Final Publishable Summary Report:

In the first year of the the project the Large Hadron Collider (LHC) potential to discover hypothetical particles called bileptons was investigated. The LHC is a machine that collide protons with protons and each proton is composed of three quarks. The mechanism to produce bileptons at the LHC consists of the annihilation of a quark from one proton with an anti-quark from the other proton. This annihilation leads to the production of a particle, a photon (γ), a Z or a Z', that decays into the bilepton pair as one can see in Figure 1. The

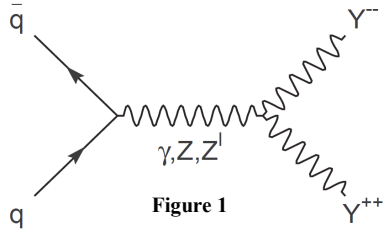

Figure 1

photon and the Z particles are particles that appear in the so-called Standard Model (SM) of particle physics, while the Z' is a new neutral particle predicted by models of new physics that predict the existence of bileptons. Note from the figure that the bileptons of interest in this project have two units of electrical charge (Y^{--}, Y^{++}). Bileptons are unstable particles so each bilepton produced would quickly decay into a pair of particles with the same electrical charge (as bileptons have two units of it). One of the bileptons could decay into a pair of electrons and the other bilepton into a pair of anti-muons, in other words, the most direct way bileptons would be observed at the LHC would be via the "golden" process: $p\,p \rightarrow Y^{--}\,Y^{++} \rightarrow e^{-}\,e^{-}\,\mu^{+}\,\mu^{+}$. Using Monte Carlo methods, **we investigated this process for the first time** and one of our main results, published in the *Physical Review D*[1], can be seen in Figure 2 below.

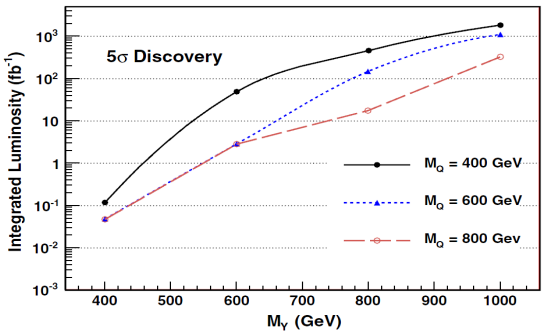

Figure 2

In Figure 2 one can see on the vertical axis the integrated luminosity (roughly, the amount of data an experiment needs to collect to observe the golden process) and in the horizontal axis the bilepton mass. We also assumed different masses for exotic quarks, which are new heavy quarks predicted by the models with bileptons we studied. To do this plot we assumed that the energy of the LHC collisions would be of 14 teraelectronvolts (TeV). We also made projections for the (now over) 7 TeV LHC run and even for the future upgrade of the LHC commonly known as the super LHC. Our results showed that if the bilepton mass lies in the TeV scale, at least ten years of machine operation would be needed for their discovery. After this projections we turned our attention to the data collected by the LHC-detector ATLAS.

1 B. Meirose et al, Phys.Rev.D84:055002, 2011.

In the second year of the project we searched for signals of a theory called Supersymmetry (SUSY) since this was likewise one of the main focus of this project. SUSY was also discussed in our *Physical Review D*[1] article.

Using data collected by the ATLAS experiment we searched for Supersymmetry in final states directly related to bileptons, in other words, in processes where the final state contained, like in the golden process, pairs of electrons or muons with the same electric charge. Theses searches assumed the conservation of a property called R-parity, that is introduced in the SUSY theory to avoid the prediction of protons decaying into lighter subatomic particles, which was never experimentally observed. The consequence of R-parity conservation is the prediction of particles that do not leave traces in the ATLAS detector, other than a potentially large energy imbalance, called missing transverse energy. In Figures 3 and 4 one can see one of the main results, published in *Physics Letters B*[2] and co-authored by us (together with the ATLAS Collaboration). Figure 3 shows the distribution of missing transverse energy in events containing a pair of electrons or of muons with the same electrical charge. Figure 4 shows the mass distribution of events with two electrons or two muons in the final state and large missing transverse energy. Our results showed complete consistency with the Standard Model of particle physics.

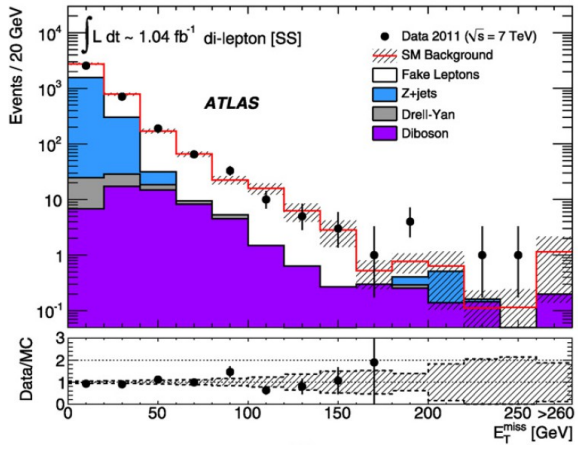

Figure 3

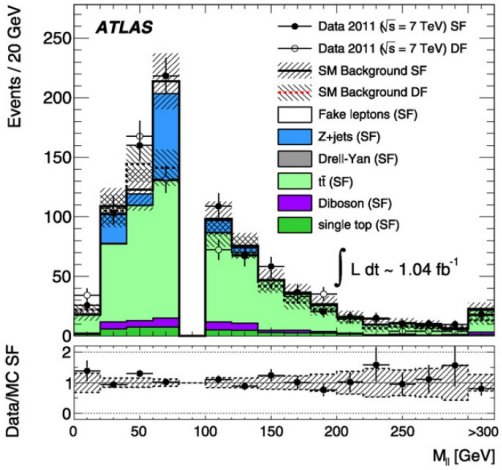

Figure 4

Impact

Many interesting processes have been studied in the literature concerning bileptons, but curiously, before our results they were all limited to bilepton production disregarding their decays into electrons and muons. Or results corrected this omission and allowed accurate predictions on the production of bileptons at the LHC, from the perspective of the collider signatures. We studied the most important process for bilepton production at the LHC, which impacts all theoretical and experimental groups working with the possible detection of these particles at the LHC. We also unambiguously established that bileptons might be discovered in the next few years at the Large Hadron Collider.

Our data results had a very significant impact not only for bileptons or for the theory of SUSY, but also for several theories that predict new physics beyond the Standard Model of particle physics. The results put significant constraints on several models that predicted similar final states. In summary, our results were central to the field of particle physics.

2 The ATLAS Collaboartion, Phys. Lett. B709 (2012) 137-157.

Dissemination activities

Our main results were published in peer-reviewed articles, presented in national and international conferences and also shown in invited seminars. The articles, seminars and conferences are listed below.

Peer-reviewed articles:

1. ***Searching for doubly-charged vector bileptons in the Golden Channel at the LHC*****, by** B. Meirose et al, Phys.Rev.D84:055002, 2011. (cited 4 times).

2. ***Search for supersymmetric particles in events with lepton pairs and large missing transverse momentum in sqrt{s} = 7 TeV proton-proton collisions with the ATLAS experiment*****, by** The ATLAS Collaboration, Eur.Phys.J.C 71 (2011) 1682 (cited 64 times).

3. ***Constraining the gauge-mediated Supersymmetry breaking model in final states with two leptons, jets and missing transverse momentum with the ATLAS experiment at sqrt(s) = 7 TeV*****, by** The ATLAS Collaboration, ATLAS-CONF-2011-156 (2011) (cited 1 time).

4. ***Searches for supersymmetry with the ATLAS detector using final states with two leptons and missing transverse momentum in sqrt(s) = 7 TeV proton-proton collisions***, **by** The ATLAS Collaboration, Phys. Lett. B709 (2012) 137-157 (cited 76 times).

5. ***Search for same-sign top-quark production and fourth-generation down-type quarks in pp collisions at sqrt(s) = 7 TeV with the ATLAS detector*****,** **by** The ATLAS Collaboration, JHEP 1204 (2012) 069 (cited 49 times).

6. ***Search for direct slepton and gaugino production in final states with two leptons and missing transverse momentum with the ATLAS detector in pp collisions at sqrt(s) = 7 TeV*** **by** The ATLAS Collaboration, Phys. Lett. B 718 (2013) 879-901 (cited 17 times).

Conferences and invited talks (by Bernhard Meirose):

1. *Supersymmetry searches in ATLAS: Past, Present and Future: an Overview,* invited talk at Chalmers University, Gothenburg, May 2012.

2. *Bilepton Searches at the LHC,* Partikeldagarna, October 2011, Chalmers UT, Gothenburg, Sweden.

3. *Supersymmetry searches with dileptons and high missing transverse momentum in ATLAS,* Physics Days, Second Nordic Physics Meeting, March 2011, Helsinki, Finland.

4. *Early SUSY searches in the 0-lepton channel*, Partikeldagarna 2010, Uppsala University, Sweden.