Dynamically groomed jet radius in heavy-ion collisions

Adam Takacs* (University of Bergen),

Paul Caucal (Brookheaven National Laboratory)

Alba Soto-Ontoso (Universite Paris-Saclay)

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

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Grooming splittings in jets

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

1. Find a jet
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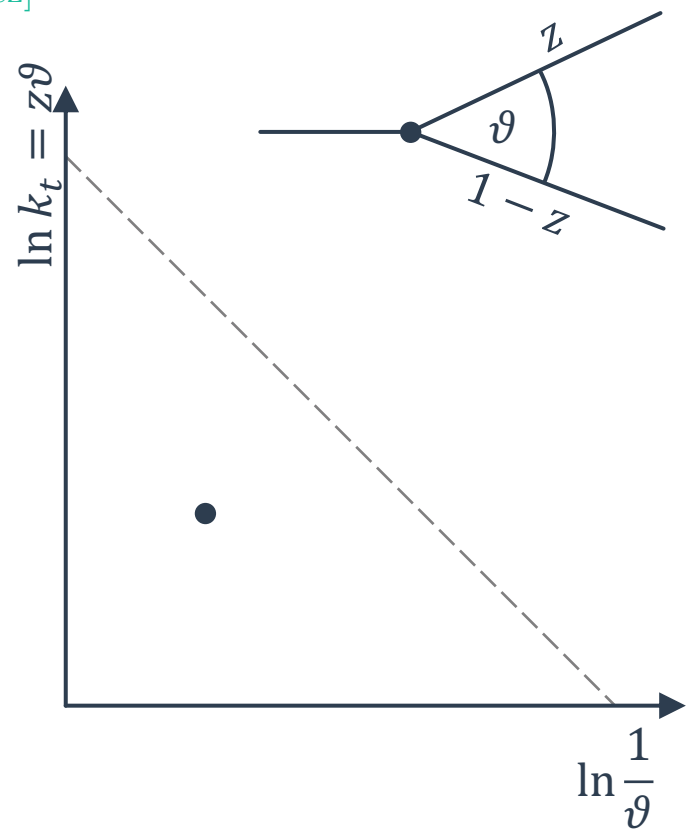
3. Follow the hardest branch ($z_i > {}^1/_2$)



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.

Dynamically grooming [Mehtar-Tani, Soto-Ontoso, Tywoniuk]:

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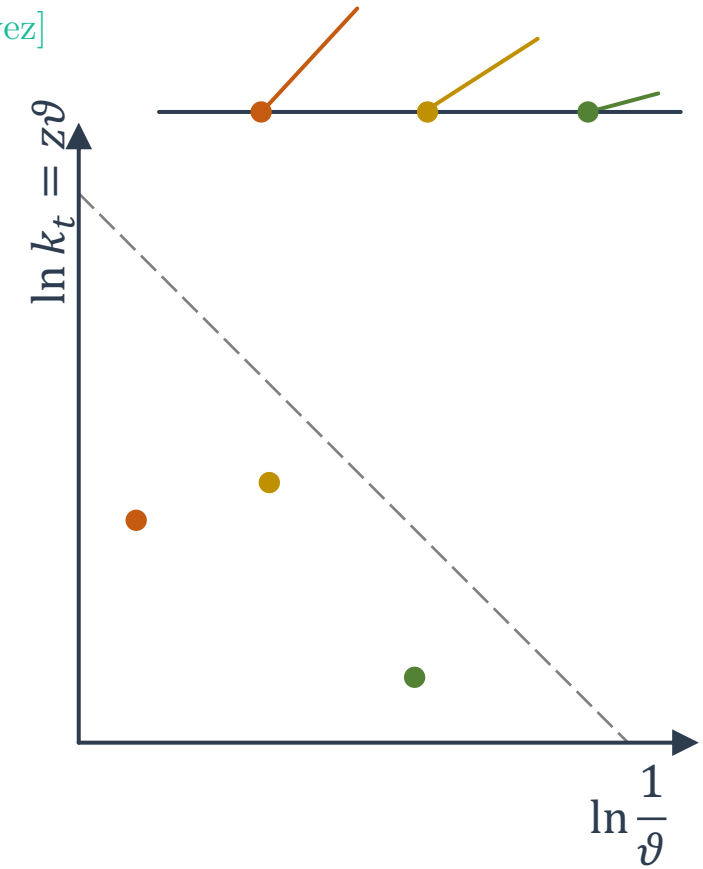

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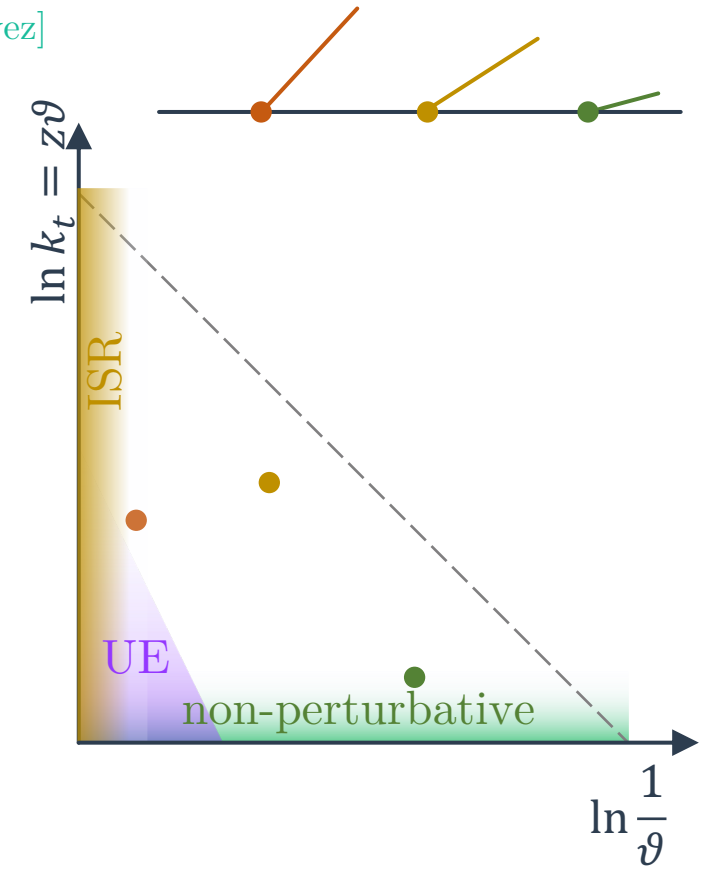

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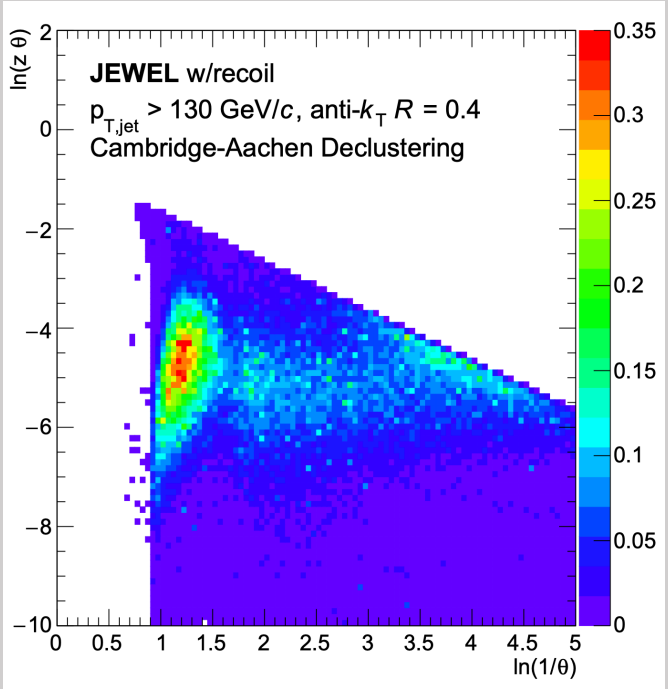

[Heavy-Ion Jet Workshop 1808.03689]

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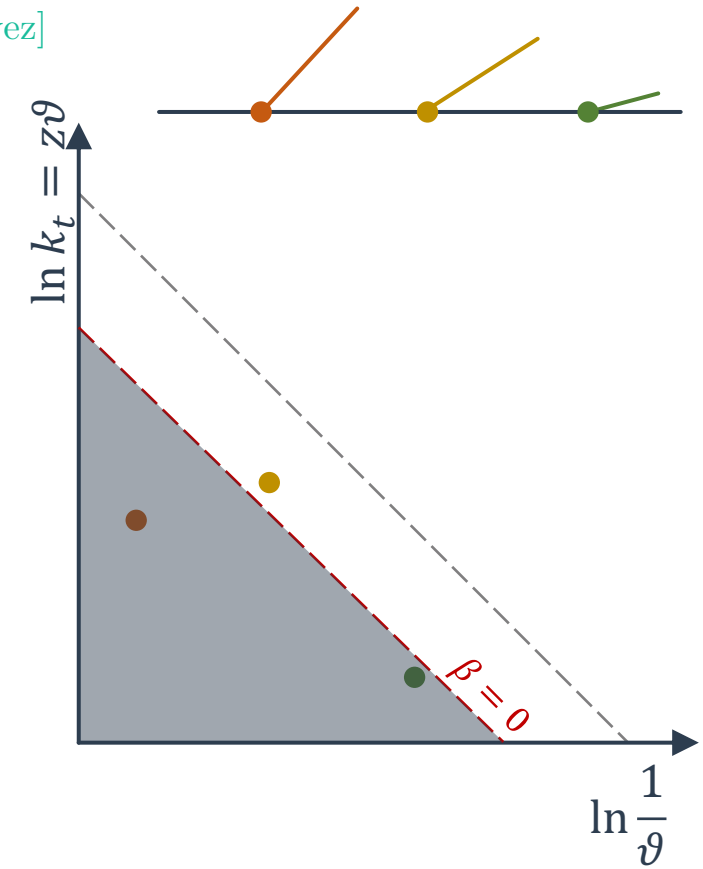

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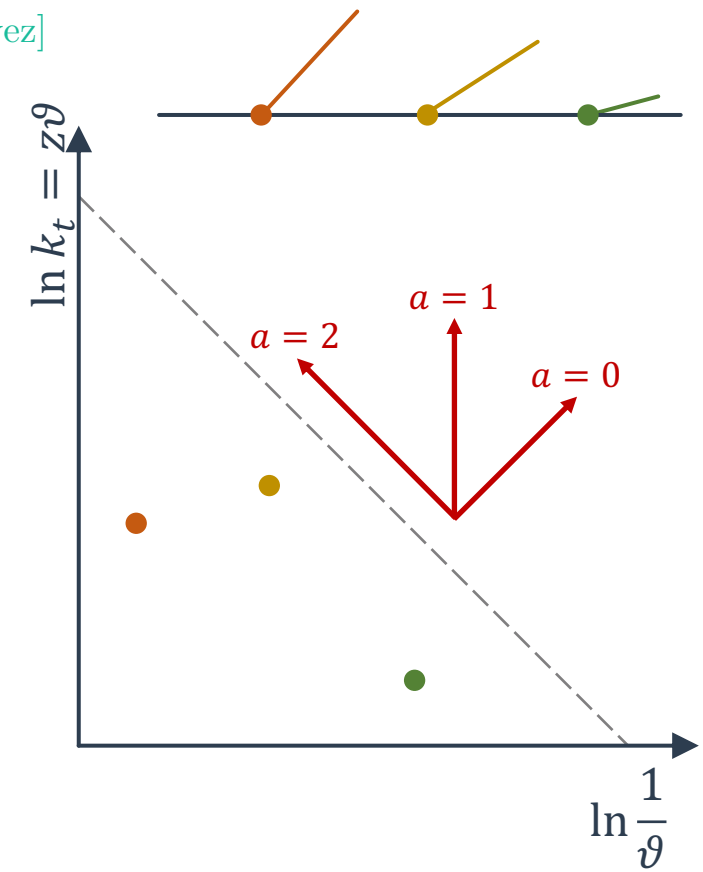

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Proton-Proton Baseline

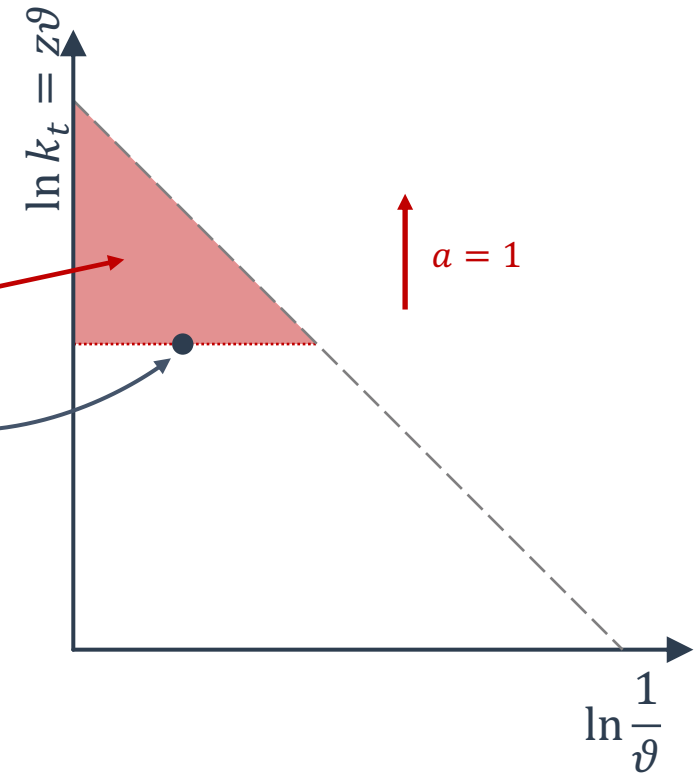
arXiv:2103.06566

Analytic properties

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

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

no harder



Measuring ϑ_g:

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

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

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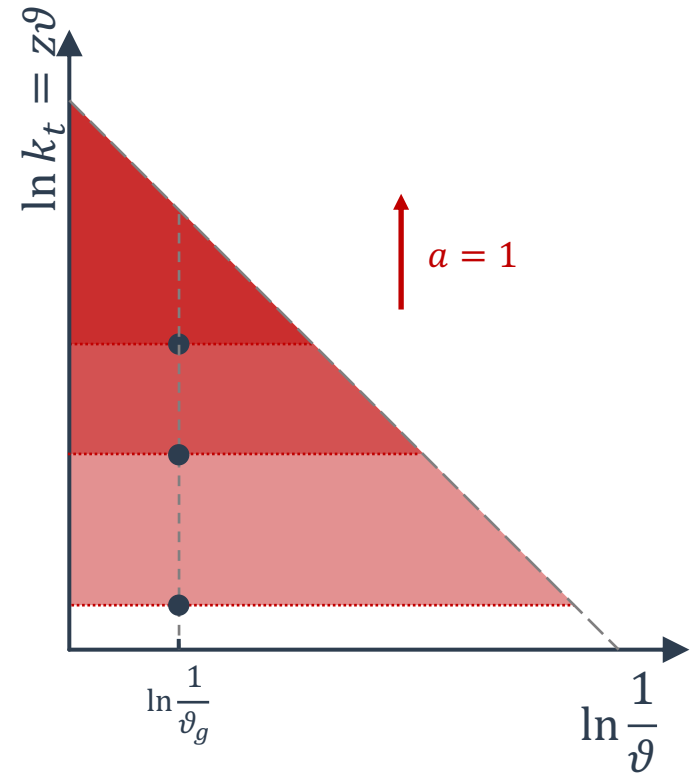

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Results

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)
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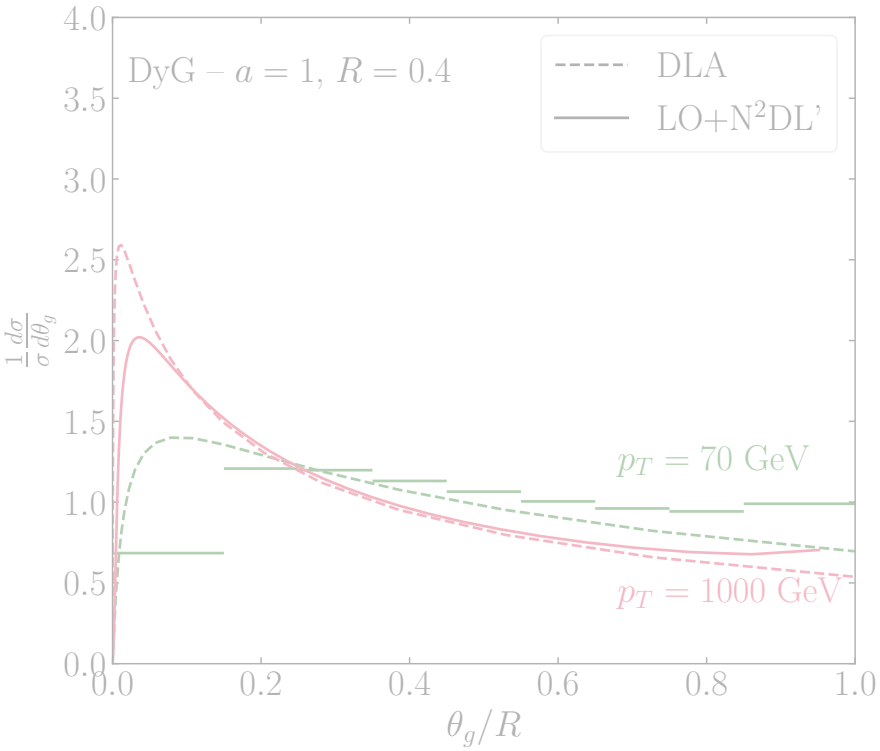

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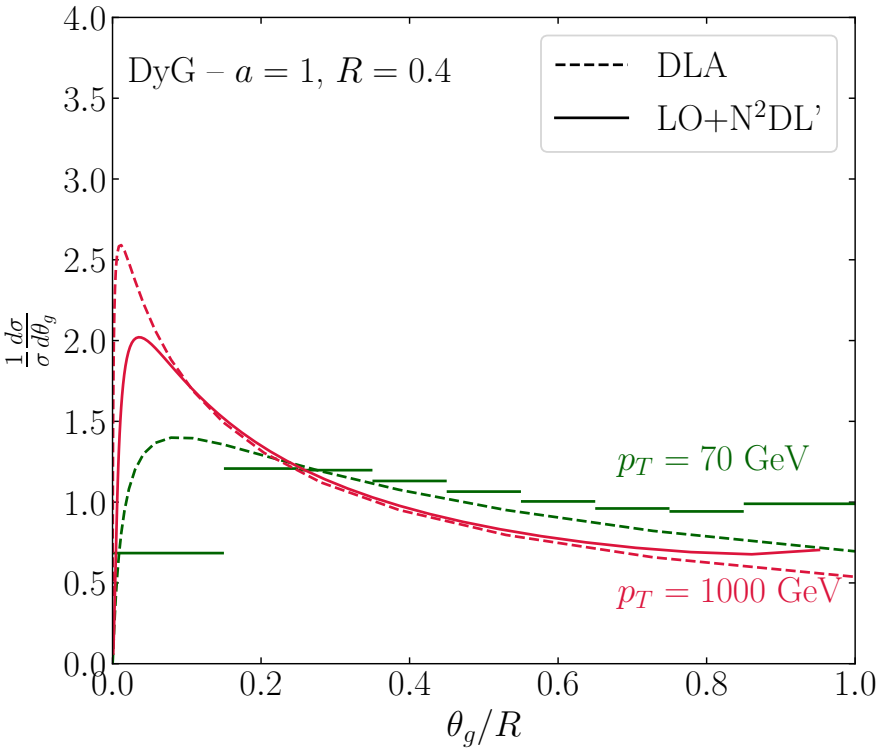
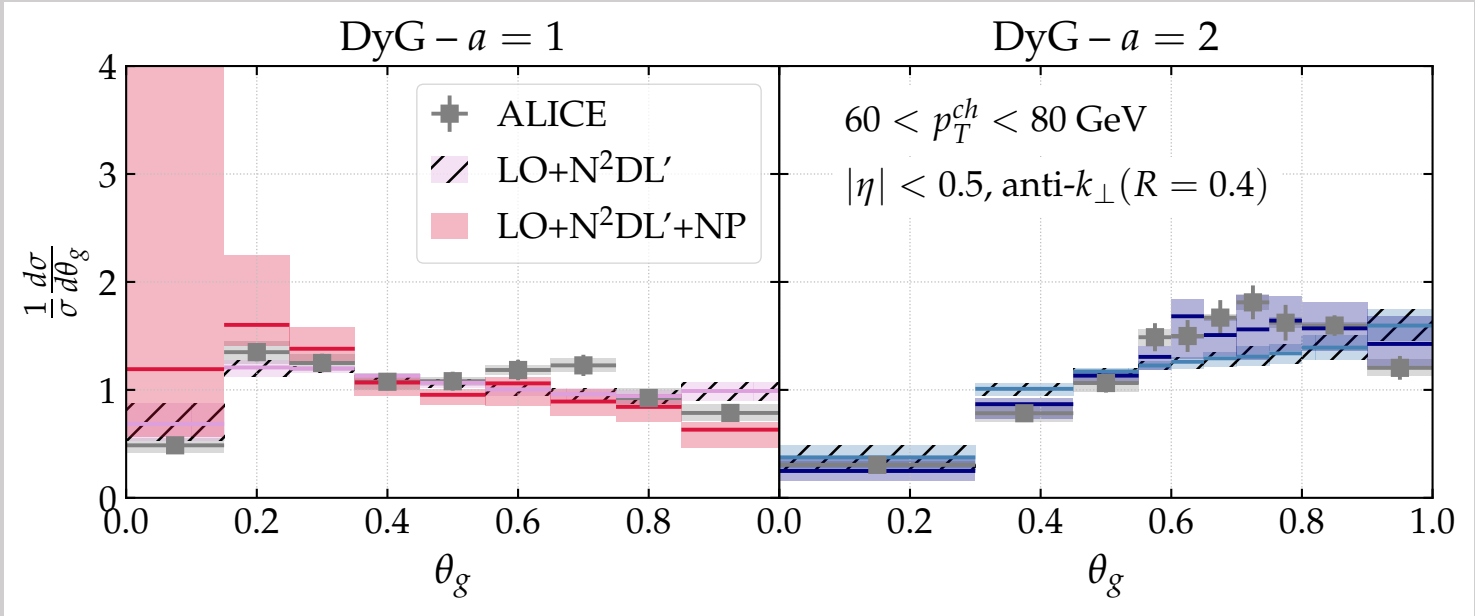


Results - Comparison to ALICE preliminary

[ALICE 2009.07172, 2009.12247]



Emission Phase Space in Heavy-Ion Collisions

arXiv:2111.14768

Medium-Induced Emissions

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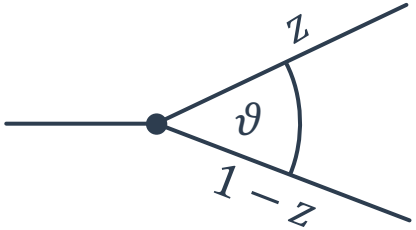

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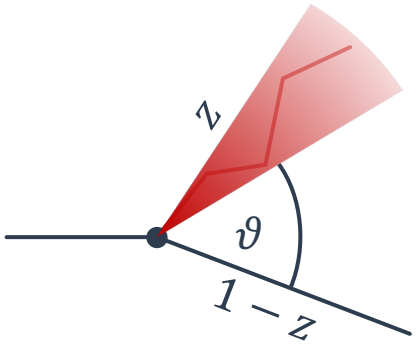

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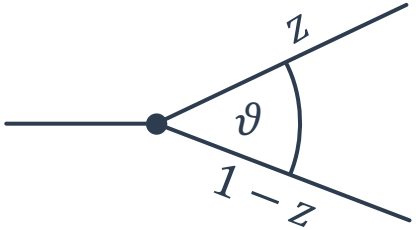

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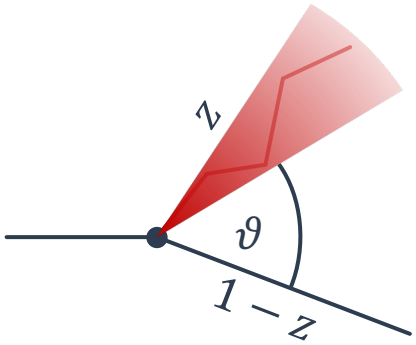

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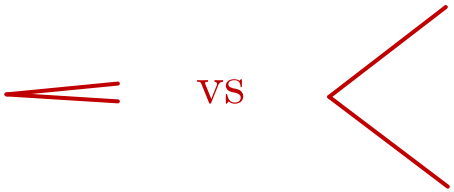

In-medium emission phase space

In-medium Lund plane regions: [Caucal, Iancu, Soyez, Mehtar-Tani, Tywoniuk]

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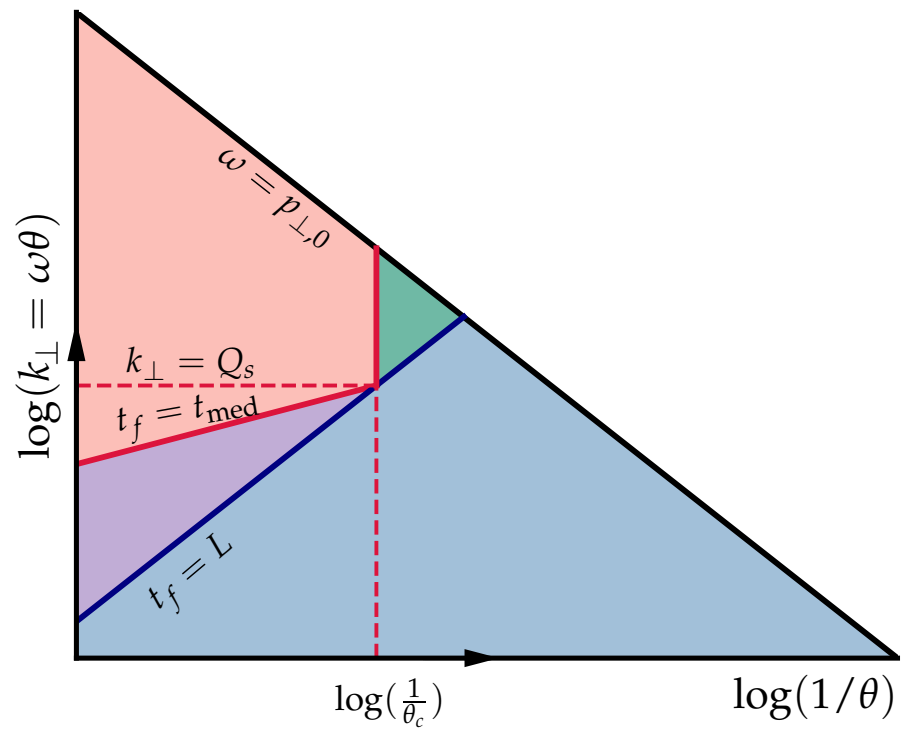

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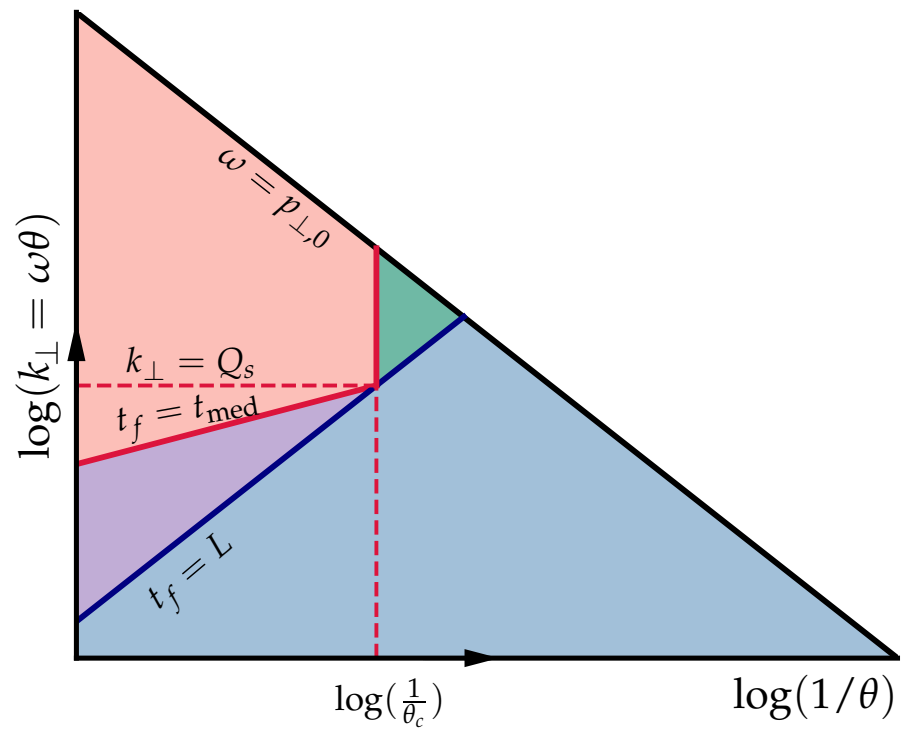

Energy-loss with quenching weights: [BDMS]

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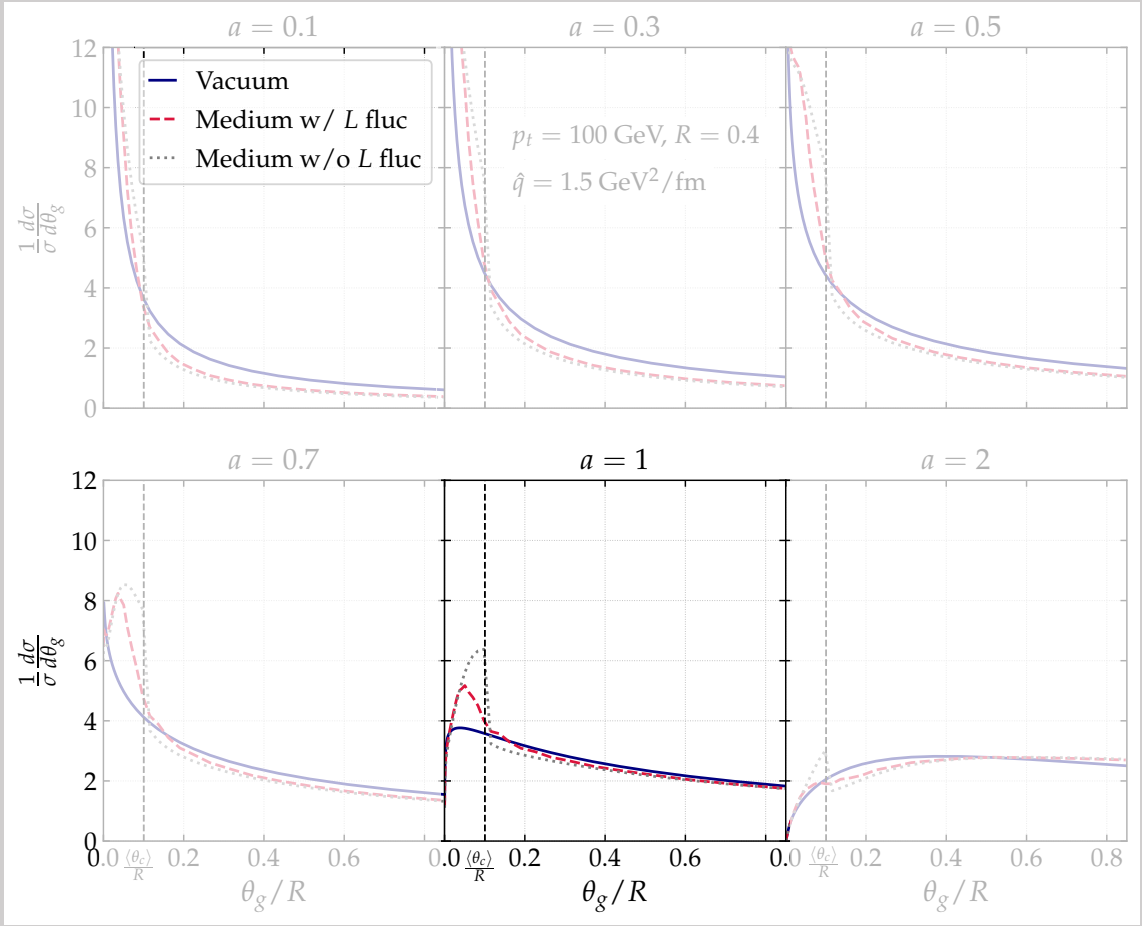
Our analytic Toy Model



Huge jump around ϑ_c!

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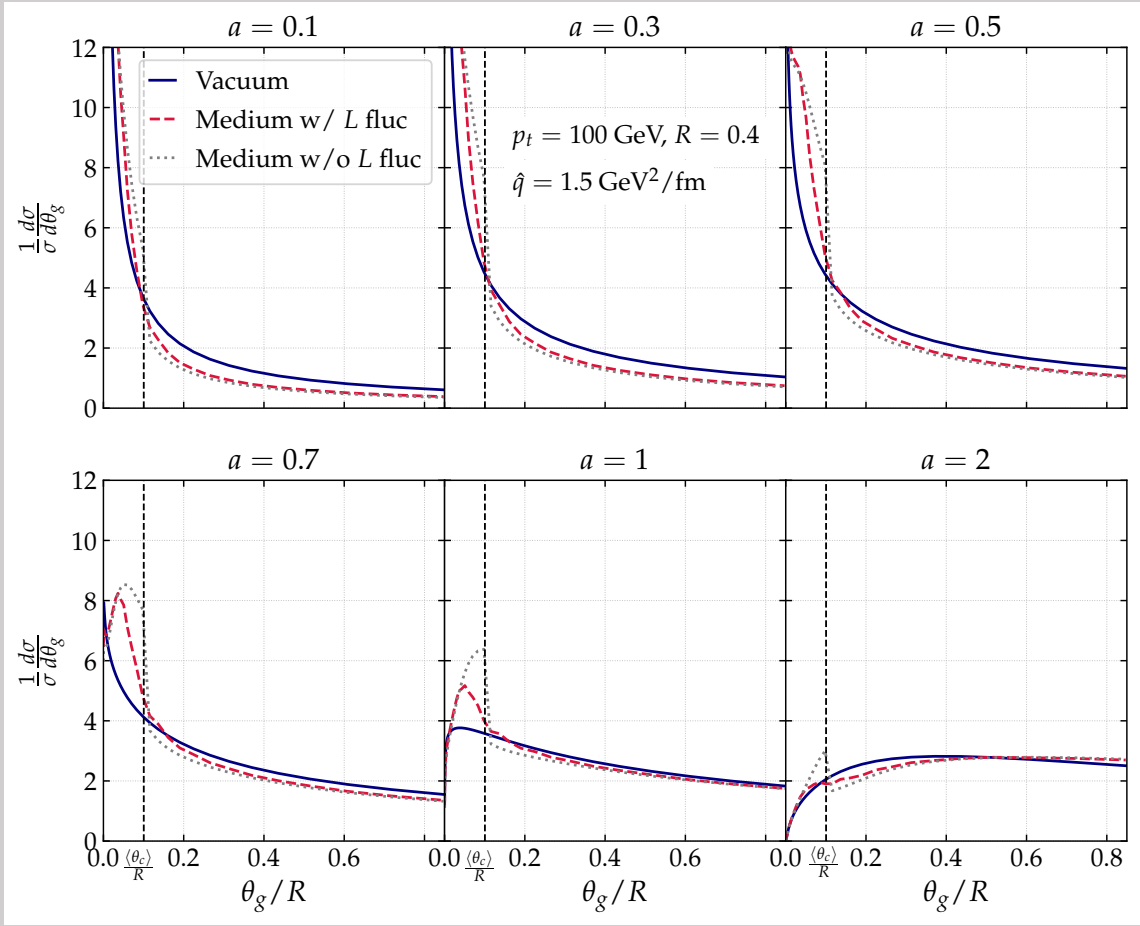


Is ϑ_c measurable?

Which a is the best?

Which phase space is the best?

[Paul's talk about JetMed,
Weiyao's talk about LIDO,
Abhijit's talk about MATTER,
also Hybrid, Jewel, ...]

Is ϑ_c really measurable?

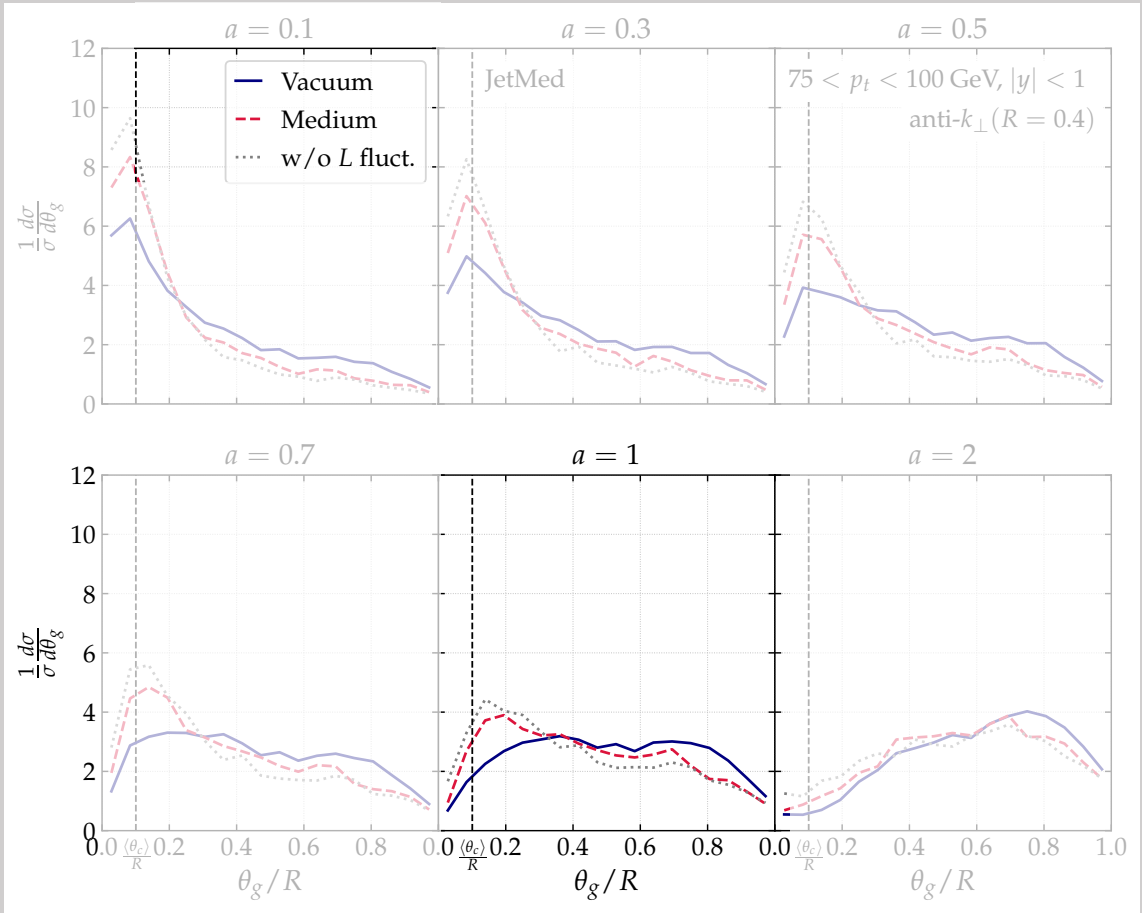
- HI Event generator study:

  JetMed [Caucal, Iancu, Soyez]

  Jewel [Zapp, Krauss, Wiedemann]

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

JetMed simulation



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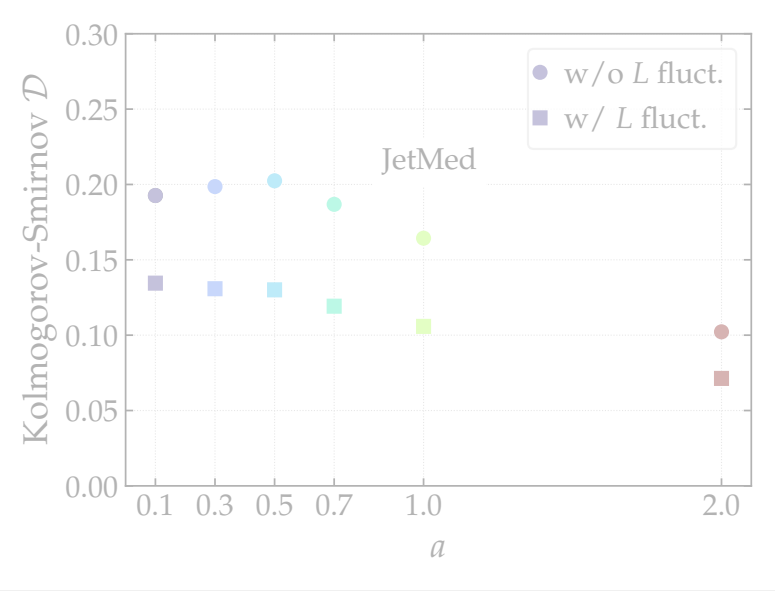
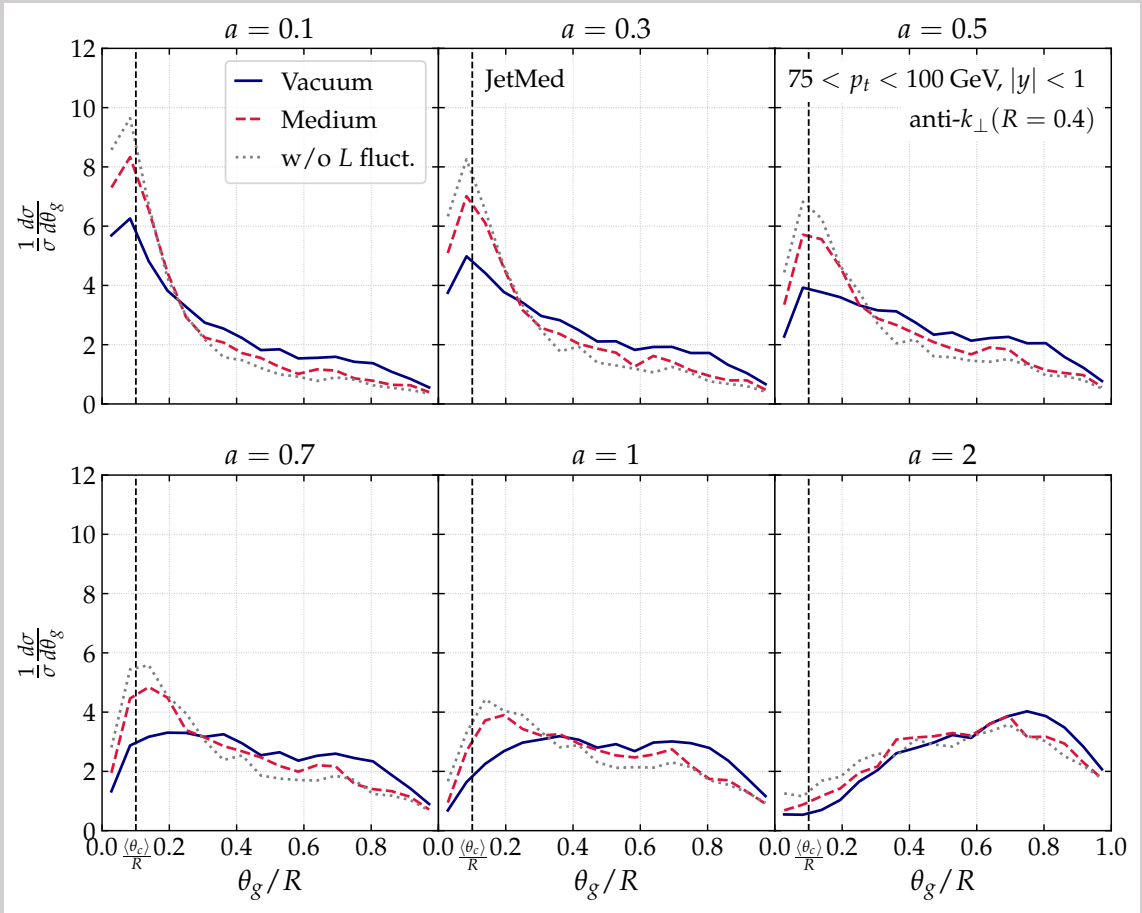


see also for Jewel and Hybrid...

JetMed simulation



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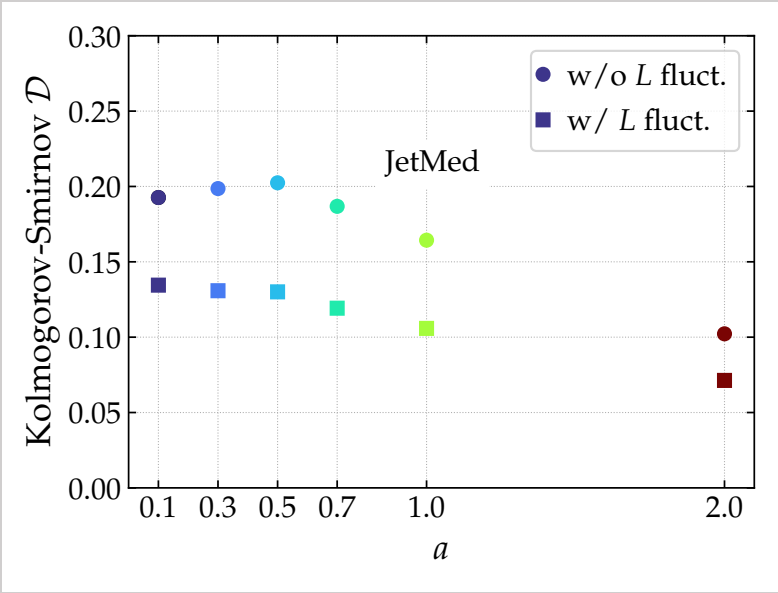

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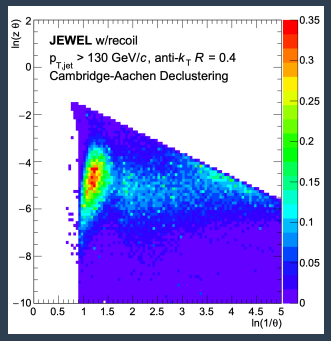
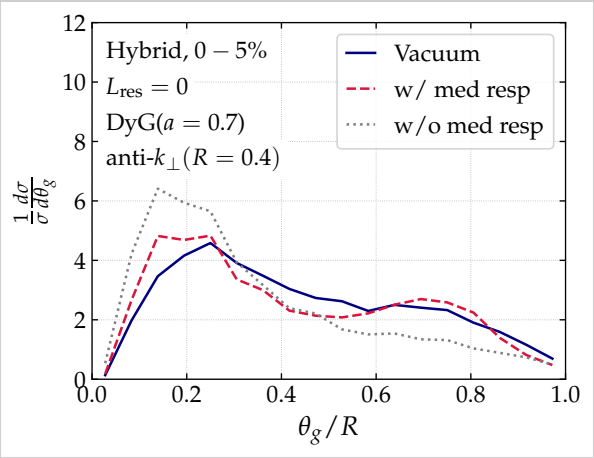
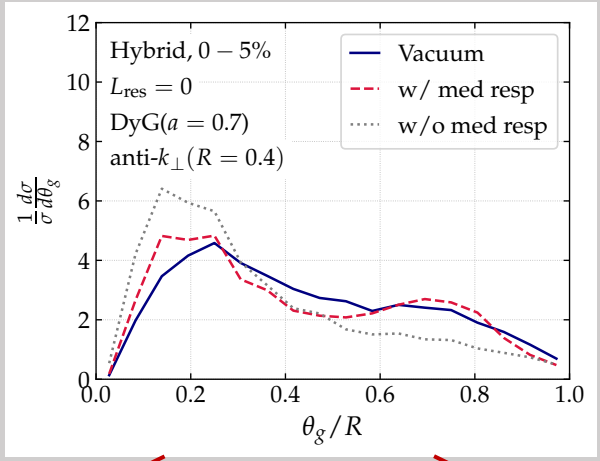
Sensitivity to medium response





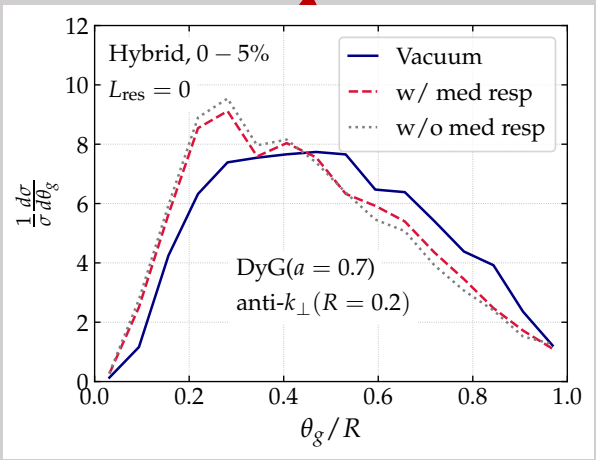
Resolution angle ϑ_c Medium response

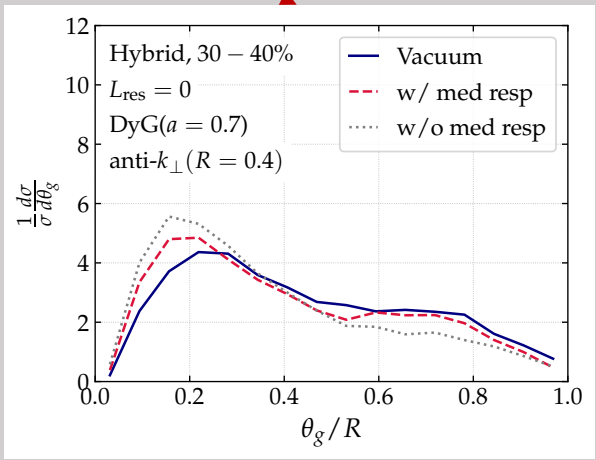
Medium response



Cone size

Centrality





Summary

- Understanding the emission phase-space 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 and the phase space: 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

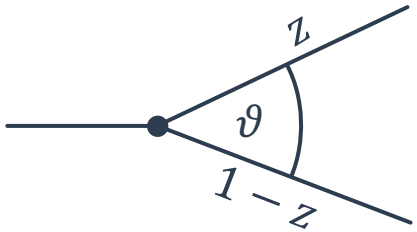
Thank you for the attention!

Jets in QCD

IRC limit of a $1 \to 2$ splitting:

$$dP_i = 2\alpha_s(k_t)C_i \frac{d\vartheta}{\vartheta}\frac{dz}{z}$$

collinear divergence, soft divergence



Emission phase space (Lund plane): [Dreyer, Salam, Soyez]

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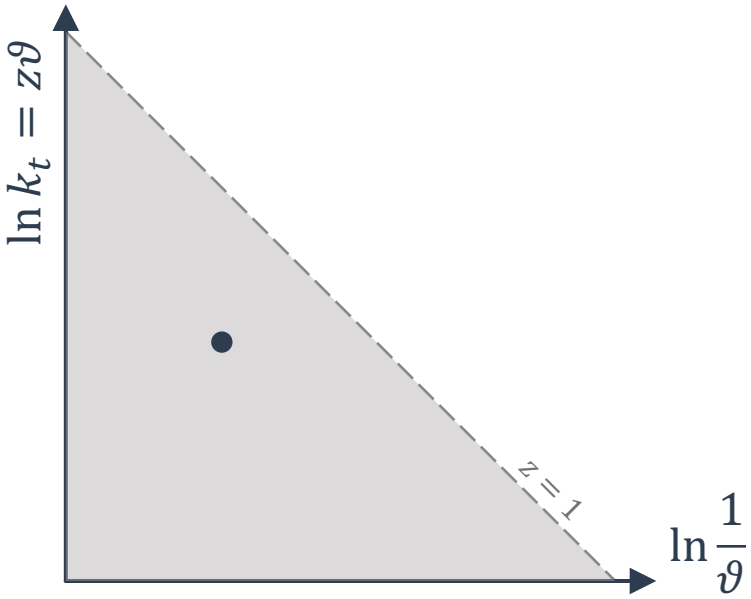

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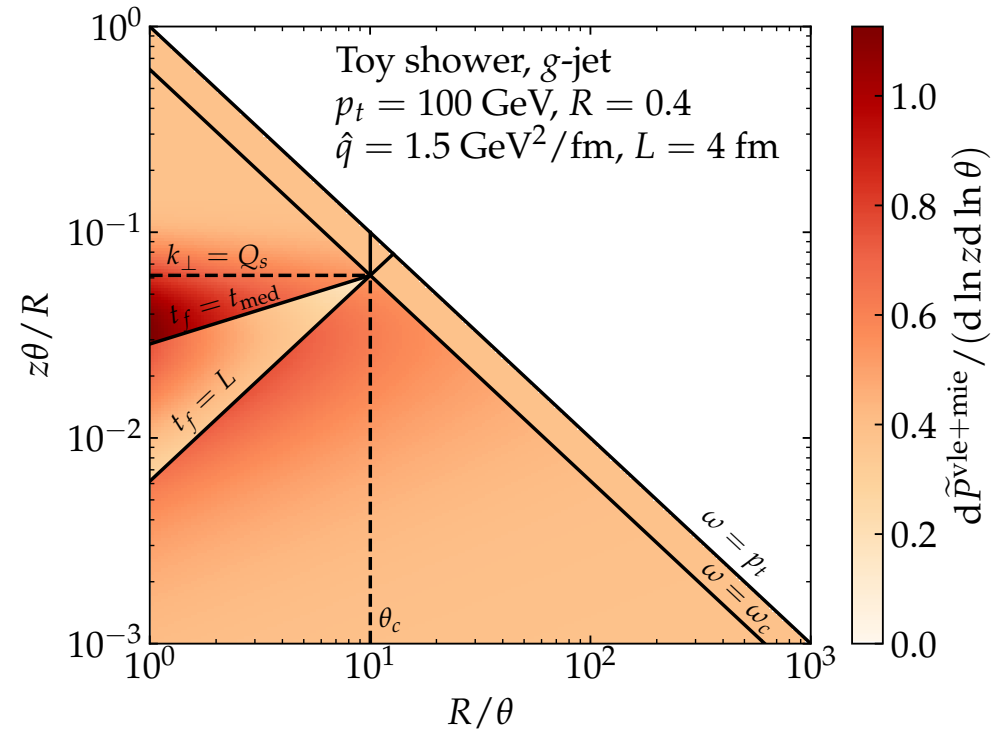

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- $\mathrm{t_{med}} < t_f < L$: veto region no vacuum emissions

Energy-loss [BDMS]:

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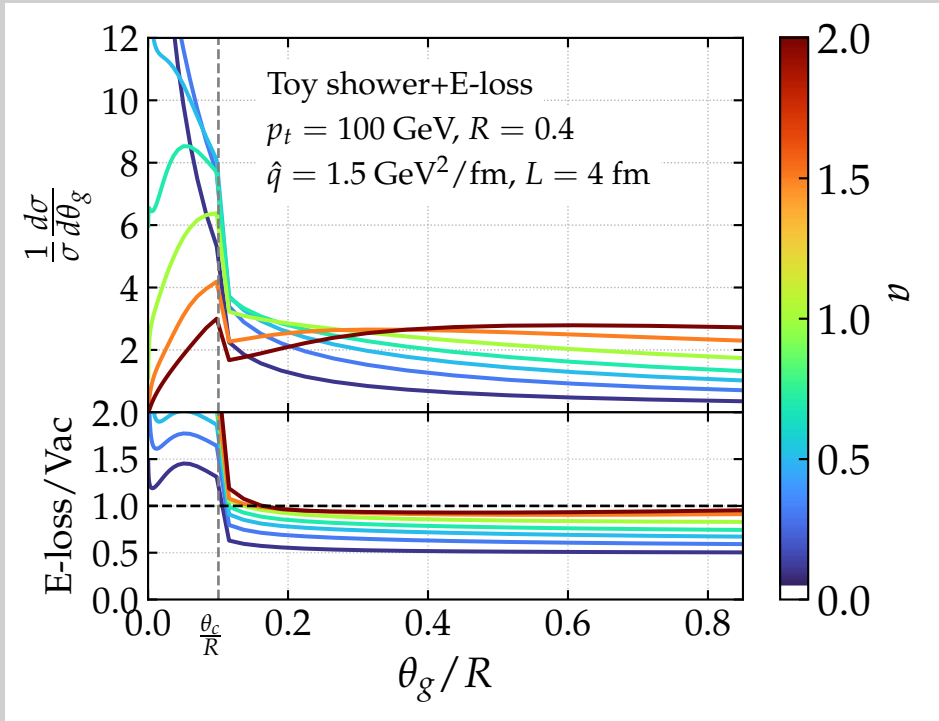

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