Comparison of radiation systematics in ATLAS and CMS

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Radiation systematics in $t\bar{t}$ events

So far (till $\sim$ Jul 13):

- **CMS relying on multi-leg : MadGraph + Pythia**
- **ATLAS relying on lowest multiplicity final state $t\bar{t}$ AcerMC + Pythia**; AcerMC $t\bar{t}$ enables simulation of $2 \rightarrow 6$; $t\bar{t}$ +decay, but no **extra** partons from the ME.
- the differences between the two approaches discussed e.g. at TOP LHC WG meeting: `https://indico.cern.ch/conferenceDisplay.py?confId=189617`

Since $\sim$ Jul 13 ($\sim$ Jan 14) ATLAS switches to multi-leg : Alpgen + Pythia for 7 (8) TeV.

- **this makes the treatment of radiation systematics between ATLAS and CMS more similar**
- **the details of adopting/not adopting the new recommendation are analysis specific (e.g. time-scales, newer/better recommendations under discussion)**

For Alpgen + Pythia vs MadGraph + Pythia : comment on aspects that are :

- **$\sim$ the same between ATLAS and CMS**: renormalization scale in running α_s variations
- **different between ATLAS and CMS**: factorization scale and UE

Setting $\Lambda \cdot 2$ for running α_s in generators

$$\alpha_s(Q^2) \propto \frac{1}{\ln\left(\frac{Q^2}{\Lambda^2}\right)} \qquad \text{(@ 1 loop)}$$

Madgraph: `alpsfact` $\cdot 1/2$

$$\alpha_s((\texttt{alpsfact}\,Q)^2) \propto \frac{1}{\ln\left(\frac{(\texttt{alpsfact}\,Q)^2}{\Lambda^2}\right)}$$

Alpgen: `ktfac` $\cdot 1/2$

$$\alpha_s((\texttt{ktfac}\,Q)^2) \propto \frac{1}{\ln\left(\frac{(\texttt{ktfac}\,Q)^2}{\Lambda^2}\right)}$$

Pythia ISR: `PARP(64)` $\cdot 1/4$; `PARP(61)` $\cdot 2$

$$\alpha_s(\texttt{PARP(64)}\,Q^2) \propto \frac{1}{\ln\left(\frac{\texttt{PARP(64)}\,Q^2}{\Lambda^2}\right)} \quad ; \quad \alpha_s(Q^2) \propto \frac{1}{\ln\left(\frac{Q^2}{\texttt{PARP(61)}^2}\right)}$$

Pythia FSR: `PARP(72)` $\cdot 2$

$$\alpha_s(Q^2) \propto \frac{1}{\ln\left(\frac{Q^2}{\texttt{PARP(72)}^2}\right)}$$

Renormalization scale : $\sim$ same

- **CMS** and **ATLAS**
- multi-leg **MadGraph+PYthia** and **Alpgen + PYthia** use variations by the same numerical factor between the **scale up** and **scale down** samples.
- **CMS MG + PY central:**
  PARP(64)=1, PARP(72)=0.25 GeV, `alpsfact`**=1.0**
- **ATLAS Alp + PY central:**
  PARP(61)=0.26 GeV, PARP(72)=0.26 GeV, `ktfact`**=1.0**

scale up ($\Lambda \cdot 1/2$, less activity)

	CMS MG+PY	ATLAS Alp + PY, 7 TeV	ATLAS Alp + PY, 8 TeV	ATLAS Acer + PY, 7 TeV
FSR: PARP(72)	0.125 GeV	0.13 GeV	0.13 GeV	0.11 GeV
ISR: PARP(64)	4.0	/	/	3.50
PARP(61)	/	0.13 GeV	0.13 GeV	/
ME: `alpsfact/ktfac`	2.0	2.0	2.0	/

scale down ($\Lambda \cdot 2$, more activity)

	CMS MG+PY	ATLAS Alp + PY, 7 TeV	ATLAS Alp + PY, 8 TeV	ATLAS Acer + PY, 7 TeV
FSR: PARP(72)	0.50 GeV	0.52 GeV	0.52 GeV	0.37 GeV
ISR: PARP(64)	0.25	/	/	0.90
PARP(61)	/	0.52 GeV	0.52 GeV	/
ME: `alpsfact/ktfac`	0.5	0.5	0.5	/

Λ values [GeV] are passed for 1 loop, 5flav.

Factorization scale and UE : different

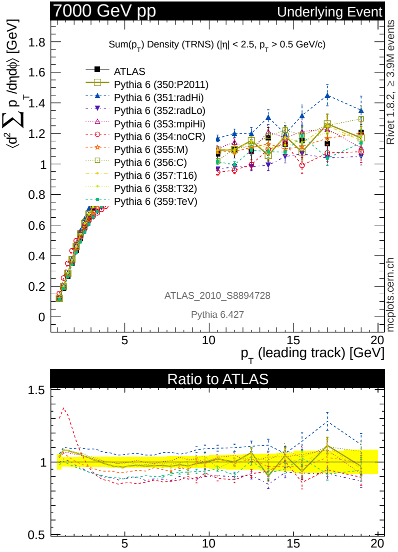
Factorization scale

- **CMS MG + PY: make a simultaneous renormalization and factorization scale, using the same numerical factor**
- **ATLAS : factorization scale treated independently of renormalization scale**

Underlying event

- **CMS : UE treated independently of scale variations**
- **ATLAS Alp + PY: UE treated as coupled to scale variations;**
  7 TeV : author Perugia2011 CTEQ5l central, radLo, radHi tunes;
  8 TeV : author P12 CTEQ6L1 central, radLo, radHi tunes

ATLAS, Phys.Rev. D83 (2011) 112001
Underlying event in *pp* collisions, 7 TeV



Data-MC : gap fraction

- $t\bar{t}$ events, dilepton decay channel, 7 TeV
- gap fraction = fraction of events without extra jet with transverse momentum above a threshold Q_0 (see ATLAS, Eur.Phys.J. C72 (2012) 2043 and CMS CMS-PAS-TOP-12-023)
- similar performance, as expected from the fact that similar setup and parameter variations are used
- outlook: we'll see how similar the CMS and new ATLAS radiation systematics procedures are for various top group analyses.

ATL-PHYS-PUB-2013-005 **CMS-PAS-TOP-12-023**