XXIII International Symposium
on Lepton and Photon Interactions at High Energy
Aug 13-18, Daegu, Korea

Searches for exotic phenomena at colliders

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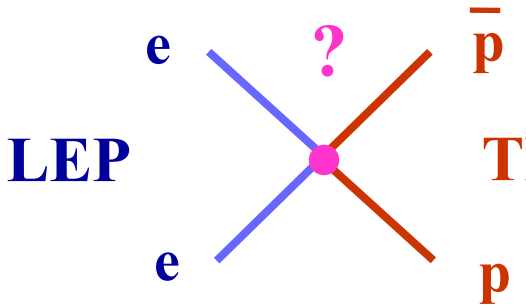
CPPM-Marseille / DESY

NB: no SUSY - no Higgs in this talk
(unless well hidden in the distributions)

The high energy frontier with o(1fb^{-1})

0.21 TeV, ~ 0.9 fb^{-1}/exp.



LEP

TEVATRON

1.96 TeV, ~ 2.5 fb^{-1}/exp.

HERA

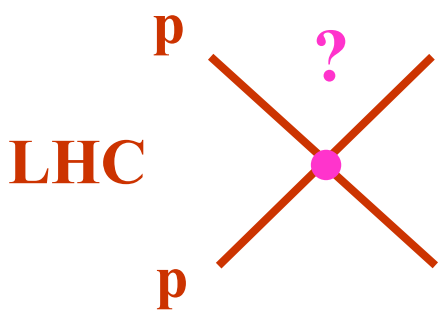
0.32 TeV, ~ 0.5 fb^{-1}/exp.

…has been shut down on June 30th

~ twice more expected until 2009

most present results based on ~1 fb^{-1}

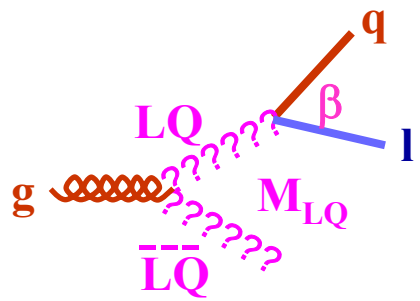
The high energy frontier with o(1fb^{-1})



14 TeV

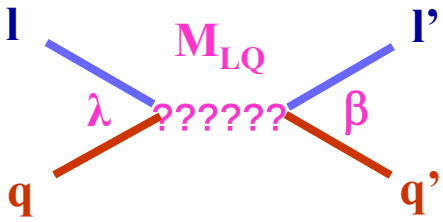
~ 1 fb^{-1}/exp.
expected in 2008-09

Effective Lagrangians for new physics

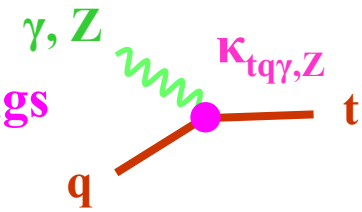


Leptoquarks

Benchmarks:
λ = 0.3 (EM strength)
β = 1 or 0.5

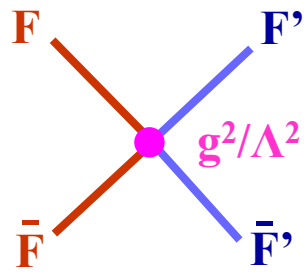


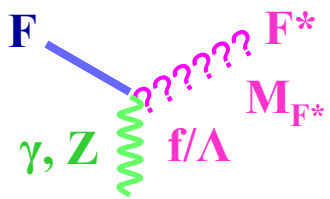
FCNC anomalous couplings



Contact Interactions

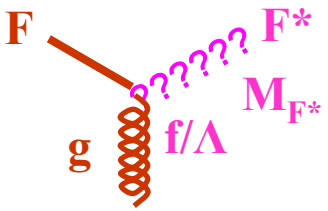
Benchmark: $g^2 = 4\pi$

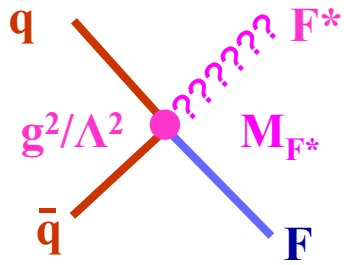




Excited Fermions

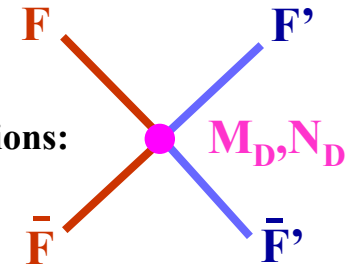
Benchmarks:
$\Lambda = M_{F*}$
$g^2 = 4\pi$

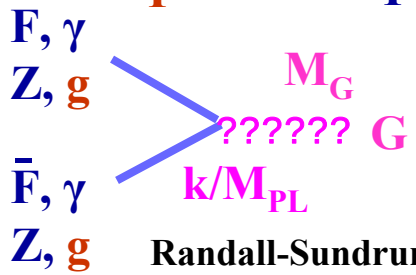




Extra dimensions

N_D large extra dimensions:





Randall-Sundrum graviton resonances

NB:
Important to use same models and benchmarks when comparing limits from different colliders

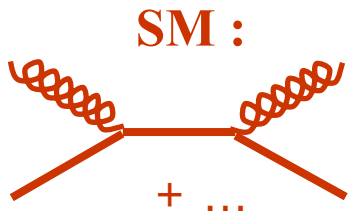
Results presentation

- Inclusive signatures
- Lepton signatures
- Photon signatures
- Model-tuned searches
- Generic searches

Inclusive signatures :

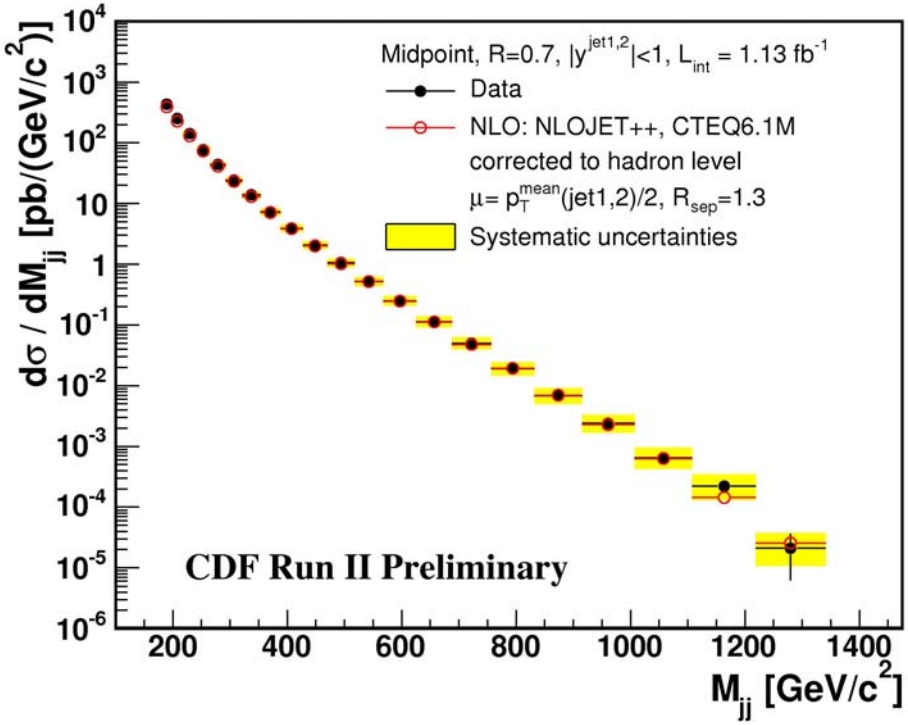
Jets at TEVATRON

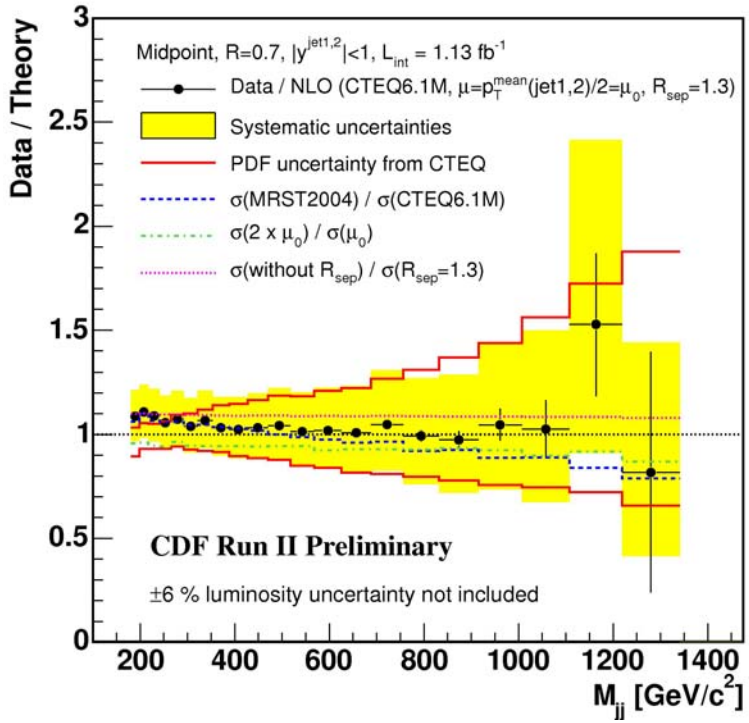
SM :



very sensitive to high-x gluon, indeed now input to PDF fits

Dijet mass spectrum





Inclusive signatures :

Jets at TEVATRON

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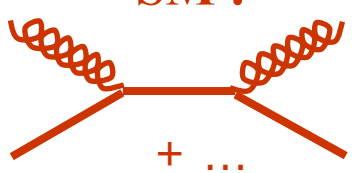

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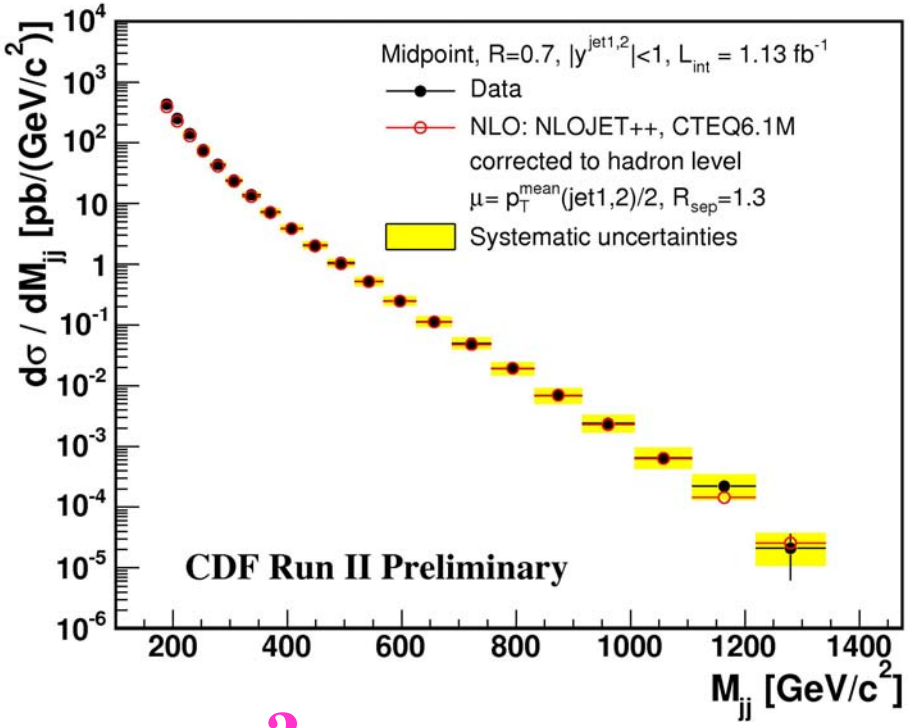
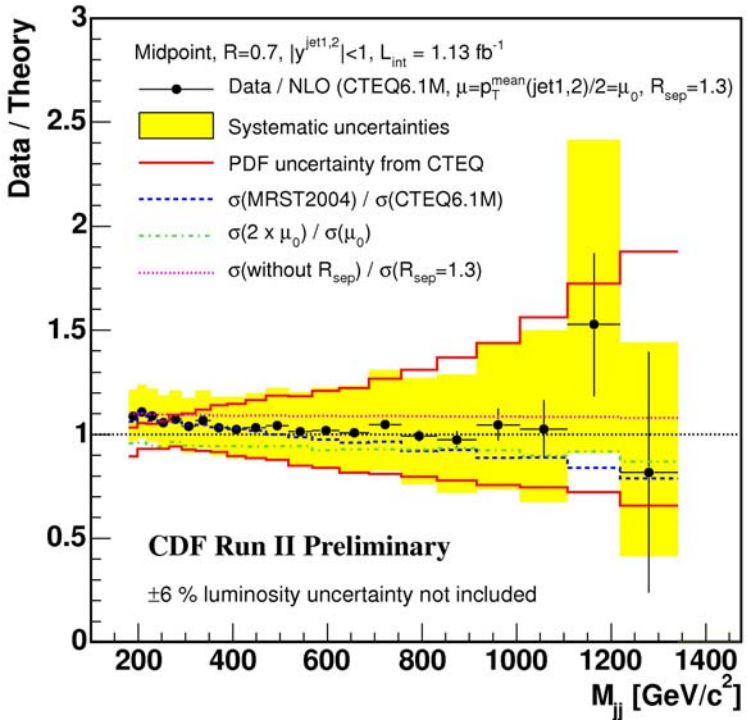
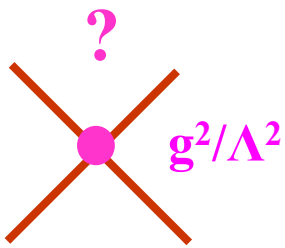
Mass spectrum







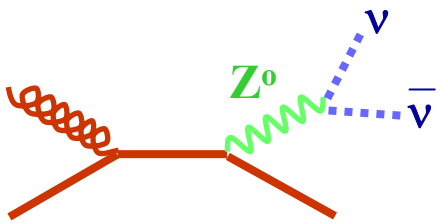
Strategy for searches :

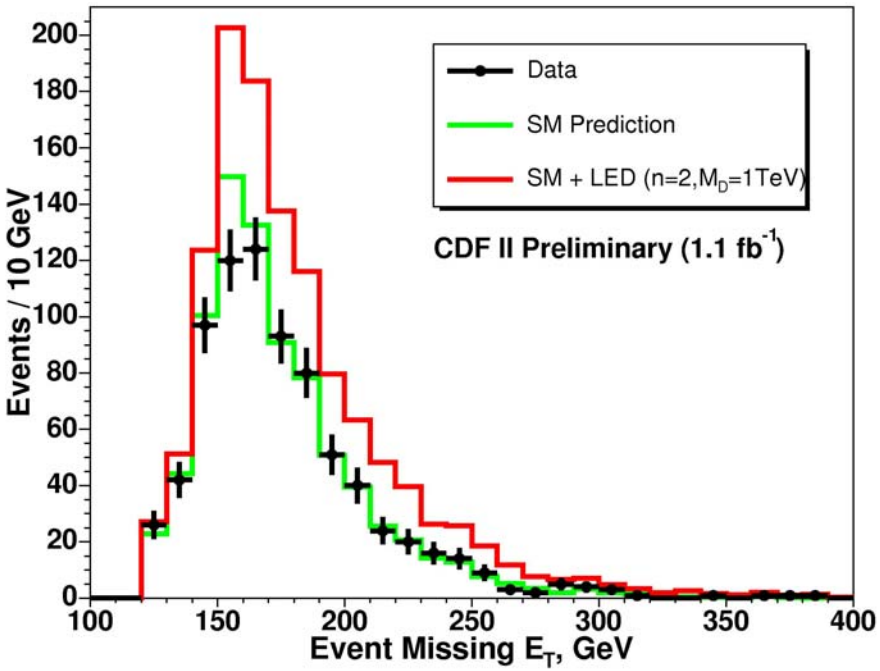
exploit expected enhanced signal in central region

(→ Λ ~ 8 TeV with 1 fb^{-1} at LHC)

Inclusive signatures : E_T^{miss} *at TEVATRON*

SM :





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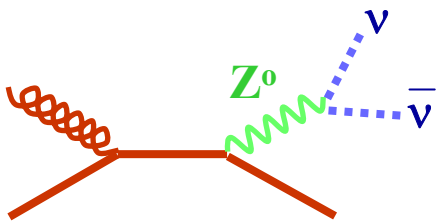
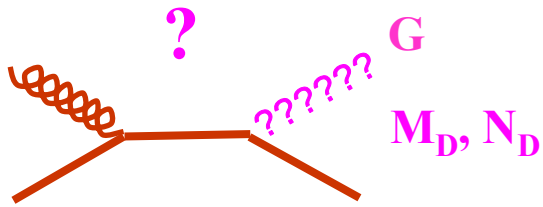
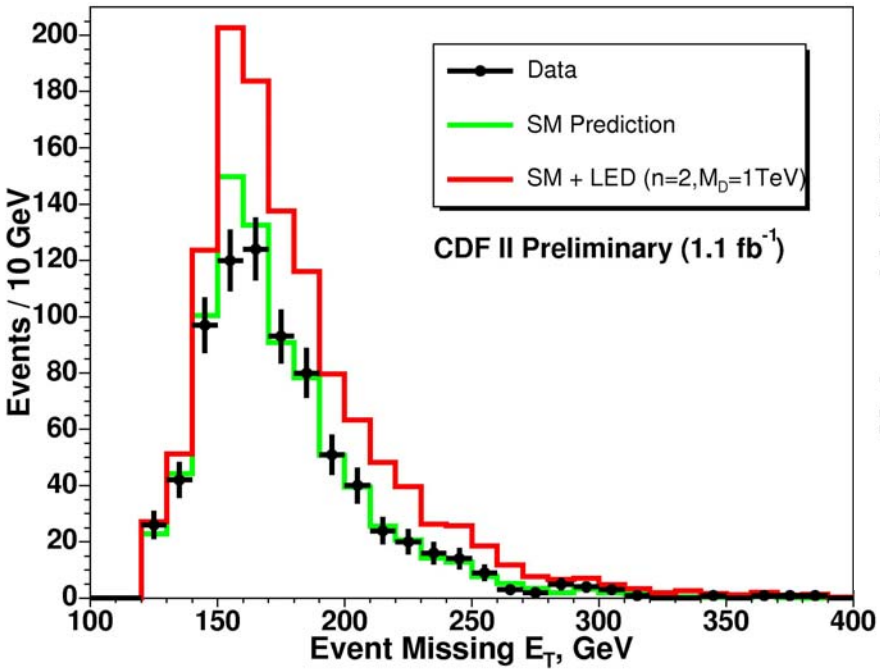
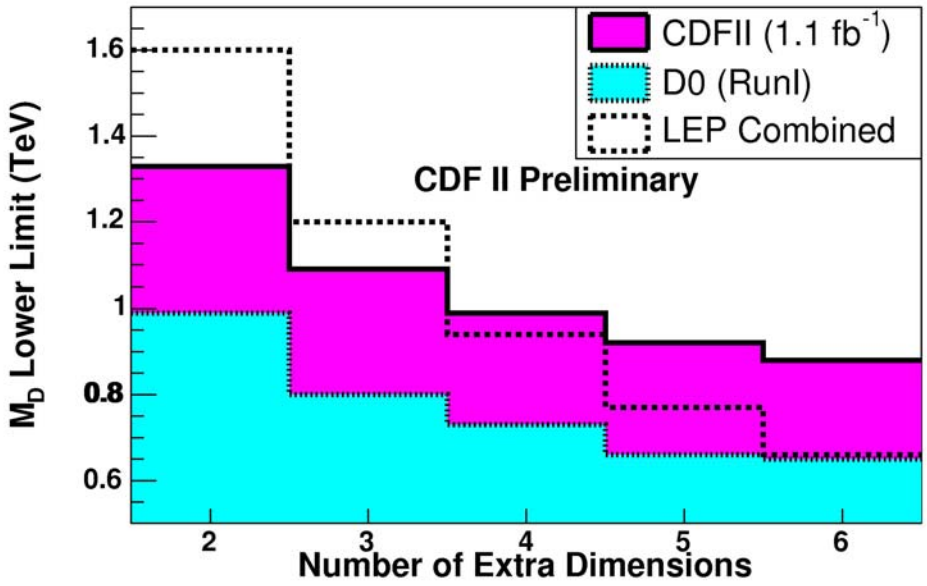








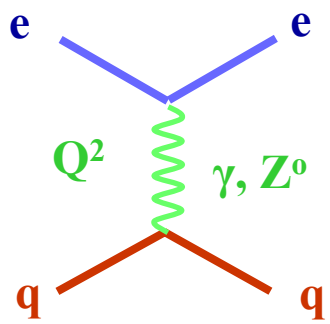
Limit on Planck scale M_D

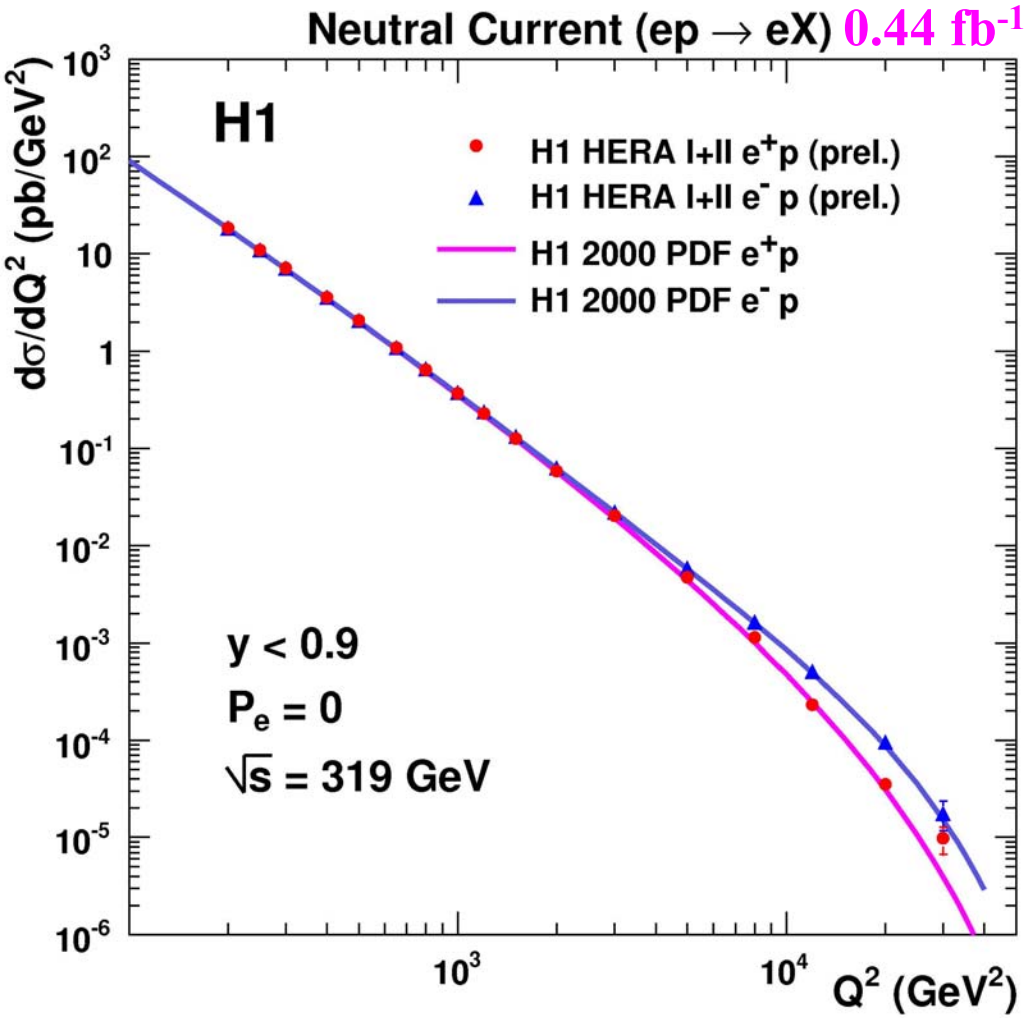
→ $R_{Extra\text{-}dim} < 0.36$ mm for $N_D = 2$

Inclusive signatures : e-jet at HERA

4-momentum transfer Q^2 spectra

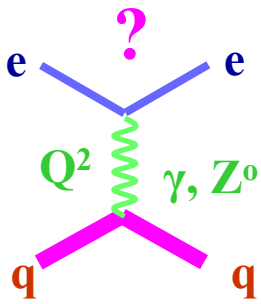
SM :



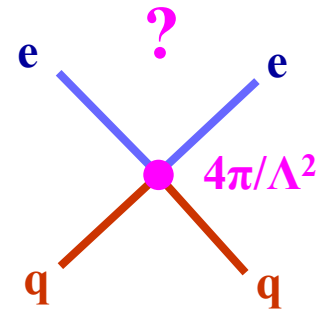


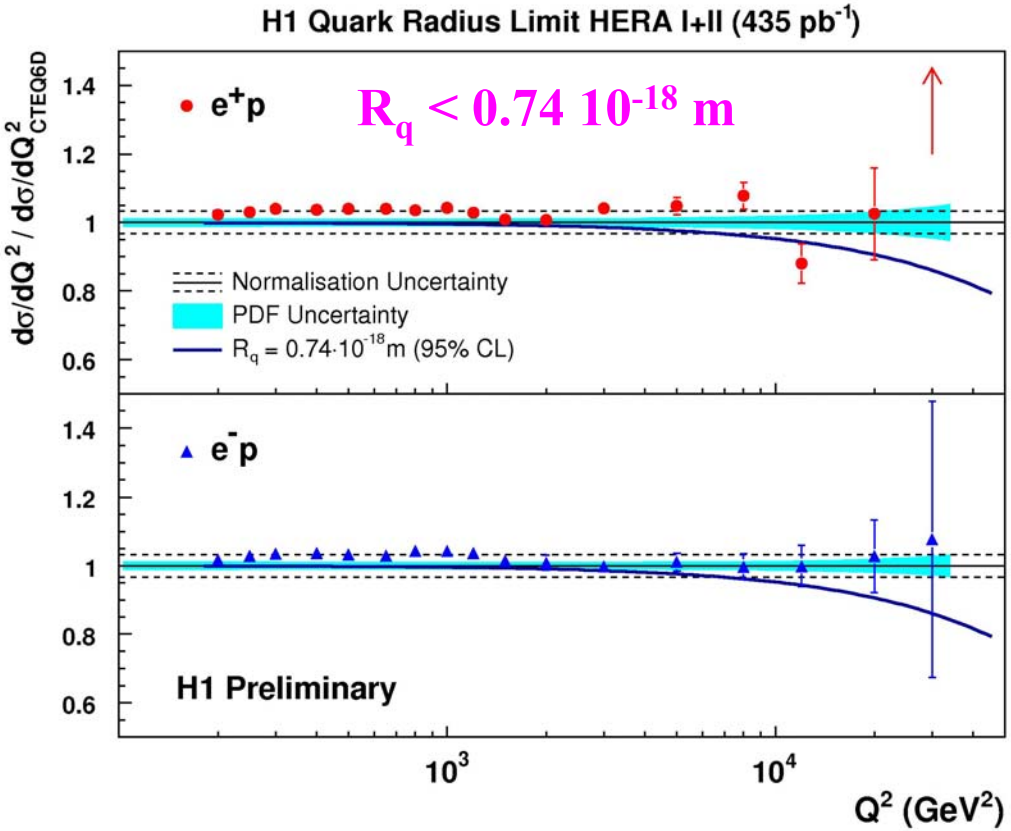
Inclusive signatures : e-jet at HERA

4-momentum transfer Q^2 spectra

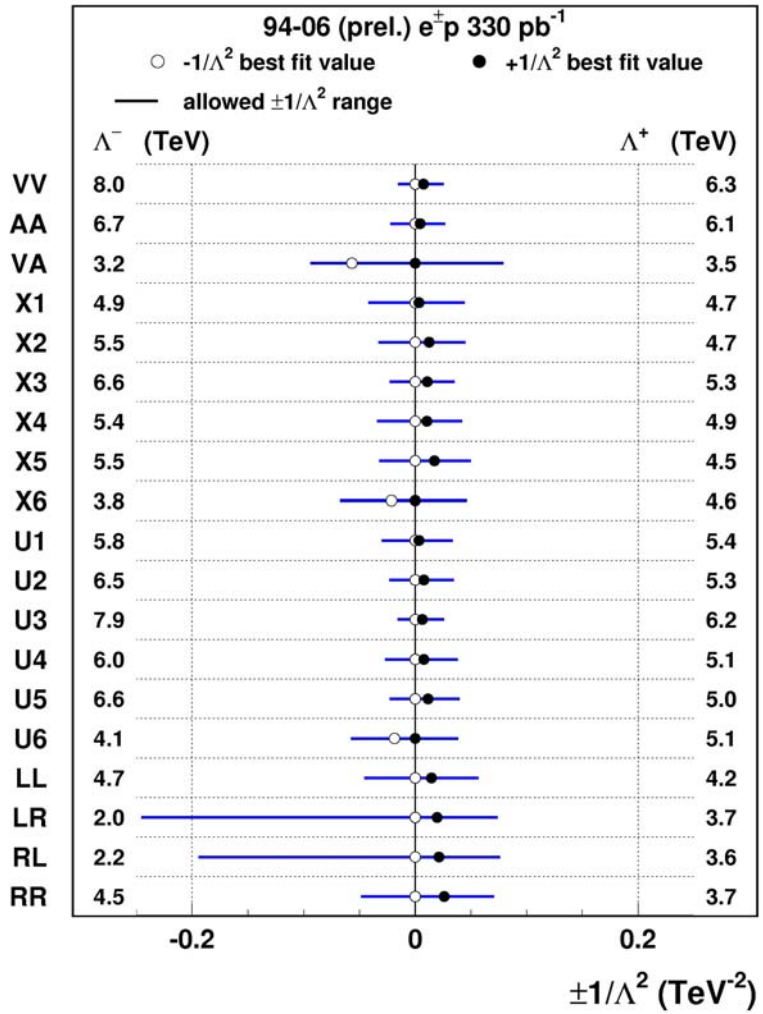


quark radius R_q
factor:$(1-R_q^2Q^2/6)$



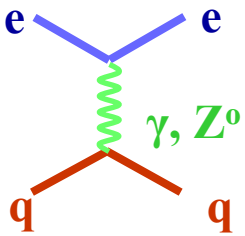


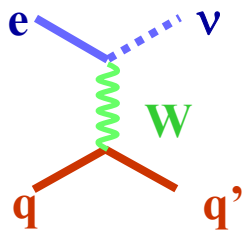
ZEUS 330 pb^{-1}: $R_q < 0.62\ 10^{-18}$ m

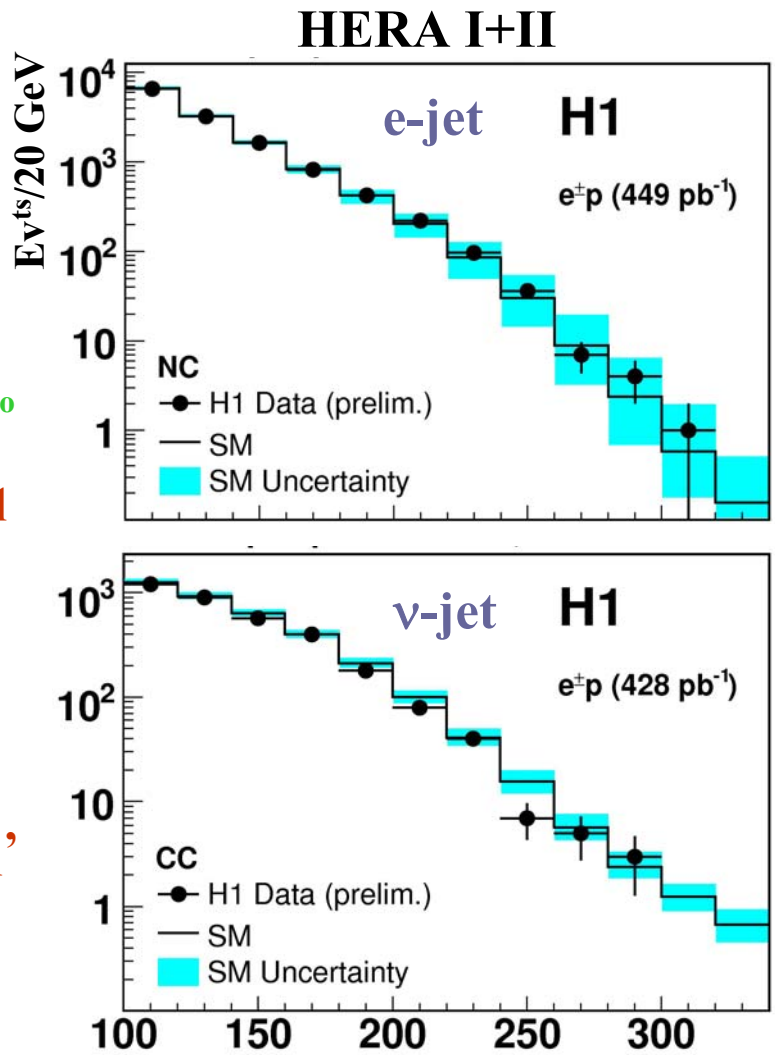


Inclusive signatures : e-jet and ν-jet at HERA

SM :



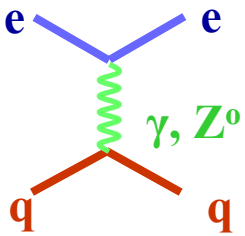


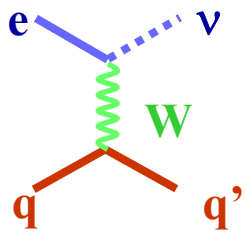


Mass spectra $M_{ej,\,\nu j}$ **(GeV)**

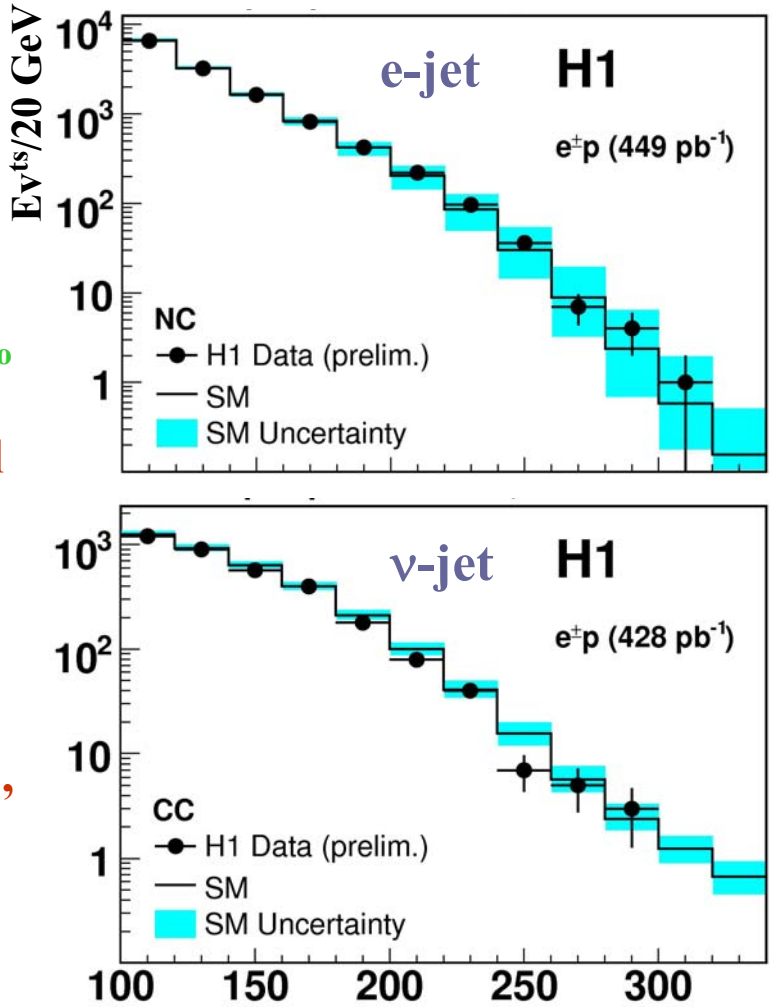
Inclusive signatures : e-jet and ν-jet at HERA

SM :

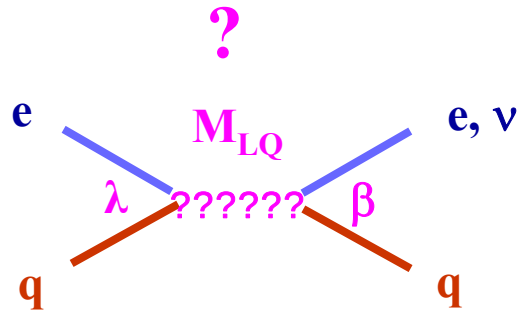




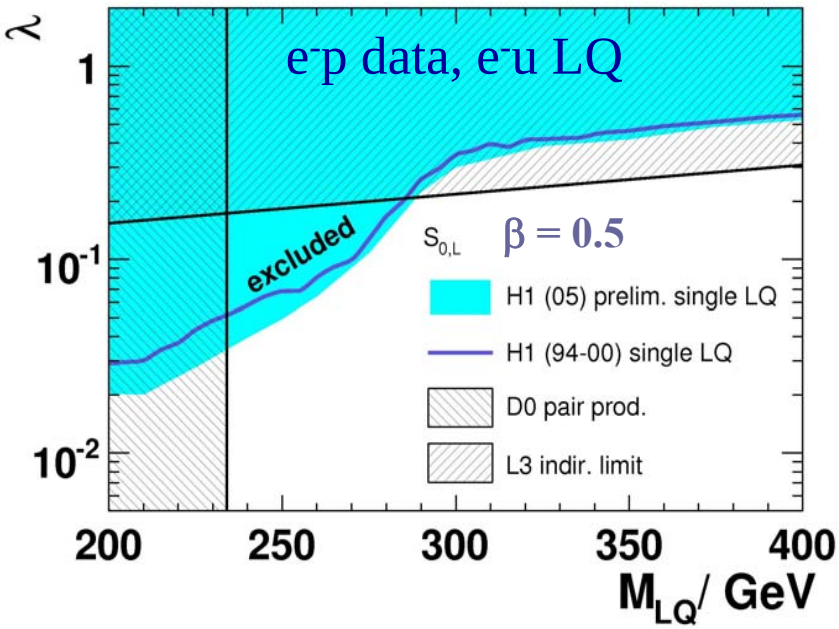
HERA I+II



Mass spectra

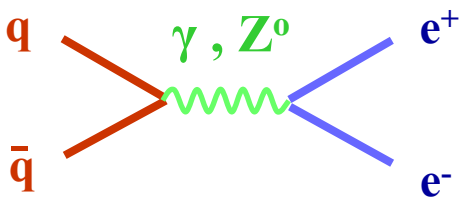


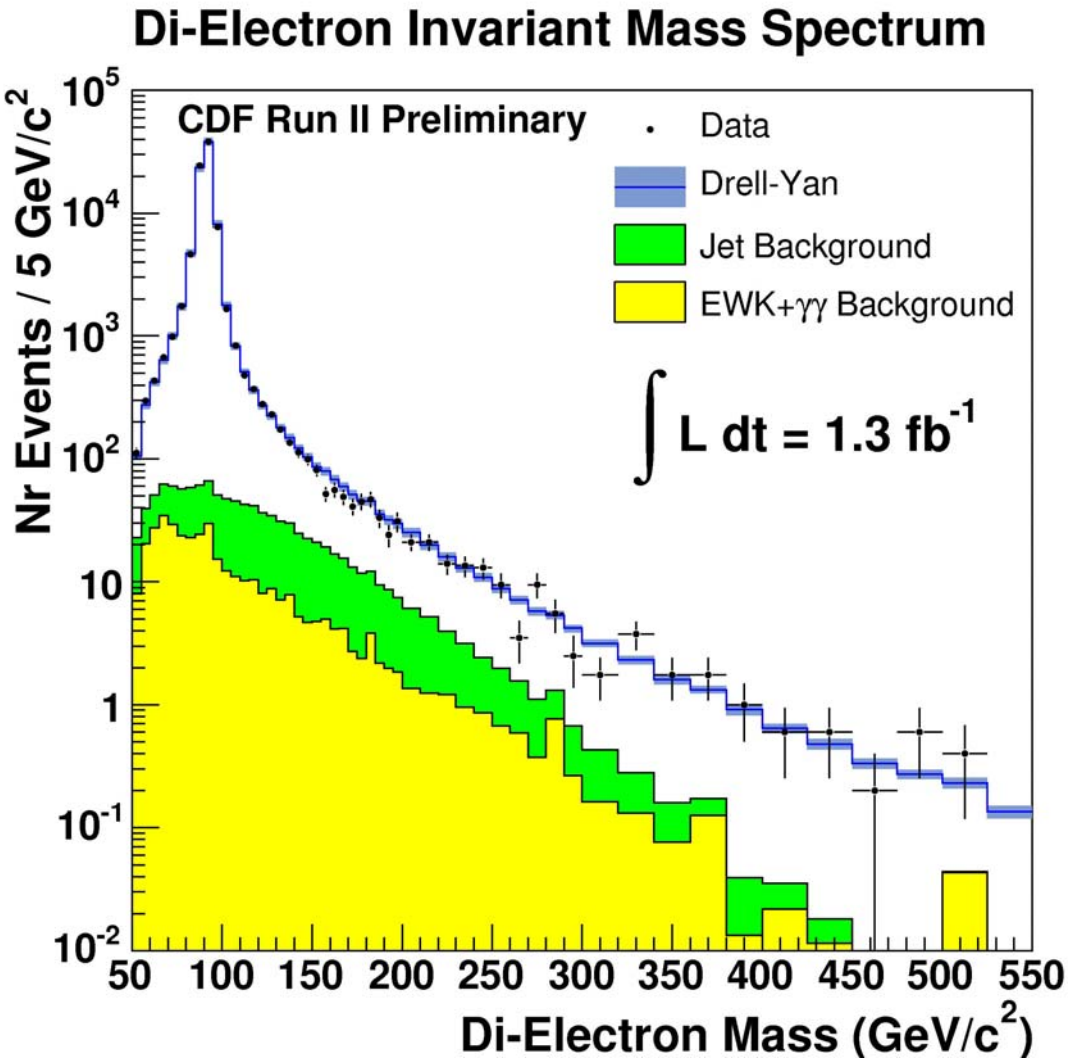
Example of limit on Leptoquarks 1st generation



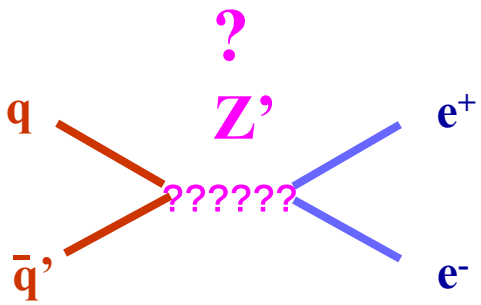
Lepton signatures : Drell-Yan at TEVATRON

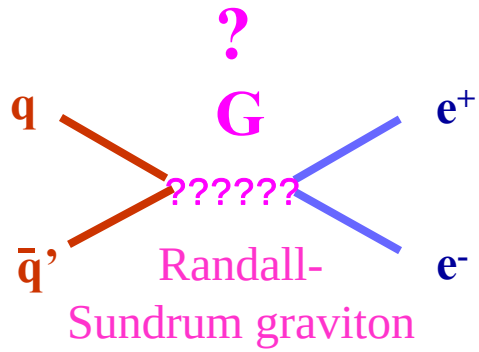
SM :

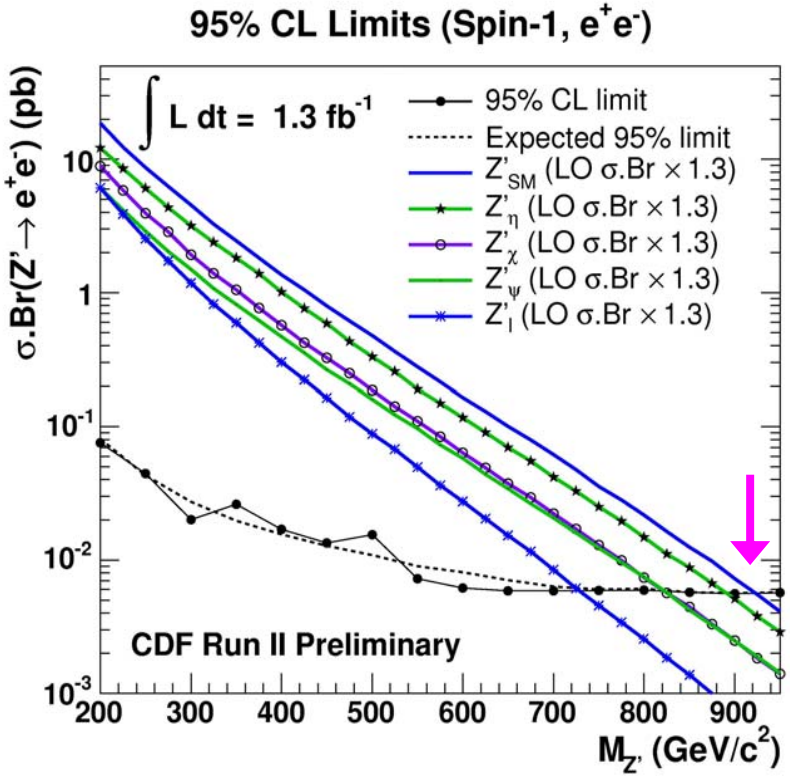


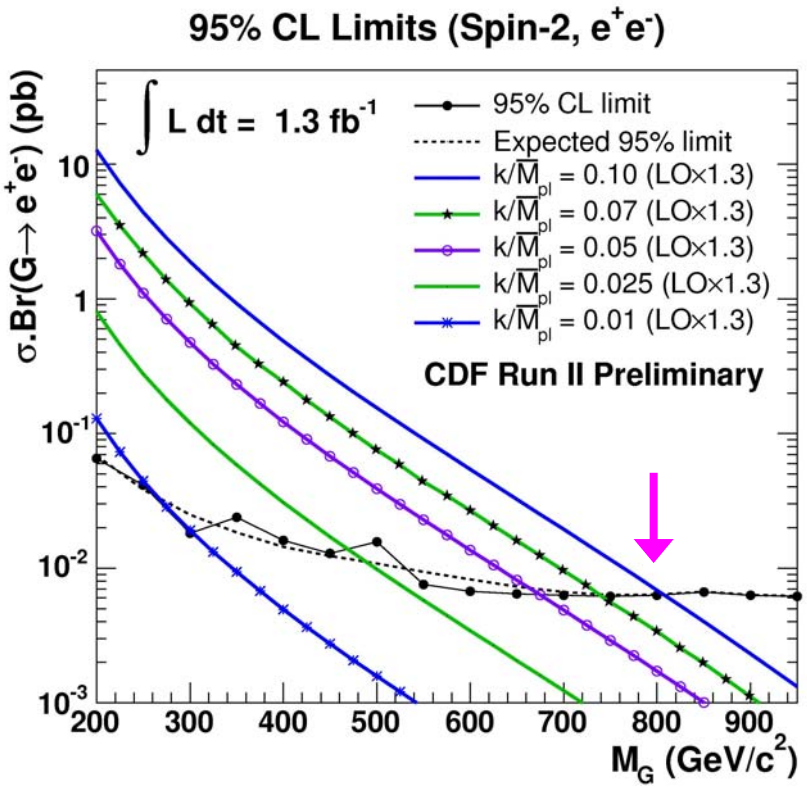


Lepton signatures : Drell-Yan at TEVATRON





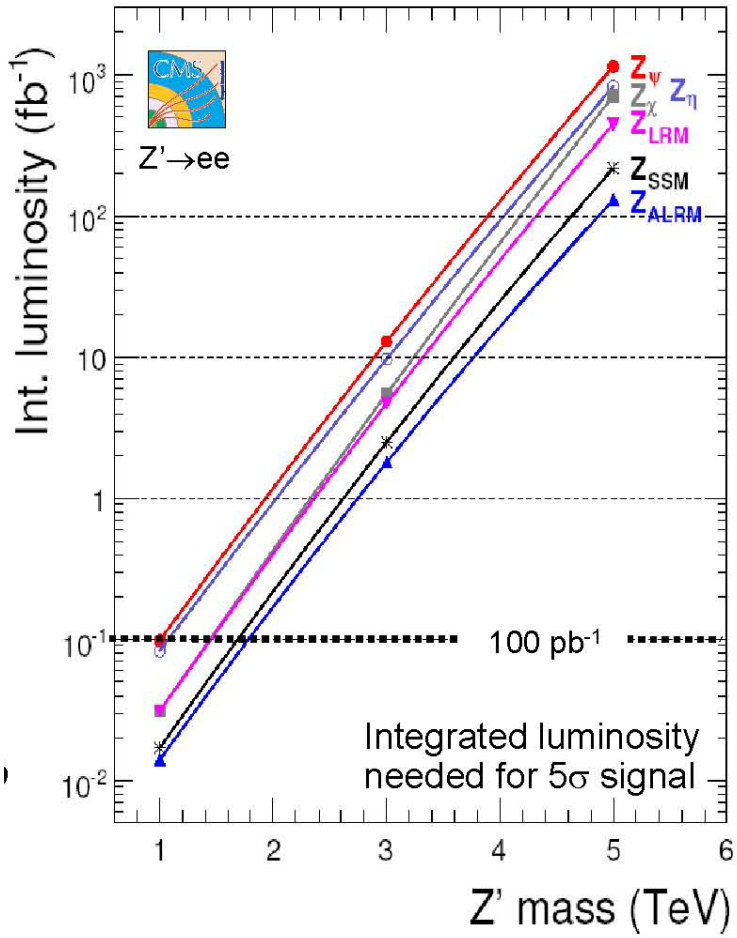




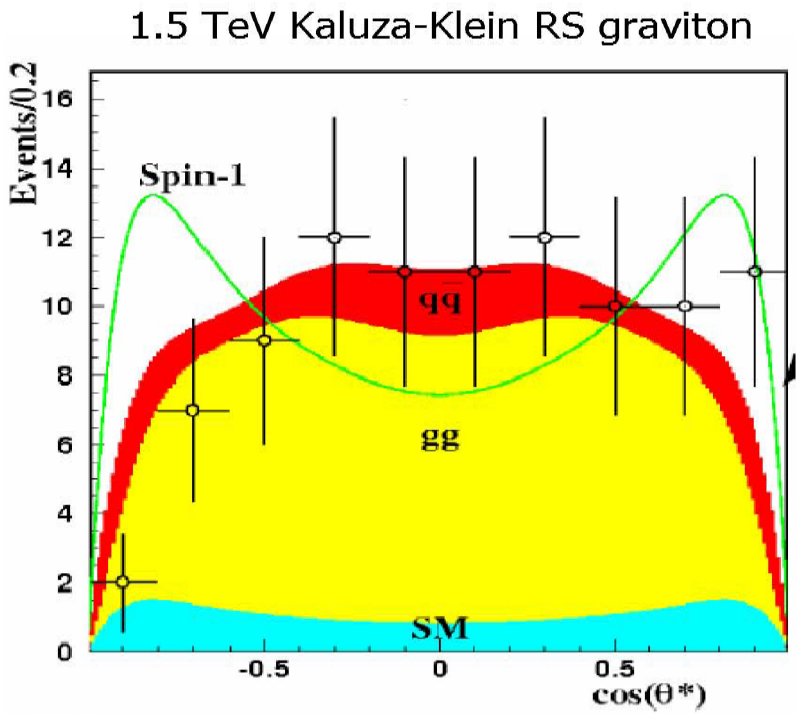
at c

Drell-Yan early prospects at LHC

Discovery potential with initial calibrations



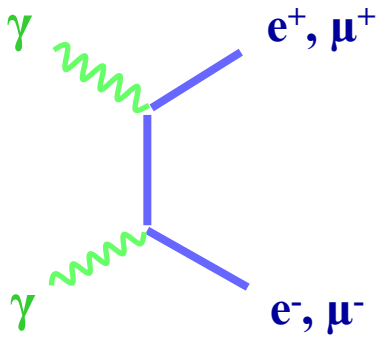
If resonance found, Z' / RSG discrimination possible from decay angular distributions

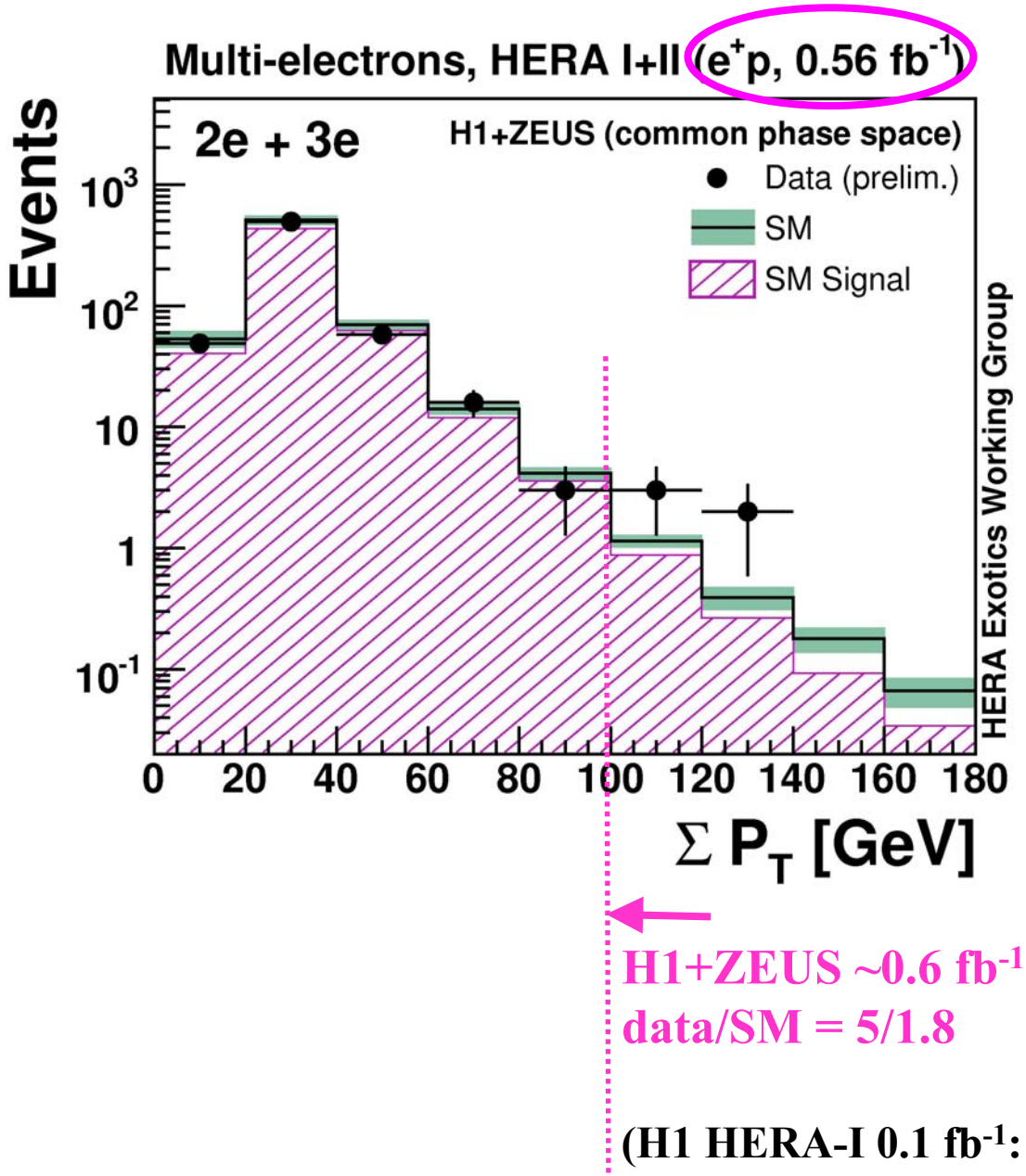


Lepton signatures :

Multi-leptons at HERA

SM :

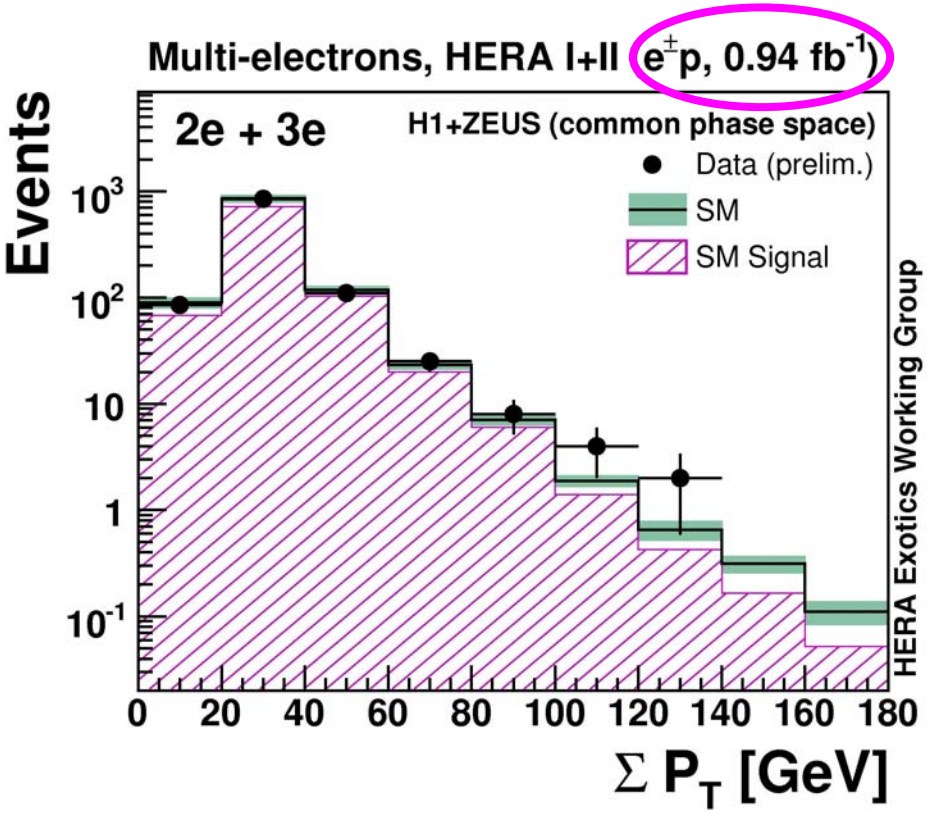




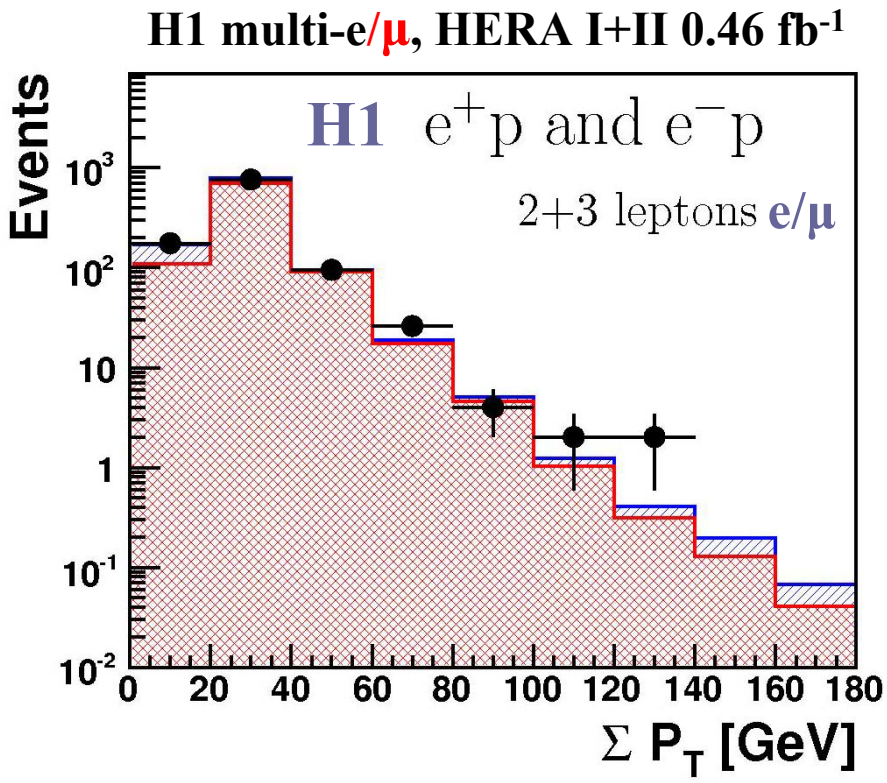
H1+ZEUS ~0.6 fb^{-1}: data/SM = 5/1.8

(H1 HERA-I 0.1 fb^{-1}: 3/0.3)

Lepton signatures : Multi-leptons at HERA



Good agreement to SM on the overall H1+ZEUS e^+p/e^-p sample

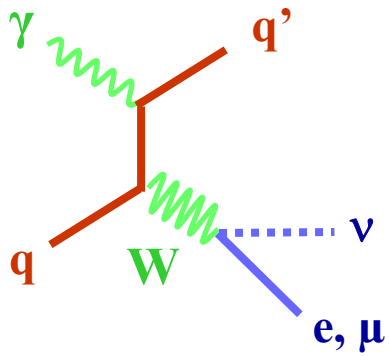


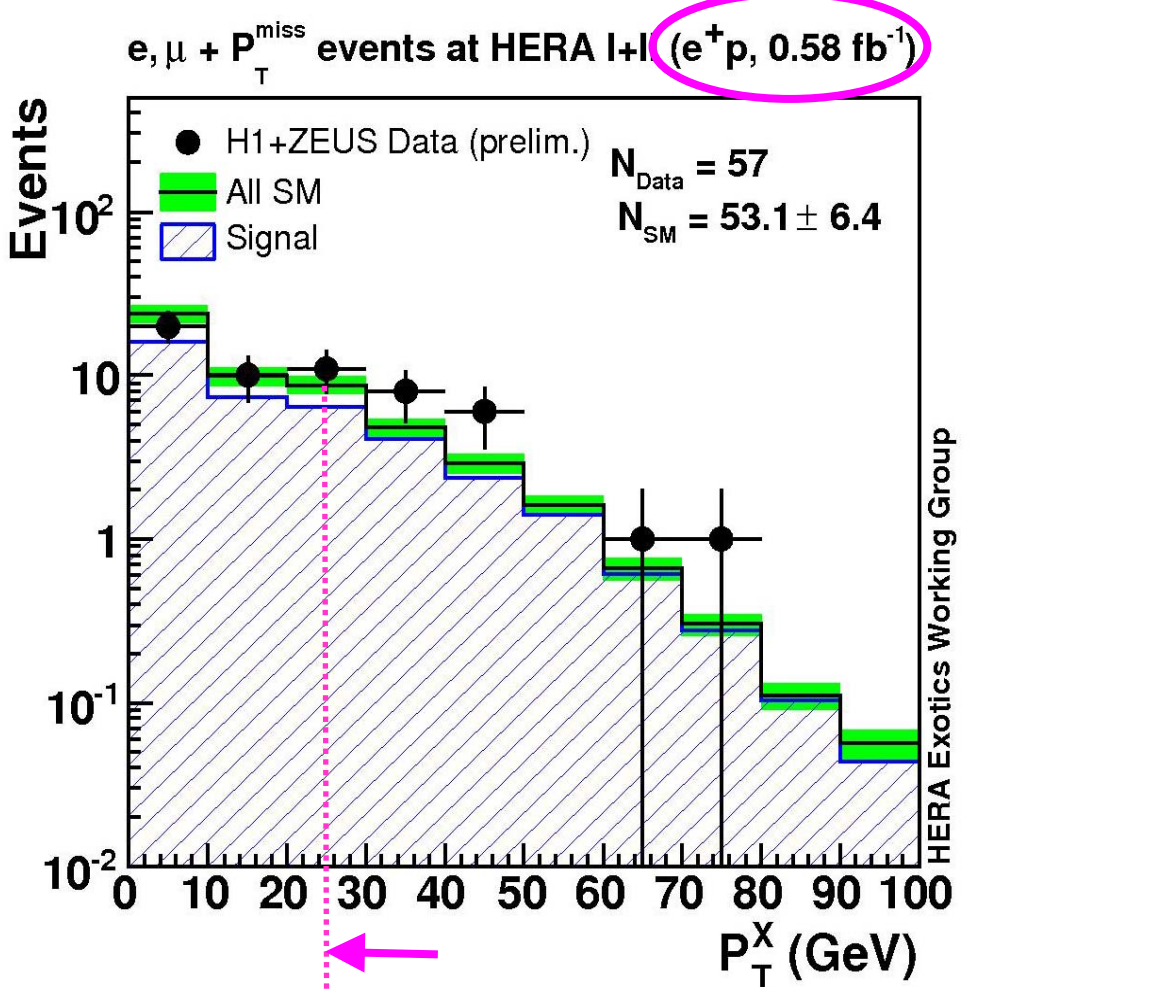
1 eμμ event observed by H1 in e^+p with $\Sigma P_T > 100$ GeV

Lepton signatures :

Leptons + E_T^{miss} at HERA

SM :



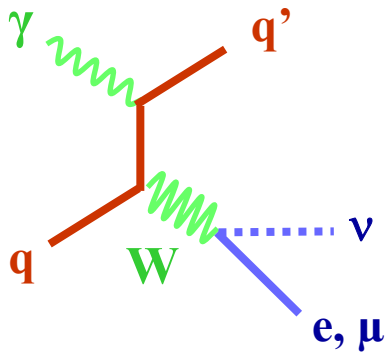


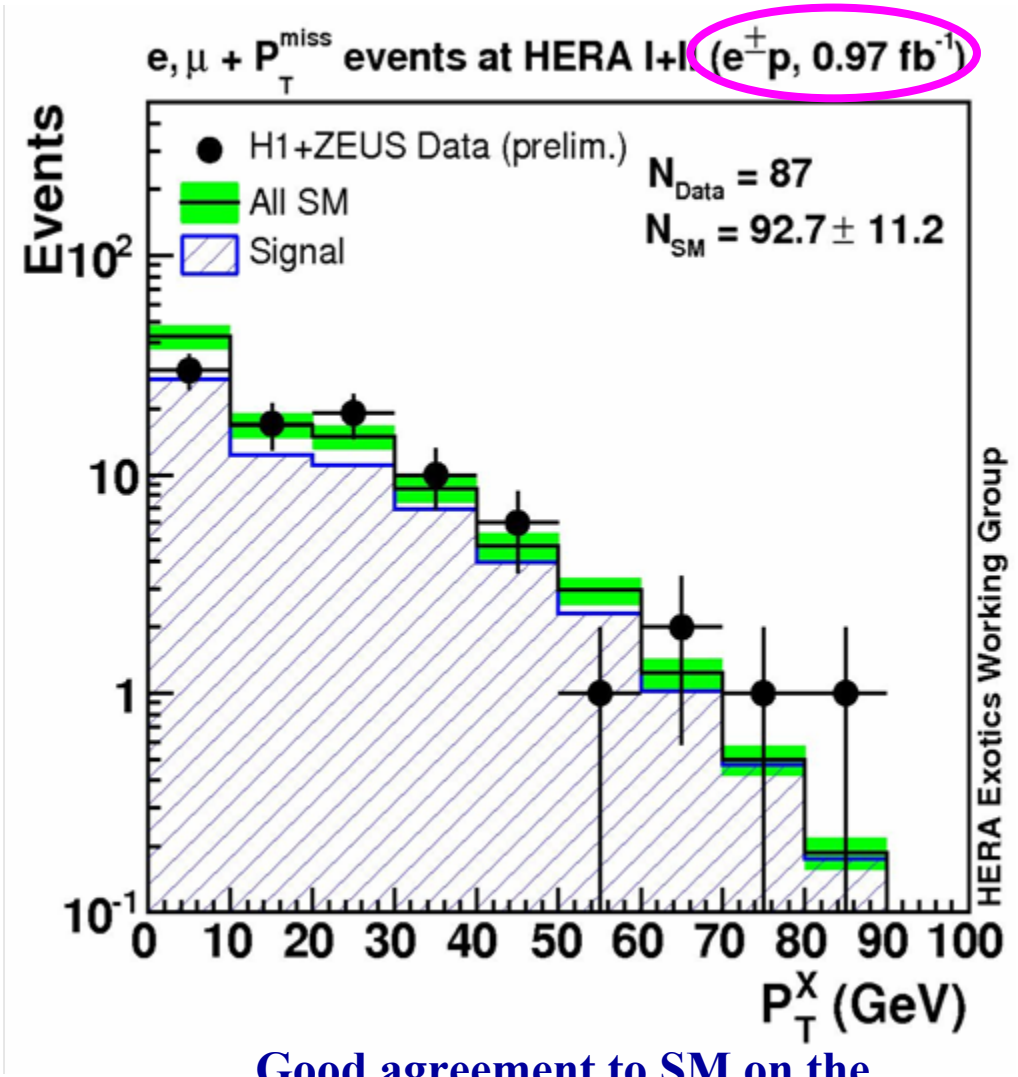
H1+ZEUS ~0.6 fb^{-1}
(common phase space)
data/SM = 23/14.6
→ remaining 1.8 σ effect in e$^+$p
(H1 HERA-I 0.1 fb^{-1}: data/SM = 10/2.9)

Lepton signatures :

Leptons + E_T^{miss} at HERA

SM :





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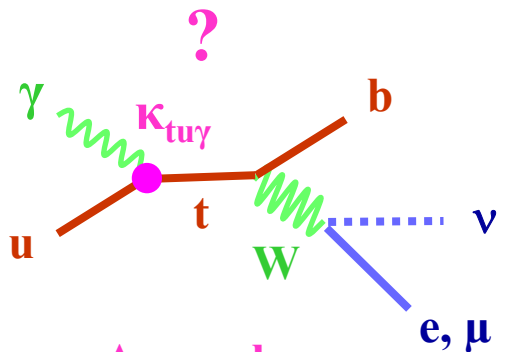
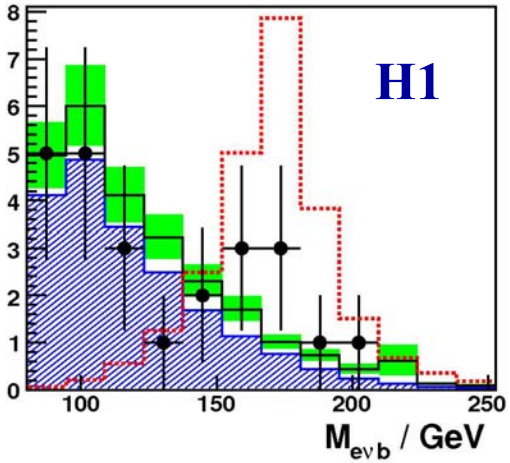
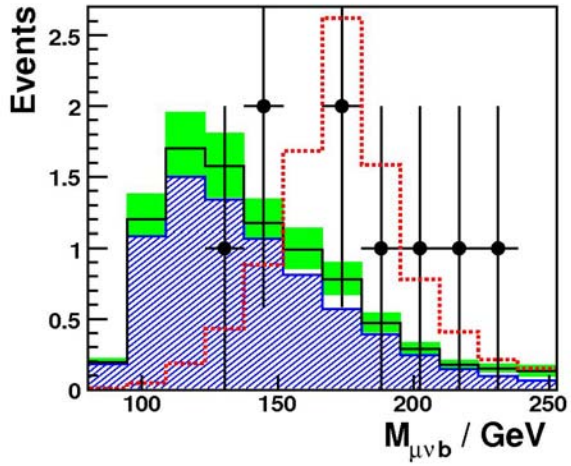
Lepton signatures :

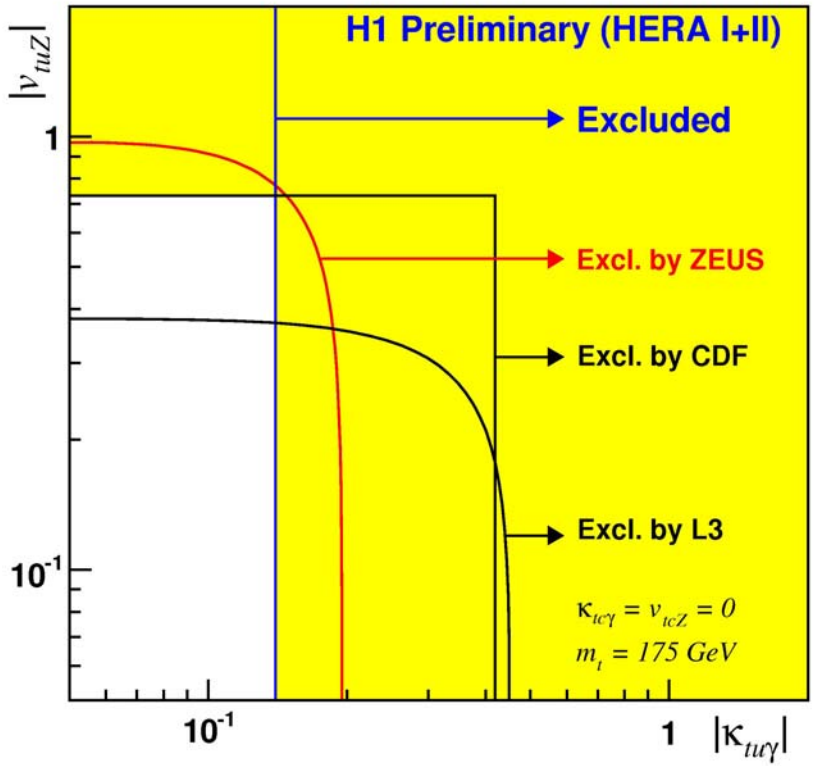
Leptons + E_T^{miss} at HERA



Anomalous top couplings

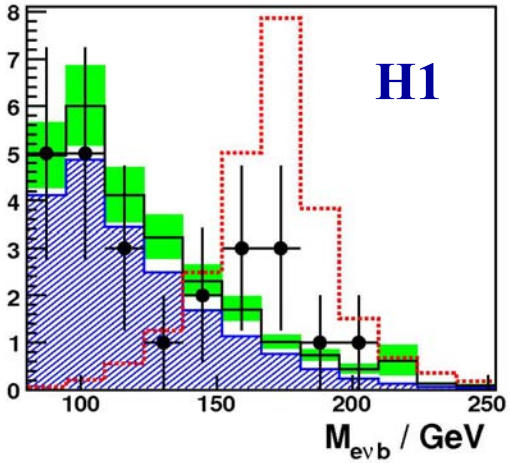


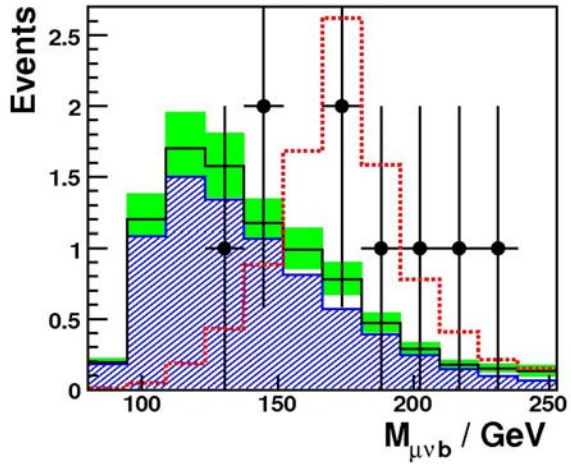


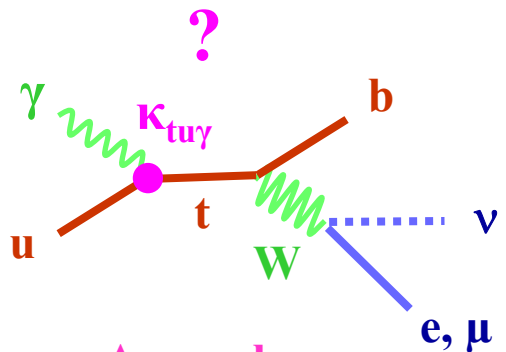


Lepton signatures :

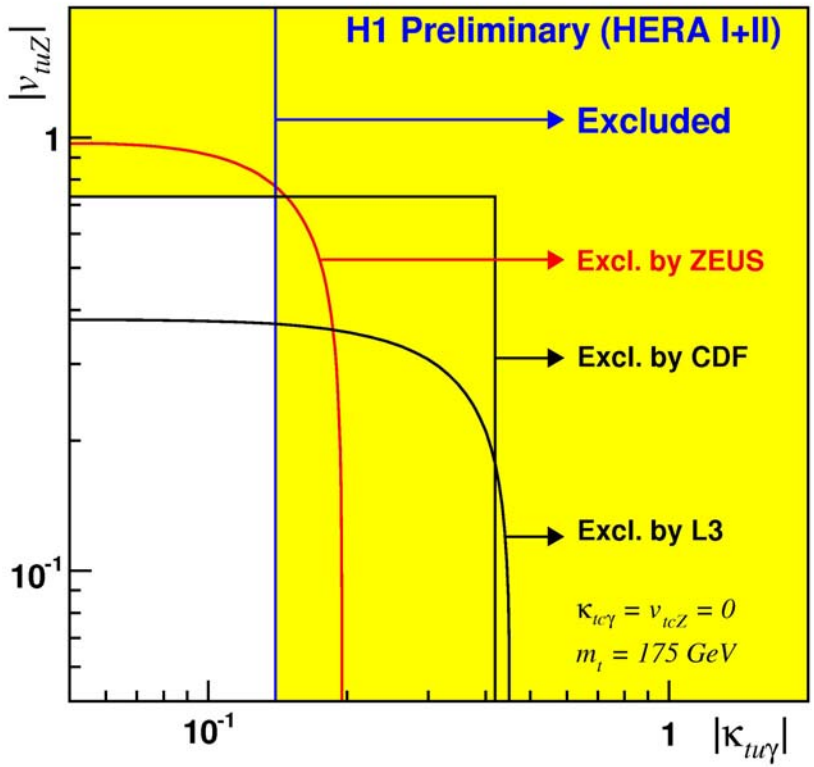
Leptons + E_T^{miss} at HERA







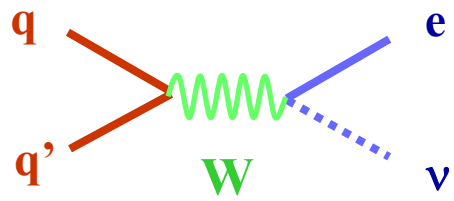
Anomalous top couplings

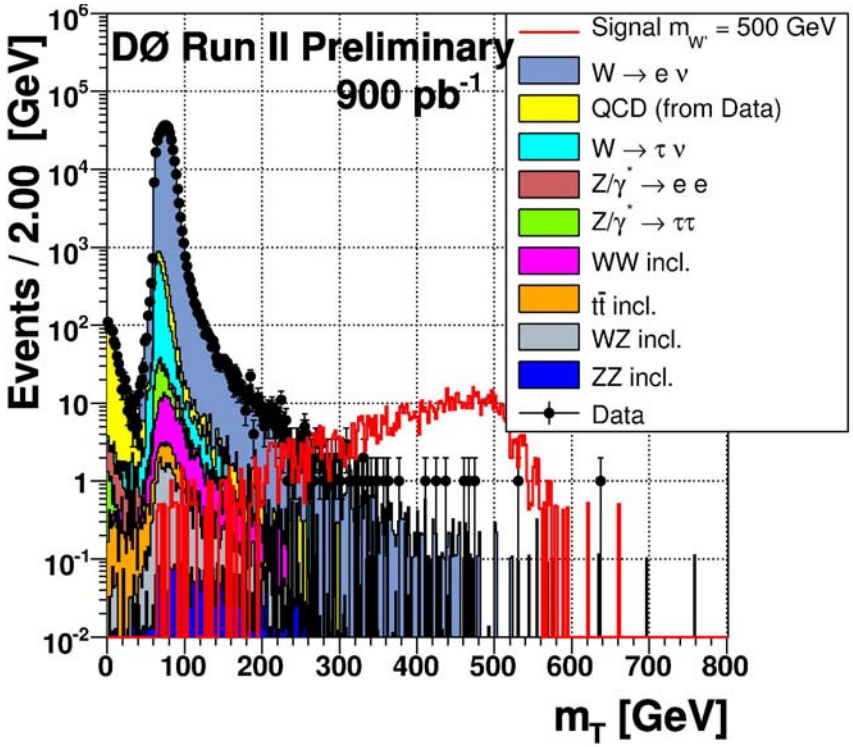


CDF 1.12 fb^{-1}:
Br(t → Zq) < 10.6% (95% CL)

Lepton signatures : Leptons + E_T^{miss} at TEVATRON

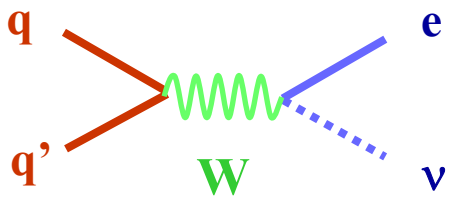
SM :

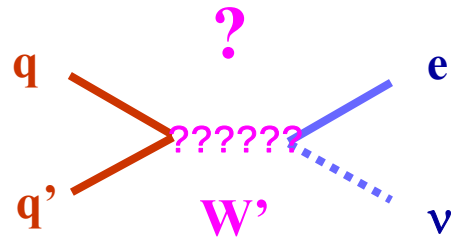


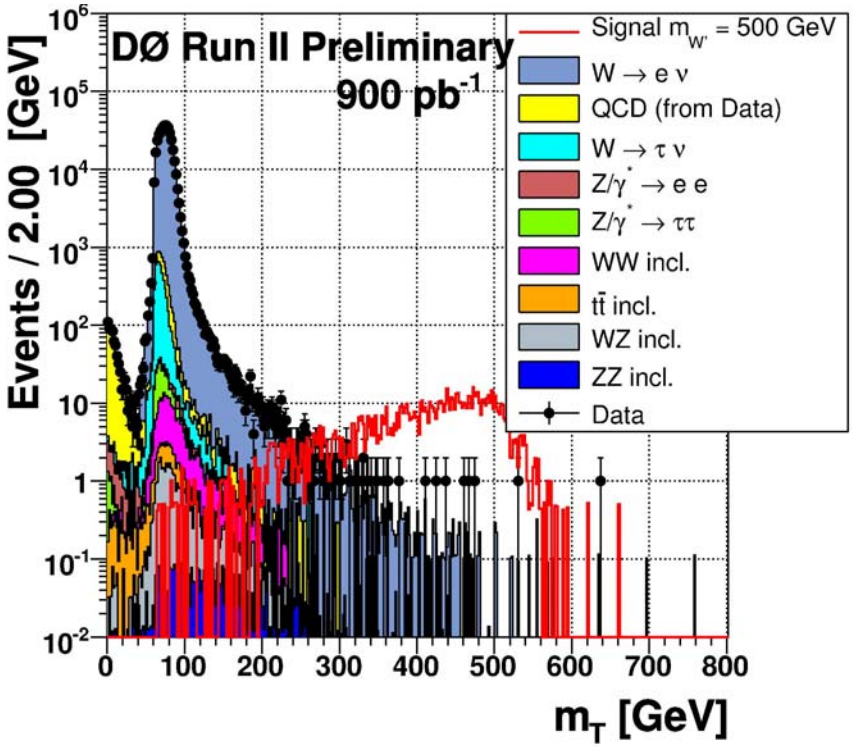


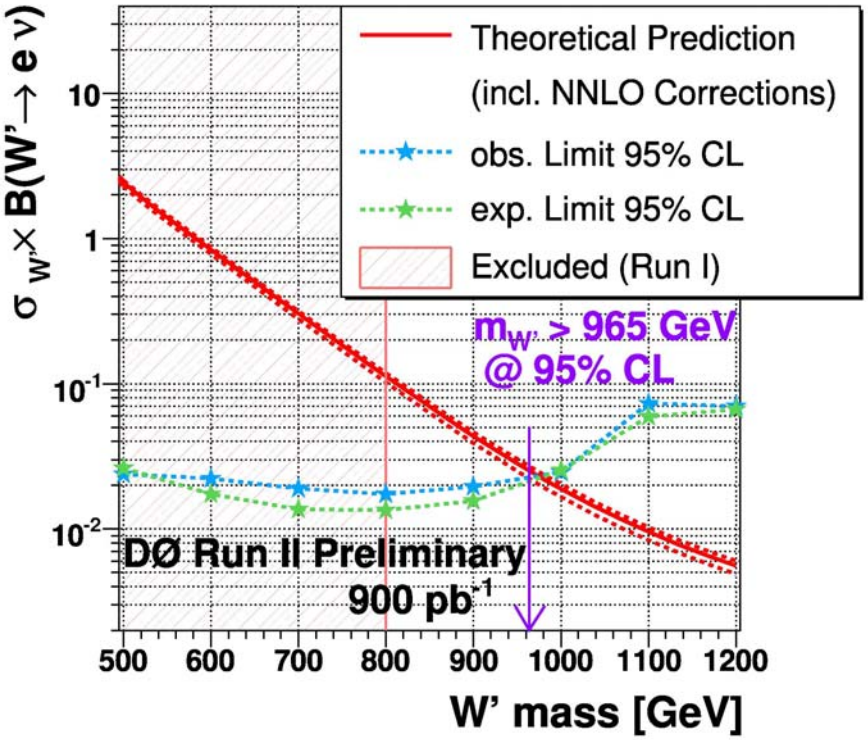
Lepton signatures : Leptons + E_T^{miss} at TEVATRON

SM :



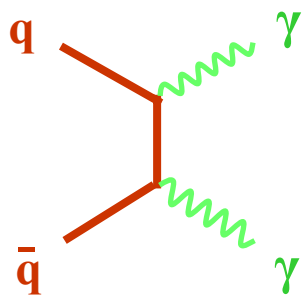


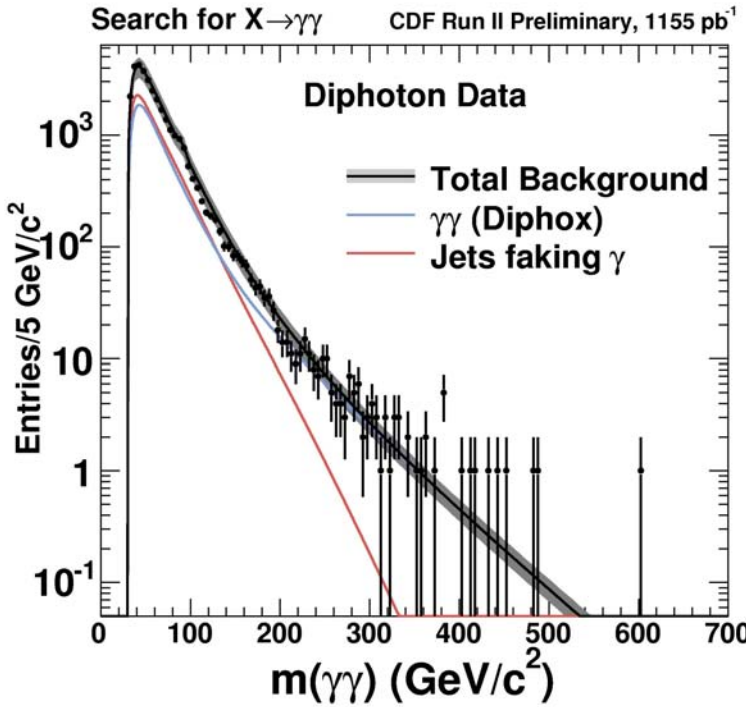




Photon signatures at TEVATRON: γγ mass spectra

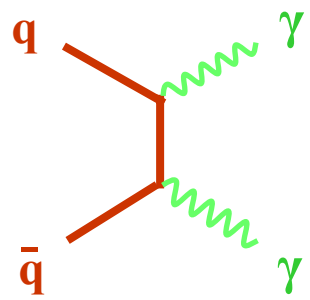
SM :

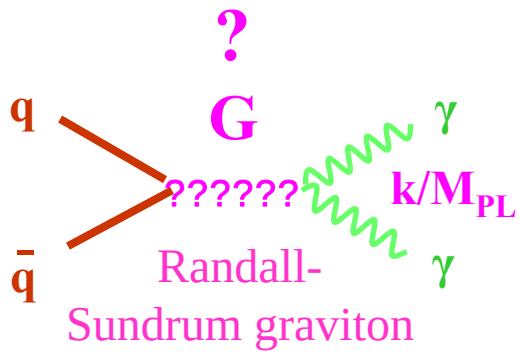


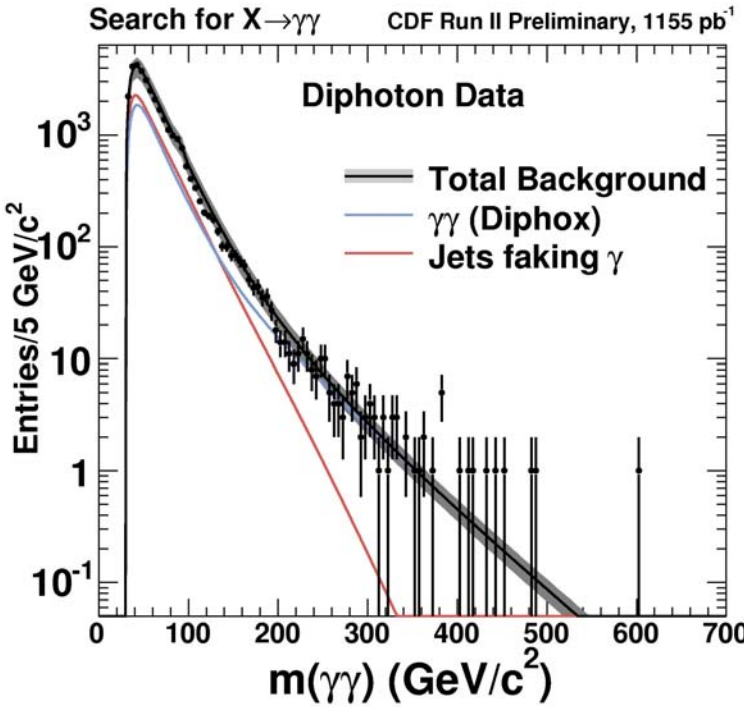


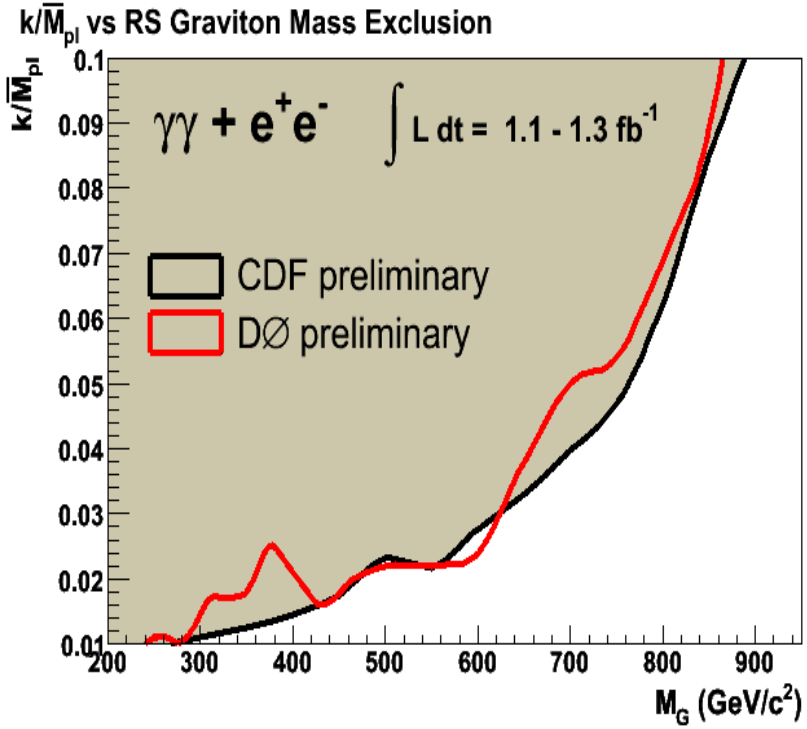
Photon signatures at TEVATRON: γγ mass spectra

SM :





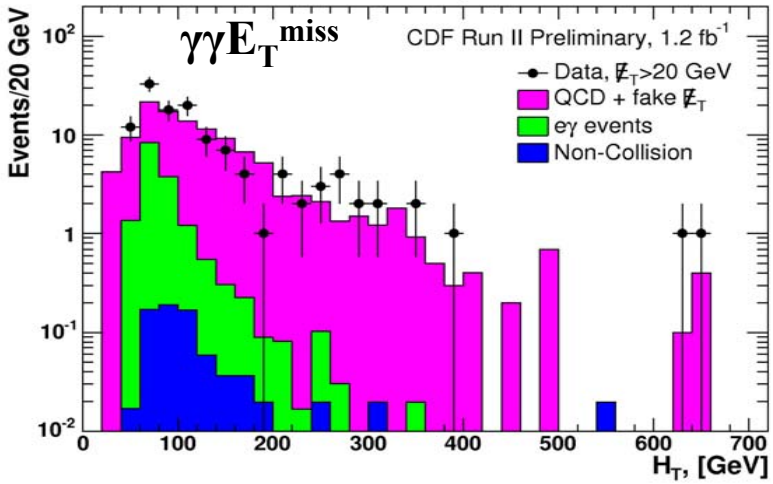




Photon signatures at TEVATRON: γγX and γlX

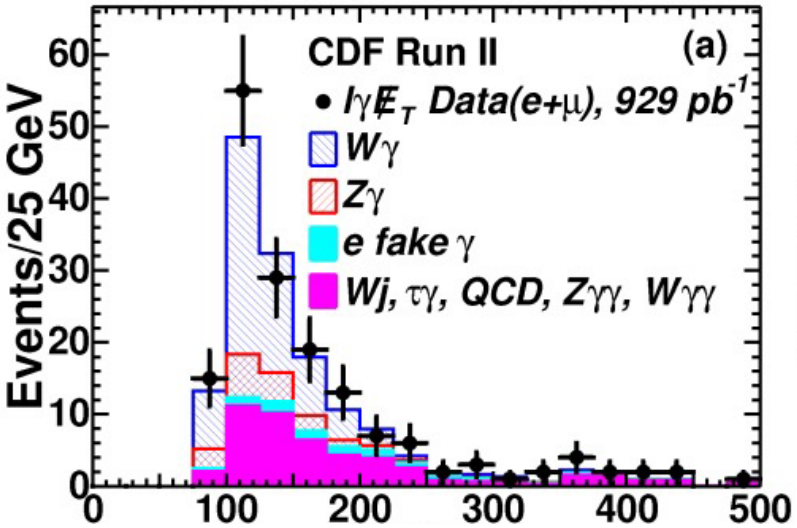
CDF run I:
1 ee$\gamma\gamma E_T^{miss}$ ev^t
for 10^{-6} exp.

no such event on run II:



CDF run I:
16 lγE_T^{miss} ev^{ts}
for 7.6 exp.

excess not confirmed by run II :

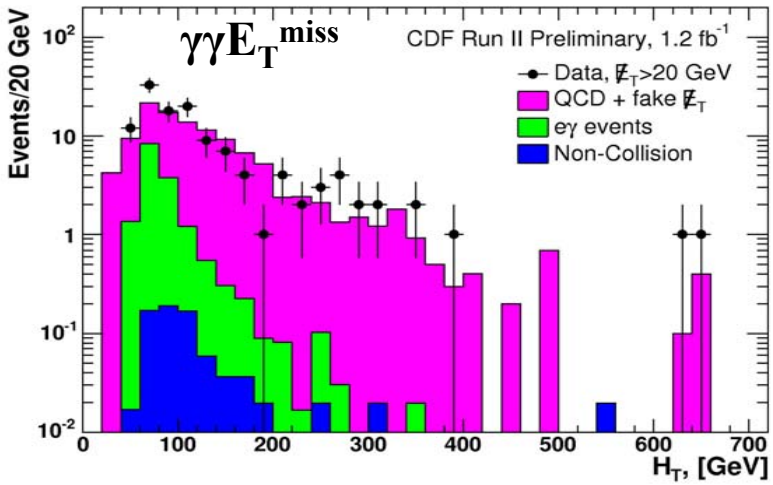


$H_T = \Sigma\ E_T^{part.}$ (GeV)

Photon signatures at TEVATRON: γγX and γlX

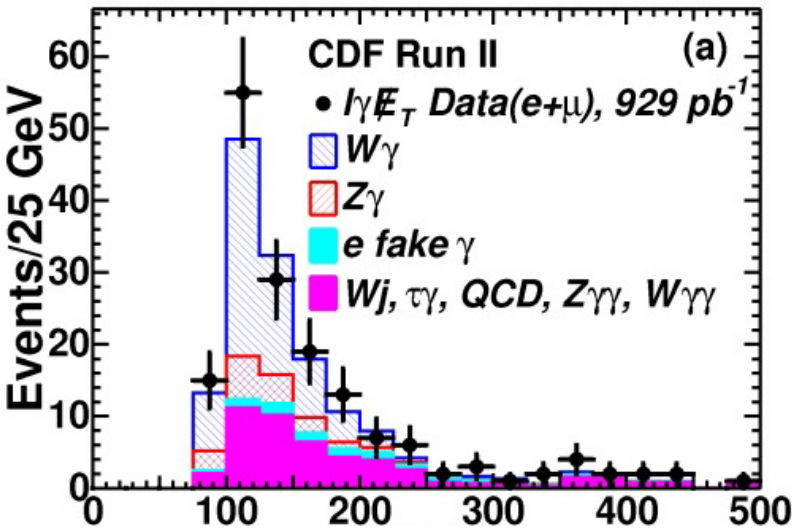
CDF run I:
1 eeγγE_T^{miss} ev^t
for 10^{-6} exp.

no such event on run II:

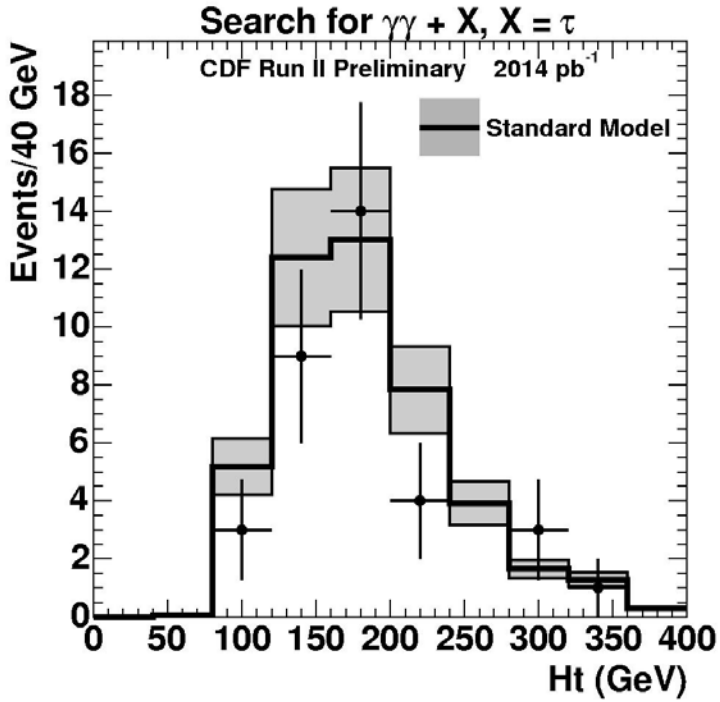


CDF run I:
16 lγE_T^{miss} ev^{ts}
for 7.6 exp.

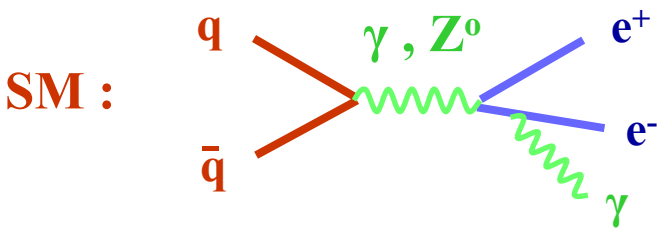
excess not confirmed by run II :

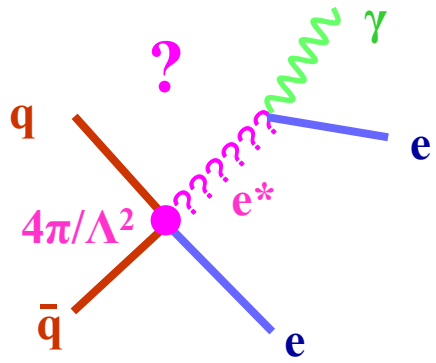


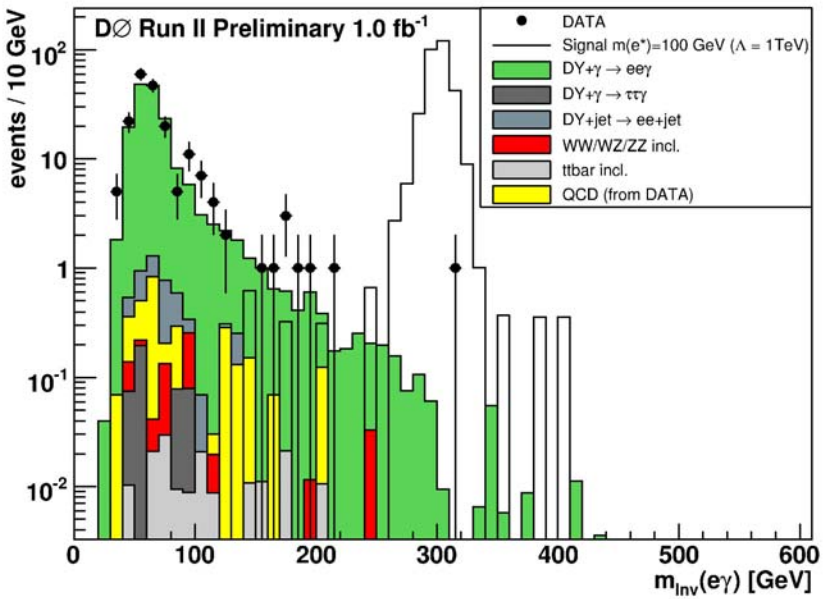
No excess seen
in γγγ, llγ, γγl
+
brand new result
in γγτ with 2.0 fb^{-1} !

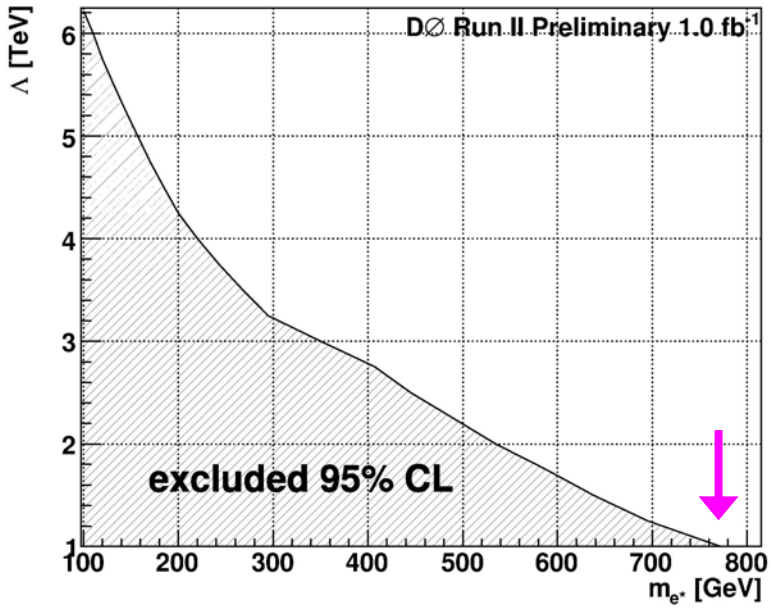


Model-tuned searches : e* at TEVATRON



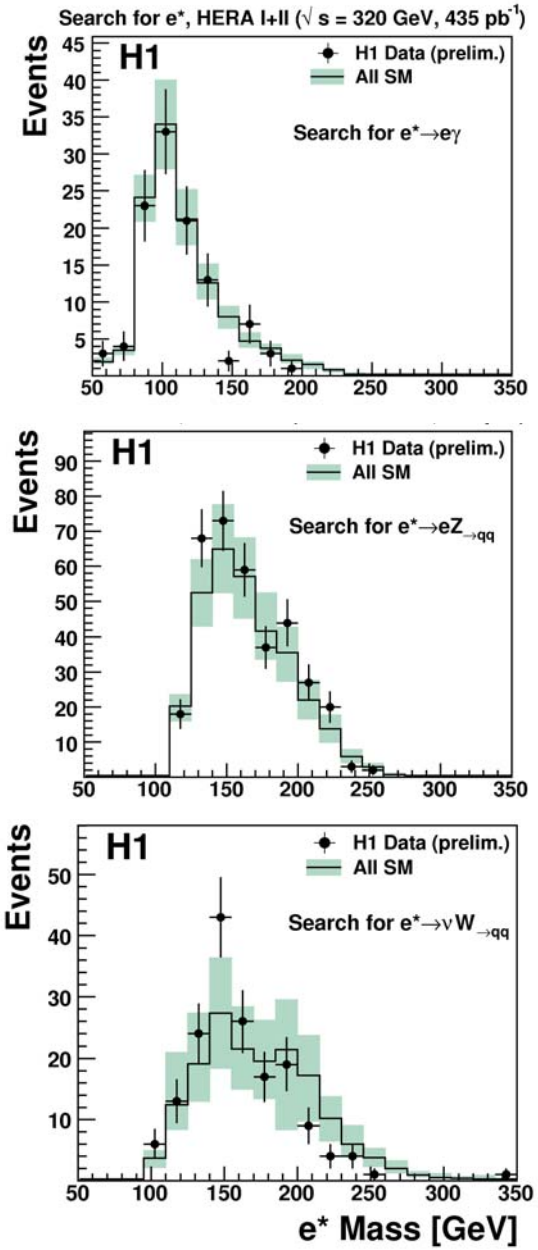


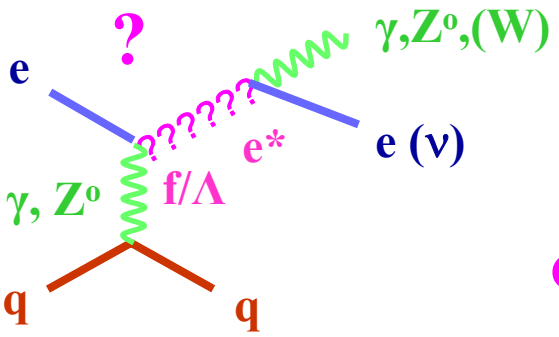




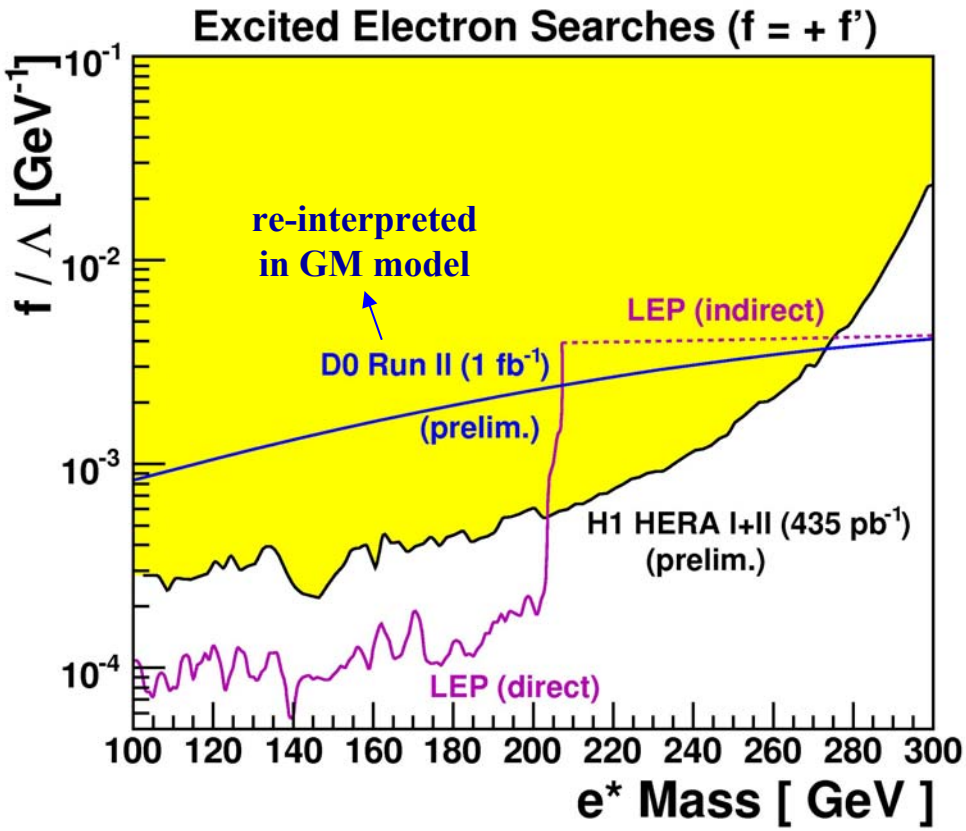
Limits derived in the context of Contact Interaction model

Model-tuned searches : e* at HERA



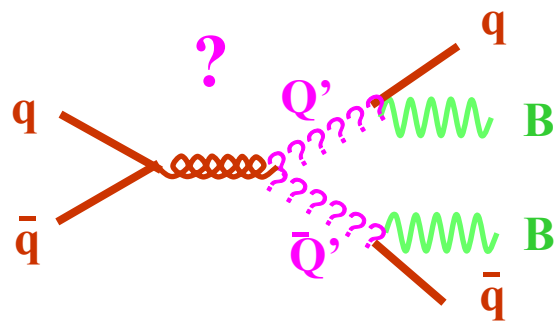


Limits derived in the context of Gauge Mediation



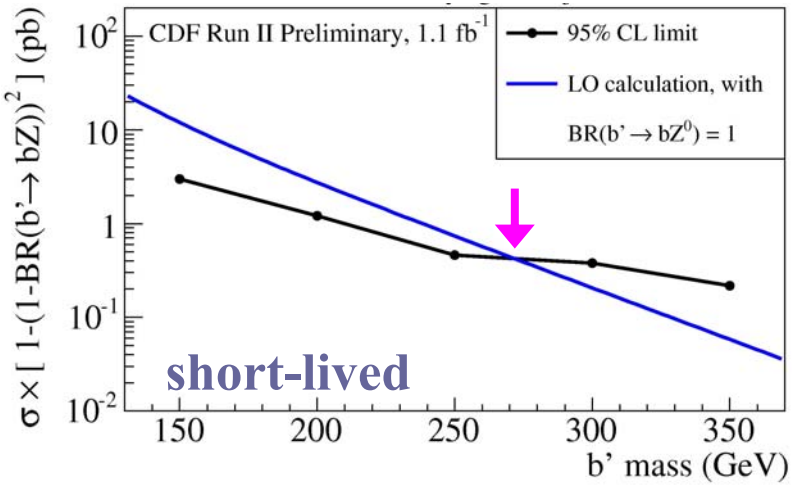
Model-tuned searches :

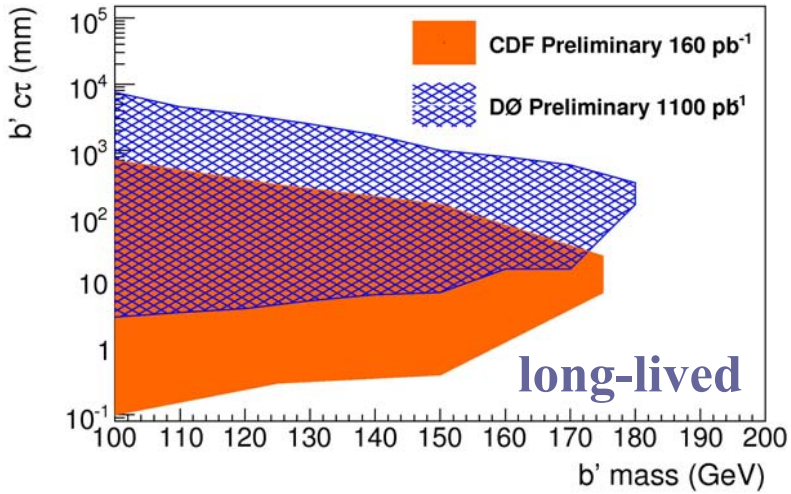
new quarks at TEVATRON



Q' = b'

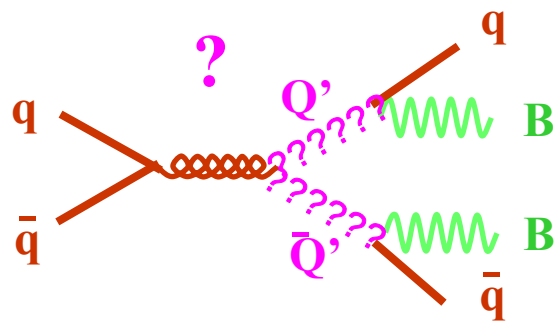
B = Z^0





Model-tuned searches :

new quarks at TEVATRON



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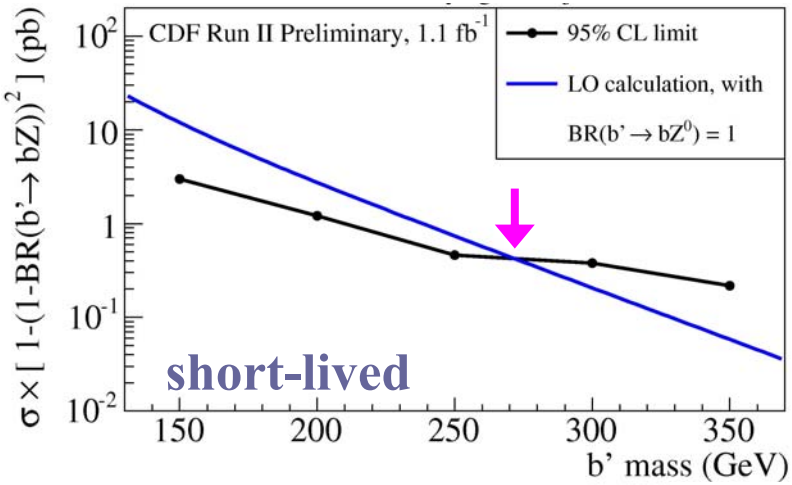
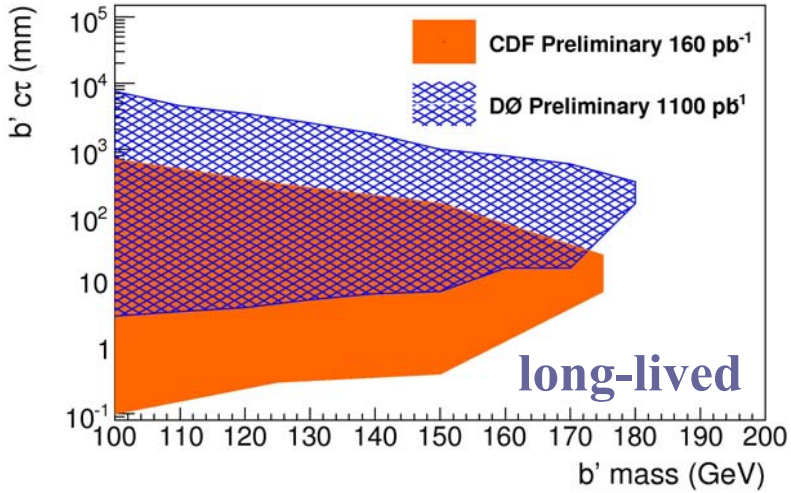
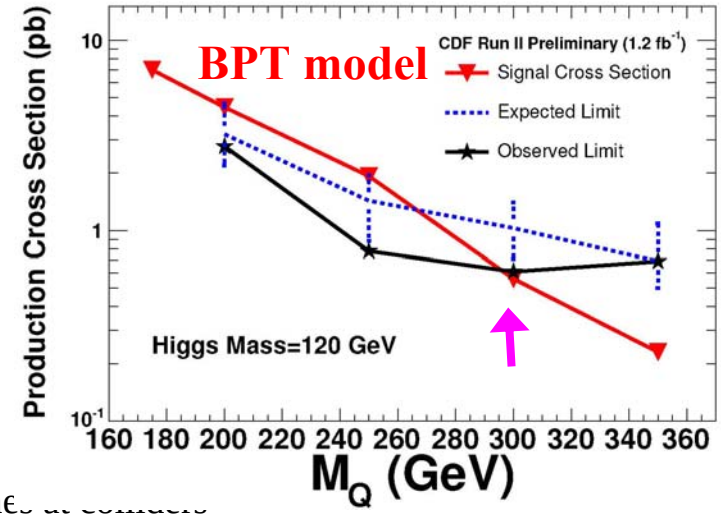


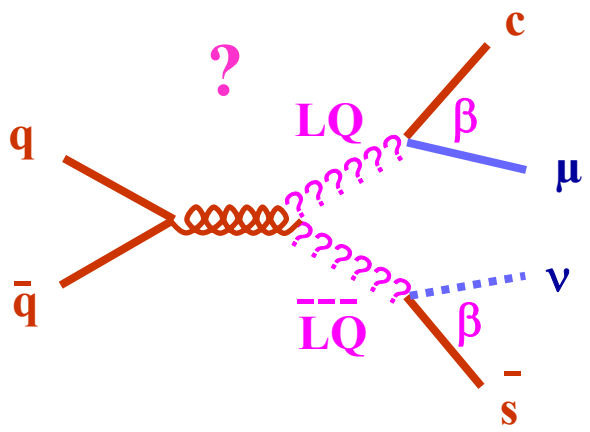


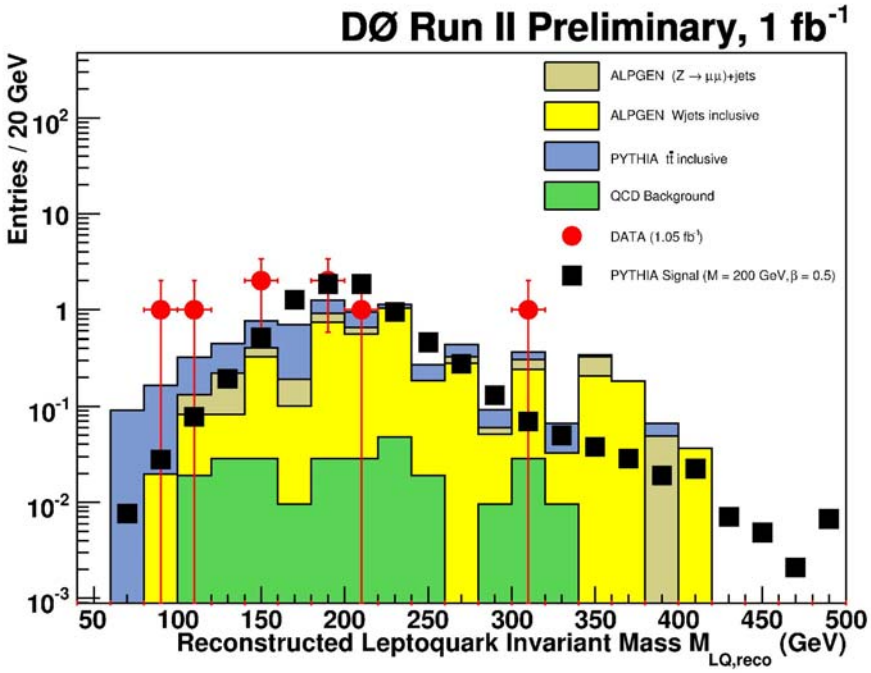
Generic ll'X search

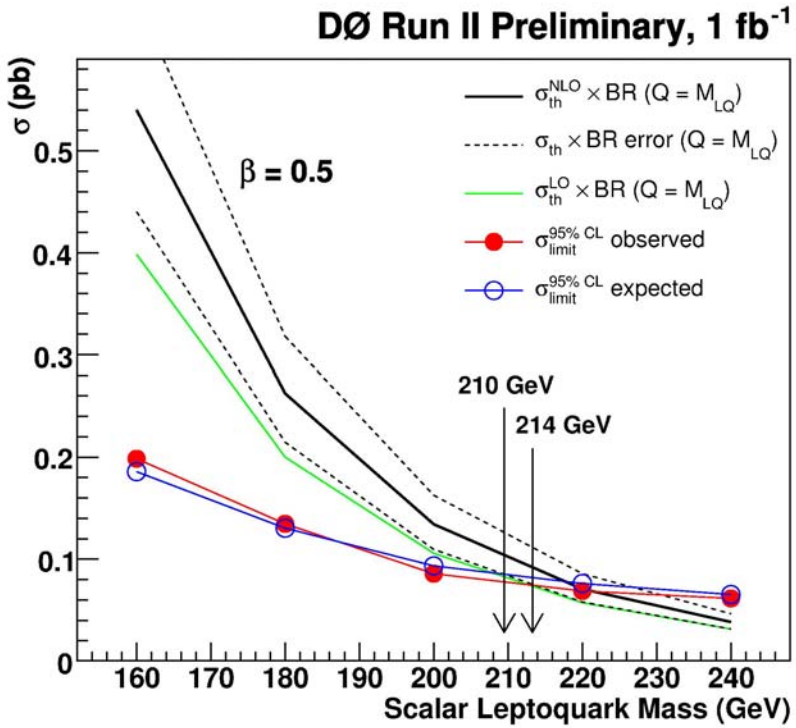
3 generations of Q'
B = W, Z, H



Model-tuned searches :
Leptoquark 2nd generation at TEVATRON

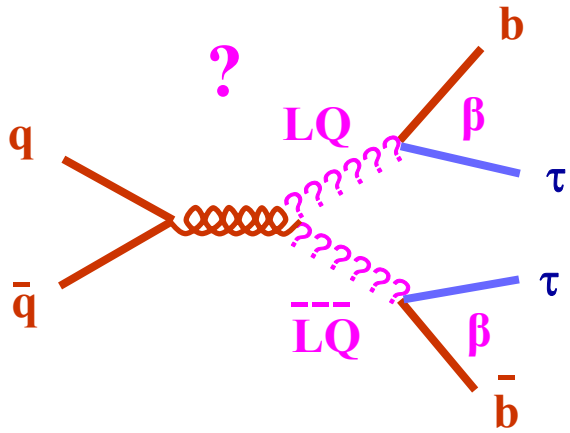


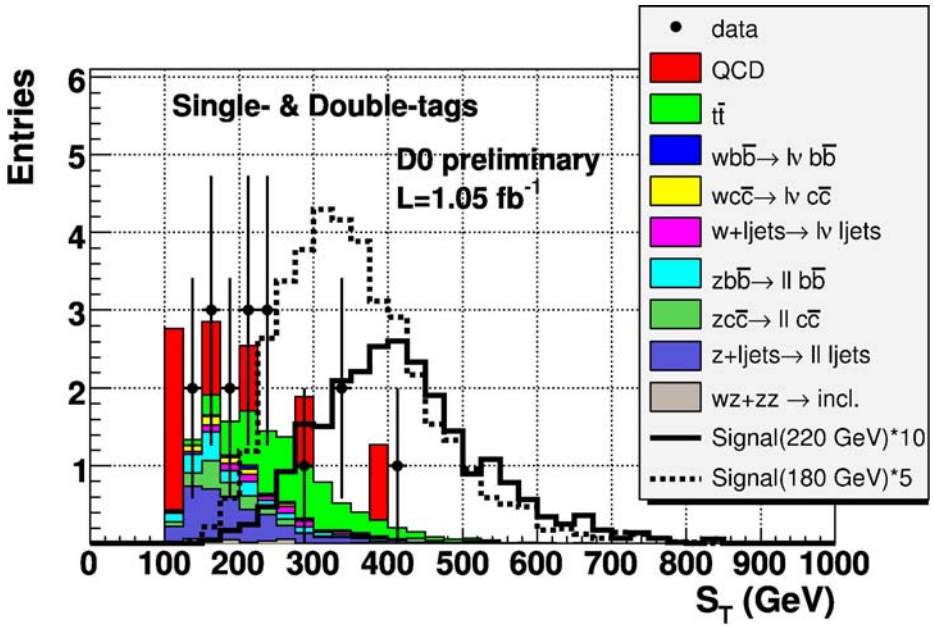




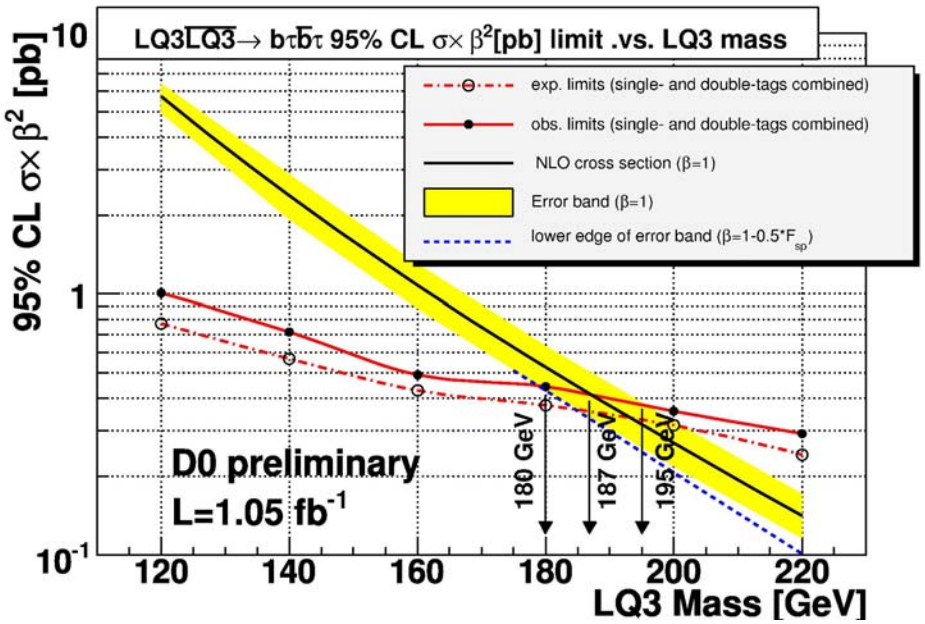
Model-tuned searches :

Leptoquark 3rd generation at TEVATRON



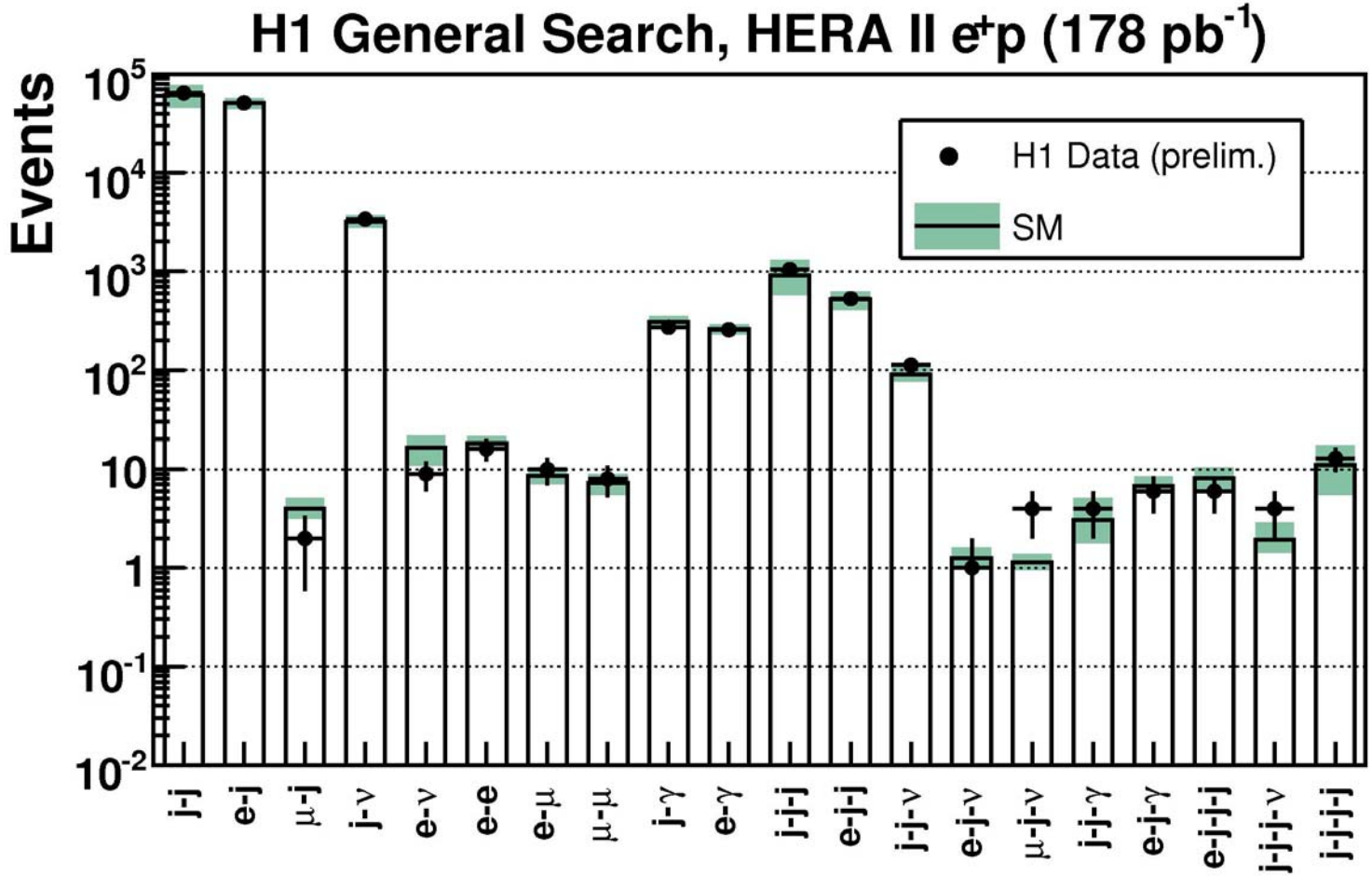


$S_T = \Sigma E_T^{part.}$



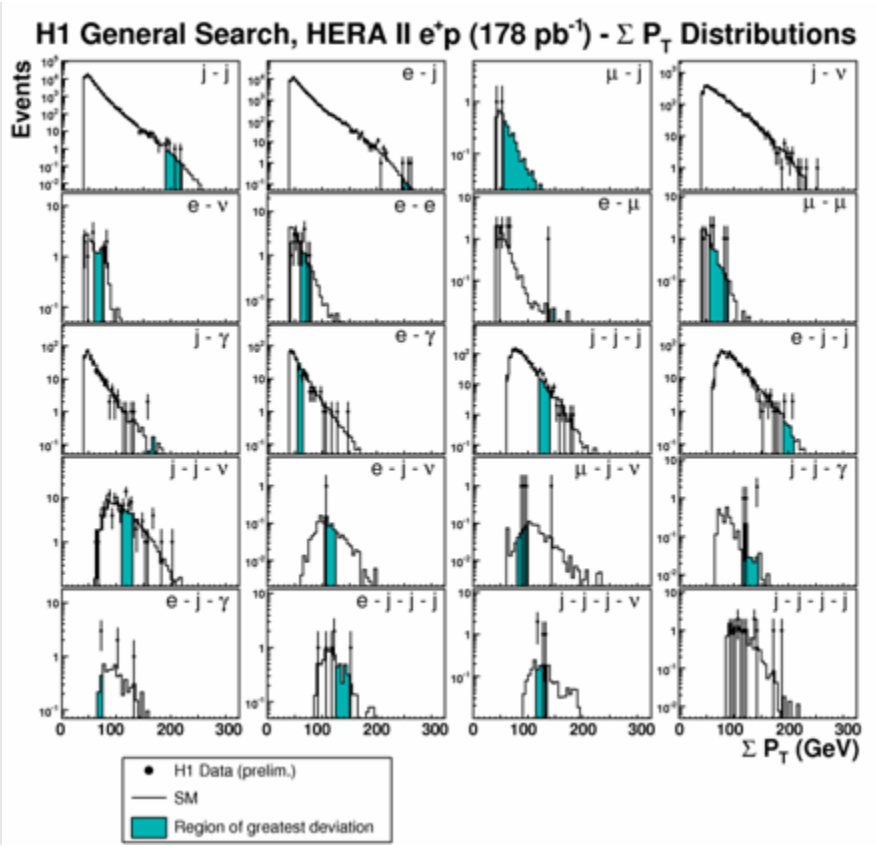
Generic search at HERA

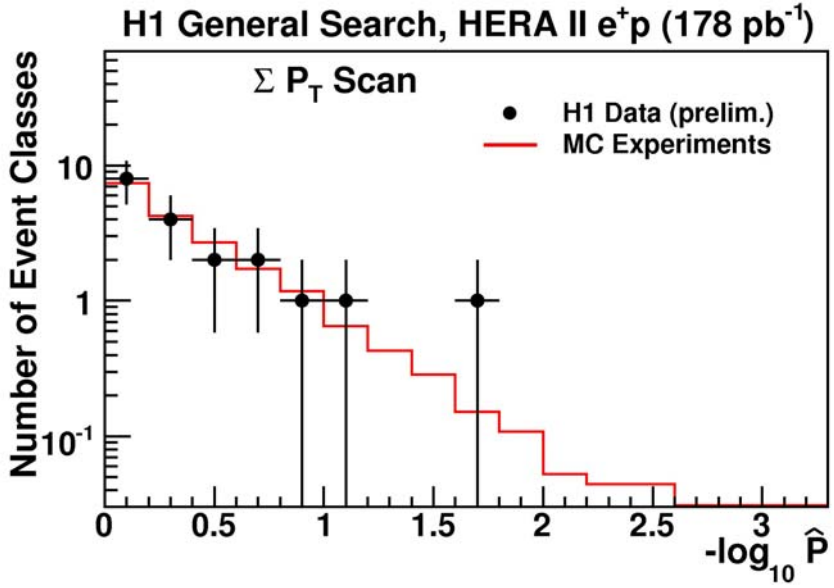
All topologies with e, μ, γ, jet, ν of P_T > 20 GeV analysed
→ good overall agreement with SM

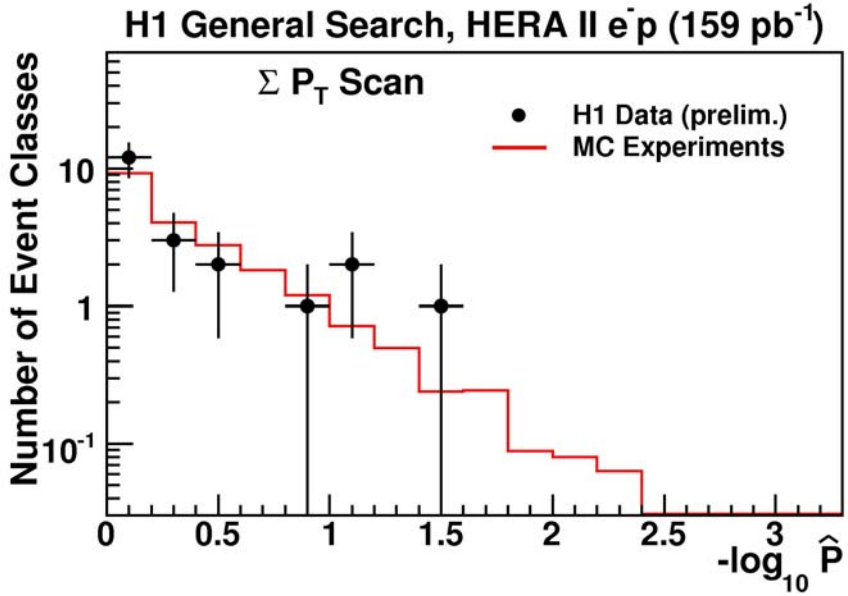


Generic search at HERA

Agreement to SM quantified by looking for maximum deviations in ΣP_T and M_{all} distributions





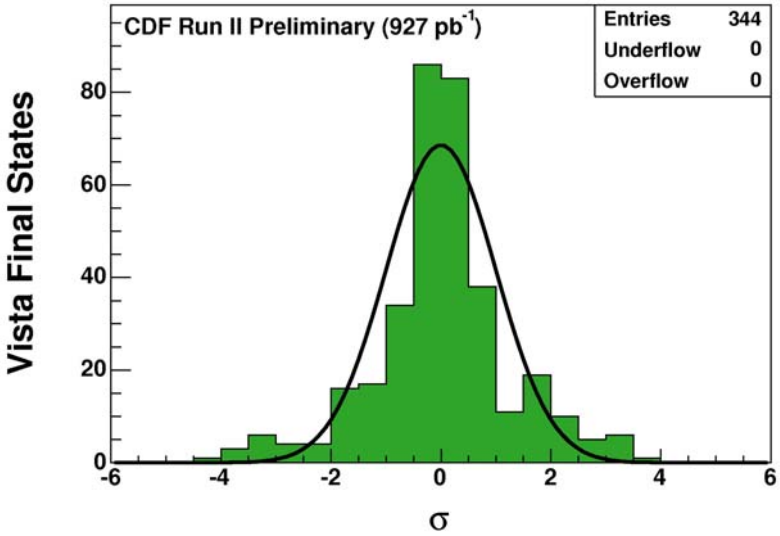


Generic search at TEVATRON: VISTA *and* SLEUTH

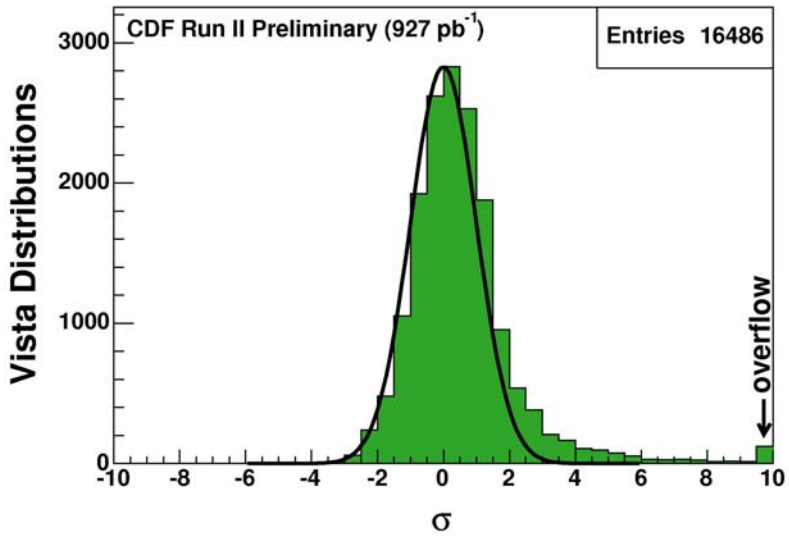
VISTA

global procedure of adjustment of experimental and higher-order theory uncertainties on the data, using ~16500 distributions of ~350 event classes

Deviation to SM on # events



Deviation to SM on distributions

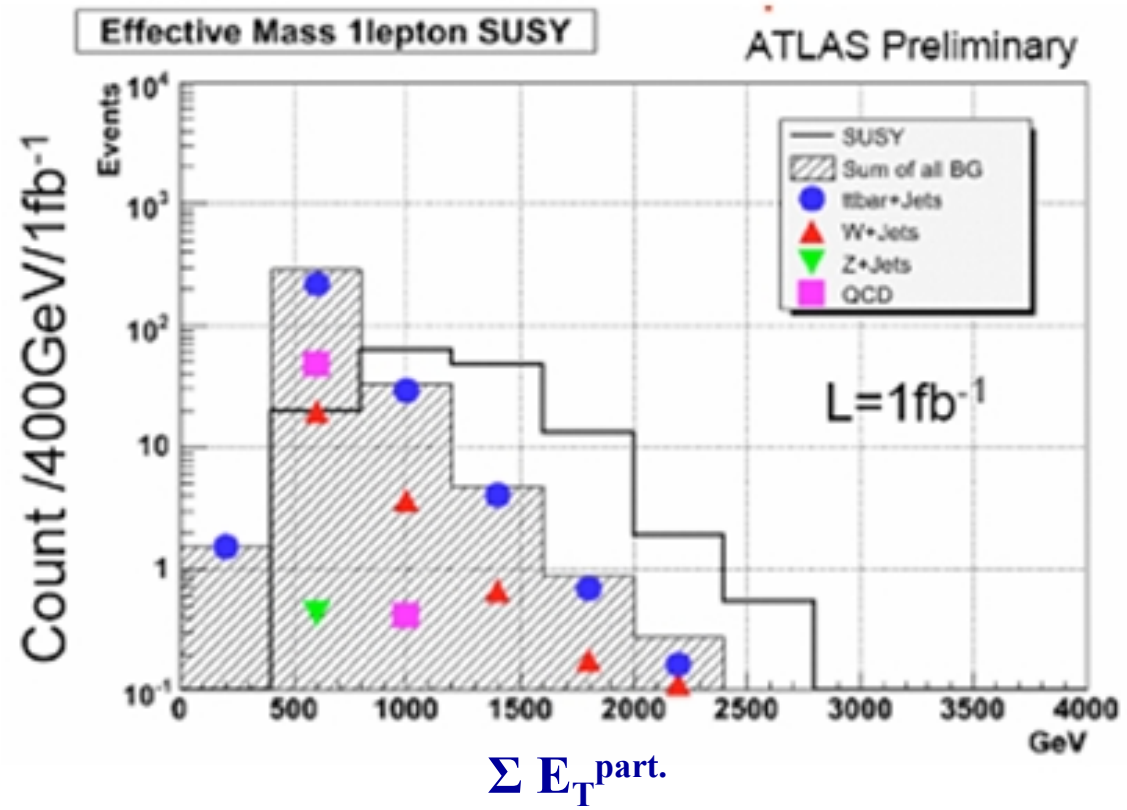


SLEUTH: Quantification of deviations in high-P_T tails

→ 46% of chances for CDF to find in any final state of the next 1 fb^{-1} a deviation higher than observed in the present data

Multi-bodies topologies : early prospects at LHC

1 lepton + jets + E_T^{miss} selection



$\Sigma E_T^{part.}$

Inclusive signatures promising for the early days

Summary

Previous indications of possible deviations to SM
have not been confirmed with increased o(1 fb^{-1}) statistics

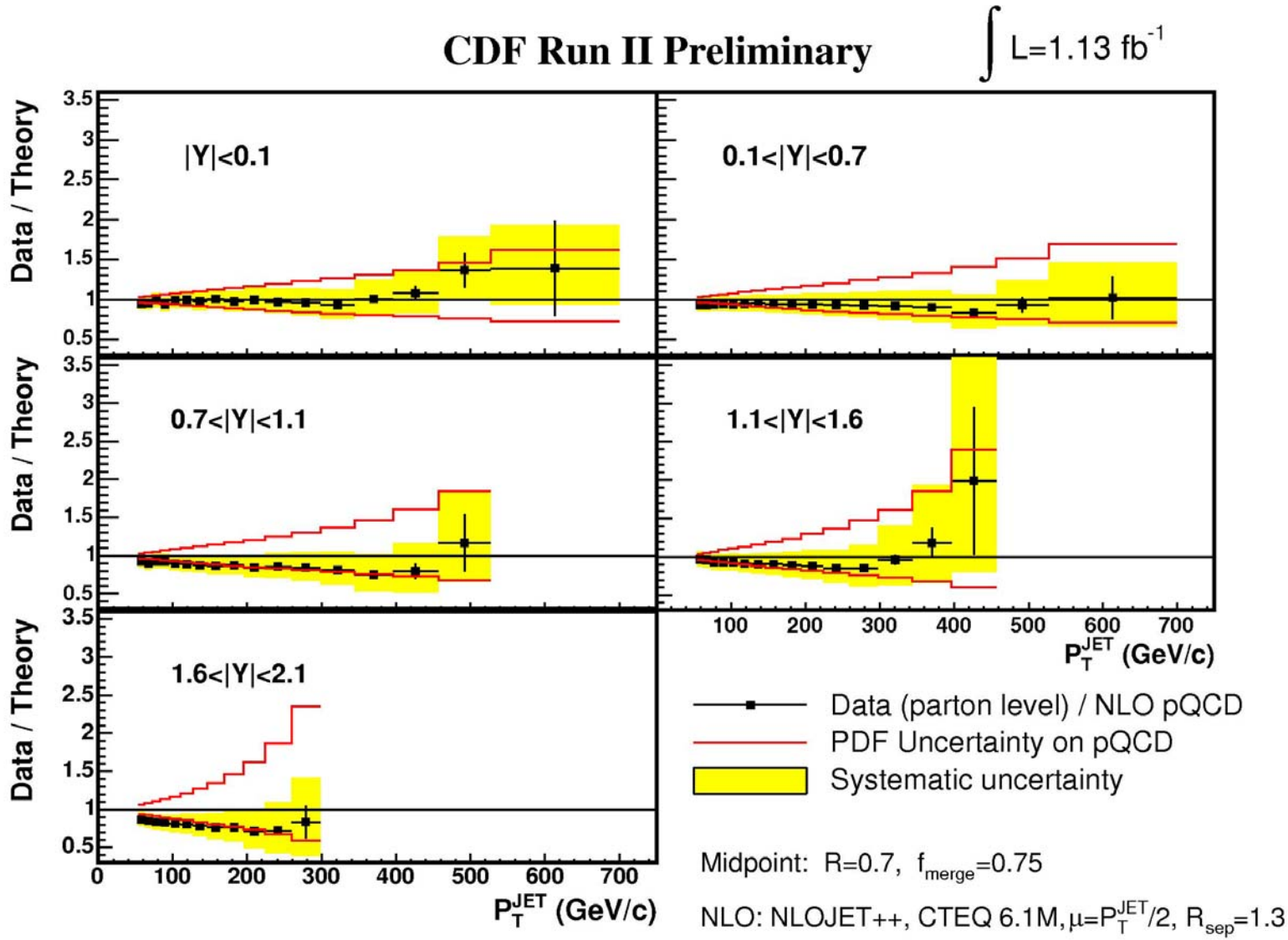
New particles currently excluded for masses ranging from
~200 GeV to ~1 TeV depending on models and assumptions,
LEP, HERA and TEVATRON complementary to many respects.

1 fb^{-1} at LHC will open a new discovery window up to ~2-3 TeV.

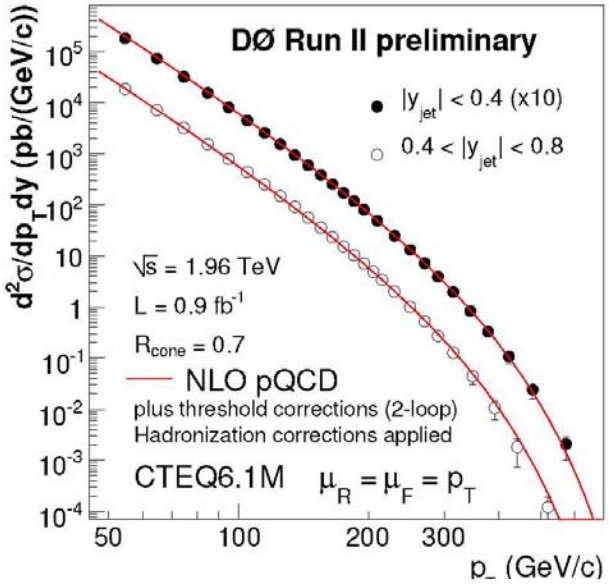
Whatever the first LHC data show,
a good understanding of SM (QCD, radiative effects, etc…)
will be vital to establish discoveries and interpret the observations.

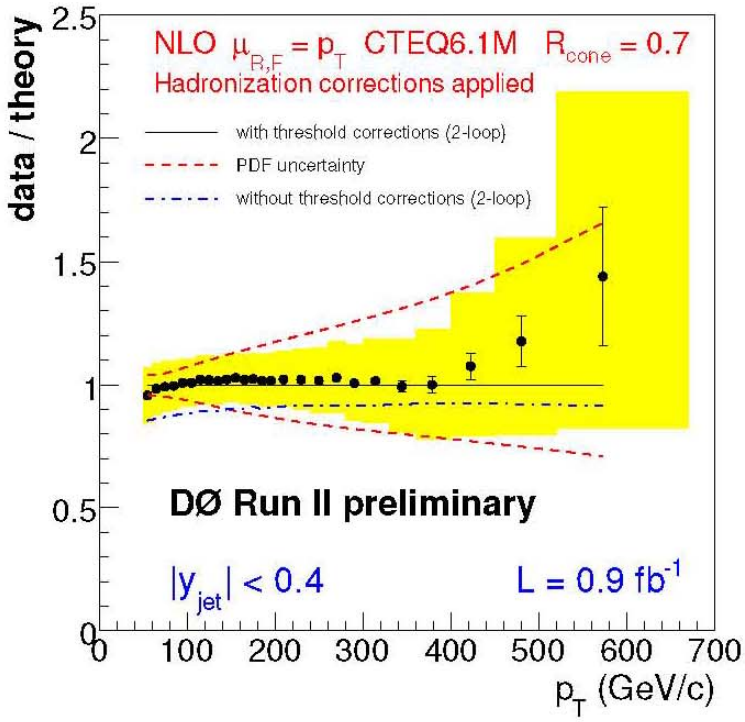
More results and details

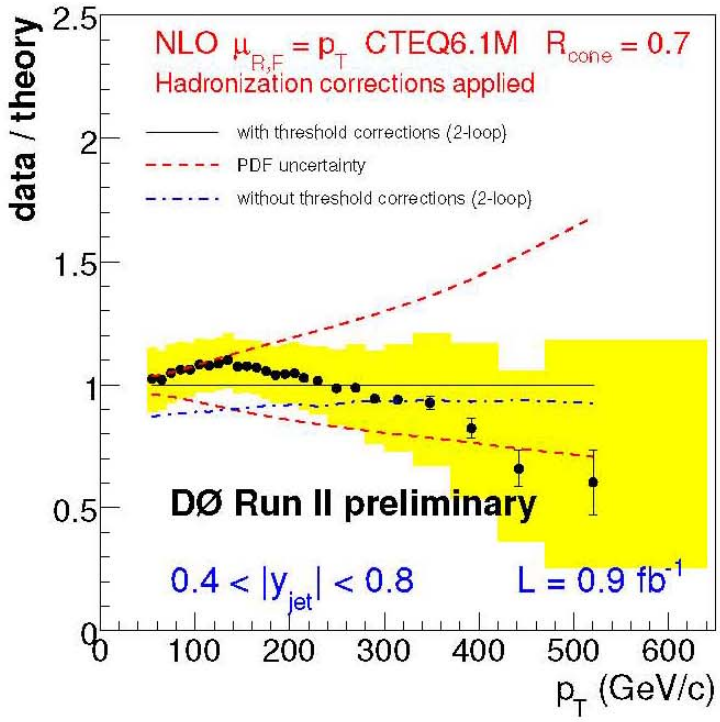
CDF *inclusive jets*



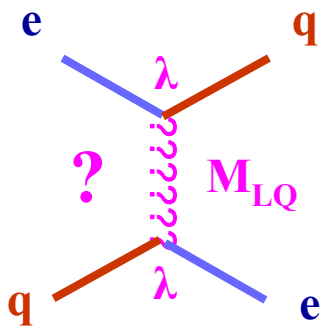
D0 *inclusive jets*

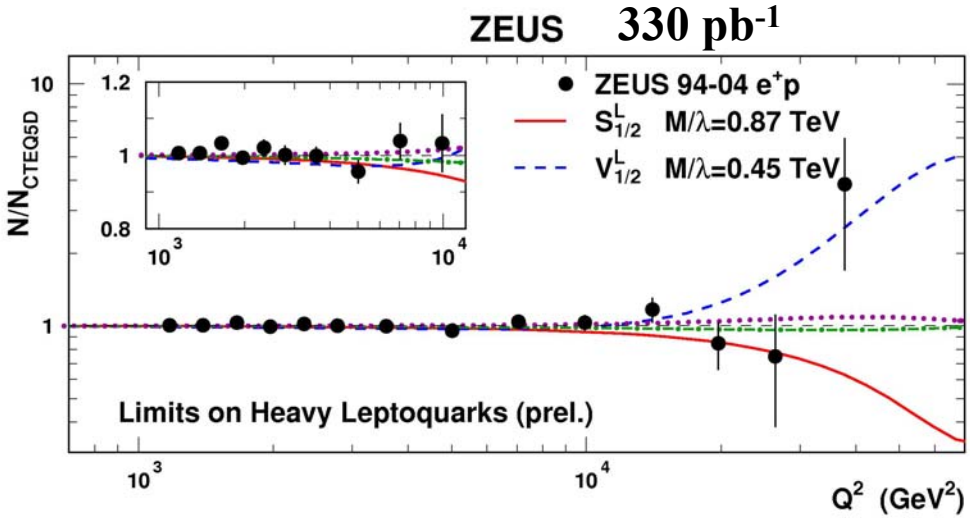


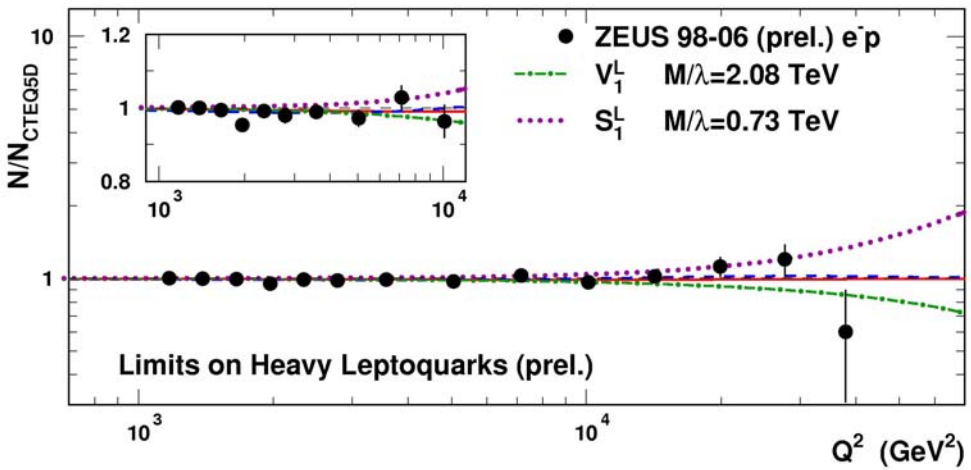




ZEUS indirect limits on leptoquarks (Q^2 spectra)

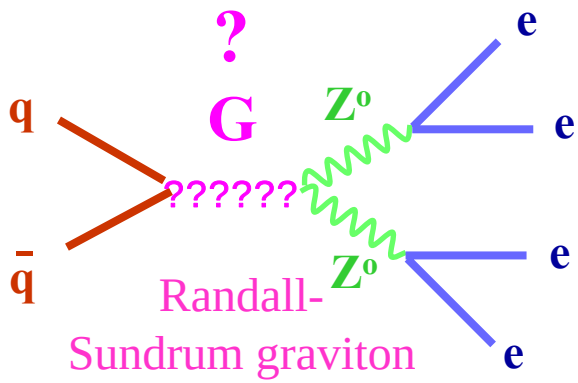


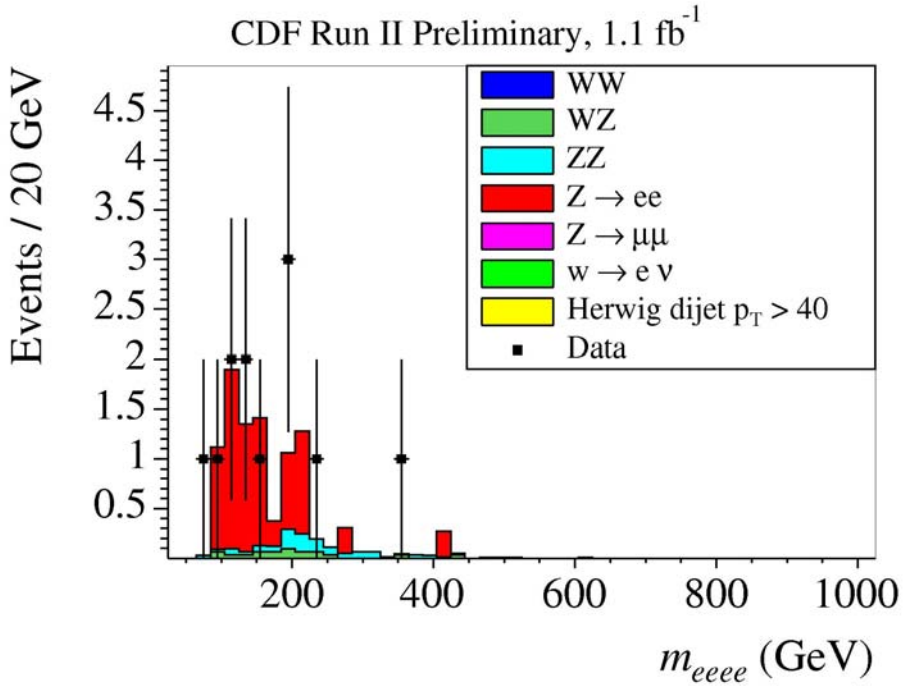


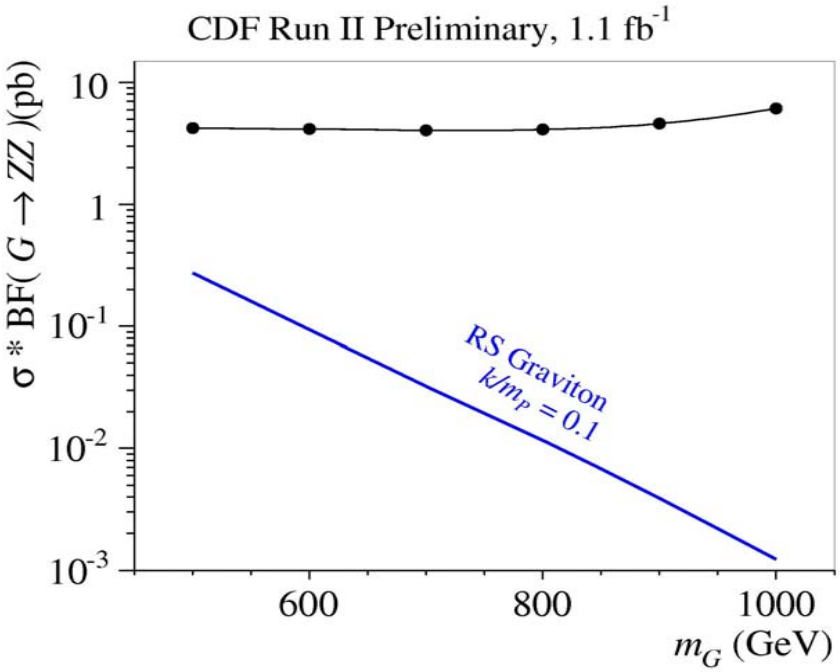


ZEUS Preliminary 1994-2006 $e^{\pm}p$		
Model	Coupling Structure	95% C.L. (TeV) M_{LQ}/λ_{LQ}
$S_{\circ}^{L}$	$a_{LL}^{eu} = +\frac{1}{2}$	0.98
$S_{\circ}^{R}$	$a_{RR}^{eu} = +\frac{1}{2}$	0.81
$\tilde{S}_{\circ}^{R}$	$a_{RR}^{ed} = +\frac{1}{2}$	0.29
$S_{1/2}^{L}$	$a_{LR}^{eu} = -\frac{1}{2}$	0.87
$S_{1/2}^{R}$	$a_{RL}^{ed} = a_{RL}^{eu} = -\frac{1}{2}$	0.45
$\tilde{S}_{1/2}^{L}$	$a_{LR}^{ed} = -\frac{1}{2}$	0.45
S_{1}^{L}	$a_{LL}^{ed} = +1,\ a_{LL}^{eu} = +\frac{1}{2}$	0.73
$V_{\circ}^{L}$	$a_{LL}^{ed} = -1$	0.82
$V_{\circ}^{R}$	$a_{RR}^{ed} = -1$	0.62
$\tilde{V}_{\circ}^{R}$	$a_{RR}^{eu} = -1$	1.48
$V_{1/2}^{L}$	$a_{LR}^{ed} = +1$	0.45
$V_{1/2}^{R}$	$a_{RL}^{ed} = a_{RL}^{eu} = +1$	1.01
$\tilde{V}_{1/2}^{L}$	$a_{LR}^{eu} = +1$	1.11
V_{1}^{L}	$a_{LL}^{ed} = -1,\ a_{LL}^{eu} = -2$	2.08

CDF *search for* Z^oZ^o *resonances*







H1 *and* ZEUS *multi-leptons*

H1 multi - electrons+muons, HERA I+II 0.46 fb^{-1}

Data sample	Data	SM	Pair Production	NCDIS + Compton
e+p L=286pb	4	1.2 ± 0.2	1.0 ± 0.2	0.2 ± 0.1
e−p L=173pb	0	0.8 ± 0.2	0.6 ± 0.2	0.2 ± 0.1
All L=459pb	4	1.9 ± 0.4	1.5 ± 0.3	0.4 ± 0.1

ZEUS multi-electrons, HERA I+II 0.48 fb^{-1}

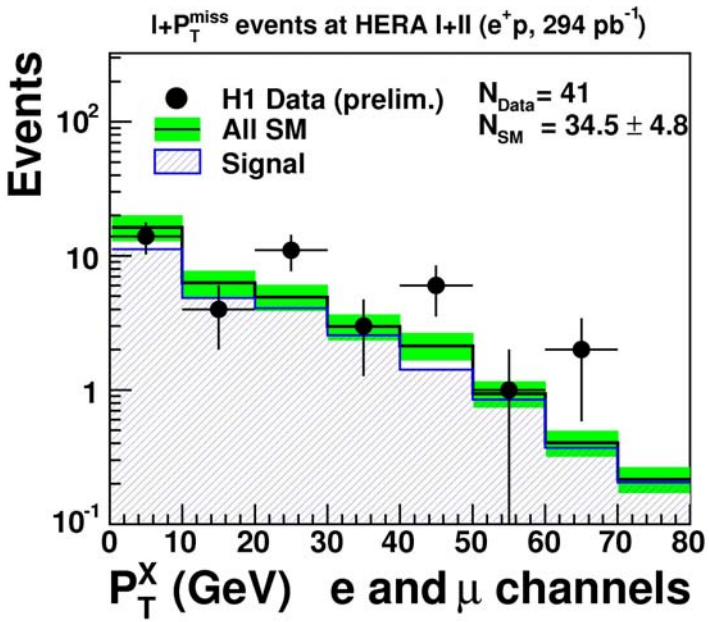
Data sample	Data	SM	Pair Production	Compton	NC DIS
e+p L=272pb	2	$0.93\ ^{+0.10}_{-0.09}$	0.67 ± 0.07	$0.23\ ^{+0.07}_{-0.06}$	0.02 ± 0.01
e−p L=206pb	1	$0.65\ ^{+0.08}_{-0.07}$	0.41 ± 0.04	$0.24\ ^{+0.07}_{-0.06}$	0.01 ± 0.01
All L=478pb	3	$1.58\ ^{+0.16}_{-0.12}$	1.08 ± 0.11	$0.47\ ^{+0.15}_{-0.11}$	0.03 ± 0.01

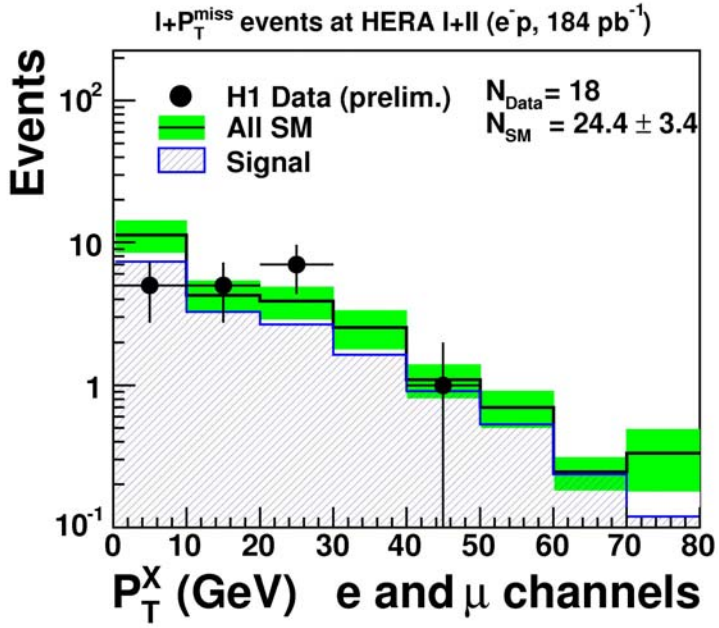
H1

Leptons + E_T^{miss}

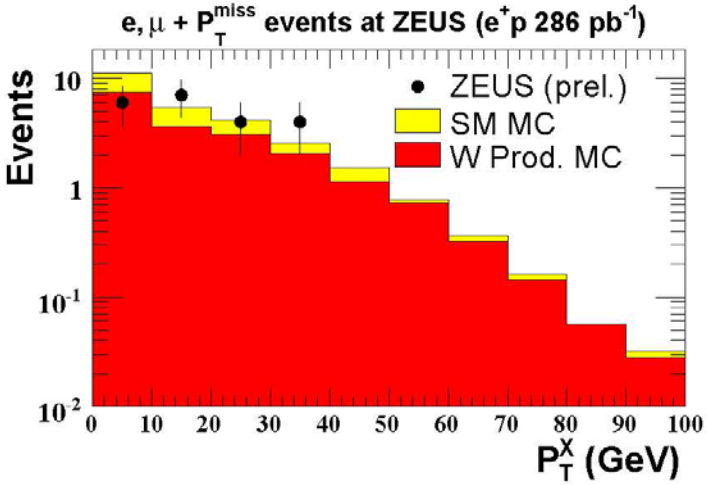
e and μ channels

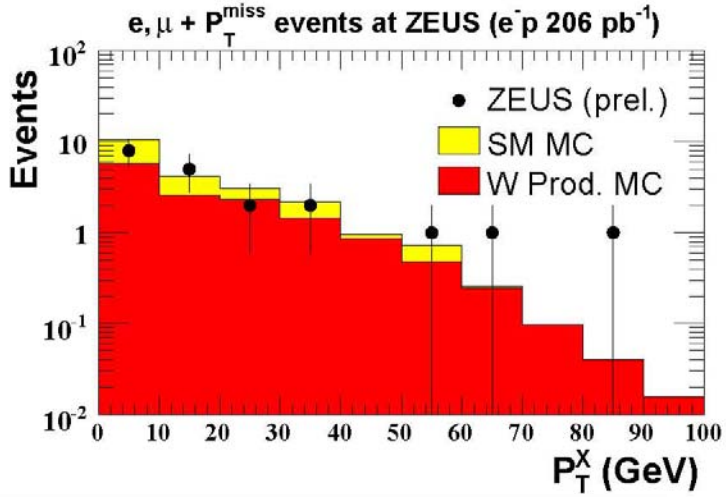
H1 Preliminary l+P_T^{miss} events at HERA I+II		Electron obs./exp. (Signal contribution)	Muon obs./exp. (Signal contribution)	Combined obs./exp. (Signal contribution)
e^+p	Full Sample	26 / 27.3 ± 3.8 (71%)	15 / 7.2 ± 1.1 (85%)	41 / 34.5 ± 4.8 (74%)
294 pb^{-1}	$P_T^X > 25$ GeV	11 / 4.7 ± 0.9 (75%)	10 / 4.2 ± 0.7 (85%)	21 / 8.9 ± 1.5 (80%)
e^-p	Full Sample	16 / 19.4 ± 2.7 (65%)	2 / 5.1 ± 0.7 (78%)	18 / 24.4 ± 3.4 (68%)
184 pb^{-1}	$P_T^X > 25$ GeV	3 / 3.8 ± 0.6 (61%)	0 / 3.1 ± 0.5 (74%)	3 / 6.9 ± 1.0 (67%)
$e^\pm p$	Full Sample	42 / 46.7 ± 6.5 (69%)	17 / 12.2 ± 1.8 (82%)	59 / 58.9 ± 8.2 (72%)
478 pb^{-1}	$P_T^X > 25$ GeV	14 / 8.5 ± 1.5 (68%)	10 / 7.3 ± 1.2 (79%)	24 / 15.8 ± 2.5 (73%)





ZEUS *Leptons* + E_T^{miss} , e *and* μ *channels*





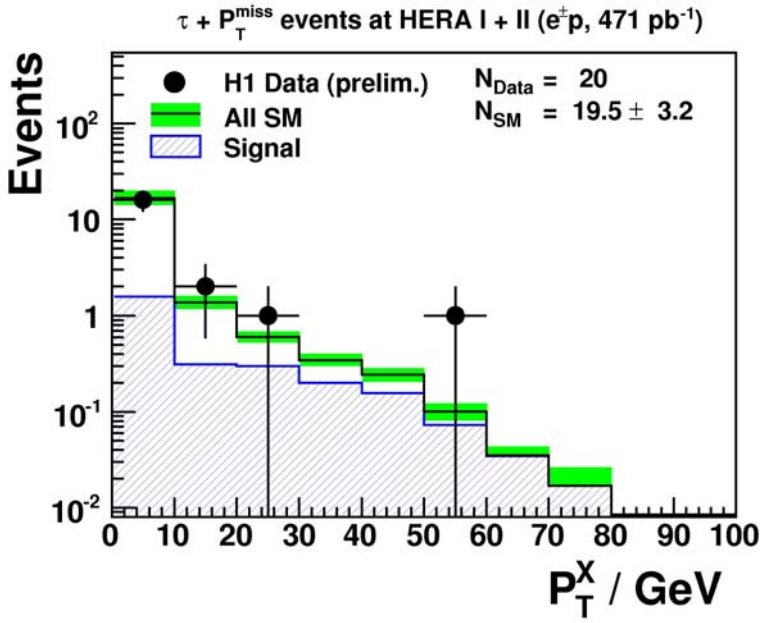
Isolated e Candidates	$P_T^X < 12$ GeV	$12 < P_T^X < 25$ GeV	$P_T^X > 25$ GeV
ZEUS (prel.) e^-p 206 pb^{-1}	$9/11.3 \pm 2.0$ (55%)	$5/3.4 \pm 0.8$ (62%)	$3/3.2 \pm 0.6$ (69%)
ZEUS (prel.) e^+p 286 pb^{-1}	$7/12.3 \pm 1.9$ (66%)	$5/4.1 \pm 0.7$ (67%)	$3/3.9 \pm 0.6$ (76%)
ZEUS (prel.) $e^\pm p$ 492 pb^{-1}	$16/23.6 \pm 3.8$ (60%)	$10/7.5 \pm 1.4$ (65%)	$6/7.1 \pm 1.1$ (73%)

Isolated μ Candidates	$12 < P_T^X < 25$ GeV	$P_T^X > 25$ GeV
ZEUS (prel.) e^-p 206 pb^{-1}	$1/1.7 \pm 0.3$ (77%)	$2/2.4 \pm 0.4$ (85%)
ZEUS (prel.) e^+p 286 pb^{-1}	$3/2.3 \pm 0.3$ (82%)	$3/3.6 \pm 0.5$ (81%)
ZEUS (prel.) $e^\pm p$ 492 pb^{-1}	$4/4.1 \pm 0.6$ (80%)	$5/6.0 \pm 0.8$ (82%)

H1

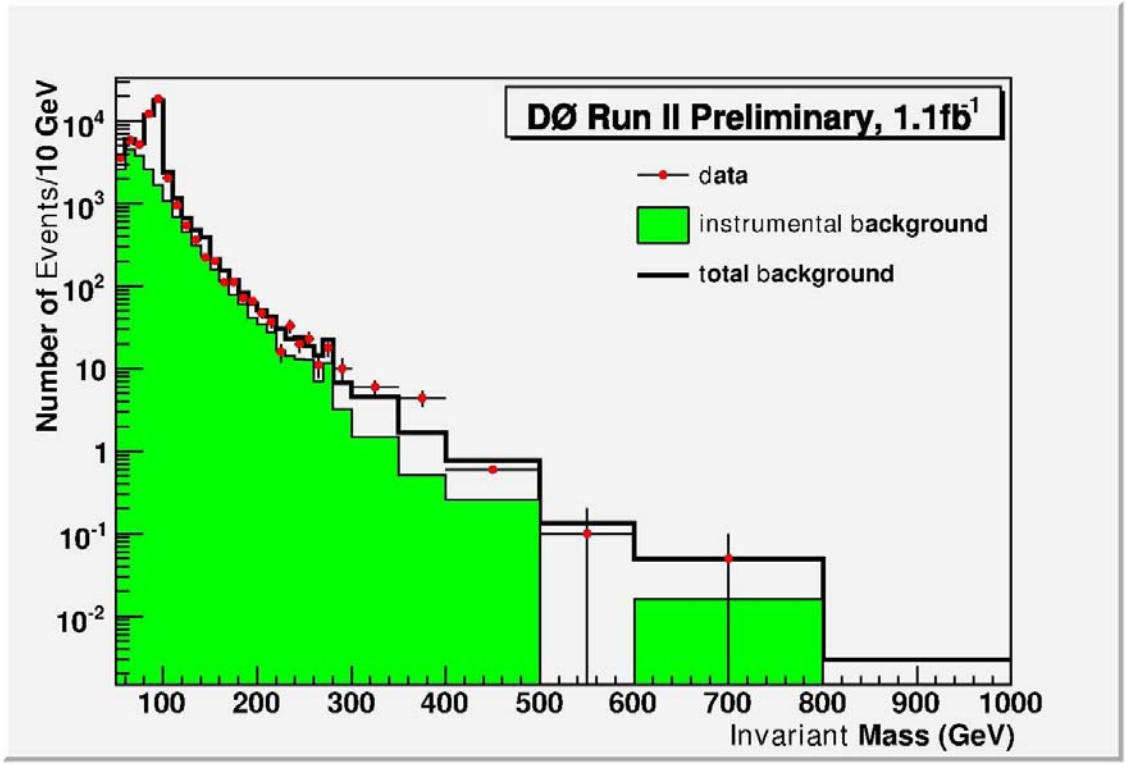
Leptons + E_T^{miss}

τ channel

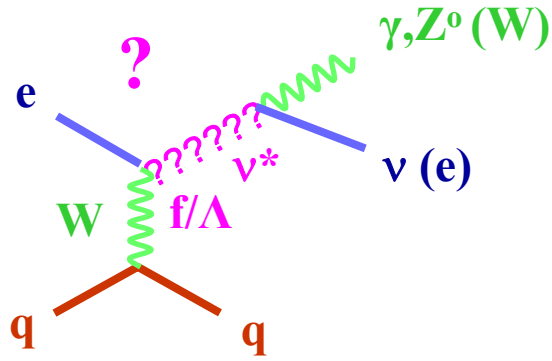


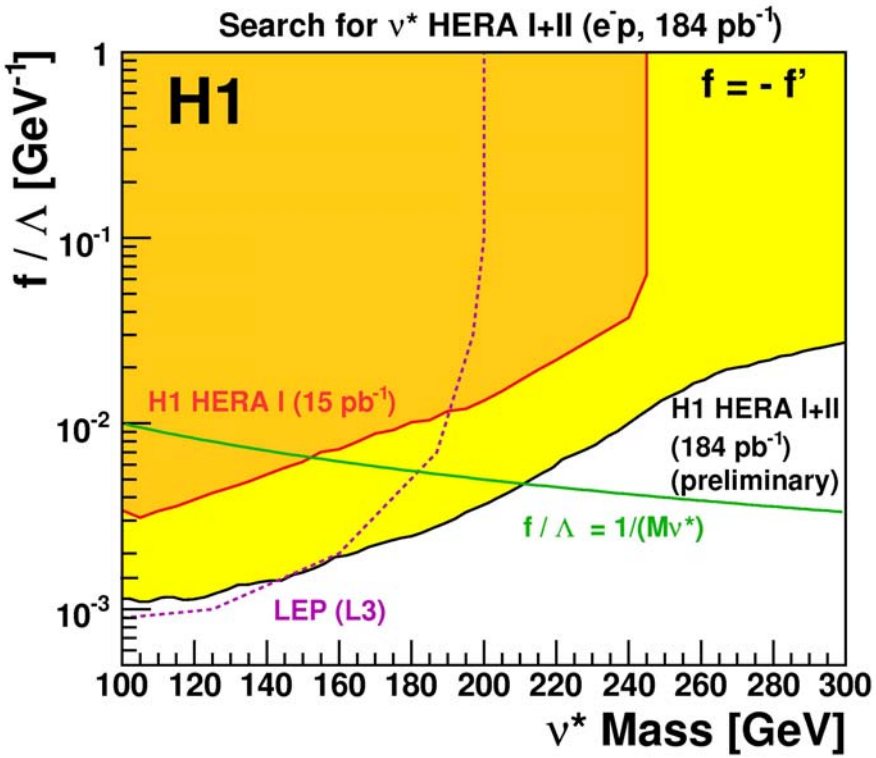
H1 Preliminary τ+P_T^{miss} events at HERA I+II		H1 Data	SM Expectation	SM Signal	Other SM Processes
e^+p	Full Sample	10	10.8 ± 1.8	1.6 ± 0.3	9.2 ± 1.6
287 pb^{-1}	$P_T^X > 25$ GeV	0	0.53 ± 0.07	0.38 ± 0.06	0.15 ± 0.01
e^-p	Full Sample	10	8.6 ± 1.5	1.0 ± 0.2	7.6 ± 1.4
184 pb^{-1}	$P_T^X > 25$ GeV	1	0.47 ± 0.07	0.25 ± 0.04	0.22 ± 0.03
$e^\pm p$	Full Sample	20	19.5 ± 3.2	2.7 ± 0.4	16.8 ± 2.8
471 pb^{-1}	$P_T^X > 25$ GeV	1	0.99 ± 0.13	0.62 ± 0.10	0.37 ± 0.03

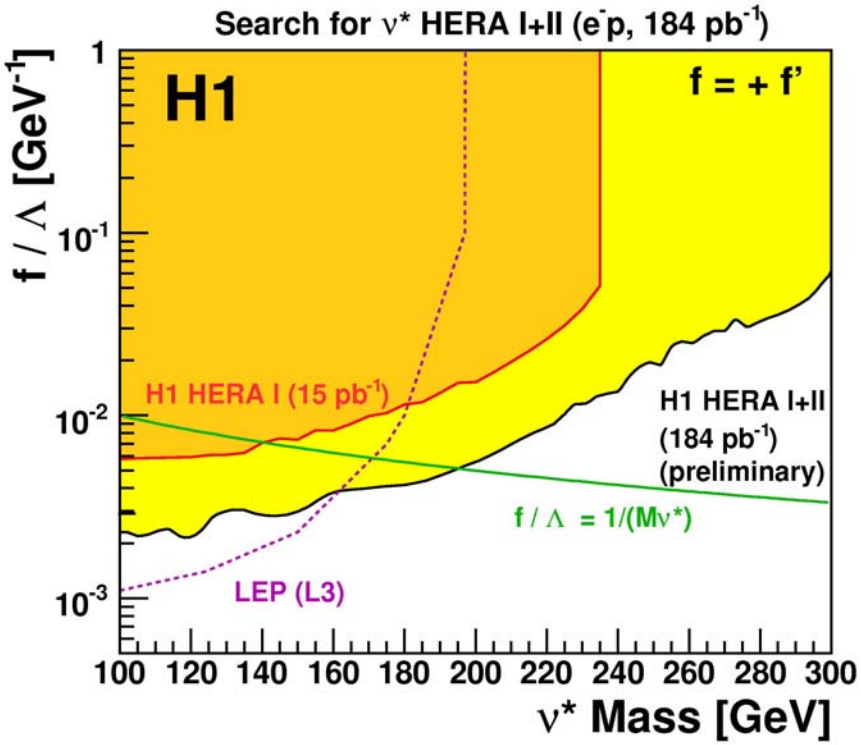
D0 ee+γγ *spectrum*



H1 ν* *searches*







CDF *search for Techni-particles*