Detecting Exotic Heavy Leptons at the Large Hadron Collider

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Outline

- Intermediate Scale Models
- Cosmological and Experimental Constraints on Heavy Leptons
- Detection of Exotic Heavy Leptons at the LHC

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Intermediate Scale Models

- Like the Minimal Supersymmetric Standard Model (MSSM) but with the gauge couplings unifying at an intermediate energy scale ($\sim 10^{11}$ GeV)

- Motivations include the strong Charge Parity problem

- Intermediate scale unification can be achieved by extra particle content which changes the running of the couplings

- Our model had extra TeV scale heavy leptons added to the MSSM

Cosmological and Experimental Constraints

- Possible cosmological or experimental constraints on exotic heavy leptons at this mass include that:
  - the relic abundance must not “over-close” the universe
  - charged leptons must not be ruled out by searches in ordinary matter
  - decays must not significantly affect nucleo-synthesis or synthesised elemental abundances
  - decays must not contradict the cosmic microwave, gamma-ray and and neutrino background limits
  - leptons must not be ruled out by previous collider experiments

Time-of-Flight Technique

- Heavy leptons will be detected as late muons in the muon system of an LHC experiment like ATLAS

- From the measured time delay and momentum it is possible to reconstruct the lepton mass

$$m^2 = p^2 \left(\frac{1}{\beta^2} - 1 \right) = \frac{p_T \Delta t}{r} \left(2p + \frac{p_T \Delta t}{r} \right)$$

- The detection of exotic heavy leptons produced by a Drell-Yan process was simulated for a range of masses using the Monte Carlo event generator HERWIG 6.3

- The angular distribution of produced lepton pairs was compared to that expected for scalar leptons

Cuts applied

- Cuts to remove background
  - Only opposite charge lepton pairs
  - p_T^{min} cut at 50 GeV
- Detector resolutions and cuts
  - 85% muon system efficiency
  - Momentum sagitta error

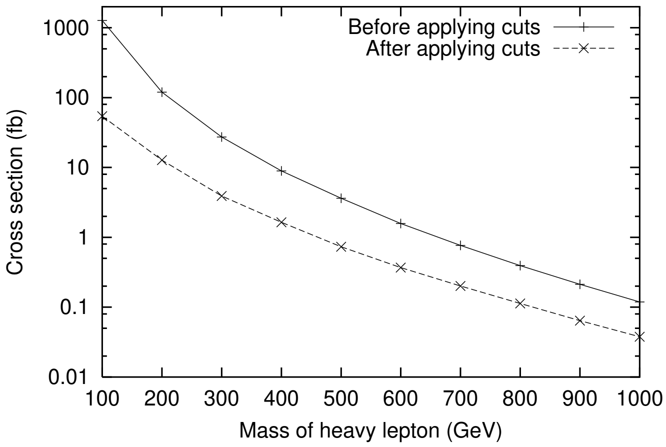
$$\Delta p_{sag} = 1.1 \times 10^{-4} p^2$$

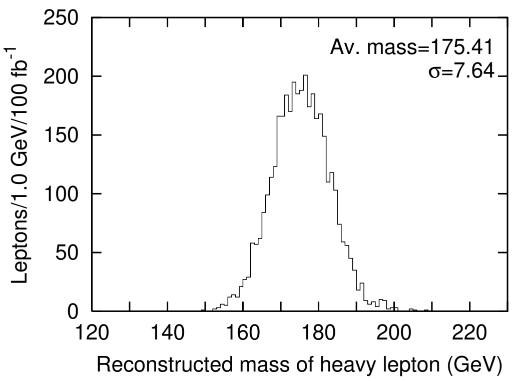
  - Momentum multiple scattering error

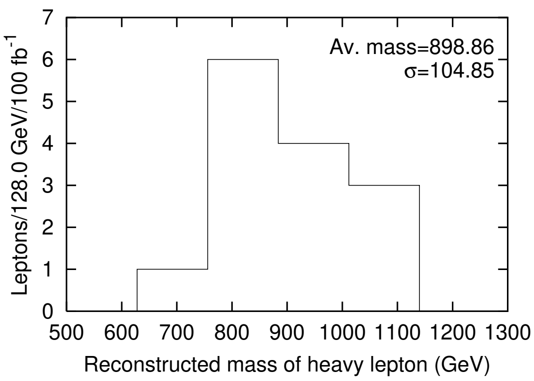
$$\Delta p_{ms} = 2 \times 10^{-2} \sqrt{p^2 + m^2}$$

  - 0.7 ns time resolution
  - Time delay cut 10 ns $< \Delta t < 50$ ns

Results

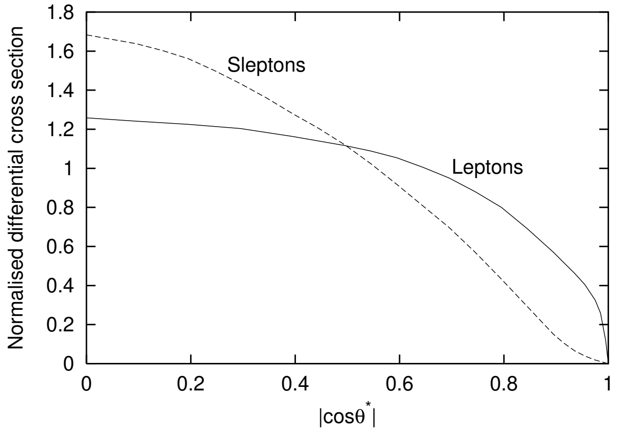






- Detection of exotic heavy leptons possible up to a mass of 950 GeV

Leptons versus Sleptons



- Sufficient statistics to distinguish angular distributions only up to 580 GeV