New results from ZEUS

HERA Symposium, DESY
19th june 2012

Olaf Behnke (DESY)

Tour through perturbation series:

$\alpha^0\alpha_s^0$ New physics: Leptoquarks

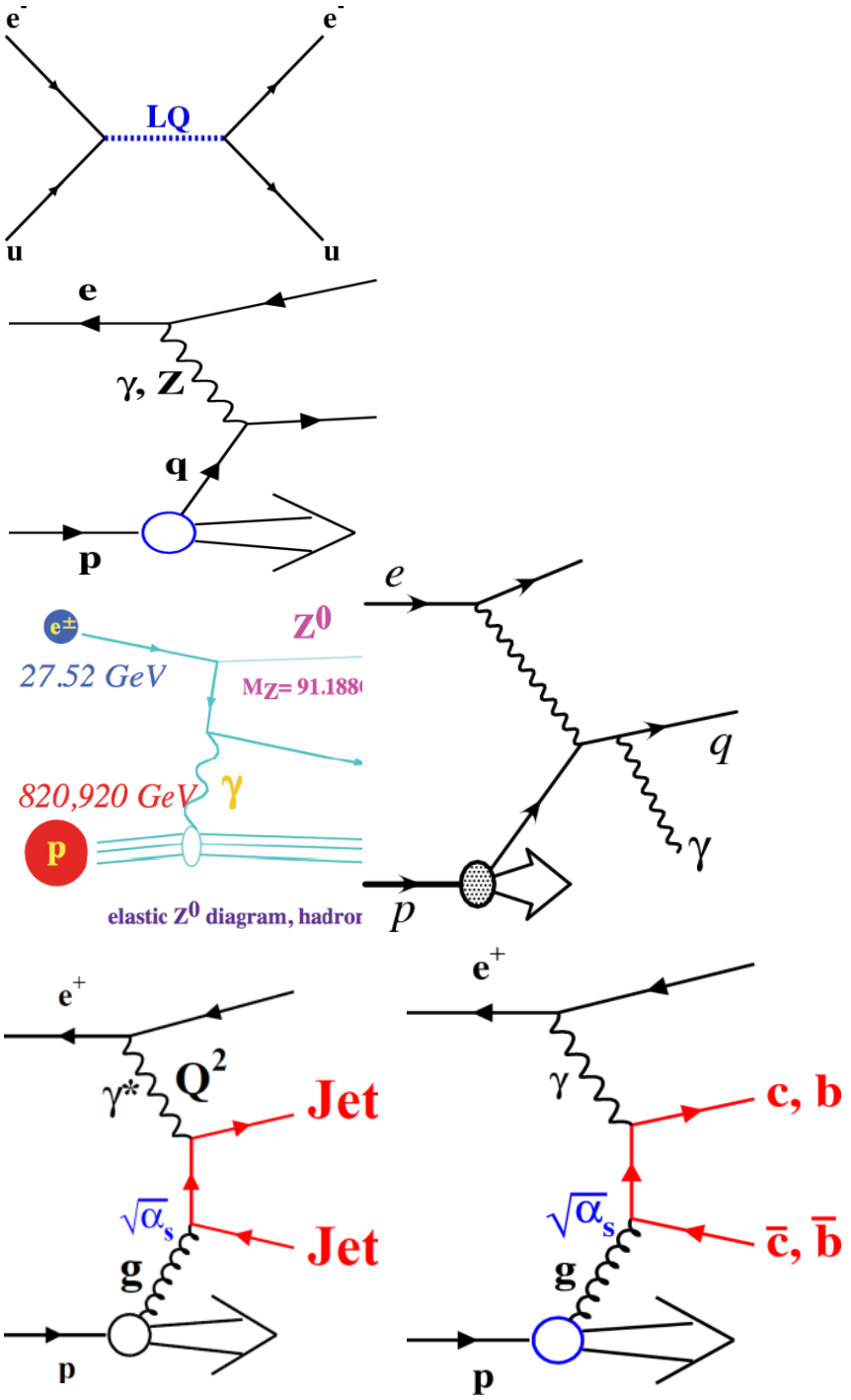
$\alpha^2\alpha_s^0$ Inclusive e+p neutral current

$\alpha_w\alpha^2\alpha_s^0$ Z0 production

$\alpha^3\alpha_s^0$ Isolated photons

$\alpha^2\alpha_s^1$ Inclusive jet photoproduction

$\alpha^2\alpha_s^1$ Charm production in DIS



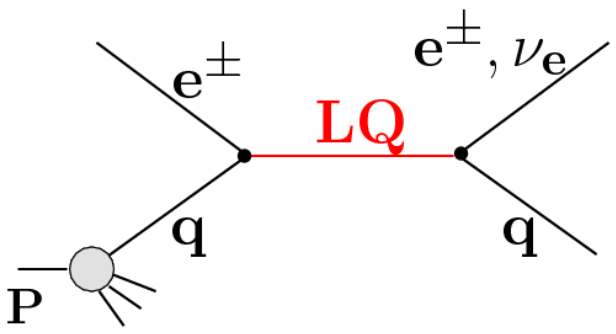
Tour through perturbation series:

$\alpha^0\alpha_s^0$	New physics: Leptoquarks	DESY-12-077
$\alpha^2\alpha_s^0$	Inclusive e+p neutral current	ZEUS-prel-11-003
$\alpha_w\alpha^2\alpha_s^0$	Z0 production	ZEUS-prel-12-001
$\alpha^3\alpha_s^0$	Isolated photons	DESY-12-089
$\alpha^2\alpha_s^1$	Inclusive jet photoproduction	DESY-12-045
$\alpha^2\alpha_s^1$	Charm production in DIS	ZEUS-prel-11-012 ZEUS-prel-12-002

Search for Leptoquarks

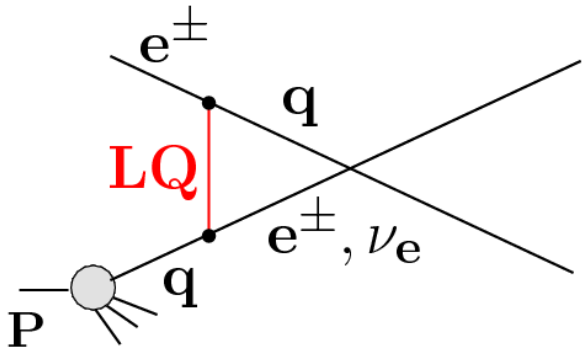
DESY-12-077

s-channel

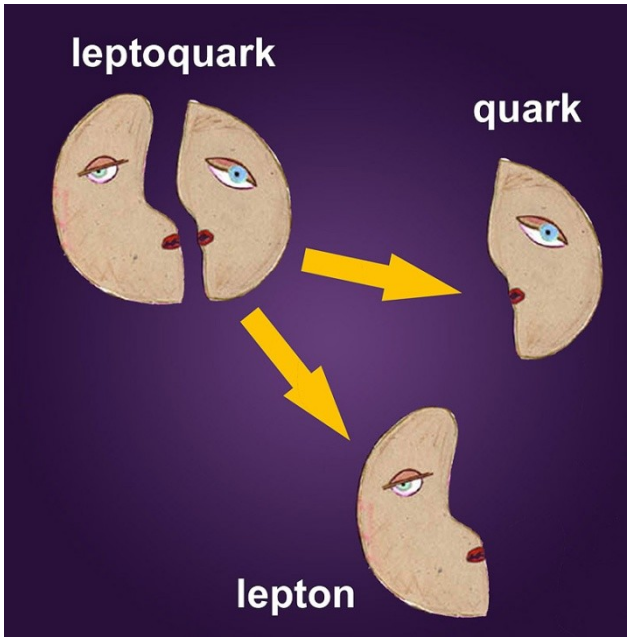


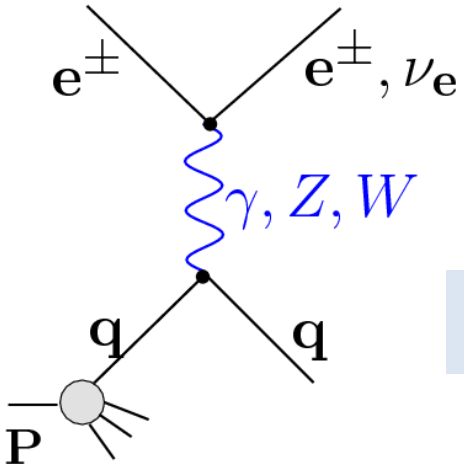
(a)

u-channel



(b)



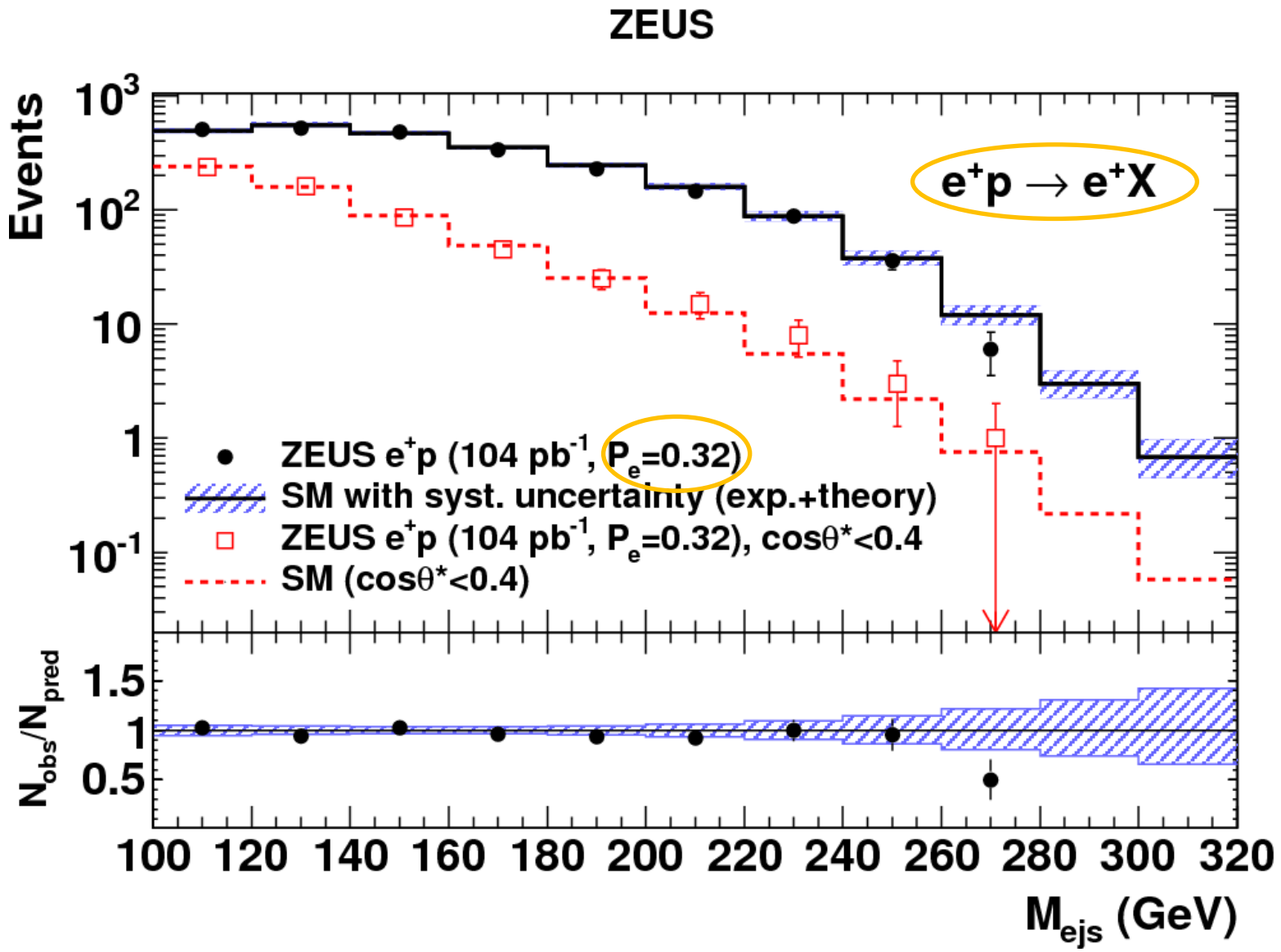


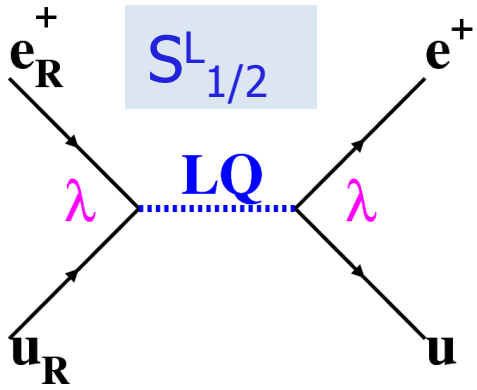
(c)

SM background

Search for Leptoquarks

DESY-12-077

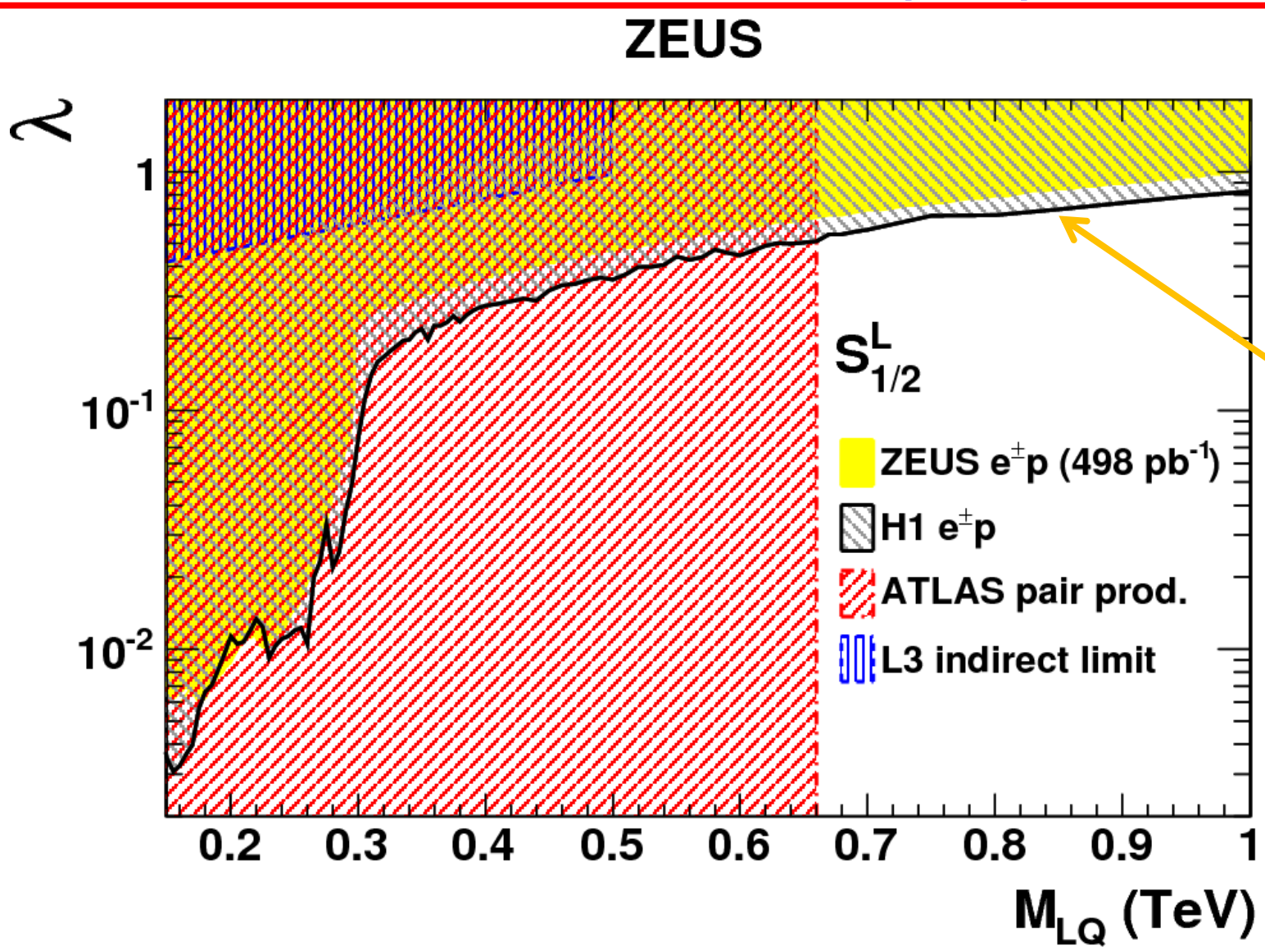




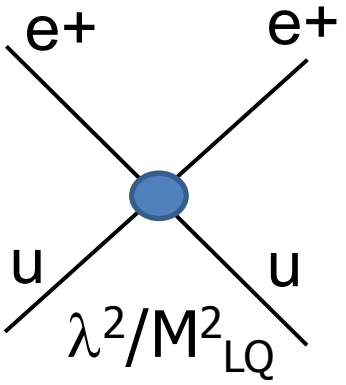
→ No signs for LQ signal

Search for Leptoquarks

DESY-12-077

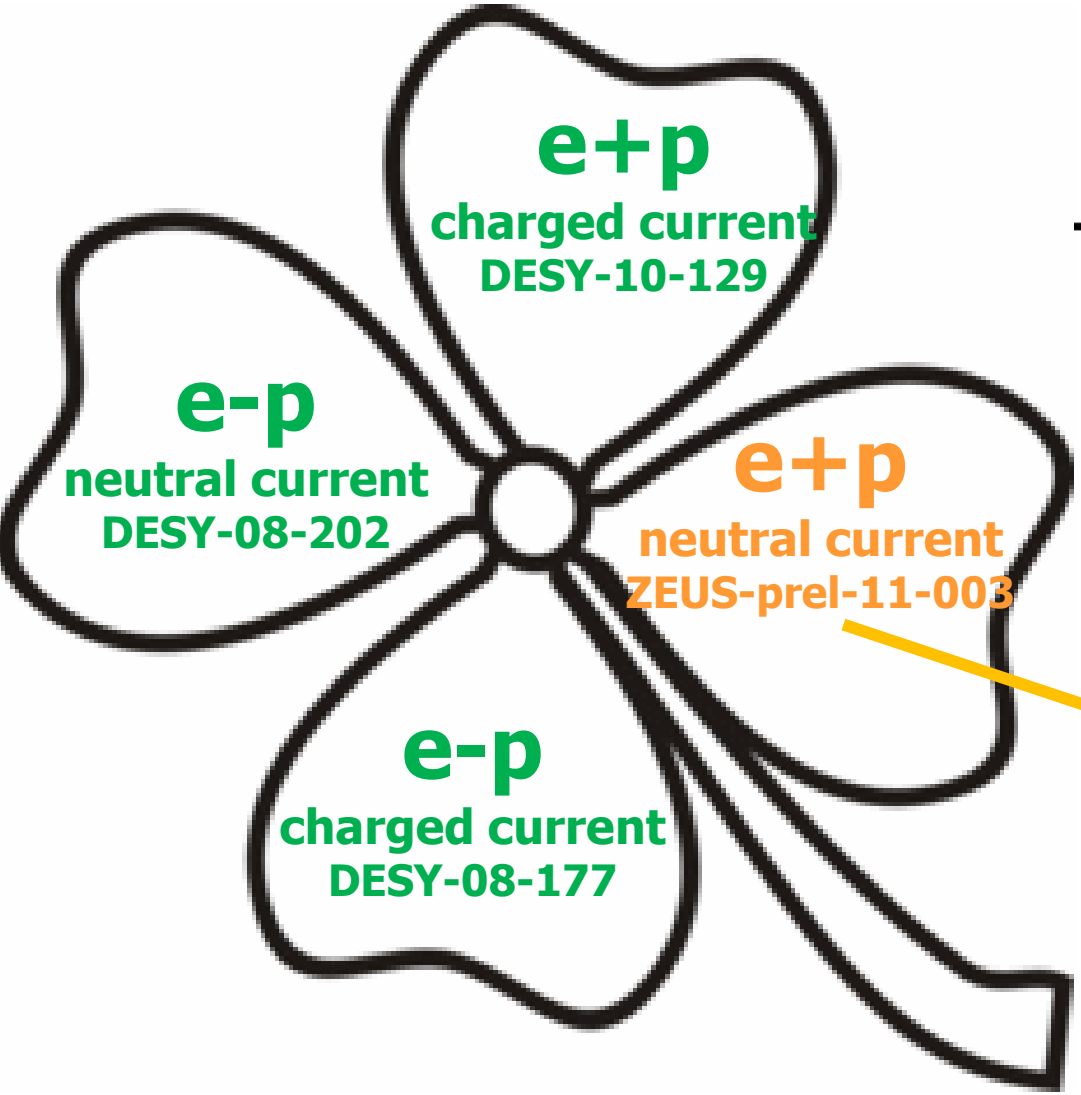


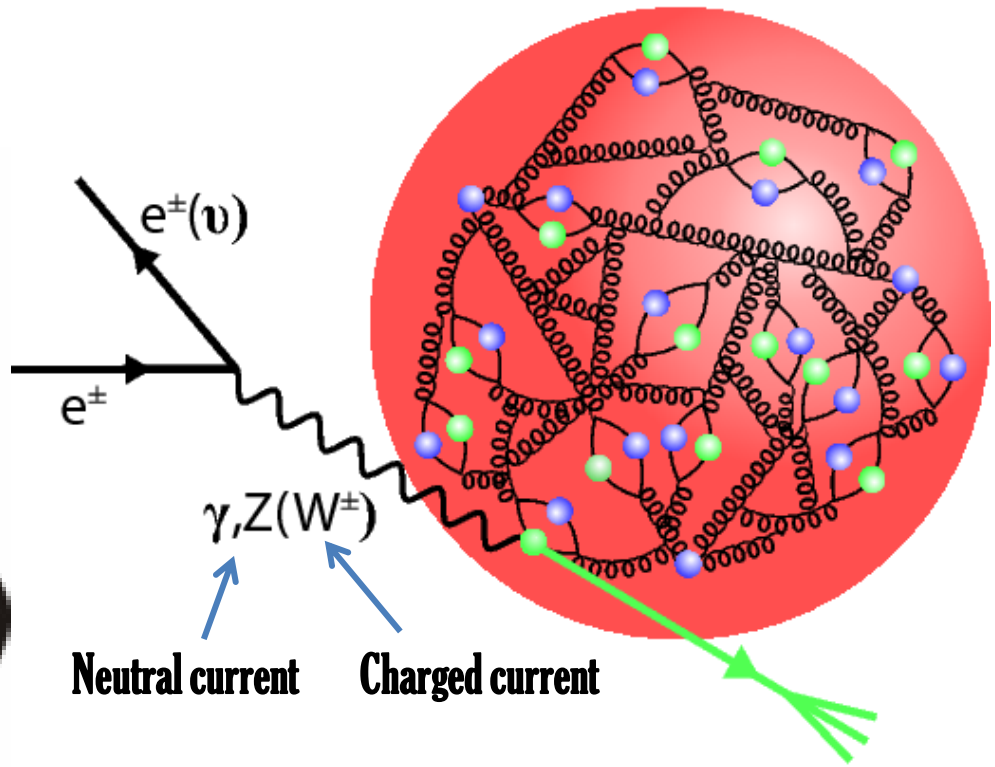
~ contact interaction



➔At high masses still window **excluded uniquely** by HERA

ZEUS inclusive high Q^2 data from HERA II

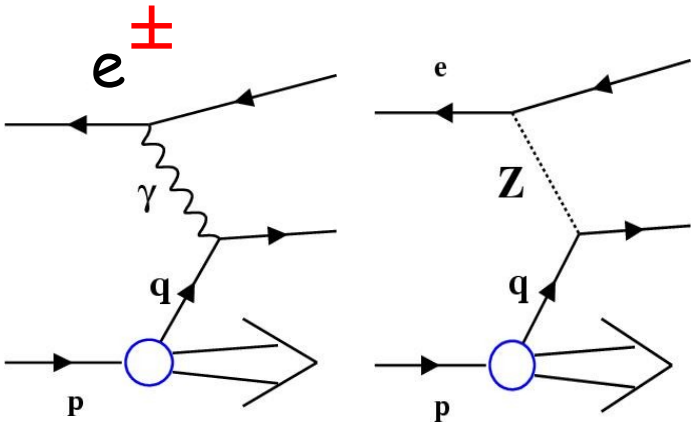




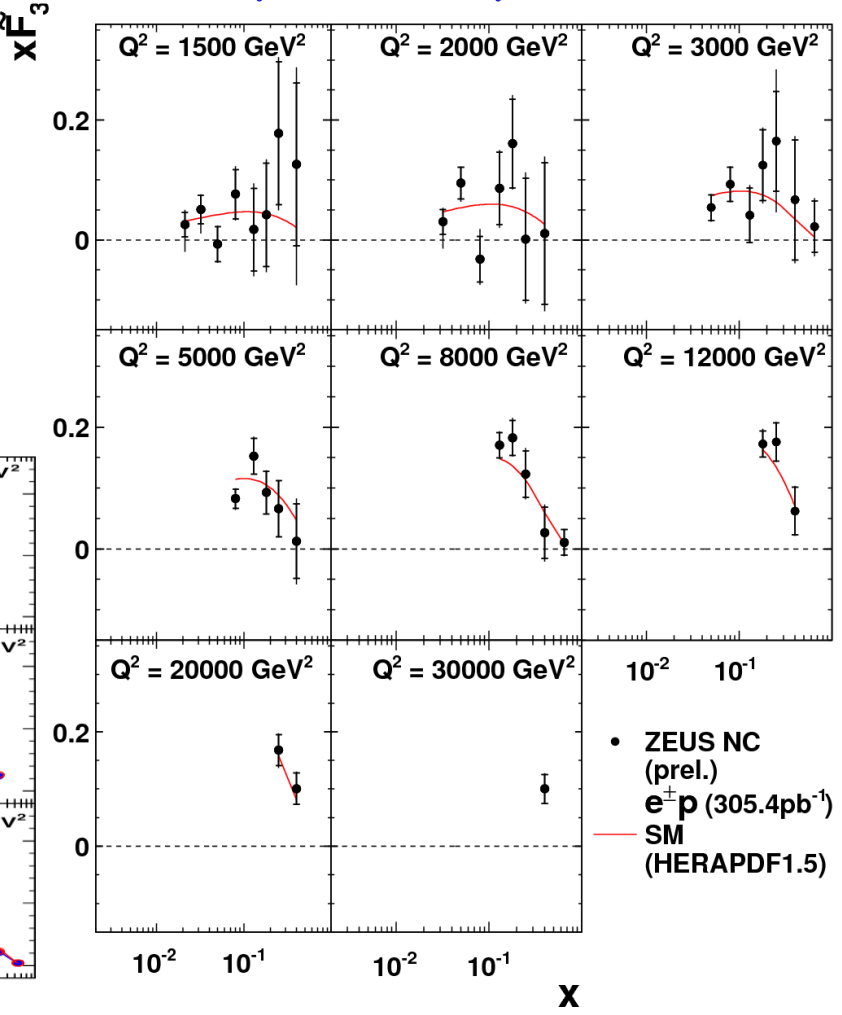
To be published soon

Need for e+p NC data → xF_3 → valence quarks

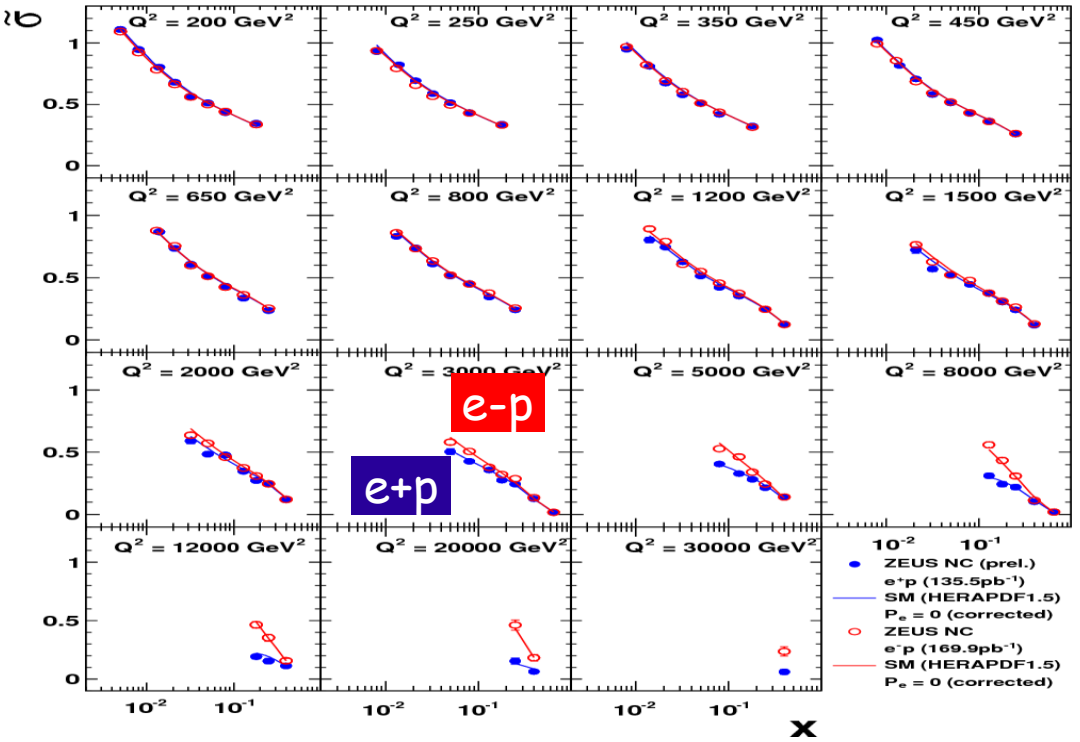
ZEUS-prel-11-003



$xF_3 \sim \sigma(e^-p) - \sigma(e^+p) \sim 2u_v + d_v$

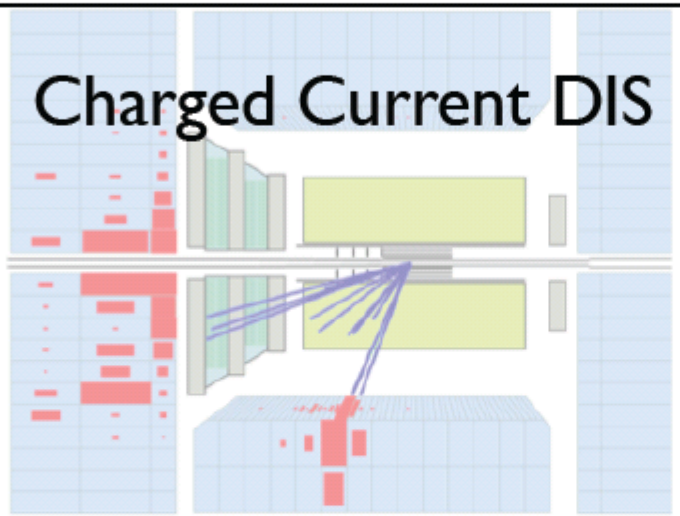
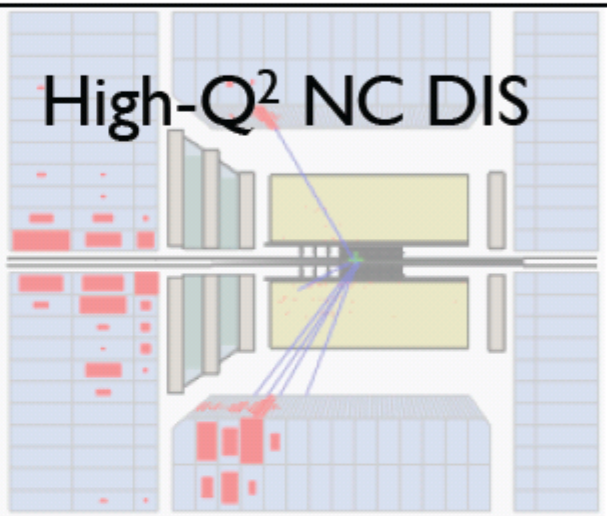
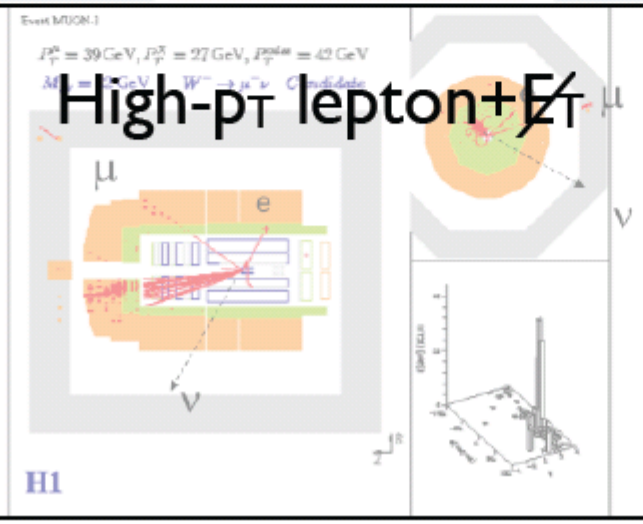


γZ interference flips sign for e^+p -> e^-p

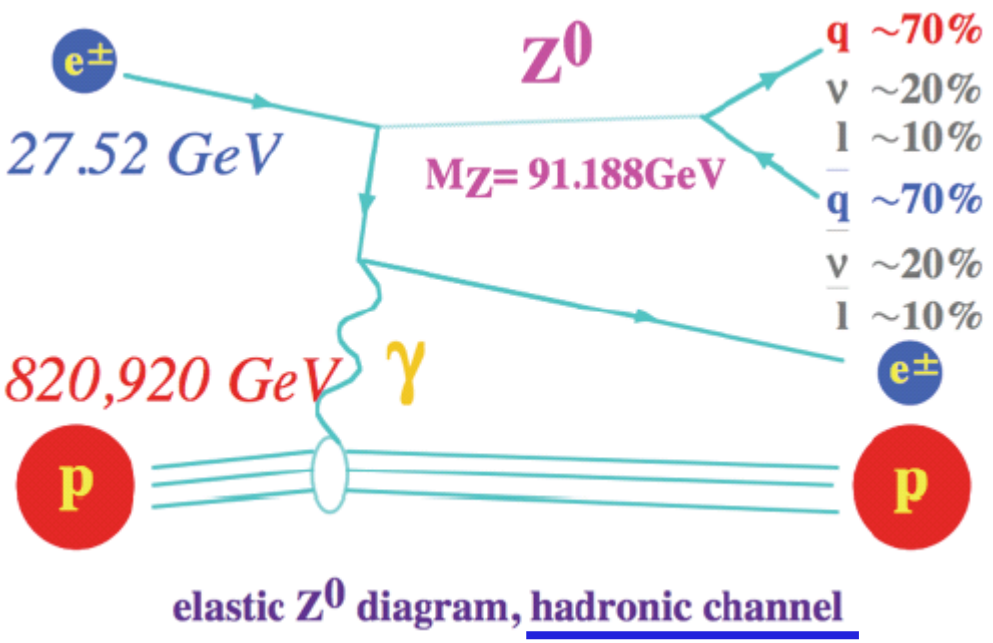


→ Valuable info on valence quarks at low x<0.1

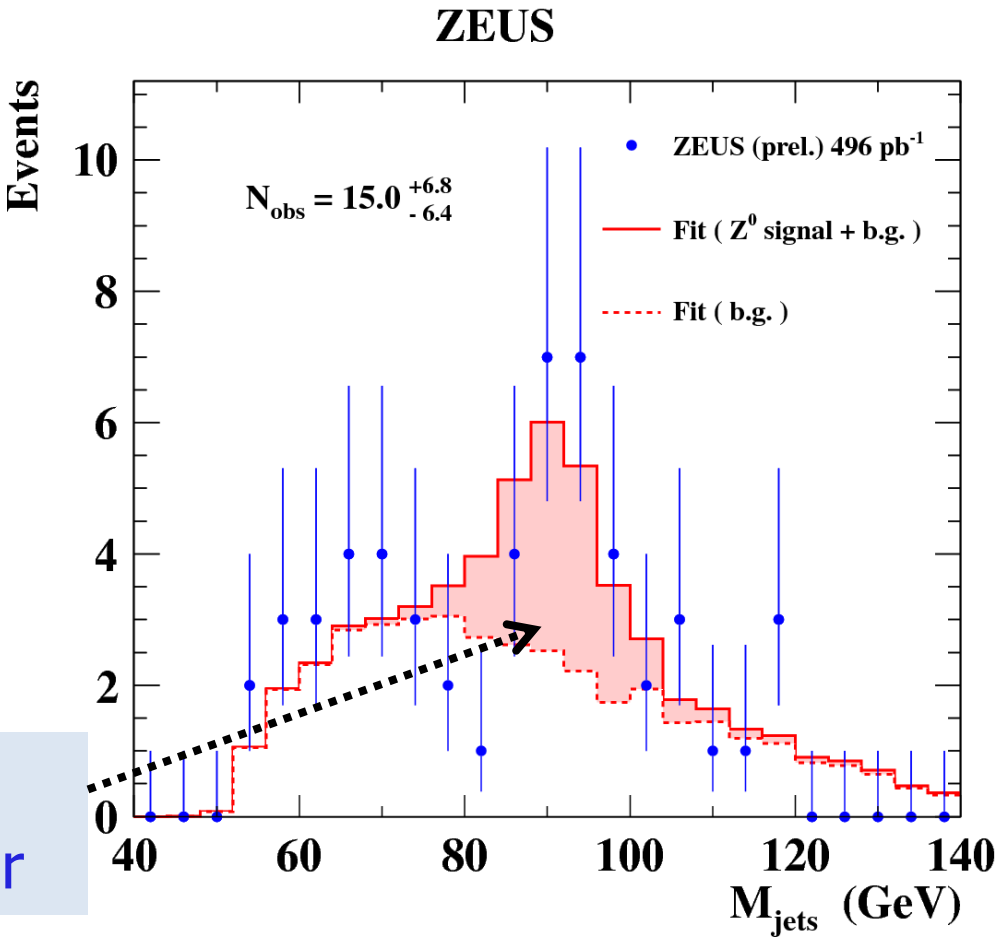
Electroweak Bosons at HERA

	W	Z
Virtual	Charged Current DIS 	High-Q^2 NC DIS 
Real	High-p_T lepton+$\not{E}_T$ 	**Missing piece in HERA EW program?**

Elastic Z0 production



elastic Z^0 diagram, hadronic channel



shows excellent $\sigma_E^{hadronic}$ of
ZEUS Uranium scintillator calorimeter

$$\sigma_{obs}\left(ep \to ep^{(*)}Z^0\right) = 0.133^{+0.060}_{-0.057}\,(\text{stat.})^{+0.049}_{-0.038}\,(\text{syst.})\ \text{pb}$$

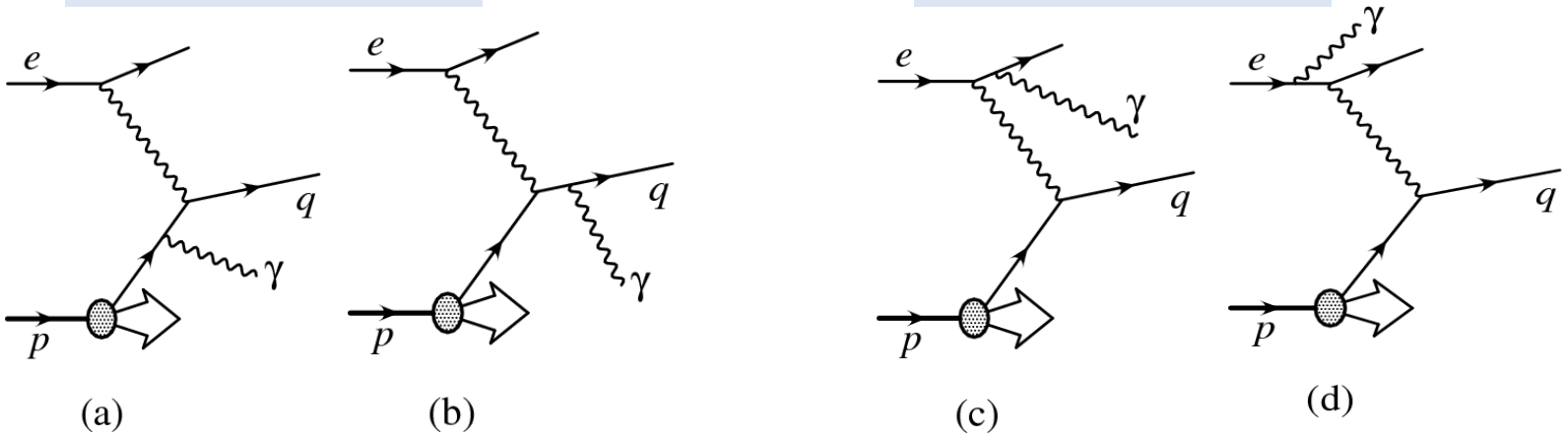
The result agrees with SM cross section of 0.16pb

Isolated photons+jets in DIS

DESY-12-089

QQ diagrams

LL diagrams

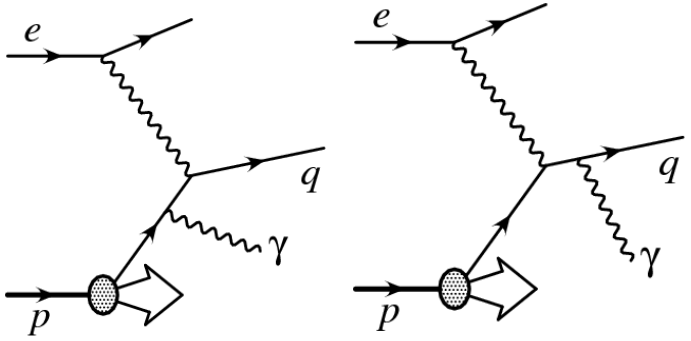


- No *hadronisation corrections* needed for photon → clean test of pQCD (hard interaction)
- Also sensitive to proton PDF (u-type quarks **radiate** γ four times more than d)
- Requirement of extra jet in suppresses LL

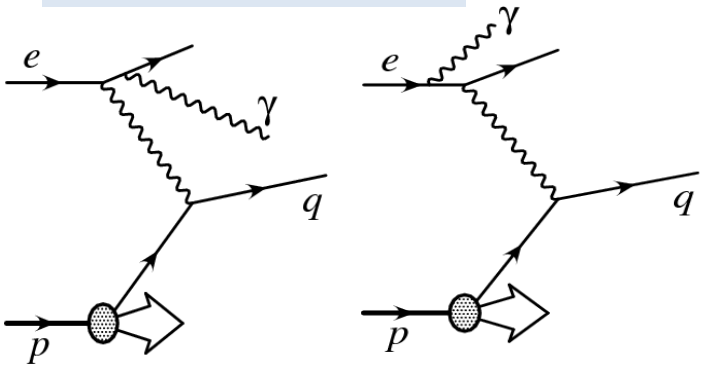
Isolated photons+jets in DIS

DESY-12-089

QQ diagrams

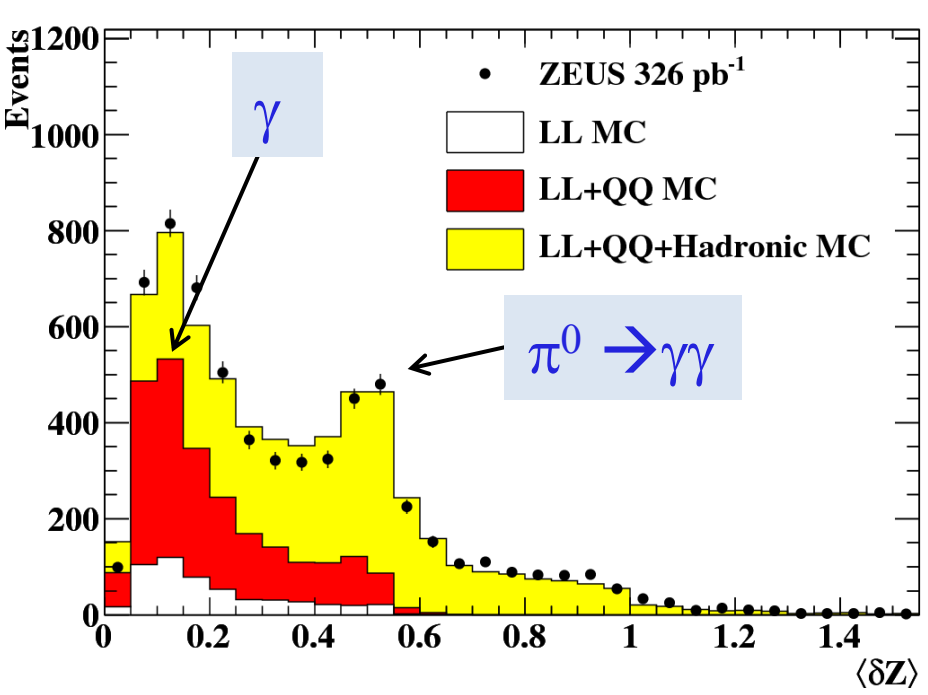


LL diagrams



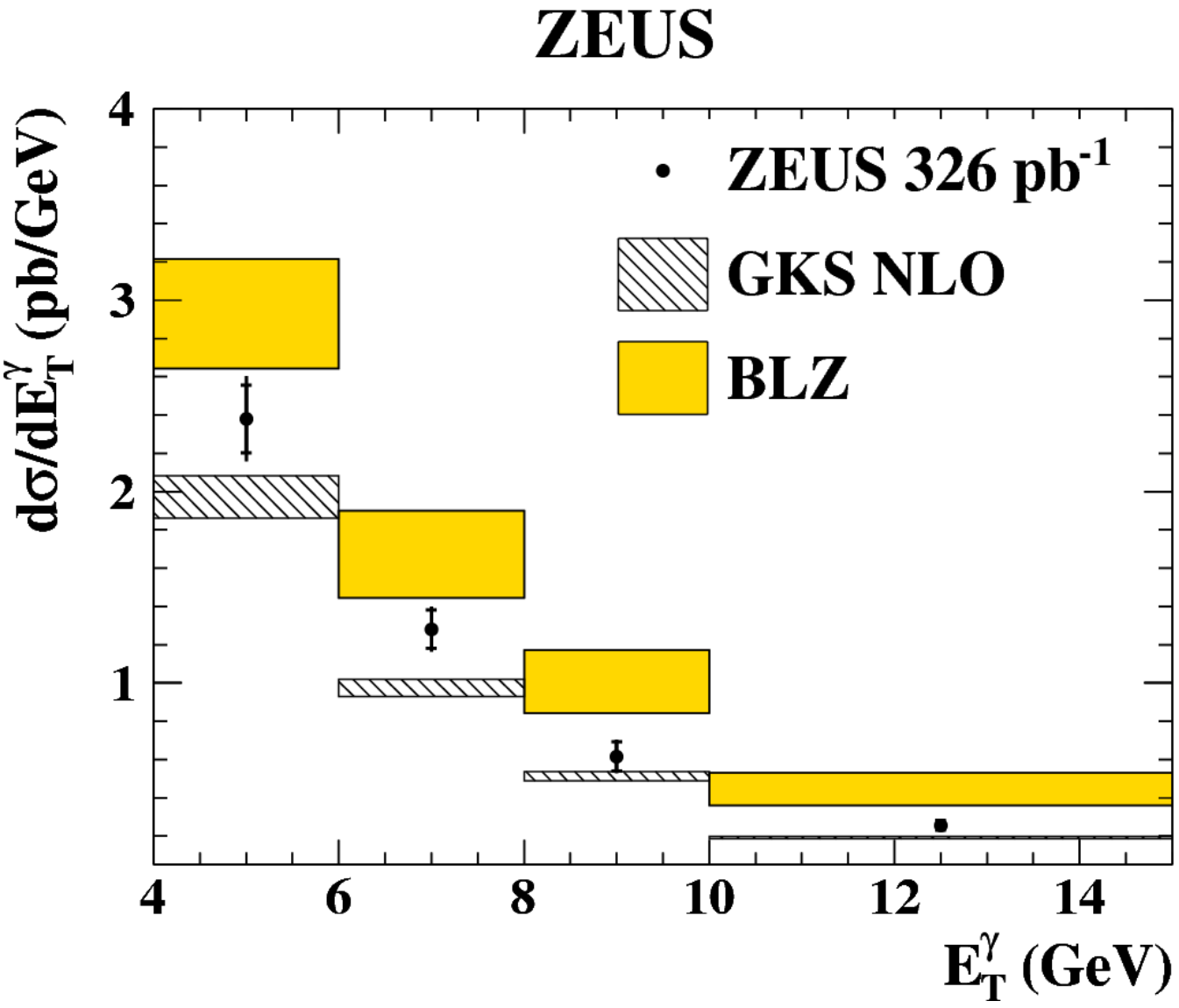
Photon Tagging:

- Use lateral w i d t h $\langle\delta z\rangle$ of cluster
- Apply template fit to determine signal and bgr.



Isolated photons+jets in DIS

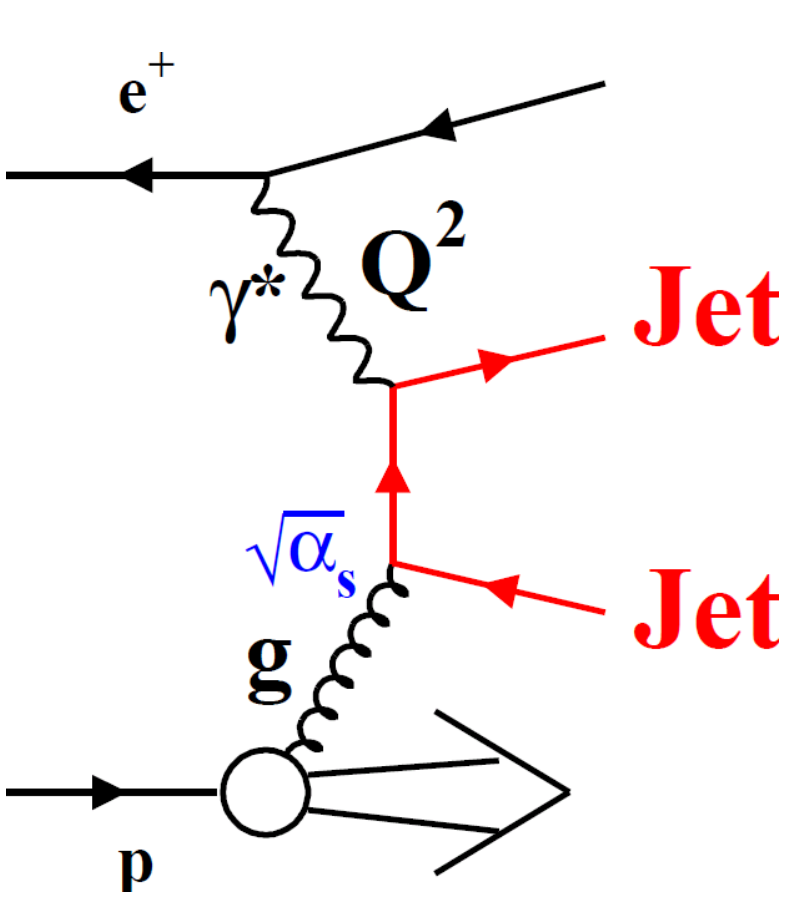
DESY-12-045

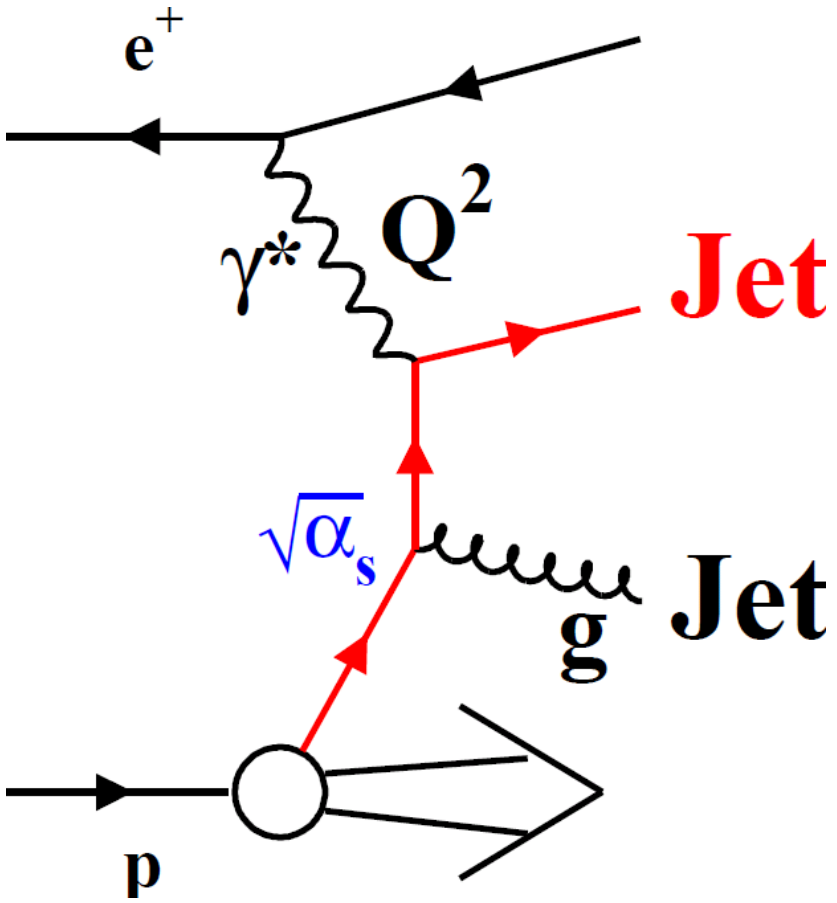


GKS NLO: $\alpha^3\alpha_s$
BLZ: k_T-factorisation

➔ Both models describe the shape but fail for the ***normalisation***

Jet production at HERA

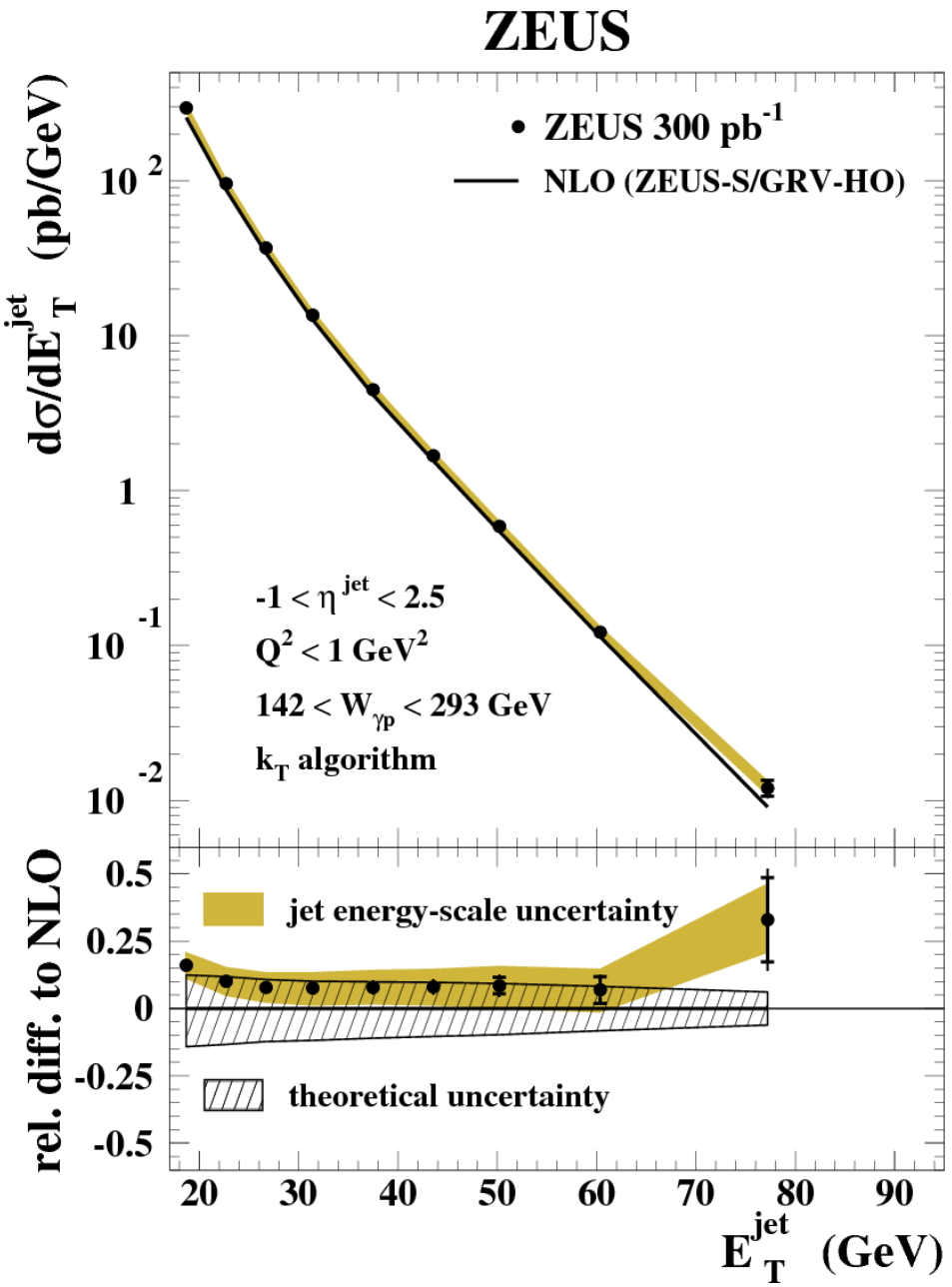




→ Different processes allow to disentangle g(x) and α_s

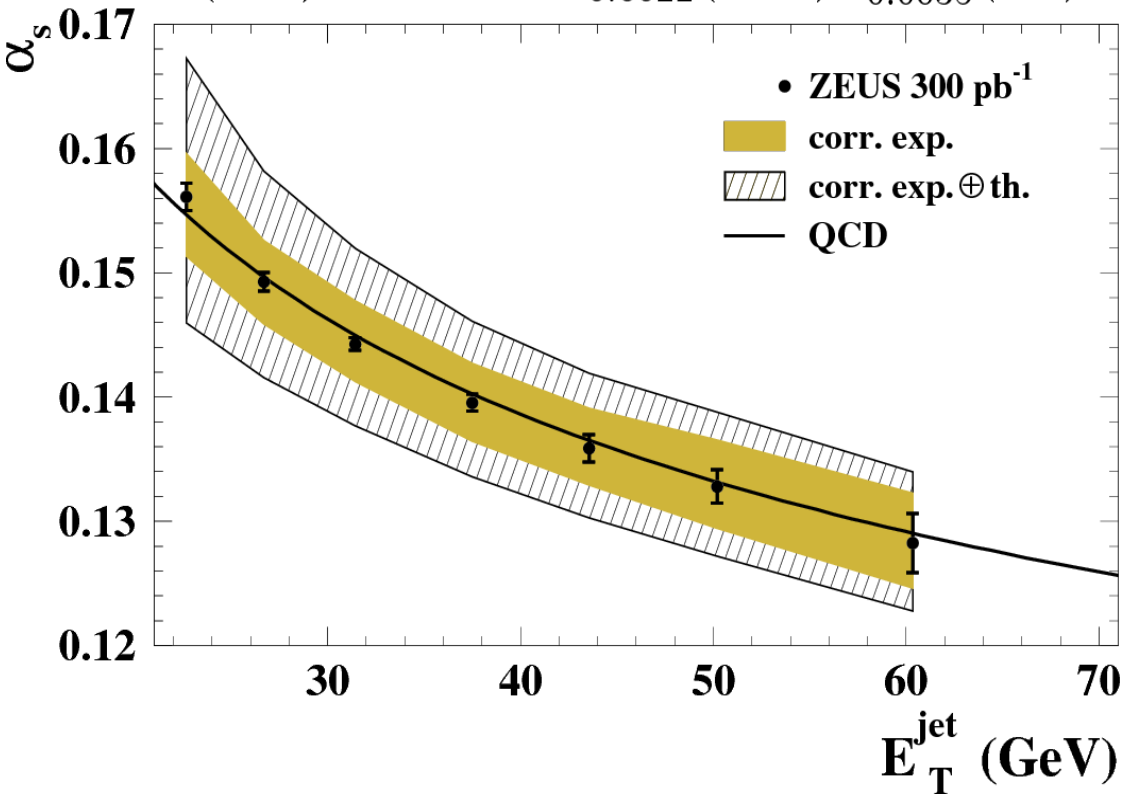
Inclusive jets in photoproduction: $Q^2 \sim 0$ GeV^2

DESY-12-045



Using $E^{jet}{}_T > 21$ GeV data:

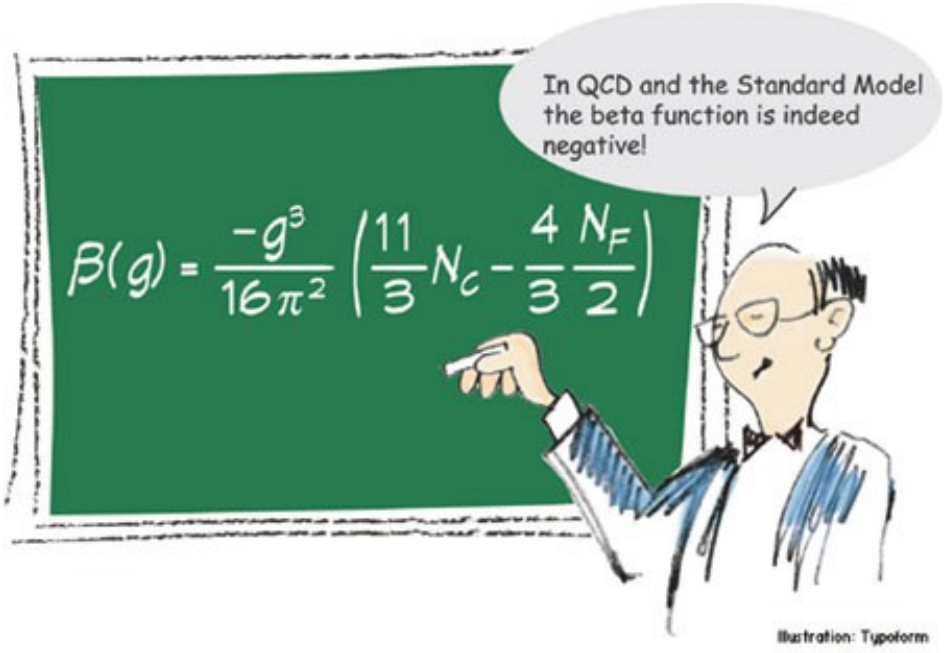
$$\alpha_s(M_Z) = 0.1206^{+0.0023}_{-0.0022}(\text{exp.})^{+0.0042}_{-0.0035}(\text{th.})$$

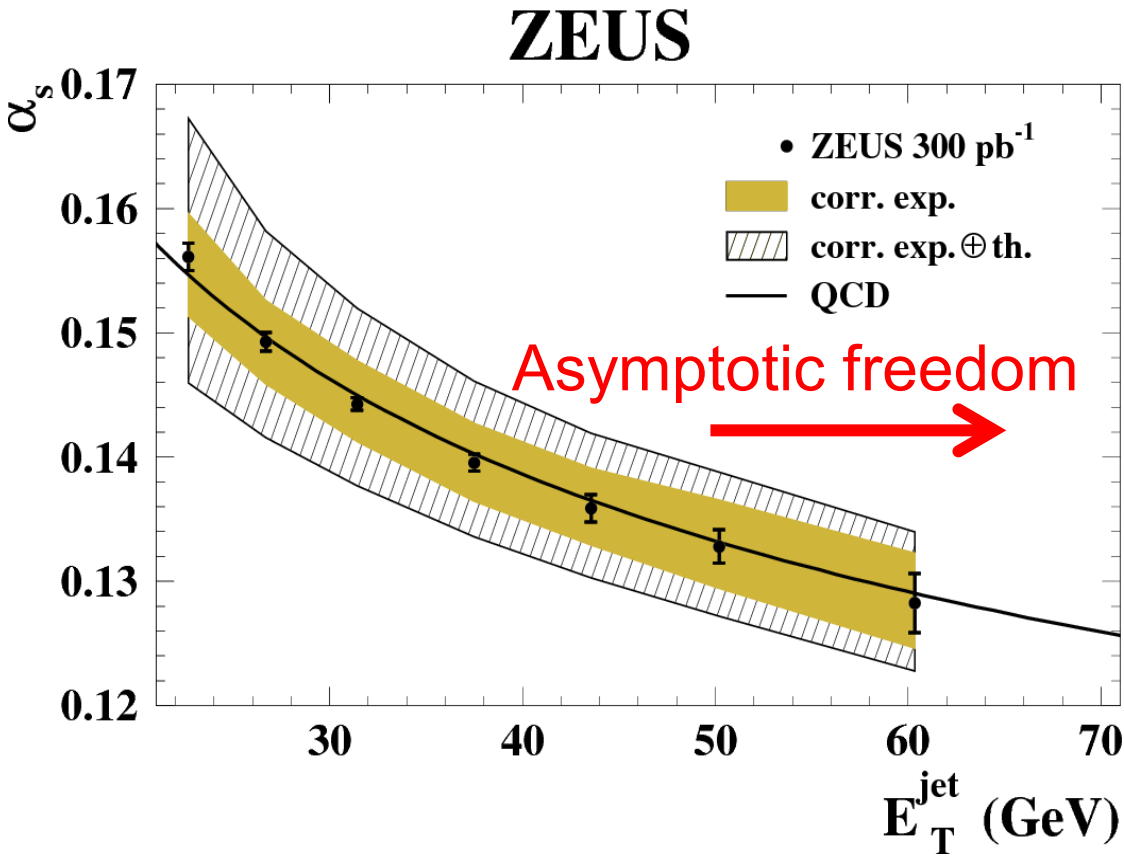


➔ Precise and consistent with NLO pQCD

Inclusive jets in photoproduction

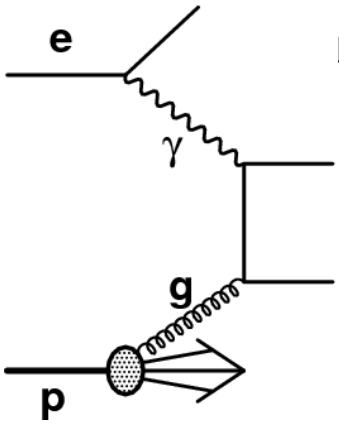
DESY-12-045

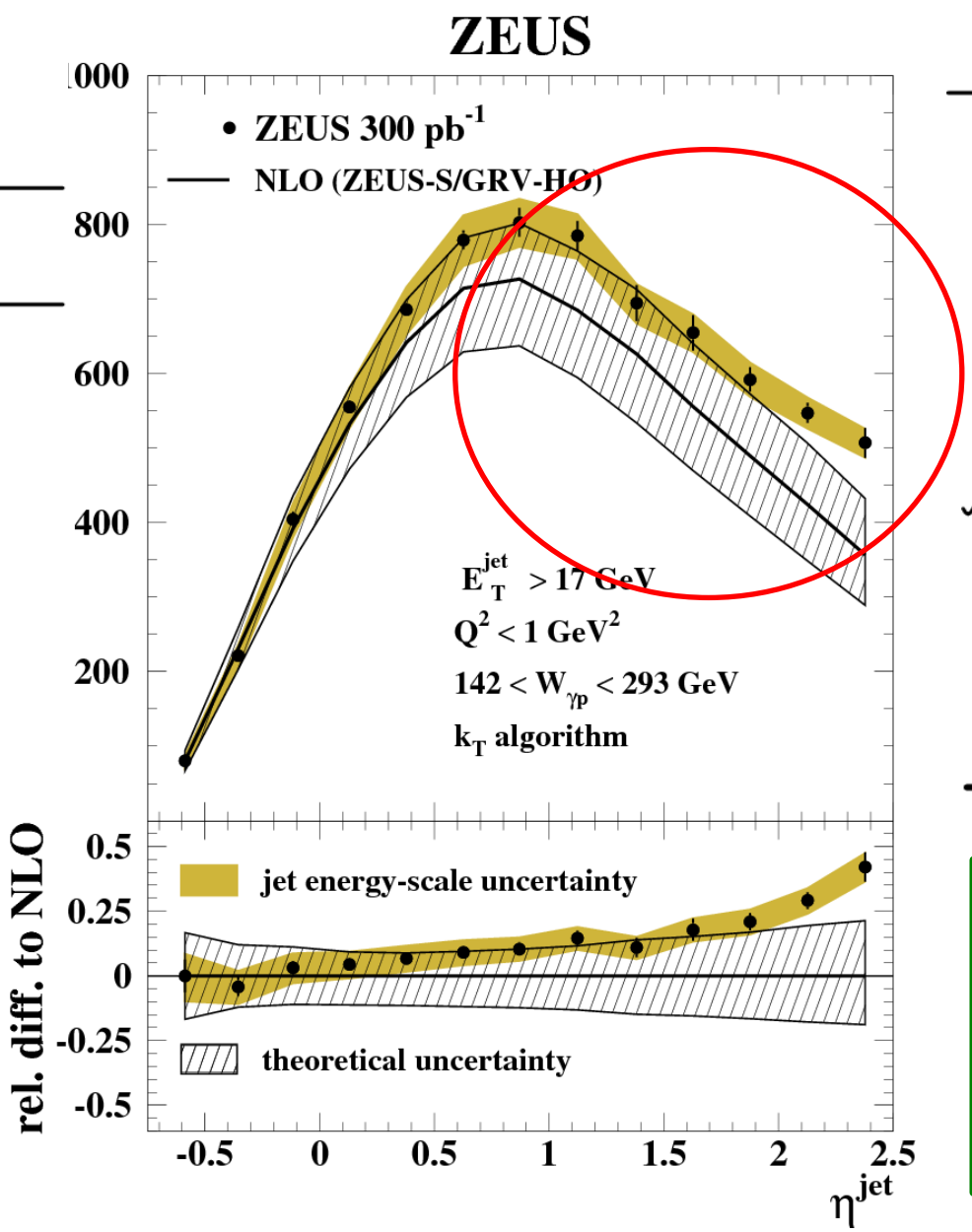


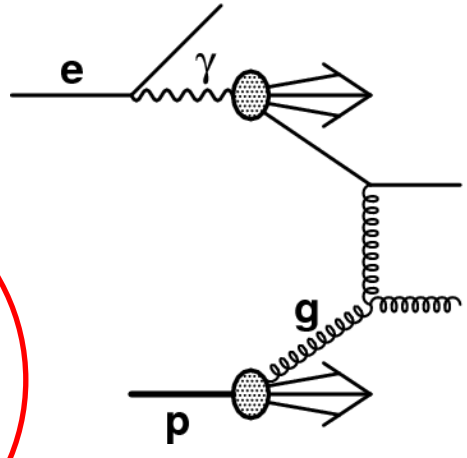


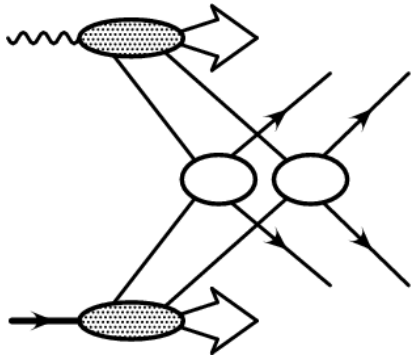
Inclusive jets in photoproduction

DESY-12-045









Not included in NLO calc.

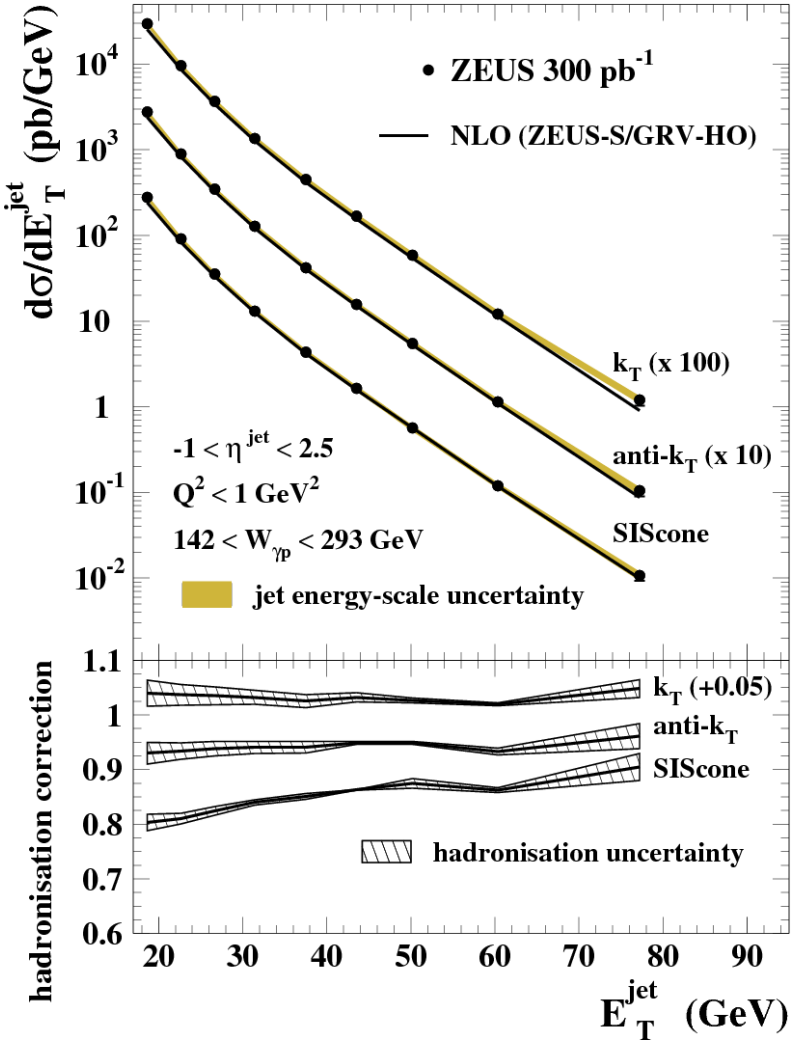
➔ Some sensitivitiy to resolved photon structure and multi parton interactions (see paper)

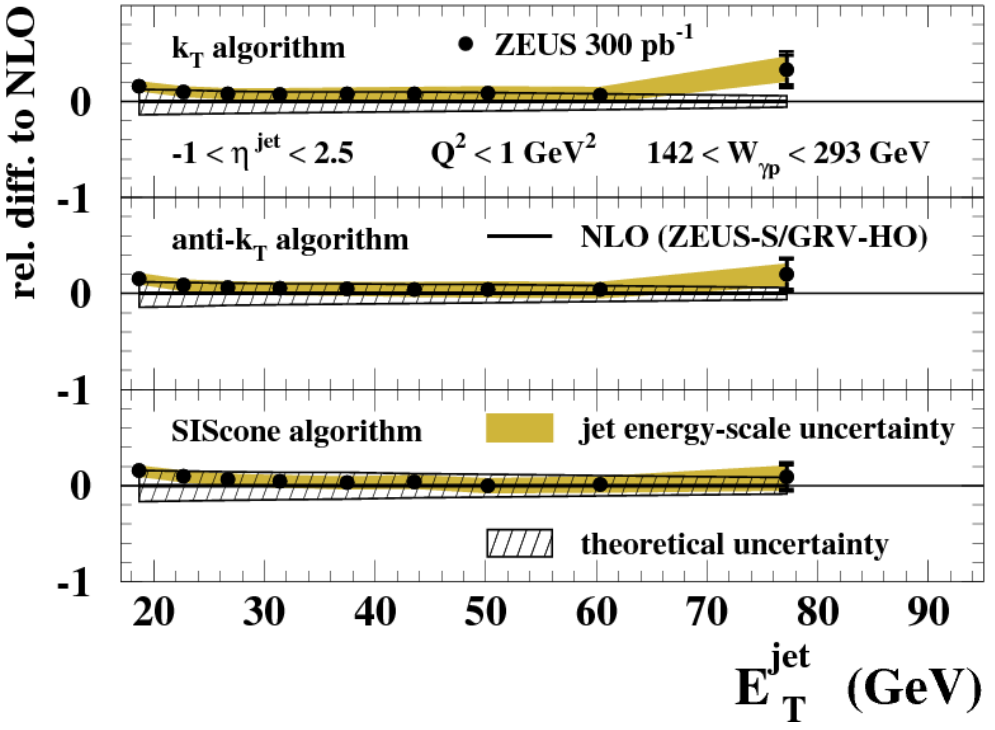
Inclusive jets in photoproduction: jet algorithms DESY-12-045

Anti-k_T and SIScone: recent new jet algorithms

- produce more circular shaped jets than inclusive k_T
- could be favourable to use them at LHC to calibrate jet energy & underlying event

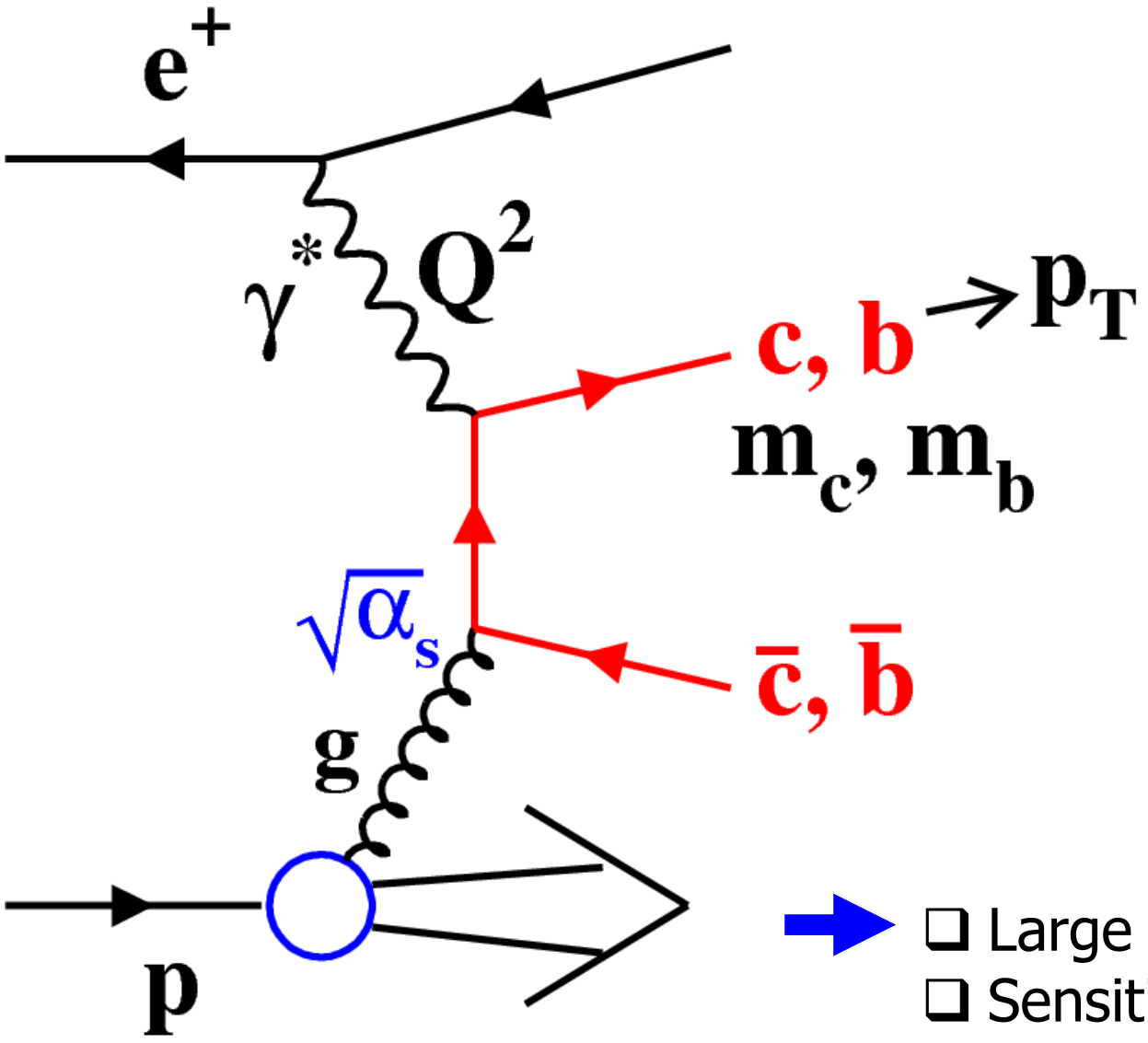
⇒ **HERA jet measurements can provide nice benchmark tests for these algorithms**





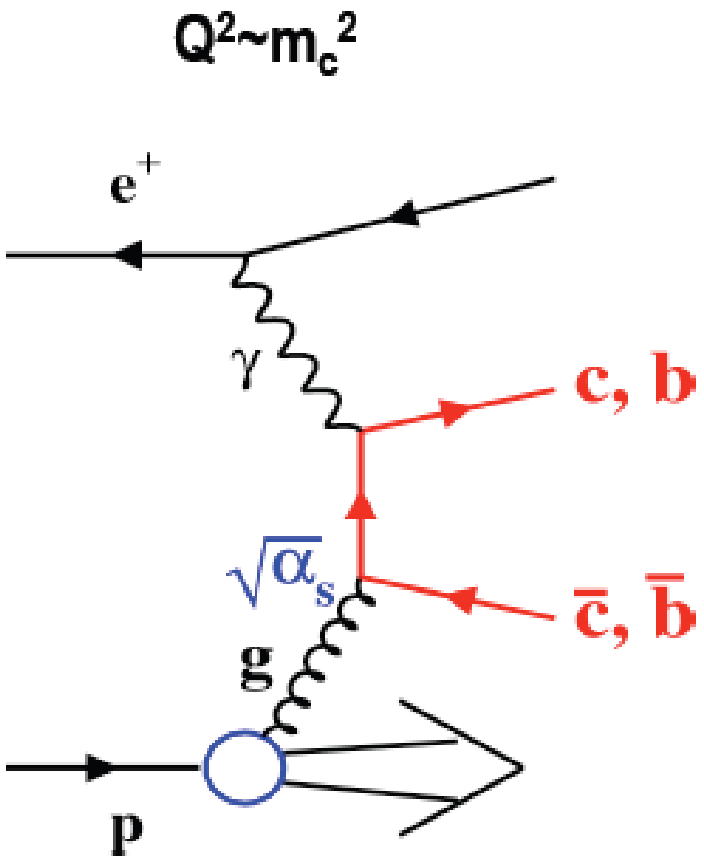
➔ Data similarly well described by all the algorithms

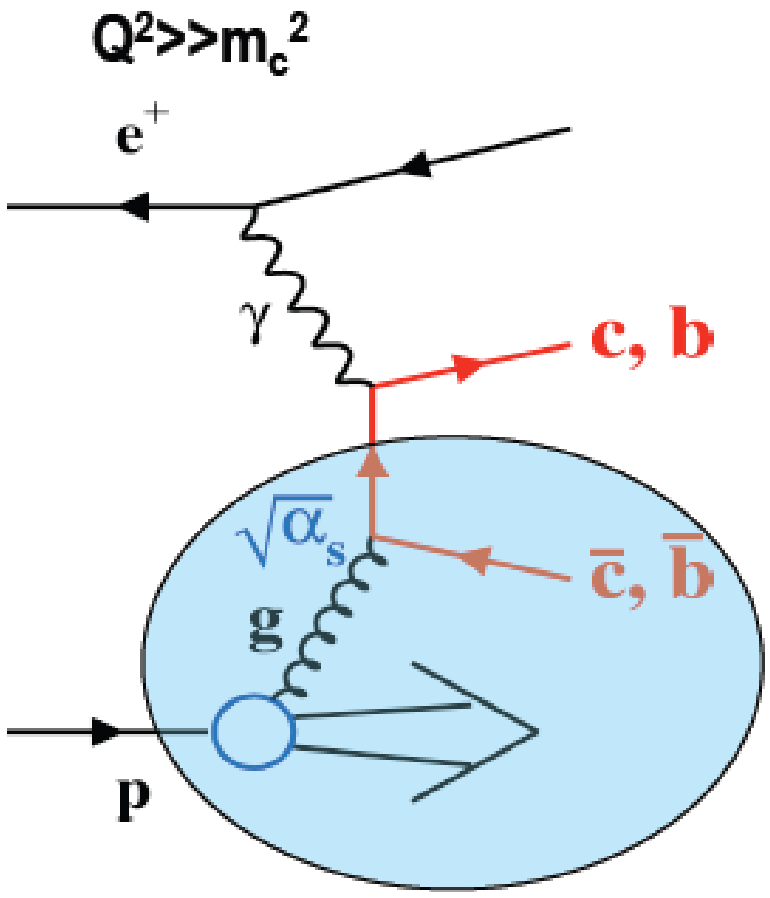
Charm and Beauty production at HERA



- ❑ Large contributions to incl. DIS
- ❑ Sensitive to g(x)
- ❑ Sensitive to m_c, m_b

Subtle topic: heavy quark mass dependent terms in pQCD





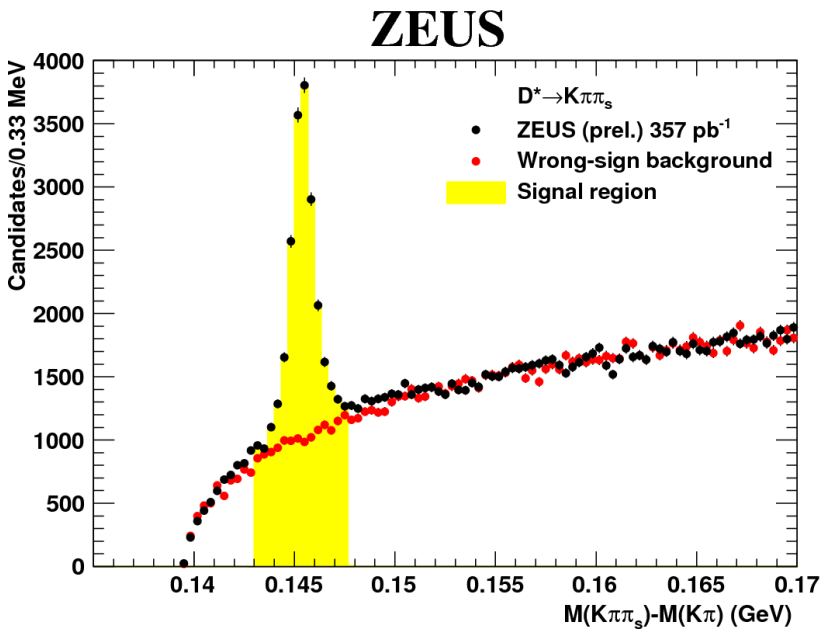
massive c,b scheme

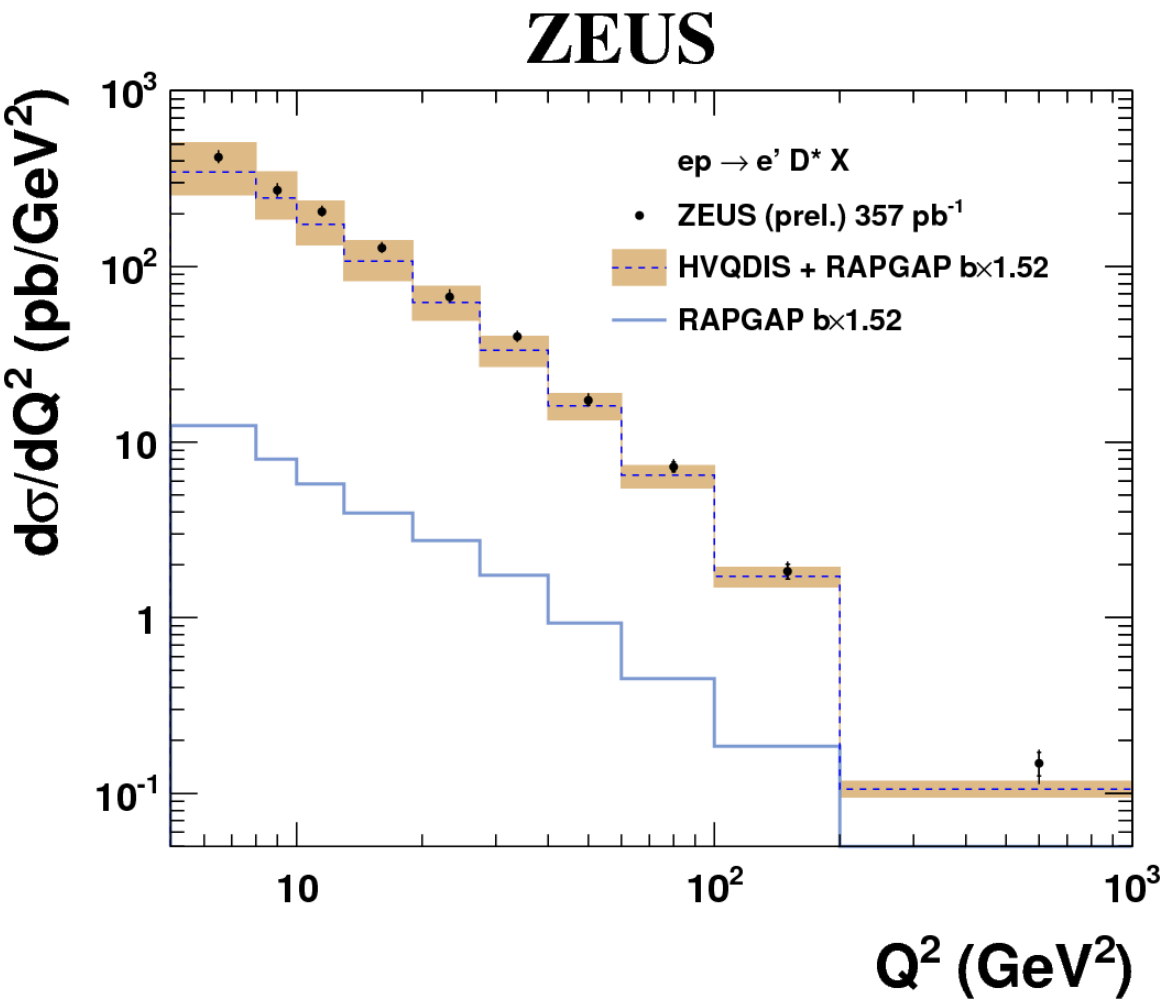
c,b = massless seaquarks

How to make properly the transition from left to right picture is a longstanding problem **for PDF fits**

Charm in DIS: New D* results

ZEUS-prel-11-012

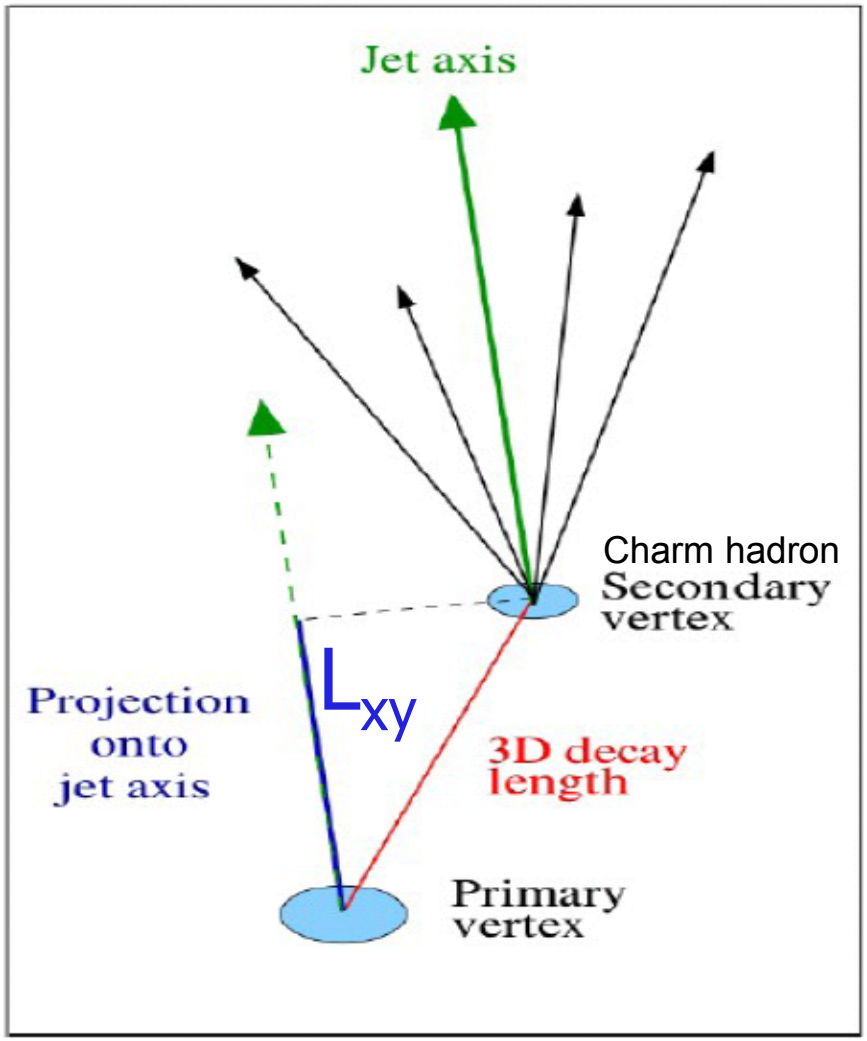


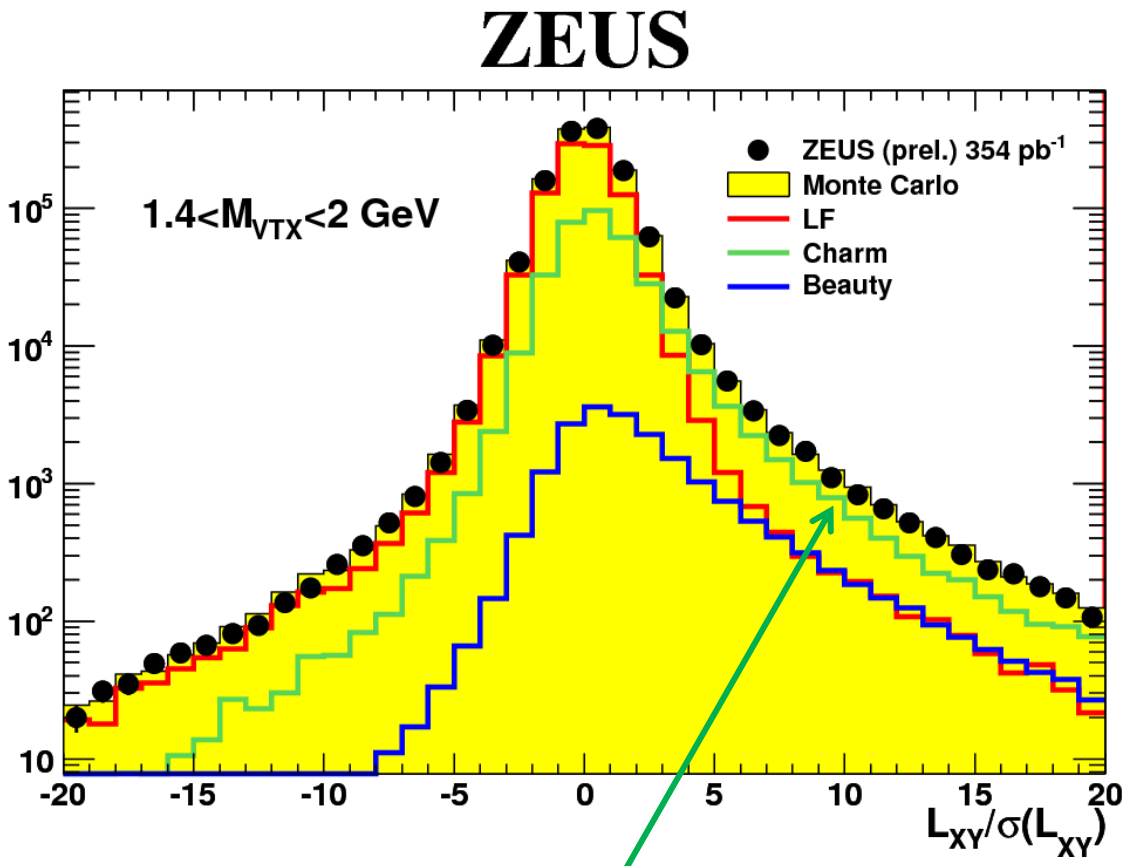


➔ Good description for all Q^2 by **massive** NLO QCD (HVQDIS)

Charm in DIS: New inclusive sec. vertex results

ZEUS-prel-12-002

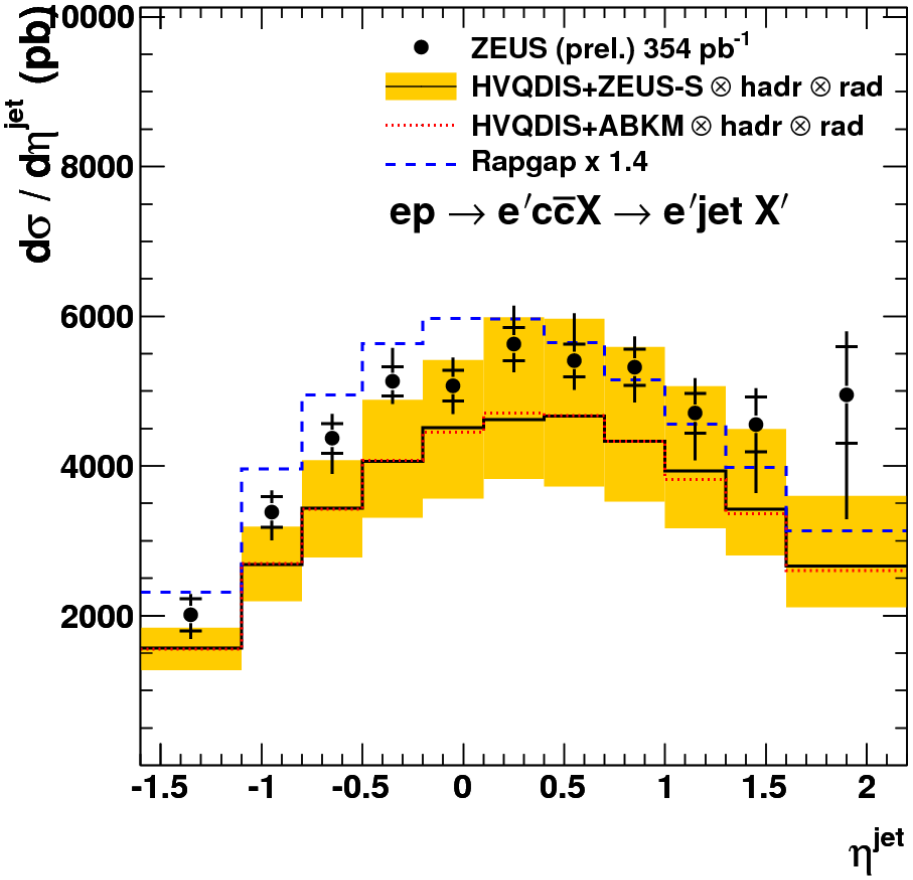


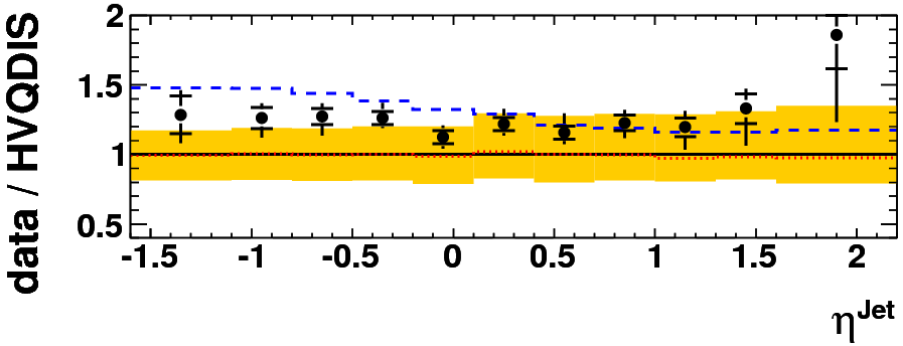


➔ Nice charm enhancement at positive significances Lxy/σ(Lxy) (reflecting lifetime of D mesons)

Charm in DIS: New inclusive sec. vertex results

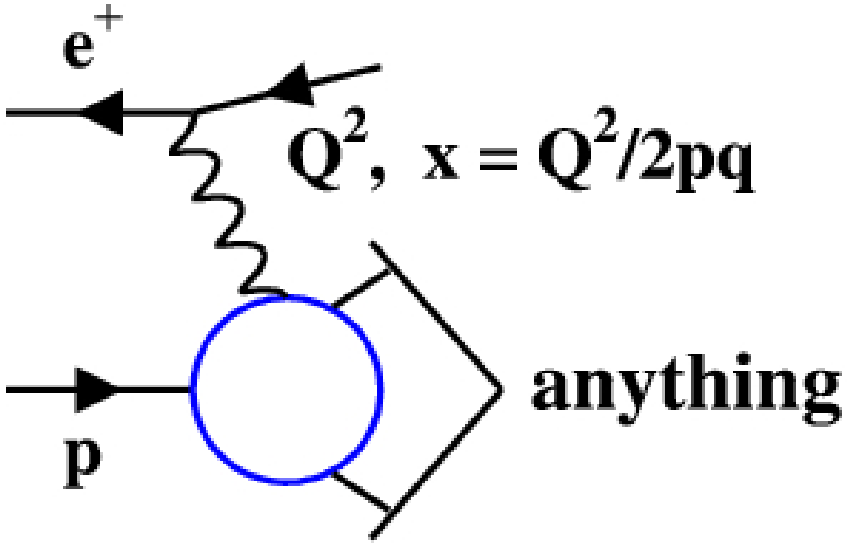
ZEUS-prel-12-002



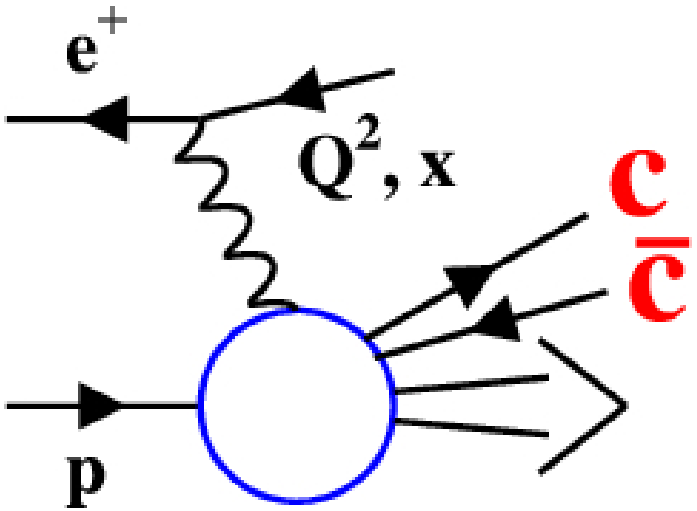


➔ Reasonable description by **massive** NLO QCD (HVQDIS)

Charm contribution to DIS: F_2^{cc}



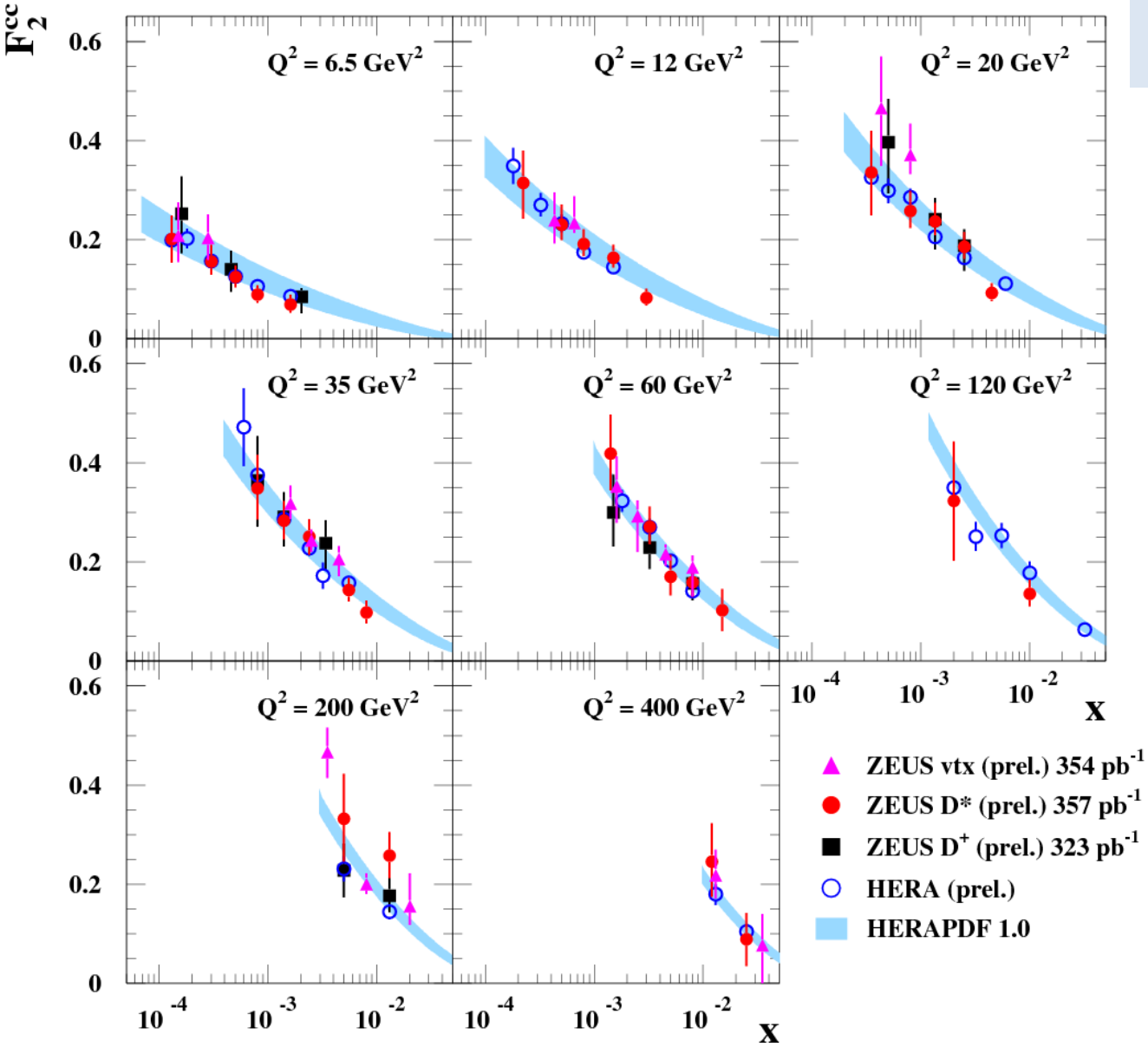
$$\frac{d^2\sigma^{ep}}{dQ^2dx} \propto F_2(x,Q^2)$$



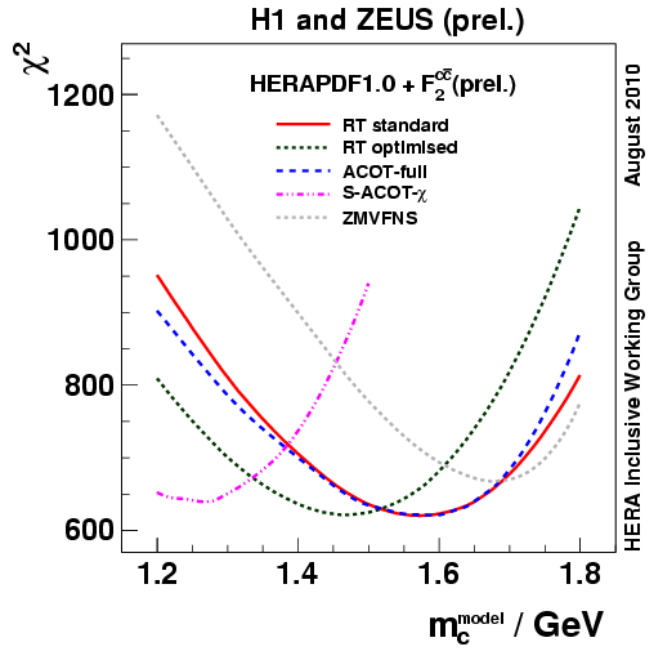
$$\frac{d^2\sigma^{ep\to c\bar{c}x}}{dQ^2dx} \propto F_2^{c\bar{c}}(x,Q^2)$$

F_2^{cc}: new D* and incl. sec. vertex vs. *HERA (prel.) results*

ZEUS-prel-12-002 ZEUS-prel-11-012 **ZEUS**



Charm mass parameter χ^2 scan from *HERA (prel). F_2^{cc}*



➔ Consistent findings
➔ New ZEUS results will **improve** combination, PDF and m_c fits

Summary/outlook:

- ***5 years -11 days*** after the end of HERA data taking – still continuous flow of exciting new results from ZEUS
- Searches: the book ***is closed*** from ZEUS, no Leptoquarks or other **exotica** found
- Inclusive ep scattering: → complete soon (e+p NC data + few more..) the **exhaustive** proton structure exploration by ZEUS, combine with H1 and obtain **best HERAPDF ever** (HERAPDF2.0)
- Real Z0 production observed for first time at HERA ☺
- Jets, photons, charm etc: → new precision results still coming in, add to the **HERA legacy** on proton structure and **unique QCD tests**

Backup slides

Tour through perturbation series:

$\alpha^0\alpha_s^0$ New physics: Leptoquarks

$\alpha^2\alpha_s^0$ Inclusive e+p neutral current

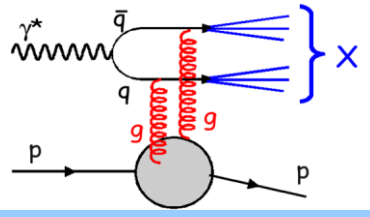
$\alpha_w\alpha^2\alpha_s^0$ Z0 production

$\alpha^3\alpha_s^0$ Isolated photons

$\alpha^2\alpha_s^1$ Inclusive jet photoproduction

$\alpha^2\alpha_s^1$ Charm production in DIS

$\alpha^2\alpha_s^2$ Inclusive diffraction



Not covered today

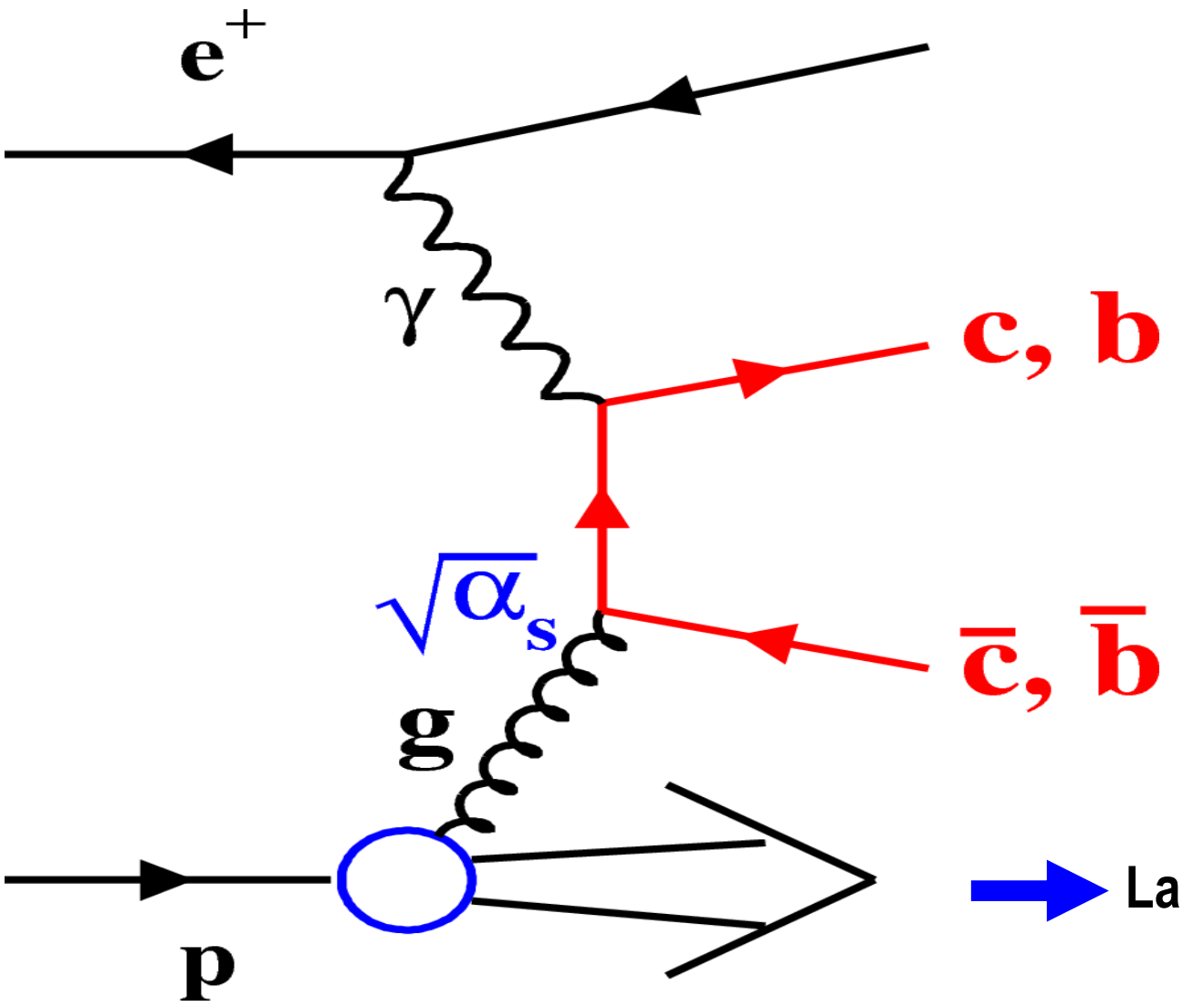
+ Fragmentation studies with K0s/lambda and Charm mesons

Menu: Walk through the elweak+QCD perturbation series

$\alpha^0\alpha_s^0$	New physics: Leptoquarks	DESY-12-077
$\alpha^2\alpha_s^0$	e+p inclusive neutral current	ZEUS-prel-11-003
$\alpha_w\alpha^2\alpha_s^0$	Z0 production	ZEUS-prel-12-001
$\alpha^2\alpha_s^0$	Isolated photon + jets in DIS	DESY-12-089
$\alpha^2\alpha_s^1$	Inclusive jet photoproduction	DESY-12-045
$\alpha^2\alpha_s^1$	Charm production in DIS	ZEUS-prel-11-012 ZEUS-prel-12-002
$\alpha^2\alpha_s^2$	Inclusive diffraction	ZEUS-prel-11-011, H1prelim-11-111 DESY-11-205 ZEUS-prel-12-003

+ Fragmentation studies with K0s/lambda and charm hadrons

Charm and Beauty



→ **Large contributions to incl. DIS**

sensitive to g(x)

sensitive to m_c, m_b

Charm mass scan