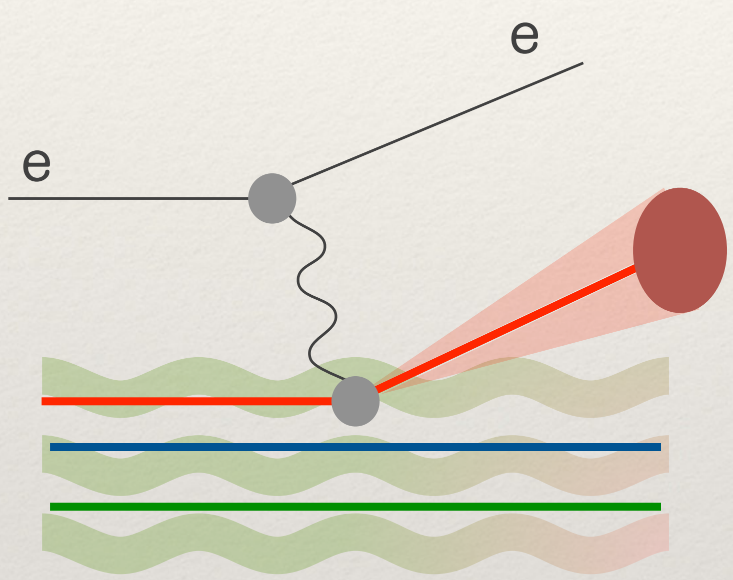
Ignazio Scimemi (UCM)

Exploring transverse momentum distribution with *Jets*

Most recent results in collaboration with
Duff Neill,
Wouter Waalewijn
JHEP 1704 (2017) 020
and Daniel Gutierrez-Reyes,
W. Waalewijn, Lorenzo Zoppi
arXiv:1807.07573, PRL…

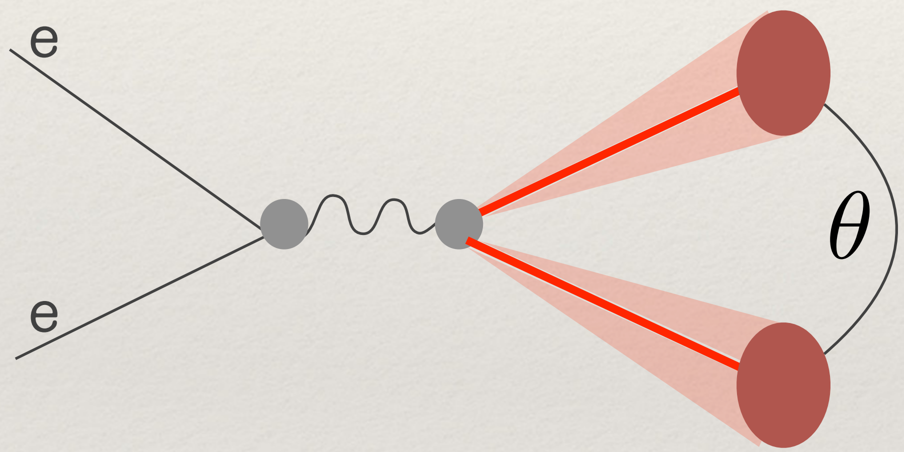
Di-jet interactions



Jets can be used also in a different way:
SIDIS with a final jet

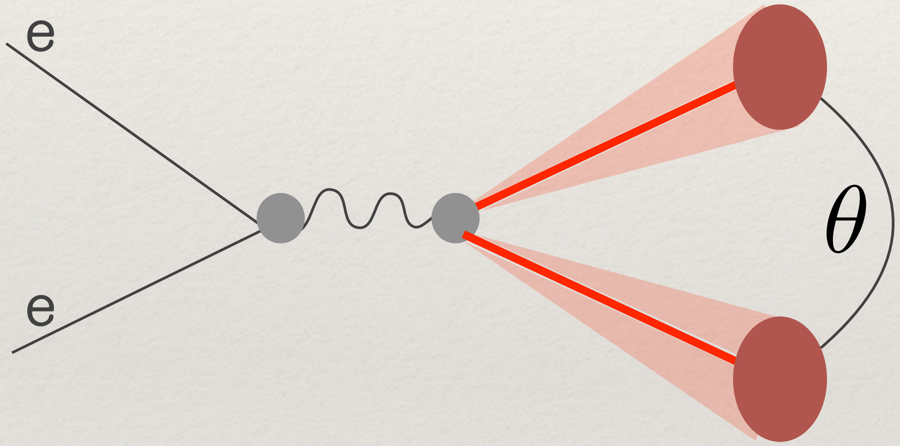
$$e + p \to e + jet + X$$

Di-jet interactions



How should we define Jet parameters to study TMDs?

Di-jet interactions



$$z_j = E_j/Q$$

Energy fraction of the initiating quark

$$\mathbf{q} = \frac{\mathbf{p_1}}{z_1} + \frac{\mathbf{p_2}}{z_2}$$

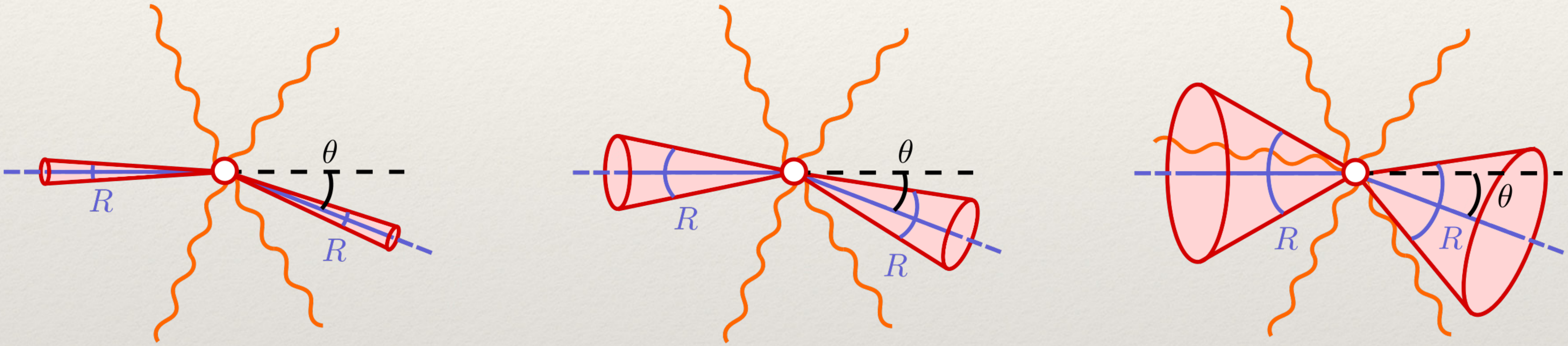
Momentum de-correlation of the 2 jets

$$\theta = 2\frac{|\mathbf{q}|}{Q}$$

Angular de-correlation of the 2 jets

Di-jet interactions

We expect to recover a TMD like limit for $\theta \ll 1$



$R \ll \theta$ $R \sim \theta$ $\theta \ll R$

...but the final result crucially depends on the angular vs radius interplay

Factorization for small radius jets

$$\frac{d\sigma}{\mathrm{d}z_1\,\mathrm{d}z_2\,\mathrm{d}Q^2\mathrm{d}\mathbf{q}} = H(Q^2,\mu)\int\frac{\mathrm{d}\mathbf{b}}{(2\pi)^2}e^{-\mathrm{i}\mathbf{b}\cdot\mathbf{q}}J_q^{\mathrm{axis}}(z_1,\mathbf{b},QR,\mu,\zeta_1)J_{\bar{q}}^{\mathrm{axis}}(z_2,\mathbf{b},QR,\mu,\zeta_2)\left[1+\mathcal{O}\left(\frac{\mathbf{q}^2}{Q^2}\right)\right]$$

The factorization works like for hadron TMD, with the same soft factor reabsorbed into each jet

$$\mu^2\frac{d}{d\mu^2}J_i^{\mathrm{axis}}(z,\mathbf{b},QR,\mu,\zeta) = \frac{1}{2}\gamma_F^i(\mu,\zeta)J_i^{\mathrm{axis}}(z,\mathbf{b},QR,\mu,\zeta),$$

$$\zeta\frac{d}{d\zeta}J_i^{\mathrm{axis}}(z,\mathbf{b},QR,\mu,\zeta) = -\mathcal{D}^i(\mu,\mathbf{b})J_i^{\mathrm{axis}}(z,\mathbf{b},QR,\mu,\zeta).$$

SAME EVOLUTION AS IN THE CASE OF HADRONS!

how small?

Factorization for small radius jets

$R \lesssim \theta$ We can evaluate the usual OPE on transverse momentum integrated objects

$$J_i^{\rm axis} \to \sum_j \int \frac{{\rm d}f\, z'}{z'}\, \mathbb{C}_{i\to j}\Big(\frac{z}{z'}, \mathbf{b}, \mu, \zeta\Big)\, \mathcal{J}_j(z', z'QR, \mu)\, \big[1 + \mathcal{O}(\mathbf{b}^2 Q^2 R^2)\big]$$

THE SAME AS FOR FRAGMENTATION FUNCTIONS!!
M.G. ECHEVARRIA, I.S., A.VLADIMIROV 1604.07869

THE SAME AS FOR HADRONS INSIDE JETS WITH SJA!!
Z.KANG, F.RINGER1705.08443...

how small?

Factorization for small radius jets

$R \ll \theta$ We recover the hadrons.. and the fragmentation functions..

$$\mathcal{J}_j(z, QR, \mu) \to \sum_h d_{j\to h}(z,\mu)\Big[1 + \mathcal{O}\Big(\frac{Q^2 R^2}{\Lambda^2_{\rm QCD}}\Big)\Big]$$

...UP TO NOW NOTHING DEPENDS ON THE JET RADIUS....

Factorization for <u>big</u> radius jets: only WTA

$\theta < R$

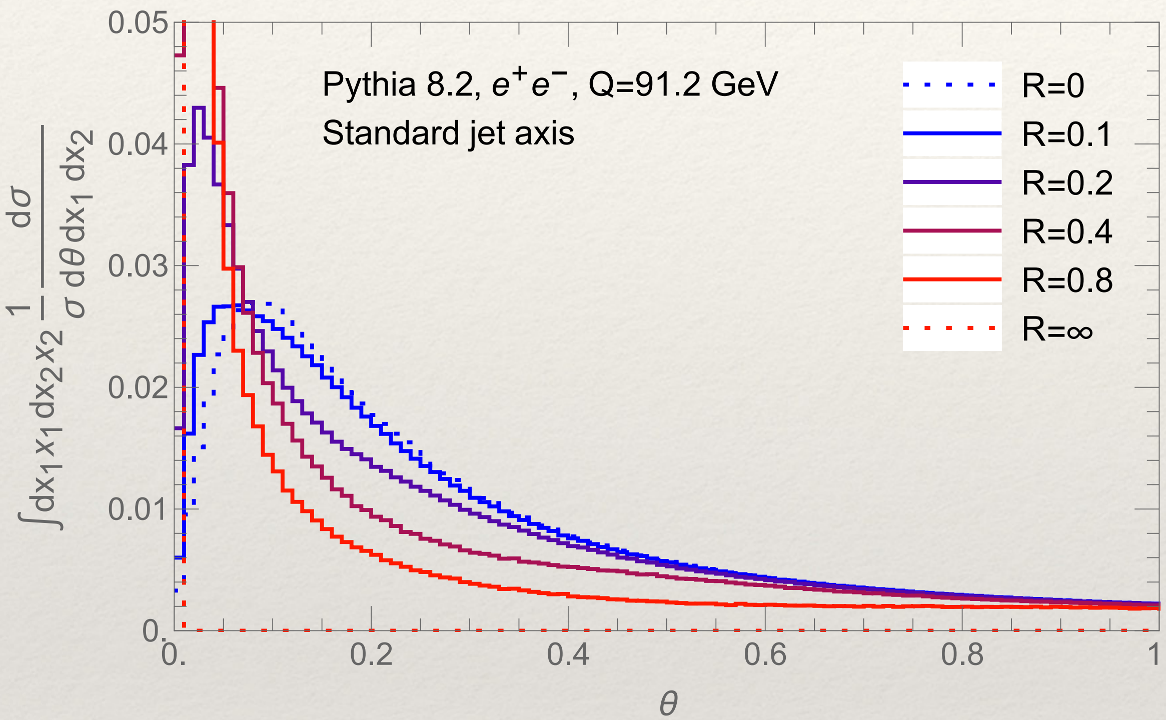
The **standard jet axis** does not allow the factorization of the cross-section! This axis is sensitive to the radiation inside the jet (which can be hard), but the momentum de-correlation is sensitive only to radiation outside the jet… which can have multiple origin.

The **WTA axis** is not affected by the origin of soft radiation, which can be inside or outside of the jet …so the soft radiation is independent on the radius of the jet!

1-loop

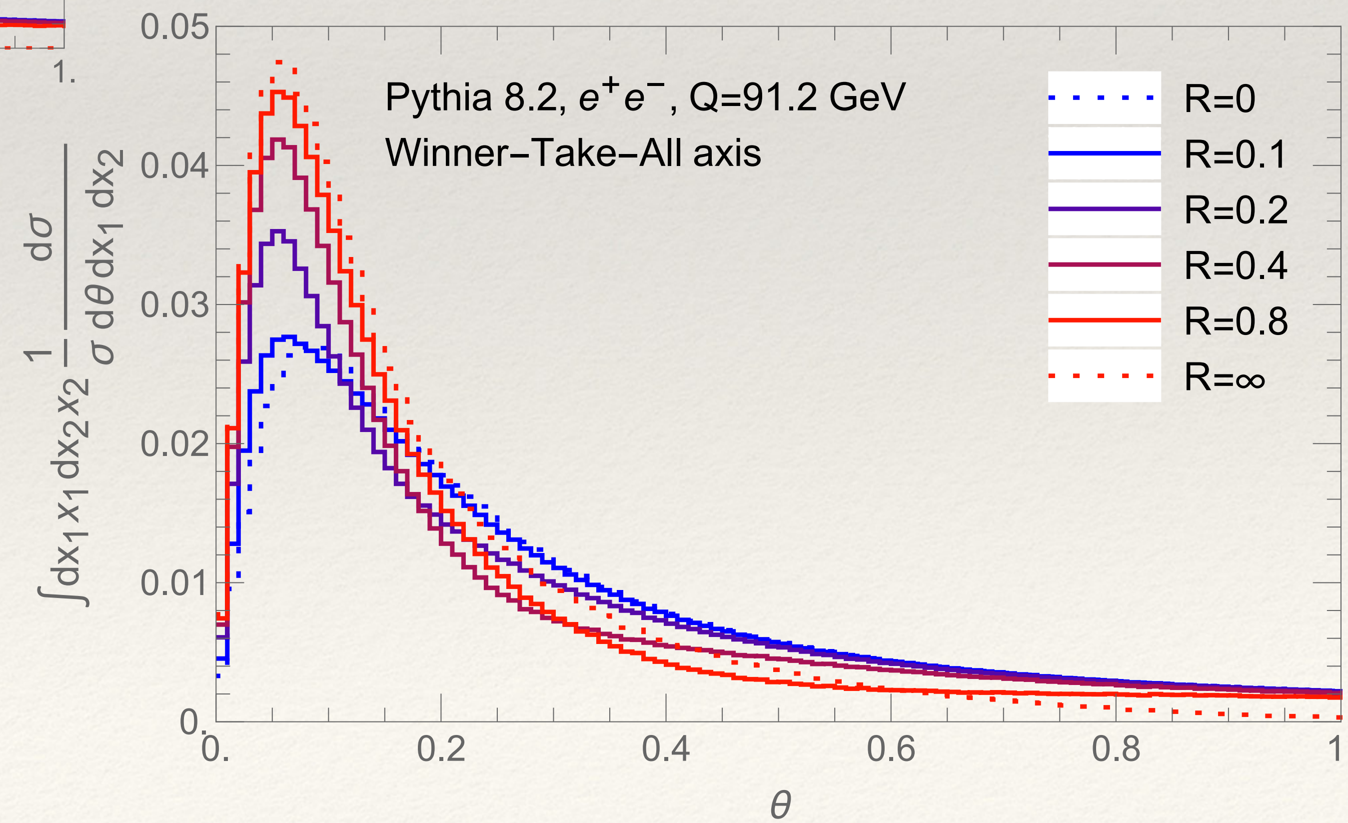
$$J_i^{[1]\,\mathrm{WTA}} = 2\delta(1-z)\Big\{N_i + L_\mu\Big[\mathcal{C}_i' + \mathcal{C}_i(\mathbf{l}_\zeta - L_\mu)\Big]\Big\}$$

A check from Pythia

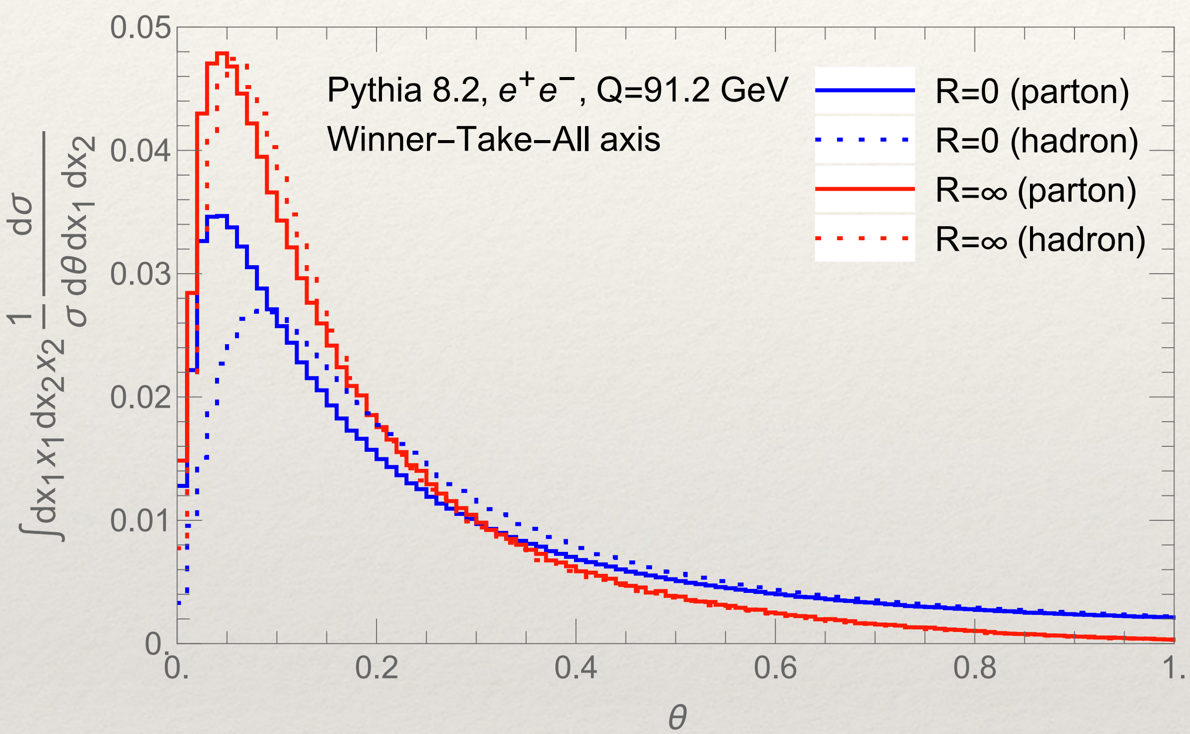


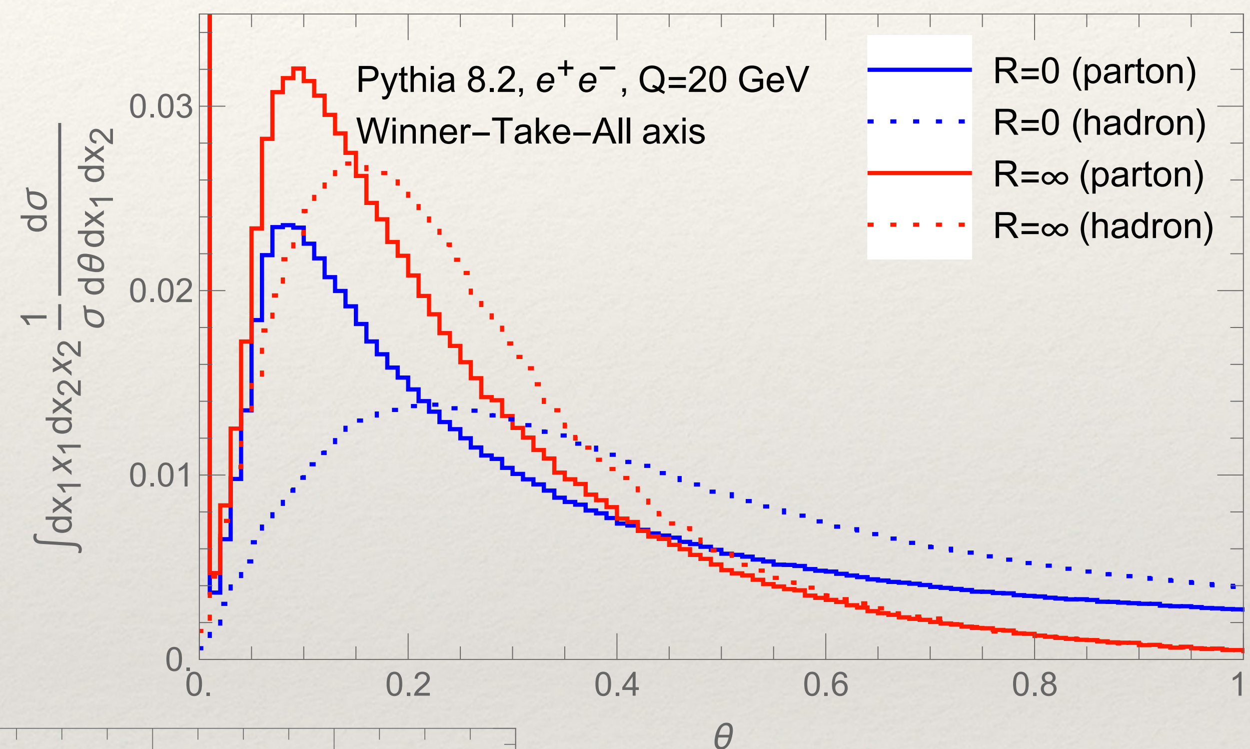
THE STANDARD JET AXIS GETS UNSTABLE FOR R>0.2 AND SMALL ANGLES

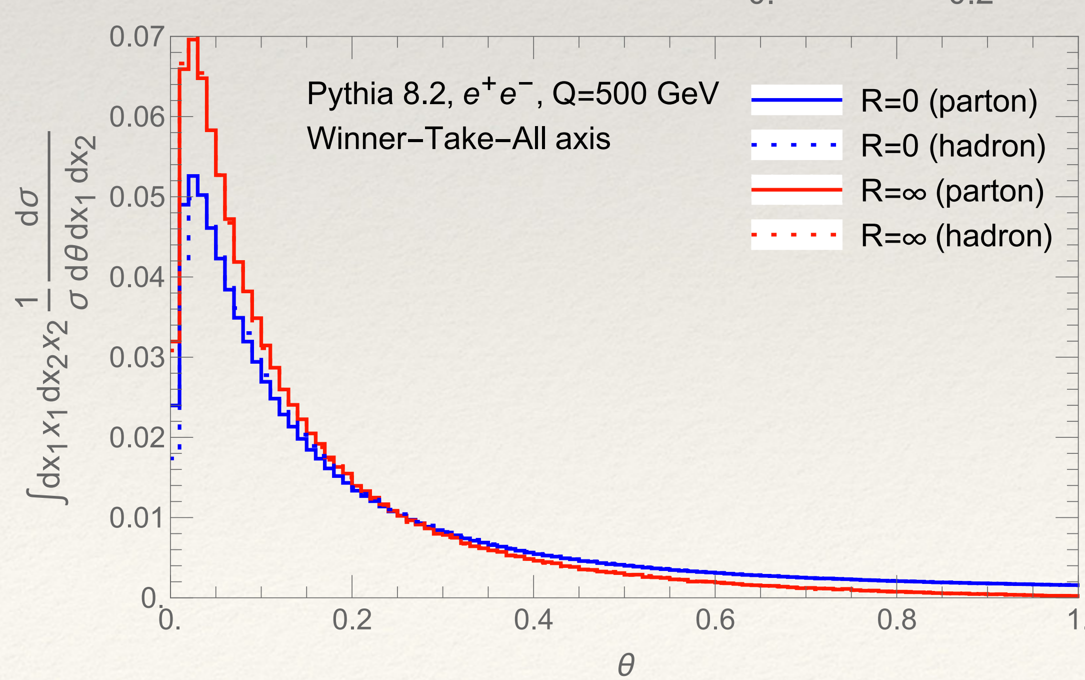
THE WTA AXIS IS STABLE FOR ALL R



A check from Pythia: hadronization effects







Conclusions

We have observables and Jet TMDs whose (double-scale) evolution is dictated by the same soft factors as for hadrons

Process/Axis	Standard Jet Axis	WTA
Hadron inside jet	Standard Hadron TMD, semi-inclusive TMD fragmenting jet function	DGLAP Hadron TMD, semi-inclusive TMD fragmenting jet function with WTA
2-jet momentum de-correlation	Double-scale evolution for Jet TMDs; it works only for R<0.2	Double-scale evolution for Jet TMDs; it works only all R