New physics @ the LHC and beyond

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Research activities and plans (in a nutshell)

We have a running machine: the LHC

- Exploit the full potential of the LHC (for new physics)
  - Priority #1 of the European strategy for particle physics
  - Designing new analyses to probe new ideas [Monotops, sgluons, top FCNC, Higgs EFT, high-lumi LHC, *etc.*]
  - Recasting LHC analyses to study models not experimentally considered [Multilepton excesses, natural SUSY, MA5-PAD, *etc.*]
  - Tools development: towards precision [NLO, QCD resummation, *etc.*]

New physics may be hidden

- Only reachable indirectly
  - Dark matter, flavor physics, electroweak precision tests [Non-minimal SUSY, *etc.*]

Future experiments

- Prepare the post-LHC era
  - One of the top priorities in the European strategy for particle physics
  - FCC: study of physics cases very timely to be on-schedule in 2035-2040
  - Proton-proton collisions @ 100 TeV [Top dipole moments, parton densities, *etc.*]
  - Electron-positron collisions @ the TeraZ, okuW, megaHiggs and megatop [Top FCNC, *etc.*]

Automating LO and NLO calculations

[with N. Christensen, E. Conte, K. de Causmaecker, C. Degrande, C. Duhr, S. Frixione, V. Hirschi, F. Maltoni, O. Mattelaer, K. Mawatari, J. Proudom, T. Schmitt, H.S.Shao]

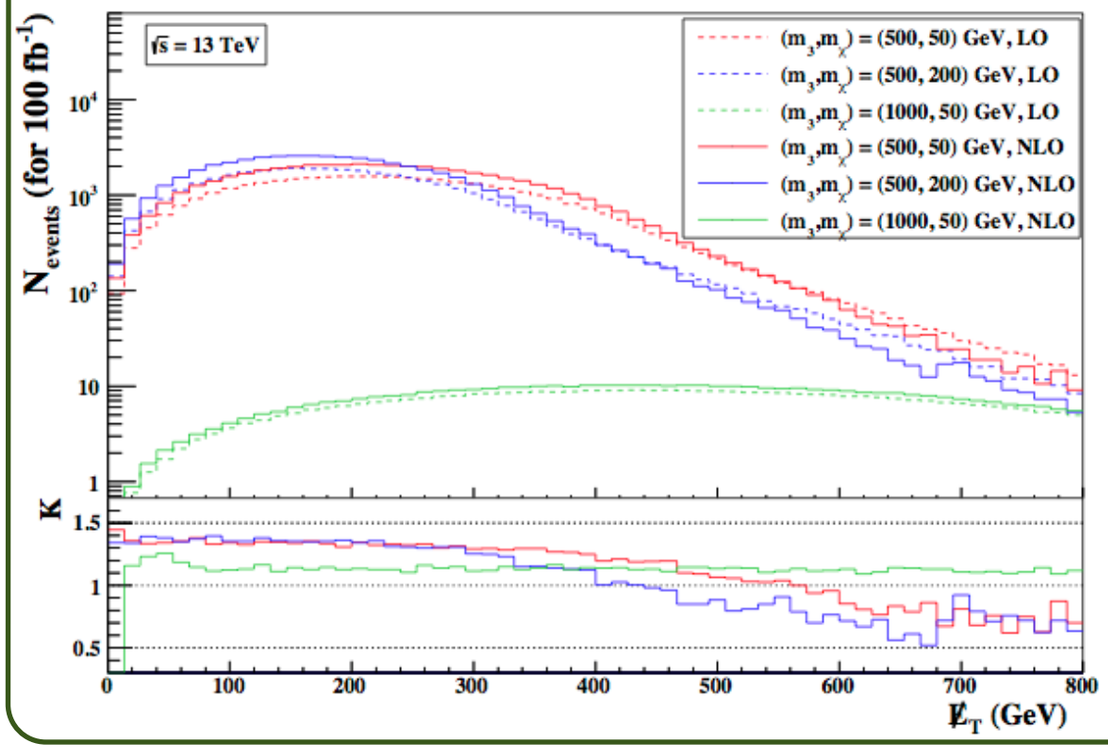
A comprehensive approach to new physics simulations

Idea ↔ Lagrangian → Simulated collisions ↔ Event analysis

FeynRules | UFO | MadGraph aMC@NLO | Pythia Herwig | FastJet Delphes | MadAnalysis

- Streamline the chain from the model Lagrangian to analyzed simulated collisions
  - Works at the leading order [Fully tested and validated for many theoretical frameworks]
  - Recently upgraded to the next-to-leading order accuracy [Being tested in different theoretical frameworks]

Stop pair production at the NLO in QCD



- Simplified model: stop → top neutralino
- Illustrative result: the missing energy distribution
- Constant *K*-factors rescaling the LO results not suitable
- First BSM application of aMC@NLO for models with a non-minimal colored sector
- First full automation of an NLO calculation in this context

- Sgluons have also been implemented
- More models are expected to be available soon

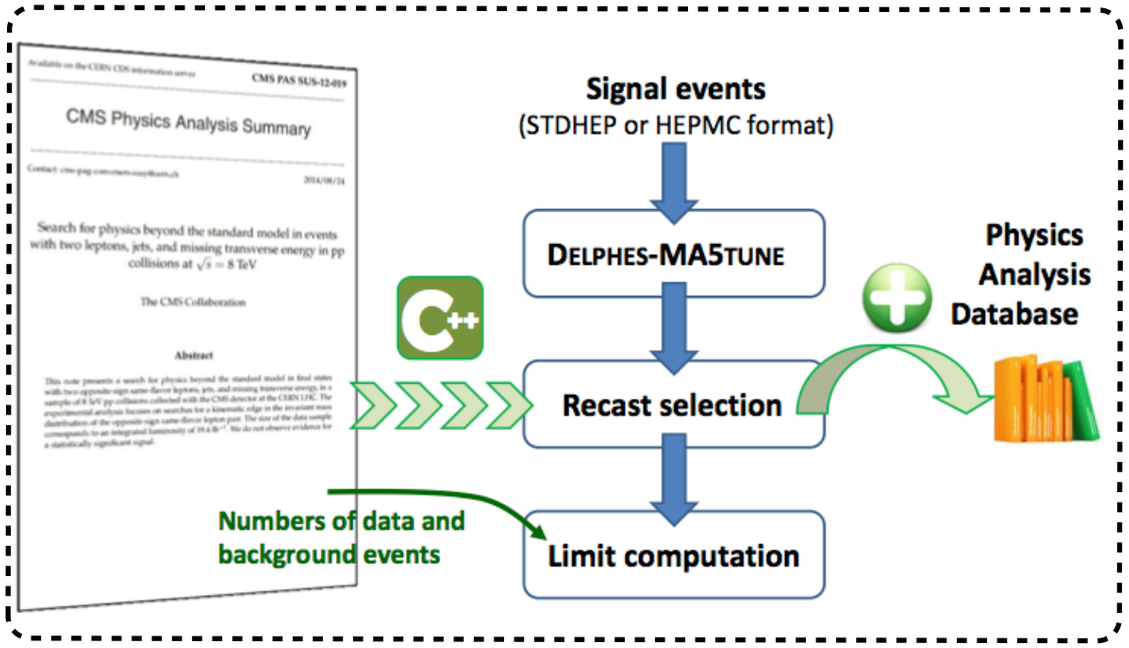
The legacy of the LHC

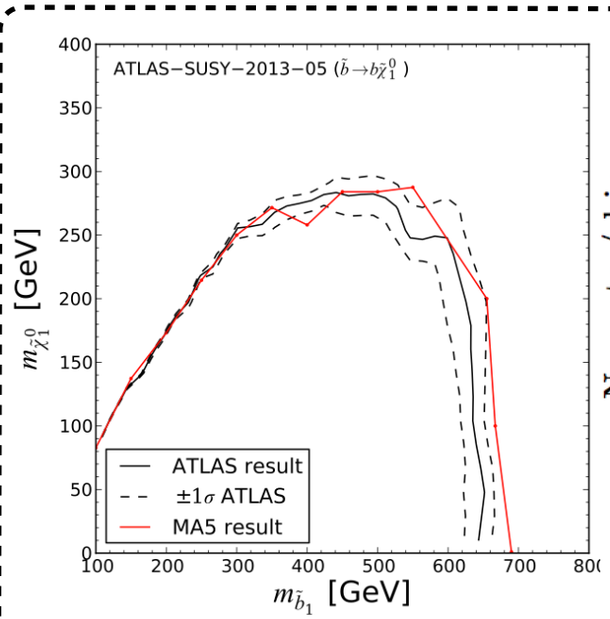
[with L. Basso, S. Bein, M. Blanke, E. Conte, K. de Causmaecker, G. Chalons, B. Dumont, I. Galon, S. Kraml, S. Kulkarni, U. Laa, K. Mawatari, L. Mitzka, G. Perez, W. Porod, D. Sengupta]

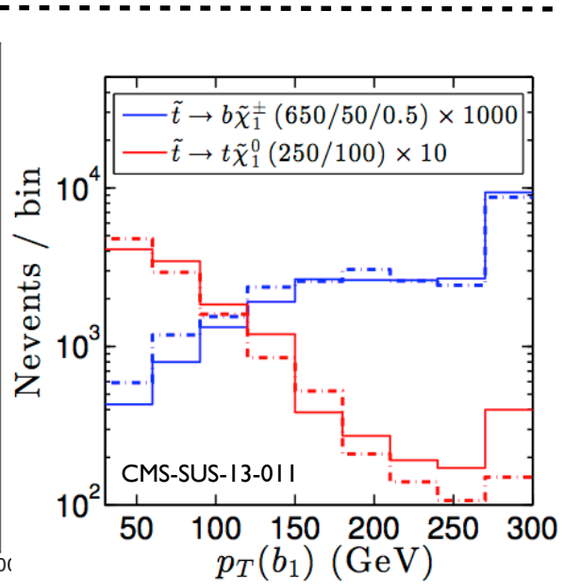
The MADANALYSIS 5 Physics Analysis Database

- The LHC has been built as a discovery machine
  - ★ Many ATLAS and CMS searches for new physics
  - ★ Interpretation within popular frameworks and simplified models
  - ★ Need to reinterpret the results for all kinds of models [Community-wide effort]
- A database with validated recasted analysis codes, easy to use and to check for everybody
  - ★ Bonus: feedback to ATLAS and CMS about their public documentation

The MADANALYSIS 5 strategy for recasting an LHC analysis





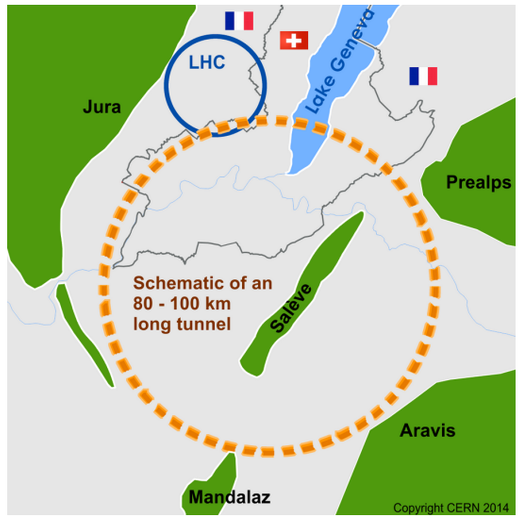


Future Circular Colliders

[with J.A. Aguilar Saavedra, P. Azzi, M. Mangano, F. Margaroli, T. Melia, J. Rojo]

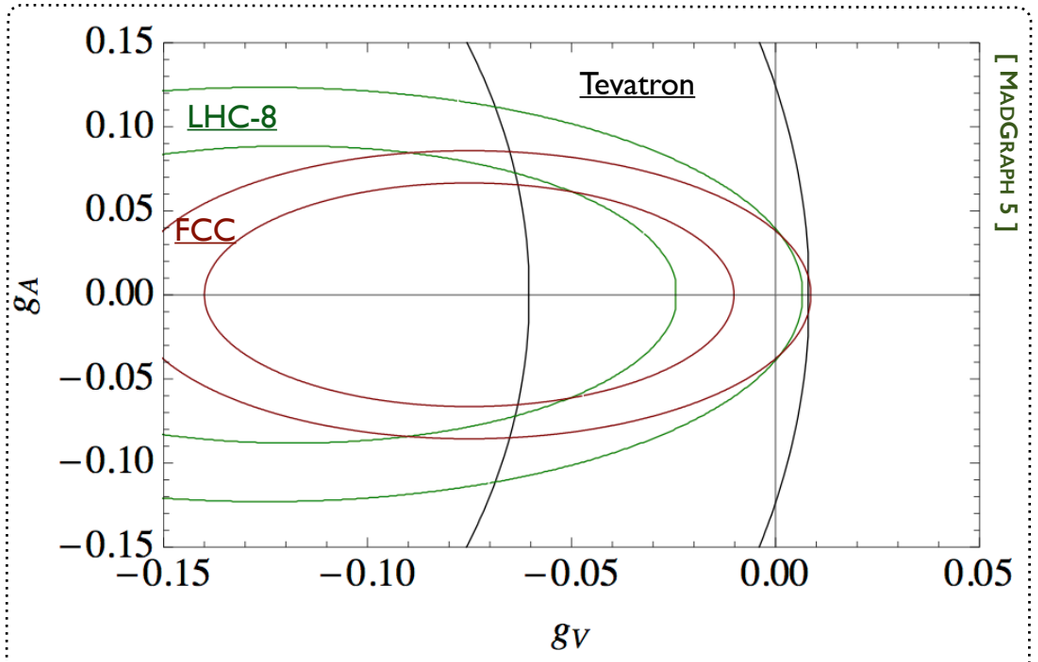
A new kinematical regime for BSM and SM processes opens

- Probing top-antitop systems at large invariant masses
  - Large cross sections ➢ not small event numbers
  - New physics effects could appear
  - Entering the super-boosted regime
    - ★ Requiring muonic top decays
    - ★ Exploiting (top and jet) jets containing muons
  - Large S/B can be obtained: $p_T[\mu]/p_T[j]$

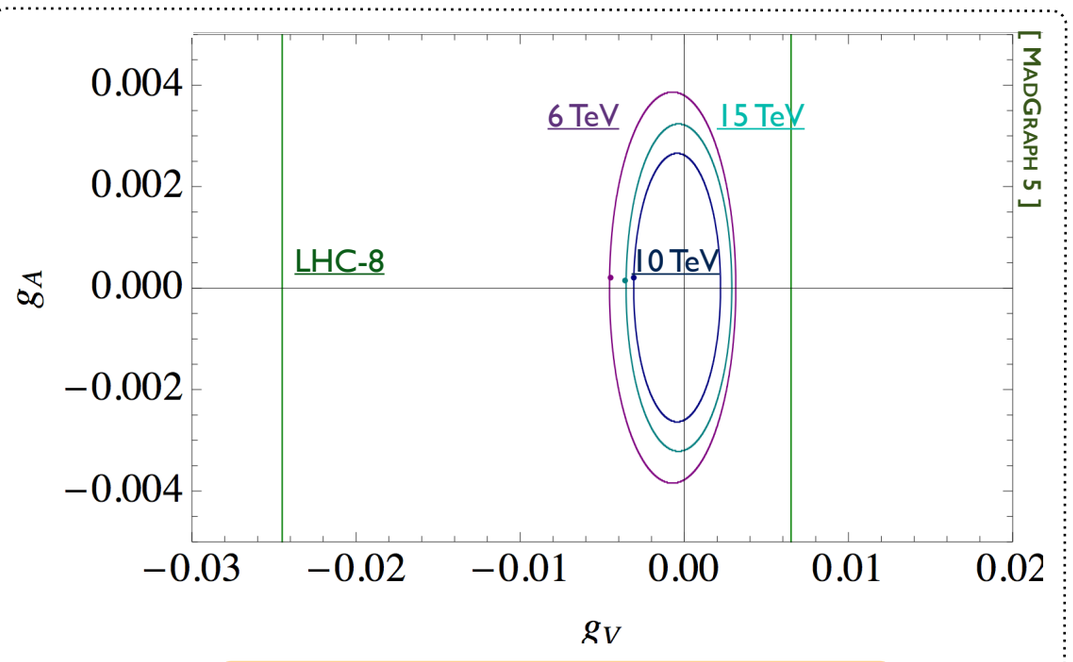


Application: top dipole moments

$$\mathcal{L} = \frac{ig_s}{m_t}\bar{t}\sigma^{\mu\nu}\left[g_V + ig_A\gamma_5\right]T_a t G^a_{\mu\nu}$$



Using total rates



Using highly massive top pairs

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