W polarizisation in top decays

An introduction to measure A_{FB}

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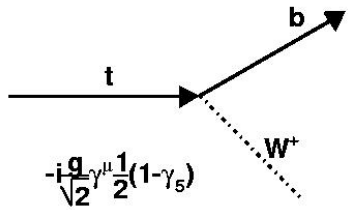
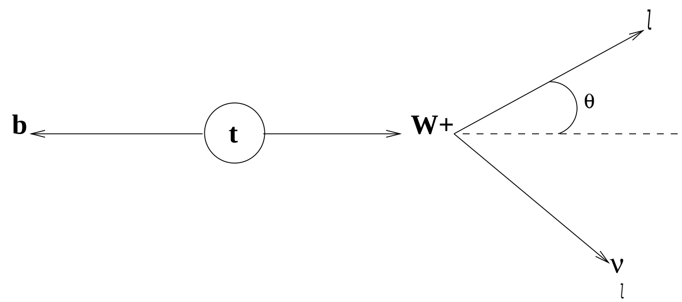
Reminder:





- Decay rate (Phys.Review D63, 031501(R) (2001)):

$$\frac{dF}{d\cos\theta} = \frac{3}{8}\left(1+\cos\theta\right)^2 F_+ + \frac{3}{8}\left(1-\cos\theta\right)^2 F_- + \frac{3}{4}\sin^2\theta F_L$$

- Forward-backward asymmetry: $A_{FB} = \frac{F_F - F_B}{F_F + F_B} = \frac{3}{4}\frac{F_+ - F_-}{F_+ + F_- + F_L}$
- SM-Born term:

$$F_L = \frac{M_t^2/2M_W^2}{1+M_t^2/2M_W^2},\ F_- = \frac{1}{1+M_t^2/2M_W^2},\ F_+ = 0$$

- Because $M_t >> M_W$, top decays give more **longitudinally** polarized W's.

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Theoretical Values & corrections for $F_L,\ F_+,\ F_-,\ A_{FB}$ (Phys.Review D67, 091501(R) (2003))

- For $M_t = 175\ GeV$ and for $M_W = 80.419\ GeV$:

$$F_L = 0.703,\ F_- = 0.297,\ F_+ = 0,\ A_{FB} = -0.2270$$

- Theoretical corrections to be into account:
  - QCD one-loop corrections
  - EW one-loop corrections
  - W finite width corrections
  - $m_b \neq 0$

	QCD	EW	FW	$m_b \neq 0$	Total
δF_-	-6.56%	2.06%	-1.97%	-0.172%	-6.64%
δF_L	-9.51%	1.32%	-1.38%	-0.357%	-9.93%
δF_+	+0.000927	+0.0000745	—-	+0.000358	+0.00136

- The EW corrections tend to cancel the FW ones.
- FW corrections for top quark mass are smaller since $\Gamma_t < \Gamma_W$
- There are not FW corrections for F_+.
- An exceeess of more than 1% at F_+ will have a non-SM origin.
- Numbers must be recalculated using new values for the top quark mass.

Till now (value $\pm$ stat $\pm$ syst):

	CDF, 162 pb^{-1}, $\sqrt{s} = 1.96$ TeV lepton+jets (CDF Note 6969)	ATLAS, 10 fb^{-1}, $\sqrt{s} = 14$ TeV semi+di leptonic (Rome Workshop)
F_-		$0.301 \pm 0.003 \pm 0.023$
F_L	$0.99^{+0.29}_{-0.35} \pm 0.19$	$0.698 \pm 0.004 \pm 0.016$
F_+	$0.23 \pm 0.16 \pm 0.08$	$0.001 \pm 0.003 \pm 0.012$

For ATLAS, the derived result for A_{FB} is: $A_{FB} = 0.226 \pm 0.003 \pm 0.016$

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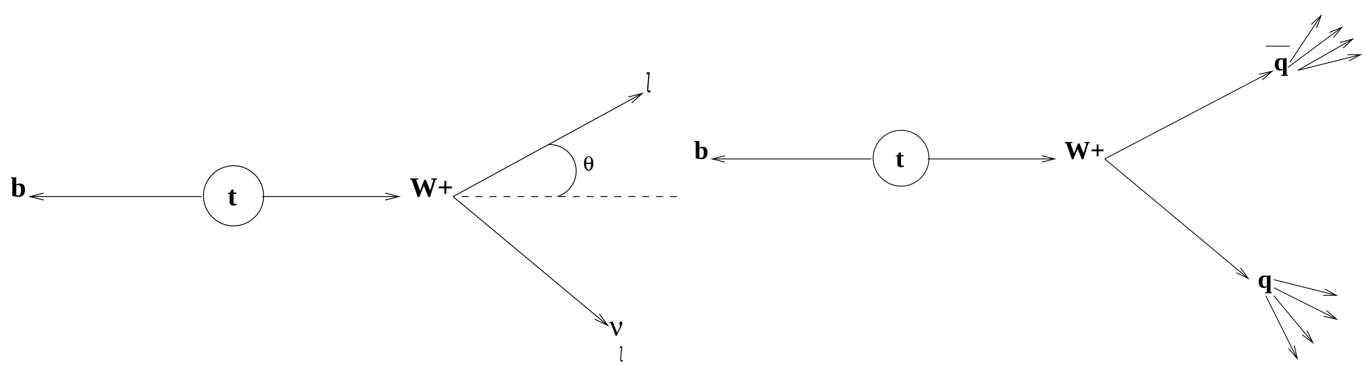
Why do we study the A_{FB}? (PhysRev. D67,014009(2003))

- Parametrize the most general CP-conserving Wtb vertex with an **effective** Langrangian with **one-loop QCD correction**:

$$\mathcal{L} = -\frac{g}{\sqrt{2}}\bar{b}\gamma^{\mu}(V_{tb}^{L}P_L + V_{tb}^{R}P_R)tW_{\mu}^{-} - \\ - \frac{g}{\sqrt{2}}\bar{b}\frac{i\sigma_{\mu\nu}q_{\nu}}{M_W}(g^{L}P_L + g^{R}P_R)tW_{\mu}^{-})$$

- Within the SM: $V_{tb}^{R} = g^{L} = 0$ and $g^{R} = -0.00642$
- A_{FB} is very **sensitive** to any deviation of these parameters from the SM value (especially on g^{R} where the dependence is linear.)

- Till now, the measurment of A_{FB} has been **indirect**, i.e calculated from the measurments of the polarization quantities.
- Effort for direct measurment with the ATLAS detector.
- $A_{FB} = \frac{N(x>0)-N(x<0)}{N(x>0)+N(x<0)}$, where $x = \cos\theta_{\ell b}$



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- The study was performed using the semileptonic decay of the top using $t\bar{t}$.
  - Why can't we use the semileptonic decay of **single** top samples?
  - $\sigma_t = 300\ pb,\ \sigma_{t\bar{t}} = 850\ pb$ but less background & less systematic errors - maybe...
- For $t\bar{t}$ events the SM backgrounds are:
  - QCD $b\bar{b}$: eliminated after selection cuts
  - W+jets, Z+jets: 0.2%
  - WW, ZZ, ZW: 0.01%
  - single t production(diagrams tbj, tW, and tb): 2%
  - $t\bar{t}_{SM}$: (10% major!)

    Both Ws decay hadronically or leptonically or the semileptonic decay involves τ : $W \to \tau\nu_\tau,\ \tau \to e(\mu)\nu_e(\nu_\mu)\nu_\tau$

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- statistical errors will be very small
- must fight the systematics errors. Major:
  - **b-jet energy scale**
  - **corrections for the bias introduced by the selection cuts**
  - b-tag efficiency
  - top mass
- Two methods applied for selecting the signal from background: sequential & probabilitstic
- Preliminary value: $A_{FB} = 0.2207 \pm 0.0033(stat) \pm 0.0236(syst)$