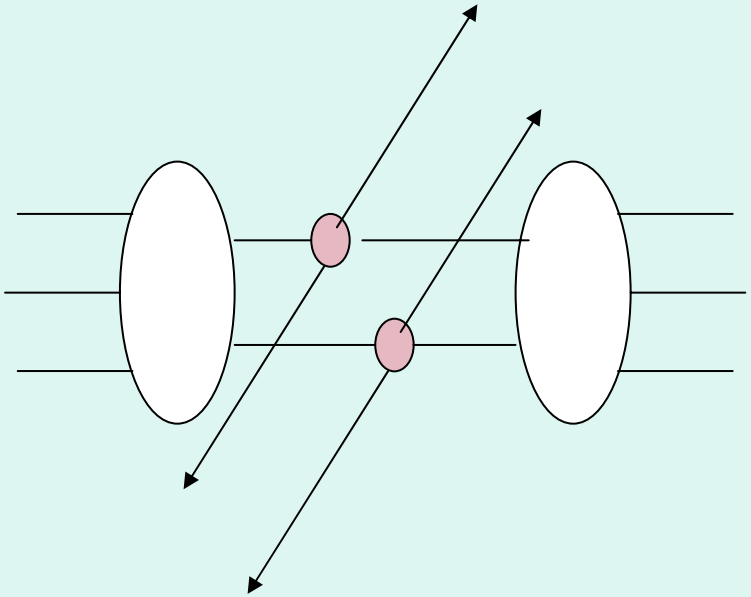
Forward jets with multiple interactions

Jacek Turnau & Izabela Milcewicz at HERA-LHC workshop CERN)october 2004

Multiple interactions



Multiple interactions: Several parton pairs undergo hard interactions

Simplest m.i. event: 4 jets, not easily distinguished from QCD cascac

Existing experimental evidence: CD

Double parton scattering in $p\bar{p}$ collisions at $\sqrt{s} = 1.8$ TeV

MULTIJETS IN PHOTOPRODUCTION AT HERA*

ZEUS:

Forward jets and m.i.

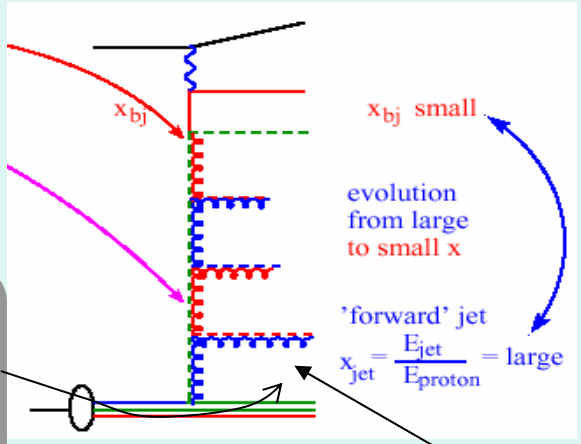
Why should m.i. matter for forward jets ?

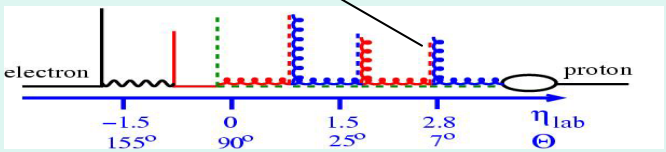
M.I. represent small correction to standard single parton interaction QCD . It may be important in those regions of phase space which standard QCD does not populate e.g. forward jet region. (Similarly as Mueller forward jets - signature of non-DGLAP evolution, are observed in the phase space region not populated by DGLAP evolution)

Large x_{jet}/x_{bj} to enhence phase space for BFKL evolution

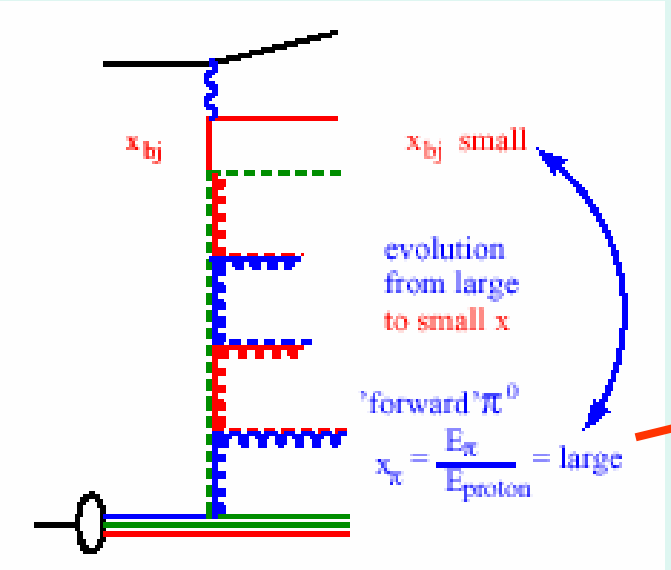
$p_{tjet}^{\ 2} \approx Q^2$

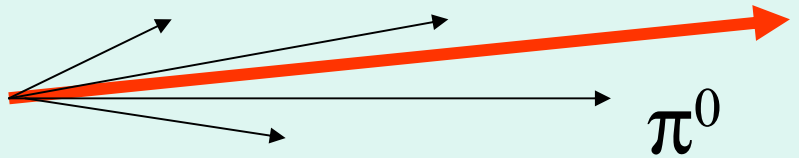
to supress DGLAP evolution





Forward jets ⇔forward particles (π^0)





$$\sigma(\pi^0) = \begin{bmatrix} \text{FF} \\ \text{JETSET} \\ \text{PYTHIA} \end{bmatrix} \otimes \sigma(jet)$$

Jet measurements

- \+ better parton correlation
- \+ higher rates
- _ ambiguities of jet algoriths
- _ exp. difficult in very forward (p) region

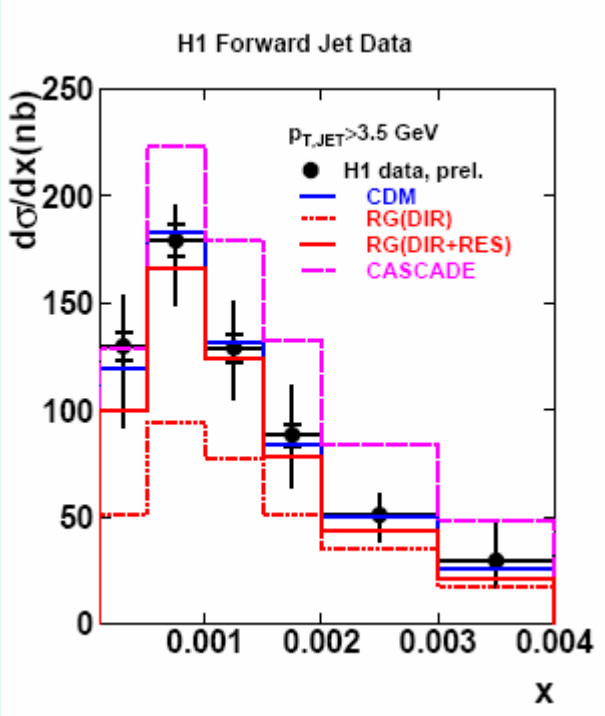
forward particle detection π^0

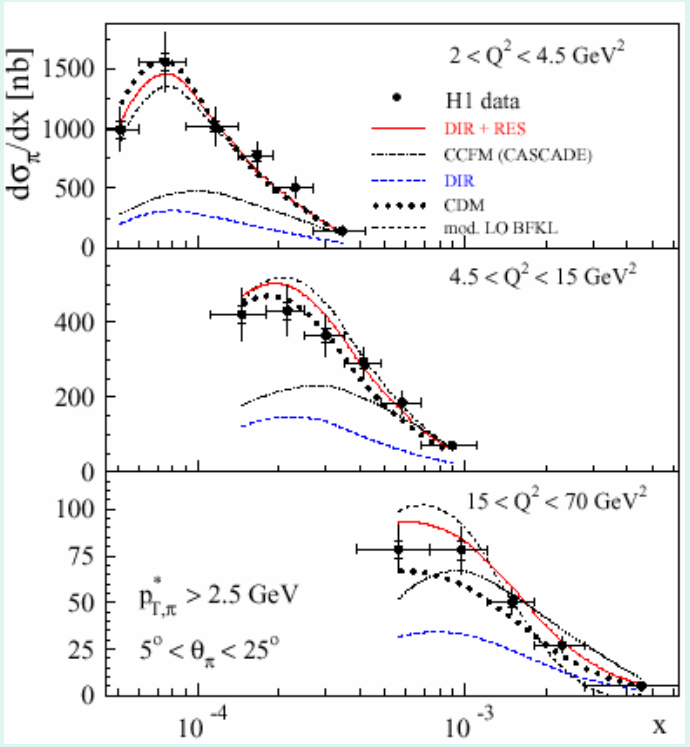
- _ fragmetation effects more significant
- _ smaller rate

- \+ identification possible in more forward region

forward jets
$5 < Q^2 < 75$ GeV^2
$0.1 < y < 0.7$
$7 < \theta_{jet} < 20°$
$p_{t\,jet} > 3.5(5.0)$ GeV (LAB)
$x_{jet} = E_{jet}/E_p > 0.035$
$0.5 < p_{t\,jet}^2/Q^2 < 2$
inclusive k_t algorithm
Breit frame

forward π^0 detection
$2 < Q^2 < 70$ GeV^2
$0.1 < y < 0.6$
$5 < \theta_{\pi^0} < 25°$
$p_{\pi^0} > 2.5(3.5)$ GeV (hCMS)
$x_{\pi^0} = E_{\pi^0}/E_p > 0.01$
$\rightarrow E_{\pi^0} > 8.2GeV$
$\pi^0 \rightarrow 2\gamma$ reconstructed
as one em cluster in H1 calo





Simulation of m.i. in DIS

At present only MC program which can simulate DIS events with m.i. is PYTHIA

Use PYTHIA 6.2

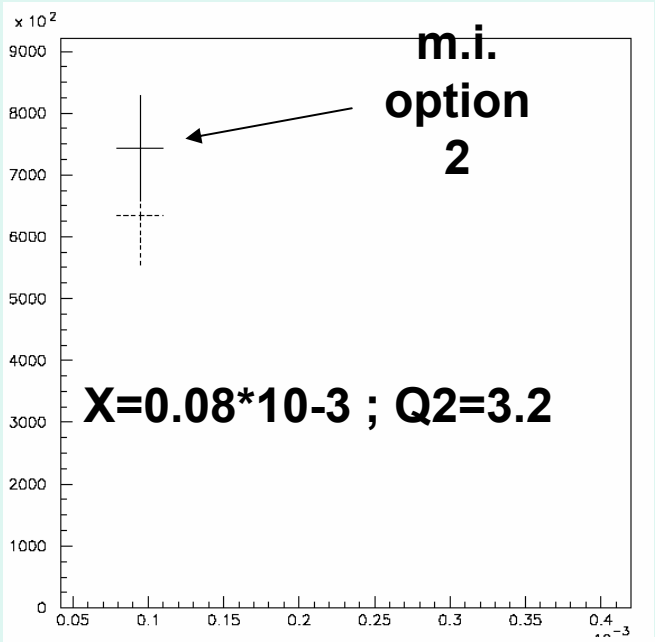
Problems:

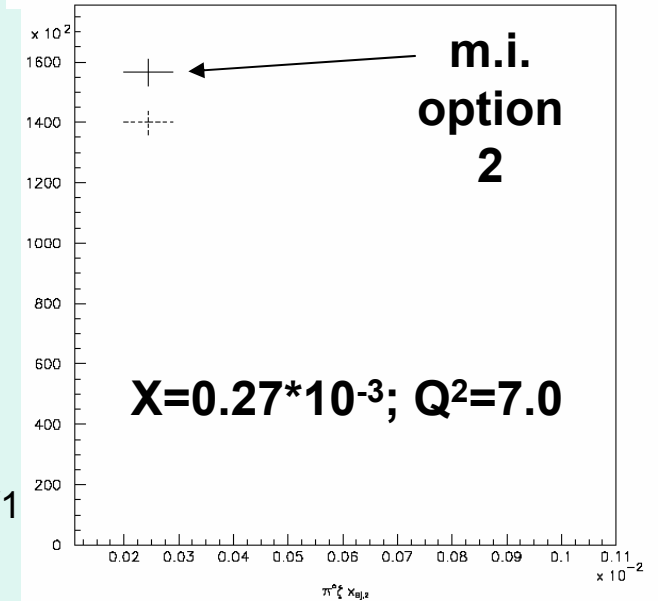
1. **Initialization of m.i. at fixed energy of** γp
2. **In PYTHIA 6.2 ep DIS ISR is not implemented →direct contribution too large, poor description of e.g. transverse energy flow for medium Q^2**

Solutions:

1. **Use gamma – p mode with photon 4-momentum calculated for given x-Q^2 bin. In this way we can only calculate ratio (fwd-jet with m.i./fwd-jet) at fixed x and Q^2**
2. **Calculate above ratio for resolved process only**

Forward π^0 with multiple interactions





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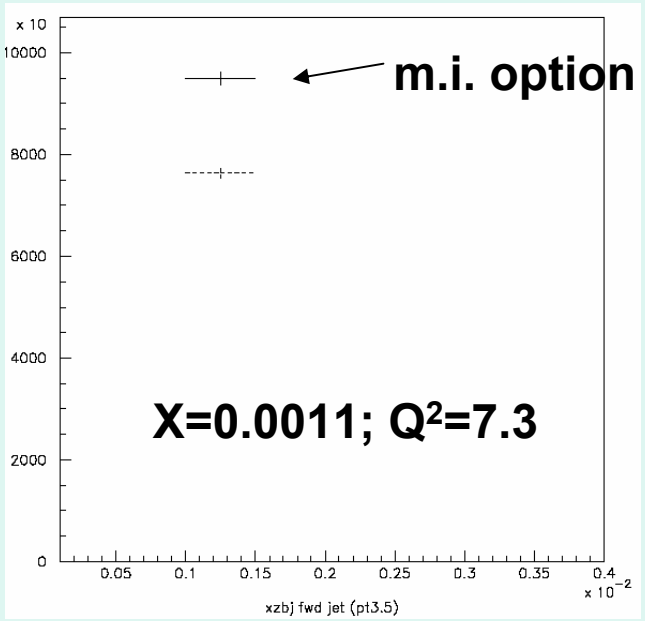
PYTHIA 6.2 in „gamma" mode

(X, Q^2)→$p_{\_gamma}$

No, cross section, arbitrary scale, only ratio m.i./no-m.i.

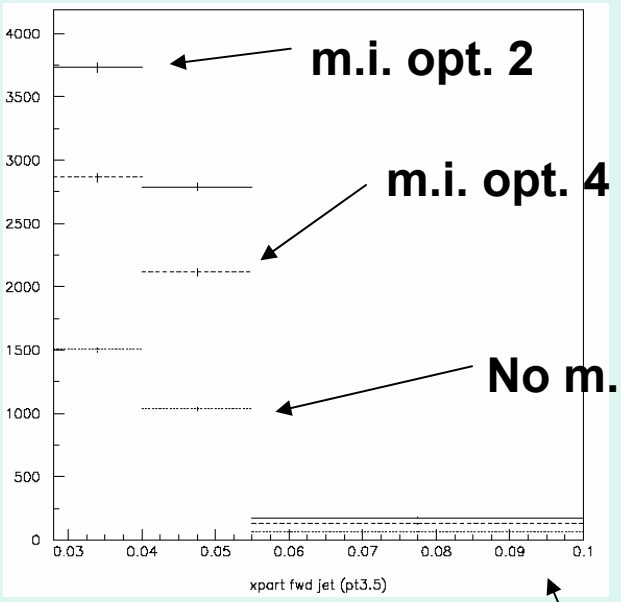
u forward jets with m.i.

Forward Jets with multiple interactions



m.i. option 2

X=0.0011; Q^2=7.3

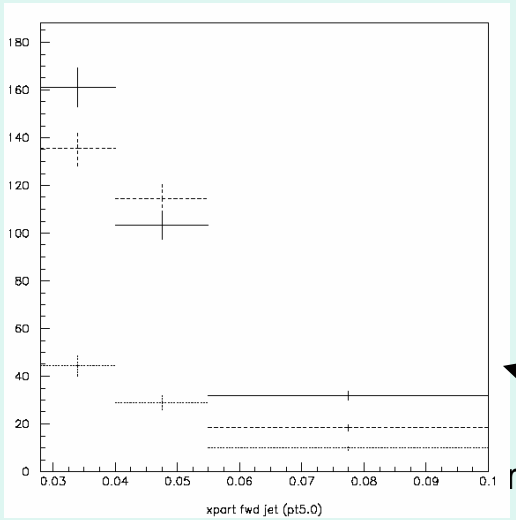


m.i. opt. 2

m.i. opt. 4

No m.i.

p_{Tjet}>3.5

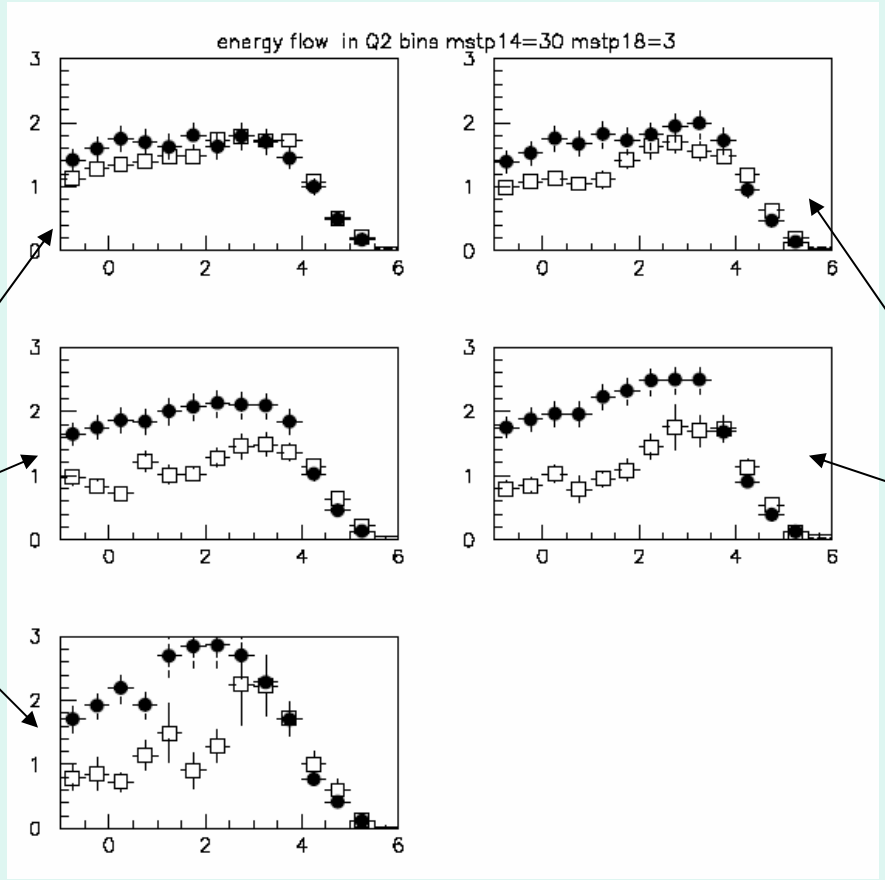


X=0.00036; Q^2=13.1

p_{Tjet}>5.0

Summary and outlook

- **PYTHIA 6.2 is not yet tuned to ep DIS at HERA**
- **Small effect of multiple interactions on forward π^0 cross section**
- **Effect of multiple interaction on the resolved contribution to „mueller" forward jets can be substantial**
- **Effect of m.i. on forward jet/particle cross sections will be checked combining RAPGAP (direct and resolved cross sections) and PYTHIA 6.2 (m.i. corrections to resolved part)**
- **Forward jet region could be interesting for studies of m.i. especially if additional observable enhencing resolved contribution could be measured together with forward jet**



$2.5\ \mathrm{GeV}^2 < Q^2 \leq 5\ \mathrm{GeV}^2$

$5\ \mathrm{GeV}^2 < Q^2 \leq 10\ \mathrm{GeV}^2$

$10\ \mathrm{GeV}^2 < Q^2 \leq 20\ \mathrm{GeV}^2$

$20\ \mathrm{GeV}^2 < Q^2 \leq 50\ \mathrm{GeV}^2$

$50\ \mathrm{GeV}^2 < Q^2 \leq 100\ \mathrm{GeV}^2$

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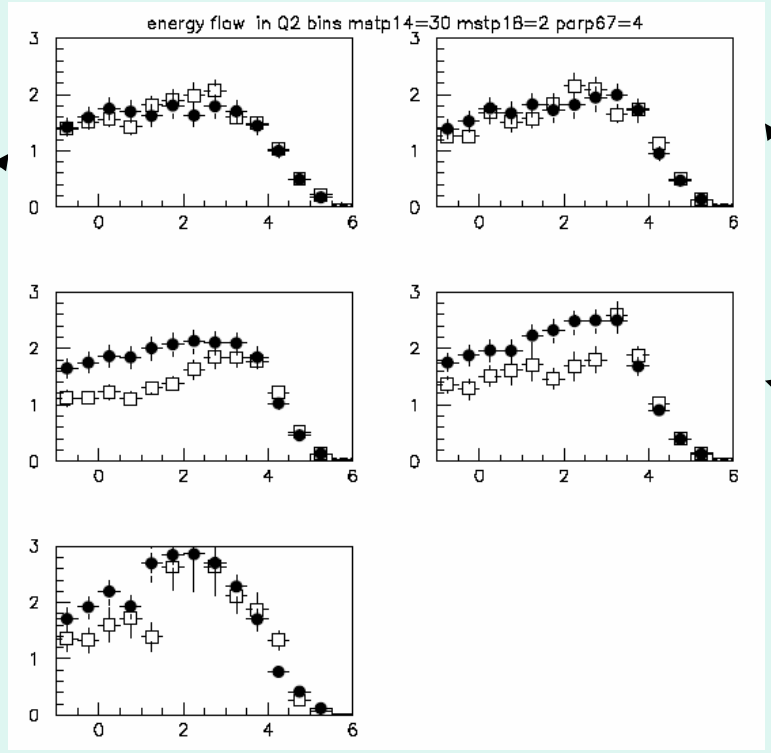
Transverse energy flow in Q^2 bins ,default PYTHIA steering



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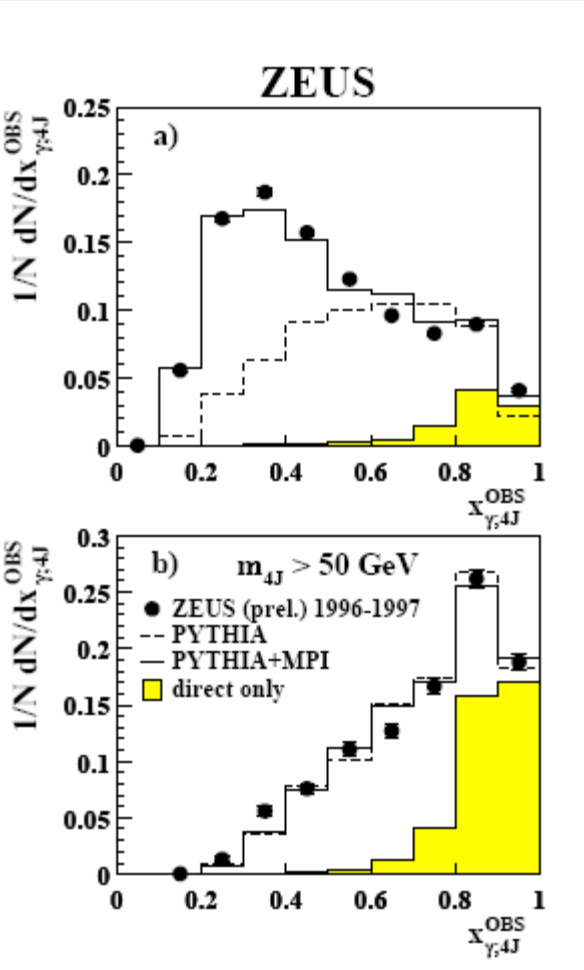
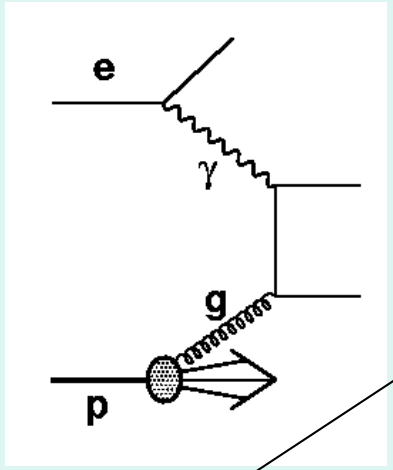
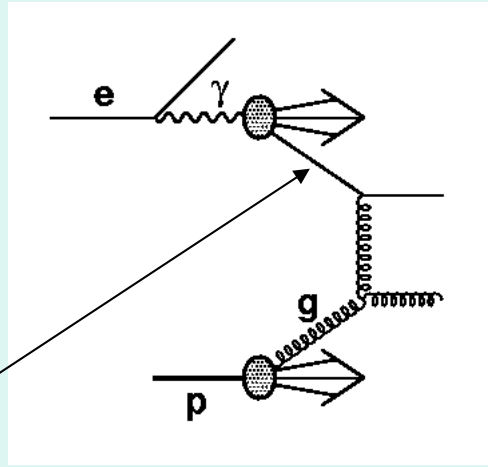
Transverse energy flow in Q^2 bins , somewhat tuned PYTHIA

ZEUS 4j events in photoproduction

$$ep \rightarrow e + 4j + X$$







$$x^{OBS}_{\gamma;NJ} = \frac{\sum_{jet=1}^{N} E_T^{jet} \exp(-\eta^{jet})}{2yE_e},$$