Measurement of top quark polarization in t-channel single-top production

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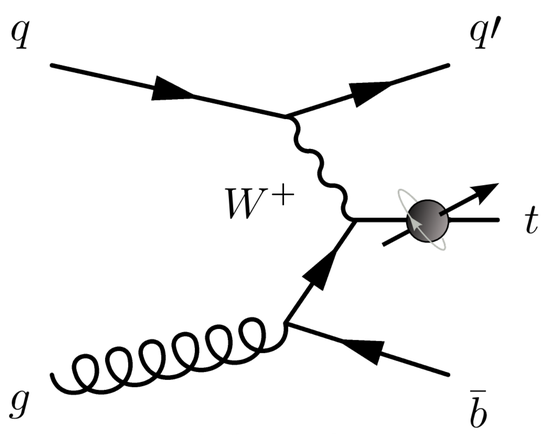
on behalf of the CMS collaboration

Top Quark Polarization



t-channel

- Single-top quark t-channel production is 100% polarized in SM due to V-A coupling
- Top quark decays before hadronization, decay products keep spin information
- **Spin asymmetry A_l** allows to measure top-quark polarization, spin analyzing power for leptons $\alpha_l \approx 1$

$$A_l \equiv \frac{1}{2} \cdot P_t \cdot \alpha_l = \frac{N(\uparrow) - N(\downarrow)}{N(\uparrow) + N(\downarrow)}$$

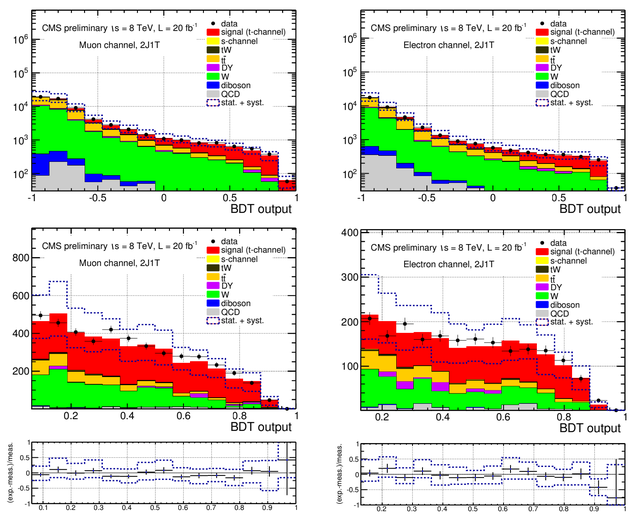
- Angular distribution of charged lepton from top-quark decay:

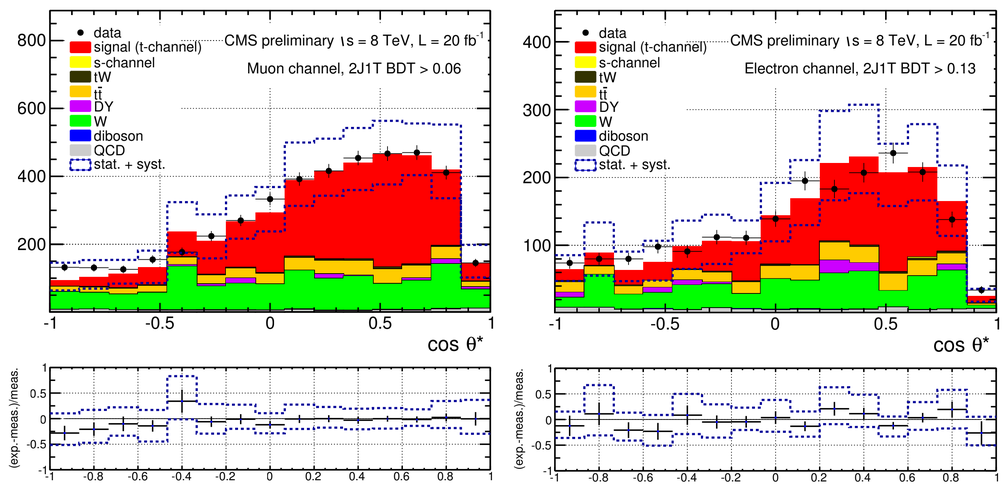
$$\frac{d\Gamma}{d\cos\theta_l} = \frac{\Gamma}{2}(1 + P_t \alpha_l \cos\theta_l) \equiv \Gamma(\frac{1}{2} + A_l \cos\theta_l)$$

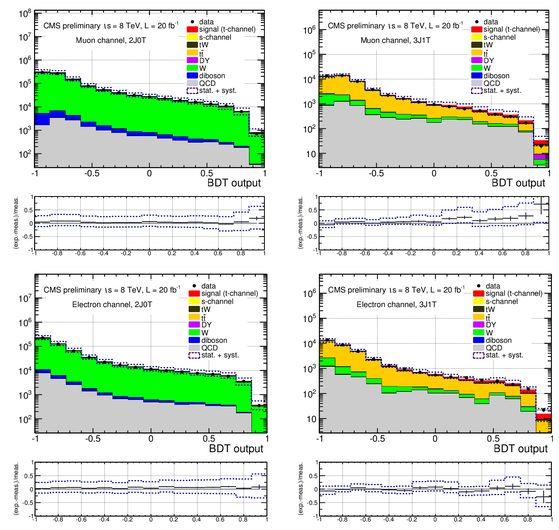
- **Measure polarization with cosθ*: θ* = ∡(charged lepton, untagged jet)** in top-quark rest-frame, prefered top-quark spin direction is parallel to recoiling light jet
- New physics can change polarization through anomalous couplings (V_L, V_R, g_L, g_R)

Event selection and background estimation

- **Selection:** e or μ, 2 jets, 1 b-tag, $M_T(W)$ (μ) or MET (e) cut
- **BDT** trained with 9 well modeled input variables not correlated to cosθ*
- Further enrichment of S/B with cut on BDT output
- Top quark is reconstructed from b-tagged jet, lepton and MET
- **Background estimation** with binned likelihood template fit to BDT output
- QCD template estimated in anti-isolated sideband region from fit to $M_T(W)$/MET
- BDT output checked in control regions (2j0t, 3j1t, 3j2t)



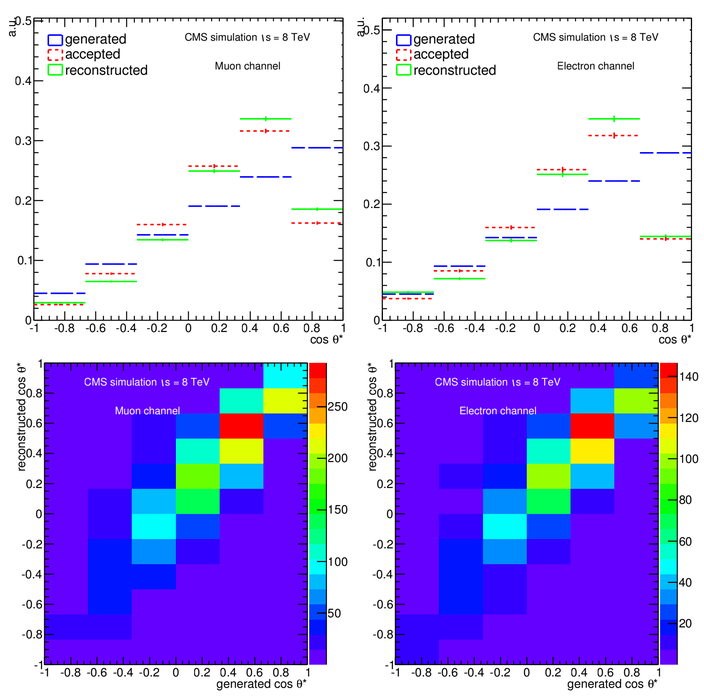


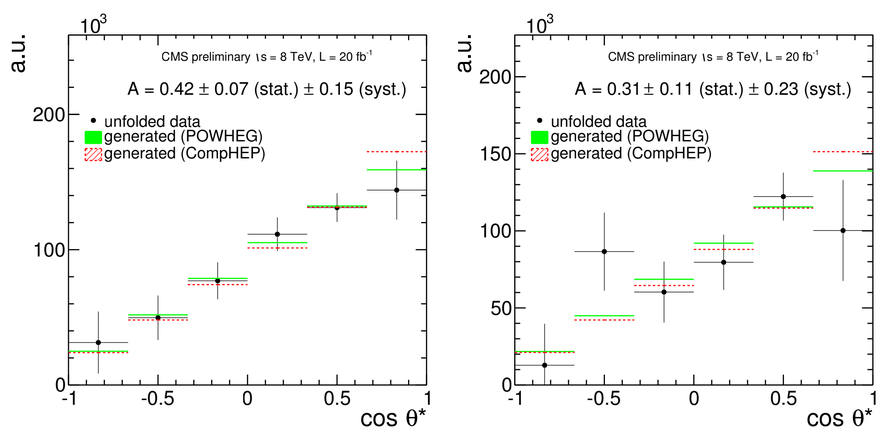


Unfolding

Reconstructed distributions are corrected for background contributions, migration effects and selection efficiency:

- Background templates are decorrelated, taking fit correlation into account, and subtracted from data
- Non-flat selection efficiency is corrected
- Regularized unfolding using a generalized matrix inversion method with TUnfold
- Regularization parameter estimated with minimum global correlation method





- Top-quark spin asymmetry extracted from unfolded distributions:

$$A_l = \frac{N(\cos\theta^*_{unfolded} > 0) - N(\cos\theta^*_{unfolded} < 0)}{N(\cos\theta^*_{unfolded} > 0) + N(\cos\theta^*_{unfolded} < 0)}$$

Results with ∫L dt = 20/fb at $\sqrt{s}$ = 8 TeV

$$A_l^\mu = 0.42 \pm 0.07(stat.) \pm 0.15(syst.)$$
$$A_l^e = 0.31 \pm 0.11(stat.) \pm 0.23(syst.)$$

- Combination with BLUE method yields:

$$A_l = 0.41 \pm 0.06(stat.) \pm 0.16(syst.) = 0.41 \pm 0.17$$
$$P_t = 0.82 \pm 0.34$$

assuming α_l = 1

- Systematic uncertainties are estimated by repeating the background estimation and unfolding with systematic varied templates

Uncertainty source	δA_l^μ	δA_l^e
generator	0.025	0.009
Q^2 scale t-channel	0.024	0.055
Q^2 scale, $t\bar{t}$	0.015	0.005
Q^2 scale, W+jets	0.036	0.038
top quark mass	0.058	0.042
W+jets shape	0.016	0.007
W+jets flavour	0.005	0.008
top p_T, $t\bar{t}$	0.010	0.025
matching, $t\bar{t}$	0.028	0.052
matching, W+jets	0.025	0.038
PDF	0.013	0.014
JES	0.074	0.074
JER	0.016	0.179
unclustered MET	0.013	0.006
lepton ID and isolation	0.001	0.002
lepton trigger	0.001	0.002
pileup	0.015	0.002
b tagging	0.007	0.009
mistagging	0.001	0.003
lepton weight	0.001	0.009
anti-isolation range of QCD	0.010	0.053
QCD fraction	0.092	0.028
background fractions	0.007	0.018
unfolding bias	0.002	0.003
total systematics	0.15	0.23
statistical	0.07	0.11
total	0.17	0.26

http://is.gd/stpol

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