Dynamically groomed jet radius in heavy-ion collisions

Adam Takacs* (University of Bergen),

Paul Caucal (Brookheaven National Laboratory, CERN),

Alba Soto-Ontoso (Universite Paris-Saclay, CERN)

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

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Supported by the Trond Mohn Foundation BFS2018REK01

Jets in QCD

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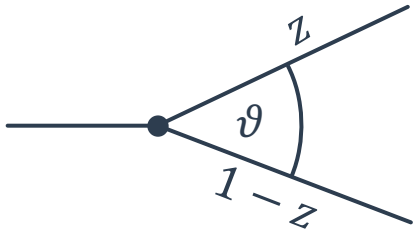

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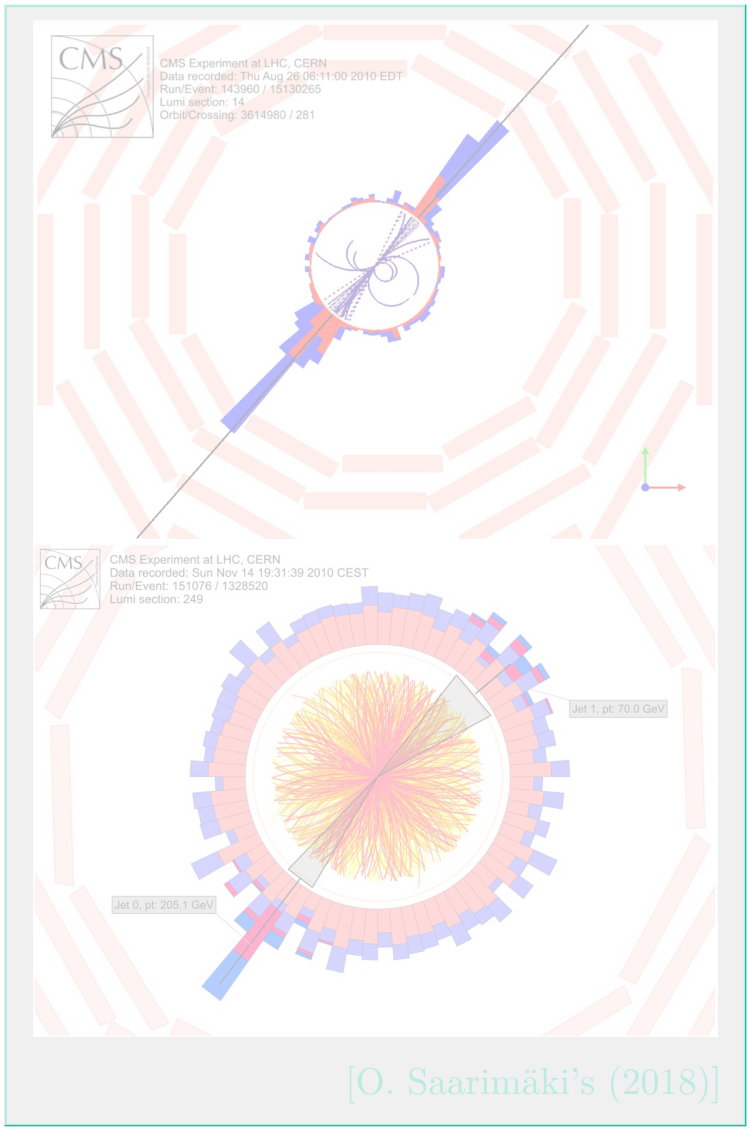
collinear divergence, soft divergence

Resummation of large logarithms!



[O. Saarimäki's (2018)]

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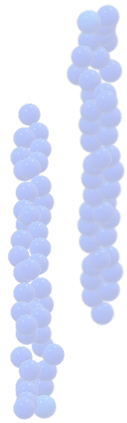

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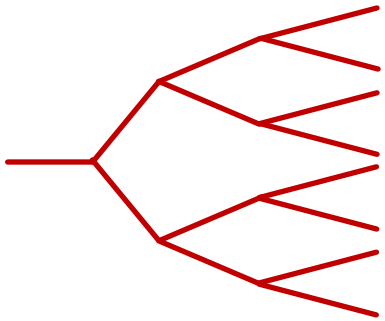

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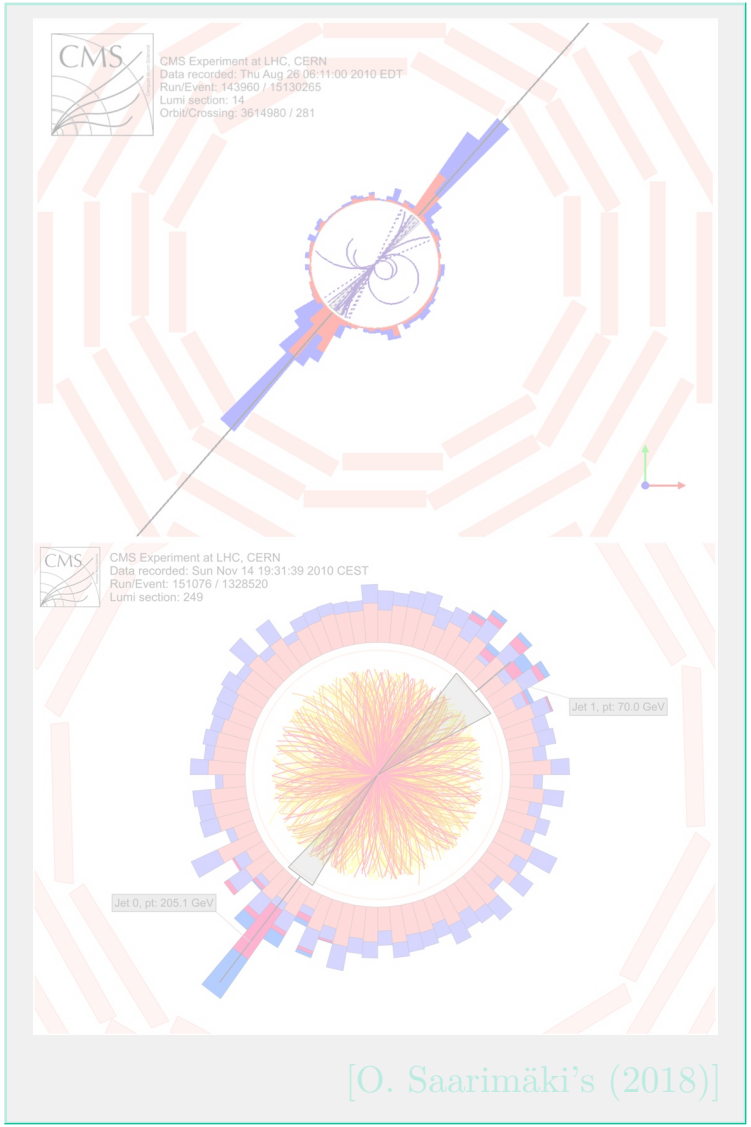

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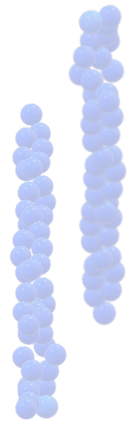

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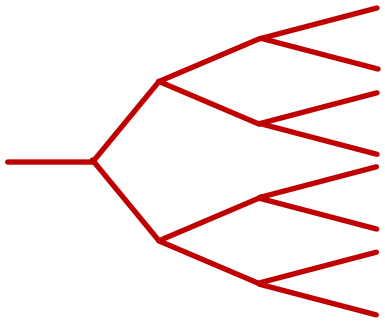

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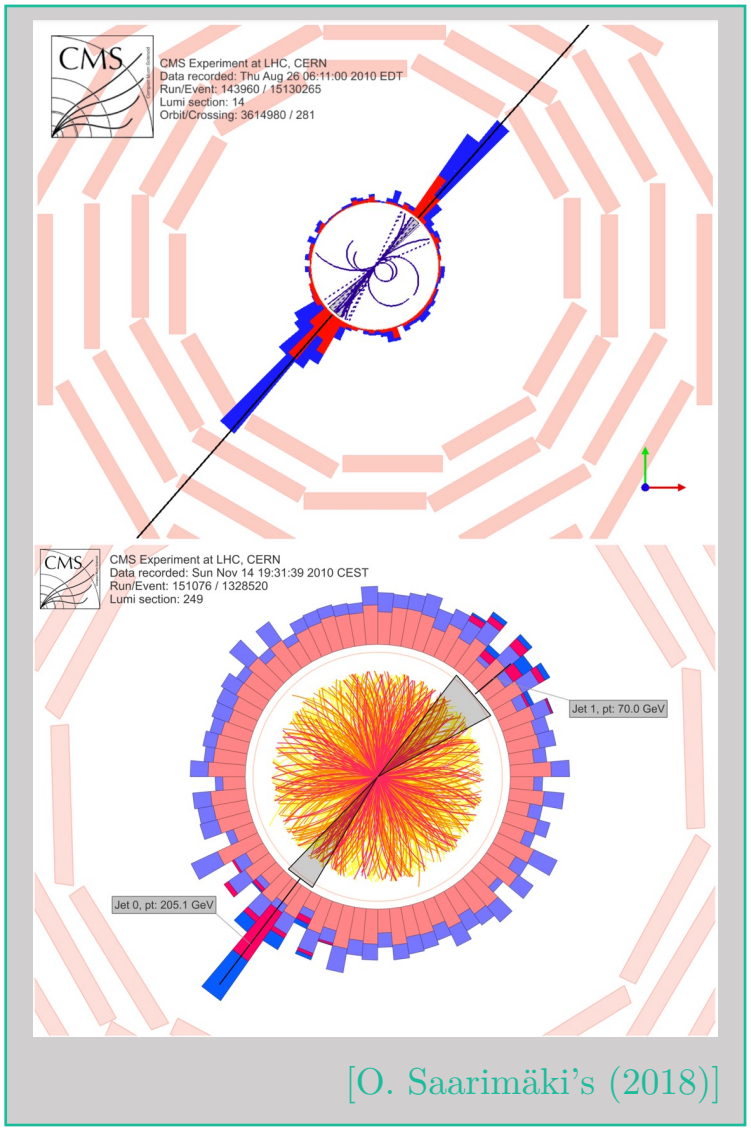

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Grooming splittings in jets

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

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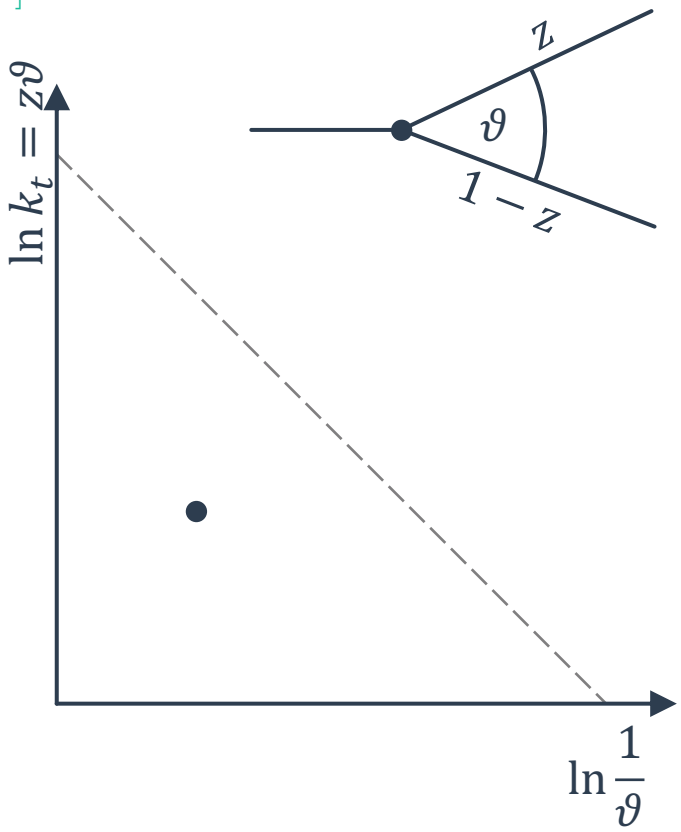

Soft Drop grooming [Larkovski, Marzani, Soyez, Thaler]:

4. Stop if $z_i > z_{cut}\vartheta_i^{\beta}$ (with the widest angle)
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Dynamically grooming [Mehtar-Tani, Soto-Ontoso, Tywoniuk]:

4. Find the hardest $\max_i(z_i\vartheta_i^a)$
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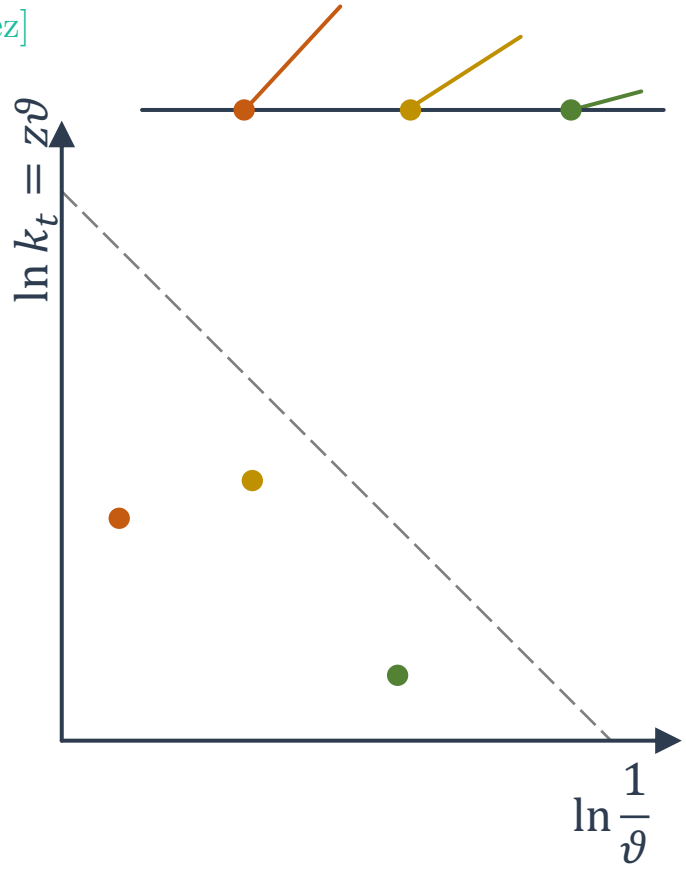

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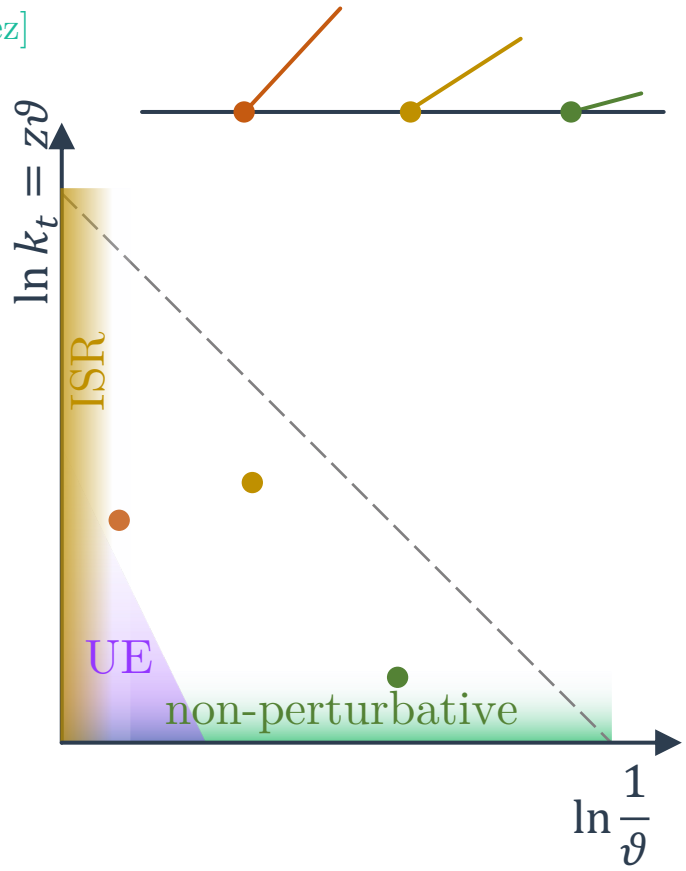

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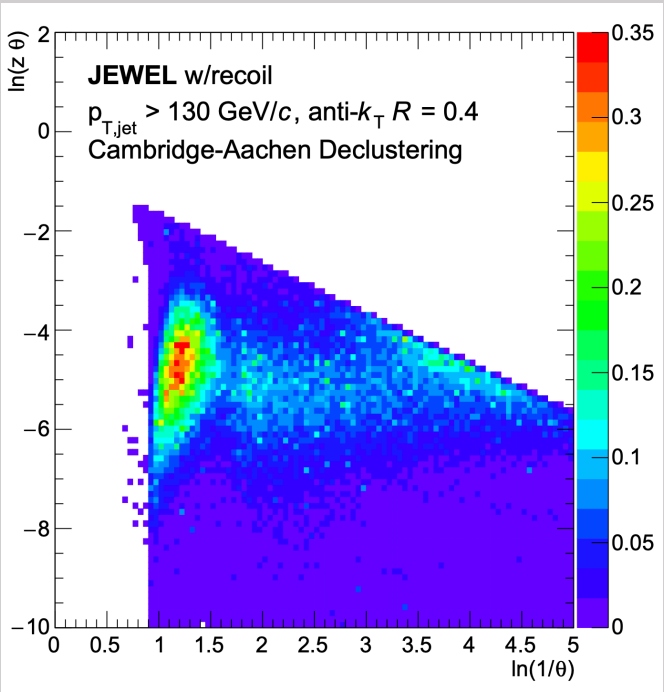

[Heavy-Ion Jet Workshop 1808.03689]

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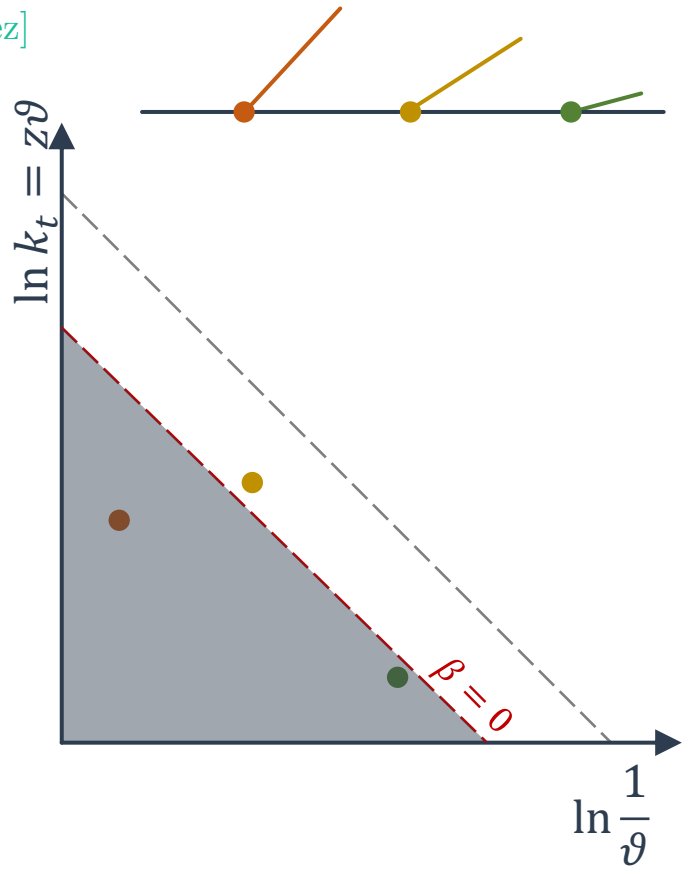

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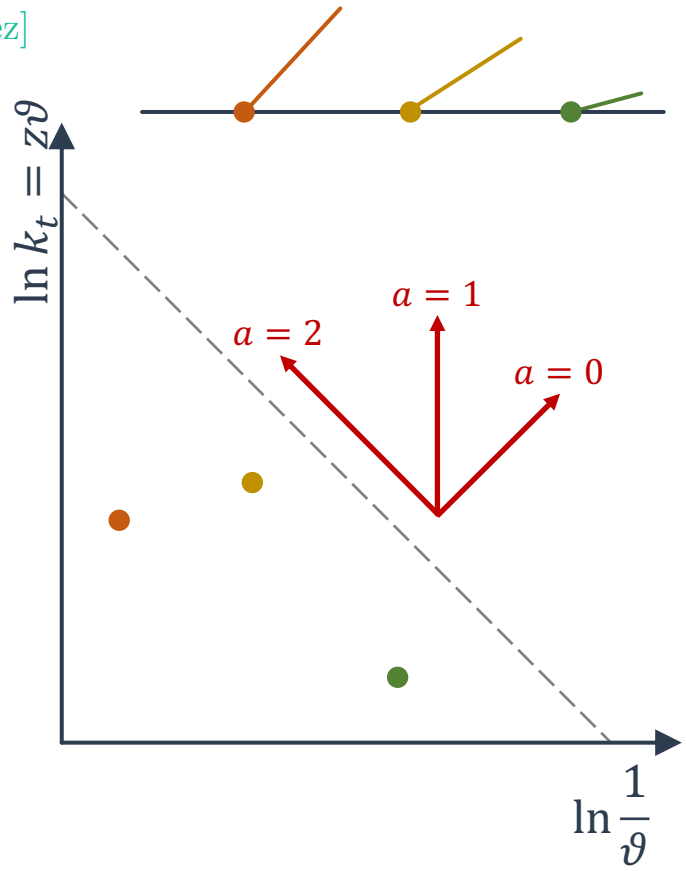

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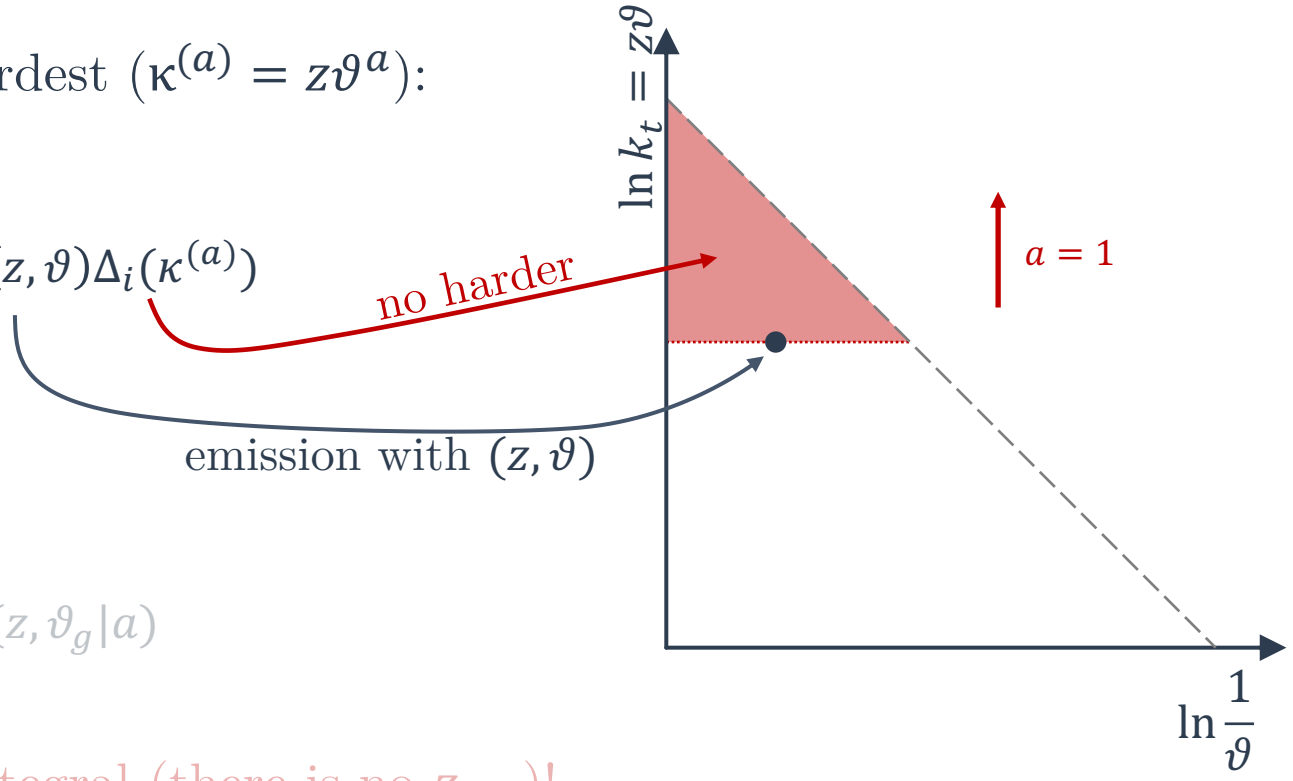
Proton-Proton Baseline

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:

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

The Sudakov regulates the integral (there is no z_{cut})!

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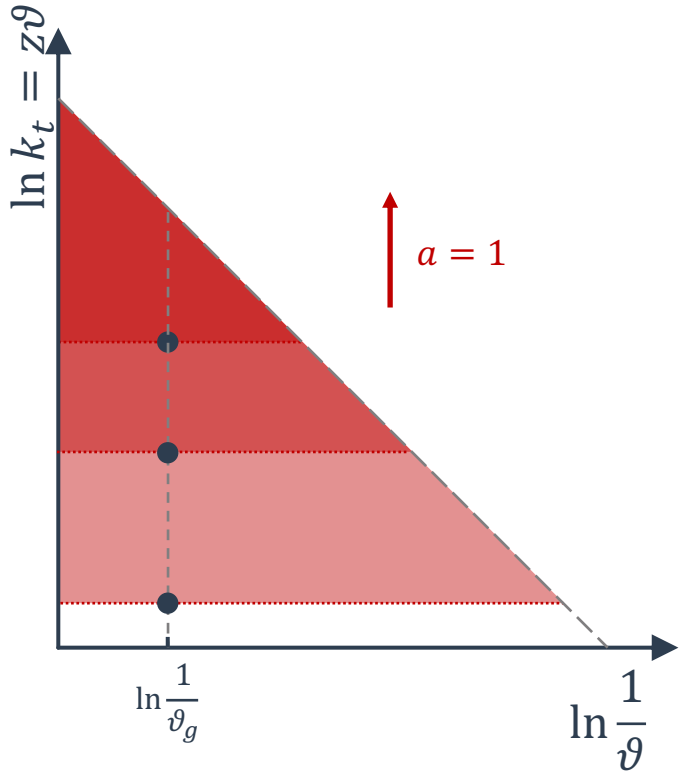


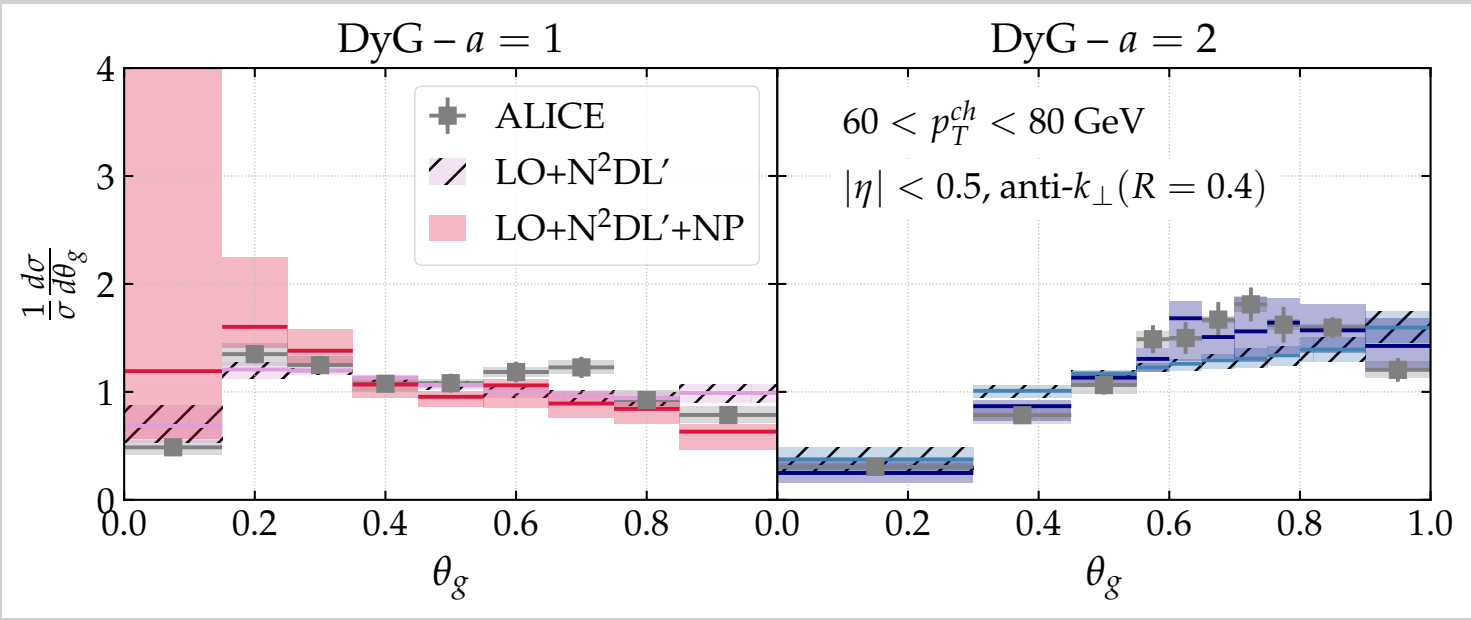
Results

Targeted accuracy is LO+N^{2}DL:

- Splitting function at 2-loop
- Running coupling at 2-loop
- Non-global contributions (large-N_c, small-R)
  - There is no clustering log
  - Boundary logs present
- No multiple emission contribution
- Matching to NLO MadGraph5
- Non-perturbative corrections

Results - Comparison to ALICE preliminary

[ALICE 2009.07172, 2009.12247]



- Good agreement with data.
- Baseline for AA calculation.

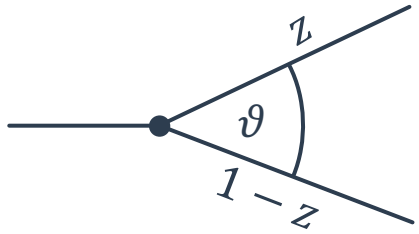
Jet Quenching in Heavy-Ion Collisions

arXiv:2111.14768

Medium-Induced Emissions

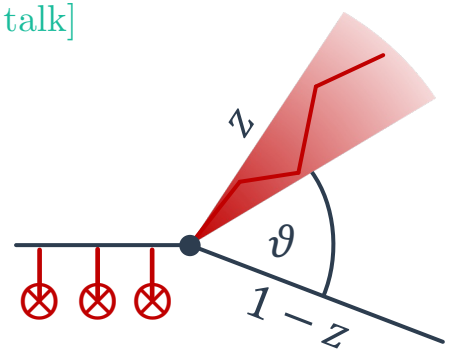
Vacuum emission:

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



Medium-induced emission and broadening: [BDMPS-Z, also Johannes' talk]

$$P_i^{med}(z,\vartheta) = \underset{\substack{\omega \ll \omega_c \\ k_\perp \ll Q_s}}{\bar{\alpha}_{med}} \sqrt{\frac{2\omega_c}{z^3 p_t}}\mathcal{B}(z,\vartheta)$$



Should one sum them up? What about resolution?

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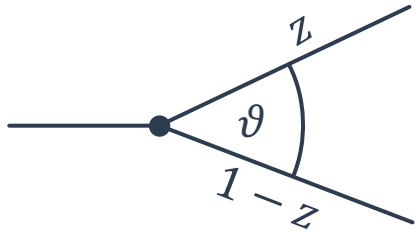

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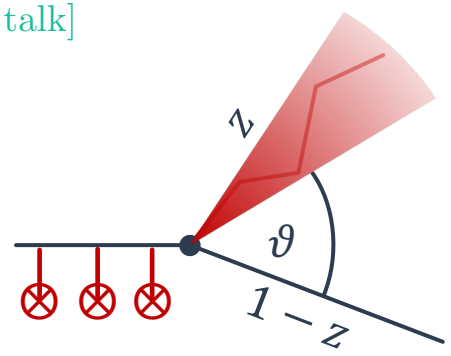

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In-medium emission phase space

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

In-medium Lund plane regions:

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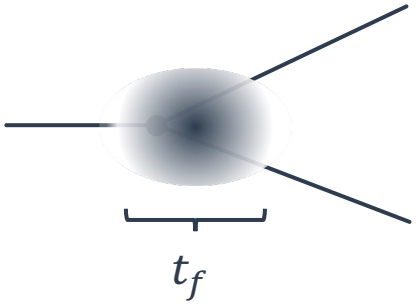
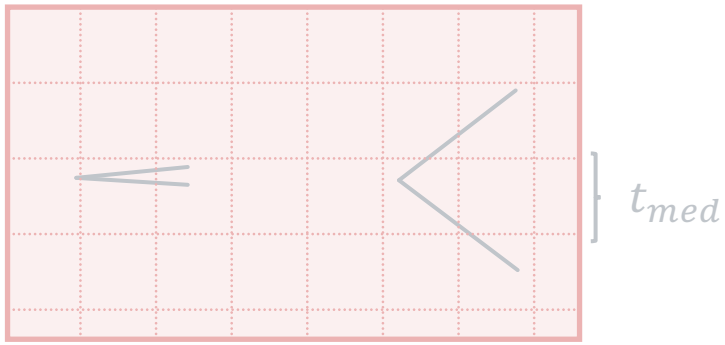
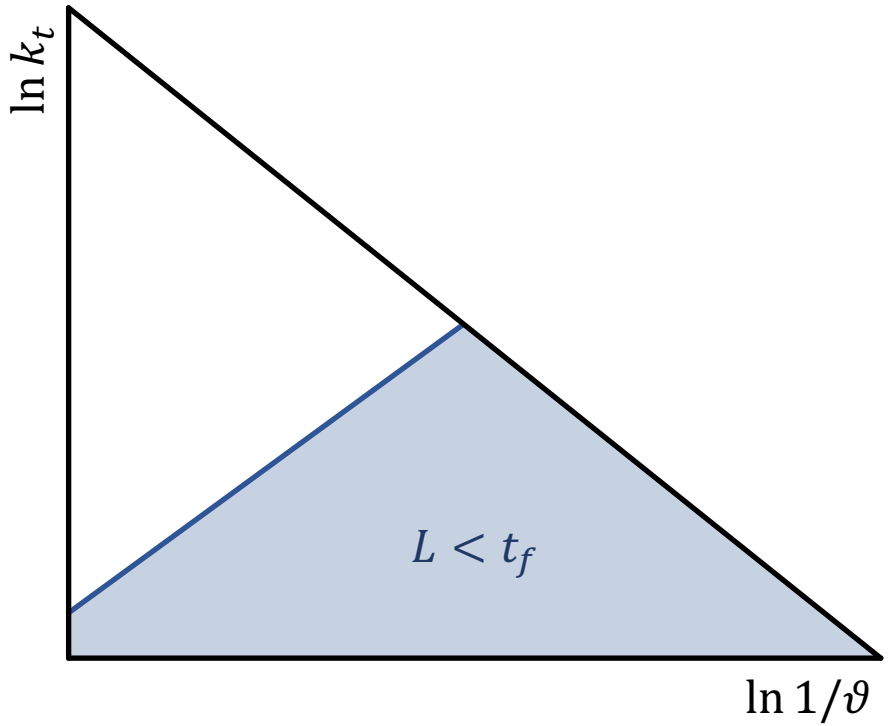


- $t_f < t_{\text{med}}$: Inside and resolved vacuum&medium emissions, energy-loss





+ also radiation out of the cone: energy loss

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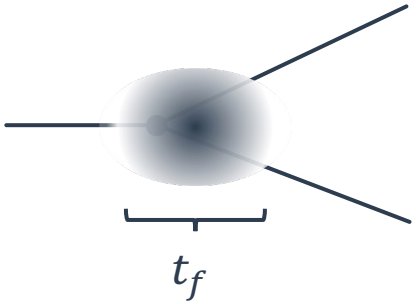

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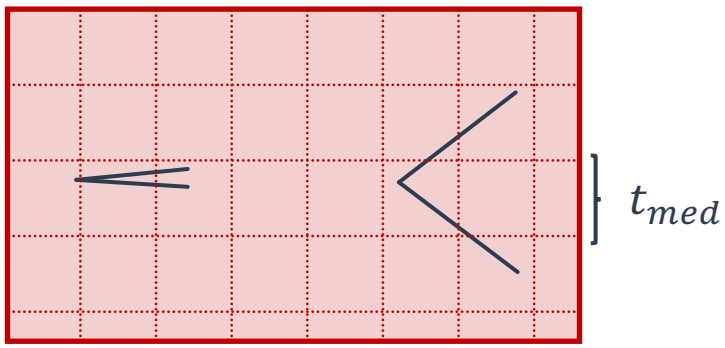

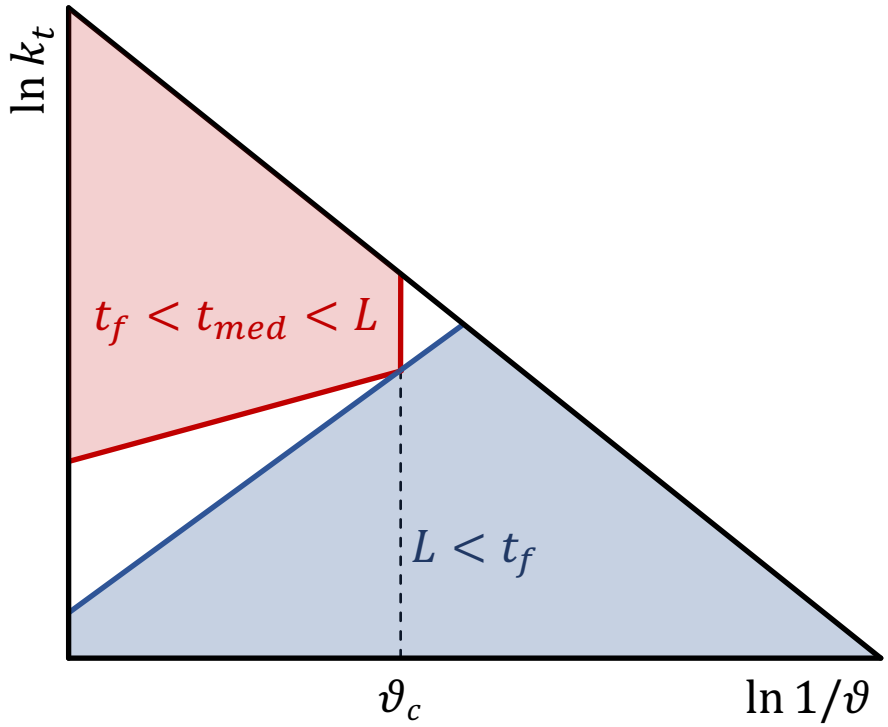

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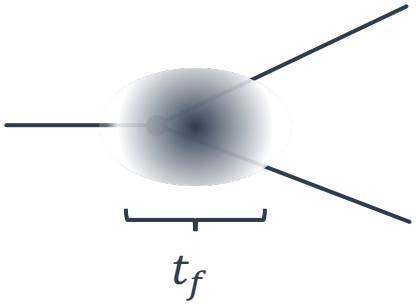

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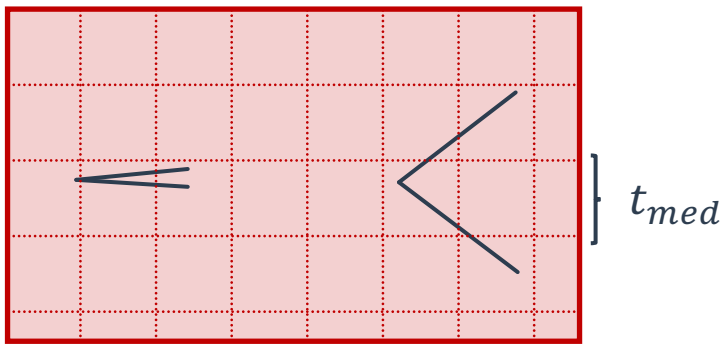

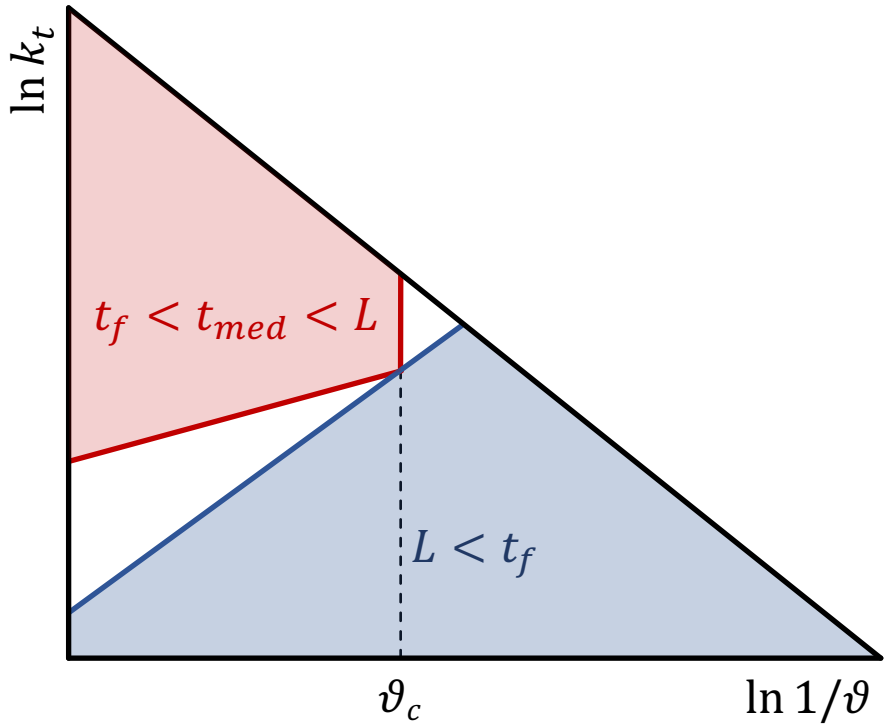

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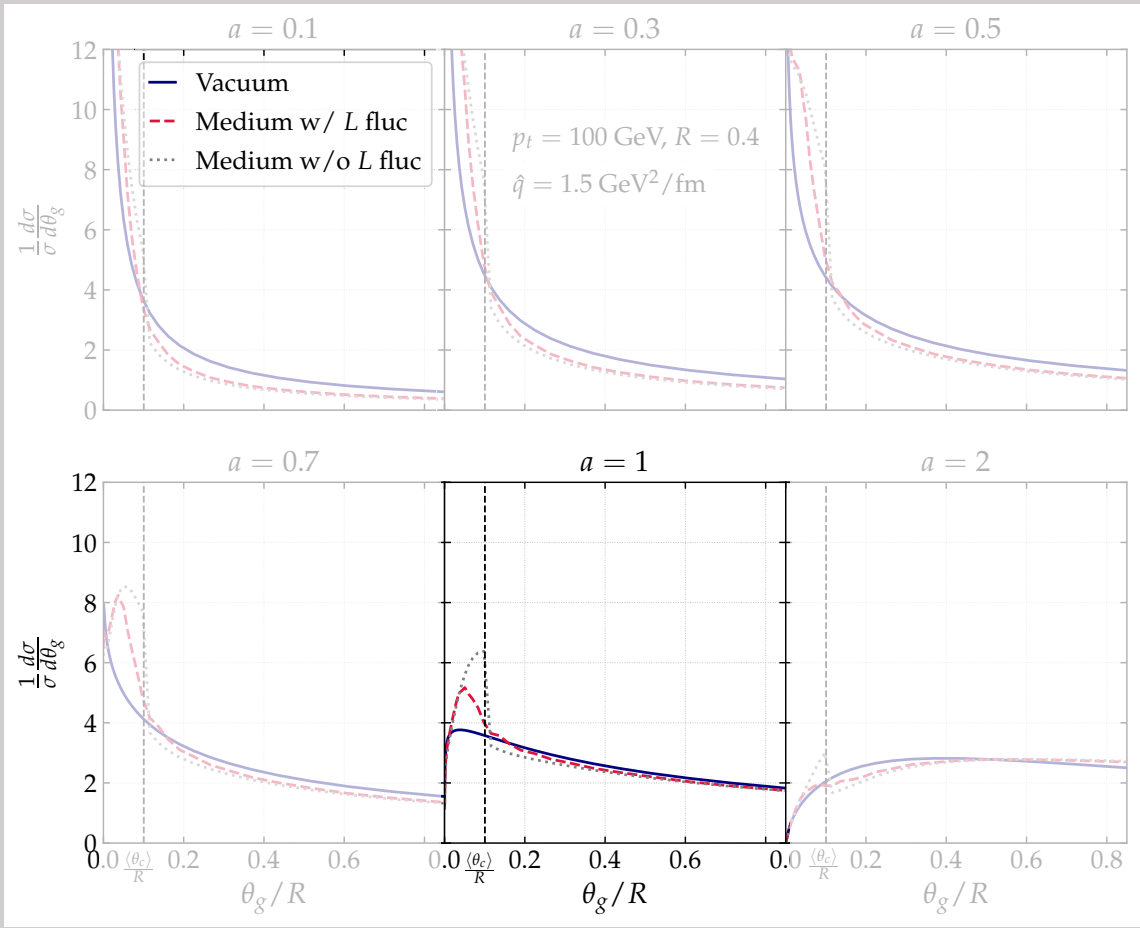

Huge jump around ϑ_c!

Is ϑ_c measurable?

Which a is the best?

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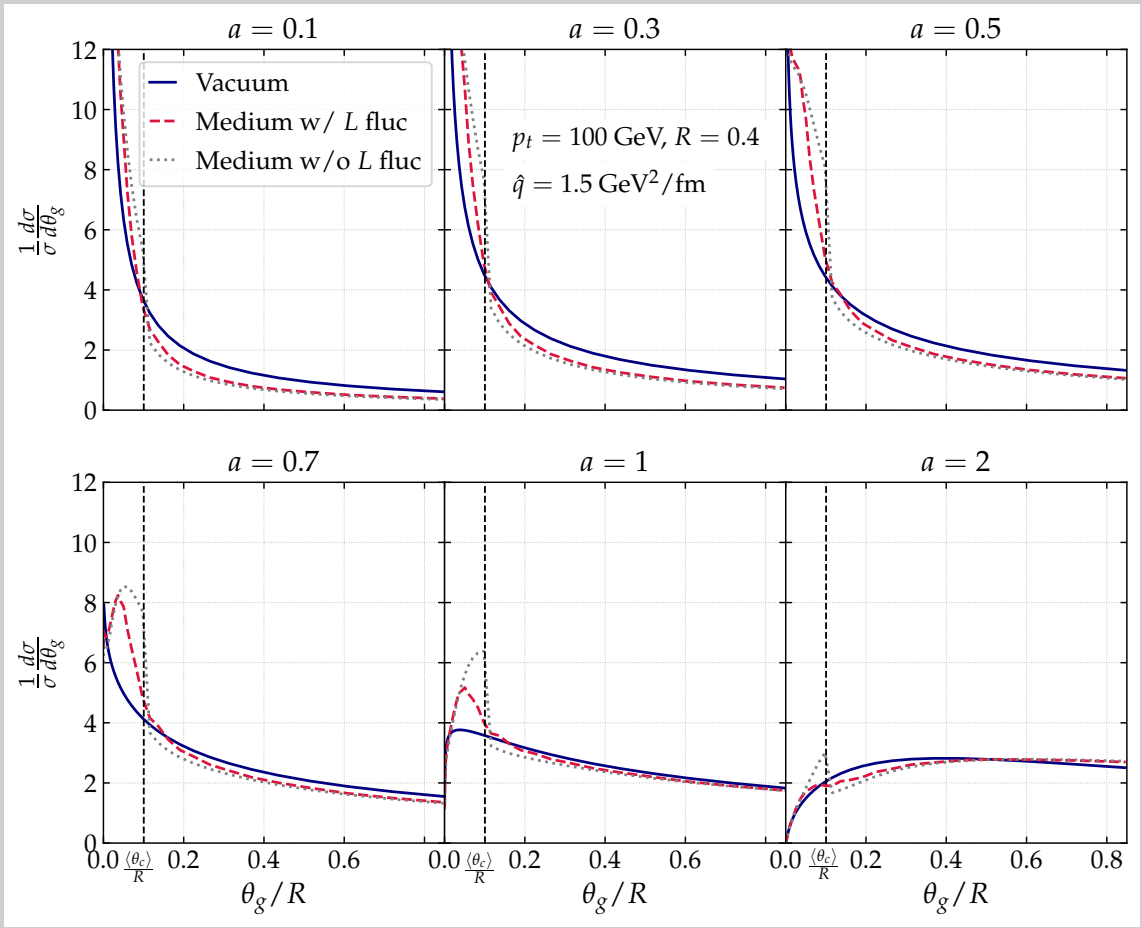

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Is ϑ_c really measurable?

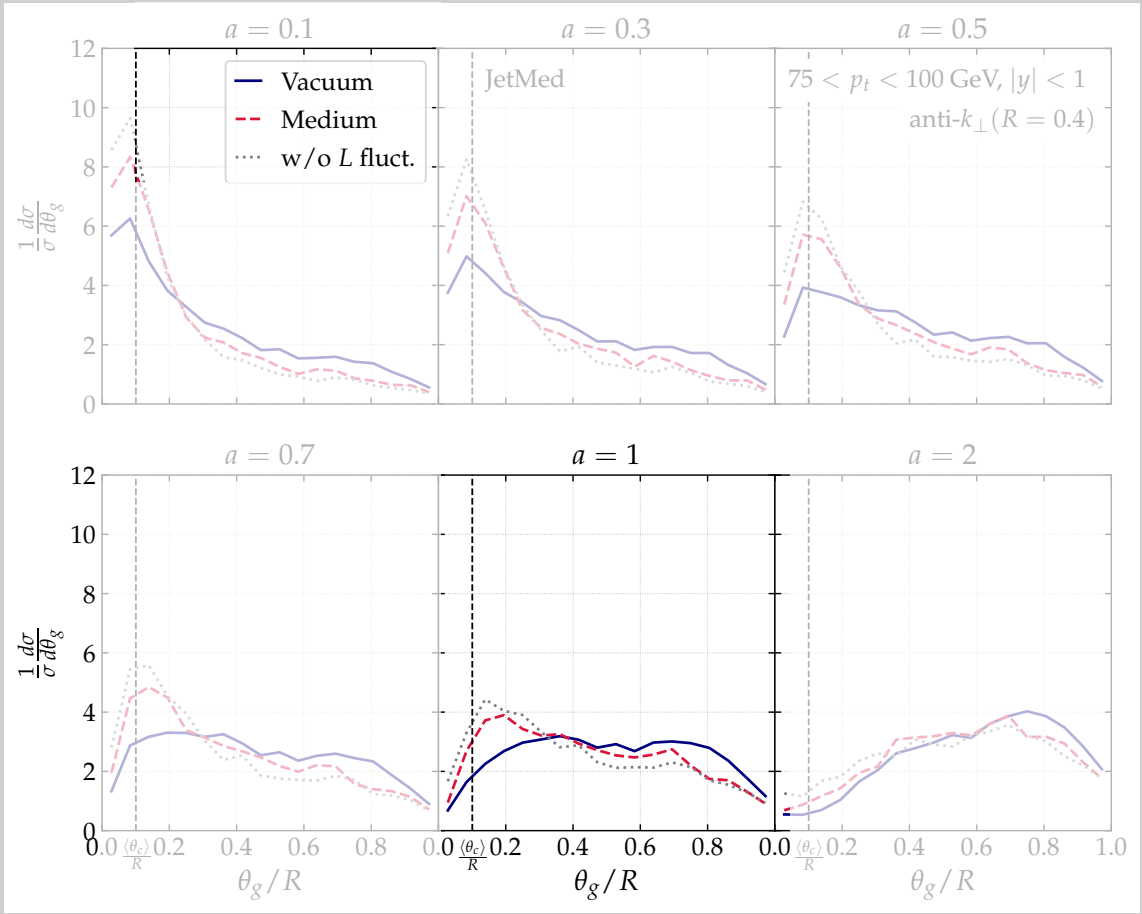
- Heavy-ion collision event generator study:

  JetMed [Caucal, Iancu, Soyez]

  Jewel [Zapp, Krauss, Wiedemann]

  Hybrid [Casalderrey-Solana, Milhano, Pablos, Rajagopal]
- Different energy-loss models
- Fluctuations: geometry, path length
- Embedded hydro/kinetic theory
- Medium response
- Hadronization
- Statistical tool: Kolmogorov-Smirnov Distance

JetMed simulation



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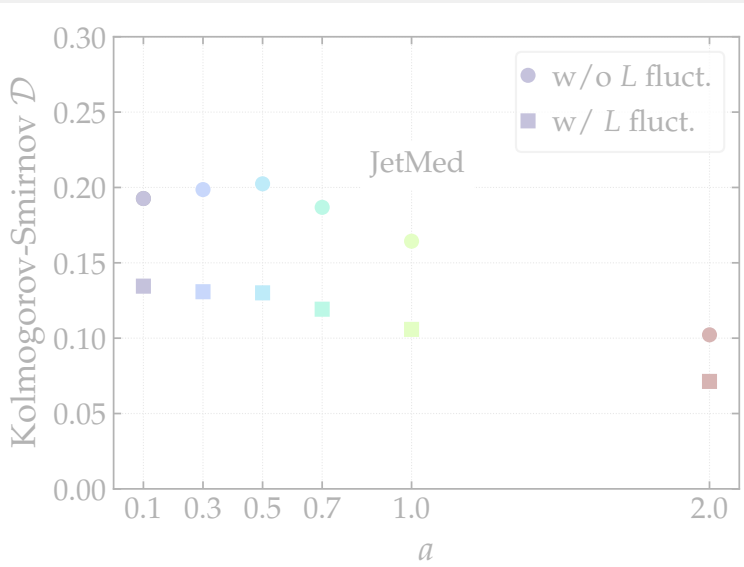

see also for Jewel and Hybrid...

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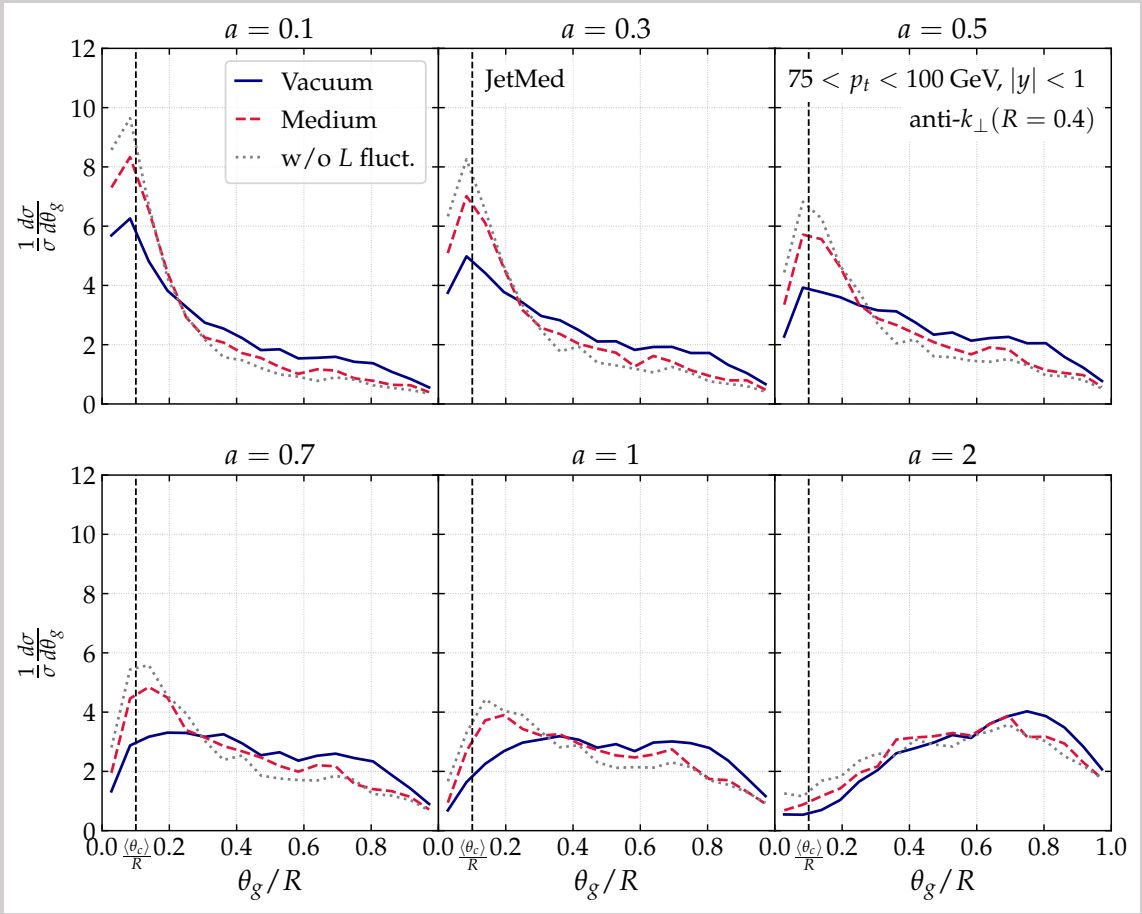

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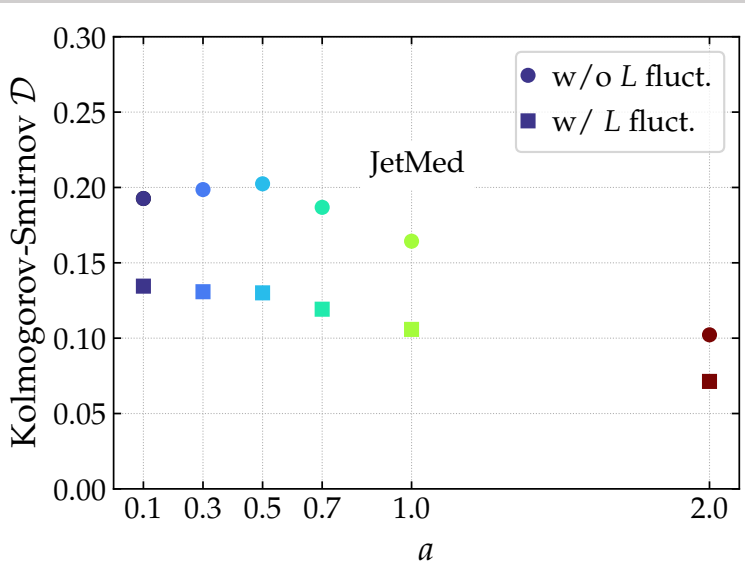

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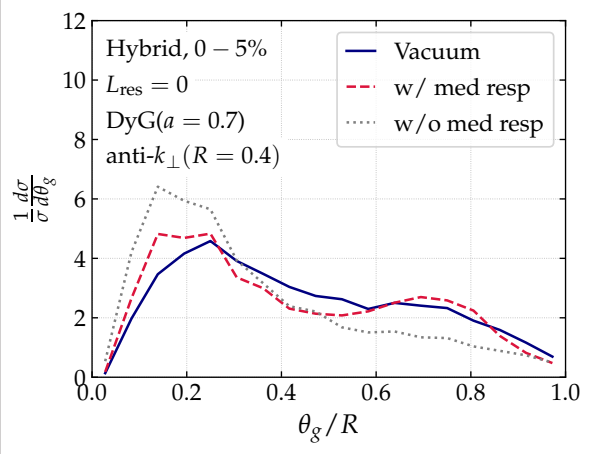
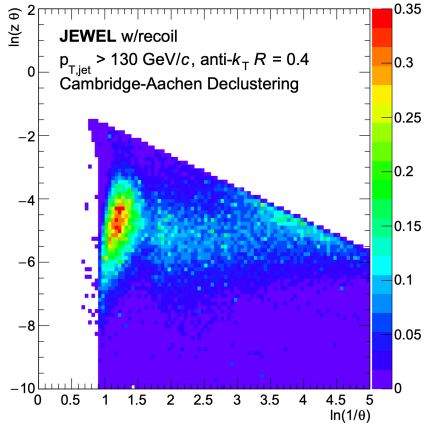
Sensitivity to medium response



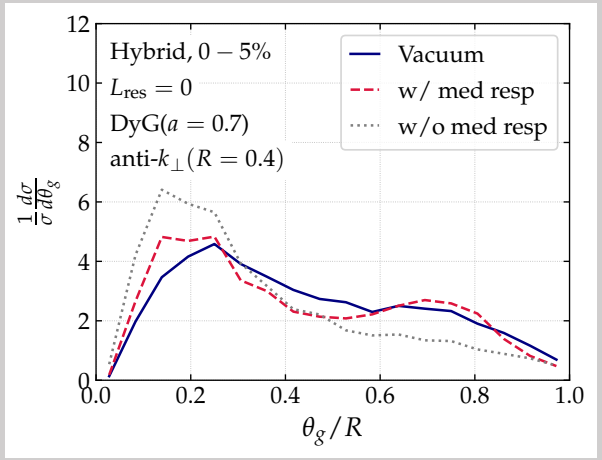
Resolution angle ϑ_c

Medium response

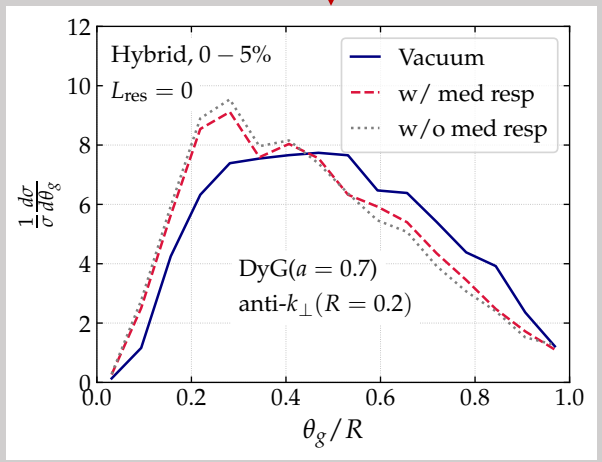
Reminder of medium response



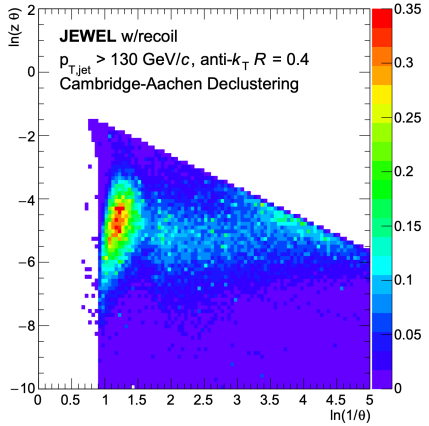
Medium response



Decreased cone size



Reminder of medium response



Free of medium response!

Summary

- Understanding jet modification in medium
- Vacuum 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: JetMed, Jewel, Hybrid
  - Statistical analysis for measuring ϑ_c
  - Studied: energy-loss, fluctuations, medium response, hadronization
  - Best parameter: $0.5 < a < 1$ and $R \sim 0.2$ to resolve the difference btw MCs

Thank you for the attention!