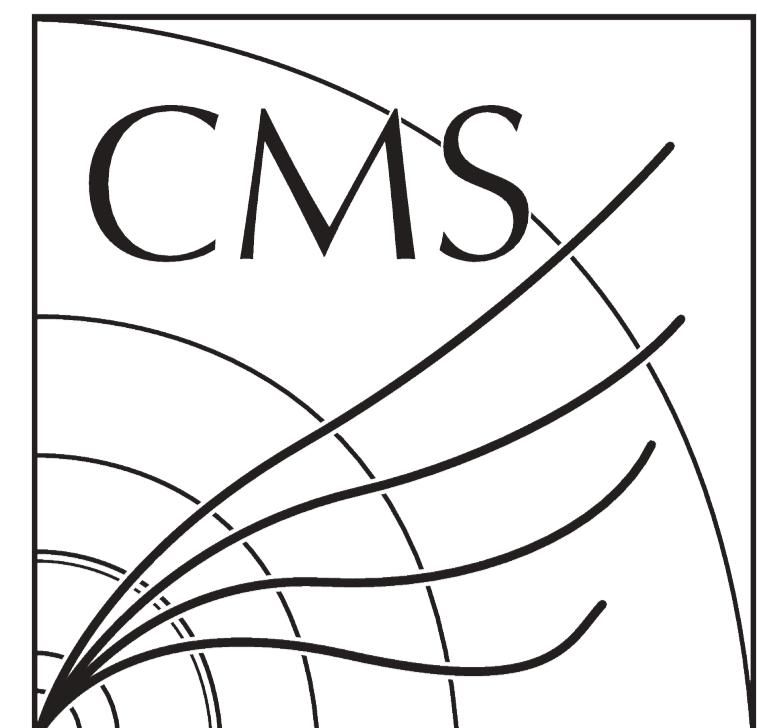




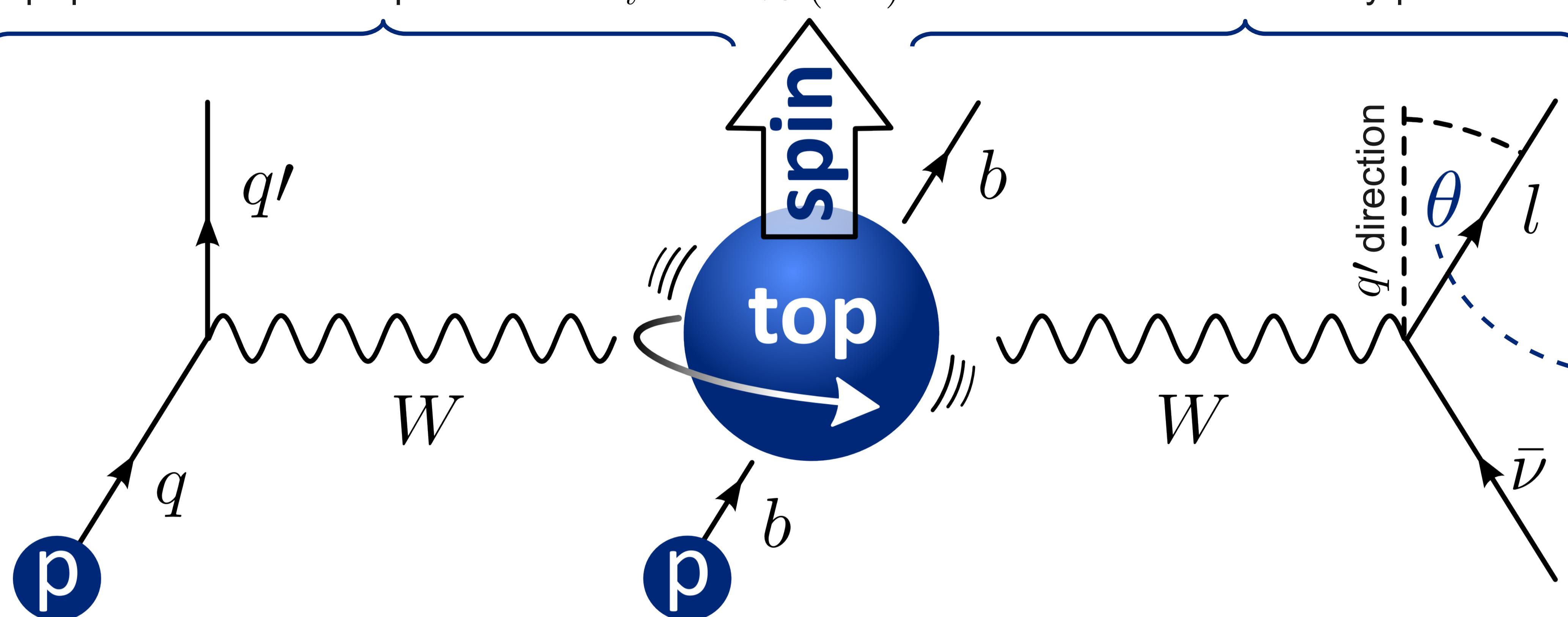
# Measurement of Top-Quark Polarization in t-channel Single-Top Production

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on behalf of the CMS Collaboration



## Top Production via t-channel

**Top spin** aligned with spectator-quark ( $q'$ ) momentum in top-quark rest frame  $\Rightarrow$  polarization  $P_t \approx 100\%$  (SM)



## Top Decay

Electroweak coupling structure (**V-A**) encodes top-spin orientation in angular distributions of decay products  $\Rightarrow$  lepton spin-analyzing power  $\alpha_l = 1$  (SM)

## Polarization: $P_t$

Anomalous top-quark ( $Wtb$ ) couplings  $V_L, V_R, g_L, g_R$  arise from dim.-six effective operators.

Angle in top-quark rest frame follows:

$$\frac{d\Gamma}{\Gamma \cdot d\cos\theta} = \frac{1}{2}(1 + P_t \alpha_l \cos\theta)$$

Measure **lepton spin asymmetry**

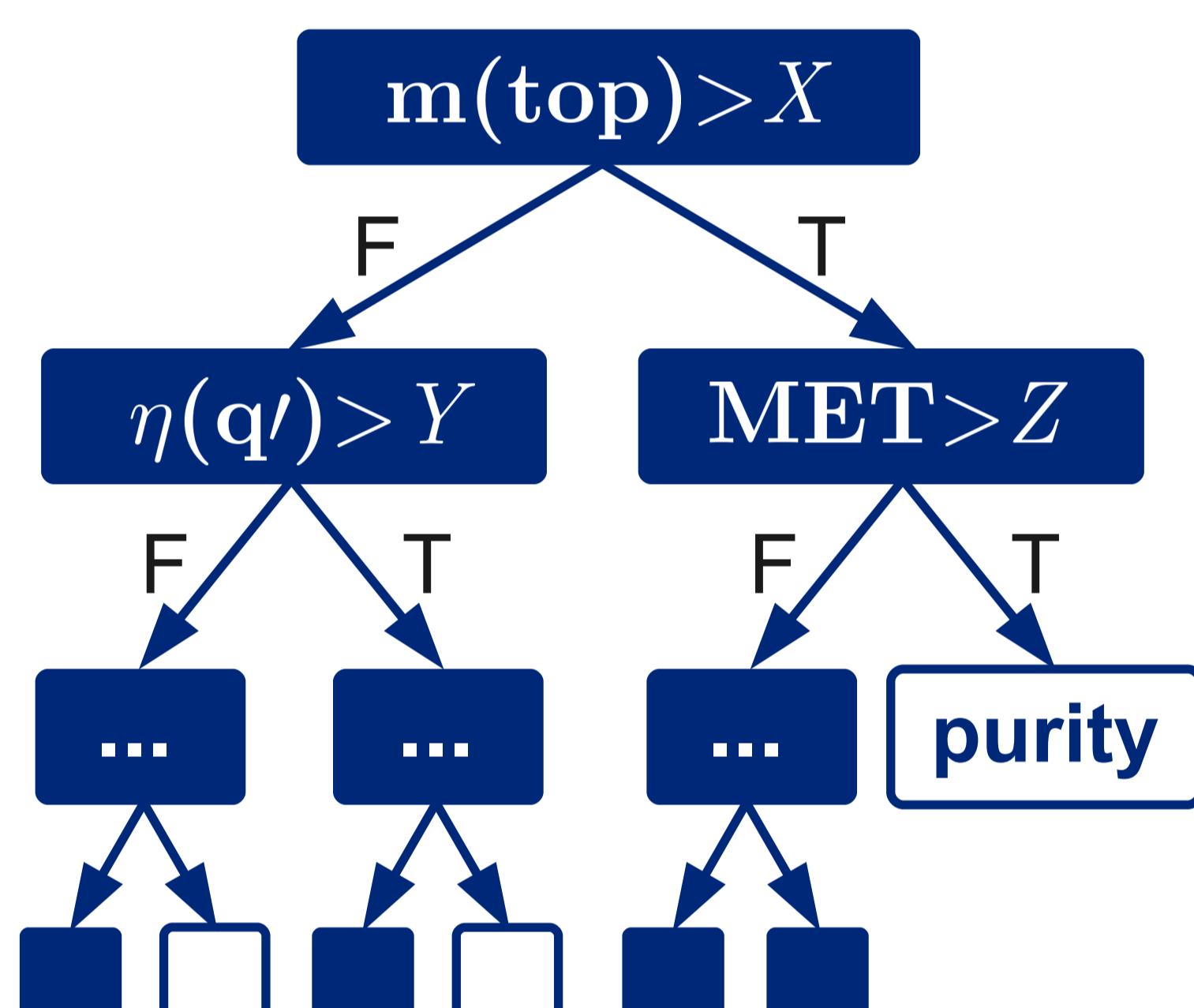
$$A = \frac{N_\uparrow - N_\downarrow}{N_\uparrow + N_\downarrow} = \frac{1}{2}P_t \alpha_l$$

to test the polarization & V-A structure.

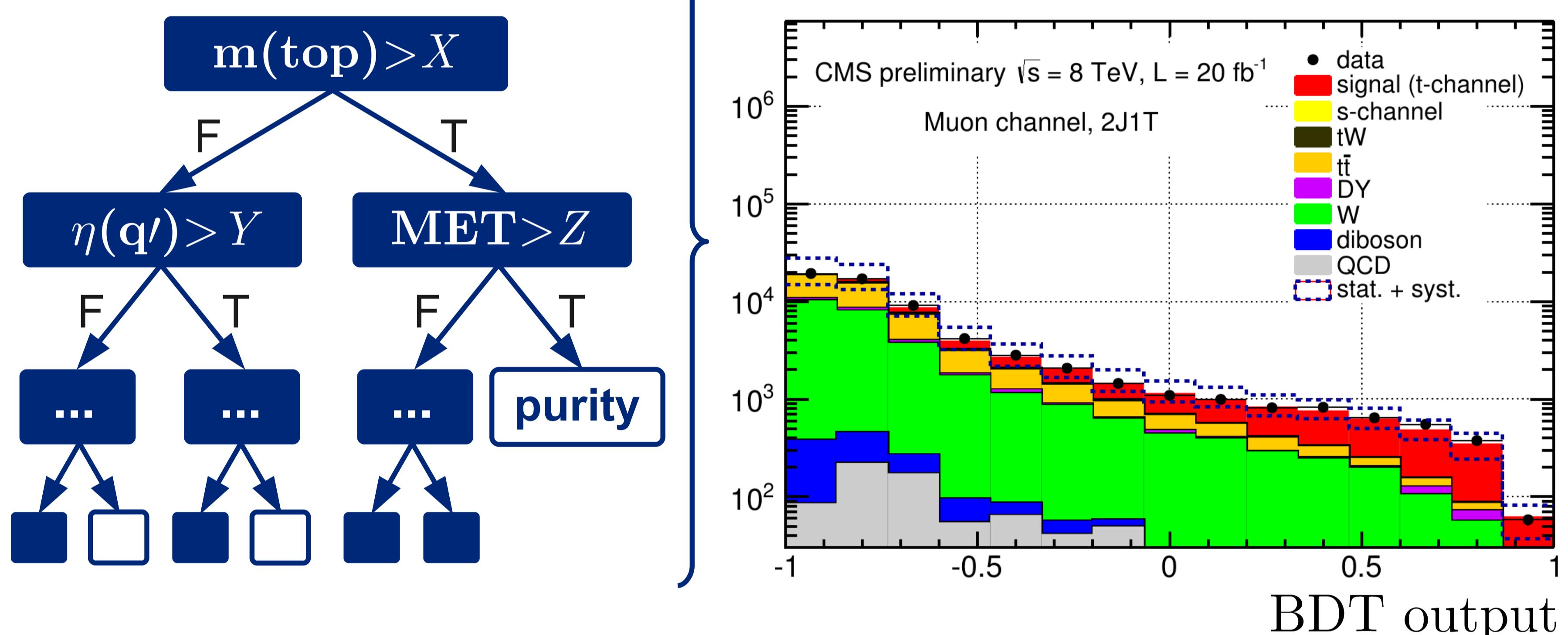
## Event Selection

1 lepton ( $e, \mu$ ), 1 b-tagged jet, 1 non-b-tagged forward jet ( $q'$ ), missing  $E_T$

### train Boosted Decision Tree



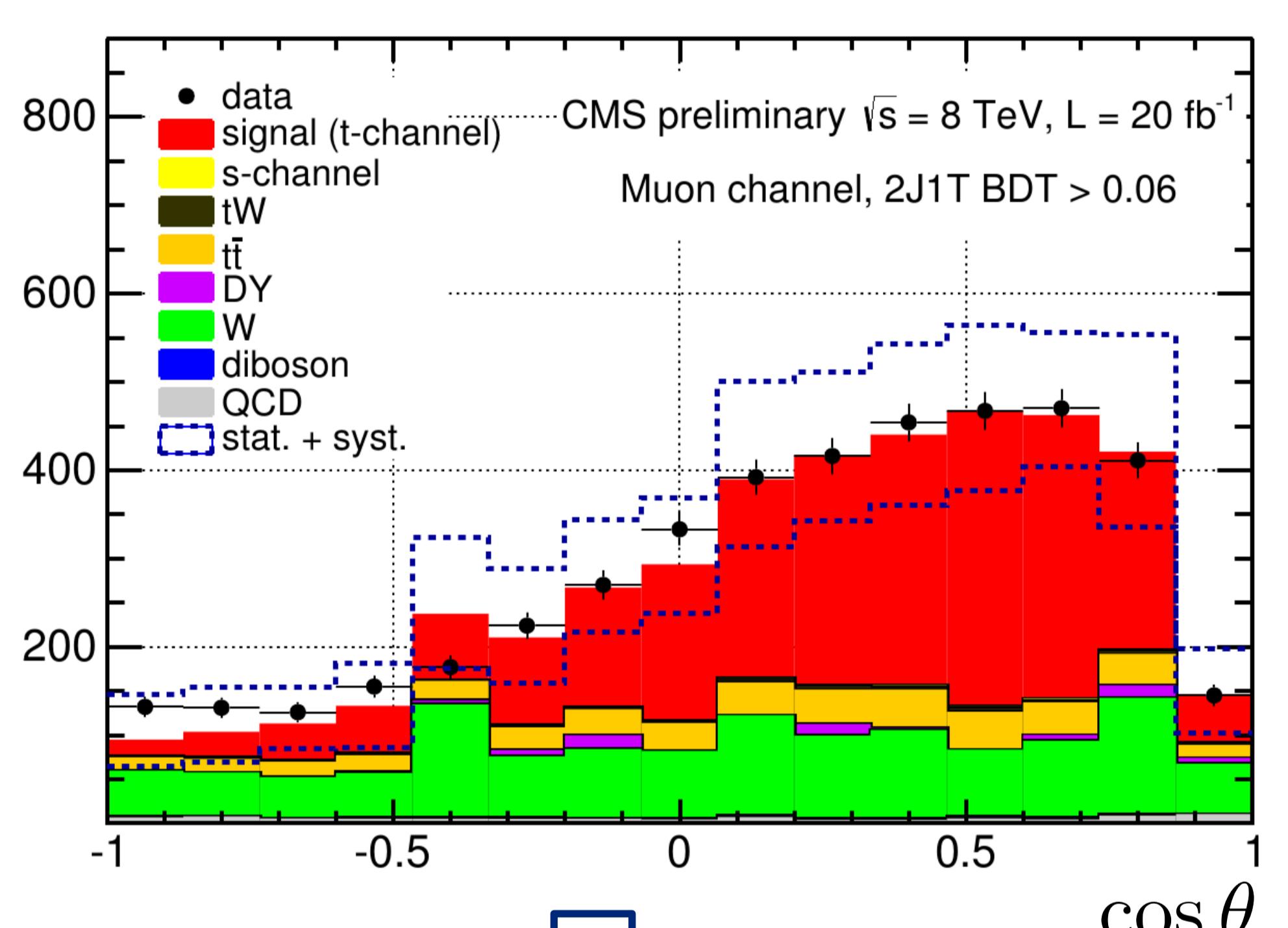
### separate signal from W+jets & tt̄



## Extract $\cos\theta$ from single top data

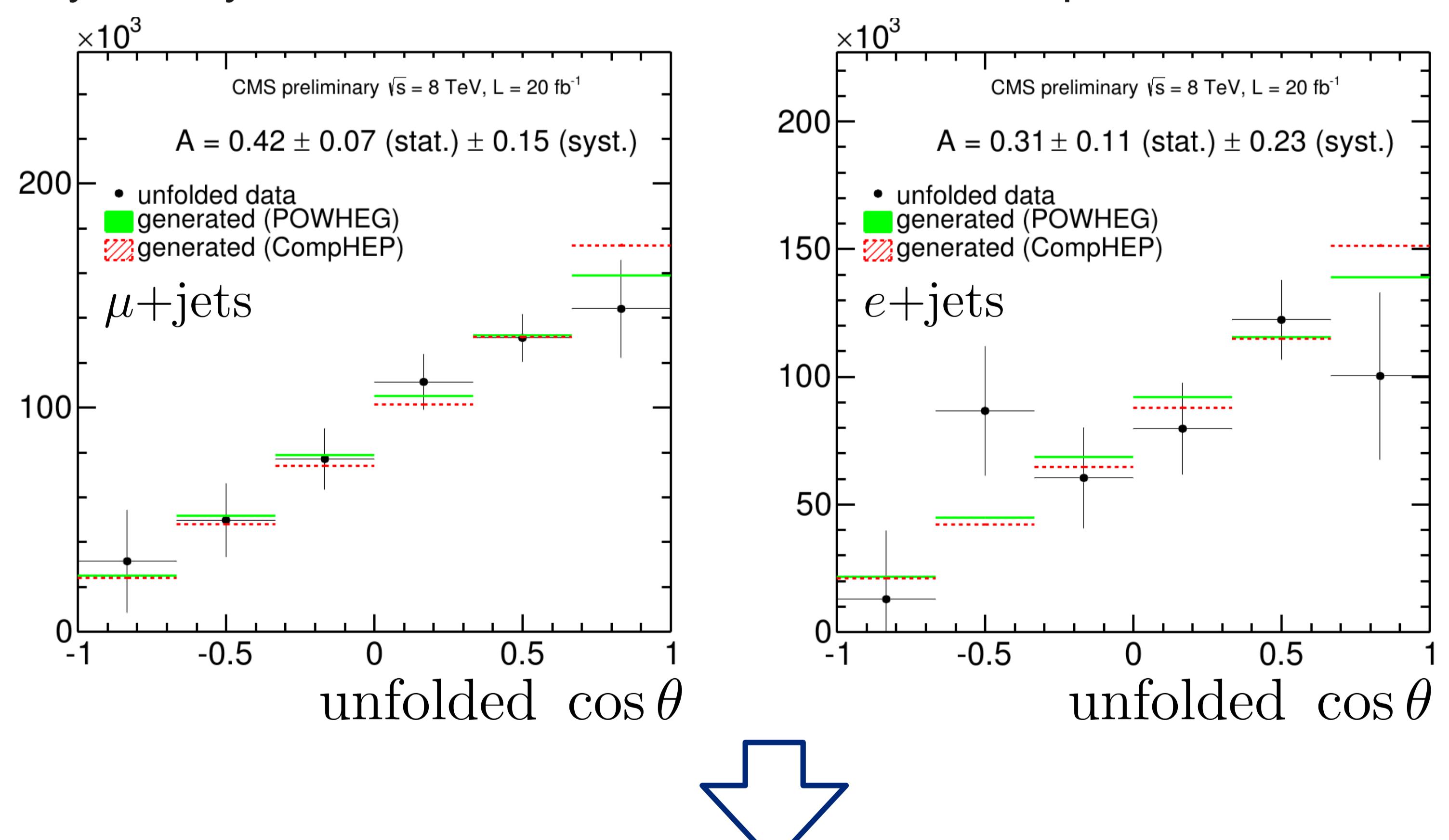
Selecting events with **high BDT** output values allows to obtain  $\cos\theta$  in a phase space dominated by t-channel single-top events.

Background contamination estimated by **ML fit**.



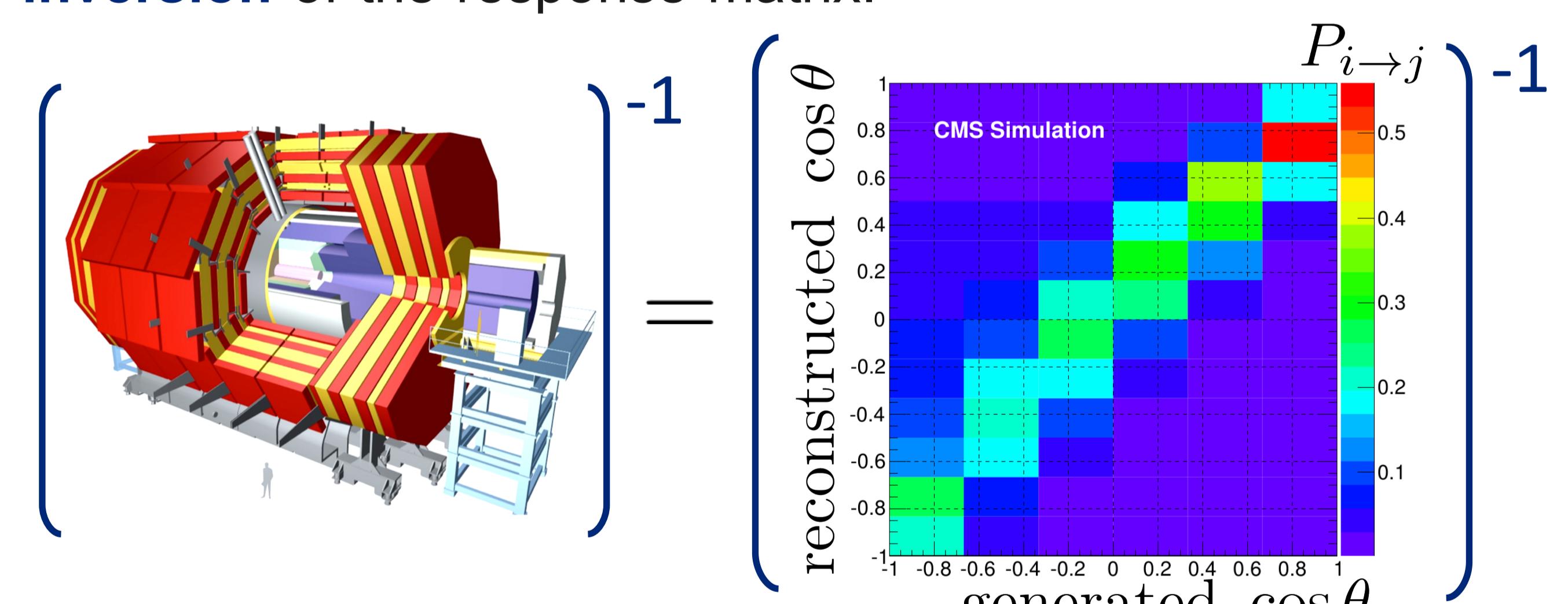
## Measure Spin Asymmetry

Asymmetry calculated from unfolded  $\cos\theta$  is comparable with **theory**.



## Unfolding

Correct distribution for remaining background contributions, detector acceptance, and resolution through **regularized inversion** of the response matrix.



## Statistical Evaluation

Impact of systematics tested by repeating background estimation & unfolding procedure with varied templates.

Uncertainty source	$\delta A_l^\mu$	$\delta A_l^e$
generator	0.025	0.009
$Q^2$ scale t-channel	0.024	0.055
$Q^2$ scale, tt̄	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 $p_T$ , tt̄	0.010	0.025
matching, tt̄	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

Uncertainty source	$\delta A_l^\mu$	$\delta A_l^e$
unclustered $E_T$	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

## Results with $\int L = 20/\text{fb}$ at $\sqrt{s} = 8 \text{ TeV}$

muon channel:  $A_l^\mu = 0.42 \pm 0.07 \text{ (stat.)} \pm 0.15 \text{ (sys.)}$

electron channel:  $A_l^e = 0.31 \pm 0.11 \text{ (stat.)} \pm 0.23 \text{ (sys.)}$

combined (BLUE):  $A_l = 0.41 \pm 0.06 \text{ (stat.)} \pm 0.16 \text{ (sys.)}$

$$\Rightarrow P_t = 0.82 \pm 0.34 \text{ assuming } \alpha_l = 1$$

More on PAS-TOP-13-001: <https://cds.cern.ch/record/1601800>