Fully hadronic $t\bar{t}H$ and $t\bar{t}$ final states

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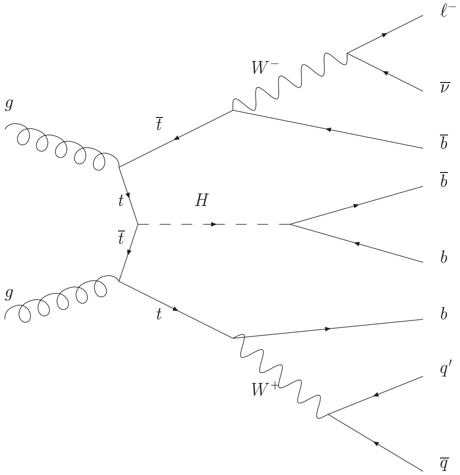
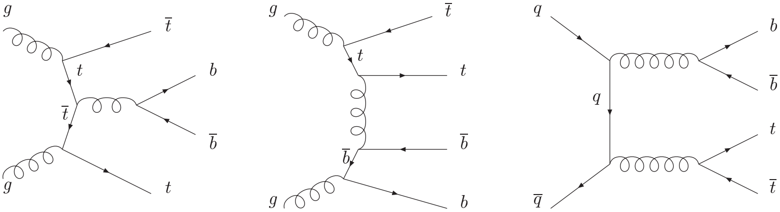
$t\bar{t}H$



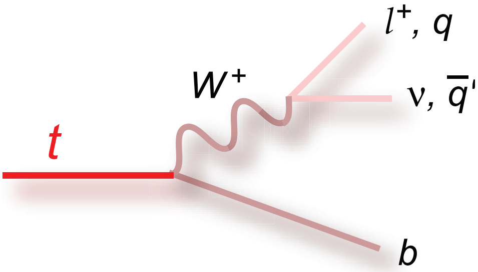
- Higgs hunting
- Measuring Yukawa coupling $V \approx g\overline{\Psi}\phi\Psi$

$t\bar{t}b\bar{b}$



- $\sigma_{\text{NLO}}\left(pp \to t\bar{t}b\bar{b}; \sqrt{s} \sim 14\ \text{TeV}\right) \sim 2600$ fb
- High jet multiplicity - challenging combinatorics
- Similar kinematics to $t\bar{t}H$
    - Background to $t\bar{t}H$
    - Needs b-tagging

Hadronic *t* decays



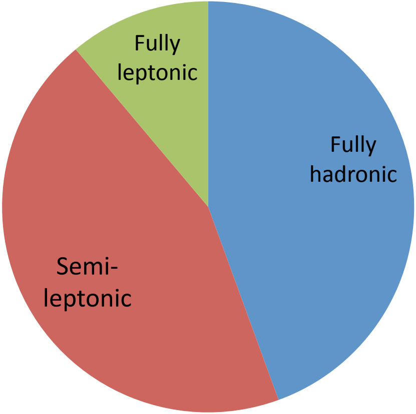
- *t* decay products

$$t \rightarrow W^+ b$$
$$\hookrightarrow q\overline{q'}$$

$$t \rightarrow W^+ b$$
$$\hookrightarrow l^+ \nu_l$$

- *b*-jets are the common signature

Branching ratios

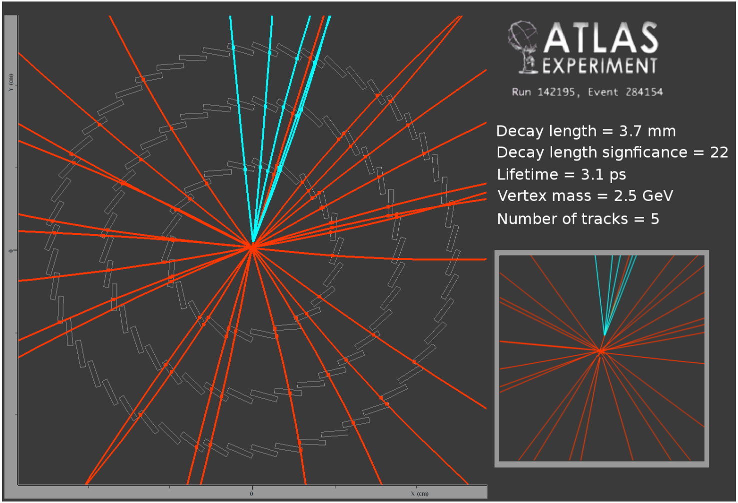


$$\mathrm{BR}(pp \to bl\nu_l bl\nu_l) = \frac{1}{9}$$

$$\mathrm{BR}(pp \to bqqbqq) = \frac{4}{9}$$

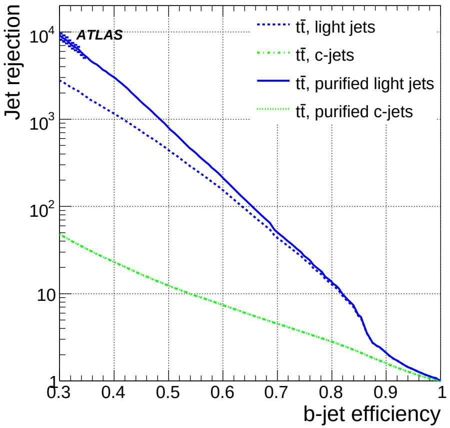
$$\mathrm{BR}(pp \to bqqbl\nu_l) = \frac{4}{9}$$

b-jets



Event display showing tracks

b-tagging



Rejection vs. efficiency of *b*-tagging (using impact parameters and secondary vertex finding) in ATLAS

b-jets characterised by displaced vertex

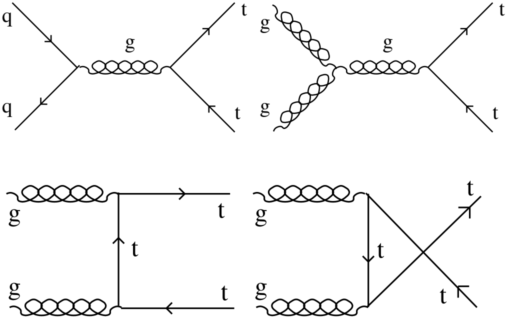
- e.g. lifetime of B_s is ~ 1.5 ps
- Gives vertex displacement of O(1 mm)

Rates and b-tagging

- Hadronic $t\bar{t}$ cross section $\sim$ 800 pb
  - Luminosity 10^{31} cm$^{-2}s^{-1}$, event rate $\sim$ 70 per day
- But fully hadronic $t\bar{t}H$ cross-section $\sim$ 460 fb
  - Luminosity 10^{31} cm$^{-2}s^{-1}$, event rate $\sim$ 0.4 per day

- b-tagging efficiency $\sim$ 0.5

Fully hadronic $t\bar{t}$ event type

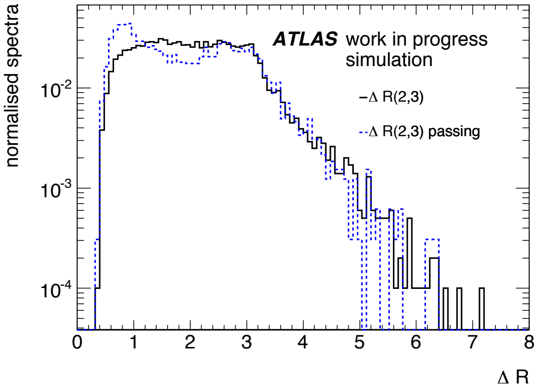


- At least 6 jets
- No leptonic signature ∴ reliant on high rate jet triggers
- At least 2 b-jets i.e. dependent on b-tagging
    - Provides a possible way to lower rate
    - Implemented in software trigger levels

Triggers for fully hadronic $t\bar{t}(*)$

- Four jets of $E > 20$ GeV
  - Prescaled in 10^{31} cm$^{-2}s^{-1}$ and 10^{32} cm$^{-2}s^{-1}$ menus (2000 and 4000 respectively)
- Four jets of $E > 40$ GeV
  - Unprescaled at 10^{31} cm$^{-2}s^{-1}$ but prescale of 100 at 10^{32} cm$^{-2}s^{-1}$
  - Efficiency $\sim$ 70%
  - Useful for 2010 runs
- Three jets of $E > 80$ GeV
  - Not in 10^{31} cm$^{-2}s^{-1}$ menu, unprescaled in 10^{32} cm$^{-2}s^{-1}$ menu
  - Higher jet energy trigger value, reducing efficiency
  - 84% of events that pass this trigger have at least six offline jets

Kinematic biasing of the fully hadronic $t\bar{t}$(*)



- Selected events have 3rd jet p_T above 80 GeV
- Collinear jets ($\Delta\phi \sim 0, \pi$) are favoured

Triggers for fully hadronic $t\bar{t}H$(*)

- Greater jet multiplicity than $t\bar{t}$
- However, 4 b-jets
  - triggering on b-jets lowers efficiency
  - but increases purity
- Unlike for $t\bar{t}$ need b-jet triggers for $t\bar{t}H$
- Only practical *existing* trigger 3 b-jets, jet energy > 20 GeV
  - Low thresholds $\rightarrow$ little biasing
  - Unprescaled at 10^{31} cm$^{-2}s^{-1}$, 10^{32} cm$^{-2}s^{-1}$
- However studies Monte Carlo only
  - Low number of events
  - MC data trustworthy?

Practical issues

- For complicated event types, the best approach would be a matrix element approach
  - i.e. all jets produced via NO or NLO matrix element calculation
  - As opposed to using simpler events types with added gluon radiation
  - e.g. `Sherpa` vs. `Pythia`
- However, that would take O(months) to calculate matrix elements for 6-8 jet events in QCD
  - Accuracy for multi-jet events in question
- Theoretical cross-section errors for fully hadronic $t\bar{t}b\bar{b}$ are $\sim$ 77% of the cross section, with K factors for LO $\rightarrow$ NLO of 1.8 (*Phys. Rev. Lett.* **103** 012002)
  - Rates unpredictable, making trigger chain design and choice even harder

Conclusion

- $t\bar{t}H$ is a long term goal of ATLAS
    - Not a goal for 1 fb^{-1} of integrated luminosity at $\sqrt{s} = 7$ TeV
- Hadronic $t\bar{t}$ will be measurable.
    - Will be able to study:
        - Jet Monte Carlo accuracy
        - b-jet triggers
    - And measure the cross section soon