



Measurement of the W boson helicity in top quark decay at DØ

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On Behalf of the DØ Collaboration



Theory - Weak Coupling



Parity violation - Cobalt 60

Theory: Weak interaction is

$$\gamma^\mu (1 + \epsilon \gamma^5)$$

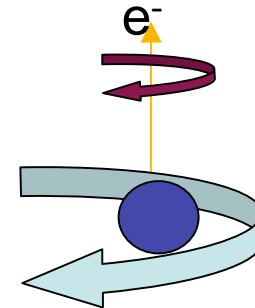
(Vector + axial vector => parity violation)

Experiments: $\epsilon = -1$ (Maximal violation)

$$\gamma^\mu (1 - \gamma^5) = \gamma^\mu - \gamma^\mu \gamma^5 = \text{“V - A”}$$

Matter is left handed: $SU(2)_L$

Anti-matter is right handed



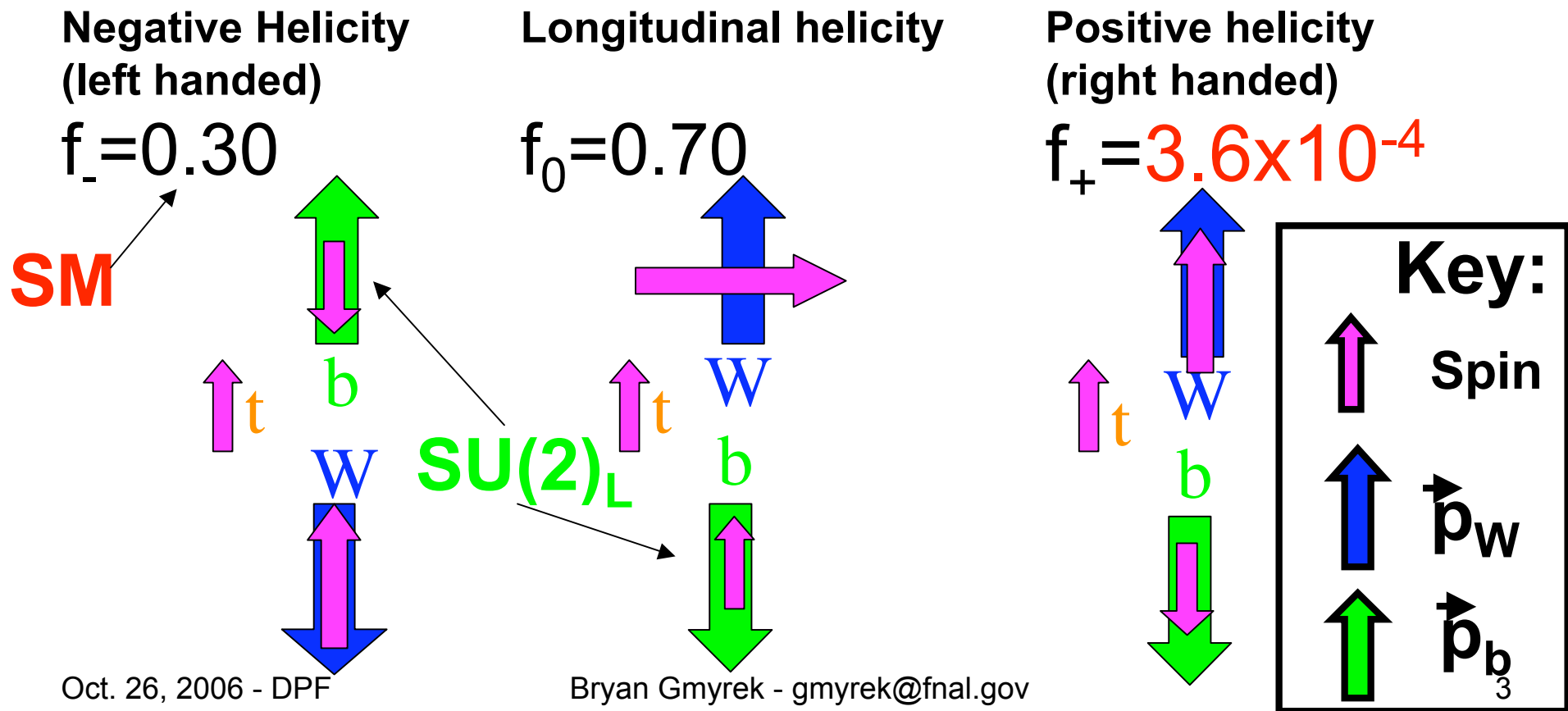


Theory - W Boson Helicity



Does V-A hold true for $t \rightarrow W + b$?

Helicity = projection of spin onto momentum





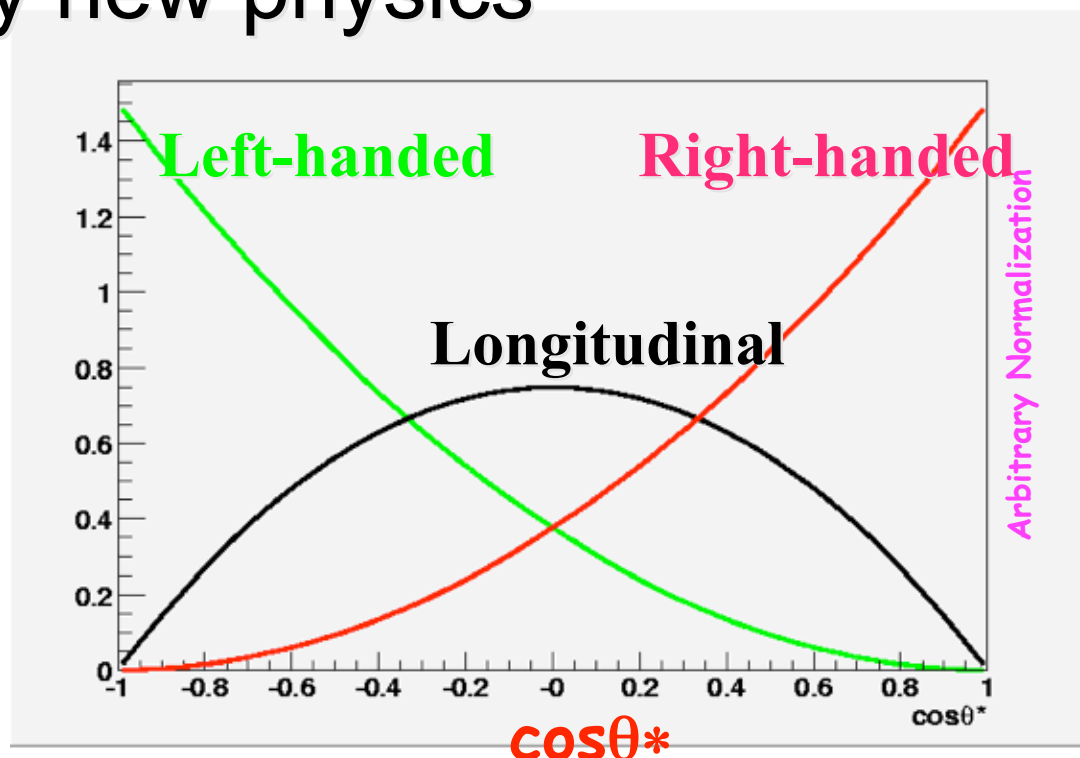
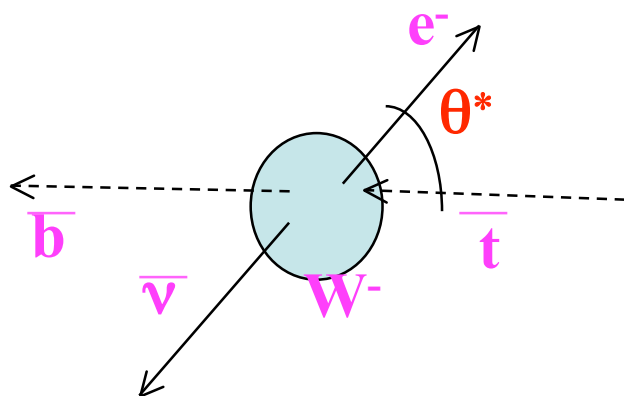
Theory - $\cos(\theta^*)$



Distribution

Helicity affects angle of lepton

$f_+ \neq 0$ would imply new physics





Data / Selection Cuts Summary



370 pb⁻¹ with Fermilab DØ Detector at $\sqrt{s}=1.96$ TeV

e+jets, μ +jets, ee, $\mu\mu$, e μ

Lepton + jets:

One Lepton $P_T > 20$ GeV, $ME_T > 20$ GeV, ≥ 4 jets

Dilepton:

Two leptons $P_T > 15$ GeV, ≥ 2 jets

Both: Jet $P_T > 20$ GeV, rapidity < 2.5



$\cos(\theta^*)$ Reconstruction (l+jets)

Need to determine jet-lepton associations.

Kinematic constrained fit to the $t\bar{t}$ hypothesis.

Use M_W and $m_{\text{top}} = 175$ GeV constraints.

12 permutations - choose lowest χ^2 .

Correct b-jet selected 58% of the time.

Neutrino 4-vector returned from fitter.

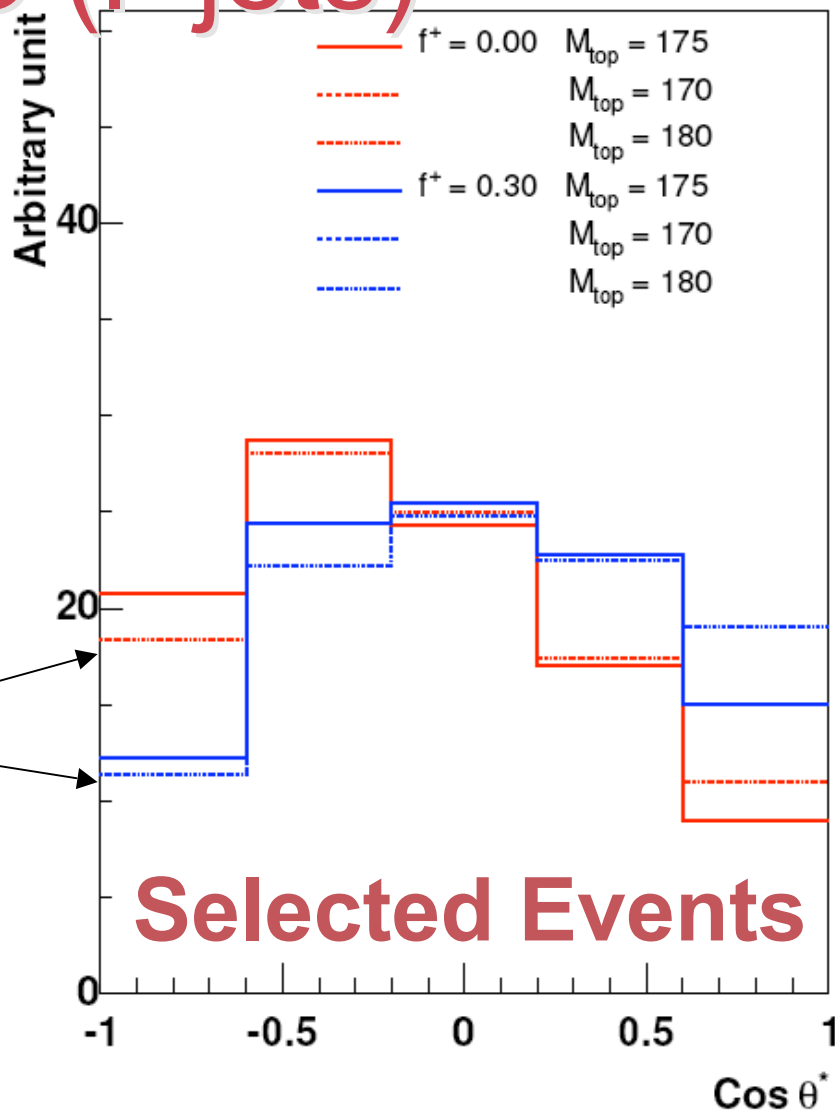
Boost into W rest frame and measure $\cos(\theta^*)$.



Signal MC (l+jets)

Generate $\cos(\theta^*)$ templates with $f_+ = 0.0$ and 0.3 using ALPGEN

Effect of varying top mass also shown



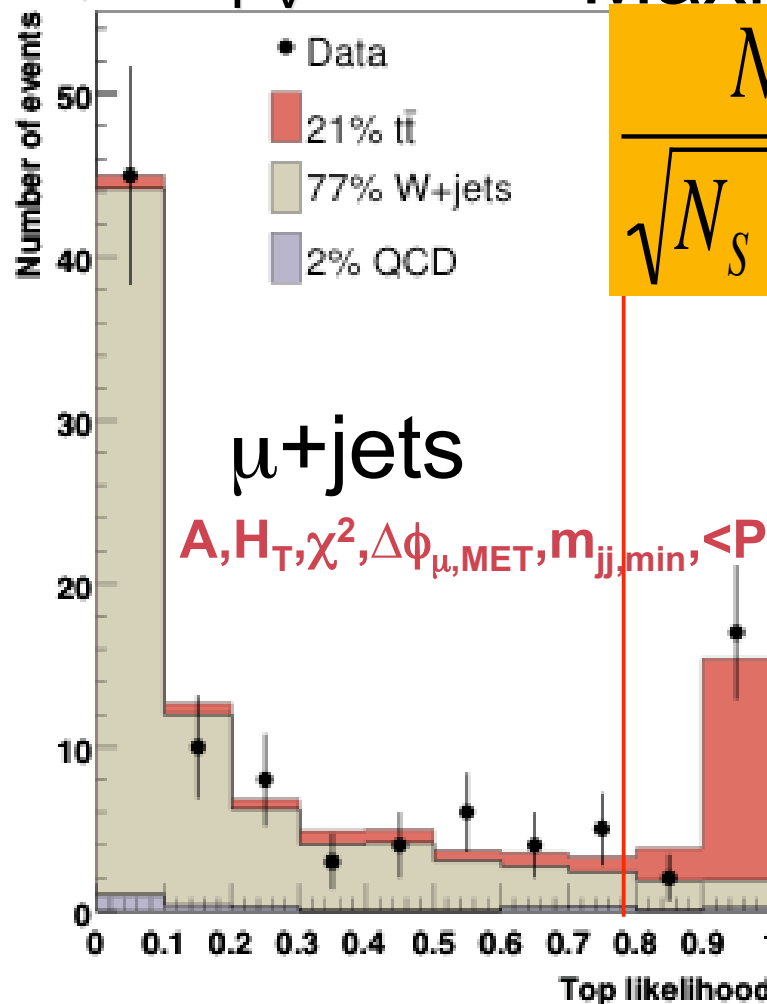
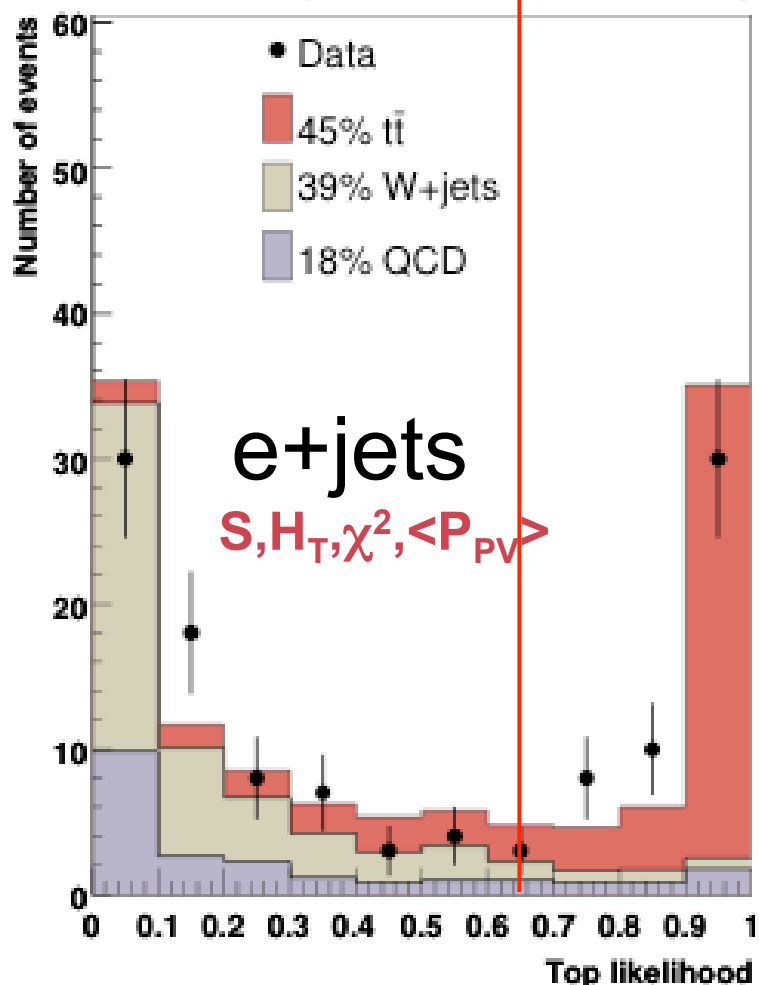


Likelihood Discriminant D



Aplanarity, Sphericity, ..., $\langle P_{PV} \rangle$.

Maximize



$$\frac{N_S}{\sqrt{N_S + N_B}}$$



$\cos(\theta^*)$ Reconstruction (dilepton)

Fix top mass, consider all permutations.

Two values of $\cos(\theta^*)$ per event.

For each lepton:

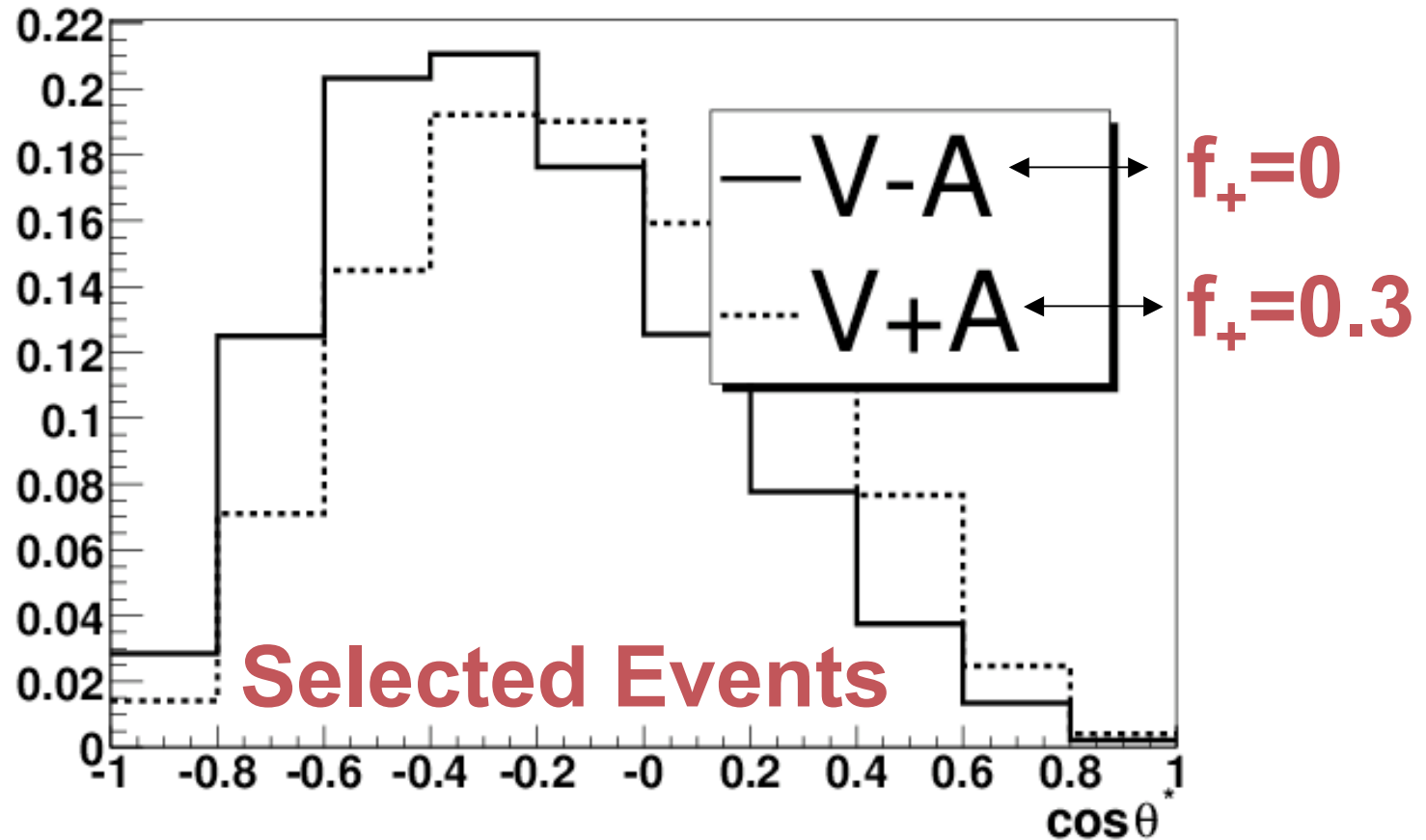
Fluctuate objects within resolutions and re-solve.

Average over all solutions.

Average result is $\cos(\theta^*)$.

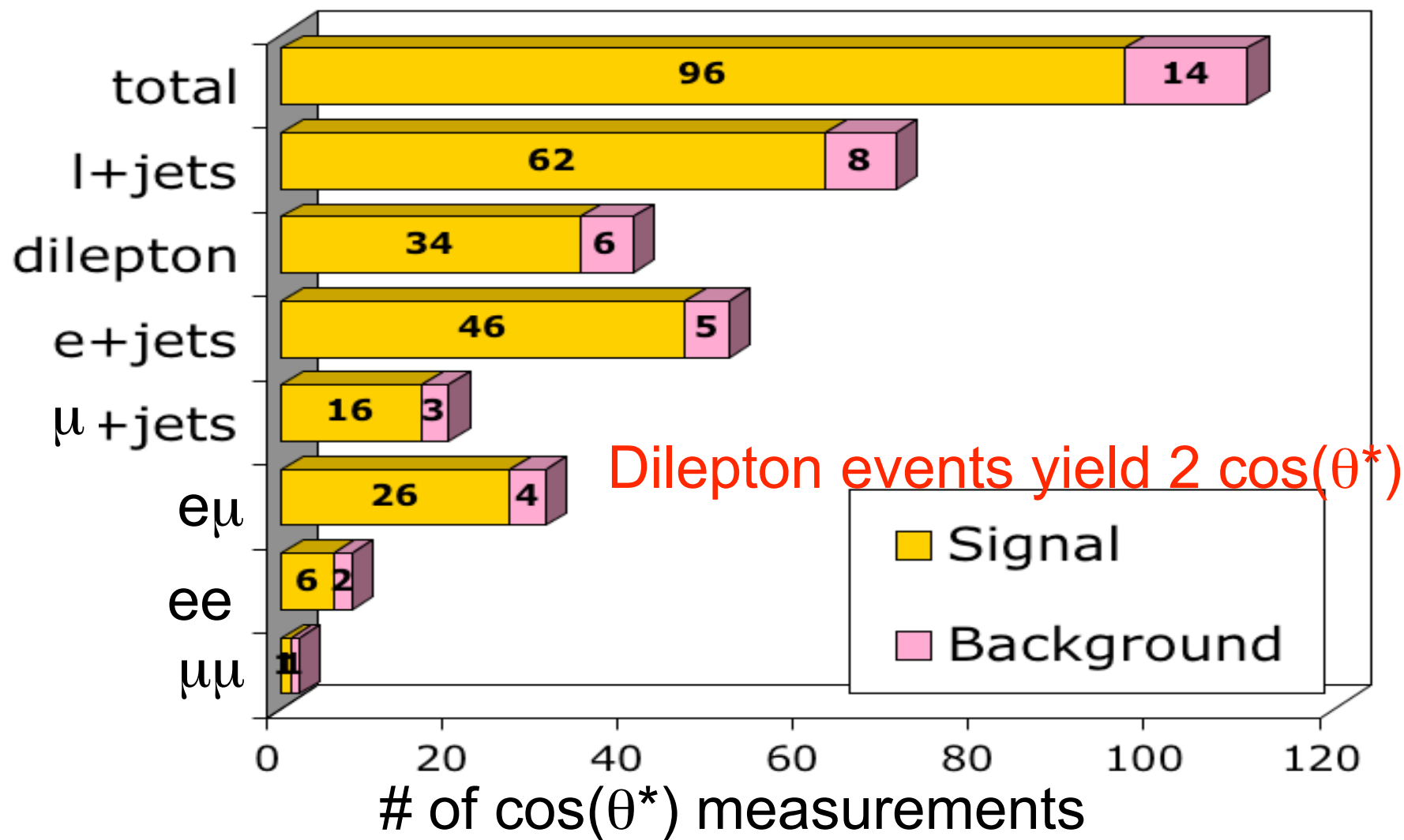


Signal MC (dilepton)





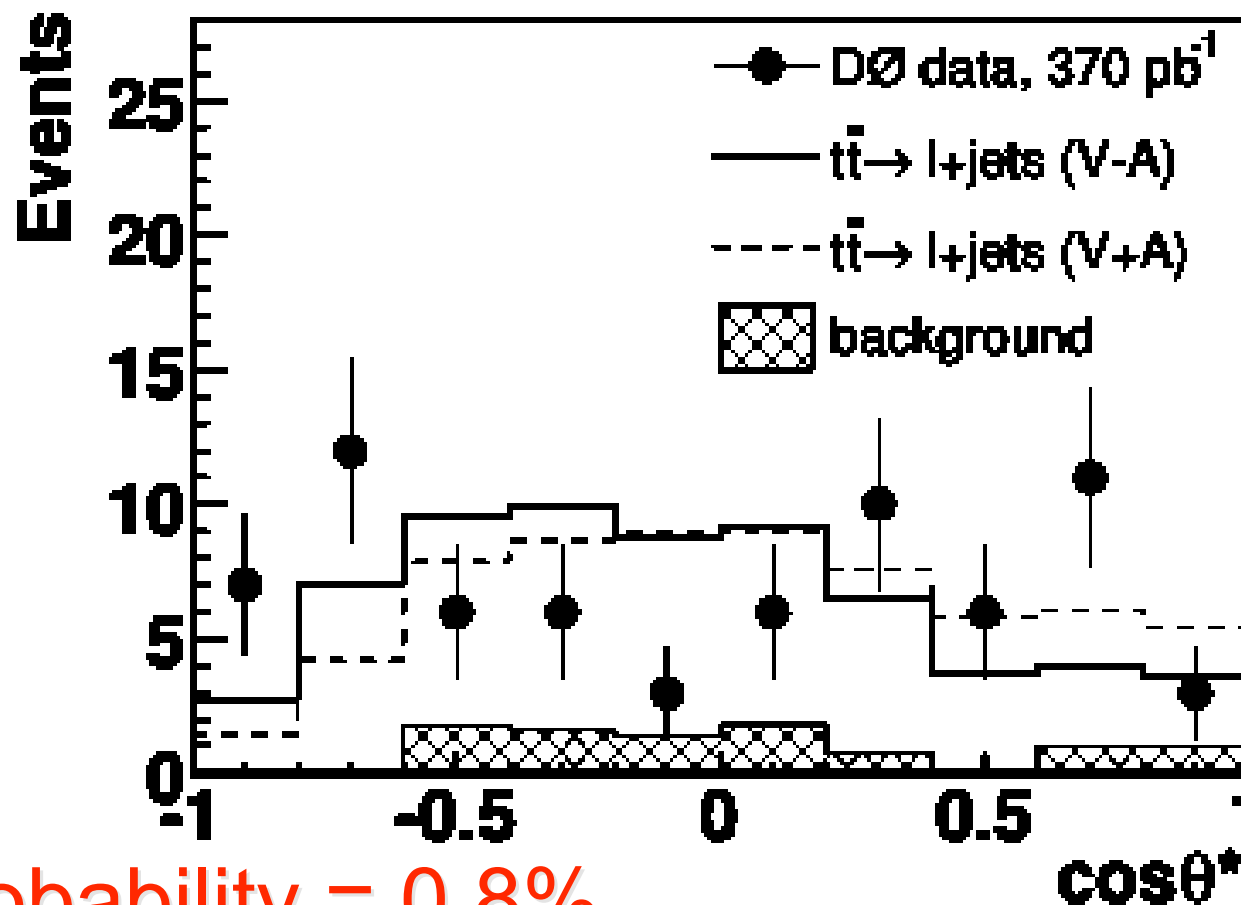
Selected Data





Data/SM Comparison

Combined e+jets and μ +jets (70 events)

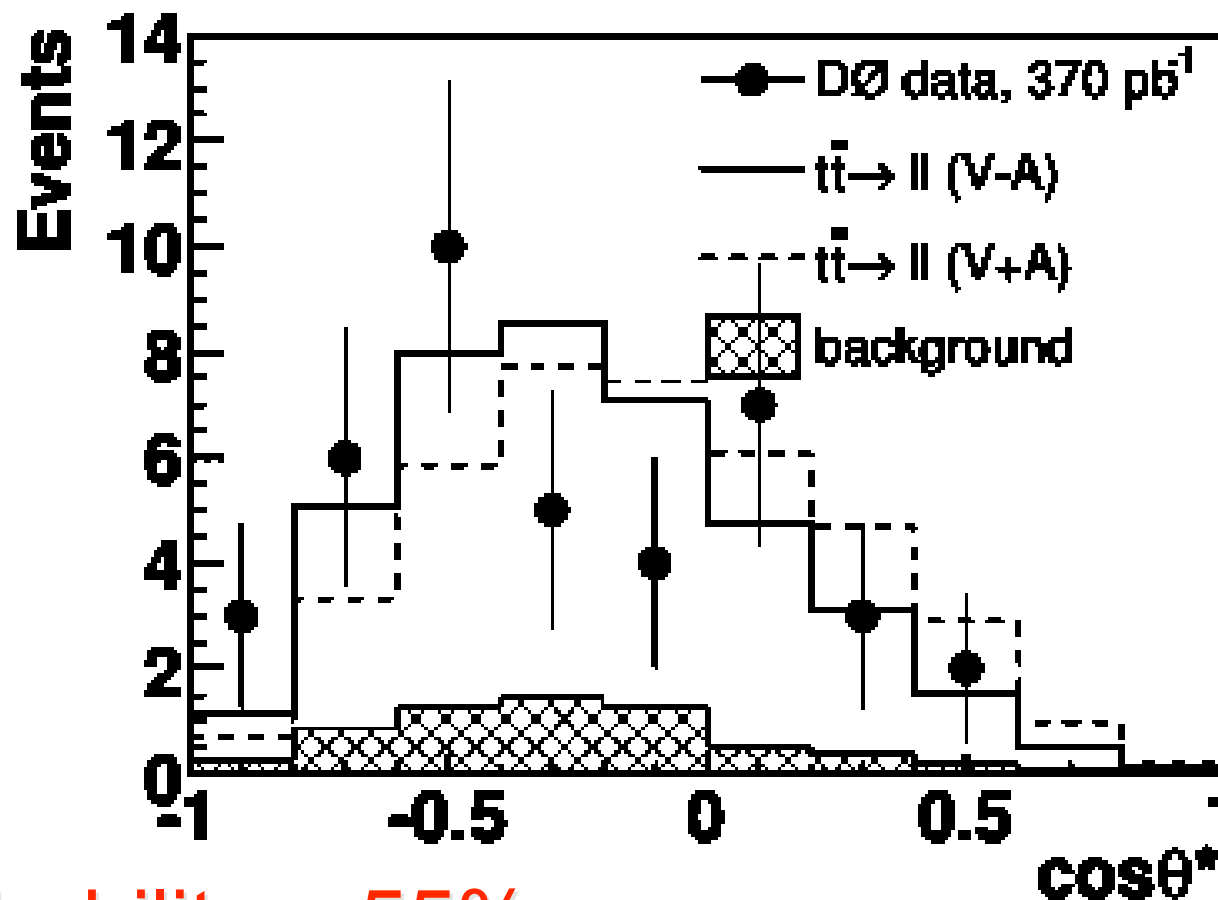


Fit Probability = 0.8%



Data/SM Comparison

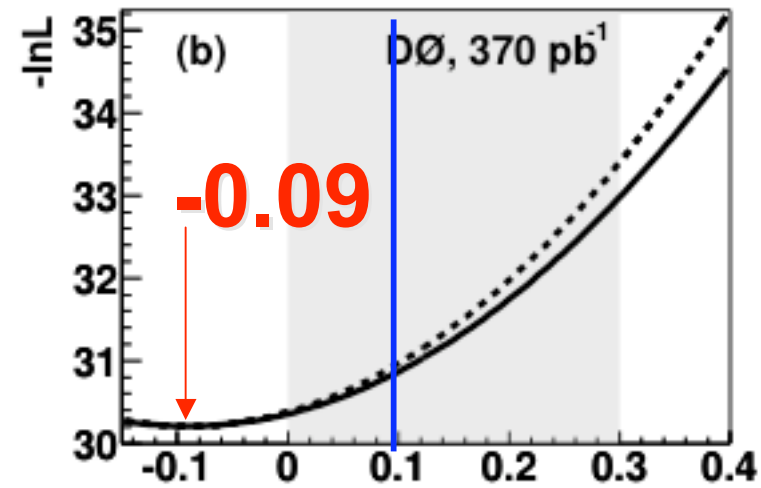
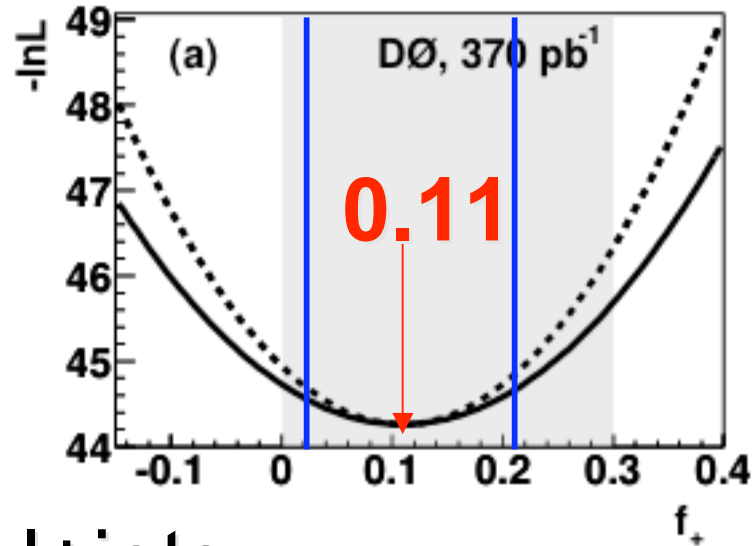
Combined ee , $\mu\mu$, $e\mu$ ($40 \cos(\theta^*)$ measurements)



Fit Probability = 55%



Maximum Likelihood Fit

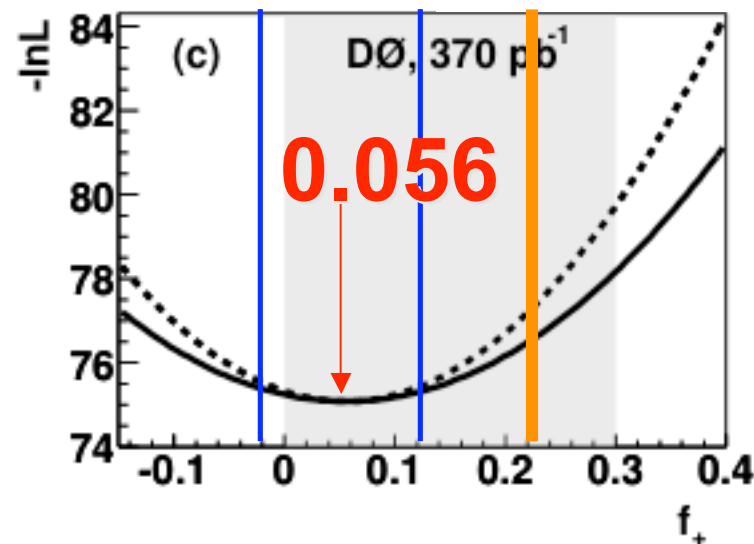


l+jets

dilepton

Fix f_0 at 0.7

Combined



Key:

Central Values

$\pm 1\sigma$

95% C.L.



Results Summary



Systematics: JES (0.038), MC Stats (0.028), M_{top} (0.021)

l+jets: $f_+ = 0.11 \pm 0.09$ (stat) ± 0.06 (syst)

dilep: $f_+ = -0.09 \pm 0.15$ (stat) ± 0.06 (syst)

both: $f_+ = 0.06 \pm 0.08$ (stat) ± 0.06 (syst)

$f_+ < 0.23$ @ 95% Bayesian C.L.

Consistent with standard model prediction

Currently investigating fit of f_+ and f_0 .



Selected References



Measurement of the W boson helicity in top quark decay at $D\emptyset$
(**Submitted to PRL**) 2006

<http://arxiv.org/abs/hep-ex/0609045>

Search for right-handed W bosons in top quark decay (2005)

<http://link.aps.org/abstract/PRD/v72/e011104>

'Plain English' Summary 2005

<http://tinyurl.com/yzcjom>