Deutsches Elektronen-Synchrotron - CMS experiment

CMS PDF Forum - 24 October 2017

Extraction of α_s and m_t from inclusive $\sigma_{t\bar{t}}$

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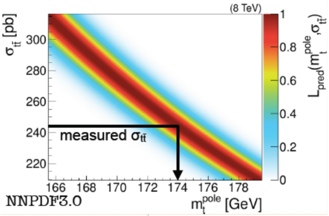
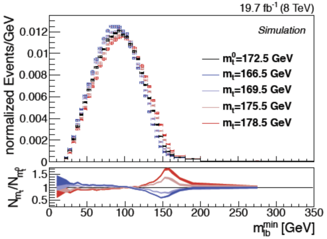
strategy:

- extract $\sigma_{t\bar{t}}$ from template fits to differential distributions of final state observables
- simultaneously fit $\sigma_{t\bar{t}}$ and m_t^{MC} to mitigate the MC dependency
- compare $\sigma_{t\bar{t}}^{obs}$ to fixed-order theory prediction to extract mass and strong coupling



idea:

- measure $\sigma_{t\bar{t}}$ in di-leptonic opposite-flavour channel ($e\mu$) with the full 2016 dataset
- extend from "baseline" strategy outlined in **TOP-17-001** to include m_t^{MC} extraction with $\boldsymbol{m_{lb}^{min}}$ **method**



simultaneous fit of $\sigma_{t\bar{t}}$ and m_t^{MC}

fit strategy:

- events classified in **12 mutually-exclusive categories** to enhance fit power
- **binned likelihood fit** to final state distributions
- systematic uncertainties and m_t^{MC} treated as nuisance parameters
- bg normalization constrained in data

modelling of m_t^{MC} dependence:

- ± 3 GeV alternative mass samples

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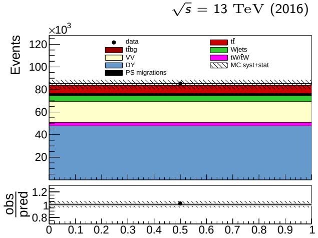
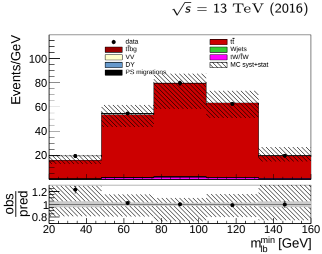
$$\sigma_{t\bar{t}}^{\text{obs}} = 826.9 \pm 1.9\ (\text{stat})\ ^{+32.2}_{-30.5}\ (\text{syst})\ \text{pb}$$
$$m_t^{MC} = 17x.xx \pm 0.16\ (\text{stat}) \pm 0.52\ (\text{syst})\ \text{GeV}$$

0 b-tags, 0 add. jets



2 b-tags, 1 add. jets



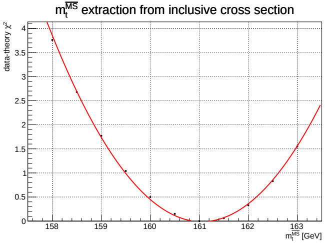
$m_t^{\overline{MS}}$ extraction at NNLO

details:

- xFitter framework interfaced with **Hathor**
- **ABMP16 NNLO** pdf set
  (consistent treatment of $m_t^{\overline{MS}}$ in pdf determ.)
- using results from combined fit of $\sigma_{t\bar{t}}$ and m_t^{MC}

uncertainties:

- experimental: from $\sigma_{t\bar{t}}$ fit (contains m_t^{MC})
- PDF: from eigenvectors
- theory: from envelope of 6 possible μ_r and μ_f variations by factor of 2



χ^2 profile - parabolic fit

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$$\boxed{m_t^{\overline{MS}}(m_t) = 161.0 \pm 1.3\ (\text{exp}) \pm 0.8\ (\text{pdf})\ {}^{+0.1}_{-0.9}\ (\text{scale})\ \text{GeV}}$$

latest result quoted in PDG:

- $m_t^{\overline{MS}} = 160\ {}^{+5}_{-4}\ \text{GeV}$ $\rightarrow$ out-performed by a factor of 3

further results at NNLO: $m_t^{\overline{MS}}$ and m_t^{pole}

- different mass definitions: $m_t^{\overline{MS}}$, m_t^{pole}
- different PDF sets: ABMP16, CT14, NNPDF3.1, MMHT2014

	$m_t^{\overline{MS}}(m_t)$ [GeV]	m_t^{pole} [GeV]
ABMP16_5_nnlo	161.0 ± 1.6 (fit) $^{+0.1}_{-0.9}$ (scale)	170.0 ± 1.4 (fit) $^{+1.4}_{-1.9}$ (scale)
CT14nnlo	164.4 ± 1.7 (fit) $^{+0.1}_{-1.1}$ (scale)	173.6 ± 1.7 (fit) $^{+1.3}_{-2.0}$ (scale)
NNPDF31_nnlo_pdfas	164.0 ± 1.4 (fit) $^{+0.1}_{-1.0}$ (scale)	173.1 ± 1.5 (fit) $^{+1.3}_{-1.9}$ (scale)
MMHT2014nnlo68cl	164.4 ± 1.5 (fit) $^{+0.1}_{-1.0}$ (scale)	173.5 ± 1.6 (fit) $^{+1.3}_{-2.0}$ (scale)

- good agreement between results with different PDF sets
- uncertainty on $m_t^{\overline{MS}}$ dominated by experimental uncertainties
- uncertainty on m_t^{pole} mostly driven by theoretical uncertainties

latest 13 TeV result from CMS: $m_t^{pole} = 170.6 \pm 2.7$ GeV (CT14, arXiv:1701.06228 (2017))

α_s extraction at NNLO

details and uncertainties:

- same setup used for m_t extraction
- m_t treated consistently with PDF fit

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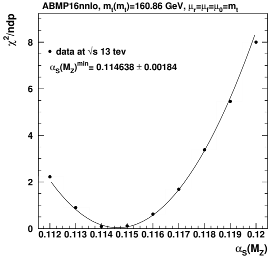
$$\boxed{\alpha_s(M_Z) = 0.1146 \pm 0.0018\ (\text{fit})\ {}^{+0.0013}_{-0.0001}\ (\text{scale})}$$

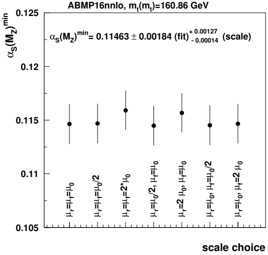
- uncertainty from m_t^{MC} automatically taken into account (combined fit with $\sigma_{t\bar{t}}$)

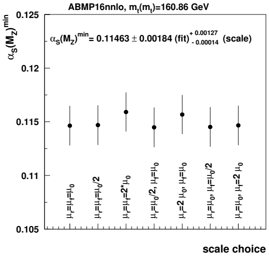
latest result from DIS: (arXiv:1709.07251)

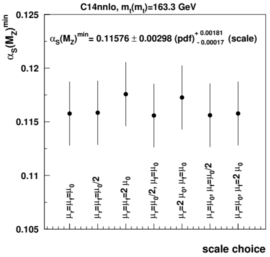
- $\alpha_s(M_Z) = 0.1142 \pm 0.0028$ (first NNLO result from hadron collider - inclusive jet production)

$\rightarrow$ **$\sigma_{t\bar{t}}$ gives the best result at hadron collider so far**

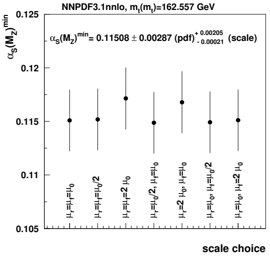








- PDF sets: ABMP16, CT14, NNPDF3.1
- results in excellent agreement
- better precision achieved with ABMP16



summary:

- simultaneous fit of $\sigma_{t\bar{t}}$ and m_t^{MC} implemented based on TOP-17-001 results
- $\sigma_{t\bar{t}}^{obs}$ used to **extract $m_t^{\overline{MS}}$, m_t^{pole} and $\alpha_s(M_Z)$** using fixed-order calculations

conclusions:

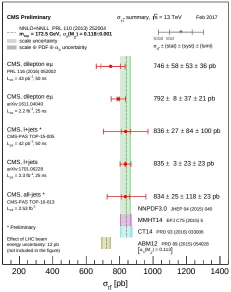
- **$m_t^{\overline{MS}}$ extraction out-performs previous measurements**
- **best α_s result at hadron collider so far**
- improved m_t^{pole} precision with respect to previous 13 TeV result

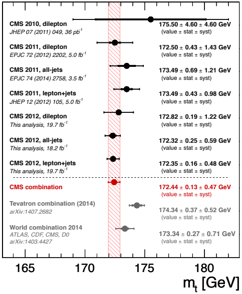
outlook:

- still in the process of finalizing the $\sigma_{t\bar{t}}$ fit
- numbers might change slightly but overall strategy is defined

BACKUP

CMS-TOP-14-022





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$$m_t^{MC} = 17x.xx \pm 0.16\ (\mathrm{stat}) \pm 0.52\ (\mathrm{syst})\ \mathrm{GeV}$$

- consistent with previous CMS measurements
- **competitive precision**

highest contrib. to $\sigma_{t\bar{t}}$ uncert.

syst	contrib [%]
JES	0.6
PDF	0.7
Lept. ID/Iso	**2.2**
b-tagging	0.3
Color reconn.	0.4
Pile-up	0.3
Trigger	0.7
$t\bar{t}$ fragm.	1.0
$t\bar{t}$ FSR scale	0.4
$t\bar{t}$ ISR scale	0.4
$t\bar{t}$ ME scale	0.3
top mass	0.2
DY norm.	**1.3**
tW norm.	0.3
VV norm.	0.6
Luminosity	**2.6**
Stat	0.2
PDF (extr)	$\pm^{0.7}_{0.6}$
top mass (extr)	$\mp^{0.1}_{0.4}$
Total	$\pm^{3.9}_{3.7}$