Search for high-mass physics with top quarks

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DESY

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BMBF-Forschungsschwerpunkt
ATLAS Experiment
Physics on the TeV-scale at the Large Hadron Collider
FSP 101 ATLAS

Theoretical introduction

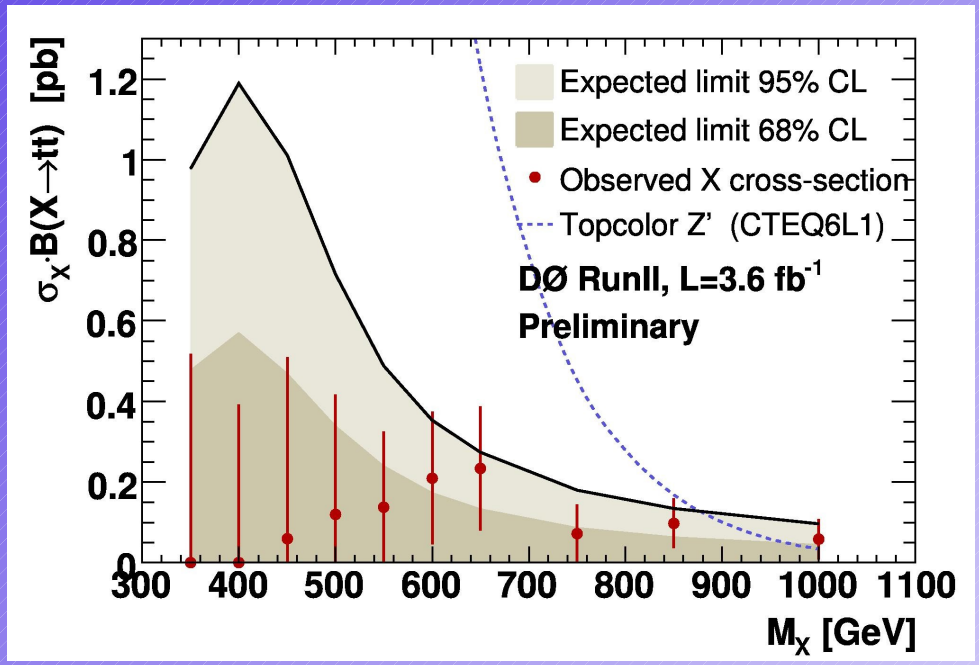
- Top quark has special role in many models and is strongly coupled to new physics
  - So far, only a few 10k of Top quark pairs are produced; differential measurements are limited

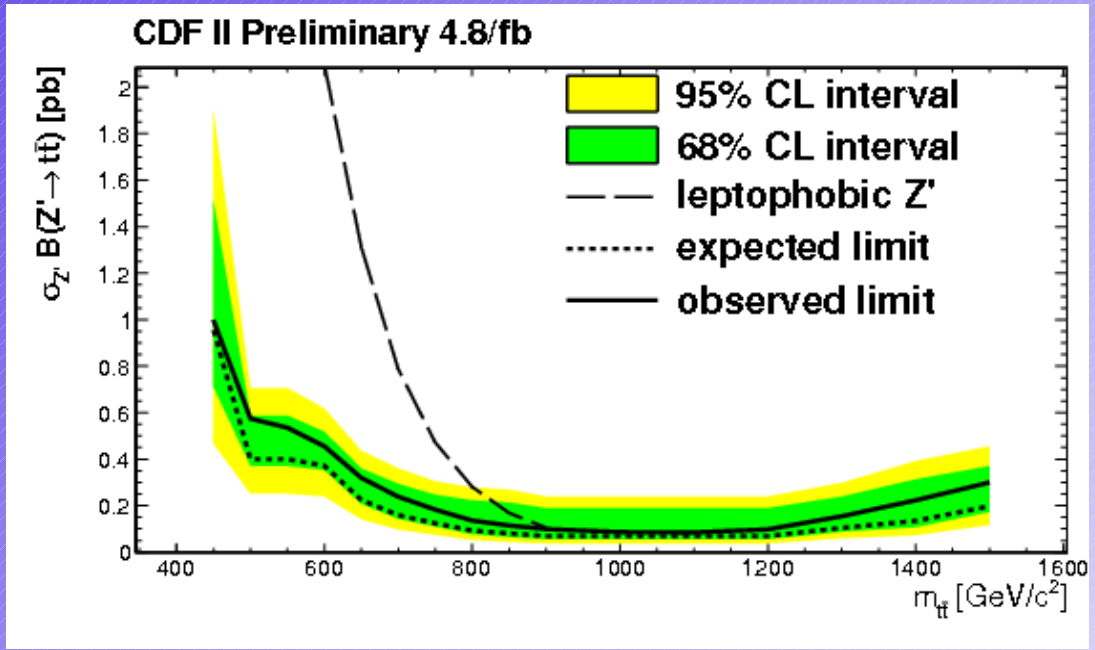
- Prediction of new phenomenas have a wide range
  - Additional high mass resonances (wide and narrow):
    - Z' (Top-color model etc)
    - Kaluza Klein gluons
  - Enrichment of top-pair production at high m_{tt}
    - Black holes

- First results for LHC shown by both experiments for last years data (~35 pb-1): X-section Limits of ~25pb for m_{tt}~500 GeV

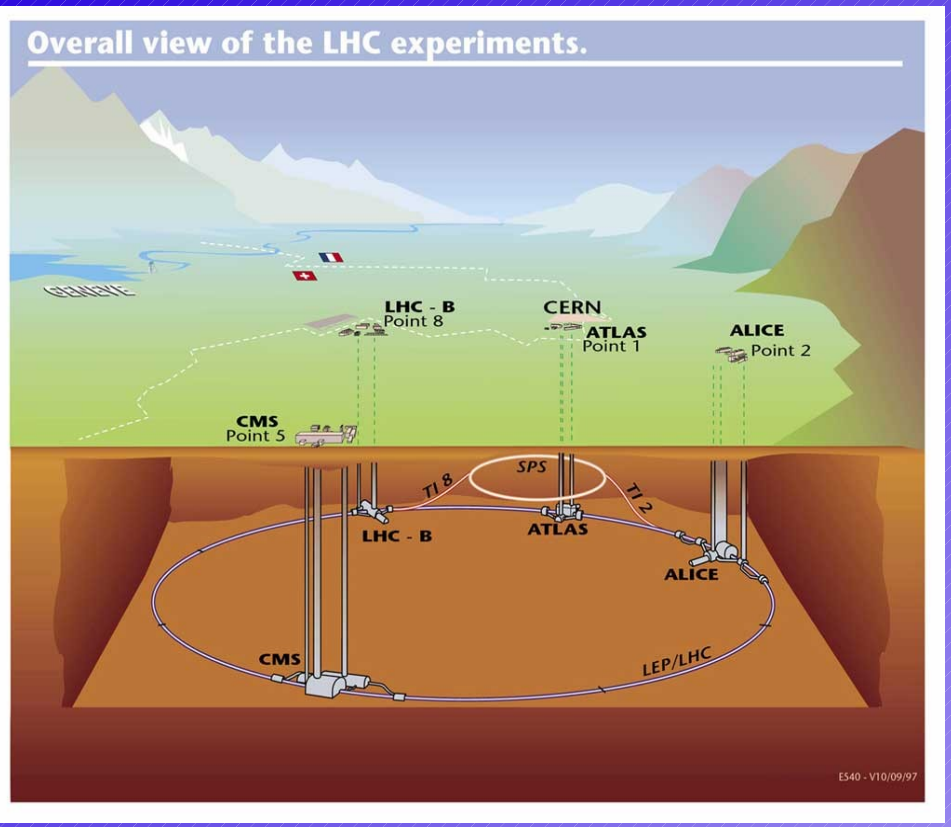
Fermilab results

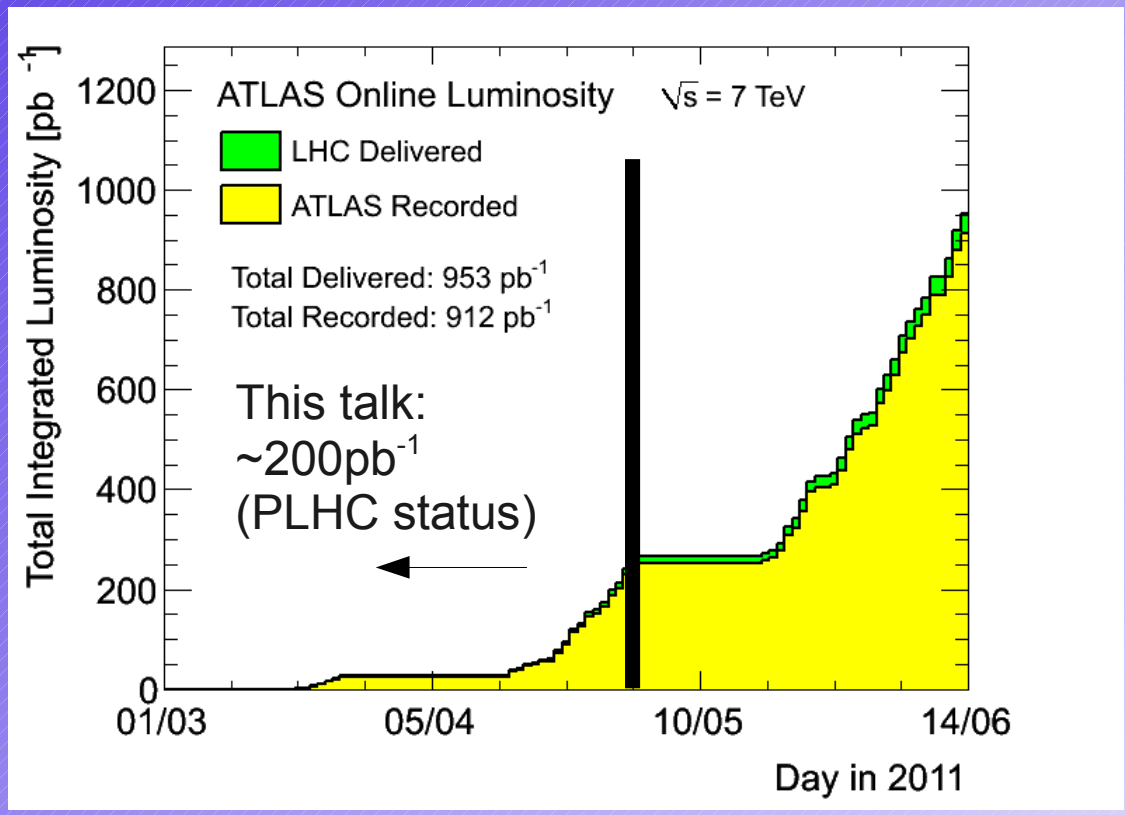
- World best limits from Fermilab:
  - Bench mark is leptophobic Z'
  - Limits for ~3.6/4.8 fb^{-1} around 900 GeV





Data samples

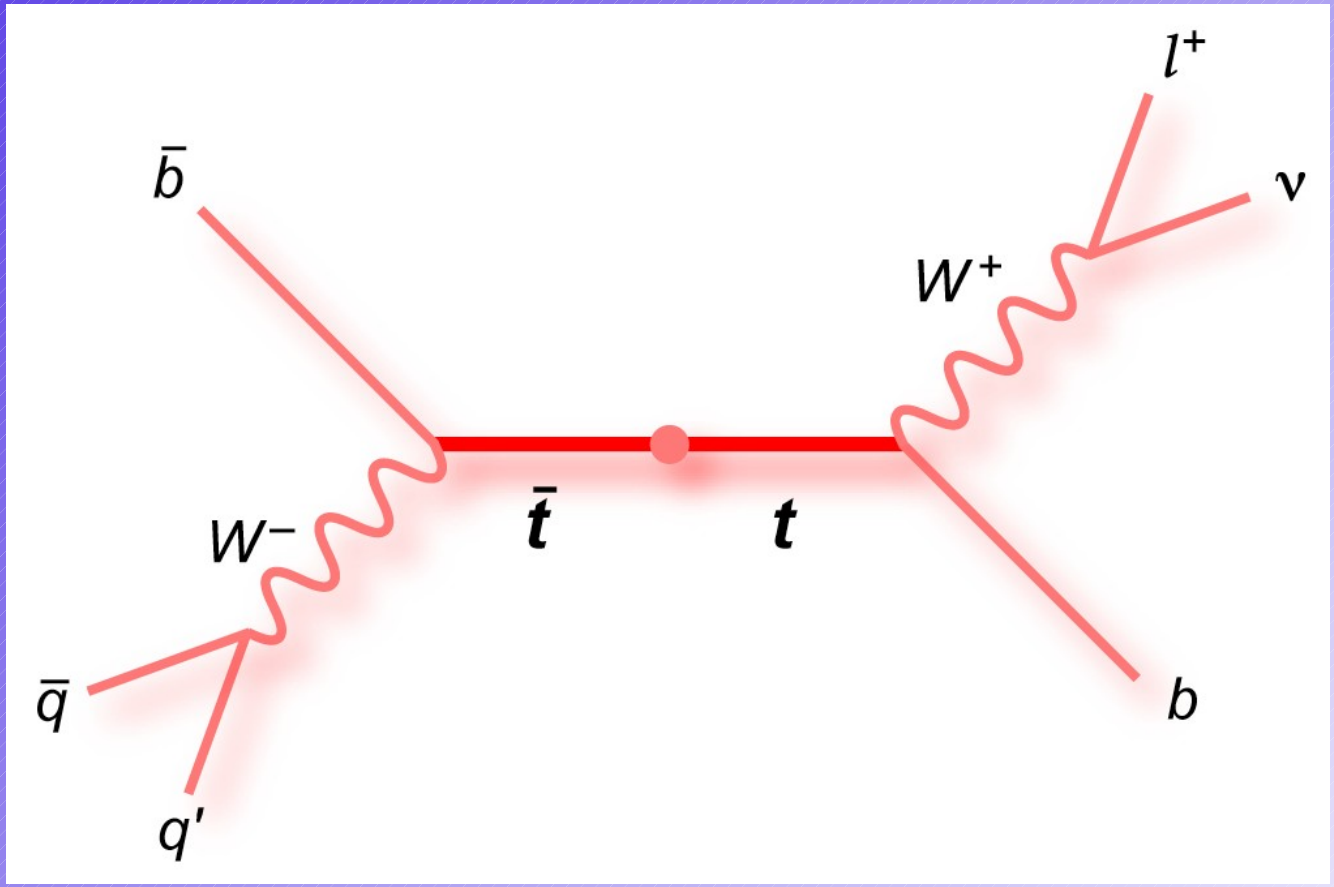




- LHC: great performance of the machine
  - Searches are pretty fast superseded by new data
  - Result: PLHC status ~200pb^{-1}

Signal topology

- Search for top-antitop final state with high m_{tt}
- Tt → 1 lepton plus jets
  - ~45% of the signal events
  - Lepton for event trigger
- „resolved" final state: looking expicitly for
  - 4 jets
  - 1 lepton
    - missing energy (neutrino)

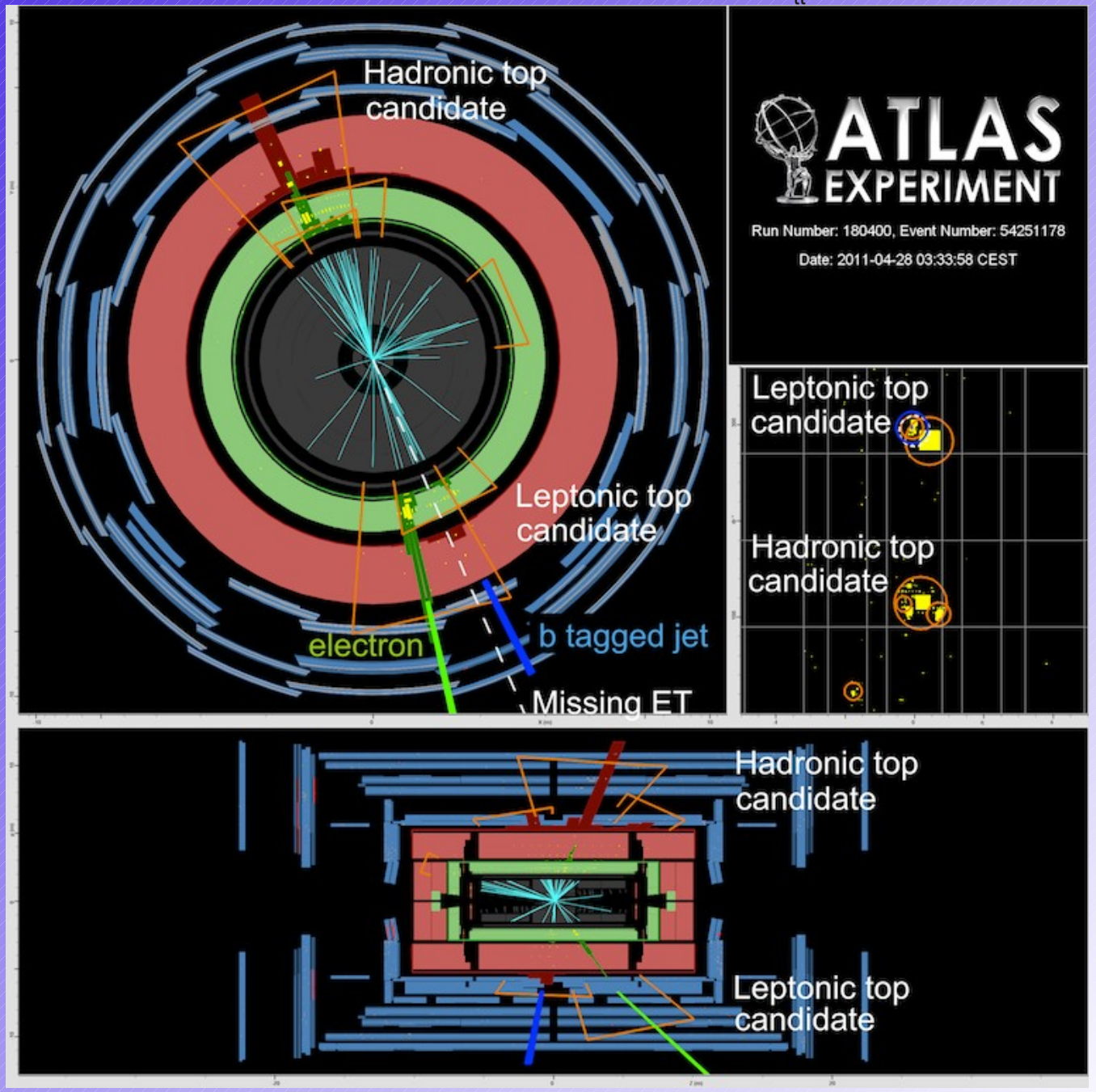


Signal topology

M_{tt} ~ 1.7 TeV

- (just) „resolved" final state: looking expicitly for
  - 4 jets
  - 1 lepton
    - missing energy (neutrino)

  → sensitive mostly for small and medium m_{tt} (Fermilab limits 800-900 GeV)
- Higher m_{tt} → boosted tops, monojets



Backgrounds

Standard Modell Top-Antitop:
- Irreducible background with
- Looking for bumb/excess on the Standard Model m_{tt} spectrum

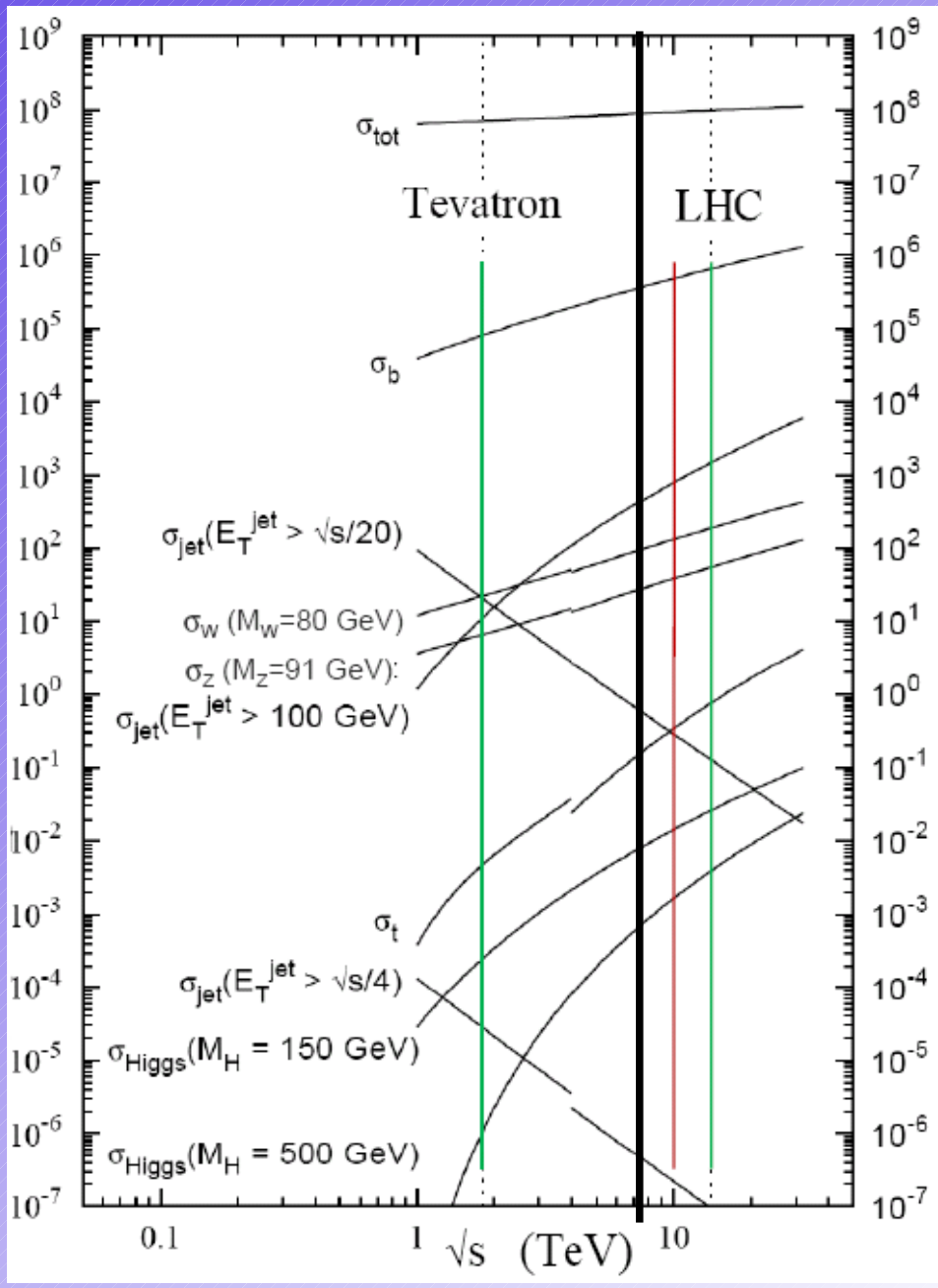
  ! interference with signal

W/Z+jet background:
- Topology simmilar
- No B' s in W decays
- But Wbb/cc etc

QCD:
- fake leptons/missing et
- Leptons/missing et from b-decays

Cross section are not well known:
Try to estimate backgrounds from (semi-)data driven methods

Proton-Proton crosssection in pb



Event Selection

	Electron channel	Muon channel
$t\bar{t}$	724	988
Single top	36	50
W+jets	93	172
Z+jets	6	8
Diboson	2	2
Total MC Background	861	1220
QCD Background	35	105
Total Expected	896	1325
Data observed	935	1396
Z', m = 500 GeV	15	21
g_{KK}, m = 700 GeV	68	93

Selection:

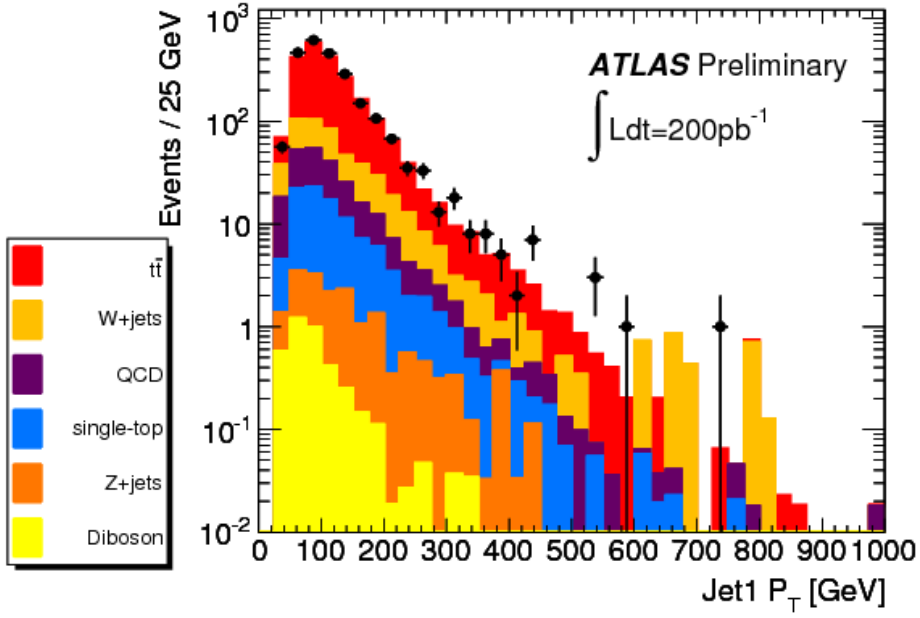
- One good high energetic isolated lepton of thigh quality
  - Electron E > 25 GeV; h<2.47 and not in the Crack
  - Muon p_t > 20 GeV, h< 2.4
- Lepton has fired the trigger
- Missing energy
- 4 high energetic jets (p_t > 25 GeV)
- One jet tagged as a B-jet

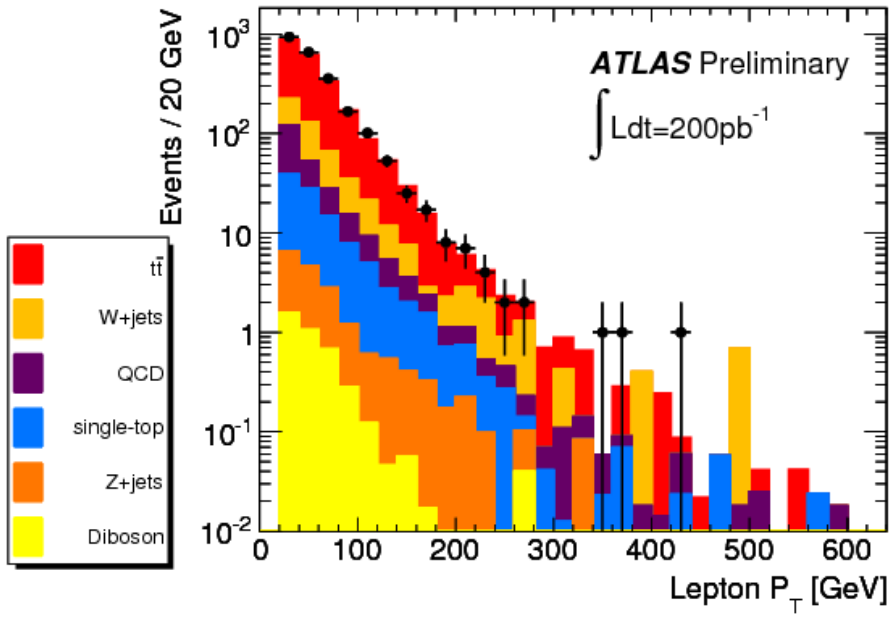
After selection:

- Most background is irreducible ttbar
- QCD highly suppressed by leptop/missing et
- W+jet suppressed by b-tag

Data agree well with Monte Carlo inside luminosity and cross section normalization errors

Event Selection (II)





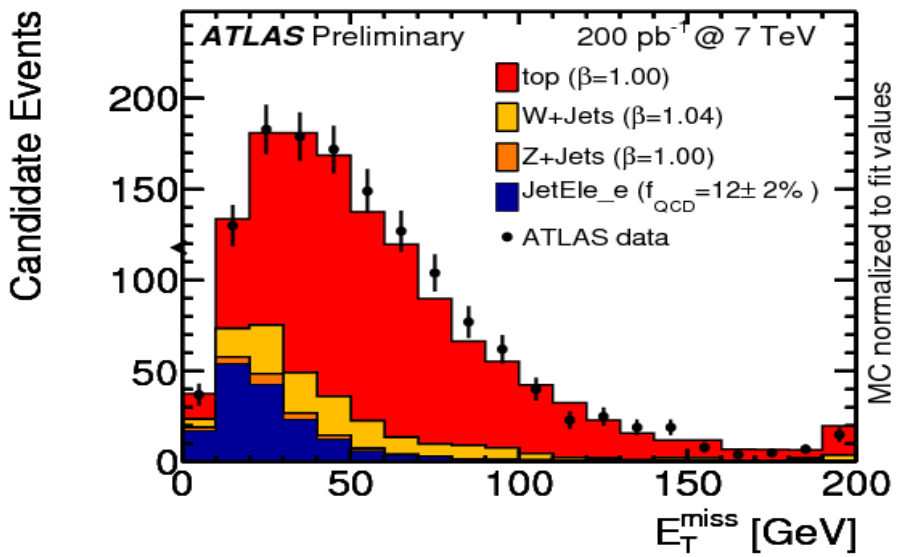
Control distributions:

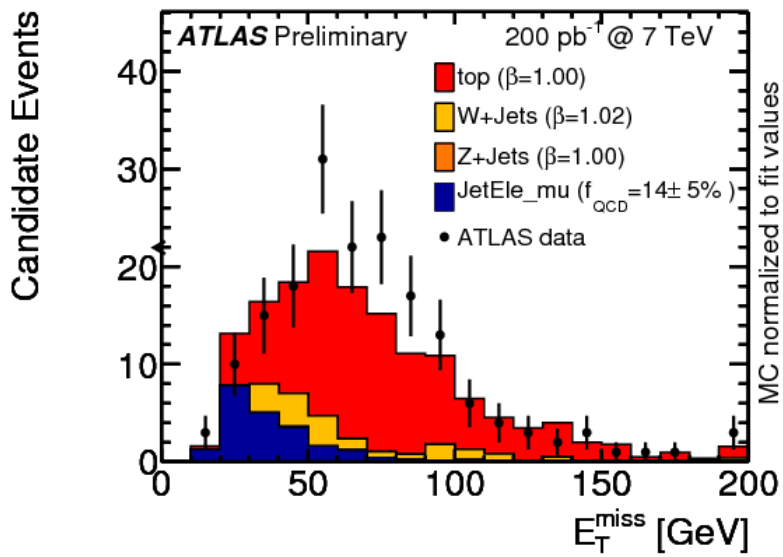
- p_t of highest energetic jet
- Lepton p_t

Muon and electron events added

Good agreement of data and Monte Carlo

QCD background estimate

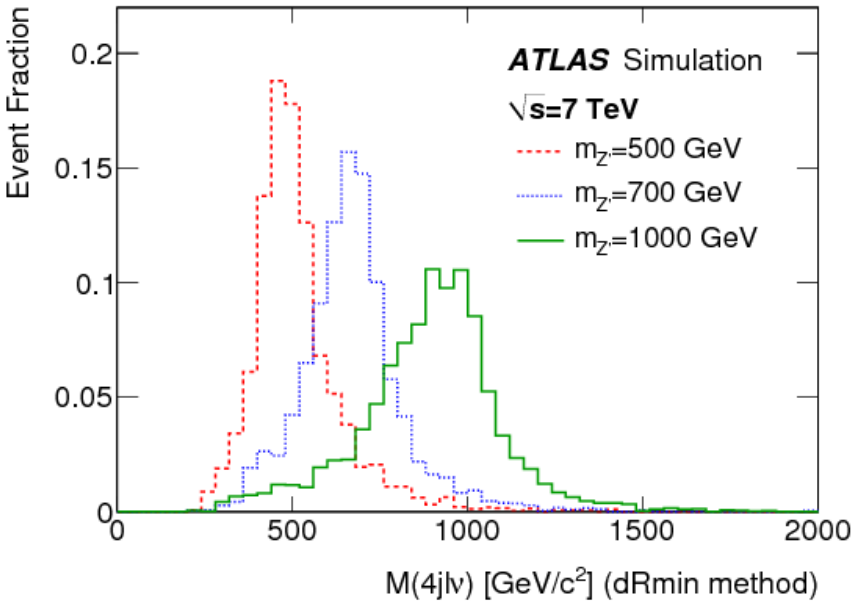


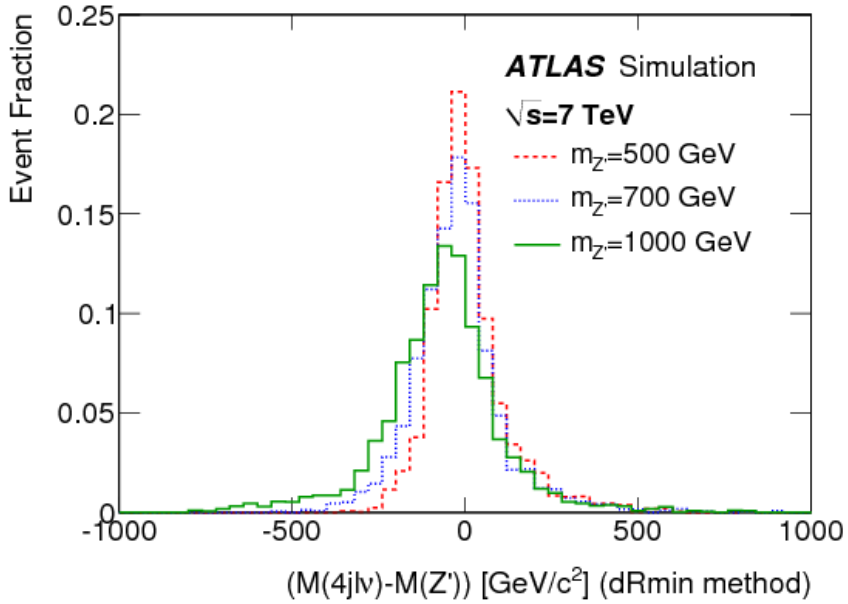


Methode:

- Data driven QCD templates fitted to the missing E_t distribution before cut
  - Templates extracted by inverting electron-ID cuts (Anti-Electrons) or Jets similar to electrons (few tracks, high em-fraction)
  - Fit use data driven QCD templates and MC templates for other processes
  - Muons: fit in lepton lepton p_t slices (similar to fermilab experiments)
  - QCD fractions after Missing E_t cut about 5% in electrons and high p_t (>30 GeV) muon
    (W+jet background is also estimate by template fit in side band)

Mass reconstruction

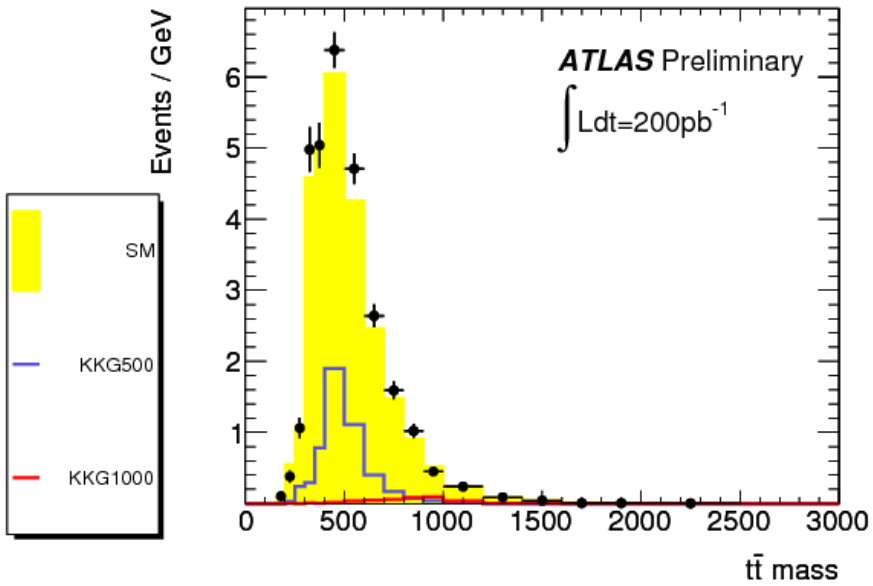


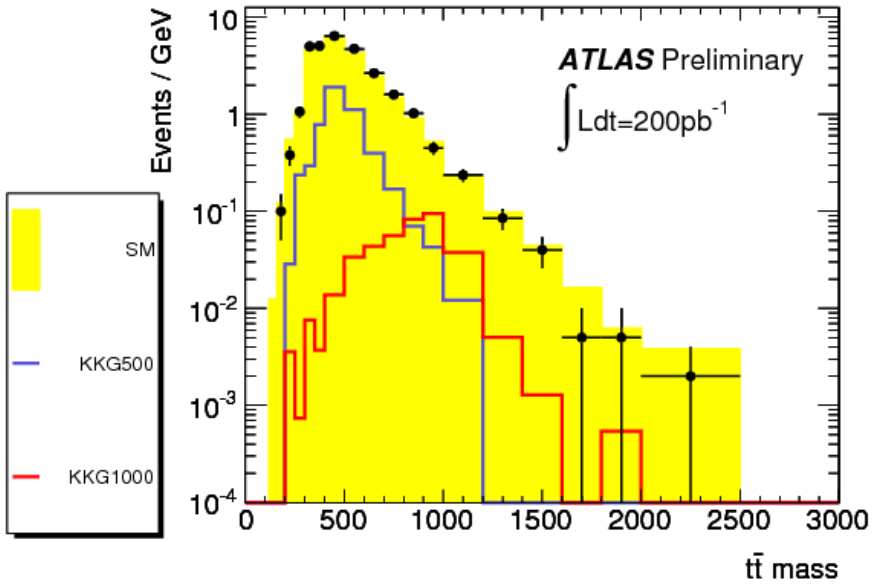


Mass reconstruction:

- Simple robust methods using jet, lepton and reconstructed neutrino
- 4 highest momentum jets : large tails because of ISR/FSR (used as cross checked
- Drmin method: removing jets which are highly isolated as ISR candidates
  - Use event if at least 3 jets pass requirement
  - Improved mass resolution
  - Tails to high m_{tt} reduced

Mass distributions



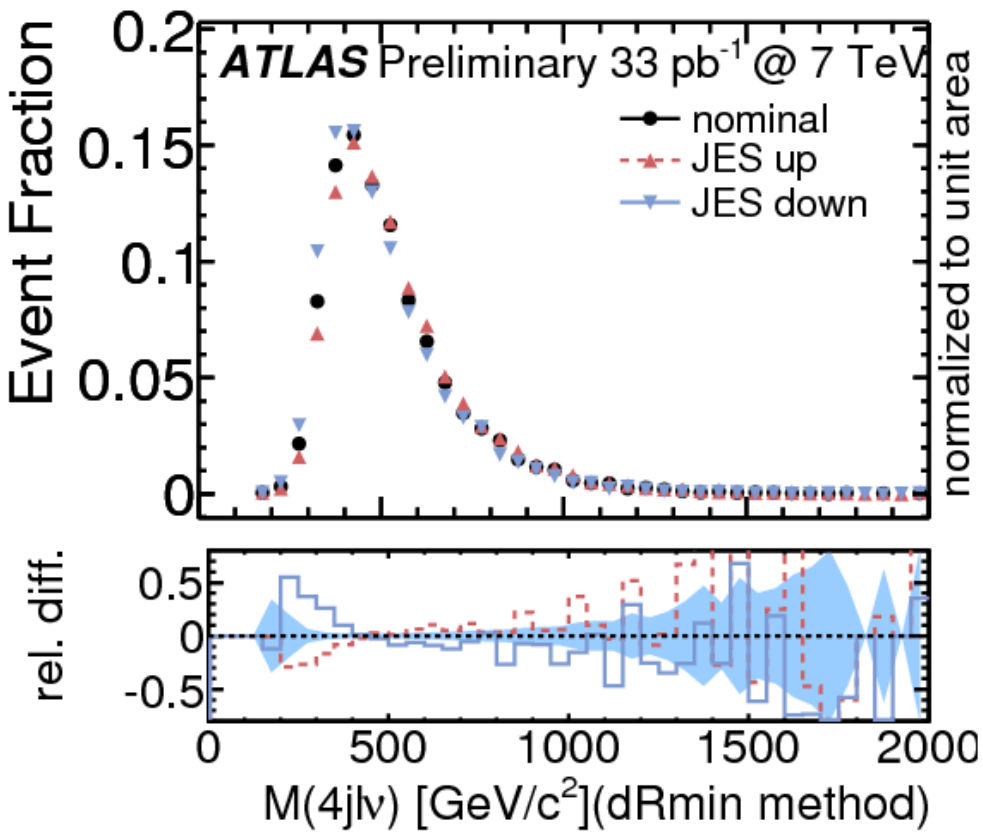


Muon and electron added up

No local excess in the data

For comparison KK signal with m=500 GeV and m=1000 GeV

Systematics

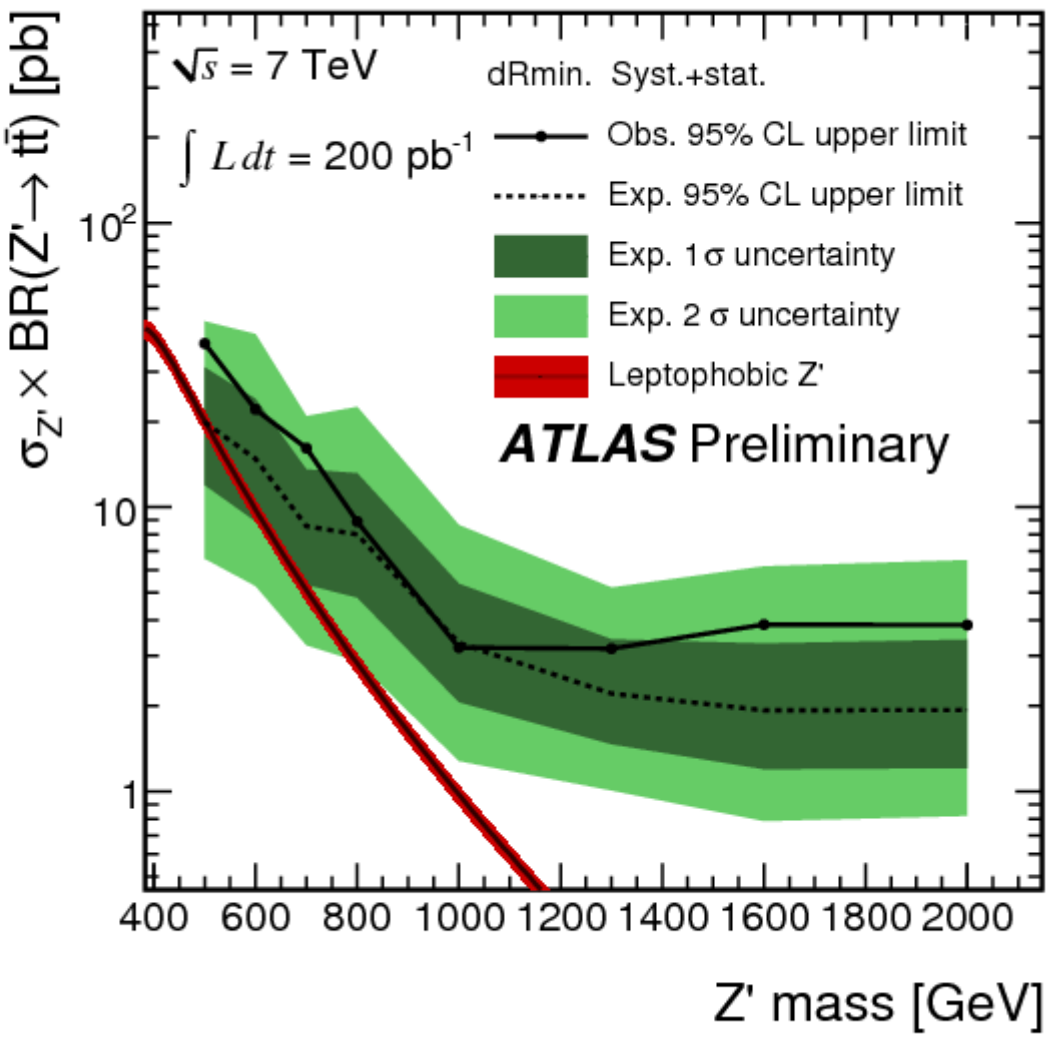


Biggest systematics:

- Normalizations:
  - Monte Carlo: ttbar ~9%; single top ~10%; di-bosons 5%
  - Data driven W+jets: 35%; QCD 30% (e)-50% (mu)
- Luminosity: 4.5%
- JES+pile up: 9%
- Btagging efficiency: 11%
- ISR/FSR ttbar: 7%
- Others <1.5%

Using also shape variations for JES, Btagging, ISR/FSR

Electroweak Z'



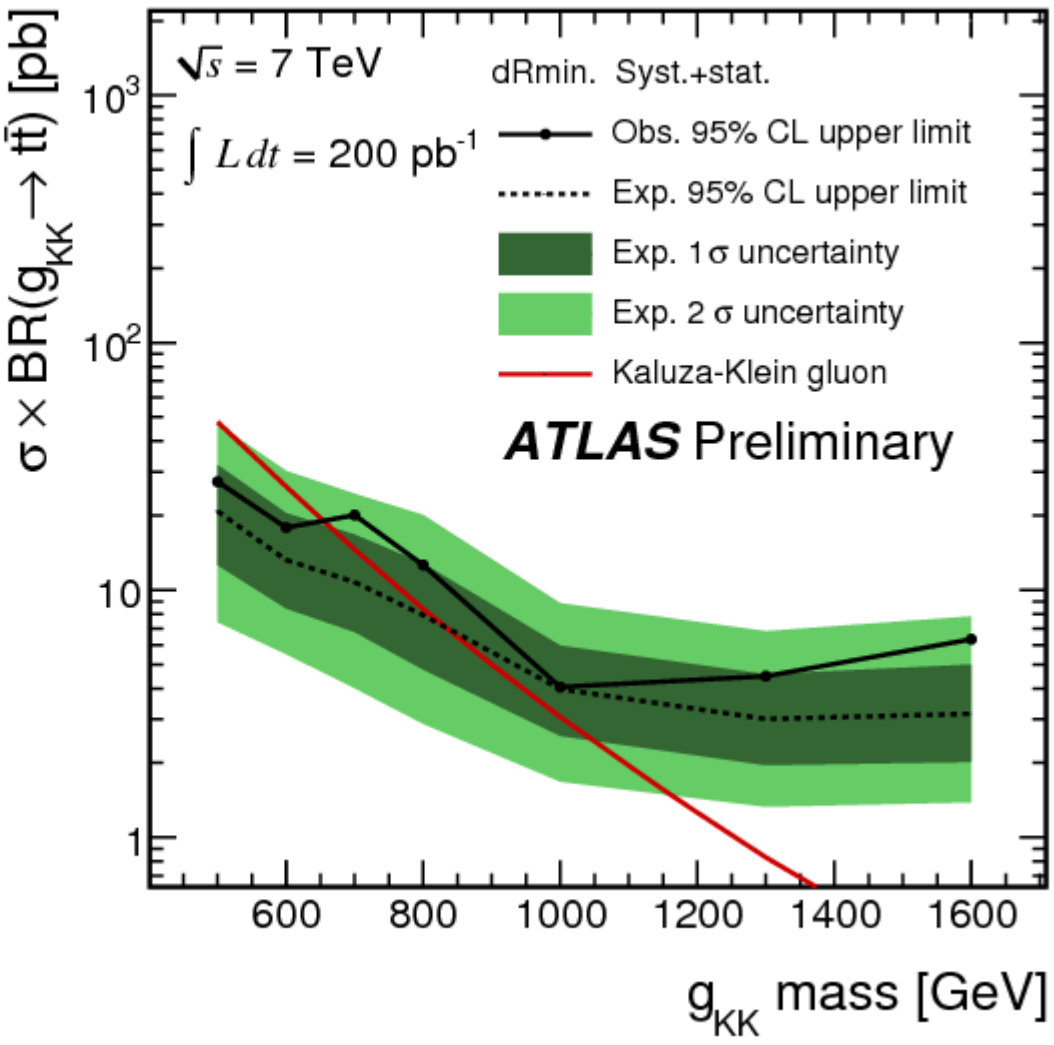
Methode:

- Bayesian method adapted from D0
- Bands using pseudo experiments
- Systematics: adding up likelihoods for several random systematic variation (profiling)
- Discriminate: m_{tt}
- Separate histograms for electrons and muons

Leptophobic scenario:

- No excess in data seen
- Close to get first exclusion
- excess in the observed limit compatible to 5% excess in global normalization

Kaluza Klein Gluons



More than factor 10 bigger cross section → easier to access

First exclusion for low mass KK gluons

Finally analysis gets sensitive to bench marks

Summary

- Analysis for ttbar resonances 200 pb^{-1}

- No exclusion in benchmark scenario
  (leptophobic Z' in top-color)
  starts to get high enough for exclusions
  - With adding additional data analysis should get sensitive to new mass region, now

- First exclusion of kk gluons at atlas

At higher m_{tt}:

- tops get more and more boost
- Partons start to merge in the jets
- Adding monojet structures to search

M_{tt} ~ 1.7 TeV