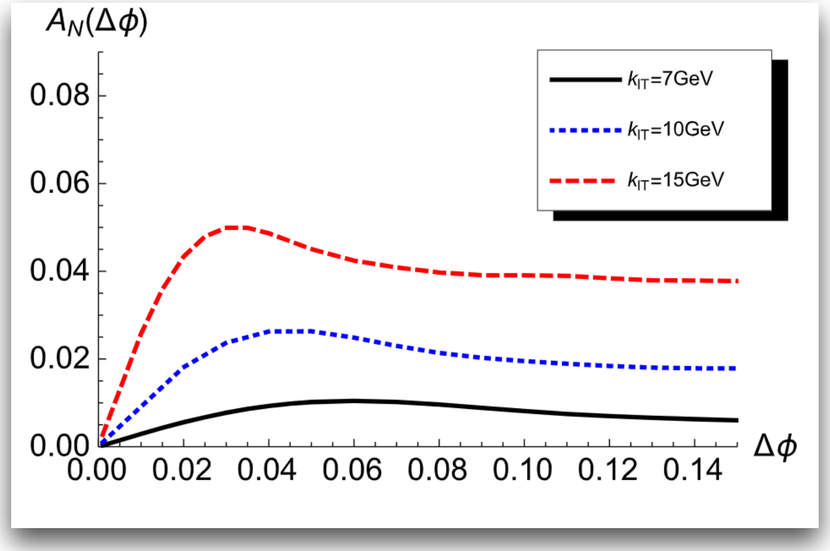
Jet charge for spin asymmetries

Xiaohui Liu

DIS, 2021

北京師範大學
BEIJING NORMAL UNIVERSITY

Jets @ EIC



e.g. Jet probes of the Sivers function

XL, Ringer, Vogelsang, Yuan, 19

For jet probes, see also,

Gutierrez-Reyes, Scimemi, Waalewijn, Zoppi, 18

Arratia, Kang, Prokudin, Ringer 20

Makris 21 + many others

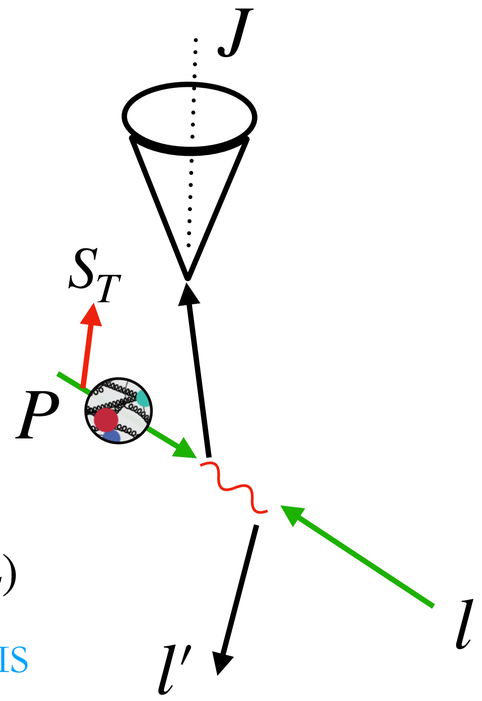
Growing interests in jet probes of the nucleon structures

$$\frac{\mathrm{d}\sigma}{\mathrm{d}q_T} \sim \hat{\sigma}_{ii}(Q)\, D_{h/i}^{\mathrm{U/T}}(z_h, k_T) \otimes f_{i/P}^{\mathrm{U/T}}(x, k_T) \otimes S(k_T)$$

For SIDIS

$$\frac{\mathrm{d}\sigma}{\mathrm{d}q_T} \sim \hat{\sigma}_{ii}(Q)\, J(P_T R)\, f_{i/P}^{\mathrm{U/T}}(x, k_T) \otimes S(k_T, p_T R)$$

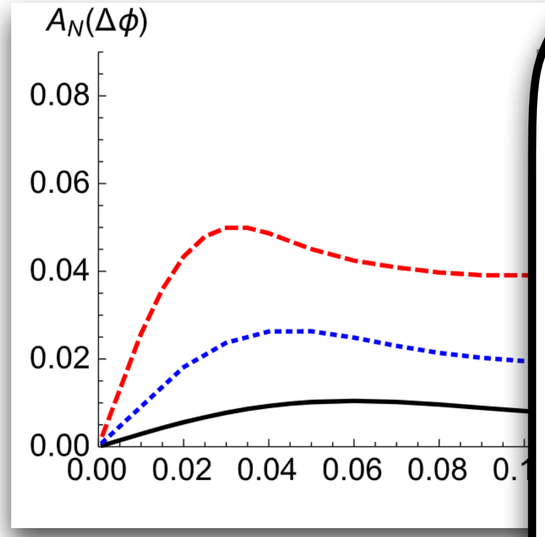
For Jets



- Reduce the non-pert. d.o.f., cleaner TMD extraction
- Accuracy @ NLL (NNLL for Breit Frame WTA jet)
- J now known to NNLO for akT ➡ NNLL

Liu, XL,Moch,2103.08680

Jets @ EIC



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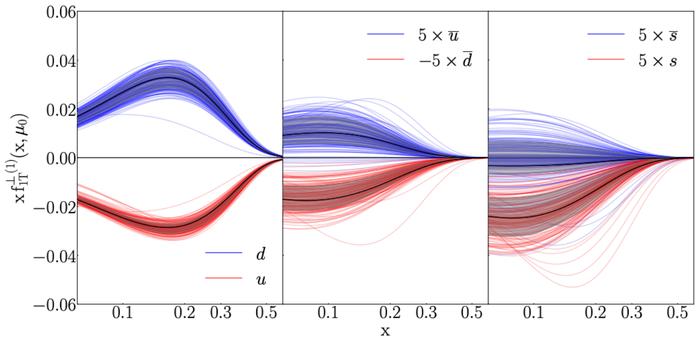
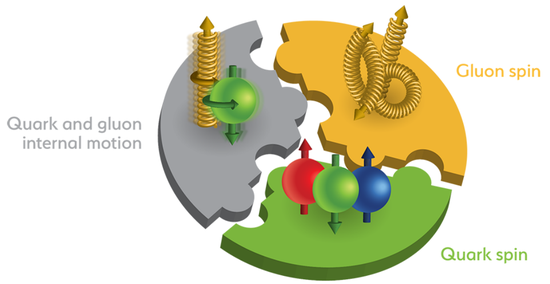
- Flavor separation in jet probes ?

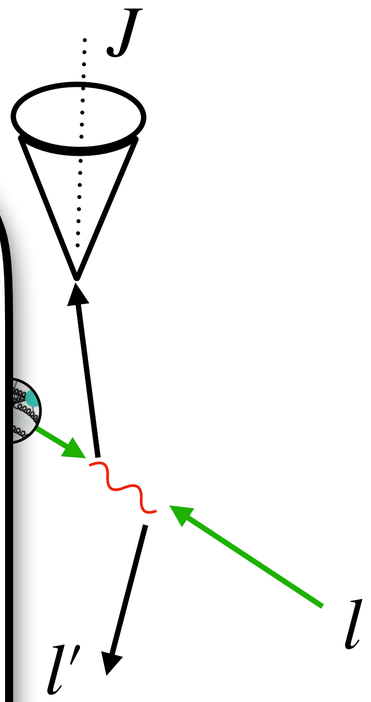
For complete knowledge

of the QCD dynamics



Echevarria,Kang,Terry, 2021





leaner TMD extraction

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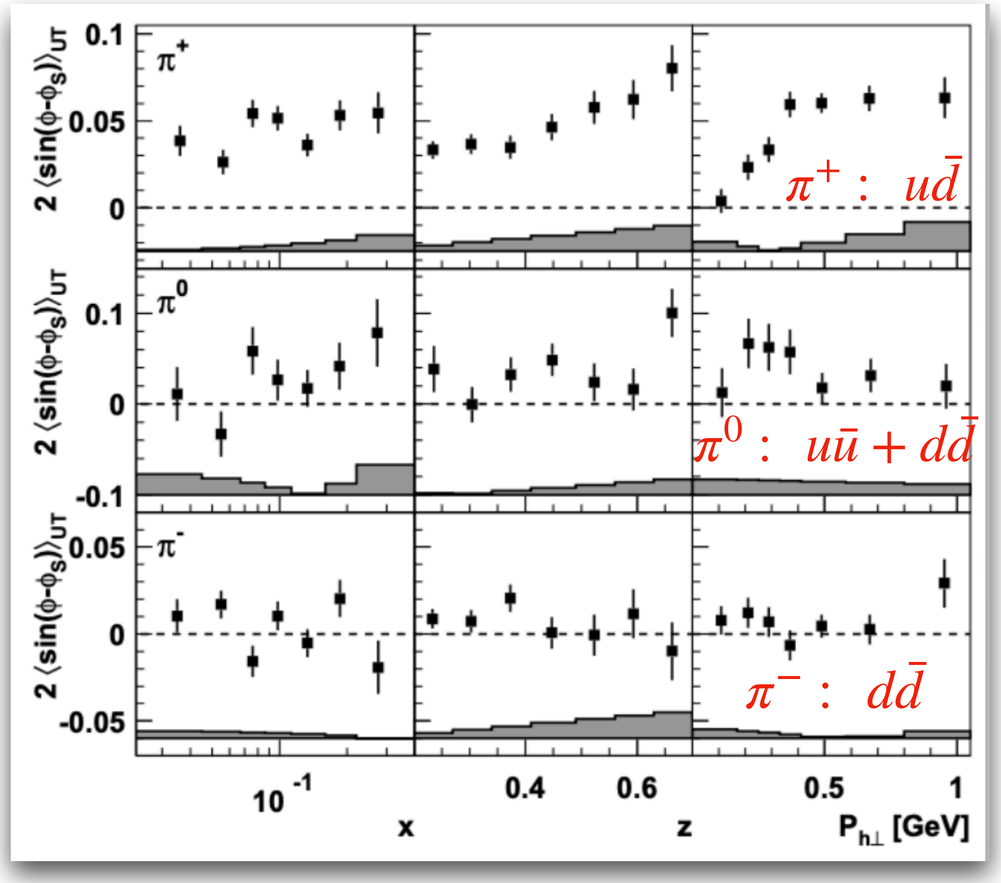
Jets @ EIC

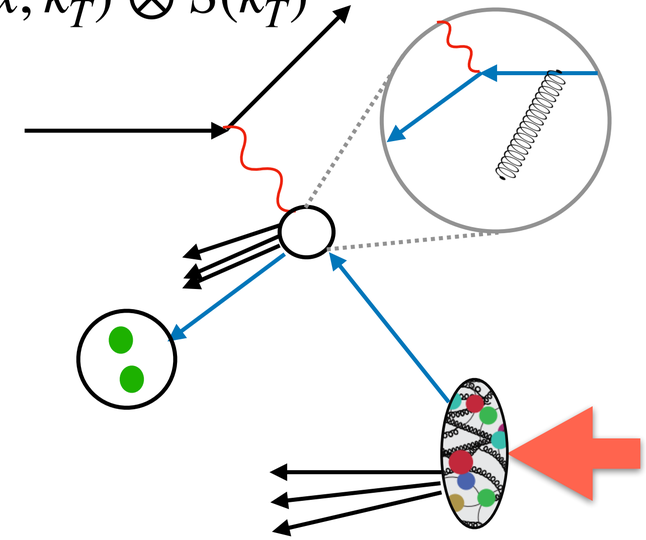


HERMES collaboration, 2009

Flavor separation in SIDIS

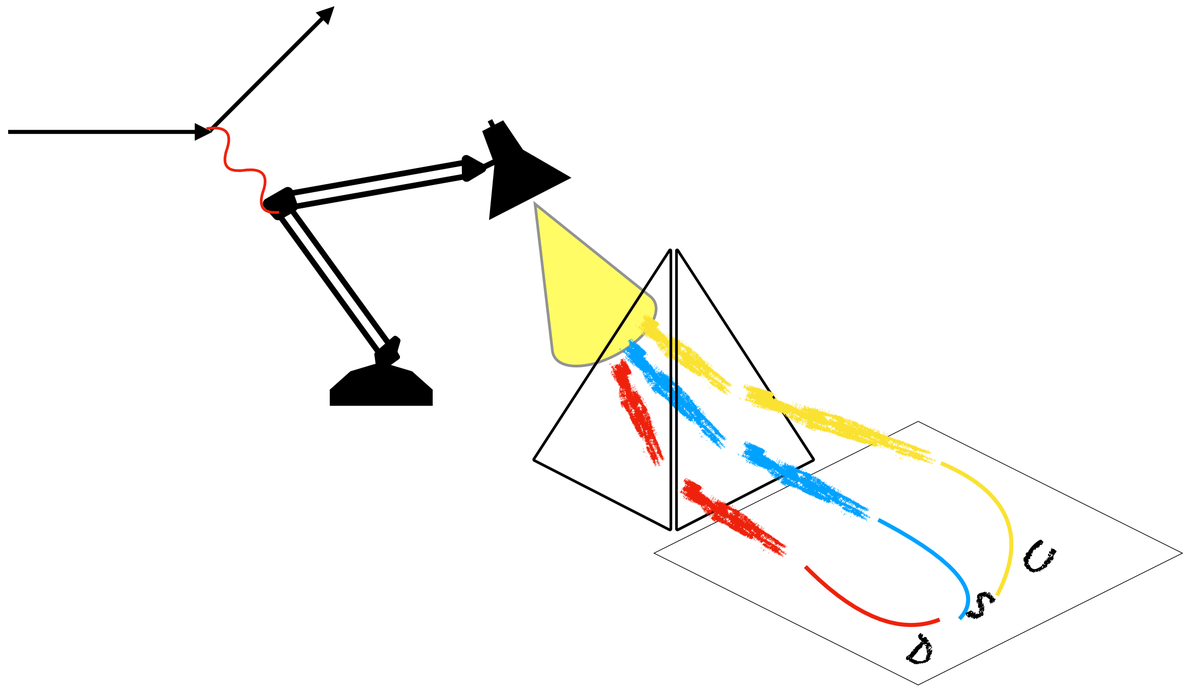
- Flavor correlated between initial and final
- Tagging final state hadrons for flavor discrimination
- Need TMD FFs / spin counterparts

$$\frac{\mathrm{d}\sigma}{\mathrm{d}q_T} \sim \hat{\sigma}_{ii}(Q) D_{h/i}^{\mathrm{U/T}}(z_h, k_T) \otimes f_{i/P}^{\mathrm{U/T}}(x, k_T) \otimes S(k_T)$$



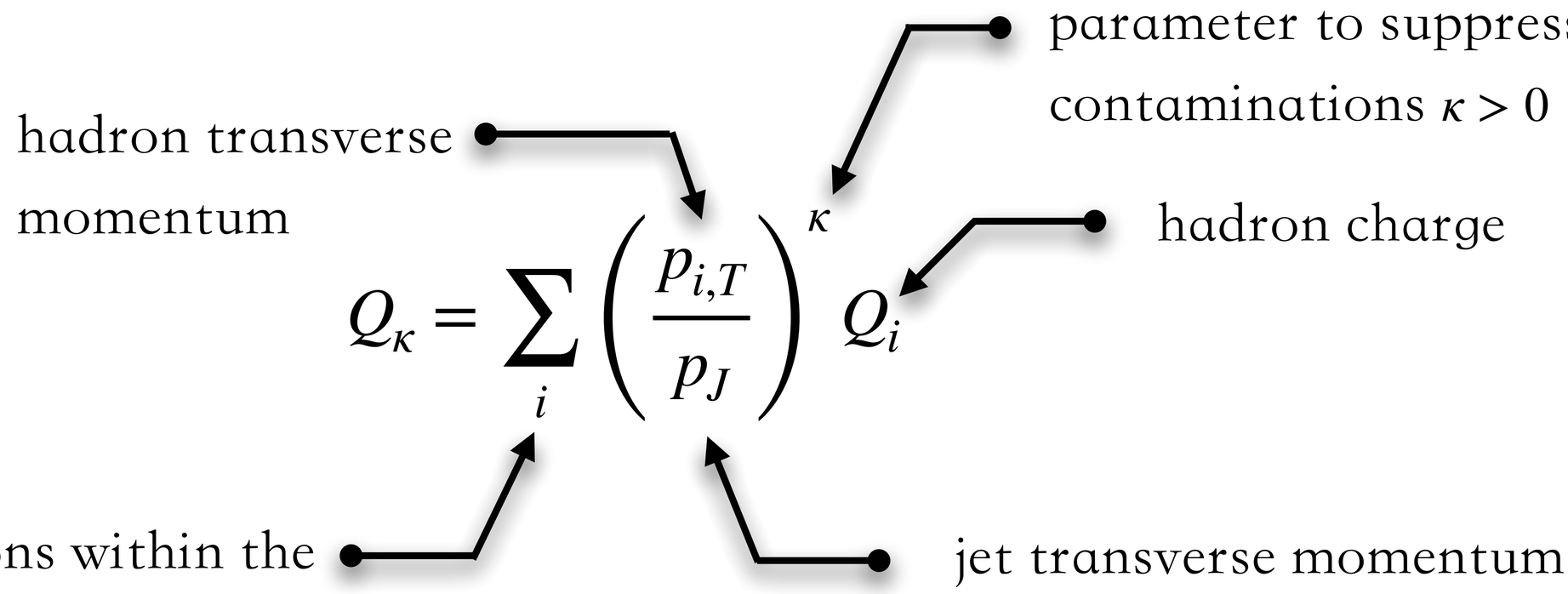
Other alternatives?

- Probe directly the light parton flavors
- No extra non-pert. distributions
- electro-charge? Robust against the hadronization?



Jet charge as a flavor prism @ EIC

- The observable

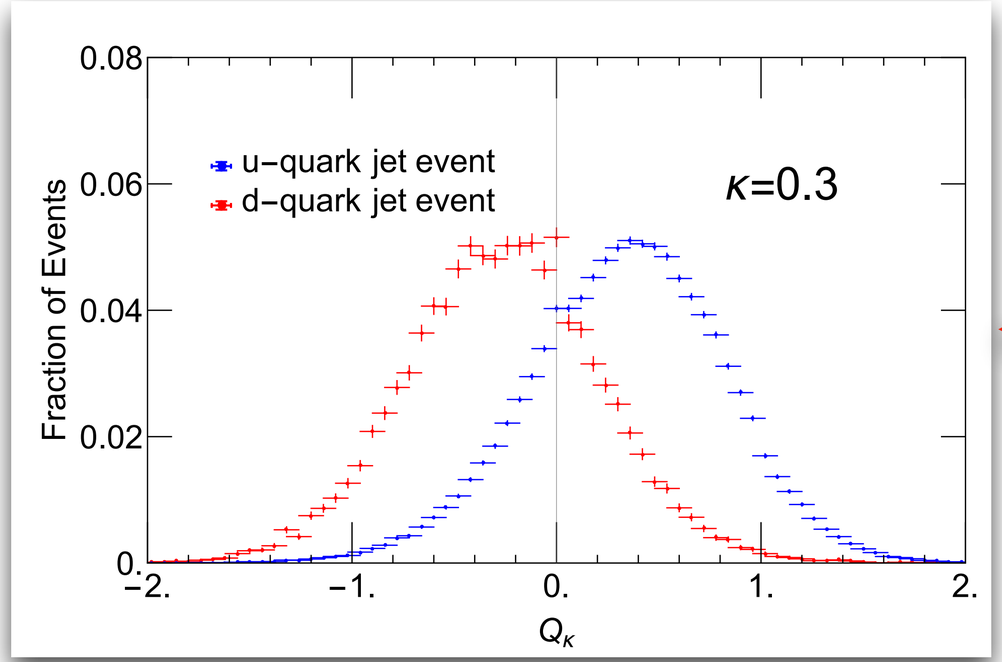


Field and R. Feynman, 1978

Krohn, Schwartz, Lin, and Waalewijn, 2013

Jet charge as a flavor prism @ EIC

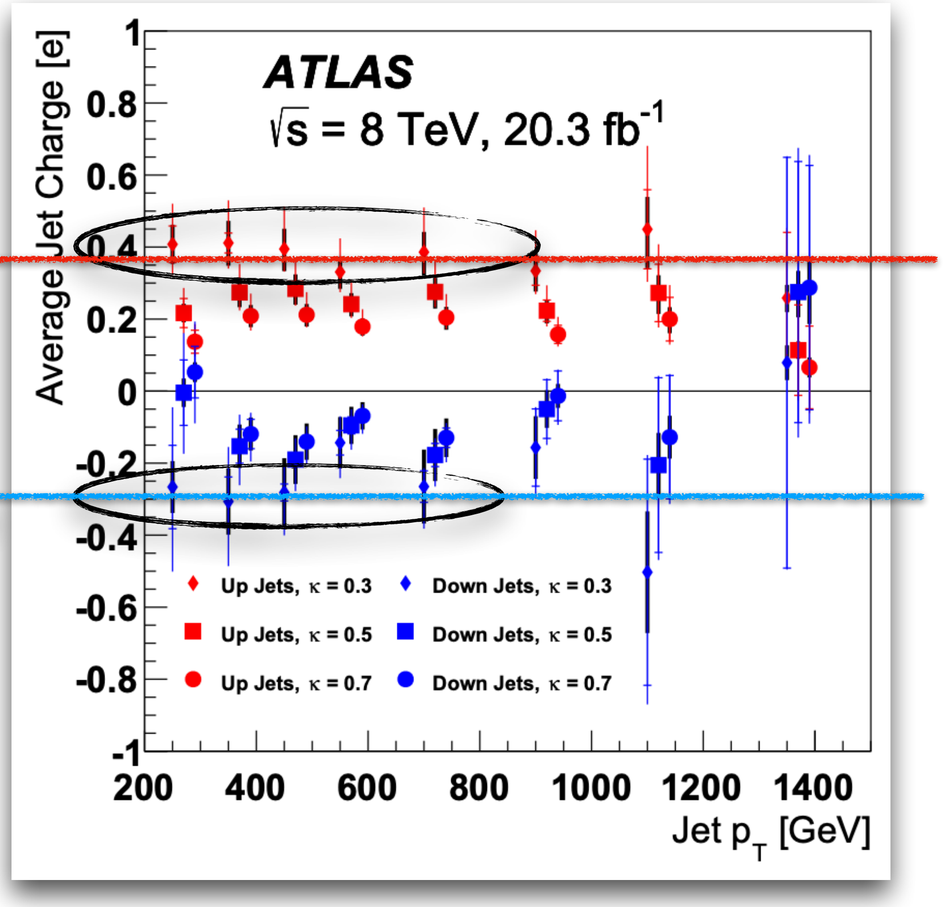
- The observable $Q_\kappa = \sum_i \left(\frac{p_{i,T}}{p_J} \right)^\kappa Q_i$



Pythia simulation

Consistent!

- $\kappa = 0.3$ seems to have the largest separation
- (Almost) independent of the jet pT



The ATLAS Collaboration, 2015

Jet charge as a flavor prism @ EIC

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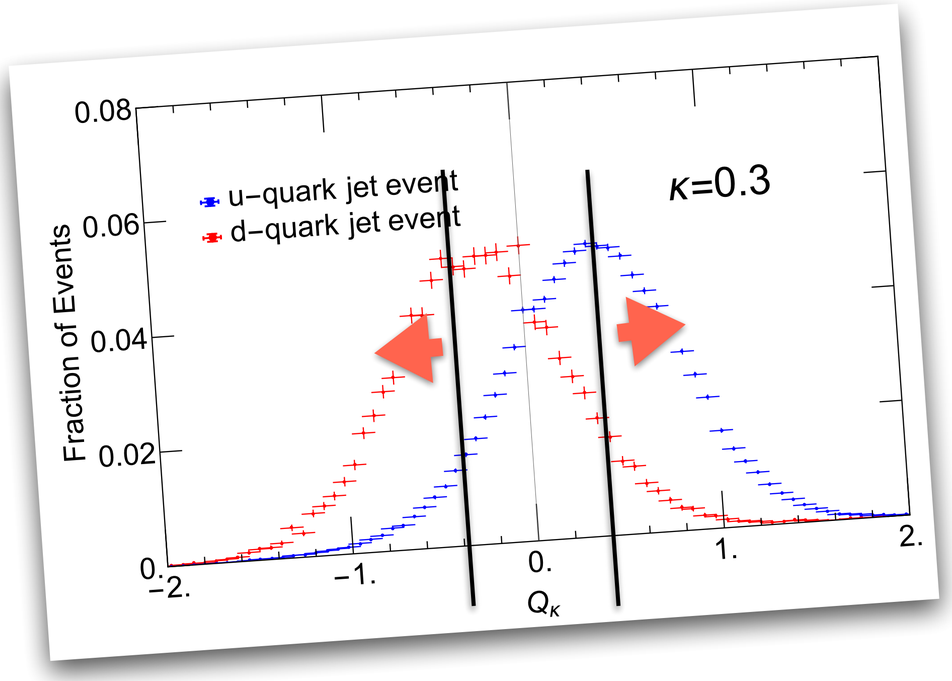
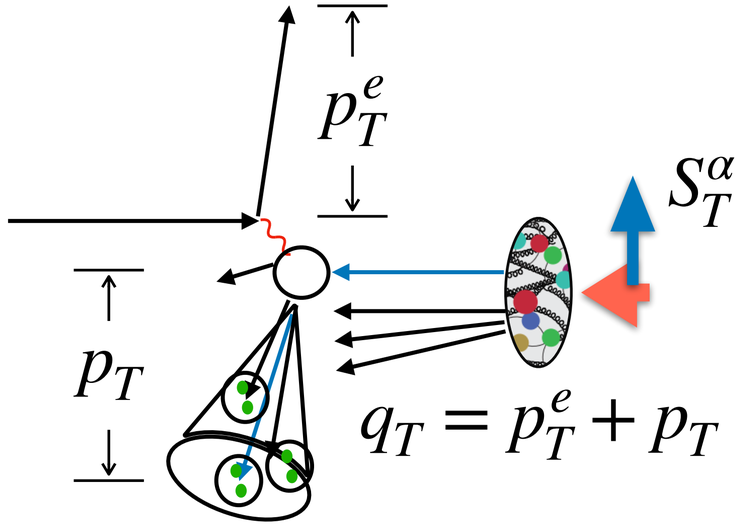


- The sign of the jet charge is largely inherited from the initiating parton, robust against the hadronization,
- Very good u- and d-quark separation by categorize the events to different charge bins

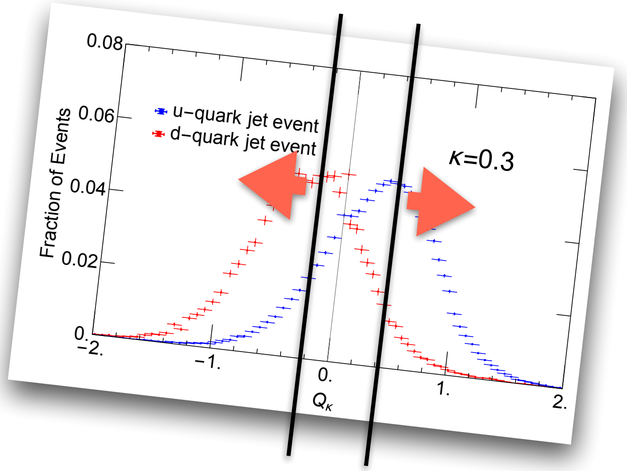
Jet charge as a flavor prism @ EIC

- The factorization Kang, XL, Mantry, Shao, 2020



$$\frac{\mathrm{d}^5\sigma_{UT}(S_\perp)}{\mathrm{d}y_e \mathrm{d}^2p_T^e \mathrm{d}^2q_T} = \sum_{i=u,d,\cdots} \int_{Q_\kappa \in \text{bin}} \mathrm{d}Q_\kappa \frac{\mathcal{G}_i(Q_\kappa, p_T R)}{\mathcal{J}_i(p_T R)} \frac{\mathrm{d}^5\sigma^i_{UT}(S_\perp)}{\mathrm{d}y_e \mathrm{d}^2p_T^e \mathrm{d}^2q_T}$$

$$= \sum_{i=u,d,\cdots} r_i \frac{\mathrm{d}^5\sigma^i_{UT}(S_\perp)}{\mathrm{d}y_e \mathrm{d}^2p_T^e \mathrm{d}^2q_T}$$



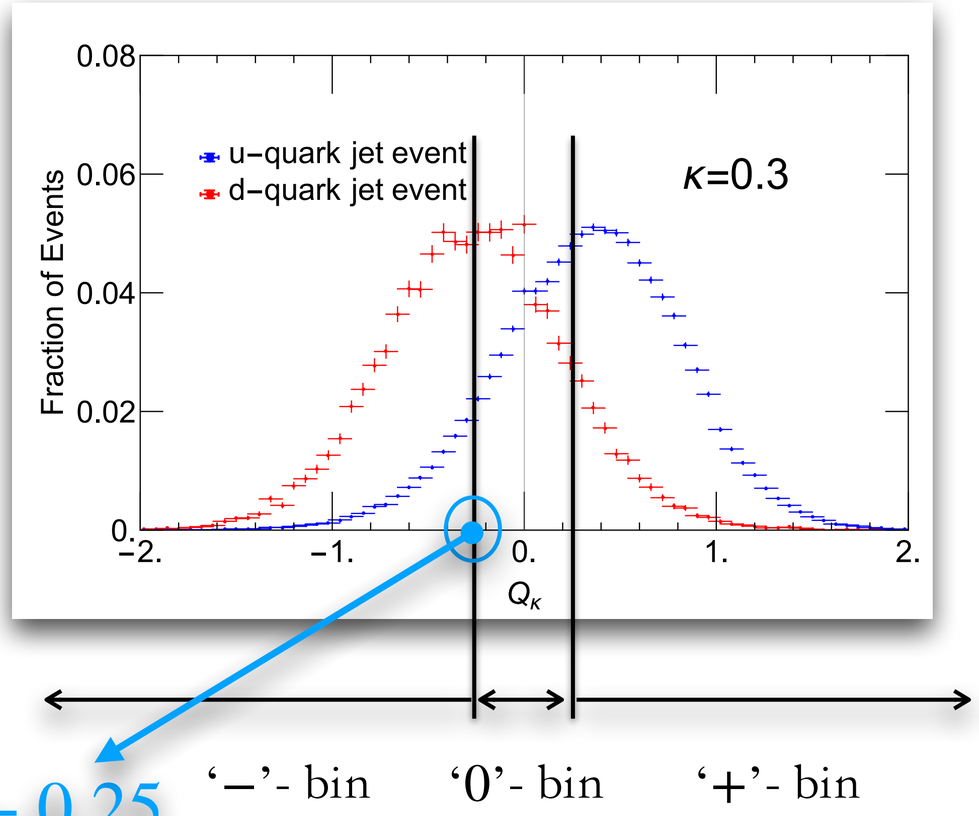
r_i the event fraction in a given charge bin

- A non-perturbative number
- Satisfies flavor symmetry
- Universal, similar to the NRQCD quarkonium matrix element.

By choosing the charge bin, we can control the relative size of r, though that we control size of the contributions from different flavors

Jet charge as a flavor prism @ EIC

- As a flavor prism Kang, XL, Mantry, Shao, 2020, see also STAR collaboration, H.Li, Vitev



	u	$\bar{u}$	d	$\bar{d}$	s	$\bar{s}$
$r_{i,+}$	0.52	0.17	0.15	0.53	0.30	0.34
$r_{i,-}$	0.15	0.49	0.52	0.15	0.36	0.32
$r_{i,0}$	0.33	0.35	0.33	0.32	0.35	0.34

$$Q_\kappa = \sum_i \left(\frac{p_{i,T}}{p_J}\right)^\kappa Q_i$$

choose $\kappa = 0.3$, large separation

choose π's in this study "π"-jet

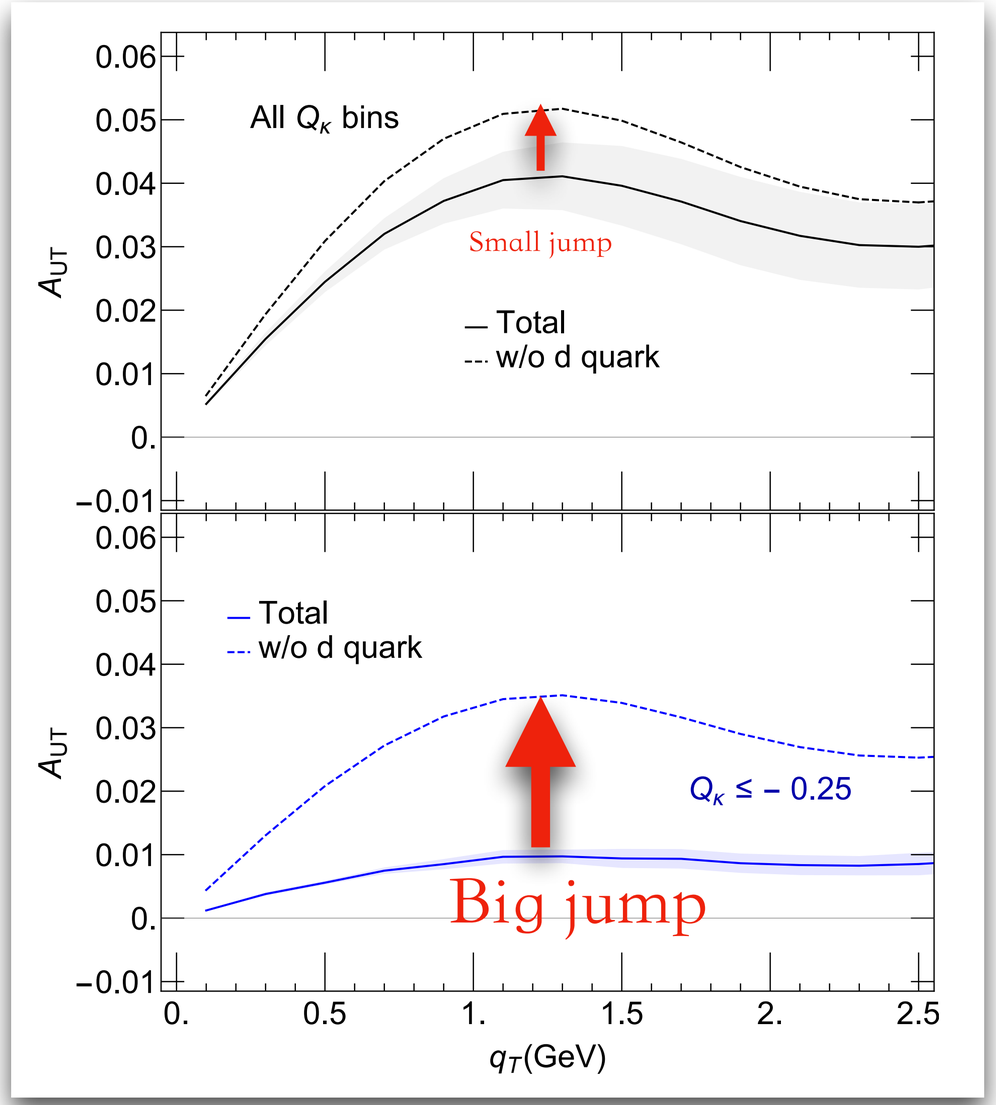
- Obvious flavor symmetries
- Expect enhancement of the d quark in the −-bin
- Expect enhancement of the s quark if the kaon component used

Jet charge as a flavor prism @ EIC

- As a flavor prism

Kang, XL, Mantry, Shao, 2020, see also STAR collaboration, H.Li, Vitev

Dramatically improved
sensitivity to the d quark
in the negative charge bin



Conclusions

- The jet charge maps out the hadron of the jet collectively and thus serves as a parton favor separation for TMD physics
- Non-pert. part of a jet but with reduced non-pert. d.o.f, could be quite interesting for femtography of nucleon
  - Jet charge
  - T-odd jet for more spin structures and different sensitivities to hadronization mechanisms XL, Xing, 2104.03328