Measurement of the single top *t*-channel cross section and charge asymmetry at CMS

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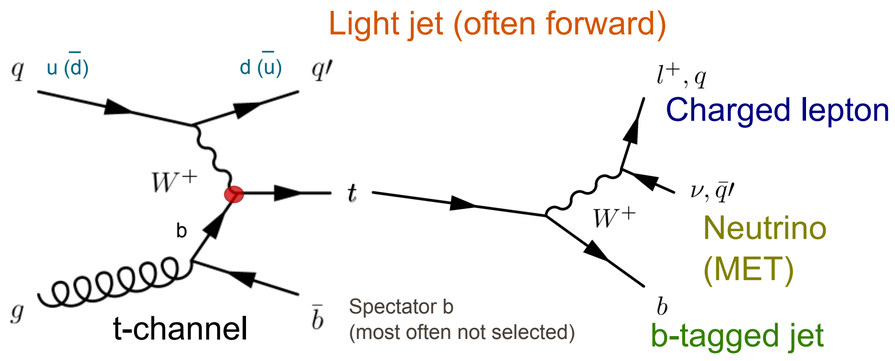
Motivation

- Direct measurement of $|V_{tb}|^2$
- Sensitive to anomalous couplings, 4th gen., FCNC
- Top/anti-top production ratio sensitive to
  - u(d) quark PDF
  - new physics: Wtb V+A, FCNC
- Important background for Higgs and SUSY searches



Event selection

- Isolated charged lepton (muon/electron)
- Veto additional charged lepton

- Two jets with $|\eta| < 4.5$
- One of those jets has to be b-tagged
- QCD multijet suppression cut (MTW/MET)

Analyses

- **Light jet pseudorapidity $|\eta_{j'}|$**
  - Binned likelihood fit to pseudorapidty of forward jet $|\eta_{j'}|$
  - Robust analysis with data-driven background estimation
    - W+jets contribution from top mass side band

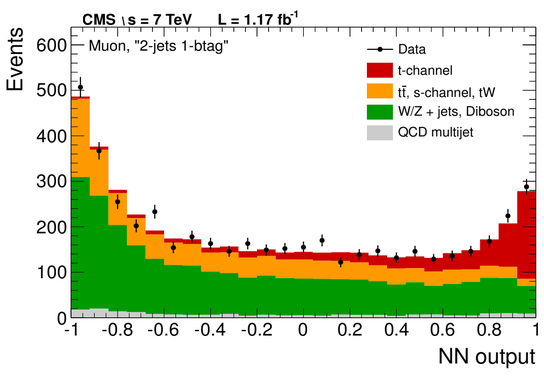
- **Multivariate analyses (7 TeV)**
  - Several well described variables validated in control regions
  - Multiple jet/tag categories (up to 4 jets and ≥ 2 b-tagged jets)

- Bayesian statistical inference

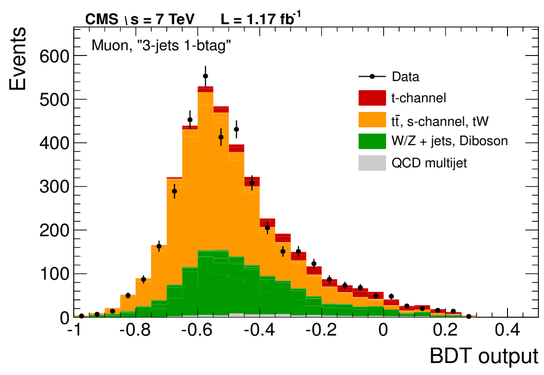
$$p(\mu|\text{data}) \propto \int p'(\text{data}|\mu,\vec{\theta}) \cdot \pi(\mu)\pi(\vec{\theta})\ \mathrm{d}\vec{\theta}$$

  - Experimental uncertainties marginalized as nuisance parameters
  - Theoretical uncertainties estimated with PEs and likelihood fit

Neural network (NN)



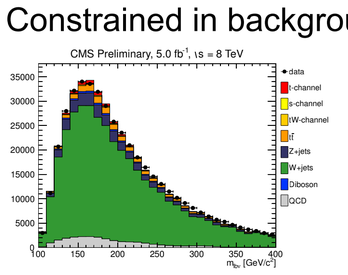
Boosted decision trees (BDT)

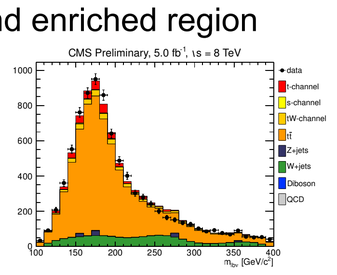


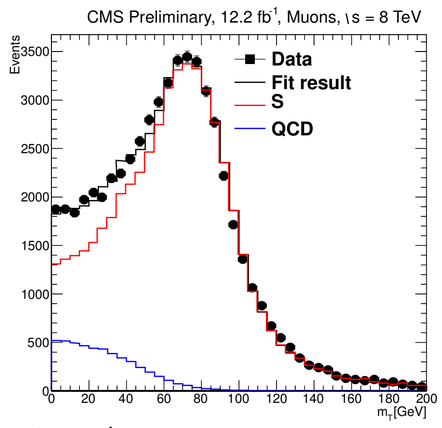
Backgrounds and data-driven estimation

W+jets ($|\eta_{j'}|$ only)
- Shape and rate from background region
- Background region: outside top mass window $130 < m_{top} < 220$

Top quark pair production
- Shape and rate from MC simulation
- Constrained in background enriched region





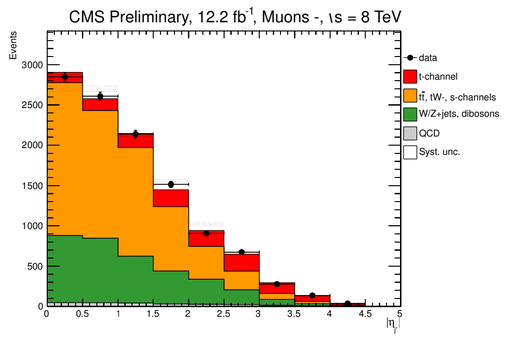


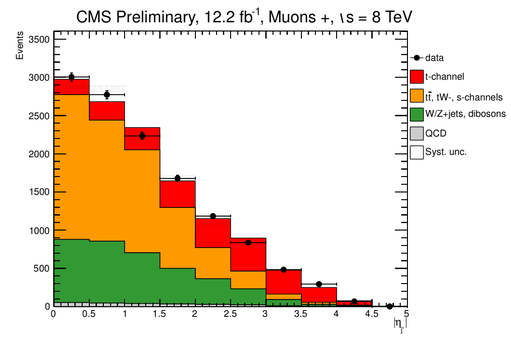
QCD multijet production
- Shape and rate from orthogonal data set
  - Muons: Inverting relative isolation
  - Electrons: Anti-electron ID
- Binned likelihood fit to MTW (muons) and MET (electrons)

Charge asymmetry

- More top than anti-top quarks produced due to initial valence quark distribution
- Ratio depends on u(d) quark PDF but also sensitive to new physics
- Measurement can be used as input to PDF fitters

Measurement:
- Binned likelihood fit to pseudorapidty of forward jet $|\eta_{j'}|$ simultaneously to muon/electron channel separately for positive/negative charge of lepton
- Systematic uncertainties estimated by pseudo experiments
  - Luminosity cancels, JES/JER/MET reduced due to ratio





Extraction of $|V_{tb}|$

$$V = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix}$$

No CKM unitarity assumed, only $|V_{tb}|^2 \gg |V_{td}|^2+|V_{ts}|^2$

7 TeV $|\eta_{j'}|$,BDT,NN

$$|f_{LV} V_{\mathrm{tb}}| = \sqrt{\frac{\sigma_{t\text{-ch.}}}{\sigma^{\mathrm{th}}_{t\text{-ch.}}}} = 1.020 \pm 0.046\ (\mathrm{exp.}) \pm 0.017\ (\mathrm{theor.})$$

with possible anomalous coupling f_{LV} (e.g., vector-like quarks)

Constrained to Standard Model:
$f_{LV}=1$ and $|V_{tb}| \in [0,1]$

$$0.92 < |V_{tb}| \leq 1 @\ 95\%\ \mathrm{CL}$$

Cross section results

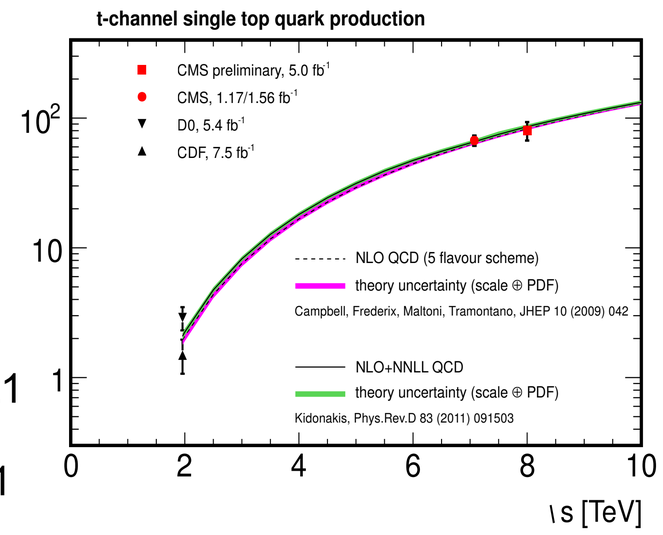
7 TeV $|\eta_{j'}|$,BDT,NN

$$\sigma_{t-ch} = 67.2 \pm 5.0(\mathrm{stat.} + \mathrm{syst.} + \mathrm{lumi.}) \pm 3.5(\mathrm{theor.})\ \mathrm{pb}$$

8 TeV $|\eta_{j'}|$

$$\sigma_{t-ch} = 80.1 \pm 5.7(\mathrm{stat.}) \pm 11.0(\mathrm{syst.}) \pm 4.0(\mathrm{lumi.})\ \mathrm{pb}$$

- Excellent agreement between prediction and measurements
- Most precise measurement of single top t-channel cross section at 7 TeV

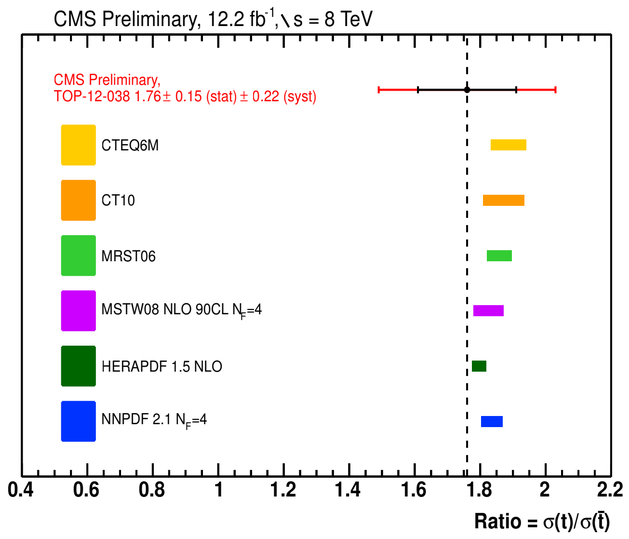


Charge asymmetry results

8 TeV $|\eta_{j'}|$

$$R_{t\text{-ch.}} = 1.76 \pm 0.15(\mathrm{stat.}) \pm 0.22(\mathrm{syst.})$$
$$\sigma_{t\text{-ch.,top}} = 49.9 \pm 1.9(\mathrm{stat.}) \pm 8.9(\mathrm{syst.})\ \mathrm{pb}$$
$$\sigma_{t\text{-ch.,anti-top}} = 28.3 \pm 2.4(\mathrm{stat.}) \pm 4.9(\mathrm{syst.})\ \mathrm{pb}$$

- Measured and predicted ratio agree within uncertainties
- More data/higher precision will allow to constrain u(d) PDF



References

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