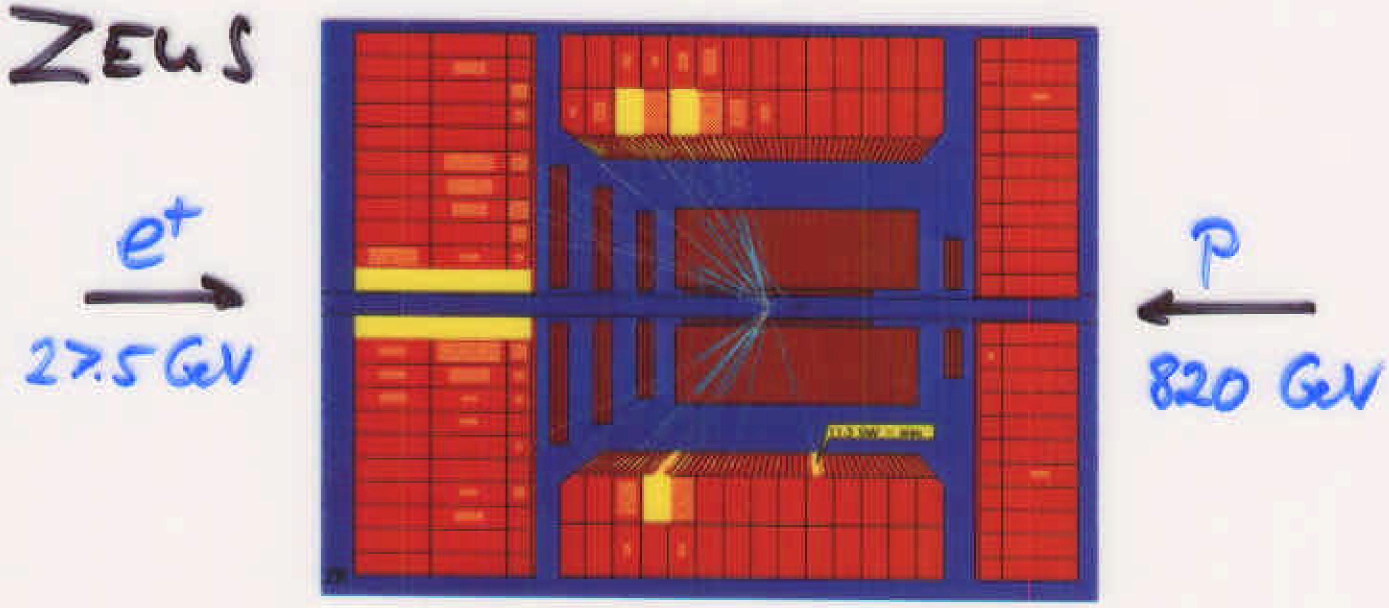
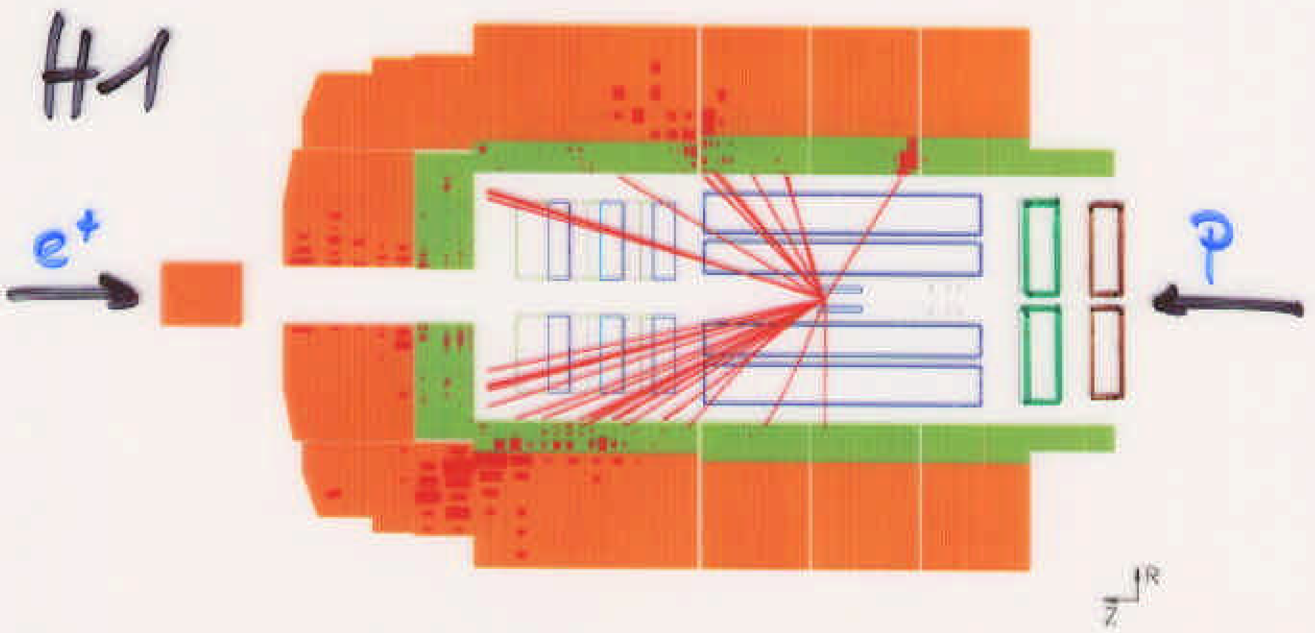
ICHEP2000

Osaka , July, 2000

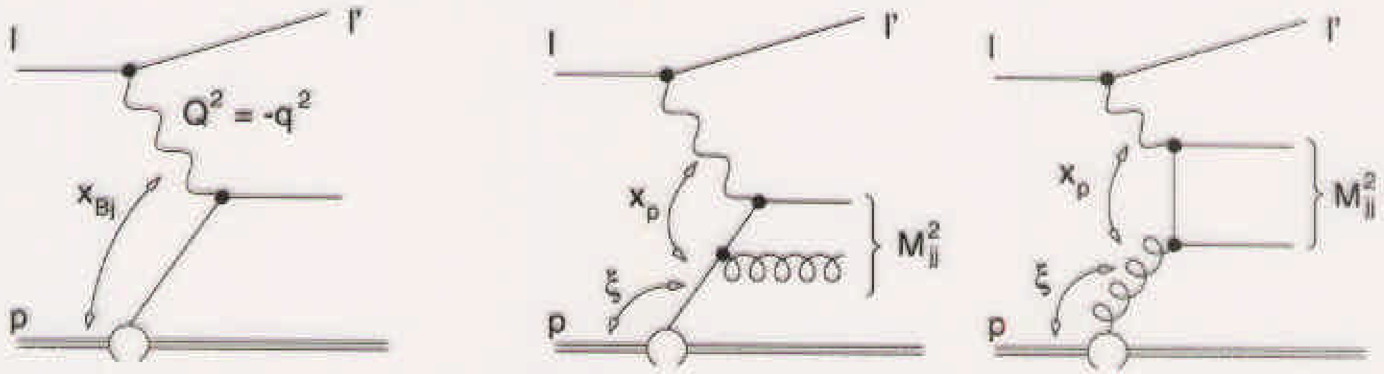
Jet Production in DIS at HERA

Jörg Gayler, DESY
for H1 and ZEUS





Kinematics and Jet algorithm



$$Q^2 = -q^2 = -(l - l')^2$$

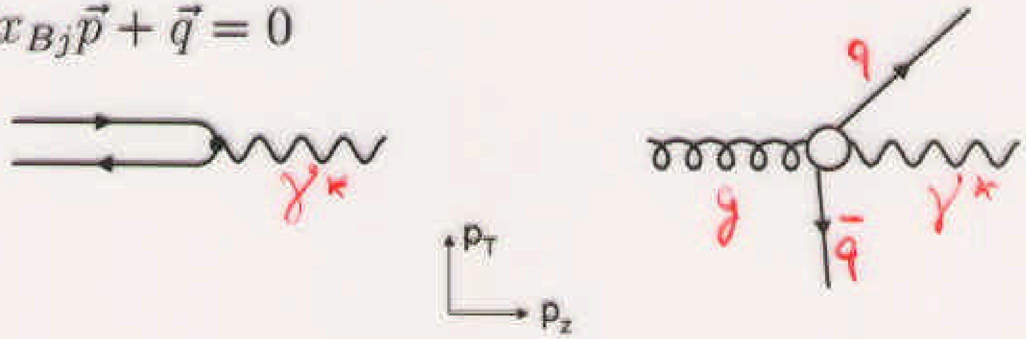
$$x_{Bj} = Q^2/2p \cdot q$$

$$\xi = x_{Bj}(1 + M_{jj}^2/Q^2) \quad , \quad x_p = x_{Bj}/\xi$$

$$\eta = -ln(tan\theta/2)$$

Breit frame :

$$2x_{Bj}\vec{p} + \vec{q} = 0$$



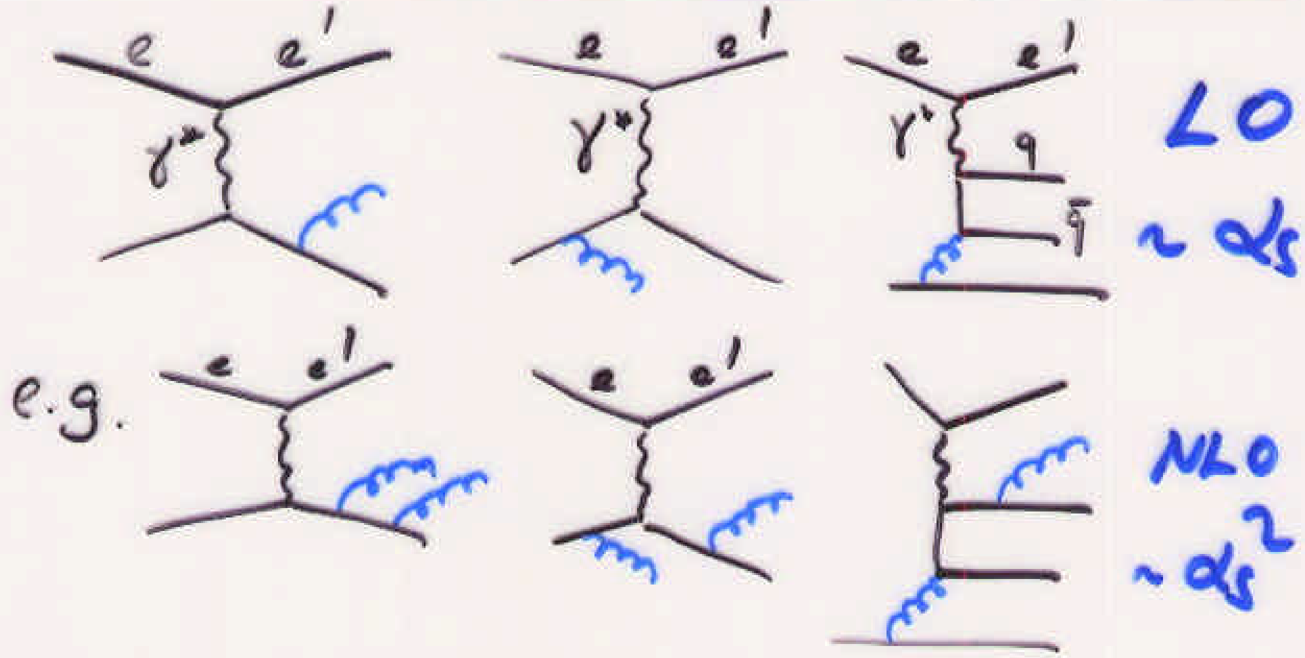
no p_T for QPM like events. **e.g. boson gluon fusion**

Jet algorithm : mostly used inclusive k_T in Breit frame

distance measures: $d_i = E_{T,i}^2$ and $d_{ij} = min(E_{T,i}, E_{T,j})R_{ij}^2$

with $R_{ij}^2 = \Delta\eta_{ij}^2 + \Delta\phi_{ij}^2$

Multi-Jet Production in pQCD



Ansatz in pQCD :

renormalization scale

$$\sigma = \sum_{a,n} \int_0^1 dx\, \alpha_s^n(\mu_r)\, c_{a,n}\left(\frac{x_{Bj}}{x}, \mu_r, \mu_f\right) f_{a/h}(x, \mu_f)$$

order n, flavour a

predicted

fact. scale

parton density

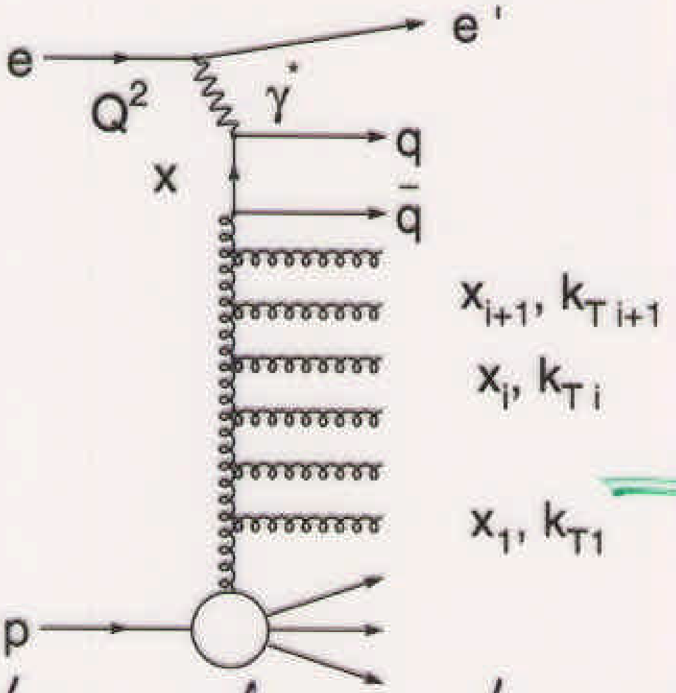
NLO programs DISENT, MEPJET used for data comparisons

Important ambiguity : μ_R

choice of suitable scale E_T^2, Q^2 ?

Forward jets

(i.e. close to proton remnant)



evolution of parton densities

standard DGLAP BFKL

resumming $\alpha_s \ln Q^2$ $\alpha_s \ln 1/x$

$k_{T_{i+1}} \gg k_{T_i}$ no k_T order

How good are DGLAP based calculations in forward region?

QCD patterns in hadronic final state

Abstract 897

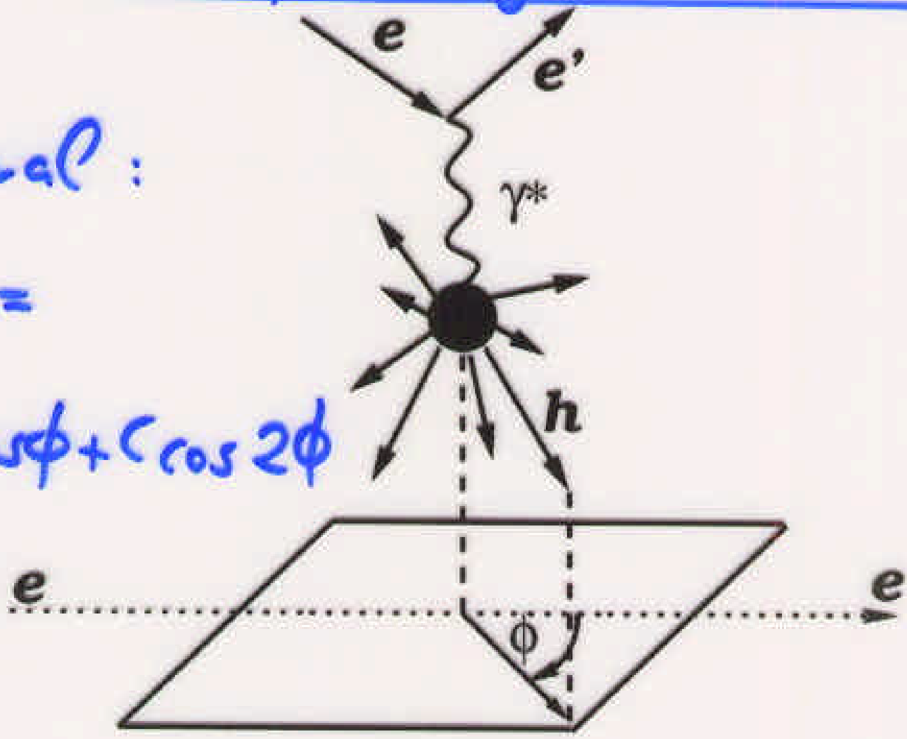
Mostly studied: jet structure (NC), see below

2 Consistency checks:

1) ϕ asymmetries

general:

$$\frac{d\sigma}{d\phi} = A + B\cos\phi + C\cos 2\phi$$



naive expectation ($O(\alpha_s)$)

a) q-g plane preferentially close to lepton plane — $C > 0$

b) $\phi \to \pi$ for q-jet (γ couples to quark) — $B < 0$

select leading track to tag q

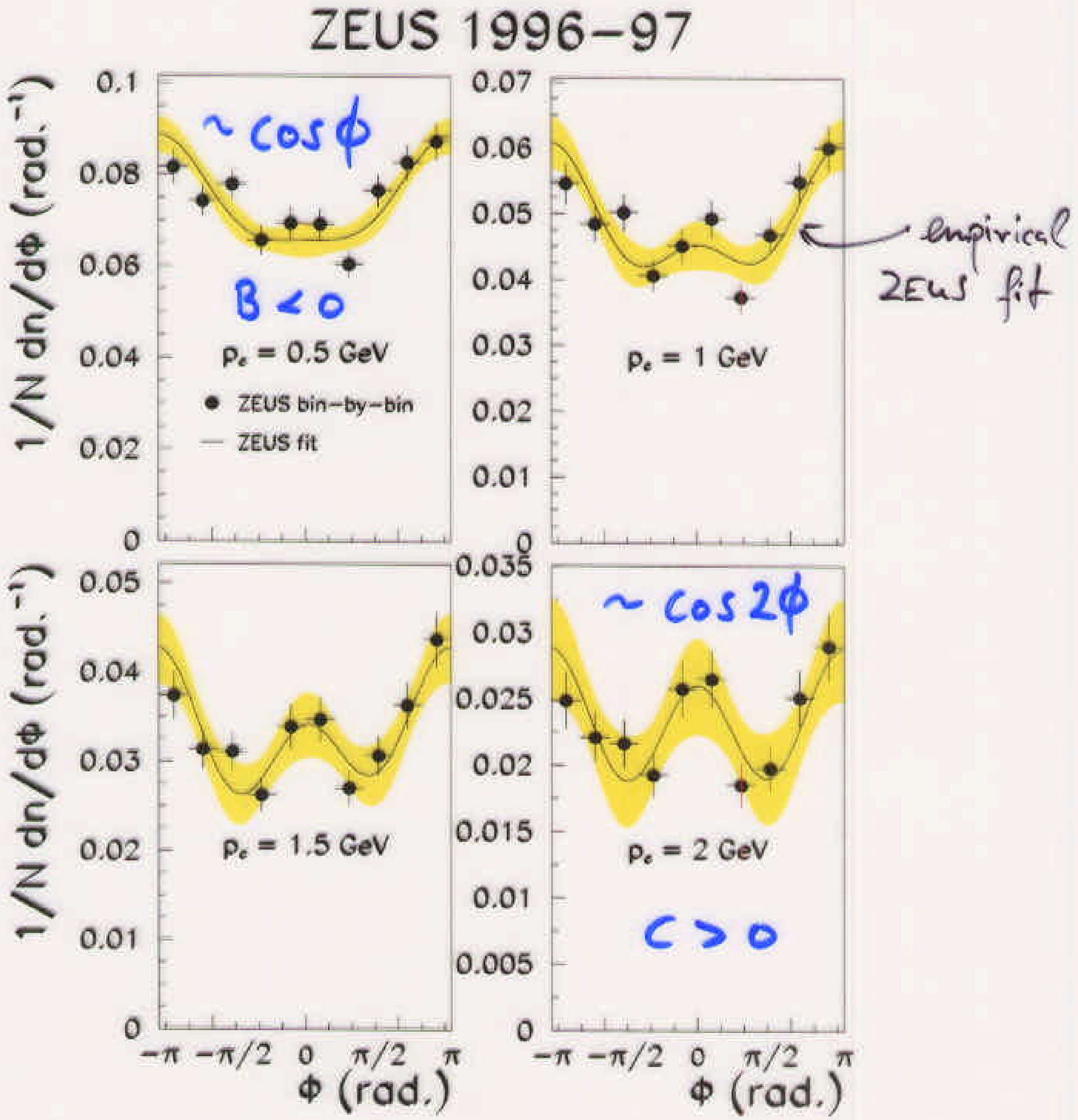
ϕ distribution of hadron with substantial p_T in Breit frame

Abstract 897

hard track: $0.2 < z_h < 1, \quad z_h = P \cdot p_h / P \cdot q$

$p_T^{Breit} > p_c$

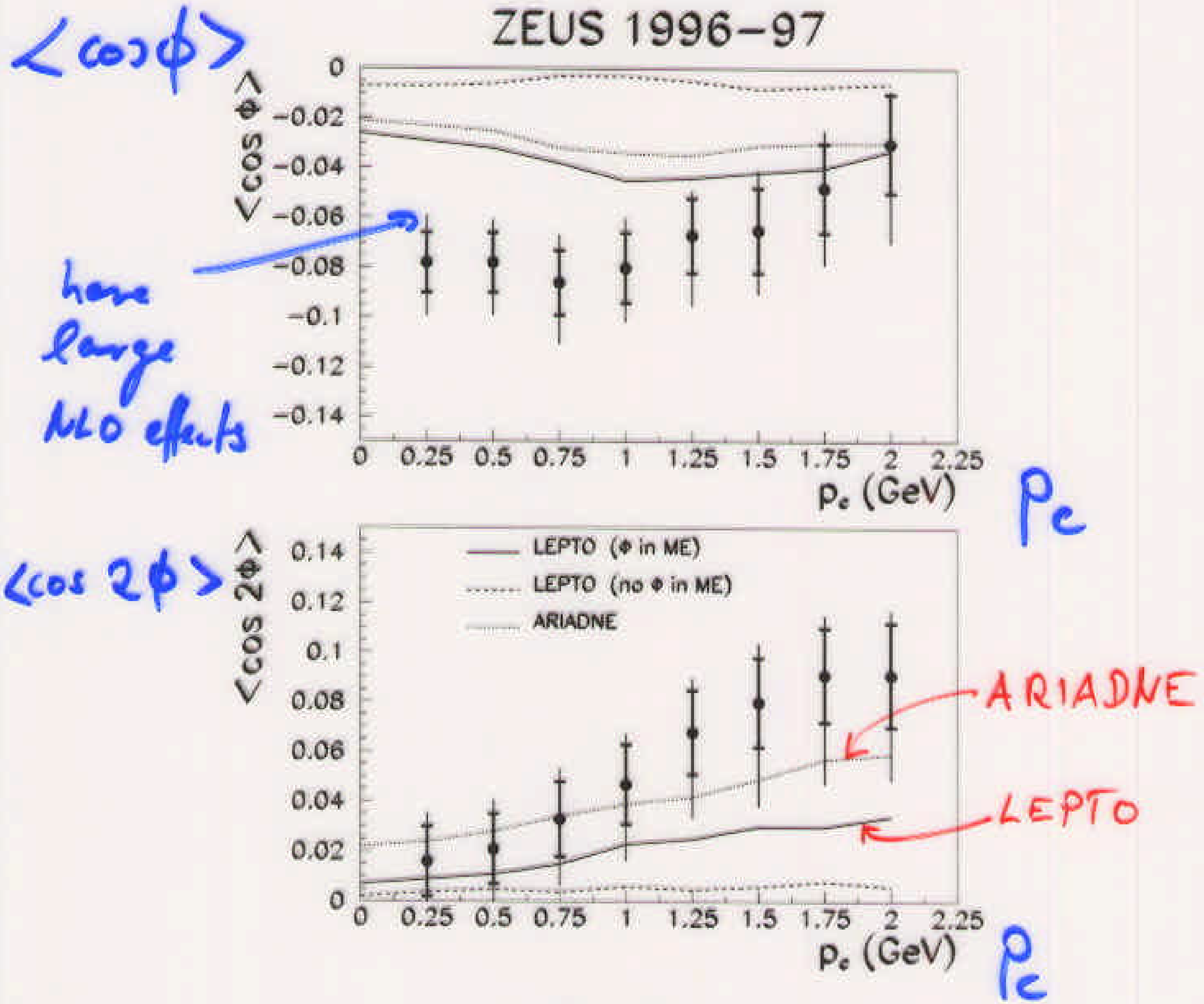
$Q^2 > 180\ \text{GeV}^2$



cos φ , cos 2φ terms clearly visible

ϕ asymmetry vs. for $p_t > p_c$

Abstract 897



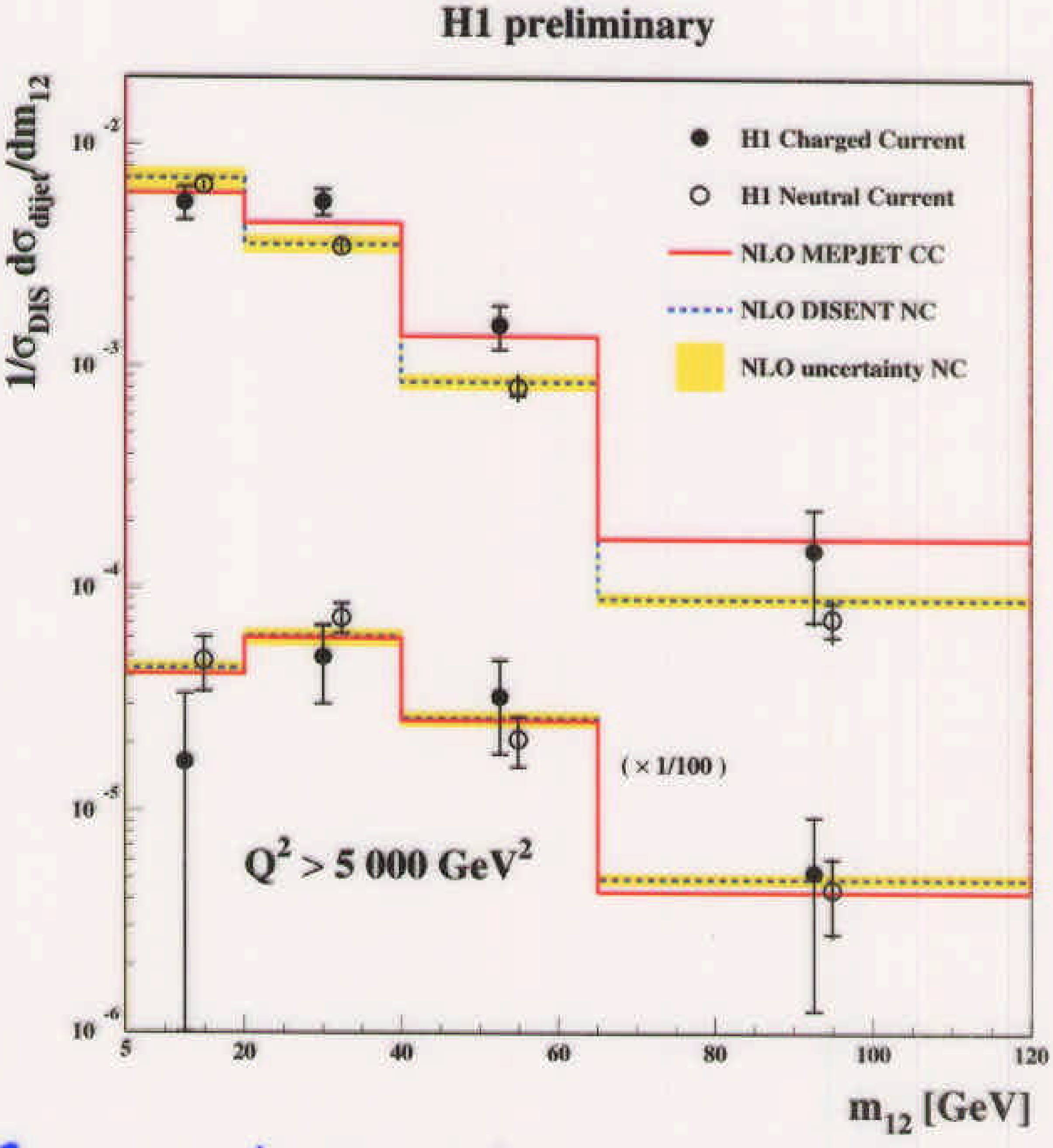
At large $p_\perp^{Breit}$ QCD models with $O(\alpha_s)$ matrix elements are roughly consistent with data

$\cos 2\phi$ effect seen also with jets
Abstract 890 (ZEUS)

2) what about CC ?

Abstract 993

$P_T^{lepton} > 25$ GeV $\quad (Q^2 > 640\ \text{GeV}^2)$



CC consistent with NLO QCD (as NC)

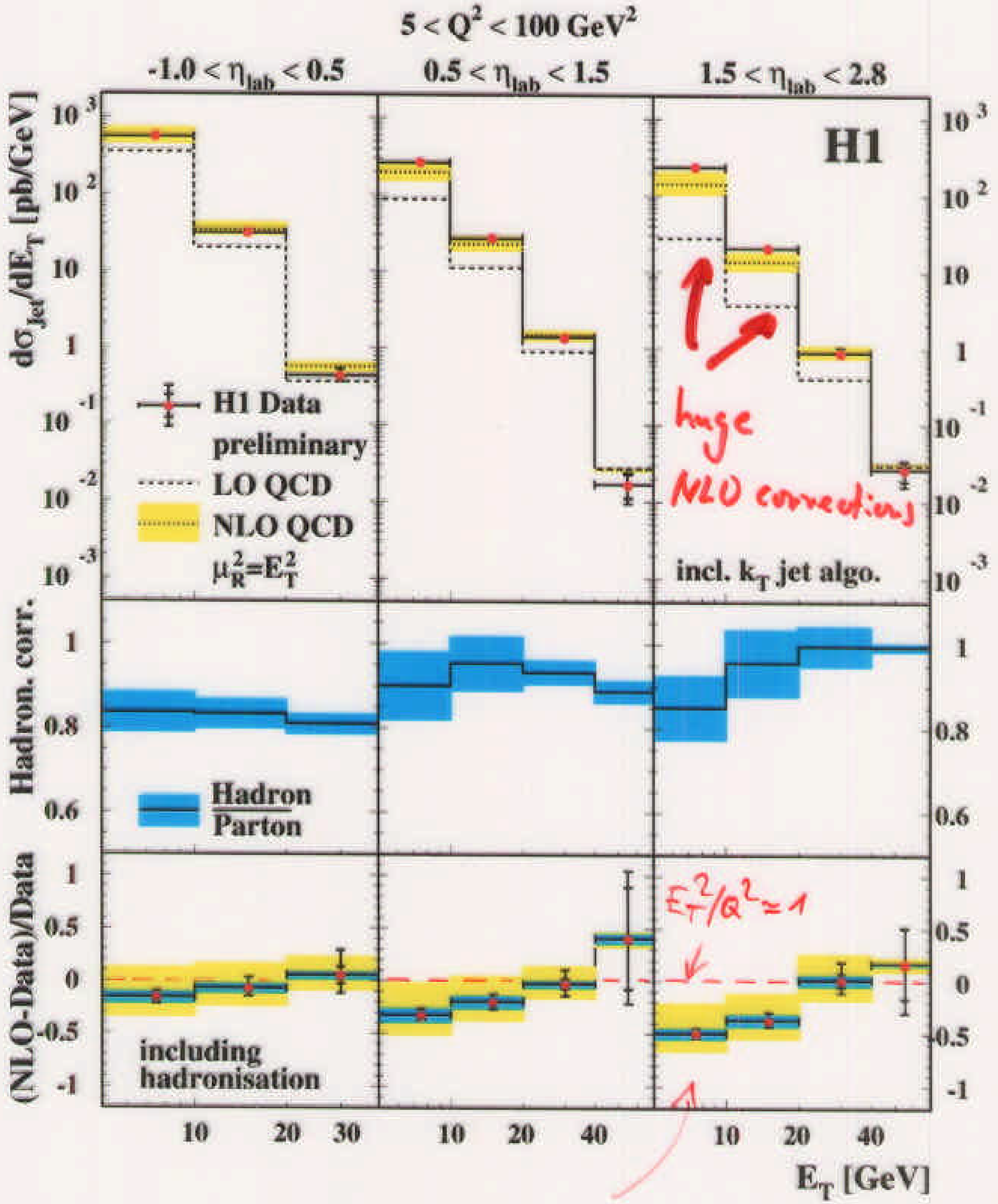
differences NC ↔ CC due to

$\sigma_{tot}(ep \to \nu X) \neq \sigma_{tot}(ep \to eX)$

Systematic Studies, low Q^2

Abstract 999

inclusive jets , $E_T^{Breit} > 5\text{GeV}$:



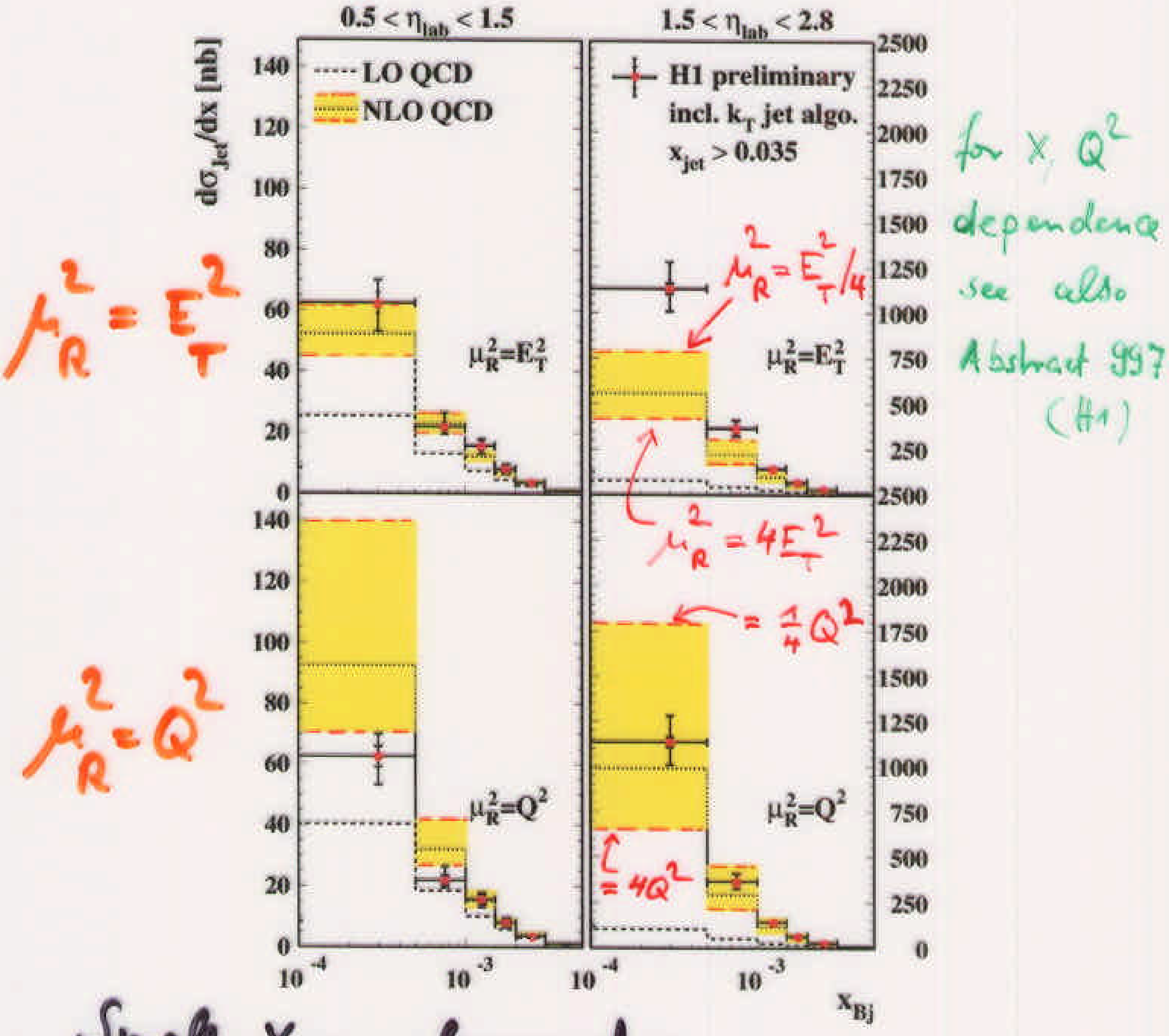
discrepancies are predominantly from small Q^2

x_{Bj} dependence and comparison with NLO, E_t^2 and Q^2 scales

Abstract 999

inclusive jets :

$Q^2 > 5\ \mathrm{GeV}^2$



Small x_{Bj}, forward :

NLO below data, $\mu_R^2 = E_T^2$

~ agreement for $\mu_R^2 = Q^2$, but

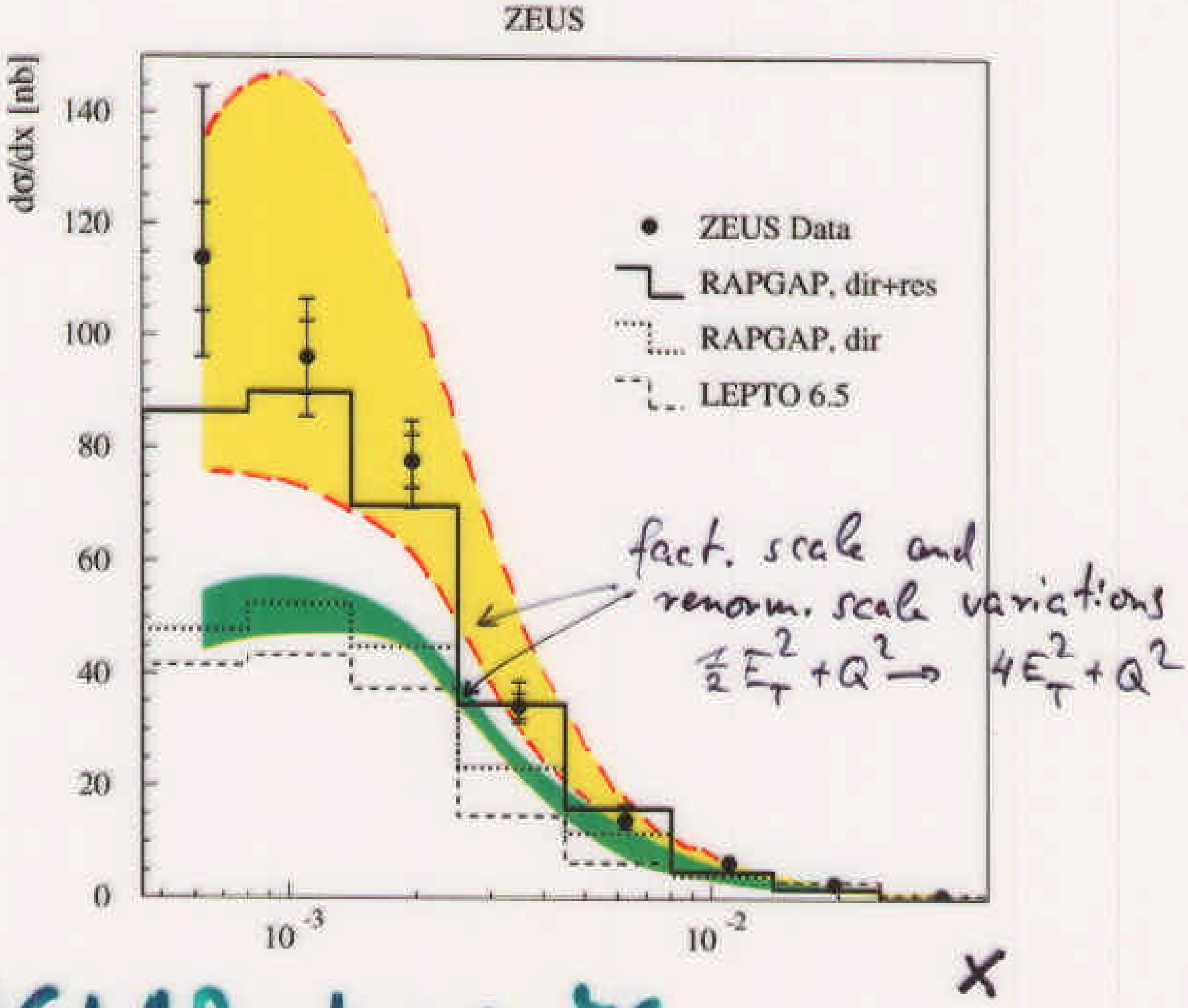
large sensitivity to scale variation

x_{Bj} dependence, comparison with models

Abstract 896

Forward jets : $p_z^{Breit} > 0$ (proton direction)

$x_{jet} = p_z^{lab} / E_{beam}^{p} > 0.036$ $Q^2 > 10\ \mathrm{GeV}^2$, $0.5 < E_T^2/Q^2 < 2$



DGLAP based MCs :

LEPTO : $O(\alpha_s)$ matrix elements + parton showers } fail
RAPGAP : " " " " "

" + resolved γ^* ~ o.k.

resolved:

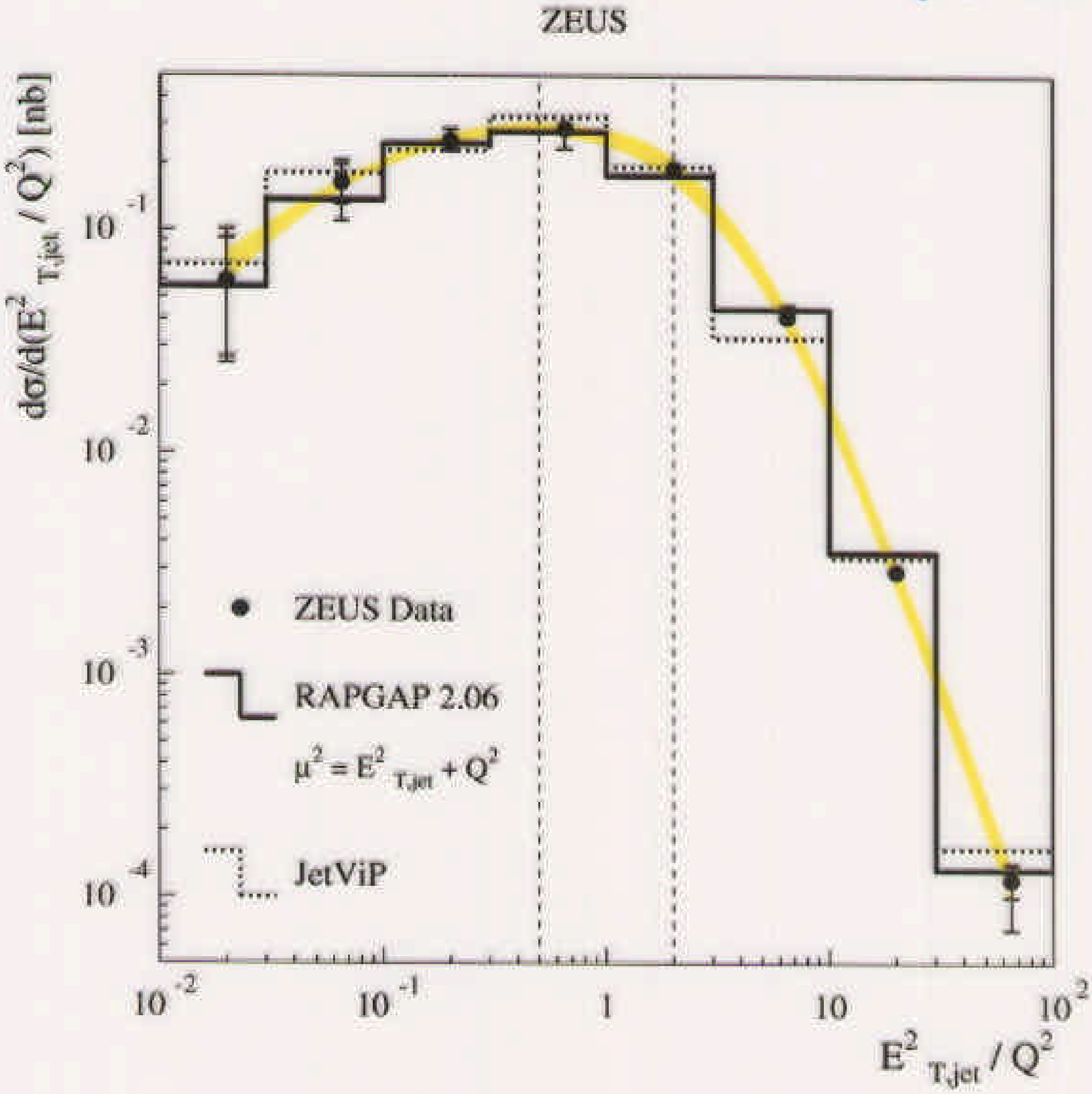
no strong $k_\perp$ ordering

E_t^2/Q^2 dependence, NLO + resolved γ

Abstract 896

Forward jets : $p_z^{Breit} > 0$ (proton direction)

$Q^2 > 10$ GeV^2

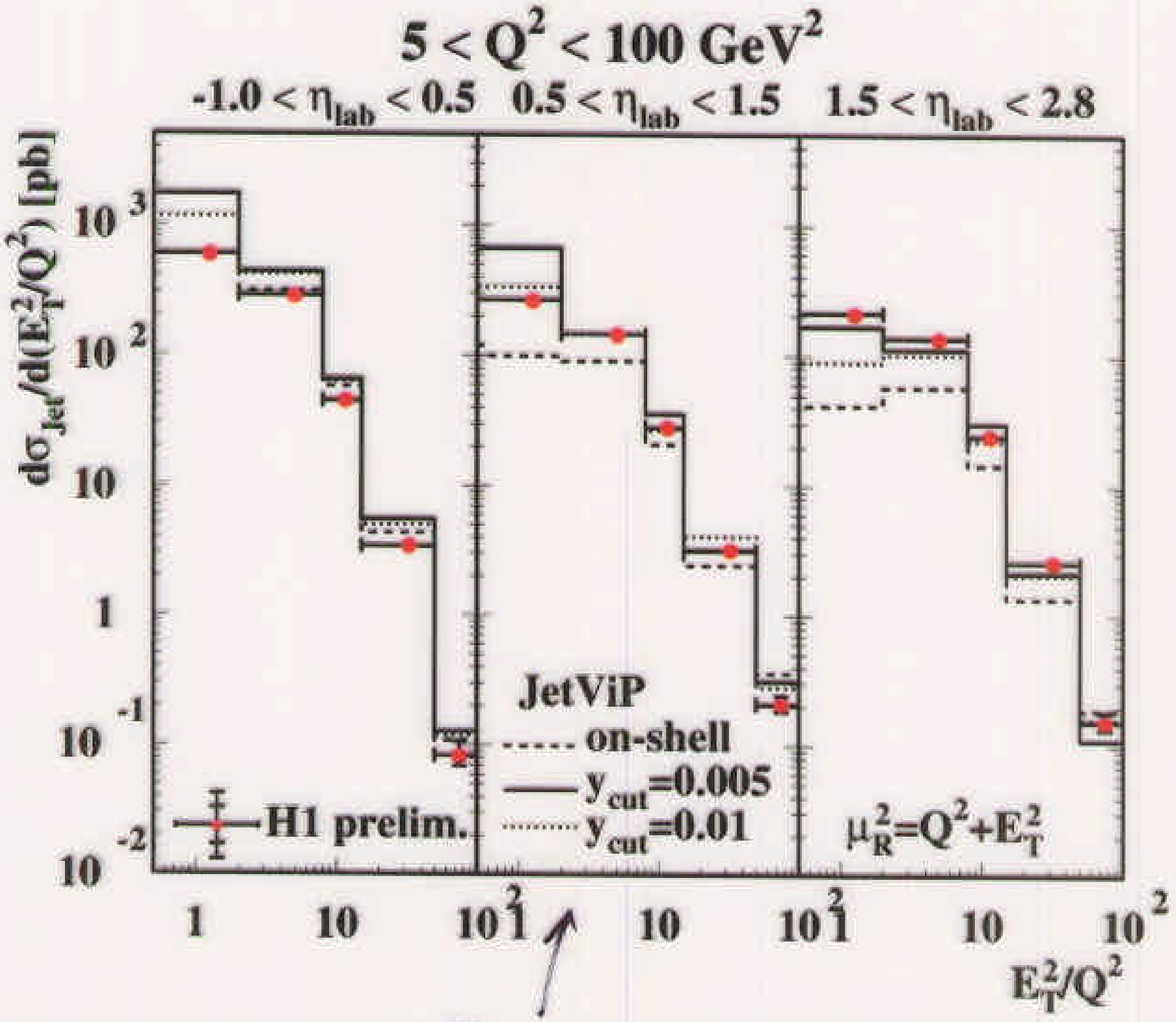


good description by RAPGAP + resolved γ^*
and
NLO pQCD + resolved γ^* (JetVip)

E_t^2/Q^2 dependence, NLO + resolved γ

Abstract 999

inclusive jets :



different treatment of parton masses (virtualities)

no solution yet for extended phase space

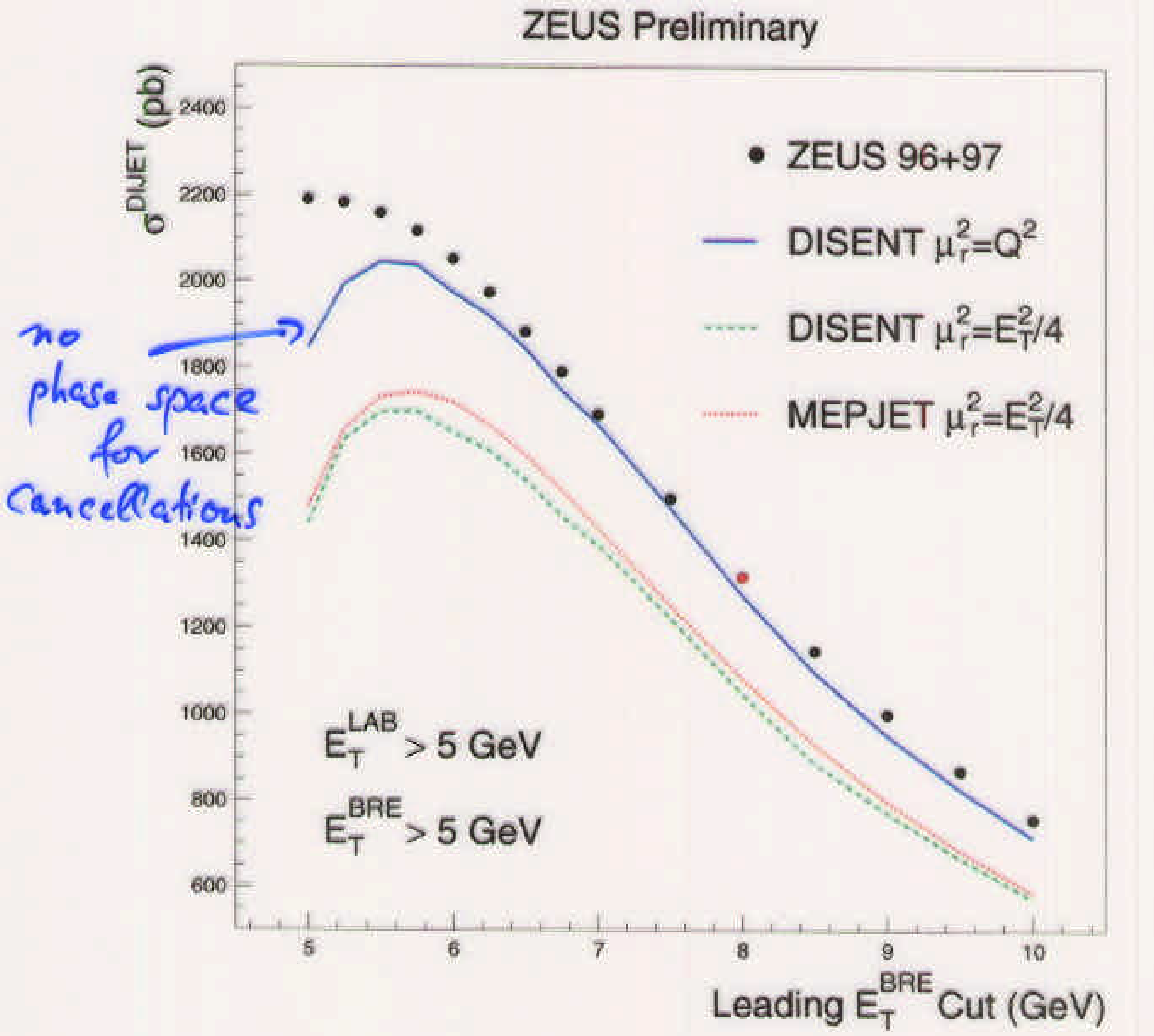
Di-Jets, need for asymmetric cuts

Abstract 888

symmetric cuts, e.g. $E_{T1}^{Breit} > 5$ GeV , $E_{T2}^{Breit} > 5$ GeV,
problematic, if compared with NLO QCD with same cuts

discussed in detail in Abstract 997 (H1)

$Q^2 > 10\ GeV^2$



↝ practice: $E_{T_1} - E_{T_2} \gtrsim 2$ GeV

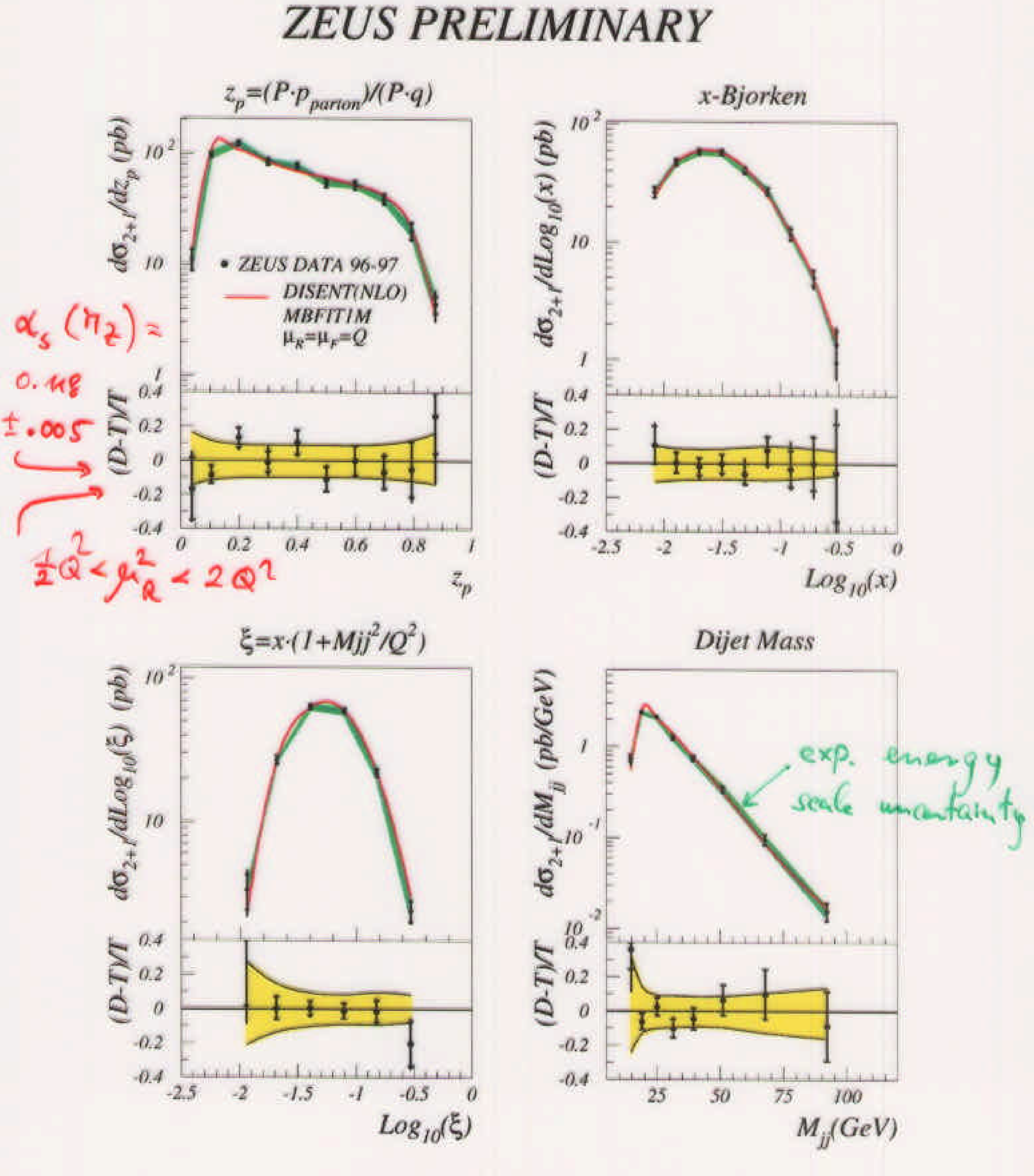
or $E_{T_1} + E_{T_2} \gtrsim 15$ GeV

Di-jets at high Q^2

Abstract 891

$470 < Q^2 < 20000$ GeV^2 , $-1 < \eta_{jet}^{lab} < 2$

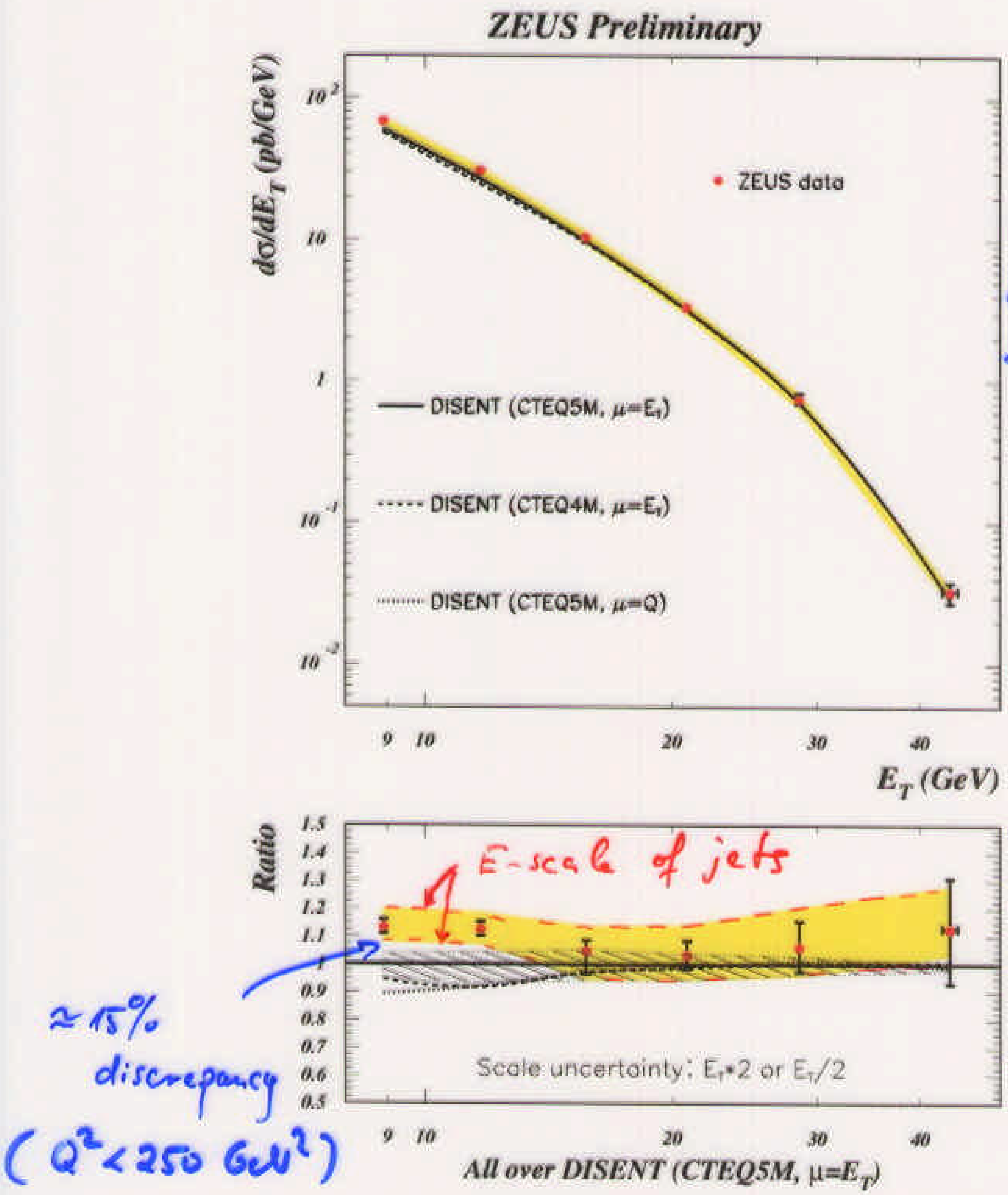
$E_T^{jet1} > 8$ GeV , $E_T^{jet2} > 5$ GeV



Inclusive Jets and NLO QCD at High Q^2

$Q^2 > 125\ \text{GeV}^2$, $-2 < \eta_{jet}^{Breit} < 1.8$ **Abstract 890**

$d\sigma/dE_T{}^{Breit}$

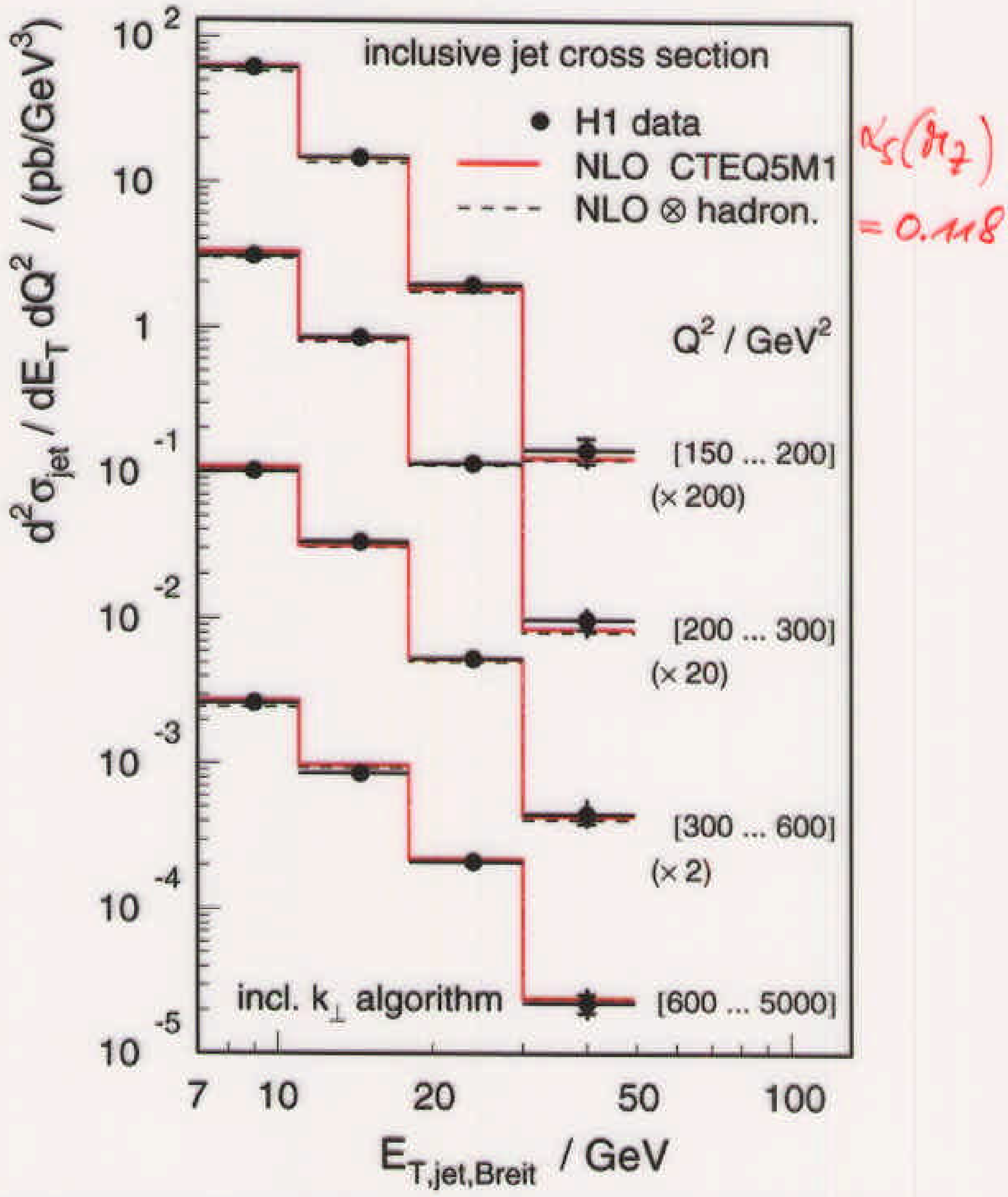


data corrected to parton level

inclusive: $d\sigma_{jet}/dE_T$ for different Q^2

(Abstract 1000)

$150 < Q^2 < 5000$ GeV^2 , $-1 < \eta_{jet}^{lab} < 2.5$



Good description at high Q^2

hadronization corrections small (<10%)

Summary

Data low Q^2, low x, forward region:

- Interplay of different scales
  - E_T^2: more definite discrepancies
  - Q^2: large effects of scale variations
- Photonstructure can not be ignored
- NLO (α_s^2) remarkably good compared to LO, but clear discrepancies

Data at high Q^2 ($Q^2 \gtrsim 150$ GeV^2)

- Good description of data by NLO pQCD
- NLO corrections moderate, effect of scale variations, hadronisation corrections $\lesssim 10\%$
- Inviting for quantitative QCD analysis
  → α_s, $G(x)$ in proton → Enrico Tassi