New Physics Searches with CMS

Jim Pivarski

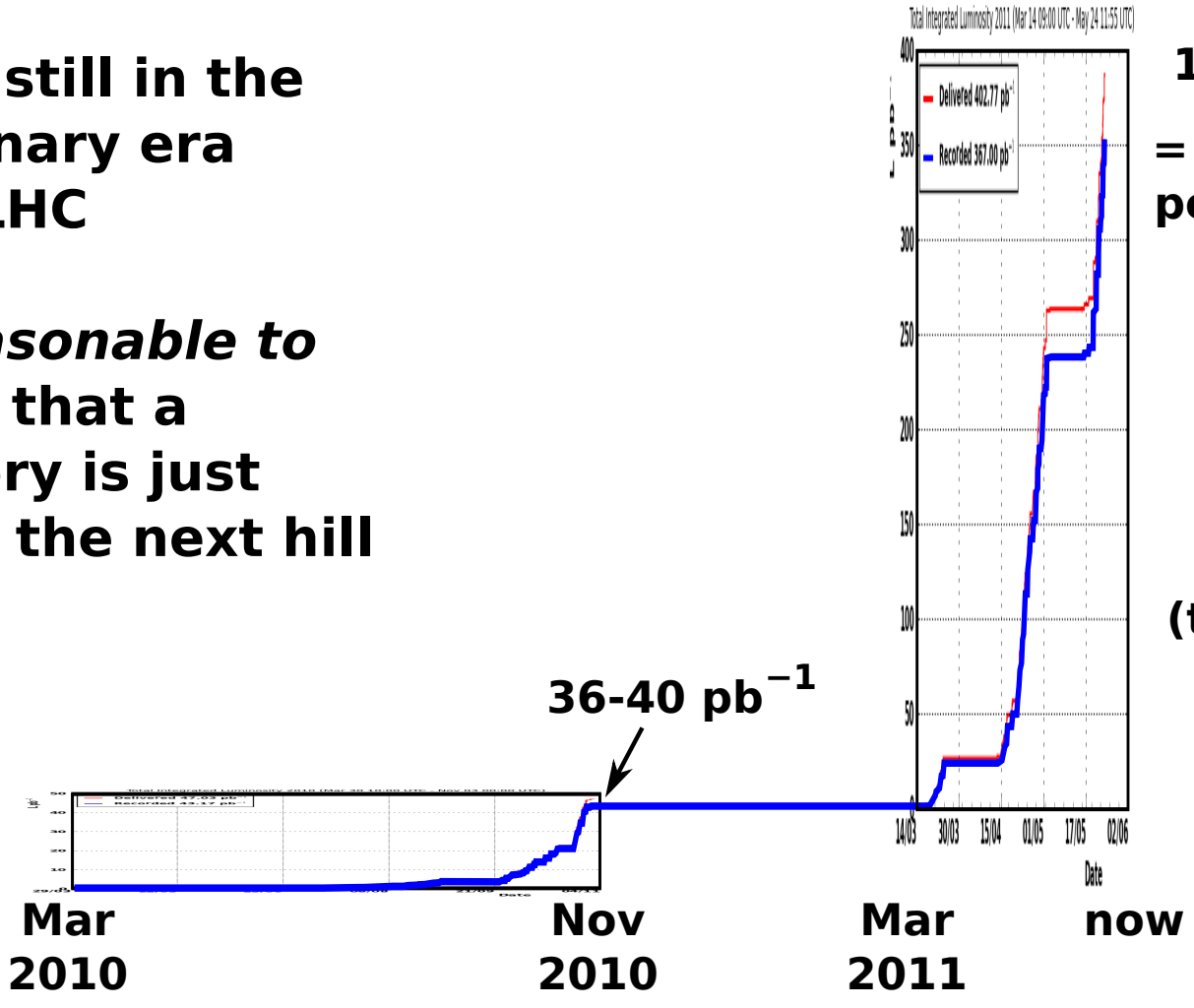
on behalf of the CMS Collaboration

1 June, 2011

Introduction

We are still in the inflationary era of the LHC

It is *reasonable to believe* that a discovery is just beyond the next hill



$10^{33}\,\mathrm{cm}^2/\mathrm{s}$

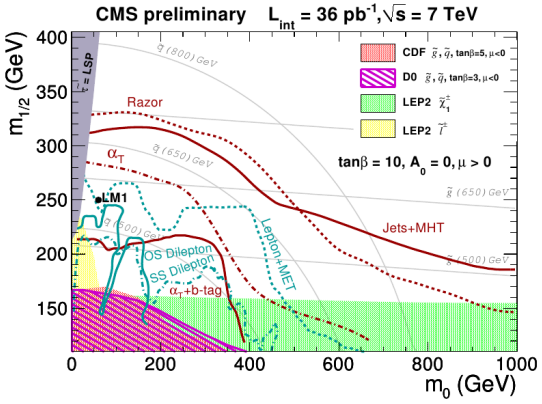
= 1 $Z \to \mu\mu$ per second

(to scale)

This talk: results from the 36-40 pb^{-1} collected in 2010

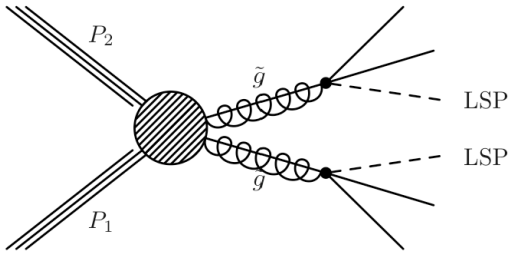
Ways of presenting search results

Explicit Models



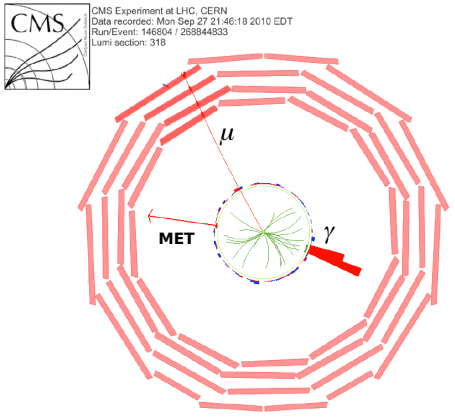
- it's the physics we want to know
- easier to compare and combine with other experiments
- more limited scope

Simplified Model Topologies



- broadly applicable limits set on particle kinematics
- interaction between theorists and experimentalists

Experimental Signatures



- empirical: what was directly measured
- overall view of search program
- implictions for physics less evident

Ways of presenting search results

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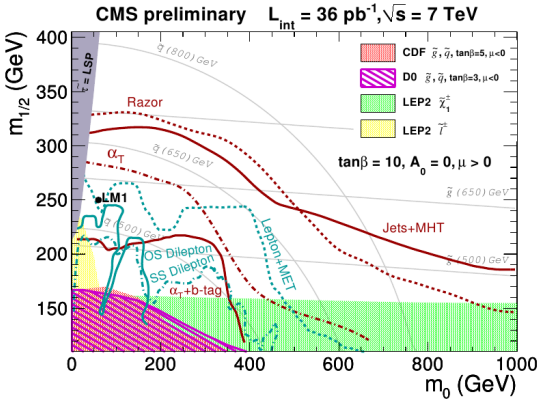

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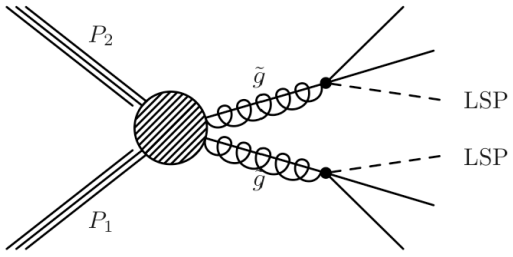

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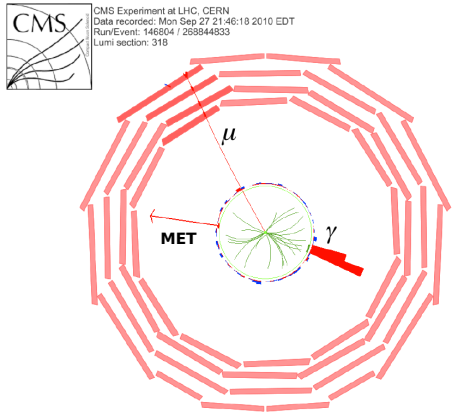

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- This talk is organized by experimental signature, for a broad overview

Ways of presenting search results

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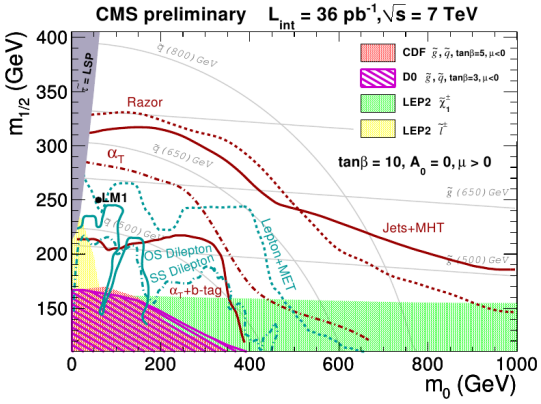

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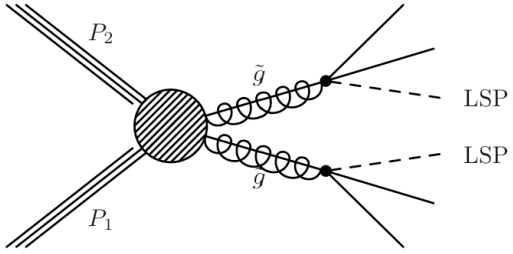

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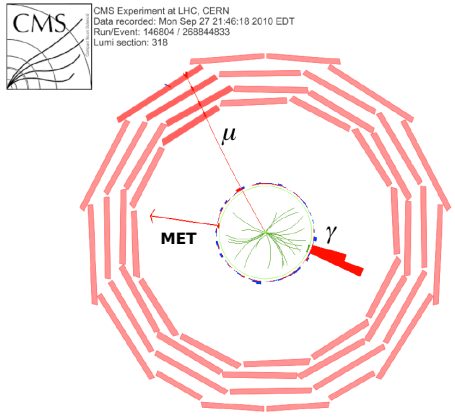

- empirical: what was directly measured
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- This talk is organized by experimental signature, for a broad overview
- For most results, I will show a plot of the experimental channel and point to a paper reference for exact limits and analysis details

Outline

- Jets and MET
- Leptons
- Photons
- Cross-channels
- High-level objects (b-jets, τ, and top)
- Weird stuff (e.g. new detector signatures)

Jets: resonances

Generic searches for hadronic resonances

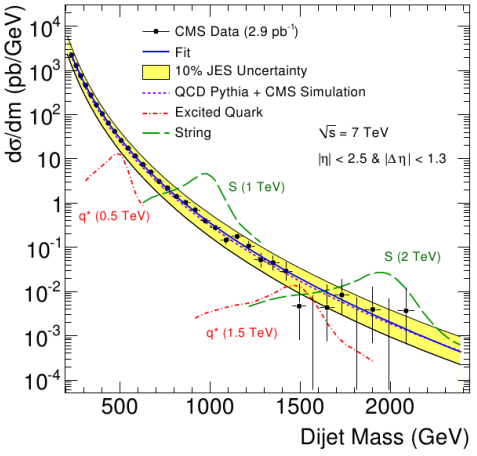
dijet: hep-ex/1010.0203

- Z' or $G^* \to q\bar{q}$

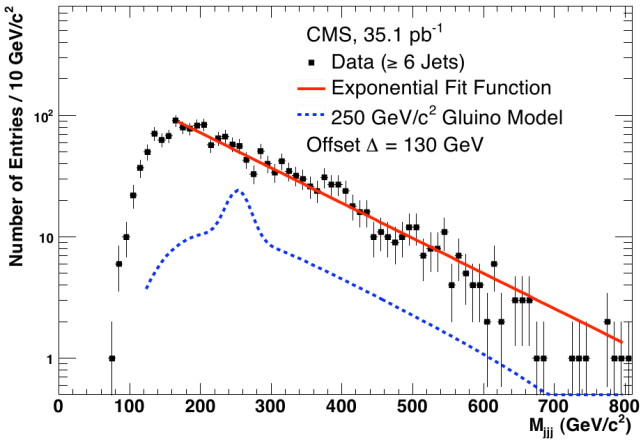
multijet: PAS EXO-11-001

- "quix" or RPV $\tilde{g}$ $\to qq\bar{q}$

dijet mass



trijet mass



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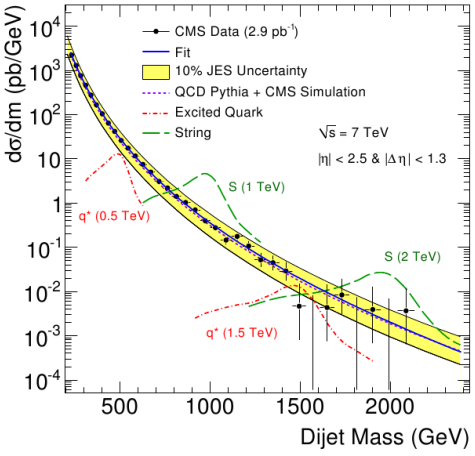

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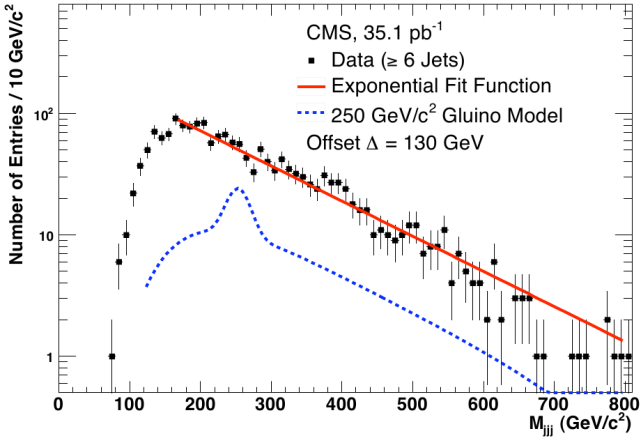
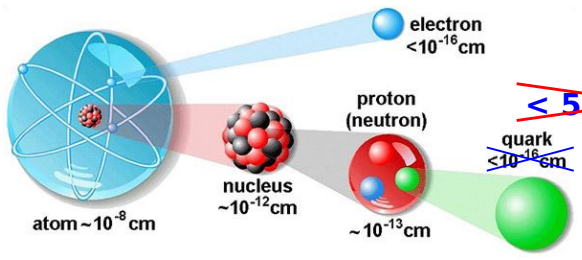


Dijet angular distributions



< 3.6×10^{-18} cm if destructive
< 3.0×10^{-18} cm if constructive interference
~~**< 5.0×10^{-18} cm**~~ **(Oct 2010, 2.9 pb^{-1})**
(Feb 2011, 36 pb^{-1})

hep-ex/1010.4439 and hep-ex/1102.2020 (update)

Centrality ratio

$$R_\eta = \frac{N_{jj}(|\eta| < 0.7)}{N_{jj}(0.7 < |\eta| < 1.3)}$$

New limits on quark compositeness:

$\Lambda^+ > 5.6$ TeV (destr.)
$\Lambda^- > 6.7$ TeV (constr.)

SUSY jets: special variables

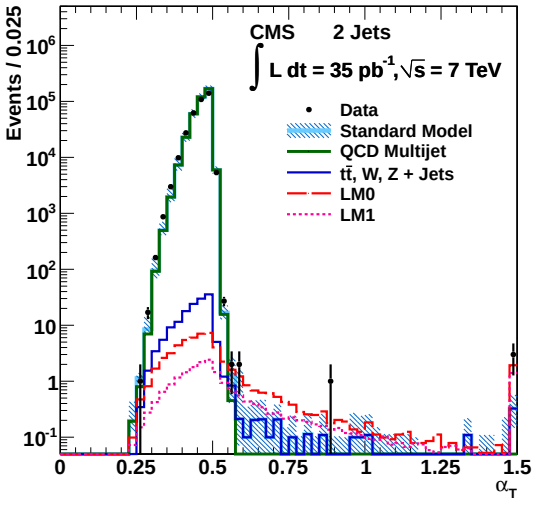
$\alpha_T = p_{T2}/M_T$ where p_{T2} is the second-highest jet momentum

Only events with real MET have $\alpha_T > 0.55$

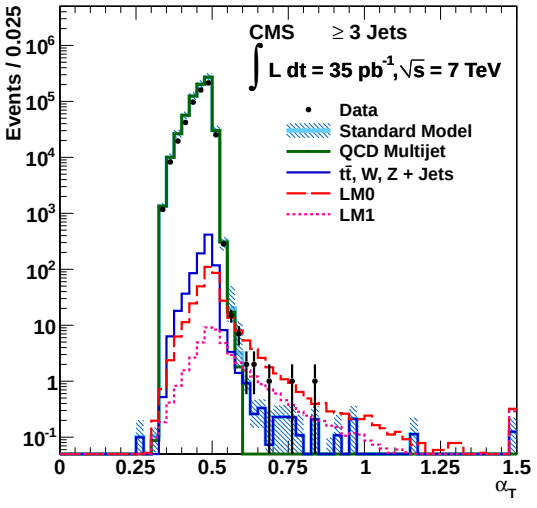
hep-ex/1101.1628 and

PAS SUS-11-001

$H_T > 350$ GeV dijets



$H_T > 350$ GeV multijets



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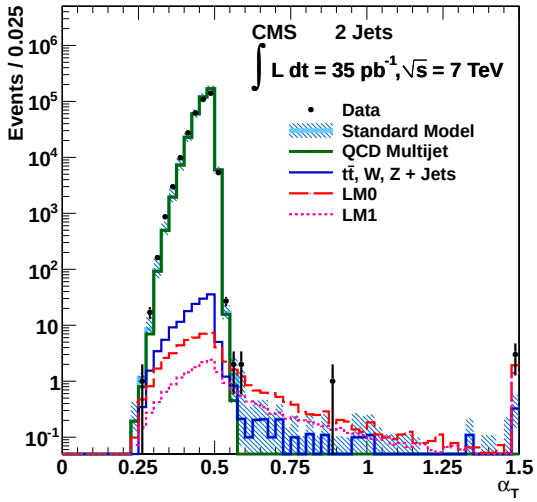

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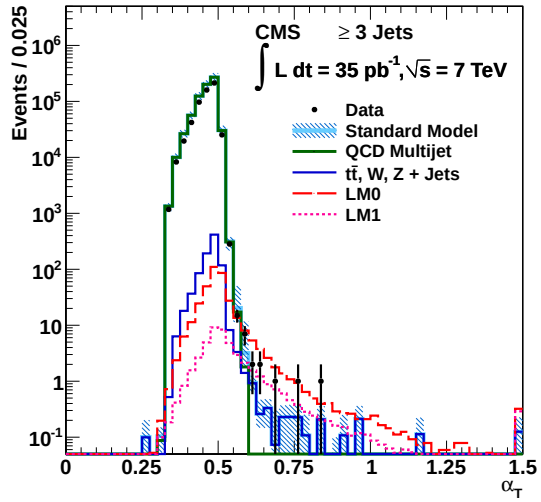
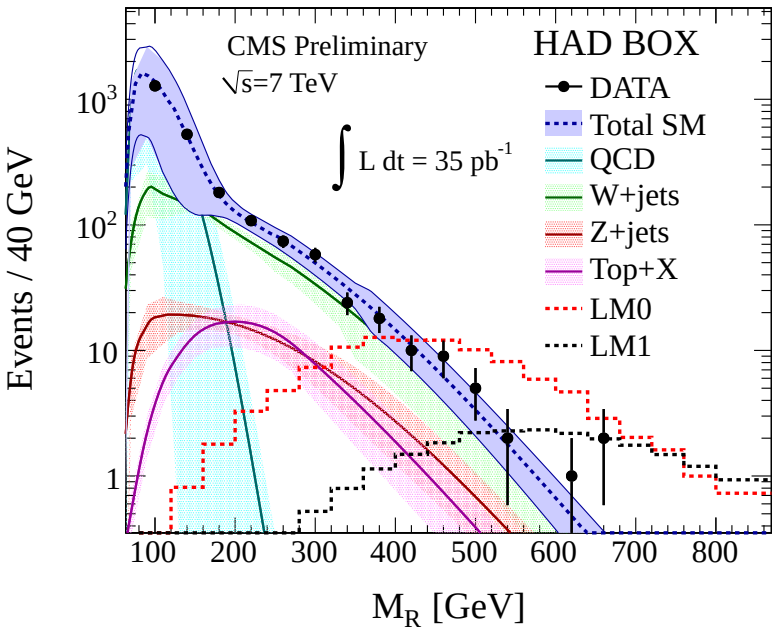




"Razor" analysis:

- interpret event as decay of two heavy objects: $pp \to MM$
- split jet activity into hemispheres; M_R = hemisphere momentum in boosted frame
- $R = M_T^R/M_R$, search in $R > 0.5$

PAS SUS-10-009

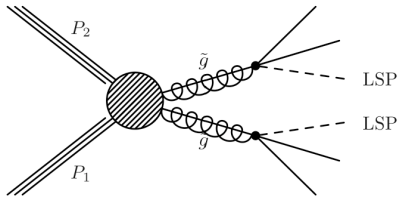
SUSY jets: simplified models

- Inclusive search for new physics in ≥ 3 jets and missing energy

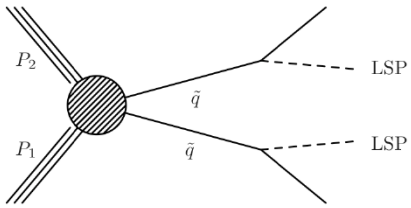
(PAS SUS-10-005)

- Results expressed as limits on cMSSM and simplified models (below)
- Data file provided with acceptances, uncertainties, and limits as a function of simplified model particle masses

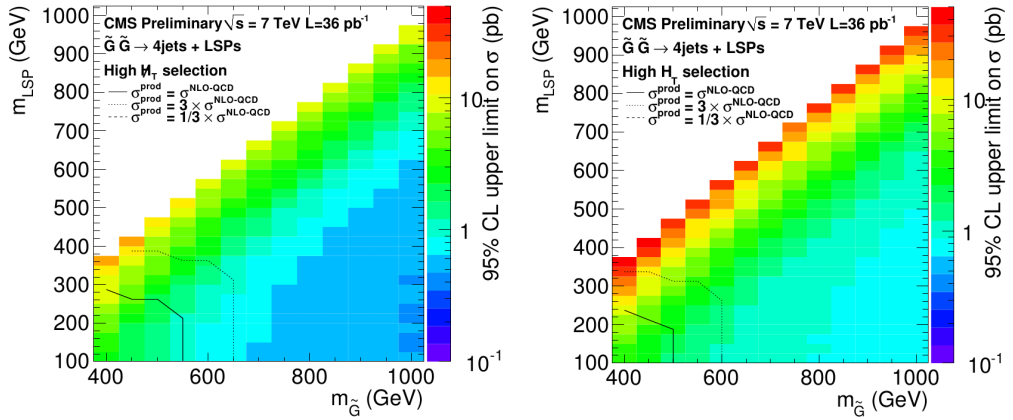
gluino-like pair production

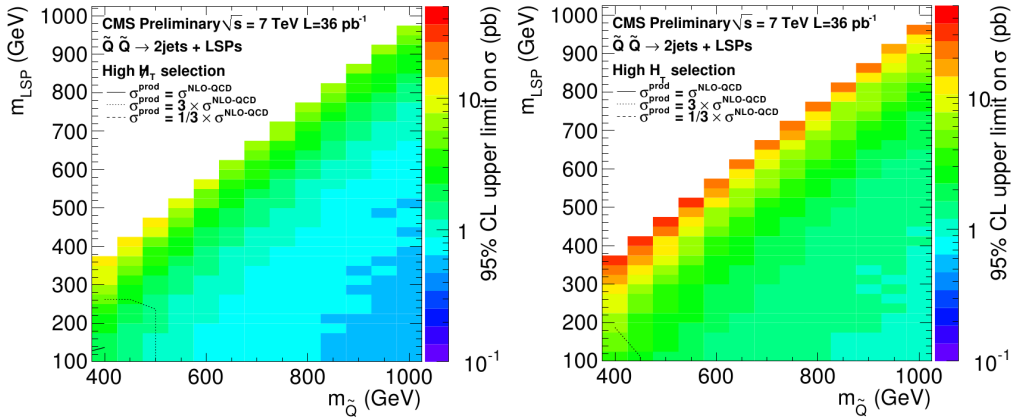


squark-like pair production



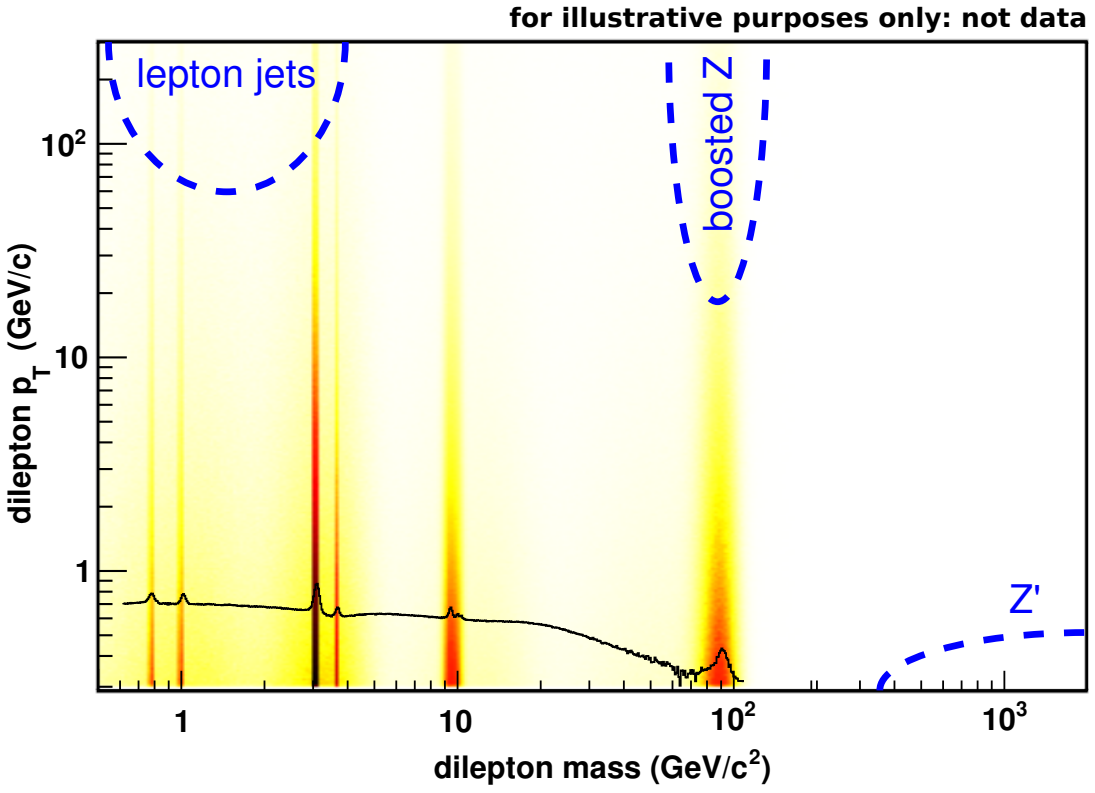
High MHT **High HT**





Leptons

- Dilepton resonances: several kinematic regions for searches



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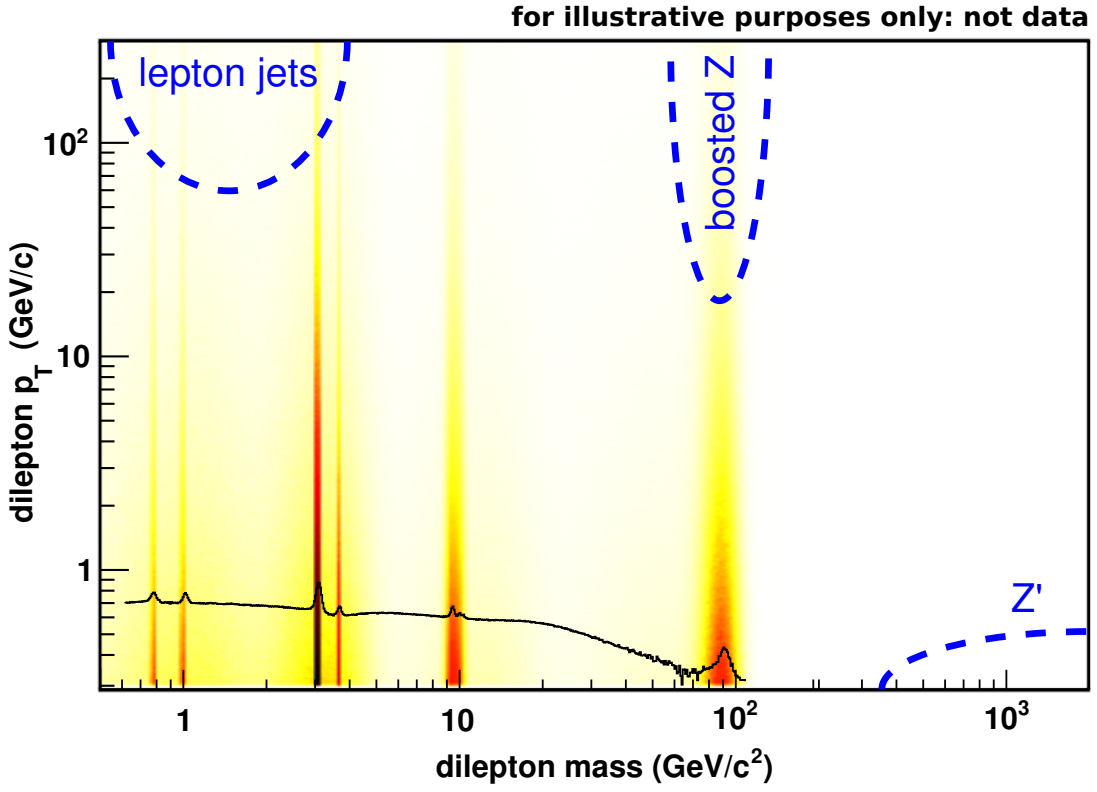

- Other exotica searches
  - non-resonant dimuons: large extra dimensions
    PAS EXO-10-020
  - high muon multiplicity: lepton jets

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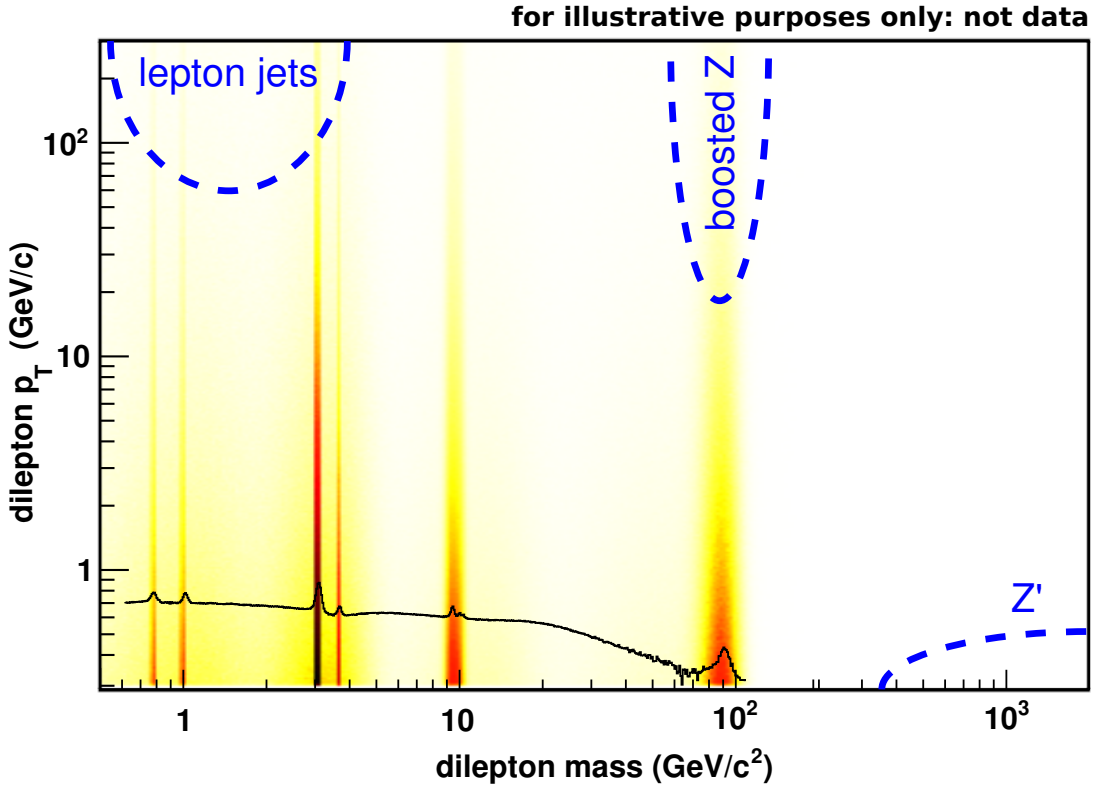

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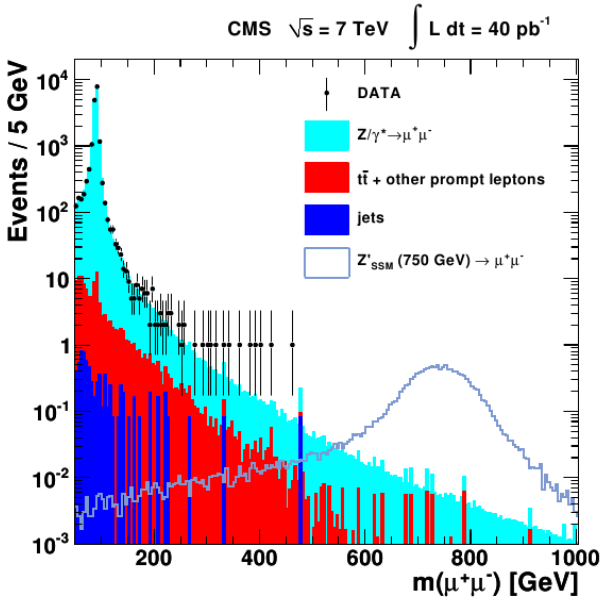
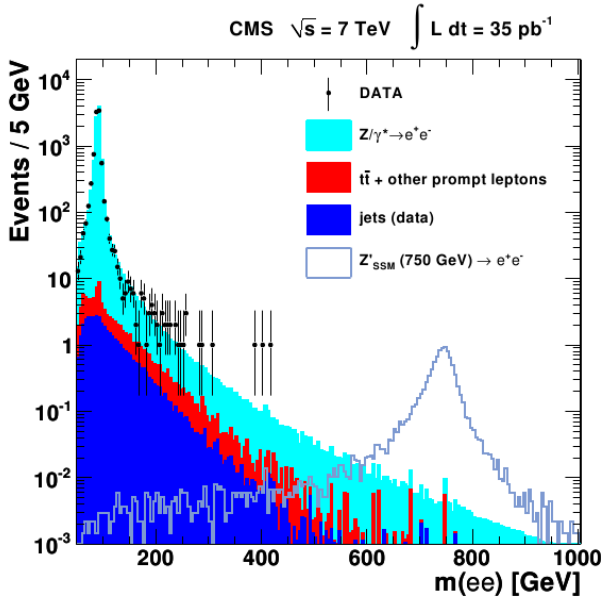
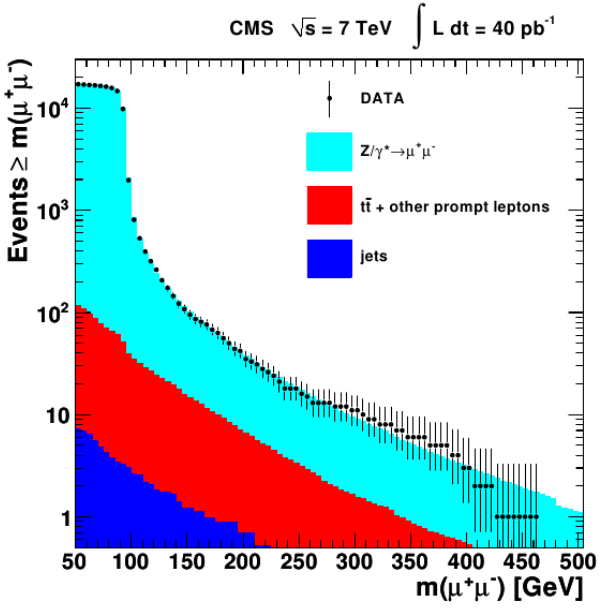
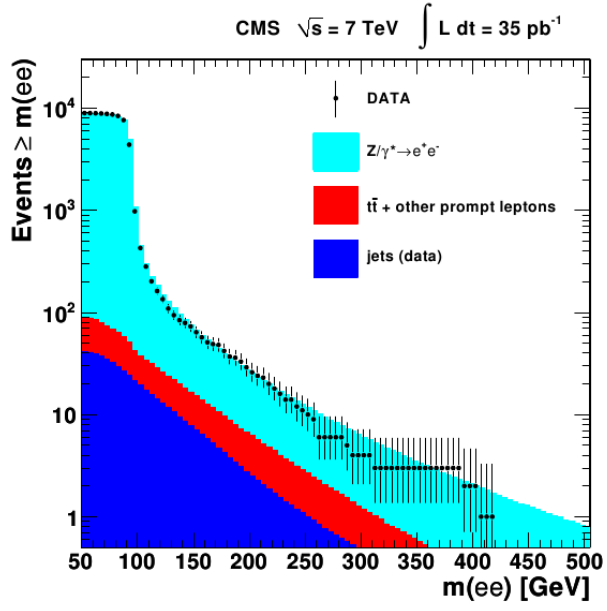
  - high muon multiplicity: lepton jets
- SUSY searches
  - single lepton SUS-10-006
  - opp-sign dilepton hep-ex/1103.1348
  - same-sign dilepton hep-ex/1104.3168
  - ≥ 3 leptons SUS-10-008

Leptons: high-mass resonances









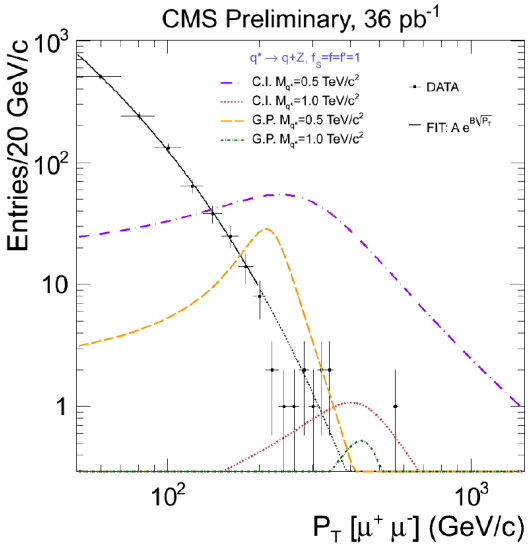
hep-ex/1103.0981

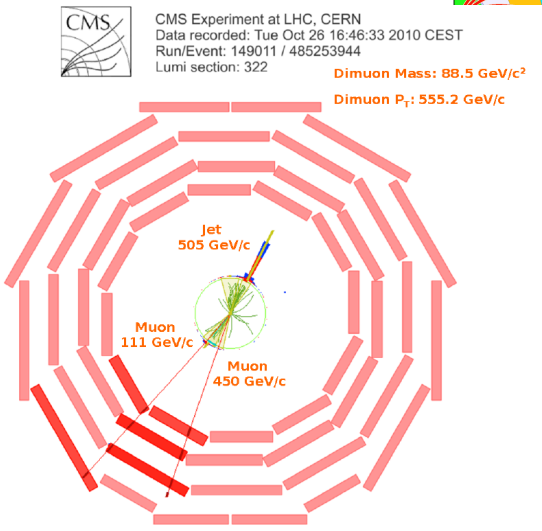
Leptons: other resonances

Z boson p_T spectrum: channel for generic neutral heavy-to-light decays, e.g.

$$q^* \to q\,Z$$

PAS EXO 10-025





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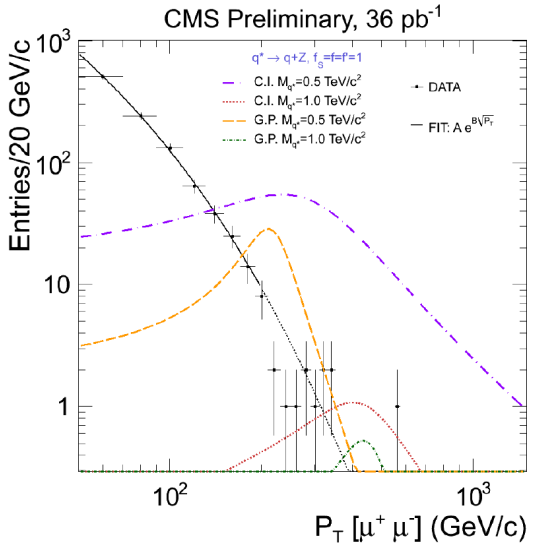
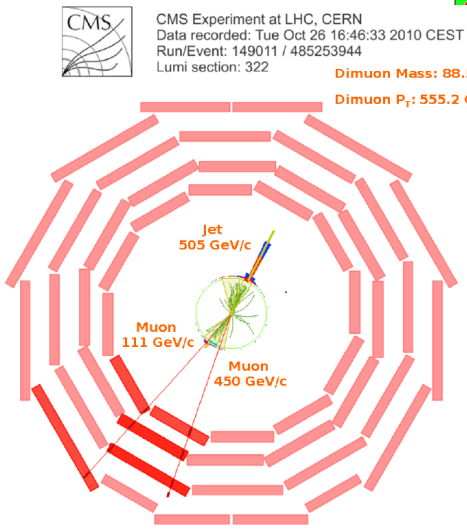
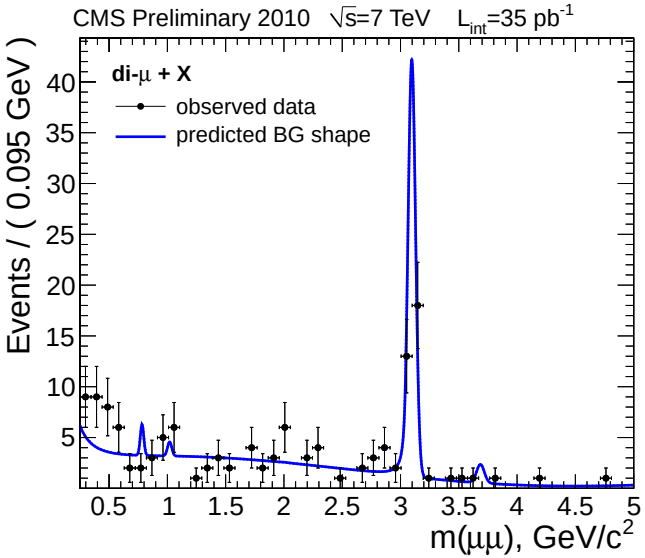




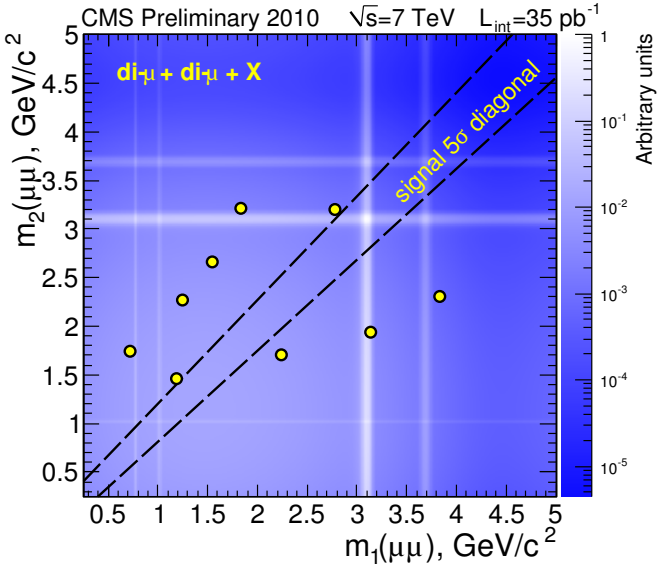
Lepton jets: one or more low-mass, high-p_T $\gamma_{dark} \to \ell\ell$ from a hidden sector



Left: high-p_T dimuons

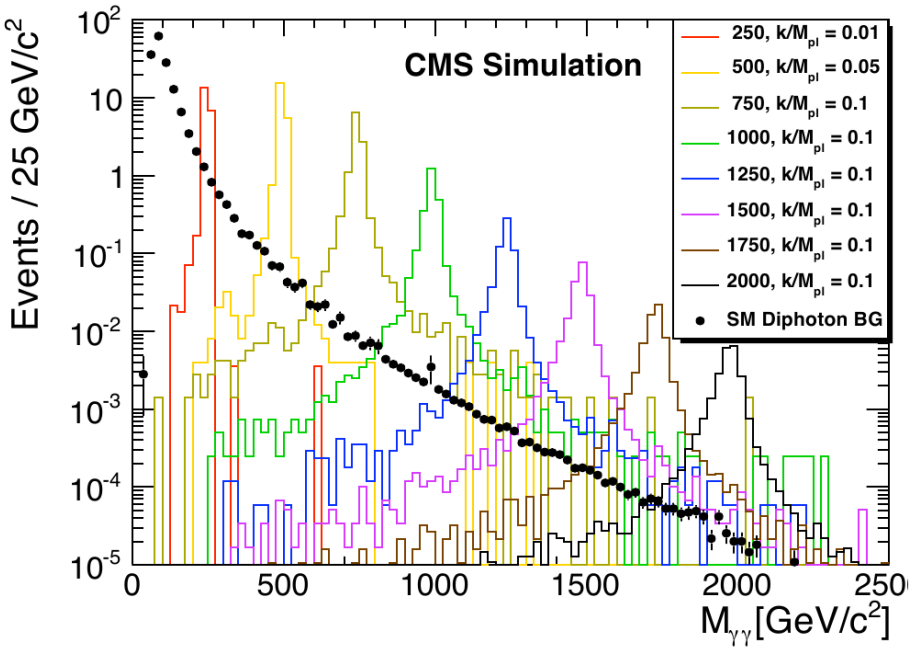
Right: two dimuons per event

PAS EXO 11-013



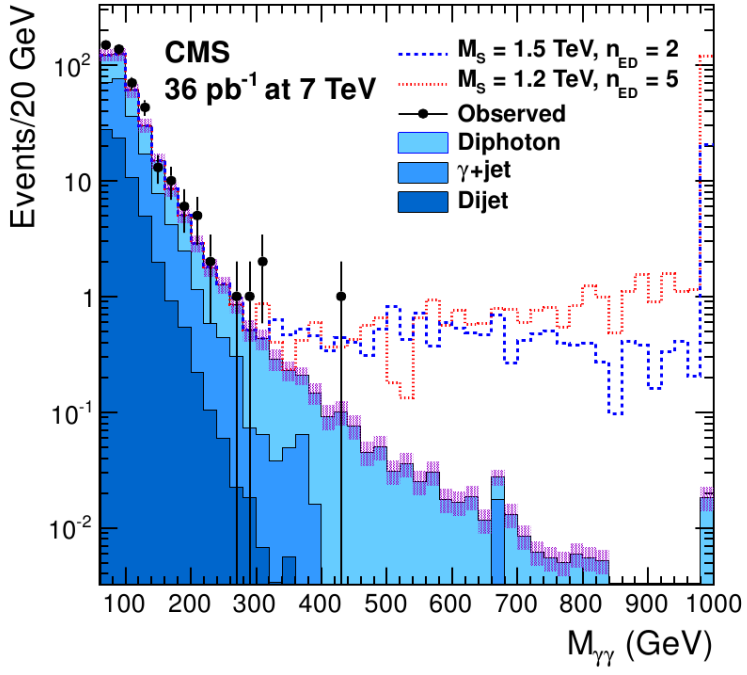
Diphoton mass spectrum

G^* resonance simulation



limits with data in PAS EXO 10-019

data with non-resonant Large Extra Dimensions prediction



hep-ex/1103.4279

Cross-channels

	jets	MET	ℓ	γ
jets		**LED** EXO 11-003	**leptoquarks** hep-ex/1012.4031 hep-ex/1012.4033	excited quarks: see high-pT Z
MET			**W'** hep-ex/1012.4945 hep-ex/1103.0030	**SUSY** hep-ex/1103.0953 hep-ex/1105.3152
ℓ				**excited leptons** EXO 10-016
γ				

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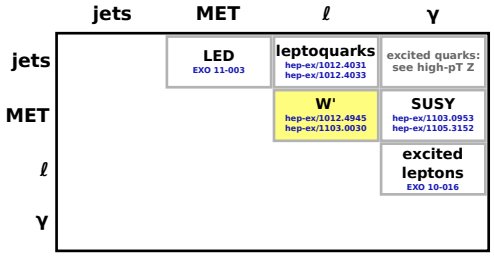
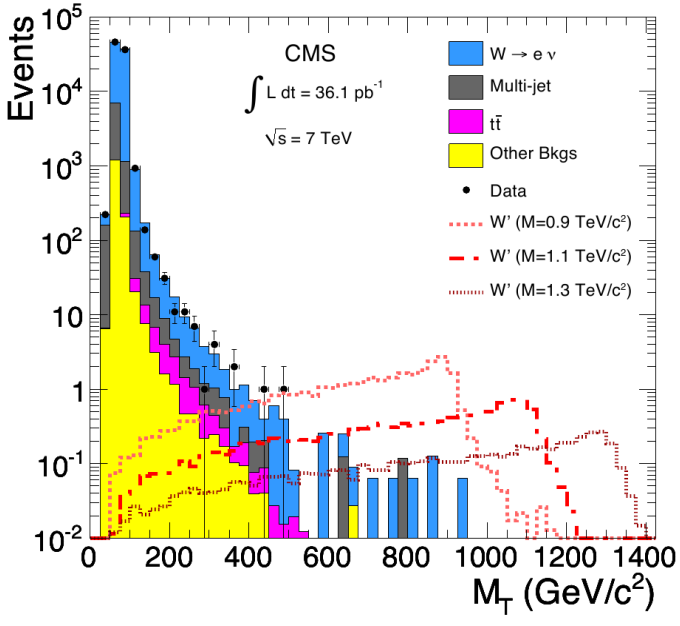
MET			**W'** hep-ex/1012.4945 hep-ex/1103.0030	**SUSY** hep-ex/1103.0953 hep-ex/1105.3152
ℓ				**excited leptons** EXO 10-016
γ				

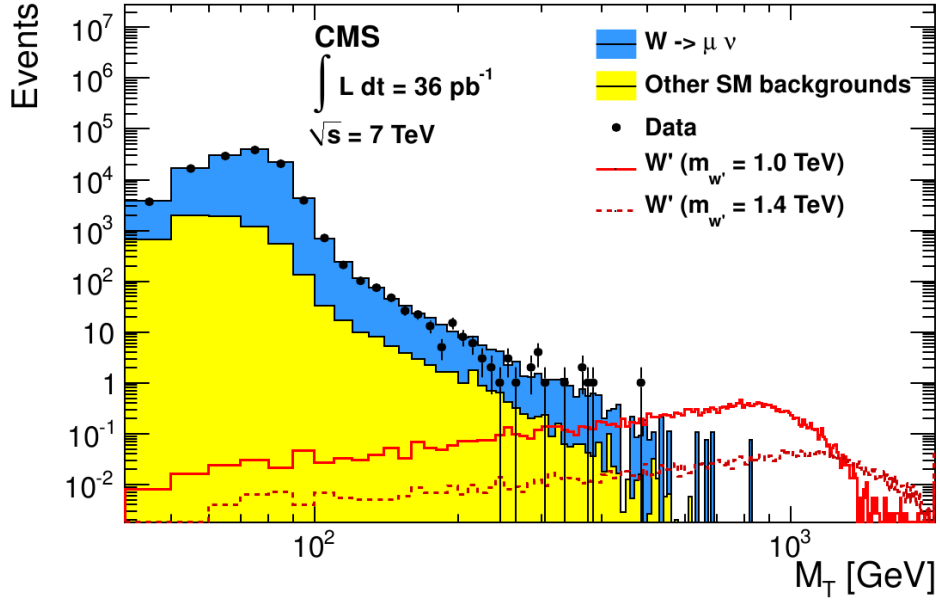
- None of the paper references in this talk are repeated

Cross-channels: lepton + MET

Search for $W' \to e\nu$ (left) and $W' \to \mu\nu$ (right)

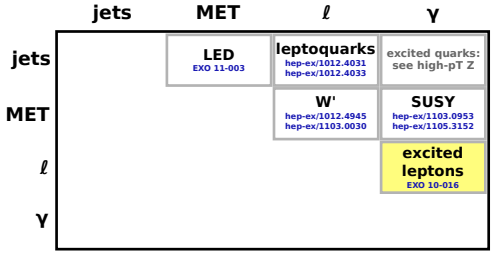


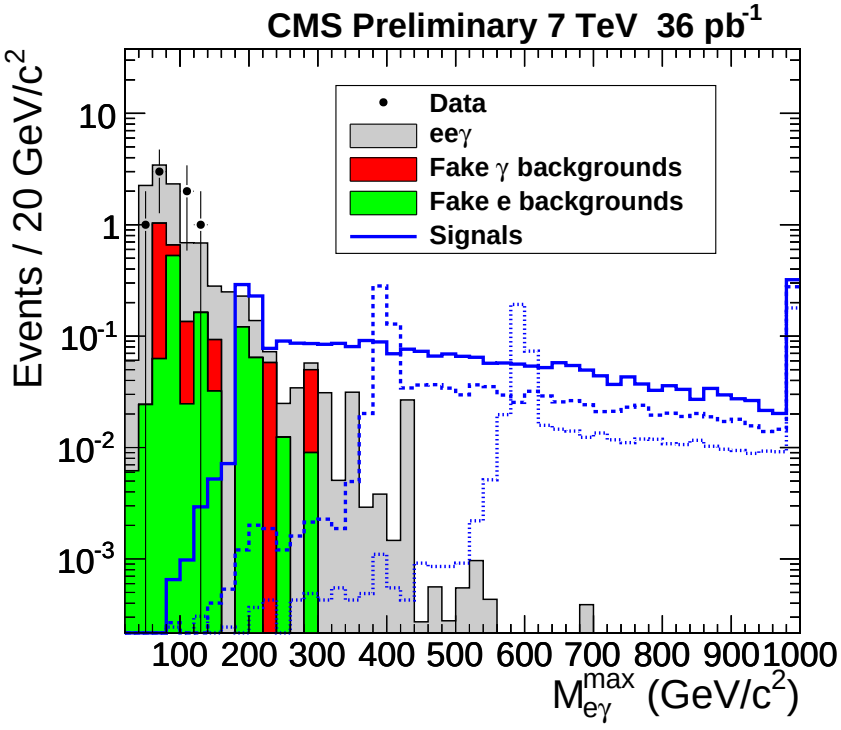


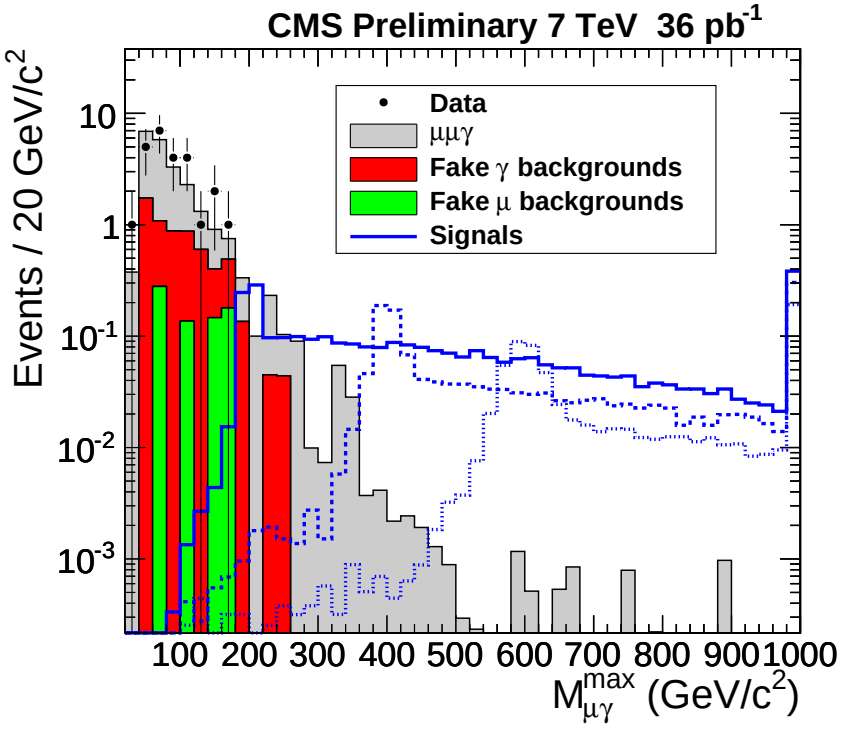


Cross-channels: lepton + photon

Search for $e^* \to e\gamma$ (left) and $\mu^* \to \mu\gamma$ (right)



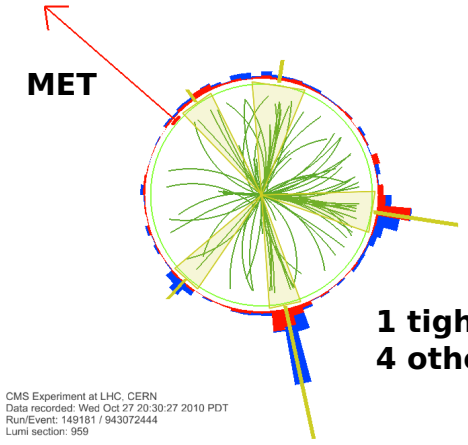




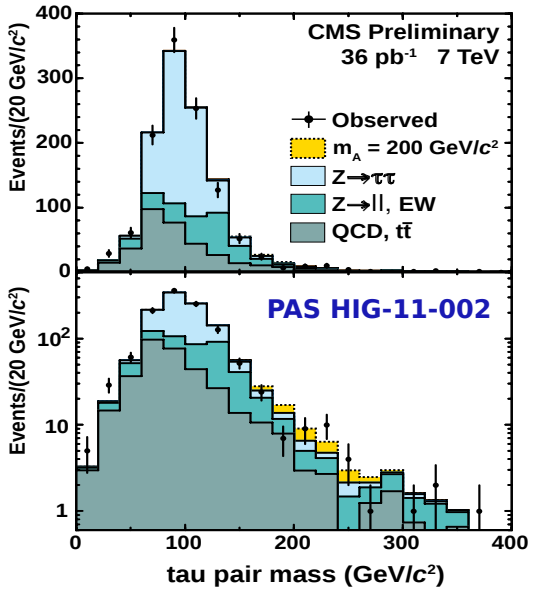
Searches using high-level objects

One surviving background event in a SUSY search with b-tagging

PAS SUS-10-011

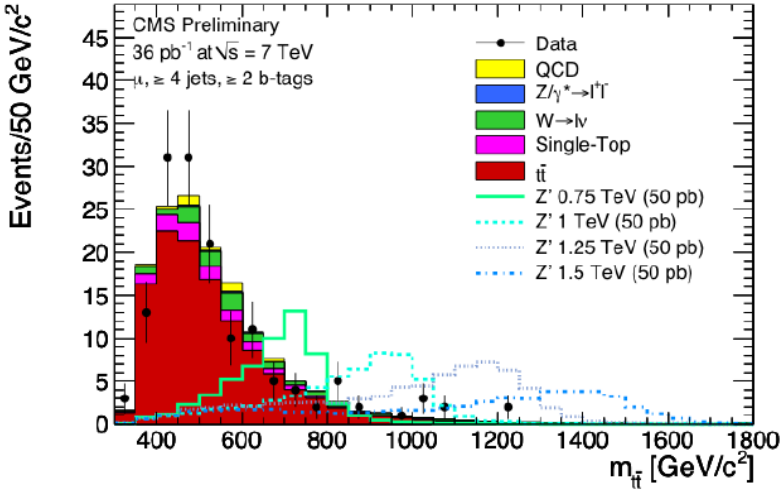


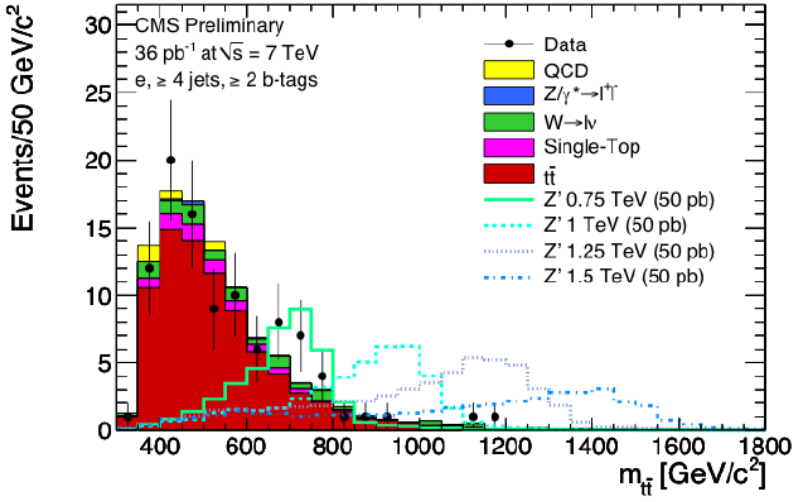
Search for a heavy di-τ resonance



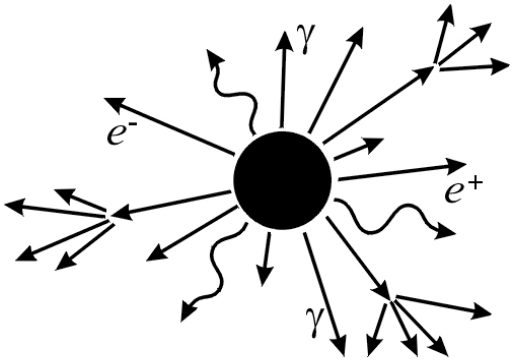
Search for resonances in top-antitop pairs (μ + jets and e + jets channels)

PAS TOP-10-007





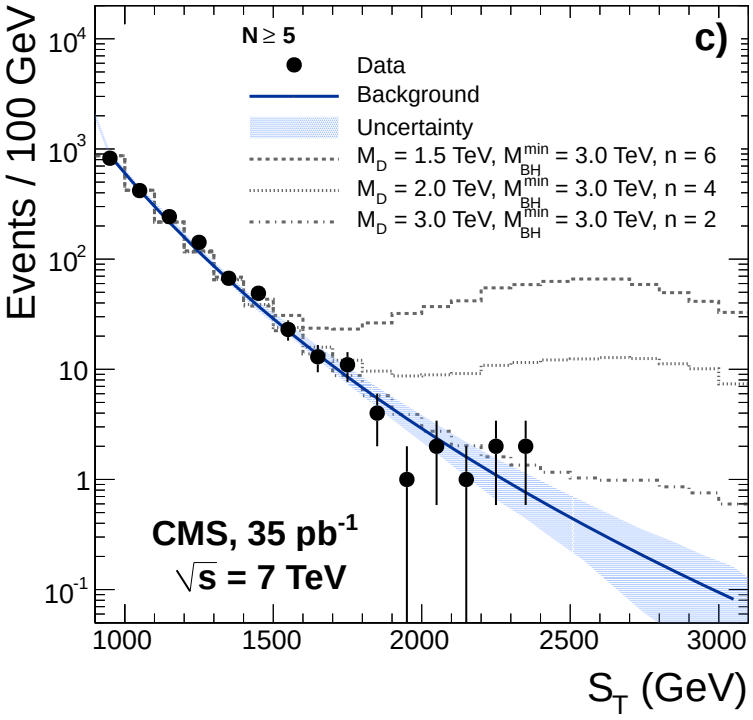
Microscopic black holes

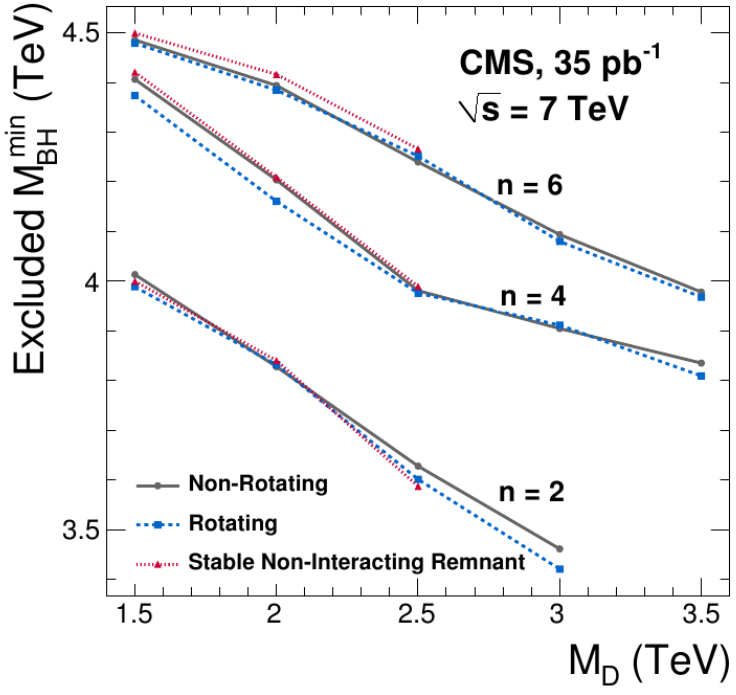


Extreme cross-channel: high multiplicities of every kind of particle $S_T = \sum_{E_T > 50\ \text{GeV}} E_T$ of jets, e, γ, μ

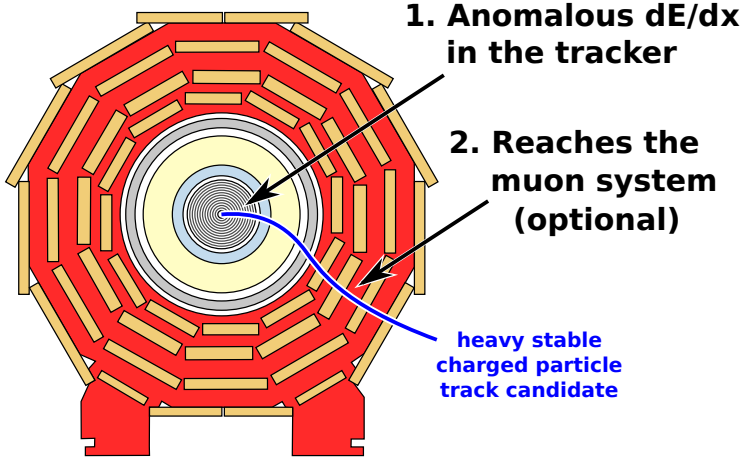
Set limits on $(4+n)$-D Planck scale M_D (right)

hep-ex/1012.3375





Heavy stable charged particles

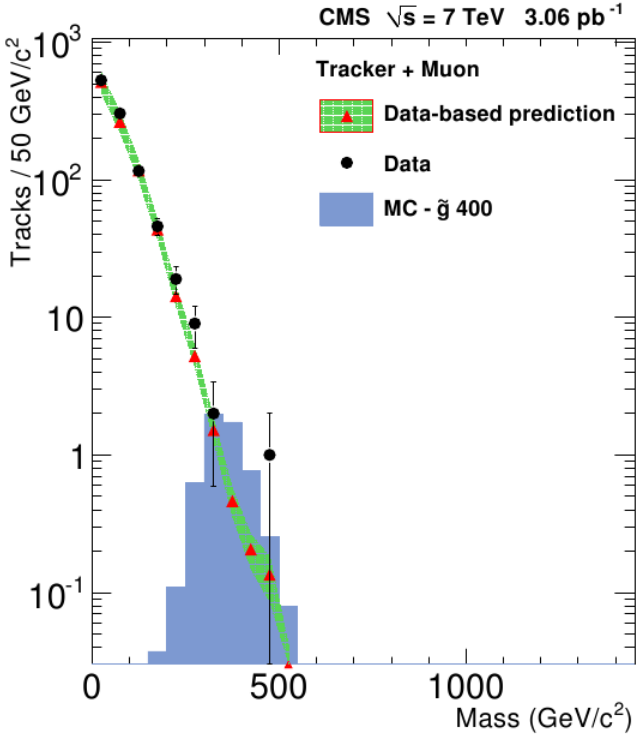


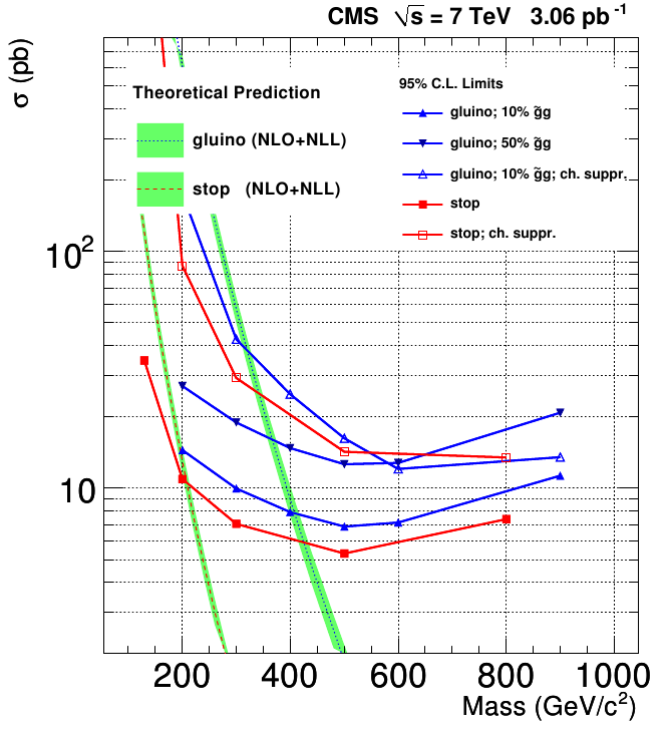
Search for anomalously large dE/dx (for $p_T > 15$ GeV/c)

Any particle with $\beta \ll 1$ is BSM

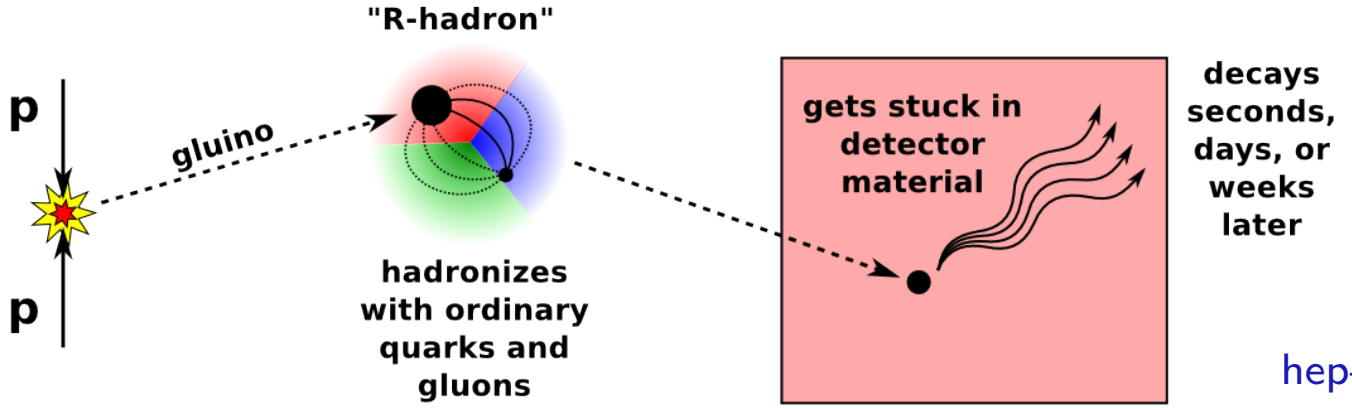
Calculate mass from dE/dx and $|\vec{p}|$

hep-ex/1101.1645

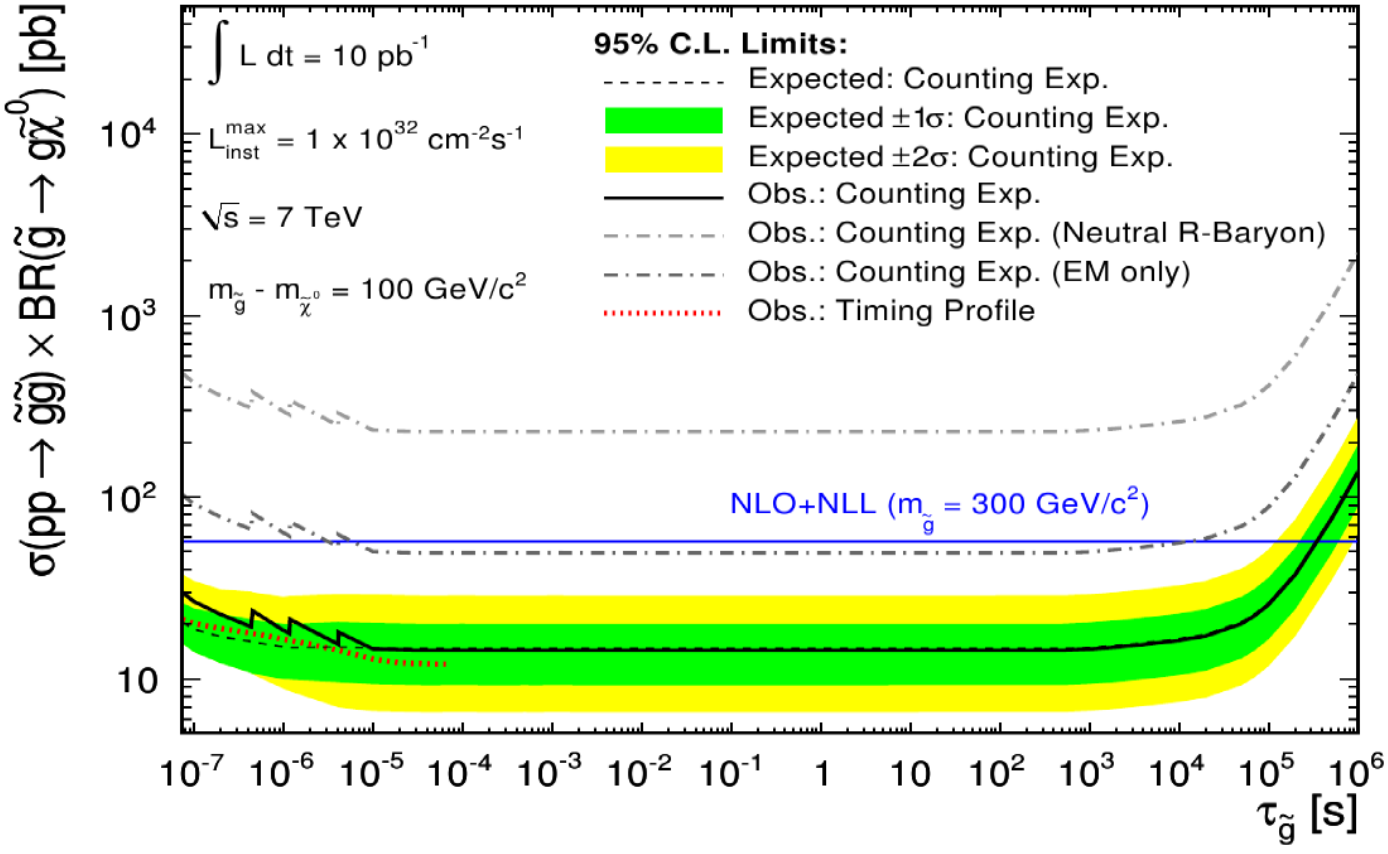




Stopped gluinos



hep-ex/1011.5861

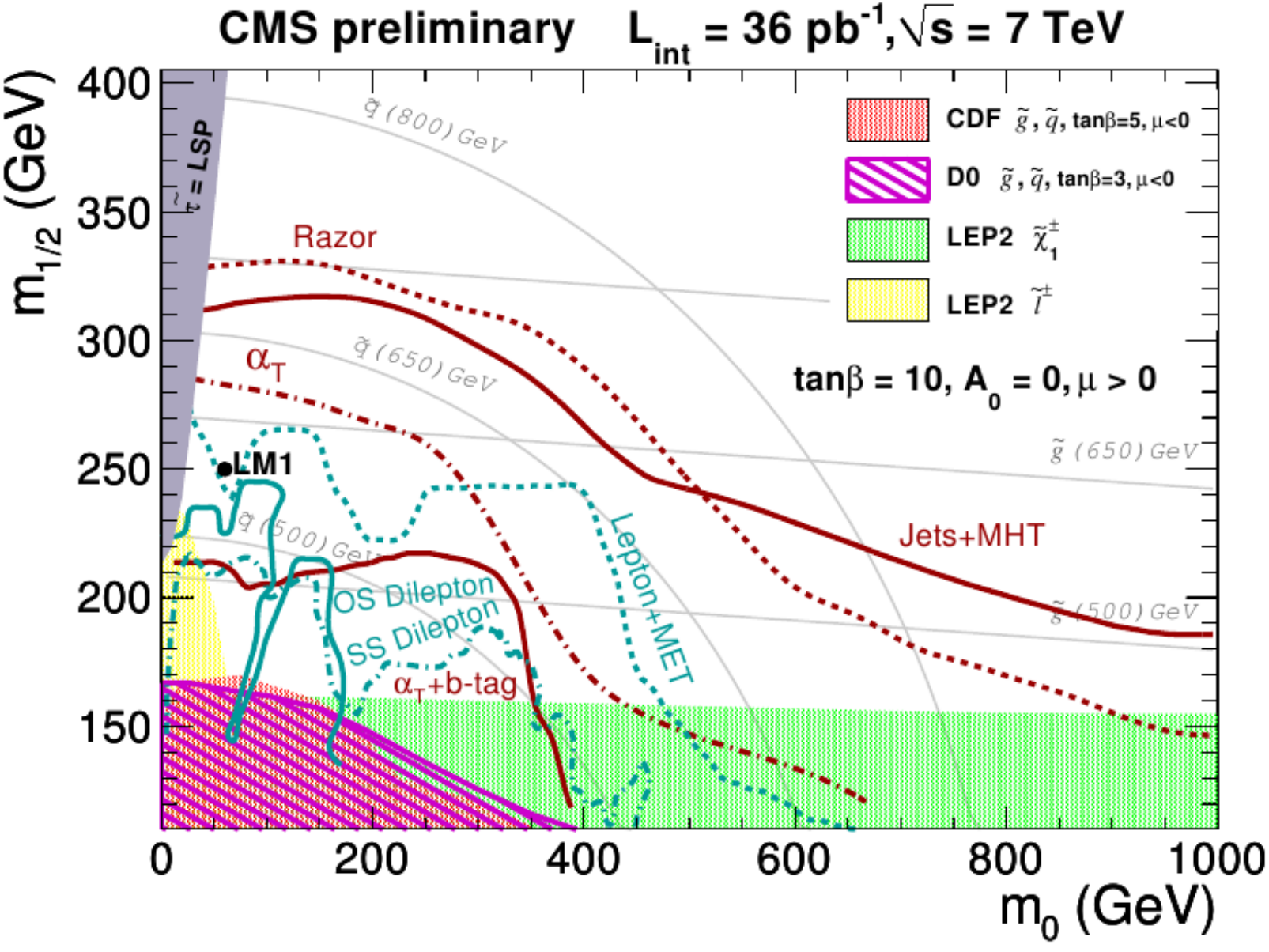
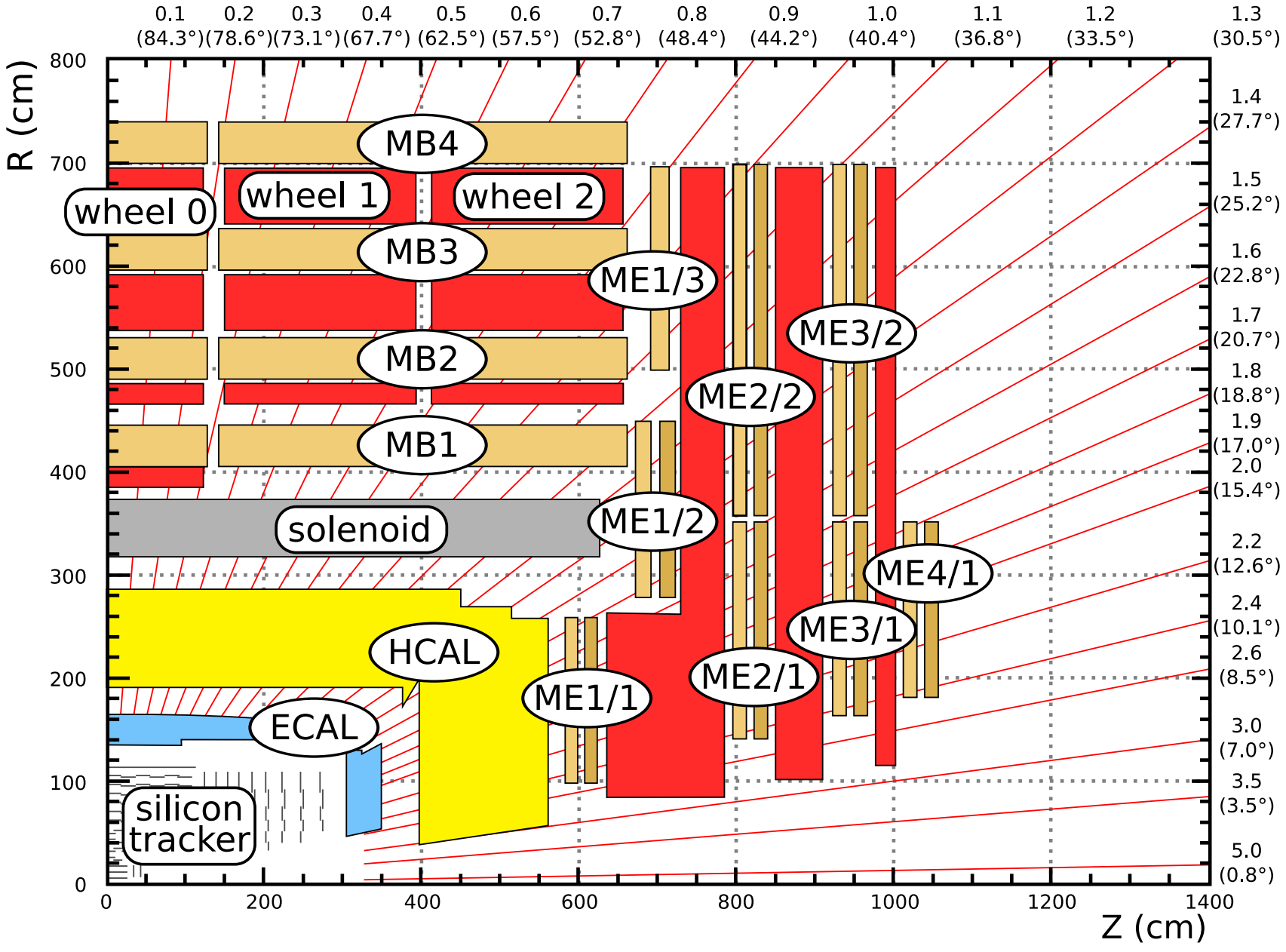


Conclusions

- Broad coverage of experimental signatures: the 2010 data were shaken through a tight sieve, searching for new physics
- CMS public results

  https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResults
- LHC dataset is still growing exponentially: it is reasonable to believe that a dramatic discovery may be in store for us soon

SUSY limits in the $m_{1/2}$, m_0 plane



CMS quarter-view