

REPORT OF $t\bar{t}H$ SUBGROUP

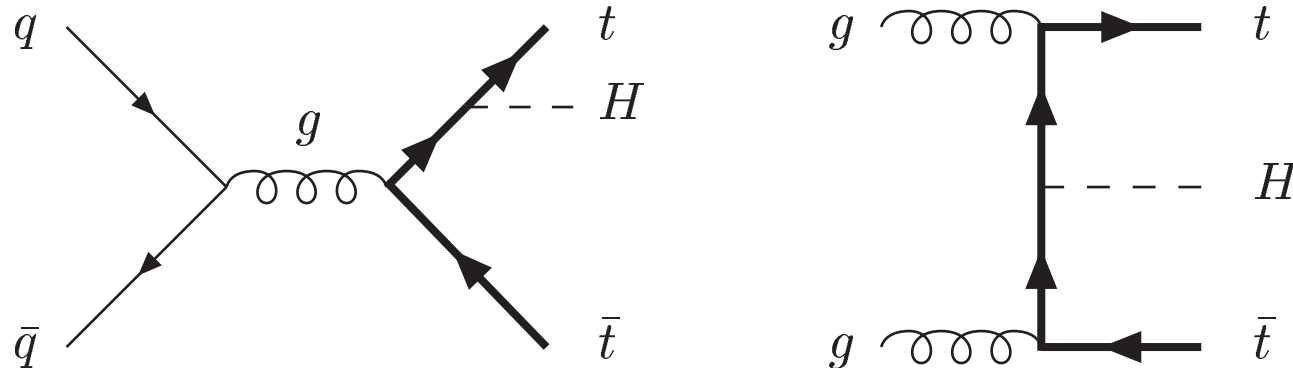
Michael Spira (PSI)

Theory convenors: Laura Reina, Michael Spira

Experimental convenors: Simon Dean (ATLAS), Chris Neu (CMS)

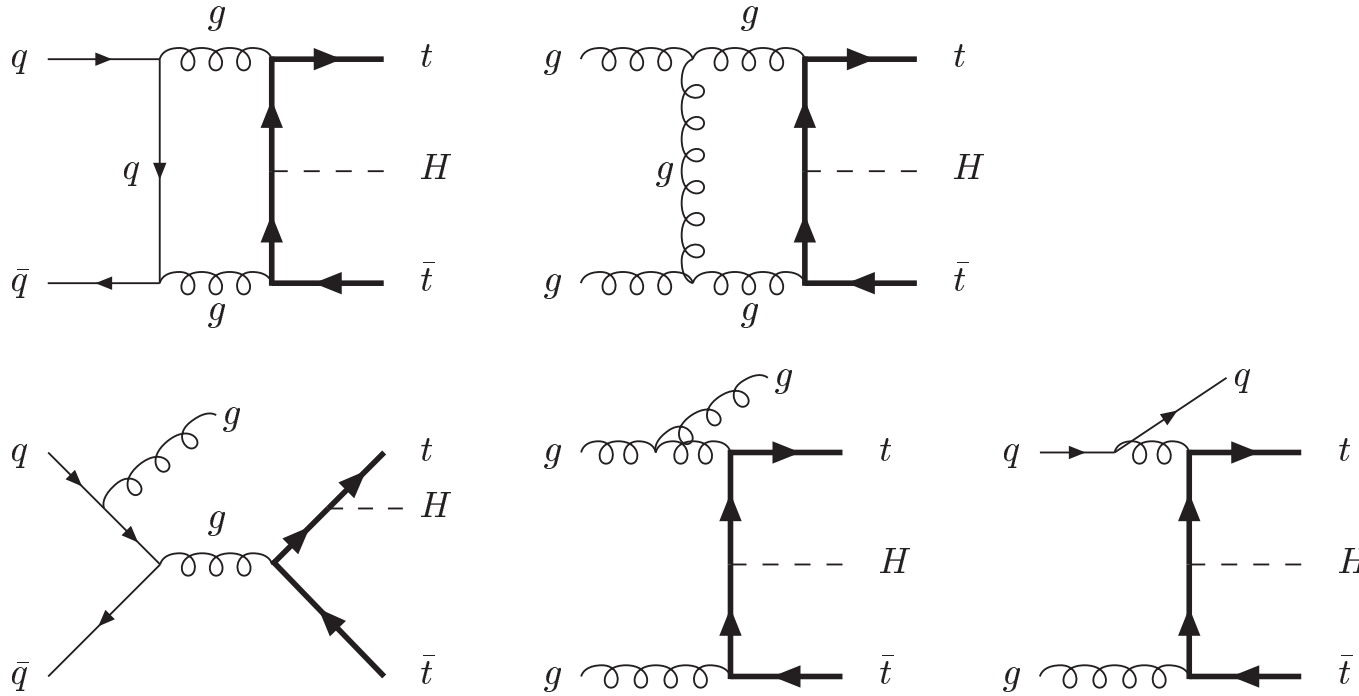
Group members: Sally Dawson, Stefan Dittmaier, David Hartanto, Michael Krämer, Doreen Wackerroth

- $gg, q\bar{q} \rightarrow t\bar{t}H$ ($H \rightarrow b\bar{b}, \gamma\gamma$) relevant for $M_H \lesssim 200$ GeV



dominant

- crucial for determination of top Yukawa coupling
- backgrounds: $pp \rightarrow t\bar{t}b\bar{b}, t\bar{t}\gamma\gamma$
- LO programs: HQQ (S.)
 Madgraph/Madevent (Maltoni, Stelzer,...)
 MCFM (Campbell, Ellis), ...



- QCD corrections $\sim 20\%$

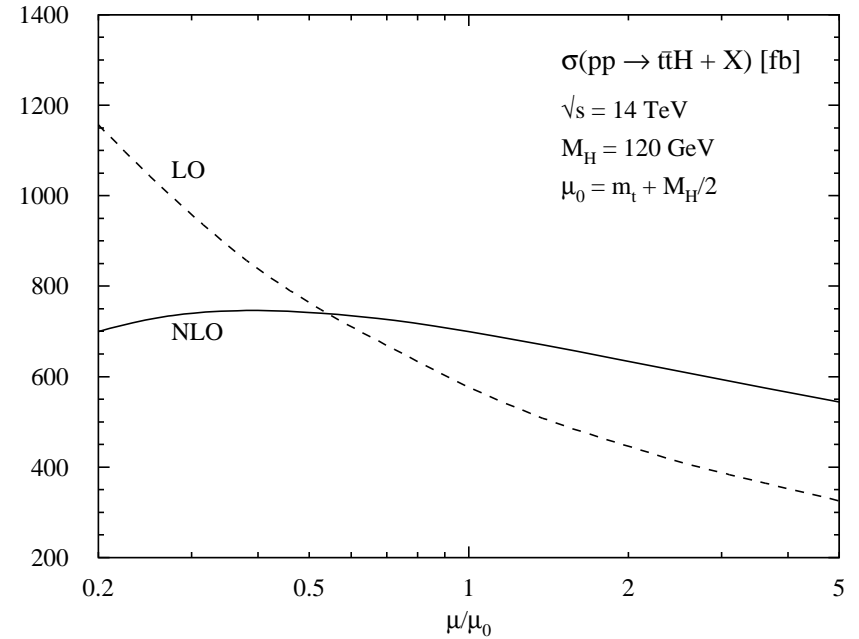
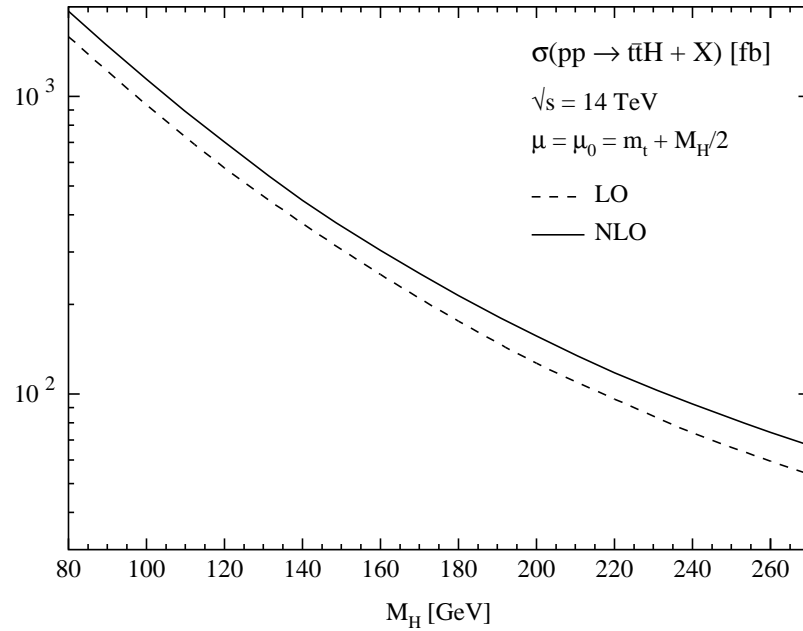
Beenakker, ...
Dawson, ...

- $pp \rightarrow t\bar{t}H \rightarrow t\bar{t}b\bar{b}$ (NWA)
 \Rightarrow no public NLO-code so far...

Bevilacqua, ...

- $pp \rightarrow t\bar{t}b\bar{b}$ (background)

Bredenstein, ...
Bevilacqua, ...



Beenakker, Dittmaier, Krämer, Plümper, S., Zerwas
 Dawson, Orr, Reina, Wackerroth

- aim: (i) provide NLO cross sections (inclusive)
(ii) theoretical errors: ren./fact. scales $[\mu_0/2, 2\mu_0]$
($\mu_0 = m_t + M_H/2$)
 α_s
PDFs
input parameters (e.g. m_t)
- agreement: use α_s consistent with PDF set:
MSTW2008: $\alpha_s(M_Z) = 0.120$ CTEQ6.6: $\alpha_s(M_Z) = 0.118$
use error PDFs of MSTW2008, CTEQ6.6 internally
(MSTW2008: only error PDFs around central set)
→ NNPDF to be done...
- NLO: Dittmaier, Krämer, S.: MSTW2008
Dawson, Reina, Wackerroth: CTEQ6.6

M_H [GeV]	LO [fb], MSTW2008	LO [fb], CTEQ6L1	scale [%]	PDF [%]
90	213.17(9)	174.14(1)	[-26.4,+39.9]	[-2.59,+2.50]
100	162.70(7)	132.95(1)	[-26.2,+39.8]	[-2.63,+2.59]
110	126.06(6)	102.80(1)	[-26.2,+39.6]	[-2.52,+2.43]
120	98.66(4)	80.428(5)	[-26.3,+39.8]	[-2.86,+2.29]
130	78.09(3)		[-26.2,+39.8]	[-2.39,+2.72]
140	62.43(3)	50.788(3)	[-26.3,+39.9]	[-2.57,+2.62]
150	50.35(2)	40.940(2)	[-26.0,+39.8]	[-2.34,+2.72]
160	40.98(2)	33.293(2)	[-26.3,+39.6]	[-2.97,+2.16]
170	33.62(1)		[-26.1,+39.9]	[-2.36,+2.85]
180	27.83(1)	22.568(1)	[-26.2,+39.7]	[-3.22,+2.28]

differences @ LO: $\sim 20\%$

HQQ

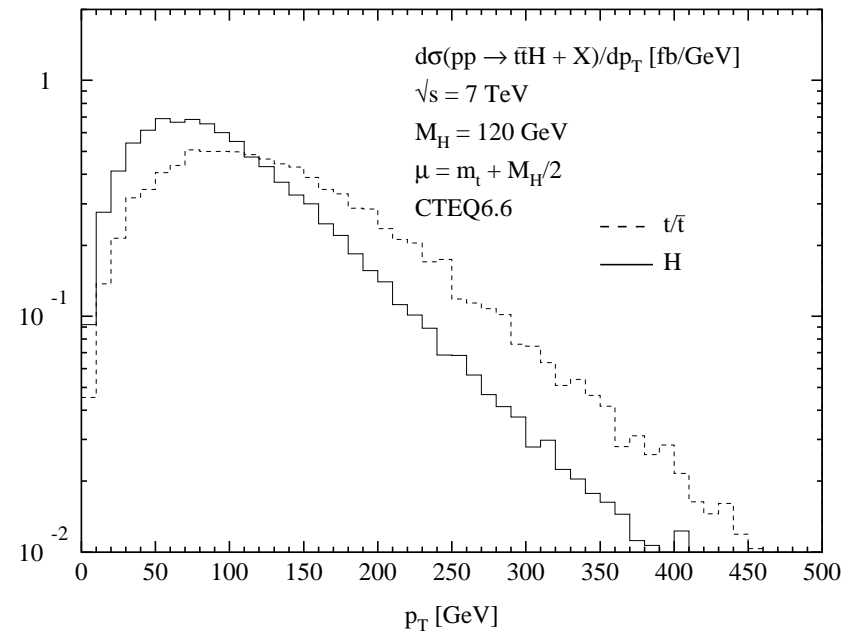
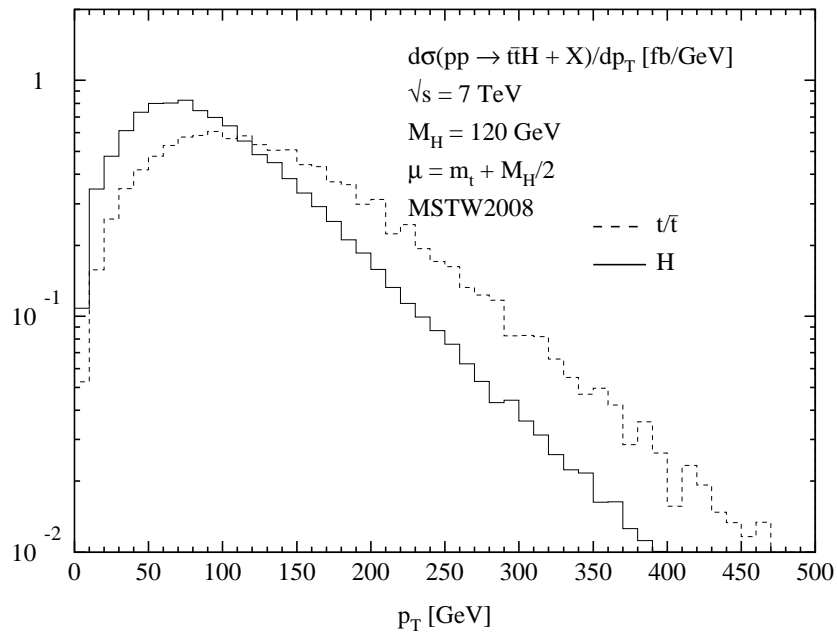
M_H [GeV]	LO [fb]	NLO [fb]	scale [%]	α_s [%]	PDF [%]
90	213.17(9)	224.8(3)	[-9.8%,+4.3%]	[-0.3%,+0.4%]	[-3.5%,+3.4%]
95	186.11(8)	195.6(2)	[-9.9%,+4.2%]	[-0.4%,+0.4%]	[-3.6%,+2.7%]
100	162.70(7)	170.4(2)	[-9.6%,+4.1%]	[-0.4%,+0.4%]	[-3.2%,+3.0%]
105	143.06(6)	149.0(2)	[-9.7%,+4.1%]	[-0.3%,+0.2%]	[-3.6%,+3.0%]
110	126.06(6)	130.8(2)	[-9.7%,+3.7%]	[-0.4%,+0.2%]	[-3.6%,+2.6%]
115	111.38(5)	115.0(1)	[-9.5%,+3.6%]	[-0.5%,+0.4%]	[-3.4%,+3.0%]
120	98.66(4)	101.4(1)	[-9.4%,+3.4%]	[-0.4%,+0.3%]	[-3.1%,+3.2%]
125	87.66(4)	89.8(1)	[-9.6%,+3.5%]	[-0.3%,+0.3%]	[-3.3%,+3.1%]
130	78.09(3)	79.57(8)	[-9.3%,+3.3%]	[-0.2%,+0.4%]	[-3.1%,+3.4%]
135	69.71(3)	70.75(7)	[-9.2%,+3.6%]	[-0.2%,+0.6%]	[-3.0%,+3.4%]
140	62.43(3)	63.06(6)	[-9.1%,+3.4%]	[0.0%,+0.6%]	[-2.9%,+3.9%]
145	55.96(2)	56.50(6)	[-9.2%,+3.2%]	[-0.5%,+0.4%]	[-3.4%,+3.1%]
150	50.35(2)	50.59(6)	[-9.2%,+3.0%]	[-0.2%,+0.3%]	[-3.3%,+3.3%]
155	45.37(2)	45.49(5)	[-9.2%,+3.1%]	[-0.5%,+0.4%]	[-3.5%,+3.0%]
160	40.98(2)	41.01(4)	[-9.2%,+2.7%]	[-0.5%,+0.2%]	[-3.8%,+2.8%]
165	37.09(1)	36.99(3)	[-9.2%,+2.9%]	[-0.3%,+0.3%]	[-3.4%,+3.1%]
170	33.62(1)	33.47(3)	[-9.2%,+2.8%]	[-0.5%,+0.3%]	[-3.7%,+3.0%]

M_H [GeV]	LO [fb]	NLO [fb]	scale [%]	α_s [%]	PDF [%]
175	30.56(1)	30.31(3)	[-9.0%, +2.7%]	[-0.4%, +0.6%]	[-3.3%, +3.6%]
180	27.83(1)	27.55(3)	[-9.1%, +2.9%]	[-0.4%, +0.4%]	[-3.2%, +3.3%]
185	25.38(1)	25.09(3)	[-9.1%, +2.8%]	[-0.4%, +0.4%]	[-3.3%, +3.5%]
190	23.20(1)	22.93(3)	[-9.3%, +2.8%]	[-0.3%, +0.3%]	[-3.7%, +3.1%]
195	21.247(8)	20.94(2)	[-9.1%, +3.1%]	[-0.3%, +0.3%]	[-3.6%, +3.6%]
200	19.481(8)	19.20(2)	[-9.2%, +2.6%]	[-0.4%, +0.5%]	[-3.4%, +3.4%]
210	16.492(7)	16.23(2)	[-9.3%, +2.8%]	[-0.5%, +0.2%]	[-4.4%, +3.2%]
220	14.040(6)	13.81(1)	[-9.3%, +3.0%]	[-0.6%, +0.2%]	[-4.1%, +3.3%]
230	12.037(5)	11.86(1)	[-9.5%, +2.9%]	[-0.7%, +0.4%]	[-4.3%, +3.3%]
240	10.384(5)	10.24(1)	[-9.4%, +3.1%]	[-0.5%, +0.5%]	[-4.1%, +4.0%]
250	9.011(4)	8.899(9)	[-9.6%, +3.5%]	[-0.4%, +0.5%]	[-3.8%, +4.5%]
260	7.850(4)	7.777(10)	[-9.5%, +3.9%]	[-0.3%, +0.7%]	[-3.8%, +5.0%]
270	6.888(3)	6.866(8)	[-9.7%, +3.6%]	[-0.4%, +0.6%]	[-4.1%, +4.3%]
280	6.075(3)	6.092(9)	[-10.0%, +3.9%]	[-0.7%, +0.6%]	[-4.8%, +4.0%]
290	5.376(3)	5.405(7)	[-10.0%, +4.4%]	[-0.5%, +1.0%]	[-4.1%, +5.6%]
300	4.780(3)	4.848(7)	[-10.3%, +4.5%]	[-0.4%, +0.6%]	[-4.9%, +5.0%]

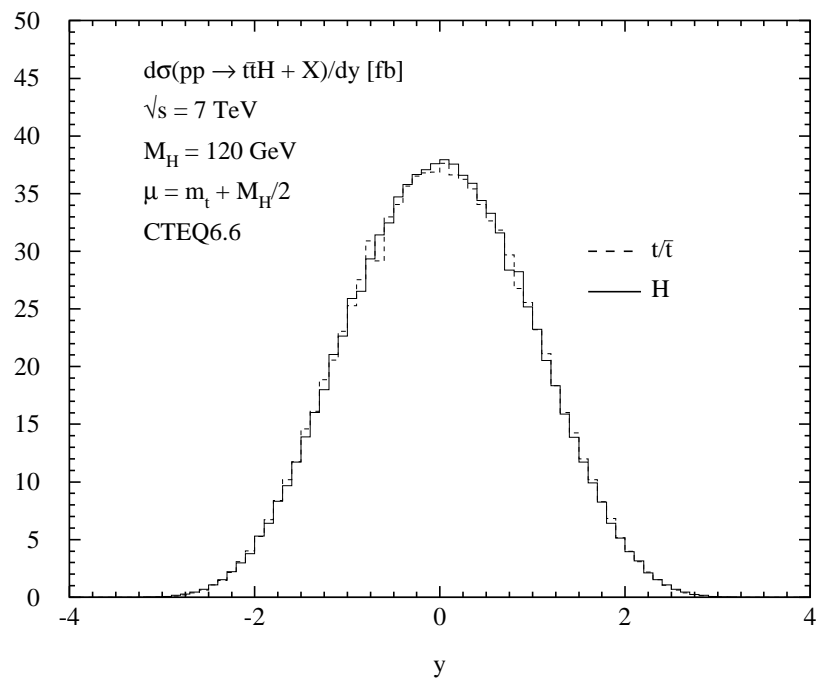
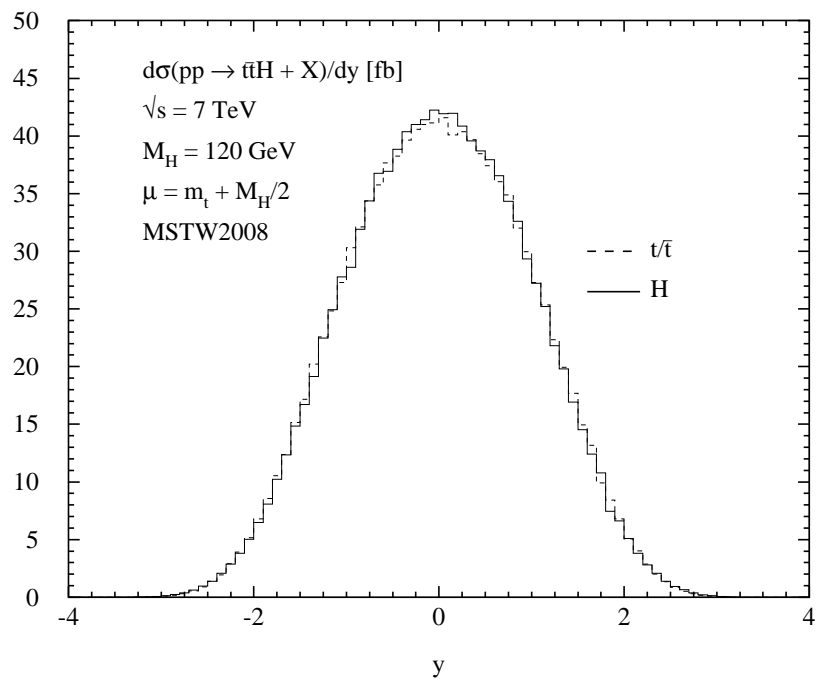
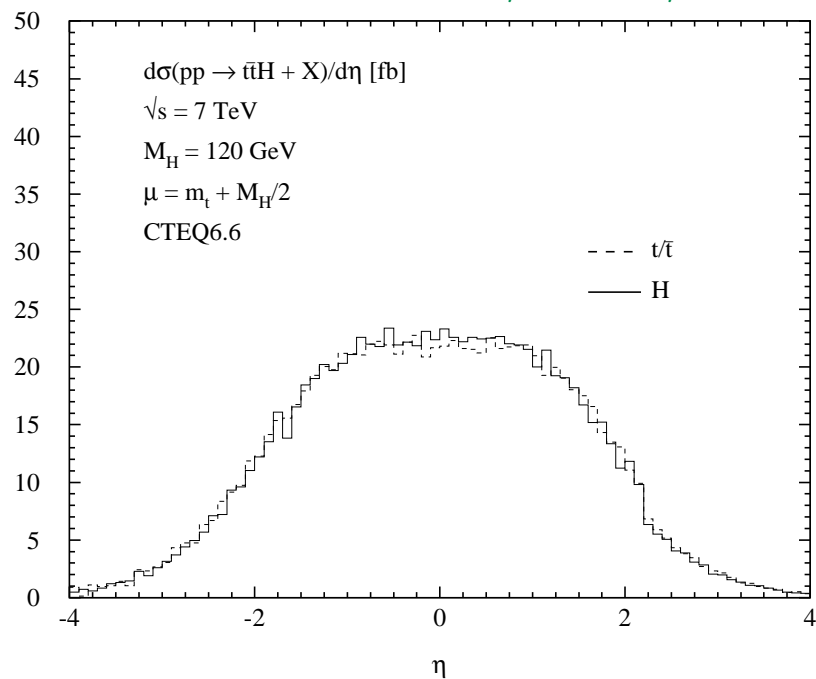
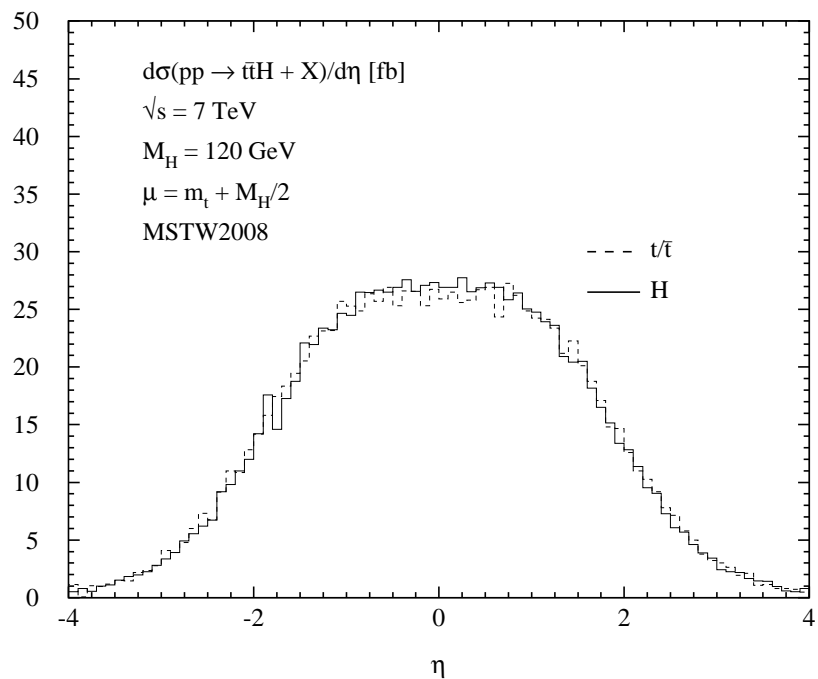
M_H [GeV]	LO [fb]	NLO [fb]	scale [%]	α_s [%]	PDF [%]
90	174.15(1)	209.7(9)			
95	151.903(9)	182.1(7)			
100	132.950(7)	156(1)			
105	116.734(7)	138.7(5)			
110	102.808(6)	121.6(4)			
115	90.806(5)	107.2(4)			
120	80.428(5)	93.2(8)		[-4,+4]	
140	50.788(3)	58.2(5)			
145	45.547(2)	52.9(2)			
150	40.940(2)	47.3(1)		[-4,+4]	
155	36.879(2)	42.6(1)			
160	33.293(2)	38.4(1)			
165	30.118(2)	34.7(1)			
180	22.568(1)	25.6(2)		[-4,+4]	

differences MSTW2008 \leftrightarrow CTEQ6.6 @ NLO: 7 – 8%

NLO distributions for $H, t/\bar{t}$



Dittmaier, Krämer, S.
Dawson, Reina, Wackerroth



GOALS

- full account for theoretical uncertainties of $t\bar{t}H$ production (✓)
- public NLO codes? interface to POWHEG?
- open issue: NLO effects on realistic distributions (e.g. $W^+W^-b\bar{b}b\bar{b}$)