

# Integration of $t\bar{t}$ Cross Sections into the H1Fitter

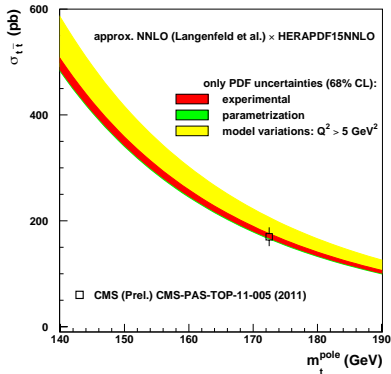
Sebastian Naumann-Emme

DESY

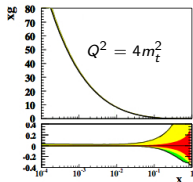
HERAFitter User's Meeting, 2011-11-23



Big impact of model variations ( $Q^2 > 5.0$  instead of  $3.5 \text{ GeV}^2$ ) in the PDF fit on the predicted  $t\bar{t}$  cross section



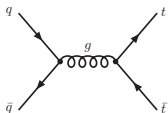
Gluon PDF at high  $x$  is very sensitive to this:



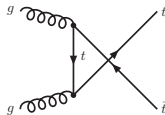
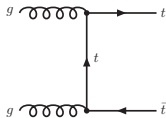
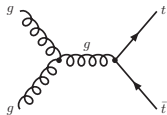
Main **production** mechanisms:  $t\bar{t}$  pairs from ...

...  $q\bar{q}$  annihilation (dominant in  $p\bar{p}$  collisions at  $\sqrt{s} = 2$  TeV, i.e. Tevatron)

... from  $gg$  fusion (dominant in  $pp$  collisions at  $\sqrt{s} = 7$  TeV, i.e. LHC)

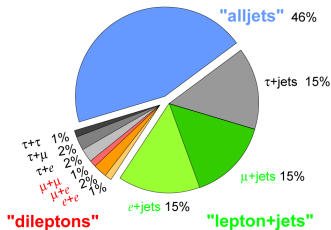


and



**Decay** almost 100% via  $t \rightarrow Wb$ , therefore  $t\bar{t}$  events classified according to  $W$  decays:

$c\bar{s}$	electron+jets	muon+jets	tau+jets	all-hadronic	
$\bar{u}d$	electron+jets	muon+jets	tau+jets		
$\tau^-$	dileptons	muon+jets	tau+jets	tau+jets	
$\mu^-$	dileptons	electron+jets	muon+jets	muon+jets	
$e^-$	dileptons	electron+jets	muon+jets	electron+jets	
$W$ decay	$e^+$	$\mu^+$	$\tau^+$	$u\bar{d}$	$c\bar{s}$



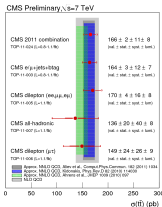


# Measured Cross Section

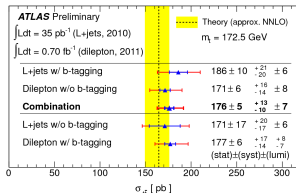


Latest combination of measurements by **CMS** in all  $t\bar{t}$  decay channels:

$$\sigma_{t\bar{t}} = 165.8 \pm 2.2 \text{ (stat)} \pm 10.6 \text{ (syst)} \pm 7.8 \text{ (lumi)} \text{ pb} \quad \text{CMS-PAS-TOP-11-024}$$



$$\frac{\delta\sigma_{t\bar{t}}}{\sigma_{t\bar{t}}} \sim 6 - 7\%$$



Combination of **ATLAS** measurements in the lepton+jets and dilepton final states:

$$\sigma_{t\bar{t}} = 176 \pm 5 \text{ (stat)} \pm_{-10}^{+13} \text{ (syst)} \pm 7 \text{ (lumi)} \text{ pb} \quad \text{ATLAS-CONF-2011-108}$$

Latest measurement by **ATLAS** in the lepton+jets channel:

$$\sigma_{t\bar{t}} = 179.0 \pm 9.8 \text{ (stat+syst)} \pm 6.6 \text{ (lumi)} \text{ pb} \quad \text{ATLAS-CONF-2011-121}$$

Three different NLO calculations for  $\sigma_{t\bar{t}}$  with higher-order corrections (approximate NNLO) available:

- **Langenfeld, Moch, Uwer:**

$$\sigma_{t\bar{t}} = 165.8^{+4.4}_{-7.0} \text{ (scale)} \pm 9.1 \text{ (PDF)} \pm 11.6 \text{ } (\alpha_S) \text{ pb}$$

- **Kidonakis:**

$$\sigma_{t\bar{t}} = 165.6^{+7.3}_{-5.1} \text{ (scale)} \pm 9.1 \text{ (PDF)} \pm 12.9 \text{ } (\alpha_S) \text{ pb}$$

- **Ahrens et al.:**

$$\sigma_{t\bar{t}} = 157.9^{+7.8}_{-8.9} \text{ (scale)} \pm 8.7 \text{ (PDF)} \pm 11.9 \text{ } (\alpha_S) \text{ pb}$$

These numbers (for  $m_t^{\text{pole}} = 172.5$  GeV and MSTW2008NNLO PDF) are in **good agreement** with each other and with the measured  $\sigma_{t\bar{t}}$

No major differences when using HERAPDF15 (slightly better uncertainties due to smaller exp. errors in HERAPDF, see backup)

Uncertainties on measured and predicted  $\sigma_{t\bar{t}}$  roughly of same size

## “HAdronic Top and Heavy quarks crOSS section calculatoR”

Developed by M. Aliev, H. Lacker, U. Langenfeld, S. Moch, P. Uwer and M. Wiedermann

Calculates the total  $t\bar{t}$  cross section in  $p\bar{p}$  and  $pp$  collisions, for a given pole or  $\overline{MS}$  mass

Available from <http://www-zeuthen.desy.de/~moch/hathor/>

Documented in Comput.Phys.Commun.182:1034-1046,2011  
(arXiv:1007.1327)

The default is to use PDF sets in LHAPDF format

But: using any PDF is possible when implementing a new PDF class that inherits from the PDF base class defined in Hathor



Introduced a new reaction type in the H1Fitter: “ttbar”  
(choosing “pp” or “ppbar” via steering parameter in the data file)

Added a new sub-directory that hosts the necessary files for interfacing Hathor with H1Fitter:

```
herafitter-0.1.0/h1fitter-0.1.0/Hathor/interface/:  
    H1FitterPdf.h  
herafitter-0.1.0/h1fitter-0.1.0/Hathor/src/:  
    H1FitterPdf.cc  HathorInterface.cc  Makefile.am
```

For each fit iteration, the current PDFs and  $\alpha_S$  are read via the corresponding QCDNUM routines and fed into Hathor for calculating a new  $\sigma_{t\bar{t}}$  prediction

The main technical steps were successful but a bit more debugging is needed before we can start looking at the impact on the PDF fits...

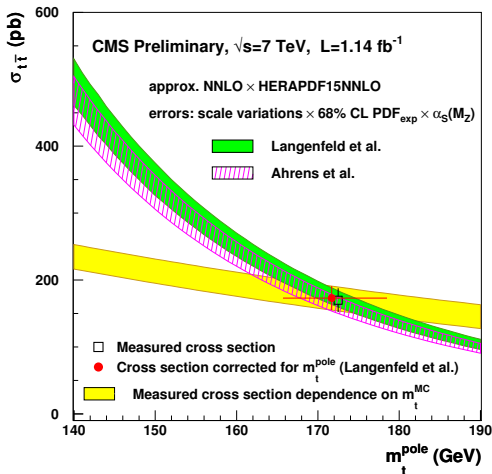
Predicted  $t\bar{t}$  cross section is mass dependent

Measured cross section is mass dependent (due to acceptance correction)

→ Extraction of most-probable mass value - either in pole or  $\overline{MS}$  scheme

See, e.g., CMS-PAS-TOP-11-008

→ Include  $\sigma_{t\bar{t}}$  in a PDF fit performing an  $m_t$  scan







$t\bar{t}$  cross sections have the potential to constrain the gluon PDF at high  $x$

Integration of the Hathor program for approx. NNLO predictions into the H1Fitter almost finished

Hope to have first results for the impact on the PDF fits soon

Later: Try to perform a top-quark mass scan as part of the PDF fit

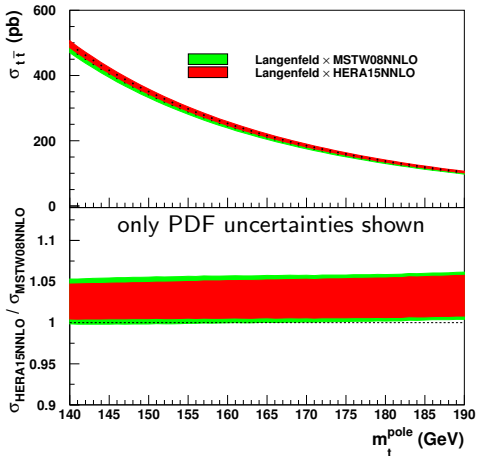
Differential  $t\bar{t}$  cross sections are in preparation by both CMS and ATLAS  
→ will we have suited predictions?

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# BACKUP

Difference of 3% in  $\sigma_{t\bar{t}}$  mostly due to different  $\alpha_S(M_Z)$

MSTW: 0.1171; HERAPDF: 0.1176



To allow comparison:  
only experimental errors  
on HERAPDF used here!  
(similar as in MSTW08)

$\curvearrowright$  Smaller uncertainty  
from HERAPDF  
( $\approx$  2% vs. 4%)