Potential search for direct slepton pair production in $\sqrt{s} = 360$ GeV at CEPC

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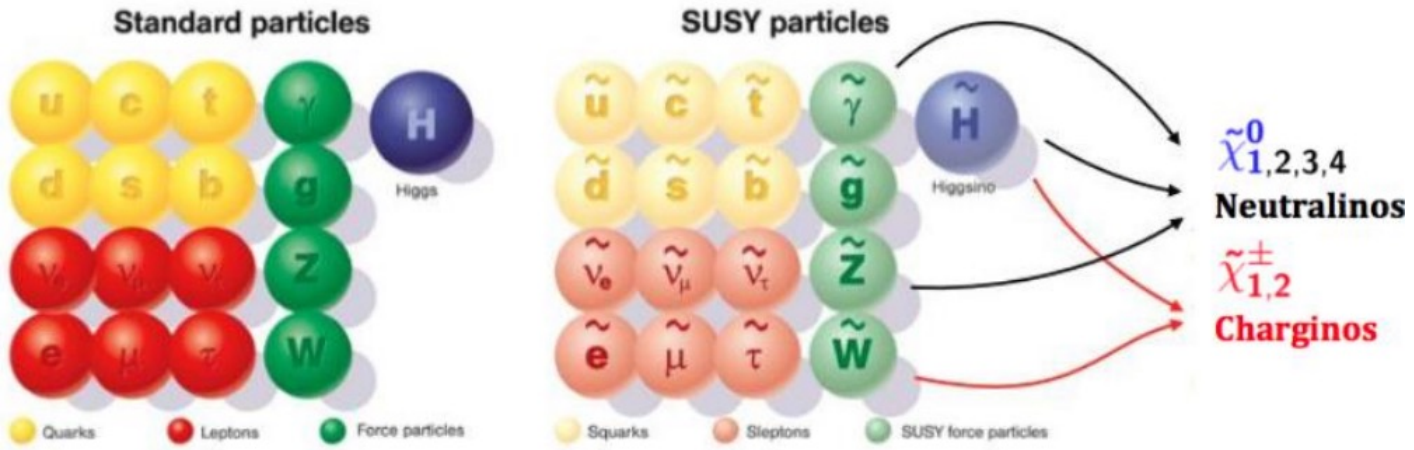
360 GeV: arXiv:2501.03600
240 GeV: arXiv:2203.10580

Structure of the talk

- Supersymmetry Introduction
- Search for direct stau production
- Search for direct smuon production
- Conclusion

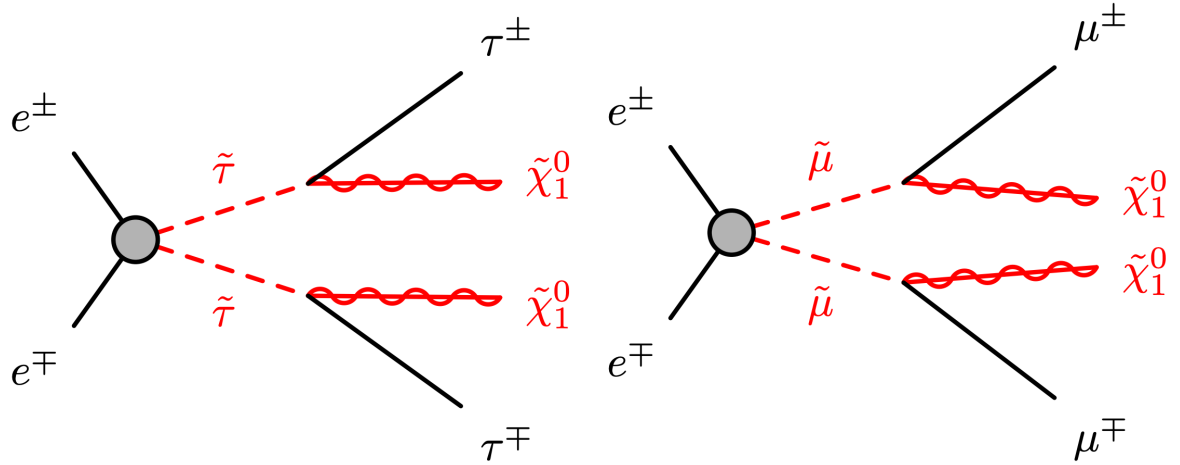
Supersymmetry (SUSY)

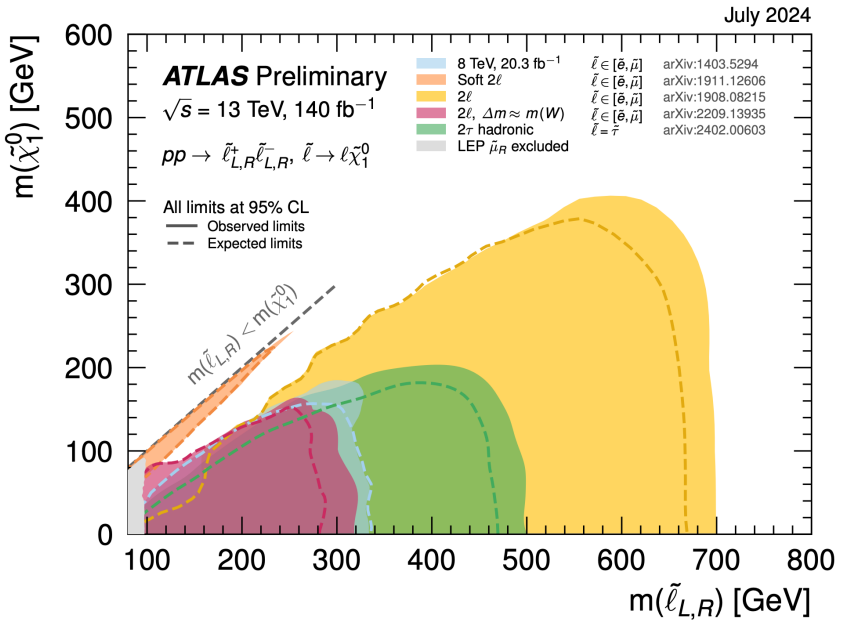
- A supersymmetric extension of the Standard Model
  - New fermionic/bosonic supersymmetric partner for each particle of the SM bosons/fermions
- R-parity introduced to avoid baryon number or lepton number violation
  - Sparticles are produced in pairs
  - Lightest supersymmetric particle (LSP) is stable
  - Sparticles will eventually decay to odd number of LSP



Slepton Analysis

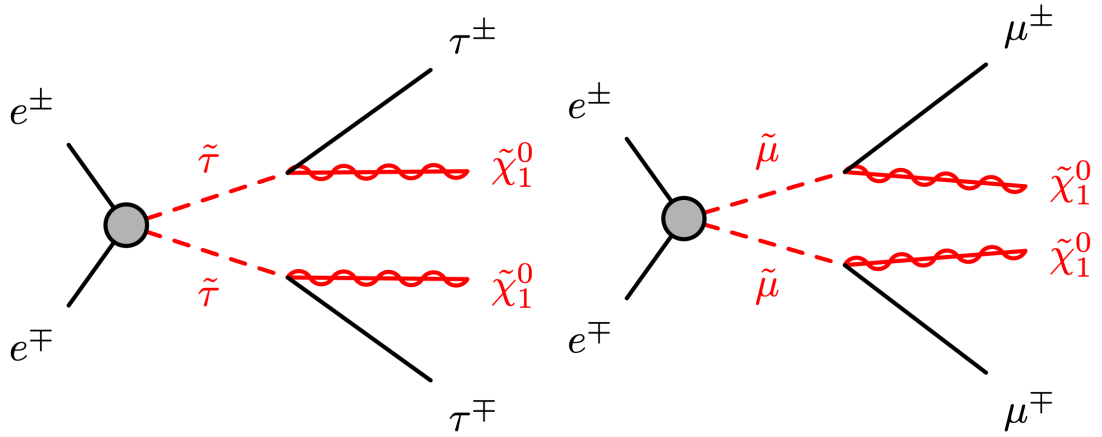
- Signal scenario
  - direct production of stau / smuon
- Motivation for light slepton
  - Light slepton could play a role in the coannihilation of neutralinos.
  - Models with light stau are consistent with dark matter cosmological observations.
  - Light smuon could explain the $(g-2)_\mu$ excess
  - In gauge-mediated and anomaly-mediated SUSY breaking models, sleptons are expected to have masses of order 100 GeV.
- Previous limit on slepton mass
  - Limited sensitivity in compressed region at LHC
- Simulation: CEPC@360 GeV with 1.0ab^{-1} integrated luminosity





Analysis Strategy

- Signal topology
  - Direct stau production: 2 τ_{had} + large M_{recoil}
  - Direct smuon production: 2 μ + large M_{recoil}
- Reconstruction
  - Reconstructed objects $E > 0.5$ GeV
  - Leading opposite sign (OS) tracks are used as the 2 τ_{had}



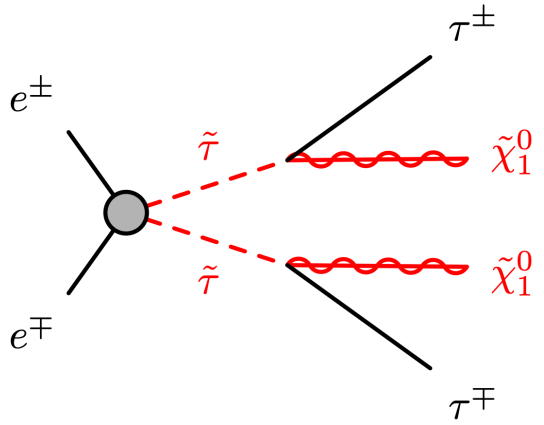
- Variables
  - $\Delta\phi$, azimuth difference
  - $\Delta R = \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2}$, where η is the pseudo-rapidity
  - sumP_T, the sum of the transverse momentum of two leptons
  - M_{recoil}, the invariant mass of the recoil system
  - M_{extra}, the invariant mass of all reconstructed visible particles except the two leading OS leptons
- Preselection: 2 OS leptons
- Signal regions are optimized using the Cut and Count method
- Sensitivity
  - Assuming flat 5% systematic uncertainty

$$Zn = \left[2\left((s+b)\ln\left[\frac{(s+b)(b+\sigma_b^2)}{b^2+(s+b)\sigma_b^2}\right] - \frac{b^2}{\sigma_b^2}\ln\left[1+\frac{\sigma_b^2 s}{b(b+\sigma_b^2)}\right]\right)\right]^{1/2}$$

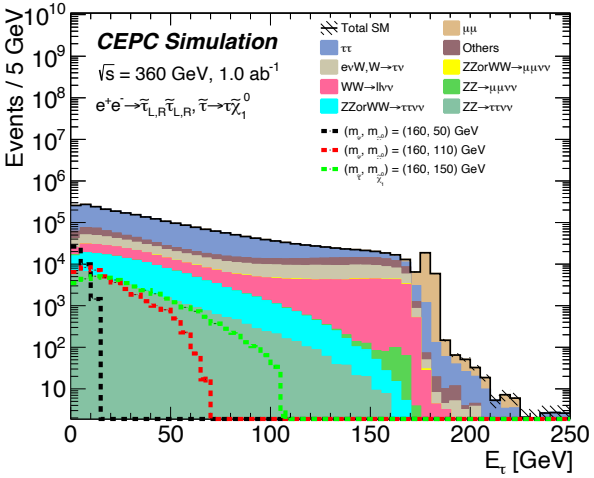
Direct Stau Production

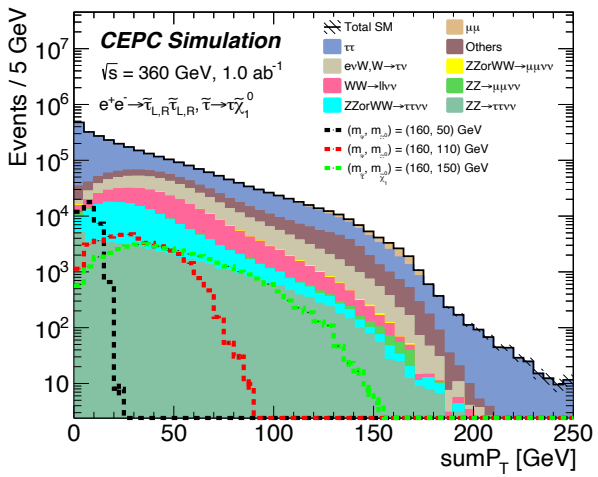
- Preselection

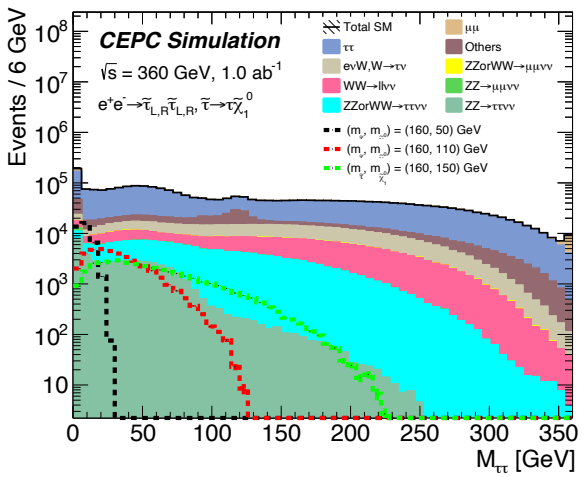
Preselection
2 OS τ_{had}

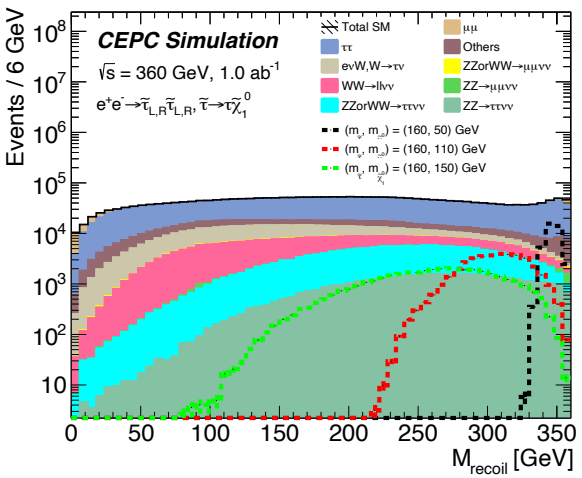


- Distributions after preselection









Direct Stau Production

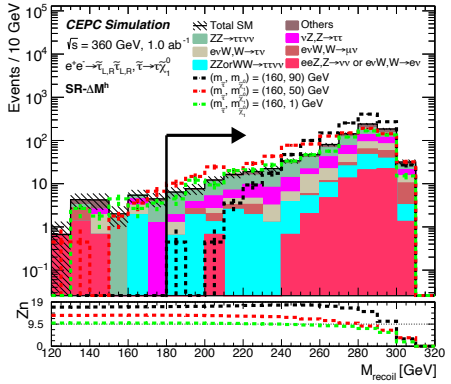
- Signal regions
  - Three signal regions according to different mass splitting between $\tilde{\tau}$ and $\tilde{\chi}_1^0$

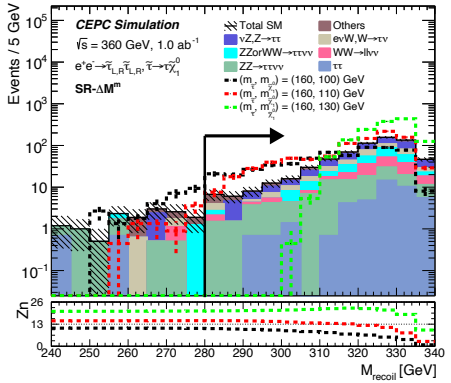
SR-ΔM^h	SR-ΔM^m	SR-ΔM^l
E_τ <40 GeV	E_τ <15 GeV	
sumP_T >50 GeV	sumP_T >20 GeV	-
2.55 <$\|\Delta\phi(\tau, recoil)\|$ <3.1	$\|\Delta\phi(\tau, recoil)\|$ <3.1	$\|\Delta\phi(\tau, recoil)\|$ >2.3
-	0.45<$\Delta R(\tau,\tau)$ <1.7	$\Delta R(\tau,\tau)$ >0.45
$\Delta R(\tau, recoil)$ <3.2	$\Delta R(\tau, recoil)$ <3.15	$\Delta R(\tau, recoil)$ <2.9
$M_{\tau\tau}$ <40 GeV	$M_{\tau\tau}$ <25 GeV	$M_{\tau\tau}$ <16 GeV
M_{recoil} >180 GeV	M_{recoil} >280 GeV	M_{recoil} >325 GeV

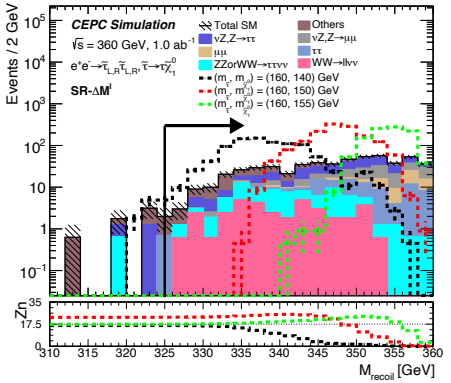
- Distributions after SR selections except the shown variable

SR-ΔM^h **SR-ΔM^m** **SR-ΔM^l**

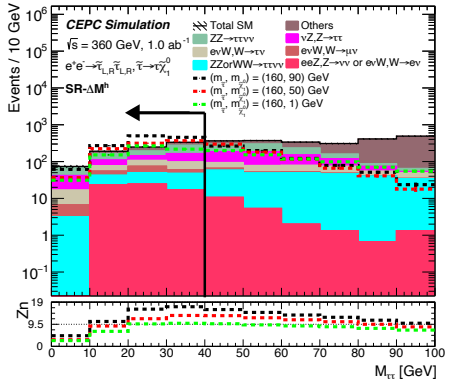
M_{recoil}

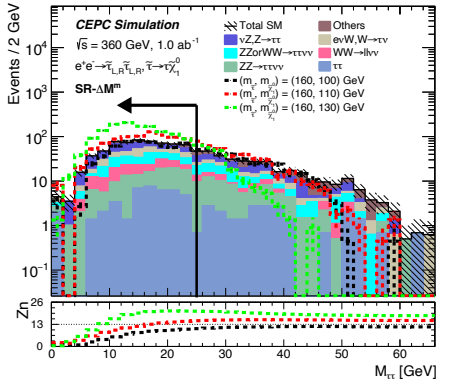


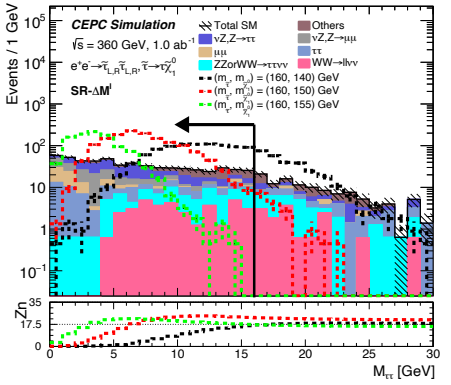




$M_{\tau\tau}$

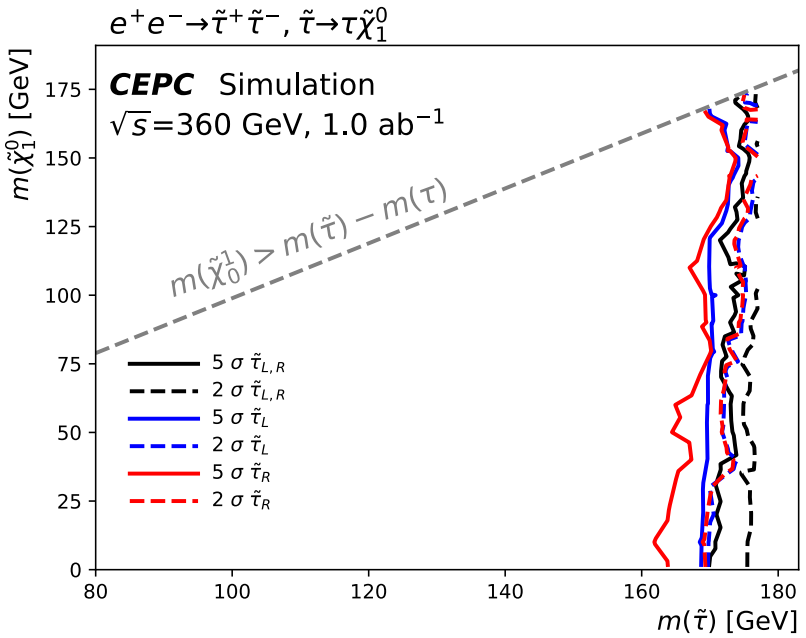


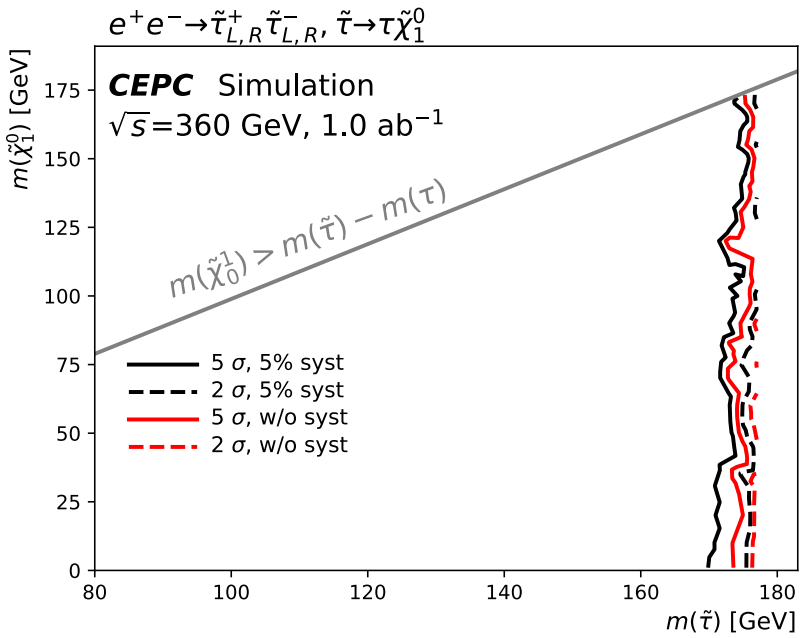




Direct Stau Production

- With **left-handed and right-handed** $\tilde{\tau}$ combination, the discovery potential can reach up to **170 GeV** in $\tilde{\tau}$ mass
- With **pure left/right-handed** $\tilde{\tau}$, the discovery potential can reach up to **169/162 GeV** in $\tilde{\tau}$ mass
- Cover the region with compressed mass spectrum
- Small impact from systematic uncertainty

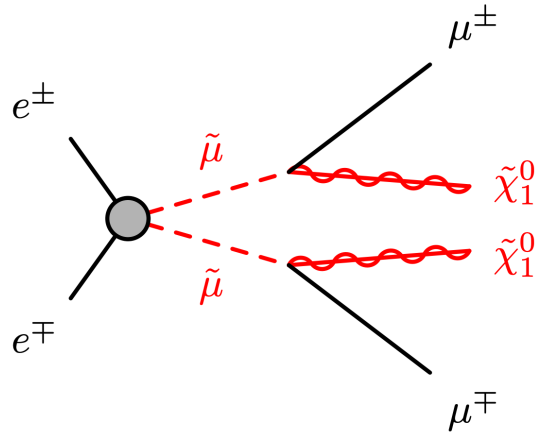




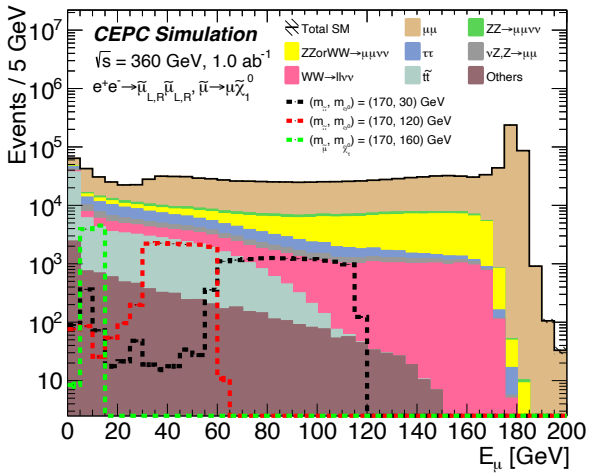
Direct Smuon Production

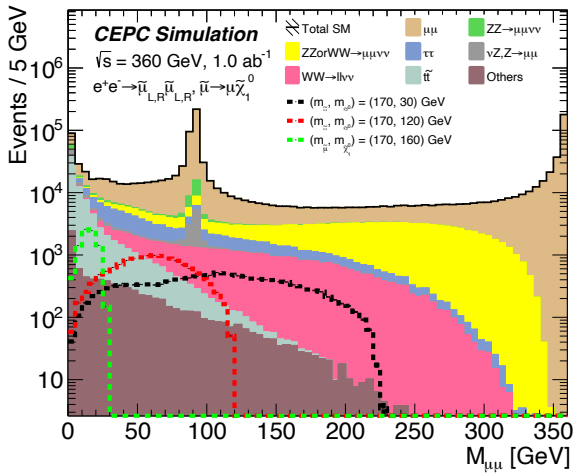
- Preselection

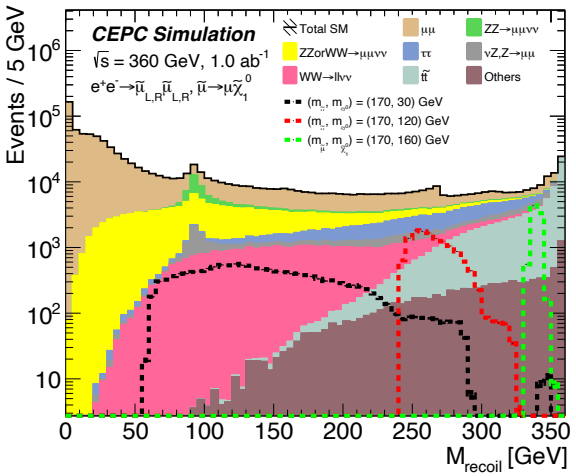
Preselection
2 OS μ

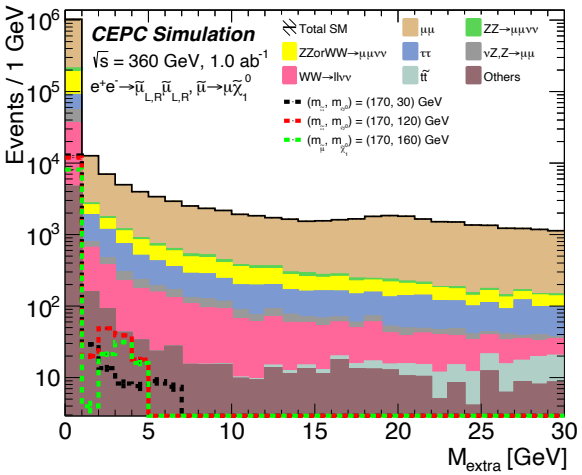


- Distributions after preselection









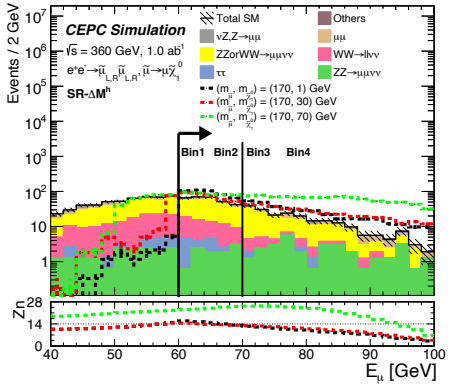
Direct Smuon Production

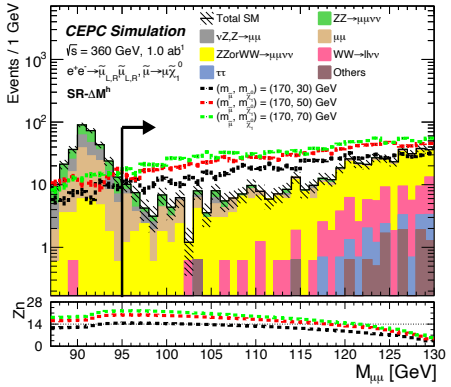
- Signal regions
  - Three signal regions according to different mass splitting between $\tilde{\mu}$ and $\tilde{\chi}_1^0$

SR-ΔM^h	SR-ΔM^m	SR-ΔM^l
$E_{\mu 1,2} > 60$ GeV	$E_{\mu 1,2} < 80$ GeV	–
$E_{\mu 1,2} \in (60-70, >70)$ GeV	$E_{\mu 1,2} \in (<35, 35-80)$ GeV	
$\Delta R(\mu, recoil) < 2.8$	$1.9 < \Delta R(\mu, recoil) < 2.9$	
$M_{\mu\mu} < 87$ GeV $\|\|$ $95 < M_{\mu\mu} < 130$ GeV	$M_{\mu\mu} < 80$ GeV	–
$M_{recoil} > 100$ GeV	–	$M_{recoil} > 340$ GeV
$M_{extra} < 15$ GeV	$M_{extra} < 10$ GeV	$M_{extra} < 10$ GeV

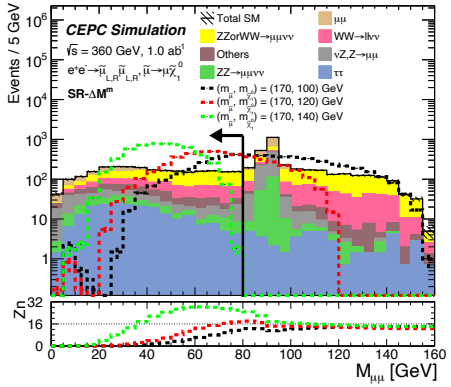
- Distributions after SR selections except the shown variable

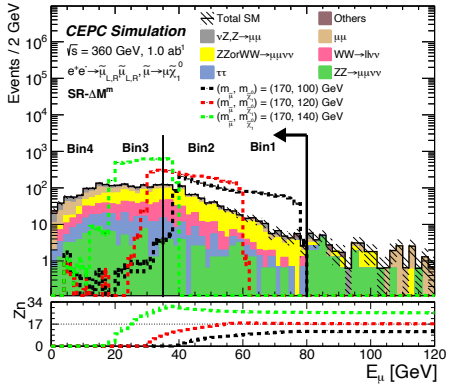
SR-ΔM^h



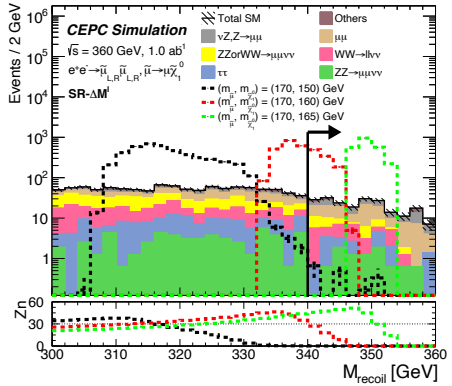


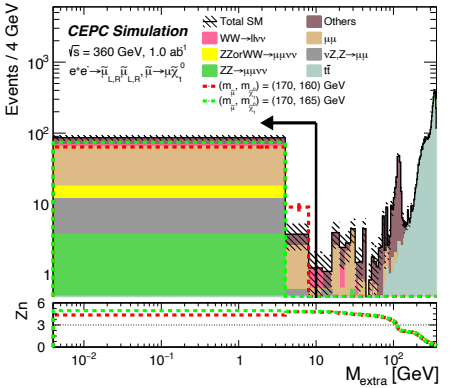
SR-ΔM^m





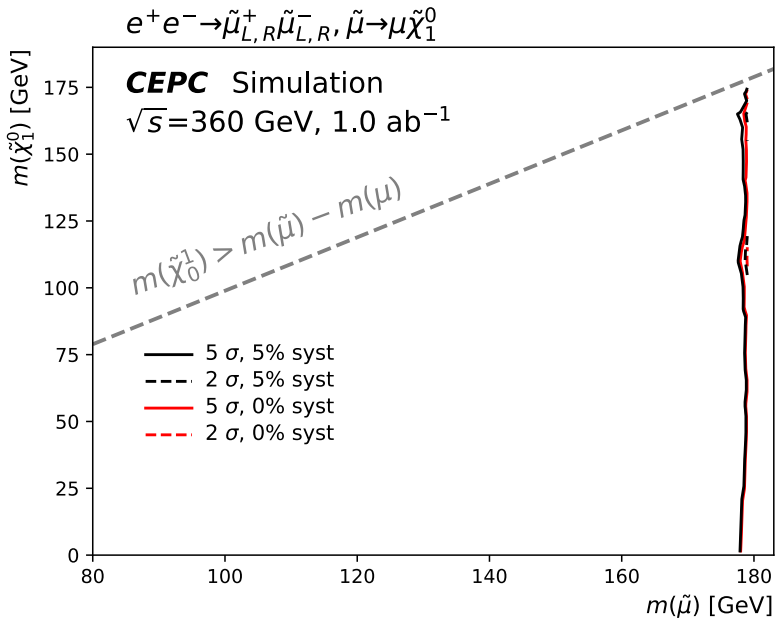
SR-ΔM^l





Direct Smuon Production

- With **left-handed and right-handed** $\tilde{\mu}$ combination, the discovery potential can reach up to **178 GeV** in $\tilde{\mu}$ mass
- Cover the region with compressed mass spectrum
- Small impact from systematic uncertainty



Conclusion

- The discovery potential of $\tilde{\tau}/\tilde{\mu}$ can reach up to 170/178 GeV
- The compressed region is covered.
- CEPC offer a great opportunity to plan for SUSY searches