Jet angularities in Z+jet and dijet production

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based on

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[JHEP 07 (2021) 076], [JHEP 03 (2022) 131]

this talk...

- jet substructure observable: jet angularities
- setup: as recent CMS measurement [JHEP 01 (2022) 188]
- theoretical predictions: NLO+NLL' based on CAESAR plugin to SHERPA
- NLL' accuracy via flavour matching
- NP corrections using transfer matrix approach
- + MC@NLO (and MEPS@NLO) predictions from SHERPA

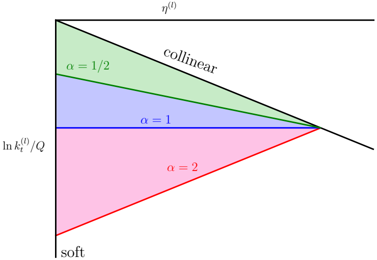
observables & setup

[JHEP 07 (2021) 076] [JHEP 03 (2022) 131]
data from [JHEP 01 (2022) 188]

- jet angularity family of observables

$$\lambda_\alpha^\kappa = \sum_{i\in J} \left(\frac{p_{T,i}}{p_{T,J}}\right)^\kappa \left(\frac{\Delta R_i}{R}\right)^\alpha$$

- parameters κ (here $= 1$ for IR safety), and α to probe different phase space regions



- measured on anti-k_t jets ($R = 0.4, 0.8$) for
  - leading jet in Z+jet
  - separately the more forward/central of the two leading jets in dijets
- jets with and without soft drop grooming

- CAESAR formalism [Banfi, Salam, Zanderighi '04]
- implemented in SHERPA

[Gerwick, Höche, Marzani, Schumann '15]

[Baberuxki, Preuss, DR, Schumann '19]

- extended for jet observables. . .
  - modified wide angle behaviour

    [Dasgupta, Khelifa-Kerfa, Marzani, Spannowski '12]

    [Caletti, Fedkevych, Marzani, DR, Schumann '21]
  - non-global logs [Dasgupta, Salam, '01]
- . . . and soft drop grooming

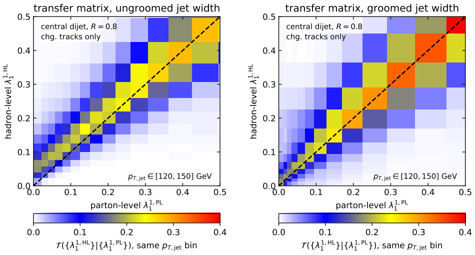
  [Larkoski, Marzani, Soyez, Thaler '14]
  - CAESAR-style formulas available

    [Baron, DR, Schumann, Schwanemann, Theeuwes '20]
- multiplicative (flavoured) matching

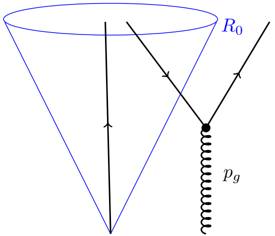
non-perturbative effects

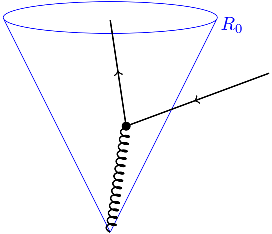
- Extract "transfer matrix" from MC

  ∼ relative probability $P(\mathrm{HL}|\mathrm{PL})$
  - migration between p_T bins
  - shifts within observable



- naive definition not IRC safe (starting at NLO)
- one solution: BSZ algorithm [Banfi, Salam, Zanderighi '06]
- practical problem: defines (BSZ) jet with flavour,
  not flavour of a given (anti-k_t) jet





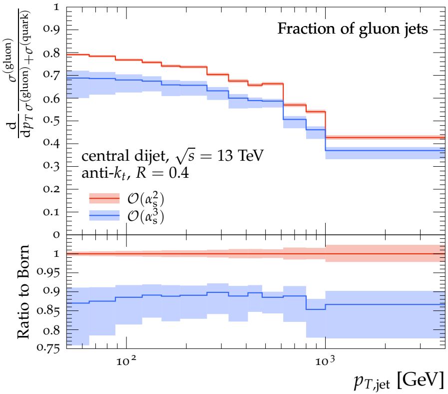
Working solution: Iterative application of BSZ:

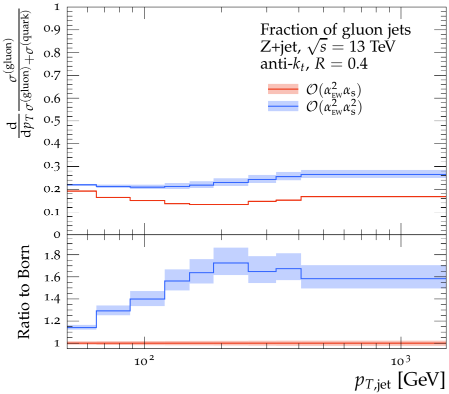
0. Start w/ list $\mathcal{O}$ of coloured final-state objects
1. Run the standard IR-safe algorithm with radius parameter R_0 on $\mathcal{O}$, and obtain the objects in the leading jet $J \subset \mathcal{O}$.
2. If $J = \{j \in \mathcal{O}\}$, terminate. The flavour is that of j.
3. Determine the pair $\{i, k\} \subset \mathcal{O}$ that minimises the BSZ measures, and combine them.

Go to step 1 and repeat.

proxies for q and g jets

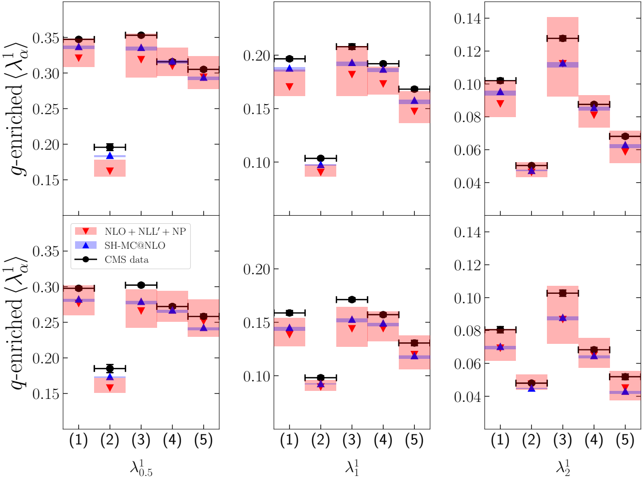
[JHEP 07 (2021) 076] [JHEP 03 (2022) 131]
data from [JHEP 01 (2022) 188]





- ▷ as expected, dijet ∼ gluon, Z+jet ∼ quark
- ▷ qualitatively similar result to [JHEP 01 (2022) 188] (w/ simpler working definition)

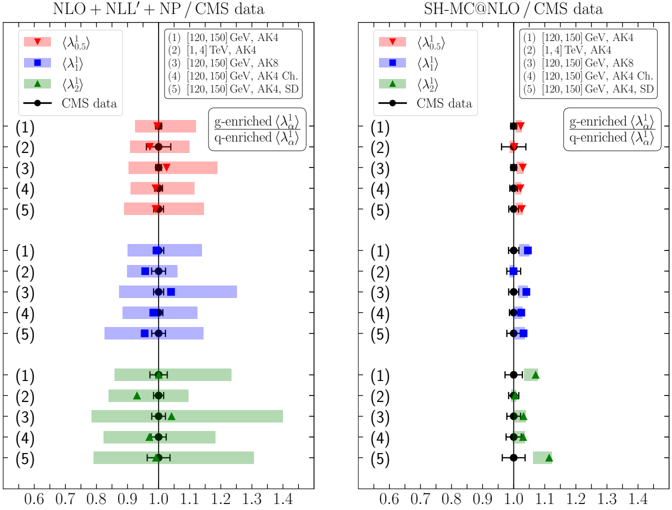
overview of mean in 5 different selections (as in [JHEP 01 (2022) 188])



- ▷ (1),(3),(4),(5): 120 GeV $< p_T <$ 150 GeV
  - quark ∼ Z+jet, gluon ∼ dijet
  - (1) $R = 0.4$, plain
  - (3) $R = 0.8$
  - (4) $R = 0.4$ charged
  - (5) $R = 0.4$ w/ grooming
- ▷ (2): 1000 GeV $< p_T <$ 4000 GeV
  - quark ∼ forward dijet, gluon ∼ central dijet
  - $R = 0.4$, plain

Long list of observables considered overall, including differential distributions, see [more results] ratios between quark and gluon enhanced samples (normalised to data)

- ▷ same selections a before
- ▷ data well described by MC@NLO and NLO+NLL′+NP ⇒ challenges traditional "quarks are better under-stood than gluons"

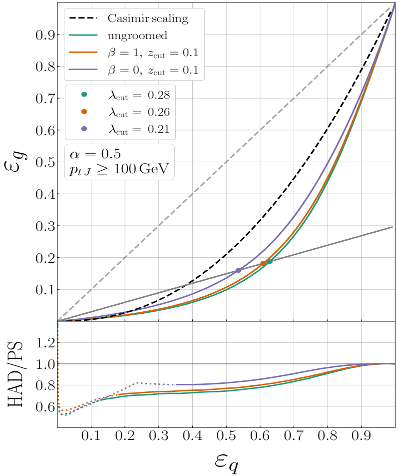


possible application: angularity as a tagger [EPJC 81 (2021), 884]

- goal: use angularities as a quark tagger (i.e., quark $\equiv \lambda < \lambda_{\text{cut}}$)
- idea: in Z+jet should contain information on initial state $\rightarrow$ useful for pdf fits (?)
- what value of λ_{cut}? (and what α, groomed/ungroomed etc.)
- at Born level $\rightarrow$ no flavour ambiguity

$\hookrightarrow$ shower $q\bar{q} \rightarrow Zg$ and $gq \rightarrow Zq$ samples separately, find optimal working points (here using PYTHIA)

- might not be the "best" tagger, but easy to study theoretically



summary

- framework for NLO + NLL$'$ calculation of jet angularities
- + transfer matrix approach for NP corrections
- + flavour separated matching

- pheno for [JHEP 07 (2021) 076], full list of results at [https://www.theorie.physik.uni-goettingen.de/ sschuma/JetAngularities].
- IRC safe flavour definitions → calculable flavour separated samples
- test our understanding of quark and gluon jets

- use cut in angularity as well defined flavour tagger
- + as initial state tagger in Z+jet

Backup

migration between transverse momentum regions