ggF Higgs Cross sections

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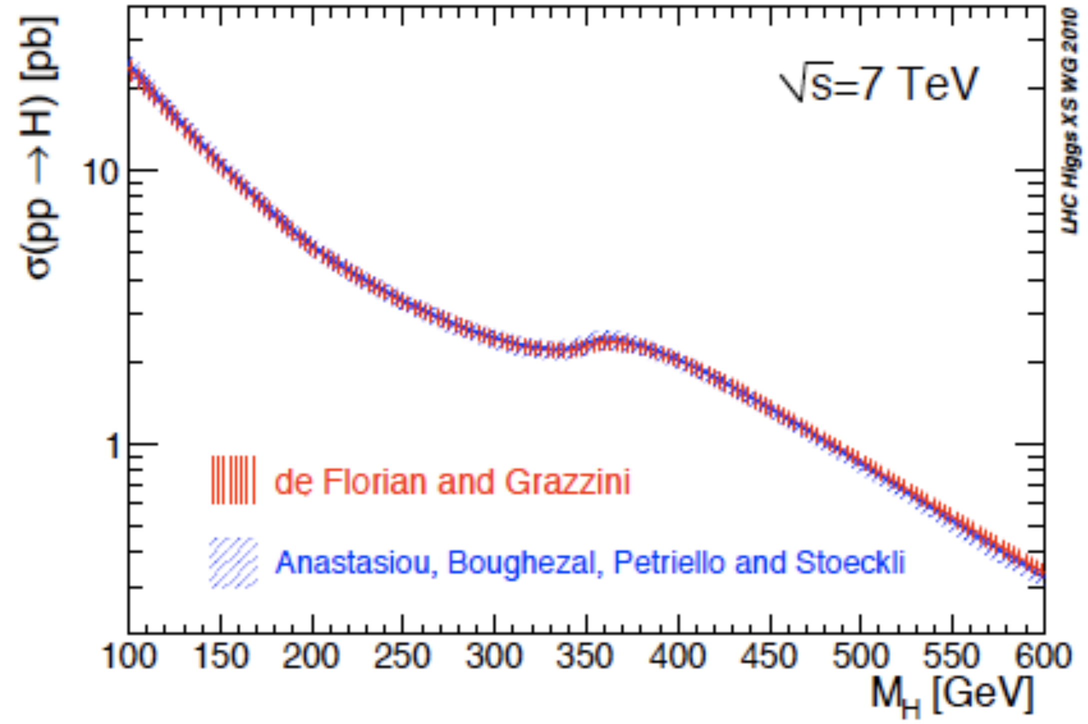
Outline

- Inclusive cross sections at 8 TeV
- Developments in jet veto efficiencies
- POWHEG reweighting and HRes
- Diphoton background at NNLO
- Interferences

Improved Higgs Cross-section @ 8 TeV

@7 TeV: combination of

- dFG: deF, Grazzini (2009)
- ABPS: Anastasiou, Boughezal, Petriello, Stoeckli (2009)
  - Agreement within 1-2%



- ABPS not producing numbers for 8 TeV
- dFG NNLL+NNLO including OFFP line-shape

line-shape checked ✓ POWHEG at NLO thanks to Carlo Oleari
✓ Giampiero's results

Comment about WG recommendation

use ZWA below 300 GeV 3.324 pb
use OFFP above 300 GeV 3.606 pb
@300 GeV
8.5% effect in switching procedure

Better use (smooth) OFFP for all masses

HTO code (Passarino) produces results that match ZWA/BW at low masses

Numbers available for both prescriptions

smooth results

Inclusive cross sections at 8 TeV

- dFG (OFFP)

MH (GeV)	Sigma (pb)	TH uncertainty %		pdf+ alpha_s uncertainty %		total uncertainty	
80.0	46.12	+8.8	-9.2	+7.9	-6.7	+16.7	-15.9
81.0	45.04	+8.8	-9.1	+7.9	-6.7	+16.7	-15.8
82.0	43.99	+8.7	-9.1	+7.9	-6.6	+16.6	-15.7
83.0	42.99	+8.7	-9.0	+7.9	-6.6	+16.6	-15.6
84.0	42.01	+8.6	-9.0	+7.9	-6.6	+16.5	-15.6
85.0	41.07	+8.6	-9.0	+7.9	-6.6	+16.5	-15.6
86.0	40.17	+8.5	-8.9	+7.9	-6.6	+16.4	-15.5
87.0	39.29	+8.5	-8.9	+7.9	-6.6	+16.4	-15.5
88.0	38.44	+8.4	-8.8	+7.9	-6.6	+16.3	-15.4
89.0	37.62	+8.4	-8.8	+7.8	-6.6	+16.2	-15.4
90.0	36.80	+8.3	-8.8	+7.8	-6.6	+16.1	-15.4
91.0	36.05	+8.3	-8.7	+7.8	-6.6	+16.1	-15.3
92.0	35.30	+8.2	-8.7	+7.8	-6.5	+16.0	-15.2
93.0	34.58	+8.2	-8.7	+7.8	-6.5	+16.0	-15.2
94.0	33.87	+8.1	-8.6	+7.8	-6.5	+15.9	-15.1
95.0	33.19	+8.1	-8.6	+7.8	-6.5	+15.9	-15.1
96.0	32.53	+8.1	-8.6	+7.8	-6.5	+15.9	-15.1
97.0	31.89	+8.0	-8.5	+7.8	-6.5	+15.8	-15.0
98.0	31.27	+8.0	-8.5	+7.8	-6.5	+15.8	-15.0
99.0	30.66	+8.0	-8.5	+7.8	-6.5	+15.8	-15.0
100.0	30.12	+7.9	-8.4	+7.8	-6.5	+15.7	-14.9
101.0	29.55	+7.9	-8.4	+7.8	-6.5	+15.7	-14.9
102.0	28.99	+7.9	-8.4	+7.8	-6.5	+15.7	-14.9
103.0	28.44	+7.8	-8.4	+7.8	-6.5	+15.6	-14.9
104.0	27.92	+7.8	-8.3	+7.8	-6.5	+15.6	-14.8
105.0	27.39	+7.8	-8.3	+7.7	-6.5	+15.5	-14.8
106.0	26.89	+7.7	-8.3	+7.7	-6.6	+15.4	-14.9
107.0	26.42	+7.7	-8.3	+7.7	-6.6	+15.4	-14.9
108.0	25.95	+7.7	-8.2	+7.7	-6.6	+15.4	-14.8
109.0	25.49	+7.6	-8.2	+7.7	-6.7	+15.3	-14.9
110.0	25.04	+7.6	-8.2	+7.7	-6.7	+15.3	-14.9
110.5	24.82	+7.6	-8.2	+7.7	-6.7	+15.3	-14.9
111.0	24.60	+7.6	-8.2	+7.6	-6.7	+15.2	-14.9
111.5	24.39	+7.5	-8.1	+7.6	-6.7	+15.1	-14.8
112.0	24.18	+7.5	-8.1	+7.6	-6.7	+15.1	-14.8
112.5	24.05	+7.5	-8.1	+7.6	-6.7	+15.1	-14.8
113.0	23.76	+7.5	-8.1	+7.6	-6.7	+15.1	-14.8
113.5	23.56	+7.5	-8.1	+7.6	-6.8	+15.1	-14.9
114.0	23.36	+7.5	-8.1	+7.6	-6.8	+15.1	-14.9

◉ iHixs

- Anastasiou, Buehler, Herzog, Lazopoulos (2012)
- Based on ABPS + BW line-shape + EW effects from real radiation

No resummation, NNLO with $\mu_F = \mu_R = M_H/2$

- different value for bottom mass and pdf uncertainty
- no OFFP scheme for heavy Higgs (BW)

$$\sigma(\mathrm{m_H} = 125\,\mathrm{GeV}) = 19.49^{+7.2\%\ +7.5\%}_{-7.8\%\ -6.9\%}\ \mathrm{pb} \quad \text{(scale, pdf} + \alpha_S\text{)}$$ dFG

$$\sigma(\mathrm{m_H} = 125\,\mathrm{GeV}) = 20.69^{+8.4\%\ +7.8\%}_{-9.3\%\ -7.5\%}\ \mathrm{pb}$$ iHixs

6% difference mostly from
fixed order vs resummed (scales)
bottom mass

in agreement within TH uncertainties for light Higgs

Discussions to reach an agreement for a possible combination

- different treatment for pdf uncertainties (~MSTW 90% cl similar to PDF4LHC)
- no (exclusive) use of complex-pole prescription. Results only up to M_H=400 GeV or use of different line-shapes to quantify uncertainty (e.g. running width).

16% difference at 400 GeV

•iHixs (running width)

m_H(GeV)	MSTW08 $\sigma(pb)$	$\%\delta_{PDF}$	$\%\delta_{\mu_F}$	ABM11 $\sigma(pb)$	$\%\delta_{PDF}$	$\%\delta_{\mu_F}$
114	24.69	$^{+7.92}_{-7.54}$	$^{+8.83}_{-9.32}$	22.78	$^{+2.28}_{-2.28}$	$^{+8.0}_{-8.85}$
115	24.27	$^{+7.91}_{-7.54}$	$^{+9.07}_{-9.31}$	22.38	$^{+2.29}_{-2.29}$	$^{+7.98}_{-8.84}$
116	23.94	$^{+7.9}_{-7.61}$	$^{+8.75}_{-9.59}$	22.0	$^{+2.29}_{-2.29}$	$^{+8.0}_{-8.83}$
117	23.55	$^{+7.93}_{-7.54}$	$^{+8.64}_{-9.33}$	21.68	$^{+2.29}_{-2.29}$	$^{+7.92}_{-9.05}$
118	23.17	$^{+7.92}_{-7.54}$	$^{+8.6}_{-9.38}$	21.33	$^{+2.3}_{-2.3}$	$^{+7.84}_{-8.84}$
119	22.79	$^{+7.92}_{-7.53}$	$^{+8.55}_{-9.35}$	20.98	$^{+2.3}_{-2.3}$	$^{+7.79}_{-8.87}$
120	22.42	$^{+7.91}_{-7.53}$	$^{+8.53}_{-9.3}$	20.63	$^{+2.3}_{-2.3}$	$^{+7.77}_{-8.85}$
121	22.06	$^{+7.91}_{-7.53}$	$^{+8.51}_{-9.34}$	20.29	$^{+2.3}_{-2.3}$	$^{+7.75}_{-8.82}$
122	21.7	$^{+7.91}_{-7.53}$	$^{+8.47}_{-9.28}$	19.96	$^{+2.31}_{-2.31}$	$^{+7.74}_{-8.82}$
123	21.36	$^{+7.8}_{-7.53}$	$^{+8.42}_{-9.28}$	19.64	$^{+2.31}_{-2.31}$	$^{+7.72}_{-8.86}$
124	21.02	$^{+7.81}_{-7.52}$	$^{+8.41}_{-9.25}$	19.32	$^{+2.31}_{-2.31}$	$^{+7.68}_{-8.81}$
125	20.69	$^{+7.79}_{-7.53}$	$^{+8.37}_{-9.26}$	19.01	$^{+2.32}_{-2.32}$	$^{+7.65}_{-8.82}$
126	20.37	$^{+7.8}_{-7.53}$	$^{+8.35}_{-9.24}$	18.71	$^{+2.32}_{-2.32}$	$^{+7.64}_{-8.8}$
127	20.05	$^{+7.8}_{-7.52}$	$^{+8.34}_{-9.21}$	18.41	$^{+2.32}_{-2.32}$	$^{+7.6}_{-8.84}$
128	19.74	$^{+7.79}_{-7.52}$	$^{+8.3}_{-9.2}$	18.13	$^{+2.33}_{-2.33}$	$^{+7.58}_{-8.79}$
129	19.44	$^{+7.8}_{-7.52}$	$^{+8.28}_{-9.26}$	17.84	$^{+2.33}_{-2.33}$	$^{+7.56}_{-8.79}$
130	19.14	$^{+7.79}_{-7.51}$	$^{+8.24}_{-9.19}$	17.57	$^{+2.33}_{-2.33}$	$^{+7.54}_{-8.84}$
131	18.86	$^{+7.8}_{-7.51}$	$^{+8.22}_{-9.17}$	17.3	$^{+2.34}_{-2.34}$	$^{+7.51}_{-8.79}$
132	18.57	$^{+7.79}_{-7.51}$	$^{+8.19}_{-9.16}$	17.03	$^{+2.34}_{-2.34}$	$^{+7.47}_{-8.77}$
133	18.3	$^{+7.8}_{-7.5}$	$^{+8.17}_{-9.15}$	16.77	$^{+2.35}_{-2.35}$	$^{+7.46}_{-8.75}$
134	18.03	$^{+7.79}_{-7.51}$	$^{+8.14}_{-9.15}$	16.52	$^{+2.35}_{-2.35}$	$^{+7.41}_{-8.74}$
135	17.76	$^{+7.8}_{-7.51}$	$^{+8.12}_{-9.19}$	16.27	$^{+2.35}_{-2.35}$	$^{+7.39}_{-8.73}$
136	17.5	$^{+7.8}_{-7.5}$	$^{+8.05}_{-9.17}$	16.03	$^{+2.36}_{-2.36}$	$^{+7.37}_{-8.73}$
137	17.25	$^{+7.78}_{-7.53}$	$^{+8.05}_{-9.17}$	15.79	$^{+2.36}_{-2.36}$	$^{+7.36}_{-8.75}$
138	17.01	$^{+7.79}_{-7.51}$	$^{+8.01}_{-9.13}$	15.56	$^{+2.37}_{-2.37}$	$^{+7.31}_{-8.73}$
139	16.77	$^{+7.8}_{-7.51}$	$^{+7.97}_{-9.08}$	15.34	$^{+2.37}_{-2.37}$	$^{+7.26}_{-8.7}$
140	16.53	$^{+7.79}_{-7.5}$	$^{+7.9}_{-9.06}$	15.12	$^{+2.37}_{-2.37}$	$^{+7.24}_{-8.69}$
141	16.3	$^{+7.79}_{-7.5}$	$^{+7.88}_{-9.03}$	14.9	$^{+2.38}_{-2.38}$	$^{+7.23}_{-8.67}$
142	16.07	$^{+7.79}_{-7.5}$	$^{+7.87}_{-9.01}$	14.69	$^{+2.38}_{-2.38}$	$^{+7.2}_{-8.62}$
143	15.85	$^{+7.78}_{-7.51}$	$^{+7.85}_{-9.0}$	14.48	$^{+2.39}_{-2.39}$	$^{+7.19}_{-8.62}$
144	15.64	$^{+7.78}_{-7.5}$	$^{+7.82}_{-8.99}$	14.28	$^{+2.39}_{-2.39}$	$^{+7.18}_{-8.62}$
145	15.43	$^{+7.78}_{-7.51}$	$^{+7.79}_{-8.99}$	14.08	$^{+2.4}_{-2.4}$	$^{+7.16}_{-8.6}$
146	15.22	$^{+7.79}_{-7.51}$	$^{+7.78}_{-8.97}$	13.88	$^{+2.4}_{-2.4}$	$^{+7.18}_{-8.57}$
147	15.02	$^{+7.79}_{-7.5}$	$^{+7.74}_{-8.97}$	13.69	$^{+2.41}_{-2.41}$	$^{+7.14}_{-8.59}$
148	14.81	$^{+7.8}_{-7.51}$	$^{+7.74}_{-8.97}$	13.5	$^{+2.41}_{-2.41}$	$^{+7.12}_{-8.58}$
149	14.62	$^{+7.8}_{-7.5}$	$^{+7.74}_{-8.93}$	13.32	$^{+2.42}_{-2.42}$	$^{+7.1}_{-8.57}$
150	14.43	$^{+7.78}_{-7.51}$	$^{+7.7}_{-8.93}$	13.14	$^{+2.42}_{-2.42}$	$^{+7.08}_{-8.55}$

Jet-veto

Use of fixed order calculations dangerous for jet-veto cross section

$\Rightarrow$ underestimate uncertainties

Better estimate of uncertainties using f.o. (Stewart, Tackmann)

Consider *inclusive* jet cross sections

$$\sigma_{\text{total}},\ \sigma_{\geq 1},\ \sigma_{\geq 2} \quad \Rightarrow \quad C = \begin{pmatrix} \Delta^2_{\text{total}} & 0 & 0 \\ 0 & \Delta^2_{\geq 1} & 0 \\ 0 & 0 & \Delta^2_{\geq 2} \end{pmatrix}$$

Transform to *exclusive* jet cross sections

$$\sigma_0 = \sigma_{\text{total}} - \sigma_{\geq 1}\,, \qquad \sigma_1 = \sigma_{\geq 1} - \sigma_{\geq 2}\,, \qquad \sigma_{\geq 2} \quad \Rightarrow \quad C = \begin{pmatrix} \Delta^2_{\text{total}} + \Delta^2_{\geq 1} & -\Delta^2_{\geq 1} & 0 \\ -\Delta^2_{\geq 1} & \Delta^2_{\geq 1} + \Delta^2_{\geq 2} & -\Delta^2_{\geq 2} \\ 0 & -\Delta^2_{\geq 1} & \Delta^2_{\geq 2} \end{pmatrix}$$

cut	$\frac{\Delta\sigma_{\text{total}}}{\sigma_{\text{total}}}$	$\frac{\Delta\sigma_{\geq 1}}{\sigma_{\geq 1}}$	$\frac{\Delta\sigma_{\geq 2}}{\sigma_{\geq 2}}$	$\frac{\Delta\sigma_0}{\sigma_0}$	$\frac{\Delta\sigma_1}{\sigma_1}$
$p_T^{\text{cut}} = 30\,\text{GeV},\ \eta^{\text{cut}} = 3$	10%	21%	45%	17%	29%

prescription used at 7 TeV $\quad \frac{\Delta\sigma_0}{\sigma_0} > \frac{\Delta\sigma_{total}}{\sigma_{total}}$

- Central values with POWHEG after HqT reweighting

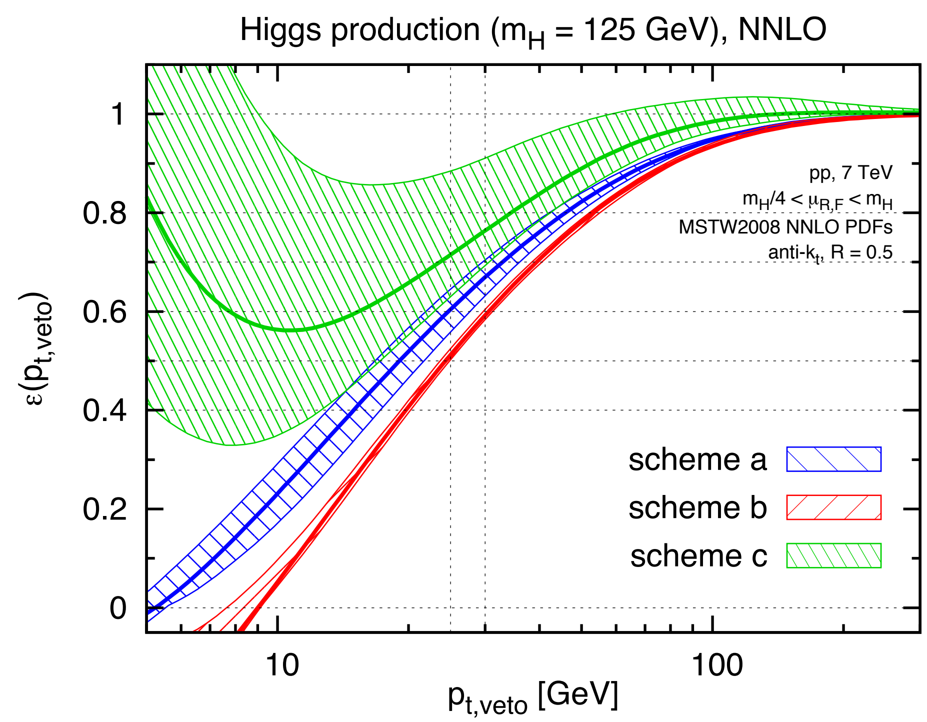
Banfi, Salam, Zanderighi (2012)

NLL+NNLO jet veto efficiencies

$$\epsilon^{(a)}(p_{\mathrm{t,veto}}) \equiv \frac{\Sigma_0(p_{\mathrm{t,veto}}) + \Sigma_1(p_{\mathrm{t,veto}}) + \Sigma_2(p_{\mathrm{t,veto}})}{\sigma_0 + \sigma_1 + \sigma_2}$$

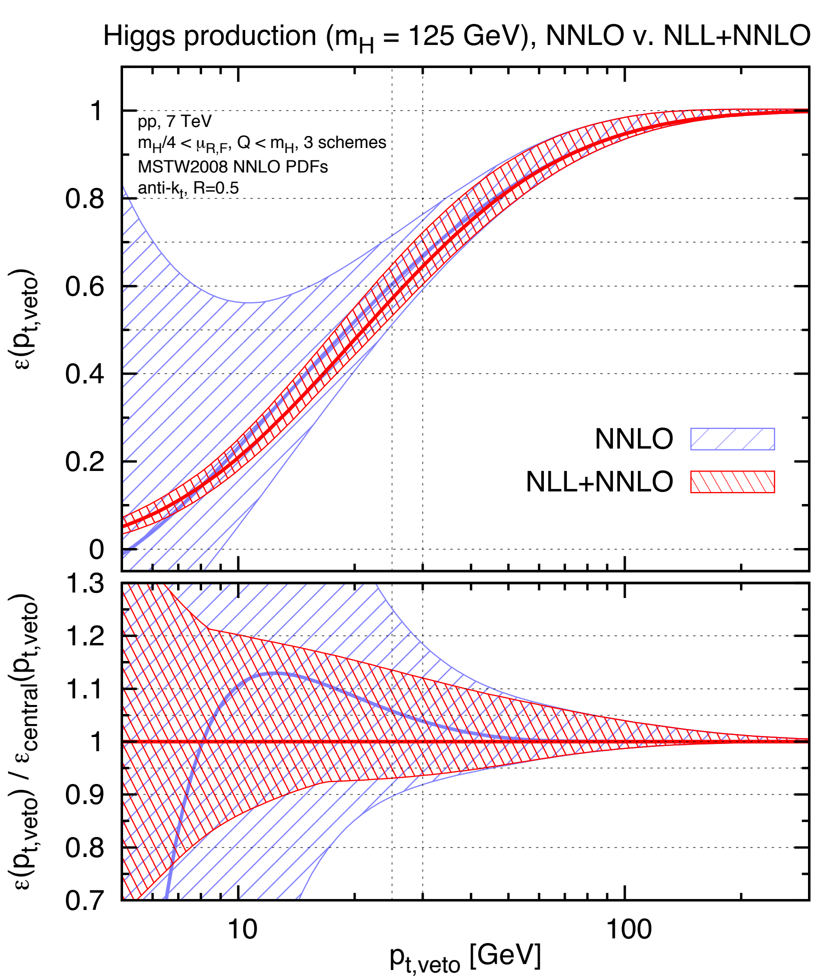
$$\epsilon^{(b)}(p_{\mathrm{t,veto}}) \equiv \frac{\Sigma_0(p_{\mathrm{t,veto}}) + \Sigma_1(p_{\mathrm{t,veto}}) + \bar{\Sigma}_2(p_{\mathrm{t,veto}})}{\sigma_0 + \sigma_1}$$

$$\epsilon^{(c)}(p_{\mathrm{t,veto}}) \equiv 1 + \frac{\bar{\Sigma}_1(p_{\mathrm{t,veto}})}{\sigma_0} + \left(\frac{\bar{\Sigma}_2(p_{\mathrm{t,veto}})}{\sigma_0} - \frac{\sigma_1}{\sigma_0^2}\bar{\Sigma}_1(p_{\mathrm{t,veto}})\right)$$



NNLO

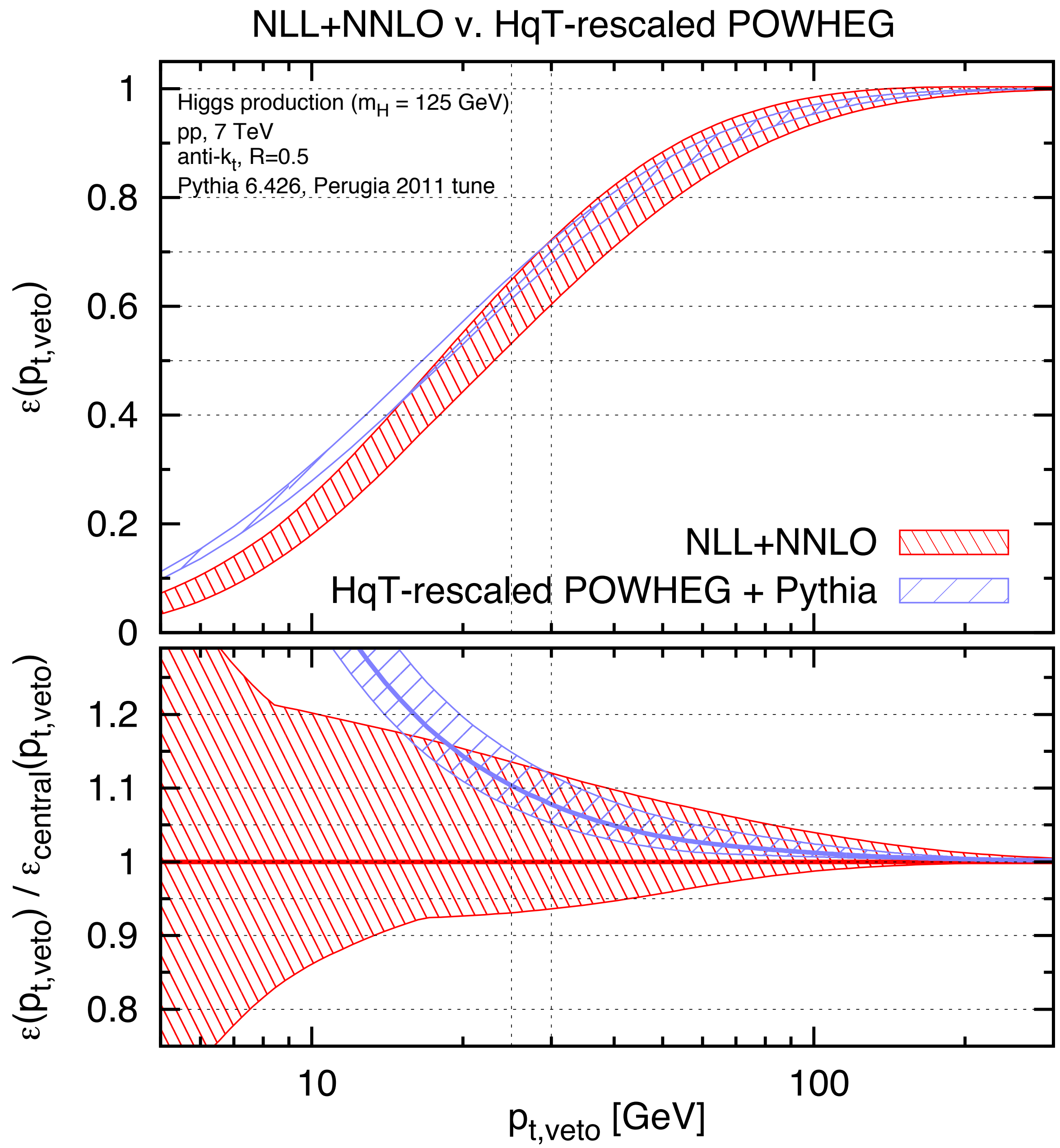
- Jet-veto resummation using CAESAR



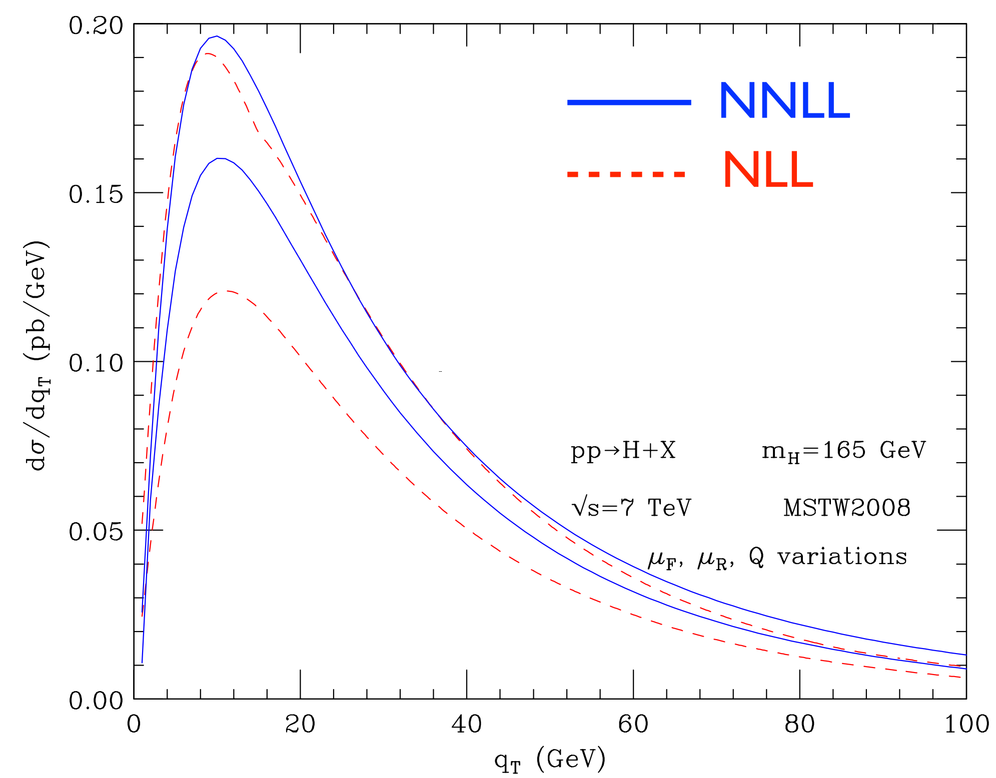
Higgs production ($M_H = 125$ GeV)

	NNLO	NLL+NNLO
$p_{\mathrm{t,veto}} = 25$ GeV	$60^{+11}_{-9}\%$	$57^{+8}_{-4}\%$
$p_{\mathrm{t,veto}} = 30$ GeV	$67^{+9}_{-8}\%$	$64^{+8}_{-4}\%$

- reduction in efficiency uncertainty
- when combined with inclusive uncertainty similar results as ST procedure



- Hqt-rescaled POWHEG central value a bit higher than NLL+NNLO: consistent within uncertainties and with increase to NNLL (see HqT NLL vs NNLL)

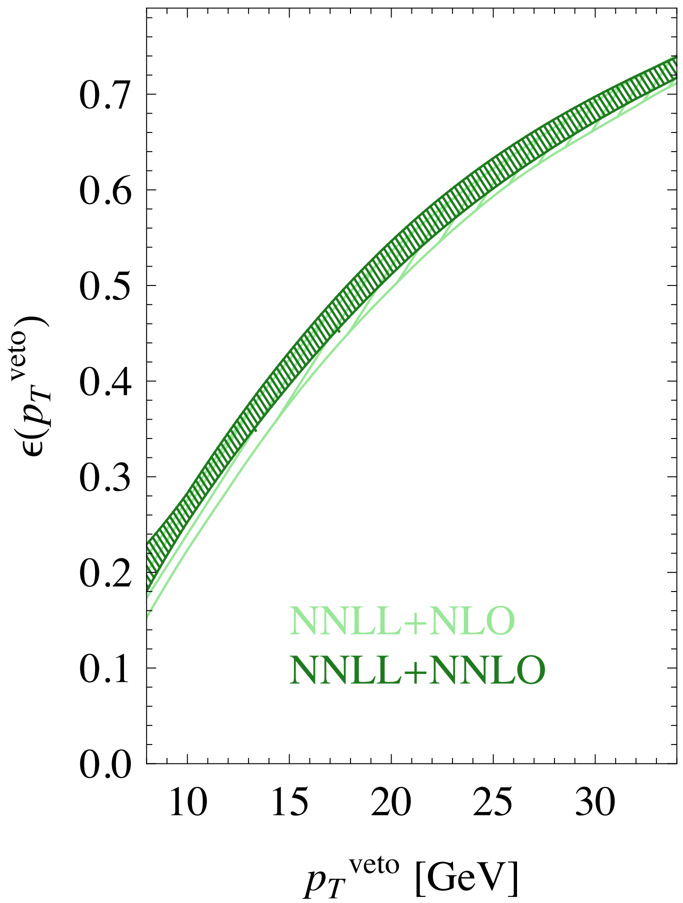


- POWHEG underestimates the uncertainty

not used for uncertainty evaluation

- ggF WG recommendation : keep for the moment ST procedure for uncertainties with reweighted POWHEG for central values

Becher, Neubert (2012) SCET resummation to ‘NNLL’



beware SCET NNLL is different from QCD NNLL

p_T^{veto}	$\sigma(p_T^{\text{veto}})$ [pb]	$\epsilon(p_T^{\text{veto}})$
10	$4.97^{+0.59+0.19}_{-0.01-0.22}$	$0.253^{+0.030}_{-0.001}$
15	$7.83^{+0.62+0.34}_{-0.05-0.35}$	$0.399^{+0.032}_{-0.002}$
20	$10.13^{+0.61+0.48}_{-0.08-0.49}$	$0.515^{+0.031}_{-0.004}$
25	$11.88^{+0.55+0.61}_{-0.07-0.61}$	$0.605^{+0.028}_{-0.003}$
30	$13.23^{+0.48+0.71}_{-0.03-0.70}$	$0.673^{+0.024}_{-0.002}$
∞	$19.66^{+0.55+1.54}_{-0.15-1.48}$	1

+3.5% -0.2% (row 30, σ)

+4% -0.5% (row 30, ϵ)

inclusive cross-section +2.8% - 0.7%

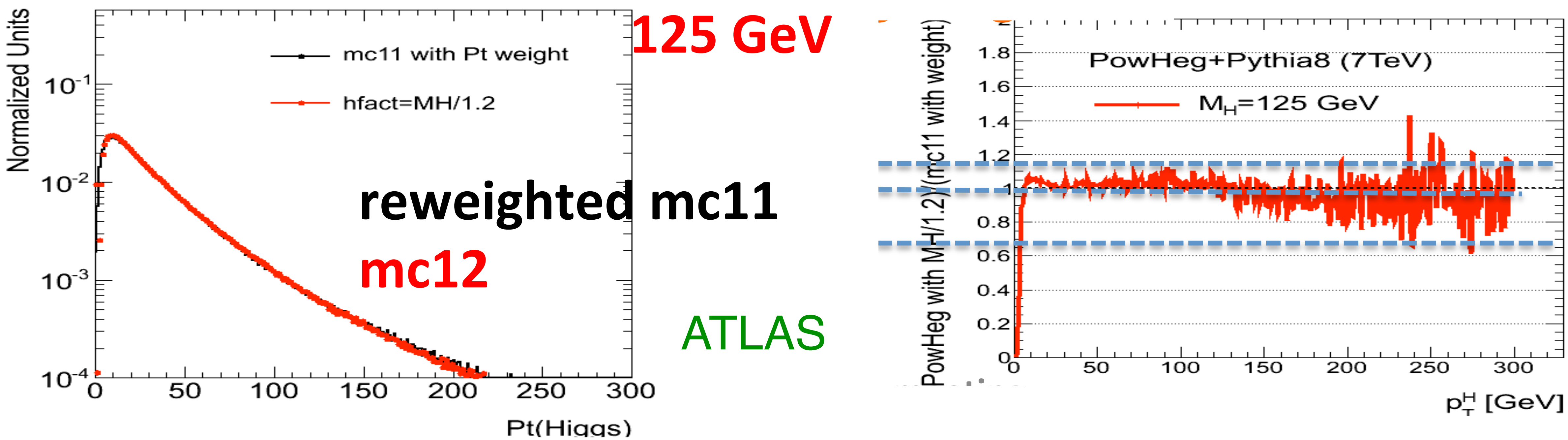
we have +7.2% -7.8%

- Central values very close to Banfi et at (3% higher)
- Seem to underestimate the uncertainties (as for the inclusive cross section)

POWHEG and HqT reweighting

POWHEG with damping factor $\mathrm{hfact} = M_H/1.2$

→ reproduce Higgs qT distribution to good accuracy ~5%



- Worth looking at other distributions before confirming this prescription

pT-thrust, pt-photon, angular distributions

HRes NNLL accuracy (as HqT) deF, Ferrera, Grazzini, Tommasini (2012)

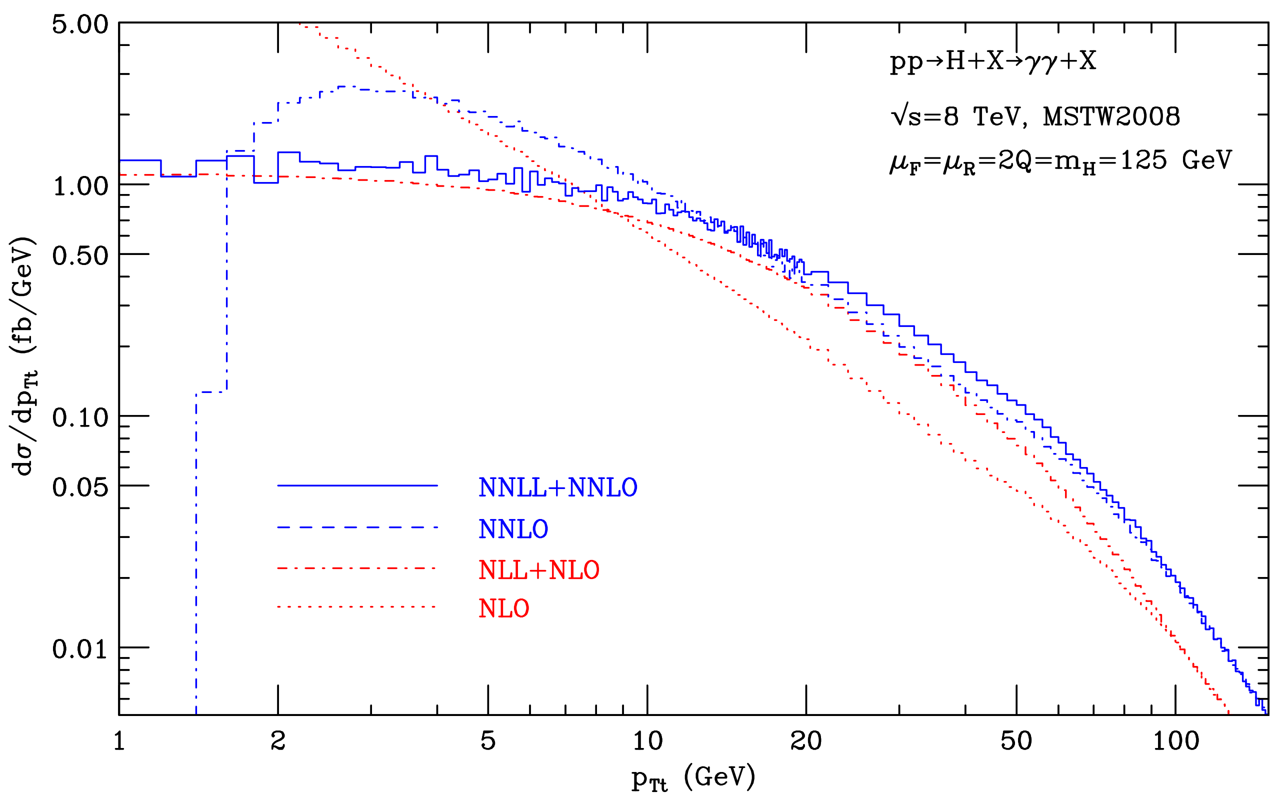
- Include full description of Higgs decay products → $\gamma\gamma$, $WW \to l\nu l\nu$, $ZZ \to 4l$

$$gg \to H \to \gamma\gamma$$

ATLAS splits analysis in categories according to thrust transverse momentum

$$\hat{t} = \frac{\vec{p}_T^{\,\gamma_1} - \vec{p}_T^{\,\gamma_2}}{|\vec{p}_T^{\,\gamma_1} - \vec{p}_T^{\,\gamma_2}|} \qquad p_{Tt} = |\vec{p}_T^{\,\gamma\gamma} \times \hat{t}|$$

- Fixed order distribution diverges when $p_{Tt} \to 0$



- Resummed distribution approaches a constant

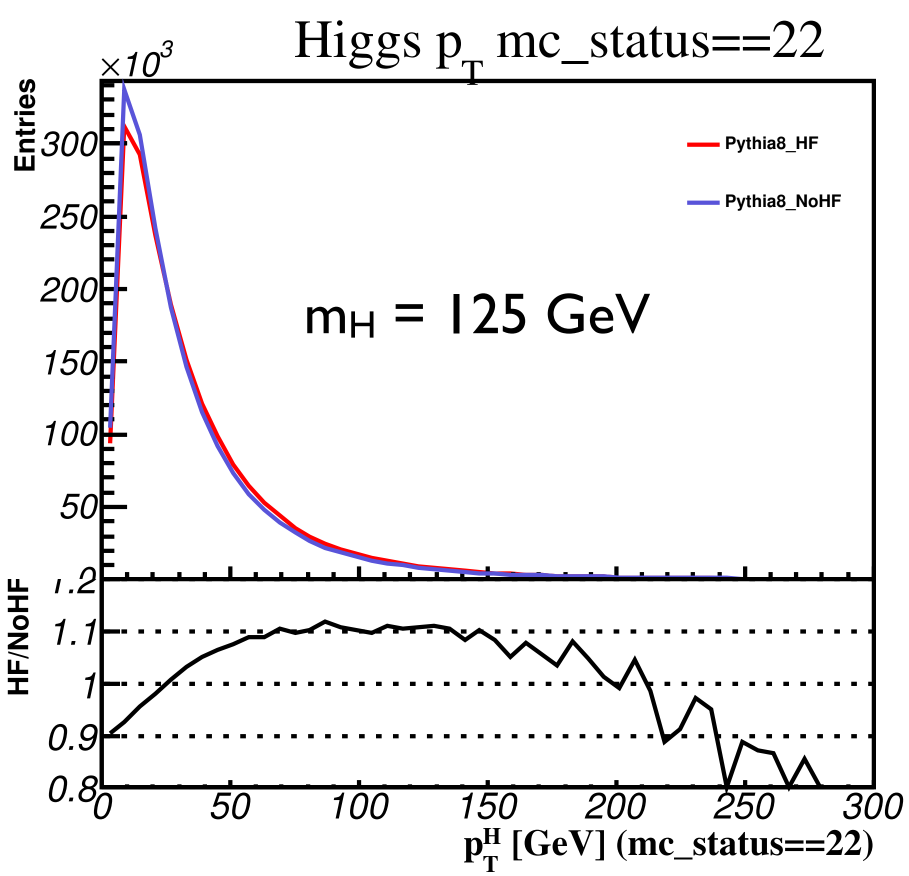
NNLL vs NLL shows good convergence

- Can be used to estimate uncertainty on this observable
- After comparison evaluate if need reweight with pT and rapidity (or hfact)

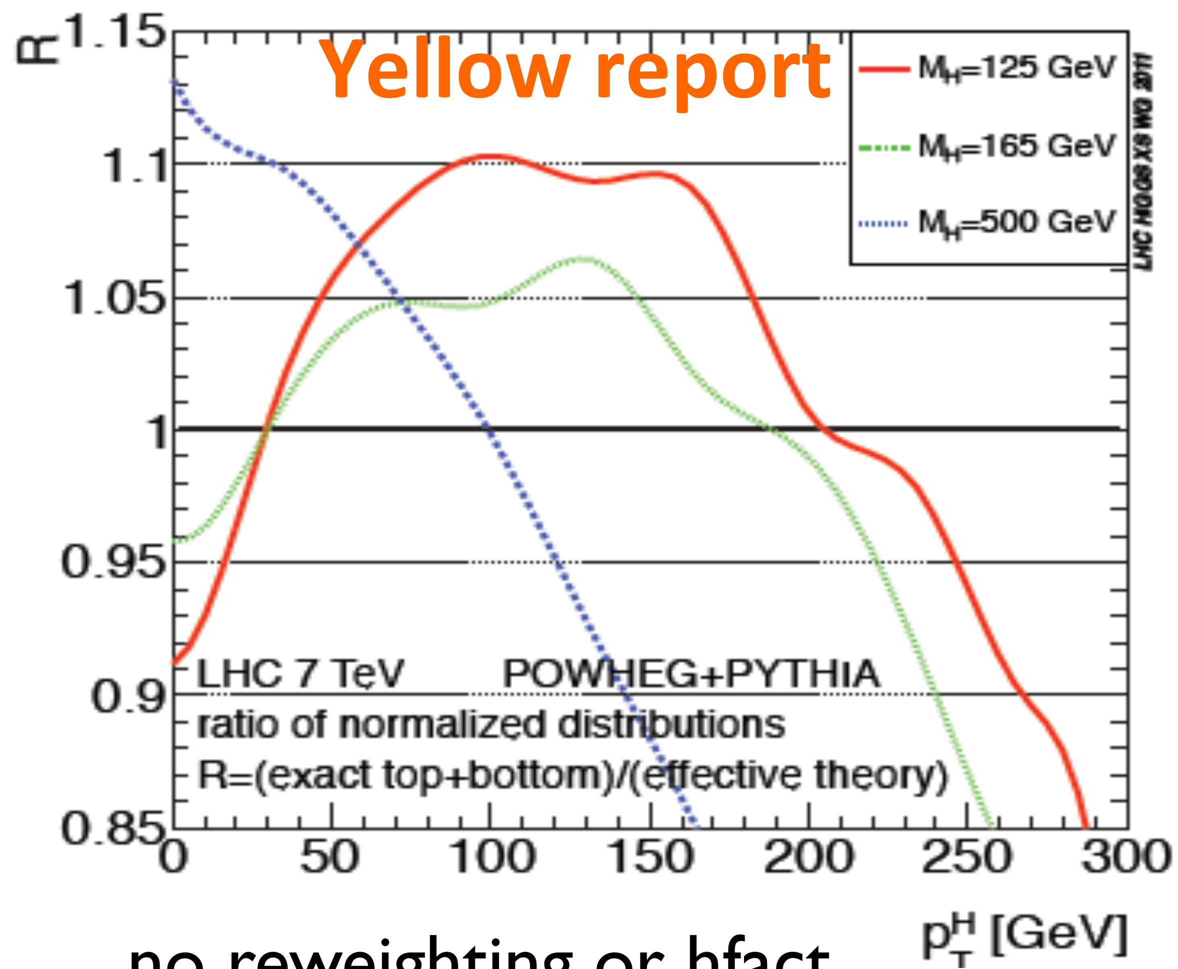
POWHEG with HQ masses

Bagnaschi, Degrassi, Slavich, Vicini

ATLAS



hfact=Mh/1.2



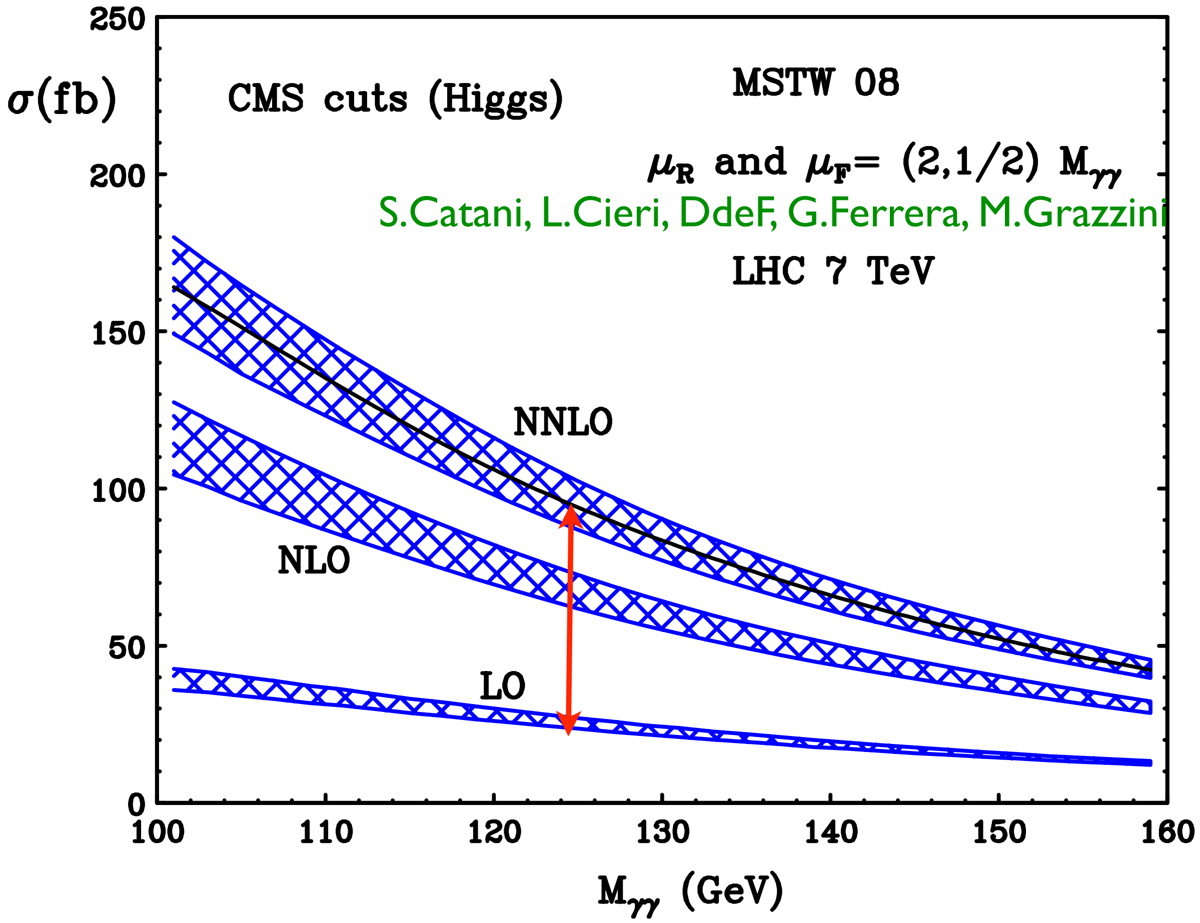
no reweighting or hfact

- HQ mass effects ~factorize : can do reweighting without HQ and then apply HQ corrections

In the pipeline

HNNLO and HRes will include HQ mass effects up to NL accuracy
Considering to include interference effects as well (later)

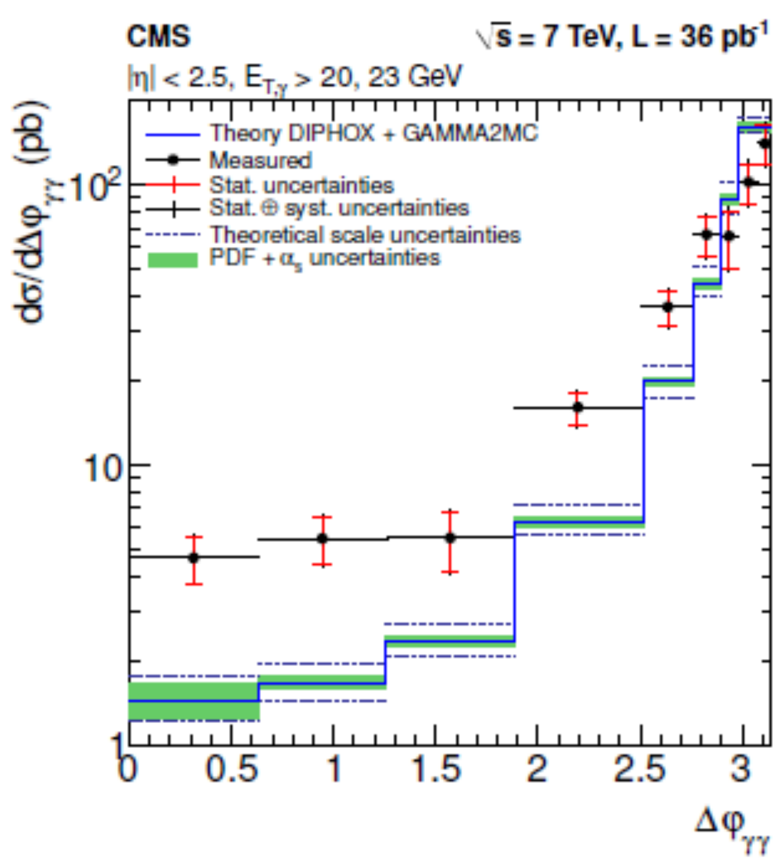
Diphoton Background

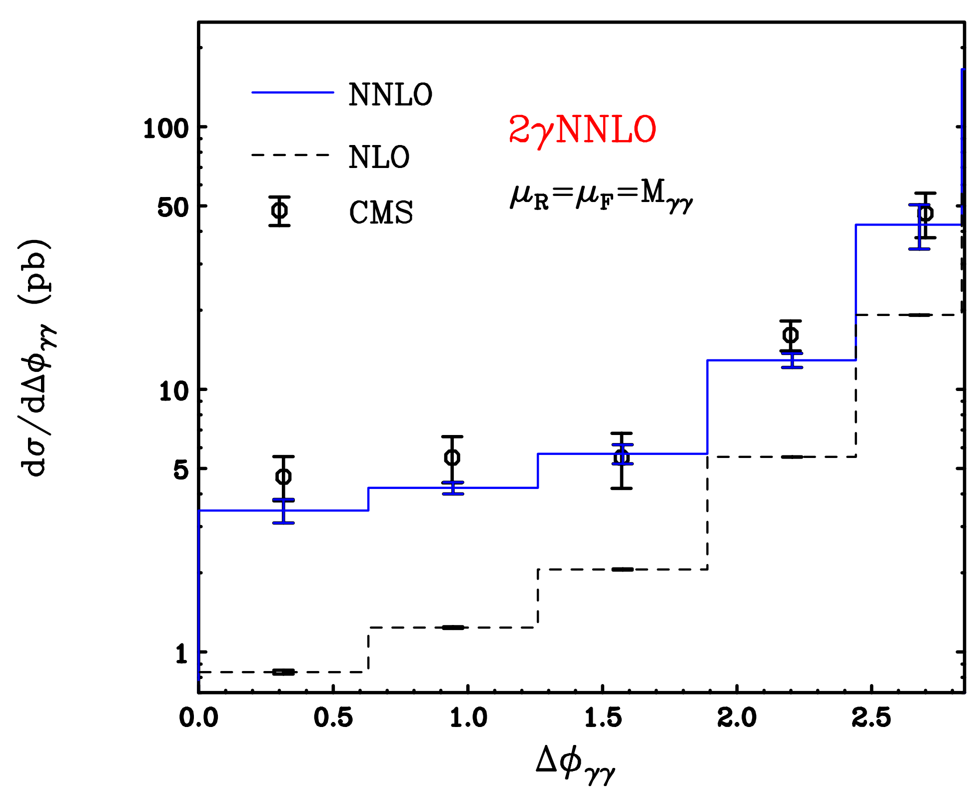


$K^{NNLO} \sim 3.5$ NLO band not enough

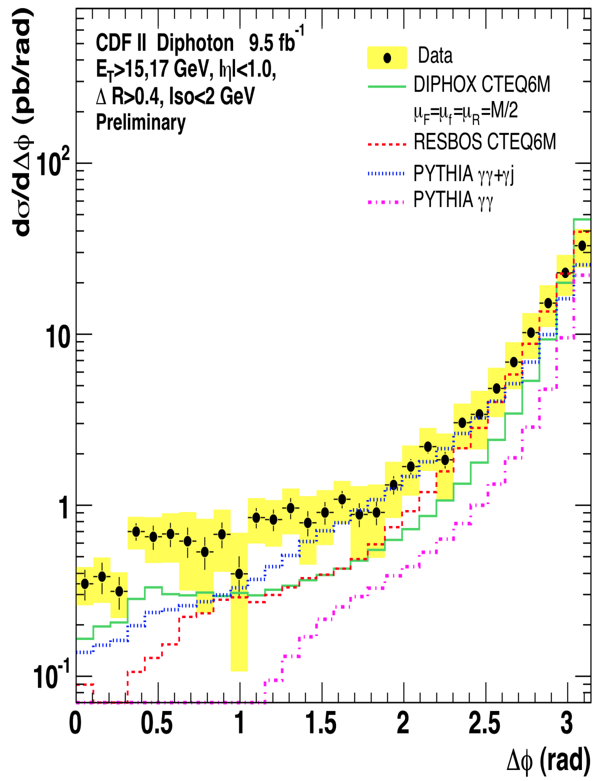
NNLO Corrections much larger in some kinematical regions where NLO effectively lowest order

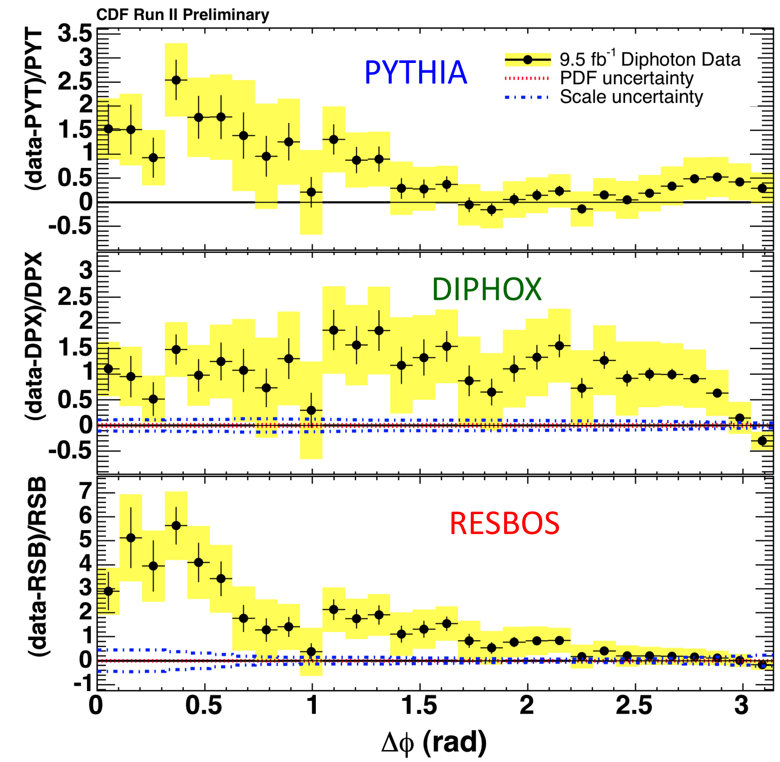
NNLO essential to understand data

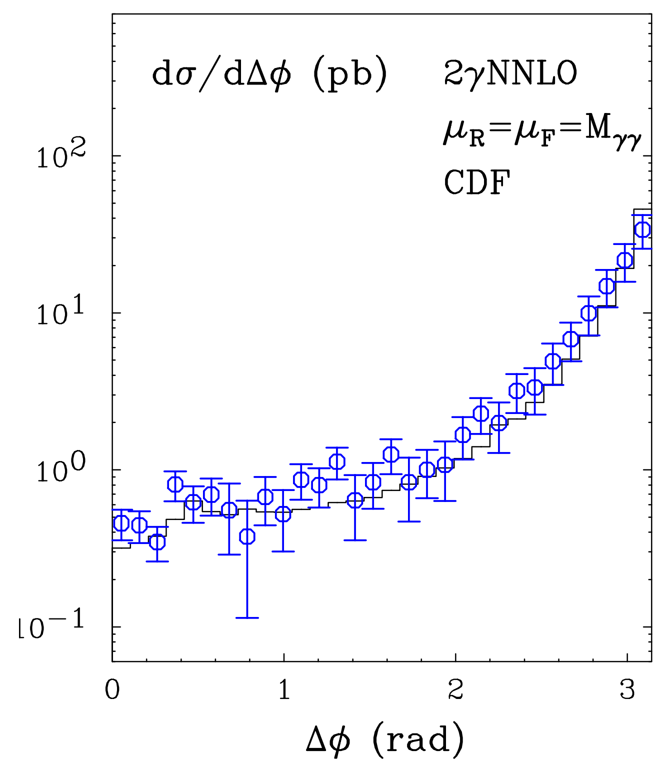


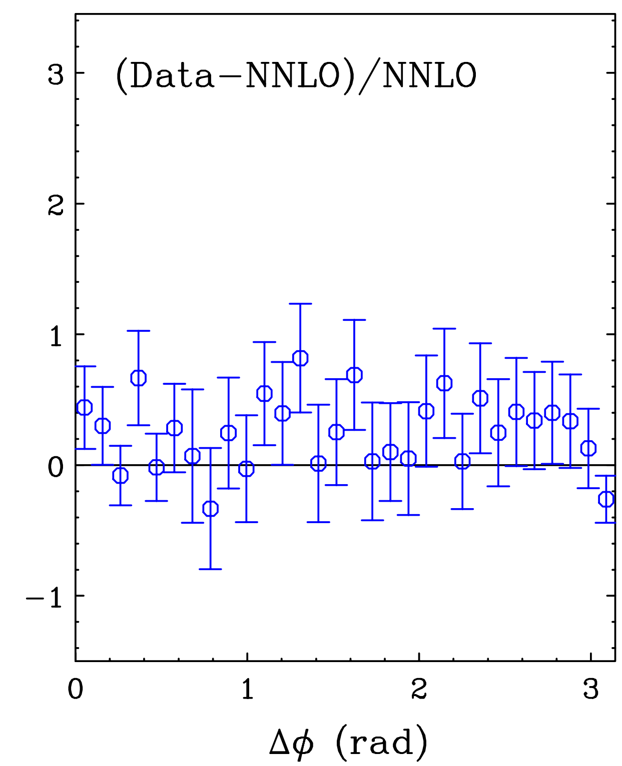


CDF diphotons





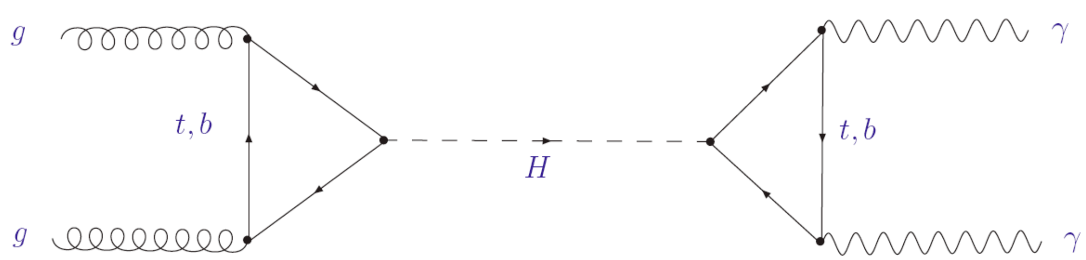


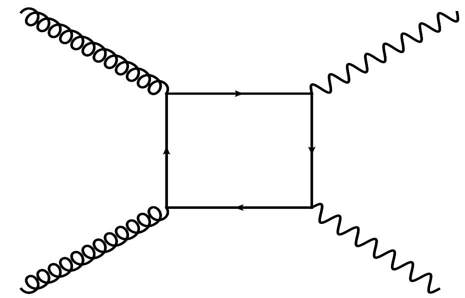


- Usual tools fail to reproduce Diphoton data
- Use NNLO for better description of background (uncertainties)
- Possible use for MVA

Interferences

Very hard to compute interferences beyond the "Born" level due to gg dominance





$\mathcal{O}(\alpha_s^2)$

Caution, Born for interference means α_s^2 which is formally NNLO for background and LO for signal

Dixon and Siu $\gamma\gamma$

MCFM (Campbell, Ellis, Williams)
gg2WW (Kauer) $WW \to l\nu l\nu$

gg2VV (Kauer) $ZZ \to 4l$ available soon

aMC@NLO coming soon?

Two issues

1. Usually rely on BW approach, need modification to OFFP
2. Only Born level available, how to combine with signal and background?

- How to include interference?

MCFM
Campbell, Ellis, Williams

usual procedure: $\sigma_{Hi} = \sigma_H + \sigma_{interference}$
add to signal

K - factor?

- Some effects (like soft gluon emission) partially cancel in ratios

full factorization of Interference effects

$$\sigma_{Hi}^{NNLO} = \sigma_H^{NNLO}\left(\frac{\sigma_{Hi}^{Born}}{\sigma_H^{Born}}\right) = \underbrace{\left(\frac{\sigma_H^{NNLO}}{\sigma_H^{Born}}\right)}_{K_{\text{signal}}}\sigma_{Hi}^{Born}$$

- Equivalent to apply signal K-factor to interference

Problems :

- Privileges the signal (distorts line-shape)
- QCD correction to signal and background (box) can be different
- Born and NNLO have different kinematics (ambiguity for exclusive)

One possible way to account for uncertainty in the procedure:

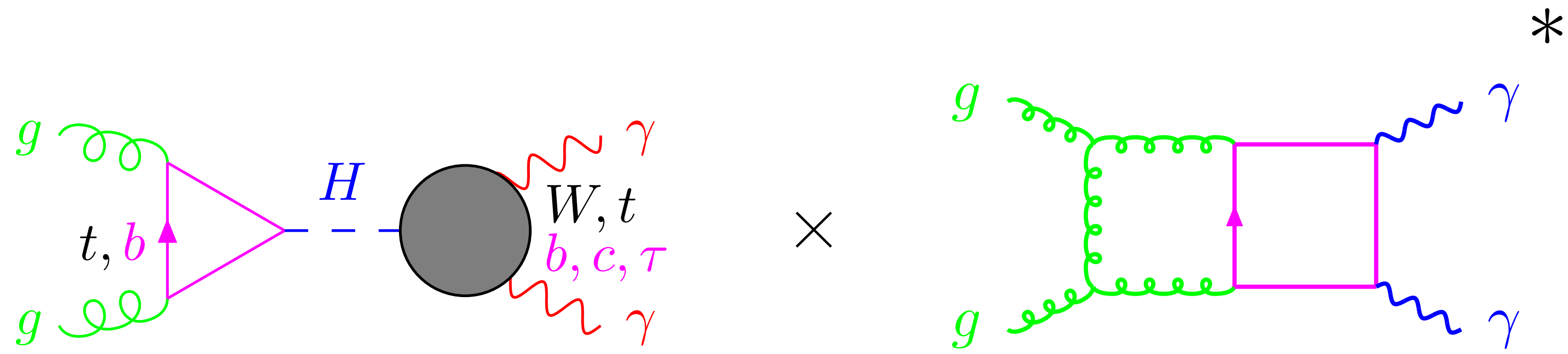
→ define uncertainty equal to interference effect ?
(if interference small, probably only meaningful for inclusive results)

Beyond Born level : Diphotons

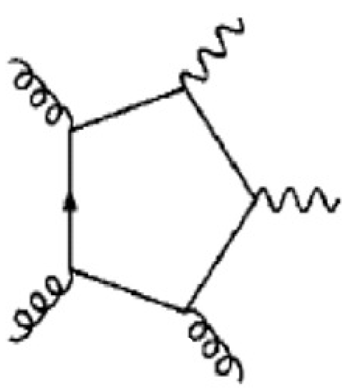
- Corrections to box partially included in the interference calculation

Dominant contribution

Dixon and Siu (2003)



- Looking now at interference for real contribution evaluation of HO effects in interference $gg \to \gamma\gamma g$



Will give some information about size of HO corrections

Might be possible for WW and ZZ also?

$gg\ (\to H) \to VV$: resonance-continuum interference

Nikolas Kauer

Royal Holloway, University of London

$gg\ (\to H) \to ZZ \to l\bar{l}\nu_{l'}\bar{\nu}_{l'}$ (2l2v) and $gg\ (\to H) \to ZZ \to l\bar{l}l\bar{l}$ (4l)

Interference for $M_H = 125$ GeV and $M_H = 500$ GeV

Settings and cuts (common cuts definition ATLAS and CMS)

$\mu_R = \mu_F = M_H/2$
$\Gamma_H = 0.004434\ (67.95)$ GeV for $M_H = 125\ (500)$ GeV (HDECAY)
MSTW2008NNLO, other: LHC Higgs Cross Section WG, arXiv:1101.0593, App. A (with NLO Γ_V and G_μ scheme)

2l2v cuts:

$p_{Tl} > 20$ GeV, $|\eta_l| < 2.5$, 76 GeV $< M_{l\bar{l}} < 106$ GeV

$M_H = 125$ GeV: $\Delta\phi_{l\bar{l}} > 1$

$M_H = 500$ GeV: $\not{p}_T > 82$ GeV, $\Delta\phi_{l\bar{l}} < 2.25$

4l cuts:

$p_{Tl} > 10$ GeV, $|\eta_l| < 2.5$, $M_{4l} > 100$ GeV

$M_{l\bar{l},1} > 40$ GeV, $M_{l\bar{l},2} > 12$ GeV, $M_{l\bar{l}} > 5$ GeV

$M_{l\bar{l},1}$: best di-candidate ($M_{l\bar{l}}$ closest to M_Z)

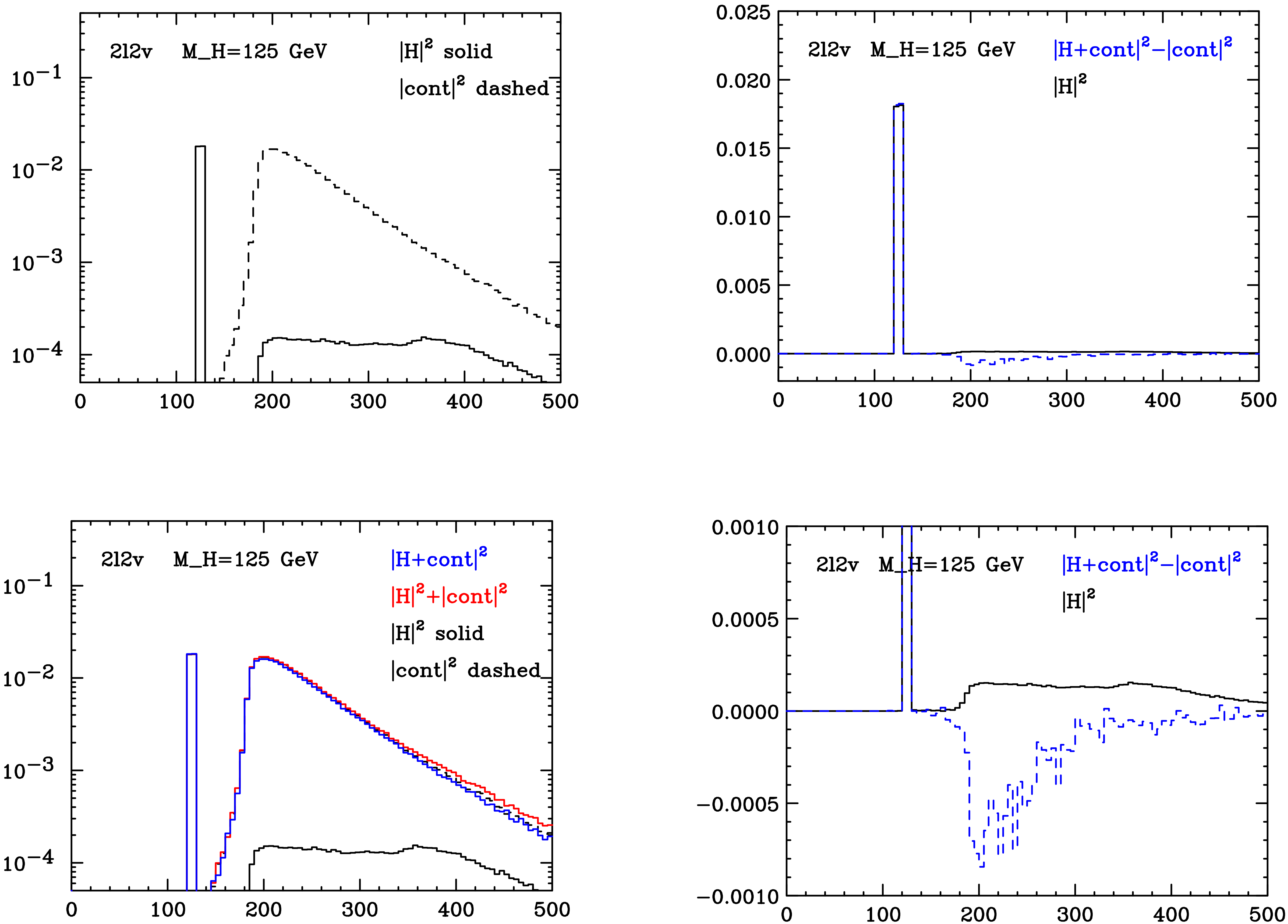
$gg\,(\to H) \to ZZ \to l\bar{l}\nu_{l'}\bar{\nu}_{l'}$ (2l2v) and $gg\,(\to H) \to ZZ \to l\bar{l}l\bar{l}$ (4l)
Integrated results

$p_T(V) > 7$ GeV		σ [fb], pp, $\sqrt{s}=8$ TeV, single flavour (l, ν)			interference	
process	M_H	$\lvert\mathcal{M}_H\rvert^2$	$\lvert\mathcal{M}_{\text{cont}}\rvert^2$	$\lvert\mathcal{M}_H + \mathcal{M}_{\text{cont}}\rvert^2$	R_1	R_2
2l2v	125 GeV	0.2227(3)	1.4694(5)	1.585(2)	0.937(1)	0.519(8)
2l2v	500 GeV	0.4264(4)	0.19956(8)	0.6284(4)	1.0039(8)	1.006(2)
4l	125 GeV	0.0514(6)	0.432(1)	0.453(4)	0.937(8)	0.40(8)
4l	500 GeV	0.1131(5)	0.2649(9)	0.382(2)	1.010(5)	1.03(2)

$p_T(V) > 1$ GeV		σ [fb], pp, $\sqrt{s}=8$ TeV, single flavour (l, ν)			interference	
process	M_H	$\lvert\mathcal{M}_H\rvert^2$	$\lvert\mathcal{M}_{\text{cont}}\rvert^2$	$\lvert\mathcal{M}_H + \mathcal{M}_{\text{cont}}\rvert^2$	R_1	R_2
2l2v	125 GeV	0.2453(3)	1.5615(6)	1.697(2)	0.9394(8)	0.554(6)

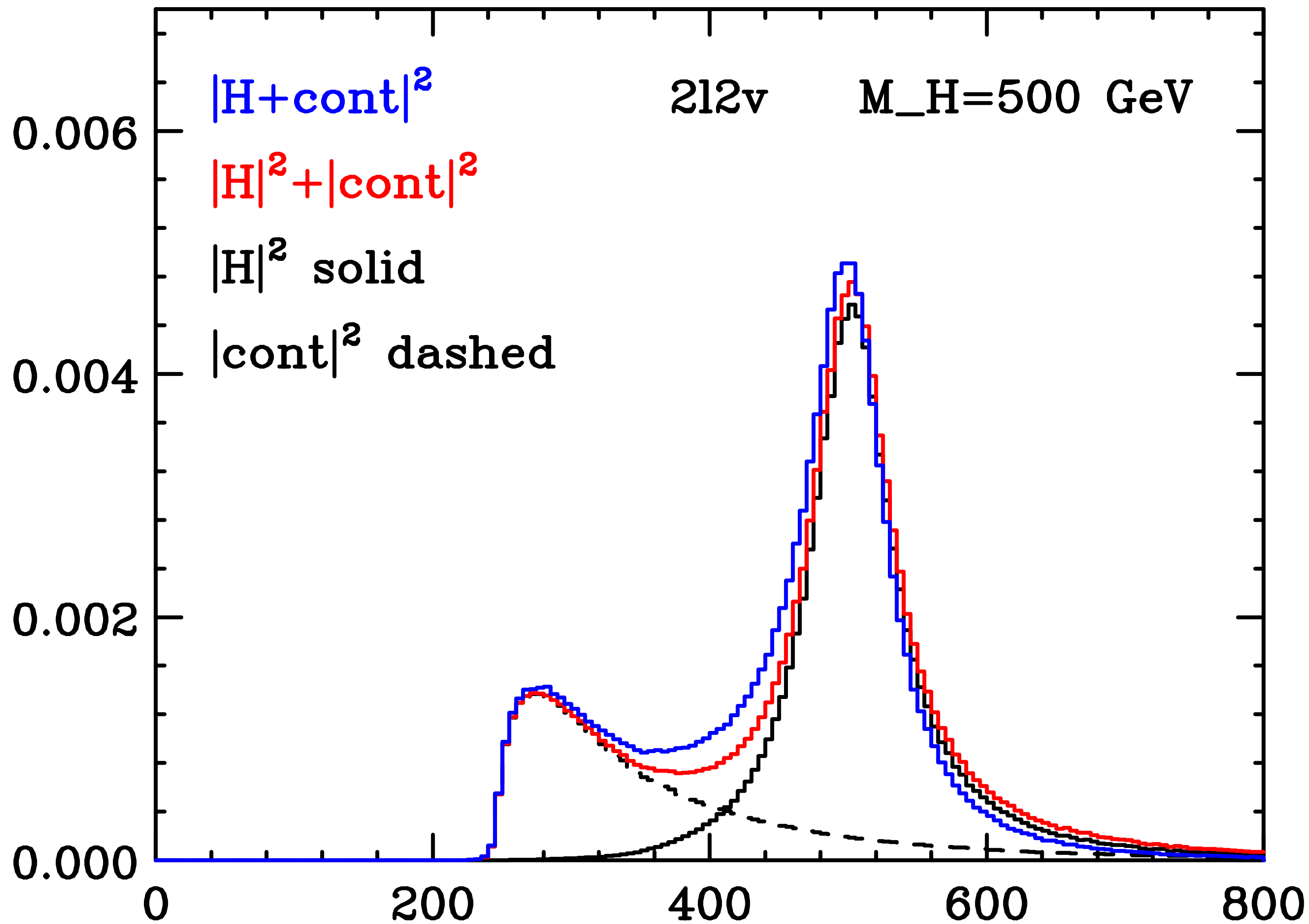
$(S+B)$-inspired interference measure: $R_1 = \sigma(|\mathcal{M}_\text{H} + \mathcal{M}_\text{cont}|^2) \Big/ \left[\sigma(|\mathcal{M}_\text{H}|^2) + \sigma(|\mathcal{M}_\text{cont}|^2)\right]$

(S/B)-inspired interference measure: $R_2 = \sigma\left(|\mathcal{M}_\text{H}|^2 + 2\,\text{Re}(\mathcal{M}_\text{H}\mathcal{M}^*_\text{cont})\right) / \sigma\left(|\mathcal{M}_\text{H}|^2\right)$



2l2v M_H=125 GeV
|H|² solid
|cont|² dashed
10⁻¹
10⁻²
10⁻³
10⁻⁴
0
100
200
300
400
500
2l2v M_H=125 GeV
|H+cont|²−|cont|²
|H|²
0.025
0.020
0.015
0.010
0.005
0.000
0
100
200
300
400
500
2l2v M_H=125 GeV
|H+cont|²
|H|²+|cont|²
|H|² solid
|cont|² dashed
10⁻¹
10⁻²
10⁻³
10⁻⁴
0
100
200
300
400
500
2l2v M_H=125 GeV
|H+cont|²−|cont|²
|H|²
0.0010
0.0005
0.0000
−0.0005
−0.0010
0
100
200
300
400
500

Backup Slides



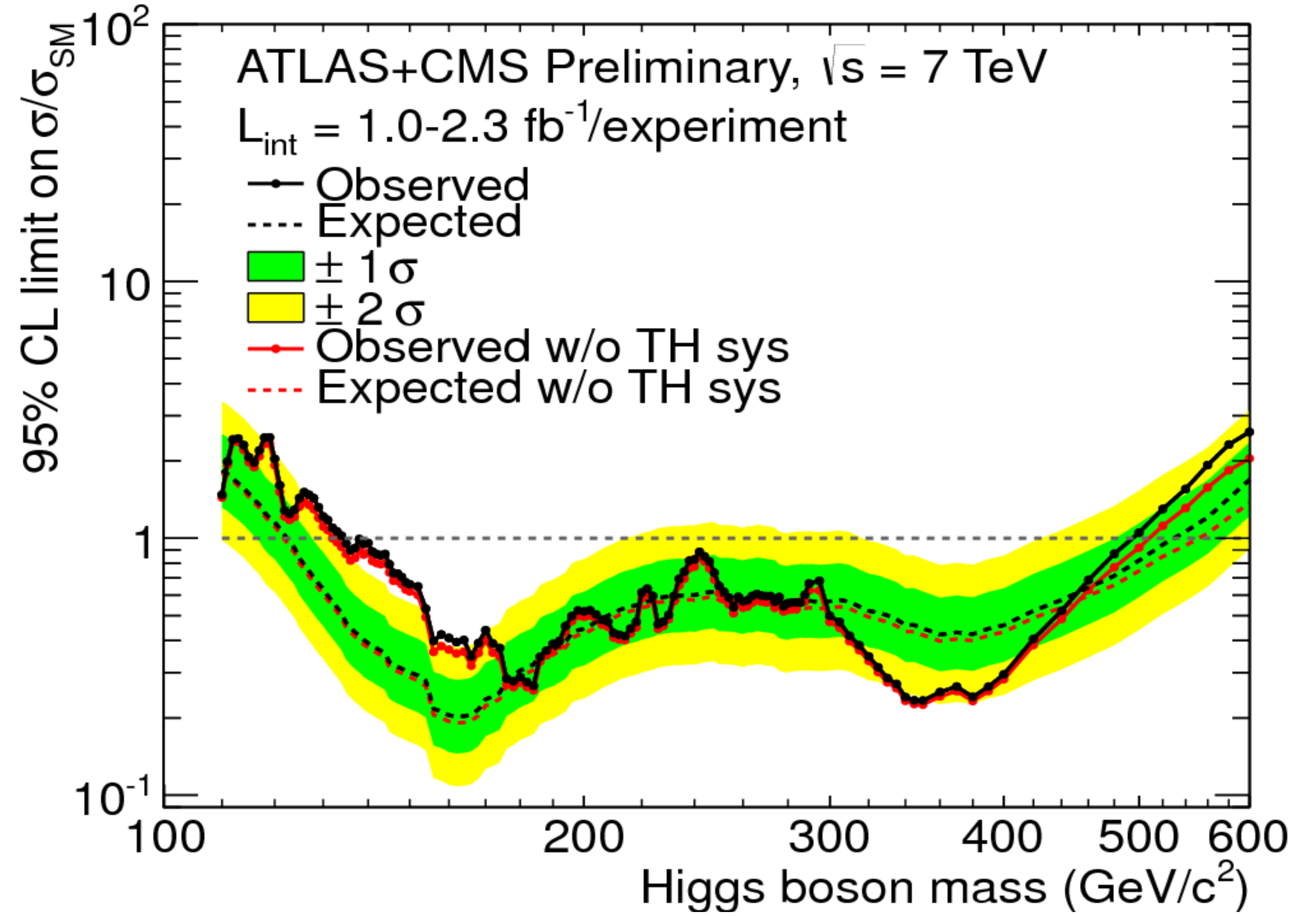
|H+cont|^2
|H|^2+|cont|^2
|H|^2 solid
|cont|^2 dashed
2l2v
M_H=500 GeV
0.006
0.004
0.002
0.000
0
200
400
600
800

TH uncertainties

Estimate of TH uncertainties ~10%

~99% of the computing time

Result in a 1% effect in the Higgs mass limit...



$$\sigma(\mathrm{m_H} = 125\,\mathrm{GeV}) = 19.49 \begin{array}{c} \text{scale} \\ \boxed{{}^{+7.2\%}_{-7.8\%}} \end{array} \begin{array}{c} \mathrm{pdf} + \alpha_S \\ {}^{+7.5\%}_{-6.9\%} \end{array} \mathrm{pb}$$

cross section somewhere in interval $20.89\,\mathrm{pb}$ $17.97\,\mathrm{pb}$

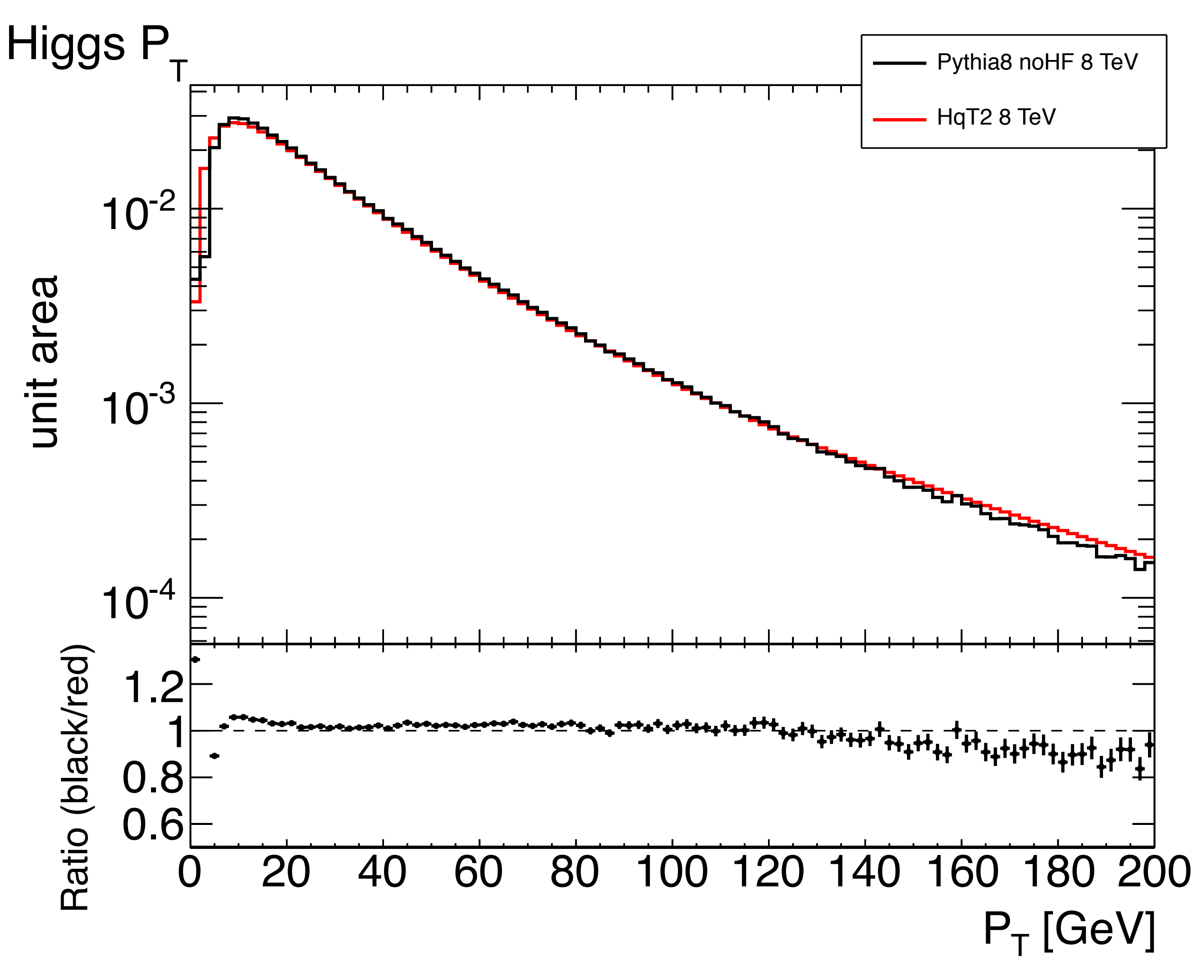
TH uncertainties underestimated in the analysis?

vary central value and produce a TH uncertainty band ?

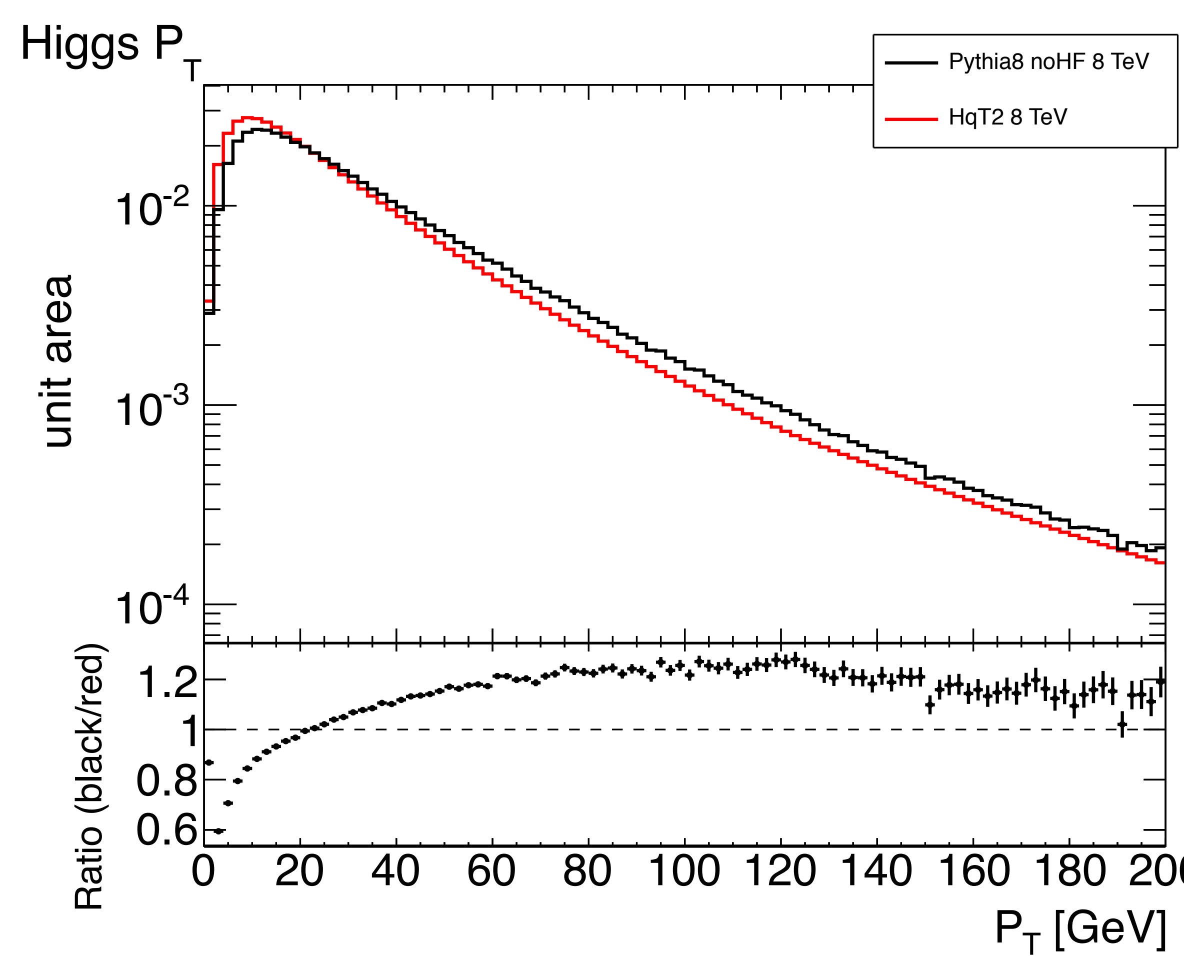
When to reweight?

- Pythia 8 MC Higgs particle status: **22 = intermediate w/preserved mass** → 44, ..., 44 = Outgoing shifted by branching → 62 = outgoing subprocess particle with primordial kt

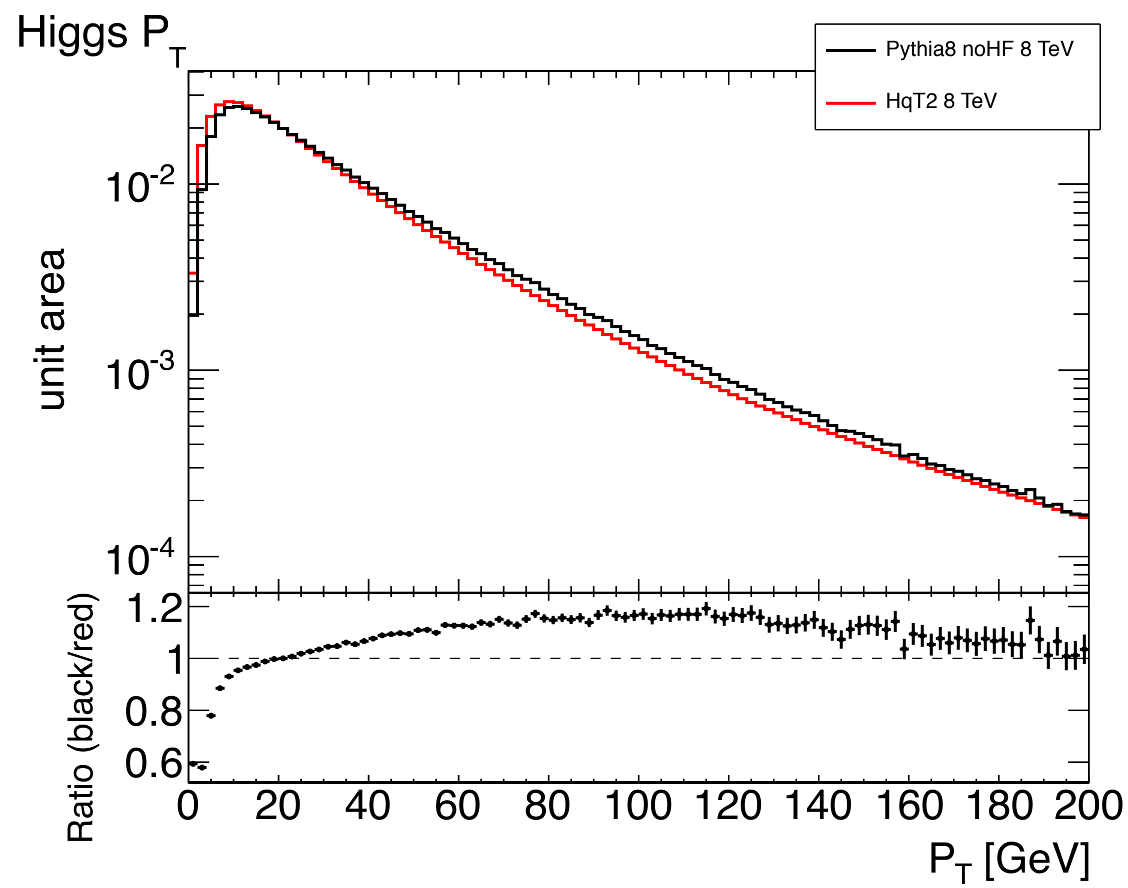
status 22 is in very good agreement with HqT (it corresponds to the pT of the Higgs from Powheg LHEF file)



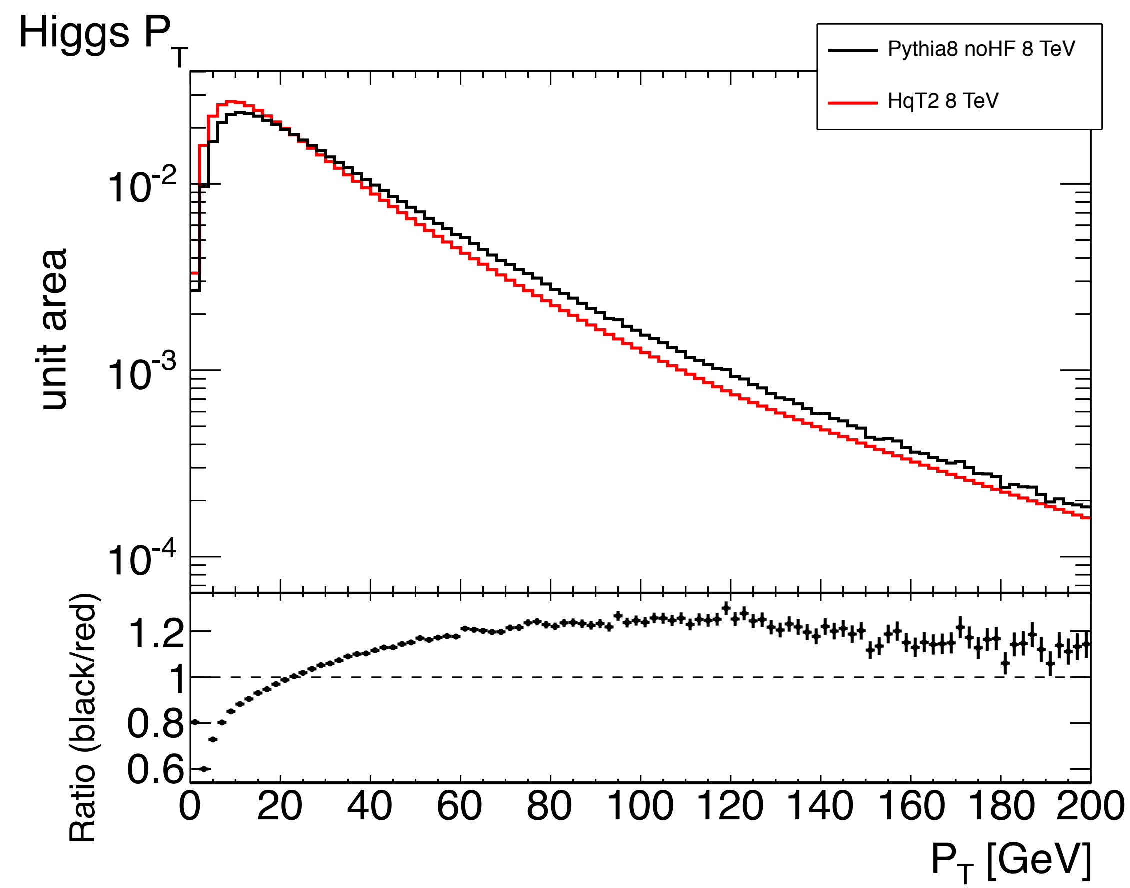
status 62 is after UE and hadronisation, the pT get modified (it was , wrongly?, reweighted to HqT in Pythia6 and in 2011)



The largest effects is at the first branching, then it increase (several branching are present)



First w/ status 44



Last w/ status 44

code range	explanation
11 – 19	beam particles
21 – 29	particles of the hardest subprocess
31 – 39	particles of subsequent subprocesses in multiple interactions
41 – 49	particles produced by initial-state-showers
51 – 59	particles produced by final-state-showers
61 – 69	particles produced by beam-remnant treatment
71 – 79	partons in preparation of hadronization process
81 – 89	primary hadrons produced by hadronization process
91 – 99	particles produced in decay process, or by Bose-Einstein effects

44 seems to include also Initial State Radiation, should not we reweight after that? ISR should be in the NLL compuation, is that right?