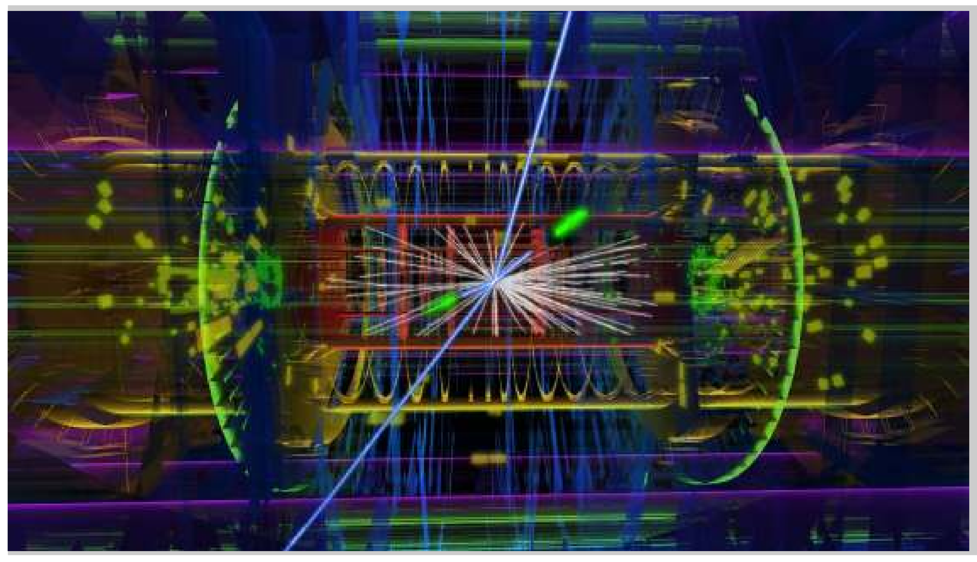


news

1/2017

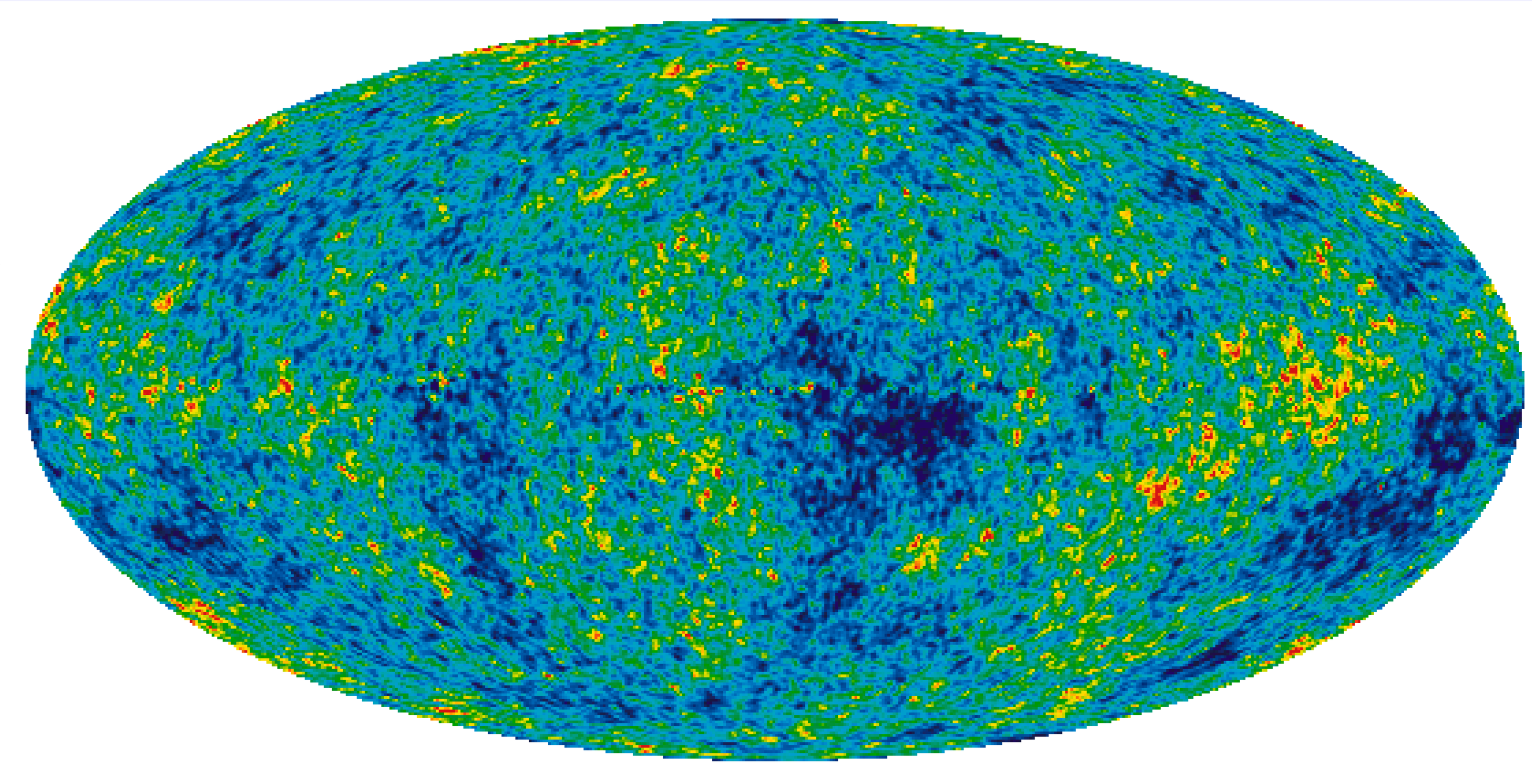
Mass and Symmetries after the Discovery of the Higgs Particle at the LHC
GRK 2044
UNI FREIBURG
DFG

Dear GRK fellows,
we are glad to finally send you the first newsletter of the year. In the first issue of 2017, we focus on cosmology and on the work done by some members of our RTG, hoping that this will be useful to get the big picture.
In case you want to contribute to the next issues, please send your suggestions to Michele Boggia.

DATES

All dates, news, and updates are given on the website of the GRK 2044: **www.grk2044.uni-freiburg.de**

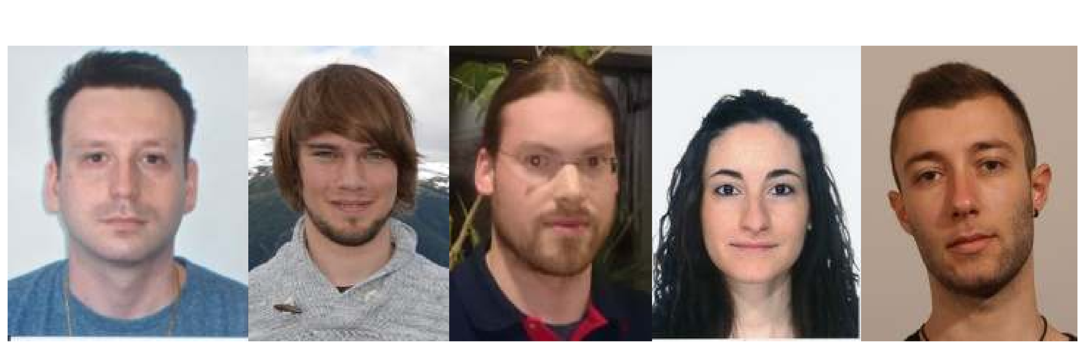
PHYSICS: Cosmology and Gravitation, Theory side



At its heart, physics is an empirical science. Experimentally observed phenomena are used to construct theories and models of nature, which are subsequently used to make predictions which can be tested in new experiments.
For example, in the case of particle physics the facilities at CERN, SLAC, DESY provide large amounts of data which can be used for the construction of models and theories. For cosmology, this is a little different. One cannot construct a laboratory in which one can reenact the creation of the universe. As a result, we have to rely on the observations of cosmological phenomena as they occur in nature. Note that there are some problems in cosmology which do translate to experiments in particle physics. For instance, many theories of dark matter predict that dark matter particles should be light enough to be (indirectly) detectable at the LHC. We will not focus on such events here. Instead, I will focus on the Cosmic Microwave Background (CMB) and inflation, which has been developed over the past decades.
The standard model of cosmology is based on the hot Big Bang scenario, and assumes that the universe is homogeneous and isotropic in space. At length scales comparable with the size of galaxy superclusters, this is in agreement with observations to a very high degree of precision. In recent years, these measurements have been performed in sky surveys with the satellites WMAP and Planck. What is observed is the CMB, a spherical surface that indicates the moment the hot plasma from the Big Bang cooled off sufficiently for atoms to form. At that point in time, photons decoupled from matter, and the universe became transparent.
As already mentioned, the CMB is highly homogeneous: the relative fluctuations of the CMB are of the order 10^{-5}. One could interpret this as the result of a thermalisation of the very early universe, which would imply that different parts of the universe are in causal contact. However, antipodal regions on the celestial sphere are too far removed from each other for this to be the case. This apparent paradox is called the ``horizon problem'' of cosmology. Furthermore, observations indicate that the spatial geometry of the universe is almost flat. General relativity predicts that if the universe was not flat at the time of the CMB, it will be even less so now. That at large scales the universe is nevertheless very close to being flat is called the ``flatness problem''.
One proposed resolution to these problems is now known as inflation: an epoch in the very early universe during which the size of the universe increased exponentially. There are several ways to construct models which implement cosmological inflation, but the most popular ones involve a scalar field, called the inflaton, the state of which determines the expansion of the universe. The result is that, even if the universe began in a ``generic'' irregular initial state, these irregularities were then smoothed out in the inflationary epoch.
The limits for inflation can be more strongly determined if one could somehow see past the CMB. Since in this epoch the universe was opaque, observations cannot rely on the electromagnetic field. Instead, one could turn to gravity. Where the photons are blocked by a hot plasma, gravity is universally present. One might therefore hope to measure gravitational waves emitted in the very early universe. This would then allow for a new perspective on the evolution of inflation.

Welcome to the new GRK PhDs of 2017!

As usual, we give the new members of the RTG a warm welcome!
Alexey (Fischer), Frank (Jakobs), Julian (Jakobs), Simona (Jakobs) and Simone (Herten), welcome to the club!



TIPS & TRICKS from your office mate!

New

<u>How to downsize your pdf file</u>
Let's say that your file 'input.pdf' is too large. You can easily resize it by using in your shell

gs -dNOPAUSE -dBATCH -sDEVICE=pdfwrite -dCompatibilityLevel=1.4 -dPDFSETTINGS=/screen -sOutputFile=output.pdf input.pdf

<u>How to change attributes to a pdf file</u>
You want to change some attributes to 'myfile.pdf'? It happens, if you edit a newsletter ;)
Firstly, dump the attributes in a text file

pdftk myfile.pdf dump_data output attributes.txt

Then change attributes in attributes.txt and get myfile2.pdf with the right attributes:

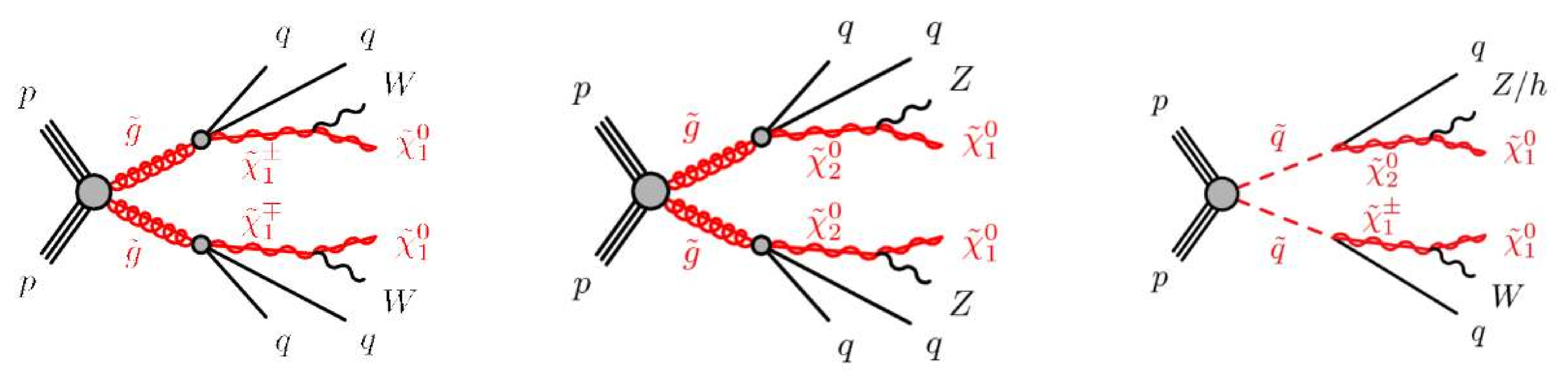
pdftk myfile.pdf update_info attributes.txt output myfile2.pdf

Enjoy your brand new, lightweight pdf file!

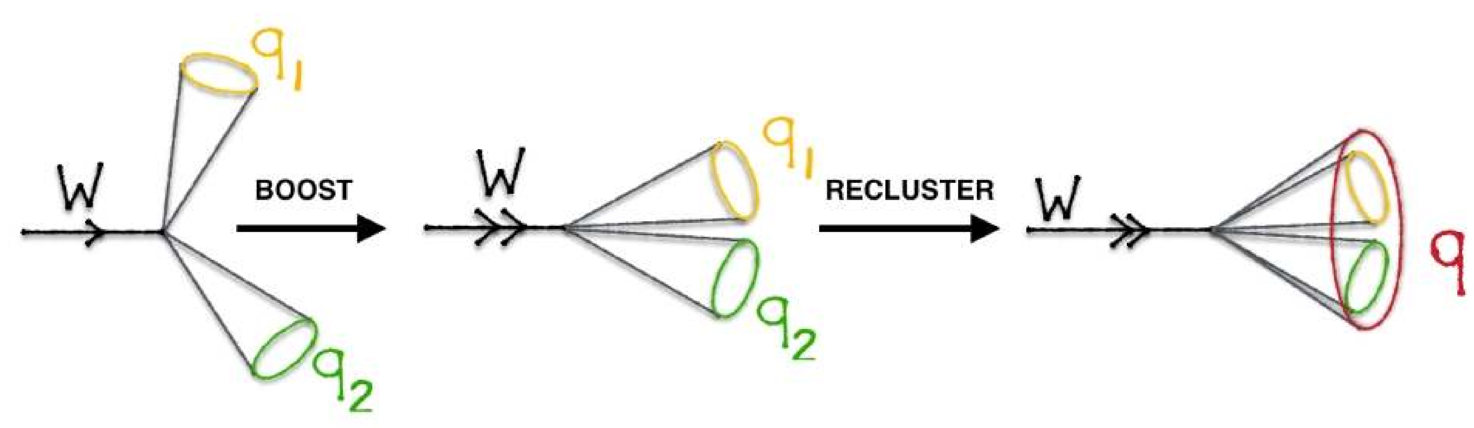
SERIES: Members of our GRK: Improving Sensitivity in Strong SUSY Searches Using Boosted Jets

Despite the lack of significant experimental signs for its existence, Supersymmetry (SUSY) is still one of the most popular extensions of the Standard Model (SM) capable of providing natural solutions to many of the well known inefficiencies of the SM, like the hierarchy problem, the particle source of dark matter (DM) or the unification of couplings at higher scales. Hence, experimentalists in both the ATLAS and the CMS collaboration are searching with unbroken fervour for the particles predicted within this theoretical framework.
In Freiburg, the groups of Prof. Gregor Herten and Prof. Karl Jakobs are contributing to these efforts.

SUSY @ LHC SUSY is a generalization of space-time symmetries that predicts new bosonic partners for the fermions and new fermionic partners for the bosons of the SM. If R-parity is conserved (RPC), SUSY particles (called sparticles) are produced in pairs and the lightest supersymmetric particle (LSP) is stable and represents a possible DM candidate. The scalar partners of the left- and right-handed quarks, the squarks $\tilde{q}_L$ and $\tilde{q}_R$, mix to form two mass eigenstates $\tilde{q}_1$ and $\tilde{q}_2$ ordered by increasing mass. Superpartners of the charged and neutral electroweak and Higgs bosons also mix to produce charginos ($\tilde{\chi}^{\pm}$) and neutralinos ($\tilde{\chi}^0$). Squarks and the fermionic partners of the gluons, the gluinos ($\tilde{g}$), could be produced in strong-interaction processes at the Large Hadron Collider (LHC) and decay via cascades ending with the stable LSP, which escapes the detector unseen, producing substantial missing transverse momentum.
The large expected cross-sections predicted for the strong production of SUSY particles make the production of gluinos and squarks a primary target in searches for SUSY in proton proton collisions at a centre-of-mass energy of 13 TeV at the LHC. Interest in these searches is motivated by the large number of RPC models in the Minimal Supersymmetric Standard Model (MSSM) in which squarks and gluinos can be produced in pairs and can decay through $\tilde{q}\rightarrow q\tilde{\chi}^0_1$ and $\tilde{g}\rightarrow qq\tilde{\chi}^0_1$ or including the production of charginos via $\tilde{q}\rightarrow q\tilde{\chi}^{\pm}$ and $\tilde{g}\rightarrow qq\tilde{\chi}^{\pm}$, or neutralinos via $\tilde{g}\rightarrow qq\tilde{\chi}^0_2$. Subsequent chargino (one-step) decay to $W^{\pm}\tilde{\chi}^0_1$ or neutralino decay to $Z\tilde{\chi}^0_1$ or $h\tilde{\chi}^0_1$, depending on the decay modes of $W^{\pm}$, Z and h bosons, can increase the jet multiplicity and the missing transverse momentum.



Boosted Analysis In the one-step decay models of SUSY particles, W/Z/h bosons can be present in the final state. In case of large mass splittings between the intermediate $\tilde{\chi}^{\pm}_1$ / $\tilde{\chi}^0_2$ and the LSP, a more probable scenario at higher energy collision as in Run2, bosons can be high energetic and hence its hadronic decay products form a boosted system subsequently decaying hadronically into 2 boosted jets, close enough to be reconstructed as a single large jet whose transverse mass lies around the boson mass value, as depicted in the sketch.

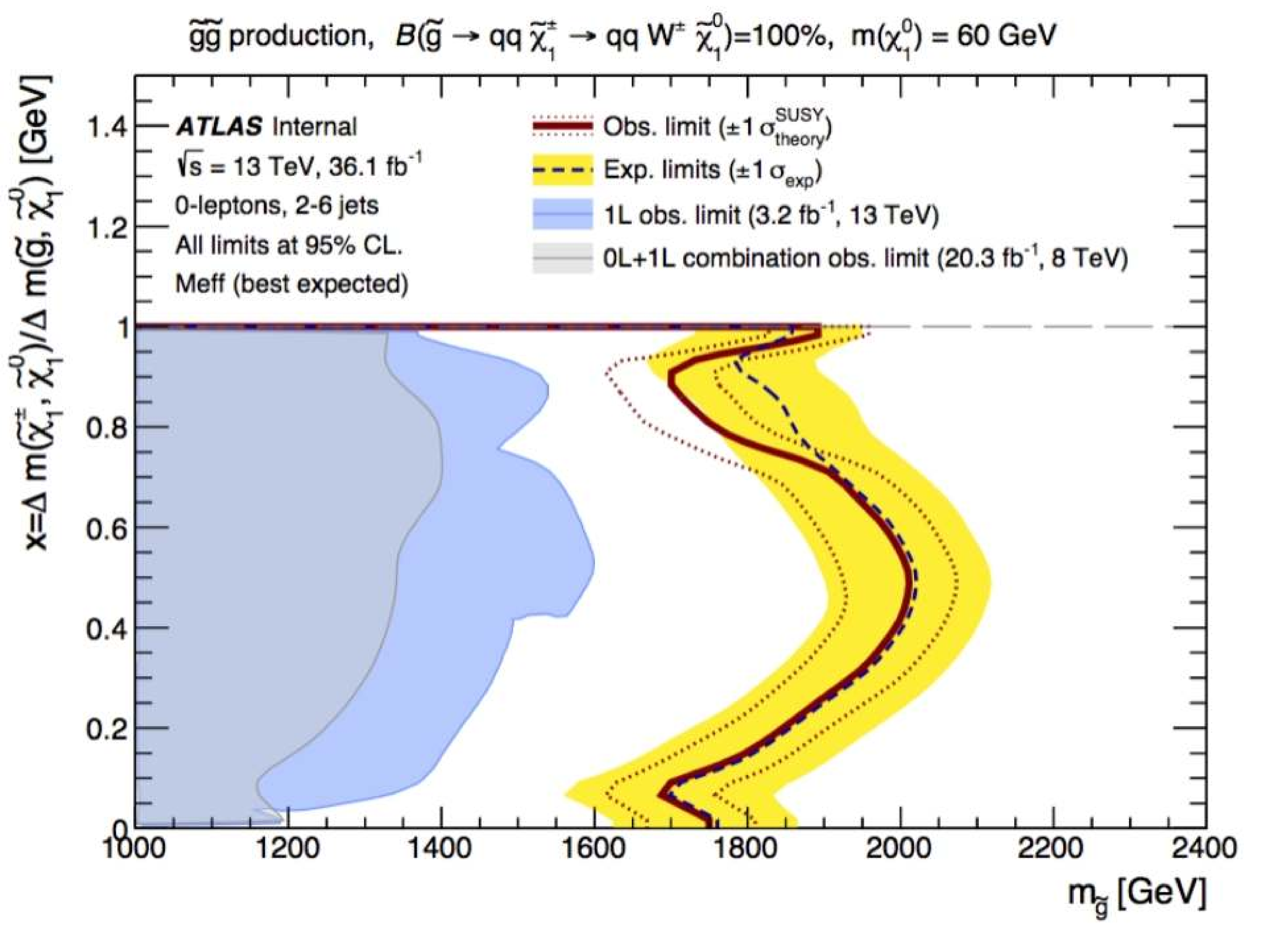


Within the 0-Lepton SUSY analysis, a set of dedicated signal regions has been developed and optimised, exploiting the selection on the large-R jets obtained from a particular algorithm called Reclustering, which is able to form a large jet from the usual small ones taken as inputs.

Results

The boosted analysis has been inserted and approved in the latest run of the SUSY 0-Lepton analysis which has been shown in the Moriond 2017 conference. The new signal regions helped in improving the sensitivity of the analysis in the boosted region and pushing the limit on gluino and squark masses in one-step decay scenarios, as shown in the exclusion limit plot on the right.

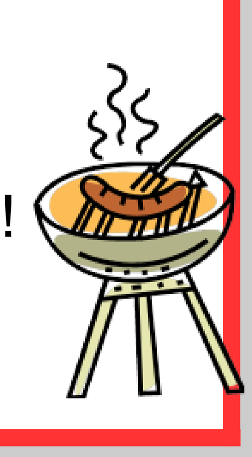
If you are interested in this topic and want to learn more about the exploitation of boosted techniques in SUSY analyses, feel free to contact the authors of this article, Manfredi and Veronika, who are both members of Prof. Herten's group.



From the GRK PhD Student speakers:

Dear PhD students,
Last week we had one of the annual block lectures by Marc Schumann and Felix Kahlhöfer. We thank the lecturers for their interesting and well-structured talks. Unfortunately, the planned barbecue had to be canceled but instead we had a nice get-together and enjoyable common dinner. We are looking forward to the warmer season to make up for the barbecue.

We wish you all a great and successful summer term!



Alena and Gernot

Thank you for the contributions to: Gernot Knippen, Alena Lösle, Veronika Magerl, Manfredi Ronzani, Martin Rotzinger, and Matthijs van der Wild. Icons made by Alfredo Hernandez from www.flaticon.com is licensed by CC 3.0 BY.