Theoretical and Experimental Progress in D-LHC-Top

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Working Topics

WG1 (ttbar and single top x-sections)
WG1 (NNLO calculations, top decay, charge asymmetry, ...)

WG2 (top quark mass)

WG3 (BSM, top as background)

Theoretical Progress

WG1: calculating top x-sections

Tools

- Total cross section $\sigma_{\mathrm{pp}\to\mathrm{t\bar{t}}}$ package available soon
- Options
  - NLO (plain vanilla)
  - resummation with NLL accuracy to all orders
  - $\mathrm{NNLO}_{\mathrm{approx}}$ threshold improved and exact scale dependence ($\ln(\mu/m)$-terms)

Phenomenology

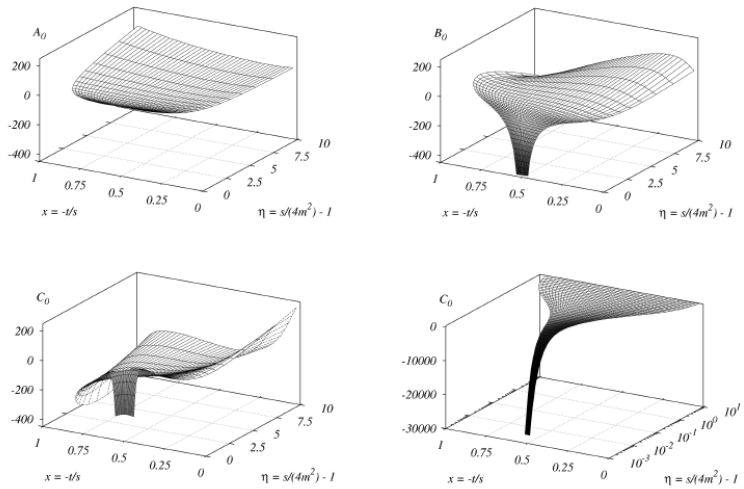
- Update on top-pair production at LHC and Tevatron
- Resummation at Tevatron revisited
- Top-pair production as standard candle for parton luminosity

WG1: calculating top x-sections

Towards an NNLO prediction for the total top-quark production cross section

Full mass dependence

- Numerical solution of differential equations M.C. '08 (to be published...)



- The exact NNLO virtual corrections in quark annihilation are almost available
- Next: remaining virtuals and real radiation

WG1: calculating top x-sections

The one-loop squared *factorized* amplitudes for heavy quark production

$$\text{NNLO QCD} \sim \alpha_s{}^4$$

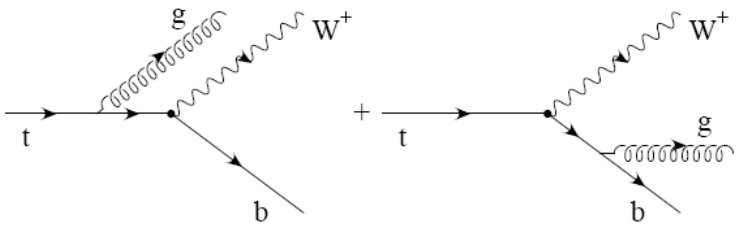
Generic diagrams :

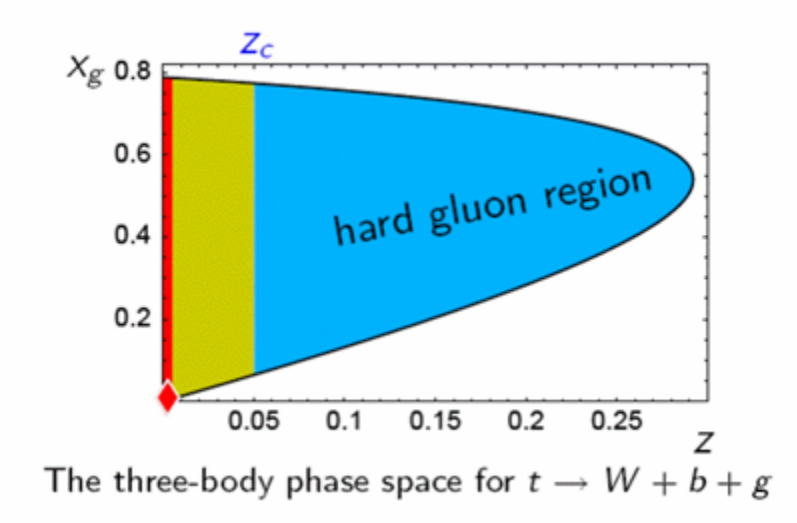
- First part of this project: One-loop contributions to

$$i)\quad g+g \to Q+\bar{Q} \qquad ii)\quad q+\bar{q} \to Q+\bar{Q}$$

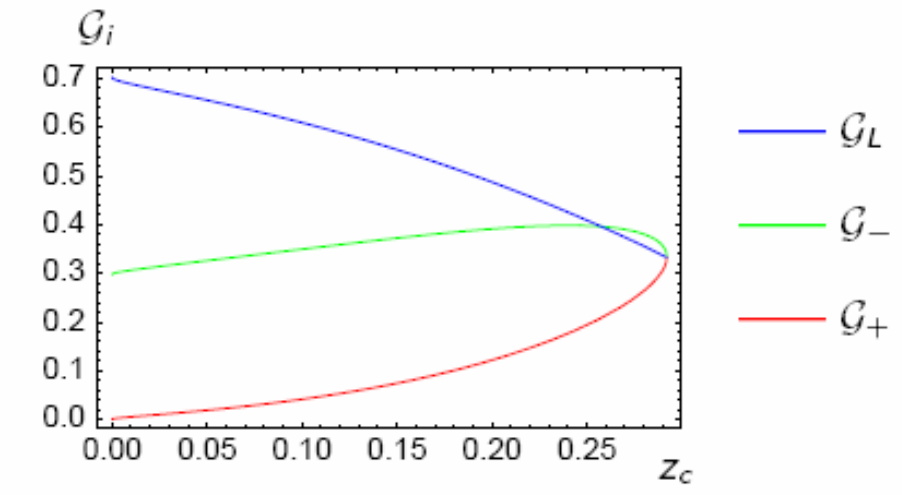
- NNLO $\mathcal{O}(\alpha_s^4)$ analytical results for one-loop squared contributions for unpolarized $q\bar{q} \to Q\overline{Q}$ subprocess, with the full mass dependence retained, in *factorized form*.

WG1: top decay - helicity





The three-body phase space for $t \to W + b + g$



WG1: top decay - helicity

Helicity Content of W-Bosons from Top quark Decays at NNLO

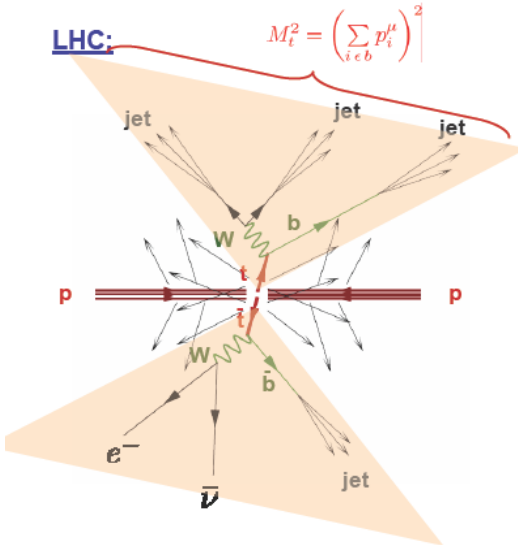
Results are presented in the form $\mathcal{G}_i = \mathcal{G}_i^{(0)} + \Delta\mathcal{G}_i^{(1)} + \Delta\mathcal{G}_i^{(2)}$ with increments $\Delta\mathcal{G}_i^{(n)} = \mathcal{G}_i^{(n)} - \mathcal{G}_i^{(n-1)}$ and also, if $\mathcal{G}_i^{(0)} \neq 0$, as $\mathcal{G}_i = \mathcal{G}_i^{(0)}(1 + \delta\mathcal{G}_i^{(1)} + \delta\mathcal{G}_i^{(2)})$.

$$
\begin{aligned}
\mathcal{G}_L &= 0.6971 - 0.0075 - 0.0023 \\
&= 0.6971(1 - 0.0108 - 0.0034) \\
\mathcal{G}_+ &= 0 \qquad + 0.00103 + 0.00023 \\
\mathcal{G}_- &= 0.3029 + 0.0065 + 0.0021 \\
&= 0.3029(1 + 0.0214 + 0.0070)
\end{aligned}
$$

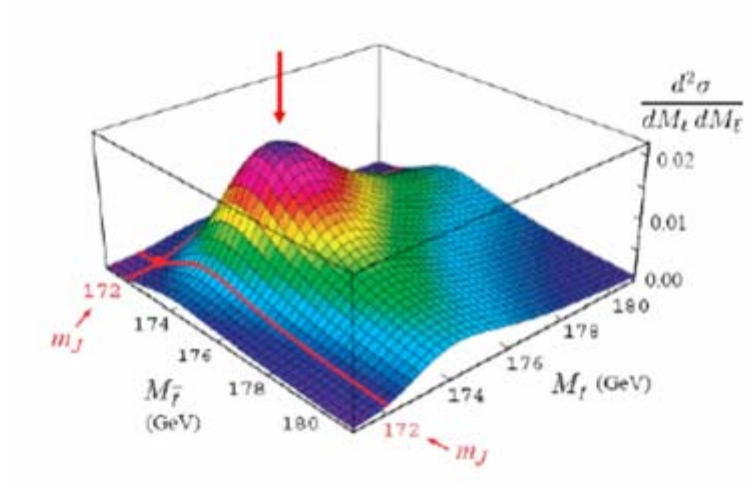
The perturbative expansion is well behaved.

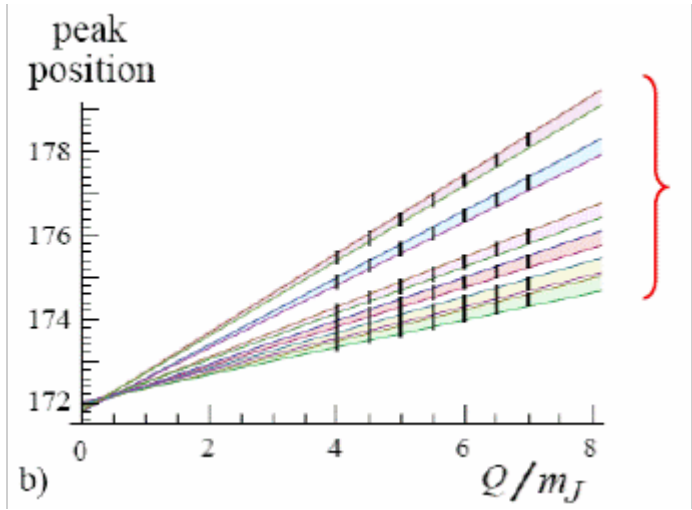
WG2: top quark mass

event shape like observables



$p_T \gg m_t$





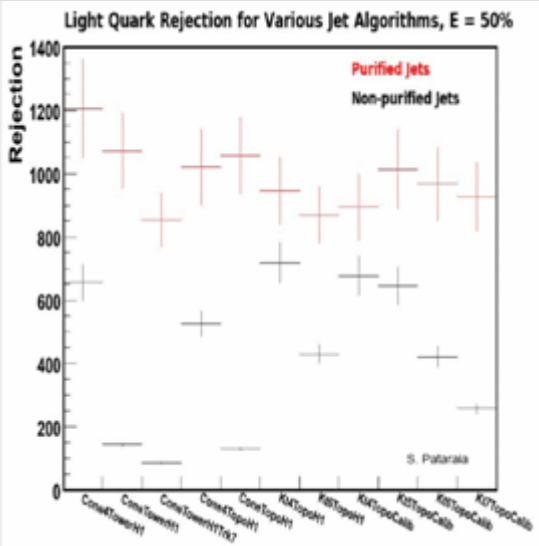
measure with different cuts, extrapolate to well defined mass

Experimental Progress

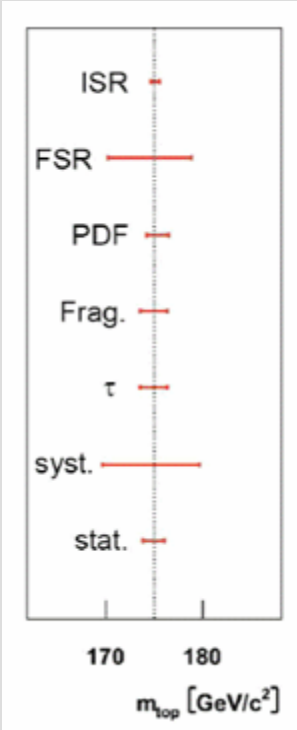
WG1: ttbar x-sections

enormous efforts on systematic effects

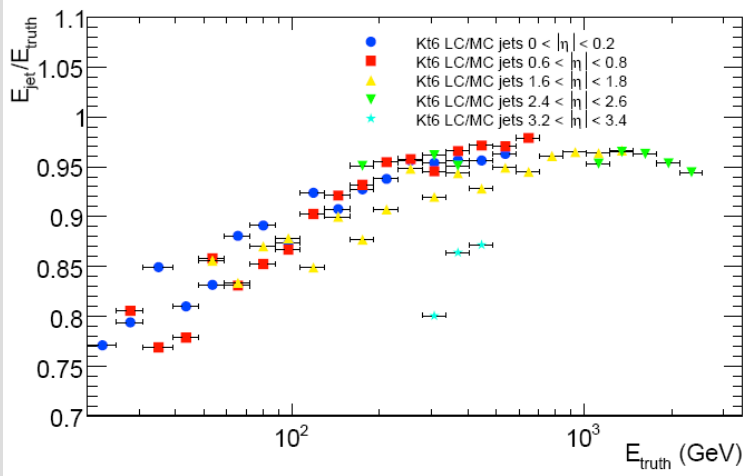
b-tag – jet definition

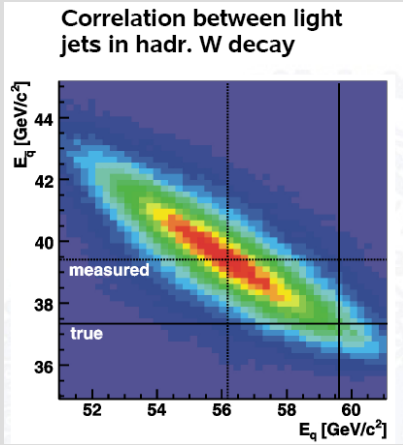


di-lepton



jet energy scale





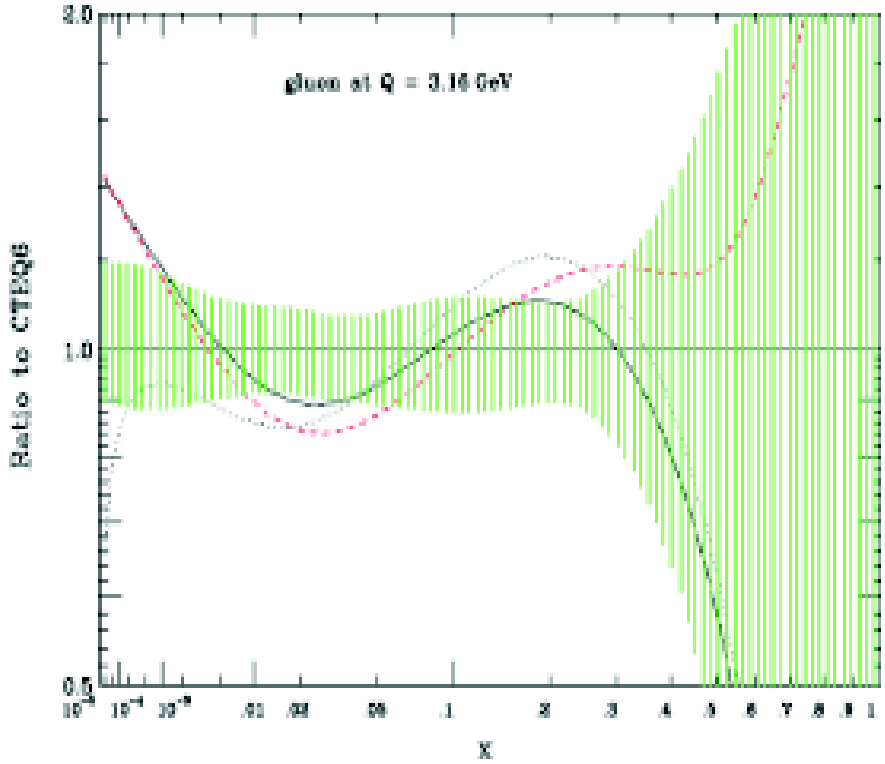
WG1: cross-section ratios

measure ratio of semileptonic to di-leptonic channel to cancel experimental uncertainties (e.g. on luminosity)

Theoretical Uncertainties

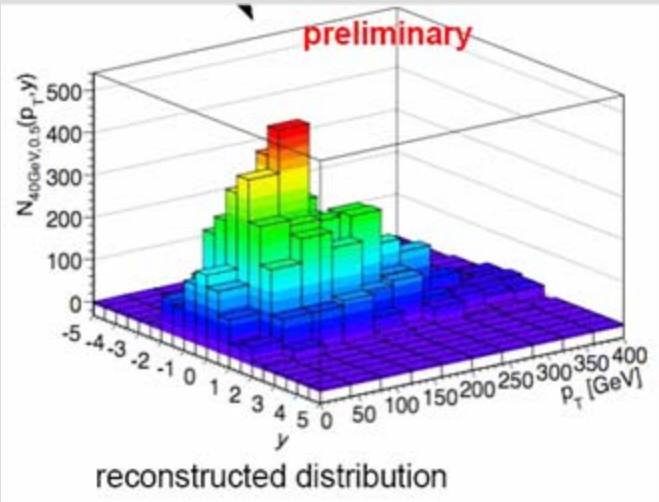
- parton density functions
- unknown effects of higher order

But: two channels



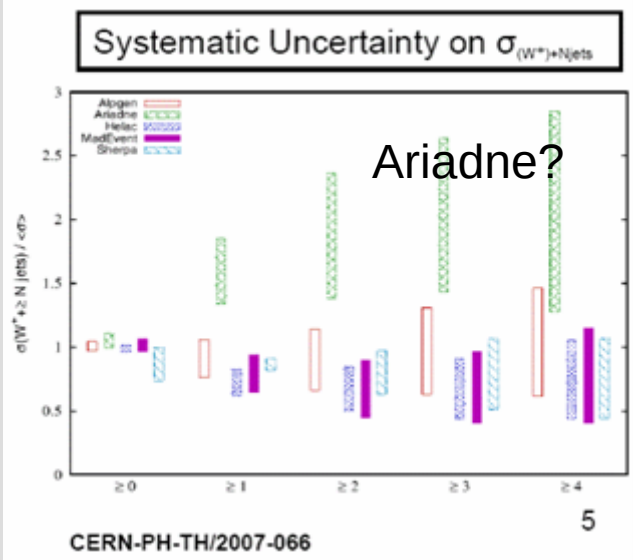
WG1:ttbar and single top x-sections

differential top cross sections



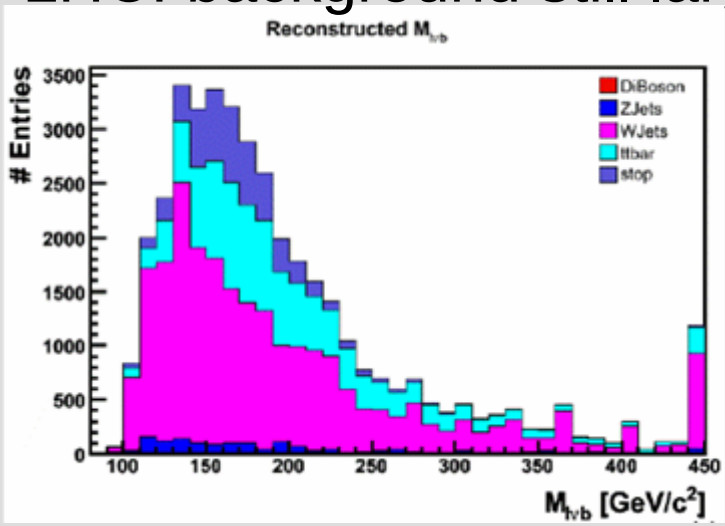
observables as in photoproduction of two jets? delta eta, average pt,...

W+jets background under control at 30%

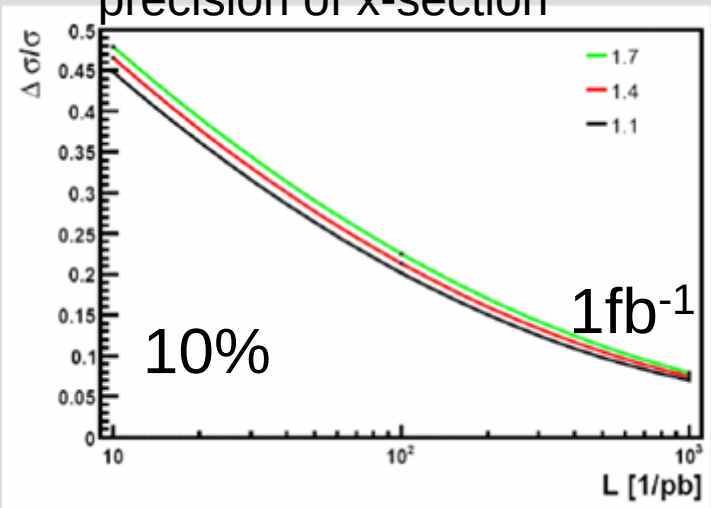


WG1: single top x-sections

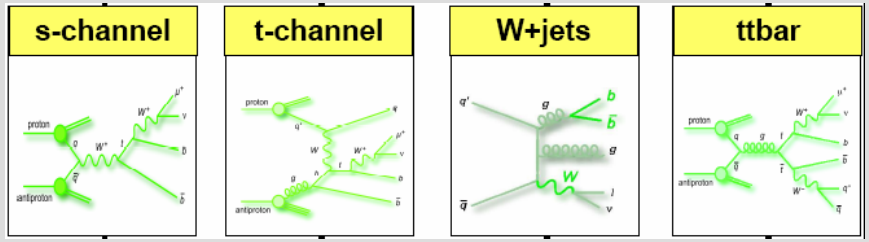
LHC: background still large

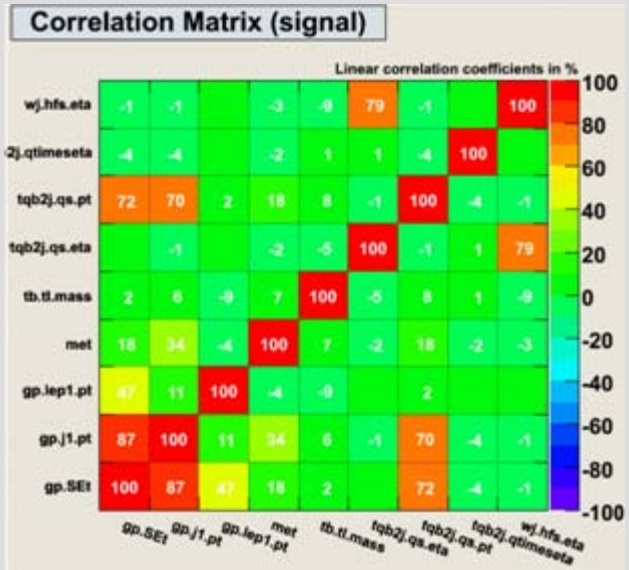


precision of x-section



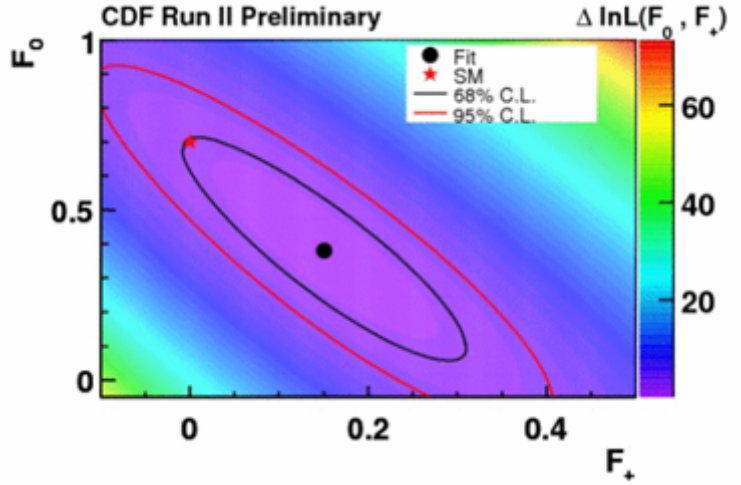
Tev: multiprocess analysis to improve S/B

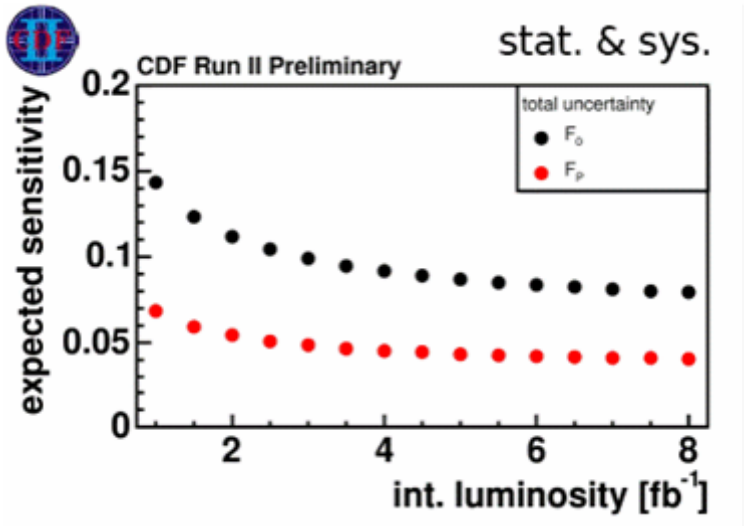




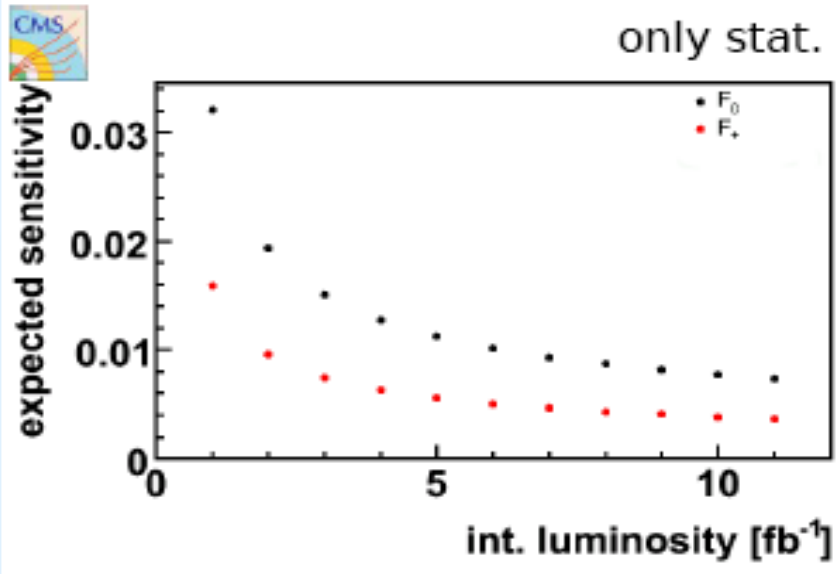
WG1: top decay - helicity

Simultaneous determination of F+,Fo

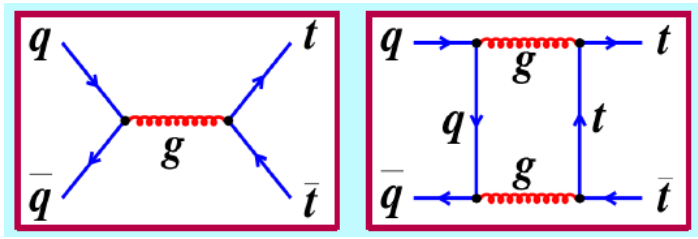


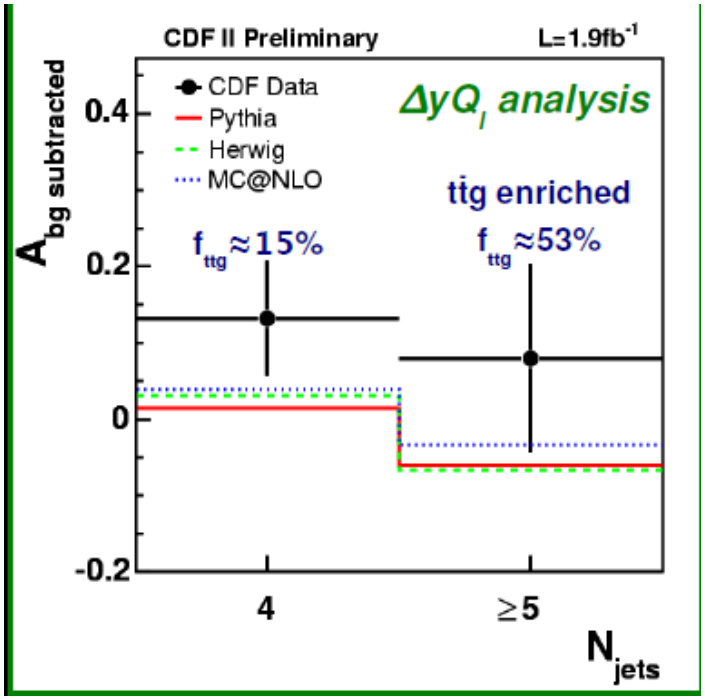


At LHC the systematic error will dominate



WG1: charge asymmetry





$A_{4\ jets} = (13.2 \pm 7.5)\%$

$A_{\geq 5\ jets} = (7.9 \pm 12.3)\%$

MC@NLO: $A_{4\ jets}$=3.8 %, $A_{\geq 5\ jets}$=- 3.3%

L=0.9/fb

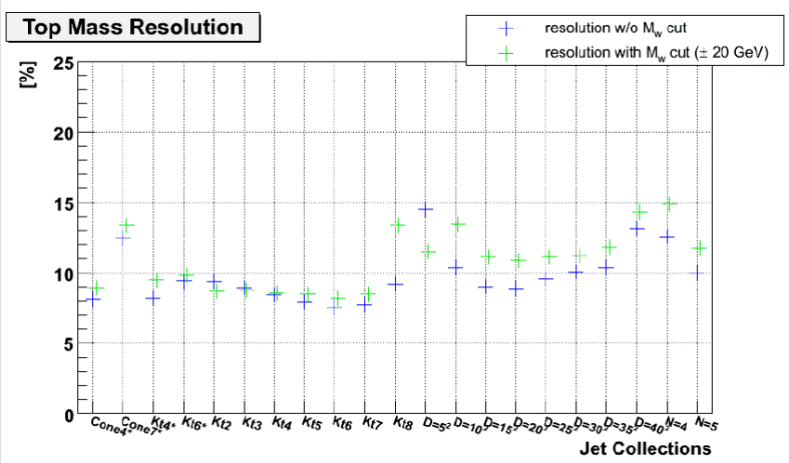
$A_{4\ jets} = (19 \pm 9 \pm 2)\%$

$A_{\geq 5\ jets} = (-16 \pm 16 \pm 3)\ \%$

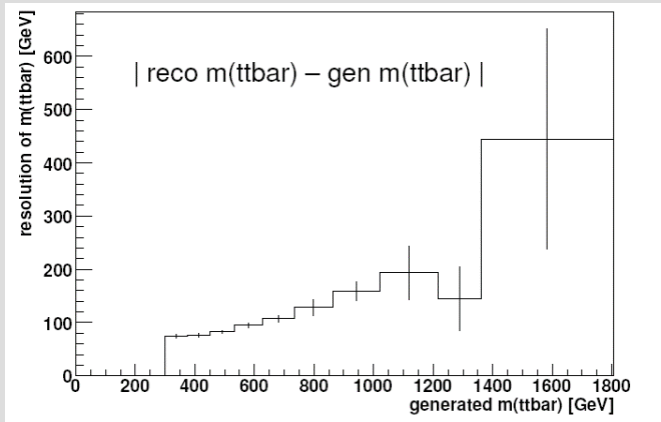
MC@NLO: $A_{4\ jets}$=2.3 %, $A_{\geq 5\ jets}$=- 4.9%

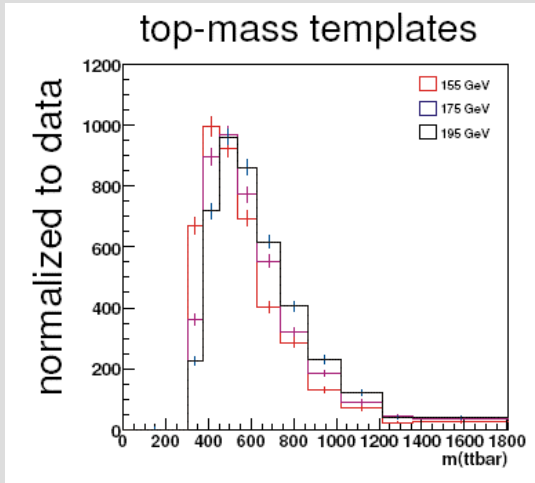
WG2: top quark mass

resolution dependence on jet definition



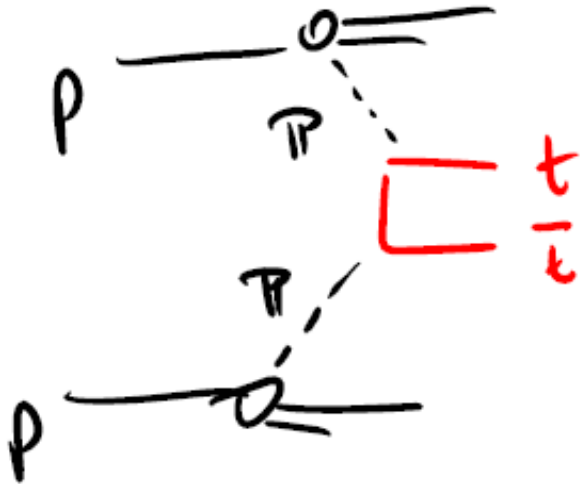
invariant mass of ttbar pair



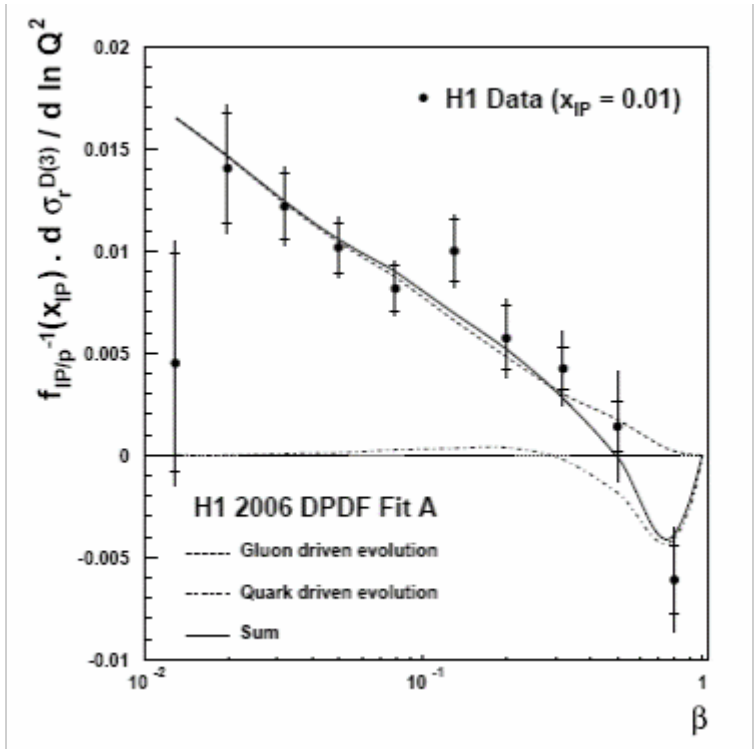


WG2: top quark mass

cross check on colour effects using diffractive production of ttbar pairs?



scaling violation of diffractive exchange

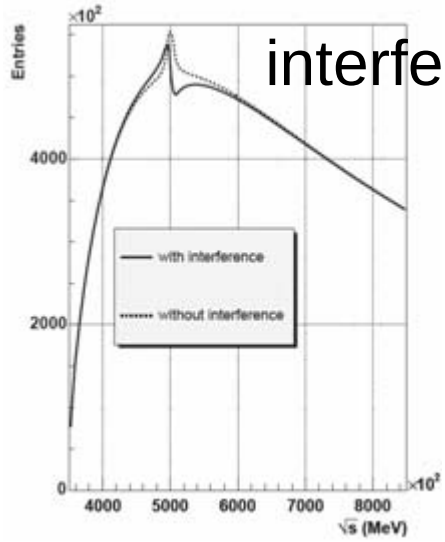


WG3: BSM, top as background

channels

Spin	color	parity $(1,\gamma_5)$	some examples
0	0	(1,0)	SM, MSSM, 2HDM
0	0	(0,1)	MSSM, 2HDM
0	8	(1,0)	
0	8	(0,1)	
1	0	(SM,SM)	Z'
1	0	(1,0)	vector
1	0	(0,1)	axial vector
1	0	(1,1)	vector-left
1	0	(1,-1)	vector-right
1	8	(1,0)	coloron, KK gluon
1	8	(0,1)	axigluon
2	0	–	graviton

[Frederix, Maltoni: arXiv:0712.2355v1 [hep-ph] 14 Dec 2007]



interference

EVENT GENERATOR

Proposal: Top Fitter

Simultaneous determination of Mtop, top-cross-sections within consistent theoretical framework ala Z-fitter