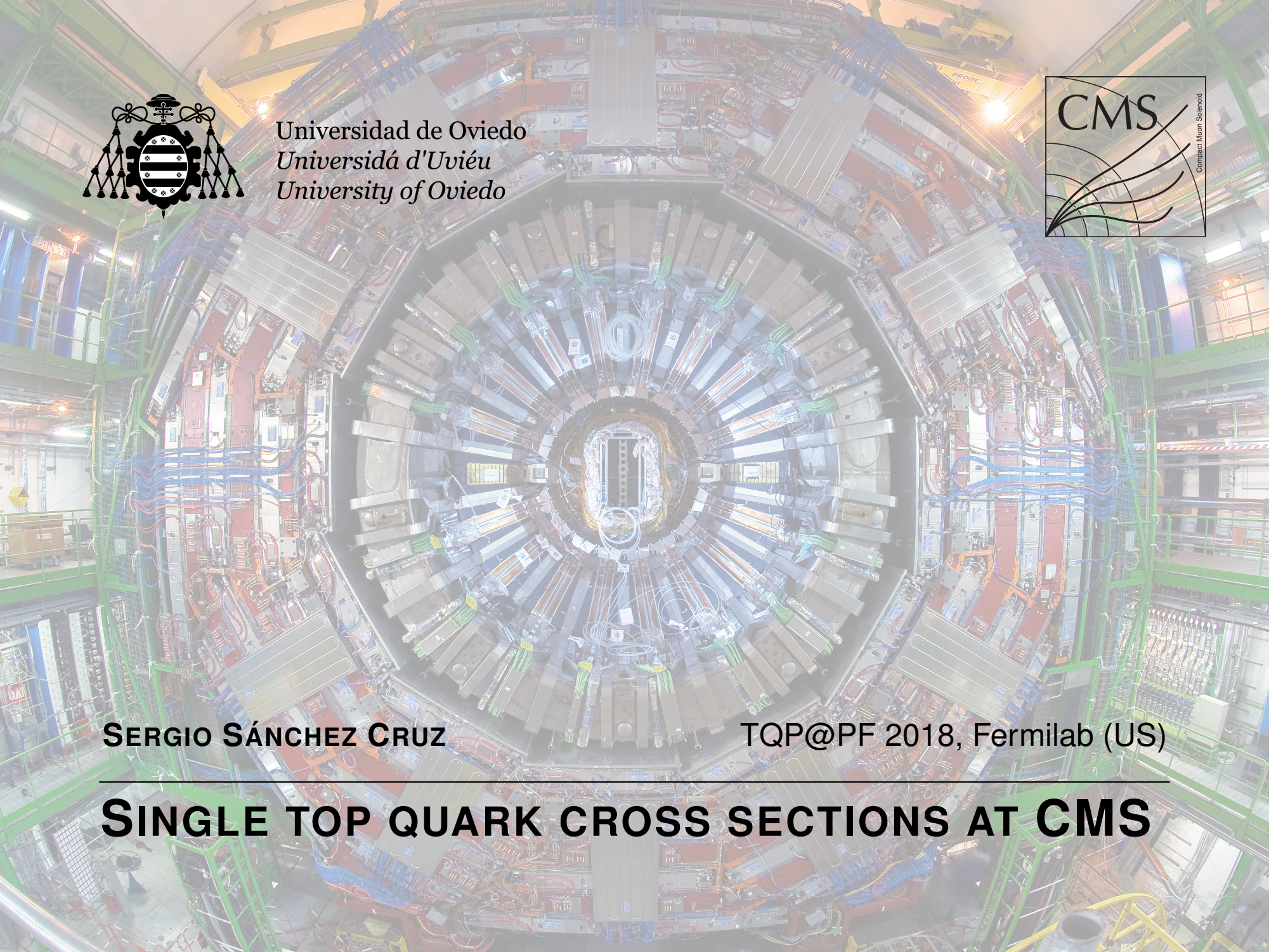

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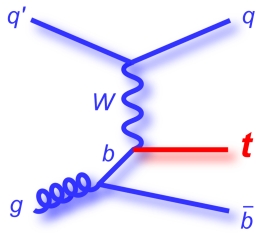
TQP@PF 2018, Fermilab (US)

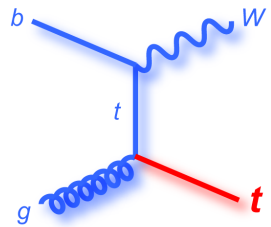
SINGLE TOP QUARK CROSS SECTIONS AT CMS

SINGLE TOP PHYSICS

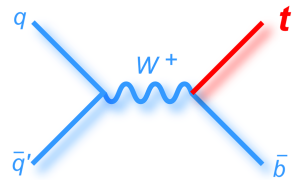
- Production modes at LHC & Tevatron:
  - *t*-channel
  - *W* associated (*tW*-channel)
  - *s*-channel
- Production through electroweak interactions
  - Sensitive to the V_{tb} matrix element
  - Study of the Wtb coupling
- Sensitive to PDFs
- Sensitive to new physics models and background for precision $t\bar{t}$ physics
- I will focus in the latest released result on each channel



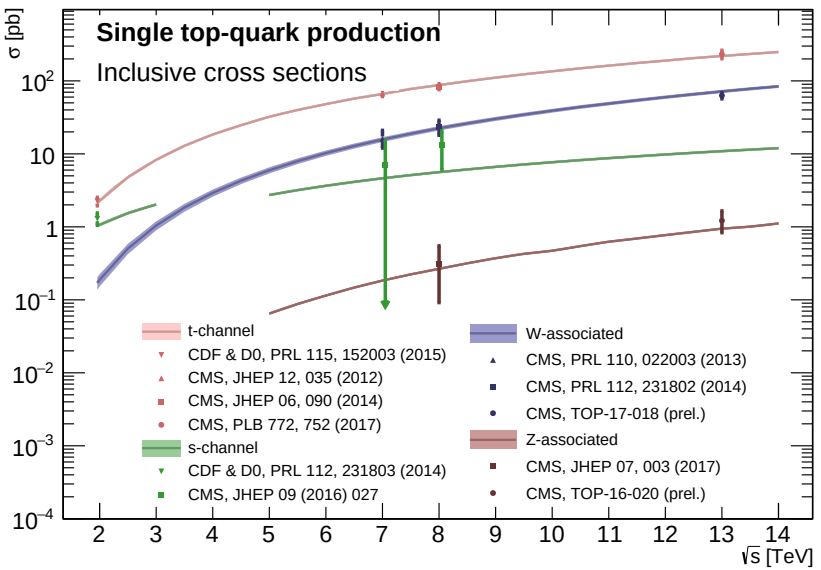
t-channel



tW-channel



s-channel



t-CHANNEL

Channel and dataset

- Measurement performed in the single μ channel
- Using the 2015 dataset (2.2 fb^{-1})

Lepton selection

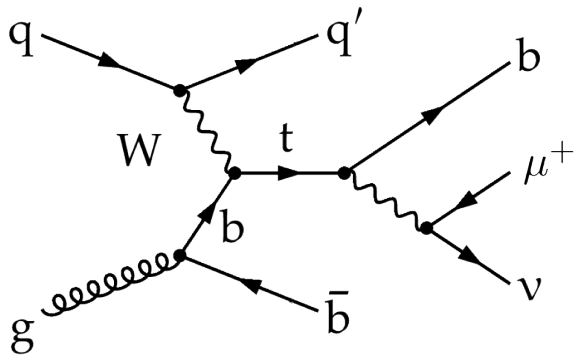
- Isolated muon ($p_T > 22$ GeV)

Jet selection

- Using jets with $p_T > 40$ GeV, $|\eta| < 4.7$
- b-tags: MVA based on secondary vertices ($\epsilon_b \approx 45\%$, $\epsilon_{fake} \approx 0.1\%$)

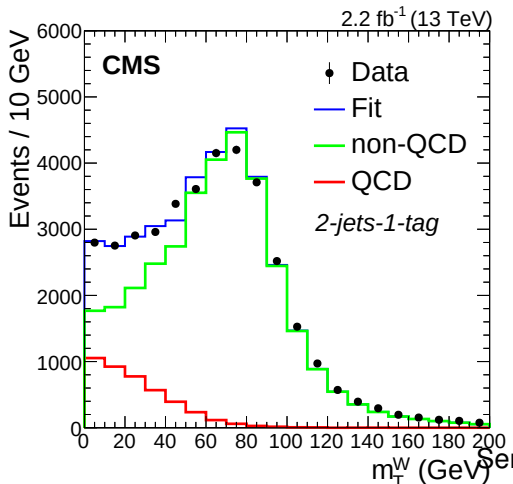
Event selection

- $m_T(W) > 50$ GeV
- Measurement regions employed: 2j1b (single top), 3j1b, 3j2b ($t\bar{t}$), 2j0b (W+jets)



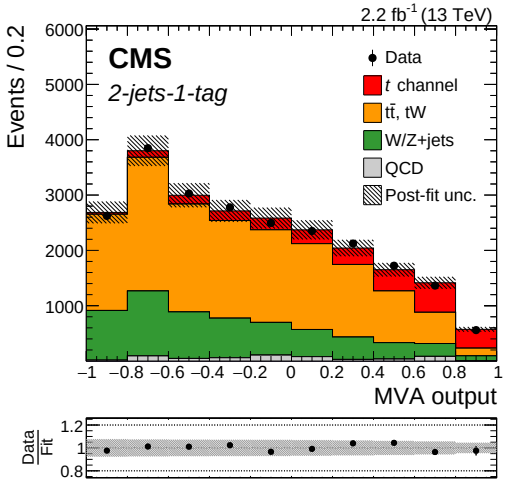
Background estimation

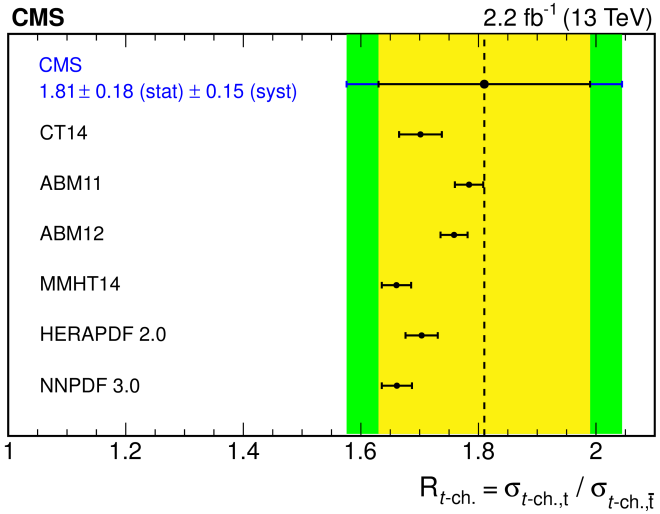
- $t\bar{t}$ + tW $\Rightarrow$ MC simulations
- W+jets $\Rightarrow$ MC simulations
- QCD normalization determined in a data-driven way



t-CHANNEL

- Signal is extracted from a likelihood fit to a ANN distribution
- Fit performed simultaneously in categories 2j1b, 3j1b and 3j2b $\otimes$ charge of the muon
- Free parameters of the fit: μ_{t-ch}, R_{t-ch}





- Result compatible with SM expectations

$$\sigma_{t\text{-ch.}} = 238 \pm 5\%\ \text{(stat.)} \pm\ 5\%\ \text{(exp.)} \pm 11\%\ \text{(theo.)}\ \pm 2\%\ \text{(lumi.)}\ \text{pb}$$
$$= 238 \pm 13\%\ \text{pb}\quad \left[\sigma^{\text{SM}} = 217^{+9}_{-8}\ \text{pb}\right]$$

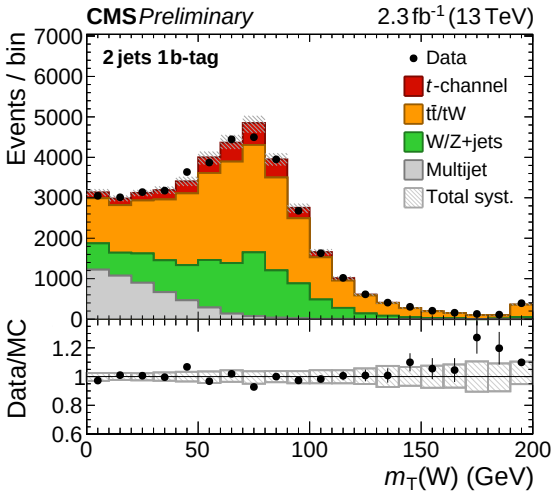
- CKM element V_{tb} assuming $|V_{tb}| \gg |V_{td}|, |V_{ts}|$

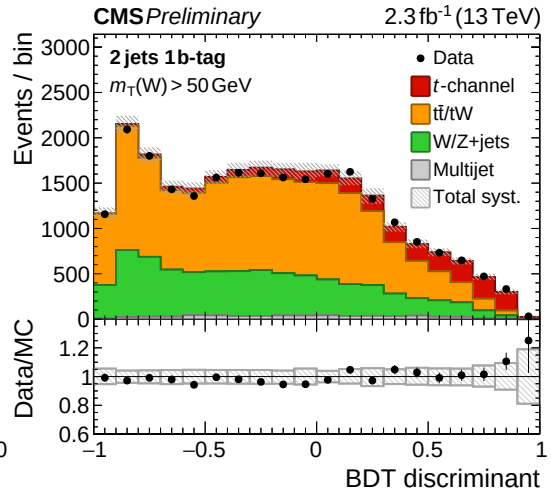
$$|f_{\text{LV}} V_{\text{tb}}| = 1.05 \pm 0.07\ \text{(exp.)} \pm 0.02\ \text{(theo.)}$$

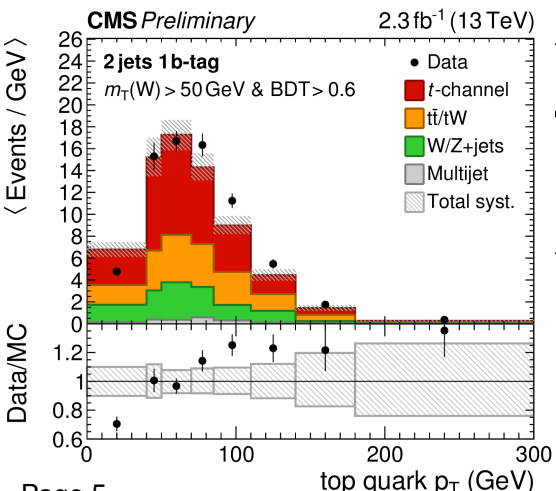
- Uncertainties: signal modeling (6.9%), experimental (5.2%),...

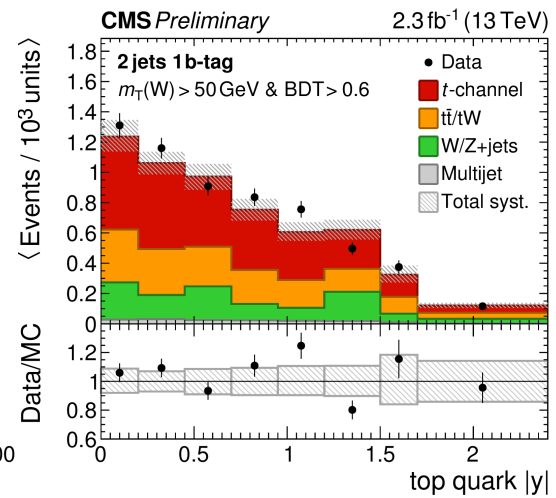
t-CHANNEL (DIFFERENTIAL)

- Identical event selection to the inclusive result
- Signal is extracted through a ML fit to each of the bins of top quark p_T and rapidity









In situ determination of the QCD background:

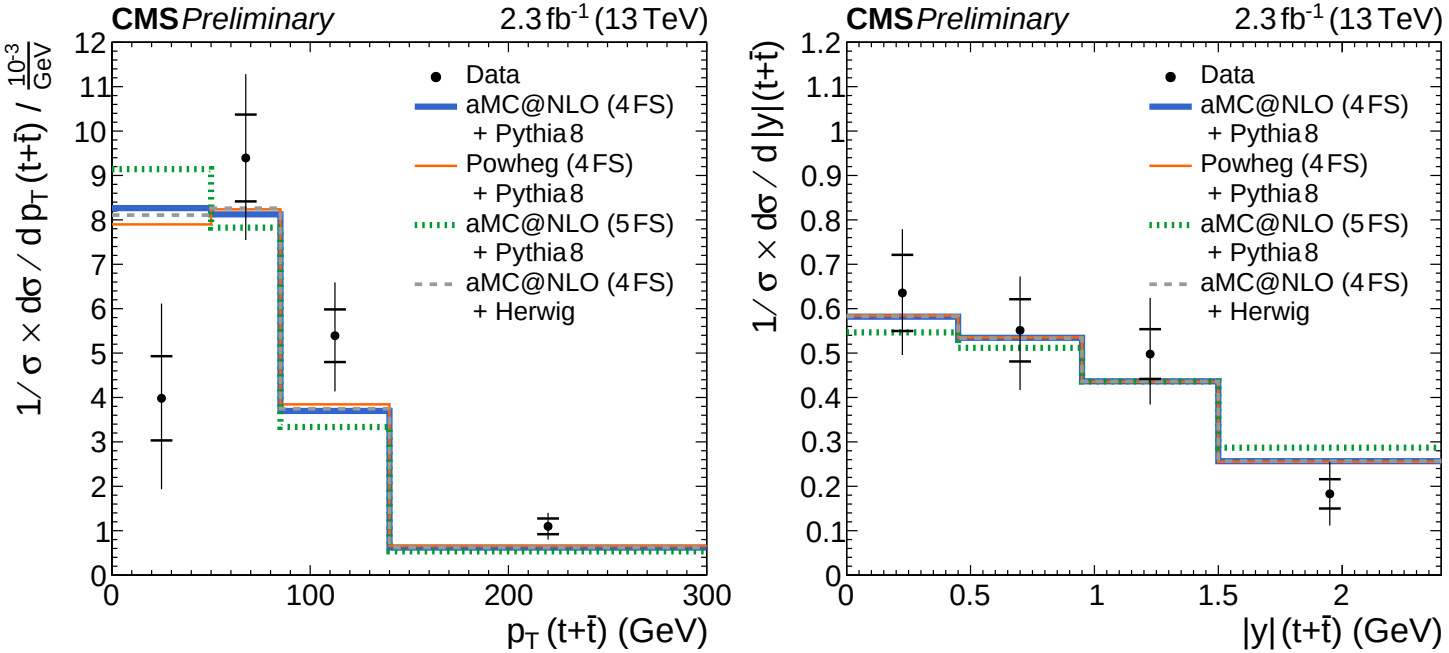
- Shape extracted from antiisolated μ data sample
- Fit performed to shape of $m_T(W)$ for events $m_T(W) < 50$ GeV and BDT for events with $m_T(W) > 50$ GeV

Validation of modeling in signal-enhanced region

- Models predict softer p_T spectrum that what is observed in data

t-CHANNEL (DIFFERENTIAL)

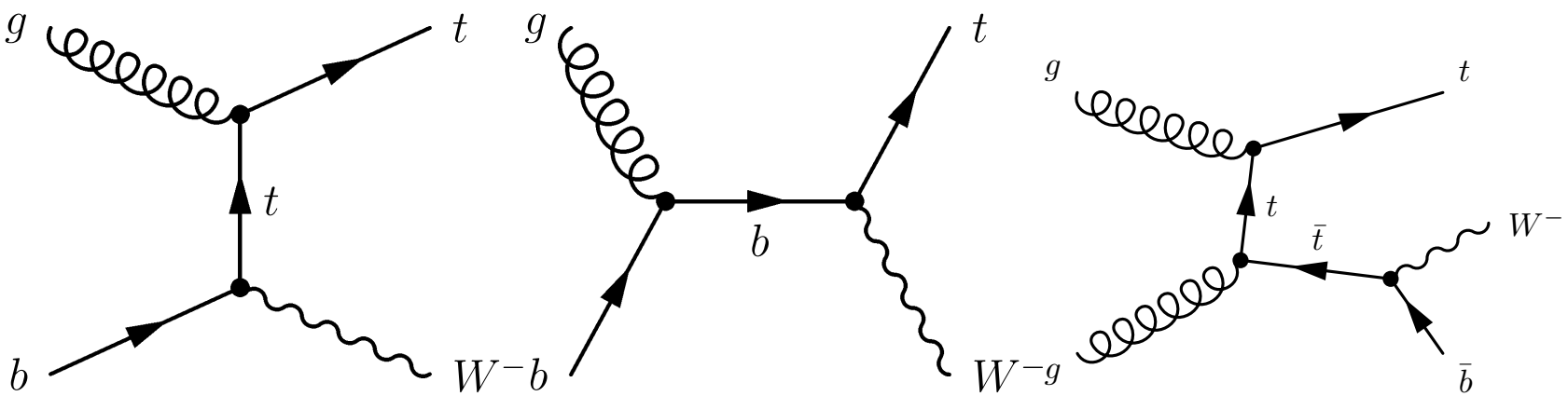
- Results unfolded to parton level:



- Uncertainties: data statistics (10%-25%), μ_R/μ_F scales (10-15%), m_t (10%-20%) and jet energy corrections (10%-15%)
- First top-quark p_T bin has lower signal acceptance and is more affected by systematic uncertainties
- Data is described by theoretical predictions

tW-CHANNEL

- Represents $\sim$ 25% of the total single top production at LHC
- It is an excellent probe of the V_{tb} matrix element
- It is the main background in $t\bar{t}$ precision measurements and also a potential background in BSM searches
- Its production interferes with $t\bar{t}$ production at NLO
  - Two configurations to subtract overlaping diagrams: diagram subtraction and removal



tW-CHANNEL AT 13 TEV

Channel and dataset

- 13 TeV analysis targets dileptonic channel
  - eμ channel is more background free
- Using the 2016 dataset (35.9 fb^{-1})

Event selection

Lepton selection

- Isolated electron and muon ($p_T > 25(20)$ GeV)

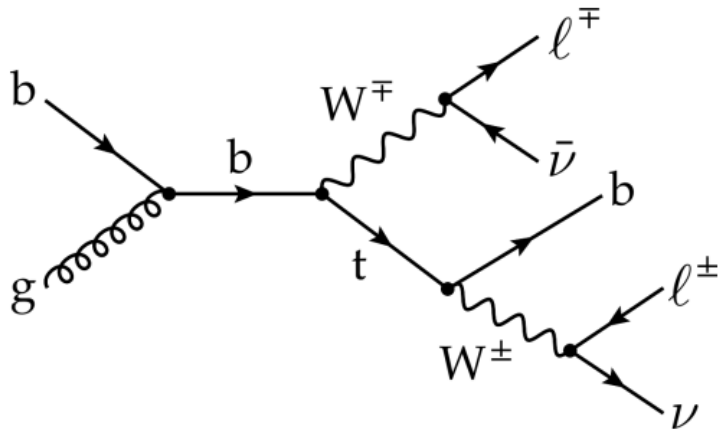
Jet selection

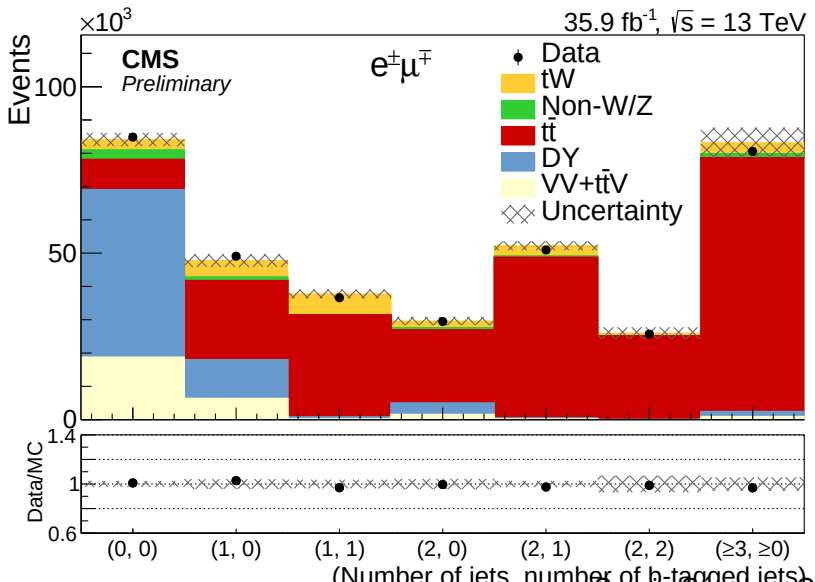
- Using jets with $p_T > 30$ GeV, $|\eta| < 2.4$
- *b*-tags: MVA based on secondary vertices ($\epsilon_b \approx 70\%$, $\epsilon_{fake} \approx 1\%$)
- "Additional" loose jets $20 < p_T < 30$ GeV

CMS-PAS-TOP-17-018

Classes

- Three regions defined: 1j1b, 2j1b, 2j2b

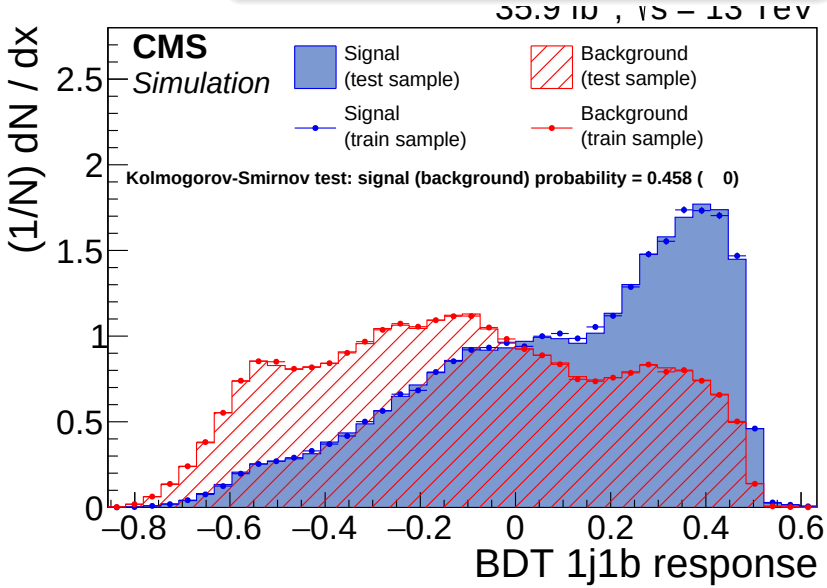


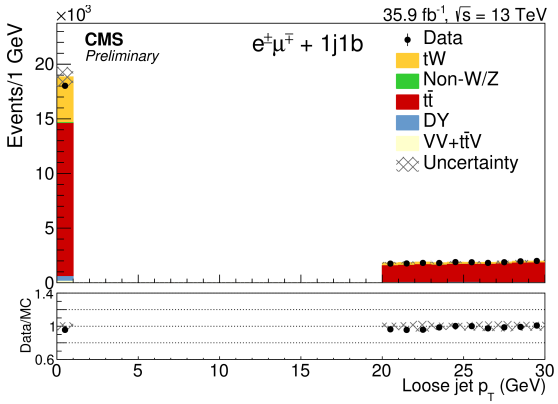


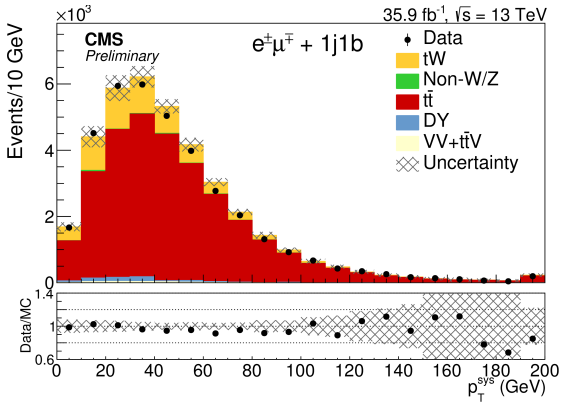
tW-CHANNEL

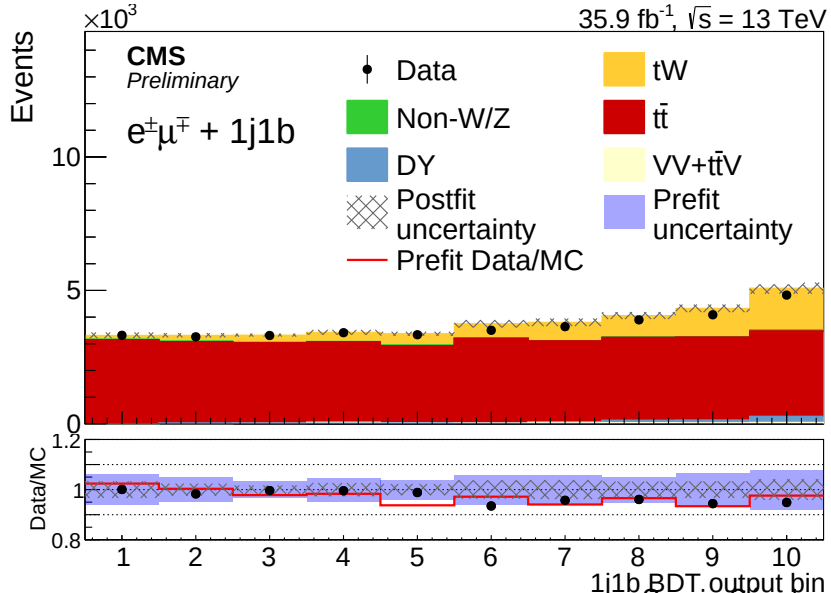
CMS-PAS-TOP-17-018

- Overwhelming $t\bar{t}$ contribution in every measurement region
- BDT discriminator in the 1j1b region exploits topological differences
  - Lost jet in $t\bar{t}$ events
  - Overall higher transverse boost in $t\bar{t}$ events





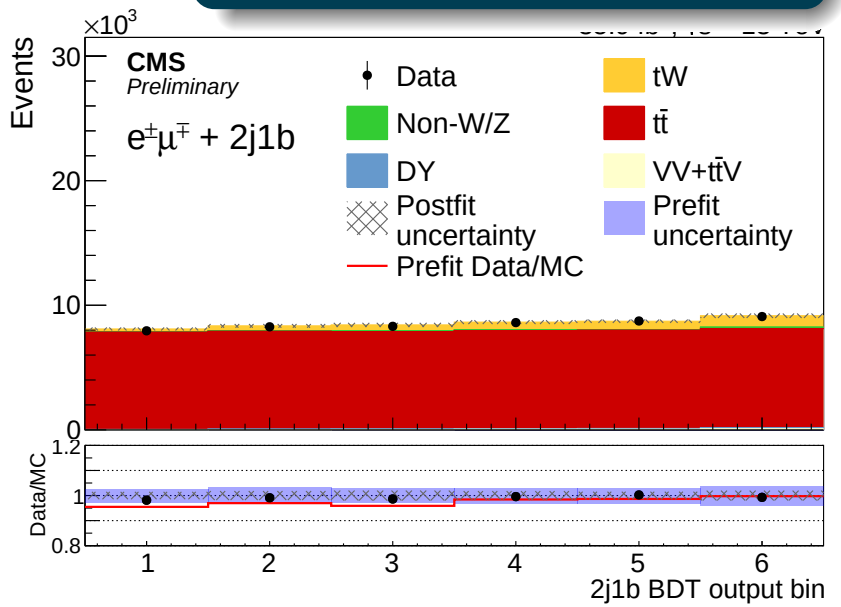


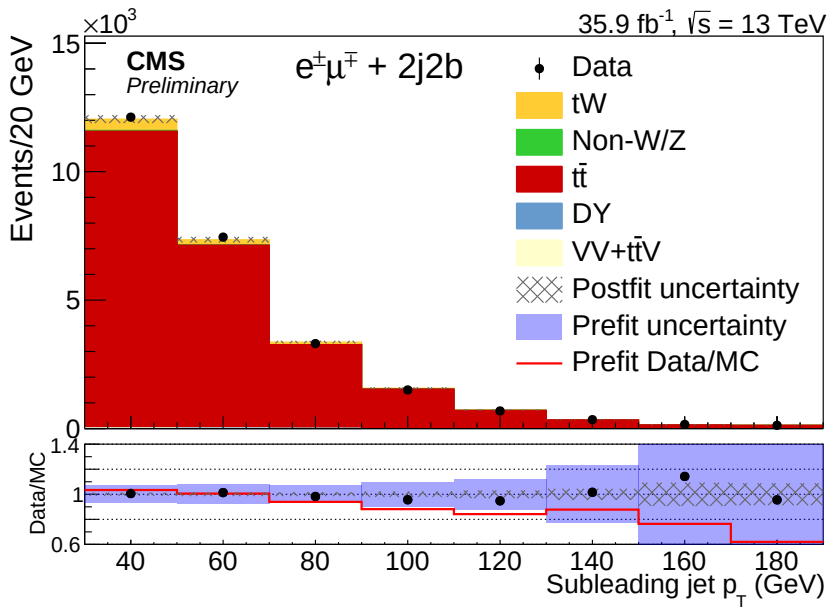


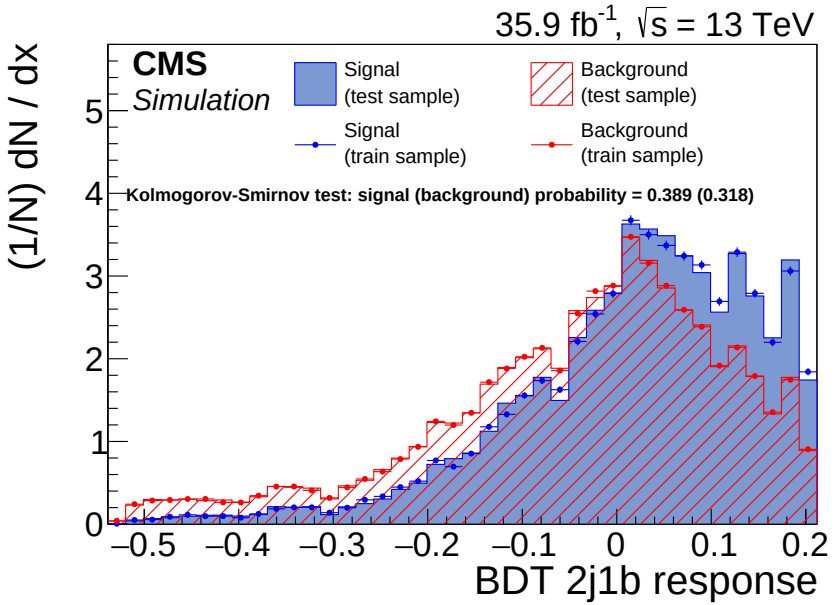
tW-CHANNEL

CMS-PAS-TOP-17-018

- Further exploit the presence of signal in the 2j1b region with a dedicated BDT
  - Input variables are angular correlations among jets and leptons
- We aditionally use the subleading jet p_T distribution in the 2j2b region to further constrain systematic uncertainties





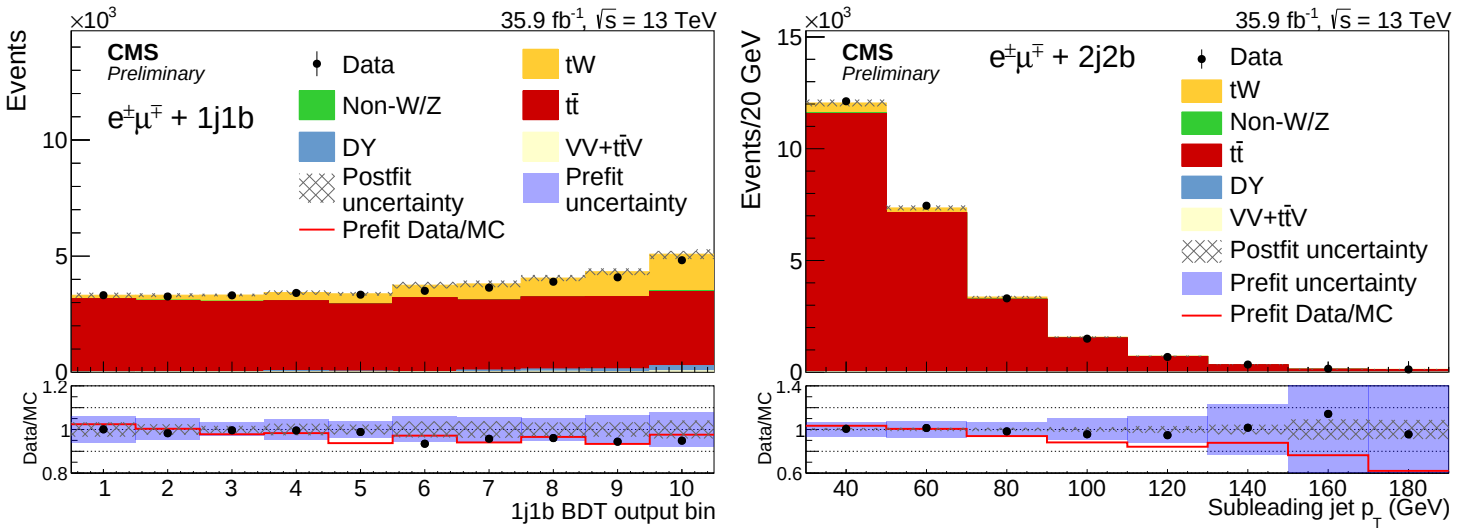


tW-CHANNEL

CMS-PAS-TOP-17-018

RESULTS

- Signal strength determined from a ML fit to BDT distribution in the 1j1b and 2j1b regions and subleading jet p_T in 2j2b
- Result consistent with SM expectations within the $\mathcal{O}(10\%)$ uncertainty



- Experimental uncertainties: pile-up (3.3%), jet energy scale (3.2%), electron/muon efficiencies (3.3%/3.1%), trigger efficiencies (2.7%),... $\Rightarrow$ mostly due to their effect in $t\bar{t}$
- Theoretical uncertainties: μ_R/μ_F scale (2.5%), color reconnection (2.0%), ME/PS matching (1.8%), ...

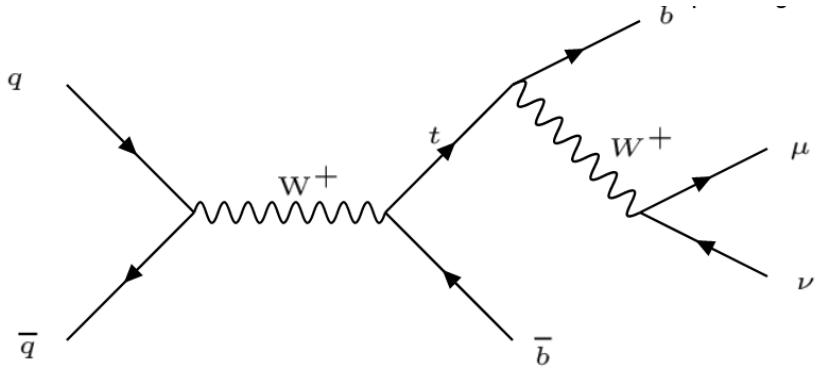
$$\sigma_{\mathrm{tW}} = 63.1 \pm 3\%\ (\mathrm{stat.}) \pm 9\%\ (\mathrm{syst}) \pm 3\%\ (\mathrm{lumi})\ \mathrm{pb}$$

$$\sigma_{\mathrm{tW}} = 63.1 \pm 6.6\ \mathrm{pb}$$

$$\left[\sigma^{\mathrm{SM}}_{\mathrm{tW}} = 72 \pm 2\ (\mathrm{scale}) \pm 3\ (\mathrm{PDF})\ \mathrm{pb}\right]$$

s-CHANNEL

- Search for *s*-channel at 7 and 8 TeV
- Challenging channel at LHC as it is suppressed in pp collisions
- Also a probe of the V_{tb} matrix element



8 TeV 19.7 fb^{-1}

- Isolated electron ($p_T > 30$) or muon ($p_T > 26$)
- Jets with $p_T > 40$ GeV, $|\eta| < 4.7$
- Zero jets with $20 < p_T < 40$ GeV in signal region
- *b*-tagging $\epsilon_{fake} \approx 0.1\%$

7 TeV 5.1 fb^{-1}

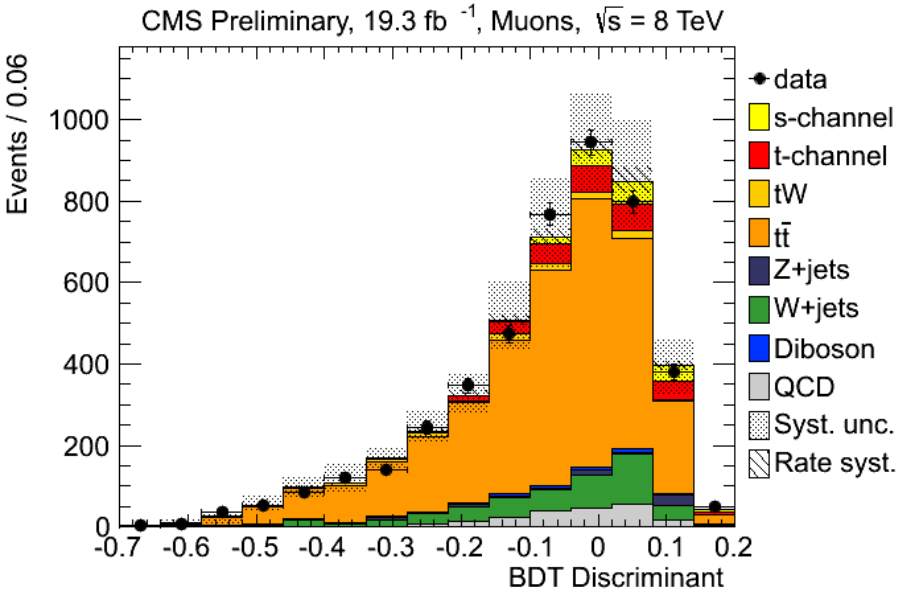
- Isolated muon ($p_T > 20$)
- Jets with $p_T > 40$ GeV, $|\eta| < 4.7$
- *b*-tagging $\epsilon_{fake} \approx 0.1\%$

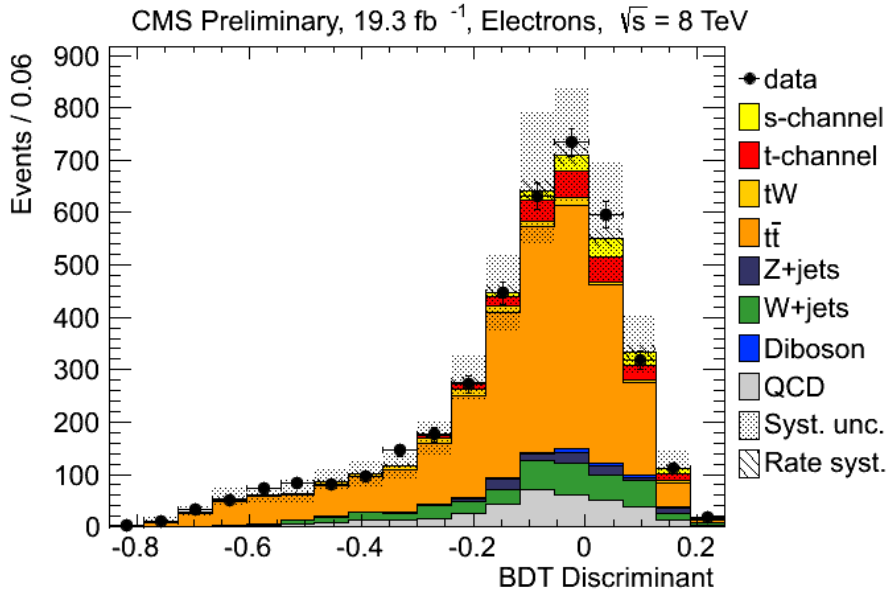
Measurement regions

- 2j2b: signal region
- 3j2b: $t\bar{t}$ control region
- 2j1b: *t*-channel and W+jets control region
- 2j0b: W+jets control region

s-CHANNEL

- Signal is extracted by performing a ML fit to BDT distributions in 2j2t, 2j1t and 3j2t
- Main uncertainties: μ_R/mu_F scales (28%), JES/JER (18%), *b*-tagging (16%)



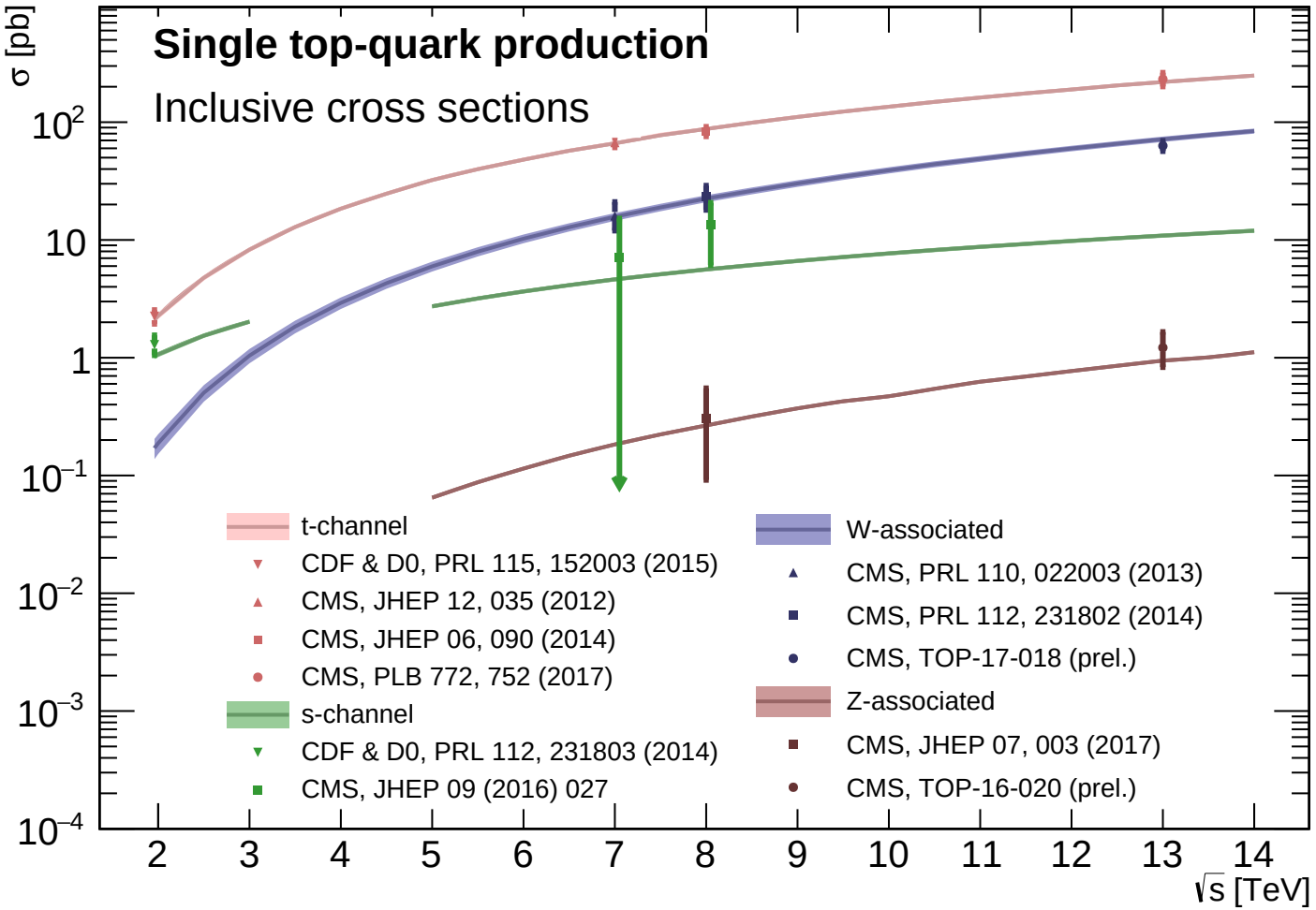


	Exp. significance	Obs. significance
7 TeV (muon)	0.5	0.9
8 TeV (el + mu)	0.8	2.3
Combined 7 + 8 TeV	1.1	2.5

	Exp. upper limit	Obs. upper limit
7 TeV (muon)	25.4 [19.0, 36.6] pb	31.4 pb
8 TeV (el + mu)	20.5 [13.4,26.7] pb	28.8 pb
Combined 7 + 8 TeV (on μ)	3.1 [2.1,4.0]	4.7

CONCLUSIONS

- Overview of the latest CMS results on single top production



- Keep tuned for interesting and more precise results!