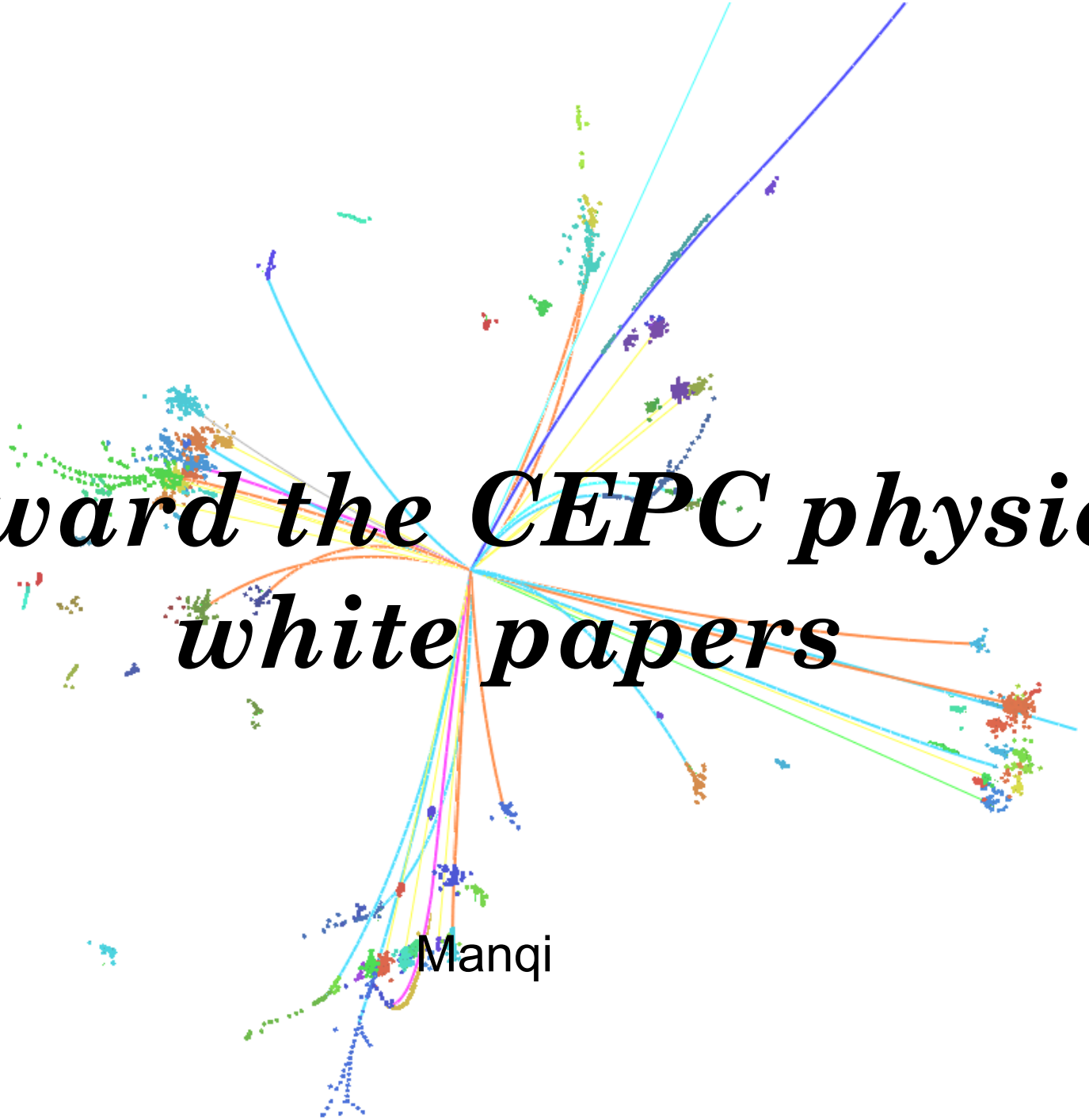


# *Toward the CEPC physics white papers*

Manqi

# 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...

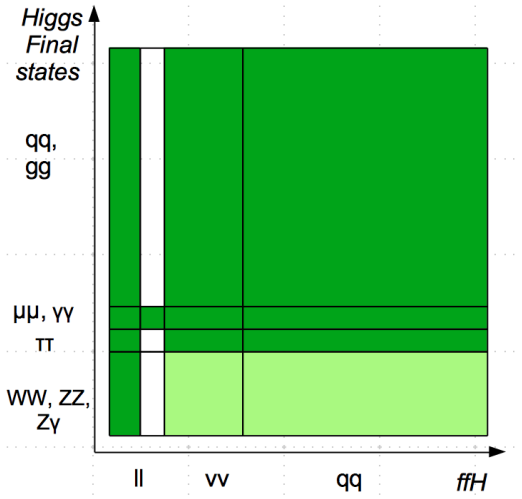
# Physics White Papers

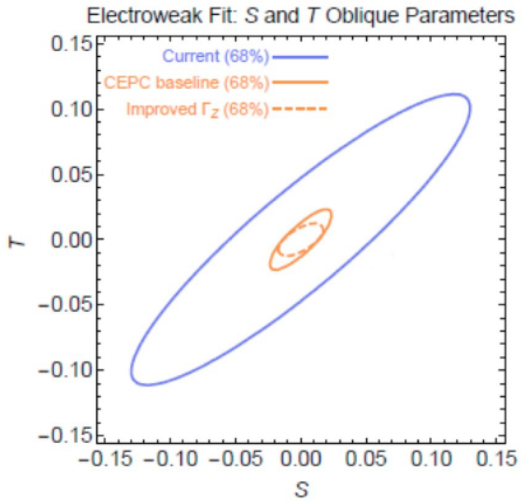
- Demonstrate & quantize the physics potential
  - *On various frontiers: Higgs, EW, QCD, Flavor & BSM*
  - *Official references*
  - *Handbook*

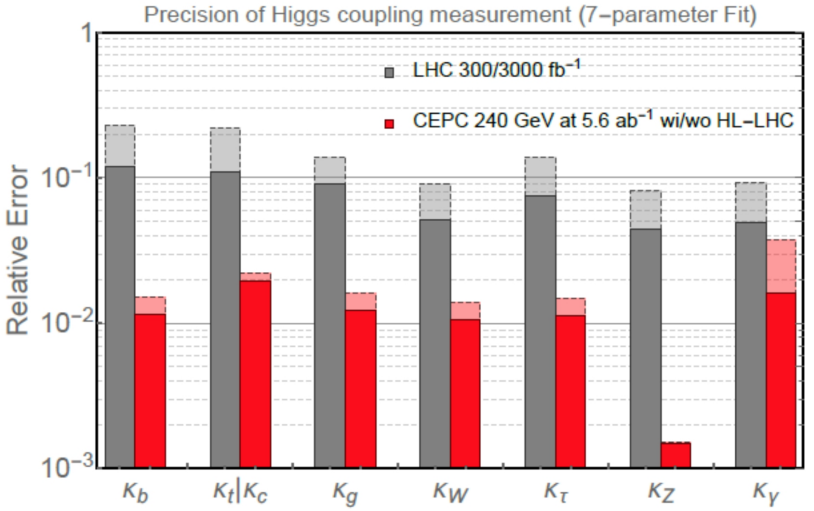
- Maximize the scientific output, by quantify
  - *The comparative advantages/synergies V.S. other facilities*
  - *The critical Luminosity & Detector performance*
  - *Identify/promote possible upgrading plan*

- Promote the project & attract collaborations

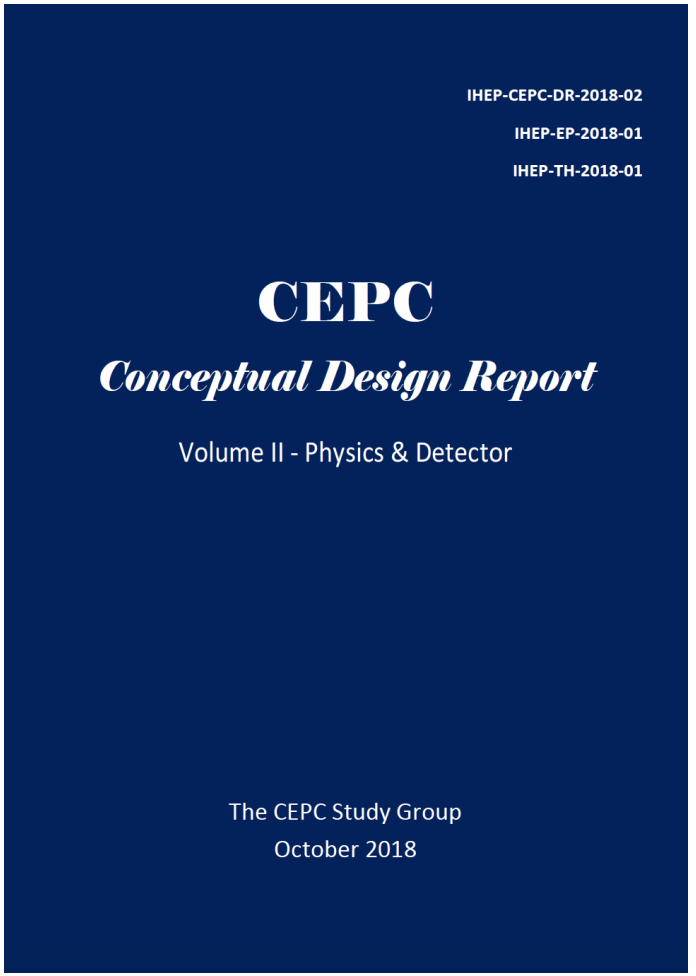
# Physics @ CDR: starting point




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

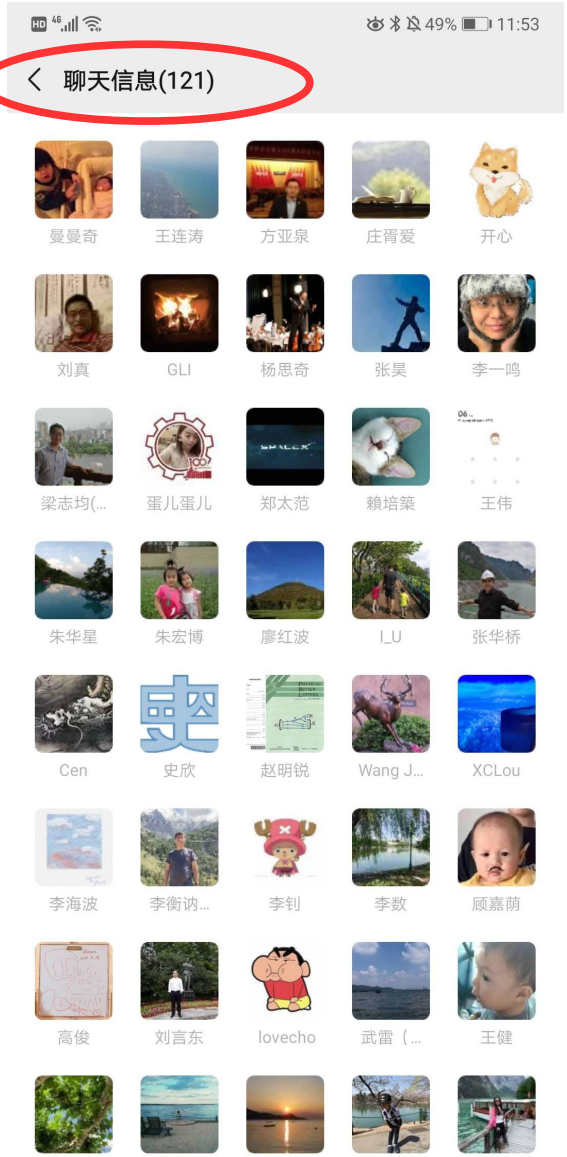
IAS PROGRAM

# High Energy Physics

**January 6-24, 2020**

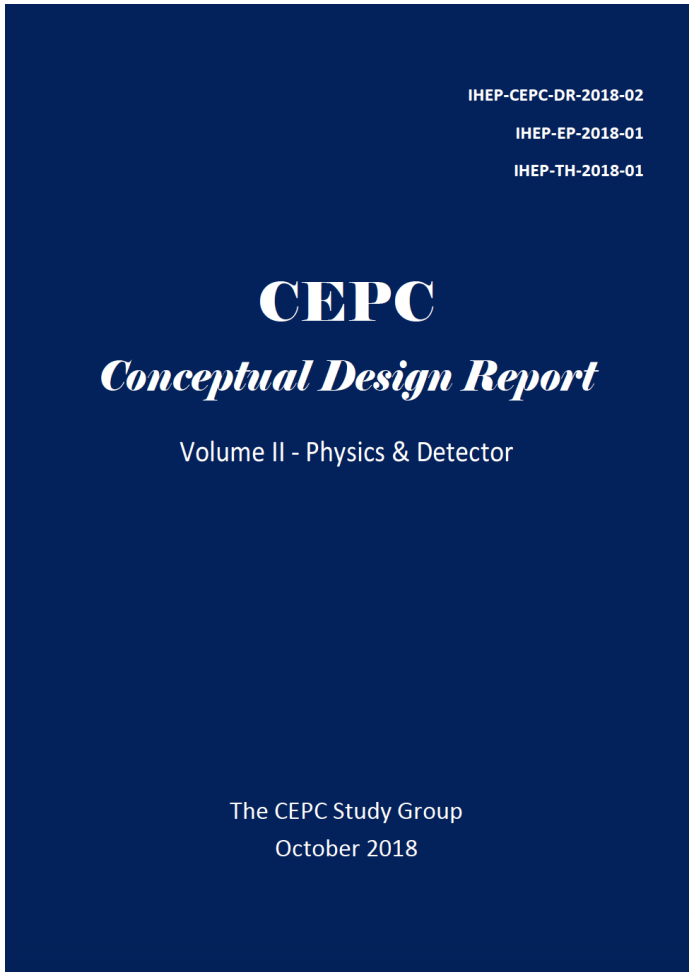
## Conference Week (Jan 20-23, 2020)

# 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*

Fenfen An(安芬芬)[4,23] Yu Bai(白羽)[9] Chunhui Chen(陈春晖)[23] Xin Chen(陈新)[5] Zhenxing Chen(陈振兴)[3]
Joao Guimaraes da Costa[4] Zhenwei Cui(崔振崴)[3] Yaquan Fang(方亚泉)[4,6,34;1)] 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)[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]
Chia-Ming Kuo(郭家铭)[21] Peizhu Lai(赖培筑)[21] Boyang Li(李博扬)[5] Congqiao Li(李聪乔)[3] Gang Li(李刚)[4,34;3)]
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]
Mingrui Zhao(赵明锐)[2] Xianghu Zhao(赵祥虎)[4] Ning Zhou(周宁)[10]

[1]Department of Modern Physics, University of Science and Technology of China, Anhui 230026, China
[2]China Institute of Atomic Energy, Beijing 102413, China
[3]School of Physics, Peking University, Beijing 100871, China
[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: $\tau$ 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

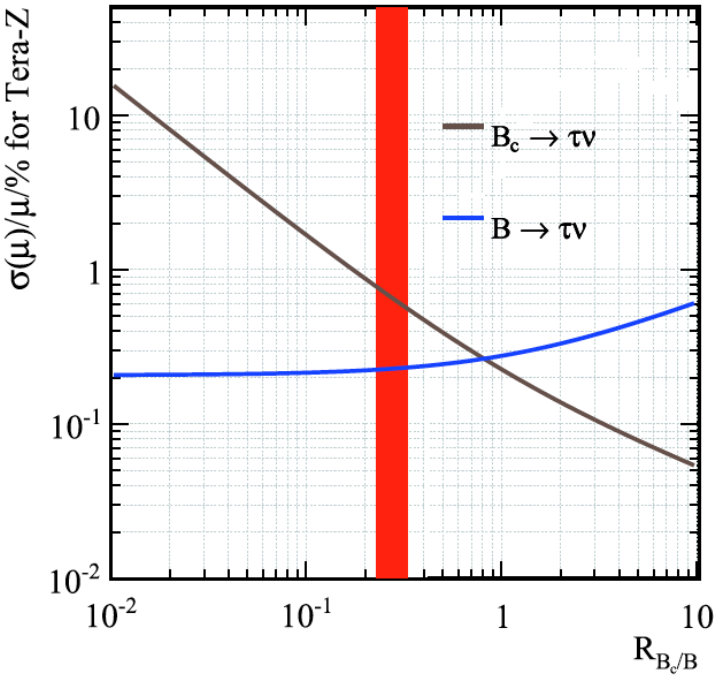
- 4 benchmarks at Full simulation + multiple performance studies: 6 + 4 talks
  - Bc->tauv Published, deeply linked with R_K puzzle
  - Bs->J/psi+Phi, CP measurement, see Mingrui's talk
  - Bs->Phi + vv, see Yudong's talk
  - Bs/B0->2pi0, see Yuexin's talk

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†]

[1]School of Physics, Nanjing University, Nanjing 210023, China
[2]INPAC, SKLPPC, MOE KLPPC, School of Physics and Astronomy, Shanghai Jiao Tong University, Shanghai 200240, China
[3]Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn, 53115 Bonn, Germany
[4]Institute of High Energy Physics, Beijing 100049, China
[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) ~ 14%/30% for b/c-jet, see Hanhua's talk

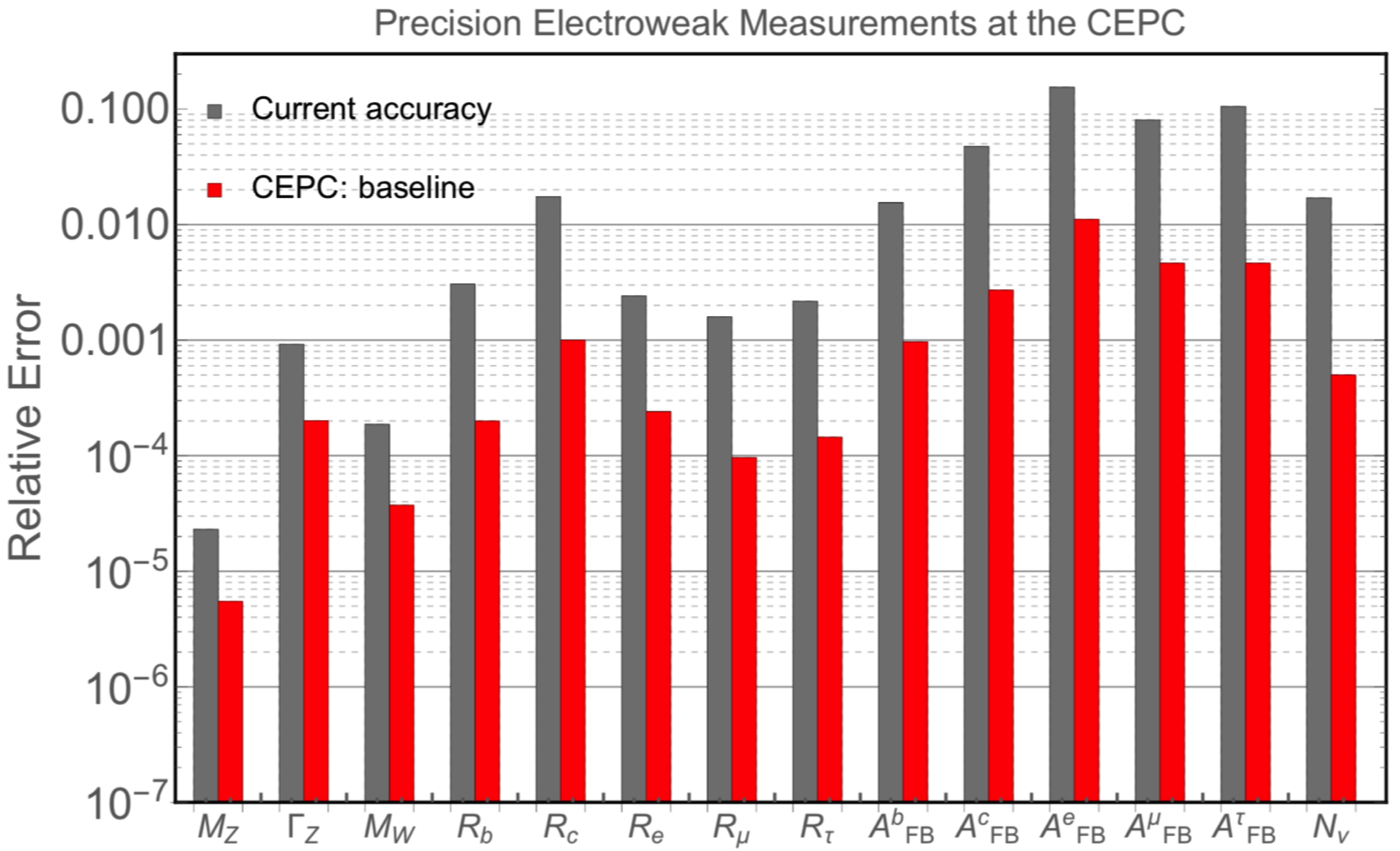
- **Is it sufficient? More benchmark and/or fast estimation?**
- **Goal luminosity & Performance, on the context of a circular collider?**

# 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



# QCD

- QCD
  - Theoretical uncertainties... Impact on other physics measurements...
  - alpha_s measurements...
  - Modeling of hadronisation...
  - Generators (see Jun & Renat's talk)...

- For Both EW & QCD: Common difficult questions for all electron positron Higgs factories.
  - How can we benefit from & make synergies with other Higgs factory studies?

# Hope you enjoy the physics at CEPC

*concerning the above mentioned questions... let's discuss during this WS – especially at the discussion session on April 17$^{th}$!*