Cross Section of Heavy Flavor Jet production in p-p collisions at 200 GeV with PYTHIA simulation

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- Simulation for heavy flavor jet
- Simulation for gamma + HF-jet
- Conclusion

Motivation

Experimental results from RHIC and LHC experiments present significant challenges to the current understanding of heavy flavor (HF) parton energy loss mechanism in the QGP.

The Heavy Flavor Tracker (HFT) provides an excellent precision to measure track impact parameters, and thus a possibility to identify secondary vertices in HF decays.

Here we propose to explore the possibility to study the HF energy loss using azimuthal correlations of HF jets and direct photon or charged hadrons. To validate the study possibility, we have a simulation to estimate the cross section of heavy flavor jet production with PYTHIA event generator.

Cross section of heavy flavor jet production

Heavy flavor jet study with PYTHIA -- setting

Pythia8170 setting:

All hard QCD processes (σ=0.63790±0.00005 mb): switched on

Minimum p_T hat: 4.0 GeV/c

Jet reconstruction:

anti_kT algorithm (SlowJet function in Pythia8)

jet cone size: 0.4

minimum pT of jet: 5.0 GeV/c

$|\eta_{jet}| \leq 0.6$, $|\eta_{hf}| \leq 1.0$

Tagging:

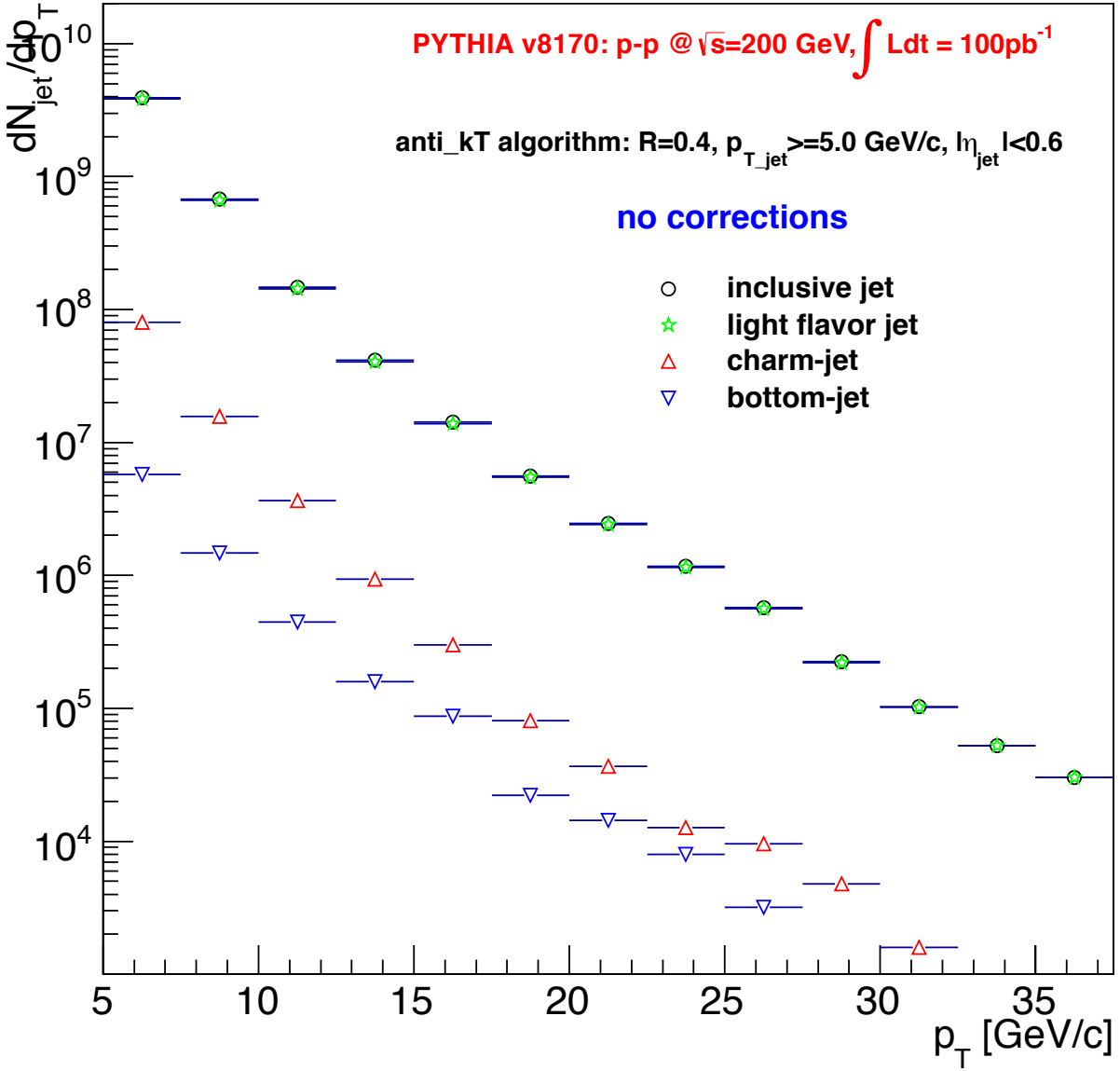
Minimum p_T of the leading heavy quark: 2.0 GeV/c

$\Delta R < 0.3$ (distance between leading heavy quark to jet axis)

Statistics:

Integrated luminosity: 100 pb^{-1}

Raw jet cross section

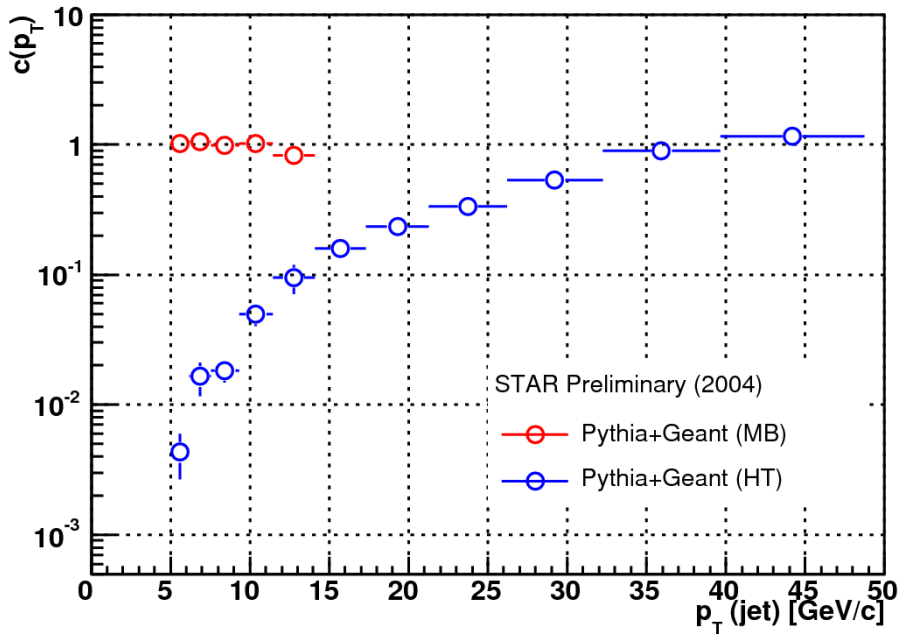


Production yield of inclusive jet, light flavor jet, charm jet and bottom jet with integrated luminosity of 100 Pb^{-1}.

No any efficiency correction and no normalization!

Jet correction factor & data sample normalization

Correction factor from S. Vigdor's talk: *Spin Physics with Jets at STAR (http://www.phy.bnl.gov/~partsem/fy07/SVigdor_070315.pdf)*



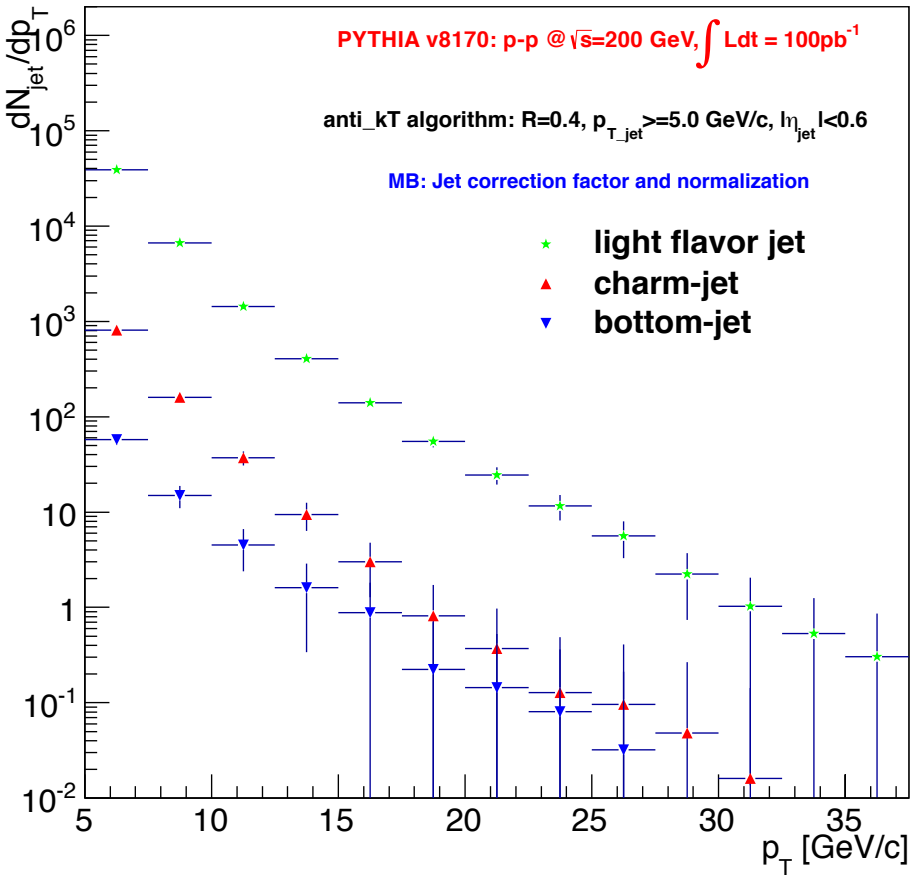
For MB p-p events:
correction factor: ~ 0.69

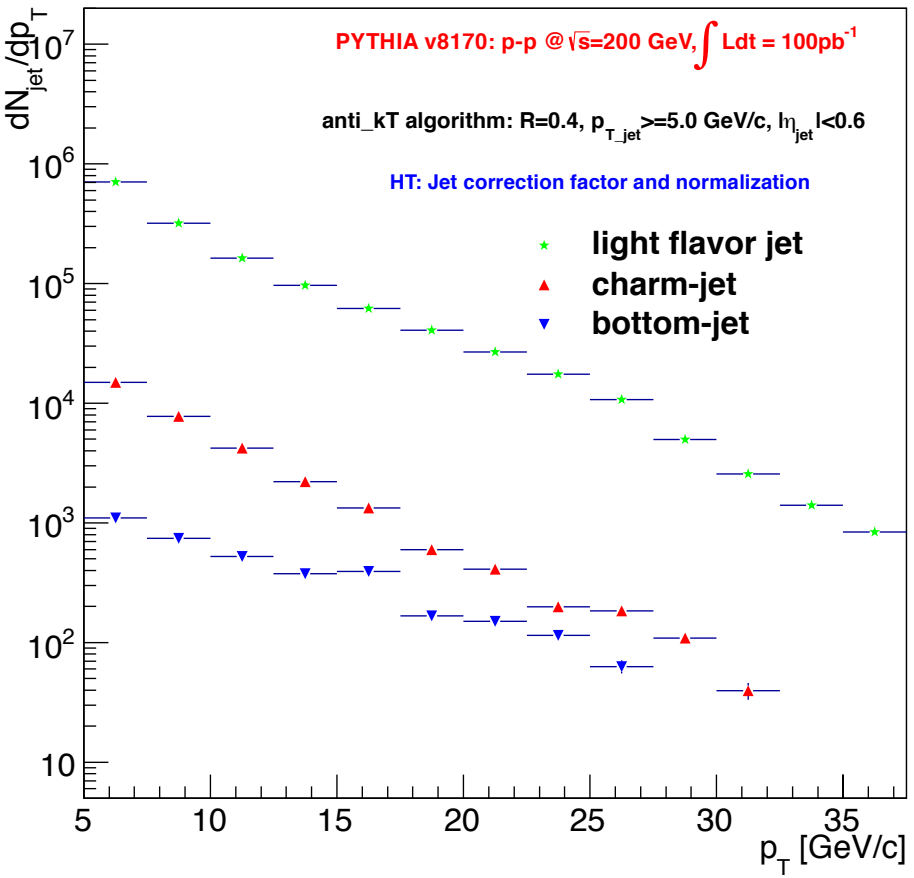
For HT p-p events:
Correction factor satisfy the following formula:
0.5 * (1 + erf((x-a)/b))
a, b are fitting parameters

Sample prescaler calculated from the paper Phys. Rev. Lett. 97, 252001 (2006): *Longitudinal Double-Spin Asymmetry and Cross Section for Inclusive Jet Production in Polarized Proton Collisions at √s=200 GeV*

Normalization for MB: ~$1.463*10^{-5}$ (= $N_{anaEvent}/\sigma_{MB}*L_{int2003}$ = 2.1e6/(26.1e9*5.5))
Normalization for HT: ~$2.859*10^{-2}$ (inclusive jet number N_{HT} = 43e3*N_{MB}/1.4e3)
(The inclusive jet number from HT is around 30 times than the number from MB)

Jet cross section – w/ $c(p_T)$ correction & normalization

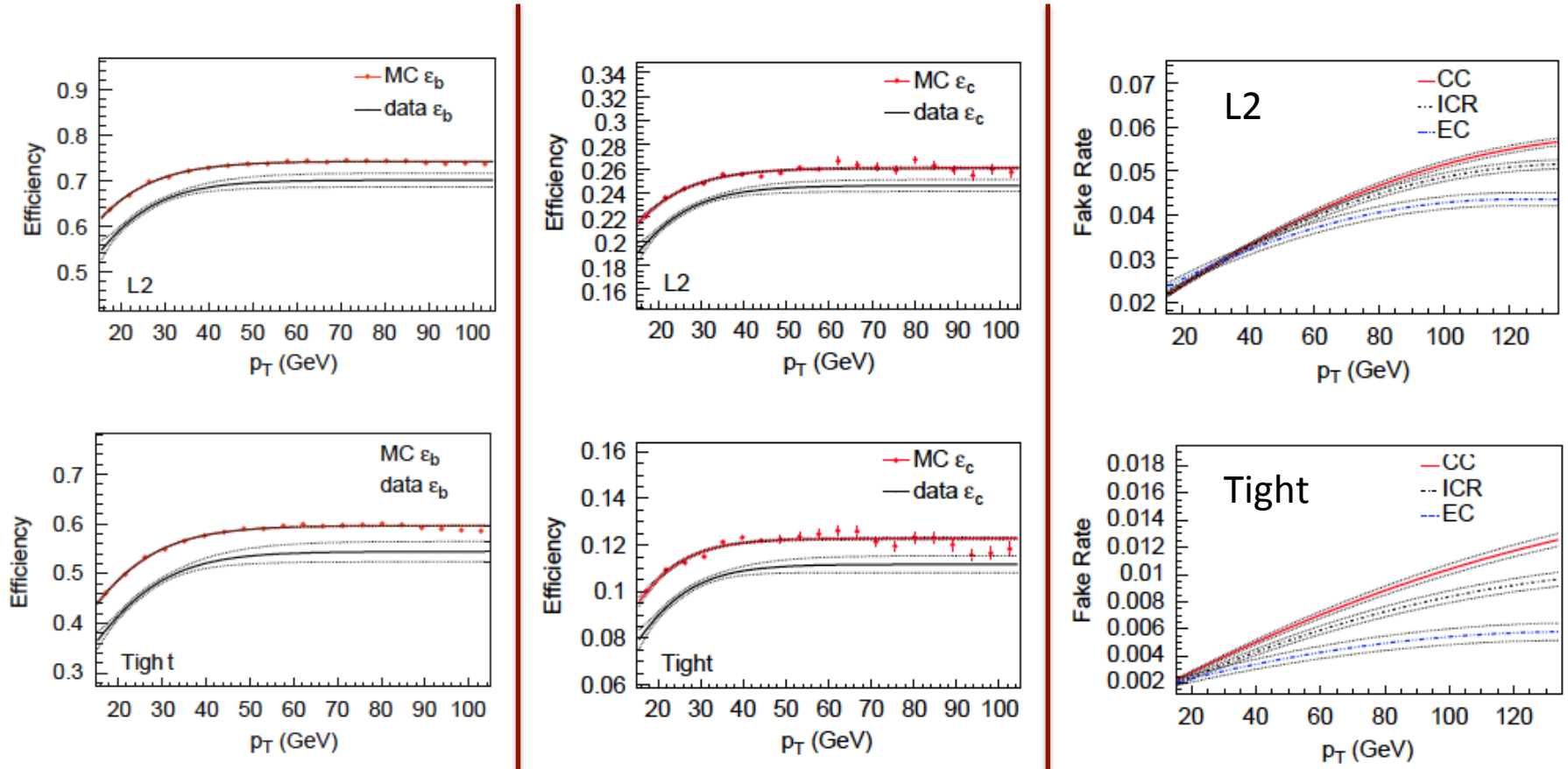




Cross sections of jet production with $c(p_T)$ correction, and also normalized to MB (left) and HT (right) events, respectively.

Heavy flavor tagging efficiency (L2 & Tight NN tagger)

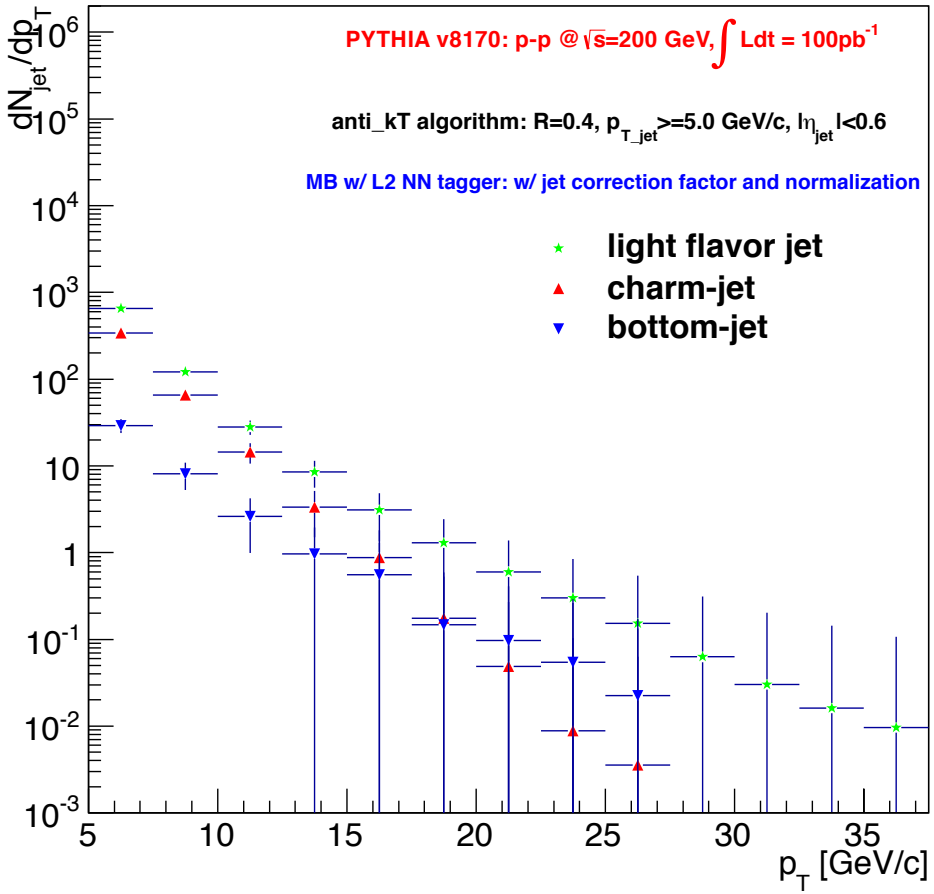
Sample prescaler calculated from the paper Nucl. Instrum. Methods in Phys. Res. Sect. A 620, 490 (2010): *b-Jet Identification in the D0 Experiment*



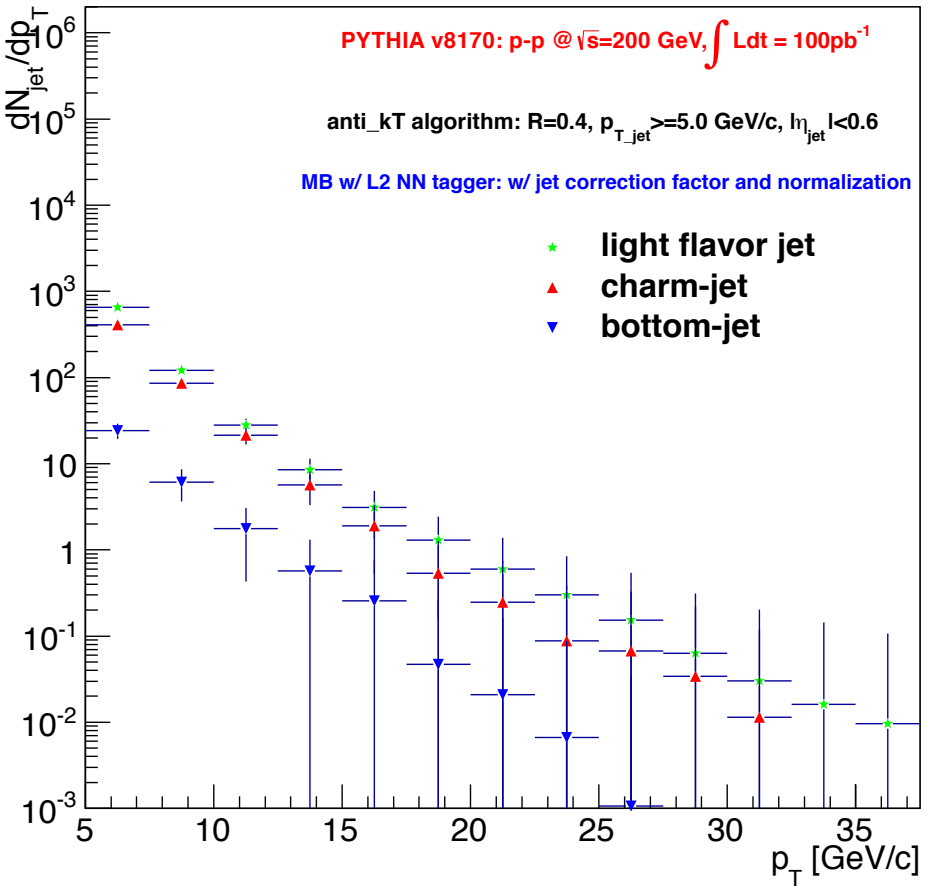
In the simulation, the tagging efficiencies for b-jet, c-jet and light flavor jet are extrapolated to lower pT range (up to 5 GeV/c) by fitting function.

Jet cross section in MB – L2 NN tagger

B_rich sample :

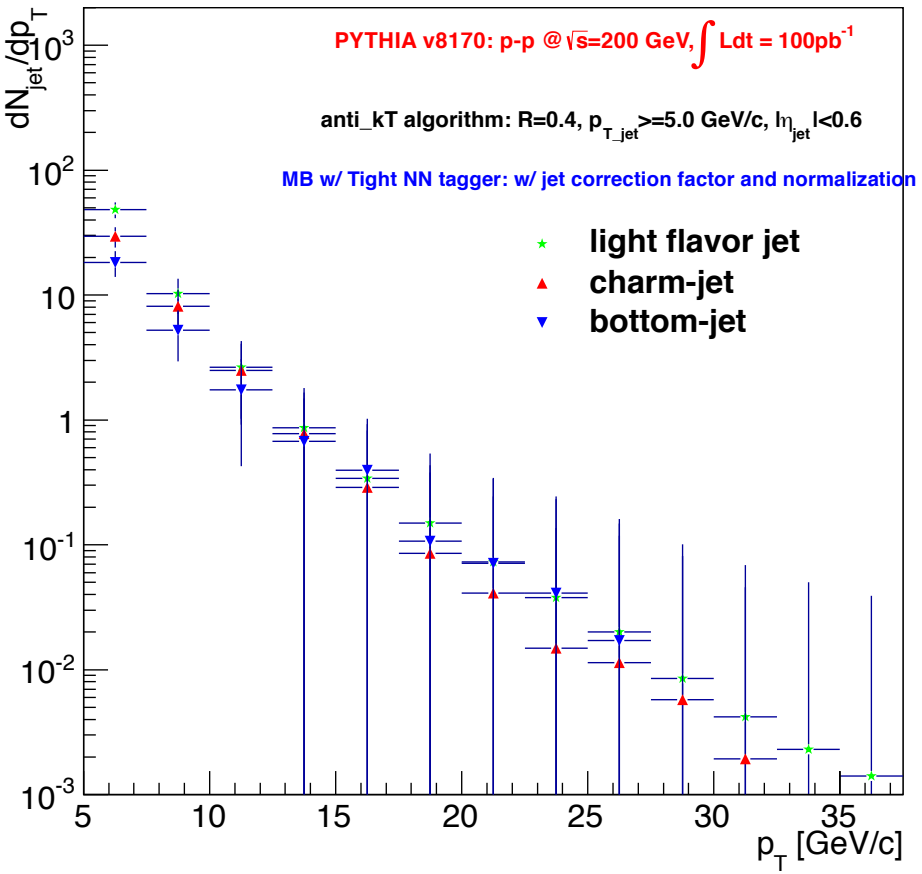


C_rich sample:

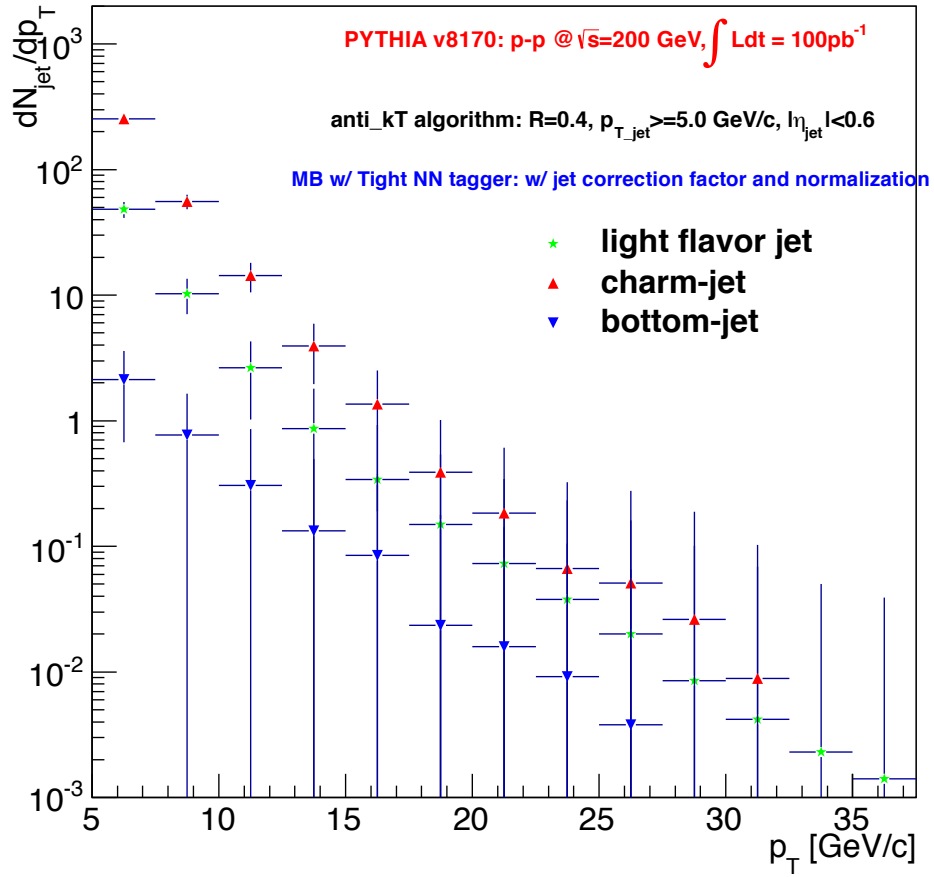


Jet cross section in MB – Tight NN tagger

B_rich sample:



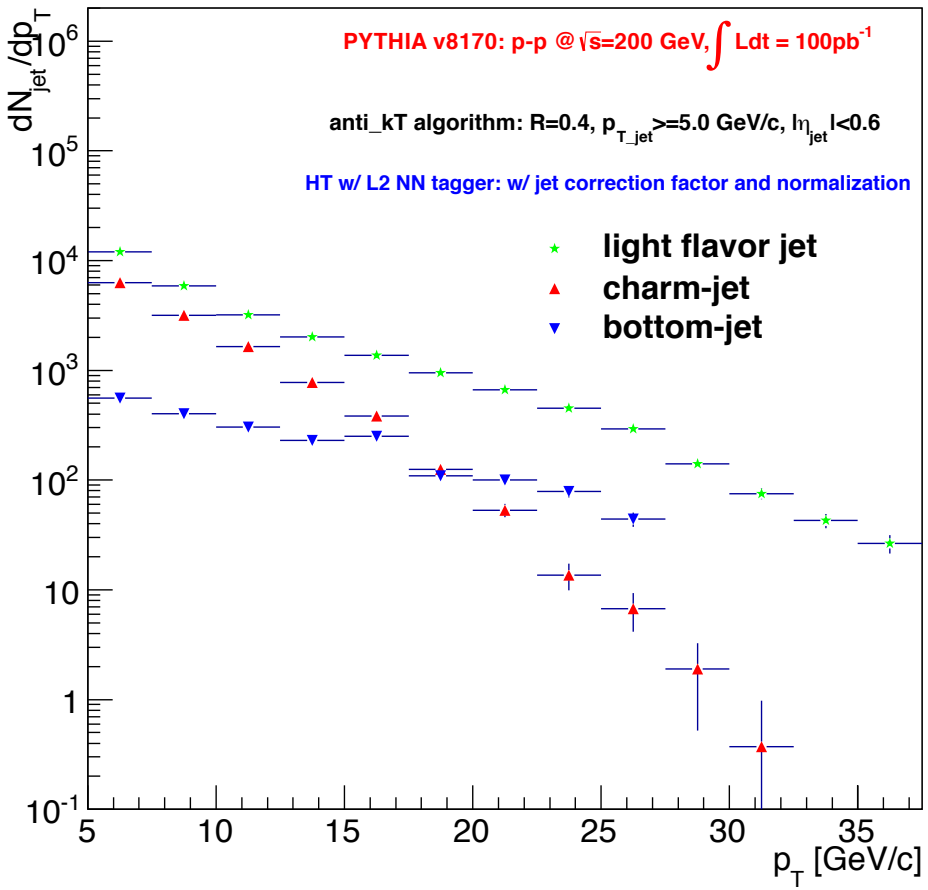
C_rich sample:



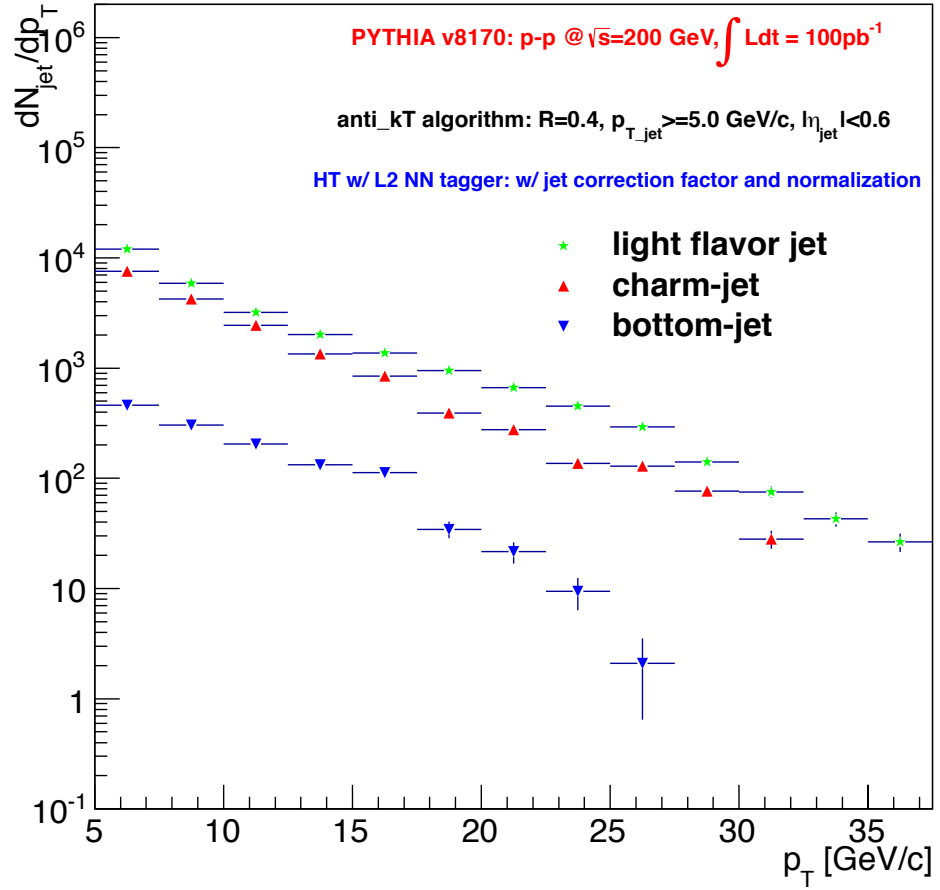
Based on the simulation results, it seems that one year statistics is not enough for heavy flavor jet studies with MB triggered data sample.

Jet cross section in HT – L2 NN tagger

B_rich sample:

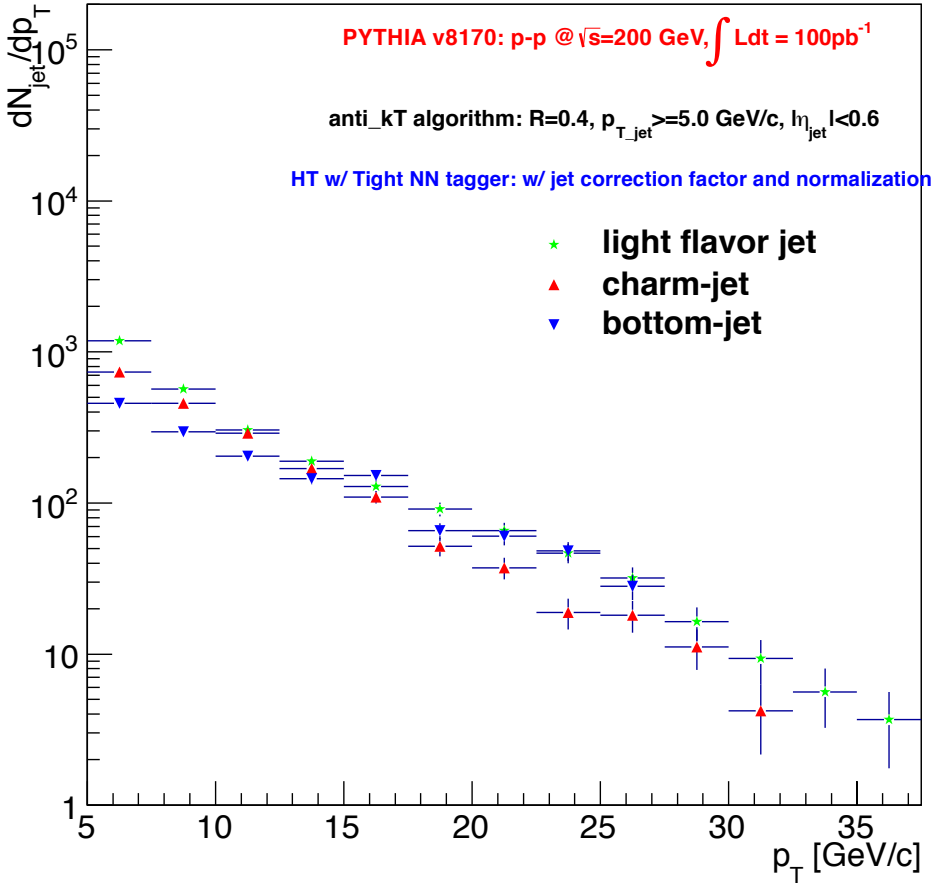


C_rich sample:

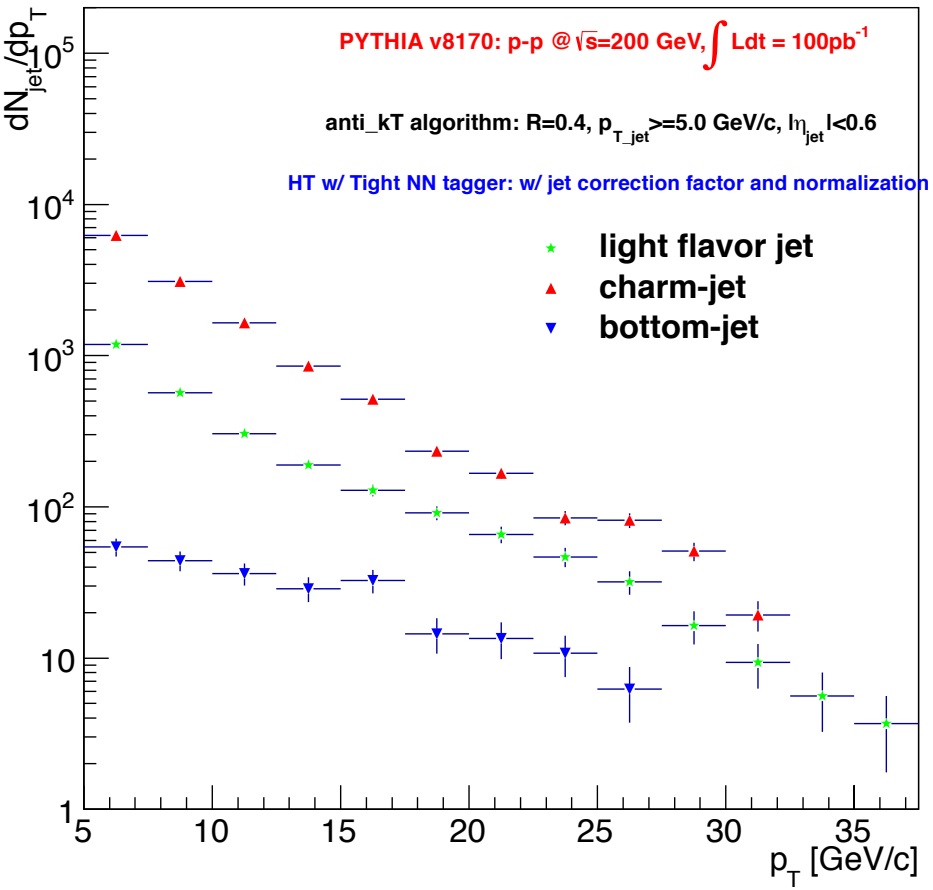


Jet cross section in HT – Tight NN tagger

B_rich sample:



C_rich sample:



According to the simulation results, it shows that c-jet study can be carried on with HT trigger events for one year p-p data sample.

Cross section of Gamma + HF-Jet production

Gamma - jet study with PYTHIA -- setting

Pythia8170 setting:

All prompt photon processes (σ=1.804e-4±1.348e-8 mb): switched on

Minimum p_T hat: 4.0 GeV/c

Jet reconstruction:

anti_kT algorithm (SlowJet function in Pythia8)

jet cone size: 0.4

minimum pT of jet: 5.0 GeV/c

$|\eta_{jet}| \leq 0.6$, $|\eta_{hf}| \leq 1.0$

Tagging:

Minimum p_T of the leading heavy quark: 2.0 GeV/c

$\Delta R < 0.3$ (distance between leading heavy quark to jet axis)

Gamma recoiling:

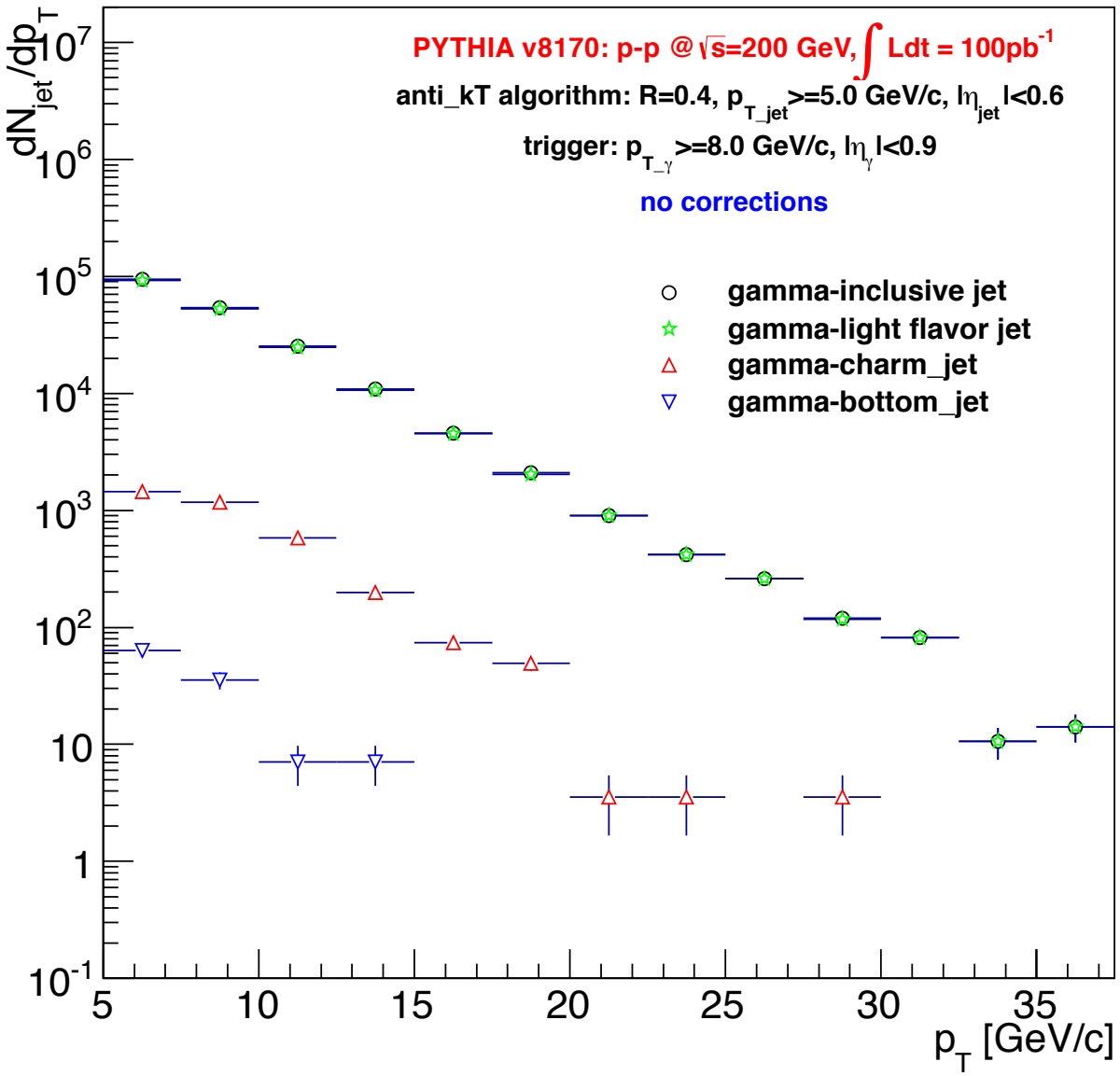
Minimum p_T of the trigger gamma: 8.0 GeV/c, $|\eta_{gamma}| \leq 0.9$

$|\Delta\phi - \pi| < 0.63$ ($\Delta\phi = \phi_{jet} - \phi_{gamma}$)

Statistics:

Integrated luminosity: 100 pb^{-1}

Raw cross section for gamma-jet production

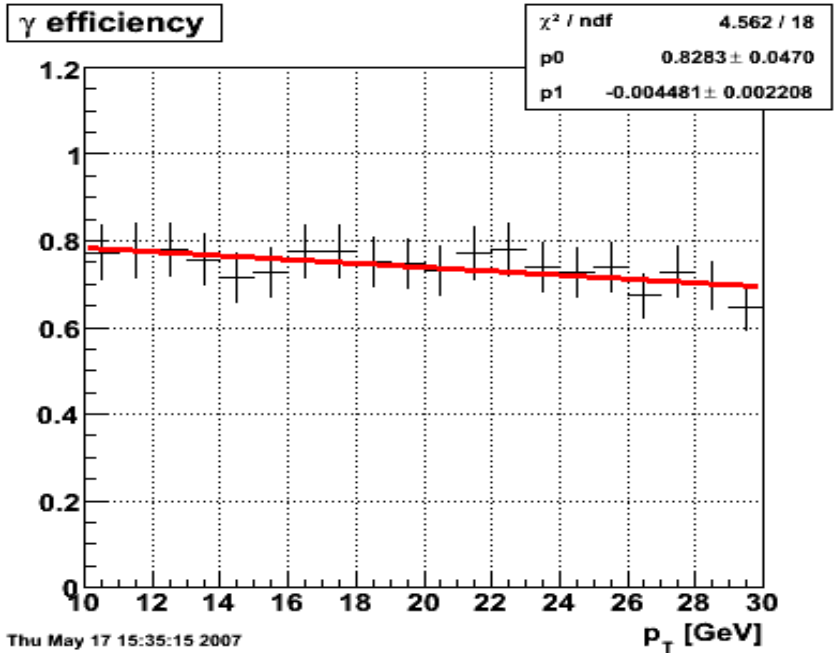


Production yield estimations for gamma-inclusive jet, gamma-light flavor jet, gamma-c_jet and gamma-bottom_jet with integrated luminosity of 100 Pb^{-1}.

No any efficiency correction and no normalization!

Photon identification efficiency

The photon identification efficiency is referred: *http://drupal.star.bnl.gov/STAR/pwg/spinanalysisstatushtml/eemc-direct-photon-studies-pibero-2006-2008/efficiency-reconstructing-photons-eemc*



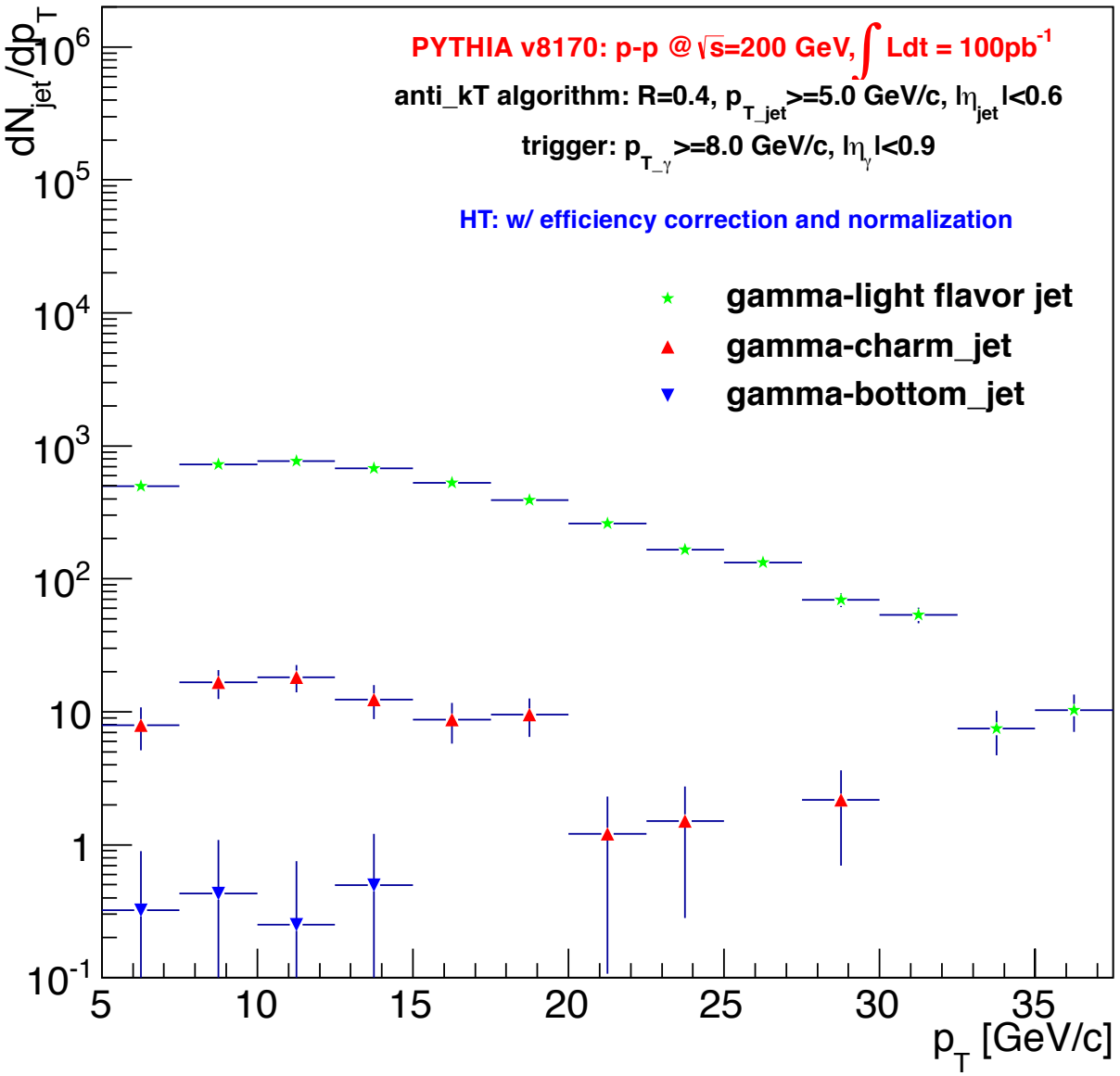
In the reconstruction level of our simulation, gamma identification efficiency is set to the average value 0.75 over the whole p_T range.

The jet correction factor and the tagging efficiency were chosen as the same as heavy flavor jet study.

The normalization factor for HT events is set to 1.0, which is estimated roughly based on: *http://www.star.bnl.gov/protected/jetcorr/hamed/Direct_photon_link/Direct_photon_link/Data_set.html*

1. Estimated gamma triggered events number in 100 pb^{-1}: (59,355+34,313)*100pb^{-1}/11pb^{-1} = 851,527
2. Accepted photon events number is 216,696 in the simulation (5,102,721 prompt photon events generated in the simulation, the corresponding integrated luminosity is 28.2856 pb^{-1}), then the number of accepted photon events is 766,085 (= 216,696*100pb^{-1}/28.2856pb^{-1})
3. Normalization factor equals to 1.0 (= 766,085* $(2.0/1.8)_{\eta\ \mathrm{correction}}$ / 851,527 ≈ 1.0)

gamma-jet production – w/ efficiency correction and normalization

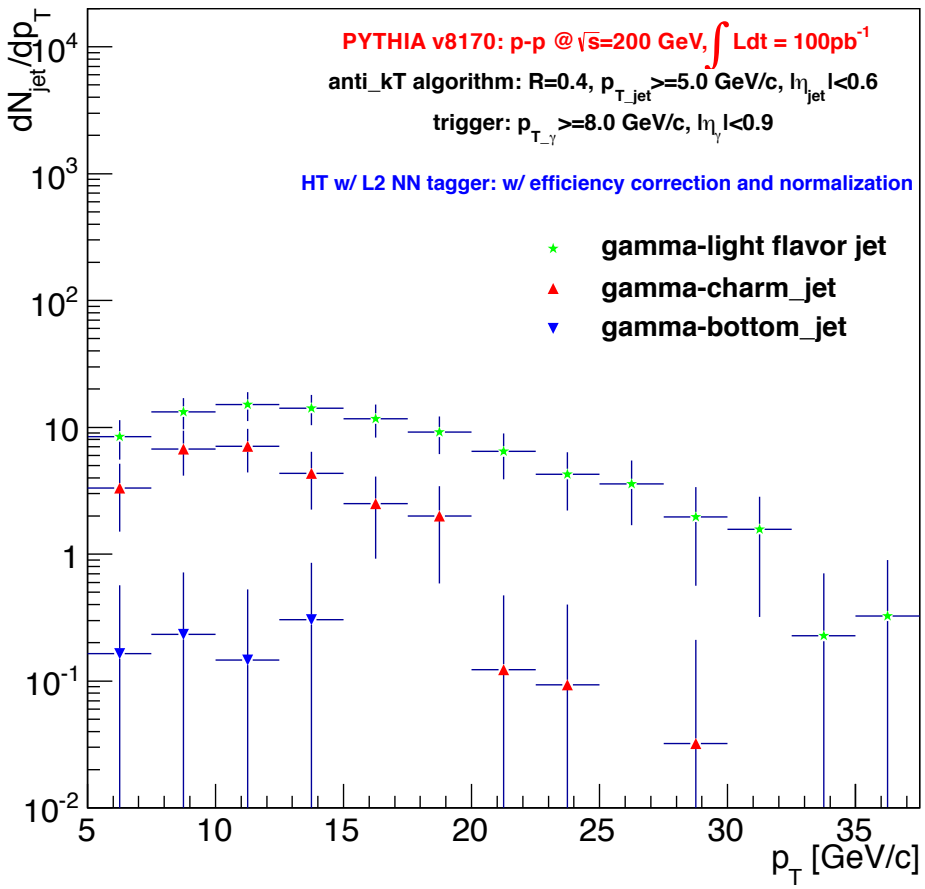


Cross sections for gamma-jet production with photon identification efficiency and jet correction factor applied, and also normalized to HT triggered events, respectively.

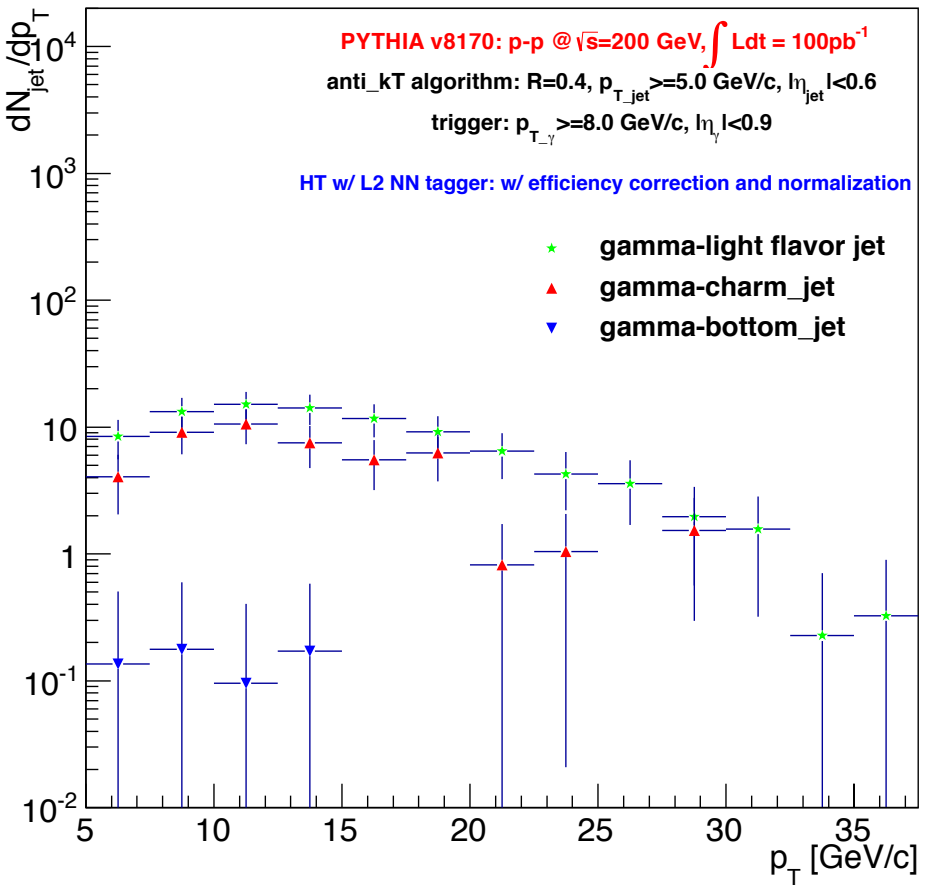
Based on the simulation results, it shows that the statistics is not enough for correlations study between gamma and heavy flavor jet with one year p+p data sample.

Gamma-jet cross section in HT – L2 NN tagger

B_rich sample:

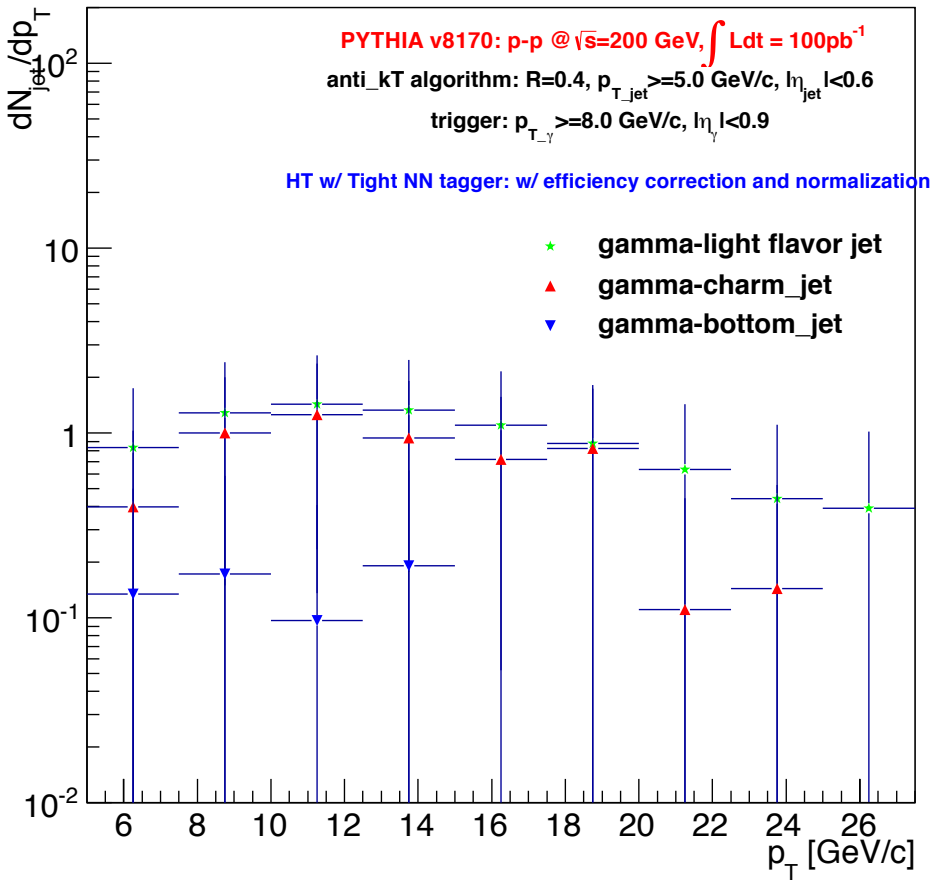


C_rich sample:

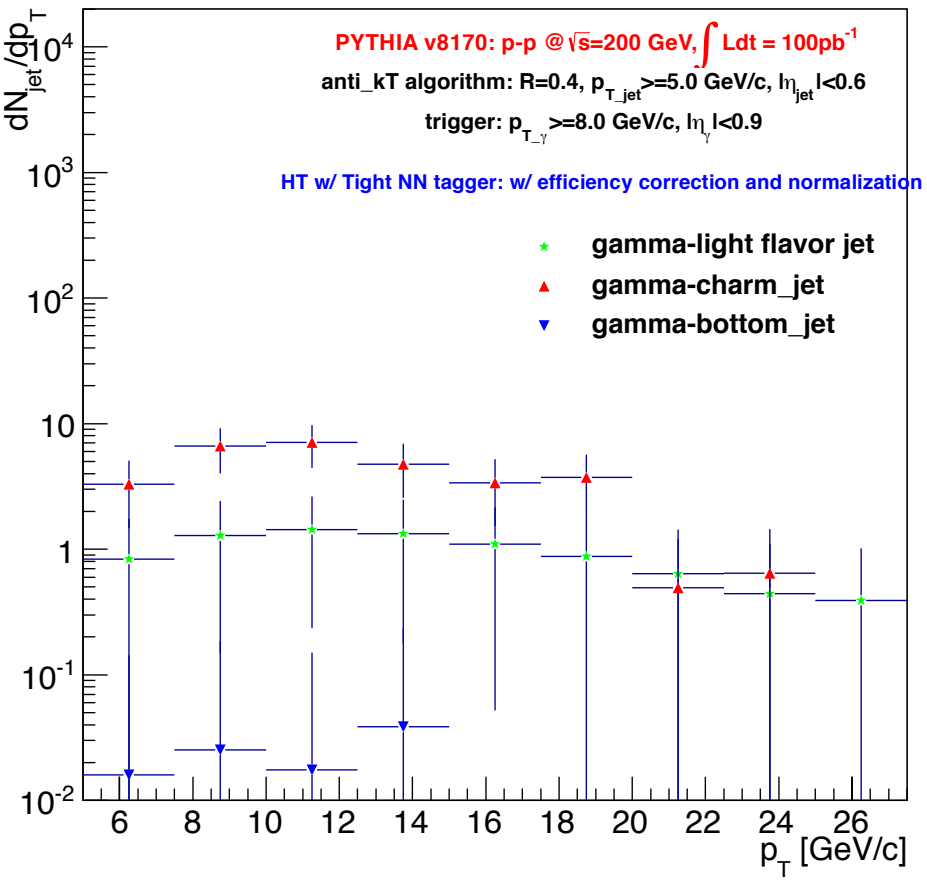


Gamma-jet cross section in HT – Tight NN tagger

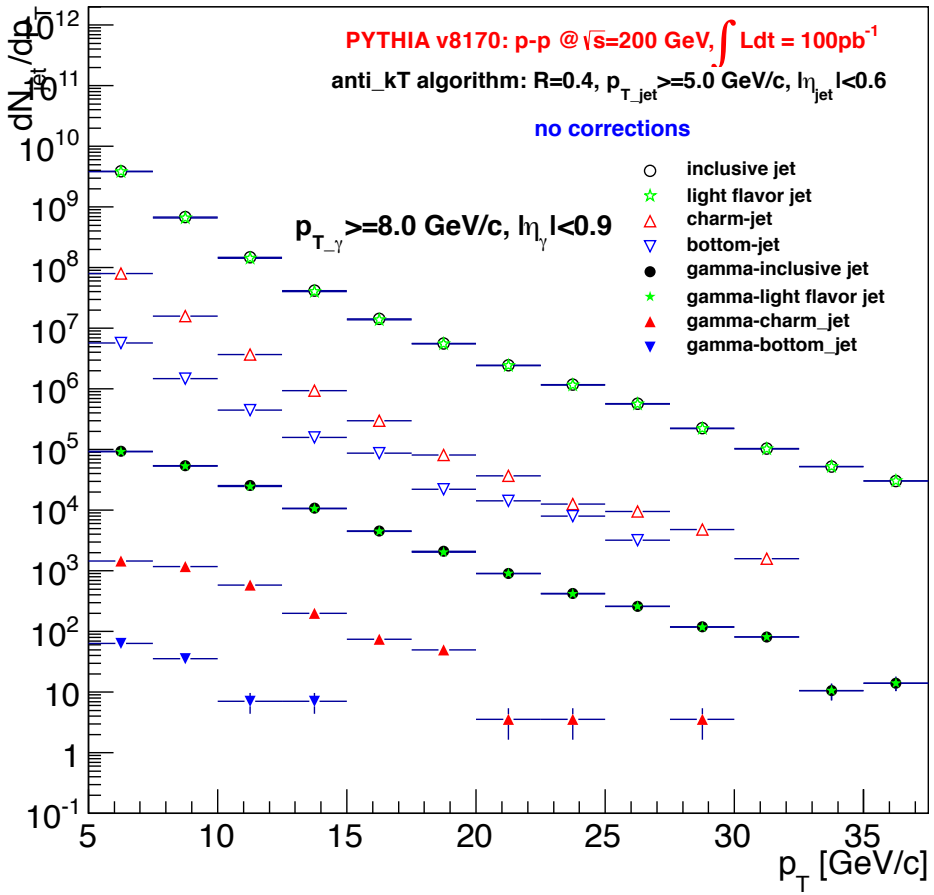
B_rich sample:

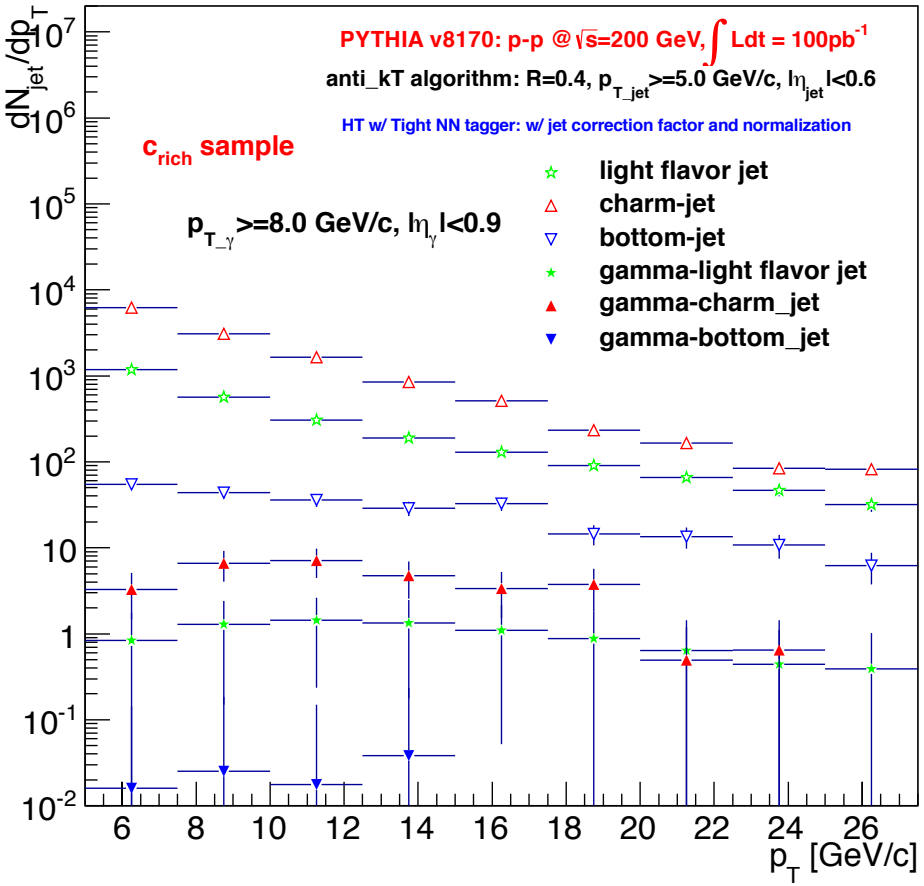


C_rich sample:



Jet yield comparisom





Conclusion

According to the PYTHIA simulation, we can give a conclusion as below:

1) c-jet study can be studied with one-year p+p data.

2) Correlations of direct photon and HF-jet is hard to carry on due to limited statistics.

3) B-jet study needs more statistics.