Measurement of the mass difference between top and anti-top quarks in pp collisions at $\sqrt{s}$=7 TeV using the ATLAS detector

The ATLAS Collaboration
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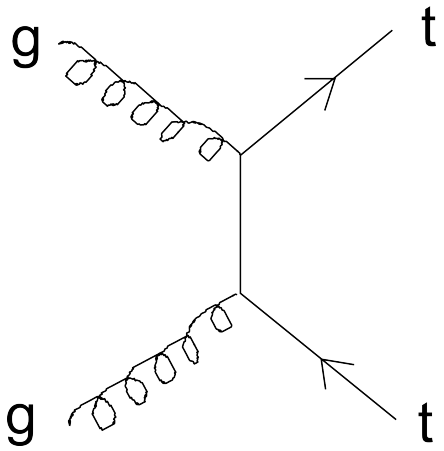
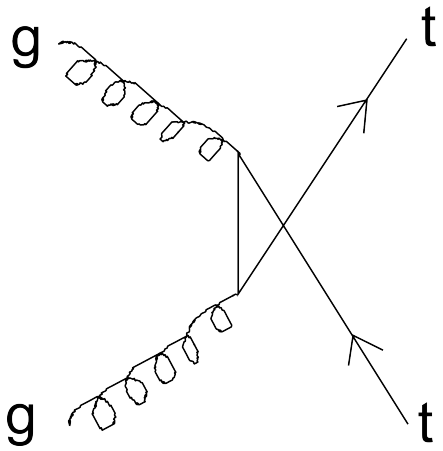
Motivation

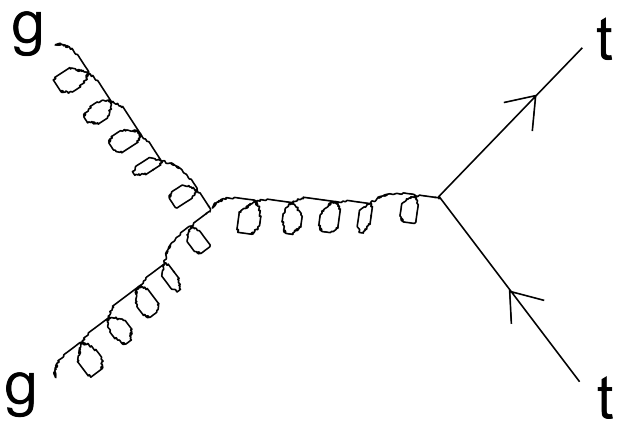
- CPT symmetry
  - C: Charge conjugation
  - P: Parity
  - T: Time reversal
- Top quark
  - Short lifetime
  - Decays before hadronization
  - Direct measurement of mass

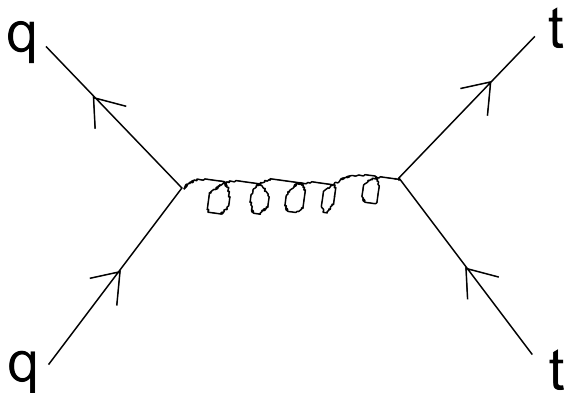
Process under study

- Proton-proton collisions ⇨ Top pair production



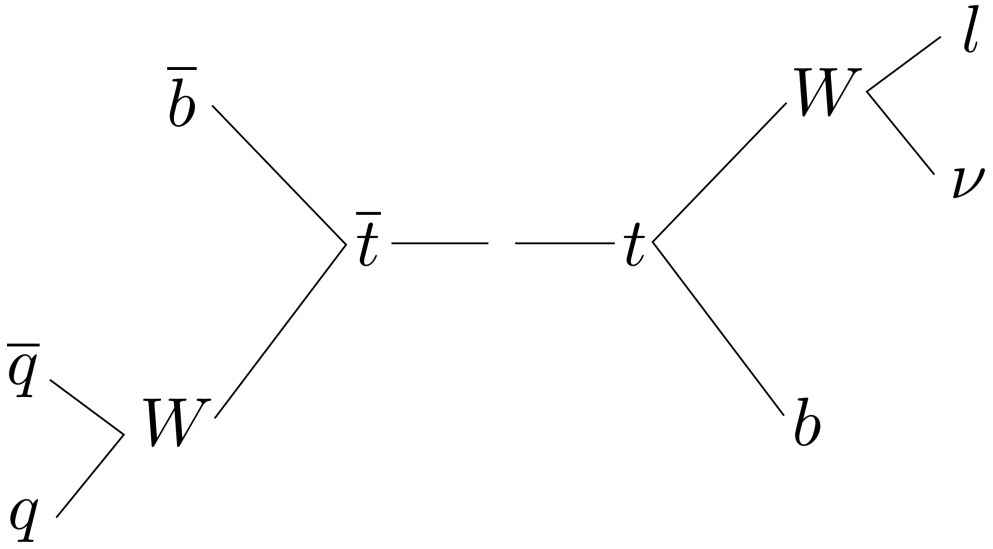






Process under study

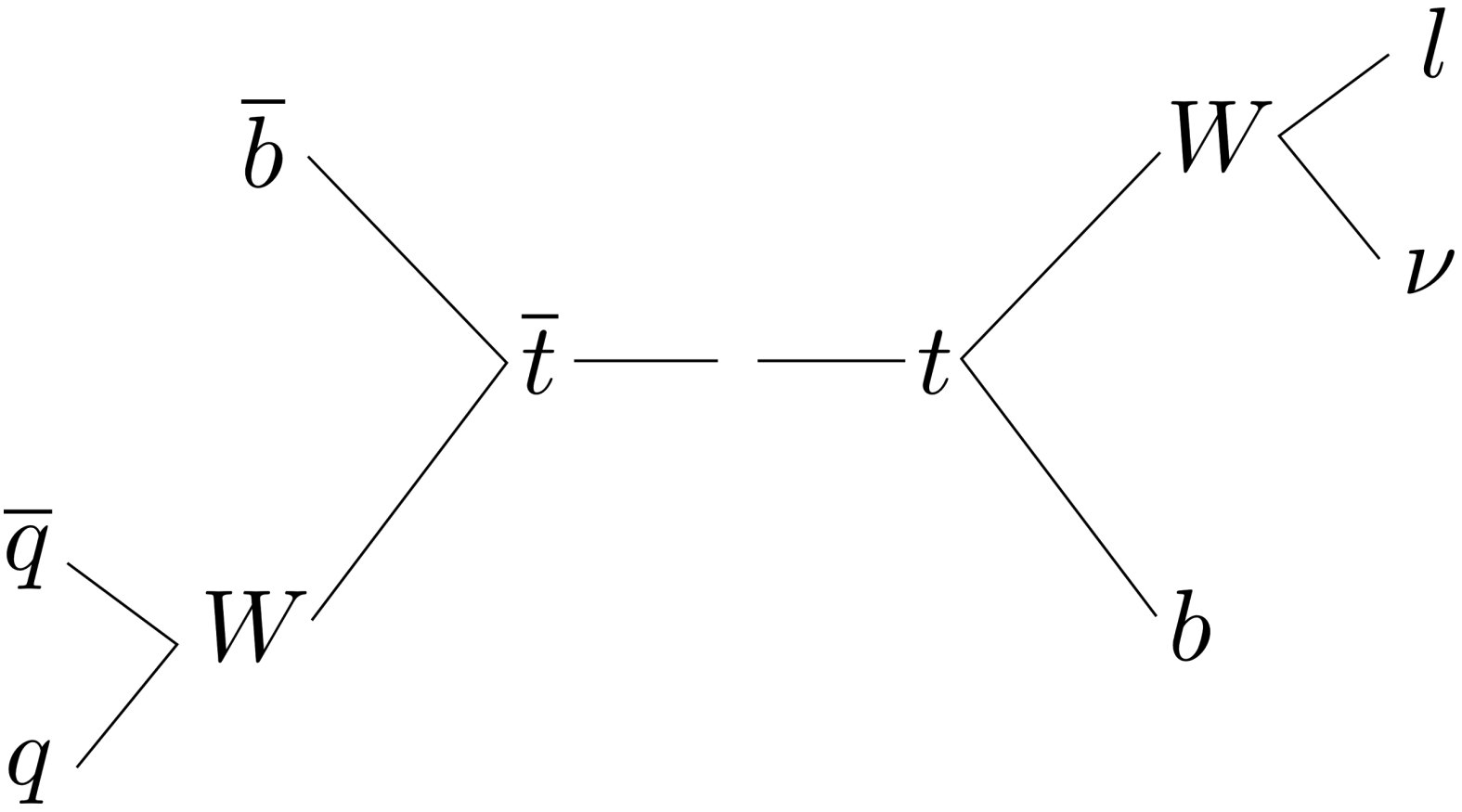
- 3 possible final states
  - Dilepton channel (BR 5%)
  - Hadronic channel (BR 40%)
  - Lepton+Jets channel (BR 30%)



Experimental setup and Measurement performance

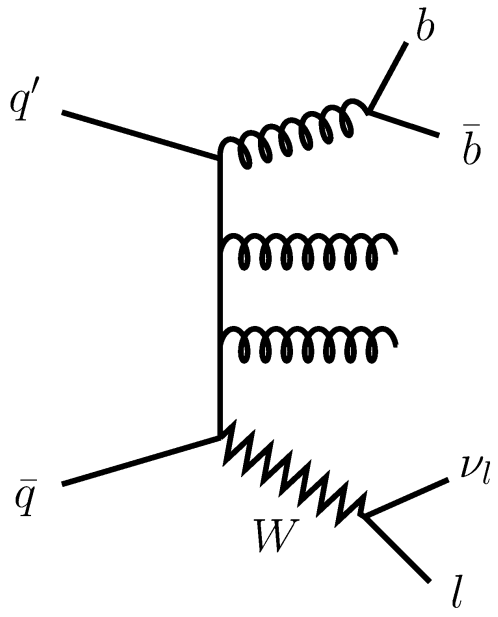
- ATLAS experiment at the LHC
- Proton-proton collisions at $\sqrt{s}$=7 TeV from 2011 (dataset size 4.7 fb^-1)
- Signature of top anti-top events
  - Lepton + Jets channel

Data interpretation and results

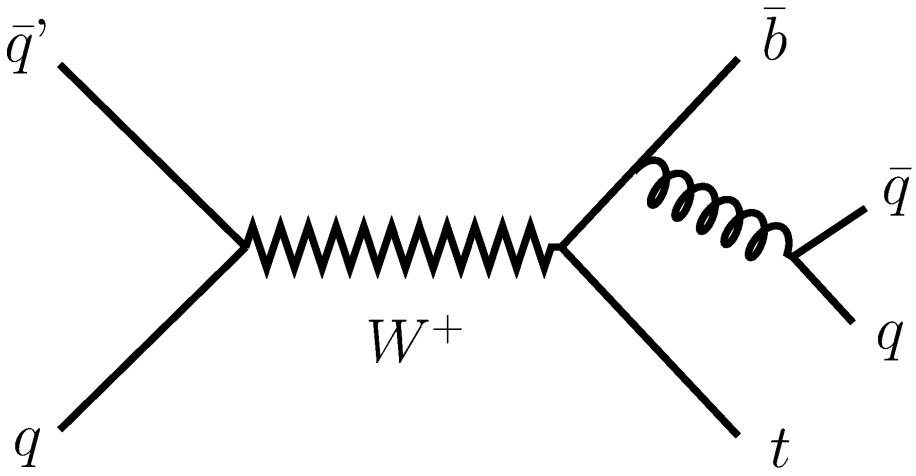


Background processes

- Background: Main contributions



W/Z + jets



Single top

- Smaller background: Diboson, Multi-jet

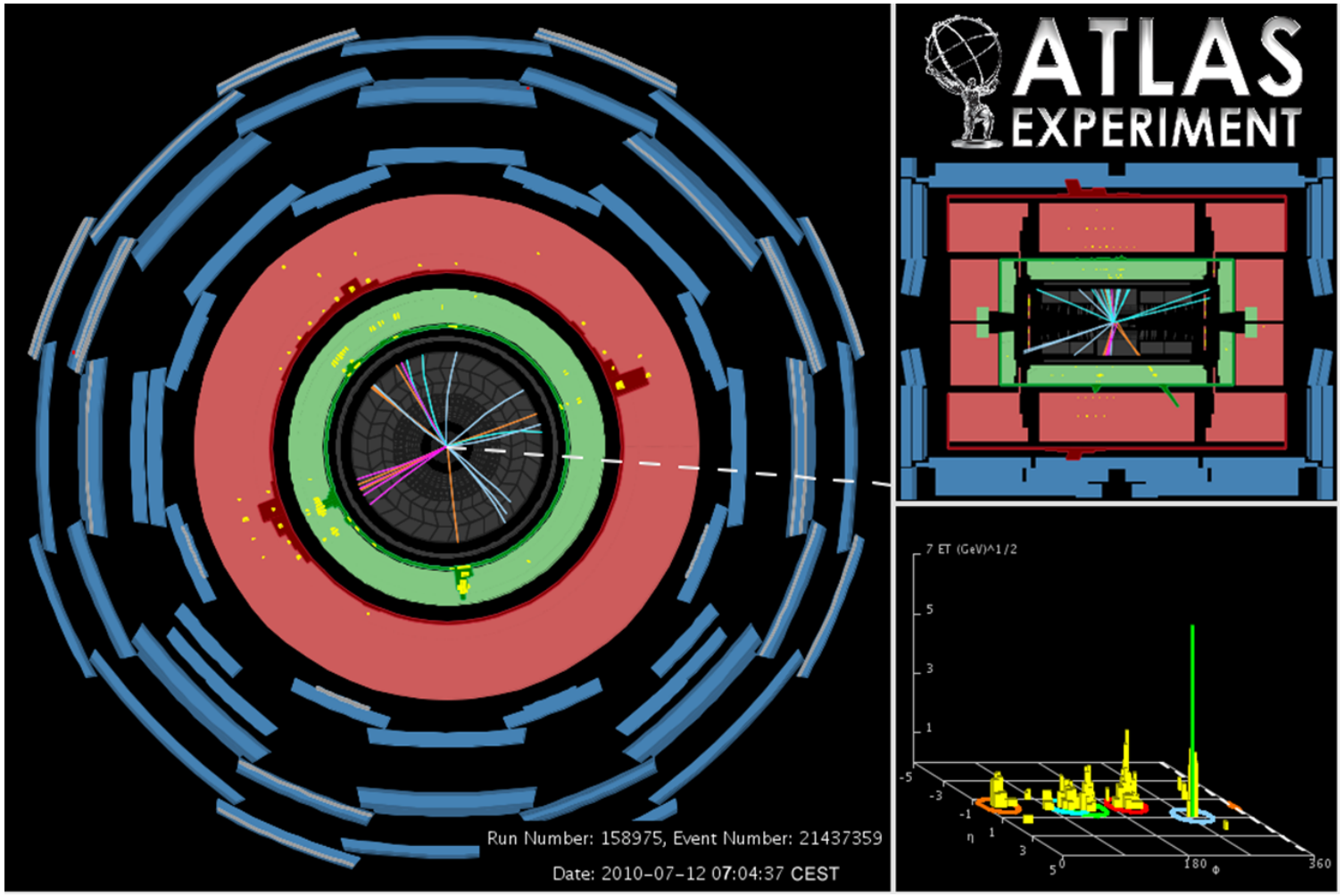
Event yield after selection (2 b-tags)

- Background

Channel	Muon	Electron
Data	8854	4941
SM $t\bar{t} \to W^+bW^-\bar{b}$	$7700\,^{+1600}_{-1700}$	$4500\,^{+900}_{-1000}$
W/Z + jets	320 ± 90	160 ± 40
Single top	300 ± 50	170 ± 30
Diboson	5 ± 1	3 ± 1
Multi-jet	220 ± 110	110 ± 60
Total expected (SM)	$8550\,^{+1600}_{-1700}$	$4900\,^{+900}_{-1000}$

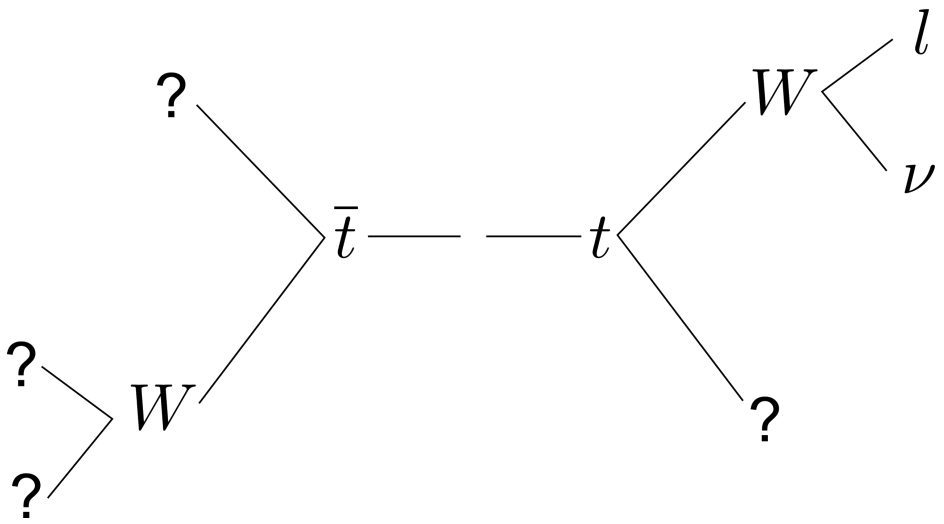
very pure ttbar sample, small background contributions

Event display of ttbar event



Event reconstruction

- searching for the jet-parton association
- 4 jets lead to 4!=24 permutations
- permutation of quarks from W does not change the top mass -> 12 permutations left

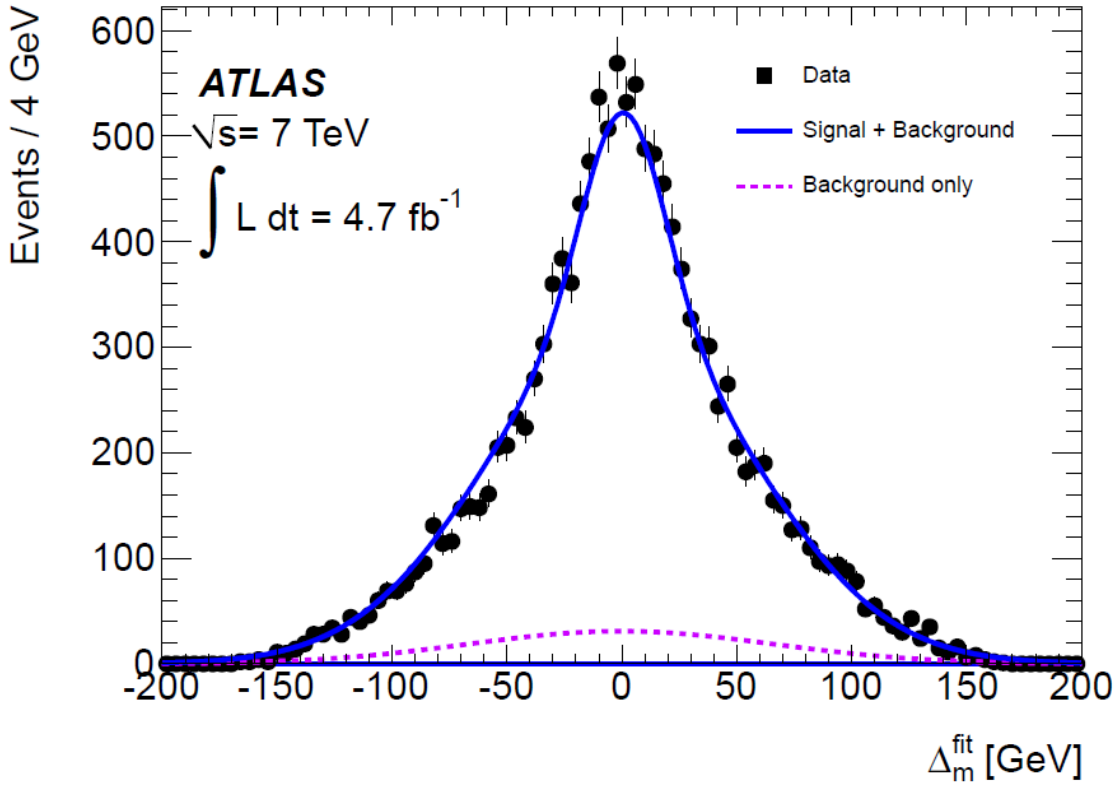


Event reconstruction with a chisquare fitter

- Expected theoretical values from PDG
- Events with $\chi^2 > 10$ rejected
- Minimize χ^2 gives the event with highest probability

$$
\begin{aligned}
\chi^2 = & \sum_{i=\ell,4jets} \frac{\left(p_{\mathrm{T}}^{i,\mathrm{fit}} - p_{\mathrm{T}}^{i,\mathrm{meas}}\right)^2}{\sigma_i^2} \\
& + \sum_{j=x,y} \frac{\left(p_j^{E_{\mathrm{U}}^{\mathrm{fit}}} - p_j^{E_{\mathrm{U}}^{\mathrm{meas}}}\right)^2}{\sigma_{E_{\mathrm{U}}}^2} \\
& + \sum_{k=jj,\ell\nu} \frac{\left(m_k^{\mathrm{fit}} - m_W\right)^2}{\sigma_W^2} \\
& + \frac{\left(m_{b\ell\nu}^{\mathrm{meas}} - \left(m_t + \frac{(m_{b\ell\nu}^{\mathrm{fit}} - m_{bjj}^{\mathrm{fit}})}{2}\right)\right)^2}{\sigma_t^2} \\
& + \frac{\left(m_{bjj}^{\mathrm{meas}} - \left(m_t - \frac{(m_{b\ell\nu}^{\mathrm{fit}} - m_{bjj}^{\mathrm{fit}})}{2}\right)\right)^2}{\sigma_t^2}
\end{aligned}
$$

Data interpretation and results



$$\Delta_m^{fit} = q_l \left(m_{blv}^{fit} - m_{bjj}^{fit}\right)$$

$$\Delta m \equiv m_{top} - m_{anti\text{-}top} = 0.67 \pm 0.61\,(stat) \pm 0.41\,(syst)\ \ GeV$$

Conclusions and Outlook

- The measured mass difference is

$$\Delta m \equiv m_{top} - m_{anti\text{-}top} = 0.67 \pm 0.61(stat) \pm 0.41(syst) \quad GeV$$

- No violation of the CPT theorem has been observed

- More data would make the statistical uncertainty smaller