Top Forward-Backward Asymmetry in Dilepton Final States

IoP

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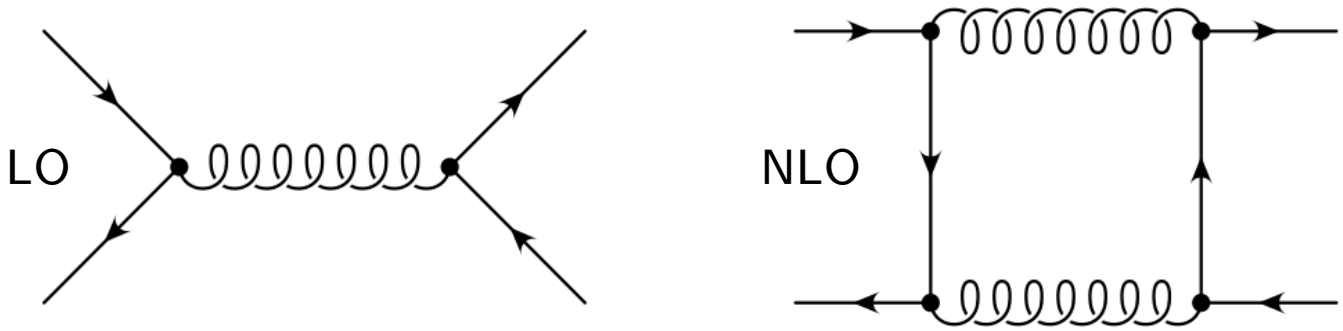
In the Standard Model

- Top quark produced more often in the direction of the proton beam.
  - Corresponding to positive η.
- Major contribution to the asymmetry from interference of:



- Size of the top quark based asymmetry is expect to be $\approx (5-9)\%$.

Observables

- Use the lepton from the top quark as proxy.
- Size of lepton based asymmetries $\approx 5\%$.
- We can define several asymmetries:

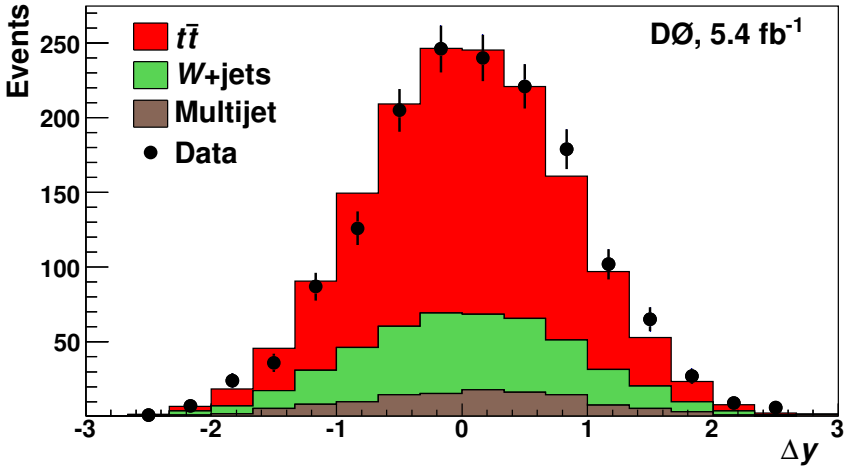
$$\text{charge signed rapidity } A_{FB}^{\ell} = \frac{N_{\ell}(q \cdot \eta > 0) - N_{\ell}(q \cdot \eta < 0)}{N_{\ell}(q \cdot \eta > 0) + N_{\ell}(q \cdot \eta < 0)}$$

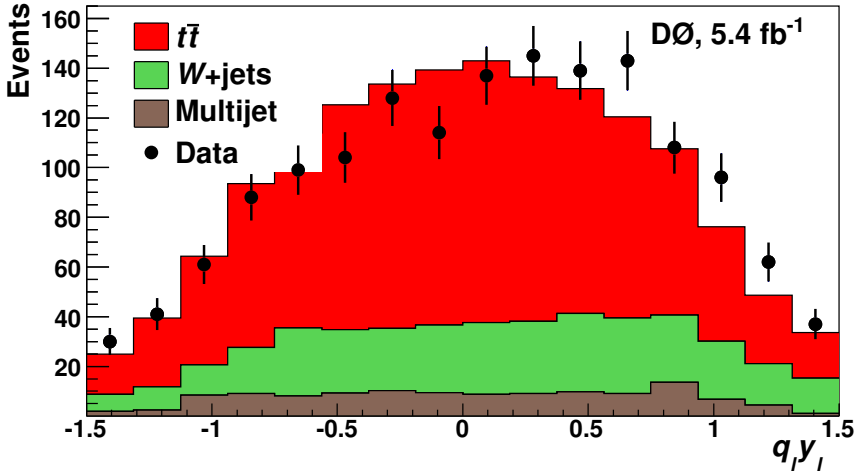
$$\text{positive \& negative leptons } A_{FB}^{\ell^{\pm}} = \frac{N_{\ell^{\pm}}(\eta > 0) - N_{\ell^{\pm}}(\eta < 0)}{N_{\ell^{\pm}}(\eta > 0) + N_{\ell^{\pm}}(\eta < 0)}$$

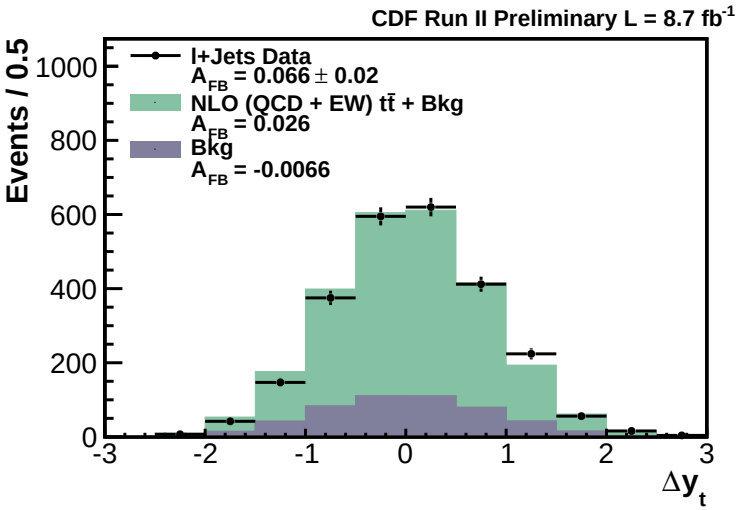
$$\text{rapidity difference } A^{\ell\ell} = \frac{N(\Delta\eta > 0) - N(\Delta\eta < 0)}{N(\Delta\eta > 0) + N(\Delta\eta < 0)}$$

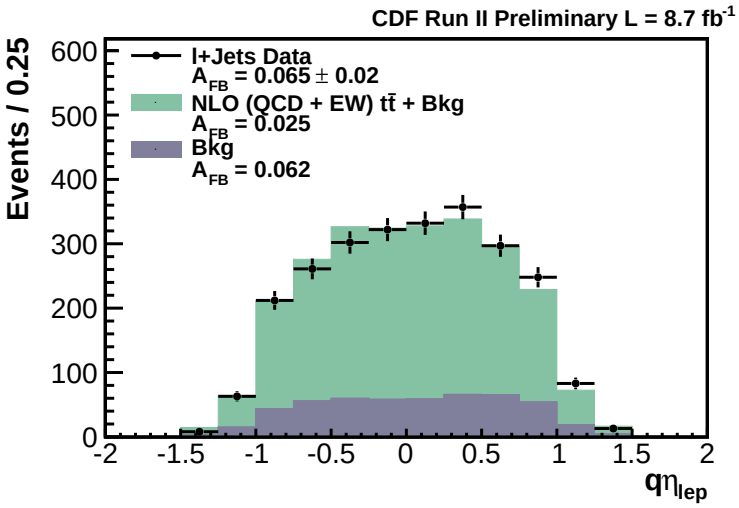
$$\text{CP asymmetry } A_{CP}^{\ell} = \frac{N_{\ell^+}(\eta > 0) - N_{\ell^-}(\eta < 0)}{N_{\ell^+}(\eta > 0) + N_{\ell^-}(\eta < 0)}$$

Results so Far





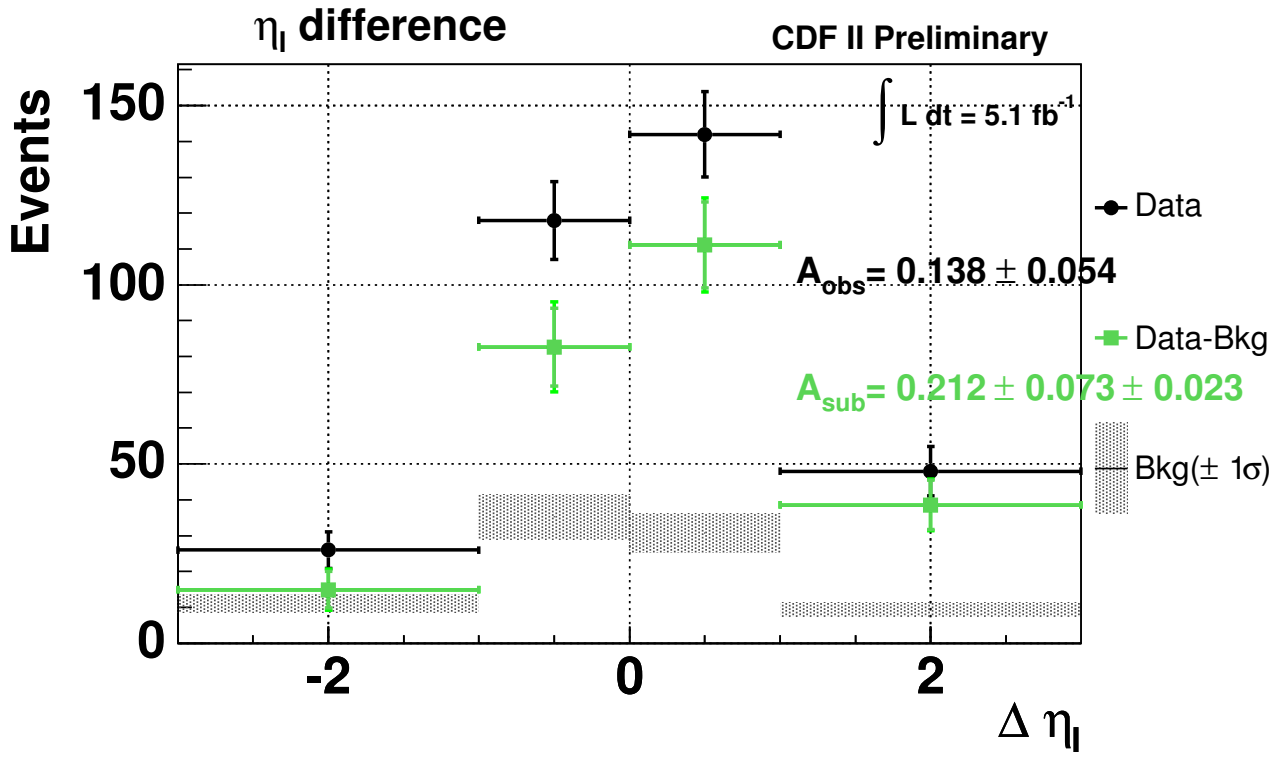




D0 sees: $A_{FB} = (9.2 \pm 3.7)\%$ and $A^{\ell}_{FB} = (14.2 \pm 3.8)\%$.

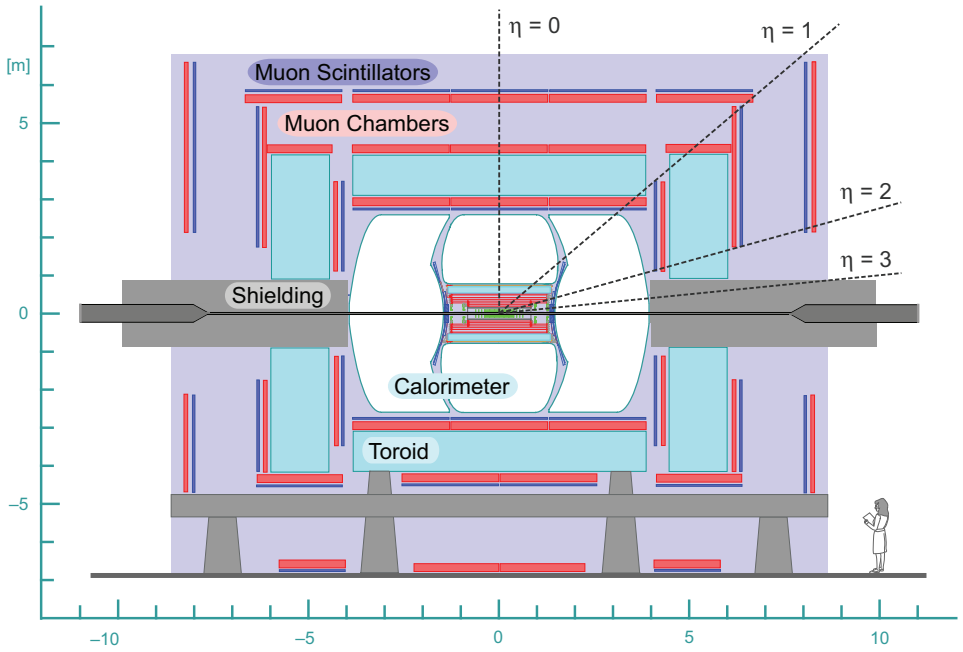
CDF sees: $A_{FB} = (6.6 \pm 2)\%$, no $A^{\ell}_{FB} = (6.5 \pm 2)\%$

Results so Far (cont)



Large $A^{\ell\ell}$ even before background subtraction and unfolding.

The DØ Experiment

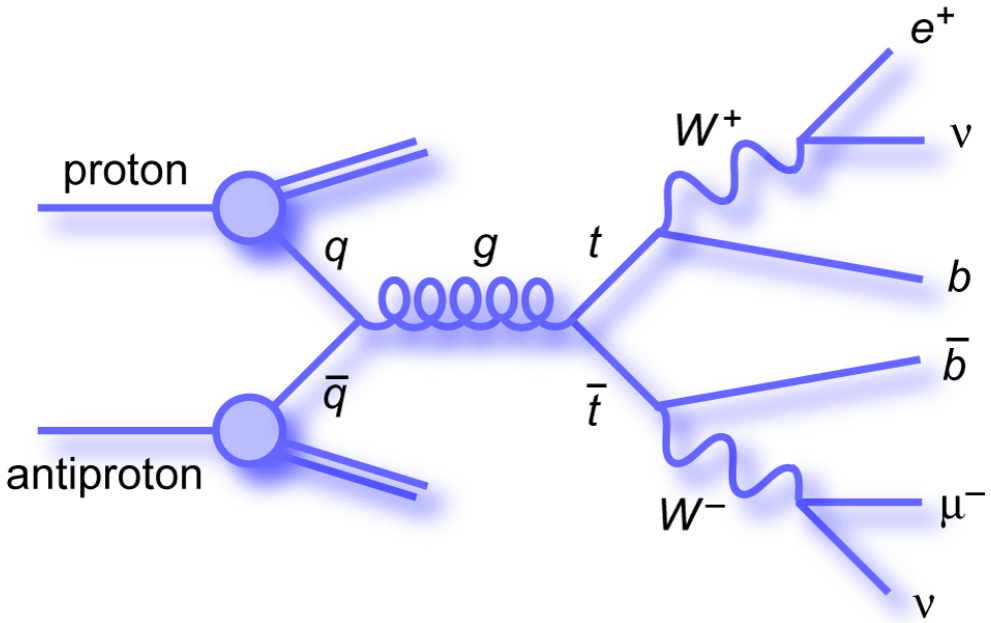


colliding protons and anti-protons at $\sqrt{s} = 1.96$ TeV, discovery of the top quark in 1995! ... shutdown in Sept 2011.

Measurement Strategy

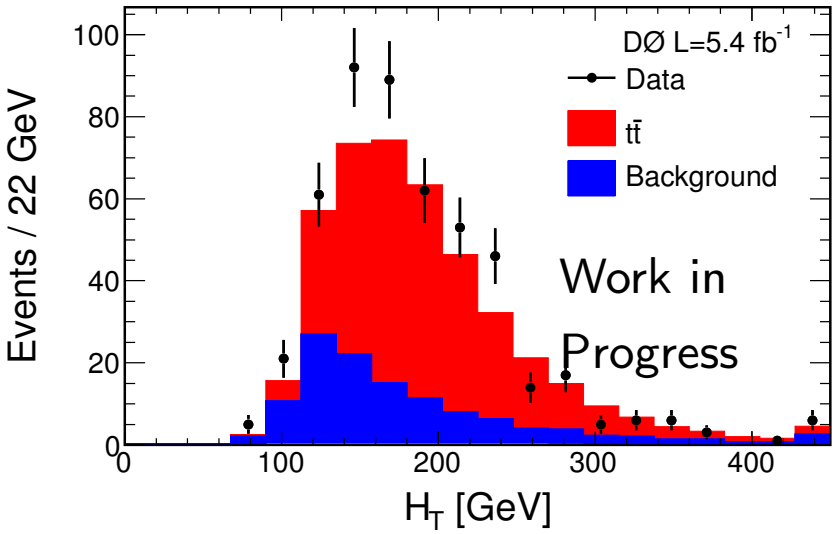
1. Select events,
2. Make predictions from MC,
3. Subtract backgrounds and correct for acceptance,
4. Estimate systematic and statistical uncertainties,
5. Done.

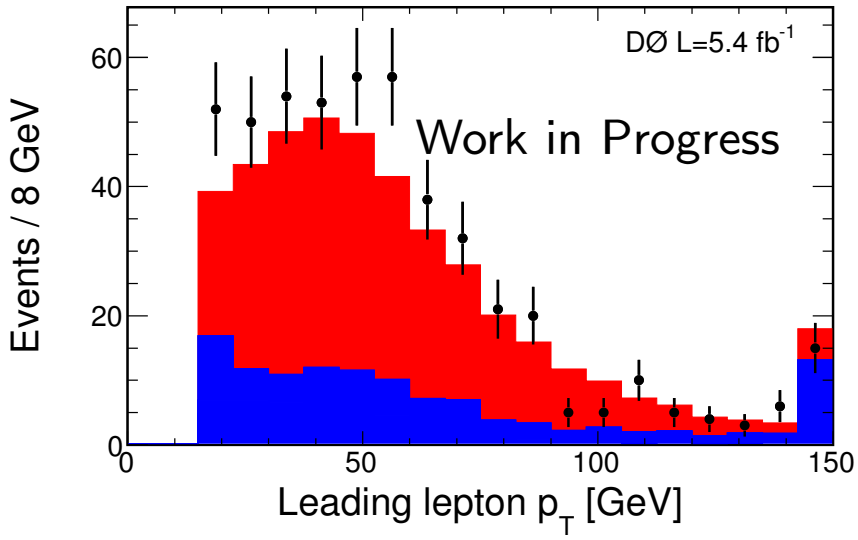
Event Selection and Monte Carlo



- Dilepton event selection as used for spin correlations measurement:
- Two opposite charge leptons ($p_T > 15$ GeV),
  - Two or more jets ($p_T > 20$ GeV),
  - Topological selection using MEt. significance, MEt or H_t.
- Comes to a total of 5.4 fb^{-1}.
- Use MC@NLO to model signal
  - Need at least NLO to observe an asymmetry.

Event Selection (cont)



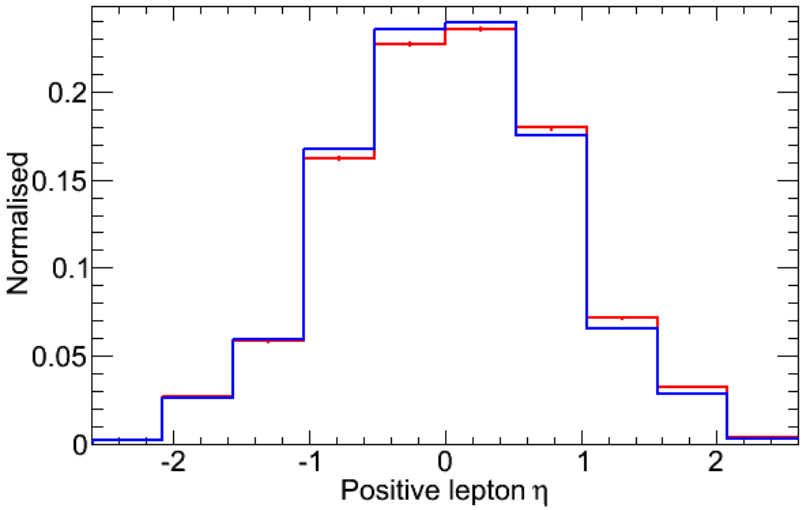


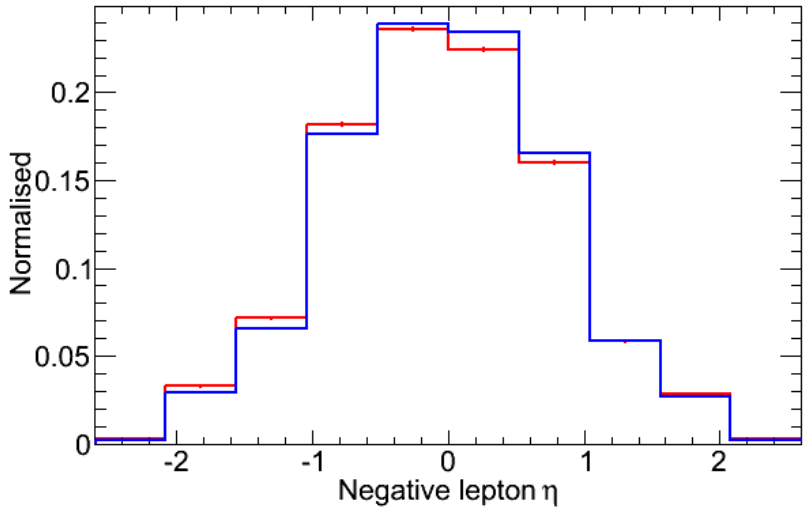
	$t\bar{t}$	Z	Diboson	Fake	Expected	Observed
$N_{jet} >= 2$	381.2 ± 0.6	9805.9 ± 29.6	183.4 ± 1.8	55.9 ± 9.4	10426.4 ± 31.1	10410
Topological	300.8 ± 0.6	84.1 ± 2.4	18.1 ± 0.9	27.6 ± 6.9	430.6 ± 7.4	487

The $t\bar{t}$ contribution is normalised to theoretical cross section.

Theory Prediction

- Asymmetry in MC@NLO is smaller than in theory calculations.
  - Only the production is NLO, decay is only LO.
- Reweight to Bernreuther's (arxiv:1003.3926) lepton rapidity distributions.
- Two dimensional reweighting as a function of η_ℓ and $\eta_{\bar{\ell}}$.
- Predictions: $A^{\ell\ell} \approx 6\%$ and $A^{\ell}_{FB} = A^{\ell+}_{FB} = -A^{\ell-}_{FB} \approx 5\%$





Blue is MC@NLO, red is reweighted.

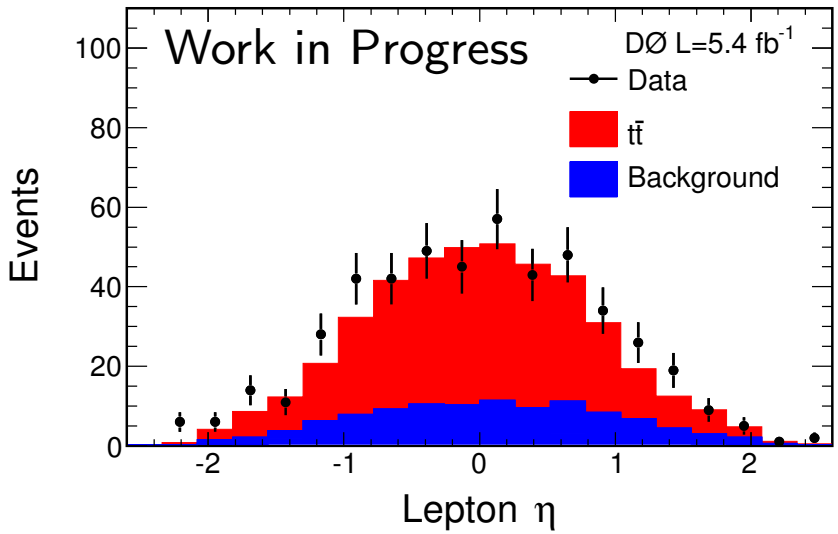
Reconstruction Effects and Acceptance Correction

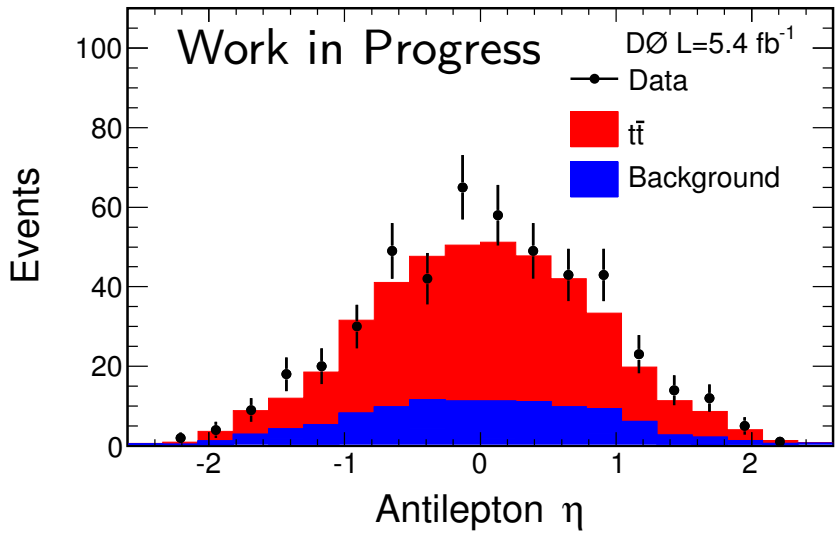
- Reconstruction effects are very small, as we only use angles.
- Calculate acceptance in MC and correct for it:

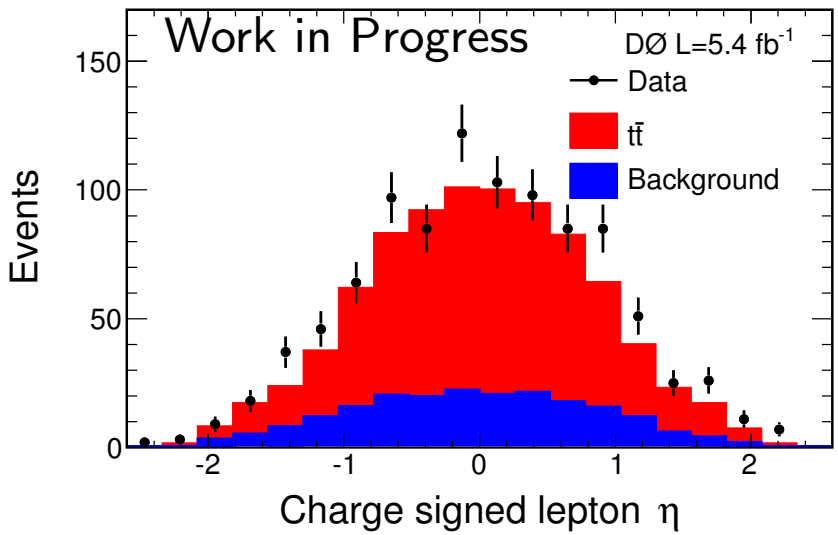
$$N_{corr} = N_{obs} \times \frac{1}{\epsilon_{acc}}$$

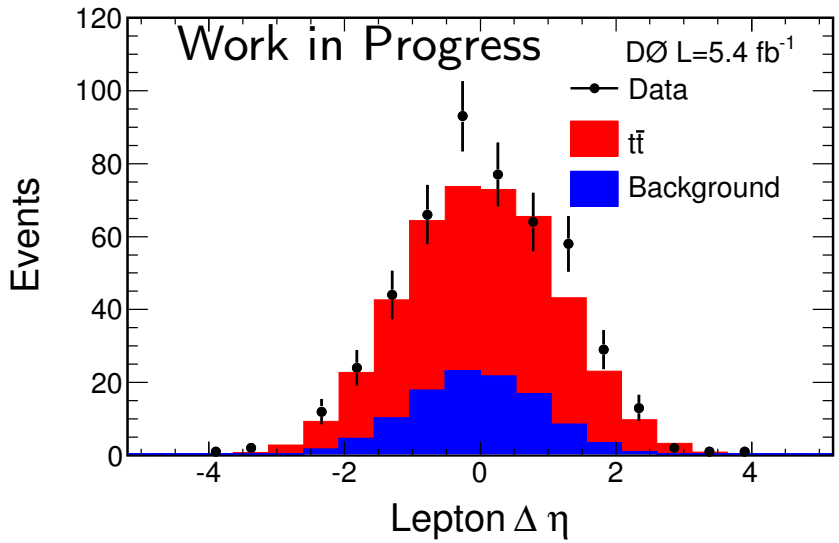
- Using MC@NLO calculate $\epsilon_{acc} = \frac{N_{acc}}{N_{tot}}$, the selection efficiency for each quantity used in the asymmetries.
- Derive a new acceptance correction for JES, bJES, JER, JetID systematic uncertainties.

Final Lepton Distributions









The contribution is normalised to theoretical cross section.

After Background Subtraction and Acceptance Correction

- This is work in progress.
- Combine channels using BLUE method.
- Rapidity difference:

$$A^{\ell\ell} = (3.3 \pm 6.2)\%$$

  MC prediction of $A^{\ell\ell} = (5.7 \pm 0.15)\%$.
- Combining positive and negative leptons:

$$A^{\ell}_{FB} = (5.8 \pm 5.3)\%$$

  MC prediction of $A^{\ell}_{FB} = (5 \pm 0.11)\%$.
- CP asymmetry:

$$A^{\ell}_{CP} = (-1.8 \pm 5.3)\%$$

- Splitting by lepton charge:

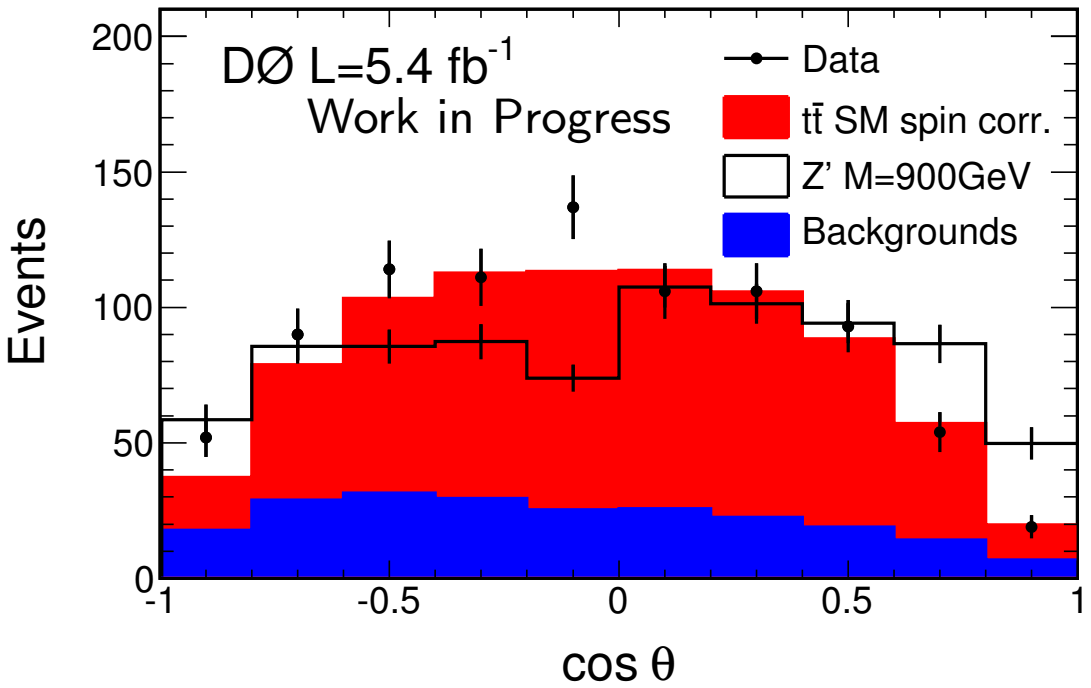
$$A^{\ell^+}_{FB} = (+4.1 \pm 6.9)\%$$
$$A^{\ell^-}_{FB} = (-8.4 \pm 7.8)\%$$

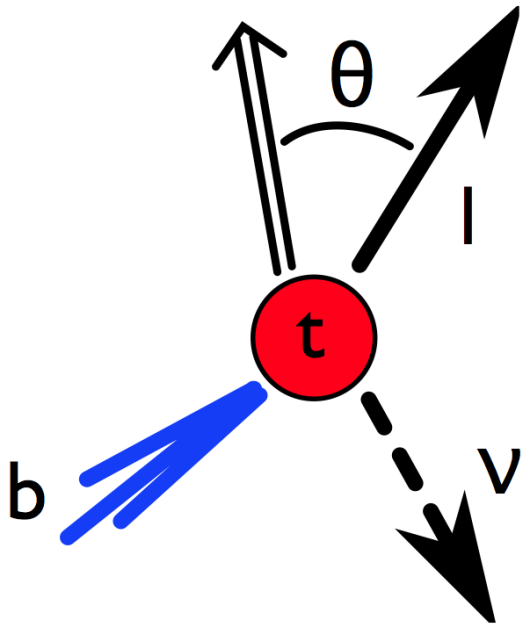
Top Polarisation

- Some models which aim to explain the D0 and CDF results predict polarised top quarks.
- This would show up as $B_{1,2} \neq 0$:

$$\frac{1}{\sigma}\frac{d\sigma}{d\cos\theta_1 d\cos\theta_2} = \frac{1}{4}(1 + B_1\cos\theta_1 + B_2\cos\theta_2 - C\cos\theta_1\cos\theta_2)$$

- Well known variables from the spin correlations analysis.





Conclusions

- No significant deviation from the SM observed in the $t\bar{t}$ dominated samples.
- Work in progress.
- After correcting for acceptance, all channels combined:

$$A^{\ell\ell} = (3.3 \pm 6.2)\%$$
$$A^{\ell}_{FB} = (5.8 \pm 5.3)\%$$

- Predictions:

$$A^{\ell\ell} = (6 \pm 0.15)\%$$
$$A^{\ell}_{FB} = (4 \pm 0.11)\%$$