

BSM Program at the CEPC

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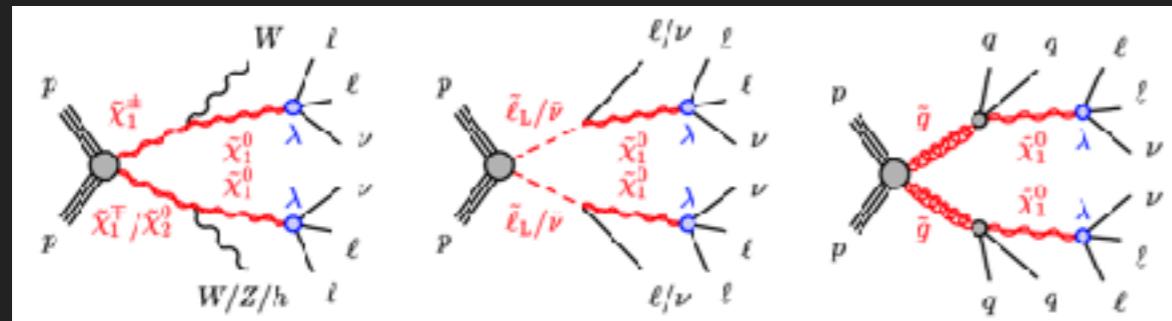
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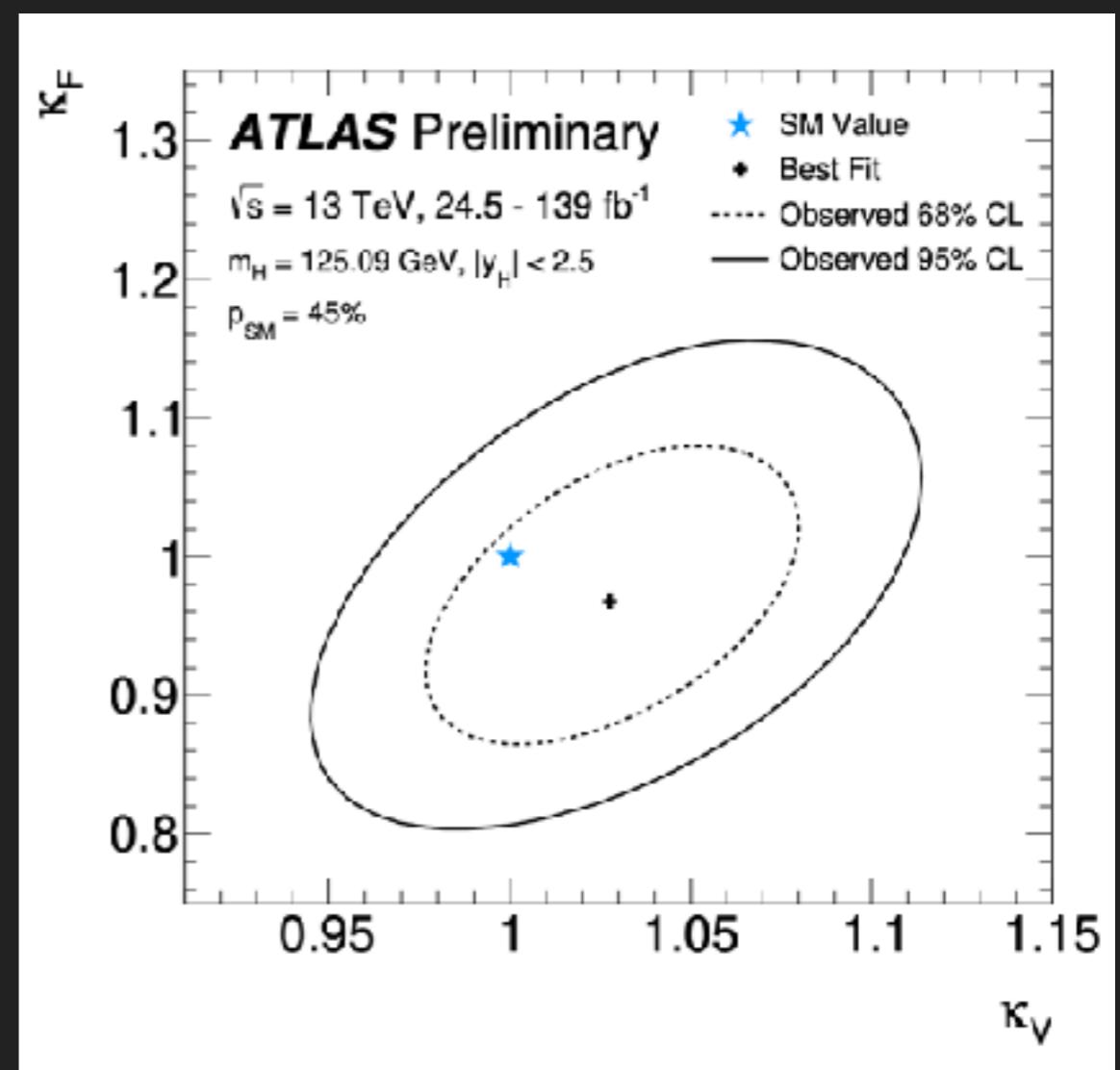
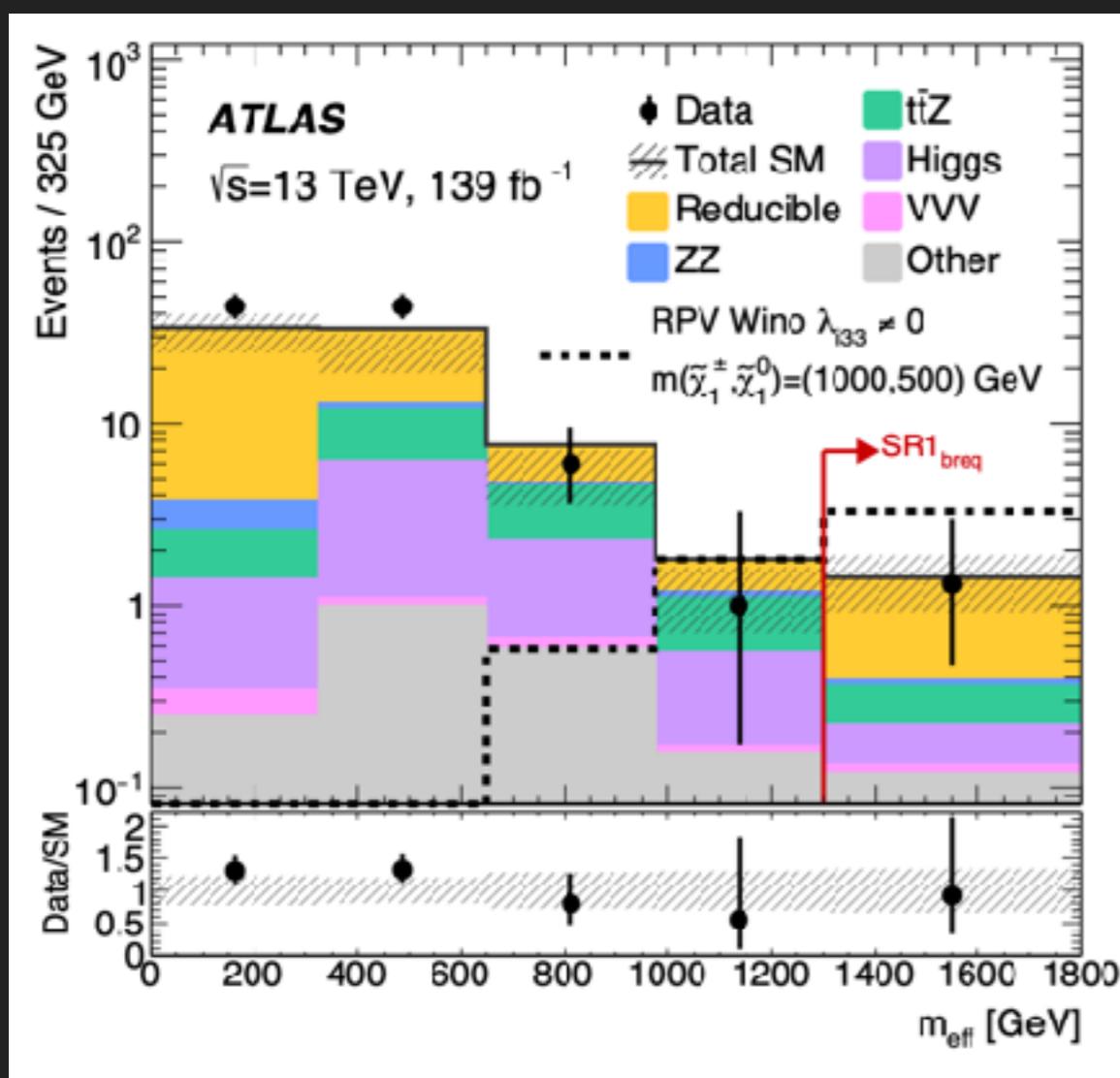
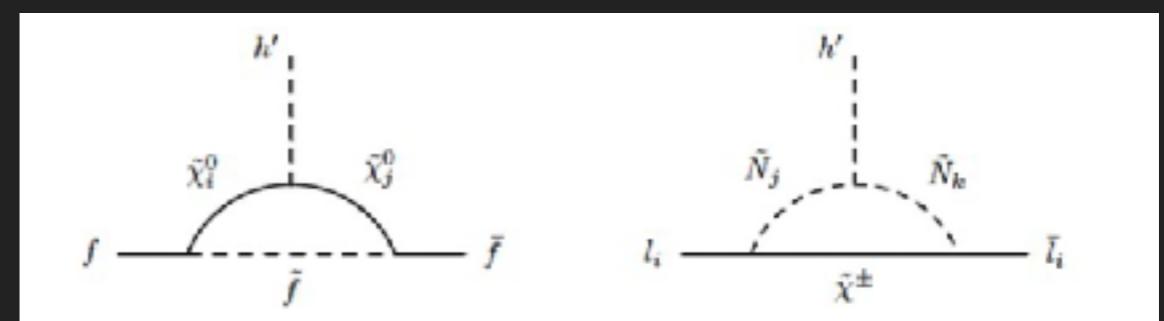
- ▶ Supersymmetry searches
 - Direct searches for sleptons and electroweakinos
 - Global fit of SUSY
- ▶ Two Higgs doublet model searches
- ▶ Dark Matter searches
 - Asymmetric DM
 - Lepton portal DM
- ▶ Electroweak phase transition
- ▶ Model independent limits
 - Higgs exotic decay, long live particle searches
- ▶

Supersymmetry searches at CEPC

Direct searches

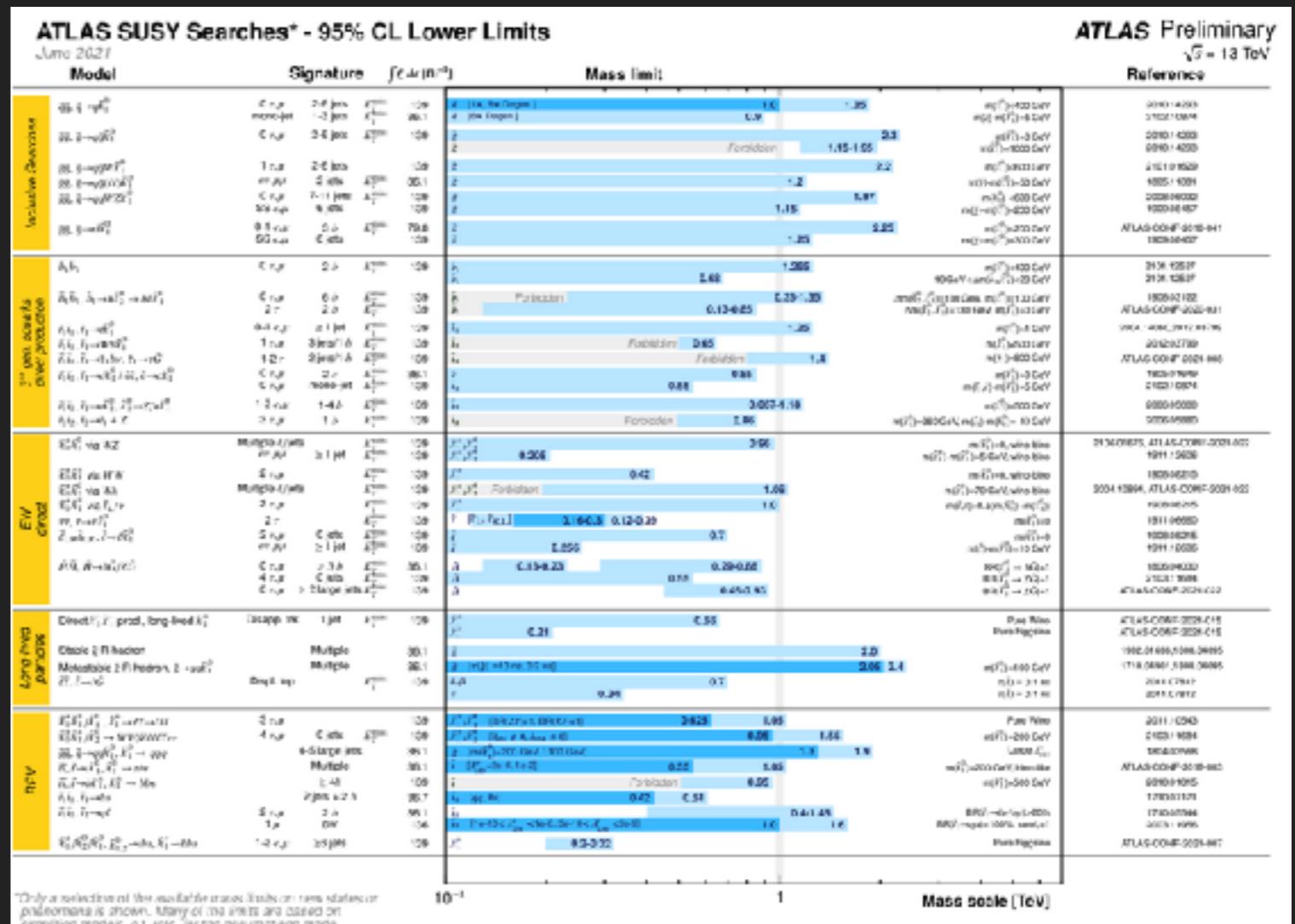


Indirect searches



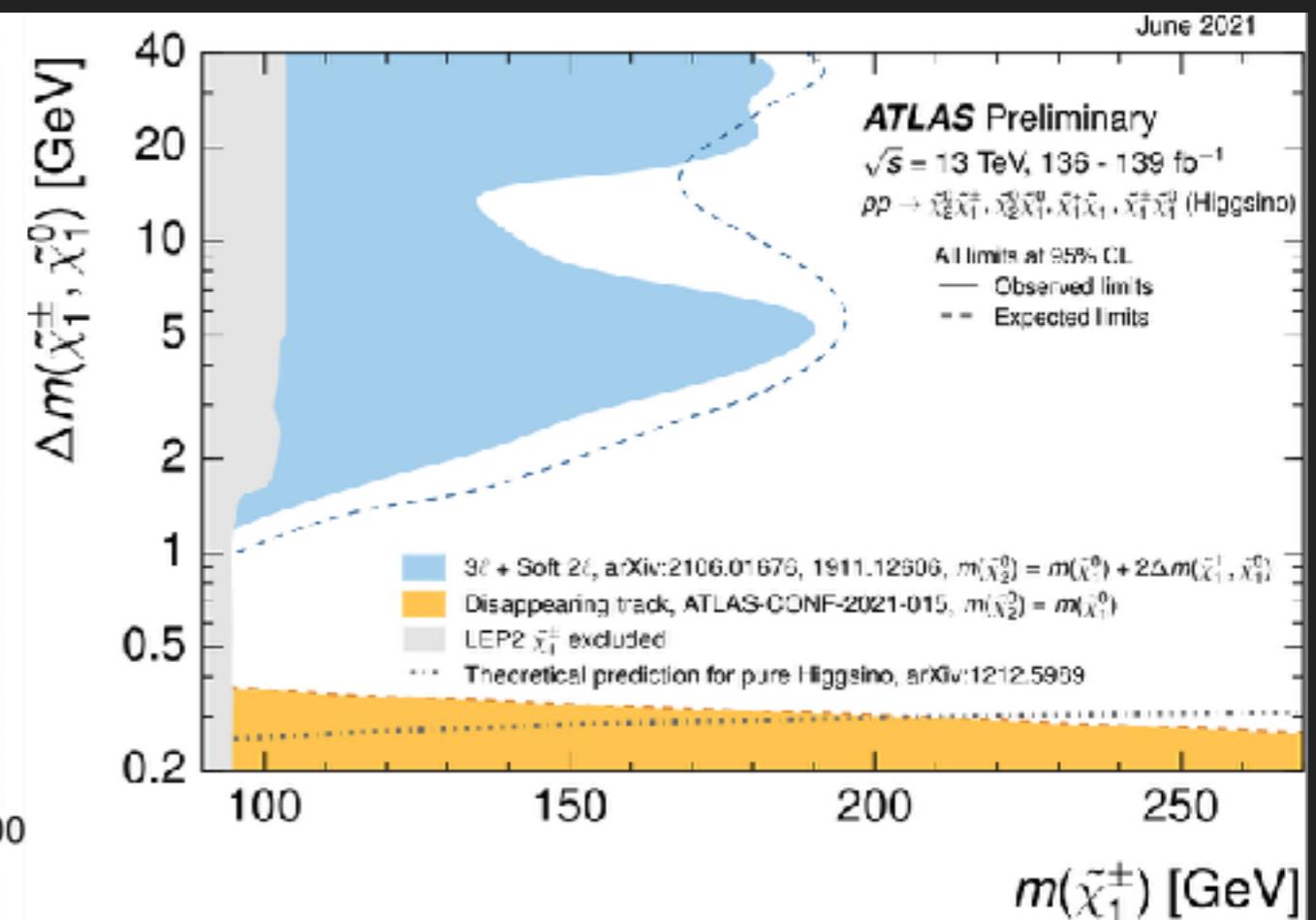
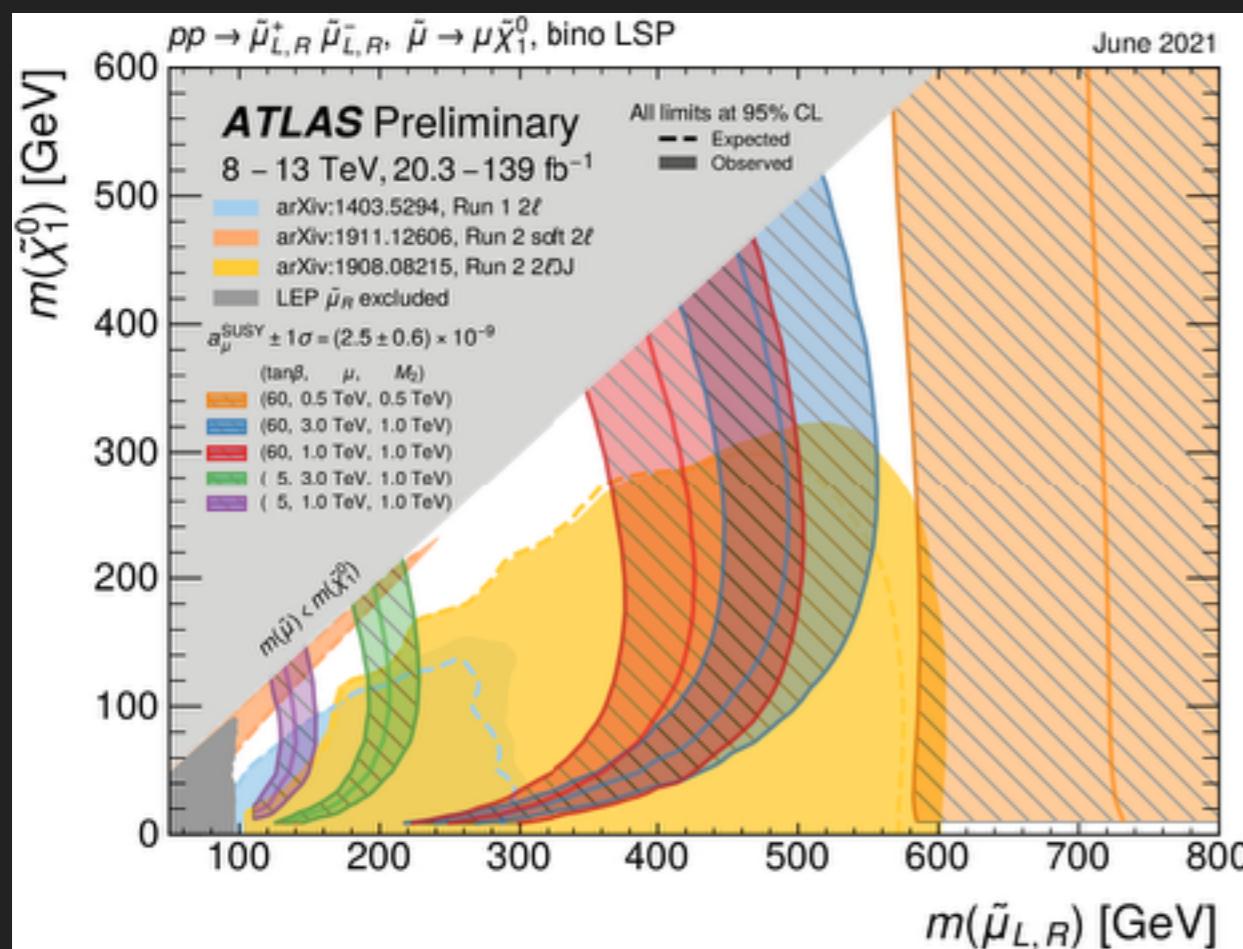
LHC direct searches

- 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.



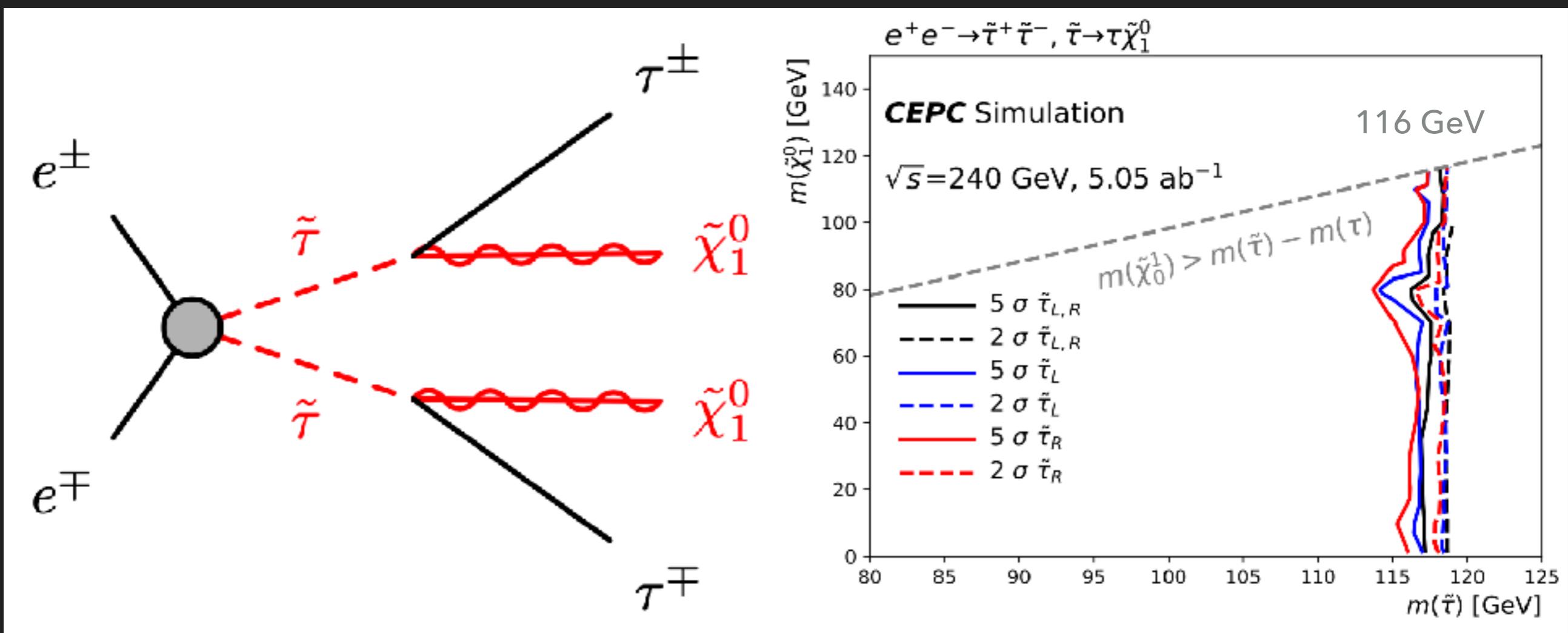
LHC direct searches

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



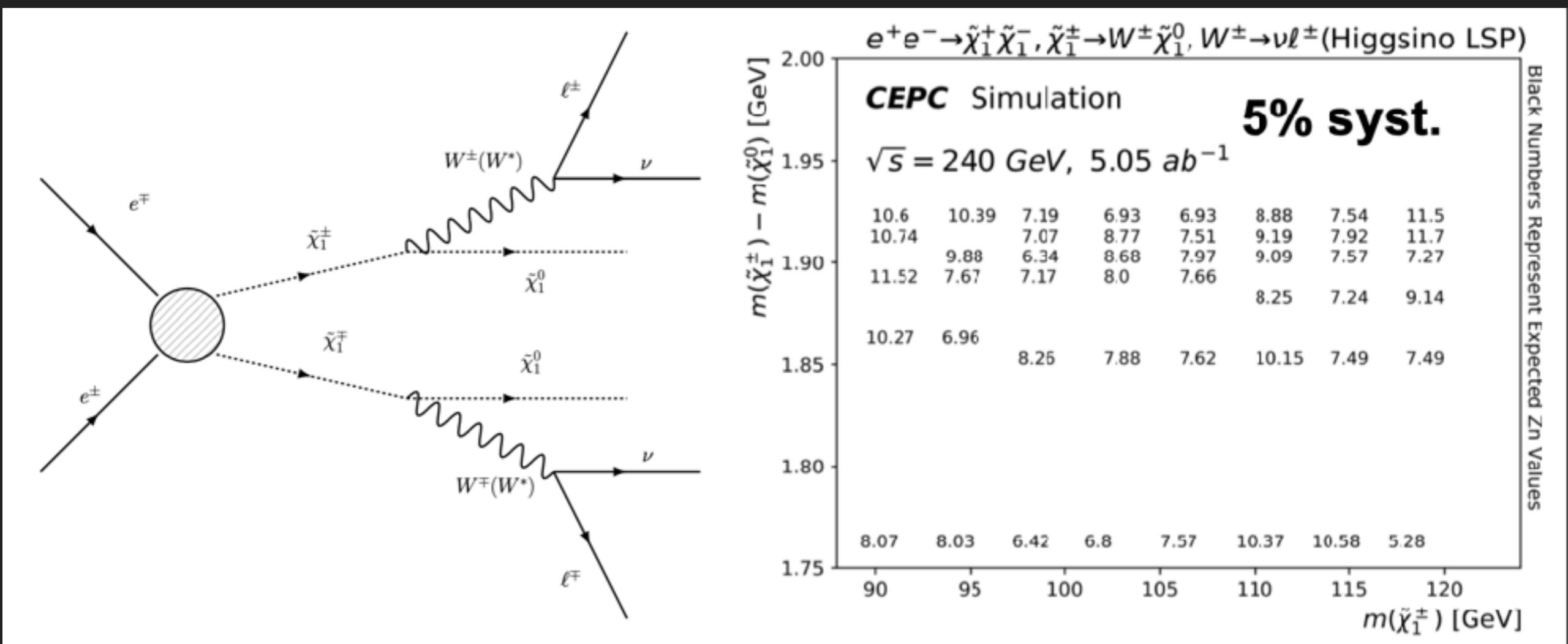
Slepton search at CEPC

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



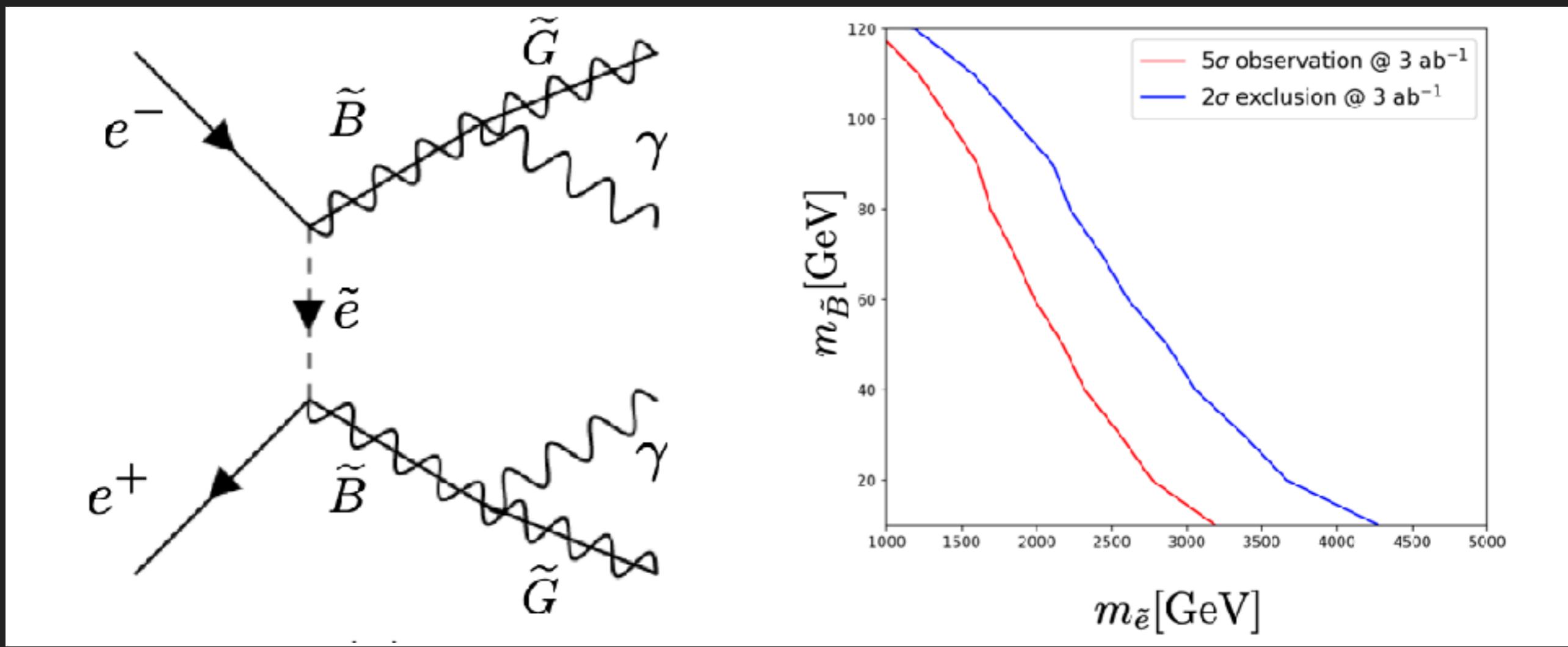
Chargino search at CEPC

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



Chargino search at CEPC

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



Indirect searches of SUSY at CEPC

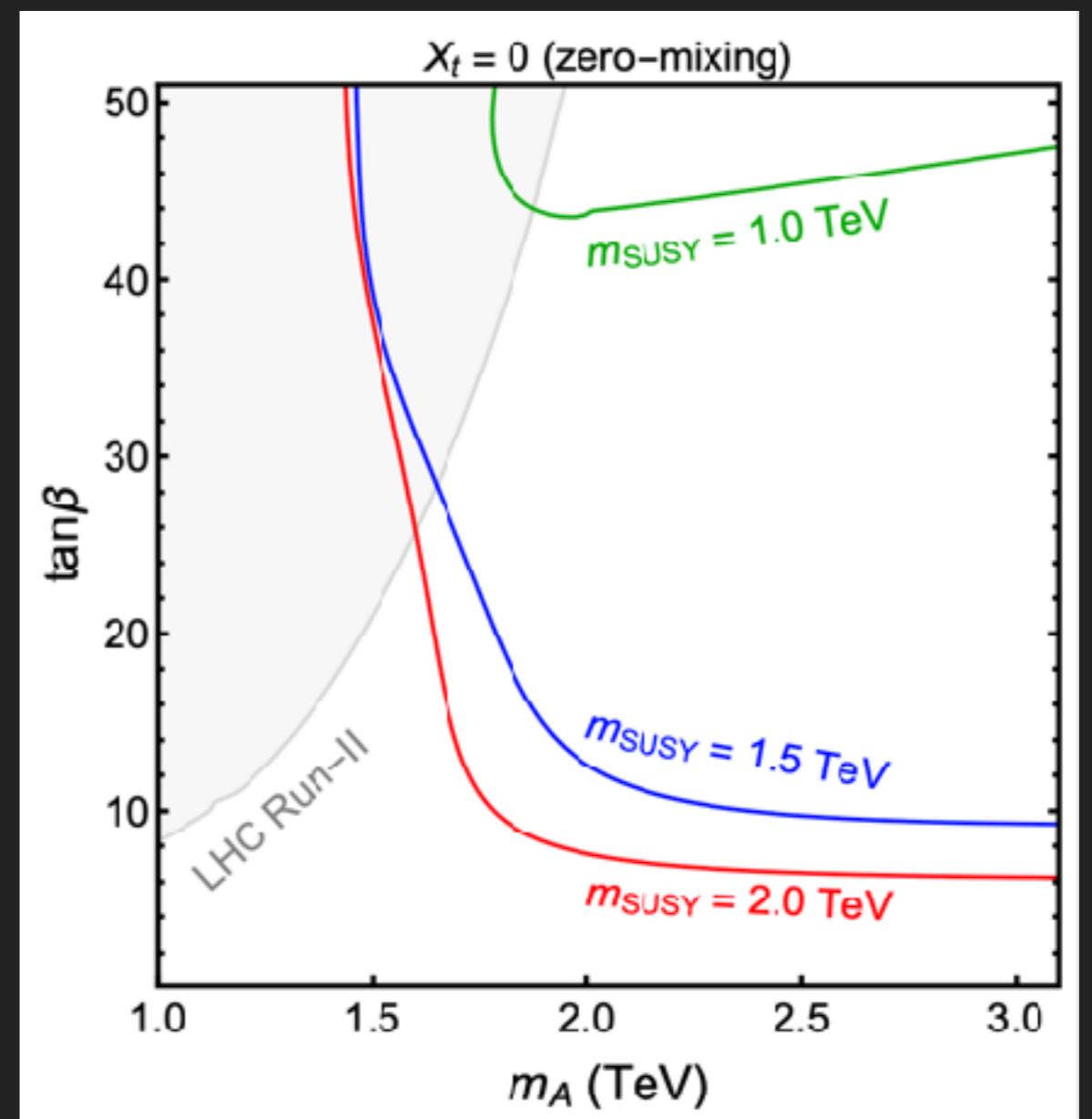
- ▶ MSSM at future Higgs factories, Honglei Li, Huayang Song, Shufang Su, Wei Su, Jin Min Yang, arXiv:2010.09782.
- MSSM contribution to κ_b , the Higgs coupling normalized to the SM value, is

$$\kappa_b = - \frac{\sin \alpha_{eff}}{\cos \beta} \tilde{\kappa}_h^b,$$

$$\tilde{\kappa}_h^b = \frac{1}{1 + \Delta m_b} \left(1 - \Delta m_b \frac{1}{\tan \alpha_{eff} \tan \beta} \right)$$

- The loop contribution of the stop sector is

$$\Delta m_b^{stop} = \frac{h_t^2}{16\pi^2} \mu A_t \tan \beta I(m_{\tilde{t}_1}, m_{\tilde{t}_2}, \mu)$$



SUSY global fit with CEPC results

- Global fits with present likelihood:

$$\begin{aligned} \mathcal{L}_{\text{Present+CEPC}} &= \mathcal{L}_{\text{CEPC}} \mathcal{L}_{\text{Present}} \\ &= \mathcal{L}_{\text{CEPC}} \mathcal{L}_{\text{collider}} \mathcal{L}_{\text{DM}} \mathcal{L}_{\text{flavor}} \mathcal{L}_{\text{EWPO}} \cdots \end{aligned}$$

where

$$-2 \ln \mathcal{L}_{\text{CEPC}} = \frac{(m_h^{\text{SUSY}} - m_h^{\text{obs}})^2}{(\Delta m_h)^2} + \sum_{i=f,V,\dots} \frac{(\mu_i^{\text{SUSY}} - \mu_i^{\text{obs}})^2}{(\Delta \mu_i)^2},$$

$$\mu_i = \frac{(\sigma_i \times \text{Br}_i)}{(\sigma_i \times \text{Br}_i)^{\text{SM}}}.$$

$$m_h^{\text{obs}} = 125.25 \text{ GeV},$$

$$\Delta m_h = \sqrt{0.17^2 + 2^2} = 2.007 \text{ GeV}$$

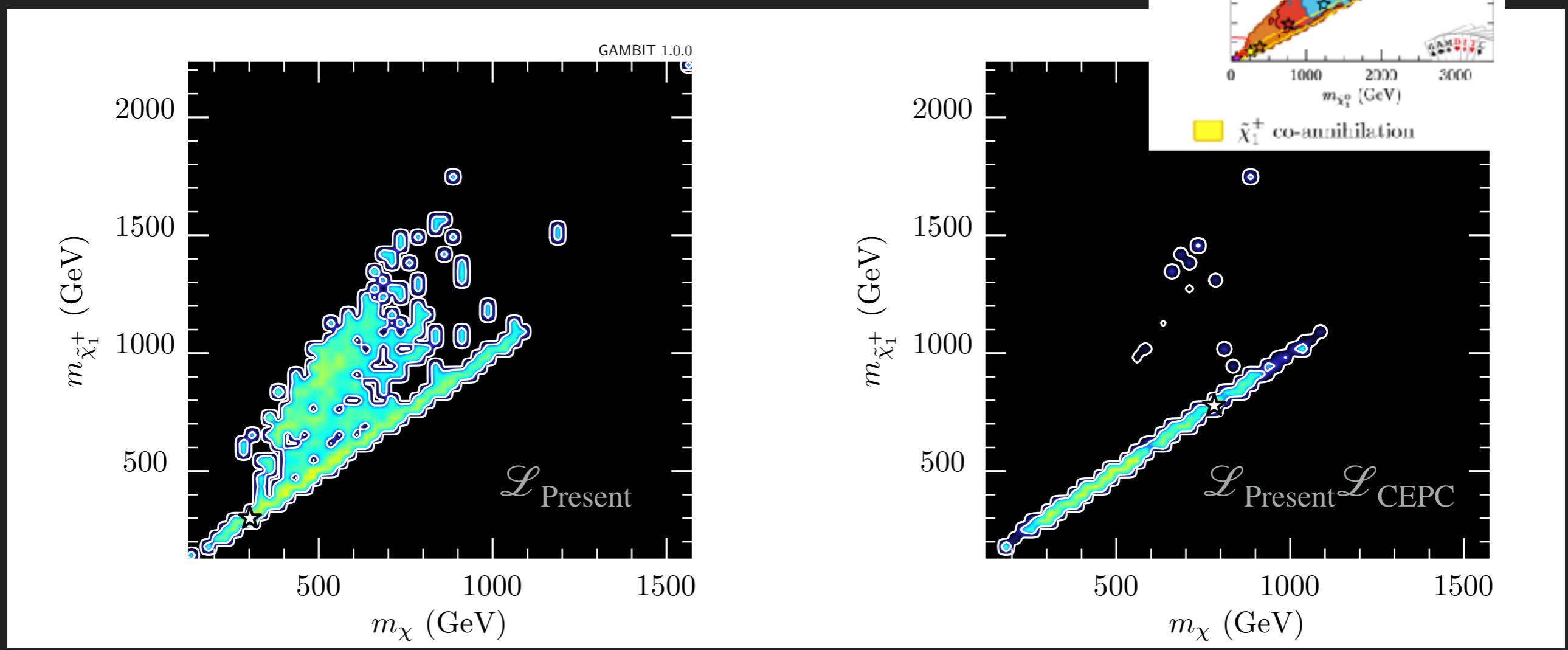
SM predictions for a 125 GeV Higgs boson

Decay mode	Branching ratio	Relative uncertainty
$H \rightarrow b\bar{b}$	57.7%	+3.2%, -3.3%
$H \rightarrow c\bar{c}$	2.91%	+12%, -12%
$H \rightarrow gg$	8.57%	+10%, -10%
$H \rightarrow \tau^+\tau^-$	6.32%	+5.7%, -5.7%
$H \rightarrow \mu^+\mu^-$	2.19×10^{-4}	+6.0%, -5.9%
$H \rightarrow WW^*$	21.5%	+4.3%, -4.2%
$H \rightarrow ZZ^*$	2.64%	+4.3%, -4.2%
$H \rightarrow \gamma\gamma$	2.28×10^{-3}	+5.0%, -4.9%
$H \rightarrow Z\gamma$	1.53×10^{-3}	+9.0%, -8.8%
Γ_H	4.07 MeV	+4.0%, -4.0%

Property	Estimated Precision	
	Decay mode	$\sigma(ZH) \times \text{BR}$
$H \rightarrow b\bar{b}$	0.27%	0.56%
$H \rightarrow c\bar{c}$	3.3%	3.3%
$H \rightarrow gg$	1.3%	1.4%
$H \rightarrow WW^*$	1.0%	1.1%
$H \rightarrow ZZ^*$	5.1%	5.1%
$H \rightarrow \gamma\gamma$	6.8%	6.9%
$H \rightarrow Z\gamma$	15%	15%
$H \rightarrow \tau^+\tau^-$	0.8%	1.0%
$H \rightarrow \mu^+\mu^-$	17%	17%
$H \rightarrow \text{inv}$	-	< 0.30%

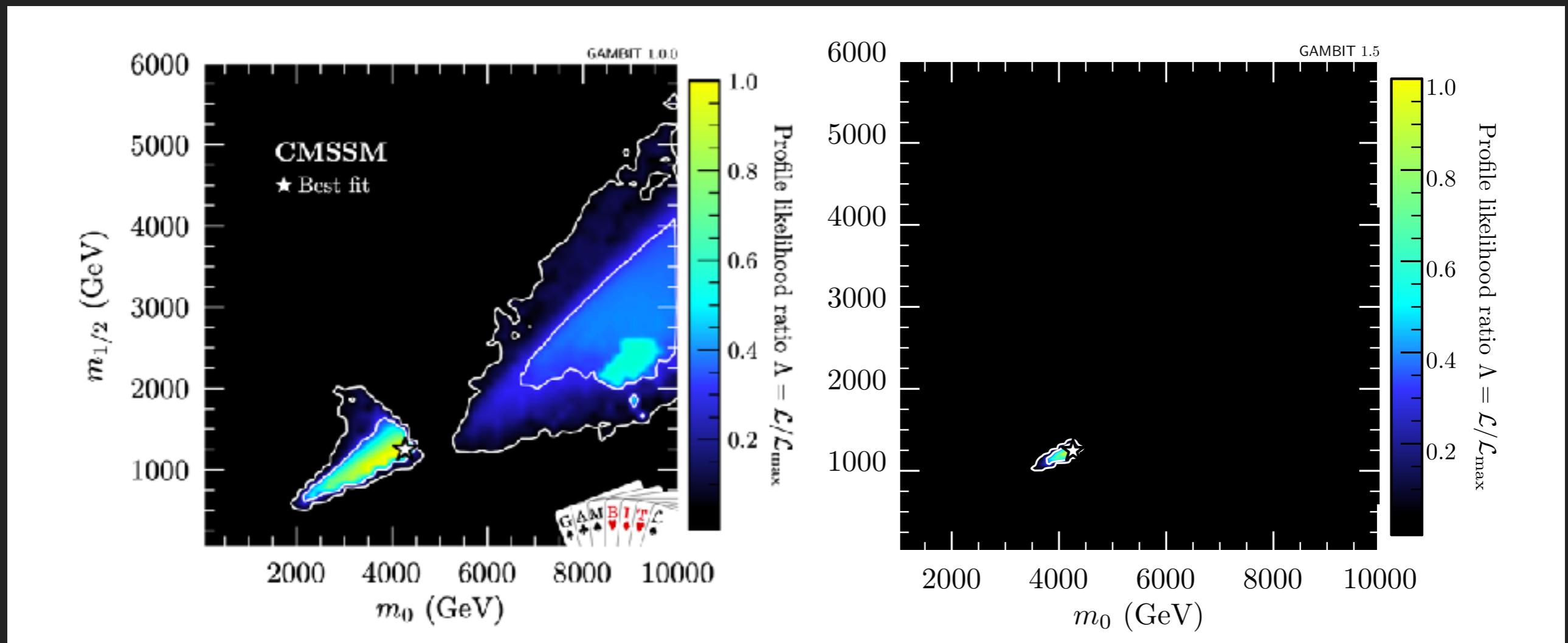
SUSY global fit with CEPC results

- ▶ Impact of the CEPC Higgs likelihood:



CMSSM global fit with CEPC results

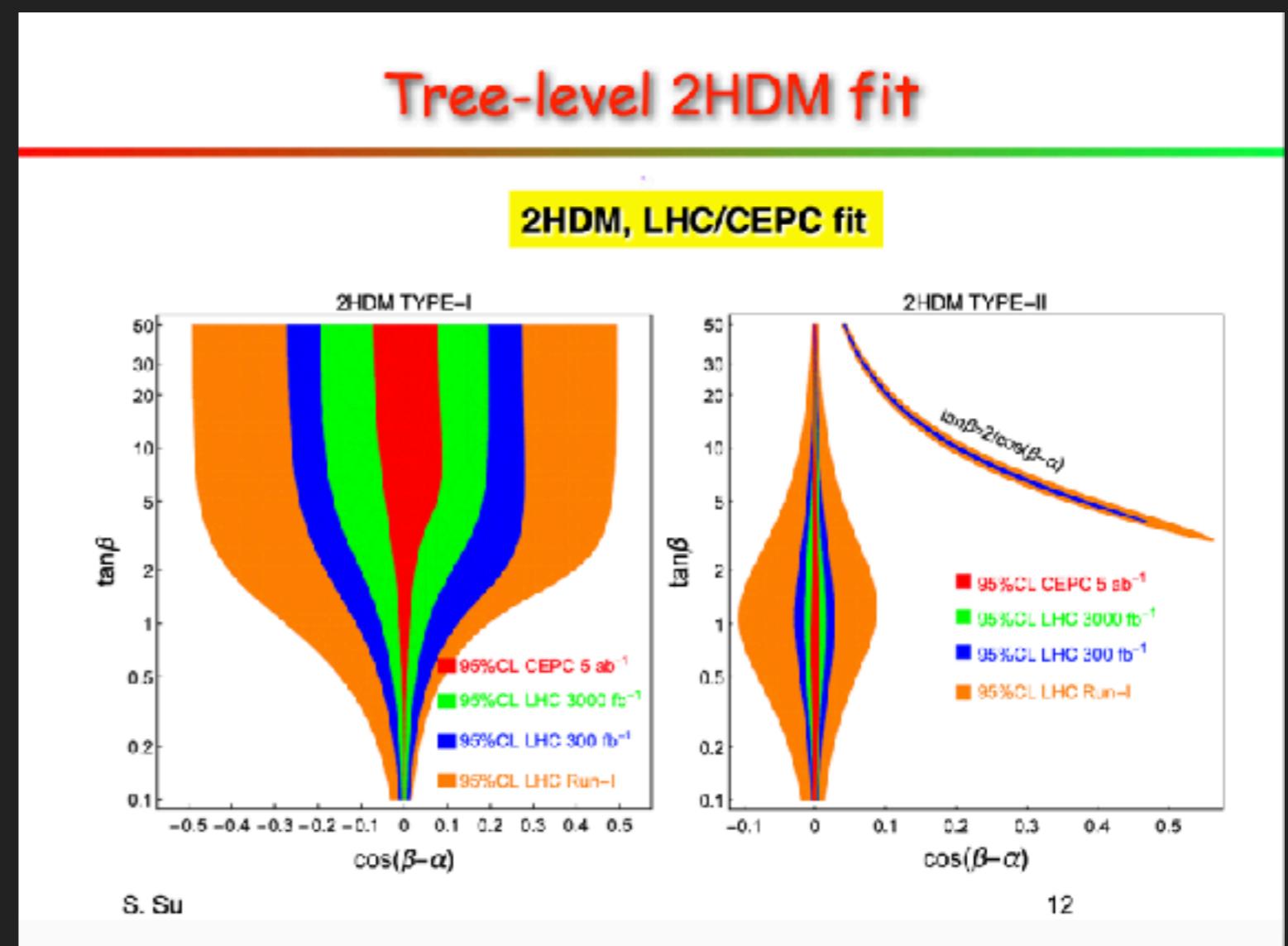
- We did similar study on the GUT-scale SUSY model, which give more , due to the correlation of input parameters.



2HDM searches at CEPC

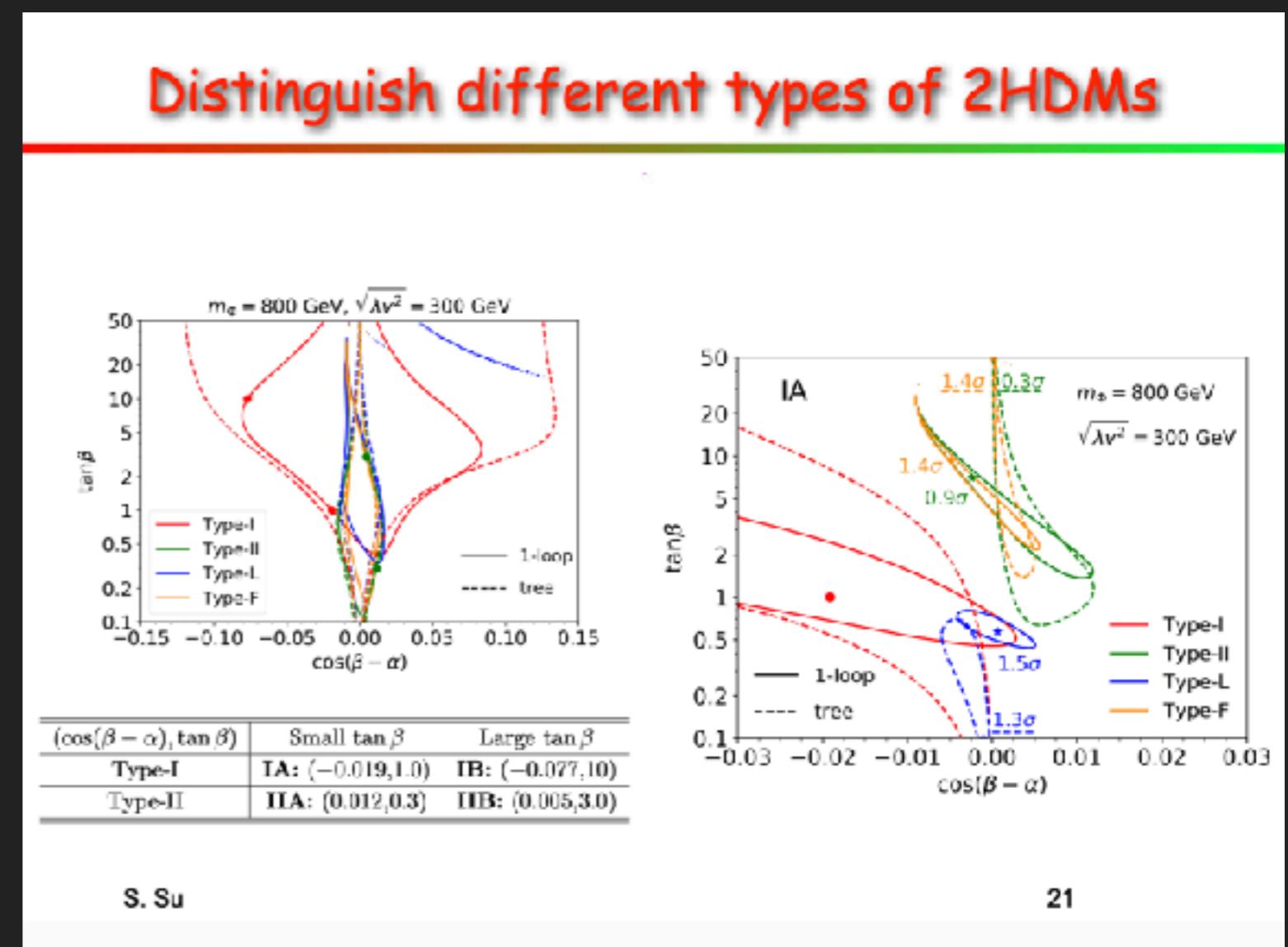
2HDM searches at CEPC

- ▶ 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



2HDM searches at CEPC

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

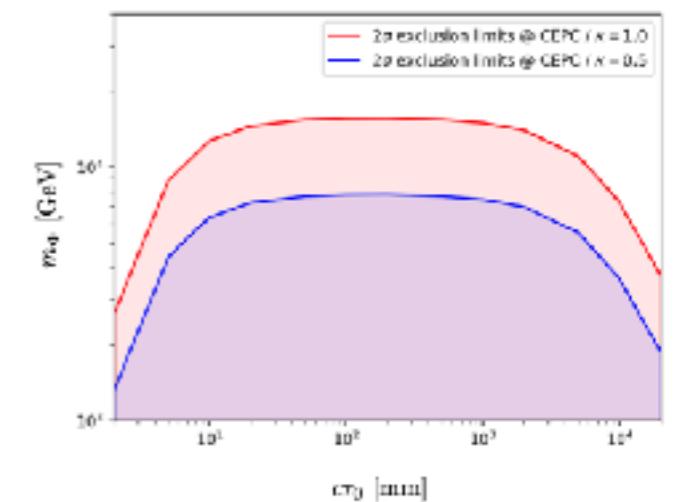
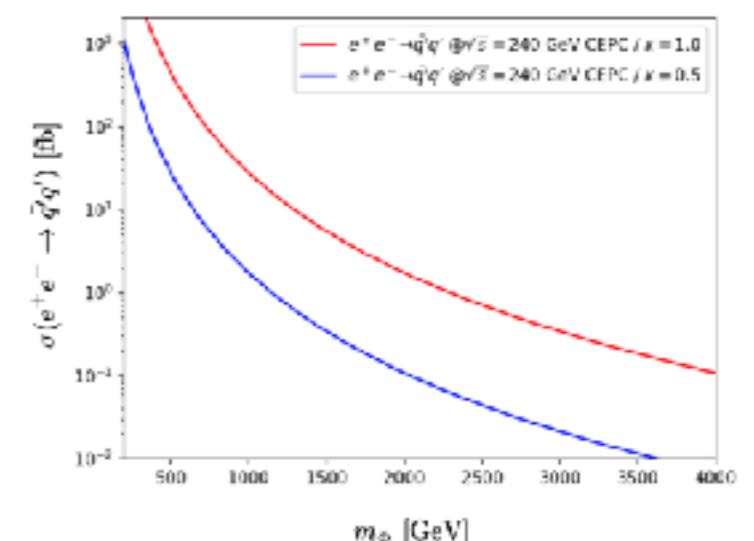
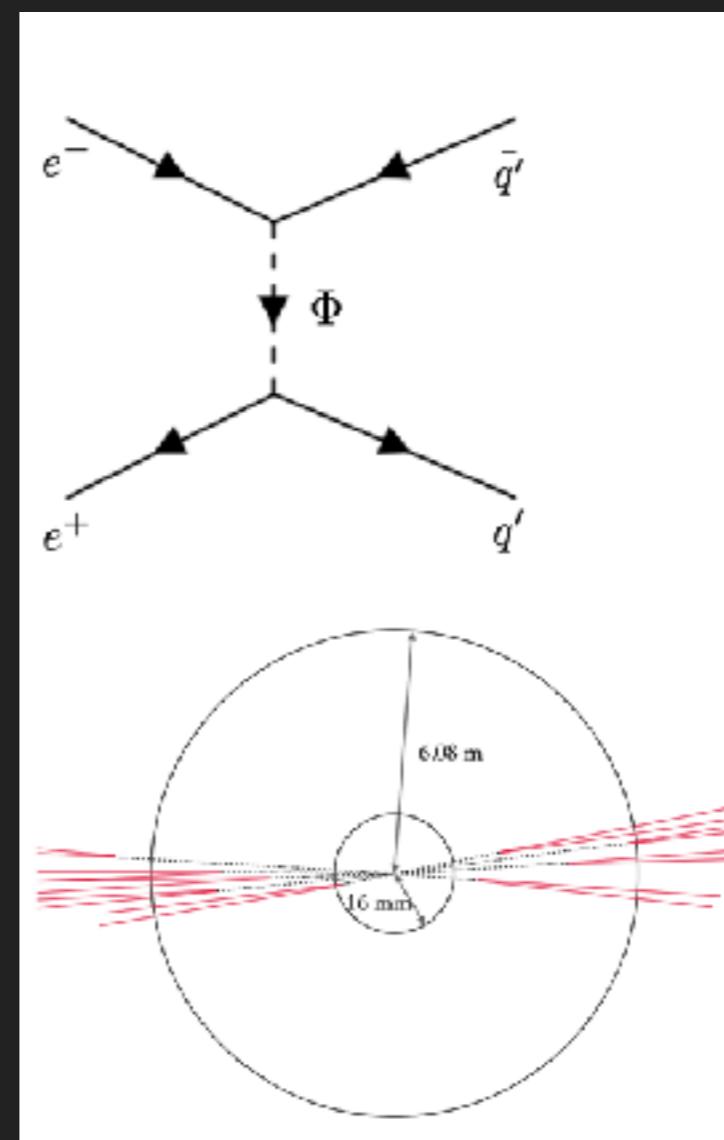


DM searches at CEPC

DM searches at CEPC

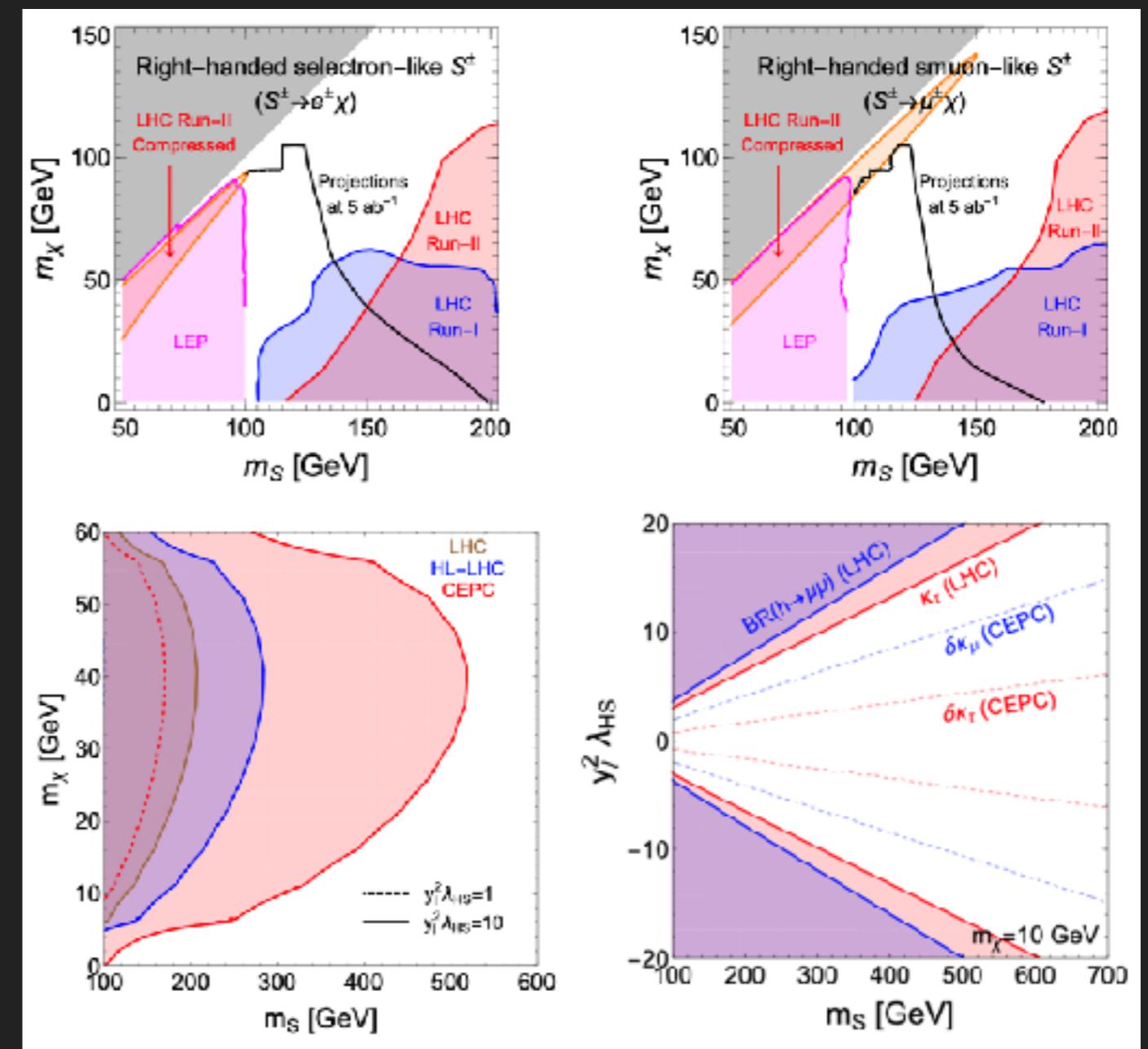
- ▶ Leptophilic Composite Asymmetric Dark Matter and its Detection,
Mengchao Zhang,
2104.06988

- ▶ On the CEPC, it is possible to directly generate dark quark pair through a t-channel process.
- ▶ Dark quark finally evolves to a jet-like object.



DM searches at CEPC

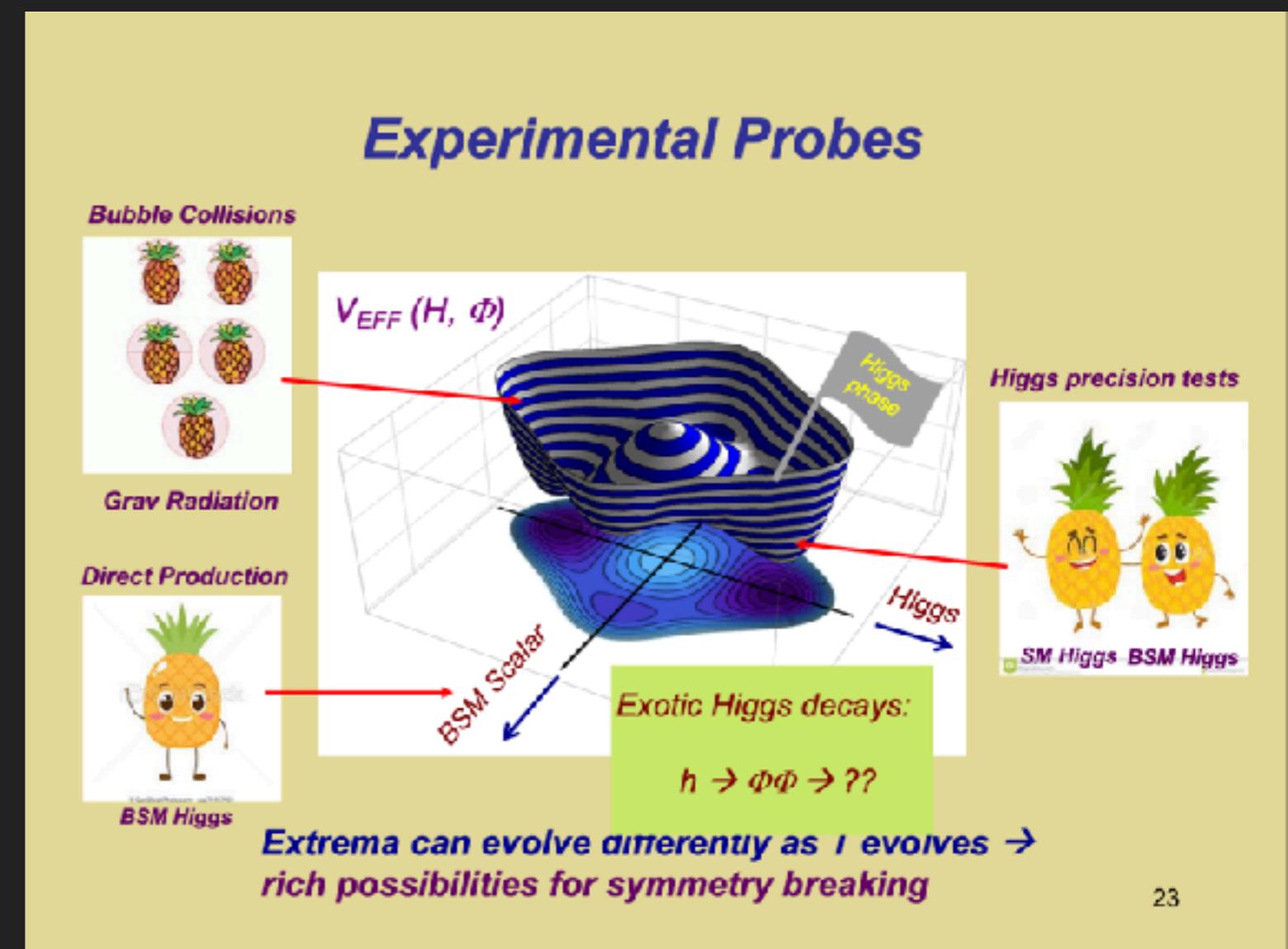
- ▶ Searching for lepton portal dark matter with colliders and gravitational waves, Jia Liu, Xiao-Ping Wang, Ke-Pan Xie, 2104.06421.
- ▶ The direct and indirect searches are not sensitive to this model.
- ▶ The scalar potential triggers a first- order phase transition.



Electroweak phase transition and CEPC

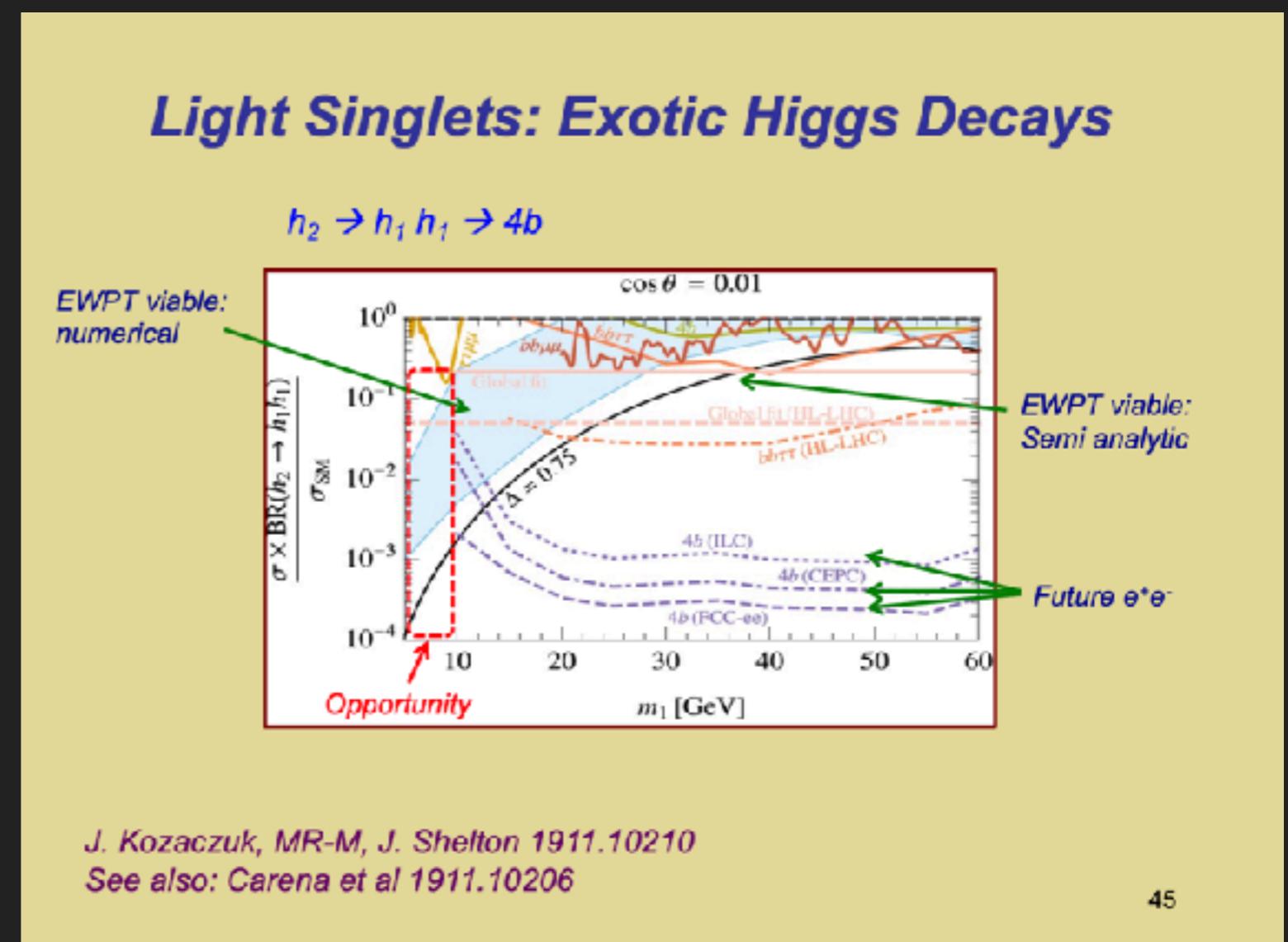
Electroweak phase transition

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

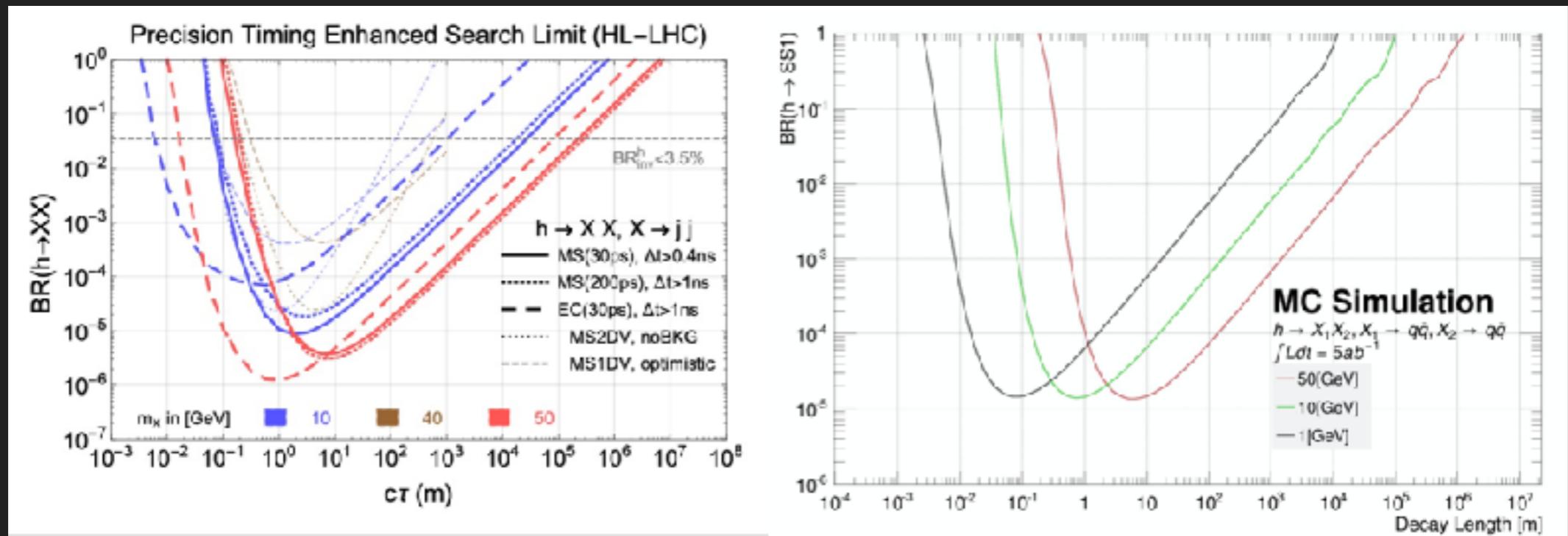
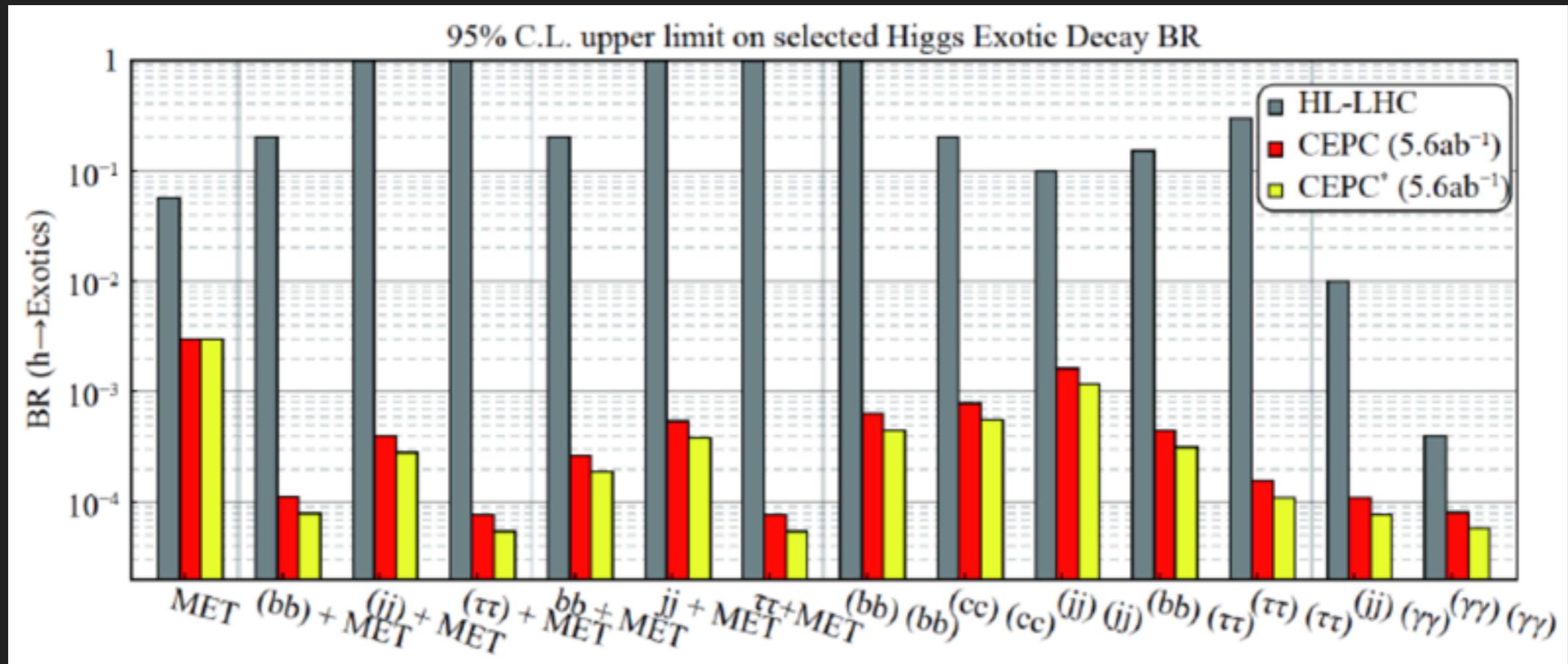


Electroweak phase transition

- ▶ The electroweak temperature T_{EW} sets a scale for colliders.
- ▶ Exotic Higgs decays provide a unique probe of light scalar-induced thermal history modifications.



Model independent limits



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 can visibly shrink the preferred regions.
- ▶ 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.



MSSM-7 global fit with CEPC results

- We explore a 7-parameter phenomenological MSSM.

Parameter	Minimum	Maximum	Priors
$A_{u_3}(Q)$	-10 TeV	10 TeV	flat, hybrid
$A_{d_3}(Q)$	-10 TeV	10 TeV	flat, hybrid
$M_{H_u}^2(Q)$	$-(10 \text{ TeV})^2$	$(10 \text{ TeV})^2$	flat, hybrid
$M_{H_d}^2(Q)$	$-(10 \text{ TeV})^2$	$(10 \text{ TeV})^2$	flat, hybrid
$m_{\tilde{f}}^2(Q)$	0	$(10 \text{ TeV})^2$	flat, hybrid
$M_2(Q)$	-10 TeV	10 TeV	split; flat, hybrid
$\tan \beta(m_Z)$	3	70	flat
sgn(μ)		+	fixed
Q		1 TeV	fixed

$$\frac{3}{5} \cos^2 \theta_W M_1 = \sin^2 \theta_W M_2 = \frac{\alpha}{\alpha_s} M_3,$$

$A_u = A_d = A_e = 0$, except for $(A_u)_{33} = A_{u3}$, $(A_d)_{33} = A_{d3}$

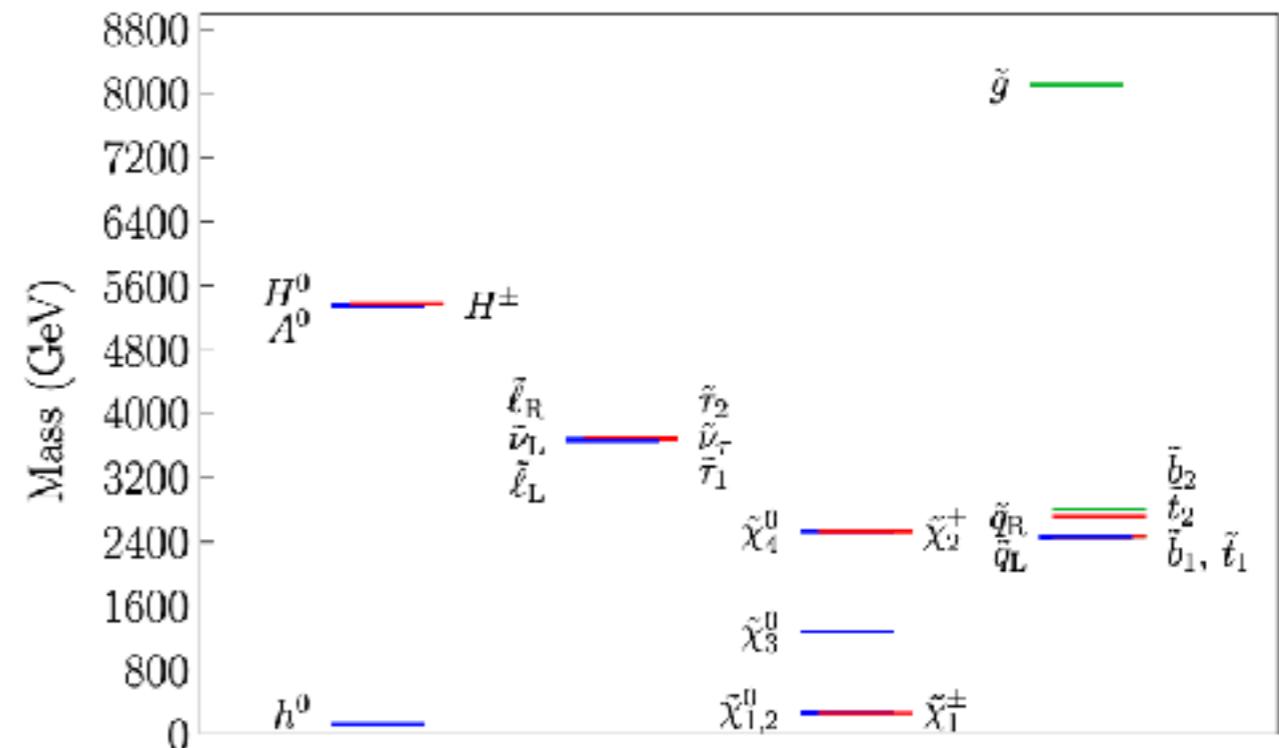


Fig. 1: Sparticle mass spectrum of the best-fit point.