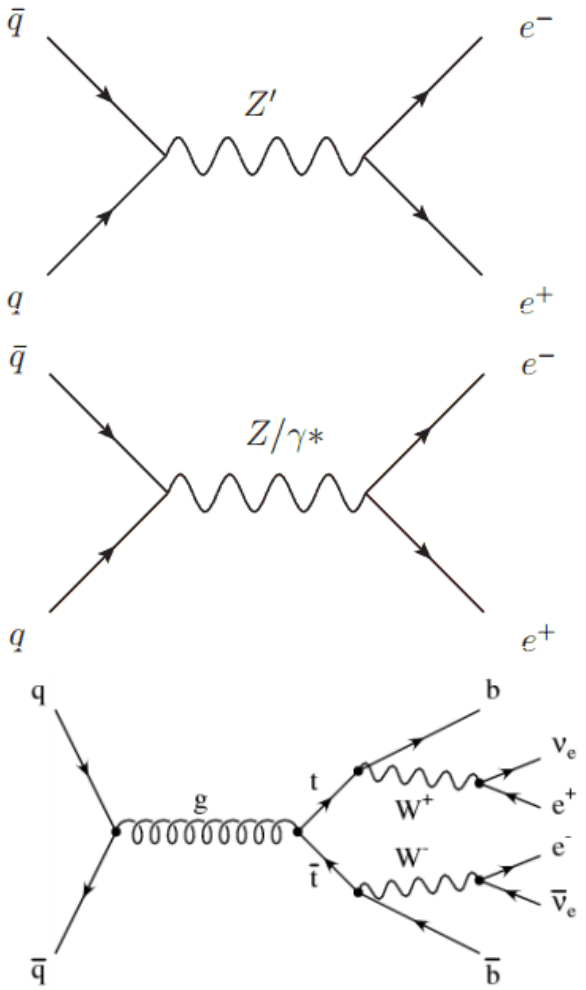
A Search for a Neutral, Massive Boson

Aaron Vermeersch
Michigan State University
Local Mentor: Dr. Daniel Hayden

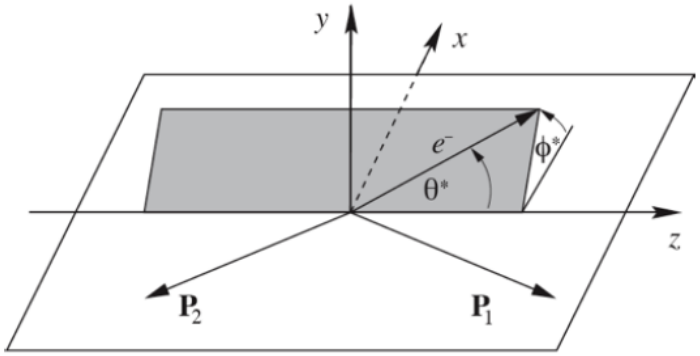
Signals and Backgrounds

- Signal
  - Electron Channel
- Irreducible Background
  - Drell Yan process
- Reducible Background
  - Diboson, ttbar, W+Jets, QCD



AFB and the Collins-Soper Frame

- Collins-Soper Frame:
  - θ^*_{CS} is the angle between the incoming quark and the outgoing electron in the dielectron rest frame with the z axis orientated such that it bisects the angle between the quark direction of motion and opposite to the anti-quark direction.
  - Used to minimize uncertainty in the momentum direction of the initial quark/anti-quark.



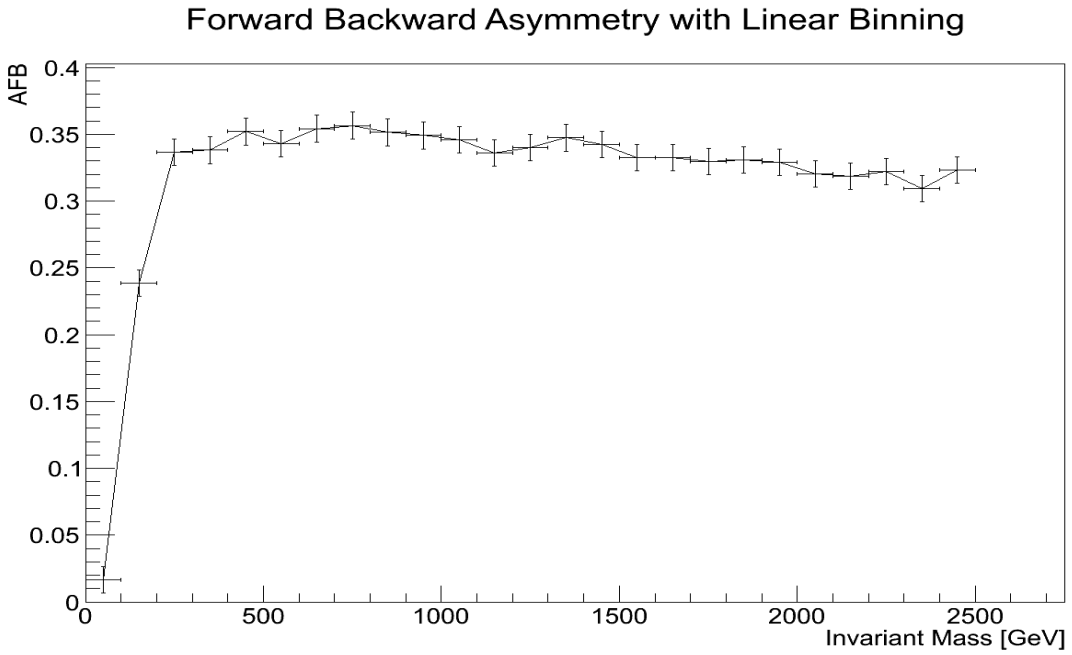
- Forward and Backward defined as:
  - Where Q = Dielectron four momentum
  - P1 (P2) = four momentum of electron (positron)
  - If greater than 0 then event is forward.
    If less than 0 then it is backwards.

$$\cos\theta^*_{CS} = \frac{Q_z}{|Q_z|}\frac{2(P_1^+P_2^- - P_1^-P_2^+)}{|Q|\sqrt{Q^2+Q_T^2}}$$

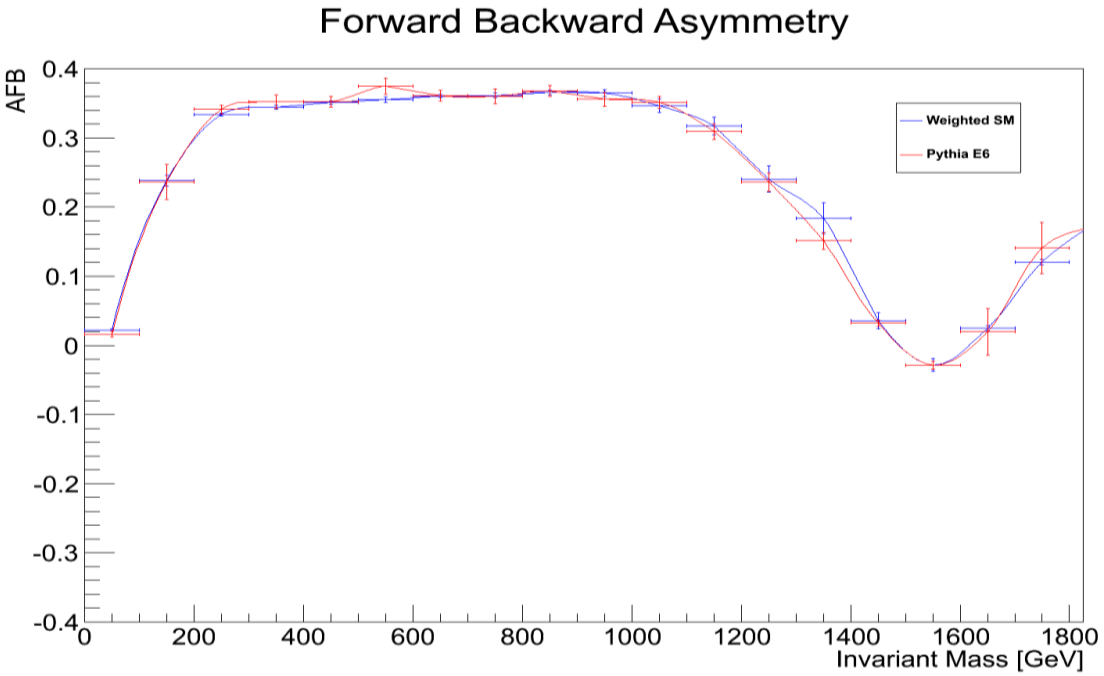
$$P_i^{\pm} = (P_i^0 \pm P_i^3)/\sqrt{2}.$$

- Forward Backward Asymmetry calculated by:

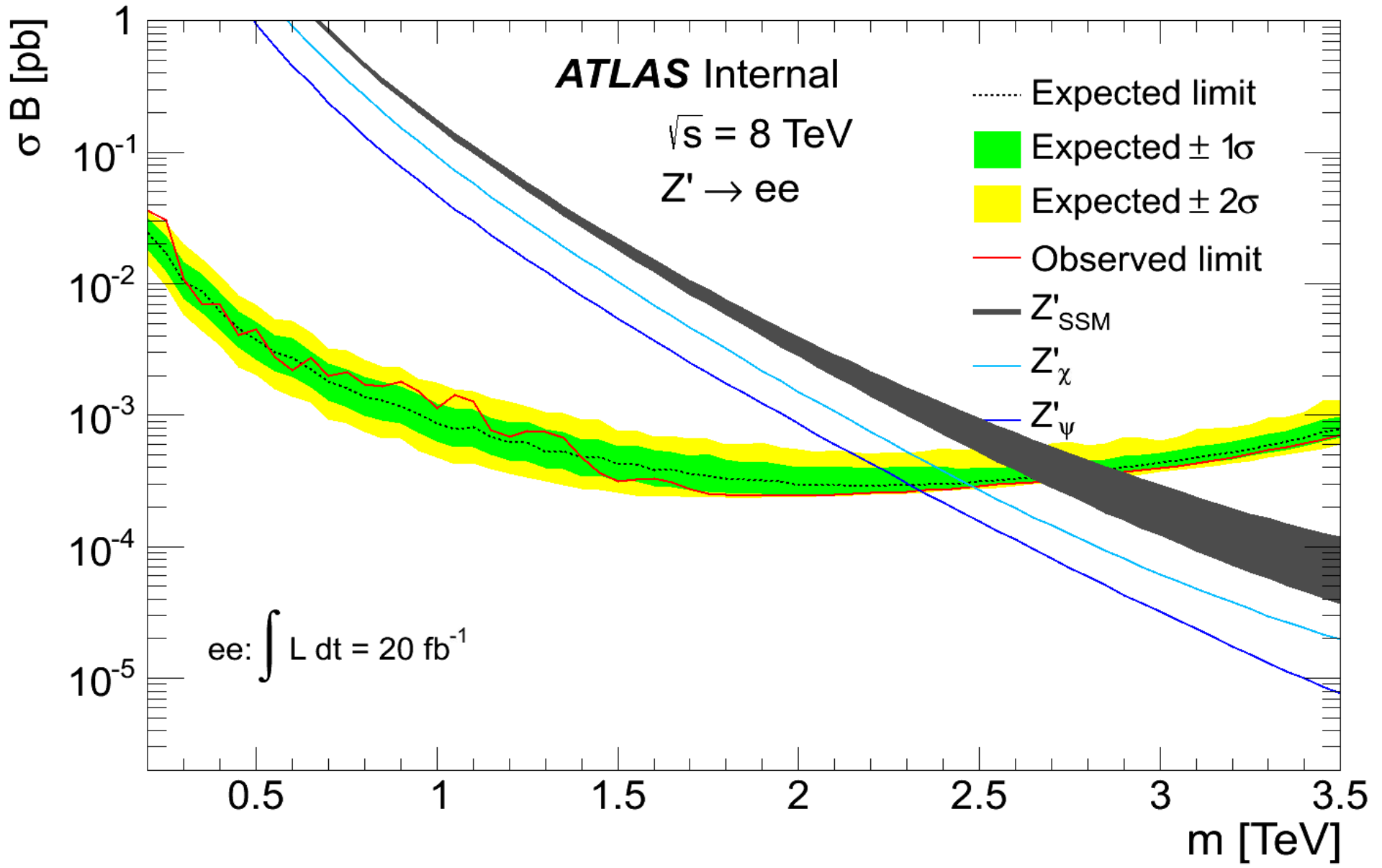
$$A_{FB} = \frac{\sigma_F - \sigma_B}{\sigma_F + \sigma_B}$$



- Standard Model Drell Yan
- $\sqrt{s} = 8$ TeV

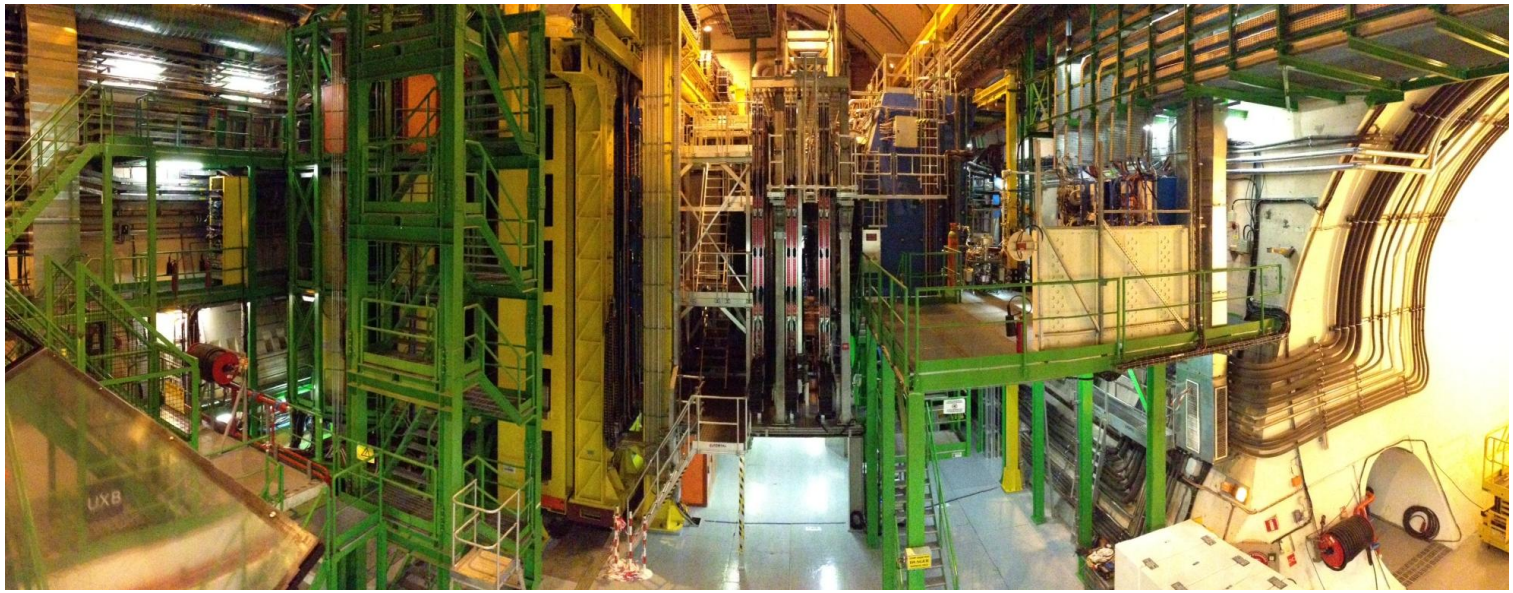


- E_6 Psi Model
- $m_{Z'} = 1.5$ TeV
- Pythia E6
  - Dedicated generation of E_6 model
- Weighted SM
  - Ratio of cross sections between the E_6 model and the SM


ATLAS Internal
√s = 8 TeV
Z' → ee
Expected limit
Expected ± 1σ
Expected ± 2σ
Observed limit
Z'SSM
Z'χ
Z'ψ
ee: ∫ L dt = 20 fb-1
σ B [pb]
m [TeV]
1
10-1
10-2
10-3
10-4
10-5
0.5
1
1.5
2
2.5
3
3.5

Summary

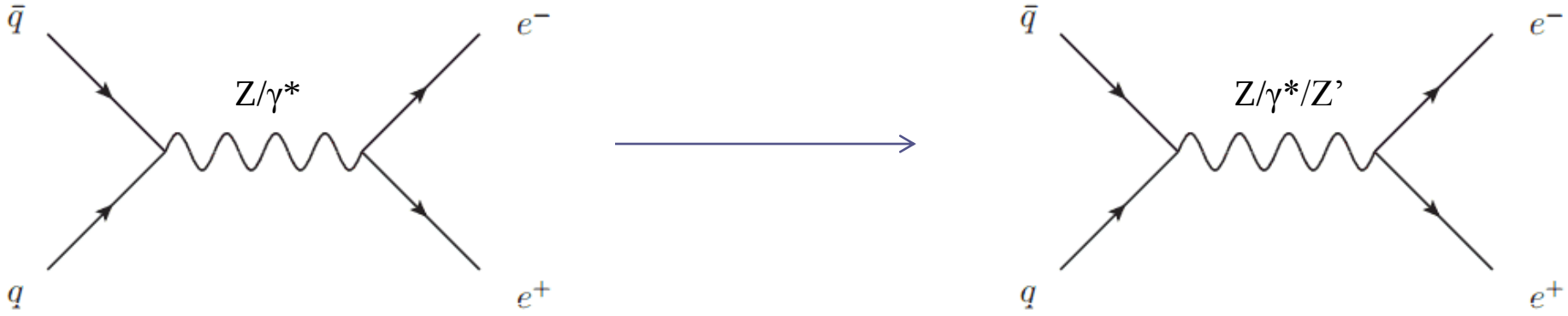
- Continuing work on re-weighting algorithm
  - Comparing multiple kinematic variables from samples with ISR/FSR .
- Analysis for official ATLAS D3PD's is finished
  - Includes 2013 event selection, latest MC corrections, and necessary calculations.
- Bayesian Analysis Toolkit setup to run on the Tier3
  - Needs to be modified for 2D search.



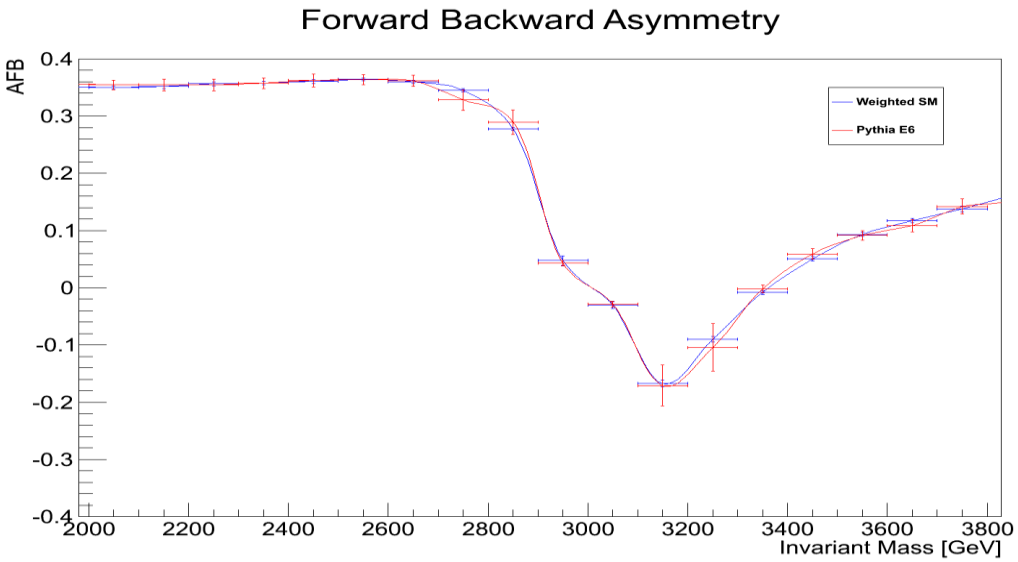
Additional Material

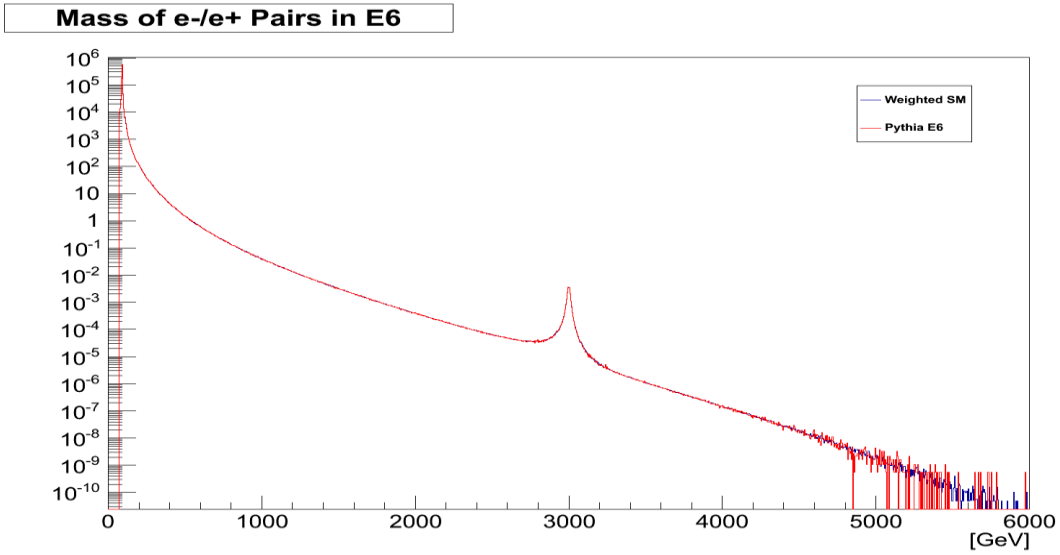
Model Re-Weighting

- To search for possible signal scenarios I will need to generate separate samples for each point in parameter space
  - Problems: Computationally Intensive and Time Consuming
- Solution: Model Re-Weighting
  - Take Standard Model Drell Yan events and apply weight to create BSM distributions
  - Given four-momentums of the initial quarks and final state electrons, the code will calculate the couplings for the relevant model (SM, SSM, E6) and determine the cross section
  - Weight that is applied is then the ratio of the cross section between BSM and SM



Validation





- Three Z' masses:
  1.5 TeV, 2.25 TeV, 3 TeV
- Four E_6 models:
  Psi, Chi, Eta, $\theta=3\pi/4$
- Compared AFB and mass plots at each point
- Propagated Uncertainties for A_{FB}
- Distributions shown here: E_6^{Psi} Z' at 3 TeV