Summary of DIS 2003 in St. Petersburg: Part IV

Christian Schwanenberger
DESY, Germany

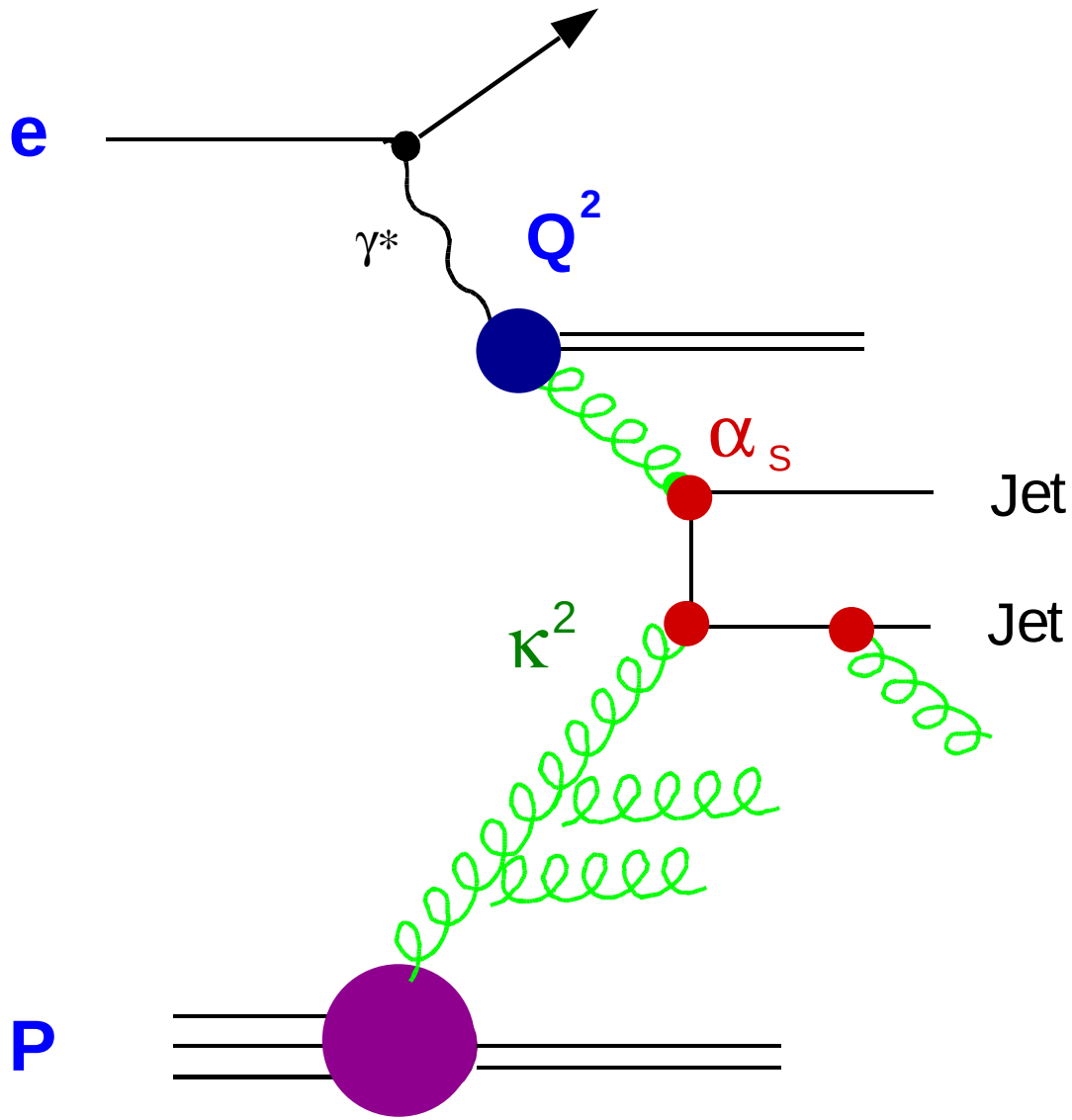
DESY Seminar, May 20, 2003

Outline

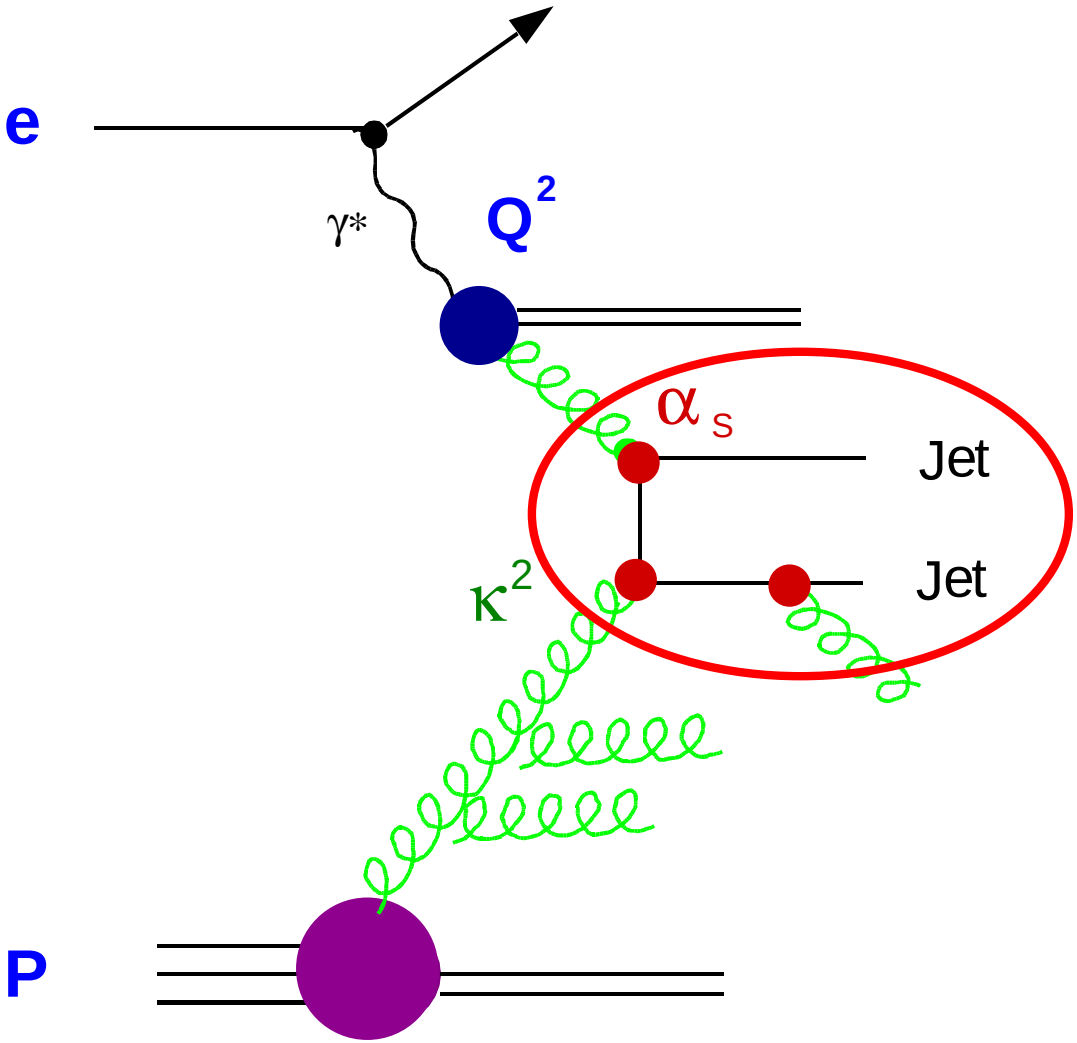
- Hadronic Final States: 37+2 talks
  tests of perturbative QCD
  - $p\bar{p}$ collisions (TeVatron)
  - $\gamma\gamma$ collisions (LEP)
  - γp collisions (HERA)
  - ep collisions (HERA)
- Electroweak and Physics Beyond the SM: 21+2 talks
  - precision tests of SM
  - searches for new physics
  - unexpected events

$\Rightarrow$ selected topics: analyses where something is new with respect to summer conferences of 2002

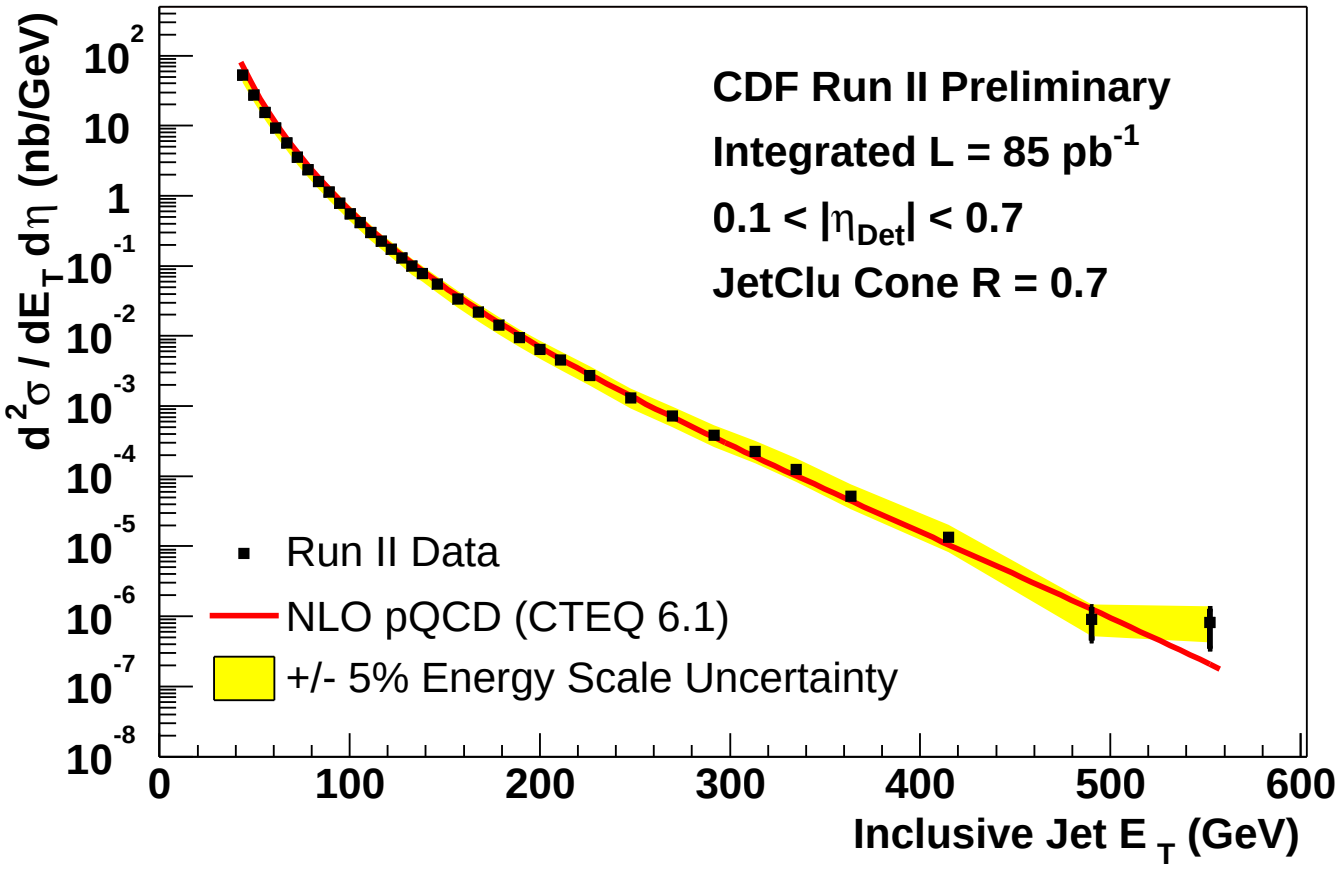
Hadronic Final States: e. g. ep Scattering



NLO QCD and α_S



$p\bar{p}$ Collisions: Inclusive Jet Cross Section



talk by A. Bhatti

NLO: Ellis, Soper

Run II: $\sqrt{s} = 1.96$ TeV (instead of 1.8 TeV at Run I)

$\Rightarrow$ transverse energy up to 550 GeV (instead of 400 GeV)

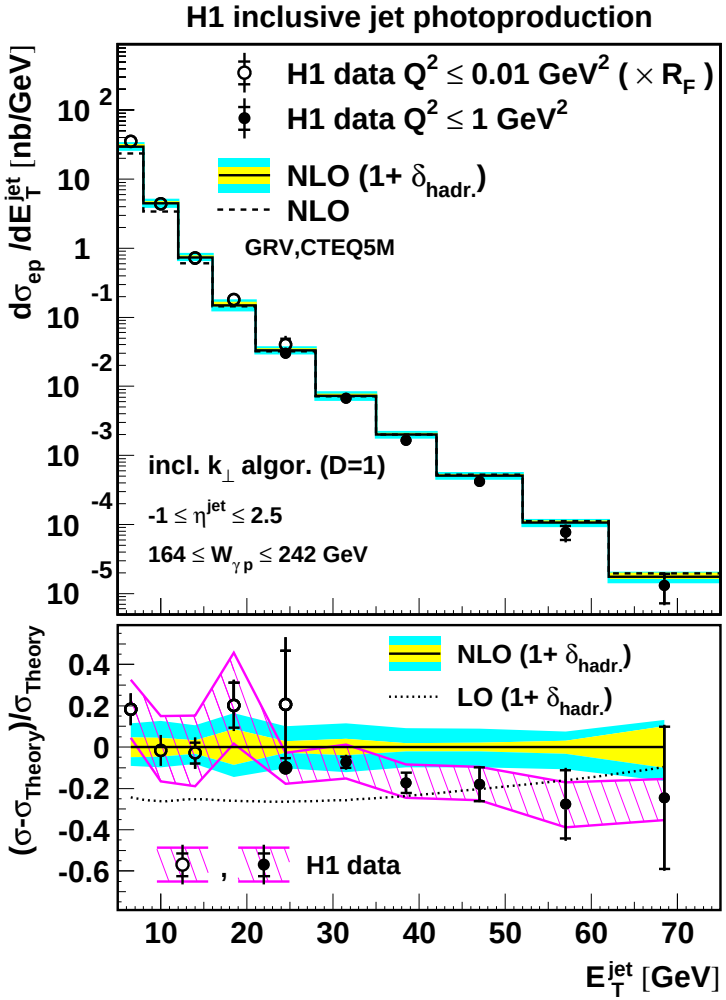
$\Rightarrow$ good agreement with NLO QCD

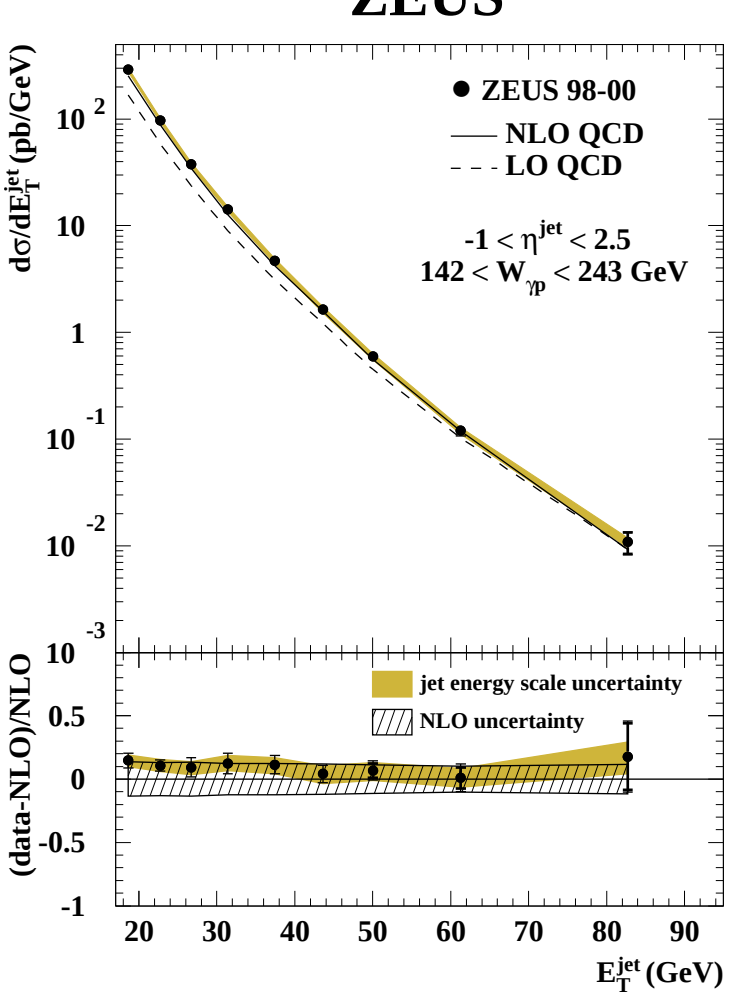
γp Collisions: Inclusive Jet Cross Section

talks by B. Andrieu, J. Terrón

NLO: Frixione, Ridolfi

NLO: Klasen, Kleinwort, Kramer





$\Rightarrow$ precise test of NLO QCD:

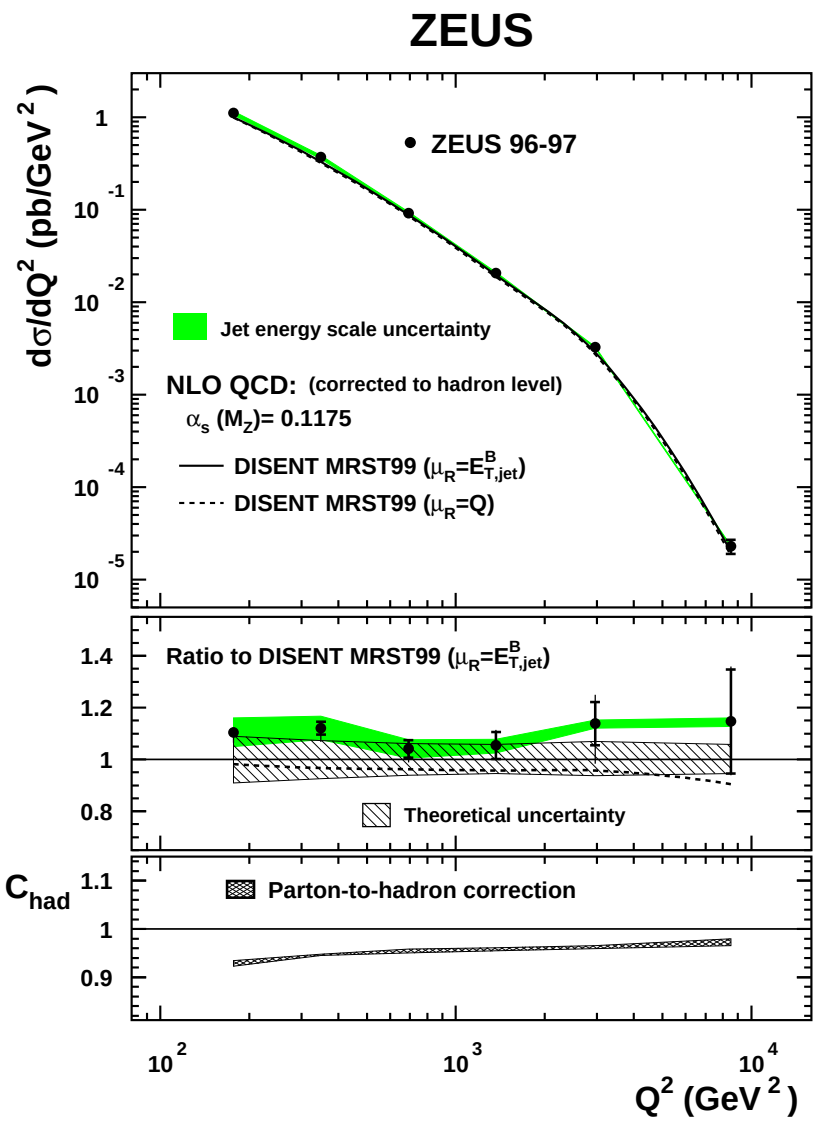
6 orders of magnitude

$\Rightarrow \alpha_s(M_Z) = 0.1224 \pm 0.0001\ (\text{stat.})$

$^{+0.0022}_{-0.0019}\ (\text{exp.})\ ^{+0.0054}_{-0.0042}\ (\text{th.})$

ep Collisions: Inclusive Jet Cross Section in NC DIS

talks by A. Specka, J. Terrón



- kinematical range:

  $Q^2 > 125\ \mathrm{GeV}^2$

  $-0.7 < \cos\gamma < 0.5$

- jets in Breit frame:

  $E^B{}_{T,jet} > 8$ GeV

  $-2 < \eta^B{}_{jet} < 1.8$

- extraction of α_s for $Q^2 > 500\ \mathrm{GeV}^2$:

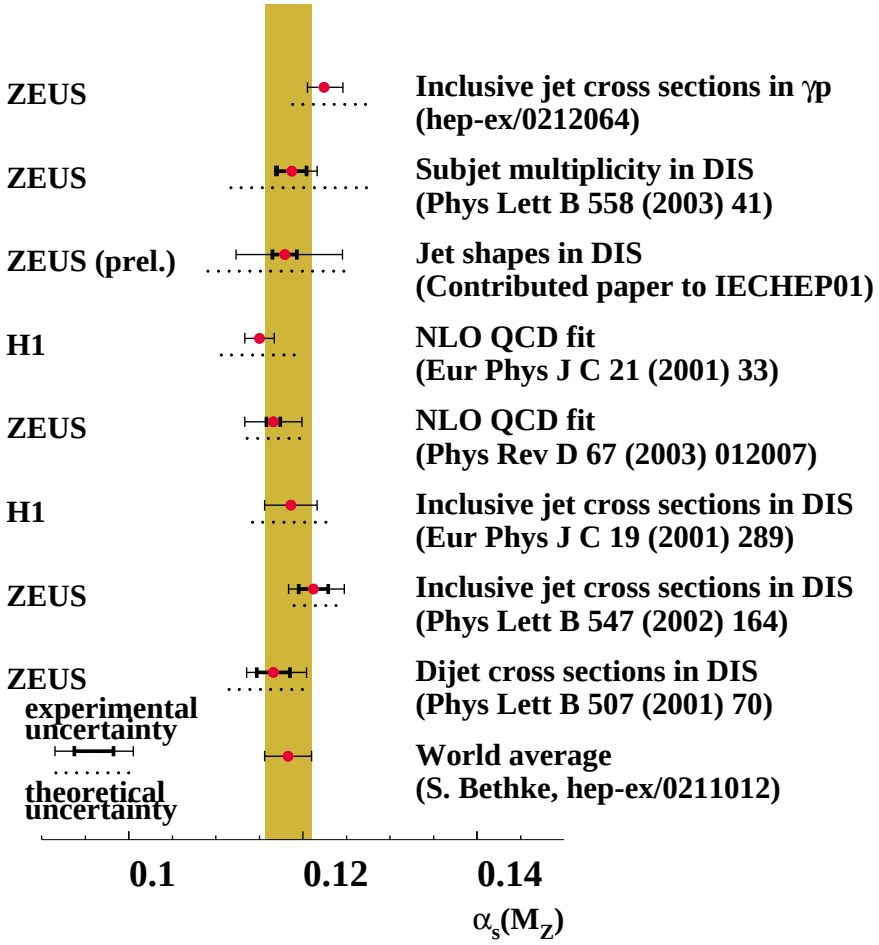
$$\alpha_s(M_Z) = 0.1212 \pm 0.0017\ (\mathrm{stat.}) \; {}^{+0.0023}_{-0.0031}\ (\mathrm{syst.}) \; {}^{+0.0028}_{-0.0027}\ (\mathrm{th.})$$

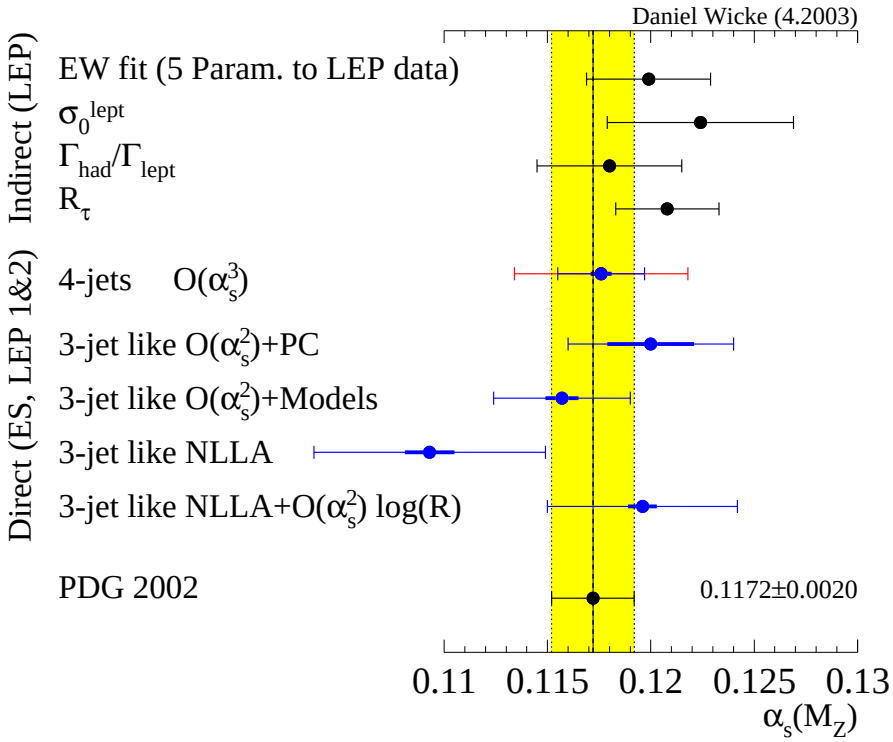
NLO: Catani, Seymour

$\Rightarrow$ very precise determination of $\alpha_s(M_Z)$

Precision Tests: Measurement of α_S

talk by J. Terrón

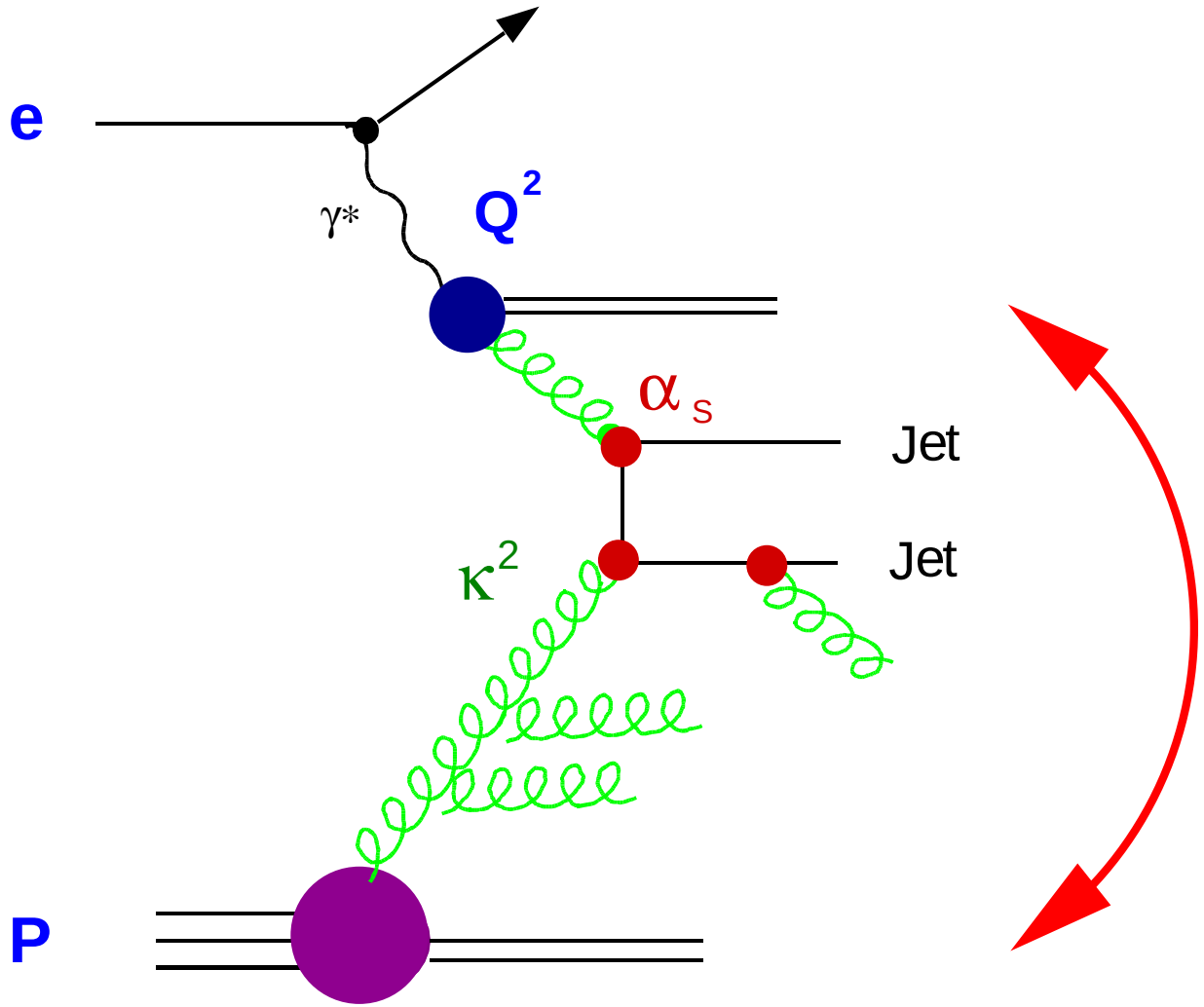




$\Rightarrow$ HERA precision is competitive to LEP

$\Rightarrow$ theoretical uncertainties (beyond NLO terms) dominate accuracy

Color Reconnection

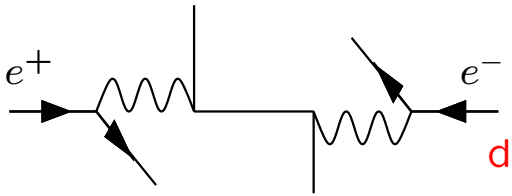


$\gamma\gamma$ Collisions: Di-Jet Cross Section

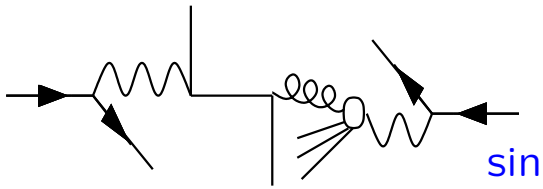
talk by K. Krüger

Estimate of fraction of photon momentum entering hard collision

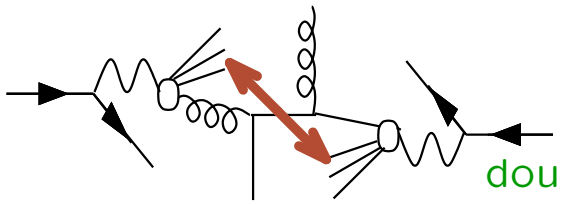
$$x_\gamma^{\pm} = \frac{\sum_{\text{jet1,2}} E \pm p_z}{\sum_{\text{hadrons}} E \pm p_z}$$



direct

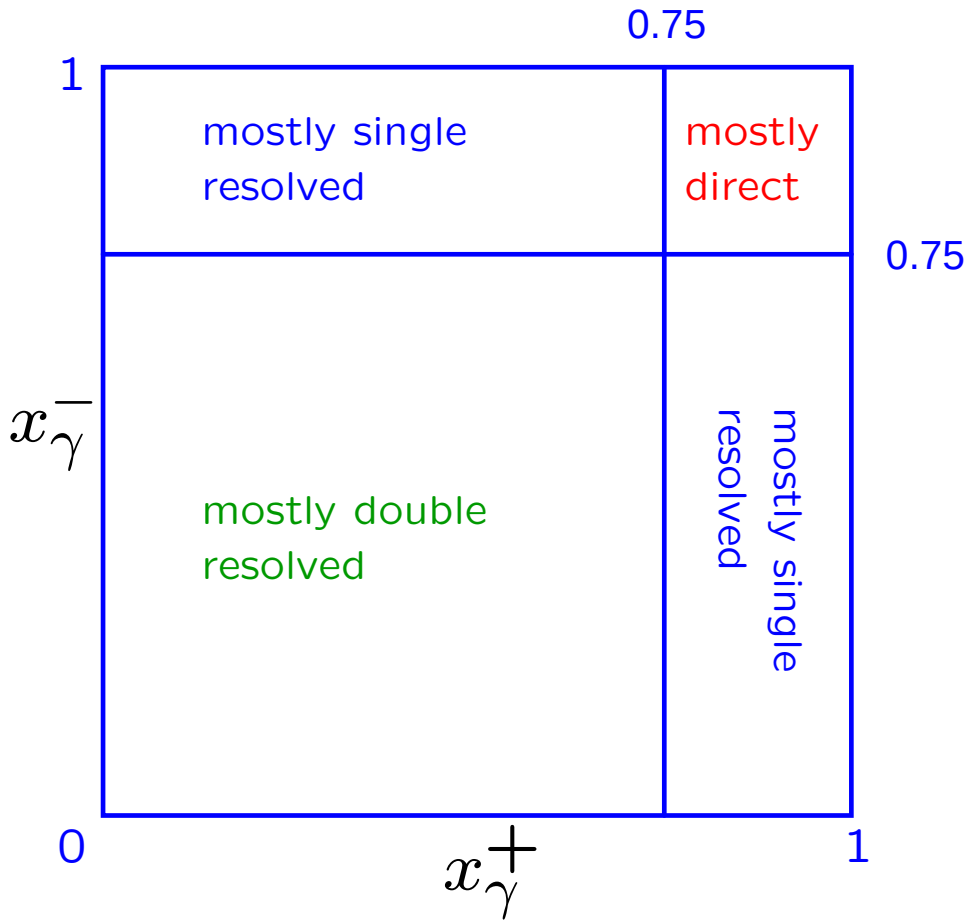


single resolved

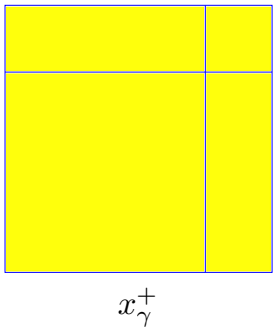


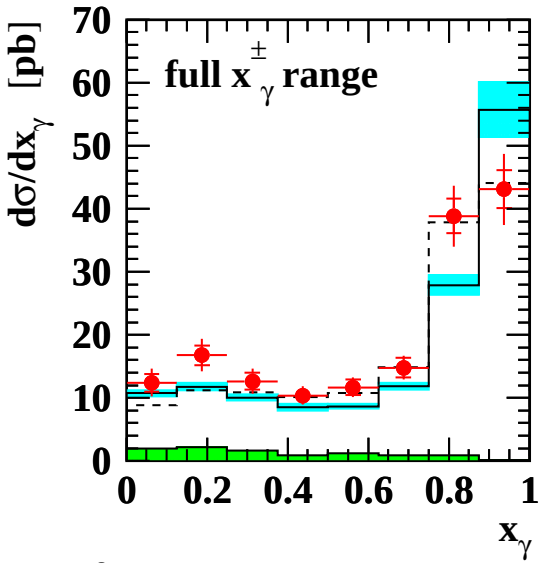
double resolved

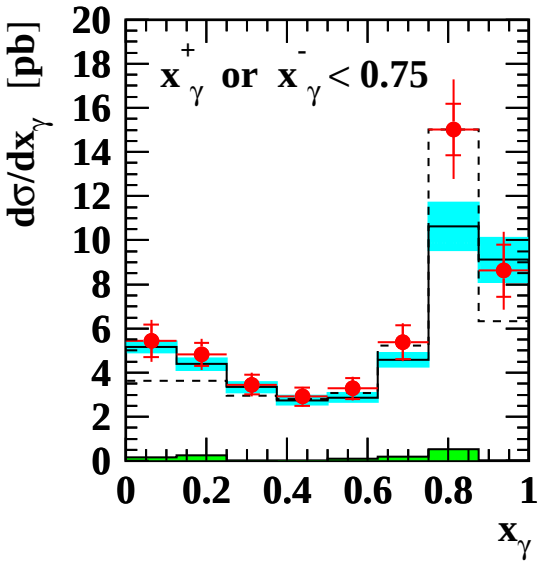
multiple parton interactions (MIA)?

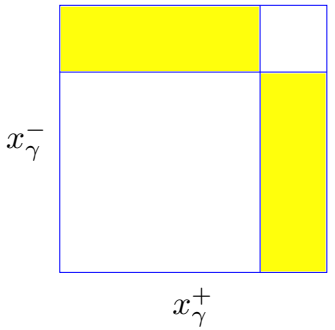


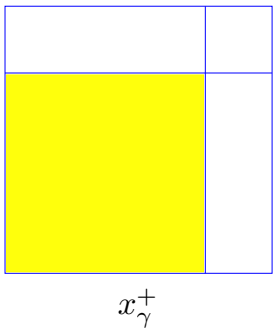
Di-Jet Cross Section vs. x_γ

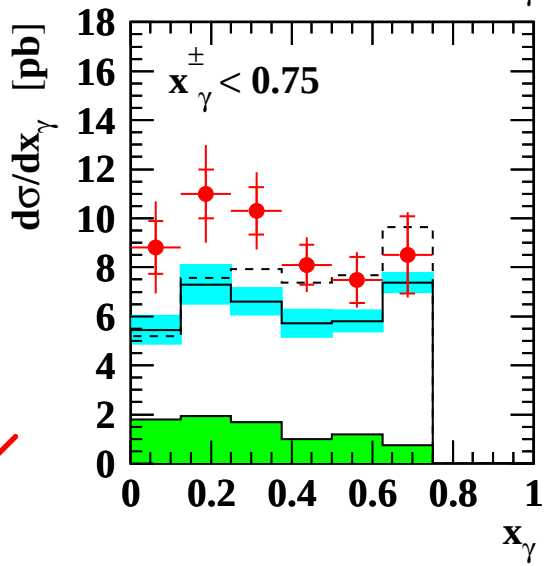












- OPAL

$7 < \bar{E}_T^{jet} < 11$ GeV

NLO / ($1+\delta_{hadr}$)

PYTHIA SaS 1D

PYTHIA MIA contribution

single resolved:

NLO describes data well

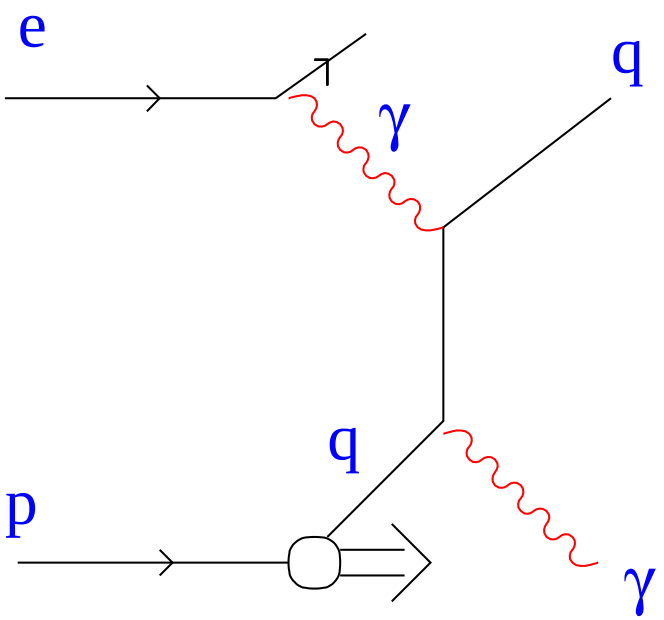
NLO: Klasen, Klein-wort, Kramer; Pötter

double resolved: no MIA included in NLO

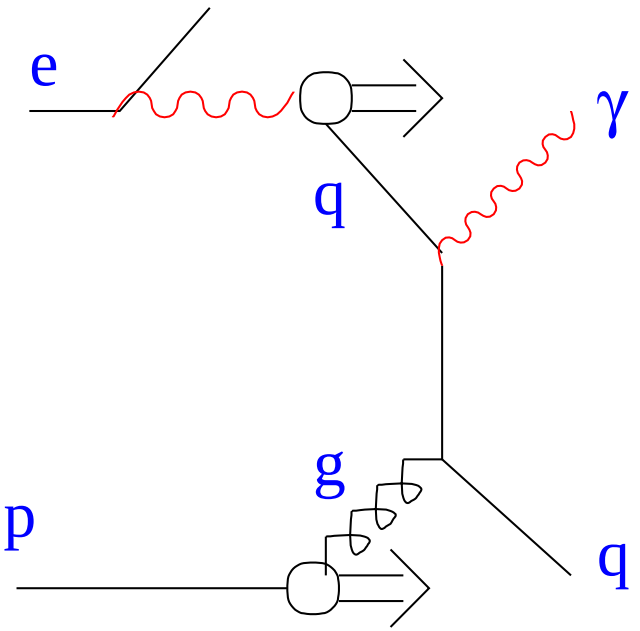
Prompt Photon Production at HERA

talk by R. Lemrani

direct



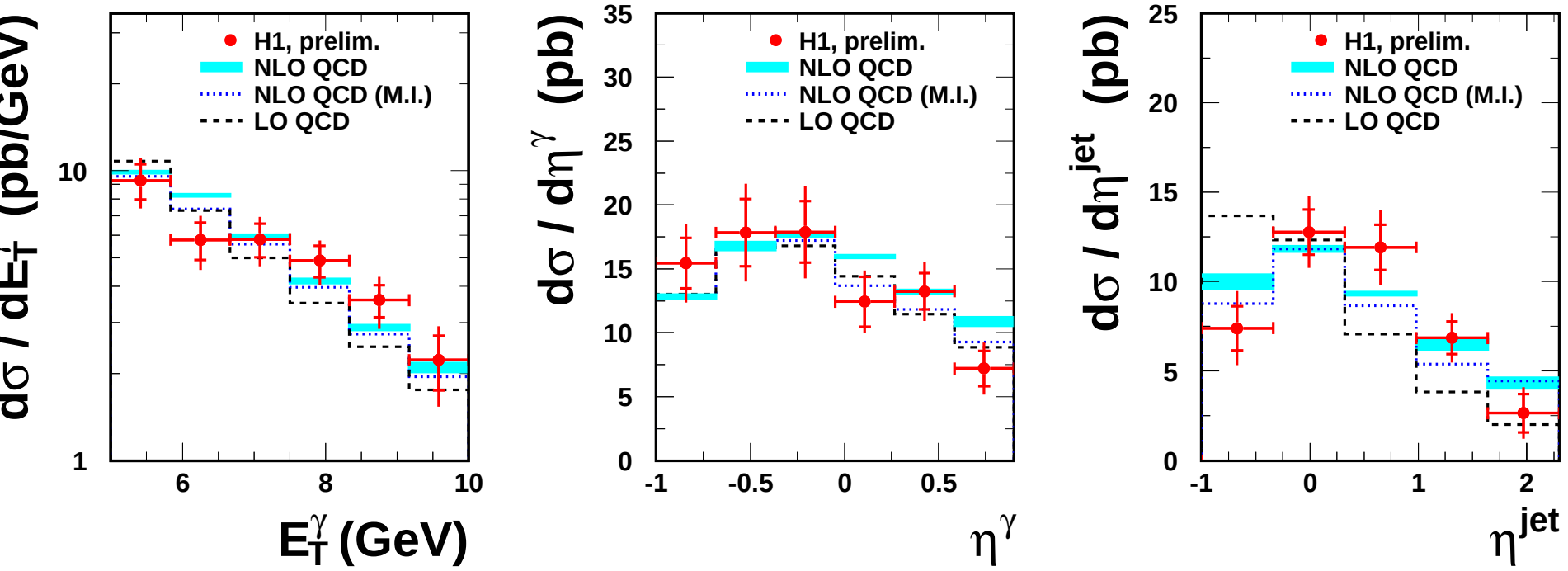
resolved



- in principle, more direct access to hard process
- good testing ground for QCD and for measurement of PDFs

Prompt Photon + Jet Cross Section

NLO: Fontannaz, Guillet, Heinrich



- correction of NLO for multiple interactions applied by PYTHIA:

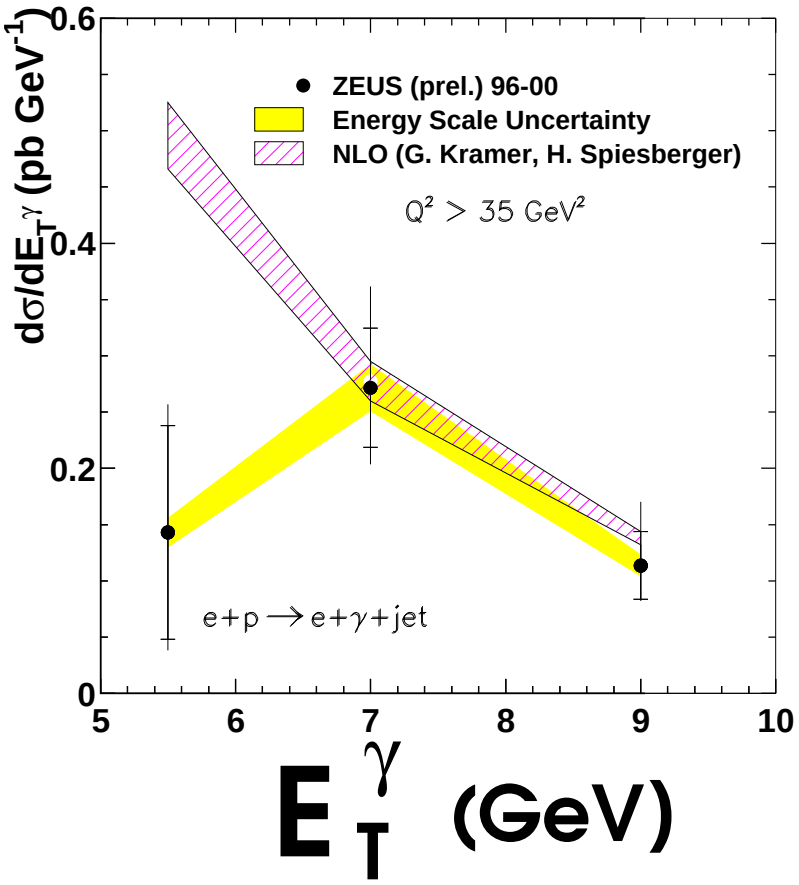
  $\Rightarrow$ improves description at large η^{γ}

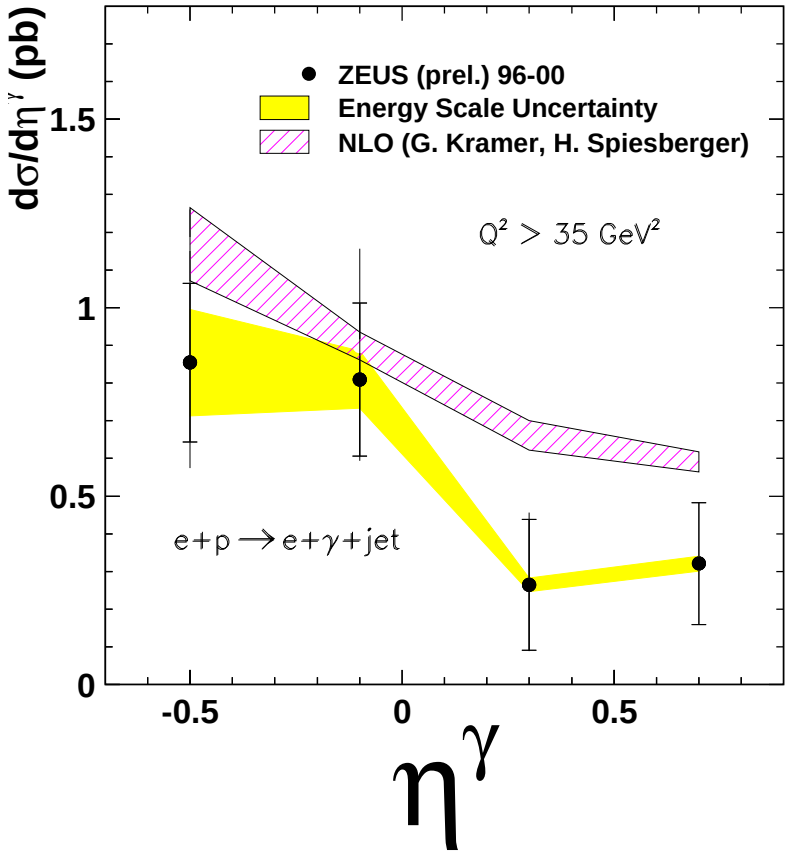
- substantial and negative NLO correctons at $\eta^{\mathrm{jet}} < 0$

$\Rightarrow$ NLO describes data within errors

New Step: Prompt Photon + Jet Cross Section in DIS

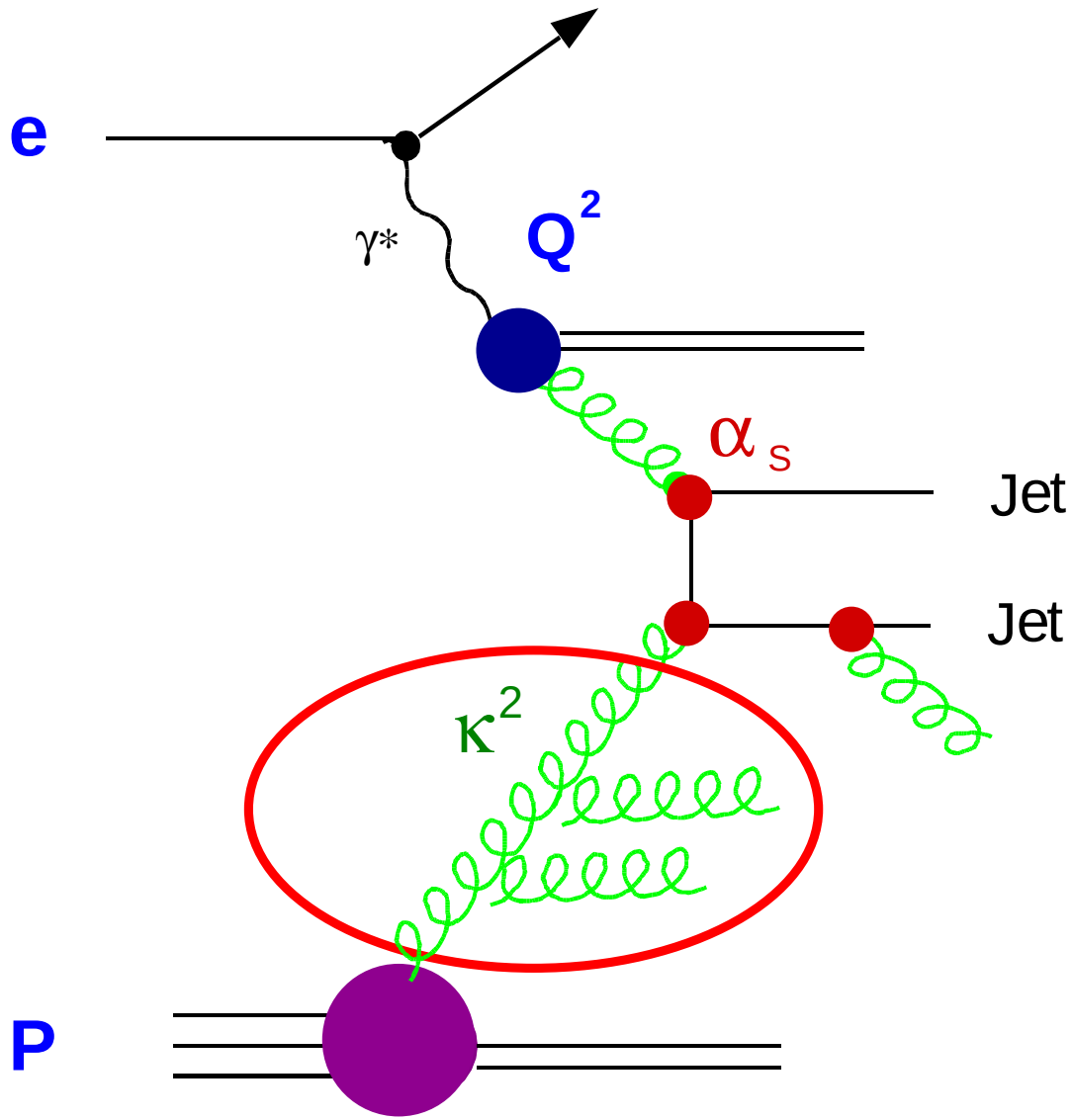
NLO: Kramer, Spiesberger





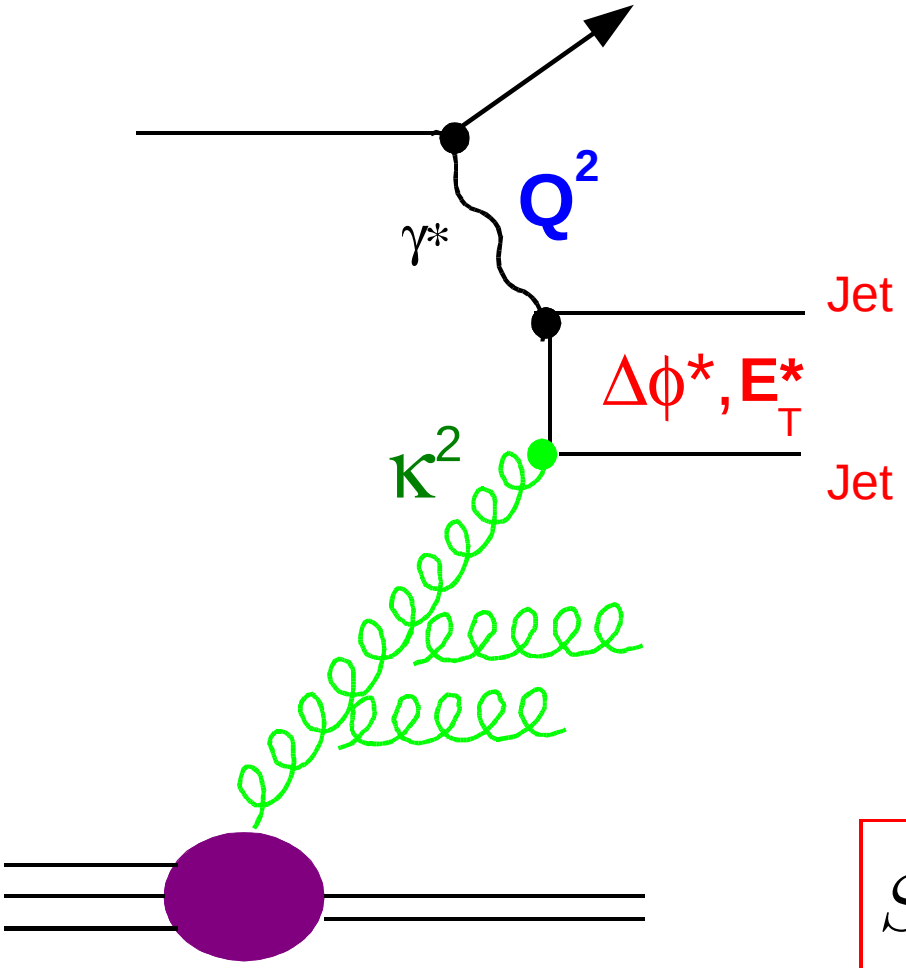
⇒ reasonable normalisation within large errors of NLO

Parton Virtuality



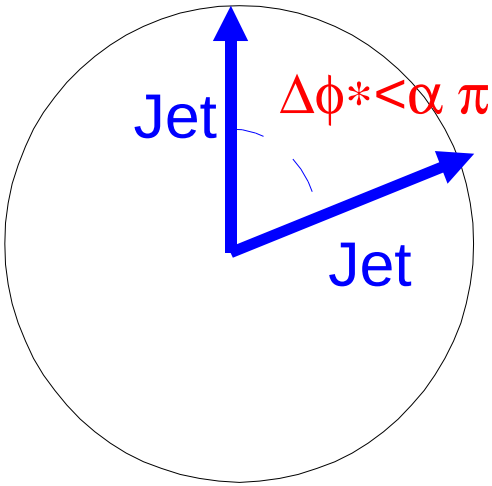
Di-Jet Production in DIS: Azimuthal Correlations

talk by R. Pöschl



"non-back-to-back" jets

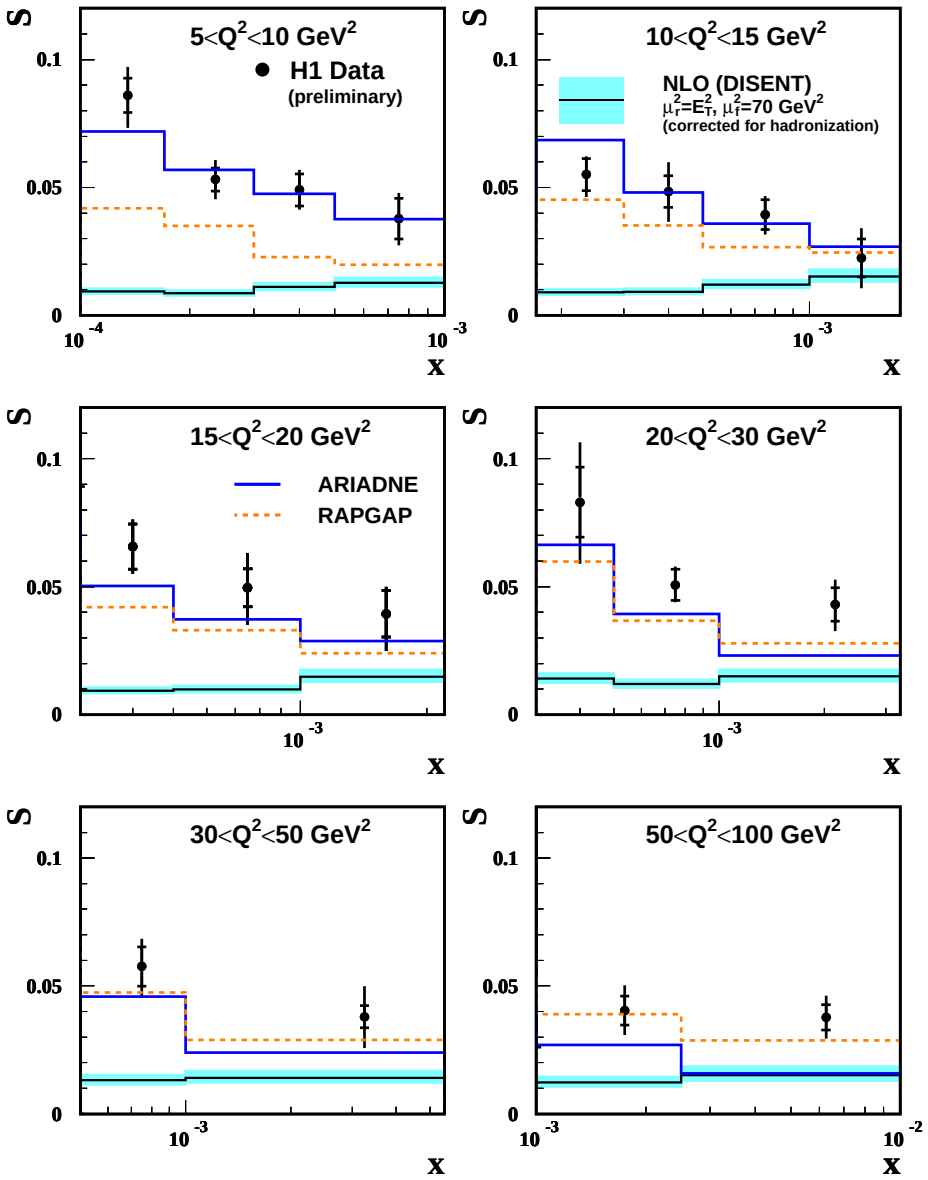
rate of di-jet events separated by an azimuthal angle (much) smaller than π



$$S(x, Q^2, \Delta\Phi^*) = \frac{\int_0^{\alpha\pi} w(x,Q^2,\Delta\Phi^*)}{\int_0^{\pi} w(x,Q^2,\Delta\Phi^*)}$$

$\Rightarrow$ can be caused by parton virtuality or NLO

Di-Jets at Low x: Results for $\Delta\Phi^* < 120^o$



$$S(x, Q^2, \Delta\Phi^*) = \frac{\int_0^{\alpha\pi} w(x,Q^2,\Delta\Phi^*)}{\int_0^{\pi} w(x,Q^2,\Delta\Phi^*)}$$

- data rise towards low x: increasing parton virtuality due to longer parton ladder **?**
- NLO away from data:

  $\Rightarrow$ virtuality of incoming parton cannot be neglected **?**
- LO MCs model higher order effects through parton cascades:

  $\Rightarrow$ give (at least) right order of magnitude

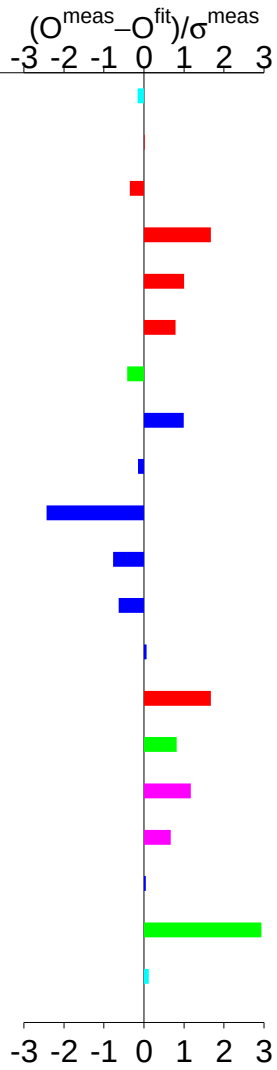
NLO: Catani, Seymour

ks by A. Mehta, J .Wilson

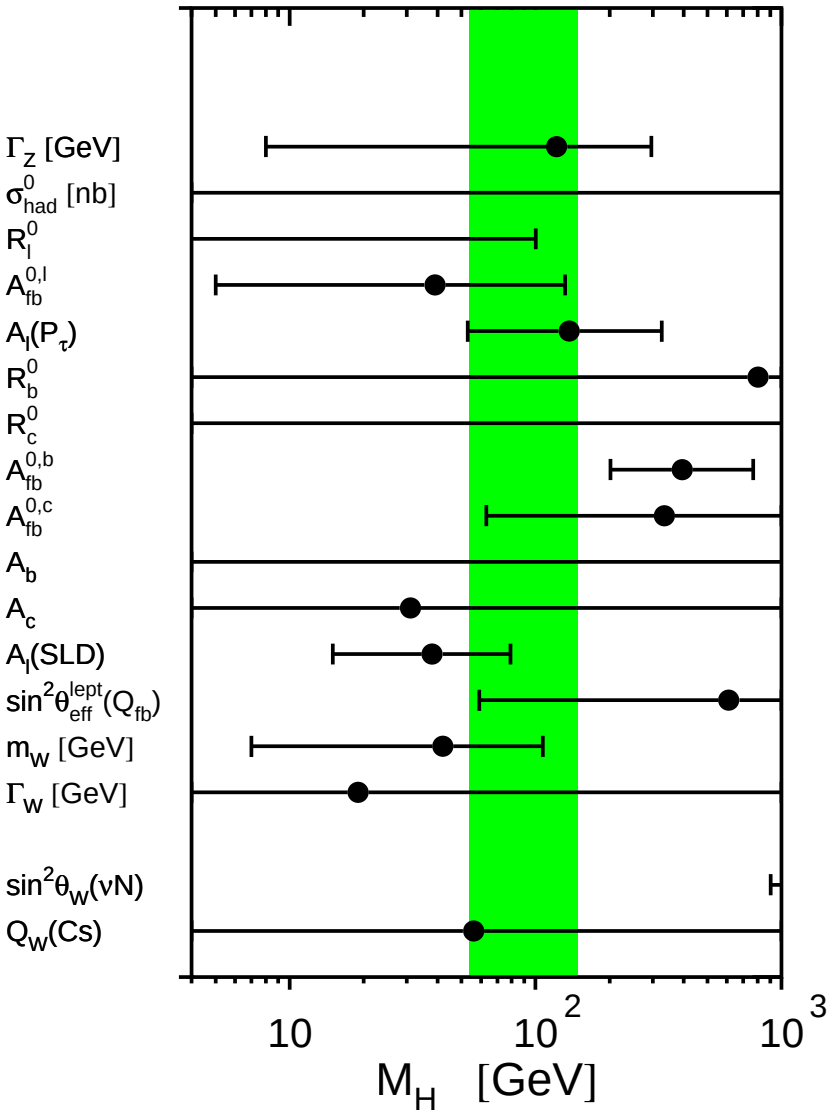
Electroweak Physics

Winter 2003

	Measurement	Pull
$\Delta\alpha^{(5)}_{had}(m_Z)$	0.02761 ± 0.00036	-0.16
m_Z [GeV]	91.1875 ± 0.0021	0.02
Γ_Z [GeV]	2.4952 ± 0.0023	-0.36
σ^0_{had} [nb]	41.540 ± 0.037	1.67
R_l	20.767 ± 0.025	1.01
$A^{0,l}_{fb}$	0.01714 ± 0.00095	0.79
$A_l(P_\tau)$	0.1465 ± 0.0032	-0.42
R_b	0.21644 ± 0.00065	0.99
R_c	0.1718 ± 0.0031	-0.15
$A^{0,b}_{fb}$	0.0995 ± 0.0017	-2.43
$A^{0,c}_{fb}$	0.0713 ± 0.0036	-0.78
A_b	0.922 ± 0.020	-0.64
A_c	0.670 ± 0.026	0.07
A_l(SLD)	0.1513 ± 0.0021	1.67
$\sin^2\theta^{lept}_{eff}(Q_{fb})$	0.2324 ± 0.0012	0.82
m_W [GeV]	80.426 ± 0.034	1.17
Γ_W [GeV]	2.139 ± 0.069	0.67
m_t [GeV]	174.3 ± 5.1	0.05
$\sin^2\theta_W(\nu N)$	0.2277 ± 0.0016	2.94
Q_W(Cs)	-72.83 ± 0.49	0.12



Winter 2003

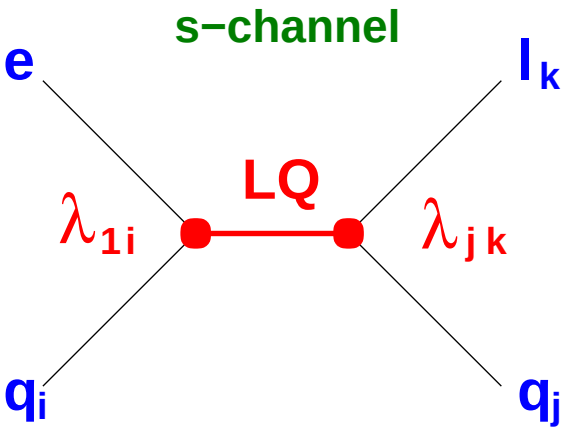


$\Rightarrow$ maximum deviation: 2.94σ !

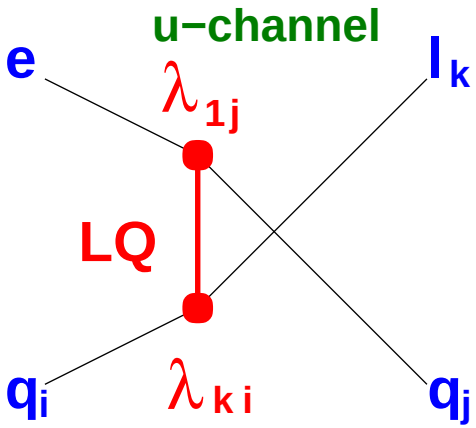
$\Rightarrow$ for each observable fit on $M_{\rm Higgs}$

Leptoquarks

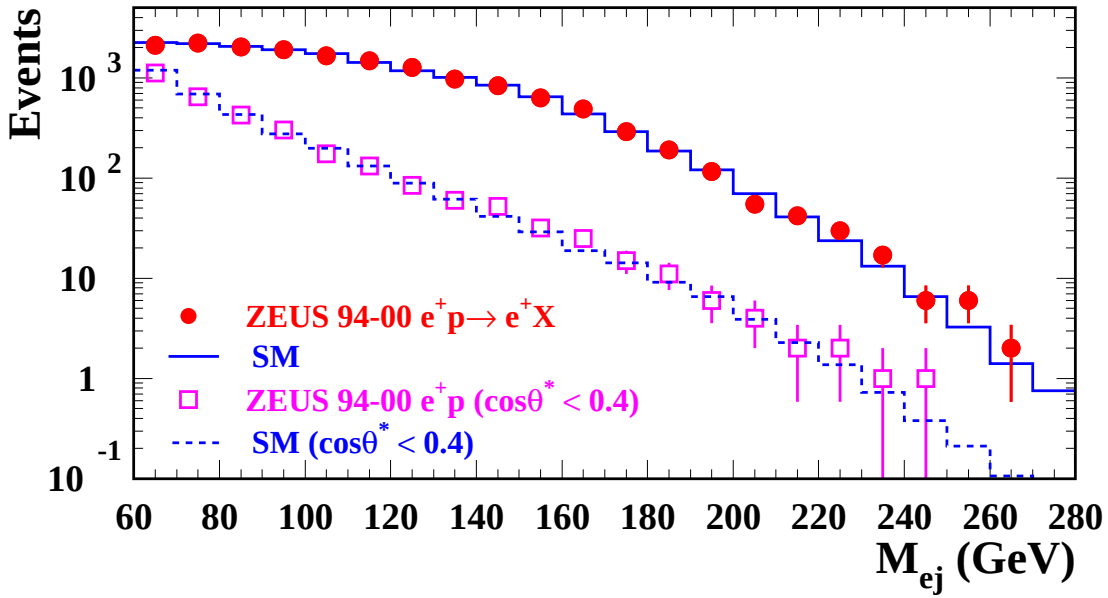
extension of SM: couple to leptons and quarks, carry $B, L \neq 0$



rect search: resonance peak



production at HERA: $\sigma_{ep}^{\text{prod}} = f(M_{LQ}, \lambda)$



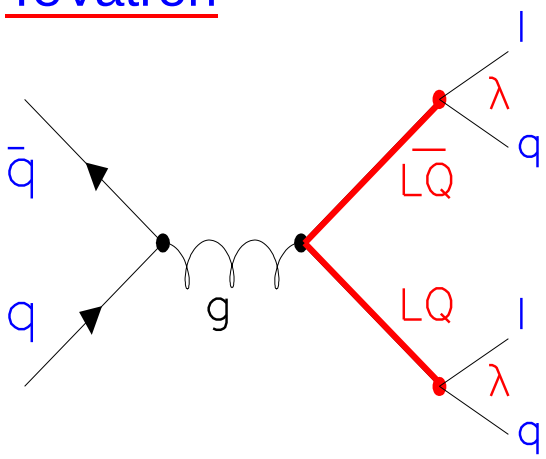
$\Rightarrow$ no deviation from SM

Buchmüller-Rückl-Wyler (BRW) "minimal" model:

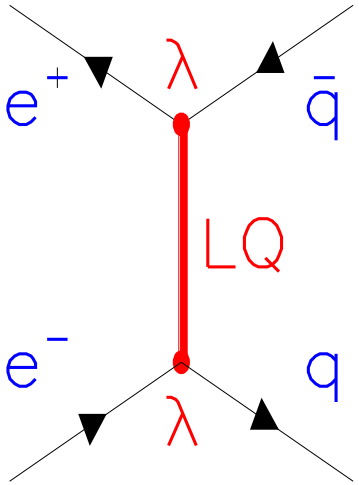
- 7 scalar and 7 vector leptoquarks with fermion number:
  $F = -(3B + L) = 0$ or 2

Leptoquarks — BRW Model

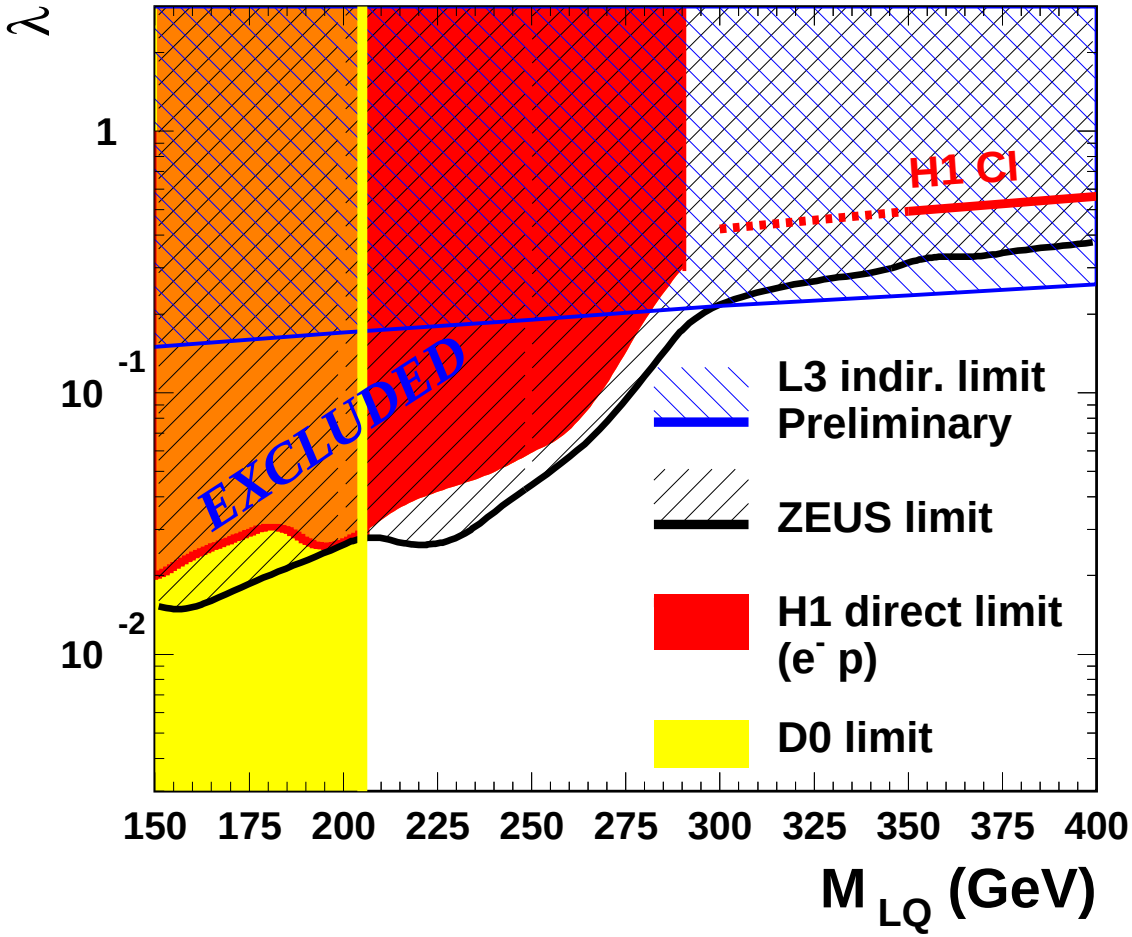
TeVatron



LEP



SCALAR LEPTOQUARKS WITH F=2 ($S_{0,L}$)



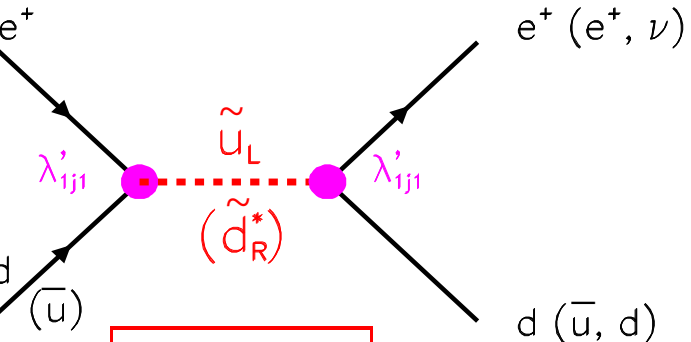
$\Rightarrow$ improved limit for $200 < M_{\mathrm{LQ}} < 300$ GeV

$= \quad 1$: SM particles
$= -1$: SUSY particles

$\not{R}_p$ Squark Production

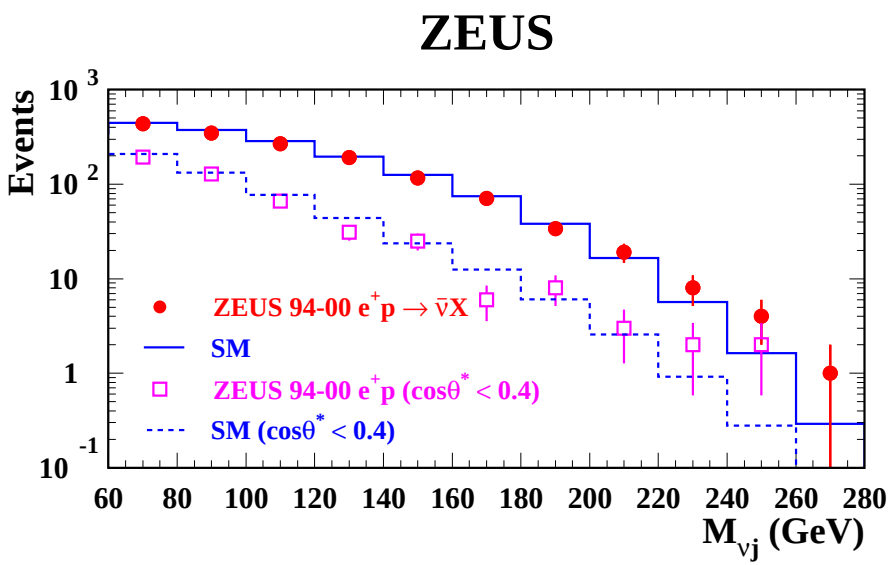
$\not{R}_p$: production of single SUSY particles possible,

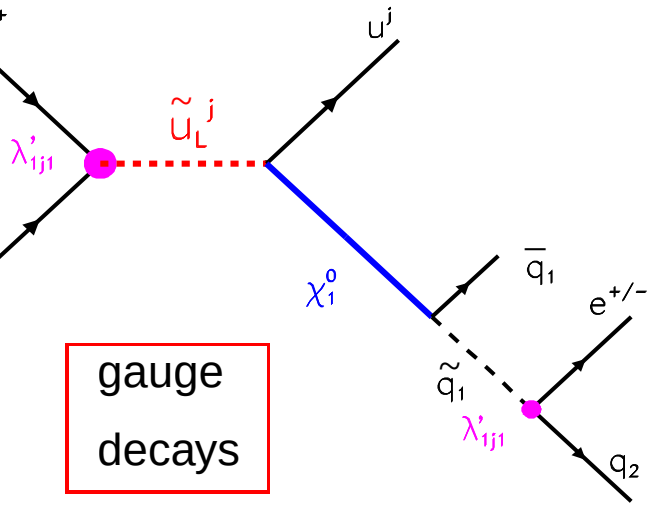
can decay into SM particles



$\not{R}_p$ decays

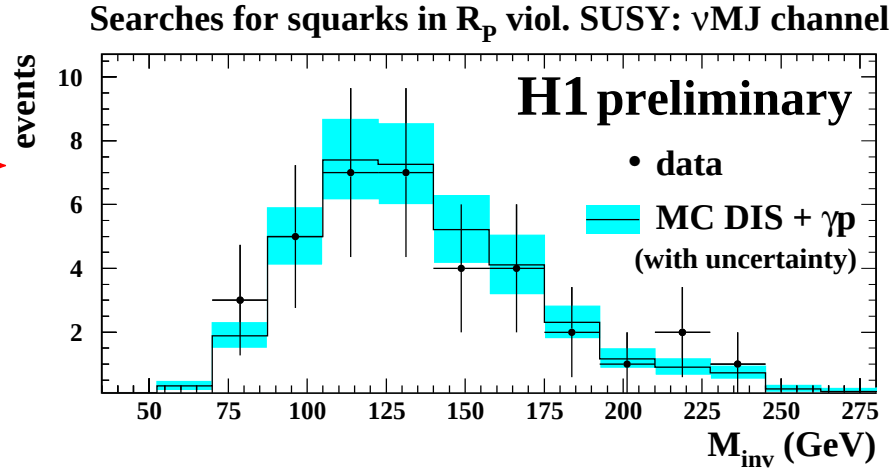
- e^+ + jet
- ν + jet $\Rightarrow$





gauge decays

- e^+ + multi-jets
- e^- + multi-jets
- ν + multi-jets $\Rightarrow$
- e + l + multi-jets
- ν + l + multi-jets

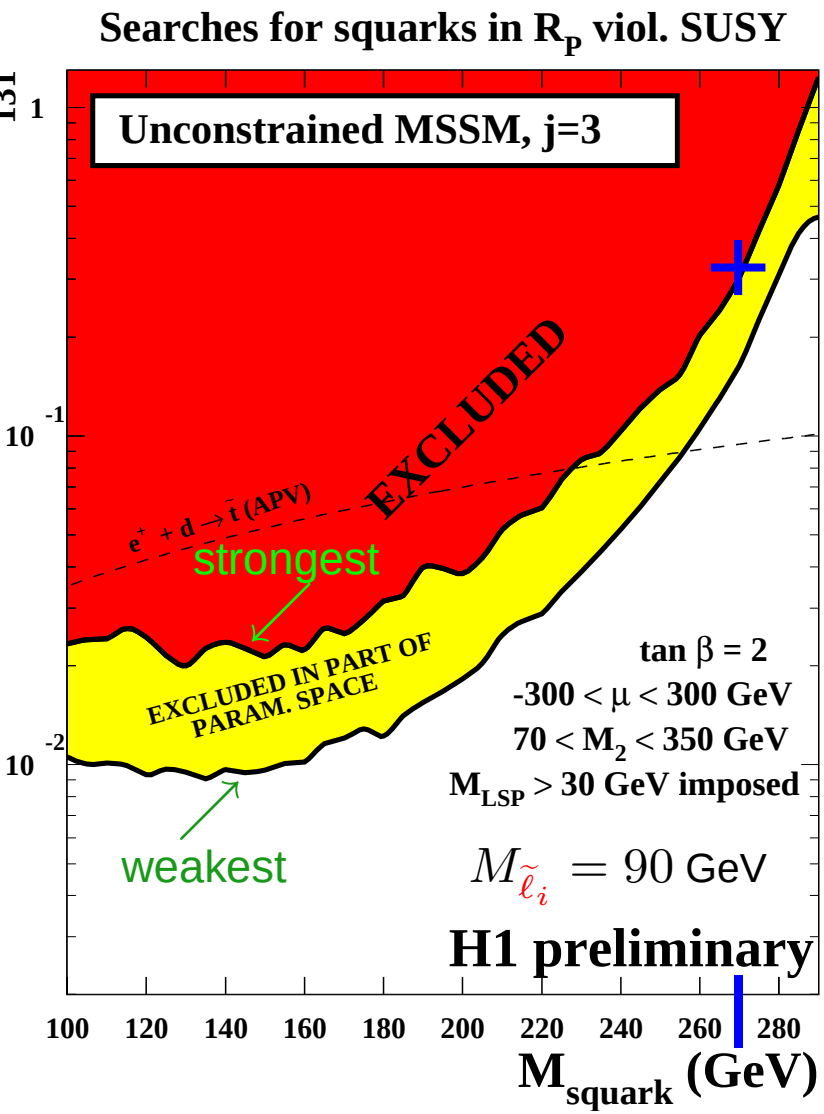


$\Rightarrow$ no evidence for squark production

Limits in $\not{R}_p$ Unconstrained MSSM

talk by E. Perez

$\tilde{t}$ production:



- sfermion masses are free

$\Rightarrow$ scan in SUSY parameter space:
(M_2, μ), $\tan\beta$

M_2: soft SUSY breaking mass term

μ: mixing mass term for 2 Higgs doublets

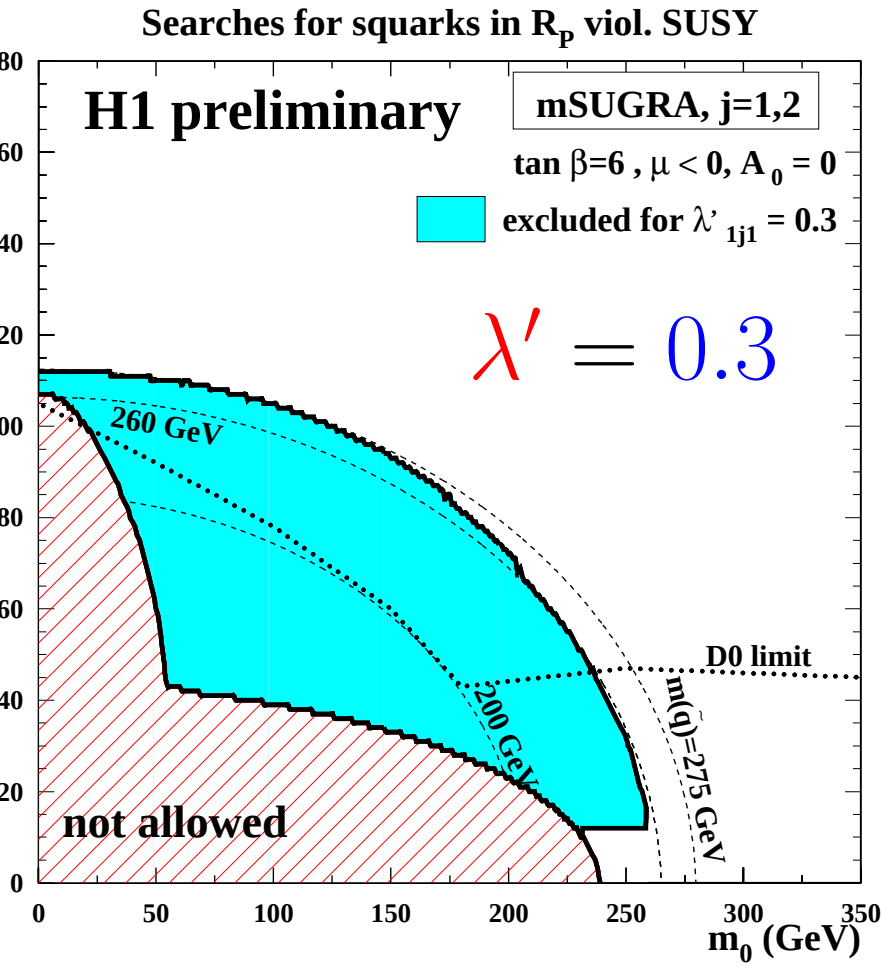
$\tan\beta$: ratio of the vev's of the 2 neutral scalar Higgs fields

$\Rightarrow$ limits widely parameter independent

$\Rightarrow$ masses up to 270 GeV ruled out for $\lambda' = 0.3$

Limits in $\not{R}_p$ Minimal SUperGRAvity

electroweak symmetry breaking driven by radiative corrections



$\Rightarrow$ only 5 parameters:

$\tan\beta$, sign of μ

m_0: common scalar mass

$m_{1/2}$: common gaugino mass

A_0: common trilinear coupling

at GUT scale

$\widetilde{u}$, $\widetilde{c}$ production:

$\Rightarrow$ HERA sensitivity follows squark mass isocurve

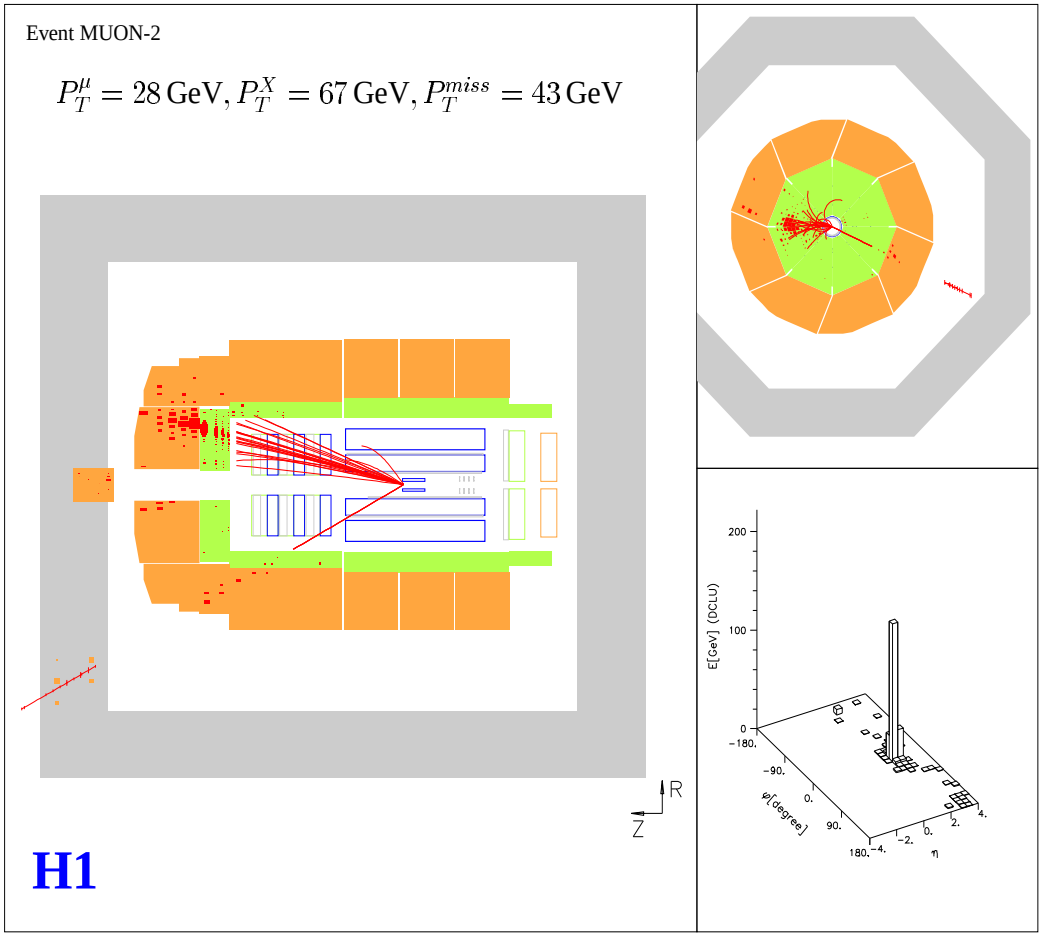
$\Rightarrow$ masses up to 275 GeV ruled out for $\lambda' = 0.3$

$\Rightarrow$ LEP very sensitive: HERA competitive for intermediate values of m_0

High p_T Lepton Events at HERA

talk by G. Frising

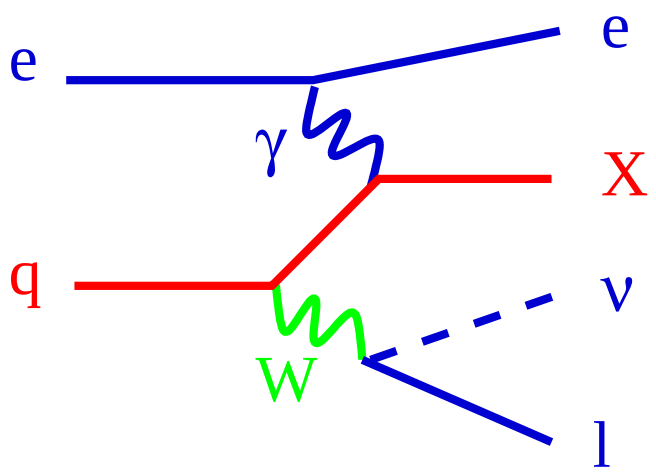
$$e^+p \rightarrow \mu^+X + PTmiss$$



- isolated lepton
- high hadronic p_T
- missing calorimeter p_T

Standard Model:

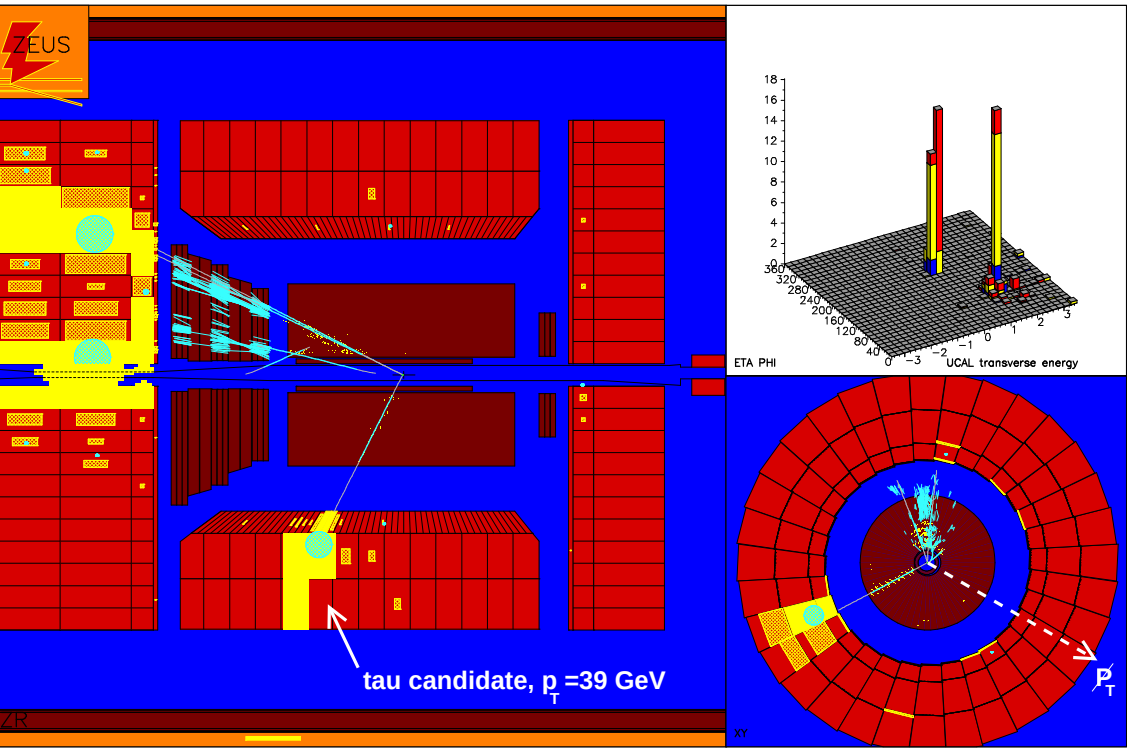
dominated by W production



High p_T Lepton Events at HERA

talk by D. Lelas

Tau candidate

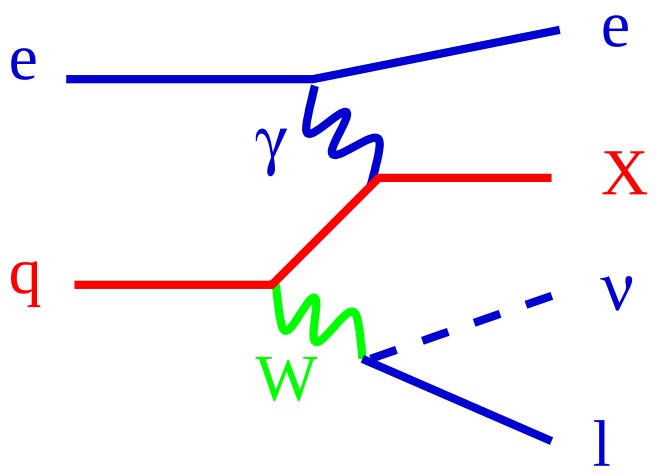


$P_T^{CAL} = 39$ GeV $\quad P_T^X = 37$ GeV $\quad M_T = 68$ GeV

- isolated lepton
- high hadronic p_T
- missing calorimeter p_T

Standard Model:

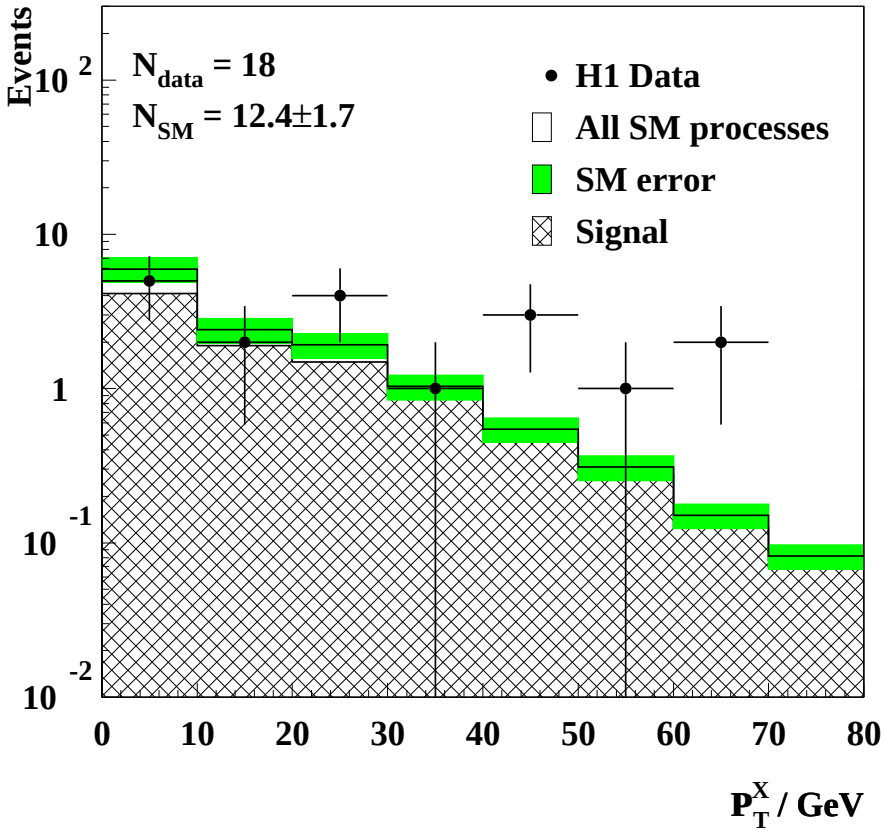
dominated by W production



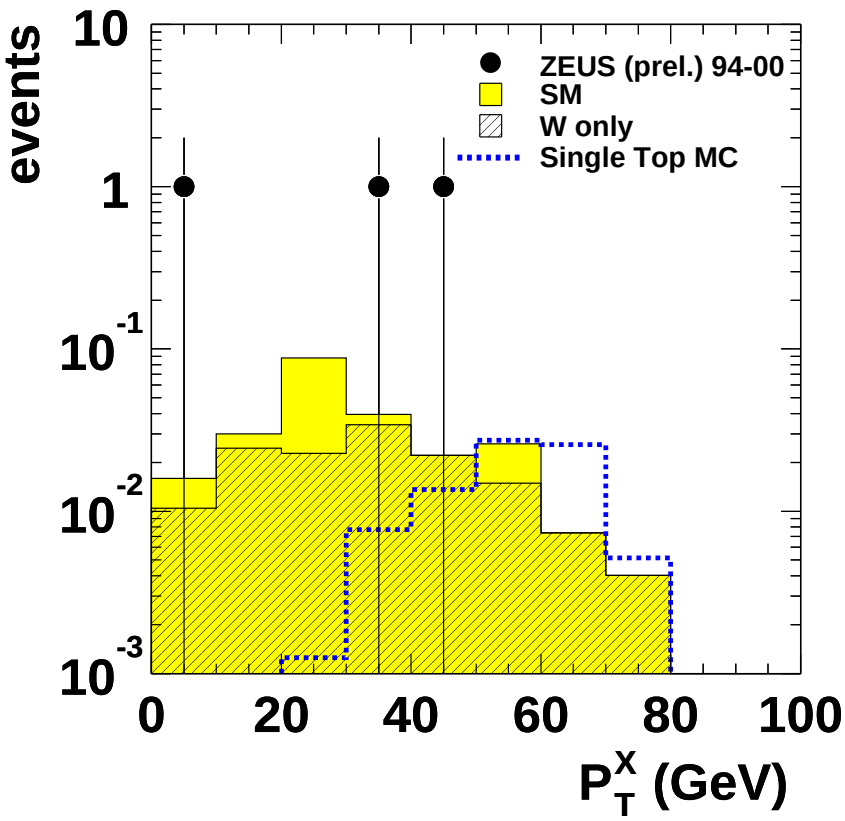
τ jet: collimated "pencil like"

Excess for Isolated Lepton Events

Electron + Muon



Tau



SUMMARY:

O: Diener, Spira,

hwanenberger

DATA / SM (incl. NLO)	H1: $e+\mu$	ZEUS: $e+\mu$	ZEUS preliminary: τ
over all	$18 \,/\, 12.4 \pm 1.7$	$36 \,/\, 32.6 \pm 3.8$	$3 \,/\, 0.23 \pm 0.06$
$P_T^X > 25$ GeV	$10 \,/\, 2.9 \pm 0.5$	$7 \,/\, 5.7 \pm 0.6$	$2 \,/\, 0.12 \pm 0.02$
$P_T^X > 40$ GeV	$6 \,/\, 1.1 \pm 0.2$	$0 \,/\, 1.9 \pm 0.2$	$1 \,/\, 0.06 \pm 0.01$

$\Rightarrow$ wait for new data at HERA II

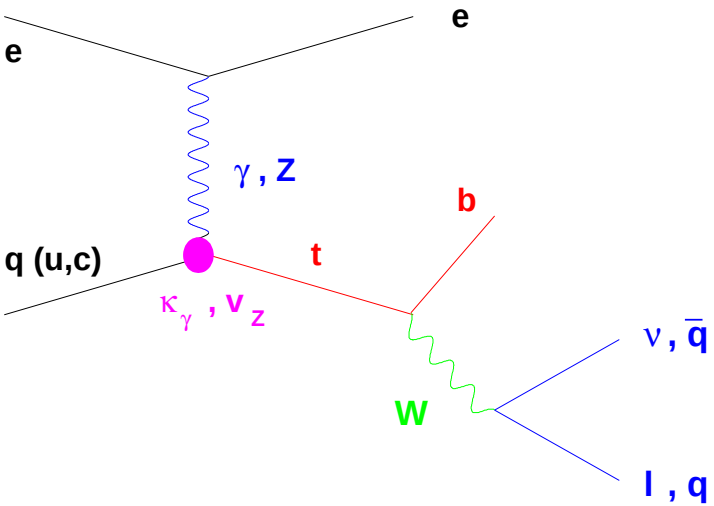
Anomalous (FCNC) Single Top Production

possible "explanation" for excess of events with isolated leptons,

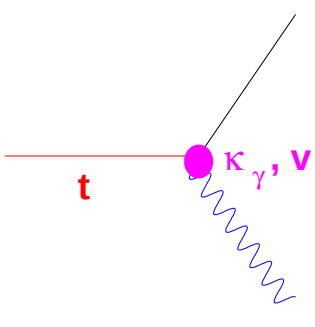
p_t^{miss} and large hadronic p_t

talks by D. Dannheim, A. Schöning

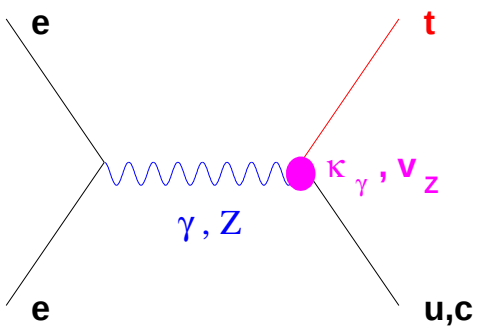
HERA

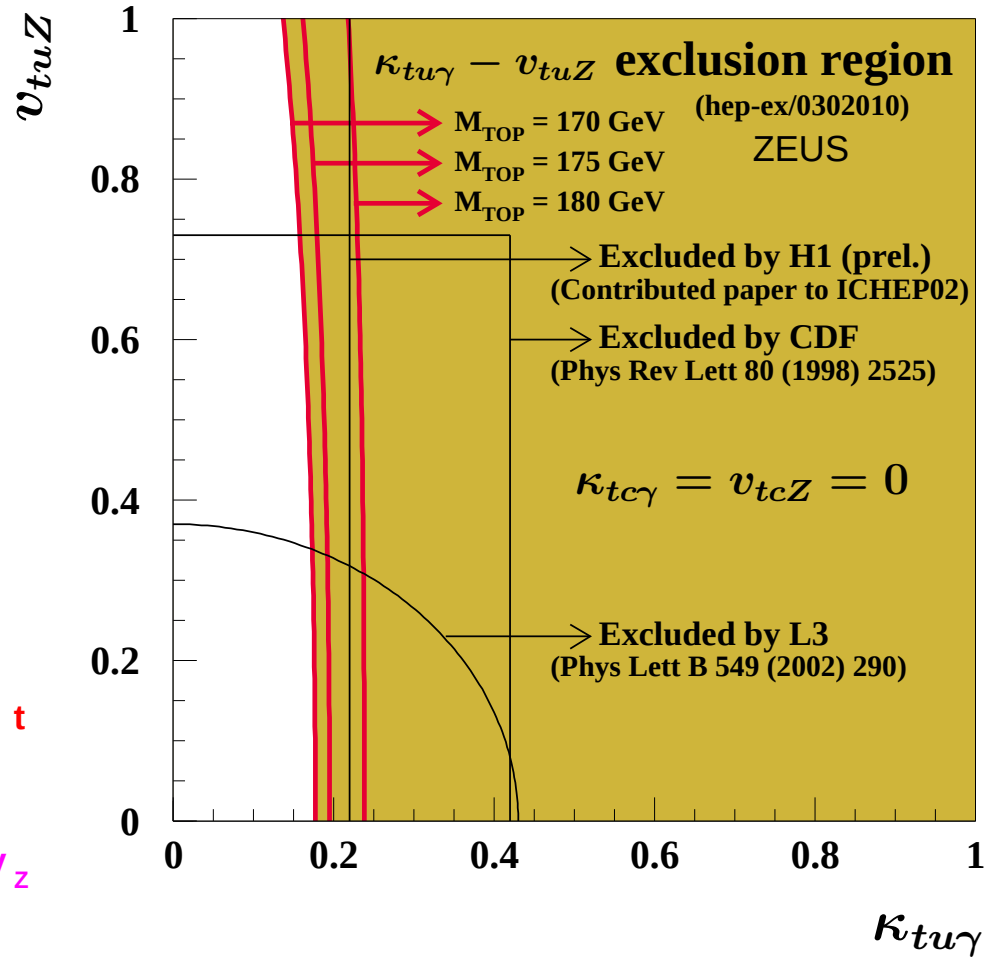


TeVatron



LEP





Summary

Hadronic Final States

- lots of excellent new measurements
  - NLO QCD generally working well
  - data not understood: e. g. low x
  - in many areas: accuracy limited by theoretical error

⇒ further progress is needed

Physics Beyond the SM

- wide search program
  - LEP 1 / 2, TeVatron Run I and HERA I results
  - TeVatron preliminary Run II
  - HERA II results to come

⇒ no clear signal yet

⇒ interesting event classes:
need confirmation at high luminosity at TeVatron and HERA

- sorry to all whose results were not shown
- thanks to the organizers of DIS 2003 !