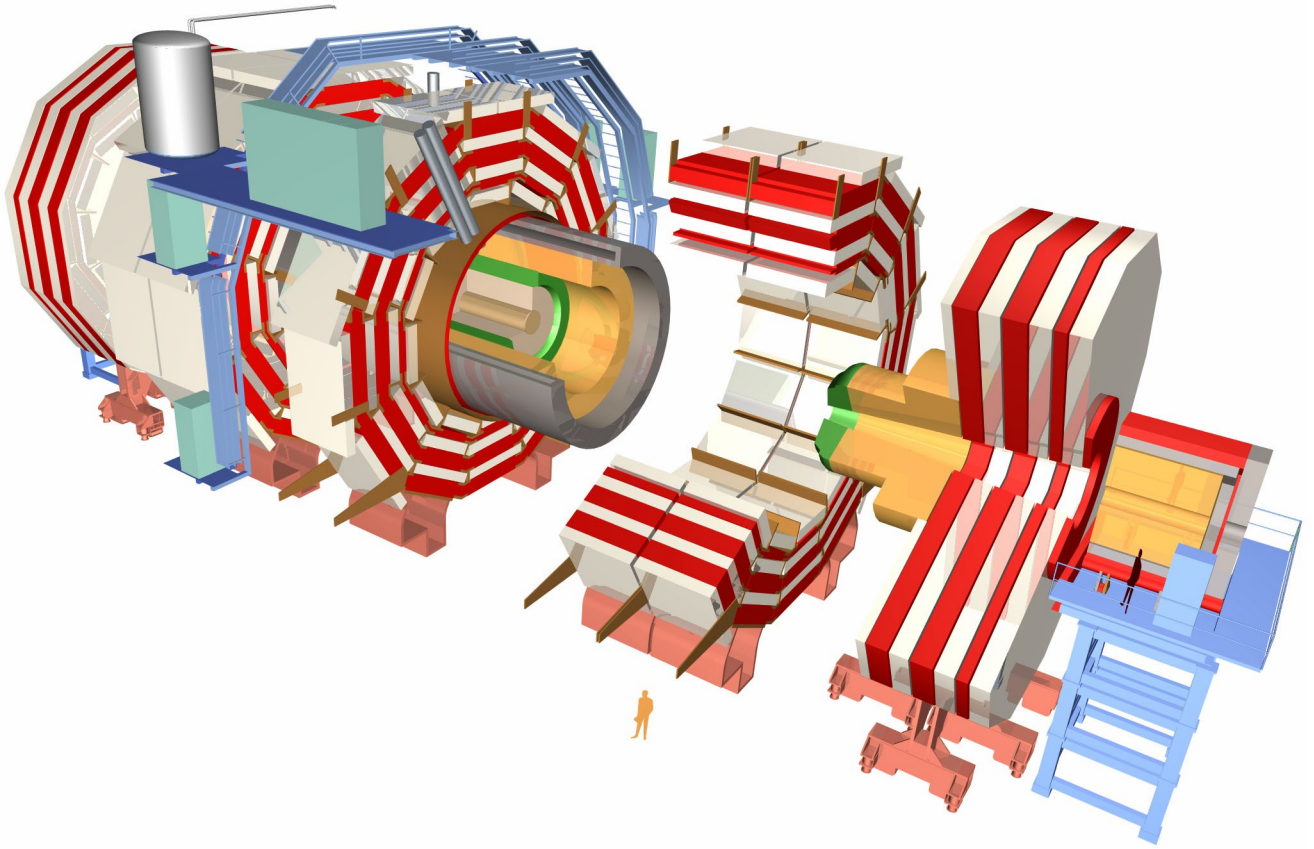
SUSY Searches at CMS



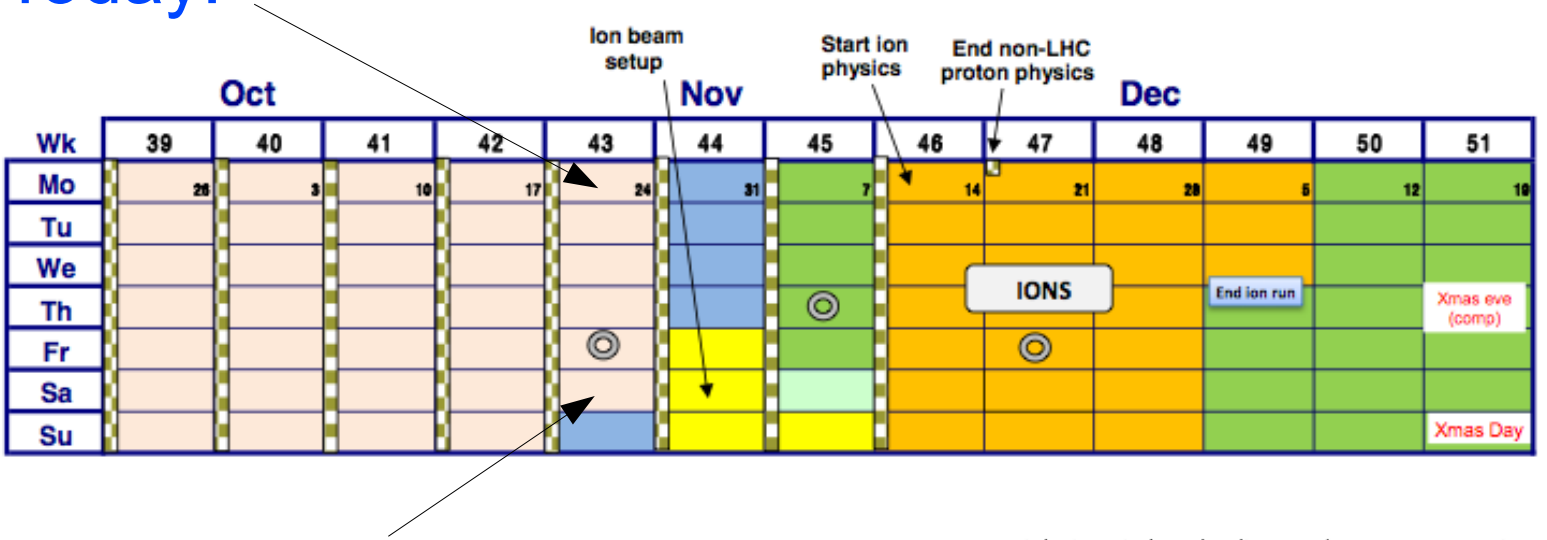
Dean Horton
DESY
24th October 2011

Contents

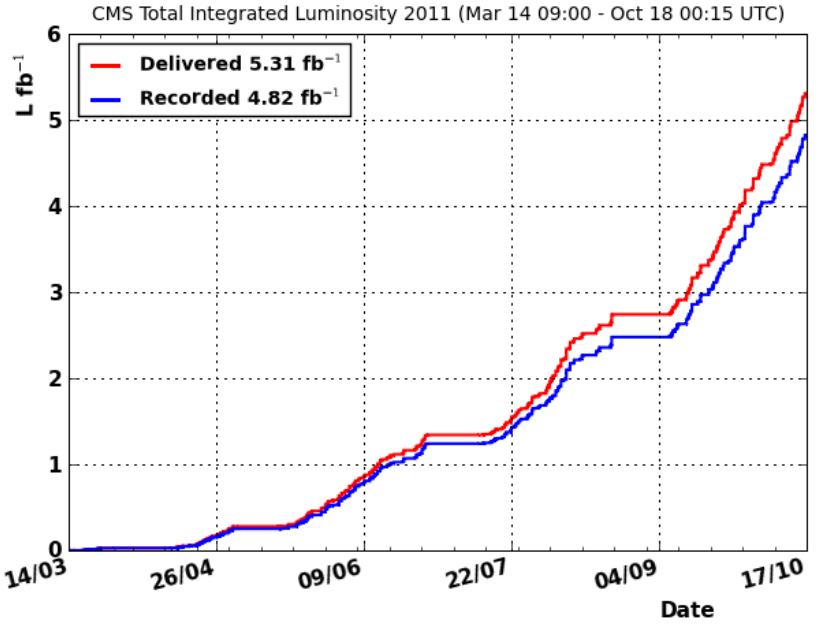
- Summary of LHC / CMS status
- Overview of CMS SUSY results
  - A closer look at the single lepton result
- Interpretation of results so far...
- Conclusion

LHC schedule and luminosity

- Today!



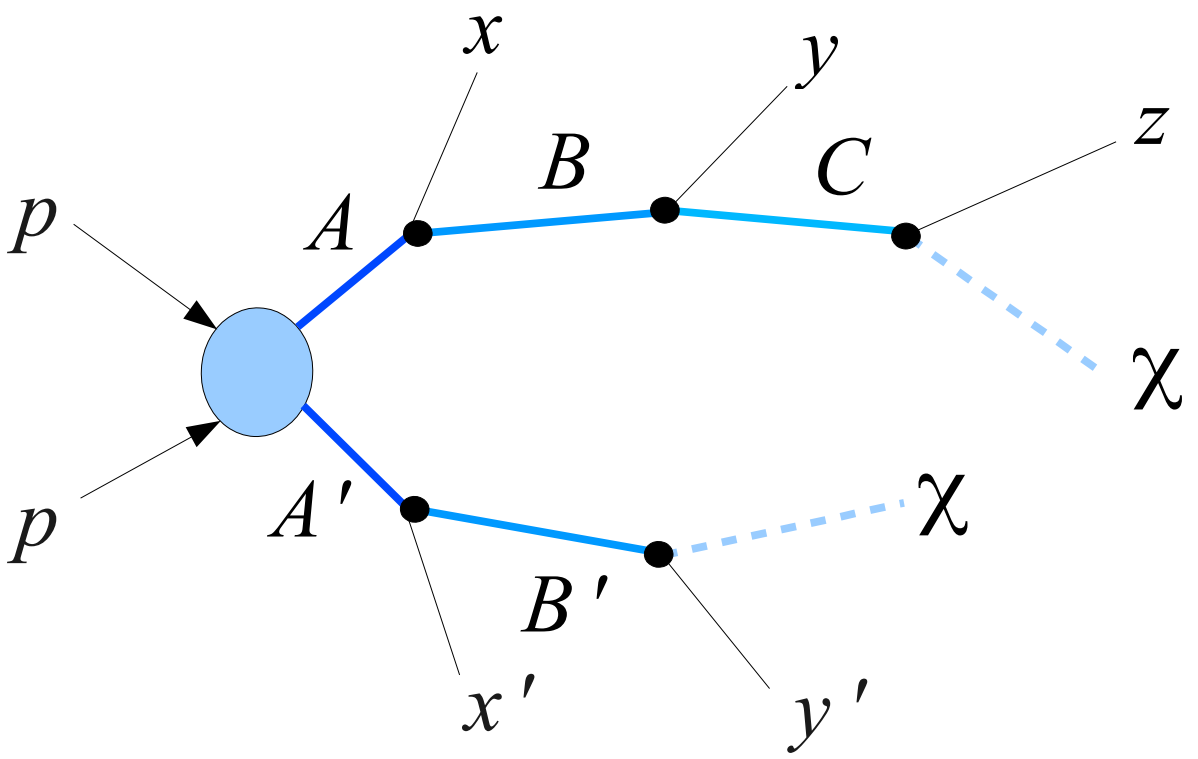
- Current pp run will end on Saturday 29th October.
- This is followed by ~four weeks of ion running and winter shutdown.



- CMS has recorded a total luminosity of ~5 fb-1

SUSY Searches at CMS

Searches are performed for events with the following assumed topology:



The final state contains multiple energetic jets / leptons / photons and two colourless, neutral, stable and massive states that generate missing transverse momentum

CMS results (hadronic)

Search	Luminosity (fb-1)	Public Note (*)	Date
Hadronic: HT + MET	1.1	SUS-11-004	30/08/2011
Hadronic: HT + MET + b-tags	1.1	SUS-11-006	15/10/2011
Hadronic: α_T	1.1	SUS-11-003	26/07/2011
Hadronic: MT2 (+ b-tags)	1.1	SUS-11-005	26/08/2011

(*) https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsSUS

CMS results (lepton/photon)

Search	Luminosity (fb-1)	Public Note (*)	Date
Single lepton + jets + MET	1.1	SUS-11-015	09/09/2011
Dilepton (same-sign) + jets + MET	0.98	SUS-11-010	23/07/2011
Dilepton (opposite-sign) + jets + MET (+ Z-veto)	0.98	SUS-11-011	26/08/2011
Photons + jets + MET	1.1	SUS-11-009	24/08/2011
Z-boson + jets + MET (dilepton channel)	0.98	SUS-11-017	23/07/2011

(*) https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsSUS

Single lepton search

Selection criteria:

- Exactly one muon or electron and at least 3 (4) jets satisfying the requirements:

Muon	Electron	Jet
$p_T > 20\,GeV$	$p_T > 20\,GeV$	$p_T > 40\,GeV$
$\|\eta\| < 2.1$	$\|\eta\| < 1.4\ ,\ 1.6 < \|\eta\| < 2.4$	$\|\eta\| < 2.4$
$I_{rel} < 0.10$	$I_{rel} < 0.07 - 0.06$	-

$$I_{rel} \equiv \sum \left(E_T^{calo} + p_T^{tracker} \right) / p_T^{lepton} \quad \text{in a cone } \delta R < 0.3$$

- 'loose' and 'tight' search regions are further defined by:

$$H_T \equiv \sum_j \left| p_T^j \right| > 500\,GeV \qquad \text{Sum over all jets, j, with } p_T^j > 20\,GeV$$

$$\not{E}_T > 250\,GeV \quad \textbf{\textit{'loose'}}$$
$$\not{E}_T > 350\,GeV \quad \textbf{\textit{'tight'}}$$

Single lepton search

Sources of SM background:

- **Semi-leptonic ttbar and W+jets**
  - W -> e, mu
    - ~75% of total background (in loose selection)
  - W -> tau, with tau -> e, mu
    - ~15% of total background
- **Dileptonic ttbar**
  - With one lepton either lost or ignored
    - ~10% of total background
- **QCD**
  - Small contribution, data-driven estimation
- **Single top, Z+jets**
  - Small contribution, estimated from MC

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Determined using lepton spectrum method

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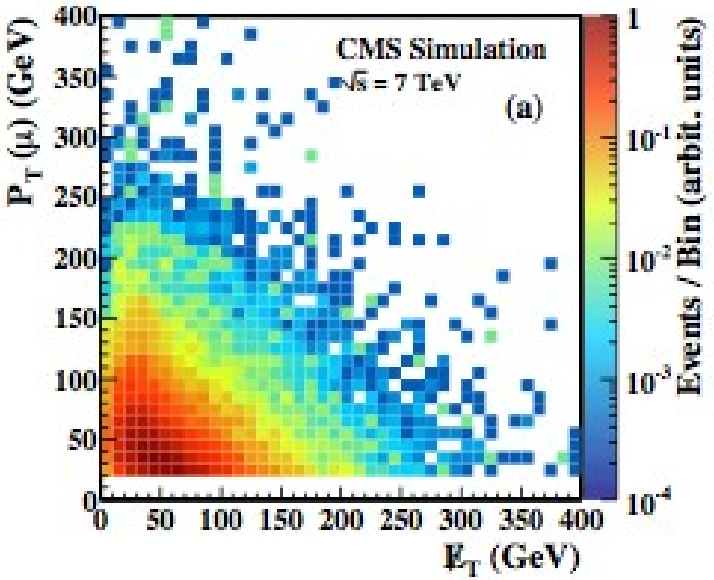
Single lepton search

Estimating the SM background:

Lepton spectrum method

- The lepton and neutrino are produced in the 2-body decay of W
- Use this kinematic relationship to determine the MET spectrum from the lepton spectrum.



The lepton spectrum is measured using the **muon** sample, with all cuts except MET applied.

Several corrections are taken into account:

- W polarization
- Bias caused by cut on lepton pT
- Different resolutions in measuring lepton pT and MET.

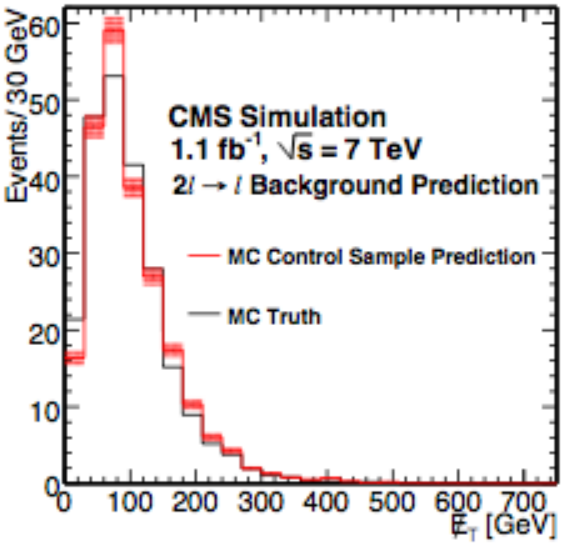
The electron contribution is determined by scaling the distribution from the muon sample using the ratio N(e)/N(mu) of events in data observed in the range 50 GeV < MET < 150 GeV

Single lepton search

Estimating the SM background:

Dilepton contribution

- Control samples containing ee, mu mu and e mu are obtained.
- Simulations are used to predict the ratio:
  N_{single lepton} / N_{control}
- The control samples are used to estimate the MET spectrum, by modifying the events (one electron is removed/ignored, or a lepton is replaced by a tau)

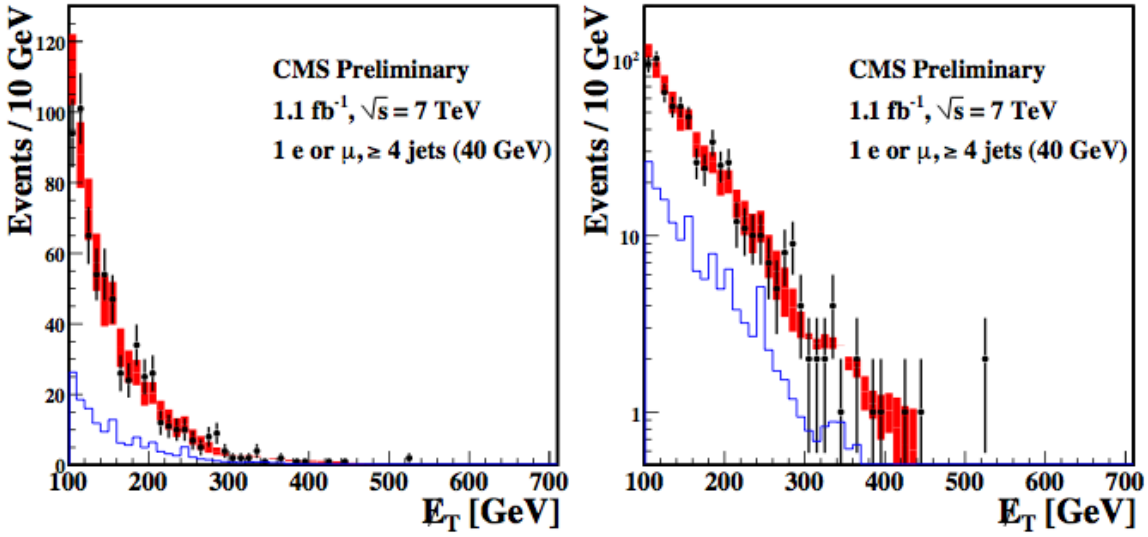


W -> tau contribution

- This is obtained using a similar method to the dilepton contribution
- The control sample is now the single lepton sample, but with the lepton replaced with a tau decaying to e or mu.

Single lepton search

Comparing data-driven estimation to data/MC



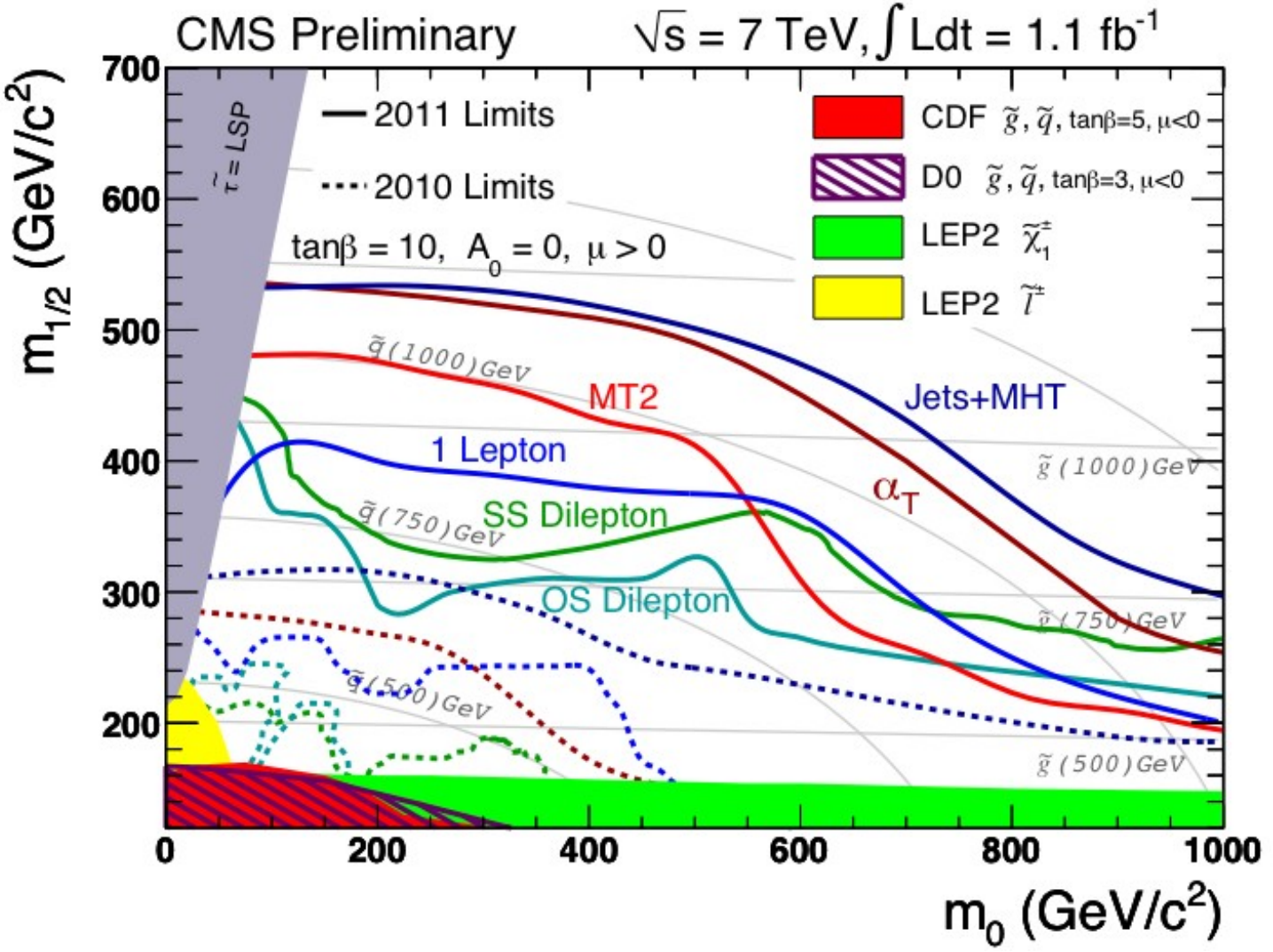
Sample	Loose (e+μ) Control pred.	Loose (e+μ) MC pred.	Tight (e+μ) Control pred.	Tight (e+μ) MC pred.
1 ℓ	$34.6 \pm 7.7 \pm 10.8$	53.6 ± 1.2	$8.8 \pm 3.7 \pm 3.4$	11.9 ± 0.5
Dilepton	$4.0 \pm 3.9 \pm 0.8$	7.6 ± 0.6	$0.9 \pm 1.9 \pm 0.9$	1.4 ± 0.2
1 τ	$10.5 \pm 1.2 \pm 0.5$	12.5 ± 0.6	$2.3 \pm 0.5 \pm 0.2$	3.1 ± 0.3
QCD	$0.0 \pm 1.2 \pm 0.3$	n.a.	$0.0 \pm 1.0 \pm 0.3$	n.a.
1 top,Z+jets	$0.7 \pm 0.2 \pm 0.2$	0.7 ± 0.2	$0.1 \pm 0.1 \pm 0.1$	0.1 ± 0.1
Total SM	$49.8 \pm 8.8 \pm 10.8$	74.4 ± 1.5	$12.1 \pm 4.3 \pm 3.6$	16.5 ± 0.6

***Final yields*:**

Sample	Loose Selection (e+μ)	Tight Selection (e+μ)
Predicted SM 1 ℓ	$34.6 \pm 7.7 \pm 10.8$	$8.8 \pm 3.7 \pm 3.4$
Predicted SM dilepton	$4.0 \pm 3.9 \pm 0.8$	$0.9 \pm 1.9 \pm 0.9$
Predicted single τ	$10.5 \pm 1.2 \pm 0.5$	$2.3 \pm 0.5 \pm 0.2$
Predicted QCD background	$0.0 \pm 1.2 \pm 0.3$	$0.0 \pm 1.0 \pm 0.3$
Single top (MC), Z+jets (MC)	$0.7 \pm 0.2 \pm 0.2$	$0.1 \pm 0.1 \pm 0.1$
Total predicted SM	$49.8 \pm 8.8 \pm 10.8$	$12.1 \pm 4.3 \pm 3.6$
Data	52	8

Good agreement between observation and SM prediction

Interpretation: CMSSM

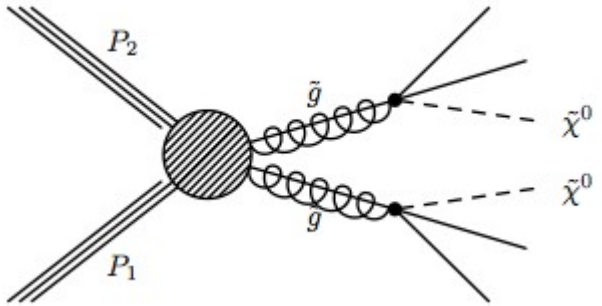


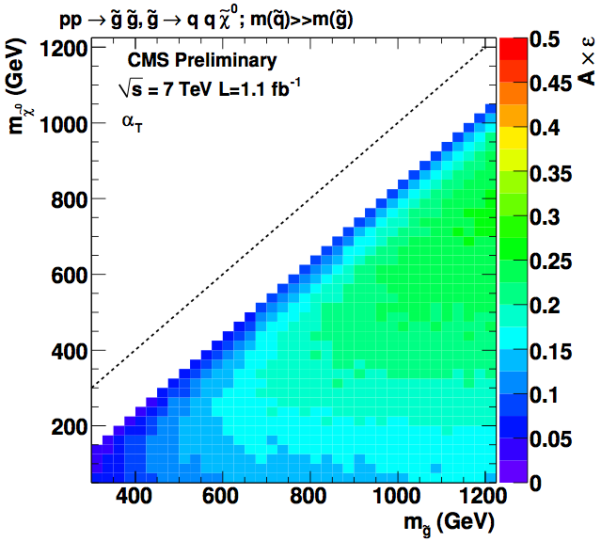
Simplified Models

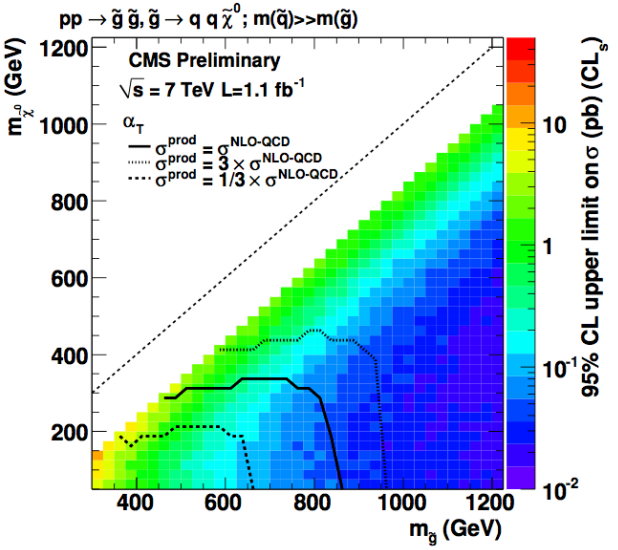
- Contain small number of parameters (2-3)
- Using the efficiencies and limits for a simplified model (determined by experiment), one can set limits in a larger class of models.

So far only a subset of analyses have released results for a small number of topologies. E.g. hadronic :

T1: $\tilde{g} \rightarrow q q \chi$





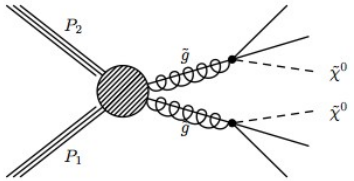


ROOT files containing the efficiencies and cross-section upper-limits can be downloaded from:
https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsSUS

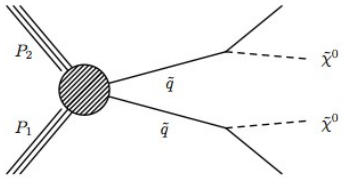
Simplified Models

Hadronic :

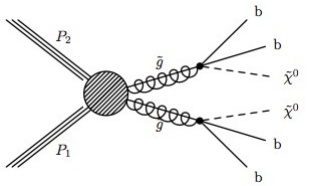
T1: $\tilde{g} \rightarrow q q \chi$



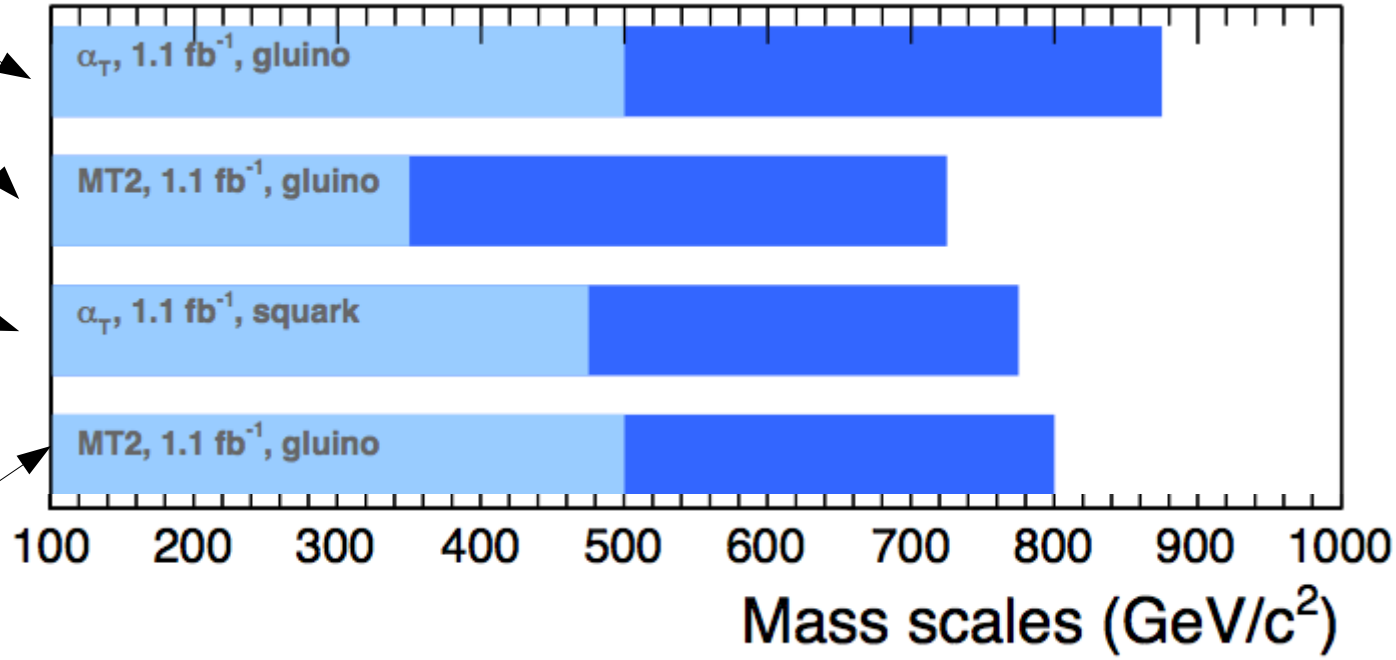
T2: $\tilde{q} \rightarrow q \chi$



T1bbbb: $\tilde{g} \rightarrow b b \chi$



Ranges of exclusion limits for gluinos and squarks, varying $m(\tilde{\chi}^0)$
CMS preliminary



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

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

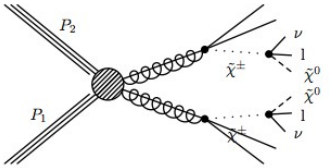
$m(\tilde{\chi}^0)$ is varied from 0 GeV/c^2 (dark blue) to $m(\tilde{g})$-200 GeV/c^2 (light blue).

Simplified Models

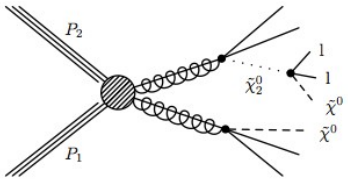
Leptonic :

Ranges of exclusion limits for gluinos and squarks, varying $m(\tilde{\chi}^0)$
CMS preliminary

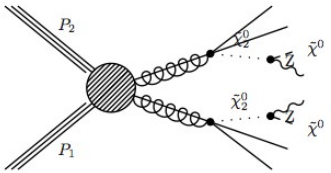
T1lnu: $\tilde{g} \to qq\tilde{\chi} \to qql\nu\chi$

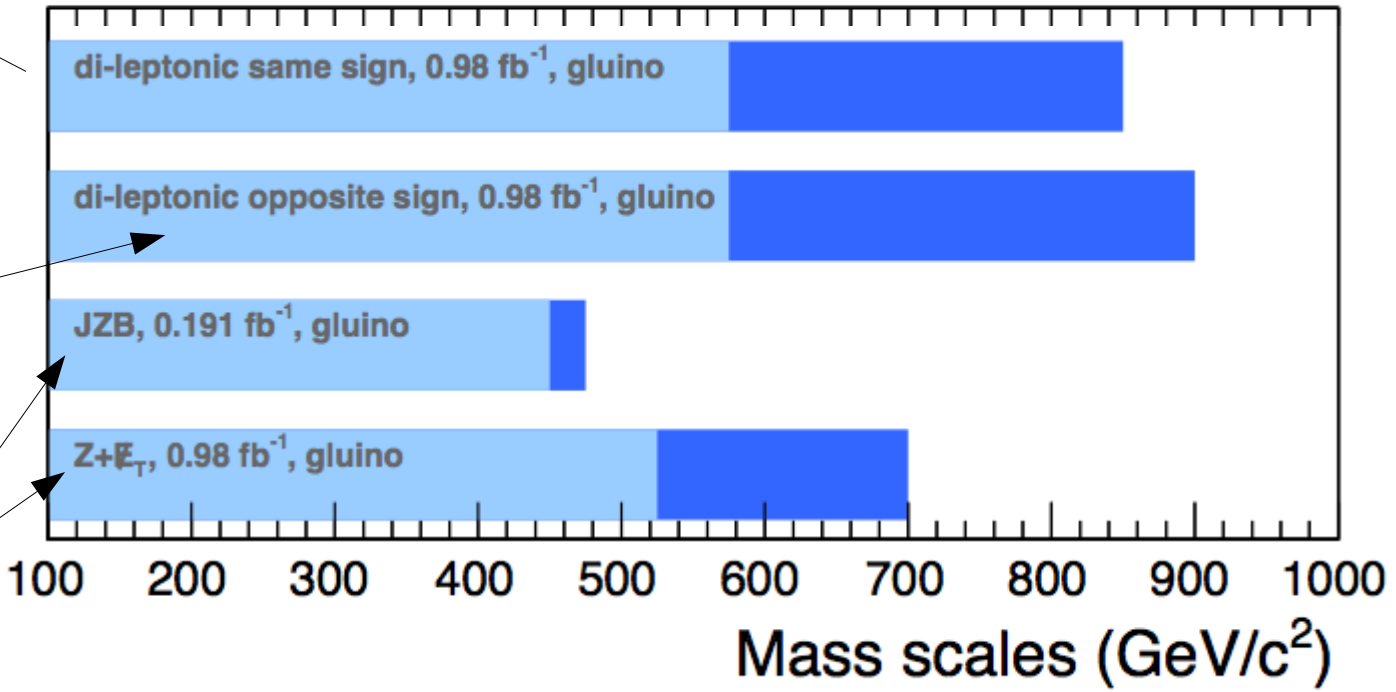


T1lh: $\tilde{g} \to qq\tilde{\chi} \to qqll\chi$
$\tilde{g} \to qq\chi$



T5zz: $\tilde{g} \to qq\tilde{\chi} \to qqZ\chi$





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

Conclusions

- Lots of results were published in the summer with ~1 fb-1. Still no definite signal detected.
- Still plenty more results to come, with updates using the full 2011 dataset and studies in new channels.
- Stay tuned!