Matter and the Universe

Fundamental Particles and Forces

Probing QCD with Top-Quark Pairs at CMS

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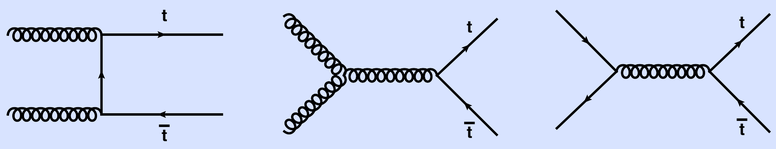
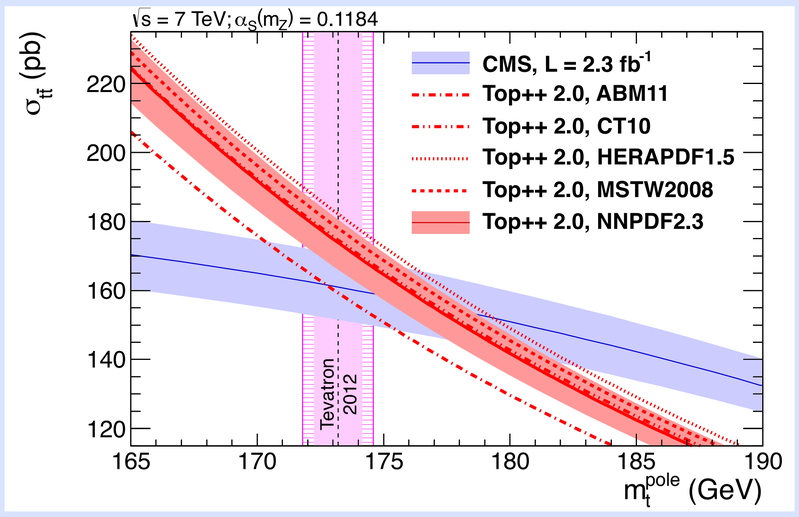
Top-quark pairs at the LHC are produced predominantly in gluon-gluon fusion.
The cross section $\sigma_{t\bar{t}}$ depends on the value of m_t, α_S, and the gluon distribution, $g(x)$.



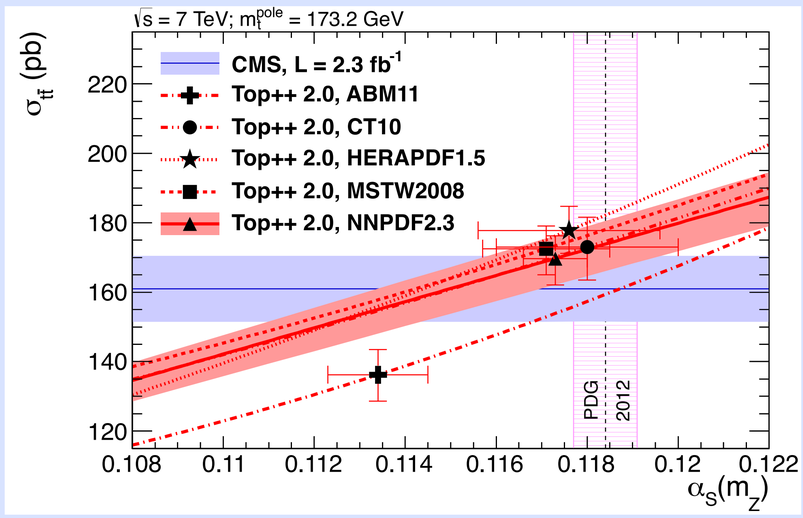
CMS Collaboration,
Phys. Lett. B728 (2013) 496:

The inclusive cross section for top-pair production as measured by the CMS experiment at $\sqrt{s}$ = 7 TeV is compared to the QCD prediction at NNLO using five PDF sets. The pole mass of the top quark, m_t, or the strong coupling constant, α_S, are extracted.

Top-pair cross-section as a function of m_t



Top-pair cross-section as a function of $\alpha_S(M_Z)$



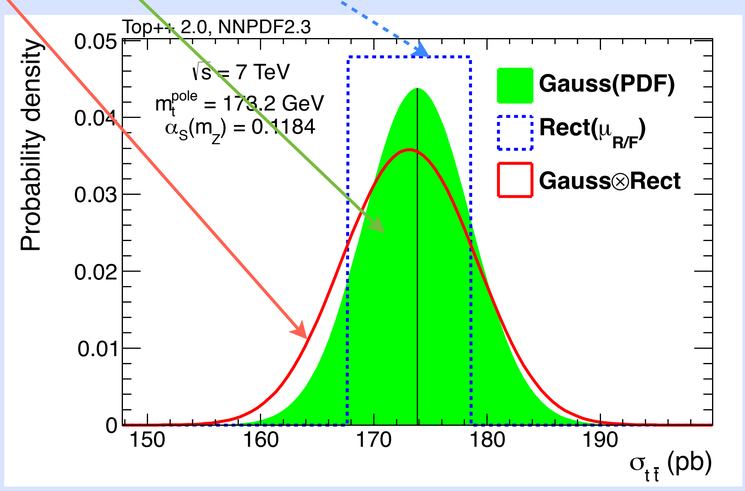
Both m_t and α_S alter the prediction for the top-pair production cross section. For the determination of α_S, m_t is fixed to the Tevatron average and for the extraction of m_t, α_S is fixed to the world average. For each PDF set, the most probable values of m_t or $\alpha_S(M_Z)$ are obtained.

Probabilistic approach: maximum of marginalized posterior $P(x) = \int f_{exp}(\sigma_{t\bar{t}}|x)\, f_{th}(\sigma_{t\bar{t}}|x)\, d\sigma_{t\bar{t}}$, $x = m_t$ or $\alpha_S(M_Z)$

Probability function for predicted cross section

$$f_{\mathrm{th}}(\sigma_{t\bar{t}}) = \mathcal{G}(\delta_{\mathrm{PDF}}) \otimes \mathrm{rect}(\sigma_{t\bar{t}}|\sigma_{t\bar{t}}^{(l)}, \sigma_{t\bar{t}}^{(h)}) = \frac{1}{2\left(\sigma_{t\bar{t}}^{(h)} - \sigma_{t\bar{t}}^{(l)}\right)} \left(\mathrm{erf}\left[\frac{\sigma_{t\bar{t}}^{(h)} - \sigma_{t\bar{t}}}{\sqrt{2}\ \delta_{\mathrm{PDF}}}\right] - \mathrm{erf}\left[\frac{\sigma_{t\bar{t}}^{(l)} - \sigma_{t\bar{t}}}{\sqrt{2}\ \delta_{\mathrm{PDF}}}\right] \right)$$

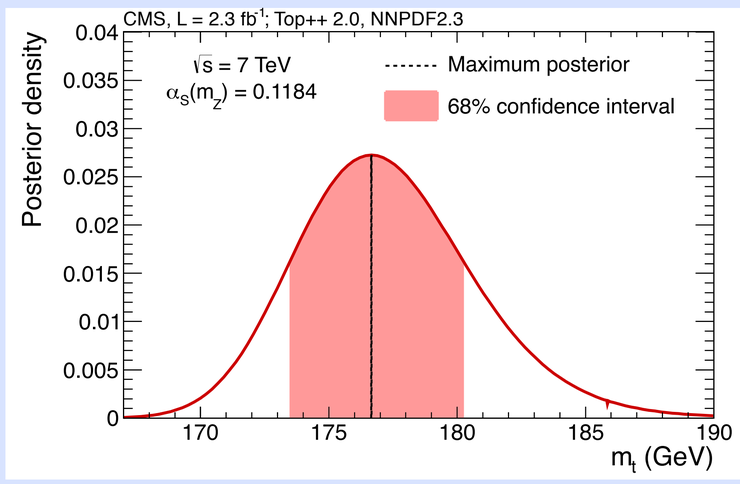
PDF error 68% CL — scale variation



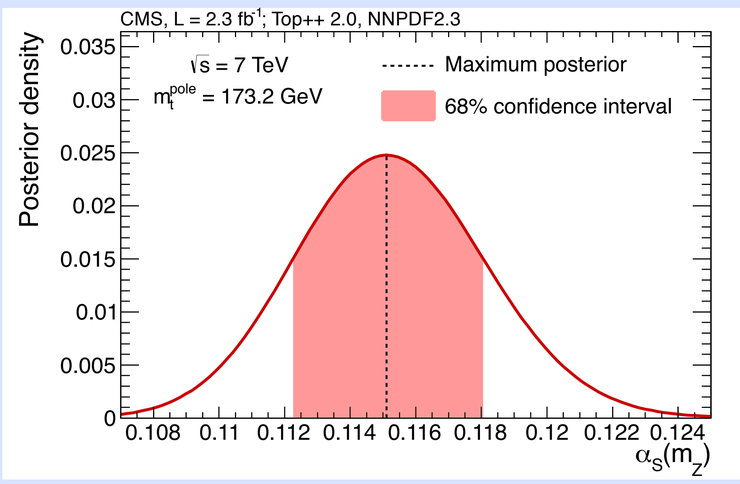
Measured cross section represented by Gaussian probability function $f_{exp}(\sigma_{t\bar{t}})$

Most probable m_t or $\alpha_S(M_Z)$ are obtained from maximum of marginalized posterior:

$P(m_t)$

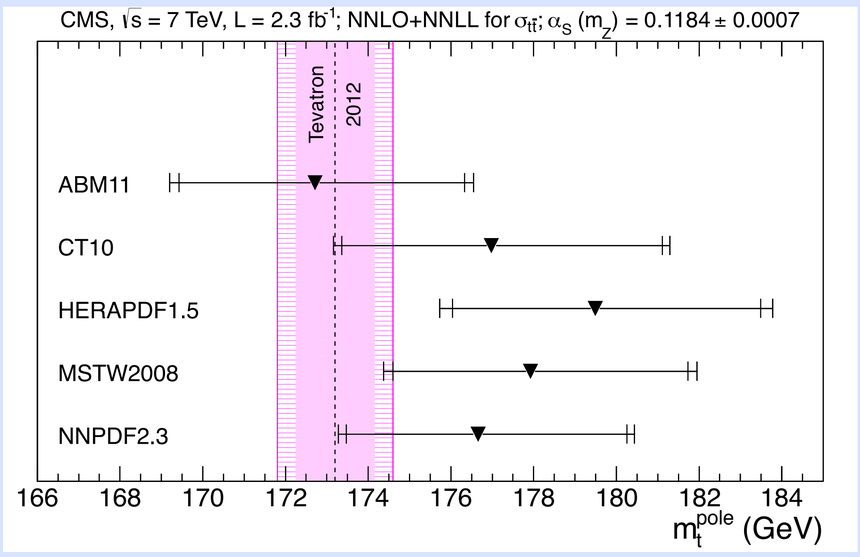


$P(\alpha_S)$

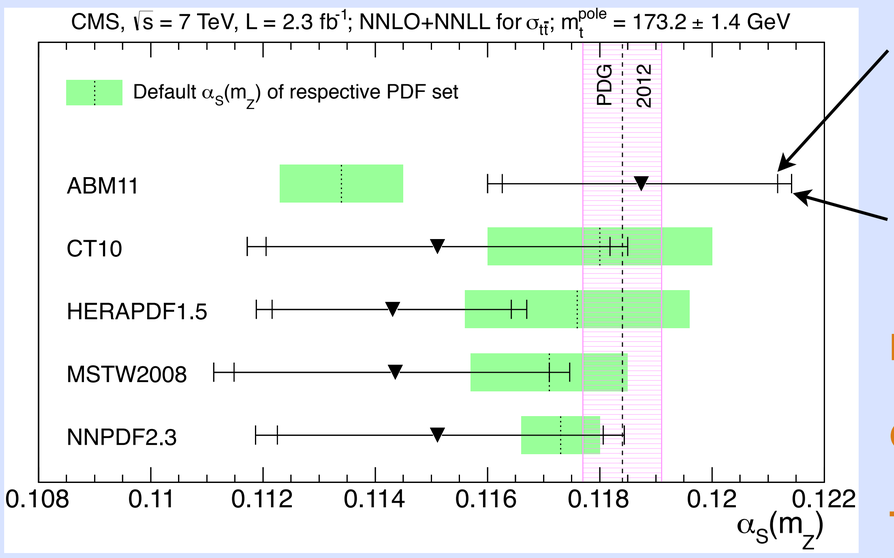


For each PDF set, the most probable values of m_t and $\alpha_S(M_Z)$ are obtained.

Values of m_t obtained by confronting $\sigma^{exp}_{t\bar{t}}$ with $\sigma^{th}_{t\bar{t}}$



Values of α_S (M_Z) obtained by confronting $\sigma^{exp}_{t\bar{t}}$ with $\sigma^{th}_{t\bar{t}}$



inner error bars:
uncertainty on $\sigma^{exp}_{t\bar{t}}$, E_{beam}^{LHC}, PDF and scale variation in $\sigma^{th}_{t\bar{t}}$

outer error bars: uncertainty on m_t and α_S (M_Z) (world average)

Results agree with world average

Consistent for different PDFs

Theory uncertainty (scales) ~1%

Using NNPDF2.3: pole mass of the top quark $\mathbf{m_t = 176.7^{+3.8}_{-3.4}\ GeV}$, strong coupling constant $\alpha_S(M_Z) = 0.1151^{+0.0033}_{-0.0032}$

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