Status Report: Muon g-2 anomaly + SUSY at the ILC

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Introduction: Muon g-2 anomaly + SUSY

- SUSY is one possibility of the BSM, but already large phase space excluded by LHC.
- But still, some parameter space is allowed, and even possible to explain muon g-2 anomaly (2104.03217).
  - Chargino-contribution dominated scenario
  - Pure-bino-contribution dominated scenario <--- can be studied at the ILC directly

The SUSY contributions to the muon $g-2$ can be sizable when at least *three* SUSY multiplets are as light as $\mathcal{O}(100)$ GeV. They are classified into four types: “WHL”, “BHL”, “BHR”, and “BLR”, where W, B, H, L, and R stand for wino, bino, higgsino, left-handed and right-handed smuons, respectively. Under the mass-insertion approximation, these four types are given as [23][#4]

$$a_\mu^{\rm WHL} = \frac{\alpha_2}{4\pi}\frac{m_\mu^2}{M_2\mu}\tan\beta\cdot f_C\left(\frac{M_2^2}{m_{\tilde{\nu}_\mu}^2},\frac{\mu^2}{m_{\tilde{\nu}_\mu}^2}\right) - \frac{\alpha_2}{8\pi}\frac{m_\mu^2}{M_2\mu}\tan\beta\cdot f_N\left(\frac{M_2^2}{m_{\tilde{\mu}_{\rm L}}^2},\frac{\mu^2}{m_{\tilde{\mu}_{\rm L}}^2}\right), \tag{6}$$

$$a_\mu^{\rm BHL} = \frac{\alpha_Y}{8\pi}\frac{m_\mu^2}{M_1\mu}\tan\beta\cdot f_N\left(\frac{M_1^2}{m_{\tilde{\mu}_{\rm L}}^2},\frac{\mu^2}{m_{\tilde{\mu}_{\rm L}}^2}\right), \tag{7}$$

$$a_\mu^{\rm BHR} = -\frac{\alpha_Y}{4\pi}\frac{m_\mu^2}{M_1\mu}\tan\beta\cdot f_N\left(\frac{M_1^2}{m_{\tilde{\mu}_{\rm R}}^2},\frac{\mu^2}{m_{\tilde{\mu}_{\rm R}}^2}\right), \tag{8}$$

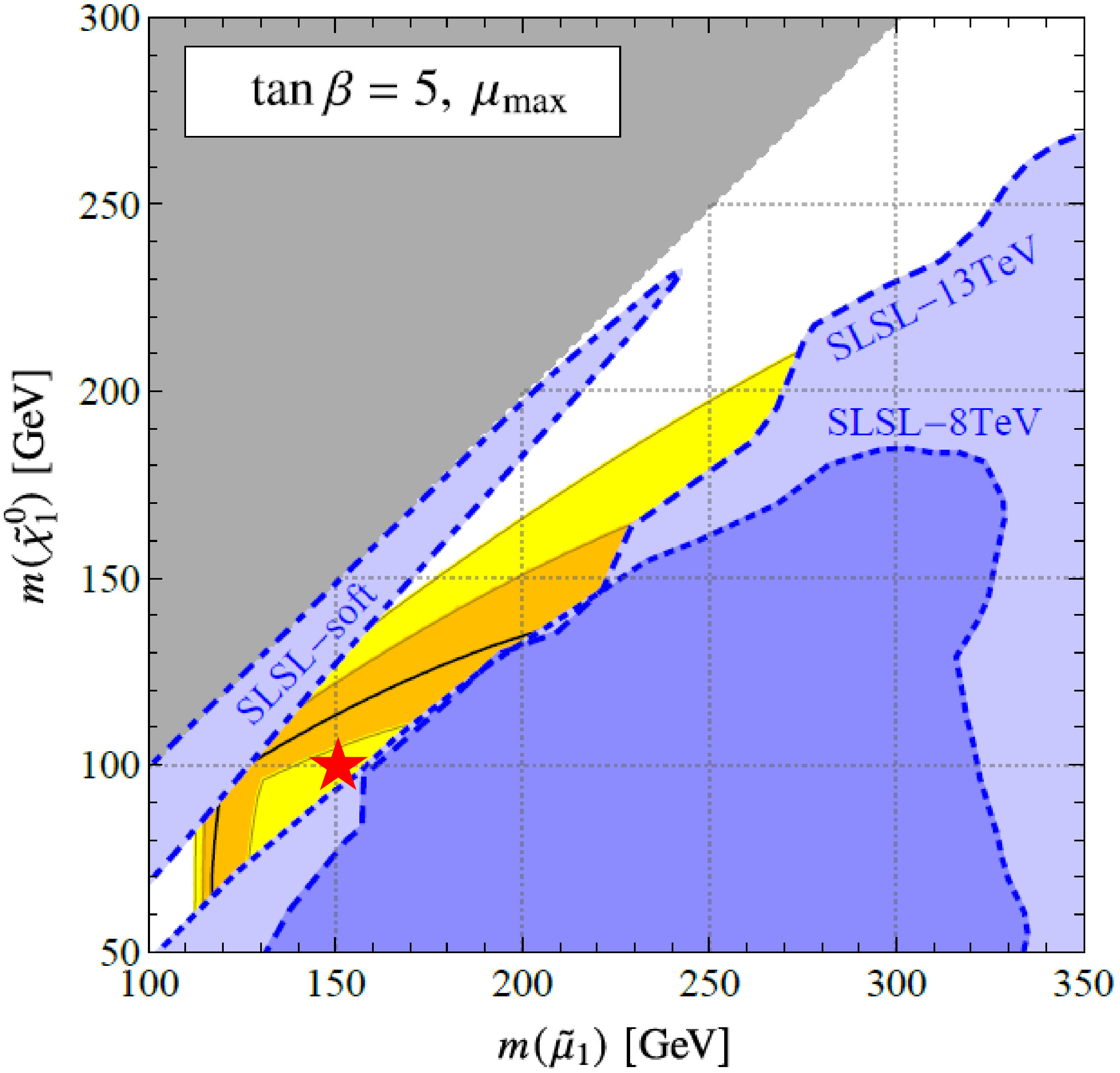
$$\boxed{a_\mu^{\rm BLR} = \frac{\alpha_Y}{4\pi}\frac{m_\mu^2 M_1\mu}{m_{\tilde{\mu}_{\rm L}}^2 m_{\tilde{\mu}_{\rm R}}^2}\tan\beta\cdot f_N\left(\frac{m_{\tilde{\mu}_{\rm L}}^2}{M_1^2},\frac{m_{\tilde{\mu}_{\rm R}}^2}{M_1^2}\right),} \tag{9}$$

where M_1 (M_2) is the bino (wino) soft mass, μ is the higgsino mass parameter, $\tan\beta = v_u/v_d$ is the ratio of the vacuum expectation values of the up- and down-type Higgs, and $m_{\tilde{\mu}_{\rm L/R}}$ and $m_{\tilde{\nu}_\mu}$ are the masses of the left/right-handed smuon and the muon sneutrino, respectively.

Assumptions

- Only $\tilde{B}$, $\widetilde{\ell_L}$, and $\widetilde{\ell_R}$ are light ($\tilde{\ell}$: slepton)
- 5 relevant parameters are left: M_1 (bino soft mass), μ (higgsino mass parameter), $(m_L^2)_i$, $(m_R^2)_i$ (soft masses of left-/right-handed sleptons, $i = \tilde{e}, \tilde{\mu}, \tilde{\tau}$), $\tan\beta$

- Studied 3 cases
  - Universal slepton masses ($m_L = m_R$ for $\forall i$) with $\Omega_{\chi_1^0} = \Omega_{\text{dark matter}}$
  - Universal slepton masses without $\Omega_{\chi_1^0} = \Omega_{\text{dark matter}}$
  - Non-universal slepton masses

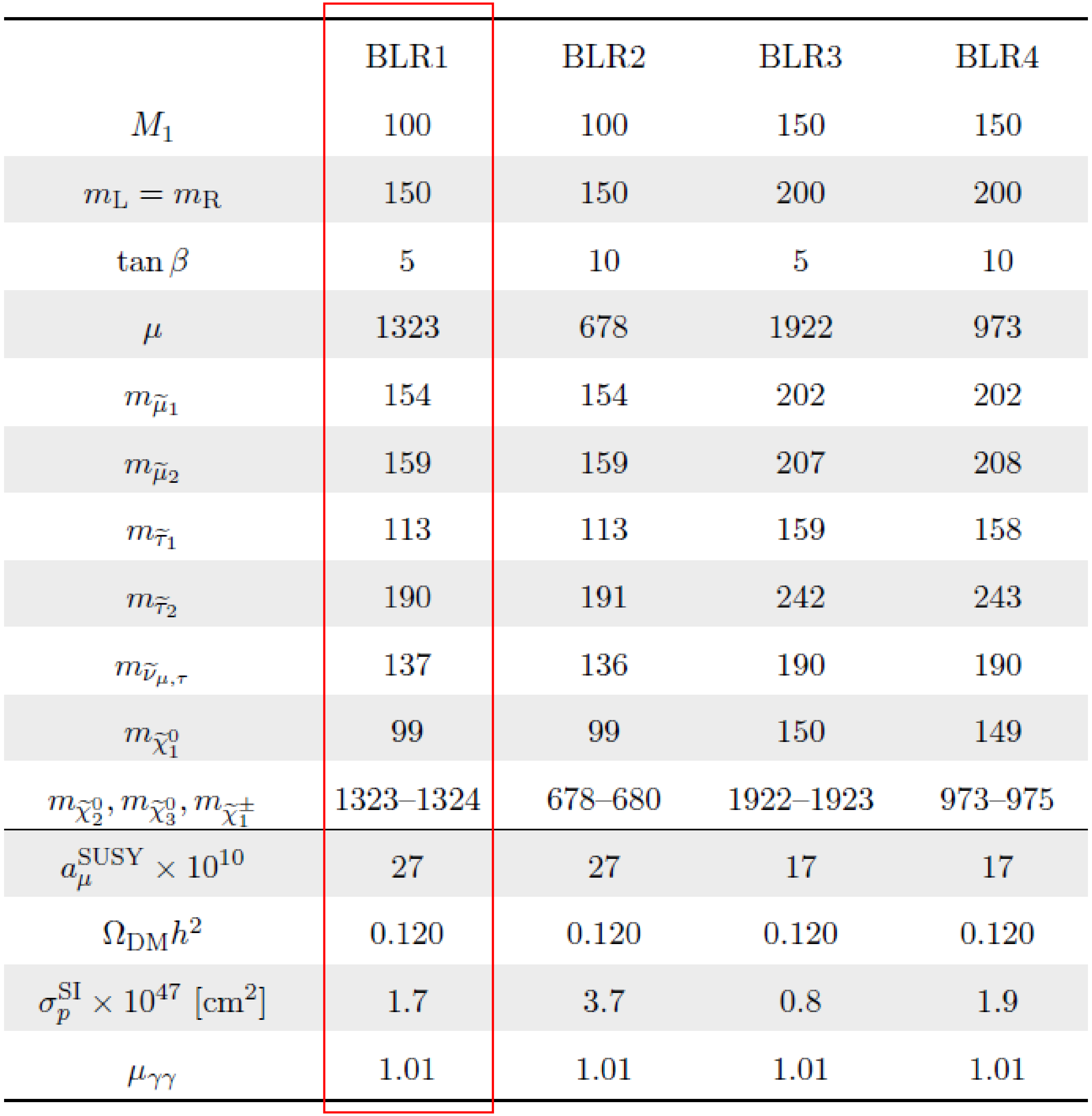


Blue area: excluded by LHC
Orange(Yellow) area: can explain muon g-2 anomaly at the $1\sigma(2\sigma)$ level
Red star: benchmark parameter in BLR1

Muon g-2 + SUSY: status report

- Produced SUSY MC samples at ILC500 with WHIZARD2.8.5
    - Included beam energy spread, ISR, PYTHIA6 with patch, and TAUOLA
    - Details in backup
- Run detector simulation: this time DELPHES used
    - PID performance depends on DELPHES PFA
    - Will improve (or be more realistic) when we use ILD full detector simulation in future
- Started physics analysis

arXiv:2104.03217



	BLR1	BLR2	BLR3	BLR4
M_1	100	100	150	150
$m_{\mathrm{L}} = m_{\mathrm{R}}$	150	150	200	200
$\tan\beta$	5	10	5	10
μ	1323	678	1922	973
$m_{\tilde{\mu}_1}$	154	154	202	202
$m_{\tilde{\mu}_2}$	159	159	207	208
$m_{\tilde{\tau}_1}$	113	113	159	158
$m_{\tilde{\tau}_2}$	190	191	242	243
$m_{\tilde{\nu}_{\mu,\tau}}$	137	136	190	190
$m_{\tilde{\chi}^0_1}$	99	99	150	149
$m_{\tilde{\chi}^0_2}, m_{\tilde{\chi}^0_3}, m_{\tilde{\chi}^\pm_1}$	1323–1324	678–680	1922–1923	973–975
$a_\mu^{\mathrm{SUSY}} \times 10^{10}$	27	27	17	17
$\Omega_{\mathrm{DM}} h^2$	0.120	0.120	0.120	0.120
$\sigma_p^{\mathrm{SI}} \times 10^{47}$ [cm^2]	1.7	3.7	0.8	1.9
$\mu_{\gamma\gamma}$	1.01	1.01	1.01	1.01

Units in GeV
So far, I am only working with BLR1 parametrization.

Produced events (1)

Process $e^+e^- \to$	**Pol (e-, e+) (%)**	**Xsec (fb)**	**N = L*Xsec (Assume L = 4 ab^{-1})**	**N = L*Xsec (Assume L = 1.6 ab^{-1})**	**N_generated**	**process ID**
$\widetilde{e_L}^+\widetilde{e_L}^-$	-80/+30	28.7091 +- 0.0012	114836	45935	500K	1
$\widetilde{e_L}^+\widetilde{e_L}^-$	+80/-30	22.30497 +- 0.00071	89220	35688	500K	2
$\widetilde{e_R}^+\widetilde{e_R}^-$	-80/+30	53.5626 +- 0.0019	214250	85700	1M	3
$\widetilde{e_R}^+\widetilde{e_R}^-$	+80/-30	54.6909 +- 0.022	218764	87505	1M	4
$\widetilde{\mu_L}^+\widetilde{\mu_L}^-$	-80/+30	99.1388 +- 0.0079	396555	158622	1.5M	5
$\widetilde{\mu_L}^+\widetilde{\mu_L}^-$	+80/-30	25.9426 +- 0.0021	103770	41508	500K	6
$\widetilde{\mu_R}^+\widetilde{\mu_R}^-$	-80/+30	26.9622 +- 0.0021	107849	43140	500K	7
$\widetilde{\mu_R}^+\widetilde{\mu_R}^-$	+80/-30	92.4999 +- 0.0072	370000	148000	1.5M	8

1.6 ab^{-1} is the integrated luminosity of ILC500 with -80/+30 and +80/-30

Produced events (2)

Process $e^+e^- \rightarrow$	Pol (e-, e+) (%)	Xsec (fb)	N = L*Xsec (Assume L = 4 ab^{-1})	N = L*Xsec (Assume L = 1.6 ab^{-1})	N_generated	process ID
$\tilde{\tau}_1{}^+\tilde{\tau}_1{}^-$	-80/+30	92.9890 +- 0.0063	371956	148782	1.5M	9
$\tilde{\tau}_1{}^+\tilde{\tau}_1{}^-$	+80/-30	86.6444 +- 0.0059	346578	138631	1.5M	10
$\tilde{\tau}_2{}^+\tilde{\tau}_2{}^-$	-80/+30	29.0410 +- 0.0033	116164	46466	500K	11
$\tilde{\tau}_2{}^+\tilde{\tau}_2{}^-$	+80/-30	26.3214 +- 0.0029	105286	42114	500K	12
$\tilde{\tau}_1{}^+\tilde{\tau}_2{}^-$	-80/+30	8.18989 +- 0.00062	32760	13104	200K	13
$\tilde{\tau}_1{}^+\tilde{\tau}_2{}^-$	+80/-30	6.48573 +- 0.00050	25943	10377	200K	14
$\tilde{\tau}_2{}^+\tilde{\tau}_1{}^-$	-80/+30	8.19128 +- 0.00062	32765	13106	200K	15
$\tilde{\tau}_2{}^+\tilde{\tau}_1{}^-$	+80/-30	6.48553 +- 0.00050	25942	10377	200K	16

1.6 ab^{-1} is the integrated luminosity of ILC500 with -80/+30 and +80/-30

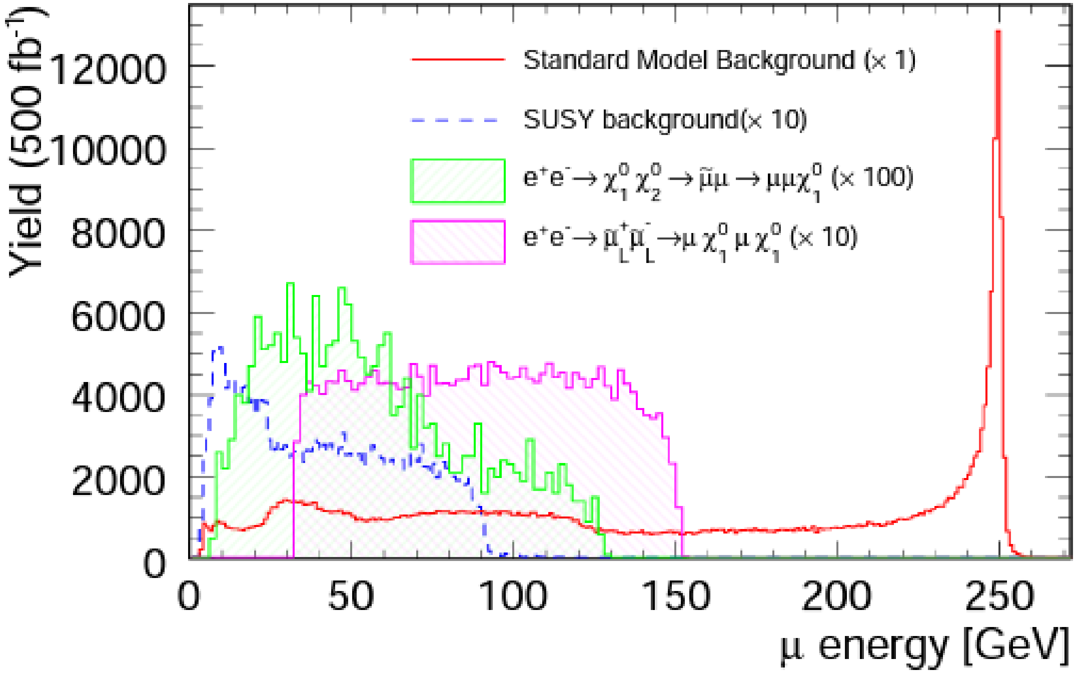
Potential problem

- The spin information is not stored in stau events
    - This might affect to the decay products of tau
    - It is OK for SM world (e.g.: Keita’s study)

arXiv:0902.2434

Energy plot

- Since selectron/smuon decay is two-body decay, the energy distribution of visible decay products have “edges”.
- Stau is technically two-body decay as well, but difficult to measure edges.



“edges” at ~30 GeV and ~150 GeV in smuon events (magenta)

Two-body decay kinematics (1)

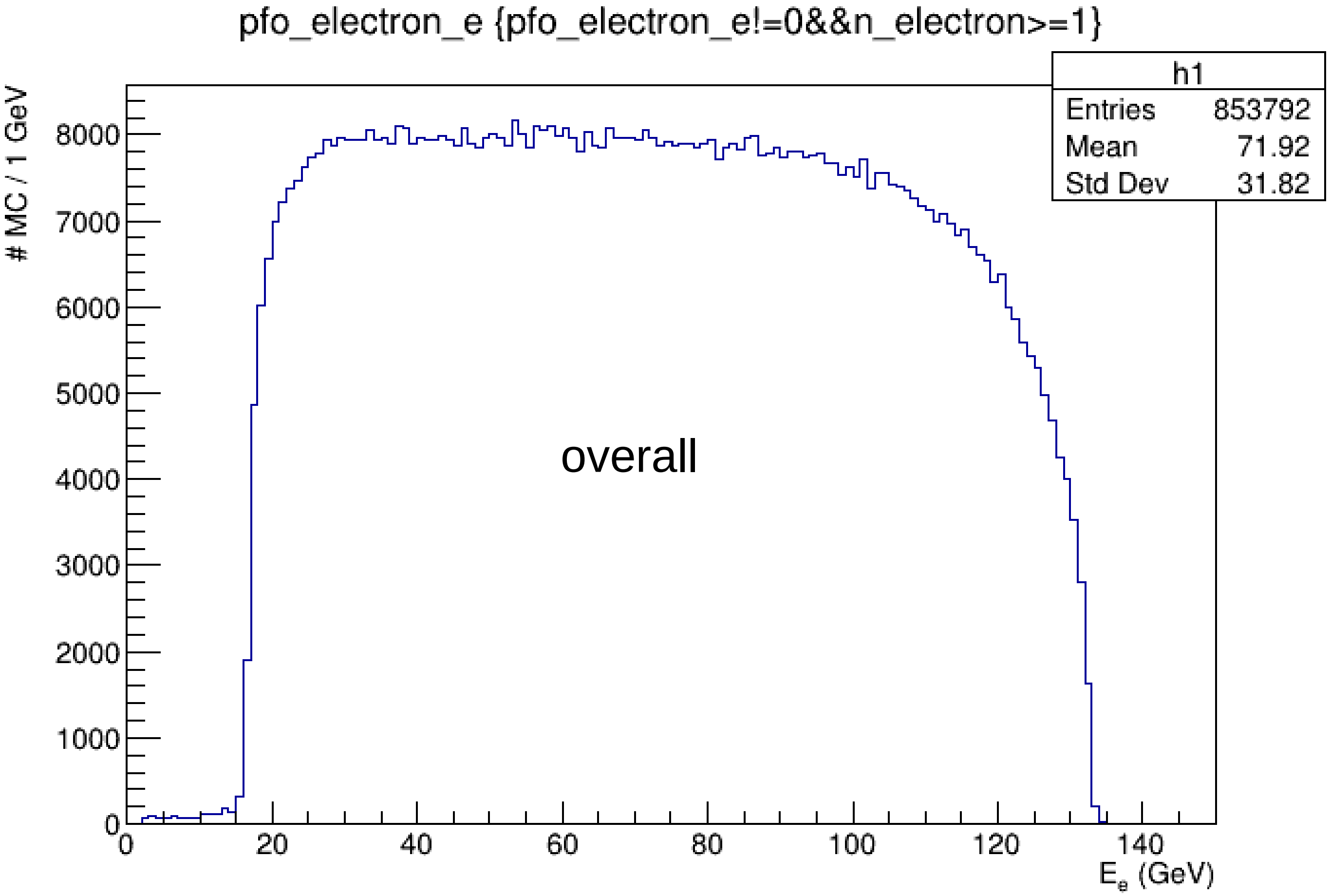
- In the end, we have
  - $E^+ = \frac{\sqrt{s}}{4}\left[1-\left(\frac{m_\chi}{m_{\mathrm{SUSY}}}\right)^2\right]\left[1+\sqrt{1-4\left(\frac{m_{\mathrm{SUSY}}}{\sqrt{s}}\right)^2}\right]$
  - $E^- = \frac{\sqrt{s}}{4}\left[1-\left(\frac{m_\chi}{m_{\mathrm{SUSY}}}\right)^2\right]\left[1-\sqrt{1-4\left(\frac{m_{\mathrm{SUSY}}}{\sqrt{s}}\right)^2}\right]$
  - where E^+/E^- is the maximum/minimum energy of lepton (electron/positron/muon/tau), m_{SUSY} is the mass of SUSY particle (selectron/smuon/stau), $\sqrt{s}$ = 500 GeV in this analysis, and m_χ is the neutralino mass and equals to 99 GeV on BLR1 parametrization
  - Ignored lepton masses

Two-body decay kinematics (2)

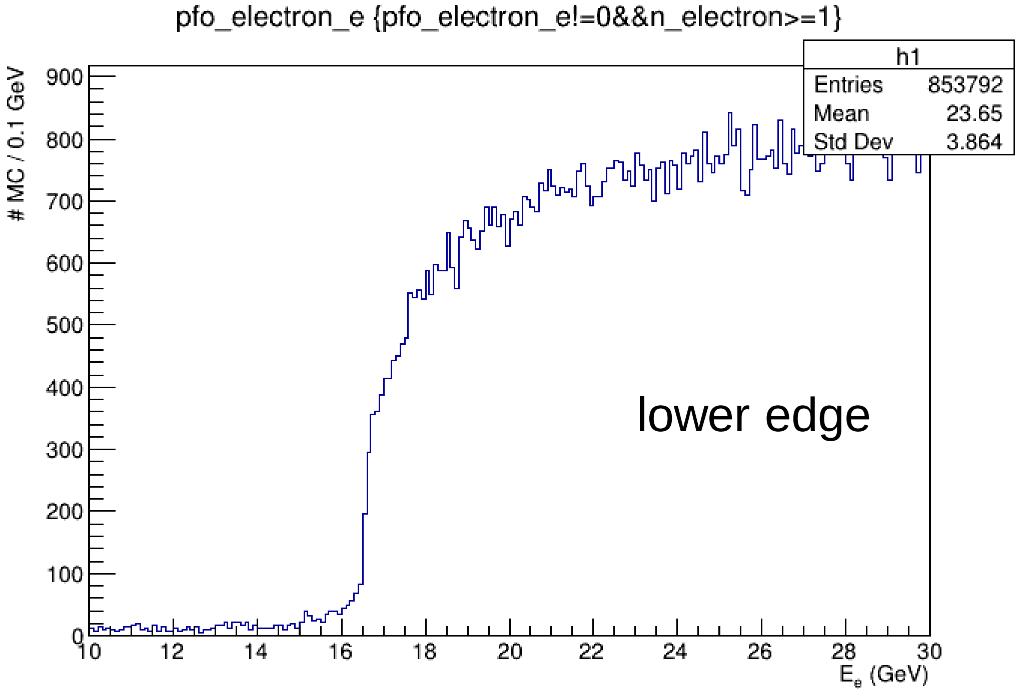
$\sqrt{s}$ = 500 GeV, $\widetilde{\chi_1^0}$ = 99 GeV, ignored lepton masses

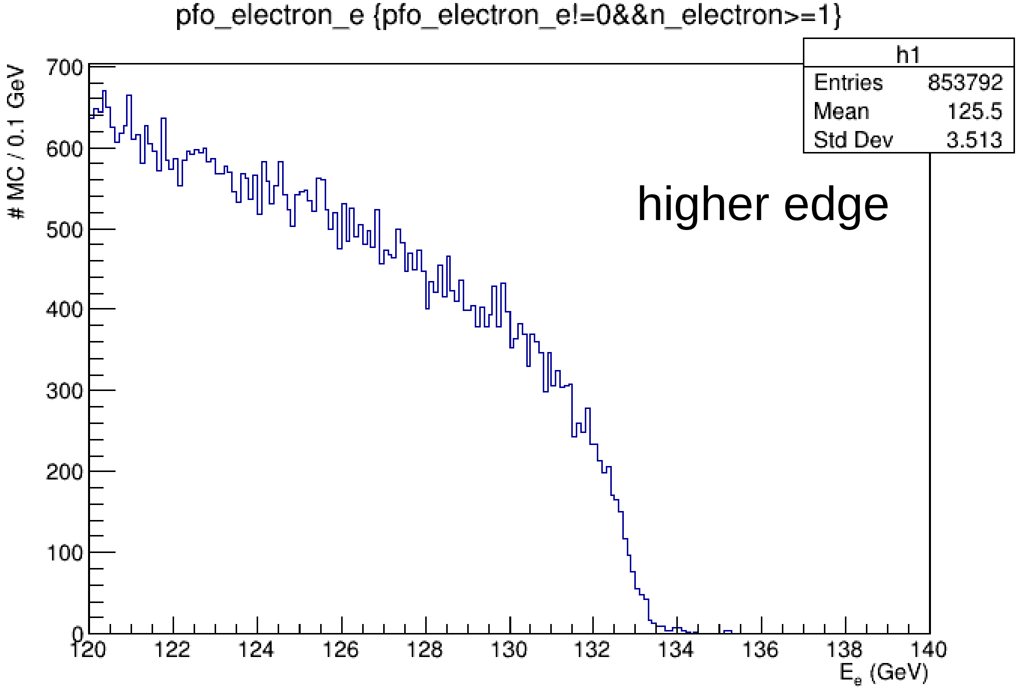
SUSY particle	mass (GeV)	E^+ (GeV)	E^- (GeV)
$\widetilde{e}_L$	157	133.9	16.7
$\widetilde{e_R}$	156	133.0	16.3
$\widetilde{\mu_L}$	158	134.8	17.1
$\widetilde{\mu_R}$	154	131.1	15.6
$\widetilde{\tau}_1$	113	55.0	3.1
$\widetilde{\tau}_2$	190	150.2	31.9

Selectron ($\widetilde{e}_L$) events

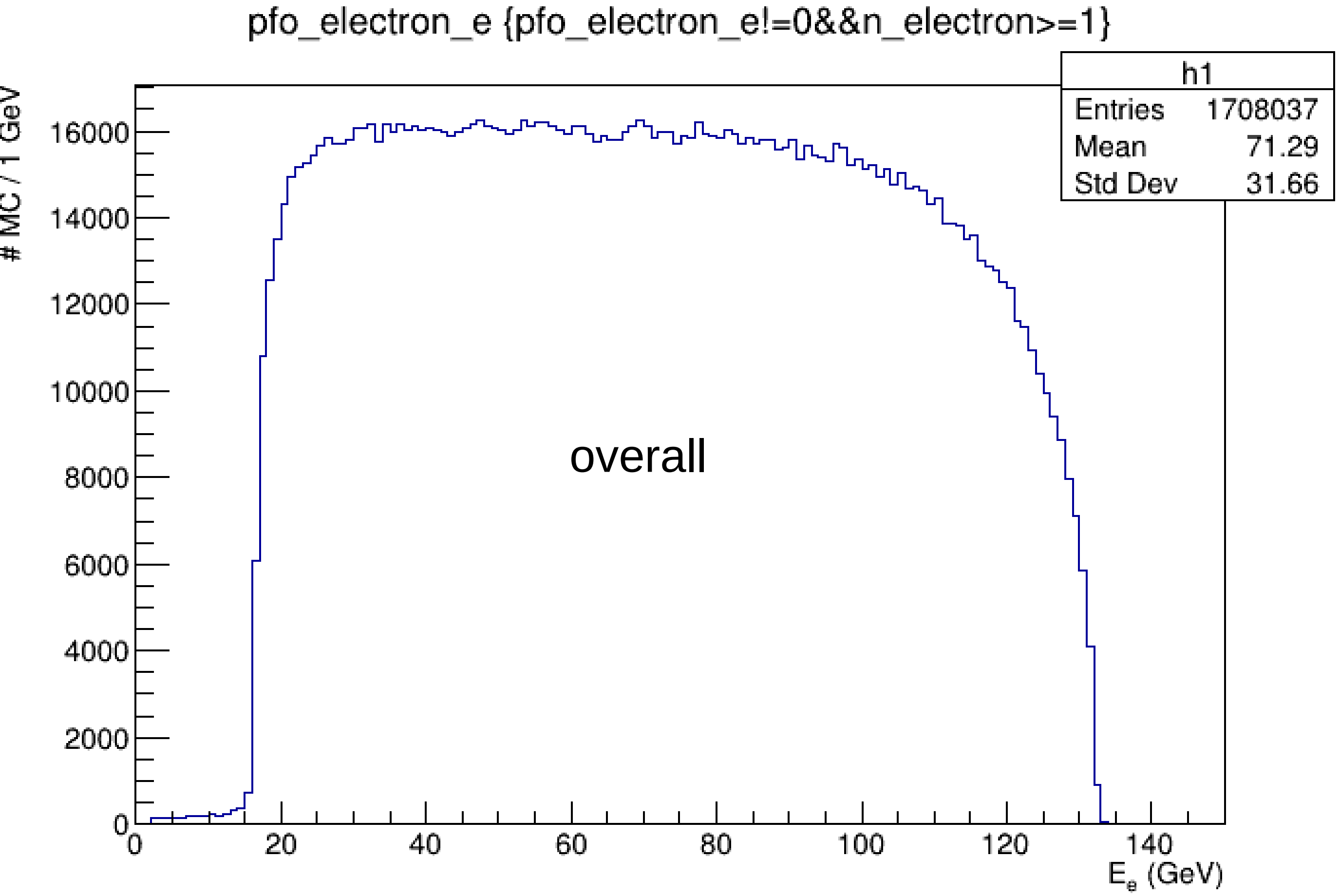


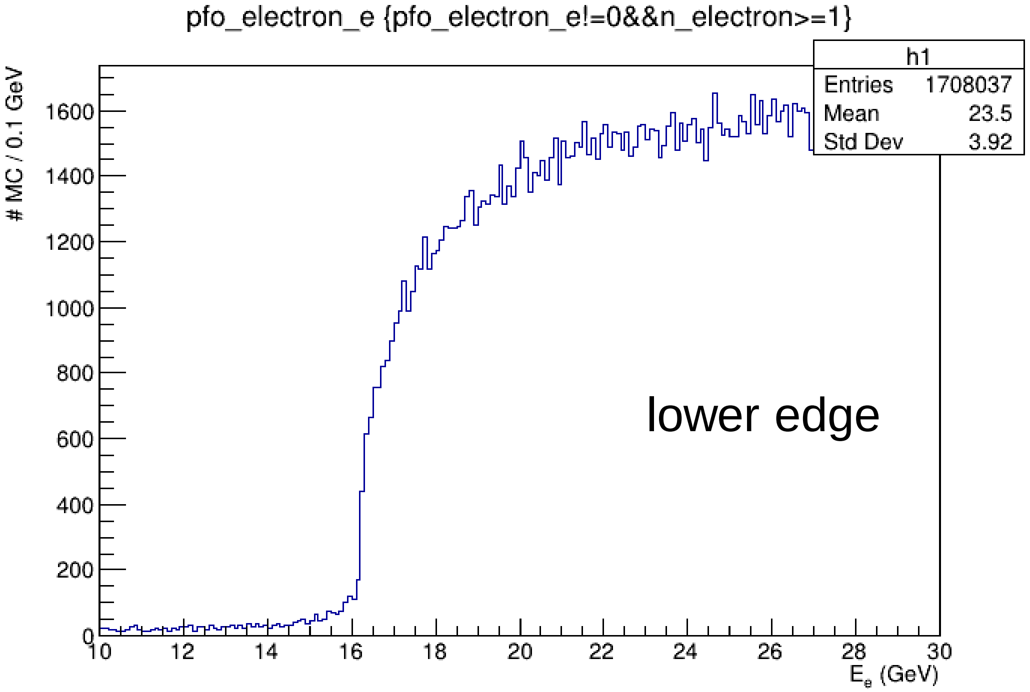
se11_eLpR (mass = 157 GeV)
e >= 1, plotted energy of electron PFOs
E^+ = 133.9 GeV and E^- = 16.7 GeV

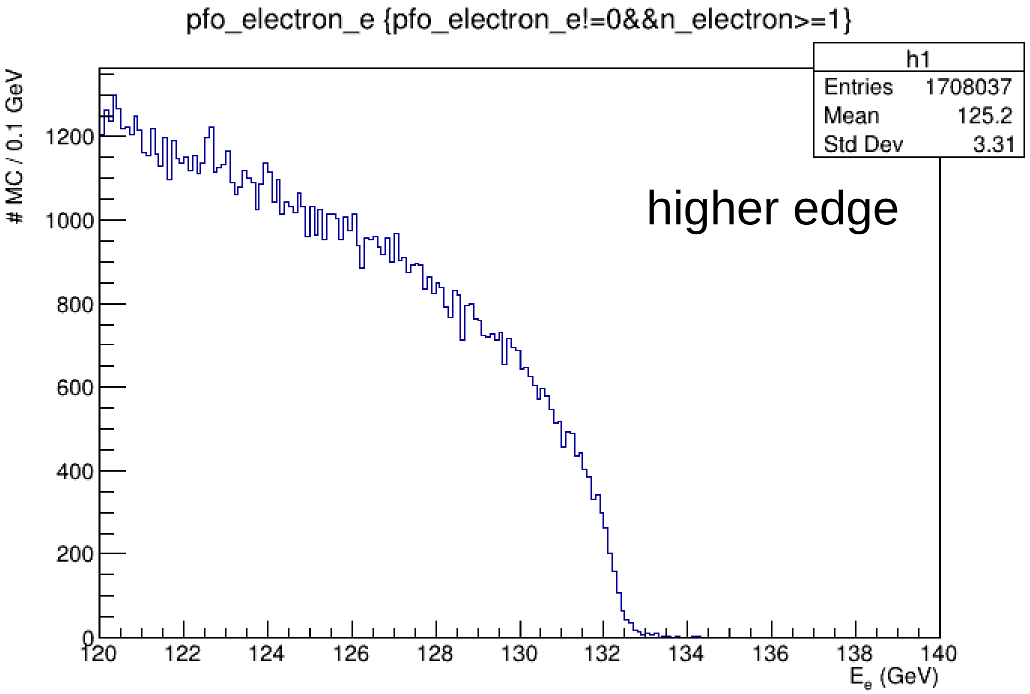




Selectron ($\widetilde{e_R}$) events

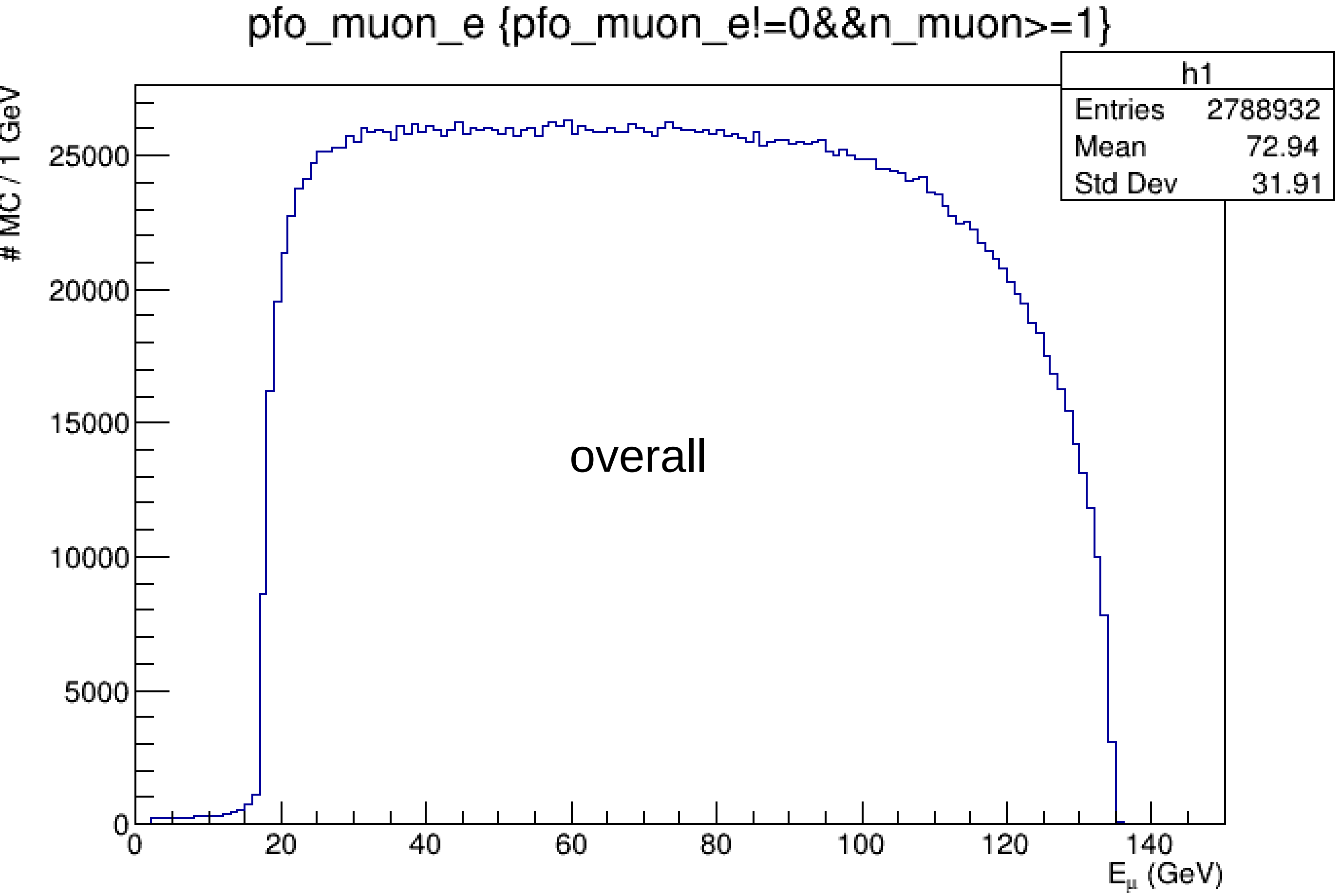


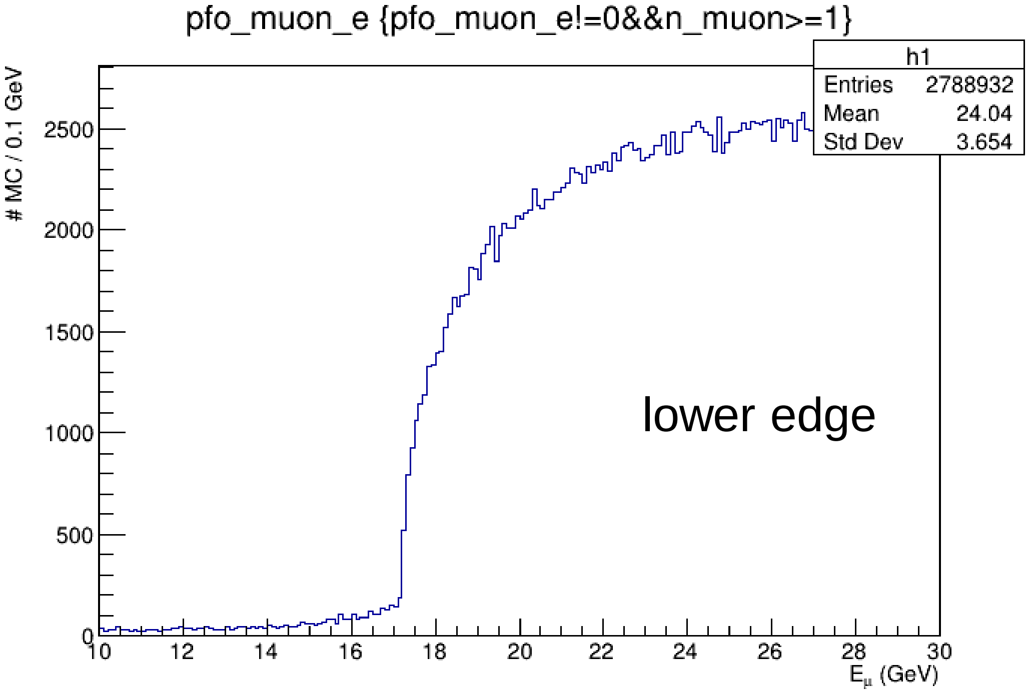


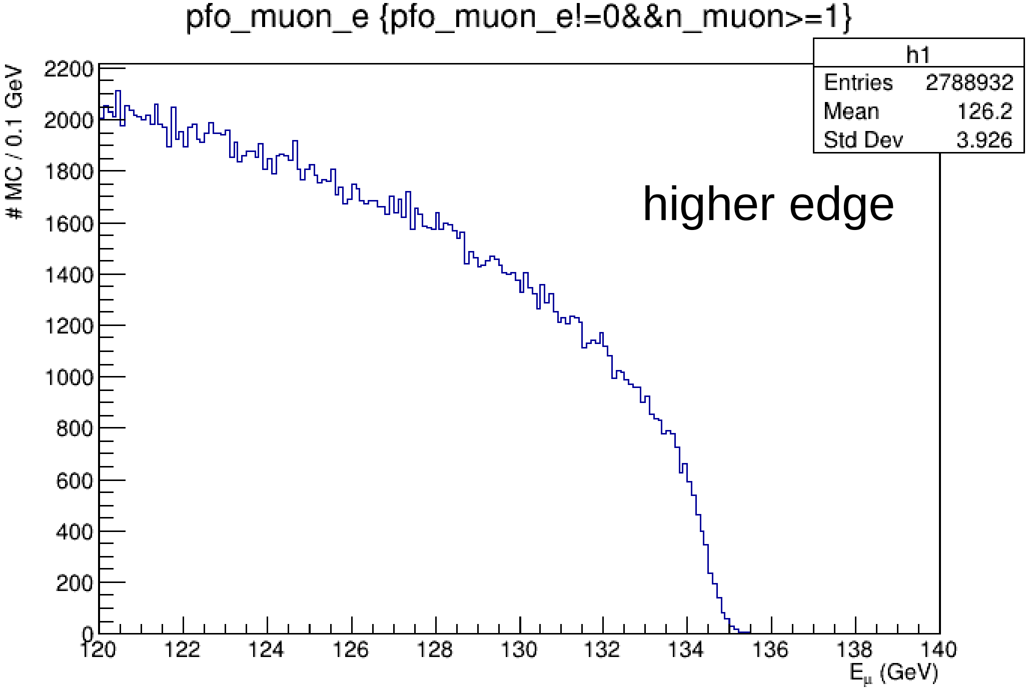


se22_eLpR (mass = 156 GeV)
e >= 1, plotted energy of electron PFOs
E^+ = 133.0 GeV and E^- = 16.3 GeV

Smuon ($\widetilde{\mu_L}$) events

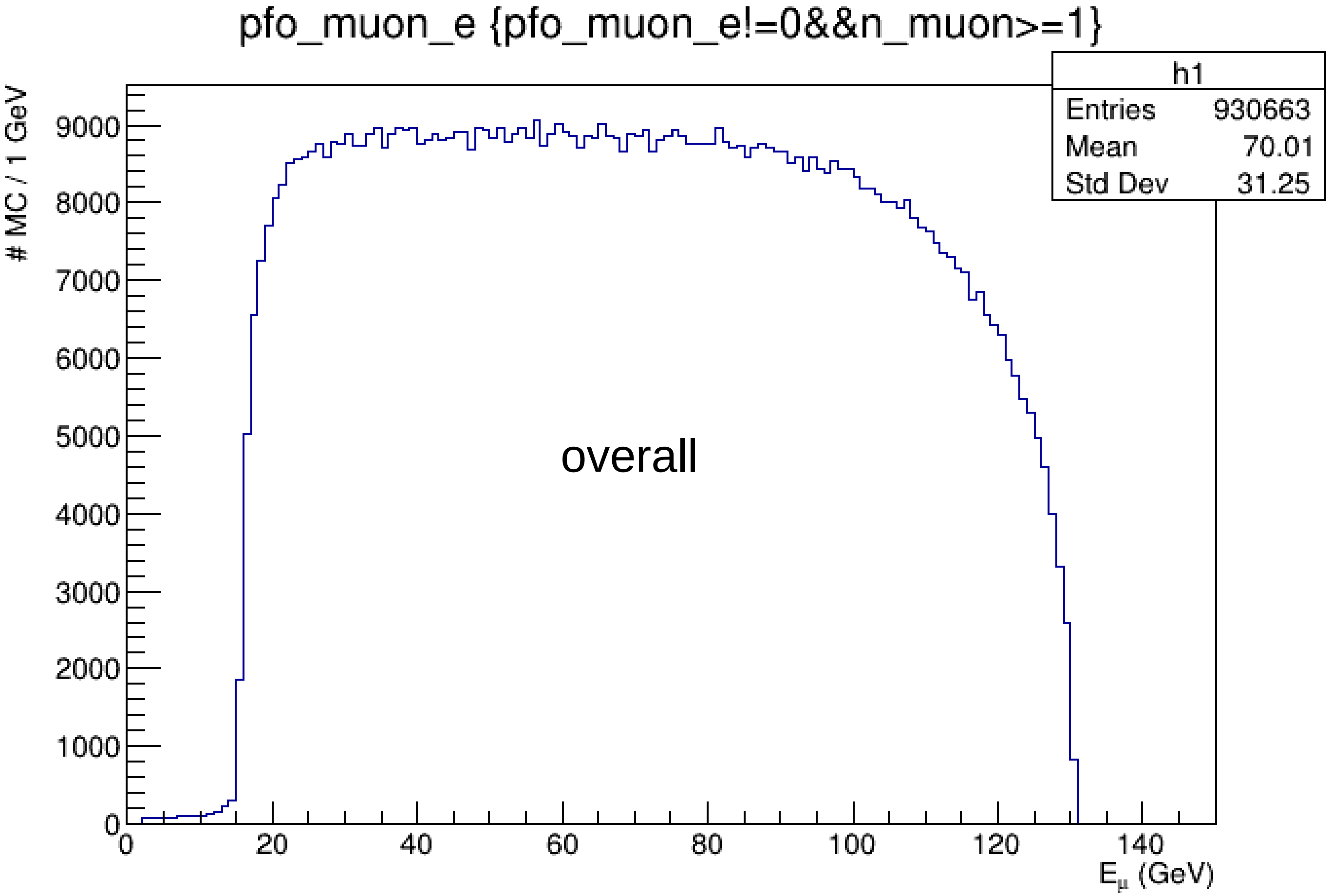




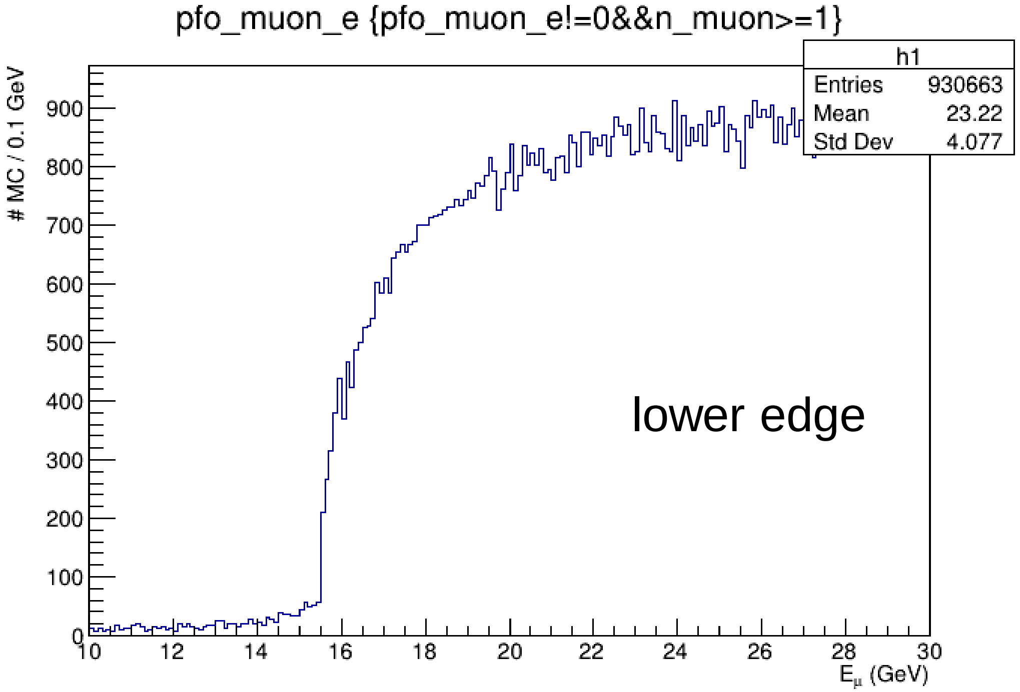


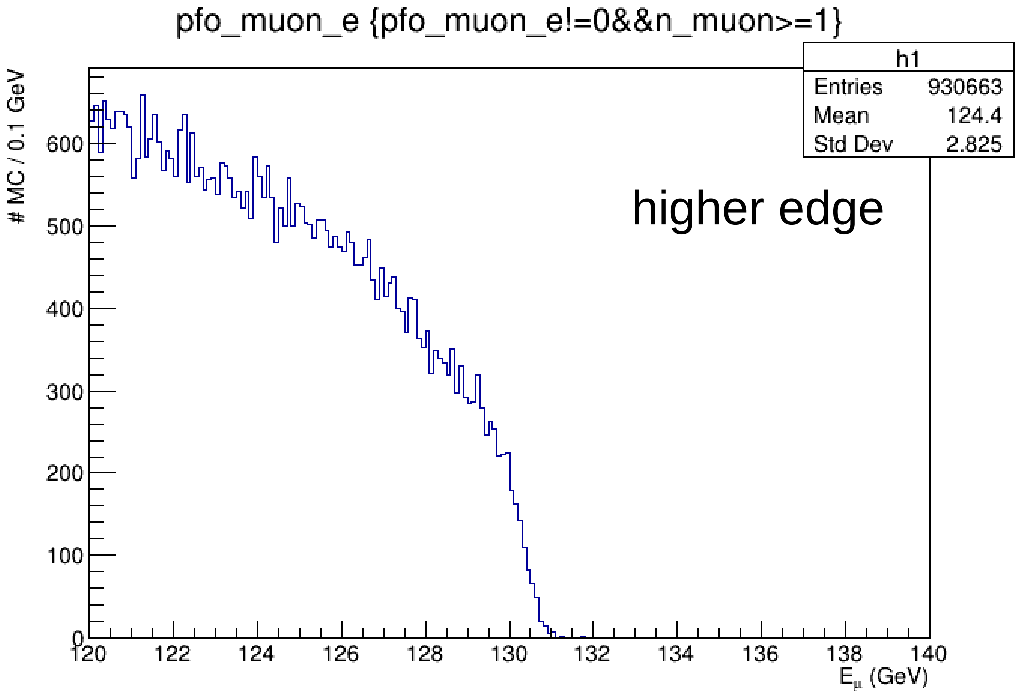
smu11_eLpR (mass = 158 GeV)
mu >= 1, plotted energy of muon PFOs
E^+ = 134.8 GeV and E^- = 17.1 GeV

Smuon ($\widetilde{\mu_R}$) events



smu22_eLpR (mass = 154 GeV)
mu >= 1, plotted energy of muon PFOs
E^+ = 131.1 GeV and E^- = 15.6 GeV

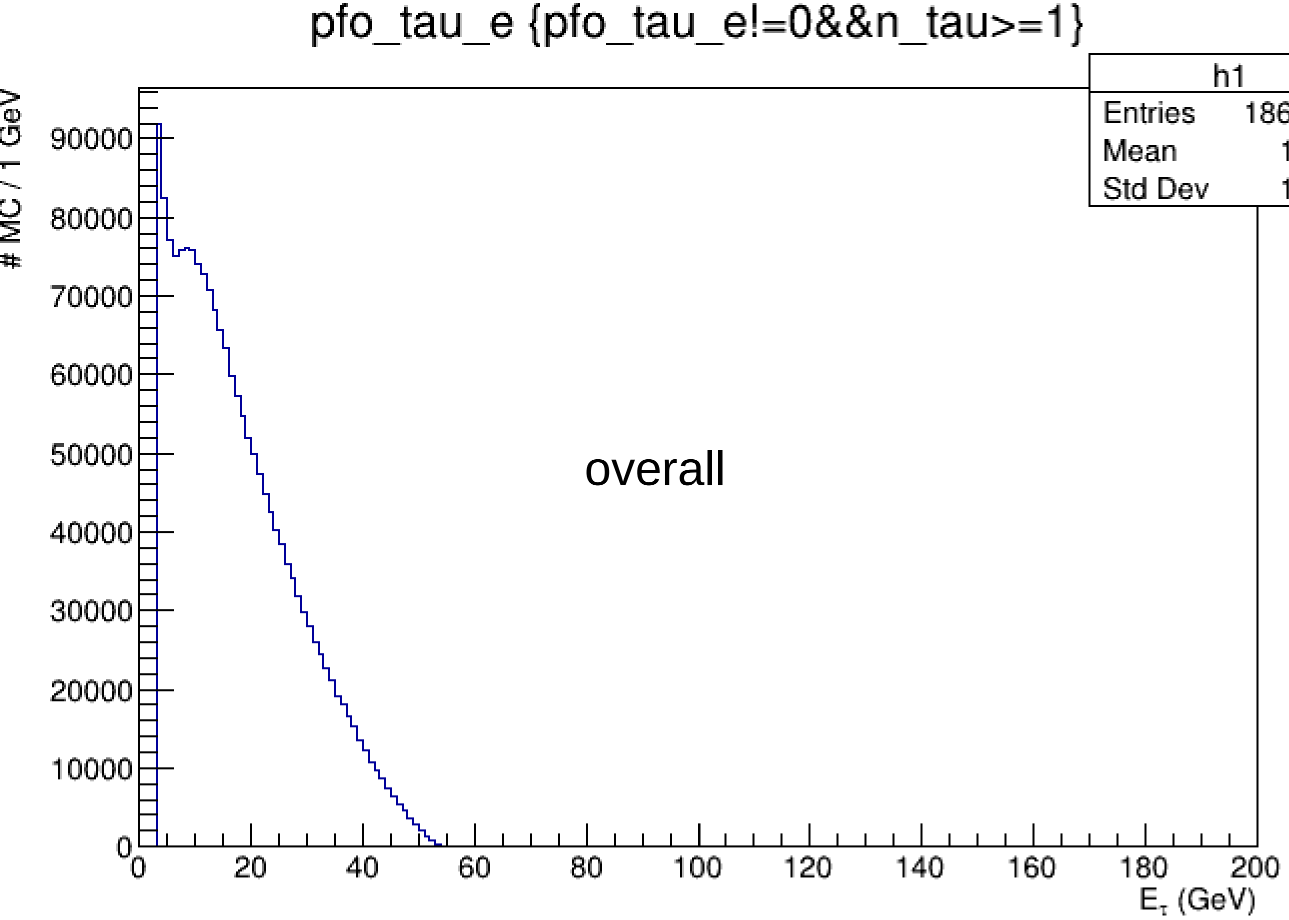


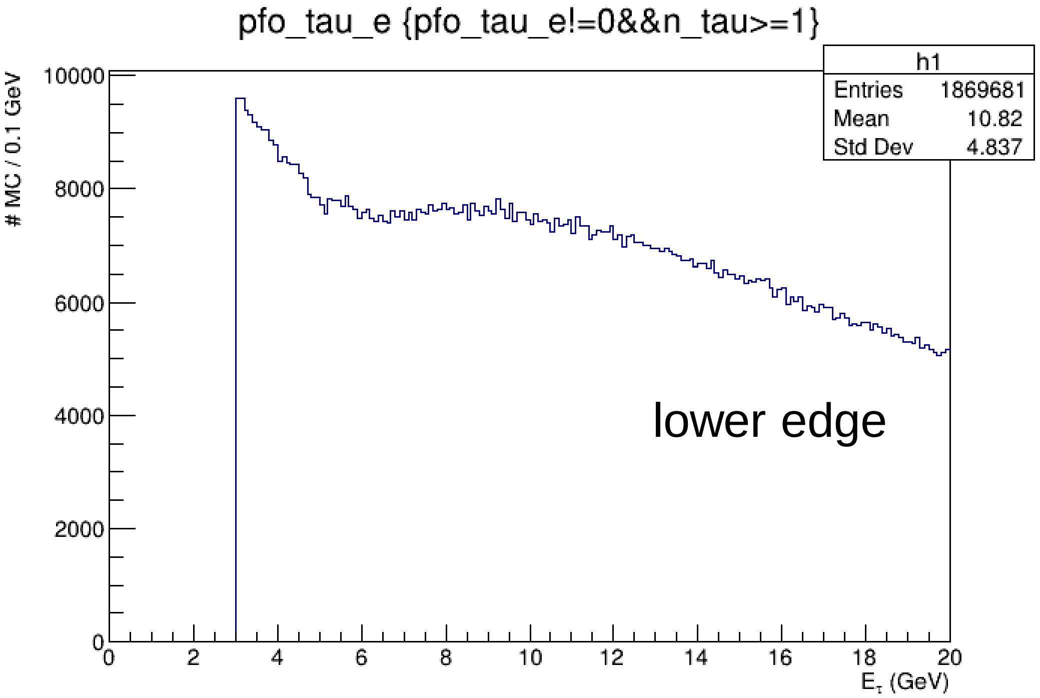


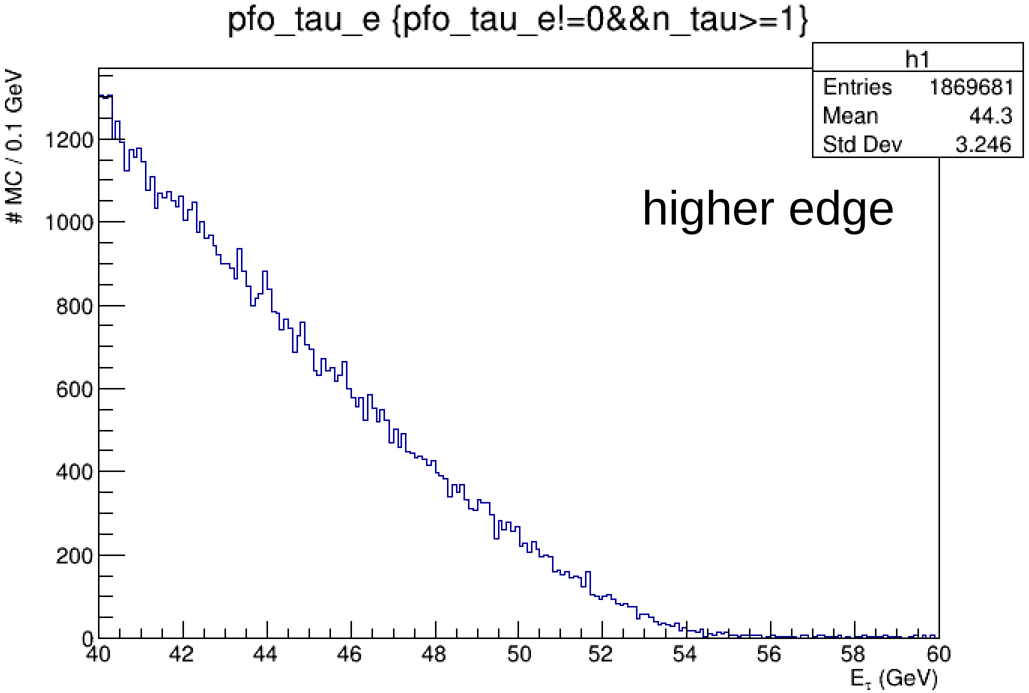
Energy distribution

- Selectron/Smuon events have edges in both side as expected. This distribution can be used to extract the mass of neutralino/selectron/smuon.
- However, stau event is not easy: tau decays to something and make everything complicated.
  - Used TaJetClustering with default values for tau reconstruction
    - Choose energetic charged PFO as a seed and combine neutral PFO near to the seed to reconstruct a tau candidate
    - Apply some selection cuts

Stau ($\tilde{\tau}_1$) events

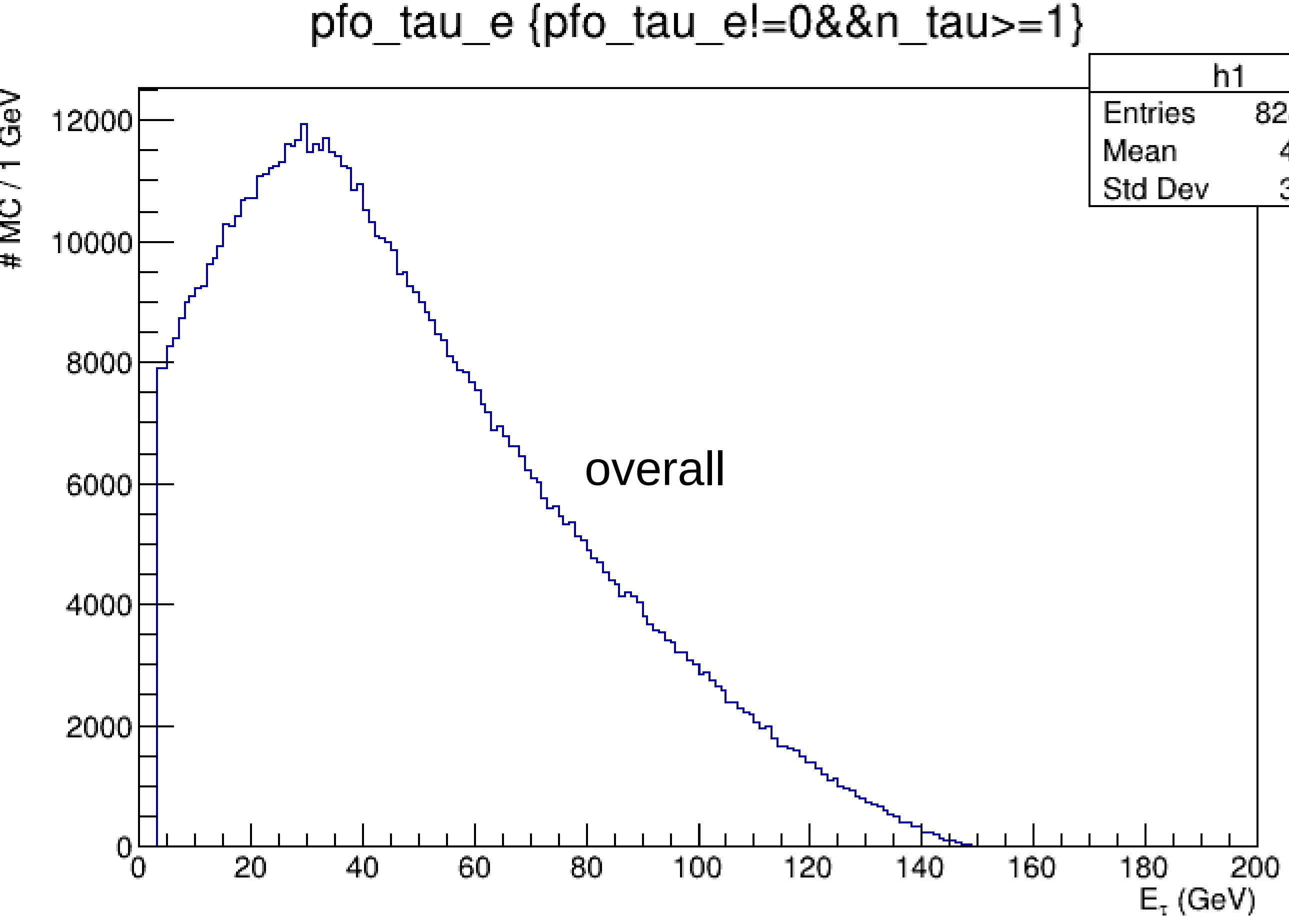


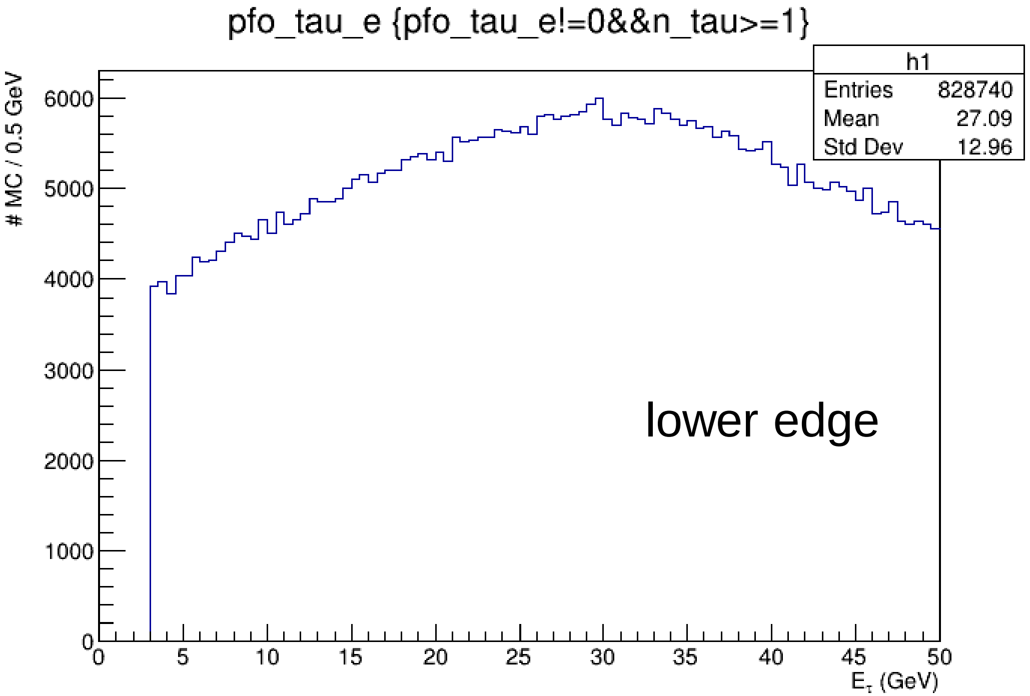


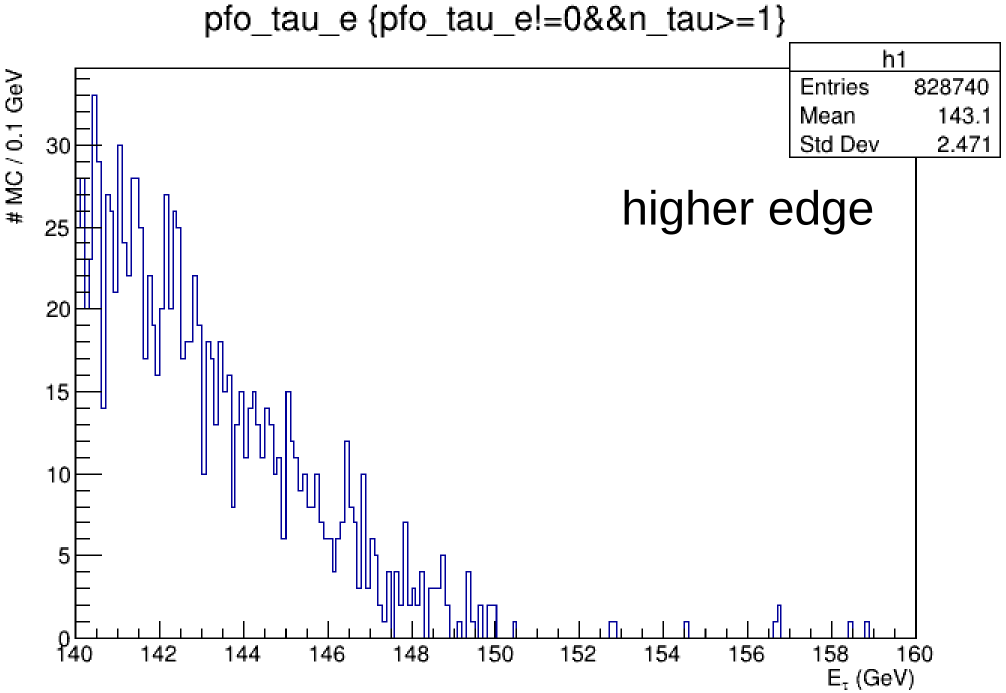


stau11_eLpR (mass = 113 GeV)
tau >= 1, plotted energy of reconstructed taus
E^+ = 55.0 GeV and E^- = 3.1 GeV

Stau ($\tilde{\tau}_2$) events







stau22_eLpR (mass = 190 GeV)
tau >= 1, plotted energy of reconstructed taus
E^{+} = 150.2 GeV and E^{-} = 31.9 GeV

Mass extraction (future work with bkg)

- It is possible to extract the masses of selectron/smuon/neutralino once we measure E^+ and E^- from the experiment
- In the end, we have
  - $m_{\mathrm{SUSY}}^2 = (\sqrt{s})^2 \frac{E^+E^-}{(E^+ + E^-)^2}$
  - $m_\chi^2 = m_{\mathrm{SUSY}}^2 \left[1 - \frac{2\left(E^+ + E^-\right)}{\sqrt{s}}\right]$

Physics analysis

- Made everything luminosity-weighted
  - Considered MC statistics
  - eLpR/eRpL for (e-, e+) = (-80%, +30%)/(+80%, -30%)
  - 1.6 ab^{-1} for both polarization (ILC500 full statistics)

- Start analysis with smuon events to measure edges

With SM background

- Added available IDR samples
  - /gpfs/group/ilc/soft/samples/mc-opt-3/ild/dst-merged/500-TDR_ws/PROCESS/ILD_l5_o1_v02/v02-00-01/~~~~~.slcio
  - processes
    - 2f: bhabha(Bhabha), leptonic (2lepton)
    - 4f: XXX_leptonic (XXX = singleW($e\nu W$), singleZee(eeZ), singleZnunu($\nu\nu Z$), singleZsingleWMix($e\nu W/eeZ/\nu\nu Z$), WW(WW), ZZ(ZZ), ZZWWMix(WW/ZZ))
    - all aa_4f (AA4f)

Statistics (so far only eLpR)

	$\widetilde{e}_L\widetilde{e}_L$	$\widetilde{e}_R\widetilde{e}_R$	$\widetilde{\mu}_L\widetilde{\mu}_L$	$\widetilde{\mu}_R\widetilde{\mu}_R$	$\widetilde{\tau}_1^+\widetilde{\tau}_1^-$	$\widetilde{\tau}_2^+\widetilde{\tau}_2^-$	$\widetilde{\tau}_1^+\widetilde{\tau}_2^-$	$\widetilde{\tau}_2^+\widetilde{\tau}_1^-$
No cuts	4.59*10^4	8.57*10^4	1.59*10^5	4.31*10^4	1.49*10^5	4.65*10^4	1.31*10^4	1.31*10^4

SM bkg	**Bhabha**	**2lepton**	$e\nu W$	eeZ	$\nu\nu Z$	$e\nu W/eeZ/\nu\nu Z$	WW	ZZ	WW/ZZ	**AA4f**
No cuts	5.40*10^6	5.44*10^6	2.59*10^6	1.14*10^7	2.62*10^5	1.04*10^6	7.40*10^5	5.82*10^4	7.68*10^5	3.36*10^5

precuts
$N_{\mu\text{-PFO}} == 2$
$N_{\text{chargedPFO}} == 2$

※These precuts might change when we switch to ILD full simulation because of different PFA performance and $\gamma\gamma \rightarrow$ low P_t hadron backgrounds.

	$\widetilde{e}_L\widetilde{e}_L$	$\widetilde{e}_R\widetilde{e}_R$	$\widetilde{\mu}_L\widetilde{\mu}_L$	$\widetilde{\mu}_R\widetilde{\mu}_R$	$\widetilde{\tau}_1^+\widetilde{\tau}_1^-$	$\widetilde{\tau}_2^+\widetilde{\tau}_2^-$	$\widetilde{\tau}_1^+\widetilde{\tau}_2^-$	$\widetilde{\tau}_2^+\widetilde{\tau}_1^-$
precuts	0	0	1.38*10^5	3.77*10^4	2.71*10^3	1.11*10^3	274	271

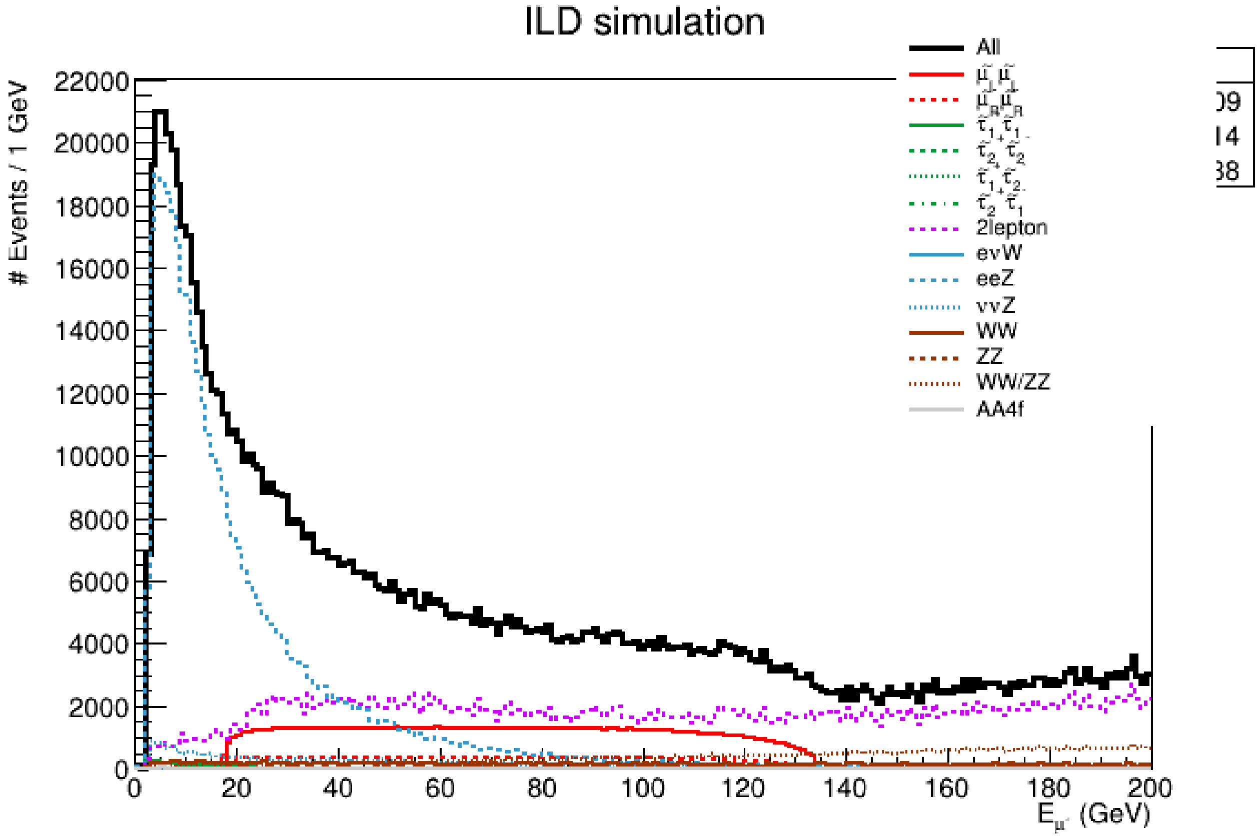
SM bkg	**Bhabha**	**2lepton**	$e\nu W$	eeZ	$\nu\nu Z$	$e\nu W/eeZ/\nu\nu Z$	WW	ZZ	WW/ZZ	**AA4f**
precuts	0	6.44*10^5	22.0	3.72*10^5	2.97*10^4	0	3.20*10^4	3.74*10^3	9.78*10^4	858

Distribution of E_{μ^-} at precuts

Black histogram is the sum up all processes and this is the histogram we can obtain from the real experiment.

Clearly, more background rejection is necessary to measure edges.
Dominant backgrounds:
2lepton, eeZ(singleZee)

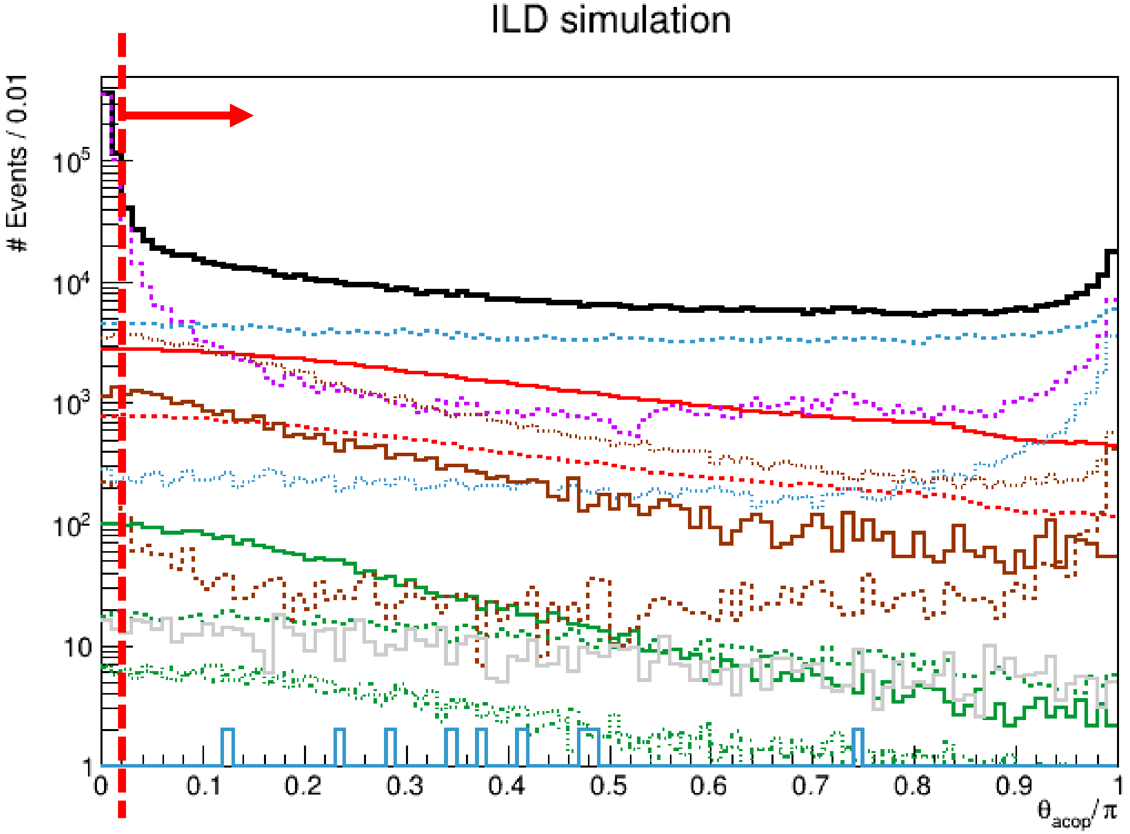
CUTS ARE WORK IN PROGRESS
Cuts are now designing not to destroy flat and edge structure with minimum bias (assume no knowledge of SUSY parametrization)

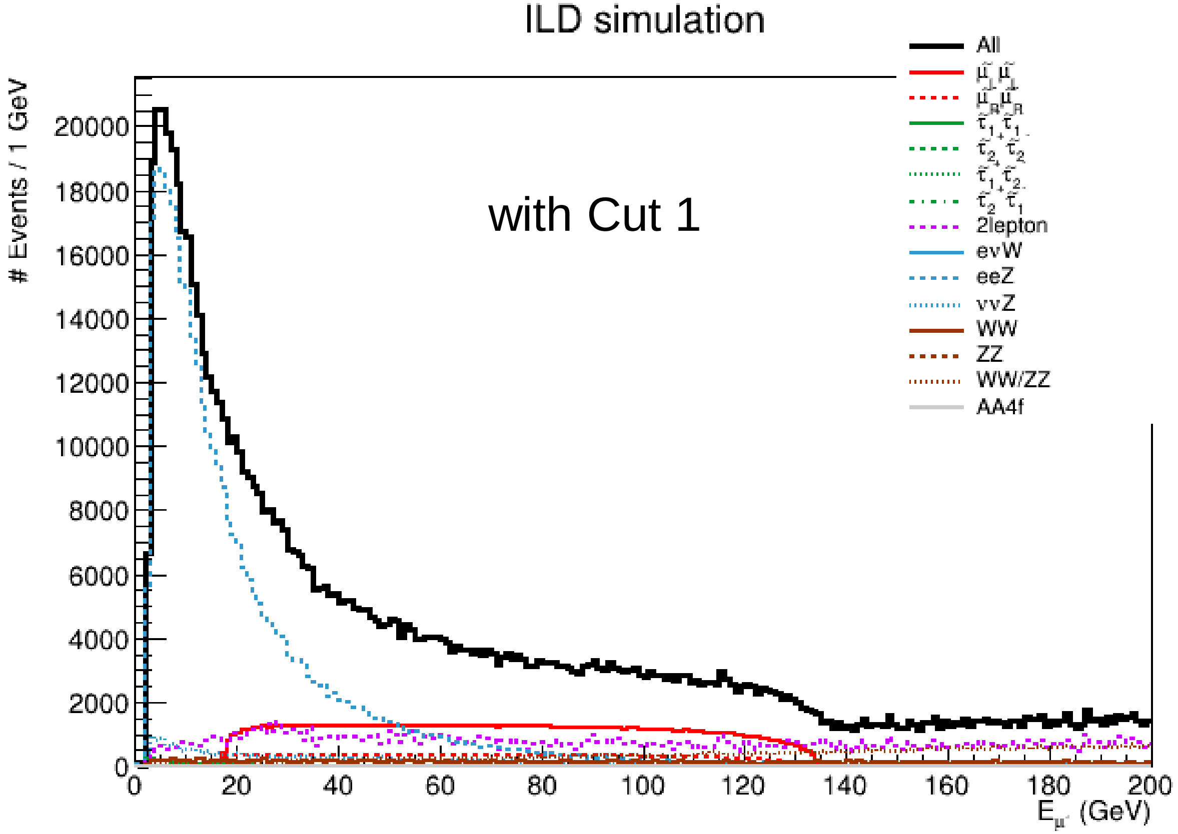


Signal signature

- Process: $e^+e^- \to \tilde{\mu}\tilde{\mu} \to \mu\mu\tilde{\chi}_1^0\tilde{\chi}_1^0$
  - 2 muons + large missing
  - missing energy level depends on neutralino mass
  - In refs.[arXiv:0902.2434, DESY-THESIS-09-004], $200 < E_{miss} < 430$ GeV was applied.
  - still we can assume some missing component

Cut on acoplanarity $\theta_{\mathrm{acop}} = \pi - (\phi_1 - \phi_2)$



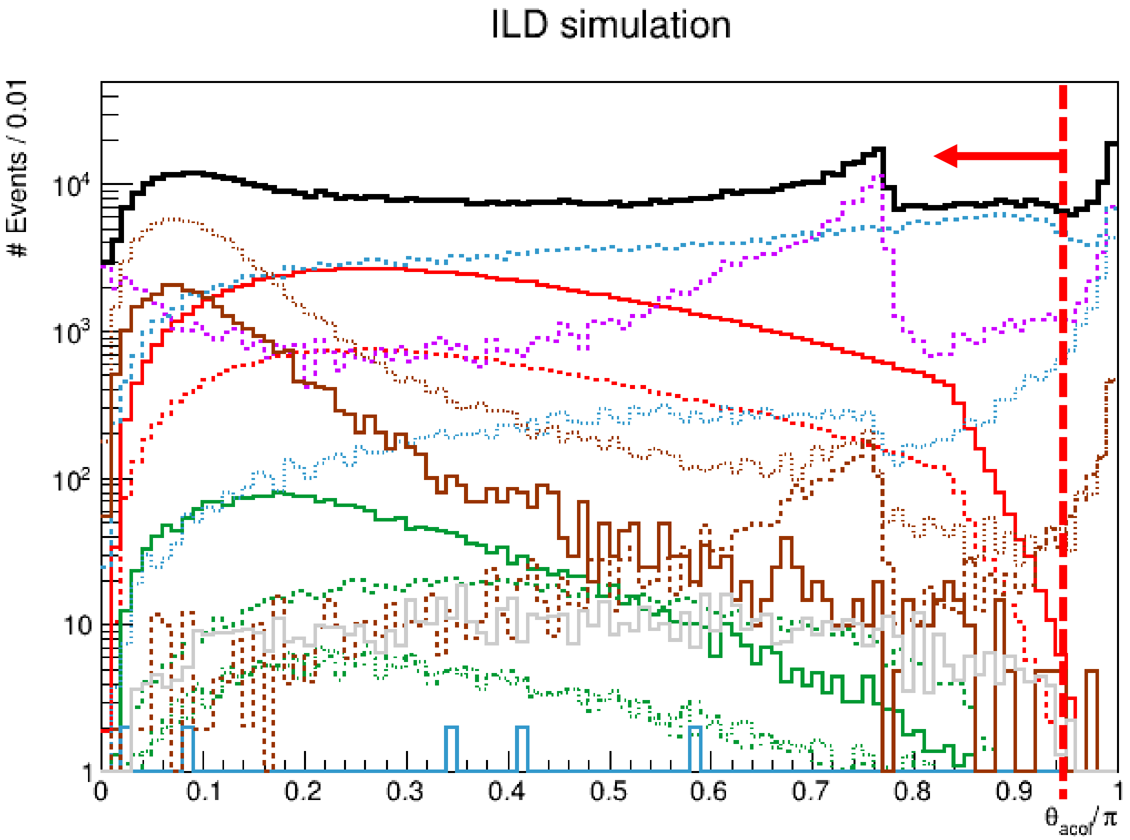


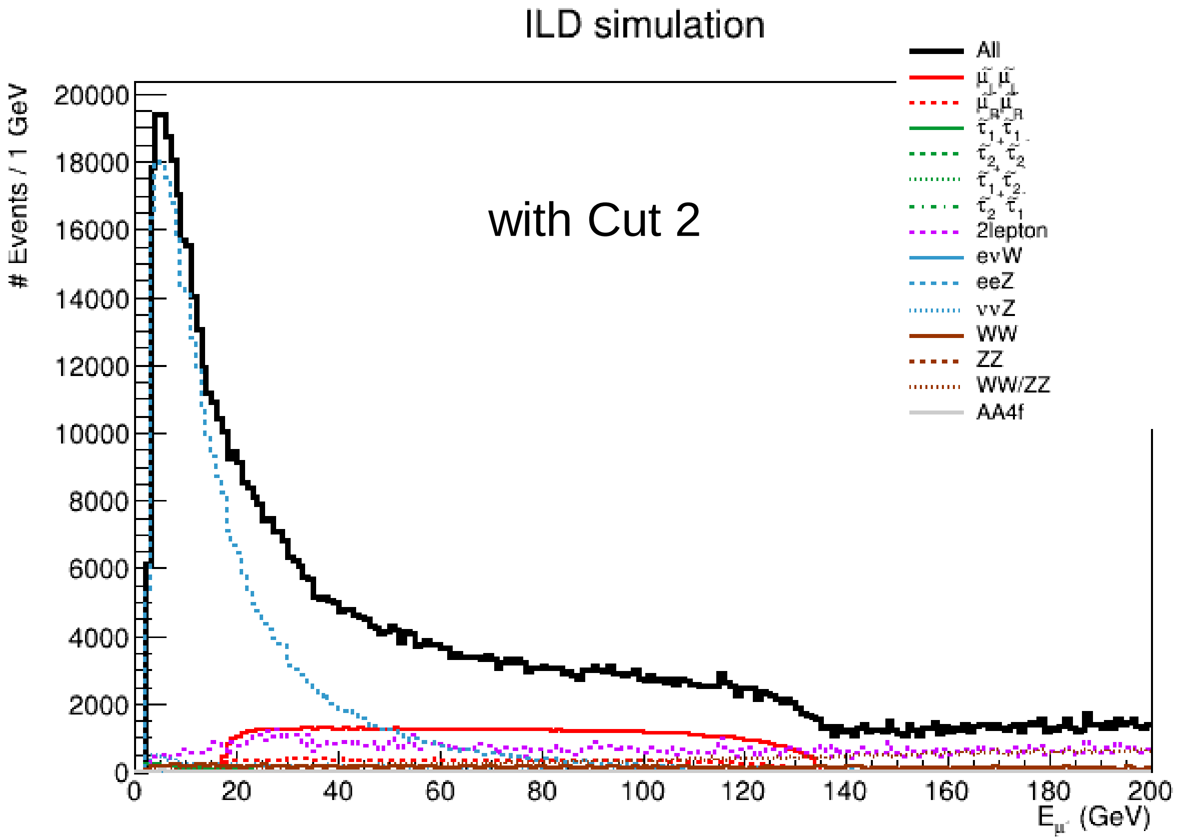
$\frac{\theta_{\mathrm{acop}}}{\pi} \sim 0$: two muons are back-to-back in xy-plane

mostly for SM background rejection, some signals rejected as well

Cut 1: $\frac{\theta_{\mathrm{acop}}}{\pi} > 0.02$

Cut on acolinearity $\theta_{\mathrm{acol}} = \pi - (\theta_1 - \theta_2)$



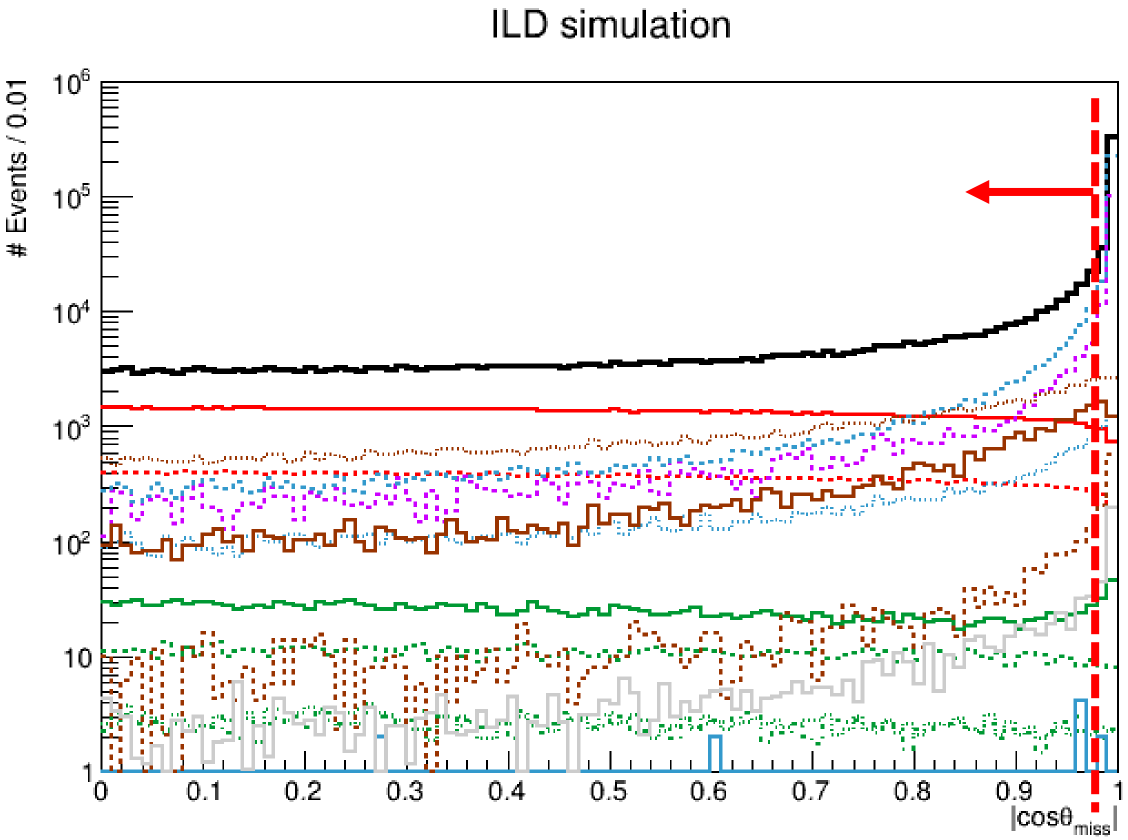


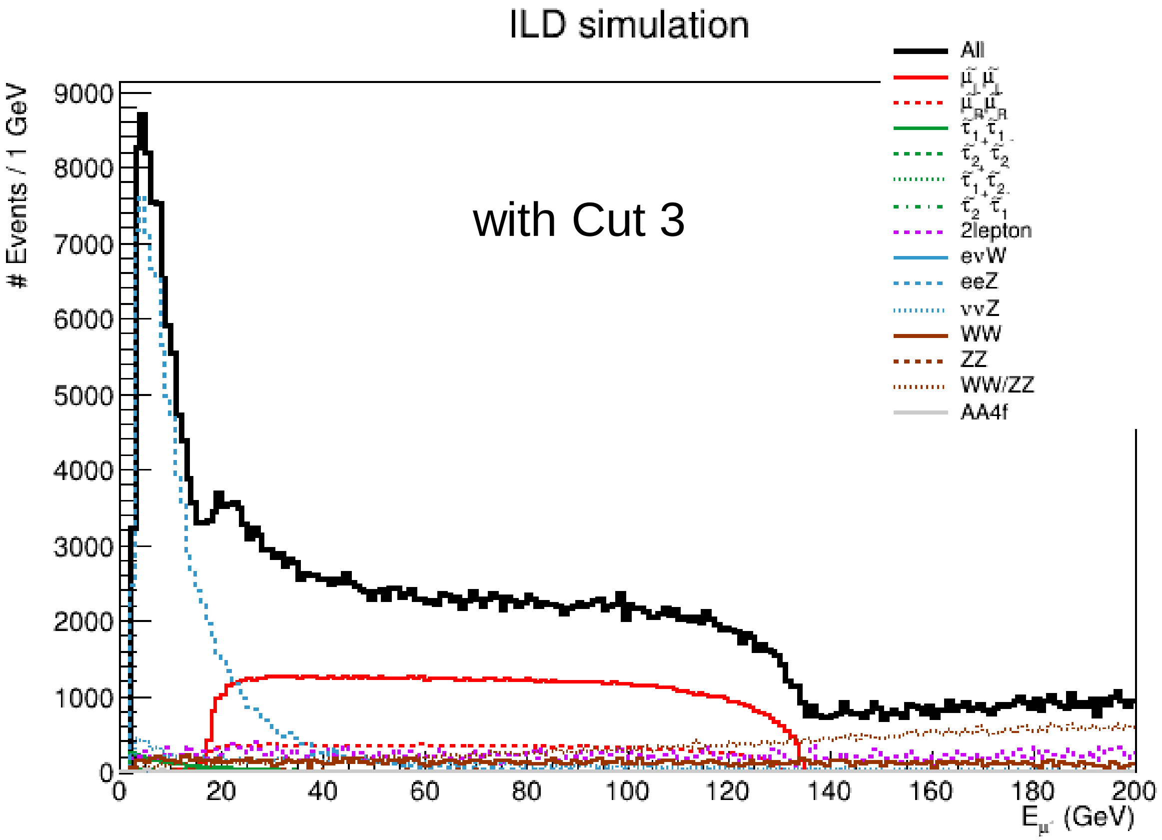
$\frac{\theta_{\mathrm{acol}}}{\pi} \sim 1$: two muons flying the same direction

such probability is expected to be small in signal

Cut 2: $\frac{\theta_{\mathrm{acol}}}{\pi} < 0.95$

Cut on $\cos\theta_{\text{miss}}$

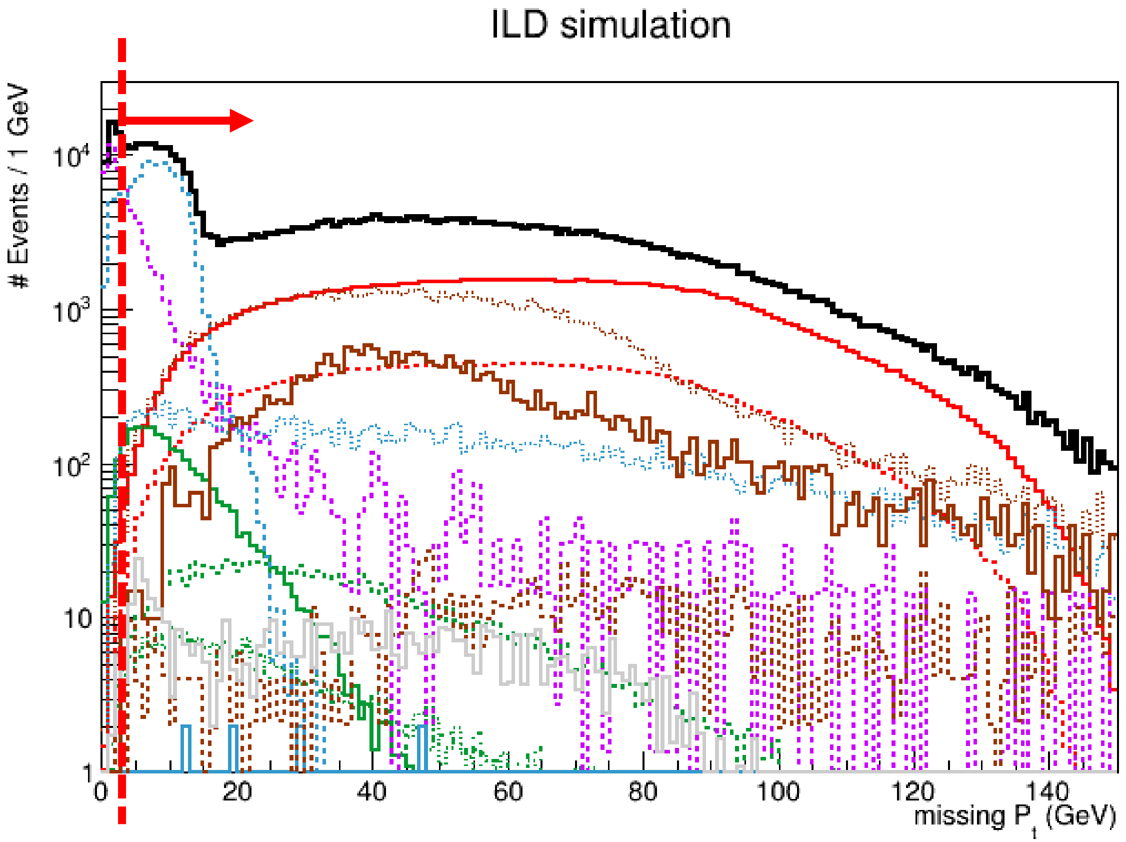


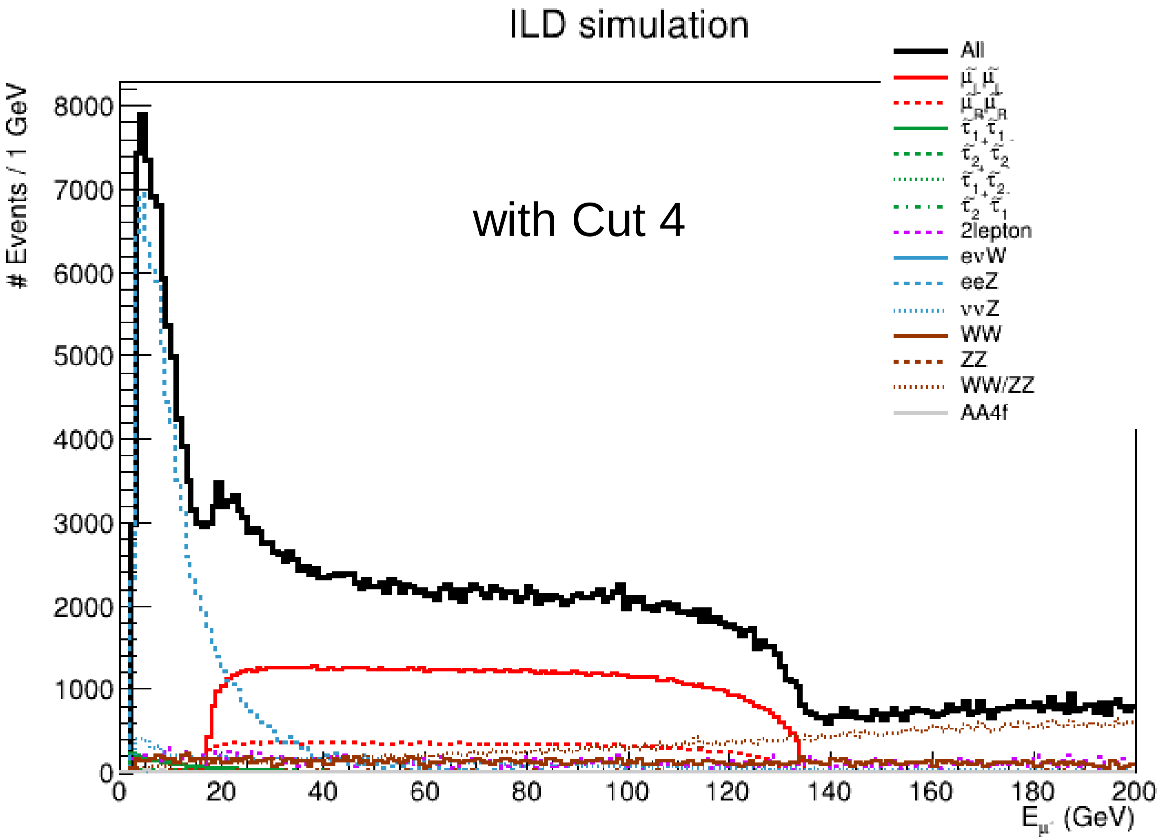


with Cut 3

$|\cos\theta_{\text{miss}}| \sim 1$: almost no missing component
signal have large missing component
Cut 3: $|\cos\theta_{\text{miss}}| < 0.98$

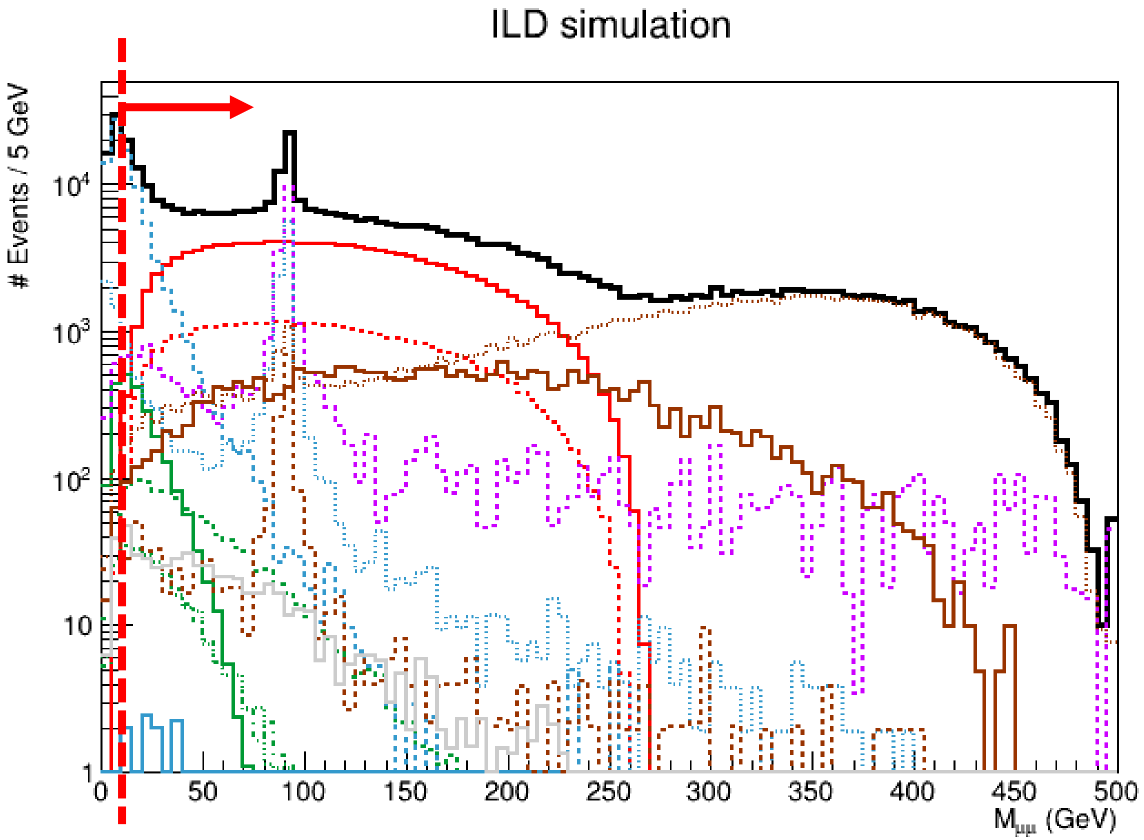
Cut on missing P_t

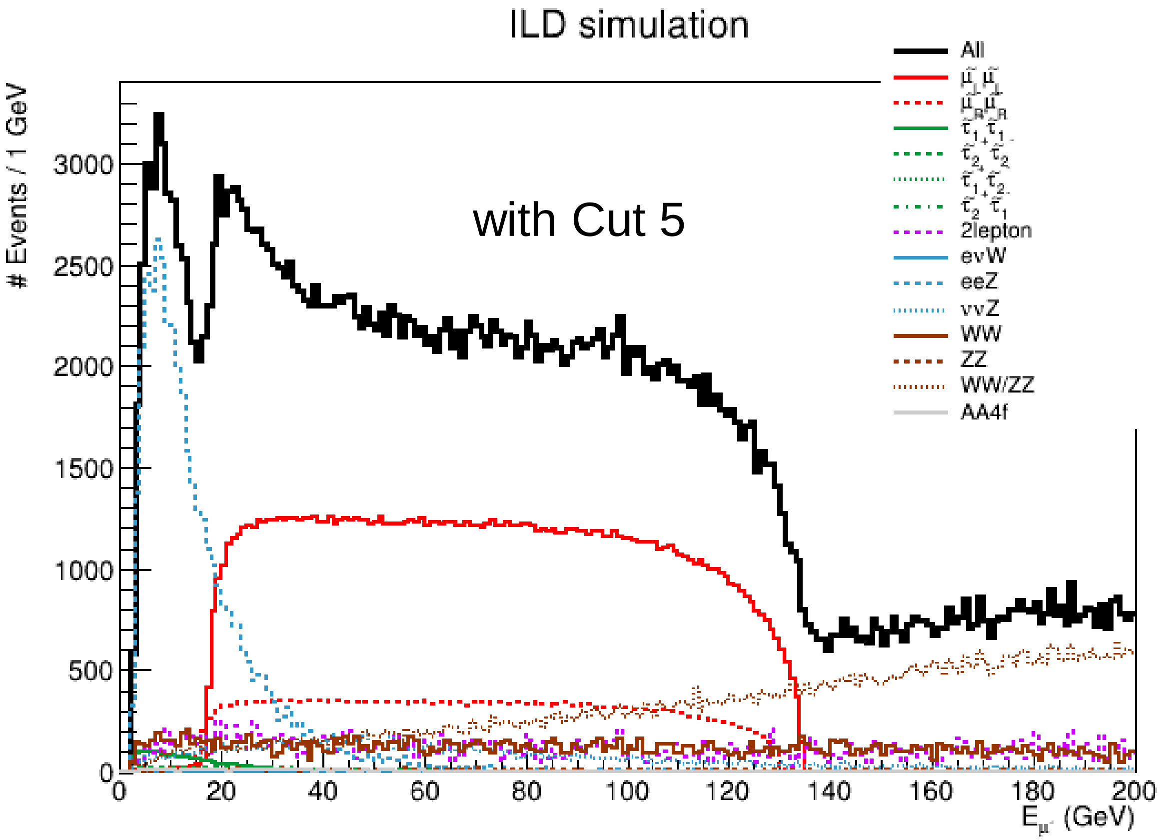




missing P_t ~ 0 GeV: almost no missing component
signal have large missing component
Cut 4: missing P_t > 3 GeV

Cut on $M_{\mu\mu}$

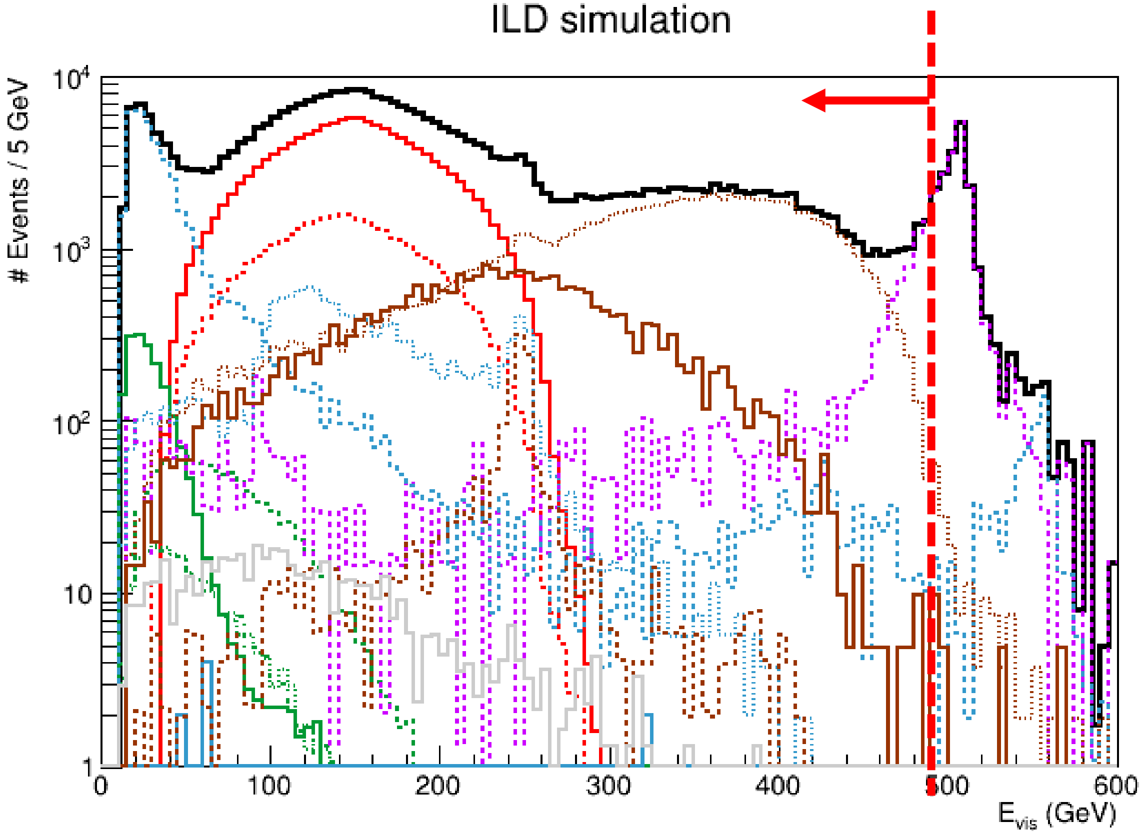

ILD simulation

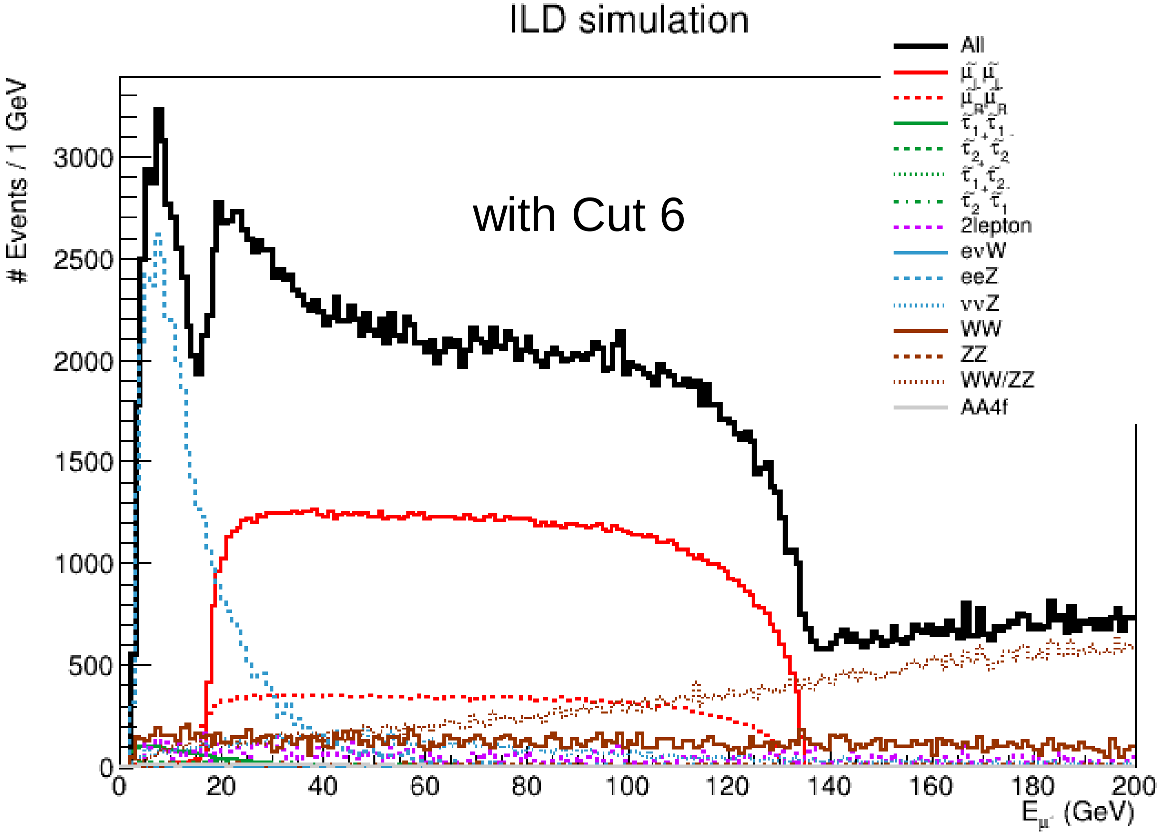

ILD simulation

with Cut 5

$M_{\mu\mu} \sim 0$ GeV: two muons produced by photon
expect no peaks around that region for signal
Cut 5: $M_{\mu\mu} > 10$ GeV

Cut on E_{vis}





E_{vis} ~ 500 GeV: almost no missing component
signal have large missing
Cut 6: E_{vis} < 490 GeV

Cut table

	$\tilde{\mu}_L\tilde{\mu}_L$	$\tilde{\mu}_R\tilde{\mu}_R$	$\tilde{\tau}_1^+\tilde{\tau}_1^-$	$\tilde{\tau}_2^+\tilde{\tau}_2^-$	$\tilde{\tau}_1^+\tilde{\tau}_2^-$	$\tilde{\tau}_2^+\tilde{\tau}_1^-$
precuts	$1.38*10^5$	$3.77*10^4$	$2.71*10^3$	$1.11*10^3$	274	271
Cut 1	$1.33*10^5$	$3.61*10^4$	$2.51*10^3$	$1.07*10^3$	262	259
Cut 2	$1.33*10^5$	$3.61*10^4$	$2.51*10^3$	$1.07*10^3$	262	259
Cut 3	$1.31*10^5$	$3.57*10^4$	$2.44*10^3$	$1.06*10^3$	258	254
Cut 4	$1.31*10^5$	$3.57*10^4$	$2.26*10^3$	$1.05*10^3$	253	250
Cut 5	$1.31*10^5$	$3.56*10^4$	$1.73*10^3$	986	219	219
Cut 6	$1.31*10^5$	$3.56*10^4$	$1.73*10^3$	986	219	219

SM bkg	**2lepton**	$e\nu W$	eeZ	$\nu\nu Z$	WW	ZZ	WW/ZZ	**AA4f**
precuts	$6.44*10^5$	22.0	$3.72*10^5$	$2.97*10^4$	$3.20*10^4$	$3.74*10^3$	$9.78*10^4$	858
Cut 1	$1.84*10^5$	22.0	$3.63*10^5$	$2.92*10^4$	$2.95*10^4$	$3.32*10^3$	$9.06*10^4$	829
Cut 2	$1.68*10^5$	12.8	$3.39*10^5$	$1.93*10^4$	$2.95*10^4$	$2.48*10^3$	$8.98*10^4$	814
Cut 3	$5.66*10^4$	10.8	$9.40*10^4$	$1.71*10^4$	$2.66*10^4$	$1.71*10^3$	$8.46*10^4$	573
Cut 4	$2.95*10^4$	10.8	$8.19*10^4$	$1.70*10^4$	$2.66*10^4$	$1.71*10^3$	$8.45*10^4$	564
Cut 5	$2.86*10^4$	10.8	$4.09*10^4$	$1.34*10^4$	$2.66*10^4$	$1.65*10^3$	$8.44*10^4$	520
Cut 6	$9.99*10^3$	10.8	$4.03*10^4$	$1.34*10^4$	$2.65*10^4$	$1.65*10^3$	$8.42*10^4$	519

current dominant backgrounds: WW/ZZ, eeZ, WW, nunuZ, 2lepton

Summary & Next steps

- Performed SUSY event sample generation and DELPHES simulation
- Observed clear edge structure in selectron/smuon events as expected, but stau events are complicated
- Analysis of background rejection started with smuon events

- More cut ideas?
    - Can we tighten the cut for missing component? (increase bias, still OK if we work with specific values assumption)
    - Any other variables?
- Mass extraction by edge detection (How?)

BACKUP

Muon g-2 + SUSY: status report

- Produce SUSY MC samples at ILC500 with WHIZARD2.8.5
  - The files “blr1.slha” and SINDARIN files prepared by theorists, but beam energy spread was not included
  - Worked to include ISR / beam energy spread by implementing CIRCE2
  - Included PYTHIA6 and TAUOLA as well
  - Calculated cross-section for each SUSY process, and generated MC events
- Run detector simulation: this time DELPHES used

Problems / Questions / Next Step (1)

- When I include Pythia, it crushed.
  - Up to Xsec calculation works, but not for event generation.
- I set Tauola is on, but it keeps PDG +-15 (no decay of tau) in the event.

- **Solved:** These are solved when I put the sentence "$ps_PYTHIA_PYGIVE = "MDCY(C1000022,1)=0"" in sindarlin file explicitly (written in Whizard manual).

Problems / Questions / Next Step (2)

- When running TAUOLA, I got the following message.
  - Subroutine fill_pyjets_spin_data: tau helicity information is not set, though polarized tau decay was requested. Most likely, the SINDARIN file does not include polarized for particles and/or not ?polarized_events=true
  - Still no tau decay exist in tau events. Maybe due to this message?

- **Solved:** Put the sentence “?polarized_events=true” in global.

Problems / Questions / Next Step (3)

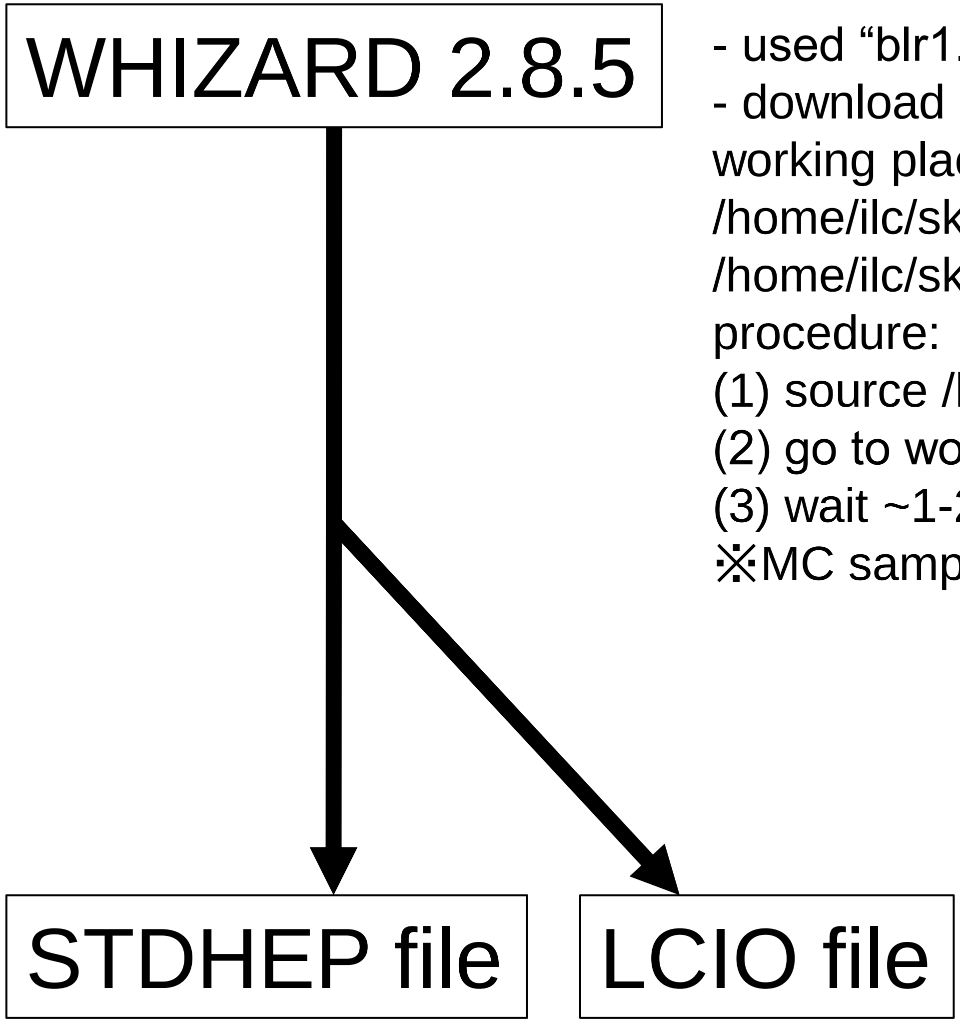
- Found ~4[7]% events have stable tau (no daughters of tau) in stau1+stau2-[stau1+stau1-] event.
- The biggest difference with Keita’s study is with or without SUSY contribution.

- **Solved**: need to apply patch for PYTHIA6 (many thanks to Mikael Berggren (DESY))
  - This needs: fresh download of Whizard2.8.5, apply patch to PYTHIA6, compile and install. The Whizard2.8.5 which is already installed in KEKCC is not enough to handle stau BSM world.

Problems / Questions / Next Step (4)

- How to do detector simulation?
  - DELPHES? SGV? ILD full simulation?
  - In any case, I need to learn how to run the jobs. Started to learn DELPHES first.
  - Sometimes DELPHES does not work ---> **Solved**: some version difference (many thanks to Daniel), input file was too large.

Workflow (1)



WHIZARD 2.8.5

- used “blr1.slha” and SINDARIN file
- download from scratch, apply patch for PYTHIA6, compile and install

working place:
/home/ilc/skawada/SUSYg-2/blr1_STDHEP
/home/ilc/skawada/SUSYg-2/blr1_LCIO
procedure:
(1) source /home/ilc/skawada/SUSYg-2/SK-setup-whizard-2.8.5.sh
(2) go to working place, type “. job.sh” and “. run.sh”
(3) wait ~1-2 hours and done
※MC samples are stored in multiple files: 50K events / 1 file.

STDHEP file

LCIO file

can use for future ILD full simulation
stored at:
/hsm/ilc/users/skawada/SUSYg-2/blr1_sample/LCIO

Workflow (2)

STDHEP file

necessary for DELPHES simulation
(LCIO is not supported as the input for DELPHES)
stored at:
/hsm/ilc/users/skawada/SUSYg-2/blr1_sample/STDHEP

DELPHES + DELPHES2LCIO

- used ILC generic card for detector
- used DELPHES2LCIO for LCIO output

working place:
/home/ilc/skawada/SUSYg-2/blr1_DEL
procedure:
(1) source /home/ilc/skawada/DJ-delphes-setup.sh
(2) go to working place and type “. run.sh”
(3) type “. check.sh”, failed job must be recovered by hand
※I don’t know why several jobs at KEKCC batch server fail.
The failure rate is ~10% even jobs controlled by one script.
※The EventSummary collection will be created at the end
of each file.

DELPHES result (LCIO file)

Workflow (3)

DELPHES result (LCIO file)

contains DELPHES simulation result
event header information is lost
stored at:
/hsm/ilc/users/skawada/SUSYg-2/blr1_sample/DEL

MARLIN

- used to recover (or restore) event header information
- recovered cross-section, beam polarization, E_{CM} (500 GeV), process ID/name
- remove unnecessary EventSummary collection

working place:
/home/ilc/skawada/SUSYg-2/analysis/modification
procedure:
(1) source /home/ilc/skawada/init_ilcsoft_v020202.sh
(2) source /home/ilc/skawada/SUSYg-2/analysis/use.sh
(3) go to working place and type “. run_modify.sh”
(4) wait ~10 minutes and done
※Need to assume each sample has exactly 50K + EventSummary

DELPHES result (LCIO file)
+ event header info

contains DELPHES simulation result and event header info
stored at:
/home/ilc/skawada/SUSYg-2/analysis/DEL_sample