HiggsTools ITN Mid Term Review

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Presentation and background

Hi!

- From Tenerife, Spain.
- Studied Physics at Universidad Complutense de Madrid.
- Masters in Theoretical Physics @ UCM.
- PhD project: *Higgs bosons in the NMSSM*.
- Supervisor: Prof. Ulrich Ellwanger.

Research work and organisation within the network

WP1: Interpretation of data

- Interpretation of experimental results in SUSY models;
  - ↪ M1.3.1 *Constraints on physics beyond the SM, distinction between different models.*
- Future European strategy for particle physics
  - ↪ M1.4.1 *Review of the current state and future directions in Higgs boson physics.*

WP2: Predictions and simulation of signal and background

- M2.2.2 *Precision calculations of non-standard Higgs boson scenarios.*
- M2.2.3 *Standardised description for non-standard Higgs boson interactions.*
- M2.2.4 **Interpretation of experimental data in the light of M2.2.3**

Training

Internal Training (HT)

- First YRM @ Lumley Castle, UK.
- 2015 HT anual meeting, Freiburg Univ., Germany.
- HT Annual School 2015, Italy.
- HT Journal Club.
- HT Second Young Researchers Meeting (**Coming soon!**).
- Daily meetings with my supervisor.
- Private secondment at **Wolfram Research** starting on April 2016.

External Training

- Monthly seminar activity at the lab
- Various courses attended at Univ. Paris on: Numerical analysis, Physics, "transversal training"...
- ICTP 2015 Summer School, Trieste, Italy.
- French course!

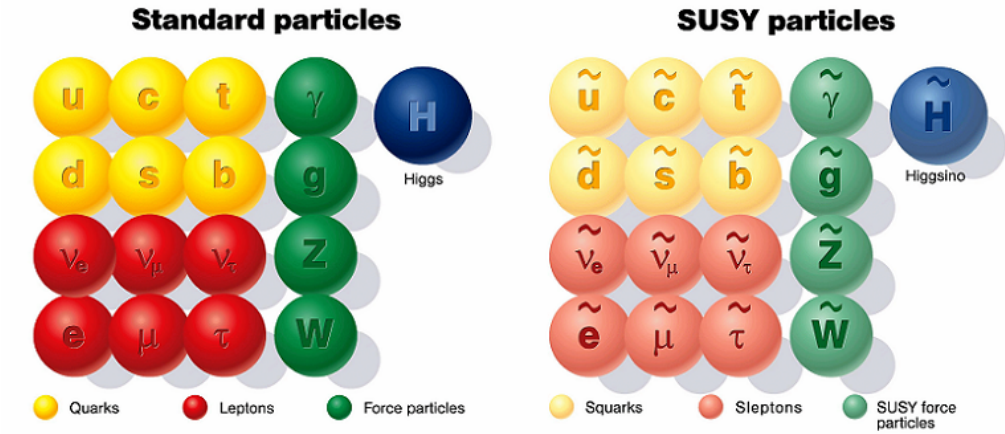
Workshops and Conferences

- Rencontre de Physique des Particules 2015, Paris, France
- Higgs Hunting 2015, Orsay, France.
- GDR Terascale, Grenoble, France.

Research

Motivation

The SM of particle physics is believed to be incomplete due to unexplained observed phenomena: neutrino masses, dark matter, gravity... A well-motivated theoretical framework to extent the SM is *Supersymmetry*.



Objectives

- Explore the parameter space of the NMSSM.
- Constrain the model using the experimental data from LHC run I and II.
- Investigate the various production channels and decays where the hypothesized Higgs(es) could be discovered at the LHC.
- Optimize search strategies for new Higgs bosons at the LHC run II.
- Interpret the experimental data within the NMSSM.

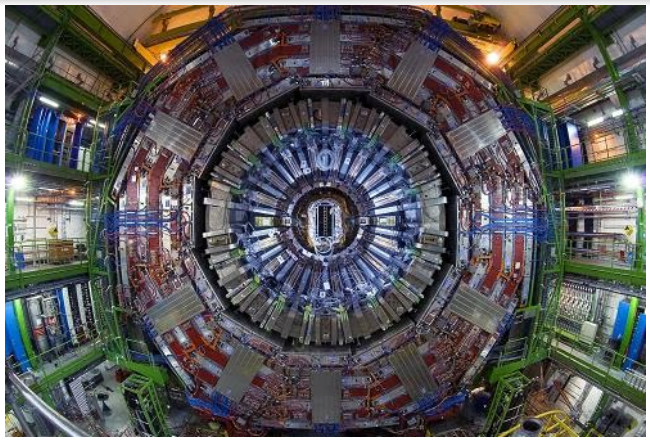
higgstools

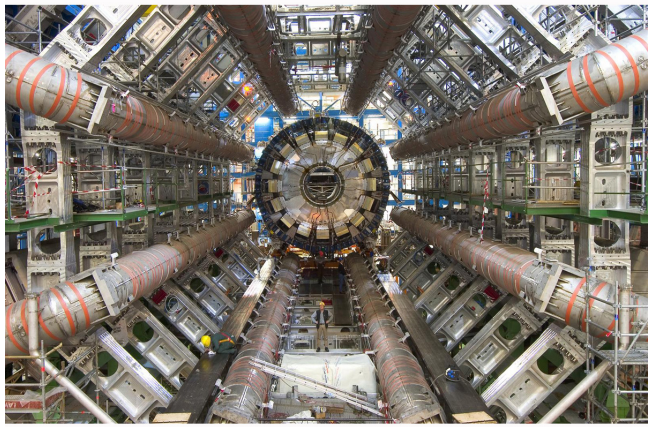
Research

Methodology

The methodology of the project relies mainly on the application and development of computational tools, as well as theoretical-oriented work. For the former, I use a spectrum generator called NMSSMTools. Also, I make extensive use of Fortran, Mathematica and other programming languages.

1. Study theoretically well-motivated regions in parameter space and understand its potential phenomenological implications.
2. Investigate the updated phenomenological constraints from LHC and other experiments.
3. Run scans using NMSSMTools (having to modify it!).
4. Analyse and understand the phenomenology of the allowed points: Look for correlations, detectability and design discovery prospects.





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Research: Results

We identified interesting regions characterized for having low fine tuning and suitably accommodating the current experimental data. These regions features a **lighter Higgs boson**, mainly singlet-like.

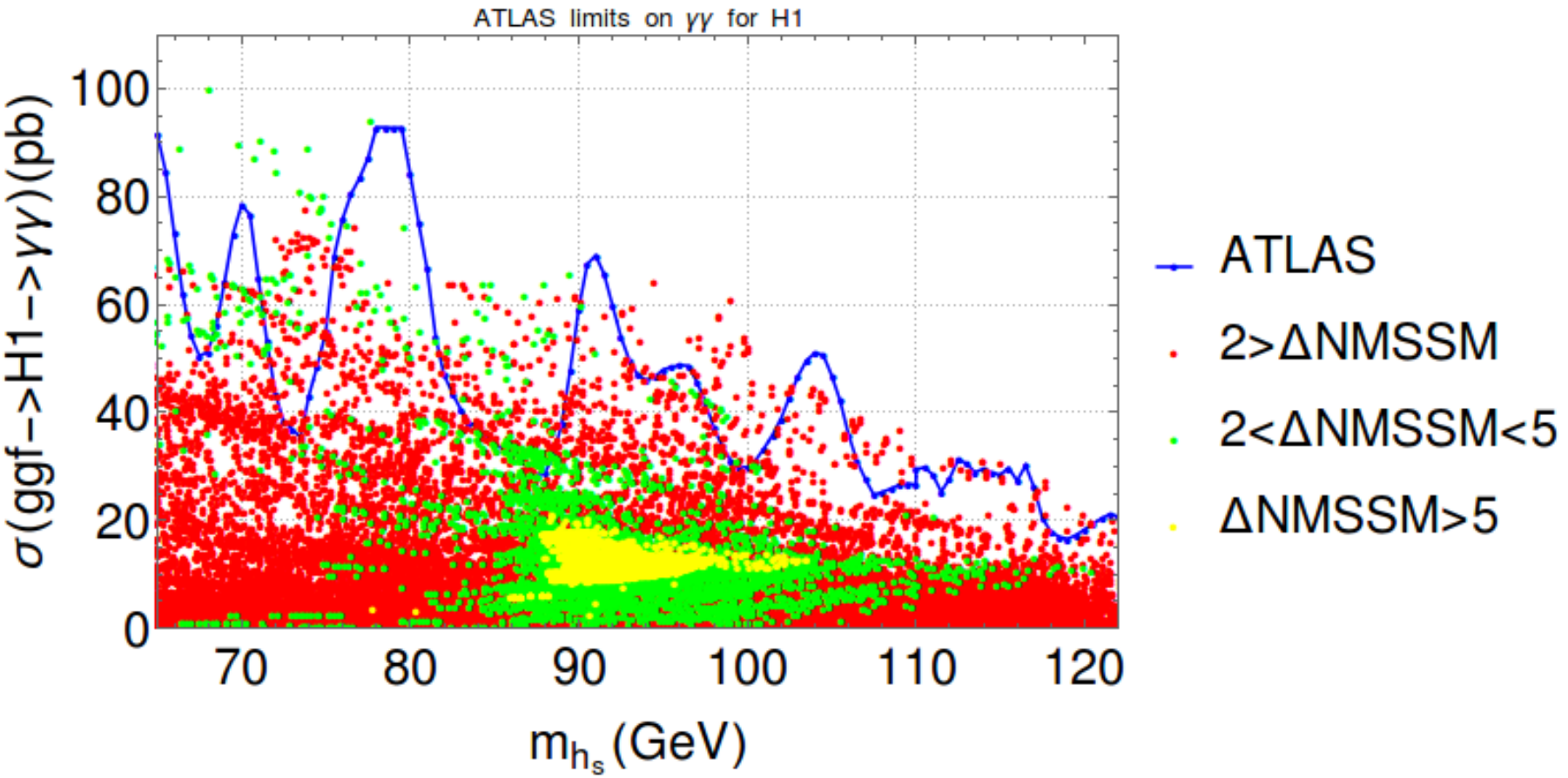

Figure : Points calculated through a scan showing the parameter Δ_{NMSSM} which is related to the amount of radiative corrections needed to reach $m_{h_{SM}} = 125$ GeV.

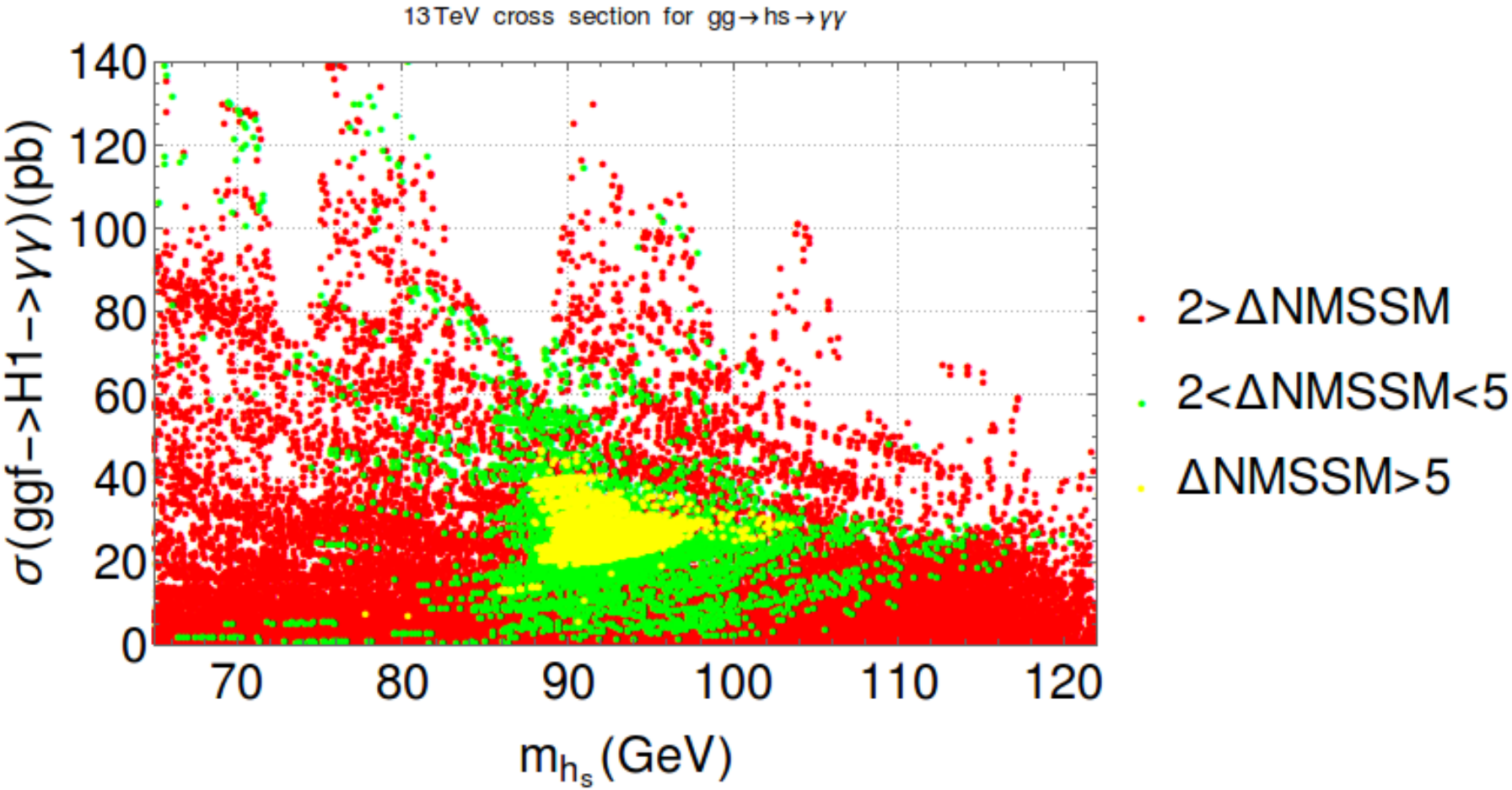

Figure : Diphoton cross section for LHC Run II (13 TeV). The cross section reaches large values which are testable at the LHC!

Research: Results

From precise measurements of the 125 GeV boson we can infer properties of the other Higgs, and exclude regions of parameter space relevant for other Higgs searches.

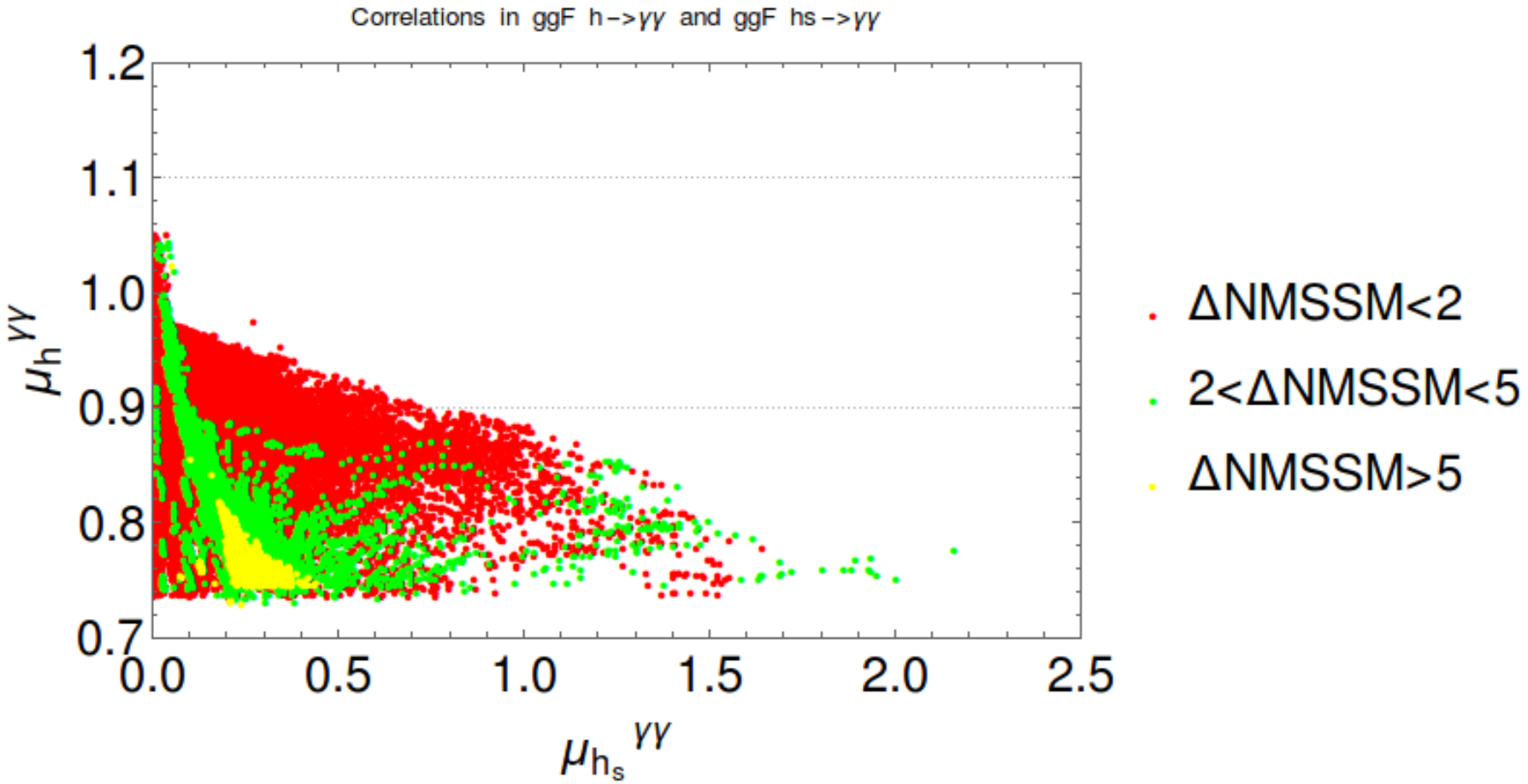

Figure : Correlations between both diphoton signal strengths. The dashed lines show the projected sensitivity on $\mu_{125}^{\gamma\gamma}$, assuming a SM central value for a integrated luminosity of 300 fb^{-1}

Future activities

Future work

- Finish the discovery prospects for a non standard Higgs boson in the gamma gamma channel.
- Study non-standard Higgs to Higgs decays.
- Interpretation of the new LHC data.
- Secondment at Freiburg with the ATLAS collaboration.

Coming soon!

- Talk at GDR Terascale conference in Grenoble, 24th November 2015.
- Publication under construction.
- Potential collaboration with other ESRs planned!

...on my future career...

Impact

- Excellent training in my research field, boosting my academic career.
- Opportunity to work for a private company, providing me with a very good opportunity to know "the other side".
- ...hence ready for any possible professional path after my PhD!