Study of Lepton Jets in ATLAS

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August 12, 2009

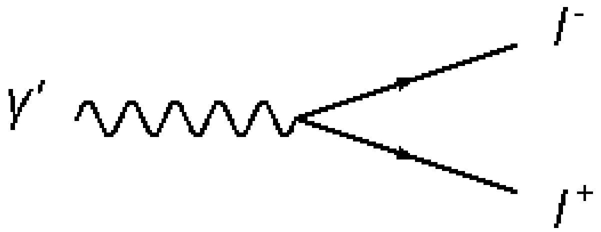
Theory At A Glance

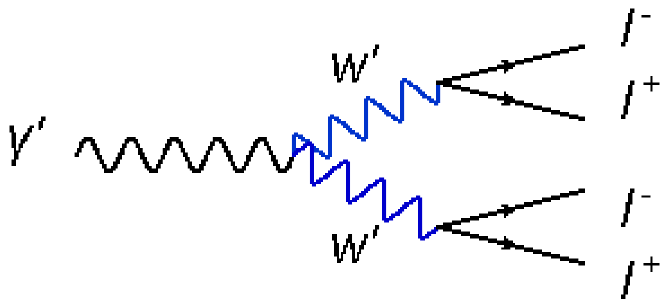
- Several astrophysics experiments (such as PAMELA, ATIC, EGRET, and WMAP) have shown an excess of positrons and electrons.
- Arkani-Hamed et al. have proposed a theory of dark matter that explains these anomalies.
- Their theory introduces a new dark gauge sector that includes heavy dark matter particles and light dark gauge bosons.
- The gauge bosons of the dark sector are too light to decay to protons and decay predominantly to electrons/positrons and muons, which would explain the anomalous astrophysics results.
- This theory predicts “lepton jets” at the LHC.

[1] N. Arkani-Hamed, D. P. Finkbeiner, T. Slatyer, and N. Weiner, *A Theory of Dark Matter*, arXiv 0810.0713.

Simulation

I wrote a Monte Carlo to simulate two typical decay chains predicted by Baumgart et al.





I produced 4-vectors for γ':
- φ uniform between (0, 2π)
- η uniform between (-2.5, 2.5)
- p_T according to $f(p_T)$*

$m_{\gamma'}$ = 1.5 GeV
$m_{w'}$ = 0.6 GeV
m_e = 0.000511 GeV

$$* \; f(p_t) = \frac{\lambda^2}{2}\exp(-\lambda\sqrt{p_t}) \quad \text{and } \lambda = 1.08 \text{ GeV}^{-1/2}$$

[2] M. Baumgart, C. Cheung, J. T. Ruderman, L. Wang, and I. Yavin, *Non-Abelian Dark Sectors and Their Collider Signatures*, arXiv 0901.0283.

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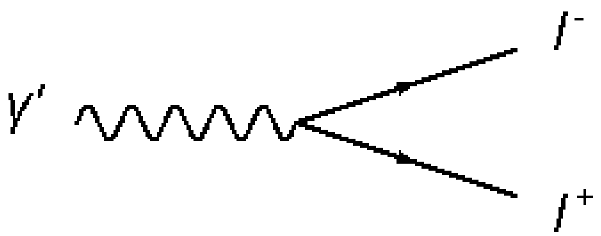
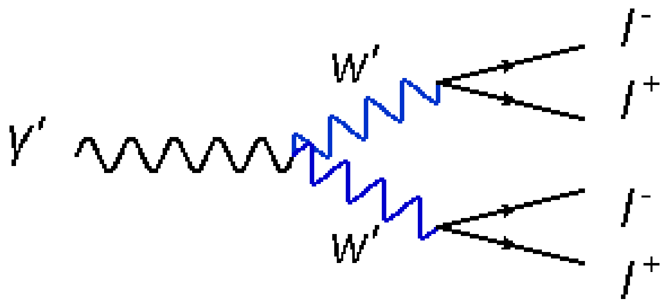




Subsequent two-body decays are spherically uniform in rest frame of γ'.

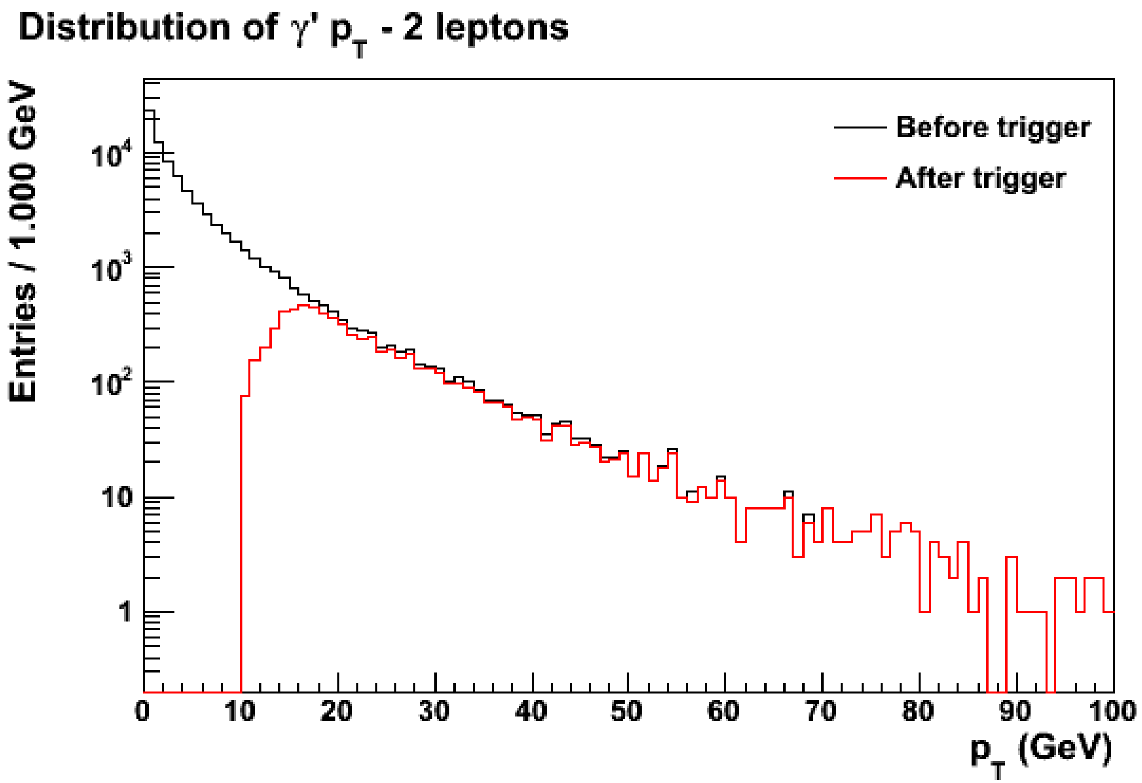
Particles are boosted back to the lab frame to get the 4-momenta of the observed leptons.

[2] M. Baumgart, C. Cheung, J. T. Ruderman, L. Wang, and I. Yavin, *Non-Abelian Dark Sectors and Their Collider Signatures*, arXiv 0901.0283.

Simulation

I used a "loose" trigger requirement requiring:

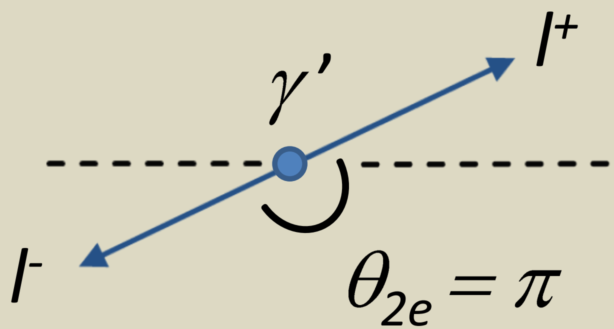
one electron with $E_T > 12$ GeV, or two electrons each with $E_T > 5$ GeV.



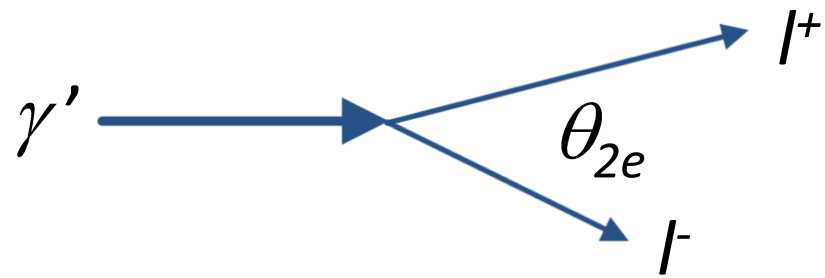
[3] ATLAS CSC Studies (at a luminosity of 10^{31} cm^{-2}s^{-1})

Opening Angle

Before Boost

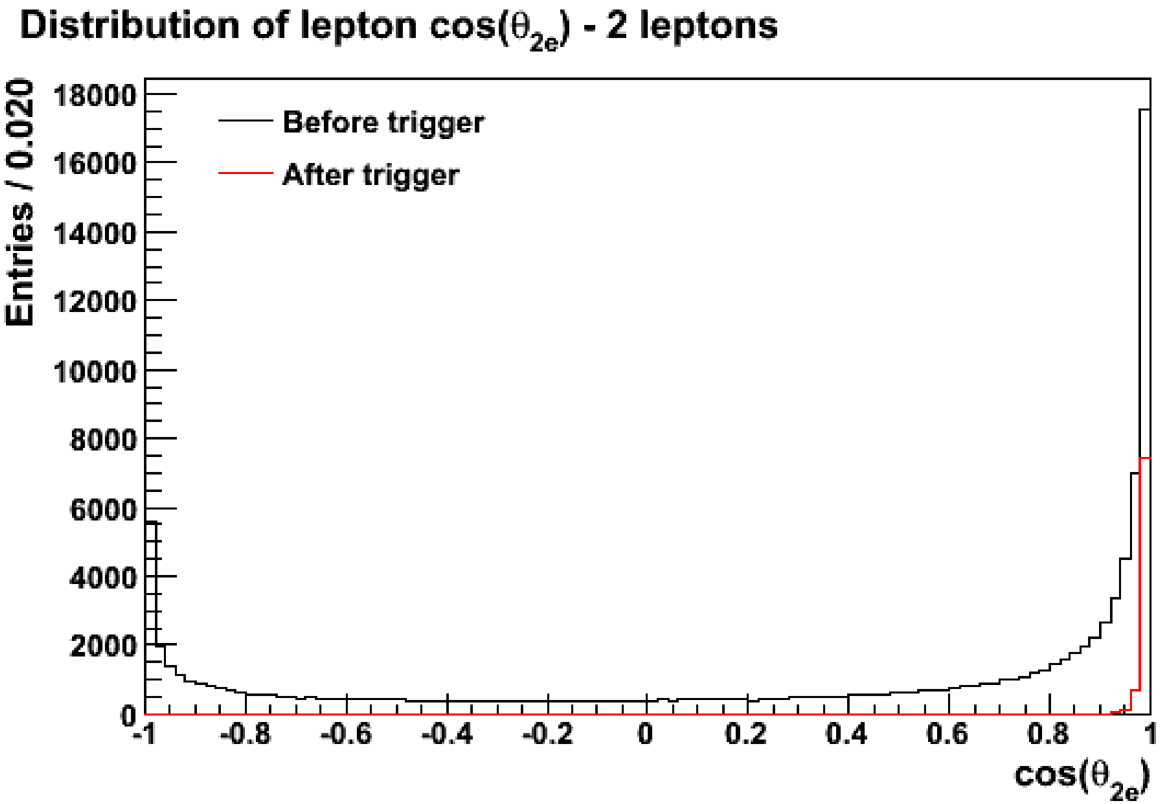


After Boost



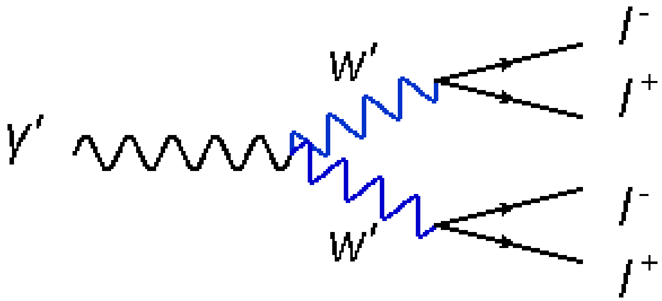
Opening Angle

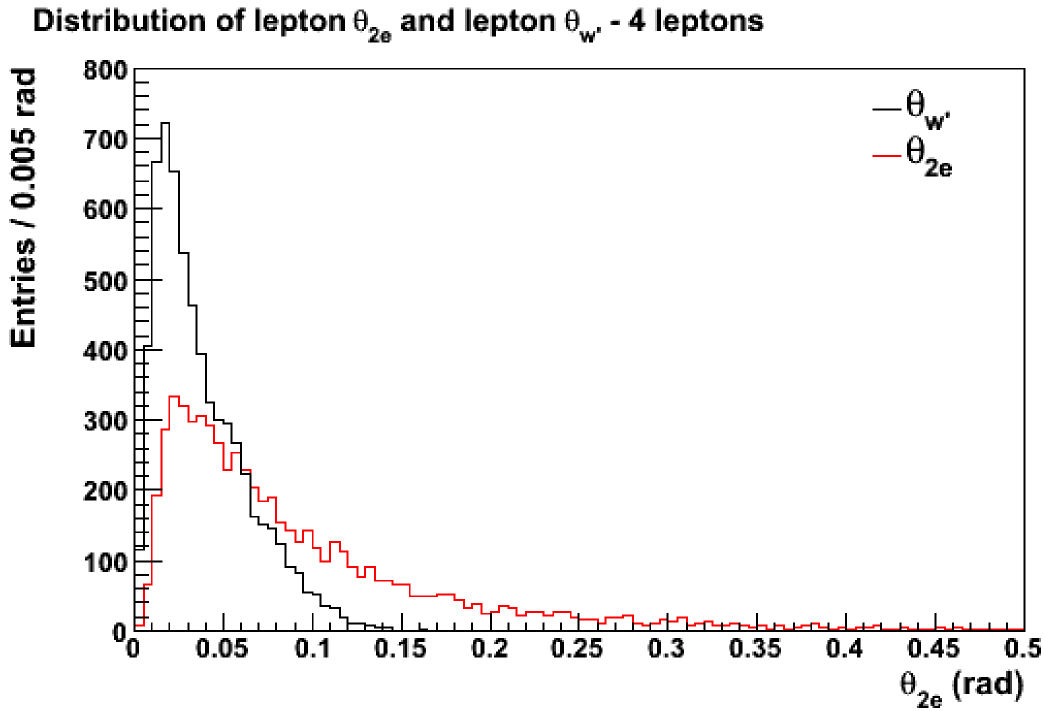
Although the γ' s are not necessarily boosted in the simulation, the trigger requirement selects only the highly boosted γ' s. These produce high collimated leptons, i.e. lepton jets.



Opening Angle

For the 4 lepton decay, the opening angle between the *w'* s is smaller than the opening angle between the leptons, so the 4 leptons make up a single jet.

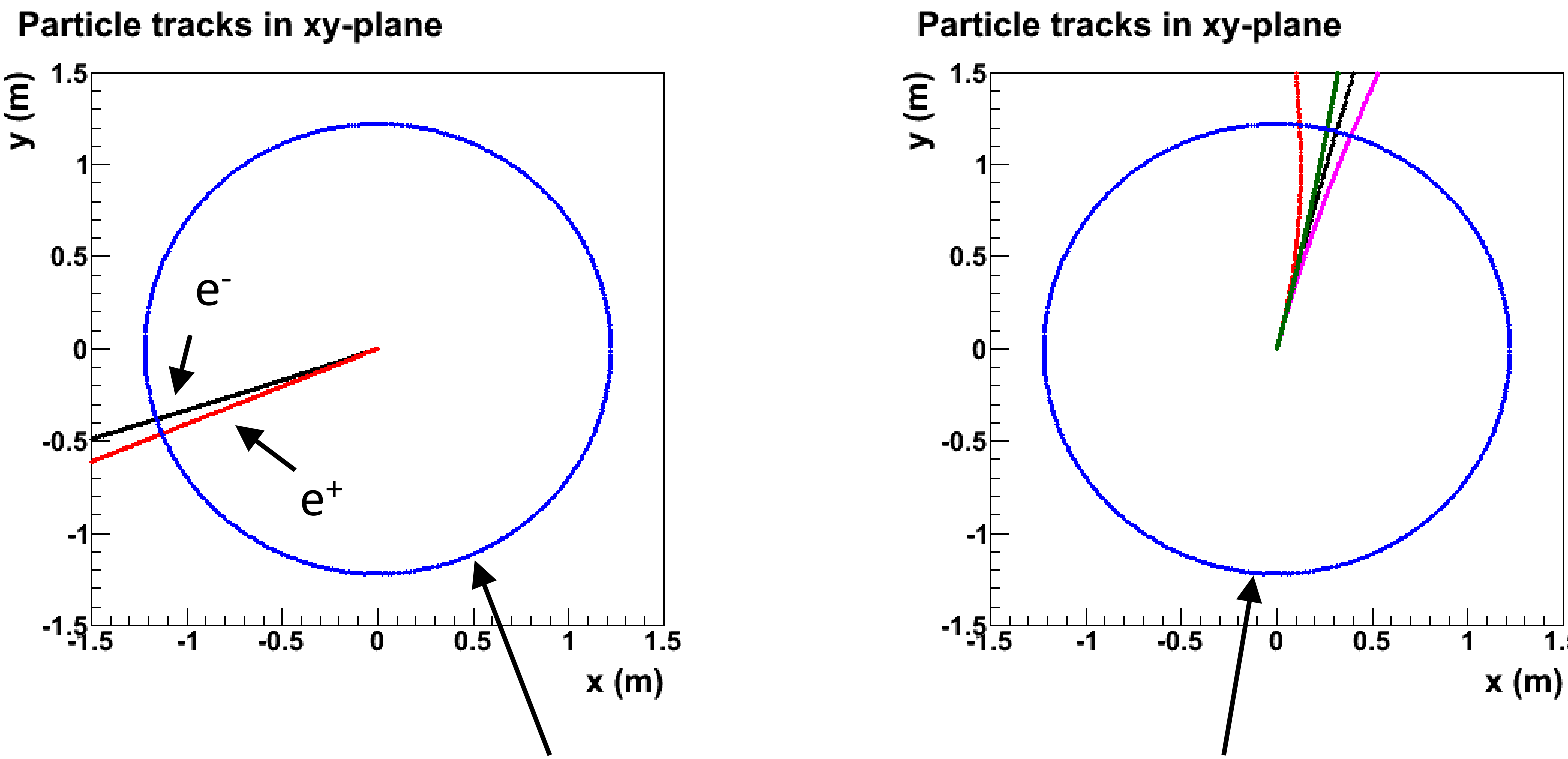




*After the trigger requirement

Particle Trajectories

To see if individual leptons can be easily distinguished it is necessary to look at trajectories in magnetic field.



Inside of solenoid in inner detector

Conclusions

- In the 2 lepton case, the leptons are highly collimated forming a jet.

- In the 4 lepton case, the leptons tend to make up a single jet.

- The effect of the trigger requirement is to select events with small opening angles.

- Further study to be done to see if the leptons in a jet can be distinguished.