

Jets/energy loss: open questions a personal view

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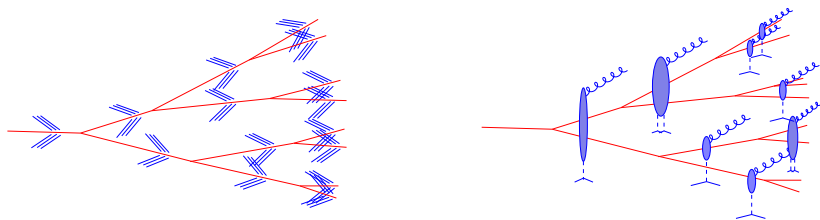
LIP (Lisbon) & CERN

Workshop on the physics at HL-LHC, and perspectives at HE-LHC
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A fundamental open question

Do jets/partons interact with quasi-particles?



- ▶ this is also a question about resolution
- ▶ relevant scale: momentum transfer
- ▶ sufficiently high momentum transfer will resolve quasi-particles
 - factorisation in deep-inelastic scattering

Two-fold strategy

Look at inner structure of jet

- ▶ modification of inner structure at all scales
- ▶ vs. scale dependent coherence of jet

Look for medium response

- ▶ excitation of hydrodynamic modes
- ▶ vs. partonic recoil cascade

⇒ both should be visible in jet shapes and jet sub-structure

Jet shape and sub-structure observables

- ▶ observables built from jet constituents
 - particles, partons, calorimeter cells, ...
- ▶ characterise distribution of momentum & find structures inside jet

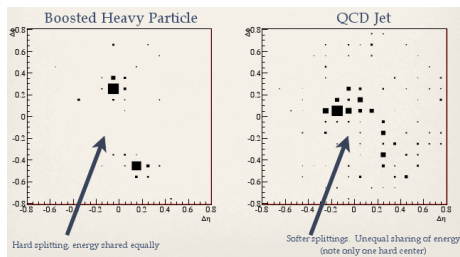
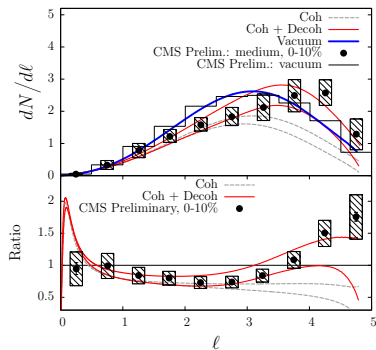


image from David Krohn

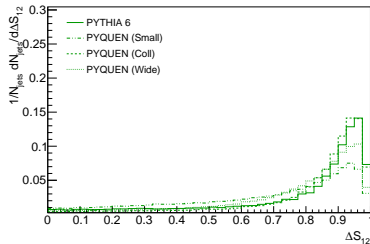
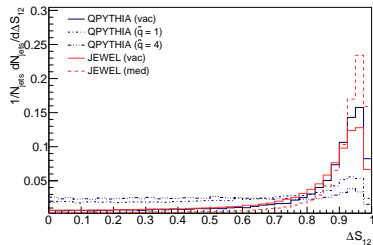
- ▶ various grooming techniques studied in p+p to separate hard structure from soft contaminations
 - filtering, trimming, pruning, ...
- ▶ interesting for heavy ions, but requires careful studies

Examples: discriminating power of jet sub-structure



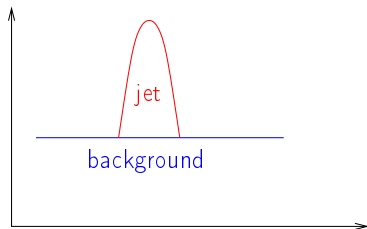
$$l = \ln(1/z)$$

$$\Delta S_{12} = \frac{p_{\perp,1} - p_{\perp,2}}{p_{\perp,jet}}$$



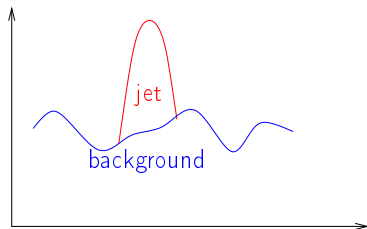
Mehtar-Tani and Tywoniuk, Phys. Lett. B 744 (2015) 284
 Apolinário, Milhano, Ploskon and Zhang, arXiv:1710.07607

Theorist's view of background



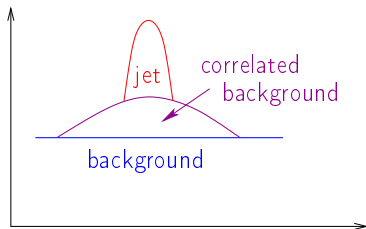
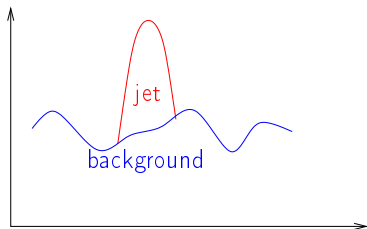
- ▶ ideal situation: flat background – can be subtracted

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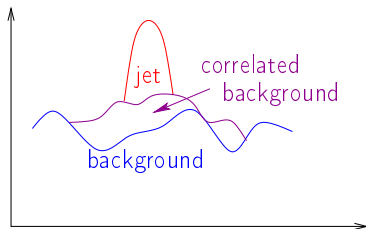
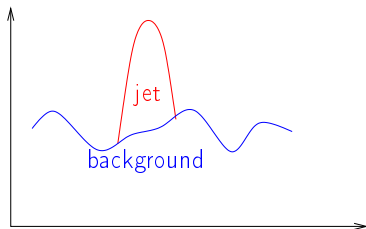
- ▶ ideal situation: flat background – can be subtracted
- ▶ more realistic: **fluctuating background** – can be subtracted on average, have to unfold

Theorist's view of background



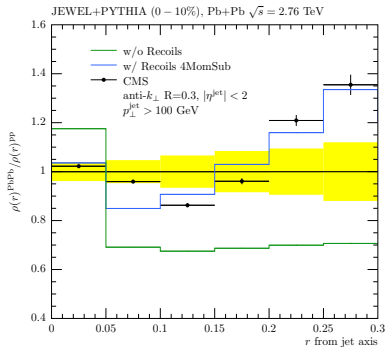
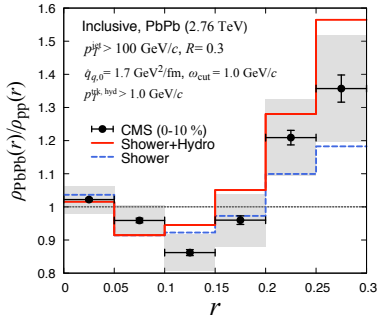
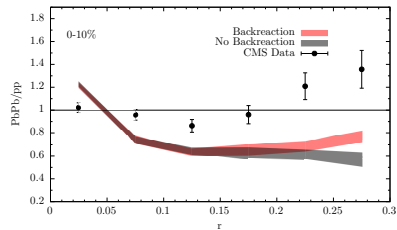
- ▶ ideal situation: flat background – can be subtracted
- ▶ more realistic: **fluctuating background** – can be subtracted on average, have to unfold
- ▶ even more realistic: **correlated background**
 - ▶ part of the background is correlated with jet → medium response
 - ▶ activity above background
 - ▶ correlated background cannot and should not be subtracted

Theorist's view of background



- ▶ ideal situation: flat background – can be subtracted
- ▶ more realistic: **fluctuating background** – can be subtracted on average, have to unfold
- ▶ even more realistic: **correlated background**
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 - ▶ activity above background
 - ▶ correlated background cannot and should not be subtracted
- ▶ finally: also fluctuations in correlated part of background matter

Examples: impact of medium response on jet profile



Casalderrey-Solana *et al*, JHEP 1703 (2017) 135
 Tachibana *et al*, Phys. Rev. C 95 (2017) no.4, 044909
 Kunnawalkam Elayavalli and Zapp, JHEP 1707 (2017) 141

Benefits of better statistics

- ▶ shrink error bars
 - ▶ clarify whether there is enhancement in FF at large z
 - ▶ clarify jet p_{\perp} dependence of z_g modification
 - ▶ ...
- ▶ study jet sub-structure in V +jet
 - ▶ better handle on initial kinematics
- ▶ compare γ +jet and Z +jet
 - ▶ different mass scale \rightarrow different initial virtuality
- ▶ look at rare events
 - ▶ e.g. sub-structure of sub-leading jet in high- A_J events

Jet sub-structure requires community effort

What jet sub-structure observables have taught us

- ▶ have to understand in detail what a particular observable is sensitive to
- ▶ this requires advanced tools
- ▶ and close collaboration between theorists & experimentalists
- ▶ **Lisbon accord**: effort involving theorists and experimentalists to
 - ▶ agree on how data should be presented
 - which corrections, unfolding etc. should be applied
 - ▶ agree on what are well defined observables
 - theoretically sound
 - should not require model dependent processing
- ▶ agree on good practice for comparisons between theory and data
- ▶ introduce standards, formats and tools
- ▶ make standard particle physics tools usable for heavy ions

If you want to contribute, please contact G. Milhano.