# BSM Prospect at the CEPC

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#### **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

#### BSM prospect at the CEPC

Contributions to Snowmass2021:

- Supersymmetry searches
  - Direct searches for sleptons and electroweakinos
  - Global fit of SUSY
- Two Higgs doublet model searches
- Dark Matter searches
  - Axion-like particles
  - Asymmetric DM
  - Lepton portal DM
- Electroweak phase transition

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## Supersymmetry searches at CEPC

**References:** 

https://arxiv.org/pdf/2105.06135.pdf

https://arxiv.org/pdf/2101.12131.pdf

https://arxiv.org/pdf/2010.09782.pdf

https://indico.ihep.ac.cn/event/14938/session/13/contribution/99/material/slides/0.pdf https://indico.ihep.ac.cn/event/14938/session/13/contribution/138/material/slides/0.pdf https://indico.fnal.gov/event/50140/contributions/220054/attachments/ 145453/185187/20210722Snowmass.pdf

#### **Direct searches**

#### **Indirect searches**







#### LHC direct searches

- In most of the SUSY parameter spaces, the mass bounds from LHC have reached TeV scale.
- They are way beyond the center-of-mass energy of CEPC.

A Ju	<b>ATLAS</b> Preliminary $\sqrt{s} = 13$ TeV					
	Model	Signat	ure	∫£dt [fb⁻	1 Mass limit	Reference
Inclusive Searches	$\tilde{q}\tilde{q}, \tilde{q} \rightarrow q\tilde{\chi}_{1}^{0}$	0 e, μ 2-6 je mono-jet 1-3 je	ts $E_T^{miss}$ ts $E_T^{miss}$	139 36.1	<u>≱ [1x, 8x Degen.] 1.0</u> 1.85 m(ℓ_1)<400 GeV ≱ [8x Degen.] 0.9 m(ψ]m(ℓ_1)=5 GeV	2010.14293 2102.10874
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow q \tilde{q} \tilde{\chi}_1^0$	0 e,μ 2-6 je	ts $E_T^{miss}$	139	ž         2.3         m(t <sup>2</sup> )=0 GeV           ž         Forbidden         1.15-1.95         m(t <sup>2</sup> )=1000 GeV	2010.14293 2010.14293
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow q\tilde{q}W\tilde{\chi}_{1}^{0}$ $\tilde{g}\tilde{g}, \tilde{g} \rightarrow q\tilde{q}(\ell\ell)\tilde{\chi}_{1}^{0}$ $\tilde{g}\tilde{g}, \tilde{g} \rightarrow qqWZ\tilde{\chi}_{1}^{0}$	1 e,μ 2-6 je ee,μμ 2 jet 0 e,μ 7-11 ju SS e,μ 6 jet	ts $E_T^{miss}$ ets $E_T^{miss}$ s	139 36.1 139 139	ឆ         2.2         m(ti)-600 GeV           ឆ         1.2         m(g)-m(ti)=50 GeV           ឆ         1.97         m(g)-m(ti)=50 GeV           ឆ         1.15         m(s)-m(ti)=50 GeV	2101.01629 1805.11381 2008.06032 1909.08457
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow t \tilde{t} \tilde{\chi}_1^0$	0-1 e,μ 3 b SS e,μ 6 jet	$E_T^{miss}$	79.8 139	ž 2.25 m(t̃) +200 GeV ž 1.25 m(t̃) +200 GeV	ATLAS-CONF-2018-041 1909.08457
	$b_1b_1$	0 e,µ 2 b	$E_T^{\rm miss}$	139	δ1         1.255         m(k <sup>0</sup> <sub>1</sub> )<400 GeV           δ1         0.68         10 GeV         2 GeV	2101.12527 2101.12527
arks tion	$\tilde{b}_1 \tilde{b}_1, \tilde{b}_1 \rightarrow b \tilde{\chi}_2^0 \rightarrow b h \tilde{\chi}_1^0$	0 e,μ 6 b 2 τ 2 b	$E_T^{miss}$ $E_T^{miss}$	139 139	b1         Forbidden         0.23-1.35         Δm(t_2^0, t_1^0)=130 GeV, m(t_1^0)=0 GeV           b1         0.13-0.85         Δm(t_2^0, t_1^0)=130 GeV, m(t_1^0)=0 GeV	1908.03122 ATLAS-CONF-2020-031
3 <sup>rd</sup> gen. squi direct produc	$\begin{split} &\tilde{i}_1\tilde{i}_1, \tilde{i}_1 \rightarrow i\tilde{k}_1^0 \\ &\tilde{i}_1\tilde{i}_1, \tilde{i}_1 \rightarrow Wh\tilde{k}_1^0 \\ &\tilde{i}_1\tilde{i}_1, \tilde{i}_1 \rightarrow \tilde{i}_1b\nu, \tilde{\tau}_1 \rightarrow \tau\tilde{G} \\ &\tilde{i}_1\tilde{i}_1, \tilde{i}_1 \rightarrow c\tilde{k}_1^0 / c\tilde{c}, \tilde{c} \rightarrow c\tilde{k}_1^0 \end{split}$	$\begin{array}{llllllllllllllllllllllllllllllllllll$	et $E_T^{miss}$ 1 b $E_T^{miss}$ 1 b $E_T^{miss}$ $E_T^{miss}$ jet $E_T^{miss}$	139 139 139 36.1 139	line         1.25         m(t <sup>2</sup> <sub>1</sub> )=1 GeV           line         Forbiddon         0.65         m(t <sup>2</sup> <sub>1</sub> )=500 GeV           line         Forbiddon         1.4         m(t <sup>2</sup> <sub>1</sub> )=600 GeV           line         0.85         m(t <sup>2</sup> <sub>1</sub> )=0 GeV           line         0.55         m(t <sup>2</sup> <sub>1</sub> )=50 GeV	2004.14060.2012.03799 2012.03799 ATLAS-CONF-2021-008 1805.01649 2102.10674
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \rightarrow i \tilde{\chi}_2^0, \tilde{\chi}_2^0 \rightarrow Z/h \tilde{\chi}_1^0$ $\tilde{t}_2\tilde{t}_2, \tilde{t}_2 \rightarrow \tilde{t}_1 + Z$	1-2 e,μ 1-4. 3 e,μ 1 b	$E_T^{miss}$ $E_T^{miss}$	139 139	Ti         0.067-1.18         m(t <sup>2</sup> <sub>1</sub> )=500 GeV           Tz         Forbidden         0.86         m(t <sup>2</sup> <sub>1</sub> )=360 GeV, m(t <sup>2</sup> <sub>1</sub> )=40 GeV	2006.05880 2006.05880
	$\tilde{\chi}_1^{\pm} \tilde{\chi}_2^0$ via $WZ$	Multiple $\ell$ /jets ee, $\mu\mu \ge 1$ jet	et $E_T^{miss}$ $E_T^{miss}$	139 139	χ <sup>*</sup> <sub>1</sub> /μ <sup>*</sup> 0.96         m(k <sup>*</sup> <sub>1</sub> )=0, wino-bino           χ <sup>*</sup> <sub>1</sub> /μ <sup>*</sup> <sub>2</sub> 0.205         m(k <sup>*</sup> <sub>1</sub> )=5 GeV, wino-bino	2106.01676, ATLAS-CONF-2021-022 1911.12606
EW direct	$ \begin{split} \tilde{\chi}_{1k}^{\dagger} \tilde{\xi}_{1}^{\dagger} & \text{via} \; WW \\ \tilde{\chi}_{1k}^{\dagger} \tilde{\xi}_{2}^{\dagger} & \text{via} \; \tilde{\chi}_{k}^{\dagger} \tilde{\chi}_{1}^{\dagger} \\ \tilde{\chi}_{1k}^{\dagger} \tilde{\xi}_{1}^{\dagger} & \text{via} \; \tilde{\xi}_{L}^{\dagger} / \tilde{\nu} \\ \tilde{\tau}_{LR}^{\dagger} \tilde{t}_{LR}^{\dagger} \tilde{t}_{LR} & \tilde{t}_{0}^{\dagger} \\ \end{split} $	$\begin{array}{llllllllllllllllllllllllllllllllllll$	$E_T^{miss}$ $E_T^{miss}$ $E_T^{miss}$ $E_T^{miss}$ $E_T^{miss}$ $E_T^{miss}$ $E_T^{miss}$ $E_T^{miss}$	139 139 139 139 139 139	k1         0.42         mlf1 = 0.4           k1 = k2         forbidden         mlf1 = 70 GeV, who bito           k1 = k2         forbidden         mlf1 = 70 GeV, who bito           k1 = k2         forbidden         mlf1 = 70 GeV, who bito           f = f1_r + k_1	1908.08215 2004.10894, ATLAS-CONF-2021-022 1908.08215 1911.06660 1908.08215 1911.12606
	ĤĤ, Ĥ→hĜ/ZĜ	$\begin{array}{ll}0 \ e, \mu &\geq 3 \\ 4 \ e, \mu & 0 \ \text{jet} \\ 0 \ e, \mu &\geq 2 \ \text{large}\end{array}$	b $E_T^{miss}$ s $E_T^{miss}$ b jets $E_T^{miss}$	36.1 139 139	$\hat{H}$ 0.13-0.23         0.29-0.88 $BR(\hat{r}_{1}^{2} \rightarrow A\delta) = 1$ $\hat{H}$ 0.55 $BR(\hat{r}_{1}^{2} \rightarrow Z) = 1$ $BR(\hat{r}_{1}^{2} \rightarrow Z) = 1$	1806.04030 2103.11684 ATLAS-CONF-2021-022
Long-lived particles	$\begin{array}{l} \text{Direct} \tilde{\mathcal{X}}_1^+ \widetilde{\mathcal{X}}_1^- \text{ prod., long-lived} \tilde{\mathcal{X}}_1^\pm\\ \text{Stable} \tilde{g} \text{ R-hadron}\\ \text{Metastable} \tilde{g} \text{ R-hadron}, \tilde{g} {\rightarrow} q q \tilde{\ell}_1^0\\ \tilde{\mathcal{U}}, \tilde{\ell} {\rightarrow} \ell \tilde{G} \end{array}$	Disapp. trk 1 je Multiç Multiç Displ. lep	$E_T^{miss}$ Ne $E_T^{miss}$	139 36.1 36.1 139	$ \begin{array}{c c} \hat{\chi}_{1}^{\pm} & 0.26 & & \text{Pure Wino} \\ \hat{\chi}_{1}^{\pm} & 0.21 & & \text{Pure Wino} \\ \hat{\chi}_{1}^{\pm} & 0.21 & & \text{Pure Wino} \\ \hat{\chi}_{1}^{\pm} & 0.21 & & 2.0 \\ \hat{\chi}_{1}^{\pm} & 0.20 & & & \\ \hat{\chi}_{1}^{\pm} & 0.34 & & & \\ \hat{\chi}_{1}^{\pm} & 0.34 & & & & \\ \chi$	ATLAS-CONF-2021-015 ATLAS-CONF-2021-015 1902.01636,1808.04095 1710.04901,1808.04095 2011.07812 2011.07812
RPV	$\begin{split} \tilde{\chi}_{1}^{\dagger} \tilde{\chi}_{1}^{T} / \tilde{\chi}_{0}^{0} , \tilde{\chi}_{1}^{\dagger} \rightarrow Z \ell \rightarrow \ell \ell \ell \\ \tilde{\chi}_{1}^{\dagger} \tilde{\chi}_{1}^{T} / \tilde{\chi}_{2}^{0} \rightarrow WW/Z \ell \ell \ell \ell \nu \\ \tilde{g} \tilde{s}, \tilde{s} - q \tilde{q} \tilde{\chi}_{1}^{0} , \tilde{\chi}_{1}^{0} \rightarrow q q q \\ \tilde{g} \tilde{s}, \tilde{s} - q \tilde{q} \tilde{s}^{0} , \tilde{\chi}_{1}^{0} \rightarrow b s \\ \tilde{n}, \tilde{i} \rightarrow b \tilde{k} \tilde{s} \\ \tilde{n}, \tilde{i}, \tilde{i} \rightarrow b s \\ \tilde{n}, \tilde{i}, \tilde{i} \rightarrow b s \\ \tilde{n}, \tilde{i}, \tilde{i}, \eta \neq \ell \\ \tilde{\chi}_{1}^{\dagger} / \tilde{\chi}_{2}^{0} / \tilde{\chi}_{1}^{0} , \tilde{\chi}_{1,2}^{0} \rightarrow t b s , \\ \tilde{\chi}_{1}^{\dagger} / \tilde{\chi}_{2}^{0} / \tilde{\kappa}_{1}^{0} , \tilde{\chi}_{1,2}^{0} \rightarrow t b s , \\ \tilde{\chi}_{1}^{\dagger} / \tilde{\chi}_{2}^{0} / \tilde{\kappa}_{1}^{0} , \tilde{\chi}_{1,2}^{0} \rightarrow t b s , \\ \tilde{\chi}_{1}^{\dagger} / \tilde{\chi}_{2}^{0} / \tilde{\kappa}_{1}^{0} , \tilde{\chi}_{1,2}^{0} \rightarrow t b s , \\ \tilde{\chi}_{1}^{\dagger} / \tilde{\chi}_{2}^{0} / \tilde{\kappa}_{1}^{0} , \\ \tilde{\chi}_{1}^{0} \rightarrow b s \\ \tilde{\chi}_{1}^{0} / \tilde{\chi}_{2}^{0} / \tilde{\kappa}_{1}^{0} , \\ \tilde{\chi}_{1}^{0} \rightarrow b s \\ \tilde{\chi}_{1}^{0} / \tilde{\chi}_{2}^{0} / \tilde{\kappa}_{1}^{0} , \\ \tilde{\chi}_{1}^{0} \rightarrow b s \\ \tilde{\chi}_{1}^{0} / \tilde{\chi}_{2}^{0} / \tilde{\kappa}_{1}^{0} , \\ \tilde{\chi}_{1}^{0} \rightarrow b s \\ \tilde{\chi}_{1}^{0} / \tilde{\chi}_{2}^{0} / \tilde{\kappa}_{1}^{0} , \\ \tilde{\chi}_{1}^{0} \rightarrow b s \\ \tilde{\chi}_{1}^{0} / \tilde{\chi}_{1}^{0} / \tilde{\chi}_{1} , \\ \tilde{\chi}_{1}^{0} \rightarrow b s \\ \tilde{\chi}_{1}^{0} / \tilde{\chi}_{1}^{0} / \tilde{\chi}_{1}^{0} , \\ \tilde{\chi}_{1}^{0} \rightarrow b s \\ \tilde{\chi}_{1}^{0} / \tilde{\chi}_{1}^{0} / \tilde{\chi}_{1}^{0} , \\ \tilde{\chi}_{1}^{0} \rightarrow b s \\ \tilde{\chi}_{1}^{0} / \tilde{\chi}_{1}^{0} / \tilde{\chi}_{1}^{0} , \\ \tilde{\chi}_{1}^{0} \rightarrow b s \\ \tilde{\chi}_{1}^{0} / \tilde{\chi}_{1}^{0} / \tilde{\chi}_{1}^{0} , \\ \tilde{\chi}_{1}^{0} \rightarrow b s \\ \tilde{\chi}_{1}^{0} / \tilde{\chi}_{1}^{0} / \tilde{\chi}_{1}^{0} , \\ \tilde{\chi}_{1}^{0} / \tilde{\chi}_{1}^{0} , \\ \tilde{\chi}_{1}^{0} / \tilde{\chi}_{1}^{0} / \tilde{\chi}_{1}^{0} , \\ \tilde{\chi}_{1}^{0} / \tilde{\chi}_{1}^{0} / \tilde{\chi}_{1}^{0} , \\ \tilde{\chi}_{1}^{0} / \tilde{\chi}_{1}^{0} , \\ \tilde{\chi}_{1}^{0} / \tilde{\chi}_{1}^{0} / \tilde{\chi}_{1}^{0} , \\ \tilde{\chi}_{1}^{0} / \tilde{\chi}_{1}$	$3 e, \mu$ $4 e, \mu$ 0 jet 4-5  targe Multip $\geq 4k$ 2  jets + k $2 e, \mu$ $2 b$ $1 \mu$ DV $1-2 e, \mu \geq 6 \text{ jet}$	s E <sub>T</sub> miss e jets kle 2 b	139 139 36.1 36.1 139 36.7 36.1 136 139	$\begin{array}{c c c c c c c c c c c c c c c c c c c $	2011.10543 2103.11684 1804.03568 ATLAS-CONF-2018-003 2010.01015 1710.07171 1710.05544 2003.11956 ATLAS-CONF-2021-007
*Only a pheni simpl						

#### LHC direct searches

However, due to large backgrounds, the compressed spectrum are very difficult to be covered for LHC and even HL-LHC.



#### **LHC direct searches**

However, due to large backgrounds, the compressed spectrum are very difficult to be covered for LHC and even HL-LHC.



#### **Chargino search at CEPC**

Prospects for chargino pair production at CEPC, Jia-Rong Yuan, Hua-Jie Cheng, Xu-Ai Zhuang, arXiv:2105.06135.



#### **Slepton search at CEPC**

Prospects for slepton pair production in the future e<sup>+</sup>e<sup>-</sup> Higgs factories, Jia-Rong Yuan, Hua-Jie Cheng, Xu-Ai Zhuang.

![](_page_9_Figure_3.jpeg)

#### **Neutralino search at CEPC**

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

![](_page_10_Figure_3.jpeg)

#### **Neutralino search at CEPC**

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

The EWSSUY from General minimal Supergravity (GmSUGRA) Model  $M_{3} = \frac{5}{2} M_{1} - \frac{3}{2} M_{2} .$  $m_{\tilde{Q}_{i}}^{2} = \frac{5}{6} (m_{0}^{U})^{2} + \frac{1}{6} m_{\tilde{E}_{i}^{c}}^{2} ,$  $m_{\tilde{U}_{i}^{c}}^{2} = \frac{5}{3} (m_{0}^{U})^{2} - \frac{2}{3} m_{\tilde{E}_{i}^{c}}^{2} ,$  $m_{\tilde{D}_{i}^{c}}^{2} = \frac{5}{3} (m_{0}^{U})^{2} - \frac{2}{3} m_{\tilde{L}_{i}}^{2} .$ 

In addition, the Higgs soft masses  $m_{H_u}$  and  $m_{H_d}$ , and the trilinear soft terms  $A_U$ ,  $A_D$  and  $A_E$  can all be free parameters

![](_page_11_Figure_6.jpeg)

#### **Indirect searches of SUSY at CEPC**

- MSSM at future Higgs factories, Honglei Li, Huayang Song, Shufang Su, Wei Su, Jin Min Yang, arXiv:2010.09782.
- MSSM contribution to  $\kappa_b$ , the Higgs coupling normalized to the SM value, is

![](_page_12_Figure_4.jpeg)

• The loop contribution of the stop sector is  $\Delta m_b^{\text{stop}} = \frac{h_t^2}{16\pi^2} \mu A_t \tan \beta I(m_{\tilde{t}_1}, m_{\tilde{t}_2}, \mu)$ 

![](_page_12_Figure_6.jpeg)

### SUSY global fit with CEPC results

Global fits with present likelihood:  $\mathscr{L}_{\text{Present+CEPC}} = \mathscr{L}_{\text{CEPC}} \mathscr{L}_{\text{Present}}$  $= \mathscr{L}_{\text{CEPC}} \mathscr{L}_{\text{collider}} \mathscr{L}_{\text{DM}} \mathscr{L}_{\text{flavor}} \mathscr{L}_{\text{EWPO}} \dots$ **GUT** scale  $\mathcal{L}_{soft} \sim M_{H_{u,d}}^2 |H_{u,d}|^2 + m_0^2 \tilde{F}_i^{\dagger} \tilde{F}_i + \frac{1}{2} m_{1/2} \tilde{G}_j \tilde{G}_j + A_0 \tilde{F}_i^c H_{u,d} \tilde{F}_i + \cdots$ CMSSM:  $m_0^2 = M_{H_{ud}}^2$ NUHM1:  $m_0^2 \neq M_{H_{ud}}^2$ ,  $M_{H_u}^2 = M_{H_d}^2$ NUHM2:  $m_0^2 \neq M_{H_{ud}}^2$ ,  $M_{H_u}^2 \neq M_{H_d}^2$ Weak scale  $\mathcal{L}_{soft} \sim M_{H_{u,d}}^2 |H_{u,d}|^2 + m_{\tilde{f}_i}^2 \tilde{F}_i^{\dagger} \tilde{F}_i + \frac{1}{2} M_j \tilde{G}_j \tilde{G}_j + A_{f_i} \tilde{F}_i^c H_{u,d} \tilde{F}_i + \cdots$ MSSM7:  $\tan \beta$ ,  $A_{\mu} = A_d = A_{\rho} = 0$ , except for 

 $(A_{\mu})_{33} = A_{\mu 3} (A_d)_{33} = A_{d3}.$ 

Likelihood term LHC sparticle searches LHC Higgs LEP Higgs ALEPH selectron ALEPH smuon ALEPH stau L3 selectron L3 smuon L3 stau L3 neutralino leptonic L3 chargino leptonic **OPAL** chargino hadronic OPAL chargino semi-leptonic **OPAL** chargino leptonic OPAL neutralino hadronic  $B_{(s)} \rightarrow \mu^+ \mu^-$ Tree-level B and D decays  $B^0 \rightarrow K^{*0} \mu^+ \mu^ B \to X_s \gamma$  $a_{\mu}$ W mass Relic density PICO-2L PICO-60 F SIMPLE 2014 LUX 2015 LUX 2016 PandaX 2016 SuperCDMS 2014 XENON100 2012 IceCube 79-string  $\gamma$  rays (Fermi-LAT dwarfs)  $\rho_0$  $\sigma_s$  and  $\sigma_l$  $\alpha_s(m_Z)(MS)$ Top quark mass

ATLAS 13TeV MultiLEP strong 139invfb TLAS 13TeV RJ3L lowmass 36invft TLAS\_13TeV\_RJ3L\_2Lep2Jets 36invft FLAS 13TeV RJ3L 3Lep 36invfl TLAS\_13TeV\_2OSLEP\_chargino\_80invf TLAS\_13TeV\_2OSLEP\_chargino\_binned\_80invfb ATLAS\_13TeV\_2OSLEP\_chargino\_inclusive\_80invfb TLAS 13TeV 20SLEP chargino 139invfl TLAS 13TeV 20SLEP chargino inclusive 139invft ATLAS\_13TeV\_20SLEP\_chargino\_binned\_139invfb ATLAS 13TeV 20SLEP Z 139invfb ATLAS 13TeV 2LEPsoft 139invfb ATLAS 13TeV 4LEP 36invf ATLAS 13TeV 4LEP 139invf ATLAS 13TeV 1Lep2b 139invft ATLAS 13TeV 2b2H sbottom 139invfb ATLAS 13TeV 2b2W stop 139invfb ATLAS\_13TeV\_2bMET\_36invfb ATLAS\_13TeV\_3b\_24invfb ATLAS\_13TeV\_3b\_discoverySR\_24invfb ATLAS 13TeV 3b 36invfb ATLAS 13TeV 3b discoverySR 36invfb TLAS 13TeV HtoPhotons 139invft ATLAS 13TeV PhotonGGM 36invft TLAS 13TeV ZGammaGrav CONFNOTE 80invft ATLAS 13TeV MONOJET 36invft

### **SUSY** global fit with CEPC results

The Higgs precision measurements at the CEPC will visibly shrink the preferred parameter regions. It has the power to rule out some DM annihilation mechanisms in the framework of constrained SUSY.

![](_page_14_Figure_3.jpeg)

**References:** 

https://arxiv.org/pdf/1709.06103.pdf https://arxiv.org/pdf/1808.02037.pdf https://arxiv.org/pdf/1912.01431.pdf https://arxiv.org/pdf/2008.05492.pdf https://indico.ihep.ac.cn/event/13888/session/13/contribution/76/material/slides/0.pdf

- J. Gu, H. Li, Z. Liu, W. Su, 1709.06103
- N. Chen, T. Han, S. Su, W. Su, Y. Wu, 1808.02037
- N. Chen, T. Han, S. Li, S.
   Su, W. Su, Y. Wu,
   1912.01431
- T. Han, S. Li, S. Su, W. Su,
   Y. Wu, 2008.05492

#### Tree-level 2HDM fit

![](_page_16_Figure_7.jpeg)

- Indirect constraints on new physics models
- Complementary to direct search at 100 TeV Hadron Collider
- Distinguish different types of 2HDMs

#### Distinguish different types of 2HDMs

![](_page_17_Figure_6.jpeg)

$(\cos(\beta - \alpha), \tan\beta)$	Small $\tan \beta$	Large $\tan \beta$
Type-I	<b>IA:</b> (-0.019,1.0)	<b>IB:</b> (-0.077,10)
Type-II	<b>IIA:</b> (0.012,0.3)	<b>IIB:</b> (0.005,3.0)

S. Su

![](_page_17_Figure_8.jpeg)

**References:** 

https://arxiv.org/abs/2103.05218.pdf https://arxiv.org/pdf/2104.06988.pdf https://arxiv.org/pdf/2104.06421.pdf

- Searching for axion-like particles at future electron-positron colliders, by Hua-Ying Zhang, Chong-Xing Yue, Yu-Chen Guo, Shuo Yang, 2103.05218.
- For heavier ALPs, the cosmological and astrophysical limits are less stringent.
- The CEPC might be more sensitive to the ALPs with mass 2
   GeV ~ 8 GeV than the LHC and CLIC.

![](_page_19_Figure_5.jpeg)

- Leptophilic Composite Asymmetric Dark Matter and its Detection, Mengchao Zhang, 2104.06988
- On the CEPC, it is possible to directly generate dark quark pair through a tchannel process.
- Dark quark finally evolves to a jet-like object.

![](_page_20_Figure_5.jpeg)

- Searching for lepton portal dark matter with colliders and gravitational waves, Jia Liu, Xiao-Ping Wang, Ke-Pan Xie, 2104.06421.
- The direct and indirect searches are not sensitive to this model.
- The scalar potential triggers a first- order phase transition.

![](_page_21_Figure_5.jpeg)

## Electroweak phase transition and CEPC

**References:** 

https://arxiv.org/pdf/1911.10210.pdf https://arxiv.org/pdf/1911.10206.pdf https://arxiv.org/pdf/2011.04540.pdf https://indico.ihep.ac.cn/event/13888/session/15/contribution/121/material/slides/0.pdf

#### **Electroweak phase transition**

- M.J. Ramsey-Musolf 1912.07189
- Profumo, MJRM,
   Shaugnessy
   0705.2425
- Kozaczuk, MJRM Shelton 1911.10210
- Carena, Liu, Wang 1911.10206

![](_page_23_Figure_6.jpeg)

#### **Electroweak phase transition**

- The electroweak
   temperature T<sub>EW</sub> sets
   a scale for colliders.
- Exotic Higgs decays provide a unique probe of light scalarinduced thermal history modifications.

#### Light Singlets: Exotic Higgs Decays

 $h_2 \rightarrow h_1 h_1 \rightarrow 4b$ 

![](_page_24_Figure_6.jpeg)

J. Kozaczuk, MR-M, J. Shelton 1911.10210 See also: Carena et al 1911.10206

#### **Electroweak phase transition**

- Strong first order electroweak phase transition in 2HDM confronting future Z & Higgs factories, by Wei Su, Anthony G. Williams, Mengchao Zhang, 2011.04540.
- SFOEWPT suggests upper limits on the masses of heavy Higgs, which is less than 1 TeV.
- The CEPC can further exclude the allowed parameters space because of the one-loop level corrections to the SM-like Higgs couplings.

![](_page_25_Figure_5.jpeg)

### Summary

- Direct searches of SUSY
  - The CEPC has the potential to discover the chargino up to 120 GeV, the stau up to 113~116 GeV, and smuon up to 117 GeV.
- Indirect searches of SUSY
  - Higgs precision measurements at the CEPC have significant impacts on SUSY global fits. It has the power to rule out some DM annihilation mechanisms in the framework of constrained SUSY.
- Two Higgs doublet models
  - The CEPC can distinguish different types of 2HDMs.
- DM searches
  - The CEPC has great potential to detect a large portion of the model parameter space.
- Electroweak phase transition
  - The CEPC can provide a unique probe of the thermal history of EW symmetry breaking.

# THANK YOU.

![](_page_27_Picture_2.jpeg)

![](_page_27_Picture_3.jpeg)