中国科学院高能物理研究所
Institute of High Energy Physics
Chinese Academy of Sciences

Status & Progress of the CEPC NP white paper

Xuai Zhuang (IHEP)

zhuangxa@ihep.ac.cn

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CEPC BSM Physics Program

1: Exotics of Higgs, W, Z, top
- Higgs exotic decay (SUSY, LLP, DS, invisible)
- Light higgs
- Z exotic decay
- Top exotic decay

Indirect searches from SM precision measurements *(not included here)*

9: Global fits
- Global fit of SUSY
- 2HDM global fit
- SMEFT global fit

8: More exotics
- Axion-like particles
- Lepton form factors
- Emergent Hadron Mass
- Exotic lepton mass
- ……

2: SUSY
- Light EWKinos
- Light sleptons
- Heavy selectrons
- ……

7: Neutrino
- Heavy neutrinos
- Active-sterile neutrino
- Non-standard neutrino interactions

3: Dark Matter & Dark Sector
- SUSY DM
- Higgs portal DM
- Vector boson portal DM
- Fermion portal DM
- EFT
- ……

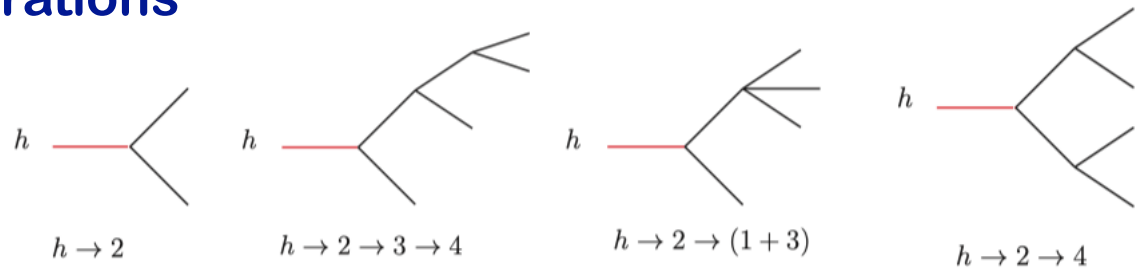
6: EWPT & GW
- Probe nature EWPT
- Higgs precision
- Higgs exotic decay

4: LLP
- At both CEPC and it's FAR detector
- H/Z decay
- SUSY LLP
- VLL, ALP, …

5: Flavor portal NP
- cLFV processes
- Decays of b and c hadrons
- ……

1. Exotic Higgs/Z/top decays

- A large class of BSM physics, such as singlet extensions, two Higgs-doublet-models (2HDM), SUSY models, Higgs portals, gauge extensions of the SM, motivates these exotic decay considerations



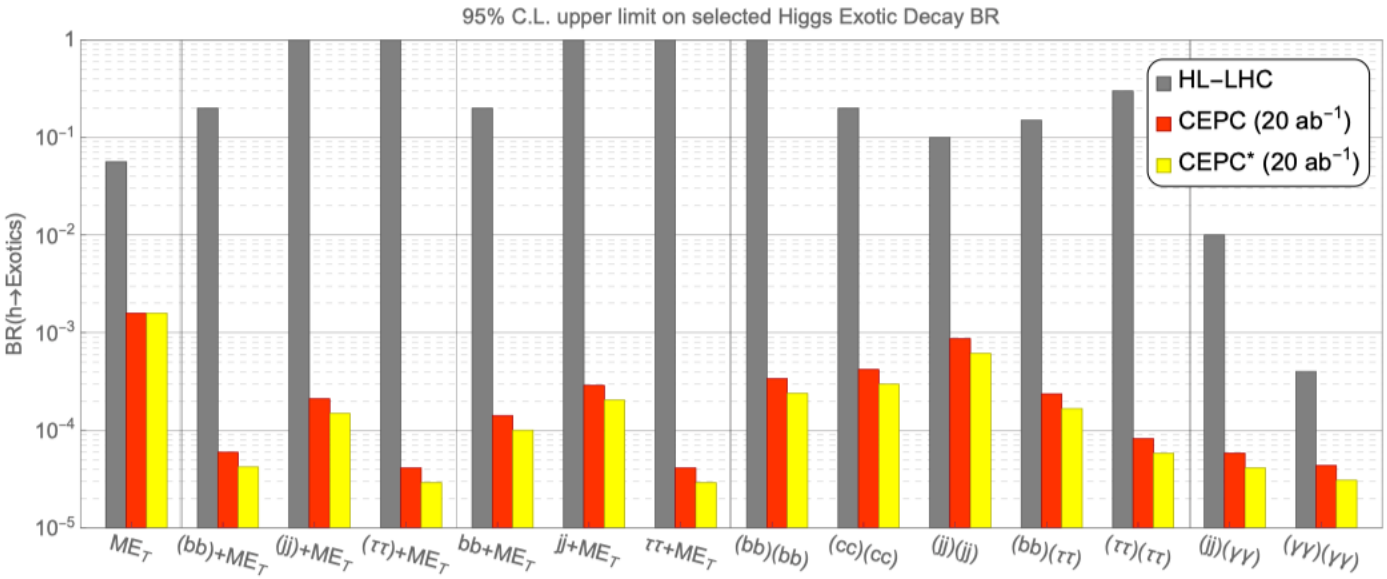
Representative topologies of the Higgs exotic decays

- **Light Higgs are motivated by 2HDM and Axion-like particle models, which can be searched at CEPC well if they exist.**
- Exotic Z or top decays are also motivated by many BSM models (ED, **Heavy Vector Triplet** , ...) and can also be searched at CEPC

BSM Higgs

- Many BSM models motivate Higgs exotic decay considerations: singlet extensions, 2HDM, SUSY models, Higgs portals, …

Z. Liu et al 1612.09284.

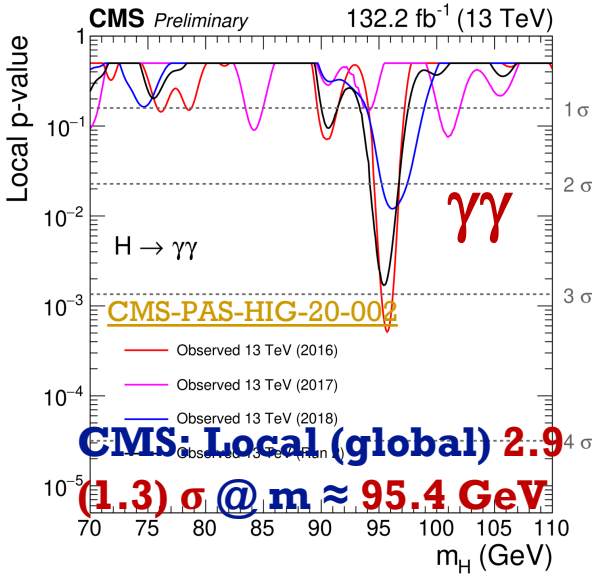


The 95% C.L. upper limit on selected Higgs exotic decay BR

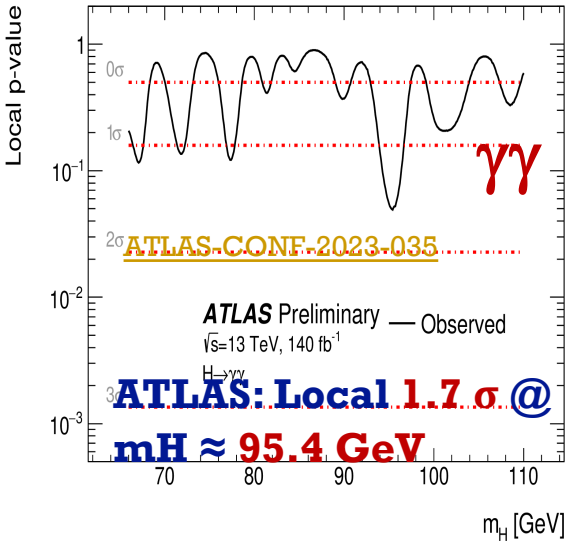
→ Good sensitivity of exotic Higgs decay from CEPC

Light Higgs

- **Light Higgs are motivated by 2HDM and Axion-like particle models**



CMS: Local (global) 2.9 (1.3) σ @ m ≈ 95.4 GeV

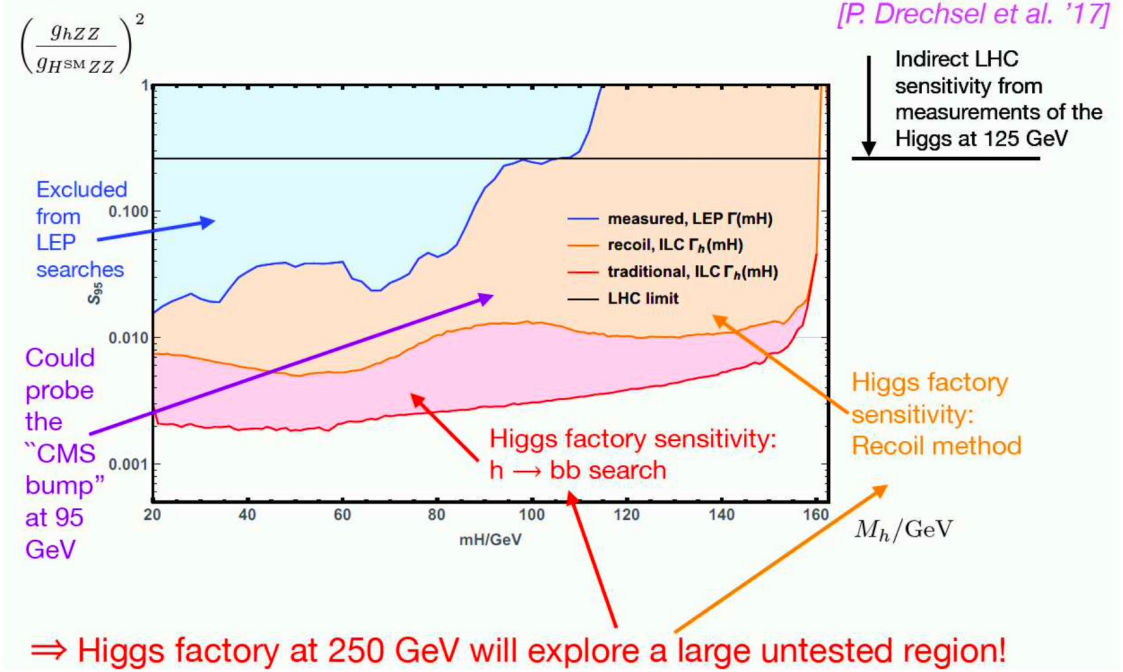


ATLAS: Local 1.7 σ @ mH ≈ 95.4 GeV

Physics opportunities at CEPC (originally for ILC, but equivalent!)

Example for discovery potential for new light states:
Sensitivity at 250 GeV with 500 fb^{-1} to a new light Higgs

[P. Drechsel et al. '17]



⇒ Higgs factory at 250 GeV will explore a large untested region!

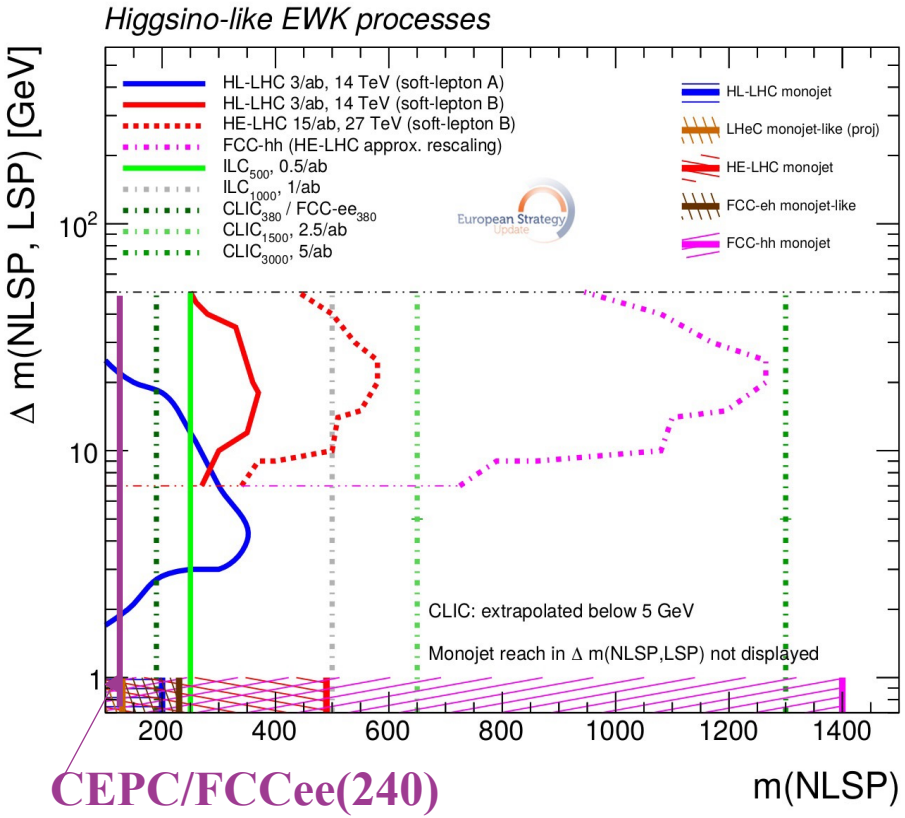
…en from G. Weiglein '18]

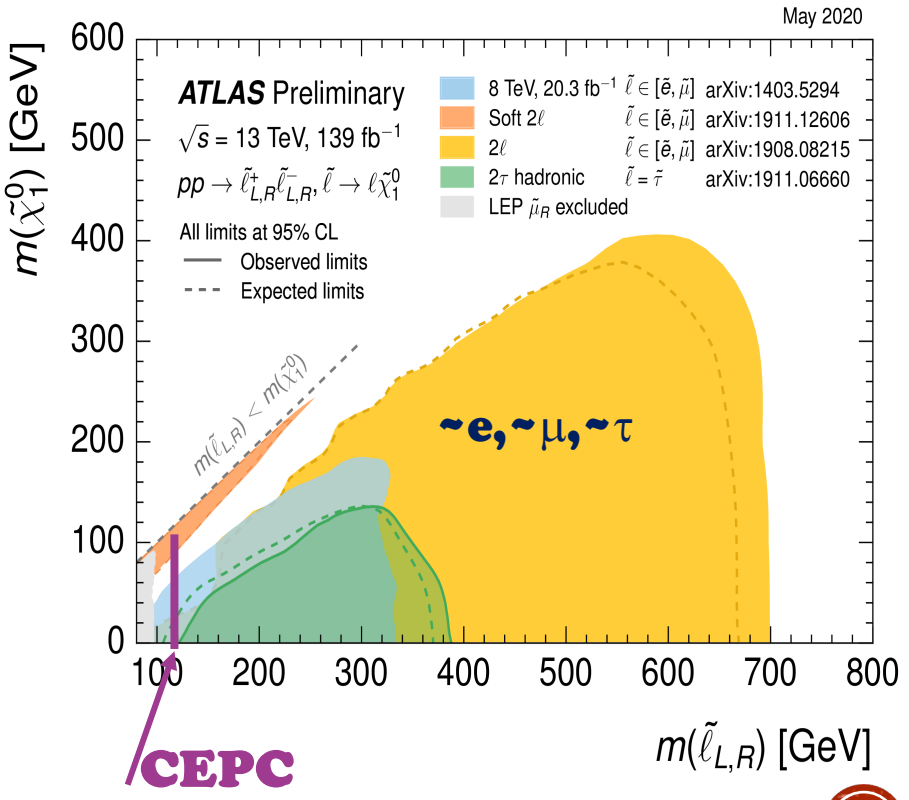
See Sven's talk

It can be searched at CEPC very well if exists.

2. SUSY Searches at CEPC

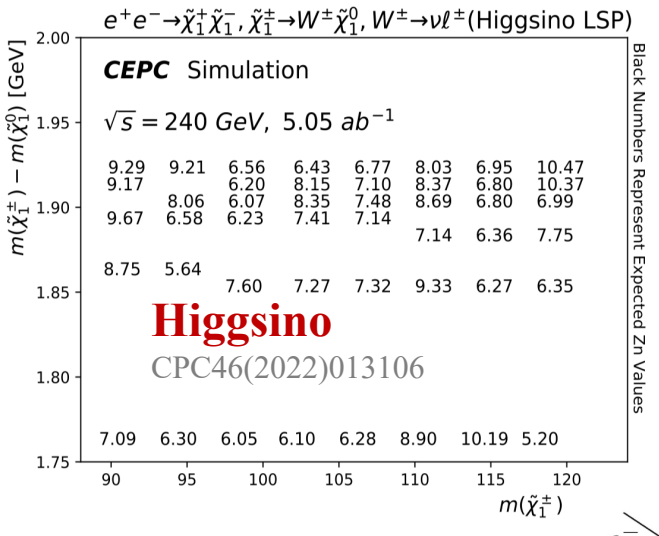
- **SUSY: establishes a symmetry between fermions and bosons, solve many big questions: unification, DM, Hierarchy, ……**
- **Complementary with LHC: lower mass/soft energy region**
  - ✓ **Mainly light EWKino and slepton for CEPC**

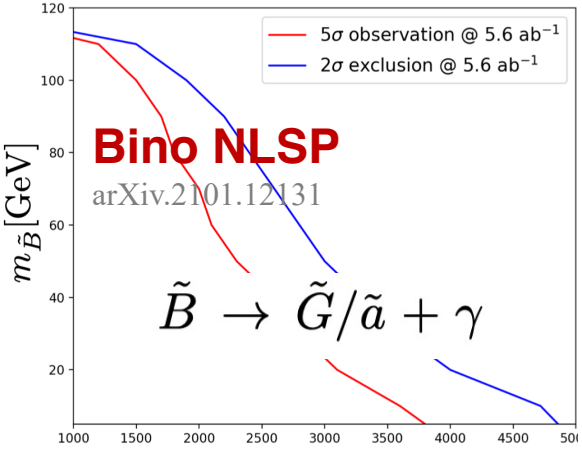


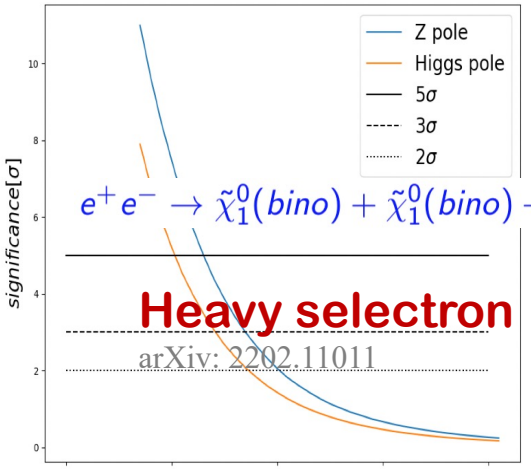


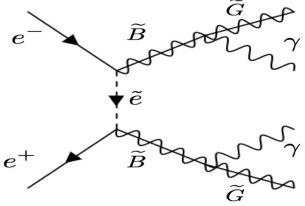
Lepton collider: discovery in all scenarios up to kinematic limit: √s/2

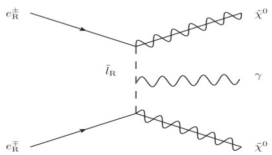
2. SUSY Searches at CEPC

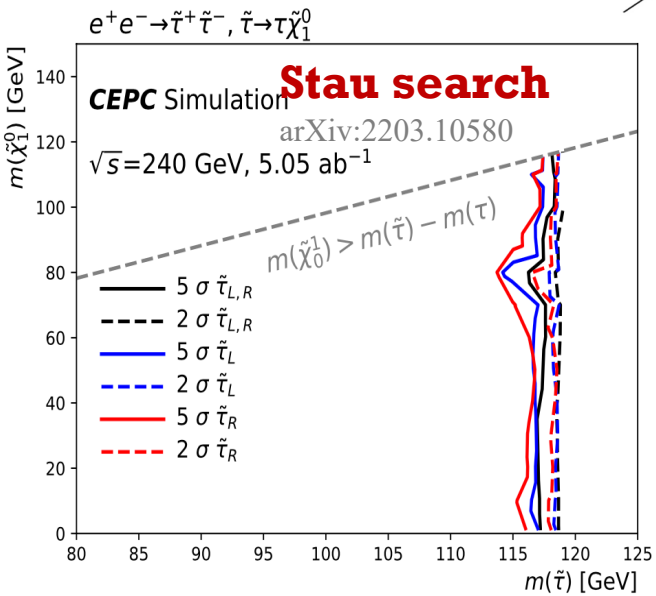


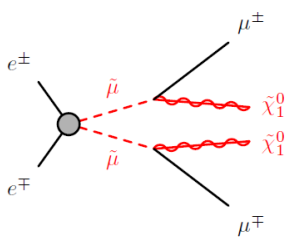


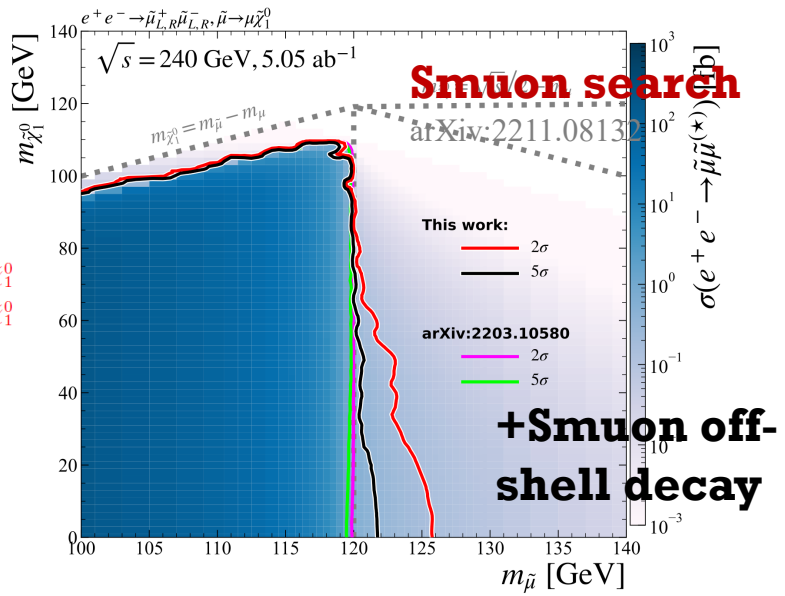






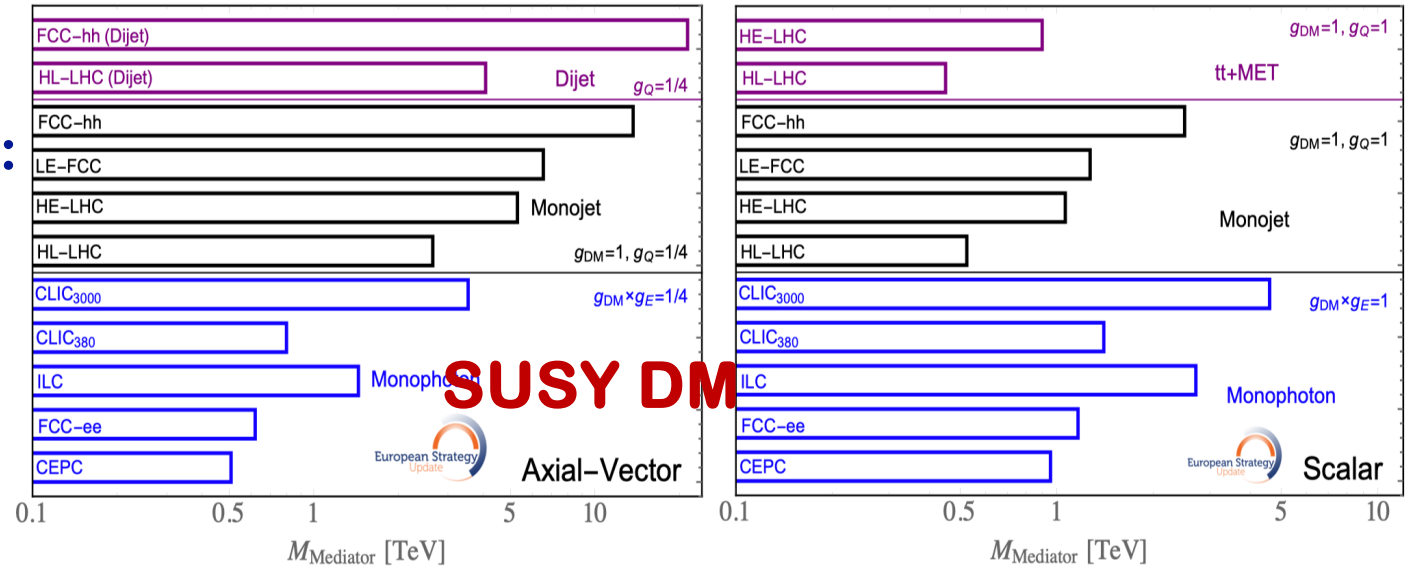


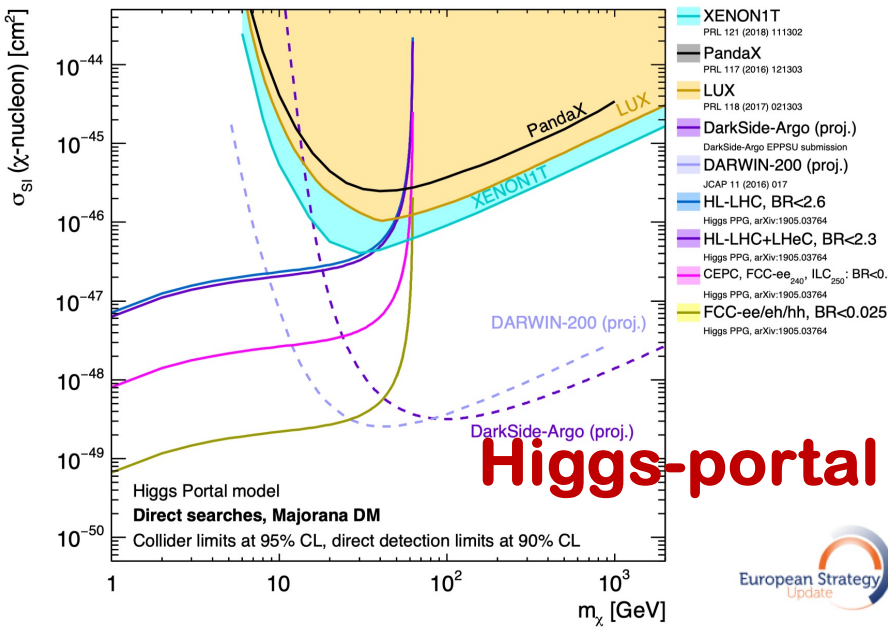


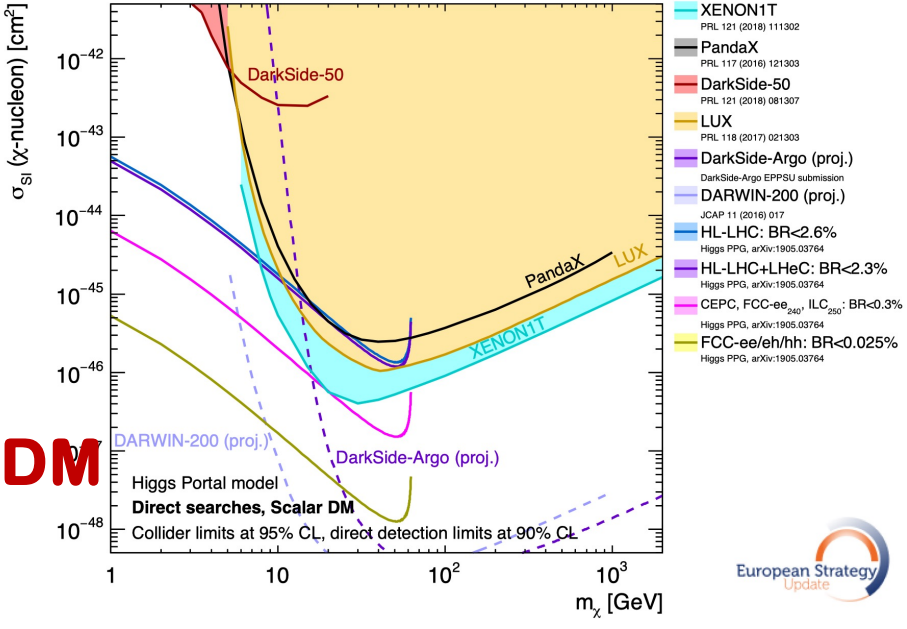


3. Dark Matter and Dark Sector

- **SUSY DM**
- **Non-SUSY DM:**
  - Higgs portal
  - Fermion portal
  - Vector portal
  - EFT



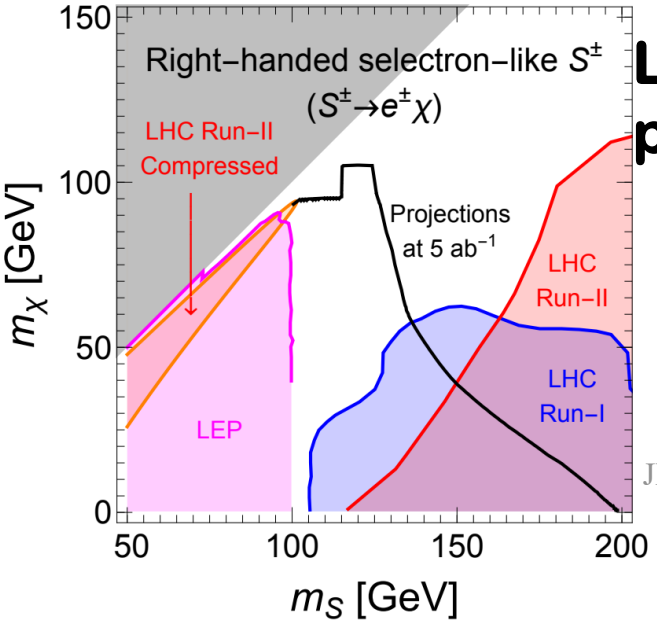




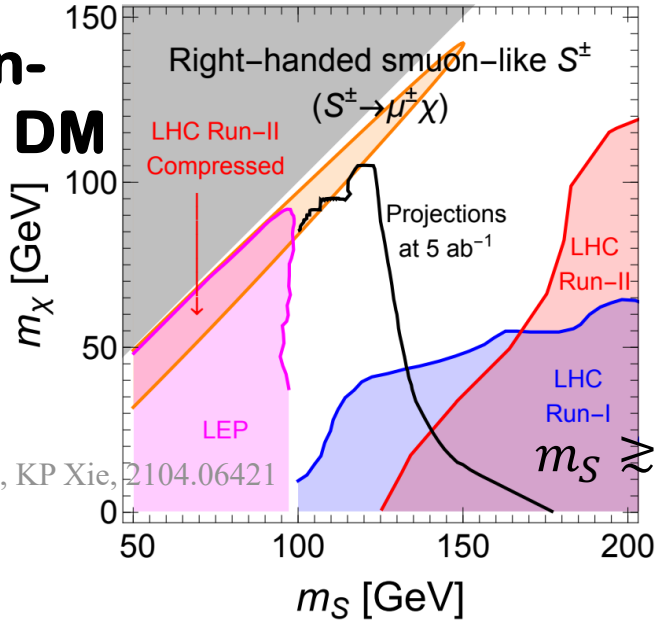
Higgs-portal DM

3. Dark Matter and Dark Sector

$$e^+e^- \to S^+S^{-*} \to S^+\ell^-\chi \to (\ell^+\chi)\ell^-\chi$$



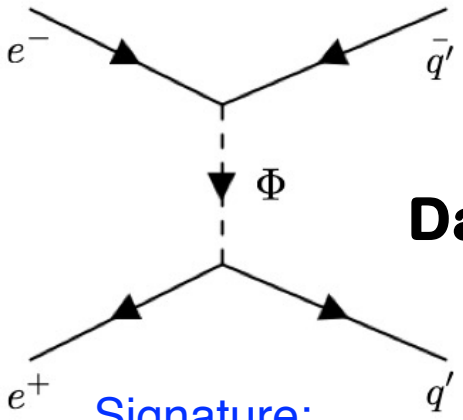
Lepton-portal DM



Fermion-portal DM

JL, XP Wang, KP Xie, 2104.06421

$m_S \gtrsim \sqrt{s}/2 = 120GeV$

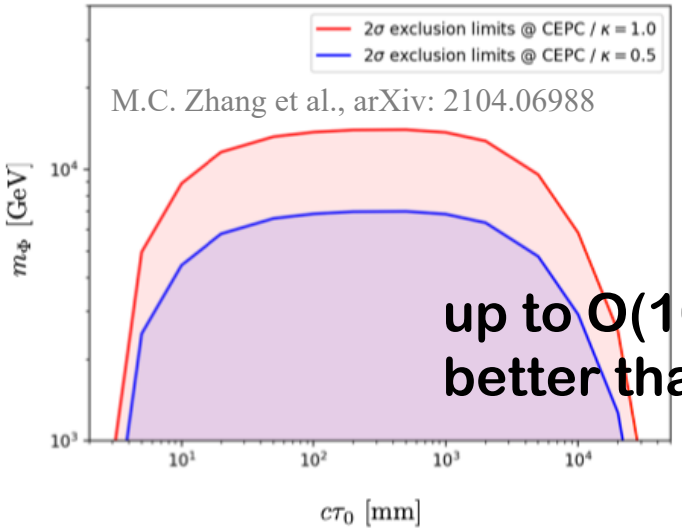


Decay to leptons

Dark jets

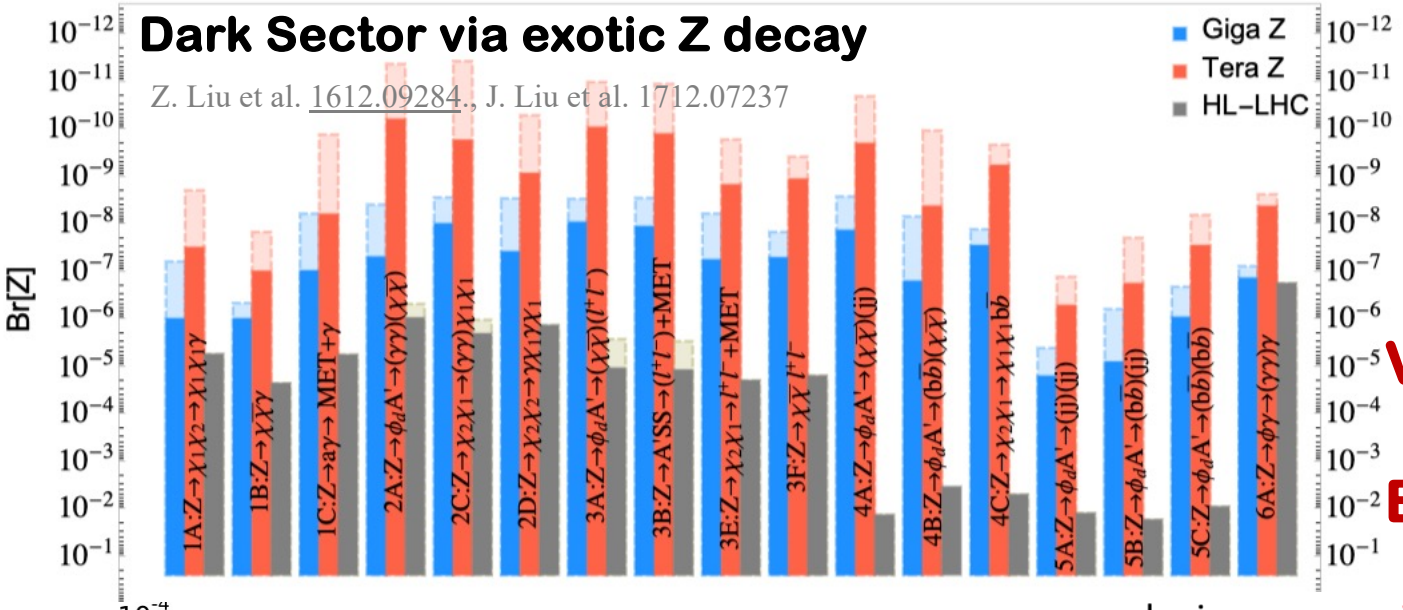
Jet-like

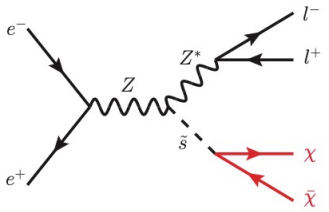
Signature:
Lepton + jet + MET



up to O(10) TeV, better than LHC

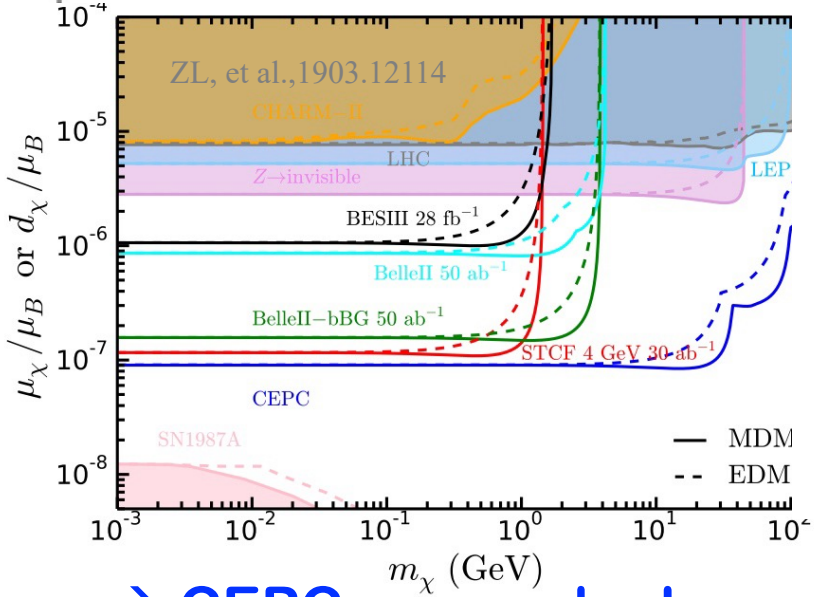
3. Dark Matter and Dark Sector



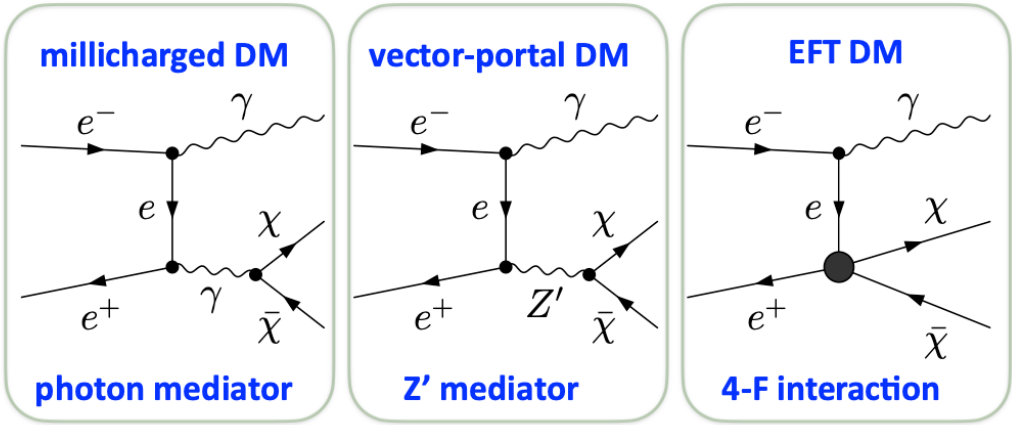


Vector-portal DM

EFT DM



new physics process: $e^+e^- \to \bar{\chi}\chi\gamma$



→ CEPC can probe low-mass light dark states.

4. Long-lived particles (LLP)

Long lifetimes result from a few simple physical mechanisms:

- **Small couplings (ex. RPV SUSY)**
- **Limited phase space: small mass splitting (ex. compressed SUSY, …)**
- **Heavy intermediate states**
- **……**

Long-lived Particle Searches (Liang Li, Ying-nan Mao, Kechen Wang, Zeren Simon Wang)

A. Computation of LLP signal-event rates

B. Studies with near detectors

1. Higgs boson decays
2. Z-boson decays
3. Supersymmetry (SUSY)
4. Vector-like leptons with scalar

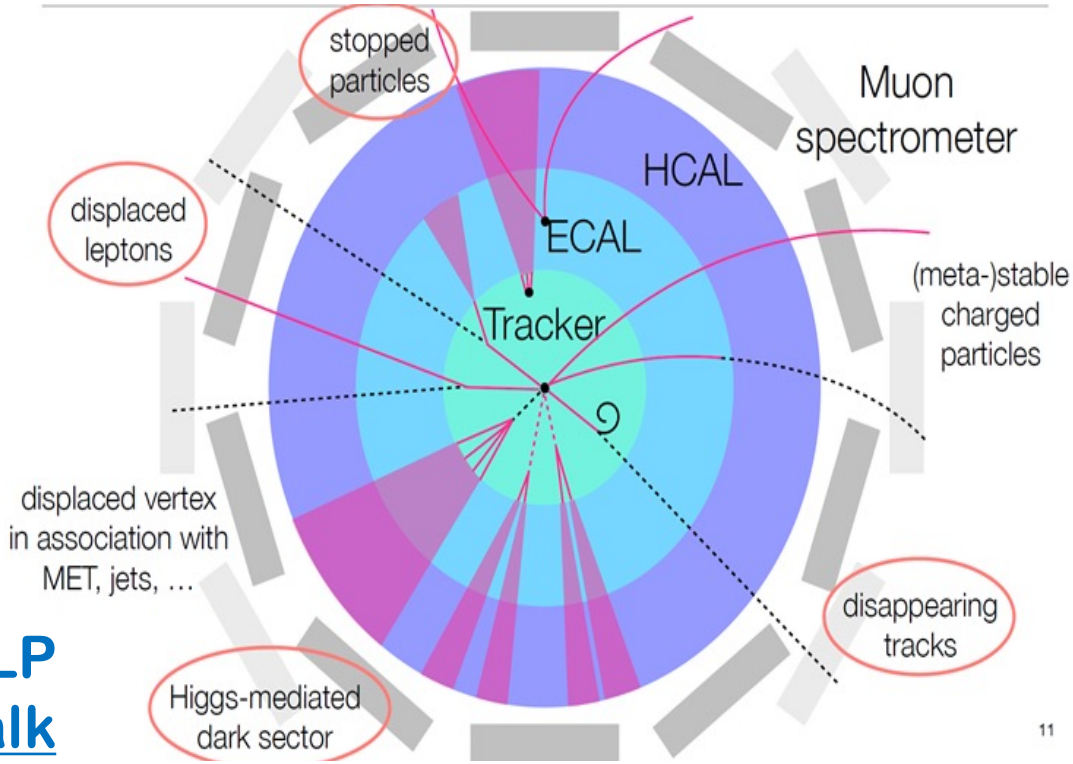
C. Studies with far detectors

1. Far detectors at hadron colliders
2. Proposed far detectors at lepton colliders
3. Higgs boson decays
4. $Z-$boson decays
5. Axion-like particles

D. Studies with beam dumps

1. ALPs and new scalar particles
2. New neutral gauge bosons

E. Summary and Discussion



See next LLP overview talk from Kechen!

5. Flavor portal NP

- CEPC is also a flavor factory (b,c,tau) when running at Z pole, which has a unique sensitivity for some rare processes due to suppression in SM
- The sensitivity of the flavor sector to new physics is underscored by several factors:
  - cLFV processes
  - Decays of b and c hadrons
  - Light BSM degrees of freedom from flavor transitions (cLFV or quark FCNC processes) with inv. BSM states or LLP

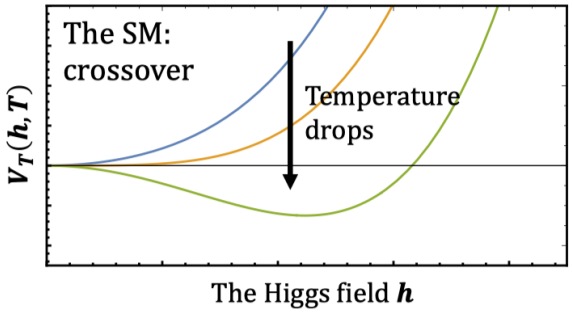
See flavor physics talk from Lingfeng!

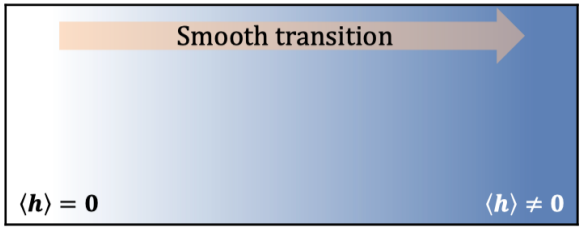
Measurement	Current Limit	CEPC [272]
$\mathrm{BR}(Z \to \tau\mu)$	$< 6.5 \times 10^{-6}$	$\mathcal{O}(10^{-9})$
$\mathrm{BR}(Z \to \tau e)$	$< 5.0 \times 10^{-6}$	$\mathcal{O}(10^{-9})$
$\mathrm{BR}(Z \to \mu e)$	$< 7.5 \times 10^{-7}$	$10^{-8} - 10^{-10}$
$\mathrm{BR}(\tau \to \mu\mu\mu)$	$< 2.1 \times 10^{-8}$	$\mathcal{O}(10^{-10})$
$\mathrm{BR}(\tau \to eee)$	$< 2.7 \times 10^{-8}$	$\mathcal{O}(10^{-10})$
$\mathrm{BR}(\tau \to e\mu\mu)$	$< 2.7 \times 10^{-8}$	$\mathcal{O}(10^{-10})$
$\mathrm{BR}(\tau \to \mu ee)$	$< 1.8 \times 10^{-8}$	$\mathcal{O}(10^{-10})$
$\mathrm{BR}(\tau \to \mu\gamma)$	$< 4.4 \times 10^{-8}$	$\mathcal{O}(10^{-10})$
$\mathrm{BR}(\tau \to e\gamma)$	$< 3.3 \times 10^{-8}$	$\mathcal{O}(10^{-10})$
$\mathrm{BR}(B_s \to \phi\nu\bar{\nu})$	$< 5.4 \times 10^{-3}$	$\lesssim 1\%$ (relative)
$\mathrm{BR}(B^0 \to K^{*0}\tau^+\tau^-)$	-	$\lesssim \mathcal{O}(10^{-6})$
$\mathrm{BR}(B_s \to \phi\tau^+\tau^-)$	-	$\lesssim \mathcal{O}(10^{-6})$
$\mathrm{BR}(B^+ \to K^+\tau^+\tau^-)$	$< 2.25 \times 10^{-3}$	$\lesssim \mathcal{O}(10^{-6})$
$\mathrm{BR}(B_s \to \tau^+\tau^-)$	$< 6.8 \times 10^{-3}$	$\lesssim \mathcal{O}(10^{-5})$
$\mathrm{BR}(B^0 \to 2\pi^0)$	$\pm 16\%$ (relative)	$\pm 0.25\%$ (relative)
$C_{CP}(B^0 \to 2\pi^0)$	± 0.22 (relative)	± 0.01 (relative)
$\mathrm{BR}(B_c \to \tau\nu)$	$\lesssim 30\%$	$\pm\ 0.5\%$ (relative)
$\mathrm{BR}(B_c \to J/\psi\tau\nu)/\mathrm{BR}(B_c \to J/\psi\mu\nu)$	$\pm\ 0.17 \pm 0.18$	$\pm 2.5\%$ (relative)
$\mathrm{BR}(B_s \to D_s^{(*)}\tau\nu)/\mathrm{BR}(B_s \to D_s^{(*)}\mu\nu)$	-	$\pm 0.2\%$ (relative)
$\mathrm{BR}(\Lambda_b \to \Lambda_c\tau\nu)/\mathrm{BR}(B_c \to \Lambda_c\mu\nu)$	$\pm\ 0.076$	$\pm 0.05\%$ (relative)
$\mathrm{BR}(\tau \to \mu X_{\mathrm{inv.}})$	7×10^{-4}	(3-5)$\times 10^{-6}$
$\mathrm{BR}(B \to \mu X_{\mathrm{LLP}}(\to \mu\mu))$	-	$\mathcal{O}(10^{-10})$ (optimal)

Preliminary sensitivities of BSM flavor physics probes at CEPC
> two orders of magnitude improv.

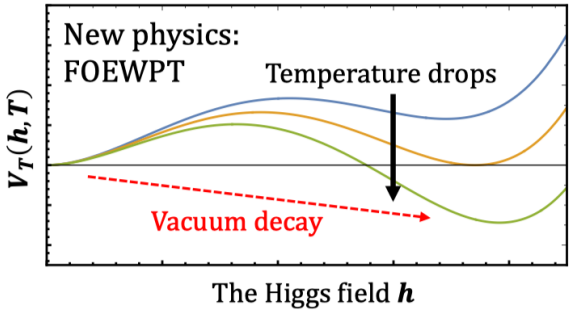
6. EWPT at CEPC

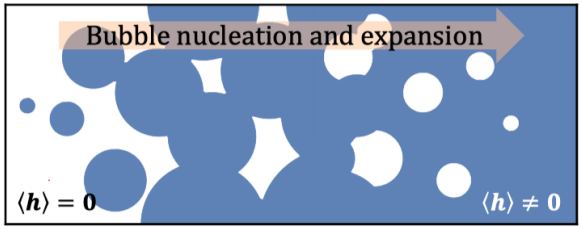
- The nature of Electroweak Phase Transition deeply impacts the thermal history of the Universe, closely linked to puzzles of DM, matter-antimatter asymmetry
  - Probing the nature of EWPT at colliders





In the SM, the transition is a smooth crossover

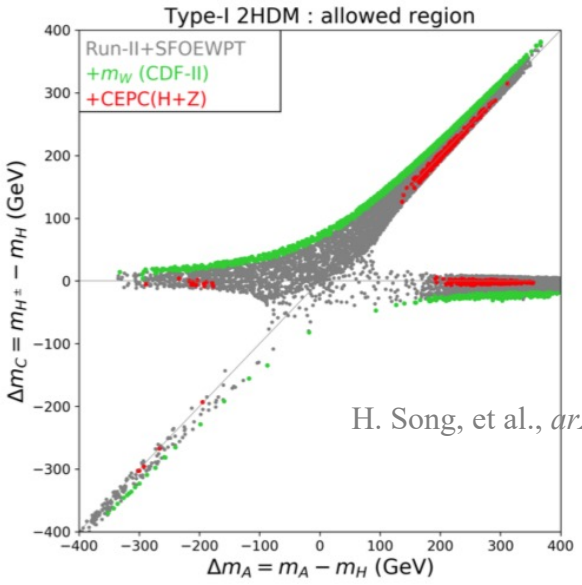


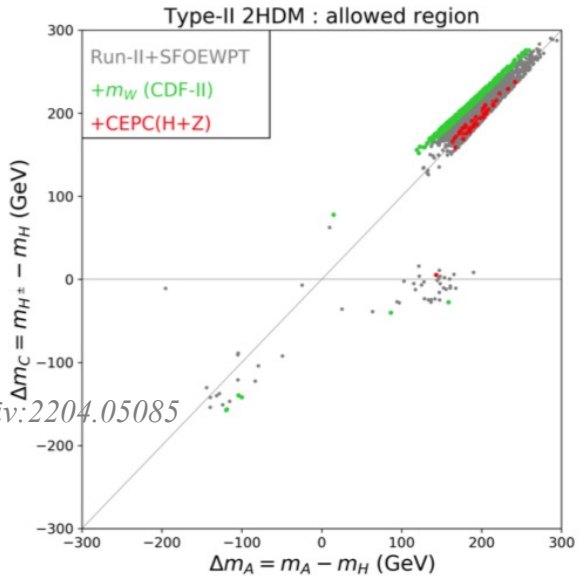


In NP, the scalar potential exhibits a barrier, allowing for a FOEWPT with bubble nucleation and expansion

  - Higgs precision measurements
  - Higgs exotic decay

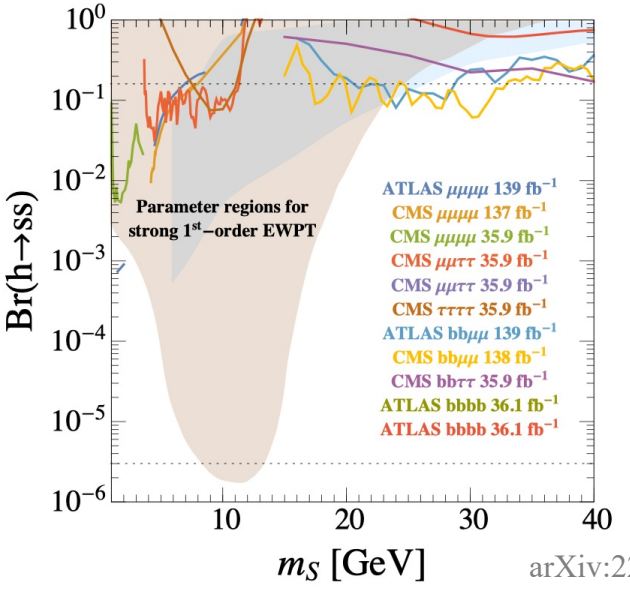
6. EWPT at CEPC



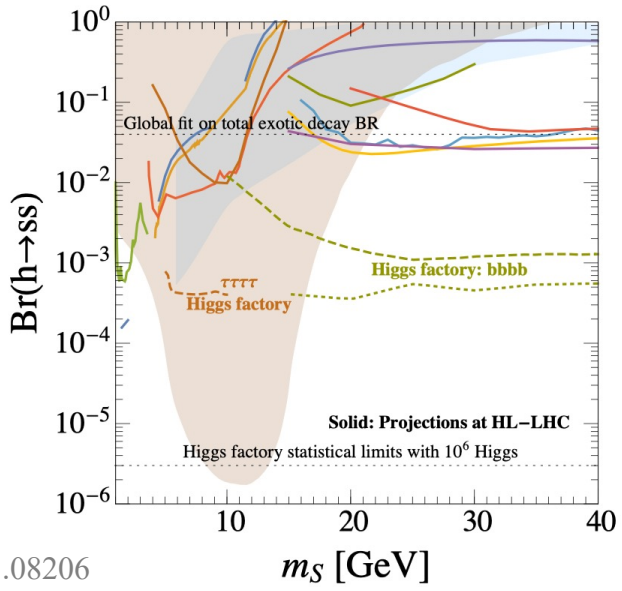


H. Song, et al., *arXiv:2204.05085*

Under current constraints, both Type-I and Type-II 2HDM can explain the SFOEWPT, Z-pole, Higgs precision measurements and mW precision measurement of CDF-II at same time.



arXiv:2203.08206



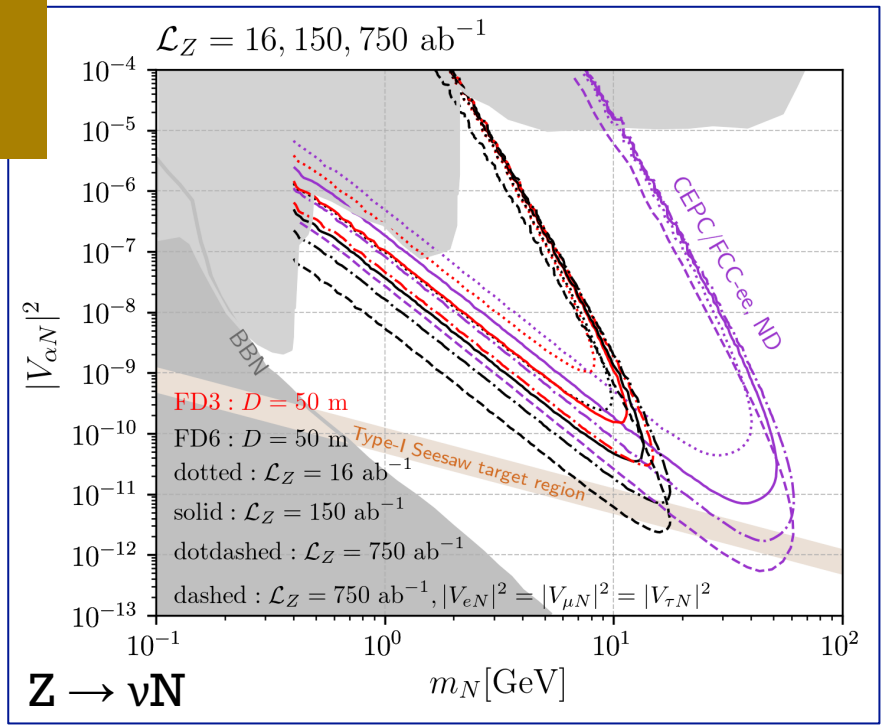
Higgs exotic decay h→ss→XXYY as a probe for the FOEWPT:

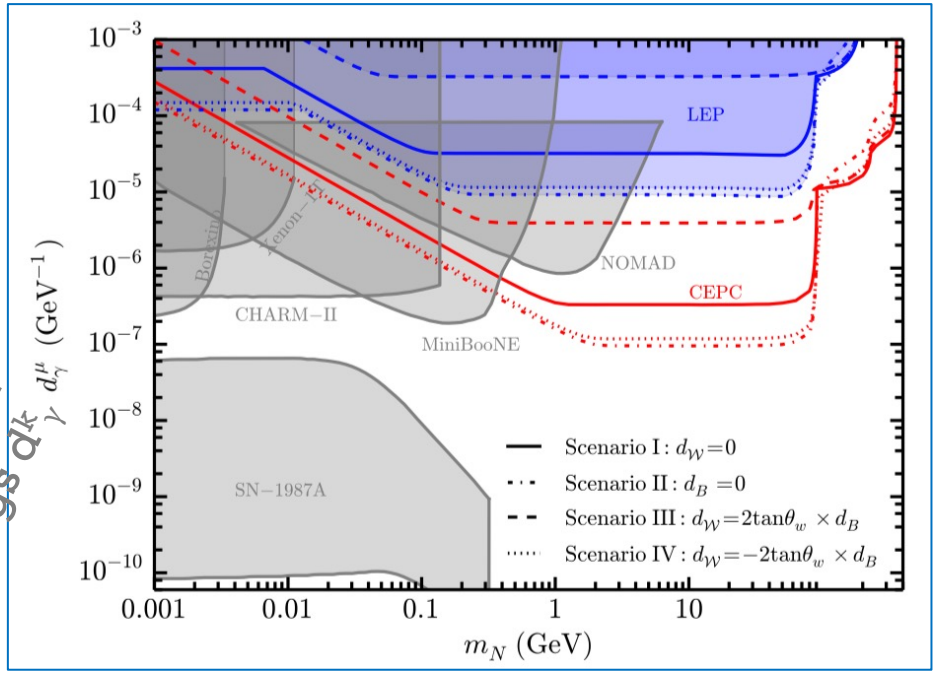
CEPC has the potential to probe almost the entire FOEWPT parameter space for 4b and 4tau channels

7. Neutrino physics

BSM related neutrino physics from new messengers and interactions at EW scale:

- Heavy neutrino (@ND, FD)
- Active-sterile neutrino transition magnetic moments
- Non-standard neutrino interactions
- Possibility of connecting to leptogenesis (collider probes)
- Possibility of connecting to dark matter (sterile neutrino in the νMSM)

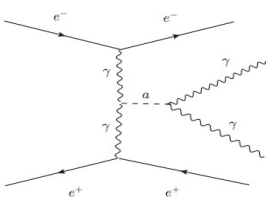


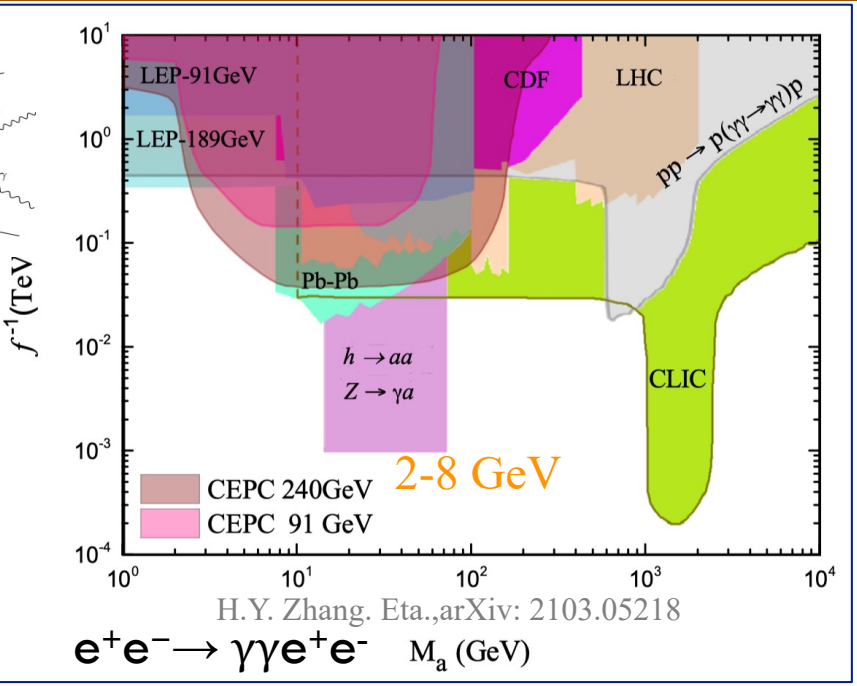


8. More exotics

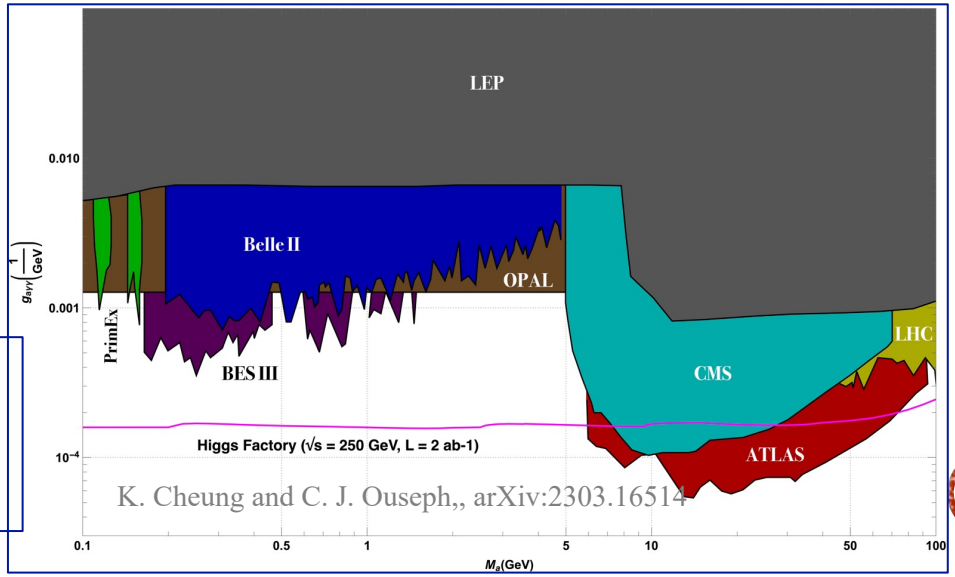
High precision of Z, h width offers power test of exotics process of Lepton number/flavor violation, Sterile states, Axion-like particles …

- Axion-like particles (solve "strong-CP" problem)
- Lepton form factors (μ /e g-2, μ /e dipole moments in SUSY, τ weak-electric dipole moments)
- Emergent Hadron Mass
- Exotic lepton mass models
- ……





H.Y. Zhang. Eta.,arXiv: 2103.05218



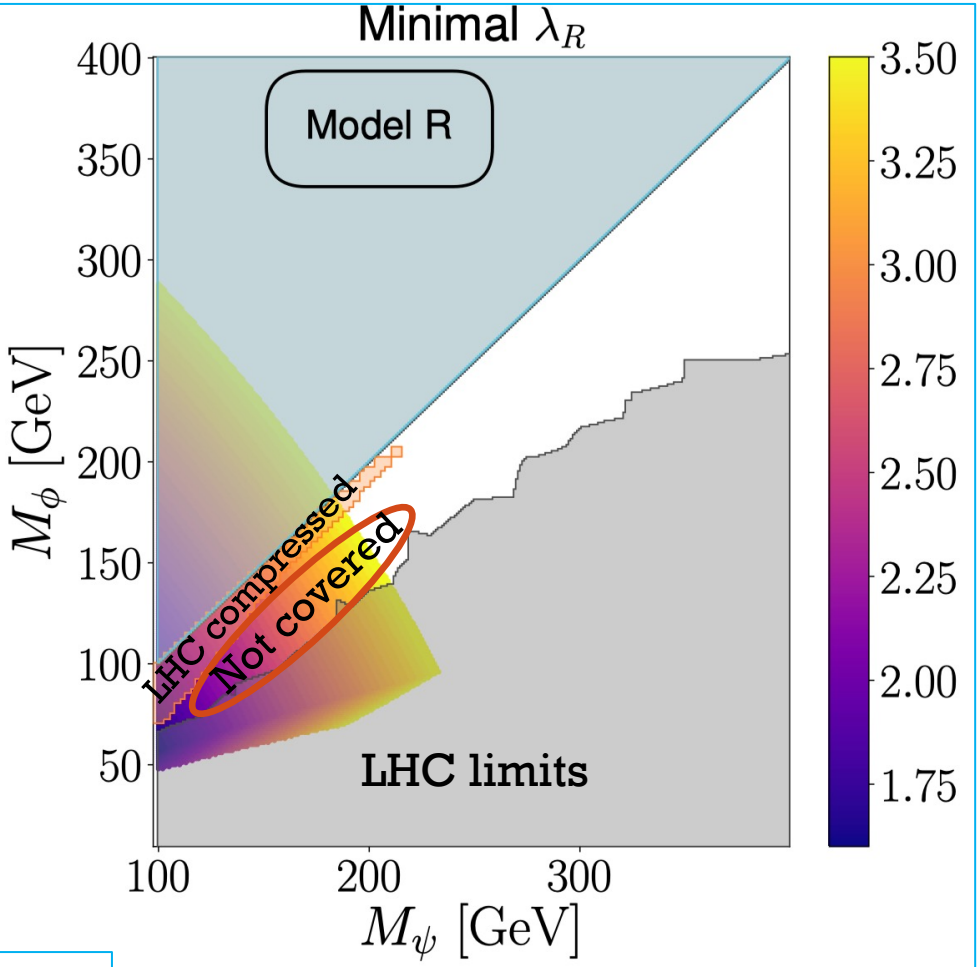
K. Cheung and C. J. Ouseph,, arXiv:2303.16514

Improve the sensitivity down to 2×10^{-4} GeV^{-1} for Ma<6 GeV

8. More exotics

High precision of Z, h width offers power test of exotics process of Lepton number/flavor violation, Sterile states, Axion-like particles …

- Axion-like particles (solve "strong-CP" problem)
- Lepton form factors (μ /e g-2, μ /e dipole moments in SUSY, τ weak-electric dipole moments)
- Emergent Hadron Mass
- Exotic lepton mass models
- ……



A simple model with a new scalar and and a new fermion

- Light EWKinos, smuon, stau co-annihilation can explain mu g-2 excess
- Gaps from LHC, can cover by CEPC

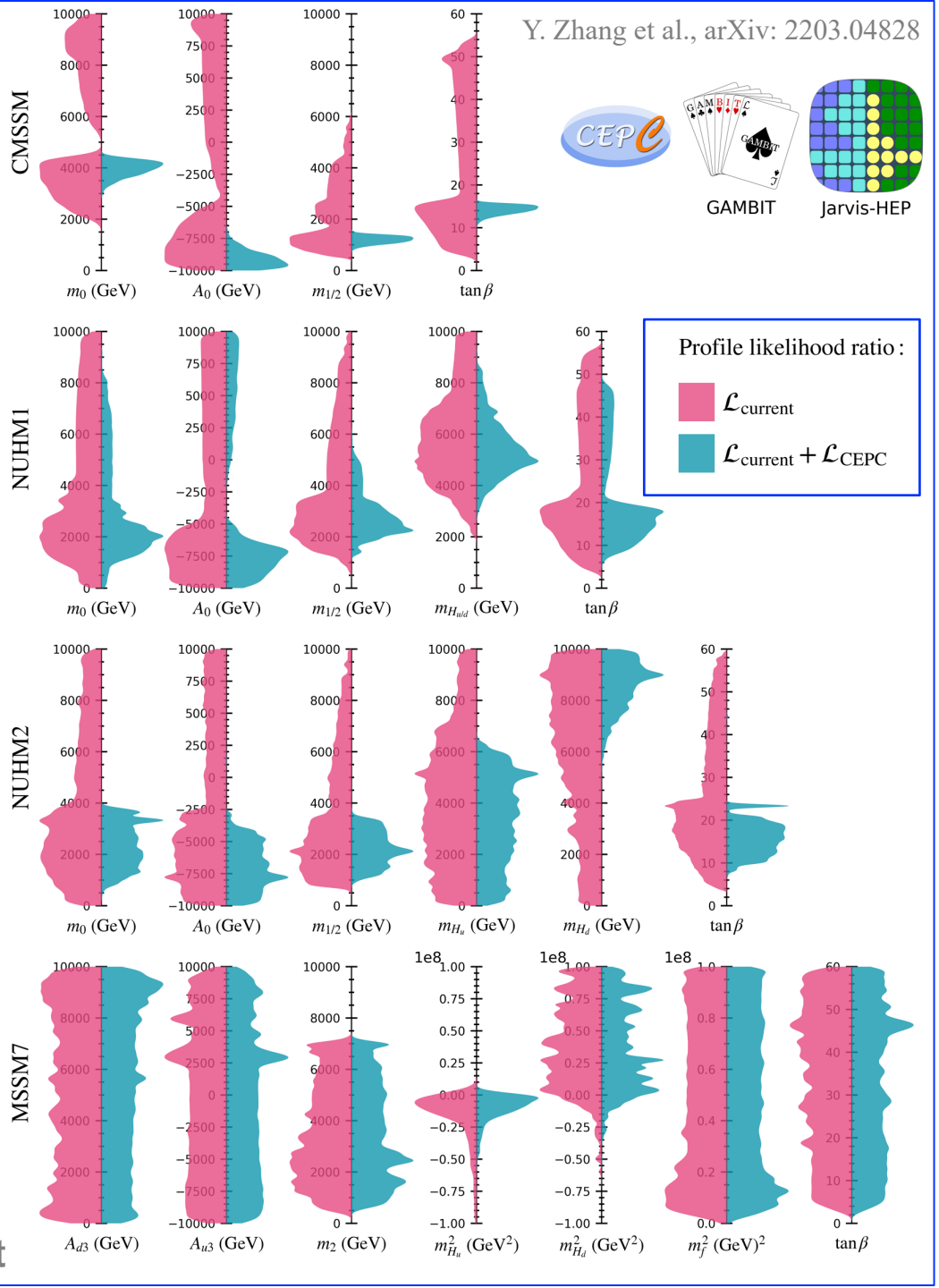
9. Global fits

Global fits: an essential tool to obtaining a thorough understanding of a NP model, and the implications and predictions of the models for future searches and experiments.

- SUSY global fits
- 2HDM
- SMEFT

CEPC has the potential to greatly enhance our understanding of the parameter space and mass spectrum in the MSSM.

One-dimensional profiled likelihood ratio for the global fit

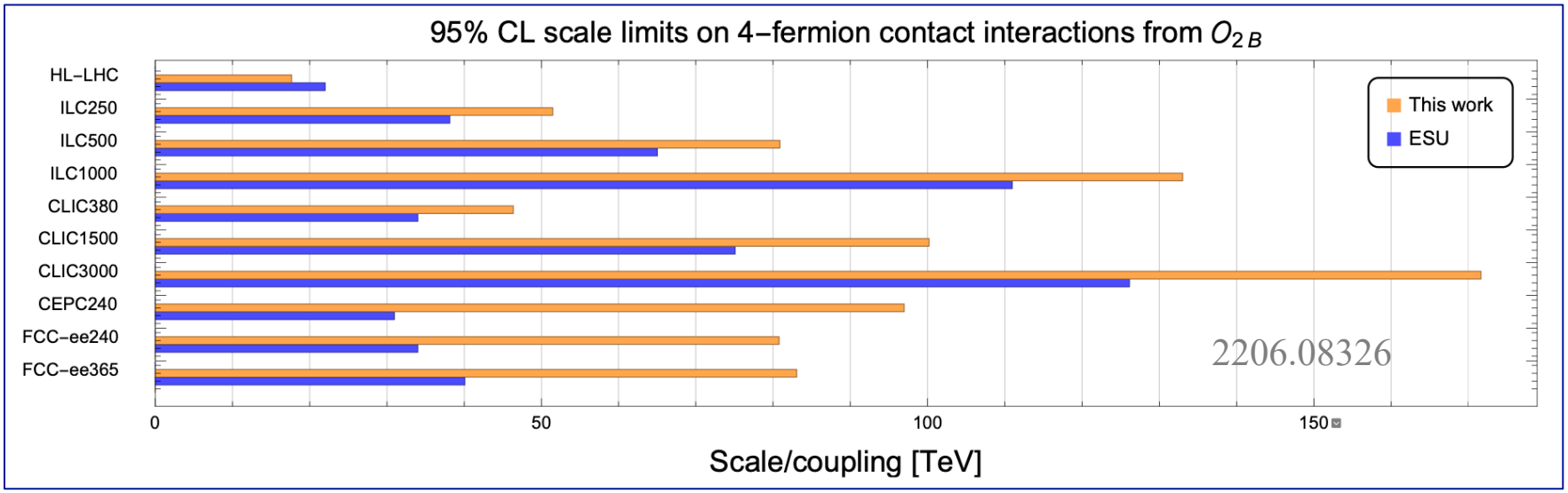


9. Global fits

Global fits: an essential tool to obtaining a thorough understanding of a NP model, and the implications and predictions of the models for future searches and experiments.

- **SUSY global fits**
- **2HDM**
- **SMEFT**

- **SMEFT global fit for 4-fermion and CPV operators at future colliders**
- The sensitivity to NP from global fit is significantly enhanced thanks to the high energy/ luminosity/beam polarization of future lepton colliders



Preliminary CEPC BSM white paper

ABSTRACT (TO BE UPDATED)

The Circular Electron Positron Collider (CEPC) is a large-scale collider facility that can serve as a factory of the Higgs, Z, and W bosons and is upgradable to run at the $t\bar{t}$ threshold. This document describes the latest CEPC nominal operation scenario and particle yields and updates the corresponding physics potential. A new detector concept is also briefly described. This submission is for consideration by the Snowmass process.

CONTENTS

Summary and Outlook

- **CEPC has good discovery potential for NP, which is good complementary to LHC**
- **BSM prospects study at CEPC is going on well, many of the analyses are already public:** partial of BSM prospects at CEPC are included in CEPC snowmass white paper in 2023: arXiv:2205.08553
- **CEPC BSM white paper is preparing and to be ready for review by this summer**
- **Please let us know if you would like to help to polish and review the BSM white paper !**

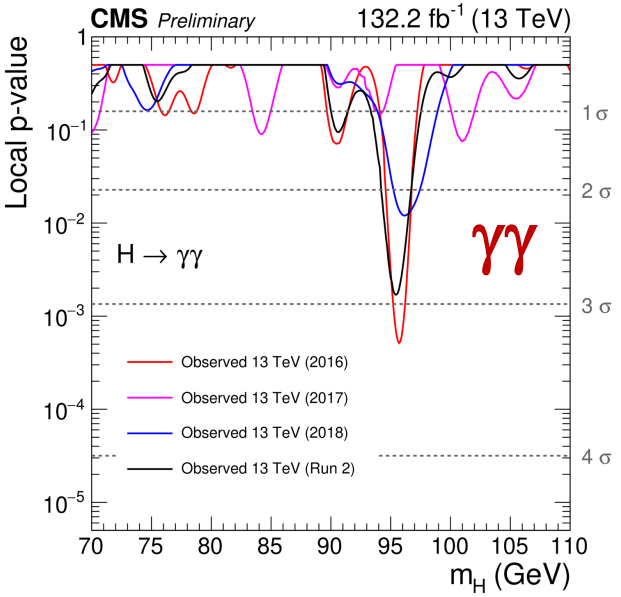
Thanks for your attention!

Backup

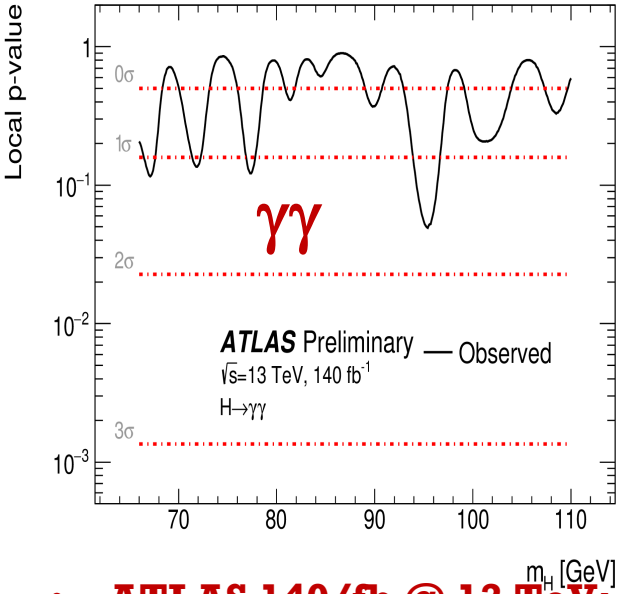
Light Higgs

- **Light Higgs are motivated by 2HDM and Axion-like particle models**

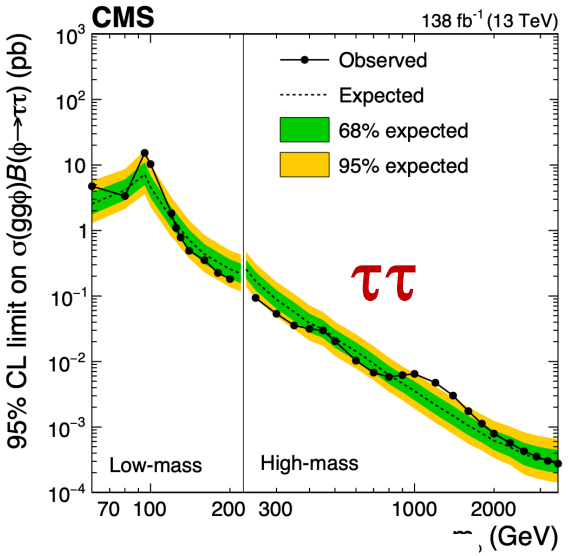
CMS-PAS-HIG-20-002



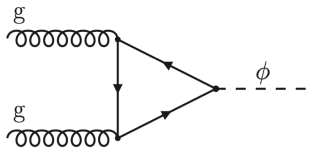
ATLAS-CONF-2023-035



arXiv:2208.02717



- **ATLAS 140/fb @ 13 TeV:**
  Local 1.7 σ @ mH ≈ 95.4 GeV



- **CMS 132.2/fb @ 13 TeV:**
  Local (global) 2.9 (1.3) σ @ m ≈ 95.4 GeV
- **Previous CMS result 20+36/fb@ 8+13 TeV:**
  Local (global) 2.8 (1.3) σ @ m ≈ 95.3 GeV

- **CMS 132.2/fb @ 13 TeV: ggϕ (ϕ–>ττ)**
  Local (global) 3.1 (2.7) σ @ m ≈ 100 GeV
  Local (global) 2.8 (2.2) σ @ m ≈ 1200 GeV

The excess did not grow with luminosity, but remains intriguing, which can be searched at CEPC very well if exists.

Identify CP-odd component in Higgs

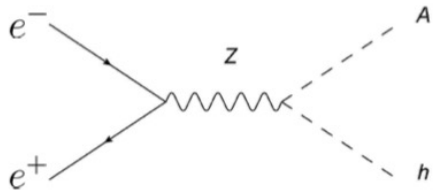
- **Use di—higgs production to identify CP-odd component in Higgs boson, Changlong Xu's talk**
- Future electron-positron colliders are more powerful for exploring the ZHH Di-Higgs production

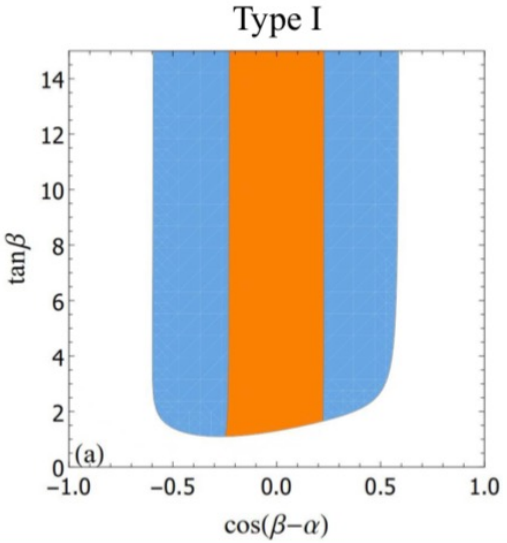
Di-Higgs in CEPC/ILC/FCC-ee

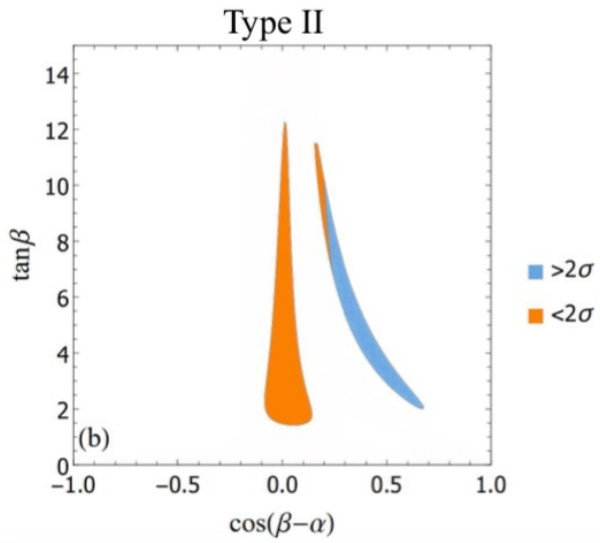
350 GeV e^+e^- collider: 1 ab^{-1}

$b\bar{b}b\bar{b}$ final state

$$\mathcal{L}_{ZhA} \sim i\,(h\partial_\mu A - A\partial_\mu h)\,Z^\mu \frac{g}{2\cos\theta_w}\cos(\beta-\alpha)$$







Type-I: $\kappa_h^f = \sin(\beta-\alpha) + \frac{\cos(\beta-\alpha)}{\tan\beta}$

$\kappa_A^u = \frac{1}{\tan\beta} \quad \kappa_A^{d,\ell} = -\frac{1}{\tan\beta}$

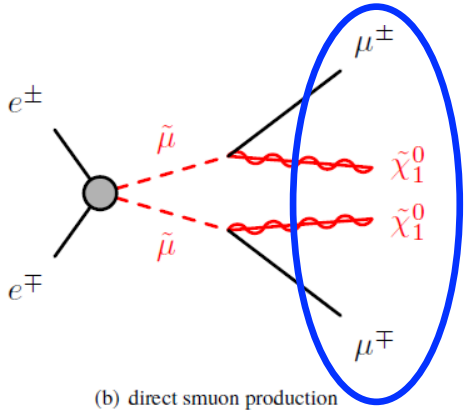
Type-II: $\kappa_h^u = \sin(\beta-\alpha) + \frac{\cos(\beta-\alpha)}{\tan\beta}$

$\kappa_h^{d,\ell} = \sin(\beta-\alpha) - \cos(\beta-\alpha)\tan\beta$

$\kappa_A^u = \frac{1}{\tan\beta} \quad \kappa_A^{d,\ell} = \tan\beta$

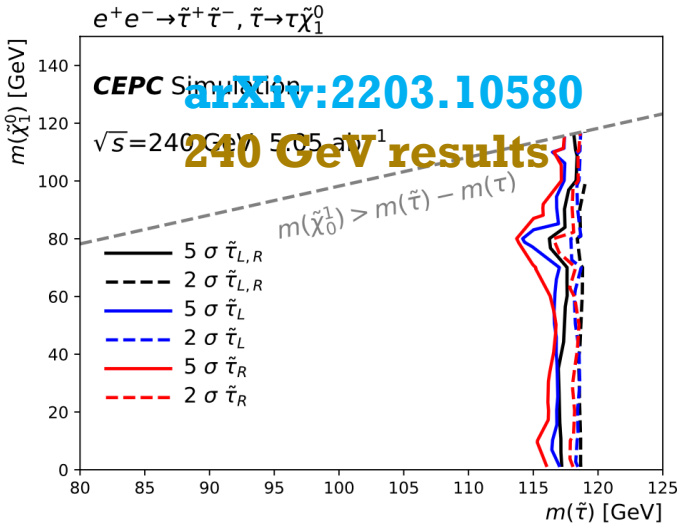
Slepton search

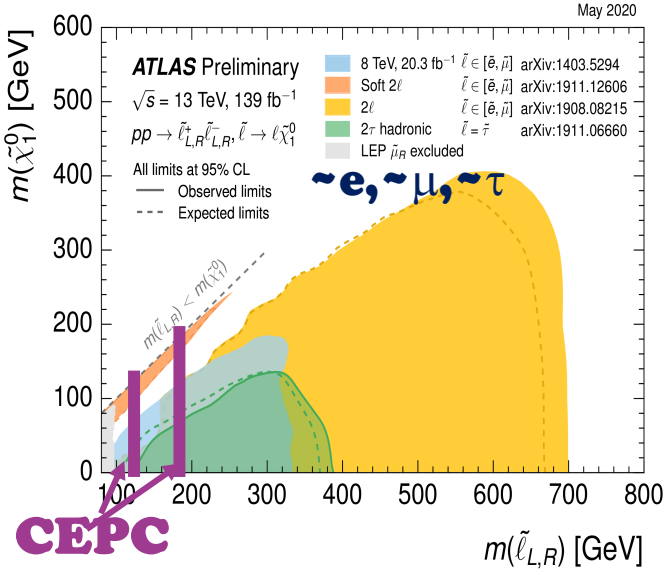
- Prospects for slepton pair production at CEPC, Jia-Rong Yuan, Hua-Jie Cheng, Xu-Ai Zhuang, arXiv: 2203.10580

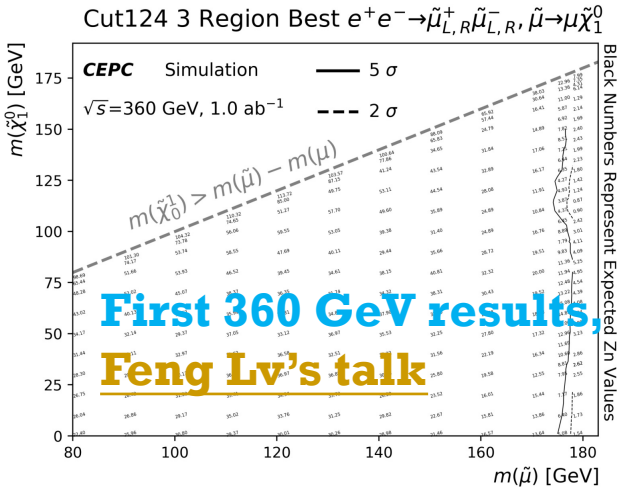


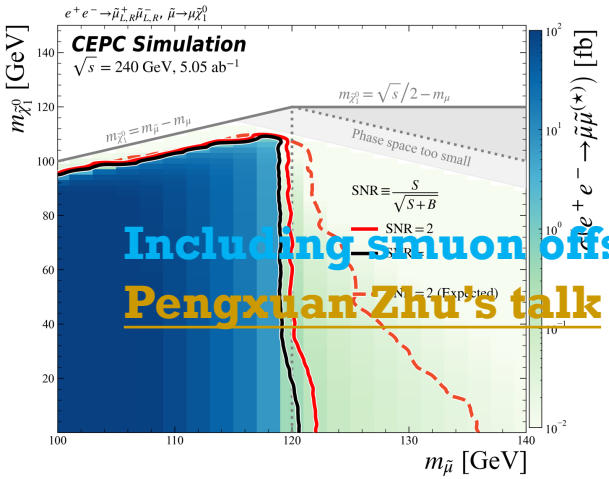
(b) direct smuon production

Signature:
2 lepton + MET





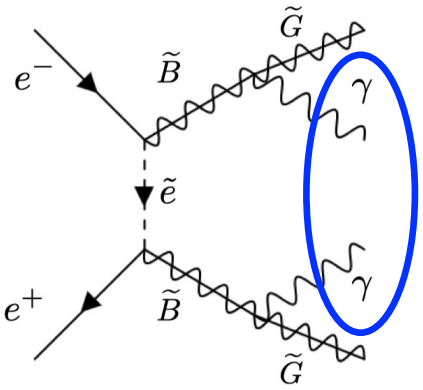




$e^+e^- \to \tilde{\mu}\tilde{\mu}^{(*)} \to \mu^+\tilde{\chi}_1^0\mu^-\tilde{\chi}_1^0$

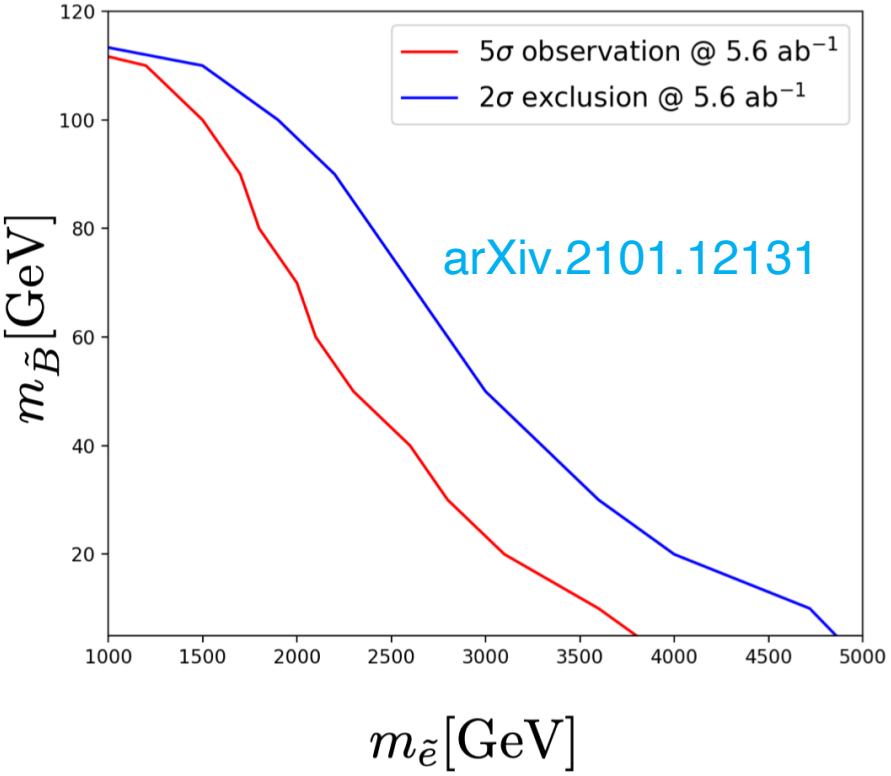
Bino NLSP at CEPC

- Probing bino NLSP at lepton colliders with Gravitino DM, Junmou Chen, Chengcheng Han, Jin Min Yang, Mengchao Zhang, arXiv:2101.12131.



$$\tilde{B} \to \tilde{G}/\tilde{a} + \gamma$$

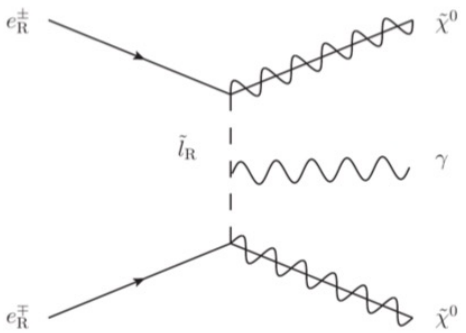
Signature:
2 photons + MET



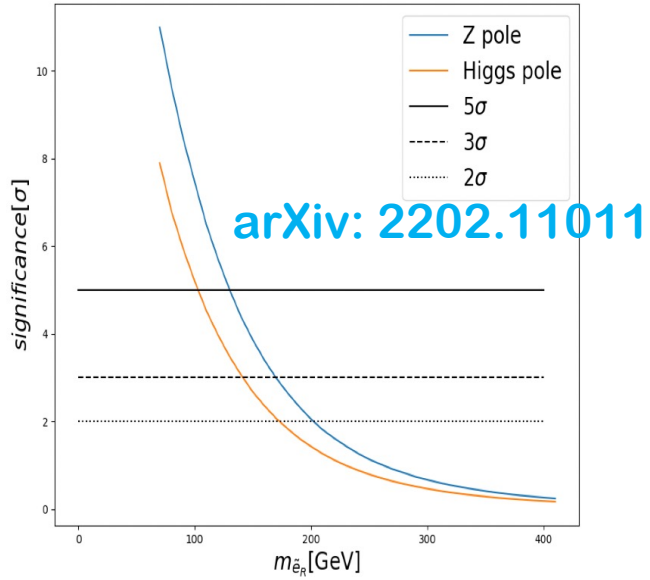
Heavy selectron search

- Probing relatively heavier right-handed selectron in the GmSUGRA, by Waqas Ahmed, Imtiaz Khan, Tianjun Li, Shabbar Raza and Wenxing Zhang, arXiv: 2202.11011
- There two types of light neutralinos that achieve the correct relic density by Z-resonance and h-resonance.

Higgs-pole $\rightarrow m_{\tilde{\chi}_1^0} \approx \frac{1}{2} m_h$ and Z-pole $\rightarrow m_{\tilde{\chi}_1^0} \approx \frac{1}{2} m_Z$.



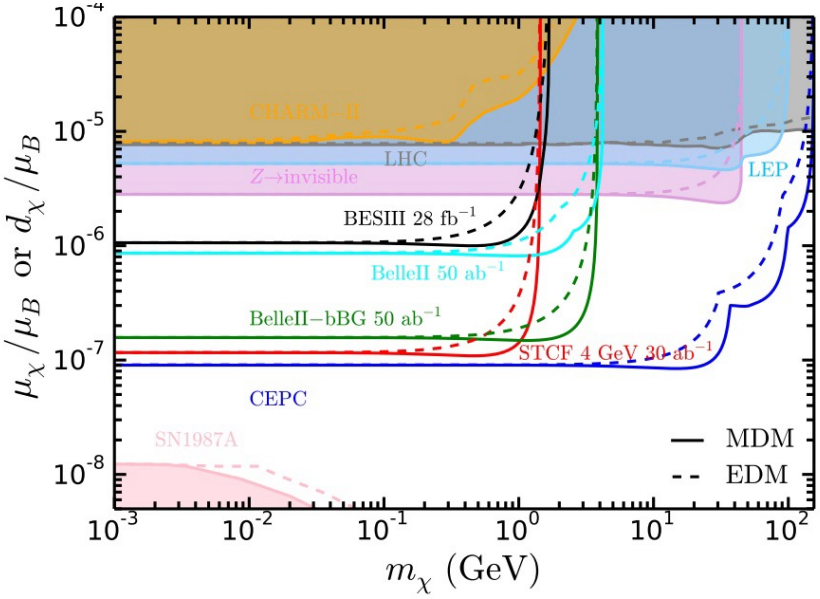
$e^+e^- \rightarrow \tilde{\chi}_1^0(bino) + \tilde{\chi}_1^0(bino) + \gamma$



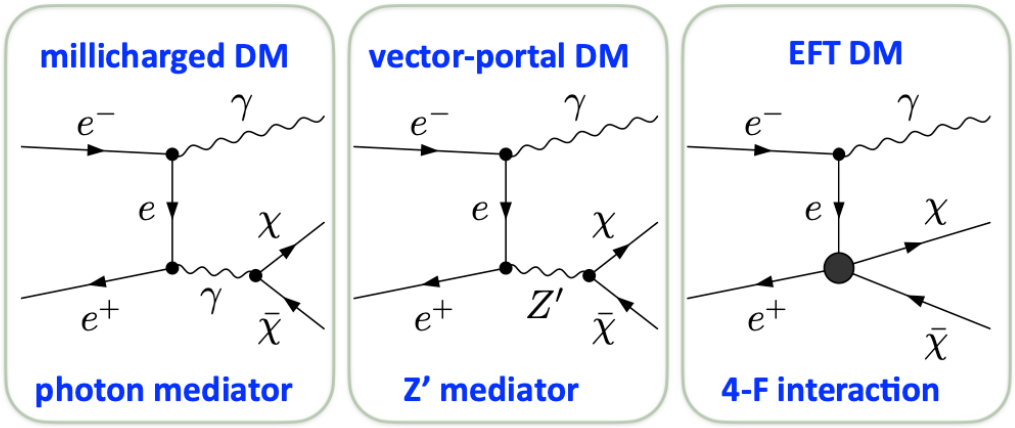
DM search at CEPC

- Probing DM particles *at CEPC* (Millicharged DM, Vector portal DM, EFT DM): ZL, Y.-H. Xu, Y. Zhang ,1903.12114
- Mono-γ Production of a Vector Dark Matter *at CEPC*, K Ma, 2205.05560
- Exposing Dark Sector-photon interactions *at CEPC*, Y. Zhang, M. Song and L. Chen, arXiv: 2208.08142, Yu Zhang's talk

→ CEPC can probe low-mass light dark states.



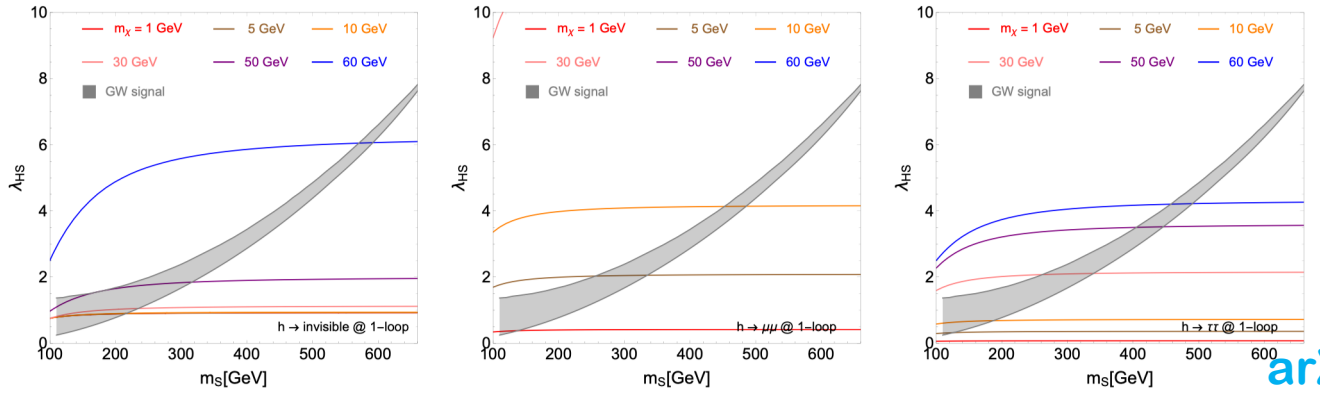
new physics process: $e^+e^- \to \bar{\chi}\chi\gamma$



DM search at CEPC

- Searching for lepton portal dark matter with colliders and interplay with the gravitational wave (GW) astronomy, Jia Liu, Xiao-Ping Wang, KePan Xie, 2104.06421, JHEP 06 (2021) 149
- The phase transition GWs can also be a probe of the model.

$$e^+e^- \to S^{\pm(*)}S^{\mp} \to \ell^+\chi\ell'^-\chi \qquad h/Z \to S^{\pm(*)}S^{\mp(*)} \to \ell^+\chi\ell'^-\chi \text{ and } h \to \chi\chi;$$

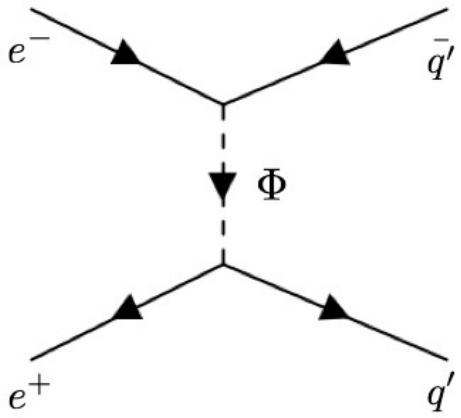


arXiv: 2104.06421

FIG. 10. Figure from Ref. [168], the interplay between GW detection and future e^+e^- collider searches. The gray shaded region is the LISA detectable parameter space. From left to right, the sensitivities for λ_{HS} are shown from future CEPC precision measurements, in which the region above a given m_χ (corresponding to a colored line) can be probed.

DM search at CEPC

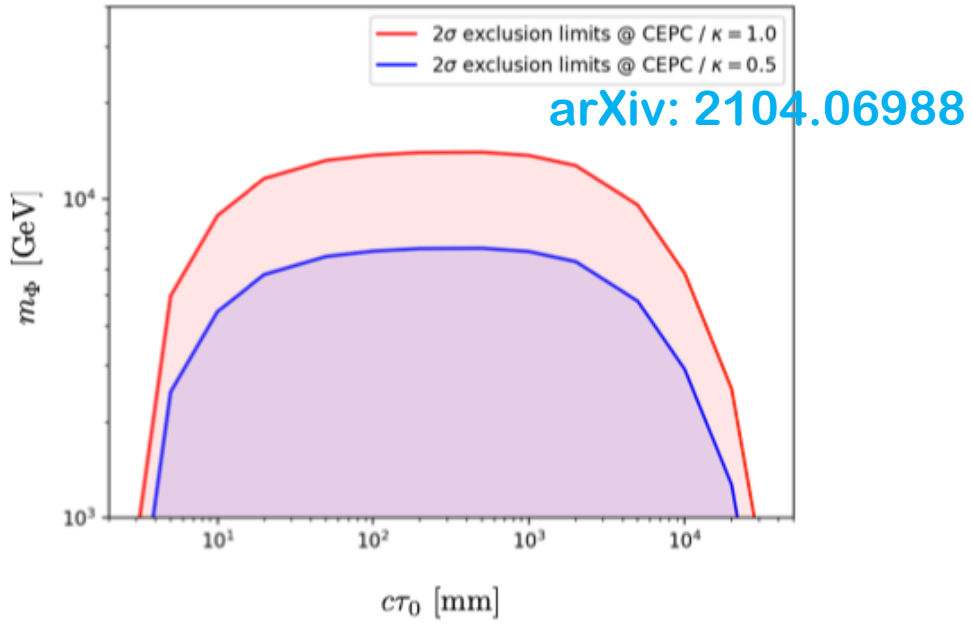
- Searching for asymmetric Dark Matter (ADM) at CEPC, Mengchao Zhang, 2104.06988, PRD 104, 055008 (2021)
- It is possible to generate dark quark pair through a t-channel process, dark quark q' will be a jet-like object in detector.



Decay to leptons

Jet-like

Signature:
Lepton + jet + MET

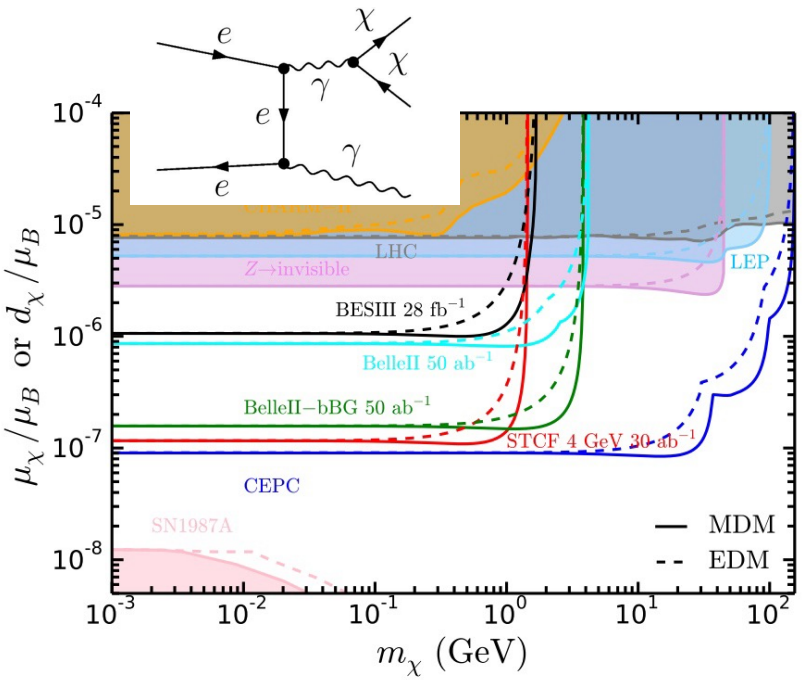


- The mass of mediator can be excluded up to O(10) TeV, better than LHC

Dark Matter/Dark Sector searches

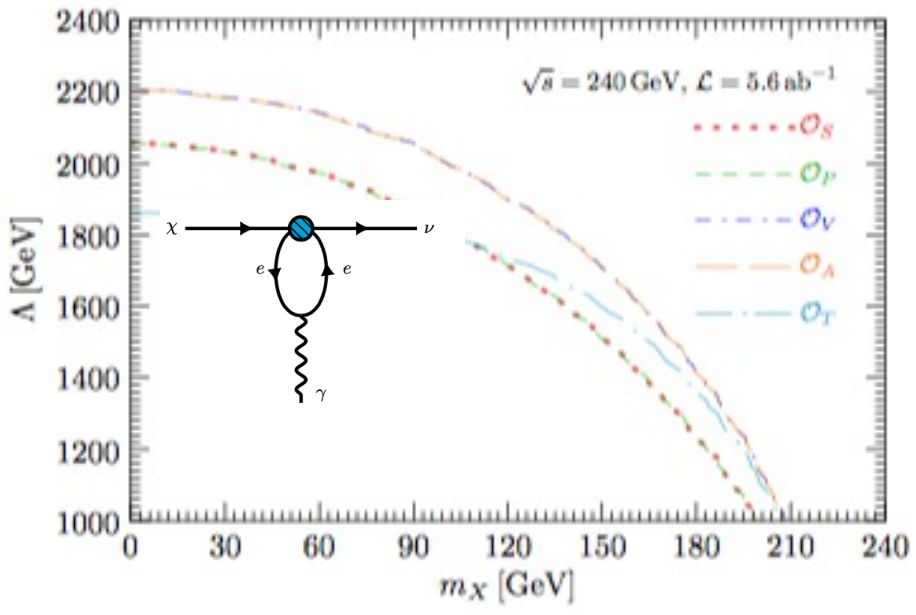
- **Exposing Dark Sector-photon interactions at CEPC, Y. Zhang, M. Song and L. Chen, arXiv: 2208.08142, Yu Zhang's talk**

→ **CEPC can probe low-mass light dark states with electromagnetic form factors via mass-dimension 5 operators.**



- **Exposing Dark Fermion in light of Electron Target Absorption at CEPC, Shao-Feng Ge and Kai Ma, Kai Ma's talk**

→ **All the effective four-fermion couplings can be constrained to be well above 1TeV scale**



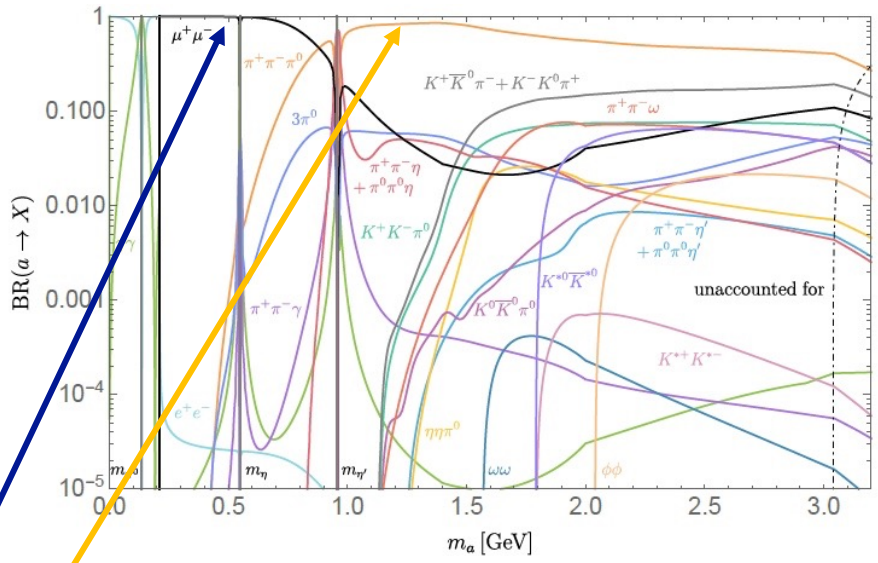
LL Dark Hadrons

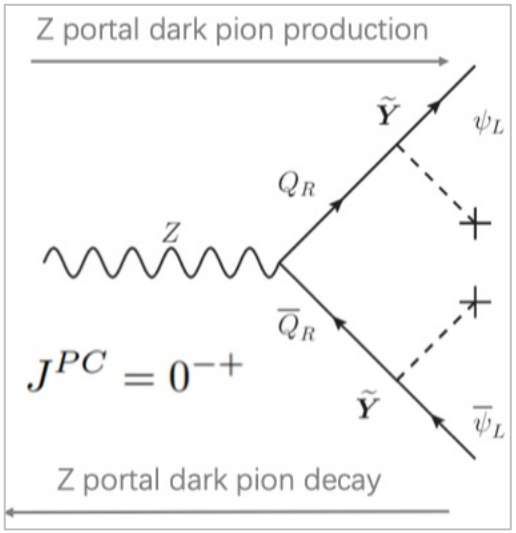
- A theory of Dark Pions, Hsin-Chia Cheng, Lingfeng Li, Ennio Salvioni, 2110.10691, JHEP 01 (2022) 122, see Lingfeng's talk
- The dark quarks couple to the SM via irrelevant Z- and Higgs-portal operators. The dark pions, behave as either composite axion-like particles (ALPs) mixing with Z or h

$$\mathcal{L}_{\rm EFT} = \frac{1}{2}\overline{\psi}_R \boldsymbol{Y}^\dagger \boldsymbol{M}^{-2}\boldsymbol{Y}\left[|H|^2 i\not{D} + i\gamma^\mu H^\dagger D_\mu H\right]\psi_R + \text{h.c.}$$
$$+ \frac{1}{2}\overline{\psi}_L \widetilde{\boldsymbol{Y}}^\dagger \boldsymbol{M}^{-2}\widetilde{\boldsymbol{Y}}\left[|H|^2 i\not{D} + i\gamma^\mu H^\dagger D_\mu H\right]\psi_L + \text{h.c.}$$
$$- \overline{\psi}_L \boldsymbol{\omega}\psi_R + \overline{\psi}_L \widetilde{\boldsymbol{Y}}^\dagger \boldsymbol{M}^{-1}\boldsymbol{Y}\psi_R |H|^2 + \text{h.c.},$$

Dimension-6 Z portal couplings — Dimension-5 Higgs portal coupling

arXiv: 2110.10691

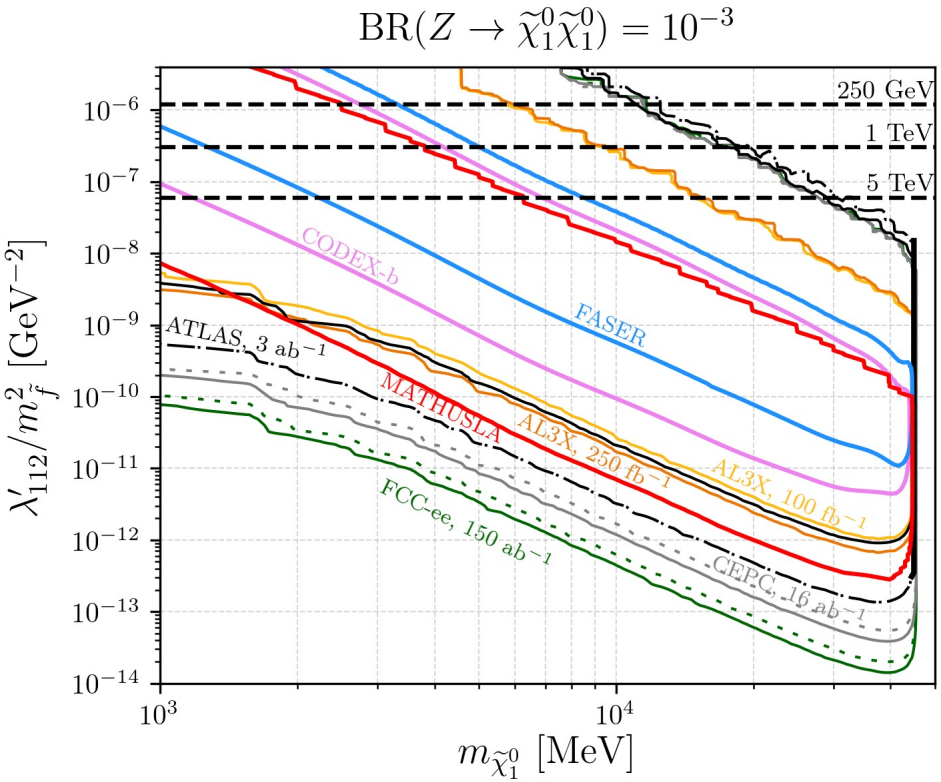




- mπ < m η′ : dimuon mode dominates
- m π > m η′ : PPP modes (mostly SM π+ π- π0)

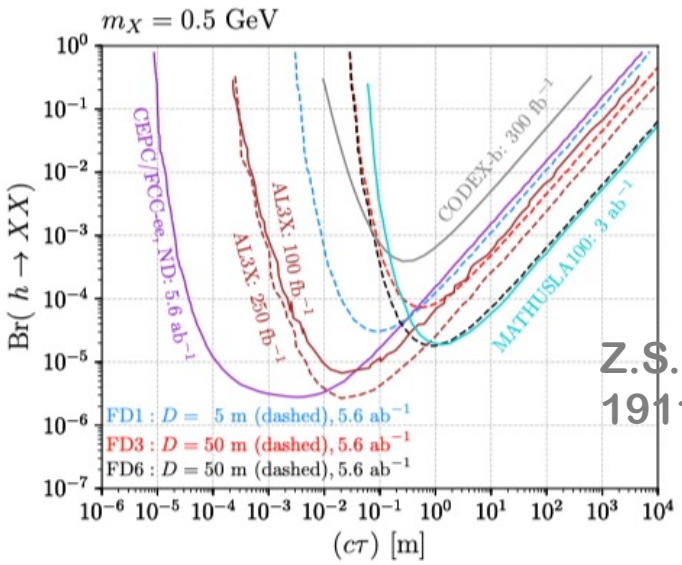
LLP at near Detector (ND)

- **Long-lived light neutralinos at future Z–factories (RPV SUSY), Zeren Simon Wang, Kechen Wang, 1904.10661, PRD 101, 115018 (2020)**
- **The model parameter $\lambda'_{112}/m^2_{\tilde{f}}$ can be discovered down to as low as ~1.5×10^{-14} (3.9×10^{-14}) GeV^{-2} at the FCC-ee (CEPC)**

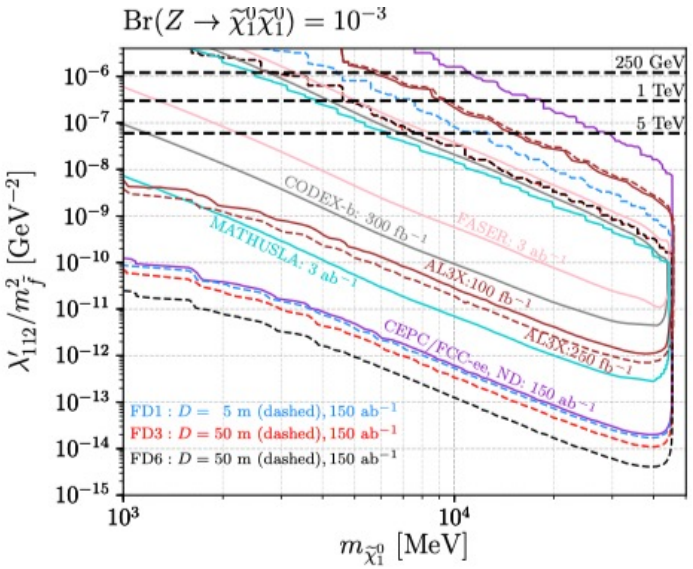


arXiv: 1904.10661

LLP at Far Detector (FD)

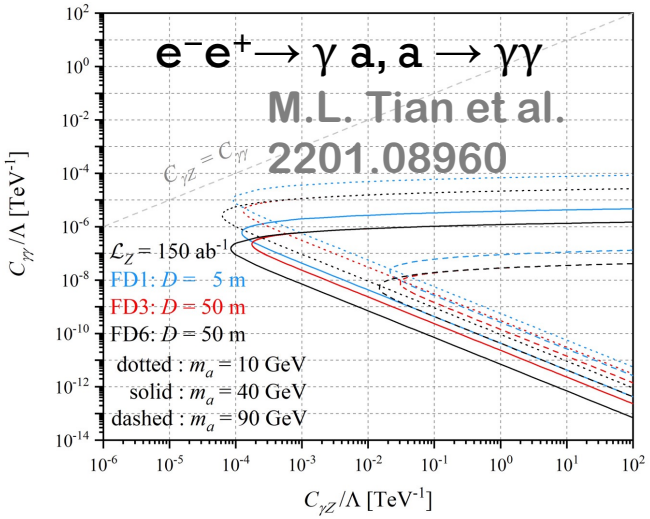


Z.S. Wang, et al.,
1911.06576



Light Scalars from Exotic Higgs Decays

Light Neutralinos from Z Decays



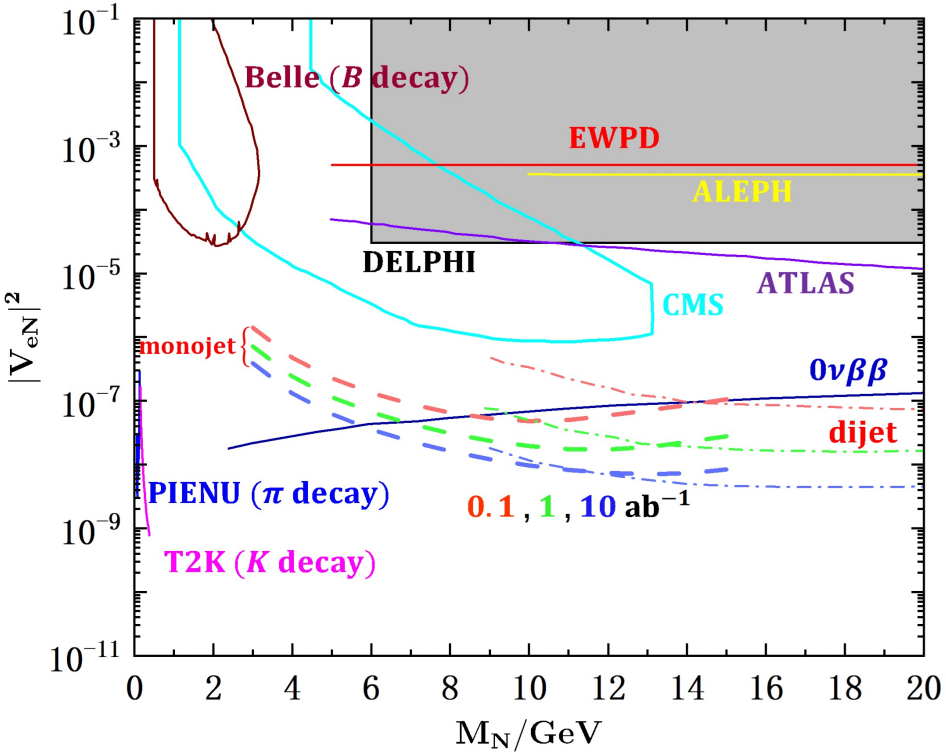
Axion-like Particles

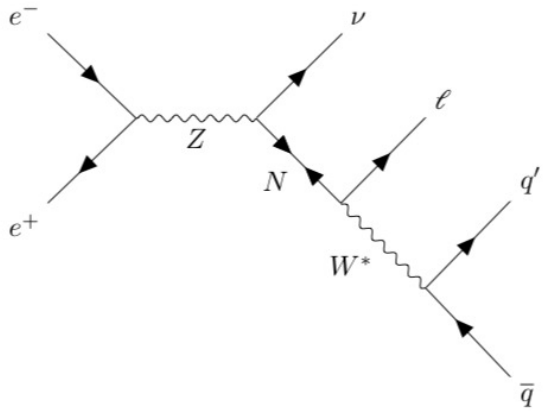
→ FD can extend and complement the sensitivity to the LLPs compared with Near Detector

Heavy neutrino search

- **Monojet Search for Heavy Neutrinos *at Future Z-Factories*, Y.F. Shen, J.N. Ding, Q. Qin, arXiv: 2201.05831, Yin-Fa Shen' talk**

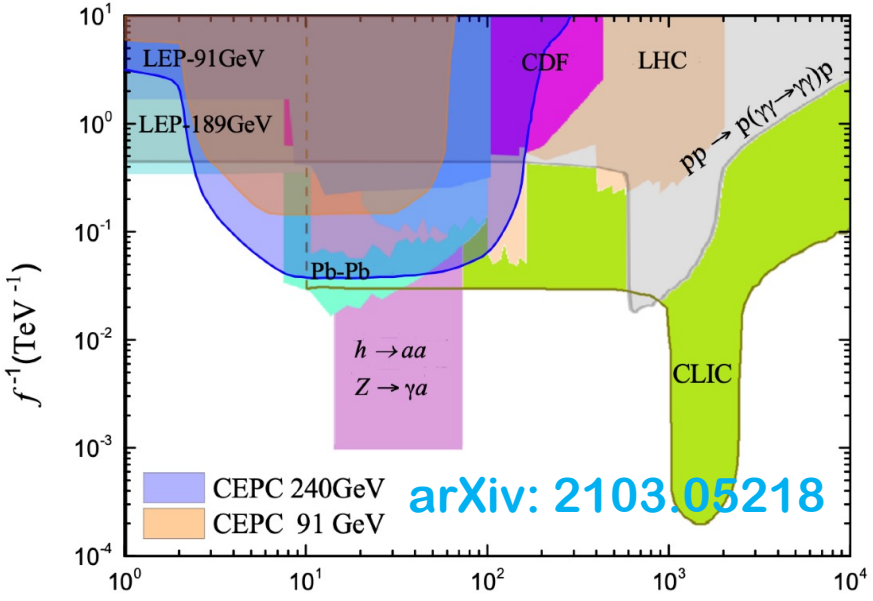
→ The monojet method will be able to fill the gap and has better sensitivity around the mass range between **5-15 GeV**.



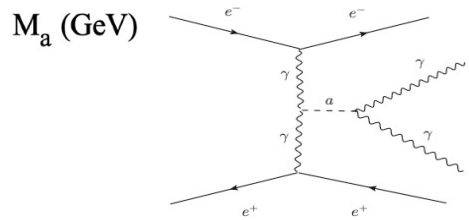


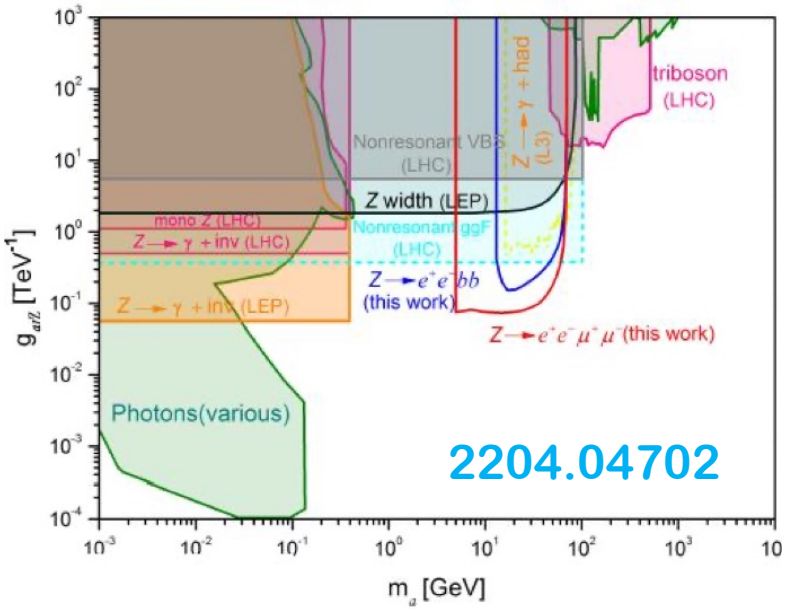
Axion-like particles (ALP)

- **Searching for ALP *at future electron-positron colliders*, H. Y. Zhang, C.X. Yue, Y.C. Guo, and S. Yang, 2103.05218, PRD104 (2021) 096008**
  - → CEPC is more sensitive to the ALPs couplings $g_{a\gamma\gamma}$ with mass 2-8 GeV than LHC and CLIC.
- **Searching for ALP via decay $Z \to a f \bar{f}$ *at future Z factories*, 2204.04702**
- **Axion-like particle solution to muon g-2 and its test *at Z-factory*, Jia Liu's talk**

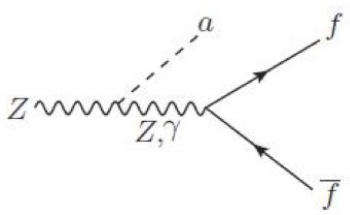


2-8 GeV





5-70 GeV

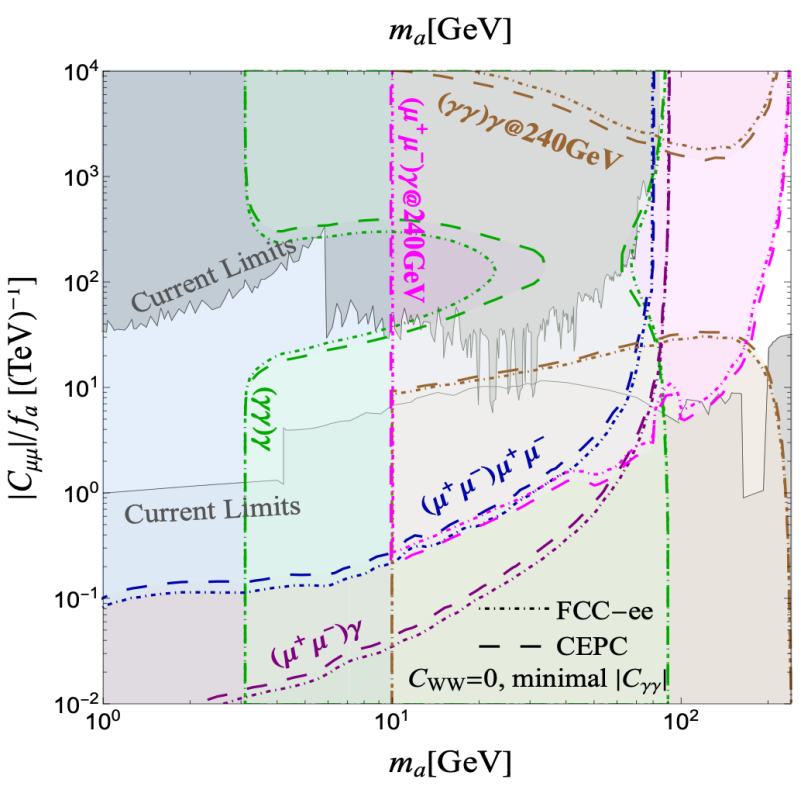


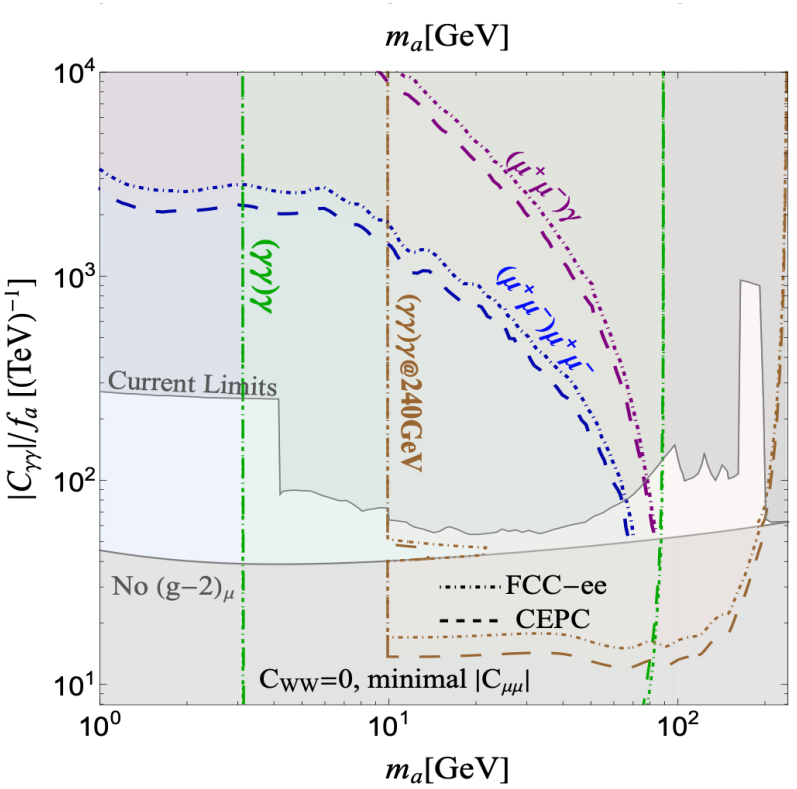
Axion-like particles (ALP)

- **The ALP explanation to muon g-2 and its test at CEPC, J. Liu, X.L. Ma, L.T. Wang, X.P. Wang, arXiv:2210.09335, Xiao-Ping Wang's talk**

→ ALP can provide a g-2 solution with couplings $C_{\mu\mu}$ and $C_{\gamma\gamma}$;

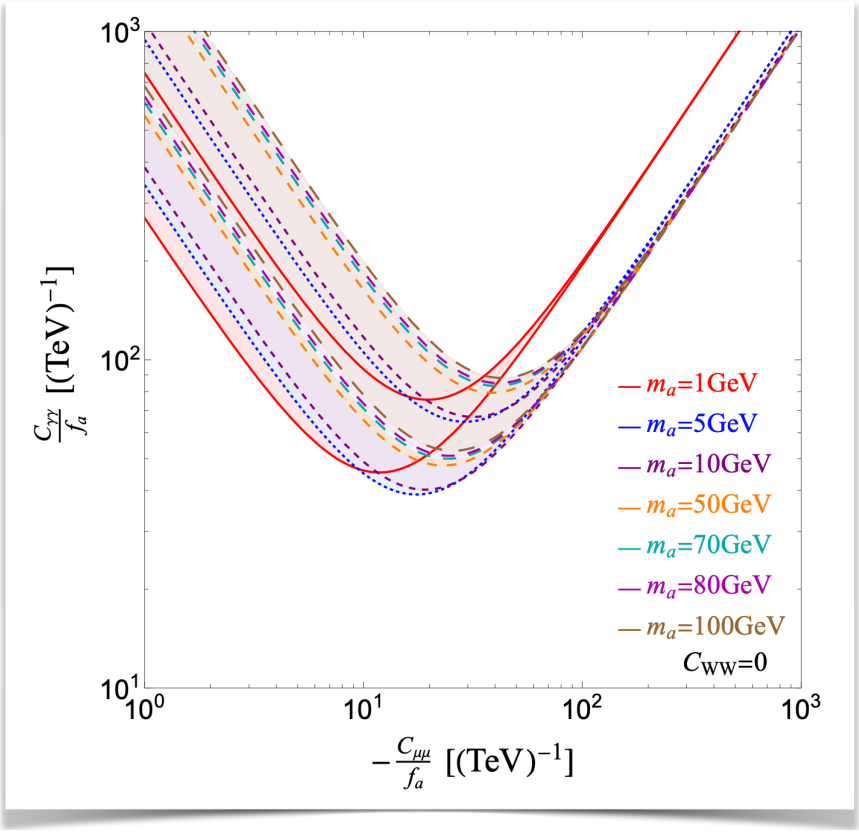
→ Tera-Z and Higgs factories, can completely cover the relevant parameter space through searches with final states (γγ)γ, (μ+μ−)γ and (μ+μ−)μ+μ−.





Axion-like particles (ALP)

- **The ALP explanation to muon g-2 and its test at CEPC, J. Liu, X.L. Ma, L.T. Wang, X.P. Wang, arXiv:2210.09335, Xiao-Ping Wang's talk**
- ALP can provide a solution with couplings $C\mu\mu$ and $C\gamma\gamma$;



- In g-2 solution region, mostly decay to $a \to \mu^+\mu^-$
- The inclusion of Z diagram makes some difference for large m_a
- Exotic Z decay should happen