hadronic searches at the Tevatron and the LHC (with bias: CDF, CMS)

Workshop	running now! **Interpreting LHC Discoveries** SCHEDULE
Conference	running now! **Interpreting LHC Discoveries Conference** SCHEDULE

M. Spiropulu
Nov. 9, 2011

CMS Collaboration, "Inclusive search for squarks and gluinos in pp collisions at sqrt(s) 7 TeV", arXiv:1107.1279.

D0 Collaboration, "Search for squarks and gluinos in events with jets and missing transverse energy using 2.1 fb^{-1} of p anti-p collision data at $s^{(1/2)}$ = 1.96 TeV", *Phys. Let* **B660** (2008) 449–457, arXiv:0712.3805. doi:10.1016/j.physletb.2008.01.042.

CDF Collaboration, "Inclusive Search for Squark and Gluino Production in p anti-p Collisions at $s^{(1/2)}$ = 1.96 TeV", *Phys. Rev. Lett.* **102** (2009) 121801, arXiv:0811.2512 doi:10.1103/PhysRevLett.102.121801.

Atlas Collaboration, "Search for squarks and gluinos using final states with jets and missing transverse momentum with the ATLAS detector in sqrt(s) = 7 TeV proton-proto collisions", arXiv:1102.5290.

Atlas Collaboration, "Search for supersymmetry using final states with one lepton, jets, and missing transverse momentum with the ATLAS detector in sqrt(s) = 7 TeV pp", arXiv:1102.2357.

CMS Collaboration, "Search for new physics with the jets and missing momentum signature at the LHC", *CMS PAS* **SUS-10-005** (2011).

CMS Collaboration, "Search for Supersymmetry in pp Collisions at 7 TeV in Events with Jets and Missing Transverse Energy", *Phys. Lett.* **B698** (2011) 196–218, arXiv:1101.1628. doi:10.1016/j.physletb.2011.03.021.

CMS Collaboration, "Search for new physics with same-sign isolated dilepton events with jets and missing transverse energy at the LHC", arXiv:1104.3168.

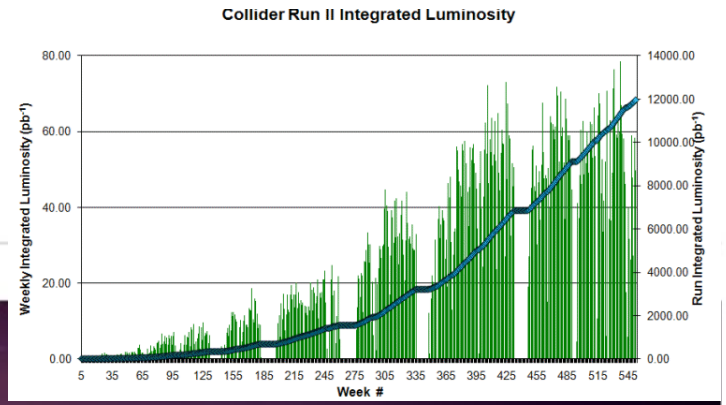
CMS Collaboration, "Search for Physics Beyond the Standard Model in Opposite- Sign Dilepton Events at sqrt(s) = 7 TeV", arXiv:1103.1348.

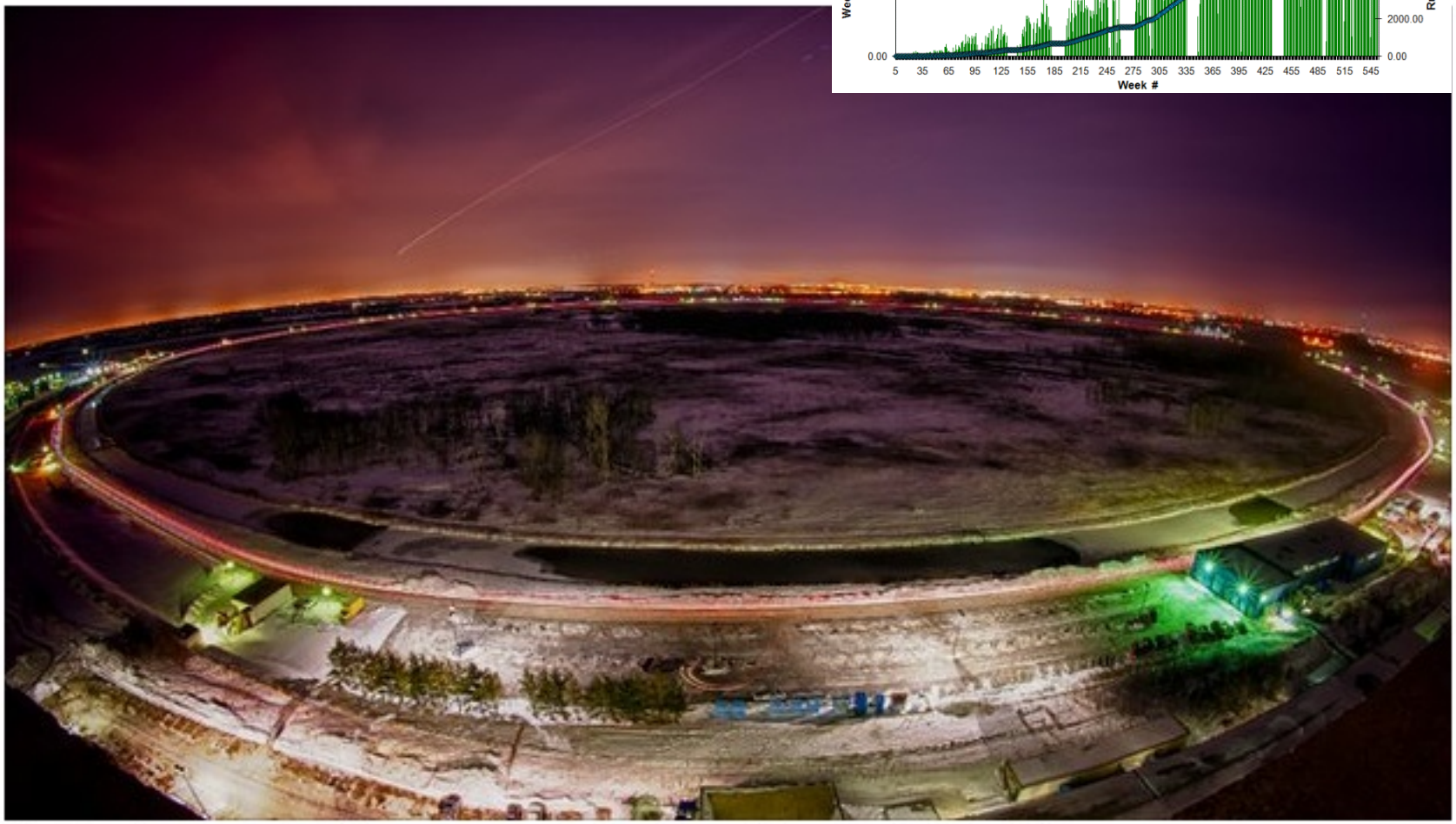
CMS Collaboration, "The CMS experiment at the CERN LHC", *JINST* **3** (2008) S08004. doi:10.1088/1748-0221/3/08/S08004.

CMS Collaboration, "CMS technical design report, volume II: Physics performance", *J. Phys. G* **34** (2007) 995–1579. doi:10.1088/0954-3899/34/6/S01.

Tevatron atom smasher shuts after more than 25 years

By Paul Rincon
Science editor, BBC News website





The Tevatron dominated the energy physics frontier until the advent of the LHC

Discoveries and Highlights (CDF, similar for D0)

- **World's Most Precise Top-Quark Mass Determination (Winter 2011, $> 4\text{fb}^{-1}$)** ℓ+jets+MET
- **Tevatron Combined Higgs Results (Spring 2009, 4.2 fb^{-1})**

$\times 2$

- **Observation of Electroweak Top Quark Production (Spring 2009, 3.2 fb^{-1})**
- **Evidence for Structure in $J/\psi\phi$ from B Decays (Spring 2009, 3.2 fb^{-1})**

$\times 2$

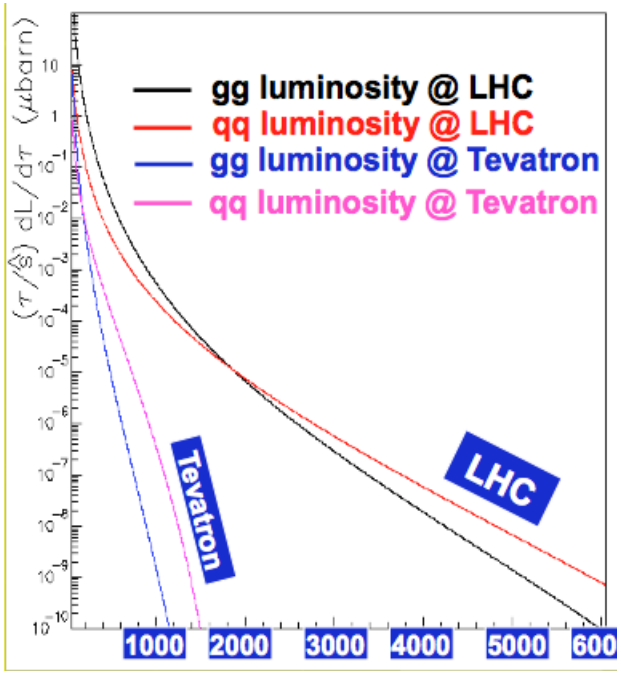
- **Observation of ZZ Production (Winter 2008, 1.9 fb^{-1})** 2ℓ+MET, 4ℓ
- **Observation and Mass of the Ξ_b baryon (2007, 1.9 fb^{-1})**
- **Evidence for $D^0 - \bar{D}^0$ Mixing (Fall 2007, 1.5 fb^{-1})**

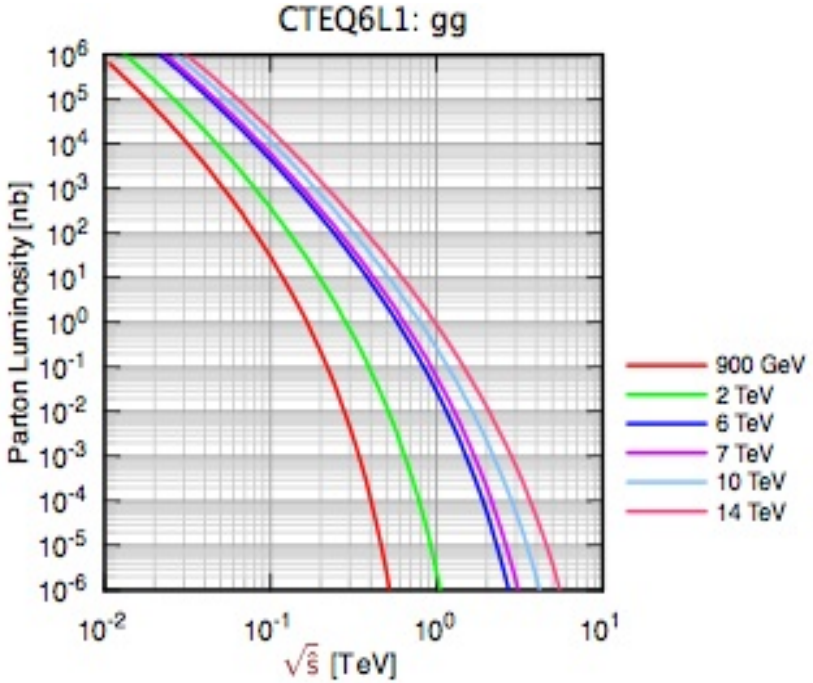
$\times 5$

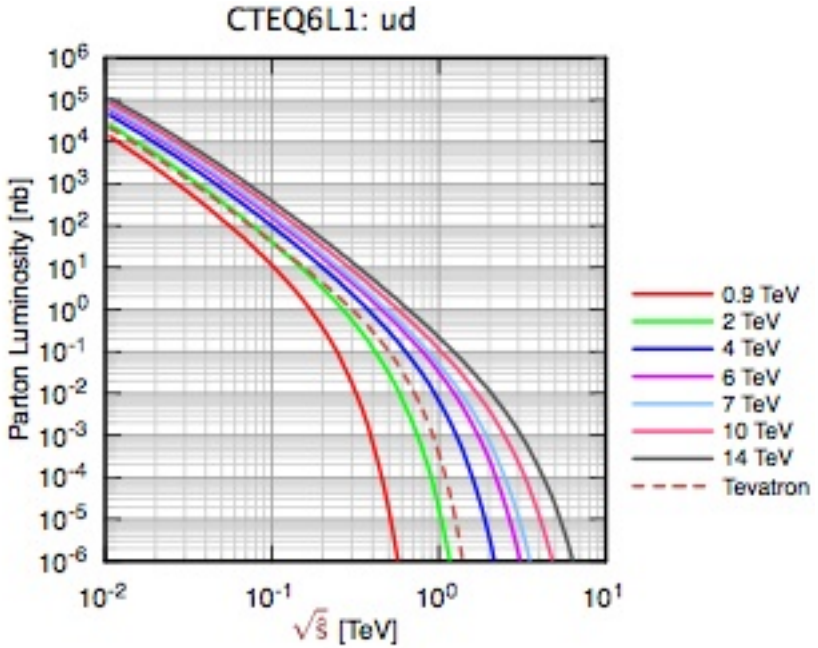
- **Discovery of the Σ_b baryon (Summer 2007, 1.1 fb^{-1})**
- **Observation of WZ events at CDF (Fall 2006, 1.1 fb^{-1})** 3ℓ+jets
- **Observation of B_s Oscillations (Fall 2006, 1.0 fb^{-1})**

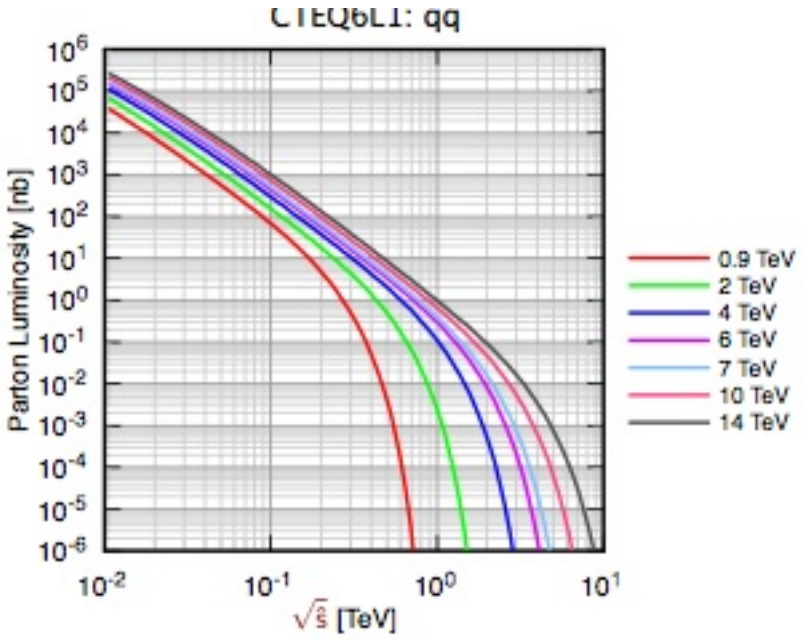
$\times 2$

- **World's Most Precise W-Boson Mass Determination (Winter 2007, 200 pb^{-1})** ℓ+jets+MET
- **Discovery of the Top Quark at CDF (Winter 1995, 67 pb^{-1})**


gg luminosity @ LHC
qq luminosity @ LHC
gg luminosity @ Tevatron
qq luminosity @ Tevatron
Tevatron
LHC
1000
2000
3000
4000
5000
600


CTEQ6L1: gg
Parton Luminosity [nb]
√ŝ [TeV]
900 GeV
2 TeV
6 TeV
7 TeV
10 TeV
14 TeV


CTEQ6L1: ud
Parton Luminosity [nb]
√ŝ [TeV]
0.9 TeV
2 TeV
4 TeV
6 TeV
7 TeV
10 TeV
14 TeV
Tevatron


CTEQ6L1: qq
Parton Luminosity [nb]
√ŝ [TeV]
0.9 TeV
2 TeV
4 TeV
6 TeV
7 TeV
10 TeV
14 TeV

N.B. Prerequisite path of Discovery Work

- Understand detectors and SM backgrounds
- Control/understand: trigger, initial calibrations, scales, resolutions, efficiencies
- Minimize poorly estimated standard model backgrounds
- Use SM “candle”/control samples (W/Z/top) to estimate backgrounds as possible
- Use **ratios** as much as possible to get rid of luminosity dependence and other cross section related systematics
- Adapt methods for background extraction as a function of luminosity
- Have in place MC tools, statistics tools

Program of work

- Data-driven estimation of Z/W+jets backgrounds to SUSY
- Data-driven estimation of top+jets backgrounds to SUSY
- Data-driven estimation of QCD/multijet backgrounds to SUSY
- Data-driven estimation of heavy flavor backgrounds and associated systematic
- Searches and inclusive studies for SUSY events
- Exclusive measurements and searches for SUSY events
- Gaugino direct productions (not here)
- Studies for Gauge mediated SUSY

some CMS SUSY related publications; similar from ATLAS

▸ J. Phys. G: Nucl. Part. Phys. 34 995 ▸ CMS-SUS-09-004 ▸ CMS-SUS-10-001 ▸ EGM-10-005

▸ CMS-NOTE-2010-008 ▸ CMS-SUS-09-002 ▸ CMS-EWK-10-002 ▸ CMS-EWK-09-006

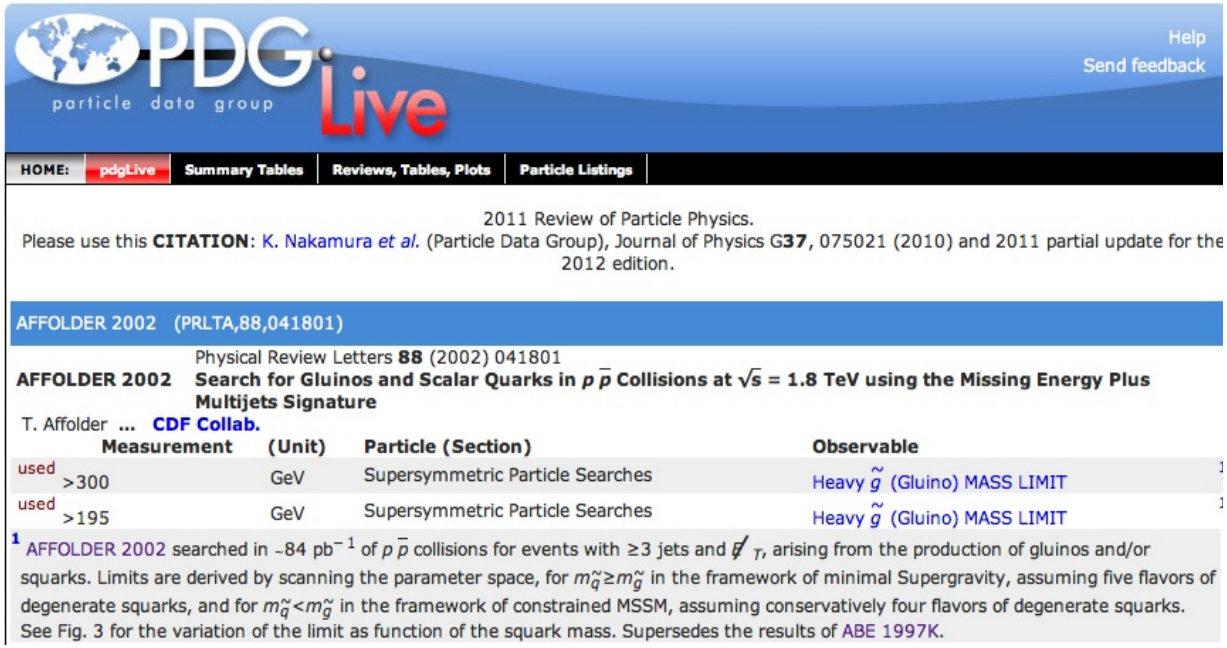
▸ CMS-EWK-08-006 ▸ CMS-SUS-08-002 ▸ CMS-SUS-09-002 ▸ CMS-MET-10-004

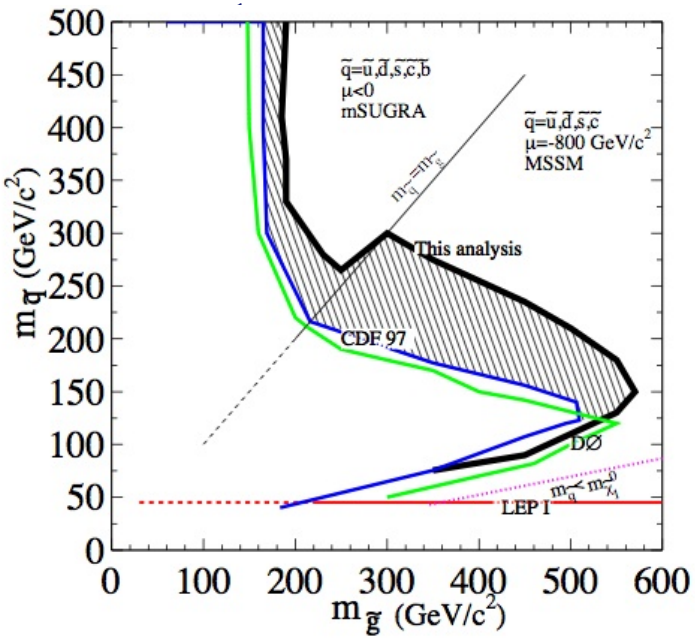
Nota Bene

1. the LHC7 has come up full-force and in one year much more progress was noted in the machine and the experiments compared to naive expectations;
2. the delay compared to the 2005 schedule have not gone in the wind: we used it to be instantly prepared for the data and the analyses;
3. all the analyses and expectations with the first xx pb^{-1} are the ones for well-understood xx pb^{-1};
4. to the LHC machine people and the people who took care of the experiments and commissioned them with their blood goes all the admiration and kudos - a feat of experimental physics has been seen with the LHC in the year 2010

2002, 100 pb^{-1} 1.8 TeV $p\bar{p}$	2007, 2.5 fb^{-1} 1.96 TeV $p\bar{p}$
2007, 1-10 fb^{-1} 14 TeV pp	2010, 35 pb^{-1} 7 TeV pp
2011, 1 fb^{-1} 7 TeV pp	2011, 5 fb^{-1} 7 TeV pp

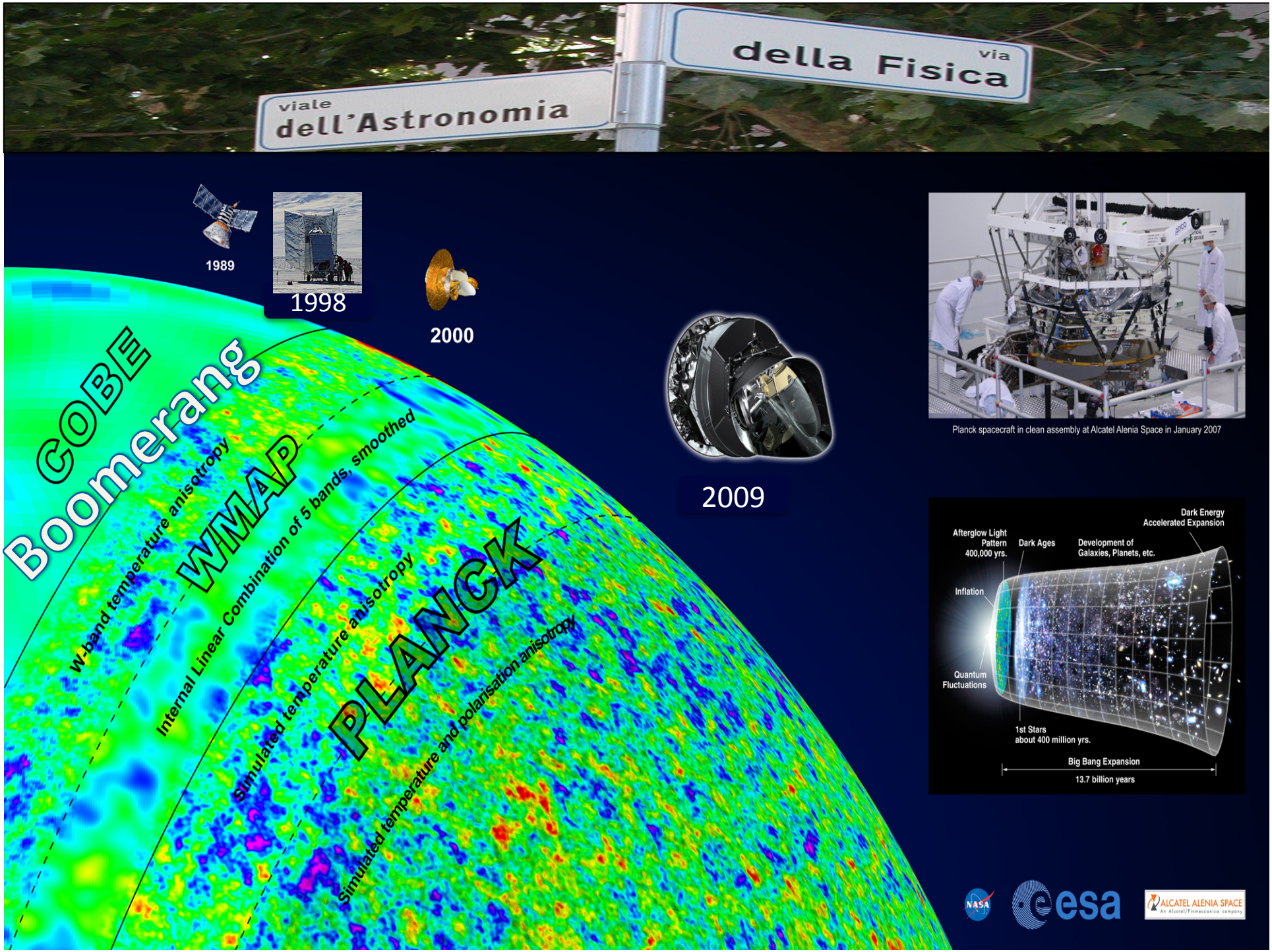
- **2002, Tevatron RUNI 1.8 TeV $p\bar{p}$ dataset, 100 pb^{-1}, gluino $\sim$ 300 GeV [Phys. Rev. Lett. 88, 041801 (2002)**





• inclusive MET+jets • huge instrumental backgrounds (main ring, beam halo, cosmics, texas towers, daq noise etc) • data-driven backgrounds (Z+jets candle) • angular correlations in jets-MET for cleaning jet mismeasurements

J. Feng, K. Matchev, F. Wilczek (v 2000)


viale
dell'Astronomia
via
della Fisica
1989
1998
2000
2009
COBE
Boomerang
WMAP
PLANCK
W-band temperature anisotropy
Internal Linear Combination of 5 bands, smoothed
Simulated temperature anisotropy
Simulated temperature and polarisation anisotropy
Planck spacecraft in clean assembly at Alcatel Alenia Space in January 2007
Dark Energy
Accelerated Expansion
Afterglow Light
Pattern
400,000 yrs.
Dark Ages
Development of
Galaxies, Planets, etc.
Inflation
Quantum
Fluctuations
1st Stars
about 400 million yrs.
Big Bang Expansion
13.7 billion years
NASA
esa
ALCATEL ALENIA SPACE

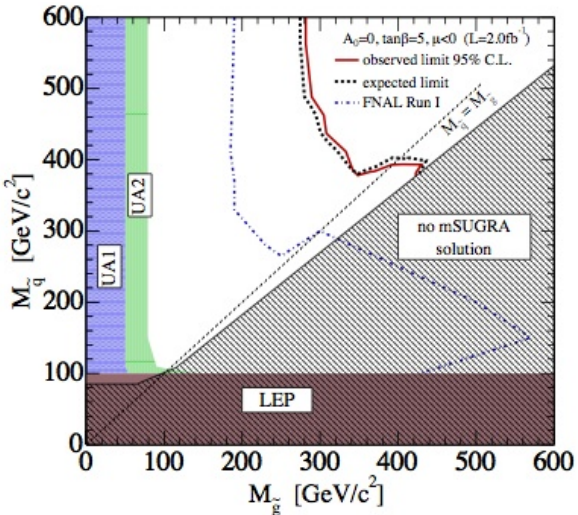
2002, 100 pb^{-1} 1.8 TeV $p\bar{p}$	2007, 2.5 fb^{-1} 1.96 TeV $p\bar{p}$
2007, 1-10 fb^{-1} 14 TeV pp	2010, 35 pb^{-1} 7 TeV pp
2011, 1 fb^{-1} 7 TeV pp	2011, 5 fb^{-1} 7 TeV pp

- **2002, Tevatron RUNI 1.8 TeV $p\bar{p}$ dataset, 100 pb^{-1}, gluino $\sim$ 300 GeV [Phys. Rev. Lett. 88, 041801 (2002)**
- **2007, Tevatron RUNII 1.96 TeV $p\bar{p}$ dataset, 2.5 fb^{-1} 2009, gluino $\sim$ 400 GeV Phys. Rev. Lett. 102, 121801 (2009) [Tevatron end-game]**

(Dated: November 15, 2008)

We report on a search for inclusive production of squarks and gluinos in $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV, in events with large missing transverse energy and multiple jets of hadrons in the final state. The study uses a CDF Run II data sample corresponding to 2 fb^{-1} of integrated luminosity. The data are in good agreement with the standard model predictions, giving no evidence for any squark or gluino component. In an R-parity conserving minimal supergravity scenario with $A_0 = 0$, $\mu < 0$ and $\tan\beta = 5$, 95% C.L. upper limits on the production cross sections in the range between 0.1 pb and 1 pb are obtained, depending on the squark and gluino masses considered. For gluino masses below 280 GeV/c^2, arbitrarily large squark masses are excluded at the 95% C.L., while for mass degenerate gluinos and squarks, masses below 392 GeV/c^2 are excluded at the 95% C.L.

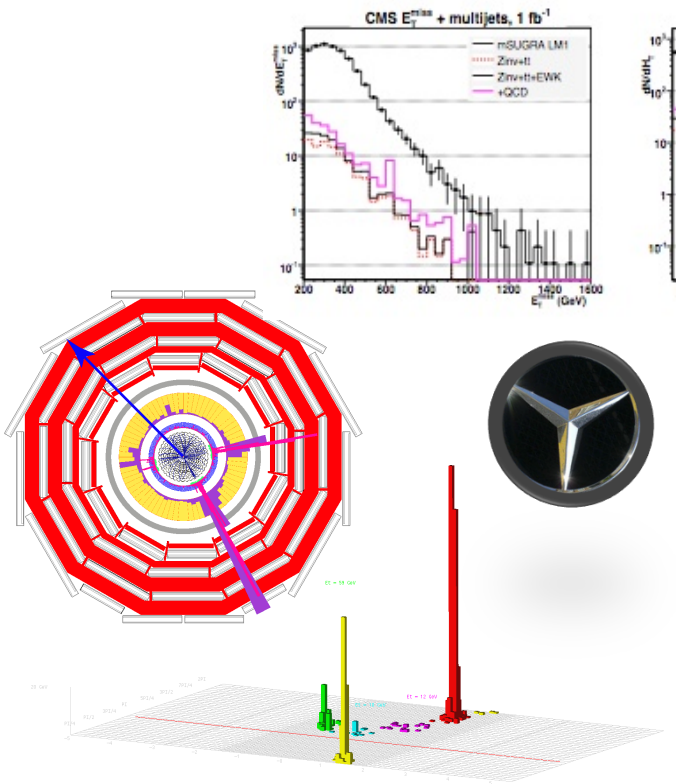
PACS numbers: 14.80.Ly, 12.60.Jv

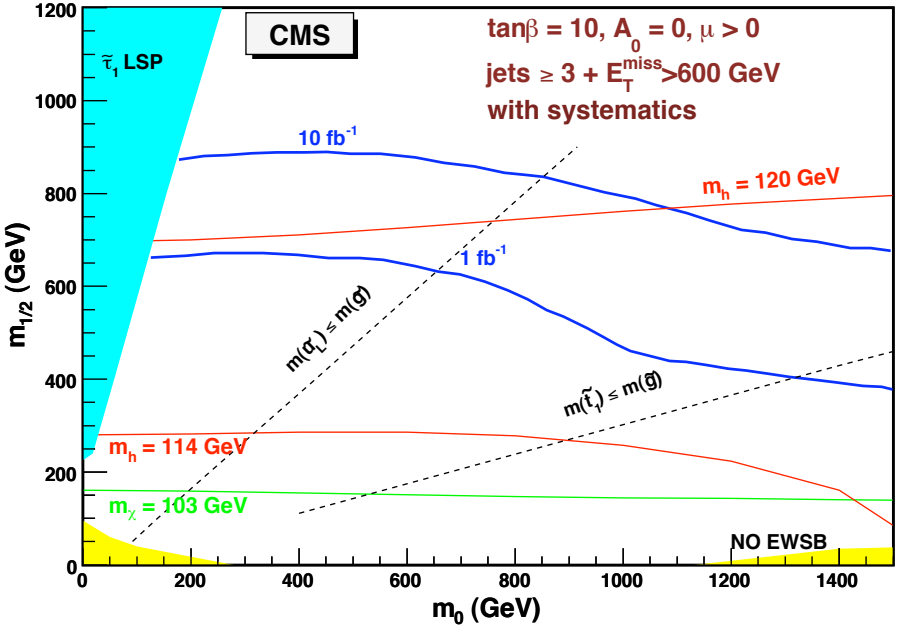


- factor of 25 in luminosity $\longrightarrow$ 100 GeV in gluino mass

2002, 100 pb^{-1} 1.8 TeV $p\bar{p}$	2007, 2.5 fb^{-1} 1.96 TeV $p\bar{p}$
2007, 1-10 fb^{-1} 14 TeV pp	2010, 35 pb^{-1} 7 TeV pp
2011, 1 fb^{-1} 7 TeV pp	2011, 5 fb^{-1} 7 TeV pp

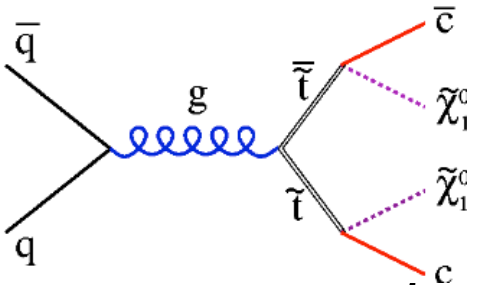
- **2007, CMS Physics TDR [preparing the search and discovery program]**





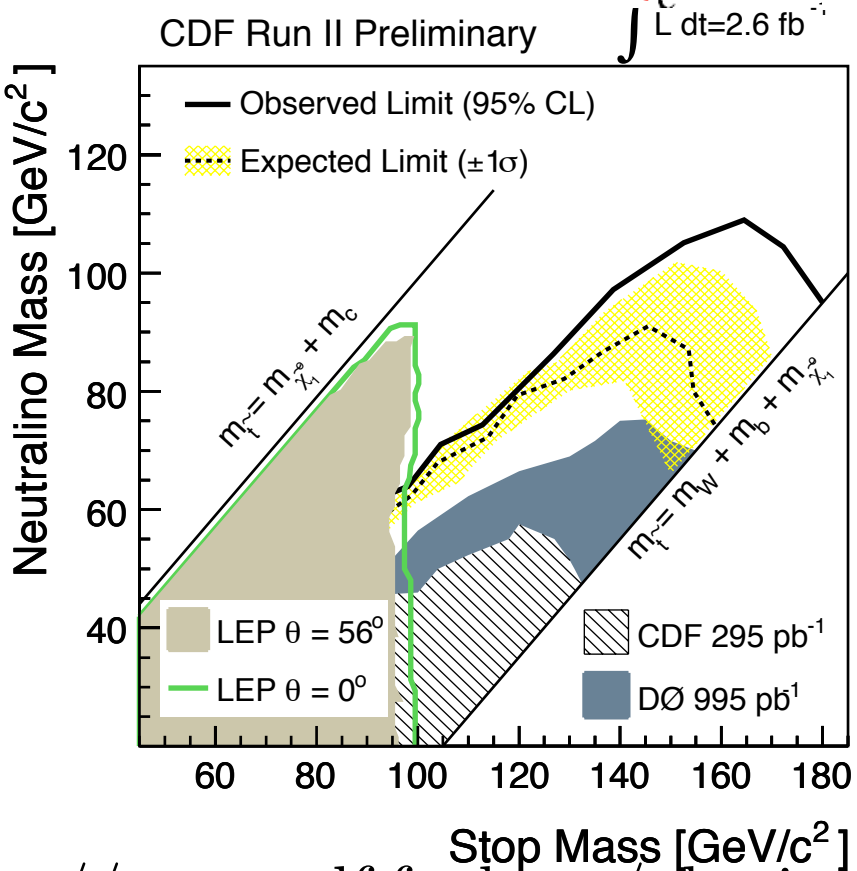
- **1 fb^{-1} 14 TeV, gluino $\sim$ 1.3 TeV**

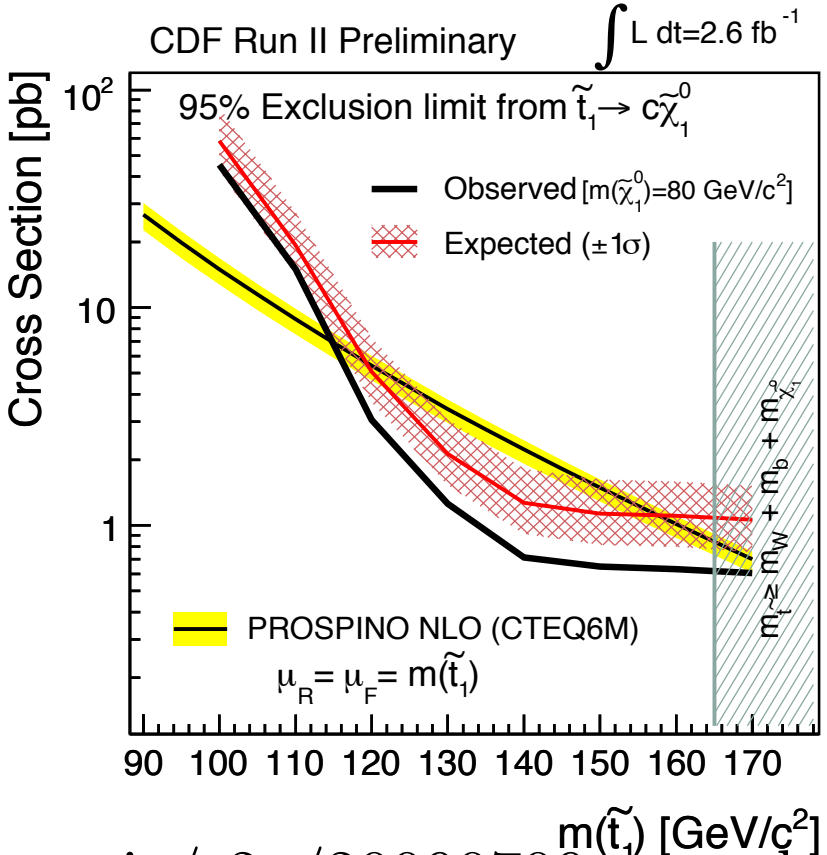
2009, 2.6 fb^{-1} $p\bar{p}$



- At least 2 Jets
- MET > 50 GeV
- ET > 25 GeV and $|\eta| < 2.4$
- Leading Jet ET > 35 GeV
- 1 Central Jet $|\eta| < 0.9$
- Jet EM Fraction < 0.9

NN+CHAOS





http://www-cdf.fnal.gov/physics/exotic/r2a/20090709.stop_charm/

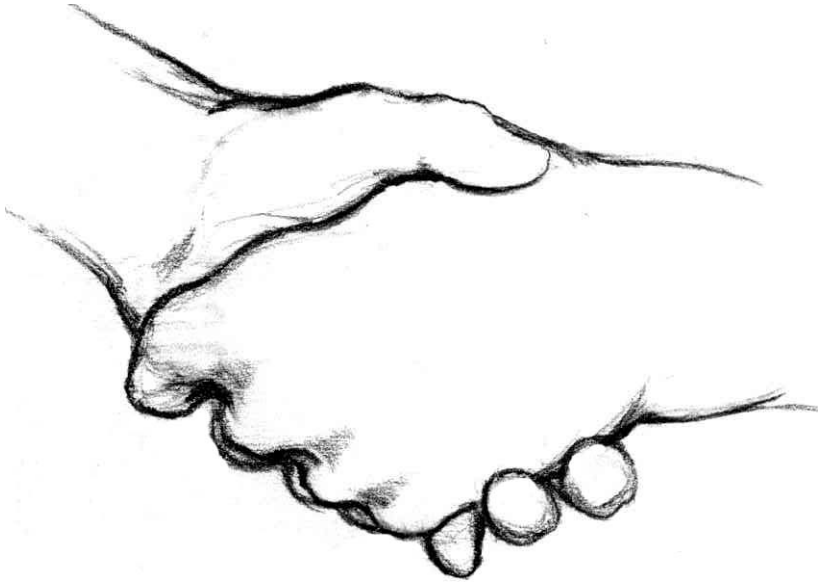
typically

super-models are attractive and come in many categories

NUHM2, NUHM1, CMSSM, RPV CMSSM, Gauge-mediated, anomaly mediated, pMSSM, G2 ....

The are non-SUSY super-models that maintain an attractive attribute of the SUSY super-models: the connection with DM. They tend to give similar experimental footprints

example of *super-all-hadronic* analysis with SUSY interpretations
RPV gluino : MUTLIJETS no MET

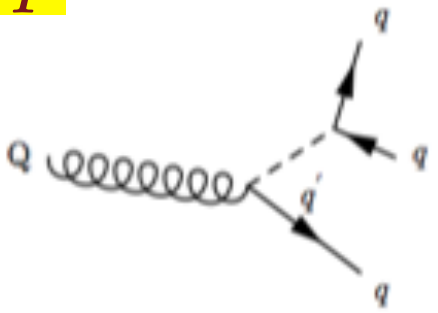


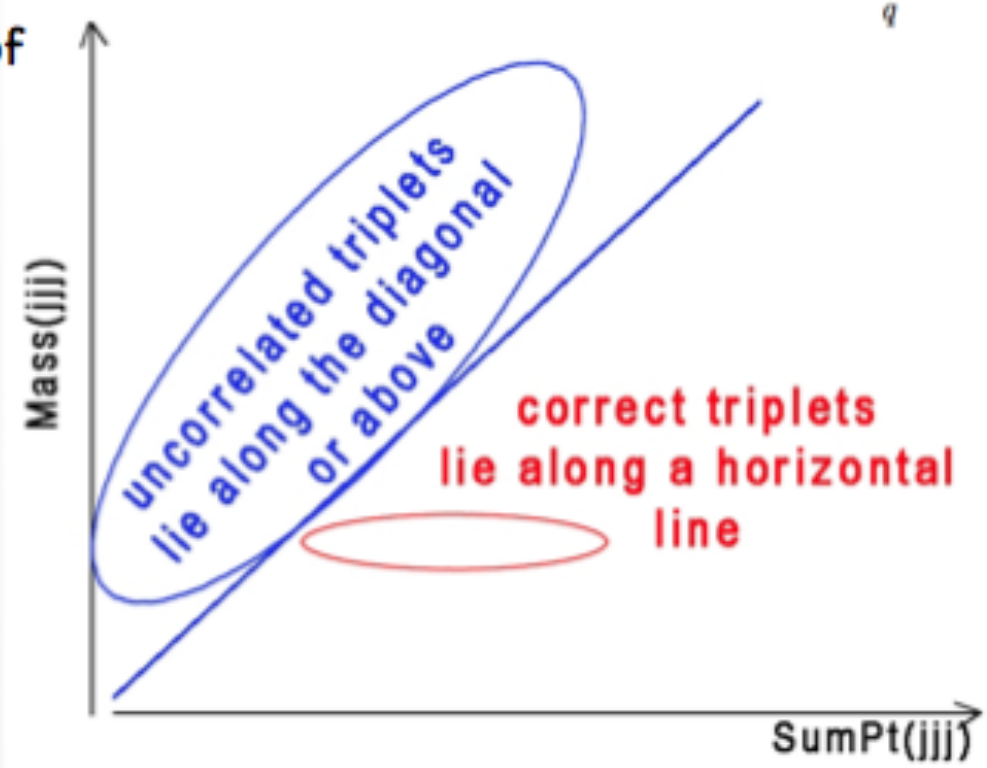
Search for 3-jet Resonances

2009, 3.2 fb^{-1}, 1.96 $p\bar{p}$

- Search for pp->QQ -> 3j + 3j
  (final state with 6 or more jets)
- Look at all possible combinations in an multijet
- Each event has an "ensemble" of 20 or more triplets

- Event Selection:
- At least 6 jets
  with p_T > 15 GeV/c
  from the same vertex
- Σ_6 p_T > 250 GeV/c
- Missing E_T < 50 GeV

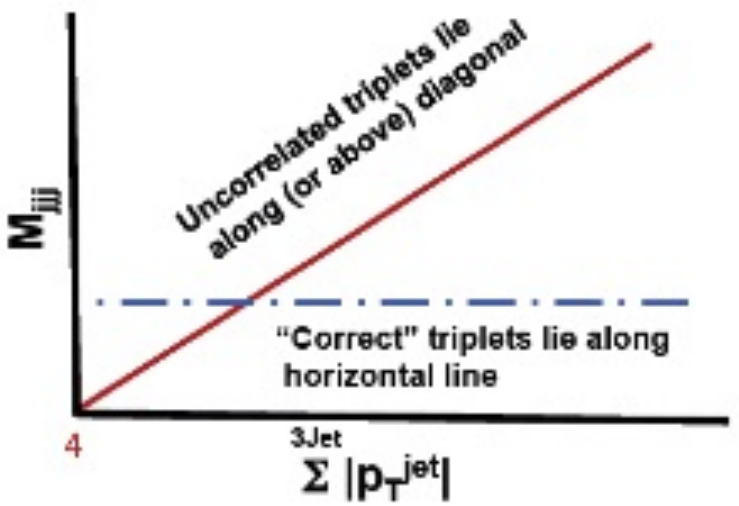




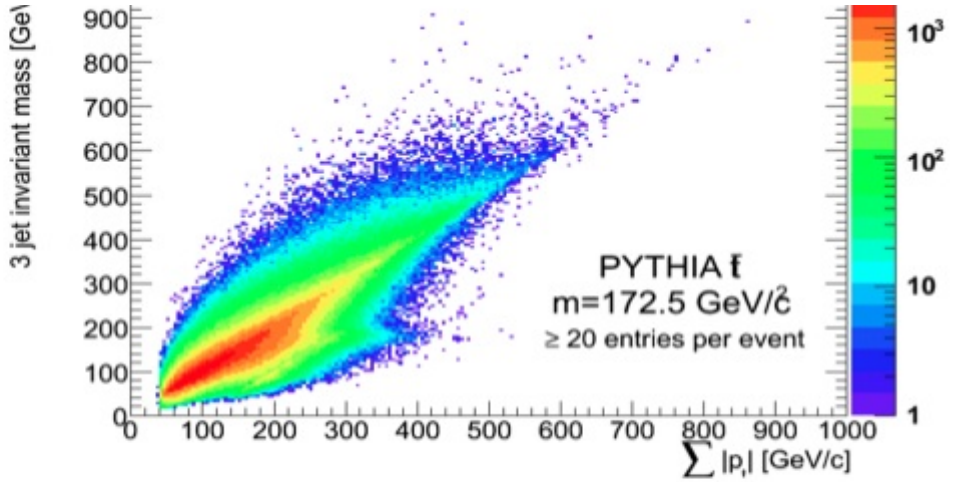
Multijet Resonances

2011, 35 pb^{-1}, 7 TeV pp

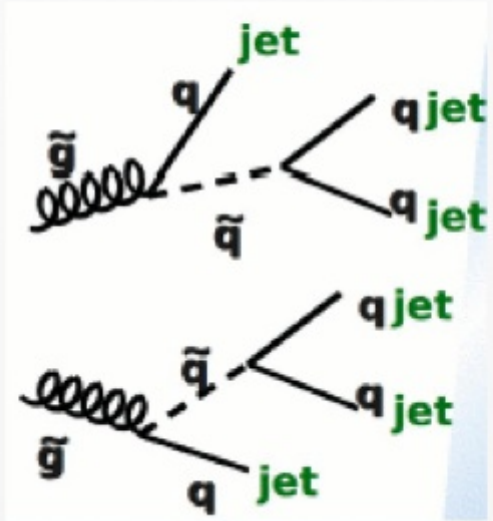
- Search for pair produced R-Parity violating Supersymmetry gluino (no MET) from 6 jet final state
- Huge combinatorial background besides QCD background
  - 20 triplet combinations from 6 jets
- Use a diagonal cut to remove combinatorial background as well as QCD background:
  - $m_{jjj} < \Sigma\ |p_T(\text{triplet})| - \alpha$ (Offset)
- Critical cut in multijet resonances search

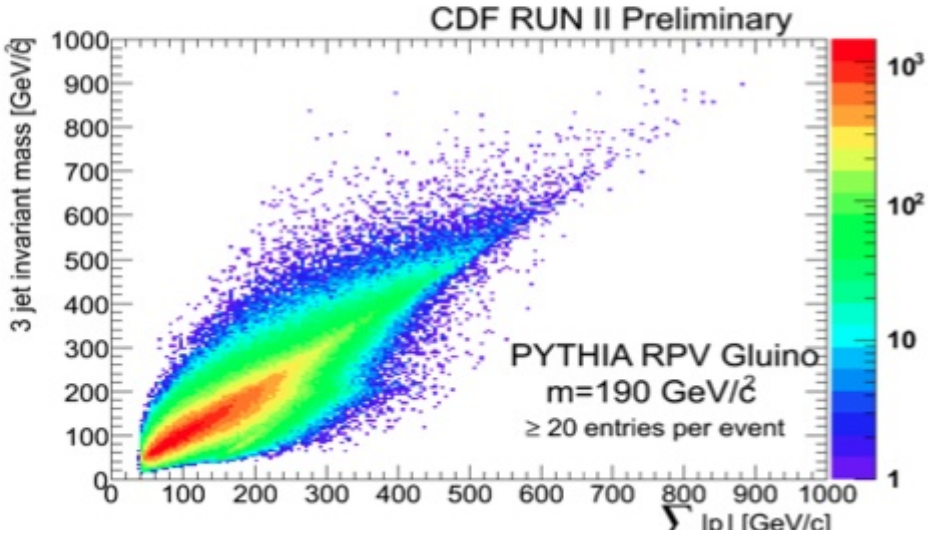


- Signal examples: tt



- RPV gluino:



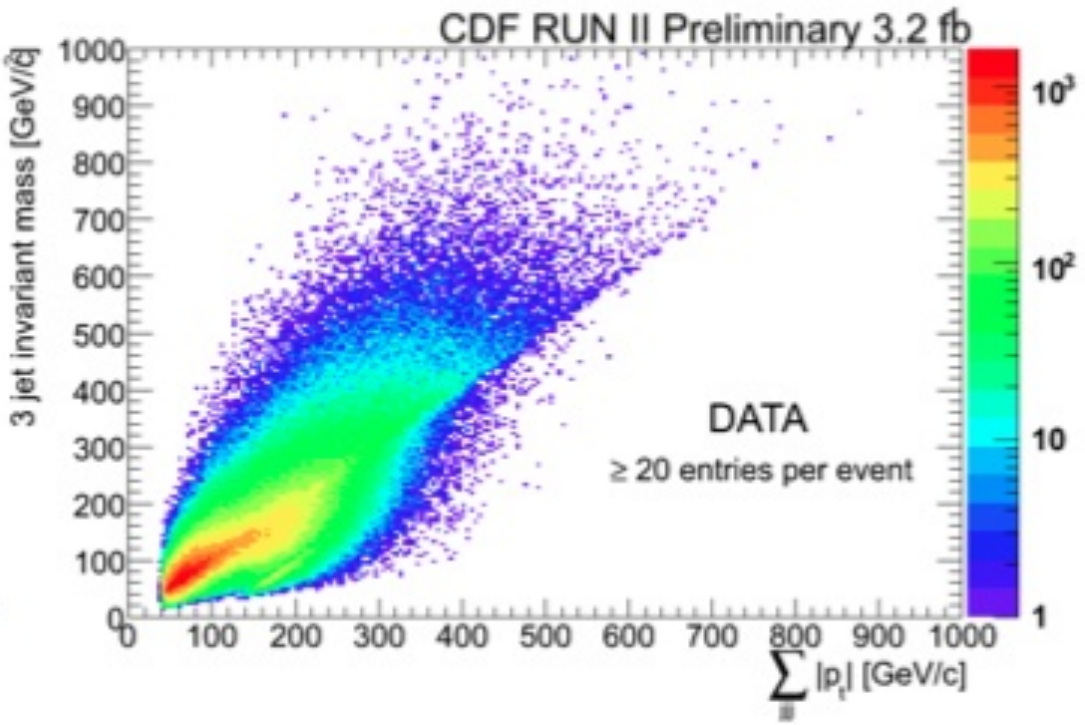


Search for 3-jet Resonances

- Analysis strategy:
- Apply diagonal cut:
- $\Sigma_{3j}\ p_T - m(jjj) > \alpha$

Optimized for each gluino mass

- Fit the final mass cut
- Use statistically independent 5-jet sample to model QCD background (Landau-shape)
- Signal is a combination of Gaus (correct triplet combination) and Landau (wrong combination)

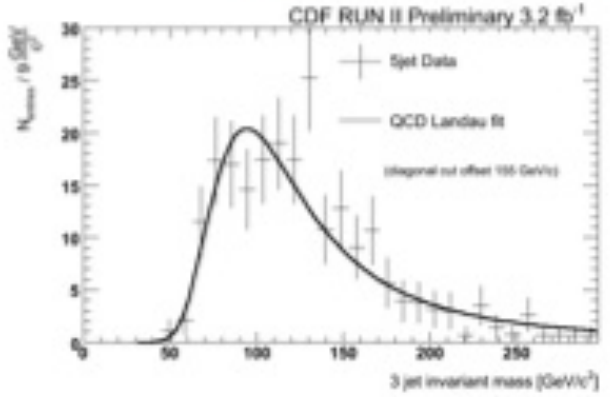


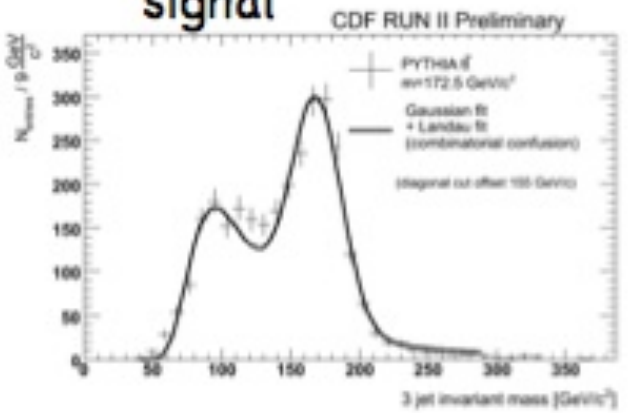
$2009,\ 3.2\ \mathrm{fb}^{-1},\ 1.96\ p\bar{p}$

2009, 3.2 fb^{-1}, 1.96 $p\bar{p}$

Search for 3-jet Resonances

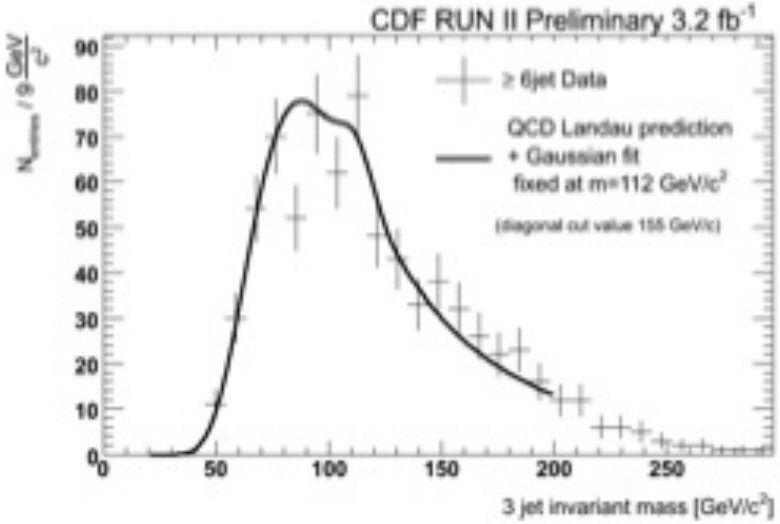
- Fit : QCD + signal

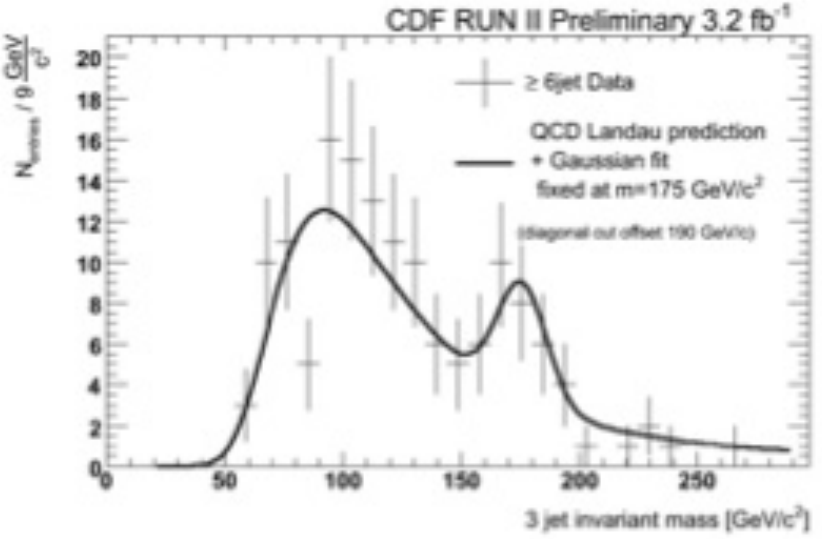




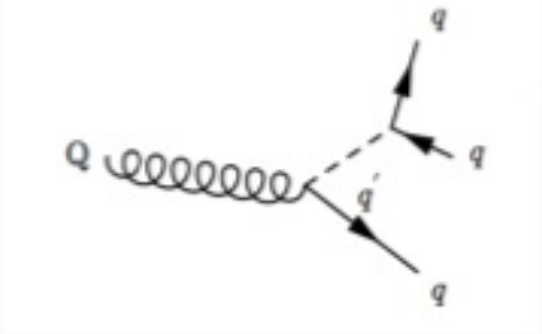
For various diagonal offset cuts

- Data Results:

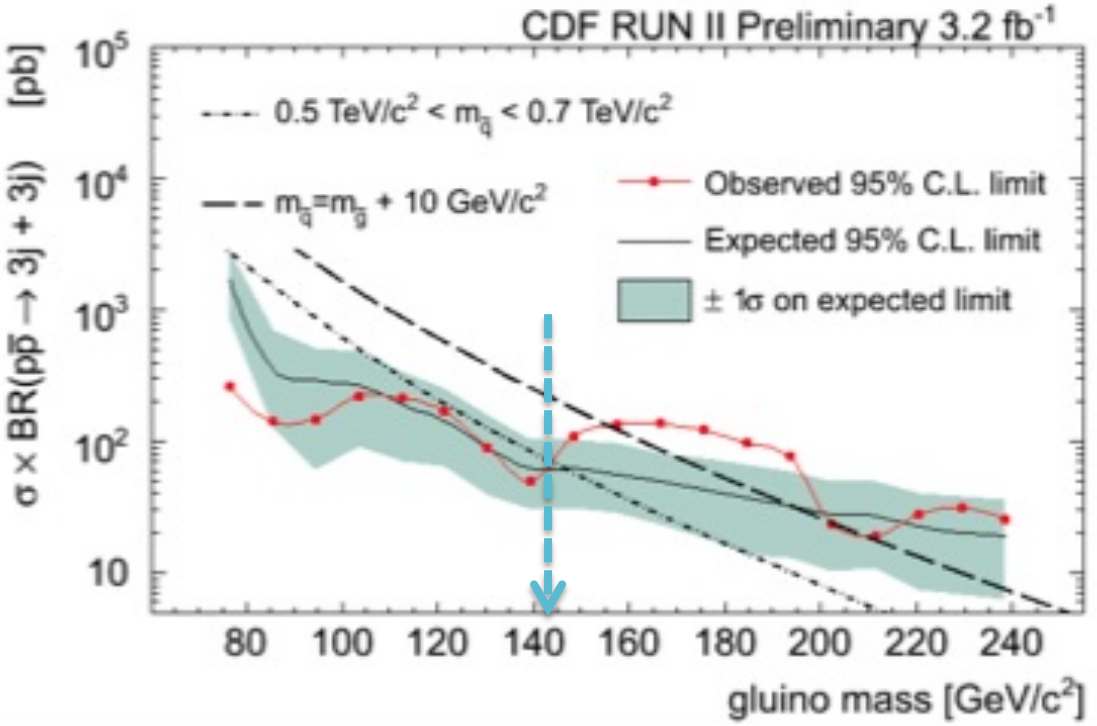




Search for 3-jet Resonances



- For benchmark scenario exclude gluino mass below 144 GeV



2009, 3.2 fb^{-1}, 1.96 $p\bar{p}$

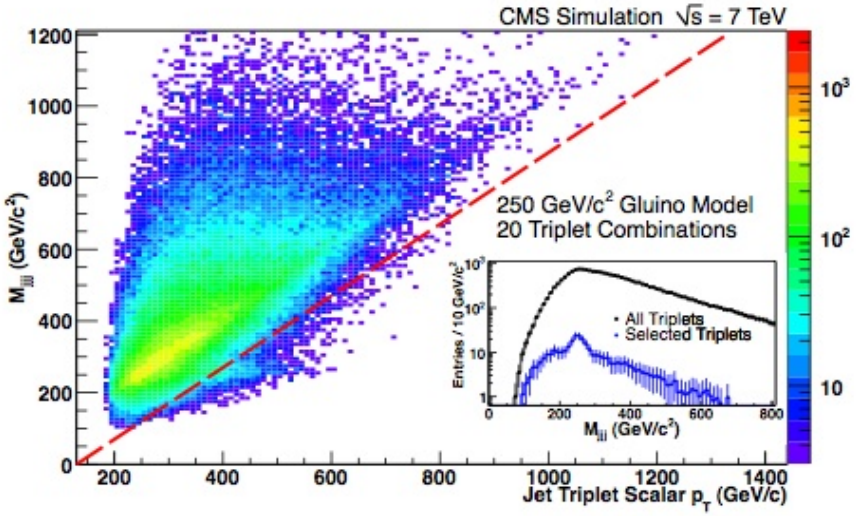


Figure 1: Simulated triplet jet invariant mass M_{jjj} versus the triplet scalar p_T of all 20 triplets, for a gluino mass of 250 GeV/c^2. All triplets falling to the right of the red dashed line pass the requirement of Eq. 1. In the insert, the invariant mass distribution for the same gluino mass is shown both before and after Eq. 1 is imposed.

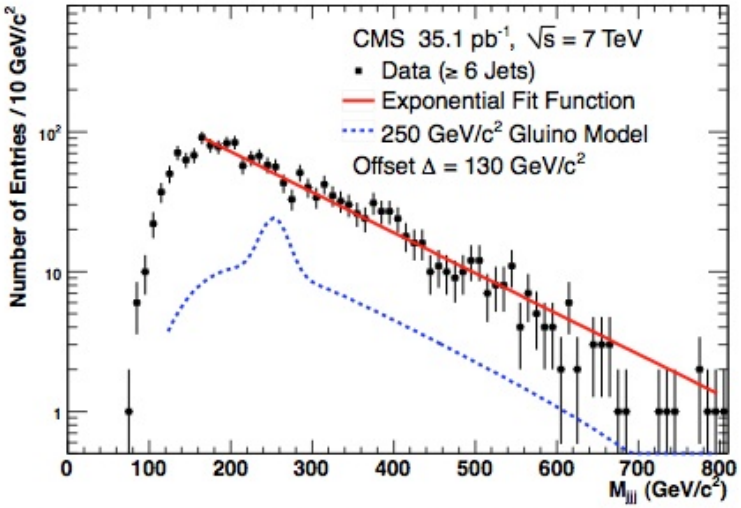


Figure 2: Three-jet invariant mass distribution of triplets passing all selection criteria for the $N_{\rm jet} \geq 6$ data sample. An exponential function representing the background shape, constrained from the $N_{\rm jet} = 4$ distribution, and the expectation for the 250 GeV/c^2 gluino signal are also shown.

Phys.Rev.Lett.107:101801,2011

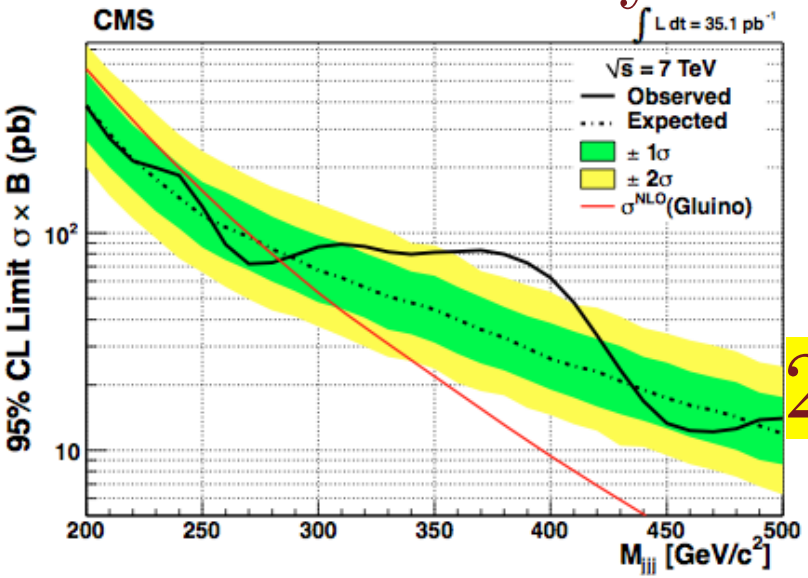
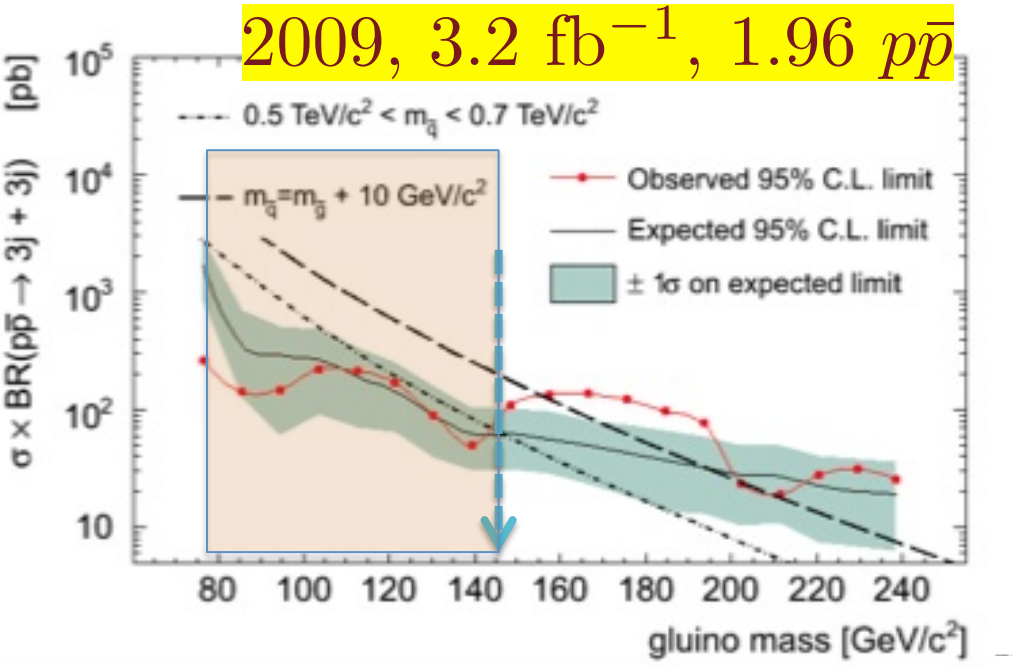


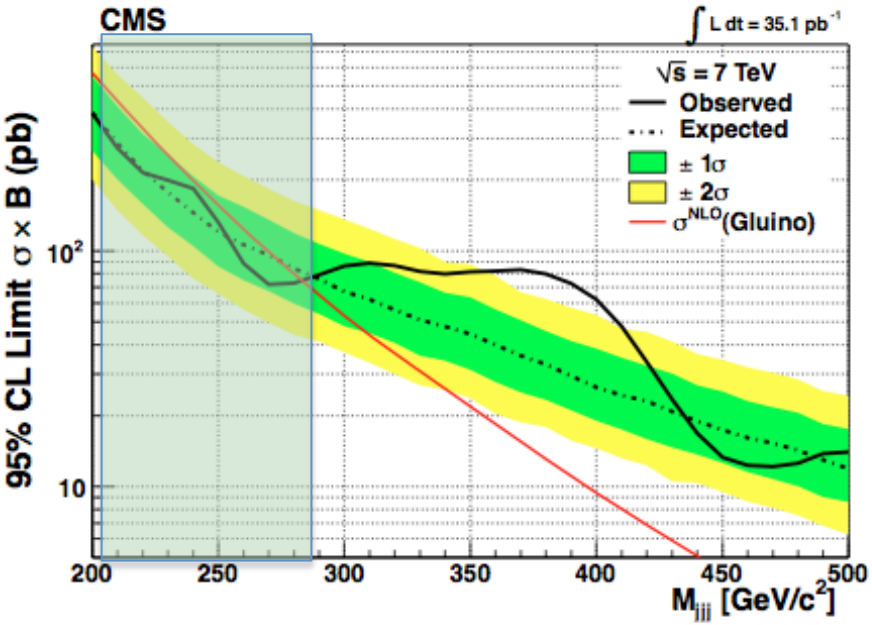
Figure 3: Observed and expected 95% CL upper limits on the cross section for gluino pair production through RPV decays, where the branching ratio of the gluino to three jets is 100%. Also shown are the $\pm 1\sigma$ and $\pm 2\sigma$ bands on the expected limit, as well as the theoretical NLO cross section for gluino production.

95% CL exlcusion

200-280 GeV

2011, 35 pb^{-1}, 7 TeV pp





2011, 35 pb^{-1}, 7 TeV pp

N.B

- **CDF jets 15 GeV, CMS jets 45 GeV**
- **CDF QCD background from 5j data: Landau; CMS QCD background from 4j data:** $e^{p0+p1M_{jjj}}$
- **CDF excludes below 144 GeV, CMS between 200-280 GeV**
- **CDF observed $>$ expected $\sim$ 180 GeV**
- **CMS observed $> 2\sigma$ expected $\sim$ 390 GeV**

targeting discovery

Discovery of new heavy particles consistent with supersymmetry
Some immediate questions:

- **Is it really SUSY? (The look-alike problem)**

- **If it is SUSY, what kind of SUSY? What is the soft-breaking mechanism? (The look-alike problem again, distinguishing different "footprints")**
- **Can you reconstruct all the decay chains and production mechanisms?**
- **Can you make an unambiguous mapping back to the parameters of the soft-breaking Lagrangian? (The inverse problem)**

re-engineering the LHC discovery analyses

Abundance of good ideas and variables attempted for SUSY in the past few years

- Stransverse mass, MT2, and variations
- $s_{min}^{1/2}$ and variations
- Kinematic boundaries and kinks
- α
- razor

why?

for example: why razor? (similar for α, stransverse massess, etc)

The razor analysis methods were born and developed in the context of the look-alike program that calls for new powerful handles for model-disambiguation at discovery

These results demonstrate the strengths of the razor analysis approach; the simple exponential behavior of the various SM backgrounds when described in terms of the razor variables is useful in suppressing these backgrounds and in making reliable estimates from data of the background residuals in the signal regions. Hence, the razor method provides an additional powerful probe in searching for physics beyond the SM at the LHC.

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH (CERN)

arXiv:1006.2727v2

CERN-PH-EP/2011-099
2011/07/07

CMS-SUS-10-009

Inclusive search for squarks and gluinos in pp collisions at $\sqrt{s} = 7\,\text{TeV}$

The CMS Collaboration*

Abstract

A search is performed for heavy particle pairs produced in $\sqrt{s} = 7\,\text{TeV}$ proton-proton collisions with $35\,\text{pb}^{-1}$ of data collected by the CMS experiment at the LHC. The search is sensitive to squarks and gluinos of generic supersymmetry models, provided they are kinematically accessible, with minimal assumptions on properties of the lightest superpartner particle. The kinematic consistency of the selected events is tested against the hypothesis of heavy particle pair production using the dimensionless *razor* variable R, related to the missing transverse energy $E_{\text{T}}^{\text{miss}}$. The new physics signal is characterized by a broad peak in the distribution of M_R, an event-by-event indicator of the heavy particle mass scale. This new approach is complementary to $E_{\text{T}}^{\text{miss}}$-based searches. After background modeling based on data, and background rejection based on R and M_R, no significant excess of events is found beyond the standard model expectations. The results are interpreted in the context of the constrained minimal supersymmetric standard model as well as two simplified supersymmetry models.

Submitted to Physical Review D

CMS Collaboration, "Search for Supersymmetry in pp Collisions at 7 TeV in Events with Jets and Missing Transverse Energy", *Phys. Lett.* **B698** (2011) 196–218, arXiv:1101.1628, doi:10.1016/j.physletb.2011.03.021.

a_T 2010 (35 pb^{-1}, updated 2011 1.1 fb^{-1})

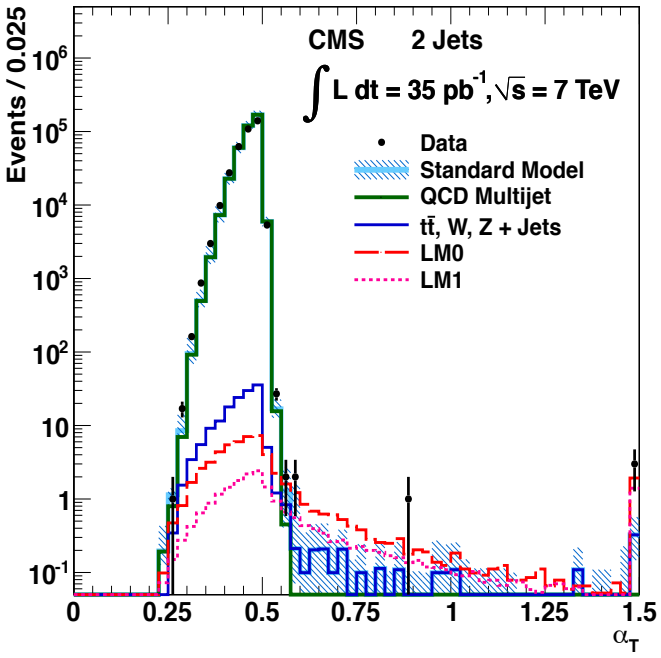
Jets+MET final state search is challenging due to QCD multijet backgrounds:

BUT QCD multi-jets' momentum must ~balance in transverse plane ➔ exploit angle between visible jets with α_T

$$H_T = \sum_{i}^{\text{jets}} |p_T^i|$$

For di-jets:

$$\alpha_T = \frac{\sqrt{p_{T2}/p_{T1}}}{\sqrt{2(1-\cos\Delta\phi)}}$$



super-cited LHC paper

a_T 2010 (35 pb^{-1}, updated 2011 1.1 fb^{-1})

Can generalize to ≥ 3 jet final states by assigning all jets to either one of two *pseudojets*, defined by minimizing

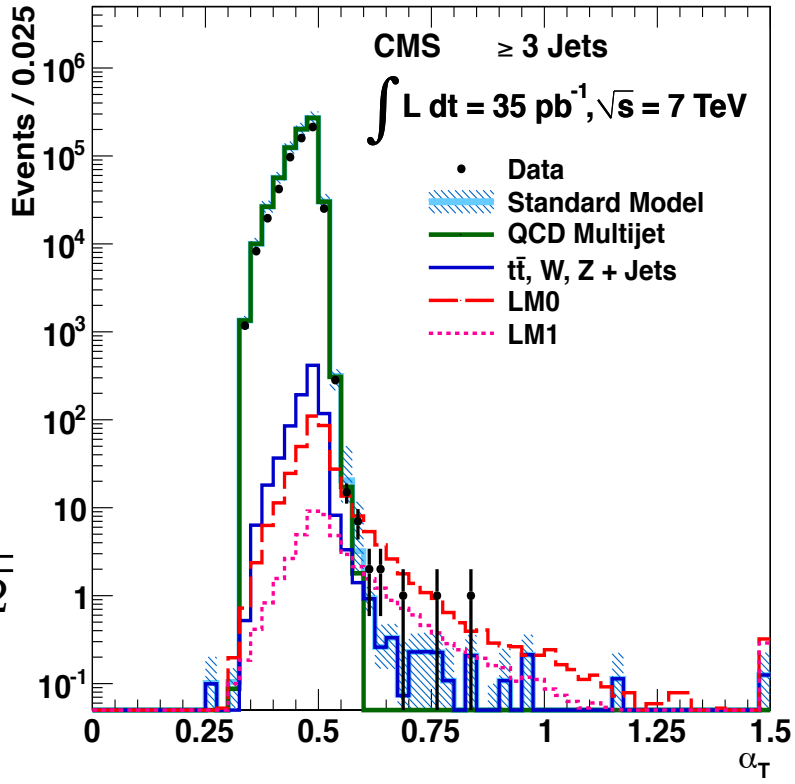
$$\Delta H_T = p_T^{\text{pseudojet 1}} - p_T^{\text{pseudojet 2}}$$

$$H_T = \sum_i^{\text{jets}} |p_T^i|$$

In general:

$$\alpha_T = \frac{1}{2} \frac{H_T - \Delta H_T}{\sqrt{H_T^2 - MHT^2}}$$

$$MHT = |\sum_i^{\text{jets}} \vec{p}_T^{\,i}|$$



Selection:

At least 2 jets with:

$$p_T > 100 \text{ GeV}/c \quad |\eta| < 2.5$$

Include additional jets with:

$$p_T > 50 \text{ GeV}/c \quad |\eta| < 3$$

Signal region defined by:

$$H_T > 350 \text{ GeV} \quad \alpha_T > 0.55$$

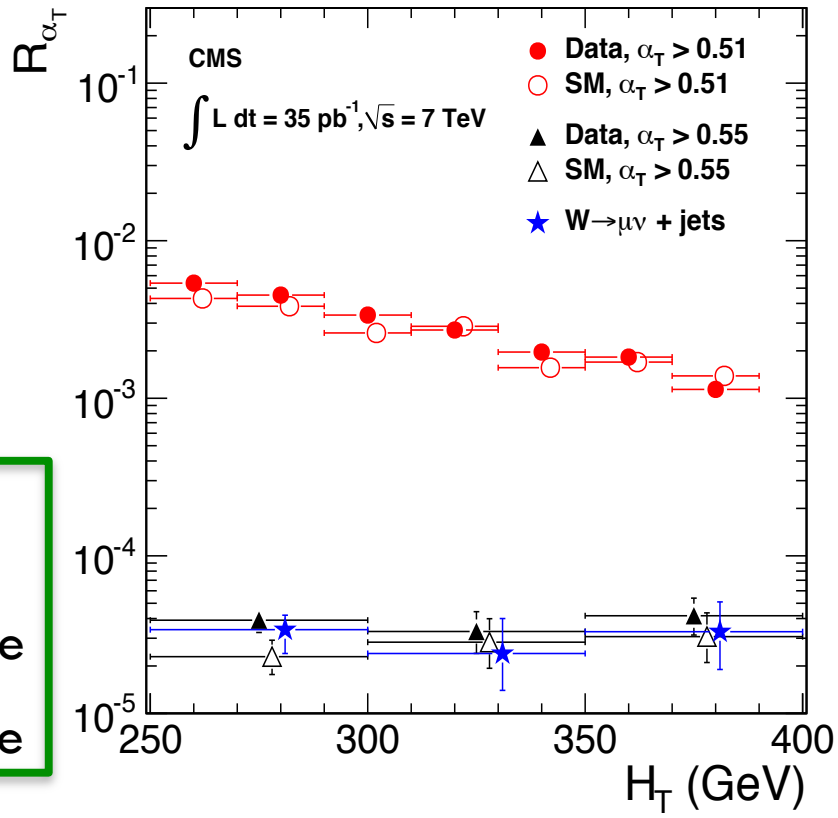
Background prediction:

QCD — Extrapolate yields from low HT to high HT using R_{α_T}

$W(\ell\nu) + \text{jets}, \; t\bar{t}$ — Use μ control sample

$Z(\nu\nu) + \text{jets}$ — Use γ +jets control sample

$$R_{\alpha_T} = \frac{\int_{0.55}^{\infty} \frac{d\sigma}{d\alpha_T} d\alpha_T}{\int_{0}^{0.55} \frac{d\sigma}{d\alpha_T} d\alpha_T}$$



Predict: $9.4^{+4.8}_{-4.0}$ (stat) ± 1.0 (syst) events

Observe: 13 event

a_T 2010 (35 pb^{-1})

Jets+MET (canonical) with HT and MHT 2010 35 pb^{-1} updated 2011 1.1 fb^{-1}

Search for high p_T jets, high HT and high MHT

$$H_T = \sum_{i}^{\text{jets}} |p_T^i|$$

$$MHT = |\sum_{i}^{\text{jets}} \vec{p}_T^{\,i}|$$

Selection (baseline):

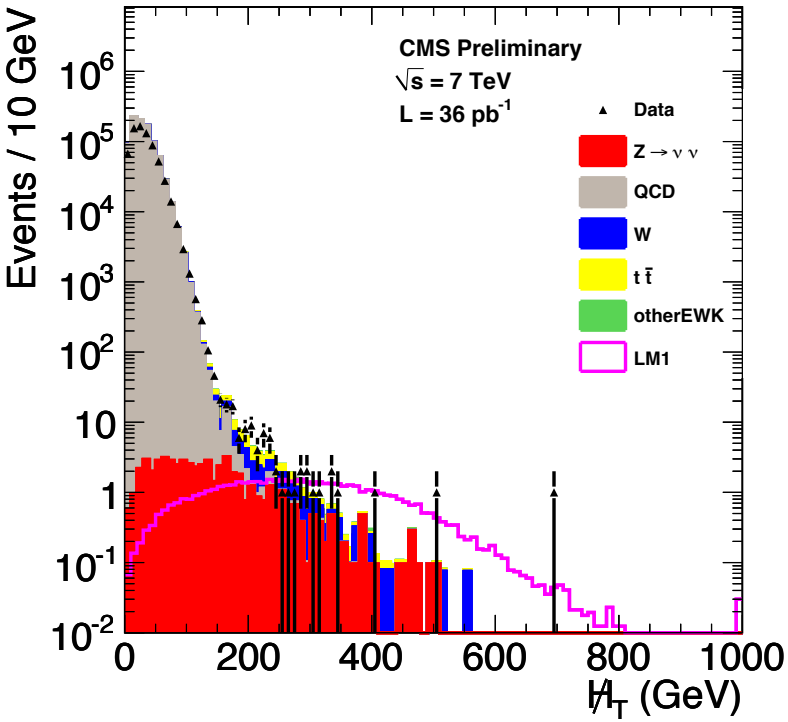
At least 3 jets with:

$p_T > 50$ GeV/c $\quad |\eta| < 2.5$

Signal region defined by:

$H_T > 350$ GeV

$MHT > 150$ GeV



YVES SAINT LAURENT

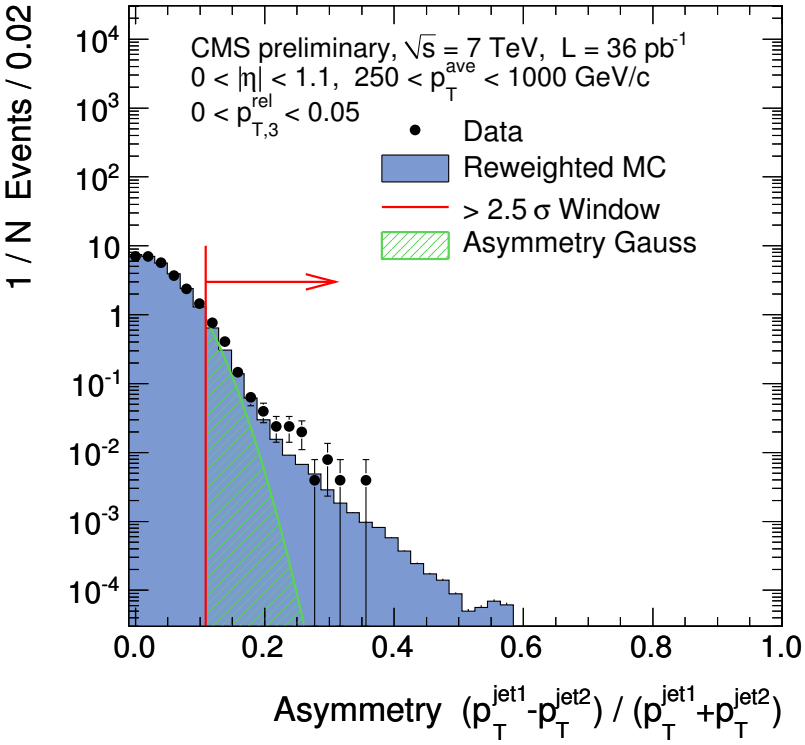
Background prediction:

QCD	Re-balance and smear
$W(\ell\nu) + \text{jets},\ t\bar{t}$	Use μ control sample
$Z(\nu\nu) + \text{jets}$	Use γ +jets and Z($\mu\ \mu$)+jets control samples

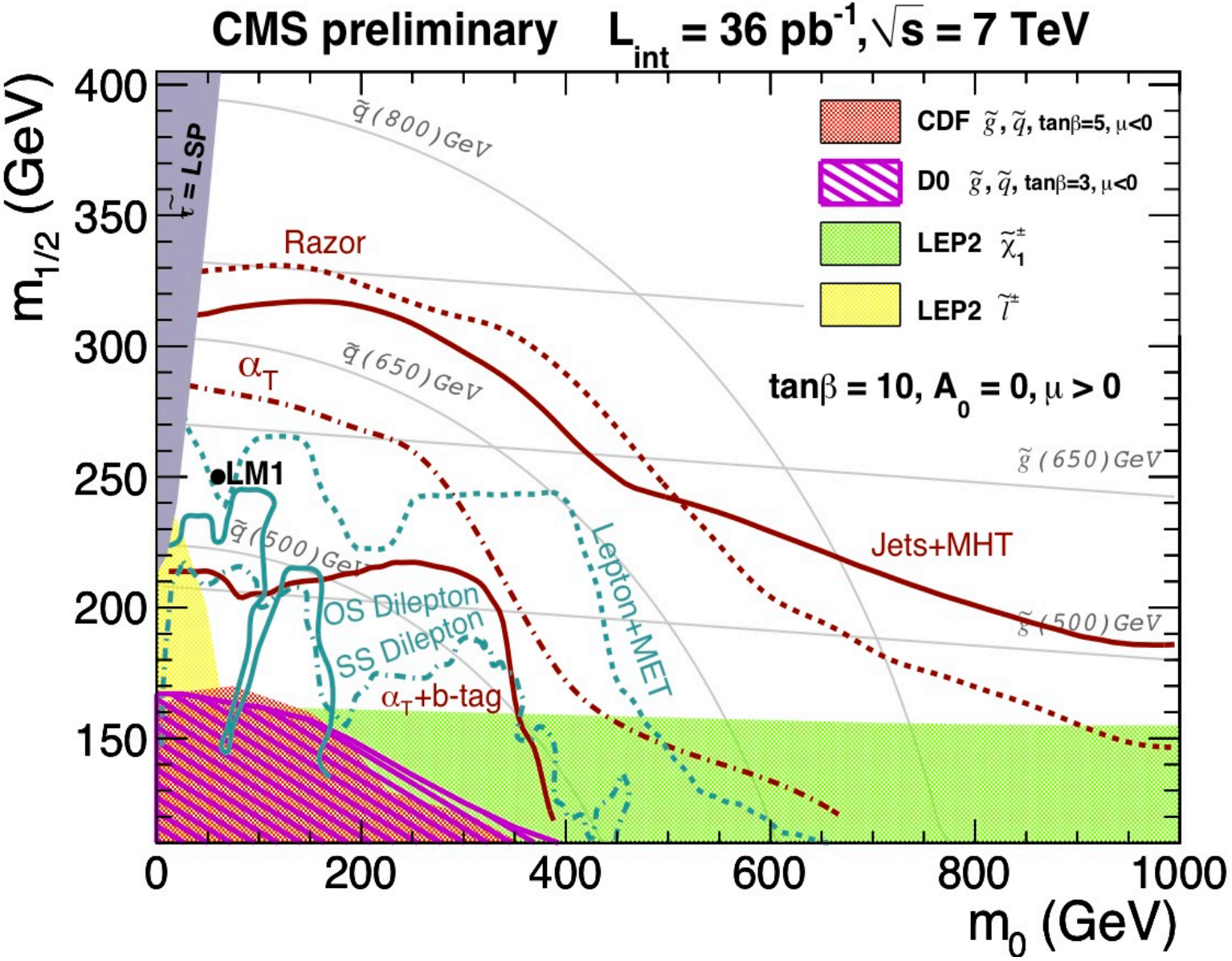
Search for high p_T jets, high HT and high MHT

QCD multi-jet events do not intrinsically populate the phase-space defined by our requirements on scale and angle -- BUT, mis-measurements of jets can result in large measured MHT

QCD multi-jet background predicted by 'smearing' balanced (no MHT) events with measured resolution functions



2010, 7 TeV pp, 35 pb^{-1}



CMS razor 2010

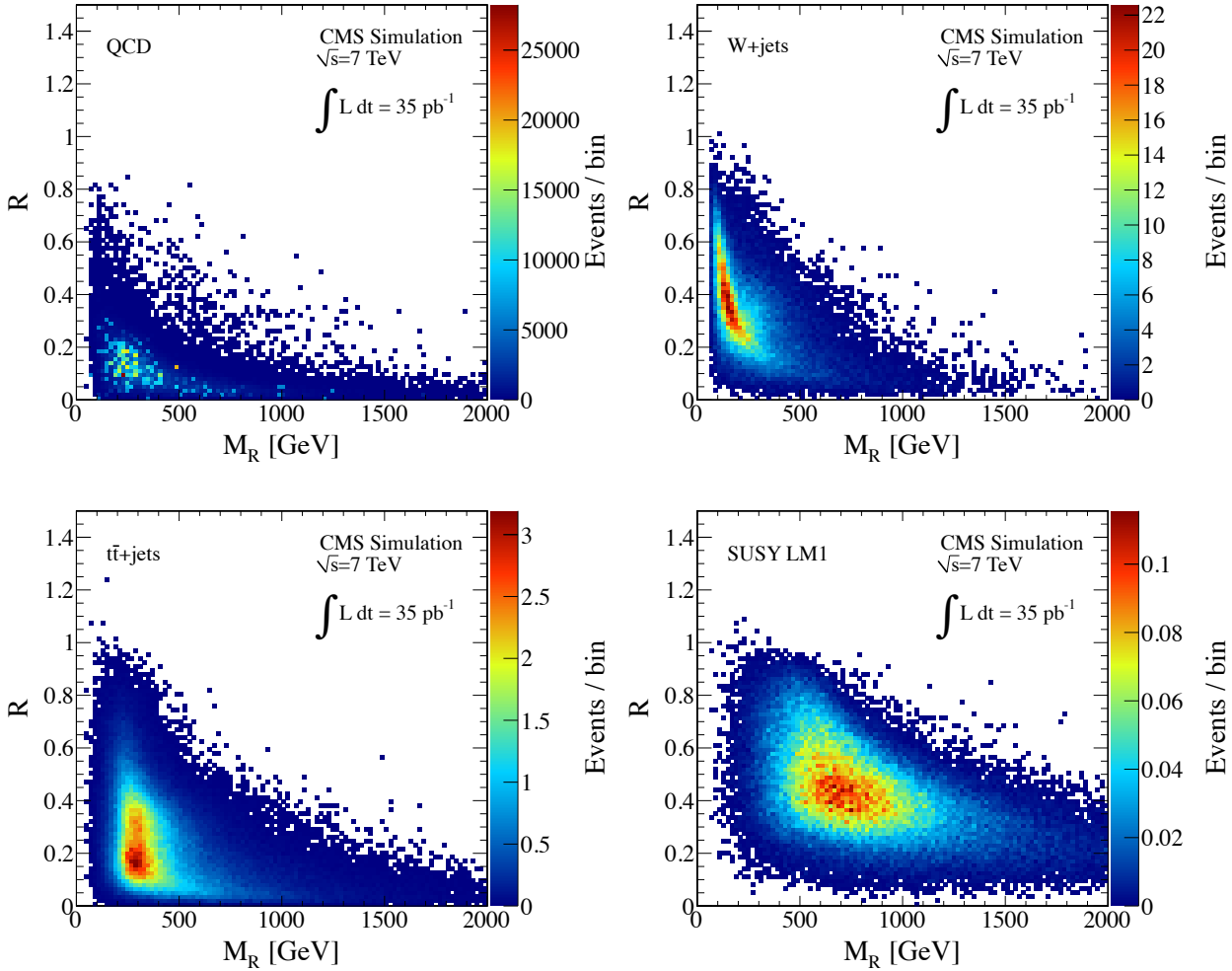
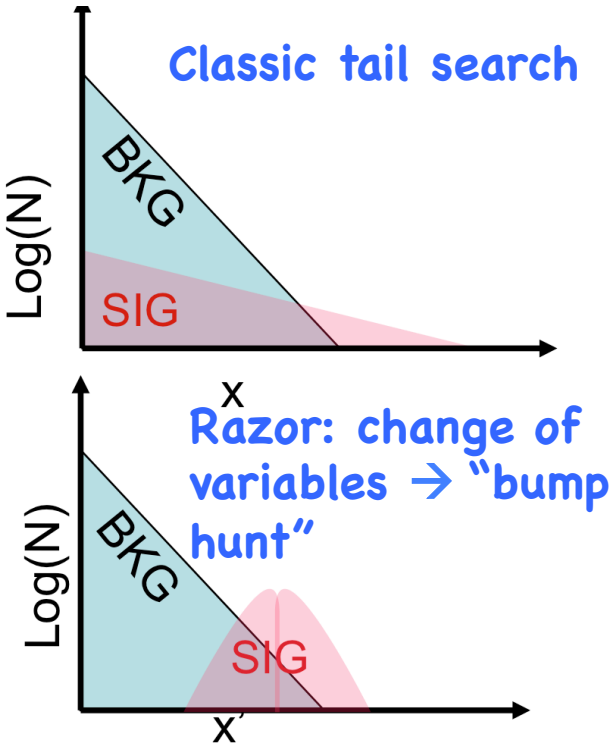
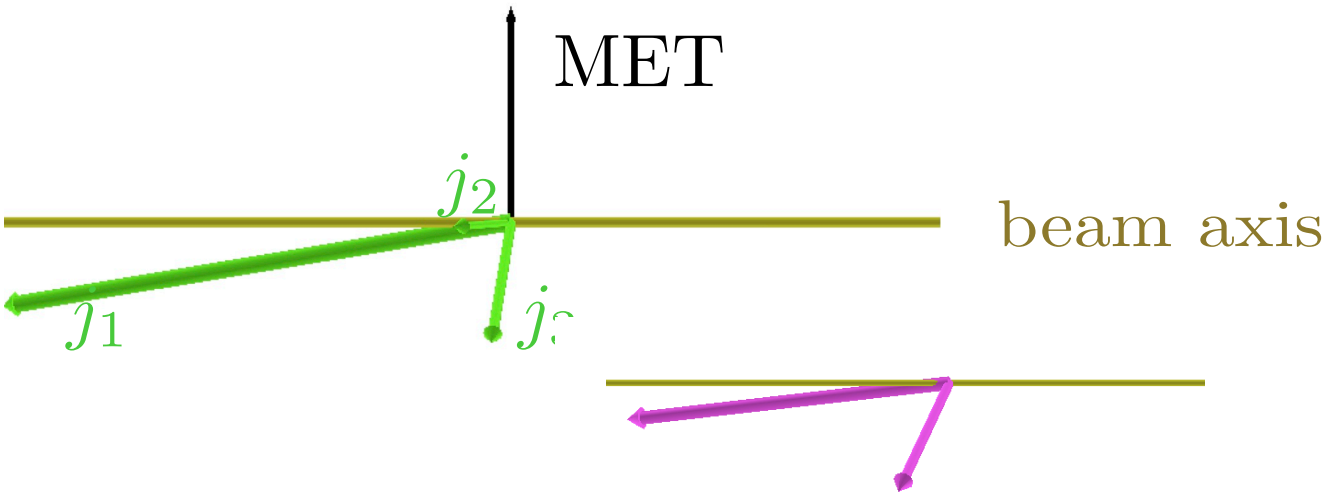
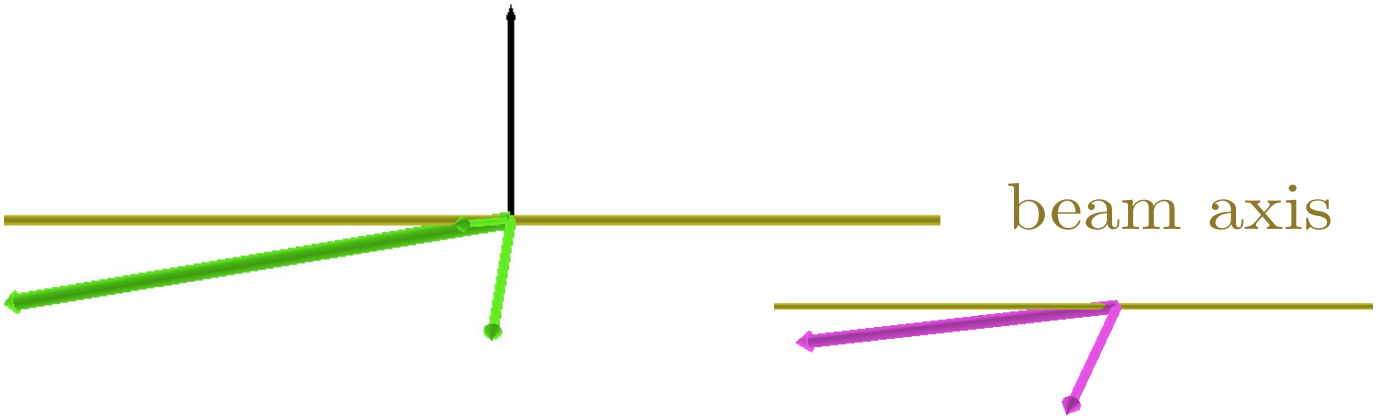


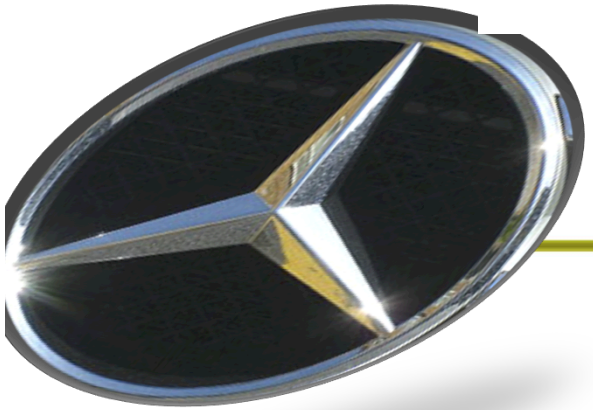
Figure 1: Scatter plot in the (M_R, R) plane for simulated events: (top left) QCD multijet, (top right) W+jets, (bottom left) $t\bar{t}$+jets, and (bottom right) the SUSY benchmark model LM1 [18] with $M_\Delta = 597\,\text{GeV}$. The yields are normalized to an integrated luminosity of $35\,\text{pb}^{-1}$. The bin size is ($20\,\text{GeV} \times 0.015$).

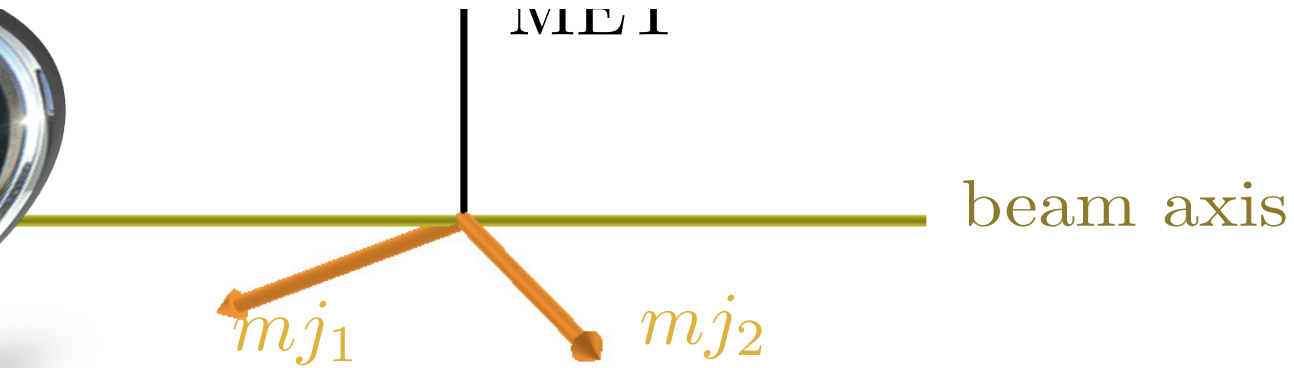


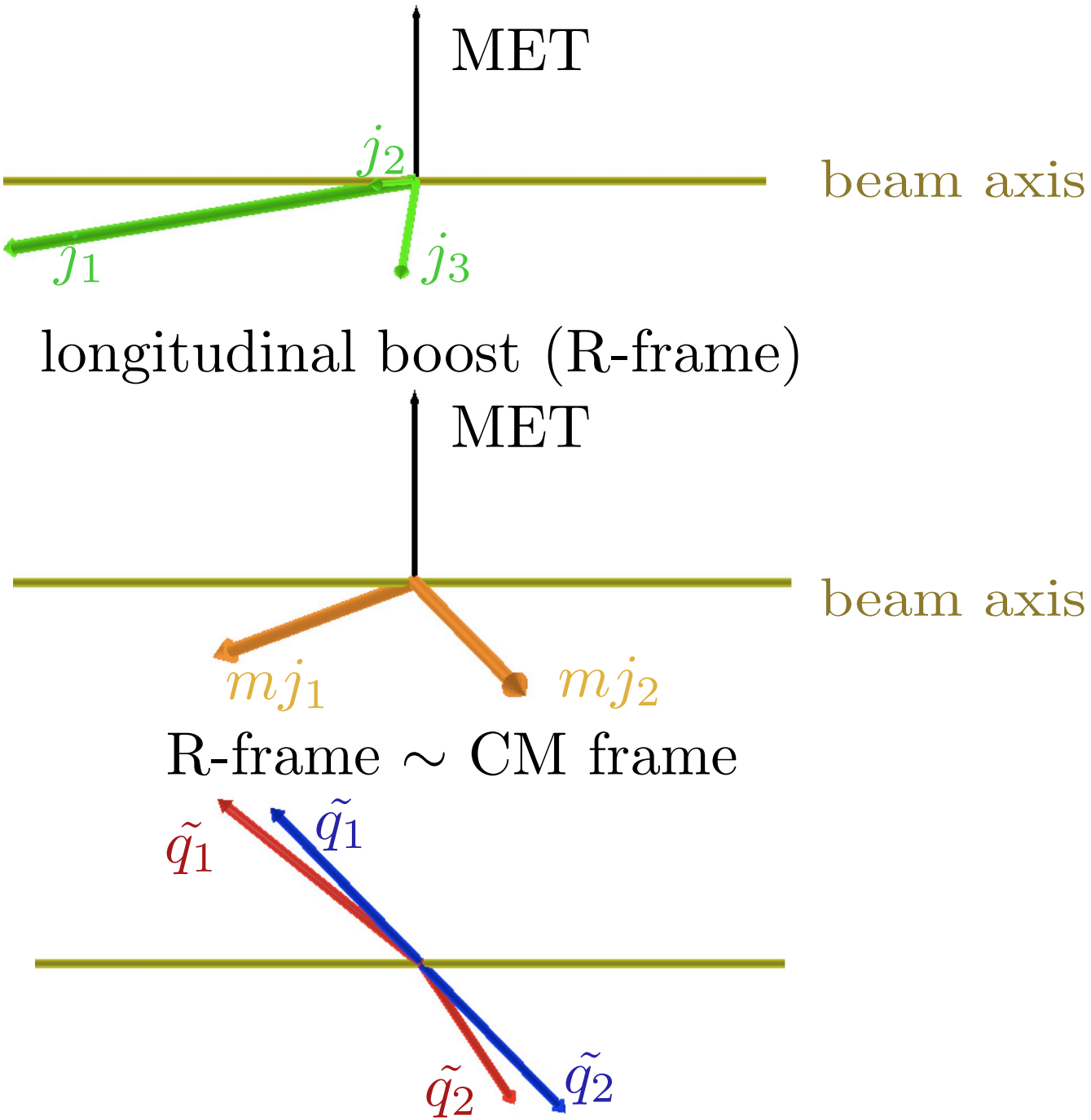

MET
j_2
beam axis
j_1
j_3



longitudinal boost (R-frame)






MET
j_2
beam axis
j_1
j_3
longitudinal boost (R-frame)
MET
beam axis
mj_1
mj_2
R-frame ∼ CM frame
$\tilde{q}_1$
$\tilde{q}_1$
$\tilde{q}_2$
$\tilde{q}_2$

M_R exponential scaling with R : data-driven modeling (QCD)

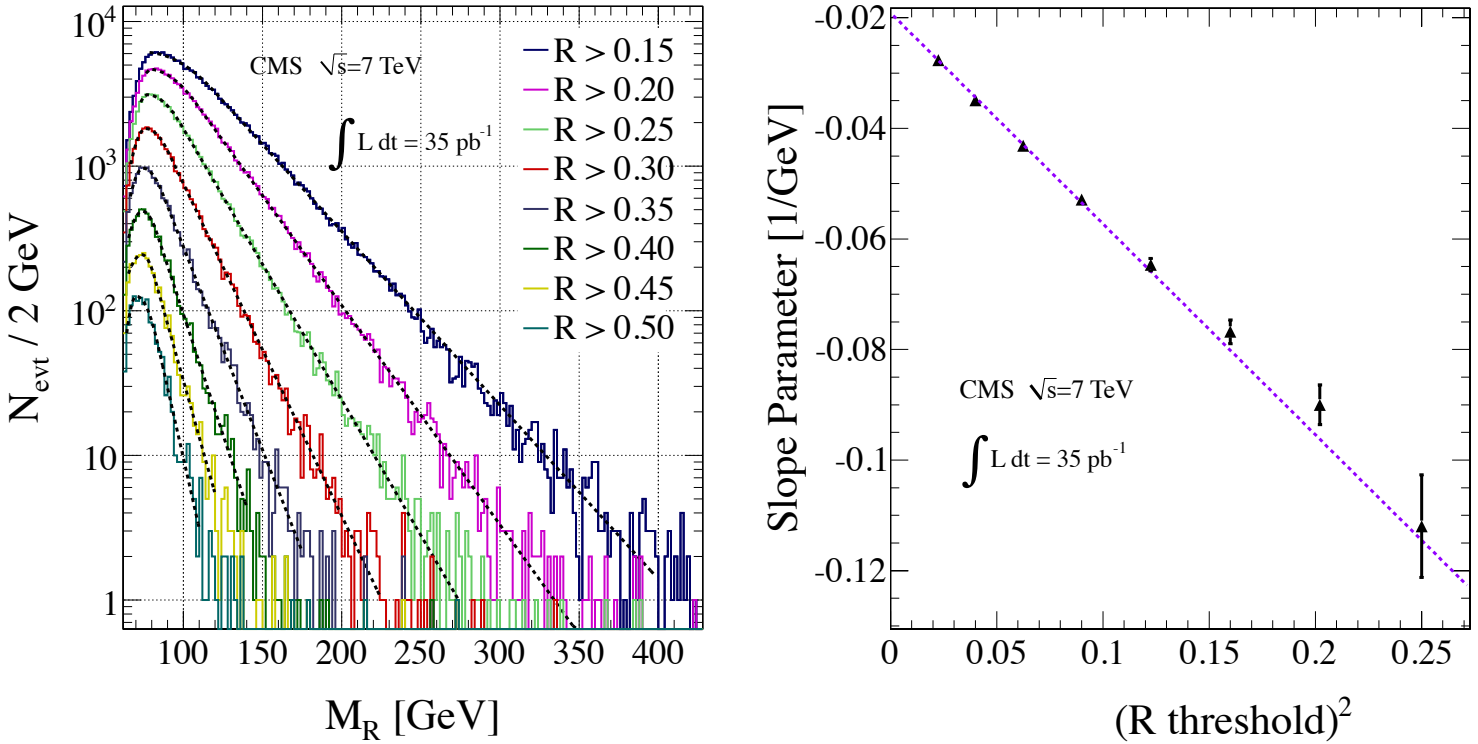


Figure 2: (Left) M_R distributions for different values of the R threshold for data events in the QCD control box. Fits of the M_R distribution to an exponential function and an asymmetric Gaussian at low M_R, are shown as dotted black curves. (Right) The exponential slope S from fits to the M_R distribution, as a function of the square of the R threshold for data events in the QCD control box.

M_R exponential scaling with R : data-driven modeling (W+jets)

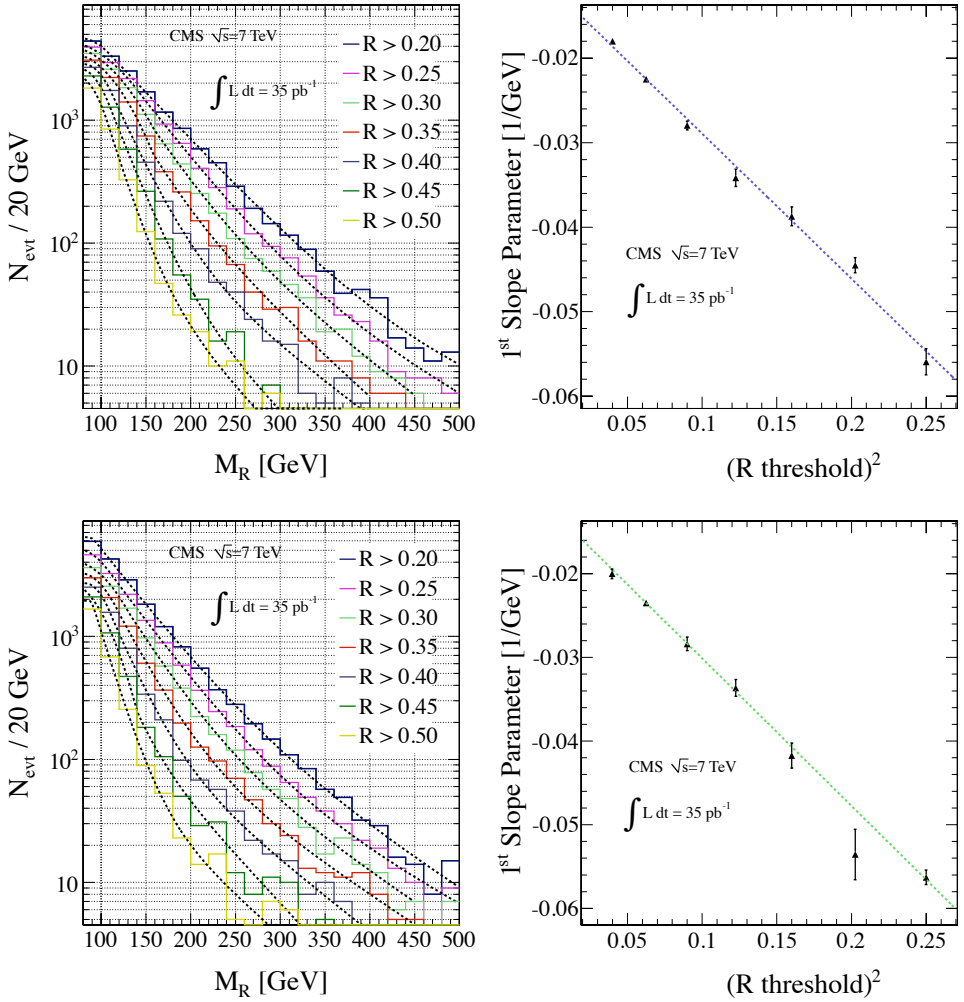
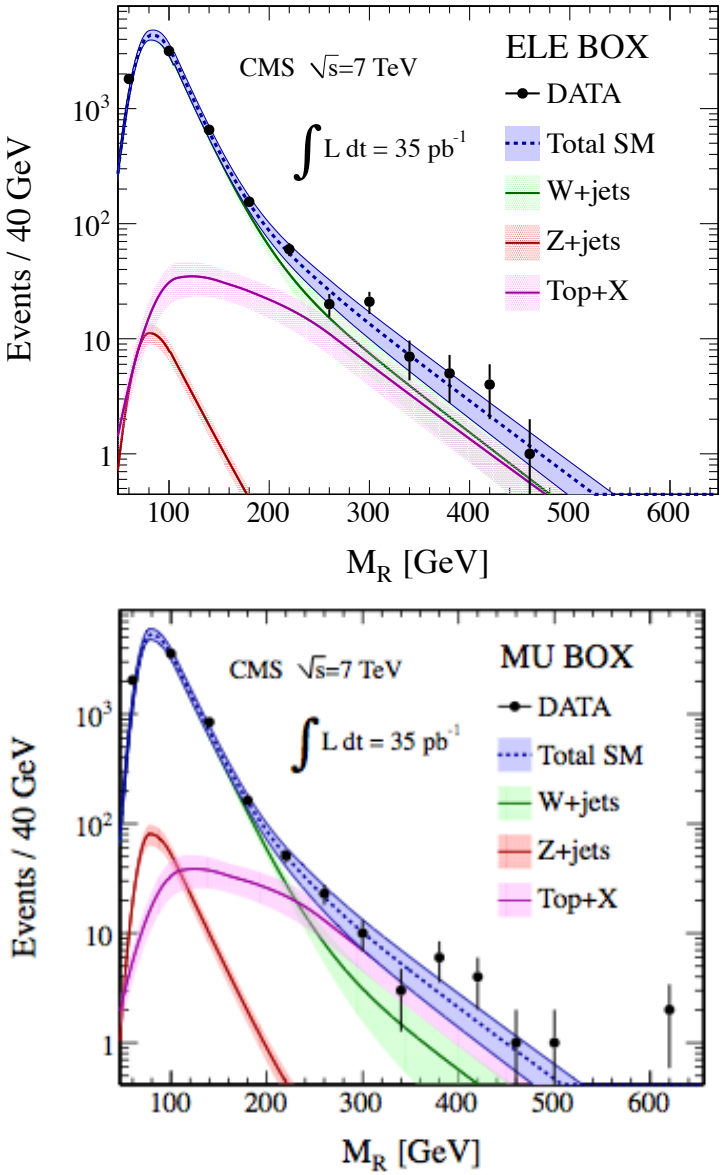
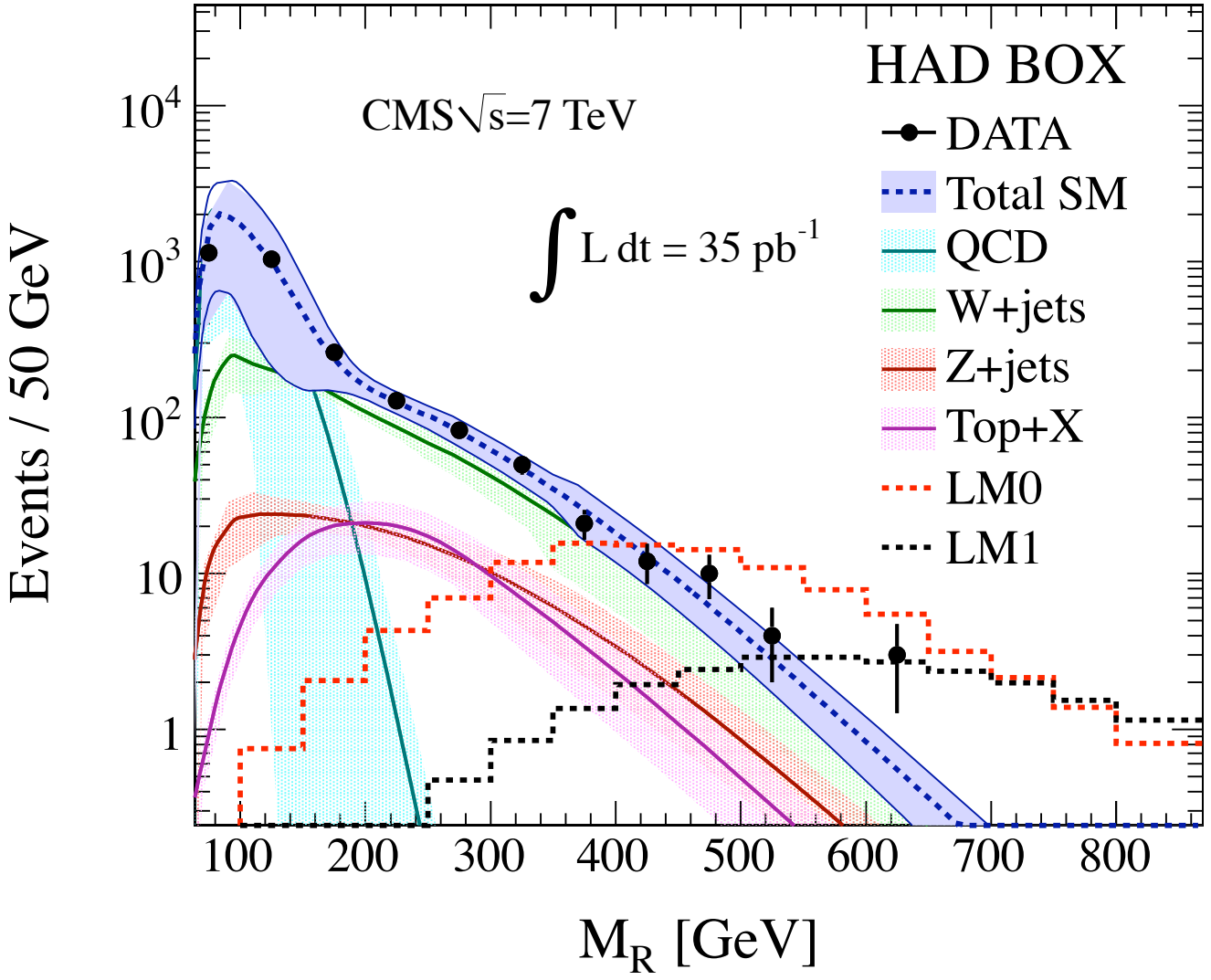


Figure 3: (Left) M_R distributions for different values of the R threshold from data events selected in the MU (upper) and ELE (lower) boxes. Dotted curves show the results of fits using two independent exponential functions and an asymmetric Gaussian at low M_R. (Right) The slope S of the first exponential component as a function of the square of the R threshold in the MU (upper) and ELE (lower) boxes. The dotted lines show the results of the fits to the form $S = a + bR^2$.



The razor paradigm: 2010 results

	Expected	Observed
MU Box	0.51 ± 0.20	3
ELE Box	0.63 ± 0.23	0
HAD Box	5.5 ± 1.4	7



Interpretation in CMSSM

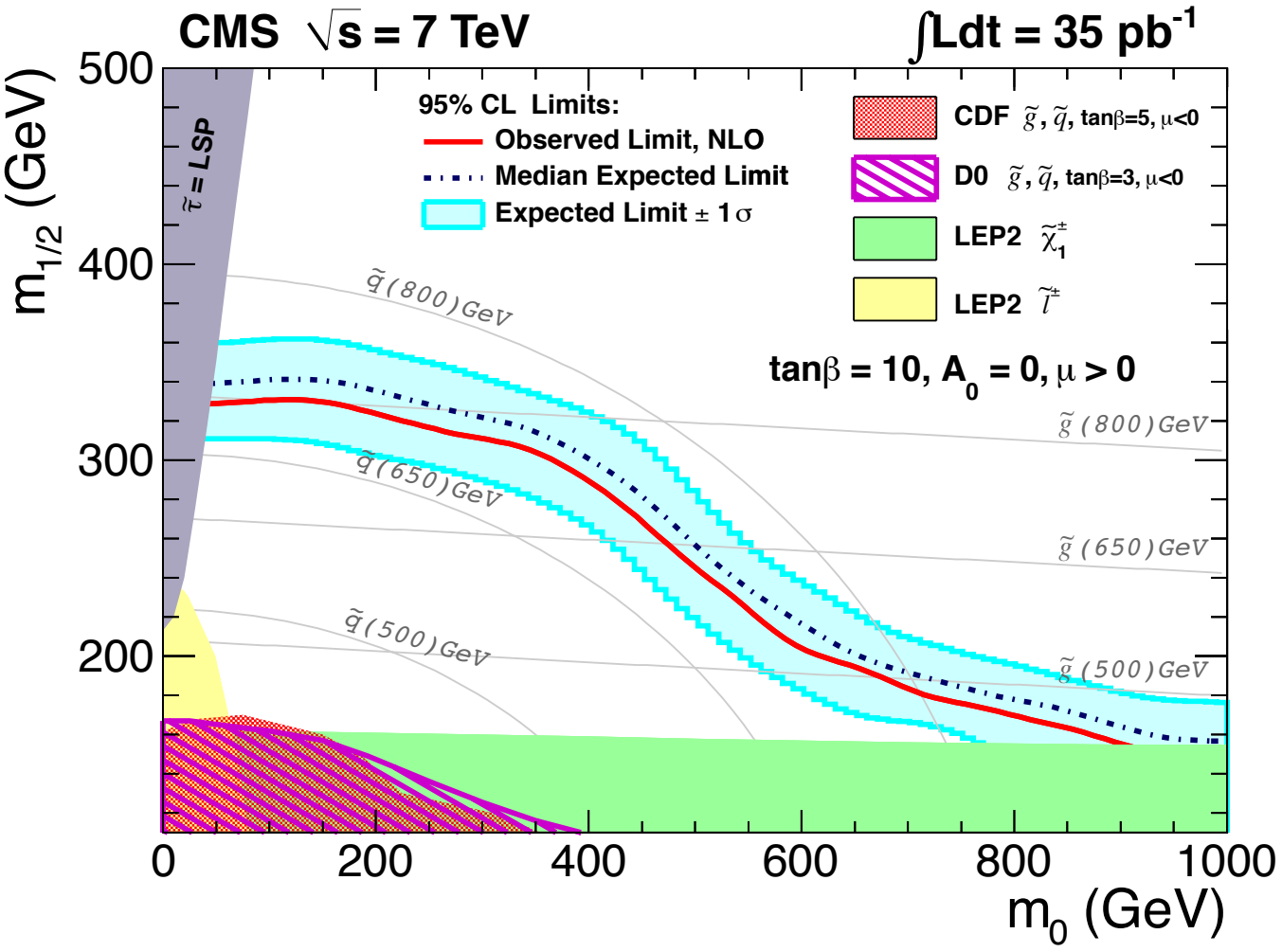
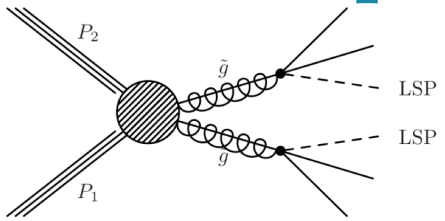
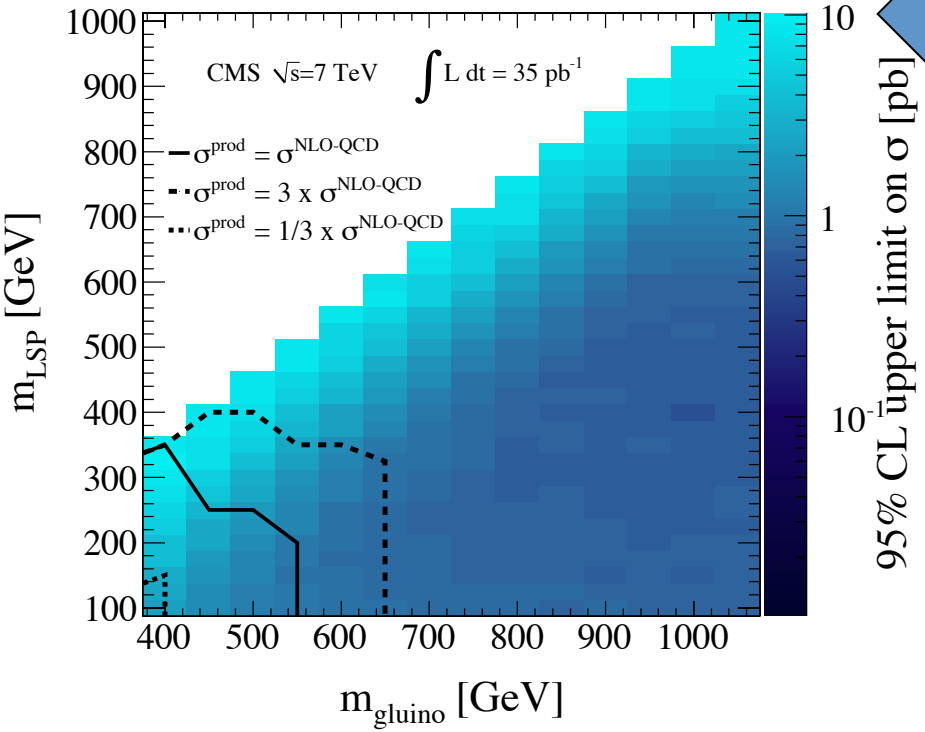


Figure 11: Observed (solid curve) and expected (dot-dashed curve) 95% CL limits in the (m_0, $m_{1/2}$) CMSSM plane with $\tan\beta = 10$, $A_0 = 0$, $\mathrm{sgn}(\mu) = +1$ from the HAD box selection ($R > 0.5$, $M_R > 500\,\mathrm{GeV}$). The $\pm$ one standard deviation equivalent variations in the uncertainties are shown as a band around the expected limits.

model independent interpretation

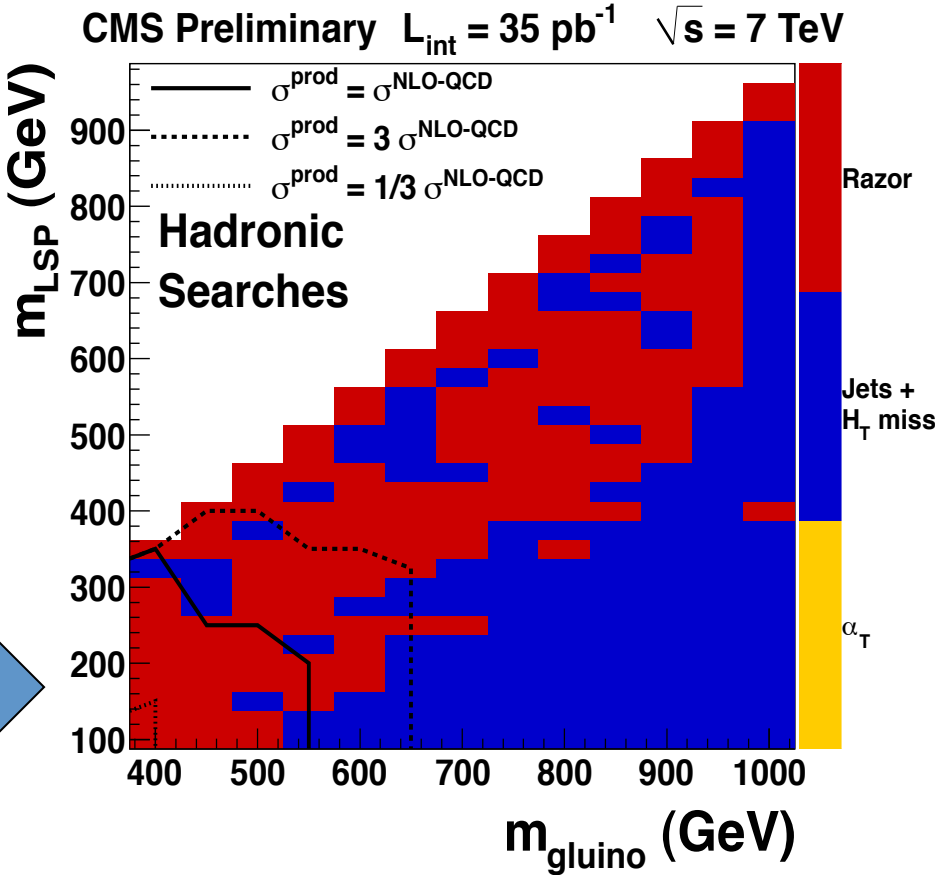


$$\tilde{g}\tilde{g} \rightarrow (qq\tilde{\chi}_1^0)(qq\tilde{\chi}_1^0)$$



Interpretation
~0.5 TeV squaks/gluinos excluded

Extended razor reach complementary to to traditional MET+jets type-analyses



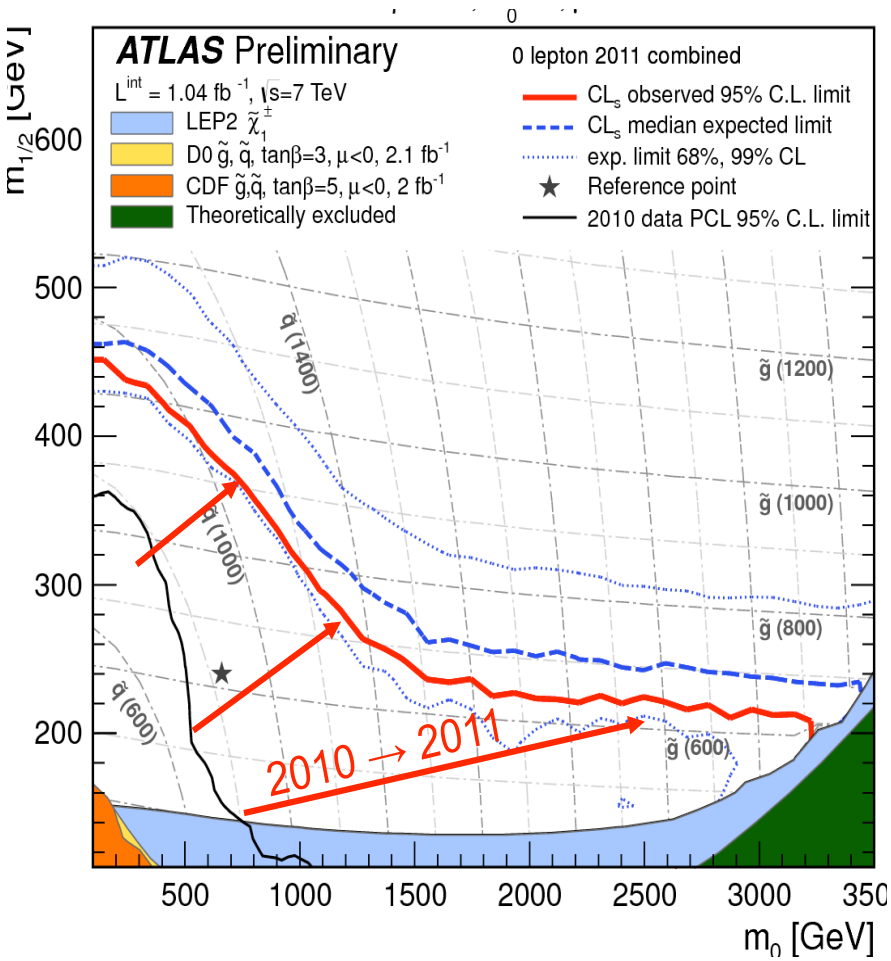
razor2010

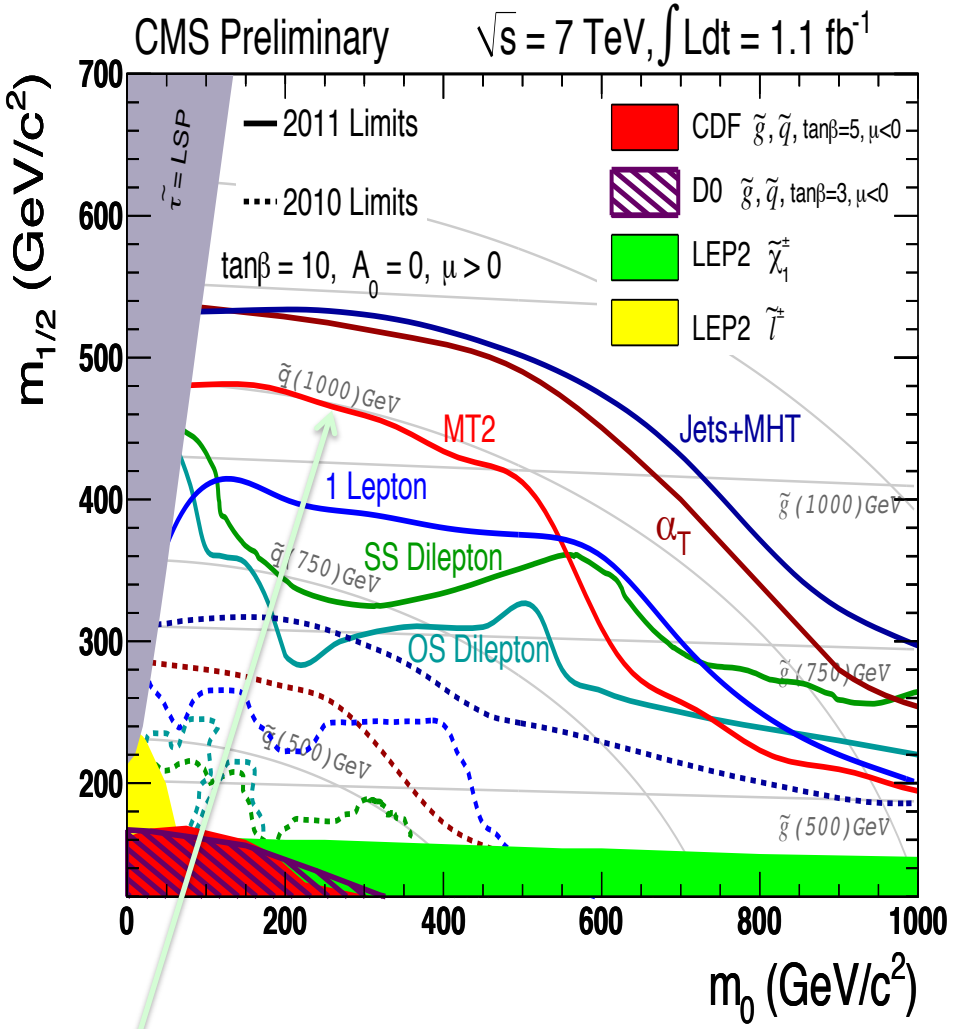
- three boxes
- 1D fit shape analysis
- cut and count for the limit

razor2011

- six boxes
- 2D fit shape analysis
- NP hypothesis testing for limit
- gearing for the discovery
  be it in the shape or in the rate

2011, now approved summary plots

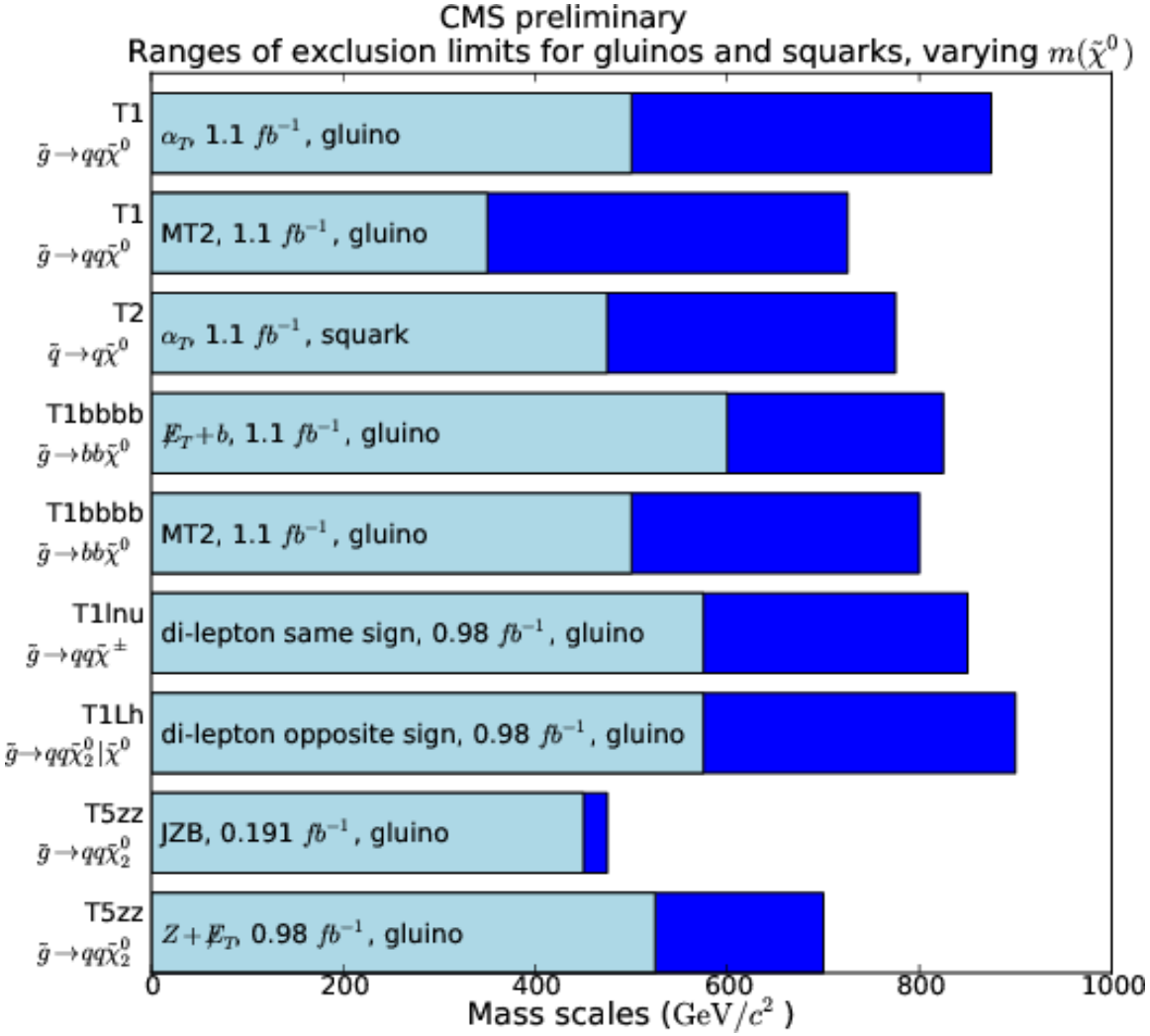


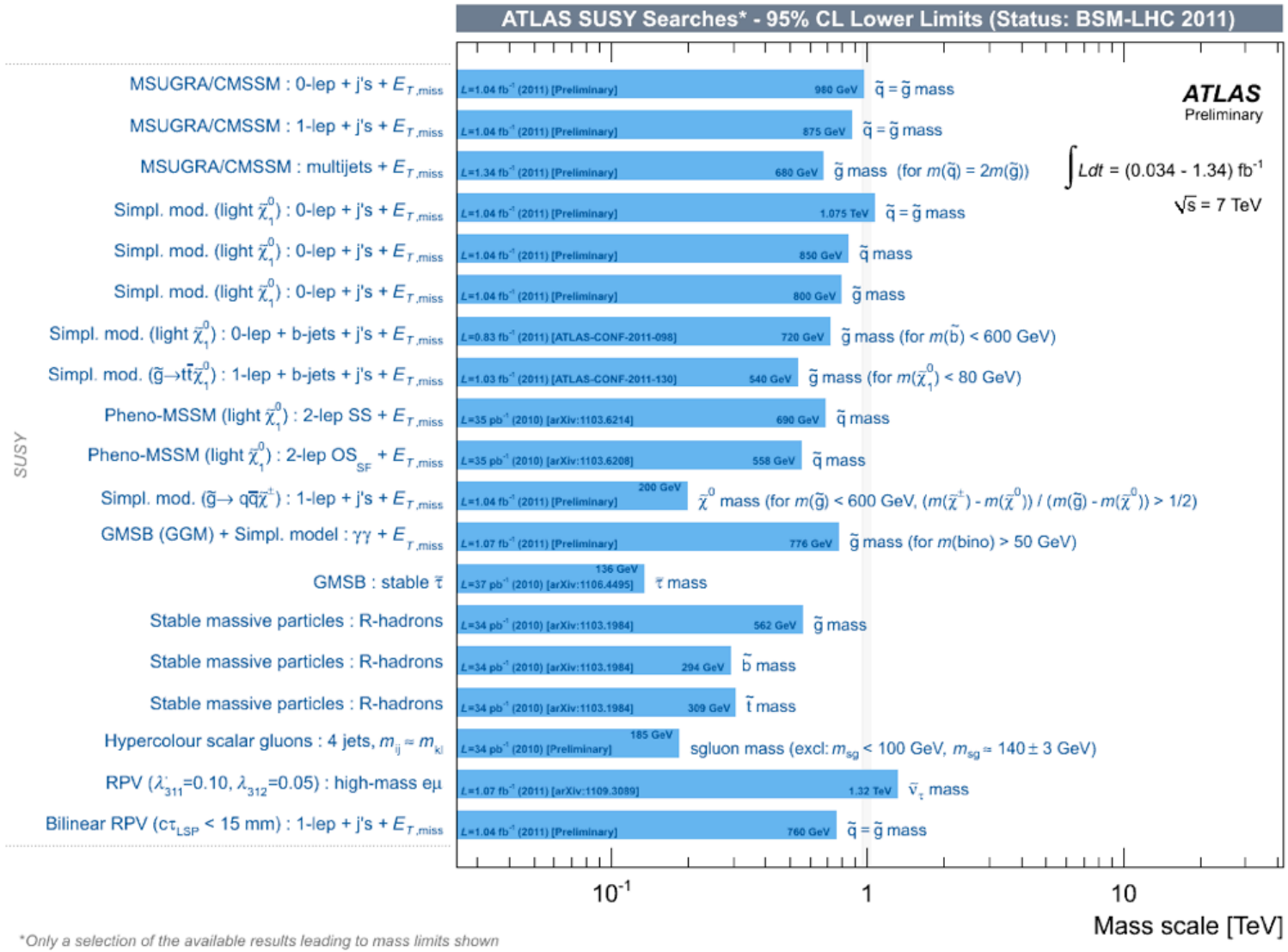


N.B. New CMS hadronic search with MT2

http://cms-physics.web.cern.ch/cms-physics/public/SUS-11-005-pas.pdf

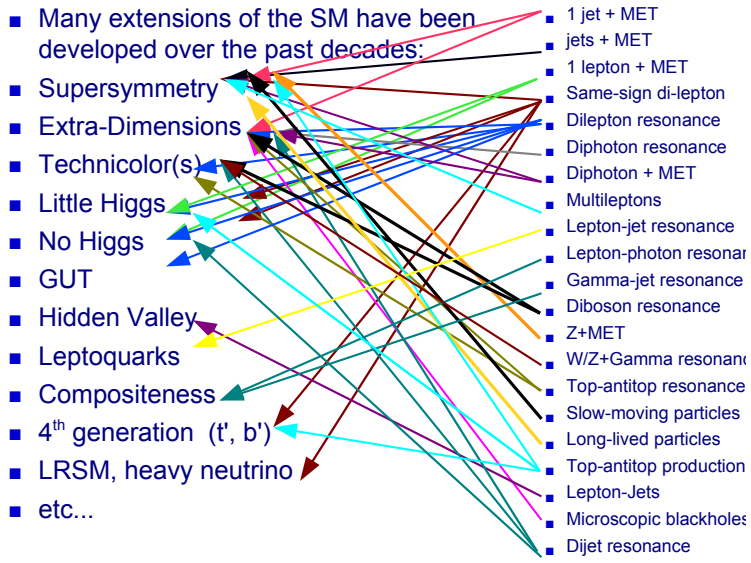
factor of 30 in lumi → 250 GeV in gluino mass (from 550 to 800 GeV)





are these enough SMSs? (Konstantin? Jay?)

- the maximum squark/gluino masses excluded by the current LHC limits is 1 TeV
- for 2012 we are planning maximally usable information content in the presentation of the searches results
- many interpretations (SMSs, pMMSM, get theorists what they need to do their interpretation and let them do it)
- level of some data analysis increasing sophistication (designed for discovery & characterization) is not currently matched with level of needed simplicity for theorists to quickly exclude many scenarios
- we need to operate at many gears at the same time




MR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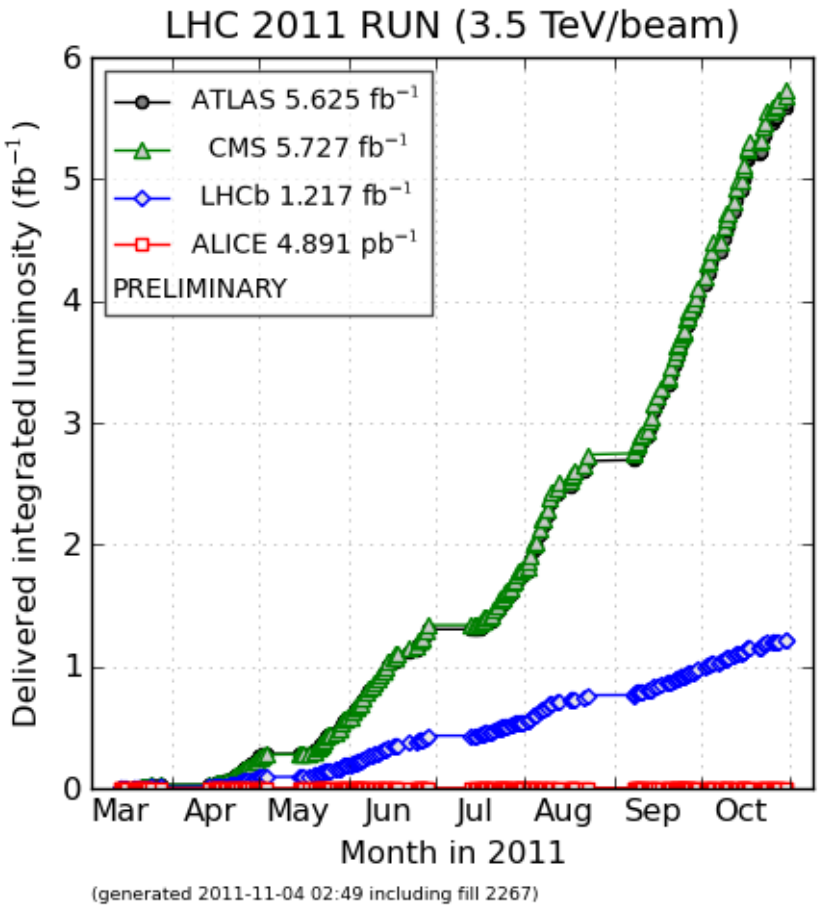
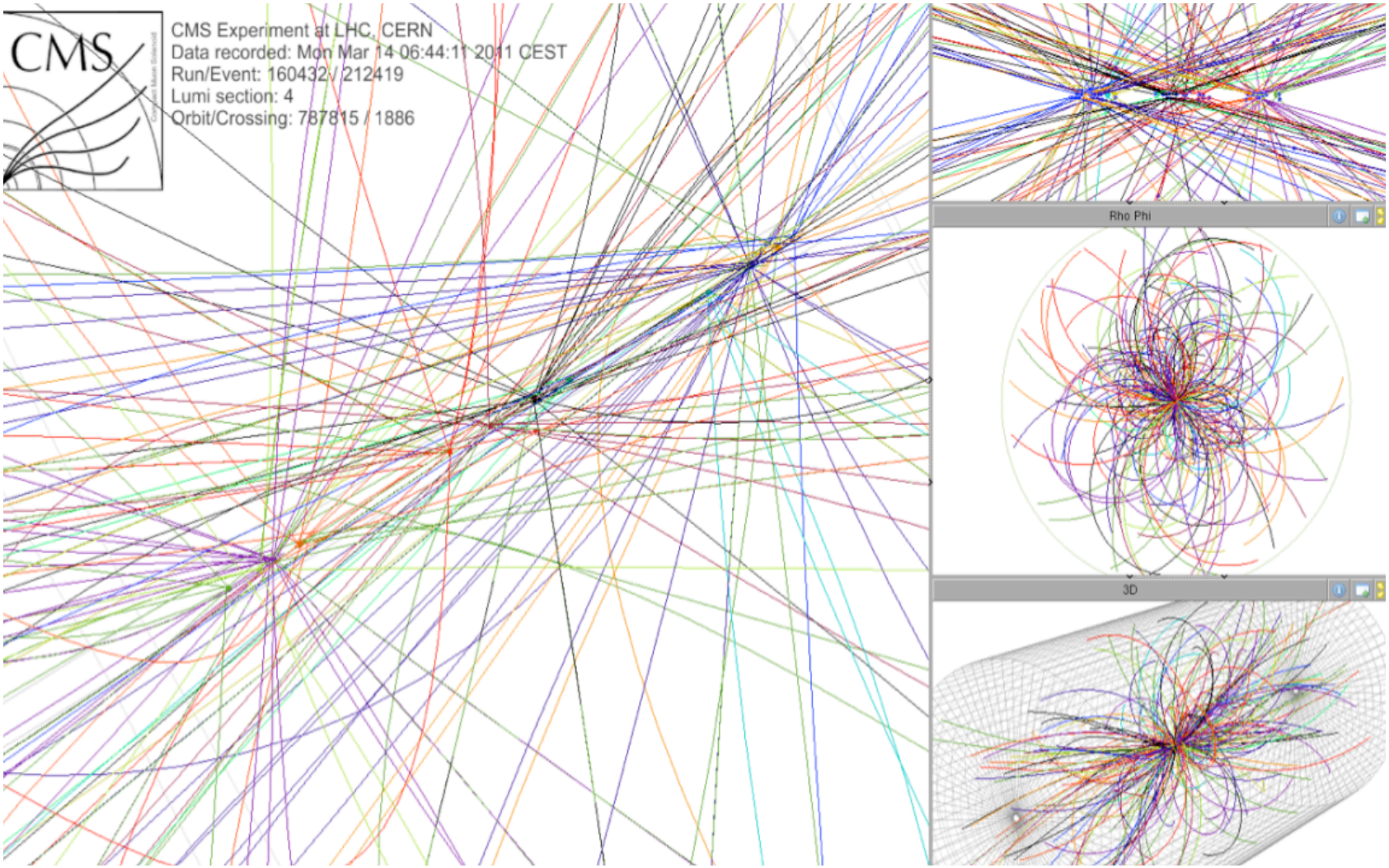
IA®

The slope of (the power and) the glory of the LHC!



un-simplified pileup

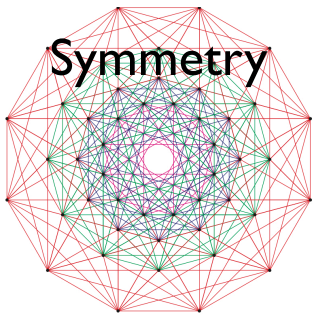


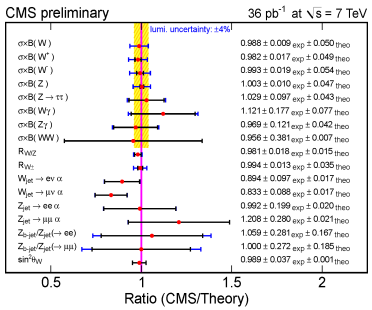
up to 30 ipc and possibly 25 ns in 2012 running (TBD in Chamonix)

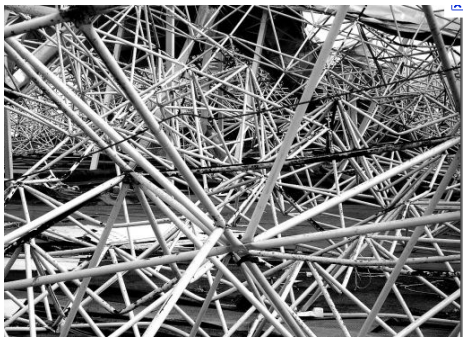
THANKS! THE END

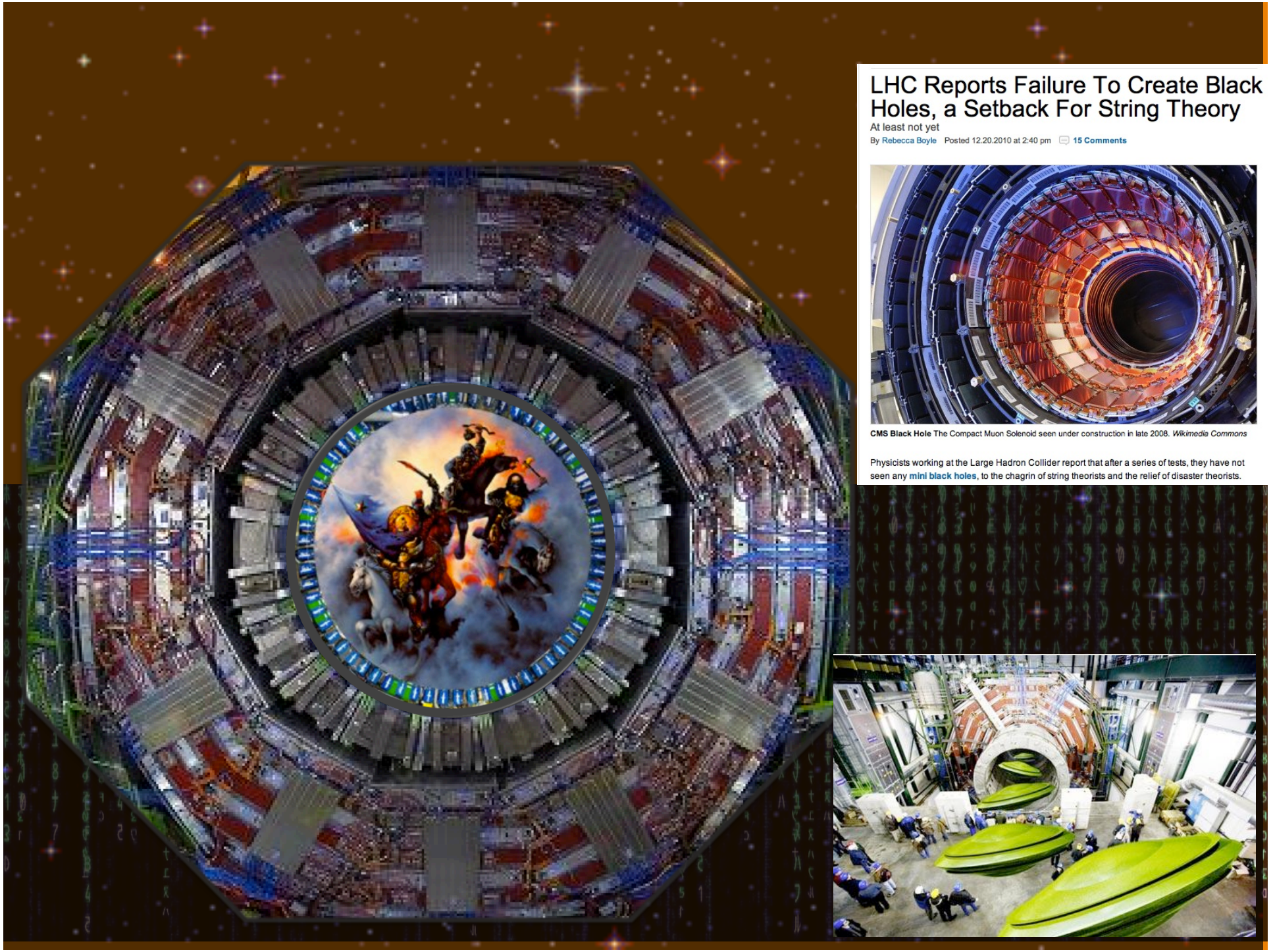
- Tevatron passed the know-how's, the experience and a very large number of results to the LHC in most-all SUSY searches
- LHC is going full thrust towards discovery: variety of methods, innovation, some complexity in SUSY searches at the LHC
- Ready for discovery of **idiosyncratic** new physics models (?)
- Onto much more data (for sure) and higher energy (sooner or later)

- MUST KEEP IN MIND THAT OUR THINKING OF PARTICLES AND FIELDS MIGHT NEED TO CHANGE BASED ON WHAT WE SEE AND DON'T SEE AT THE LHC









LHC Reports Failure To Create Black Holes, a Setback For String Theory

At least not yet

By Rebecca Boyle Posted 12.20.2010 at 2:40 pm 15 Comments

CMS Black Hole The Compact Muon Solenoid seen under construction in late 2008. *Wikimedia Commons*

Physicists working at the Large Hadron Collider report that after a series of tests, they have not seen any **mini black holes**, to the chagrin of string theorists and the relief of disaster theorists.

Facility	Original purpose, Expert Opinion	Discovery with Precision Instrument
P.S. CERN (1960)	π N interactions	Neutral Currents -> Z, W
AGS Brookhaven (1960)	π N interactions	2 kinds of neutrinos, Time reversal non-symmetry, New form of matter (4th Quark)
FNAL Batavia (1970)	Neutrino physics	*5th Quark, 6th Quark*
SLAC Spear (1970)	ep, QED	Partons, 4th Quark, 3rd electron
ISR CERN (1980)	PP	*Increasing PP Cross section*
PETRA Hamburg (1980)	6th Quark	*Gluon*
Super Kamiokande (2000)	Proton decay	Neutrinos have mass
Hubble Space Telescope	Galactic survey	*Curvature of the universe, dark energy*