New jet algorithms with OPAL: Theory update

- Motivation
- Reminder: Differential distributions analysed
  - Durham ('k_t '), optionally with fixed E_{min}-cut
  - Anti-k_t, SISCone with fixed E_{min}-cut **– problems !**
- **New calculations:** Inclusive rates
- New Anti-k_t and SISCone analysis:
  - Measurement
  - Hadronisation correction (provisional)
  - Qualitative comparison with theory
- Conclusion
- Further steps

Motivation

- Algorithms developed at hadron colliders
- Are studied also in ep (HERA, ZEUS)
- But not yet at e^+e^- collider
- e^+e^- environment cleaner :
  - No underlying event
  - No pileup
  - No ISR/FSR interference
  - Event well measured in any direction
- So they should be studied qualitatively (then quantitatively) in e^+e^-

Reminder: Differential distributions analysed

- Durham algorithm: Measured to check consistency with OPAL (PR408)
  - Sensible agreement, some more detailed study required
- Durham algorithm with fixed E_{min}-cut
  - Some region of three jet rate has moderate corrections and is described perturbatively
- Anti-k_t algorithm with fixed E_{min}-cut (w/o radius!)
  - Moderate corrections only in nonperturbative region
- SISCone algorithm with fixed E_{min}-cut
  - Moderate corrections in perturbative three-jet region

New calculations

- Hadron collisions: inclusive analysis with known hard scale (Atlas Z+jets Phys. Rev. D85 032009, W+Jets Phys. Rev. D85 092002) :
  - Fix R
  - Study jet rates as function of p_t ($\triangleq$ E_{min}, e+e-), not of d_{cut} (as in OPAL Z.Phys. C63, 197)
- Calculations
  - Anti-k_t algorithm including R parameter (-> next slide)
  - SISCone
  - Both for R=0.4, 0.5, 0.6, 0.7 (anti-k_t ATLAS: 0.4, 0.6; CMS: 0.5, 0.7)

    and E_{min}/Q=0.005 ... 0.35 (cut **relative** to cms energy)

Anti-k_T algorithm including radius R

R = opening half angle

1. Depends on parameter E_{min}

2. For every pair (p_k, p_l) of final-state particles compute the resolution variable

$$y_{kl} = 1/8 \min(E_k^{-2}, E_l^{-2})(1-\cos\theta_{kl})/\mathbf{(1-cos\ R)}$$

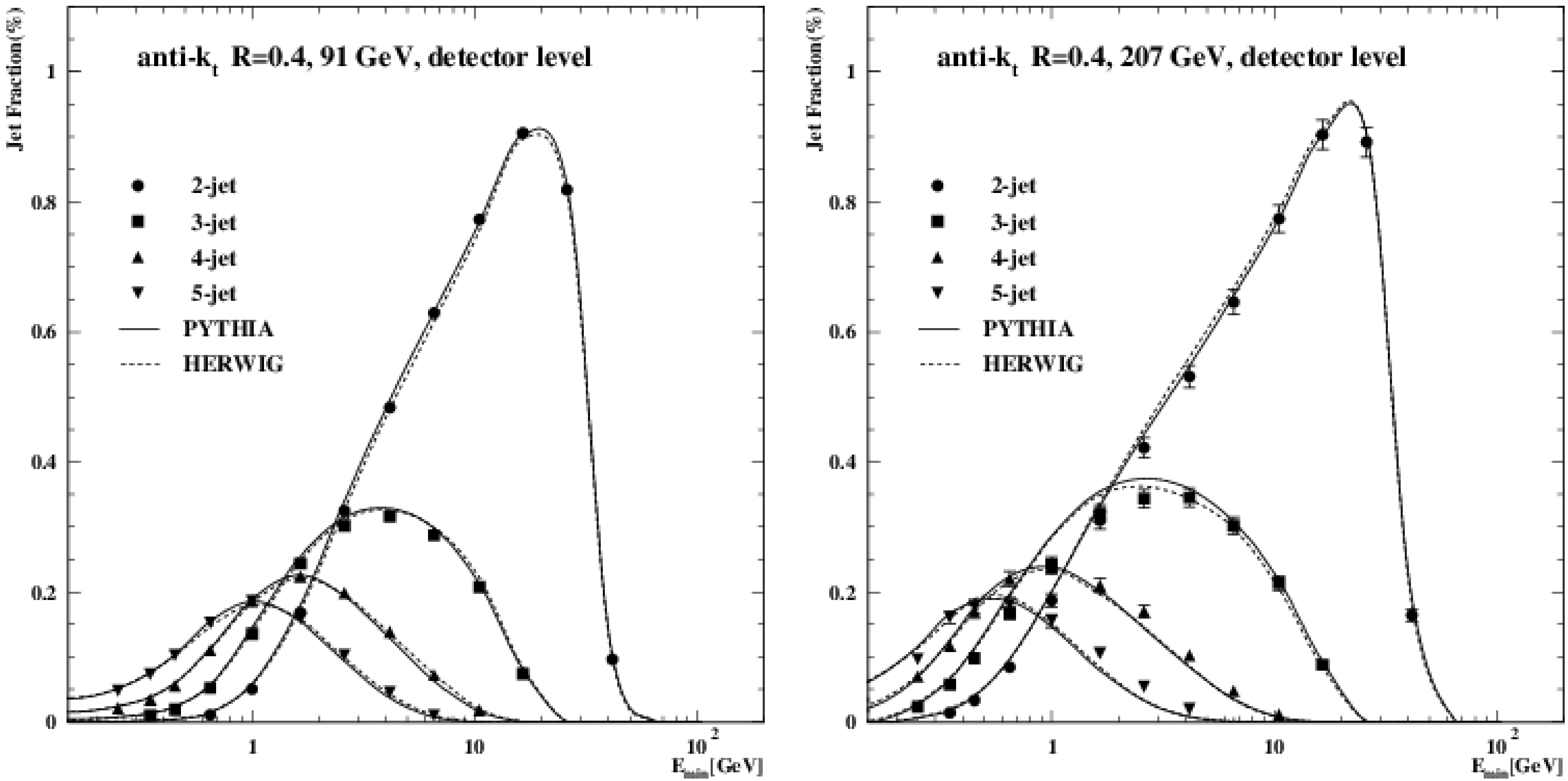
3. If y_{ij} is the smallest value of y_{kl} then combine (p_i, p_j) into a single jet ('pseudo-particle') with momentum p_{ij}:

$$E_{ij}=E_i+E_j,\ p_{ij}=(E_i+E_j)(p_i+p_j)/|p_i+p_j|$$

4. Repeat until no more changes

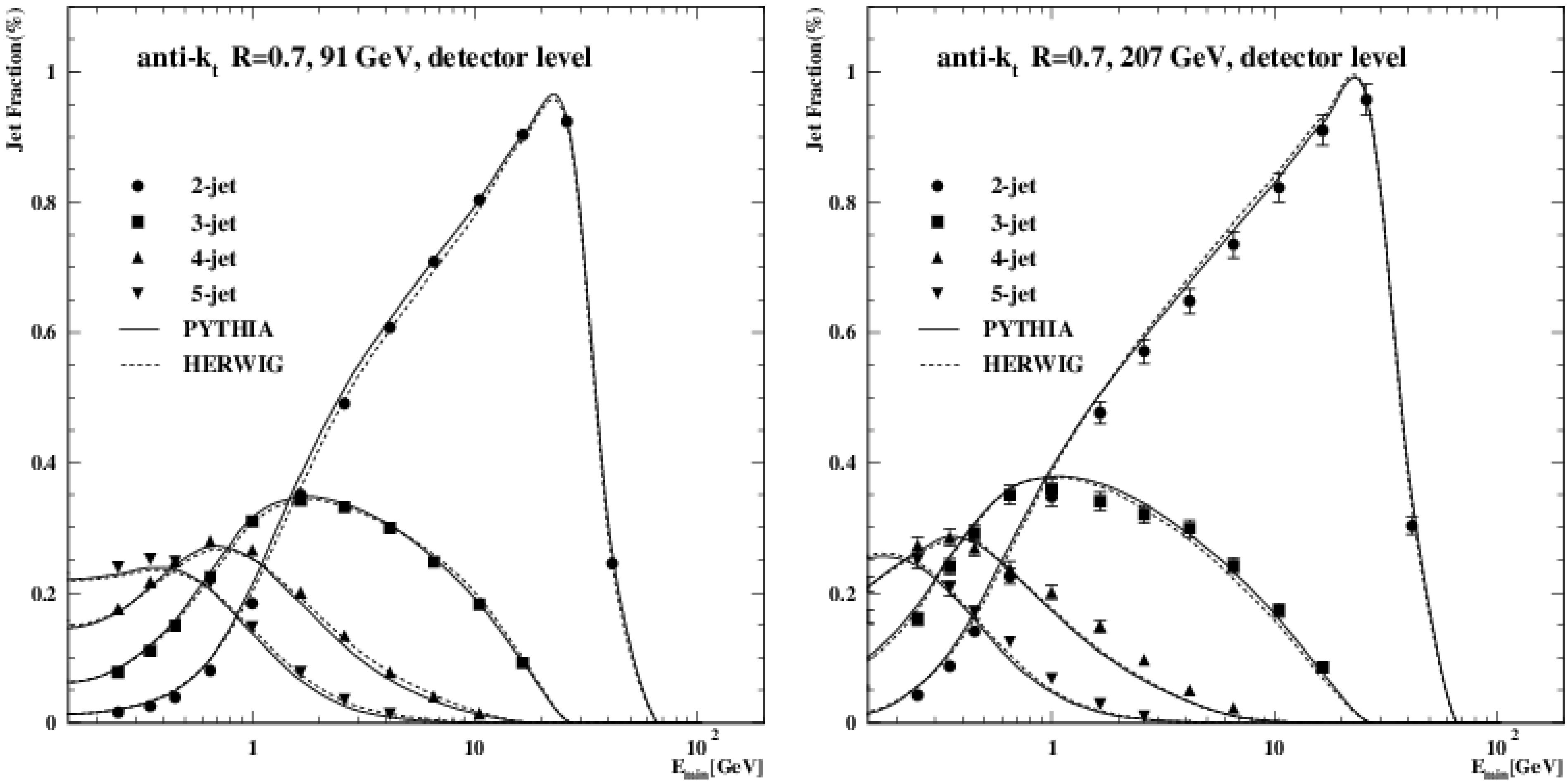
5. Only particles and pseudo-particles with $E > E_{min}$ are taken as jets

Measurement: anti-k_t algorithm R=0.4 on detector level



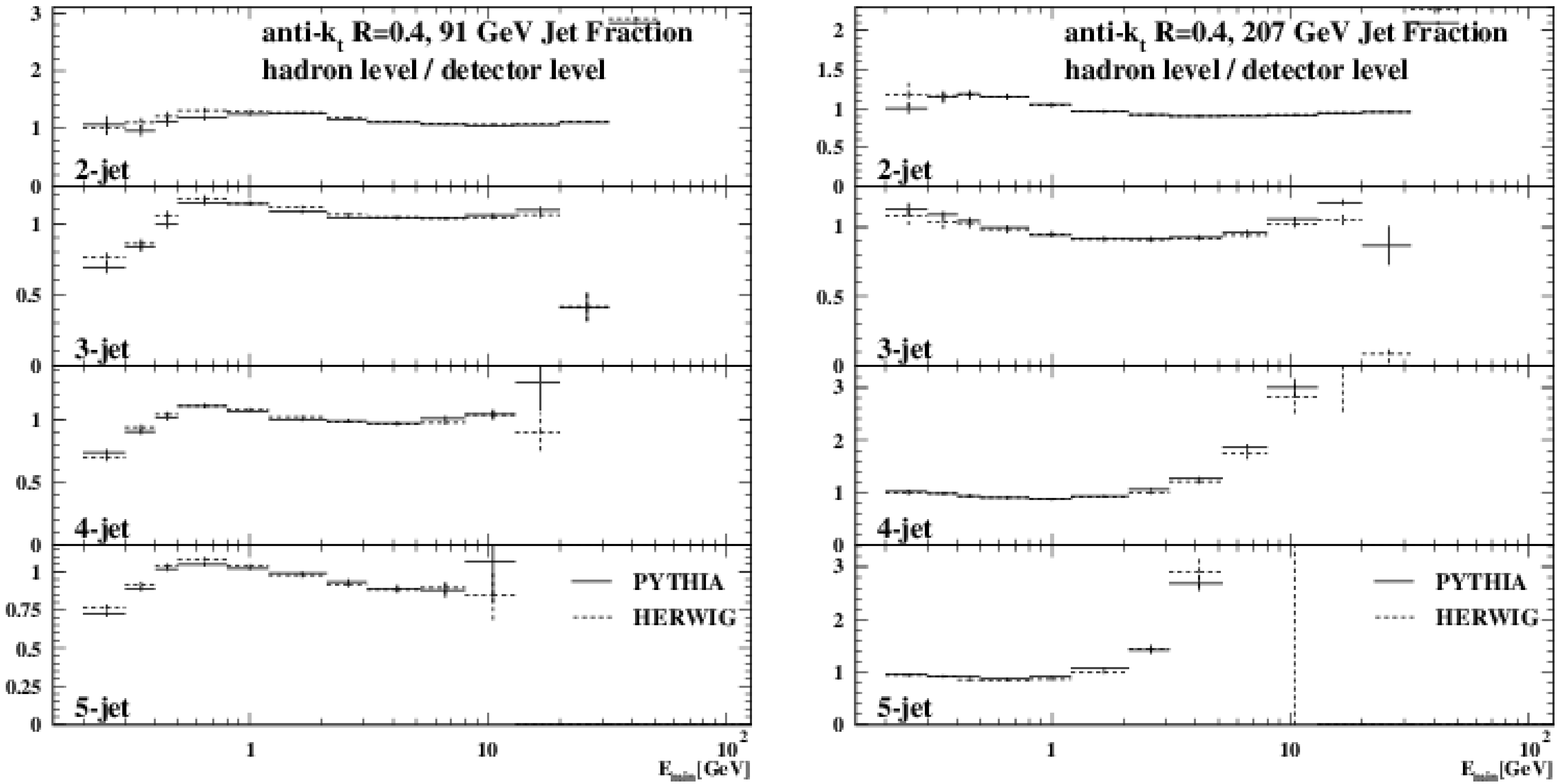
Jet fraction vs. absolute E_{min} cut [GeV]

Measurement: anti-k_t algorithm R=0.7 on detector level



Jet fraction vs. absolute E_{min} cut [GeV]

Detector correction: anti-k_t algorithm R=0.4



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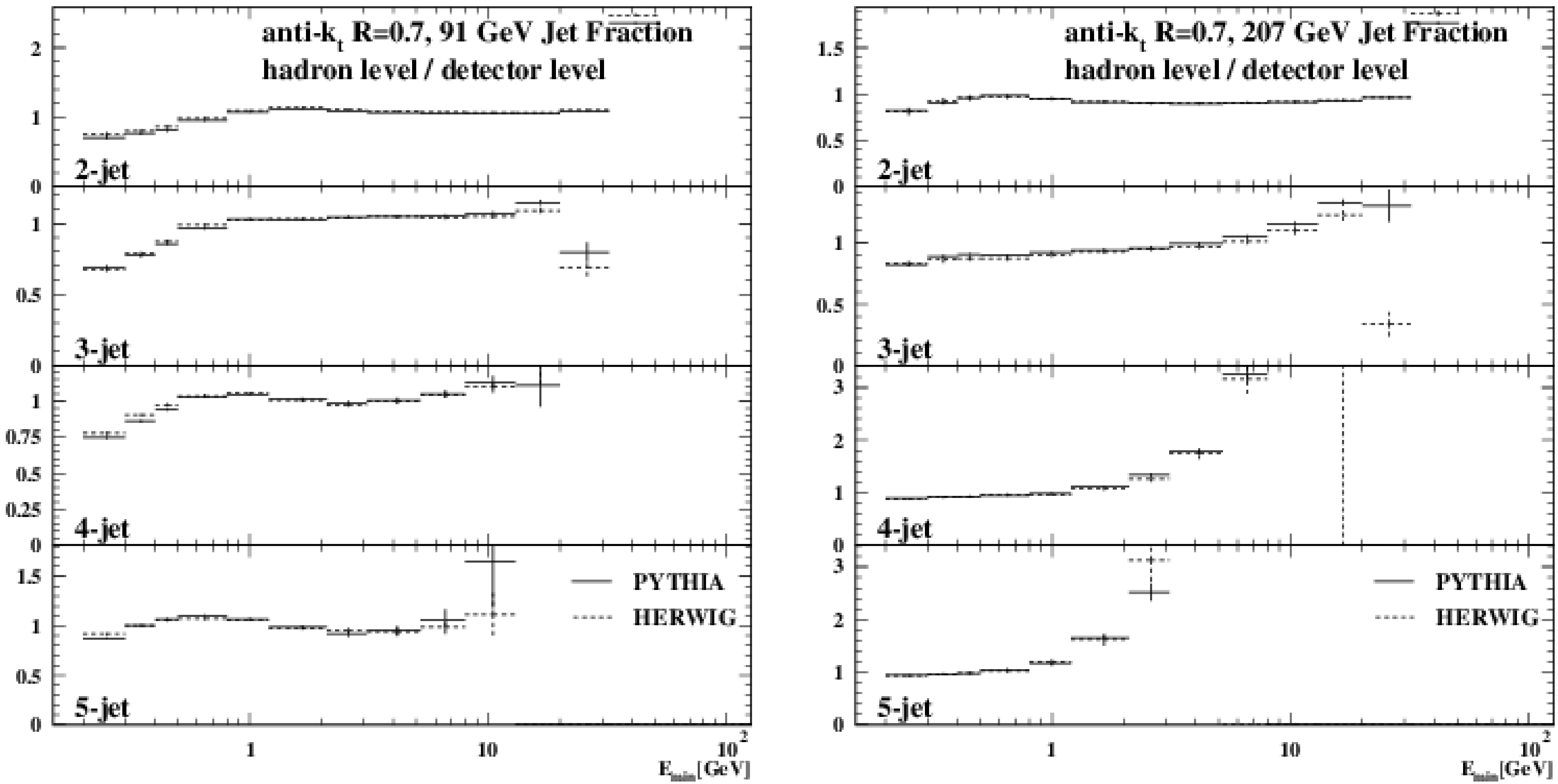

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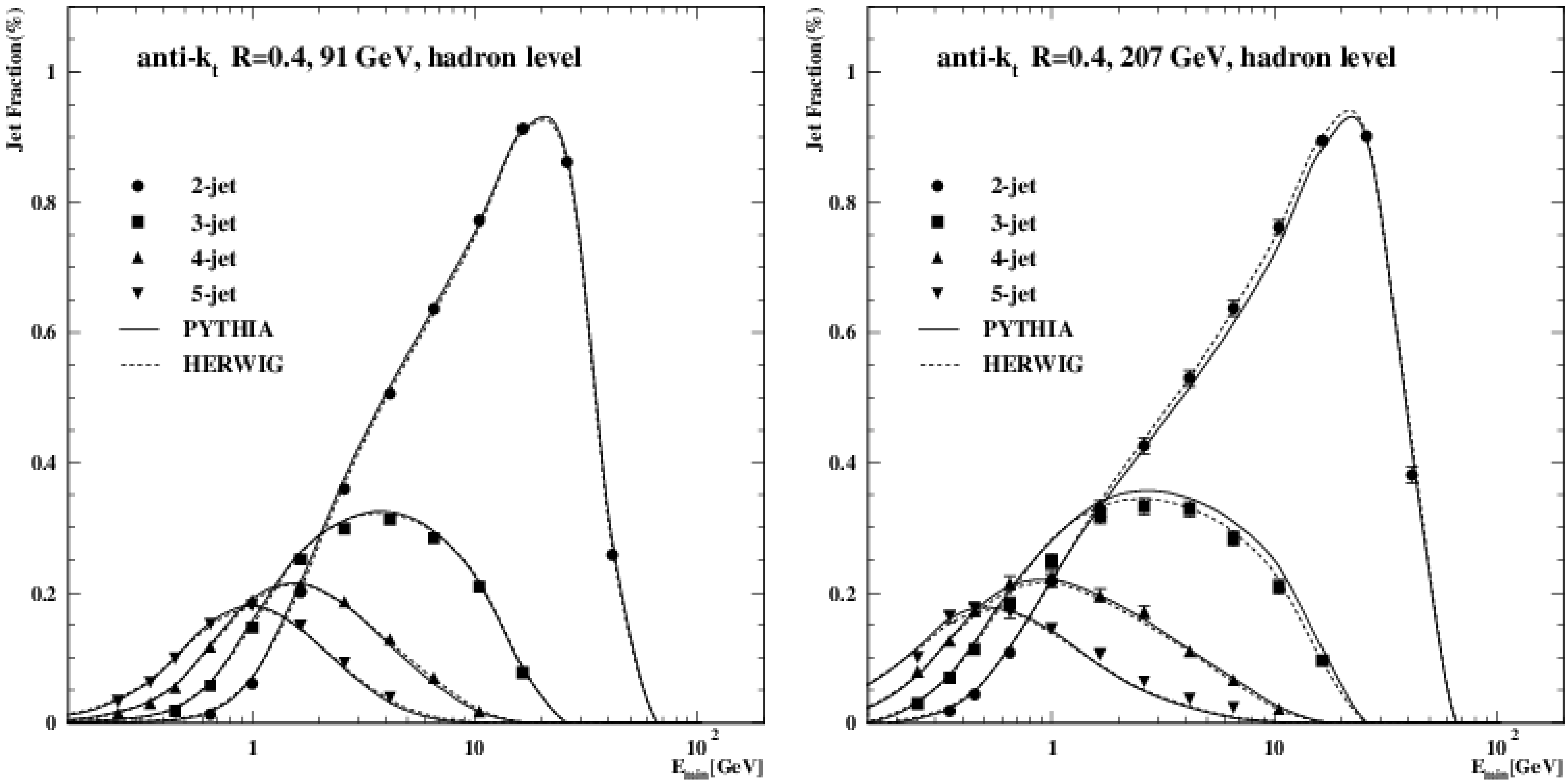

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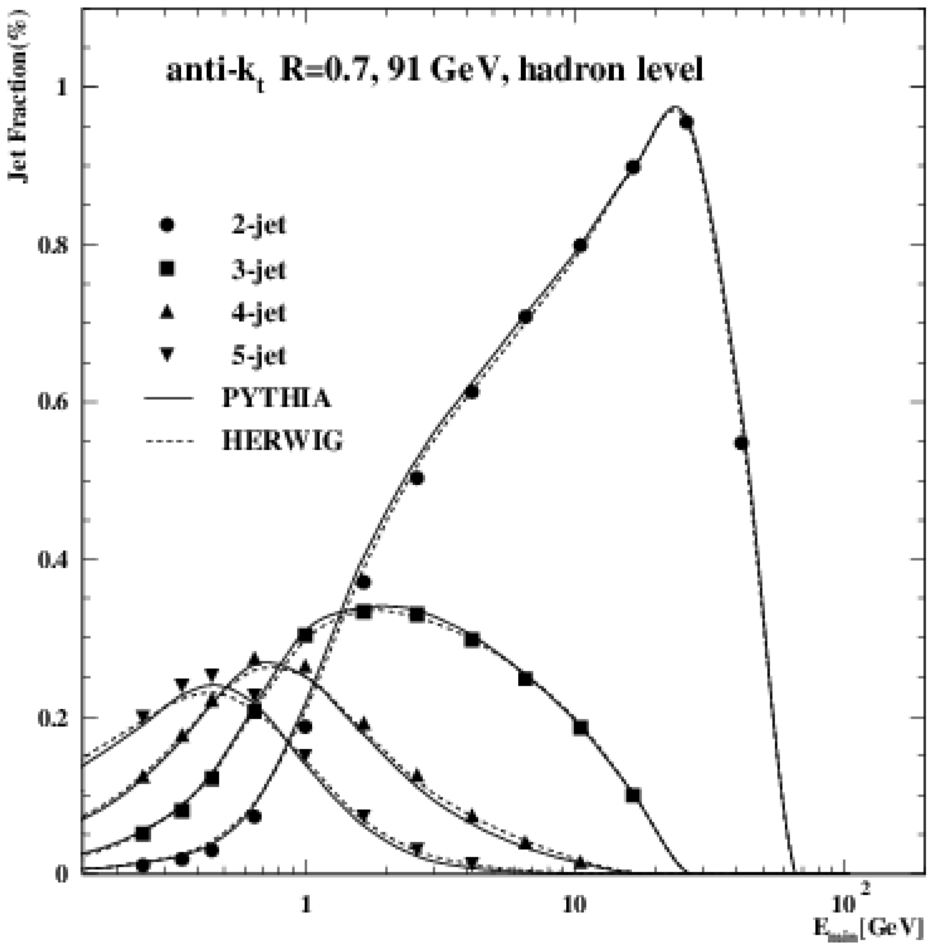

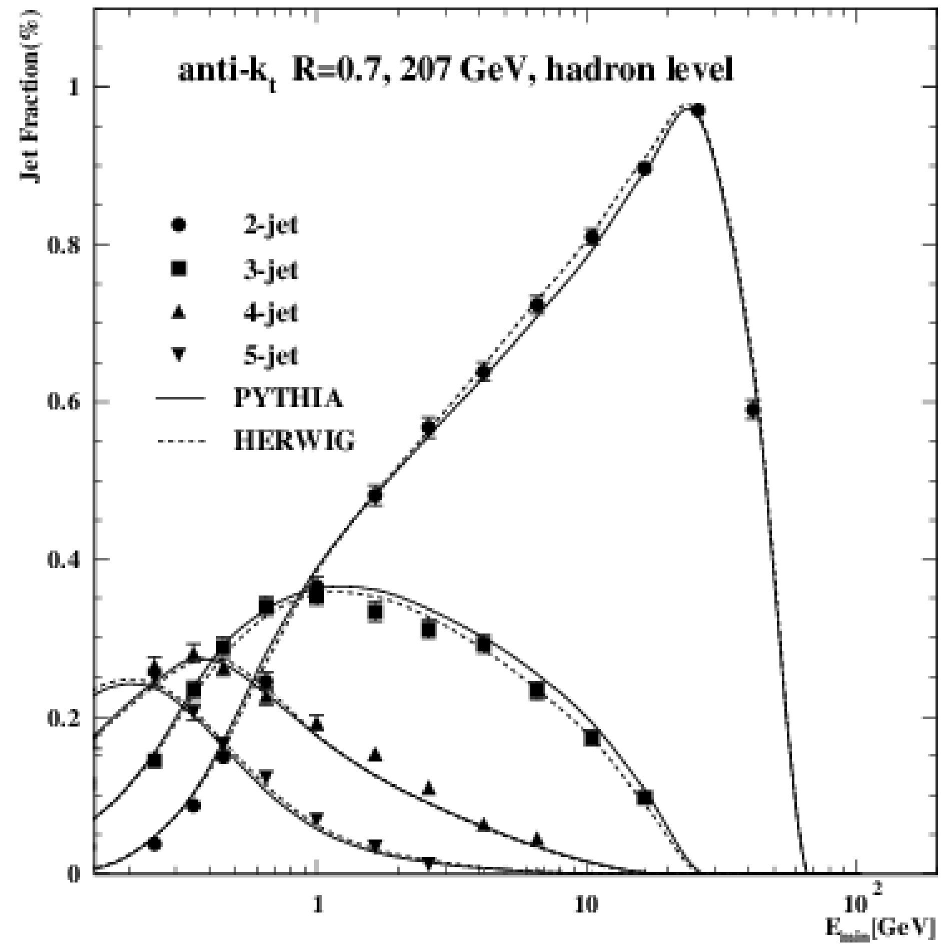

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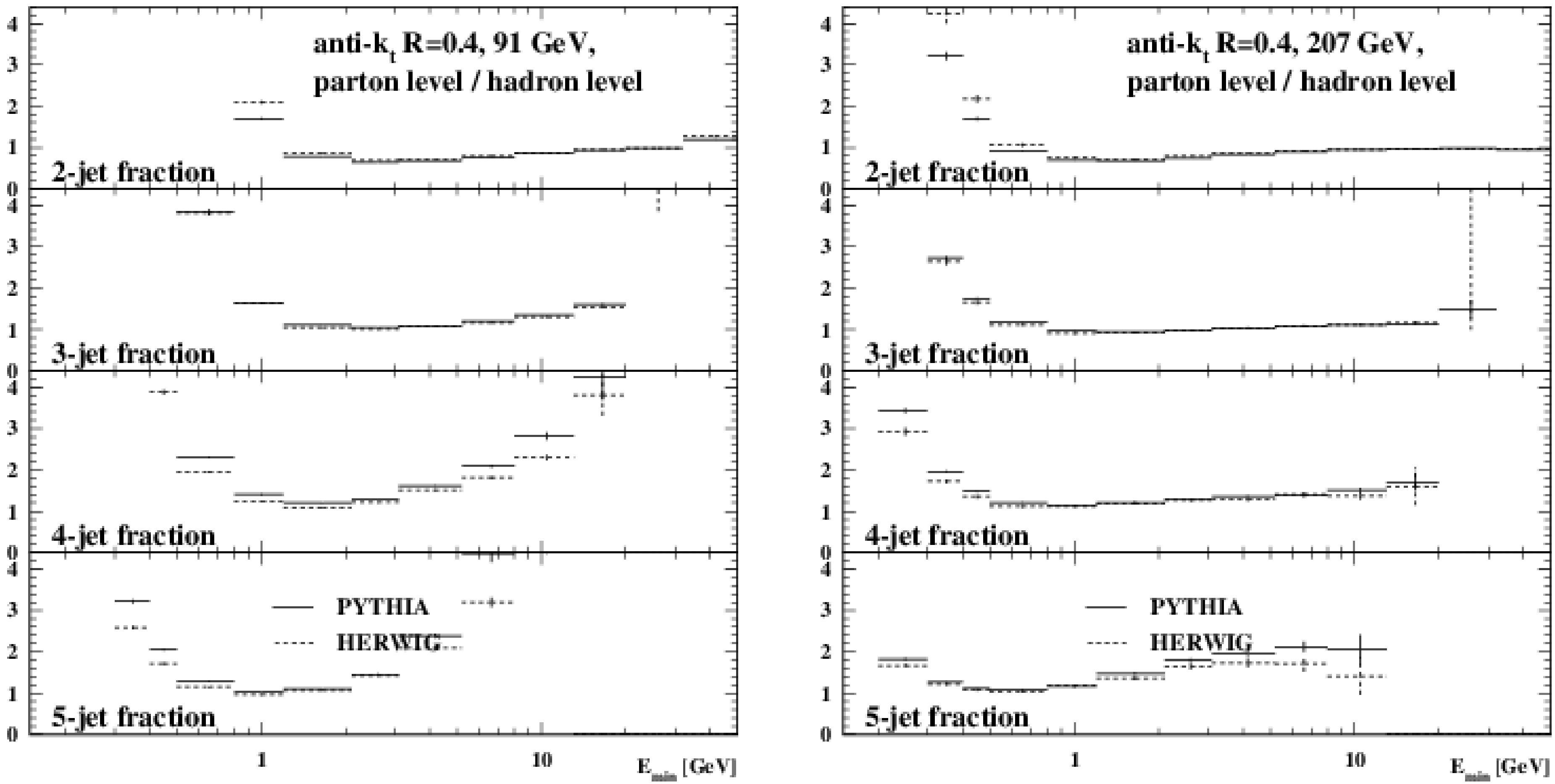

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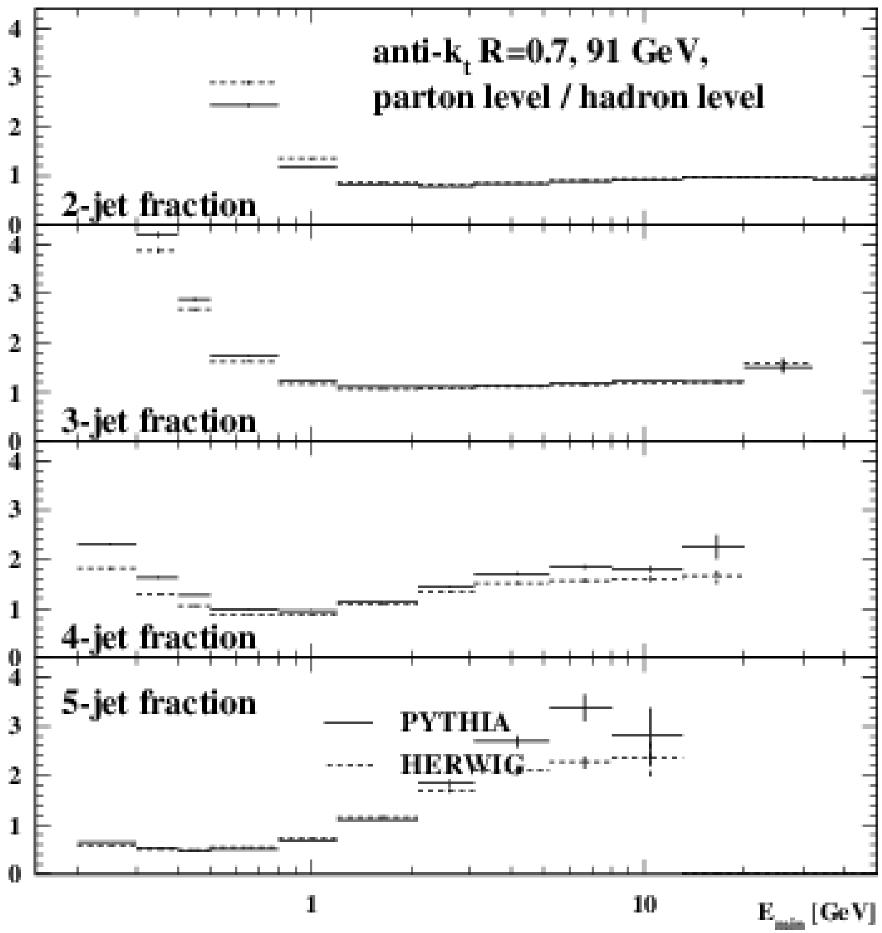
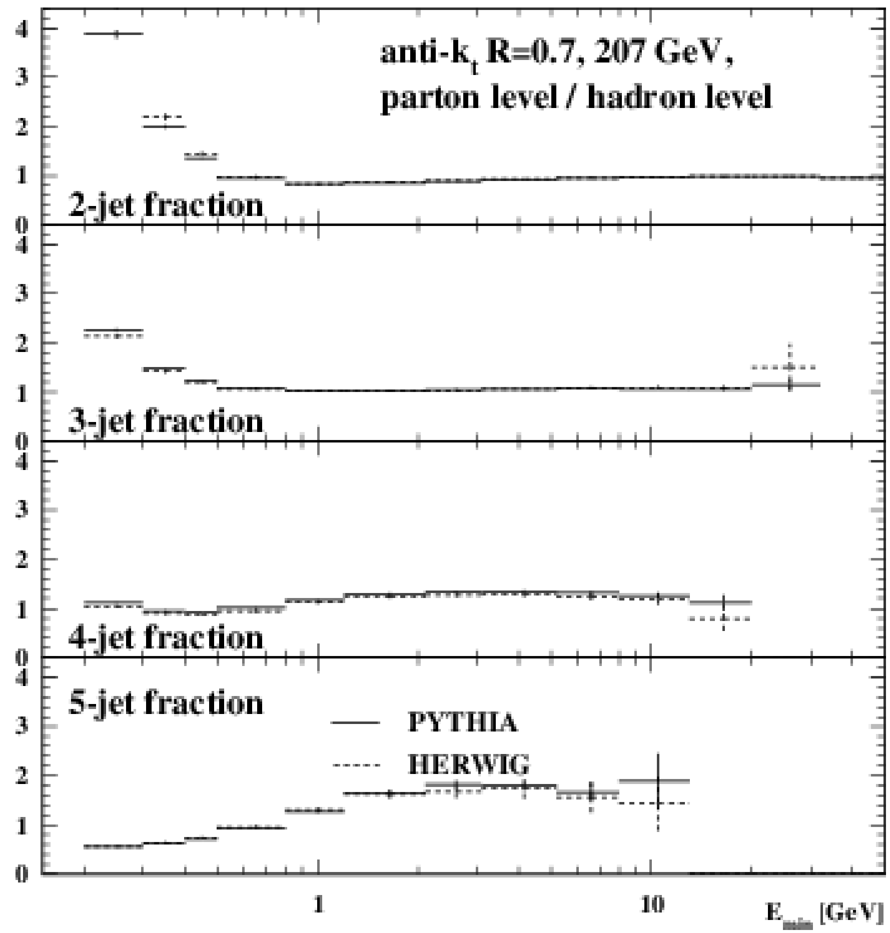
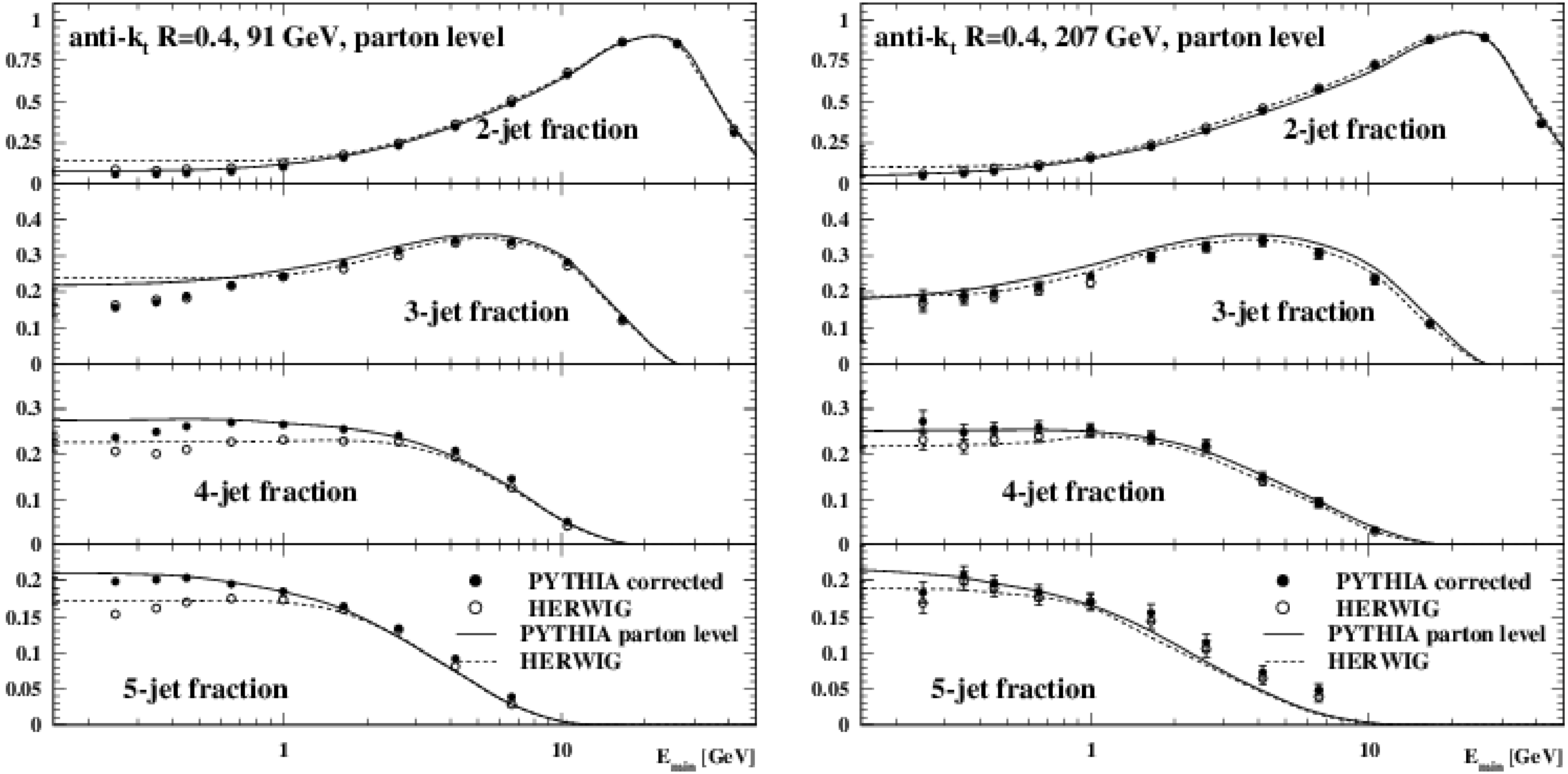




Jet fraction vs. absolute E_{min} cut [GeV]

anti-k_t algorithm R=0.4 on parton level



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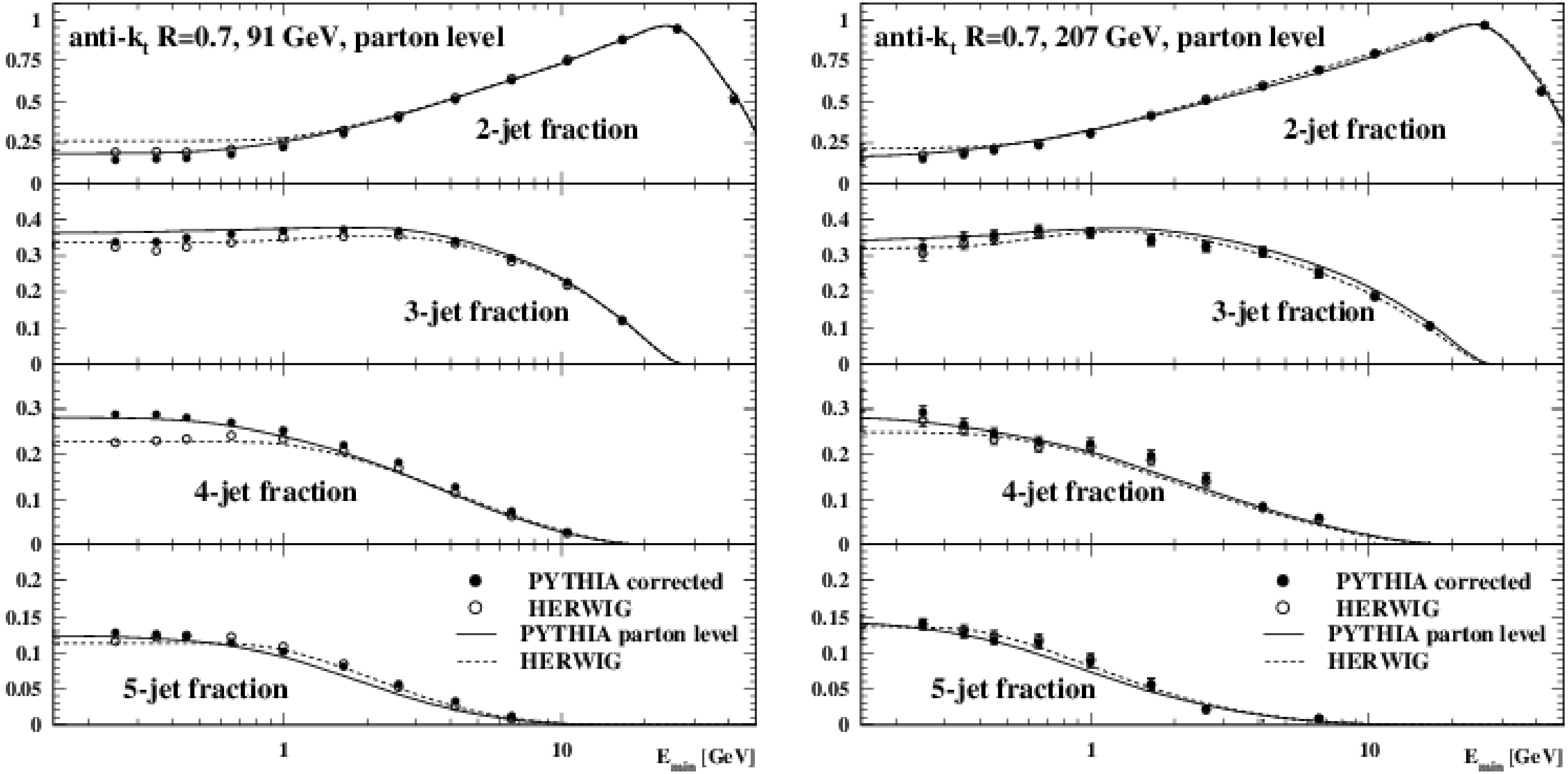
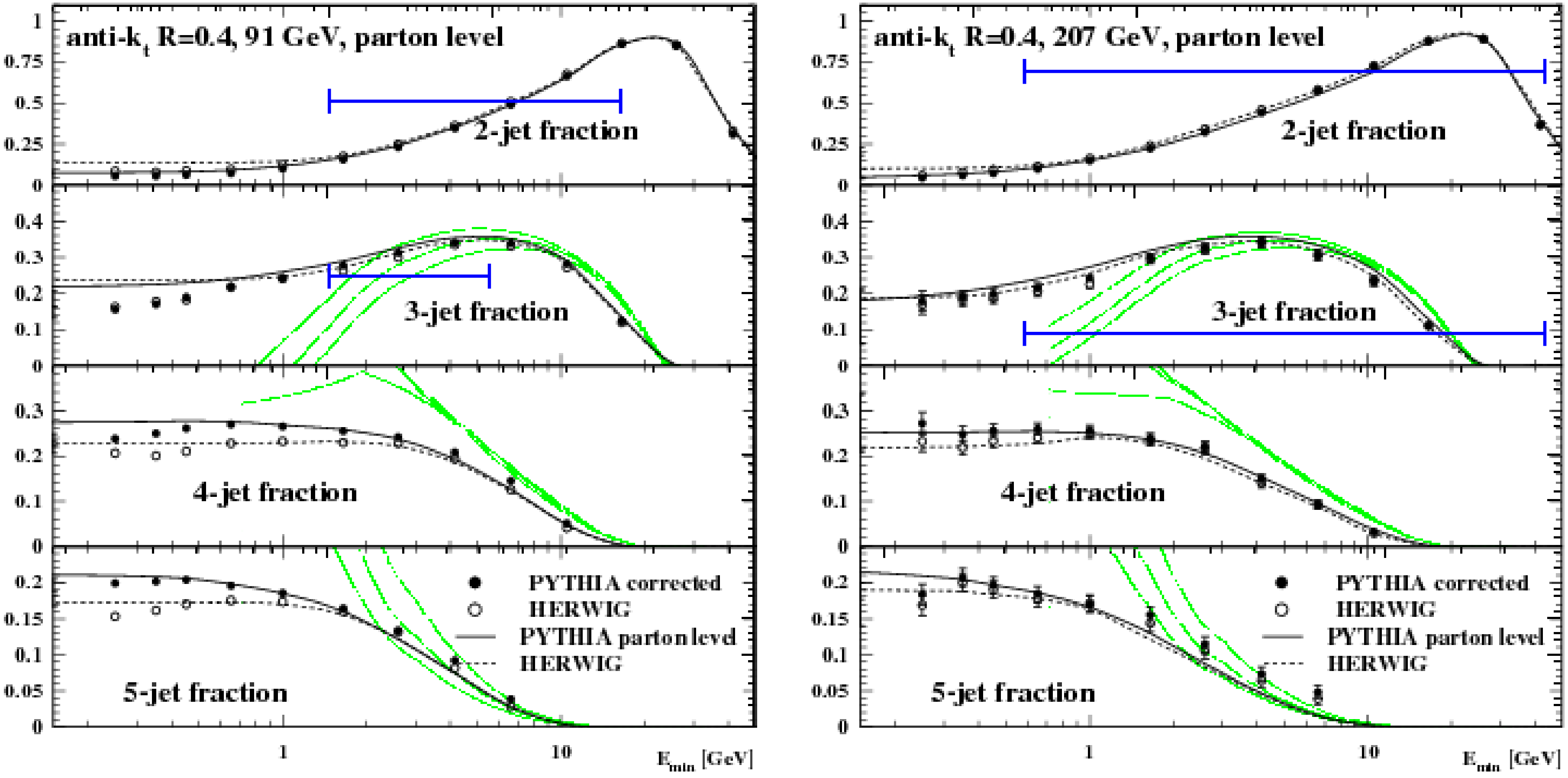


Jet fraction vs. absolute E_{min} cut [GeV]

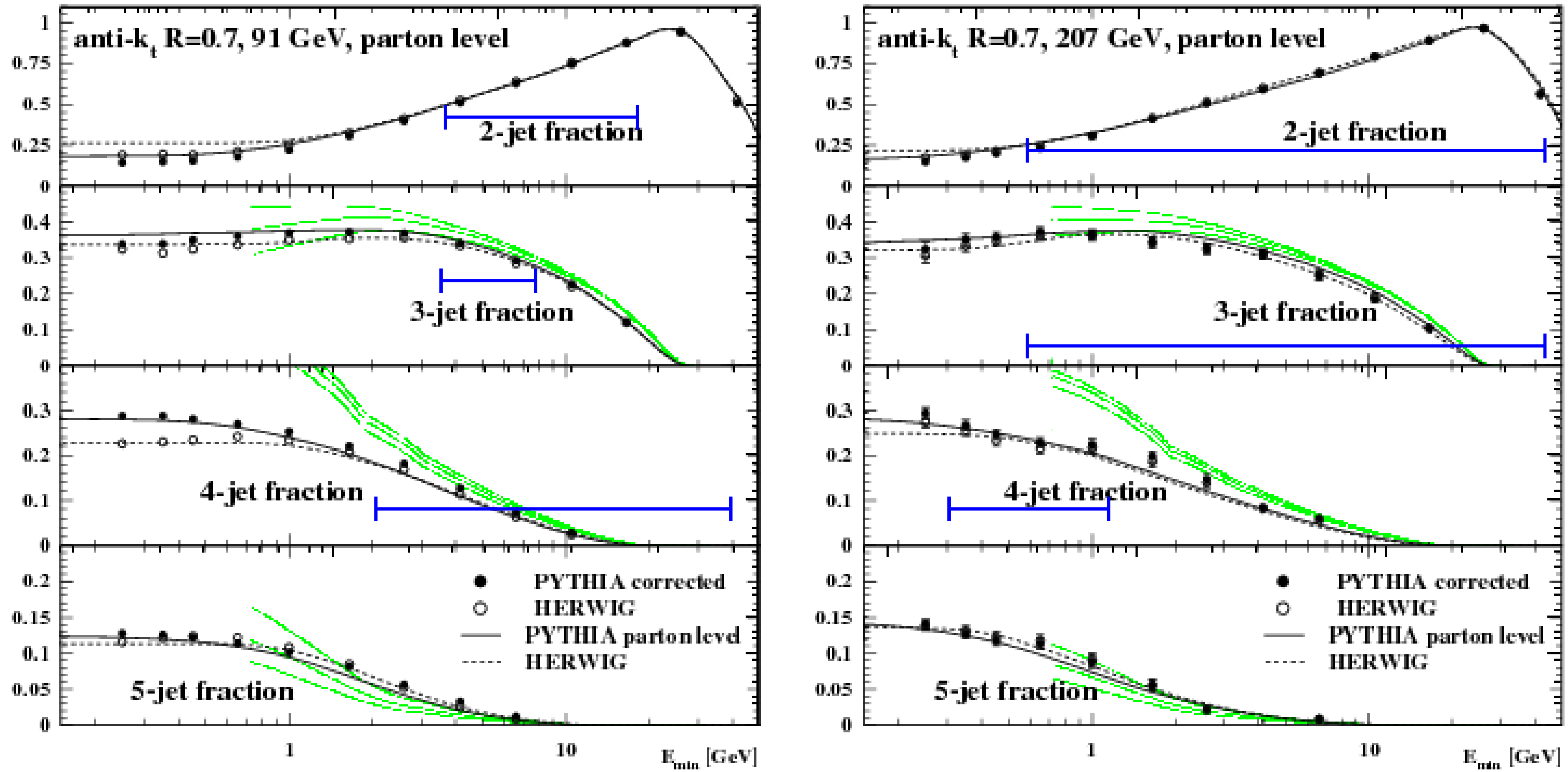
anti-k_t algorithm R=0.4 on parton level +prediction



Jet fraction vs. absolute E_{min} cut [GeV]

Corrections < 20 % x_μ=0.5, 1.0, 2.0

anti-k_t algorithm R=0.7 on parton level +prediction



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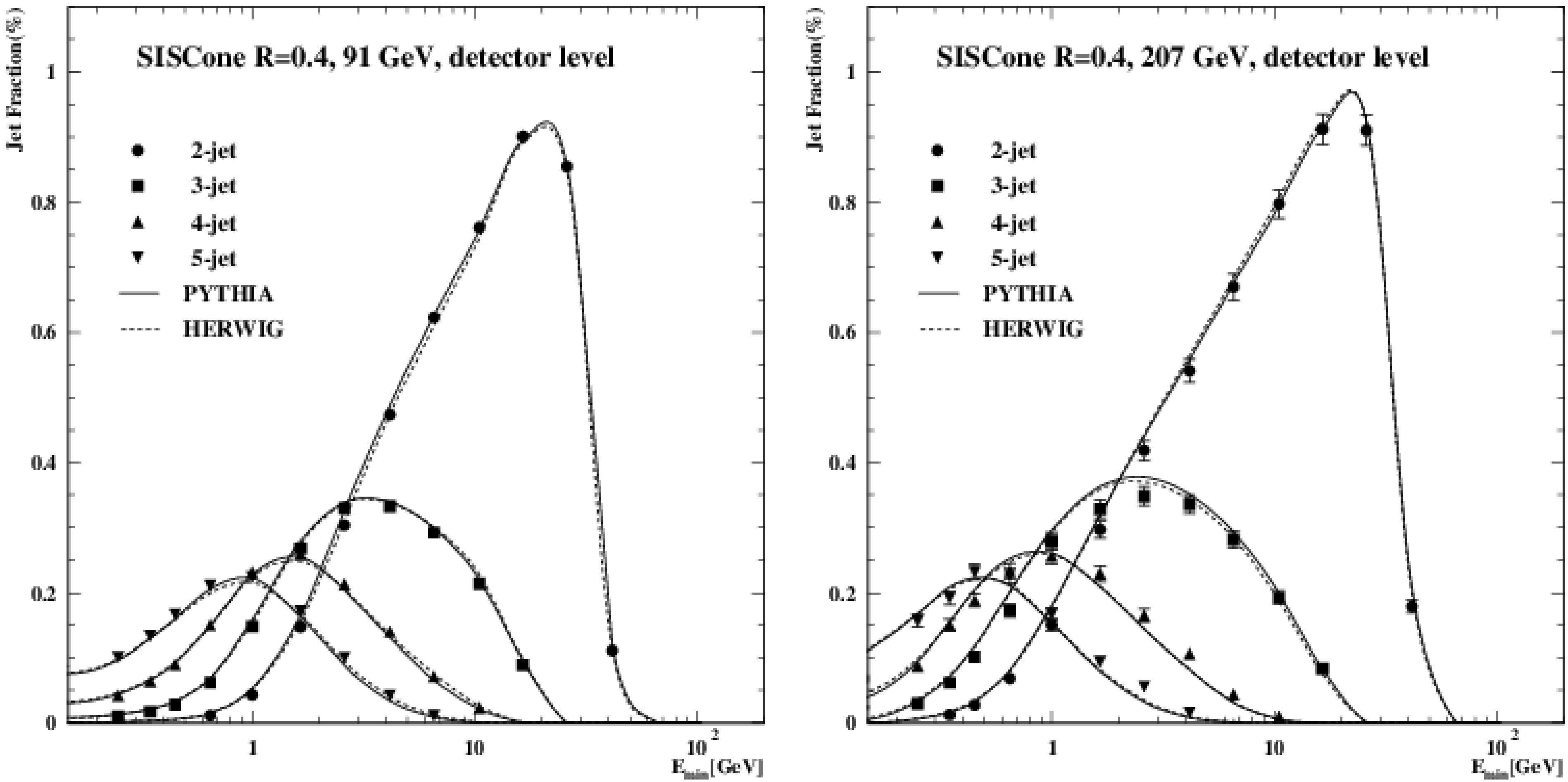

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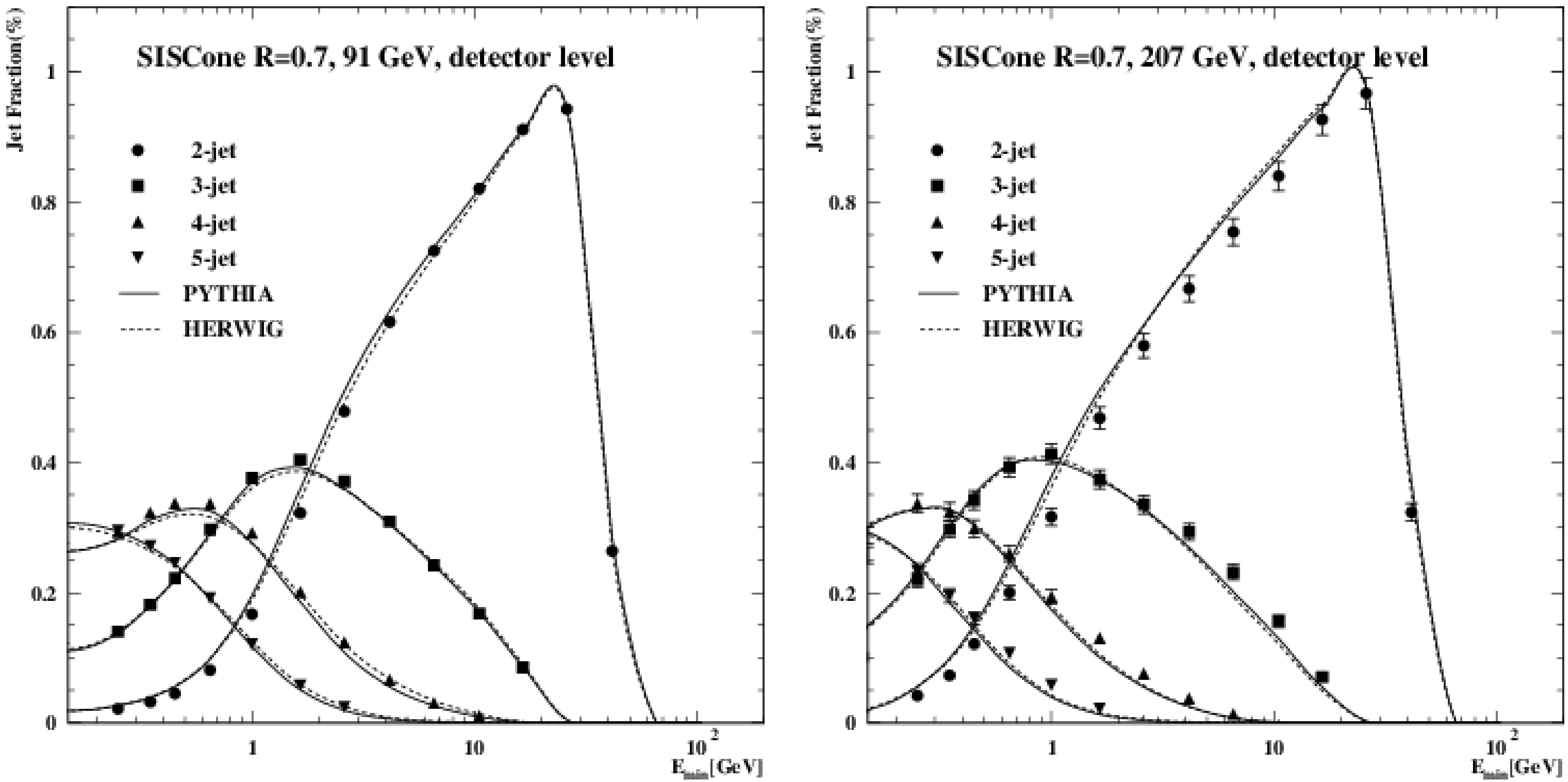

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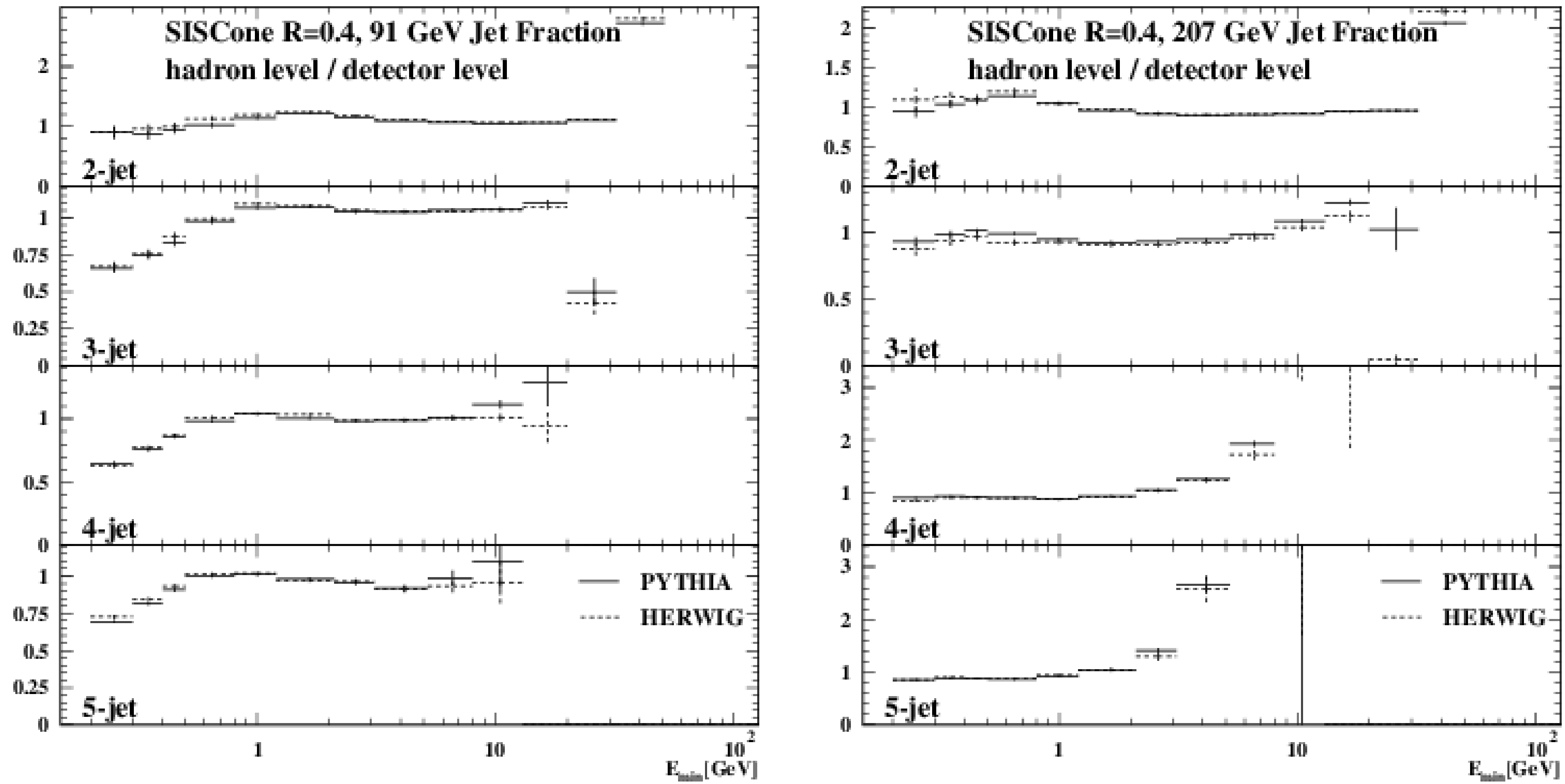

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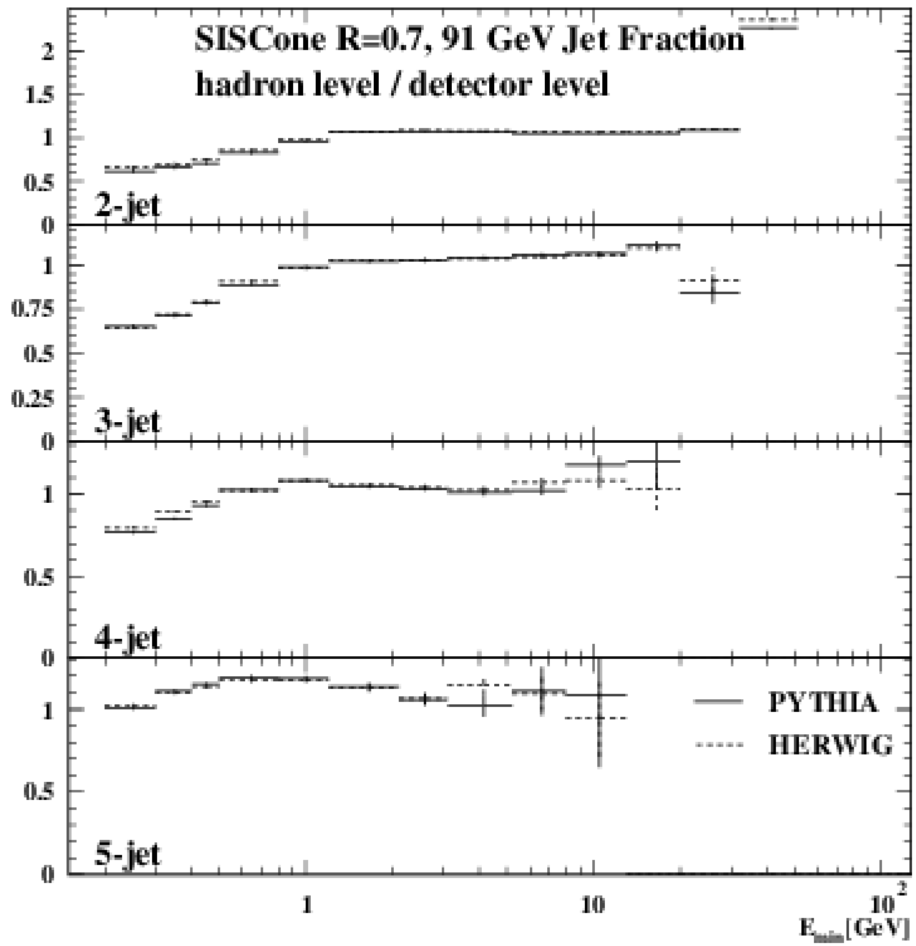

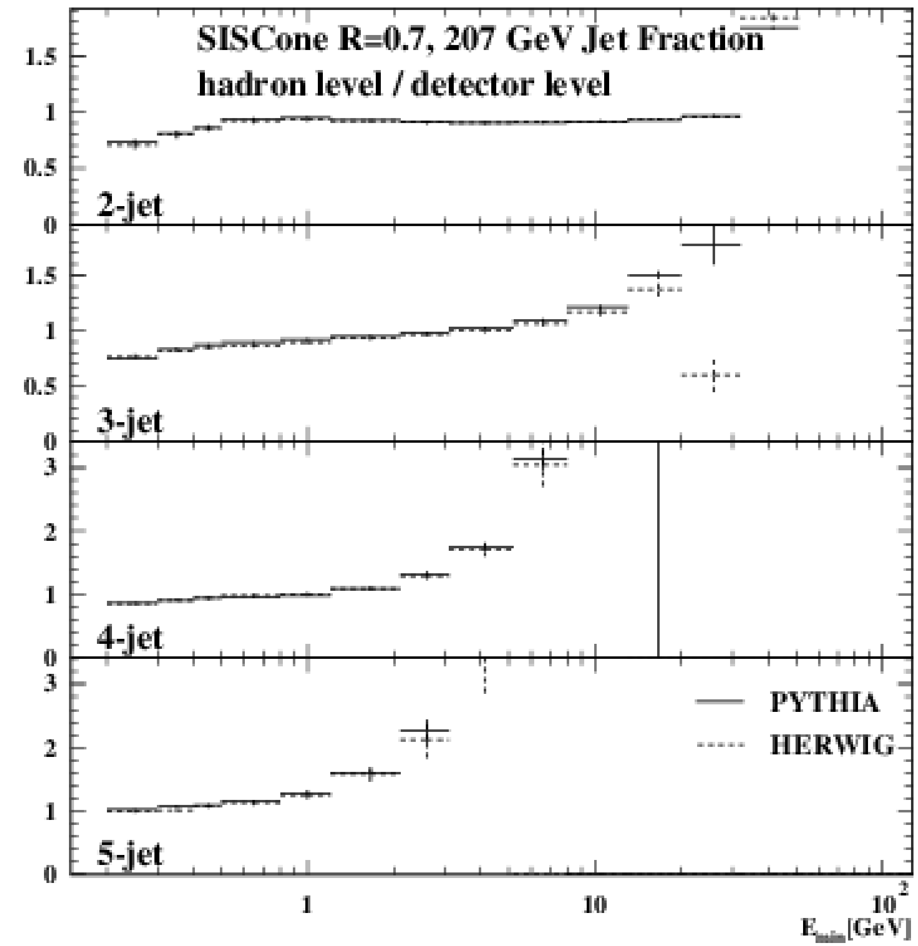

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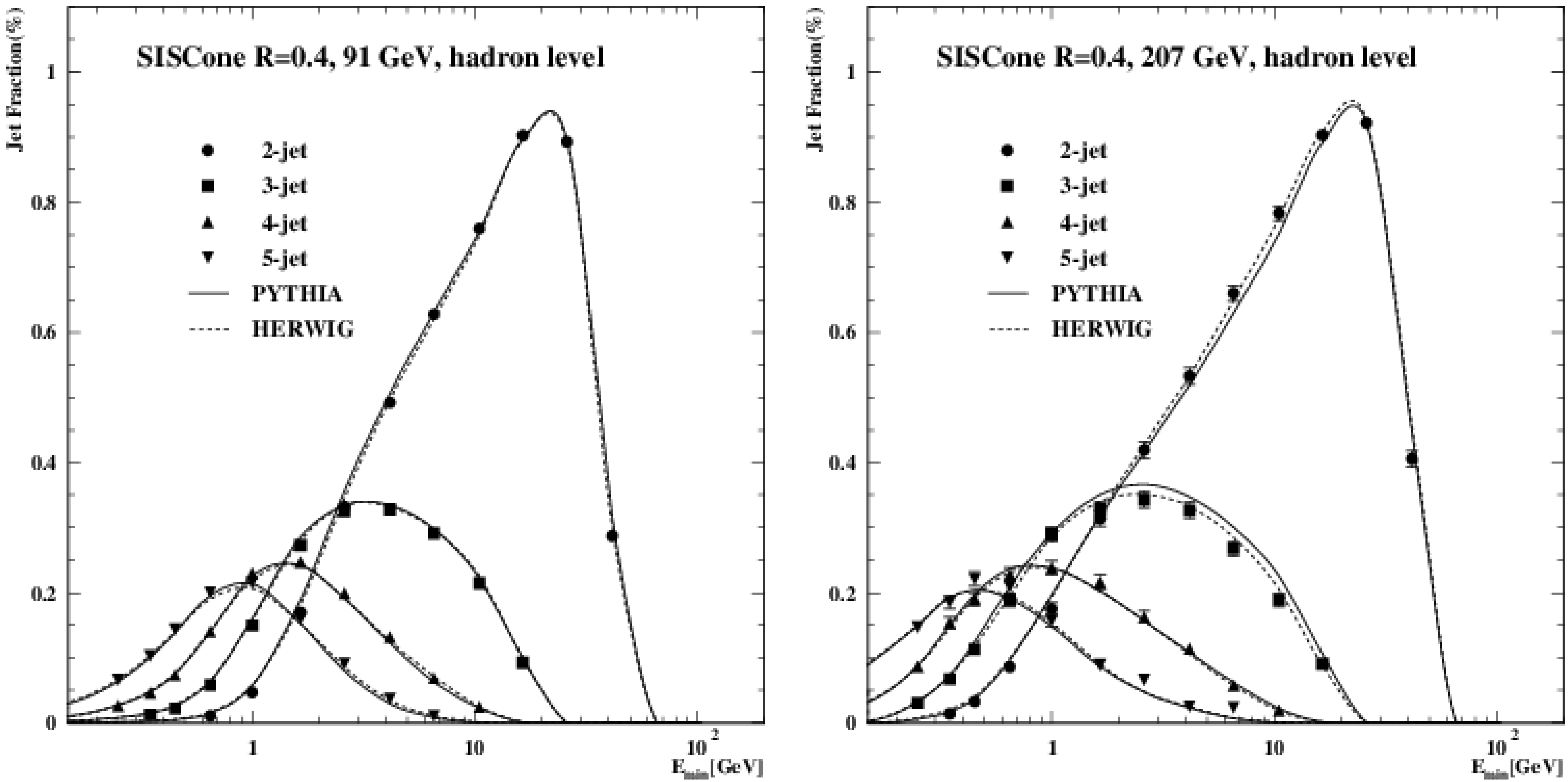

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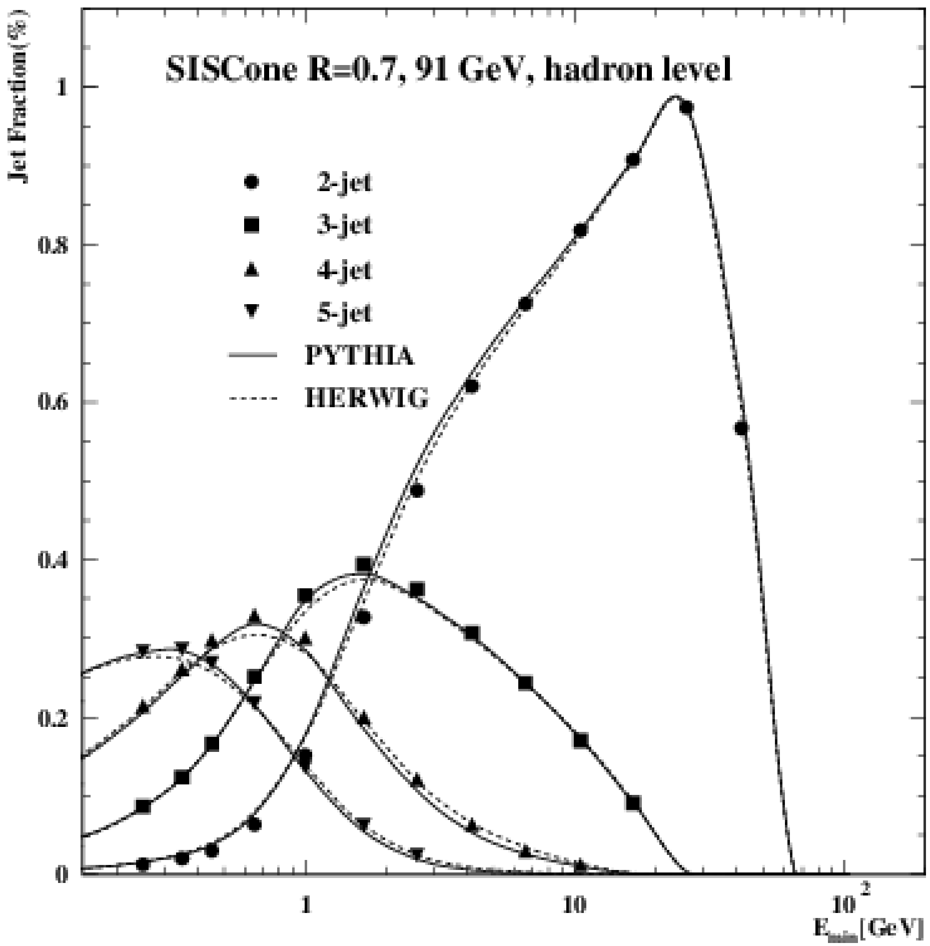
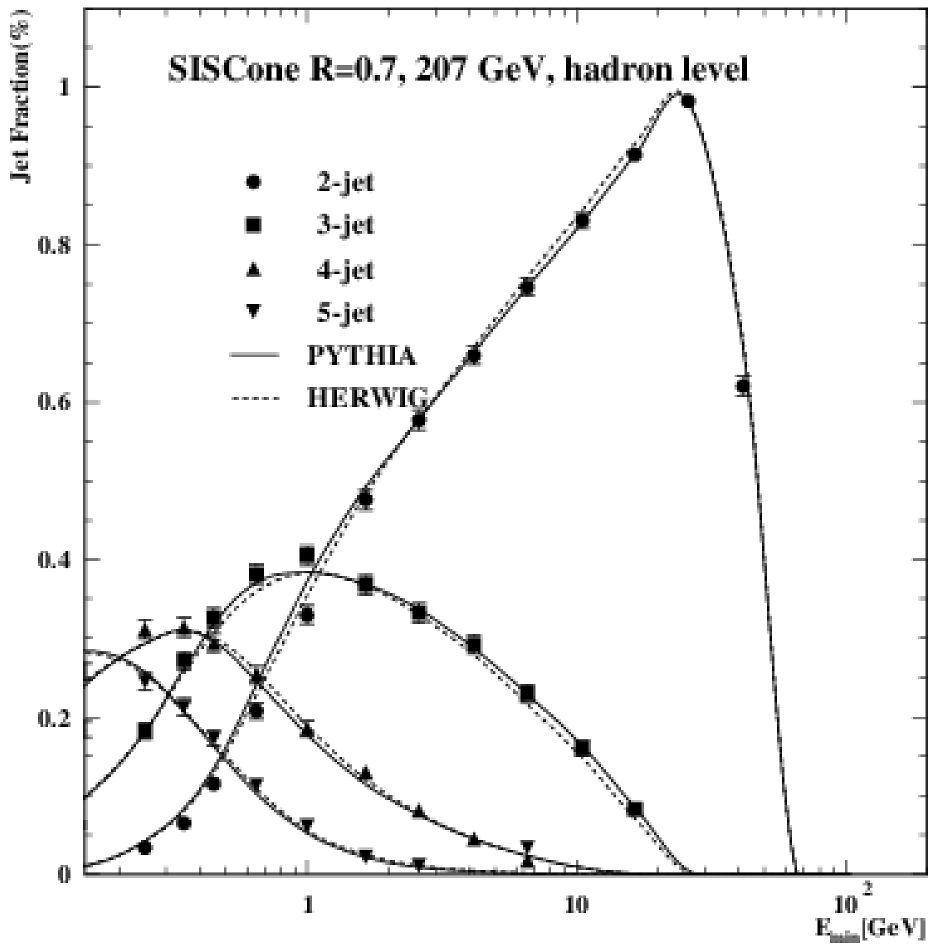
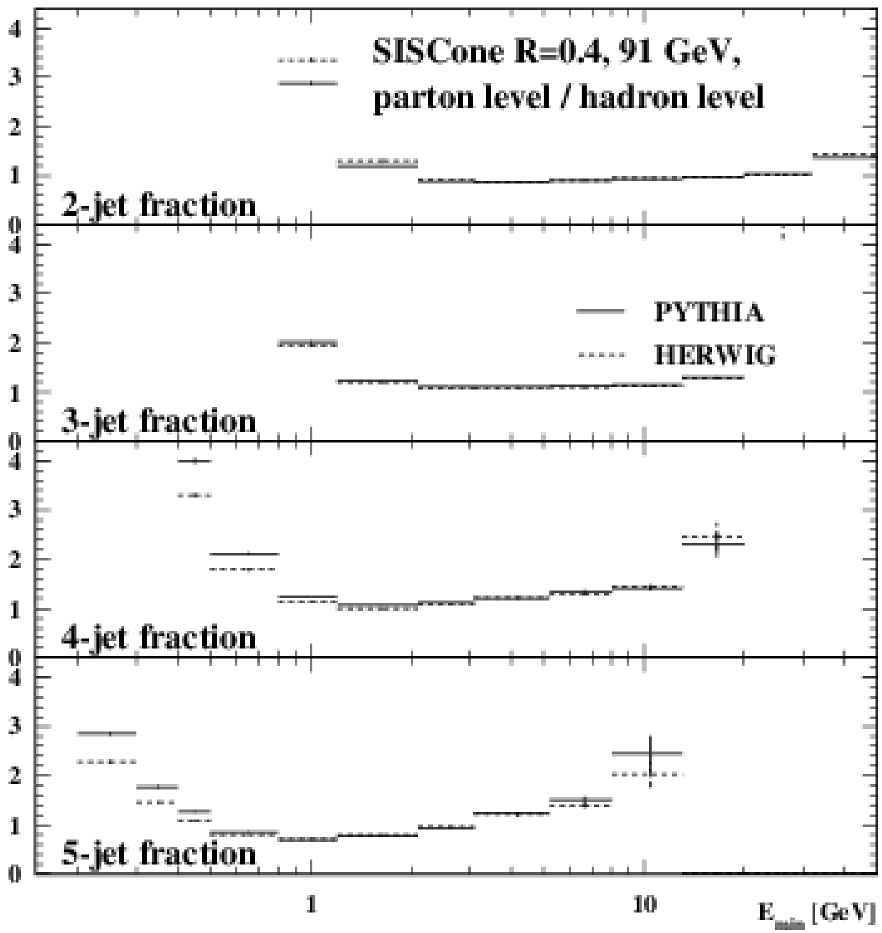
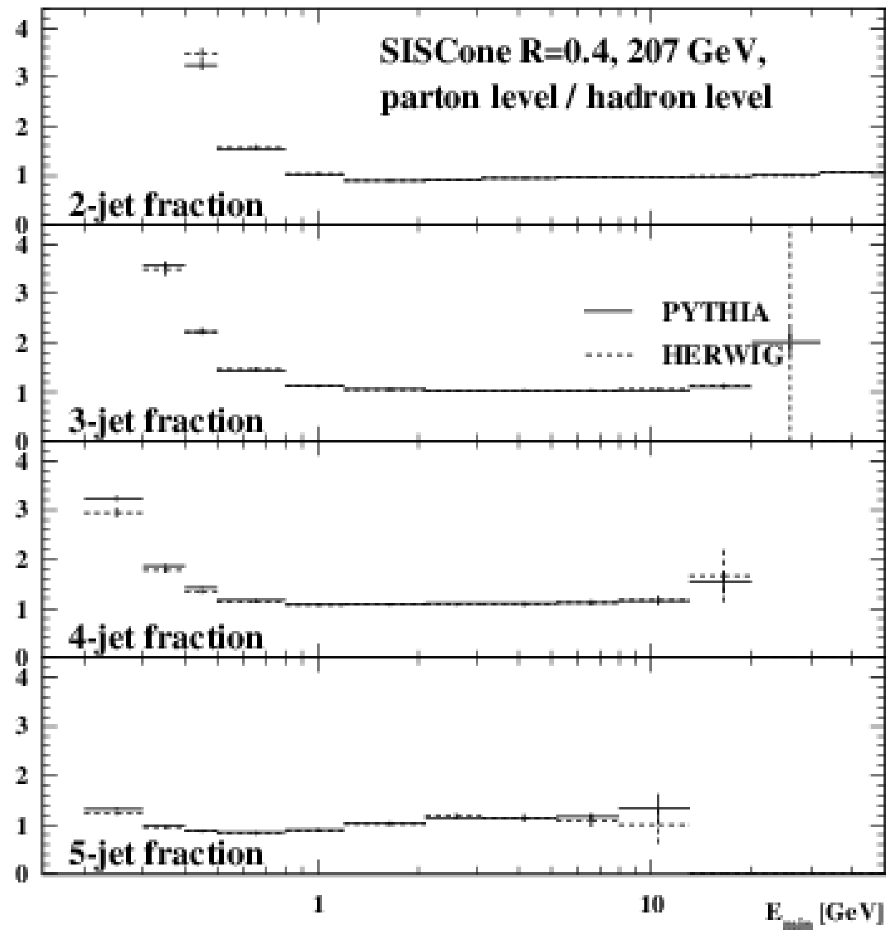




Jet fraction vs. absolute E_{min} cut [GeV]

Hadronisation correction: SISCone algorithm R=0.4





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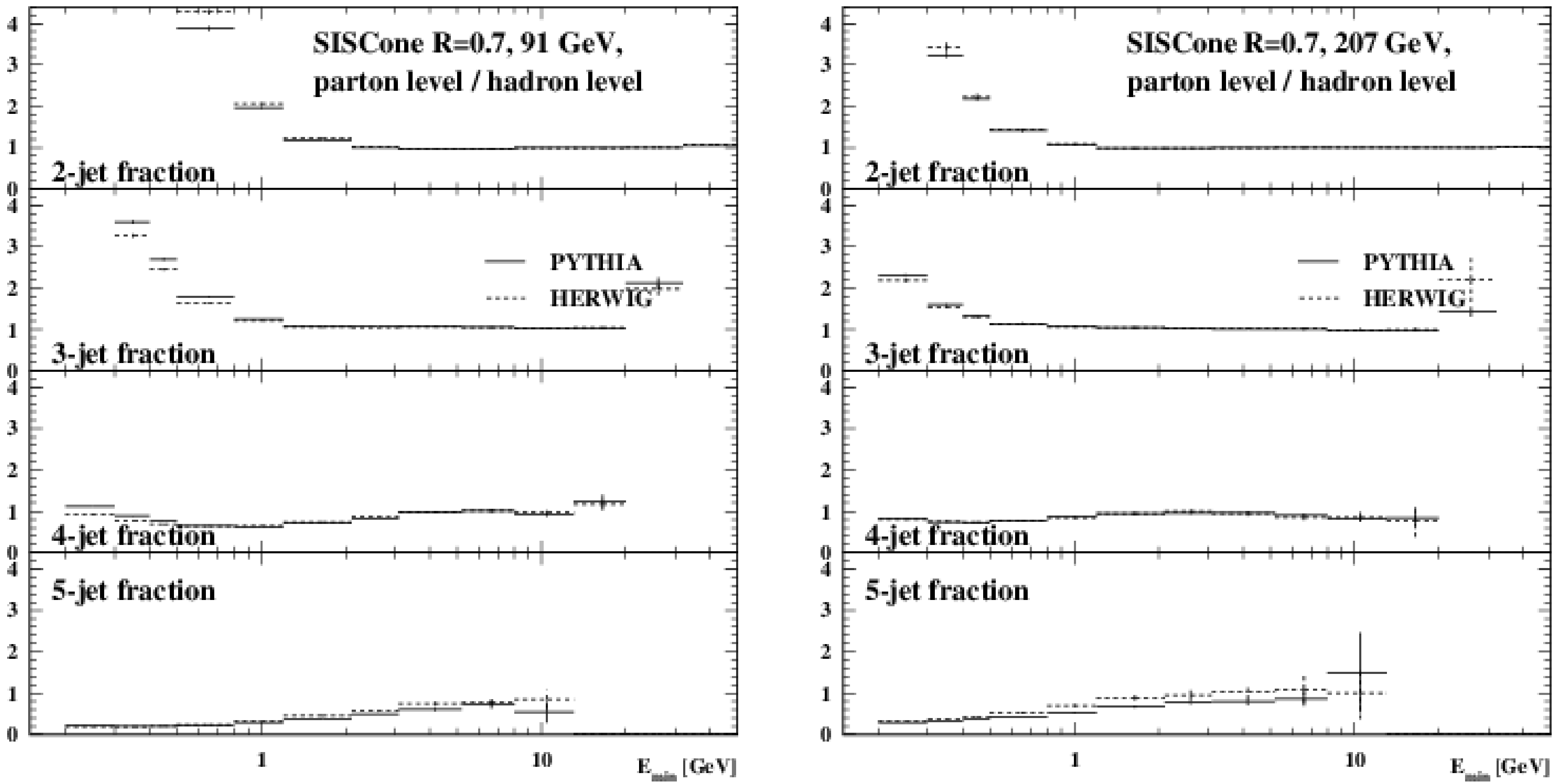

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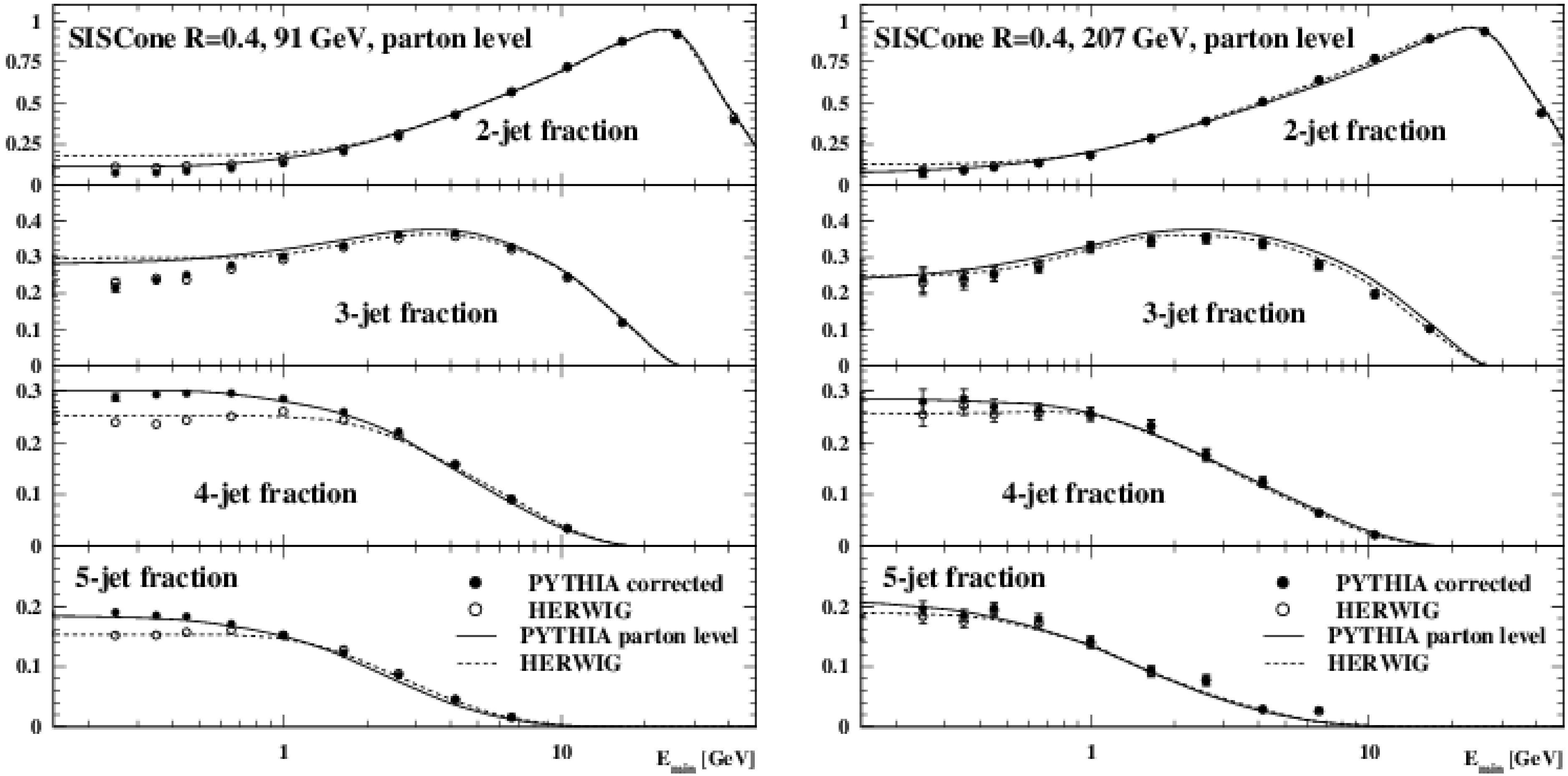
SISCone algorithm R=0.4 on parton level



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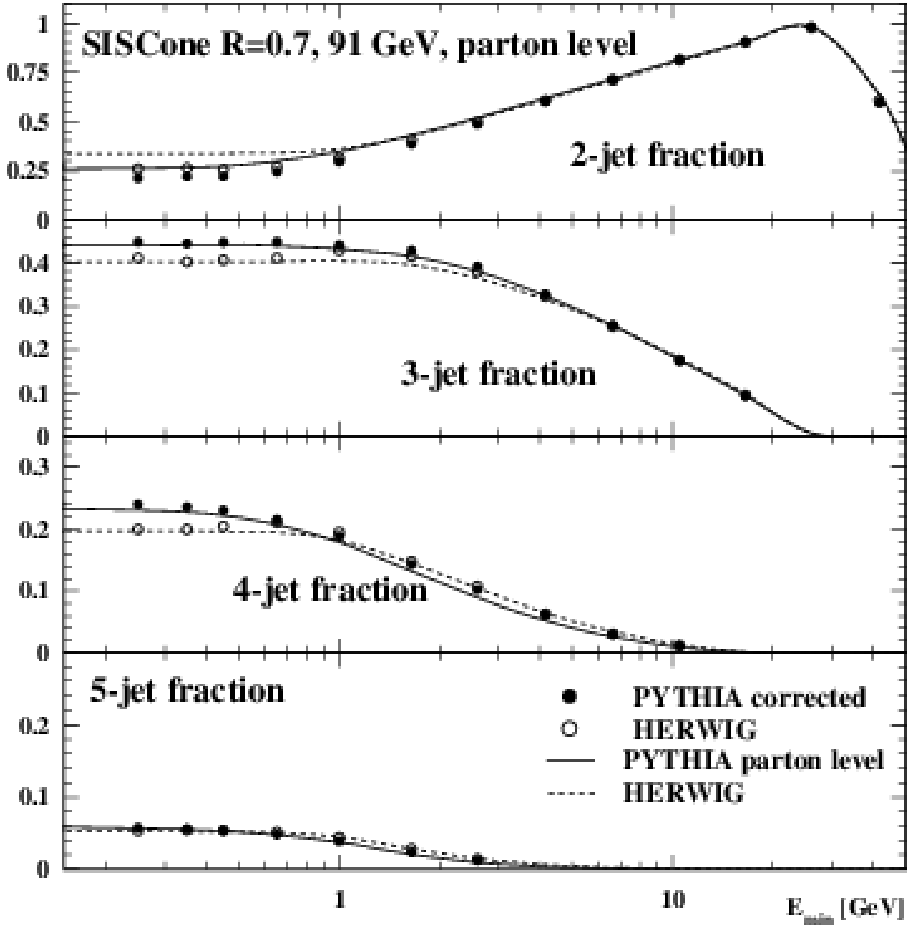

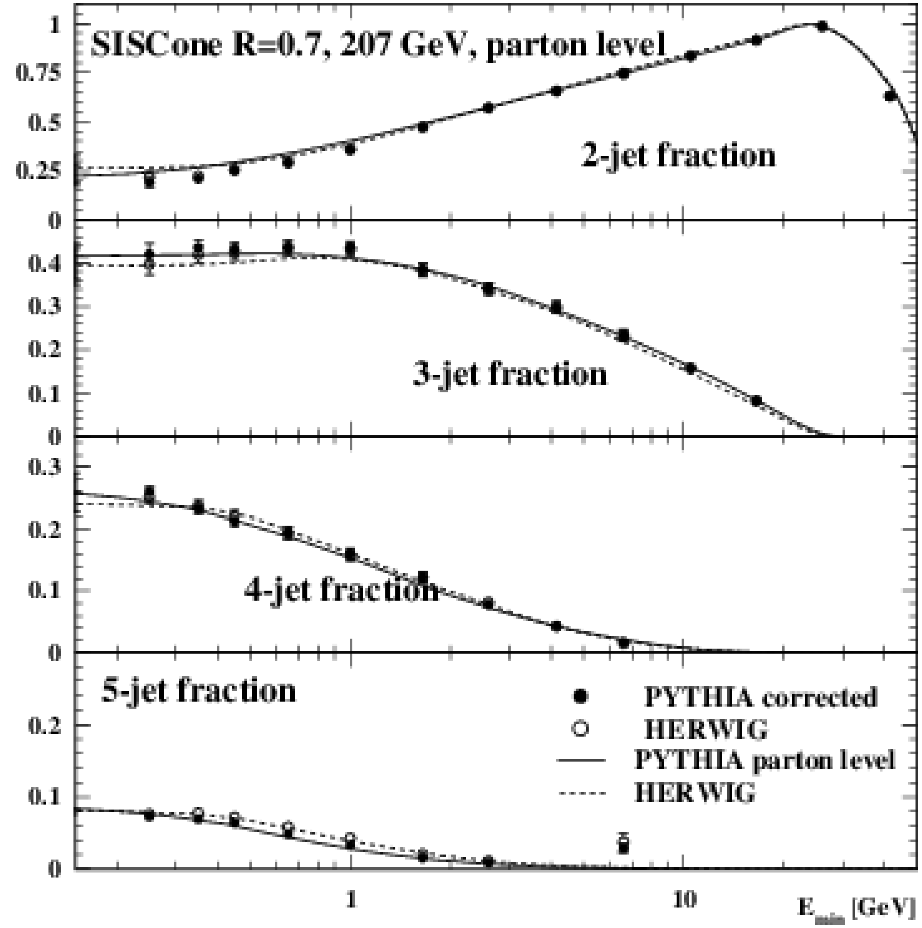

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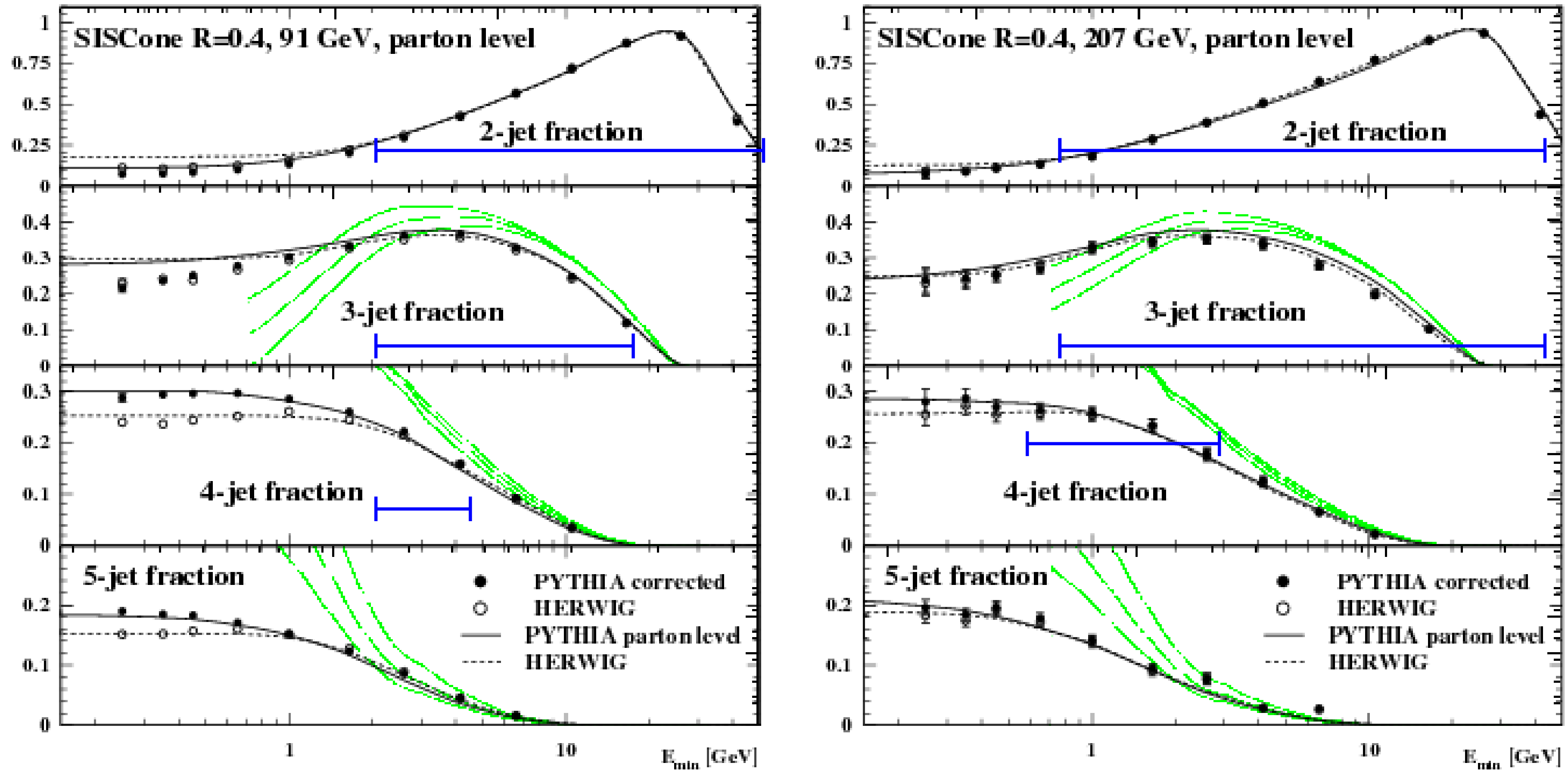

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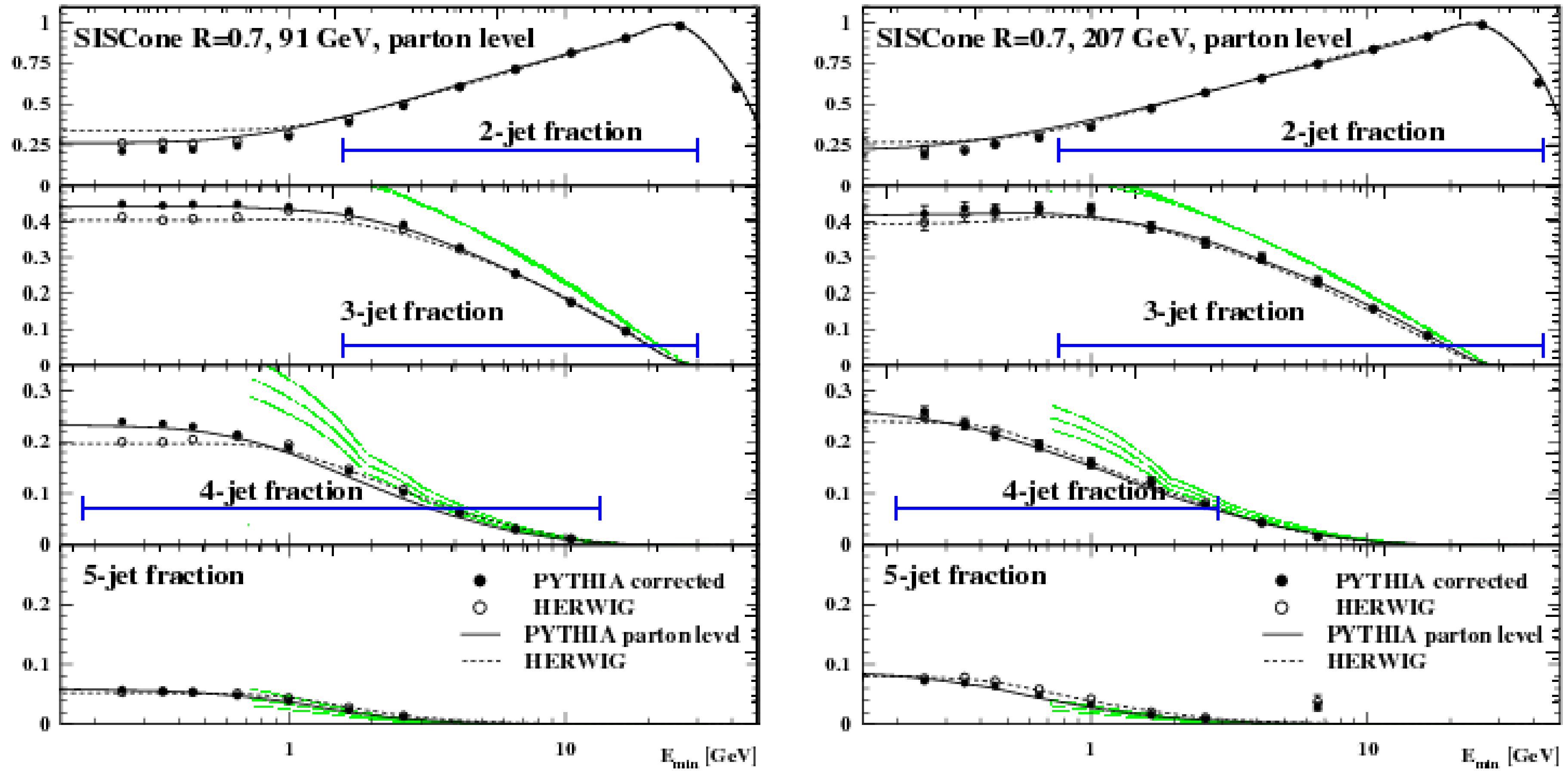

Jet fraction vs. absolute E_{min} cut [GeV]

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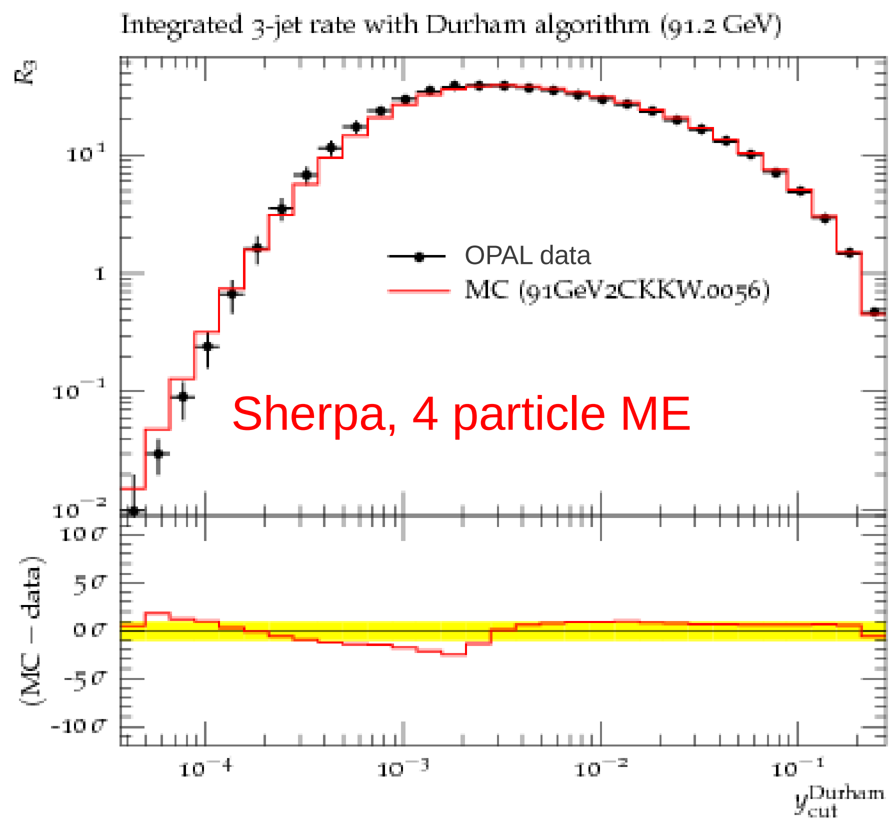
Conclusion

- Inclusive 2-5 jet rates measured with anti-k_t and SISCone algorithms, for radii 0.4, 0.5, 0.6, 0.7, in dependence of E_{min}
- Detector- and hadronisation corrections smallest for E_{min}~2GeV, studies E_{min} =7GeV (my first talk) not adequate
- Suitable fit ranges for
  - Anti-k_t : 2- and 3-jet rates
  - SISCone: 2-, 3- and 4-jet rates
- Three- to five-jet rates : Theory implemented and compared qualitatively with the data (two-jet soon)
  - Agreement in suitable E_{min} ranges
  - Theory uncertainties smaller for higher E_{min} ~5 GeV

Further Steps: Hadronisation correction

- Hadronisation correction employing modern Monte Carlo generator SHERPA – reliable perturbative treatment of high multiplicities + parton shower (with Jan Winter, Frank Siegert, Hendrik Hoeth)
- OPAL tune via PROFESSOR – will discuss inputs soon !



Further Steps : Which Analyses ?

- Proposal Stefan Kluth :
  - Study more radius values ~ 0.2—0.9. In case small corrections are found : Ask Stefan Weinzierl for calculations
  - Study differential distributions (my 1st talk) with E_{min} ~ 2 GeV, ask Stefan Weinzierl for calculations
- My Proposal :
  - Stick to analogy with hadron collider studies
  - Avoid further theory iterations