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Final Report for OJI Award DE-FG02-08ER41558
SEARCHES FOR PHYSICS BEYOND THE STANDARD MODEL AND TRIGGERING ON PROTON-PROTON COLLISIONS AT $\sqrt{s} = 14$ TeV LHC

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This document describes the work achieved under the OJI award received May 2008 by myself as principle investigator. This report covers the full period of the proposal. The proposal covered an experimental particle physics project: searching for physics beyond the standard model at the Large Hadron Collider (LHC) at the European Organization for Nuclear Research (CERN). In the time since the grant was initially awarded, my work on the CMS experiment at the LHC has progressed on all fronts described in the proposal. The main areas discussed in the proposal are monitoring the CMS trigger and searches for new physics.

Current status

The monitoring program for the CMS trigger was completed successfully, and we have seen the first run of CMS data-taking in 2010 and the data-taking in 2011 use the tools we have been developing for the last few years. My post-doc, Lorenzo Agostino, was responsible for the on-line Monitoring of the CMS trigger through the first period of data-taking. Using the tools we helped develop, CMS was able to take data with high operational efficiency, which lead directly to the publication of many physics papers in the end of 2010 and start of 2011. In the meantime, Agostino has stepped down from the management position and taken a job in the financial industry. Our work in the trigger monitoring area continues though with diminished intensity with Agostino's departure. Most recently, student Don Teo has been working on a project to validate trigger rates to allow us to certify data quality. Our trigger work is documented in a published paper in a technical journal [1].

We have been actively involved in the analysis of early data. Darren Puigh, who is funded by the OJI money, was one of the two main analyzers for a new physics search $W' \to e\nu$. Fig. 1 shows the invariant mass distribution of events with large missing E_T and a high-momentum lepton, along with what evidence for a W' would look like in our data for $m = 0.9 - 1.3$ TeV. No evidence for new physics is observed. With this result, we set the world's most stringent limits in this channel. This paper was published within weeks of the end of the 2010 data-taking in *Phys. Lett. B* [2]. Unusual for a large collaboration such as CMS, due to a lucky confluence of factors this work was almost entirely done by Puigh and another Italian graduate student. The OJI support was therefore crucial in getting this early result published! Puigh has recently graduated and is now a post-doc in the CMS group at Ohio State University. Other CMS publications in the work are a search for new physics in final states with b quark jets, which was recently approved as a conference result and has been shown at international conferences [3].

Before the arrival of data, this grant supported us in the preparation for physics analyses. We published five internal CMS notes documenting our work (see [4]-[8]). These notes describe a sensitivity study which we started after it was clear that the data-taking would be delayed until the end of 2009. The notes describe a data-driven approach for a search for new physics in the final state with electrons and large missing E_T. The work resulted in the thesis of a Cornell student and has lead to a thesis topic of another student (though neither of these students are supported by this grant.)

In summary, much progress has been made in due to the OJI support, in both the trigger and data analysis efforts aimed at searching for new physics at the Large Hadron Collider. I would like to thank the DOE Office of Science for its support.

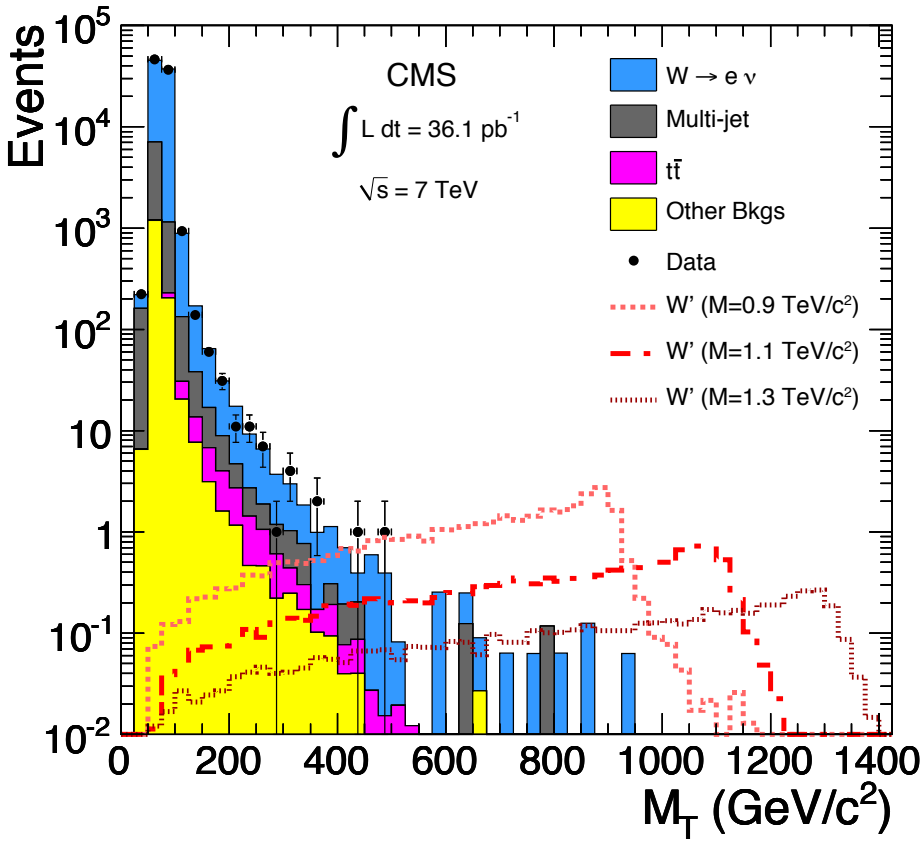

Figure 1: Invariant mass distribution of events with large missing E_T and a high-momentum lepton. No evidence for new physics is observed. With this result, we set the world's most stringent limits in this channel.

References

[1] S. Chatrchyan *et al.* (CMS Collaboration), "Commissioning of the CMS High-Level Trigger with Cosmic Rays", Journal of Instrumentation JINST **5** T03005 (arXiv:0911.4889).

[2] CMS Collaboration, "Search for a heavy gauge boson W' in the final state with an electron and large missing transverse energy in pp collisions at $\sqrt{s} = 7$ TeV." *Phys. Lett. B* **698** 21 (2010) (arXiv:1012.5945v2).

[3] CMS Collaboration, "Search for New Physics in Events with b-quark Jets and Missing Transverse Energy in Proton-Proton Collisions at 7 TeV," Physics Analysis Summary CMS-PAS-SUSY-11-006 (2011).

[4] L. Agostino *et al.*, "W Background Estimate for SUSY Searches in the e + jets + Missing E_T Channel," CMS Internal Note CMS AN-2010/042 (2010).

[5] L. Agostino *et al.*, "Estimation of Fake Electron Background using Data-Driven Techniques," CMS Internal Note CMS AN-2010/043 (2010)

[6] L. Agostino *et al.*, "Validation of Electron Identification Using a $Z \to e^+e^-$ Cross Section Measurement, " CMS Internal Note CMS AN-2010/044 (2010).

[7] L. Agostino *et al.*, "Extracting $t\bar{t}$ background in single lepton SUSY searches, " CMS Internal Note CMS AN-2010/045 (2010).

[8] L. Agostino *et al.*, "Sensitivity study for new physics in final states with electrons and large missing E_T from new physics," CMS Internal Note CMS AN-2010/046 (2010).