Dynamically groomed jet radius in heavy-ion collisions

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Paul Caucal (SUBATECH, Nantes)

Alba Soto-Ontoso (CERN TH)

Based on: arXiv:2103.06566 vacuum baseline
arXiv:2111.14768 resolving the medium phase space

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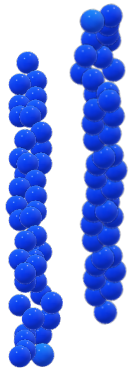
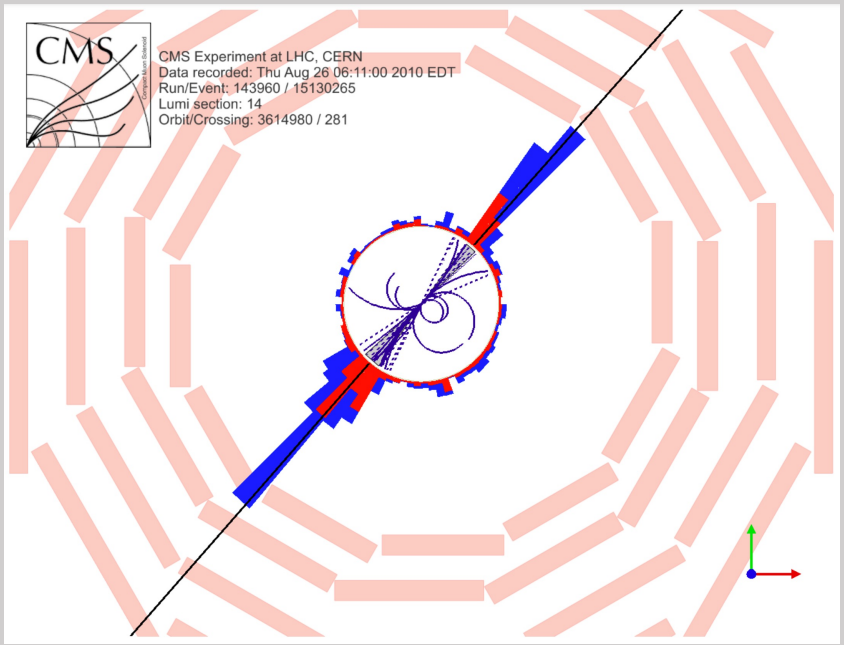
Jets in pp and in AA

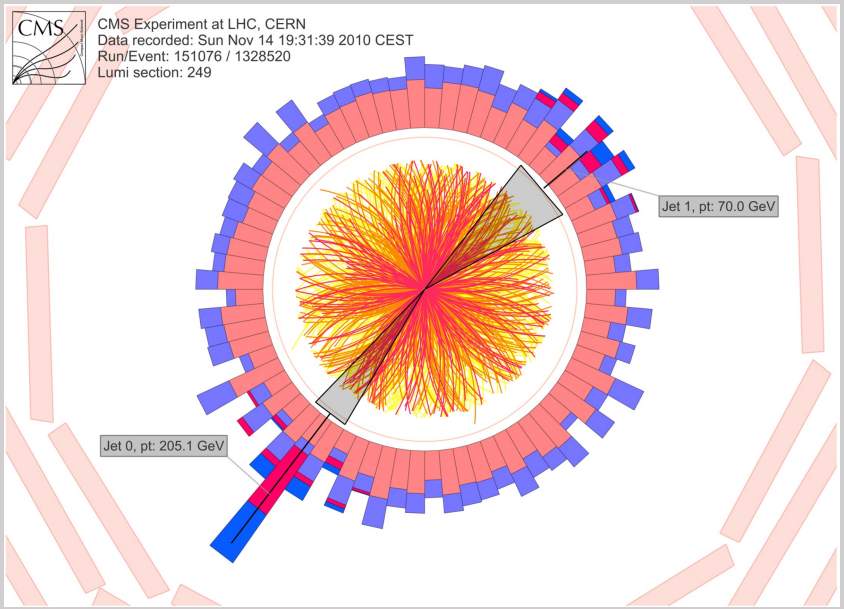
[also Raymond's talk]

pp

AA







[O. Saarimäki's (2018)]

Grooming splittings in jets

The Lund plane: phase space of emissions [Dreyer,Salam,Soyez]

1. Find a jet
2. Recluster with C/A (widest angle first)
3. Follow the hardest branch ($z_i > {}^1/_2$)

Soft Drop grooming [Larkovski, Marzani, Soyez, Thaler]:

4. Stop if $z_i > z_{cut}\vartheta_i^{\beta}$ (with the widest angle)
   - Free parameters z_{cut} and β.

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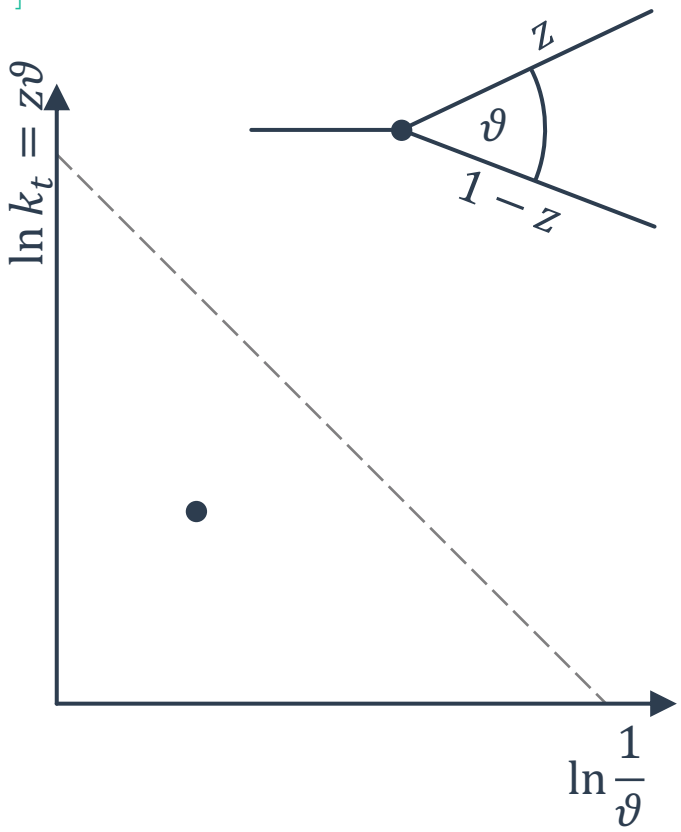
   - No cuts, autogenerated jet-by-jet



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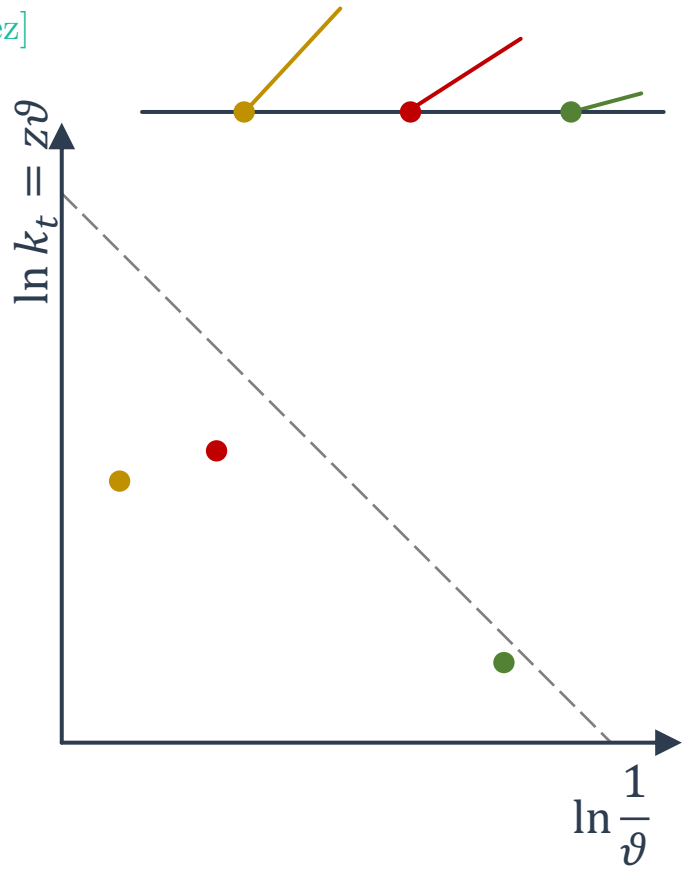

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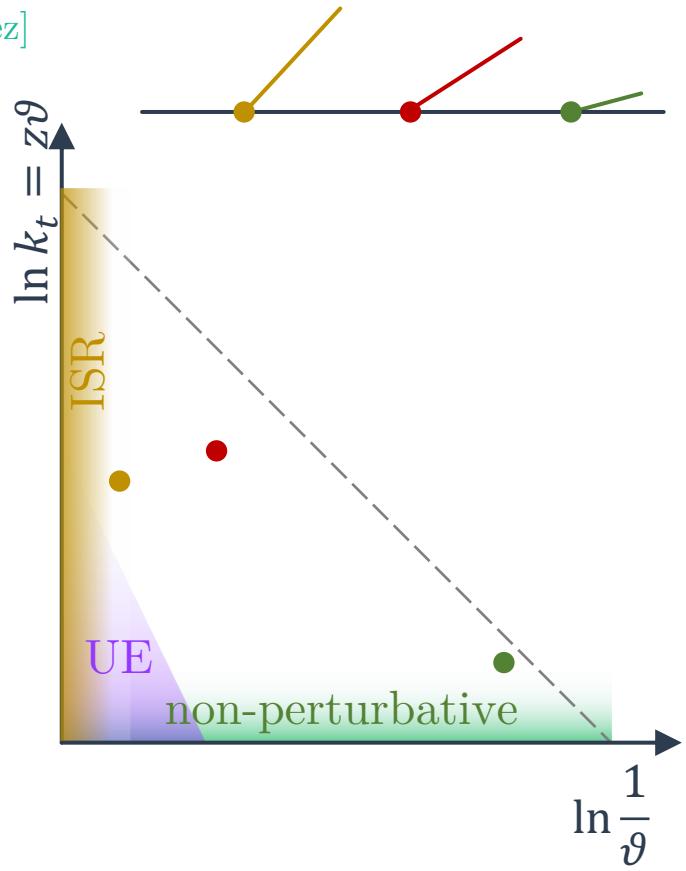

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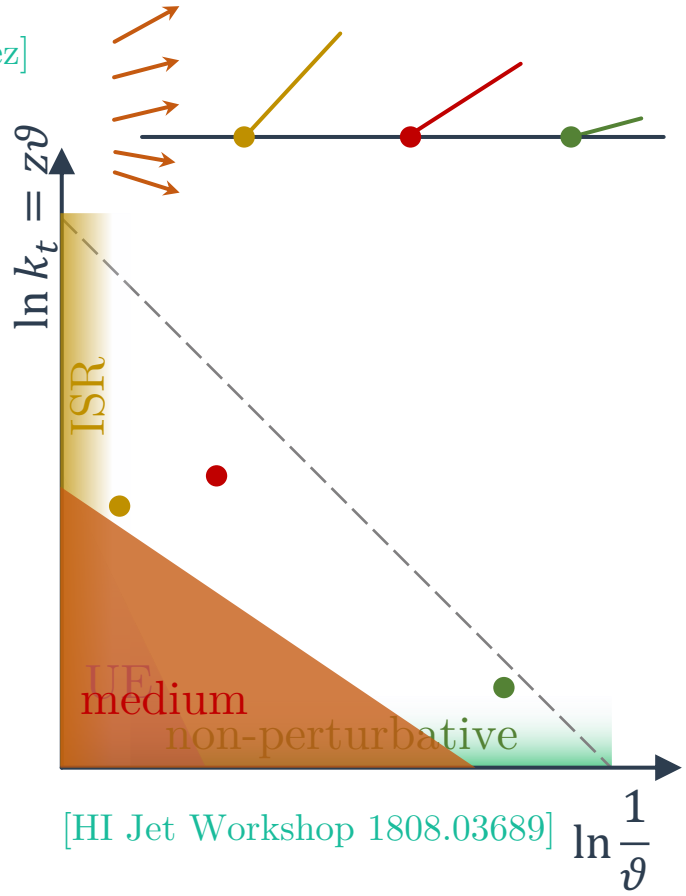

[HI Jet Workshop 1808.03689]

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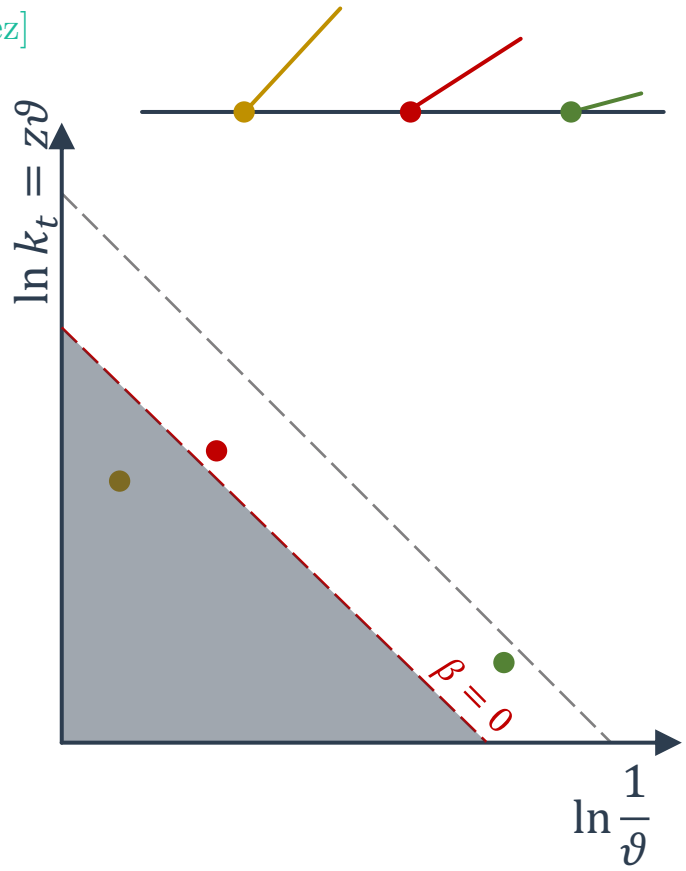

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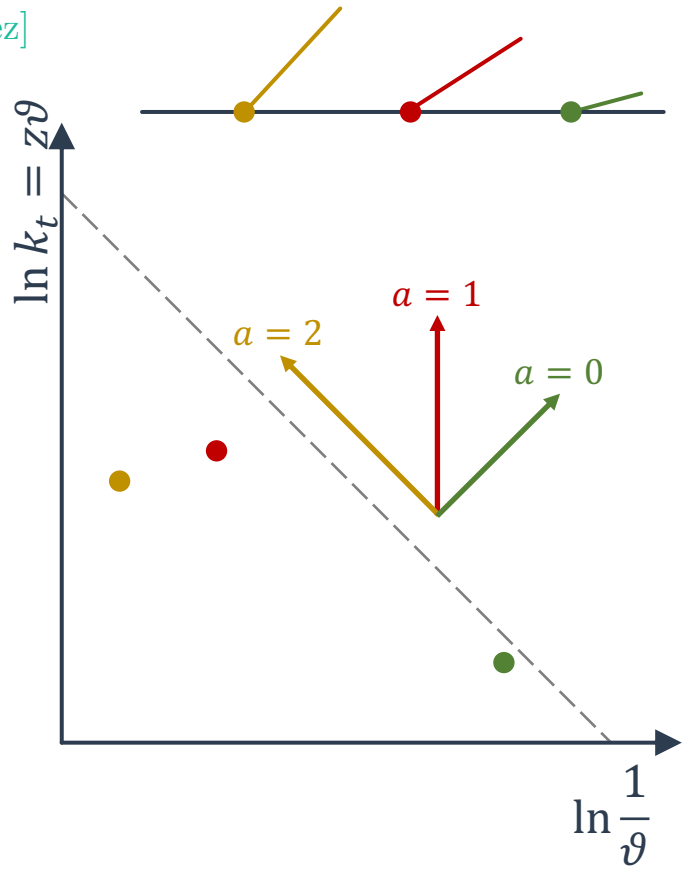
     - W/Z, t tagging, [Mehtar-Tani, Soto-Ontoso, Tywoniuk]
     - color coherence [Caucal,Soto-Ontoso,Takacs],
     - time drop [Apolinaro, Cordeiro, Zapp],
     - dead-cone [Cunqueiro, Napoletano, Soto-Ontoso]
     - Moliere scatterings [in prep., Raymond's talk]



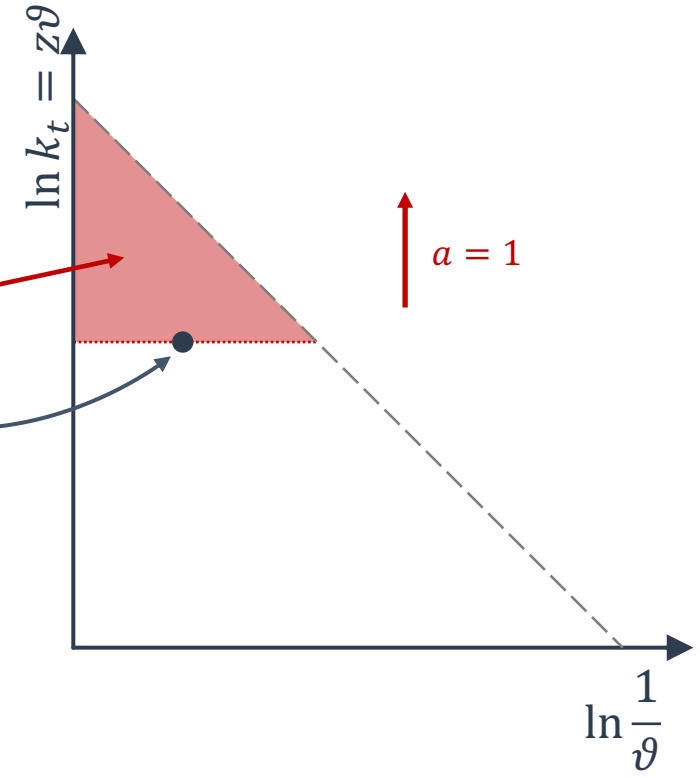
Proton-Proton Baseline

arXiv:2103.06566

Analytic properties

Probability of (z, ϑ) is the hardest $(\kappa^{(a)} = z\vartheta^a)$:

$$\frac{d^2\mathcal{P}_i(z,\vartheta|a)}{d\vartheta dz} = P_i(z,\vartheta)\Delta_i(\kappa^{(a)})$$



Measuring ϑ_g:

$$\left.\frac{1}{\sigma}\frac{d\sigma}{d\vartheta_g}\right|_a = \int_0^1 dz\, \mathcal{P}_i(z,\vartheta_g|a)$$

Prediction at LO+N^{2}DL:

- Splitting function and running coupling at 2-loop
- Non-global contributions (boundary logs)
- Matching to NLO MadGraph5

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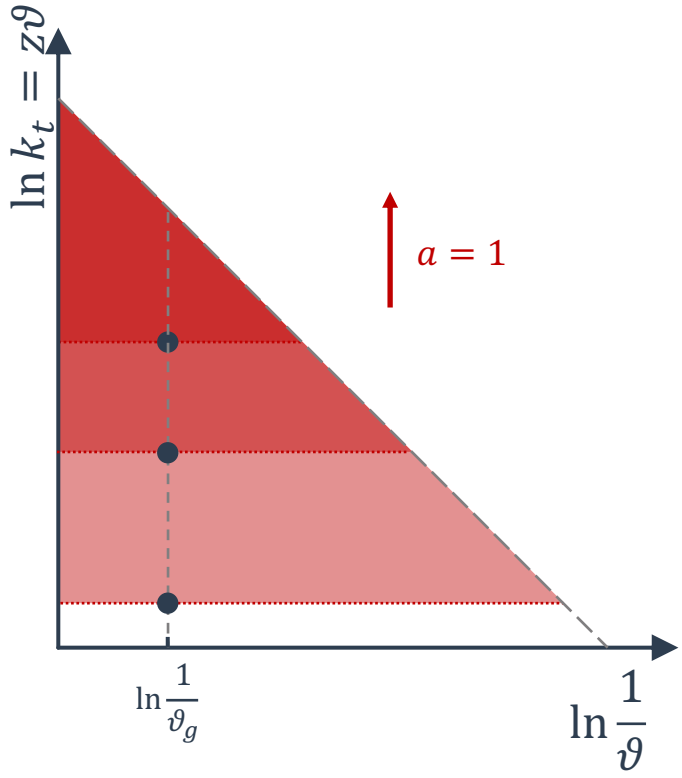

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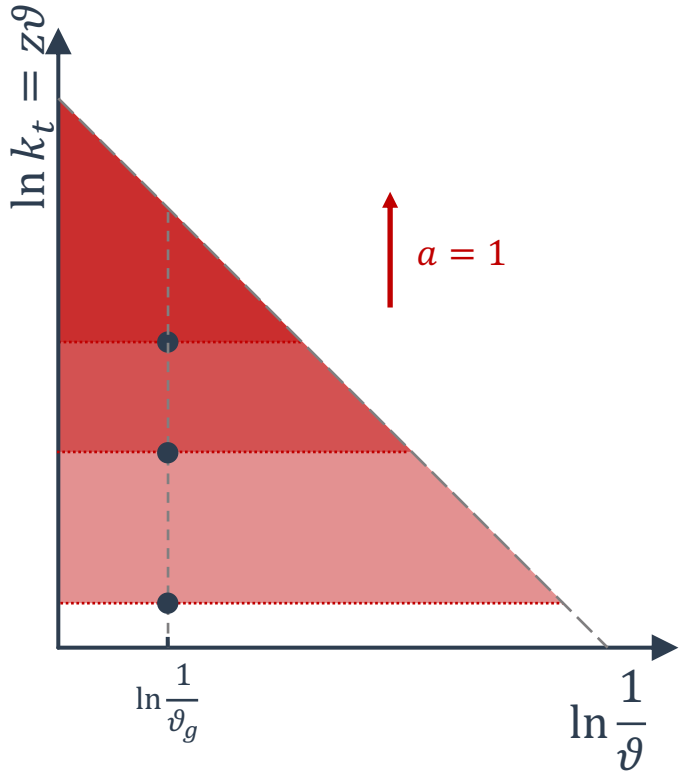

Prediction at LO+N^{2}DL [Silvia's talk]:

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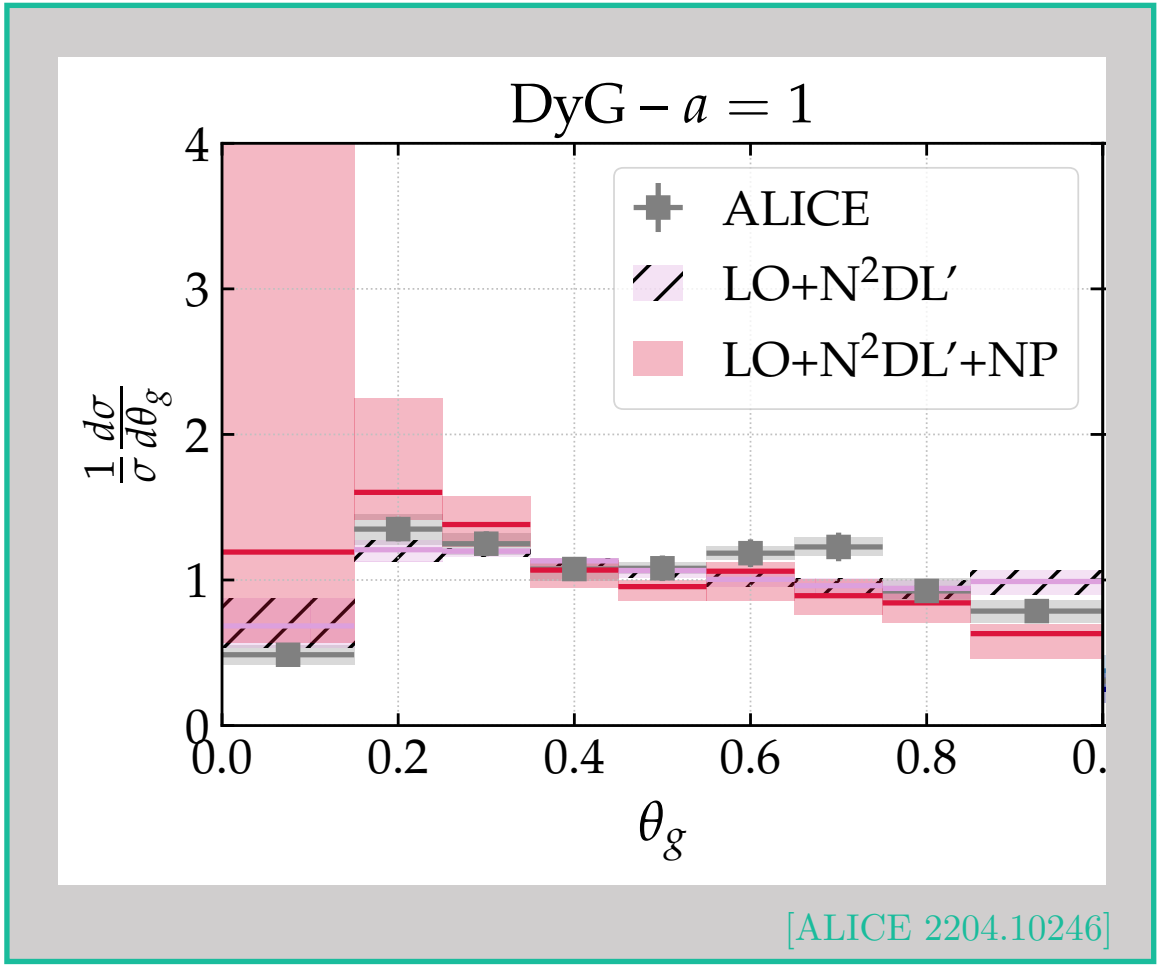
Results - Comparison to ALICE data

The angle of the hardest k_t emission inside the jet



$60 < p_T^{ch} < 80$ GeV

$|\eta| < 0.5$, anti-$k_\perp$($R = 0.4$)

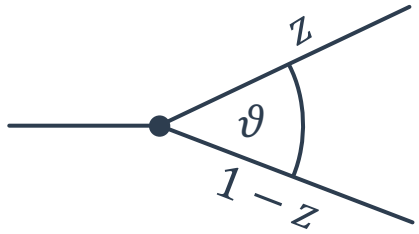
Emission Phase Space in Heavy-Ion Collisions

arXiv:2111.14768

Medium-Induced Emissions

Vacuum emission:

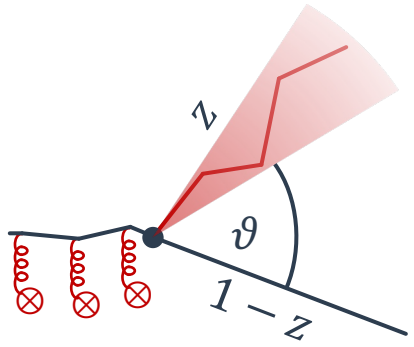
$$P_i^{vac}(z,\vartheta) = 2\alpha_s(k_t)C_i\frac{1}{\vartheta}\frac{1}{z}$$



Medium-induced emission and broadening: [BDMPS-Z, Fabio's talk]

$$P_i^{med}(z,\vartheta) = \alpha_{s,med}C_i\frac{1}{z^{3/2}}\mathcal{B}(z,\vartheta)$$

$\omega \ll \omega_c$
$k_\perp \ll Q_s$



Both splitting can be tagged!

Energy goes out of the jet cone → energy-loss of jets

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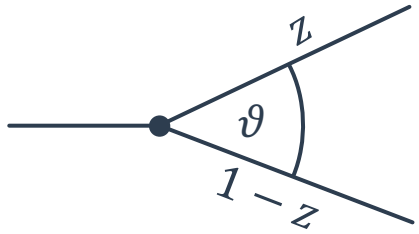

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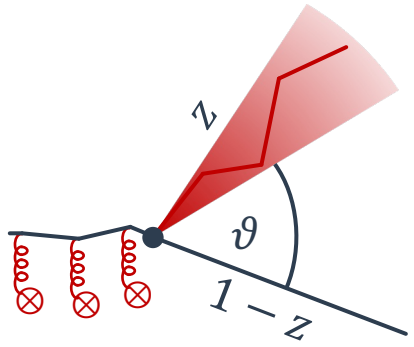

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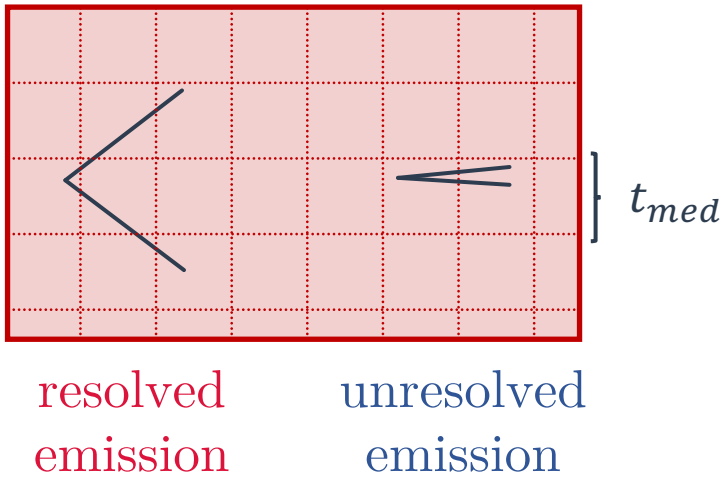
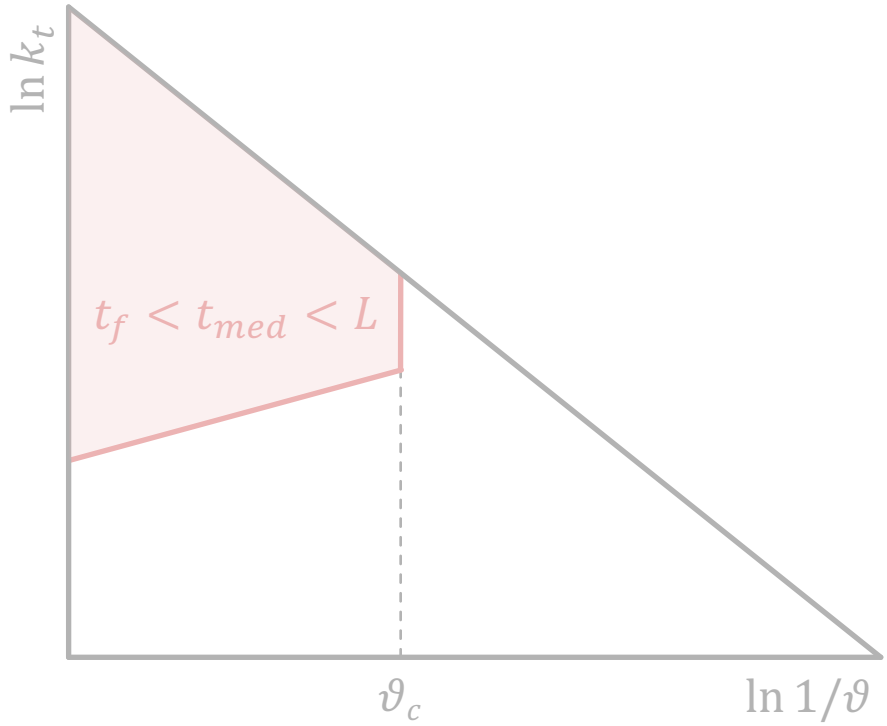
Energy-loss and resolution in medium

[Caucal, Iancu, Soyez, Mehtar-Tani, Casalderrey-Solana, Tywoniuk]

In-medium Lund plane:

- $t_f < t_{\text{med}}$: resolved emissions





- Jets with wide substructure angle loose more energy!

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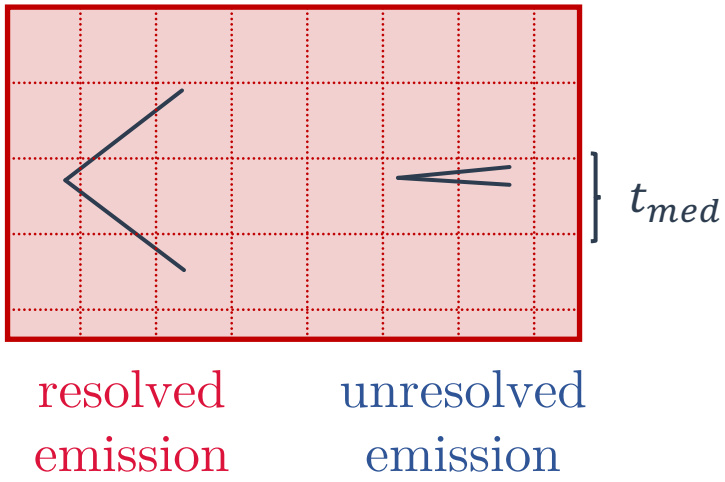

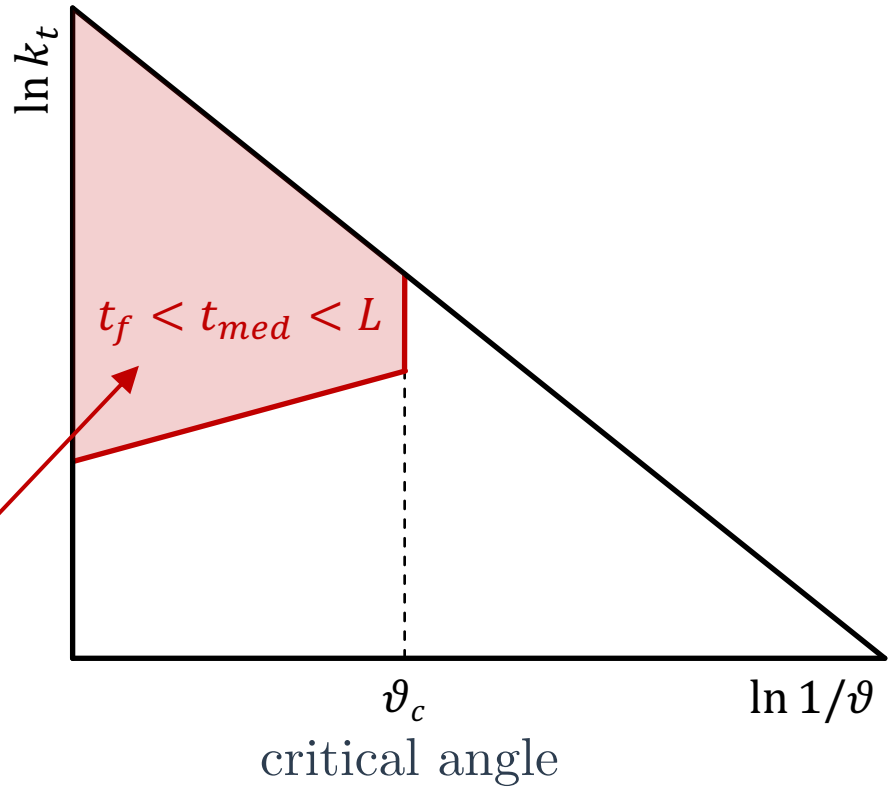

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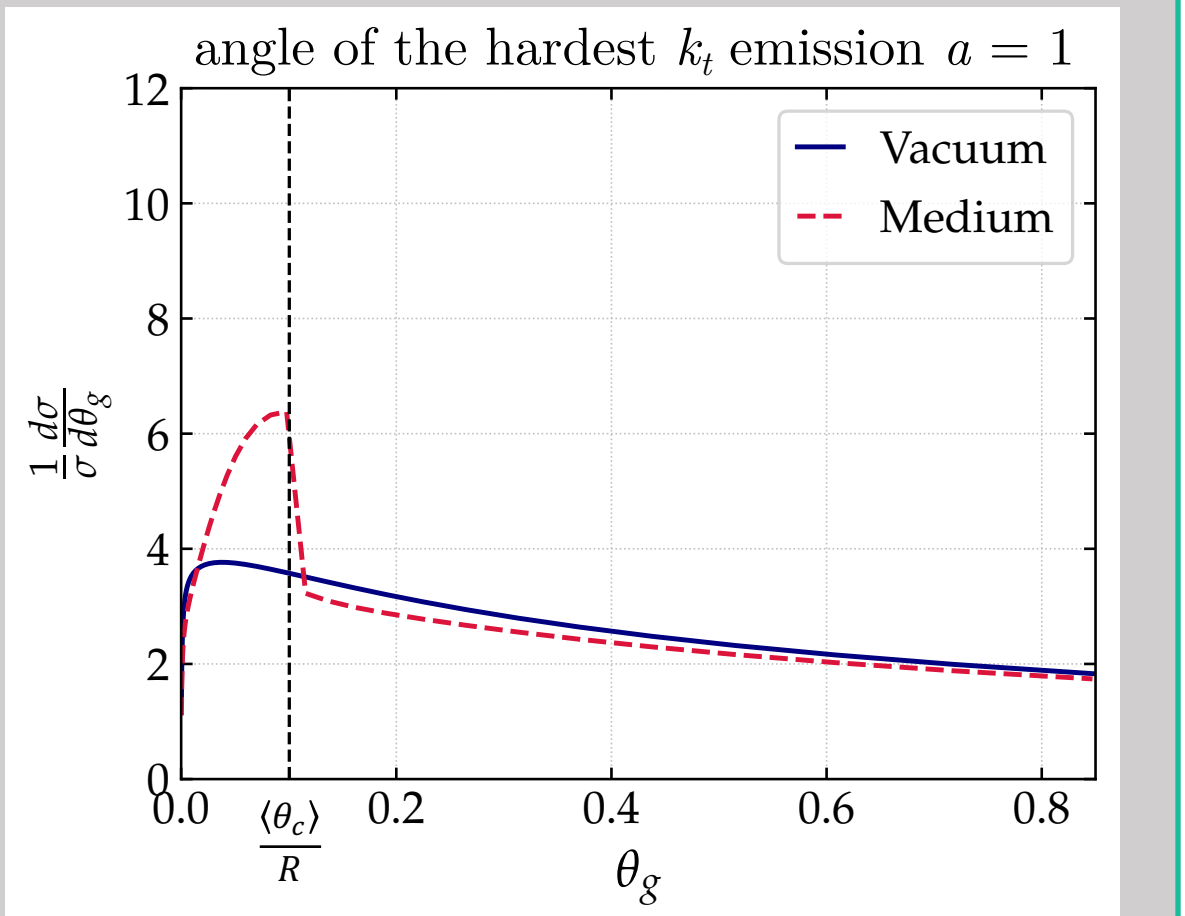
Our simple analytic model



- Jets with wide subjet loose more energy
- Huge jump around ϑ_c!
- Which a is the best?
- Is ϑ_c measurable?

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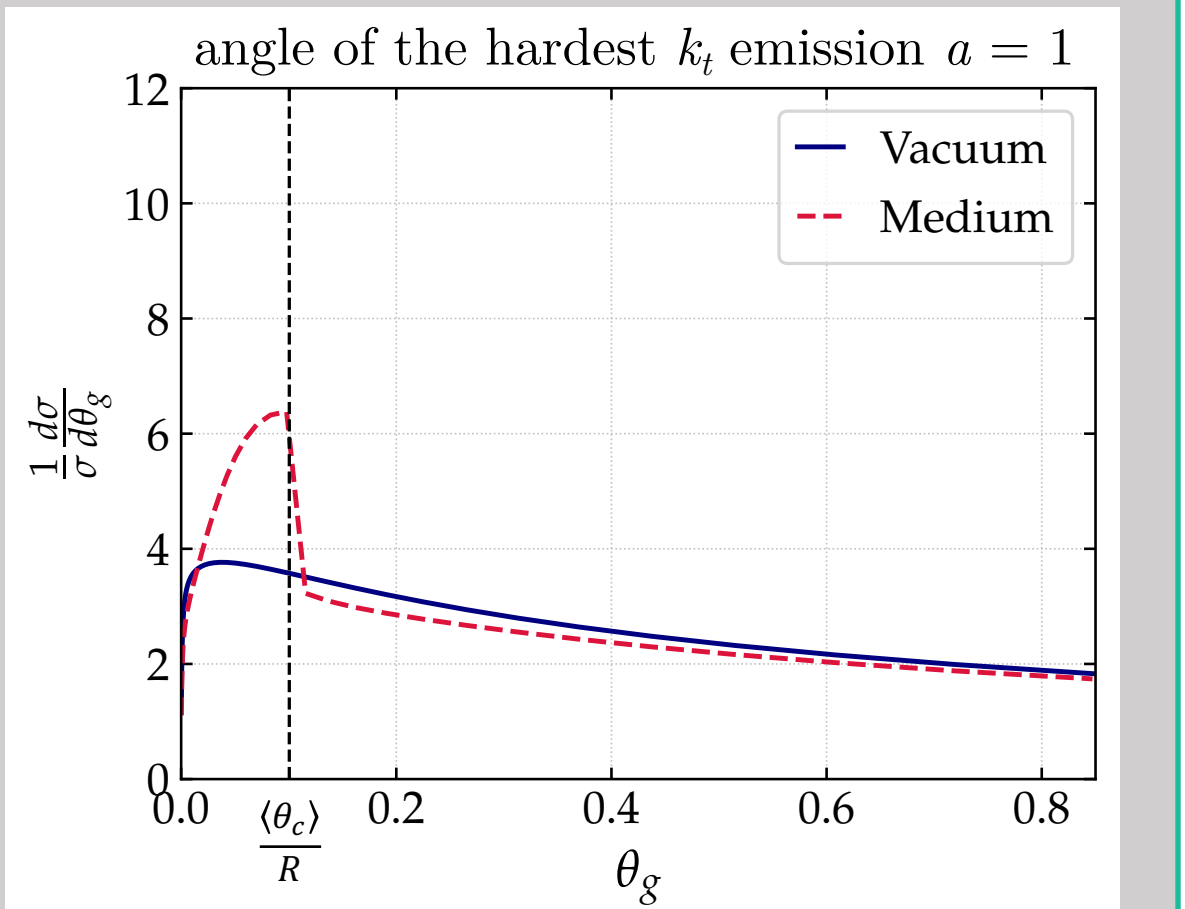

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Is ϑ_c really measurable?

- HI Event generator study:

  JetMed [Caucal, Iancu, Soyez]

  Jewel [Zapp, Krauss, Wiedemann]

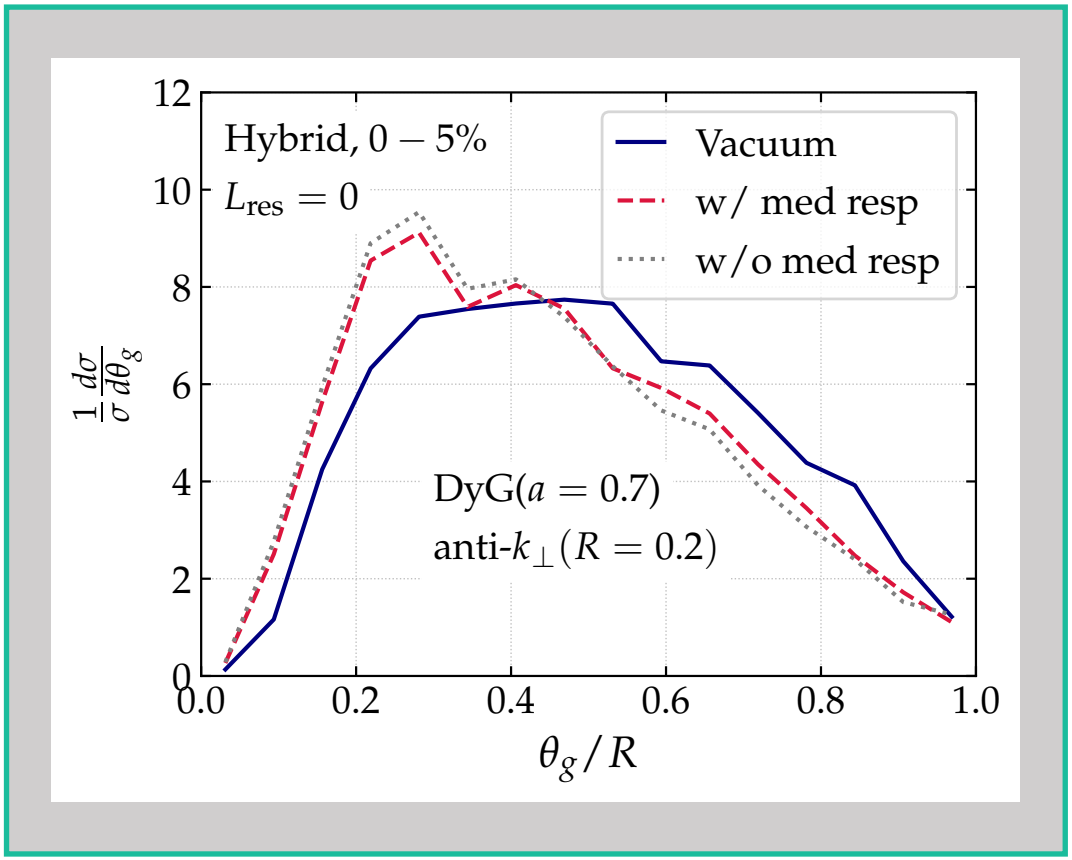
  Hybrid [Casalderrey-Solana, Milhano, Pablos, Rajagopal]

Different energy-loss models

- Non-perturbative physics:
  - Embedded hydro/kinetic background
  - Fluctuating geometry
  - Medium response
  - Hadronization

Medium response

angle of the hardest emission $a = 0.7$



- Not sensitive to med. resp. → grooming ✓
- Enhancement remains

Summary

- Understanding the resolution in quark-gluon plasma [also Carlota's talk with EEC]

- pp baseline:
  - Dynamical tagging at LO+N^{2}DL
  - Good agreement with ALICE data

- Heavy-Ion collisions:
  - analytical understanding of enhancement around ϑ_c
  - MCs to test ϑ_c and the phase space: JetMed, Jewel, Hybrid
  - Best parameter: $0.5 < a < 1$ and $R \sim 0.2$ to resolve the difference btw MCs

Thank you for the attention!