

Matrix element corrections and parton shower matching in inclusive Z production @LHC

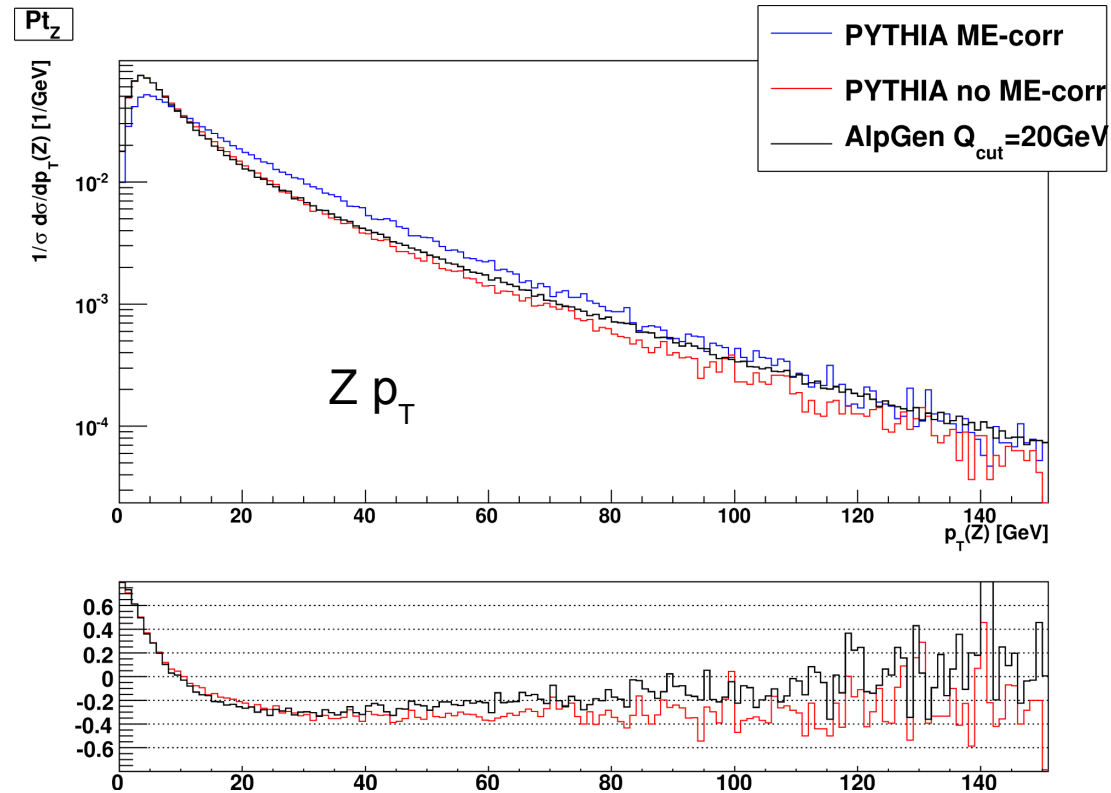
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13-01-2010**

- Matrix element corrections in Pythia
 - Effect on $Z p_T$ (two Pythia versions)
- Comparison among different Pythia tunes
- Pythia, Alpgen and Sherpa compared
 - Alpgen and Sherpa were allowed to emit at most one parton from matrix element
 - In this configuration the matched calculations should reproduce Pythia, so we can estimate the goodness of the matching

- In 2008 me and Jon Butterworth noticed that Alpgen+Pythia did not reproduce Pythia

- *ME corrections are switched off when Pythia showers external events*
- *Alpgen leaves the low p_T region untouched, as it should*
- *ME corrections seem to have a very big effect at low p_T which seems strange*
- *It looked like we needed a dedicated tuning for Alpgen+Pythia*



- In Les Houches Peter told me that a bug had been found and corrected in vector boson production in Pythia that may cause this behavior

Analysis setup



- We studied inclusive Z production at LHC with 10TeV CoM energy
 - Multiple interactions were switched off
 - QED radiation off leptons was switched off
- We required
 - two leptons with p_T greater than 20 GeV, $|\eta| < 2.5$
 - $66\text{GeV} < M_{ll} < 116\text{GeV}$
- Jets were reconstructed with an inclusive kT algorithm with radius of 0.4 and p_T greater than 30GeV

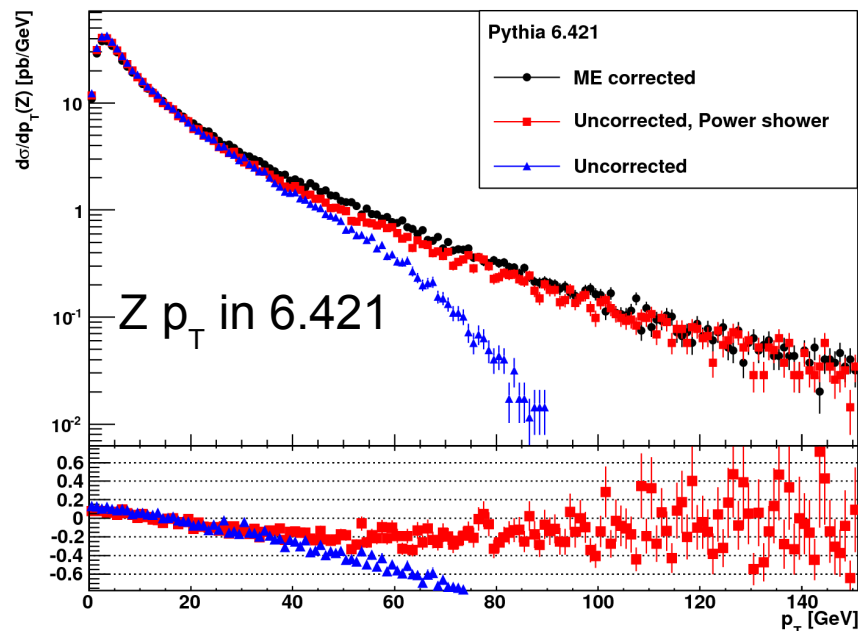
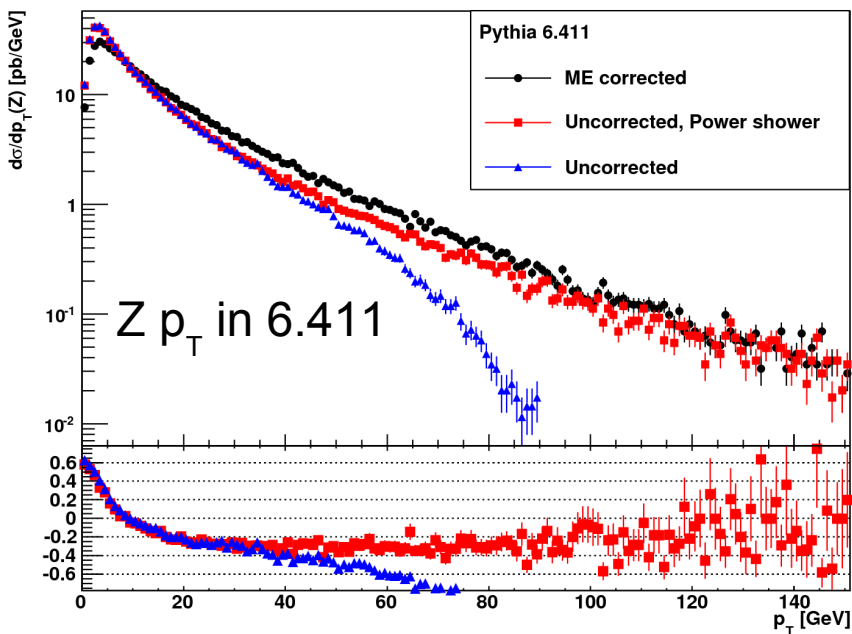
Matrix element corrections in Pythia



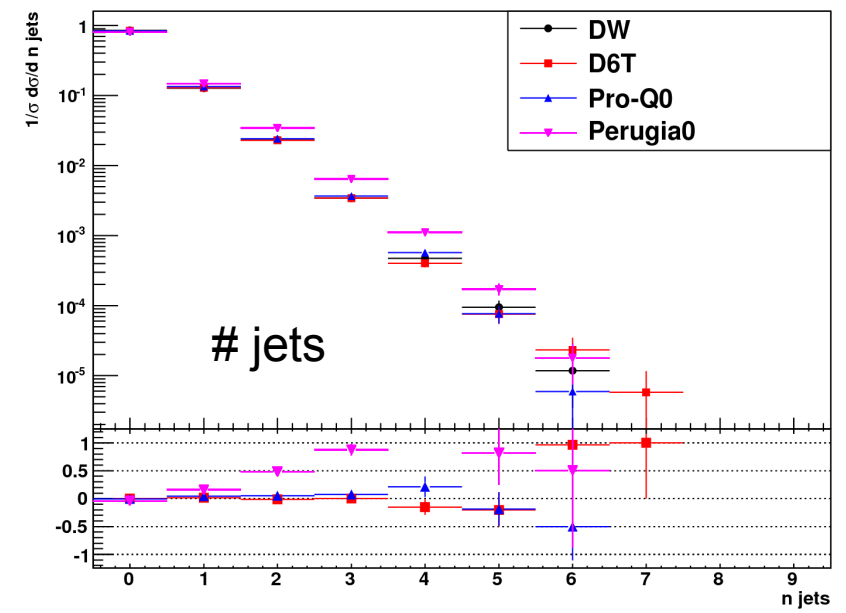
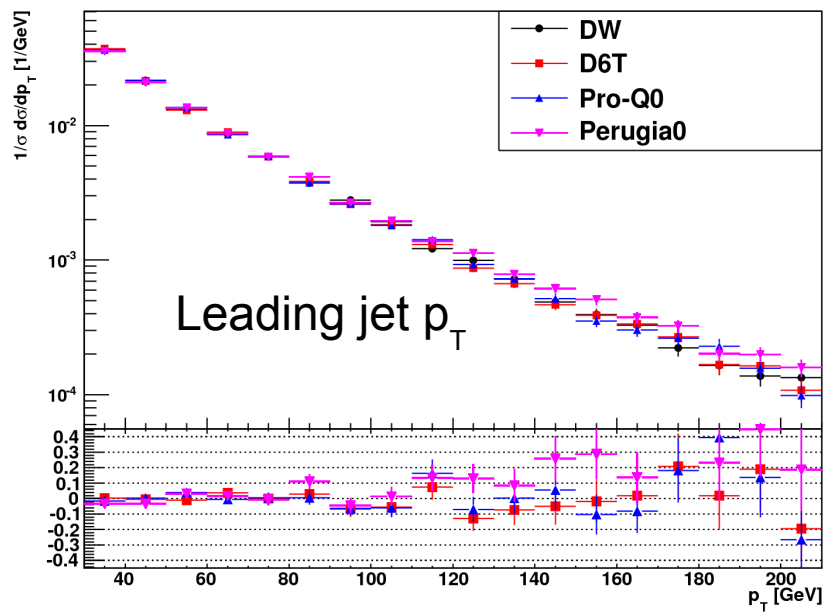
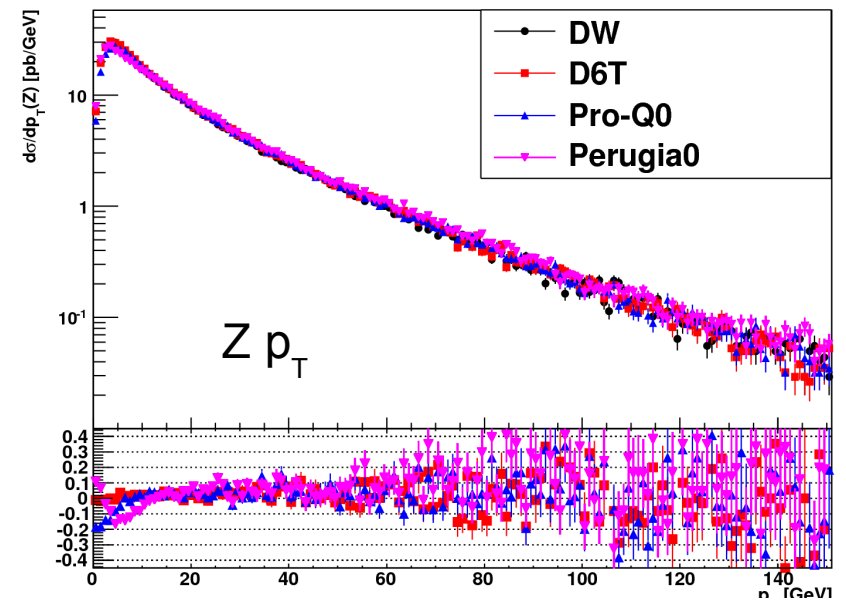
- Matrix element corrections modify the shower in a way which ensures that the effect of $Z + 1$ parton matrix element is fully taken into account
 - Cross section remains at LO
- The shower is modified in two steps:
 - The starting scale is raised to the hadronic CoM energy, so that any hard emission is kinematically possible (power shower)
 - The emission probability for the first (hardest) emission from the shower is corrected
 - The correction factor is the ratio between the exact 1 parton ME and the splitting function used in the shower

Pythia 6.411 VS 6.421

- We compared three setups in version 6.411 and 6.421
 - Full matrix element corrections
 - Power shower only
 - No corrections, shower starting scale at M_Z
- In the newer version the low p_T shape is almost unaffected by ME corrections, as expected



- Multiple interactions are off
- QED fsr from leptons is off
 - Very good agreement between DW and D6T
 - Some discrepancies at low p_T for Professor and Perugia0
 - Perugia0 predicts more jets



- Objective:

- Combine multi parton ME avoiding double counting

- Strategy

- Compute cross sections for +1, +2, ..., +n partons (with a minimum p_T for partons)

- These are inclusive in the number of partons

- Re-weight to obtain exclusive cross sections, that can be added without double counting

▪ Sherpa:

- events are produced according to the inclusive cross sections
- A parton-shower history is reconstructed
- Truncated showers are applied to connect the scales identified in the history reconstruction

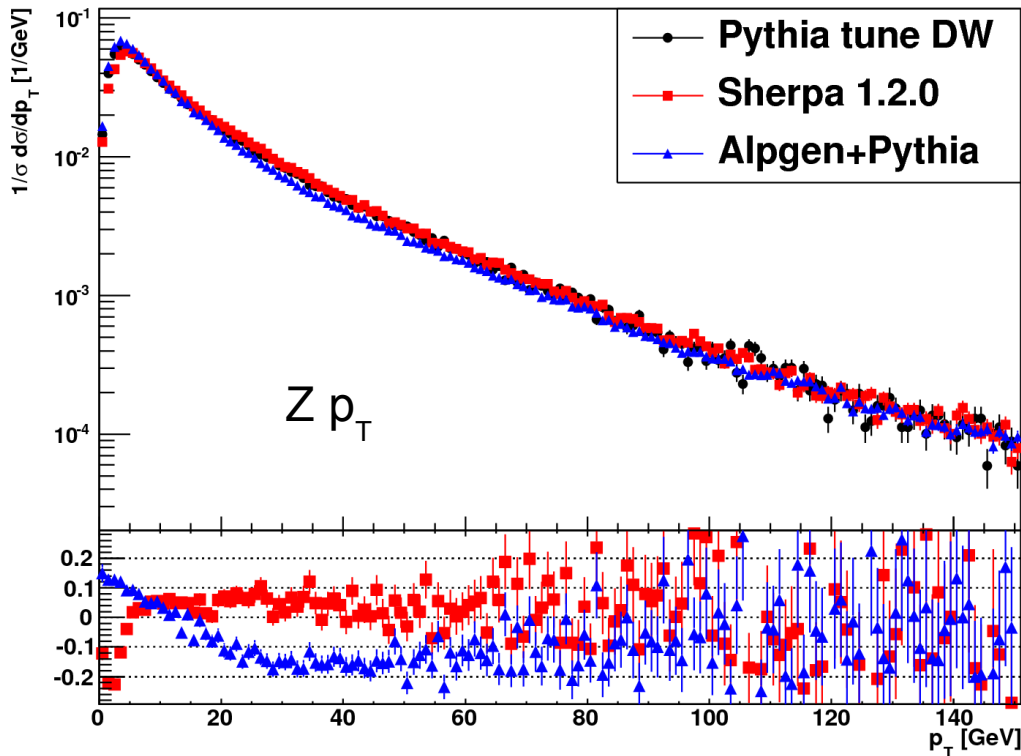
▪ Alpgen:

- events produced according to the inclusive ME are showered with Pythia or Herwig
- Resulting partons are clustered with a cone algorithm and matched to the partons before shower
- Unmatched events are rejected

Pythia Alpgen and Sherpa compared



- Alpgen and Sherpa are configured to emit at most 1 parton from ME
 - They should reproduce ME corrected Pythia
 - We can carefully check the behavior around the parton p_T cut used in the matching

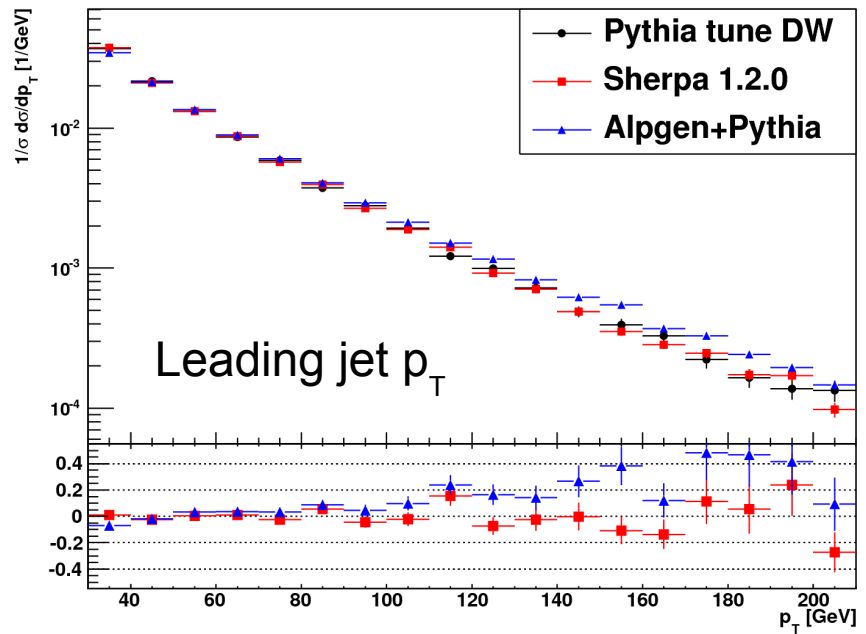
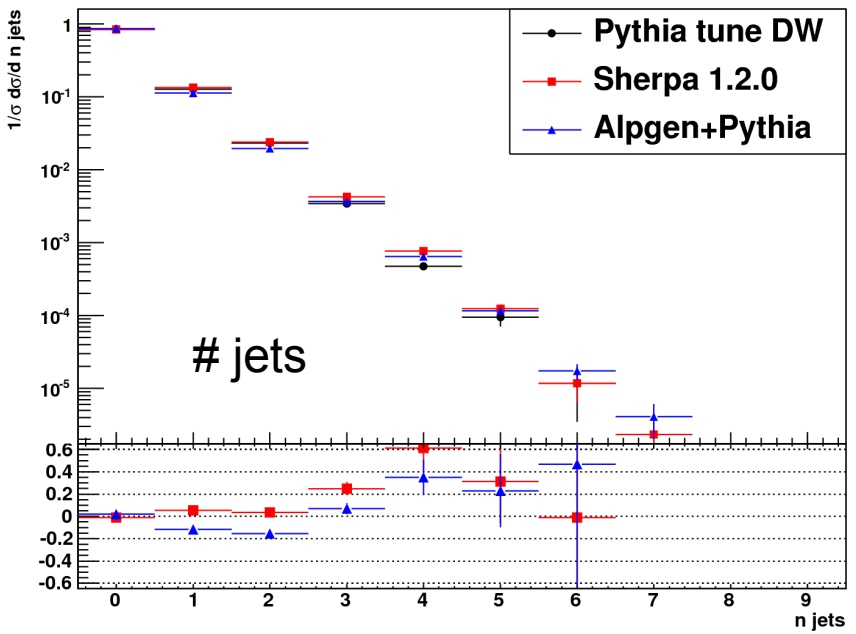


- *Good agreement between Pythia and Sherpa*
- *Alpgen+Pythia is now much closer to Pythia than it used to be in our previous studies with the older version of Pythia*
- *This means that we can reuse Pythia tunes in Alpgen+Pythia*

Pythia Alpgen and Sherpa compared



- Alpgen has less events with 1 and 2 jets, consistent with the softer Z p_T spectrum
- Alpgen also predicts a slightly harder leading jet p_T spectrum



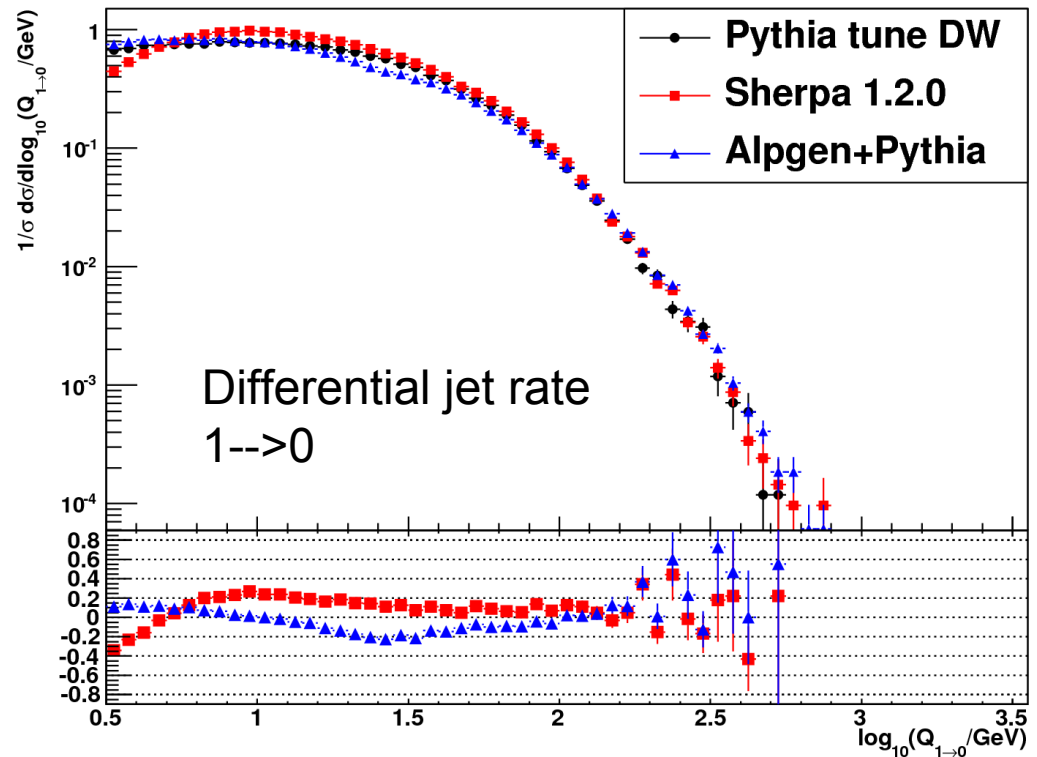


Pythia Alpgen and Sherpa compared



- Differential jet rate $1 \rightarrow 0$ is the distribution of the k_T resolution parameter that makes a 1 jet event turn into a 0 jet event
- It describes the radiation pattern for the hardest emission
- In the matched calculations, the region above the ME p_T cut is filled by the ME, the region below by the PS
 - We can check how smooth the transition is

- *The ME-PS transition is smooth in Alpgen and Sherpa*
- *The shape of the region above the matching threshold is well reproduced*
- *Some differences below the threshold.*
 - *Sherpa uses a different shower*



Conclusion



- A strange behavior of ME corrections in Pythia was spotted in 2008
- We checked that this behavior is now fixed in version 6.421
 - This also cures some discrepancies observed in the past between Alpgen+Pythia and Pythia
 - This assesses the re-usability of Pythia tunes when Pythia is used to shower Alpgen events
- We compared four Pythia tunes
 - Small differences in the Z low p_T and jet multiplicity

Backup

