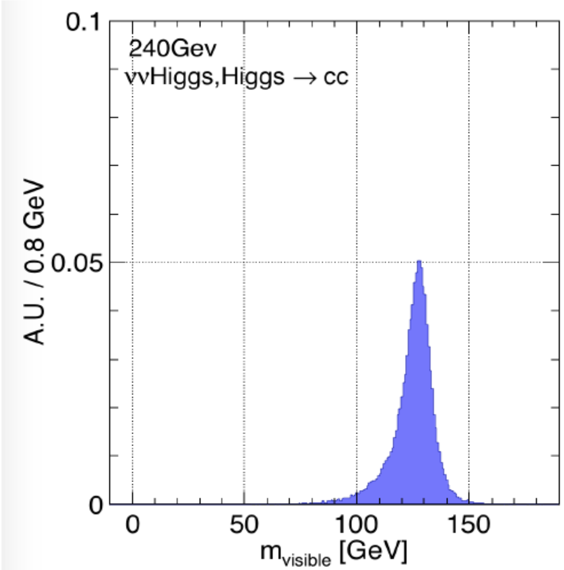
The CEPC Physics & detector CDR is reviewed mid. September

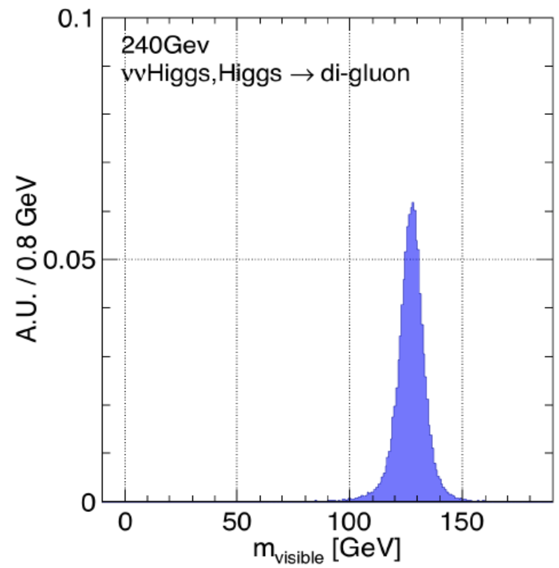
Physics Objects

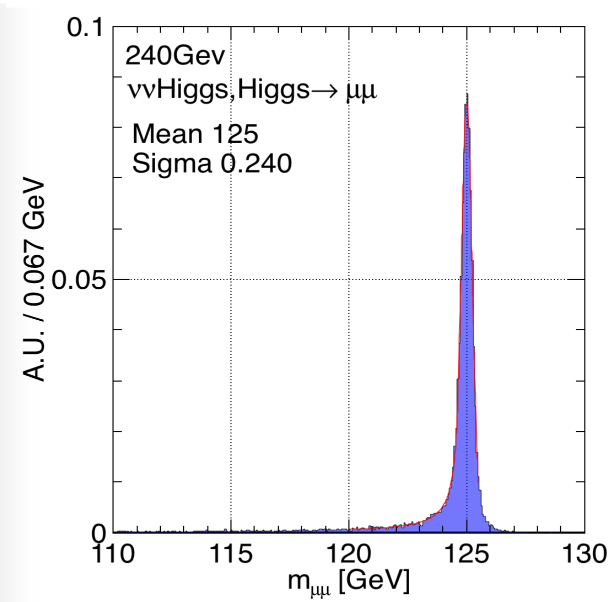


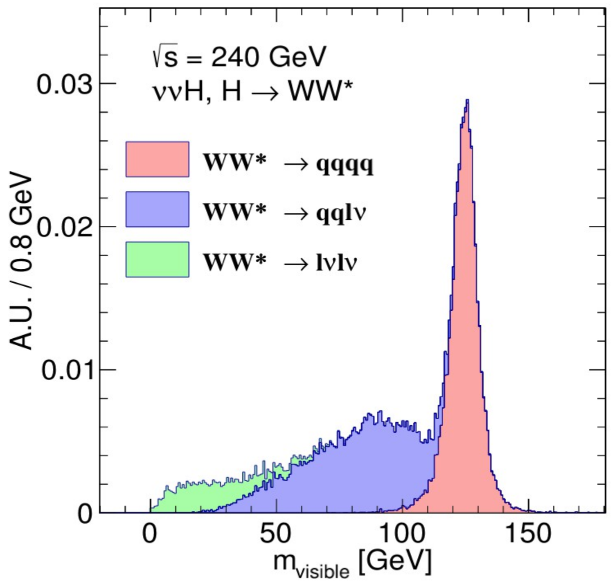
Higgs Signals at APODIS

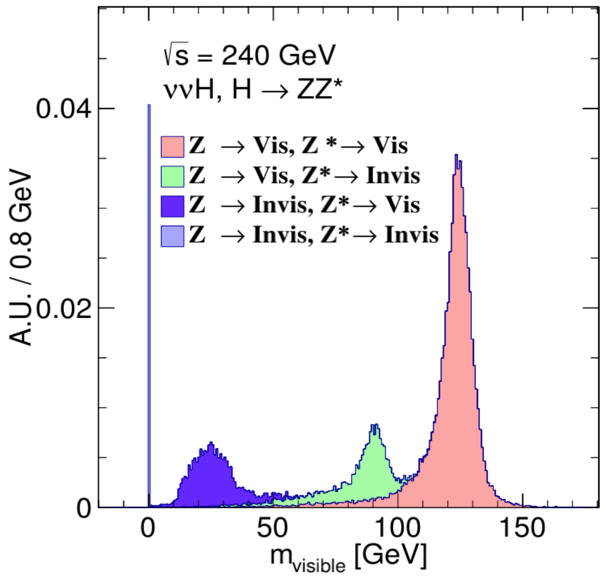




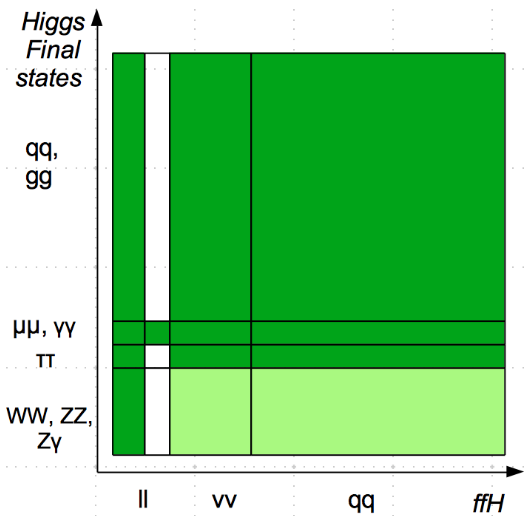


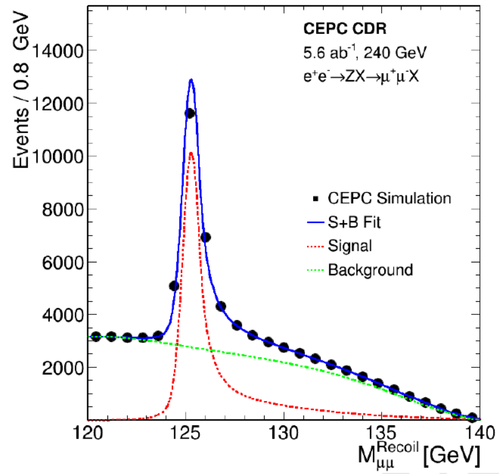


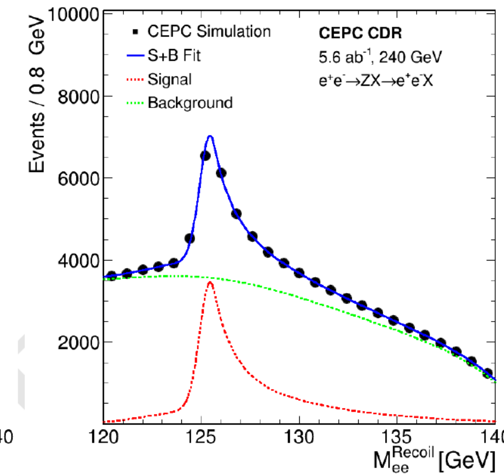




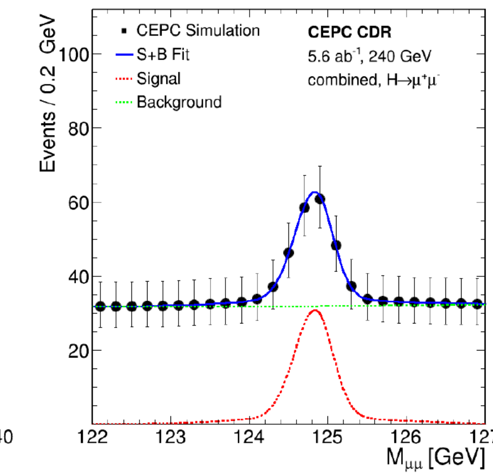
Higgs benchmark analyses



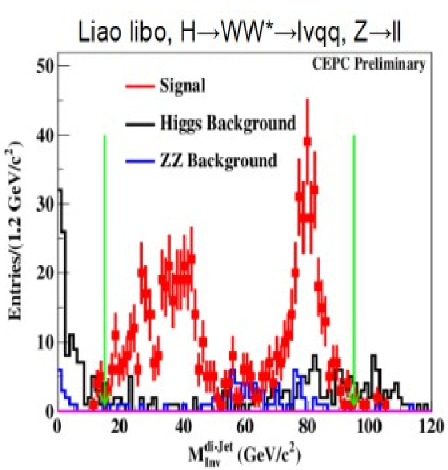




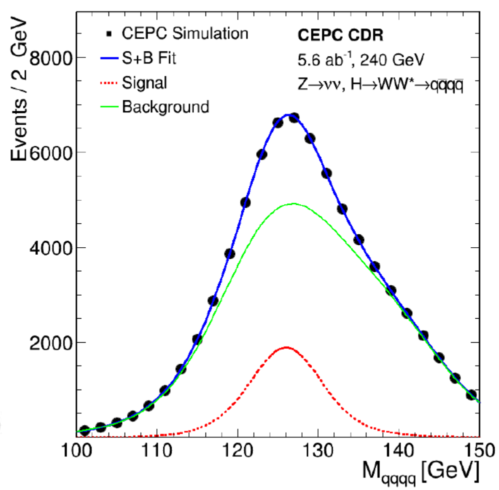
σ(ZH) measurements



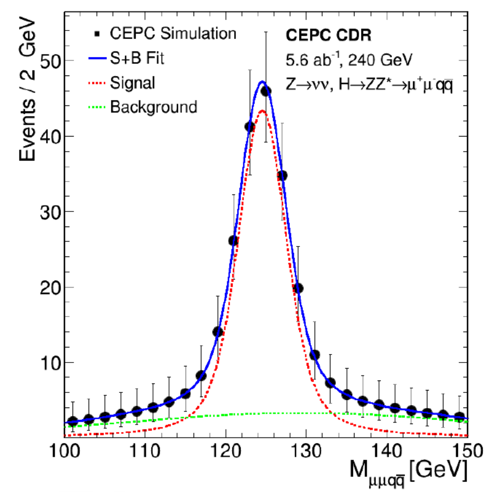
Br(H→μμ)



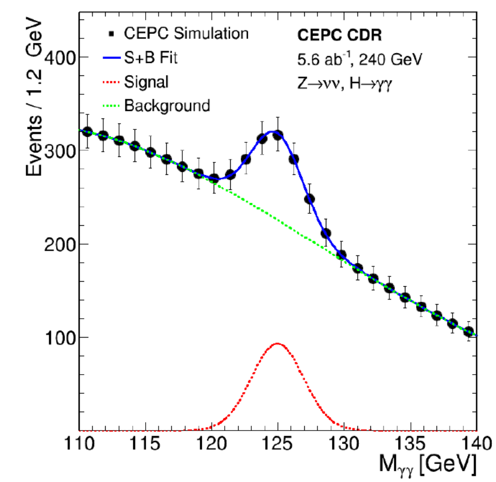
Br(H→WW)



σ(ννH)*Br(H→bb)

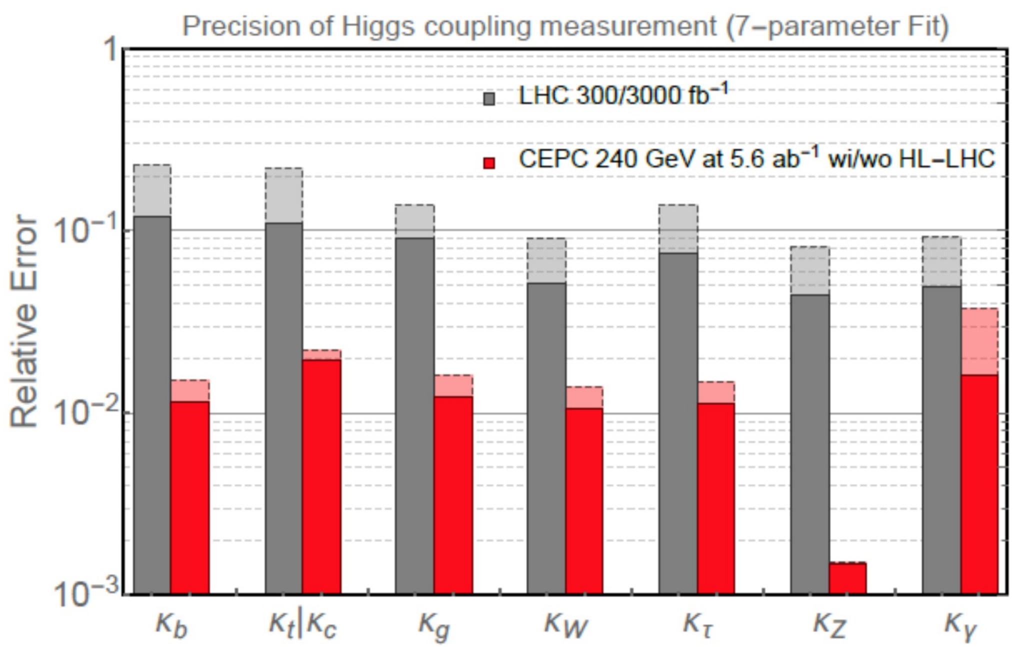


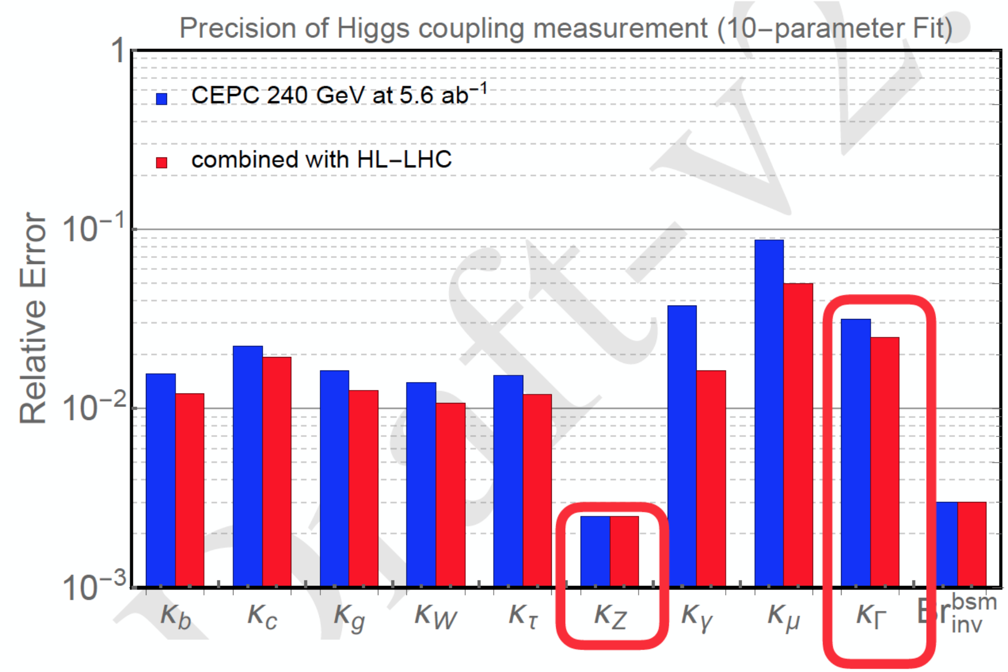
Br(H→ττ)



Br(H→γγ) (Asimov)

Higgs coupling measurements





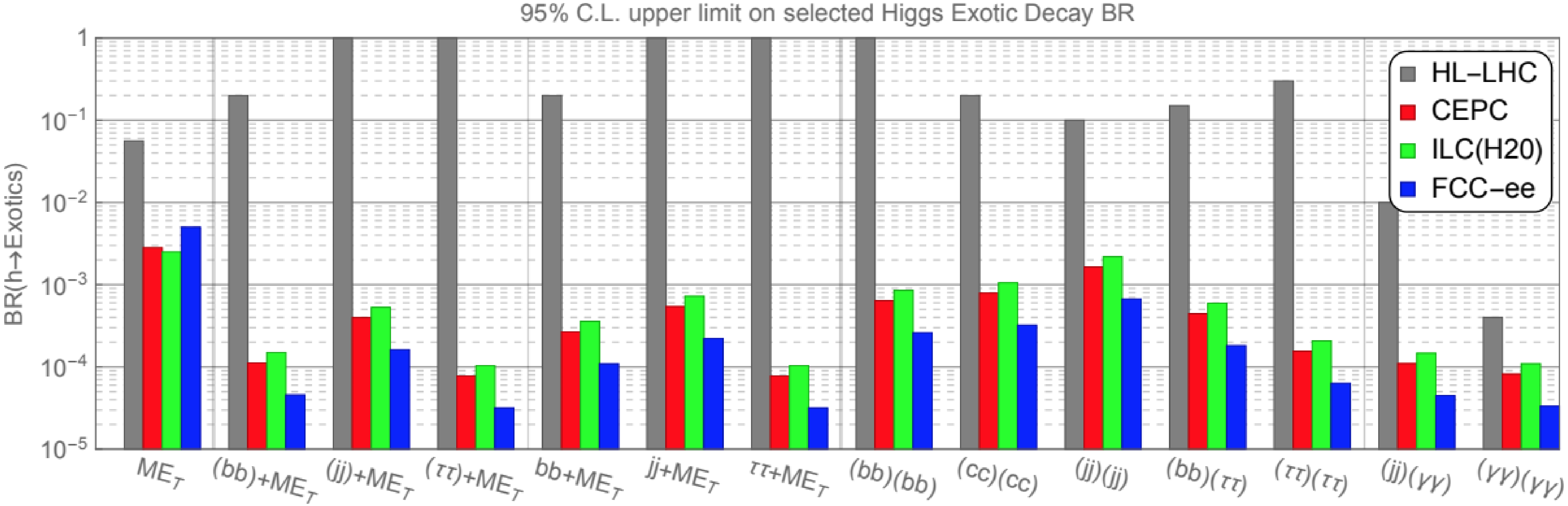
Full simulation on measurement with Event Counting

Comparing to HL-LHC: accuracy improved by 1 order of magnitude

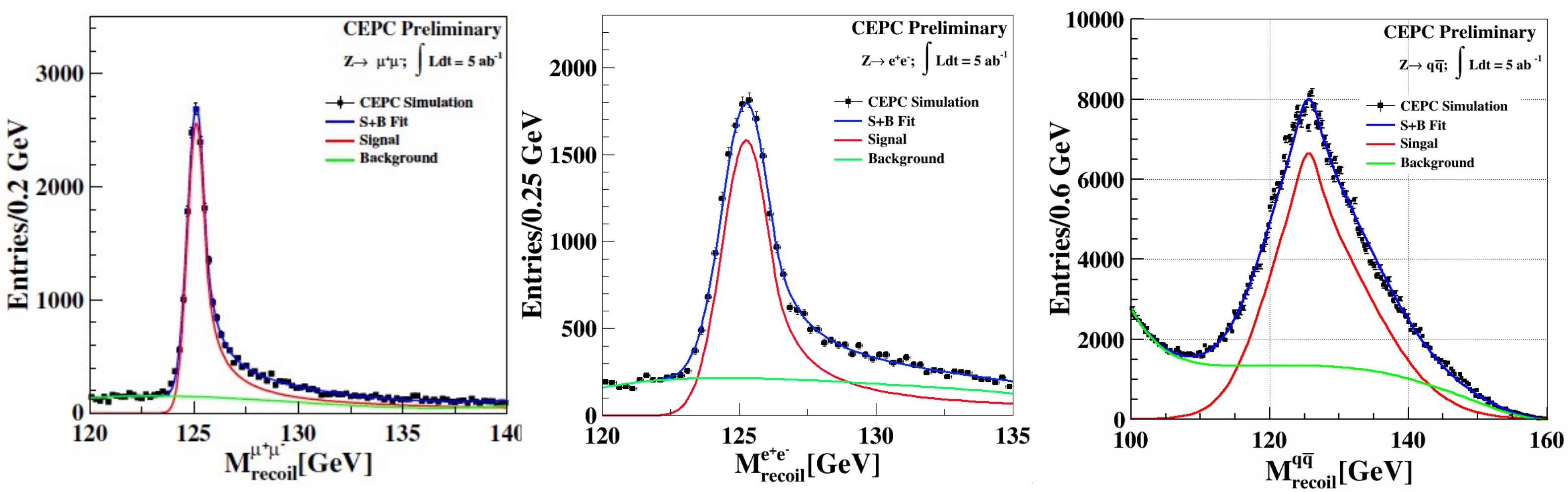
Combined with HL-LHC: several measurement can be significantly improved

To be covered: Differential Measurements, etc.

Higgs exotic decays



Invisible up limit at CEPC: 0.28% at 95% C.L

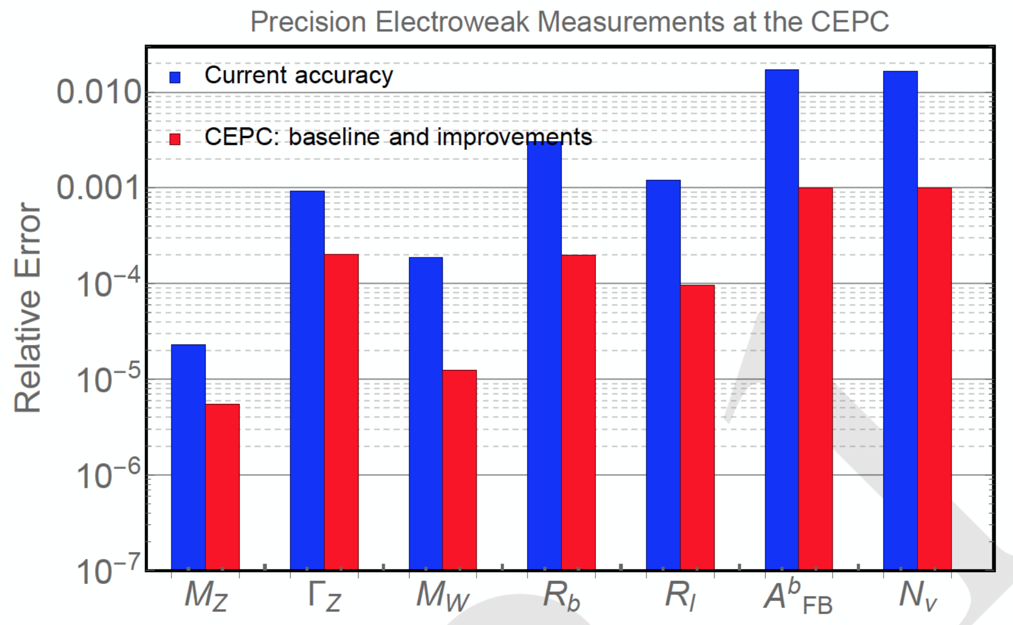


Assuming
*σ(ZH)*Br(H->inv) = 200 fb*

EW measurement at the CEPC

Observable	LEP precision	CEPC precision	CEPC runs	CEPC $\int \mathcal{L}dt$
m_Z	2 MeV	0.5 MeV	Z pole	8 ab^{-1}
$A_{FB}^{0,b}$	1.7%	0.1%	Z pole	8 ab^{-1}
$A_{FB}^{0,\mu}$	7.7%	0.3%	Z pole	8 ab^{-1}
$A_{FB}^{0,e}$	17%	0.5%	Z pole	8 ab^{-1}
$\sin^2 \theta_W^{\text{eff}}$	0.07%	0.001%	Z pole	8 ab^{-1}
R_b	0.3%	0.02%	Z pole	8 ab^{-1}
R_μ	0.2%	0.01%	Z pole	8 ab^{-1}
N_ν	1.7%	0.05%	ZH runs	5.6 ab^{-1}
m_W	33 MeV	2–3 MeV	ZH runs	5.6 ab^{-1}
m_W	33 MeV	1 MeV	WW threshold	2.6 ab^{-1}

Table 11.9: The expected precision in a selected set of EW precision measurements in CEPC and the comparison with the precision from LEP experiments. The CEPC accelerator running mode and total integrated luminosity expected for each measurement are also listed.

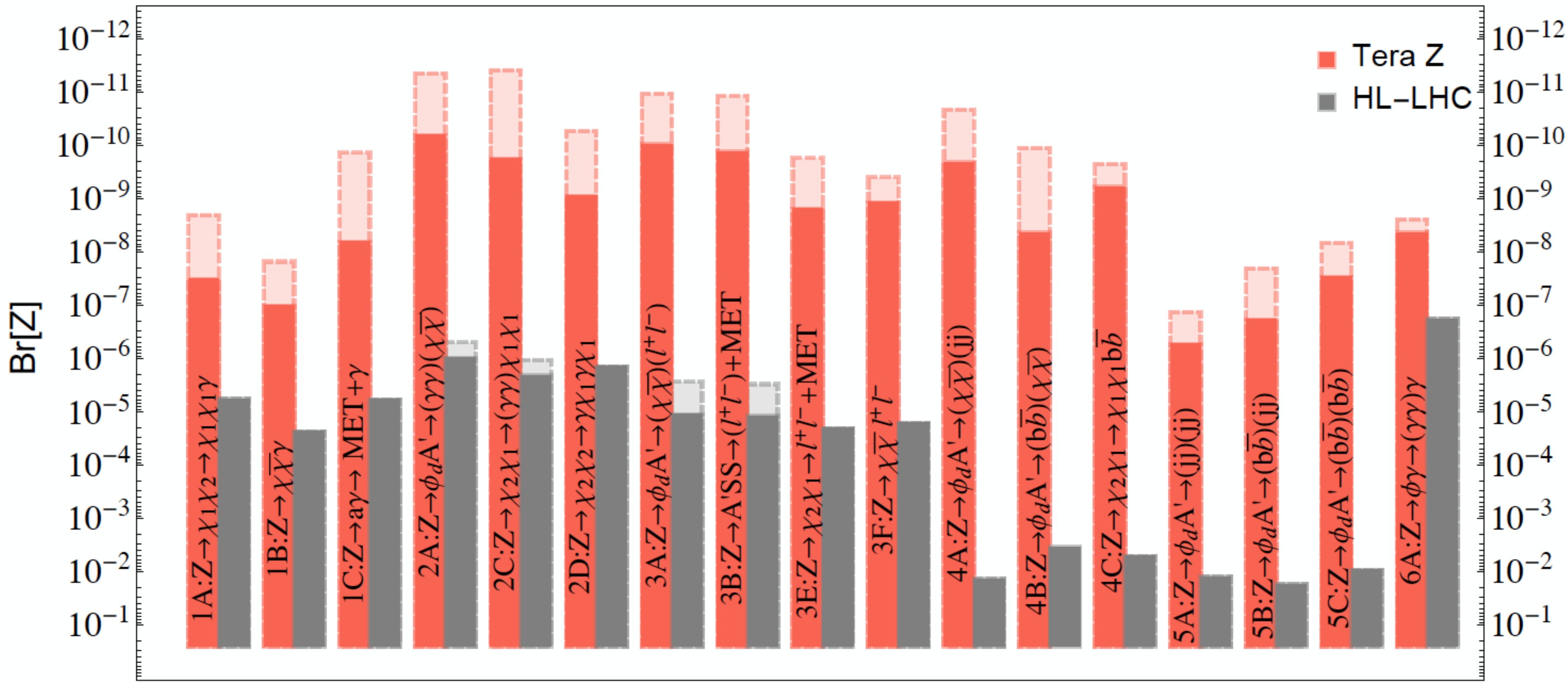


EW precision measurements: Art of Systematic Control

1 order of magnitude with respect to current accuracy

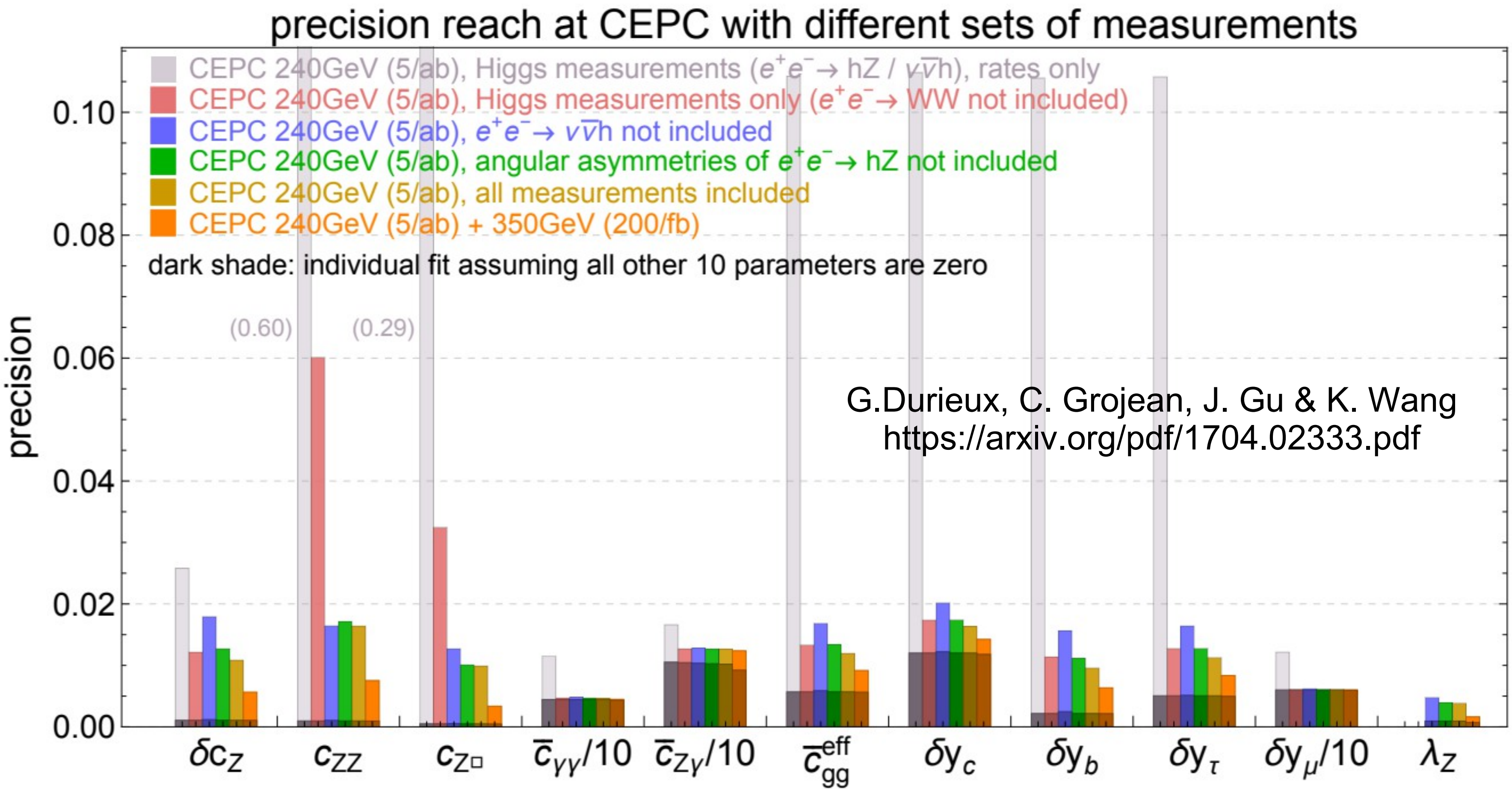
Data driven method & detector requirements to be specified

Rare Z decay



Tera Z
HL−LHC
Br[Z]
10^{-12}
10^{-11}
10^{-10}
10^{-9}
10^{-8}
10^{-7}
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1A:$Z\to\chi_1\chi_2\to\chi_1\chi_1\gamma$
1B:$Z\to\chi\overline{\chi}\gamma$
1C:$Z\to a\gamma\to$ MET$+\gamma$
2A:$Z\to\phi_d A'\to(\gamma\gamma)(\chi\overline{\chi})$
2C:$Z\to\chi_2\chi_1\to(\gamma\gamma)\chi_1\chi_1$
2D:$Z\to\chi_2\chi_2\to\gamma\chi_1\gamma\chi_1$
3A:$Z\to\phi_d A'\to(\chi\overline{\chi})(l^+l^-)$
3B:$Z\to A'SS\to(l^+l^-)$+MET
3E:$Z\to\chi_2\chi_1\to l^+l^-$+MET
3F:$Z\to\chi\overline{\chi}\,l^+l^-$
4A:$Z\to\phi_d A'\to(\chi\overline{\chi})(jj)$
4B:$Z\to\phi_d A'\to(b\overline{b})(\chi\overline{\chi})$
4C:$Z\to\chi_2\chi_1\to\chi_1\chi_1 b\overline{b}$
5A:$Z\to\phi_d A'\to(jj)(jj)$
5B:$Z\to\phi_d A'\to(b\overline{b})(jj)$
5C:$Z\to\phi_d A'\to(b\overline{b})(b\overline{b})$
6A:$Z\to\phi\gamma\to(\gamma\gamma)\gamma$

Pheno-studies: EFT & Physics reach



The Physics reach could be largely enhanced if the EW measurements is combined With the Higgs measurements (in the EFT)

Flavor physics at Z factory

Particle	@ Tera-Z	@ Belle II	
b **hadrons**			
B^+	6×10^{10}	3×10^{10}	$(50\,\text{ab}^{-1}$ on $\Upsilon(4S))$
B^0	6×10^{10}	3×10^{10}	$(50\,\text{ab}^{-1}$ on $\Upsilon(4S))$
B_s	2×10^{10}	3×10^{8}	$(5\,\text{ab}^{-1}$ on $\Upsilon(5S))$
b baryons	1×10^{10}		
Λ_b	1×10^{10}		
c **hadrons**			
D^0	2×10^{11}		
D^+	6×10^{10}		
D_s^+	3×10^{10}		
Λ_c^+	2×10^{10}		
τ^+	3×10^{10}	5×10^{10}	$(50\,\text{ab}^{-1}$ on $\Upsilon(4S))$

$\text{BR}(B \to K^* \tau\tau)$ 10^{-7}

High boosted objects + good reconstruction of photons/VTXs

Timeline

Milestones

1st, PreCDR (end of 2014)

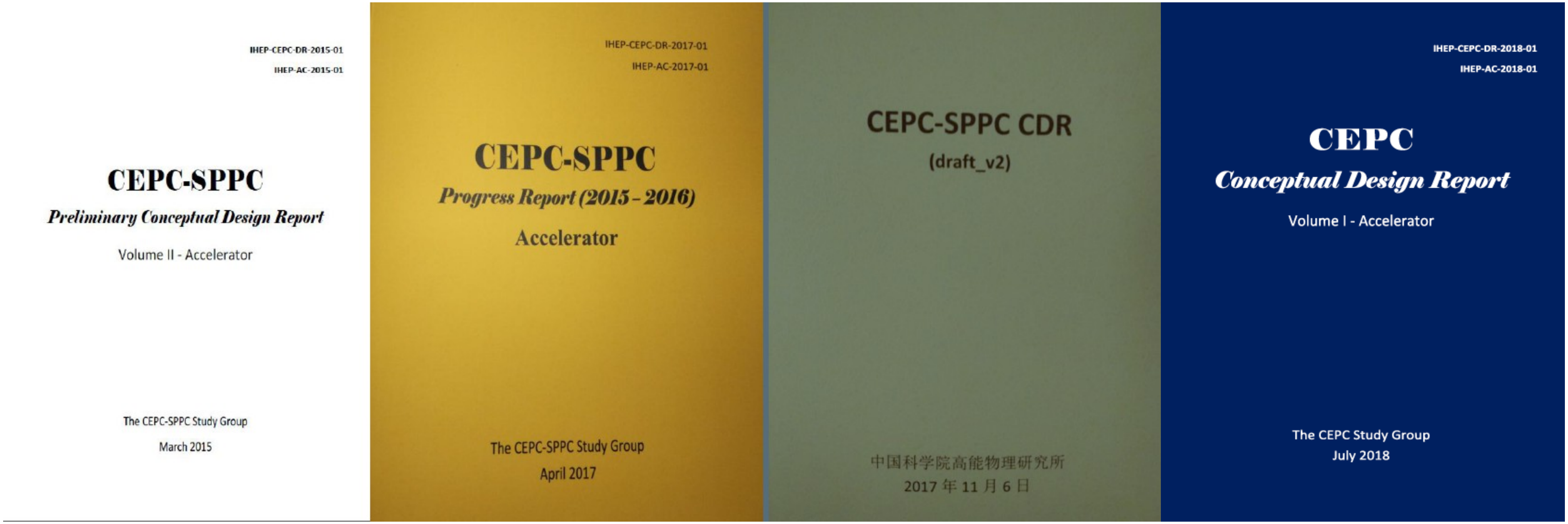
2nd, R&D funding from MOST (Middle 2016, 35 M CNY/5yr for the 1st phase)

3rd, CDR (Acc./Dec Volume: July/Nov 2018)

4th, R&D funding from MOST (Middle 2018, 2nd phase)

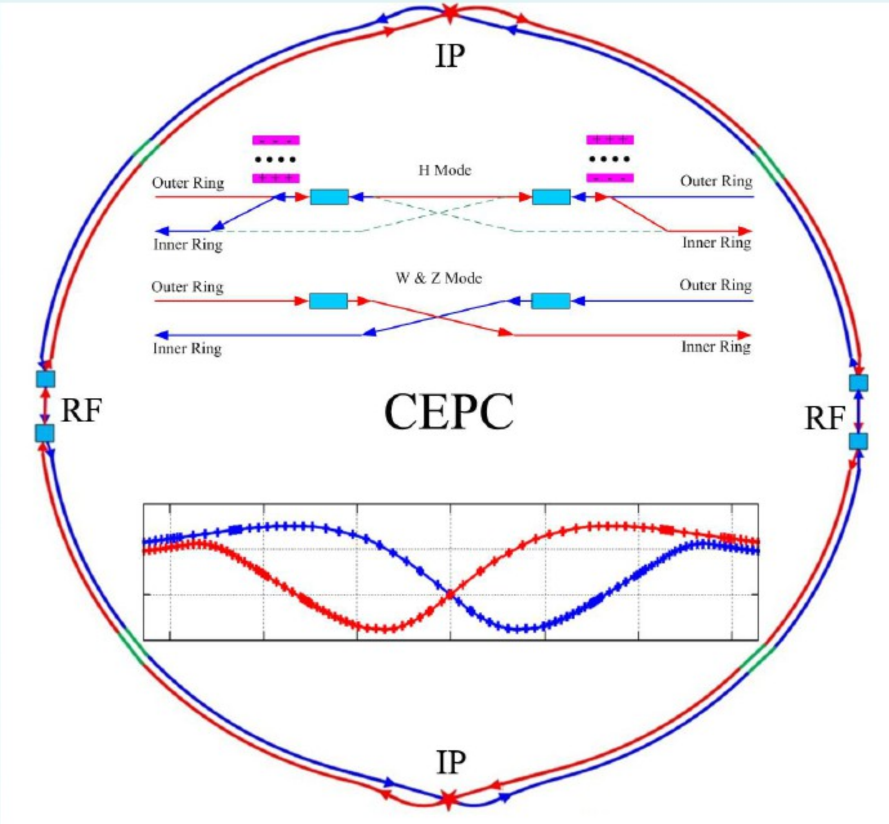
...

Accelerator design

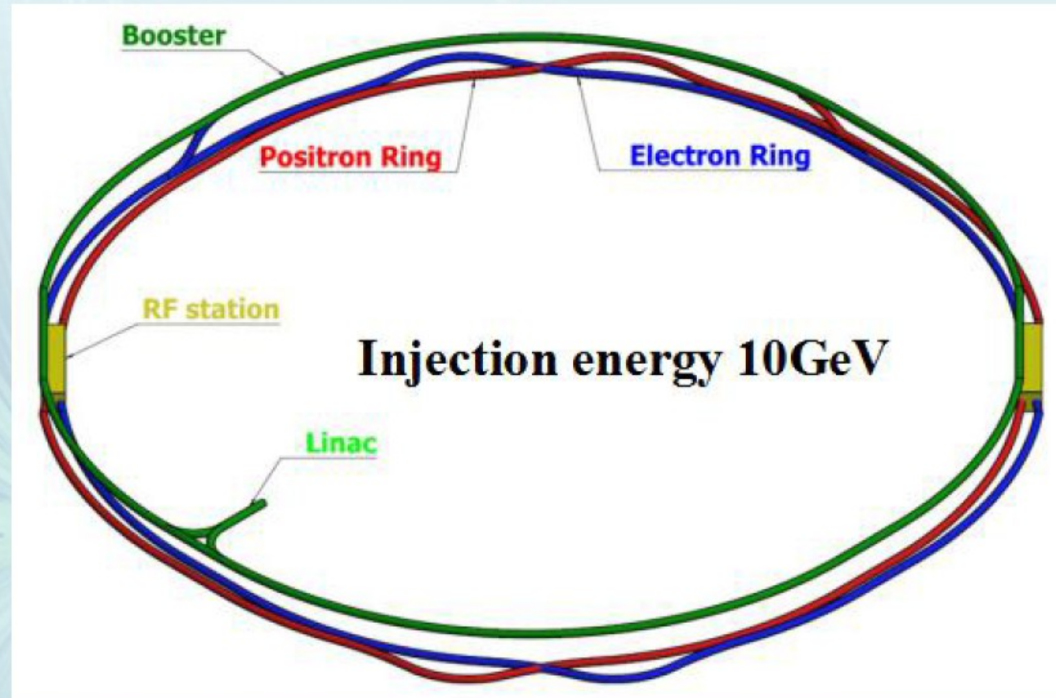


- PreCDR: no show stopper & crucial R&D programs identified
  - Cavity, high efficiency Klystron, etc...
- CDR: a workable machine (on paper)

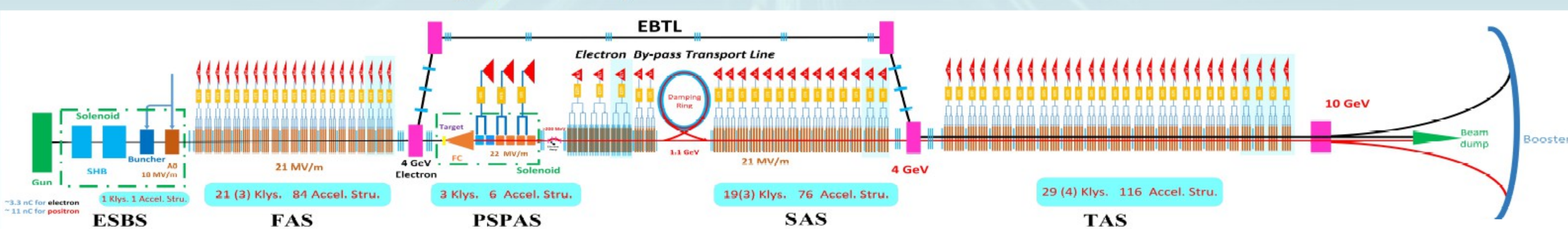
CEPC CDR Layout



CEPC collider ring (100km)



CEPC Complex



CEPC Linac injector (1.2km, 10GeV)

CEPC CDR Parameters

	Higgs	W	Z (3T)	Z (2T)
Number of IPs	2			
Beam energy (GeV)	**120**	**80**	**45.5**	
Circumference (km)	100			
Synchrotron radiation loss/turn (GeV)	1.73	0.34	0.036	
Crossing angle at IP (mrad)	16.5×2			
Piwinski angle	2.58	7.0	23.8	
Number of particles/bunch N_e (10^{10})	15.0	12.0	8.0	
Bunch number (bunch spacing)	**242 (0.68μs)**	**1524 (0.21μs)**	**12000 (25ns+10%gap)**	
Beam current (mA)	17.4	87.9	461.0	
Synchrotron radiation power /beam (MW)	**30**	**30**	**16.5**	
Bending radius (km)	10.7			
Momentum compact (10^{-5})	1.11			
β function at IP β_x^* / β_y^* (m)	**0.36/0.0015**	**0.36/0.0015**	**0.2/0.0015**	**0.2/0.001**
Emittance $\varepsilon_x/\varepsilon_y$ (nm)	1.21/0.0031	0.54/0.0016	0.18/0.004	0.18/0.0016
Beam size at IP σ_x/σ_y (μm)	20.9/0.068	13.9/0.049	6.0/0.078	6.0/0.04
Beam-beam parameters ξ_x/ξ_y	0.031/0.109	0.013/0.106	0.0041/0.056	0.0041/0.072
RF voltage V_{RF} (GV)	2.17	0.47	0.10	
RF frequency f_{RF} (MHz) (harmonic)	650 (216816)			
Natural bunch length σ_z (mm)	2.72	2.98	2.42	
Bunch length σ_z (mm)	3.26	5.9	8.5	
HOM power/cavity (2 cell) (kw)	0.54	0.75	**1.94**	
Natural energy spread (%)	0.1	0.066	0.038	
Energy acceptance requirement (%)	**1.35**	**0.4**	**0.23**	
Energy acceptance by RF (%)	2.06	1.47	1.7	
Photon number due to beamstrahlung	0.1	0.05	0.023	
Lifetime _simulation (min)	100			
Lifetime (hour)	**0.67**	**1.4**	**4.0**	**2.1**
F (hour glass)	0.89	0.94	0.99	
Luminosity/IP L (10^{34}cm^{-2}s^{-1})	**2.93**	**10.1**	**16.6**	**32.1**

CEPC Power for Higgs and Z

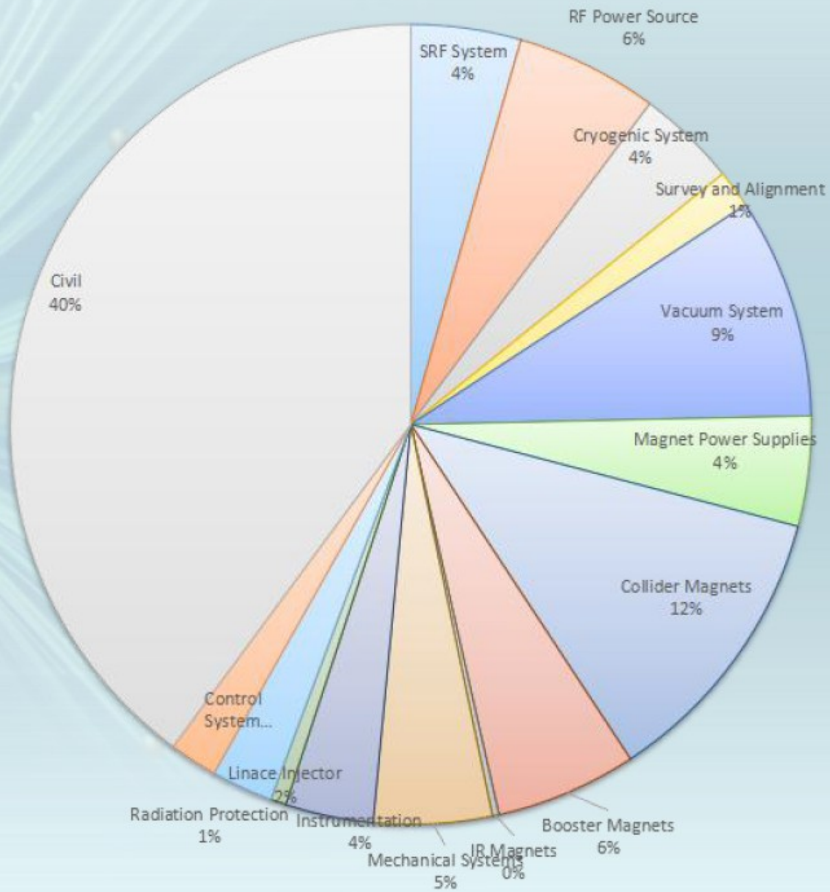
	System for Higgs (30MW)	Location and electrical demand(MW)						Total (MW)
		Ring	Booster	LINAC	BTL	IR	Surface building	
1	RF Power Source	103.8	0.15	5.8				109.75
2	Cryogenic System	11.62	0.68			1.72		14.02
3	Vacuum System	9.784	3.792	0.646				14.222
4	Magnet Power Supplies	47.21	11.62	1.75	1.06	0.26		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

266MW

	System for Z	Location and electrical demand(MW)						Total (MW)
		Ring	Booster	LINAC	BTL	IR	Surface building	
1	RF Power Source	57.1	0.15	5.8				63.05
2	Cryogenic System	2.91	0.31			1.72		4.94
3	Vacuum System	9.784	3.792	0.646				14.222
4	Magnet Power Supplies	9.52	2.14	1.75	0.19	0.05		13.65
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	19.95	2.22	1.38	0.55	1.2		25.3
10	General services	7.2		0.2	0.15	0.2	12	19.75
	Total	108.614	9.812	10.276	0.895	7.175	12	148.772

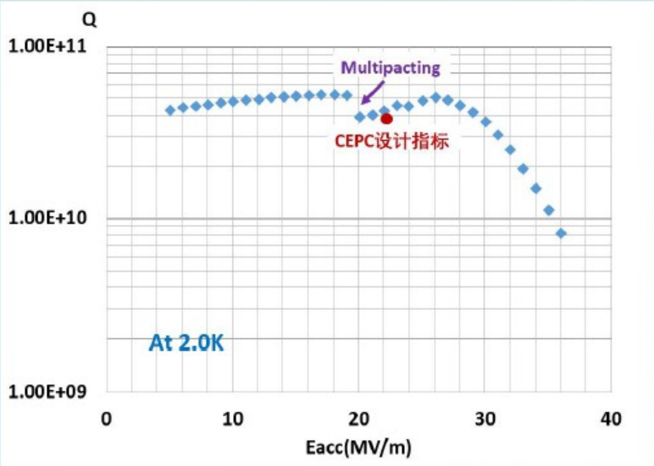
149MW

CEPC Cost Breakdwon (no detector)

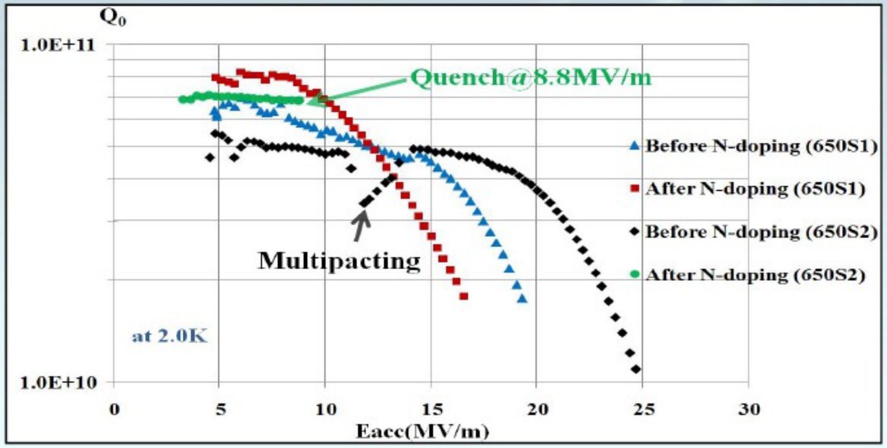


CEPC 650 MHz Cavity Development

- Vertical test result: Q_0=5.1E10@26MV/m, which has reached the CEPC target (Q_0=4.0E10@22.0MV/m).
- Next, the CEPC target will be again improved by N-doping and EP, to increas Q_0 and to reduce further AC power



After N-doping, Q_0 increased obviously at low field for both 650MHz 1-cell cavities.

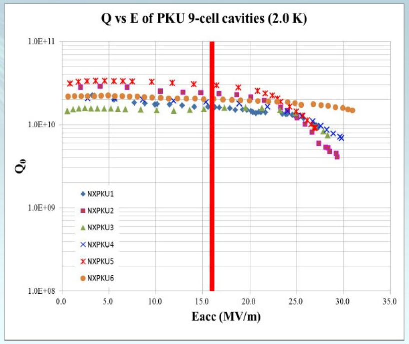


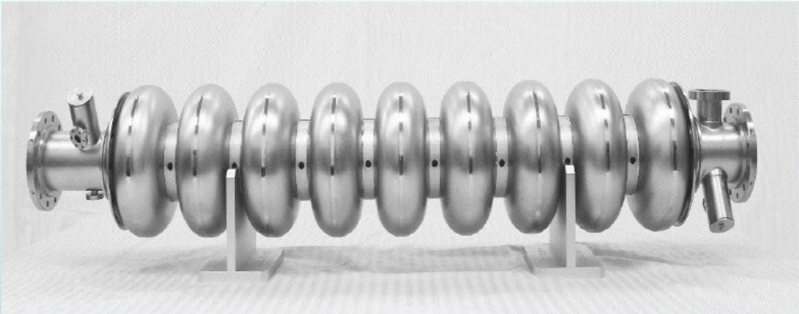
The civil construction of the EP facility is on going, and the commissioning will be at the end of 2018.

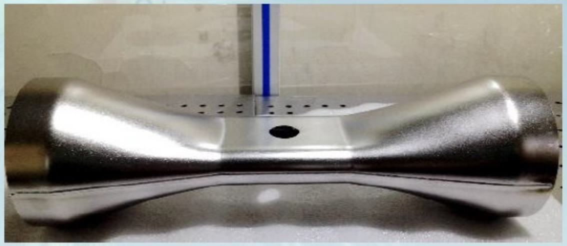
SCRF industrialization

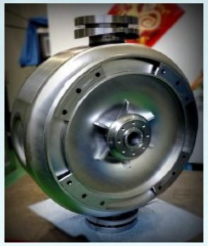
High RRR Nb ingot

High RRR Nb sheet









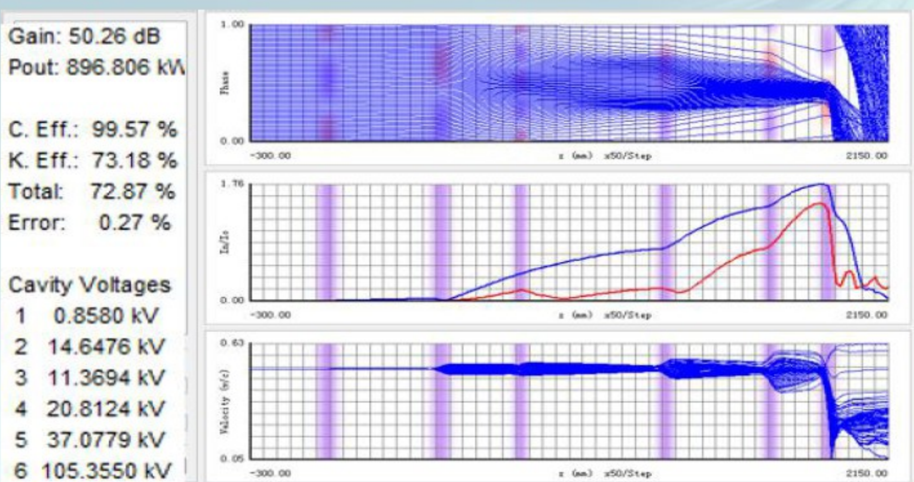
ILC 1.3GHz cavity capacity: ~200cavities/year

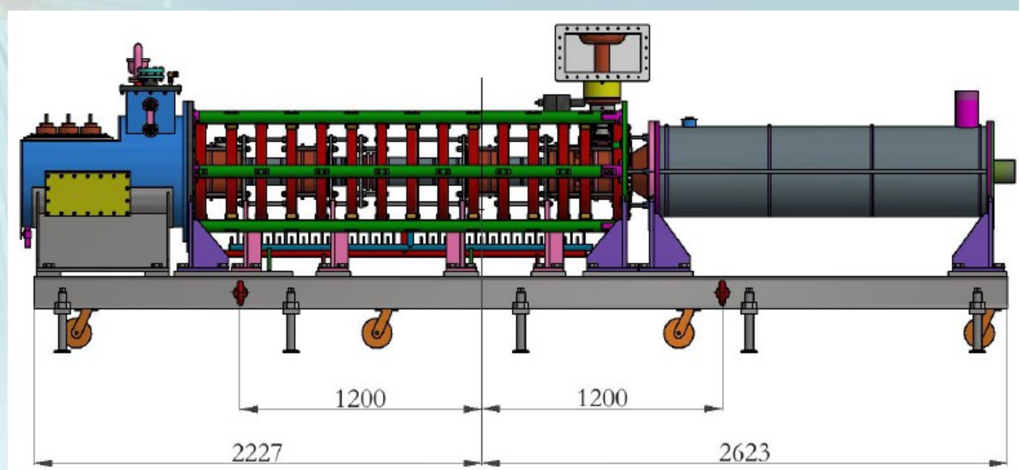
High Efficiency Klystron Development

Established "High efficiency klystron collaboration consortium", including IHEP & IE(Institute of Electronic) of CAS, and Kunshan Guoli Science and Tech.

- **2016 – 2018: Design conventional & high efficiency klystron**
- **2017 – 2018: Fabricate conventional klystron & test**
- **2018 - 2019 : Fabricate 1st high efficiency klystron & test**
- **2019 - 2020 : Fabricate 2nd high efficiency klystron & test**
- **2020 - 2021 : Fabricate 3rd high efficiency klystron & test**

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**





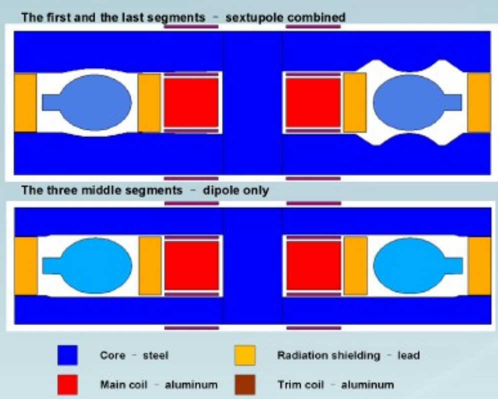
Mechanical design of conventional klystron

⇨ 73%/68%/65% efficiencies for 1D/2D/3D

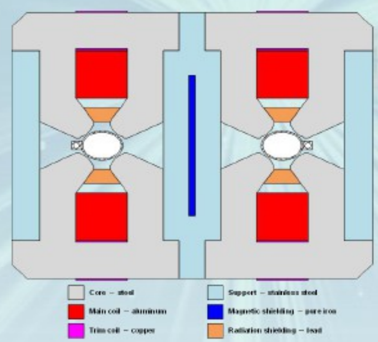
CEPC Collider and Booster Ring Conventional Magnets

CEPC collider ring magnets

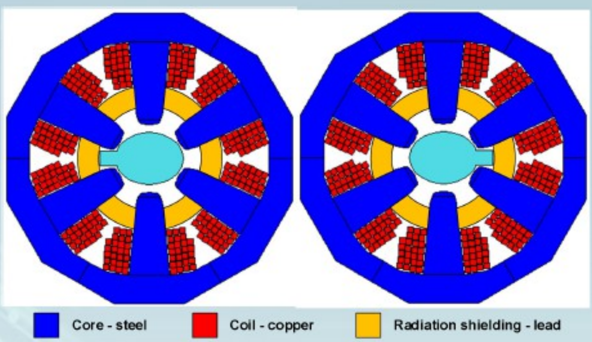
	Dipole	Quad.	Sext.	Corrector	Total
Dual aperture	2384	2392	-	-	13742
Single aperture	80*2+2	480*2+172	932*2	2904*2	
Total length [km]	71.5	5.9	1.0	2.5	80.8
Power [MW]	7.0	20.2	4.6	2.2	34



Dipole



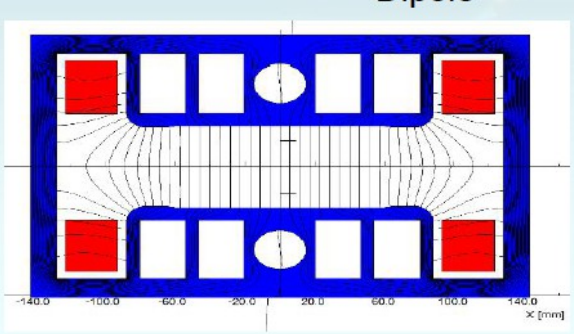
Quadrupole



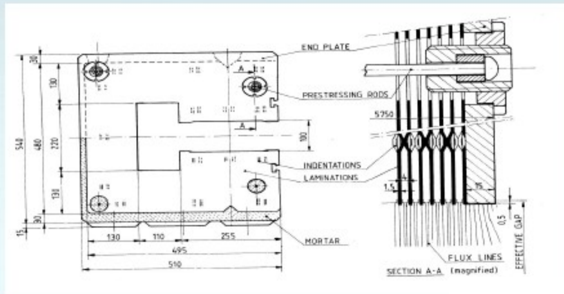
Sextupole

Booster ring low field magnets

Dipole

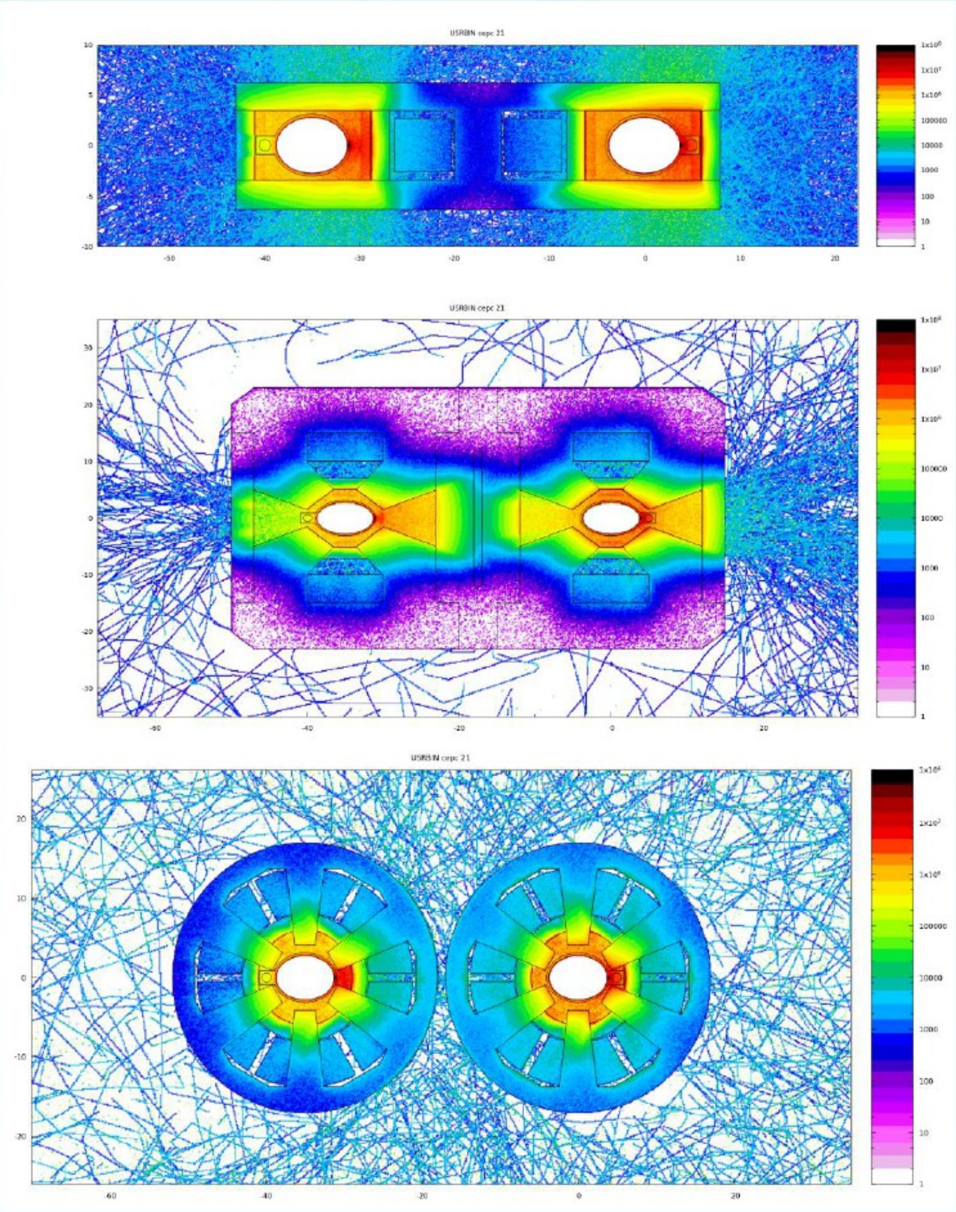


Quantity	16320
Magnetic length(m)	4.711
Max. strength(Gs)	338
Min. strength(Gs)	28
Gap height(mm)	63
GFR(mm)	55
Field uniformity	5E-4



Magnets R&D:-SR Analysis

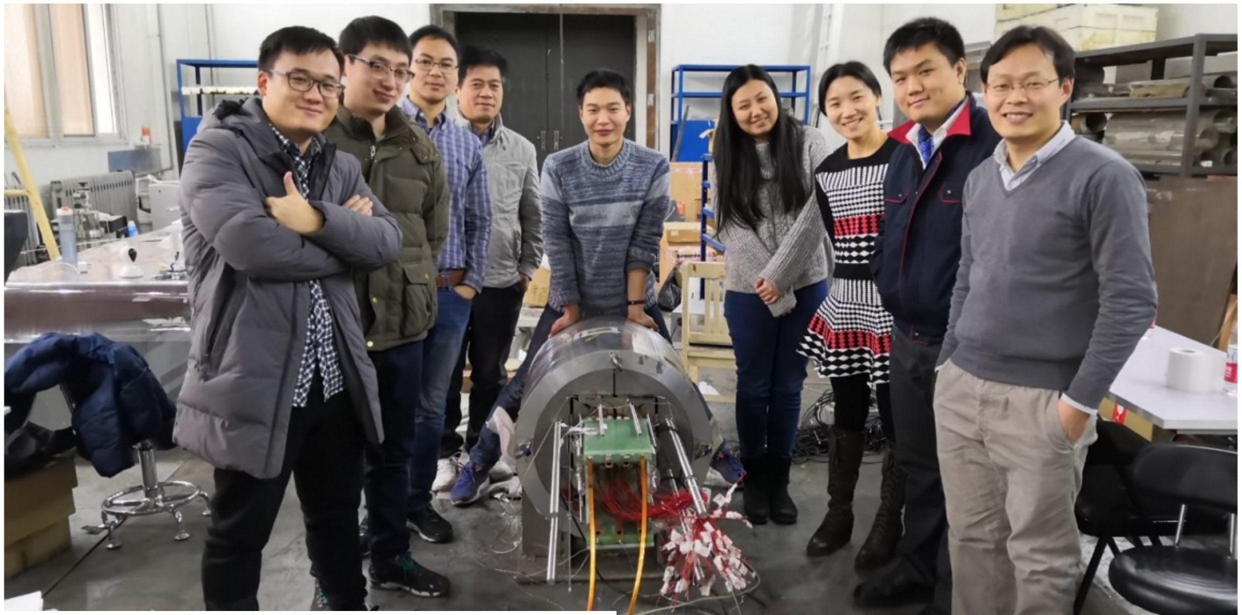
Total power 870 W/m			
Beam direction: left W/m		Beam direction: right W/m	
Al chamber	199	Al chamber	186
Cu chamber	308	Cu chamber	332
Dipole	186	Dipole	182
Lead A	60.6	Lead A	29.2
Lead B	33.5	Lead B	80.0
Lead C	46.8	Lead C	18.8
Lead D	14.3	Lead D	20.4
Quadrupole	279	Quadrupole	268
Lead A	37.8	Lead A	36.4
Lead B	18.1	Lead B	21.7
Sextupole	179	Sextupole	174
Lead A	95.1	Lead A	107
Lead B	60.3	Lead B	43.1

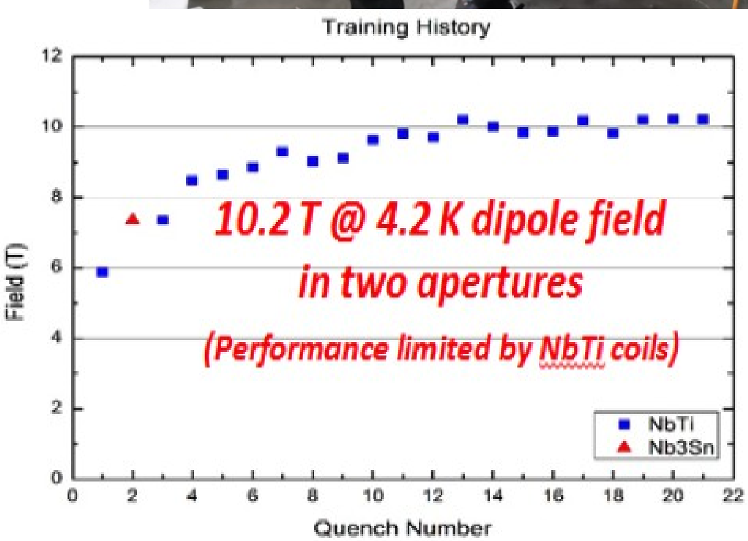


HTC Superconducting Cables

- Huge impact If magnet can be used at ~ 4.5K - 20 K
- Fe-based HTC cable
  - Metal, easy to process; Isotropic; Cheap in principle
- Background in CAS
  - World highest Tc Fe-based materials
  - World first ~ 115 m Fe-based SC cables: 12000 A/cm^2 @ 10 T
- A collaboration on "HTC SC materials" : Institute of Physics, USTC, Institute of electric engineering, IHEP, 3 SC cable companies in China
  - Iron based HTC cables
  - ReBCO & Bi-2212
  - Goal: ~ 3-5 $ /kA·m
    - Current density: × 10
    - Cost/m: ÷10

Dipole Prototype: B = 10.2T @ 4.2K



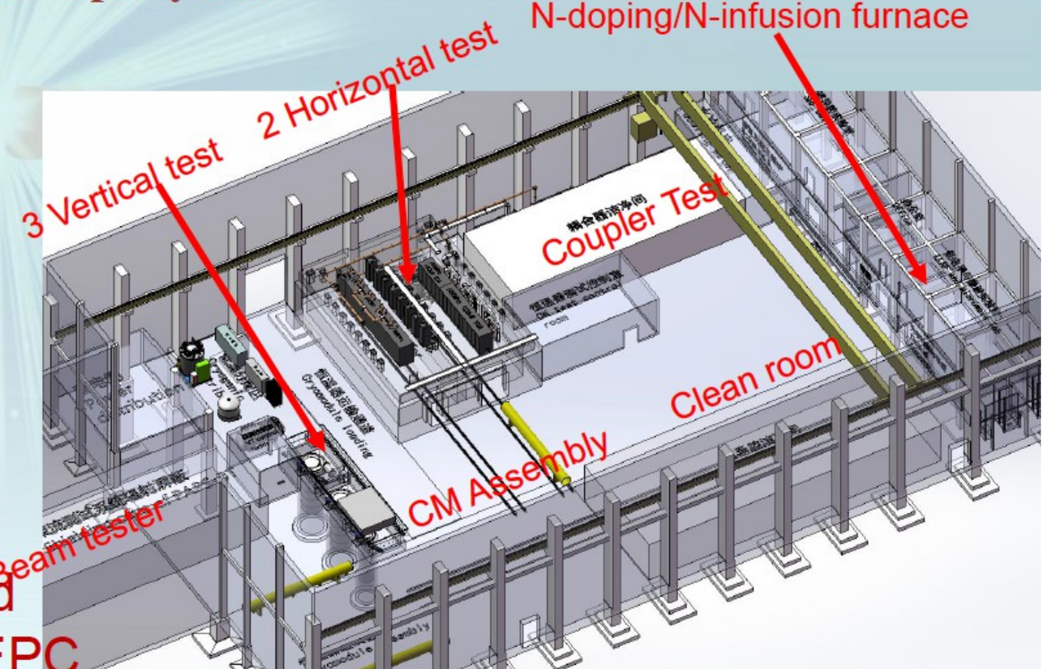


IHEP New SRF Infrastructure

- **4500 m² SRF lab in the Platform of Advanced Photon Source Technology R&D (PAPS), Huairou Science Park, Beijing.**
- **Mission to be World-leading SRF Lab for Superconducting Accelerator Projects and SRF Frontier R&D.**
- **Mass Production:**
  - **200 ~ 400 cavities & couplers test per year**
  - **20 cryomodules assembly and horizontal test per year.**
- **Construction : 2017 - 2020**

⇨ 3 VT dewars , 2 HT caves,

⇨ 500m2 Clean Room



Shanghai city government decided to built Shanghai Coherent Light Facility(SCLF).

- 432 1.3 GHz cavities
- 54 Cryomodules
- IHEP plans to provide > 1/3 of cavities and cryomodules, an excellent exercise for CEPC

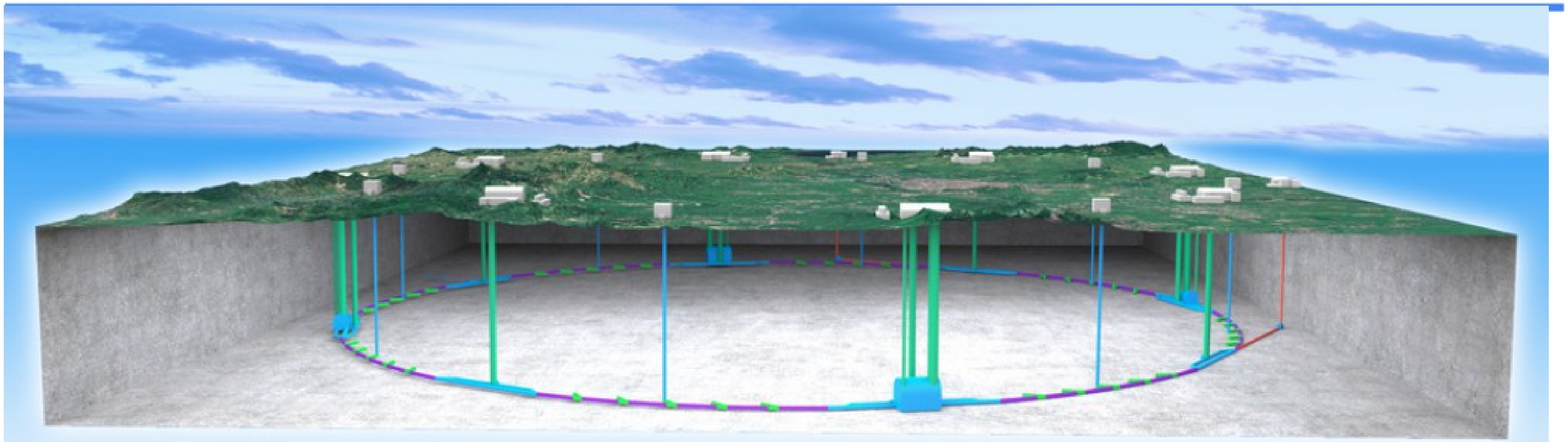
CEPC Industrial Promotion Consortium (CIPC)

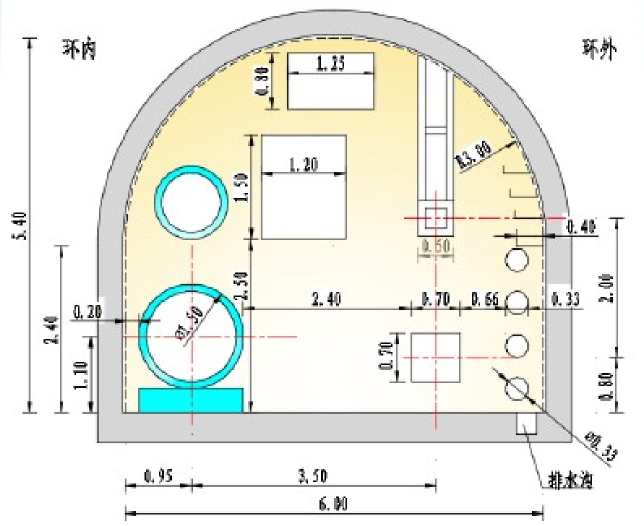
1) Superconduting materials (for cavity and for magnets)
2) Superconductiong cavities
3) Cryomodules
4) Cryogenics
5) Klystrons
6) Vacuum technologies
7) Electronics
8) SRF
9) Power sources
10) Civil engineering
11) Precise machinary.....

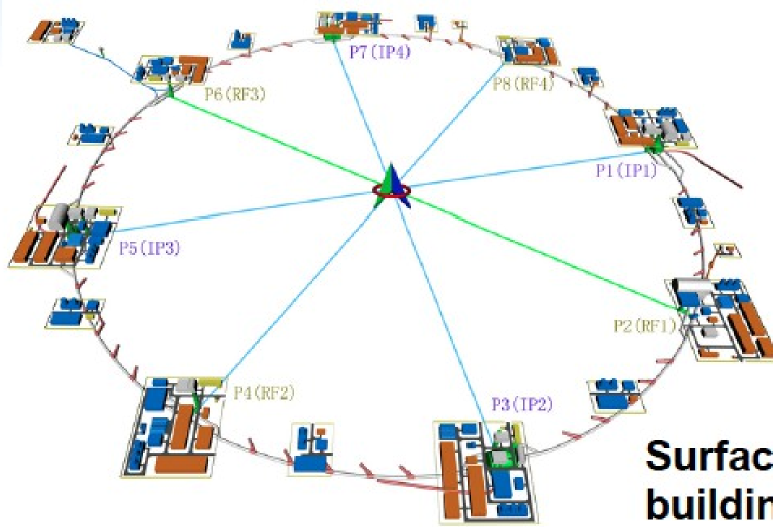
Established in Nov. 7 , 2017

CIPC Annual Meeting, July 26 , 2018

Civil Construction

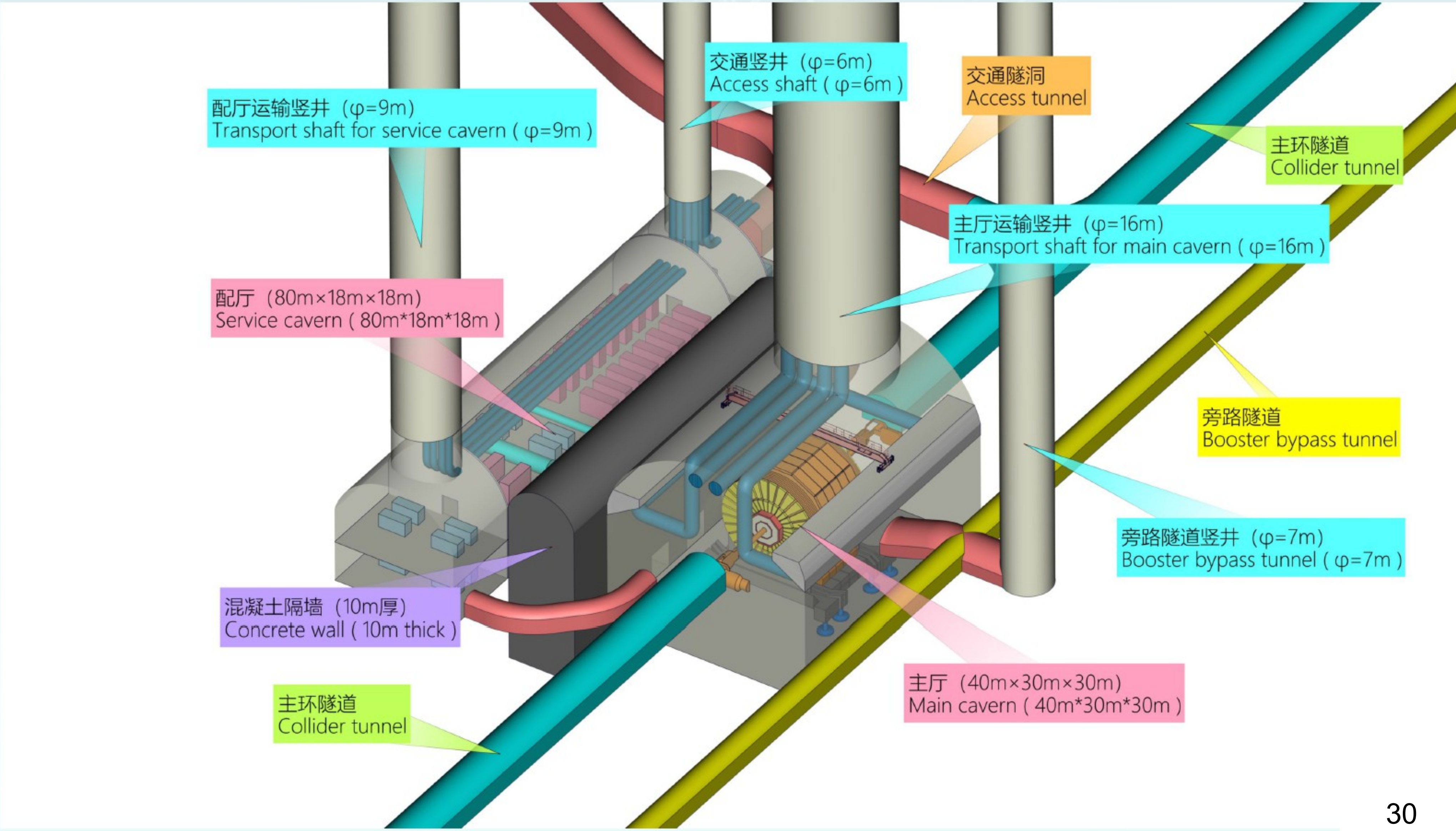






Surface buildings

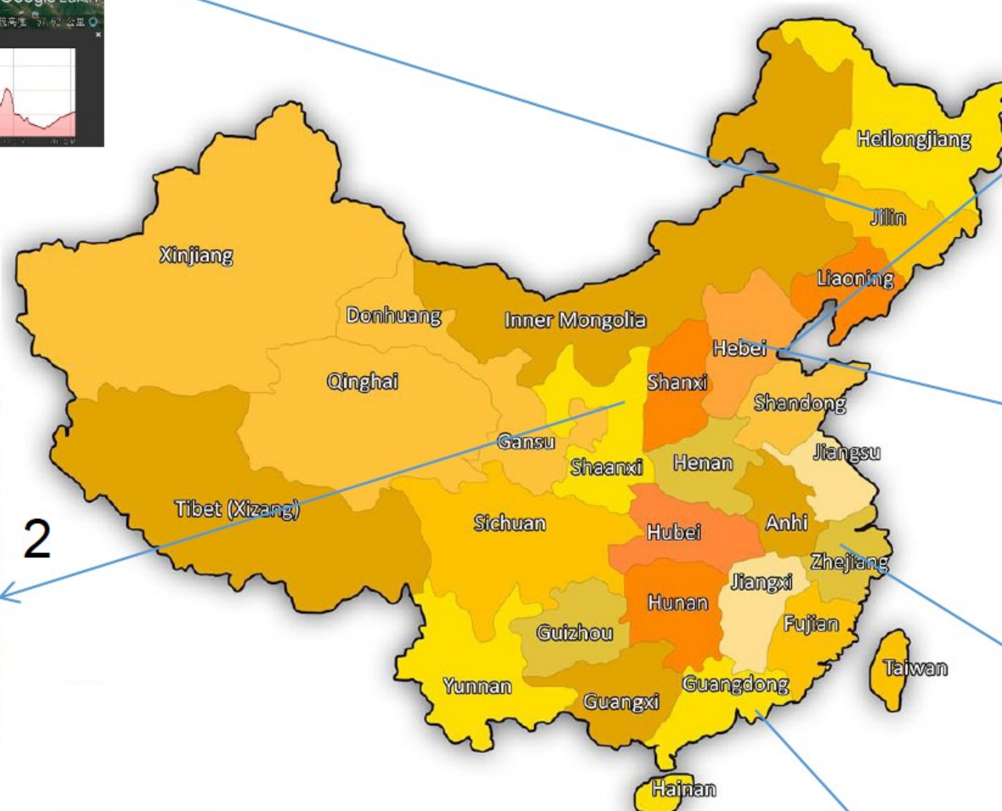
CEPC Detector Hall Area-1



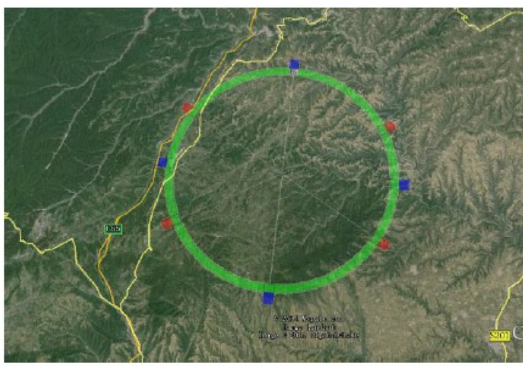
CEPC Site Selections

6

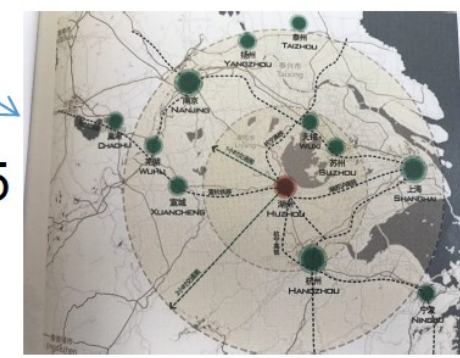
1



4



2



5

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)

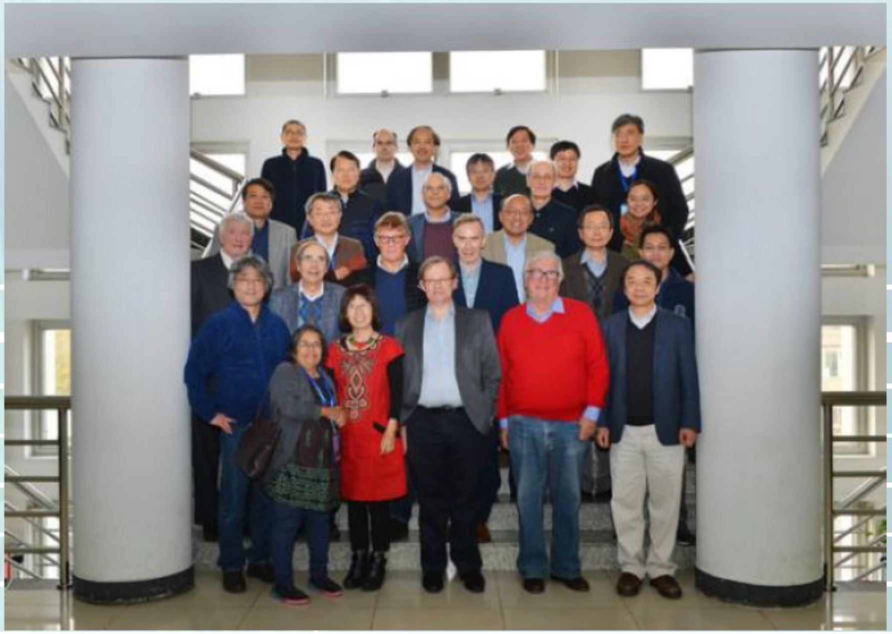
3

CEPC-SppC International Advisory Committee

Young-Kee Kim IAC Chair

- The first IAC meeting in 2015
- The Second IAC meeting in 2016
- The third IAC meeting in 2017

David Gross	Eckhard Elsen
Luciano Maiani	Peter Jenni
M. Mangano	Harry Weerts
Joe Lykken	Young-Kee Kim*
Henry Tye	Ian Shipsey
H.Murayama	Michael Davier
R. Godbole	Geoffrey Tayler
Katsunobu Oide	George Hou
S. Stapnes	Lucie Linssen
John Seeman	Barry Barish
E. Levichev	Brain Foster
Robert Palmer	Hesheng Chen



The the third CEPC-SppC International Advisory Committee Meeting, Nov 8-9, 2017, Beijing

CEPC International Collaboration Status-2

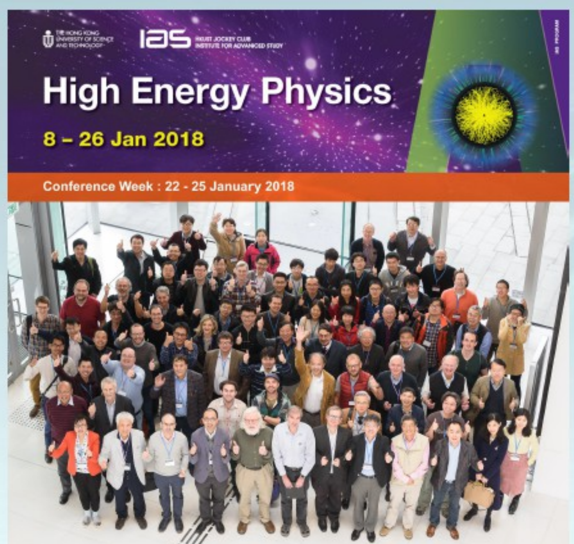
The first CEPC-SppC international Collaboration Workshop
Nov 6-8, 2017, IHEP, Bejing

http://indico.ihep.ac.cn/event/6618

Workshop on the Circuar Electron Positron Collider-EU edition

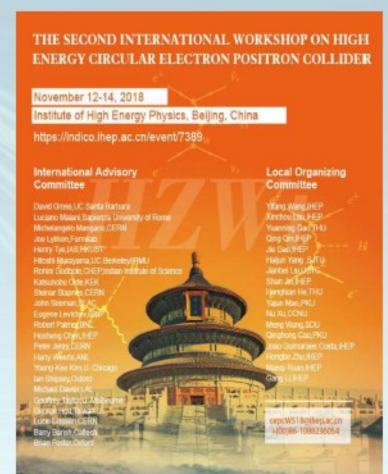
May 24-26, 2018, Università degli Studi Roma Tre, Rome, Italy

https://agenda.infn.it/conferenceDisplay.py?ovw=True&confId=14816



IAS Higgh Energy Physics Workshop
(Since 2015)

http://iasprogram.ust.hk/hep/2018



The sencond CEPC-SppC international Collaboration Worksho
Nov 12-14, 2018, IHEP, Beijng

https://indico.ihep.ac.cn/event/7389/

China New Scientific Policies

January 23, 2018 : The China Reform and Development Committee (led by President J.P. Xi) had the meeting on Jan 23, 2018, and passed the plan of "Chinese Initiated International Large Scientific Plan and Large Sicentific Project"

March 28, 2018 : Chinese Government (led by Premier Minister Keqiang Li) made public details of "Chinese Initiated International Large Scientific Plan and Large Sicentific Project" :

...till 2020 China will prepare 3~5 projects (hopefully, CEPC is inside)and finally select 1~2 projects to construct...(hopefully, CEPC will be selected)

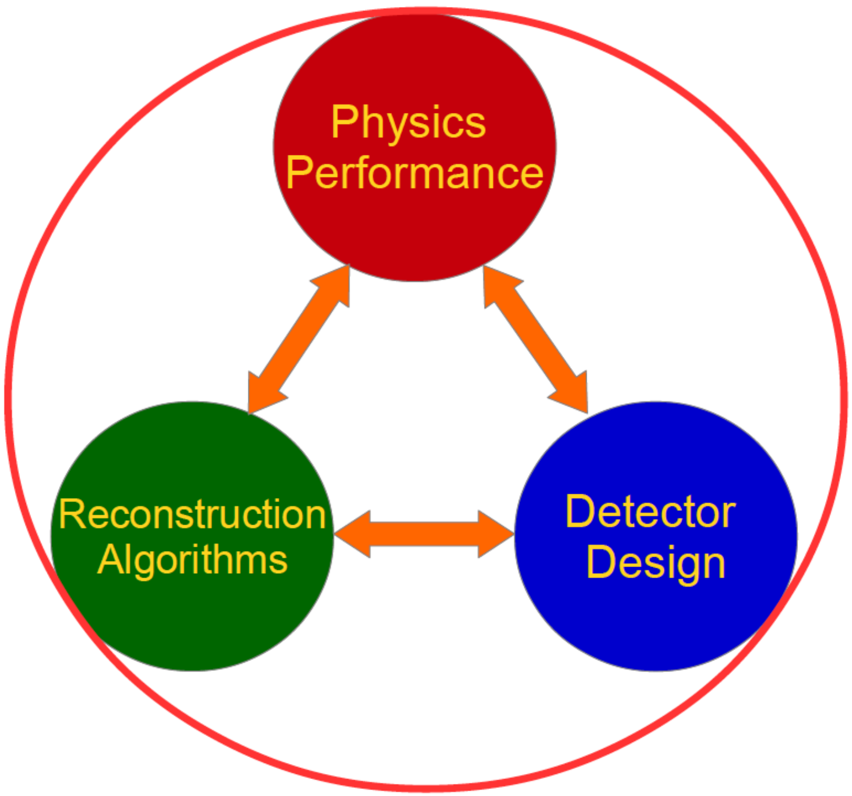
...Actively participate the other country or multicountries's initiated Large Scientific Pojects (hopefully, ILC will have good news from Japan at the end of 2018)

...Actively participate important international scientific organizations' sicientific projects and activities...

(translated by J. Gao)

From CDR to TDR

- **Physics Potential:** White paper towards
  - **Higgs,**
  - **EW,**
  - **Flavor,**
  - **QCD,**
  - **New Physics**…
- **Systematic**
  - **Calibration, Alignment**
  - **Stability (aging – homogeneity)**
  - **Data driven control...**
- **Integration**
- **Performance evaluation - Optimization**
-



...keep rolling the wheel...

Summary

- CEPC, a tremendous clean Higgs/W/Z factory,
  - Boost our precision horizon by at least 1 order of magnitude!
  - Surprises
- CDR Studies
  - Accelerator: Baseline design secures high productivity for Higgs, Z and W bosons.
  - Detector: Baseline design exhibit high efficiency/accuracy reconstruction of all key physics objects + clear Higgs signal in every SM decay channel.
  - Alternative designs, New ideas are always welcome
- Key technology development: significant progresses & firm link to industrial
- Intensive & Excitement in the March from CDR to TDR (**white papers!**)

Significant Progresses are made – challenges & excitement everywhere

Your ideas and participations are more than welcome!

Thank you!

CEPC CDR Accelerator Chain and Systems

10 GeV

1) Injector

L=1.2km

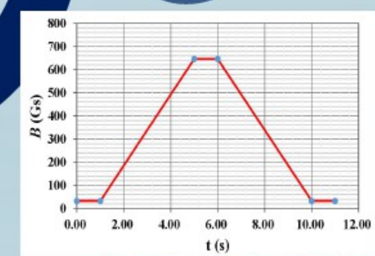
Electron

Positron

2) Booster

C=100km

Energy Ramp
10 ->45/120GeV



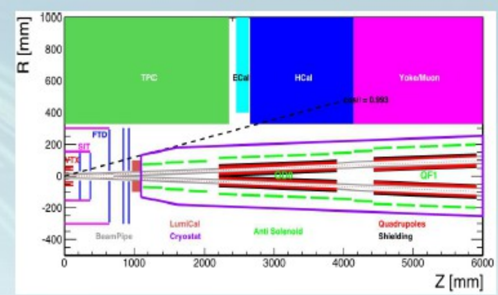
Booster Cycle (0.1 Hz)

Three rings in the sane channel：
- CEPC & booster
- SppC

3) Main Ring

C=100km
2IP

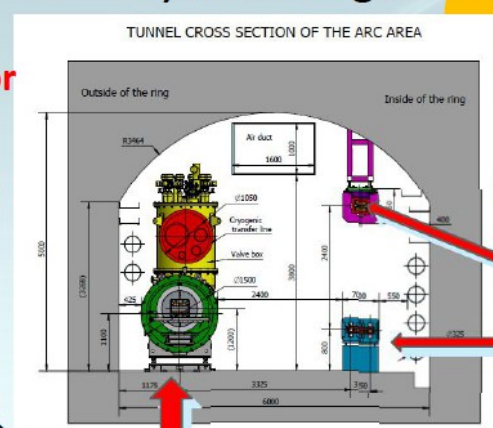
45/120 GeV



4) Detector Machine Interface (MDI)

The key systems of CEPC:
1) Linac Injector
2) Booster
3) Collider ring
4) MDI
5) Civil Eng.

5) Civil Eng.

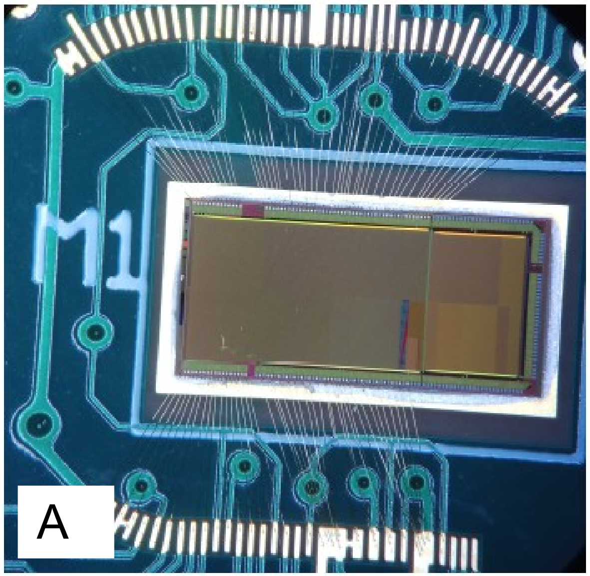


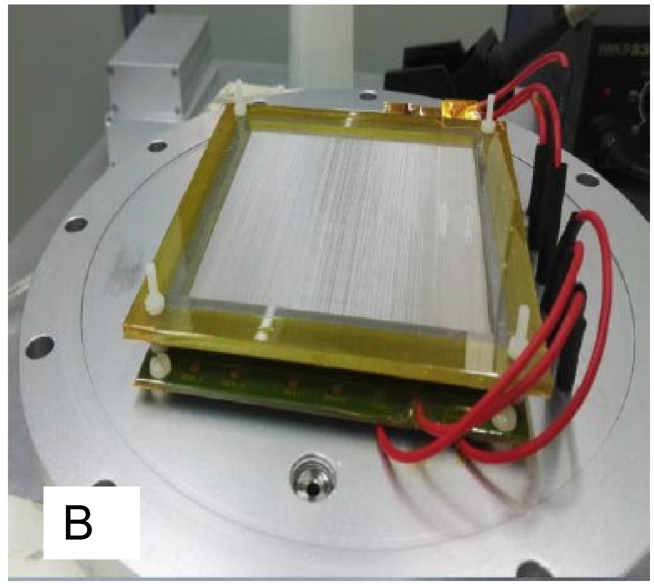
CEPC Booster

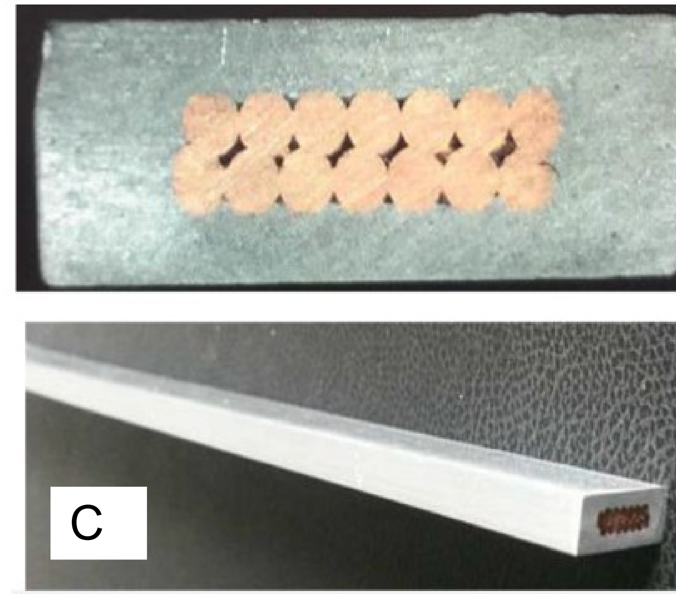
CEPC Collider

SppC

Detector studies





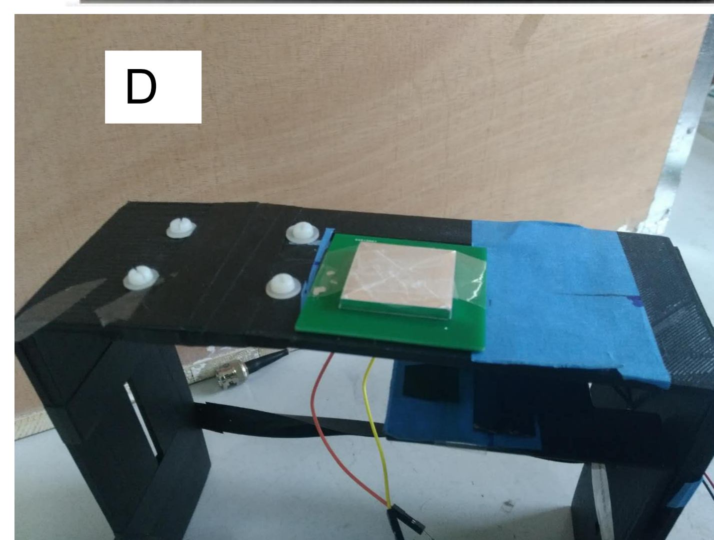


A: Silicon Sensor wire binding & test

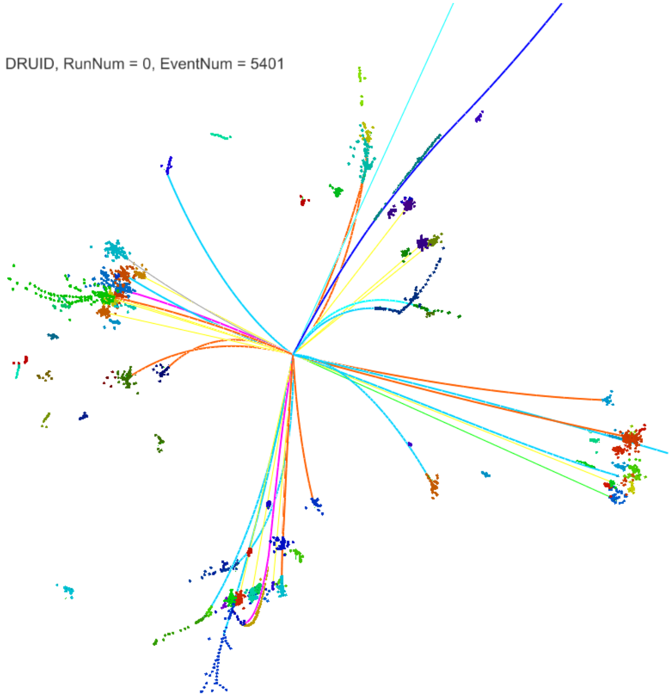
B: TPC amplification module

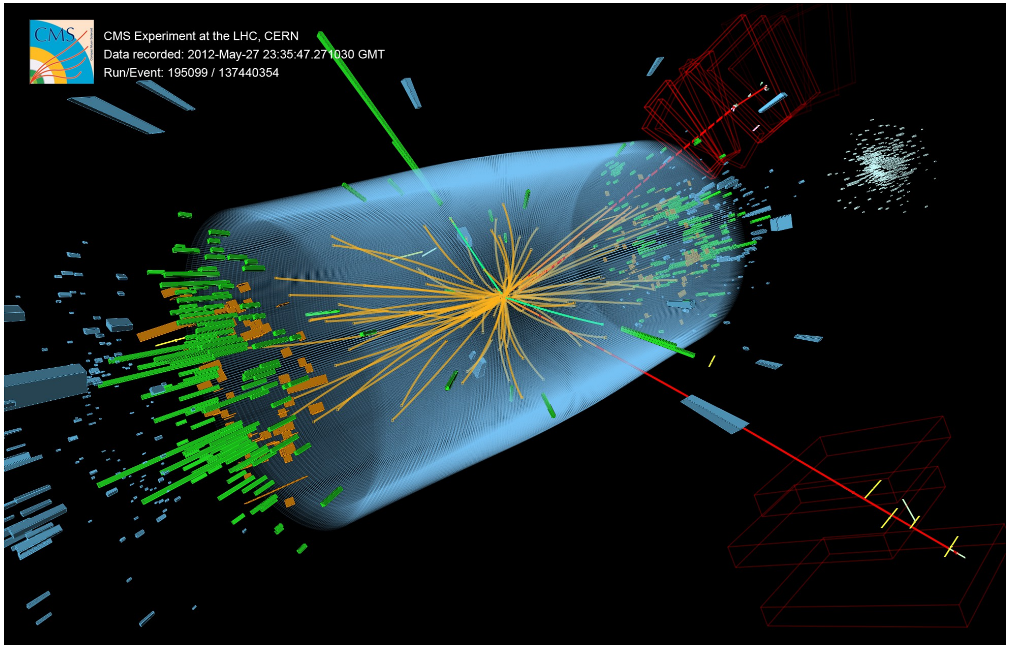
C: Rutherford cable for the Solenoid

D: Calorimeter sensor test



Higgs measurement at e+e- & pp



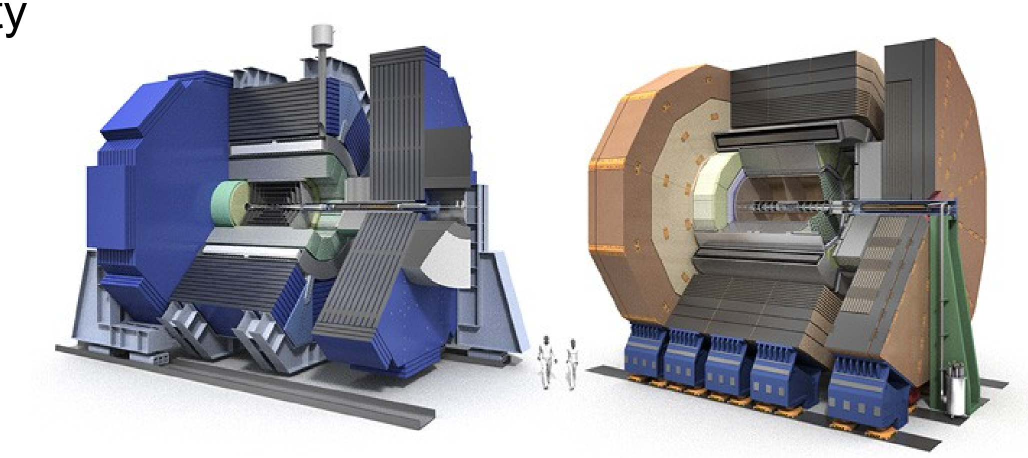


	Yield	efficiency	Comments
LHC	Run 1: 10^{6} Run 2/HL: $10^{7\text{-}8}$	~o(10^{-3})	High Productivity & High background, Relative Measurements, Limited access to width, exotic ratio, etc, Direct access to g(ttH), and even g(HHH)
CEPC	10^{6}	~o(1)	Clean environment & Absolute measurement, Percentage level accuracy of Higgs width & Couplings

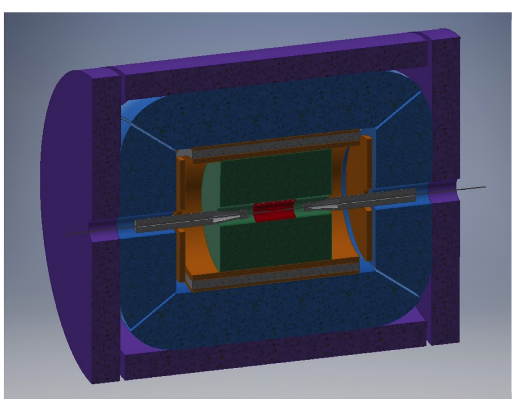
Complementary

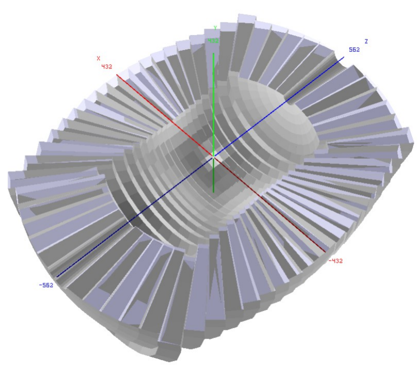
Two classes of Concepts

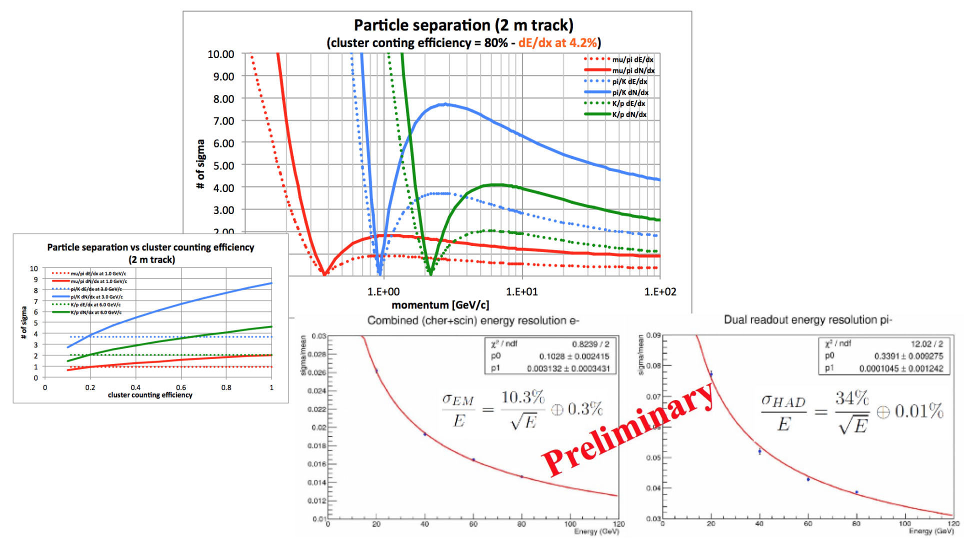
- PFA Oriented concept using High Granularity Calorimeter
  - **+ TPC (ILD-like, Baseline)**
  - + Silicon tracking (SiD-like)



- Low Magnet Field Detector Concept (IDEA)
  - Wire Chamber + Dual Readout Calorimeter





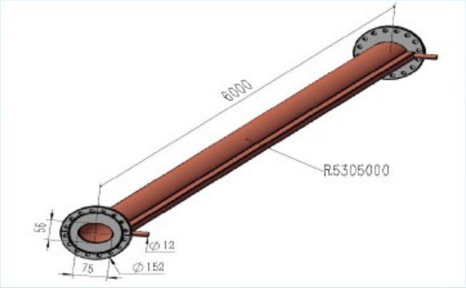


https://indico.ihep.ac.cn/event/6618/

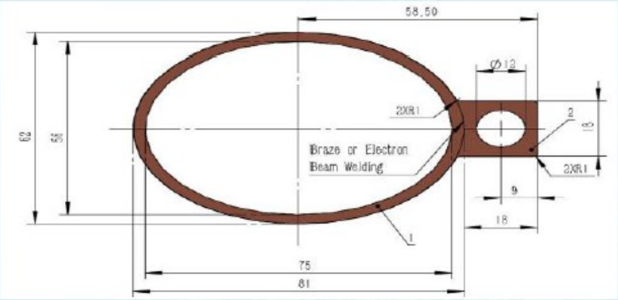
https://agenda.infn.it/conferenceOtherViews.py?view=standard&confId=14816

Vacuum System R&D

- The vacuum pressure is better than 2 x 10-10 Torr
- Total leakage rate is less than 2 x 10-10 torr.l /s.

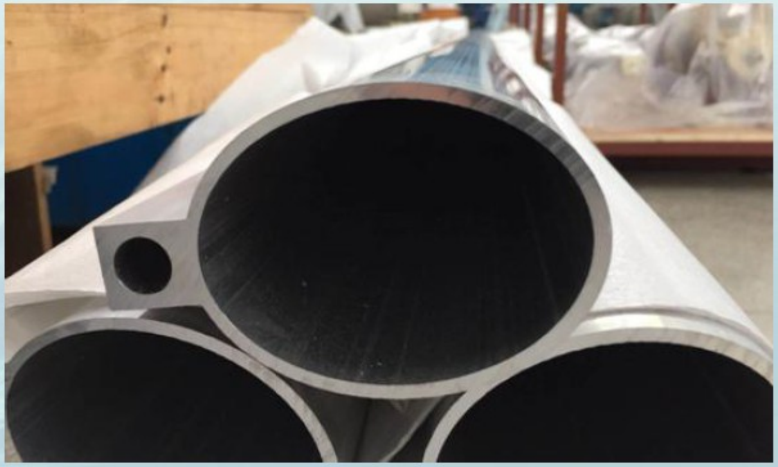


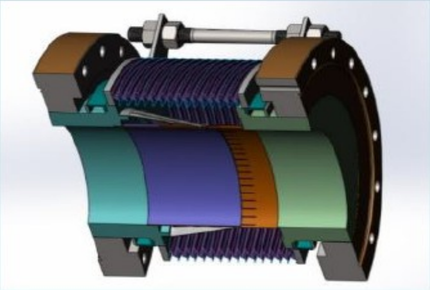
Positron ring

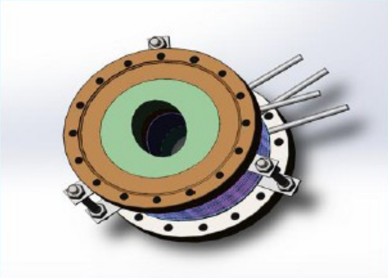


Copper vacuum chamber (Drawing) (elliptic 75×56, thickness 3, length 6000)

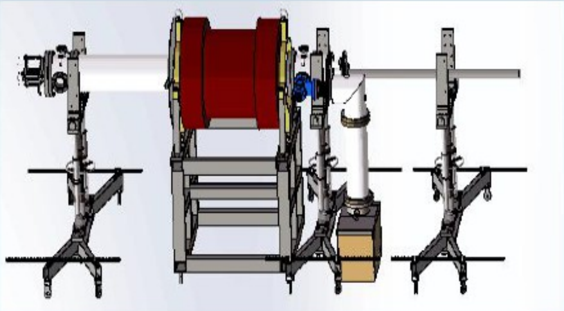
First test vacuum chamber

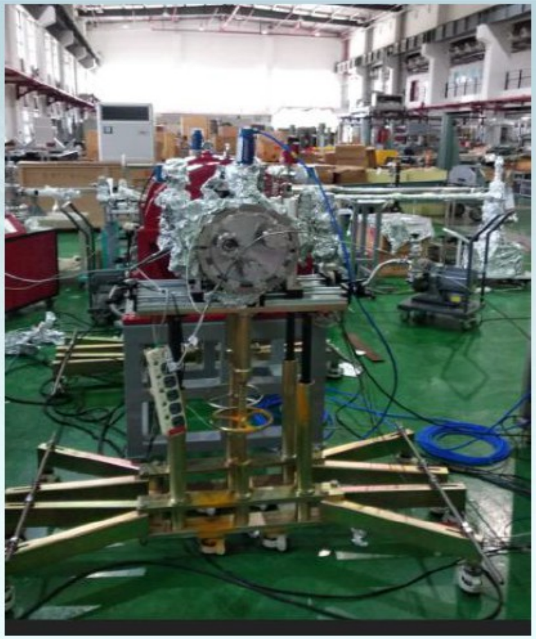






NEG coating suppresses electron multipacting and beam-induced pressure rises, as well as provides extra linear pumping. Direct Current Magnetron Sputtering systems for NEG coating was chosen.





Progress in Key R&D

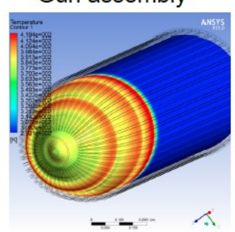
RF power source: Efficiency

Key parameters of NEW klystron design

Parameters mode	Now	Future
Centre frequency (MHz)	650+/-0.5	650+/-0.5
Output power (kW)	800	800
Beam voltage (kV)	80	70
Beam current (A)	16	15
Efficiency (%)	65	80

Gun assembly

- Key factors for the cost and the power consumption
- Used by radar, radio and television broadcasting, …



Collector design

SRF System: three key issues

- Extremely high Q_0 cavities
  - New technology: N-doping to improve Q_0 by a factor ~ 4
- Efficient thermal power extraction
  - SR power
  - HOM power
- Mass production

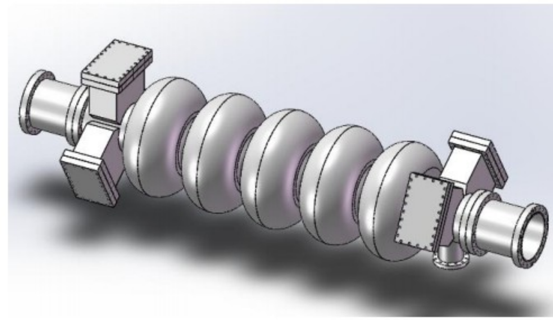
- Largest SRF system next to ILC
- Technically challenge
- Used by all future acclerators
- Key factors for the cost

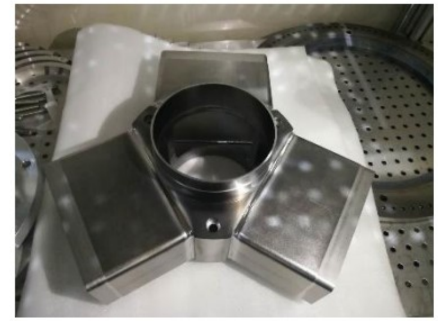
- Accelerator: Key technology development on going (budget + power)
  - *RF source (efficiency)*
  - *High Q SRF cavities*
  - High power Cryogenic system
  - Beam Monitoring and Diagnostics
  - High field SC magnets

…

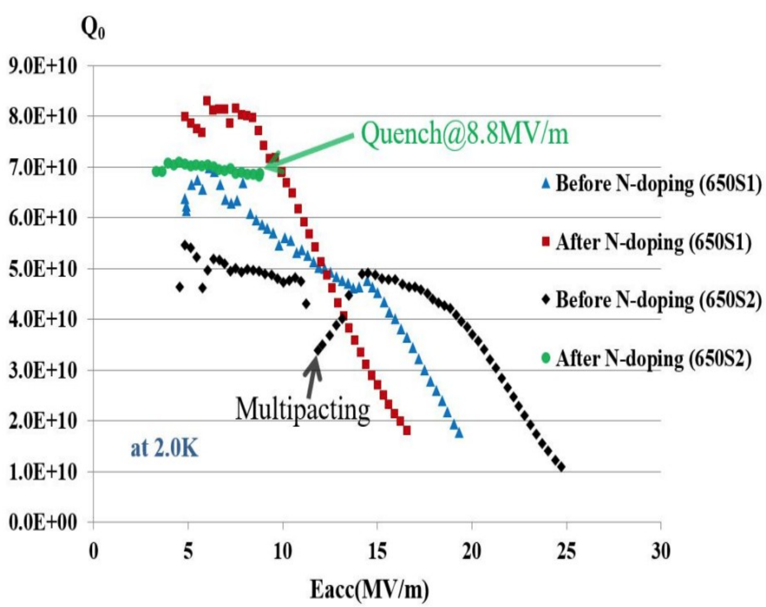
SRF prototyping & tests

650 MHz 2-cell cavity





650 MHz 5-cell cavity with waveguide HOM coupler

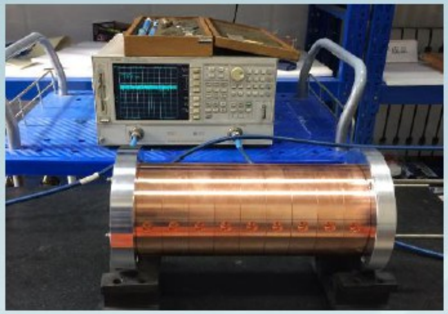


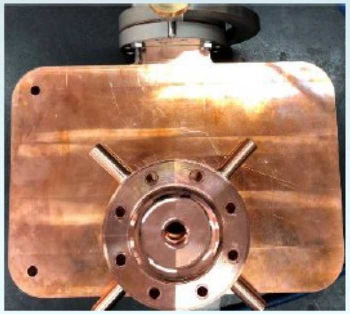
New furnaces for
N-doping and infusion study

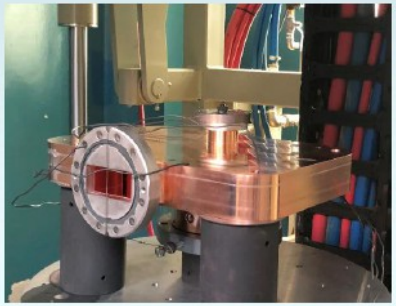
Helmholtz coil & flux gate
for high Q research

High Gradient S-band Accelerating Structre and Possitron Source

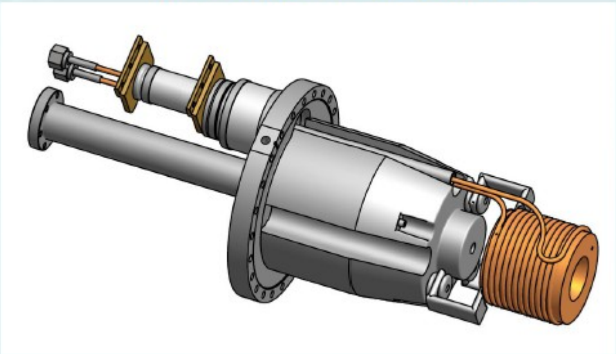
High gradient S-band structure completed







Positron source



Current Status and the Plan

- Pre-CDR completed
  - No show-stoppers
  - Technical challenges identified → R&D issues
  - Preliminary cost estimate
- Working towards CDR
  - A working machine on paper
  - Ready to be reviewed by government at any moment
- R&D issues identified and funding request underway
  - Seed money from IHEP: 12 M RMB/3 yrs
  - MOST: 36 M/5 yr approved, ~40 M to be asked next year
  - NSFC: ~12M RMB approved/4 yrs → 6 M/yr to be approved
  - NCDR: ~0.8 B RMB/5 yr, failed in a voting process
  - CAS: ~ 8M/yr, more under discussion
  - CNSF: under discussion
  - Beijing Municipal Government: R&D platform

Feasibility & Optimized Parameters

Feasibility analysis: TPC and Passive Cooling Calorimeter is valid for CEPC

	CEPC_v1 (~ ILD)	Optimized (Preliminary)	Comments
Track Radius	1.8 m	>= 1.8 m	Requested by Br(H->di muon) measurement
B Field	**3.5 T**	**3 T**	**Requested by MDI**
ToF	**-**	**50 ps**	**Requested by pi-Kaon separation at Z pole**
ECAL Thickness	84 mm	84(90) mm	84 mm is optimized on Br(H->di photon) at 250 GeV; 90mm for bhabha event at 350 GeV
ECAL Cell Size	5 mm	10 – 20 mm	Passive cooling request ~ 20 mm. 10 mm should be highly appreciated for EW measurements – need further evaluation
ECAL NLayer	30	20 – 30	Depends on the Silicon Sensor thickness
HCAL Thickness	**1.3 m**	**1 m**	-
HCAL NLayer	**48**	**40**	Optimized on Higgs event at 250 GeV; Margin might be reserved for 350 GeV.

PFA Oriented Detector: Performance

- Solid Angle Coverage : $|\cos(\theta)| < 0.99$
- Lepton id : eff > 99.5%, mis id < 1%
- Calorimeter Shower Separation : 9 – 16 mm
- Tracking: $\delta(1/Pt) \sim 2e\text{-}5\ GeV^{-1}$, 1 order of magnitude better than current status
- C-tagging is feasible
- Photon Energy resolution: σ/Mean ~ 1.7 – 2.4% for H->γγ events
- Jet Energy resolution: σ/Mean ~ 4% for H->gg events
- Pi-Kaon Separation: at 3-4 sigma level with E < 20 GeV

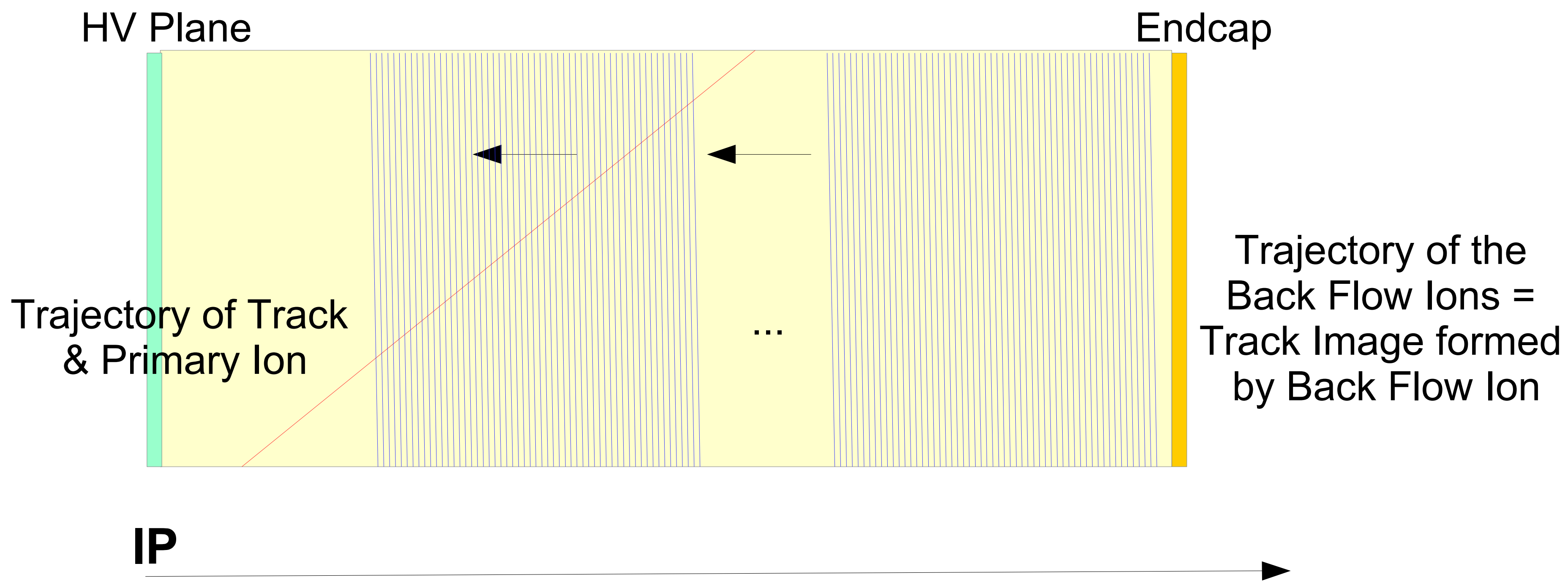
- Systematic control : ~ 1 order of magnitude better
  - Beam energy monitoring, Calibration, Alignments...

TPC Usage

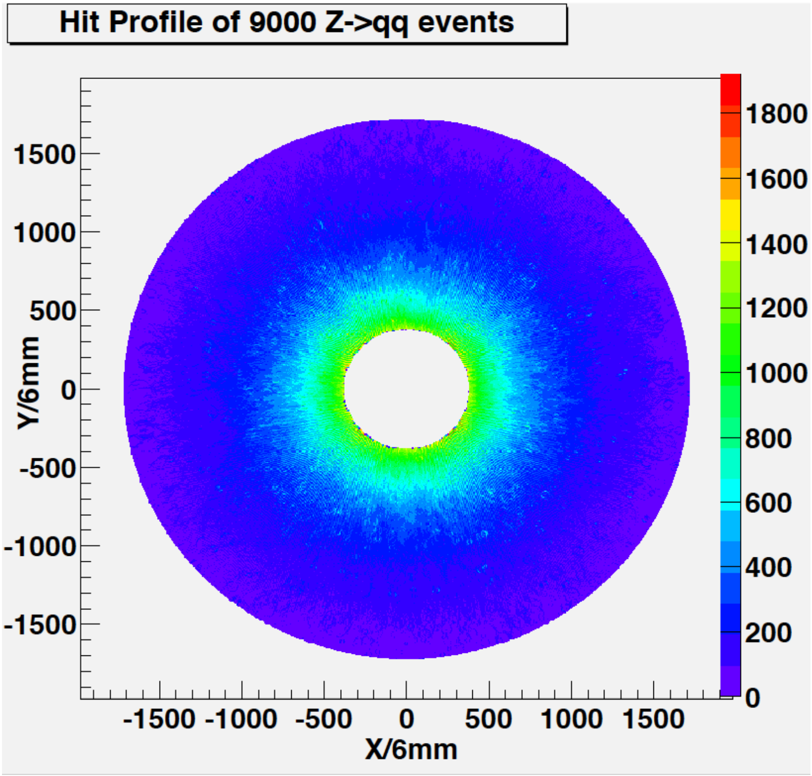
- Feasibility not limited by
  - Voxel occupancy (1E-4 - 1E-6)
  - IBF & Ion Charge Distortion
- Dedx: TPC +50 ps ToF: a full range pi-kaon separation at Z pole operation
- Tech. Difficulties to be further studied
  - Complex, unstable field maps
  - Stability & Homogeneity of Amplification/DAQ system, temperature/pressure monitoring & corrections
  - Radiation background: Working Gas selection is essential
    - Neutron Flux + Working gas with hydrogens
    - Delta Ray Noise
    - Gamma Ray Noise
- Be iterated with Hardware/Electronic Design & Test beam studies

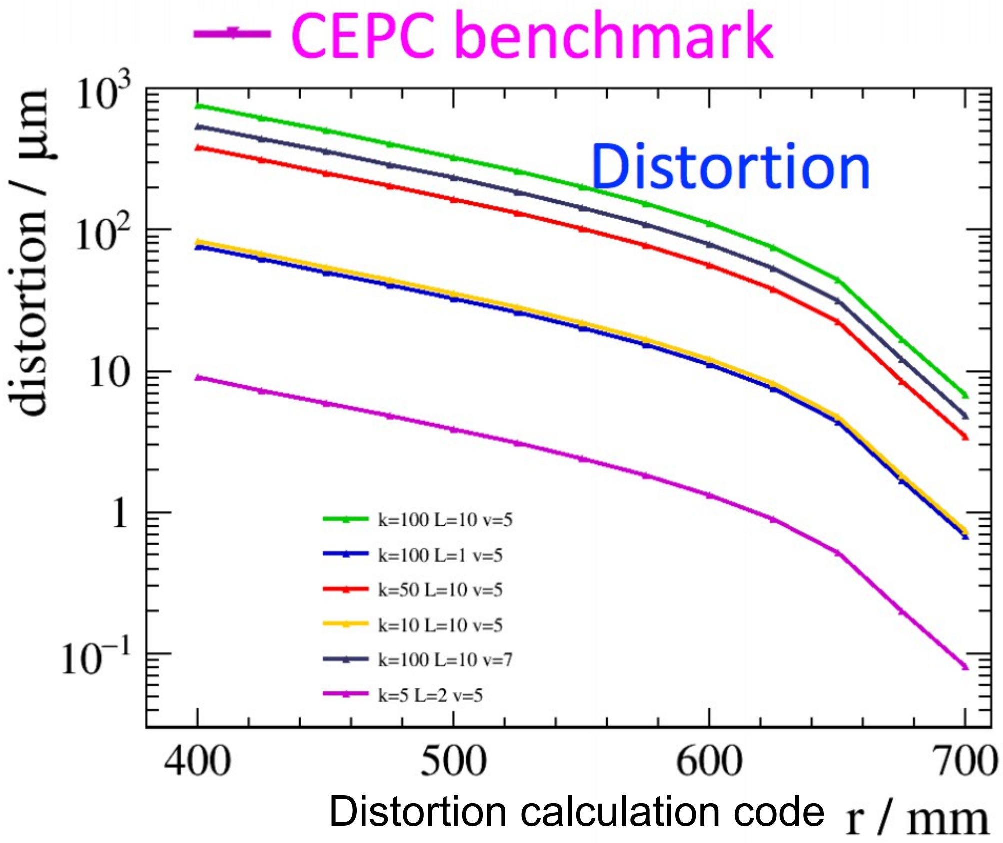
Feasibility of TPC at Z pole

- 600 Ion Disks induced from Z->qq events at 2E34$cm^{-2}s^{-1}$
- Voxel occupancy & Charge distortion from **Ion Back Flow** (IBF)
- Cooperation with CEA & LCTPC



TPC Feasibility (Preliminary)

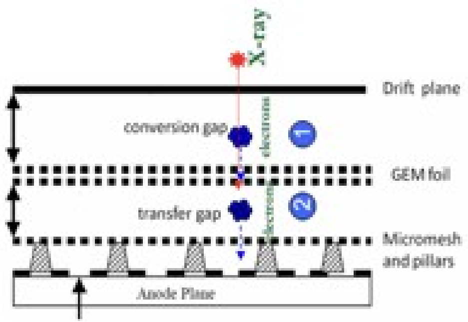


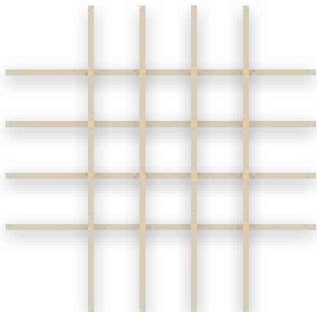


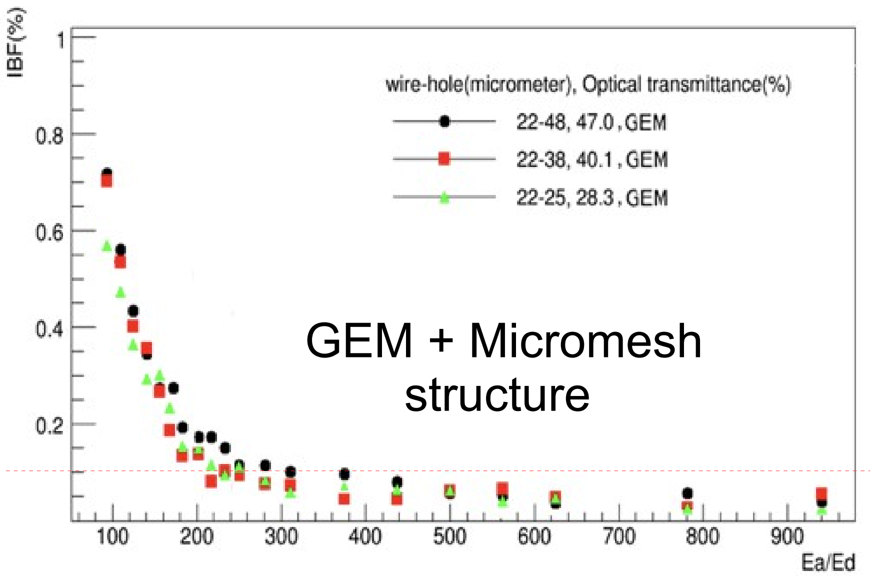
Distortion calculation code provided by KEK

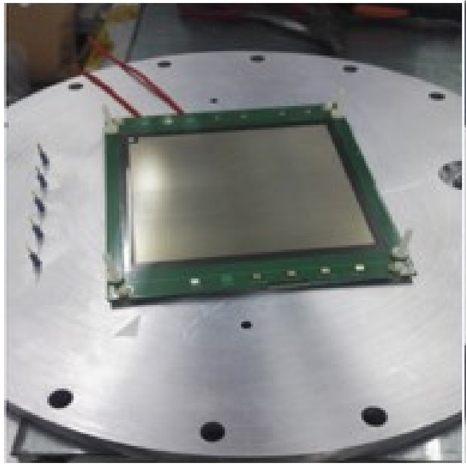
- Conclusion:
  - Voxel occupancy ~ (10^-4 – 10^-6) level, safe
  - **Safe for CEPC If the ion back flow be controlled to per mille level** - The charge distortion at ILD TPC would be one order of magnitude then the intrinsic resolution (L = 2E34 $cm^{-2}s^{-1}$)

R&D on the IBF control

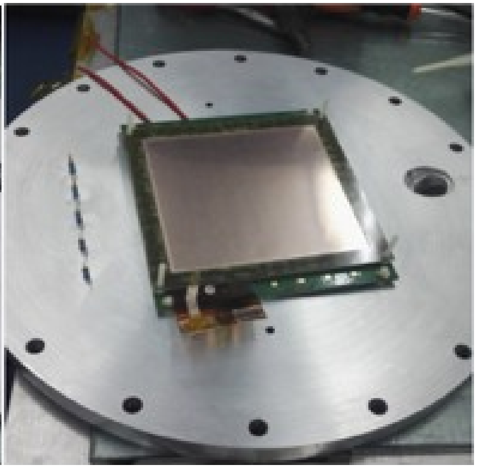




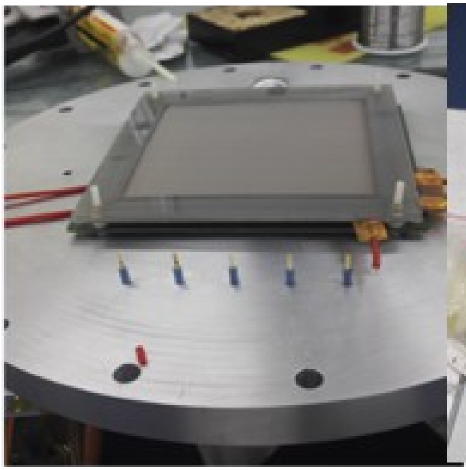




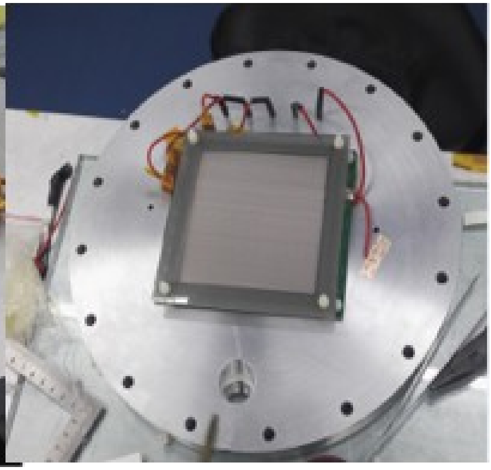
Micromegas(Saclay)



GEM(CERN)



Cathode with mesh



GEM-MM Detector