Angular efficiencies of semileptonic W pair decay at the ILC

FLC group presentation

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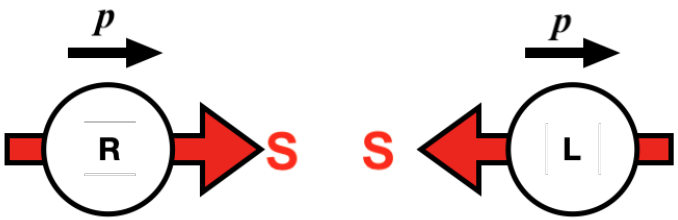
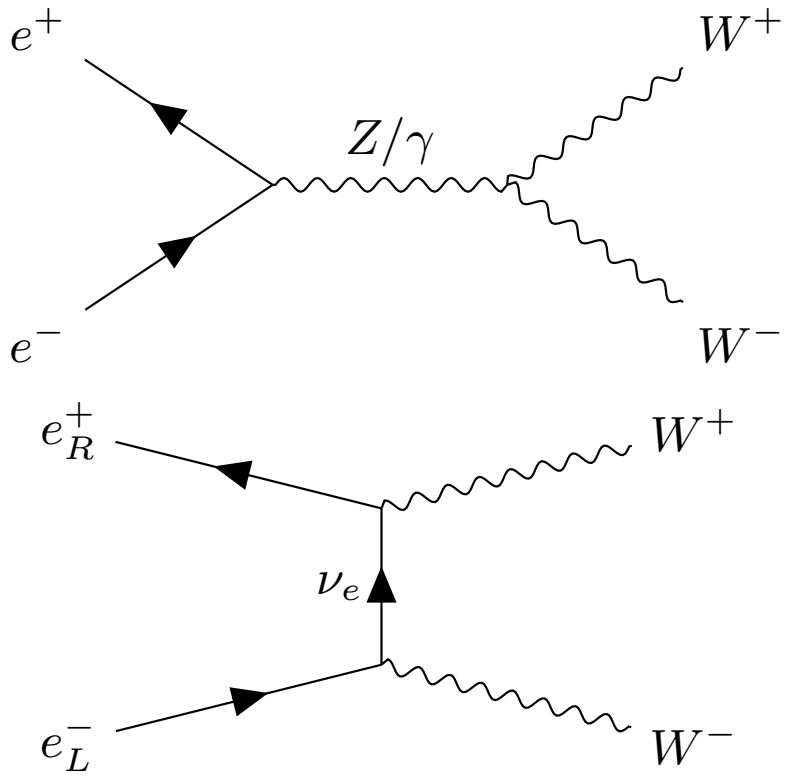
September 2, 2019

W pair production and chiral structures

- Chiral structure of weak interaction



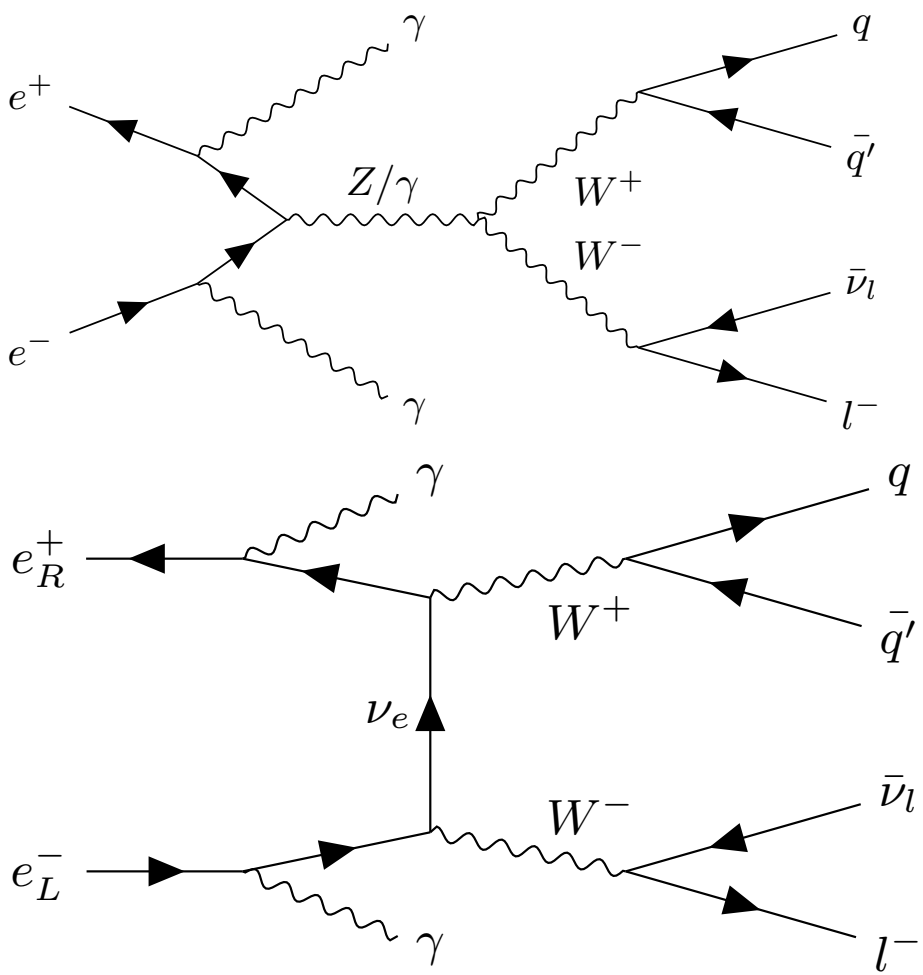
- initial state $e_L^- e_R^+$



Neutrino and ISR Corrections The hard collision

The final state

- **Visible 4-momenta**
  $p^\mu = (E, p_x, p_y, p_z)$
- **Neutrino 4-momenta**
  $p^\mu_\nu = (E_\nu, p_{x,\nu}, p_{y,\nu}, p_{z,\nu})$
- **ISR Photon 4-momenta**
  $p^\mu_\gamma = (E_\gamma, 0, 0, p_\gamma)$

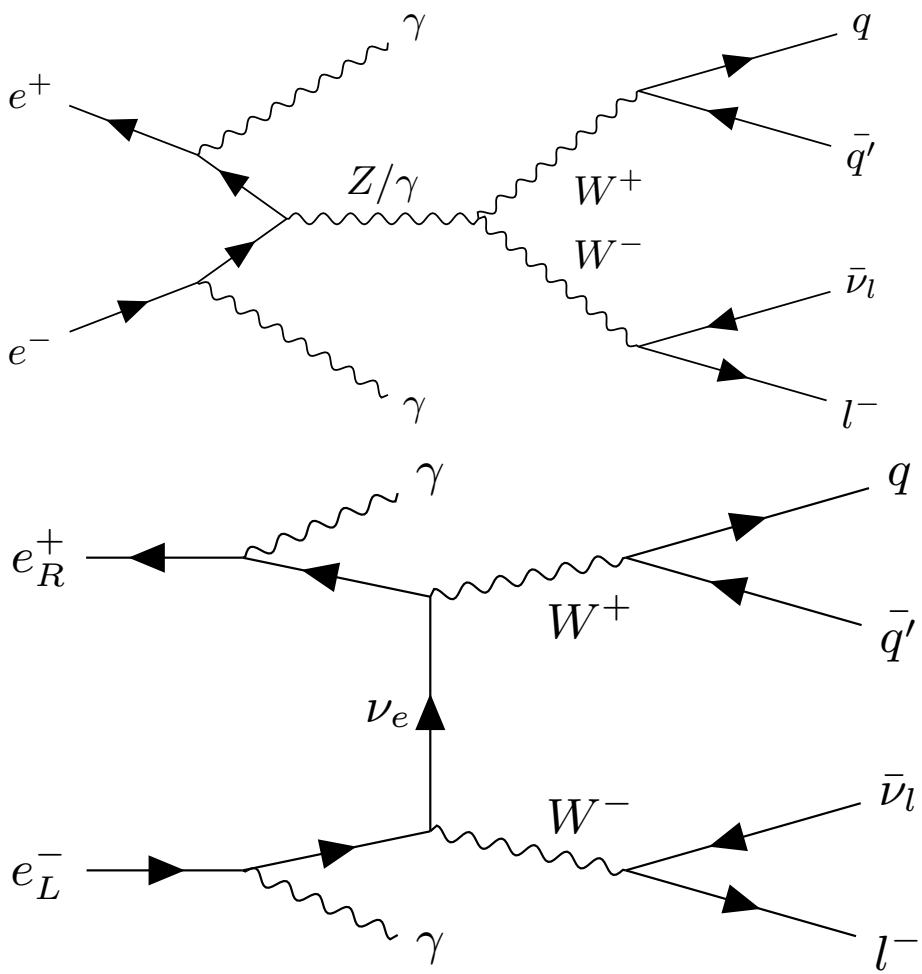


Neutrino and ISR Corrections ISR energy

Energy conservation
+
momentum conservation
=
ISR energy equation

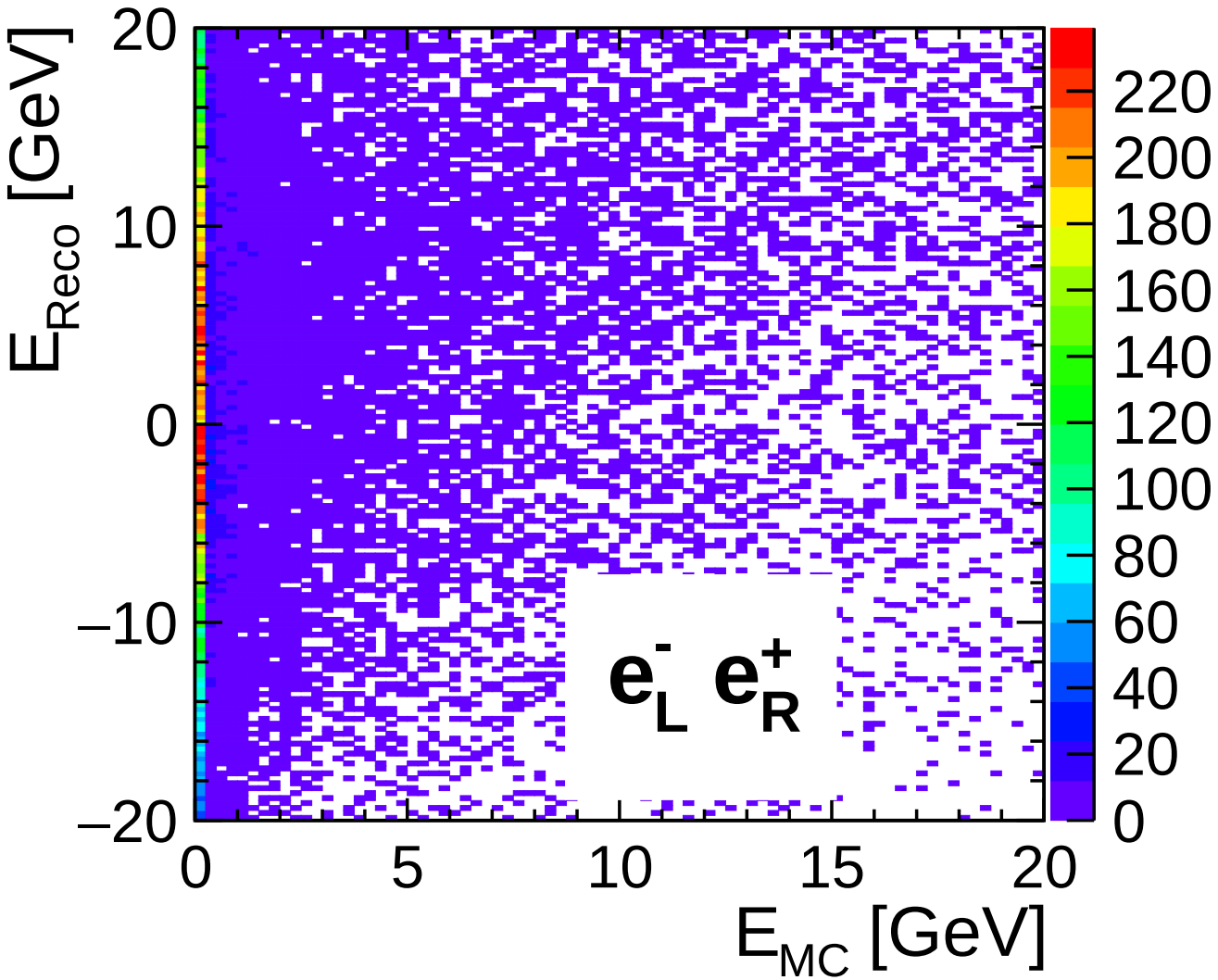
$$E_\gamma = \frac{(\sqrt{s} - E)^2 - p^2}{2\sqrt{s} - 2E \mp 2p_z}$$

$$\sqrt{s} = 500 \text{ GeV}$$



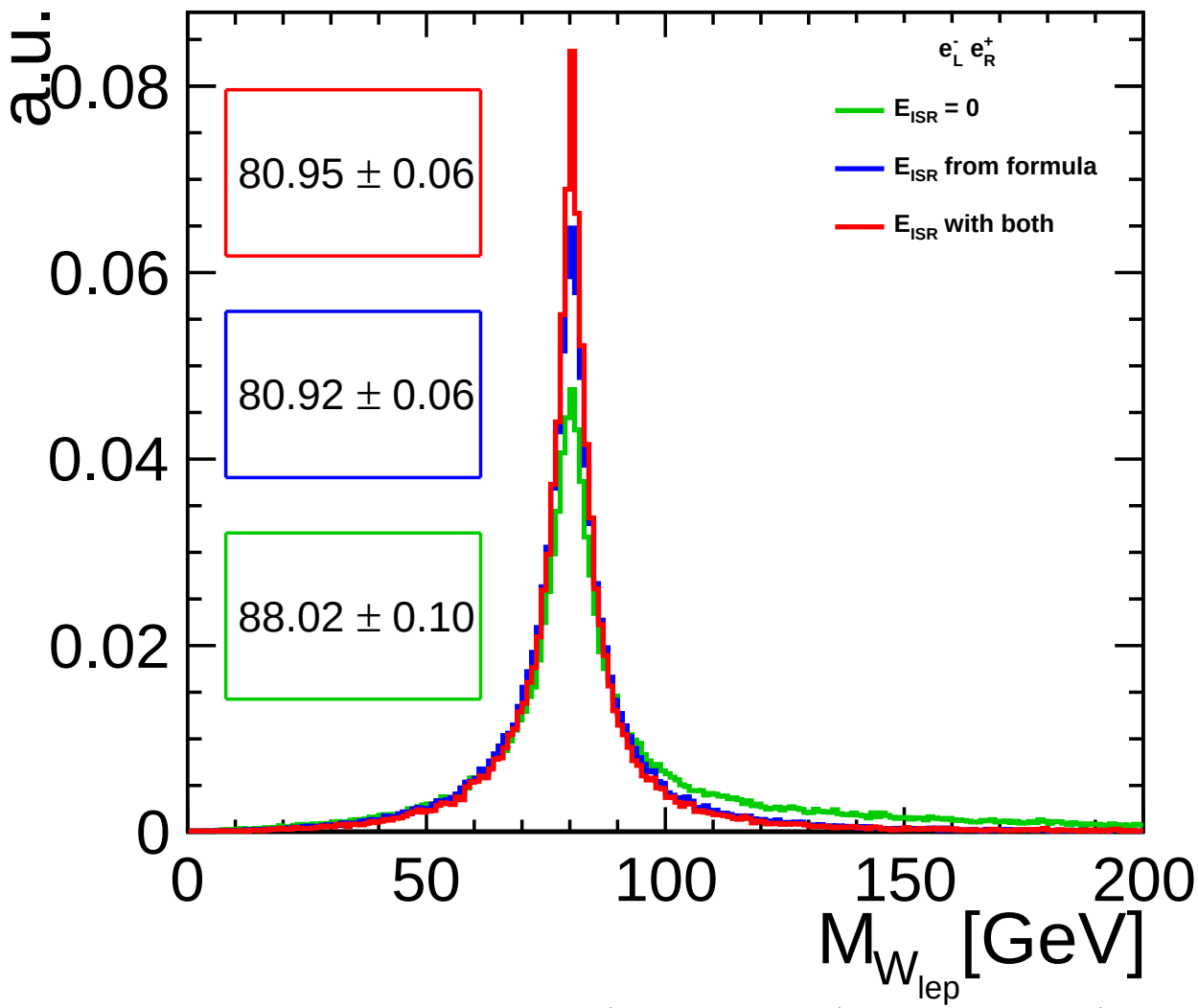
Neutrino and ISR Corrections $E_\gamma = 0$ solution

Only considering muon signal



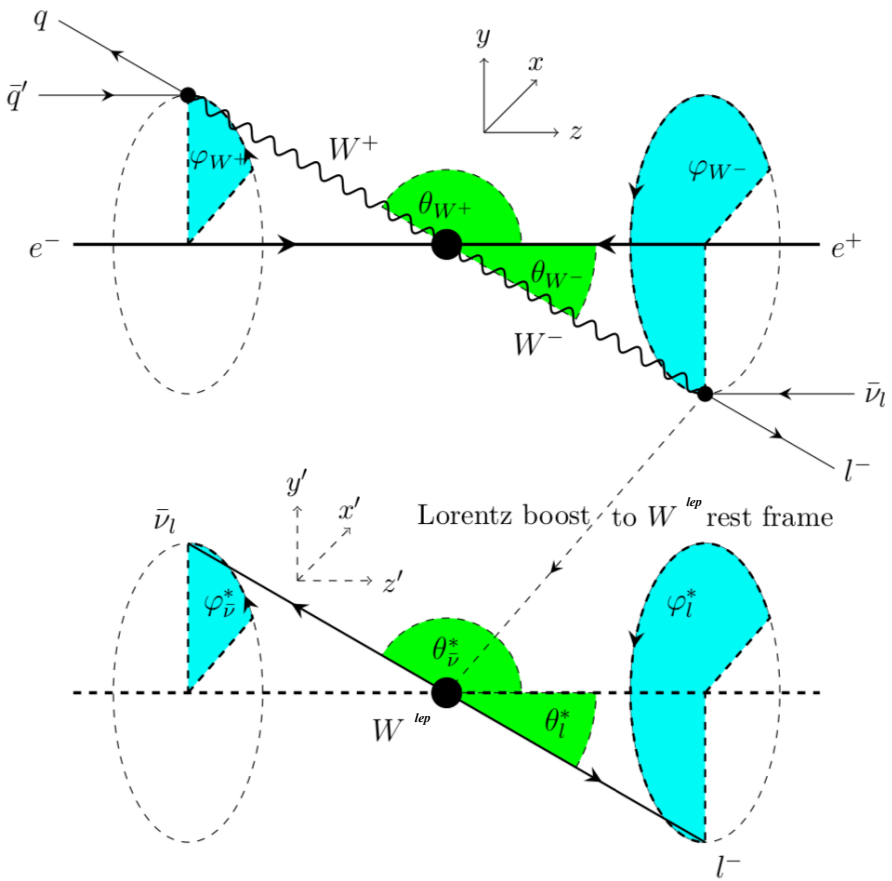
Neutrino and ISR Corrections Reconstruction evaluation

Only considering muon signal

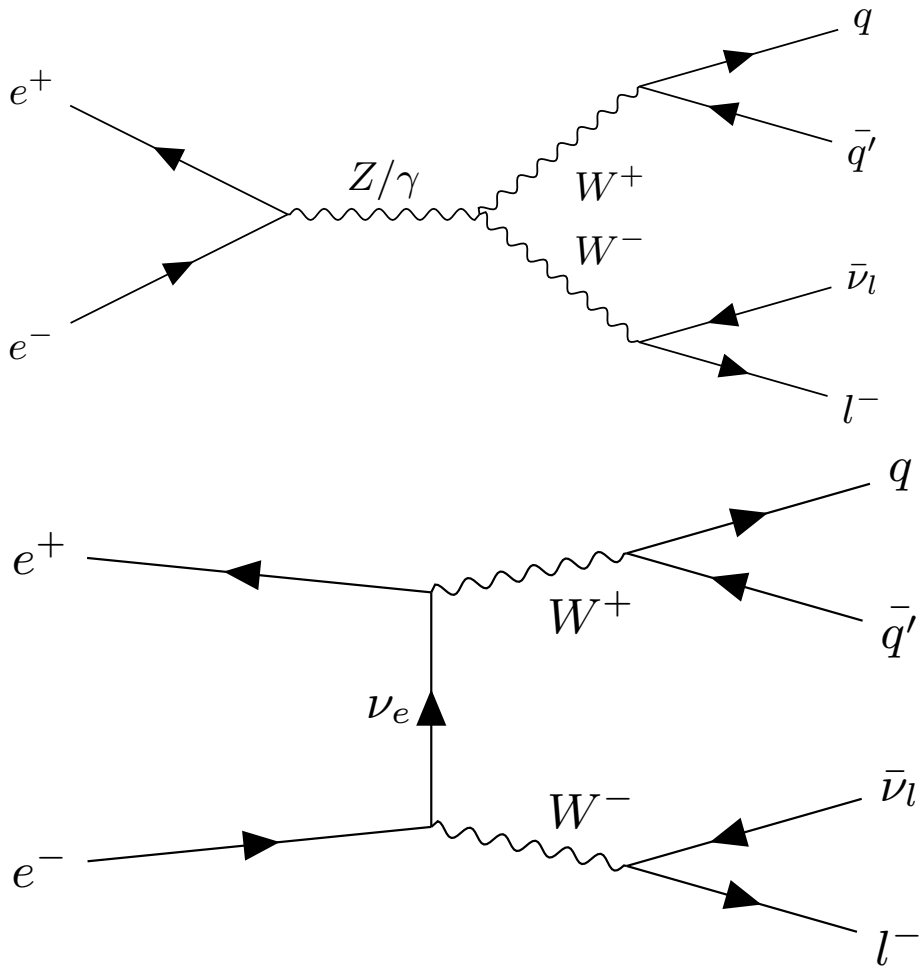


Angle Extractions Angle definitions

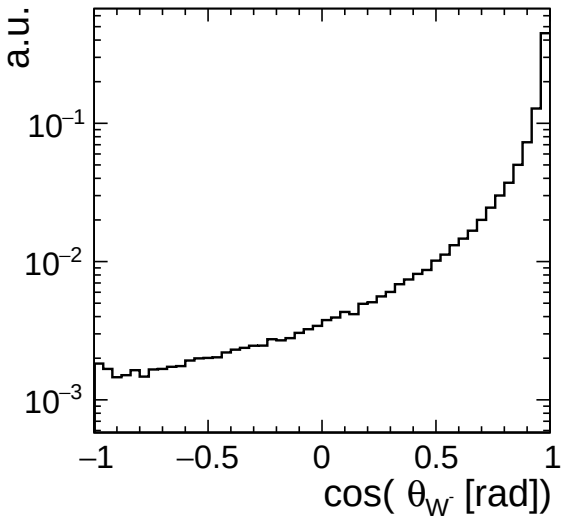
Angles $\theta_{W-}, \theta_l^*, \phi_l^*$

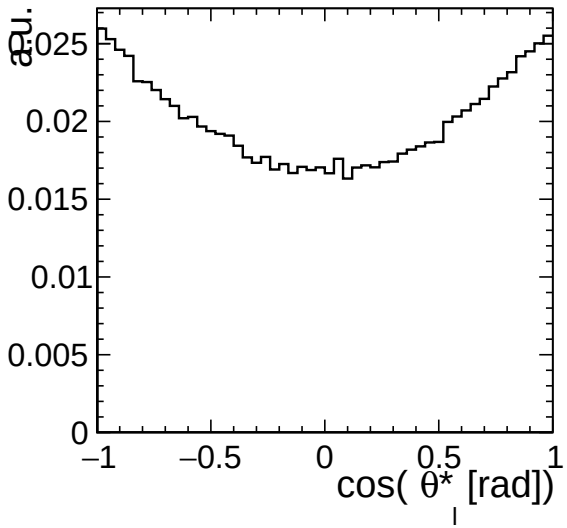


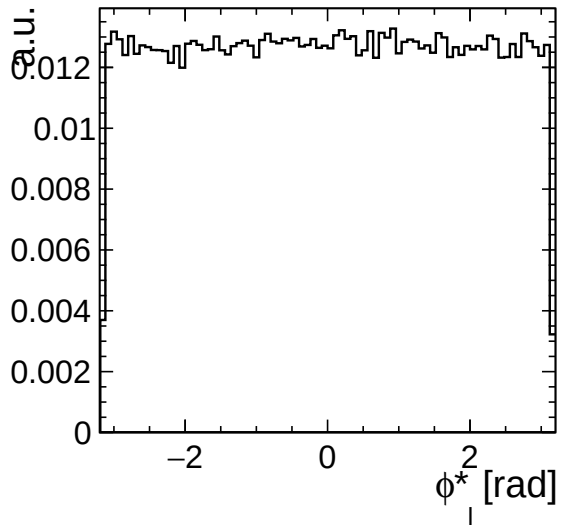
(Modified from Robert Karl 2019)

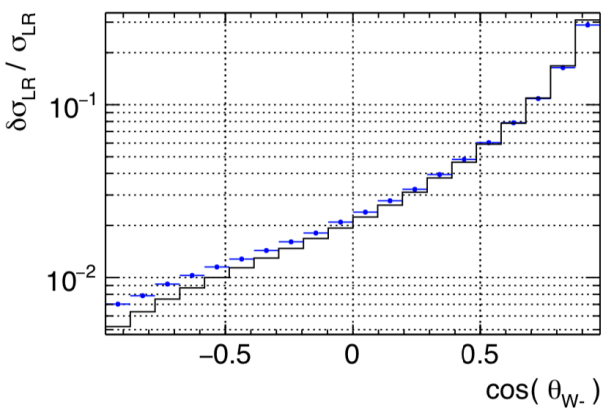


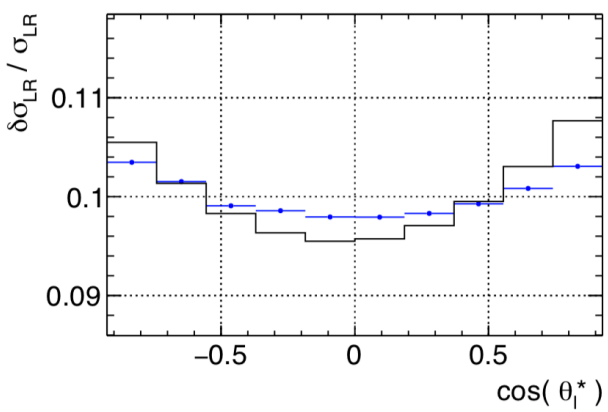
Angle Extractions Consistent with previous results





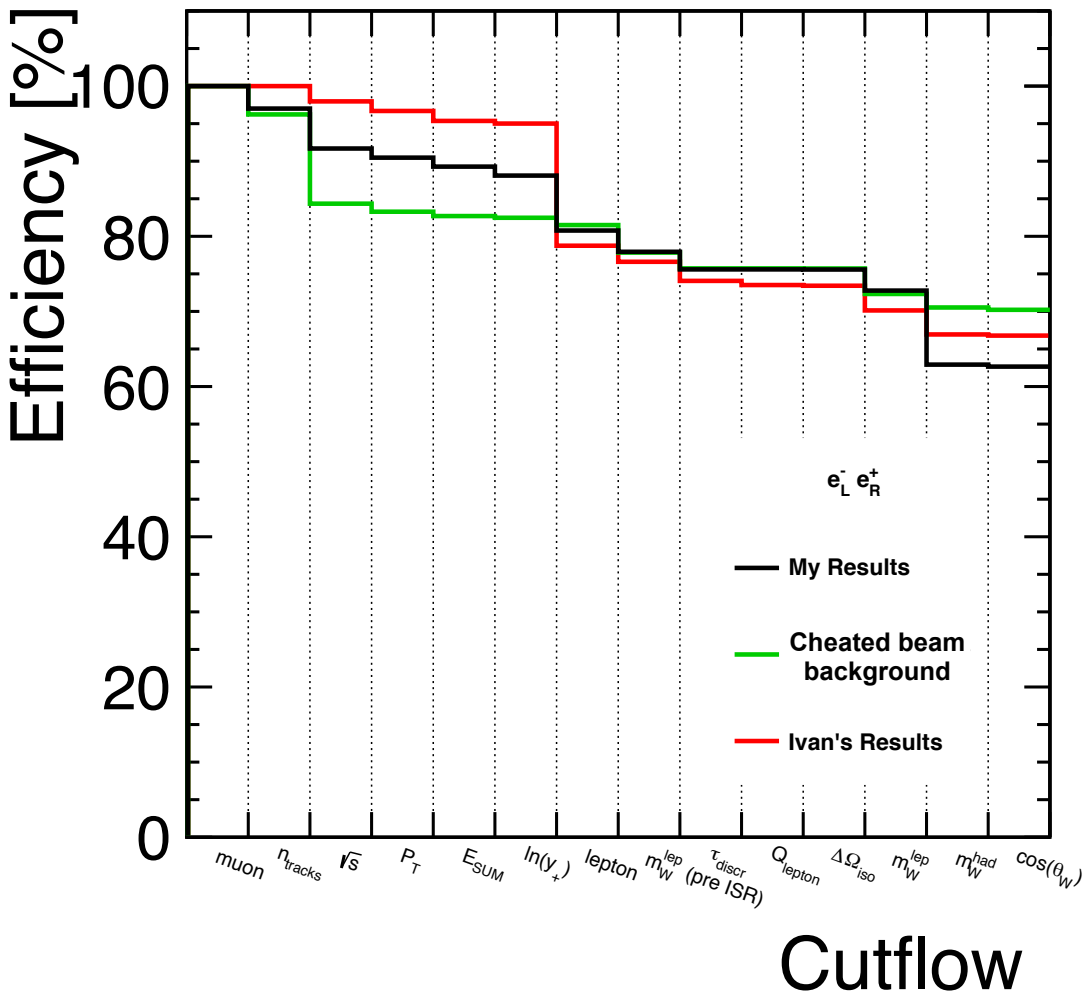




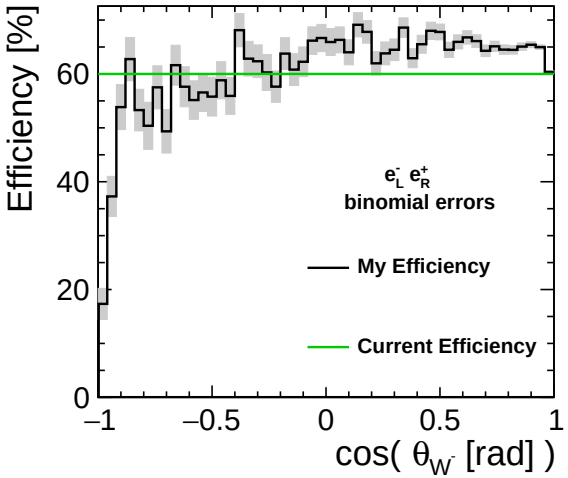


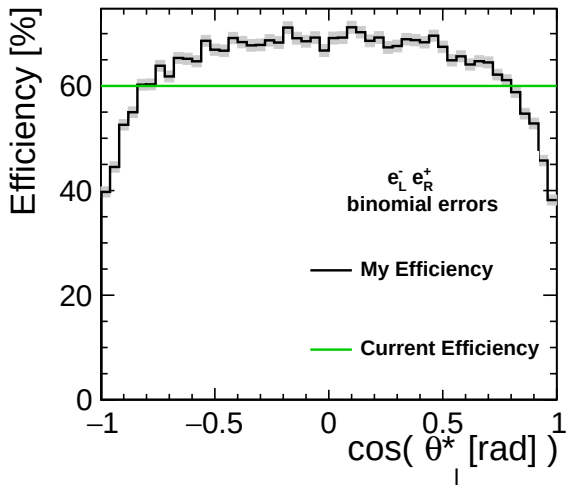
"it was verified that the ϕ^*_l angle distributions are completely flat and yield no information on the chiral structure."

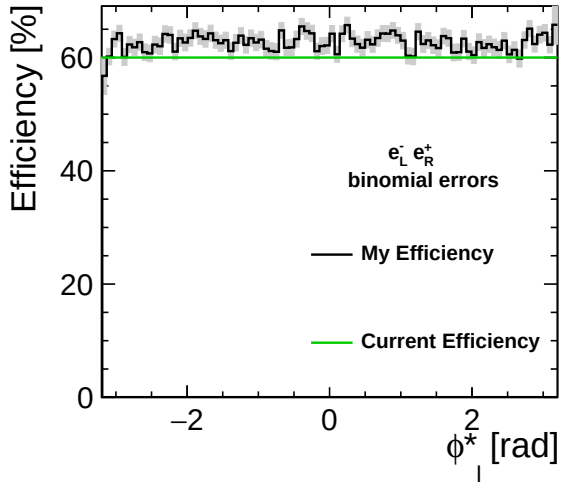
Angle Efficiencies Cut Flow

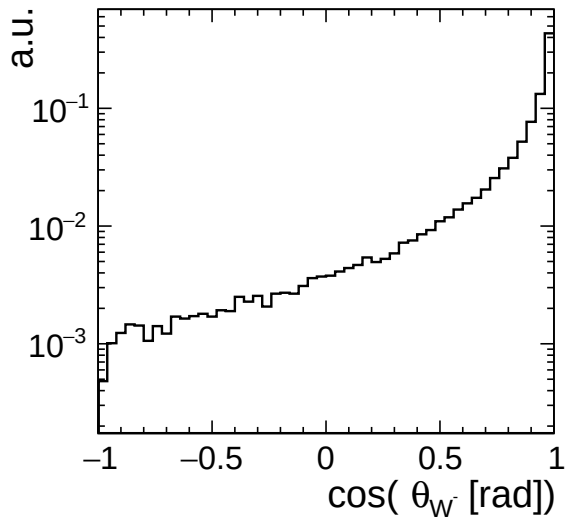


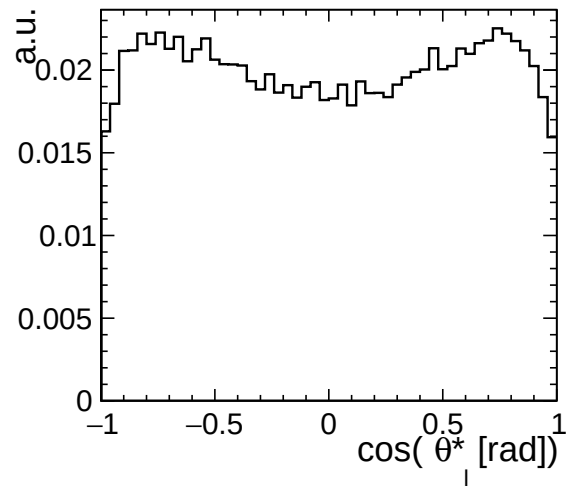
Angle Efficiencies Applying the Cuts

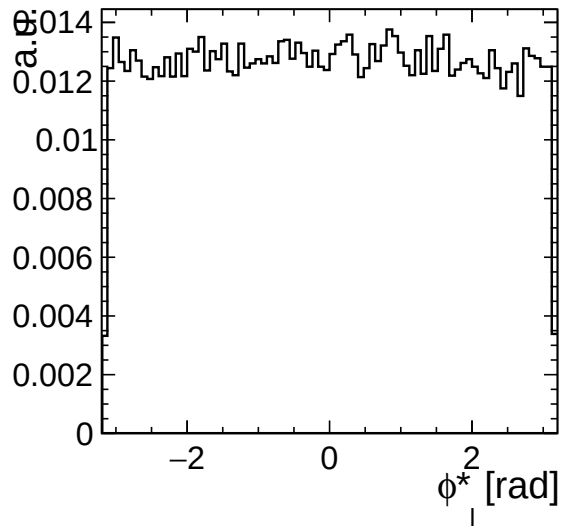




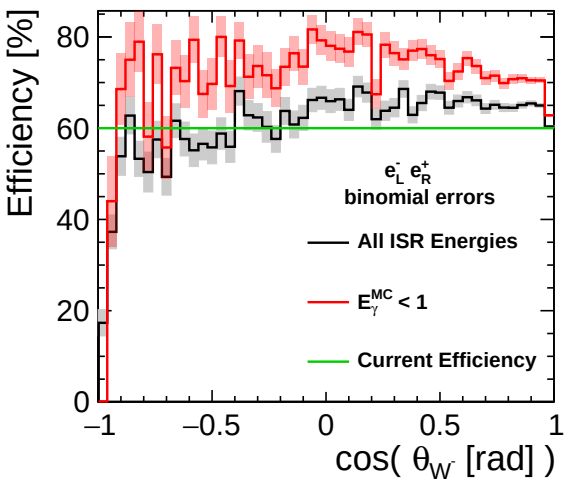


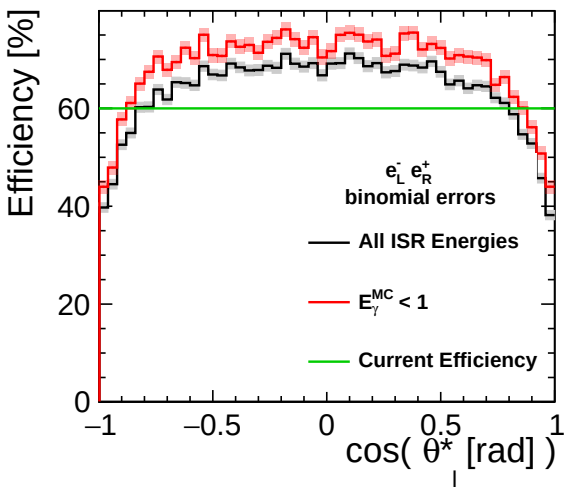


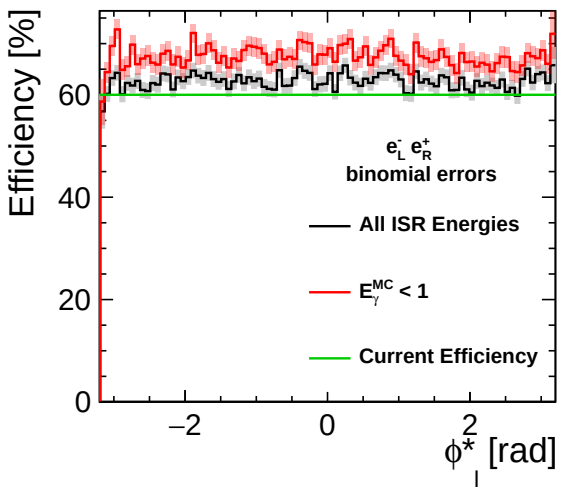




Angle Efficiencies $E_\gamma < 1$ GeV







Back Up Slides Cut Flow table

Order	Cut description	Efficiency [%]			
		My Results			Ivan's Results
		n = 2129	n = 99419		n = 107233
			no cheat	cheat	
0	muon signal	100.00	100.00	100.00	100.00
1	track multiplicity $n_{tracks} \geq 10$	97.13	97.01	96.23	99.996
2	center of mass energy $\sqrt{s} > 100$ GeV	92.29	91.69	84.35	97.96
3	total transverse momentum $P_T > 5$ GeV	91.16	90.47	83.28	96.69
4	total energy $E_{SUM} < 500$ GeV	89.66	89.28	82.70	95.36
5	$\ln(y_+) \in [-12, -3]$ (*)	88.69	88.08	82.47	95.01
6	1 lepton found (*)	80.65	80.77	81.50	78.75
7	pre ISR correction $m_W^{lep} \in [20, 250]$ GeV	78.23	77.94	77.84	76.61
8	tau discrimination	76.05	75.60	75.73	74.07
9	charged lepton (*)	76.05	75.60	75.73	73.51
10	isolation variable $\Delta\Omega_{iso} > 0.5$	76.01	75.58	75.72	73.42
11	post ISR correction $m_W^{lep} \in [40, 120]$ GeV	72.90	72.77	72.33	70.13
12	post ISR correction $m_W^{had} \in [40, 120]$ GeV	63.21	62.92	70.52	66.93
13	$\cos\theta_W > -0.95$	63.02	62.65	70.21	66.78

Back Up Slides Cut definitions

- $\Delta\Omega_{iso}$ defined as,

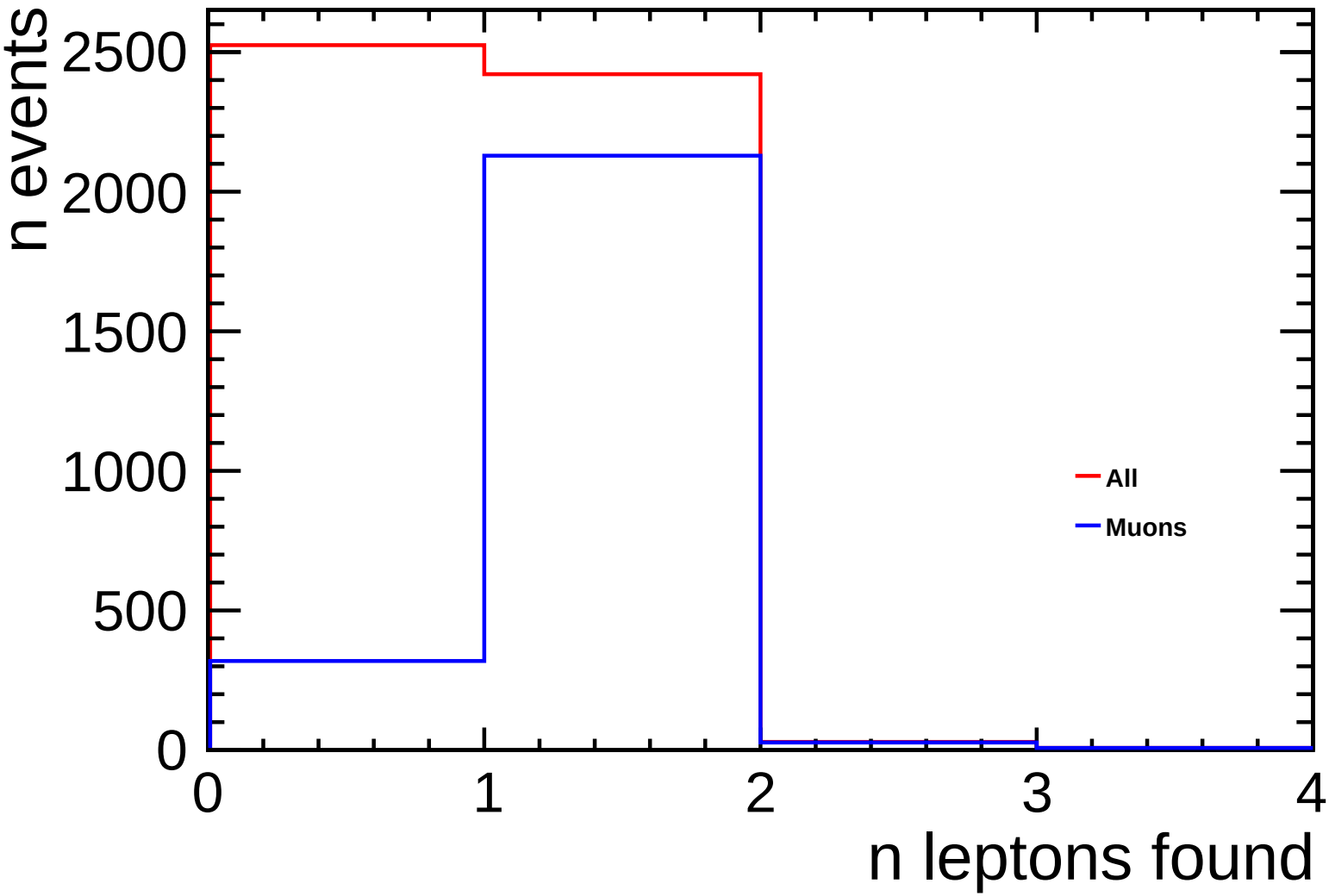
$$(\phi_{lep} - \phi_{had}) < \pi \rightarrow \Delta\Omega_{iso} = \sqrt{(\theta_{lep} - \theta_{had})^2 + (\phi_{lep} - \phi_{had})^2} \tag{1}$$

$$(\phi_{lep} - \phi_{had}) \geq \pi \rightarrow \Delta\Omega_{iso} = \sqrt{(\theta_{lep} - \theta_{had})^2 + (2\pi - |\phi_{lep} - \phi_{had}|)^2}\,. \tag{2}$$

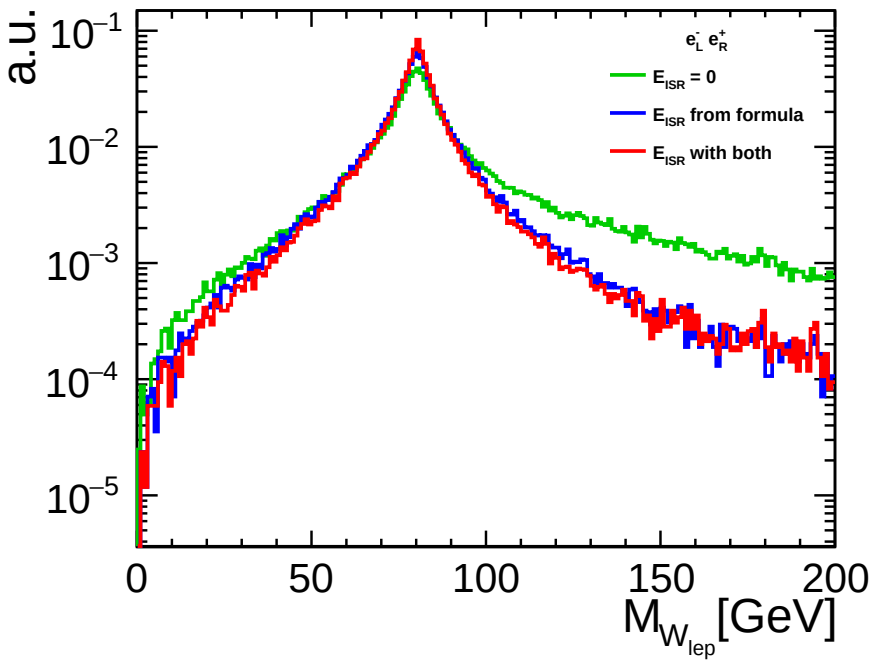
- τ_{discr} defined by

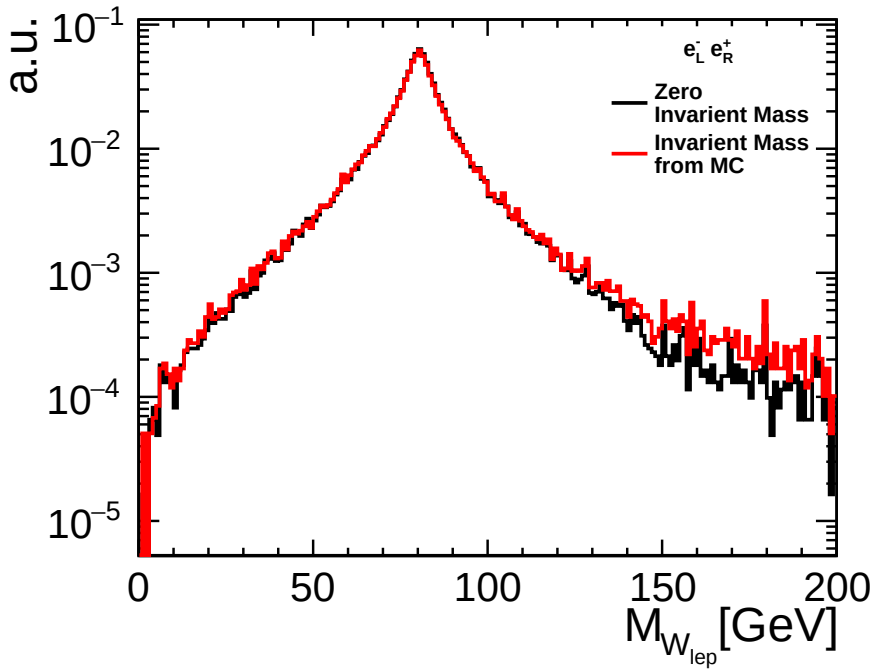
$$\tau_{discr} = \left(\frac{2E_{lep}}{\sqrt{s}}\right)^2 + \left(\frac{m_W^{lep}}{m_W^{true}}\right)^2 \tag{3}$$

Back Up Slides Number of Isolated leptons found

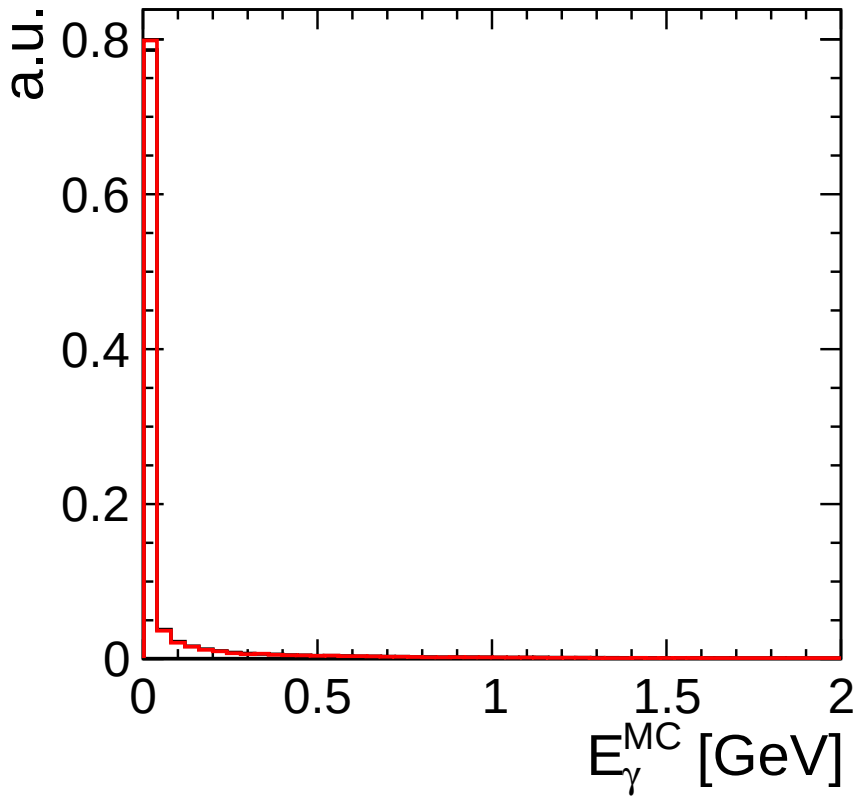


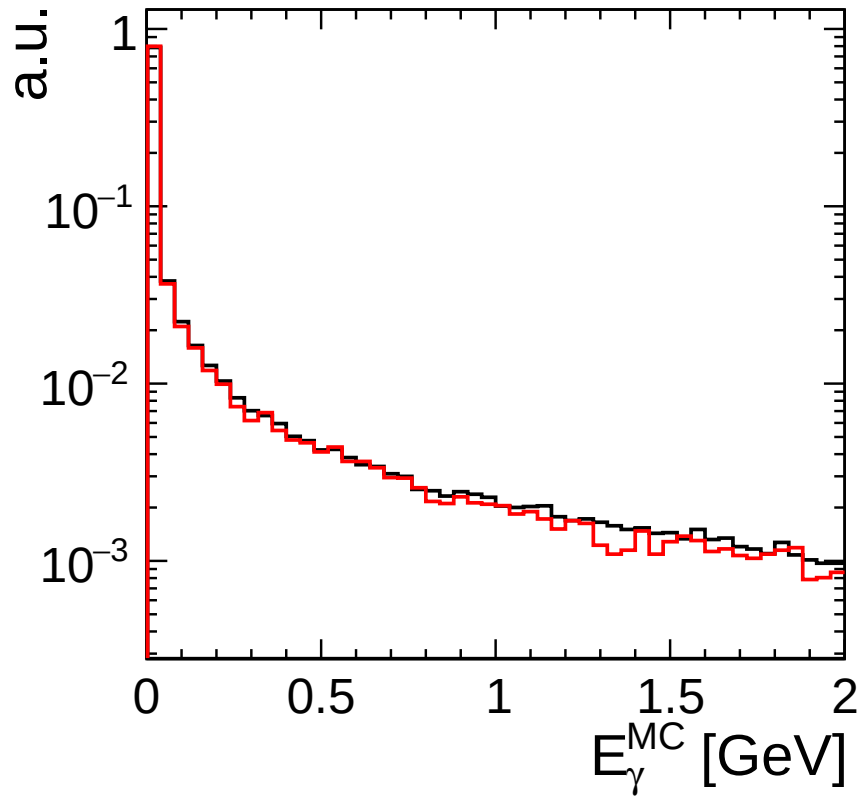
Back Up Slides Logarithmic mass plots





Back Up Slides MC ISR invariant mass

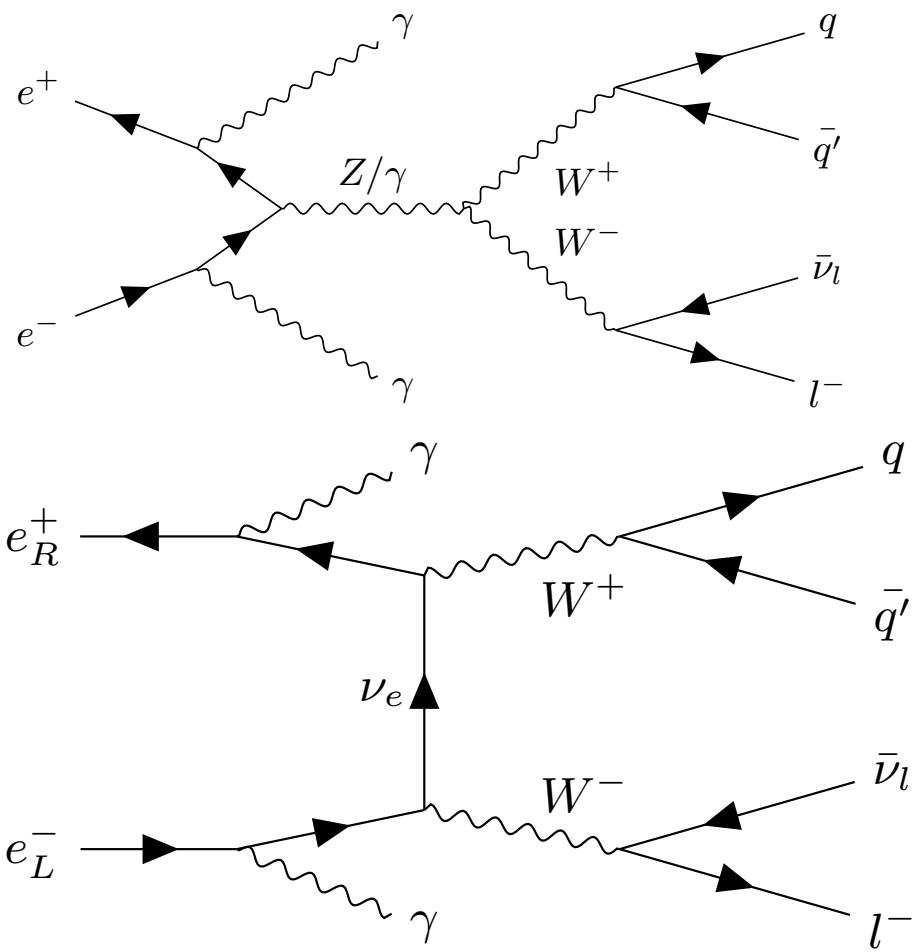




Back Up Slides Negative Energy

$$E_\gamma = \frac{(500 - E)^2 - p^2}{1000 - 2E \mp 2p_z}$$

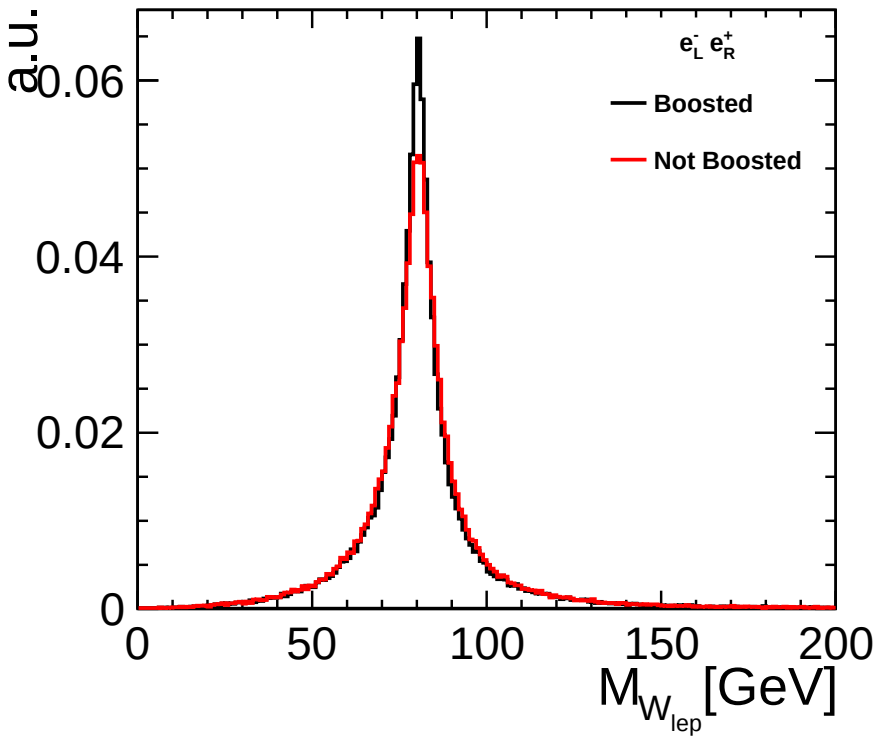
- $E_\gamma < 0$ in ~20% of events
- $m^2_{inv} < 0$



Back Up Slides Lortenz boost

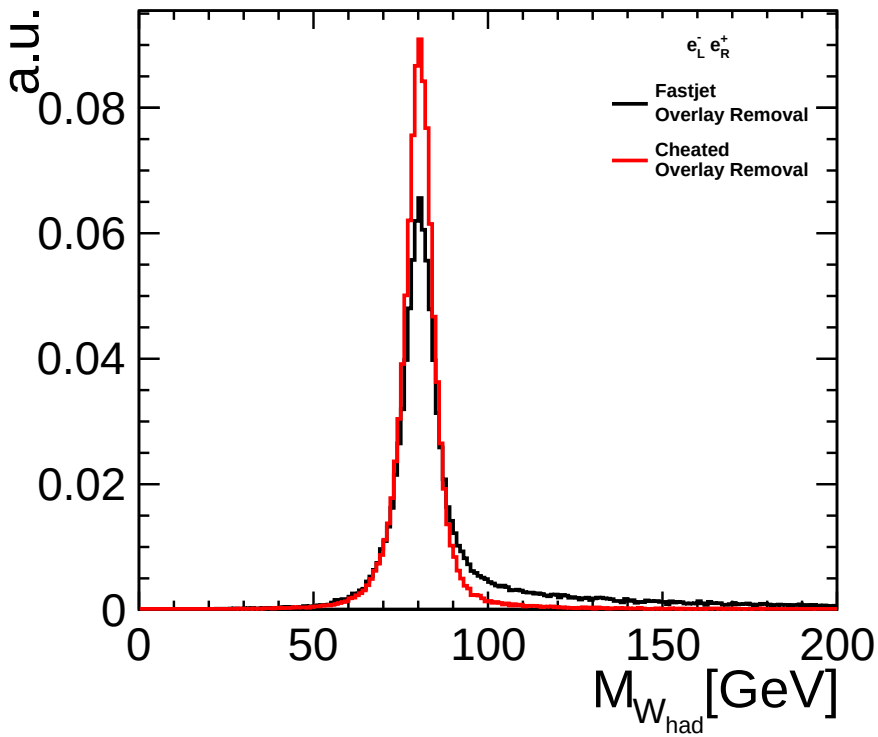
- The $e^- e^+$ collision is **not in the center of mass frame**

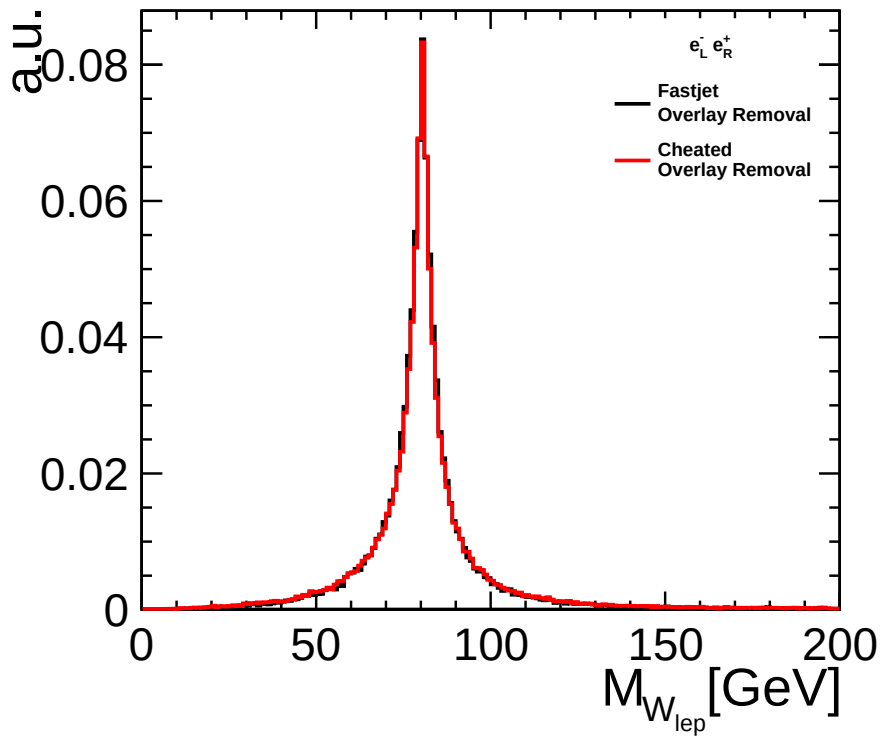
$$p^\mu = (500 \sin(\frac{0.014}{2}), 0, 0, 500)\, GeV. \tag{4}$$



Back Up Slides Beam background cheating

- Try **cheat beam background** using TrueJet





Back Up Slides ISR invarient mass

- Invarient mass of the neutrino and ISR photon is nolonger assumed zero.

Full energy equation

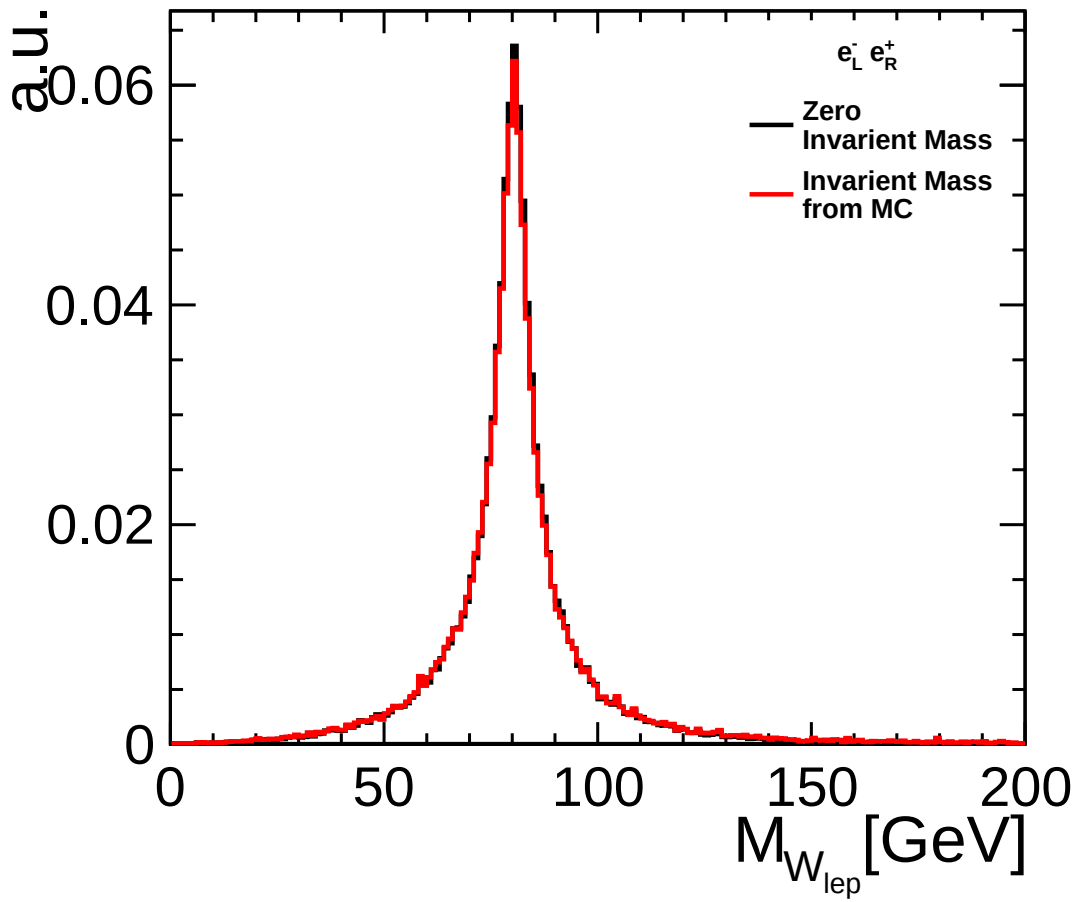
$$E_\gamma = \frac{\lambda(500 - E) \pm p_z \sqrt{\lambda^2 - [(500 - E)^2 - p_z^2]m_\gamma^2}}{(500 - E)^2 - p_z^2} \tag{5}$$

Where for convenience I have defined **lambda**,

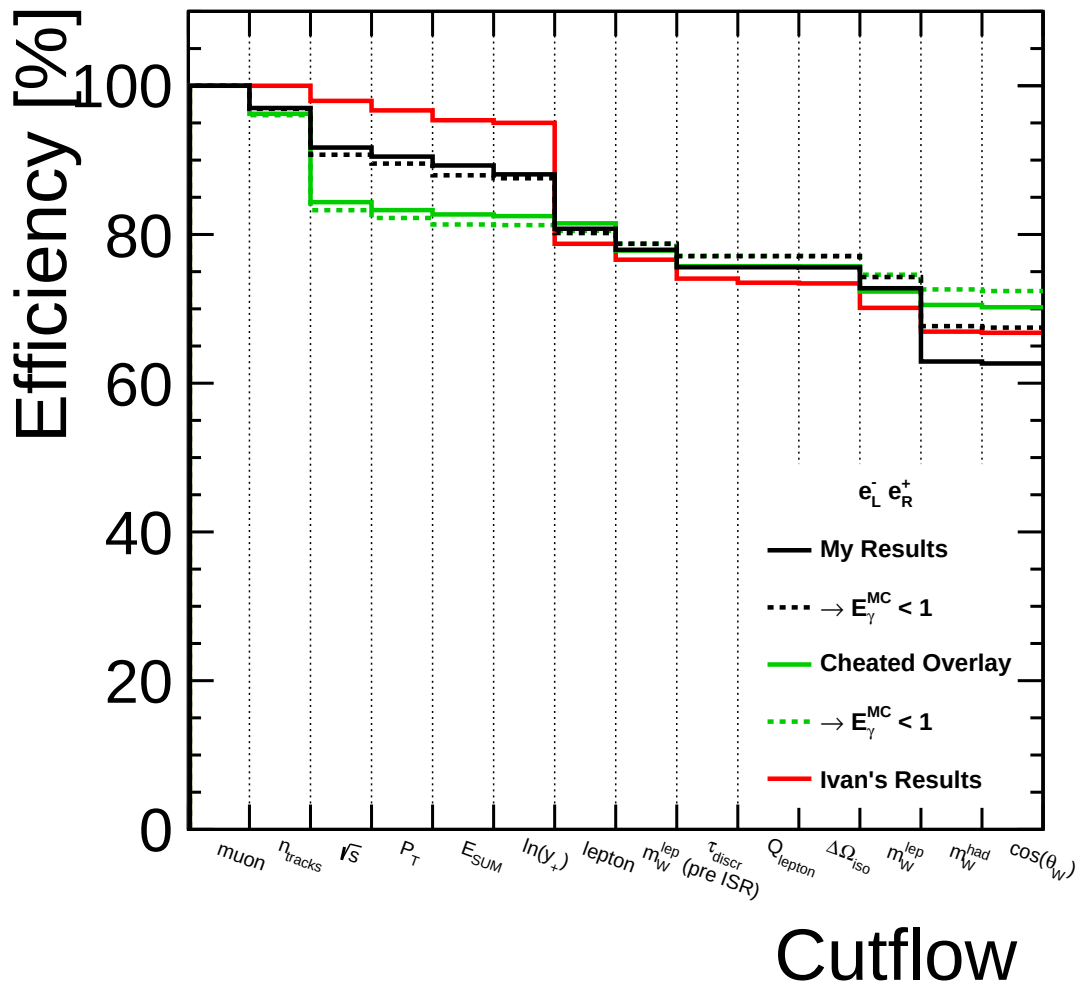
$$\lambda = \frac{1}{2}[(500 - E)^2 - p^2 + m_\gamma^2 - m_\nu^2]\,. \tag{6}$$

Back Up Slides ISR invarient mass

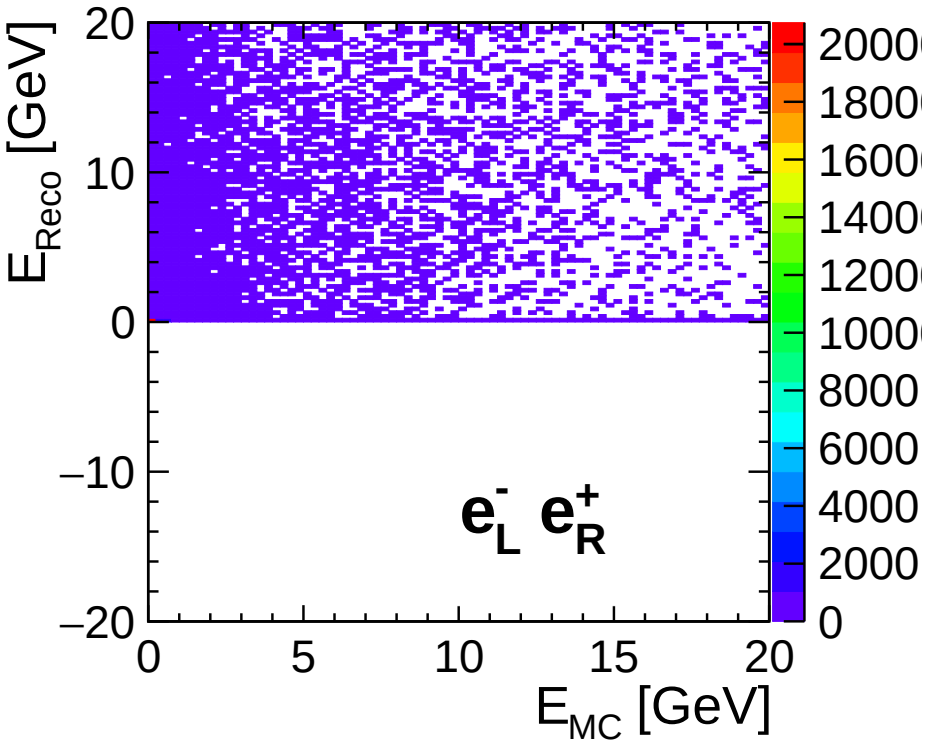
- $m_\nu = 0$ and m_γ from MC

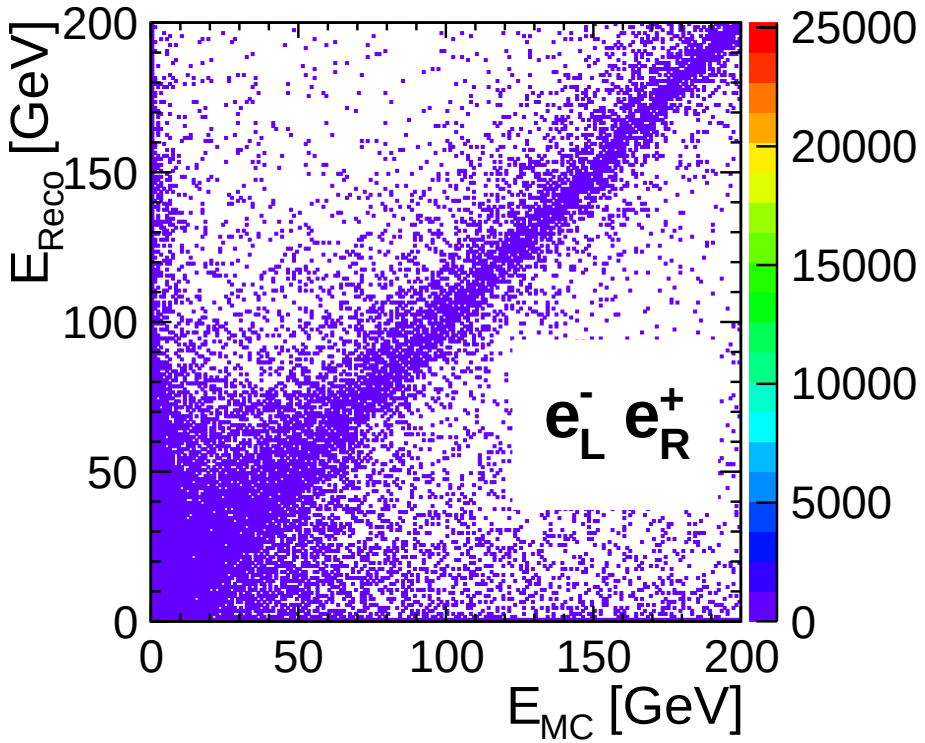


Back Up Slides Cut Flow



Back Up Slides New ISR Energy Plots





Back Up Slides 1 lepton found in 1st cut