Summer Student Report 2019

FLC group presentation

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Presentation Structure

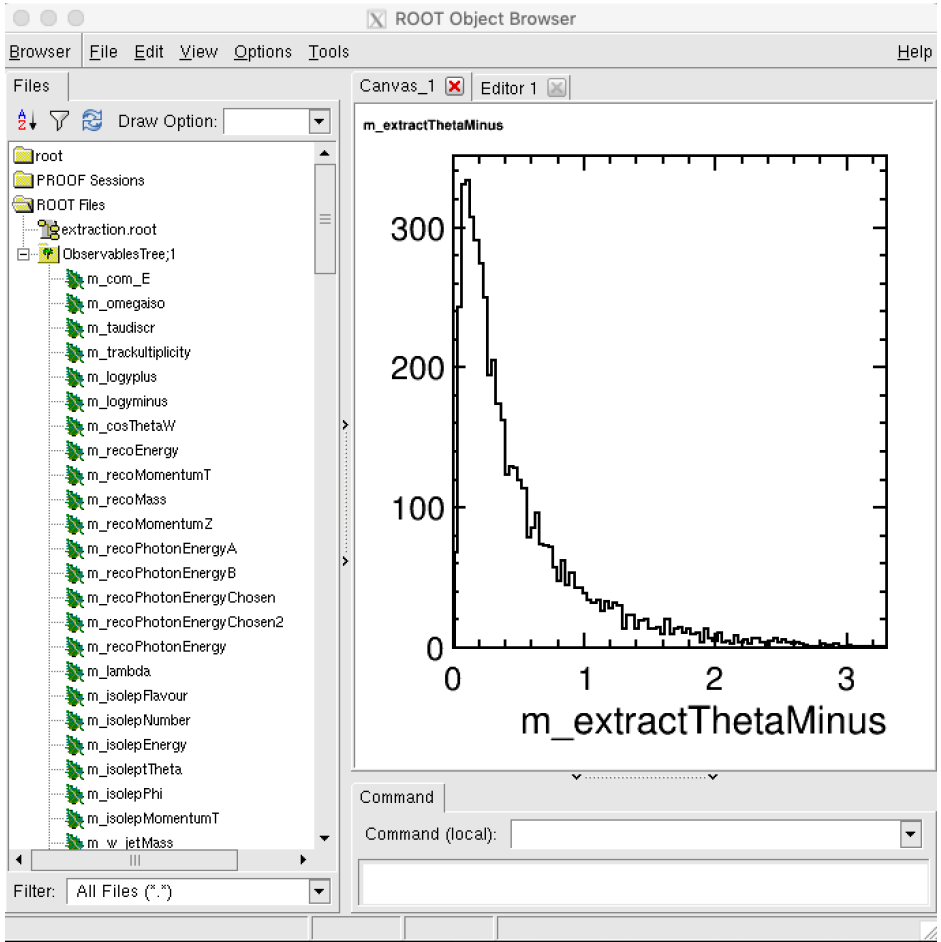
- Motivation
- My Processor
  - Funciton
  - Neutrino and ISR Corrections
  - Angle Extrctions
- Efficiencies
- Conclusions
- Outlook

Motivation Jakobs thesis

I want to extract some angles and do some efficinecies because UPDATE ME

My Processor Overview

- Register Inputs
  - **IsolatedLeptonTagger** - isolated lepton
  - **Fastjet** - quark jets and overlay removal
  - **MCParticle** - hard collision particles
- Analyses Reconstructed particles extracting W bosons 4-momenta
- Analyses MC collection extracting angles
- Outputs a root file with various relevant variables

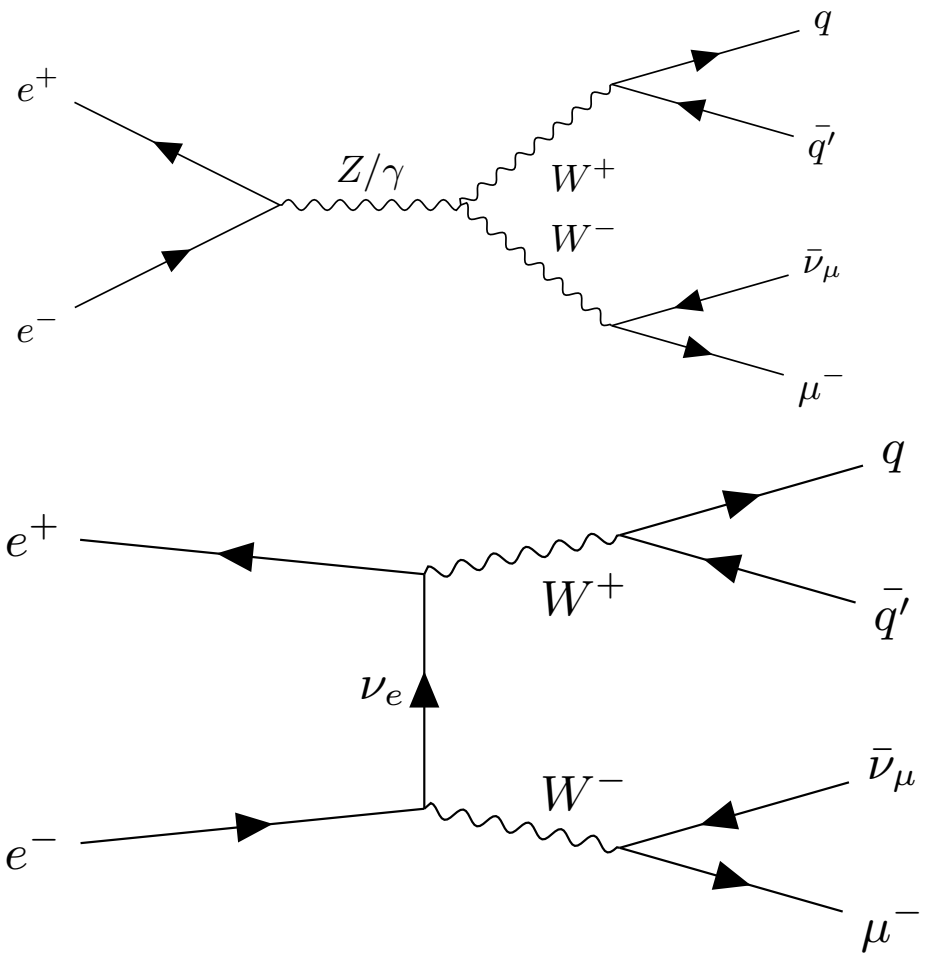


My Processor Neutrino and ISR Corrections

The system

- **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**
  $p^{\mu}_{\nu} = (E_{\gamma}, 0, 0, p_{\gamma})$

c.f The unconventional ordering of the 4-momenta is because that is how TLorentzVector handels 4-vectors



My Processor Neutrino and ISR Corrections

Consider only energy and momentum conservation, where the invarient mass of the neutrino and ISR photon is zero.

Simple energy equation (I. Marchesini ***CITE***)

$$E_\gamma = \frac{(500 - E)^2 - p^2}{1000 - 2E \mp 2p_z} \tag{1}$$

My Processor Neutrino and ISR Corrections

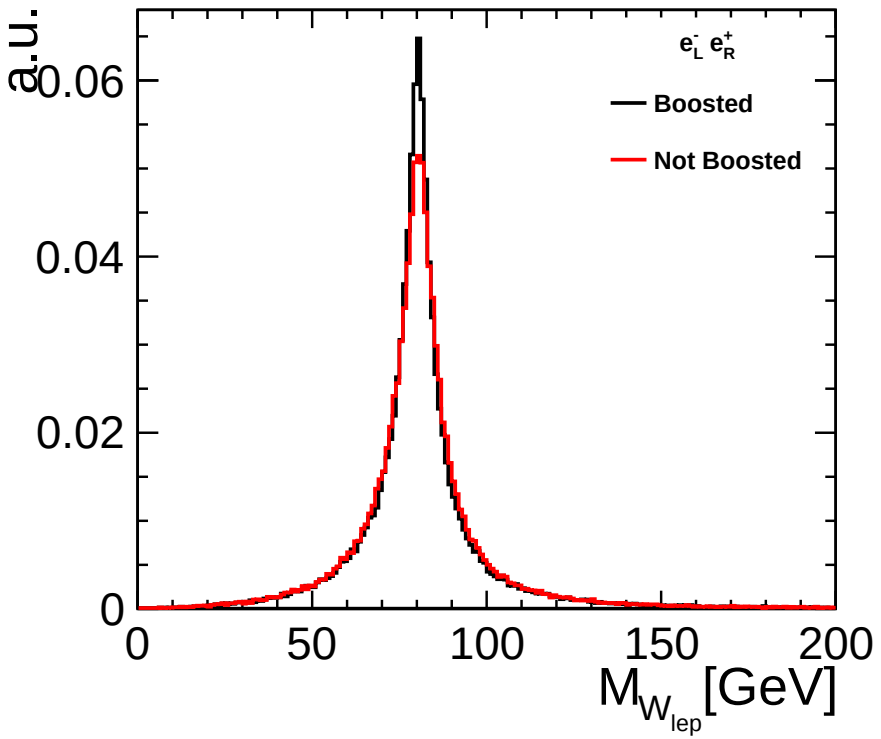
- Negative energies arise!
- It often boils down to negative invisible invarient mass
- This is because of Reconstruction
- Handel carefully in code
- Perhaps energy assumption is invalid
- Perhaps zero invarient mass of photon is invalid
- What else can we check?

My Processor Neutrino and ISR Corrections

- The $e^- e^+$ collision is **not in the center of mass frame**, the inital state has a 4-momentum of,

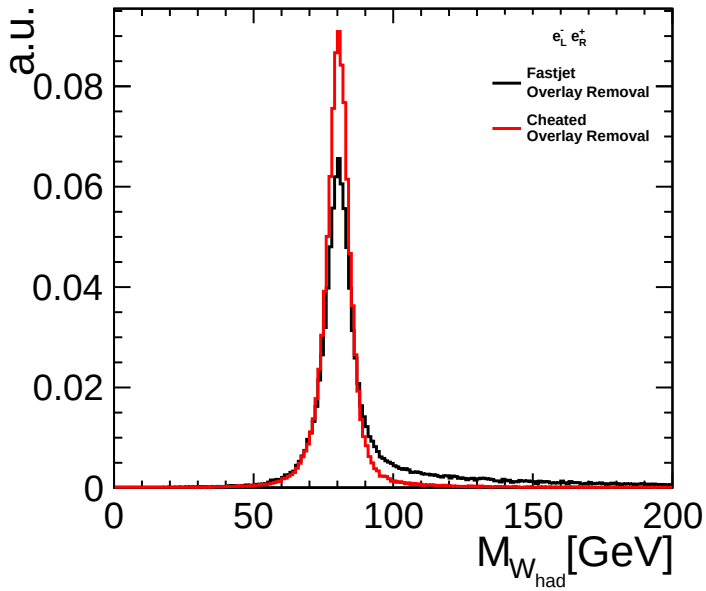
$$p^\mu = (500 \sin(\frac{0.014}{2}), 0, 0, 500)\, GeV. \tag{1}$$

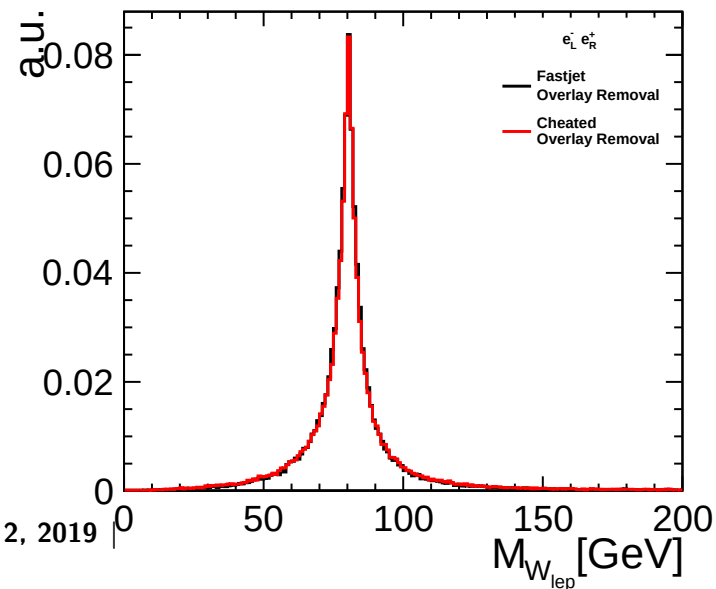
- **Lorentz Boost** into center of mass frame to conduct calculations
- Improvement



My Processor Neutrino and ISR Corrections

- Perhaps the overlay removal processor is not performing properly
- Try **Cheat Overlay** using TJJetOverlayRemoval (Jakob ***CITE***)
- Improves m_W^{had} as expected
- Slightly worsens m_W^{lep}
  $\rightarrow$ statistical fluctuation?
- m_W^{lep} is **not particularly sensitive** to it due to the complicated nature of the E_γ formula





My Processor Neutrino and ISR Corrections

Consider only energy and momentum conservation, where the invarient mass of the neutrino and ISR photon is nolonger assumed zero.

Full energy equation

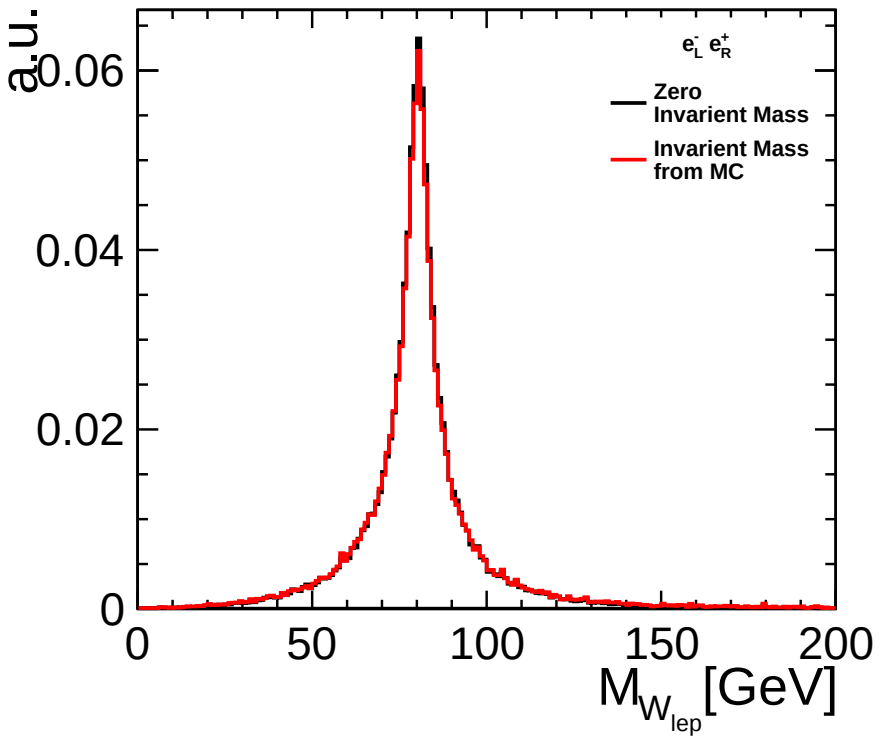
$$E_\gamma = \frac{\lambda(500 - E) \pm p_z \sqrt{\lambda^2 - [(500 - E)^2 - p_z^2]m_\gamma^2}}{(500 - E)^2 - p_z^2} \tag{1}$$

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

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

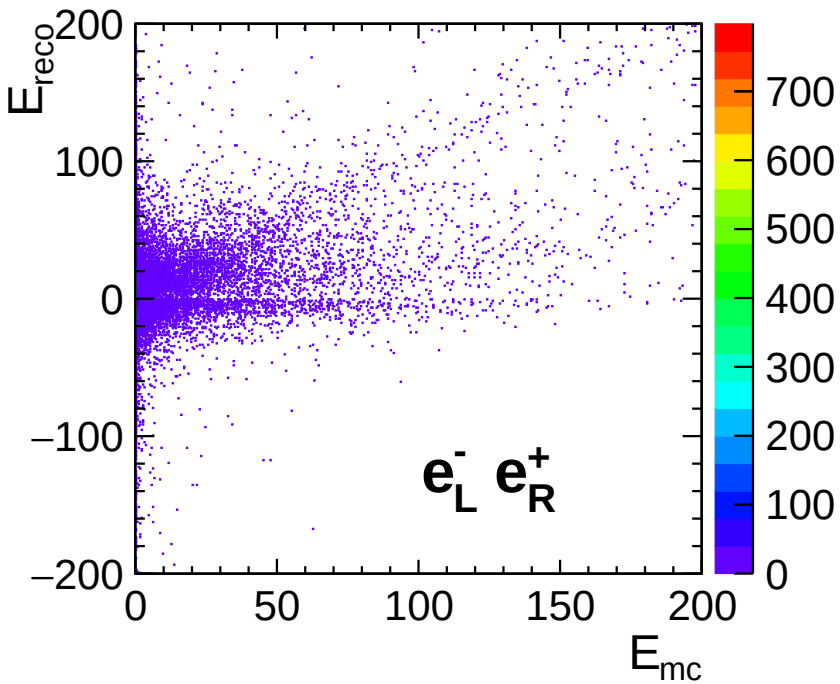
My Processor Neutrino and ISR Corrections

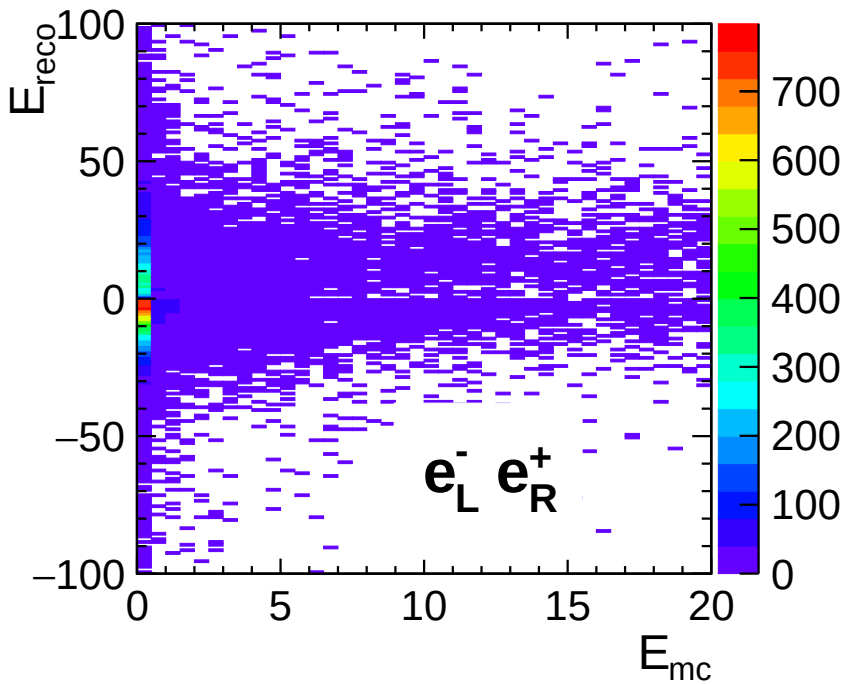
- Using this formula with $m_\nu = 0$ and m_γ extracted from the MonteCarlo collection
- At low statistics there appeard to be a difference but at high statistics it was seen to be negligable
- The reconstruction is not sensitive to the ISR invairent mass



My Processor Neutrino and ISR Corrections

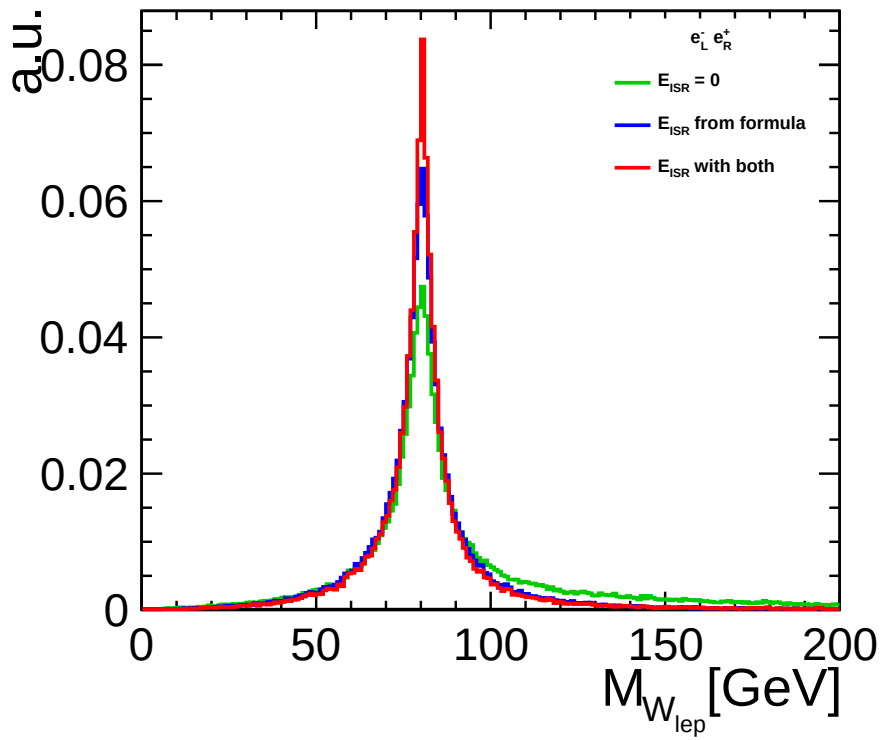
- Add a third option of there being no ISR photon such that $E_\gamma = 0$
- When this option is chosen, the **formula struggles to reconstruct small E_γ values**, so it is an improvement.





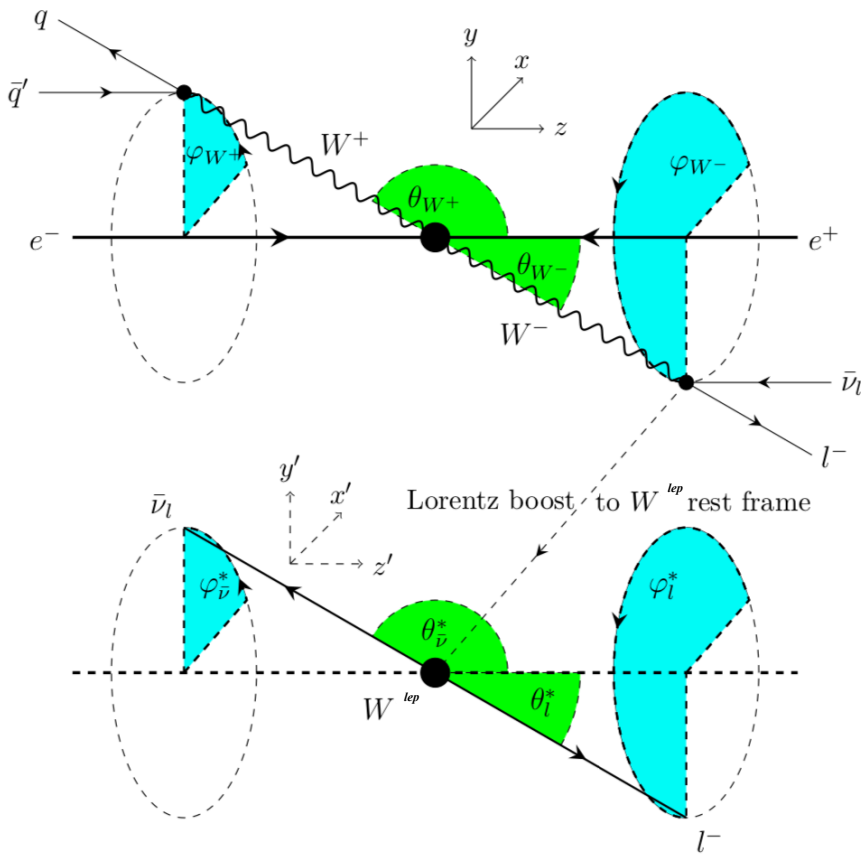
My Processor Neutrino and ISR Corrections

- The E_γ forumula is an improvement on the solution that neglects ISR
- Adding a solution for no ISR improves the estimate again



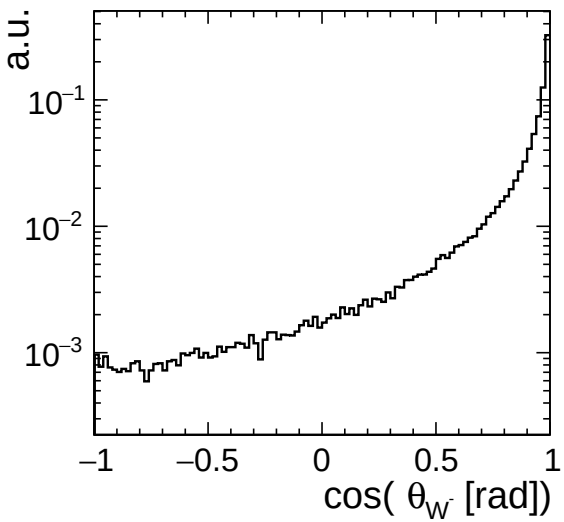
My Processor Angle Extractions

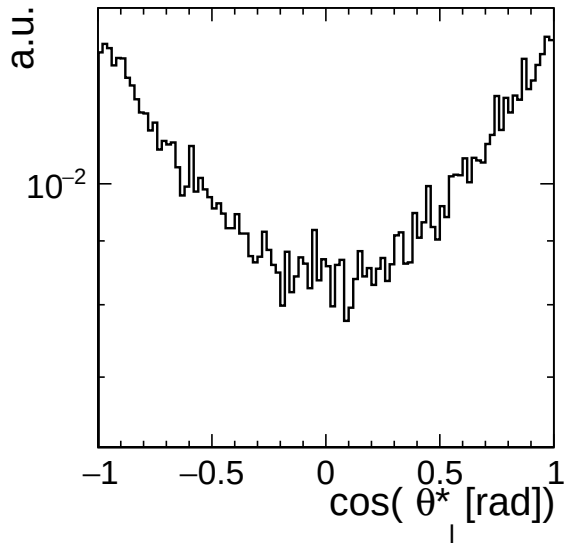
From the MC collection I extracted the appropriate angles $(\theta_{W-}, \theta_l^*, \phi_l^*)$ for Jakob as defined by R.Karl ***CITE*** slightly edited such that we boost into the W^{lep} frame

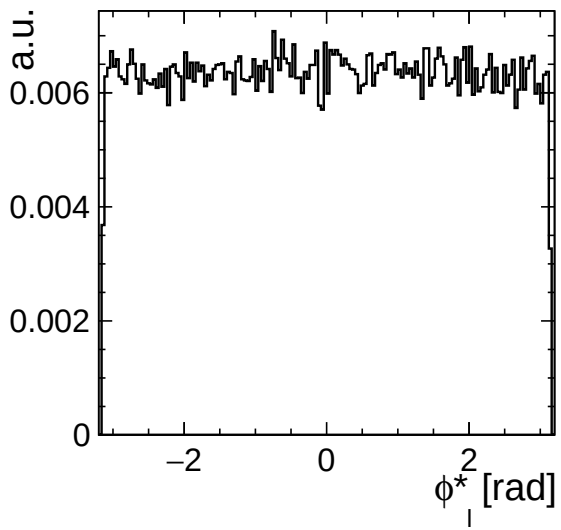


not the W^-

My Processor Angle Extractions



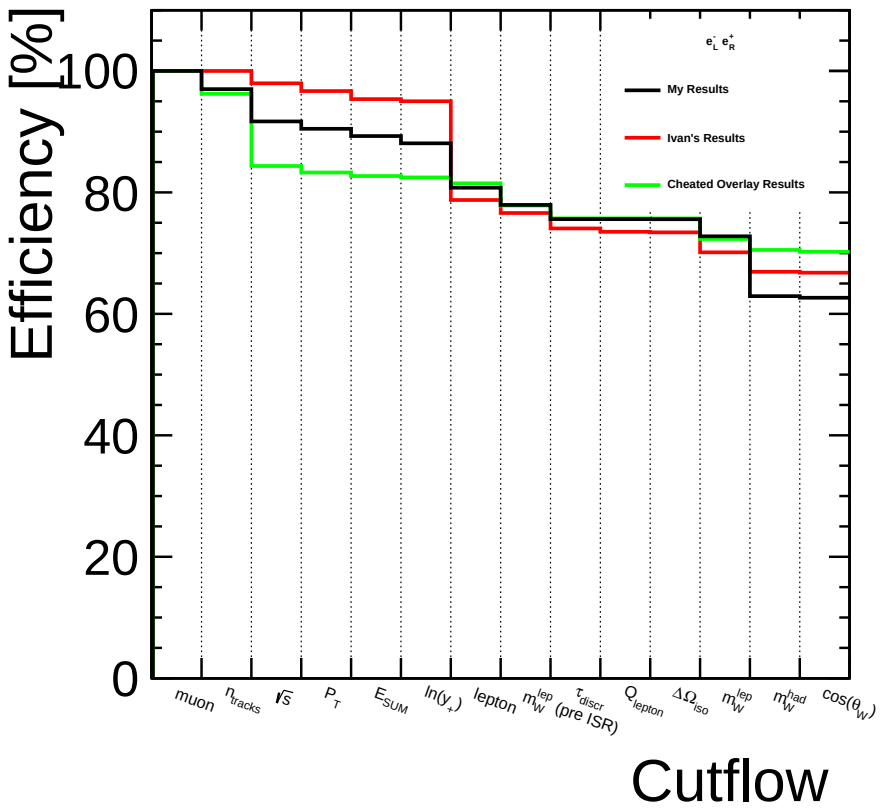




Efficiencies Applying cuts

Table: Selection efficiency of sequantially applied cuts. Where the post ISR correction m_W^{lep} was calculated using all 3 possible E_γ solutions. (*) Means my and Ivan's cuts differ slightly

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



Efficiencies Applying cuts

- track mulitplicity was taken as the number of reconstructed charged particles.
- $\Delta\Omega_{iso}$ defined as,

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

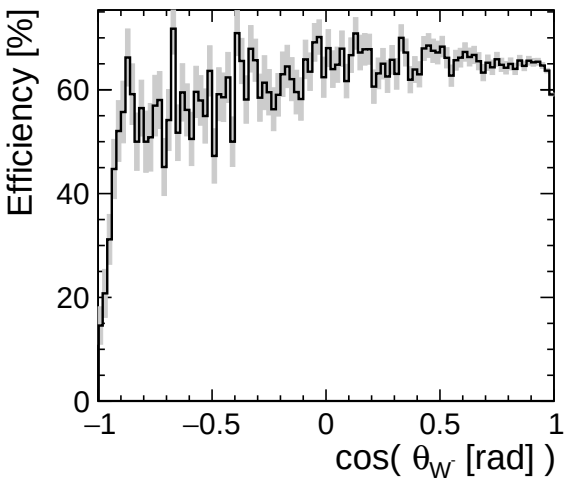
$$(\phi_{lep} - \phi_{had}) \geq \pi \rightarrow \Delta\Omega_{iso} = \sqrt{(\theta_{lep} - \theta_{had})^2 + (2\pi - |\phi_{lep} - \phi_{had}|)^2}\,. \tag{2}$$

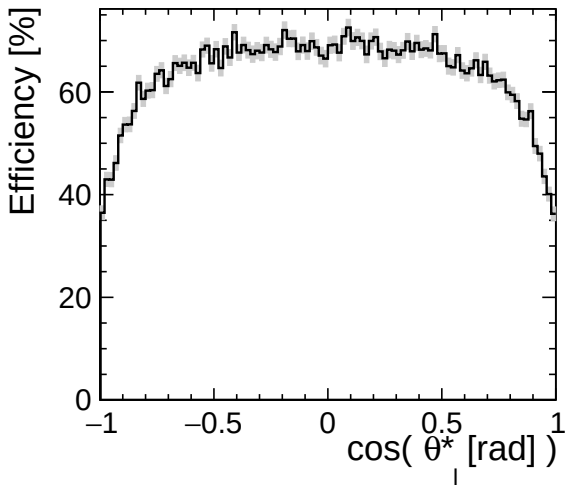
- τ_{discr} defined by

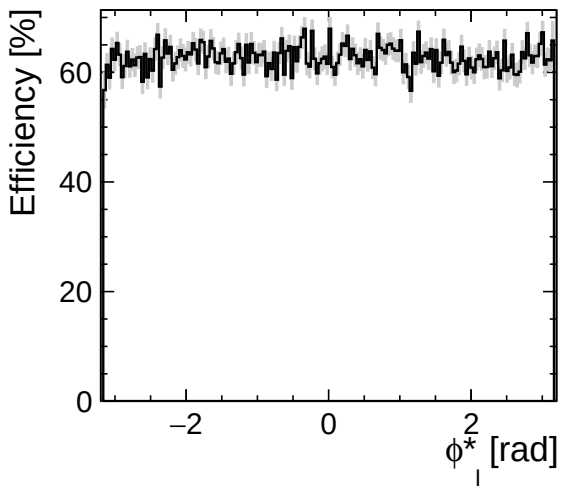
$$\tau_{discr} = \left(\frac{2E_{lep}}{\sqrt{s}}\right)^2 + \left(\frac{m_W^{lep}}{m_W^{true}}\right)^2 \tag{3}$$

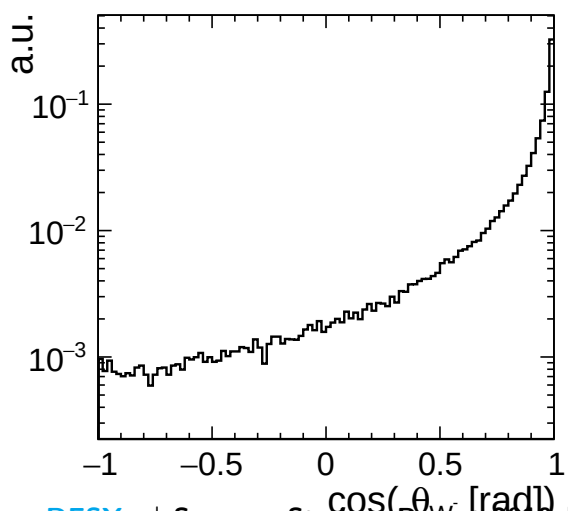
Efficiencies Applying cuts

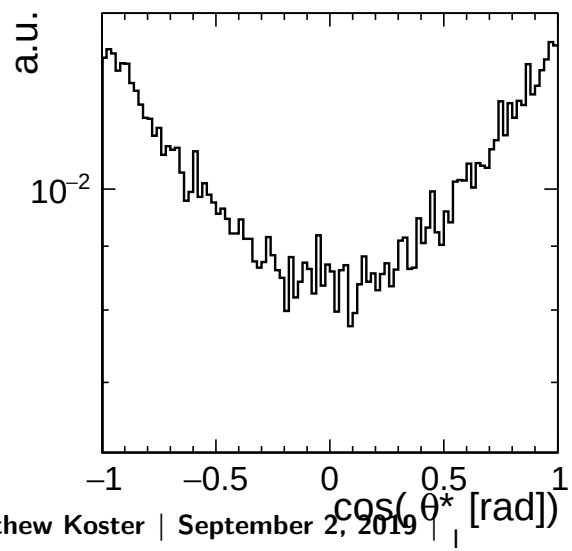
The selection efficiencies of the extracted angles after applying all the previous cuts (binomal errors), with the angular distribution below for reference

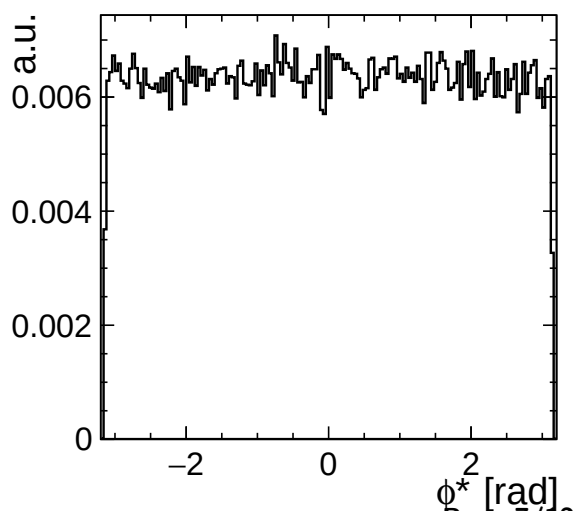








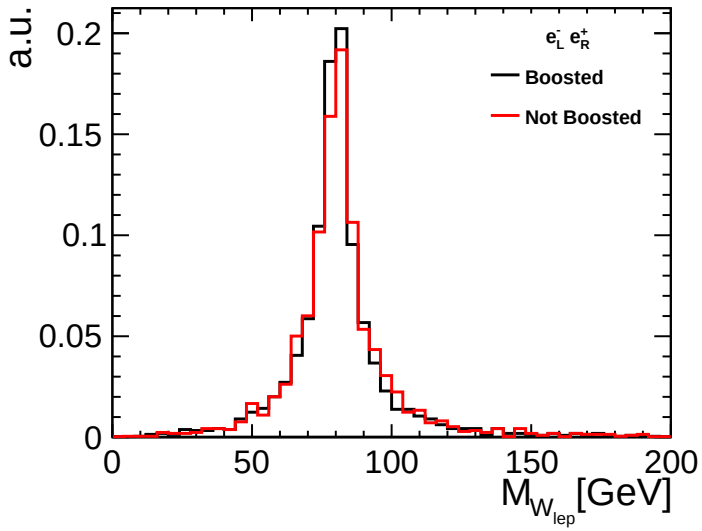


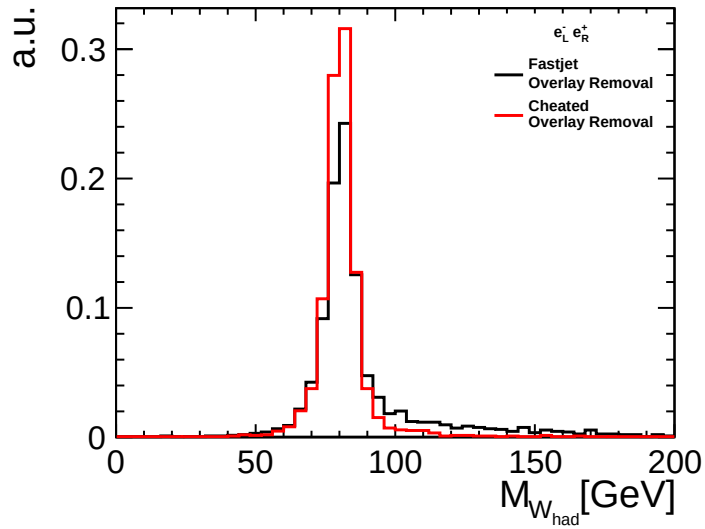


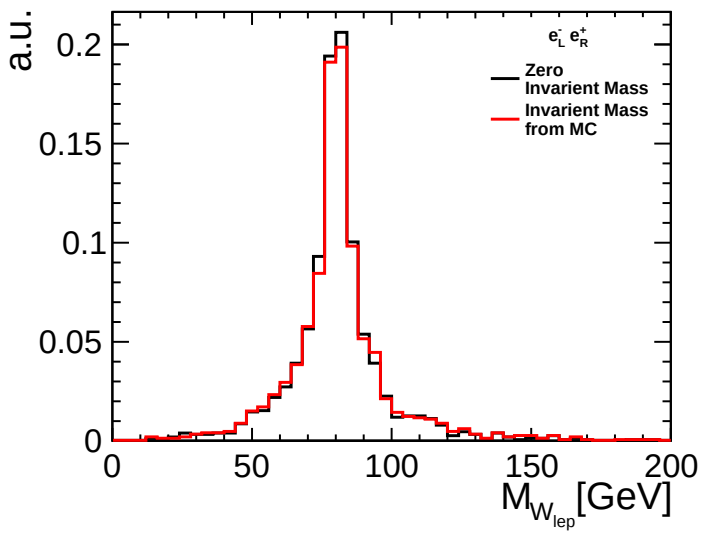
Conclusions do tacheyons exist?

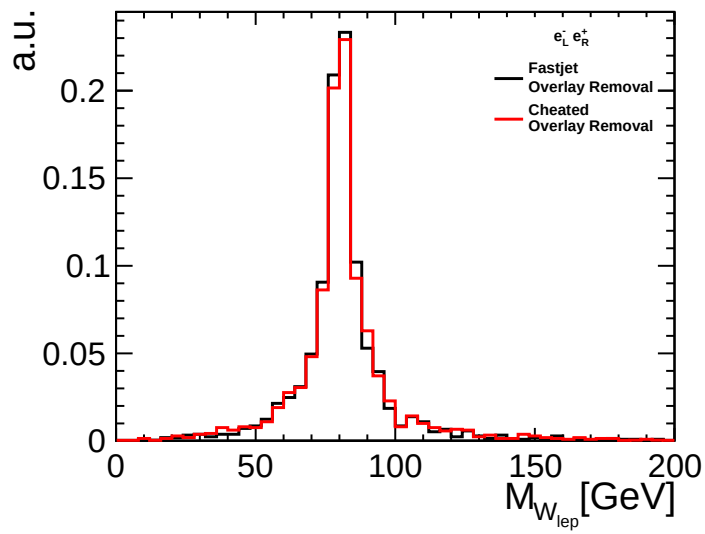
Outlook do things

Back Up Slides Low Statistics









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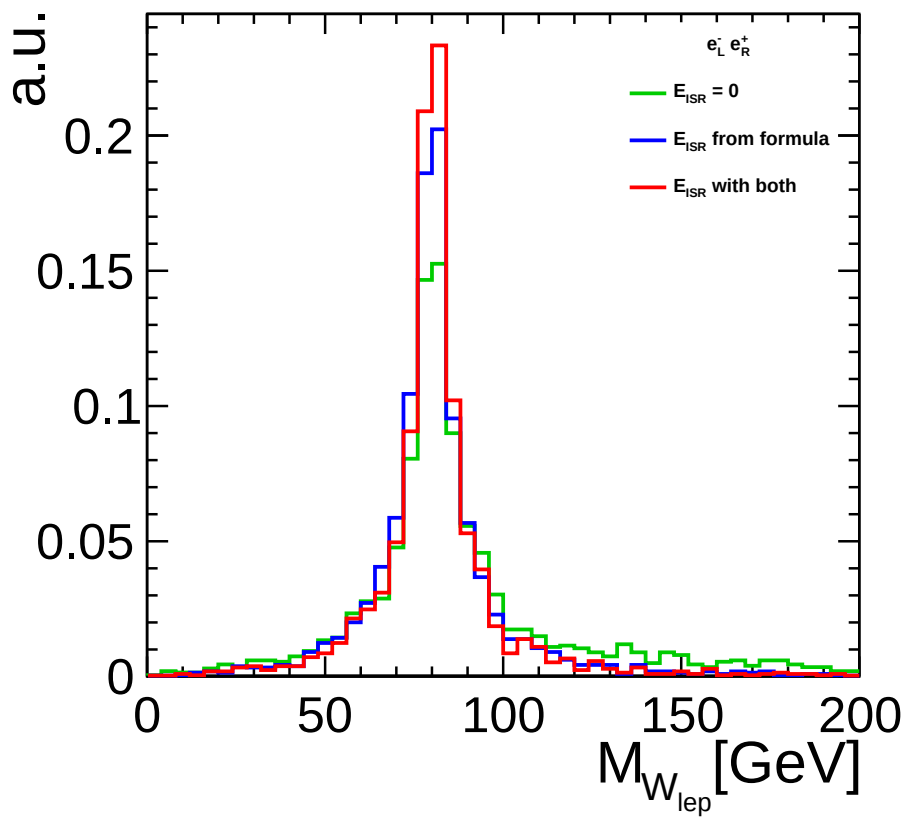

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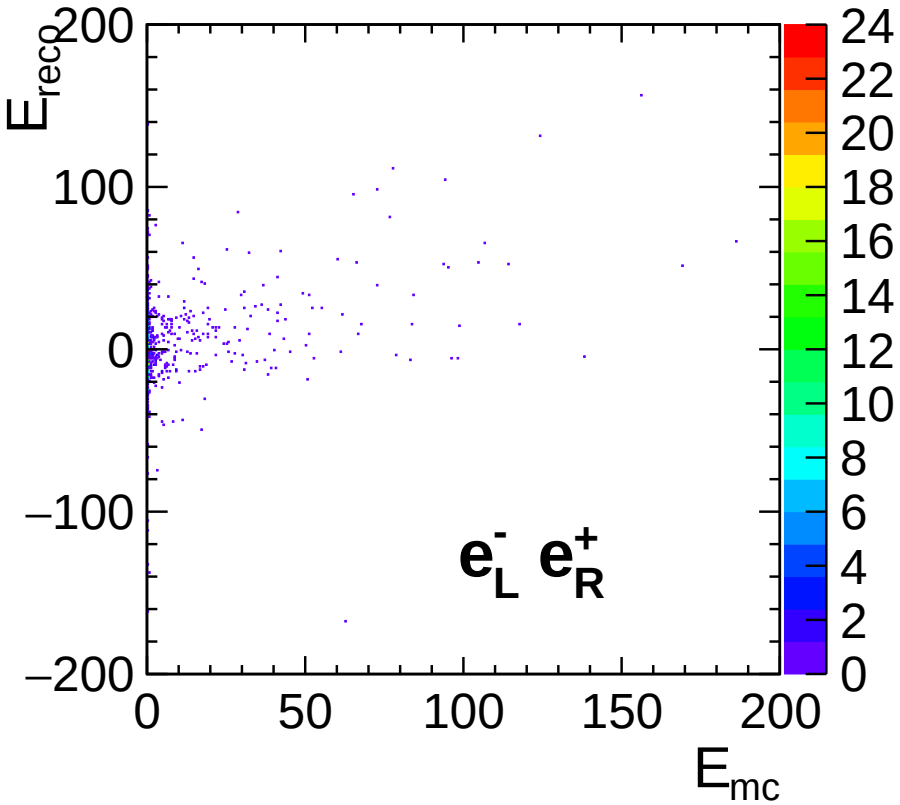
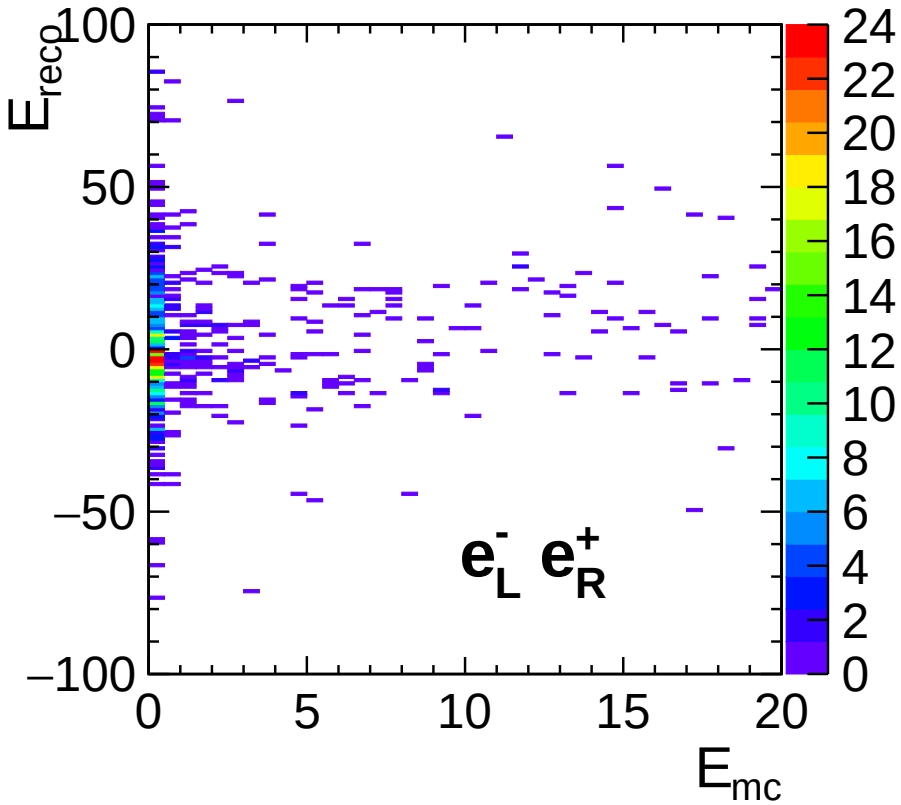
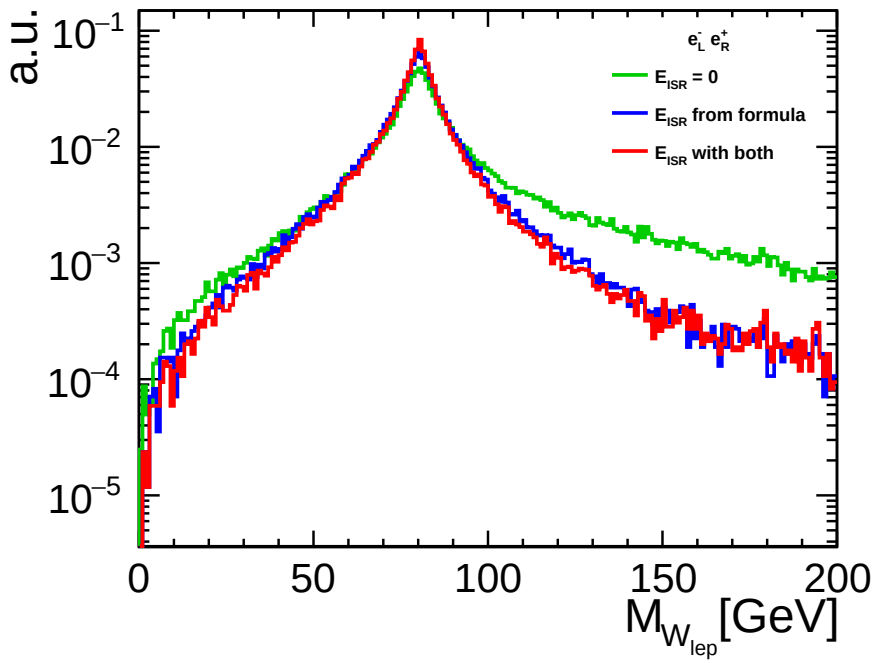
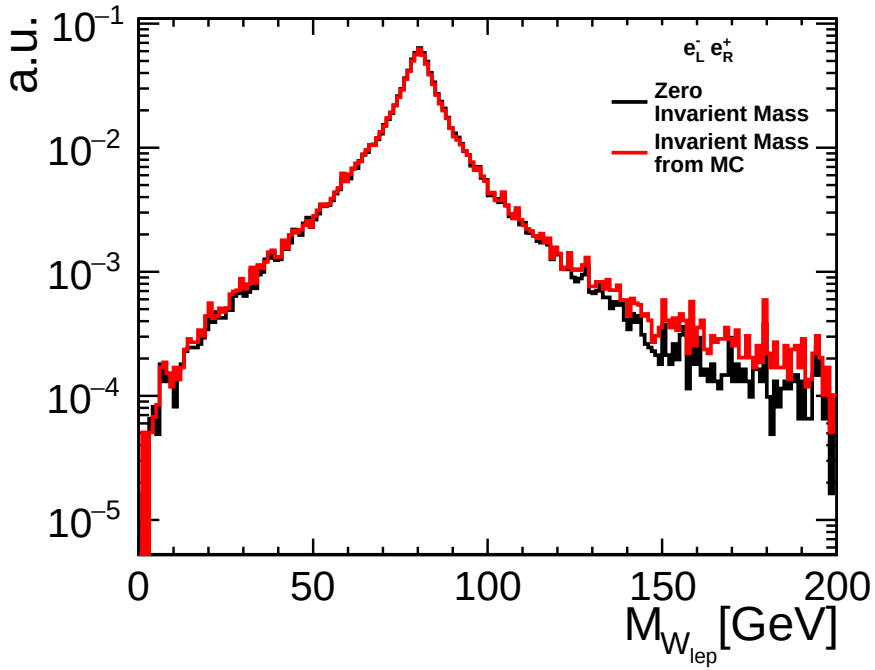


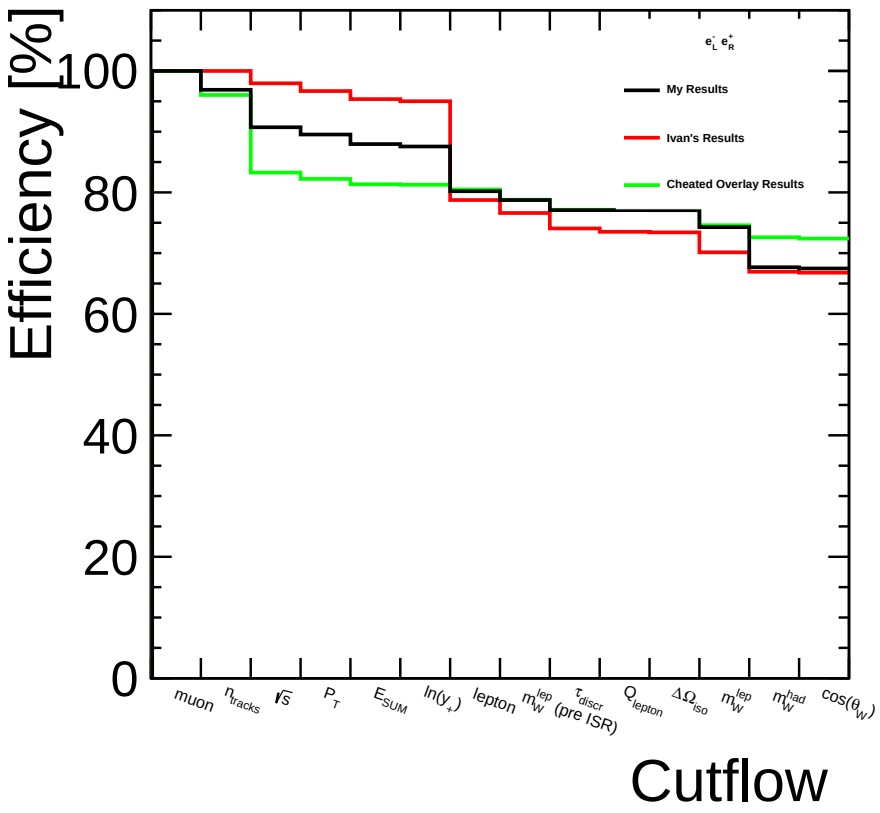


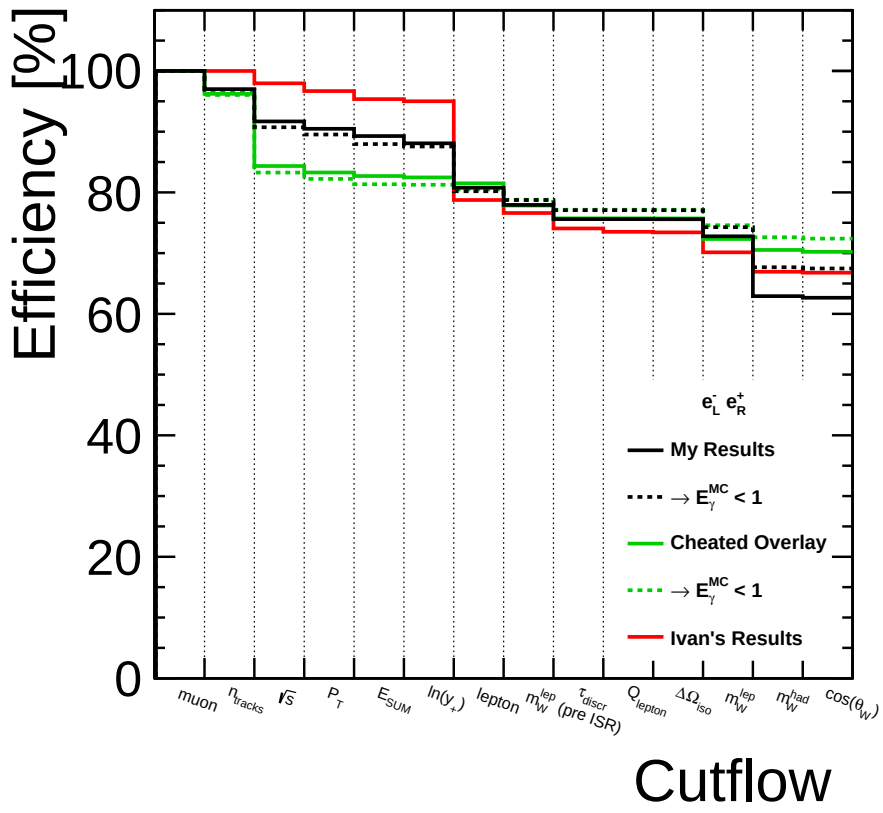
Back Up Slides Log Plots





Back Up Slides $E_\gamma < 1$ Efficiencies





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