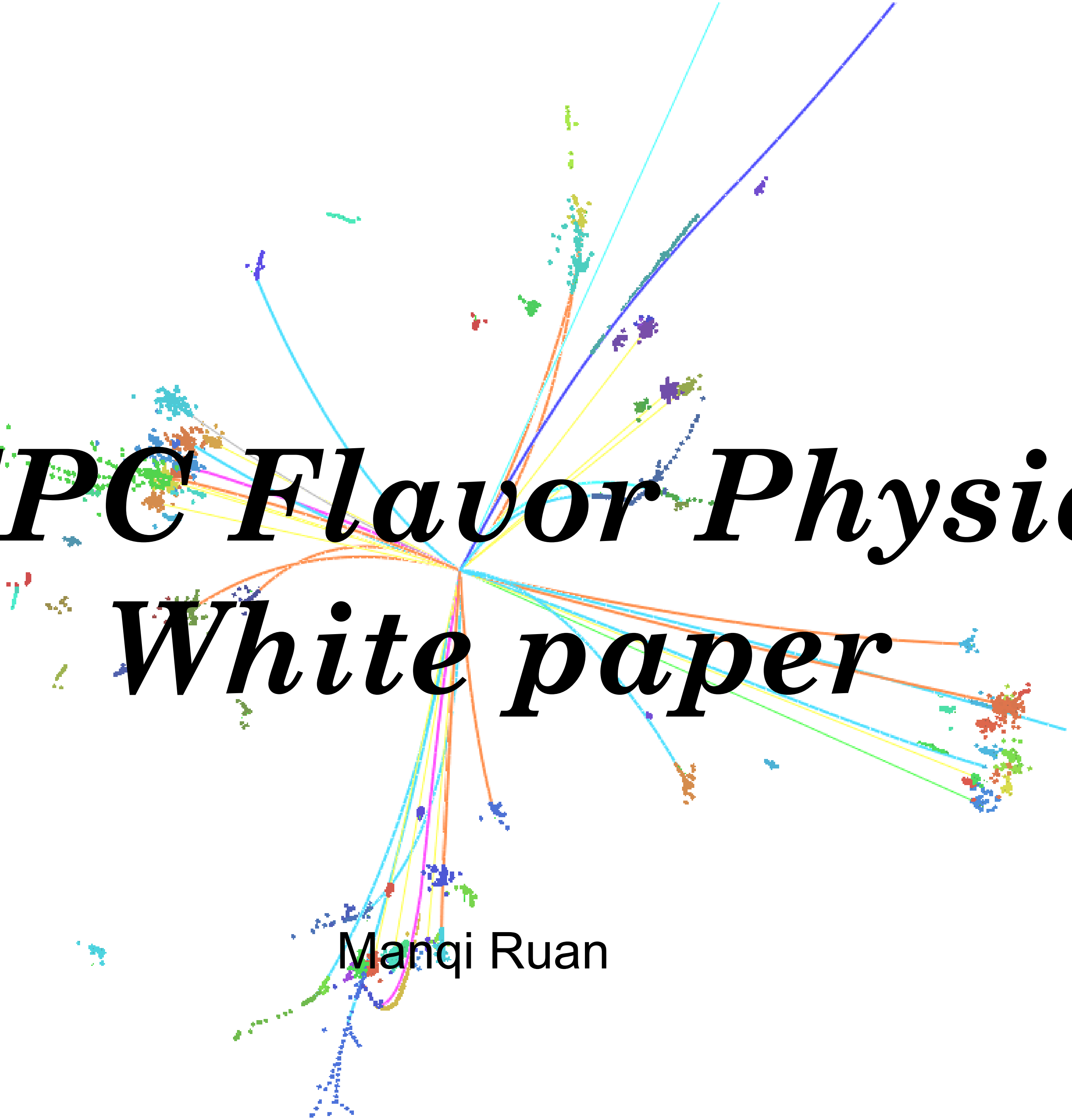


# *CEPC Flavor Physics White paper*

Manqi Ruan

# 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

# Ref: BSM ToC

## CEPC BSM White Paper: ToC

Session 1, Executive Summary

Session 2, Description of CEPC facility, nominal luminosity & Typical Detector Performance

Session 3, Higgs portal & Exotic Higgs decays

Session 4, Z portal & Exotic Z/W decay (including W?)

Session 5, Dark Sector (including H->inv, etc)

Session 6, SUSY (including Gambit)

Session 7, EWPT

Session 8, g-2 associated

Session 9, Test of QFT principle

Session 10, Conclusion

# Status

- Comprehensive Performance Studies -> Description of Detector Facilities
  - CDR & Recent Activities
- Benchmarks analyses
  - Bc → tau v
  - Bs → J/psi Phi
  - Bs → Phi vv
  - B0/Bs → 2 pi0

https://indico.ihep.ac.cn/event/13888/registration/registrants

- Many Studies & Discussions at FCC
  - Rare decays, LFV,... of Mogens Dam
  - Physics Briefing book of EUSPP

# Key points

- Main conclusion?
  - *Impact/Comparative advantage on Physics Potential*
  - *Corresponding requirement on detector – a reference (baseline) detector/setup can satisfy those requirement*

- Key information of each session?
  - *Supported by which benchmark + interpretation?*
    - *Do we have sufficient benchmark?*
      - *Extra benchmark, how to evaluate efficiently & accurately?*
      - *Reference from?*
    - *Optional: Corresponding luminosity & performance requirements: V.S. benchmark accuracies*

# Back up

# Key detector Performance for flavor physics

- Acceptance: |cos(θ)| < 099
- Tracks:
  - Pt threshold, ~ 100 MeV
  - δp/p ~ o(0.1%)
- Photons:
  - Energy threshold, ~ 100 MeV
  - δE/E: 3 – 15%/sqrt(E)
- Pi-Kaon separation: 3-sigma
- Pi-0: rec. eff*purity @ Z→qq > 60% @ 5GeV
- B-tagging: eff*purity @ Z→qq: 70%
- C-tagging: eff*purity @ Z→qq: 40%
- Jet charge: eff*$(1-2\omega)^2$ ~ 15%/30% @ Z→bb/cc
- Lepton inside jets: eff*purity @ Z→qq ~ 90% (energy > 3 GeV)
- Tau: eff*purity @ WW→tauvqq: 70%, mis id from jet fragments ~ o(1%)
- Reconstruction of simple combinations: Ks/Lambda/D with all tracks @ Z→qq: 40 - 85%

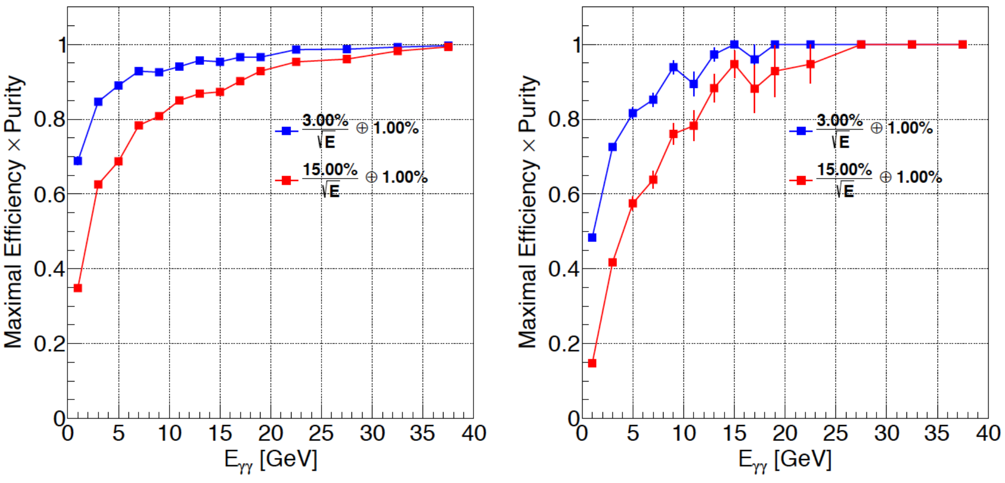
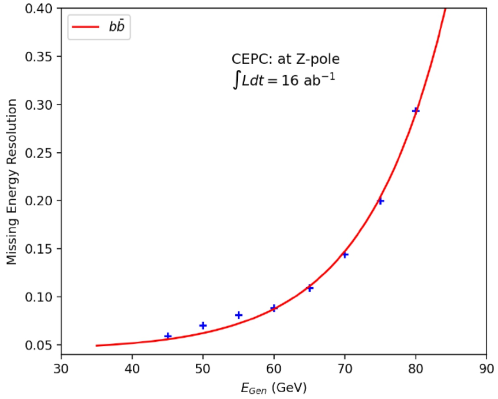
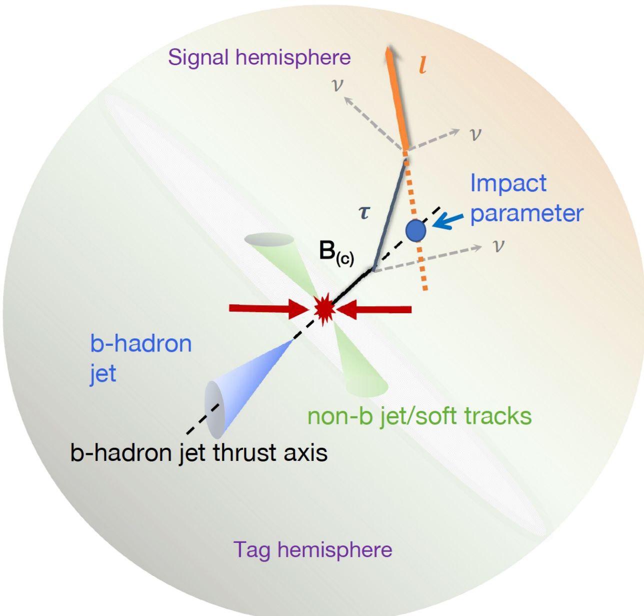
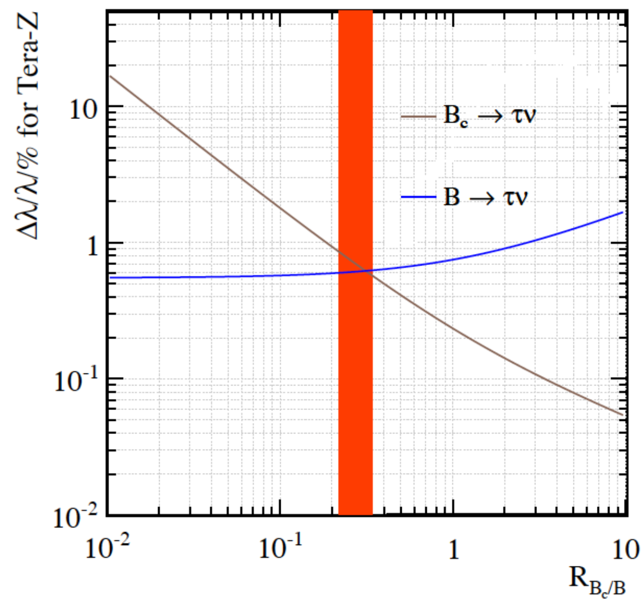



Figure 13: Energy differential maximal $\epsilon \times p$ for $Z \to \tau^+\tau^-$ (left) and $Z \to q\bar{q}$ (right).



# Bc->Tauv



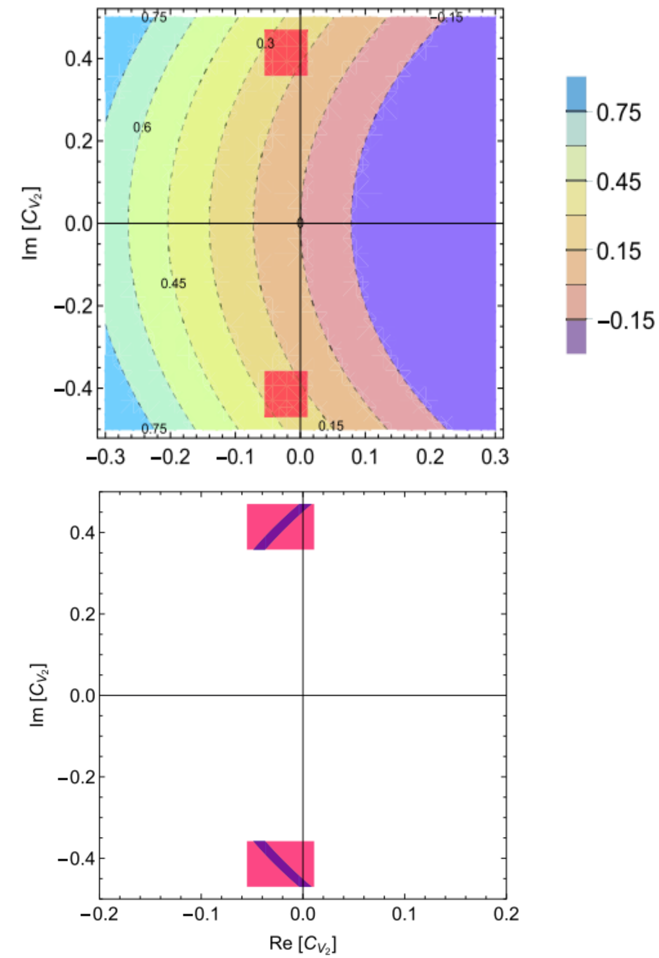




**Fig. 10.** (color online) Constraints on the real and imaginary parts of $C_{V_2}$. The red shaded area corresponds to the current constraints using available data on $b \to c\tau\nu$ decays. If the central values in Eq. (9) remain while the uncertainty in $\Gamma(B_c^+ \to \tau^+\nu_\tau)$ is reduced to 1%, the allowed region for $C_{V_2}$ shrinks to the dark-blue regions.

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

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**Abstract:** Precise determination of the $B_c \to \tau\nu_\tau$ branching ratio provides an advantageous opportunity for understanding the electroweak structure of the Standard Model, measuring the CKM matrix element $|V_{cb}|$, and probing new physics models. In this paper, we discuss the potential of measuring the process $B_c \to \tau\nu_\tau$ with $\tau$ decaying leptonically at the proposed Circular Electron Positron Collider (CEPC). We conclude that during the $Z$ pole operation, the channel signal can achieve five-$\sigma$ significance with $\sim 10^9$ $Z$ decays, and the signal strength accuracies for $B_c \to \tau\nu_\tau$ can reach around 1% level at the nominal CEPC $Z$ pole statistics of one trillion $Z$ decays, assuming the total $B_c \to \tau\nu_\tau$ yield is $3.6\times10^6$. Our theoretical analysis indicates the accuracy could provide a strong constraint on the general effective Hamiltonian for the $b \to c\tau\nu$ transition. If the total $B_c$ yield can be determined to $O(1\%)$ level of accuracy in the future, these results also imply $|V_{cb}|$ could be measured up to $O(1\%)$ level of accuracy.

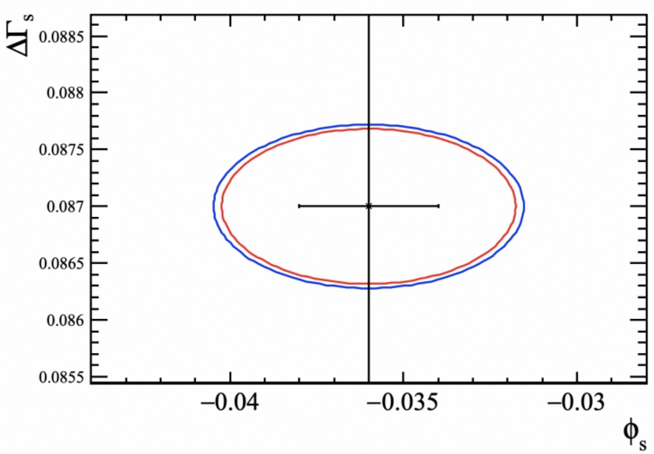
Taifan, etc, Accepted by CPC.
Collaborate with Wei Wang, et.al.

# CP measurement with Bs->J/psi Phi

$\Delta\Gamma_s \equiv \Gamma_L - \Gamma_H, \phi_s = -2\arg(-V_{ts}V_{tb}^*/V_{cs}V_{cb}^*)$

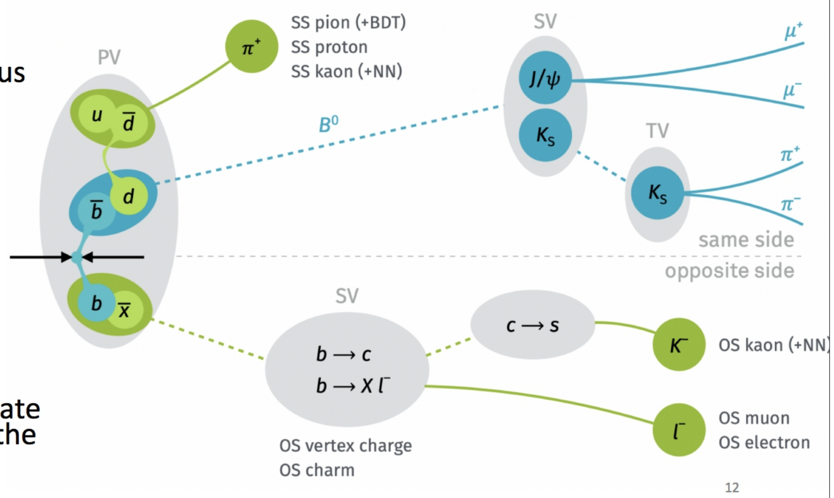
SM: small CPV phase $\phi_s$

Contributions from physics beyond the SM could lead to much larger values of $\phi_s$.

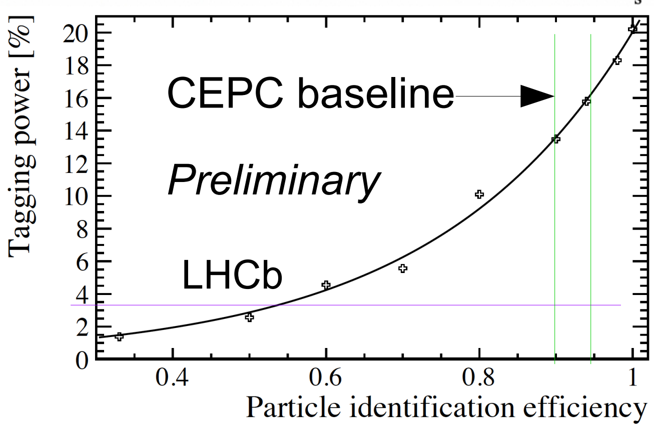



## Flavour tagging power

- LHCb: 3~4%
- CEPC: 15% (Previous estimation)
- B factory: ~30%




- For Bs:
  - OS lepton
  - OS kaon
  - SS kaon
- A naïve algorithm developed to validate the robustness of the estimation




- With a decent Pid, the effective tagging power on jet Charge can be 5-6 times better than LHCb, which can compensate the statistic difference between LHCb & CEPC.
- Strong motivation to higher Luminosity at Z pole