Investigating dependence of inclusive jet properties on √s and multiplicity in pp collisions at LHC energies

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Motivation

Jets are produced from the fragmentation of hard scattered partons (quarks and gluons) in high energy collisions. Jets originating from quarks and gluons, which differ in their color charges, are expected to have different properties. In experiments, measurements of inclusive jets contain contributions from both quarks and gluons. The properties of inclusive jets are expected to depend on the quark or gluon fraction in them. The gluon density inside a hadron is known to increase with increasing √s [1]. In high multiplicity pp events also the production of hard probes are argued to increase due to increase in gluonic contributions [2]. One would therefore naively expect a change in the properties of inclusive jets at higher √s and also for high multiplicity pp events.

Jet Definition
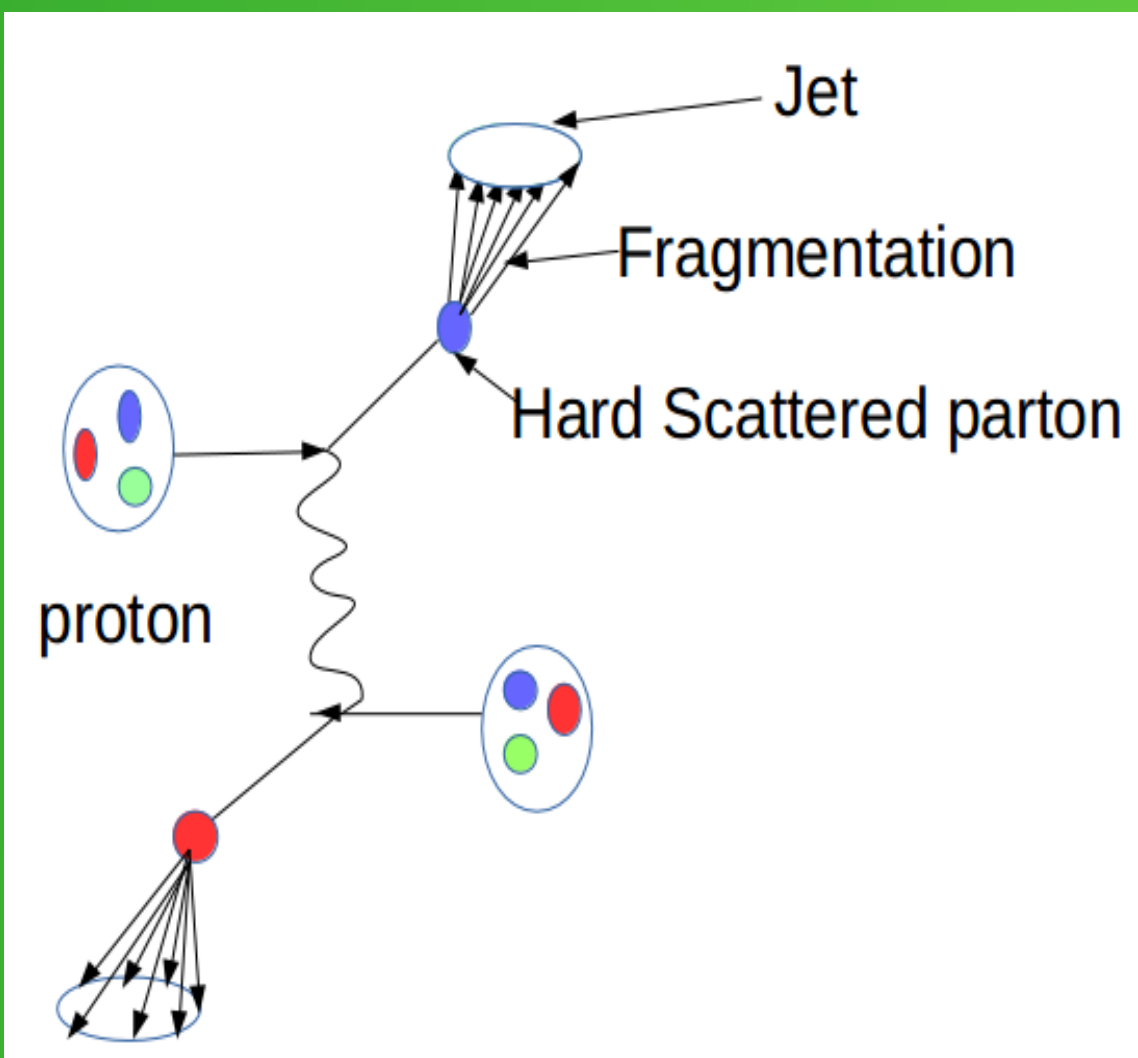
Jets : Collimated bunches of hadrons produced from the fragmentation and hadronization of hard scattered partons in high energy collision.

Jets are : Important probes to study QGP.
: Proxy to the initial hard scattered partons.
: Testing ground for pQCD calculations.

Analysis details

Data Generation
PYTHIA 6.214 simulation
√s = 2.76, 7, 13 TeV

Track and Jet selection
$p_T^{track} > 0.15$ GeV/c, $|\eta^{track}| < 0.9$
Jet Algo : FastJet Anti-k_T
$5 < p_T^{jet} < 100$ GeV/c
Jet Radius, $R = \sqrt{\Delta\eta^2 + \Delta\phi^2} = 0.4$

Underlying event
Perpendicular cone method is used.

Observables & terminology

The mean particle multiplicity in jet, $<N_{ch}> = \dfrac{1}{N_{ch,jets}} \sum\limits_{i=1}^{N_{ch,jets}} N_i$

where N_i is the no. of particles in the i-th charged jet.

$<R80_{ch}>$: The average radius in the Δη-ΔΦ space that contains 80% of the total p_T found in charged jet cone.

Gluon fraction (f_g) = $\dfrac{No. of hard scattered gluons}{No. of total hard scattered partons}$
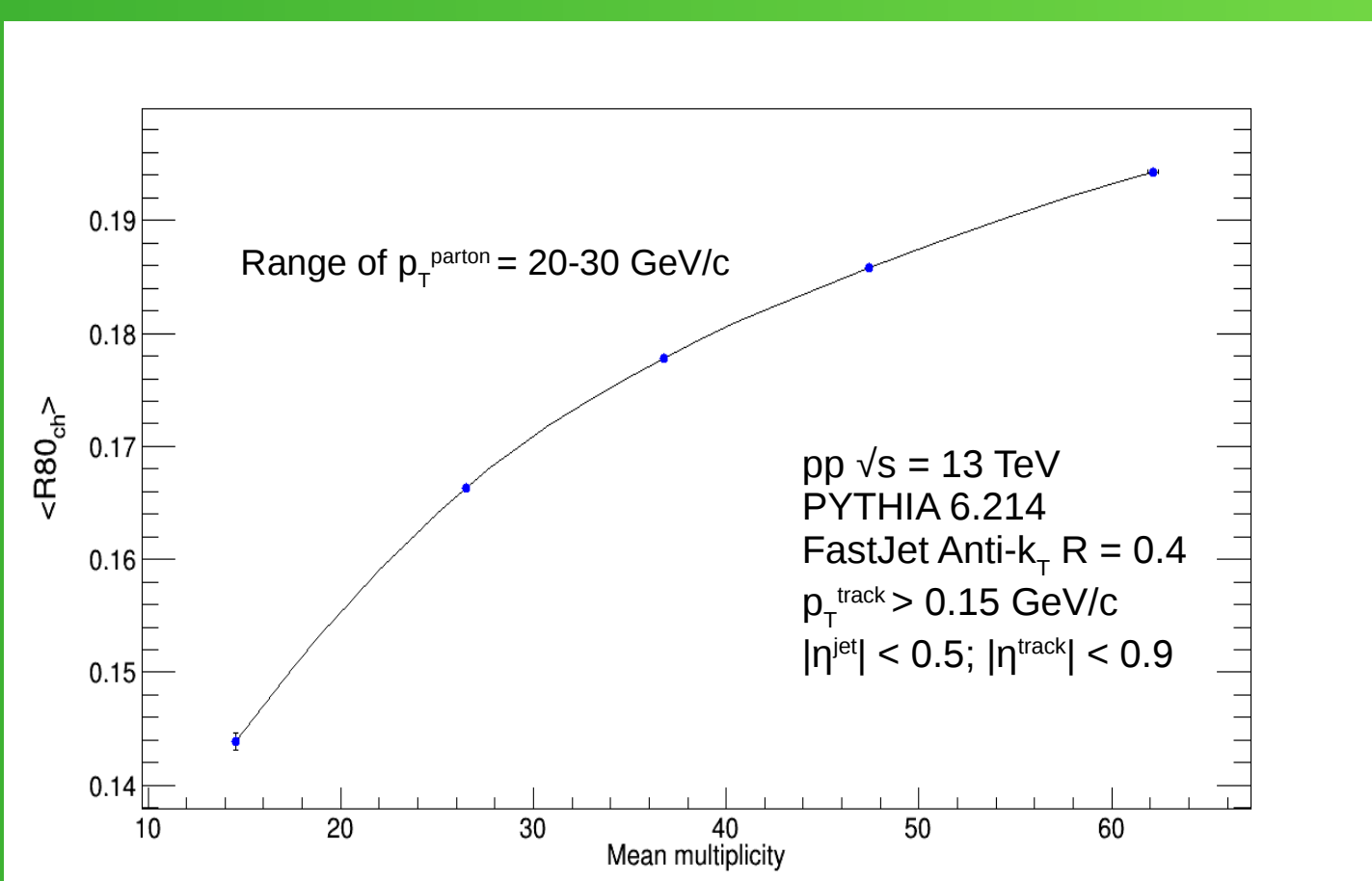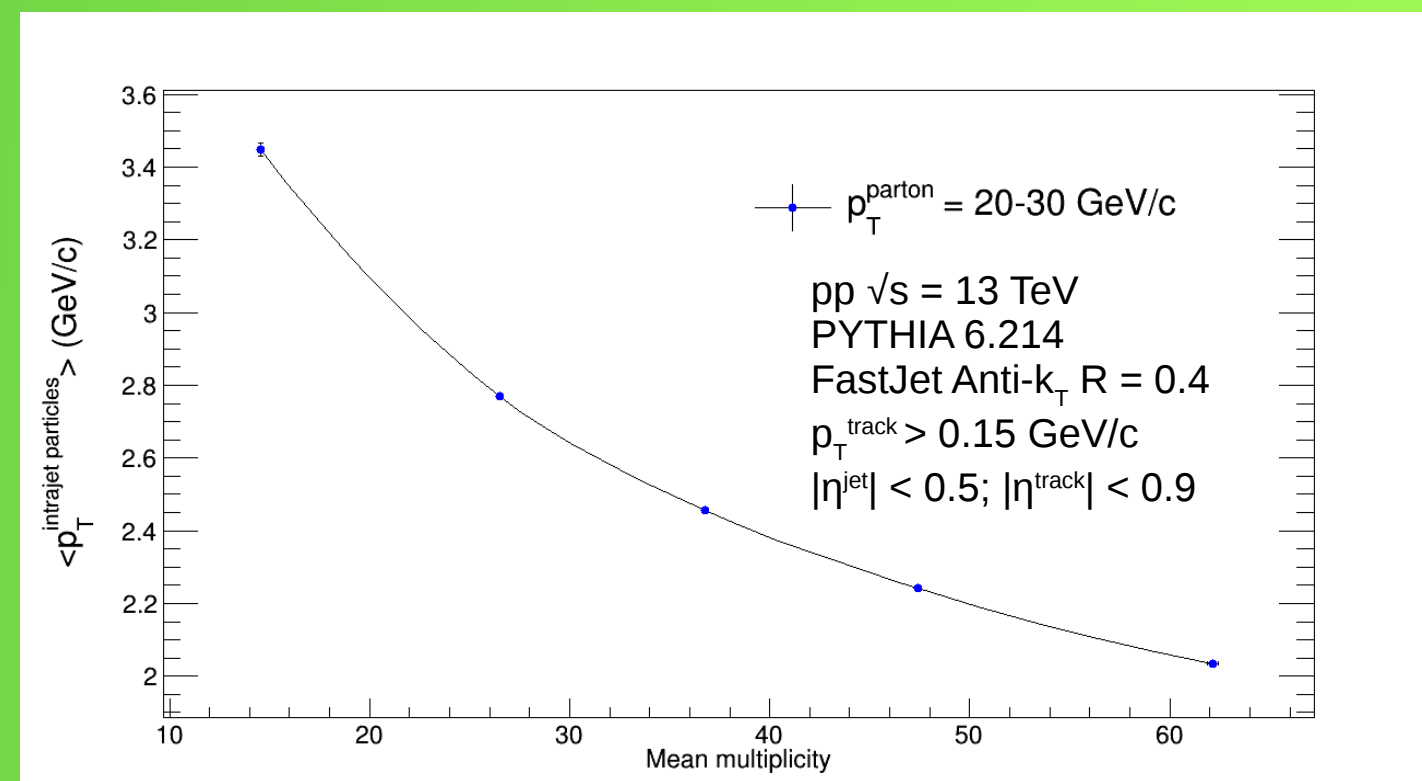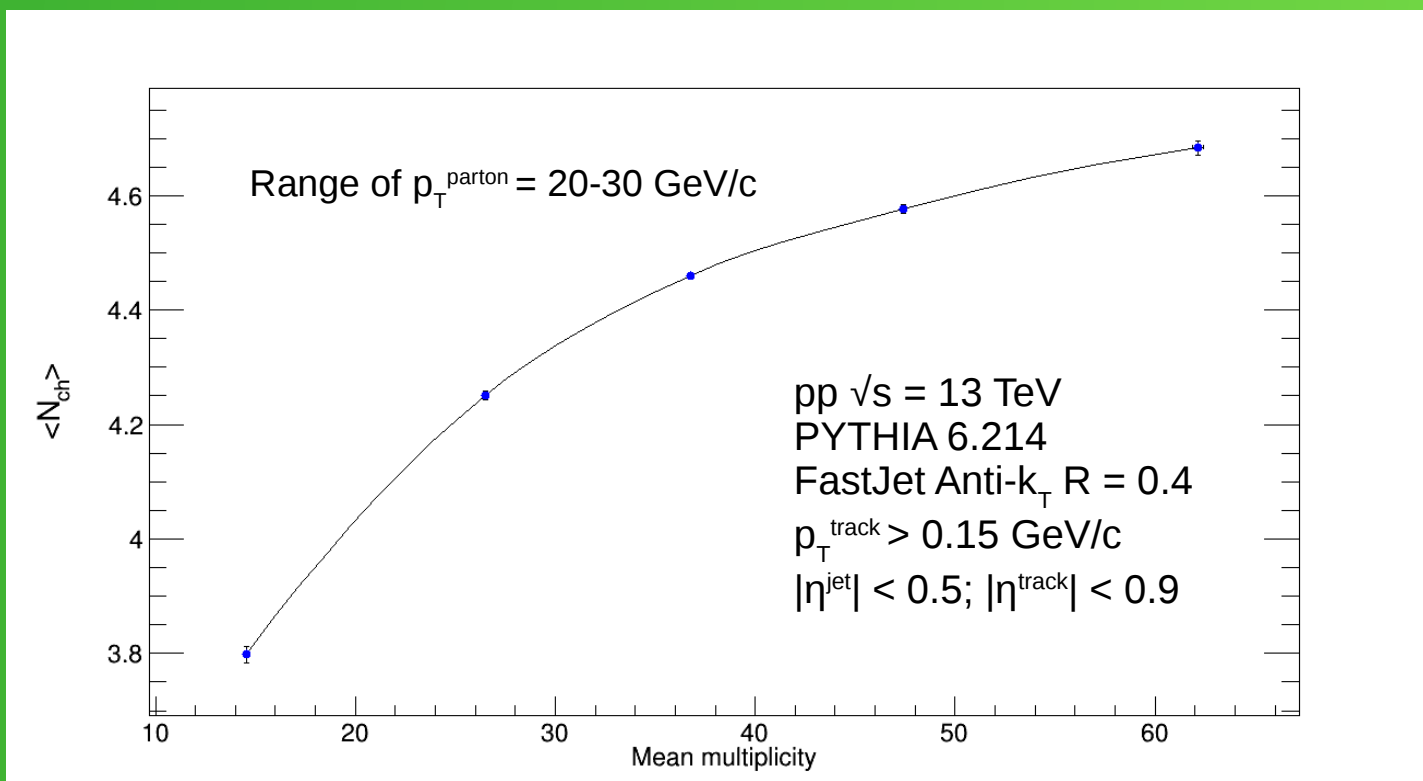
Quark Jet : Reconstructed jet initiated by quark.

Gluon Jet : Reconstructed jet initiated by gluon.

Jet Matching : Reconstructed jets are matched to initial partons using a closest distance approach

Multiplicity bins : 0-1% (>55), 2-6% (43-55), 7-20% (33-42), 21-50% (22-32), 51-100% (<22)
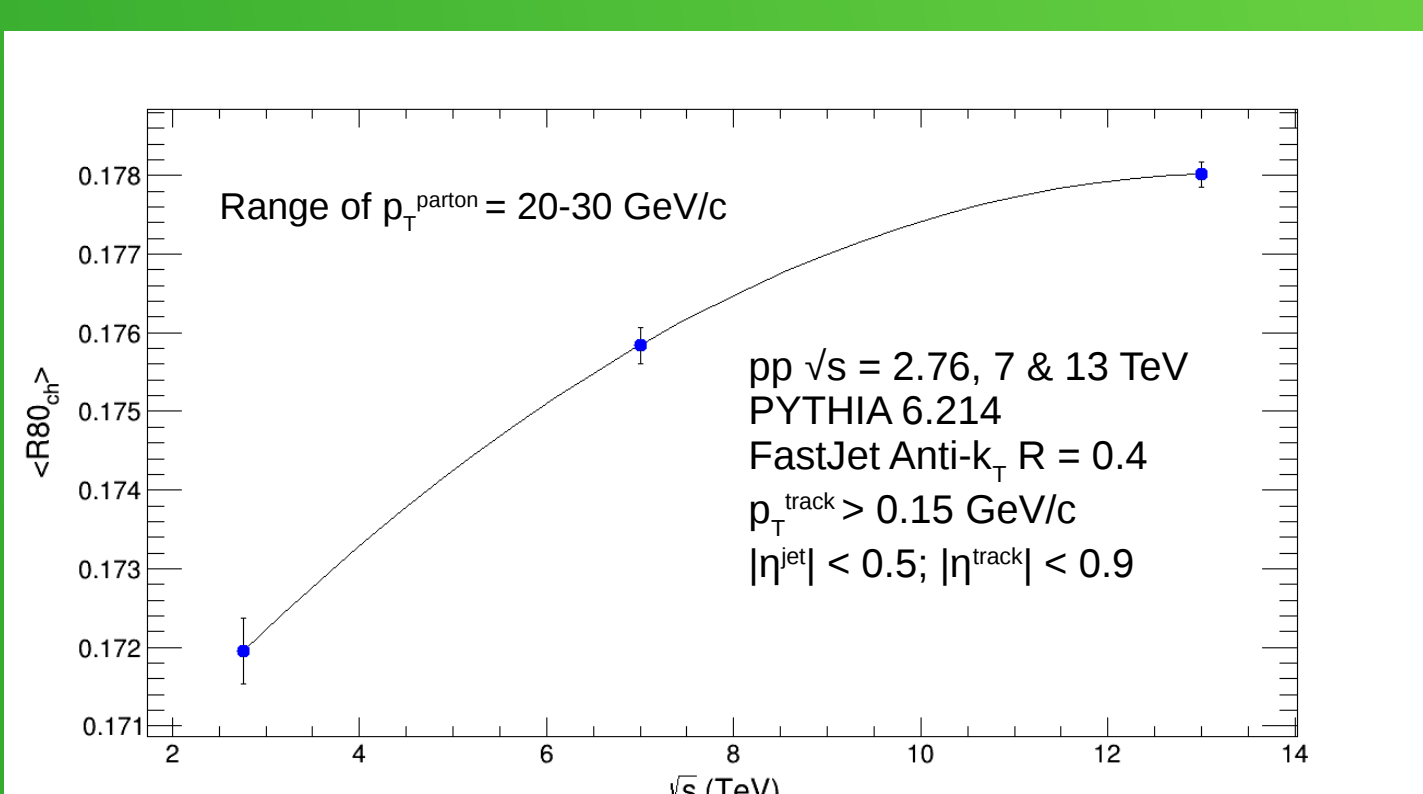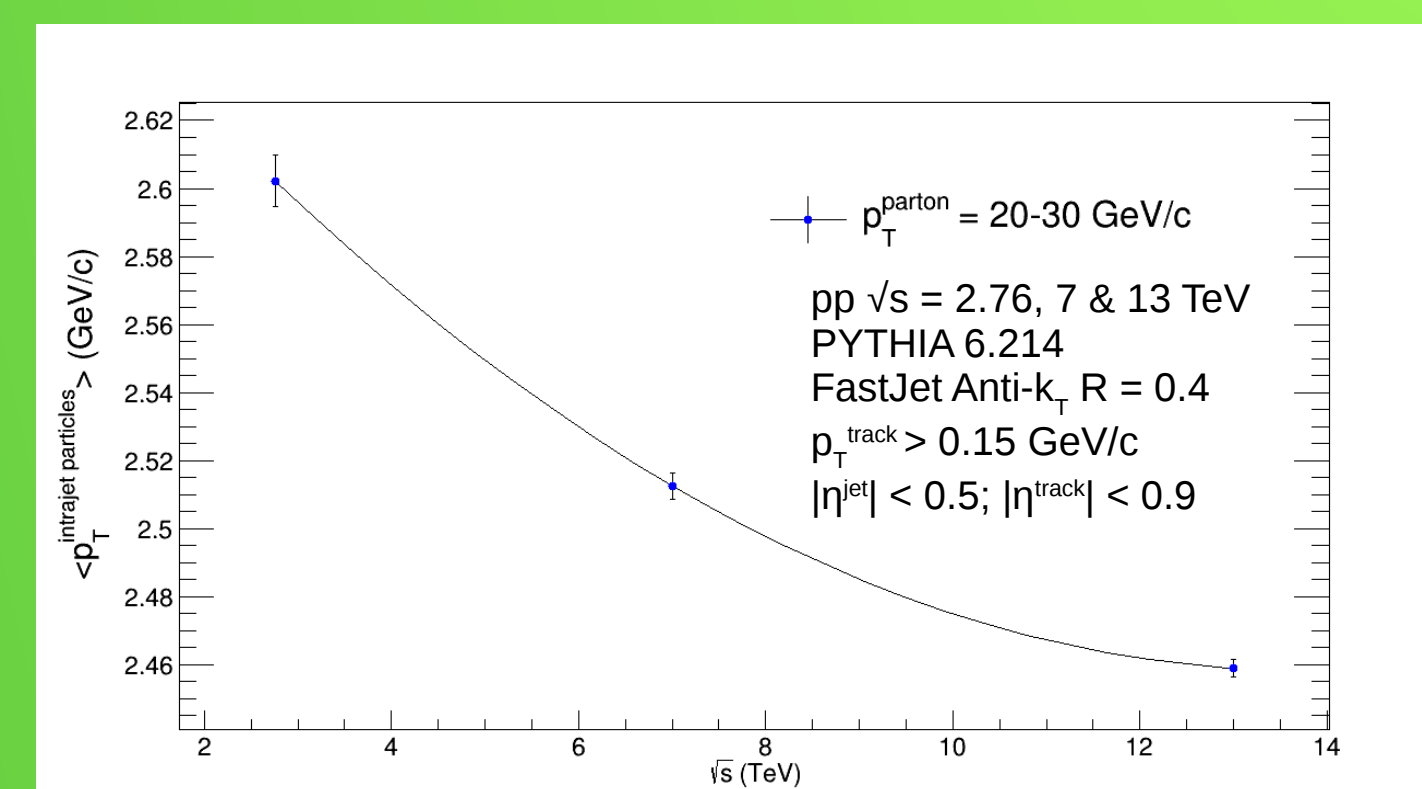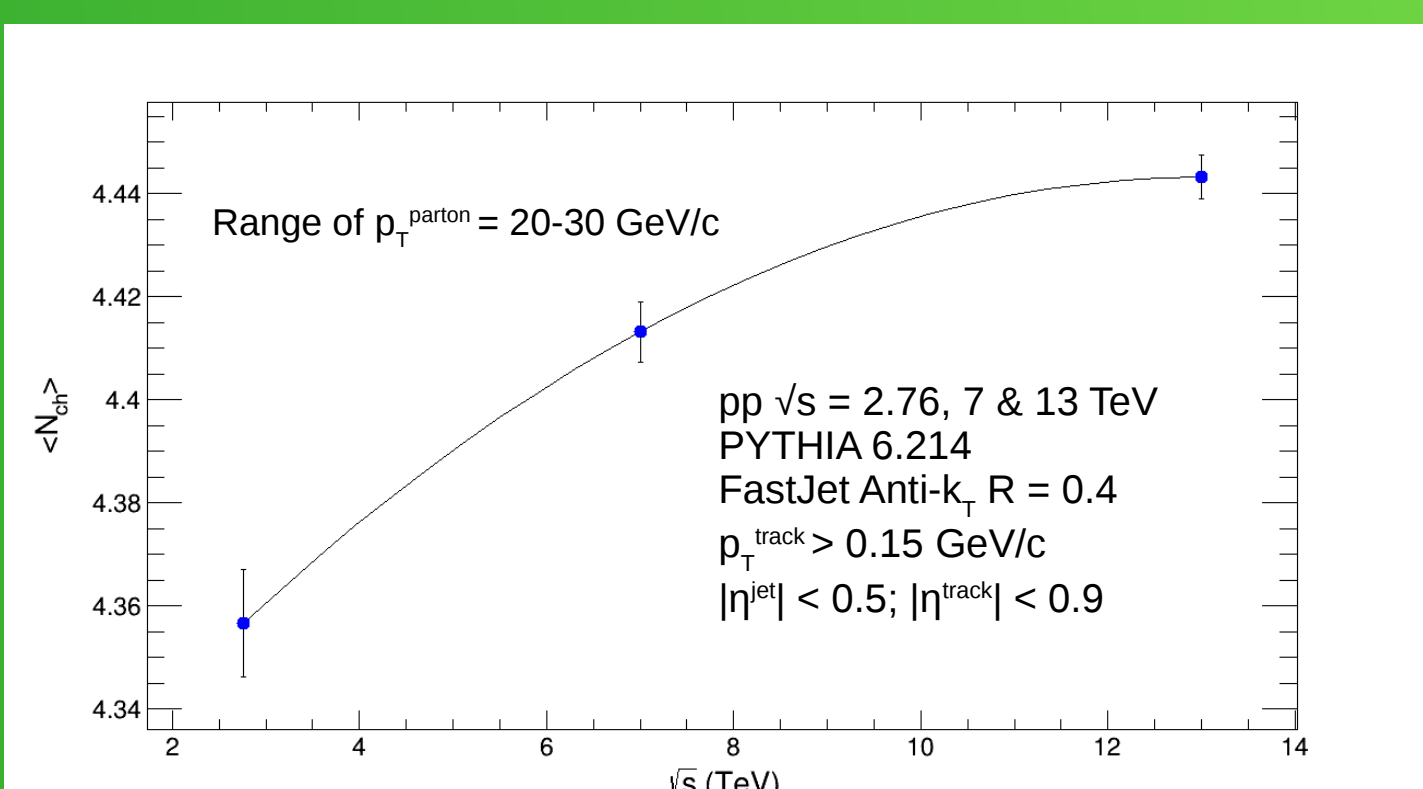
Results and Discussions

Evolution of $<N_{ch}>$, $<R80_{ch}>$ and $<p_T^{intrajet particles}>$ with multiplicity

- $<N_{ch}>$ and $<R80_{ch}>$ increase while $<p_T^{intrajet particles}>$ decreases with increase in event multiplicity.
- For the change in mean event multiplicity from 14 to 62, 23% change in $<N_{ch}>$ and 35% change in $<R80_{ch}>$ are observed.
- Indication of jet softening and broadening.

Evolution of $<N_{ch}>$ and $<R80_{ch}>$ with √s

- $<N_{ch}>$ and $<R80_{ch}>$ increases with √s.
- $<p_T^{intrajet particles}>$ decreases with increase in √s.
- For the change in √s from 2.76 to 13 TeV, 2% change in $<N_{ch}>$ and 3.5% change in $<R80_{ch}>$ are observed.
- Indication of jet softening and broadening.

$<N_{ch}>$ vs p_T^{parton}

- Quark and gluon initiated jet show different properties.
- $<Nch>$ is large for gluon jets.
- Inclusive jets contain both quark and gluon jets.
- Change in fraction of gluon jets will bring a change in the properties of inclusive jets.

Evolution of Gluon fraction (f_g) with √s and Multiplicity
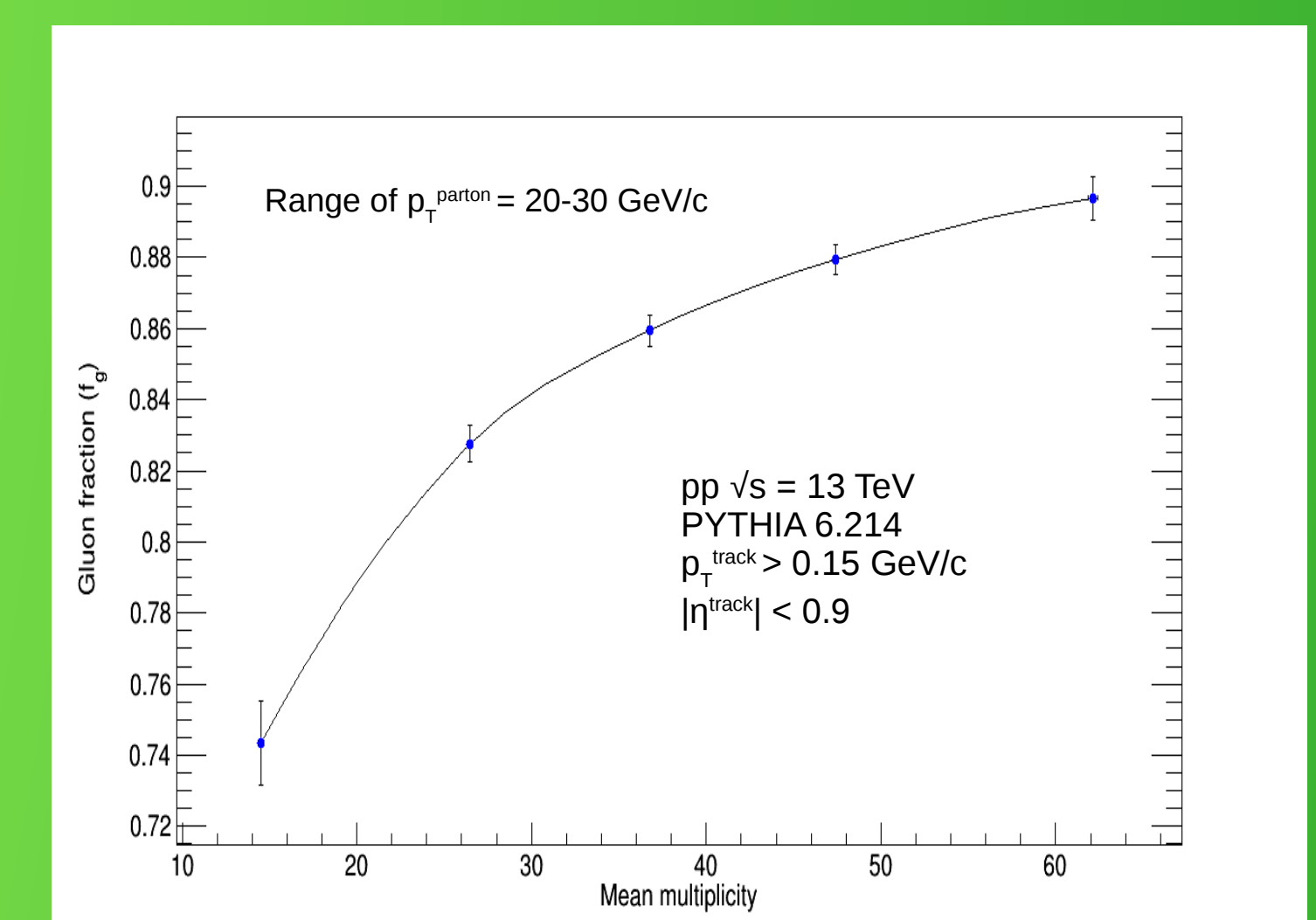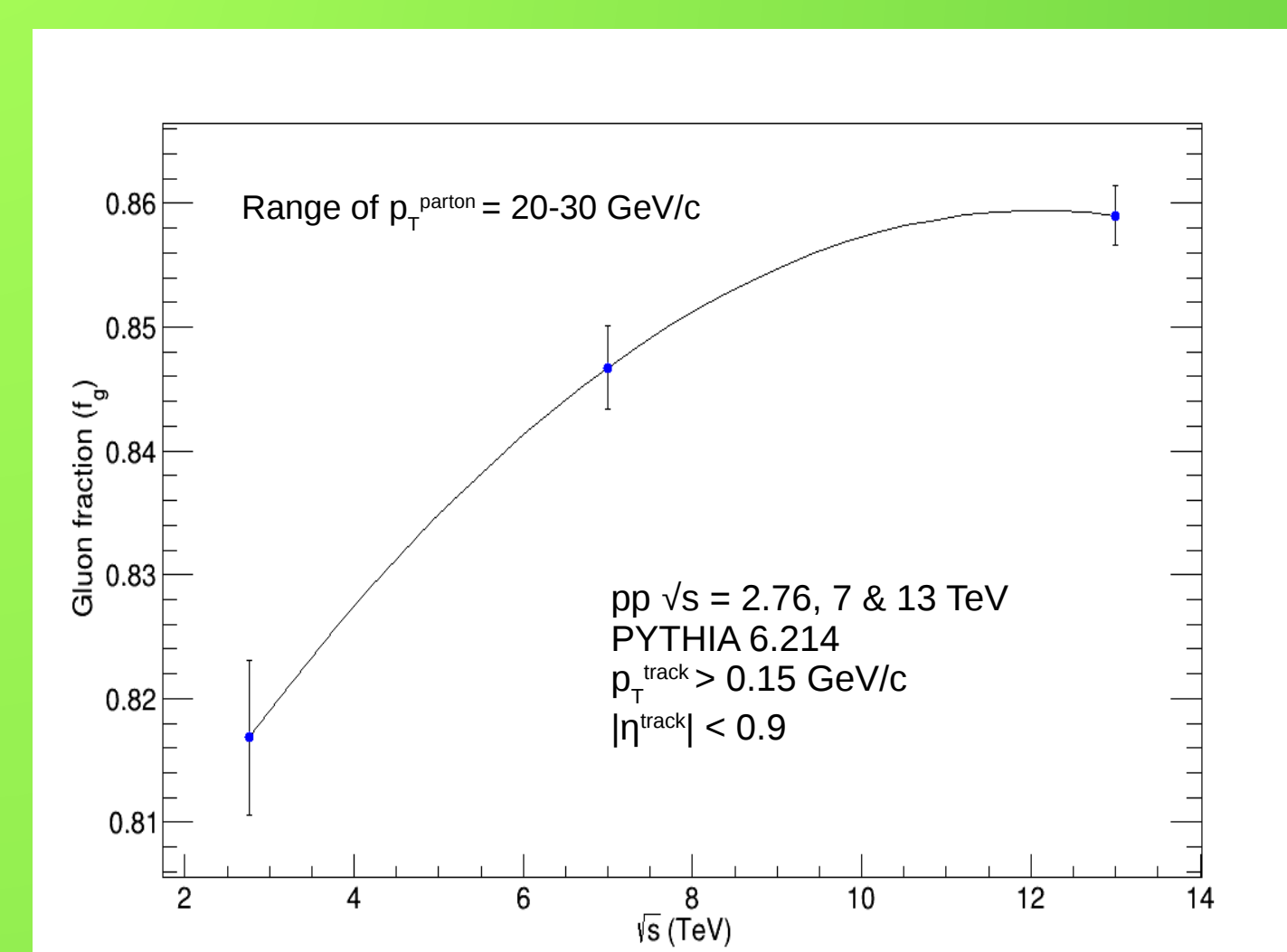
- f_g increases with √s and multiplicity.
- 5% increase in f_g due to change in √s from 2.76 to 13 TeV.
- 20% increase in f_g due to change in mean event multiplicity from 14 to 62.
- The increase in gluon fraction can be accounted for the observed softening and broadening of inclusive jets with √s and event multiplicity.

Summary

- We studied evolution of inclusive charged jet properties with √s and multiplicity using PYTHIA.
- Fraction of gluon jets increases with √s and multiplicity.
- The $<N_{ch}>$ and $<R80_{ch}>$ of the inclusive jets increase with √s and multiplicity.
- $<p_T>$ decreases with multiplicity.
- Increase in $<N_{ch}>$ and $<R80_{ch}>$ and decrease in $<p_T>$ with multiplicity indicate softening and broadening of jets.
- The softening and broadening of the jets in PYTHIA can be attributed to increase in the gluon fraction with √s and multiplicity.

References :

[1] Eur. Phys. J. C 49, 155162 (2007)
[2] arXiv:1803.11093v1 [hep-ex] (2018)
[3] https://arxiv.org/abs/1310.4554v2

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