MEtop
top FCNC event generator

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Outline

The physical problem

- Flavour Changing Neutral Currents (FCNC)
- $t \to b, W^+$ (SM), $t \to G, u$ (FCNC)
- FCNC highly suppressed in the SM

$BR(t \to FCNC)$ in several modes						
	SM	QS	2HDM	FC 2HDM	MSSM	R SUSY
$t \to q\gamma$	$\sim 10^{-14}$	$\sim 10^{-9}$	$\sim 10^{-6}$	$\sim 10^{-9}$	$\sim 10^{-6}$	$\sim 10^{-6}$
$t \to qZ$	$\sim 10^{-14}$	$\sim 10^{-4}$	$\sim 10^{-7}$	$\sim 10^{-10}$	$\sim 10^{-6}$	$\sim 10^{-5}$
$t \to qg$	$\sim 10^{-12}$	$\sim 10^{-7}$	$\sim 10^{-4}$	$\sim 10^{-5}$	$\sim 10^{-5}$	$\sim 10^{-4}$

Acta Phys. Polon. B 35, 2695 (2004) [arXiv:hep-ph/0409342]

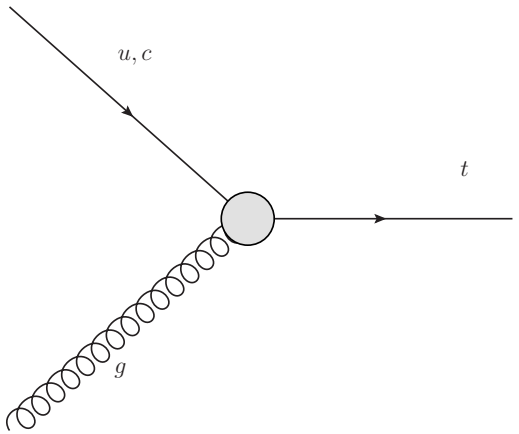
Effective Lagrangian

$$\mathcal{L}_{Total} = \mathcal{L}_{SM} + \frac{1}{\Lambda^5}\mathcal{L}^{(5)} + \frac{1}{\Lambda^6}\mathcal{L}^{(6)}$$

- FCNC can be studied through an effective Lagrangian
- This extra Lagrangian terms will be composed by effective operators that obey SM symmetries
- Buchmuller and Wyler calculated all possible operators of dimension 6 that respect the SM symmetries (Nucl. Phys. B 268 (1986) 621.)
- Now reduced by B. Grzadkowski, M. Iskrzynski, M. Misiak, J. Rosiek (arXiv:1008.4884v2)

$$\frac{ico_1 g_s}{\Lambda}\bar{u}\lambda^a\sigma^{\mu\nu}(f_u + h_u\gamma_5)tG^a_{\mu\nu} + H.C.$$

LO event generation



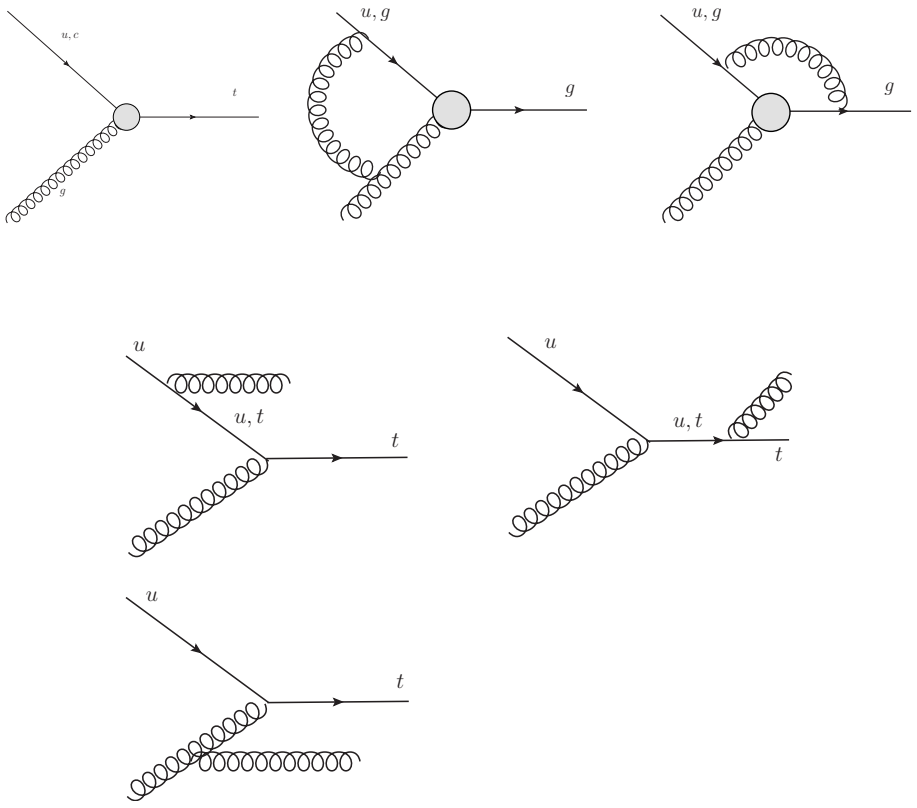
- Generate phase-space for $2 \rightarrow 1$ process
- Weight with $|M|^2 \times PDF_1 \times PDF_2$
- Write the events within "Les Houches Accord"
- Shower and Hadronization (PYTHIA or HERWIG)
- Simulate the detector (DELPHES)

Inclusive NLO Direct top cross sections

FCNC Direct top cross sections ($\frac{k^g_{tq}}{\Lambda} = 0.01\,Tev^{-1}$) (pb) (PRD 72 074018 (2005))				
Subprocess	LHC (LO)	LHC (NLO)	Tevatron Run2 (LO)	Tevatron Run2 (NLO)
$gu \to t$	11.068	16.818	0.259	0.413
$gc \to t$	1.817	2.537	0.0176	0.0283

- The NLO cross section highly enhanced
- About 60% for Tevatron and 40%-50% for LHC
- FCNC BR limits improvements of the same order
- It is desirable to generate NLO Direct top events

Next to Leading order



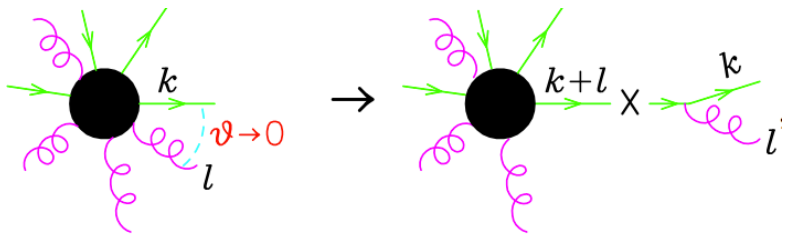
$$\sigma_{NLO} = \int_m d\sigma^{Born} + \int_m d\sigma^{virtual} + \int_{m+1} d\sigma^{Real}$$

NLO generation

$$\sigma_{NLO} = \int_m d\sigma^{Born} + \int_m d\sigma^{virtual} + \int_{m+1} d\sigma^{Real}$$

- The analytical calculation is "easily" done.
- Full phase-space is totally integrated and infrared infinities are cancelled
- Problem to generate events because there are two different configurations (m and m+1)

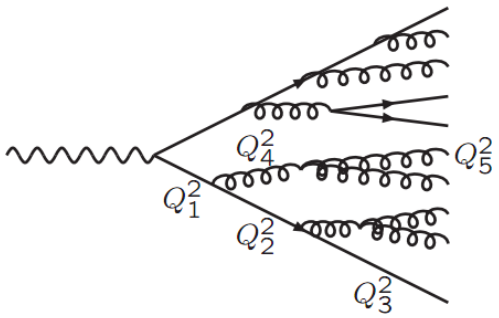
NLO approximation



$$|M_{m+1}|^2 d\Phi_{m+1} \rightarrow |M_m|^2 d\Phi_m \frac{\alpha_S}{2\pi} \frac{dt}{t} P_{q,qg}(z)$$

- For low PT and low energies the NLO corrections can be be approximated by a branching mechanism (shower)
- Approximation highly broken for high PT
- We can use different approaches for different PT (Matching)

NLO approximation



Sudakov form factor provides "time" ordering of shower:
lower $Q^2 \Longleftrightarrow$ longer times

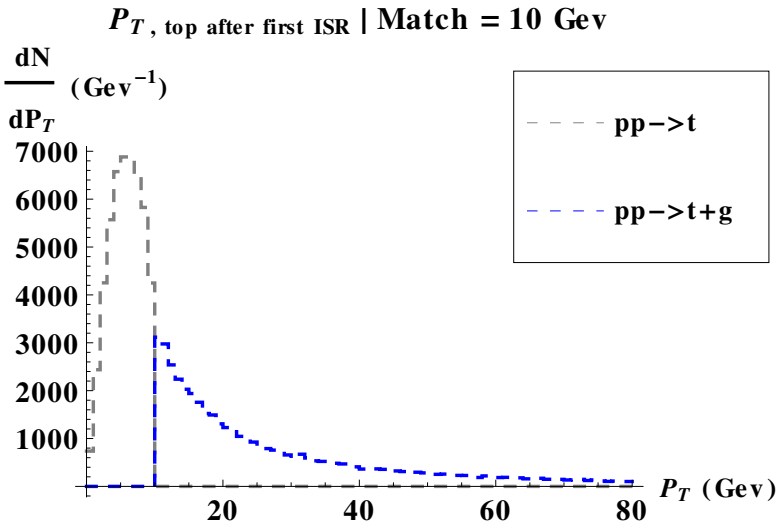
$Q_1^2 > Q_2^2 > Q_3^2$
$Q_1^2 > Q_4^2 > Q_5^2$
etc.

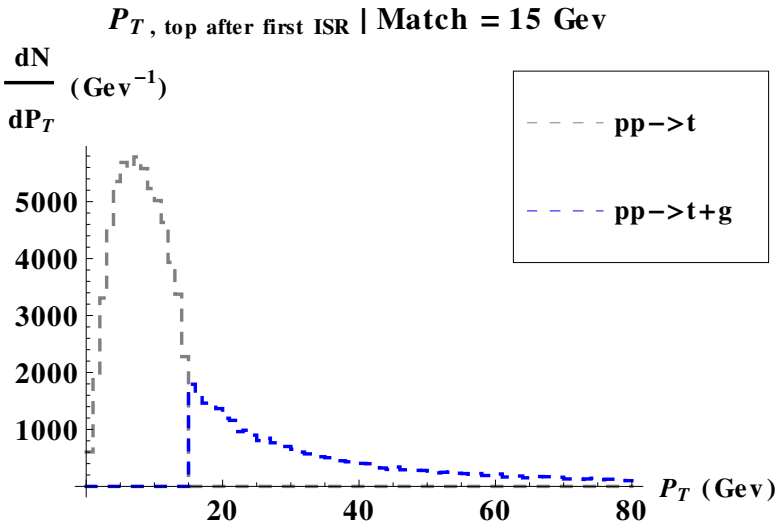
- generate LO Direct top
- Veto for $PT > PTmatch$ in Showering

- If Showering made by PT order, we can just set the max $PT = PT_{match}$
- generate events LO with real emission with $PT(g) > PT_{match}$
- Normalise to the total NLO cross section

$$\sigma^{NLO} = k\sigma^{LO}_{PT(g)<PT_{math}} + \sigma^{Real}_{PT(g)>PT_{match}}$$

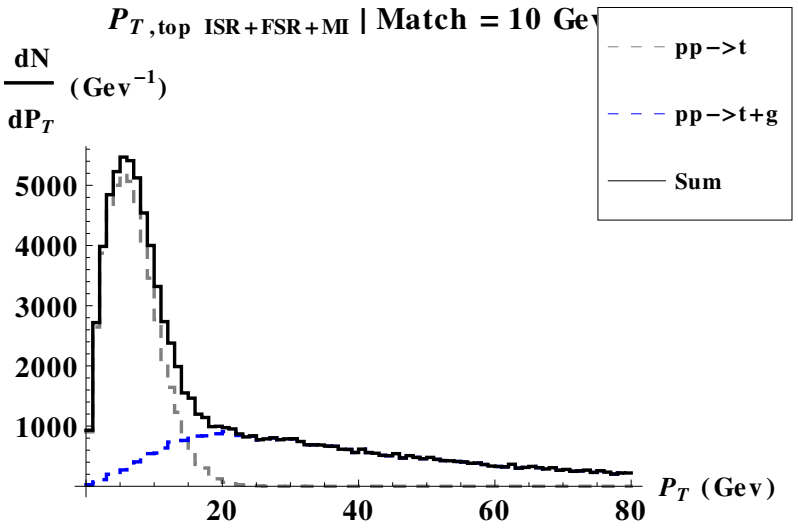
First ISR

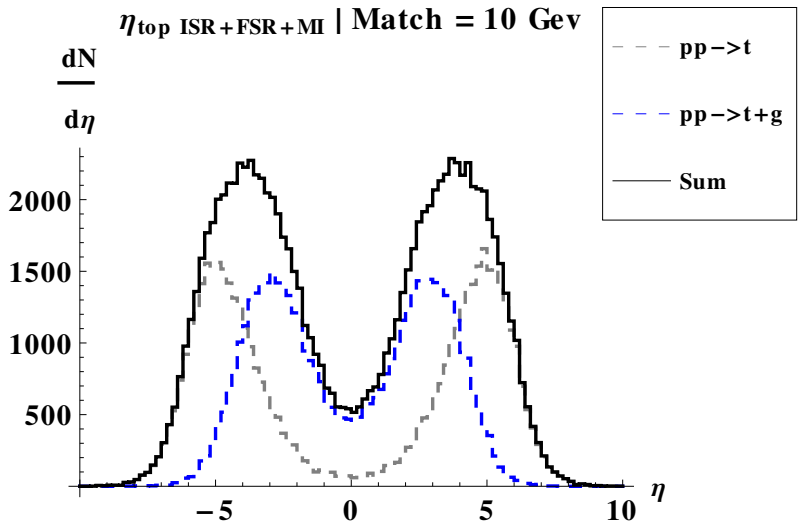




- We choose the match according to the smoothness of the distribution
- PT_{match} works as a resolution parameter and can be considered as a systematic error.

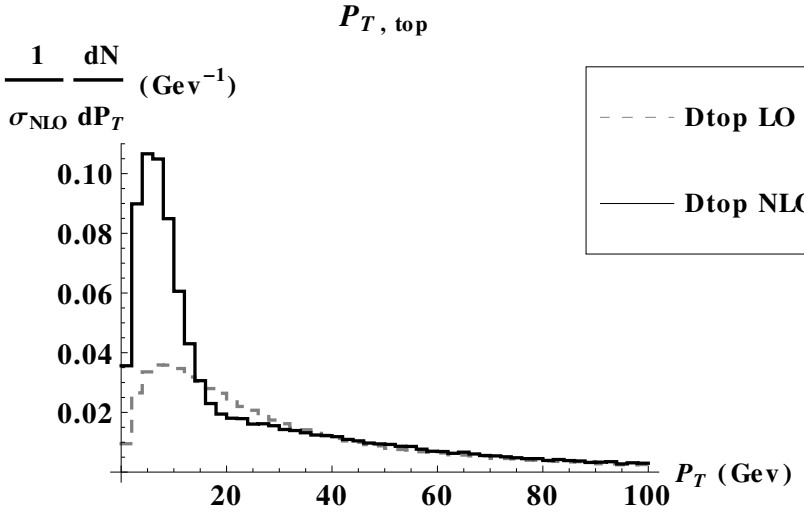
Full Shower

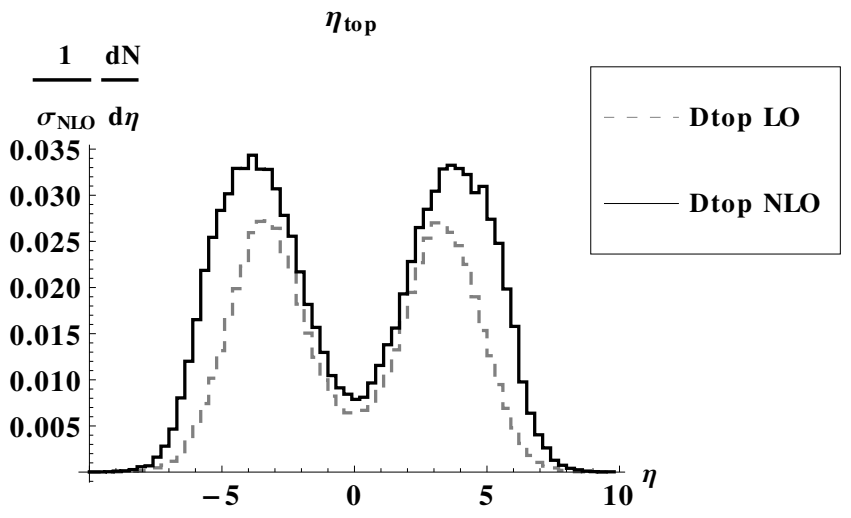




- Direct top at NLO after ISR+FSR+MI

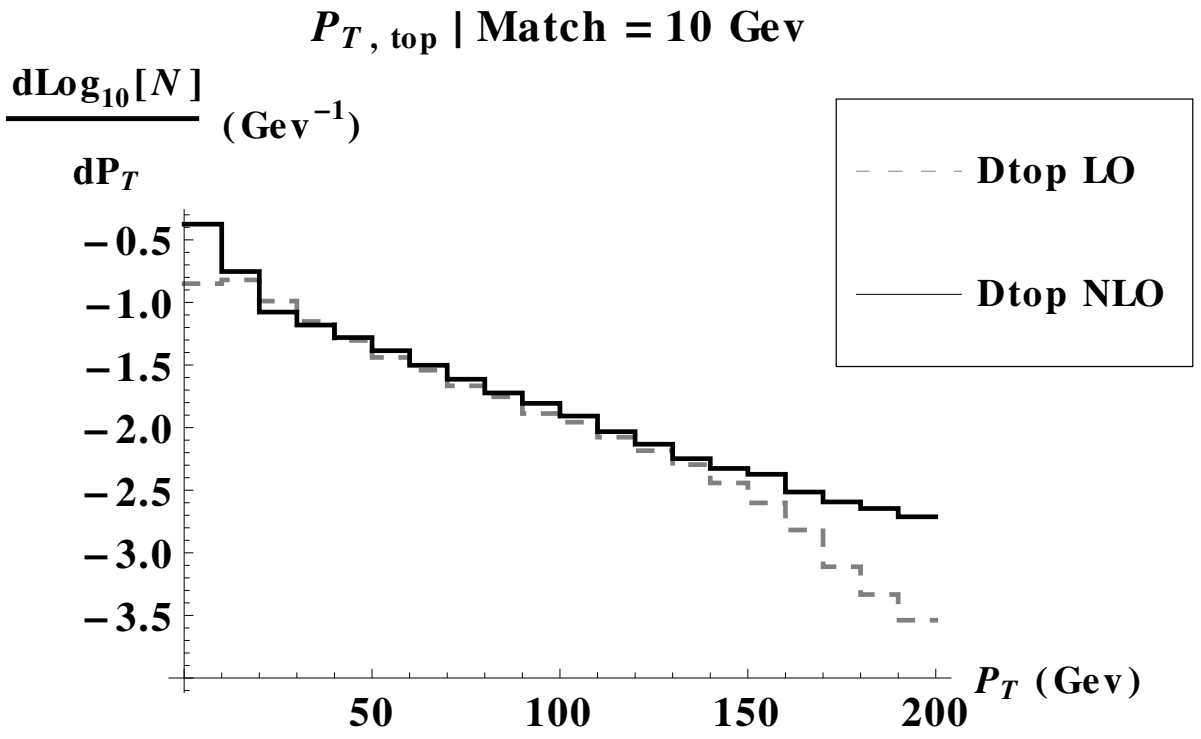
NLO vs LO





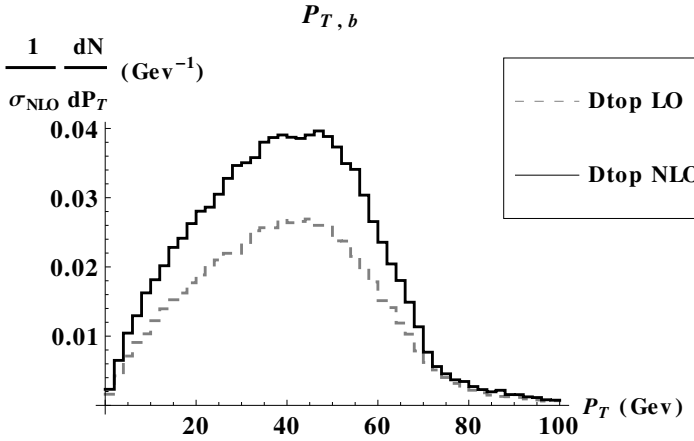
- Direct top at NLO vs LO
- More than just a K-factor
- Consequences when top reconstructed
- Asymmetries cuts under study

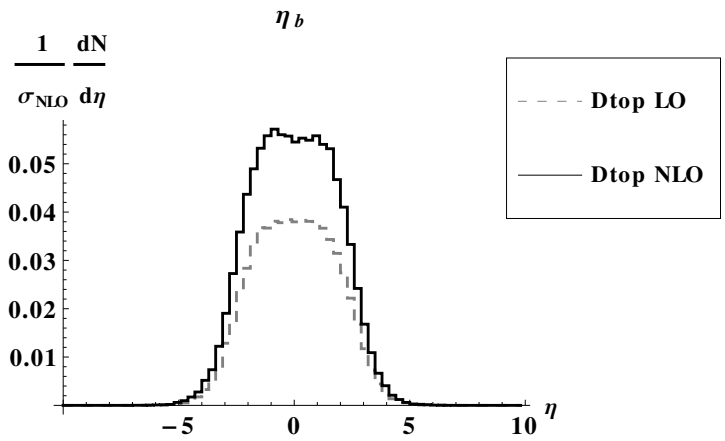
NLO vs LO

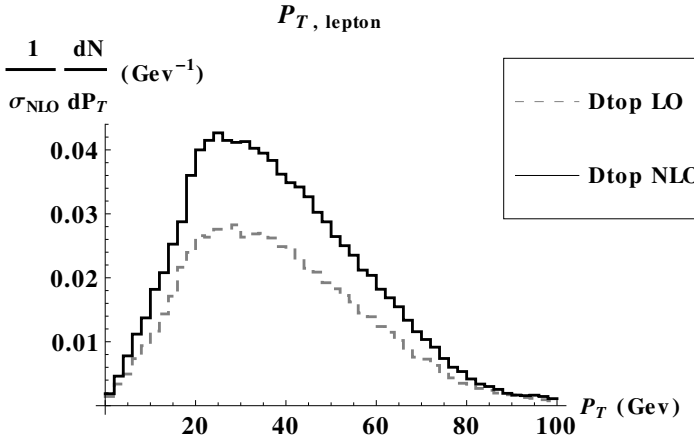


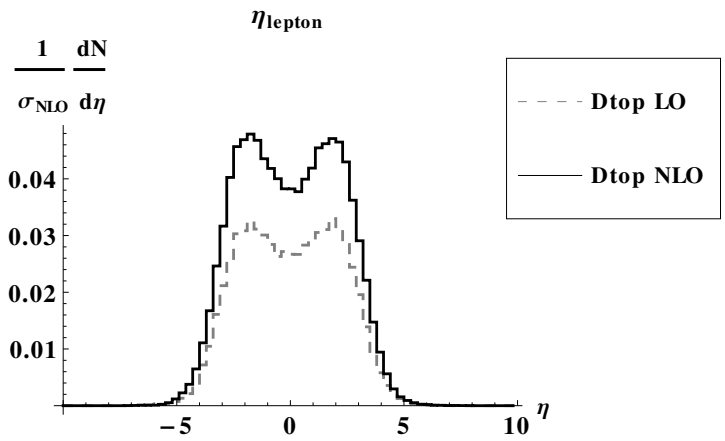
- Hard region corrected.

NLO vs LO

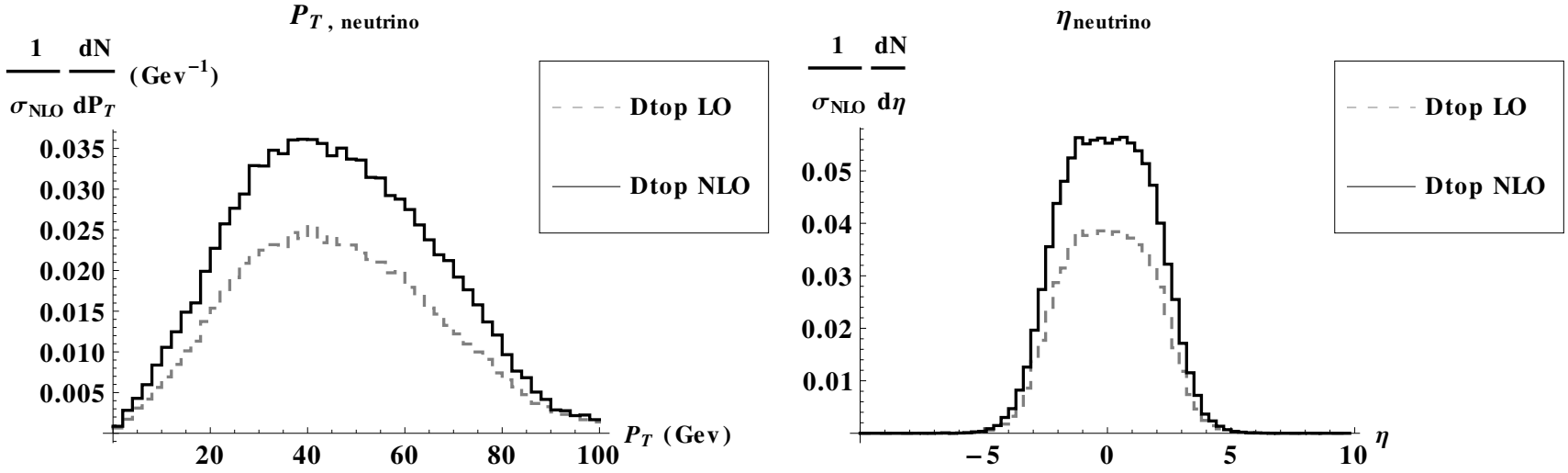

$P_{T,b}$
$\frac{1}{\sigma_{NLO}}\frac{dN}{dP_T}$ (Gev^{-1})
0.04
0.03
0.02
0.01
20
40
60
80
100
P_T (Gev)
Dtop LO
Dtop NLO


η_b
$\frac{1}{\sigma_{NLO}}\frac{dN}{d\eta}$
0.05
0.04
0.03
0.02
0.01
−5
0
5
10
η
Dtop LO
Dtop NLO


$P_{T,\,lepton}$
$\frac{1}{\sigma_{NLO}}\frac{dN}{dP_T}$ (Gev^{-1})
0.04
0.03
0.02
0.01
20
40
60
80
100
P_T (Gev)
Dtop LO
Dtop NLO


η_{lepton}
$\frac{1}{\sigma_{NLO}}\frac{dN}{d\eta}$
0.04
0.03
0.02
0.01
−5
0
5
10
η
Dtop LO
Dtop NLO

NLO vs LO



- top products distributions can be reproduced through a K-factor

Single top beyond the strong FCNC operators

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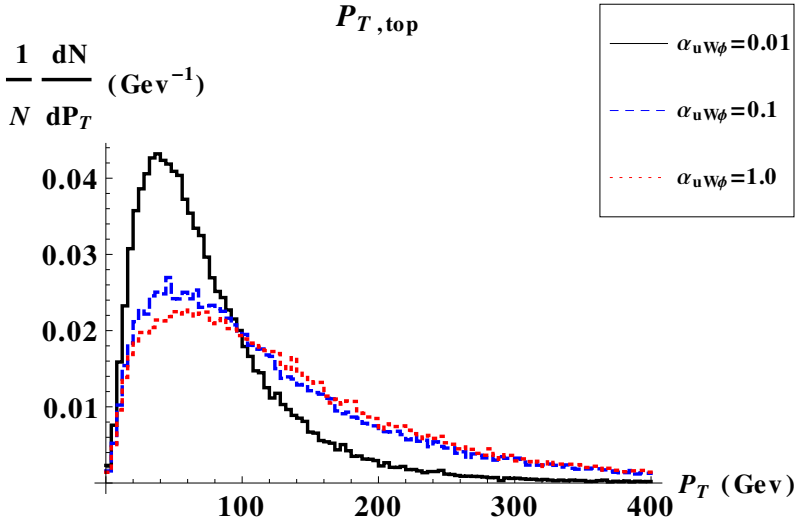
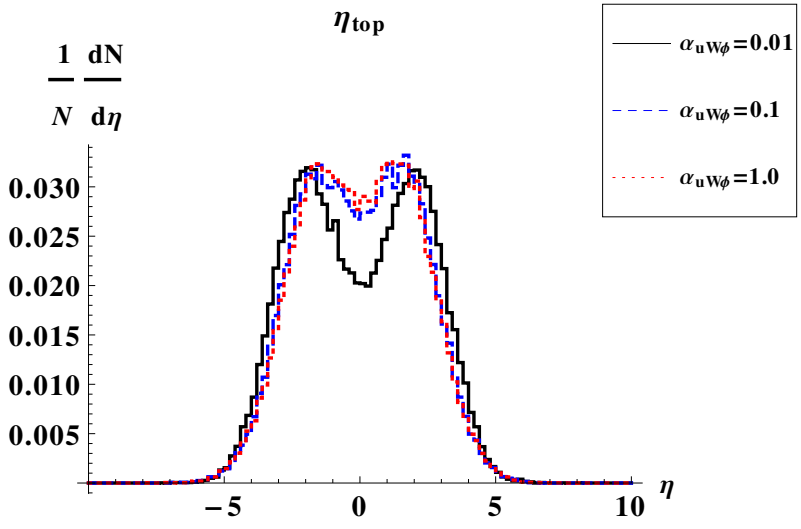
- Electroweak and 4F operators contribute to FCNC Single top.
- Different sets of independent EW and 4F operators are included.
- Possibility to introduce extra operators.

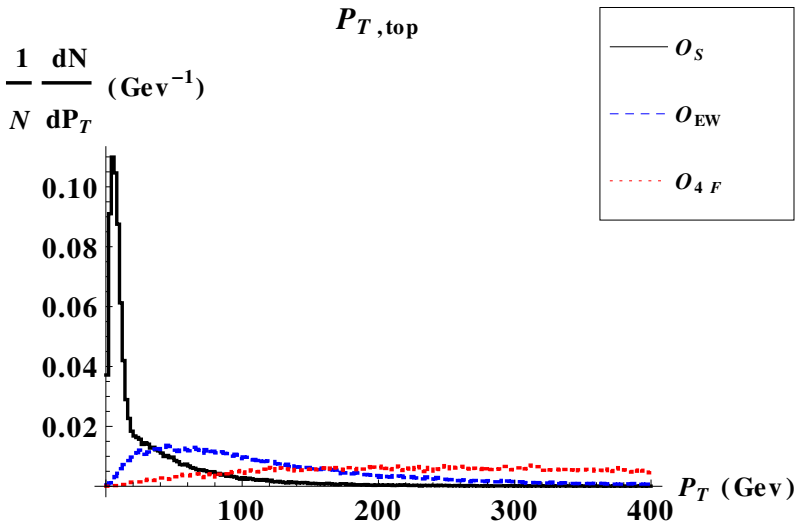
EW operators

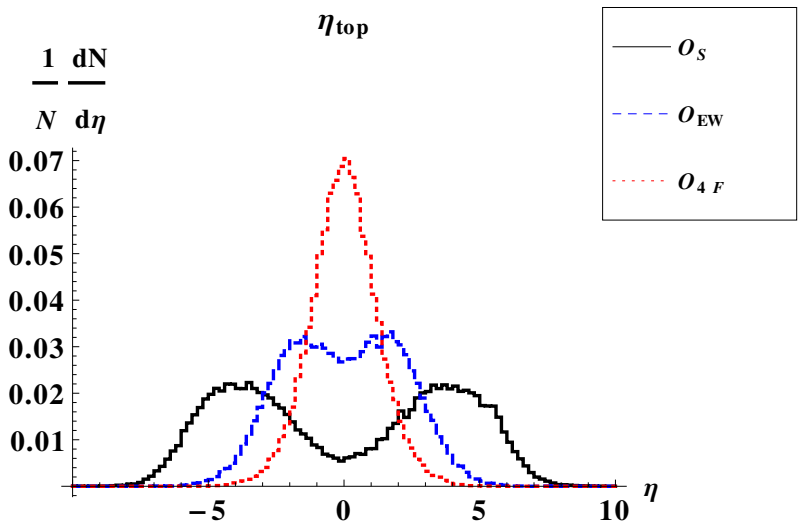




- SM Single top competes with Electroweak FCNC interactions

4F operators





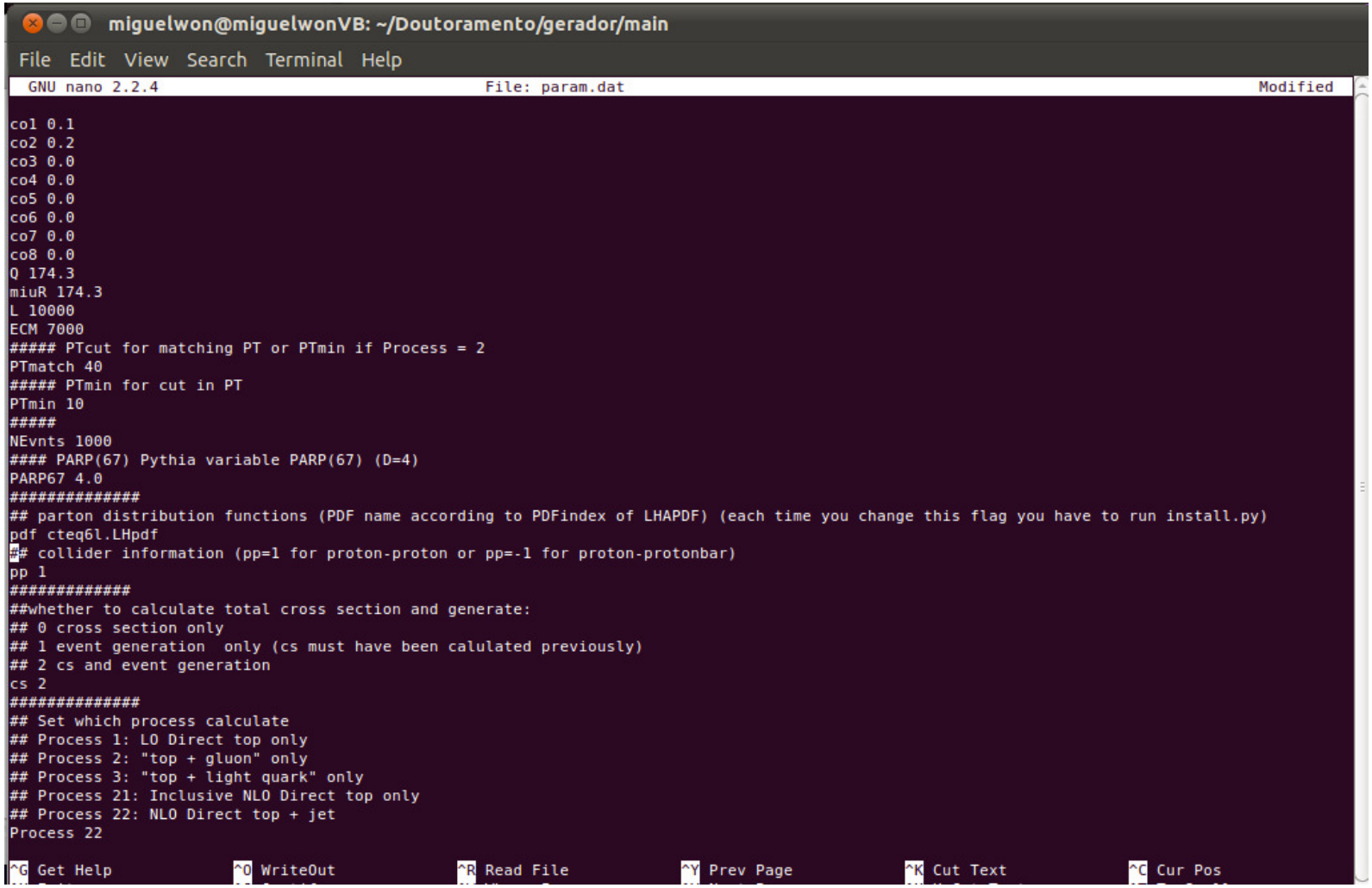
- Different operators result in different distributions

Code

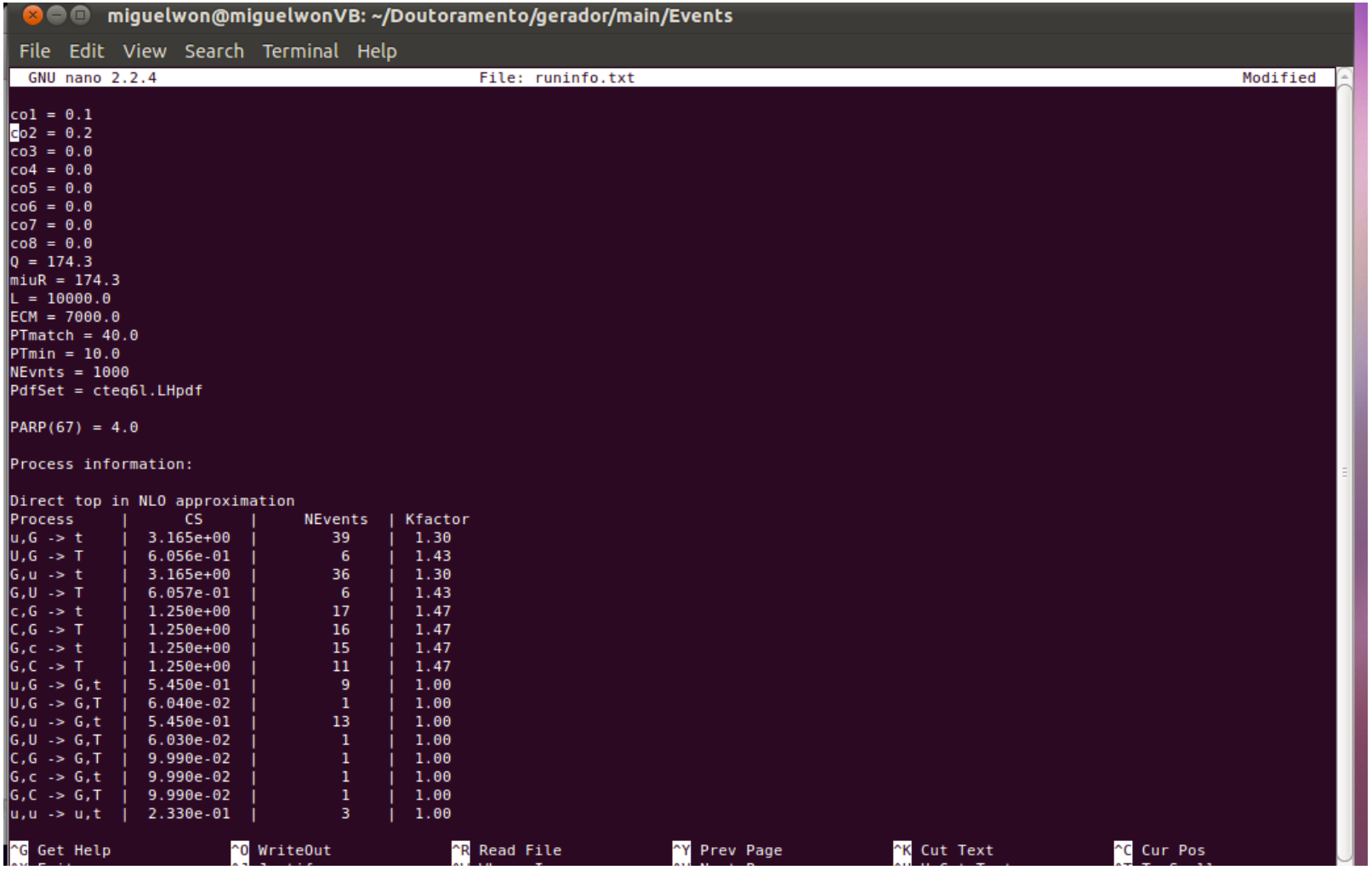
- Written in C and python 2.6
- Feynman Rules were calculated using LanHep
- Amplitudes calculated with CalcHep
- Cuba library for Vegas integration

- Events written in LHE
- Spin correlations included (switch on and off)
- New interactions can be included

User friendly



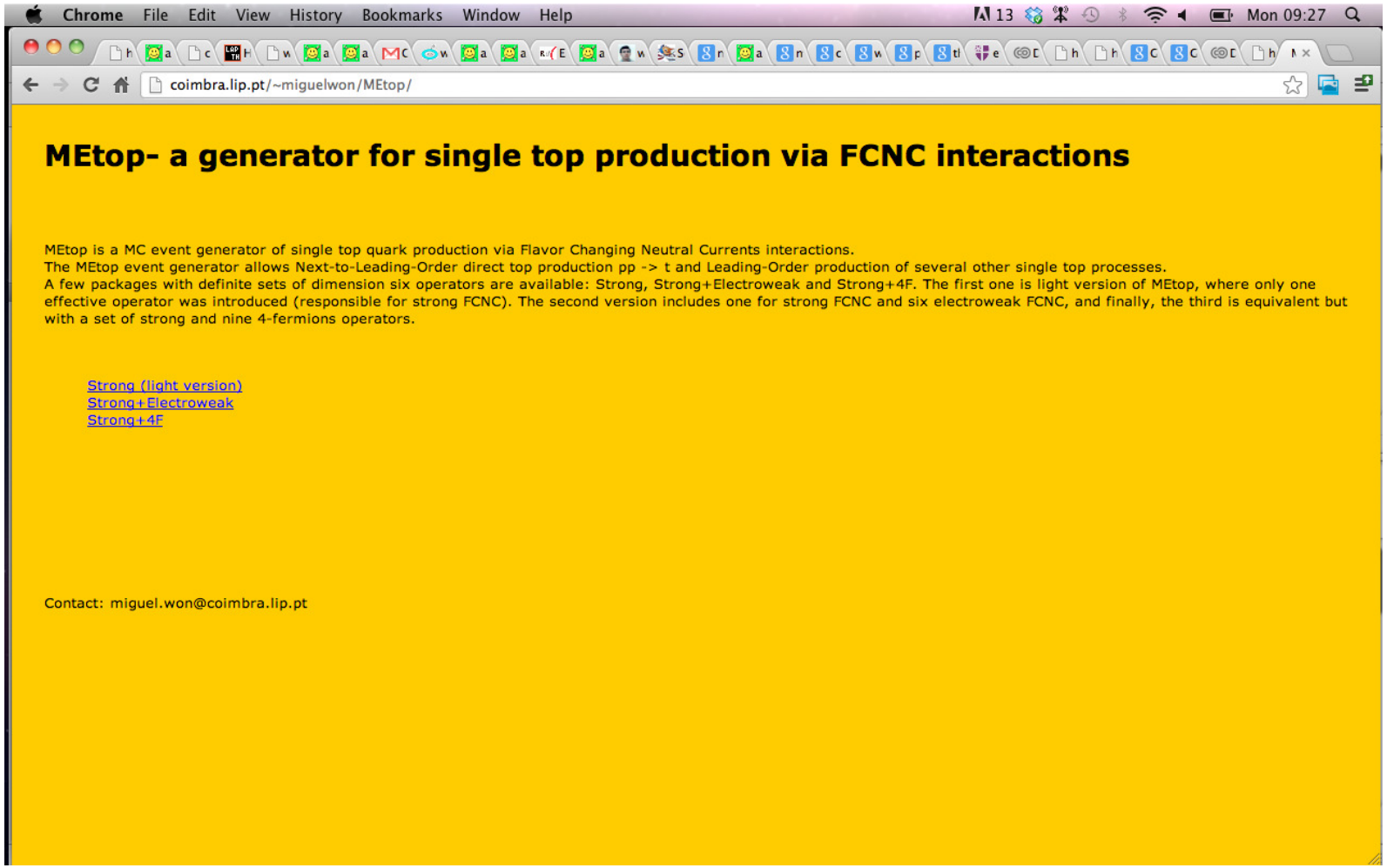
Info


miguelwon@miguelwonVB: ~/Doutoramento/gerador/main/Events
File Edit View Search Terminal Help
GNU nano 2.2.4 File: runinfo.txt Modified
co1 = 0.1
co2 = 0.2
co3 = 0.0
co4 = 0.0
co5 = 0.0
co6 = 0.0
co7 = 0.0
co8 = 0.0
Q = 174.3
miuR = 174.3
L = 10000.0
ECM = 7000.0
PTmatch = 40.0
PTmin = 10.0
NEvnts = 1000
PdfSet = cteq6l.LHpdf
PARP(67) = 4.0
Process information:
Direct top in NLO approximation
Process | CS | NEvents | Kfactor
u,G -> t | 3.165e+00 | 39 | 1.30
U,G -> T | 6.056e-01 | 6 | 1.43
G,u -> t | 3.165e+00 | 36 | 1.30
G,U -> T | 6.057e-01 | 6 | 1.43
c,G -> t | 1.250e+00 | 17 | 1.47
C,G -> T | 1.250e+00 | 16 | 1.47
G,c -> t | 1.250e+00 | 15 | 1.47
G,C -> T | 1.250e+00 | 11 | 1.47
u,G -> G,t | 5.450e-01 | 9 | 1.00
U,G -> G,T | 6.040e-02 | 1 | 1.00
G,u -> G,t | 5.450e-01 | 13 | 1.00
G,U -> G,T | 6.030e-02 | 1 | 1.00
C,G -> G,T | 9.990e-02 | 1 | 1.00
G,c -> G,t | 9.990e-02 | 1 | 1.00
G,C -> G,T | 9.990e-02 | 1 | 1.00
u,u -> u,t | 2.330e-01 | 3 | 1.00
^G Get Help ^O WriteOut ^R Read File ^Y Prev Page ^K Cut Text ^C Cur Pos

Conclusions

- MEtop is a FCNC Direct top generator at NLO
- top products distributions can be simulated through a K-factor
- NLO corrections enhanced by top reconstructed analysis
- Events can be used in PYTHIA without the need of an interface
- Set of electroweak and 4F operators are included
- Possibility to compare different Lorentz structures

How to get it



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