Institute of High Energy Physics
Chinese Academy of Sciences

Smuon-Smuon Analysis TDR meeting

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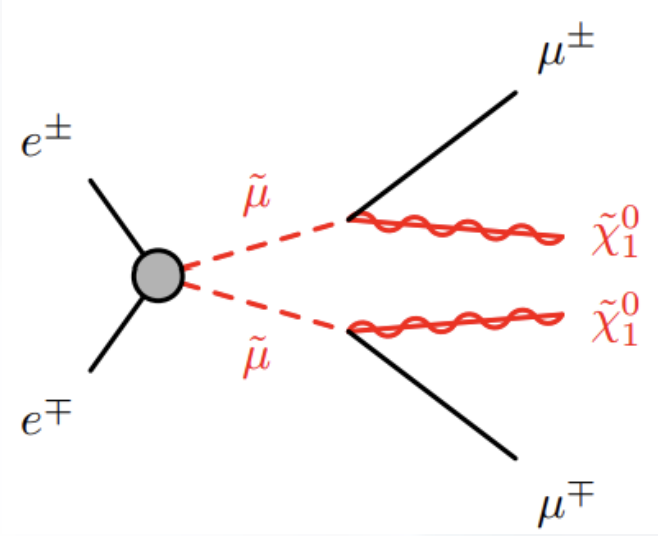
Xuai Zhuang, Shiyi Liang, Jiarong Yuan, Minlin Wu

Introduction

- Direct search for smuon pair production at the CEPC with $\sqrt{s} = 240$ GeV.
- This study is taking this paper (slepton pair production at the CEPC) as reference.
- Three signal points have been produced:
  - $m(\tilde{\mu}, \tilde{\chi}_1^0) = (115,110), (115, 70), (115, 20)$ GeV.
  - Reconstruction done using CEPCSW release – tdr25.1.2.
- Created the distributions with the current available samples and developments:
  - Validated by comparing to the truth distributions and the distributions from the paper (see backup).
  - The muon ID is not included yet.
  - Some SM background samples are still missing.



Background samples

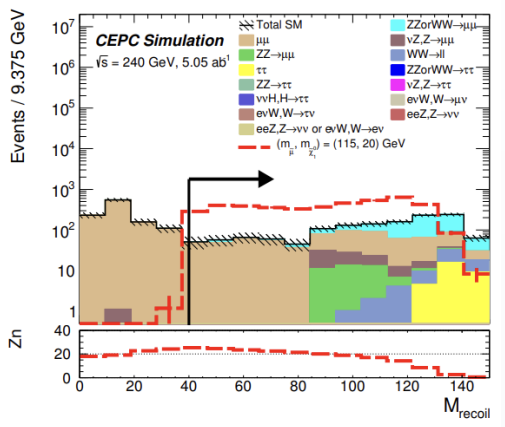
- Background samples taken from: /cefs/higgs/liugeliang/CEPC/202501/Production/4fermions
- Three signal regions defined base on Δm.
- ✓ - samples included currently.

SR-highDeltaM	SR-midDeltaM	SR-lowDeltaM
== 2 muons (OS, both energy >0.5 GeV)		
$E_\mu > 40$ GeV	9 GeV$< E_\mu <$ 48 GeV	-
$\Delta R(\mu, recoil) < 2.9$	$1.5 < \Delta R(\mu, recoil) < 2.8$	
$M_{\mu\mu} < 60$ GeV	$M_{\mu\mu} < 80$ GeV	-
$M_{recoil} > 40$ GeV	-	$M_{recoil} > 220$ GeV

- Yields table from the reference paper which published in 2022.
- The $\mu\mu$ and $\tau\tau$ backgrounds are dominant and missing.

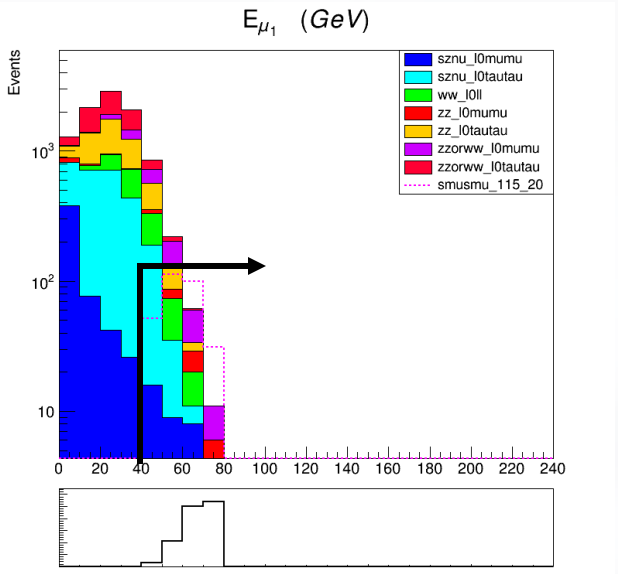
process	SR-highDeltaM	SR-midDeltaM	SR-lowDeltaM
$ZZorWW \to \mu\mu\nu\nu$ ✓	597±25	18020±140	168±13
$\mu\mu$	578±59	8000±220	2190±120
$\nu Z, Z \to \mu\mu$ ✓	59.0±8.1	423±22	467±23
$ZZ \to \mu\mu\nu\nu$ ✓	41.5±7.6	161±15	52.6±8.5
$WW \to \ell\ell$ ✓	37.9±6.2	7671±89	282±17
$\tau\tau$	29.5±8.2	3748±92	1782±64
$ZZorWW \to \tau\tau\nu\nu$ ✓	-	2128±47	325±18
$ZZ \to \tau\tau\nu\nu$ ✓	-	69.1±6.1	19.8±3.3
$\nu Z, Z \to \tau\tau$ ✓	-	83.7±7.9	51.9±6.2
$\nu\nu H, H \to \tau\tau$	-	47.9±2.7	5.11±0.89
$e\nu W, W \to \mu\nu$	-	-	-
$e\nu W, W \to \tau\nu$	-	-	-
$eeZ, Z \to \nu\nu$	-	-	-
$eeZ, Z \to \nu\nu or e\nu W, W \to e\nu$	-	-	-
Total background	1343±66	40350±300	5340±140
m($\tilde{\mu}$,$\tilde{\chi}_1^0$) = (115,20) GeV	4288±72	1638±44	-
m($\tilde{\mu}$,$\tilde{\chi}_1^0$) = (115,70) GeV	-	41140±220	-
m($\tilde{\mu}$,$\tilde{\chi}_1^0$) = (115,110) GeV	-	-	14540±130

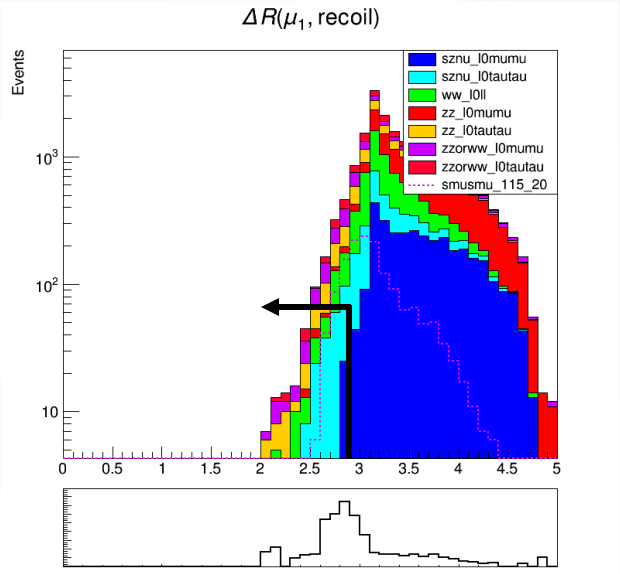
Distributions in SR-highDeltaM

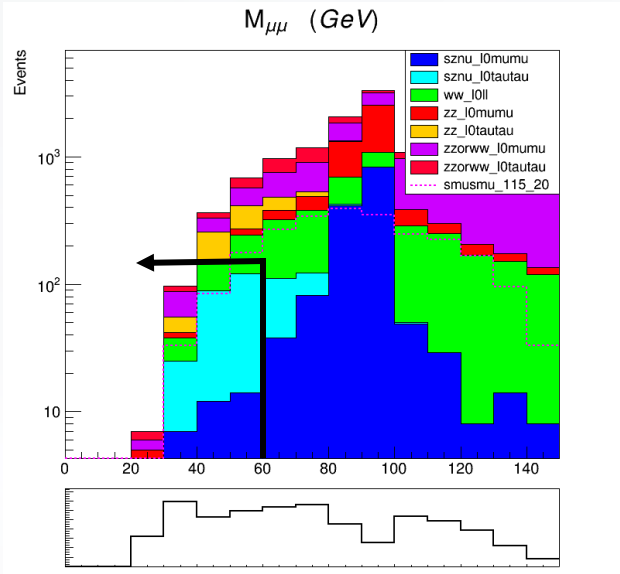


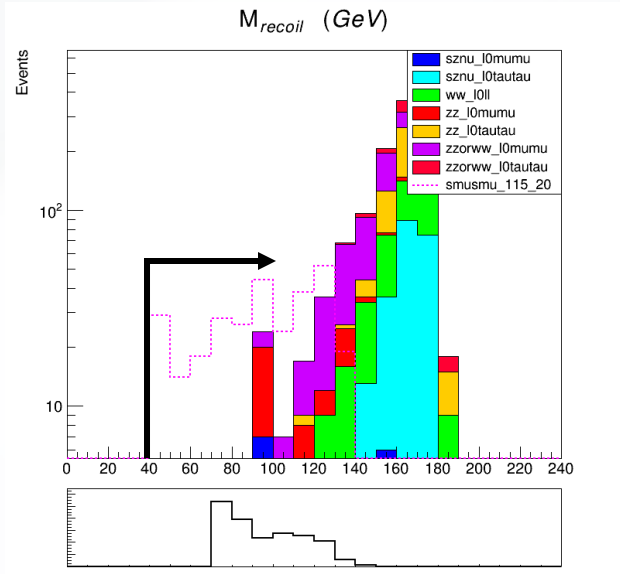
Obtained same level of yields compare to the paper results (although the comparison is not fair enough). Except that the $\mu\mu$ processes are missing and have large impact on the Mrecoil distribution.

SR-highDeltaM	SR-midDeltaM	SR-lowDeltaM
== 2 muons (OS, both energy >0.5 GeV)		
$E_\mu > 40$ GeV	9 GeV$< E_\mu <$ 48 GeV	-
$\Delta R(\mu, recoil) < 2.9$	$1.5 < \Delta R(\mu, recoil) < 2.8$	
$M_{\mu\mu} < 60$ GeV	$M_{\mu\mu} < 80$ GeV	-
$M_{recoil} > 40$ GeV	-	$M_{recoil} > 220$ GeV







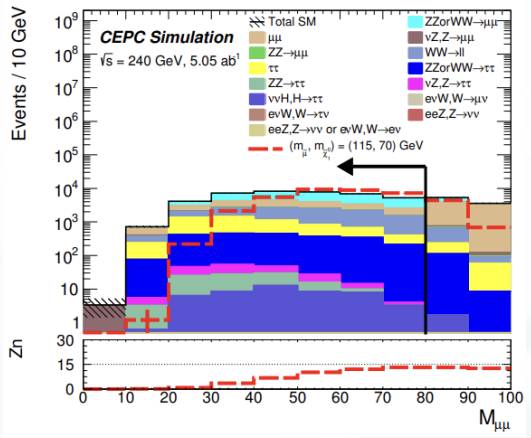


Distributions in SR-midDeltaM

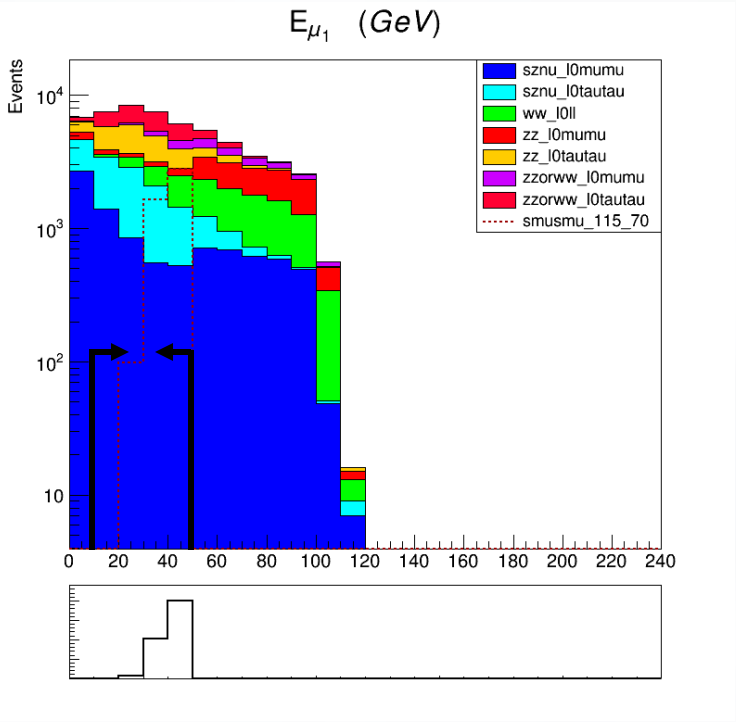
Similar SR yields compare to the paper results.

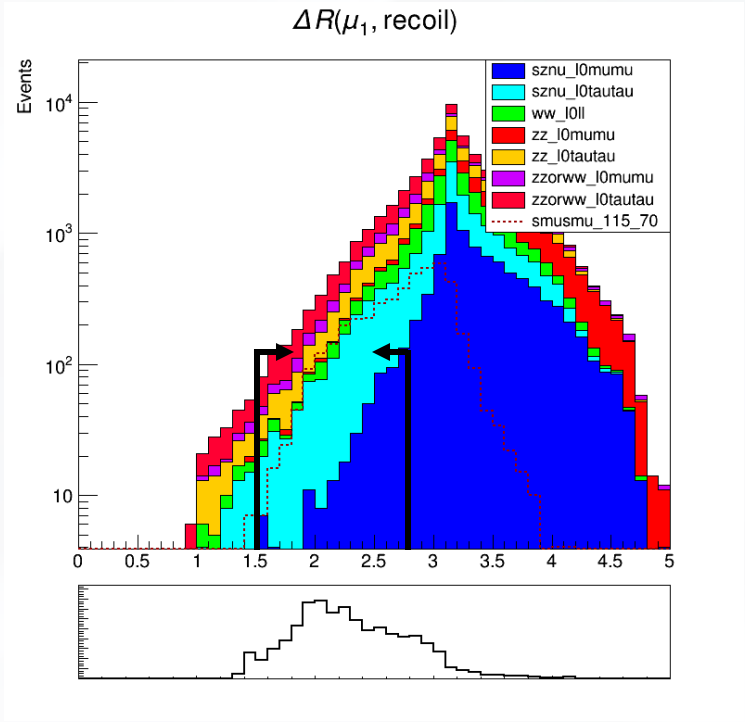
No need to re-optimize SR cuts (base on the Zn shapes).

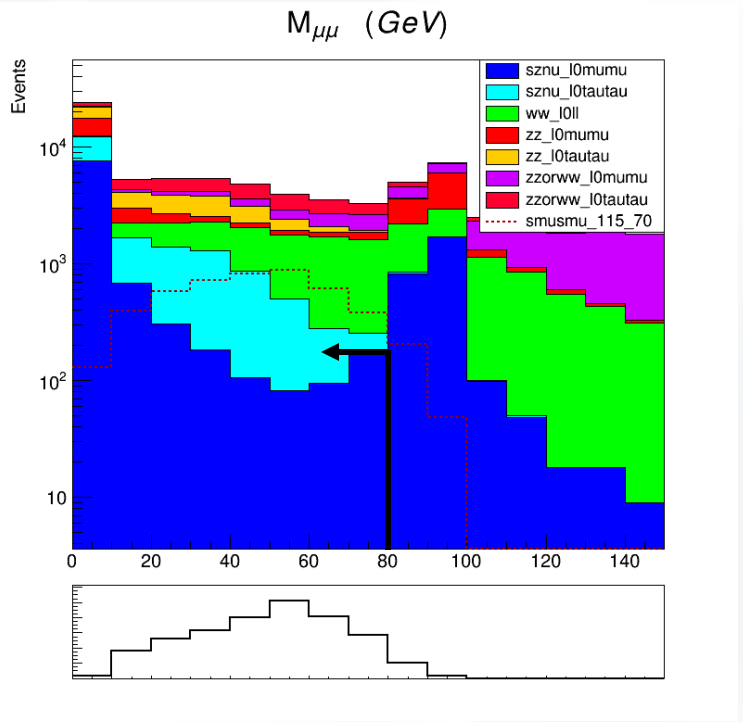
Need to check the first bin of $M_{\mu\mu}$ distribution, it seems have some unexpected zero or NaN entires.



SR-highDeltaM	SR-midDeltaM	SR-lowDeltaM
== 2 muons (OS, both energy >0.5 GeV)		
$E_\mu > 40$ GeV	9 GeV$< E_\mu <$ 48 GeV	-
$\Delta R(\mu, recoil) < 2.9$	$1.5 < \Delta R(\mu, recoil) < 2.8$	
$M_{\mu\mu} < 60$ GeV	$M_{\mu\mu} < 80$ GeV	-
$M_{recoil} > 40$ GeV	-	$M_{recoil} > 220$ GeV





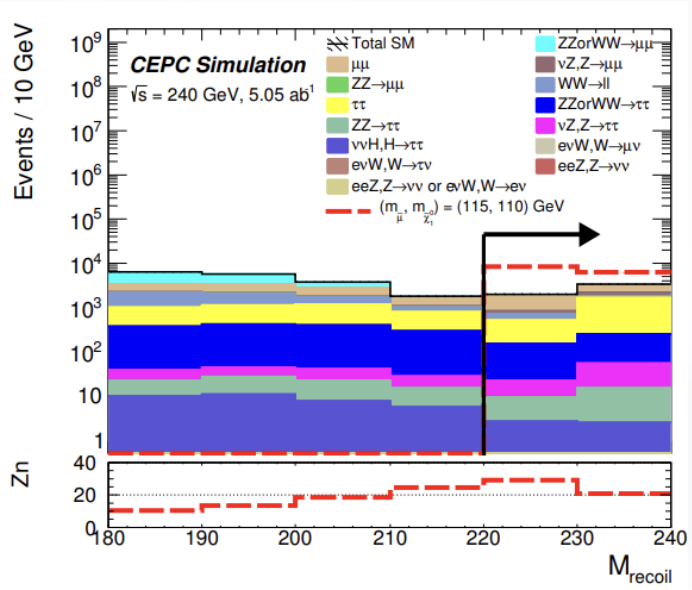


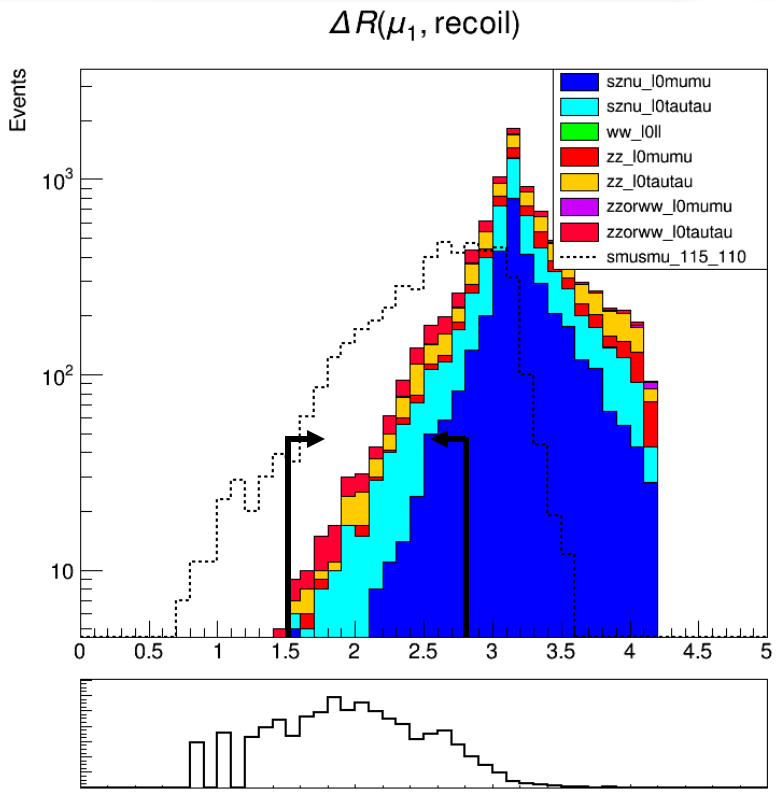
Distributions in SR-lowDeltaM

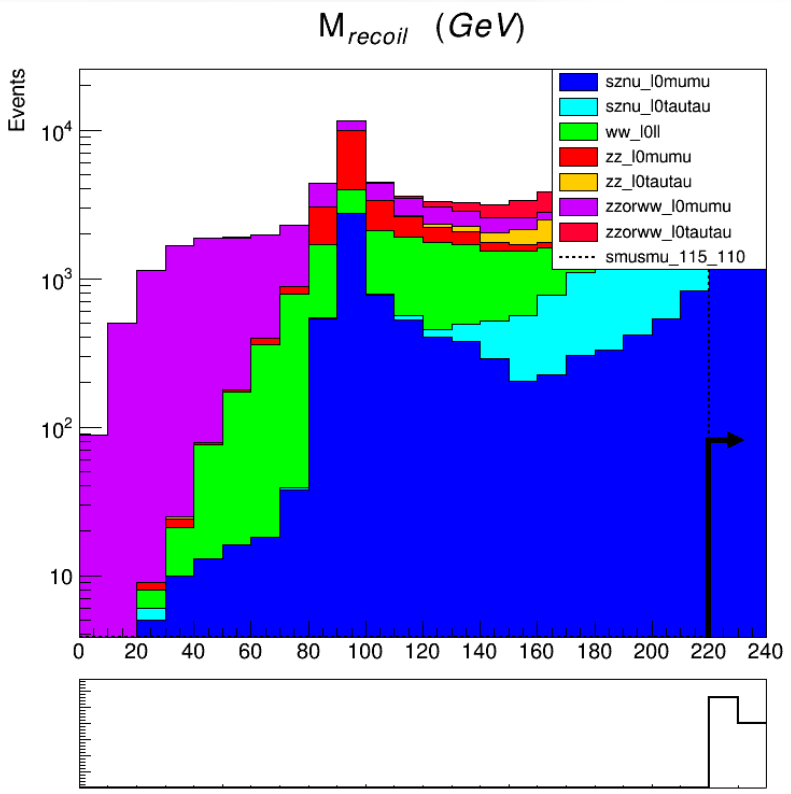
Similar SR yields compare to the paper results.

Good sensitivity can be achieved in the recoil mass distribution by including a strong cut, which matched with the distribution from the paper.

SR-highDeltaM	SR-midDeltaM	SR-lowDeltaM
== 2 muons (OS, both energy >0.5 GeV)		
$E_\mu > 40$ GeV	9 GeV$< E_\mu <$ 48 GeV	-
$\Delta R(\mu, recoil) < 2.9$	$1.5 < \Delta R(\mu, recoil) < 2.8$	
$M_{\mu\mu} < 60$ GeV	$M_{\mu\mu} < 80$ GeV	-
$M_{recoil} > 40$ GeV	-	$M_{recoil} > 220$ GeV







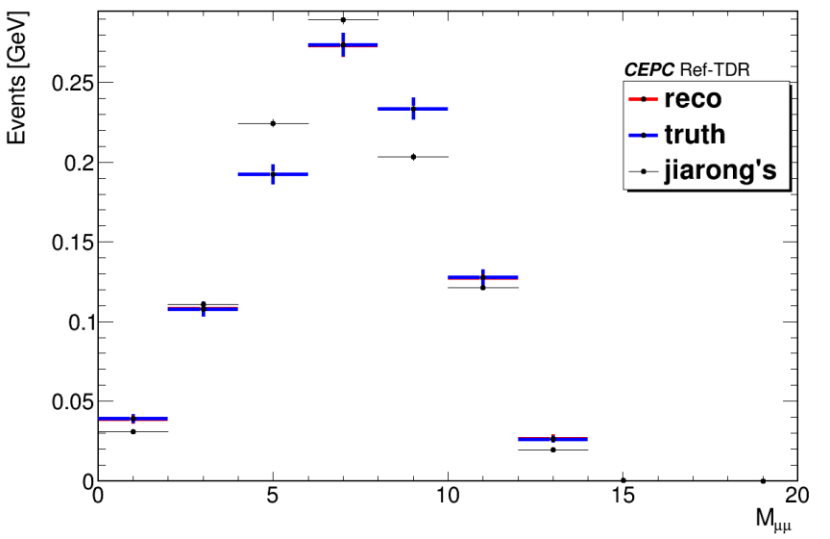
Summary

- Ran through the reconstruction for three signal points using release – tdr25.1.2.
- The background samples are taken from: /cefs/higgs/liugeliang/CEPC/202501/Production/4fermions
  - But some processes are still missing including the dominant ones ($\mu\mu$ and $\tau\tau$).
- In overall, the yields are at the same level compare to the paper results.
- Good sensitivity can be obtained by using the current SR selections.
- Next step:
  - Include the muon ID.
  - Include the missing backgrounds.
  - Fix the minor issues observed from the distributions.

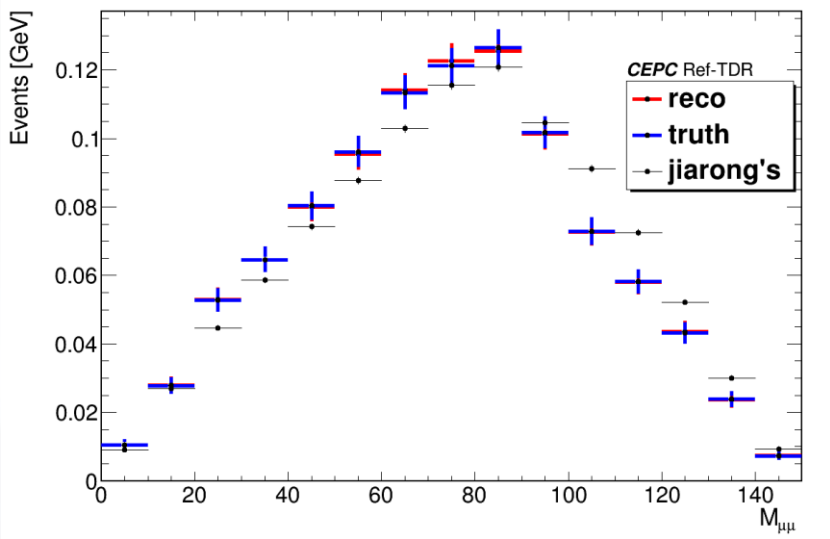
BACKUP

Signal distributions with preselection

$m(\tilde{\mu}, \tilde{\chi}_1^0) = (115,20)$ GeV



$m(\tilde{\mu}, \tilde{\chi}_1^0) = (115,70)$ GeV



$m(\tilde{\mu}, \tilde{\chi}_1^0) = (115,110)$ GeV