Effects of Multiple-Parton-Interactions (MPI) and Pile-Up

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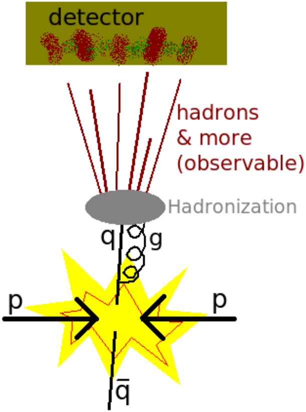
Outline

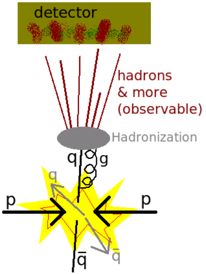
Introduction

- Detector level
  - what we measure; problem: finite resolution, limited acceptance of detector
- Particle level
  - observable particles
- Parton level
  - compare with theory

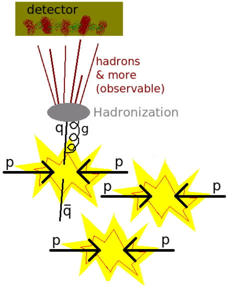


part of the **Underlying Event**:

- Multiple-Parton-Interactions (MPI)
  additional parton-parton-interactions during proton-proton-interaction



- Pile-Up
  proton-proton-interactions additional to the hard interaction during bunch-crossing



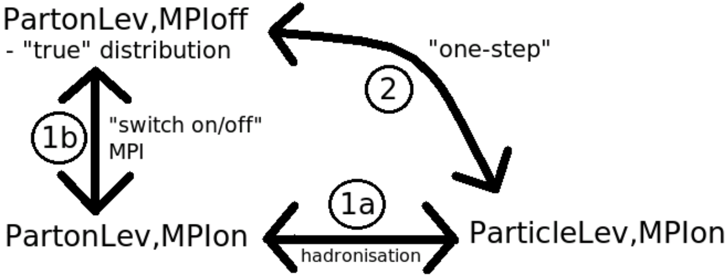
Multiple-Parton-Intercations (MPI) with PYTHIA 6.4

- study several multijet-scenarios with PYTHIA 6.4

specifications:

- HepMCAnalysis Tool 3.2, modified a lot
- PYTHIA 6.421
- cuts: $|y| < 2.8$, jet-$p_T > 60$ GeV
  - y ... rapidity
  - p_T .. transverse momentum

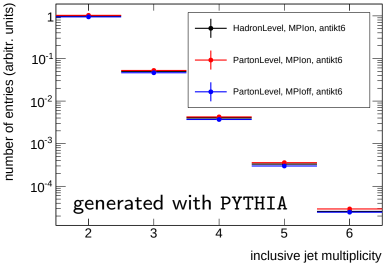
- we have to consider Multiple Parton Interactions (MPI) and hadronization effects:

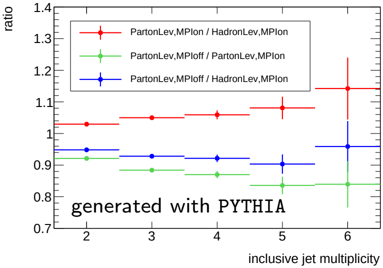


little glossary

- HadronLevel = Particle Level = Final State Particle Level
- PartonLevel = Level containing "every strong coupling particle (excluding incoming protons) included in the process before clustering and/or hadronization", e.g. quarks, gluons, coming from Inialial-State-Radiation (ISR), ...
- MPIon = Multiple Parton Interactions enabled (PYTHIA 'new model')
- MPIoff = Multiple Parton Interactions disabled (PYTHIA 'new model')

- inclusive jet multiplicity, events with 2 or more jets





- right-hand side:
- red dots (hadronization effects, way (1a))

  ↯ opposite effect on unfolding factors
- green dots (MPI effects, way (1b)) → opposite and larger effect
- blue dots : product of the two above (way (2))

Pile Up with PYTHIA 6.4

- pile-up events in PYTHIA are of minimum-bias type
- processes included:
  - low-p_T scattering
  - double-diffractive
  - single-diffractive
  - elastic

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  - y ... rapidity
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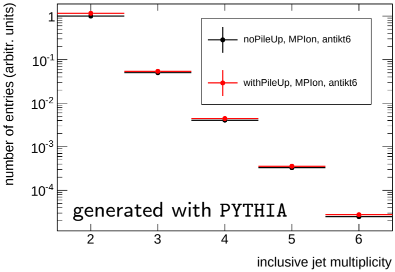
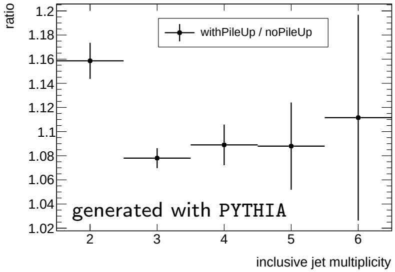
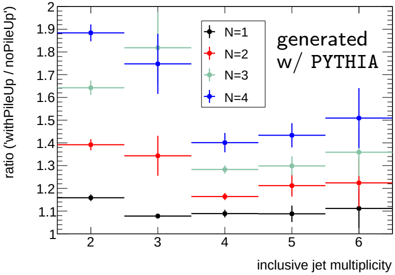
- inclusive jet multiplicity (number of pile-up vertices N=1), events w/ 2 or more jets



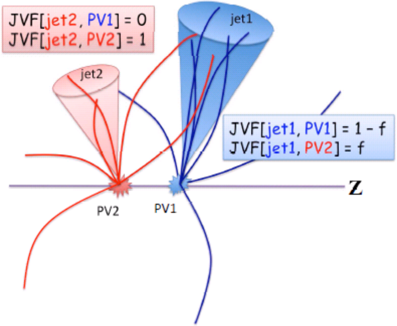




- pile-up events give us higher multiplicity, as expected
- more pile-up events ⇒ higher multiplicity, as expected
- one additional pile-up event doesn't change the distributions too much, even in high multiplicity region

Jet-Vertex-Fraction (JVF) with Data

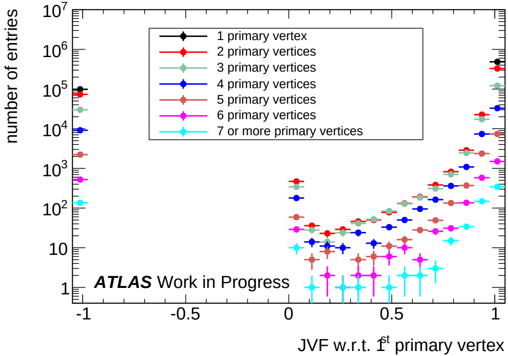
- how to handle pile-up? ⇒ **JVF**



taken from
`ATL-PHYS-INT-2009-090`

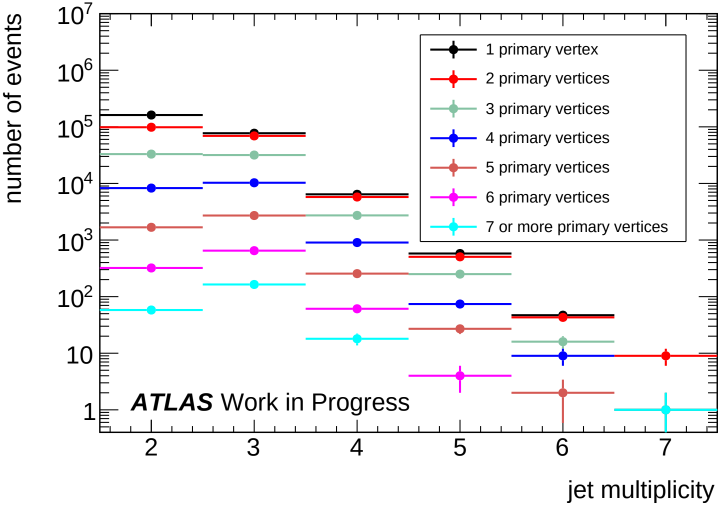
- for every jet:
  - find all tracks that match with jet
  - look from which vertex the tracks inherit
  - JVF is the p_T^{sum} of all matched-tracks from a given vertex divided by the total jet-matched track p_T
- for a given jet, the JVF is the jet-matched track p_T contribution from a certain vertex (in our case: hard-scatter vertex)

results (from data)



- $JVF = 1 \Rightarrow$ jet-matched tracks come from 1st primary vertex
- $JVF = 0 \Rightarrow$ jet-matched tracks come from another vertex
- $0 \leq JVF \leq 1 \Rightarrow$ jet has track contributions from several vertices
- $JVF = -1 \Rightarrow$ no statement for jet (e.g. because no matching tracks are found, or $|\eta_{jet}| \gtrsim 2.0$ (JVF method only works in this range))

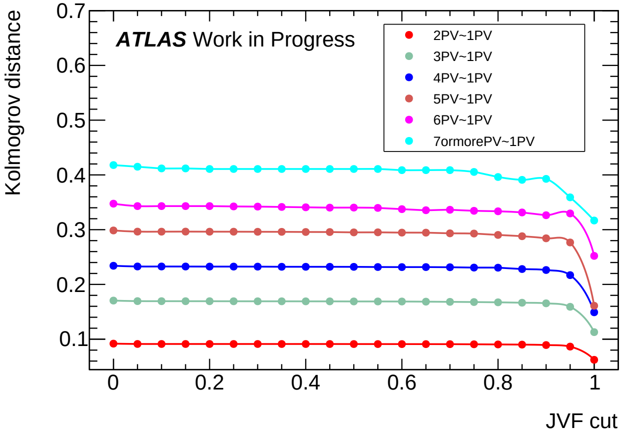
jet multiplicity (from data)



optimal JVF cut

- how to get optimal JVF cut?
- ▶ compare jet multiplicity distribution for events with 1 primary vertex with jet multiplicity distribution for events with exactly N primary vertices that have a certain JVF cut applied
- comparison is done by calculating the Kolmogorov distance
- do that for several JVF cuts and several N (number of primary vertices)
- for each N (number of primary vertices) find the JVF cut corresponding to the minimal Kolmogorov distance (here the distributions are "most identical")

for multiplicity distribution (from data)



- flat distribution ⇔ multiplicity distribution doesn't change if we apply JVF cut
- minimum JVF cut: $|JVF| = 1$

Summary

- effects of **Multiple-Parton-Interactions (MPI)** and **Pile-Up** have been shown
  - with the help of Monte-Carlo simulation, i.e. the `PYTHIA` generator
  - hadronization- and MPI-effects have been quantified
- one important variable concerning pile-up, the **JVF**, has been presented
- in order to handle pile-up: search for the "optimal" JVF cut
  - optimal JVF cut: $|JVF| = 1$