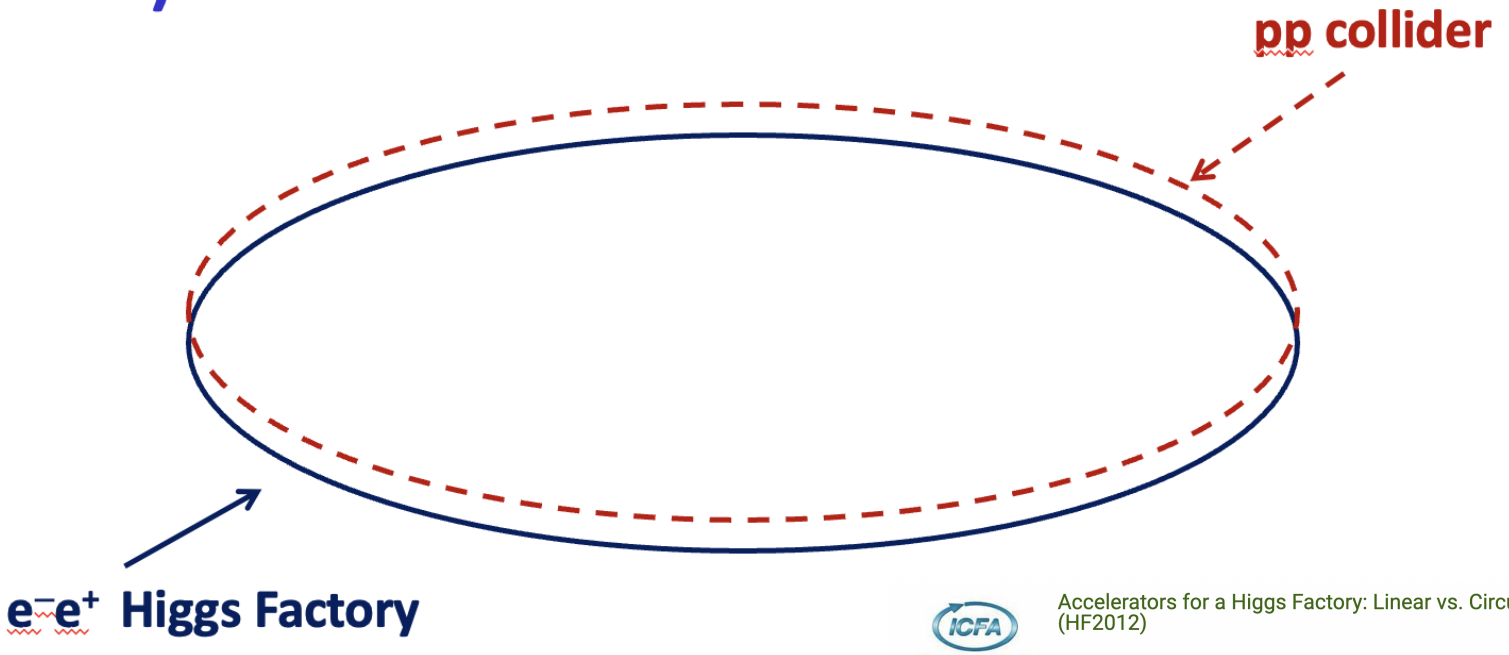
CEPC status briefing & objectives of workshop

Manqi Ruan

What is a (CHF + SppC)

- **Circular Higgs factory (phase I) + super pp collider (phase II) in the same tunnel**



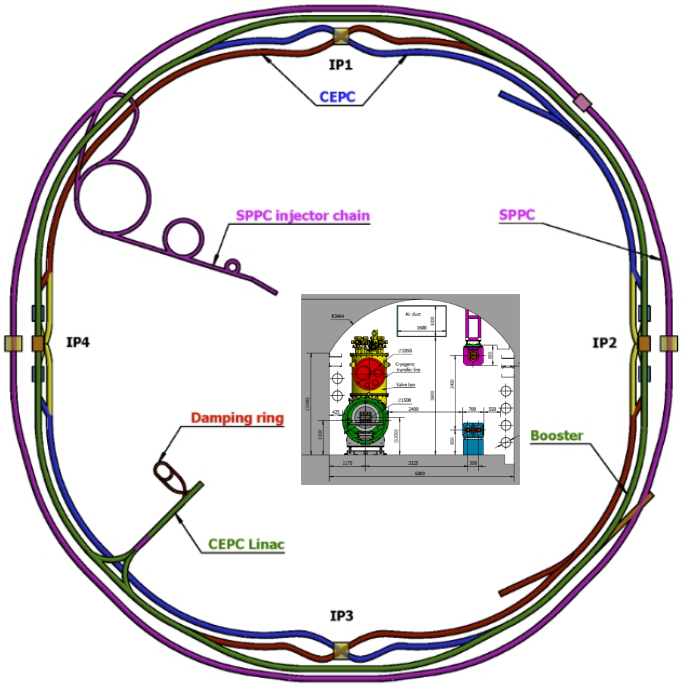
ICFA Fermilab

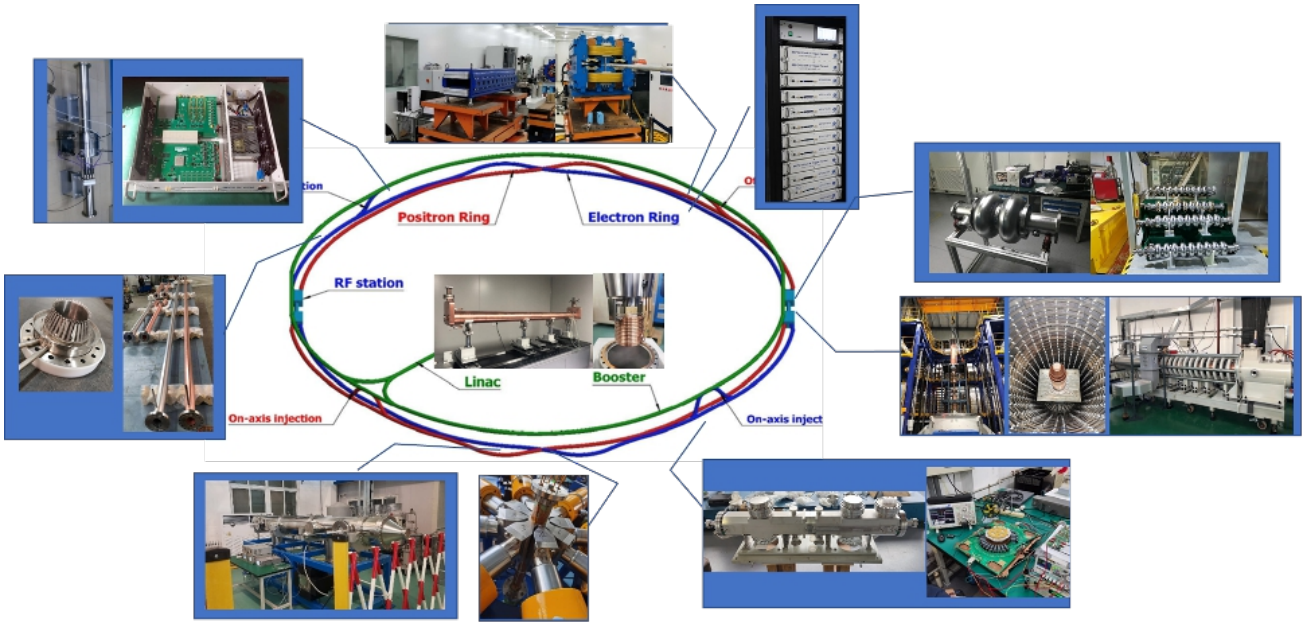
Accelerators for a Higgs Factory: Linear vs. Circular (HF2012)

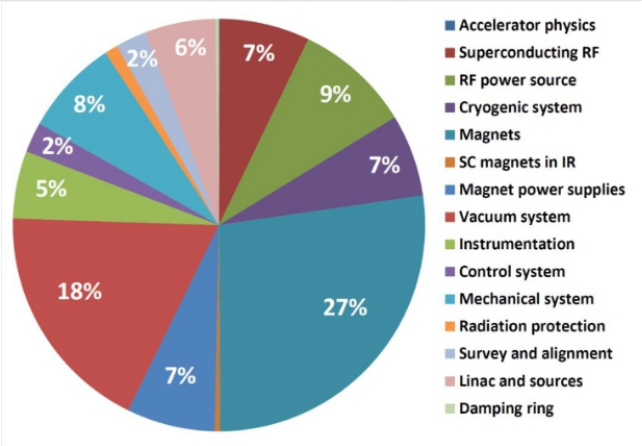
Nov 14 – 16, 2012
Fermilab
US/Central timezone

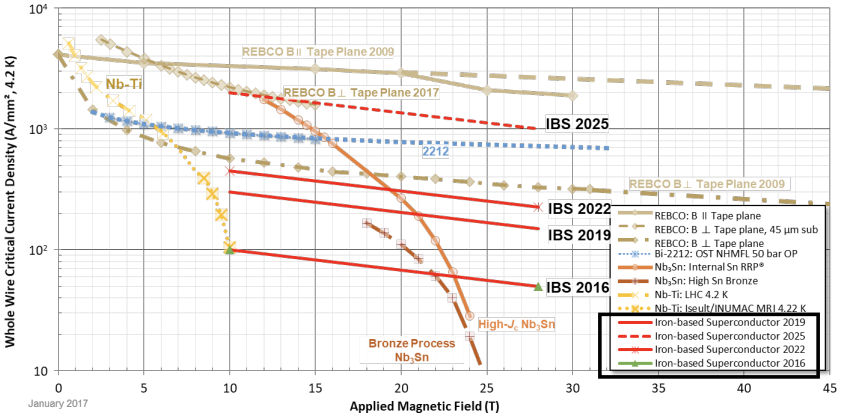
Enter your search term

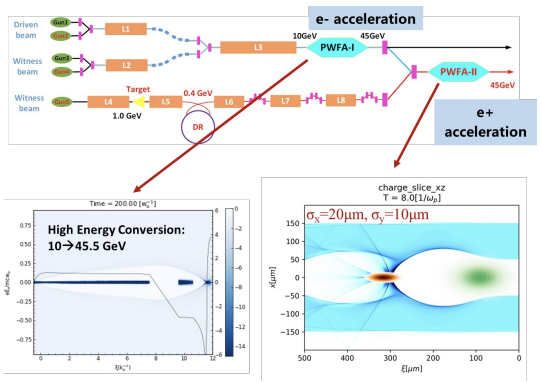
Accelerator at 2023











Platform for key technology R&D

Accelerator key technology R&D platform was established:

- SRF cavity and module
- High precision magnet
- Vacuum assembly & coating
- High efficiency Klystron
- Mechanics and alignment
- Beam test facility

TDR review: HK June 2023

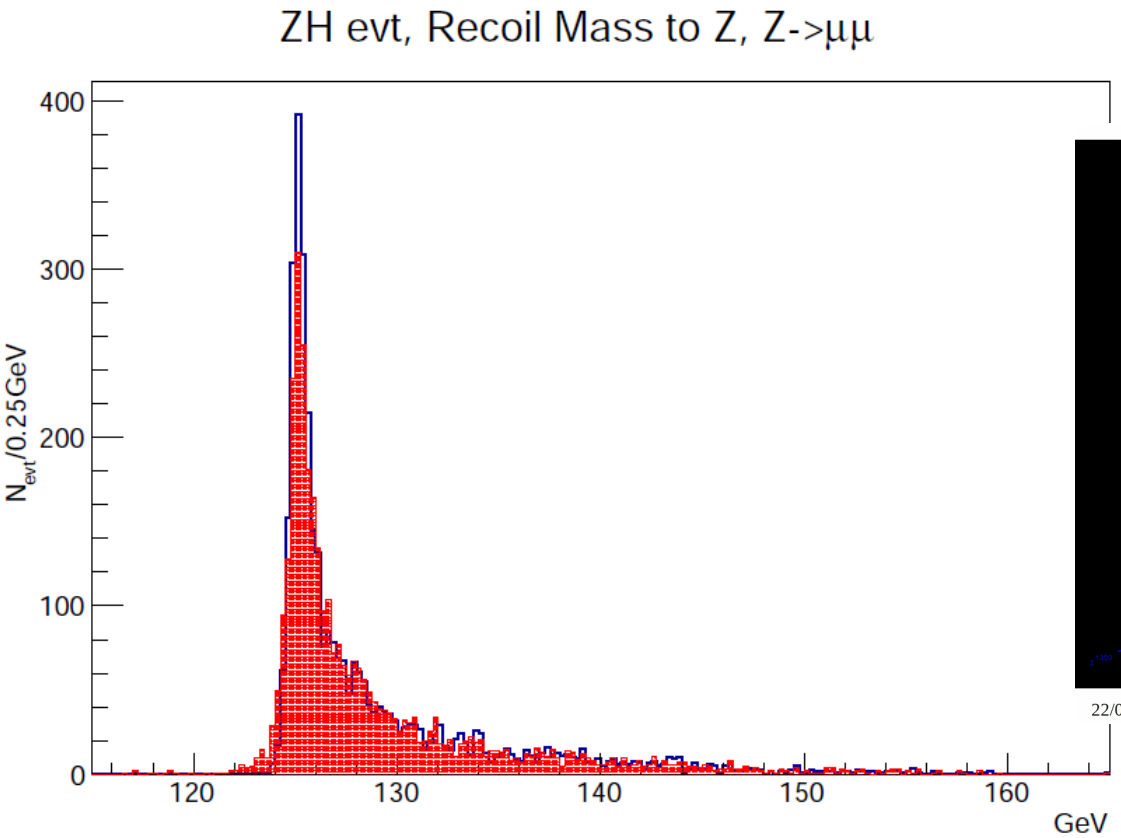
1 Executive Summary

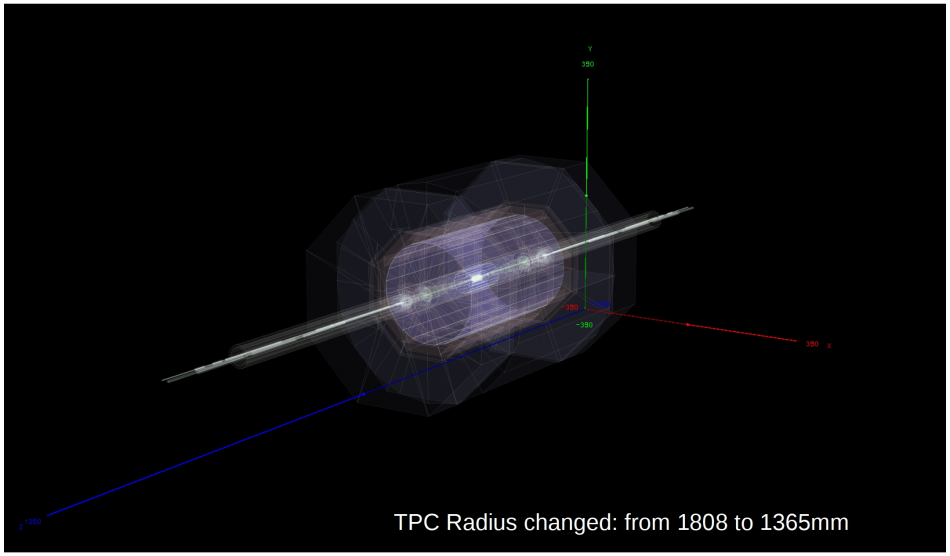
Five years after the completion of the CDR, the draft TDR for the CEPC accelerator has been prepared. The TDR will be completed taking into account the feedback from this Committee. The key technologies for CEPC have been developed. Prototypes meeting or exceeding the specifications are available. The CEPC team is on track to launch an engineering-design effort. After a site has been selected, the construction of the CEPC could start in 2027 or 2028. The Committee endorses this plan.

The Committee wishes to congratulate the CEPC team on the excellent progress. The Committee is impressed by the amount and quality of the work performed and presented.

The next section provides answers to the different charge questions, the following sections contain comments and recommendations related to the individual presentations.

Physics - Detector study: 2013

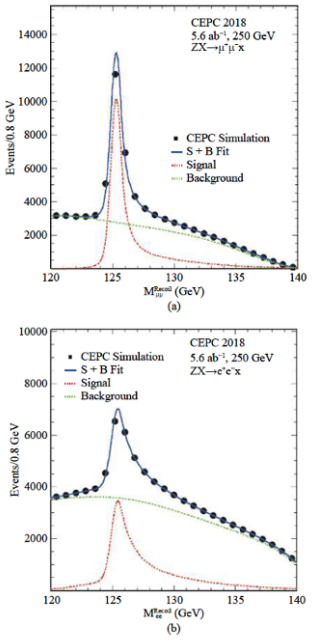


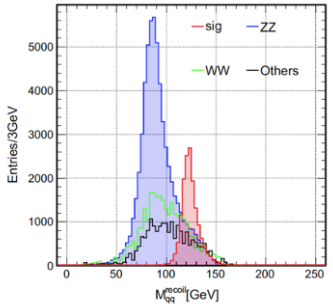


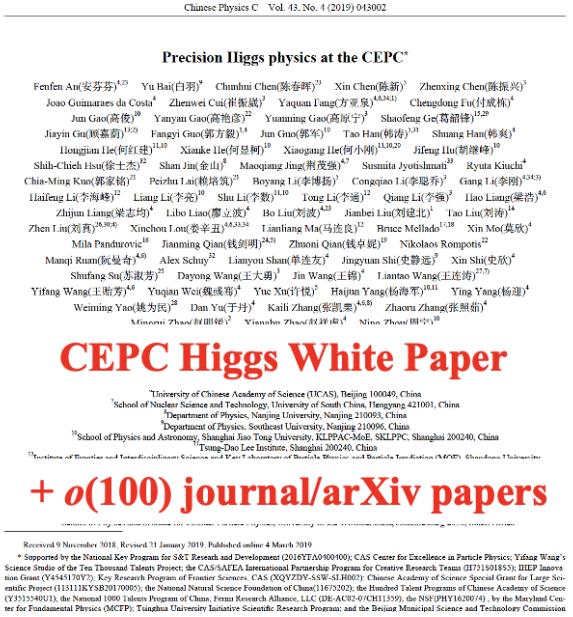
22/06/2013 39

- *Detector optimization – detector scale (track radius)*

Physics study: 2023






Chinese Physics C Vol. 43, No. 4 (2019) 043002

Precision Higgs physics at the CEPC*

Fenfen An(安芬芬)[4,23] Yu Bai(白羽)[9] Chunhui Chen(陈春晖)[23] Xin Chen(陈新)[3] Zhenxing Chen(陈振兴)[3] Joao Guimaraes da Costa[4] Zhenwei Cui(崔振威)[3] Yaquan Fang(方亚泉)[4,6,34,41] Chengdong Fu(付成栋)[4] Jun Gao(高俊)[10] Yanyan Gao(高艳彦)[22] Yuanning Gao(高原宁)[3] Shaofeng Ge(葛韶锋)[15,29] Jiayin Gu(顾嘉荫)[1,2,3] Fangyi Guo(郭方毅)[1,4] Jun Guo(郭军)[10] Tao Han(韩涛)[1,31] Shuang Han(韩双)[4] Hongjian He(何红建)[21,10] Xianke He(何显轲)[10] Xiaogang He(何小刚)[13,10,20] Jifeng Hu(胡继峰)[10] Shih-Chieh Hsu(徐士杰)[32] Shan Jin(金山)[8] Maoqiang Jing(荆茂强)[4,7] Susmita Jyotishmati[23] Ryuta Kiuchi[4] Chia-Ming Kuo(郭家铭)[25] Peizhu Lai(赖培筑)[25] Boyang Li(李博扬)[3] Congqiao Li(李聪乔)[3] Gang Li(李刚)[4,34,35] Haifeng Li(李海峰)[12] Liang Li(李亮)[10] Shu Li(李数)[11,10] Tong Li(李通)[12] Qiang Li(李强)[3] Hao Liang(梁浩)[4,6] Zhijun Liang(梁志均)[4] Libo Liao(廖立波)[4] Bo Liu(刘波)[4,23] Jianbei Liu(刘建北)[1] Tao Liu(刘涛)[14] Zhen Liu(刘臻)[26,30,42] Xinchou Lou(娄辛丑)[1,8,33,34] Lianliang Ma(马连良)[12] Bruce Mellado[17,18] Xin Mo(莫欣)[4] Mila Pandurovic[16] Jianming Qian(钱剑明)[24,25] Zhuoni Qian(钱卓妮)[19] Nikolaos Rompotis[22] Manqi Ruan(阮曼奇)[4,6] Alex Schuy[22] Lianyou Shan(单连友)[4] Jingyuan Shi(史静远)[3] Xin Shi(史欣)[4] Shufang Su(苏淑芳)[25] Dayong Wang(王大勇)[3] Jin Wang(王锦)[4] Liantao Wang(王连涛)[27,7] Yifang Wang(王贻芳)[4,6] Yuqian Wei(魏威骞)[4] Yue Xu(许悦)[7] Haijun Yang(杨海军)[10,11] Ying Yang(杨瑛)[4] Weiming Yao(姚为民)[28] Dan Yu(于丹)[4] Kaili Zhang(张凯丽)[4,6,8] Zhaoru Zhang(张照茹)[4]

CEPC Higgs White Paper

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+ *o*(100) journal/arXiv papers

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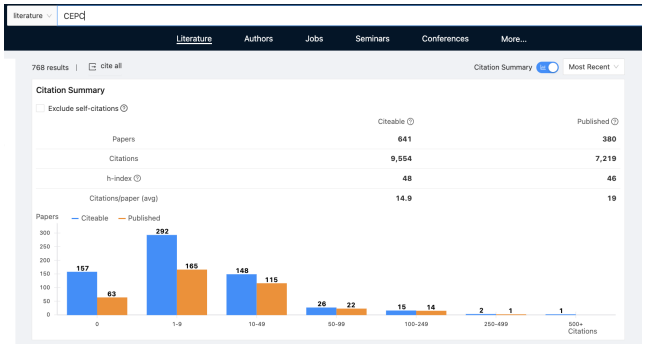
Table 2.1: Precision of the main parameters of interests and observables at the CEPC, from Ref. [1] and the references therein, where the results of Higgs are estimated with a data sample of 20 ab^{-1}. The HL-LHC projections of 3000 fb^{-1} data are used for comparison. [2]

Higgs			W, Z and top		
Observable	HL-LHC projections	CEPC precision	Observable	Current precision	CEPC precision
M_H	20 MeV	3 MeV	M_W	9 MeV	0.5 MeV
Γ_H	20%	1.7%	Γ_W	49 MeV	2 MeV
$\sigma(ZH)$	4.2%	0.26%	$M_{\rm top}$	760 MeV	$\mathcal{O}(10)$ MeV
$B(H \to bb)$	4.4%	0.14%	M_Z	2.1 MeV	0.1 MeV
$B(H \to cc)$	-	2.0%	Γ_Z	2.3 MeV	0.025 MeV
$B(H \to gg)$	-	0.81%	R_b	3×10^{-3}	2×10^{-4}
$B(H \to WW^*)$	2.8%	0.53%	R_c	1.7×10^{-2}	1×10^{-3}
$B(H \to ZZ^*)$	2.9%	4.2%	R_μ	2×10^{-3}	1×10^{-4}
$B(H \to \tau^+\tau^-)$	2.9%	0.42%	R_τ	1.7×10^{-2}	1×10^{-4}
$B(H \to \gamma\gamma)$	2.6%	3.0%	A_μ	1.5×10^{-2}	3.5×10^{-5}
$B(H \to \mu^+\mu^-)$	8.2%	6.4%	A_τ	4.3×10^{-3}	7×10^{-5}
$B(H \to Z\gamma)$	20%	8.5%	A_b	2×10^{-2}	2×10^{-4}
$B\text{upper}(H \to \text{inv.})$	2.5%	0.07%	N_ν	2.5×10^{-3}	2×10^{-4}

Scientific Significance quantified by **CEPC physics** studies, via full simulation/phenomenology studies:

- Higgs: Precisions exceed HL-LHC ~ 1 order of magnitude.
- EW: Precision improved from current limit by 1-2 orders.
- Flavor Physics, sensitive to NP of 10 TeV or even higher.
- Sensitive to varies of NP signal.
- …



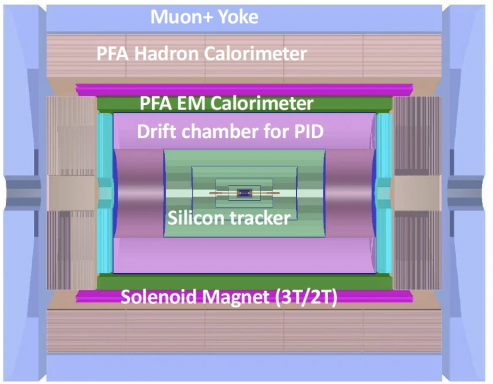
Detector study: 2023

Design of experimental facility and technical requirements

Detector

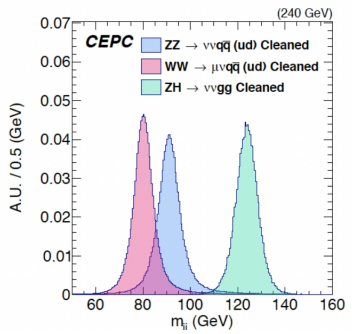
Requirements
boson mass resolution (BMR ~3%)

Challenges
- Support Particle flow with
  - High granularity
  - High precision

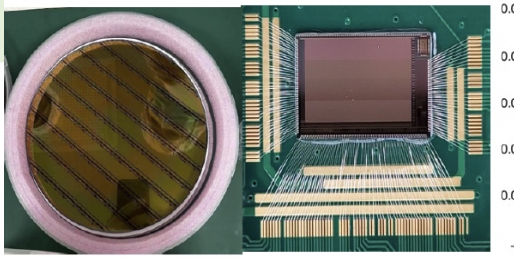


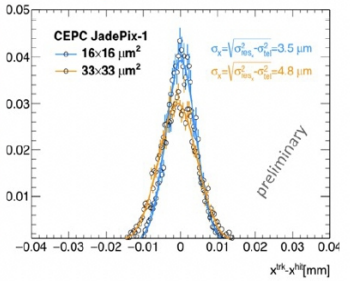
Novel detector design based on PFA calorimeter. Aim at improving BMR from 4% to 3%

Detector	Key parameter	World-class level	CEPC design
PFA based EM calorimeter	EM shower E resolution	~20%/√E	<3%/√E
PFA based Hadron calorimeter	Single hadron E resolution	~50%/√E	~40%/√E

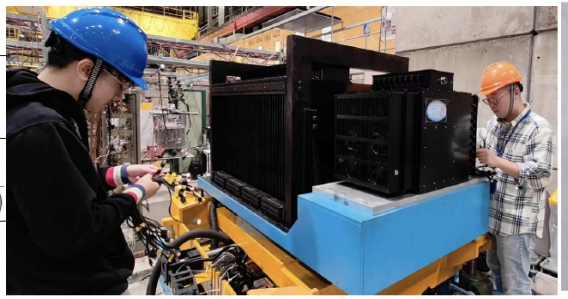


Vertex detector R & D (3- 5 μm reso.)

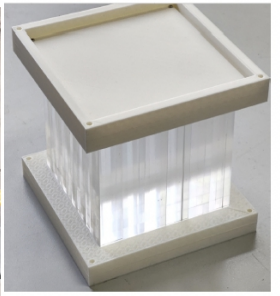


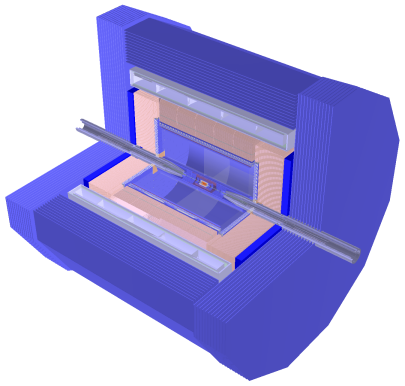


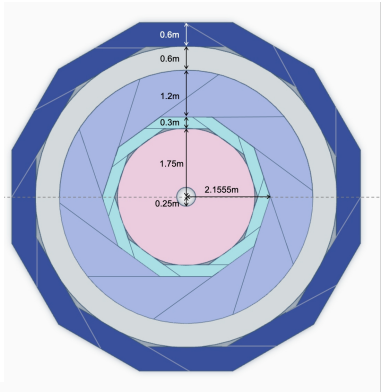
PFA scintillator-W ECAL

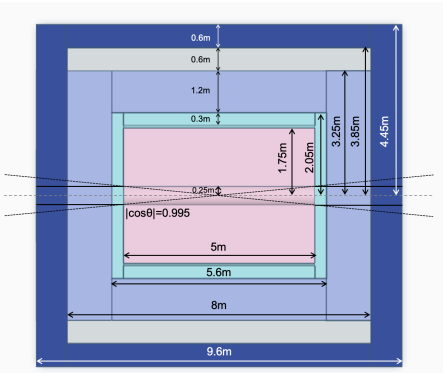


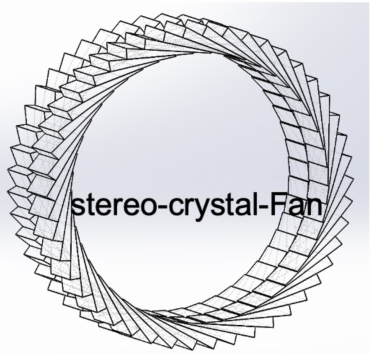
4D crystal ECAL

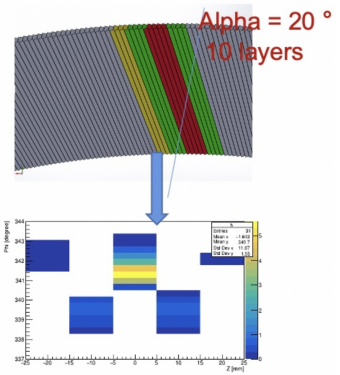


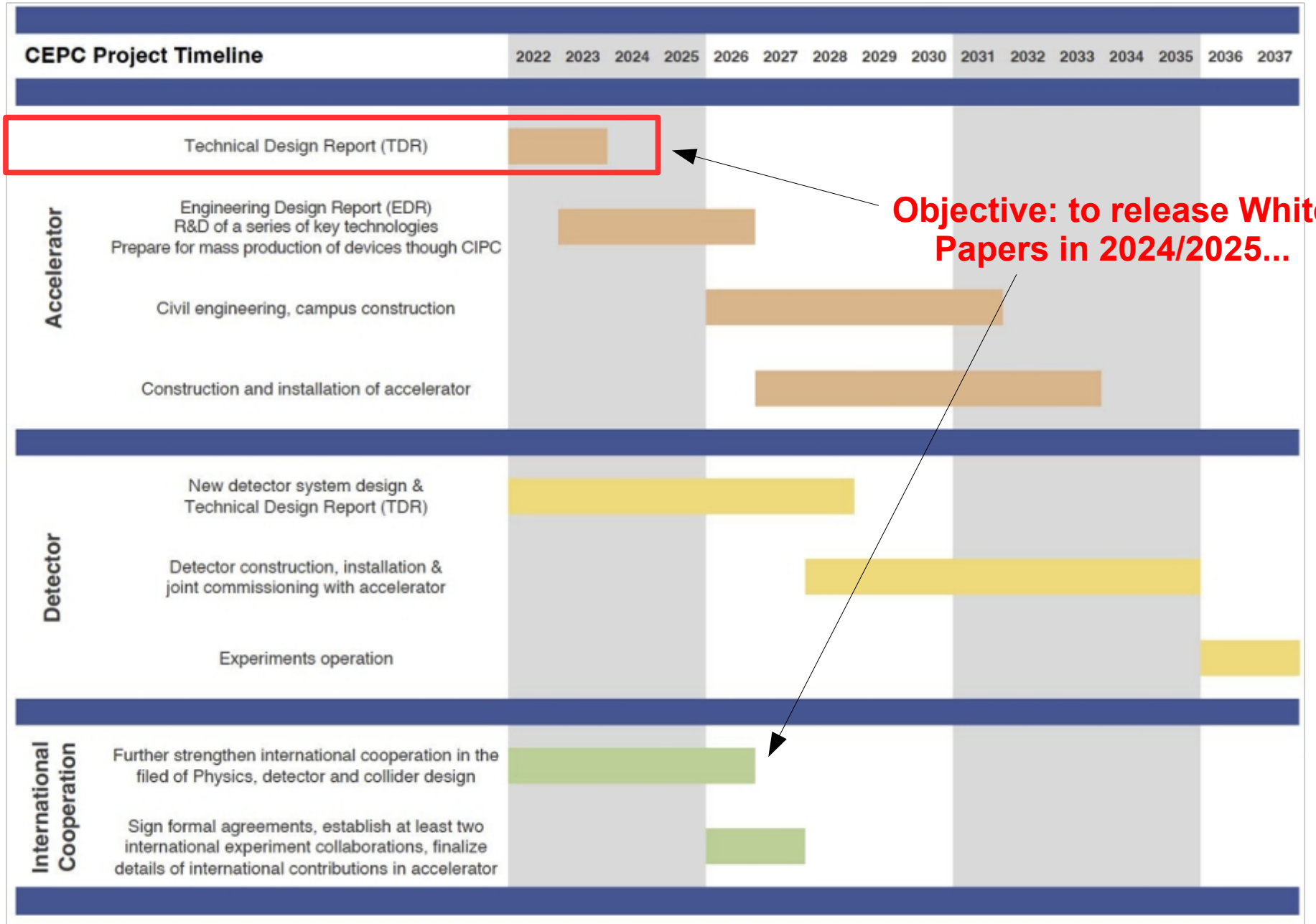











CEPC Project Timeline
2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037
Technical Design Report (TDR)
Accelerator
Engineering Design Report (EDR)
R&D of a series of key technologies
Prepare for mass production of devices though CIPC
Civil engineering, campus construction
Construction and installation of accelerator
Detector
New detector system design &
Technical Design Report (TDR)
Detector construction, installation &
joint commissioning with accelerator
Experiments operation
International Cooperation
Further strengthen international cooperation in the filed of Physics, detector and collider design
Sign formal agreements, establish at least two international experiment collaborations, finalize details of international contributions in accelerator
Objective: to release White Papers in 2024/2025...

Physics Studies

- 2019:
  - 1st CEPC Phy/Det WS at PKU, initialize the physics white paper studies
  - Higgs white paper delivered
- ~ 2020: EUSPP studies: provide CEPC inputs
- ~ 2022: Snowmass studies
  - 40 LoIs, ~ 20+ citables,
  - Snowmass white papers
- 2023: Flavor white paper – phase-1 delivered
- ~ 2024: Draft version of White paper on EW, NP

...

- Multiple WS/Discussions organized:
  - Yangzhou (2019), HKIAS, etc
  - Joint with Cosmology...

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Jiayin Gu(顾嘉荫)[13;2)] Fangyi Guo(郭方毅)[1,4] Jun Guo(郭军)[10] Tao Han(韩涛)[5,31] Shuang Han(韩爽)[4]

CEPC Input to the ESPP 2018
- Physics and Detector

CEPC Physics-Detector Study Group

Abstract

ESPPU input

arXiv: 1901.03170
1901.03169

Snowmass2021 White Paper AF3- CEPC

CEPC Accelerator Study Group[1]

1. Design Overview

1.1 Introduction and status

Snowmass input

arXiv: 2203.09451
2205.08553

New ideas: Physics & interpretation

- New Observables:
  - Bc→tau v
  - Vcb from W decay
  - CKM measurements
  - Time dependent CP measurements + Jet Charge...
  - ALPs...
  - ...

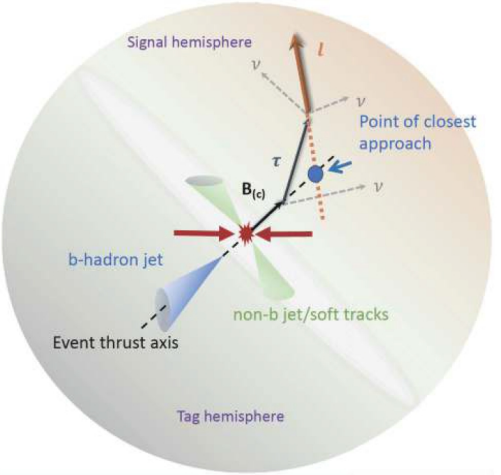
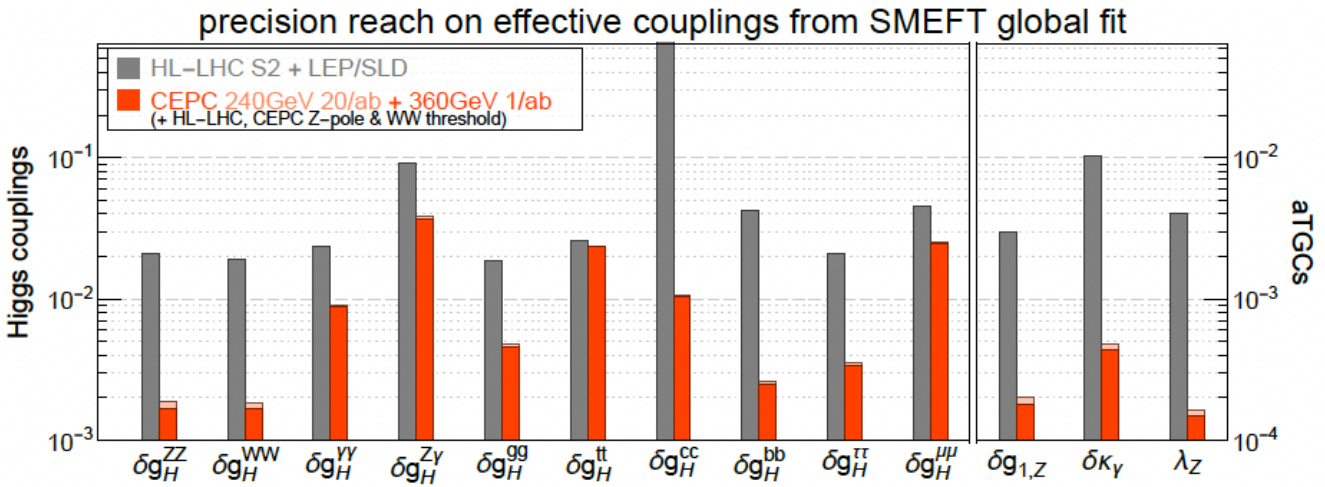


Fig. 6. (color online) $B_c/B \to \tau\nu, \tau \to e/\mu\nu\bar{\nu}$ in $Z \to b\bar{b}$ event topology. The extension of the lepton track passes close by the



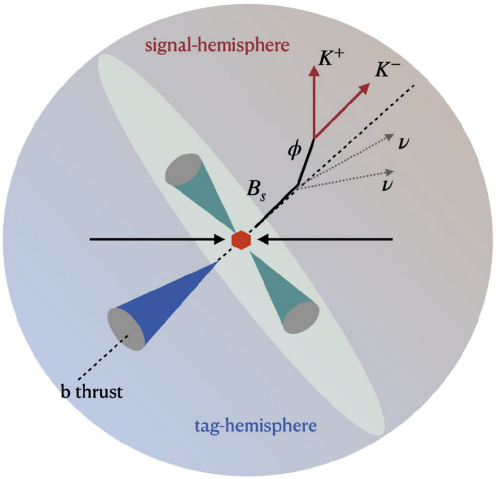
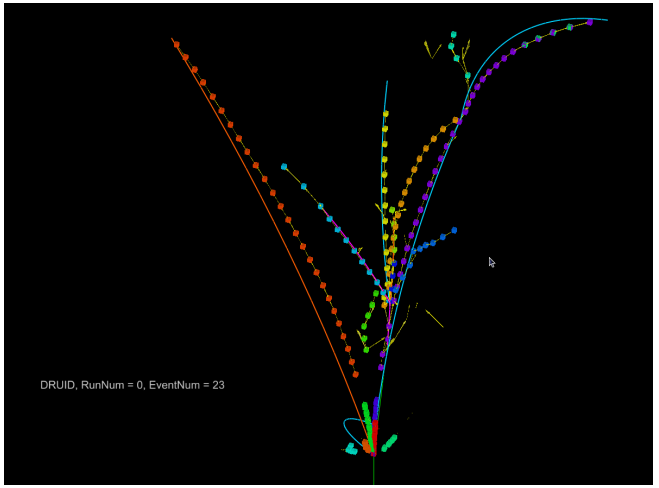
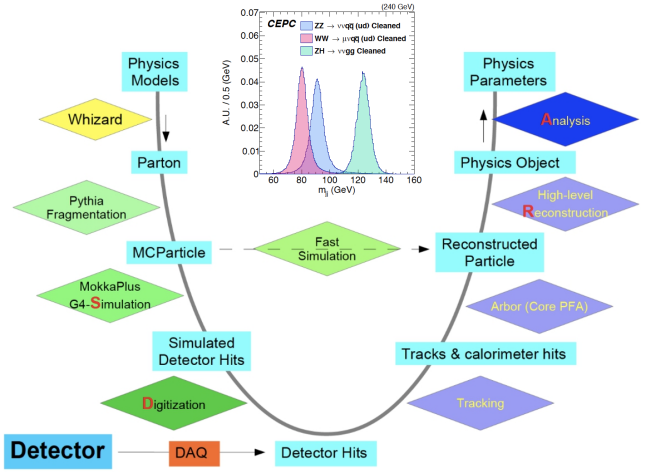
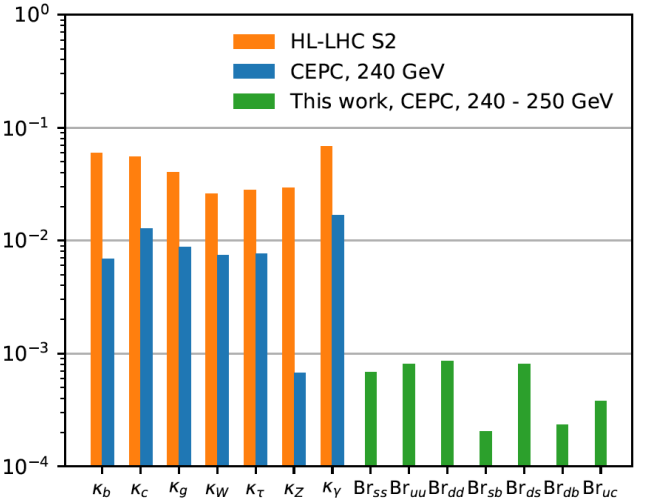


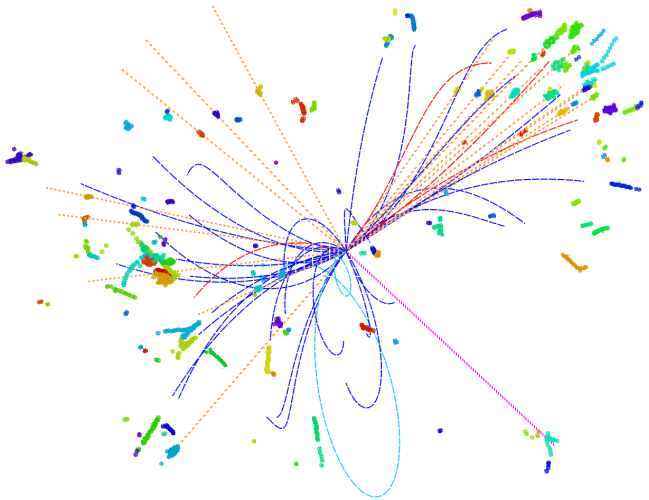
FIG. 2. The topology of FCNC $B_s \to \phi\nu\bar{\nu}$ decay at the Z pole.

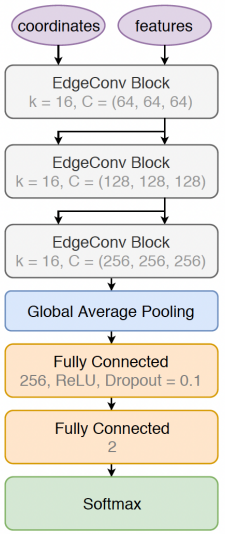
New algorithms: Arbor (PFA), Particle Net (Flavor Tagging)...

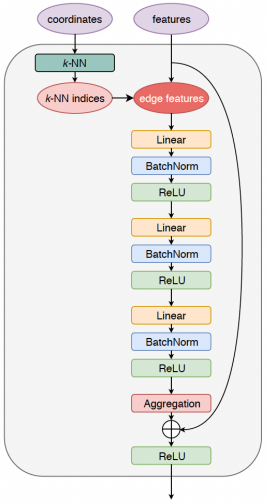


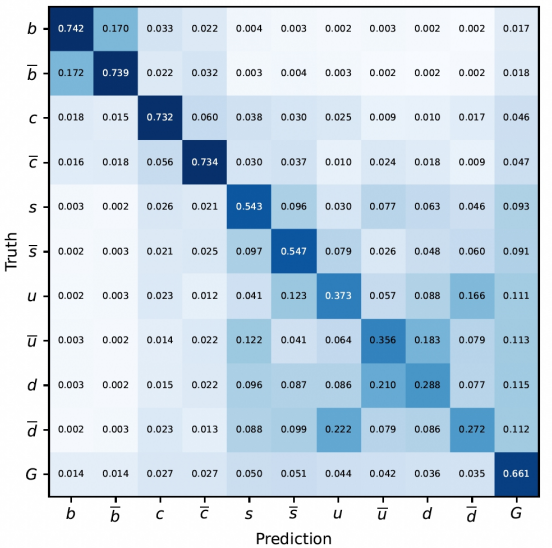






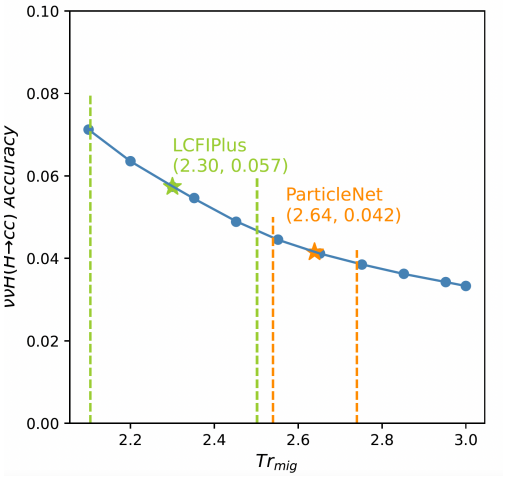


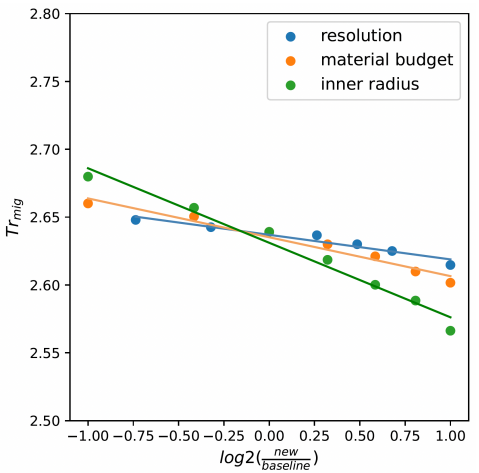


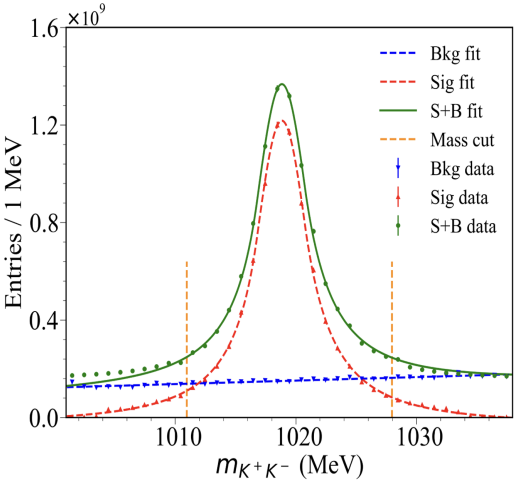


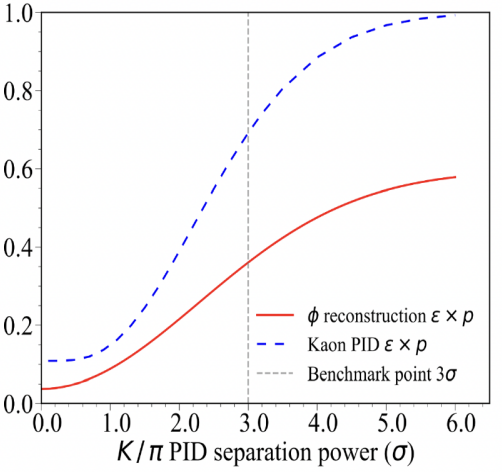
...Access to Higgs rare (ss, uu, dd) & FCNC exotic modes (uc, sb, bd, sd)...

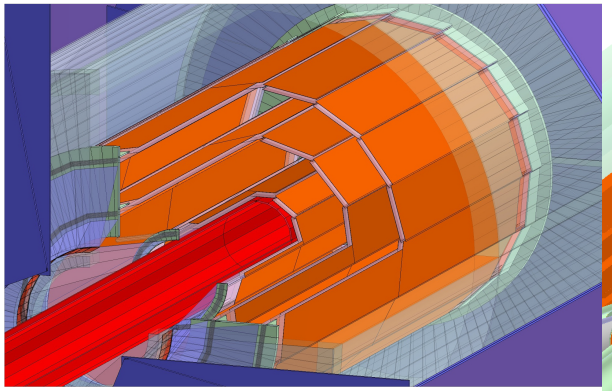
New designs: requirement – optimization

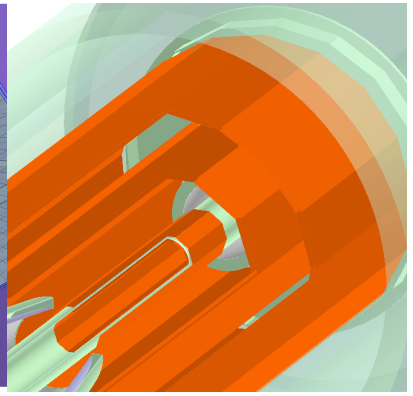












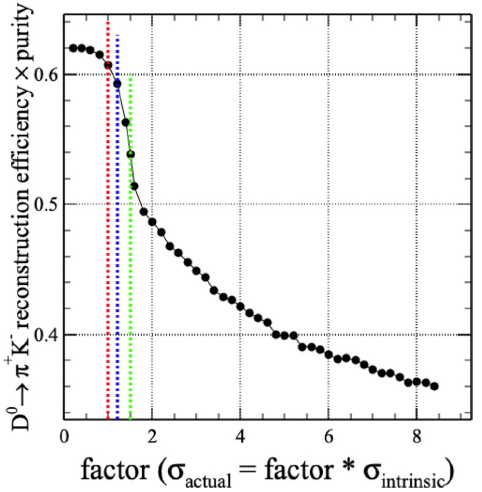


Fig. 12. The distribution of $D^0 \to \pi^+K^-$ reconstruction performance as a function of the factor defined in $\sigma_{actual} = factor \cdot \sigma_{intrinsic}$. The red/blue/green line corresponds to the 0%/20%/50% degradation of dE/dx resolution.

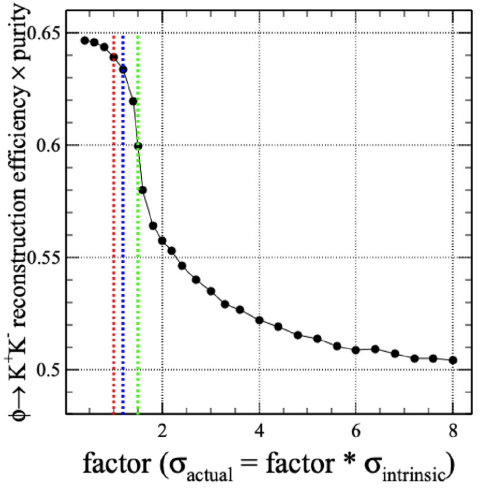


Fig. 13. The distribution of $\phi \to K^+K^-$ reconstruction as a function of the factor defined in $\sigma_{actual} = factor \cdot \sigma_{intrinsic}$. The red/blue/green line corresponds to the 0%/20%/50% degradation of the dE/dx resolution.

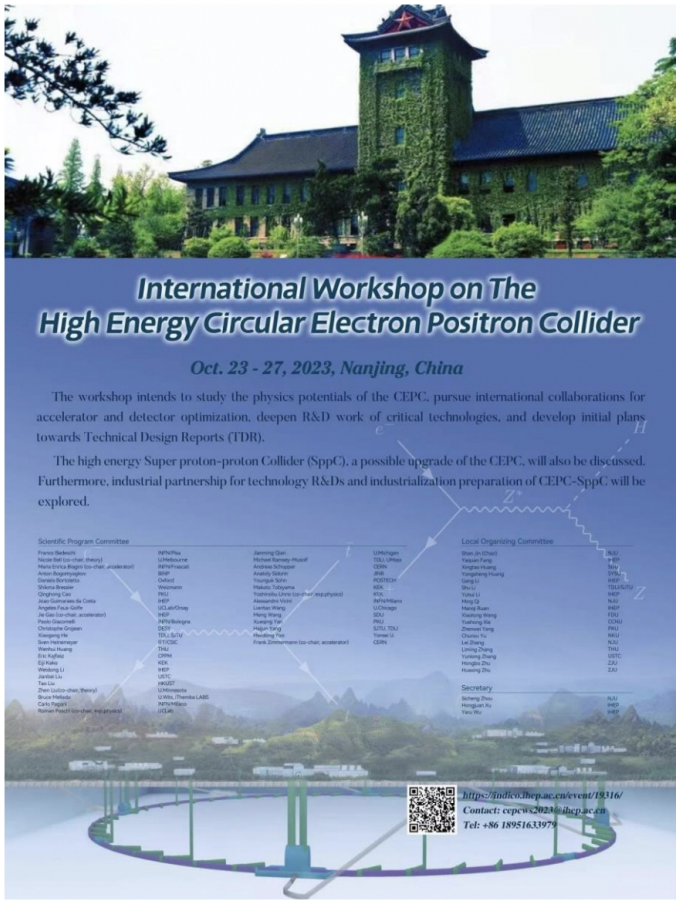
Summary

- Endeavor of 11 years: CEPC is technologically ready for construction
- Physics studies are critical to promote, to realize CEPC and to maximize its scientific output
  - *New ideas, excellent tools & results, Iterated with facility designs*
  - *White paper: Higgs released in 2019, Flavor (phase-I) about to release*
  - *Objective: to have NP, EW & QCD in 1-2 years...*
  - *Young talents emerge...*
- Pid is essential to the CEPC physics program: to be addressed

- Everything initiated from ideas – anticipate lots of fun in our discussion
- **~ 100 talks – please be concise**
- Many Thanks & Enjoy the workshop!

Next events

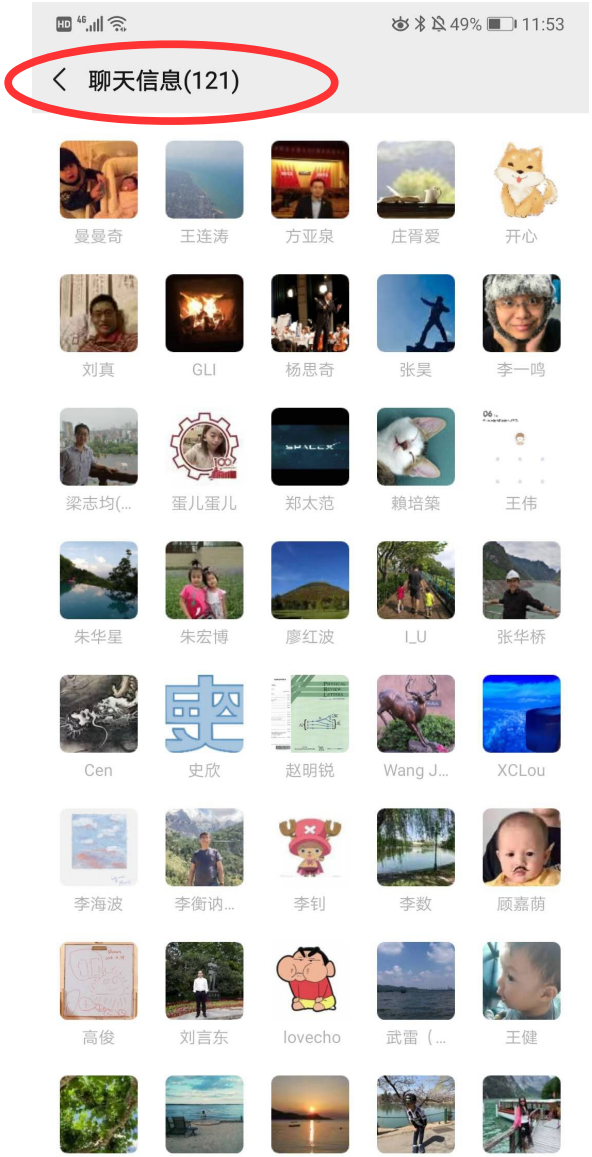
- Oct 23-27 2023, CEPC WS @ Nanjing U
- Jan 8-25, 2024, HEP Working Month @ HKIAS
- ...NP/QCD/Joint WS...



Back up

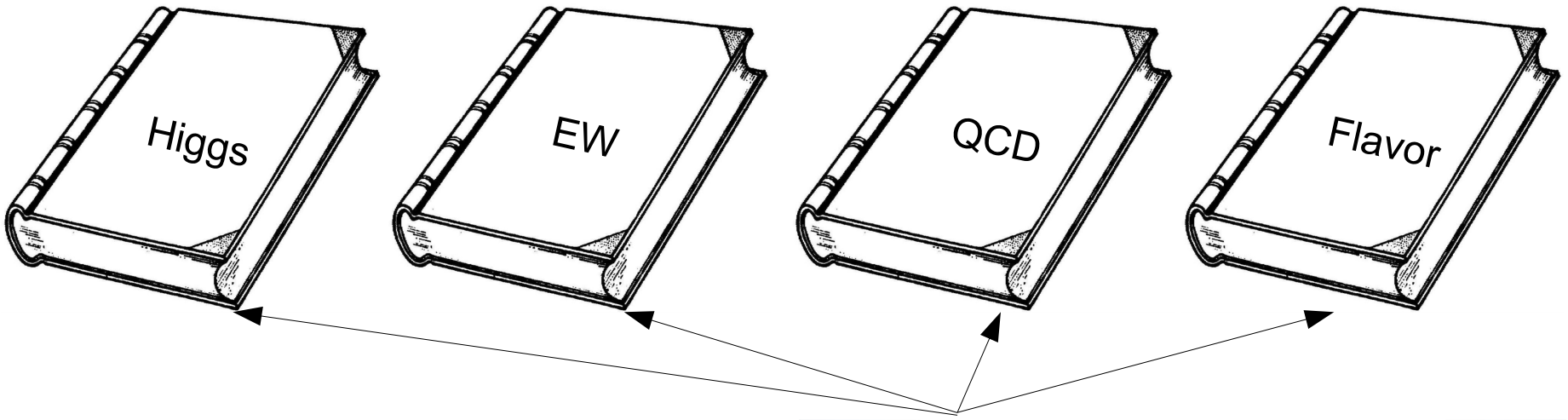

CEPC物理、软件和探测器新概念联合研讨会
Joint Workshop of the CEPC Physics, Software and New Detector Concept
2021.4 江苏·扬州

CEPC @ Snowmass

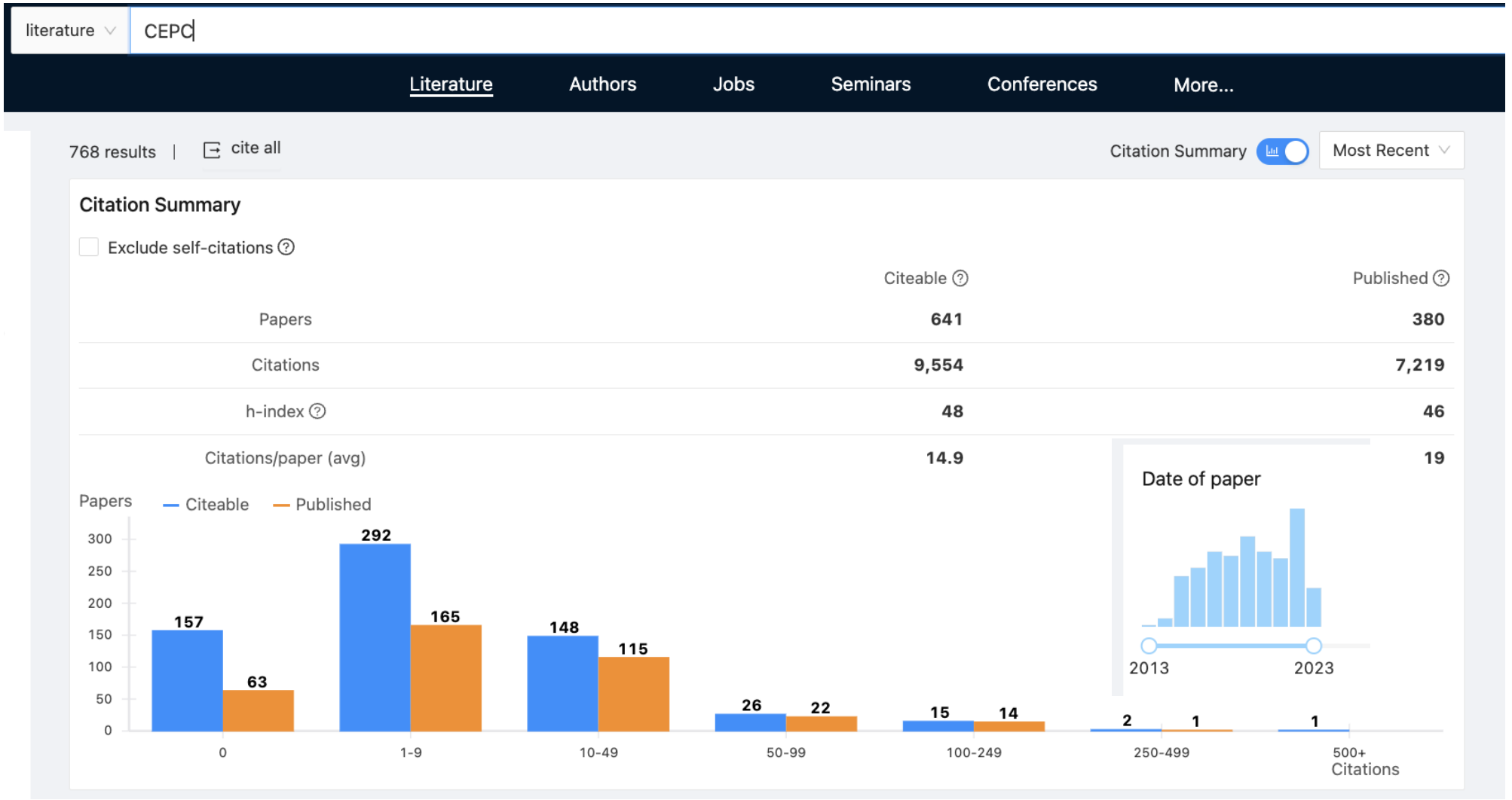


title	ID	author	link	
Study of electroweak phase transition in exotic Higgs decays with CEPC Detector simulation	229-v1	Michael Ramsey-Musolf	URL	
Exclusive Z decays	226-v1	Qin Qin	URL	
Measurement of the leptonic effective weak mixing angle at CEPC	233-v1	Siqi Yang	URL	
Heavy Neutrino search in Lepton-Rich Higgs Boson Rare Decays	244-v1	Yu Gao	URL	★
Higgs boson CP properties at CEPC	227-v1	Xin Shi	URL	★
Measurement of branching fractions of Higgs hadronic decays	228-v1	Yanping Huang	URL	
Feasibility study of CP-violating Phase phi_s measurement via Bs->J/PsiPhi channel at CEPC	230-v1	Mingrui Zhao	URL	
Probing top quark FCNC couplings tqr, tqZ at future e+e- collider	231-v1	Peiwen Wu	URL	★
Searching for $B_s \to \phi\nu\nu$ and other b->dvv processes at CEPC	232-v1	Yanyun Duan	URL	
Probing new physics with the measurements of e+e- -> W+W- at CEPC with optimal observables	234-v1	Jiayin Gu	URL	★
NNLO electroweak correction to Higgs and Z associated production at future Higgs factory	235-v1	Zhao Li	URL	
SUSY global fits with future colliders using GAMBIT	237-v1	Peter Athron	URL	
Probing Supersymmetry and Dark Matter at the CEPC, FCCee, and ILC	238-v1	Waqas Ahmed	URL	
Search for t + j + MET signals from dark matter models at future e+e- collider	239-v1	Peiwen Wu	URL	
Search for Asymmetric Dark Matter model at CEPC by displaced lepton jets	240-v1	Mengchao Zhang	URL	
Dark Matter via Higgs portal at CEPC	241-v1	Tianjun Li	URL	
Lepton portal dark matter, gravitational waves and collider phenomenology	242-v1	Jia Liu	URL	
CEPC Detectors Letter of Intent	245-v1	Jianchun Wang	URL	

Central simulation group will help



- **Input for the benchmarks**
- Dedicated performance study
- Official MC samples
- Training for new analysts
- Analysis a few benchmark
- Feedback to detector
- Services: webpage, indico, mailing list, DocDB, Git.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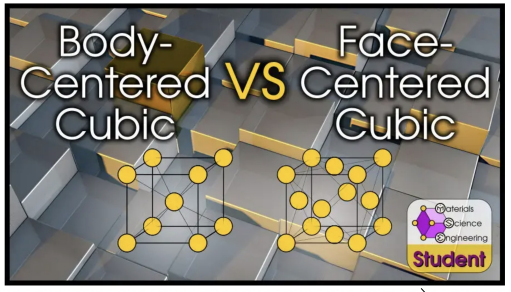

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Citations	31,457	25,821
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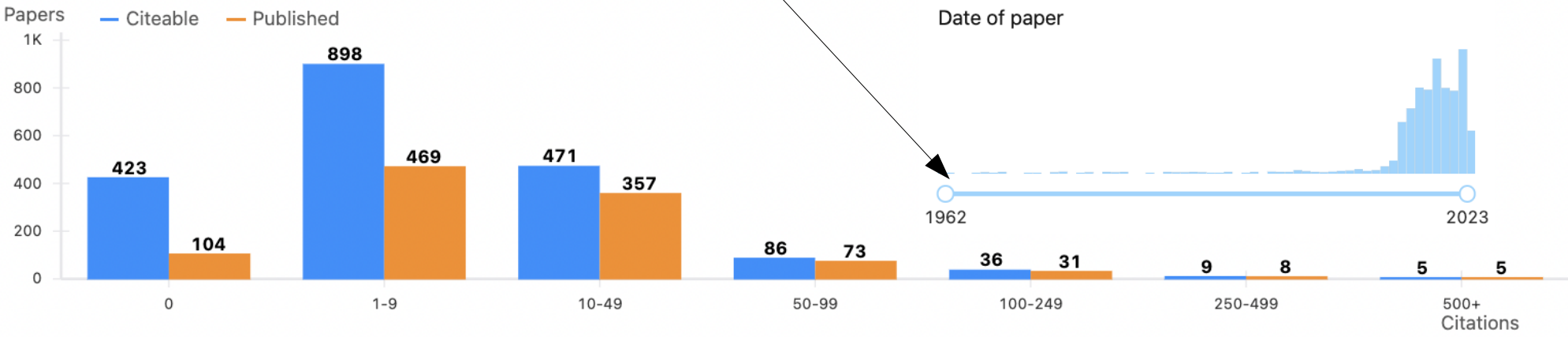

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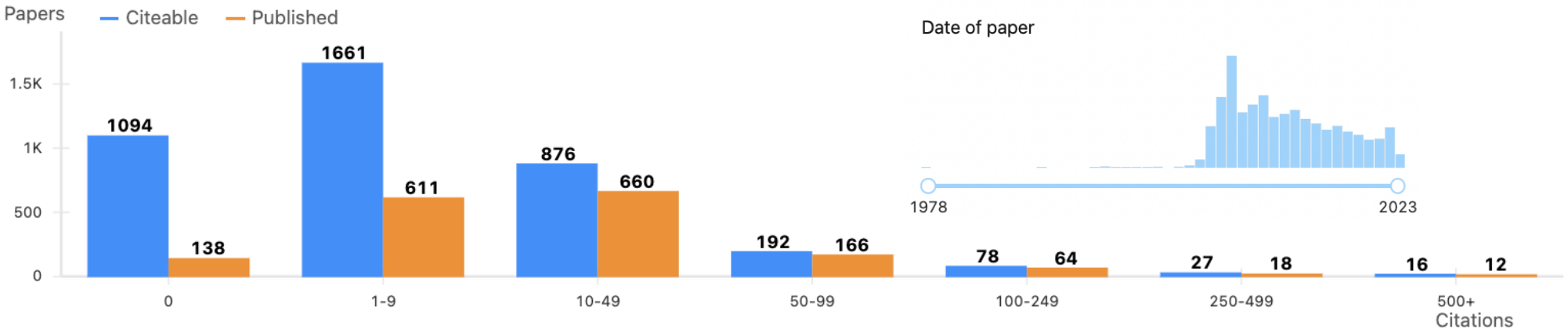
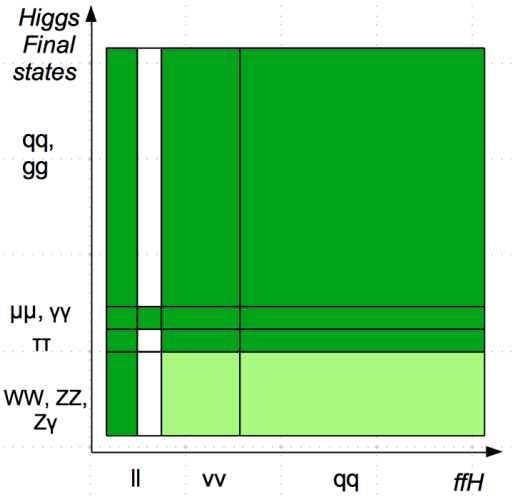
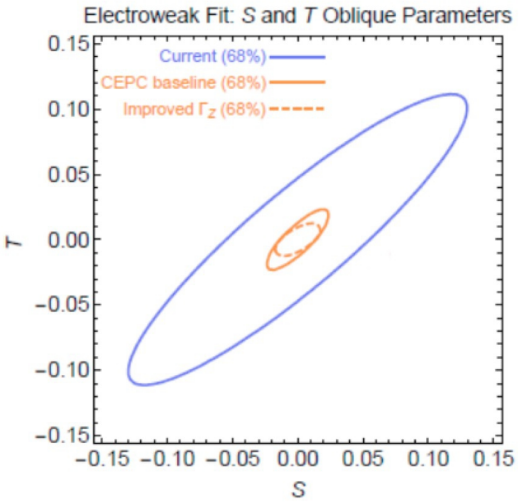
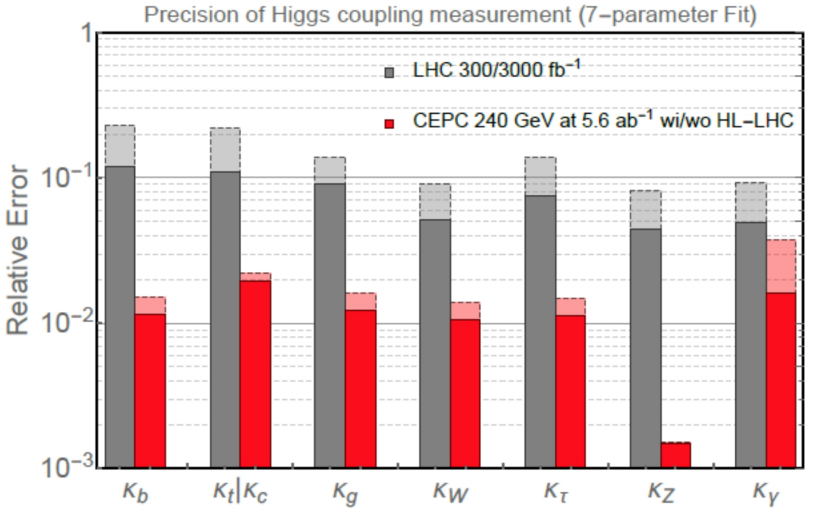


Physics @ CDR: starting point







Discussed also the Flavor & QCD Programs without dedicated simulation Studies at that time...