CEPC WP

—— SUSY session

Nanjing chat @ Oct 2023

Contributions

- Five contributions collected since Sept-call
  - 1.1 Off-shell smuon search (Peng-Xuan Zhu)
  - 1.2 Lighting Electroweak-Violating ALP-Lepton Interactions at CEPC (Chih-Ting Lu)
  - 1.3 CEPC tau weak electric dipole moment (Long Chen)
  - 1.4 Muon g-2 (Peter Athron)
  - 1.5 Explanation of muon (electron) g-2 anomaly (Fei Wang)
- To be merged together with SNOWMASS contribution
  - Wino/higgsino/slepton search (Jiarong Yuan)

1 New Physics for CEPC White Paper

1.1 Off-shell smuon search (Peng-Xuan Zhu)

The excellent resolution of CEPC allows for an accurate determination of the missing energy and momentum $p^{\mu}_{\rm miss}$, which benefits the event reconstruction procedures in a Lorentz-invariant way. For the semi-invisible decaying particles pair-produced at lepton colliders shown in the left panel of Fig. 1, we can construct a geometric representation as illustrated in the right panel. Once a specific $\vec{p}_{\mathbf{I}_a}$ is selected, one can solve for all the unknown momenta. It is worth noting that the vector $\vec{p}_{\mathbf{I}_a}$ is constrained within a certain phase space (the yellow round disc in Fig. 1), further limiting the allowed range of particle masses $m_{\mathbf{P}}$ and $m_{\mathbf{I}}$ can be reconstructed solely based on kinematic information. The procedure is described in more detail in Ref. [1], which introduces a set of Lorentz invariant variables:

$$m^{\rm max}_{\rm LSP} = \sqrt{E^2_{\mathbf{I}_a} - \frac{1}{4\,|\vec{p}_{\rm miss}|^2}\left(|\vec{p}_{\rm miss}|^2 + E^2_{\mathbf{I}_a} - E^2_{\mathbf{I}_b}\right)^2}. \tag{1}$$

$$m^{\rm min}_{\rm RC} = \sqrt{\frac{E^2_{\mathbf{PP}}}{4} - |PC|^2 - (|OC| + |OA|)^2}, \tag{2}$$

$$m^{\rm max}_{\rm RC} = \begin{cases} \sqrt{\frac{E^2_{\mathbf{PP}}}{4} - |PC|^2}, & \text{if point } C \text{ is inside the disc,} \\ \sqrt{\frac{E^2_{\mathbf{PP}}}{4} - |PC|^2 - (|OC| - |OB|)^2}, & \text{if point } C \text{ is outside the disc.} \end{cases} \tag{3}$$

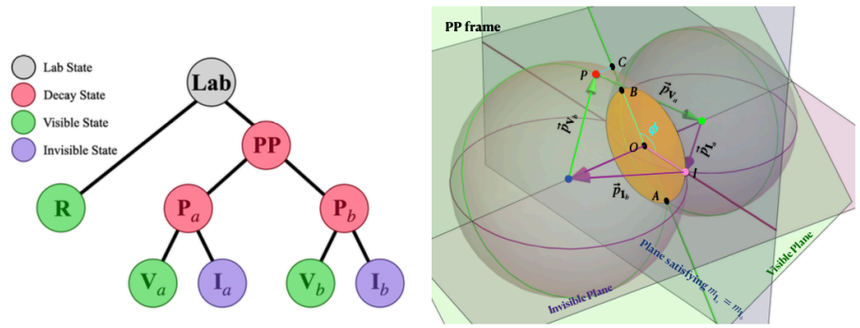
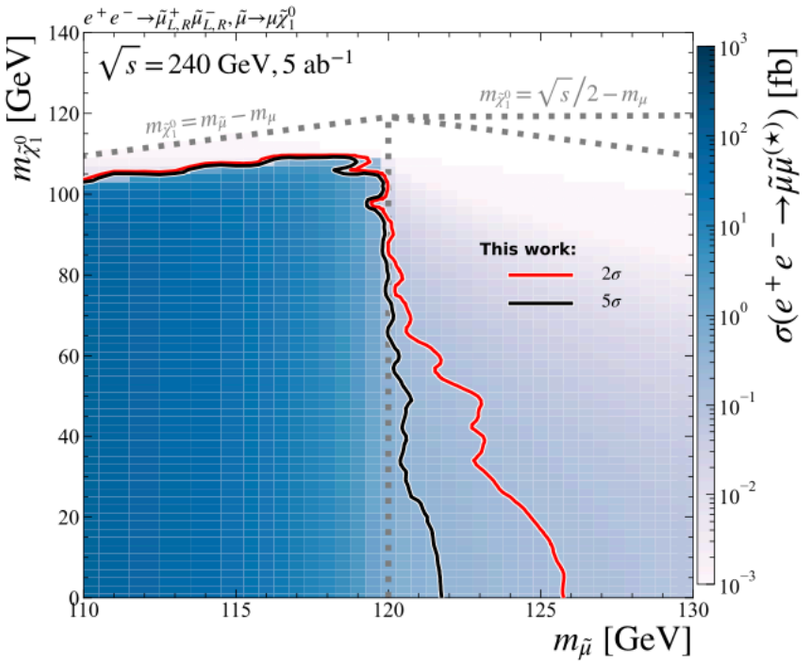


Figure 1: The decay tree and three-momentum vectors of semi-invisibly decaying particles pair-produced at lepton collider. Three reconstructing masses $m^{\rm max}_{\rm LSP}$, $m^{\rm min}_{\rm RC}$, and $m^{\rm max}_{\rm RC}$ are build to benefit the relevant searches in [1].

For a given semi-invisibly decayed event, these variables follow the relation

$$0 \le m^{\rm min}_{\rm RC} \le m_{\mathbf{P}} \le m^{\rm max}_{\rm RC} \le \sqrt{s}/2, \quad 0 \le m_{\mathbf{I}} \le m^{\rm max}_{\rm LSP}. \tag{4}$$

Off-shell smuon search



tau weak electric dipole moment

$e^+e^- \to \tau^+\tau^-$ Table 1: Ideal 1 s.d. statistical errors on $\mathrm{Re}[d_\tau^w]$ and $\mathrm{Im}[d_\tau^w]$.

$\delta\mathrm{Re}[d_\tau^w]$ [e cm]			$\delta\mathrm{Im}[d_\tau^w]$ [e cm]		
$\langle T_{33}\rangle$	$\langle \hat{T}_{33}\rangle$	$\langle O_R\rangle$	$\langle Q_{33}\rangle$	$\langle \hat{Q}_{33}\rangle$	$\langle O_I\rangle$
3.4×10^{-21}	3.4×10^{-21}	1.4×10^{-21}	3.2×10^{-19}	4.0×10^{-20}	2.1×10^{-21}

Muon g-2

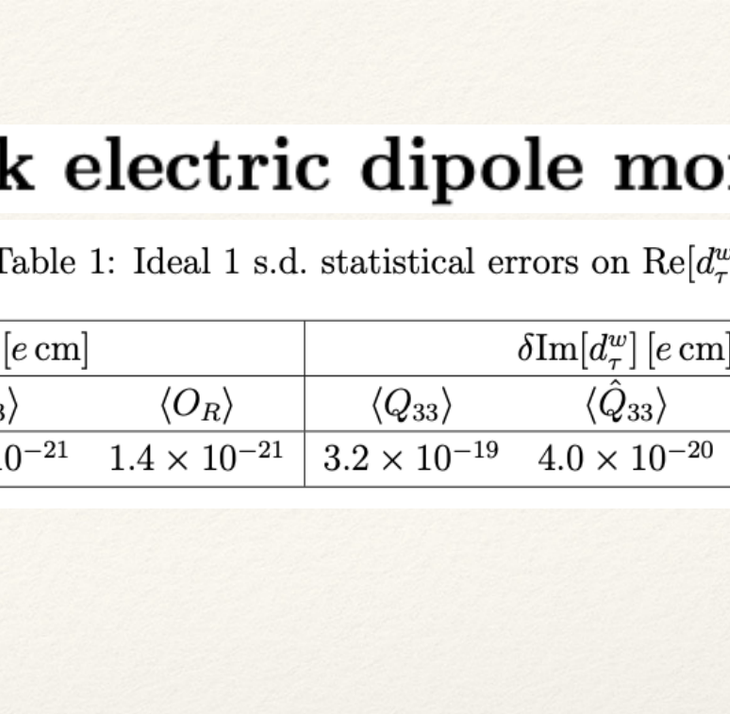


Figure 4: A simple model with a new scalar and and a new fermion. The purple-orange contour colour contours show the minimum value of the coupling to right handed muons required to explain muon g-2. outside of this region muon g-2 cannot be explained with $1-\sigma$. The shaded grey region shows LHC exclusions while the shaded orange region shows exclusions from compressed spectra. The shaded blue region in the top left is excluded because it predicts a stable charged particle.

Axion-like particles (ALPs) $e^+e^- \to \nu_e a\overline{\nu_e}$

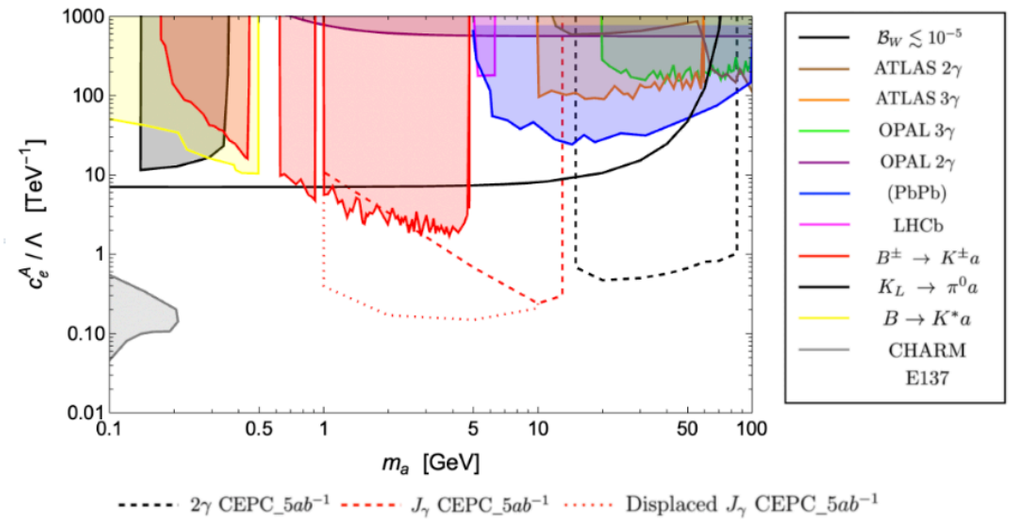


Figure 3: The future bounds on the coupling c_e^A/Λ of eALPs from CEPC with $\mathcal{L} = 5ab^{-1}$ within 95% confidence level or with a requirement of at least 10 survival events for background-free cases (dashed lines for the eALP prompt decay and dotted lines for the eALP as a long-lived particle) as well as existing bounds (bulk regions). Here we label "2γ" and "J_γ" to identify two distinct signatures at CEPC. $\mathcal{B}_W \lesssim 10^{-5}$ represents $\mathcal{B}(W^\pm \to \ell^\pm \nu a) < 10^{-5}$ [1] (solid-black line). Several collider bounds are