A Search for Resonances in Semileptonic Top Pair Production

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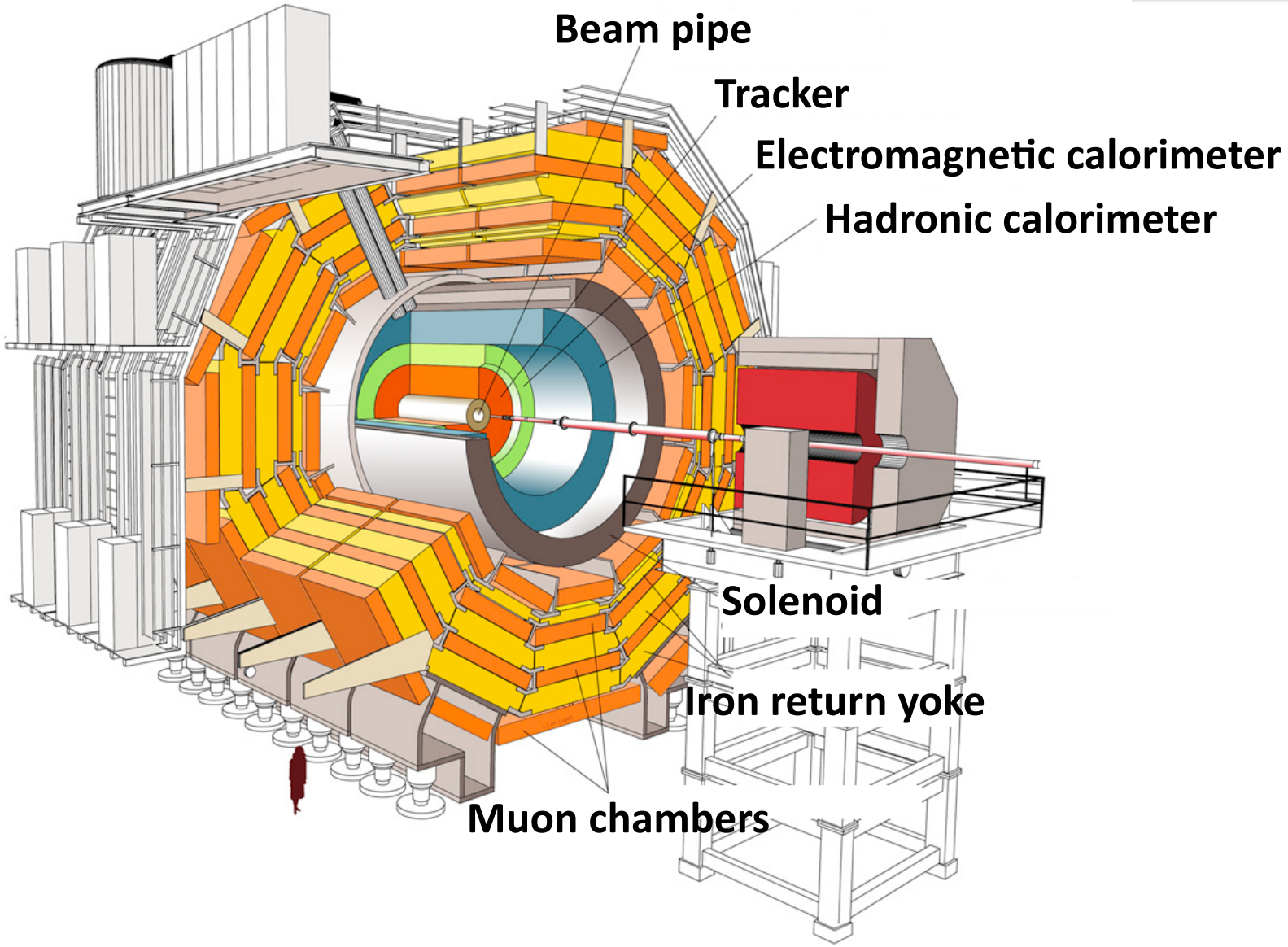
Outline

- Motivation
- CMS Experiment
- Event Selection and Reconstruction
- Results
- Summary

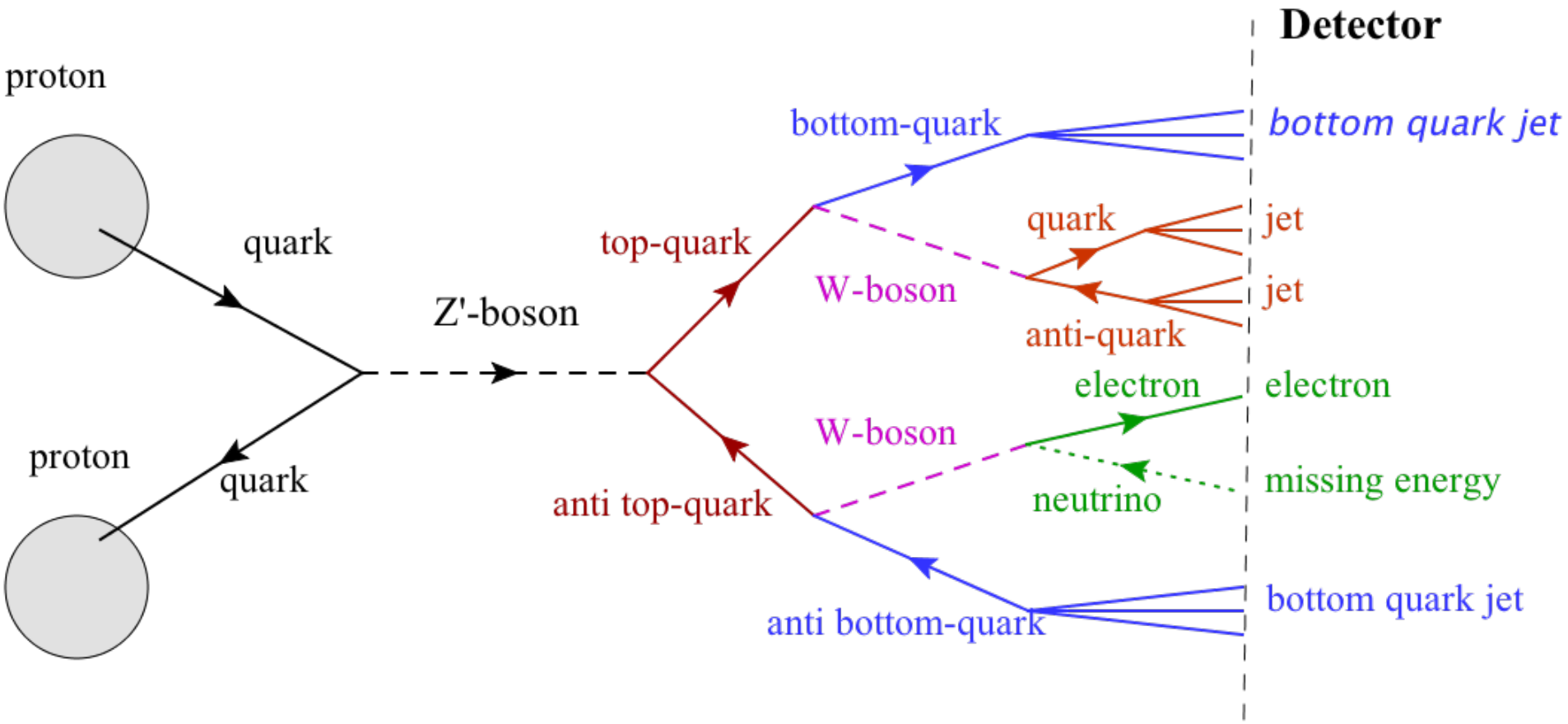
Motivation

- Heavy Neutral Gauge Boson predicted in many BSM theories
- Coupling to third generation can be enhanced (e.g. topcolor)
- Invisible in dilepton channels
- Look in top pair production

The CMS Experiment



Signature of a top quark pair



- Decay $t\bar{t}$ -> $b\bar{b}$ $q\bar{q}$' ev 15% branching ratio
- Clean signature (lepton)

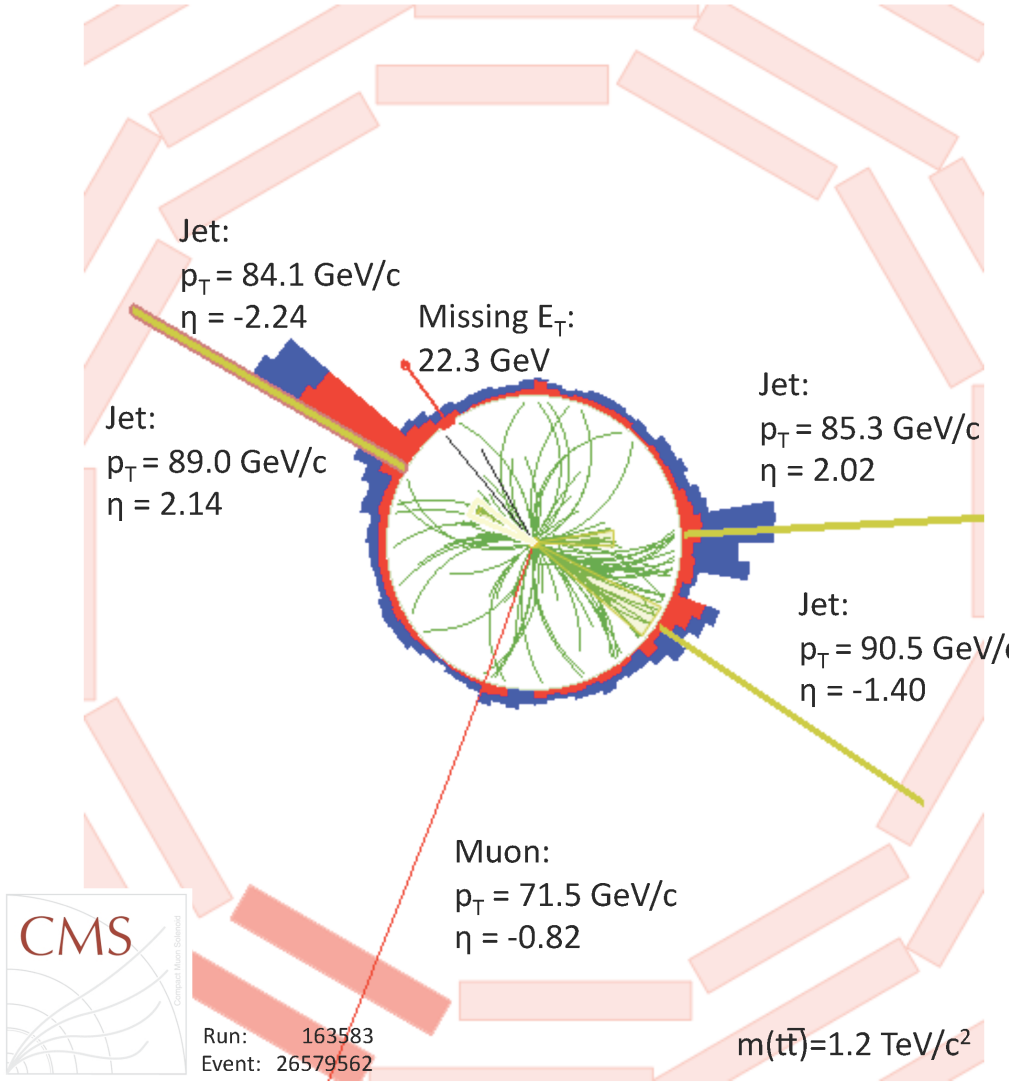
Background Processes

- QCD Multi-jet production:
  - Jets can be mis-identified as electrons
  - Electrons from b/c-decays
  - Mis-measured jets can cause false missing transverse energy
- W + jets production:
  - Real isolated electron + missing energy
- Standard Model Top pair production:
  - Irreducible background

Electron Event Selection

- Loosely isolated electron + 3 jets trigger
- To reduce backgrounds require:
  - One *isolated* electron with conversion veto
  - At least 3 jets with p_T > (70, 50, 50, 30) GeV
  - Missing transverse energy > 20 GeV
  - B-tagging for b-jet selection
- Remaining backgrounds are estimated from either a data control region (QCD) or from MC simulation

High Invariant Mass Event



1. Combine MET and lepton to W Boson: 2 solutions
2. Combine two jets to W bosons: 4 jets -> 6 possibilities
3. Combine 1 jet + 1 W boson to top quark x 2

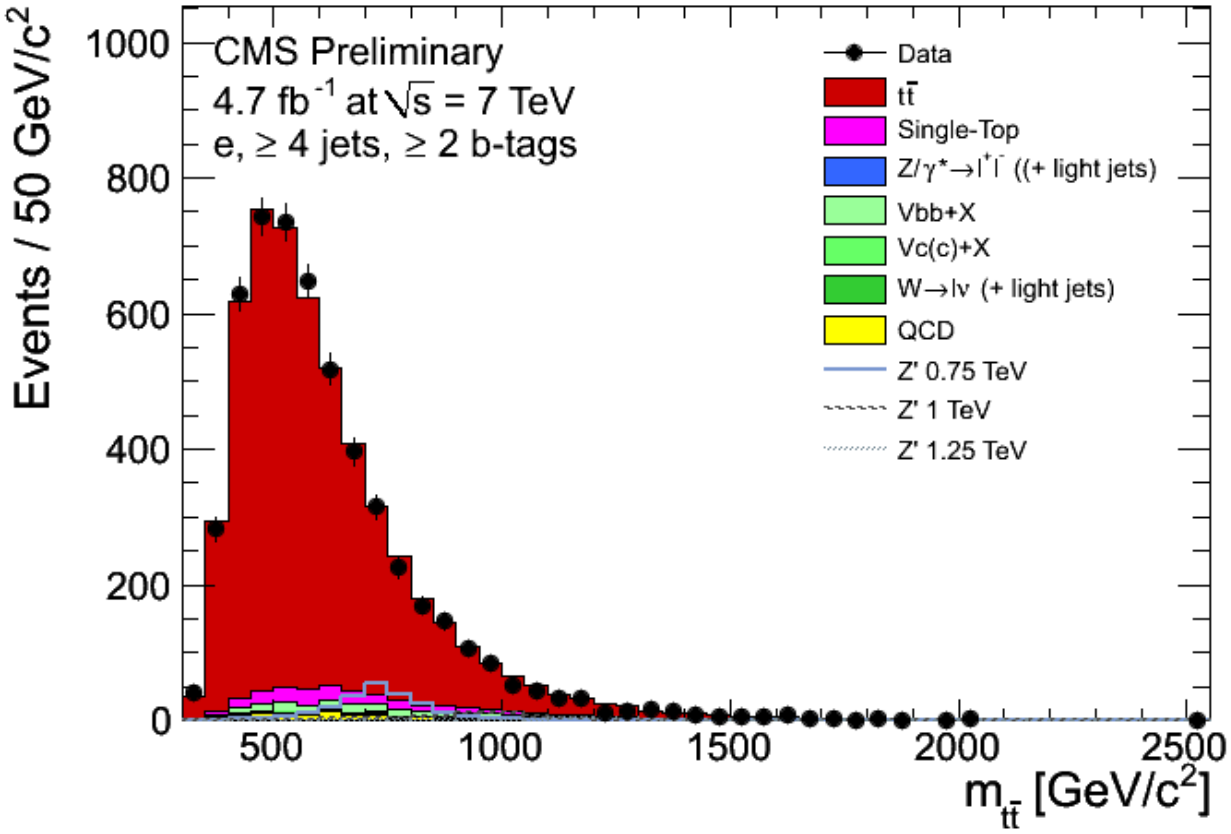
Total number of different combinations: 24

Which one is the correct combination?

Selecting the best combination

- Form a χ^2 by comparing reconstructed quantities to the expected central values
- Weights used are obtained from simulation
- Solution with the smallest χ^2 is chosen

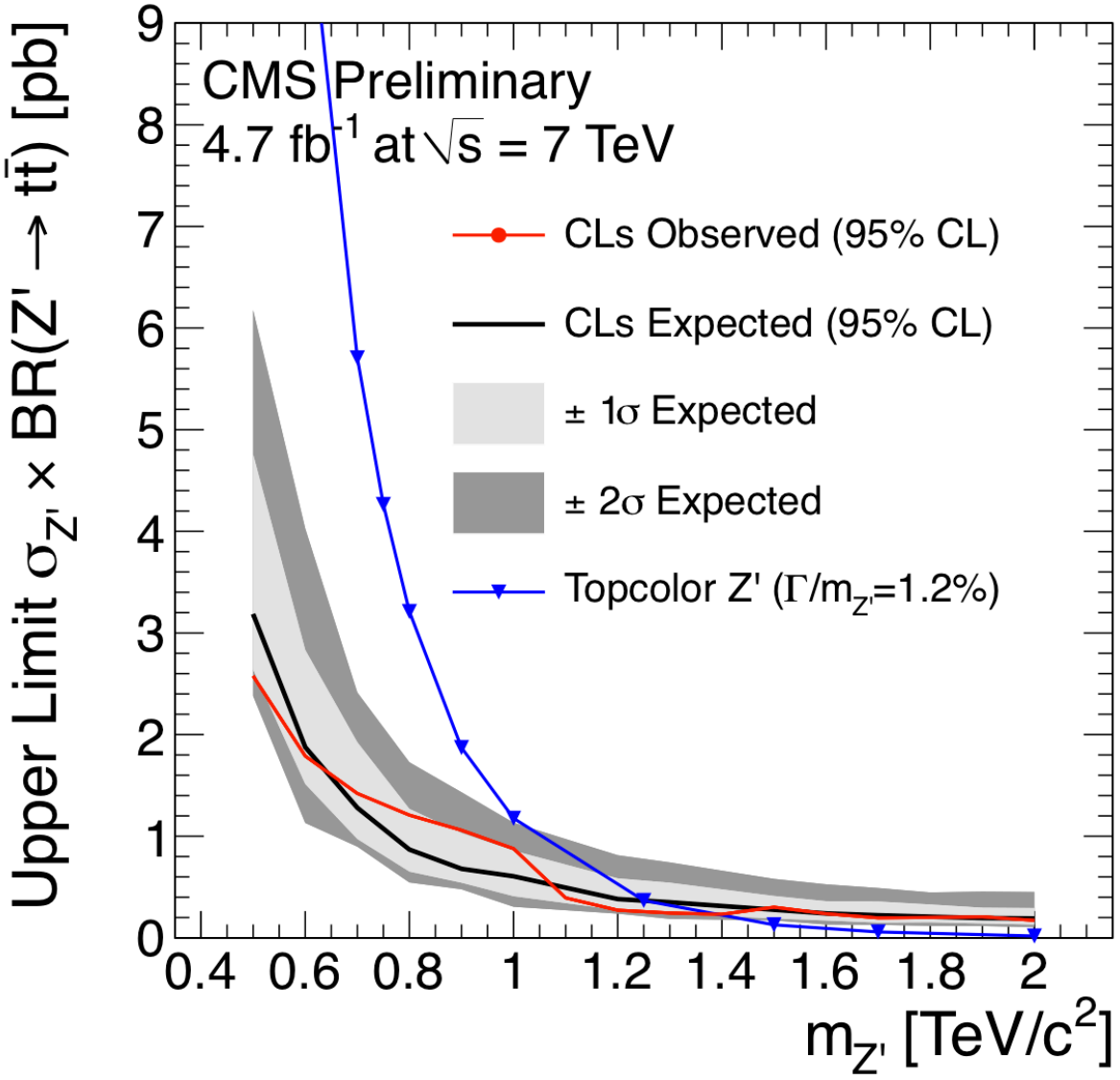
2011 Results



The invariant mass distribution of the reconstructed top quark pair.

No significant excess observed.

Limits



- Calculated limits for various Z' models and masses
- Excluding with 95% confidence:
  - Narrow width (1.2% of mass) $m_{Z'} > 1.3$ TeV
  - Wide width (10% of mass) $m_{Z'} > 1.7$ TeV
  - Kaluza-Klein gluon $m_{KK} > 1.4$ TeV

Summary

- Top physics can provide a window into new physics
- Some theoretical models will reveal themselves in top pair production but not in di-leptonic modes
- No new physics found with ~5fb^{-1} of 2011 data
- This year more energy (7-> 8TeV) and more data: increased chances to see new physics!

THANK YOU FOR LISTENING.

Any questions?

BACKUP SLIDES

BSM Z' Models

S. Dimopoulos and H. Georgi Nucl. Phys. B193 150	S. Weinberg Phys. Rev. D13 974
L. Susskind Phys. Rev. D20 2619	C. T. Hill and J. Parke Phys. Rev. D49 4454
R. S. Chivukula et al. Phys. Rev. D59 075003	N. Arkani-Hamed, A. G. Cohen, and H. Georgi Phys. Lett. B513 232
N. Arkani-Hamed, S. Dimopoulos, and G. R. Dvali Phys. Lett. B429 263	L. Randall and R. Sundrum Phys. Rev. Lett. 83 3370

Background Estimation

- For QCD Mutli-jets: template fit to missing transverse energy for normalisation and conversion control region for shape in M(ttbar)

- W+jet normalised to reproduces yields in data for events with no b-tagged jets

Electron Event Selection

- Trigger selection: loosely isolated electron: $E_T > 25$ GeV + ≥ 3 jets: $p_T > 30$ GeV, within $|\eta| < 2.6$
- Offline selection:
  - Isolated electron with tight ID and conversion veto: $E_T > 30$ GeV, $|\eta| < 2.5$
  - At least 3 or 4 particle flow jets with $p_T > (70, 50, 50, 30)$ GeV, $|\eta| < 2.4$, loose ID
  - Veto events with a good muon or second electron
  - Missing transverse energy > 20 GeV
- Analysis performed in (b)jet multiplicity bin: 3 jets + at least 1 b-tagged jet, ≥ 4 jets with 0, 1 or at least 2 b-tagged jets

Event Reconstruction

- Missing transverse energy + electron: calculation of neutrino z-momentum with W-mass constrain
- Chi-squared based solution selection for jet combinations:

$$\chi^2 = \sum_i \frac{(x_{meas} - x_{MC})^2}{\sigma_{MC}^2}$$

- Variables used: W-mass, top-quark-mass, p_T of tt system, fraction of Σp_T of selected jets divided by all jets. Values and errors extracted from tt simulation –

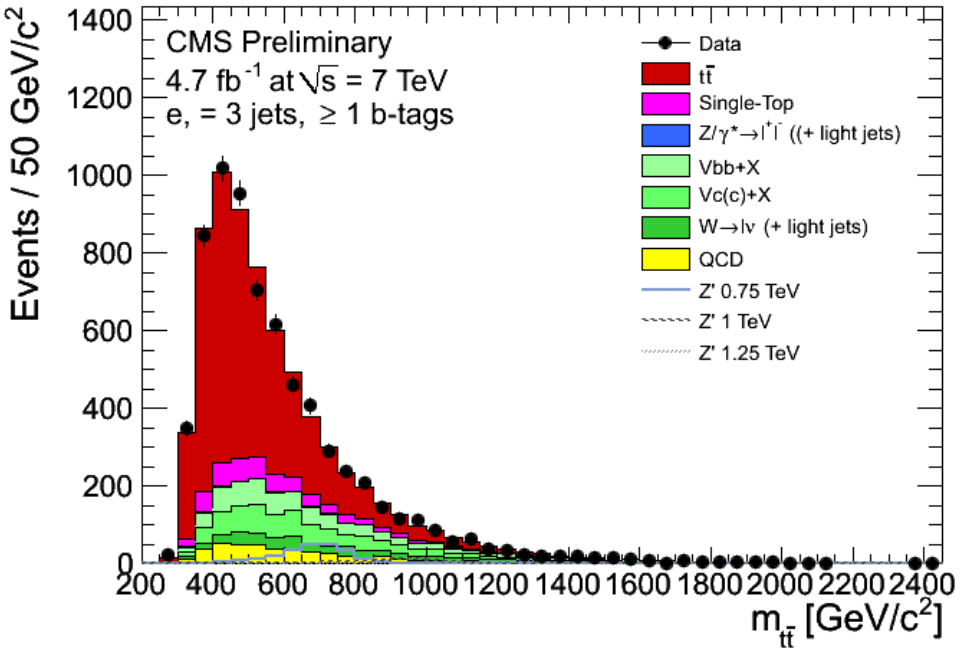
Limit Setting: CLs techique

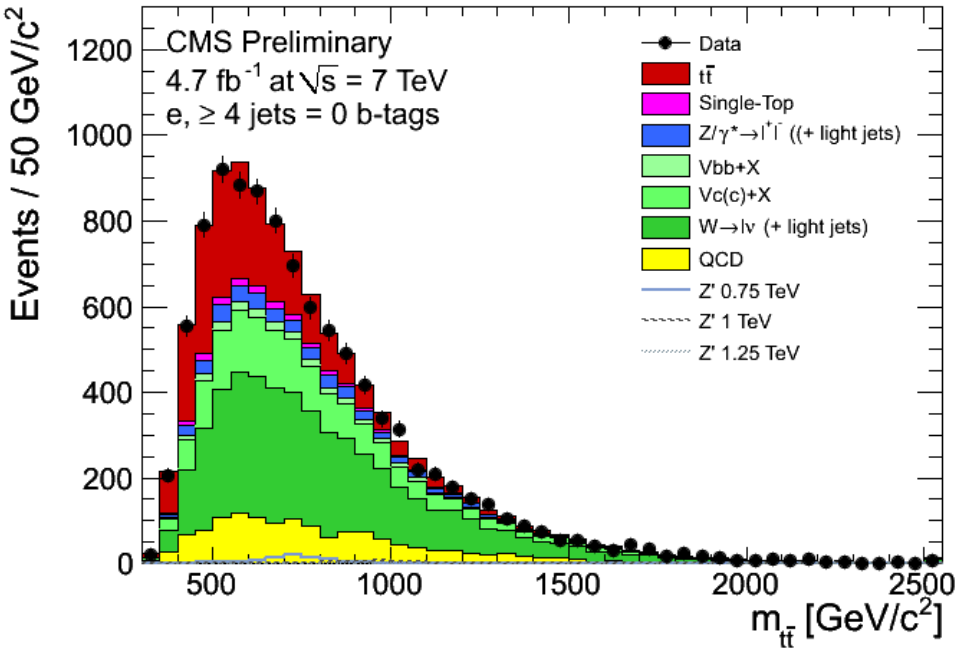
- Implemented with *theta* package
- Use Higgs-like test statistic as default
- Likelihood ratio of background only hypothesis to background plus arbitrary amount of signal

$$q_\mu = -2\ln\frac{L(data\,|\,\mu=0,\vec{\sigma})}{L(data\,|\,\hat{\mu},\vec{\sigma})}$$

Systematic Uncertainties

Uncertainty	Variation
Luminosity	4.5%
Electron efficiency (trigger + ID + isolation)	3%
Muon efficiency (trigger + ID + isolation)	3%
ttbar cross section	15%
Single top cross section	30%
W/Z+jets yield	50%
Drell-Yan yield	30%
W/Z+c+X	100%
W/Z+b+X	100%
Muon multijet yield	50-75%
Electron multijet yield	45-70%


CMS Preliminary
4.7 fb^{-1} at $\sqrt{s}$ = 7 TeV
e, = 3 jets, ≥ 1 b-tags
Data
tt̄
Single-Top
Z/γ*→l⁺l⁻ ((+ light jets)
Vbb+X
Vc(c)+X
W→lν (+ light jets)
QCD
Z' 0.75 TeV
Z' 1 TeV
Z' 1.25 TeV
Events / 50 GeV/c^2
$m_{t\bar{t}}$ [GeV/c^2]


CMS Preliminary
4.7 fb^{-1} at $\sqrt{s}$ = 7 TeV
e, ≥ 4 jets = 0 b-tags
Data
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Single-Top
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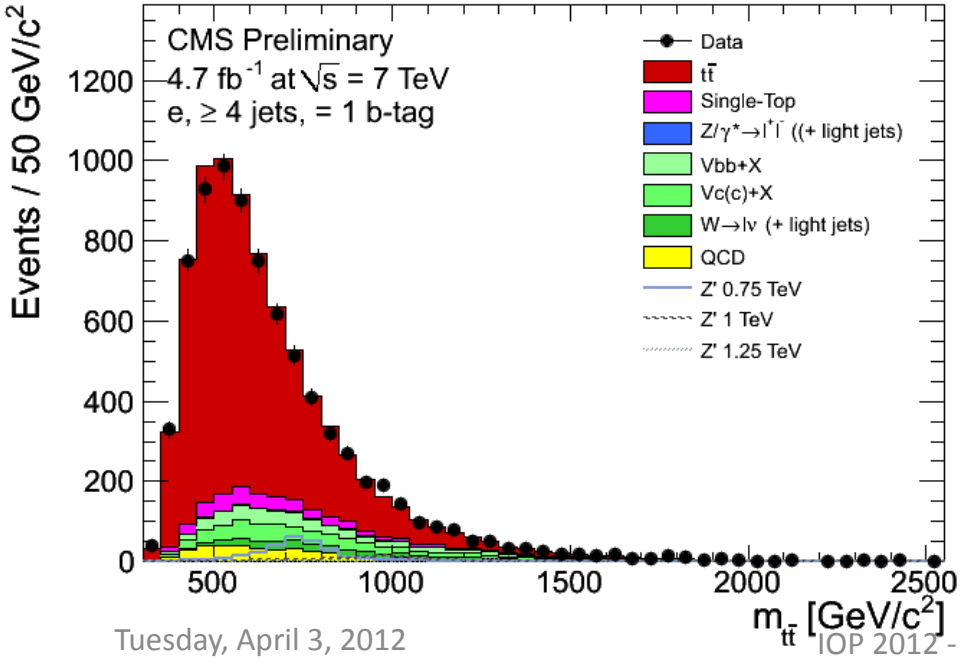
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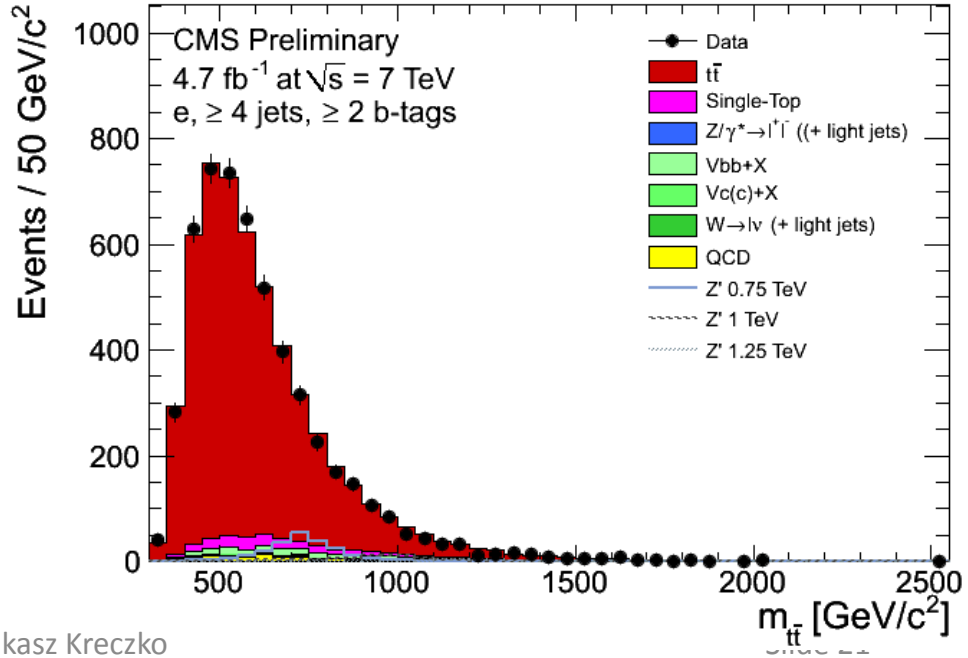
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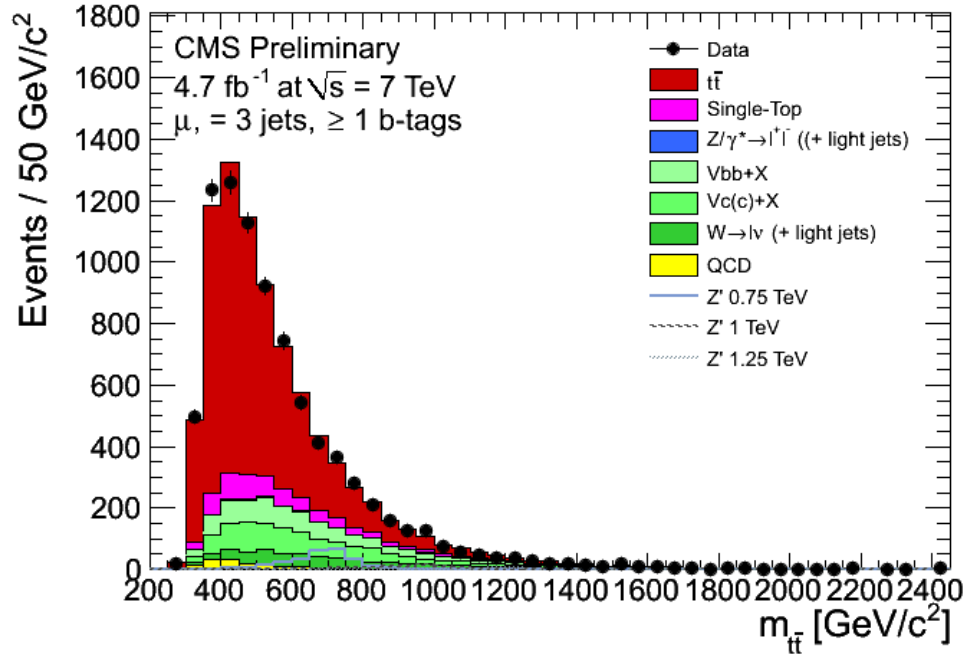
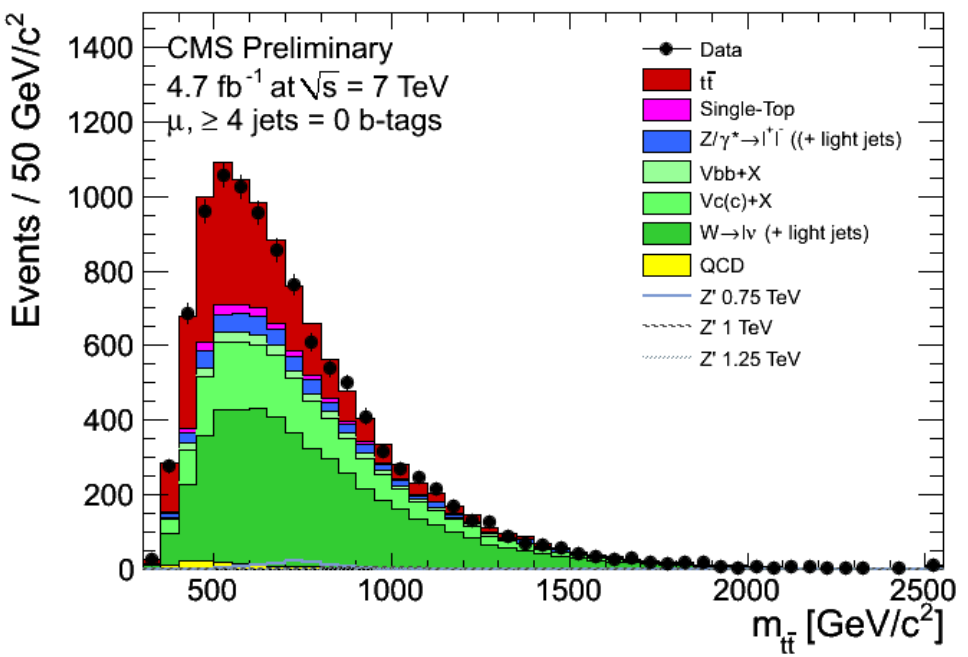
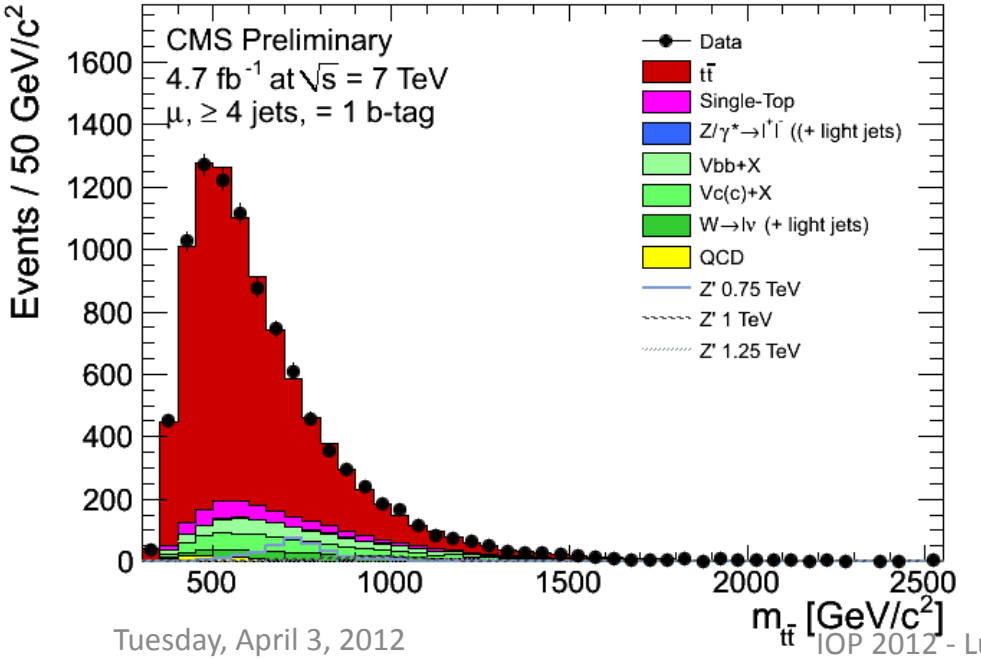
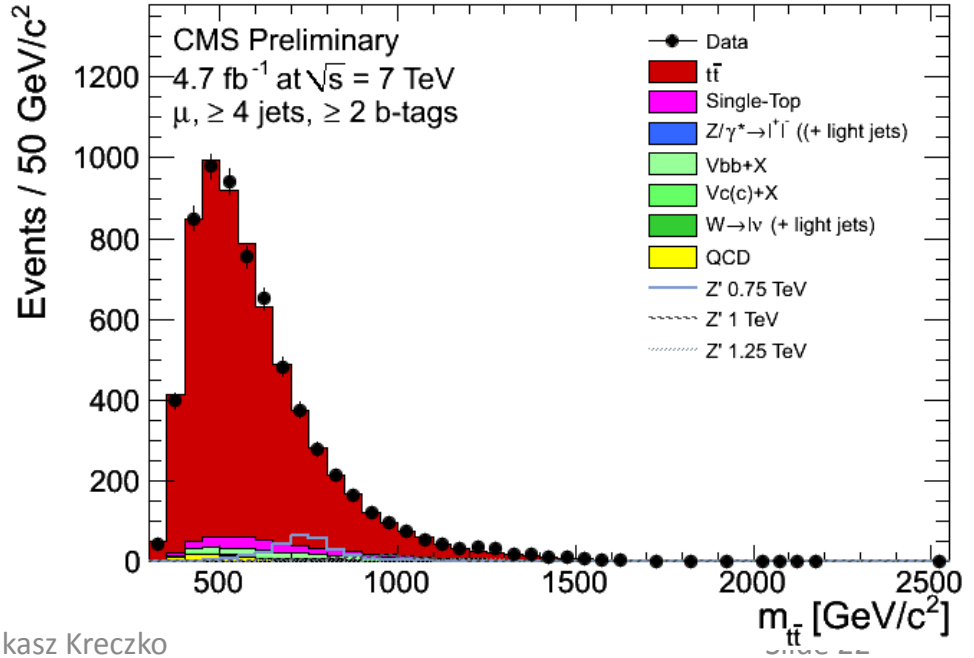
Z' 1.25 TeV
Events / 50 GeV/c^2
$m_{t\bar{t}}$ [GeV/c^2]

M$_{t\bar{t}}$ (μ + jets)









Other questions

- Picking the right combination: ~80% efficiency in simulated events where all jets have been reconstructed