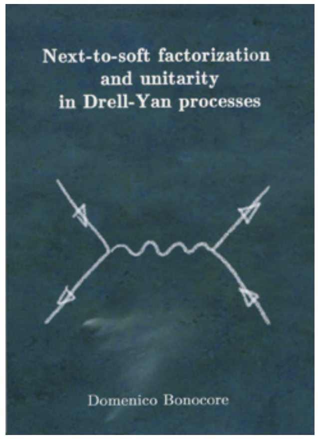
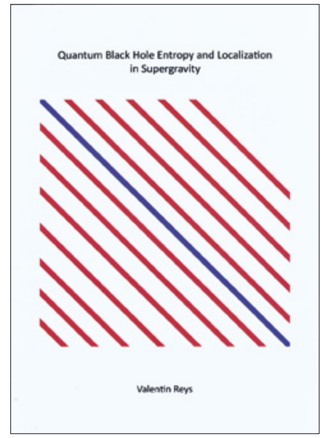
PhD student Valentin Reys at the blackboard.

Theoretical physics



Domenico Bonocore
18 May 2016



Valentin Reys
13 June 2016

Management
prof.dr. E. Laenen

Theoretical physics at Nikhef addresses a wide range of research, in part relevant for the experimental program, and some going beyond that. The highlights mentioned below exemplify both these aspects. To do this research, group members work with each other as well as with colleagues from all over the world, a flexibility of working that leads to lively exchanges, and rapid spreading of new ideas.

On the quite theoretical front, Nikhef theorists managed to construct all N=4 conformal supergravity theories (that is, gravity theories extended such that they are invariant under four types of super symmetry, and have conformal symmetry as well), a result that has long been looked for.

In the physics of B_s-mesons, a new strategy was devised to explore CP violation through its decay to charged kaons. Moreover, its oscillation into its antiparticle and back can also be used as a tool for such exploration when charm quarks are involved.

A substantial amount of new insight was gained in the structure and perturbative behaviour of QCD. New classes and types of large logarithmic corrections were resummed to all perturbative orders, or shown to have predictable patterns. The role of initial state gluons and their transverse momenta in probability functions for incoming protons was clarified in various settings, such as polarised high-energy scattering.

Group members continue to explore the notion that the Higgs boson and the cosmological inflaton are one and the same particle. This year the ultraviolet sensitivity of this notion was studied, and it was found that the parameters of the Cosmic Microwave Background spectrum are poorly related to the top quark and Higgs mass measurements at the LHC.

Besides scientific papers researchers in the group publish computer codes that can be used by others for a variety of purposes. This year saw the release of Axodraw v2 (for very nice renditions of Feynman diagrams), NNLLFast (for precise estimates of squark and gluino production rates), and of FORCER (a FORM program for four-loop propagator diagrams, which even contains automatic code generation).


Robert Fleischer


Marcel Merk

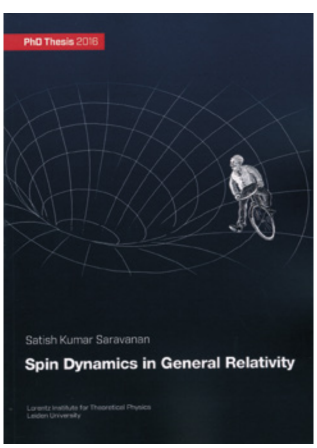
FOM-projectruimte Robert Fleischer & Marcel Merk

A FOM-*'projectruimte'* was granted to Robert Fleischer of the Nikhef theory group and Marcel Merk of the Nikhef LHCb group for their (combined theoretical and experimental) proposal "Very rare beauty decays: a magnifying glass for quantum physics".
"Through research into very rare forms of particle decay, the first evidence for which has been found in data from the Large Hadron Collider, the researchers hope to discover new physics that possibly reaches beyond the Standard Model of particle physics. 'The awarded project consists of a combination of a new theoretical (Robert Fleischer) approach and an experimental (Marcel Merk) one to focus on these extraordinary quantum processes."

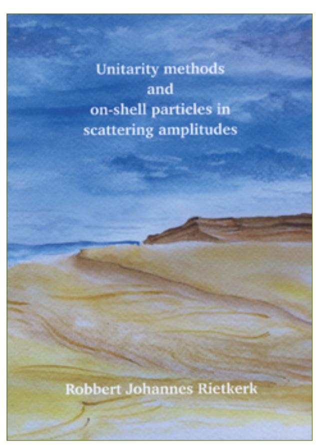
Amsterdam Master of Physics and Astronomy Award 2016 Ruben Jaarsma


Ruben Jaarsma (middle) at the award ceremony among his fellow competitors.

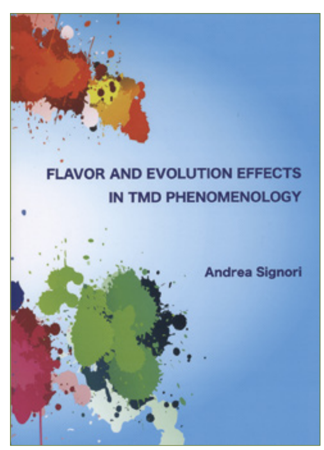
Ruben Jaarsma won the Amsterdam Master of Physics and Astronomy Award 2016 for the best presentation of a master research project with his talk "Hunting New Physics at the LHC High-Precision Frontier". Students of the joined master programmes Physics and Astronomy of the University of Amsterdam and the VU University Amsterdam were competing for this award at the Amsterdam Master of Physics and Astronomy Symposium 2016. Jaarsma conducts his research on B physics in the Nikhef Theory group.



Satish Kumar Saravanan
7 July 2016



Andrea Signori
17 October 2016



Robbert Johannes Rietkerk
19 October 2016

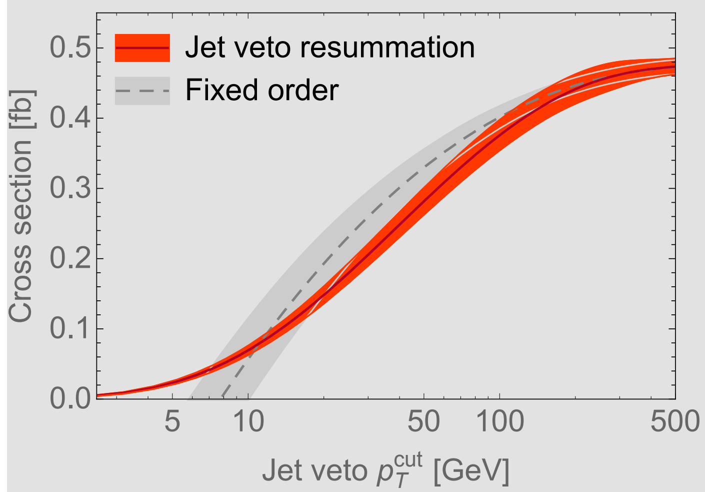
Jet vetoes in new physics searches at the LHC

F.J. Tackmann, W.J. Waalewijn and L. Zeune,
Impact of Jet Veto Resummation on Slepton Searches
JHEP **1607** (2016) 119, arXiv:1603.03052 [hep-ph]

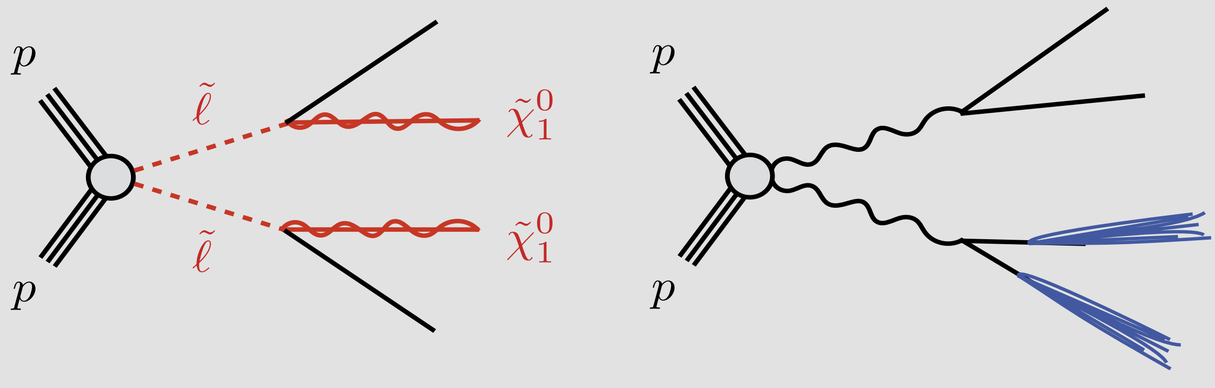
The LHC experiments undertake enormous efforts to search for particles predicted by new physics models, trying to find answers to the big, open questions of modern physics, such as 'What is dark matter?'. To distinguish the new physics from the overwhelming Standard Model background, experimental analyses require a specific number of jets and demand the absence of ('veto') additional jet activity. Already an important experimental tool in new physics analyses, the importance of jet vetoes will further increase when a new particle is discovered, facilitating clean and precise measurements.

However, jet vetoes lead to additional complications in the theoretical description of the new physics events. They introduce large logarithms which require resummation, a method to sum an infinite number of logarithmic terms in the theoretical prediction.

Members of the Nikhef theory group were the first ones to analytically calculate a new physics process including jet veto resummation. Taking the production of supersymmetric leptons as example, they found that the jet veto effect and in particular the associated theoretical uncertainties are large, which has a sizeable impact on the present and future LHC limits on the mass of these new particles.



The improvement of resummation on the cross section as opposed to the fixed order compution: notice how much narrower the uncertainty bands are.



The production of supersymmetric leptons on the left, and a background process with jets on the right.