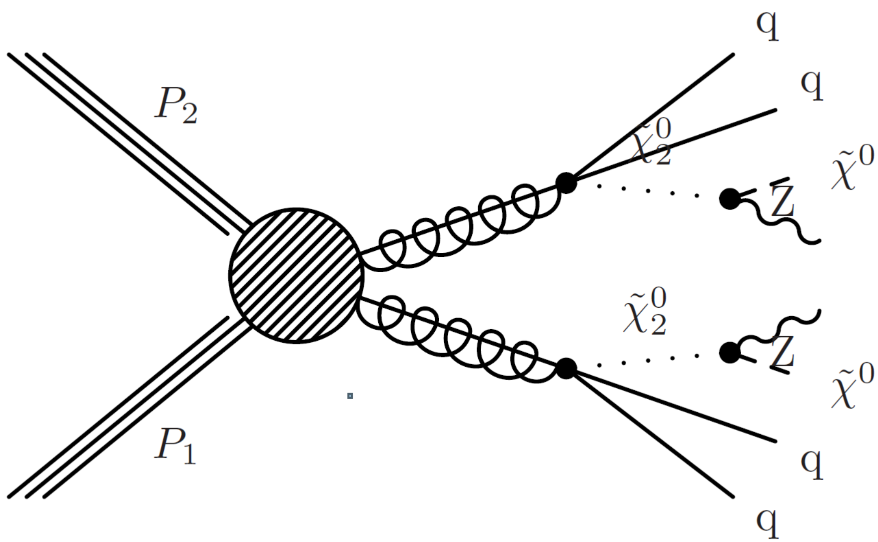
CMS SUSY Searches – Interpretation in Terms of Simplified Models



Wolfgang Waltenberger (HEPHY Vienna)
on behalf of the CMS collaboration

Brookhaven Forum 2011, Brookhaven, NY, USA

October 2011

Introduction

Many searches for new physics have already been implemented or are in the works by the CMS experiment.

No significant excesses above the Standard Model prediction have been observed so far in the data.

In this talk, we distinguish between the *experimental results*, which are model independent and their *interpretation*. This distinction is important because the same experimental results can be interpreted in different ways.

In this talk we concentrate on interpretation in terms of simplified models.

SUSY limits in CMSSM

Historically, the SUSY search groups have focused on CMSSM and GMSB models. Many benchmark points have been identified to cover many possibilities.

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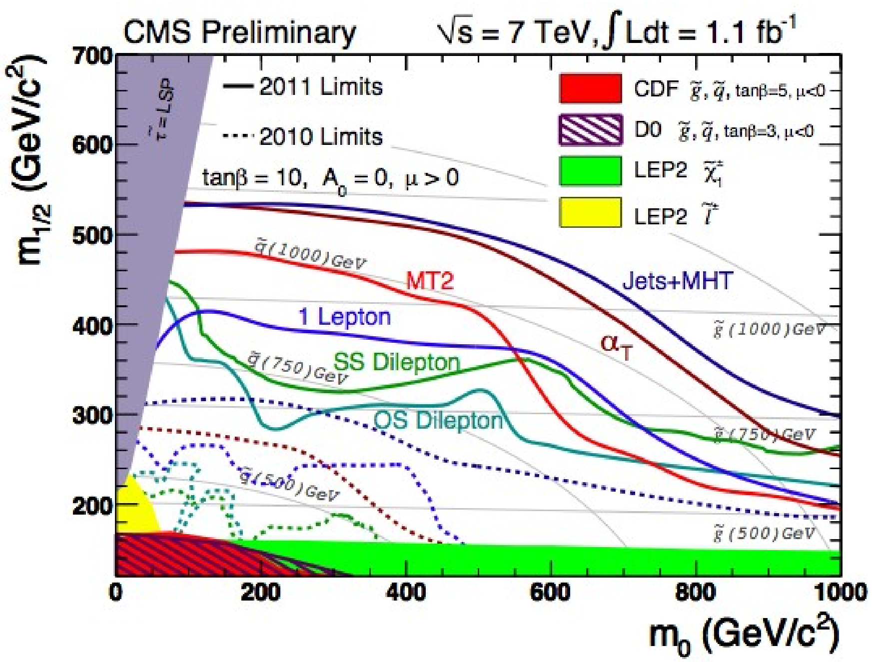


But the CMSSM approach offers only a limited spectrum of mass splittings, and many production and decay channels contribute to each benchmark point in a model-dependent way.

Exclusion contours in the CMSSM plane, for many different CMS analyses

A complementary approach

In addition to the traditional approach using constrained models, it is useful to pursue more flexible interpretations of CMS results. To this end, simplified models are employed.

In a simplified model a limited set of hypothetical particles and decay chains is introduced to describe experimental results of a specific search channel.

The main free parameters of the simplified models are the particle masses and the branching ratios.

No constraints on the parameters are enforced – e.g. the branching ratio is made independent from the particle masses.

The existing exclusion results are re-interpreted as upper limits on the cross-sections times branching ratios (σ x BR) in various simplified models.

The CMS simplified models were chosen to cover a large part of the kinematic phase space of all considered final states. Limits are presented exclusively for each topology.

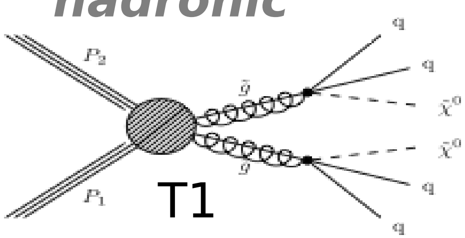
Topologies under study

In the following, we discuss the few topologies that are both distinguishable and salient for a few CMS analyses.

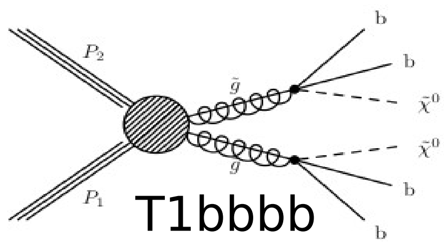
Assumptions:

- Presence of missing transverse energy from stable weakly interacting massive particle (LSP).
- The new particles are strongly produced in pairs.

hadronic

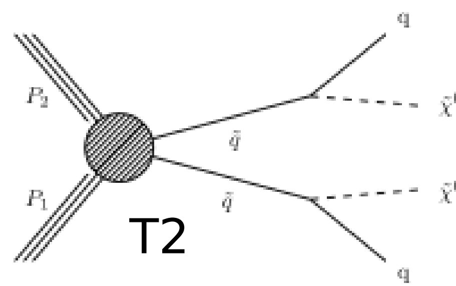


T1



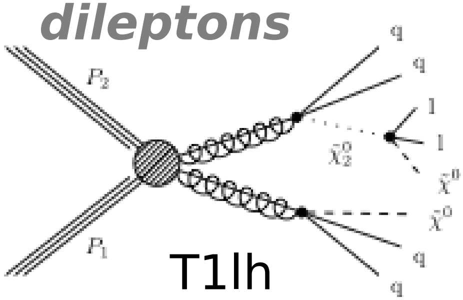
T1bbbb

(a)

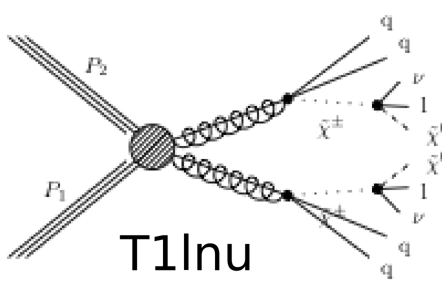


T2

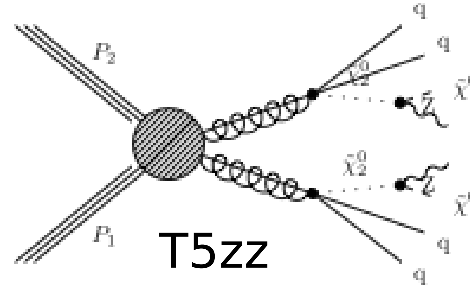
dileptons



T1lh



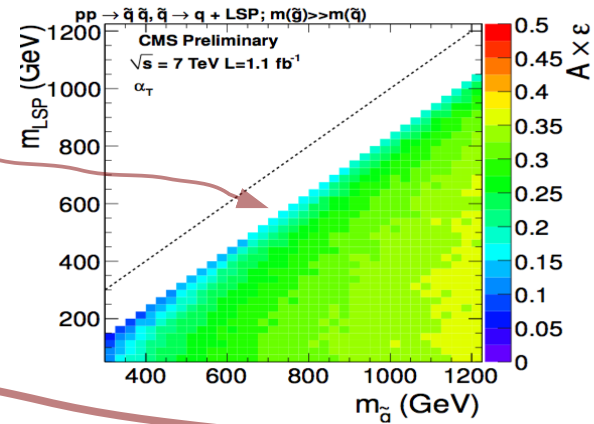
T1lnu

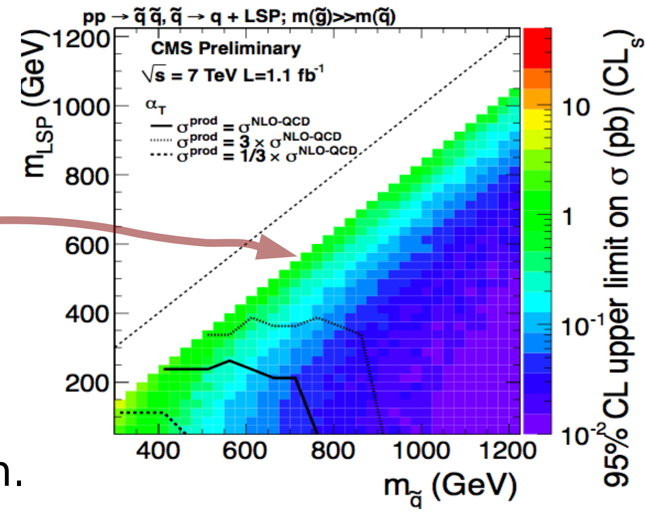


T5zz

Presentation of results

The results are presented in terms of **signal efficiency** and an **upper limit on cross section x BR**.





As reference, these cross sections calculated with Prospino will be used to draw the 95% exclusion contours on the cross section times branching fraction.

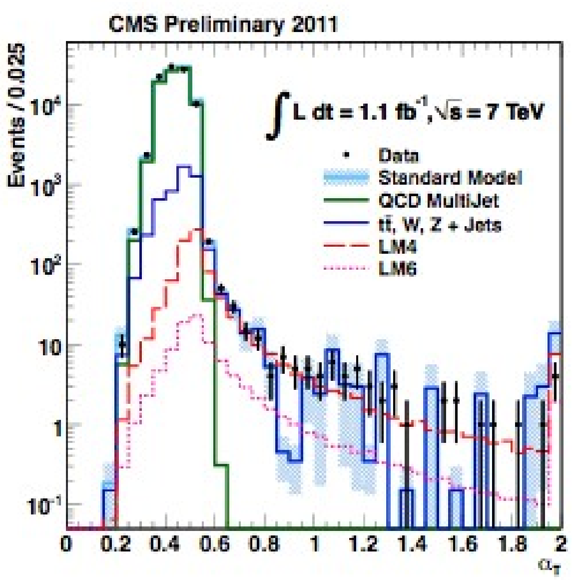
The results are shown as a function of the masses of the particles involved.

Only regions with m(gluino)-m(lsp)> 200 GeV are considered. For lower mass splittings, systematic effects (e.g. initial state radiation) must be better understood.

α_T analysis

CMS-PAS-SUS-11-003

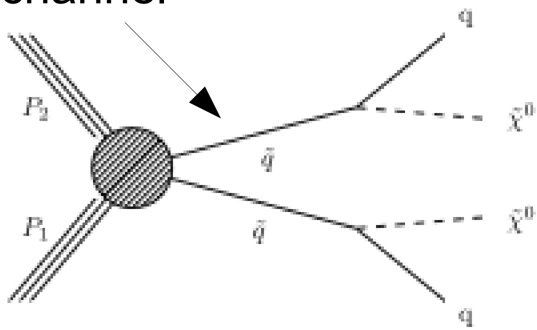
$$\alpha_T = \frac{E_T^{\text{jet}_2}}{M_T} = \frac{E_T^{\text{jet}_2}}{\sqrt{\left(\sum_{i=1}^{2} E_T^{\text{jet}_i}\right)^2 - \left(\sum_{i=1}^{2} p_x^{\text{jet}_i}\right)^2 - \left(\sum_{i=1}^{2} p_y^{\text{jet}_i}\right)^2}},$$



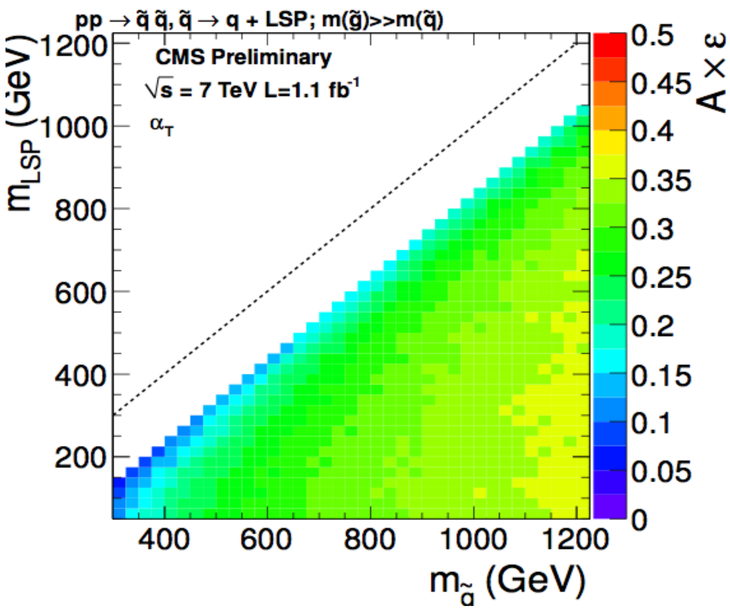
Rather than defining a specific signal region, this analysis searches for an excess of events in data over the Standard Model (SM) expectation in a range of exclusive bins of HT . This is done to make the searches less dependent on the (unknown) energy scale of a new physics signal.

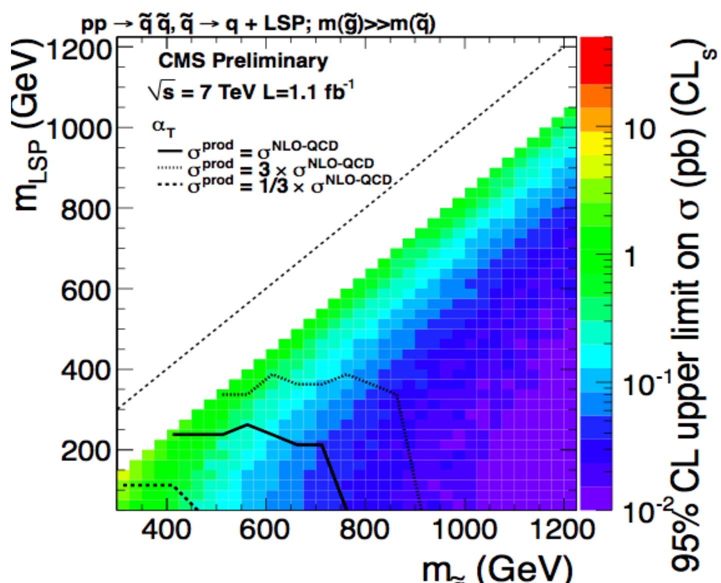
CMS-PAS-SUS-11-003

squark production channel



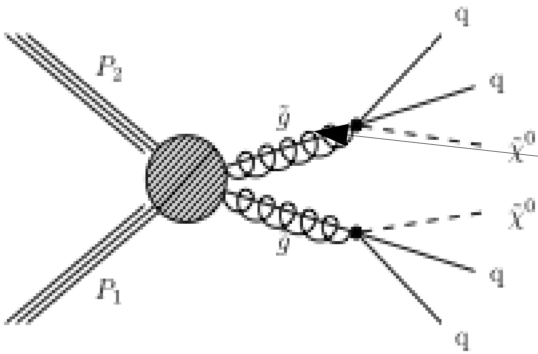
- Low efficiency in the low squark-LSP mass splitting translates into a low cross section upper limit.
- At high squark mass, higher selection efficiency compensated by lower cross section.
- For compressed spectra, results in a poor limit as well.



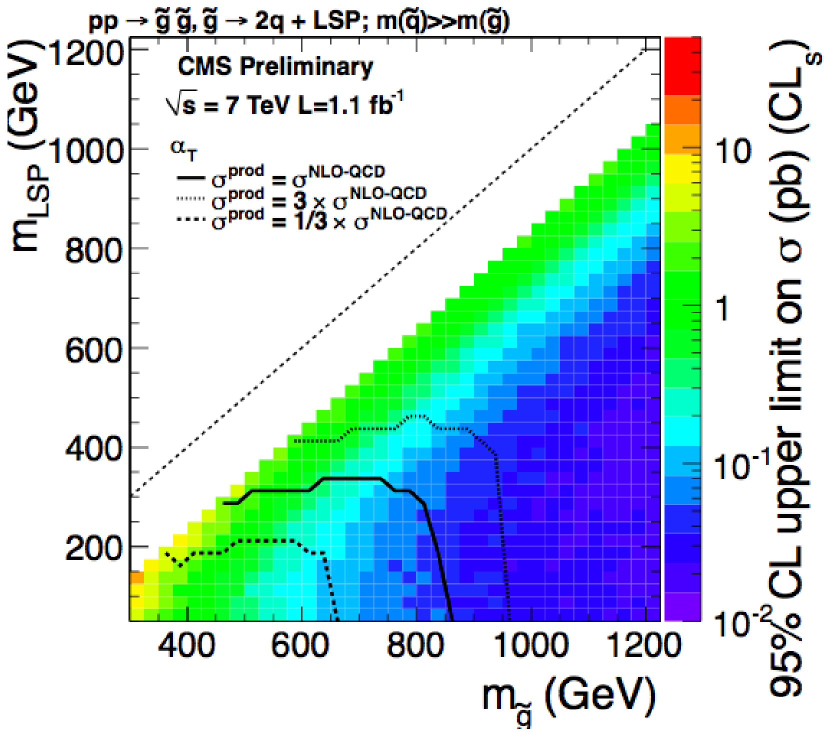


α_T analysis: limits on T1

CMS-PAS-SUS-11-003

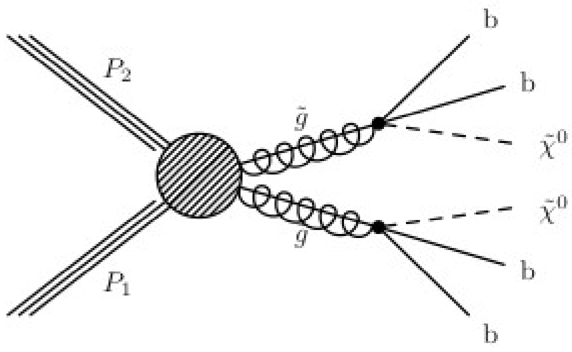


gluino production channel



MT2 analysis: limits on T1bbbb

CMS-PAS-SUS-11-005

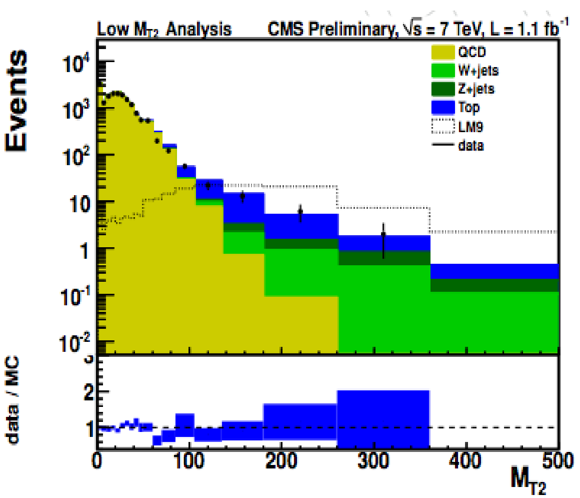


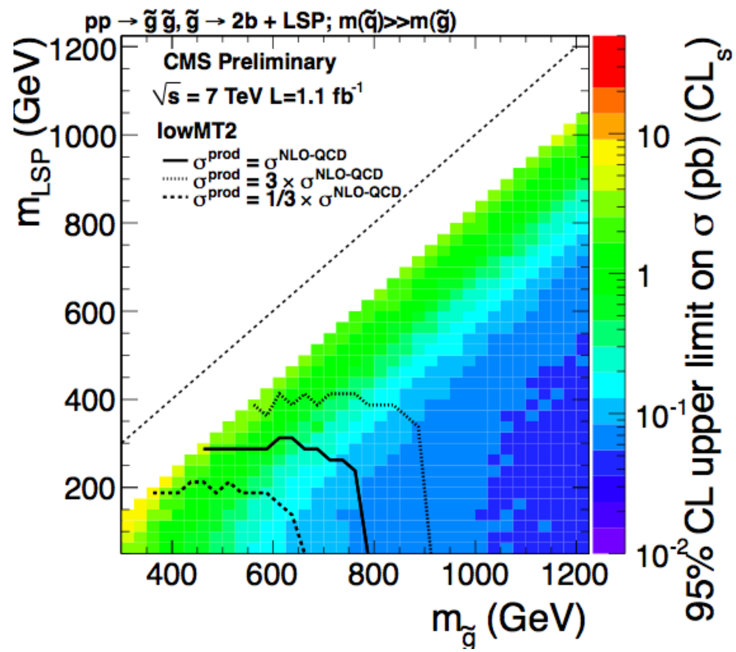
(a)

This is our first simplified model to look at third generation activity.

This analysis uses the MT2 observable to suppress the background and requires at least one jet in the final state to be identified as b.

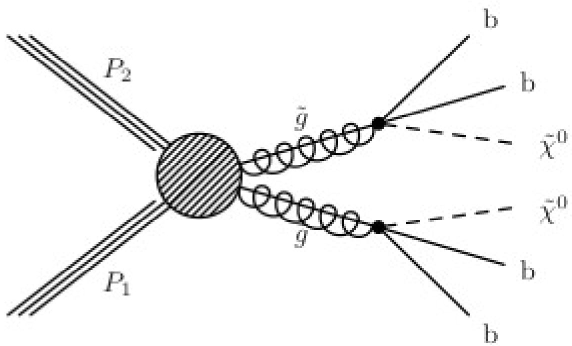
$$(M_{T2})^2 = 2A_T = 2p_T^{vis(1)} p_T^{vis(2)} (1 + cos\phi_{12}),$$





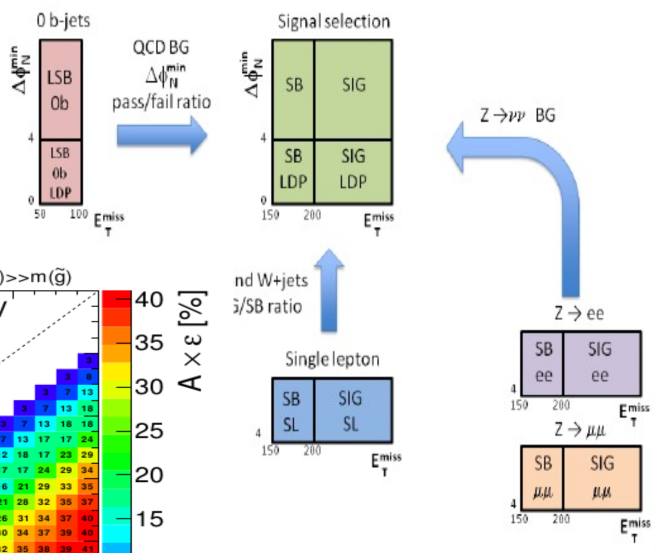
MET+b analysis: limits on T1bbbb

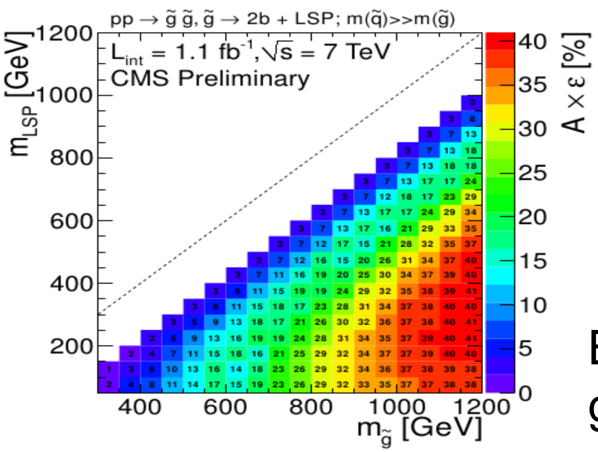
CMS-PAS-SUS-11-006

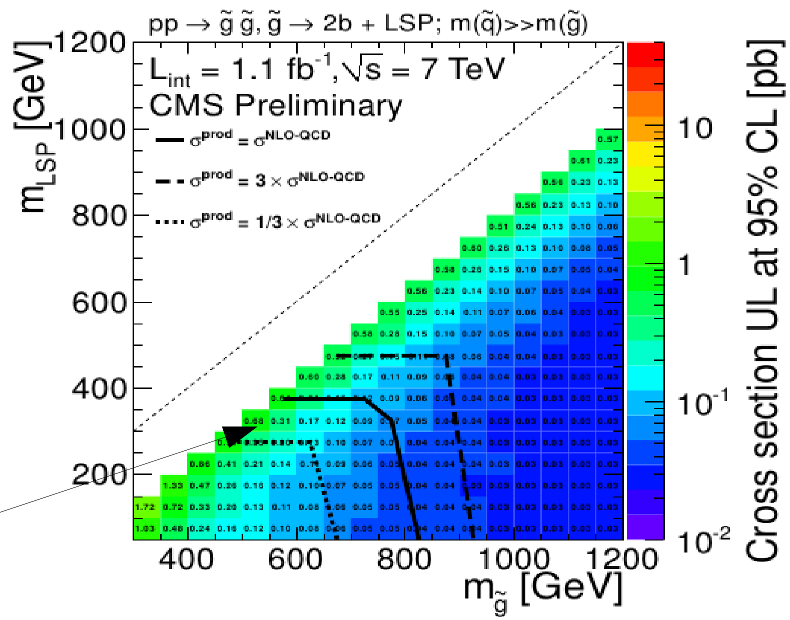


(a)

Another analysis that looks for missing energy, jets and one or more b-tagged jets.



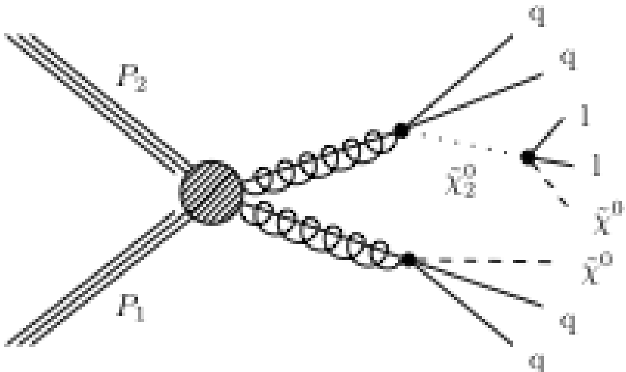




B-jets requirements good for compressed spectra.

Opposite-sign dileptons: limits on T1Lh

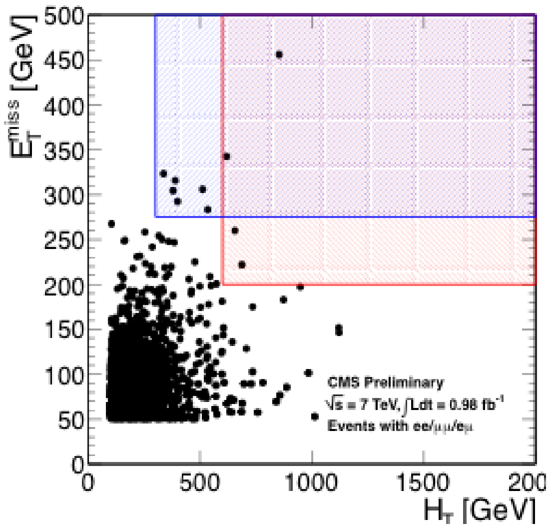
CMS-PAS-SUS-11-011

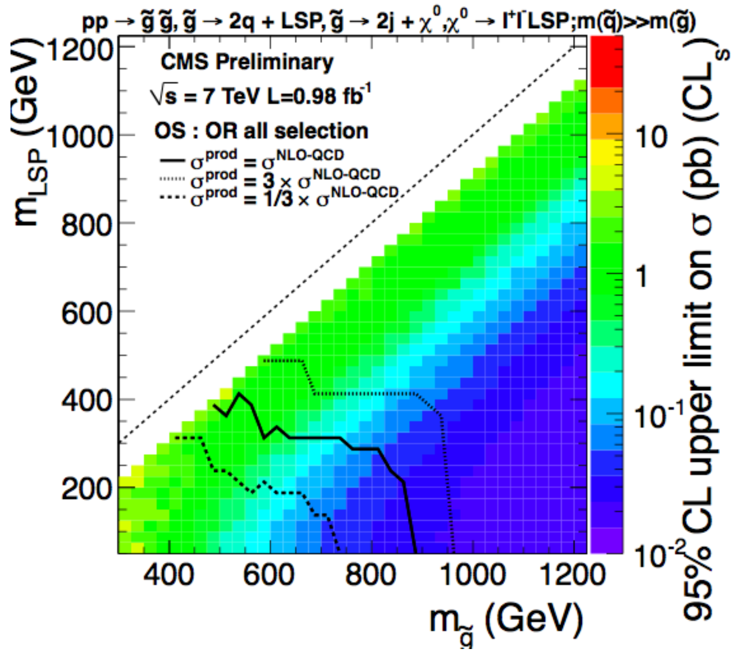


In this topology the heavy neutralino is forced to decay in a three-body final state.

We search for an excess of events with opposite flavor or same flavor and outside the Z mass window accompanied by large MET and HT.

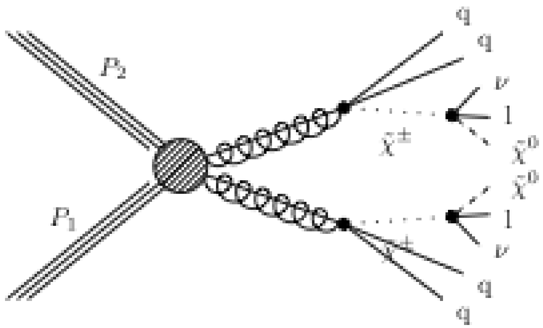
$$m(\tilde{\chi}^{\pm}\ l\ \tilde{\chi}_2^0) \equiv \frac{m(\tilde{g}) + m(\tilde{\chi}^0)}{2}$$





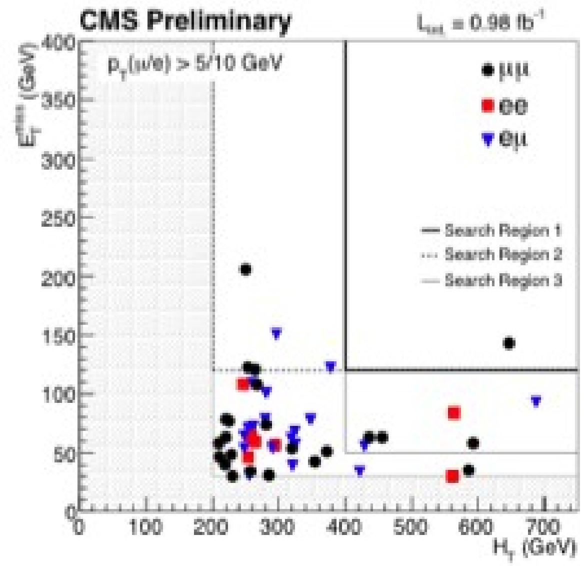
Same-sign dileptons: limits on T1lnu

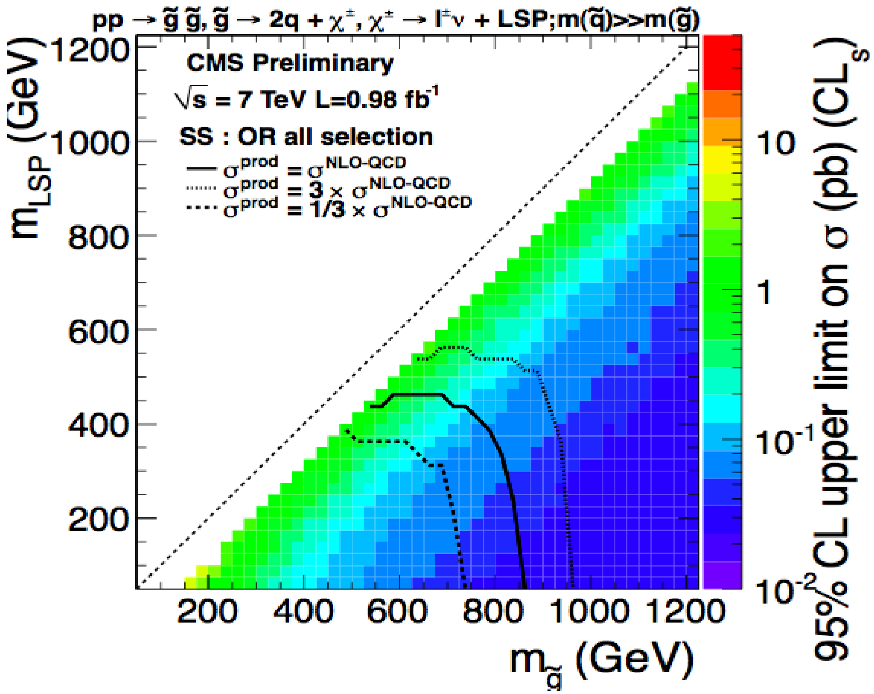
CMS-PAS-SUS-11-010



A search for the same-sign dileptons is almost background-free.

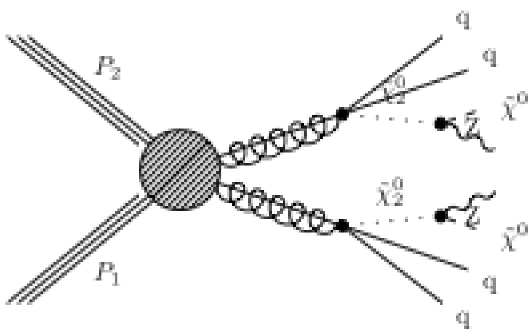
$$m(\tilde{\chi}^{\pm}\,|\,\tilde{\chi}_2^0) \equiv \frac{m(\tilde{g}) + m(\tilde{\chi}^0)}{2}$$





Z+MET analysis: limits on T5zz

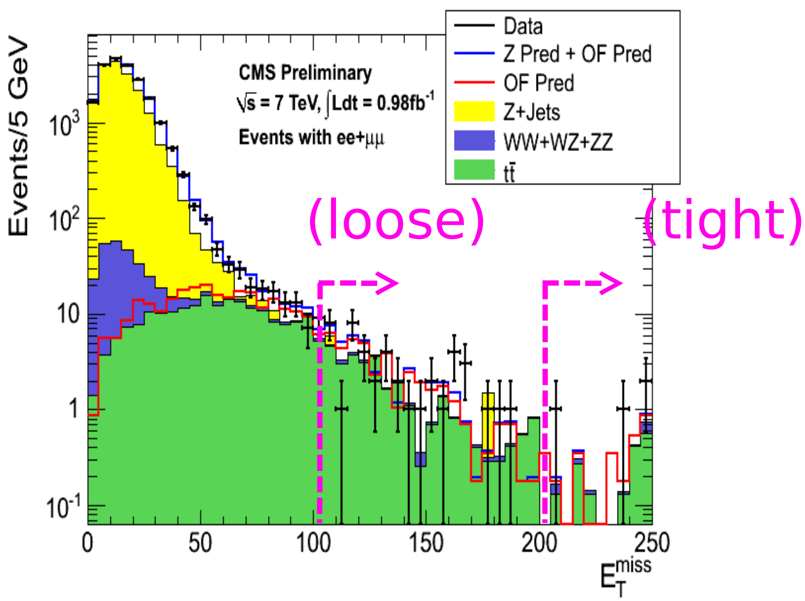
CMS-PAS-SUS-11-017

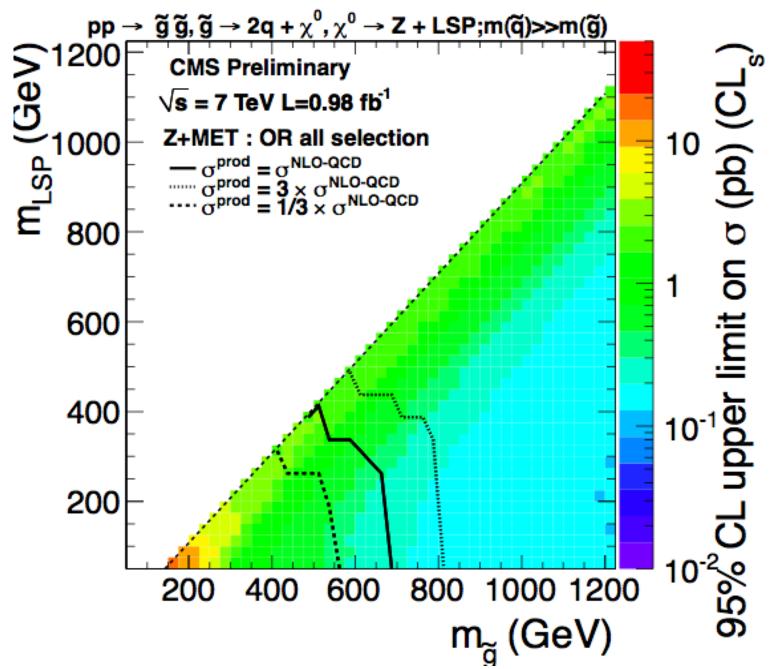


$$m(\tilde{\chi}^{\pm}\ \mathrm{l}\ \tilde{\chi}^{0}_{2}) \equiv \frac{m(\tilde{g}) + m(\tilde{\chi}^{0})}{2}$$

A search for the Z to leptons plots jets final state allows a low threshold on the jet activity requirements.

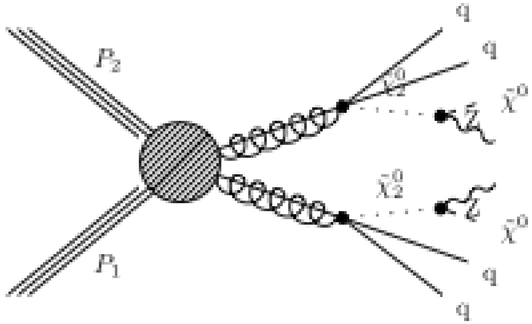
Low gluino-LSP mass splitting can be probed with the loose met selection.





JZB analysis: limits on T5zz

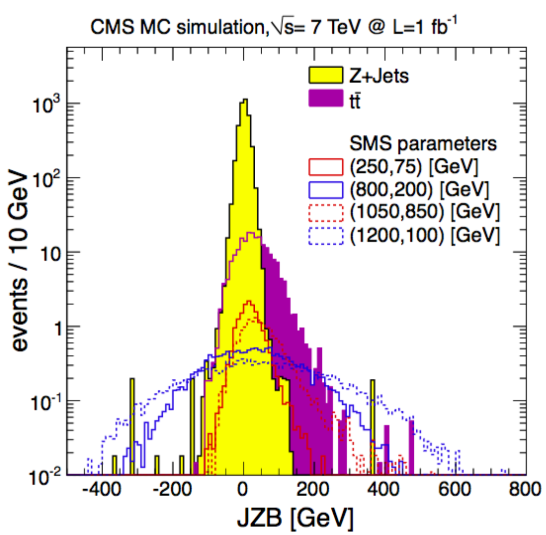
CMS-PAS-SUS-11-012

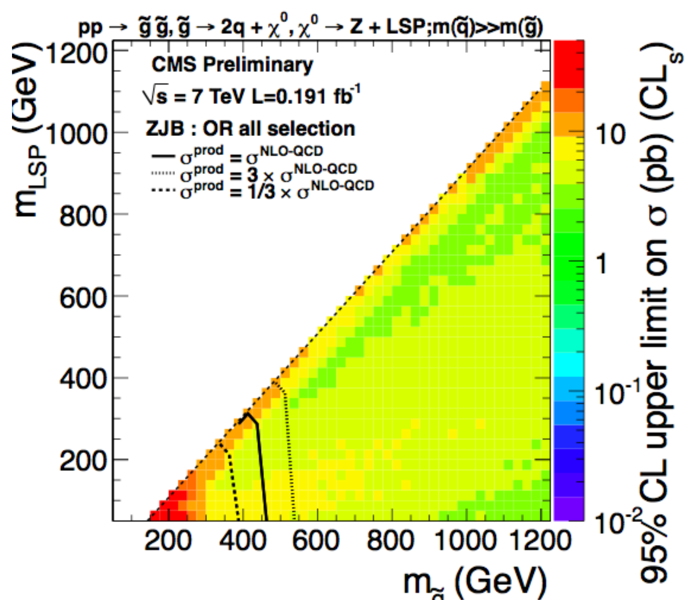


A complementary method probing the same signature but based on different control samples.

m($\tilde{g}$) + m($\tilde{\chi}^0$)

$$JZB = \left| -\sum_{\text{jets}} \vec{p}_T \right| - \left| \vec{p}_T^{\,(Z)} \right|$$

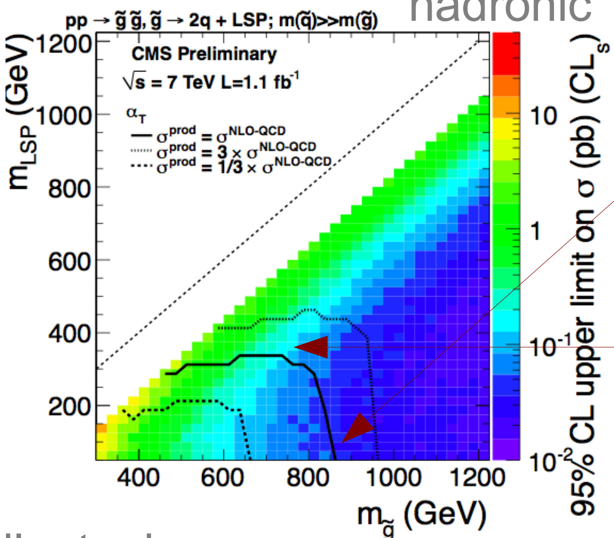




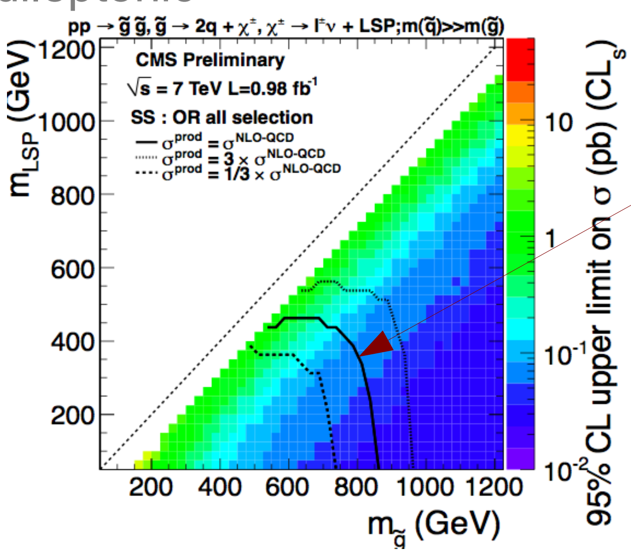
Signal contamination in the data driven method prediction subtracted.

Summary

hadronic



dileptonic

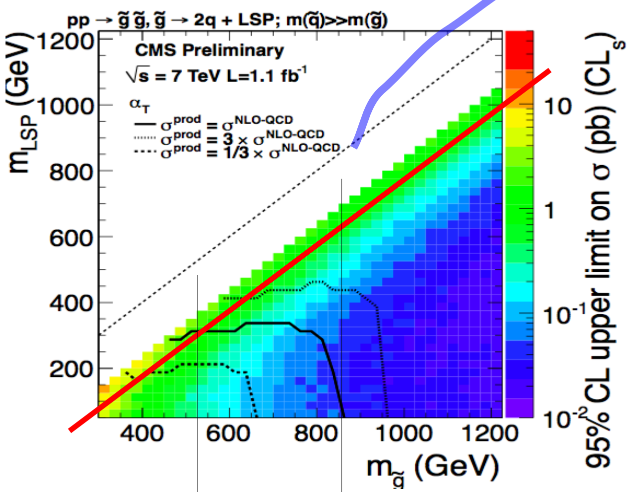


For (hadronic) models similar to the CMSSM (i.e. low LSP mass), the typical exclusion limit is ~ 800 GeV in gluino mass.

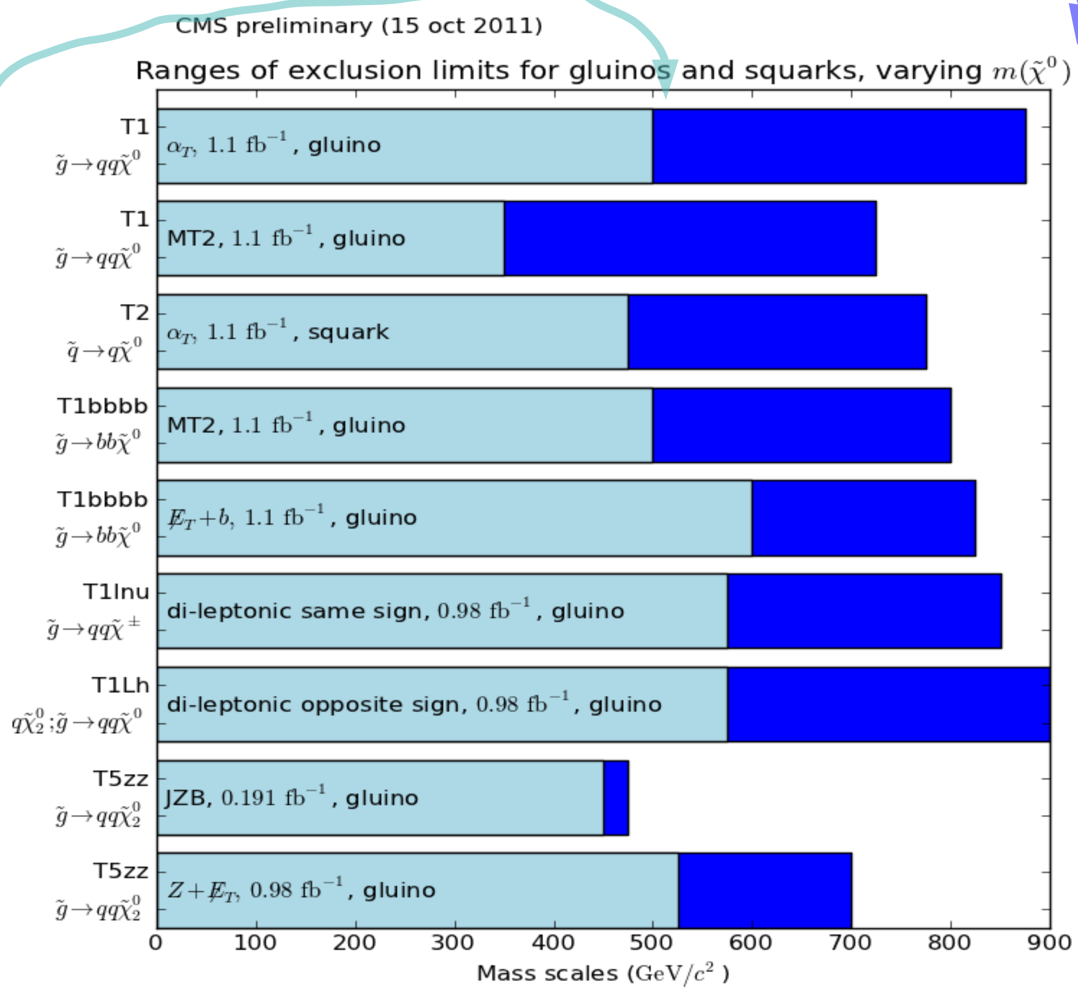
But for more compressed spectra the picture changes.

E.g. the same-sign dilepton methods are better at probing compressed spectra.

Summary



Exclusion limits for BR=1, with varying assumption for m(LSP).



For limits on $m(\tilde{g})$, $m(\tilde{q}) >> m(\tilde{g})$ (and vice versa). $\sigma^{\rm prod} = \sigma^{\rm NLO-QCD}$.

$m(\tilde{\chi}^{\pm}), m(\tilde{\chi}_2^0) \equiv \frac{m(\tilde{g})+m(\tilde{\chi}^0)}{2}$.

$m(\tilde{\chi}^0)$ is varied from 0 GeV/c^2 (dark blue) to $m(\tilde{g})-200$ GeV/c^2 (light blue).

Summary

- Simplified models have been a valuable tool to understand the sensitivities of our searches, especially when probing a wider spectrum of kinematic possibilities.

- Summer results have been shown, based on ~ 1 fb^{-1} on data. Exclusions only, so far.
- Winter results will be based on up to 5 fb^{-1} .

- Simplified models are a good model-independent way of summarizing and publishing our search results.

Outlook

- More CMS analyses will likely present their results in simplified models with more data soon.
- More simplified models on our list. Focus of the new models: third generation activity, new production modes (e.g. associate production)
- Work on showing closure of simplified models approach underway.