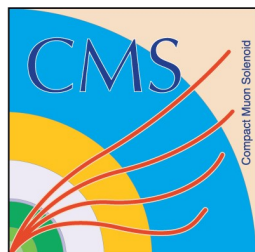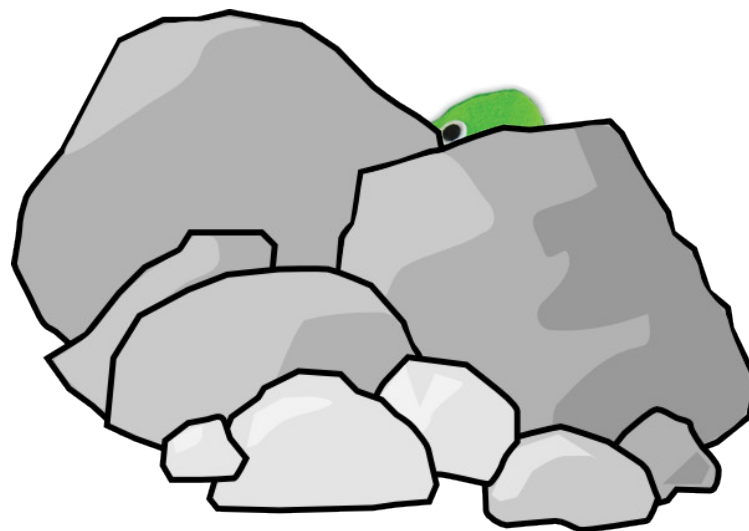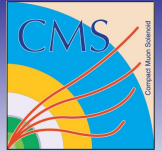# Measurement of the t-channel single top quark production cross section at 13 TeV with the CMS detector

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on behalf of the CMS collaboration

TOP2015
Ischia, 15.09.2015

Introduction

- Electroweak production of top quarks

- Sensitive to BSM physics (FCNC, new particles, …)

- Early measurement with 42 pb^{-1} integrated luminosity of 50ns LHC data at 13 TeV

  ▸ Challenging due to low statistics, detector performance after upgrade phase, QCD, ...

- Signature of t-channel events with leptonically decaying top quarks

  ▸ Light quark with high $|\eta|$

  ▸ Hard b quark

  ▸ Soft second b quark, often fails detector acceptance

- Main backgrounds: $t\bar{t}$, W+jets
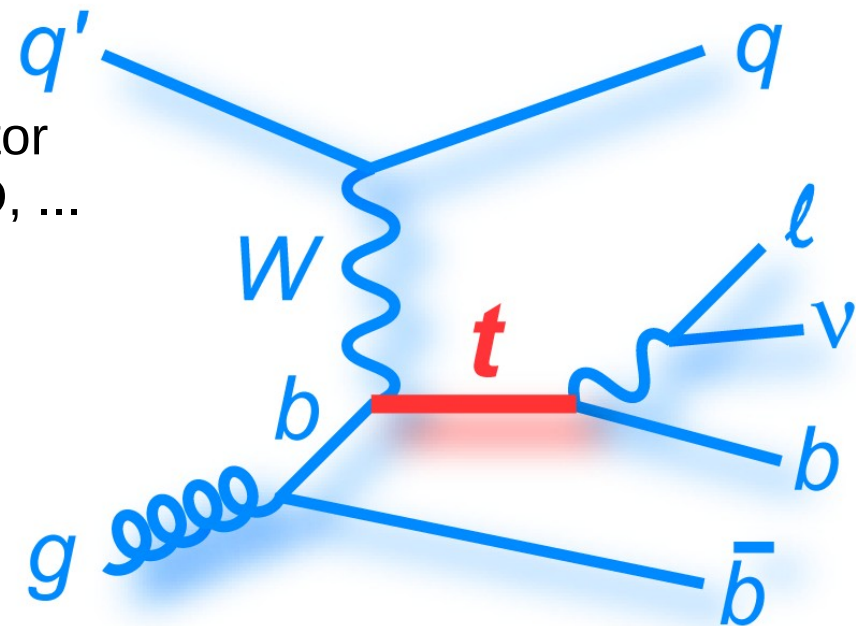
Analysis
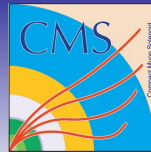
- Event selection:
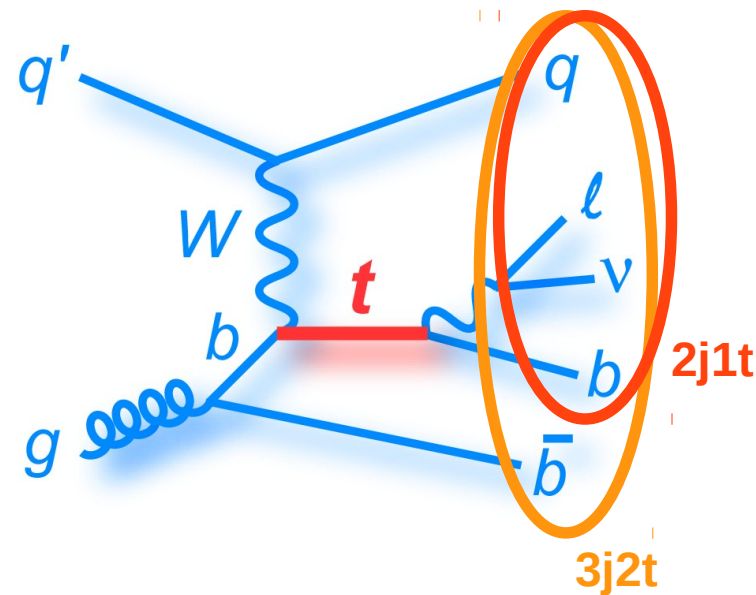 - Single muon trigger, one isolated muon with $p_T > 22$ GeV, $|\eta| < 2.1$
  - Jets with $p_T > 40$ GeV, $|\eta| < 4.7$ (2.4 for b-tagging)
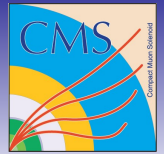 - Transverse W boson mass $m_T > 50$ GeV
- Define different categories:
  - 2 jet 1 tag (2j1t), main signal region
  - 3 jet 2 tag (3j2t), dominated by $t\bar{t}$
- Process modeling:
  - aMC@NLO: t-channel (4FS), W/Z+jets
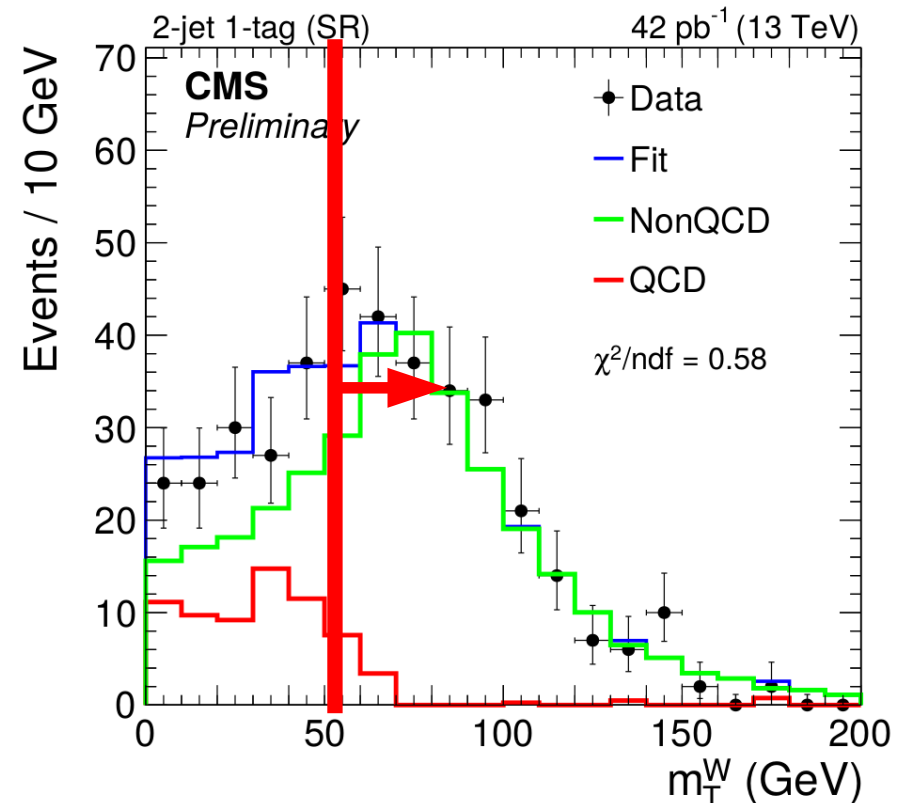 - Powheg: $t\bar{t}$, tW
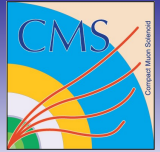 - Hadronization for all with Pythia8

QCD estimation

- QCD is expected to be a challenge at higher energies

- Do not rely on MC, use data-driven approach:

  ▶ Inverting muon isolation to derive QCD-enriched template

  ▶ Relax m_T cut, maximum likelihood fit to m_T distribution
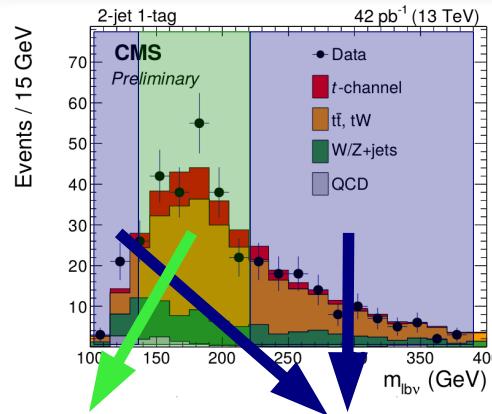
  ▶ Extrapolate QCD to $m_T > 50$ GeV region

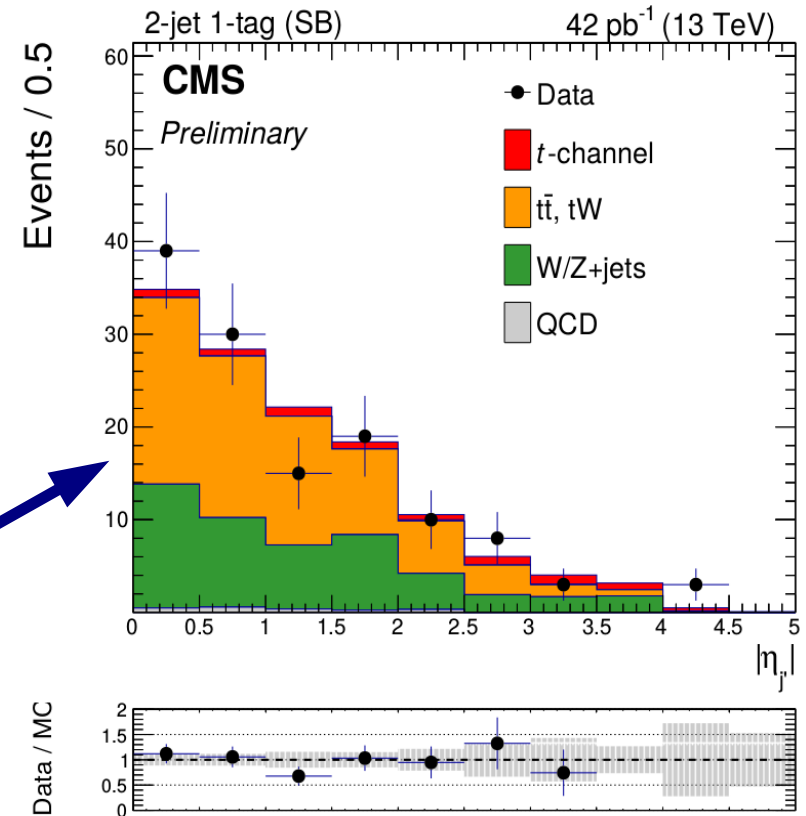See also poster from Georgios Krintiras

Event yields

Event yields for 42 pb^{-1} in 2j1t:
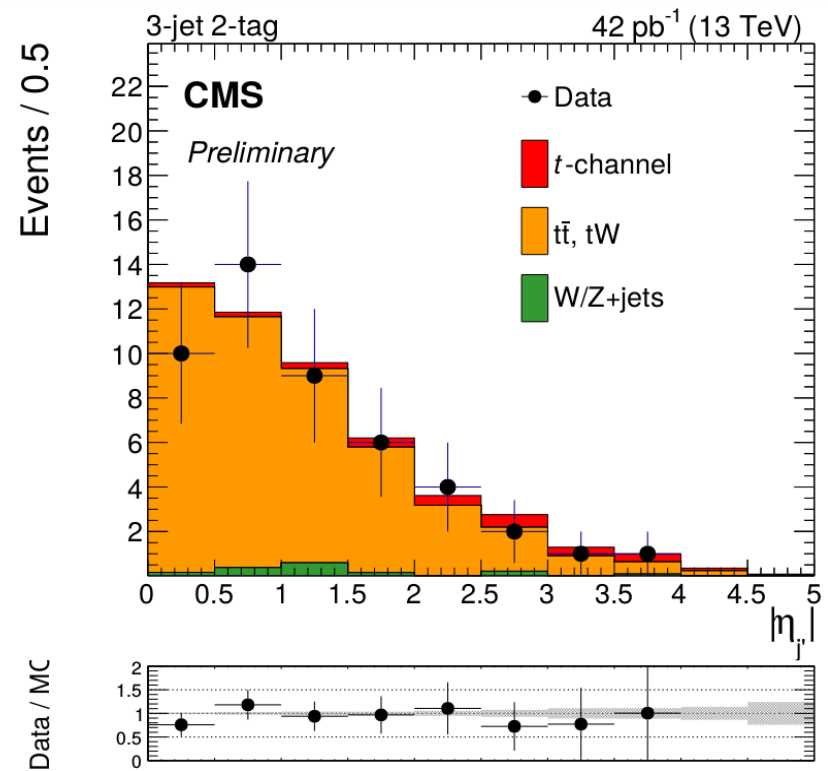

Process	SR	SB
$t\bar{t}$ & tW	157 ± 1	71.7 ± 0.4
W/Z+jets	40 ± 4	47 ± 4
QCD	10 ± 5	2 ± 1
t-channel	33 ± 1	7.2 ± 0.3
Total expected	240 ± 6	128 ± 4
Data	252	127

- Define a signal region (SR) and sideband (SB) in 2j1t around the top mass: 130 GeV < m_{top} < 225 GeV

- Reduction of W/Z+jets background, modeling cross-check

Signal extraction
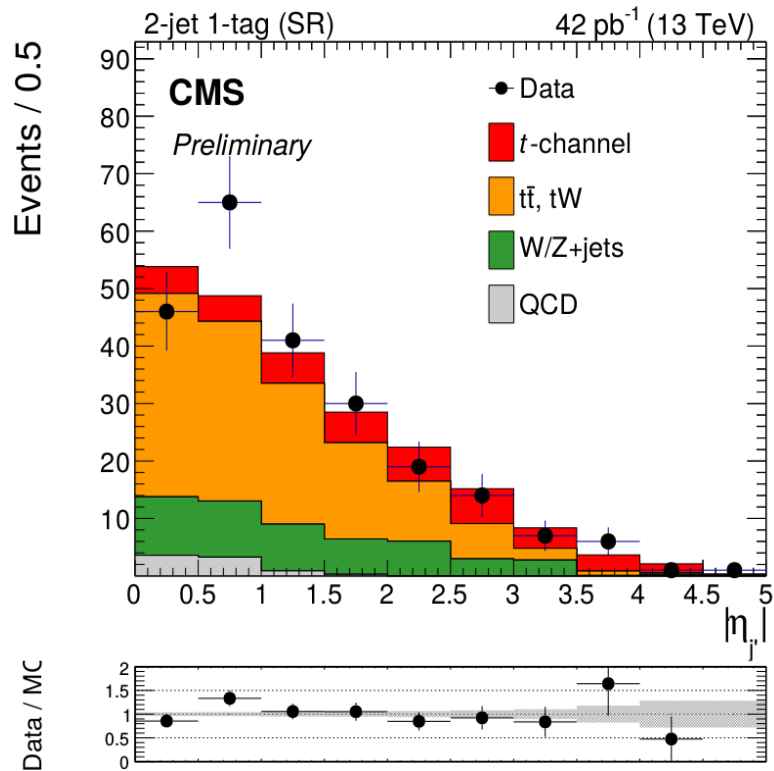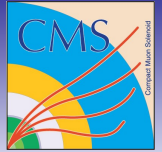
- Extract cross section with maximum likelihood fit

- Simultaneously in 2j1t (SR) and 3j2t

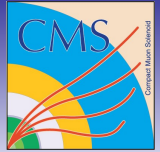- Background normalization constrained, signal unconstrained

Systematic uncertainties

- **Statistical uncertainties dominating**

- **Dominant systematics:**

  - ▶ JES due to preliminary 13 TeV estimation

  - ▶ Luminosity (pre VdM scan)

  - ▶ b-tagging SF

  - ▶ PDF (NNPDF variations), muon trigger & reconstruction, Q^2 scale

Uncertainty source	$\Delta\sigma_{t-\text{ch}}/\sigma_{t-\text{ch}}^{\text{obs}}$
Statistical uncertainty	36%
JES	17%
JER	1.1%
b-tagging	5.6%
Muon trigger/reconstruction	3.4%
QCD extraction	1.1%
Signal generator	1.9%
Factorization and renormalization scales (Q^2)	3.3%
PDF	4.5%
MET	1.2%
Pileup	1.4%
Total systematic uncertainty	19%
Luminosity	12%
Total uncertainty	42%

Results
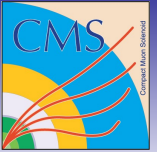
- Observed a signal with 3.5σ significance (2.7σ exp.)

- Inclusive cross section:

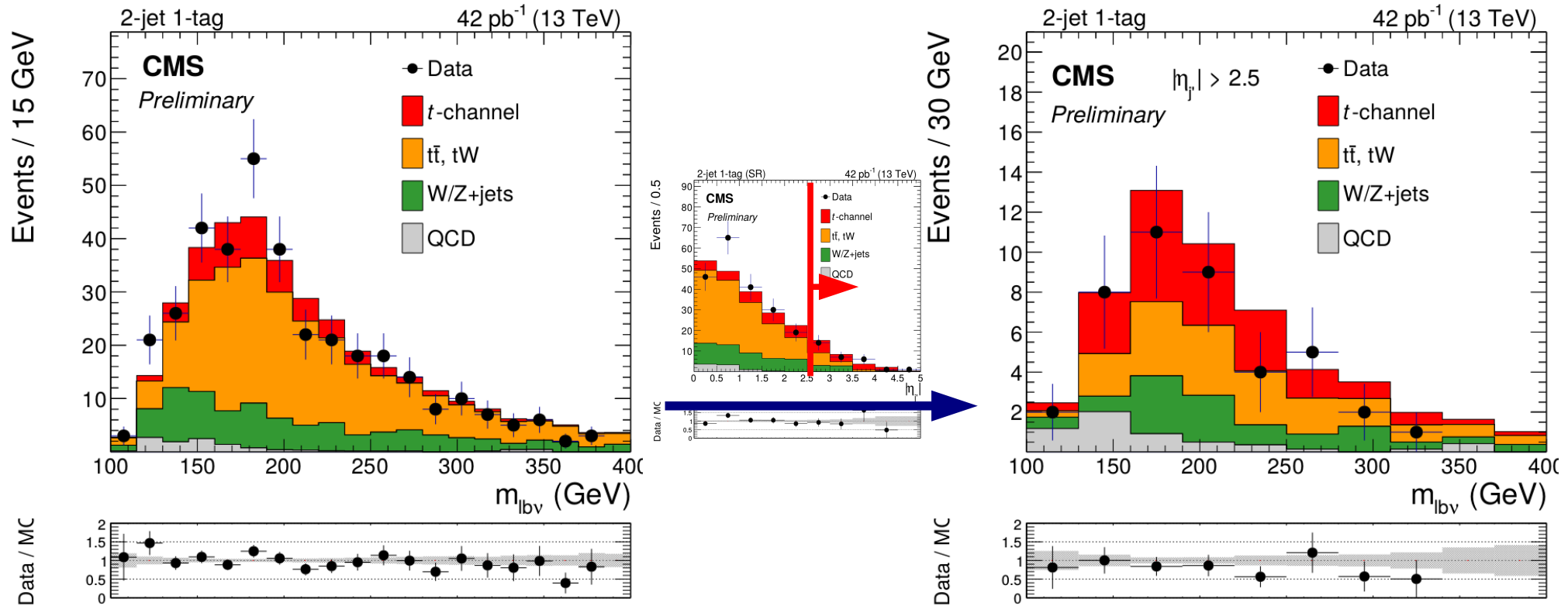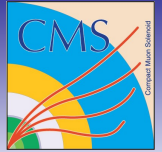 ▶ $\sigma_{\text{t-channel}}$ = 274 ± 98 (stat.) ± 52 (syst.) ± 33 (lumi) pb

  σ^{theo} = 216.99 pb (NLO)
  [Hathor v2.1]

- CKM matrix element:

  ▶ $|V_{tb}| = \sqrt{\dfrac{\sigma_{t-ch.}^{meas.}}{\sigma_{t-ch.}^{theo.}}}$ = 1.12 ± 0.24 (exp.) ± 0.02 (theo.)

Cross-check: top mass

- Reconstructed top mass in the 2j1t, normalized to fit result

- Additional cut on the right: $|\eta_{j'}| > 2.5$

- Signal-enriched events in the forward region

Conclusion

- Strong evidence for t-channel from fit significance and top-mass distribution in forward region

- Results compatible with Standard Model expectation