Top quarks and search for New Physics

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LIP Lisbon

- Heavy flavor in top events
- Heavy resonances
- SUSY and 4^{th} generation
- Boosted topology
- Same sign

Contents

will use c=1

- Introduction (discovery, object ID)
- Top pair production at the Tevatron
- Top pair production at LHC

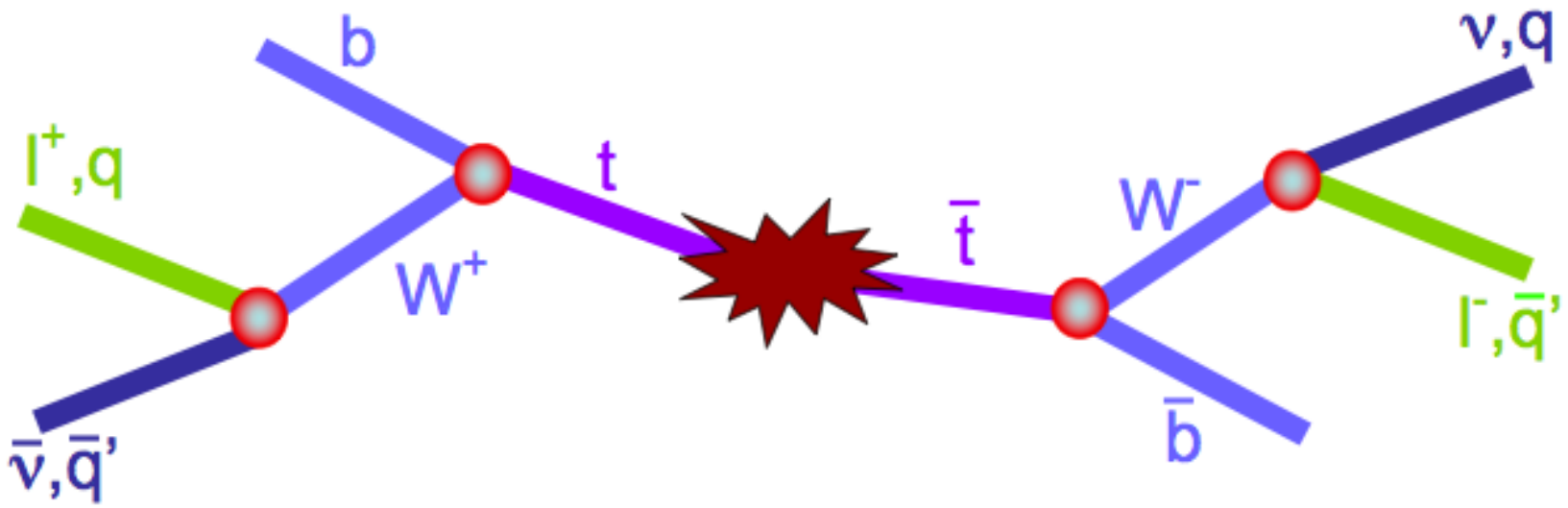
- Properties, mass
- Spin correlation, charge asymmetry, etc.

- Single top production
- Flavor Changing Neutral Currents (FCNC)

- V_{tb}, Search for top partners and 4^{th} generation quarks
- Search for ttbar resonances, same-sign, boosted tops

today

Interesting physics with Top quark



PRODUCTION
Cross section
Resonances X→tt
Fourth generation t'
Spin-correlations
New physics (SUSY)
Flavour physics (FCNC)
...

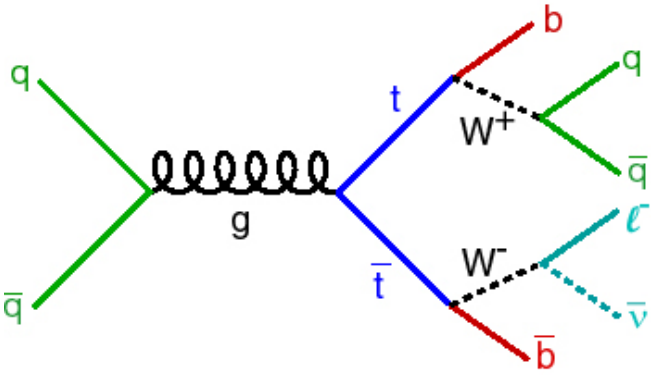
PROPERTIES
Mass
Kinematics
Charge
Lifetime and width
W helicity
Spin
...

DECAY
Branching ratios
Charged Higgs (non-SM)
Anomalous couplings
Rare decays
CKM matrix elements
Calibration sample @LHC
...

Vtb

Top decays

top decay t→Wb, but really 100%?



Indirect measurement using the CKM matrix:

- Elements $|V_{ub}|$ and $|V_{cb}|$ measured to be very small from decay of B mesons
- Unitarity and only three generations implies $|V_{tb}|$ is 0.998 @ 90% CL

With top quark samples we can measure it directly as "R":

$$R \equiv \frac{BR(t \to Wb)}{BR(t \to Wq)} = \frac{|V_{tb}|^2}{|V_{td}|^2 + |V_{ts}|^2 + |V_{tb}|^2} \qquad \text{where } q = \{d, s, b\}$$

Use the ability to identify jets with a distinguished secondary vertex: b-tagging

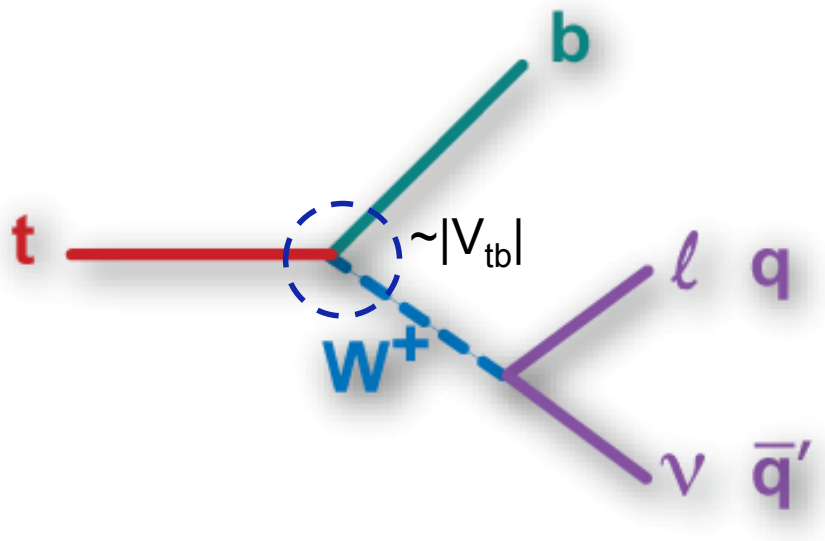
- The number of b-tagged jets depends strongly on R and b-tagging efficiency ε_b

We classify the ttbar sample based on the number of b-tagged jets

- The relative rates of events with 0/1/2 b-tags is very sensitive to R

Is BR(t→Wb)~100% ?

- In the SM, $R = \frac{BR(t\to Wb)}{BR(t\to Wq)} \approx |V_{tb}|^2$ (q=b,s,d) $0.9980<R<0.9984$
- measure R by comparing the number of ttbar events with 0, 1 and 2 b-tags
- SM: R=1 constrained by CKM unitarity. R<1 could indicate new physics (e.g. 4th generation hep/ph-0607115)



Measure R simultaneously with ttbar cross section:

$\sigma_{p\bar{p}\to t\bar{t}}(pb)$	7.4 ± 1.1
R	0.91 ± 0.09
$\lvert V_{tb}\rvert$	0.95 ± 0.05

CDF prelim. 7.5 fb^{-1}
lepton+jets channel

$\sigma_{t\bar{t}} = 7.74^{+0.67}_{-0.57}$ pb
R=0.90±0.04 (stat+syst)
$|V_{tb}|$=0.95±0.02 (stat+syst)
$|V_{tb}|$>0.88 @99.7% C.L.

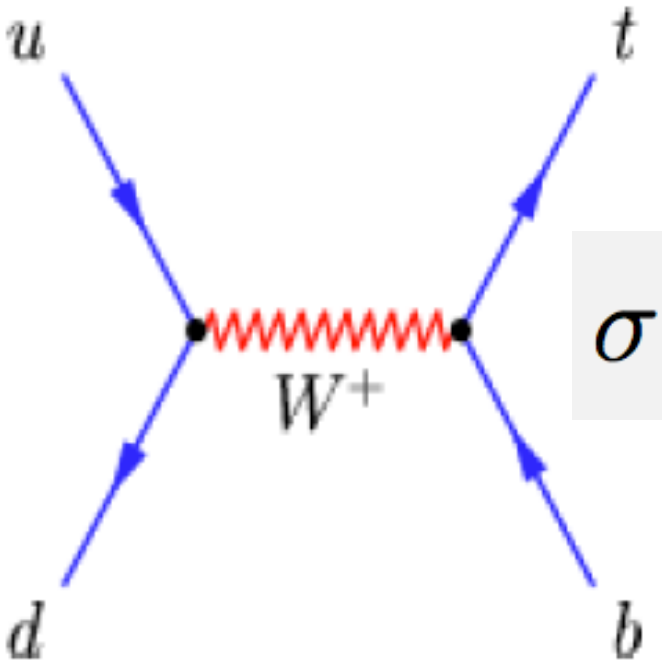
D0 5.4 fb^{-1}
l+jets & dilepton

PRL 107, 121802 (2011)

Not yet sensitive to SM

Measure of V_{tb}

- Measurement with the single top production final state
- direct measure of |Vtb|
- sensitive to non-SM phenomena (W', FCNC)



$$\sigma \approx |V_{tb}|^2$$

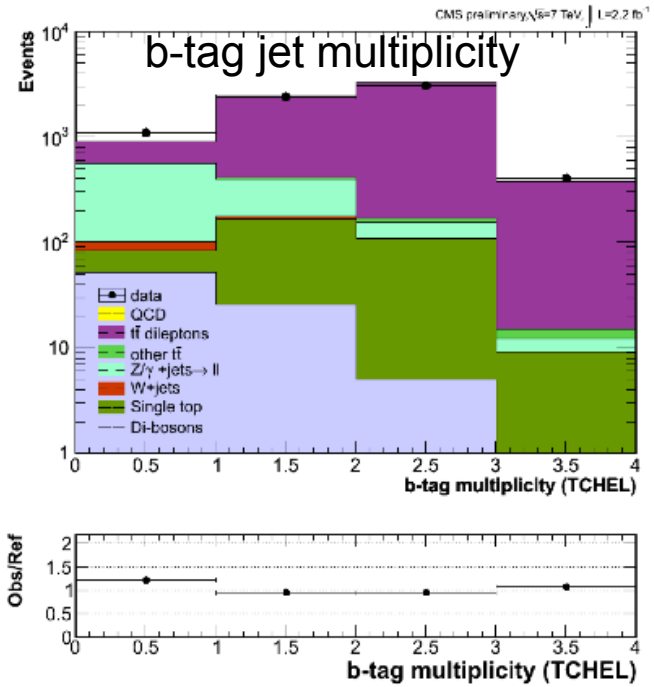
Measure R in dilepton channel

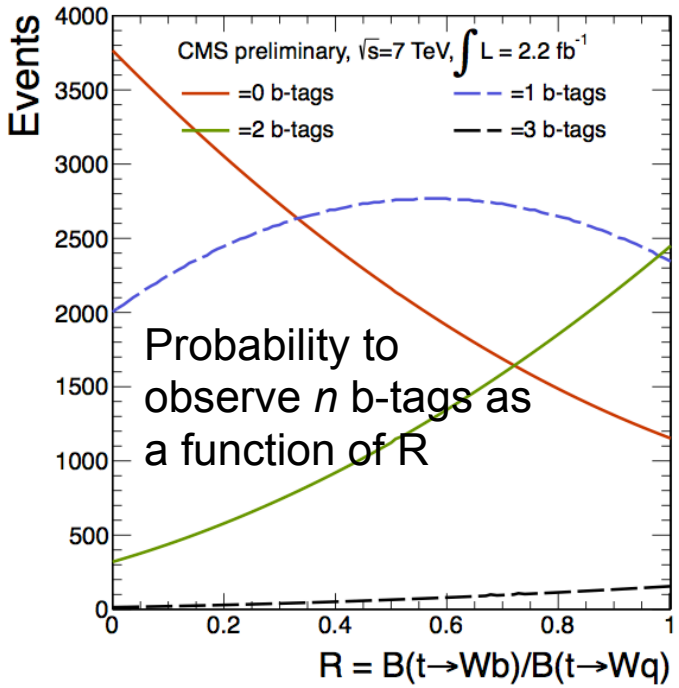
- Probe heavy flavor content of ttbar events
- Use ttbar dilepton final state
- Advantages:
  - less background
- Disadvantages:
  - lower statistics
  - jet assignment

$$R \equiv \frac{BR(t \to Wb)}{BR(t \to Wq)}$$

CMS TOP-11-029

- Selection:
  - 2 leptons+ ≥2 jets + MET
  - no b-tagging in preselection
- Clean signature
- Goals:
  - measure ε(b) and R



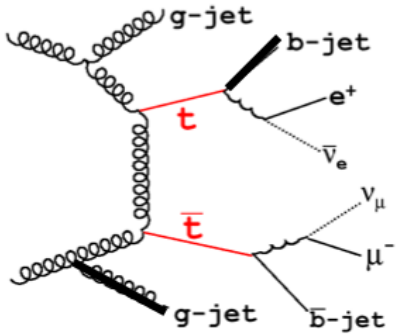


How to model the background

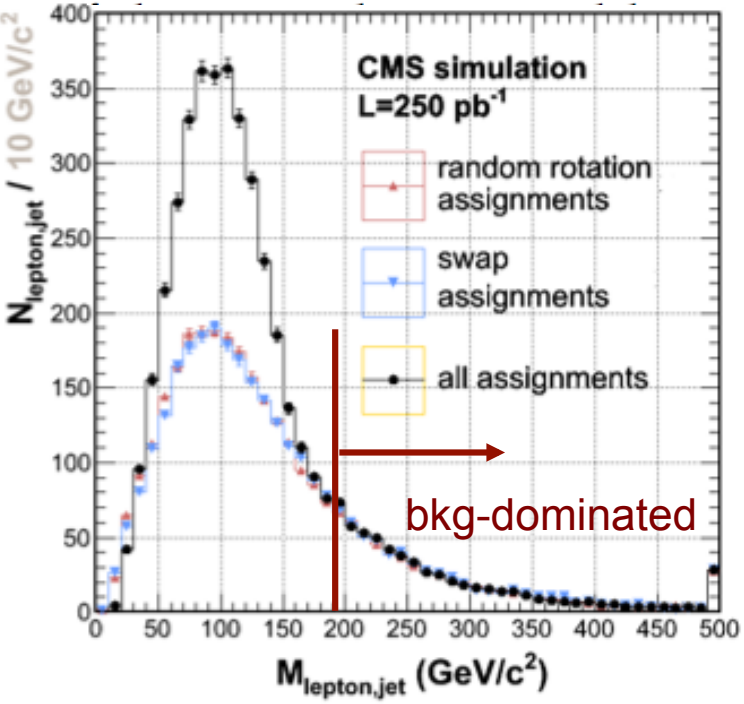
Events are classified in 3 cases (weight α):

1) 2 correctly assigned b-jet
2) 1 corr. ass. b-jet
3) 0 corr. ass. b-jet

1 reconstructed b-jet (α_1)



$$M_{l,j} \approx \sqrt{m_t^2 - m_W^2} = 156 \text{ GeV}/c^2$$



Compute invariant mass of all lepton-jet pairs

Model background using:

- jets from different events
- rotate lepton direction

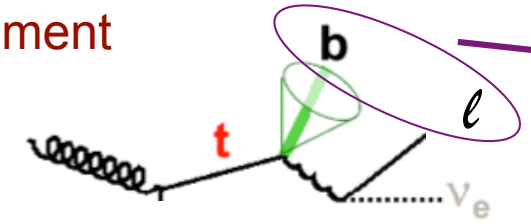
Background dominates at $M > M_{cut}$

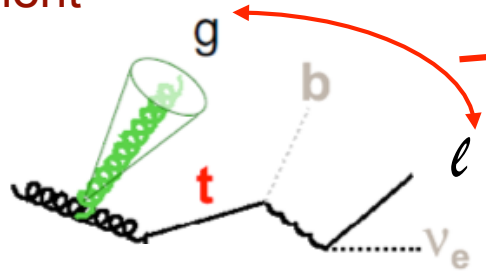
Signal or background?

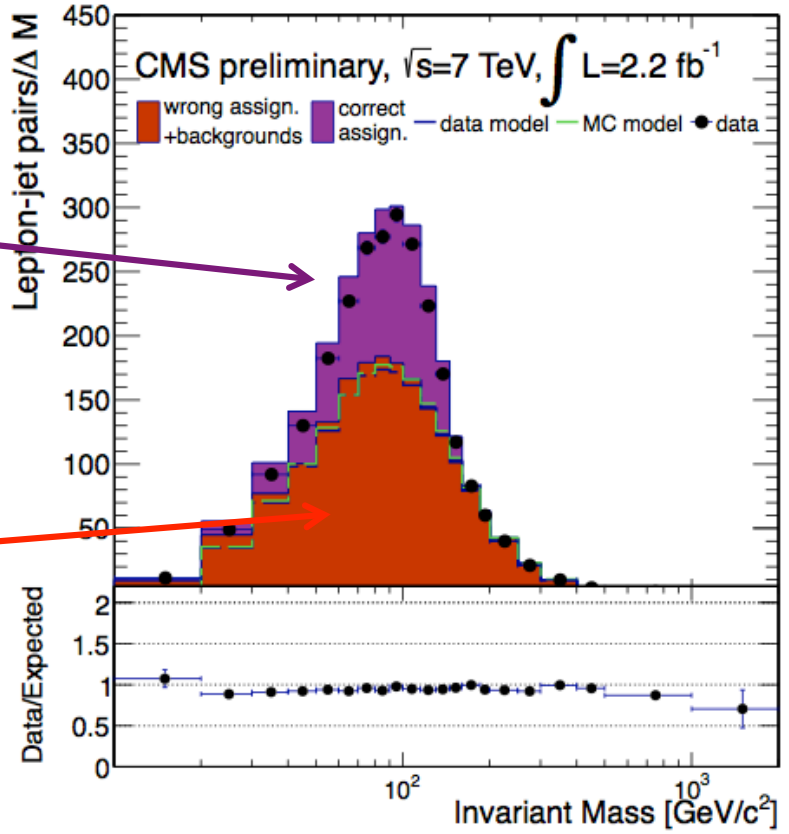
CMS TOP-11-029

Data-driven determination of background

- Reconstruct lepton-jet invariant mass
  - Correct assignment
  - Wrong assignment





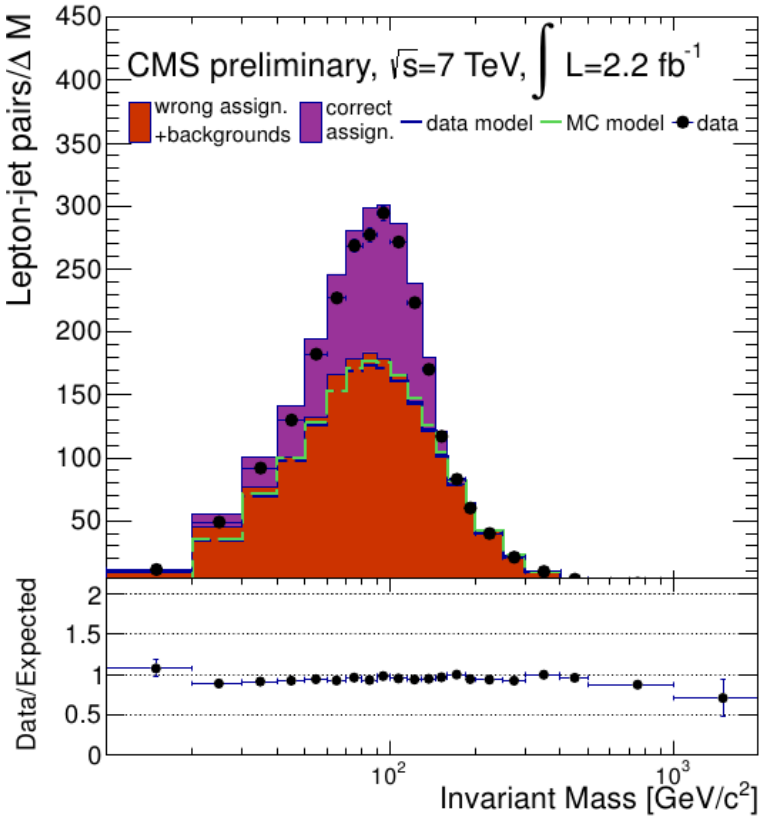


- Use tail to model background in signal region

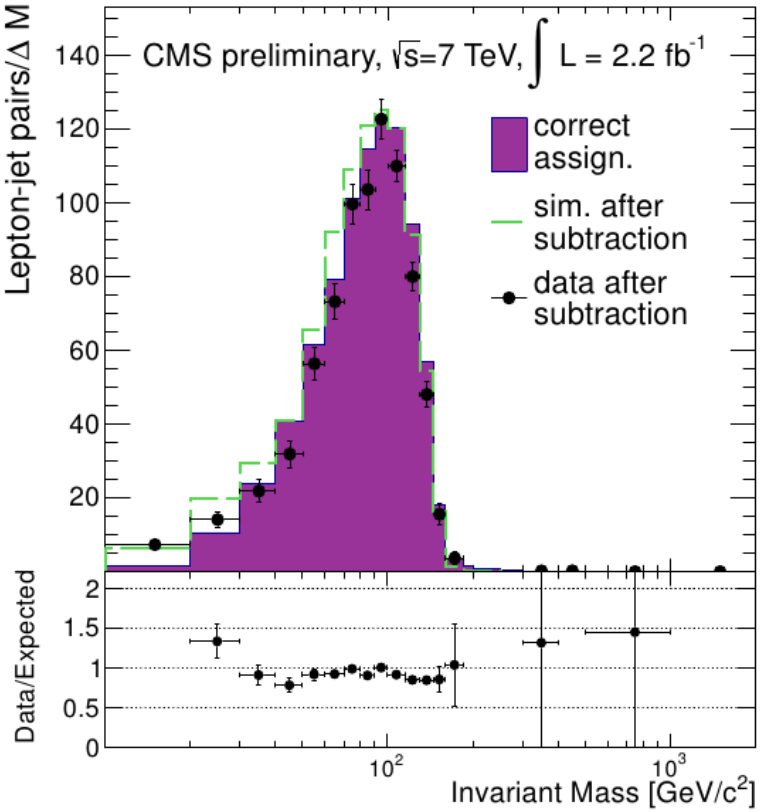
Signal or background

CMS TOP-11-029

Scale shape to match spectrum observed with M_{lj}>180 GeV



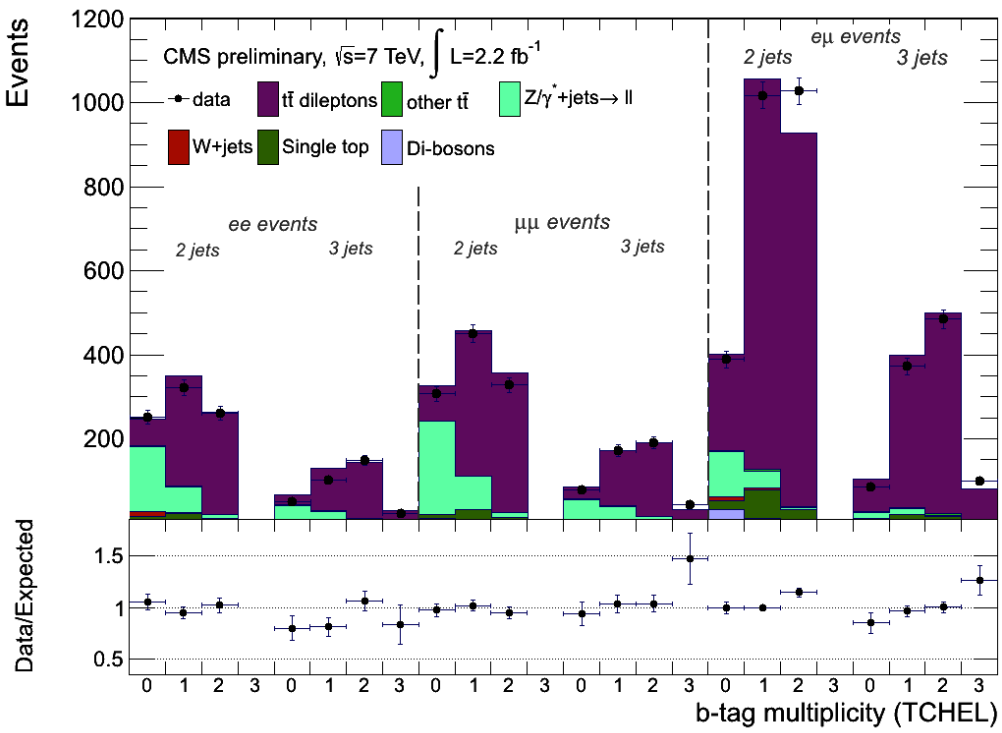
after background subtraction

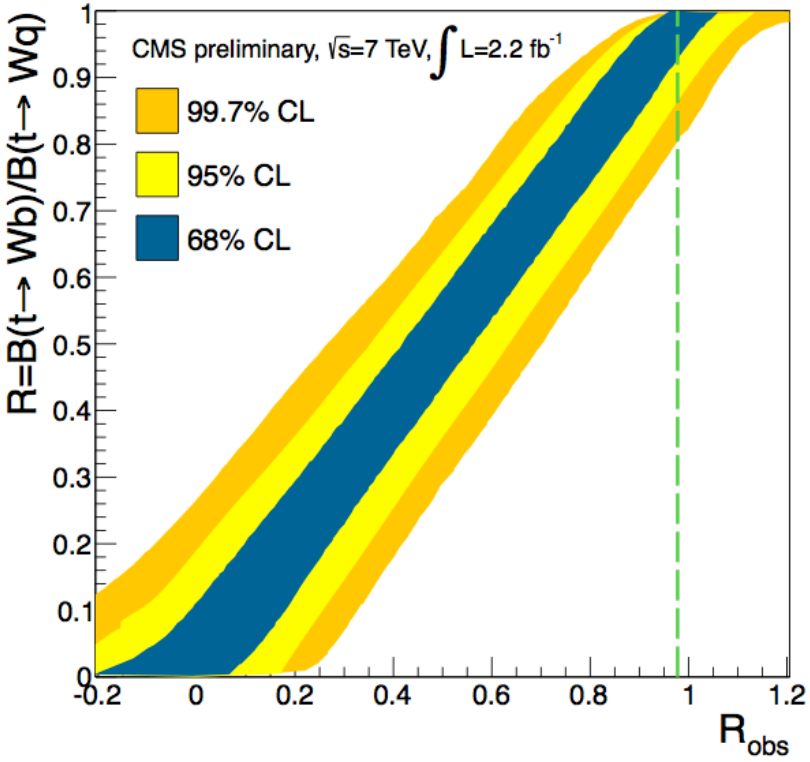


Heavy flavor content

CMS TOP-11-029

- Fully data-driven measurement
  - b-tagging multiplicity parametrized as function of R ε_b, ε_q, top contribution
  - Number of reconstructed t→Wq is estimated from lepton-jet invariant mass
- R=0.98±0.04 (stat.⊕ syst.)
  - Lower boundary with confidence interval @95%CL after requiring R≤1 ⇒ **R>0.85**

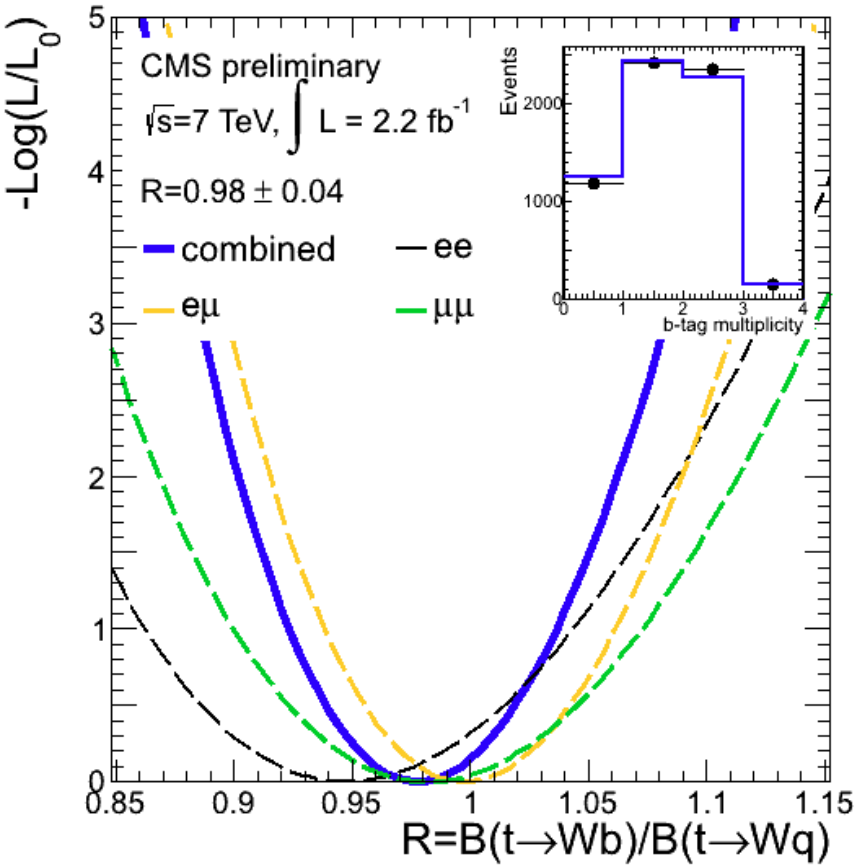


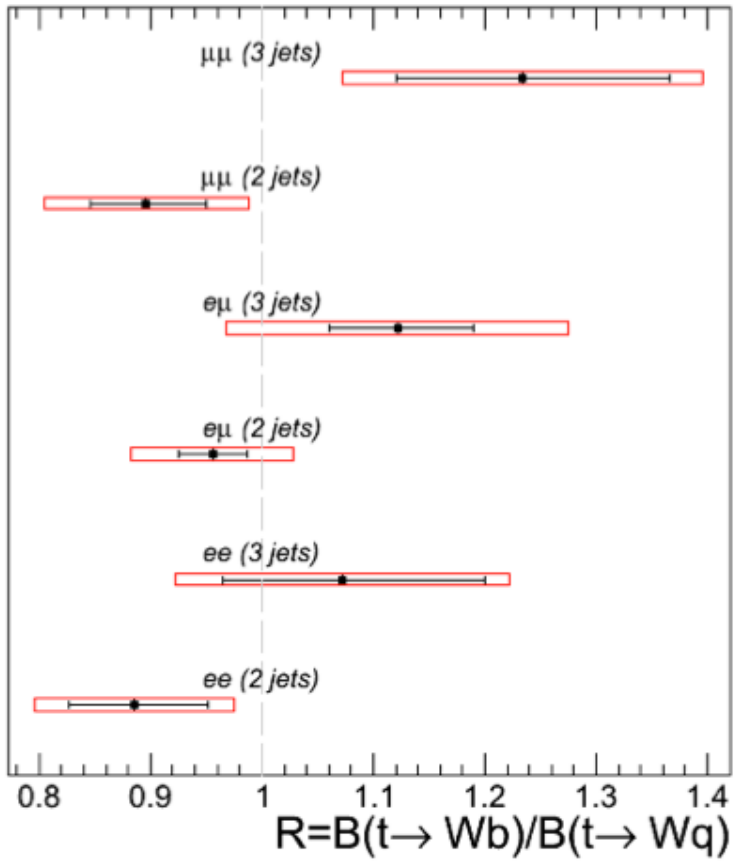


Measure R

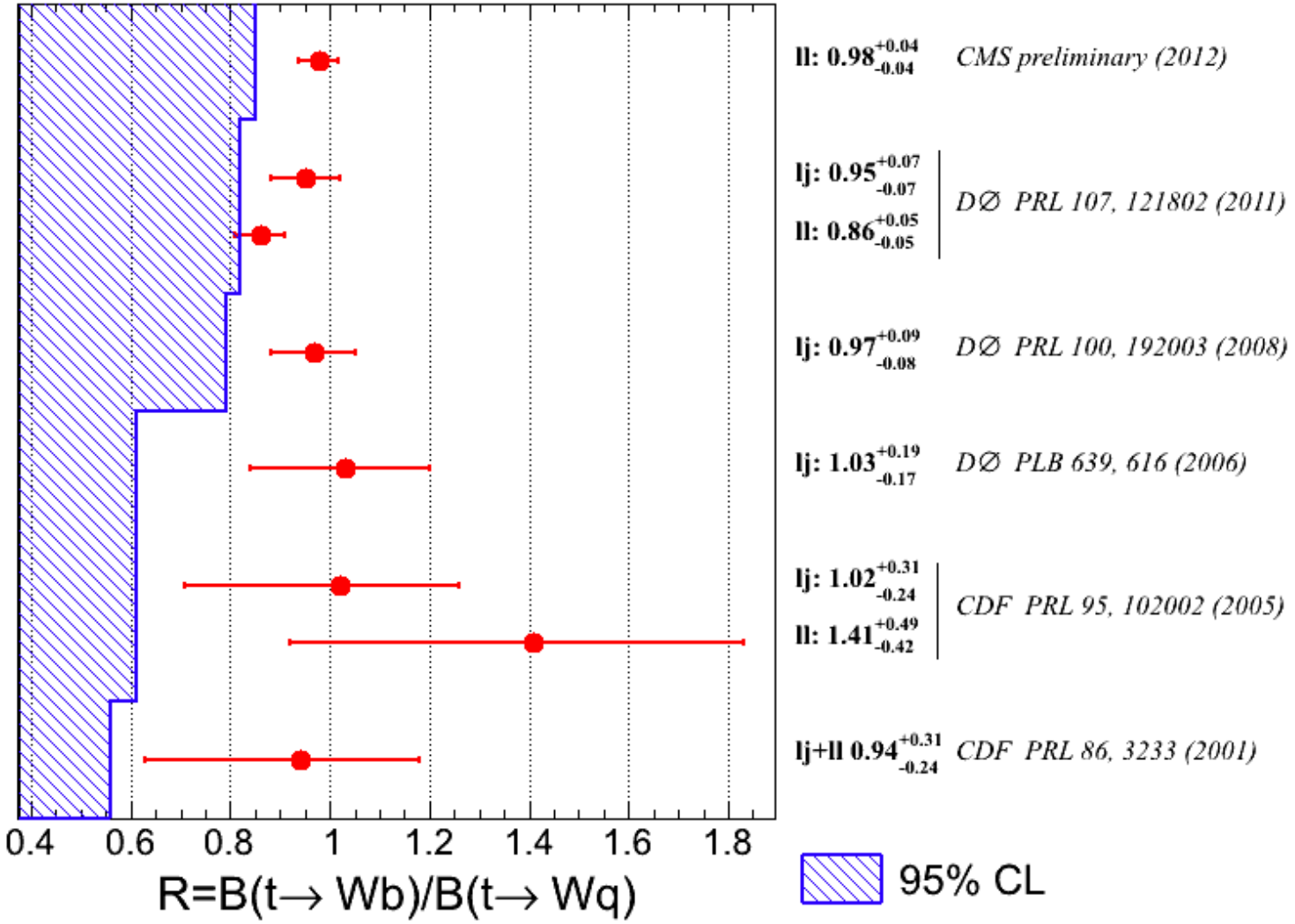
CMS TOP-11-029

- Variation of the likelihood used to measure R from data
- Fit different categories





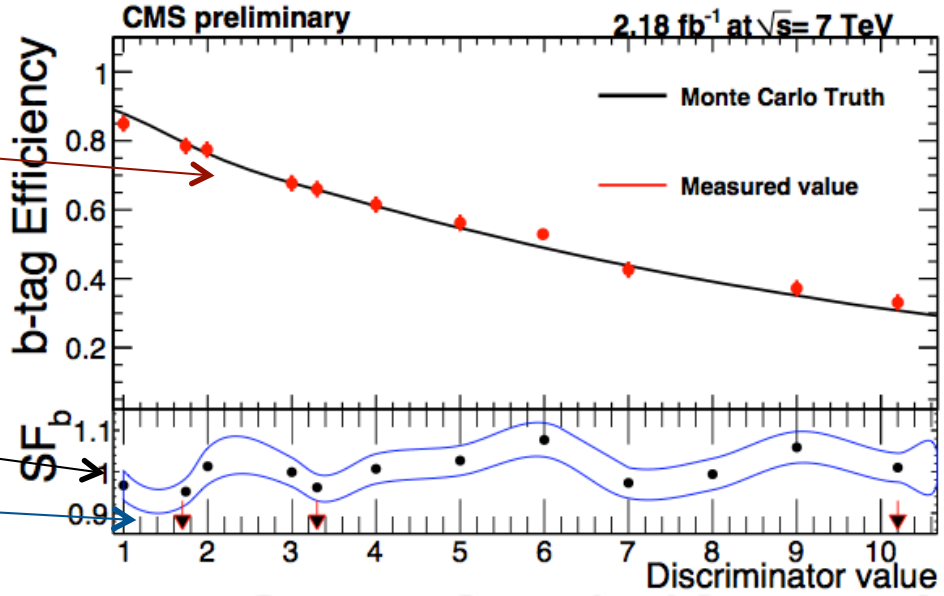
Summary of R results

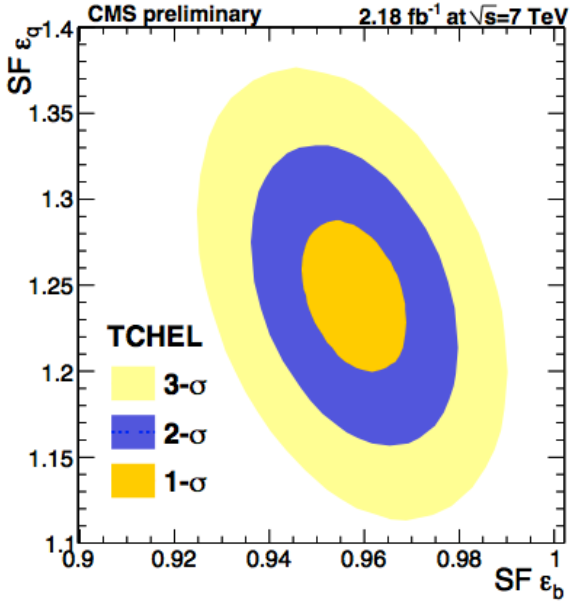


b-tagging efficiency

CMS BTV-11-003

- Can determine b-tag efficiency and/or R
- b-tagging efficiency measured
  - (assume R=1)
- absolute *b-tagging* efficiency measured from data and predicted from simulation
- Ratio of data/simulation
- Total (stat.+syst.) uncertainties





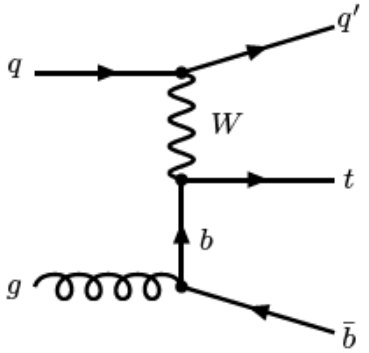
Results of the fit to the b-tagging multiplicity

ttbar resonances

How else is top produced?

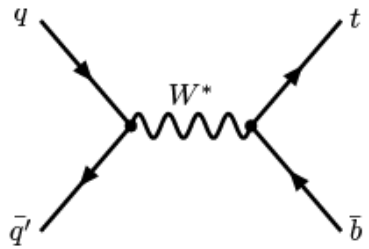
For single top:
see A. Onofre,
Lecture #7
March 19, 2012

Standard Model LHC Single Top Production



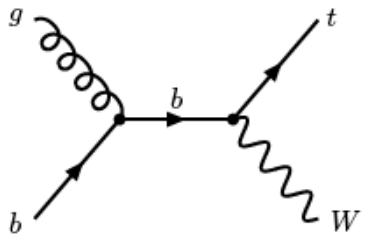
$64.57^{+2.09\ +1.51}_{-0.71\ -1.74}$ pb

Kidonakis,N.
PRD83:091503,2011



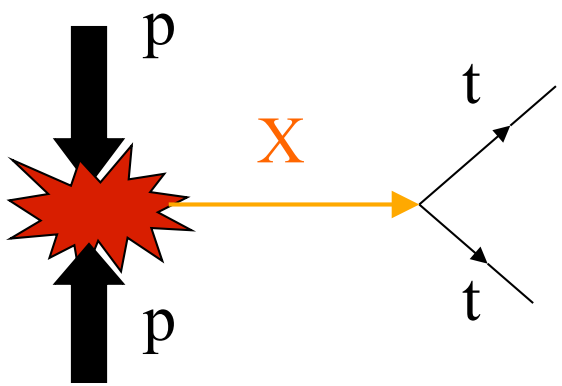
$4.63 \pm 0.07^{+0.19}_{-0.17}$ pb

Kidonakis,N.
PRD81:054028,2010



$15.74 \pm 0.40^{+1.10}_{-1.14}$ pb

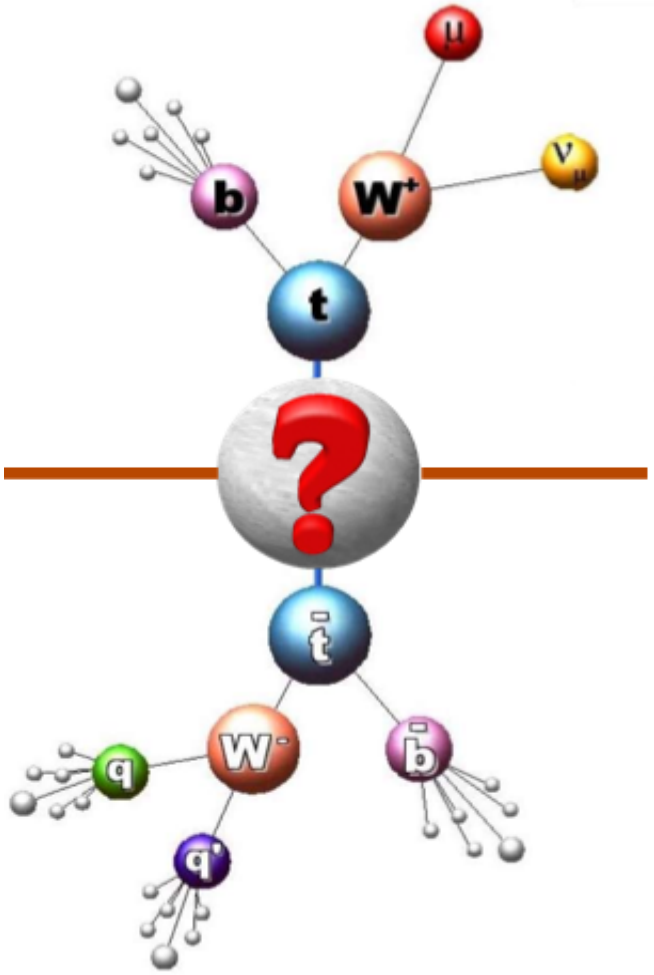
Kidonakis,N.
PRD82:054018,2010



Resonance Production?
Top Color-Assisted Technicolor
OR
?????

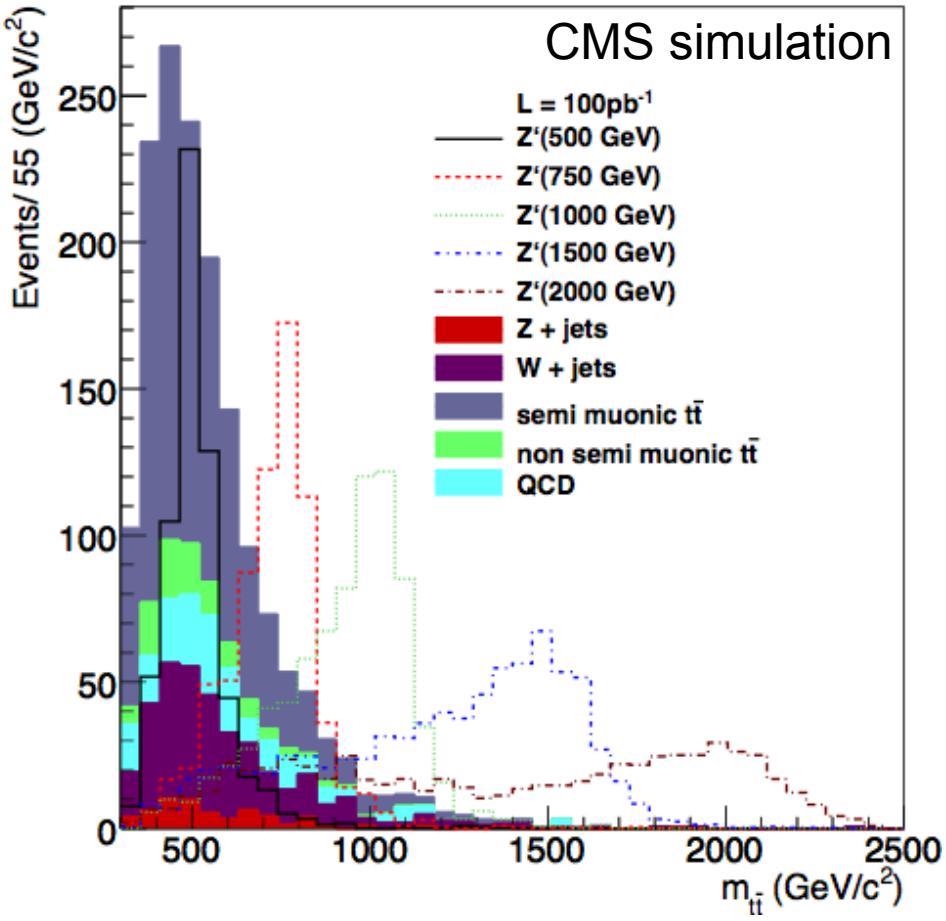
Top quark pair resonance

- No resonance expected in SM
- Why is Top so heavy?
  - new physics?
  - is third generation ‘special’?
  - couples predominantly to third generation quarks
- Top is relatively unknown experimentally
- Experimental check
  - search for a bump in the invariant mass spectrum



Search for resonances

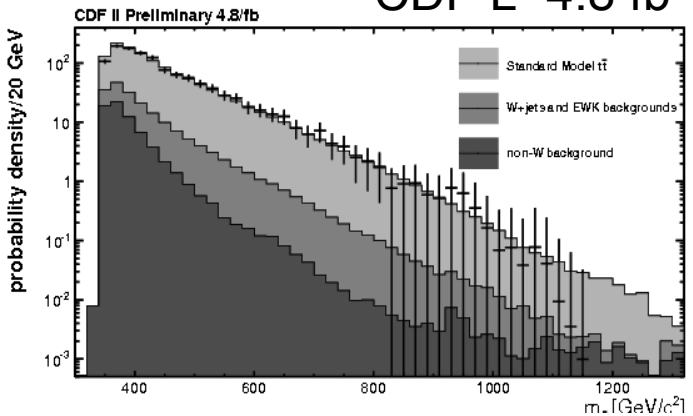
- Semi-leptonic (muon+jets) channel
- Z' ➞ttbar cross section normalized to SM ttbar
- Progressive loss in reconstruction ability due to jet merging

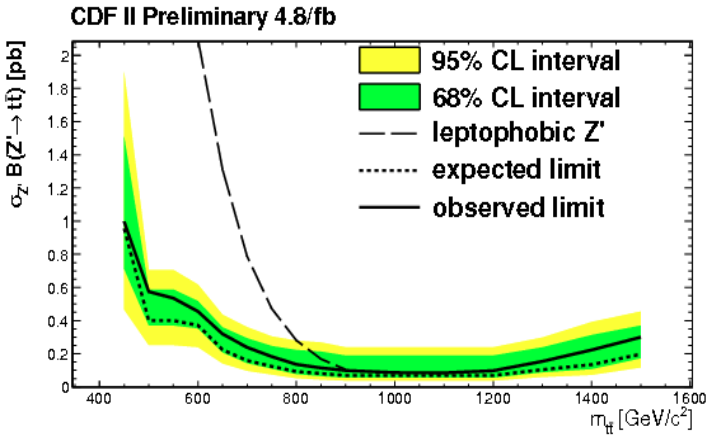


Search for resonance X→ttbar

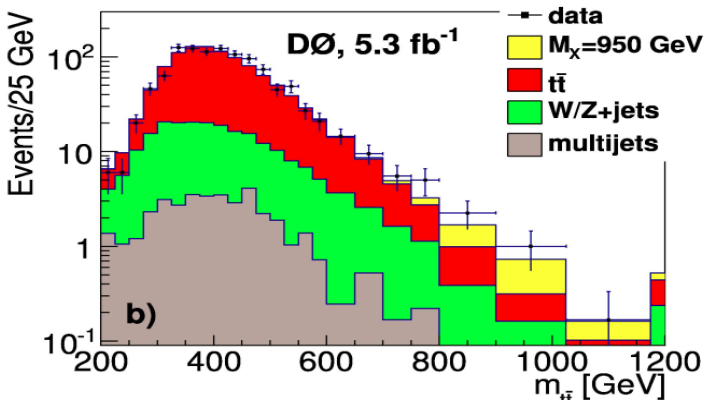
Look at the M_{ttbar} spectrum in the lepton+jets final state, to see any deviation over SM

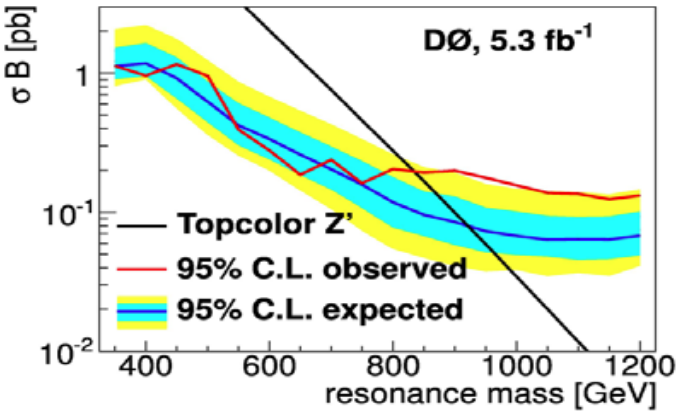
CDF L=4.8 fb^{-1}





D0 L=5.3 fb^{-1}





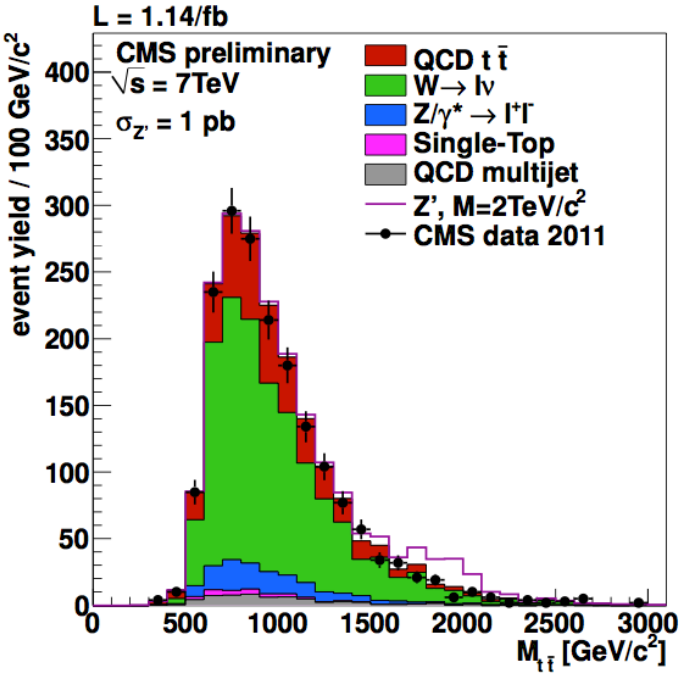
A topcolor leptophobic Z' → ttbar is excluded at 95%CL with:

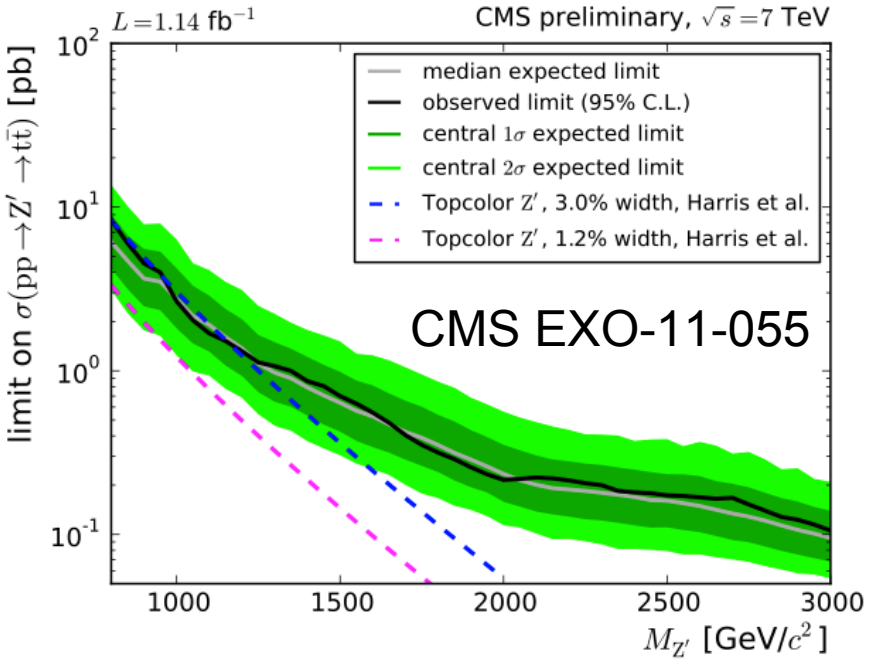
$M_{Z'} < 900$ GeV/c^2
PRD 84, 072004 (2011)

$M_{Z'} < 835$ GeV/c^2
arXiv:1111.1271 , PRD

Search for heavy resonances

- search for narrow heavy resonances decaying to top quark pairs
- Use muon+jet final state
- Look for narrowly collimated decay products
- Reconstruct ttbar invariant mass
- Set limits on Z' production cross section $\sigma(pp \to Z' \to t\bar{t})$

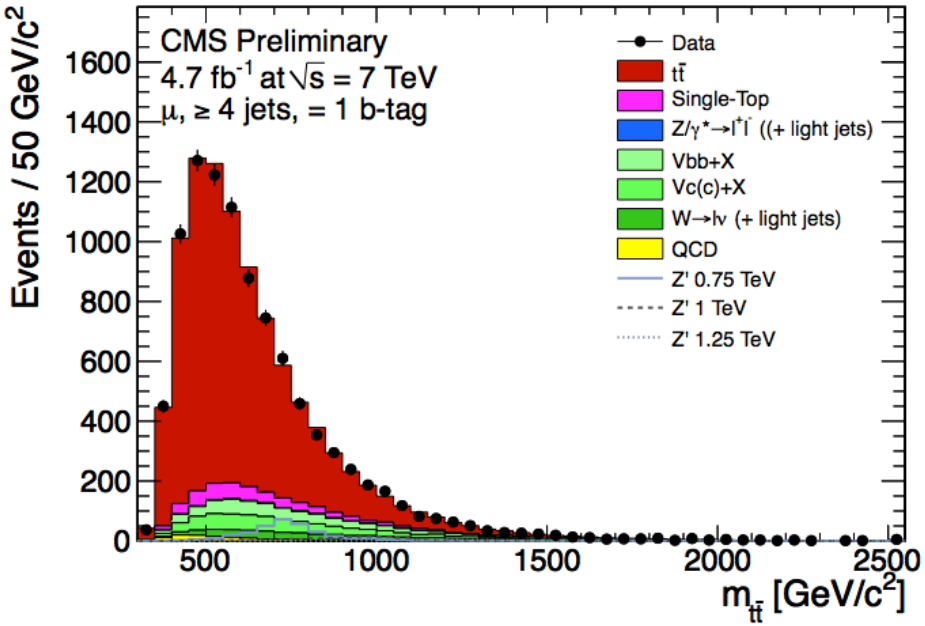


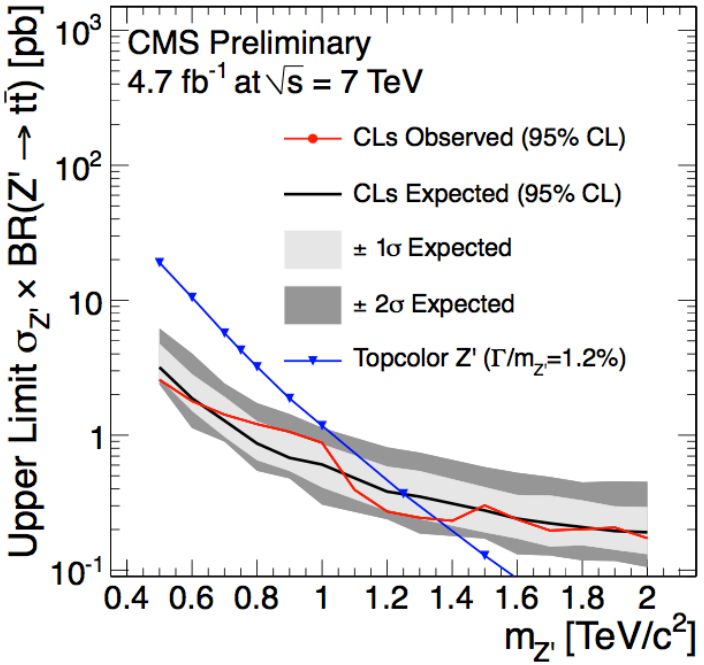


Search for heavy resonances

- search for massive neutral bosons decaying via a ttbar quark pair
- Use lepton+jet final state (electron and muon)
- Reconstruct M_{ttbar} in different categories (e/μ, *n*-jets, *n* b-tags)
- Model background
- Set limits: leptophobic topcolor Z′ with width much less than the detector resolution excluded for masses below 1.3 TeV

CMS TOP-11-009



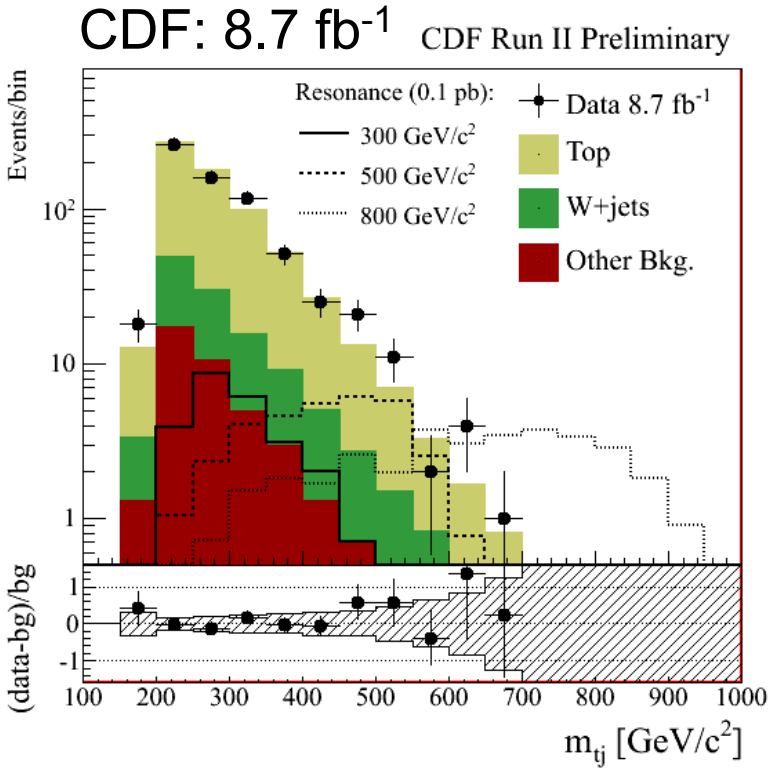


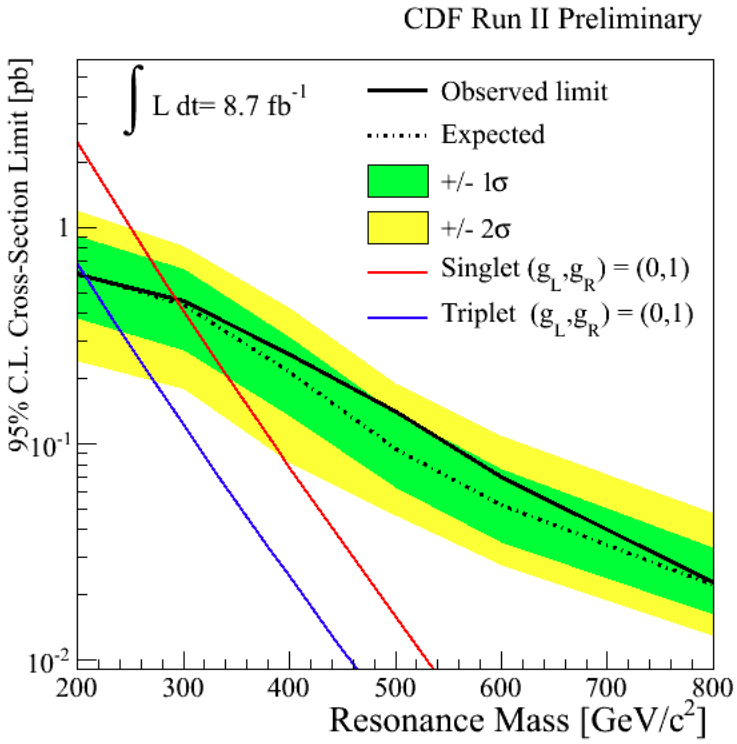
Search for ttbar+jet resonance

- Search for a heavy new particle M produced in association with a top quark:

$$p\bar{p} \rightarrow Mt \rightarrow \bar{t}qt$$

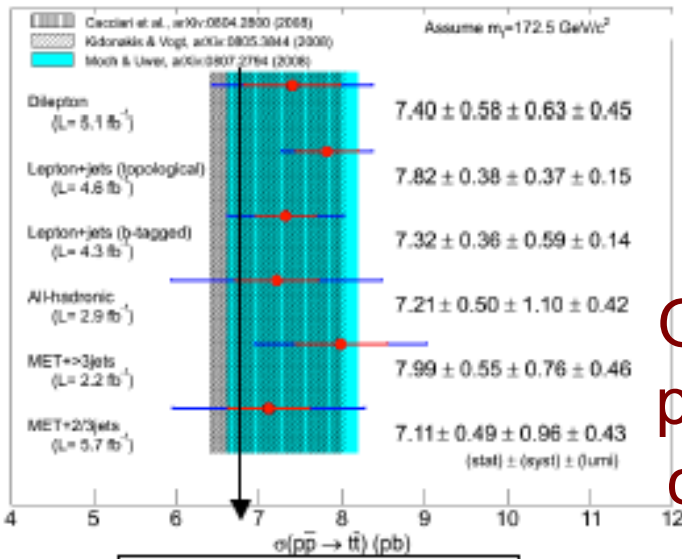
- Resonance in the system t+jets ot ttbar+jets
- Select events in lepton+jets channel with at least 5 jets and 1 b-tag



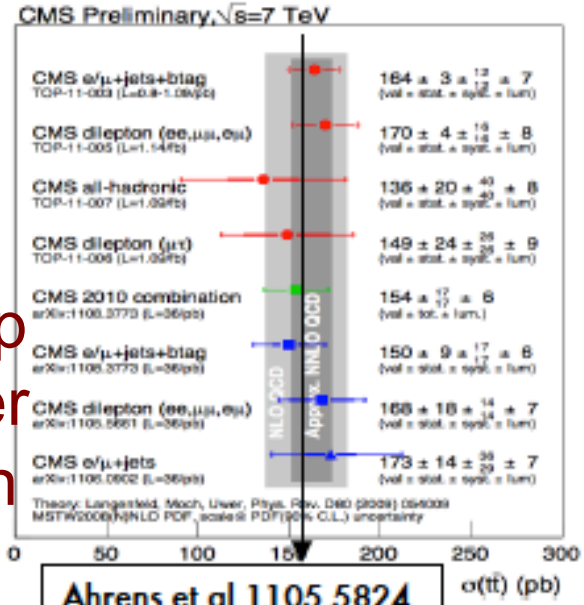


SUSY and 4th generation

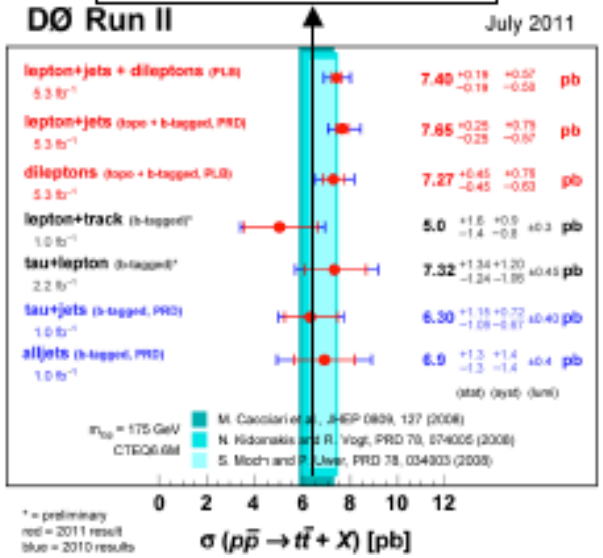
Cross section measurements



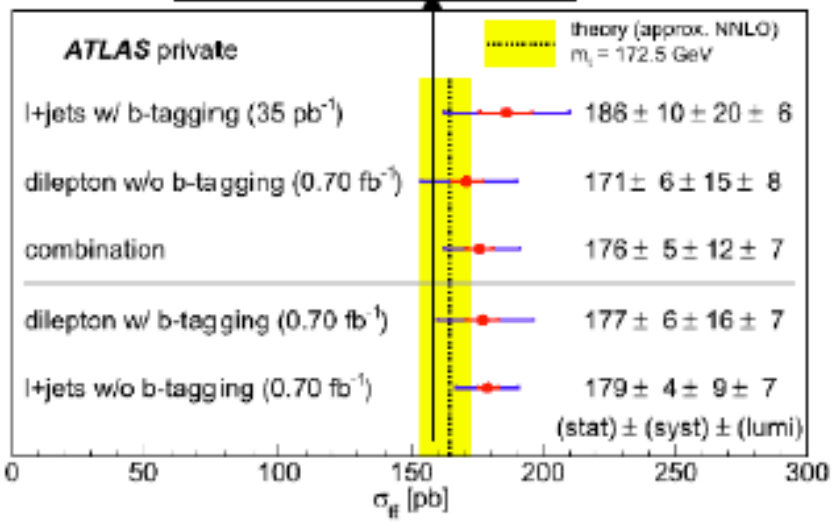
One th. group predicts lower cross section values



Ahrens et al 1105.5824



Ahrens et al 1105.5824

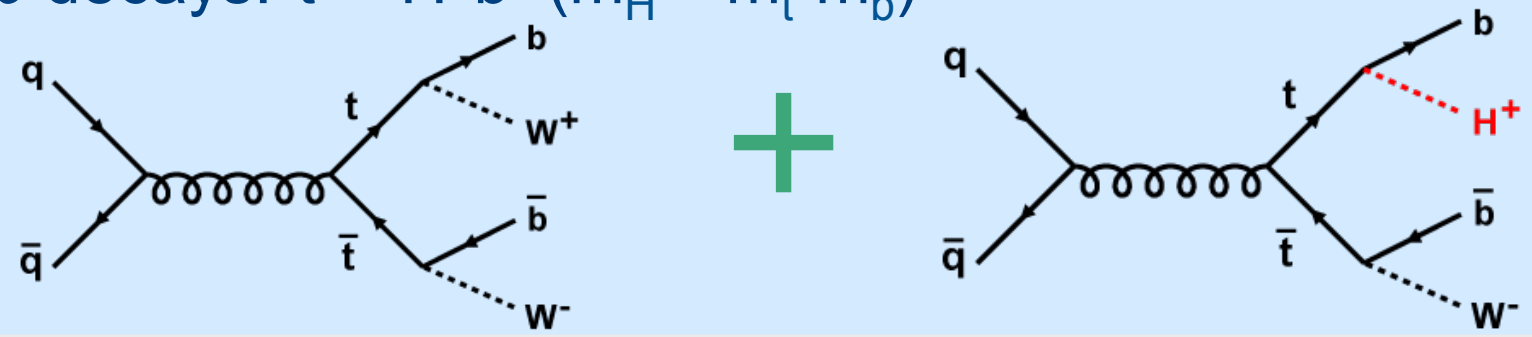


Charged Higgs

CMS HIG-11-019

This study focuses on the mass range $100 \leq H^+ \leq 160\,\mathrm{GeV}/c^2$, where we may observe an anomalous excess of events in the τ dilepton channel when compared to the SM decay of $t\bar{t} \rightarrow W^+W^-b\bar{b} \rightarrow \tau\nu_\tau l\nu_l b\bar{b}, \quad l = e, \mu.$

If top decays: $t \rightarrow H^+b$ $(m_H < m_t - m_b)$

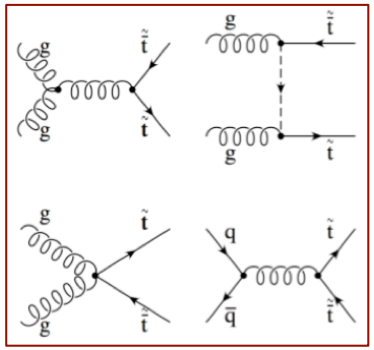


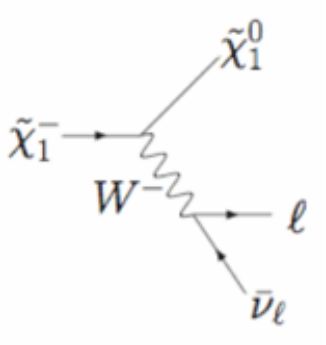
Implies a larger measured cross section (see MG, Lecture #6)

⇨probe non-standard physics ($t \rightarrow H^{\pm}b$, …)

Scalar top quark

- SUSY is one plausible extension of the SM
- due to the heavy top quark, mass splitting between $\tilde{t}_1$ and $\tilde{t}_2$ can be large, such that the lighter stop $\tilde{t}_1$ can be even lighter than the top quark
- Decays dictated by mass spectrum of other SUSY particles





i.e. similar signature as in ttbar

- Light stop:

$$m_{\tilde{t}_1} \lesssim m_t \qquad \tilde{t}_1 \rightarrow b + \tilde{\chi}_1^{\pm} \rightarrow b + \tilde{\chi}_1^0 + \nu + \ell$$

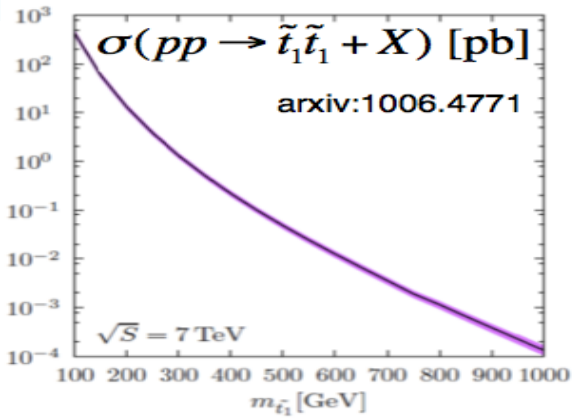
- Heavy stop:

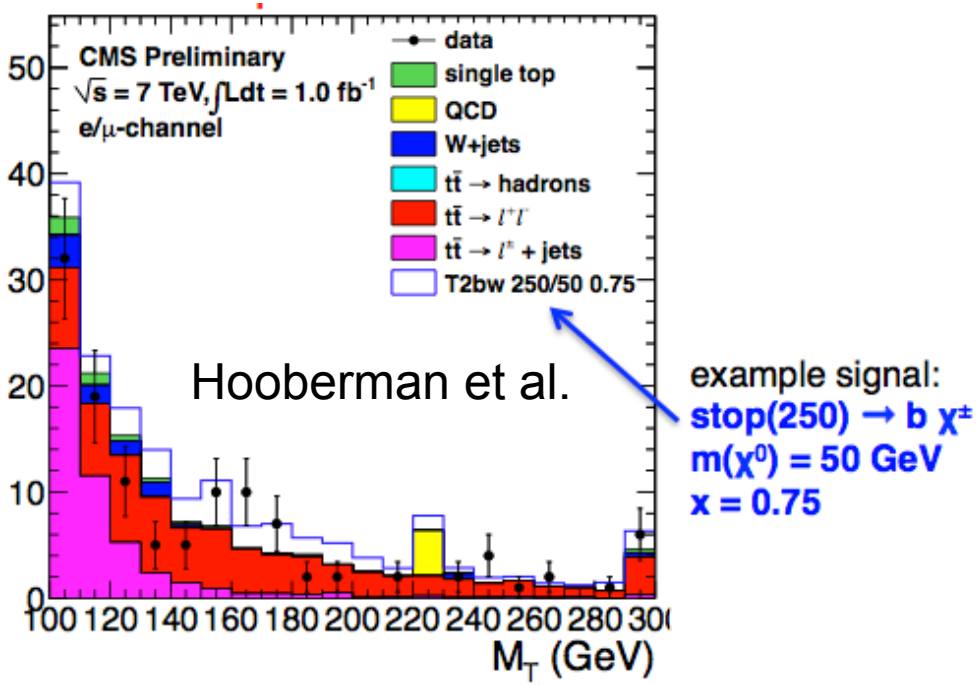
$$\tilde{t} \rightarrow t\tilde{\chi}^0$$

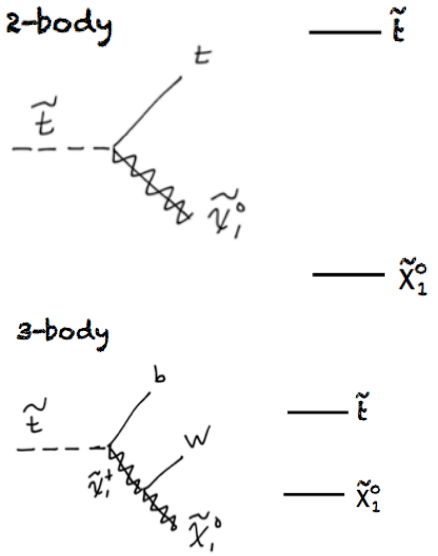
SUSY: search for scalar top

$$\tilde{t}\tilde{t} \rightarrow t\bar{t}\,\chi^0\chi^0 \qquad \tilde{t}\tilde{t} \rightarrow b\bar{b}\,\chi^+\chi^- \rightarrow b\bar{b}W^+W^-\chi^0\chi^0$$

- Status:
  - Final state: both dileptons and 1lepton+MET +2jets+2b jets
  - limitations due to small xsec, large ttbar background



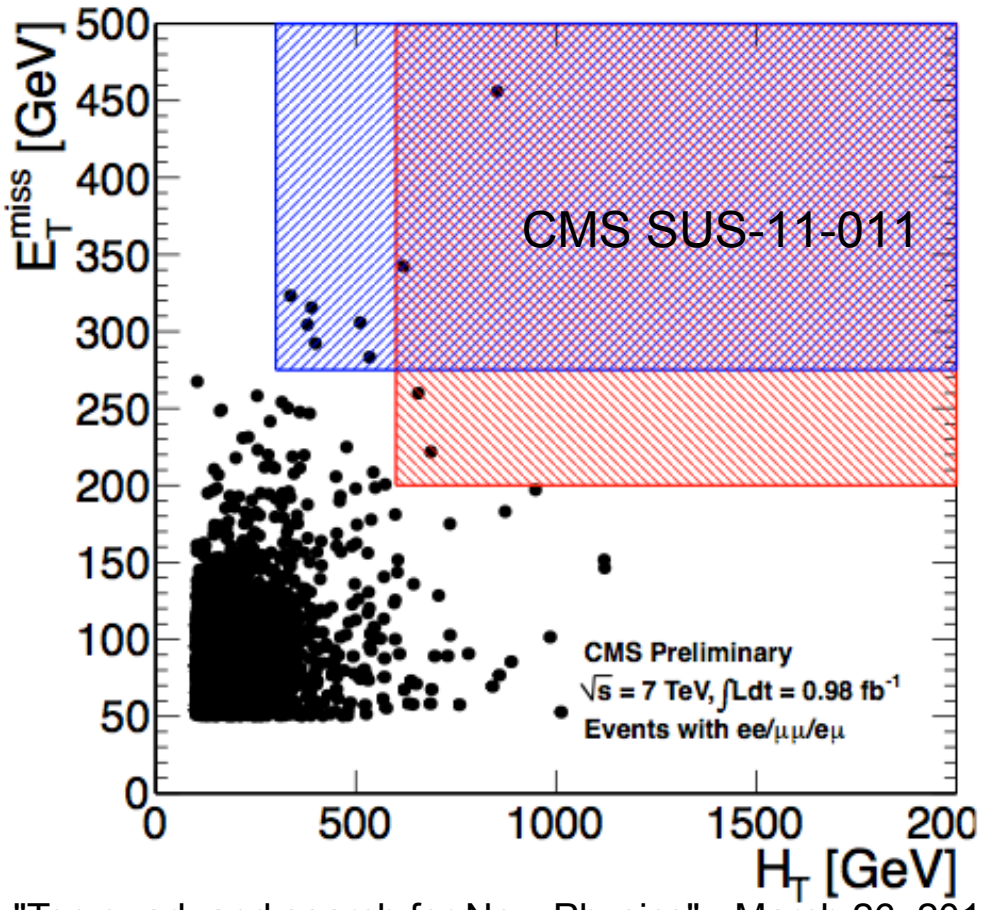




One example: dilepton sample

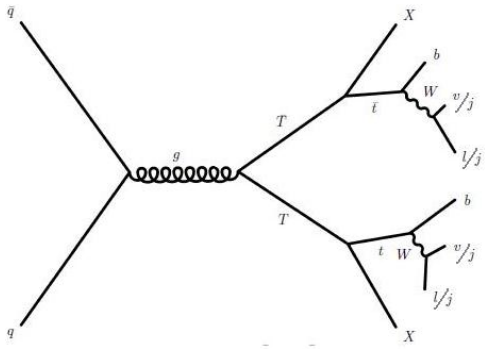
Define signal region: look for possible contributions of NP in dilepton sample

- Astrophysical evidence for dark matter suggests it may lie in high MET region
- New physics signals should have large sqrt(s)
- New physics with large cross section should be produced strongly (i.e. large hadronic activity)



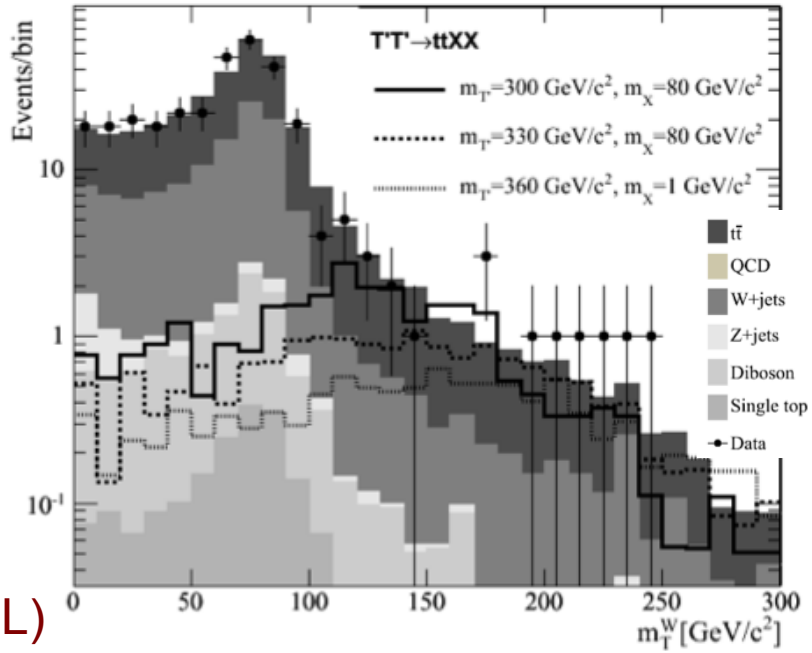
Stop quark: lepton+jets

- Investigate same signature in the context of a vector-like top partner, decaying to top plus dark matter candidate
  - search for new particle T′ decaying via T′→t + X (X invisible)
  - interpret results in terms of a model where T′ are exotic fourth generation quarks and X are dark matter particles
- Kinematics similar to SUSY stop scenario
- Study lepton+jets+MET+btag



$$m_T^W \equiv m_T(E_T^\ell, \not{E}_T) = \sqrt{2|E_T^\ell||\not{E}_T|(1 - cos(\Delta\phi(E_T^\ell, \not{E}_T)))}$$

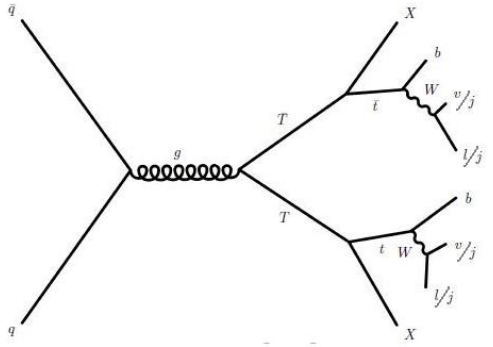
CDF Phys.Rev.Lett.106 191801



- set 95% CL limits on T'T'→tt+X production
- Exclude 4th generation exotic quarks T ′ (95% CL) up to $m_{T'}$=360 GeV for m_X ≤100 GeV

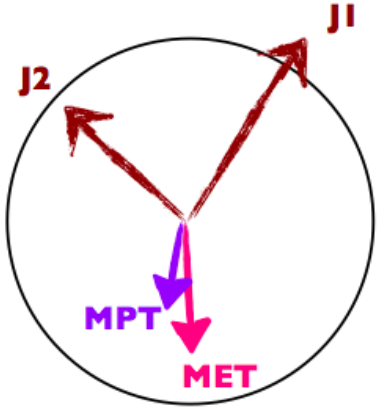
Stop quark: all-hadronic

- signature in the context of a vector-like top partner, decaying to top plus dark matter candidate
- Kinematics similar to SUSY $t \rightarrow t\chi^0$ scenario
- Signature: MET+jets

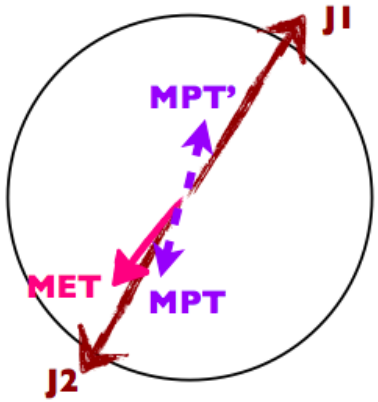


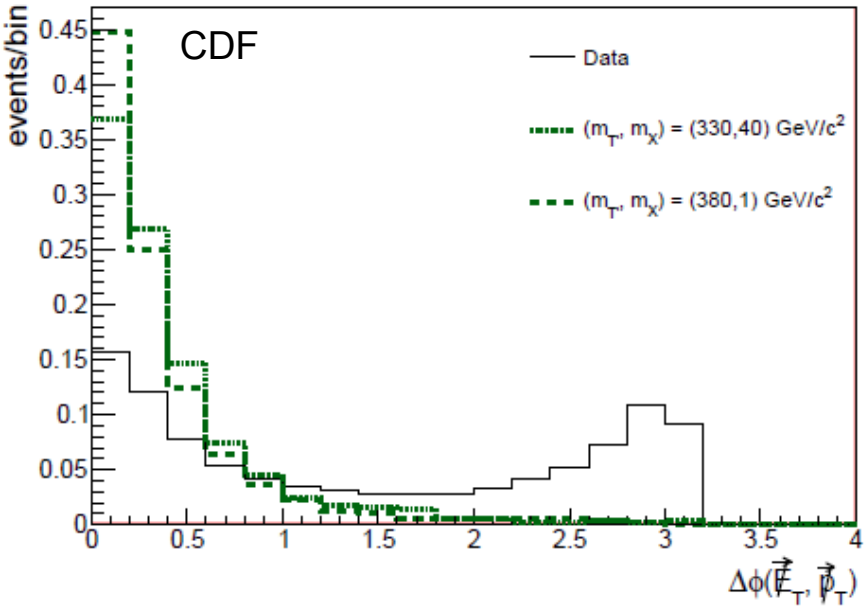
PRD 81 072003
PRL 104 141801

True MET: $ZZ \rightarrow \nu\nu qq$



QCD: mis-measured jet



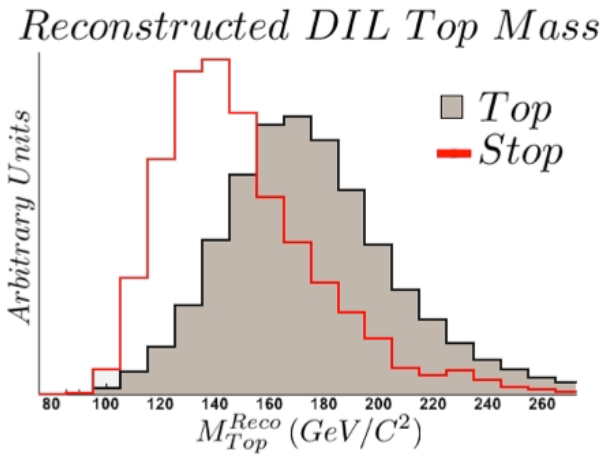


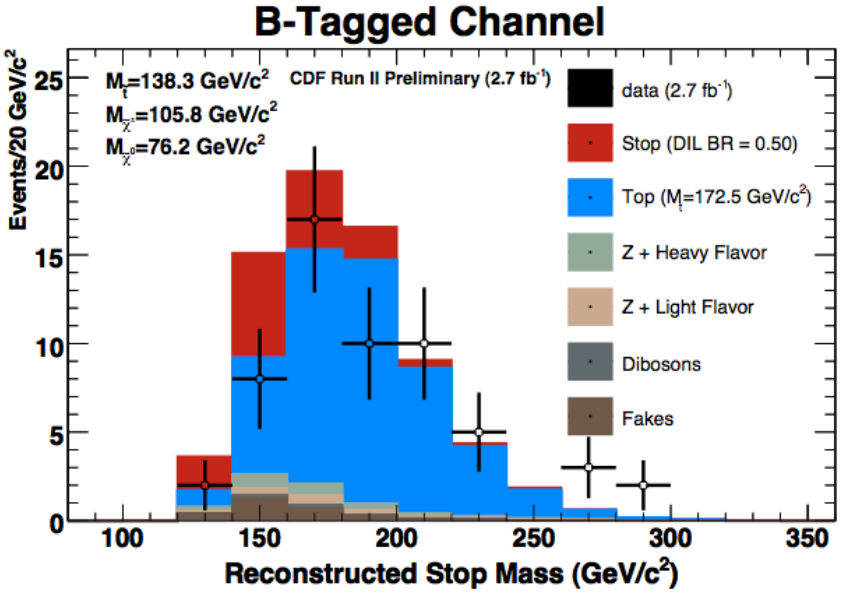
$\Delta\phi(\vec{\not{P}}_T, \vec{\not{E}}_T)$

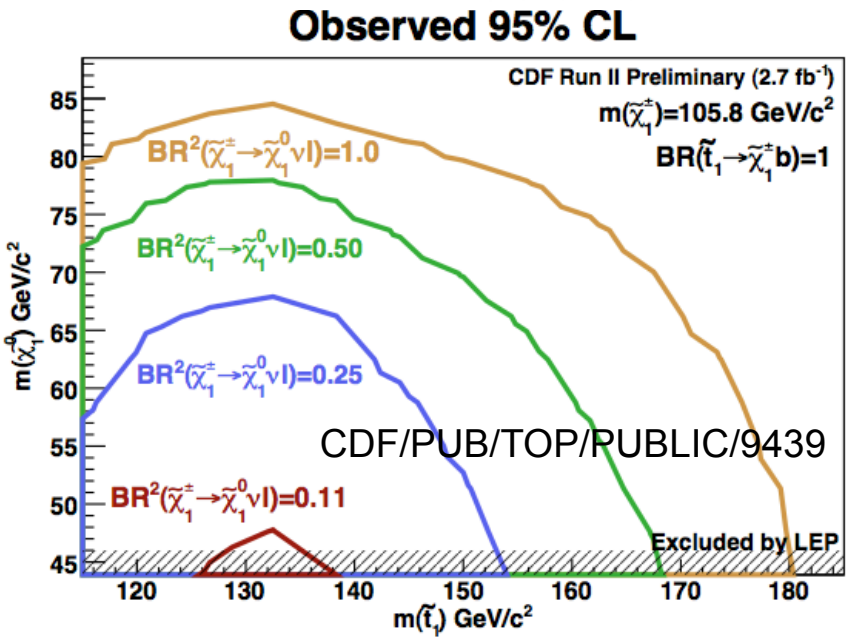
Scalar top quark

- Similar event signature as ttbar dilepton final state
- Reconstruct events under stop hypothesis
- Stop mass as discriminating variable in fit to data
  - Use two categories: with b-tag and without b-tags
  - Results consistent with SM predictions
- Set 95%CL limit in dilepton BR, in 3D space of SUSY particle masses $\tilde{t}_1, \tilde{\chi}_1^{\pm}, \tilde{\chi}_1^0$

CDF 1.9-2.7fb^{-1}



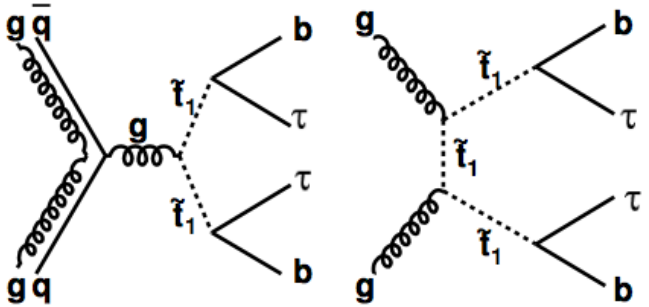




Taus

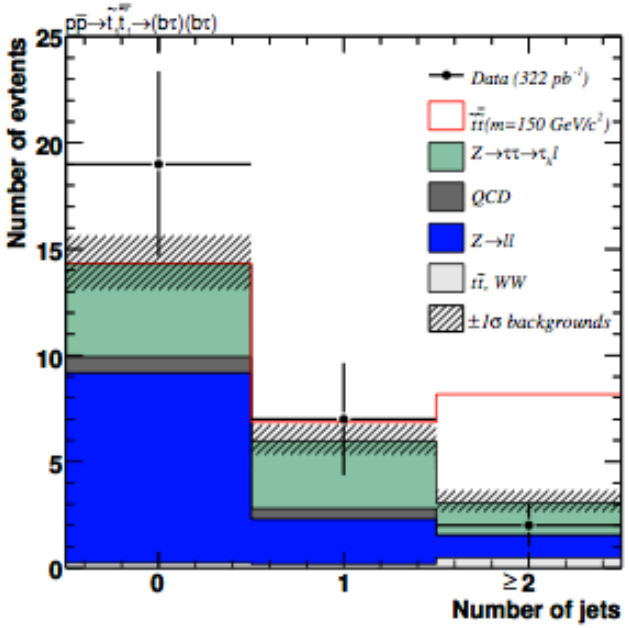
- Assume each stop decays to tau and b (R-parity violation)

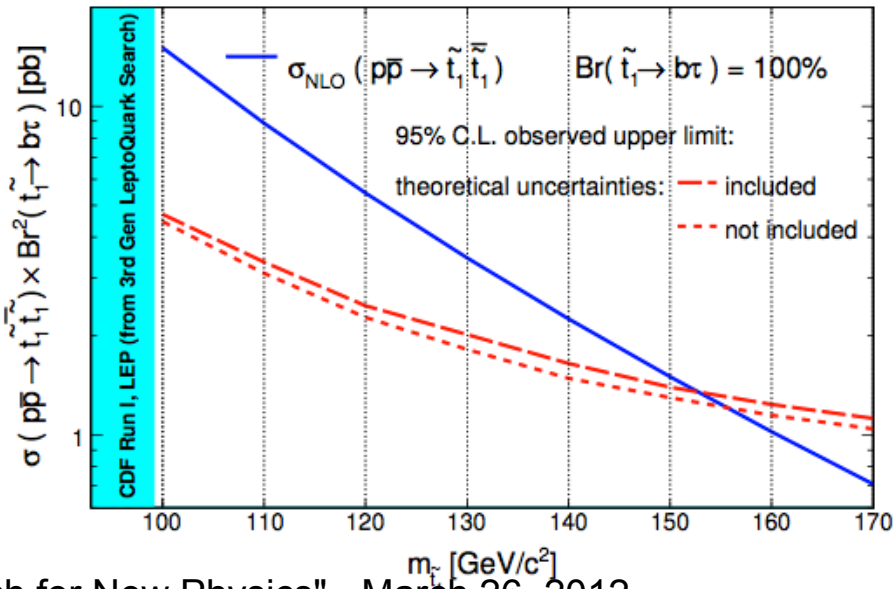
$$\tilde{t}_1\bar{\tilde{t}}_1 \rightarrow \tau^+\tau^- b\bar{b}$$



- Similar final state as in ttbar dilepton with taus
- Look for e/μ+ ≥2 jets + MET
- Define 6 regions in: m_T(l,MET) vs N_{jet} plane
- Find 2 evts in signal region (2.2 expected)

FERMILAB-PUB-08-045-E
CDF: PRL 101 (2008) 071802

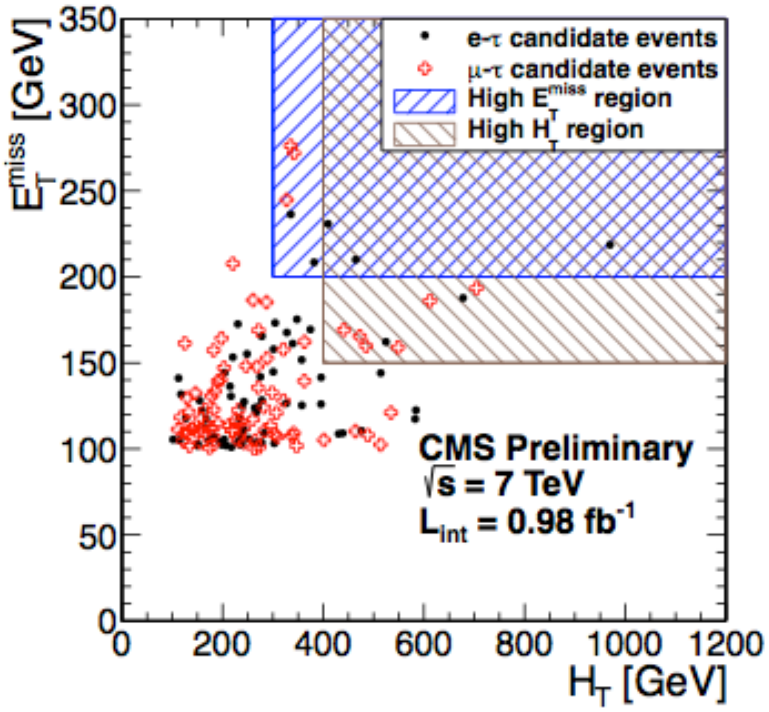


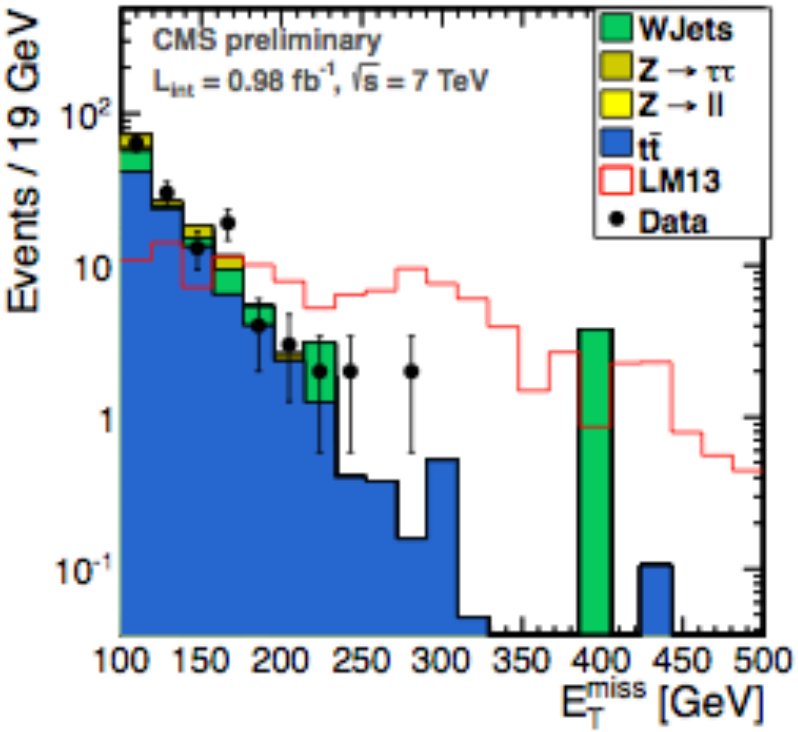


Search for Dark Matter with taus

CMS SUS-11-007

- search concentrates on heavy BSM particle production
  - astrophysical evidence for dark matter points to the existence of weakly-interacting massive particles (WIMPs) at EWSB scale
  - These particles escape detection ⇒ large MET
- Not constrained to a specific theory
  - general BSM search in events with jets, MET, and OS dileptons (at least one tau)
  - $e\tau_h$, $\mu\tau_h$, $\tau_h\,\tau_h$ final states





4^{th} generation searches

Search for 4^{th} generation quarks

- T (or t') and B (or b')
- Pair production or single production
- Mechanism and cross section depend on nature of quarks (vector-like, scalar, charge)

Final state is complex

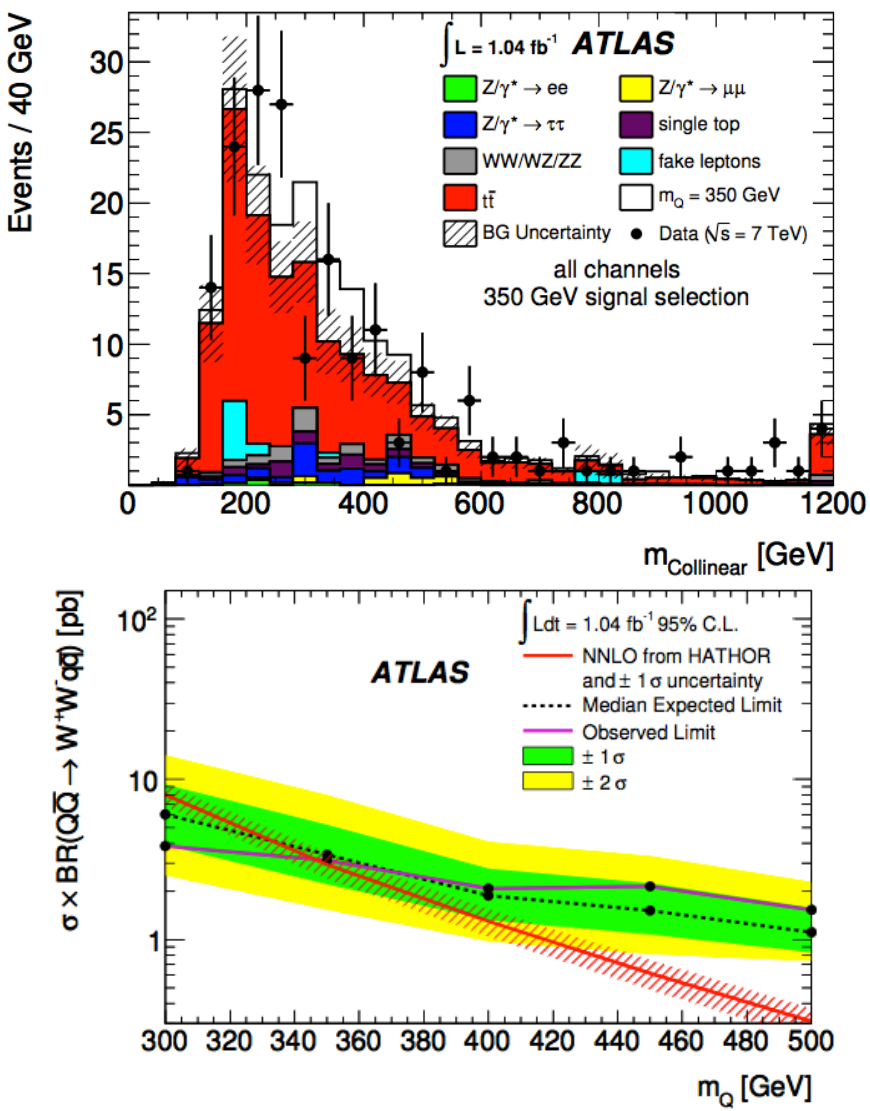
Search for heavy quarks

- Search for heavy quark (q=u,d,c,s,b):

$$Q\bar{Q} \rightarrow W^{+}qW^{-}\bar{q}$$

- Use dilepton channel
  - Select events with 2 leptons, MET, ≥2 jets
- Reconstruct “top” mass
- Use W collinear approximation for neutrinos
- Set limits: M_Q>350 GeV @95% CL

ATLAS: arXiv:1202.3389

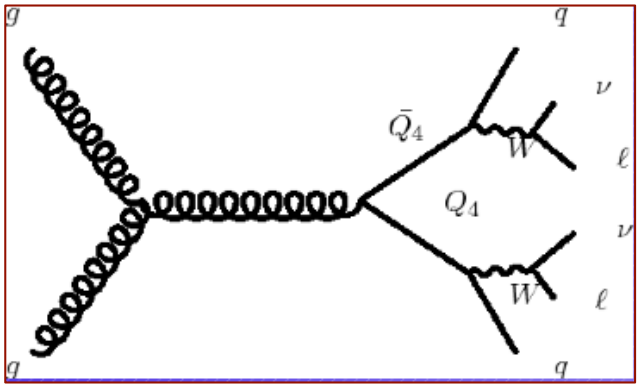


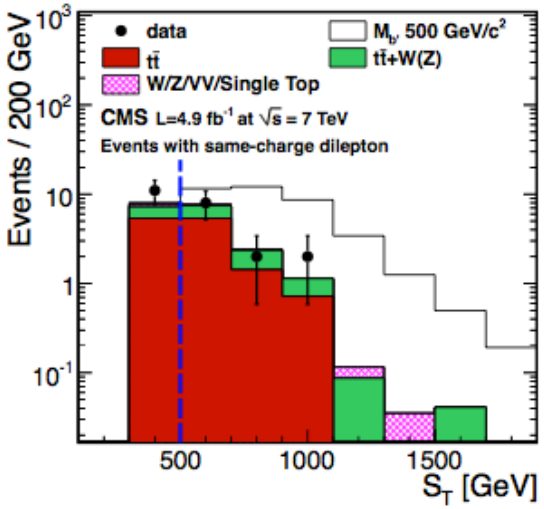
Search for b' production

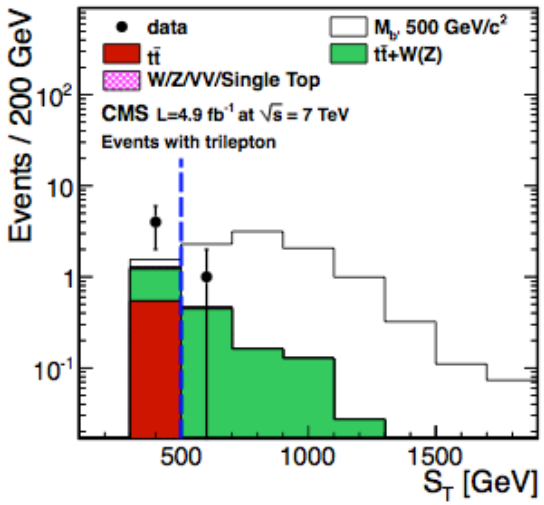
CMS EXO-11-036

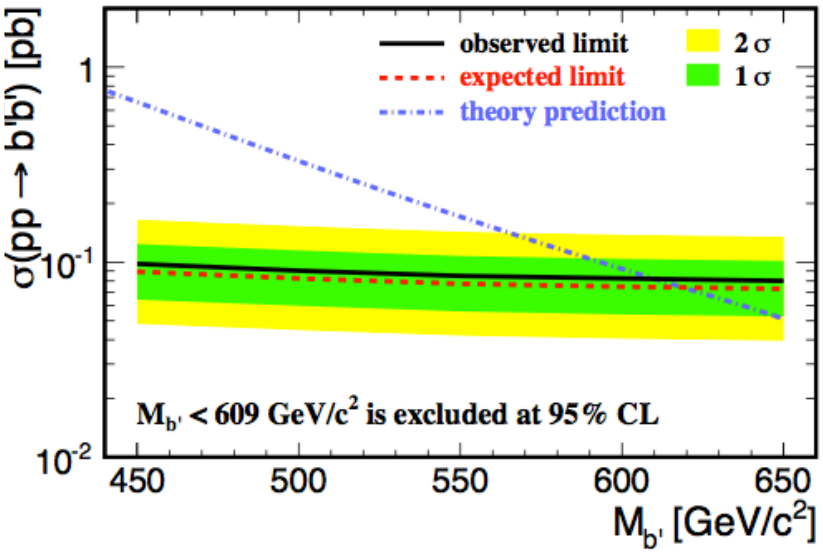
- Final state with top-like signature

$$b'\bar{b}' \rightarrow tW^-\bar{t}W^+ \rightarrow bW^+W^-\bar{b}W^-W^+$$





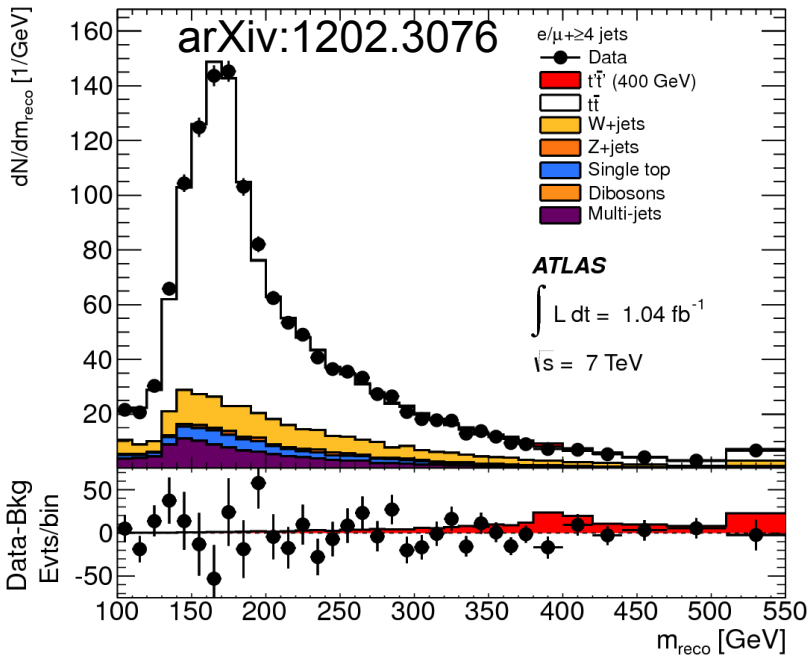




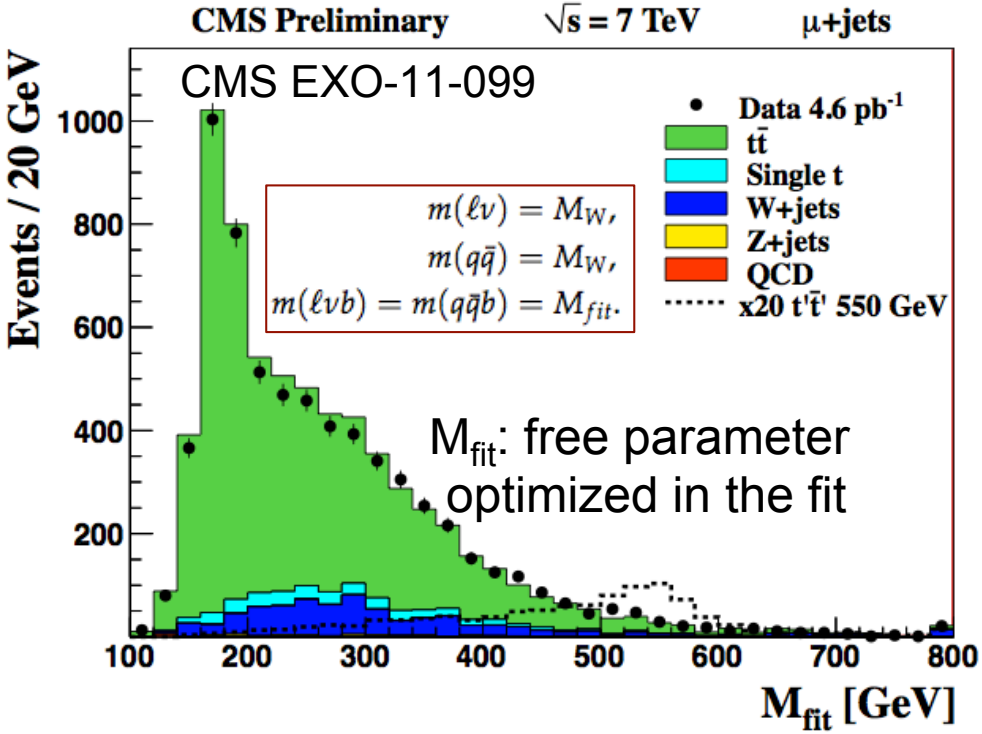
Heavy t': lepton+jets

- Search for the pair production of a 4th generation up-type t′ quark
- Study lepton+jets (at least 1 b-tag)
  - Largest background is from ttbar
- Reconstruct t' mass
  - kinematic fit is performed by minimizing the χ^2

$$t'\bar{t}' \rightarrow WbW\bar{b}$$

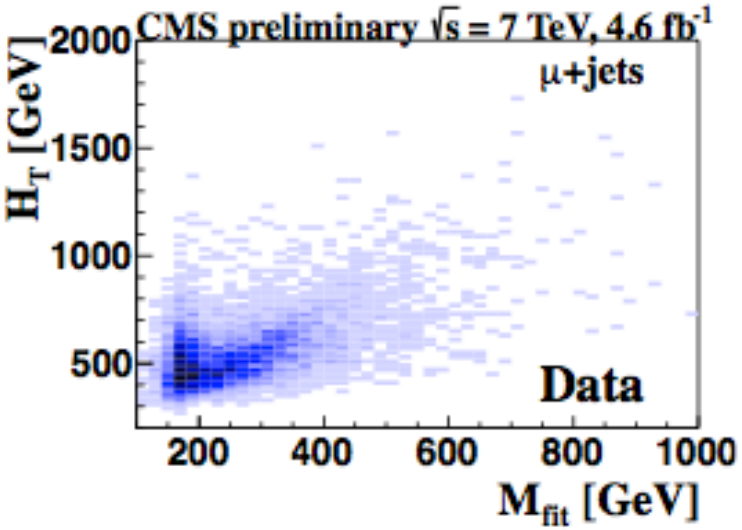


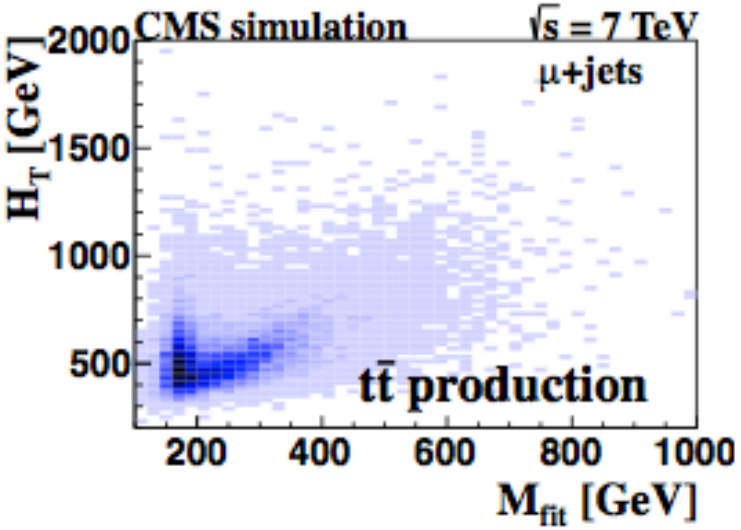
$M_{t'}$>404 GeV

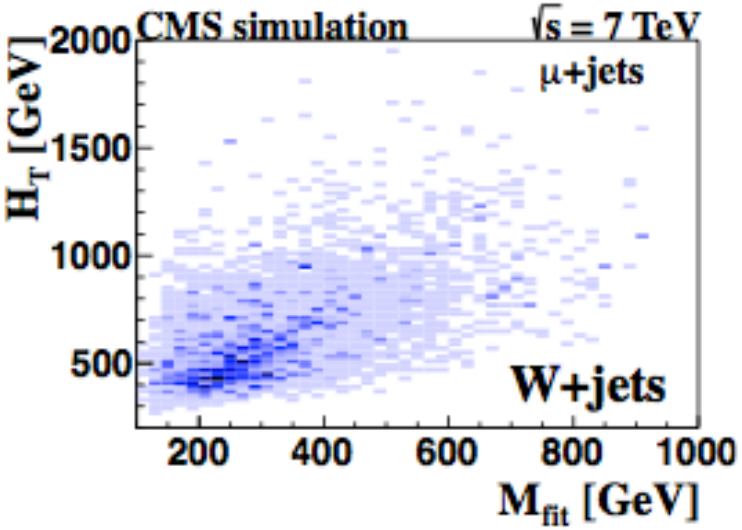


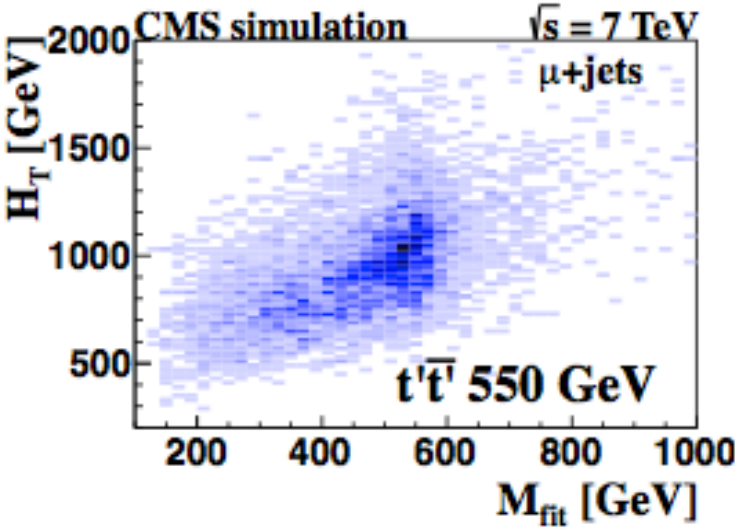
$M_{t'}$>560 GeV

Heavy t': lepton+jets









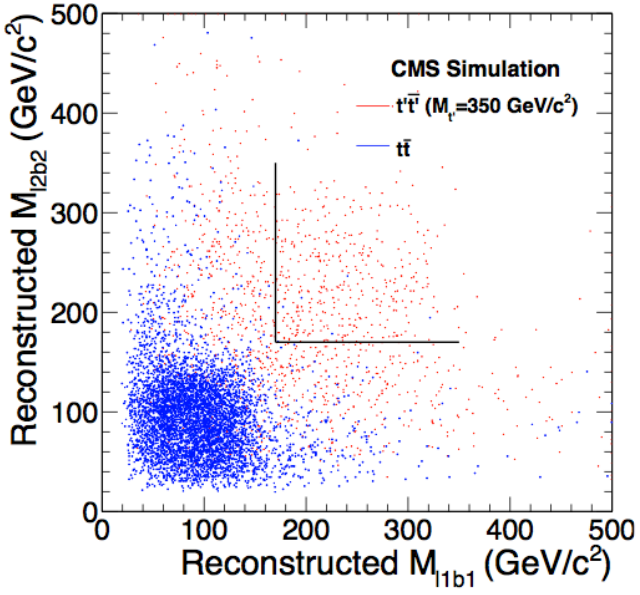
Heavy t': dileptons

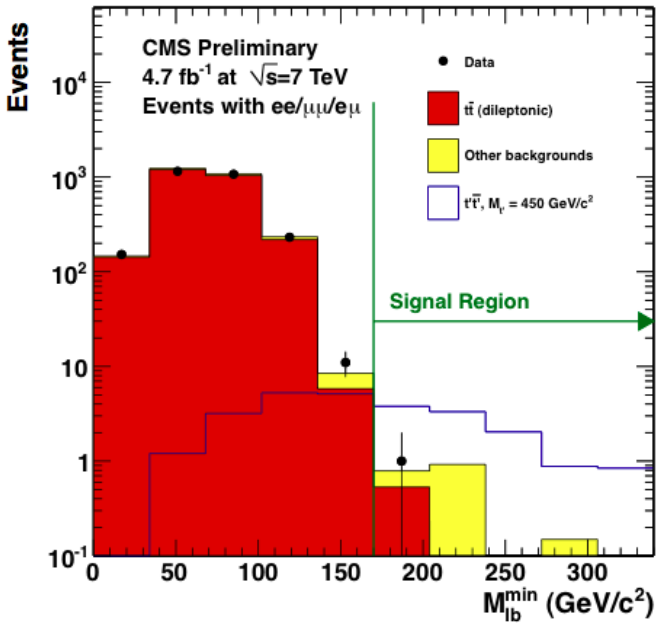
- Search for heavy t' quark in **dilepton** final state

$$t'\bar{t}' \rightarrow bW^+\bar{b}W^- \rightarrow b\ell^+\nu\,\bar{b}\ell^-\bar{\nu}$$

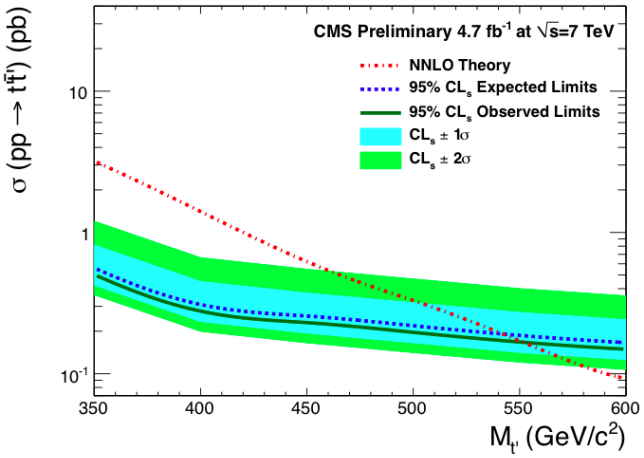
- use variables related to the quark mass to distinguish signal from bkg
  - M_{top}<156 GeV; Signal region with M>170 GeV
  - use lepton-jet invariant mass
  - lepton-jet pair with minimal ΔR

$$M_{l,j} \approx \sqrt{m_t^2 - m_W^2} = 156\ \text{GeV}/c^2$$





EXO-11-050+update



⇒observed (expected) 95% C.L. lower bounds on *t'* mass 557 (547) GeV

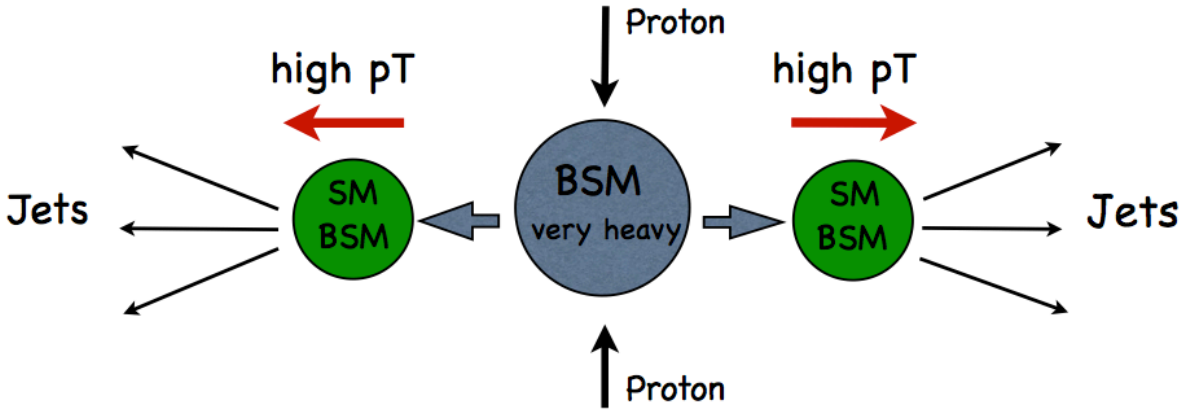
Boosted topology

Boosted topology

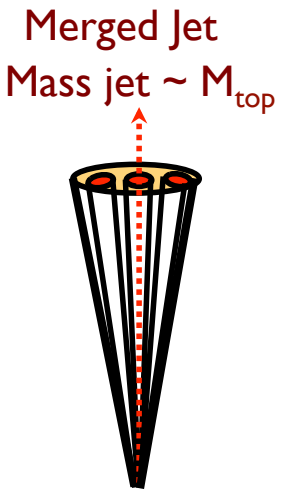
- In many models there is high potential to discover new physics in the top sector in search for heavy resonances

$$pp \rightarrow X \rightarrow t\bar{t}$$

- Simple approach to merge neighboring jets

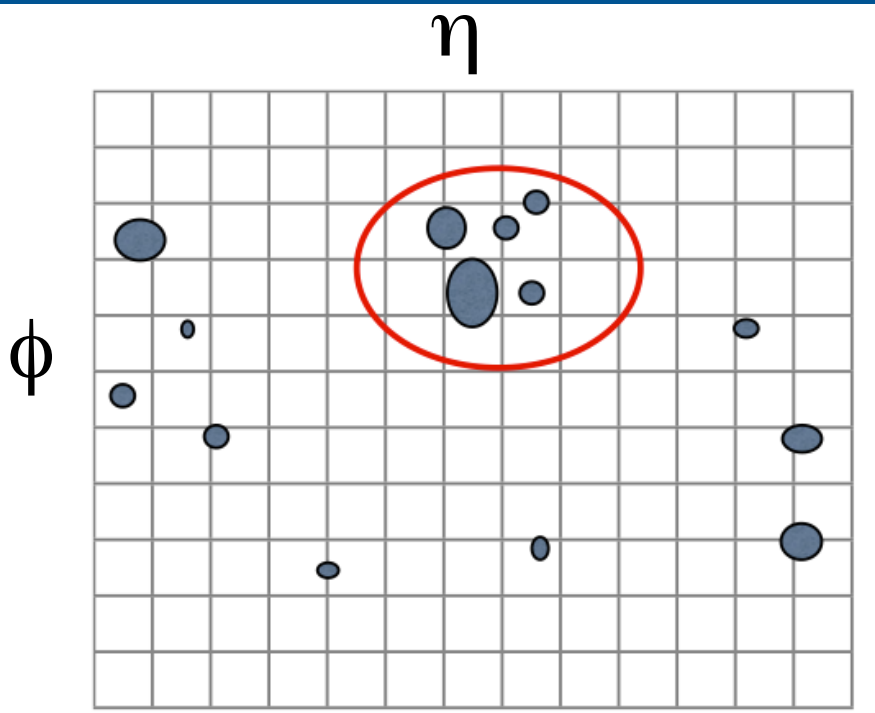


- At LHC energy, EWK scale particles produced beyond threshold
- Jets are highly collimated
- Jet-parton matching breaks down
- Decay products and FSR collected in a fat jet

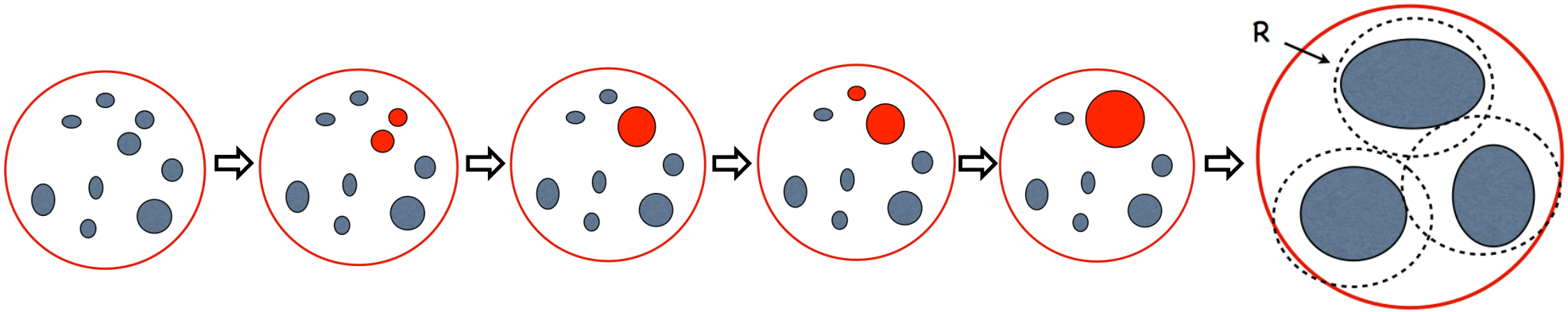


Jet/Event selection

- Locate hadronic energy deposit in detector by choosing initial jet finding algorithm
- Impose jet selection cuts on fat jet
  - Recombine jet constituents with new algorithm
  - Filtering: recombine n sub-jets min d(i,j)
  - Trimming: recombine sub-jets with min p_T
- Minimum distance between jets is R

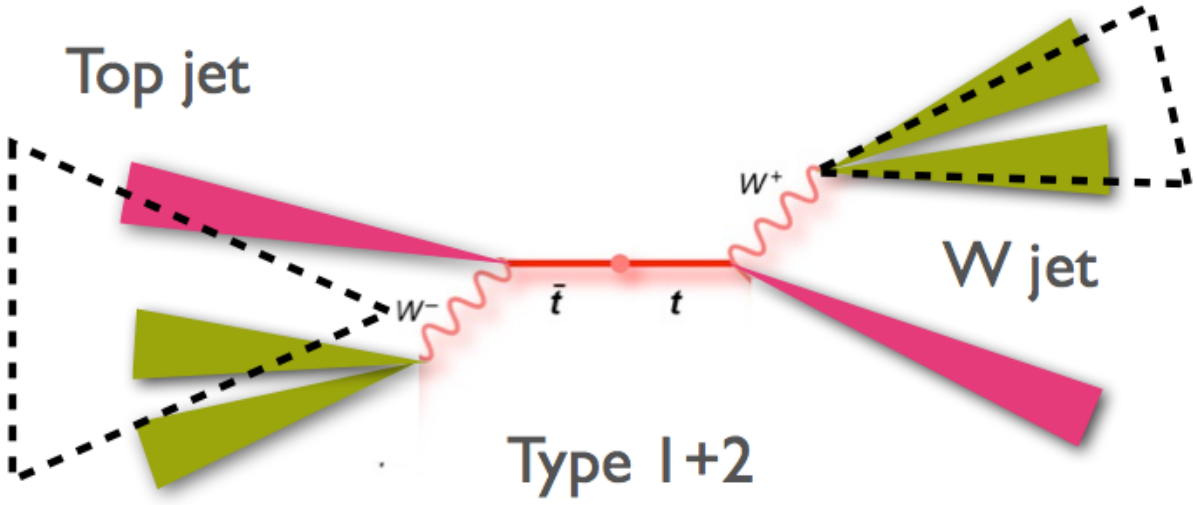


UE, ISR, Pile-up, hard interaction



Boosted top topology

- Highly boosted top: three hadronic decays of the top are merged in one top jet
- Moderately boosted top: three hadronic decays of the top are merged in one W jet plus and one b jet candidates

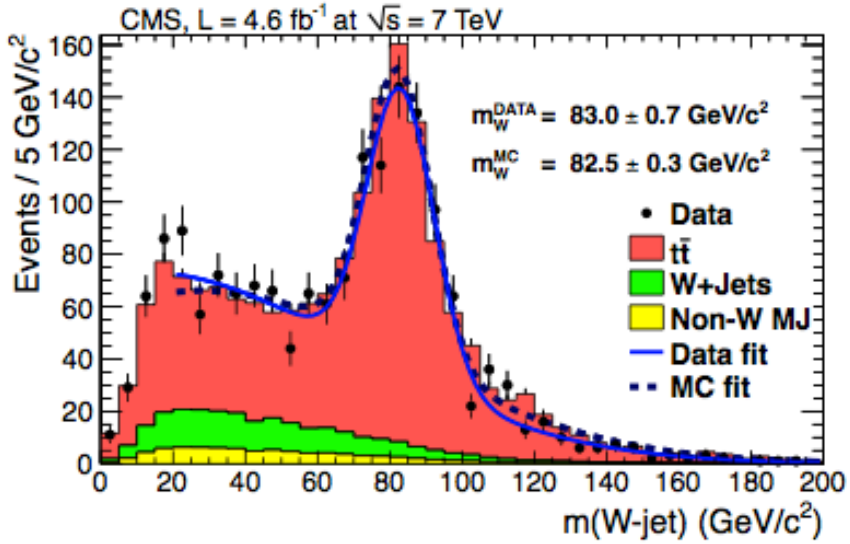


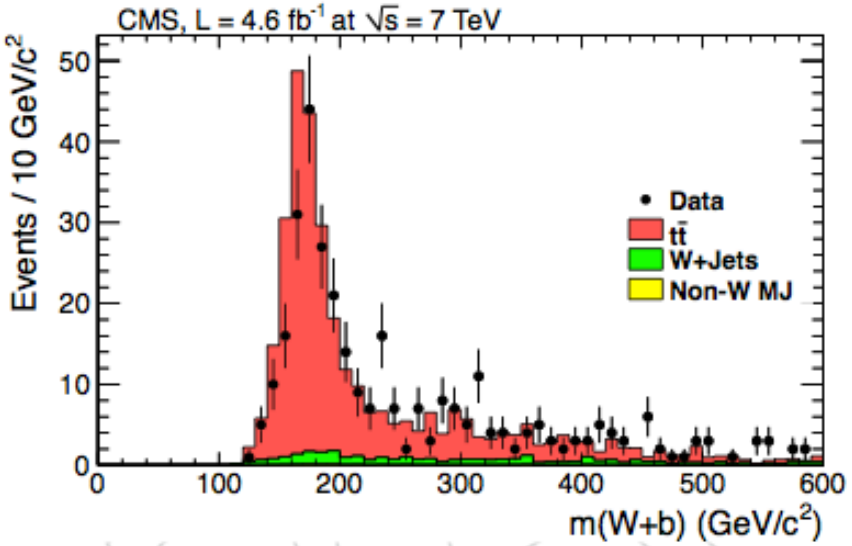
Boosted top topology

Tested using hadronic top in semilep. tt events:

- One high-pT isolated muon from PV.
- At least two jets p_T>30 GeV with a leading jet p_T>200 GeV and at least one b-tagged jet
- Events with W tagged jets used to reconstruct W and the top mass of the hadronic side

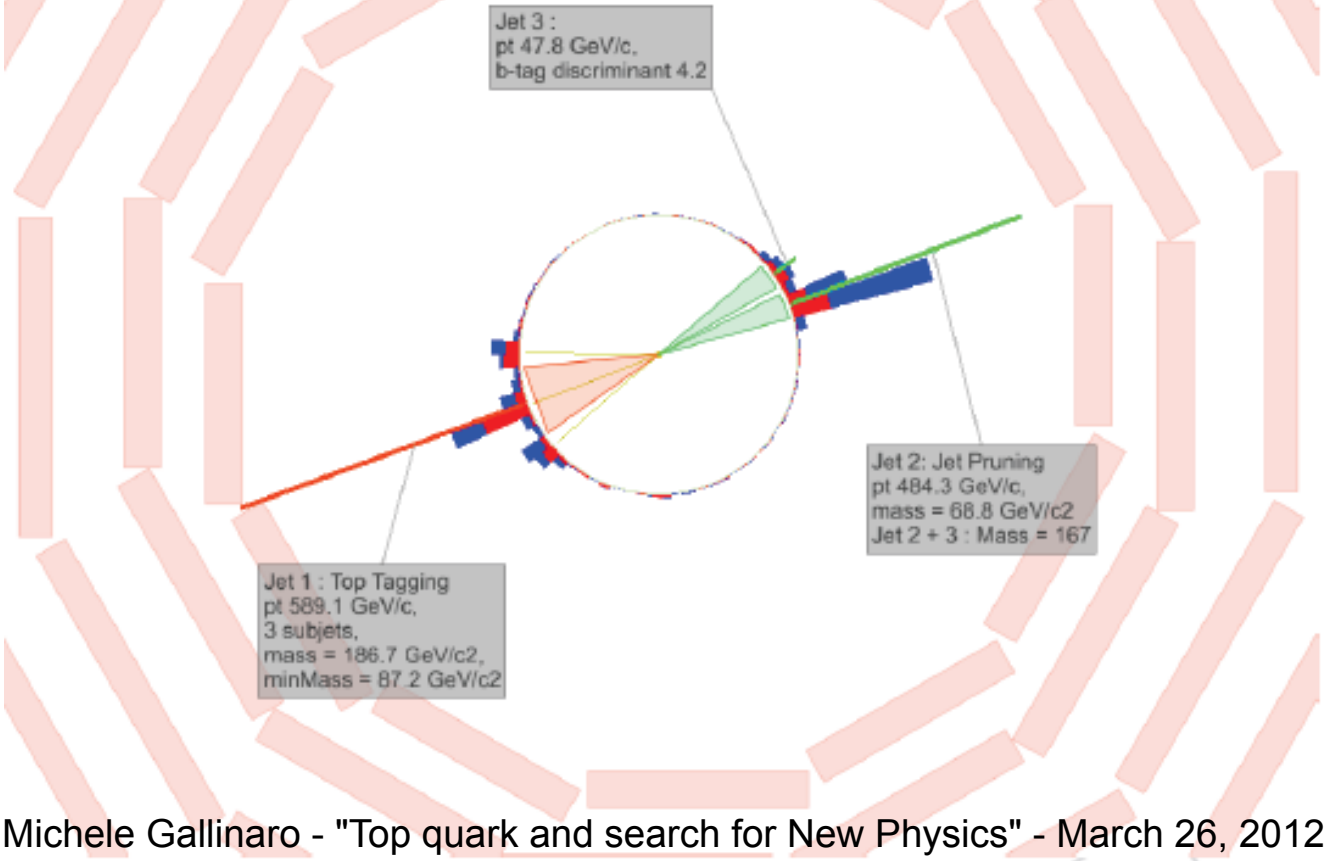
CMS EXO-11-006





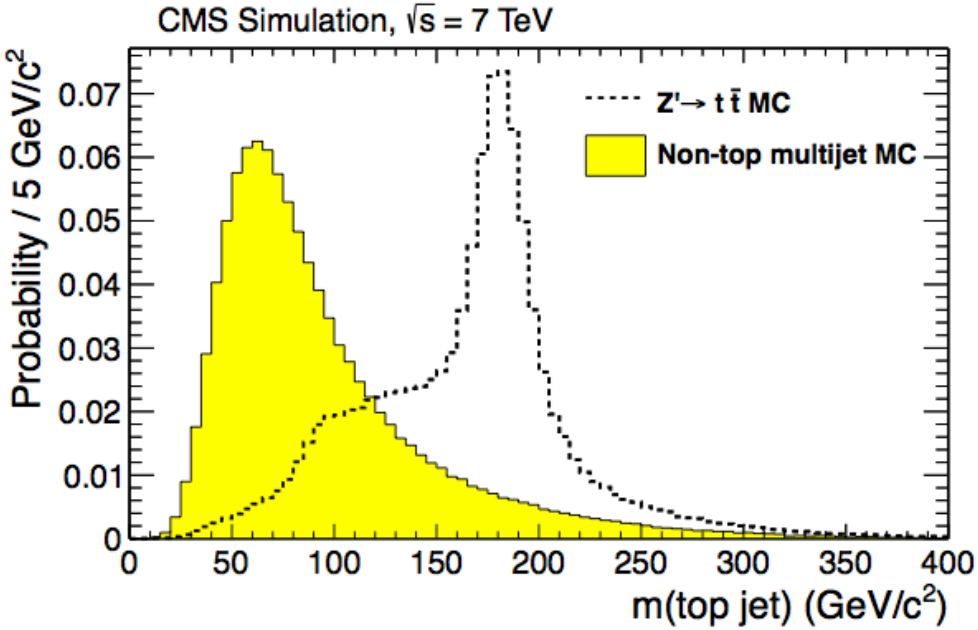
Search for Z': boosted topology

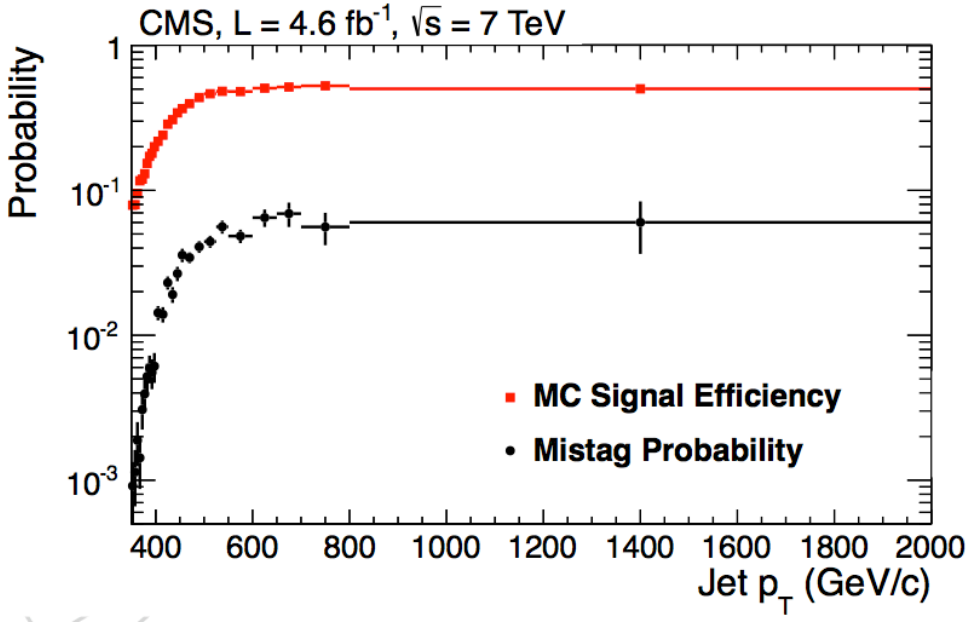
- Search for massive Z' resonance
- Search in the all hadronic decay channel for top quarks
- Top quarks are boosted for high mass Z', jets merge
- Start from jet algorithm, then find jet sub-structure
- QCD background estimated from data (mistag method)



Efficiency/Mis-tag probability

CMS EXO-11-006

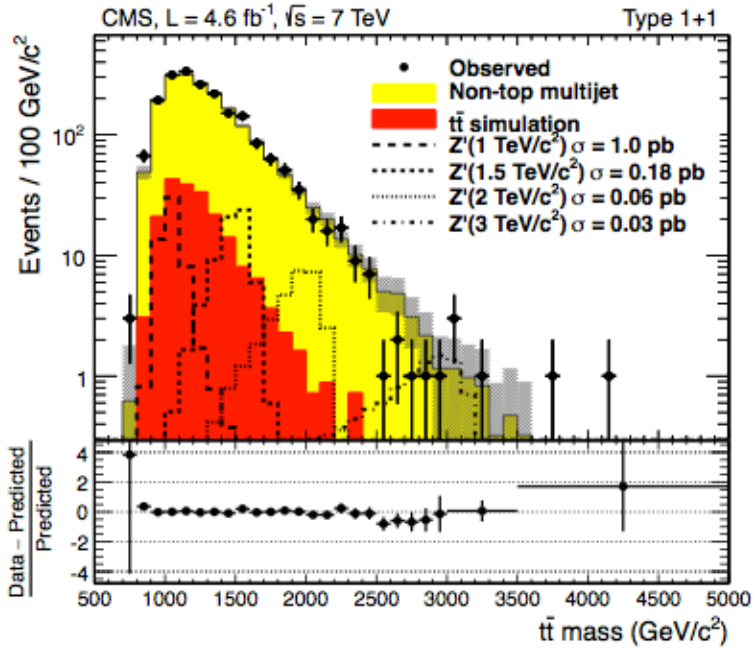


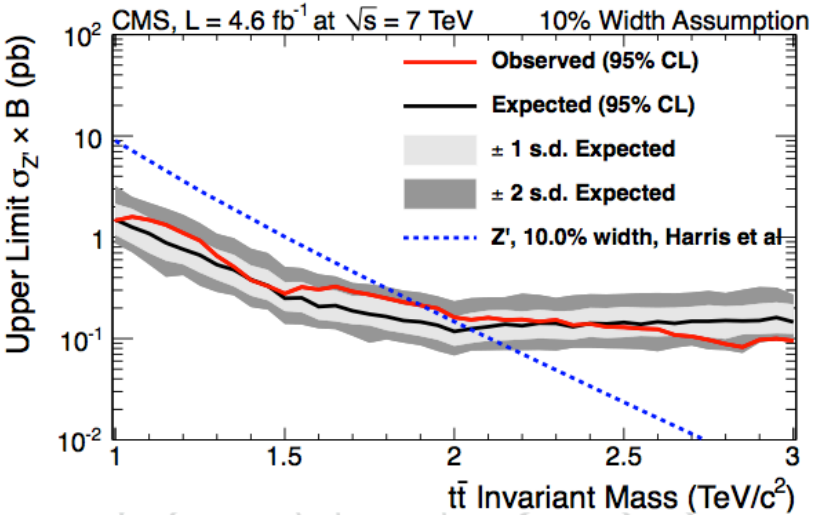


Search for Z': boosted topology

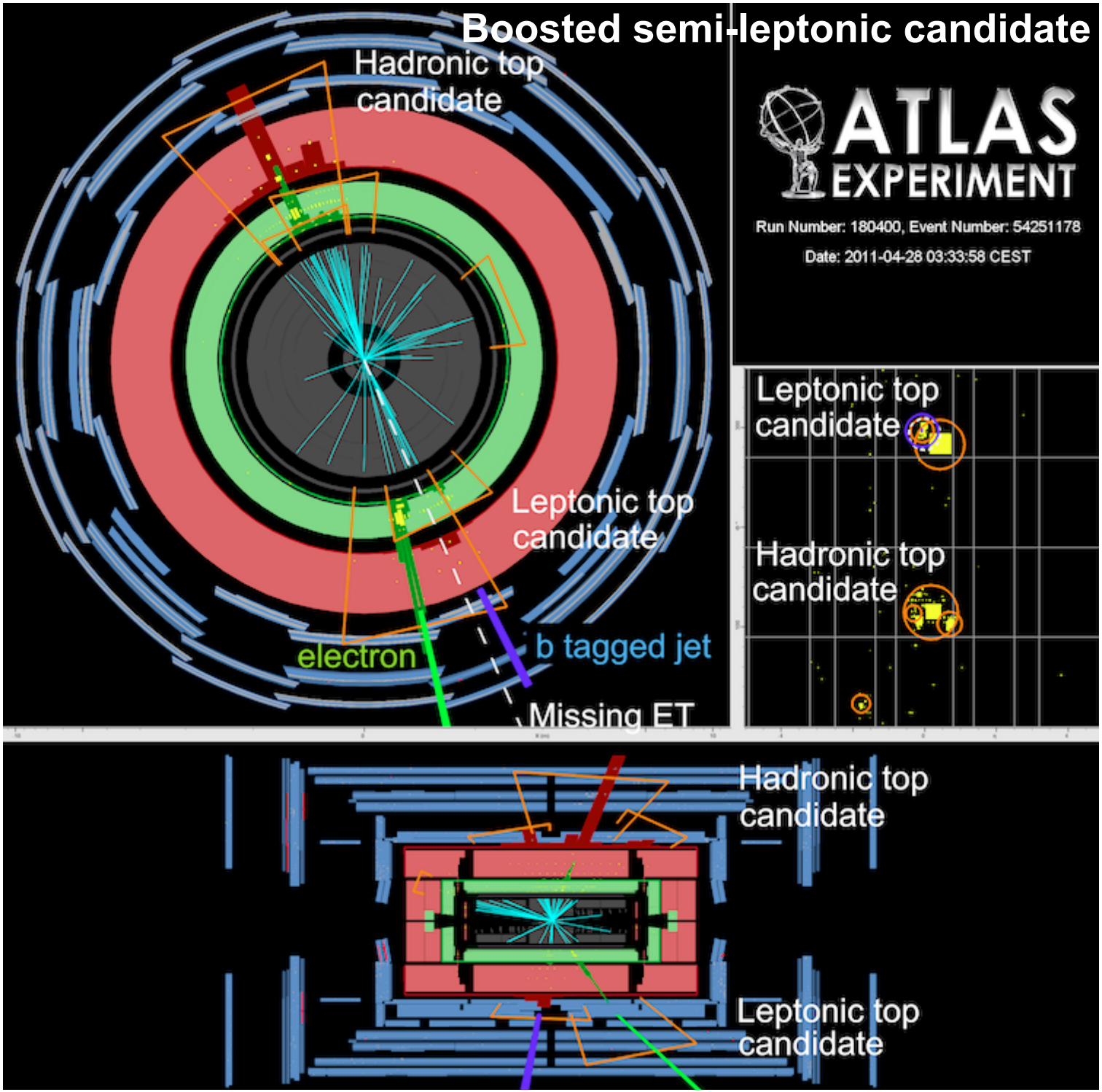
CMS EXO-11-006

- Massive Z′ resonances
  - produce highly Lorentz-boosted top quarks
  - collimated decay products partially/fully merged into single jets
- Two categories of events
  - 1+1 channel comprises di-jet events in which each jet corresponds to a fully merged top candidate
  - 1+2 channel comprises tri-jet events, with a Type-1 top-quark candidate in one hemisphere, and at least two jets in the other, one being a jet from a b quark no b-tag is applied) and the other a merged jet from a W
- Set upper limits on Z' production: ~1pb





Boosted semi-leptonic candidate event



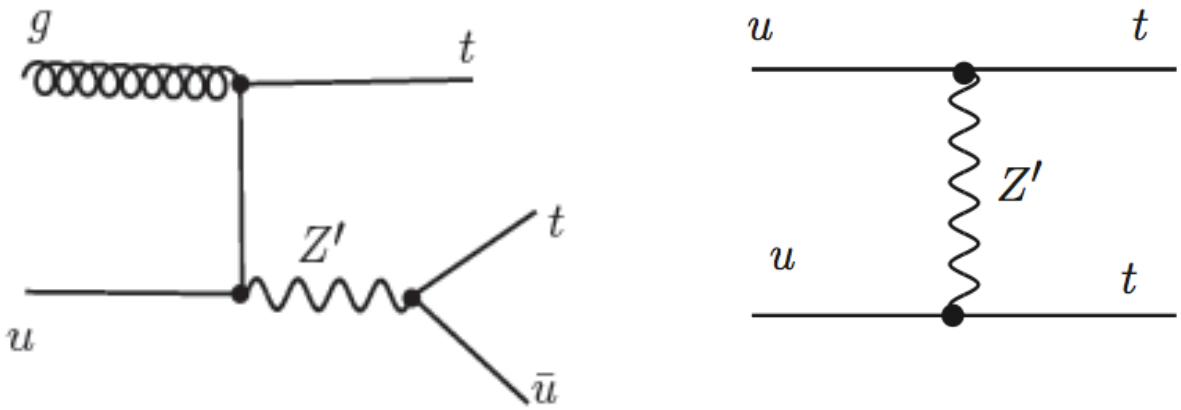
Same sign and multi-top

Same sign dileptons

- search for anomalous production of events with two like-sign isolated leptons (e or *μ),* b-quark jets, and missing energy
- SM sources with two isolated like-sign leptons, jets, and missing energy are rare. Anomalous production of such events would be an indication of new physics
- SUSY models predict presence of 2 to 4 b-quark jets in such events
- fraction of strongly produced SUSY events with top and bottom quarks in the final states is enhanced

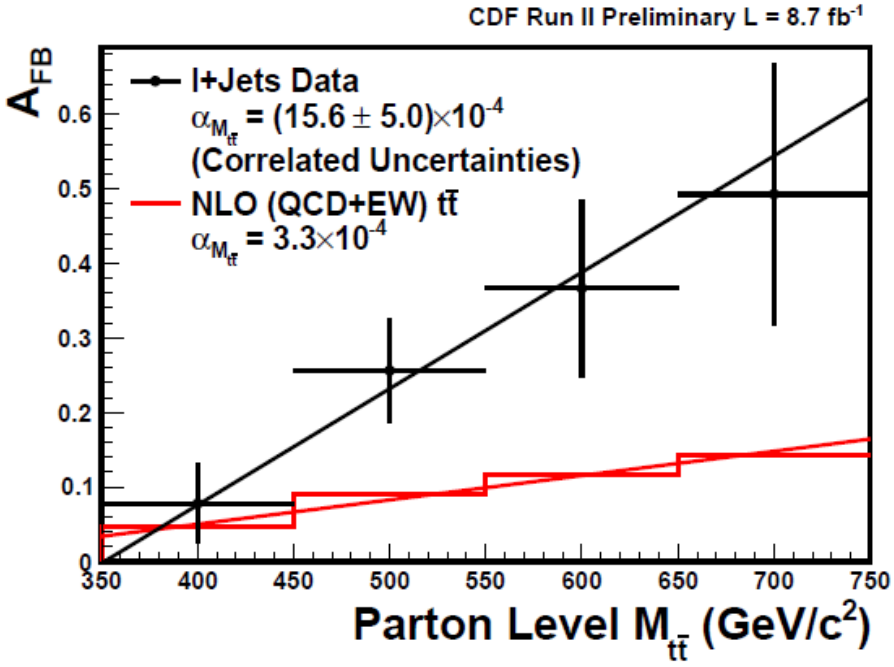
Same sign top production

- FCNC in top sector could explain A_{FB} at Tevatron
- t-channel exchange of Z' coupling to u and t
- Would manifest as same-sign top pair production



Same sign top production

- Measurements of forward-backward asymmetry A_{FB} in ttbar production at the Tevatron inconsistent (?) with SM
- A_{FB} increases with invariant mass of ttbar system
  - at high (>450 GeV) invariant mass: A_{FB}=0.30±0.07



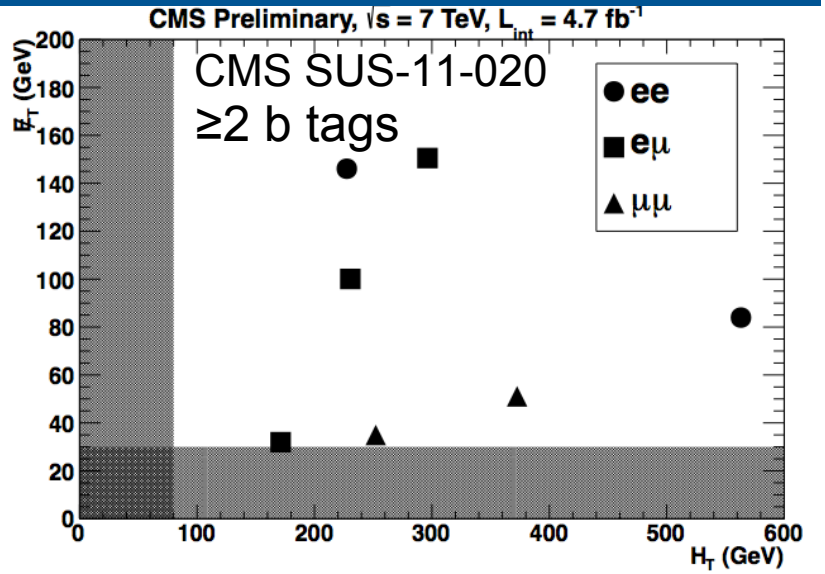
- Many attempts to explain A_{FB} invoke FCNC mediated by massive Z' boson
- Z' exchange would create a high inv. mass asymmetry at the Tevatron

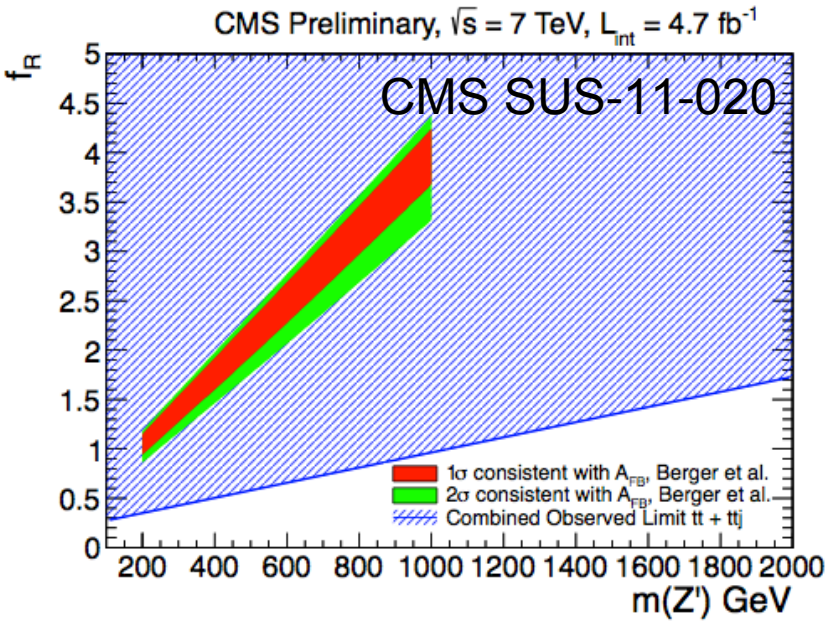
⇒ Search for same sign tops in data
  – Berger et al. (arXiv:1101.5625)

Same sign events

CMS EXO-11-065, SUS-11-020

- Similar event selection as in ttbar, except same-sign leptons
- Use sum of jet p_T (H_T) and MET
- 7 events are selected in the data
- All main backgrounds data-driven
  - Background dominated by jets faking leptons
  - ttbar lepton+jets with one fake lepton
  - Mis-measured charge in dilepton (DY/ttbar)
- Set exclusion limits
- This FCNC Z' production limit inconsistent with Tevatron FB asymmetry
- provide constraints on several models in a topology with 2 like-sign leptons, MET, b-jets
  - like-sign top quarks production in Z′ model
  - production of two sbottom quarks

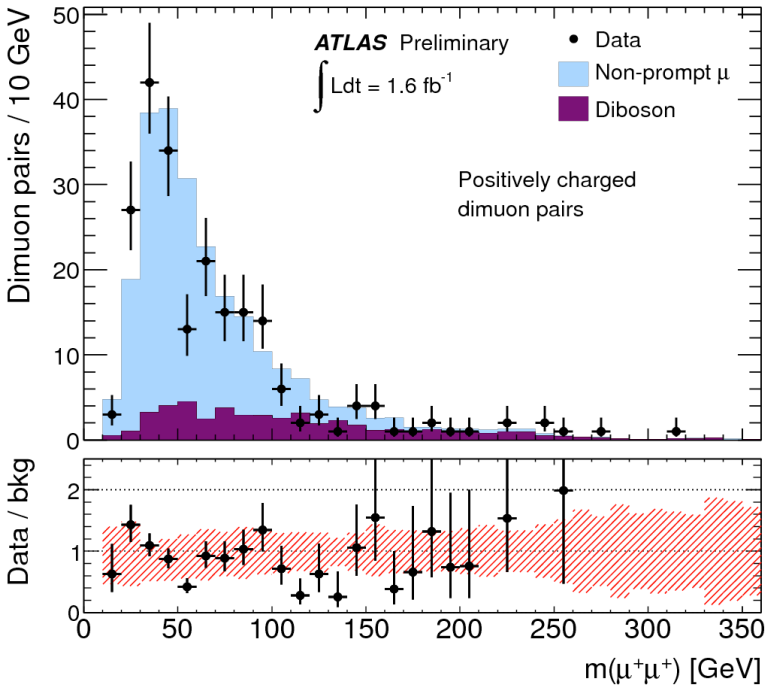




Same sign top production

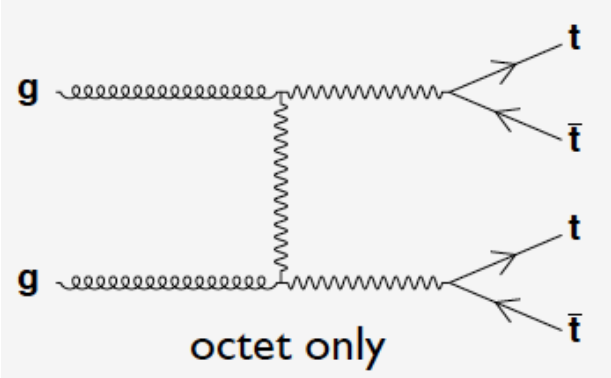
- ATLAS and CMS have similar strategy
  - Search for SS di-muon pairs (ATLAS)
  - Any SS lepton pair (CMS)
- Limits set on cross section of SS top pairs
  - CMS, ee,mm,em: $\sigma(Z' \rightarrow ttX) < 17.0$ pb (35 pb^{-1})
  - ATLAS,mm: $\sigma(Z' \rightarrow ttX) < 2.9$–$4.0$ pb (1.6 fb^{-1})
- Both experiments disfavour the Z' model as explanation to Tevatron asymmetry A_{FB}

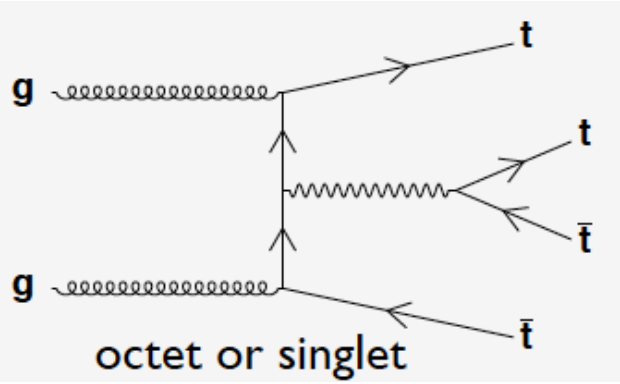
ATLAS-CONF-11-139



Multi-top production

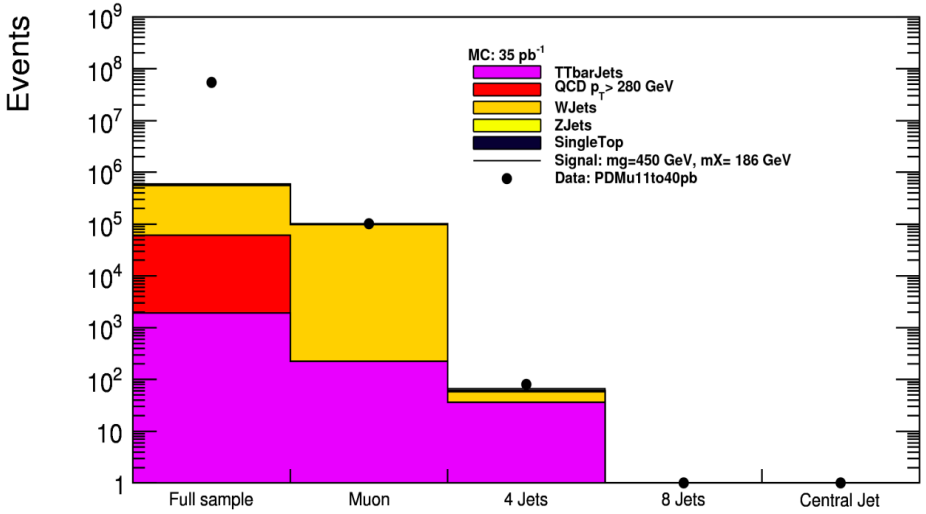
- Production of 4 tops is an attractive scenario in a number of new physics models (SUSY, compositeness, resonances strongly coupled to top, etc.)
- The SM cross section is a few fb





Multi-top in SUSY? $\tilde{g}\tilde{g} \rightarrow t\bar{t}t\bar{t}\chi_0\chi_0$

- Example: require one muon, at least 8 jets (one central)
- Yields in 30 fb^{-1} (gluino mass 450 GeV)
  - 330 signal events, 120 ttbar+jets, 30 W+jets



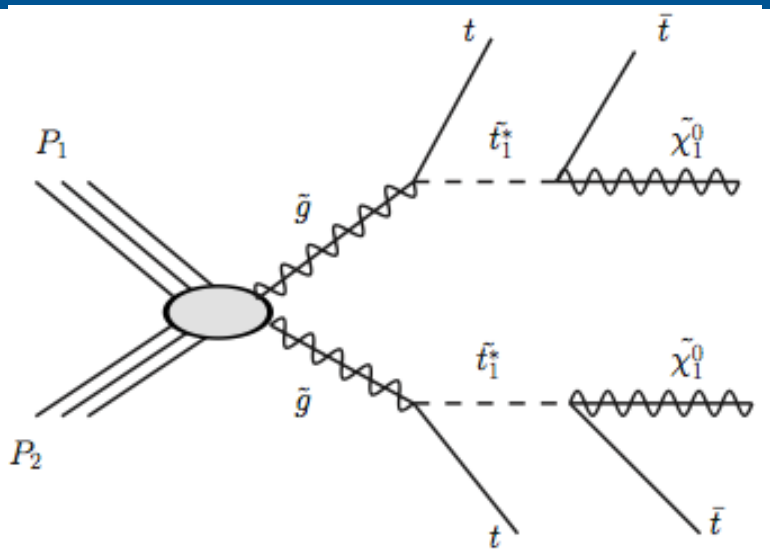
Multi-top production

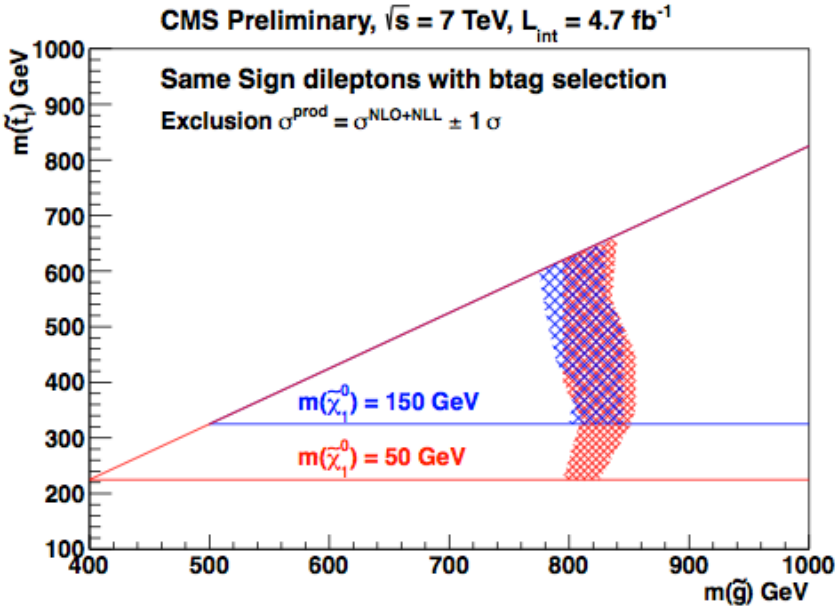
CMS SUS-11-020

- SUSY models with four top quarks
- Consider models of gluino pair production

$$\text{Type A1}: \ \tilde{g} \to t\bar{t}\tilde{\chi}_1^0$$
$$\text{Type A2}: \ \tilde{g} \to \tilde{t}_1\bar{t}, \quad \tilde{t}_1 \to t\tilde{\chi}_1^0 \text{ (stop on-shell)}$$

- Final state: $t\bar{t}t\bar{t}\tilde{\chi}_1^0\tilde{\chi}_1^0$





Multi-top production

CMS SUS-11-020

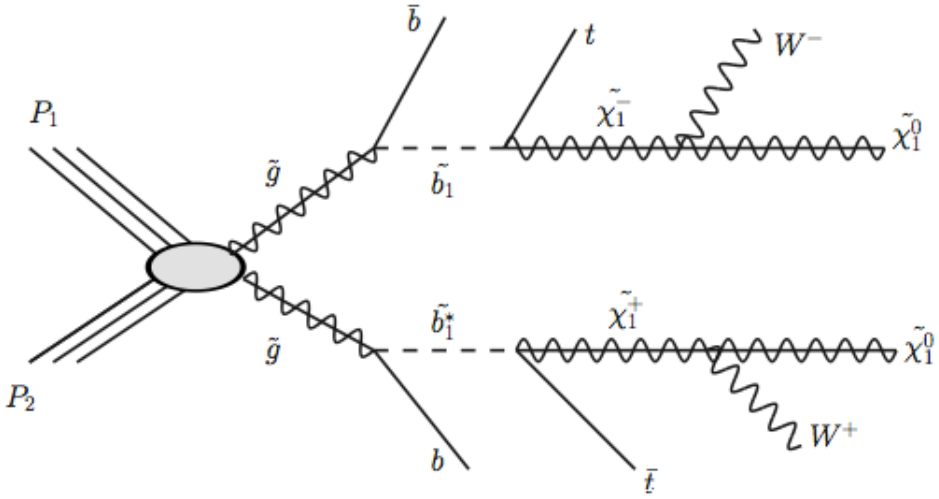
- Study of SUSY signal with pairs of sbottom quarks

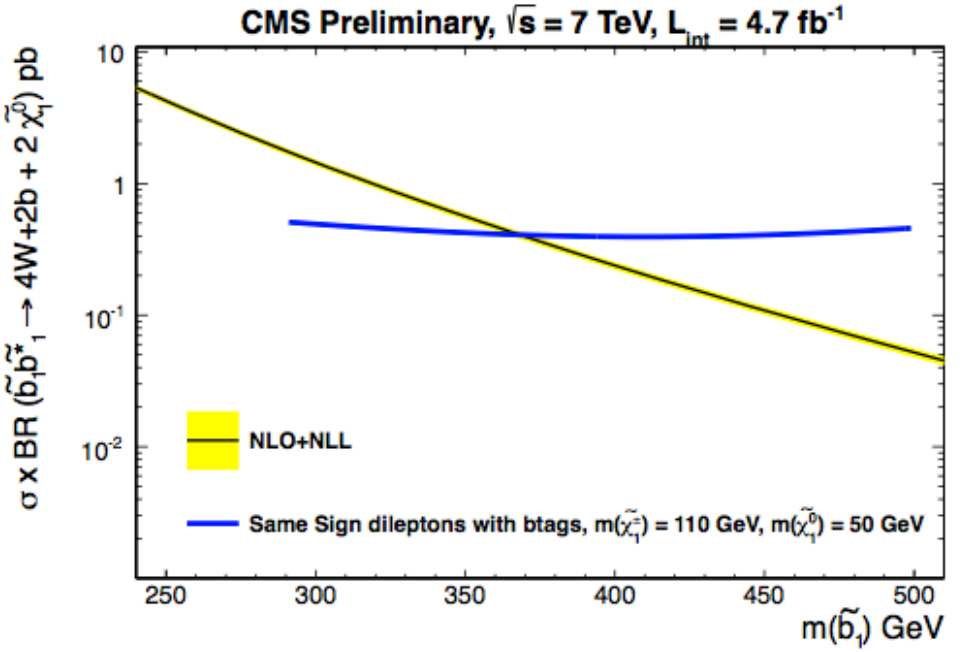
$$\tilde{b_1} \to t\tilde{\chi^-}$$

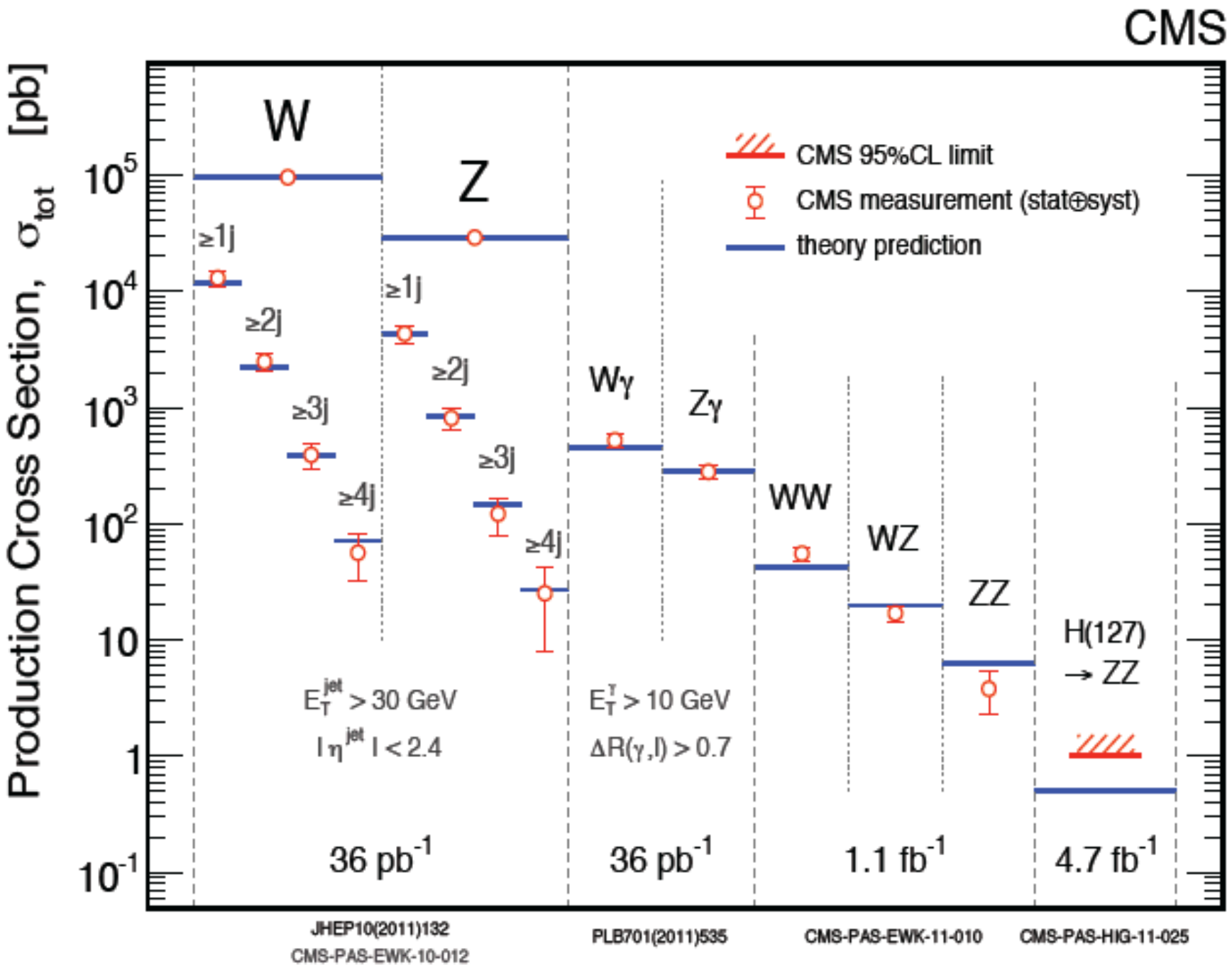
Type B1 : $pp \to \tilde{b}_1\tilde{b}_1^*$
Type B2 : $pp \to \tilde{g}\tilde{b}_1, \quad \tilde{g} \to \tilde{b}_1\bar{b}$

- Final states with up to 4 isolated leptons

$$m(\tilde{b}_1) > 380 \text{ GeV } @95\% C.L.$$

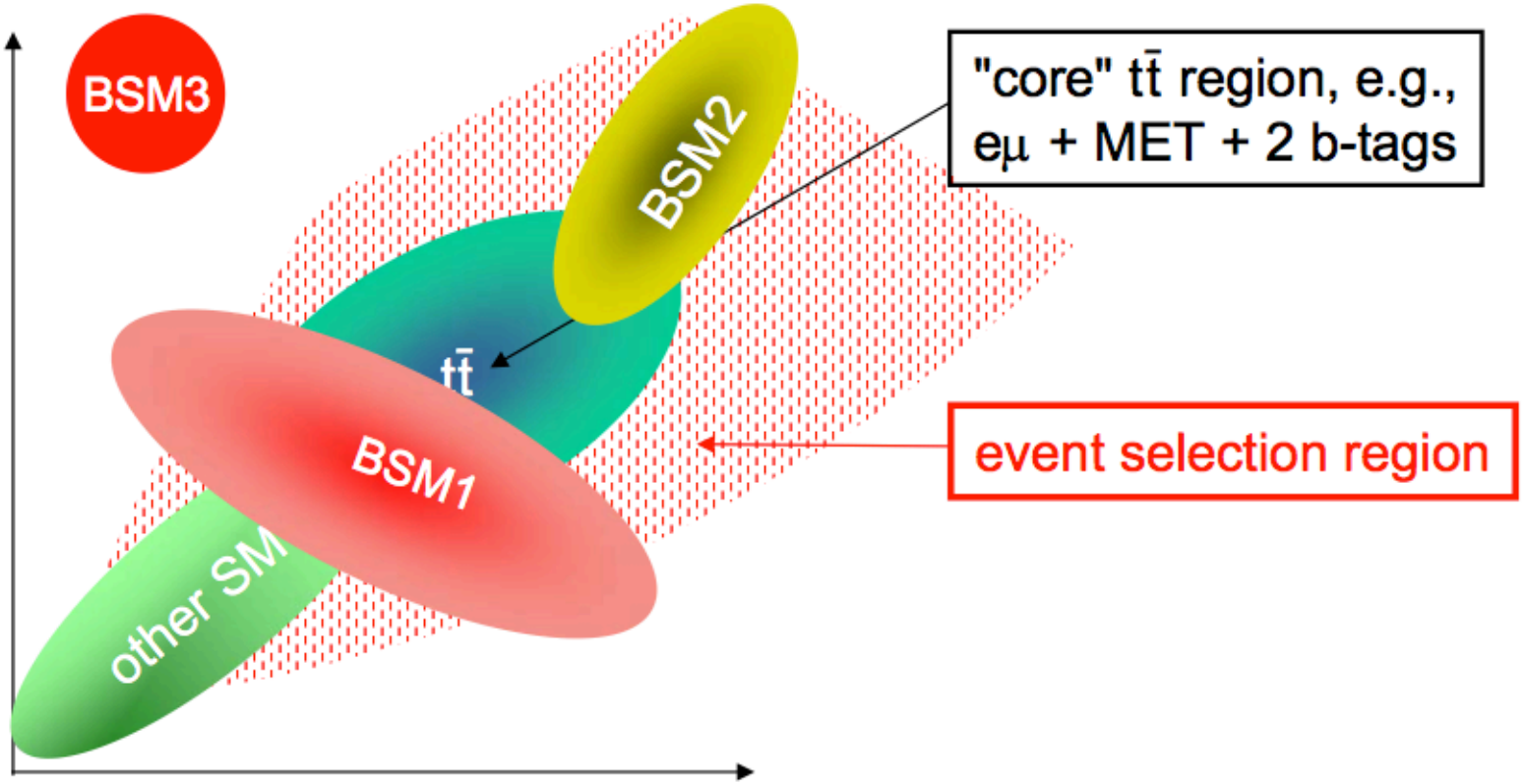





CMS
Production Cross Section, σ_{tot} [pb]
10^5
10^4
10^3
10^2
10
1
10^{-1}
W
Z
≥1j
≥2j
≥3j
≥4j
≥1j
≥2j
≥3j
≥4j
Wγ
Zγ
WW
WZ
ZZ
H(127)
→ ZZ
CMS 95%CL limit
CMS measurement (stat⊕syst)
theory prediction
$E_T^{jet} > 30$ GeV
$|\eta^{jet}| < 2.4$
$E_T^{\gamma} > 10$ GeV
$\Delta R(\gamma, l) > 0.7$
36 pb^{-1}
36 pb^{-1}
1.1 fb^{-1}
4.7 fb^{-1}
JHEP10(2011)132
CMS-PAS-EWK-10-012
PLB701(2011)535
CMS-PAS-EWK-11-010
CMS-PAS-HIG-11-025

Top quark and new physics

- Top quark production is main background in many searches for new physics
- Top quark sample may be contaminated by NP processes
- Is top quark sample compatible with top quark SM hypothesis?
- Need to compare distributions, gain good understanding of top sample



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