Leading jets and energy loss at the EIC

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EIC opportunities for Snowmass
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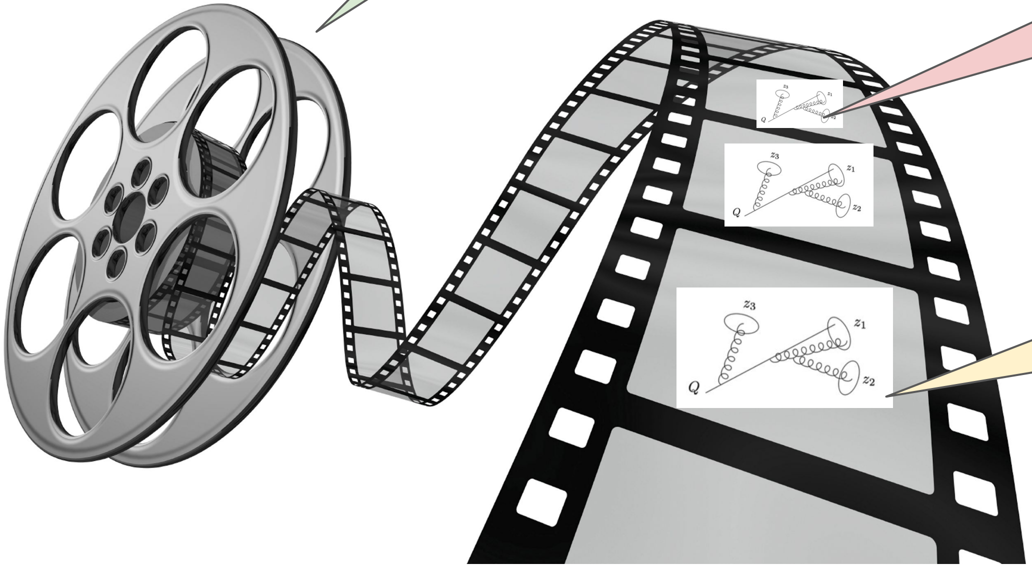
Jefferson Lab

Why **jets**?

Jets can act as “image” recorders for the evolution of the event

Momentum fluctuations at large angles will not be changed at small angles

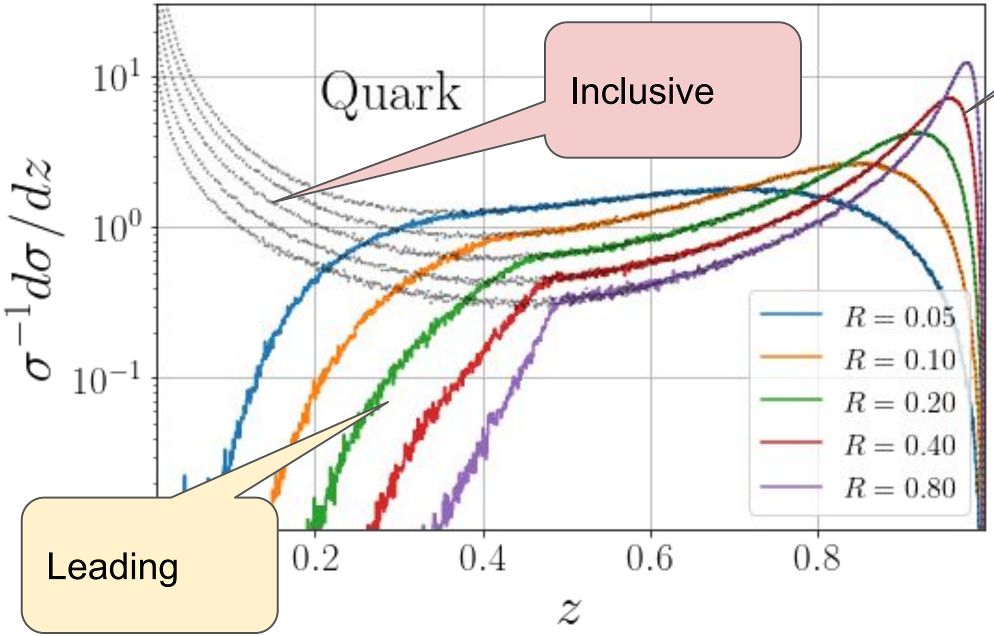
Angular-Ordering: Angles form an irreversible “time” for dynamics

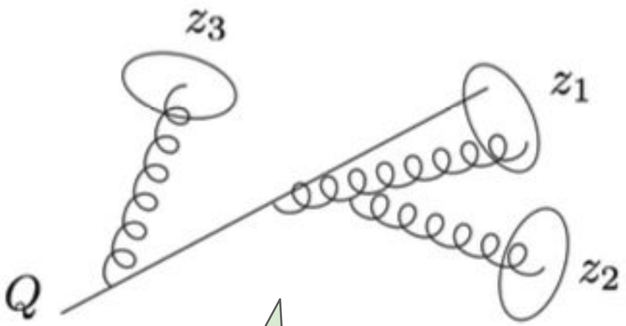


What is a leading Jet ?

Threshold resummation

e+e- half hemisphere

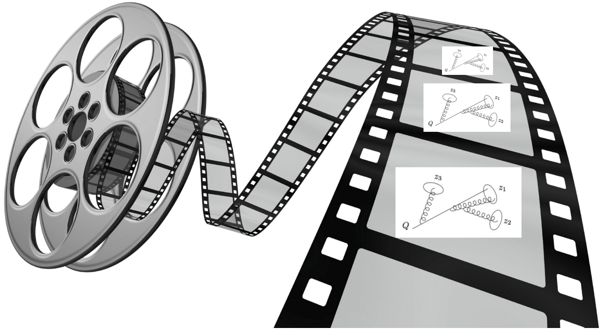




Pick the largest z

QCD evolution for inclusive and leading jets

“Angular time”



Can be solved analytically

Inclusive jets

$$\mu \frac{\mathrm{d}}{\mathrm{d}\mu} J_i = \frac{\alpha_s}{2\pi} \sum_j P_{ji} \otimes J_i$$

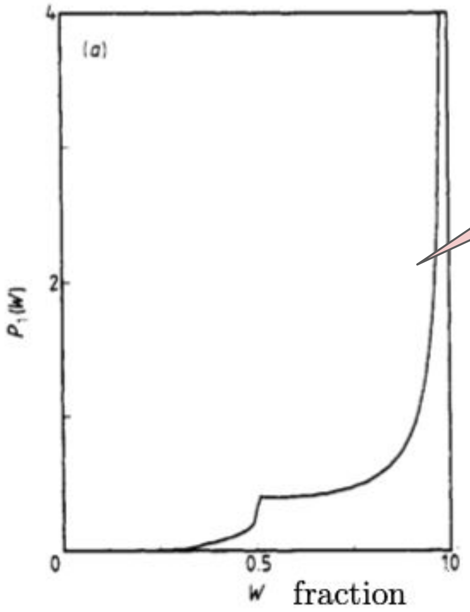
Requites MC approach

Leading jets

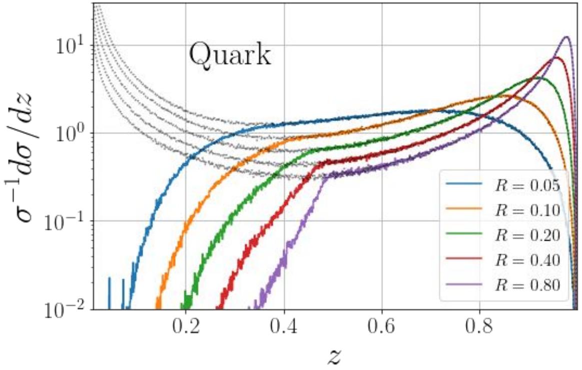
$$\mu \frac{\mathrm{d}}{\mathrm{d}\mu} \mathcal{J}_i(z, \hat{p}_T R, \mu) = \frac{1}{2} \sum_{jk} \int \mathrm{d}z' \mathrm{d}z_j \mathrm{d}z_k \frac{\alpha_s(\mu)}{\pi} P_{i\to jk}(z') \, \mathcal{J}_j(z_j, \hat{p}_T R, \mu) \, \mathcal{J}_k(z_k, \hat{p}_T R, \mu)$$
$$\times \, \delta(z - \max\{z' z_j, (1-z') z_k\})$$

see also 1411.5182, 1912.06673

Connection of leading jets with broken objects

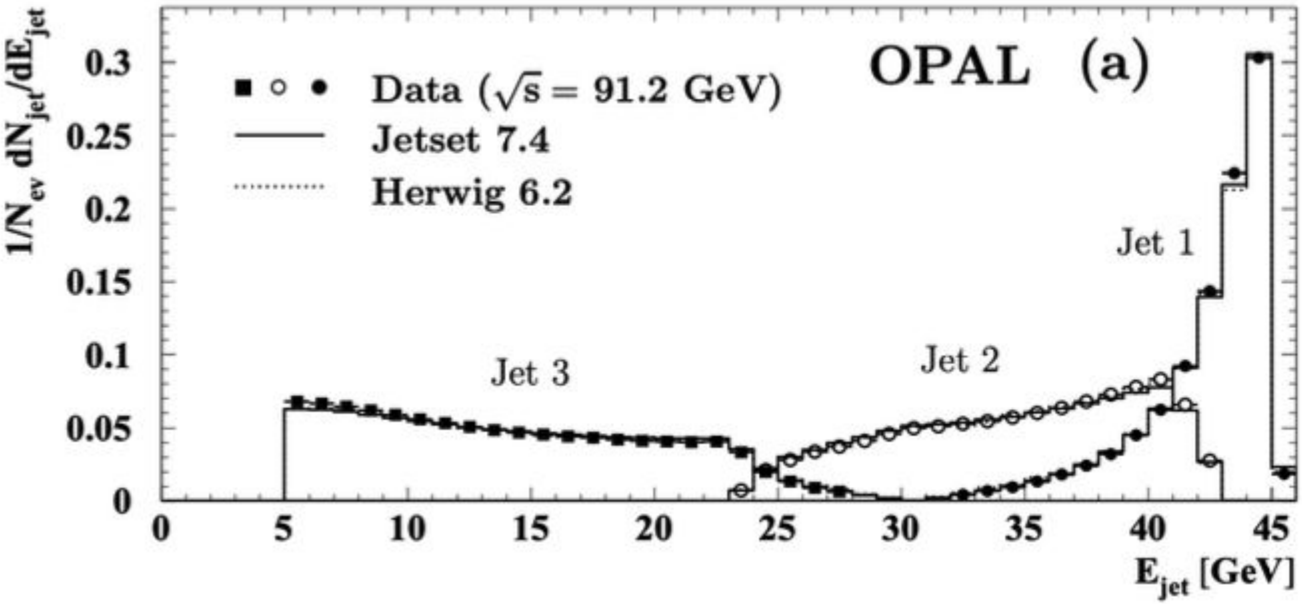


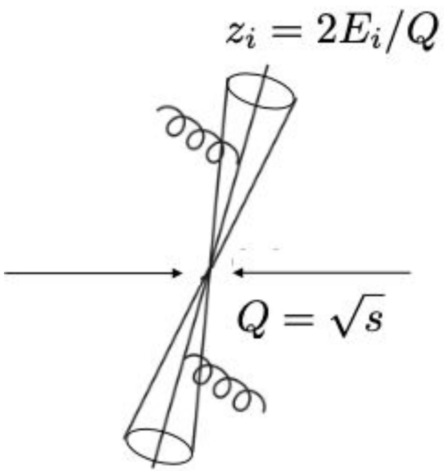
Probability distribution of the largest fragment



Derrida, Flyvbjerg 1987

Existing measurements



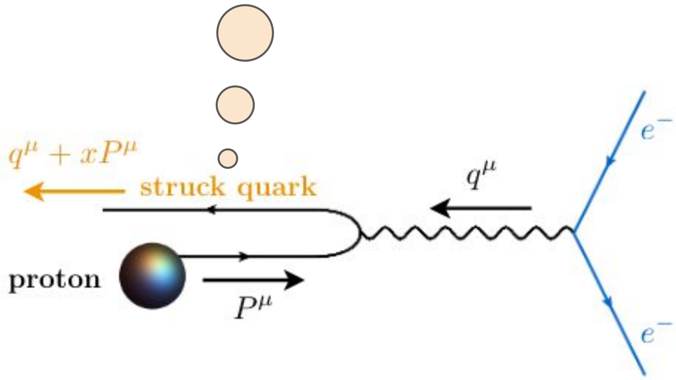


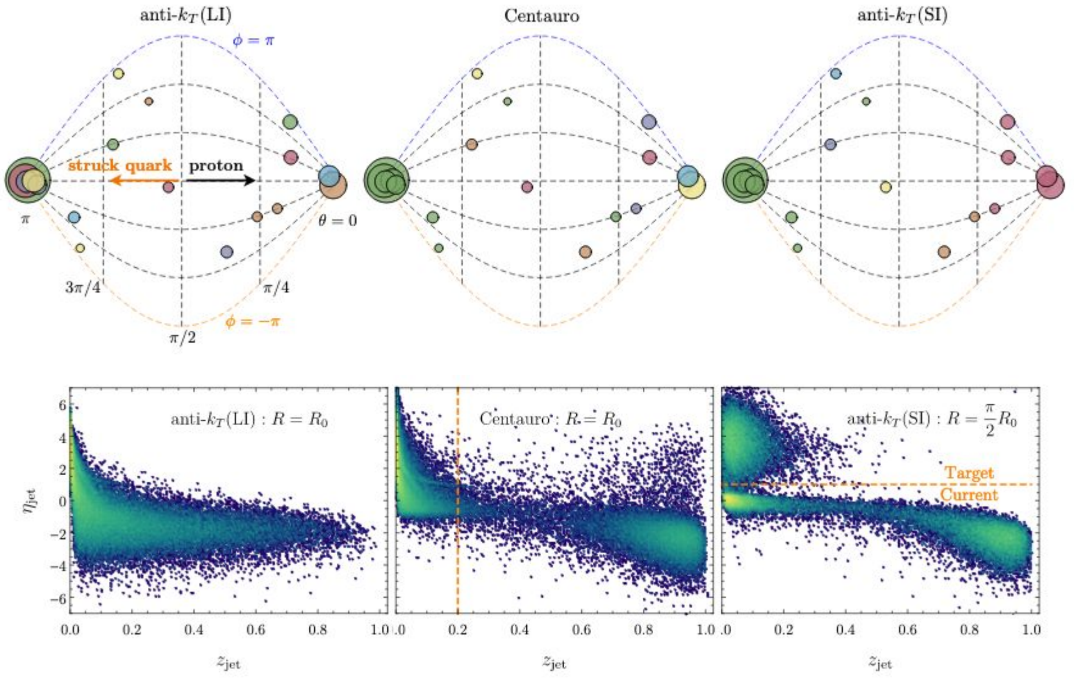
OPAL, Eur, Phys, J C37:25 (2004)

Why leading jets at EIC?

Arratia, Makris, Neill, Ringer, NS

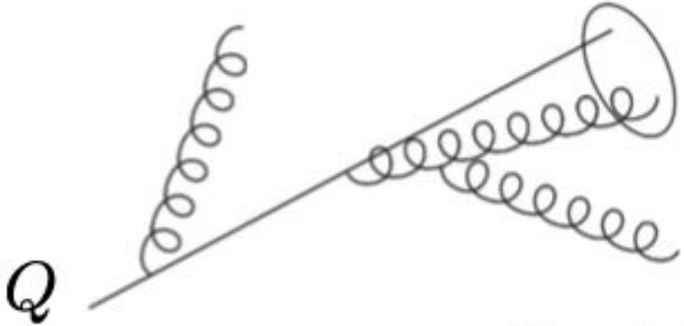
Leading jets are much closer proxy for “struck quarks”





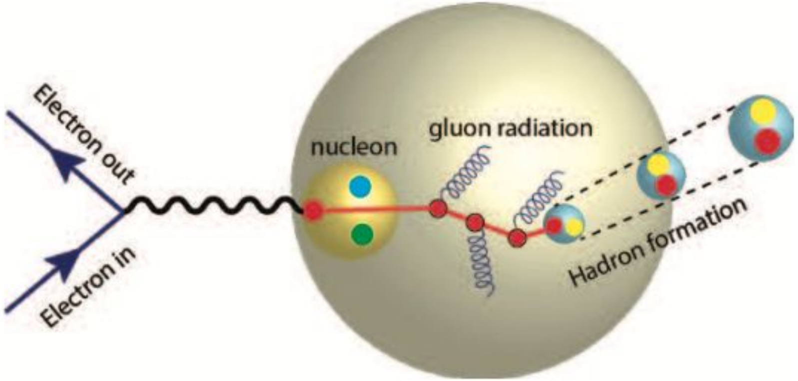
Why leading jets at EIC?

$$z_1 = \frac{p_{T1}}{Q}$$



$$z_{\rm loss} = 1 - z_1$$

Provides a clean definition for energy loss



Why leading jets at EIC?

Leading jets are probability distributions

$$\int_0^1 dz_1 P(z_1) = 1$$

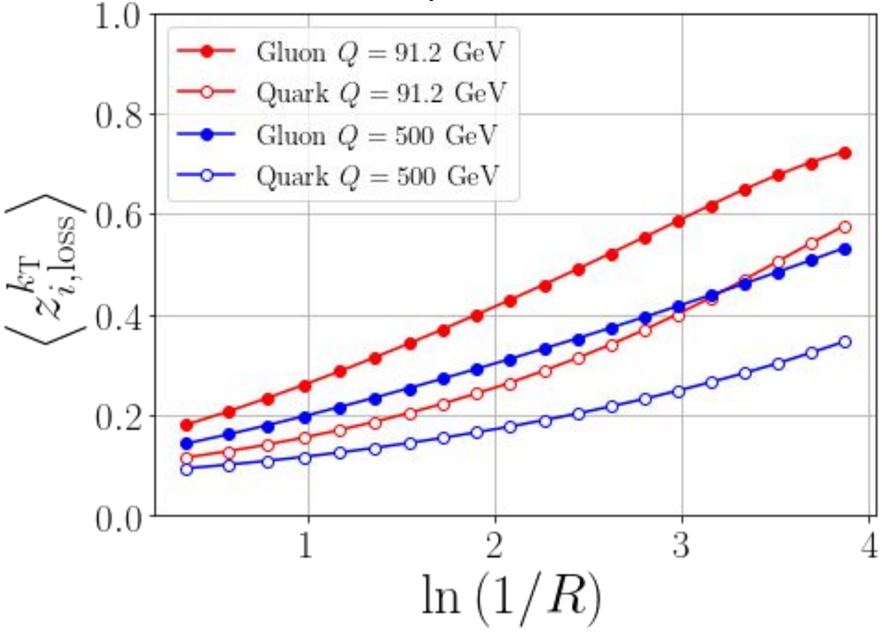
$$\int_0^1 dz_1 \; z_1 P(z_1) = \langle z_1 \rangle$$

Allows to define consistently statistical measures

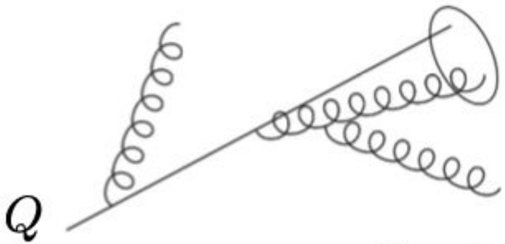
We can use more statistics, shannon, KL etc

Example: energy loss

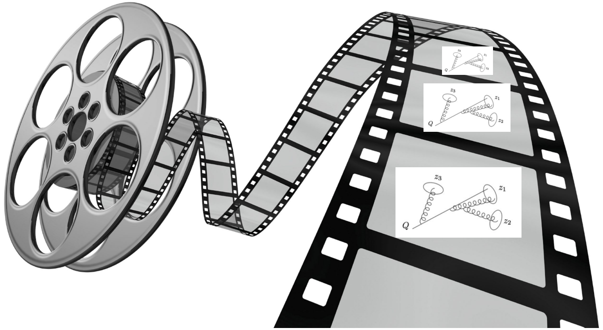
e+e- half hemisphere



$$z_1 = \frac{p_{T1}}{Q}$$

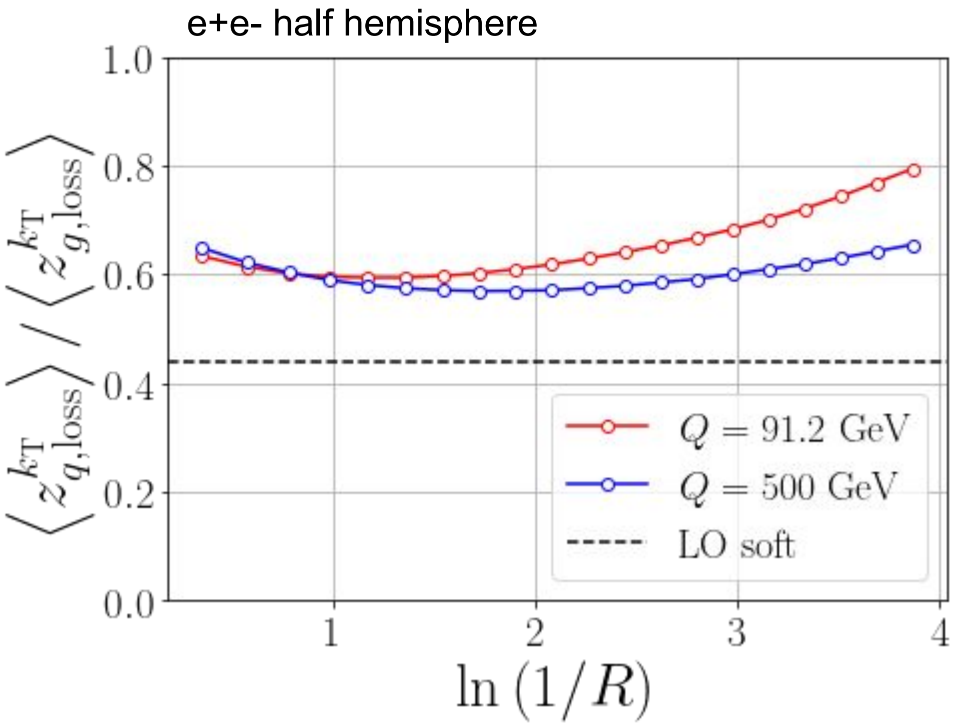


$$z_{\mathrm{loss}} = 1 - z_1$$



R: **"angular time"**

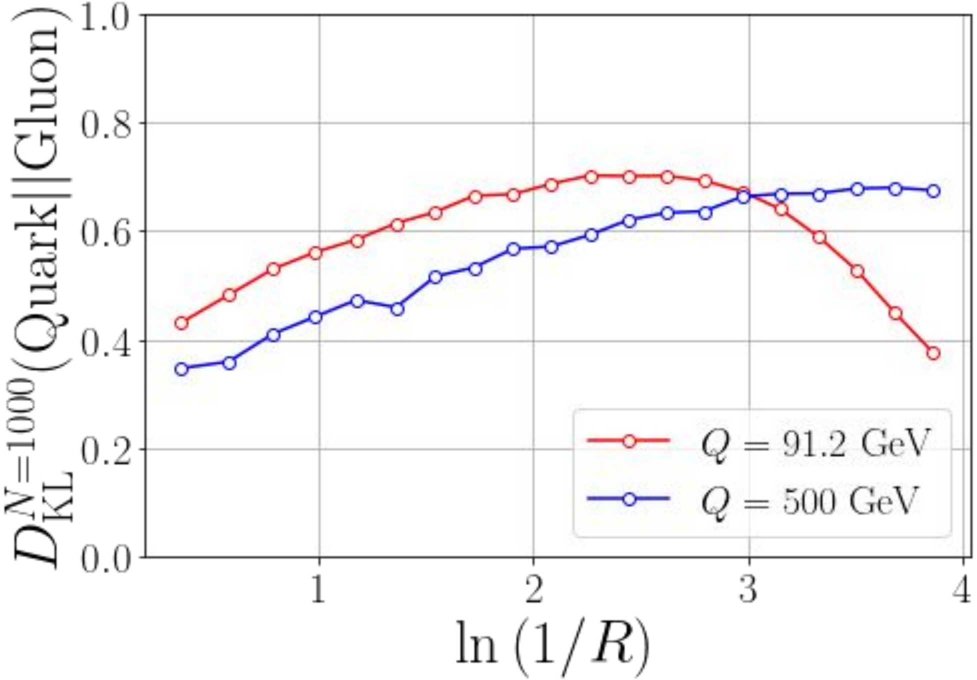
Example: energy loss



Quark gluon fractions are approximately constant across angular time

Example: KL divergence

e+e- half hemisphere



$$D_{\mathrm{KL}}(P \parallel Q) = \sum_{x \in \mathcal{X}} P(x) \log\left(\frac{P(x)}{Q(x)}\right)$$

There is an optimal “angular time” for quark/gluon discrimination

Summary & outlook

- Theory framework for **leading jets** with higher order corrections (threshold corrections)
- New venues to study hadronization of quarks and gluons
- Extension to leading hadrons are now possible