Summary of HFS WG

Part II: Experiment

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on behalf of
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XV International Workshop on Deep Inelastic Scattering, April 2007, Munich

28 experimental talks

H1 x5

ZEUS x9

hermes x2

CDF x3

DØ x2

BaBar x1

OPAL x1

PHENIX x1

STAR x1

CLAS x2

ATLAS x1

Outline

- Particle production
  - spectroscopy;
  - general properties.
- Jet production
  - prompt photons with/without jets;
  - some recent jets measurements;
  - jets and underlying events;
  - jets cross sections.
- Precise measurements and future plans

Pentaquark searches

$\Theta^+(1522-1555)$

The CLAS program

Exp	Target	Reaction	Comment		E_γ	Status
G10	d	$\gamma d \to pK^- \Theta^+$ ↳$K^+ n$ $\gamma d \to pK^- \Theta^+$ ↳$K^0 p$ $\gamma d \to \Lambda(1116)\,\Theta^+$	Test of CLAS(d) data	Θ^+	0.8-3.6	Published in progress Published
G11	p	$\gamma p \to K^0 \Theta^+$ $\gamma p \to K^- \Theta^{++}$	test of SAPHIR data (cfr STAR in d+Au)	Θ^+ Θ^{++}	1.6-3.8	Published Published
EG3	d	$\gamma d \to K^- K^+ \Xi^{--}$	test of NA49 data	Ξ_5	4-5.4	Analysis in progress
SUPER-G	p	$\gamma p \to K^- \pi^+ \Theta^+$	test of CLAS(p) test of NA49 data	Θ^+ Ξ_5	3.8-5.7	Data to be taken

Pentaquark searches

2006 PDG *

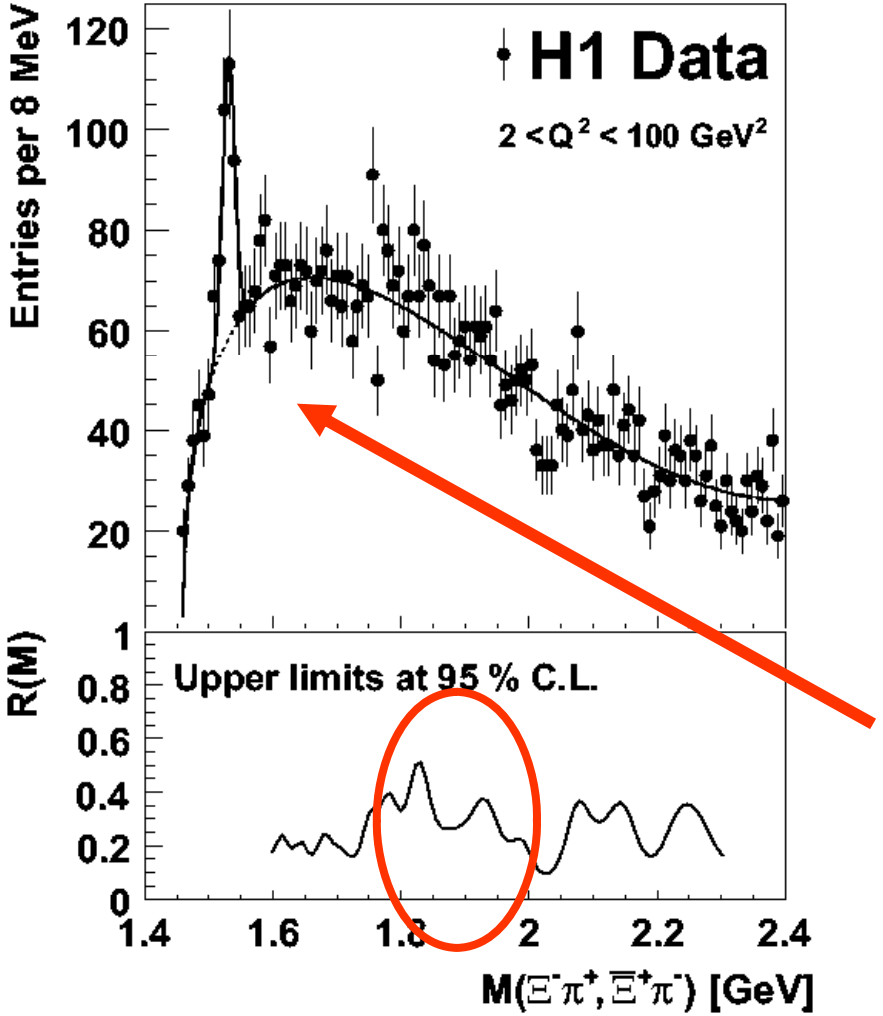
ORIGINAL EXPERIMENT			REPEATED MEASUREMENT			
Exp	Reaction	σ	Exp	Reaction	Stat X	Results
CLAS	$\gamma d \to pnK^- K^+$	~5	CLAS	$\gamma d \to pnK^- K^+$	>6	$\sigma_{TOT} < 3$ nb
SAPHIR	$\gamma p \to K^0 K^+ n$	~5	CLAS	$\gamma p \to K^0 K^+ n$	>10	$\sigma_{TOT} < 1$ nb
HERMES	$e+d \to pK^0 X$	~4	BaBar	$e+Be \to pK^0 X$	>100	No Θ^+
DIANA	$K^+Xe \to pK^0 X$	~4	Belle	$K^+Si \to pK^0 X$	~10	No Θ^+;$\Gamma_{\Theta^+} < 1$ MeV
DIANA	$K^+Xe \to pK^0 X$	~4	DIANA	$K^+Xe \to pK^0 X$	~2	σ 4.3–7.3
LEPS	$\gamma C \to K^+ K^- X$	~4	LEPS	$\gamma d \to K^+ K^- X$	~5	~3–5 σ
SVD-2	$pA \to K^0 pX$	~5–6	SVD-2	$pA \to K^0 pX$	~3–4	~8 σ

WORK IN PROGRESS

Exp	Reaction	σ	Comment
ZEUS	$e+p \to pK^0 X$	~4–5	Analysis of new data with improved vertex det
COSY	$pp \to K^0 p\Sigma^-$	~5	Analysis of new data with 5X statistics
CLAS	$\gamma p \to \pi^+ K^- K^+ n$	~7–8	Run in 2008
CLAS	$\gamma d \to K^- K^+ \Xi^{--}$	~4 (by NA49)	Analysis in progress

Pentaquark searches

$\Theta^{+}(1540) \rightarrow \Xi^{0/--}(1860)$ only NA49

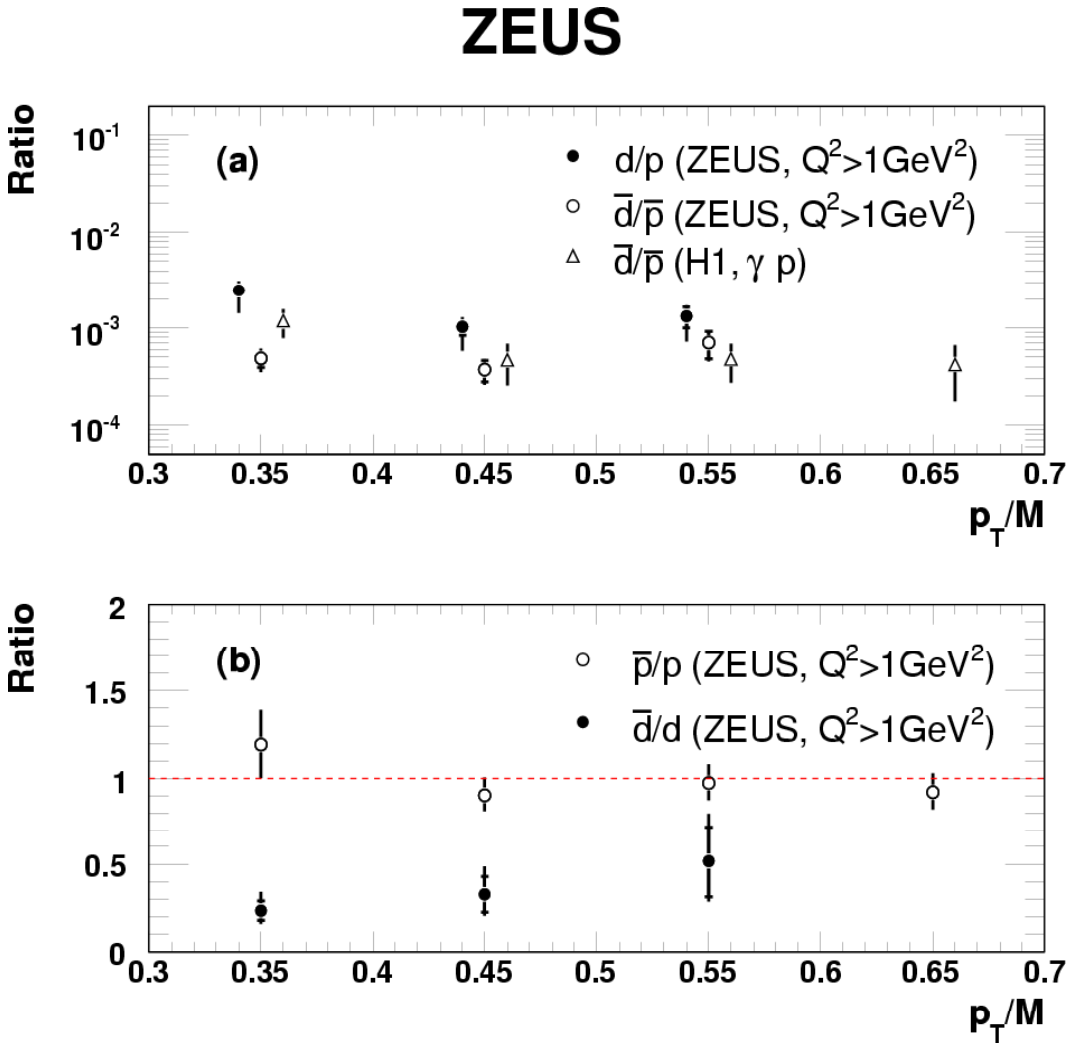


$\Xi^{0}(1530)$

No signal

agree

Deuterons and antideuterons in DIS



- **First measurement in DIS;**
- **First d in elem.particles collisions**

Coalesence model

$$\frac{E_d}{\sigma_{tot}}\frac{\mathrm{d}^3\sigma_d}{\mathrm{d}p_d^3} = B_2\left(\frac{E_p}{\sigma_{tot}}\frac{\mathrm{d}^3\sigma_p}{\mathrm{d}p_p^3}\right)^2$$

$$\frac{\bar{d}}{d} = \left(\frac{\bar{p}}{p}\right)^2$$

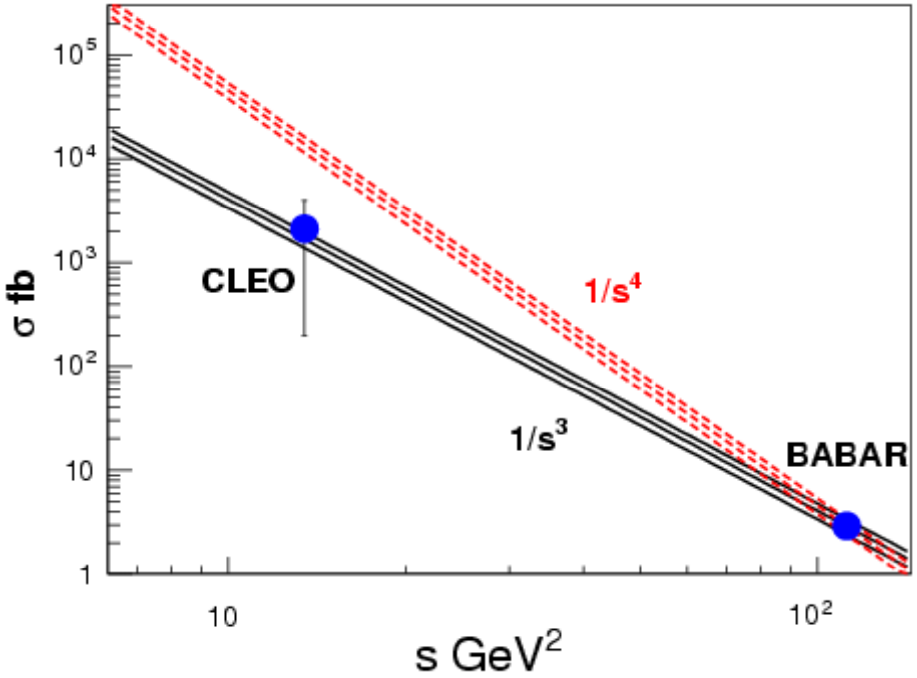
Does not work. App.3 times less antideuterons, than deuterons

Particle production in ee

First observation of:

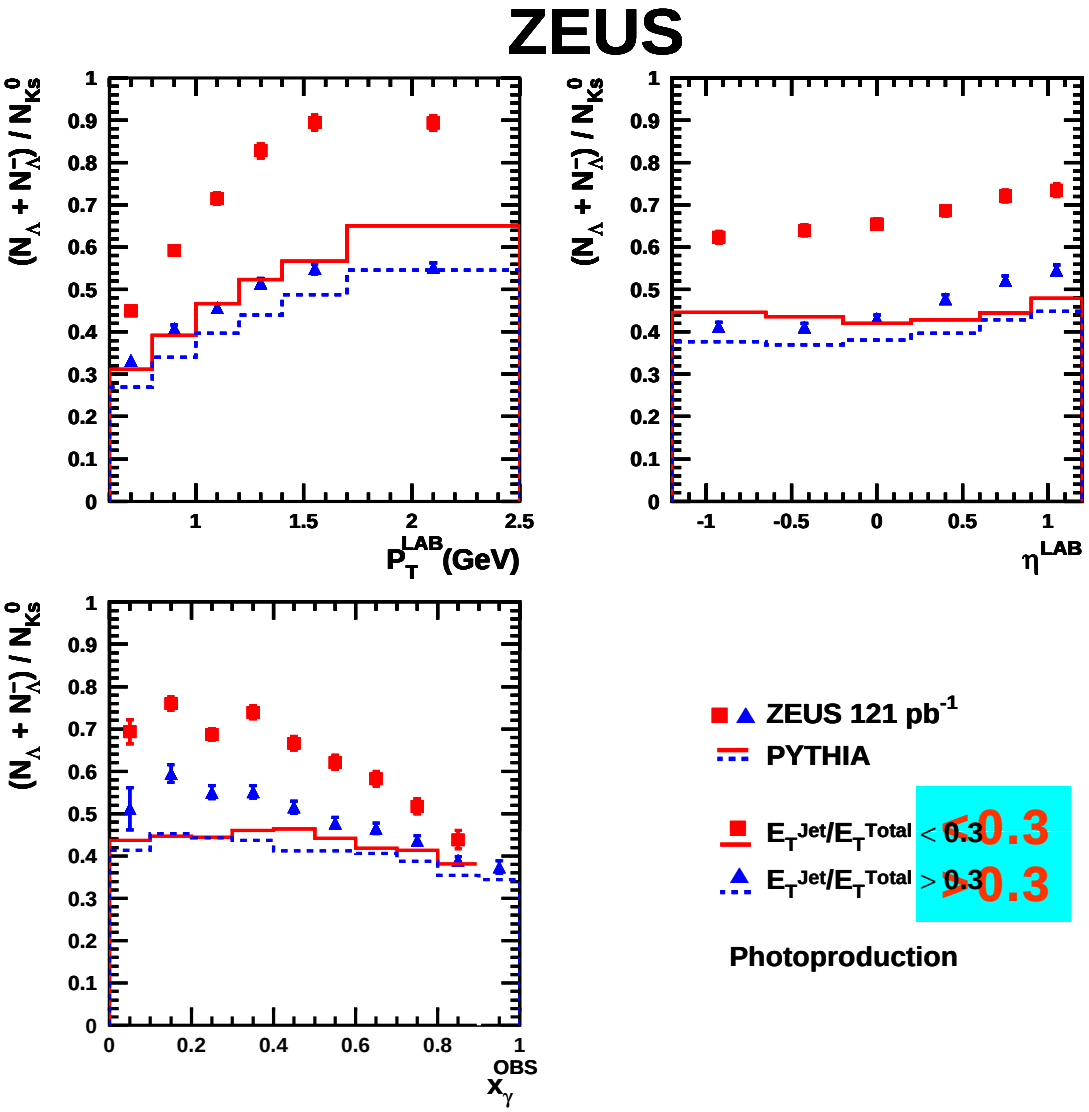
$$e^+e^- \to \rho^0\rho^0(\phi) \qquad e^+e^- \to \gamma^*\gamma^* \to q\bar{q}q\bar{q} \to \rho^0\rho^0(\phi)$$

Two virtual-photons annihilation



$$e^+e^- \to \phi\eta$$

Barion-to-meson ratio in pp and ep

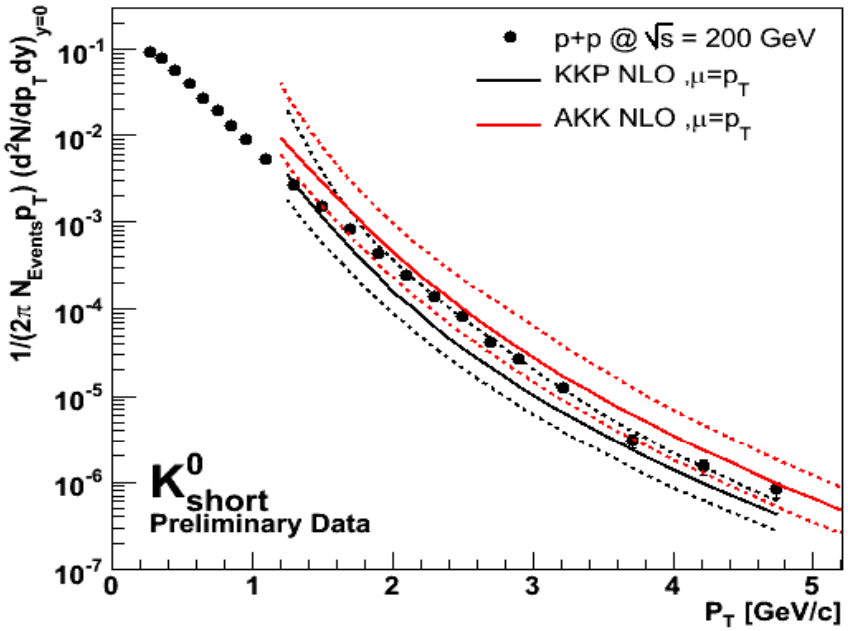


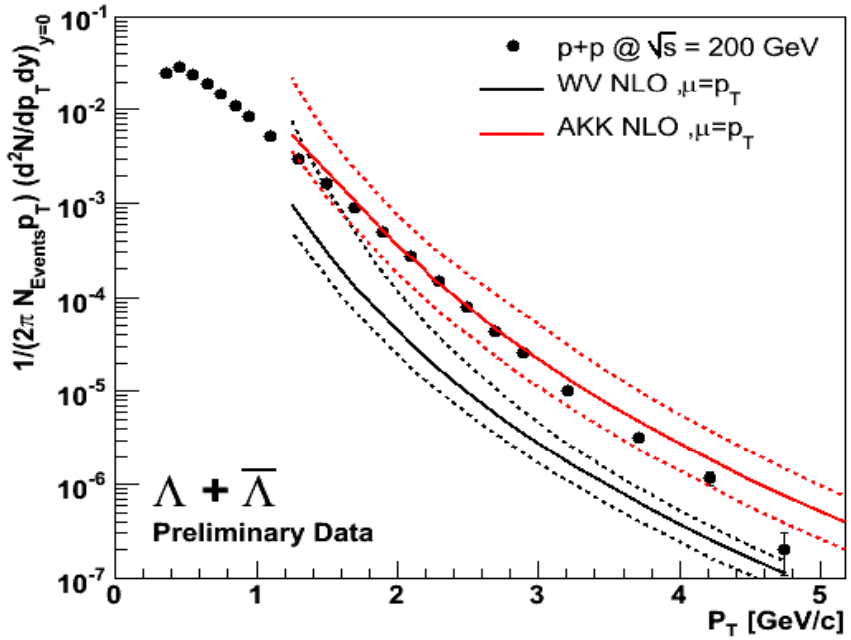
PYTHIA does not describe the ratio

The same we see at ZEUS. Splitting the sample to "collimated" and "isotopic" events shows that the latter are not described.

Particle production in pp and NLO

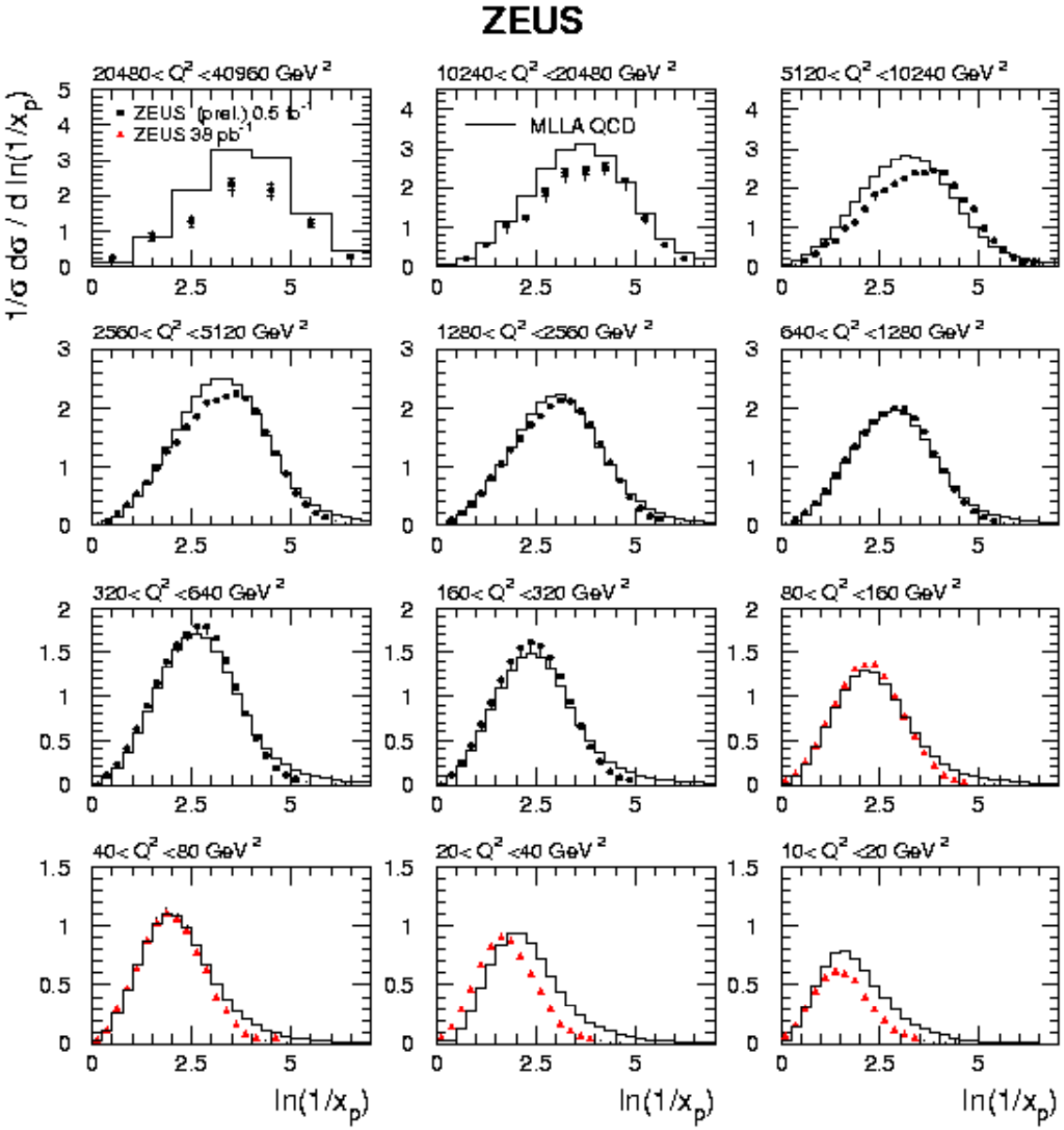
AKK NLO uses the **light flavor FF** obtained
from the light flavor separated measurements in e+e- collisions by OPAL





And even strange particle production

Scaled momentum spectra in ep



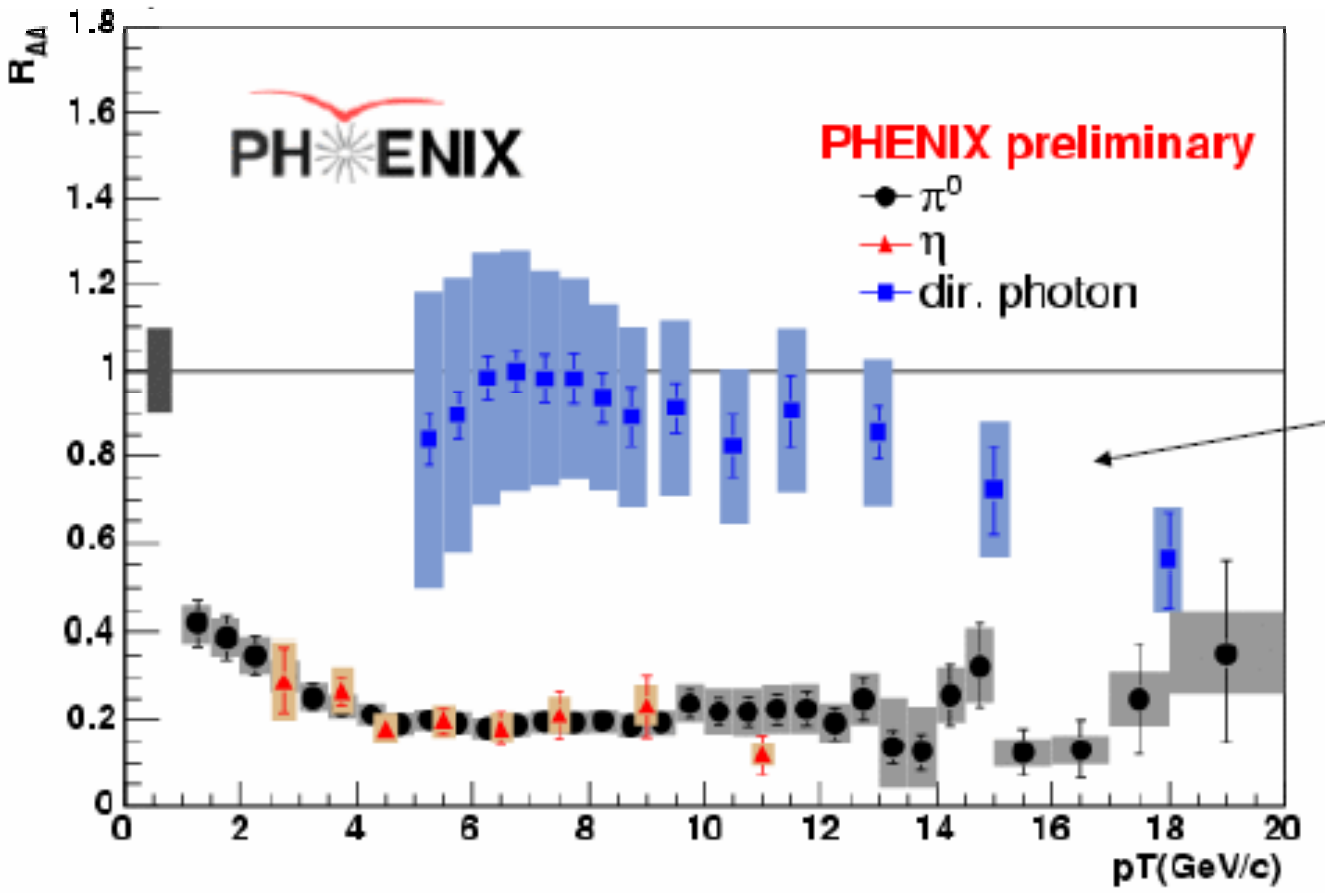
$$x_P = \frac{2P^{Breit}}{Q}$$

This measurement uses almost all HERAI+HERAII data

$$0.5\,pb^{-1}$$

Fragmentation in jets from CDF

Particles in pp and heavy-ion collisions

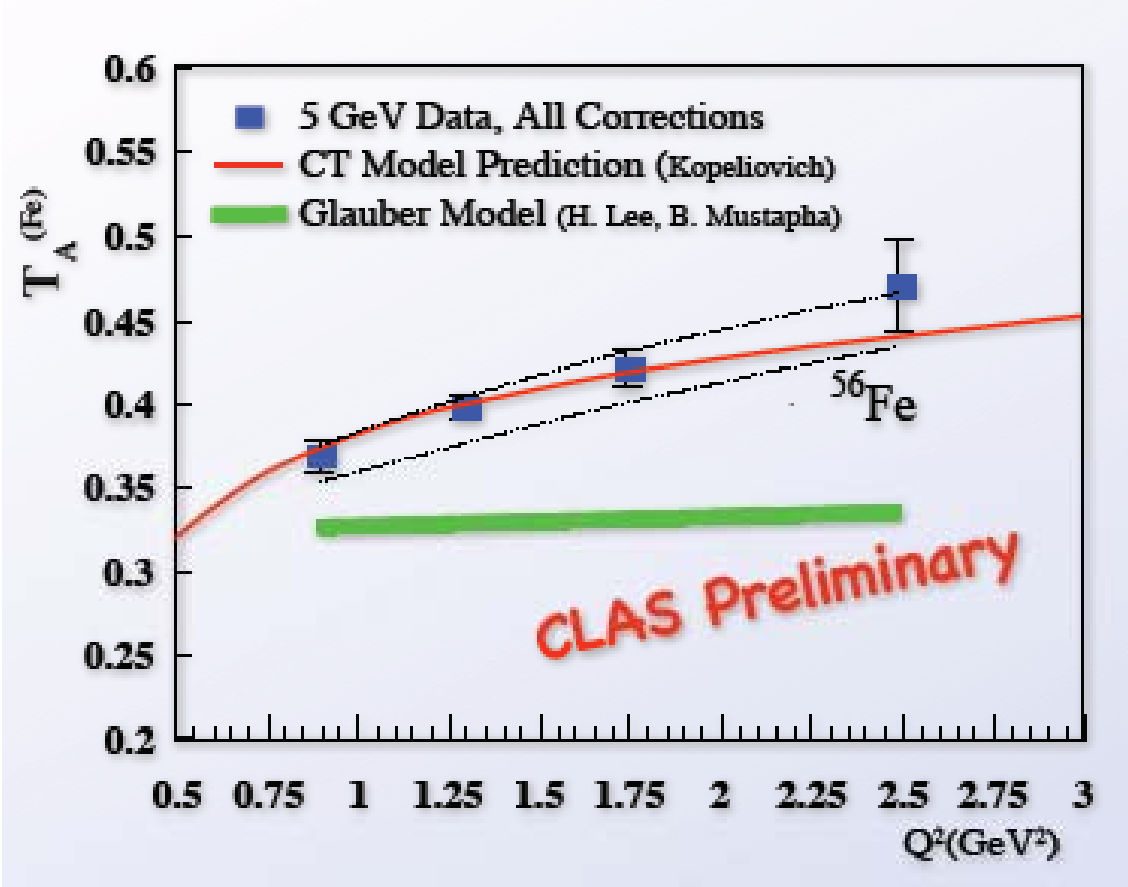


Ratio of (Au+Au)/ (scaled p+p spectra)

QGP effects

Color transparency at CLAS

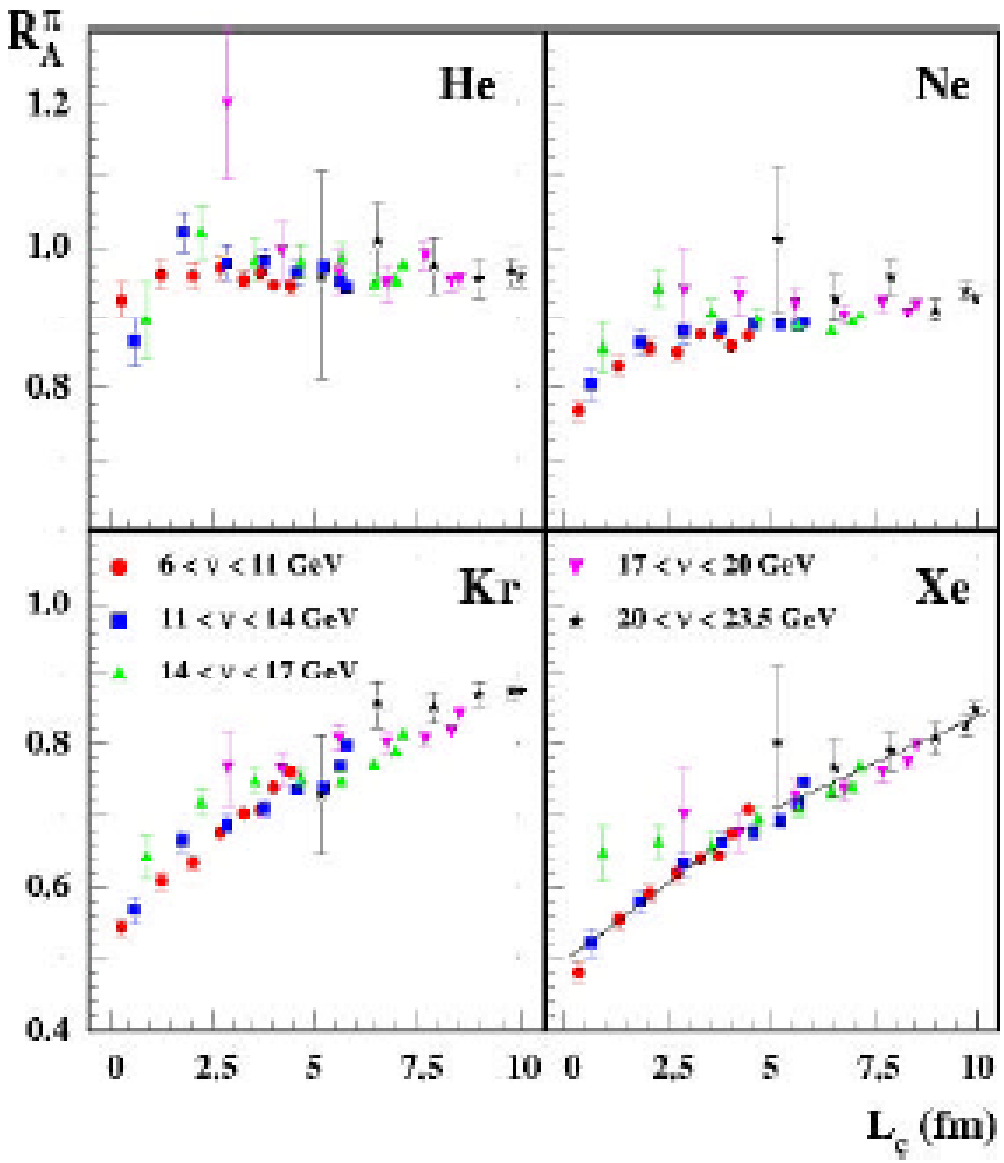
Reduction of the strong interaction due to "minihadrons" effect



$$T(A,Q^2) = \frac{\sigma_A}{A\sigma_N}$$

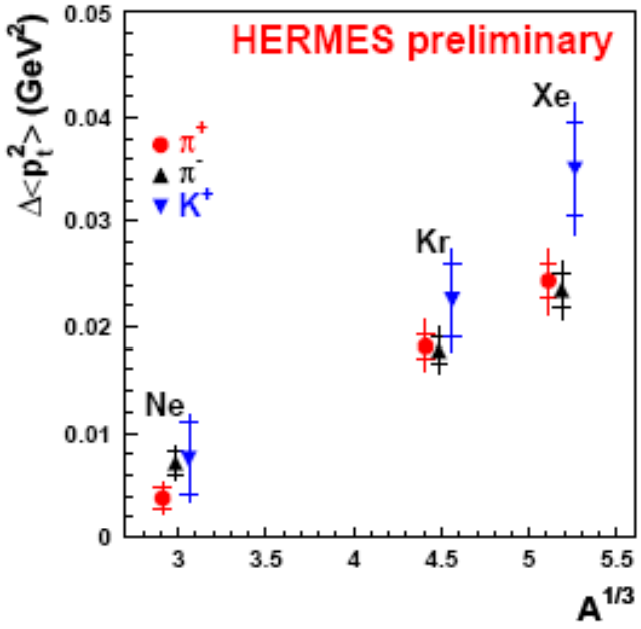
Nuclear transp. should increase with hardening of the scale

Nuclear Attenuation dependence on the formation length



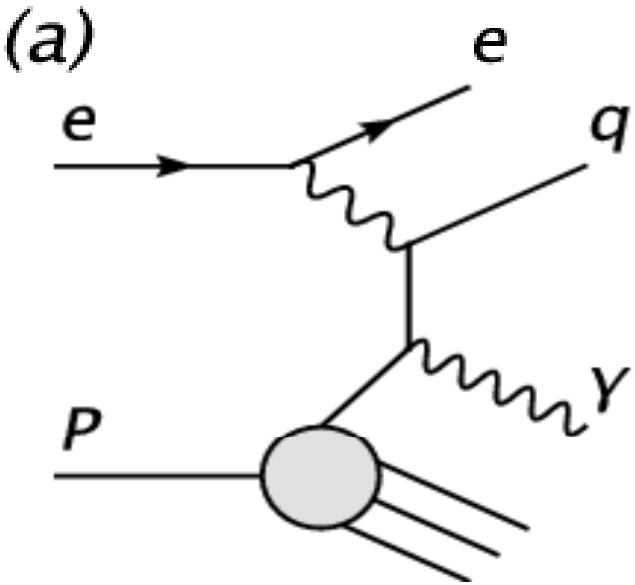
$$R_A^h(\nu, z, Q^2, p_t^2; \phi) = \frac{\left\{ \frac{N_h^{SIDIS}(\nu, z, Q^2, p_t^2; \phi)}{N_h^{DIS}(\nu, Q^2)} \right\}_A}{\left\{ \frac{N_h^{SIDIS}(\nu, z, Q^2, p_t^2; \phi)}{N_h^{DIS}(\nu, Q^2)} \right\}_D}$$

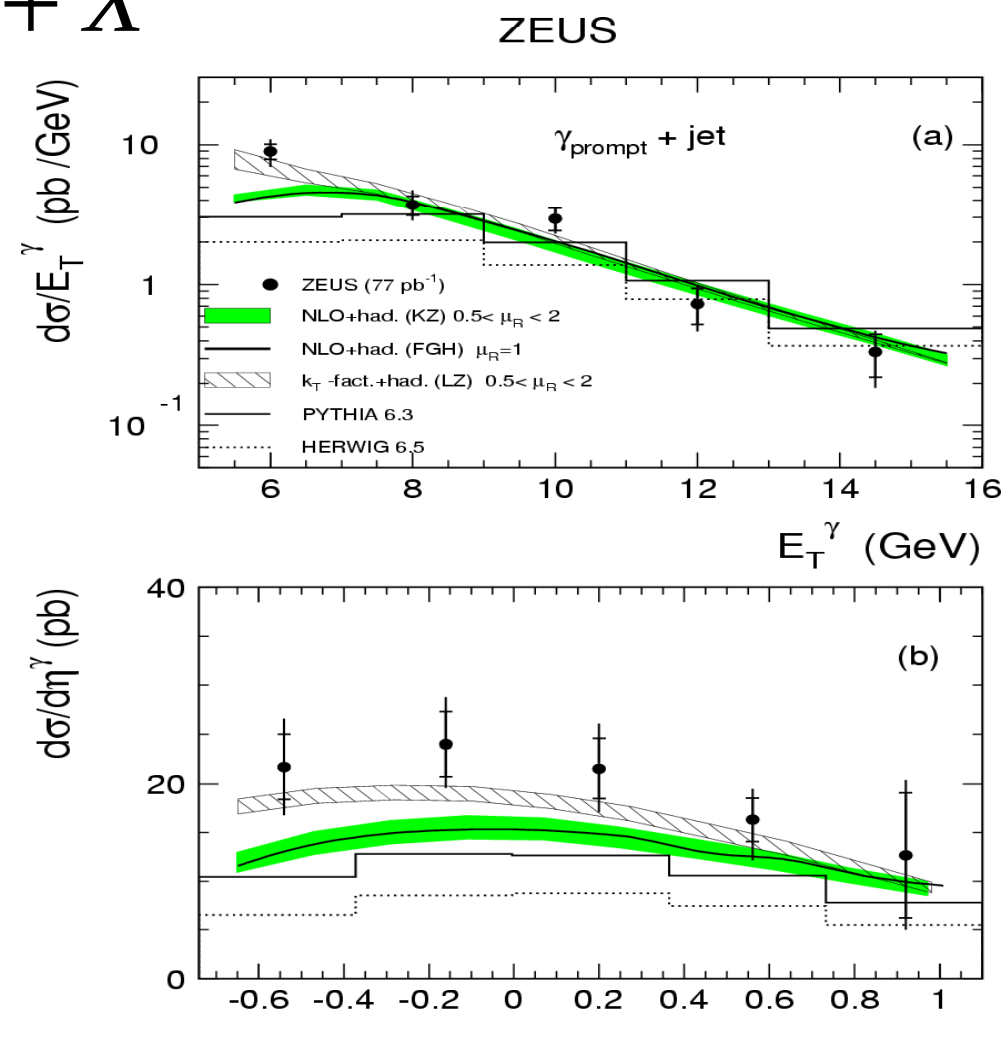
Pt-broadening



Prompt photons with jet in PHP

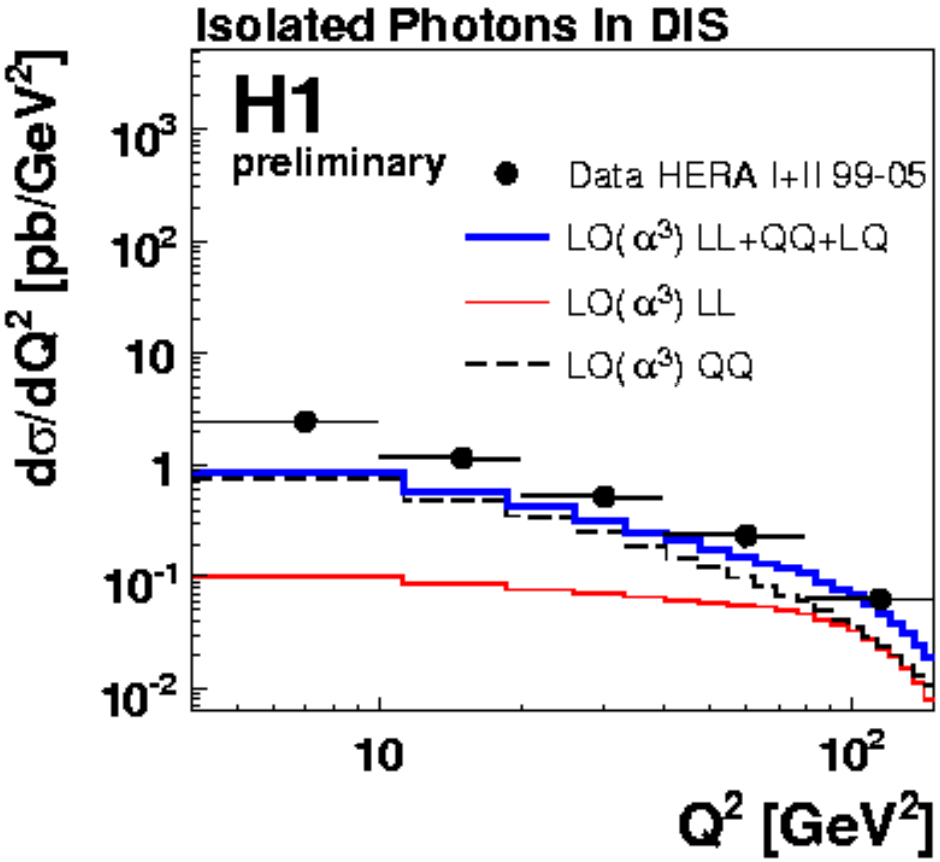
$$e + p \rightarrow e + \gamma + jet + X$$





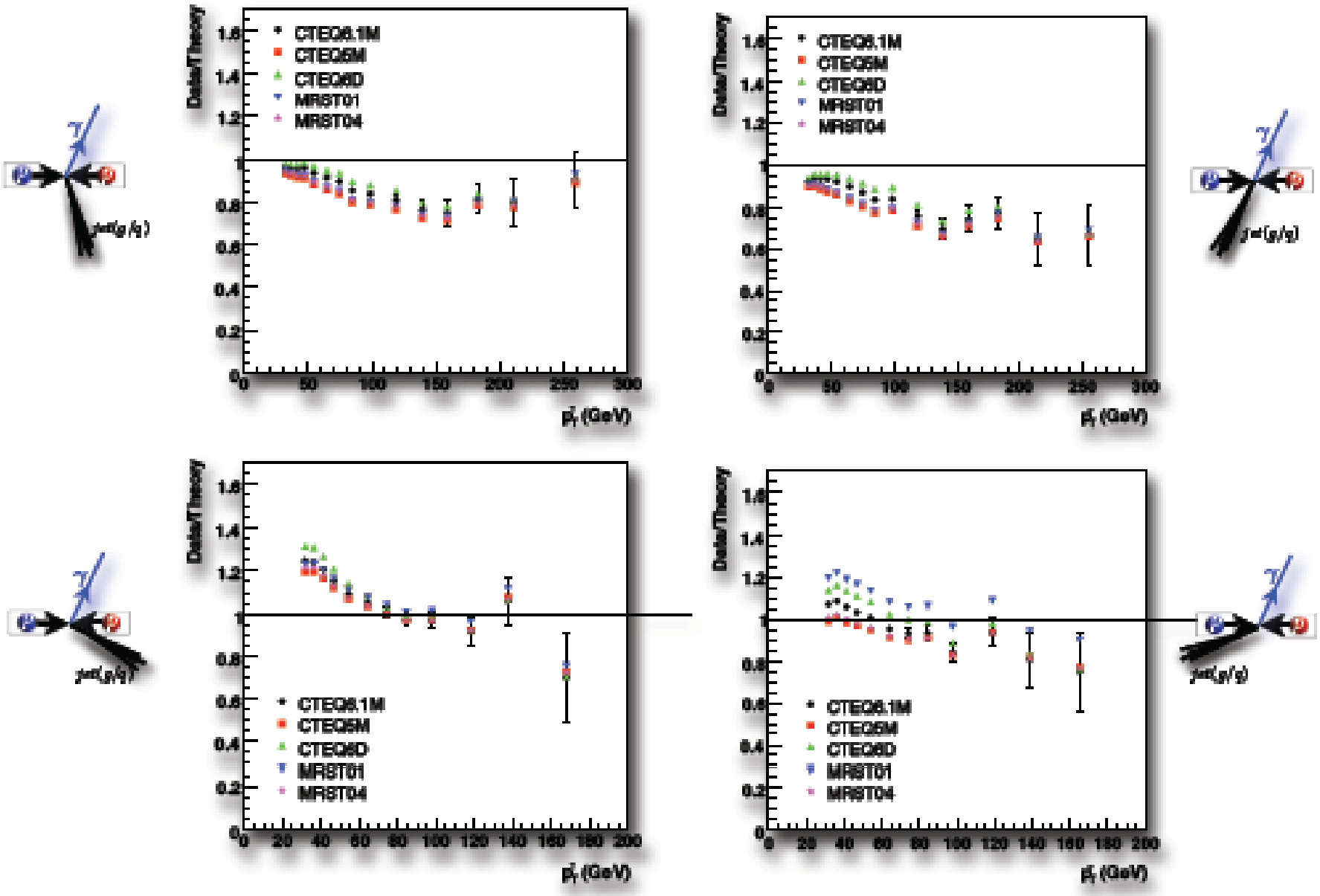
Only the resent LZ calculation describes the data (with.unc.)

Prompt photons with/without jet in DIS

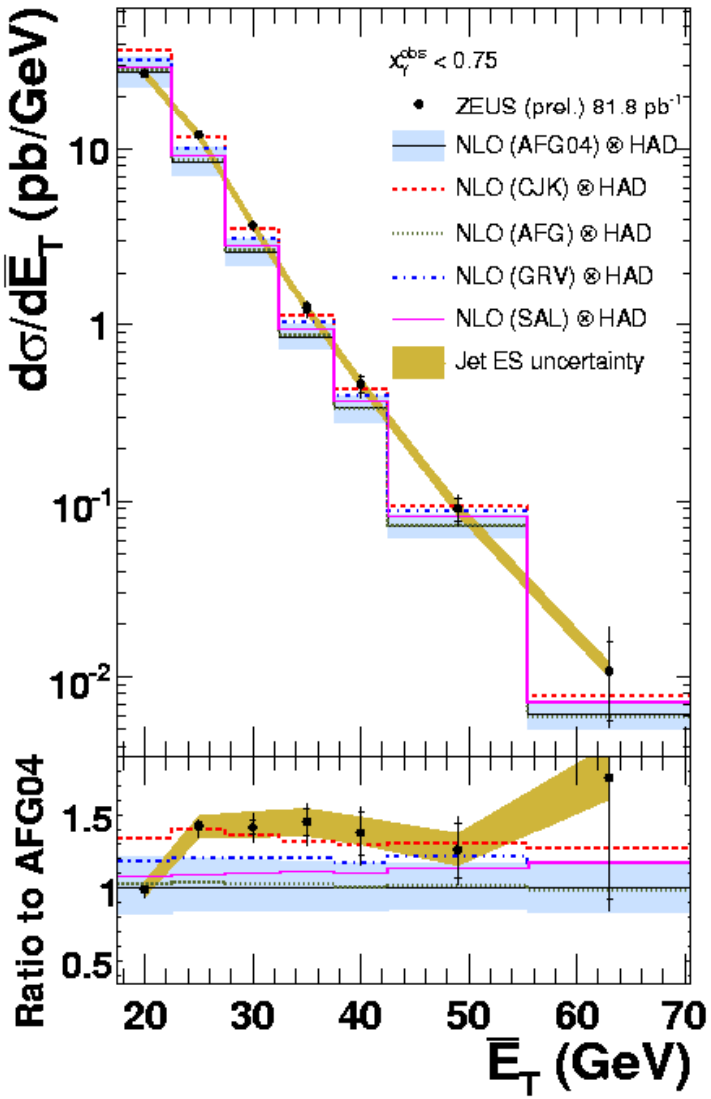


The LO calculations and MC do not describe the data

Photon plus jet at D0 (data/NLO)

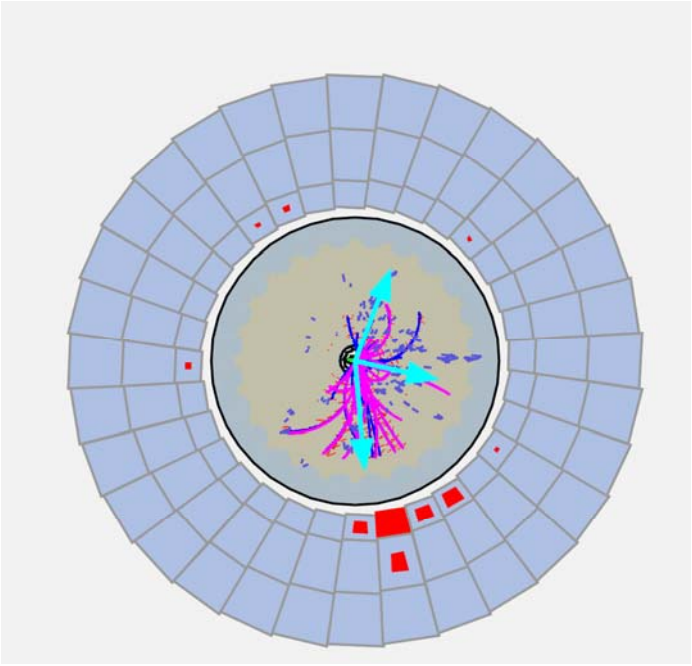


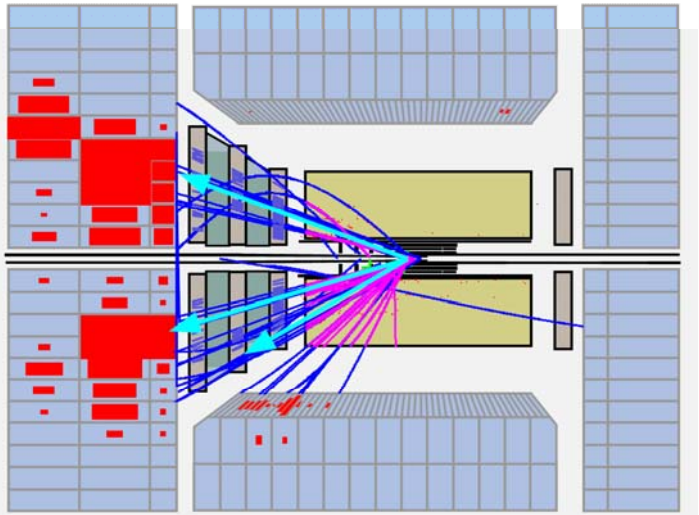
High Et forward dijets in PHP



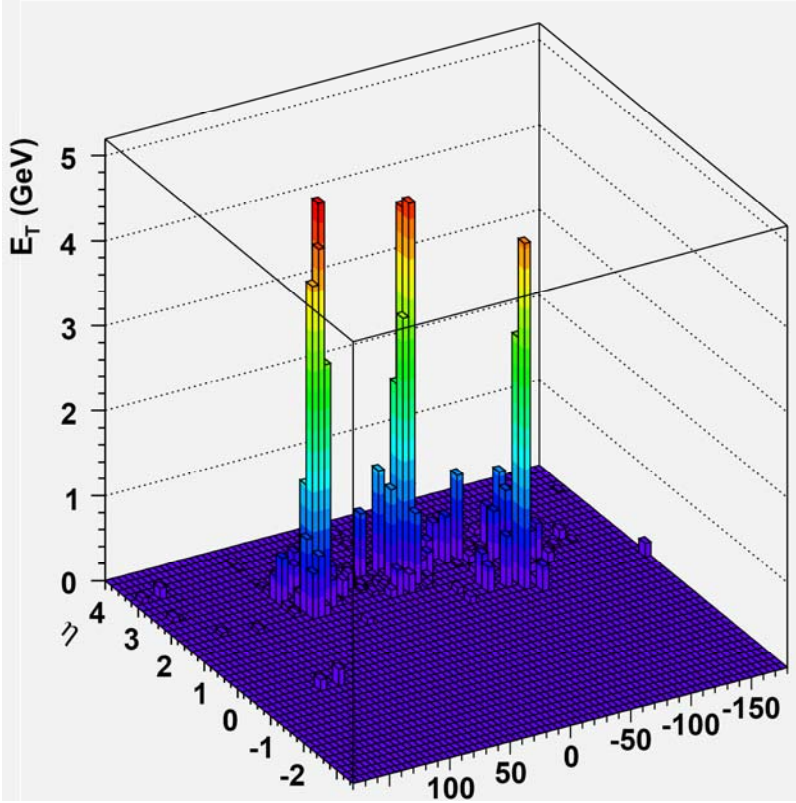
Data have the potential to further constrain the parton densities of the proton and photon

Jets in CC from ZEUS

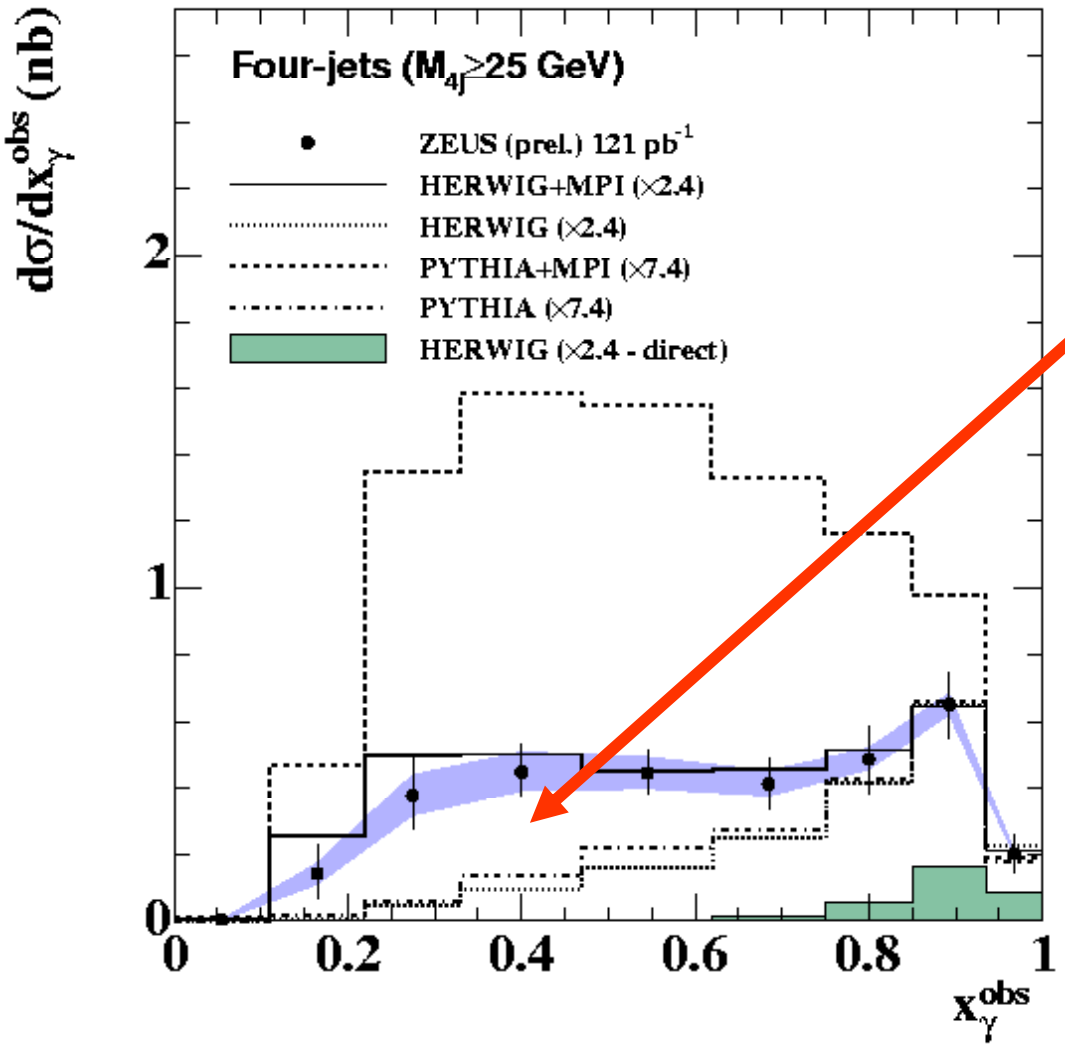




First analysis of trijet events



Multijet production in PHP

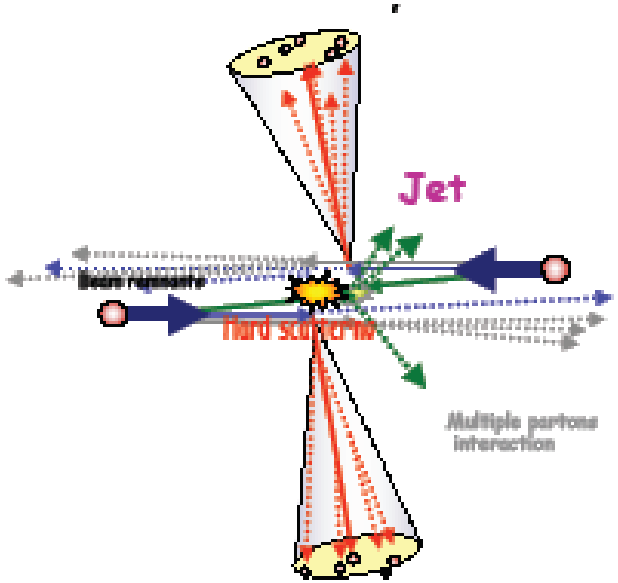


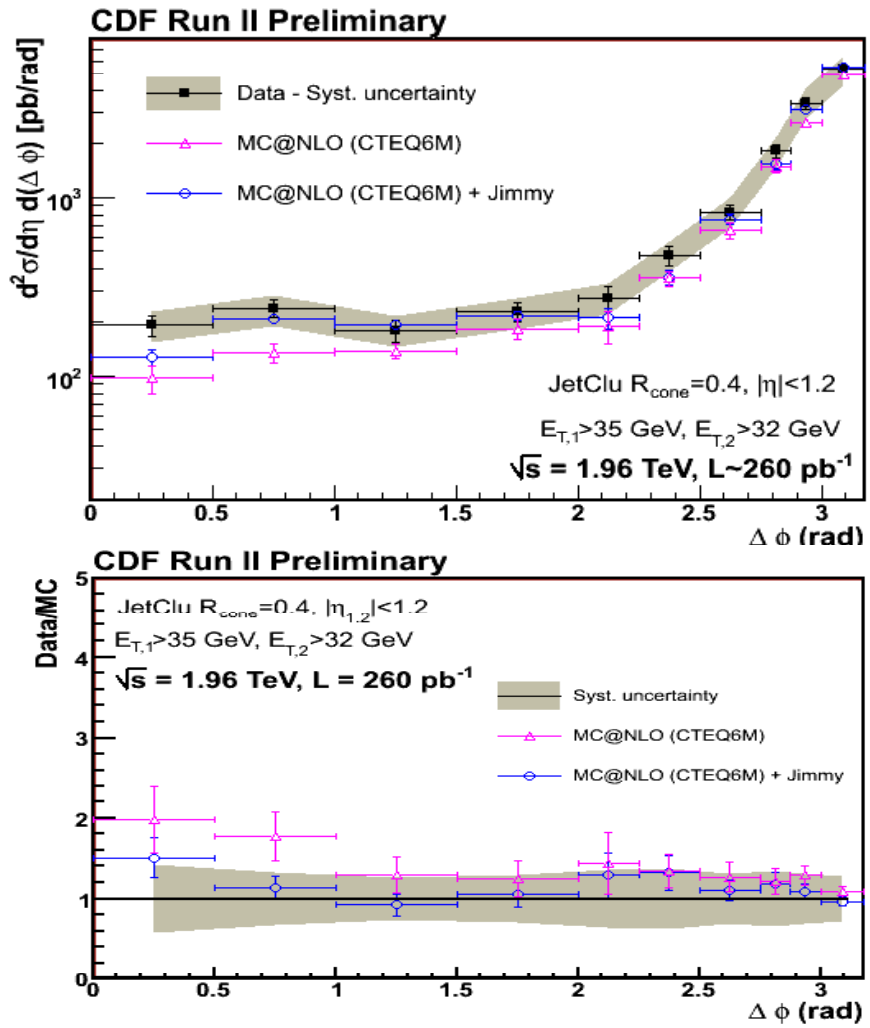
Need for MPI

- Multijets
- Resolved
- Low Mnj

H1 works on minijets in DIS

$b\bar{b}$ measurements at CDF

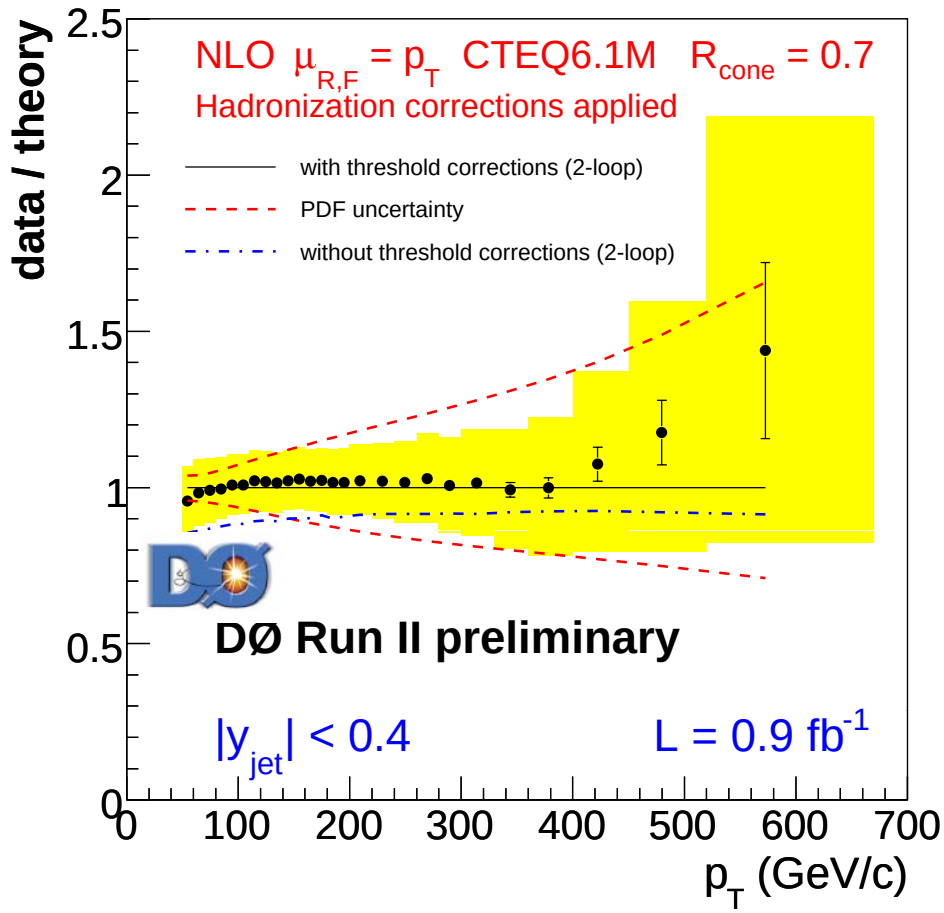




Azimuthal correlation is sensitive to production mechanism, but it also demonstrates importance of MPI

Jets in pp

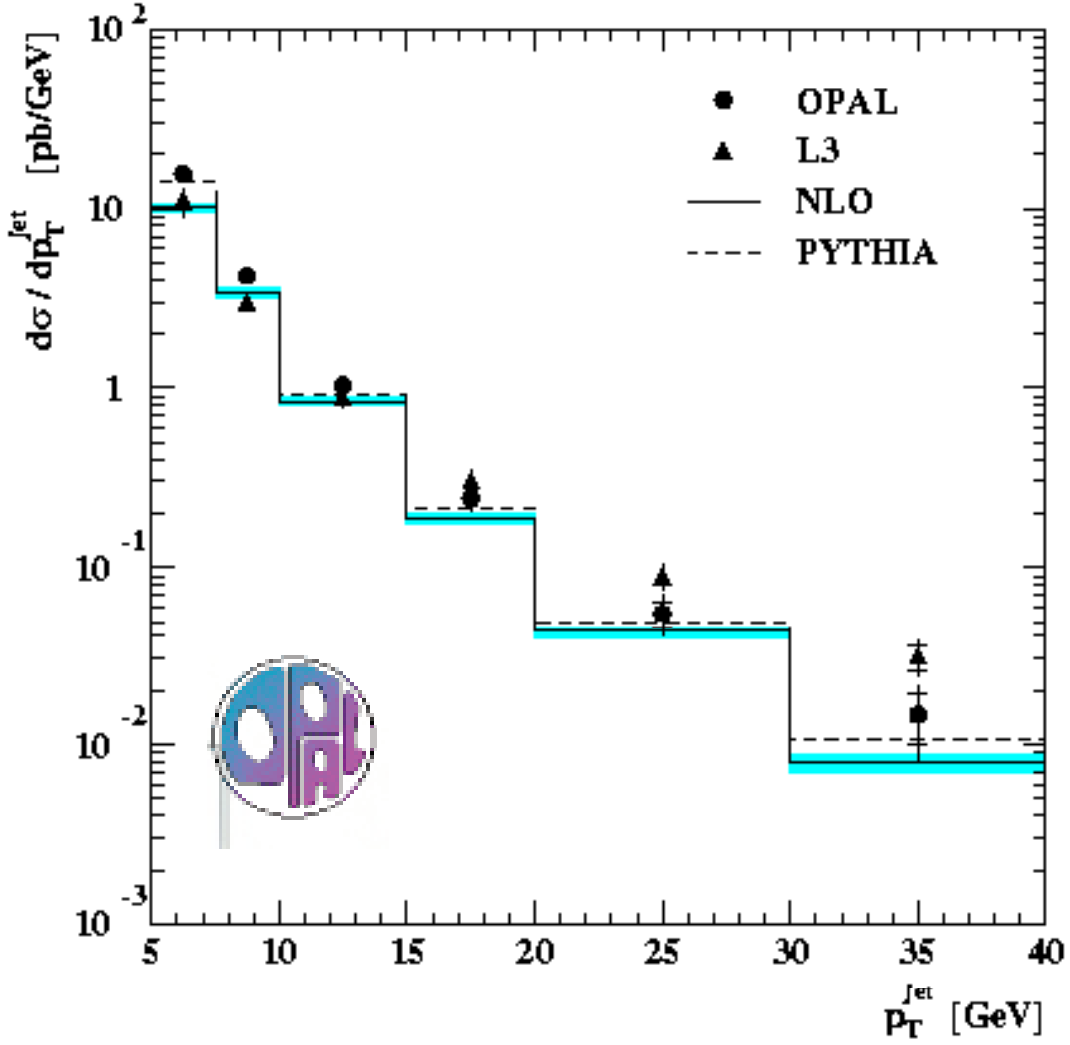
Inclusive jets from D0



W+jets, Z+jets from CDF

Well described by NLO

Jets in ee



Inclusive jet cross section is reasonably described by NLO.

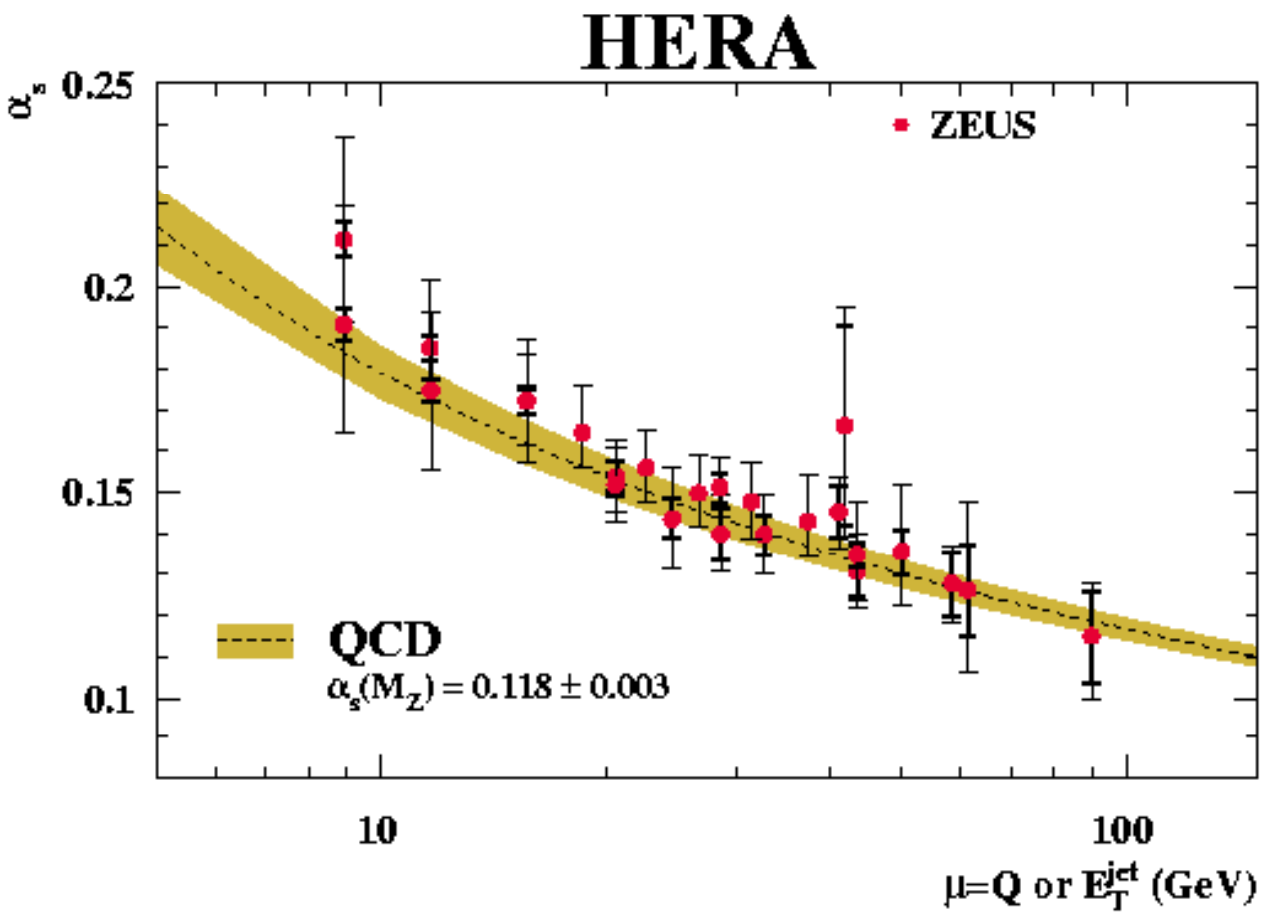
Why different from L3?

Jets in ep

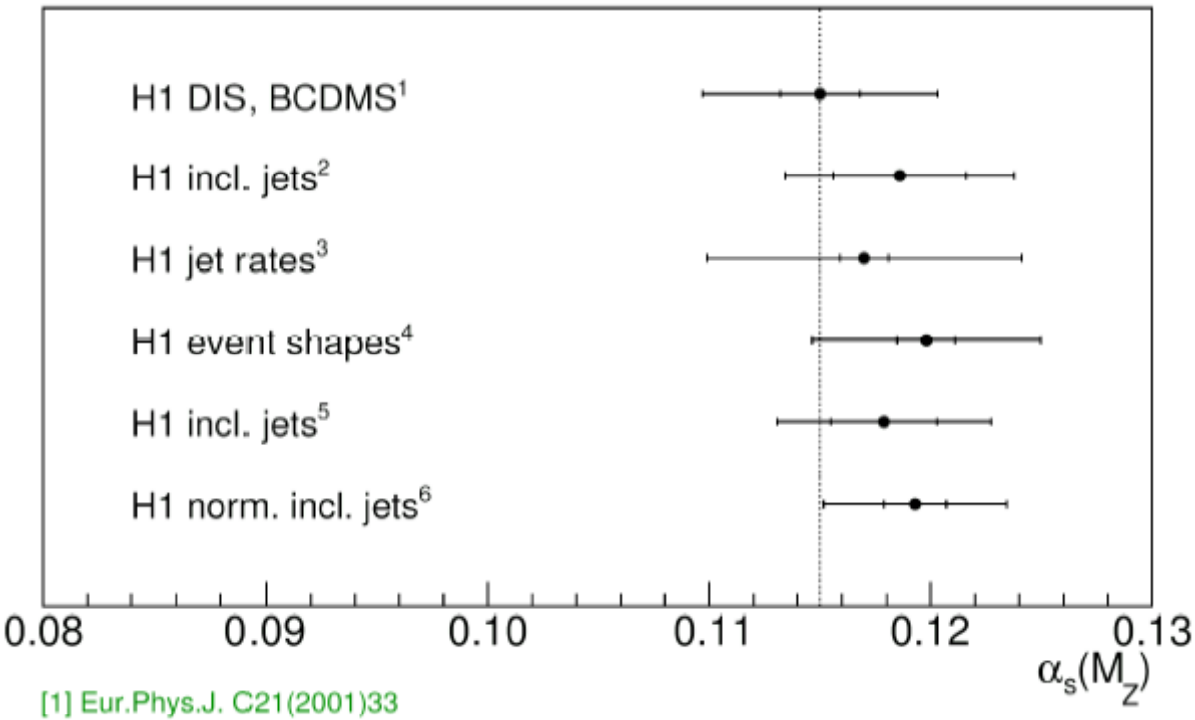
- Inclusive from H1 at high and low Q^2;
- Inclusive from ZEUS using HERAI+II;
- Jet radius;
- etc

Very good description by NLO

Precise QCD measurements

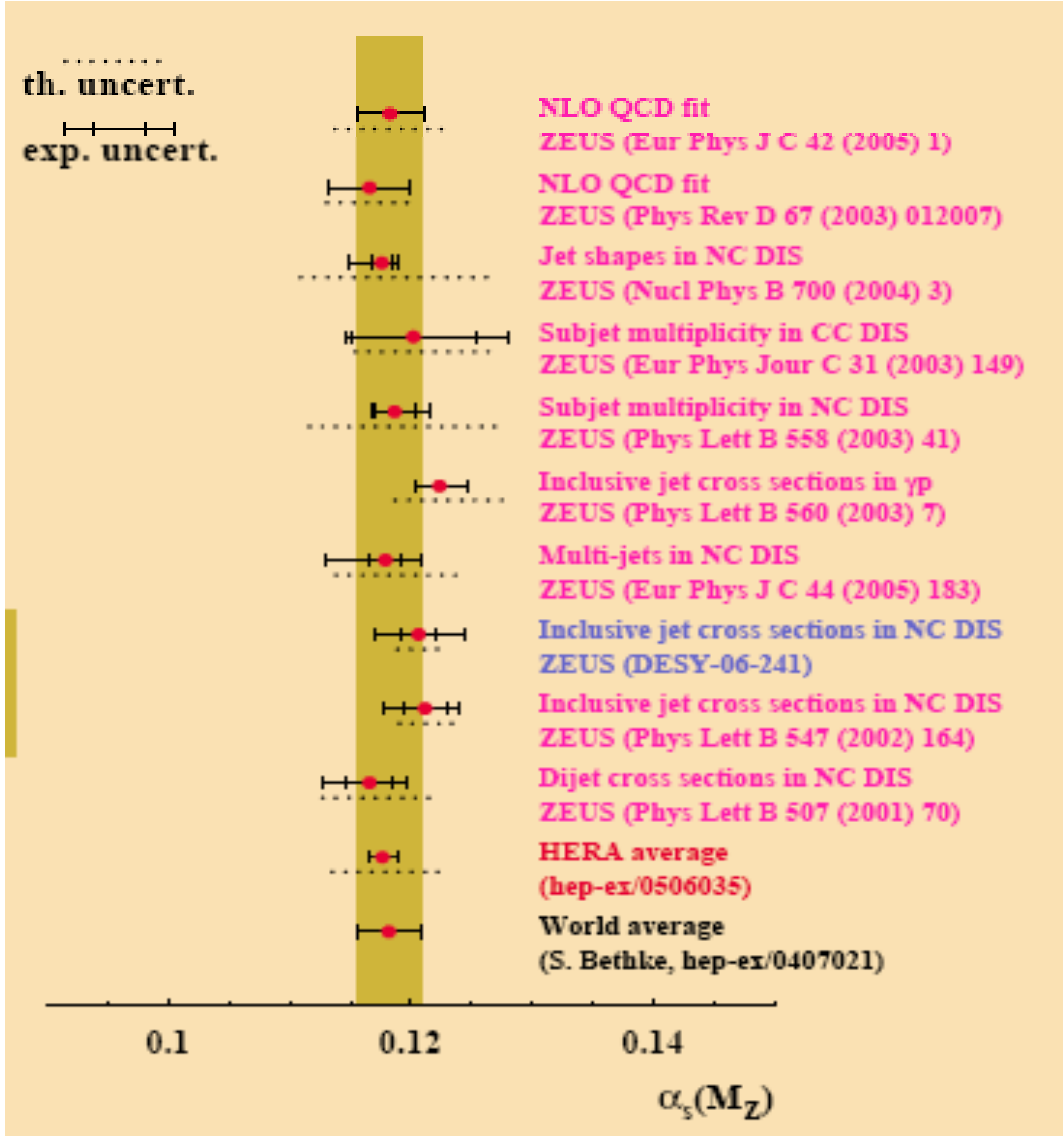


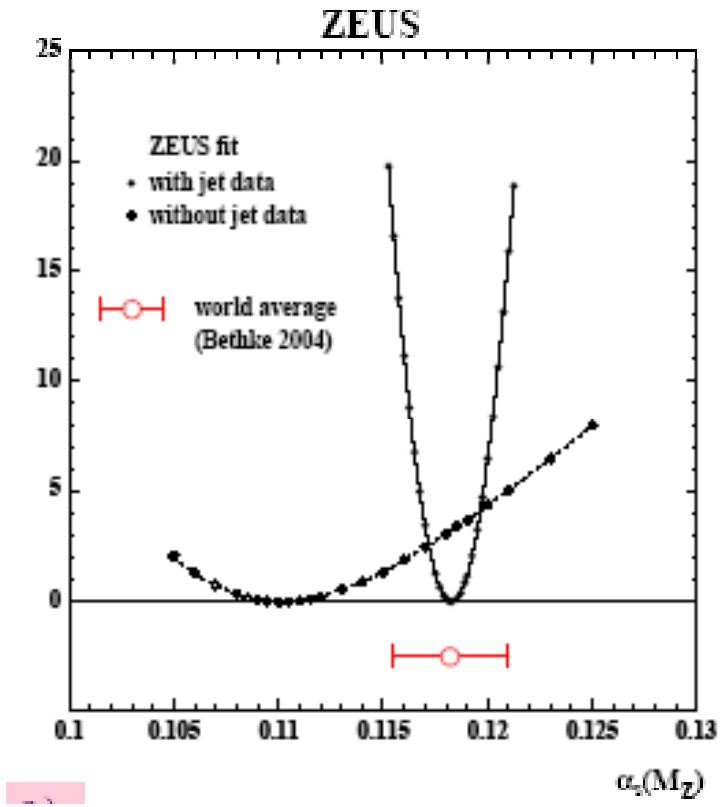
Precise QCD measurements



[1] Eur.Phys.J. C21(2001)33
[2] Eur.Phys.J. C19(2001)289-311
[3] Eur.Phys.J. C6(1999)575
[4] Eur.Phys.J. C46(2006)343-356
[5] submitted to DIS07
[6] submitted to DIS07

Precise QCD measurements





Future

- More precise measurements. Increased statistics, improved systematics and theoretical uncertainties.
- There was already one QCD LHC talk - “Prospects for inclusive jet measurements at ATLAS” .