Searches at HERA

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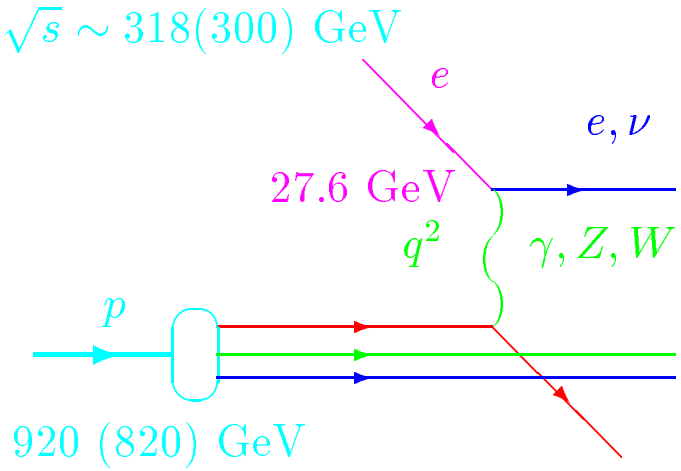
on behalf of the H1 and ZEUS collaborations

Contents:

- HERA
- Inclusive DIS events at high Q^2
- Leptoquarks
- $\not{R}_p$Supersymmetry
- Excited fermions
- Isolated leptons
- Beyond 2001...

Lake Louise Winter Institute February 2001

Physics at HERA



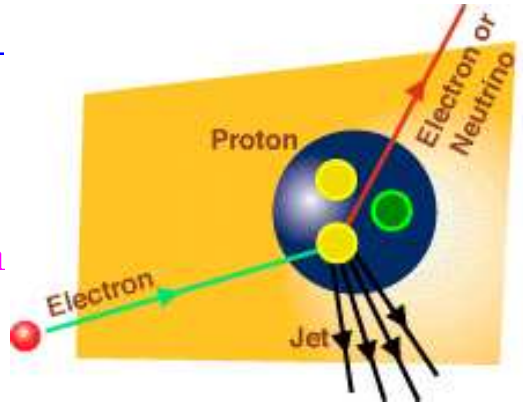
Spatial resolution

$Q^2 = -q^2$

angular distribution: y

p momentum fraction

carried by the quark: x

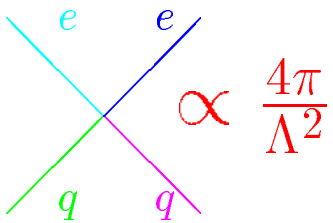


Year	Collision type	p energy GeV	Luminosity (pb^{-1}) H1	ZEUS
1994-1997	e^+p	820	37	48
1998-1999	e^-p	920	15	17
1999-2000	e^+p	920	$\simeq$ 80 (partly analysed)	

Inclusive DIS events at high Q^2

New phenomena at mass scales (Λ) higher than HERA's kinematic limit ($\sqrt{s} \simeq 318$ GeV) should affect σ at HERA's scale...

Contact Interactions



$$\propto \frac{4\pi}{\Lambda^2}$$

Comparison of

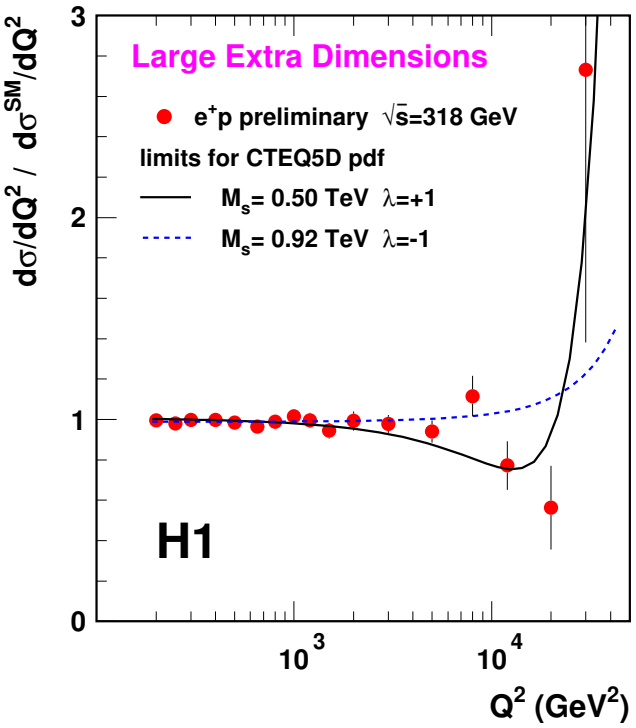
Differential NC cross-sections measured

at HERA with SM predictions

No deviation seen for Q^2 up to $\sim$ 10,000 GeV^2

Exclusion limits on Λ up to 9 TeV

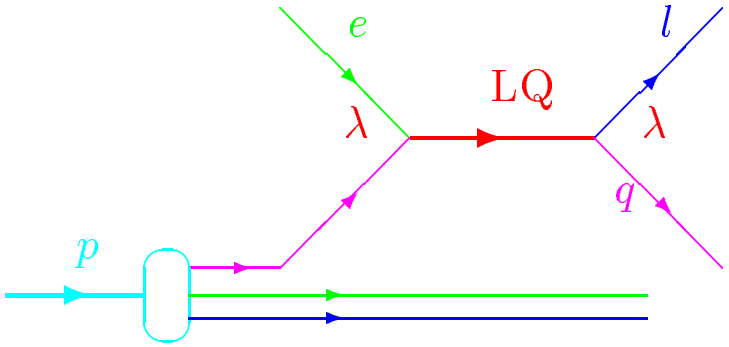
Extra dimensions



Leptoquarks

Leptoquarks (LQ) are particles which couple to quarks & leptons pairs

They can be resonantly produced at HERA



Spin: 0 or 1

Mass $= \sqrt{xs}$

y-distribution $\sim$ angular distribution

Buchmüller, Rückl and Wyler (BRW) model

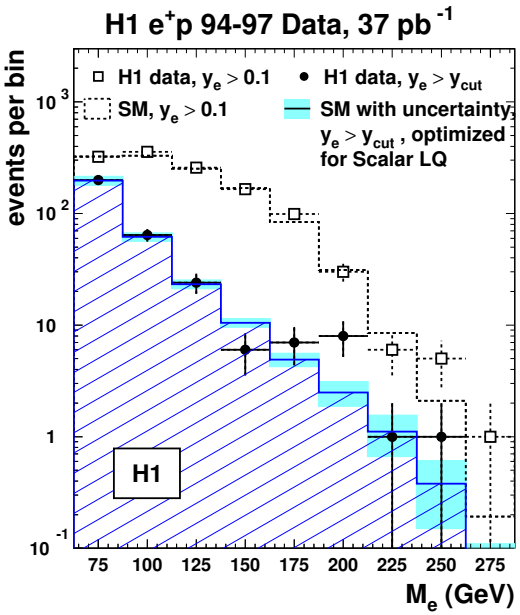
- Scalar LQ: y-distribution flat Vector LQ: y-distribution $\propto (1-y)^2$
- Same topology as NC & CC DIS, but y-distribution $\propto 1/y^2$ for NC

$\Rightarrow$ LQ NC-like signal most prominent at high y

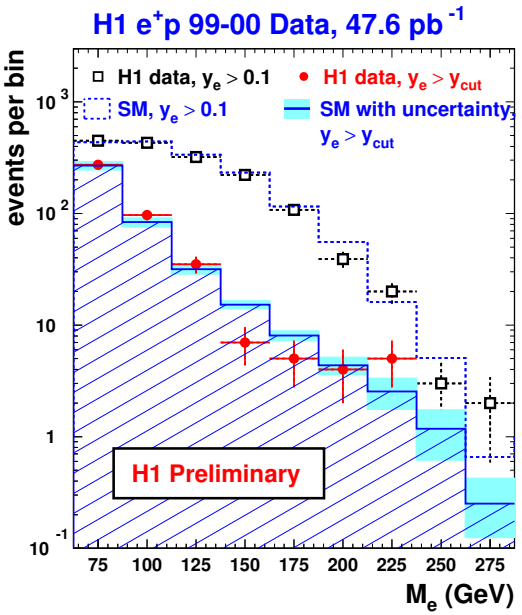
Reminder: Data 1994-97 showed an excess for $M_{\mathrm{LQ}} \gtrsim 200$ GeV

LQ searches: Mass distribution

H1 1994-97 e^+



H1 1999-2000 e^+



ZEUS: No significant deviations from SM seen in new data

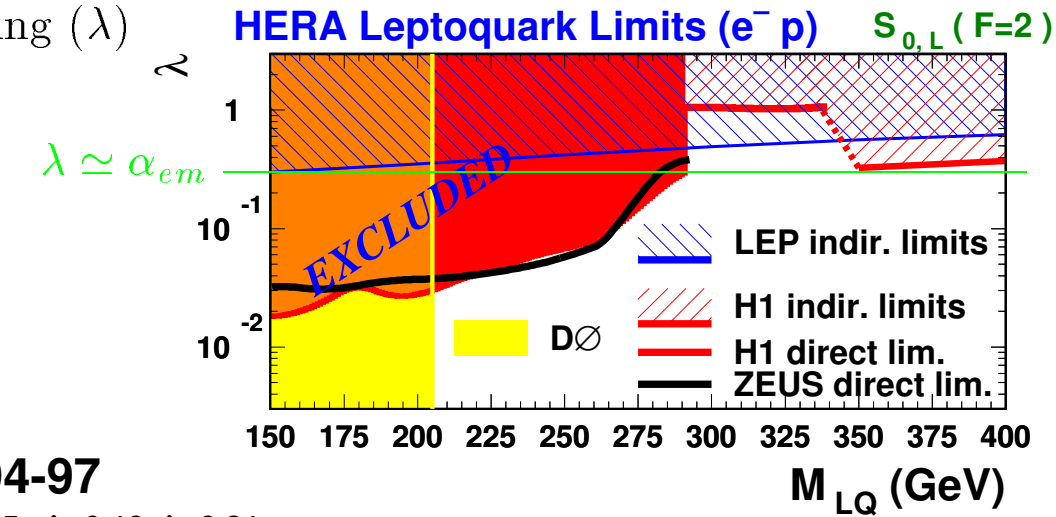
Excess seen in 1994-97 data is not confirmed by new data in both experiments

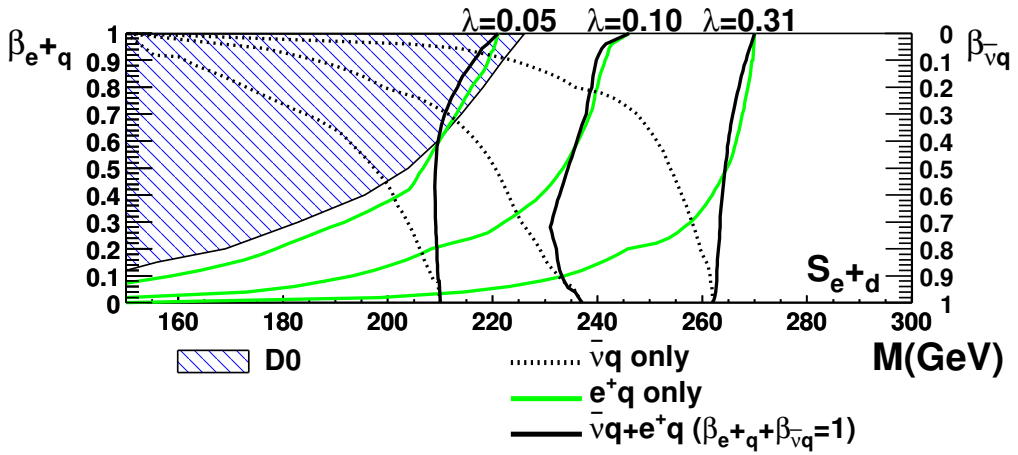
LQ searches: Limits

Limits on the Yukawa coupling (λ)

BRW model: β fixed

$\lambda \simeq 0.3 \leftrightarrow \frac{\lambda^2}{4\pi} \simeq \alpha_{\rm em}$





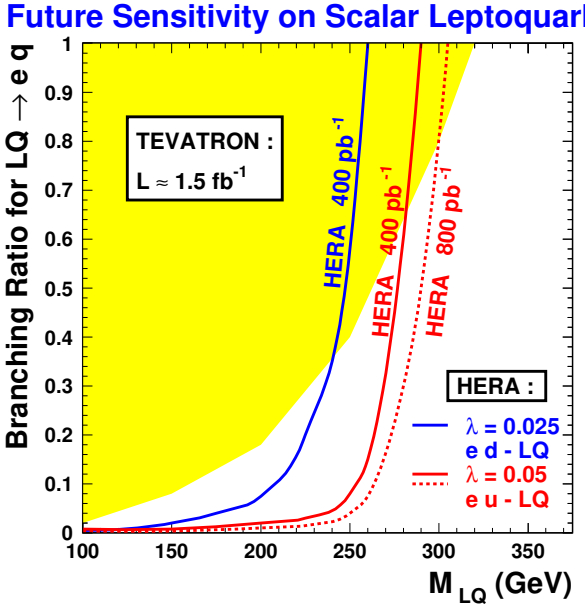
More generally,

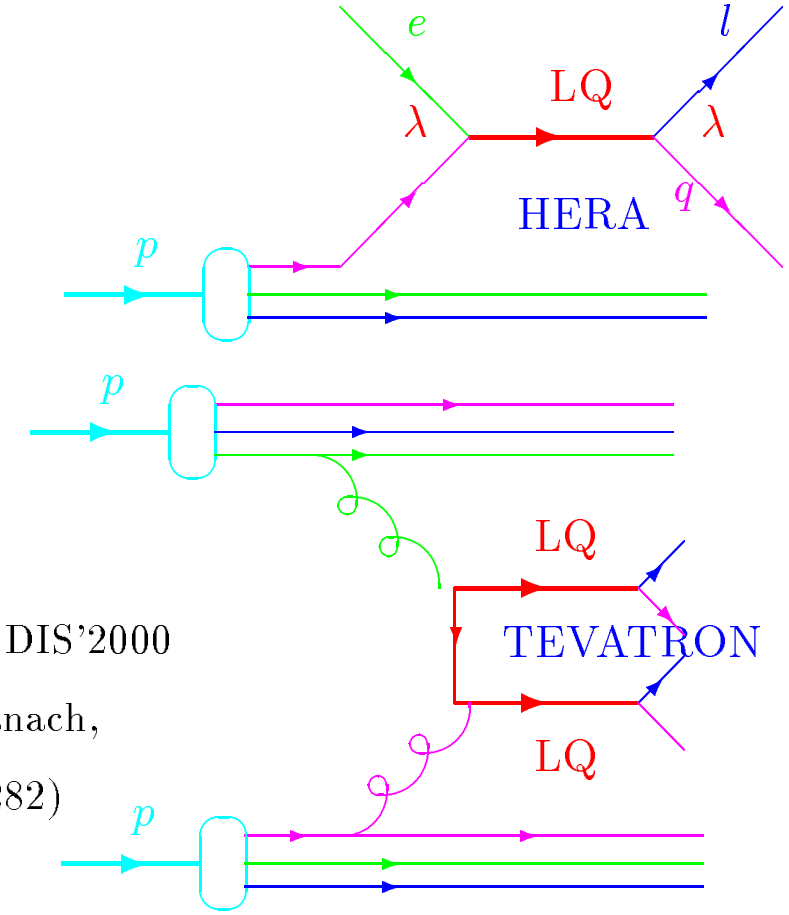
Using a generic model

with λ fixed

Limits on $\beta(\mathrm{LQ} \to eq)$

Leptoquark searches prospects at HERA and TEVATRON





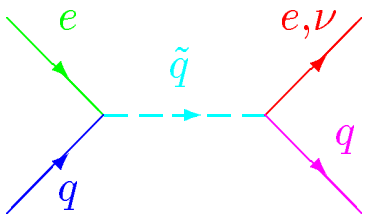
Physics at high Q^2 and $\not{P}_t$: summary of DIS'2000

(M. Kuze, S. Lola, E.Perez & B. Allanach,

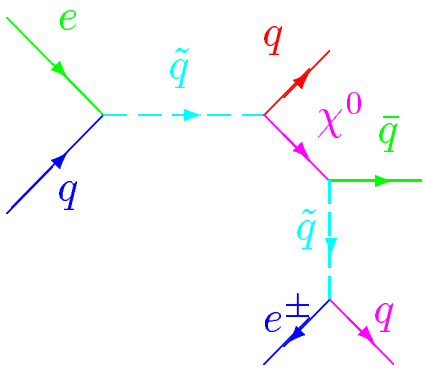
CERN-TH-2000-223, hep-ph/0007282)

$\not{R}_p$ Supersymmetry

$\not{R}_p$ squarks can be produced at HERA up to the kinematical limit

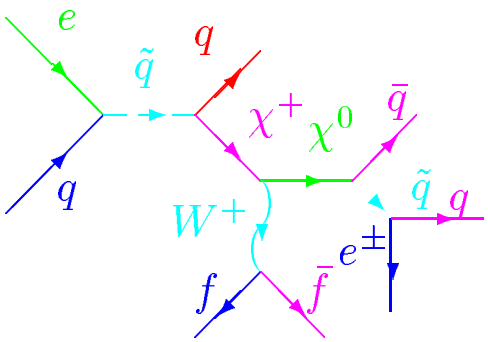


LQ-like topologies



Wrong sign lepton

(background free)



Multijets and/or

Multileptons

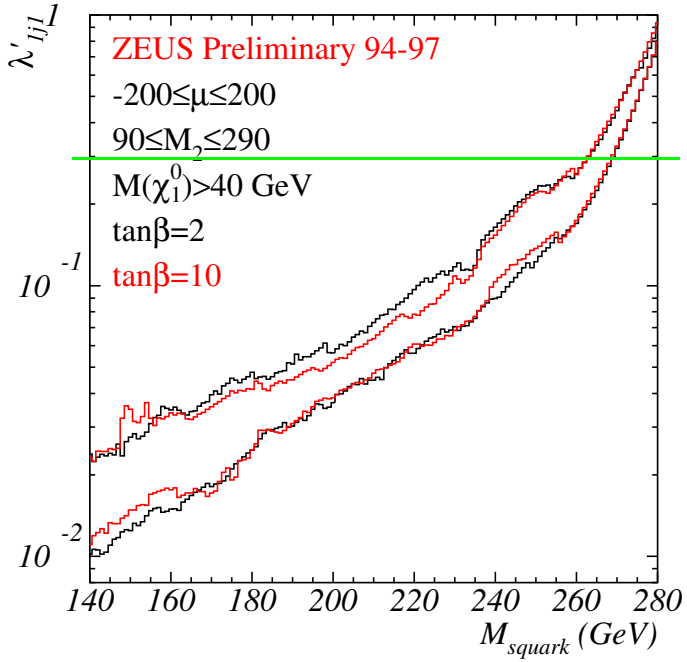
Many possible decays.

Signal looked for in almost all decay modes

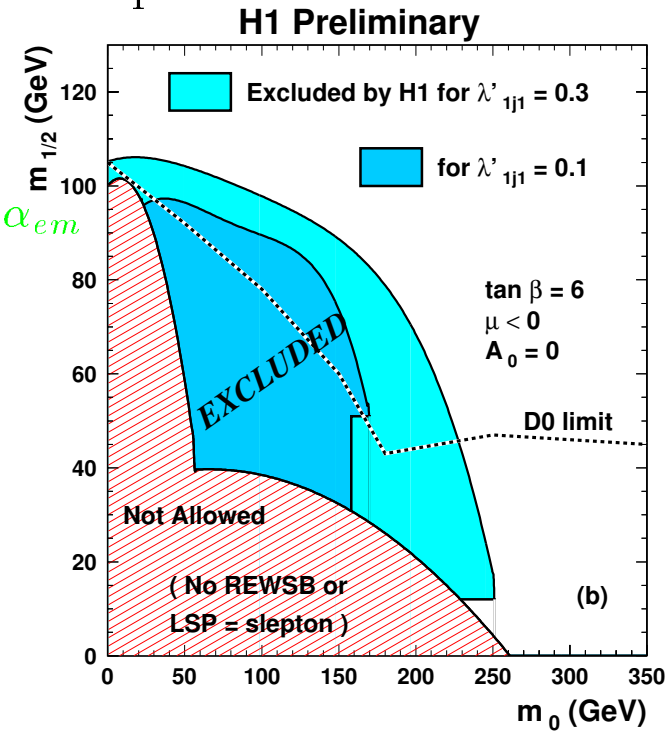
No excess observed $\Rightarrow$ limits

$\not{R}_p$SUSY limits

Scan of the parameters space



$\lambda \simeq \alpha_{em}$



Unconstrained MSSM

($\Rightarrow \sim$ model independent)

mSUGRA

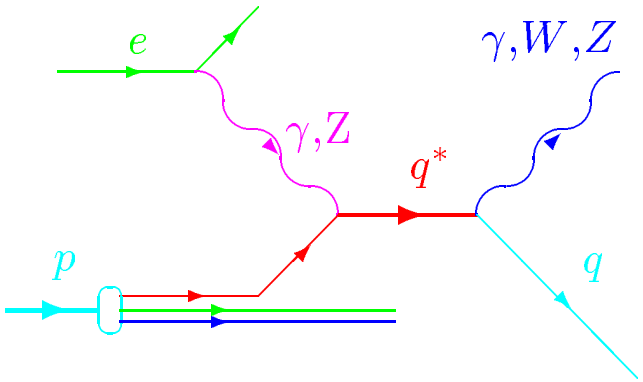
HERA extends TEVATRON's limits

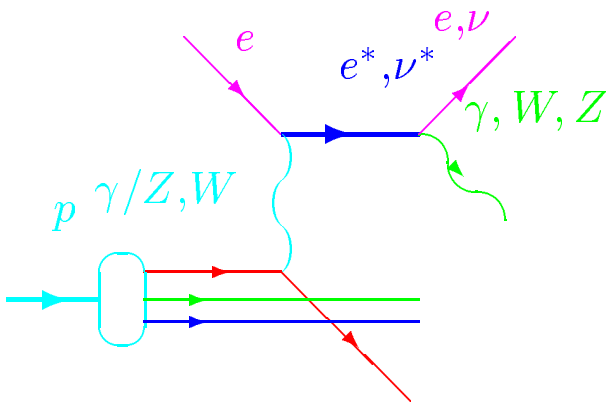
for reasonably large λ'

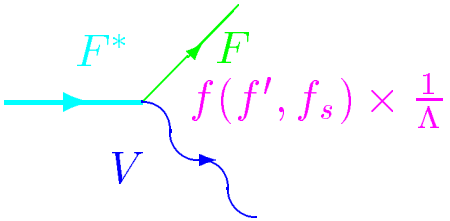
Excited fermions

Compositeness would manifest in excited states of fermions

Single production of excited fermions is considered at HERA







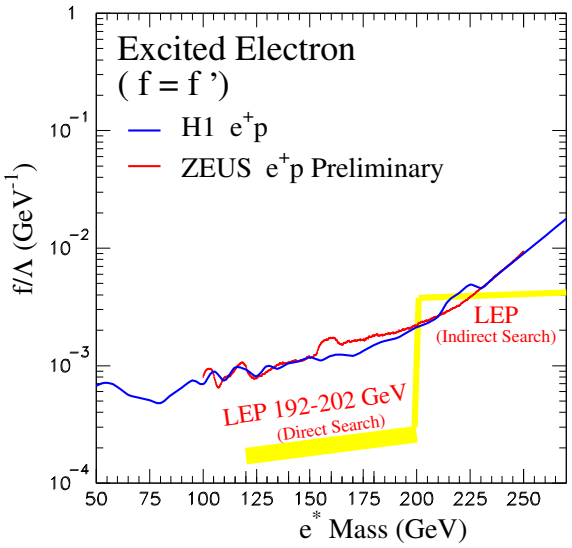
Effective Lagrangian

Hagiwara et *al.*

$$\mathcal{L} = \frac{1}{2\Lambda} F_R^* \left[f SU(2)_W + f' U(1)_Y + f_s SU(3)_C \right] F_L$$

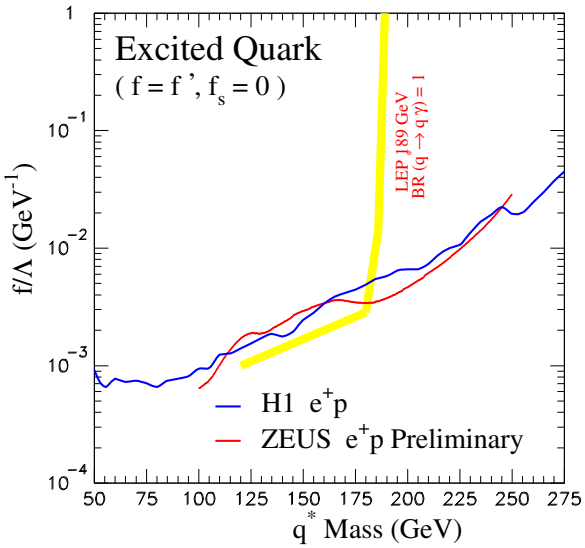
Λ: Compositeness scale

Excited fermions: 820 GeV data



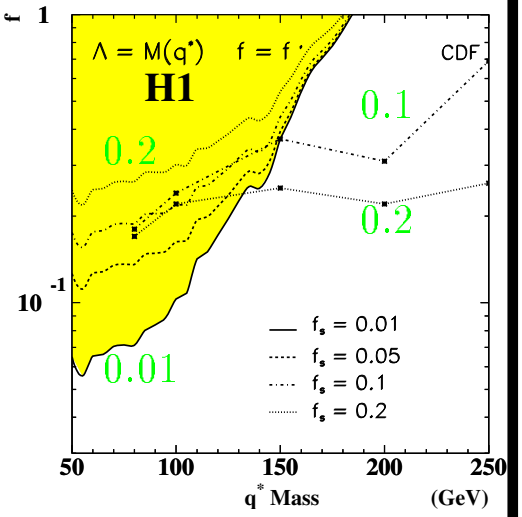
Excited Electron

$M_{e^*} < 229$ GeV excluded



Excited Quark

$M_{q^*} < 203$ GeV excl.



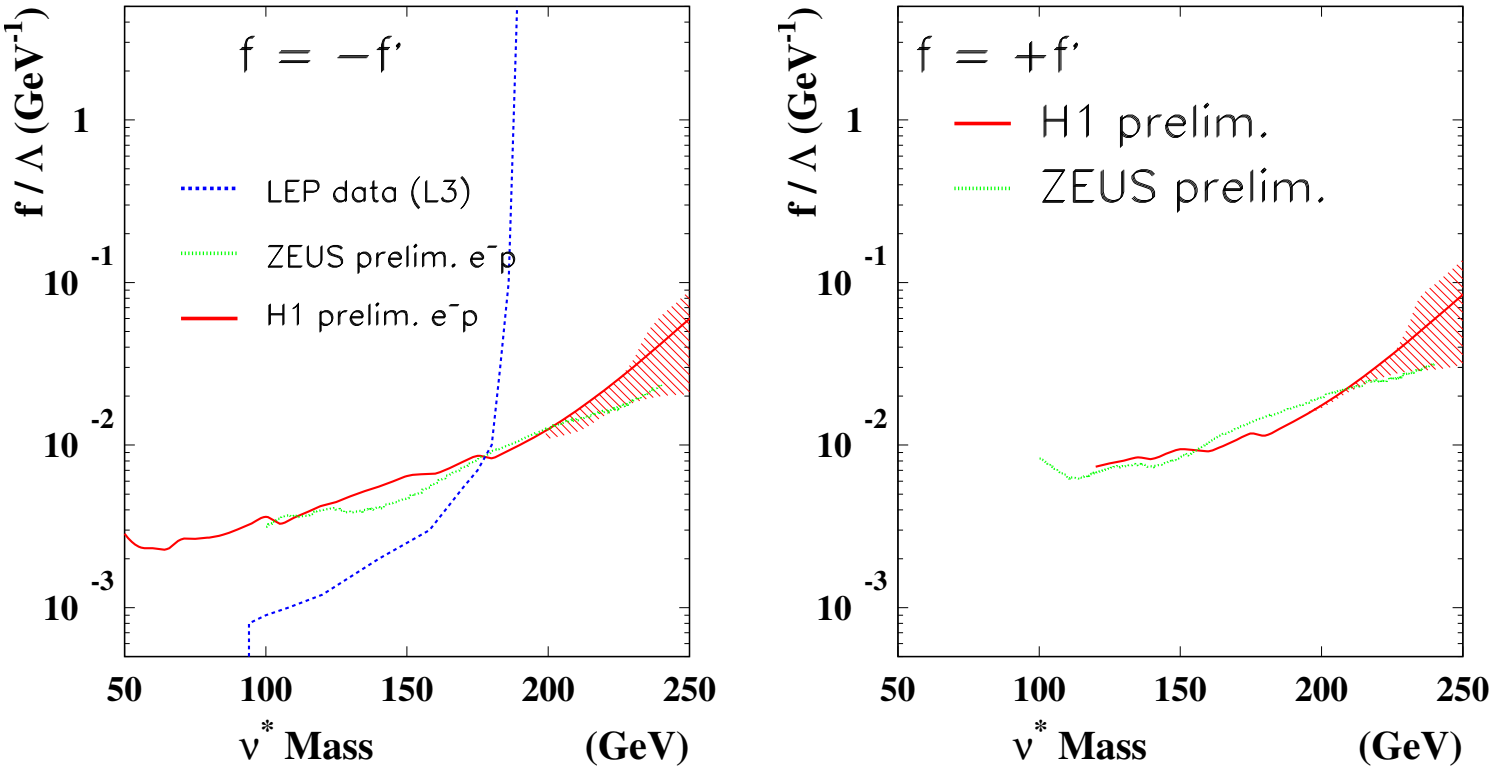
Excited Quark

Lim. on f

for $\Lambda = M(q^*)$

Assuming $\frac{f}{\Lambda} = \frac{1}{M^*}$

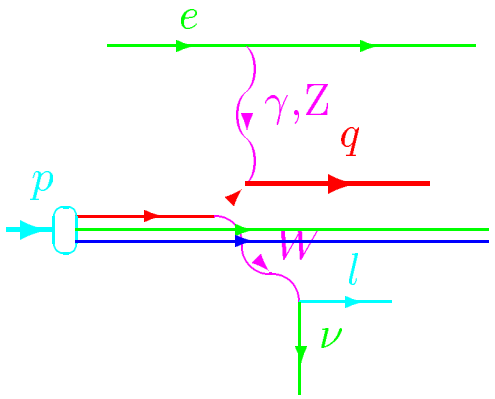
Excited fermions: ν^* limits with e^-p data



At high M_{f^*}, the NWA doesn't apply

Above 190 GeV, HERA extends the LEP limits

Isolated leptons (W production)



Main selection cuts:

$P_t^l > 10$ GeV 1 track or more

$\not{P}_t > 12$ GeV $P_t^{\text{calo}} > 12$ GeV

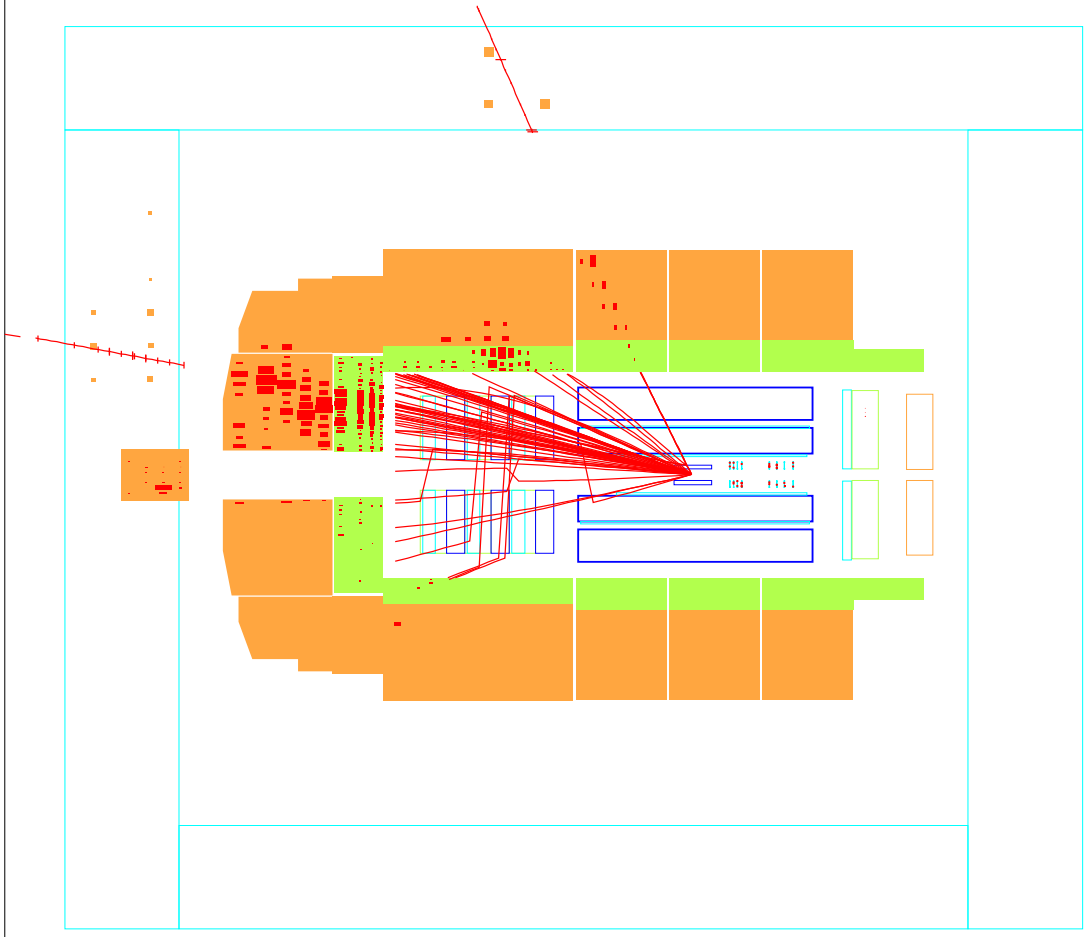
$5^o < \theta_l < 145^o$ $D_{\text{jet}} > 1.0$

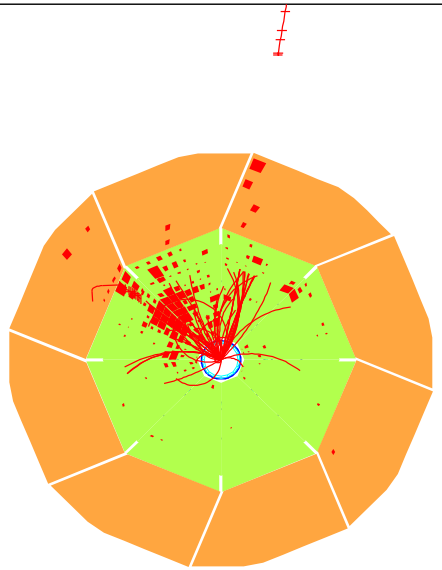
	H1 data preliminary	SM expectation H1	SM expectation ZEUS	ZEUS data preliminary
Luminosity	82 pb^{-1}			82 pb^{-1}
Dataset	1994 to may 2000			1994 to 1999
$P_T^X(e) > 25$ GeV	3	0.84	0.78	1
$P_T^X(\mu) > 25$ GeV	6	0.94	0.82	0

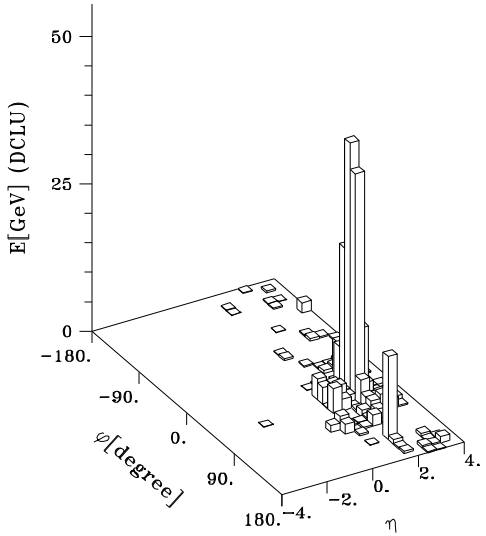
H1 still see deviation from SM, ZEUS not...

Need to be resolved with more statistics

H1 Run 266336 Event 4126 Class: 4 5 6 7 8 10 11 15 16 19 22 24 25 28 Date 8/07/2000



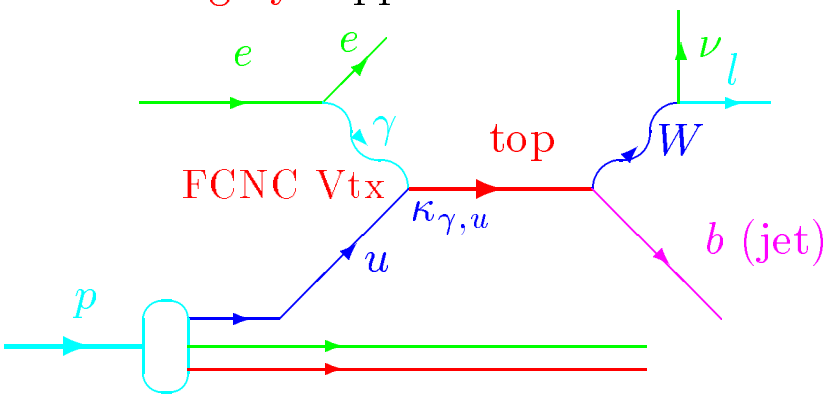


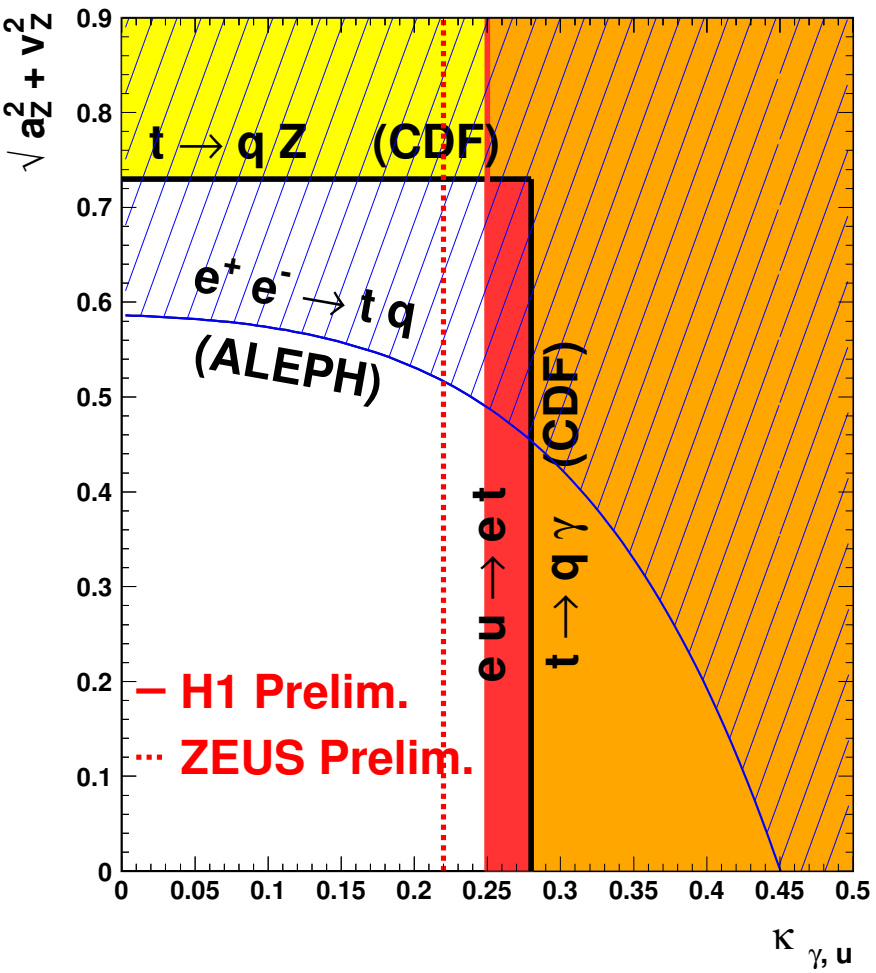


FCNC

Flavour Changing Neutral Currents

highly suppressed in SM





Beyond 2001...

- Searches have been performed for
  - Contact Interactions
  - Extra dimensions
  - Leptoquarks
  - $R\!\!\!/_p$ Supersymmetry
  - Excited fermions
- HERA data up to 2000 do not show evidence for the above processes
- Limits have been inferred and are comparable with LEP or TEVATRON
- H1's isolated lepton events are still puzzling
- HERA upgrade $\Rightarrow$ 5 times more lumi expected starting this autumn

- Searches have an exciting future at HERA...