MC validation in ATLAS

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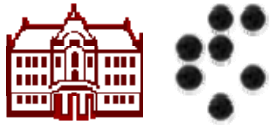


ATLAS experience:

- Generators used
- Validation procedures
- Future

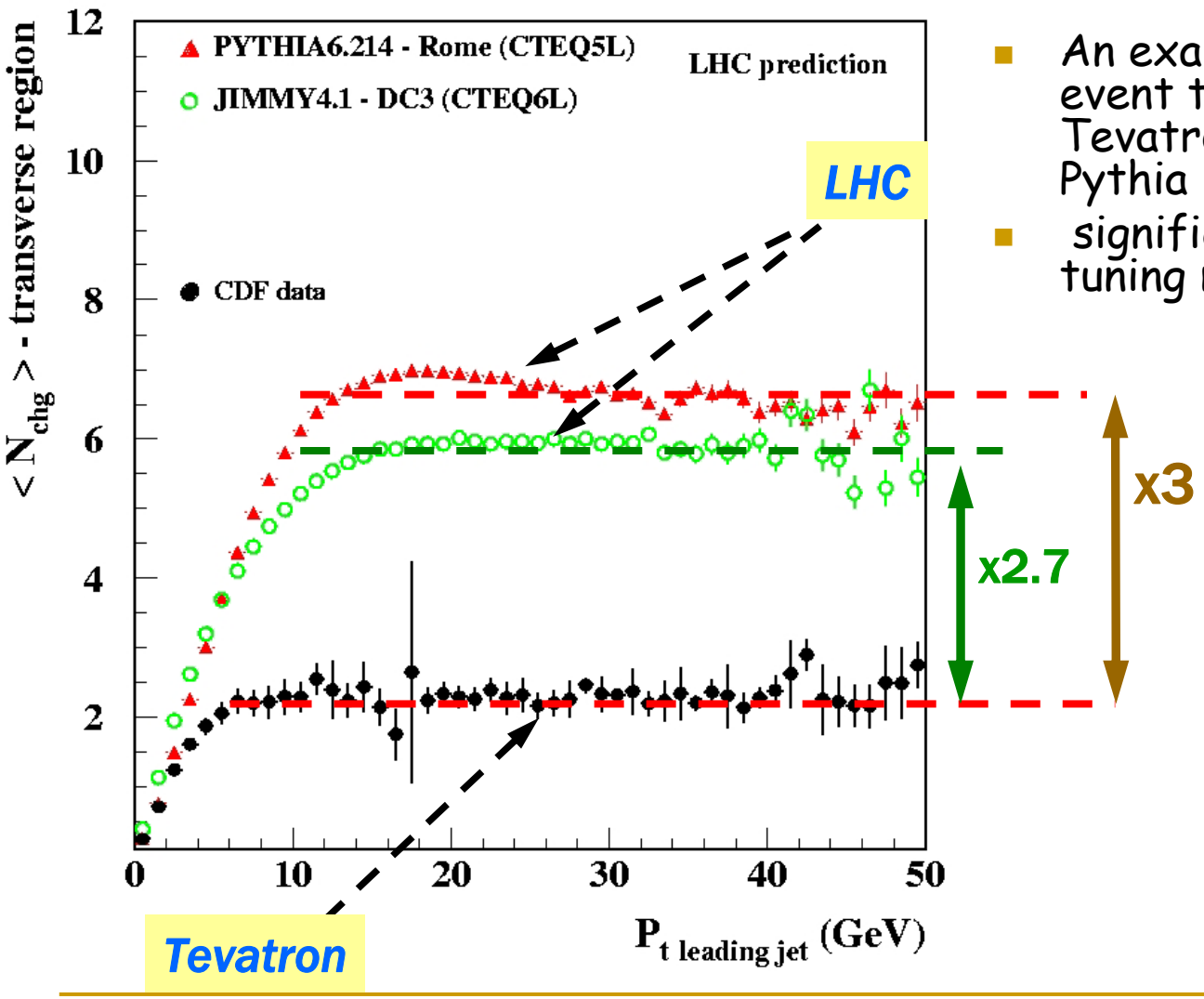
Generators used at ATLAS

- We try to use as many generators as reasonable:
  - The final answer which is best will be given only by the data.
  - Need some overlap: different generators for the same processes.
- So far tried:
  - AcerMC
  - Alpgen (+ MLM matching)
  - Charbydis
  - CompHEP
  - Hijing
  - HERWIG (+ Jimmy)
  - MadEvent
  - MC@NLO
  - Phojet
  - Photos (both with HERWIG and Pythia)
  - Pythia (old and new showering and UE algorithms)
  - Tauola (both with HERWIG and Pythia)
  - Sherpa
  - TopReX

Common validation procedures at ATLAS

- There are in general two approaches:
  - We take into account the experience and results at the Tevatron (tunings) and/or we try to tune/check the generators using available Tevatron information ourselves.
  - We compare the results of different MC generators in the quantities where they should match (to a certain precision) either at the generator level or by performing full analysis studies.
- In all cases we of course check the obvious parameters (masses, resonance shapes, angular (a)symmetries etc.)
- We also check the stability of the algorithms and their sensitivity to parameter changes (e.g. cutoff parameters in MLM matching algorithm etc..).
- Detailed checks when switching versions of the same MC tool.

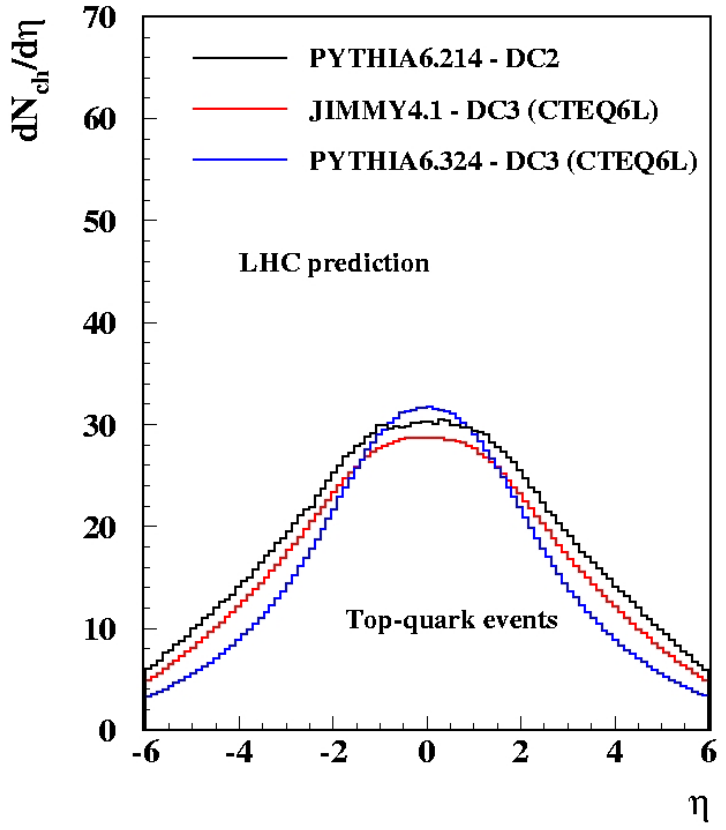
Validation using the Tevatron information

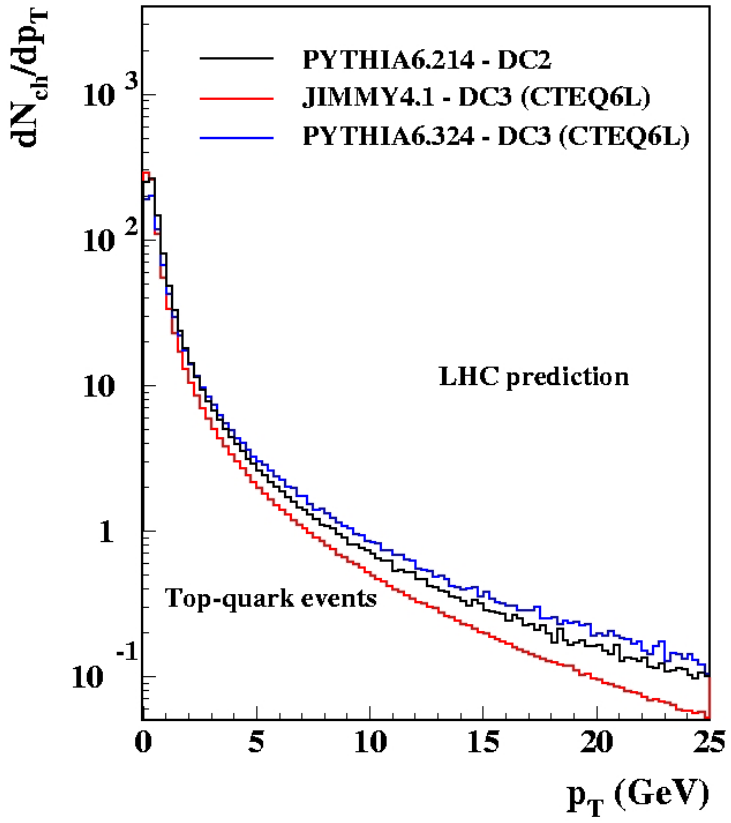


- An example is the underlying event tuning: comparing Tevatron-tuned Jimmy and Pythia UE at LHC energies:
- significant progress in the tuning methods achieved!

Validation using the Tevatron information

- Further comparisons of UE with different Pythia versions (and UE models):



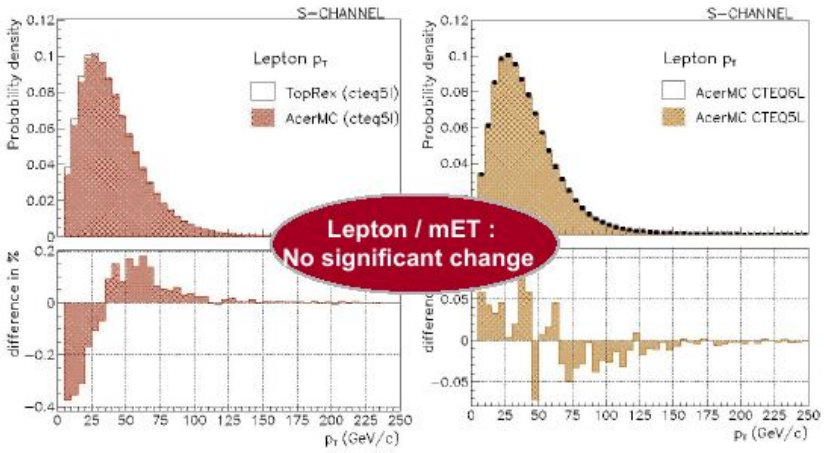


Validation using generator comparisons

- An example of very detailed comparison when moving from TopReX to AcerMC for generating single top production:
  - Full fastsim analysis repeated to check for possible discrepancies

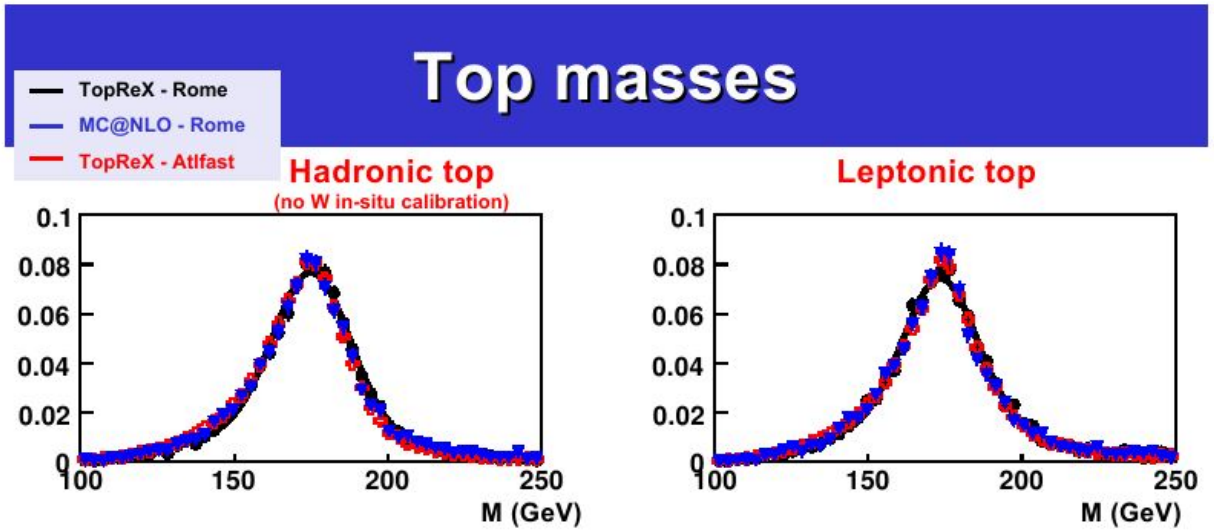
W* channel : lepton+mET

	TopReX CTEQ5L	AcerMC CTEQ5L	AcerMC CTEQ6L
N_{lep}	75.26 ± 0.05%	75.41 ± 0.06%	75.40 ± 0.06%
P_T^{lep}	53.37 ± 0.05%	53.43 ± 0.06%	53.60 ± 0.08%
lep. veto	52.65 ± 0.05%	52.68 ± 0.06%	52.85 ± 0.08%
mE_T	42.93 ± 0.05%	43.00 ± 0.06%	43.23 ± 0.08%
N(jet)=2	21.18 ± 0.04%	21.67 ± 0.05%	20.40 ± 0.06%
N(b-jet)=2	4.51 ± 0.02%	4.65 ± 0.03%	4.22 ± 0.03%
H_T	2.96 ± 0.02%	2.98 ± 0.02%	2.77 ± 0.03%
M_{lvb}	1.38 ± 0.01%	1.27 ± 0.01%	1.16 ± 0.02%



Validation using generator comparisons

- Comparison between MC@NLO and TopReX tt~ results (also using fastsim/fullsim comparison):
  - Result somewhat surprising: NLO vs LO…



	Had. top	Lep. top
TopReX Atlfast	174.3 σ=11.4	173.9 σ=11.1
TopReX Full Sim	175.2 ± 0.5 σ=12.3 ± 0.5	173.5 ± 0.5 σ=11.8 ± 0.5
MC@NLO Full Sim	174.5 ± 0.5 σ=11.6 ± 0.5	172.9 ± 0.5 σ=11.3 ± 0.5

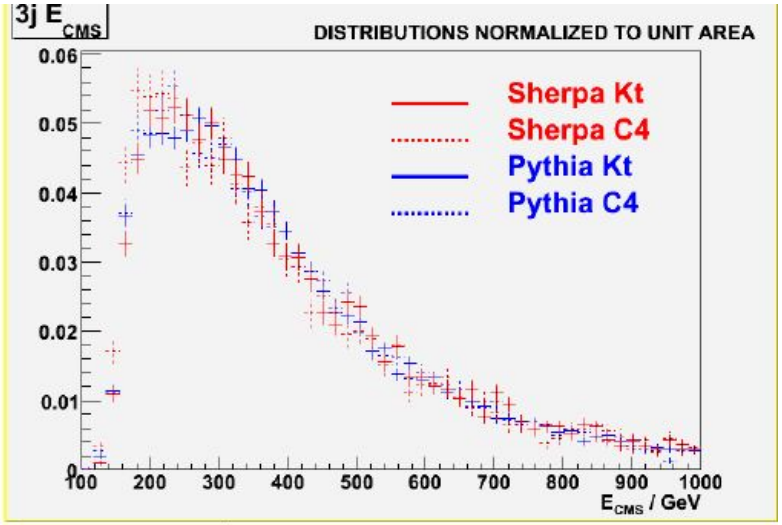
→ good agreement Full sim / Fast sim

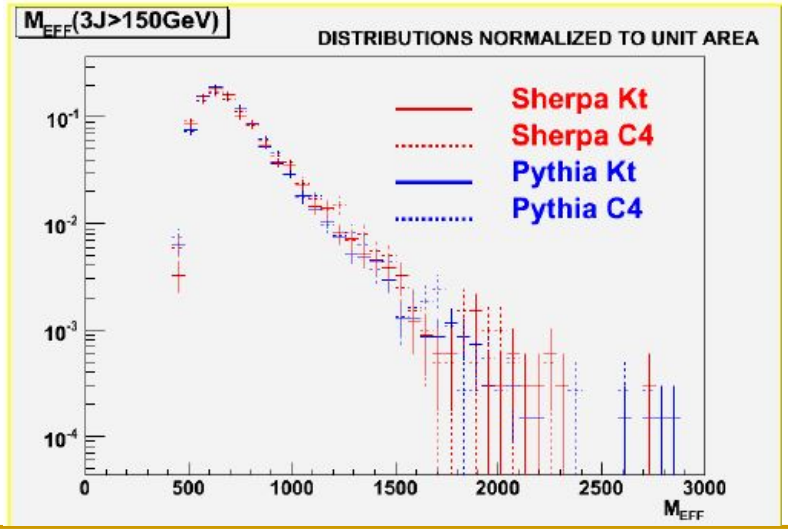
→ good agreement LO / NLO

Despite calibration of MC@NLO jets using TopReX sample

Validation using generator comparisons

- Comparing Pythia and Sherpa (CKKW matching) in multi-jet events:
  - The complex answer (Sherpa) might give similar results to the simple one (Pythia).





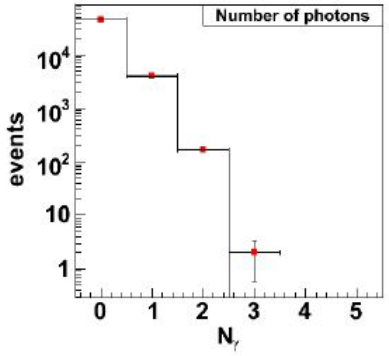
Validation using generator comparisons

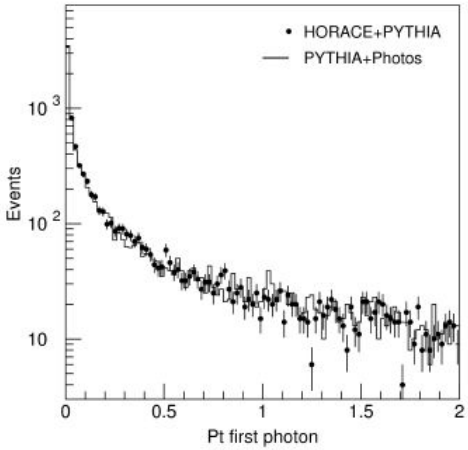
- Comparison between PHOTOS (supposed to be an approximate algorithm in principle) and HORACE (exact QED DGLAP solution):
  - Turns out that PHOTOS is doing an excellent job!

HORACE vs Photos (3)

- Photon multiplicity and transverse momentum spectrum done with standalone generators (outside Athena)

perfect agreement for all p_T range





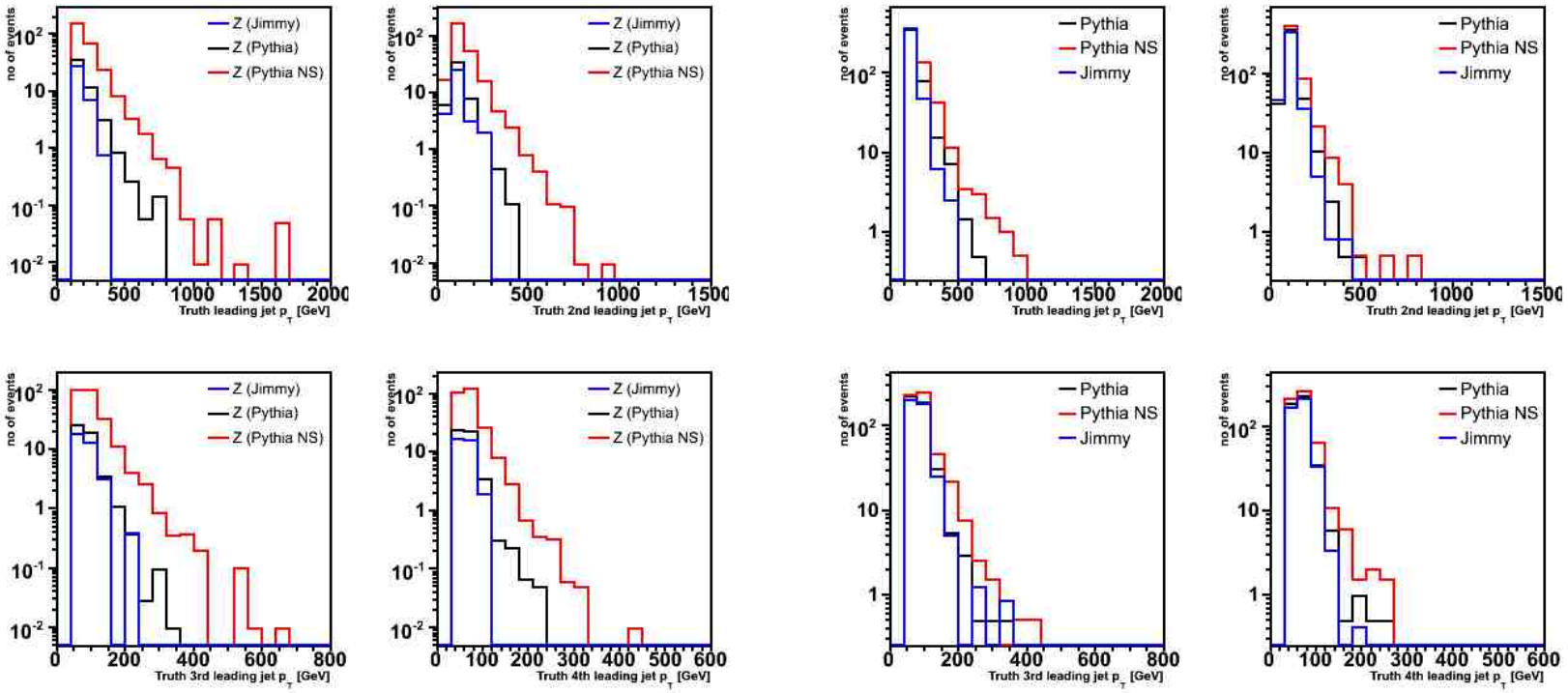
with cut $p_T(\gamma) > 500$ MeV perfect agreement also in Athena iterfaced version to third hard photon

Pythia + HORACE

Pythia + Photos

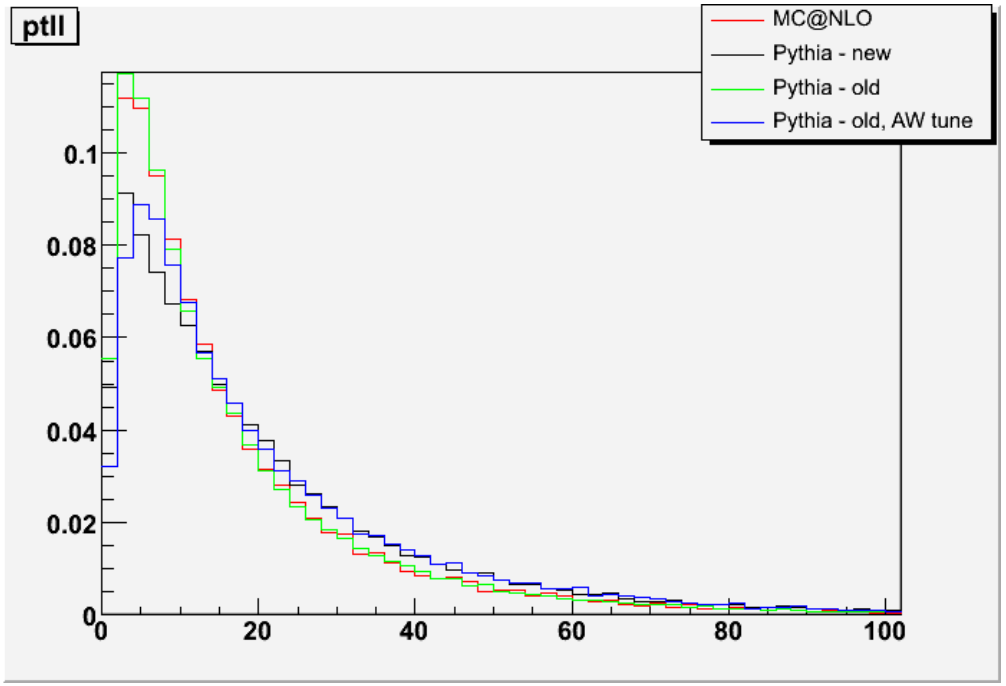
Validation using generator comparisons

- The new Pythia showering in many cases results in a harder pT spectrum of jets – stronger ISR/FSR/UE activity: Also quite harder than HERWIG/Jimmy..



Validation using generator comparisons

- Sometimes the comparisons need some thought:
  - Comparing Pythia old and new showering models and MC@NLO in case of Drell-Yan process
  - AW tune is the best tune achieved at the Tevatron (R. Field) to match old Pythia showering with the data.
  - Turns out that the new pythia showering is closer to the Tevatron-derived result



Stability checks

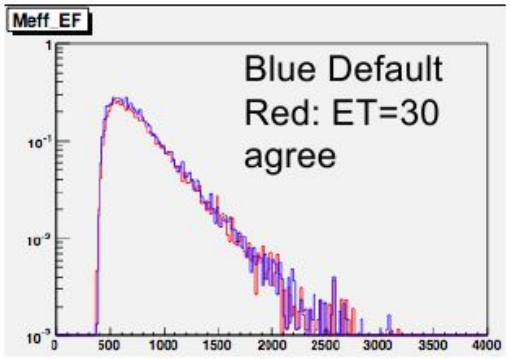
- A nice example is the check of the stability of the MLM matching procedure using Alpgen W+n jets process:
  - The default ET and cone values were shifted by about 30%
  - The plot shows checks done in a SUSY analysis after the selection cuts were performed

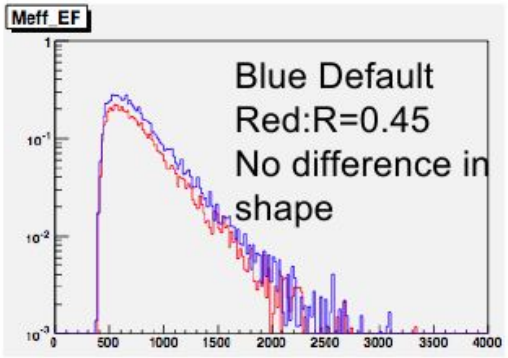
	Default	ET(THS)=30GeV	R=0.45
W+2parton	0.29	0.19	0.12
W+3parton	2.20	1.60	1.64
W+4parton	2.67	2.19	2.12
W+5parton	1.65	2.34	1.39
Sum	6.84	6.32	5.27

σ*Br after MLM matching

SUSY CUT

(-20% difference)

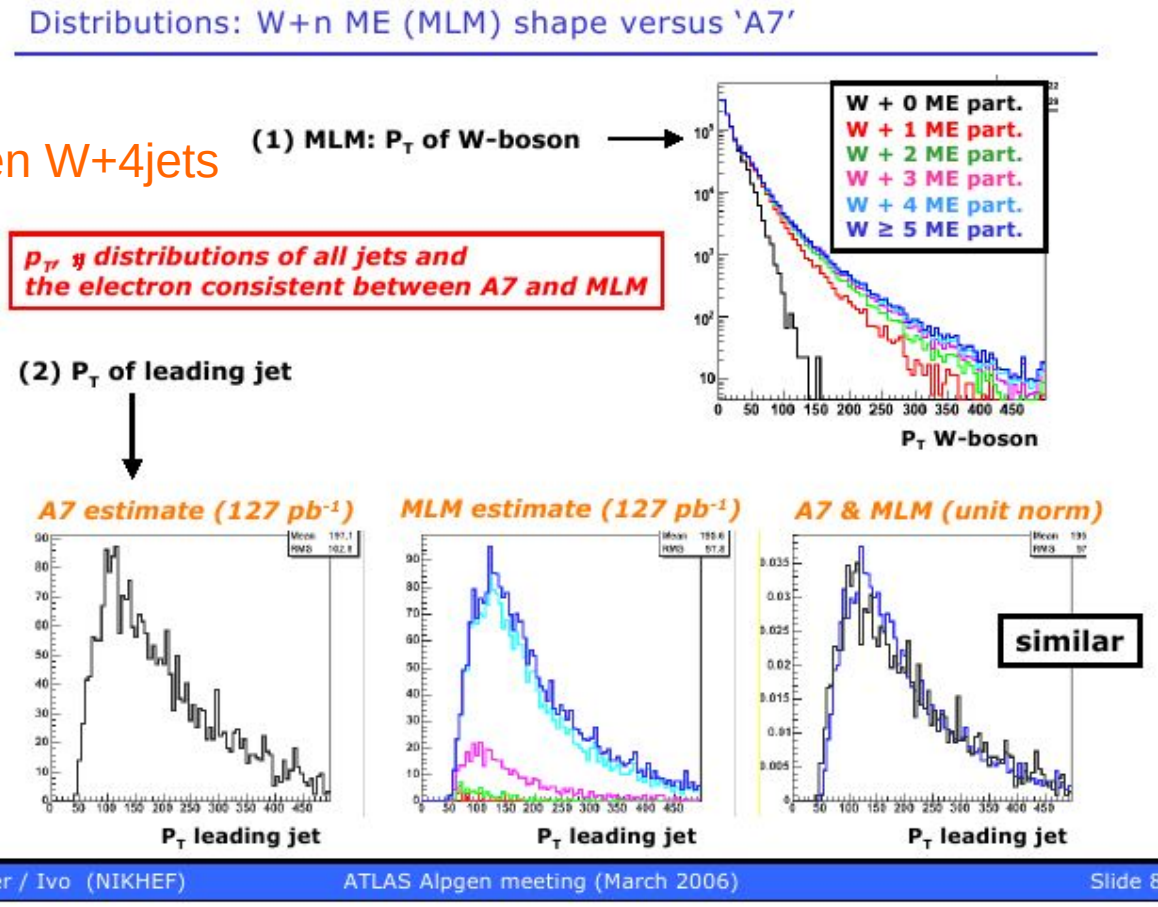




Stability checks

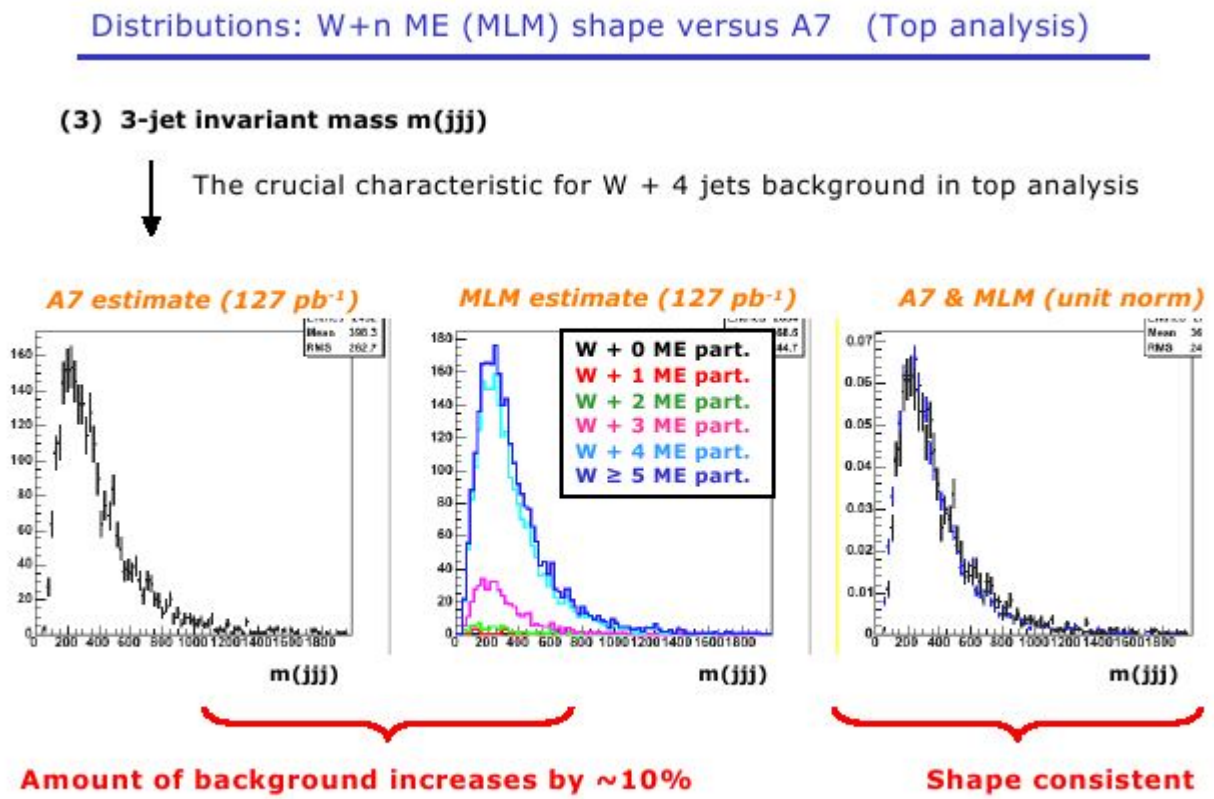
- A similar check was performed in the tt~ semi-leptonic analysis where W+4jets is assumed to be the dominant background:

A7 Sample = Alpgen W+4jets



Stability checks

- After the selection cuts the results are consistent and agree with other observations



Common Experience

- Possible bugs and/or discrepancies are reported back to the MC authors or GENSER through the MC group conveners:
  - In general very helpful and fast response in bug fixes.
- It would be very useful if relevant/recent Tevatron results (corrected for detector effects) would be available.
- A lot of effort used for MC validation in the ongoing ATLAS CSC production – effort by no means wasted!

Future

- At ATLAS we will soon have to 'freeze' the generator set used with the first data analyses
  - Bug fixes will certainly have to go in.
- The MC base will of course expand:
  - Pythia 8
  - HERWIG++
  - ???
- We strongly believe we will have the MC tools in good shape when the first data arrives...