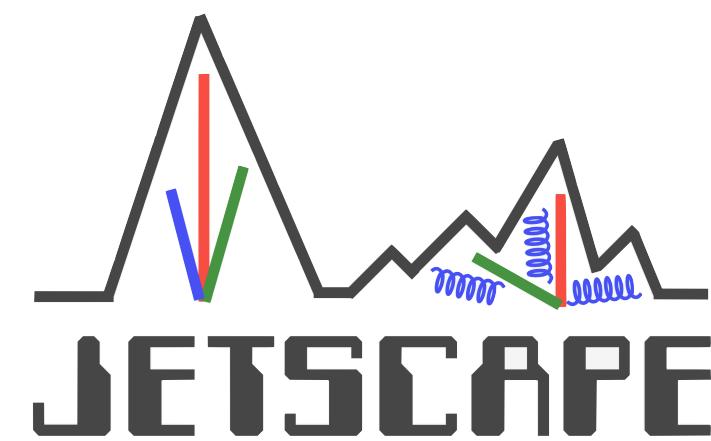




Constraints on jet quenching from a multi-stage energy-loss approach

Chanwook Park
for the JETSCAPE collaboration

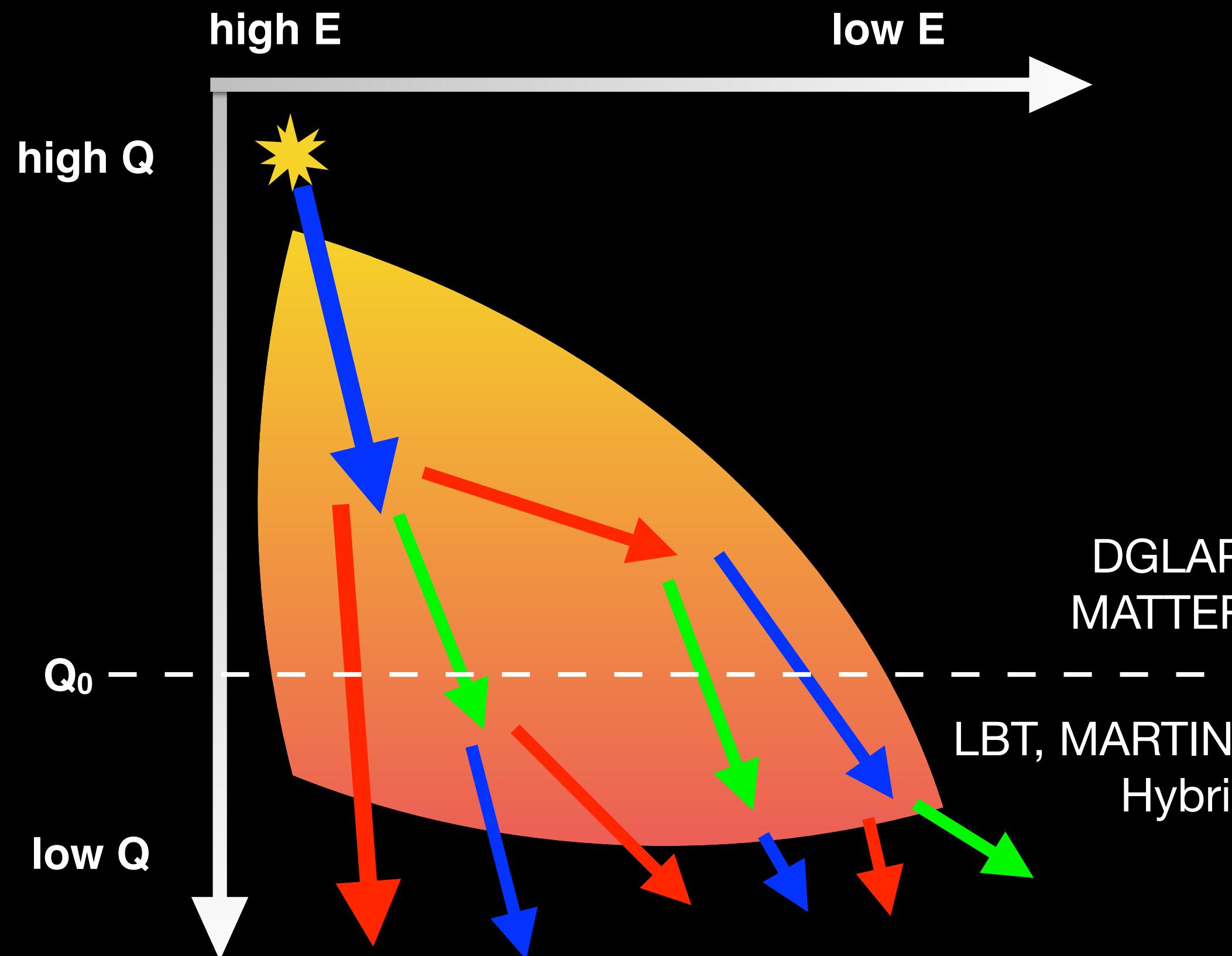


June 3, 2020



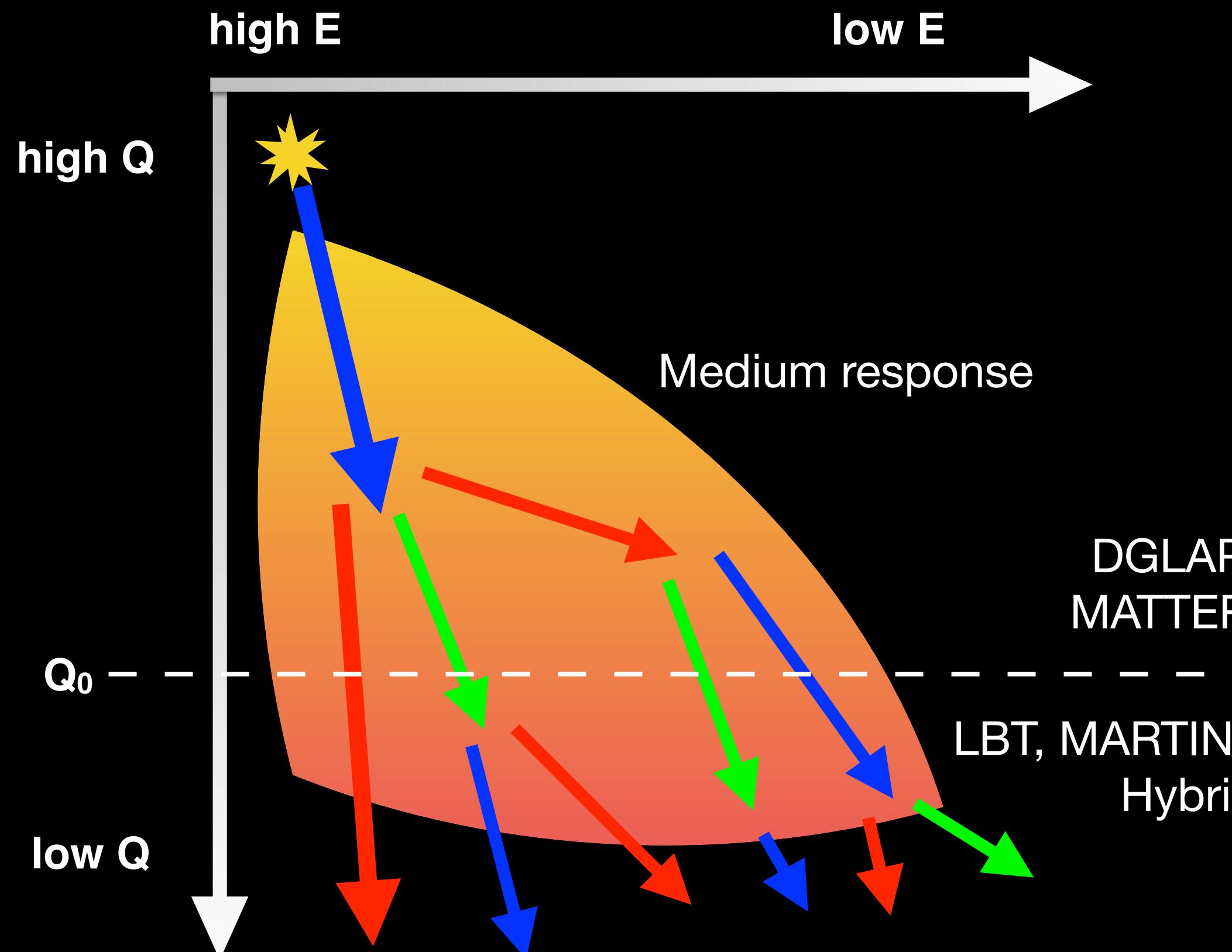
McGill
UNIVERSITY

Unified description of jet evolution in QGP

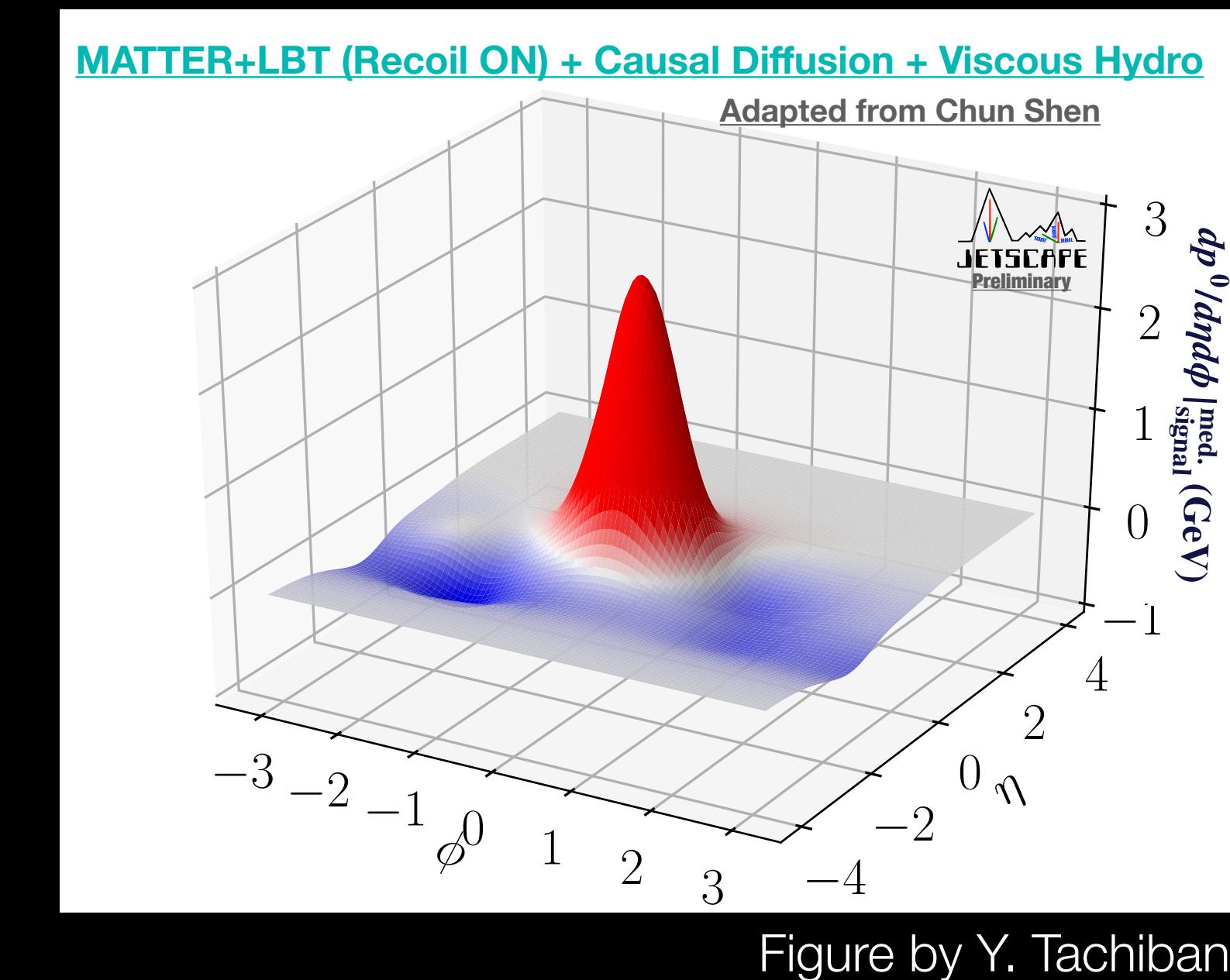


- Multi-stage jet evolution in heavy-ion collisions
- Different mechanisms at different scales
 - High Q: Virtuality splitting dominant
 - Low Q: Scattering becomes important

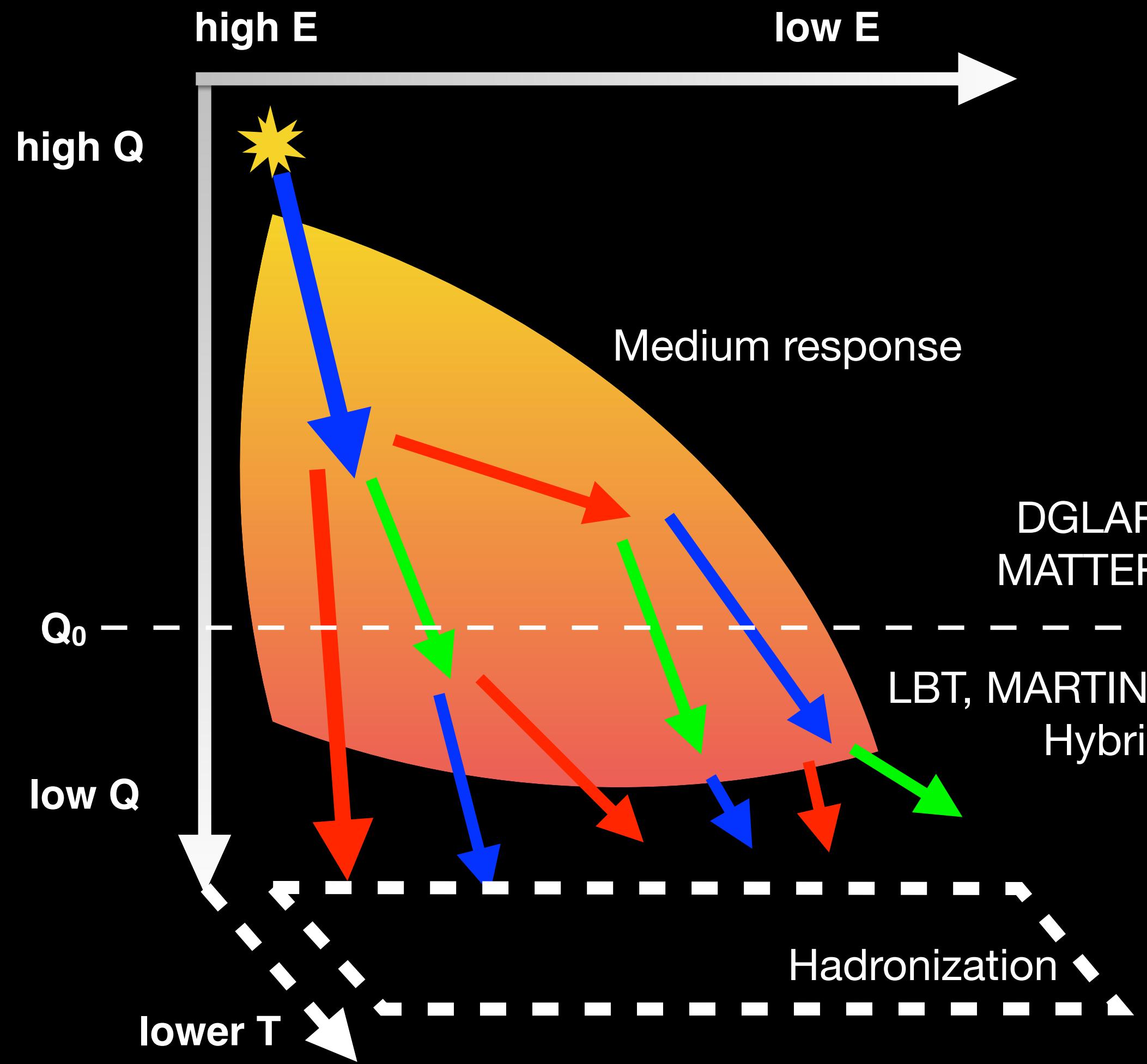
Unified description of jet evolution in QGP



- Medium response to jet evolutions:
jet correlated background



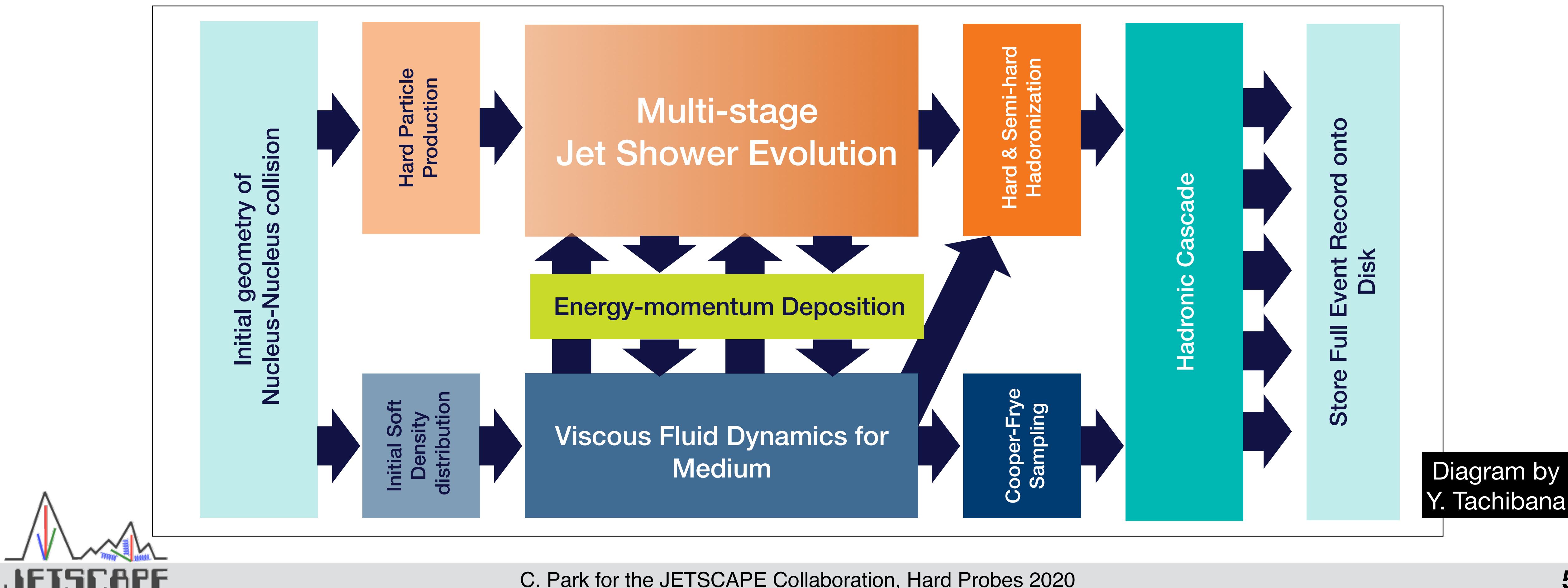
Unified description of jet evolution in QGP



- Medium response to jet evolutions:
jet correlated background
- Non-pQCD prescription for hadronization below
switching temperature

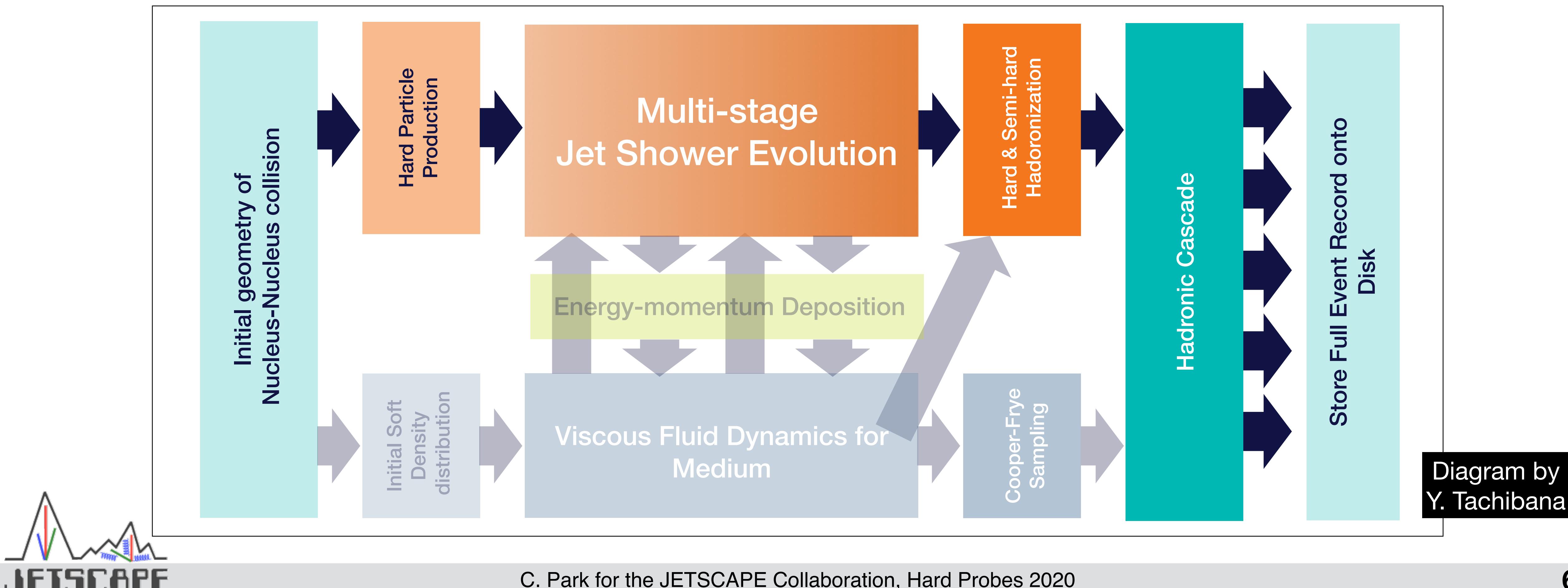
JETSCAPE framework

- Monte-Carlo event generator for a unified description of jet evolution
- JETSCAPE 3.0.1 available: github.com/JETSCAPE
- Manual ([arXiv:1903.07706](https://arxiv.org/abs/1903.07706)), JETSCAPE PP19 tune ([arXiv:1910.05481](https://arxiv.org/abs/1910.05481))



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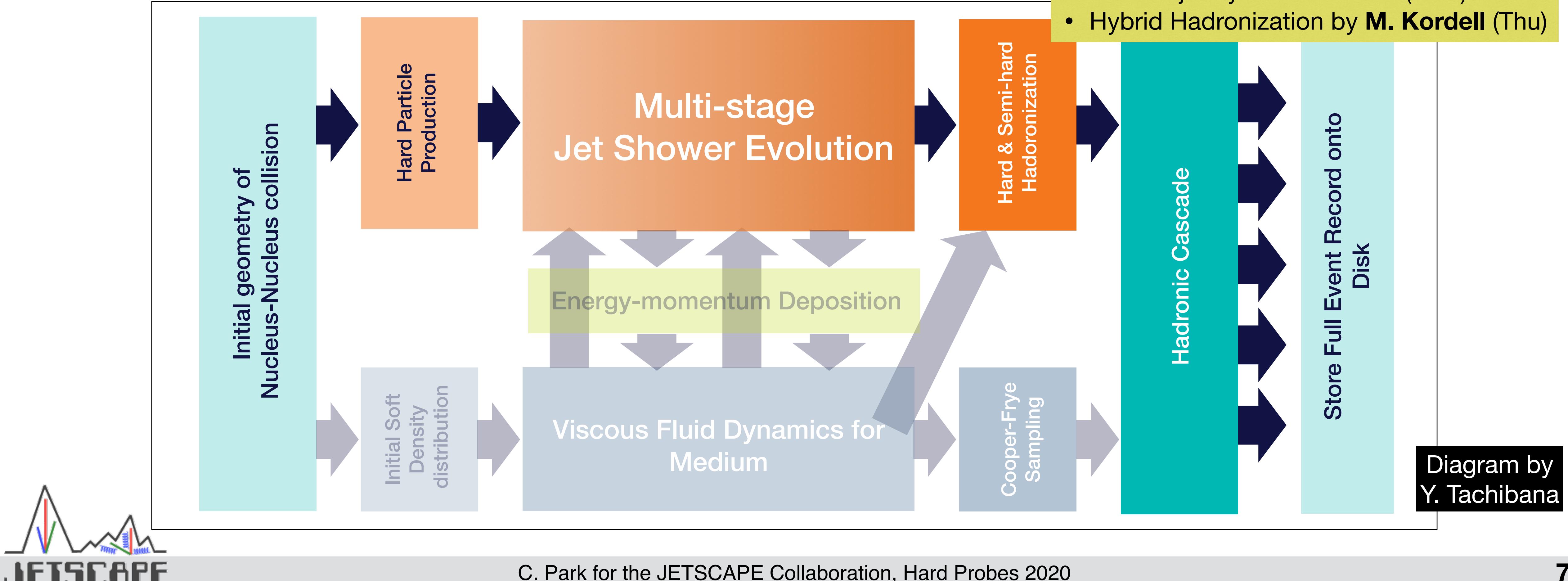


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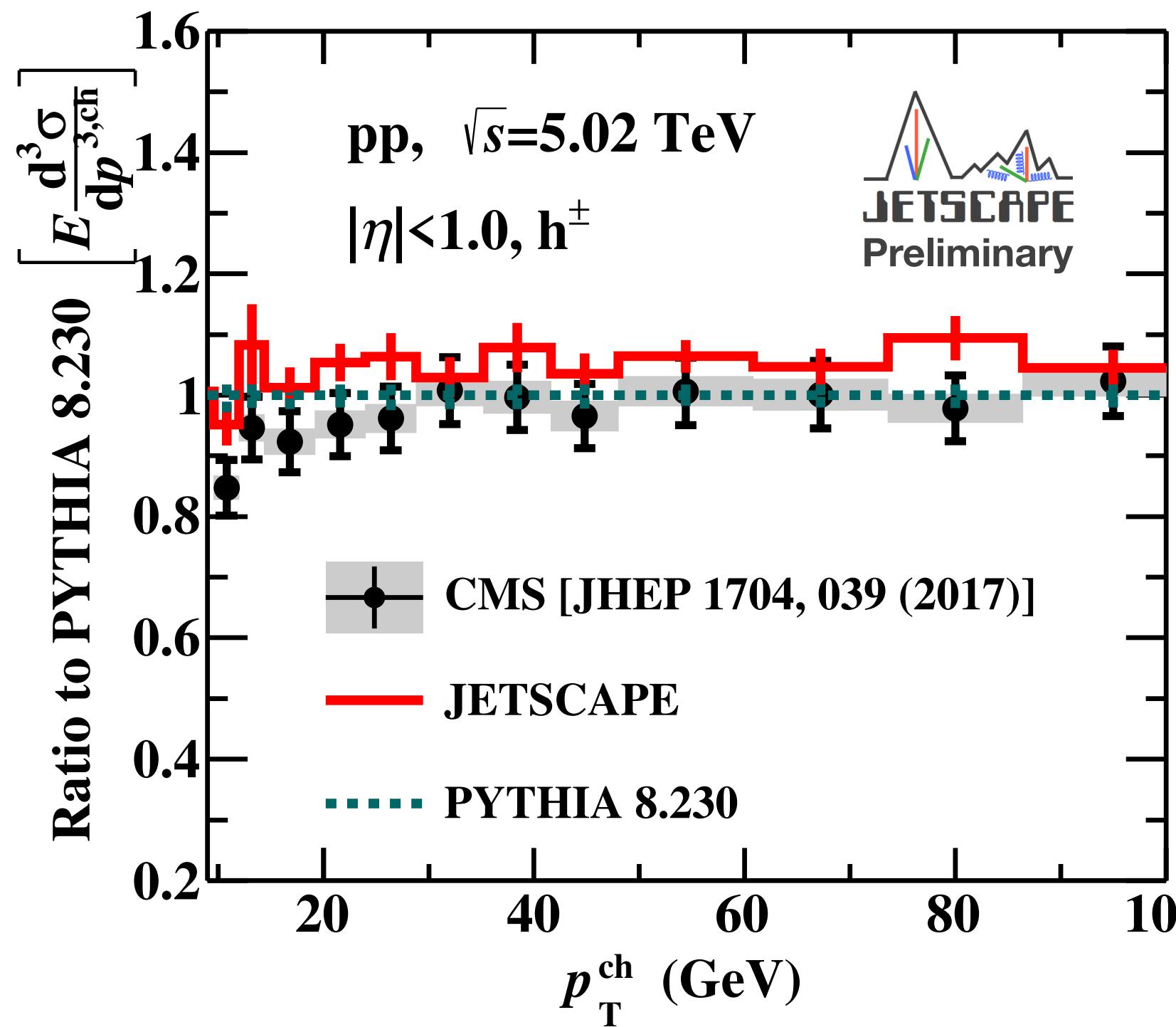
JETSCAPE talks at HP2020

- Heavy quarks by **W. Fan** (Tue)
- Photon-jet by **C. Sirimanna** (Wed)
- Hybrid Hadronization by **M. Kordell** (Thu)

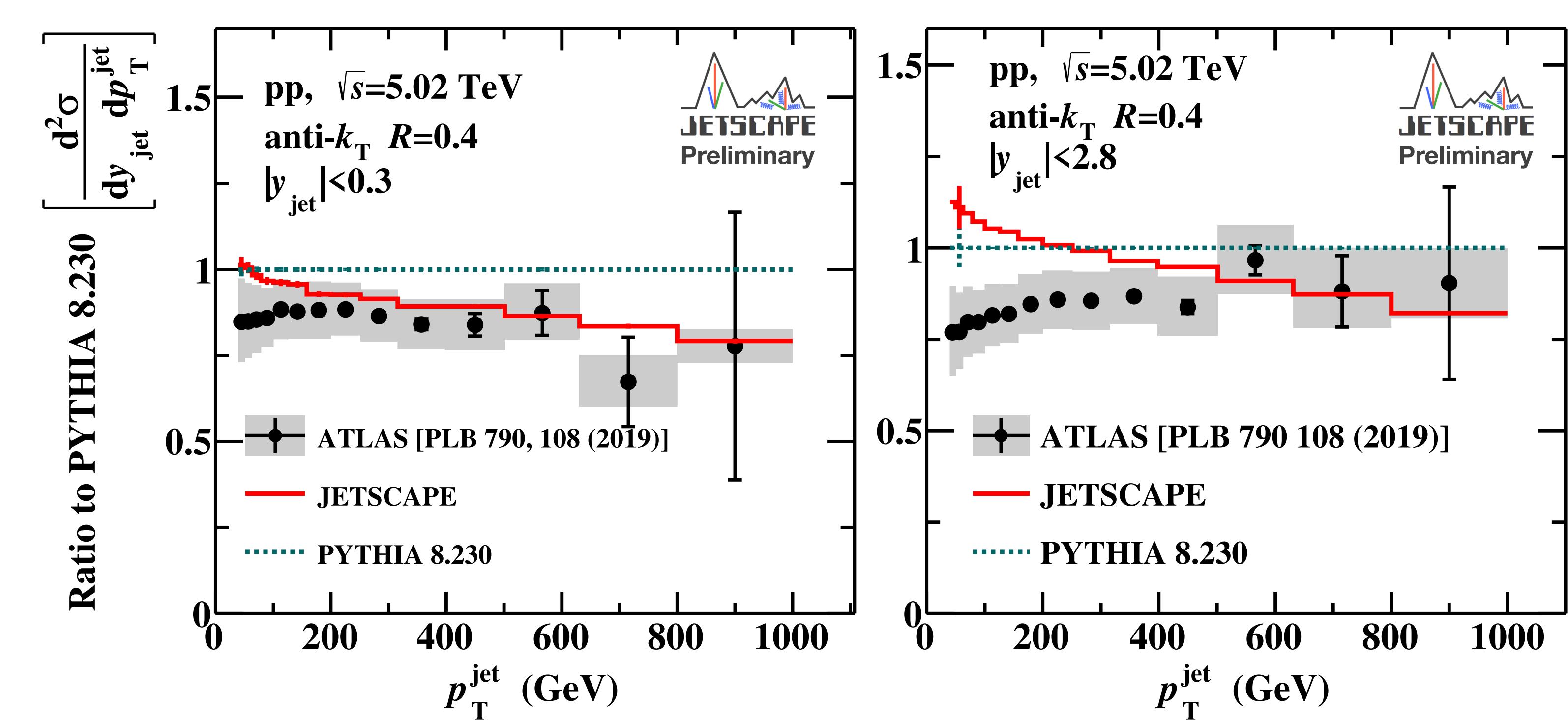


JETSCAPE “PP19 tune”

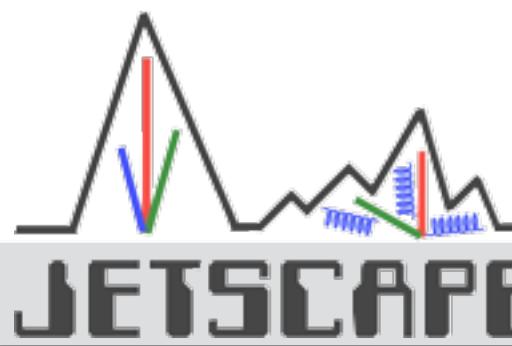
Charged hadron yield



Jet cross-section

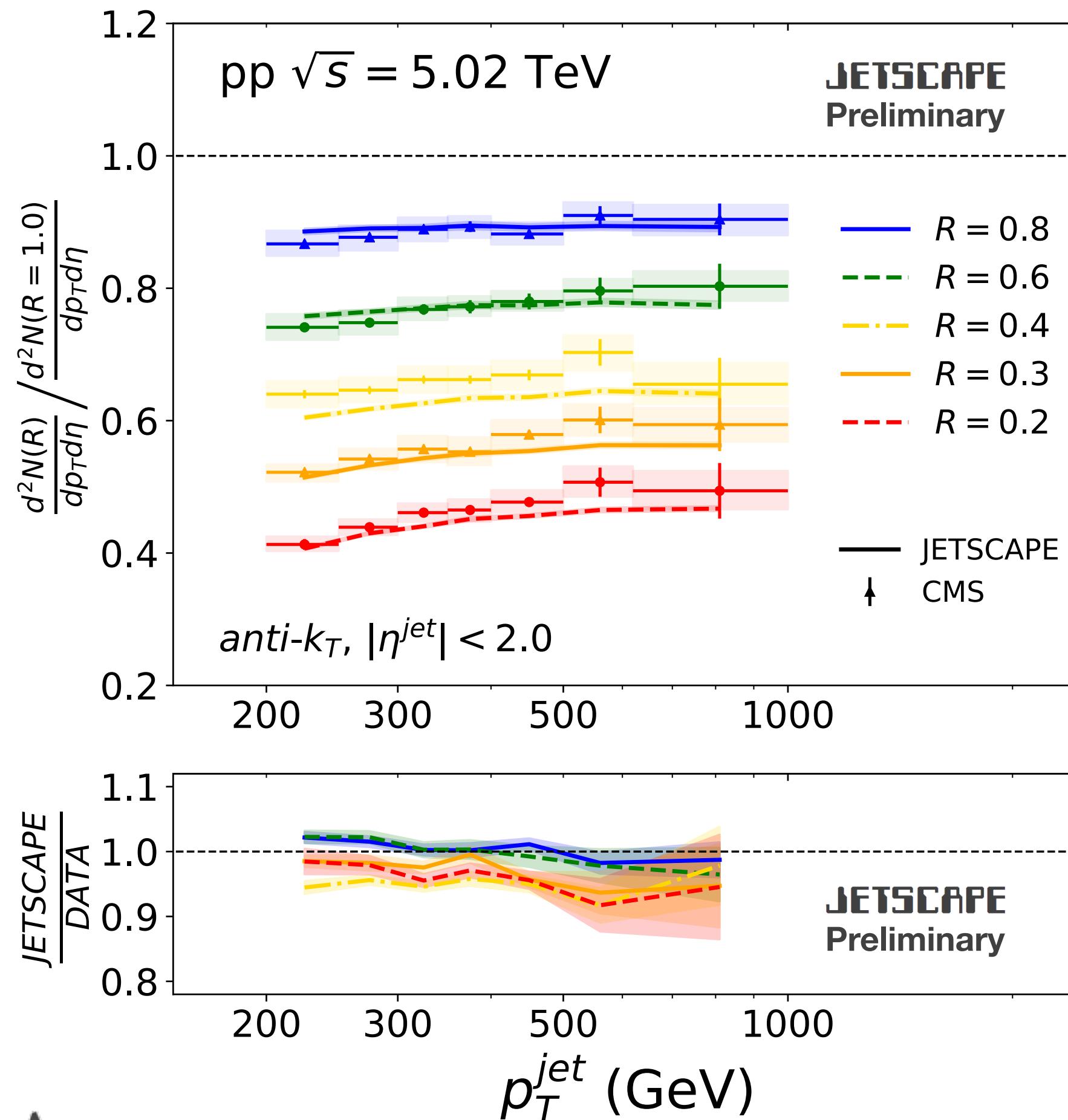


- MATTER vacuum shower down to $Q_0 = 1$ GeV
- Charged hadron yield slightly overestimated < 10%
- Jet cross-section: reasonable agreement at mid-rapidity, disagreement in p_T dependence at wider rapidity

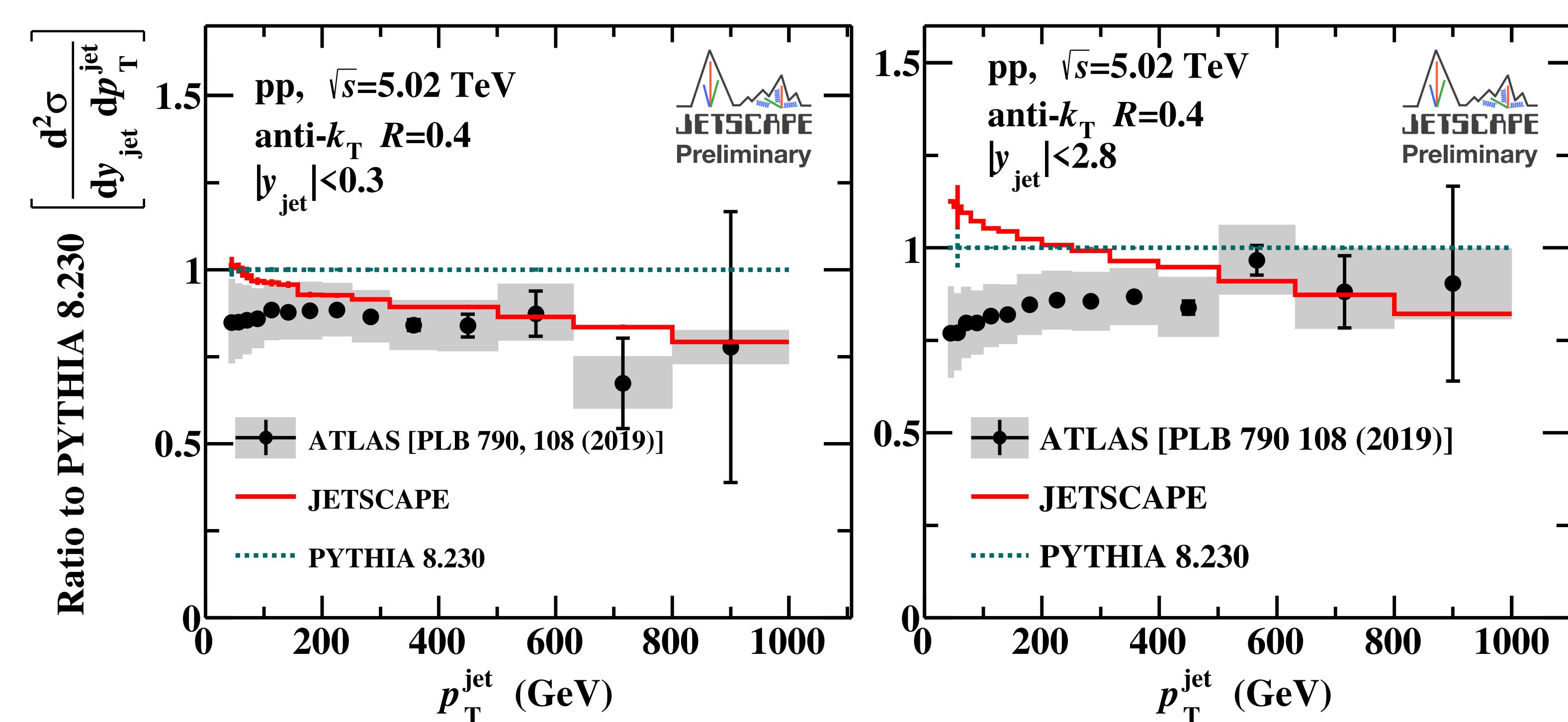


JETSCAPE “PP19 tune”

Comparison to CMS at $|y| < 2.0$



Comparisons to ATLAS at $|y| < 0.3, 2.8$



- Angular dependence reasonably reproduced at $|y| < 2$ with various R from 0.2 to 0.8 w.r.t. R=1.0; deviation only less than 10%
- “PP19 Tune” shows good performance within rapidity space $|y| < 2$

Configuration for PbPb simulations

Hydrodynamics

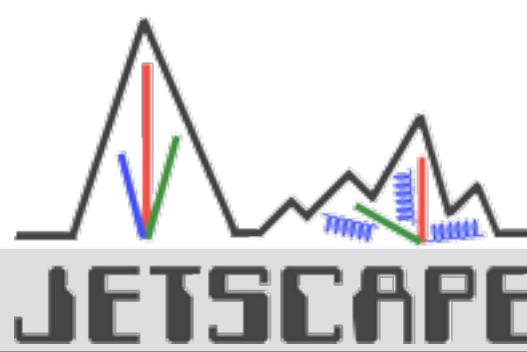
- Event-by-event VISHNew Hydro (2+1D)
- TRENTO (2+1D) initial conditions with free streaming

Jet evolution

- MATTER + LBT
- Switching virtuality between MATTER and LBT shower, $Q_0 = 1, 2, 3$ GeV
- $\hat{q} \propto \alpha_s^2 T^3 \ln \left(\frac{cE}{\alpha_s T} \right)$ based on HTL where $\alpha_s = 0.25$

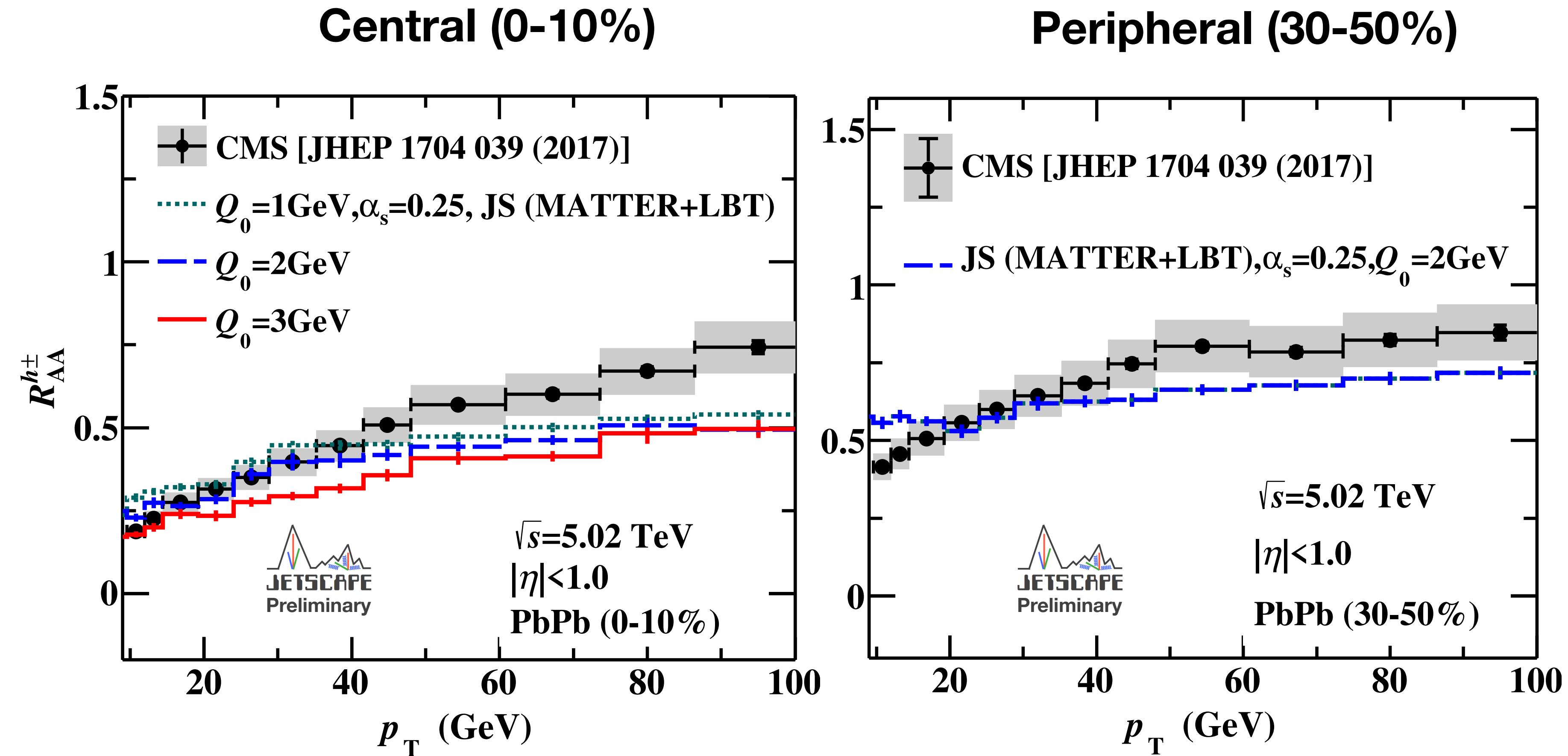
Medium response

- Recoils: Kinetic theory based approach
- Medium constituents kicked out by jet propagate in jet shower
- Energy/momentum from medium subtracted from jet signals



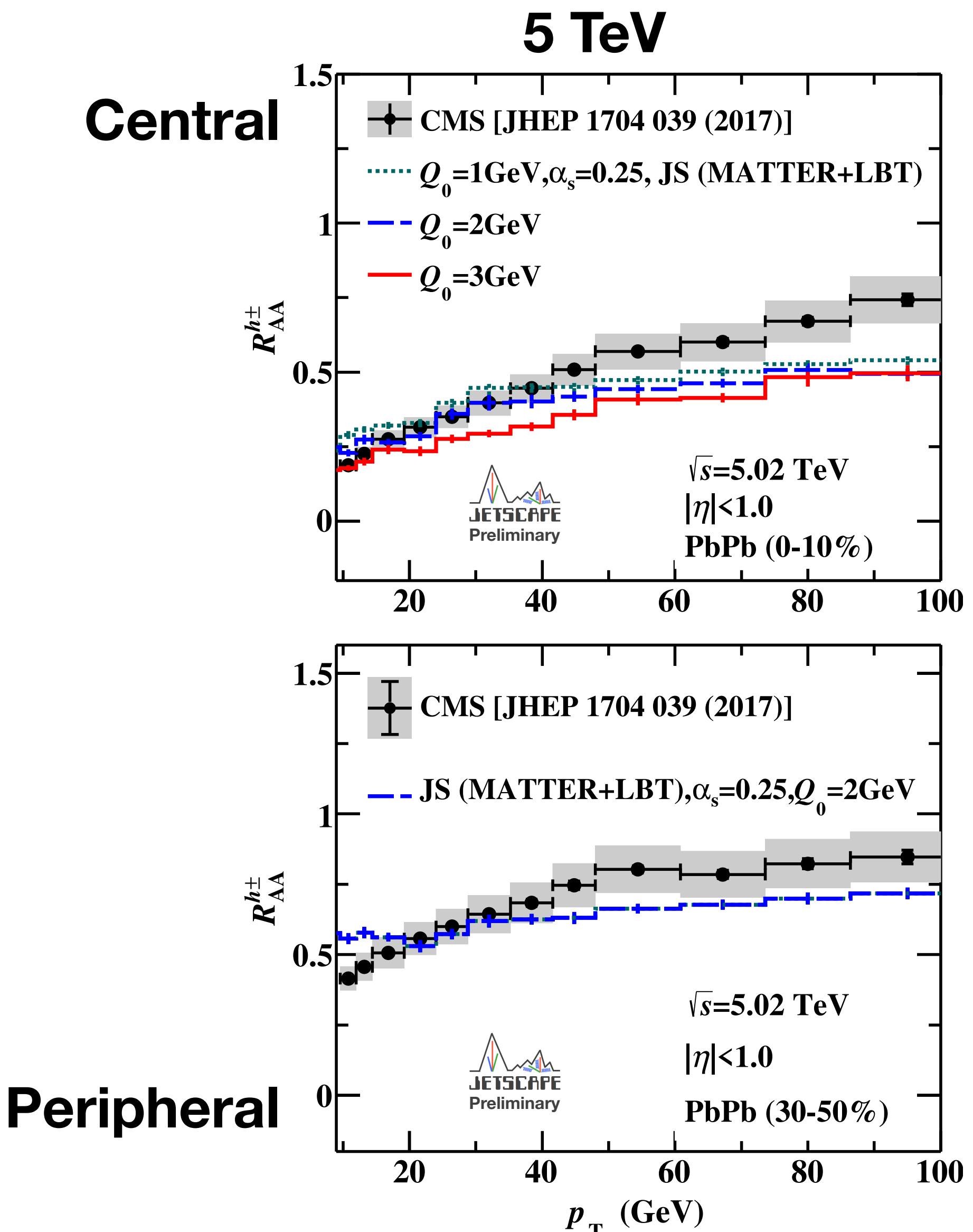
Single hadron dynamics at 5 TeV

- More quenching in charged hadron R_{AA} with larger Q_0
- Slight underestimation for charged hadron; weak p_T dependence compared to CMS

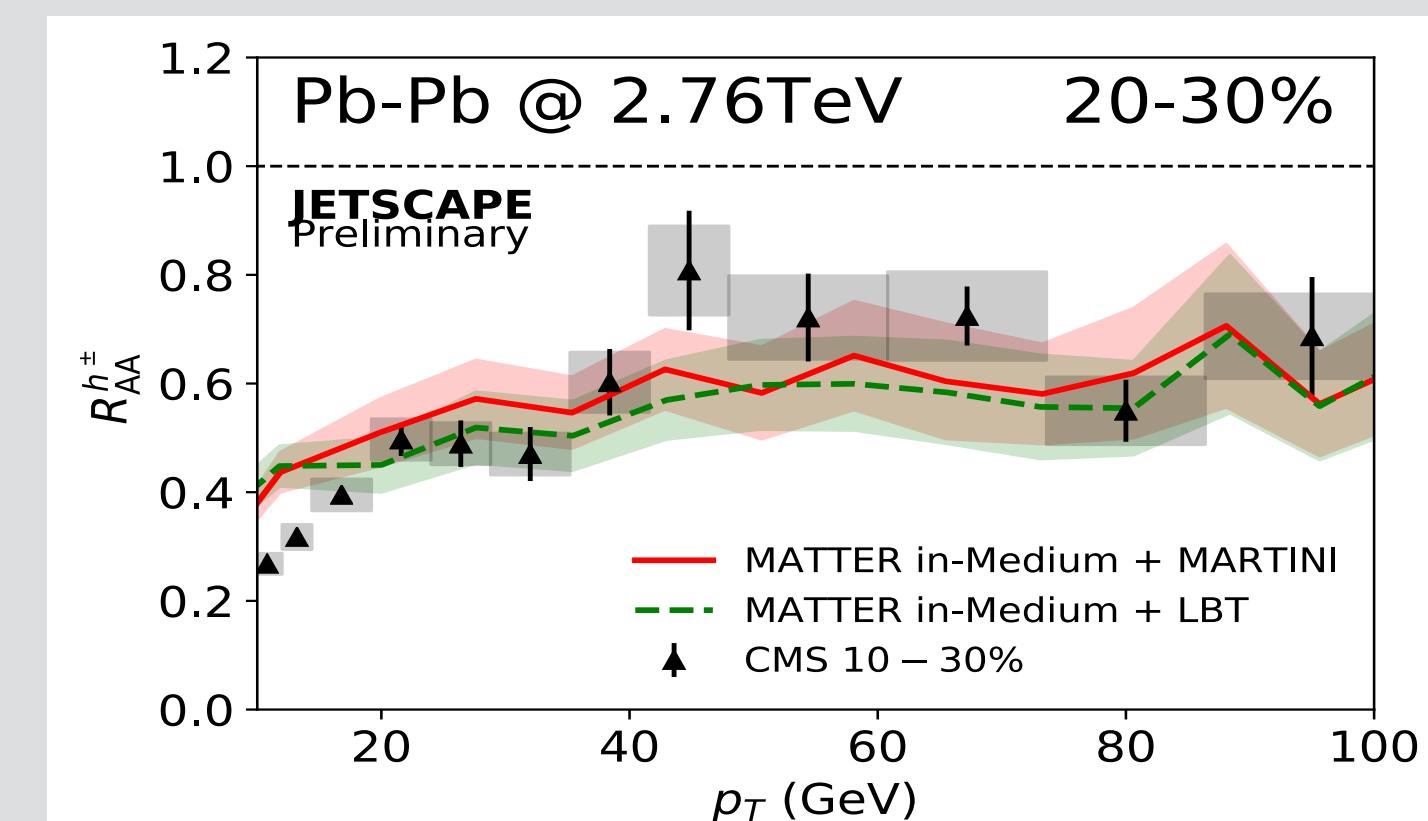
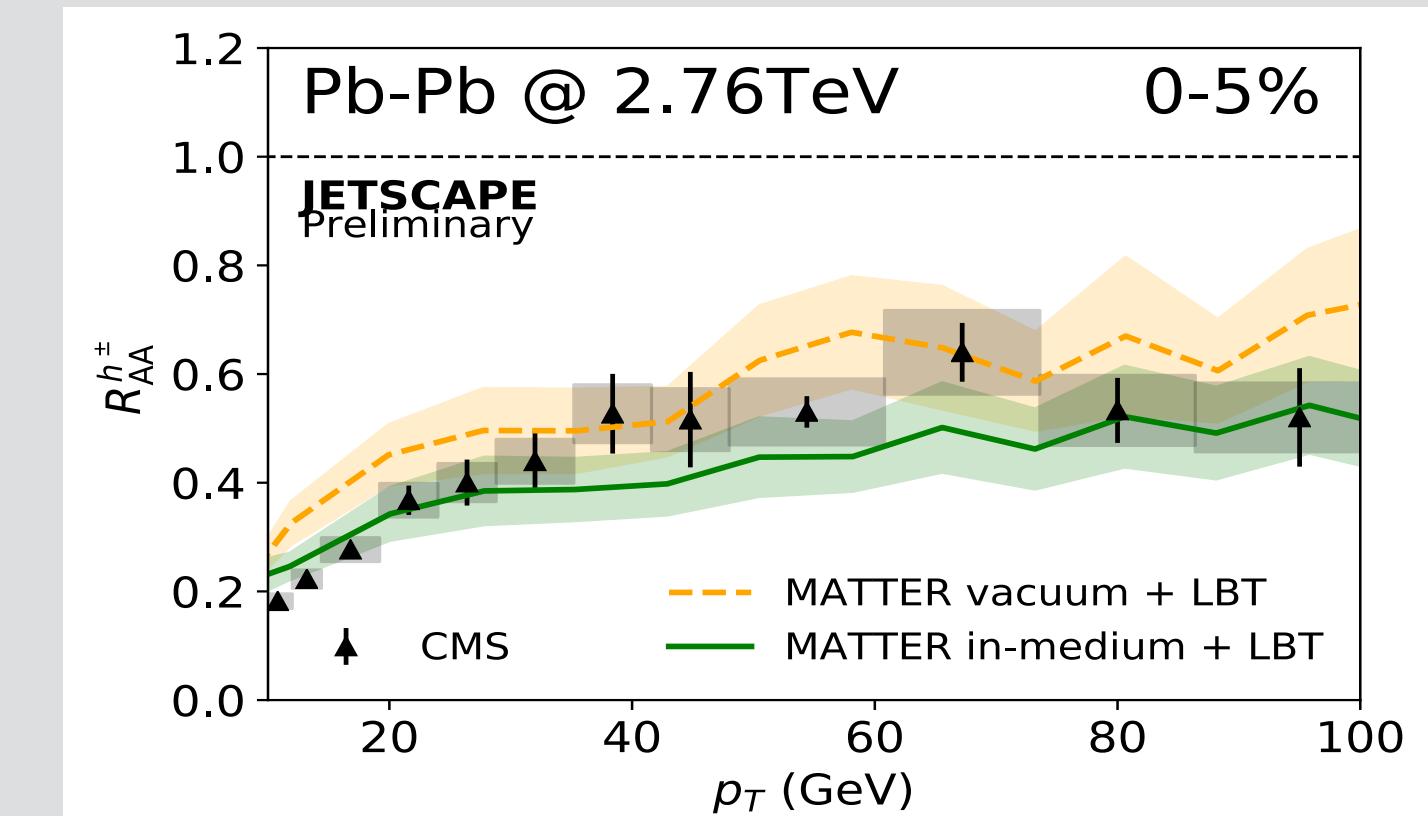


Single hadron at 5 TeV vs 2.76 TeV

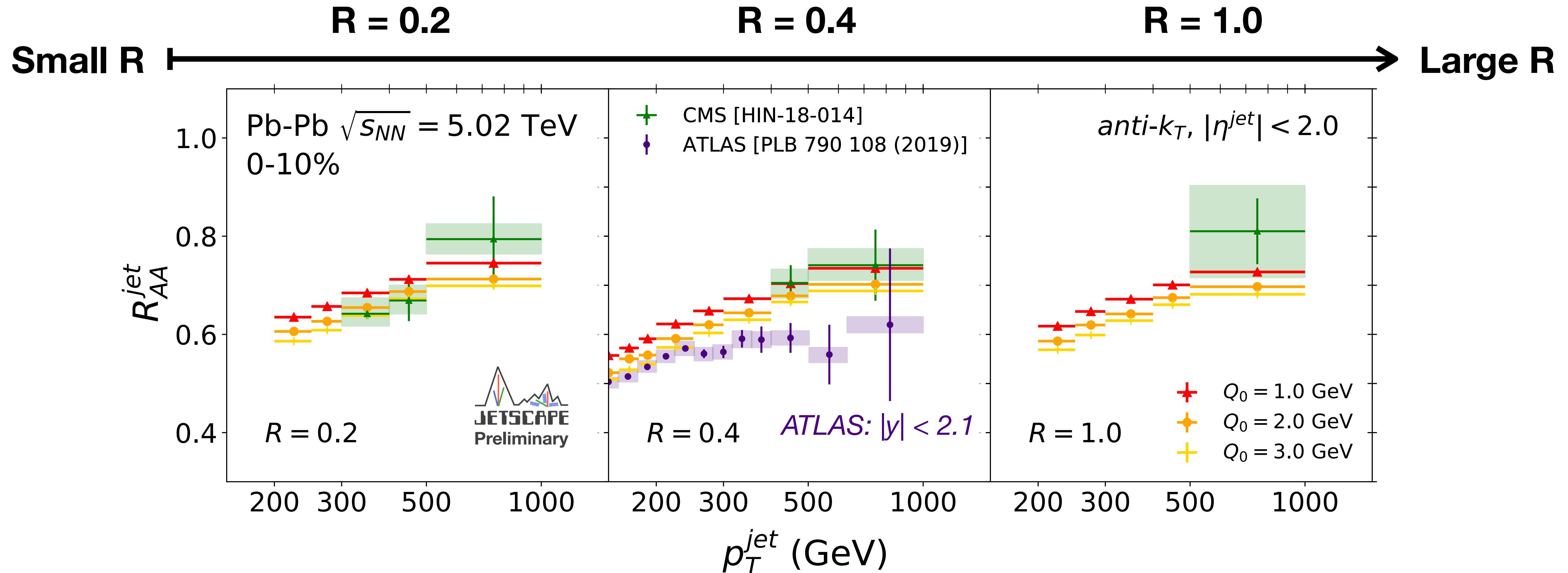
- More quenching in charged hadron R_{AA} with larger Q_0
- Slight underestimation for charged hadron; weaker p_T dependence compared to CMS
- Similar p_T dependence at 2.76 and 5 TeV within same kinematic range (< 100 GeV); requires examination of scale dependent jet quenching



2.76 TeV (from HP 2018)

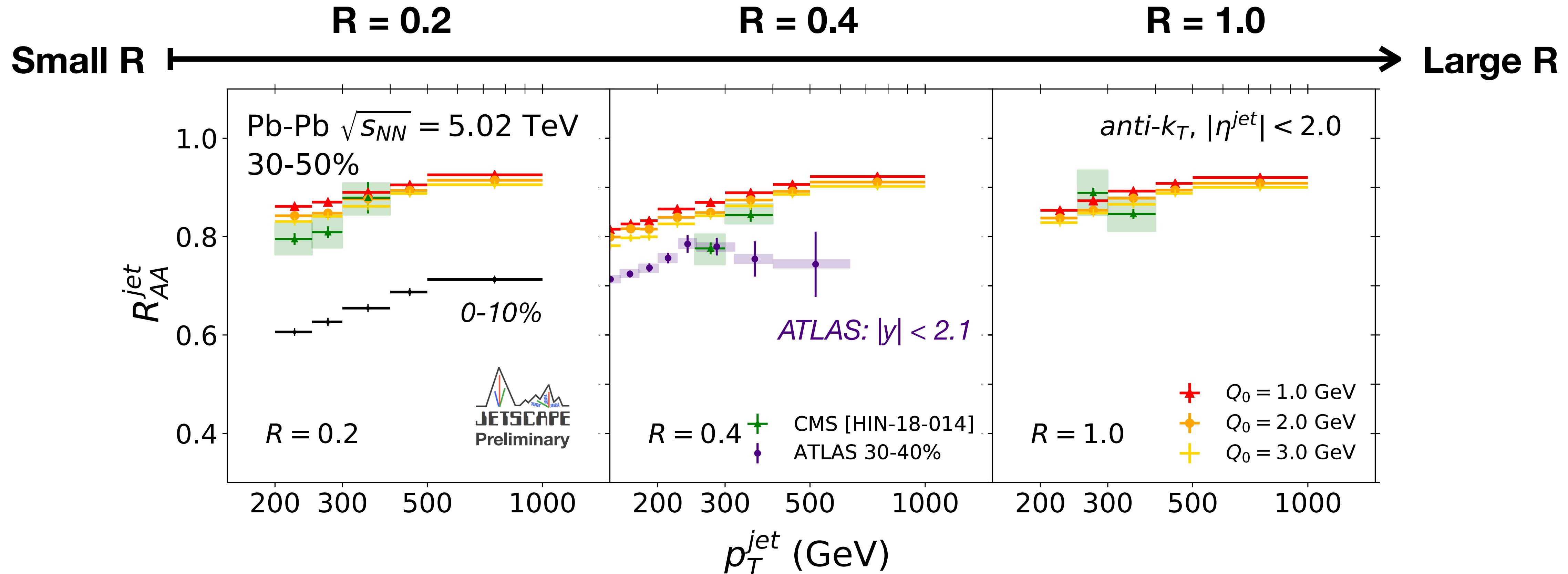


Cone size scan of jet R_{AA} (Central)



- Larger Q_0 , more quenching in Jet R_{AA} ; consistent with charged hadron R_{AA}
- Weak R dependence; majority of jet energy within $R = 0.2$
- Overall general agreement with data: Caveat - different cuts for two experiments

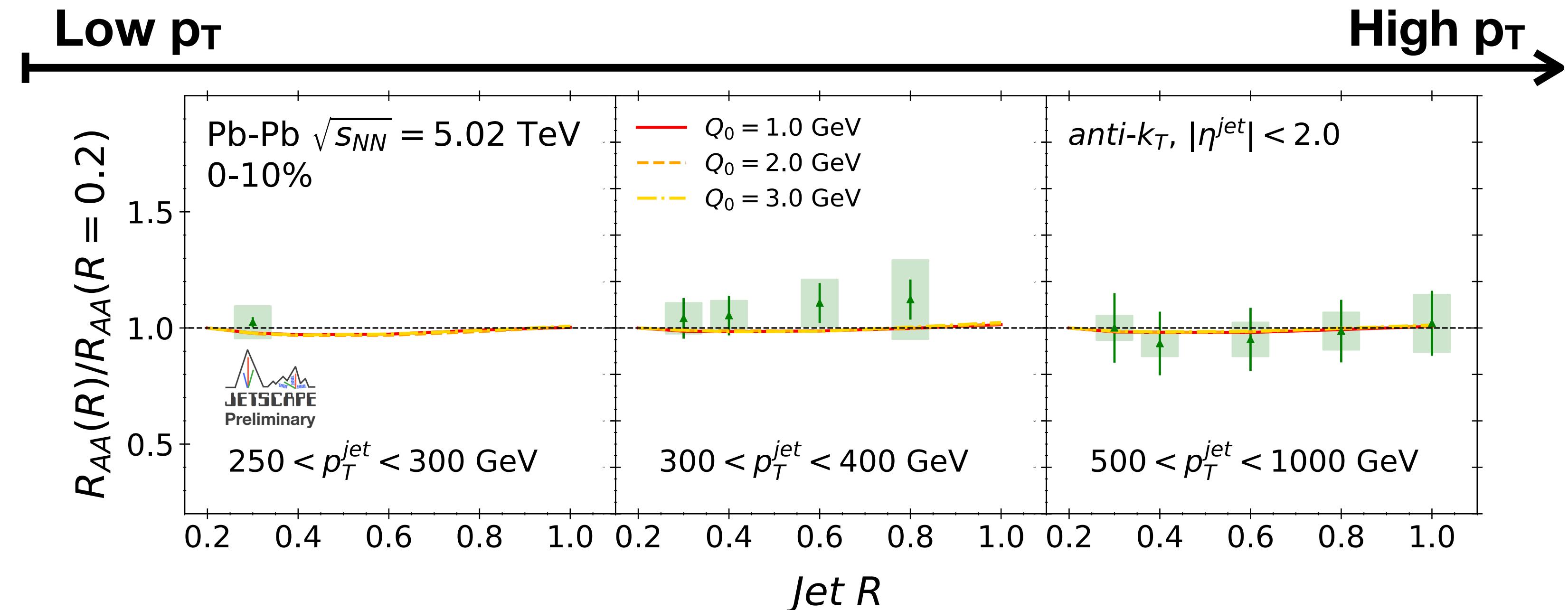
Cone size scan of jet R_{AA} (Peripheral)



- Overall shift in magnitude; no significant changes in p_T and R dependence
- Strong centrality dependence in JETSCAPE as in CMS

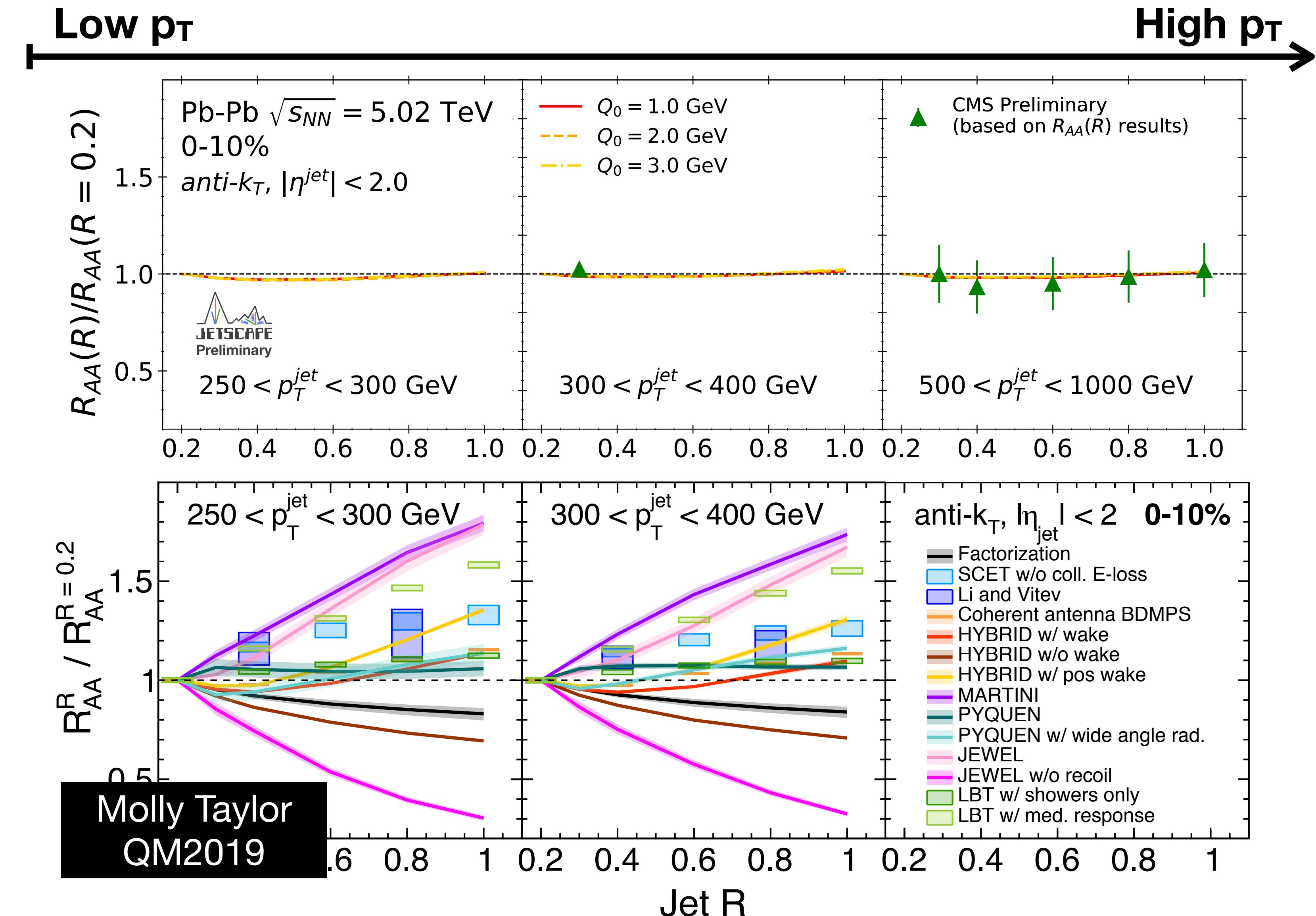
Double ratio of jet RAA at 5 TeV

- Double ratio of jet R_{AA} w.r.t R=0.2 close to unity



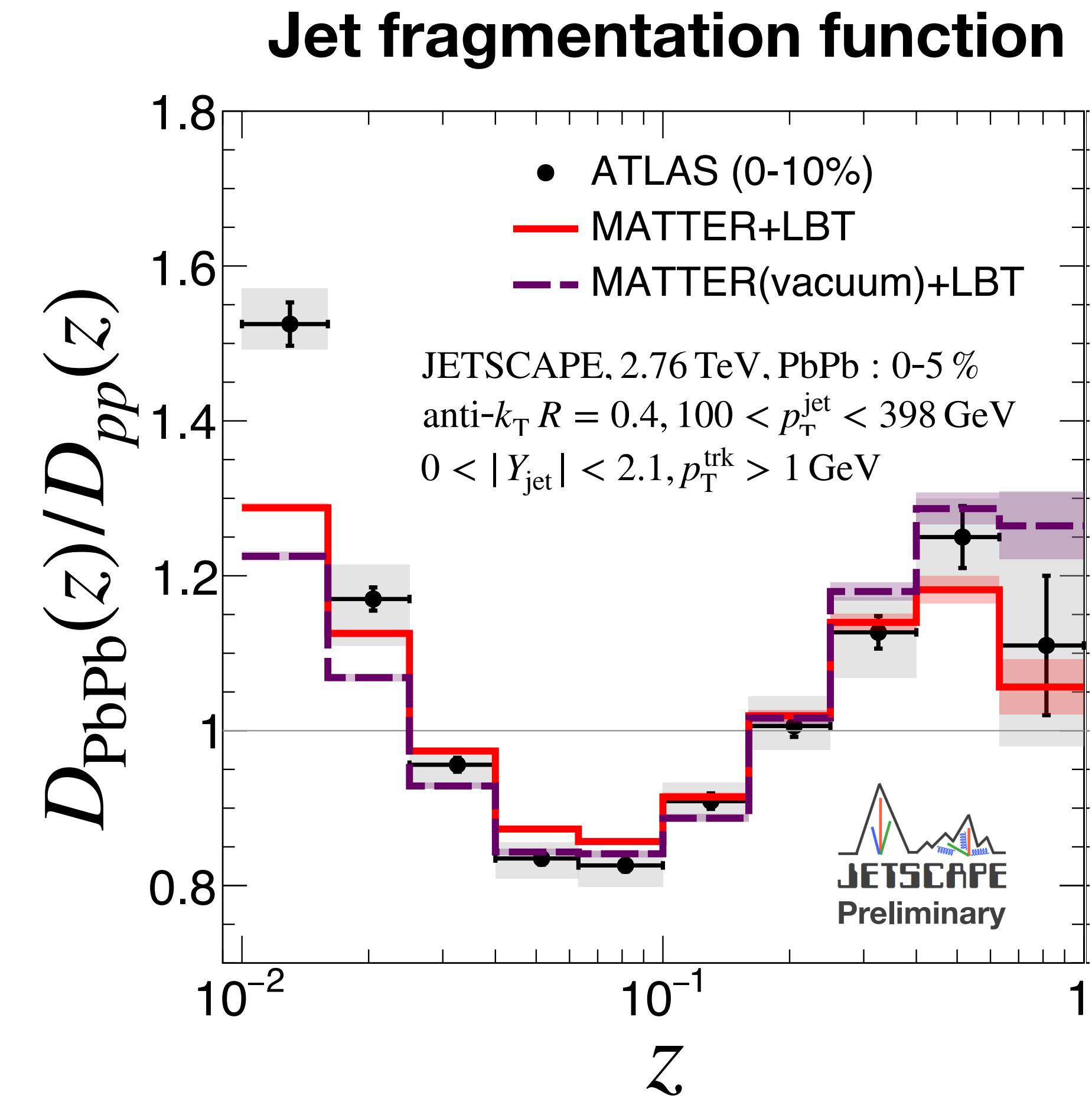
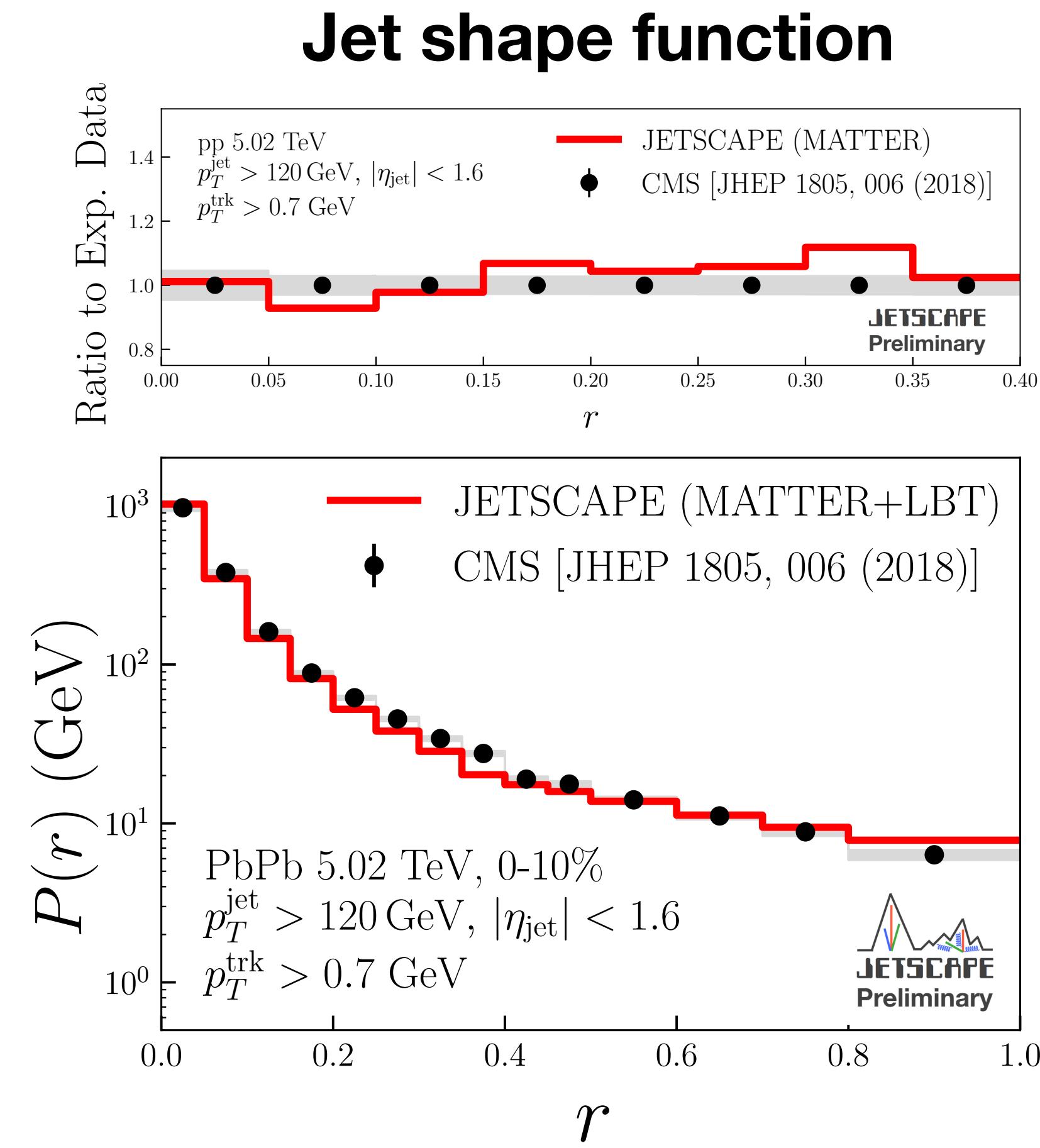
Double ratio of jet RAA at 5 TeV

- Double ratio of jet R_{AA} w.r.t R=0.2 close to unity
- Theory predictions sensitive to jet quenching mechanism, medium response
- Effective in discriminating different models
 - well reproduced by JETSCAPE



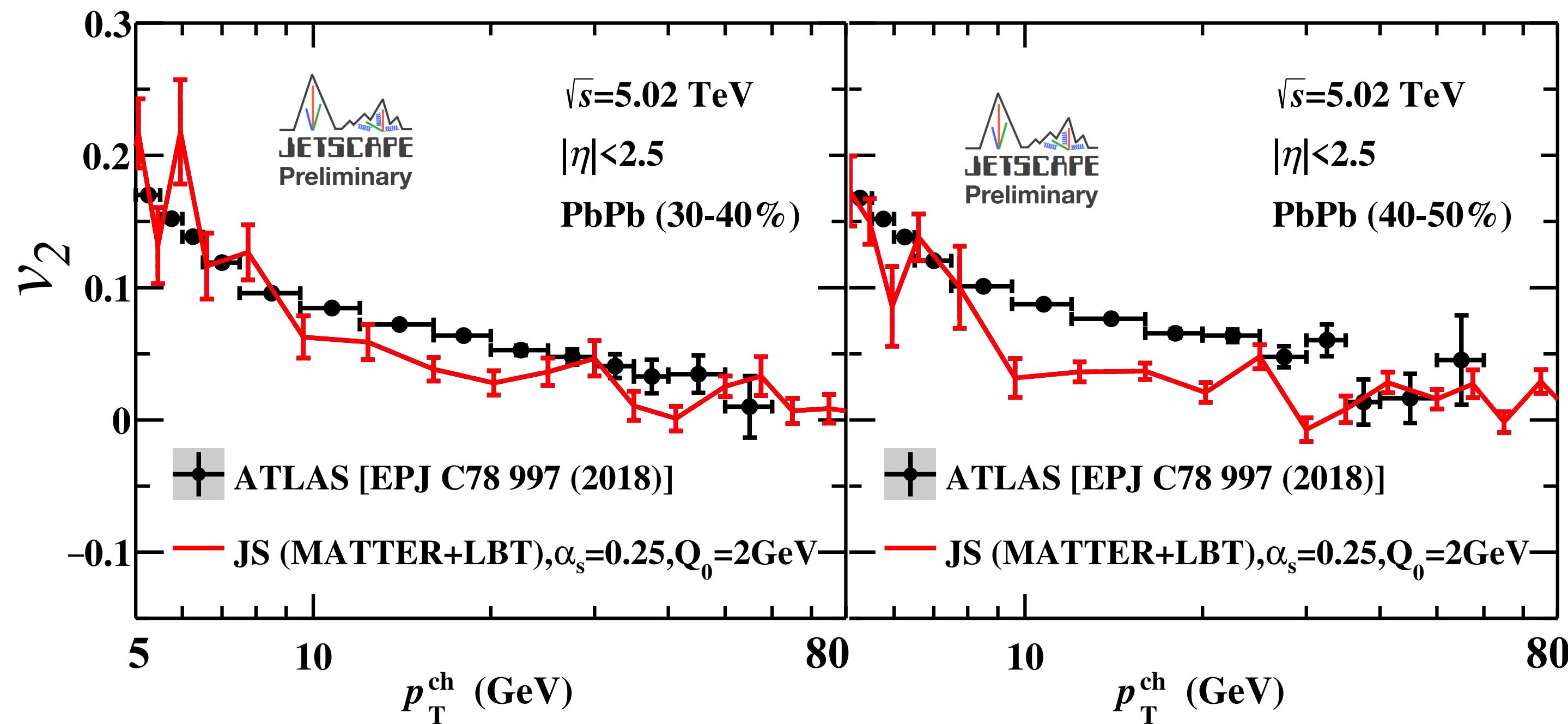
Jet sub-structure observables

- Jet shape functions for pp and PbPb consistent with CMS at 5 TeV
- Jet energy mostly confined in small R - supports double ratio of jet R_{AA} close to unity
- Insufficient enhancement at low z; sensitive to hydro/jet interplay and hadronization

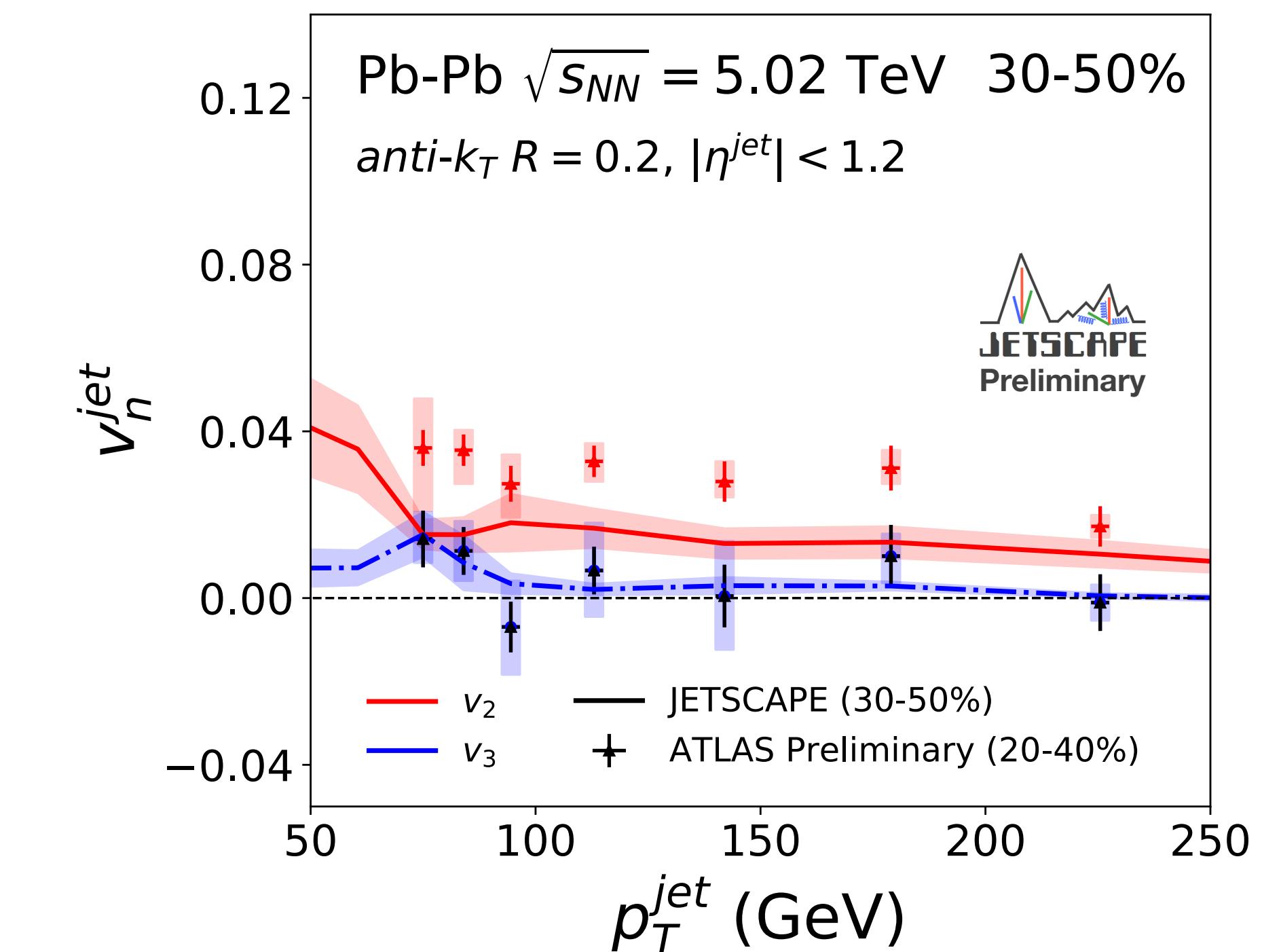


Charged hadron and jet v_n at 5 TeV

Charged hadron v_2



Jet v_2, v_3



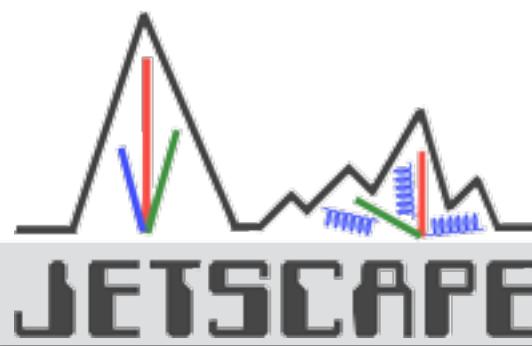
- Charged hadron elliptic flow coefficients compatible to ATLAS
- Jet elliptic flow developed by path-length dependent jet quenching, triangular flow nearly zero

Conclusion and outlook

- The JETSCAPE framework allows for a unified description of multi-scale jet evolution inside QGP.
- A satisfactory agreement between the PP19 tune and data within $|y| < 2$, room for future improvement at larger rapidity.
- Multi-stage approach is essential in describing a variety of integrated and differential jet observables.
- A reasonable description of the double ratio of jet RAA, potential for discriminating models.
- Future work to study:
 - Scale dependence of \hat{q} for better descriptions of the collision energy dependence of jet quenching
 - Strongly-coupled description of medium response for better treatment of jet/medium interplay

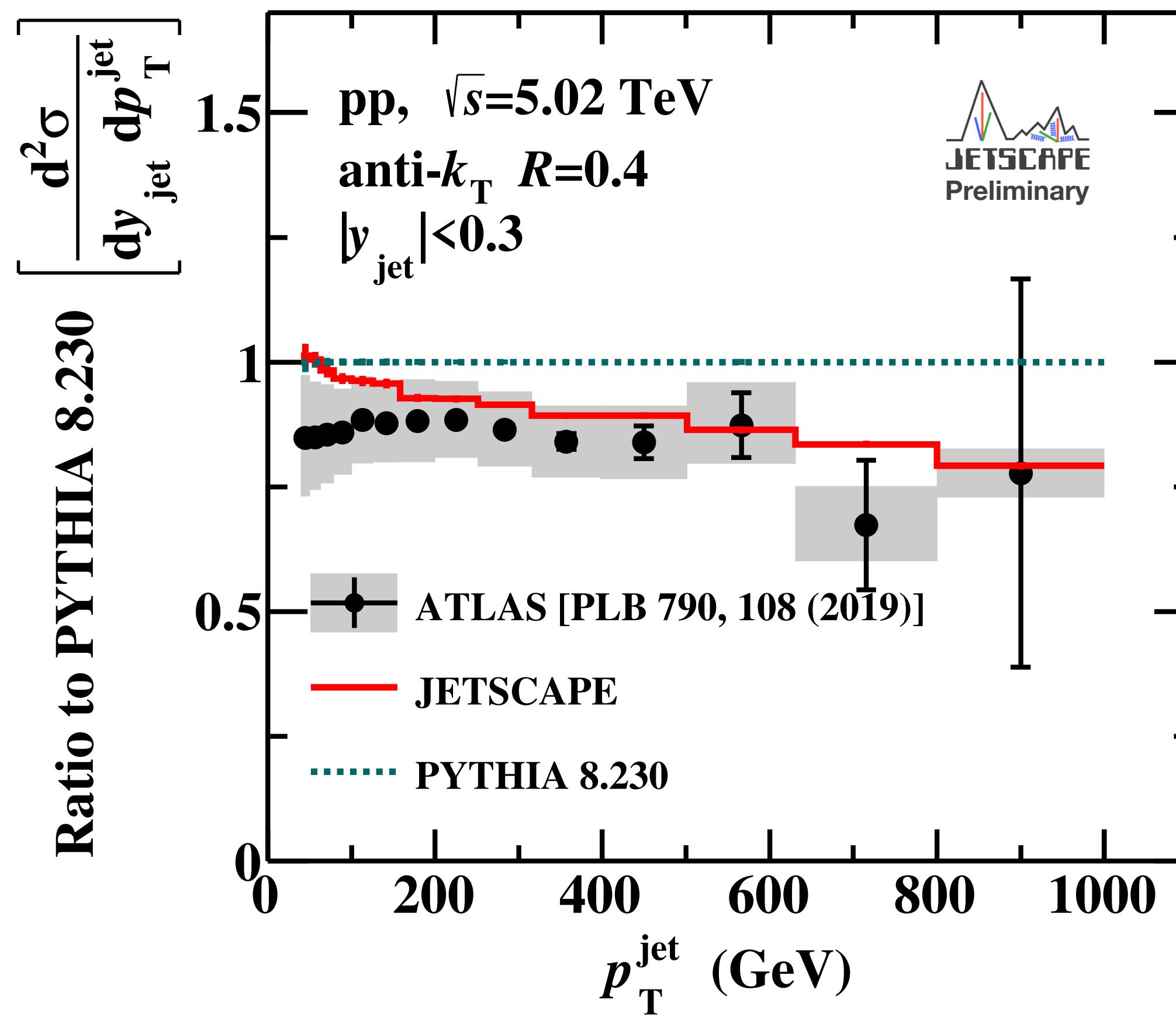


Backup

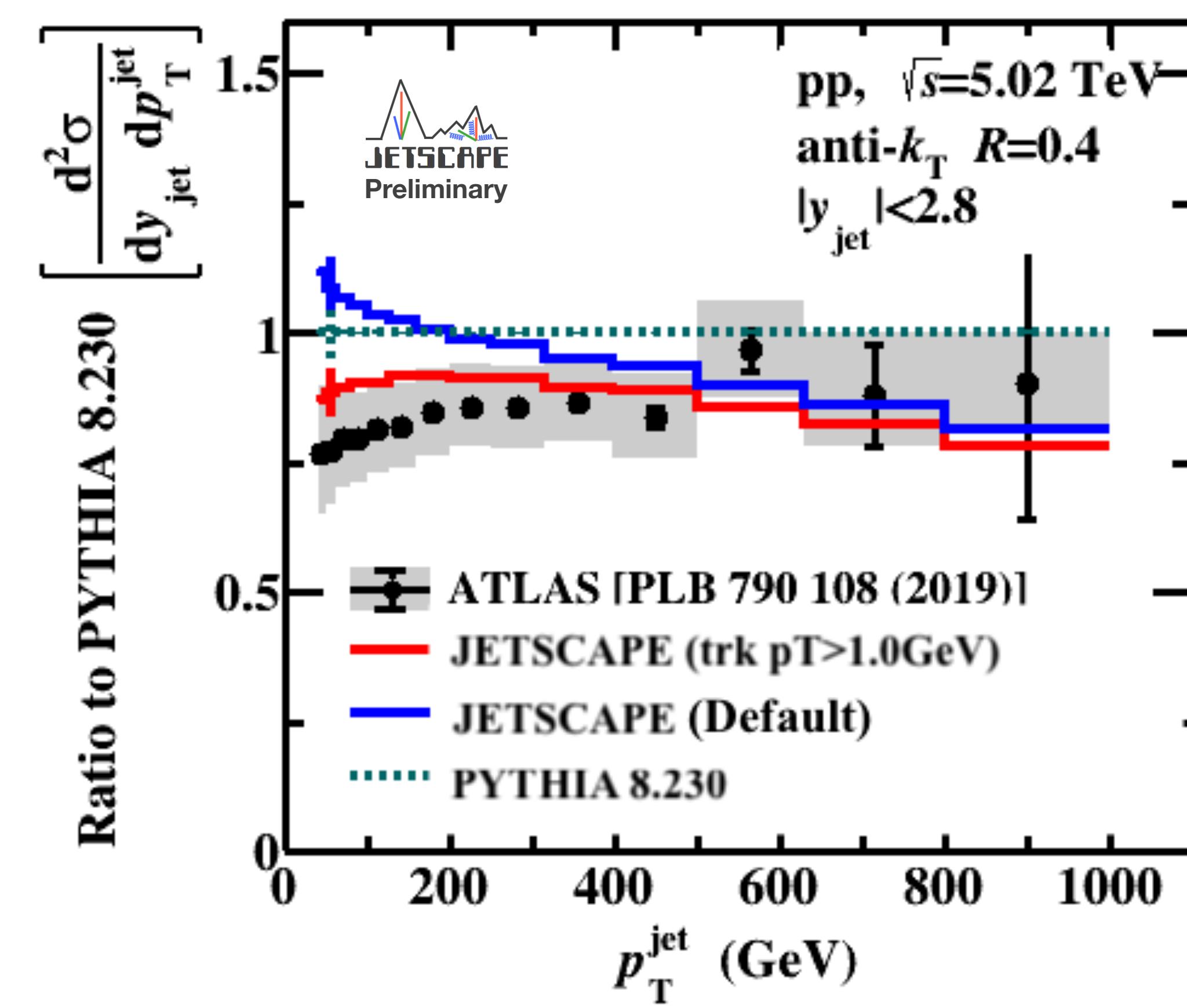


JETSCAPE “PP19 tune”

$|y| < 0.3$

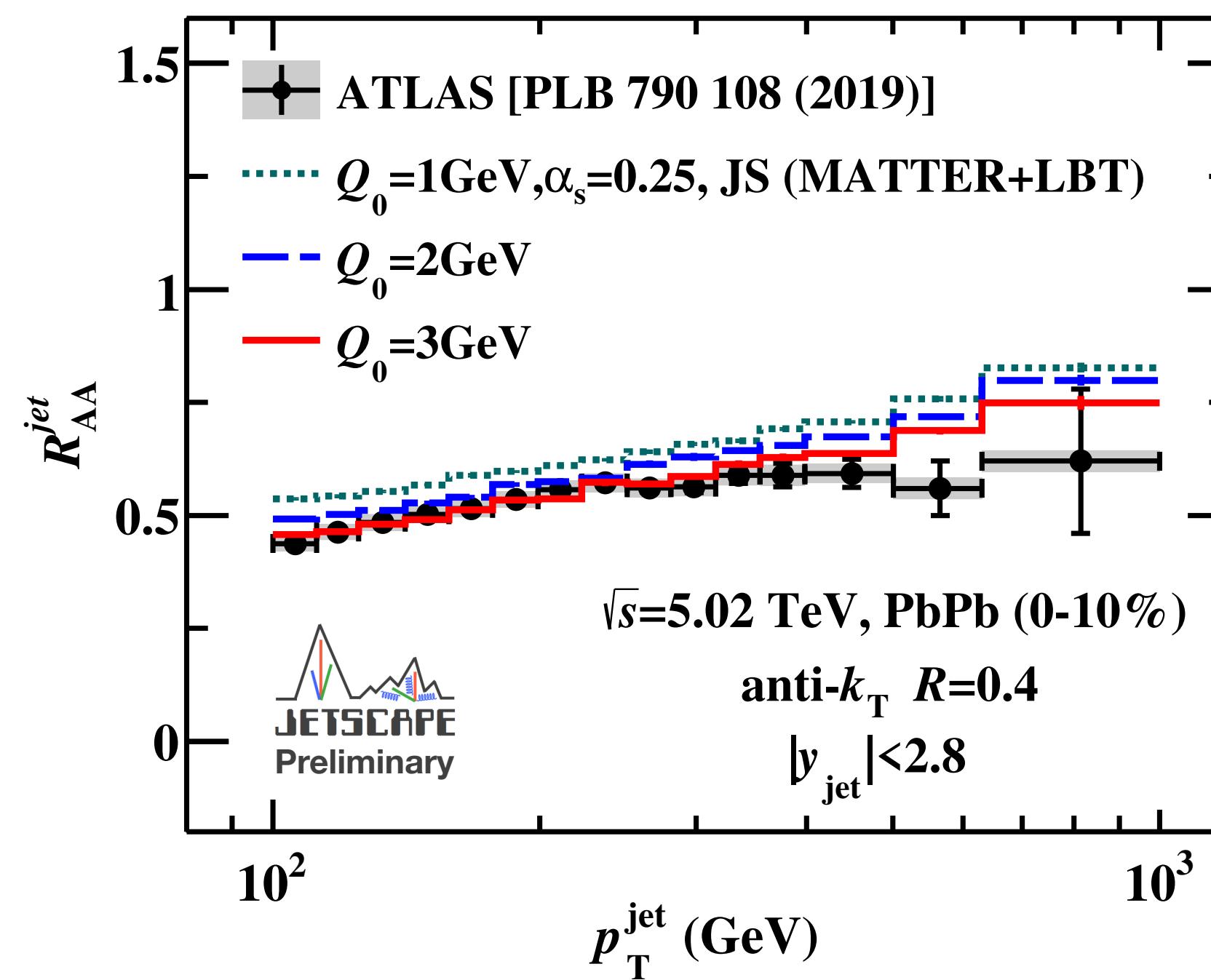


$|y| < 2.8$

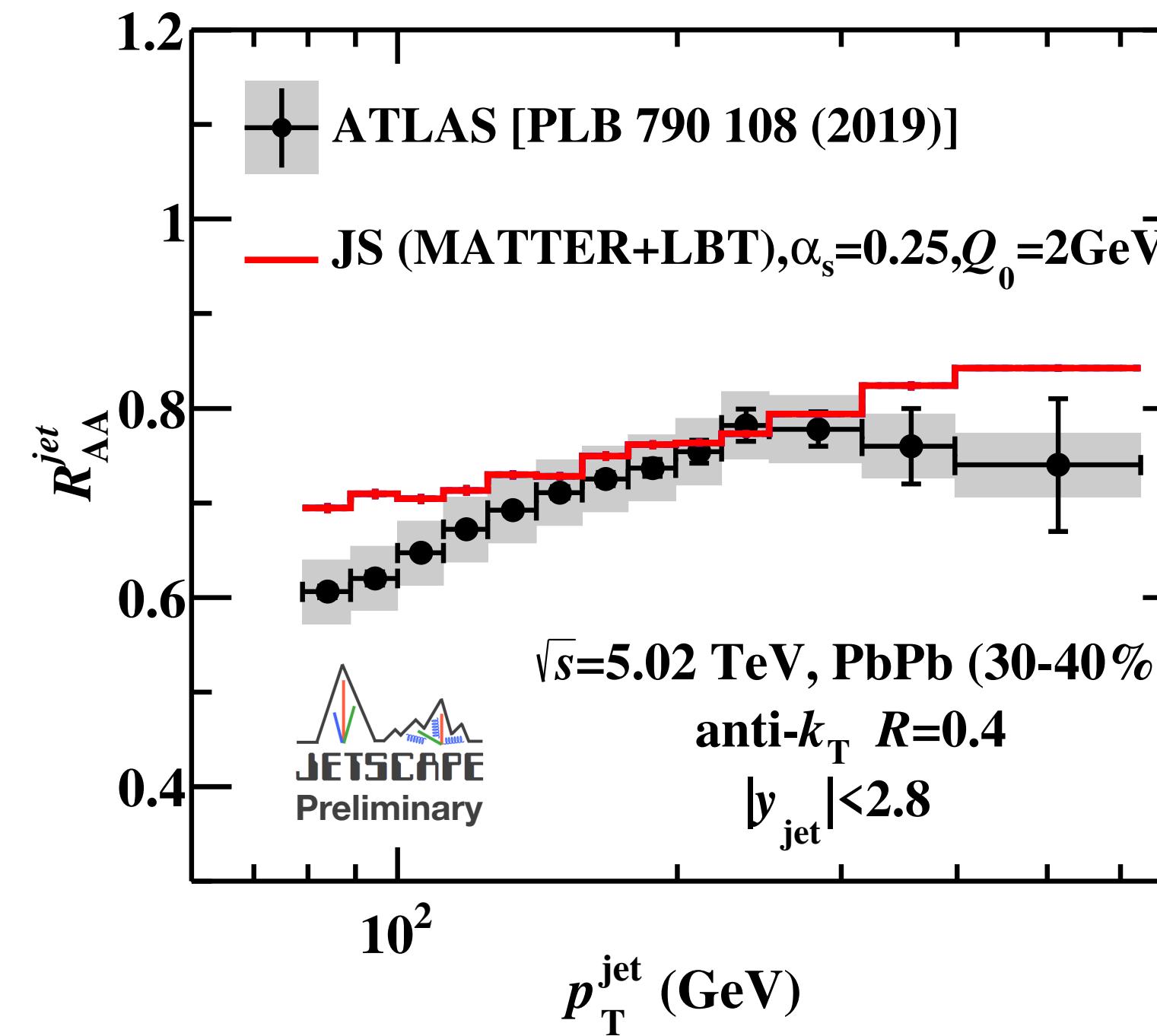


Jet RAA at 5 TeV with ATLAS

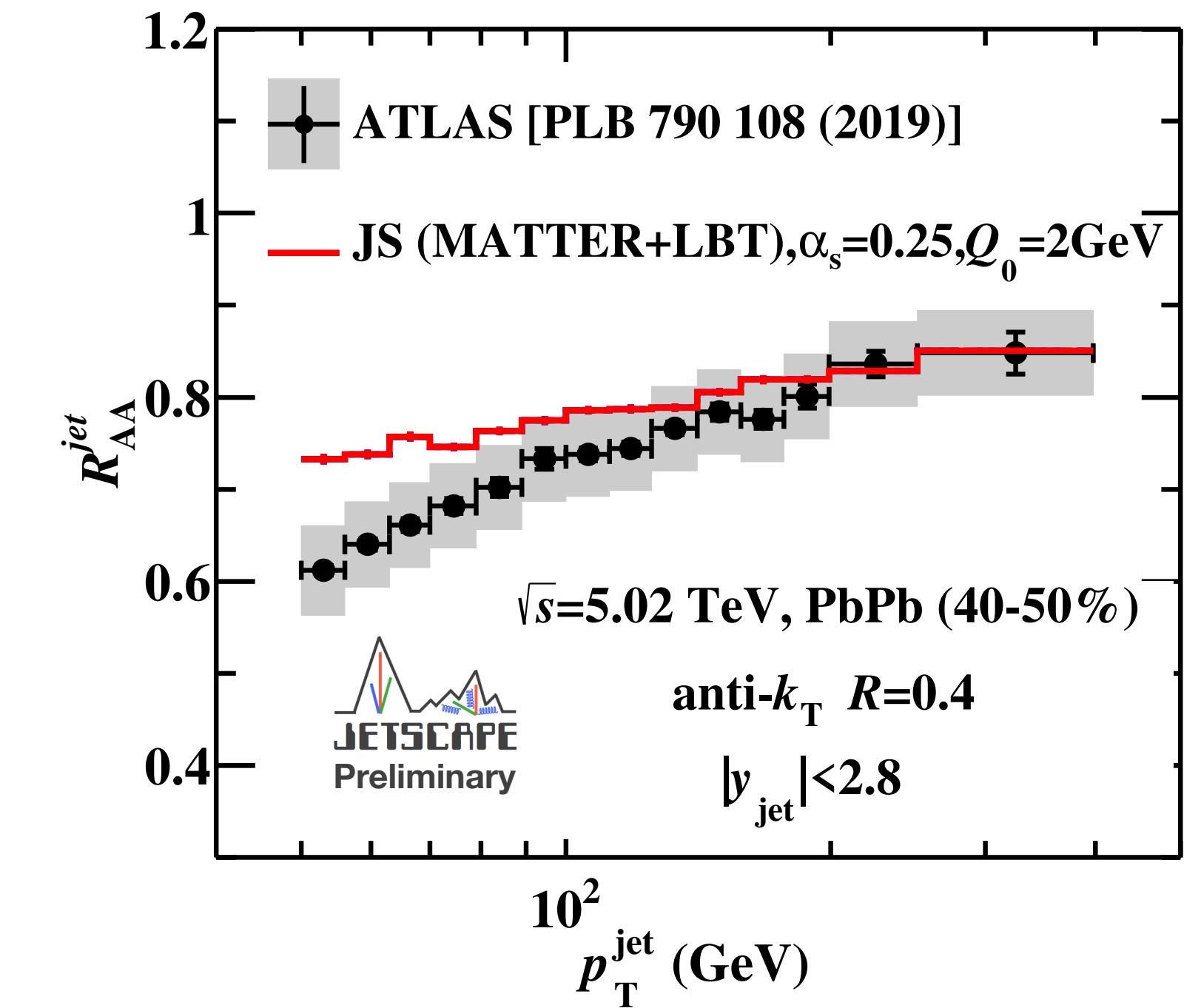
Central (0-10%)



Peripheral (30-40%)



Peripheral (40-50%)



- p_{T} dependence in JETSCAPE remains unchanged across centralities
- Fits the data at low p_{T} for 0-10%, high p_{T} for 40-50%