Precise measurement of the top quark mass and decay width with single top events at CMS

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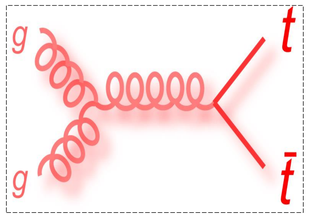
Introduction

High center of mass energy → Top quark factory LHC

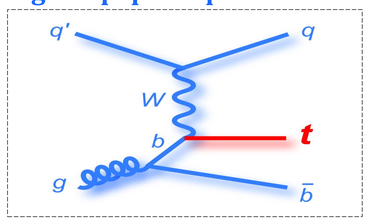
Precision lab for top quark property measurement such as its mass (m_t)

$t\bar{t}$ is the largest contributor to top quark production at LHC



$\approx 831\ pb$ @13 TeV

t channel is the largest contributor to single top quark production



$\approx 217\ pb$ @13 TeV

Top quark is the heaviest particle of the SM

Largest Yukawa coupling with the higgs boson

Major impact on the stability of EWK vacuum

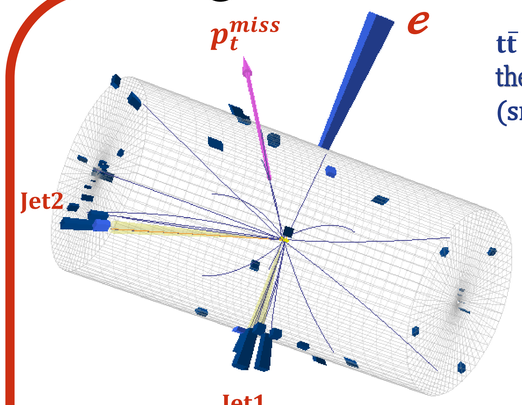

Top quark


Top antiquark

$\Delta m_t = m_t - m_{\bar{t}}$

Sensitive to the CPT violation

Signal and backgrounds



$t\bar{t}$ is the irreducible bkg & $W + jes$ is the second domi. bkg. QCD multiJet (small selection efficiency)

I Lepton (e/μ)

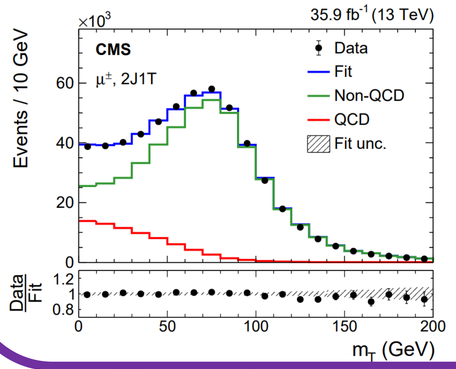
2 Jets (I b-tagged jet) + large p_t^{miss}

derive QCD template using SB data

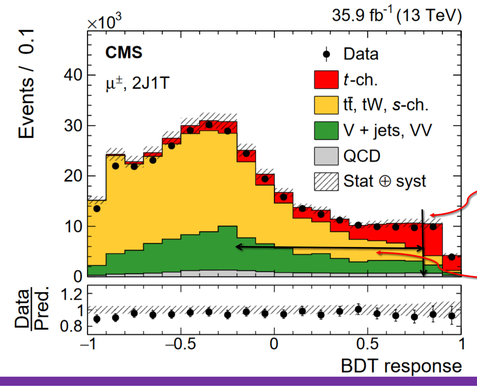
Analysis overview

- Two component ML fit → QCD contribution

$F(m_T) = N_{QCD} \times Q(m_T) + N_{non-QCD} \times W(m_T)$



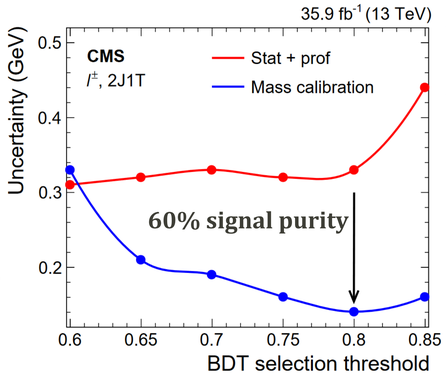
- 2 BDTs (per lepton flavour) are trained
- Training variables → low correlation with m_t



BDT > 0.8
Signal enriched reason

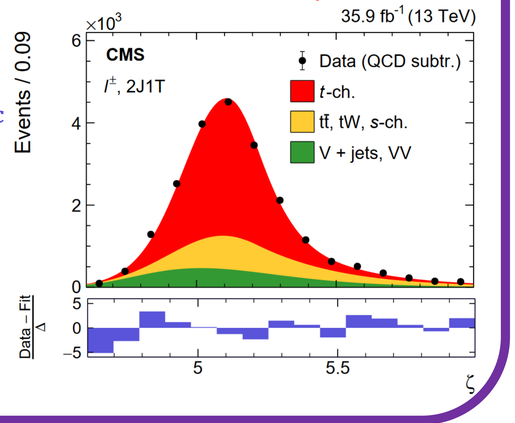
-0.2 < BDT < 0.8
$t\bar{t}$ enriched reason for fit validation

- Cut on BDT is optimized to reduce the uncertainty on the measured top quark mass

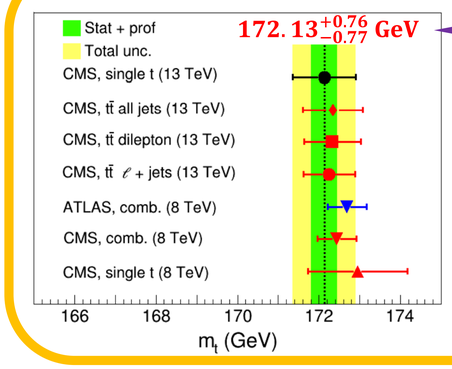


- Simultaneous ML fit performed
- Appropriate parametric shapes for sig. and bkg
- Three parametric shapes are used:
  1. Asym. Gaussian core + Landau tail
  2. Crystal ball function
  3. Novosibirsk function

- Tansform $\zeta = ln(m_t)$ for the final fit
- Calibration with true m_t

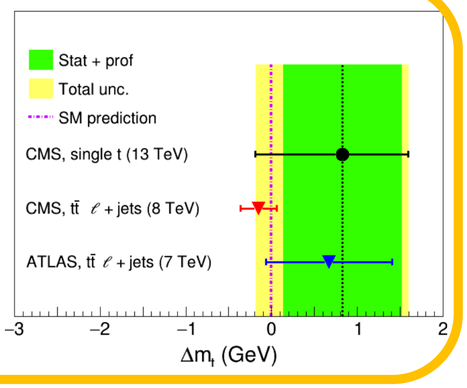


Results

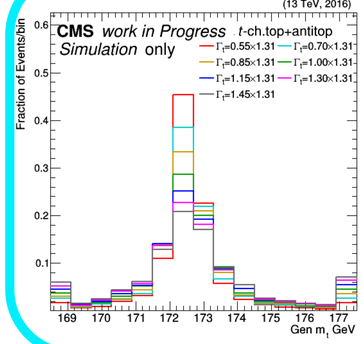


Sub GeV precision is achieved first time in such phase space

$\Delta m_t = 0.83^{+0.77}_{-1.01}$ GeV



Outlook



- Simultaneous ML fit to m_T for QCD shape extraction
- DNN to separate signal from bkg
- Fit the Top quark mass and its width simultaneously
- Add new control region to control syst.
- Improve width precision ?

Reference:

1. JHEP 12 (2021) 161
2. Phys. Lett. B 716 (2012) 214
3. CMS Top Quark Physics Group