Describing Ridge behavior via kinematics between jets and medium

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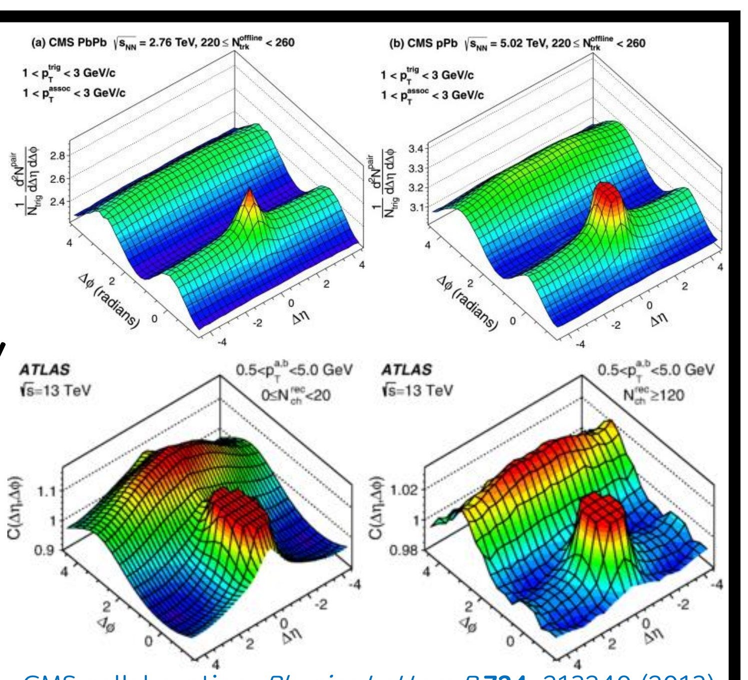
Introduction

Ridge structure

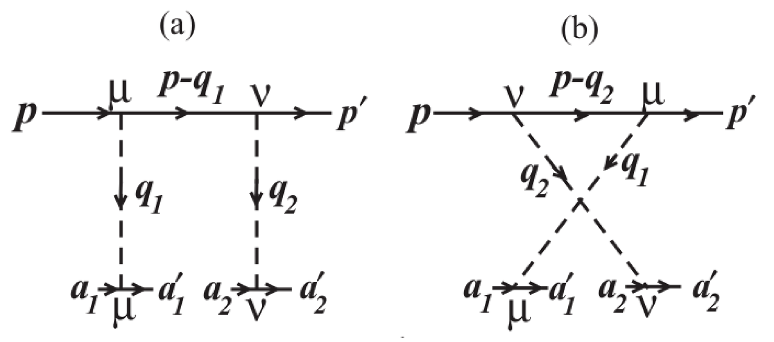
- AA collisions
  - Explained by hydrodynamics
  - Regarded as one of evidence for QGP
- pp collisions with high-multiplicity
  - Reported from LHC
  - Not enough to produce QGP
- Try to understand via kinematics
  - Interaction between jet & medium



CMS collaboration, *Physics Letters B* **724**, 213240 (2013)
ATLAS collaboration, *Physical Review Letters* **116**, 172301 (2016)

Jet & Medium interaction

- Energy loss mechanism for jet
  - Collision
  - Radiation
    - Photon (**Bremsstrahlung**)
    - Gluon

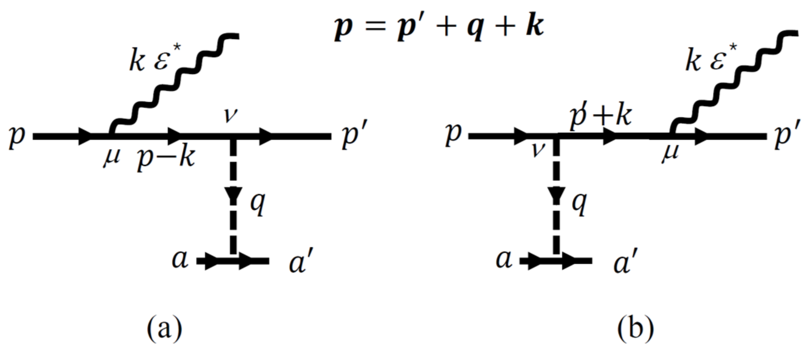


C.-Y. Wong, *Physical Review C* **85**, 064909 (2012)

- Based on previous study

$$d\sigma \sim |\mathcal{M}_{(a)} + \mathcal{M}_{(b)}|^2 = |\mathcal{M}_{(a)}|^2 + |\mathcal{M}_{(b)}|^2 + (\boldsymbol{interference})$$

  - Collision between jet & medium partons
  - Collective motion
    - Medium partons aligned along the jet
- Bremsstrahlung process
  - Might interfere constructively
  - Explain Ridge structure



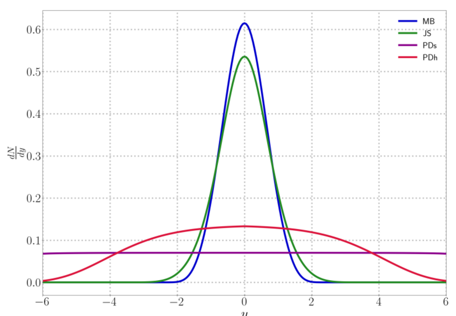
Select PDF

PDF for Initial states

- We need initial medium parton's momentum distribution.

$$\frac{d\sigma}{dy_{a'}d\varphi_{a'}} = \int \frac{d\sigma}{dy_{a'}d\varphi_{a'}d^3\vec{a}} f(\vec{a})d^3\vec{a} = \int \frac{d\sigma}{dy_{a'}d\varphi_{a'}d^3\vec{a}} f(y_a, a_T)|\mathcal{J}|\, dy_a da_T d\varphi_a$$

- Possible choices of $f(y_a, a_T)$
  - Maxwell-Boltzmann distribution (**MB**)
  - Juttner-Synge distribution (**JS**)
  - Phenomenological Parton Distribution from Soft scattering (**PDs**)
  - Phenomenological Parton Distribution from Hard scattering (**PDh**)

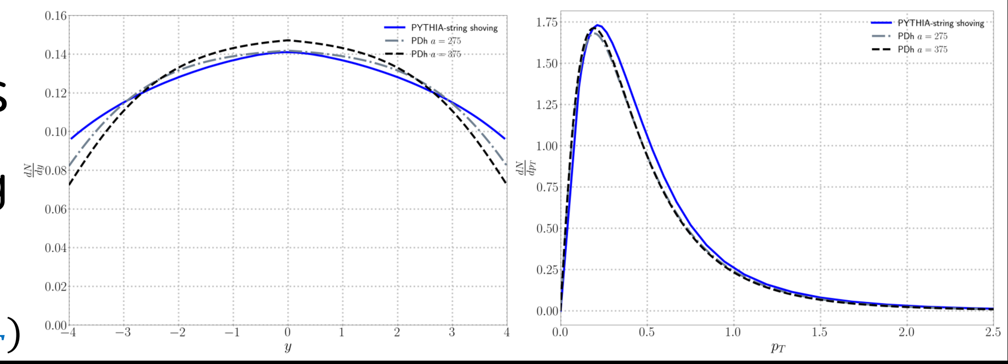


PDh

$$f(y_a, a_T) = A(1-x)^{a}\left[1-(1-q)\frac{m_T}{T}\right]^{\frac{1}{1-q}}$$

C.-Y. Wong, G. Wilk, L. J. Cirto and C. Tsallis, *Physical Review D* **91** 114027 (2015)
R. Hagedorn, *Nuovo Cimento* **6** , 1 (1983)
C. Michael and L. Vanryckeghem, *Journal of Physics G* **3** , L151 (1977)

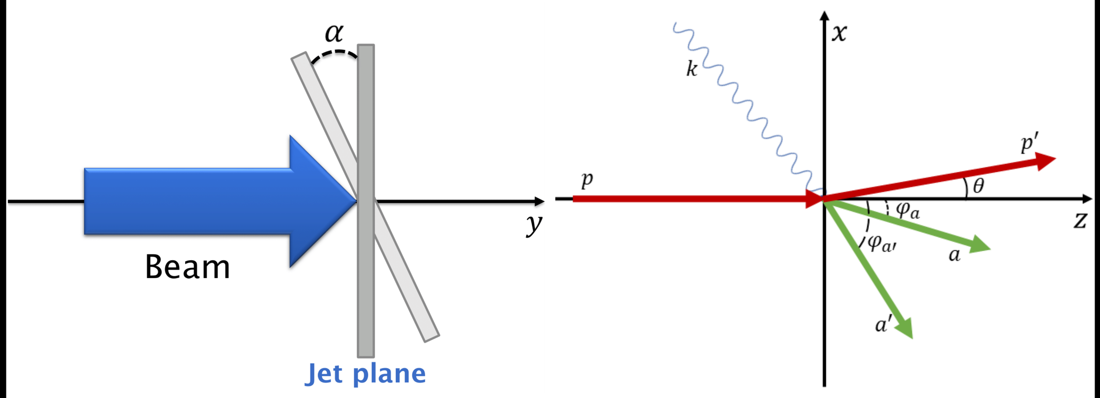
- x : Lightcone variable
- Free parameters
  - a : Fallout parameter which decide shape of rapidity distribution
  - q : Non-extensive parameter which phenomenologically equivalent to the quasi-power law
  - T : Temperature of system
- Choose parameter values
  - Use PYTHIA string-shoving
    - $a = 275,\ q = 1.14,\ T = 150$ MeV (y)
    - $a = 375,\ q = 1.14,\ T = 150$ MeV (p_T)



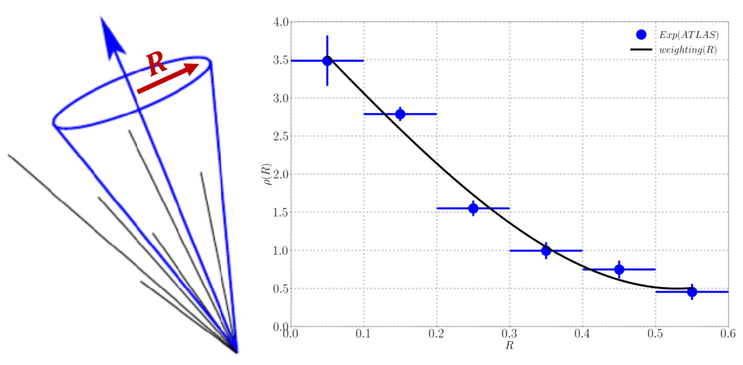
Calculation

Coordinate

- Assumption
  - Jet plane is perpendicular to the beam



Jet radius



ATLAS collaboration, *Physical Review D* **83**, 052003 (2011)

$$\int d\sigma(\theta)d\theta \rightarrow \sum_i d\sigma(\theta_i)w(\theta_i)$$

- $\theta = 3°, 5°, 10°, 20°$
- $w(\theta_i)$: weighting function

Correlation

- In experiment

$$C(\Delta\eta, \Delta\varphi) = \frac{S(\Delta\eta, \Delta\varphi)}{B(\Delta\eta, \Delta\varphi)}$$

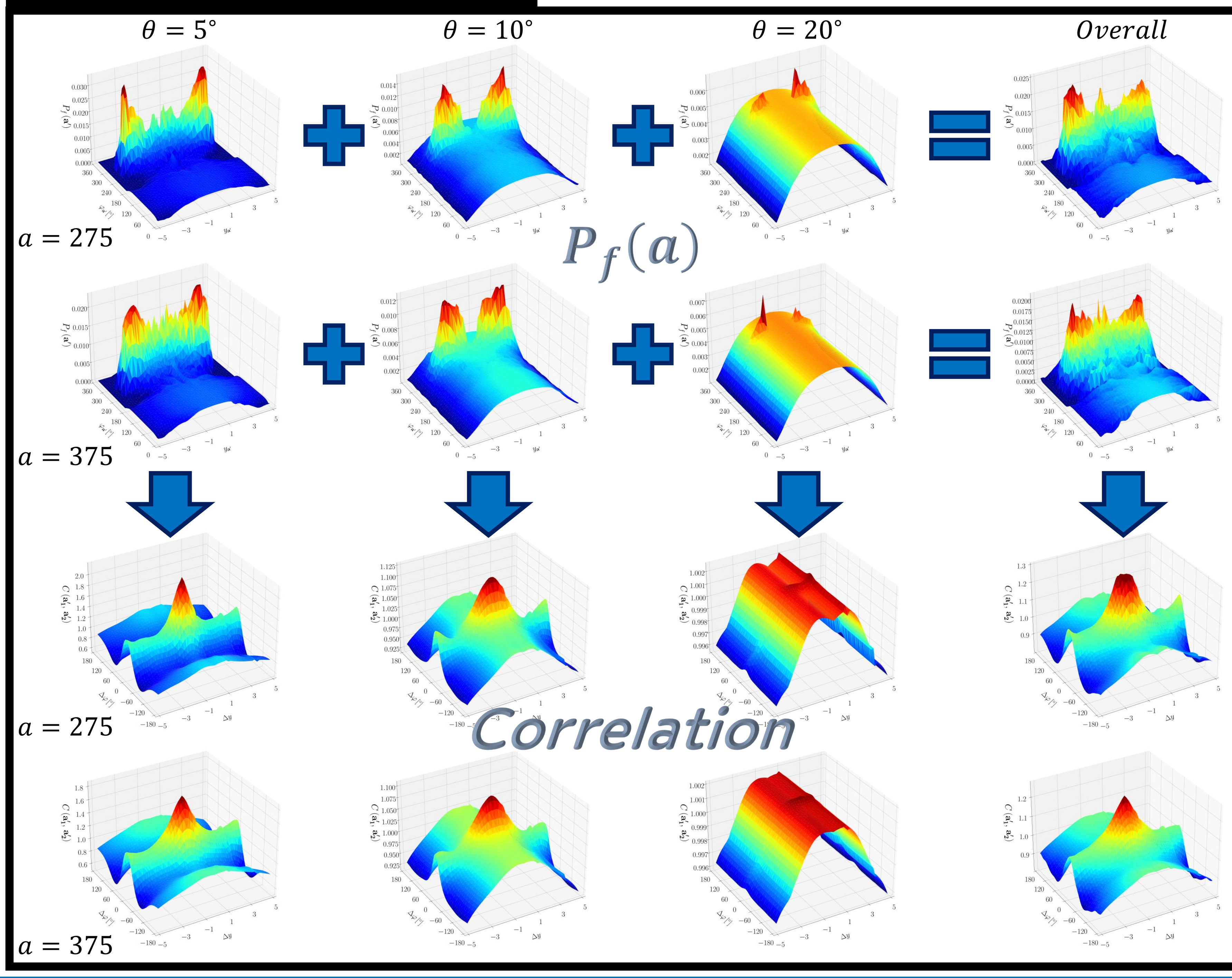
- In theory

$$C(a_1, a_2) = \frac{P_f(\boldsymbol{a_1}, \boldsymbol{a_2})}{P_i(\boldsymbol{a_1}) \cdot P_i(\boldsymbol{a_2})}$$

  - $P_f(\boldsymbol{a_1}, \boldsymbol{a_2}) = \cdot P_f(\boldsymbol{a_2})$
  - $P_i(\boldsymbol{a})$: Probability of final medium partons **before interaction with jet particle**
  - $P_f(\boldsymbol{a})$: Probability of final medium partons **after interaction with jet particle**

Results

$P_f(a)$ & Correlation



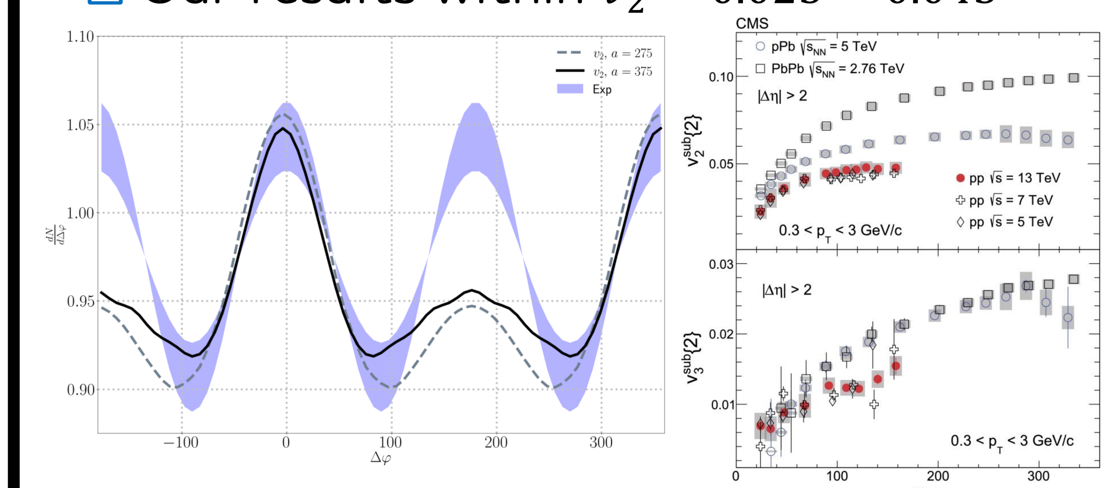
- $P_f(\boldsymbol{a}) = d\sigma + P_{non\_interact}$
  - $\theta \uparrow \Rightarrow d\sigma \downarrow$
  - $d\sigma(a = 275)$ is wider
    - Expected from rapidity dist.
  - Overall
    - $d\sigma$ at low θ is dominant
- Correlation
  - Shape of correlation depends on θ
    - Related on scales of $d\sigma$
  - Ridge like shape appear
    - Shoulder in near side
    - Flat structure in away side

v_2

- Calculate v_2 via

$$\frac{dN}{d\varphi} \propto 1 + 2\sum_{n=1} v_n \cos n\varphi$$

  - Our results within $v_2 = 0.025 \sim 0.045$



CMS collaboration, *Physics Letter B* **765**, 193220 (2017)

Summary & Outlooks

- Calculate correlation and v_2
  - Integrate $d\sigma$ for θ
- Add gluon radiation