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Status report of ALPGEN

M.L. Mangano, M. Moretti, F. P., R. Pittau, A.D. Polosa, JHEP07(2003)001

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1. what is new on the implemented processes
2. Merging samples with different jet multiplicities: the MLM prescription
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Thanks to A. Lucotte for his invitation

Top Workshop/IN2P3: from D0 to Atlas, Grenoble, 9–10 October, 2006

Available processes in ALPGEN v2.0

- $(W \to f\bar{f}') + N$ jets, $N \leq 6$, $f = l, q$
- $(Z/\gamma^* \to f\bar{f}) + N$ jets, $N \leq 6$, $f = l, \nu$
- $(W \to f\bar{f}')Q\bar{Q} + N$ jets, $(Q = b, t)$, $N \leq 4$, $f = l, q$
- $(Z/\gamma^* \to f\bar{f})Q\bar{Q} + N$ jets, $(Q = c, b, t)$, $N \leq 4$, $f = l, \nu$
- $(W \to f\bar{f}') + c + N$ jets, $N \leq 5$, $f = l, q$
- $n\ W + m\ Z + k\ \gamma + l\ H + N$ jets, $n + m + k + l \leq 8$, $N \leq 3$
- $Q\bar{Q} + N$ jets, $(Q = c, b, t)$, $N \leq 6$
- $Q\bar{Q}Q'\bar{Q}' + N$ jets, $(Q, Q' = c, b, t)$, $N \leq 4$
- $Q\bar{Q}H + N$ jets, $(Q = b, t)$, $N \leq 4$
- N jets, $N \leq 6$
- $N\ \gamma + M$ jets, $N \geq 1$, $N + M \leq 8$, $M \leq 6$
- $gg \to H + N$ jets $(m_t \to \infty)$ $N < 5$
- single top (4 different subprocesses) No extra jets at present
- $Q\bar{Q} + m\,\gamma + N$ jets, $(Q = c, b, t)$, $m + N \leq 6$
- $W + m\gamma + N$ jets
- $Wb\bar{b} + m\gamma + N$ jets

ALPGEN is a matrix element based Monte Carlo event generator

It generates samples for given partonic final states weighted with the exact LO matrix elements

What is the connection of these samples with the real final states seen in the detector? $\Rightarrow$ give these events as input to parton showering and hadronization

two problems:

- Double counting: configurations with n final state partons can be obtained starting from $(n-m)$ partonic configurations, with m partons provided by the parton shower. The same n-jet configuration can be generated starting with different $(n-m)$ configurations

- Results depend on the unphysical partonic set of cuts, while they should not

CKKW matching in a nutshell

For e^+e^- physics a solution has been proposed

S. Catani et al., JHEP 0111 (2001) 063

L. Lönnblad, JHEP 0205 (2002) 046

which avoids double counting and shifts the dependence on the resolution parameter beyon NLL accuracy

The method consists in separating arbitrarily the phase-space regions covered by ME and PS, and use vetoed parton showers together with reweighted tree-level matrix elements for all parton multiplicities

Proposal to extend the procedure to hadronic collisions even if formal proof doesn't exist up to now

F. Krauss, JHEP 0208 (2002) 015

Necessary steps for CKKW procedure

- select the jet multiplicity n according to the jet rates obtained with matrix elements with resolution $y_{ij} > y_{cut}$, defined according to the k_T-algorithm
- generate n parton momenta according to the matrix element with fixed $\alpha_s(y_{cut})$ and reweight the event with the probability of no further branching by means of Sudakov form factors
- build a "PS history" by clustering the partons to determine the values at which 1,2,...n jets are resolved. In so doing a tree of branchings is constructed and the nodal scales characteristic of each branching are used to reweight the event with running α_s
- apply a coupling constant reweighting factor $\alpha_s(y_1)\ \alpha_s(y_2)\ ...\ \alpha_s(y_n)\ /\ \alpha_s(y_{cut})^n \leq 1$, where y_i are the nodal scales
- after successful unweighting, use the n-parton kinematics as initial condition for the shower, vetoing all branchings such that $y_{ij} > y_{cut}$

The CKKW procedure has been successfully tested on LEP data

e.g. S. Catani et al., JHEP 0111 (2001) 063

R. Kuhn et al., hep-ph/0012025

F. Krauss, R. Kuhn and G. Soff, J. Phys. G26 (2000) L11

recent work for hadronic collisions with different implementations

- `HERWIG` (P. Richardson), `PYTHIA` (S. Mrenna)
- `SHERPA with APACIC++/AMEGIC++` (F. Krauss et al.)
- `ALPGEN v2.0`, implementation according to the MLM prescription
- `ARIADNE` (Lavesson and Lönnblad))

Several parameters need to be tuned to the data in order to have smooth interpolation between the regions below and above the resolution. Missing virtual corrections $\Rightarrow$ still a residual cutoff dependence (main difference w.r.t `MC@NLO`)

MLM prescription for parton-jet matching

- Generate partonic events for different jet multiplicities $(p_T > p_T^{\min}, \Delta R_{jj} > R_{\min})$
- Shower the events with default PSMC
- Before hadronization, process the showered events with a cone jet algorithm
- Require partons-jets matching
  - require for each hard parton a jet within $\Delta R_{\text{match}} \simeq R_{\text{jet}}$
  - reject the event if two partons match to the same jet or if one parton has no match
  - keep the event if all partons are matched
- The above procedure defines the **inclusive** sample
- For **exclusive** samples rejects events where there is an extra jet not matched to any ME parton. Cross section $= \sigma$ partonic $\cdot$ matching efficiency
- **Inclusive sample containing events with all multiplicities** obtained combining exclusive samples **without double-counting**
- Physics analysis with inclusive samples should be as much as possible **independent** of generation cuts

Technically in `ALPGEN v2.0` this is implemented in the following way:

- set `ickkw = 1` (default value = 0)
- run with `imode = 1` (producing weighted events) where for each event the minimum $k_\perp^2 = \min(m_{T,i}^2, m_{T,j}^2)\Delta R_{ij}^2$ is calculated (compatible with the flavour and colour assignment of the given event) and used as the resolution scale in the evaluation of $\alpha_s(Q_0)$
- run with `imode = 2` to produce unw events. After usual unweighting of the previous wgt events, the α_s reweighting factor is calculated for each event in the following way:
  - event by event a particular colour-flow is selected according to its weight
  - the partons color-connected with minimum $k_\perp^2$ are clustered
  - repeat the procedure recursively with the new set of momenta until a minimum process $2 \to 2$ is reached
  - in so doing a tree of branchings is constructed and the nodal scales Q_i characteristic of each branching are used as input for the running $\alpha_s(Q_i)$

Warning! The cross section value with `ickkw=1` & `imode=1` is not yet meaningful (it is overestimated)

The matching procedure in `ALPGEN` is being tested/validated against:

- Tevatron data
- independent implementation of CKKW algorithm (`Sherpa`, `ARIADNE`)

on $W+$ jets, S. Höche et al., hep-ph/0602031

- NLO calculation when possible (`MC@NLO`). Detailed comparison between `ALPGEN` and `MC@NLO` in progress on $t\bar{t}$ production

M.L. Mangano, M. Moretti, F.P. and M. Treccani, work in progress

Documentation update as soon as possible

Preliminary results on ALPGEN - MC@NLO comparison for $t\bar{t}$ at LHC

M.L. Mangano, M. Moretti, F.P. and M. Treccani

We generated samples for $t\bar{t} + i_{\rm excl}$, $t\bar{t} + 1_{\rm incl}$ and $t\bar{t} + 3_{\rm incl}$ in order to build samples

$$S_1 = 0_{\rm excl} + 1_{\rm incl}; \qquad S_3 = 0_{\rm excl} + 1_{\rm excl} + 2_{\rm excl} + 3_{\rm incl}$$

with default generation cuts and matching parameters

Collider	$p_{\rm T}^{\rm min}$(jet)	$\eta^{\rm j}_{\rm max}$	Rmin
Tevatron	20 (GeV)	4	0.7
LHC	30 (GeV)	5	0.7

Table 1: default choices of the generation parameters

$E^{\rm clus}_{\rm T,min}$	$\eta^{\rm clus}_{\rm max}$
$\max(p_{\rm T}^{\rm min} + 5,\ 1.2 \times p_{\rm T}^{\rm min})$	$1.5 \times R_{\rm min}$

Table 2: default choices of the matching parameters

Even if not realistic the top-quark is kept on-shell

Jets are reconstructed with a cone algorithm (routine `GETJET`) with parameters given by

LHC	$p_{\mathrm{T}} \geq 20$ GeV	$\lvert\eta_{\mathrm{parton}}\rvert \leq 6$	$R = 0.7$
Tevatron	$p_{\mathrm{T}} \geq 15$ GeV	$\lvert\eta_{\mathrm{parton}}\rvert \leq 6$	$R = 0.4$

Table 3: default choices of the matching parameters

Different generation and matching parameters have been considered

Param set	Generation parameters		Matching parameters	
	$p_{\mathrm{T}}^{\mathrm{min}}$	R_{min}	min $E_{\mathrm{T}}^{\mathrm{clus}}$	R_{sep}
Tevatron, default	20	0.7	25	1.5× 0.7
Tevatron, Set G1	15	0.7	20	1.5× 0.7
Tevatron, Set G2	30	0.7	36	1.5× 0.7
Tevatron, Set M1	20	0.7	20	1.5× 0.7
Tevatron, Set M2	20	0.7	25	1.5× 1.0
LHC, default	30	0.7	36	1.5× 0.7
LHC, Set G1	25	0.7	30	1.5× 0.7
LHC, Set G2	40	0.7	48	1.5× 0.7
LHC, Set M1	30	0.7	30	1.5× 0.7
LHC, Set M2	30	0.7	36	1.5× 1.0

Table 4: Variations of the generation and matching parameters used for the study of the systematics.

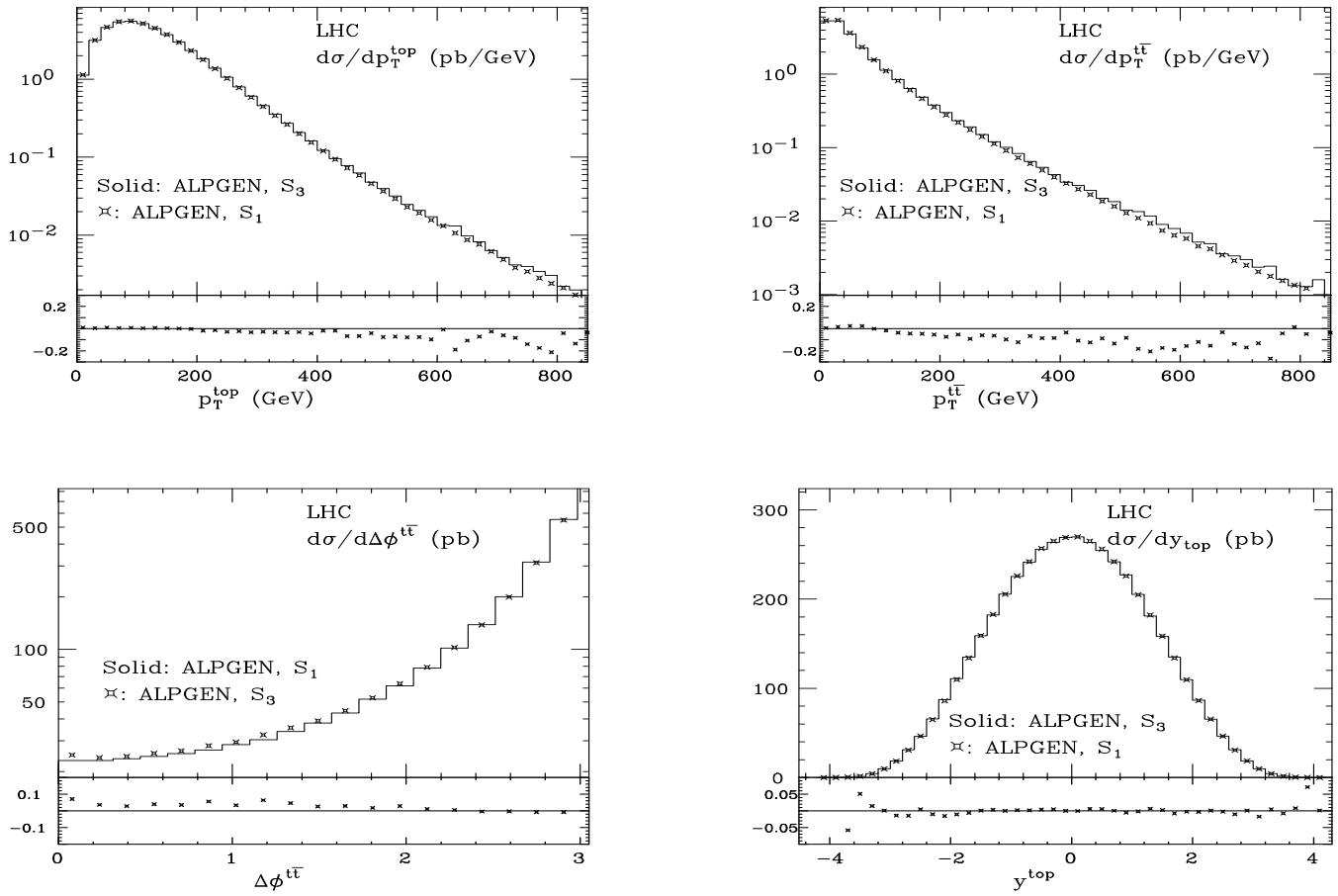
Tevatron	Default	Set G1	Set G2	Set M1	Set M2
$0_{\rm exc}$	3.42	3.15	3.79	3.14	3.33
$1_{\rm exc}$	0.66	0.82	0.42	0.78	0.74
$2_{\rm exc}$	0.09	0.15	0.036	0.13	0.11
$3_{\rm inc}$	0.010	0.024	0.002	0.021	0.012
Total	4.18	4.14	4.25	4.08	4.19

Table 5: Cross sections (in pb), for $t\bar{t}$ production at the Tevatron. The contribution of the different parton samples, for various generation and matching options. The columns are labeled according to the parameter definitions introduced in table 4. The relative numerical integration precision is of the order of 0.05% level.

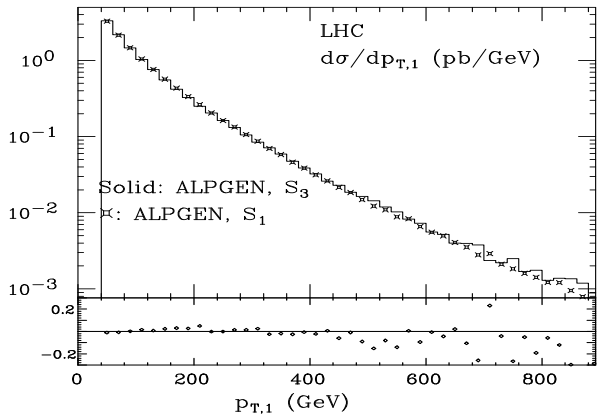
LHC	Default	Set G1	Set G2	Set M1	Set M2
$0_{\rm exc}$	216.6	185.2	267.2	185.2	203.4
$1_{\rm exc}$	149.9	155.6	133.5	148.2	160.4
$2_{\rm exc}$	65.8	80.9	44.3	74.1	76.1
$3_{\rm inc}$	29.9	44.9	14.7	39.9	34.8
Total	462.2	466.7	459.9	447.4	474.6

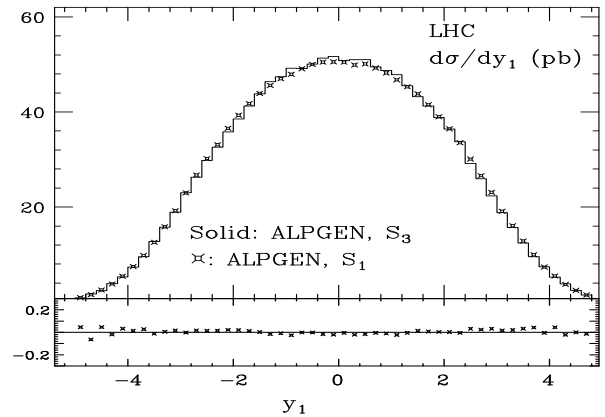
Table 6: Same as table **??**, for the LHC.

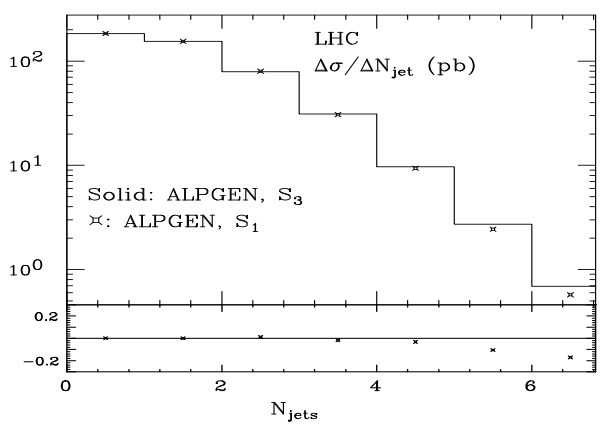
Comparison S_3 – S_1 for inclusive quantities

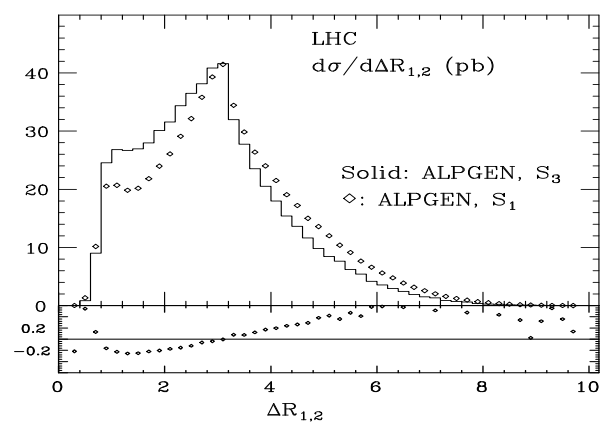


Comparison $S_3 - S_1$ for radiation related quantities

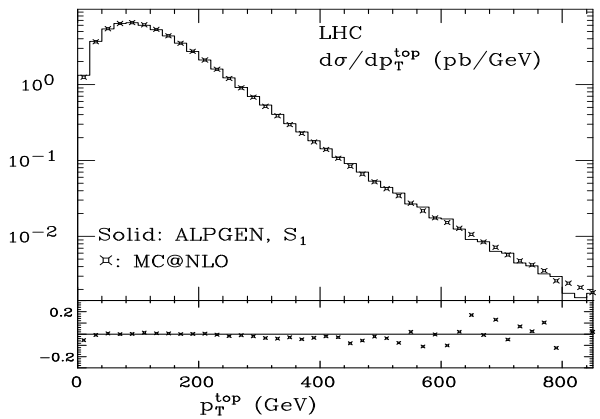


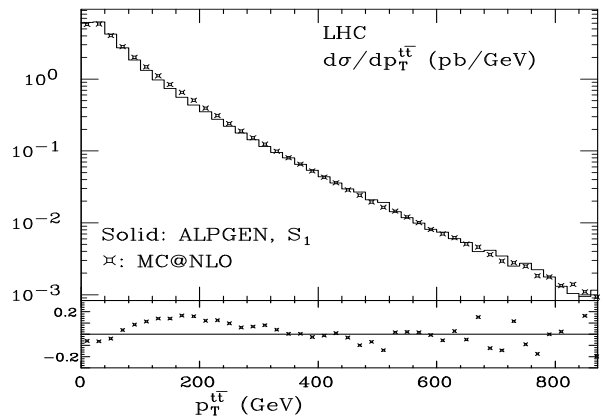


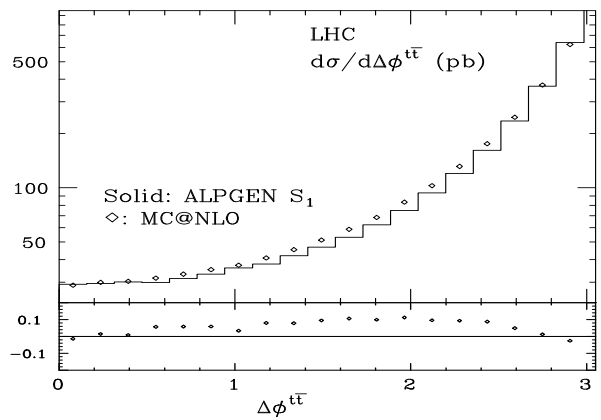


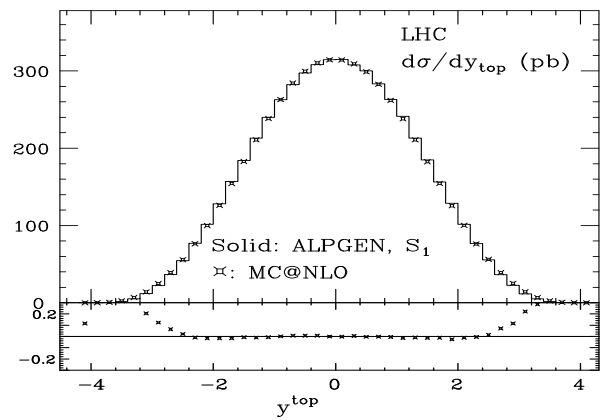


Comparison S_1^{ALPGEN} – MC@NLO for inclusive quantities

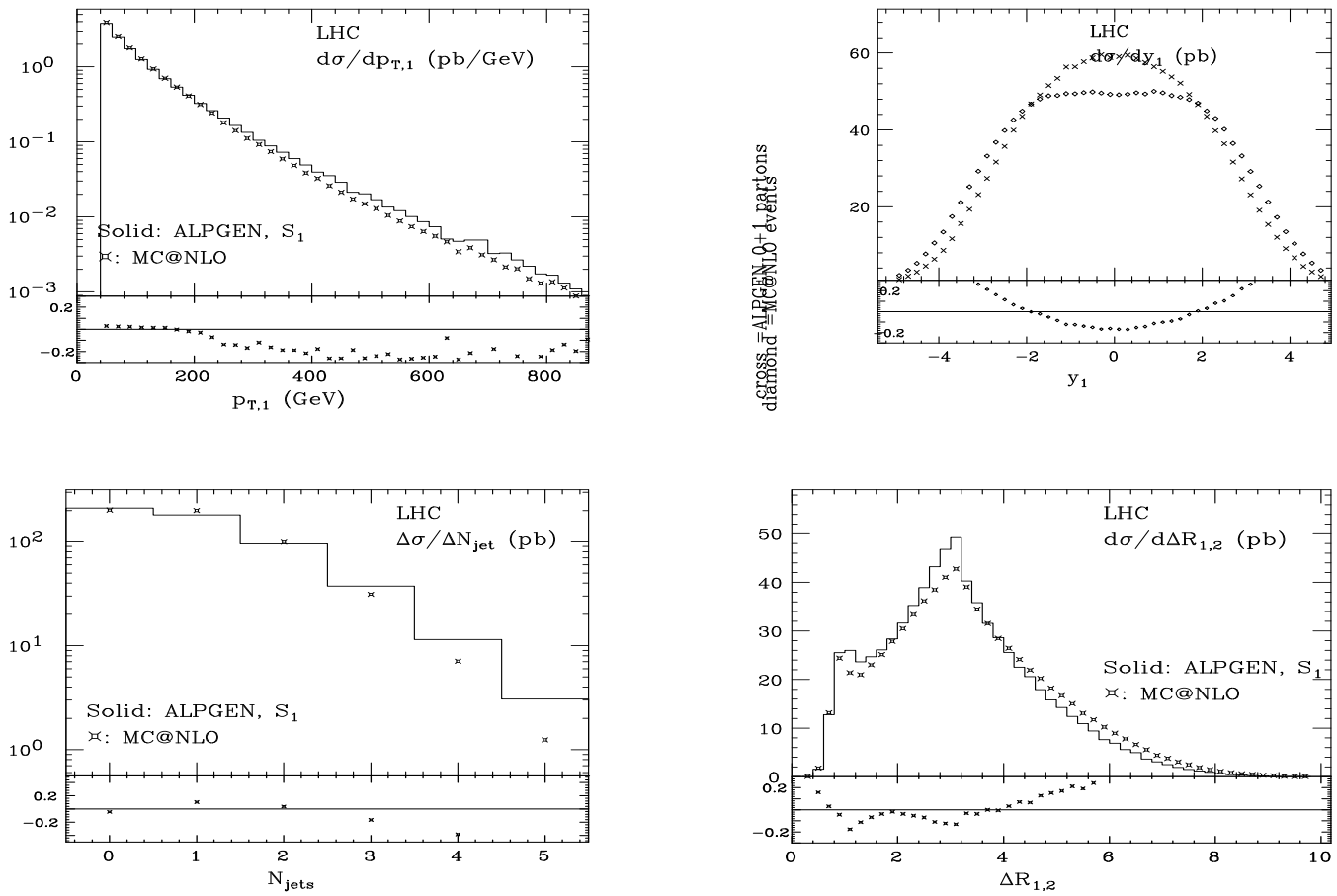




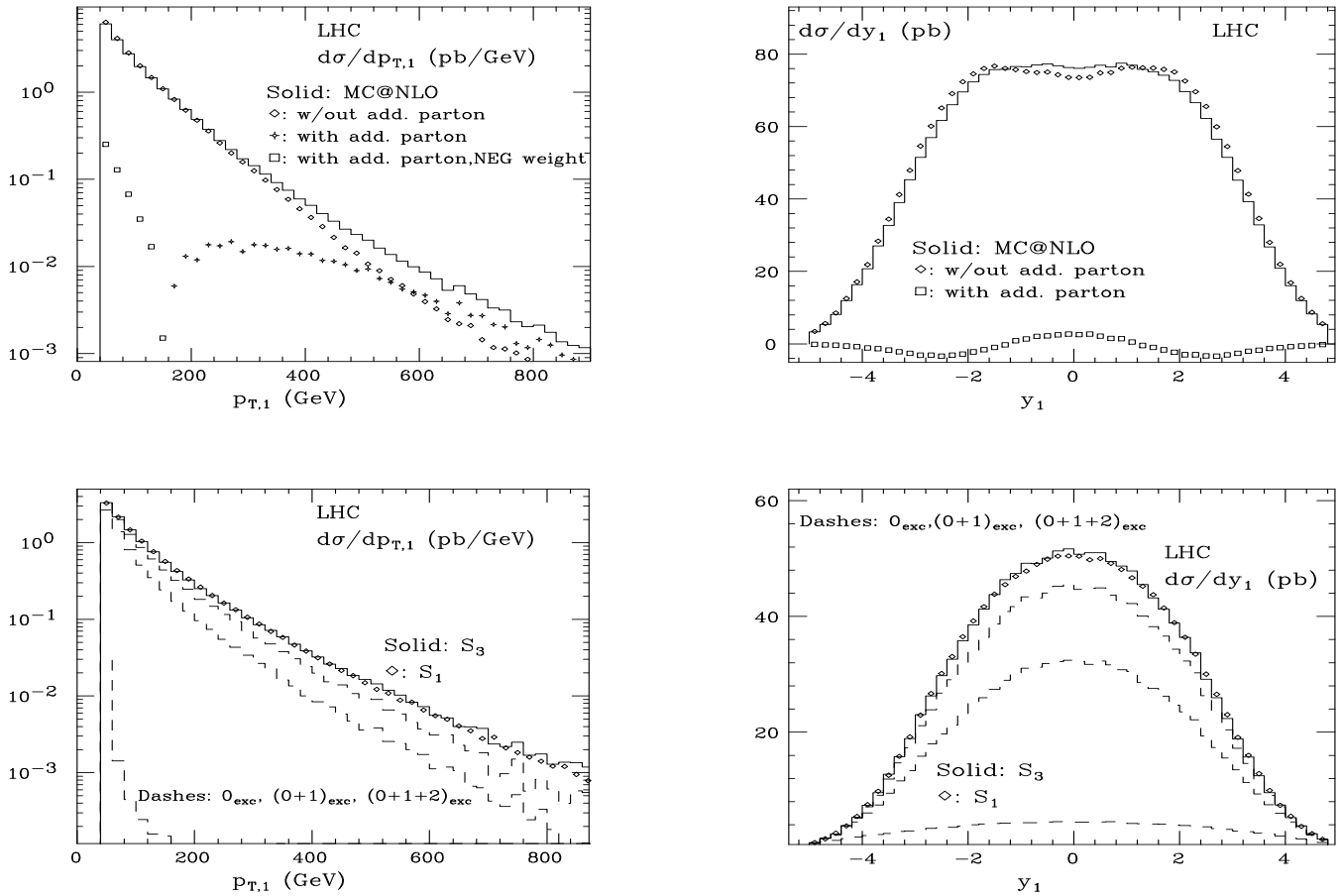




Comparison S_1^{ALPGEN} – MC@NLO for radiation related quantities



Some anatomy



Summary

- ALPGEN v2.1 will be available soon
- few new processes have been added to the list
- improvement on matching
- Comparison with data and other codes on $W+$ jets signature
- Comparison with MC@NLO on $t\bar{t}$ production
  - very good agreement on top distributions
  - interesting differences on radiation exclusive distributions
  - How much do these differences survive after top decay and detector simulation?