New physics @ the LHC

Automation and precision

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CERN - IPHC - U. Strasbourg

CERN Theory group retreat

@ Les Houches

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A new physics story at the LHC

Assumption

There is some new physics to be discovered (at the LHC)

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✦ *A priori* preparation
- ✤ Viable model building (top-down & bottom-up)
- ✤ Phenomenological studies
- ✤ Prospective LHC analyses
- ✤ Some tasks rely on Monte Carlo simulations

→ Systematizing/automating the implementation steps
→ Systematizing/automating some of these tasks
→ Physics applications

✦ *A posteriori* reactions to LHC announcements
- ✤ Model building (top-down & bottom-up)
- ✤ Recasting the experimental analyses
- ✤ Designing new analyses to probe new ideas

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The future

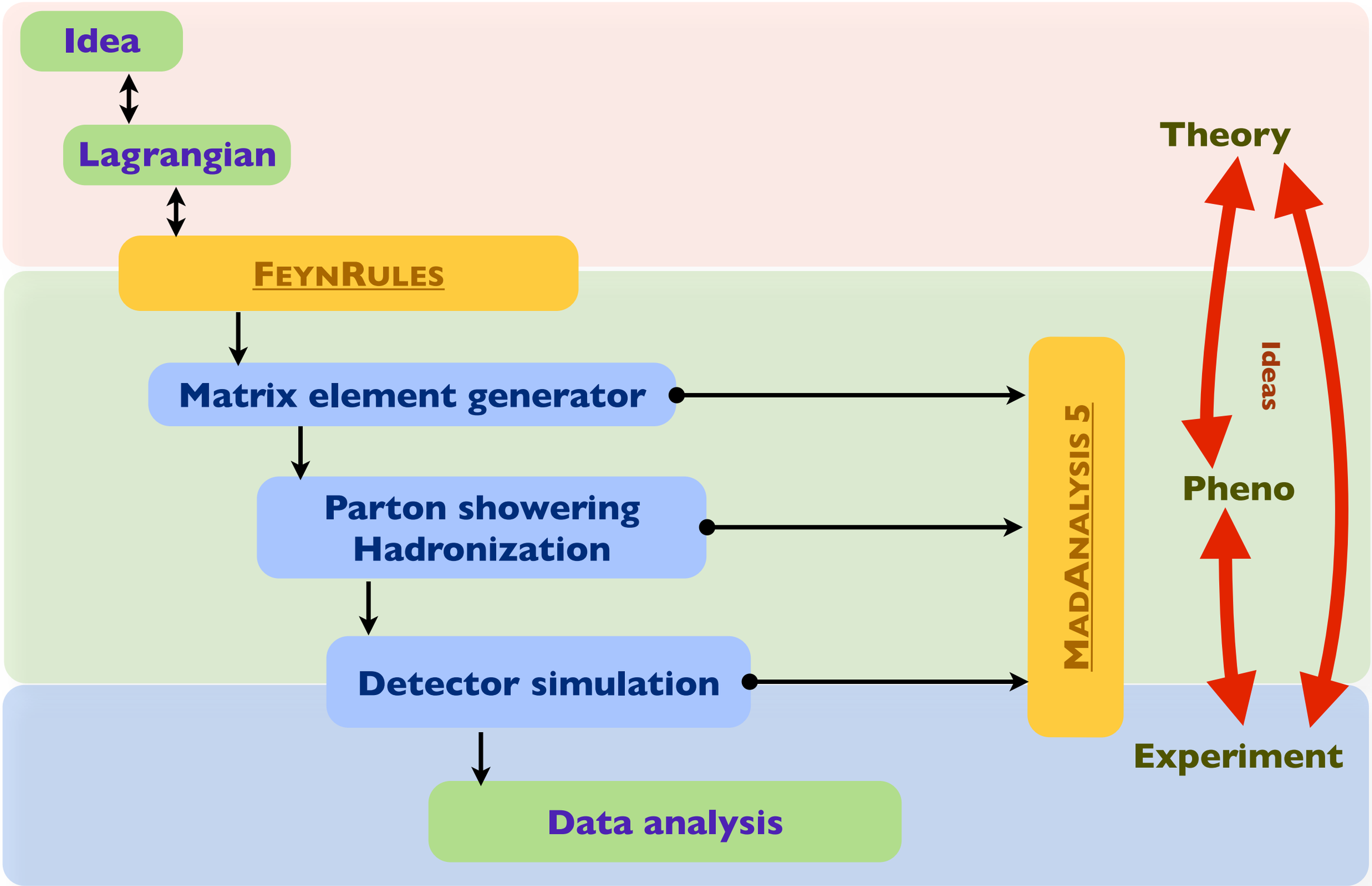
✦ Option 1: new physics clarification
- ✤ Precision predictions ⇔ parameter extractions
- ✤ Higher order computations (also for EFT)
- ✤ Soft gluon resummation

→ Ready-to-be used precision results and tools

✦ Option 2: no excess (new interests)
- ✤ New physics may be hidden elsewhere
  - ★ Flavor physics
  - ★ Dark matter
  - ★ Electroweak precision tests

→ Other tracks must be followed
→ Systematizing/automating the computations

A framework for LHC analyses



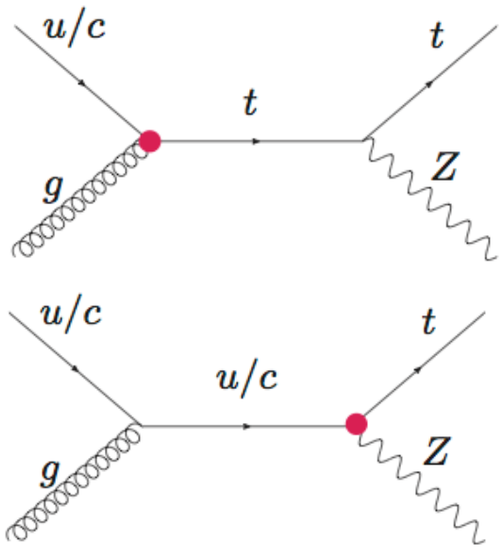
Prospective analyses and recasting

An effective theory for flavor-changing neutral top interactions

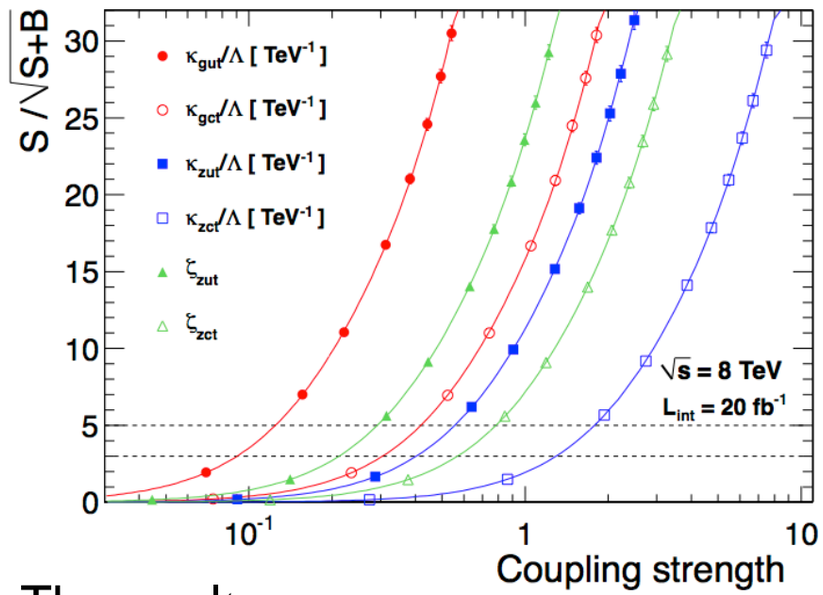
$$\mathcal{L} = \sum_{q=u,c} \Bigg[\sqrt{2} g_s \frac{\kappa_{gqt}}{\Lambda} \bar{t} \sigma^{\mu\nu} T_a (f_q^L P_L + f_q^R P_R) q \; G^a_{\mu\nu} + \frac{g}{\sqrt{2} c_W} \frac{\kappa_{zqt}}{\Lambda} \bar{t} \sigma^{\mu\nu} (\hat{f}_q^L P_L + \hat{f}_q^R P_R) q \; Z_{\mu\nu} + \frac{g}{4 c_W} \zeta_{zqt} \bar{t} \gamma^{\mu} (\tilde{f}_q^L P_L + \tilde{f}_q^R P_R) q \; Z_{\mu} \Bigg] + \text{h.c.}$$

The Lagrangian

This has motivated CMS-TOP-12-021



A novel channel



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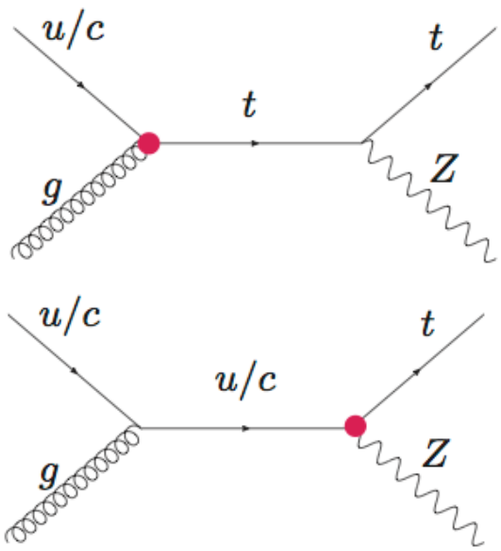

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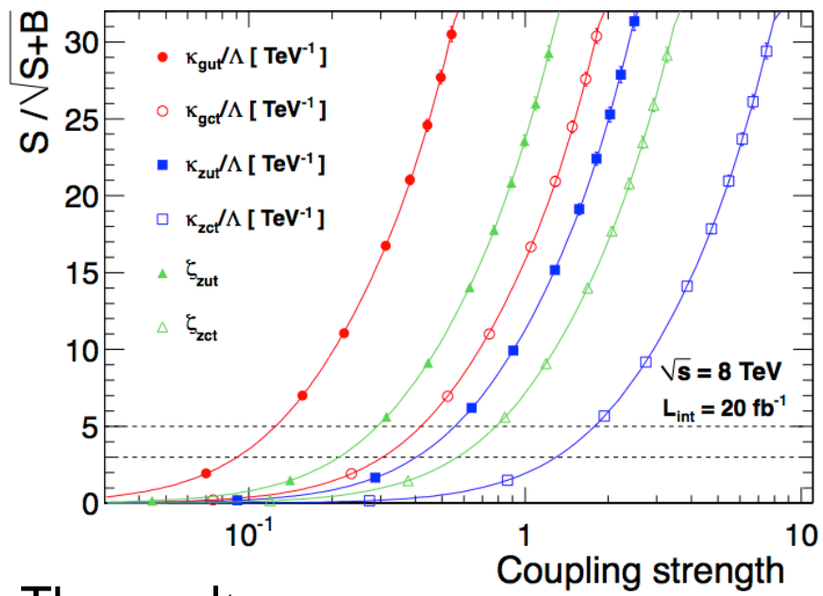

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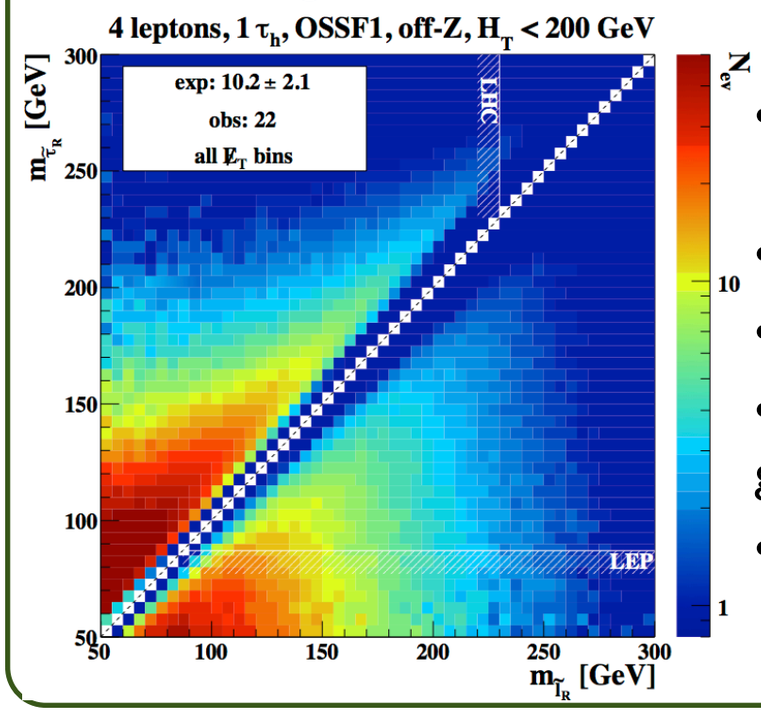
Recasting CMS-SUS-13-002



- Signal: 4 leptons (with one τ_h), low $\not{E}_T$, low H_T, 1 OSSF lepton pair, no reconstructed Z-boson
- 22 observed for 10 expected events
- No other sign of new physics (ATLAS, CMS, LEP)
- All these observations can be explained by general gauge mediated SUSY breaking models
- We propose further possible tests of the model

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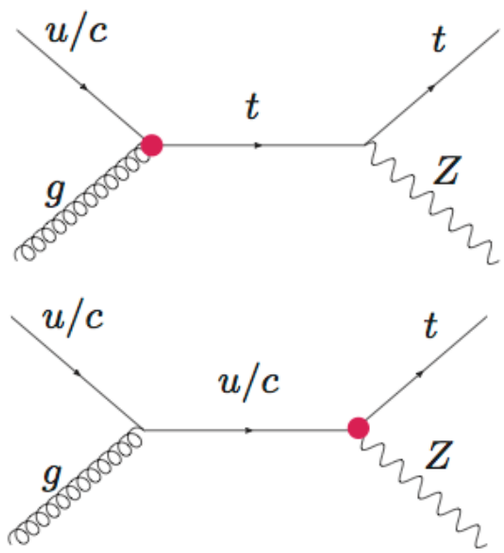

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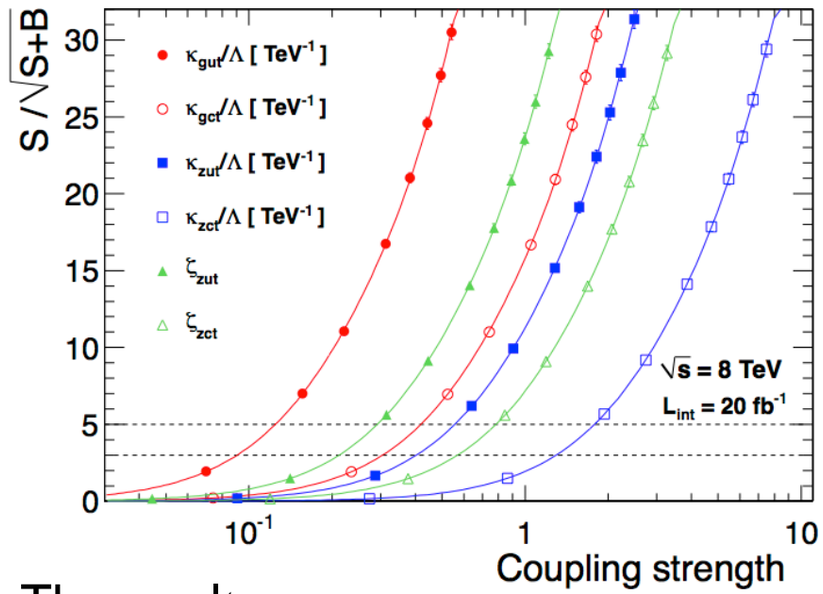

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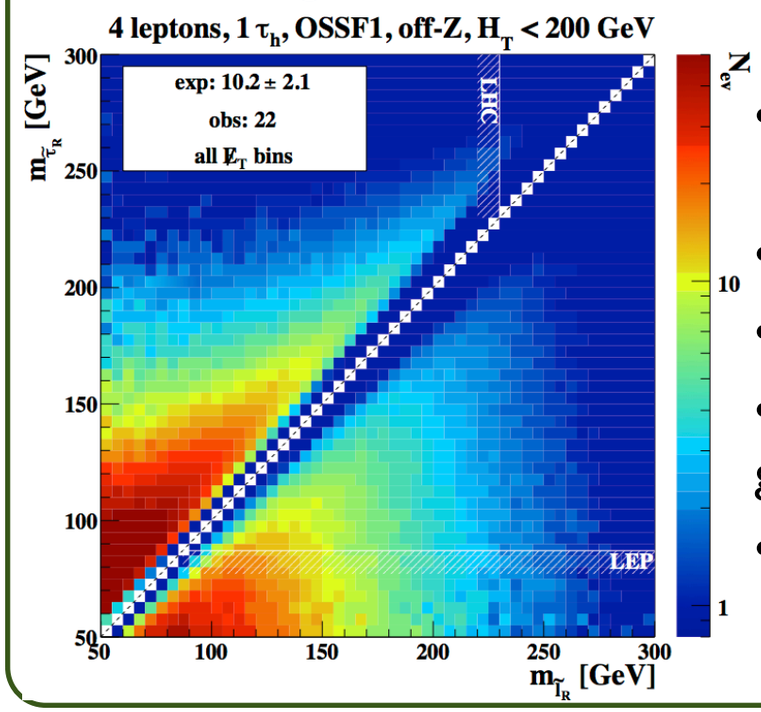

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Current interests

- General GMSB
- Higgs EFT
- Left-right symmetry
- Monotops
- Natural SUSY
- Non-minimal flavor structures in SUSY
- Top EFT

Precision predictions

✦ QCD resummation for new physics processes

- ✤ We consider an IR sensitive observable *R*
- ✤ Soft and collinear radiation gives rise to large logs of scales
- ✤ Generically, two scales M^2 and m^2 to separate:

$$R(M^2, m^2) \to H\left(M^2/\mu^2\right)\, S\left(m^2/\mu^2\right) \to H(1)S(1)\exp\left[-\int_{m^2}^{M^2}\frac{\mathrm{d}q^2}{q^2}\gamma_S(q^2)\right]$$

- ✤ Exponentiation + reduction of the theoretical uncertainties

$M_{\tilde{\ell}}$ [GeV]	Final state	LO [fb]	NLO [fb]	NLL+NLO [fb]
150	$\tilde{\ell}_L^+\tilde{\ell}_L^-$	$18.06^{+3.4\%}_{-19.8\%}$	$21.13^{+11.6\%+4.0\%}_{-2.0\%-5.6\%}$	$20.80^{+0.5\%+4.0\%}_{-0.2\%-5.6\%}$
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✦ Current interests

- ✤ BSM @ NLO
  - ★ Soft gluon resummation
  - ★ Automated counterterm calculations
- ✤ EFT @ NLO
  - ★ Automated calculations of anomalous dimension matrices, beta functions, effective operator mixings, *etc.*
  - ★ In particular for the Higgs

Publications from 01.12.2012

BSM phenomenology

1. Alloul, Fuks & Sanz
   Phenomenology of the Higgs Effective Lagrangian via FeynRules
   arXiv:1310.5150 (submitted to JHEP)
2. d'Hondt, de Causmaecker, Fuks, Mariotti, Mawatari, Petersson & Redigolo
   Multilepton signals of gauge mediated SUSY breaking at the LHC
   arXiv:1310.0018 (submitted to PLB)
3. Alloul, Frank, Fuks, & Rausch de Traubenberg
   Chargino and neutralino production at the LHC in left-right SUSY models
   JHEP 1310 (2013) 033, arXiv:1307.5073
4. Alloul, Frank, Fuks, & Rausch de Traubenberg
   Doubly-charged particles at the Large Hadron Collider
   PRD 88 (2013) 075004, arXiv:1307.1711
5. Agram, Andrea, Conte, Fuks, Gelé & Lansonneur
   Probing top anomalous couplings at the LHC with trilepton signatures
   PLB 725 (2013) 123-126 arXiv:1304.5551
6. Calvet, Fuks, Gris & Valéry
   Searching for sgluons in multitop events at a center-of-mass enerfgy of 8 TeV
   JHEP 1304 (2013) 043, arXiv:1212.3360

MadAnalysis 5

1. Conte & Fuks
   MadAnalysis 5, status and plans
   arXiv:1309.7831 (ACAT proceedings)

CMS notes

1. *Search for flavor-changing neutral currents in single top events*
   CMS-PAS-TOP-12-021

Resummation

1. Fuks, Klasen, Lamprea & Rothering
   Revisiting slepton pair production at the Large Hadron Collider
   arXiv:1310.2621 (submitted to JHEP)
2. Fuks, Klasen, Lamprea & Rothering
   QCD resummation in the framework of supersymmetry
   arXiv:1305.1645 (Moriond proceedings)
3. Fuks, Klasen, Lamprea & Rothering
   Precision predictions for electroweak superpartner production at hadron colliders with Resummino
   EPJC 73 (2013) 2480, arXiv:1304.0790

FeynRules

1. Alloul, Christensen, Degrande, Duhr & Fuks
   FeynRules 2.0 - A complete toolbox for tree-level phenomenology
   arXiv:1310.1921 (submitted to CPC)
2. Alloul, Christensen, Degrande, Duhr & Fuks
   New developments in FeynRules
   arXiv:1309.7806 (ACAT proceedings)
3. Christensen, de Aquino, Deutschmann, Duhr, Fuks, Garcia-Cely, Mattelaer, Mawatari, Oexl & Takaesu
   Simulating spin-3/2 particle at colliders
   EPJC 73 (2013) 2580, arXiv:1308.1668
4. Alloul, d'Hondt, de Causmaecker, Fuks & Rausch de Traubenberg
   Automated mass spectrum generation for new physics
   EPJC 73 (2013) 2325, arXiv:1301.5932