Jets and energy loss: chapter status

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Outline

- Introduction
- Precision Energy Loss
- Jet Deflection
- Jet Internal Structure
- Rare Events / Jets
- Heavy Quark Jets + Top Quarks
- Interplay with RHIC
- Summary

Will start writing soon

Introduction

What is jet quenching and what can it tell us?

- how can jet quenching be used to constrain the QGP properties?
- how do jet quenching measurements connect to flow/bulk observables?
- how can jet quenching help differentiating between fundamentally different pictures?

Review of what we learned so far

Potential of jet quenching measurements will be shown using projections of specific analyses

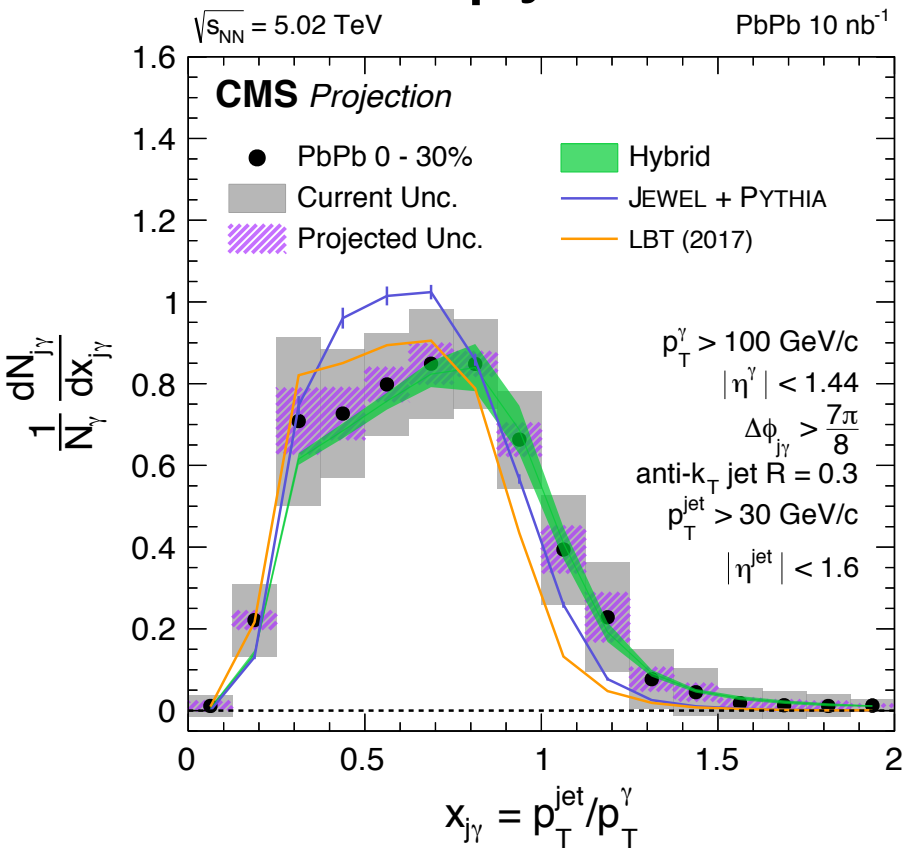
Precision energy loss

Main tool: X+ jet (X=gamma,Z,h) measurements

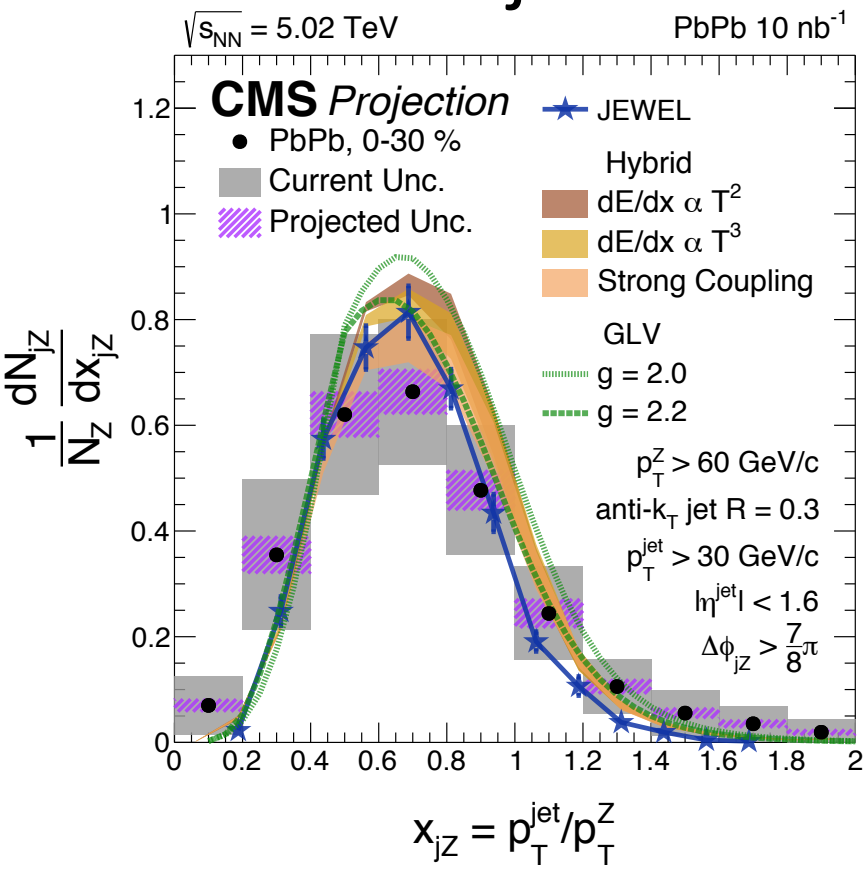
Try to measure ALL the recoiling energy

- Photon + multijet: NLO + semi hard emissions
- Photon + hadrons (missing p_T, radial profiles)

γ-jet



Z-jet



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Precision energy loss: low p_T

Main tool: X+ jet (X=gamma,Z,h) measurements

Very low jet p_T measurements: measure full energy loss distribution

- Potentially larger sensitivity to medium properties
- Connection to small systems where low p_T measurements are easier
- Larger sensitivity to non-perturbative effects
  → should measure nevertheless

ALICE: can go down to p_T=10 GeV

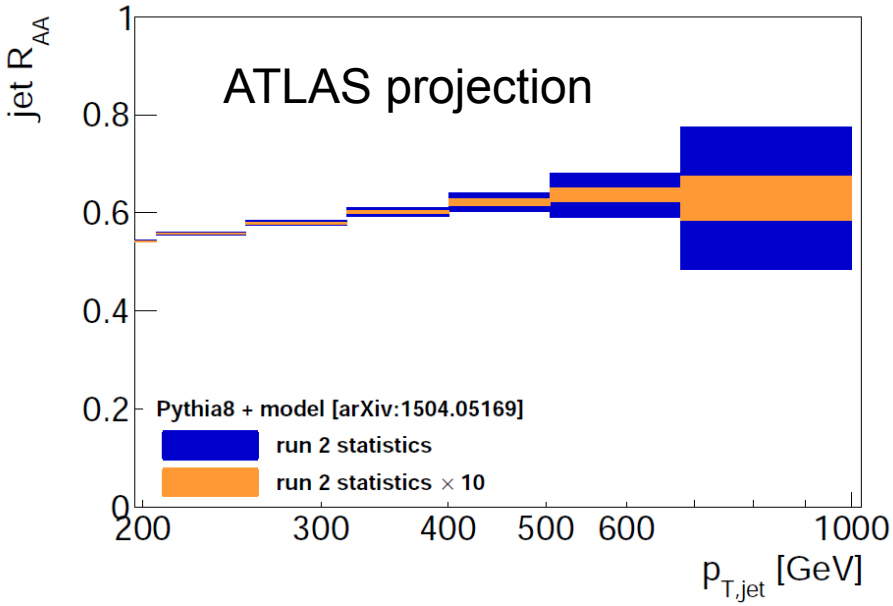
ATLAS/CMS: in pp can go down to p_T=20 GeV. Needs work in AA

Alternative: go to higher p_T photon/Z so that you can measure the full energy loss distribution

A classic: inclusive jet R_{AA}

Projection from ATLAS for $200<p_T<1000$ GeV available

Very high precision over wide jet p_T range



Missing: model comparisons.
Plan to have 1-2 models with various values of medium density.
R-dependence might be added.

- Forward high-p_T:
  interplay between flavor and spectral steepness, path length.
- Future runs allow to access higher p_T where the rapidity dependence is stronger.

A classic: inclusive jet R_{AA}

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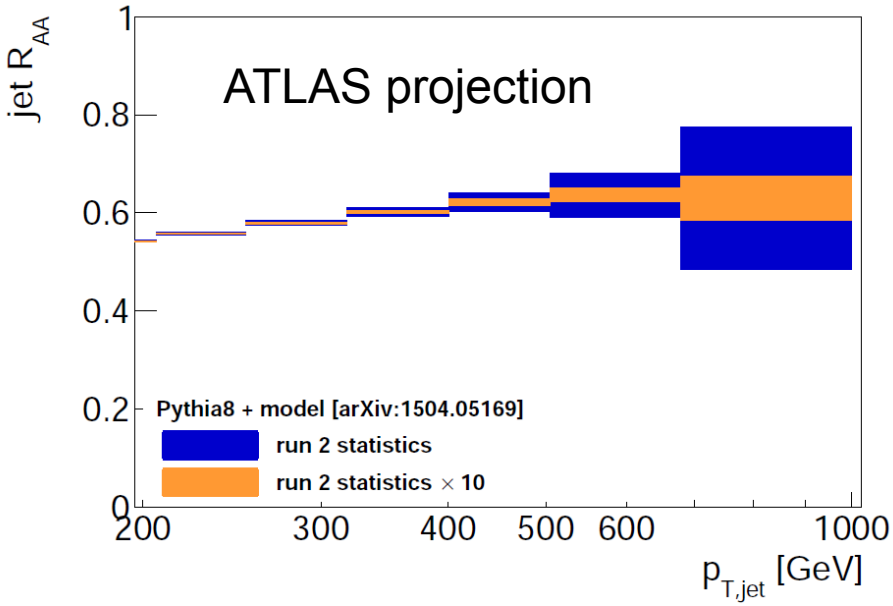
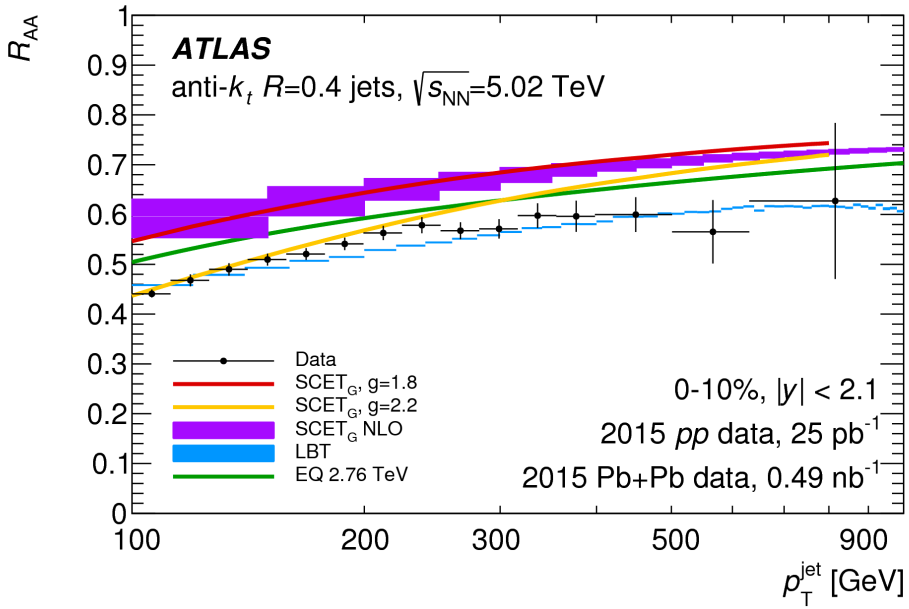


arXiv:1805.05635



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- Forward high-p_T:
  interplay between flavor and spectral steepness, path length.

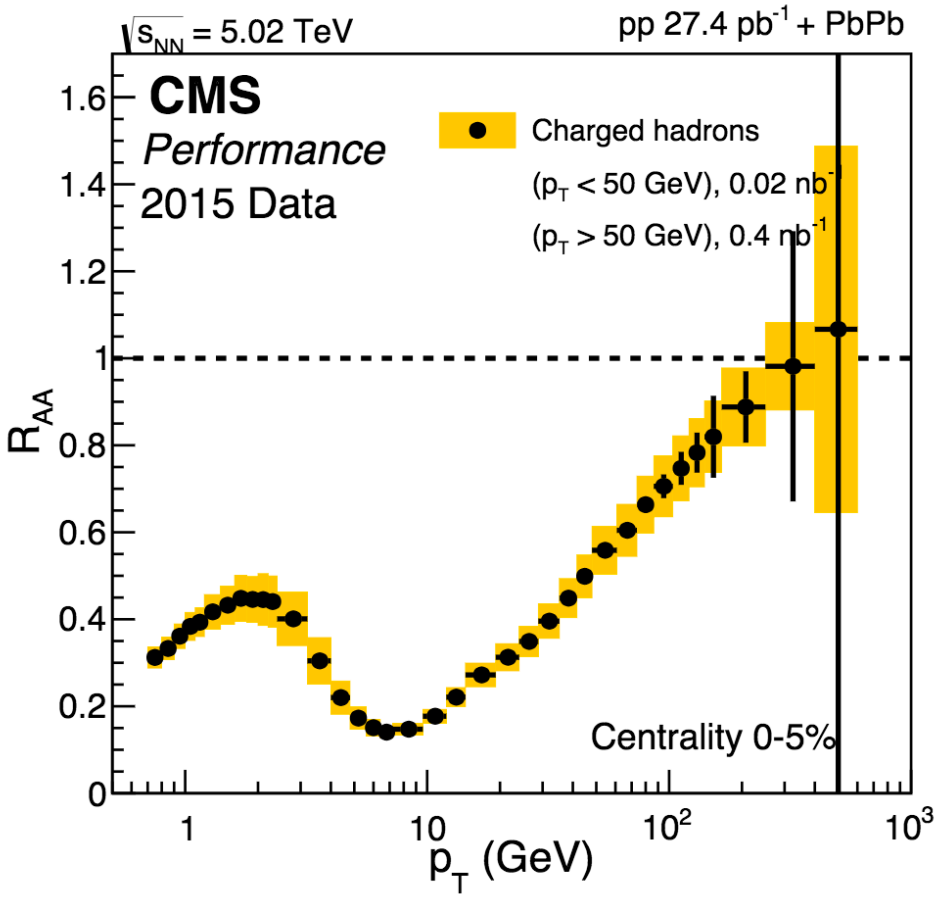
- Future runs allow to access higher p_T where the rapidity dependence is stronger.

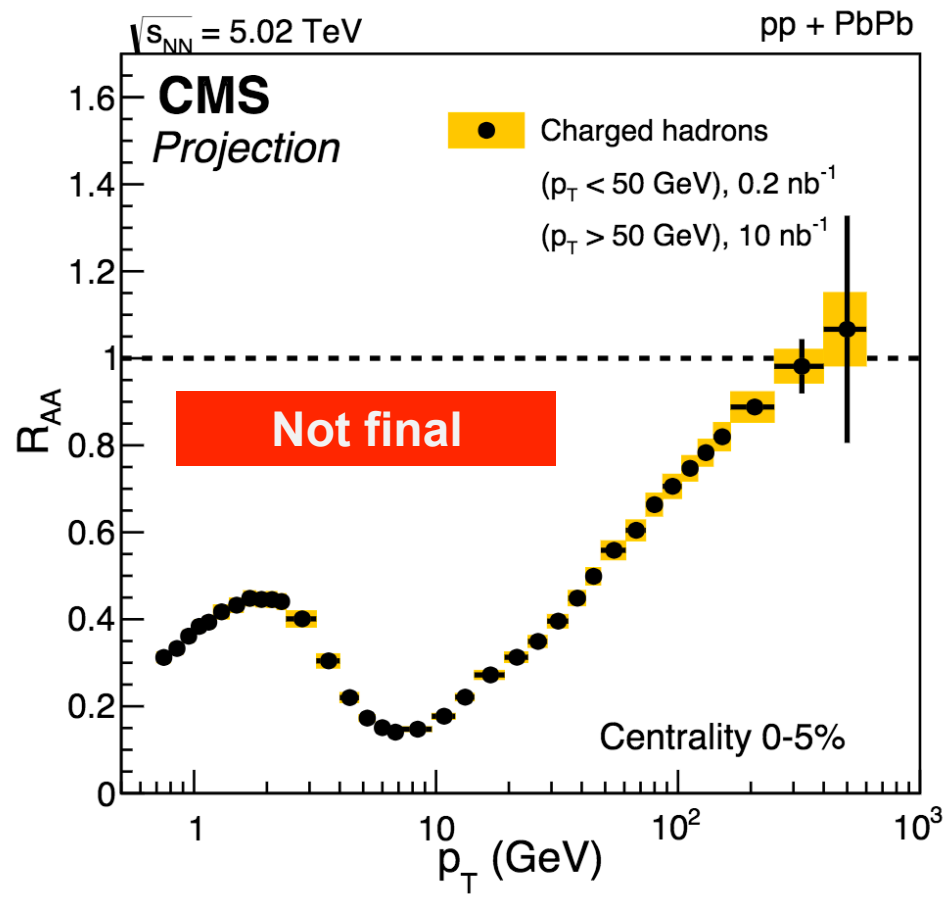
A classic: hadron R_{AA}

Current data limited precision at very high momentum

With 10/nb negligible uncertainty up to p_T=300 GeV

→ Does R_{AA} reach unity?

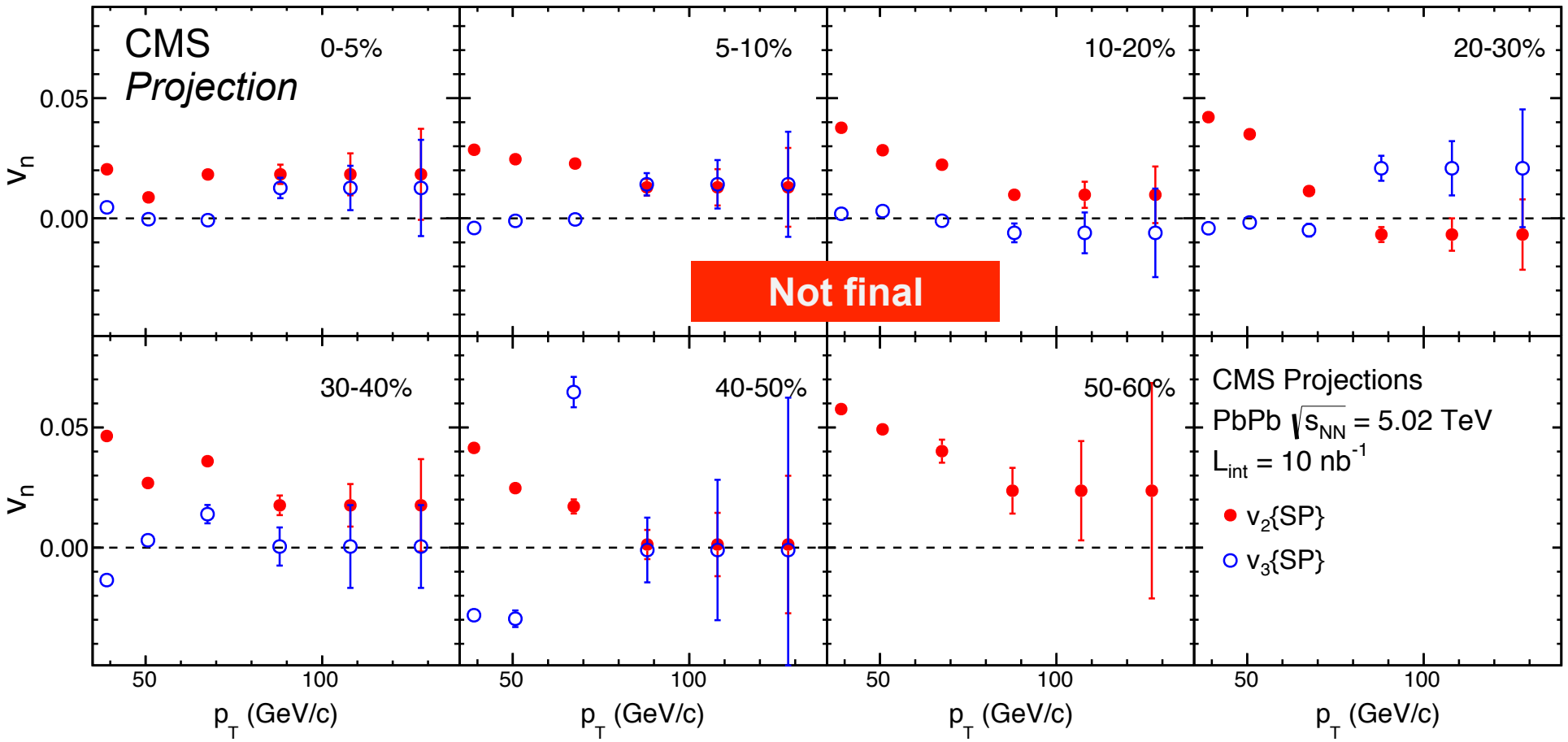




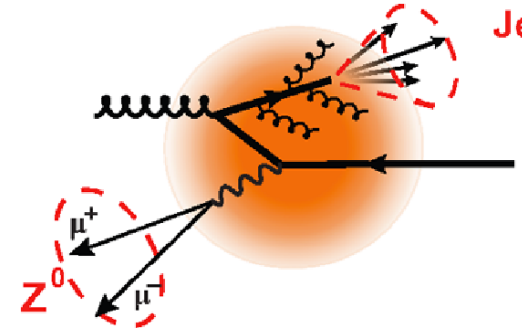
A classic: hadron $v_2 + v_3$

Current data limited precision at very high momentum

High momentum v_2: sensitivity to path length dependent energy loss
With HL-LHC study path length dependence at highest momenta



Jet Deflection



Angular distribution of recoil jet relative to trigger axis

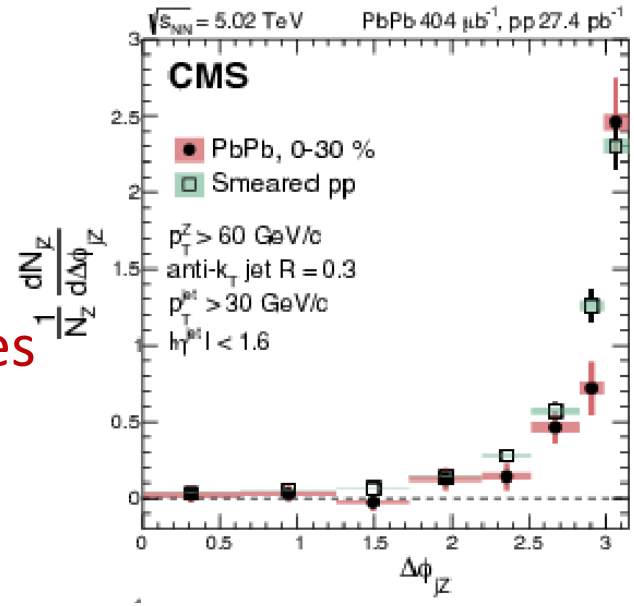
- Trigger: hadron, jet, boson (γ, Z, W)
  - Boson cleanest since it isn't affected by the medium
  - Hadron and jet much higher statistics + tool to probe geometry

Coherent scattering of recoil jet

- In competition with shower broadening
- Significant if early in-medium

No evidence for jet deflection within uncertainties

→ Rule out or not with run3+4 data



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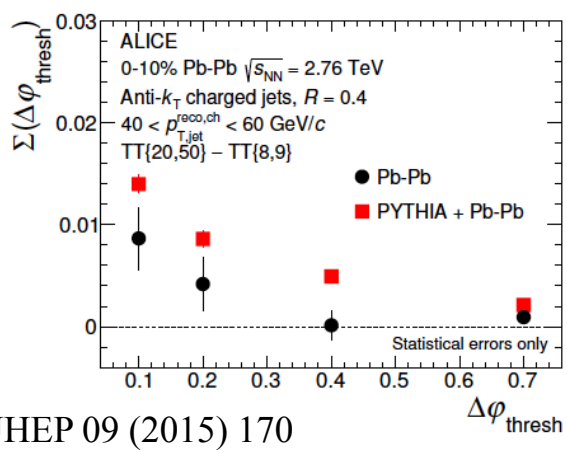

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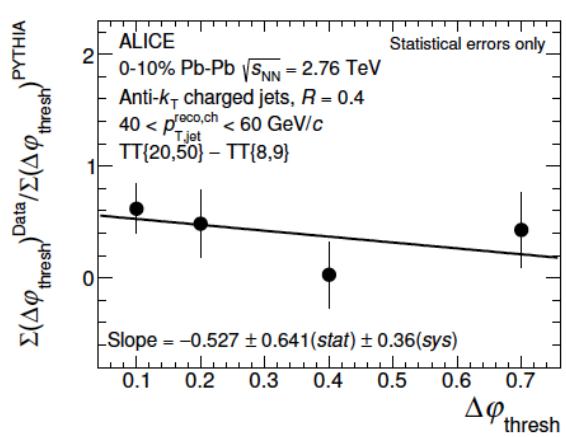


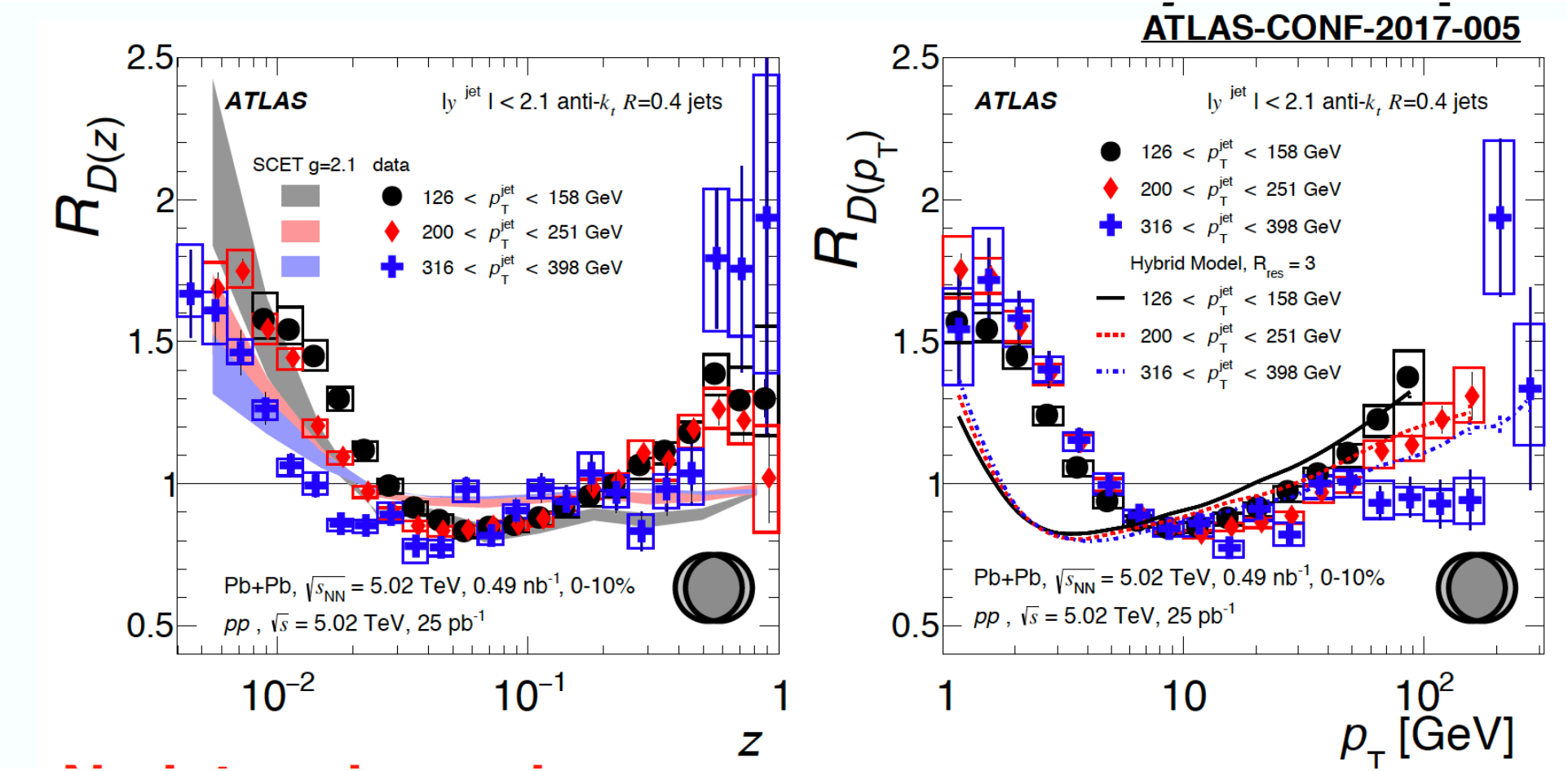
It is very unlikely the distributions are different
p-value > 0.4
But effect might be larger for lower momentum partons

Expecting projections from ALICE soon

Jet internal structure

1) Fragmentation functions + jet shapes

- high p_T: sensitive to parton shower modification
- low p_T: sensitive to medium response?



Still missing: projections to 10/nb

Jet internal structure

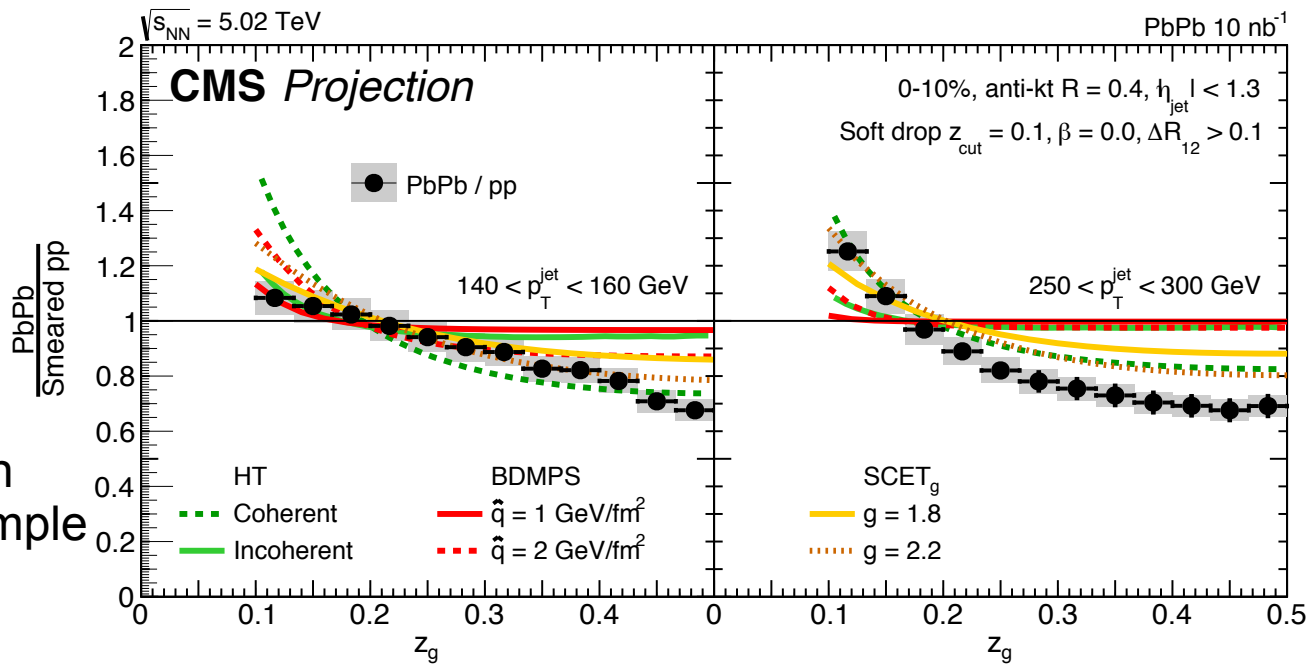
2) substructure with 'new' tools

Can we probe the evolution of the medium using jet substructure techniques?

Experimental tools: p_T-dependence, angular separation, mass

10 nb^{-1} will allow us to study the p_T-dependence of jet substructure modifications in detail.

z_g projection shown as example



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To be added for YR: projections from ALICE

To be quantified for YR: gain in angular resolution from tracking upgrades

Rare events / jets

Isolate events in which at least one jet was heavily modified or not modified at all

Tools: Aj/xj as done during run1. Studies were limited by statistics
New opportunities with more data.

With the selections one applies, systematically go to extreme

Jets with exotic substructure that are super rare in pp

→ Hard to predict what the unknown will bring

No projections expected.
To be decided if we add a short discussion to to the YR

For anything that is rare: smaller ion favorable in order to accumulate more rare events

Heavy quark jets

Consistency of picture re extracted with light and heavy quark jets
-- cross talk with heavy flavor section --

Top quarks
- not measured before
- clean probe for b-quark energy loss
- less dependent on assumptions of b-tagging

Smaller ion favorable in order to accumulate more top quark pairs

Connection with HE-LHC and FCC

Summary of section

Where do the biggest constraints come from?

Table to be produced:

sensitivity of qhat to different observables within a certain model.
Ideally ‘independent’ observables:
least correlated experimental and theoretical uncertainties

Summary

Goal for HL-LHC: Measure the microscopic structure of the QGP

Large statistics of jets up to p_T=1 TeV for ATLAS+CMS
and p_T=200 GeV for ALICE

Precision energy loss and jet deflection measurement with X+jet

Dynamics of parton shower accessible through

- Jet correlations
- Jet shape observables
- Jet substructure with subjets

Probe different regimes of the radiation phase space to

1) Understand the mechanism responsible for jet quenching
2) Map out the properties of the QGP

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