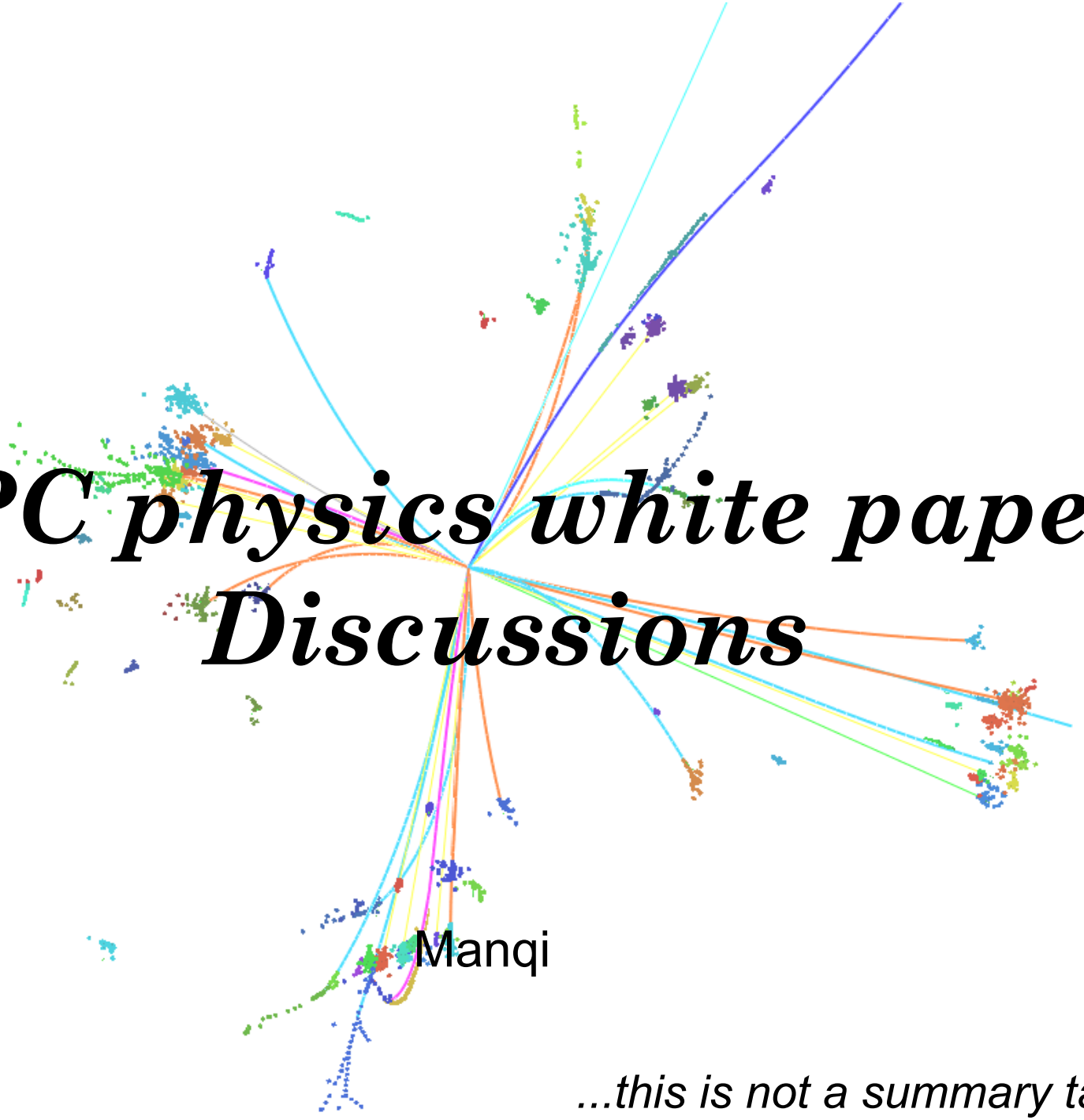


CEPC physics white papers: Discussions

Manqi

...this is not a summary talk...

Observation

- Lots of
  - Exciting ideas & progresses–
    - New methods,
    - New observables/benchmarks,
    - New interpretation
  - Fresh blood from Snowmass studies, and many talks from students
  - Interactions

- I learned & enjoyed a lot!

White paper

- Essential for us to promote the project, and serve as official reference of its scientific merit
- What kind of information, are we going to describe in the “Executive summary” for these white papers
- With previsions for technology advancement for future projects

White papers

- Timeline: end of 2022
  - Main context be ready by middle (August) next year

- Personal perspectives on key questions

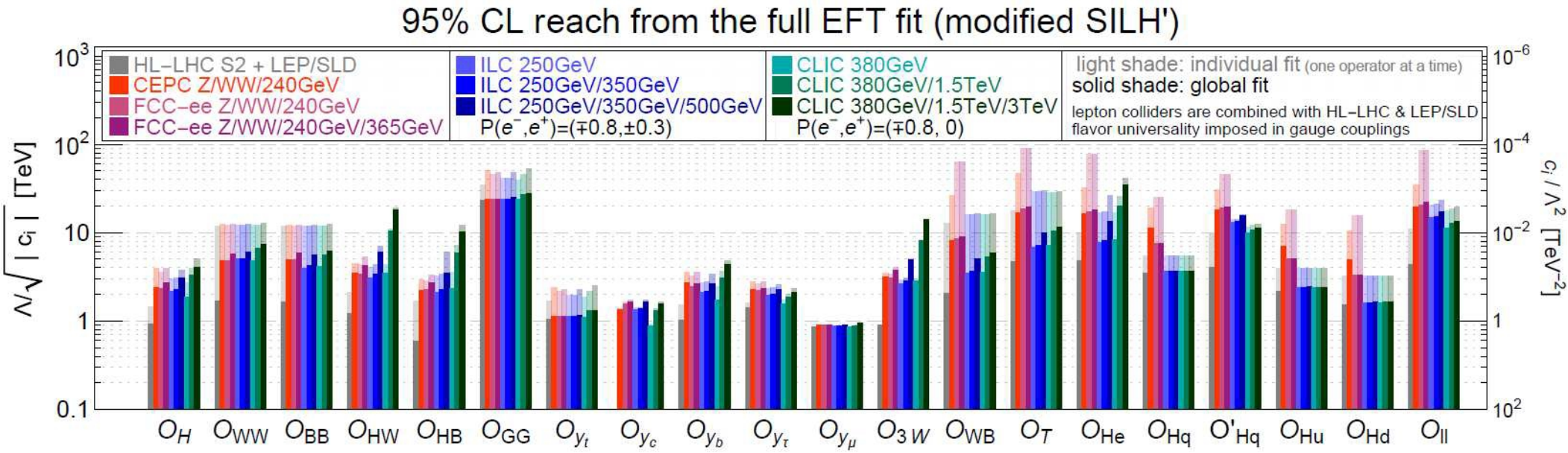
White paper: key contents

- **Benchmark** selection & analyses
  - Anticipated Accuracy (AA) of benchmarks: via analysis/estimation
  - AA & its dependence on
    - Luminosity,
    - Detector performance,
    - Theoretical uncertainty control

- **Interpretation**
  - To quantify the scientific merit: why it's important? How important?
  - Synergies & comparative advantage with other facilities

EW + top runs

- Significant progress
- Proposal: integrate the recent Higgs progresses + top measurement into the EW white paper
  - Global interpretations with SMEFT



EW

- Interacting with Snowmass

A. Freitas
University of Pittsburgh

Quantity	current	ILC	CLIC	FCC-ee	CEPC
M_Z [MeV]	2.1	–	–	0.1	0.5
Γ_Z [MeV]	2.3	–	–	0.1	0.5
M_W [MeV]	12	2.5	?	0.7	1.0
$\sin^2\theta^\ell_{\rm eff}$ [10^{-5}]	14	2	7.8	0.5	2.3
$R_b = \Gamma^b_Z/\Gamma^{\rm had}_Z$ [10^{-5}]	66	23	38	6	4.3

- We need to understand the quantitative difference with other facilities – and to 'gauge' this comparison at whitepaper, Snowmass & other platform

BSM

- EWPT, etc: early Universe...
- SUSY
- Neutrino related
- Unconventional signals: background free or not – what detector is needed to make it background free
  - LLP
  - Lepton Jet
  - ...
- ...

- Is SMEFT always an appropriate language to parametrize devations from SM? What do we learn about specific BSM models?

A. Freitas
University of Pittsburgh

Flavor: benchmarks

- *Extremely rich*
- *Very demanding on detector performance -> any superb performance will be appreciated for some physics measurements...*
- *We have several benchmarks: orthogonal ones?*
- *We have intensive requirement/performance studies: enables fast estimation via the collaboration/discussion between theorists (pheno-study) & experimentalists*

- *Clearly state the requirement on*
  - *Luminosity: sub-Tera Z, or Multi-Tera Z?*
  - *Detector requirements*

Flavor: interpretations

- CKM originated topics
- Rare decay
- ...
- Puzzle/tension originated topics
  - Bc->Tauv & its addressing to the R_D puzzle
  - Phase space coverage of R_D, R_D*, ...
  - g-2
  - *Factorization method validation via Exclusive Z decay study*

QCD

- Alphas measurement
- pQCD: QCD related theoretical uncertainty control for other, especially EW/Higgs measurements
- Innovative methods: energy correlation (EEC)

- Open question: Innovative Color Singlet identification, to best use the qqH events

QCD白皮书撰写计划

- 2019年2月在杭州举行了第一次白皮书撰写成员的研讨会，各位成员表达了积极性。

HX. Zhu

- 2020年9月开始每月举行在线研讨会。
- 2021年5月在上海的微扰量子场论研讨会上将进一步讨论和总结两年来成员的研究成果，定下白皮书的最终目标。
- 2021年7月中旬在撰写成员提供的稿件的基础上形成白皮书初稿。
- 鼓励成员在ILC的top/heavy flavor/QCD组上交流结果，并鼓励国际同行贡献到白皮书的部分章节。

Interactions with larger community

- Many common interests & common difficulties
  - Theoretical uncertainty control: NNLO, etc
  - QCD precision calculation
  - EW Systematic estimation
  - Interpretation frameworks
  -
- Existing & emerging platforms: domestic & international
  - Snowmass
  - LCWS & various international conferences
  -
- Publication, Presentation, Proposals.

Thank you!

White papers contacts

- Higgs: Yaquan Fang, Gang Li, Xin Shi
- EW: Zhijun Liang, Siqi Yang
- QCD: Huaxing Zhu, Jun Gao
- Flavor: Chenping Shen, Manqi
- BSM: Xuai Zhuang, Lei Wu

CEPC: a boson & top factory

operation mode	Z factory	WW threshold	Higgs factory
$\sqrt{s}$/GeV	91.2	160	240
run time/y	2	1	7
instantaneous luminosity/(10^{34} cm^{-2} s^{-1})	16–32	10	3
integrated luminosity/(ab^{-1})	8–16	2.6	5.6
Higgs boson yield	–	–	10^6
W boson yield	–	10^7	10^8
Z boson yield	10^{11}–10^{12}	10^8	10^8

- Possible upgrade: 2 inv(ab) @ 360 GeV ~ 1 Million top quark, + 300 k Higgs
- State-of-Art detector + reconstruction: identify & characterize all those clean events...

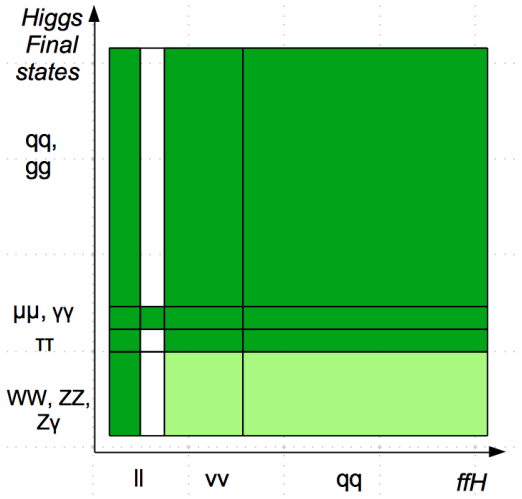
Physics White Papers

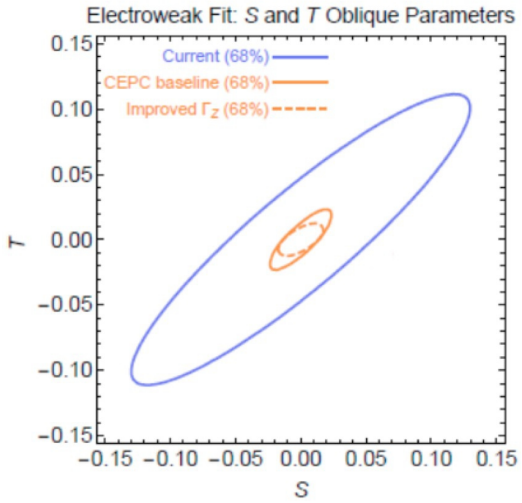
- Demonstrate & quantize the physics potential
  - *On various frontiers: Higgs, EW, QCD, Flavor & BSM*
  - *Official references*
  - *Handbook*

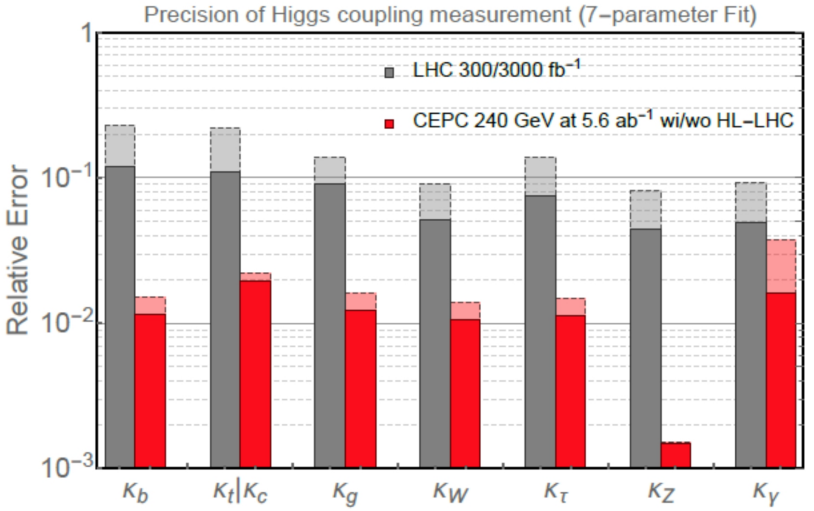
- Maximize the scientific output, by quantify
  - *The comparative advantages/synergies V.S. other facilities*
  - *The critical Luminosity & Detector performance*
  - *Identify/promote possible upgrading plan*

- Promote the project & attract collaborations

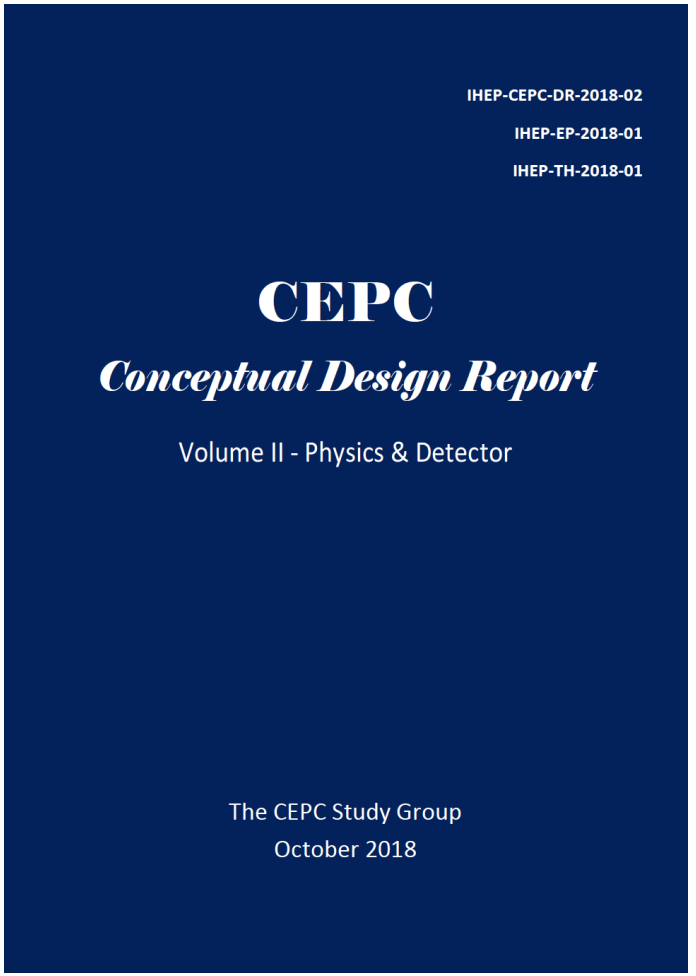
Physics @ CDR: starting point







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



75 registrant + several visitors; ~ 50 talks. Covers Physics, Pheno, and Performance studies
Multiple Benchmarks are proposed, related performance/analysis are presented
Supported by IHEP CFHEP & PKU

THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY | IAS HKUST JOCKEY CLUB INSTITUTE FOR ADVANCED STUDY

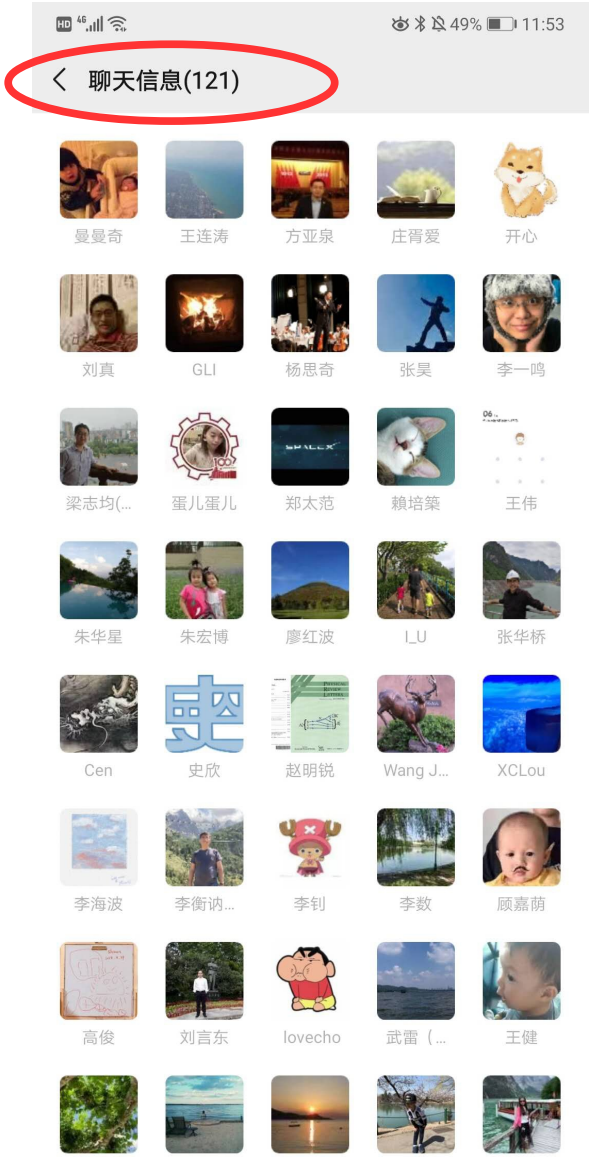
IAS PROGRAM

High Energy Physics

January 6-24, 2020

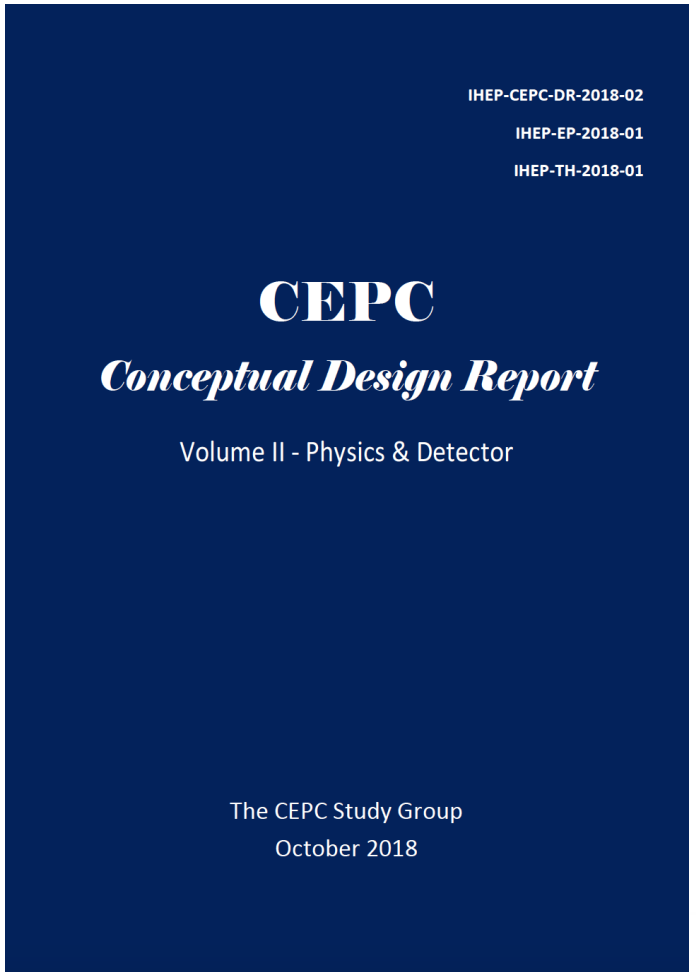
Conference Week (Jan 20-23, 2020)

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	

Higgs: white paper delivered



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

Precision Higgs physics at the CEPC*

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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)[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]
Hongjian He(何红建)[11,10] Xianke He(何显柯)[10] Xiaogang He(何小刚)[11,10,20] 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[33] Ryuta Kiuchi[4]
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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(刘真)[26,30;4)] Xinchou Lou(娄辛丑)[4,6,33,34] Lianliang Ma(马连良)[12] Bruce Mellado[17,18] Xin Mo(莫欣)[4]
Mila Pandurovic[16] Jianming Qian(钱剑明)[24;5)] Zhuoni Qian(钱卓妮)[19] Nikolaos Rompotis[22]
Manqi Ruan(阮曼奇)[4;6)] Alex Schuy[32] Lianyou Shan(单连友)[4] Jingyuan Shi(史静远)[9] 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(魏彧骞)[4] Yue Xu(许悦)[5] Haijun Yang(杨海军)[10,11] Ying Yang(杨迎)[4]
Weiming Yao(姚为民)[28] Dan Yu(于丹)[4] Kaili Zhang(张凯栗)[4,6;8)] Zhaoru Zhang(张照茹)[4]
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[4]Institute of High Energy Physics, Beijing 100049, China

Higgs: significant progress

- 13 (Parallel session) + 1 (Young Scientist Forum) talks
- Run at top thresholds:
  - *240 + 360 GeV, boost the precision of Higgs width measurement by a factor of 2... with respect to 240 GeV Higgs Runs.*
  - ...
- Differential measurements
- New analysis technologies
- New interpretations...

- **A major update?**

Flavor

- *Extremely rich Physics... with access to High Energy Physics principles...*
- *Different detector performance requirements w.r.t. the Higgs/EW*
- *Very strong competition from dedicated flavor physics facilities: LHCb & Belle II, etc*
-
- *Kick off at PKU meeting, and part of the white paper is converged*
- *Benchmark studies are processed in past ~2 year*

Flavor Physics at CEPC

Working Group and Conveners

Chapter One: Introduction
Conveners: Marek Karliner, Luciano Maiani, Jonathan Rosner, Abner Soffer, Lian-Tao Wang

Chapter Two: Leptonic and semileptonic b-hadron decays
Conveners: Sebastien Descotes-Genon , Jeorme Charles, Abner Soffer,Florian Bernlochner, Bob Kowalewski

Chapter Three: b-hadronic decays and CP violation
Conveners: I.I. Bigi, Chao-Qiang Geng, Abner Soffer, Yue-Hong Xie

Chapter Four: Rare and forbidden b-hadron decays
Conveners: Wolfgang Altmannshofer, Soeren A. Prell, Emmanuel Stamou

Chapter Five: Charm physics
Conveners: Chun-Hui Chen, Hai-Yang Cheng, Marek Karliner, Jonathan Rosner

Chapter Six: Exotic hadron and Spectroscopy with heavy flavors
Conveners: Marek Karliner, Luciano Maiani, Jonathan Rosner, Wei Wang

Chapter Seven: τ Physics
Conveners: Emilie Passemar, Emmanuel Stamou, Lorenzo Calibbi

Chapter Eight: Flavor physics in Z decays
Conveners: Wolfgang Altmannshofer, Lorenzo Calibbi

Chapter Nine: Two photon and ISR physics with heavy flavors
Conveners: Igor R. Boyko, Vladimir V. Bytiev, Alexey S. Zhemchugov, Lian-Tao Wang

Chapter Ten: Summary and Conclusion
Conveners: Lorenzo Calibbi, Hai-Bo Li, Manqi Ruan, Abner Soffer, Jian-Chun Wang

味物理本身是极为丰富的，而不同的味物理实验设施各有特色，具有明显的比较优势。因此，标志性测量的适当选取，是明确 Higgs/Z 工厂在味物理上的物理目标、量化其物理潜力、明确其比较优势，进而量化探测器需求的前提条件。这是 Higgs/Z 粒子工厂实验设计的重要前提和不可或缺的研究，可以说没有这些量化分析探测器的要求，Higgs/Z 粒子工厂上的味物理仅是一纸空谈。

Flavor

- 4 benchmarks at Full simulation + multiple performance studies: 6 + 4 talks
  - Bc->tauv Published, deeply linked with R_D puzzle
  - Bs->J/psi+Phi, CP measurement, see Mingrui's talk
  - Bs->Phi + vv, see Yudong's talk
  - Bs/B0->2pi0, see Yuexin's talk

Chinese Physics C Vol. 45, No. 2 (2021)

Analysis of $B_c \to \tau\nu_\tau$ at CEPC*

Taifan Zheng(郑太范)[1] Ji Xu(徐吉)[2] Lu Cao(曹璐)[3] Dan Yu(于丹)[4] Wei Wang(王伟)[2] Soeren Prell[5]
Yeuk-Kwan E. Cheung(张若筠)[1] Manqi Ruan(阮曼奇)[4†]

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[3]Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn, 53115 Bonn, Germany
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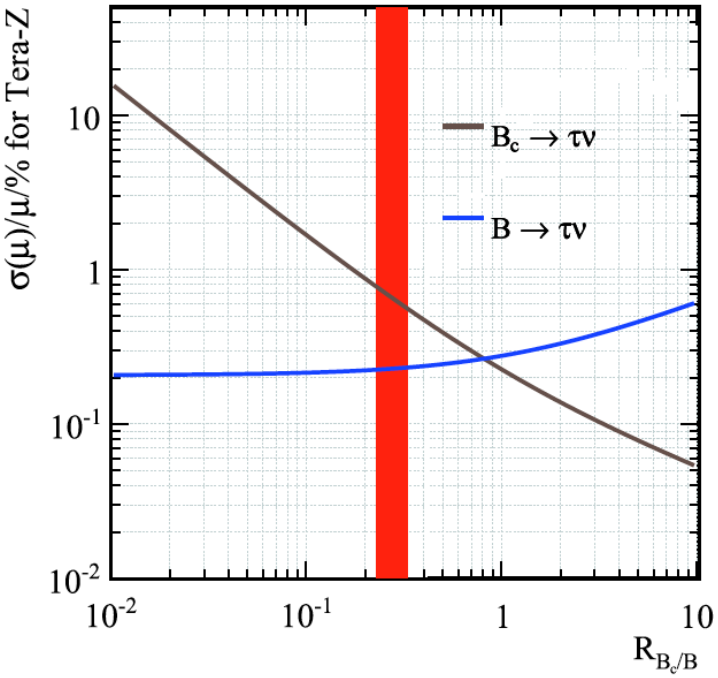
[5]Department of Physics and Astronomy, Iowa State University, Ames, IA, USA



Flavor

- Good understanding of all(?) key physics objects
  - Pi0: see Yuexin's talk, eff*purity > 60%, especially for high energy ones
  - Lepton & Tau: isolated, in jets, see Kongyi's talk
  - Pi/kaon separation, see Zhiyang's talk ~ need 3-sigma pi-kaon separation
  - ECAL resolution, see Yong/Yuexin's talk
  - Tracking precision: delta(p)/p ~ o(0.1%)
  - Flavor tagging: eff*purity ~ 70% for b-jet, 40% for c-jet @ Z->qq, see Gang's talk
  - Jet Charge: eff*(1-2*omega)^2 ~ 14%/30% for b/c-jet, see Hanhua's talk

- **Is it sufficient? More benchmark and/or fast estimation?**
- **Goal luminosity & Performance, on the context of a circular collider?**

BSM: 11 talks

- CEPC is not only a precision machine!
- Quantify its discover power is essential
  - SUSY
  - 2HDM
  - EWPT
  - Dark Portal
  - Heavy Neutrinos...
  - ...
- **A BSM white paper is definitely needed**
- **Content & Global interpretations?**

EW

- Systematic uncertainties: major limitation
- Significant Progress on physics benchmarks, NNLO calculations, etc
- 9 talks: physics analyses, interpretations, and interactions with Snowmass team