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Predictions for Azimuthal asymmetry

in e^+p DIS at HERA

NC DIS at $Q^2 > 100$ GeV^2

Outline

- Monte Carlo DIS codes
- Experimental problems
- Predictions for asymmetries
  multiplicity method versus energy flow methods
  - Parton level (matrix element and parton showers)
  - Hadron level
  - next-to-leading order (NLO) versus leading order (LO)
- Summary

Definition of the azimuthal angle

no Trento2004 convention

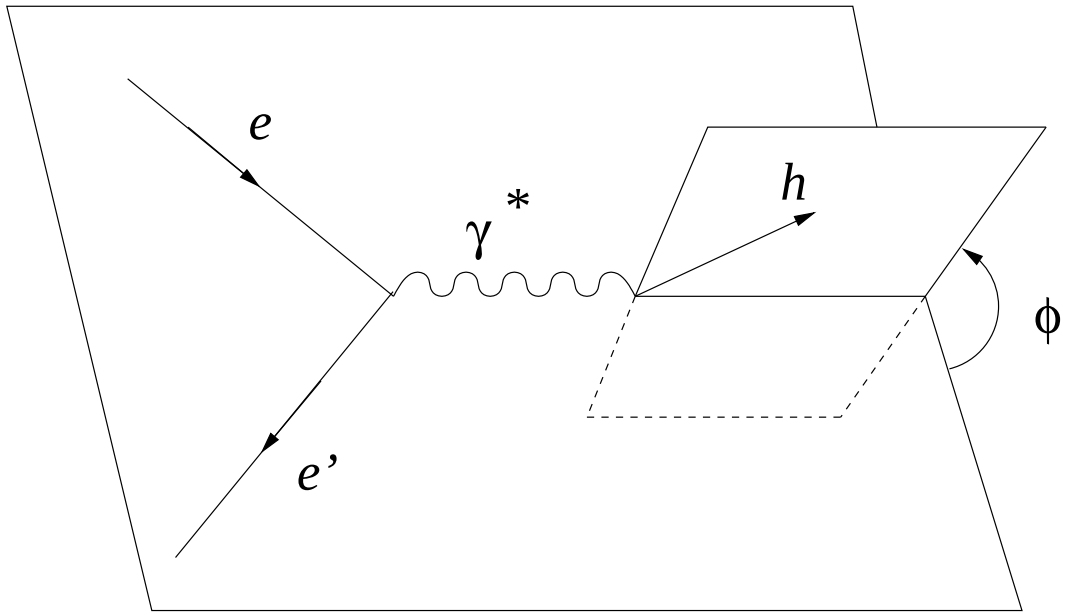
$\phi = \phi_{e'} - \phi_h$

$\phi_{e'}$ the azimuthal angle of the final electron

ϕ_h the azimuthal angle of the final particle h

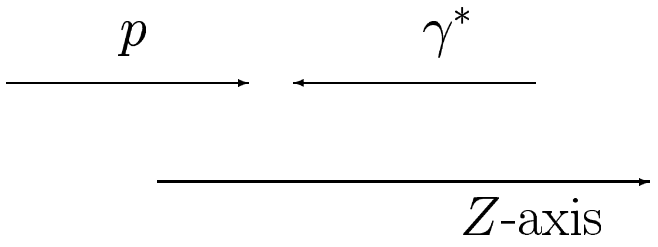
h outgoing hadron (or charged and neutral cluster in calorimeter)

$$\frac{d^5\sigma^{ep\to ehX}}{dxdQ^2dP_T^2dzd\phi} = A + \mathcal{B}\cos\phi + \mathcal{C}\cos 2\phi + \mathcal{D}\sin\phi + \mathcal{E}\sin 2\phi$$



$\gamma^* p$ frame

Breit or $\gamma^* p$ cms



Monte Carlo Investigation

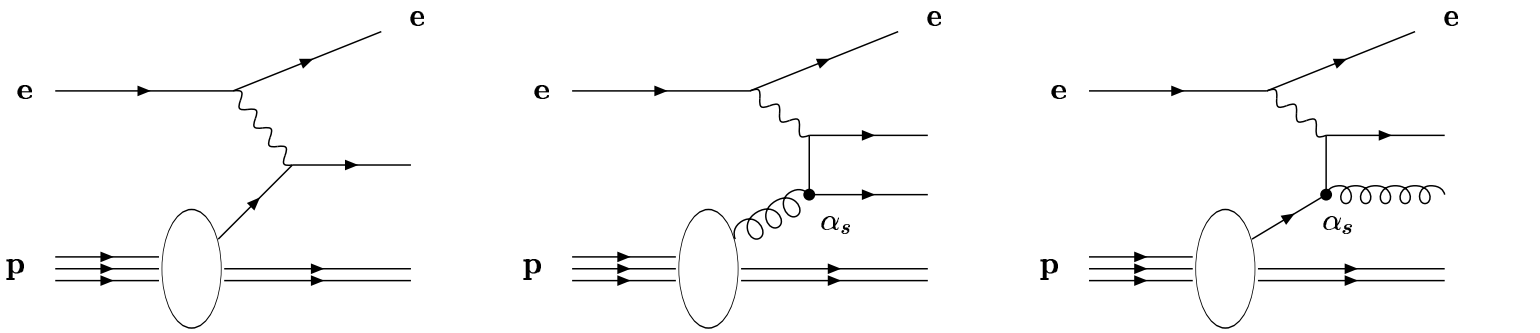
Generators used in leading order (LO) with hadronisation included:

LO

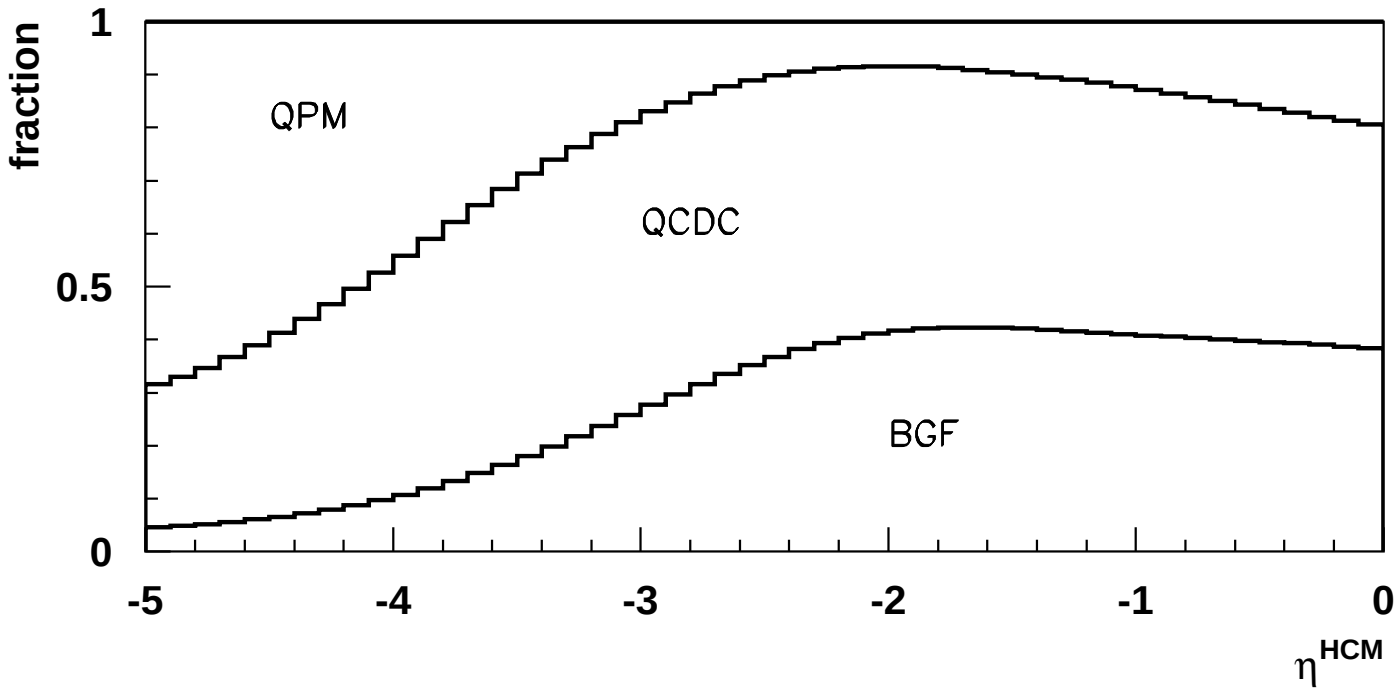
LEPTO 6.5.1	Matrix element and parton showers
ARIADNE 4.12	Colour dipole model

NLO or LO

DISENT	NLO dipole factorization formulae, subtraction method



QPM **BGF** **QCD Compton**



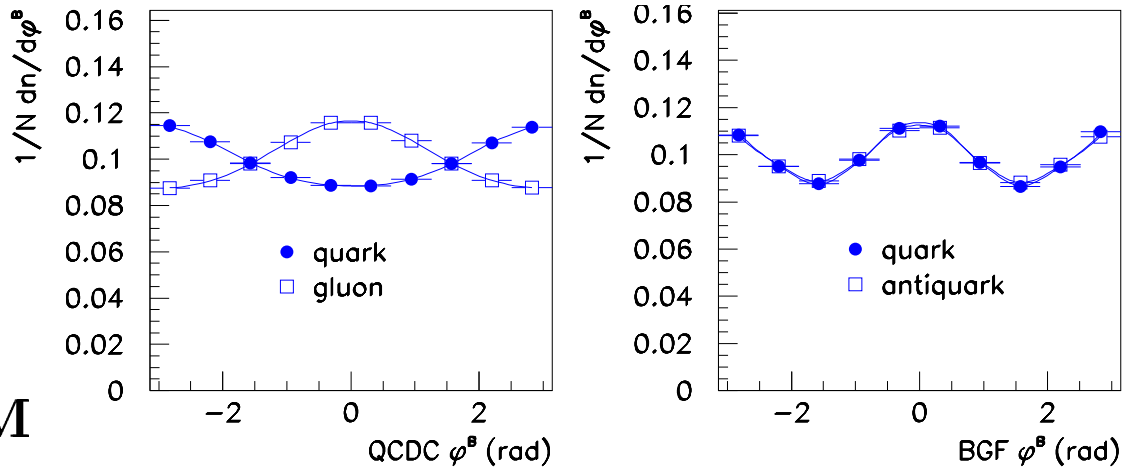
LEPTO 6.5.1

Proton remnant

The dominant contribution to:

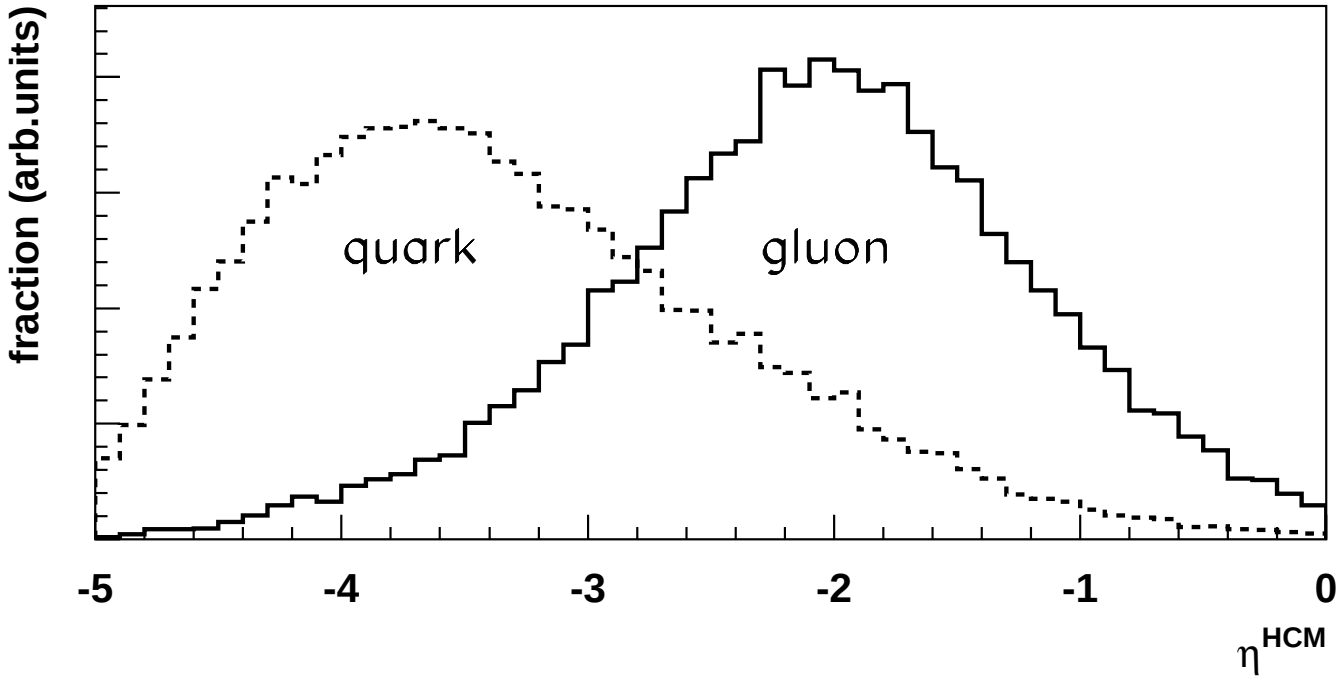
- $cos\phi$ from QCD Compton $(\gamma^* q \to qg)$
- $cos2\phi$ from BGF $(\gamma^* q \to q\bar{q})$

hadronic centre of mass HCM

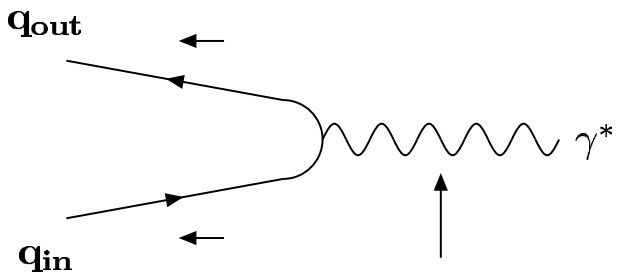


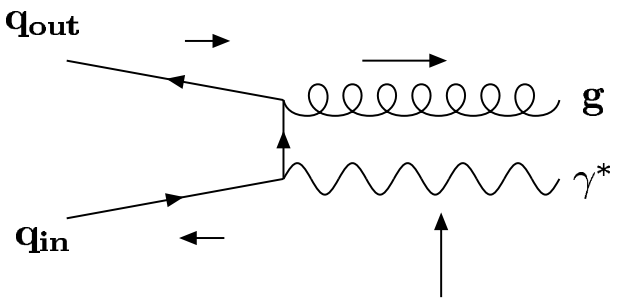
QCD Compton

LEPTO 6.5.1



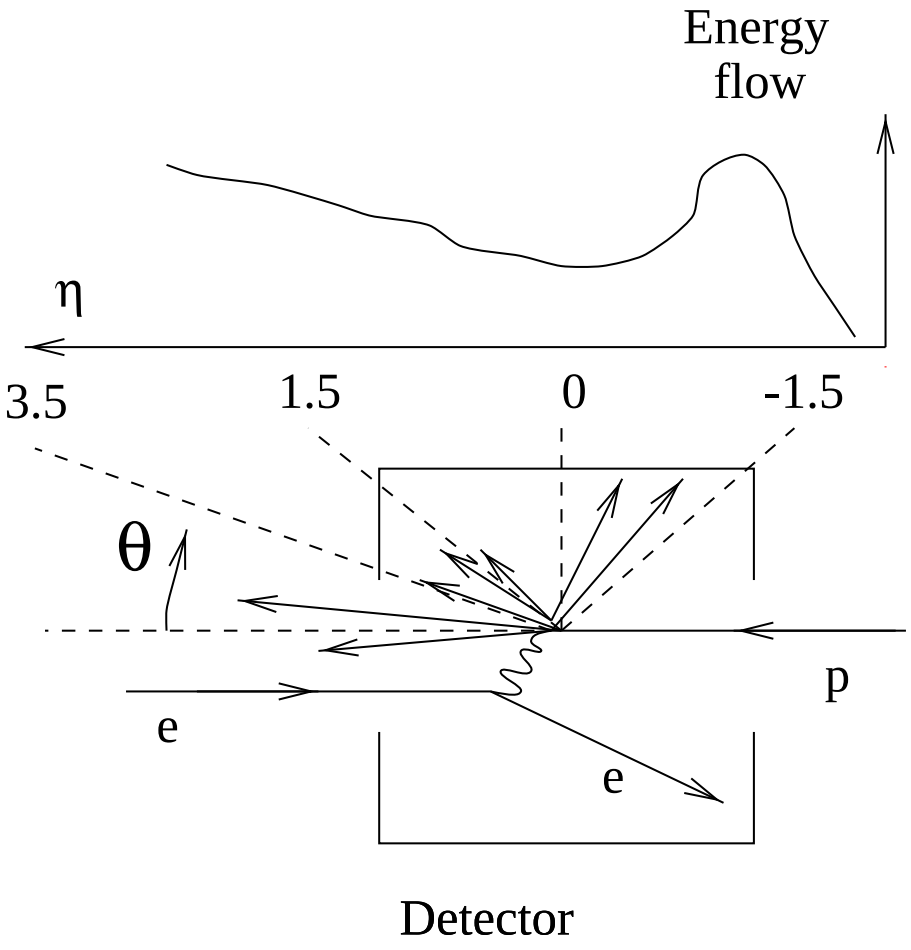
Longitudinally polarised virtual photons F_L





Methods for Inclusive Measurements of Asymmetries

- Multiplicity method
- Energy flow method (E_T, E_{tot}, z)



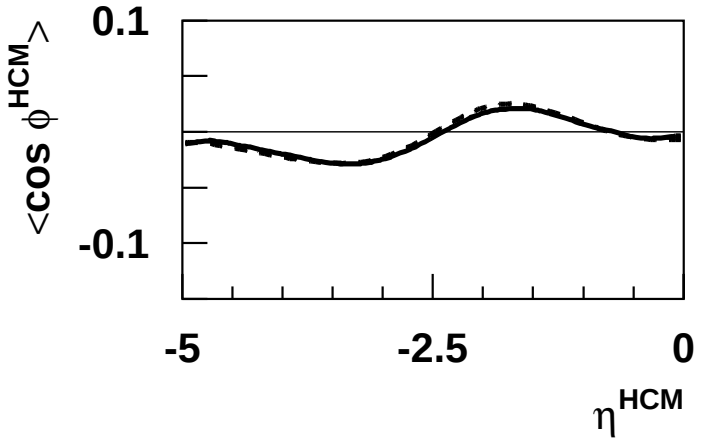
Problems:

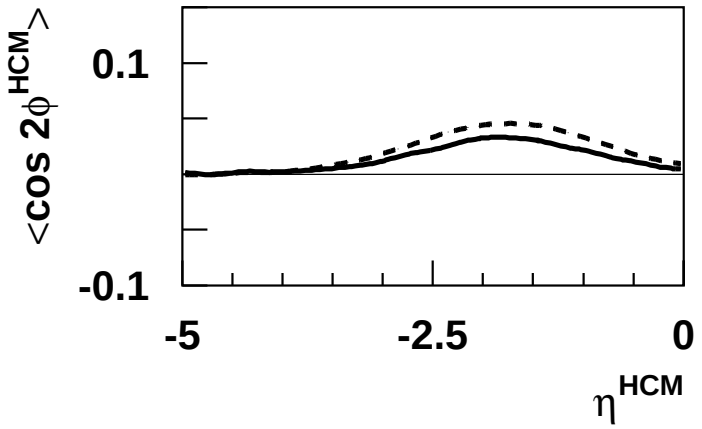
- Losses of
  - soft particles ($P_T^{\mathrm{LAB}} < 150$ MeV)
  - fragments of proton remnant
- Clustering of particles

All hadrons detected

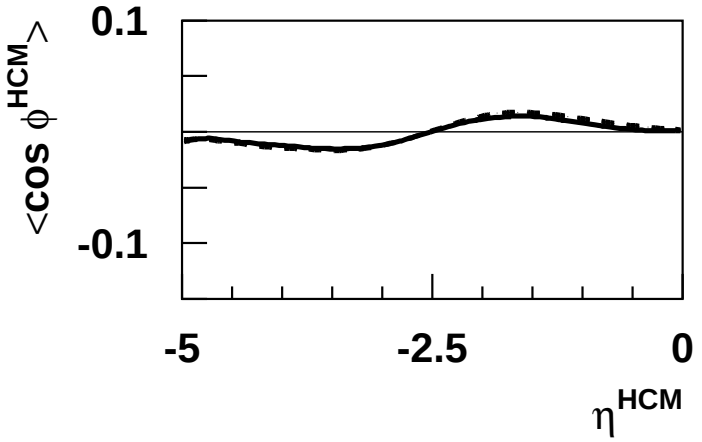
	line
LEPTO	— solid
ARIADNE	— dashed

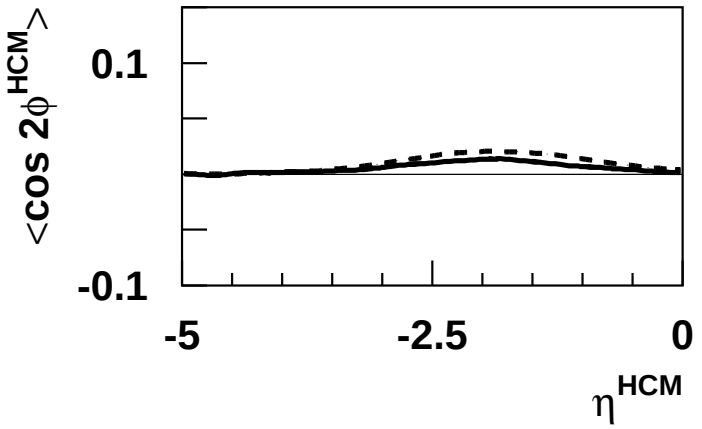
Energy flow





Multiplicity

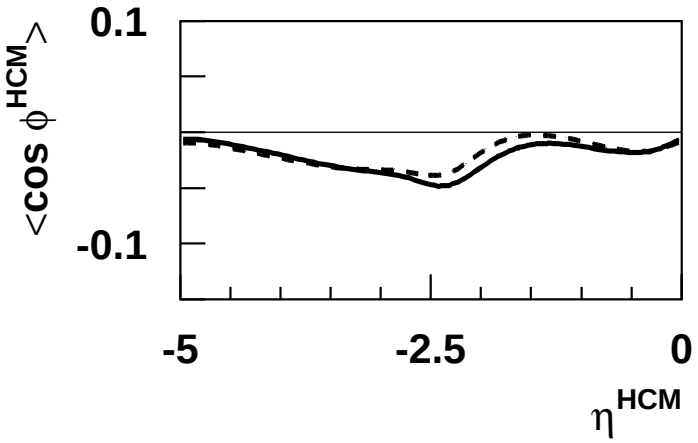


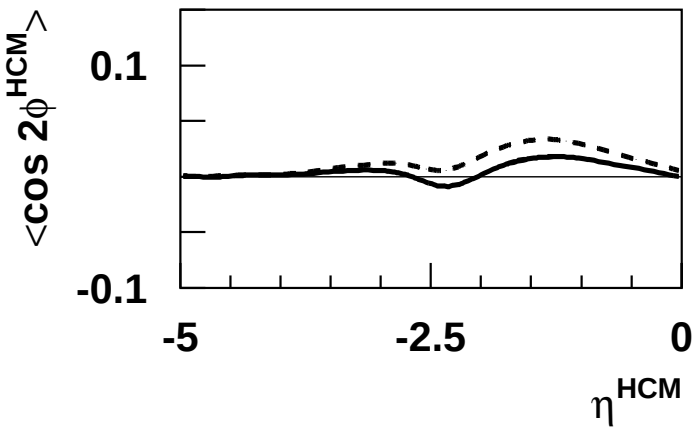


Soft hadron lost $P_T^{LAB} < 150$ MeV

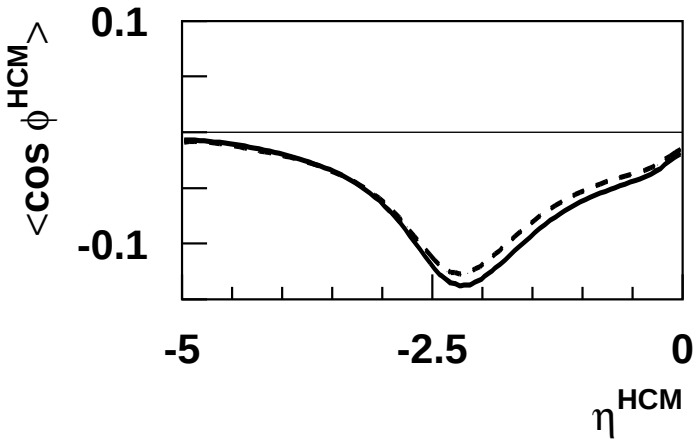
	line
LEPTO	— solid
ARIADNE	— dashed

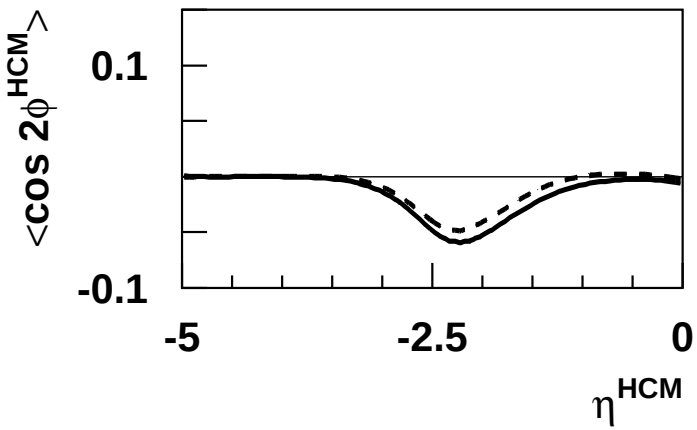
Energy flow





Multiplicity





Partons versus Hadrons

LEPTO predictions for

$\mathcal{B} = \langle \cos\phi \rangle$

$\mathcal{C} = \langle \cos 2\phi \rangle$

Investigated processes:

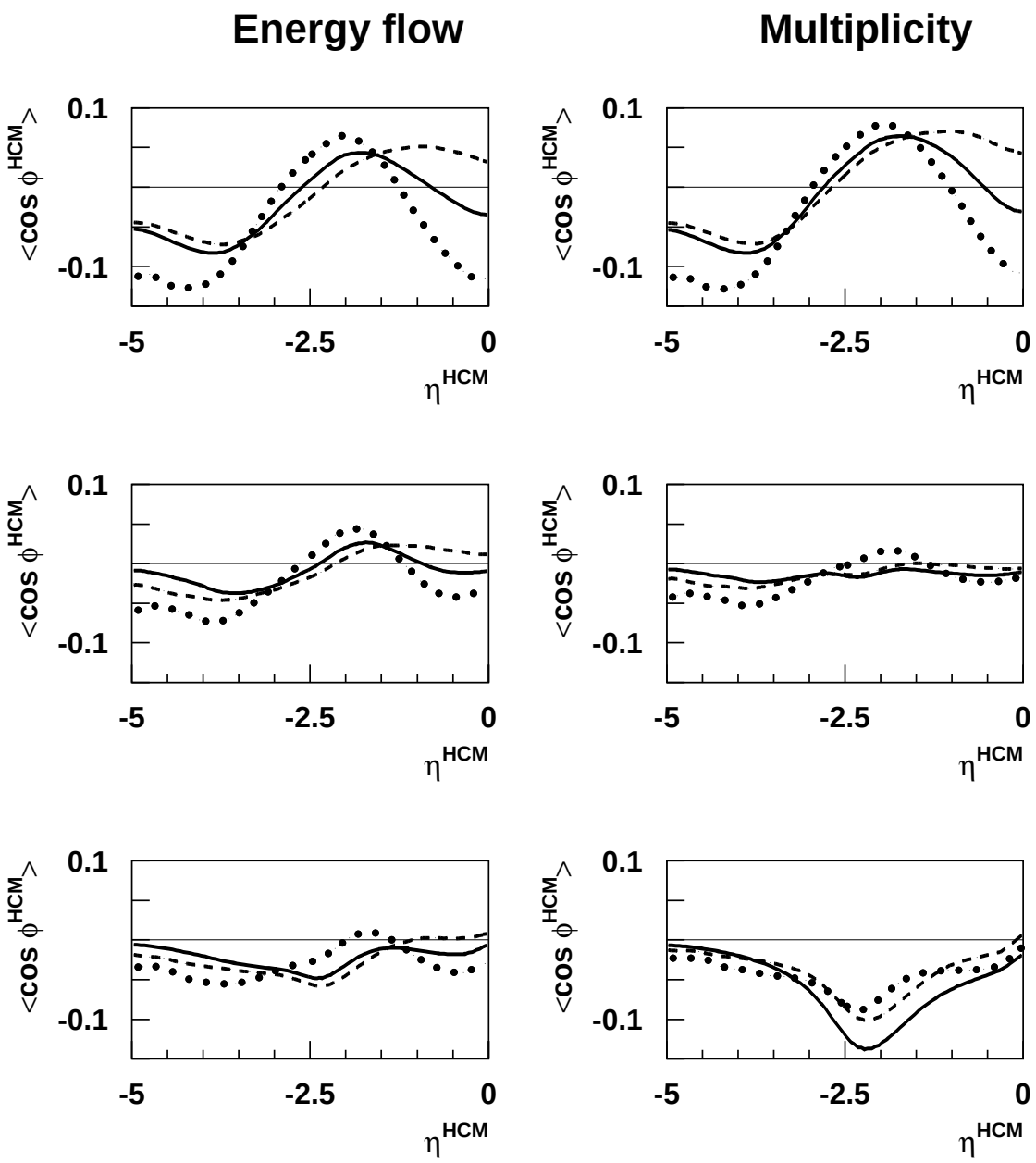
all processes together — solid line

and separately for

boson-gluon fusion (BGO) — dotted line

QCD Compton — dashed line

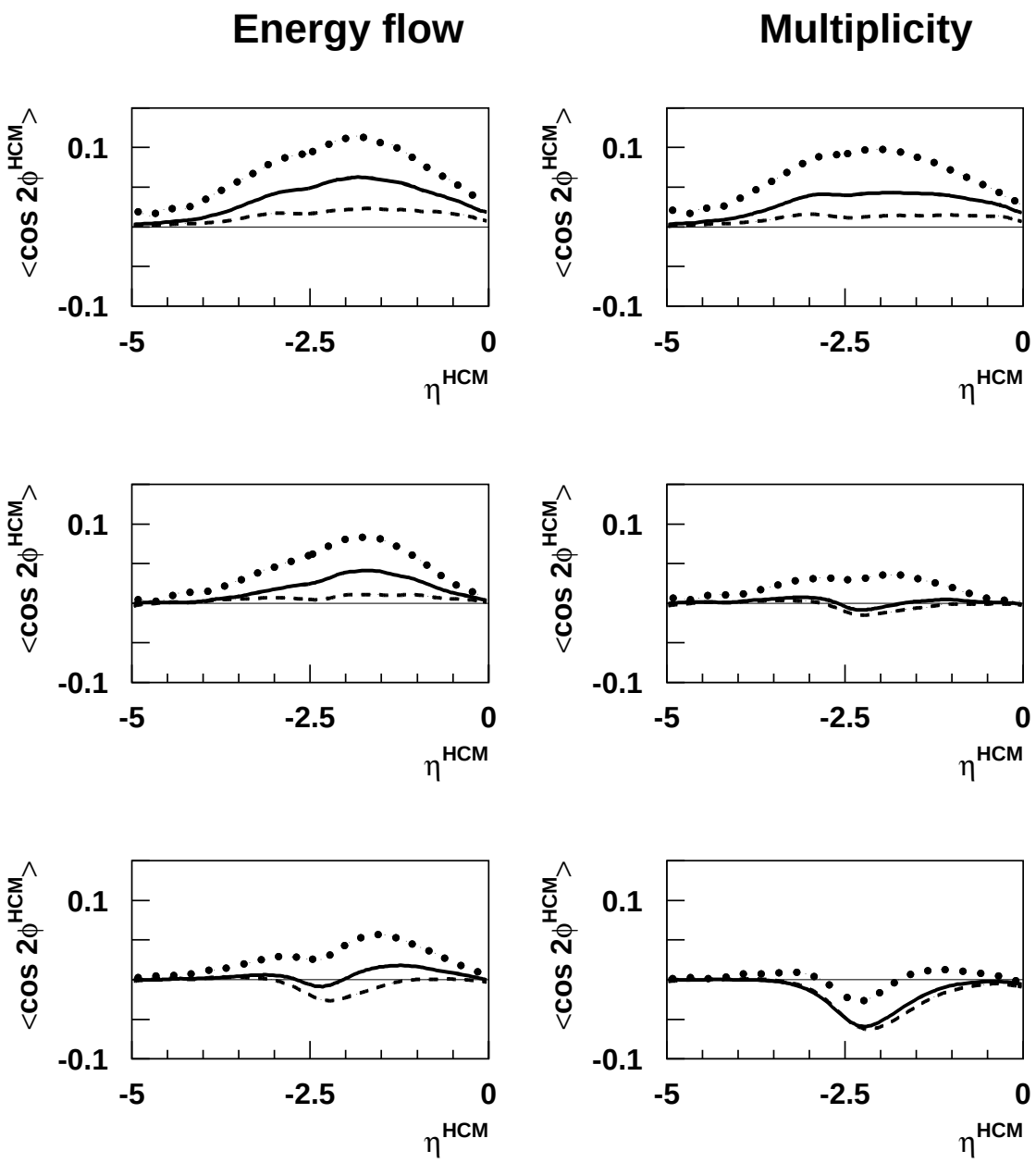
$\mathcal{B} = \langle \cos\phi \rangle$



Parton level
Matrix element only

Parton level
ME +parton shower

Hadron level
detection included



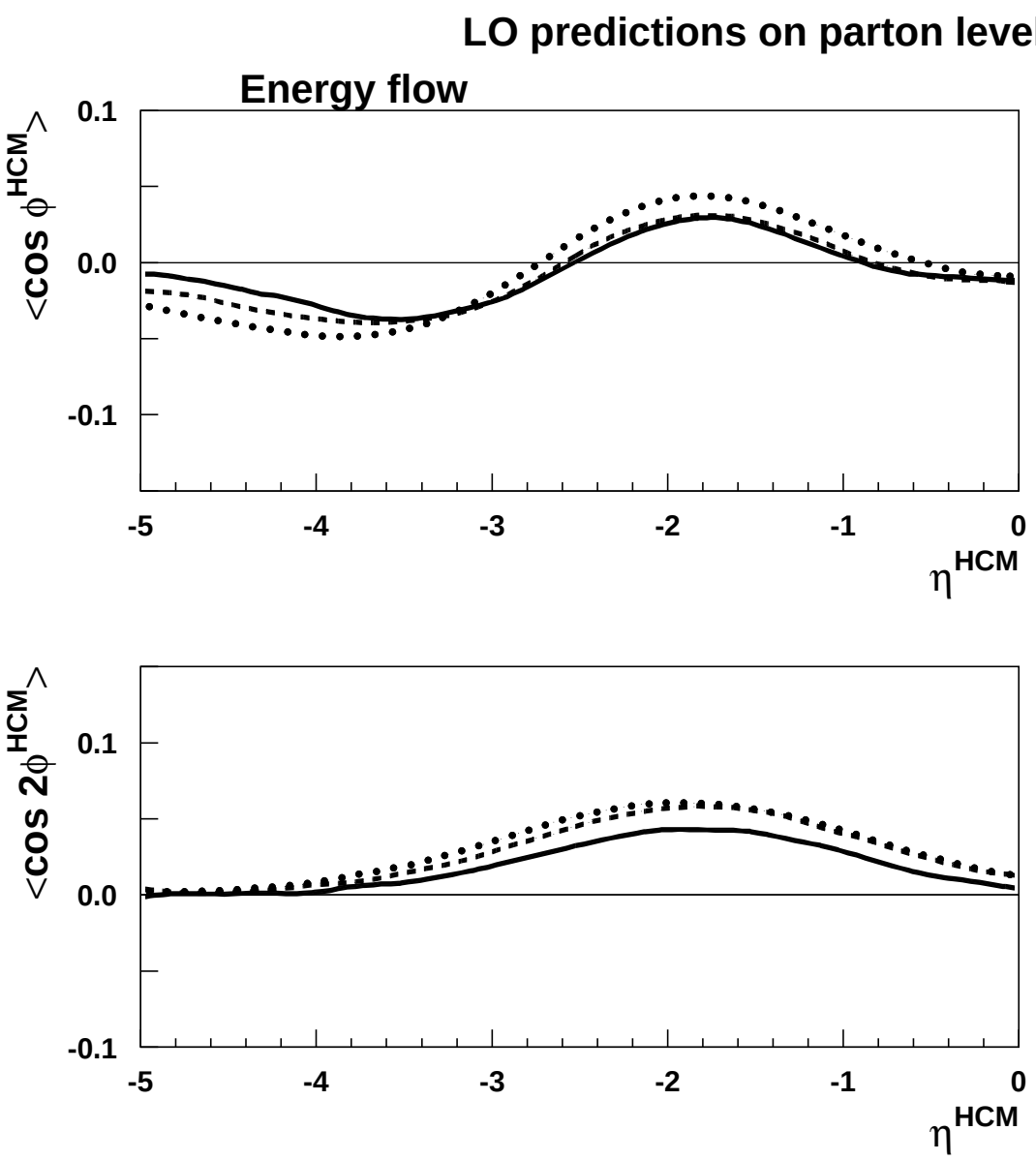
$\mathcal{C} = \langle \cos 2\phi \rangle$

Parton level
Matrix element only

Parton level
ME +parton shower

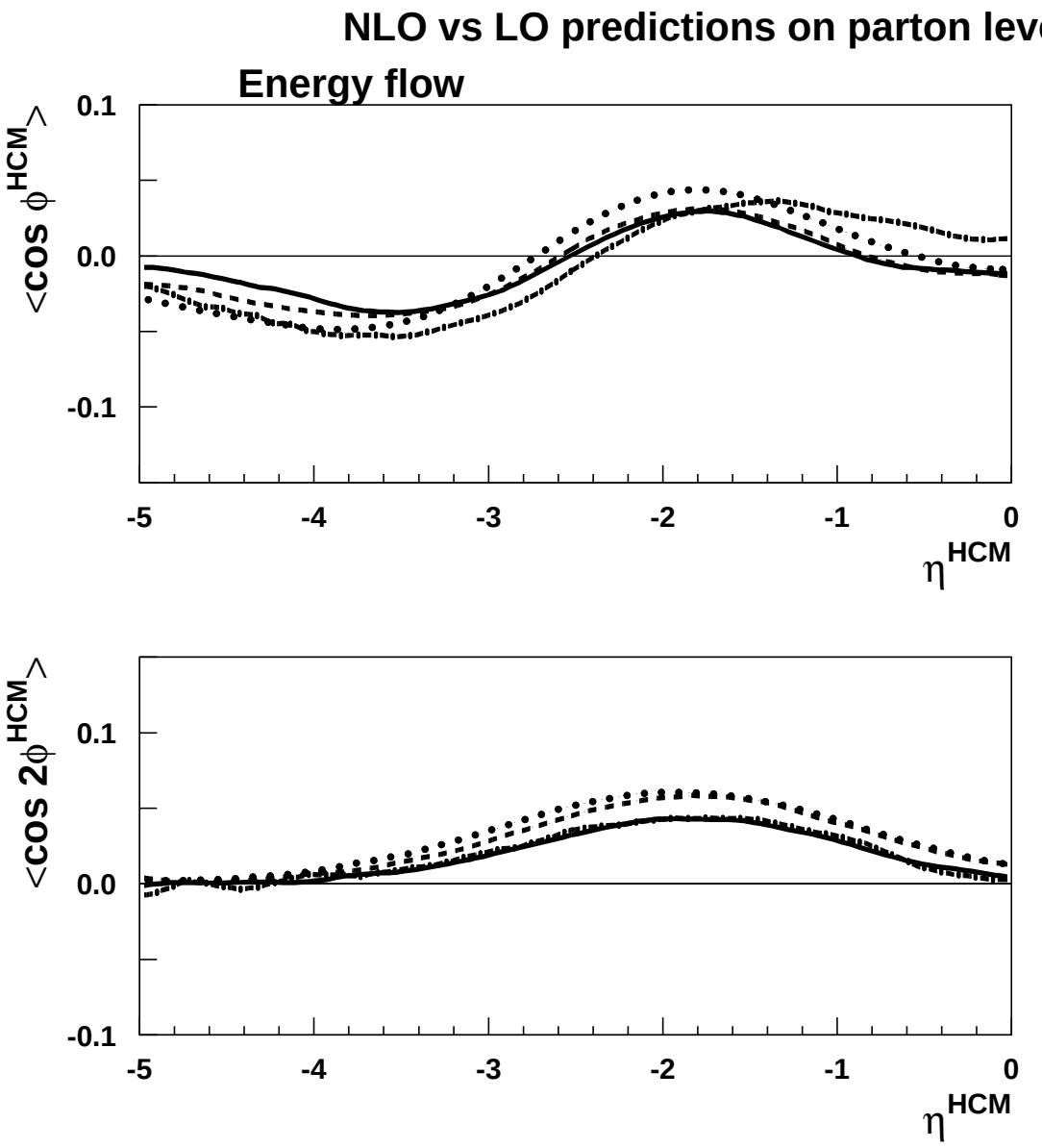
Hadron level
detection included

NLO versus LO



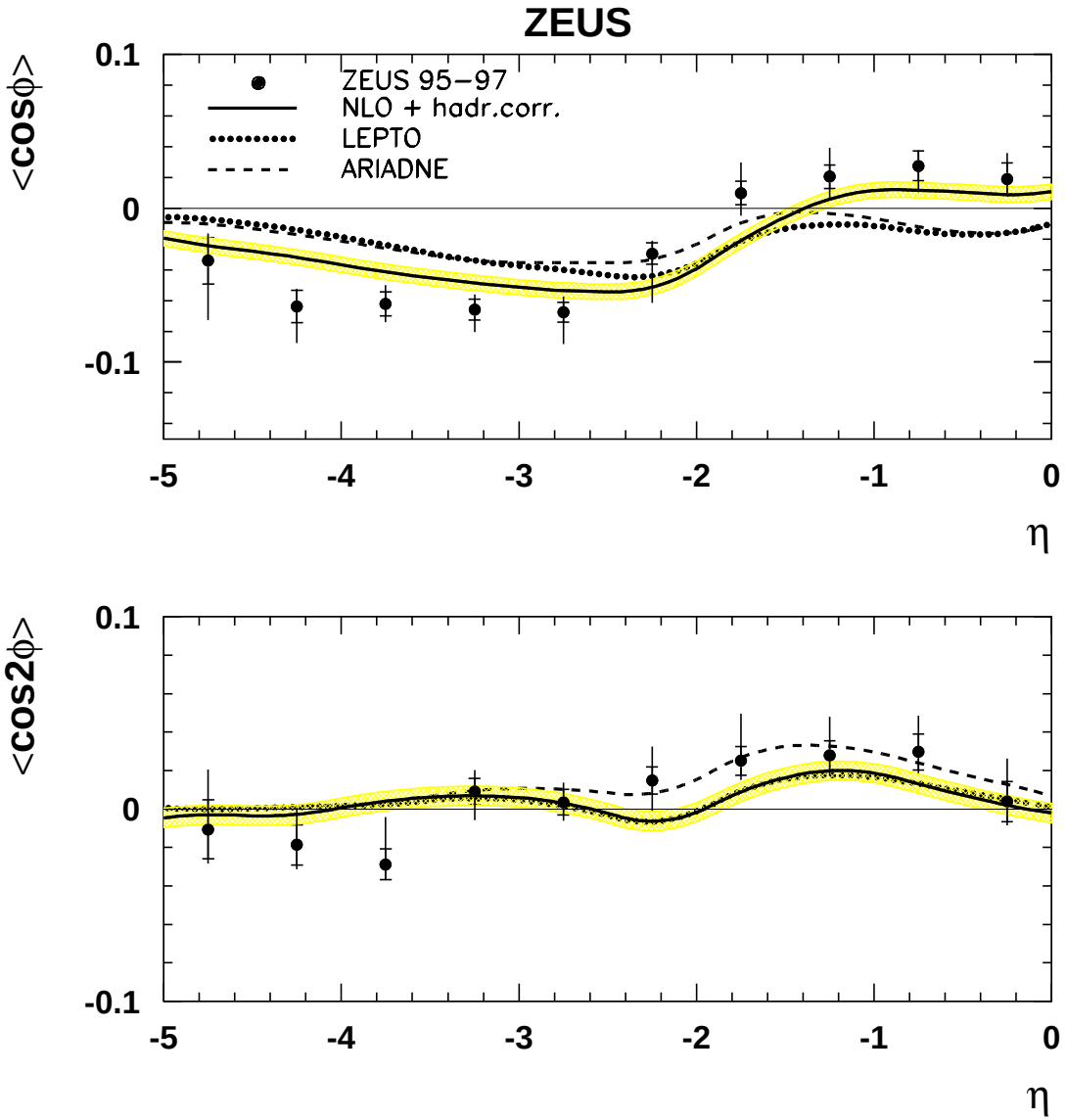
		line
LEPTO	—	solid
ARIADNE	—	dashed
DISENT LO		dotted
DISENT NLO		dashed-dotted

NLO versus LO



		line
LEPTO		solid
ARIADNE	-	dashed
DISENT LO		dotted
DISENT NLO		dashed-dotted

Experimental Data

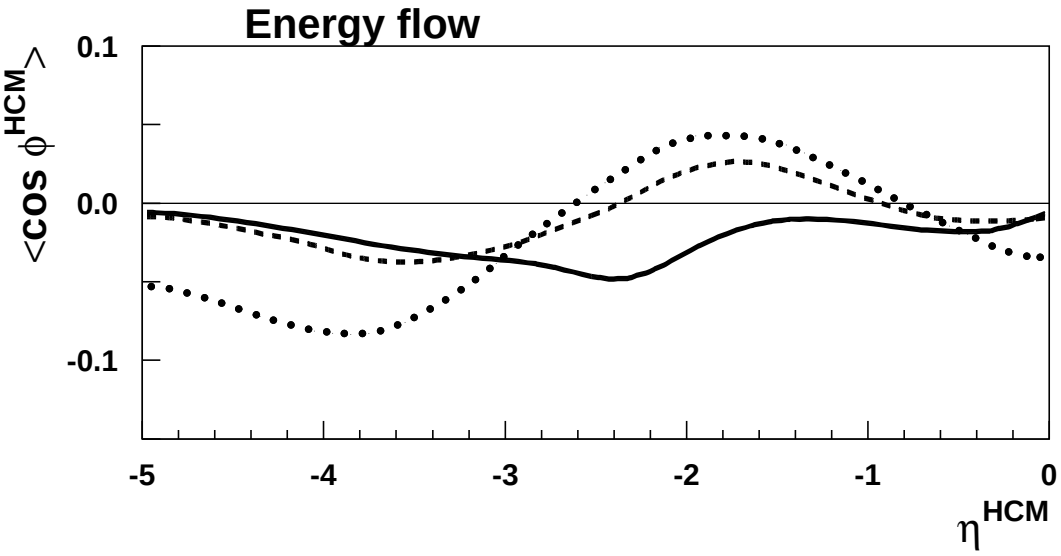


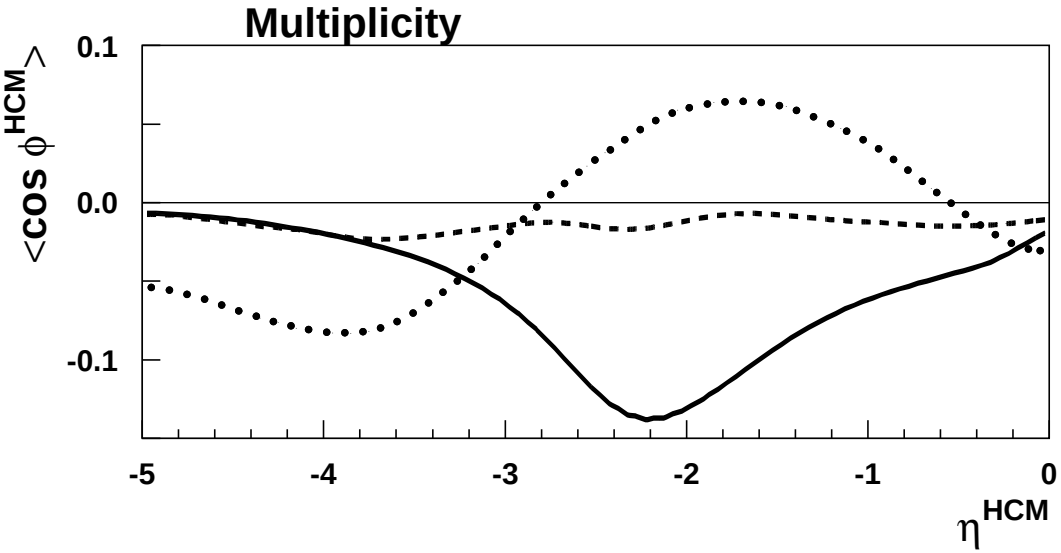
Summary

For the inclusive investigation of azimuthal asymmetries:

- Energy flow method is better than multiplicity method
- Energy flow method is less sensitive to undetected hadrons

Partons versus Hadrons $\mathcal{B} = \langle \cos\phi \rangle$

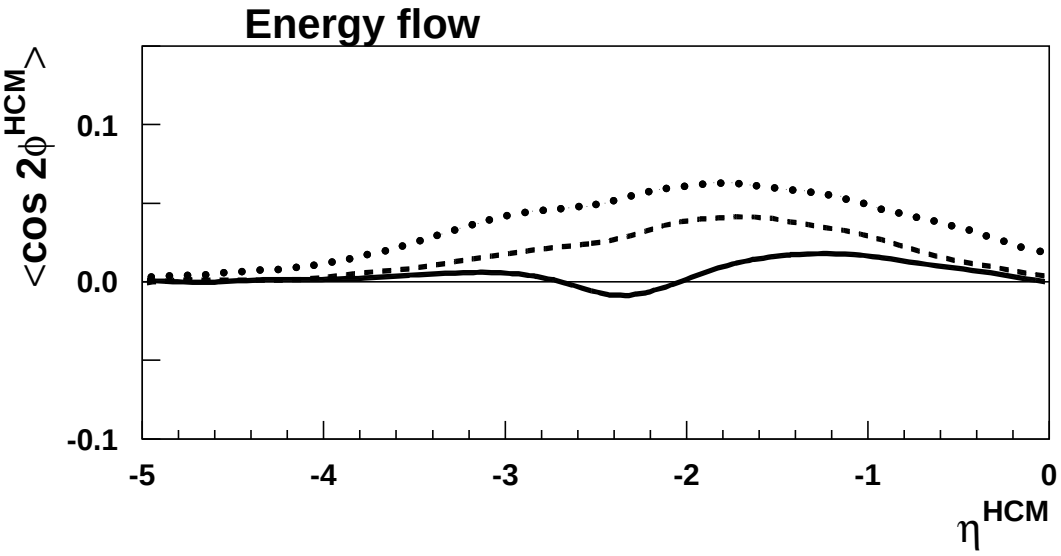


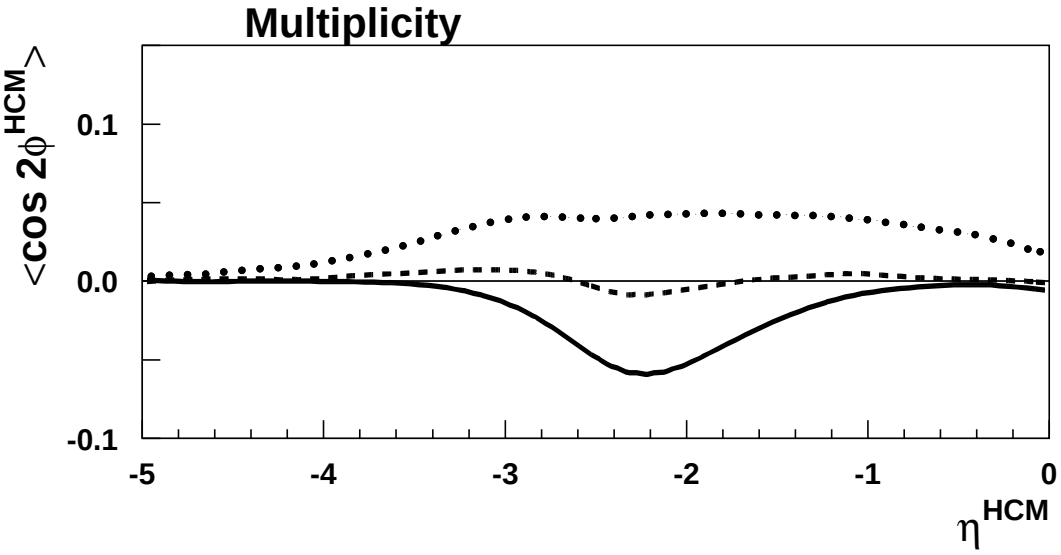


LEPTO

		line
hadron level	—	solid
parton level (MEPS)	—	dashed
parton level (ME)	—	dotted

Partons versus Hadrons $\mathcal{C} = \langle \cos 2\phi \rangle$





LEPTO

		line
hadron level	—	solid
parton level (MEPS)	—	dashed
parton level (ME)	—	dotted