R-dependence of jet observables with JEWEL+v-USPhydro

Based on: 2208.02061

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2023 HARD PROBES Aschaffenburg

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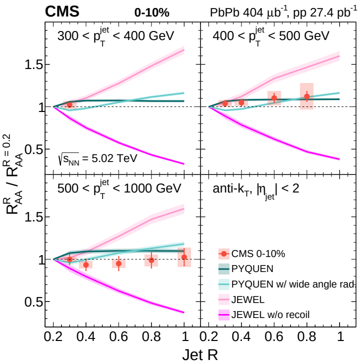
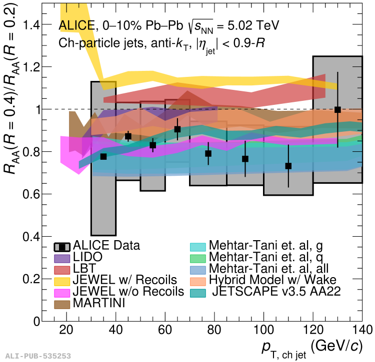
Motivation

- Realistic hydrodynamic evolution **v-USPhydro** effects on jets
- Variation of R resolution parameter $\Rightarrow$ better understanding of **jet quenching** and **medium response** effects
- Interest by experimental collaborations: CMS, ALICE...



CMS (2021)



ALICE (2023)

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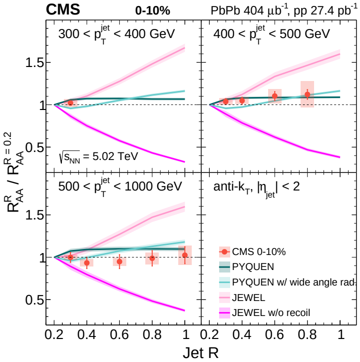

CMS (2021)

- JEWEL calculations do not replicate data for **large R**
- **JEWEL + v-USPhydro**: good test for the hydro implementation + predictions
- **R-dependence**: model constrain and impact of **medium response**

JEWEL 2.2.0 + v-USPhydro

JEWEL: BDMPS-Z Monte-Carlo generator for parton showers with **medium interaction** + coherent gluon emissions Zapp et al. (2012) Zapp et al. (2011)

PYTHIA 6.4: hard scattering + hadronization Sjostrand et al. (2006)

Apply a **state-of-the-art description** of the medium:

Default Medium

- Smooth and static Glauber approach
- Bjorken-only expansion
- No event-by-event fluctuations

→

2+1 Hydrodynamics

- T_RENTo Moreland et al. (2014)
- **v-USPhydro** Noronha-Hostler et al. (2013)
- Shear viscosity Noronha-Hostler et al. (2014)
- Local flow Baier et al. (2006)

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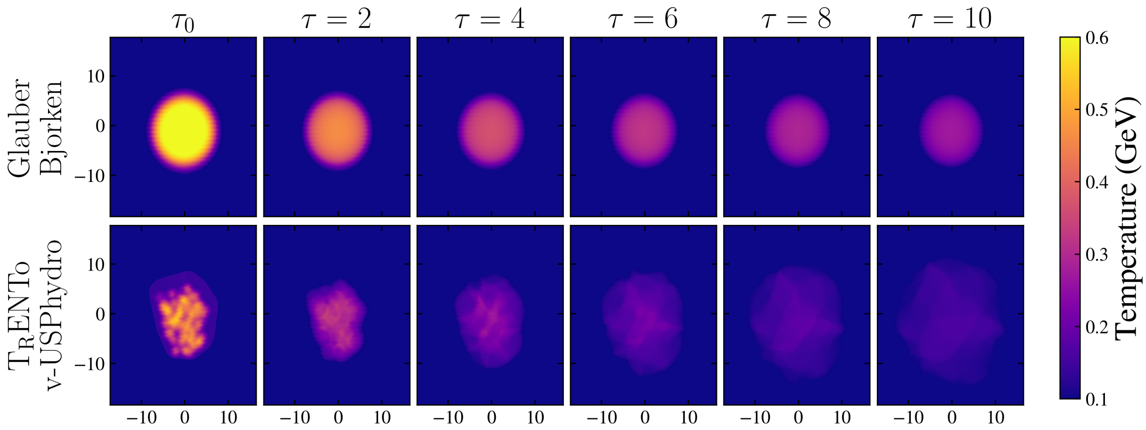
Apply a **state-of-the-art description** of the medium:

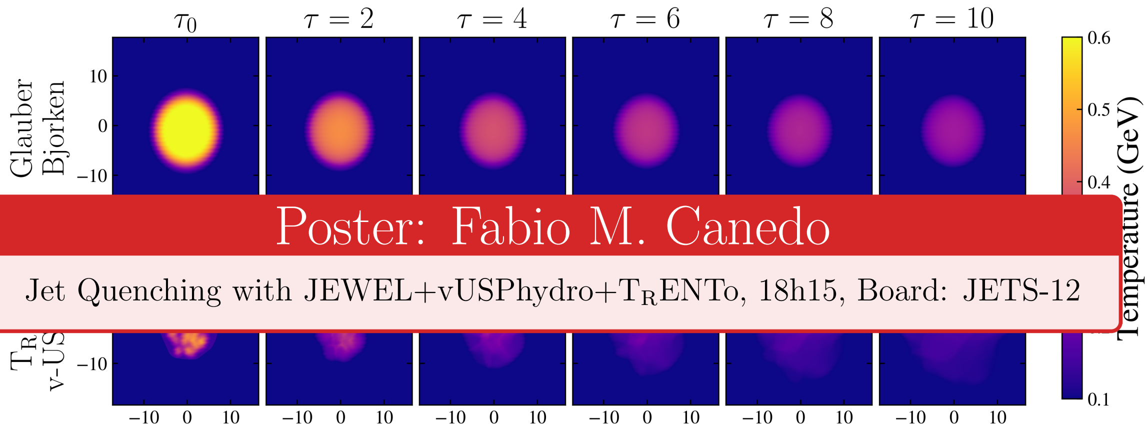
Glauber+Bjorken → TRENTo+**v-USPhydro**

Canedo (2020)

- Recoil methodology (4MomSub) Elayavalli, Zapp (2017)
- No concurrent evolution or soft contamination in final state
- EPS09LO nuclear PDF Eskola et al. (2009)
- Rivet+FastJet analyses Bierlich et al. (2019) Cacciari et al. (2011)
- Statistical uncertainties only



JEWEL's parton shower evolution and medium interaction calculations are not modified
Original model can be found at jewel.hepforge.org



Poster: Fabio M. Canedo

Jet Quenching with JEWEL+vUSPhydro+T$_{\rm R}$ENTo, 18h15, Board: JETS-12

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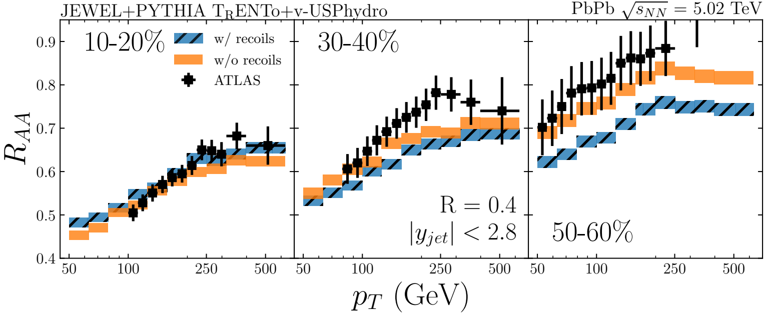
Nuclear Modification Factor R_{AA}

$$R_{AA}(p_T) = \frac{1}{\langle N_{coll} \rangle} \frac{\frac{1}{N_{evt}} \frac{d^2N}{dp_T dy}\Big|_{AA}}{\frac{1}{N_{evt}} \frac{d^2N}{dp_T dy}\Big|_{pp}}$$

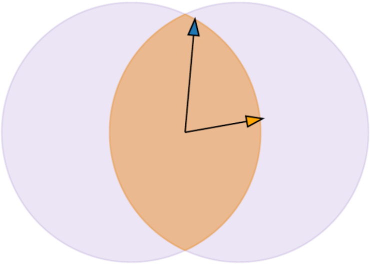
Tuned to 0-10% ATLAS data:

- Scattering centers' Debye mass scale = 1.0 (w/ recoils) and 1.1 (w/o recoils)
  ⇒ baseline for **data description**
  ⇒ impact on centrality-dependence



Data from ATLAS (2022)

Anisotropic Flow for Jets



Longer path ⇒ more energy loss

Shorter path ⇒ less energy loss

$\mathcal{E}_n$ + **path-length** dependent energy-loss mechanism

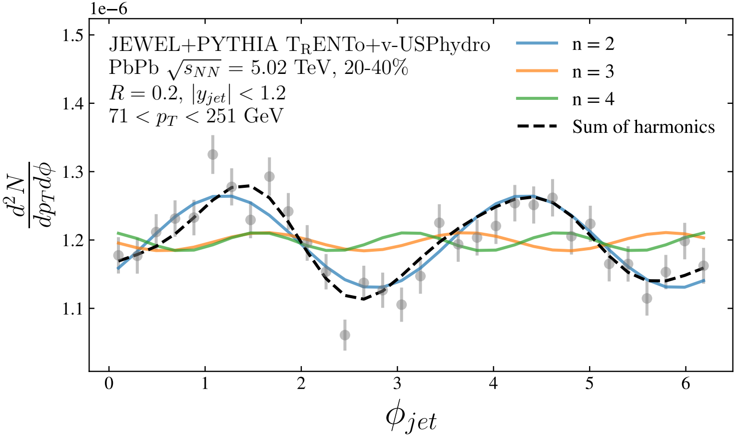
=

modifications in jets' azimuthal distribution

***R*-dependence**: UE is highly anisotropic

⇒ insight into background subtraction

Anisotropic Flow Coefficients $v_{n=2,3}$



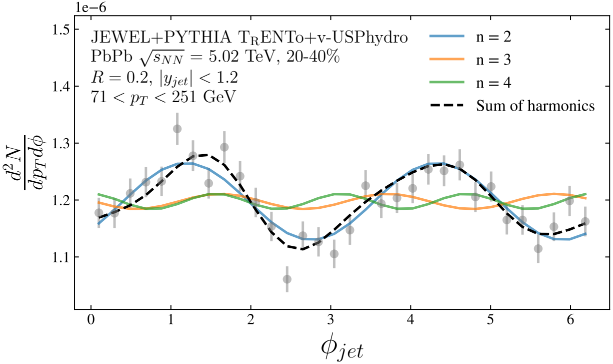
$$\Psi_n^{jet} = \frac{1}{n}\tan^{-1}\left(\frac{\int_0^{2\pi} d\phi \sin(n\phi) R_{AA}(p_T,\phi)}{\int_0^{2\pi} d\phi \cos(n\phi) R_{AA}(p_T,\phi)}\right) \qquad v_n^{jet}(p_T) = \frac{1}{2\pi}\int_0^{2\pi} d\phi \cos(n(\phi - \Psi_n^{jet}(p_T)))\frac{R_{AA}(p_T,\phi)}{R_{AA}(p_T)}$$

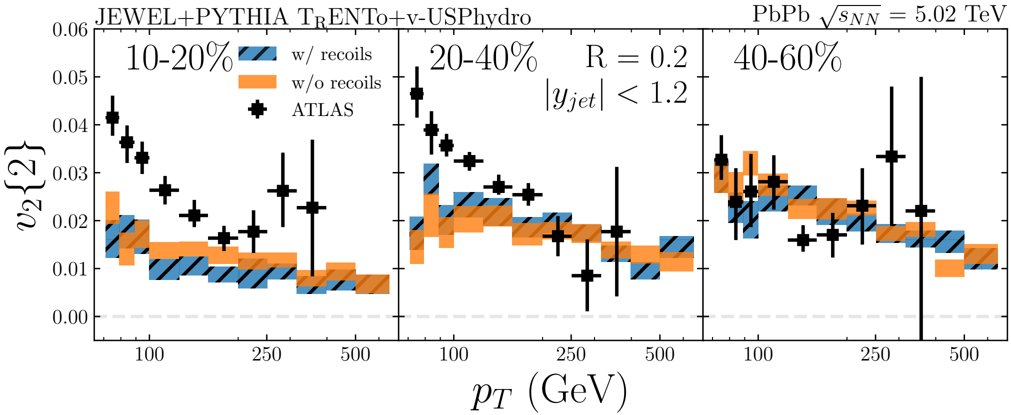
Anisotropic Flow Coefficients $v_{n=2,3}$ Noronha-Hostler et al. (2016)

Calculated coefficients given by **Jet-Soft correlations**:

$$v_n\{2\}(p_T) = \frac{\langle v_n^{soft} v_n^{jet}(p_T) \cos(n(\Psi_n^{soft} - \Psi_n^{jet}(p_T)))\rangle}{\sqrt{\left\langle \left(v_n^{soft}\right)^2 \right\rangle}}$$

- $\langle \ldots \rangle \doteq \frac{\sum_i M_i R_{AA}(p_T)_i (\ldots)}{\sum_i M_i R_{AA}(p_T)_i}$
- Not possible in out-of-the-box JEWEL
- $\sim 10^5$ hard scatterings per medium profile, 100 hydro calculations





Data from ATLAS (2022), similar calculations in Y. He et al. (2022)

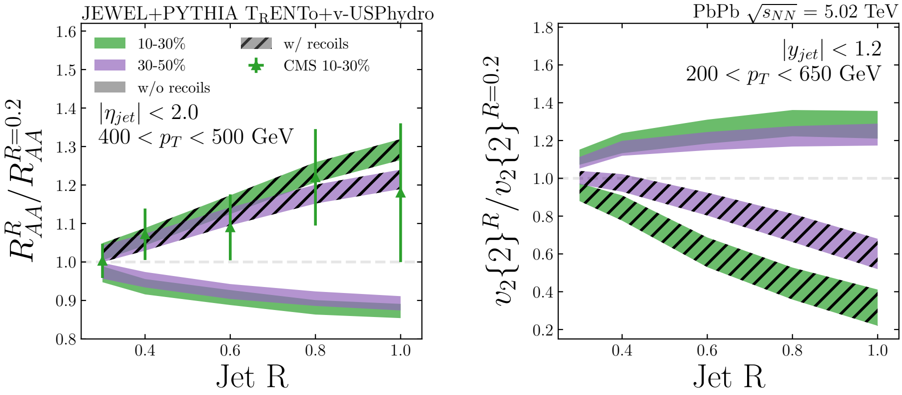
High-p_T vs low-p_T mismatch with experiment

Barreto (2021) **Decorrelation**: misalignment of Ψ_n^{soft} and Ψ_n^{jet} for $71 < p_T < 251$ GeV

$\langle\cos(2(\Psi_2^{soft} - \Psi_2^{jet}(p_T)))\rangle$ varies between 0.5 (central) to 0.9 (peripheral)

$\Rightarrow$ missing effect?

R-dependence in Jet Distributions

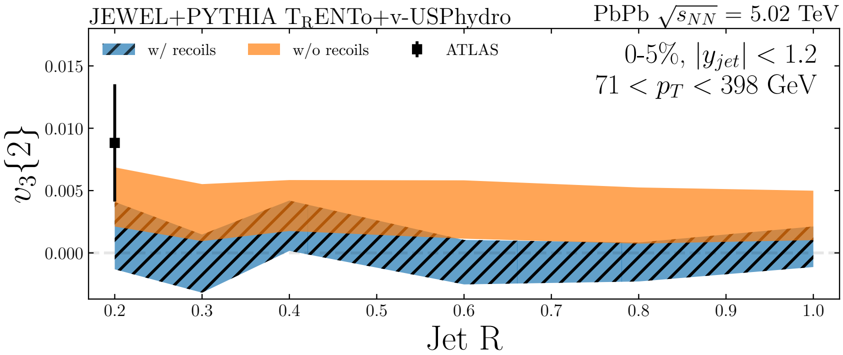


Data from CMS (2021)

Recoils are necessary for describing CMS increasing trend

Opposite behavior between R_{AA} and v_2 **with R**

R-dependence in Triangular Flow



Data from ATLAS (2022)

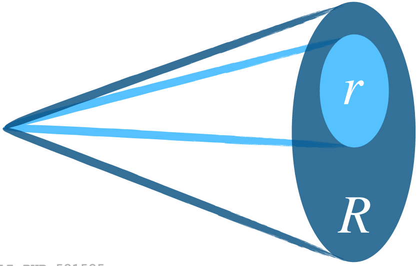
$v_3\{2\} \sim 0$ with **recoils**
$\Rightarrow$ Indication recoil interaction must be considered?

No indication of R-dependent behavior

Leading Subjet Fragmentation

$$z_r = \frac{p_T^{\text{ch subjet}}}{p_T^{\text{ch jet}}},$$

Anti-k_t charged (sub)jets



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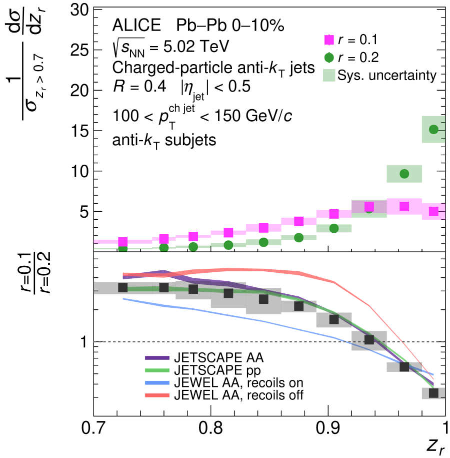
ALICE (2022)



ALI-PUB-521560

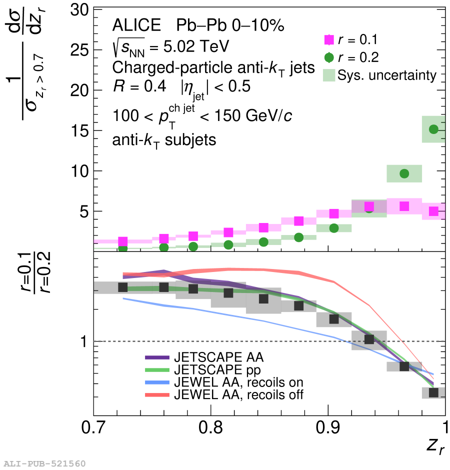
ALICE (2022)

Leading Subjet Fragmentation

$$z_r = \frac{p_T^{\text{ch subjet}}}{p_T^{\text{ch jet}}},$$

Anti-k_t charged (sub)jets

- Better understanding of p_T distribution inside jet
- Insight into energy-loss mechanism
- Out-of-the-box JEWEL: recoils have considerable impact
- Normalized by number of jets with $z_r > 0.7$
- JEWEL+v-USPhydro: preliminary results!



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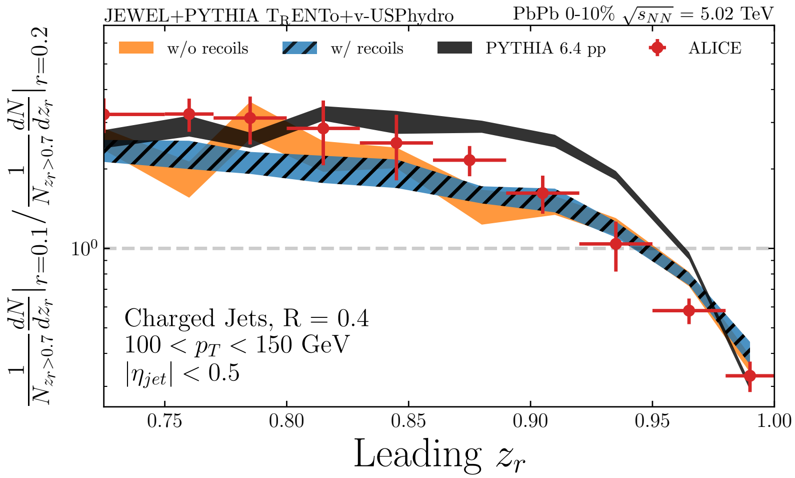

Data from ALICE (2022)

v-USPhydro better describes the data

No discrepancy given recoil methodology

Final Remarks

- Implementation of a realistic 2+1 **event-by-event** **hydrodynamic medium** description in JEWEL
  ⇒ **overall improvement with v-USPhydro**
  ⇒ no improvement by **recoils** methodology in **small** R, but needed for **large** R

- Opposite behavior in R**-dependence** between R_{AA} and v_2, while v_3 is unchanged

- Indications of missing effect in JEWEL
  ⇒ working on **v-USPhydro** implementation in JEWEL 2.3.0 (reworked recoils/thermal background subtraction) and 2.4.0 (ISR) Milhano, Zapp (2022) Zapp (2022)

- Preliminary study of **jet substructure** in JEWEL+v-USPhydro

Thanks!

JEWEL+v-USPhydro code:
github.com/leo-barreto/USP-JEWEL

Rivet analyses:
github.com/leo-barreto/USPJWL-rivetanalyses

Poster: Fabio M. Canedo

Jet Quenching with JEWEL+vUSPhydro+T_RENTo, 18h15, Board: JETS-12