Asymmetric Leptons For Asymmetric Tops

(How to find like-sign tops without like-sign dileptons)

Ze'ev Surujon

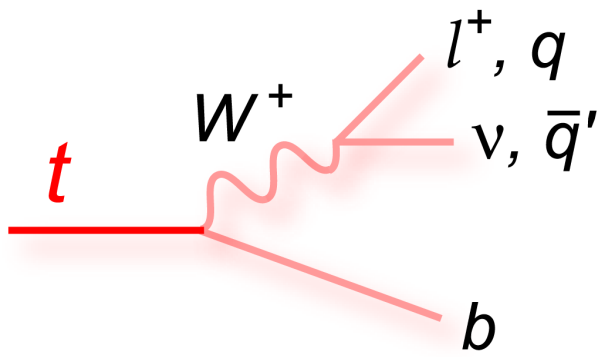
UC Riverside

April 14, 2011

arXiv:1104.0947 with Arvind Rajaraman and Tim Tait

Question: How do we look for like-sign tops?

Usual answer: Look for like-sign leptons

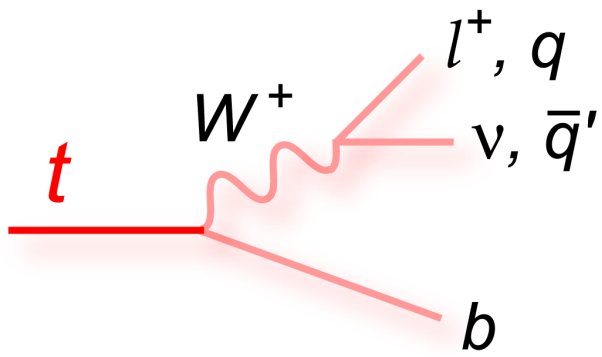


Good: **almost no background** (charge mis-ID, lepton mis-ID,...)

Bad: $\left(\frac{2}{9}\right)^2 \sim 5\%$

Question: How do we look for like-sign tops?

Usual answer: Look for like-sign leptons

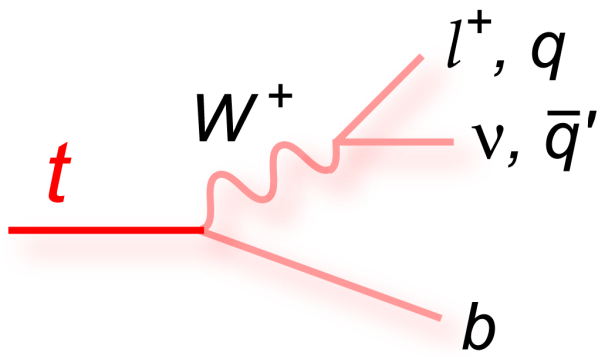


Good: **almost no background** (charge mis-ID, lepton mis-ID,...)

Bad: $\left(\frac{2}{9}\right)^2 \sim 5\%$ **almost no signal**

Question: How do we look for like-sign tops?

Usual answer: Look for like-sign leptons



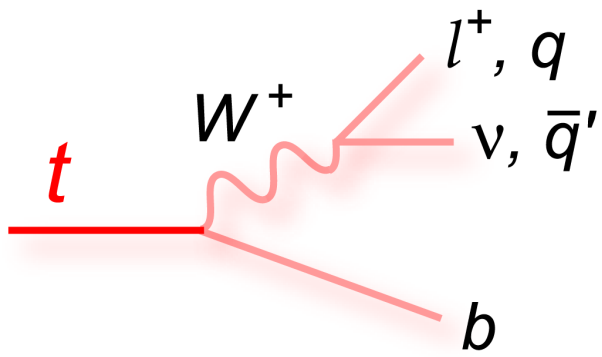
Good: **almost no background** (charge mis-ID, lepton mis-ID,...)

Bad: $\left(\frac{2}{9}\right)^2 \sim 5\%$ **almost no signal**

Is there an alternative?

Question: How do we look for like-sign tops?

Usual answer: Look for like-sign leptons



Good: **almost no background** (charge mis-ID, lepton mis-ID,...)

Bad: $\left(\frac{2}{9}\right)^2 \sim 5\%$ **almost no signal**

Is there an alternative? **Use Lepton Charge Asymmetry.**

Lepton Charge Asymmetry

$$\mathcal{A}_\ell \equiv \frac{N(\ell^+) - N(\ell^-)}{N(\ell^+) + N(\ell^-)}$$

v1: veto $\ell^+\ell^-$ **v2: veto all dileptons**

Look at: $\Delta N \equiv N(1\ell^+) - N(1\ell^-)$

Relevant processes: $t\bar{t}$ tt $\bar{t}\bar{t}$

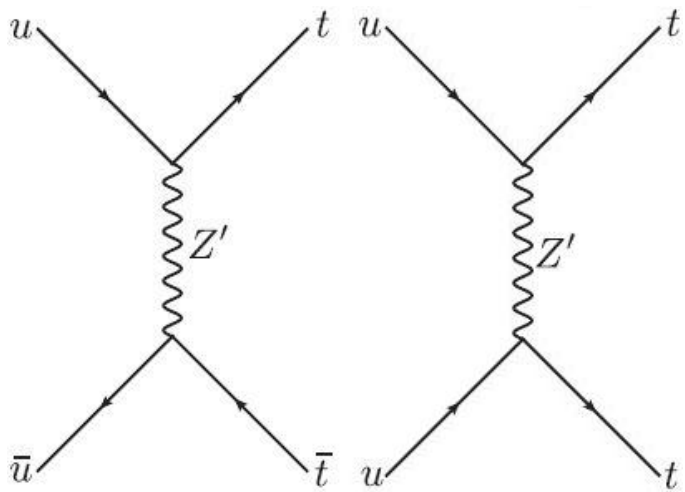
$\langle \mathcal{A}_\ell \rangle = 0$ $\mathcal{A}_\ell = 1$ $\mathcal{A}_\ell = -1$

In pp collider: (PDF-suppressed)

$$\Delta N = \underbrace{\cancel{\Delta N(t\bar{t})}}_{N\to\infty} + \Delta N(tt) + \underbrace{\cancel{\Delta N(\bar{t}\bar{t})}}_{\text{in } pp}$$

Example: Z' Model for the Forward-Backward Asymmetry

Example: Z' Model for the Forward-Backward Asymmetry



Jung, Murayama, Pierce and Wells (2009)

$$\Delta\mathcal{L} \supset Z'_\mu \bar{u}_R \gamma^\mu \left(g_X t_R + g'_X u_R \right) + \text{c.c.}.$$

Constraints:

- Like-Sign Dileptons
- $\sigma(t\bar{t})$ measurement
- Lepton Charge Asymmetry

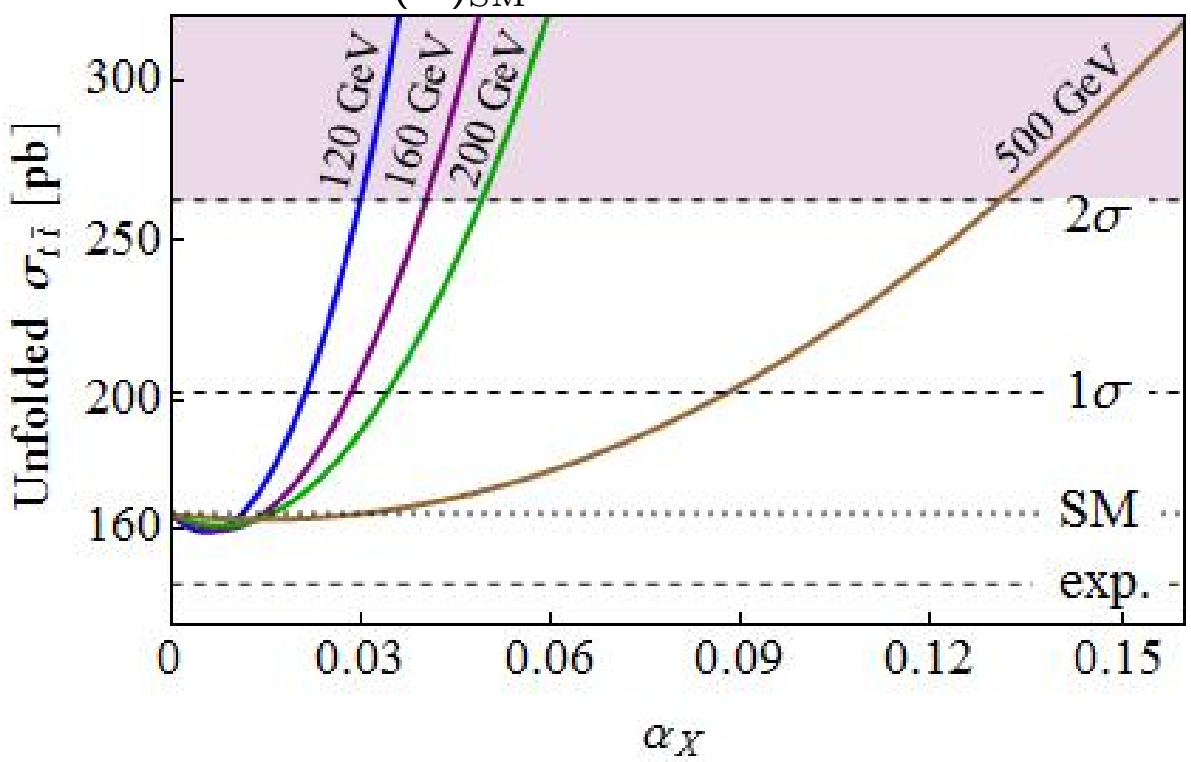
$t\bar{t}$ Cross Section Measurement

Two event categories:

1. single-lepton: $1\ell + \not{E}_T + 4j$ (tagged)
2. dilepton: $\ell^+\ell^- + 2j + \not{E}_T$

Many tt events pass the "single-lepton" cuts:

$$\sigma_{\text{unfolded}}(t\bar{t}) = \frac{\sigma(t\bar{t})\varepsilon(t\bar{t}) + \sigma(tt)\varepsilon(tt)}{\varepsilon(t\bar{t})_{\text{SM}}}$$



Lepton Charge Asymmetry

Method:

- Measure $\Delta N = N(1\ell^+) - N(1\ell^-)$ in the single-lepton sample of the ATLAS $t\bar{t}$ cross-section measurement.

- Subtract background:

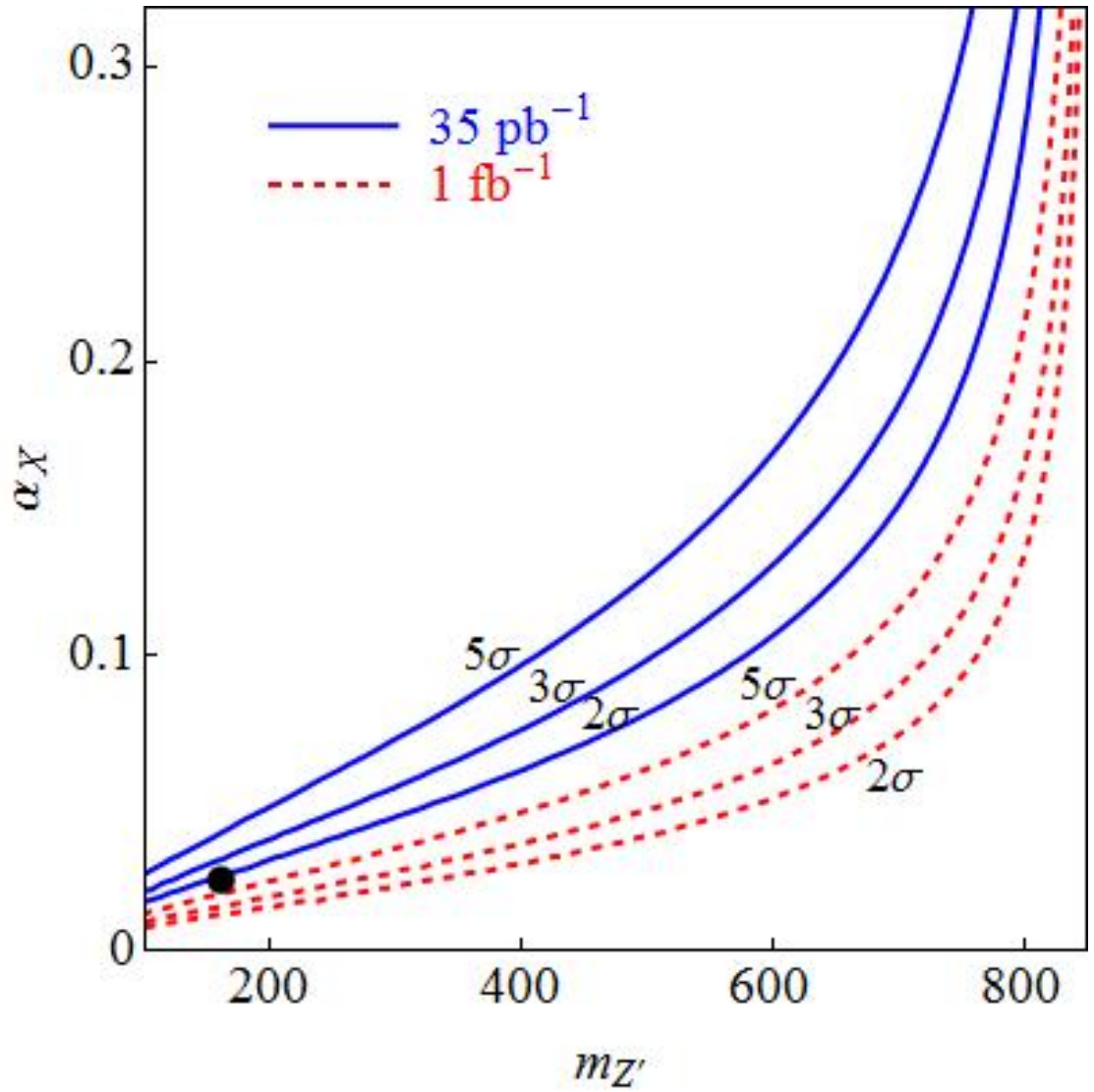
Background Process	σ_{eff}[pb]	$\mathcal{A}_\ell$
$t\bar{t}$	5.17$\pm$1.17	0
W+jets	0.586$\pm$0.552	$+1/3$
Z+jets	0.034$\pm$0.034	0
Single top	0.241$\pm$0.069	$+1/3$
QCD jets	0.276$\pm$0.173	0
SM combined	6.31$\pm$1.31	$+0.044$

$$\text{significance} = \frac{\Delta N - \Delta N_{\text{SM}}}{\sqrt{\delta^2_{\text{sys}} + \delta^2_{\text{stat}}}}$$

$$\delta_{\text{sys}} = \delta\sigma_{\text{eff}} \times \mathcal{A}_\ell \times L \quad , \quad \delta_{\text{stat}} = \sqrt{N_{\text{SM}}} = \sqrt{\sigma^{\text{SM}}_{\text{eff}} \times L}$$

Lepton Charge Asymmetry - in simulation

Simulation: MadGraph/MadEvent(4) $\rightarrow$ Pythia(6) $\rightarrow$ PGS4
Cuts: as prescribed in the ATLAS $t\bar{t}$ measurement paper (2010)



Conclusion

- Alternative Method for Like-Sign Tops:

  Lepton Charge Asymmetry

  $$\mathcal{A}_\ell \equiv \frac{N(\ell^+) - N(\ell^-)}{N(\ell^+) + N(\ell^-)} \quad \text{(veto } \ell^+\ell^-\text{)}$$

- "Non-deterministic" algorithm: targets $t\bar{t}$ events *deliberately*.

  In contrast: Like-sign dileptons target *only* tt event.

  Inherent $t\bar{t}$ contamination $\longrightarrow 1/\sqrt{N}$.

- Complementary to like-sign dilepton analysis.