Processes with HQ in the initial state: trick or treat?

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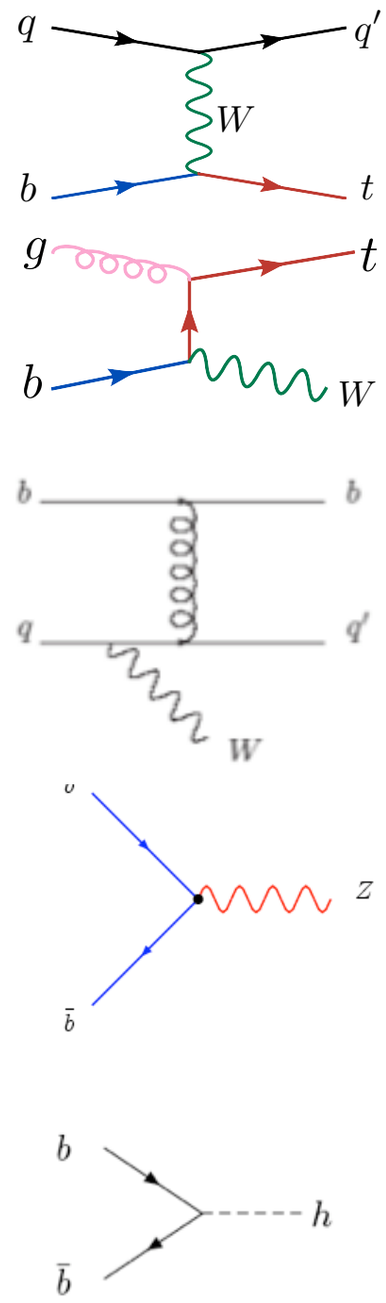
b-initiated processes

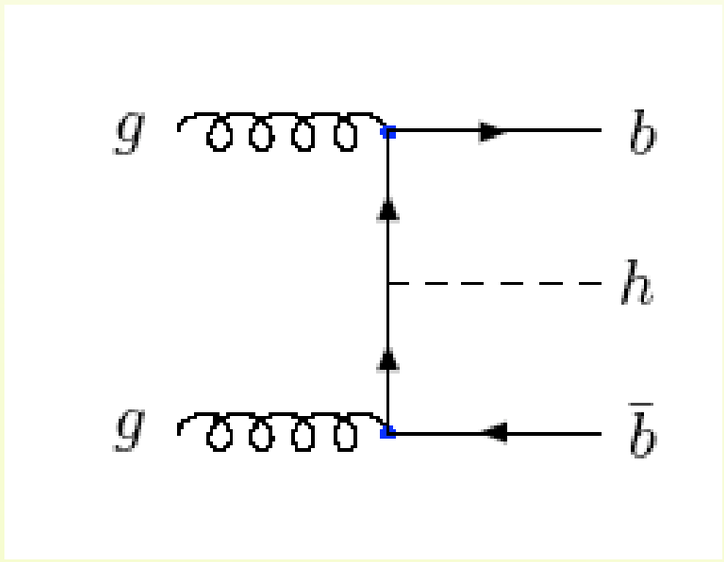
Class	Process	Interest
Top	qb→tq (t-channel)	SM, top EW couplings and polarization, Vtb. Anomalous couplings. H+ : SUSY,2HDM
	gb→t(W,H+)	
Vector Bosons	pp→Wb pp→Wbj	SM, bkg to single top
	bb→Z gb→Zb pp→Zbj	Standard candle: SM BSM bkg, b-pdf
	gb→gamma+b	
Higgs	bb→ (h,A) gb→(h,A)+b	SUSY discovery/ measurements at large tan(beta)



Schemes

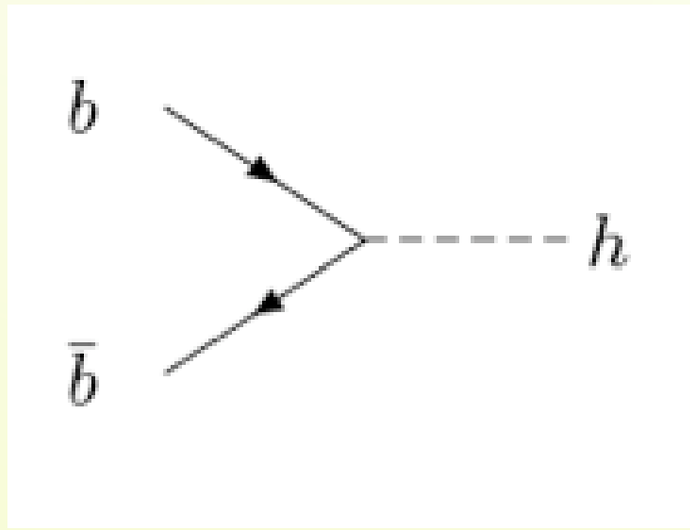
Two different ways of computing the same quantities:

4F



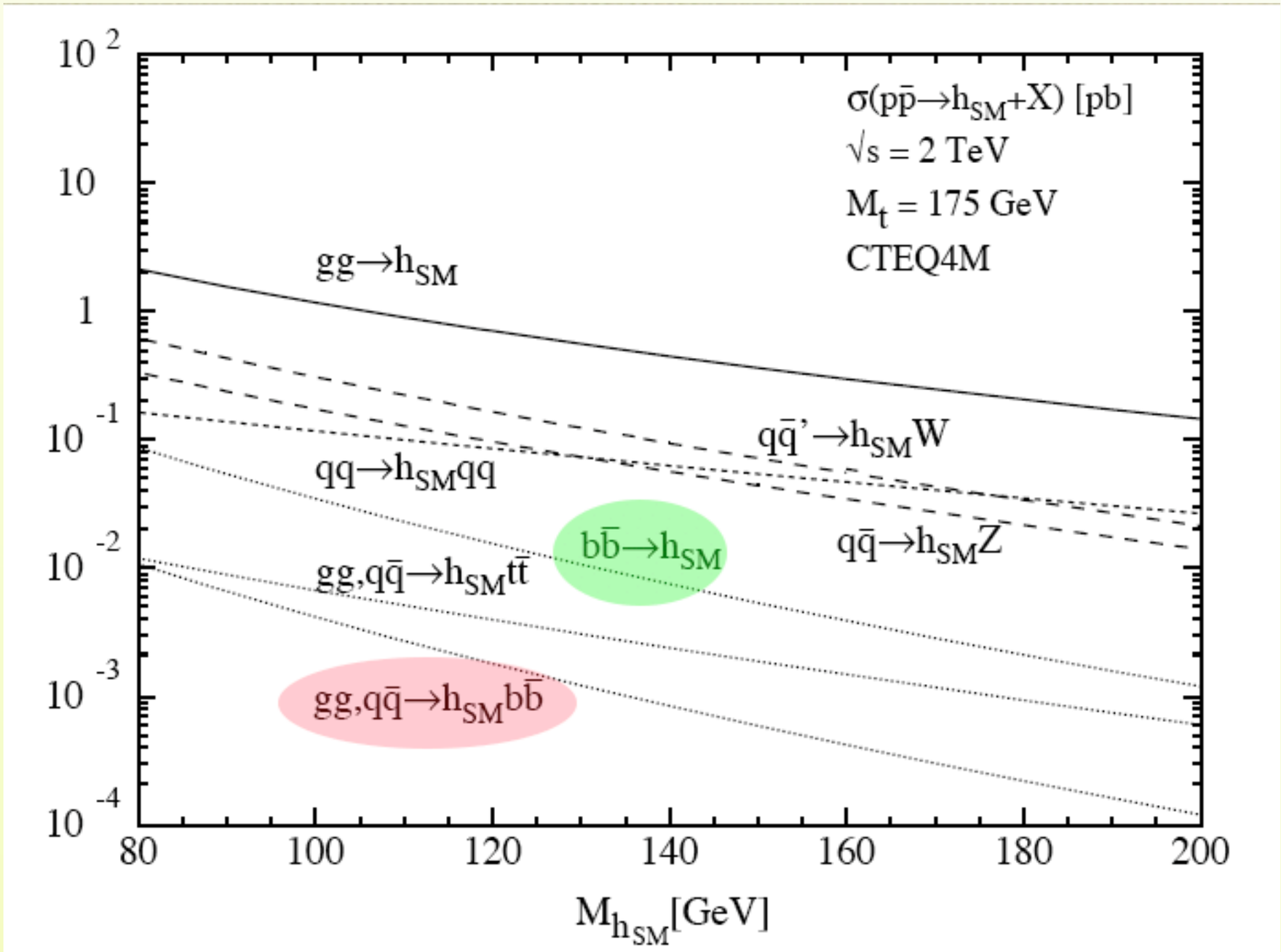
1. It does not resum (possibly) large logs (⇒norm. uncertainties)
2. Going NLO might be difficult.
3. Mass effects are there at any order in PT.
4. MC implementation with ME/PS merging a bit involved.

5F



1. It resums initial state large logs in the b pdf, leading to more stable predictions
2. Going NLO (and NNLO) "easy".
3. Mass effects are normally corrections and enter at higher orders.
4. Implementation in MC relies on mass effects given by the PS, which are presently not very accurate.

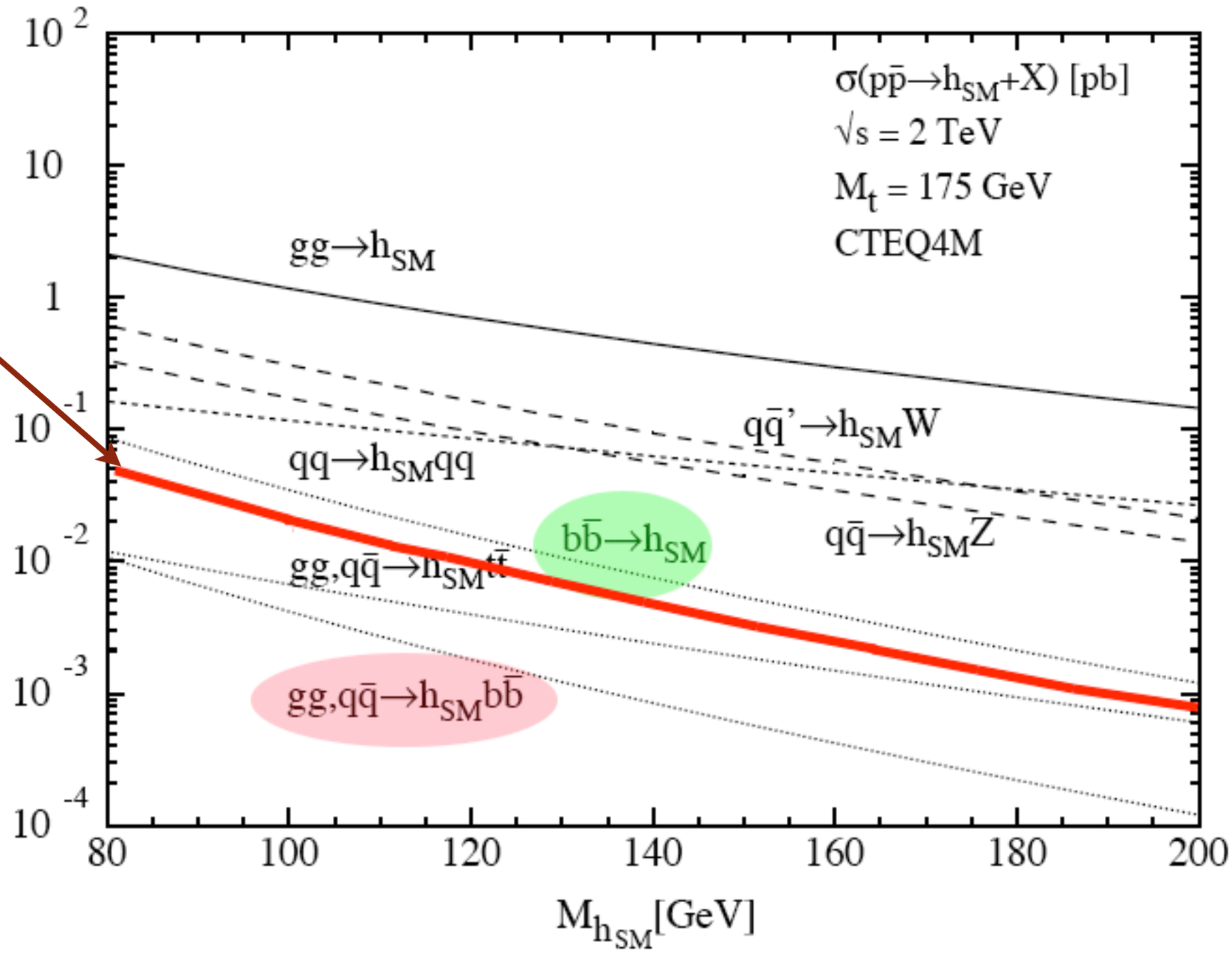
Progress in Higgs production



Higgs Tevatron Workshop 1998

Progress in Higgs production

Les Houches 03
HO corrections+
Scale choice!



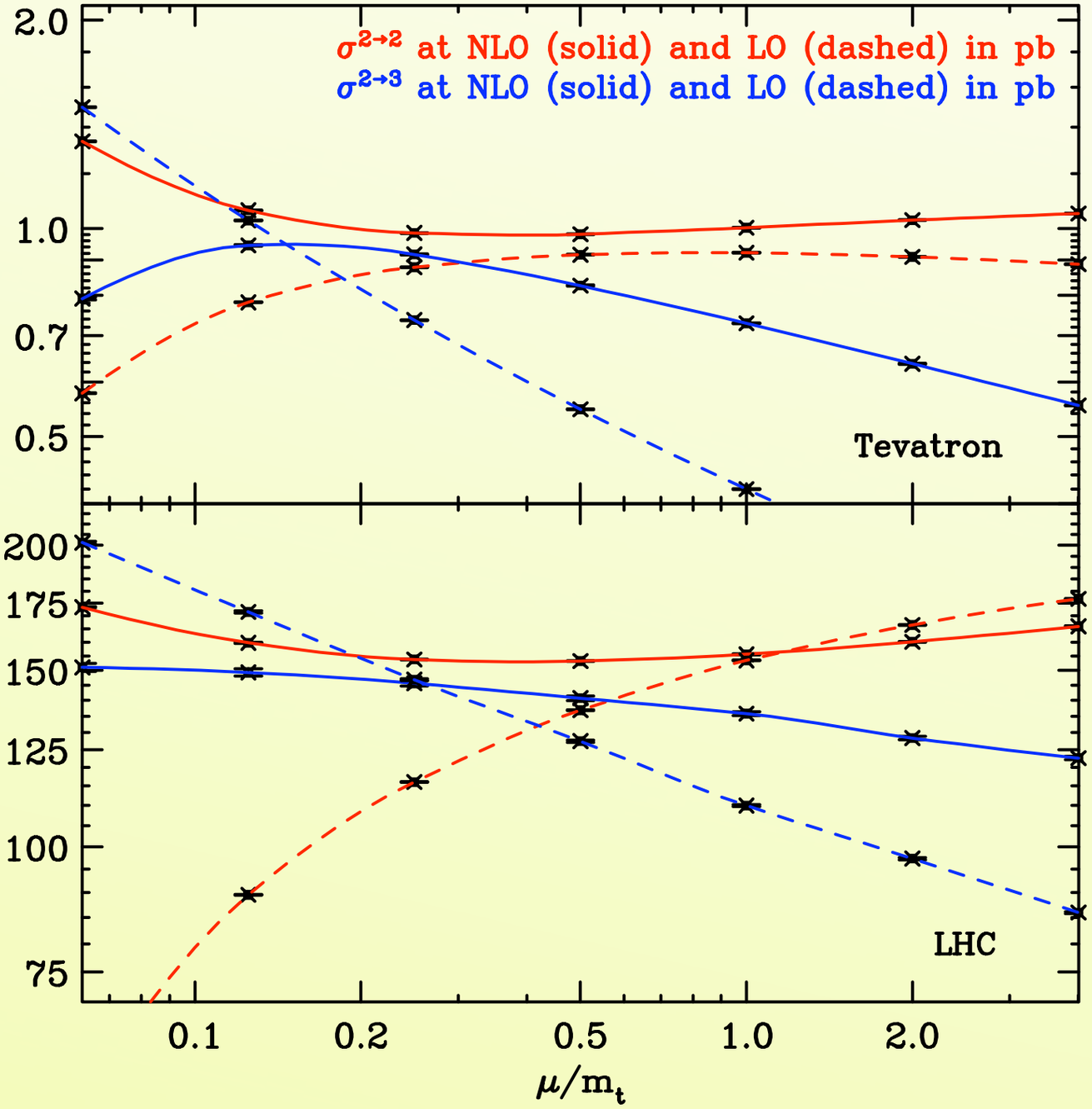
Higgs Tevatron Workshop 1998

Main question

Given that in general we can go only up to NLO is there a preferred way of performing these calculations?

t-channel single top : 2→2 vs 2→3

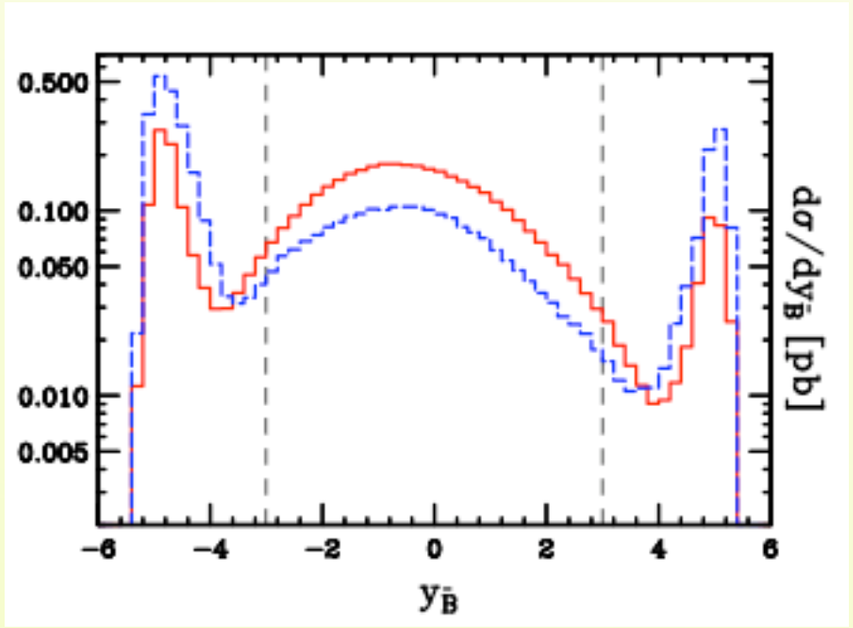
[Campbell, Frederix, FM, Tramontano, 0903.0005]

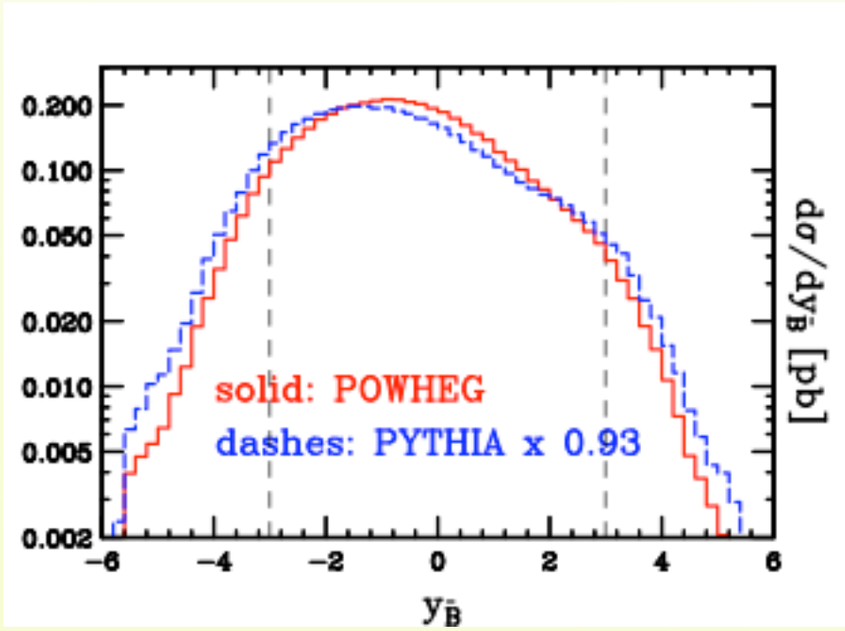


- Both schemes much improved from LO
- 5F (2 → 2) only mildly sensitive to scales at NLO (use m_t in what follows)
- 4F (2 → 3) expected to be worse, but isn't much

t-channel single top at Tevatron

[Aioli, Nason, Oleari, Re, 0907.4076]



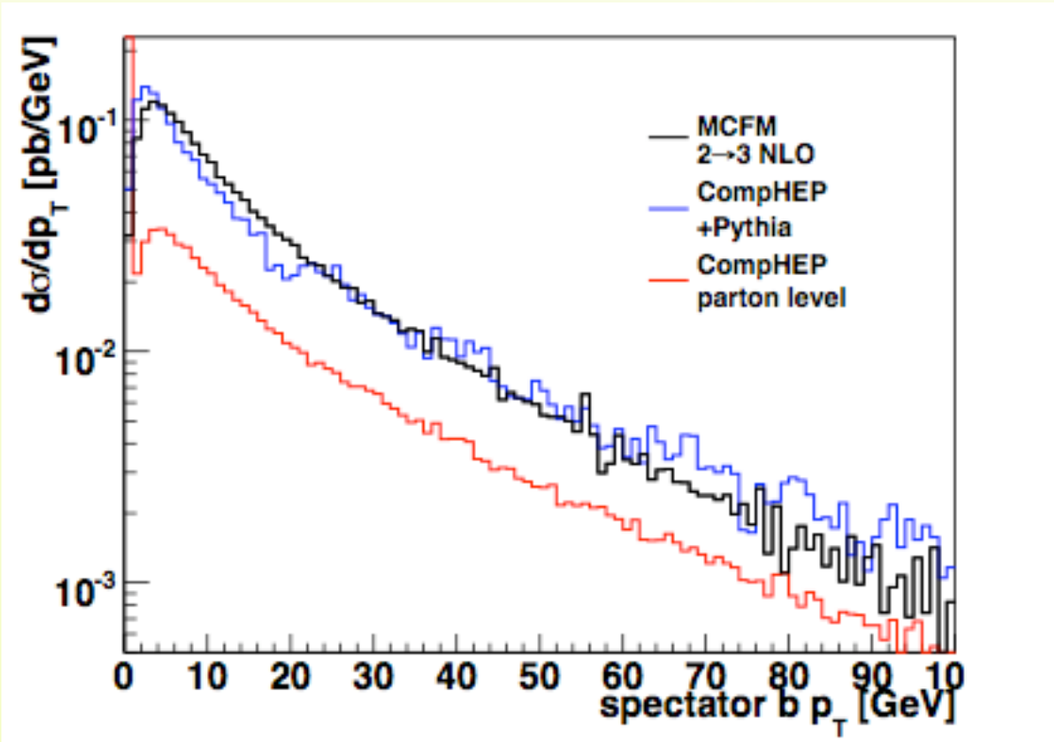


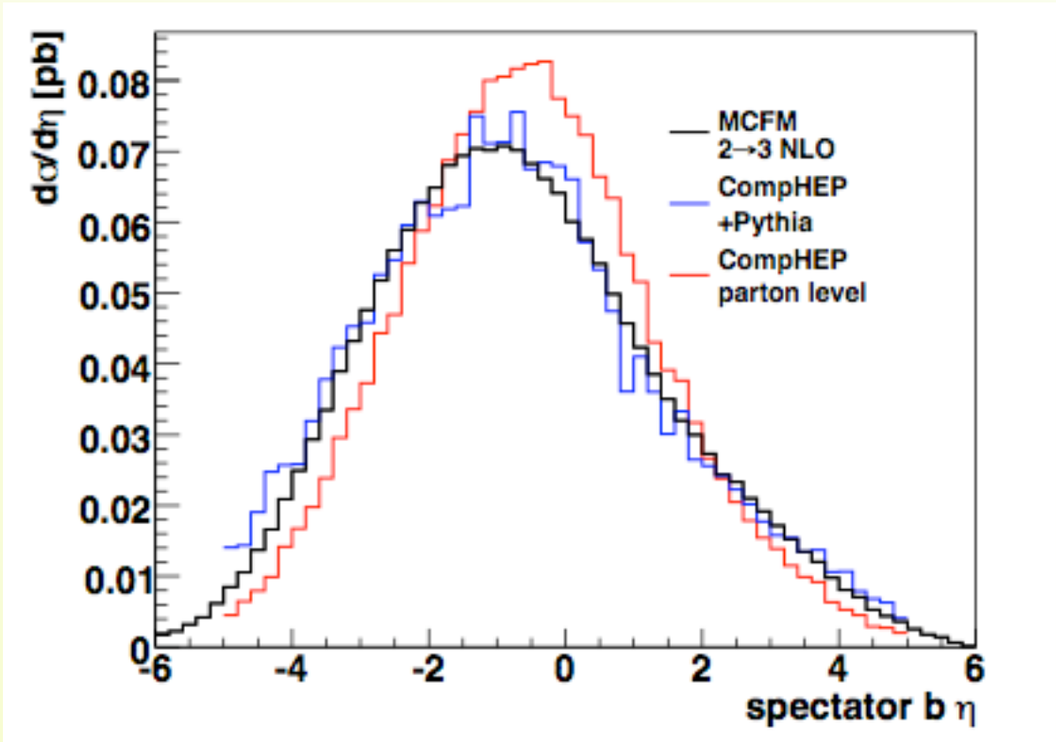
Shower: HERWIG Pythia

Shower for initial states HQ needs to be improved!

t-channel single top at Tevatron

[Frederix, FM, Schwienhorst, Les Houches 2009]





D0 has used samples obtained by COMPHEP+Pythia with a "hard pt matching" that are in a very reasonable agreement with the 2→3 NLO predictions.

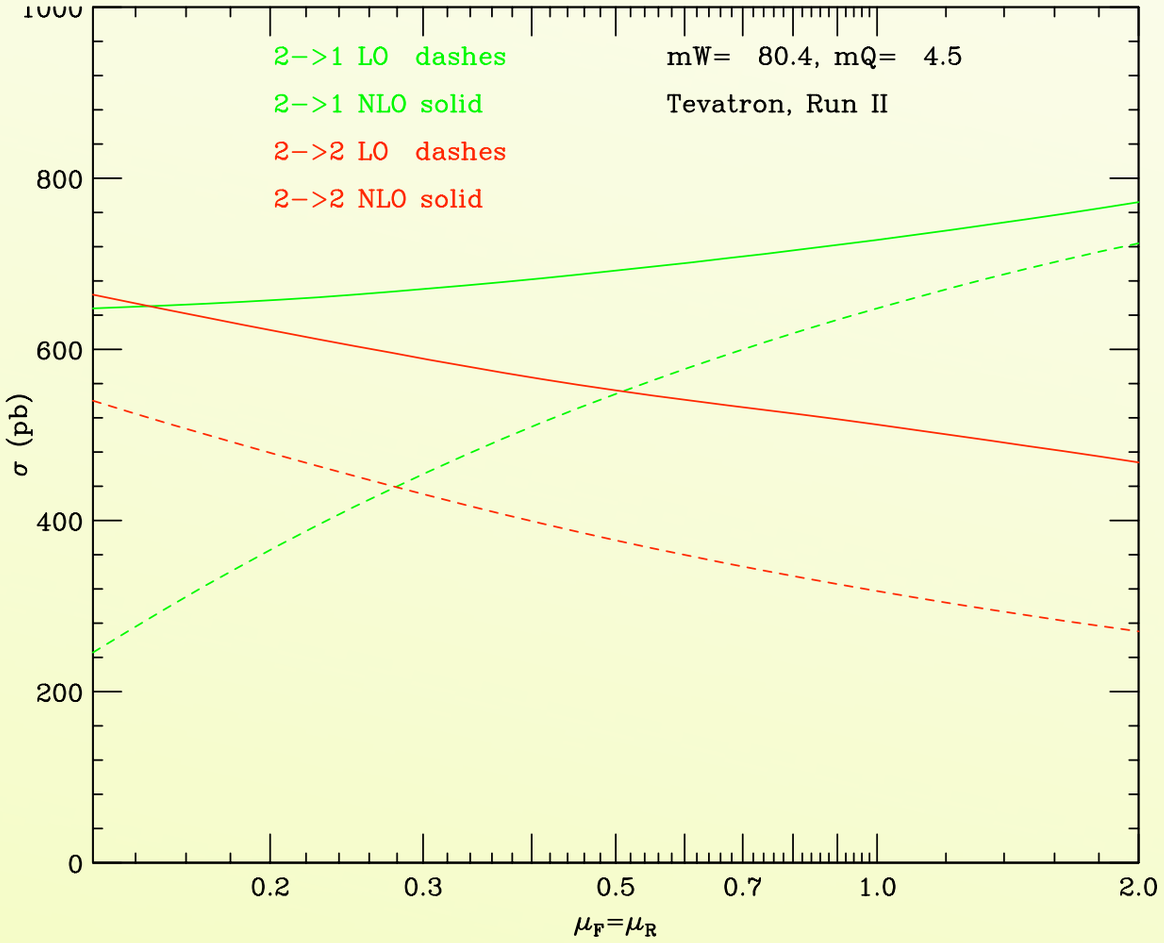
Burning questions

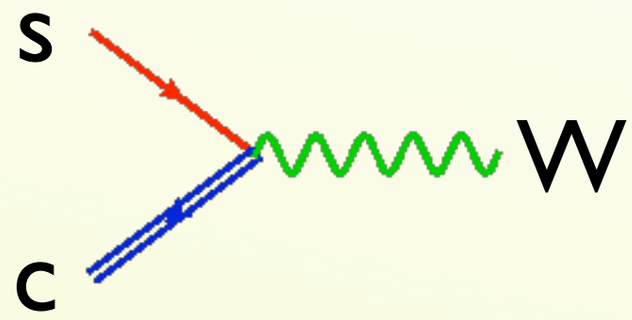
Burning questions

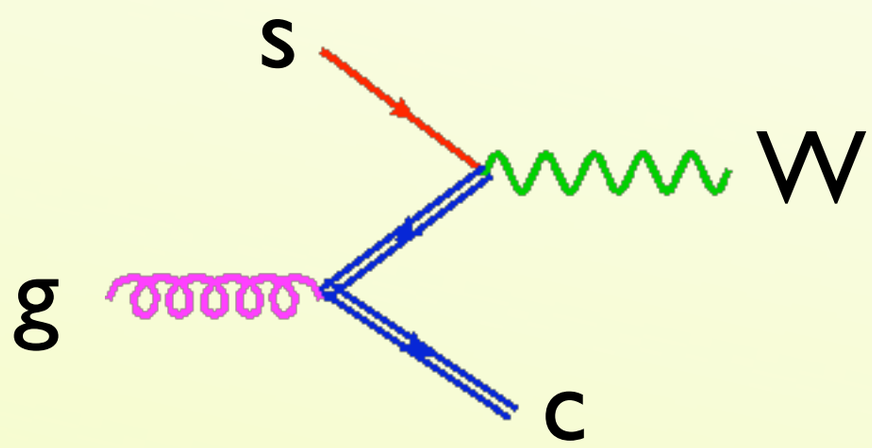
1. What is the effect of the resummation of the IS logs? Is it really needed or the 5F is just a trick to be able to do a NLO or NNLO calculation?
2. Which scheme provide better predictions for total cross sections? And for distributions?
3. What about the Monte Carlo implementation? Are the current PS codes able to correctly simulate the kinematics of the heavy quarks coming from gluon splitting in the IS?
4. What about the PDF side? Are the uncertaintes on the HQ pdf reliable? Are the uncertaintes coming from the threshold behaviour, matching, HQ mass correctly accounted for? [See Paolo Nason's talk this Friday]
5. The answers to the above questions are general or process dependent?

WQ : 2→1 vs 2→2

[Campbell, Maltoni, Mangano, Tramontano, in progress]



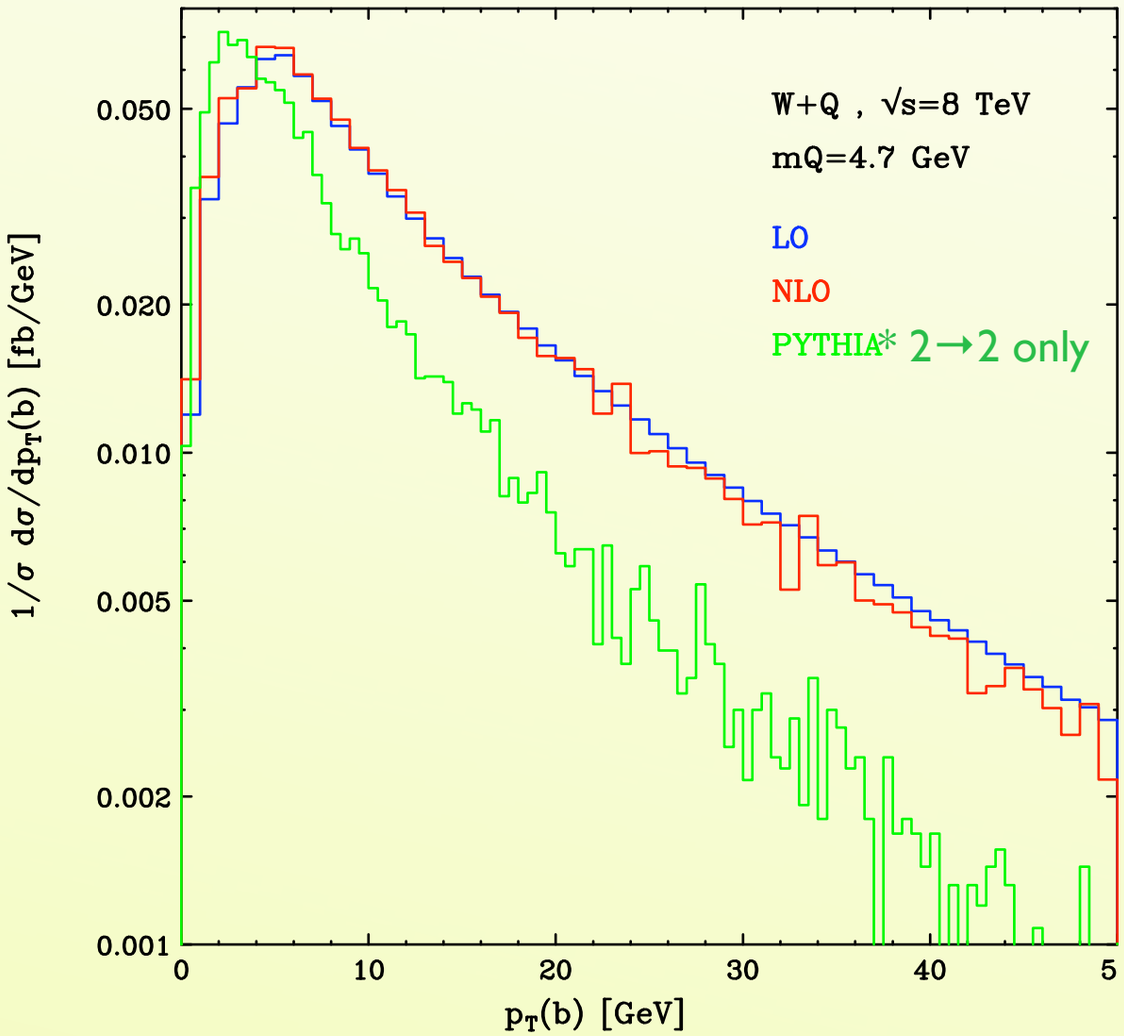


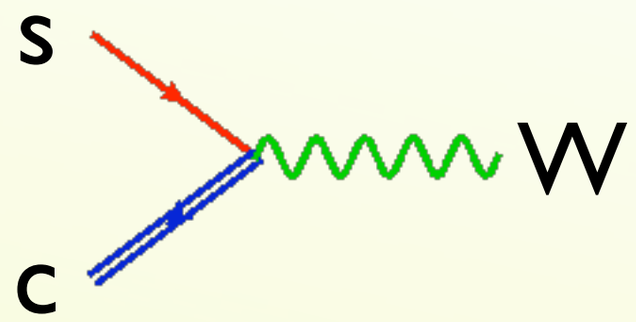


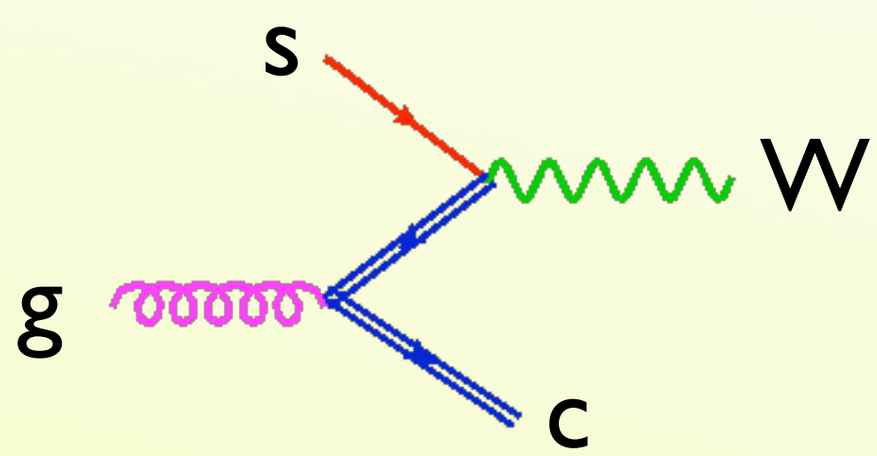
Conjecture: "Universal behaviour" for the scale dependence of the 5F and 4F calculations. No clear evidence for the need of resummation.

Similar behavior in WQ : 2→1 vs 2→2

[Campbell, Maltoni, Mangano, Tramontano, in progress]



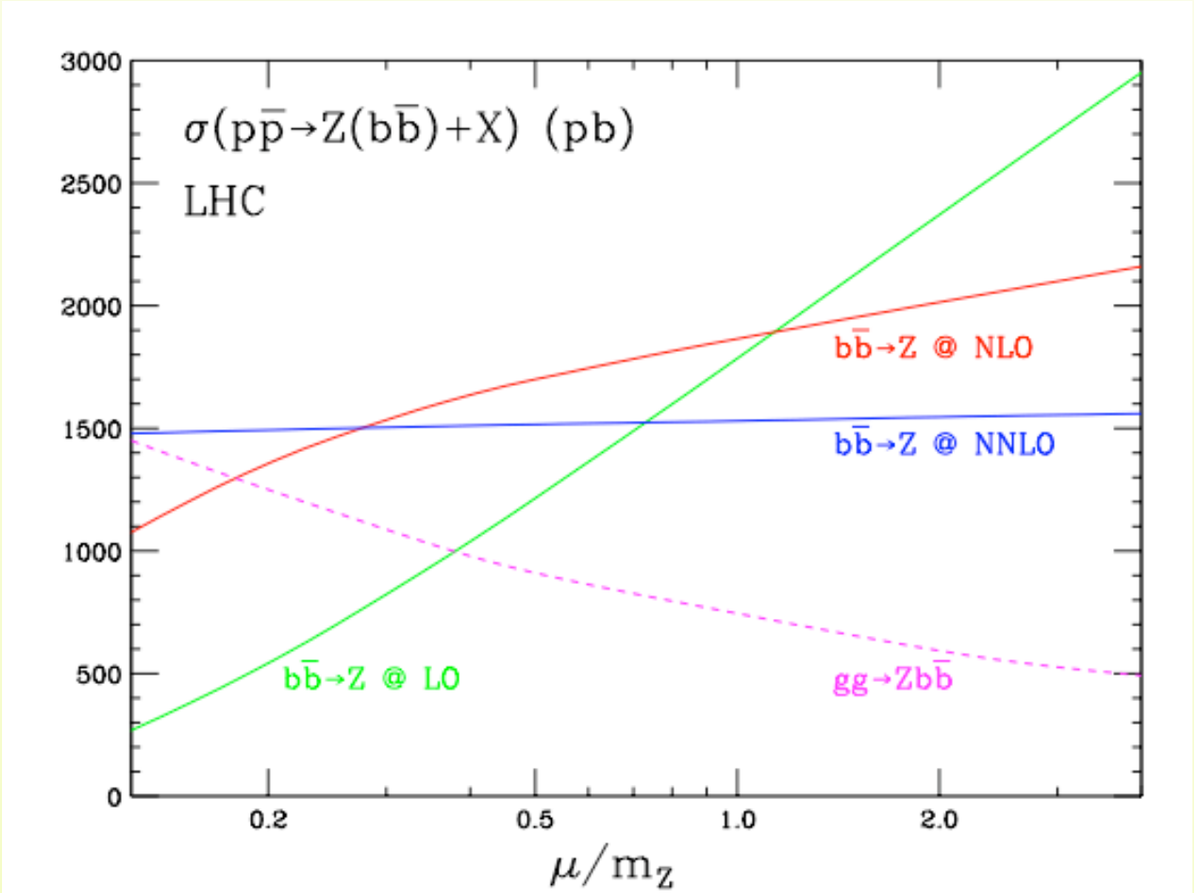


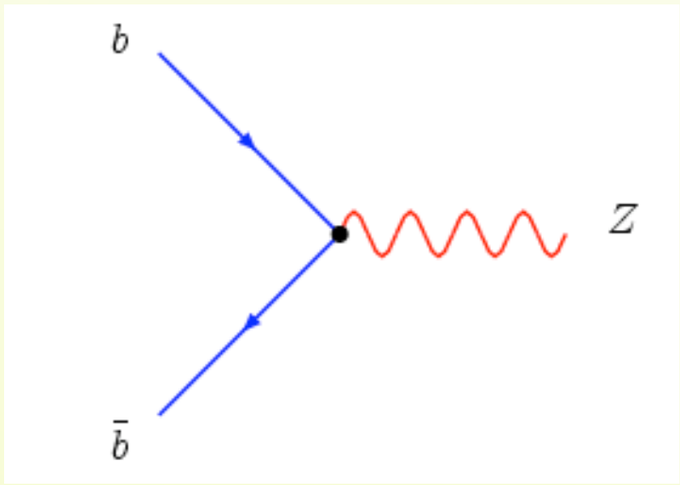


- pT spectrum of the spectator HQ unchanged
- no call for resummation
- the 2→2 prediction for the spectator theoretically solid.

Z + b's at the LHC in the 5F scheme

[FM, McElmurry, Willenbrock, 2005]



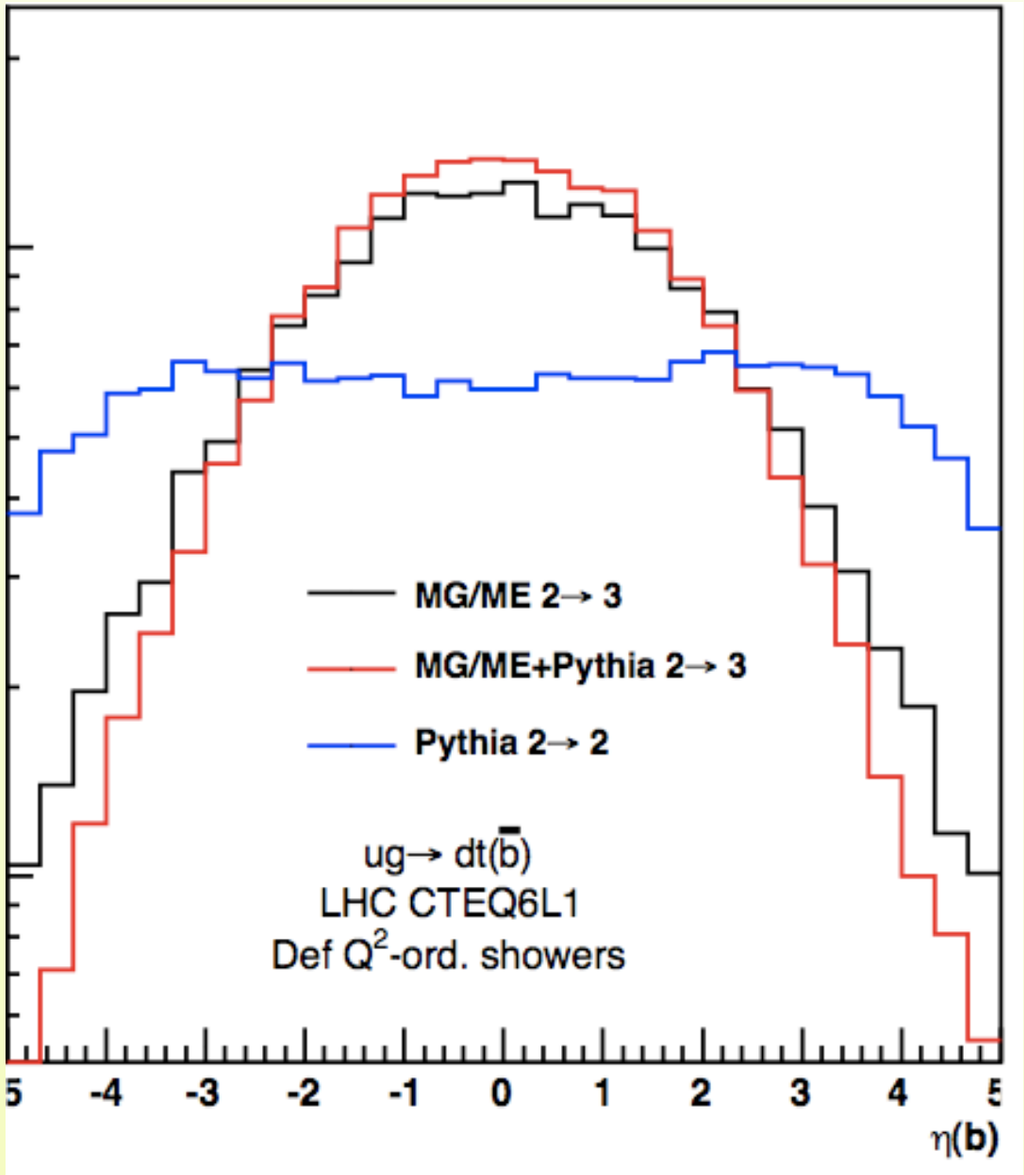


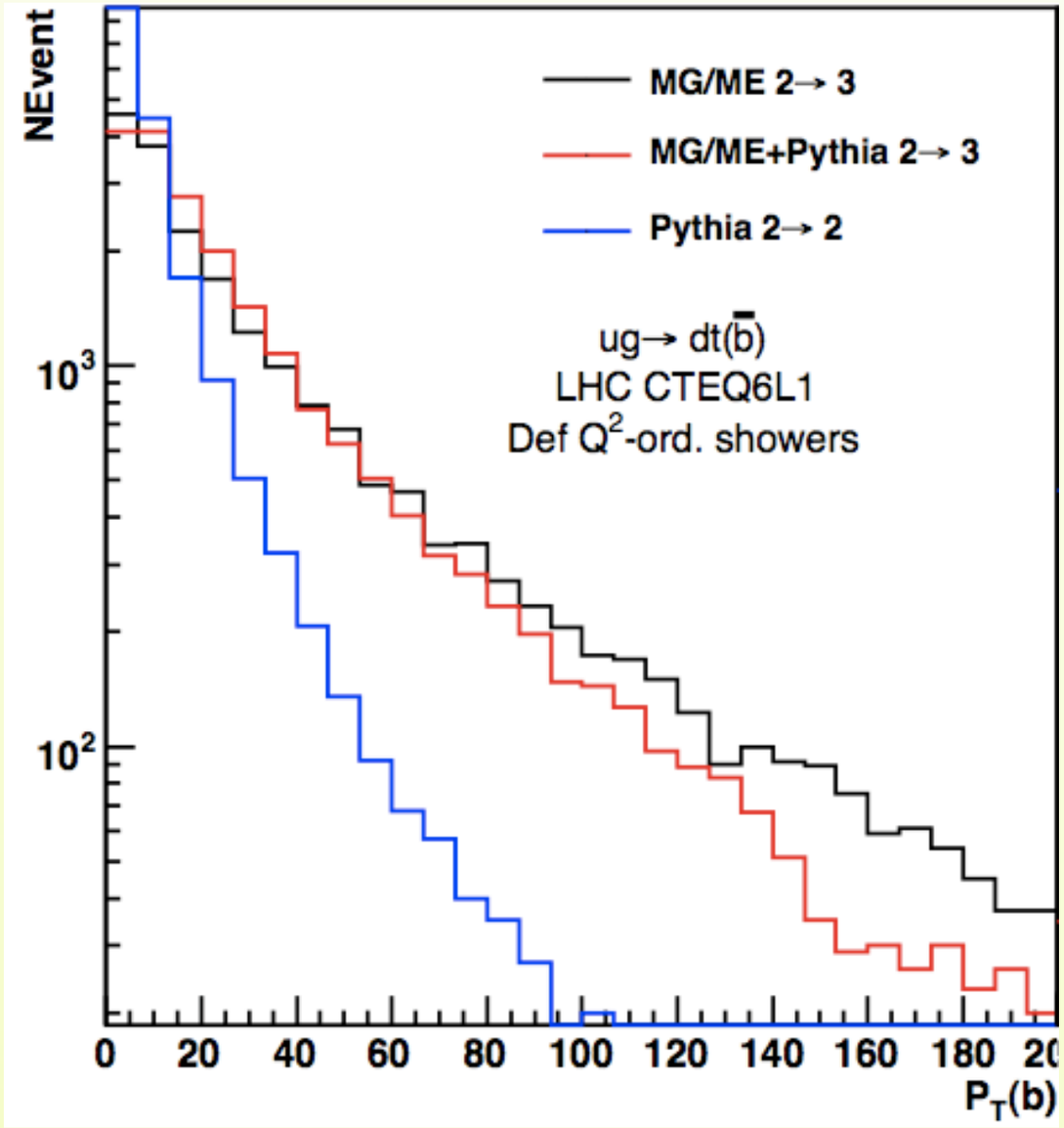
Comparison with pp→Zbb at NLO (with massive b's) now possible

[Febres-Cordero, Reina, Wackeroth 2005].

Impact on Z cross section measurement as a standard candle.

t-channel single top at LHC

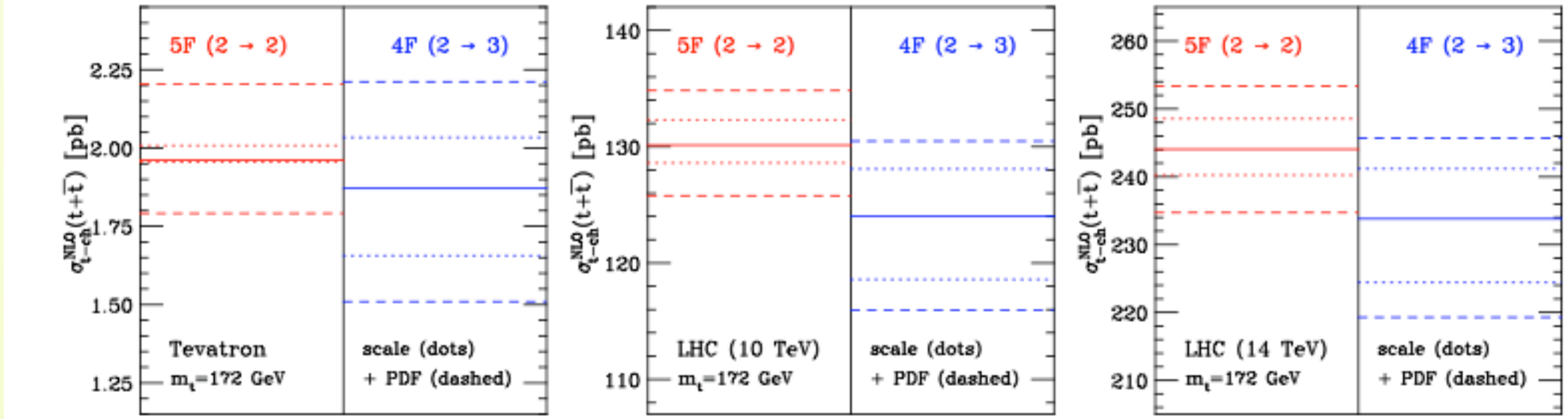




pT and η spectra of the spectator HQ from the 2→3 prediction are ok...

t-channel single top : 2→2 vs 2→3

[Campbell, Frederix,FM, Tramontano, 0907.3933]



$\sigma^{\rm NLO}_{\rm t-ch}(t+\bar{t})$	$2 \to 2$ (pb)				$2 \to 3$ (pb)				
Tevatron Run II	1.96	$^{+0.05}_{-0.01}$	$^{+0.20}_{-0.16}$	$^{+0.06}_{-0.06}$	$^{+0.05}_{-0.05}$	1.87	$^{+0.16}_{-0.21}$	$^{+0.18}_{-0.15}$	$^{+0.06}_{-0.06}$	$^{+0.04}_{-0.04}$
LHC (10 TeV)	130	$^{+2}_{-2}$	$^{+3}_{-3}$	$^{+2}_{-2}$	$^{+2}_{-2}$	124	$^{+4}_{-5}$	$^{+2}_{-3}$	$^{+2}_{-2}$	$^{+2}_{-2}$
LHC (14 TeV)	244	$^{+5}_{-4}$	$^{+5}_{-6}$	$^{+3}_{-3}$	$^{+4}_{-4}$	234	$^{+7}_{-9}$	$^{+5}_{-5}$	$^{+3}_{-3}$	$^{+4}_{-4}$

Applications of the new 4F t-channel calculation

- Event though b quarks in the 4F ($2 \to 3$) scheme are more forward and softer, we expect to see more b's than in the 5F ($2 \to 2$)
- In 5F ($2 \to 2$) only a subset of real emission diagrams have a final state b quark
- Define "acceptance" as the ratio of events that have a central, hard b over inclusive cross section:

$$\frac{\sigma(|\eta(b)| < 2.5,\, p_T(b) > 20\ \mathrm{GeV})}{\sigma_{\mathrm{inclusive}}}$$

Acceptance at Tevatron

- Very large scale dependence for 5F ($2 \to 2$), → effectively a LO quantity
- NLO 4F ($2 \to 3$) much stabler
- Dramatic effect at the Tevatron, less so at the LHC.