Monte Carlo tuning in the presence of Matching

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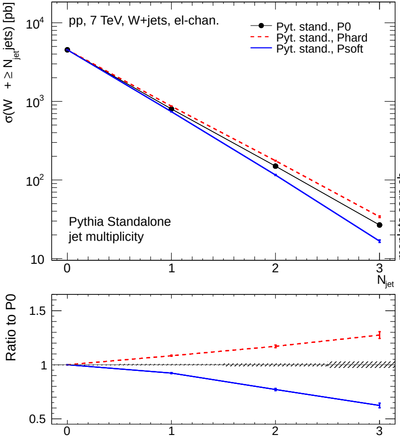
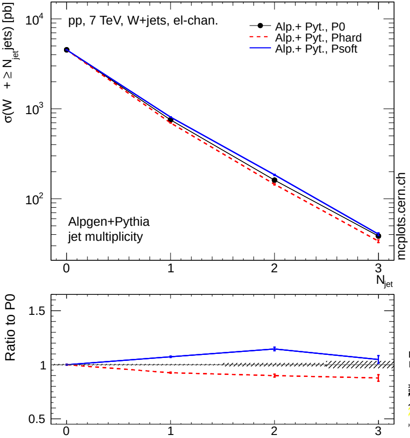
Article Summary

1. We consider the impact of varying α_s choices (and scales) on each side of the so-called *matching scale* in MLM-matched matrix-element + parton-shower predictions of collider observables.
2. We explain how inconsistent prescriptions can lead to counter-intuitive results and present a few explicit examples, focusing mostly on W/Z + jets processes.
3. We give a specific prescription for how to improve the consistency of the matching and also address how to perform consistent tune variations (e.g., of the renormalization scale) around a central choice.
4. Comparisons to several collider processes are included to illustrate the properties of the resulting improved matching, relying on AlpGen + Pythia 6, with the latter using the so-called Perugia 2011 tunes, developed as part of this effort.

PS Parameter Variations: Standalone vs Matched

- Compare Peruga Soft (less perturbative, more non-perturbative activity wrt. P0) and Perugia Hard (more perturbative, less non-perturbative activity wrt. P0)
- for jet ($p_T > 20$ GeV and $|\eta| < 2.8$) multiplicity distribution in W+jets electron channel events in pp collisions at 7 TeV.
- Distributions are shown for the samples generated with Pythia 6 standalone (left) and with AlpGen + Pythia 6 (right).





What is happening here?

Please see the article for the theoretical discussion!

The observed is a symptom of a more general issue in ME-PS matched calculations for which:

- α_s definition (order, Λ_{QCD}) should be the same on both sides;
- in case this is not set internally by a generator, one should set Λ_{QCD} to the same values in ME and PS.

- This is not the case in the previous plots, and as a result the vetoing of the matching becomes too aggressive/passive under variation of Λ_{QCD} in the shower only.

Perugia Hard vs Perugia Soft

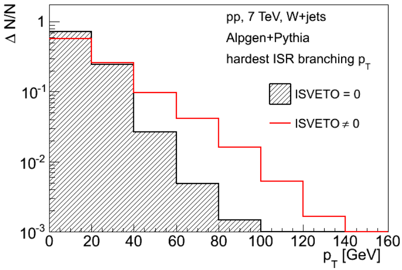
Perugia Hard and Perugia Soft differ in both perturbative and non-perturbative aspects; table below:

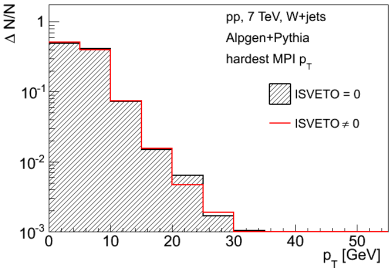
- impact of variations of the Pythia 6 tunes on the cross sections of AlpGen W+jets sub-samples with different matrix element parton multiplicities (NpX), and the total inclusive W cross section (after MLM matching).
- See article for parameter variation details.
- Gist: perturbative (ISR, IFSR) rather than non-perturbative (UE,CR) activity parameters are the ones that affect the MLM matching efficiencies.

tune	Np0	Np1	Np2	Np3	Np4+	total [pb]
Phard	7287 $\pm$ 3.9	728 $\pm$ 2.6	141 $\pm$ 1.3	27 $\pm$ 0.2	6.6 $\pm$ 0.2	8190 $\pm$ 8
P0	7556$\pm$ 3.6	814 $\pm$ 2.7	166 $\pm$ 1.3	32 $\pm$ 0.3	7.8 $\pm$ 0.3	8576 $\pm$ 8
Psoft	7804 $\pm$ 3.4	944 $\pm$ 2.8	207 $\pm$ 1.5	42 $\pm$ 0.3	10.1$\pm$ 0.3	9007 $\pm$ 8
P0 with Phard ISR	7207 $\pm$ 6.9	735 $\pm$ 2.6	143 $\pm$ 1.3	27 $\pm$ 0.2	6.9 $\pm$ 0.2	8119 $\pm$ 11
P0 with Psoft ISR	7831 $\pm$ 4.9	881 $\pm$ 2.7	186 $\pm$ 1.4	36 $\pm$ 0.3	8.8 $\pm$ 0.3	8943 $\pm$ 10
P0 with Phard FISR	7548 $\pm$ 6.0	814 $\pm$ 2.7	167 $\pm$ 1.3	32 $\pm$ 0.3	7.8 $\pm$ 0.3	8569 $\pm$ 10
P0 with Psoft FISR	7505 $\pm$ 6.1	878 $\pm$ 2.7	188 $\pm$ 1.4	37 $\pm$ 0.3	9.4 $\pm$ 0.3	8617 $\pm$ 10
P0 with Phard UE	7513 $\pm$ 6.1	826 $\pm$ 2.7	171 $\pm$ 1.4	33 $\pm$ 0.3	7.8 $\pm$ 0.3	8551 $\pm$ 10
P0 with Psoft UE	7576 $\pm$ 5.9	817$\pm$ 2.7	166 $\pm$ 1.3	32 $\pm$ 0.3	8.1 $\pm$ 0.3	8599 $\pm$ 10
P0 with Phard CR	7561 $\pm$ 5.9	821 $\pm$ 2.7	167 $\pm$ 1.3	32 $\pm$ 0.3	8.1 $\pm$ 0.3	8589 $\pm$ 10
P0 with Psoft CR	7556 $\pm$ 5.9	815 $\pm$ 2.7	165 $\pm$ 1.3	32 $\pm$ 0.3	8.1 $\pm$ 0.3	8576 $\pm$ 10

Perugia Hard vs Perugia Soft Cont'd

- Distribution of the probabilities for the event acceptance (ISVETO=0) or rejection (ISVETO≠0) during the MLM matching step, as a function of the largest p_T shower emission from the initial state radiation (left) and the largest p_T multiple proton-proton interaction in the event (right) in one of the NpX sub-samples.





MLM matching veto probability is:

- LHS: larger for more ISR activity
- RHS: independent of MPI activity

Tune / parameters variation suggestion for Alpgen + Pythia

The parameters in the AlpGen and Pythia 6 codes that are important for ensuring the consistency of matching:

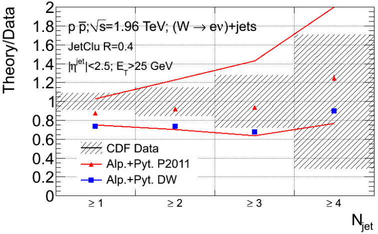
- Peter developed Perugia-2011 tunes (6.425) family that comply to the guidelines passed for consistent matching [1]; locks relevant Pythia parameters to the same values:
  - `PARP(61)` for $\Lambda_{\rm QCD}$ for ISR.
  - `PARJ(81)` for $\Lambda_{\rm QCD}$ for FSR inside resonance decays.
  - `PARP(72)` for $\Lambda_{\rm QCD}$ for FSR outside resonance decays (e.g., FSR off hard jets from the matrix element and/or from ISR).
  - ...
- Effective *value* for $\Lambda_{\rm QCD}$ set according to comprehensive Professor tunings [2] of the $p_\perp$-ordered shower in Pythia to event shapes and other LEP data:

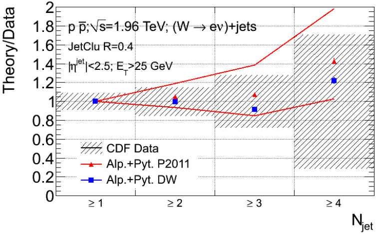
$$\Lambda^{(5)}_{\rm QCD} \sim 0.26$$

- Michelangelo introduced new Alpgen (v2.14) parameters (`ktfac` = 1.0) :
  - $\Lambda_{\rm QCD}$ (5-flavour): `xlclu` =0.26
  - Running order: `lpclu` = 1
- central suggestion for CTEQ5L, but similar CTEQ6L1 setup exists.

Data comparisons: Tevatron W+jets

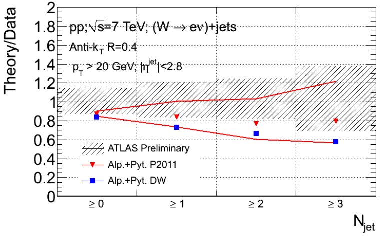
- The ratio of predicted theory and CDF measured data cross-sections for the production of a $W \to e\nu$ in association with at least $\mathrm{N_{jet}}$ jets [3].
- LHS: theory predictions not normalised to the data, RHS: theory predictions are normalised to the 1st data bin.
- jets : CDF JetClu alg., $R_{cone} = 0.4$, $p_T > 20$ GeV and $|\eta| < 2.5$.
- red lines: coherent rescaling of α_S with `ktfac` =0.5, 2 (has a little effect on the shapes of the differential cross-sections)

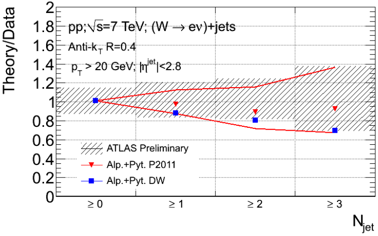




Data comparisons: LHC W+jets

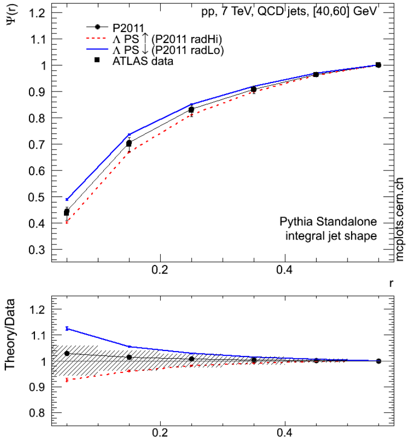
- ratio of predicted theory and ATLAS measured data cross-sections for the production of a $W \to e\nu$ in association with at least N_{jet} jets [4] (1.3 ipb!).
- LHS: theory predictions not normalised to the data, RHS: theory predictions are normalised to the 1st data bin.
- jets : anti-Kt alg., $R = 0.4$, $p_T > 20$ GeV and $|\eta| < 2.8$.
- red lines: coherent rescaling of α_S with `ktfac` =0.5, 2 (has a little effect on the shapes of the differential cross-sections)

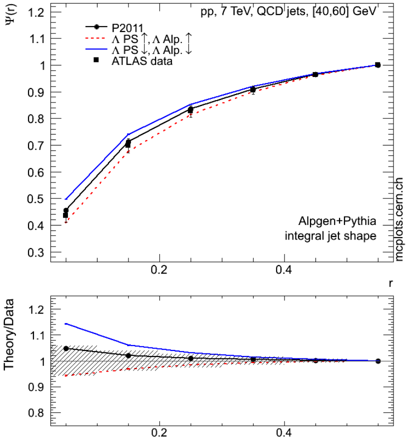




Data comparisons: LHC QCD jet shapes 1

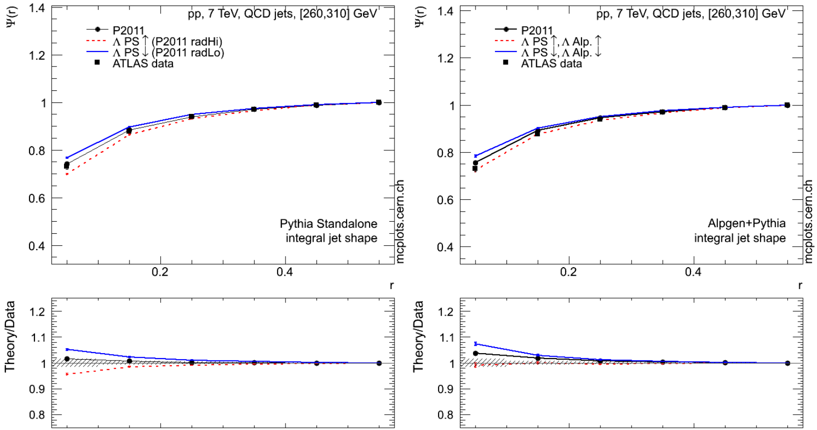
- integral jet shape distributions are compared to the ATLAS data [5] for the jets in the transverse momentum range of 40-60 GeV in the whole measured rapidity range ($|y| < 2.8$).
- Pythia 6 standalone (left) and AlpGen + Pythia 6 (right) with Perugia 2011,
- both provide reasonably good description of the jet shapes, but due to MLM matching the jets in the AlpGen + Pythia 6 case tend to be more narrow than in the Pythia 6 standalone case.





Data comparisons: LHC QCD jet shapes 2

- integral jet shape distributions are compared to the ATLAS data for the jets in the transverse momentum range of 260-310 GeV in the whole measured rapidity range ($|y| < 2.8$).
- Pythia 6 standalone (left) and AlpGen + Pythia 6 (right) with Perugia 2011,
- both provide reasonably good description of the jet shapes, but due to MLM matching the jets in the AlpGen + Pythia 6 case tend to be more narrow than in the Pythia 6 standalone case.



Conclusions & References

- We have passed a suggestion for AlpGen + Pythia 6 setup and guidelines for the tuning in the presence of matching.
- We have demonstrated the setup does a decent job for set of Tevatron and LHC measurements, when tuning to the new LHC data, the guidelines passed in the article will likely be useful.

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3. CDF Collaboration, Measurement of the cross section for W-boson production in association with jets in ppbar collisions at s**(1/2) = 1.96-TeV, Phys. Rev. D77, 2008, arXiv:0711.4044 [hep-ex].

4. ATLAS Collaboration, Measurement of the production cross section for W-bosons in association with jets in pp collisions at sqrt(s) = 7 TeV with the ATLAS detector, Phys.Lett.B, 2010, arXiv:1012.5382 [hep-ex].

5. ATLAS Collaboration, Study of Jet Shapes in Inclusive Jet Production in pp Collisions at sqrt(s) = 7 TeV using the ATLAS Detector, Phys. Lett. B698, 2011, arXiv:1101.0070 [hep-ex].