Search for new Physics at HERA

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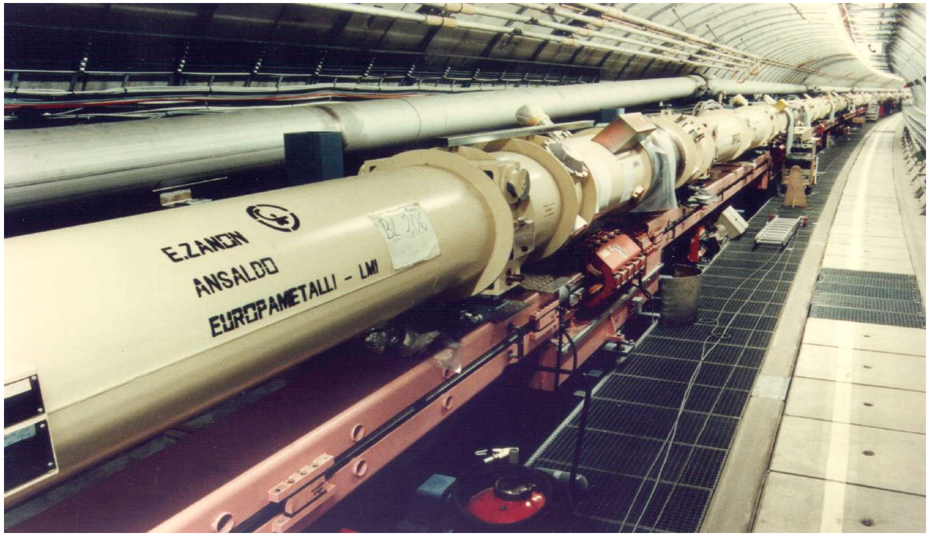
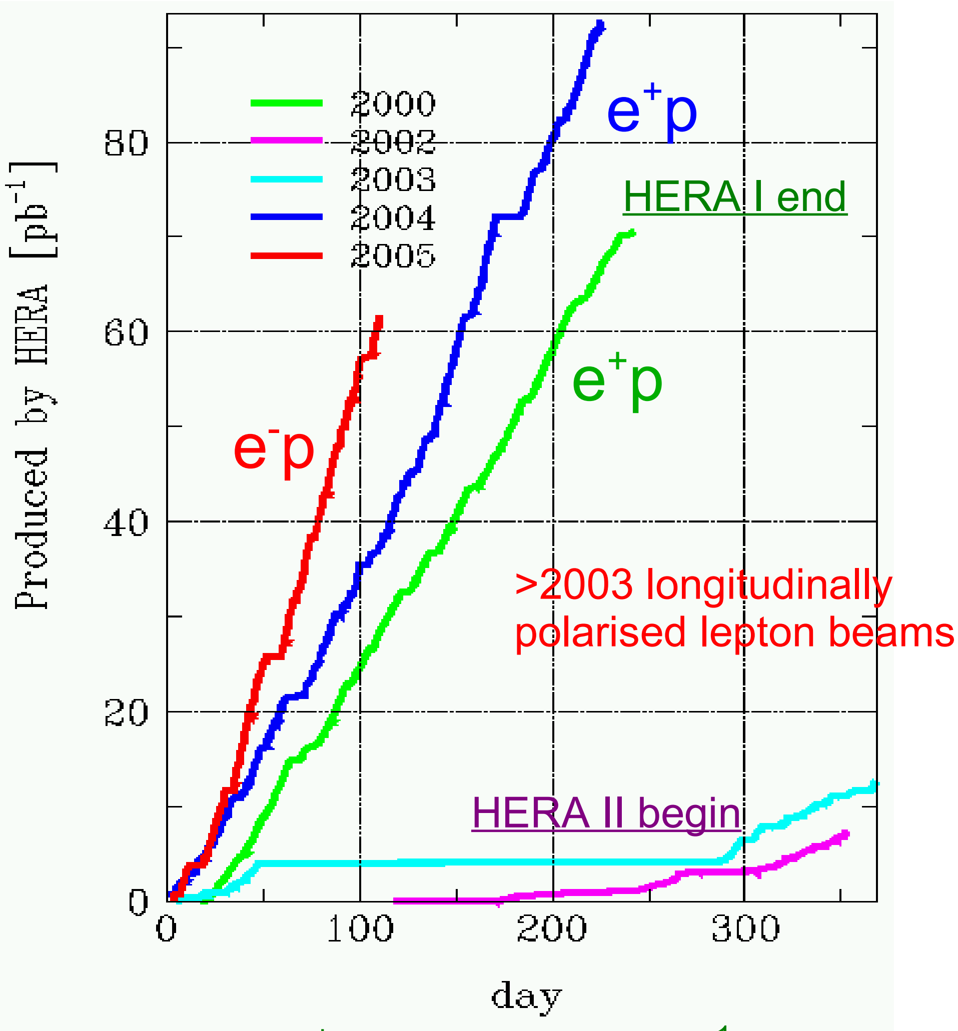
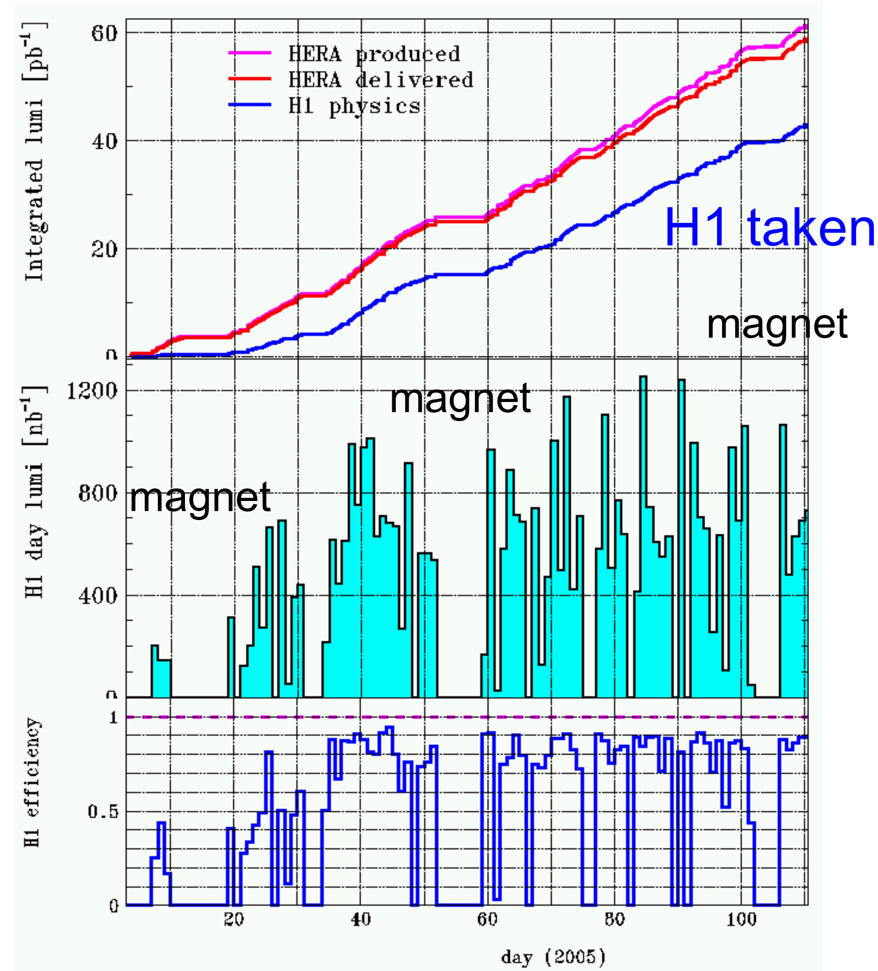
on behalf of the
H1 and ZEUS collaborations



27.5 GeV electron – 920 GeV proton

HERA Luminosity in 2005





up to 1.2 pb^{-1}/day

1994-2000: e$^\pm$p data ~ 120 pb^{-1} (H1/ZEUS)

2003-2004: e$^+$p data ~ 50 pb^{-1} (H1 prel.)

new 2005: e$^-$p data ~ 21 pb^{-1} (H1 prel.)

- 2005 best year ever in terms of delivered luminosity
- had many machine breaks and high backgrounds
- background situation is improving!

Overview

New Results:

- Electroweak Physics
- Beyond the SM

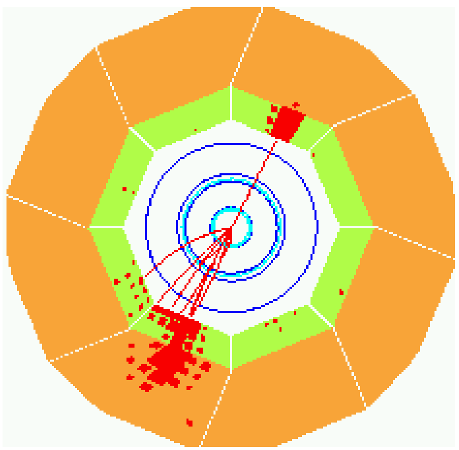
HERA Kinematics + Processes

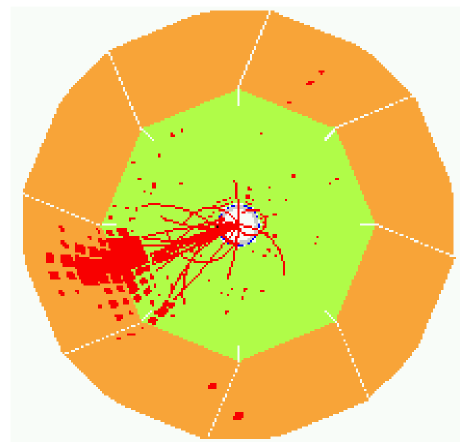
- Dominant SM processes at high p_T:

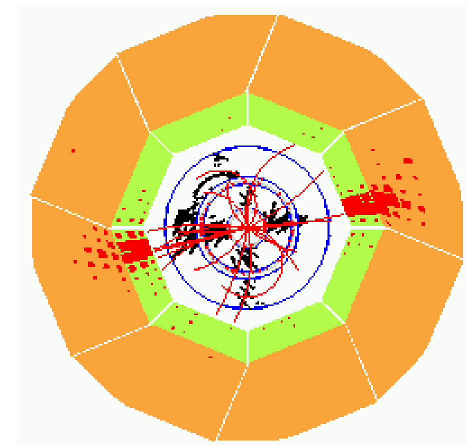
NC DIS: $ep \rightarrow eX$

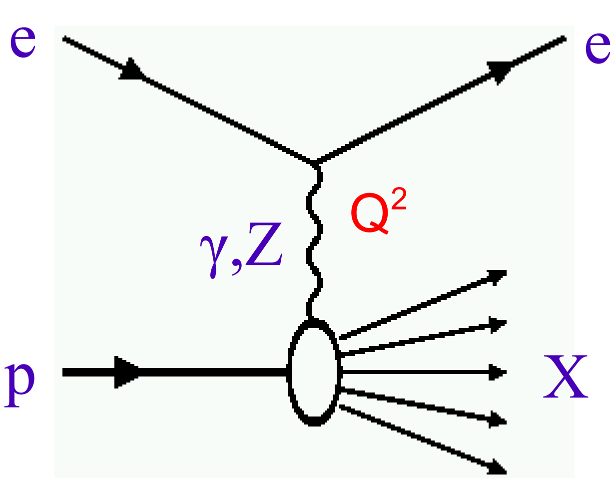
CC DIS: $ep \rightarrow \nu X$

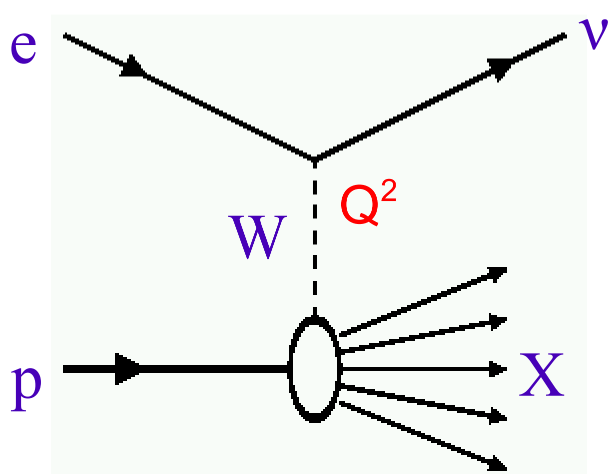
photoproduction: $\gamma p \rightarrow jj$

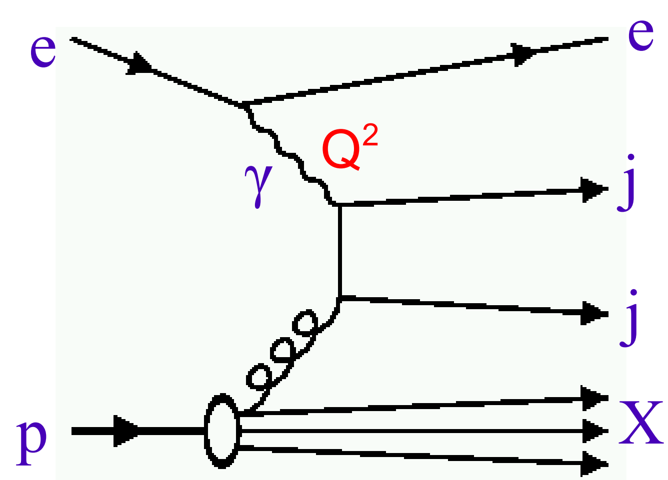




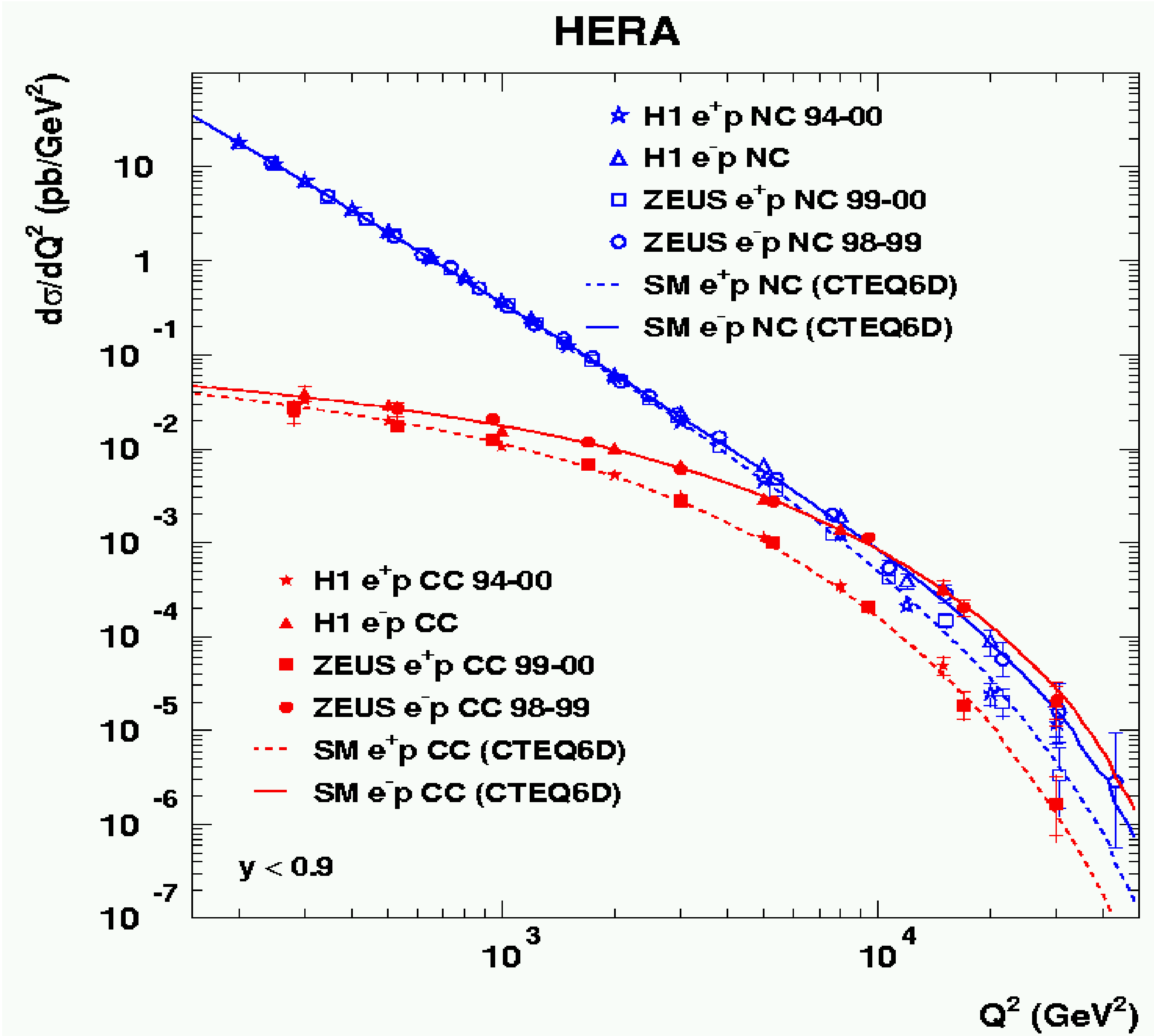








HERA: Electroweak Unification



- agreement with SM over large range (7 orders) in cross section

CC Polarised Cross Sections

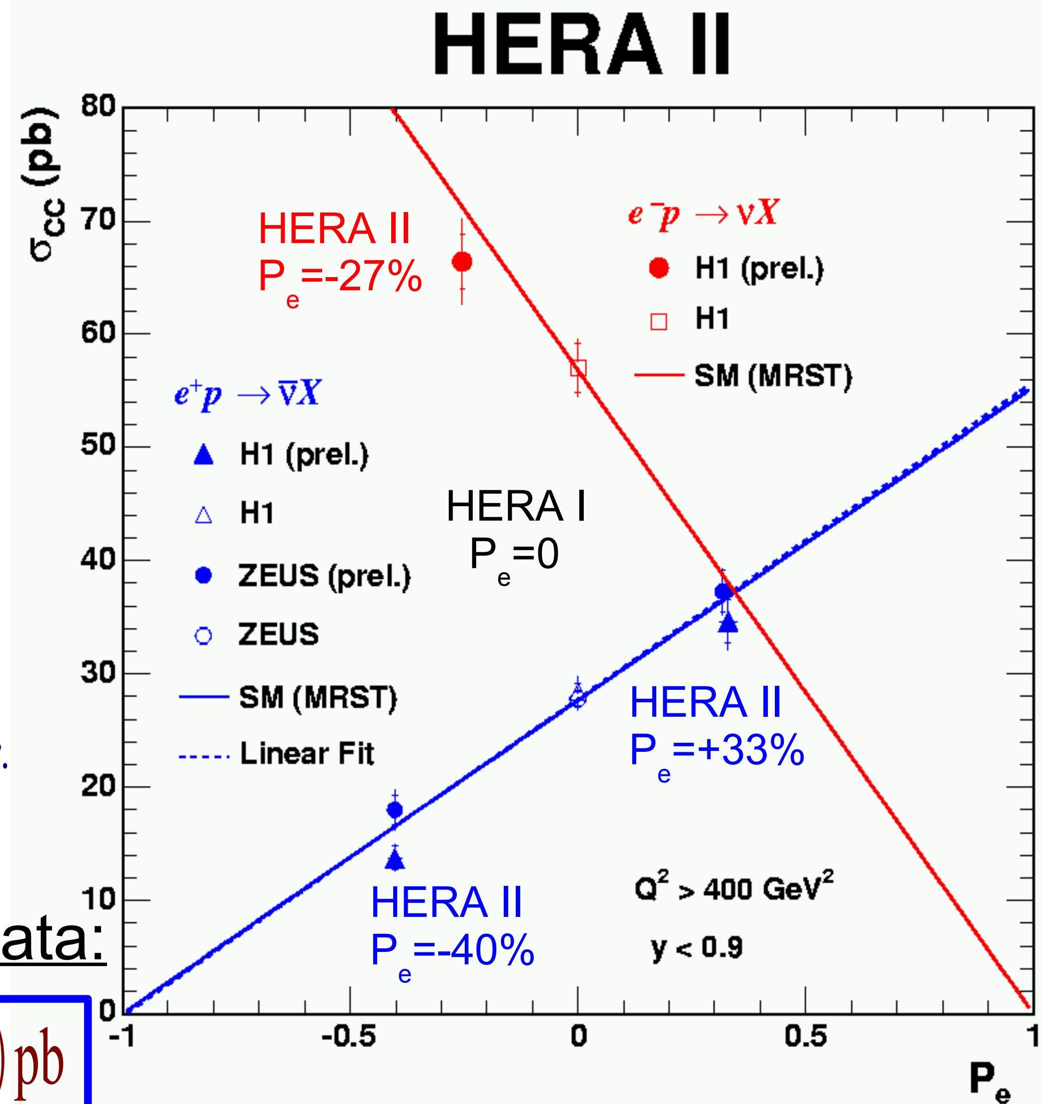
- CC polarised cross section for e^+p and and e^-p scattering:

$$\sigma^{\pm}_{CC} = (1 \pm P_e)\,\sigma^{\pm}_{CC,unpol}$$

P_e = longitudinal $e^\pm$ polarisation

$$L_{CC,L} = -\frac{e}{2\sqrt{2}\sin\Theta_W}\left[W_\mu \bar{e}\gamma^\mu(1-\gamma^5)\nu\right] + h.c.$$

$$L_{CC,R} = -\frac{e}{2\sqrt{2}\sin\Theta_W}\left[W_\mu \bar{e}\gamma^\mu(1+\gamma^5)\nu\right] + h.c.$$



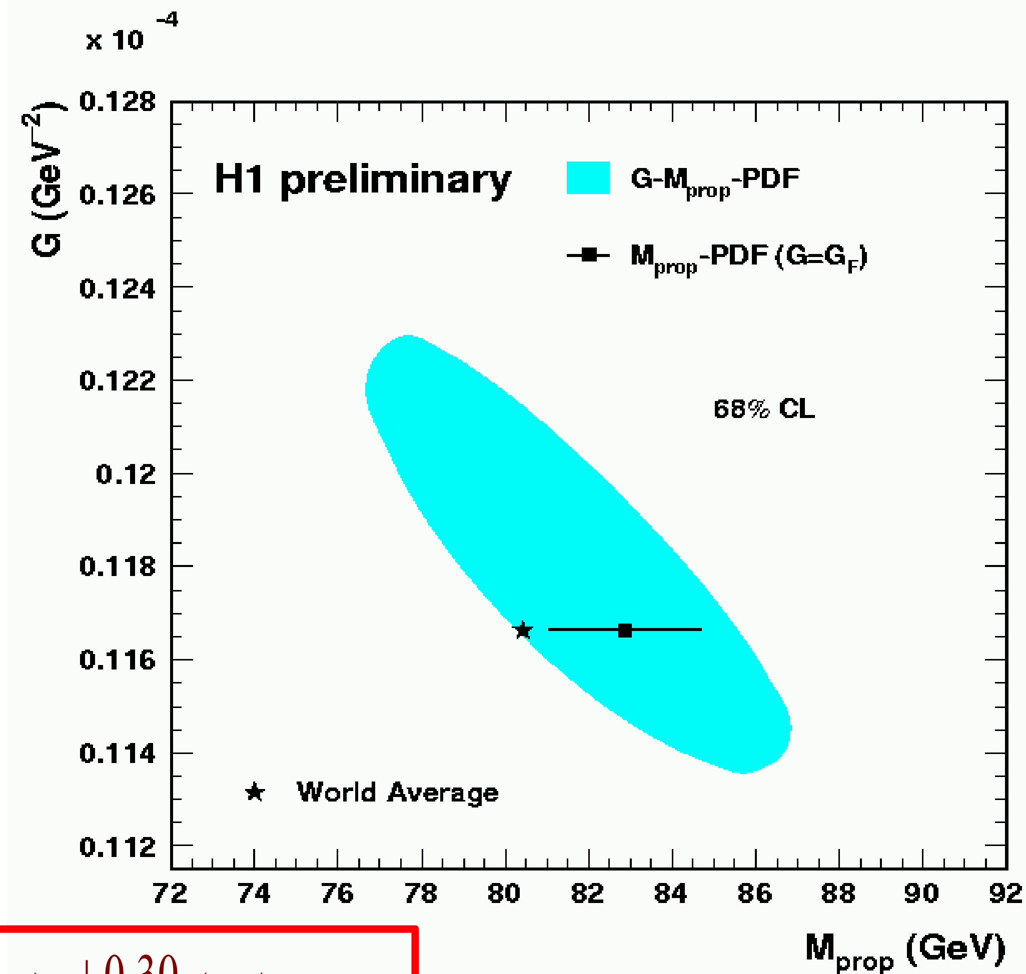
- <u>combined H1/ZEUS fit of e^+p data:</u>

$$\sigma^{tot}_{CC}(P_e = -1) = -0.2 \pm 1.8(\mathrm{stat}) \pm 1.6(\mathrm{syst})\,\mathrm{pb}$$

e^+p/e^-p results consistent with left-handed CC only!

Electroweak Fits at HERA

- CC and NC combined fit of HERA I data
- H1: simultaneous fit of el.weak. parameters and pdf 's



fit W-propagator mass:

$$\sigma_{CC} \propto \frac{G_F^2}{2\pi x} \cdot \left[\frac{M_{propa}^2}{M_{propa}^2 + Q^2} \right]^2 \phi_{CC}(x, Q^2)$$

$M_{propa} = M_W$ pdf

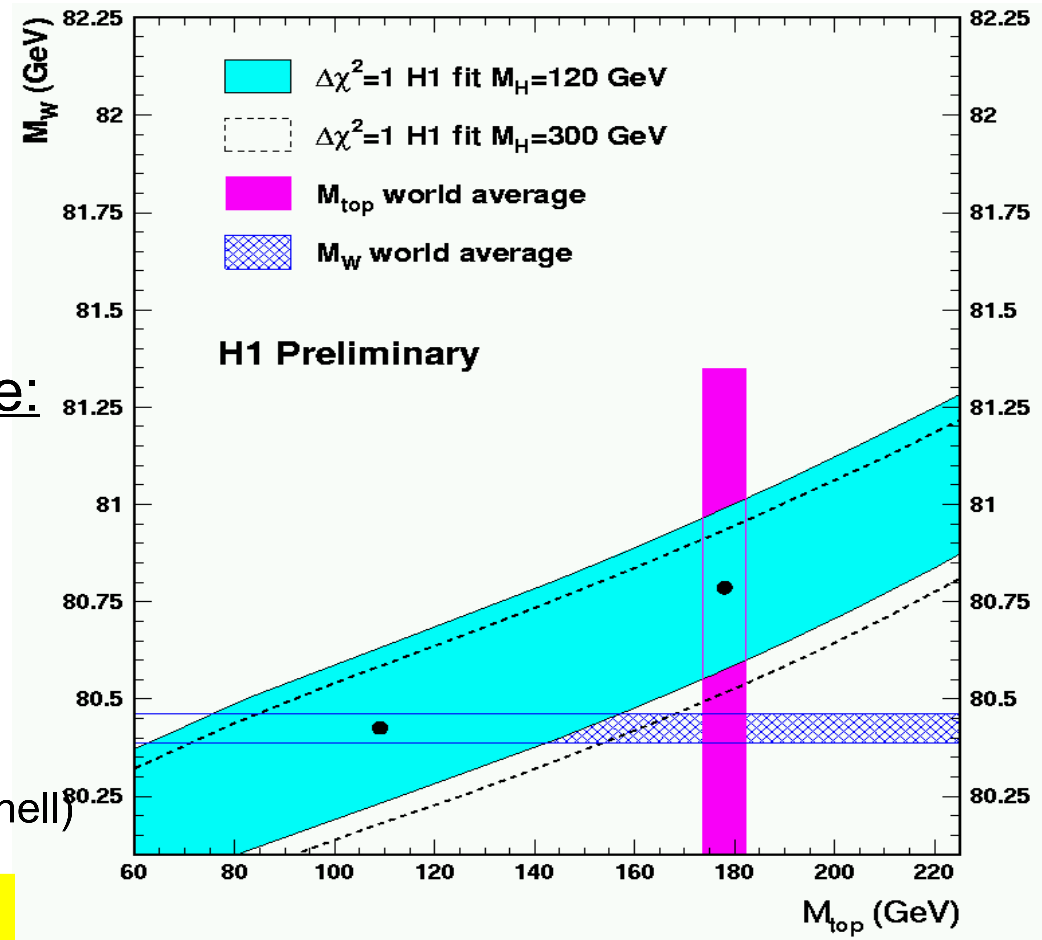
H1 (prel.): $M_{propa} = 82.87 \pm 1.82(\exp) \, {}^{+0.30}_{-0.16} (\mathrm{th}) \;\; \mathrm{GeV}$

ZEUS : $M_{propa} = 78.9 \pm 2.0(\mathrm{stat}) \pm 1.8(\mathrm{syst}) \, {}^{+2.0}_{-1.8} (\mathrm{pdf}) \;\; \mathrm{GeV}$ (from CC only)
(EPJ C32 (2003) 1)

→ consistent with M_W (PDG)

Electroweak Fits at HERA (cont.)

- CC and NC combined fit of HERA I data
- simultaneous fit of el.weak. parameters and pdf 's



fit W-mass in "on-mass-shell" scheme:

$$\sigma_{CC} \propto \frac{G_F^2}{2\pi x} \cdot \left[\frac{M_{propa}^2}{M_{propa}^2 + Q^2} \right]^2 \phi_{CC}(x, Q^2)$$

$M_{propa} = M_W$ — pdf

$$G_F = \frac{\pi\alpha}{\sqrt{2} M_W^2 \left(1 - \frac{M_W^2}{M_Z^2}\right)^2} \cdot \frac{1}{1 - \Delta r}$$ (on-mass-shell)

radiative corr. $\Delta r = \Delta r\left(\frac{M_t^2}{M_Z^2}, \frac{M_H}{M_W}\right)$

Result incl. M_H and M_t uncert.:

$$M_W = 80.786 \pm 0.207(\exp) \begin{matrix} +0.063 \\ -0.098 \end{matrix} (\mathrm{th})$$

→ consistency check of the SM

Electroweak Physics at HERA

- derived from (unpolarised!) NC DIS:

$$\frac{d^2\sigma^{\mathrm{NC}}(e^\pm p)}{dx\,dQ^2} = \frac{2\pi\alpha^2}{x\,Q^4}\left[Y_+\tilde{F}_2 \mp Y_-\,x\,\tilde{F}_3 - y^2\tilde{F}\right]$$

$$Y_\pm = 1\pm(1-y)^2$$

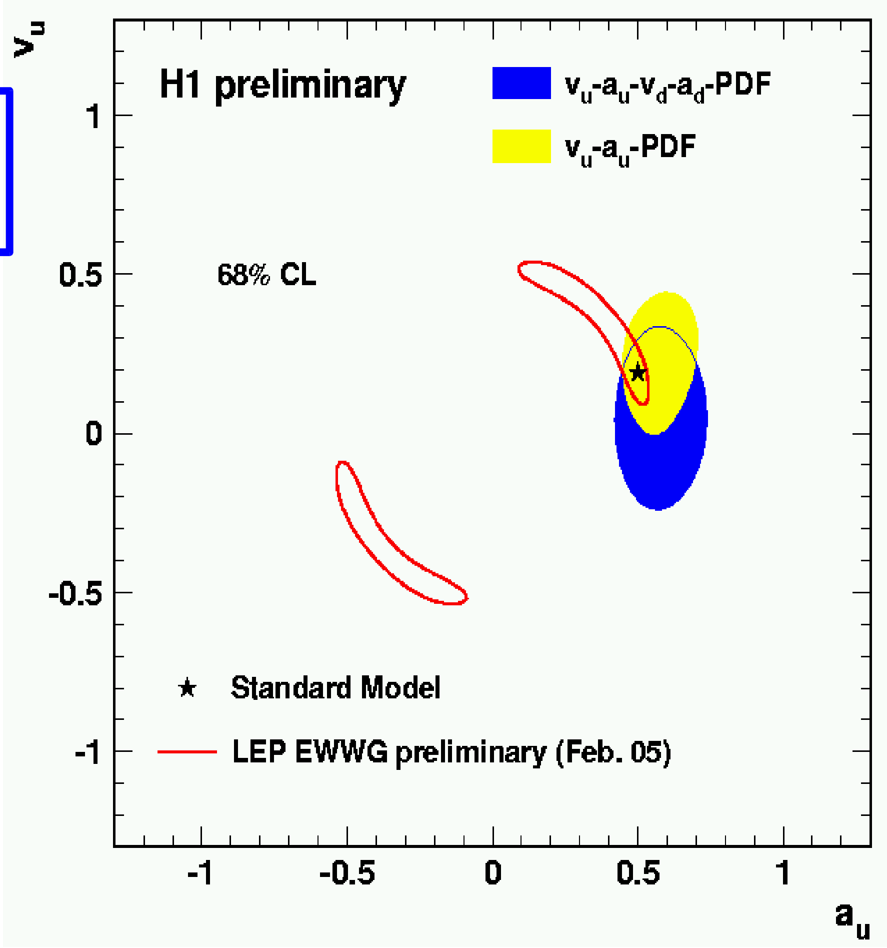
$$\tilde{F}_2 \overset{\mathrm{def}}{=} F_2 - v_e\frac{\kappa Q^2}{Q^2+M_Z^2}F_2^{\gamma Z} + (v_e^2+a_e^2)\left(\frac{\kappa Q^2}{Q^2+M_Z^2}\right)^2 F_2^Z$$

$$\tilde{F}_3 \overset{\mathrm{def}}{=} a_e\frac{\kappa Q^2}{Q^2+M_Z^2}F_3^{\gamma Z} + (2v_e a_e)\left(\frac{\kappa Q^2}{Q^2+M_Z^2}\right)^2 F_3^Z$$

$$(\kappa^{-1} \overset{\mathrm{def}}{=} 4\sin^2\Theta_W\cos^2\Theta_W)$$

$$[F_2, F_2^{\gamma Z}, F_2^{\gamma Z}] = x\sum_q[e_q^2, 2e_q v_q, v_q^2+a_q^2]\,(q+\bar{q})$$

$$[F_3^{\gamma Z}, F_3^{\gamma Z}] = 2x\sum_q[e_q a_q, v_q a_q]\,(q-\bar{q})$$



→ results in good agreement with SM prediction!

- similar results for v_d and a_d (weaker bounds)

Electroweak Physics at HERA

- derived from (unpolarised!) NC DIS:

$$\frac{d^2\sigma^{NC}(e^\pm p)}{dx\,dQ^2} = \frac{2\pi\alpha^2}{xQ^4}\left[Y_+\tilde{F}_2 \mp Y_- x\tilde{F}_3 - y^2\tilde{F}\right]$$

$$Y_\pm = 1 \pm (1-y)^2$$

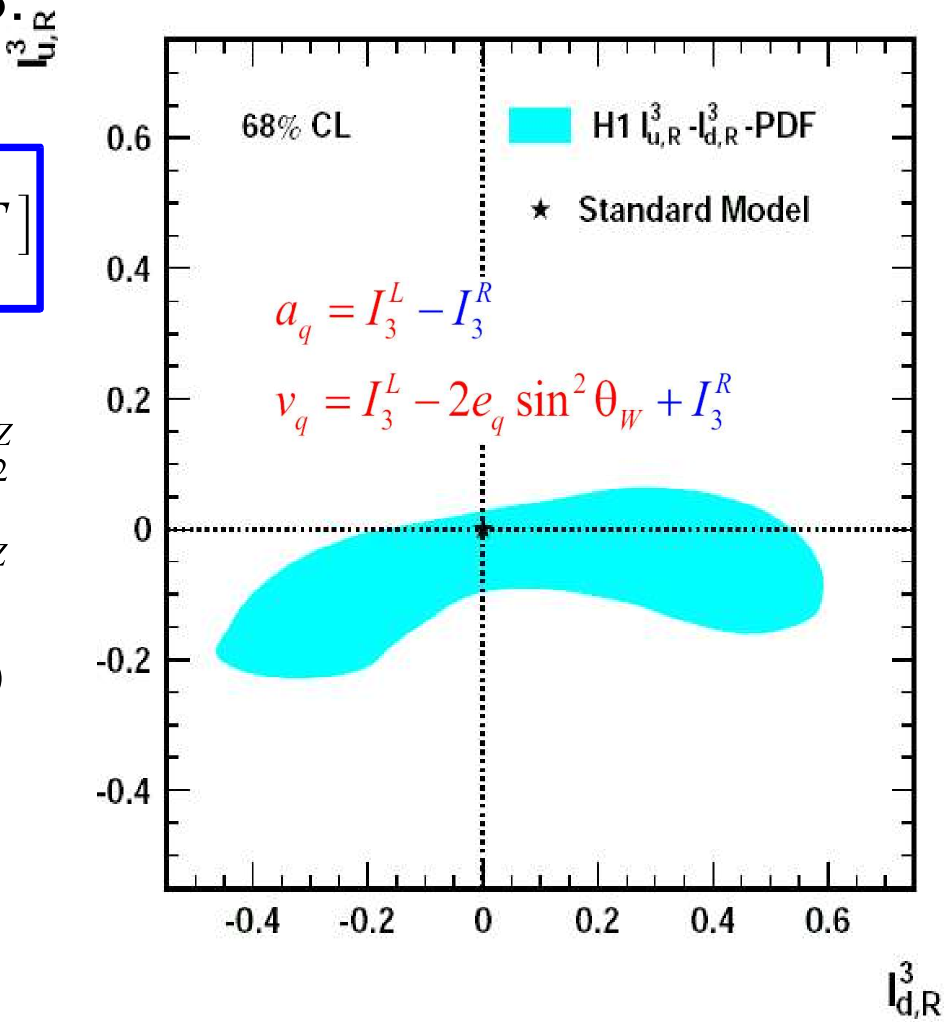
$$\tilde{F}_2 \stackrel{\text{def}}{=} F_2 - v_e \frac{\kappa Q^2}{Q^2+M_Z^2} F_2^{\gamma Z} + (v_e^2+a_e^2)\left(\frac{\kappa Q^2}{Q^2+M_Z^2}\right)^2 F_2^Z$$

$$\tilde{F}_3 \stackrel{\text{def}}{=} a_e \frac{\kappa Q^2}{Q^2+M_Z^2} F_3^{\gamma Z} + (2v_e a_e)\left(\frac{\kappa Q^2}{Q^2+M_Z^2}\right)^2 F_3^Z$$

$$(\kappa^{-1} \stackrel{\text{def}}{=} 4\sin^2\Theta_W \cos^2\Theta_W)$$

$$[F_2, F_2^{\gamma Z}, F_2^{\gamma Z}] = x\sum_q [e_q^2, 2e_q v_q, v_q^2+a_q^2]\,(q+\bar{q})$$

$$[F_3^{\gamma Z}, F_3^{\gamma Z}] = 2x\sum_q [e_q a_q, v_q a_q]\,(q-\bar{q})$$



→ results in good agreement with SM prediction!

- limits on right-handed couplings

BSM

- General Search
- Interesting Events
  - isolated lepton events
  - multilepton events (Higgs)
- Models
  - Leptoquarks/LFV
  - SUSY

General Search HERA I

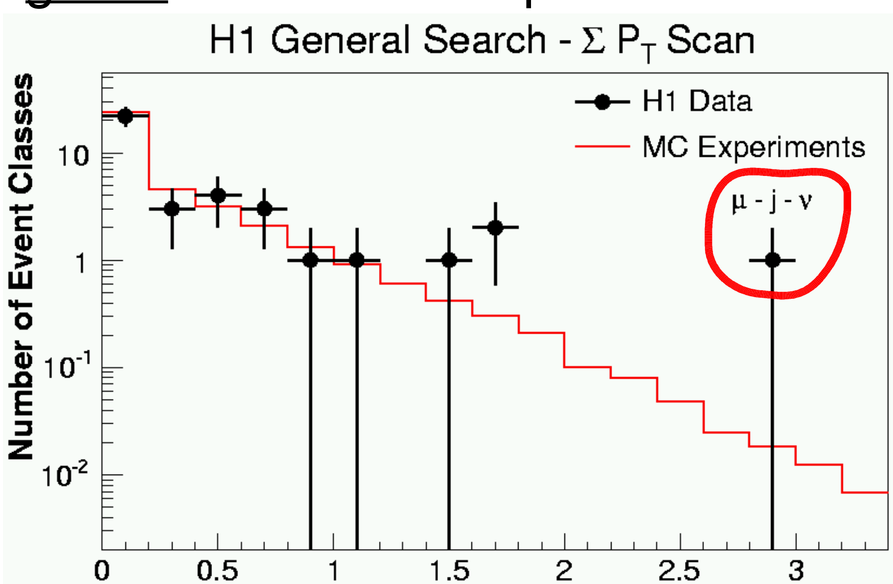
H1 Collab., Phys Lett B602 (2004)14

- study of ALL high p_T final states
  in a single coherent analysis
- model independent:
  → search for deviations

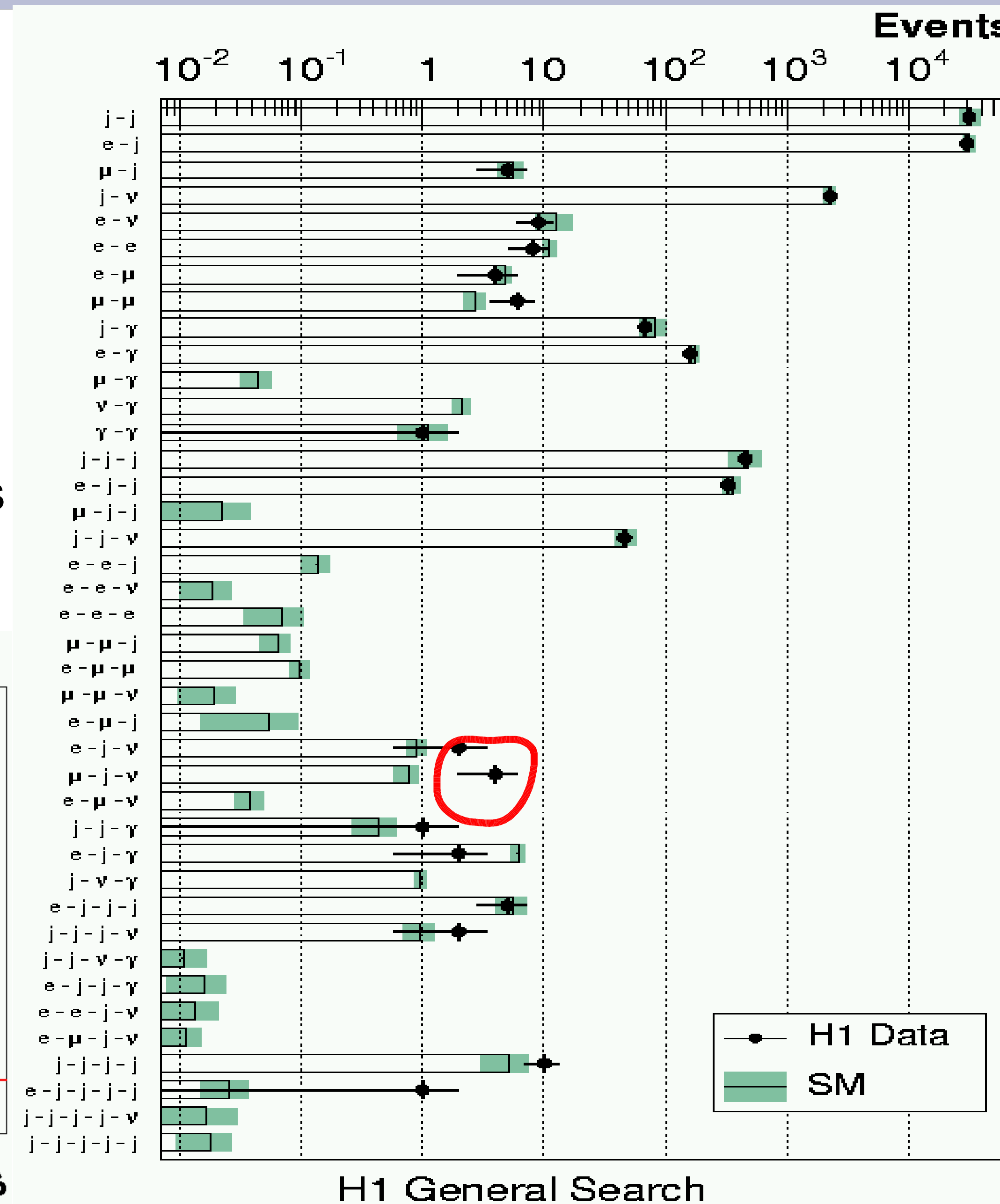
objects: e, μ, γ, jet ,ν

p_T > 20 GeV → define classes

- global statistical interpretation:



8% SM agreement

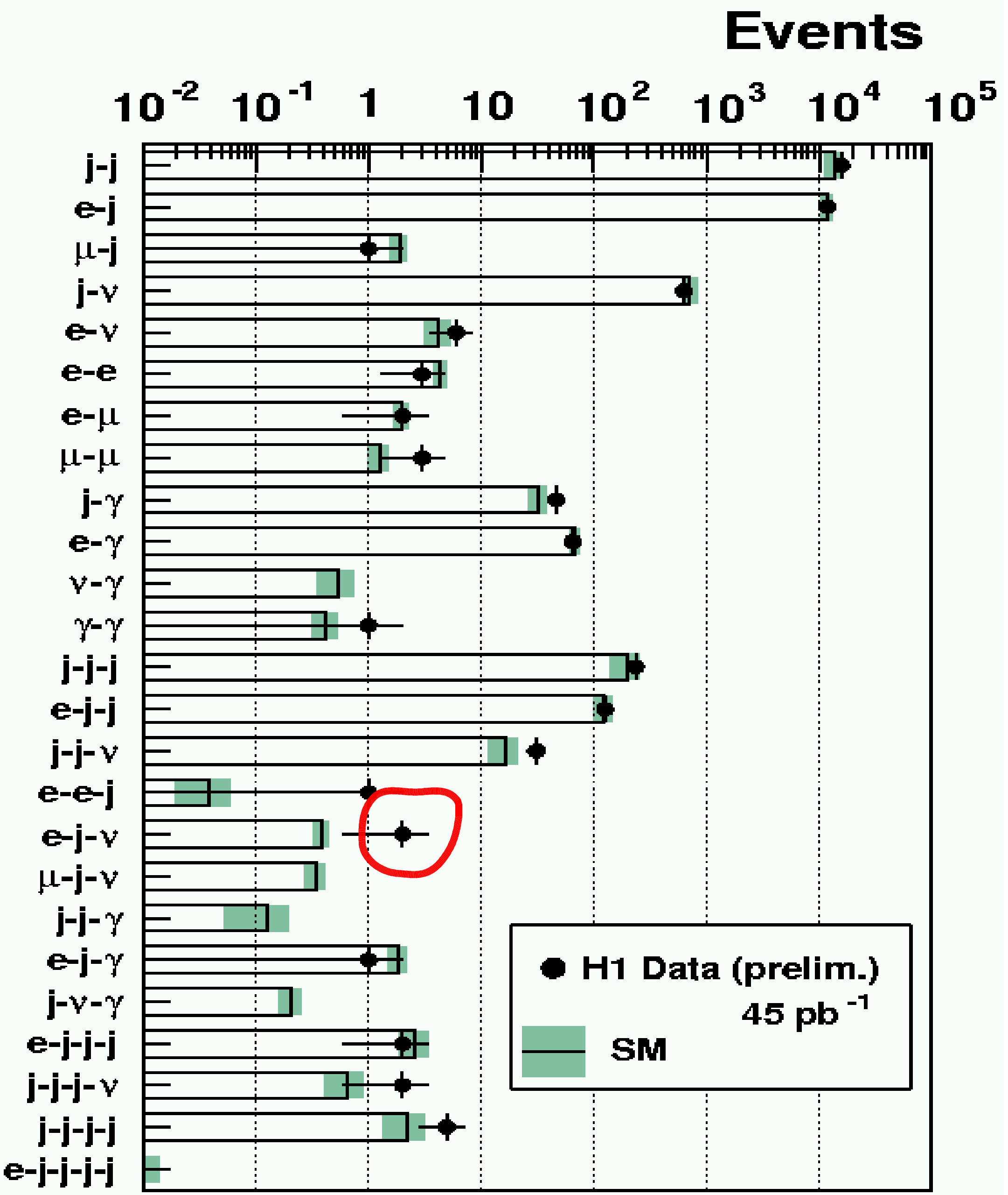


General Search HERA II update

- study of ALL high p_T final states
  in a single coherent analysis
- model independent:
  → search for deviations

objects: e, μ, γ, jet ,ν

p_T > 20 GeV → define classes



HERA II results:

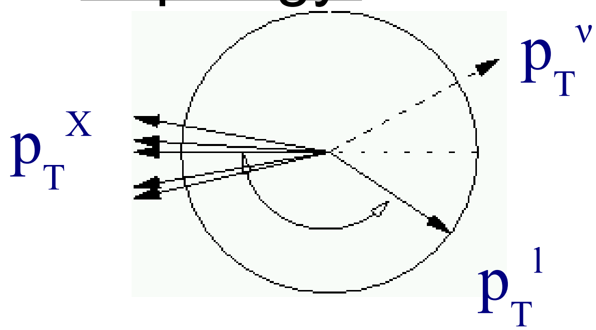
- in general good agreement with SM
- same excess in ejν channel

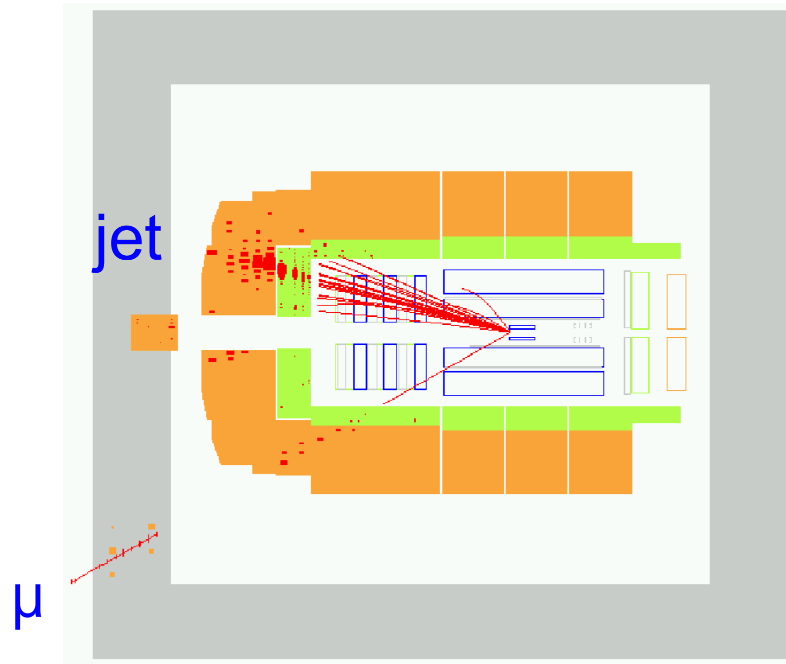
→ isolated lepton events

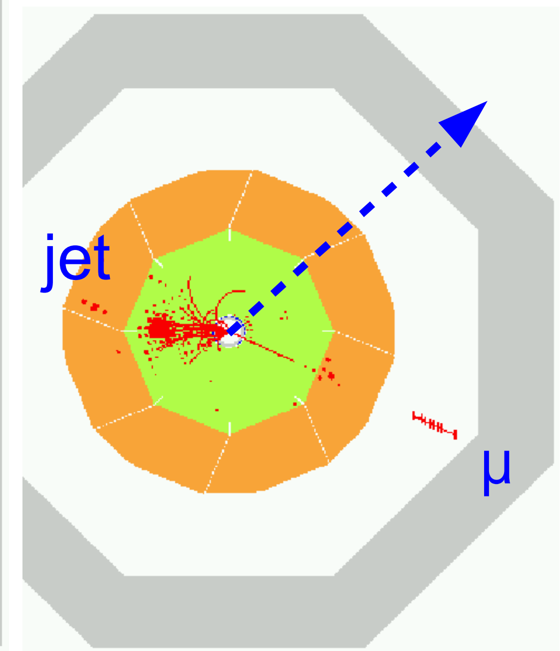
Isolated Lepton Events

H1 Collab., Phys. Lett. B561 (2003) 241; ZEUS Collab. Physics Letters B 559 (2003) 153

- **Topology:**







- **SM Process:**

  W-production (p_T^X small)

  ep → eX W
  ↳ l ν

- **BSM Process:**

  ➔ anomalous single top production

  ➔ RPV SUSY: stop

  predict high p_T^X !

HERA I Results H1/ZEUS

H1 1994-2000 $L(e^{\pm}p)=118\ pb^{-1}$	electron obs./exp.	muon obs./exp.	tau (prel) obs./exp.	W eff. e,mu(tau)
Full Sample	$11 / 11.5 \pm 1.5$	$8 / 2.94 \pm 0.51$	$5 / 5.81 \pm 1.36$	~75% (~15%)
$p_T^X > 25$ GeV	$5 / 1.76 \pm 0.29$	$6 / 1.68 \pm 0.30$	$0 / 0.53 \pm 0.10$	~85% (~50%)

ZEUS 1994-2000 $L(e^{\pm}p)=130\ pb^{-1}$	electron obs./exp.	muon obs./exp.	tau obs./exp.	W eff. e,mu(tau)
Full Sample	$24 / 20.6 \pm 3.2$	$12 / 11.9 \pm 0.6$	$3 / 0.40 \pm 0.12$	~17% (~48%)
$p_T^X > 25$ GeV	$2 / 2.90 \pm 0.46$	$5 / 2.75 \pm 0.21$	$2 / 0.20 \pm 0.05$	~50% (~50%)

Isolated Lepton Events HERA II

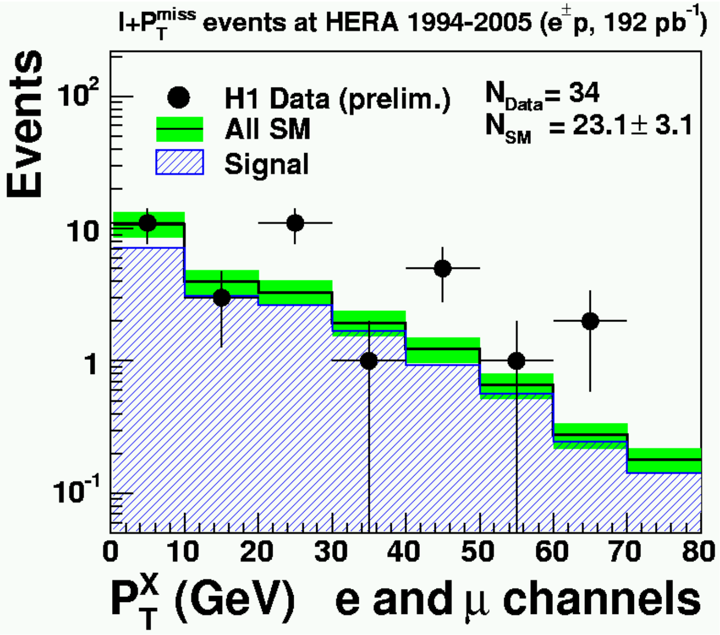
e^+p scattering (H1: 2003-2004)

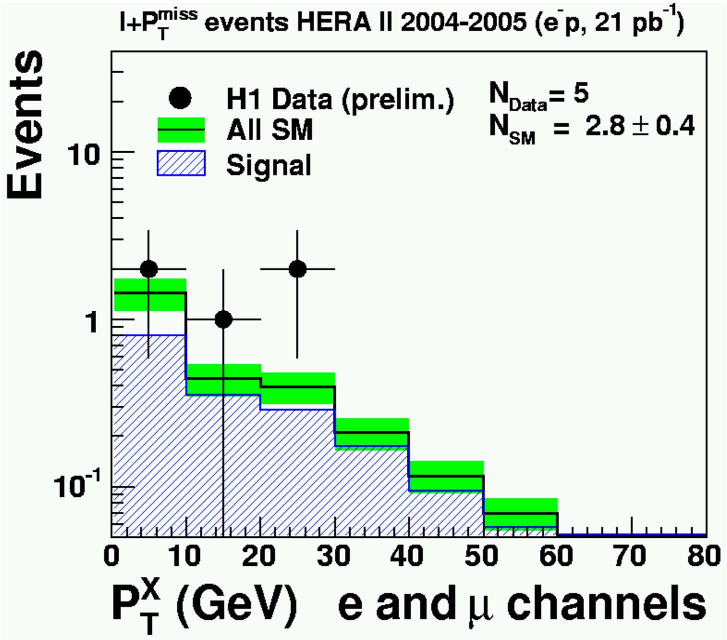
H1 2003-2004 $L(e^+p)$=53 pb^{-1}	electron obs./exp.	muon obs./exp.	total obs./exp.
Full Sample	$9 / 4.75 \pm 0.76$	$1 / 1.33 \pm 0.19$	$10 / 6.08 \pm 0.92$
$p_T^X > 25$ GeV	$5 / 0.84 \pm 0.19$	$0 / 0.85 \pm 0.13$	$5 / 1.69 \pm 0.28$

excess for $p_T^X > 25$ GeV again

in electron channel !

combined $e^\pm p$ 1994-2005





e^-p scattering (H1: 2005)

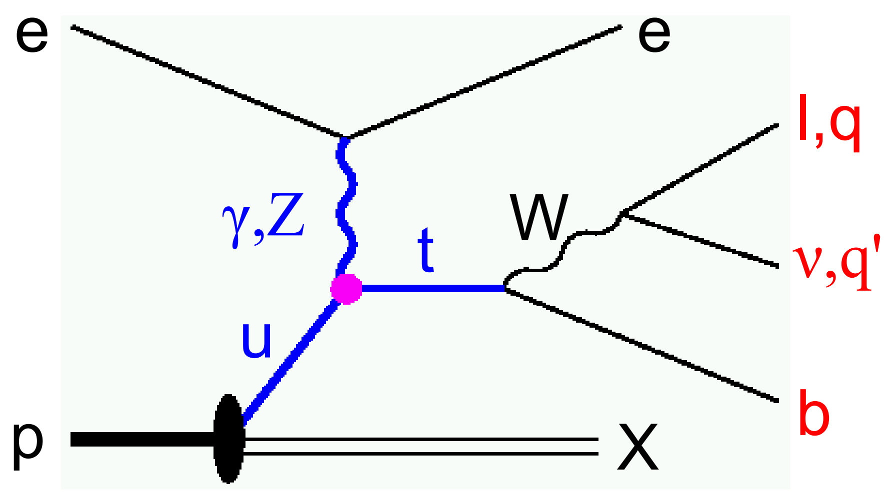
H1 2004-2005 $L(e^-p)$=21 pb^{-1}	electron obs./exp.	muon obs./exp.	total obs./exp.
Full Sample	$5 / 2.15 \pm 0.33$	$0 / 0.59 \pm 0.09$	$5 / 2.75 \pm 0.40$
$p_T^X > 25$ GeV	$1 / 0.30 \pm 0.05$	$0 / 0.36 \pm 0.06$	$1 / 0.66 \pm 0.10$

no significant ecess at high p_T^X in e^-p

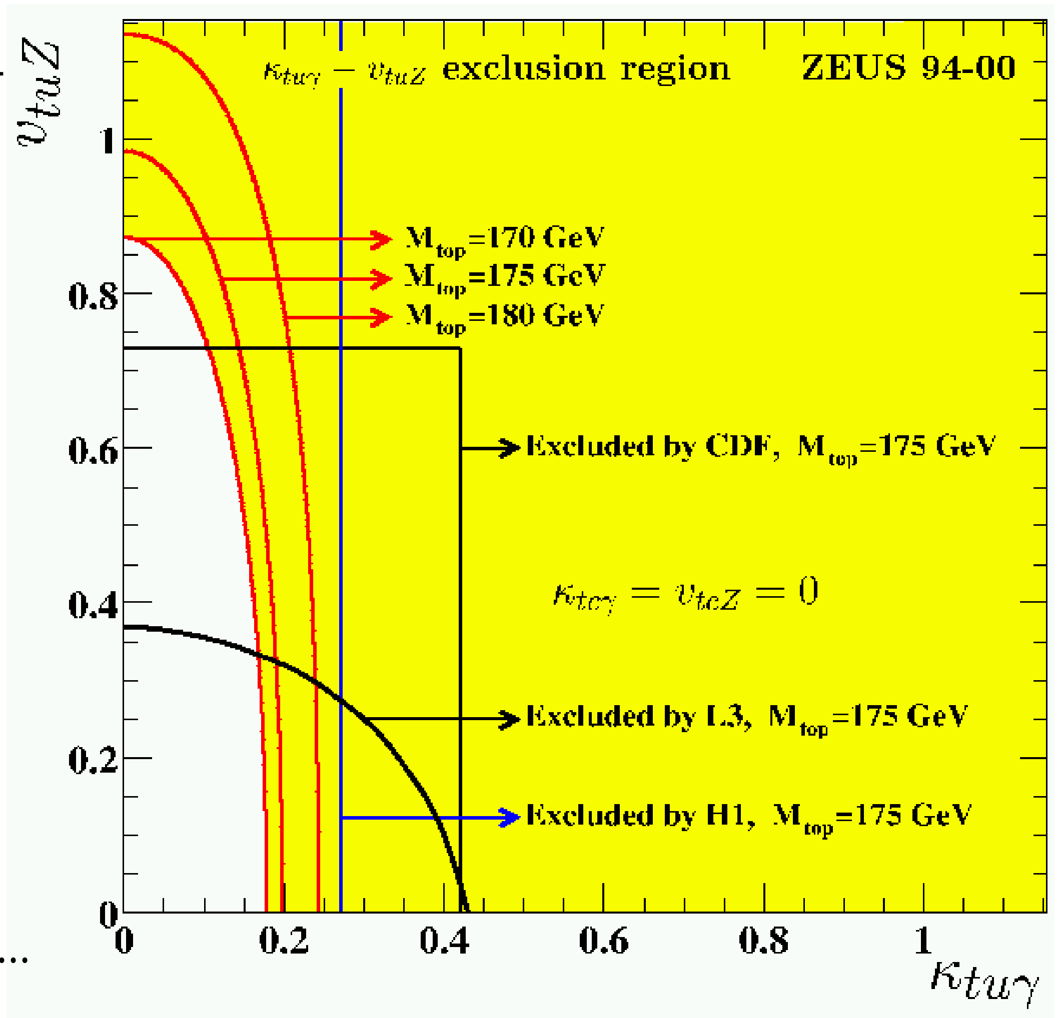
Anomalous single top production

H1 Collab., Eur. Phys. J. C33 (2004) 9; ZEUS Collab. Physics Letters B 559 (2003) 153

HERA: top production and decay:



$$L_{\text{eff}} = \sum_{U=u,c} i \frac{e e_U}{\Lambda} \bar{t}\, \sigma_{\mu\nu}\, q^\nu\, \kappa_{\gamma,U}\, U\, A^\mu \quad + \quad \frac{g}{2\cos\Theta_W} \bar{t}\, \gamma_\mu\, v_{Z,U}\, U\, Z^\mu \quad + \quad \ldots$$



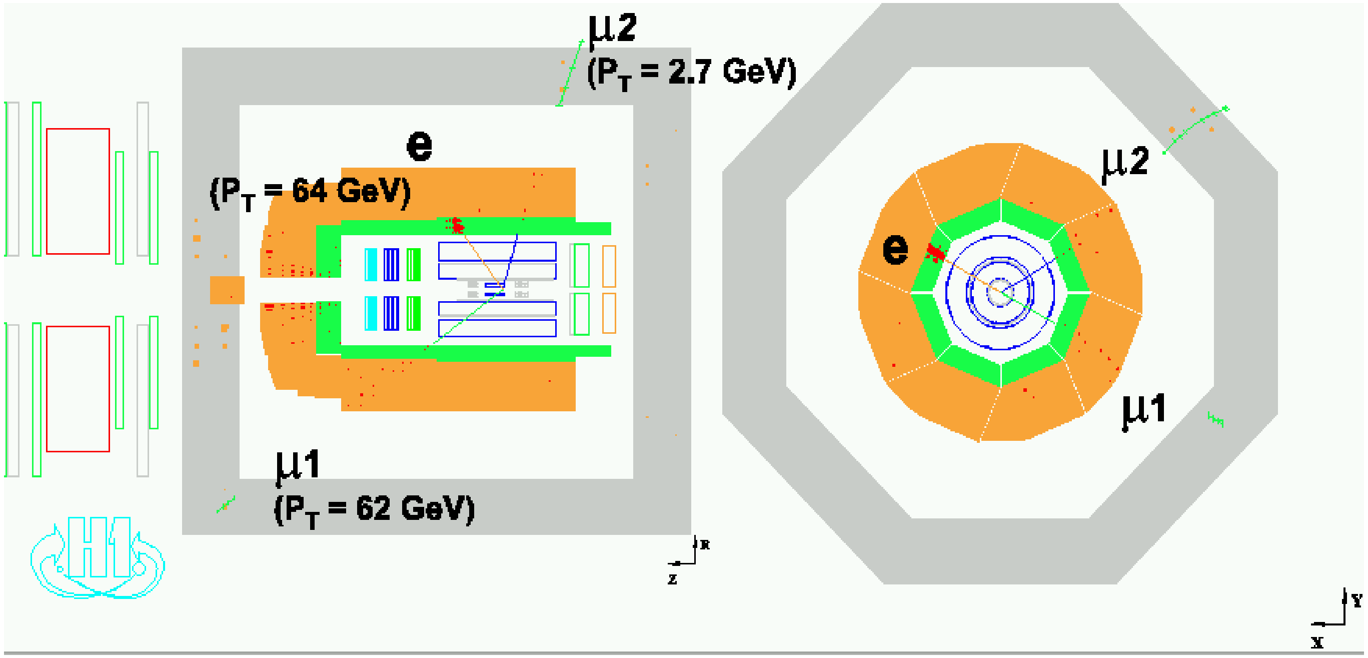
$\kappa_{\gamma,U}$ is the anomalous magnetic coupling

$v_{Z,U}$ is the anomalous Z boson vector coupling

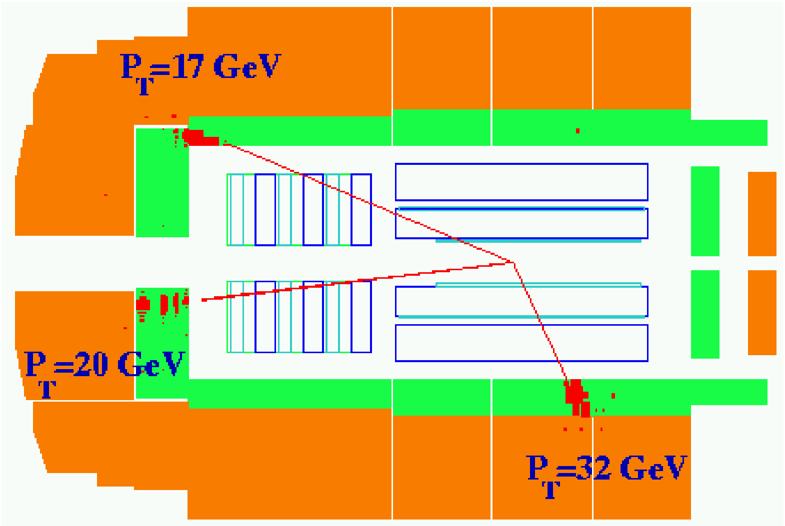
→ complementary sensitivities by different colliders

Multi-Lepton Events in H1

μμe event:



eee event:



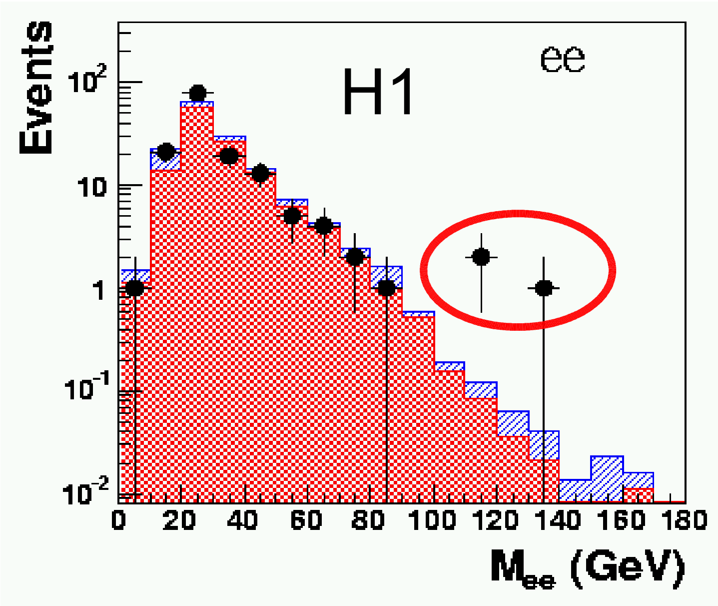
- Study events with 2 or 3 isolated leptons (electron, muon, tau)
- SM processes:
  - lepton pair production
  - NC DIS

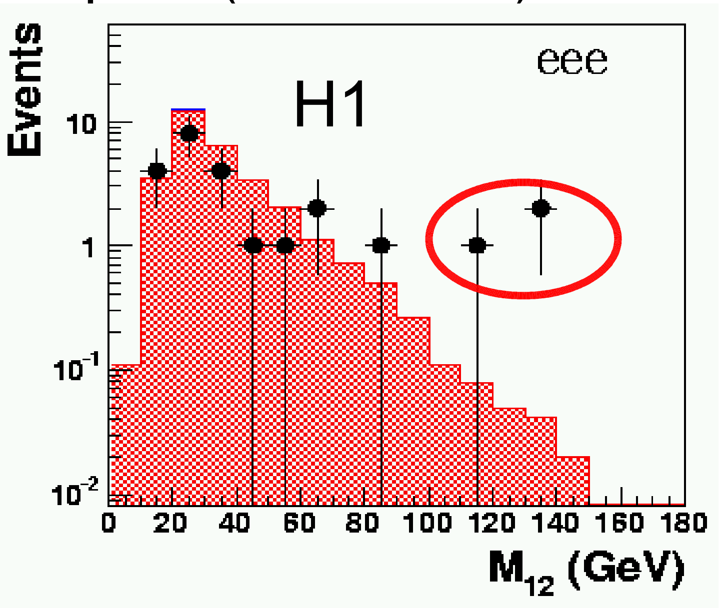
  (misidentified hadrons, photons)

HERA Multi-Electrons

H1 Collab., Eur Phys J C31 (2003) 17

1996-2004 $e^{\pm}p$ $L=163pb^{-1}$ (ICHEP 04)





Full Analysis

H1($L=163pb^{-1}$)	data	SM
ee	147	149.8 ± 24.8
eee	24	30.4 ± 3.9

ZEUS($L=130pb^{-1}$)	data	SM
ee	191	213.9 ± 3.9
eee	26	34.7 ± 0.5

⇒ good agreement with SM

M_{12}>100 GeV:

H1 ($L=163pb^{-1}$)	data	SM
ee	3	0.44 ± 0.10
eee	3	0.31 ± 0.08

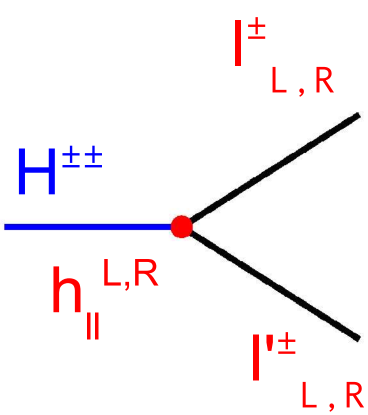
ZEUS($L=130pb^{-1}$)	data	SM
ee	2	0.8 ± 0.1
eee	0	0.4 ± 0.04

⇒ excess at high invariant mass

Doubly Charged Higgs Limits

Motivation:

- Higgs triplet(s) of non-zero hypercharge (Left-Right symmetries, GUT)
- can be singly produced at HERA
- couplings to standard leptons unknown:



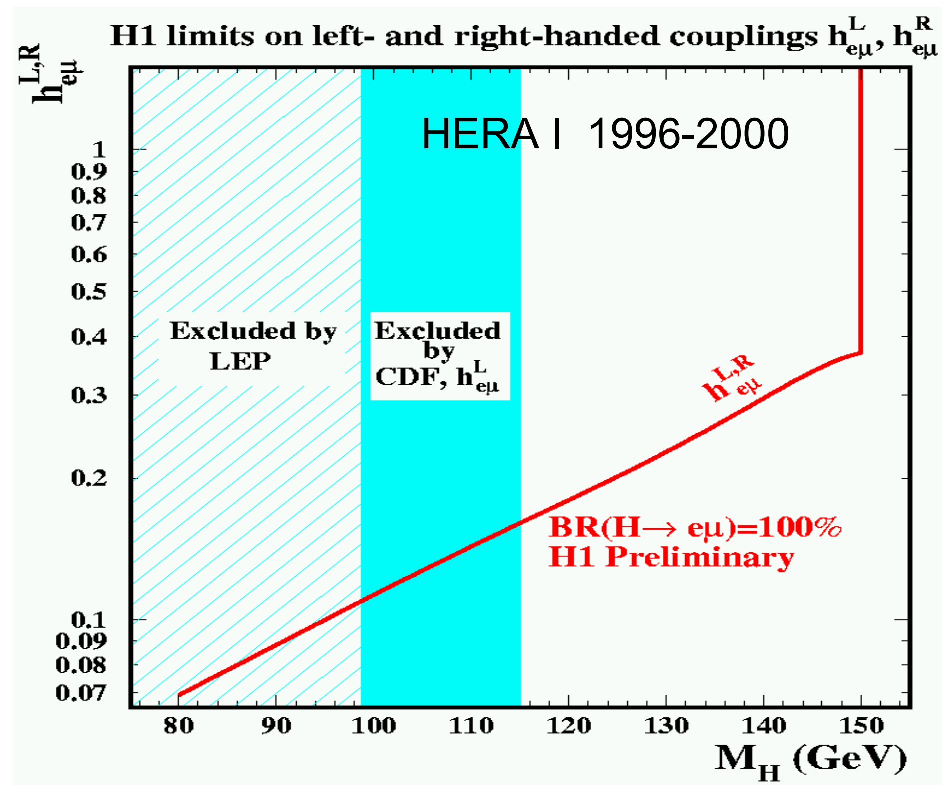
$$h_{ll'}^{L,R} = \begin{vmatrix} h_{ee} & h_{\mu e} & h_{\tau e} \\ h_{e\mu} & h_{\mu\mu} & h_{\tau\mu} \\ h_{e\tau} & h_{\mu\tau} & h_{\tau\tau} \end{vmatrix}$$

expect:

- 2 equally charged high p_T leptons
- lepton charge = electron beam charge

Results (H1)

- excess in ee/eee incompatible with $H^{\pm\pm}$ interpretation
- $e\mu$ final state (LFV)



⇒ limit on LFV coupling $h_{e\mu}$ set

Leptoquarks/LFV

Properties:

- multiple charges of 1/3
- carry lepton & baryon number, $SU(3)_C$ color

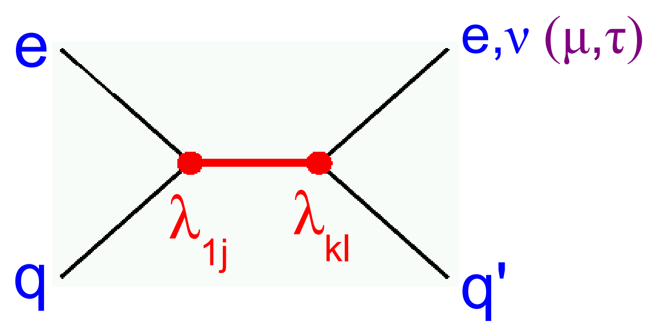
- <u>Motivation:</u> light Leptoquarks $M_{LQ} < M_{GUT}$ predicted
- GUTs: E_6, SO(10)
- SUSY, Technicolor, Superstrings

Production at HERA:

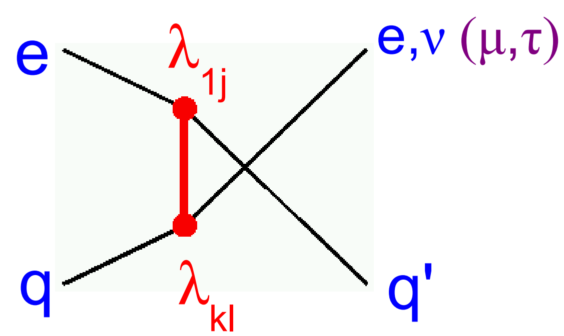
Yukawa coupling λ_{ij}

(i,j = family indices)

→ single production



s-channel



u-channel

Model:

- $SU(3)_C \times SU(2)_L \times U(1)_Y$ symmetry
- 7 scalar / 7 vector (Buchmüller, Wyler, Rückl)
- F = B+L = 0, 2

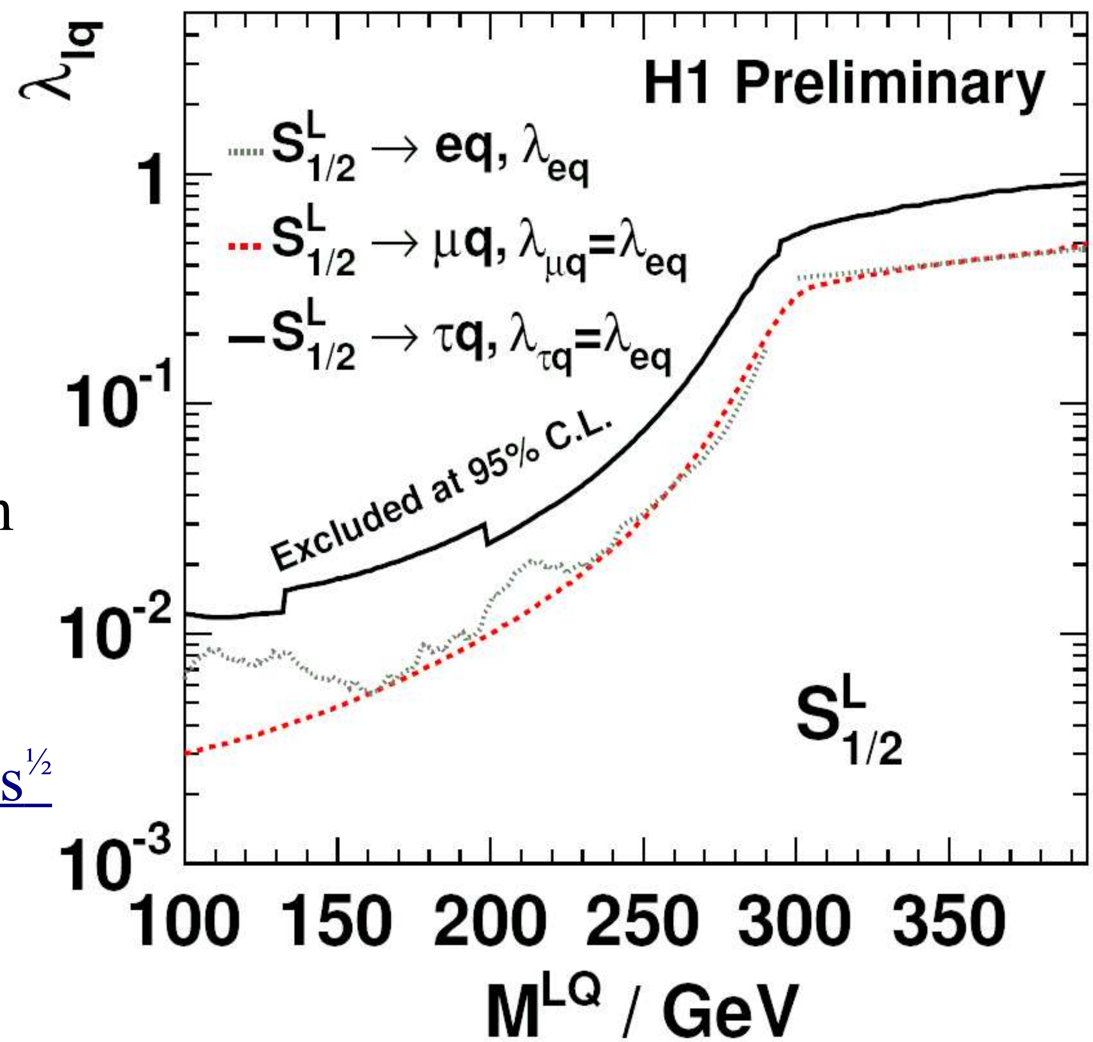
→ if $k \neq 1$ mediate Lepton Flavor Violation

Leptoquark Results

- Study of eq and μq, τq (LFV)
- no excess found by H1/ZEUS
- limits set on 14 types of LQs
  (notation $J^{L,R}_{Isospin}$)

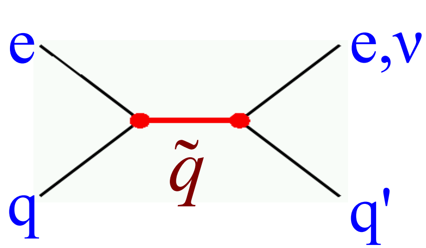
→ similar limits for
all 14 types of LQs

→ for λ couplings of e.m. strength
mass exclusions ~ 280 GeV



(similar limits obtained by ZEUS)

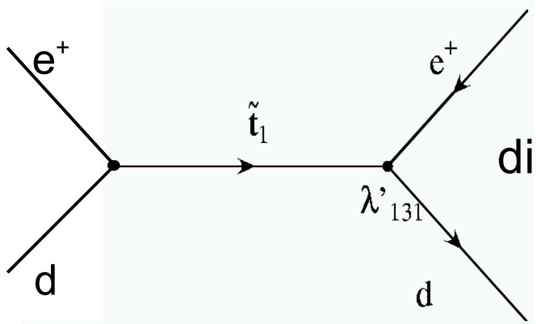
NB: similar limits apply also for RPV squarks if $M >> s^{½}$ or if $M < s^{½}$ and



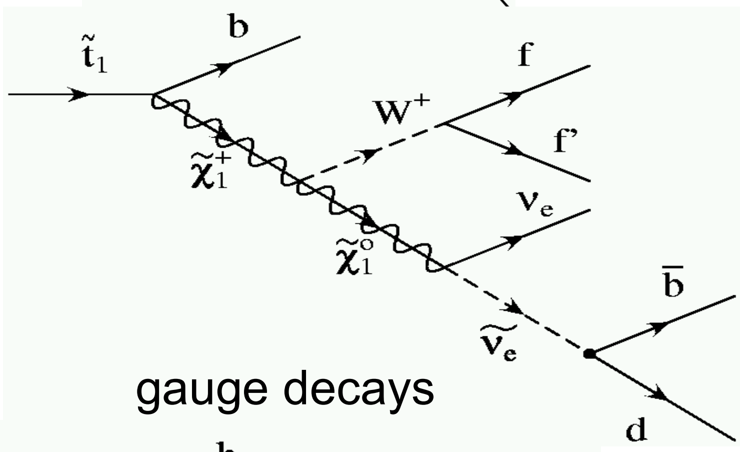
if direct RPV decay BR=100%

R_P Violating SUSY : light stop

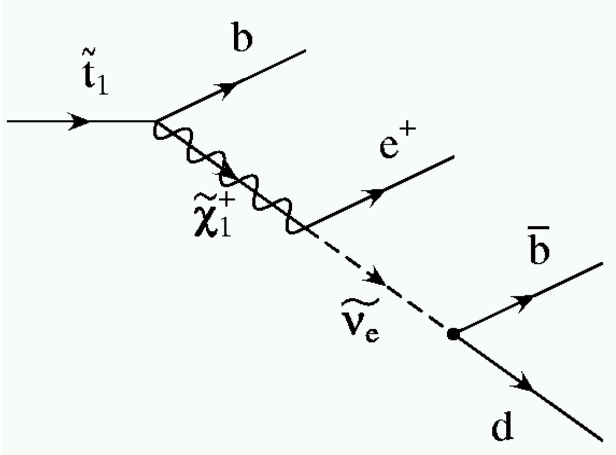
production: $e^+ d \rightarrow \tilde{t}$

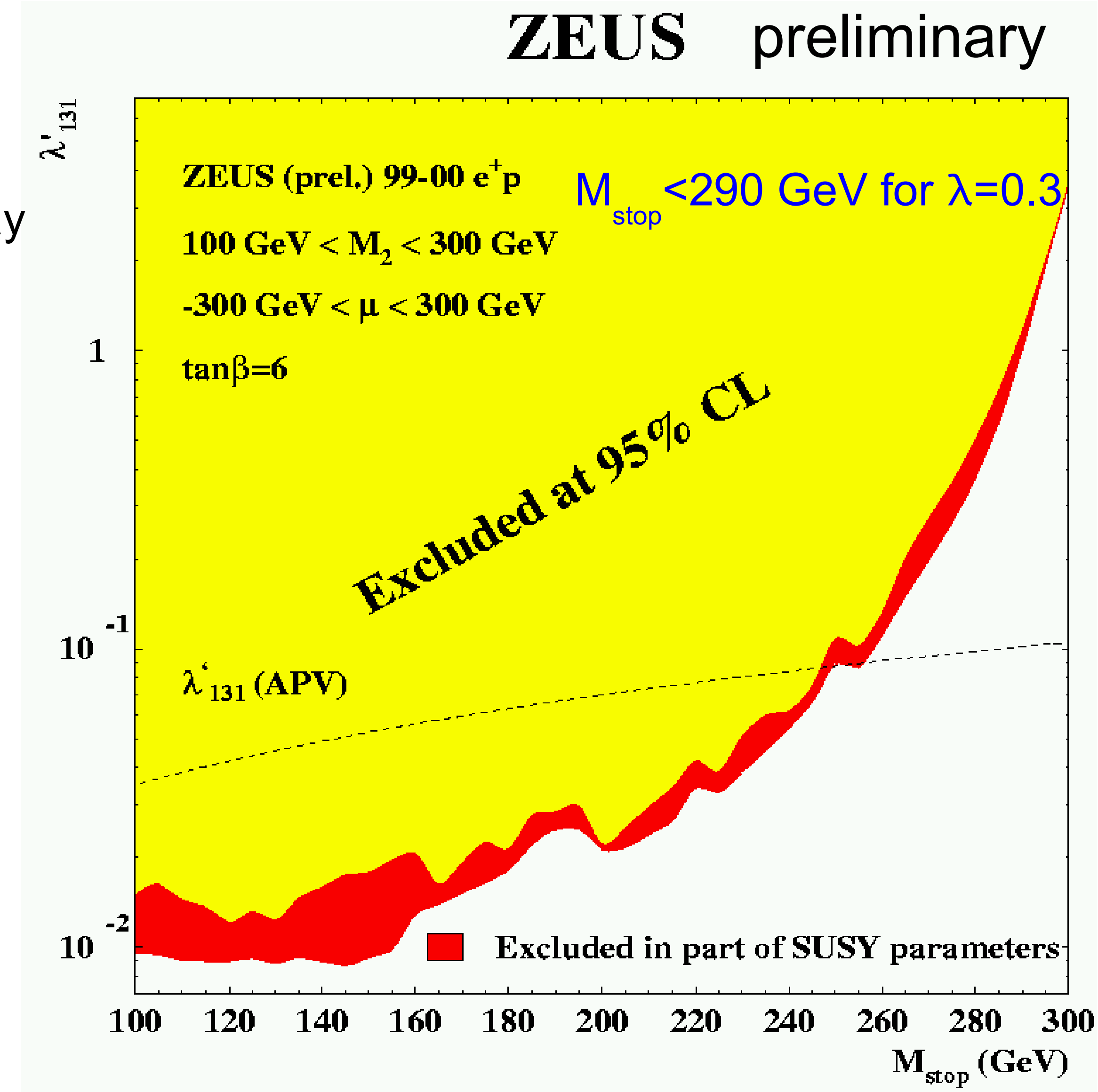


direct RPV decay



gauge decays



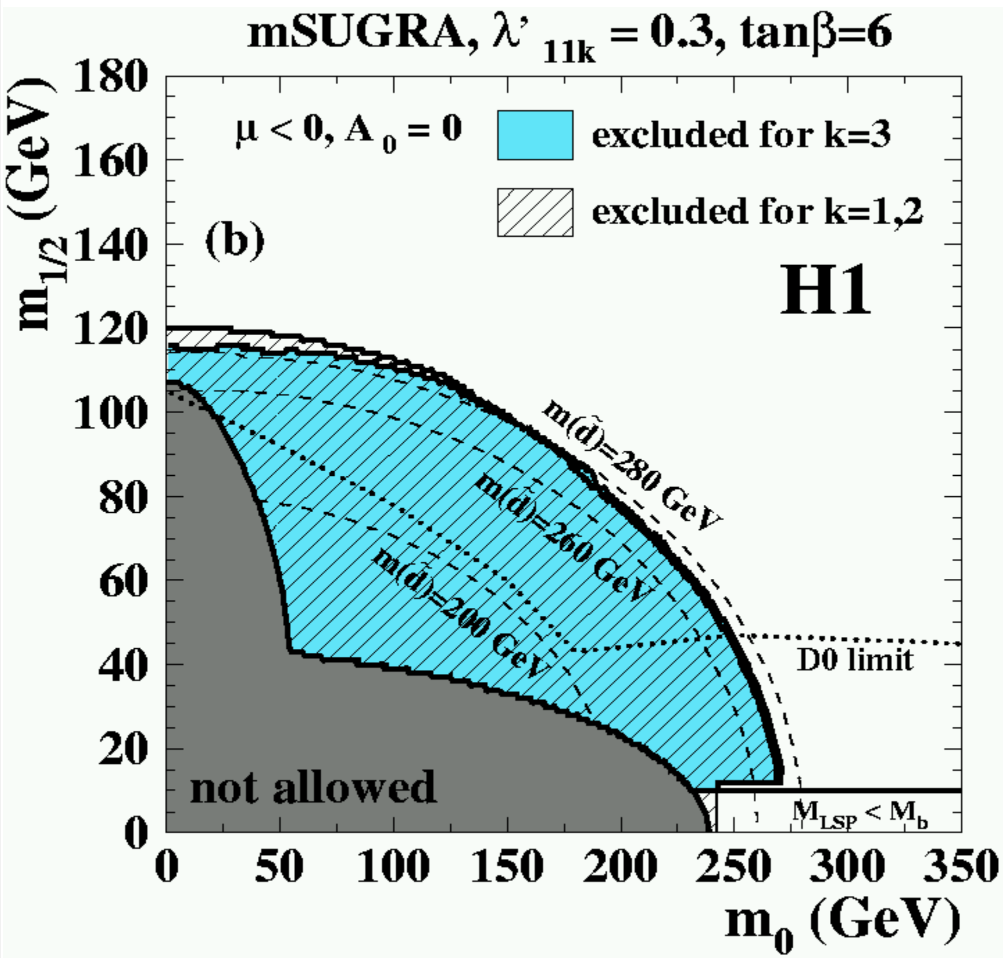


R_P Violating SUSY : light squarks

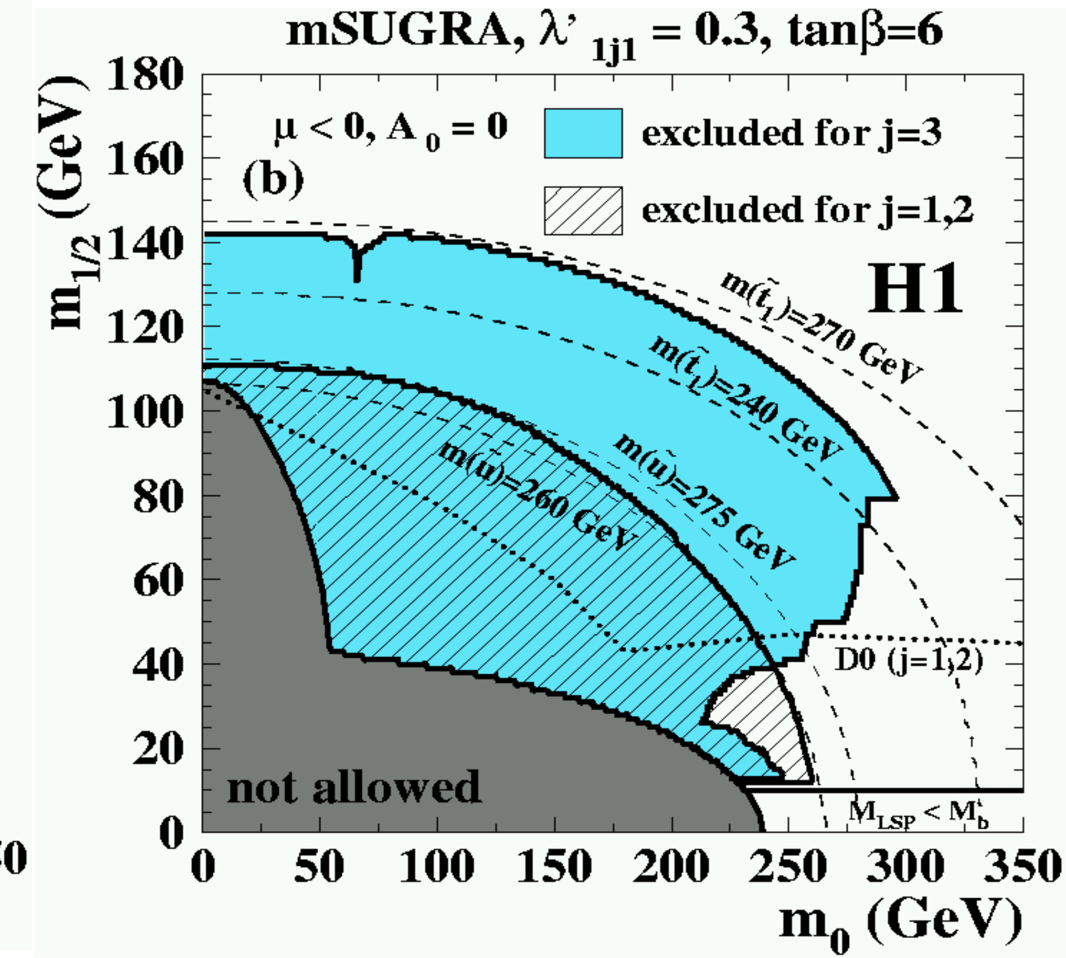
→ limits for all quark flavors interpretated in mSUGRA

(H1 Collab., Eur. Phys. J. C36 (2004) 425)

scalar down,strange,bottom



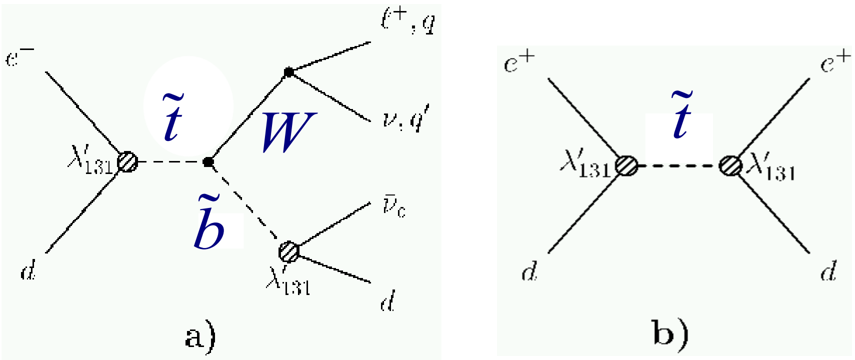
scalar up,charm,top



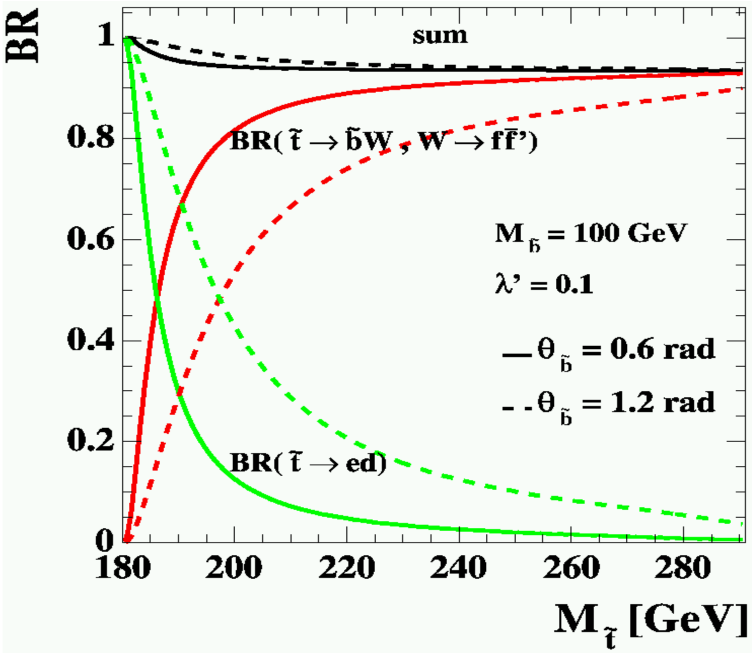
Stop with Bosonic Decay

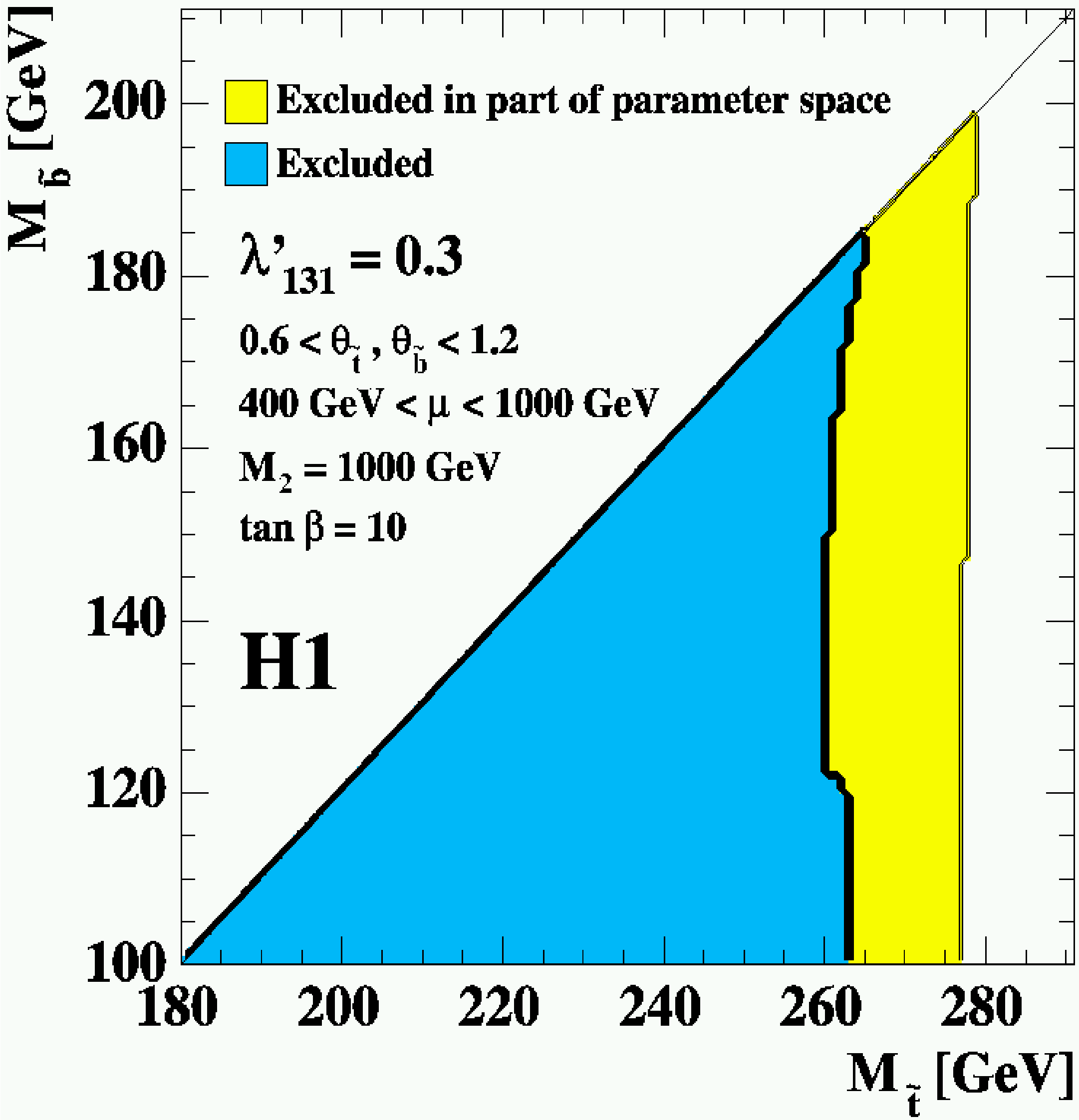
H1 Collab., A. Aktas et al., Phys Lett B599 (2004) 159-172

- Sbottom is LSP: $M_{stop} > M_{sbottom} + 80$ GeV



sbottom decay   direct RPV decay

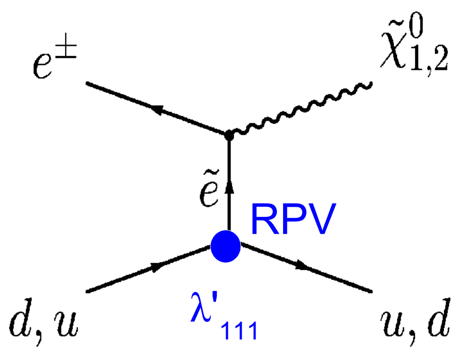


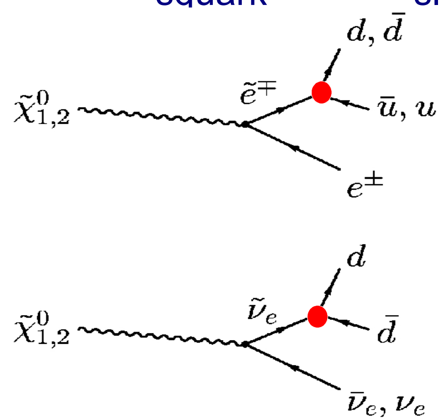


→ stop mass exclusion limits up to 260-280 GeV ($\lambda'_{131}=0.3$)

RPV Gaugino Production at HERA

- mSUGRA: scenario: $M_{squark} >> M_{sleptons}$

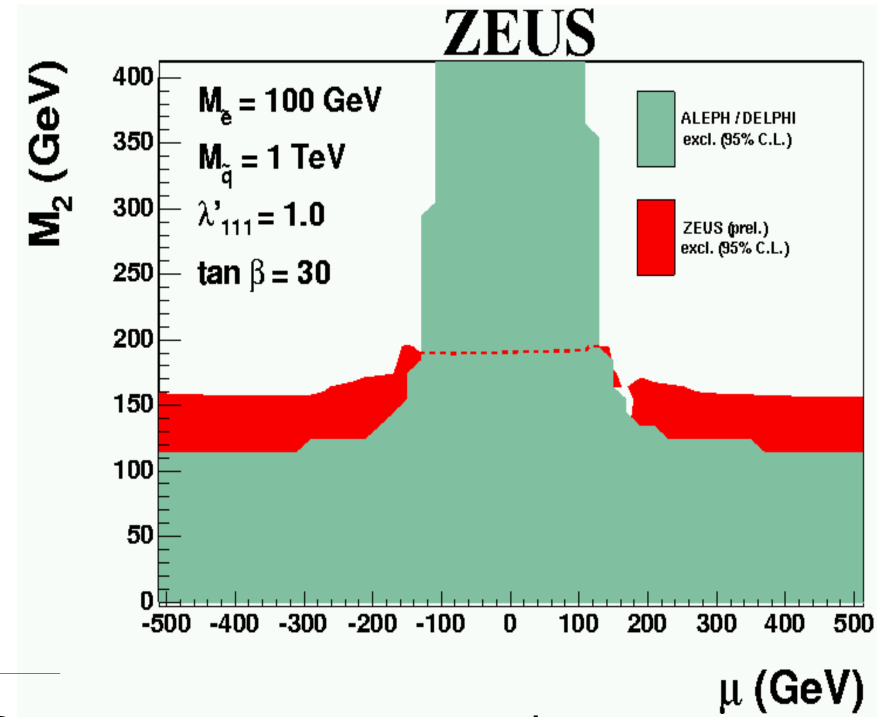




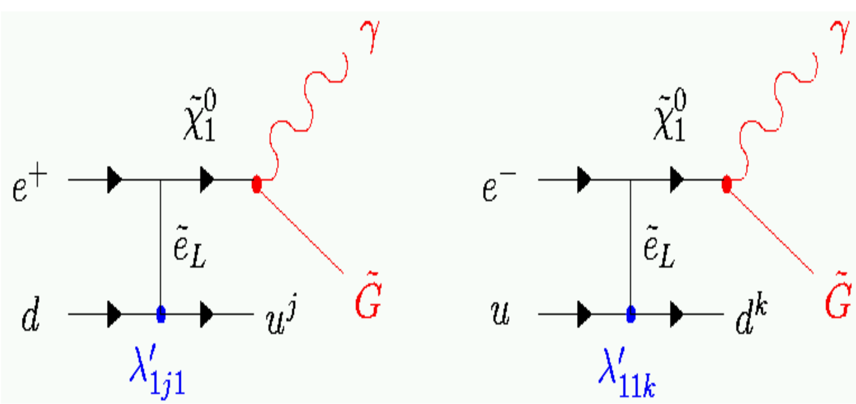
production

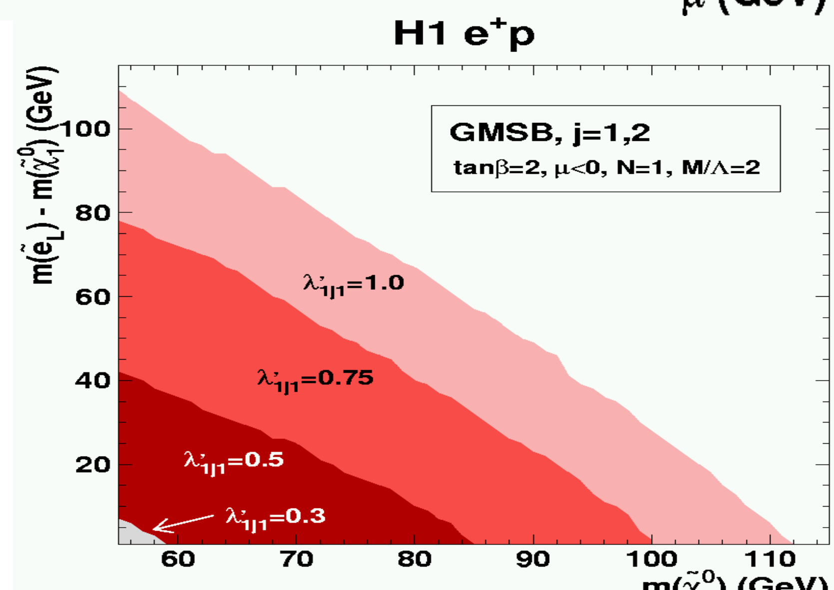
RPV neutralino decay

uses discrimant



- GMSB: $M_{squark} >> M_{sleptons}$ + light gravitino





clean signature

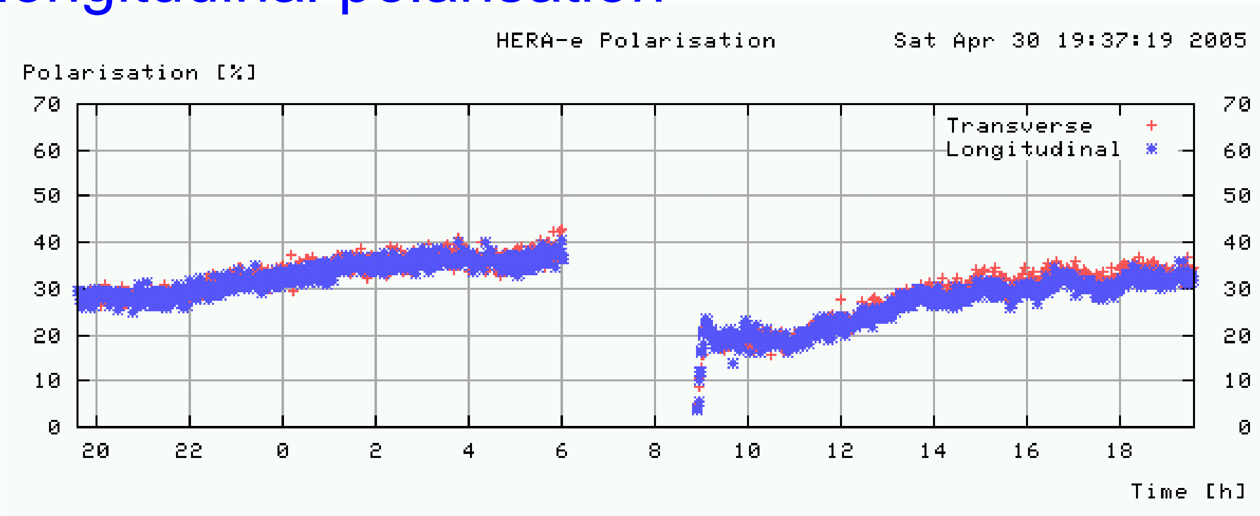
HERA Summary

- Many interesting new results and puzzling excesses (H1)
- Results often competitive and complementary to LEP/Tevatron
- HERA II has become a high luminosity machine

➔ More interesting HERA results expected in near future by exploiting :

  ➔ different lepton beam charges and

  ➔ longitudinal polarisation



Backup: Isolated Lepton Events

H1 $e^{\pm}p$ Results 1994-2005

H1 1994-2005 $L(e^{\pm}p)$=192 pb^{-1}	electron obs./exp.	muon obs./exp.	combined obs./exp.
Full Sample p_T^X > 25 GeV	25 / 18.3 ± 2.5 11 / 3.0 ± 0.6	9 / 4.8 ± 0.8 6 / 3.0 ± 0.6	34 / 23.1 ± 3.2 17 / 6.0 ± 1.1

H1 $e^{+}p$ Results 1994-98,1999-2004

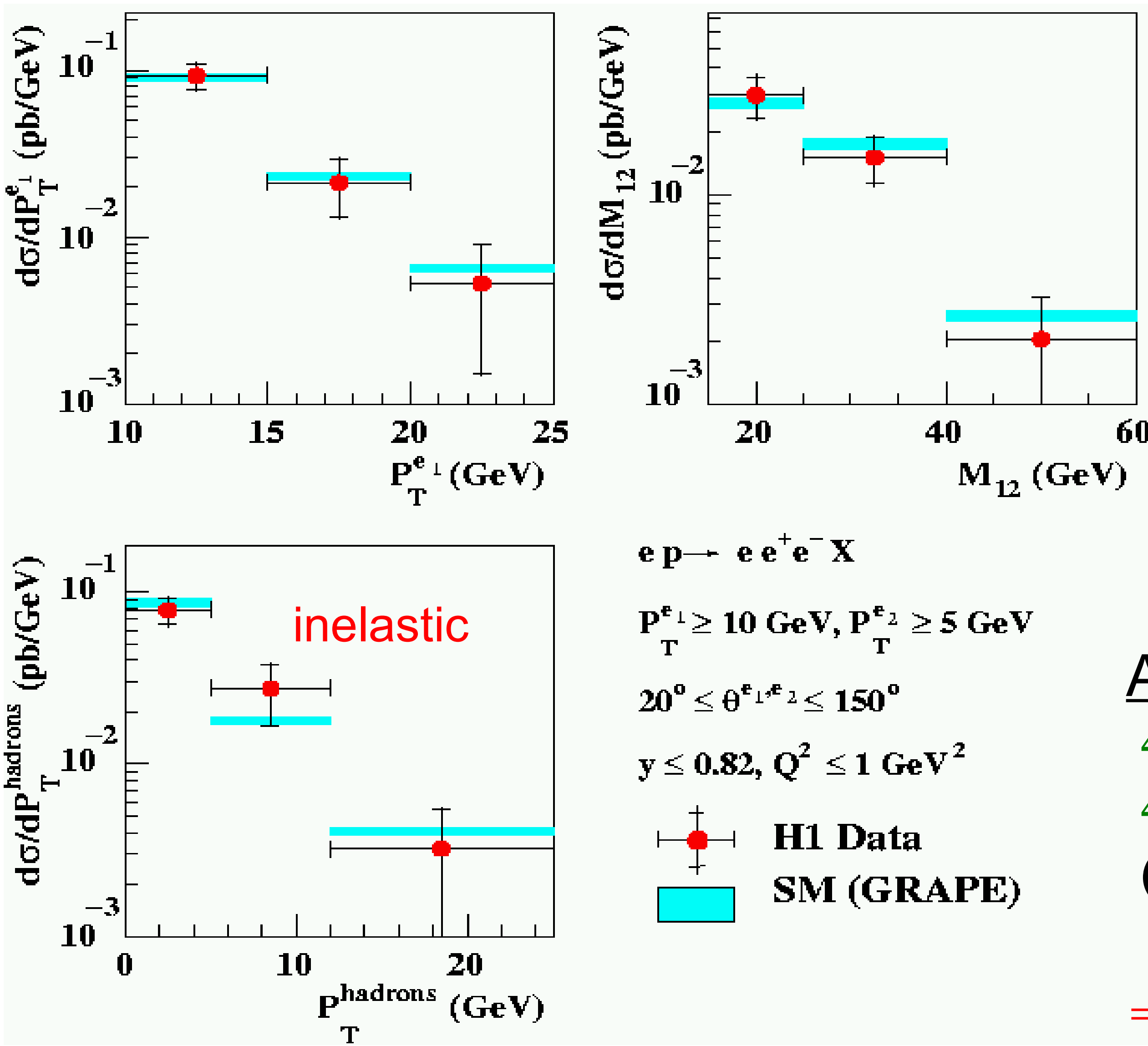
H1 94-98,99-04 $L(e^{\pm}p)$=157 pb^{-1}	electron obs./exp.	muon obs./exp.	combined obs./exp.
Full Sample p_T^X > 25 GeV	19 / 14.6 ± 2.1 9 / 2.3 ± 0.4	9 / 3.9 ± 0.6 6 / 2.3 ± 0.4	28 / 18.5 ± 2.7 15 / 4.6 ± 0.8

H1 $e^{-}p$ Results 1998/99,2005

H1 98/99,2005 $L(e^{\pm}p)$=35 pb^{-1}	electron obs./exp.	muon obs./exp.	combined obs./exp.
Full Sample p_T^X > 25 GeV	6 / 3.9 ± 0.6 2 / 0.7 ± 0.1	0 / 1.0 ± 0.2 0 / 0.7 ± 0.1	6 / 4.8 ± 0.7 2 / 1.4 ± 0.2

Backup: Cross Check Analysis

process: $\gamma\gamma \rightarrow e^+ e^-$ opposite charges, $E\text{-}p_z < 45$ GeV



<u>After selection:</u>

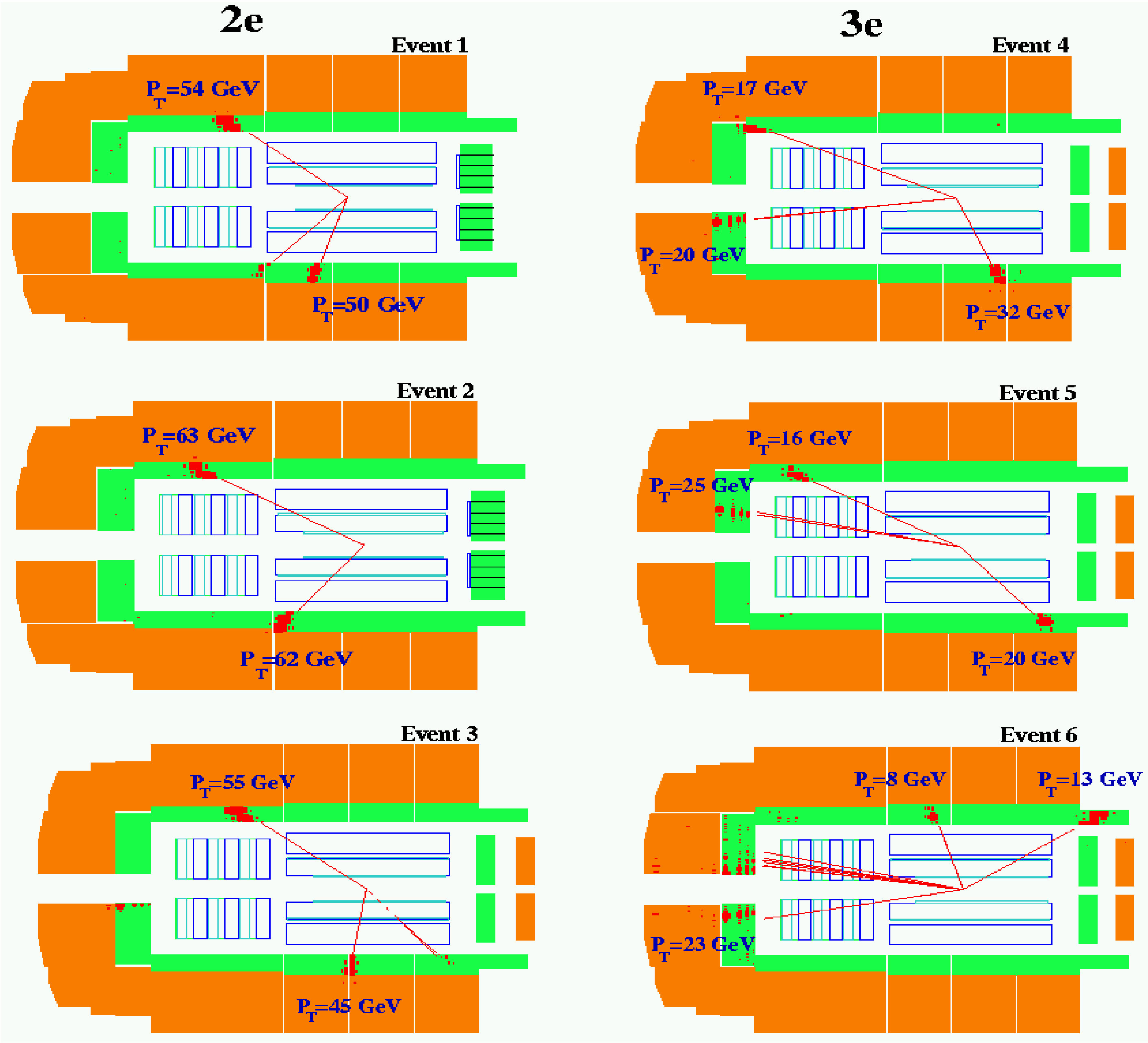
42 data

44.9 ± 4.2 MC

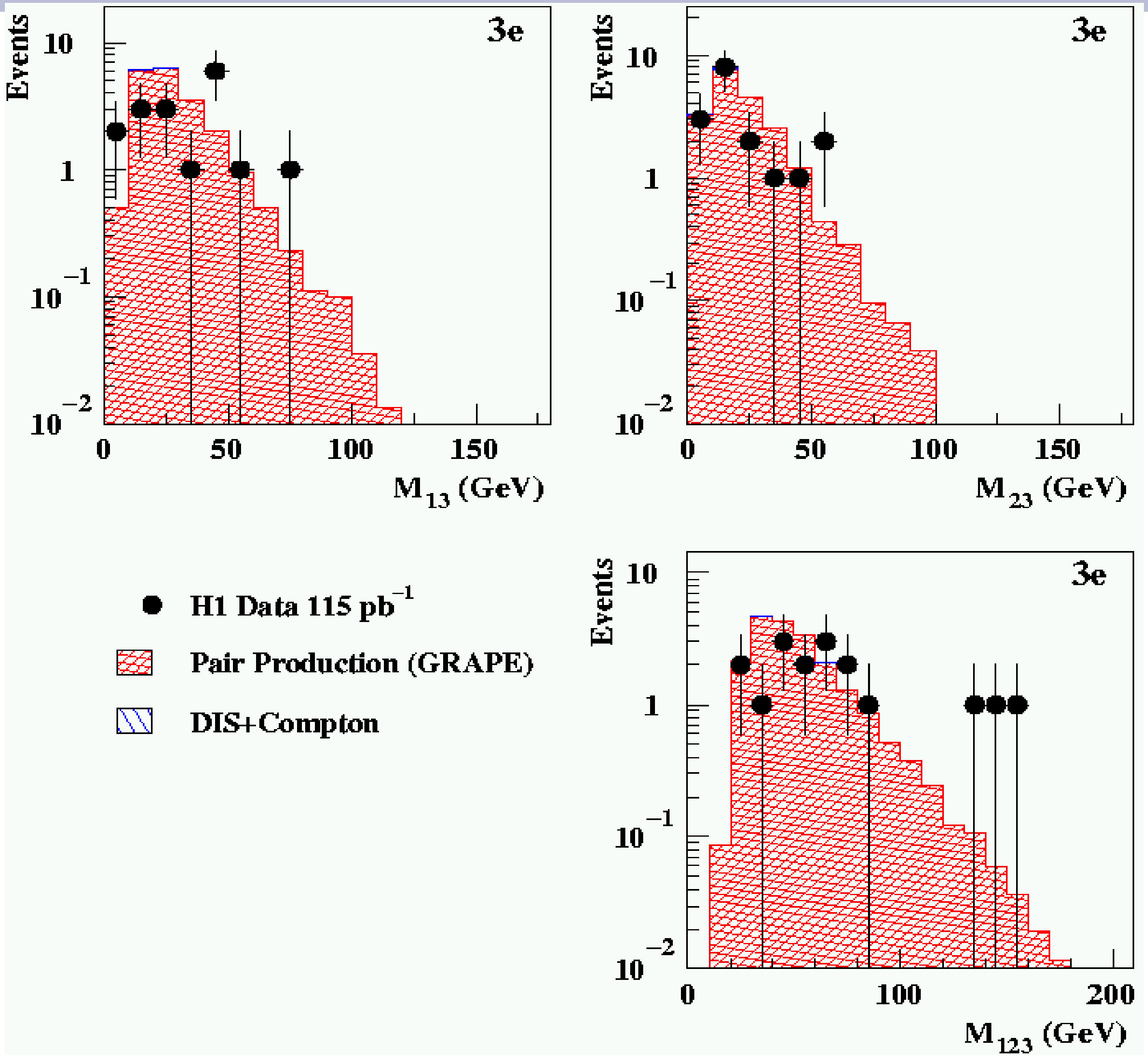
(1.2 ± 0.4 background)

$\Rightarrow$ good agreement

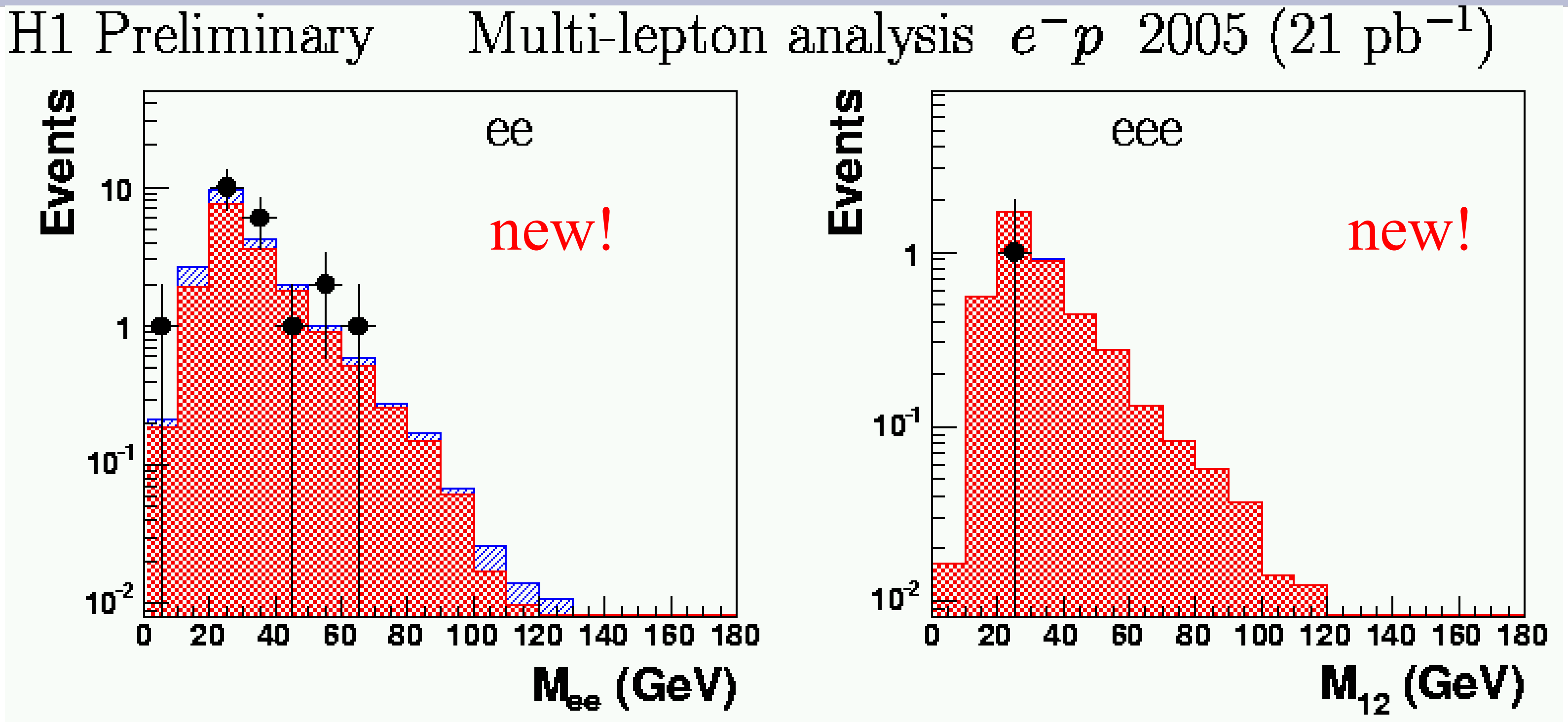
Backup: Multi-Electrons Events



Backup: Tri-electron HERA I



Backup: Multi- e 04/05 Preliminary



2004-2005 e^-p (Preliminary)

(HERA 04/05)	data(L=21 pb^{-1})	SM	Pair Production (Grape)
ee	21	21.1 ± 1.9	17.2
eμ	8	10.8 ± 2.5	6.6
eee	1	4.2 ± 0.7	4.2
eμμ	6	5.4 ± 0.9	5.4

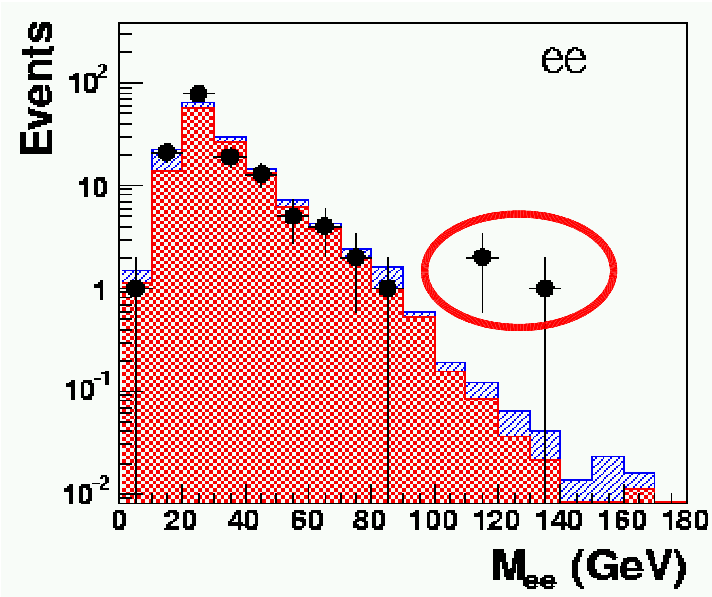
$\Sigma E_T > 100$ GeV: 0 data for 0.08±0.008 expected

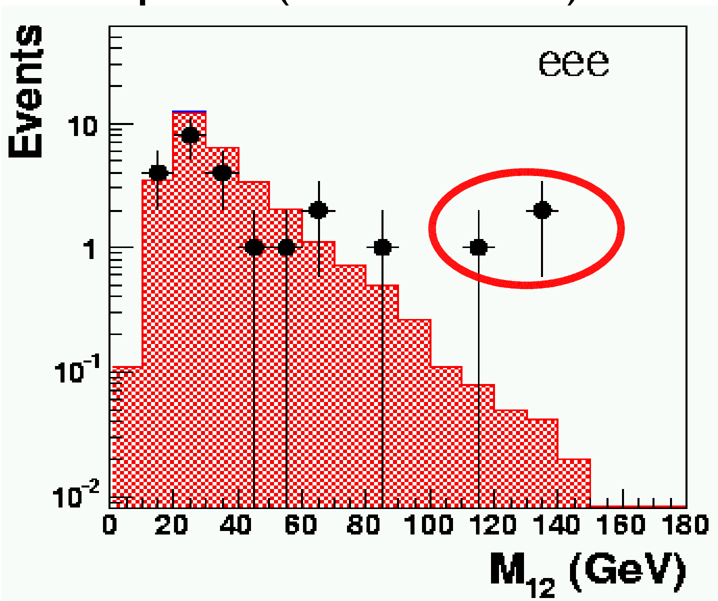
no event for M>100 GeV

⇒ no new high mass events

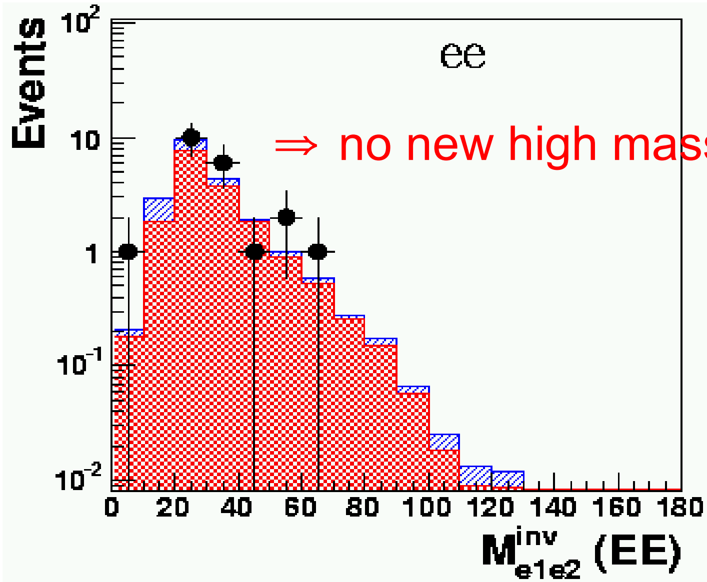
Backup: Multi-e All Recent Numbers

1996-2004 $e^{\pm}p$ L=163pb^{-1} (ICHEP 04)

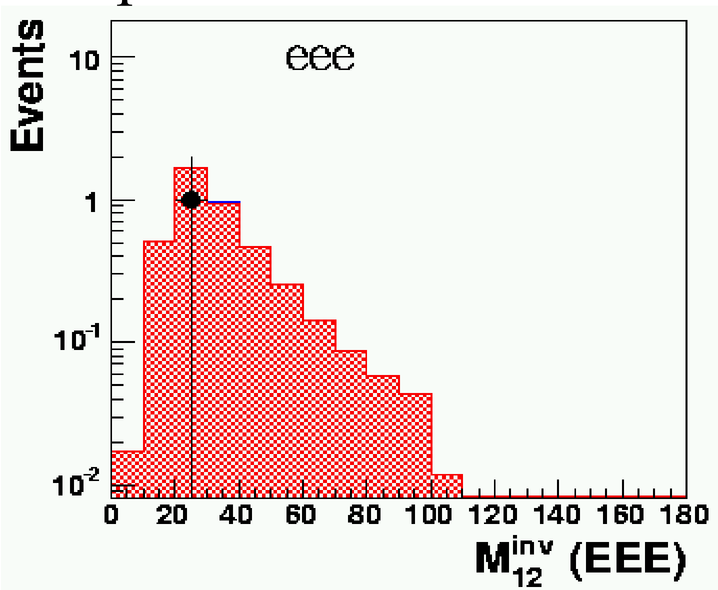




2004-2005 $e^{-}p$ L=22pb^{-1} new!



⇒ no new high mass events



Backup: HERA I+II Results (ICHEP 04)

1996-2004 $e^{\pm}p$ All

(HERA I+II)	data(L=163 pb^{-1})	SM	Pair Production (Grape)
ee	147	149.8 ± 24.8	125.5
μμ	66	63.7 ±12.7	63.7
eμ	86	78.4 ± 12.0	46.4
eee	24	30.4 ± 3.9	30.4
eμμ	41	39.5 ± 6.5	39.5

⇒ good agreement with SM

1996-2004 $e^{\pm}p$ M>100 GeV

(HERA I+II)	data(L=163 pb^{-1})	SM	Pair Production (Grape)
ee M_{12}>100 GeV	3	0.4 ± 0.1	0.32
μμ M_{12}>100 GeV	0	0.04 ± 0.02	0.04
eμ M_{12}>100 GeV	0	0.31 ± 0.03	0.01
eee M_{12}>100 GeV	3	0.04 ± 0.02	0.31
eμμ $M_{e\mu}$>100 GeV	1	0.04 ± 0.01	0.04
eμμ $M_{\mu\mu}$>100 GeV	1	0.02 ± 0.01	0.02

⇒ multi-electrons excess

Backup: Multi-e All Recent Numbers

1996-2004 e^+p (e^-p) All

(HERA I+II)	data(L=163 pb^{-1})	SM	Pair Production (Grape)
ee	147	149.8 ± 24.8	125.5
μμ	66	63.7 ±12.7	63.7
eμ	86	78.4 ± 12.0	46.4
eee	24	30.4 ± 3.9	30.4
eμμ	41	39.5 ± 6.5	39.5

⇒ good agreement with SM

2004-2005 e^-p All

(HERA I+II)	data(L=21 pb^{-1})	SM	Pair Production (Grape)
ee	21	21.1 ± 1.9	17.2
eμ	8	10.8 ± 2.5	6.6
eee	1	4.2 ± 0.7	4.2
eμμ	6	5.4 ± 0.9	5.4

$\Sigma E_T > 100$ GeV: 0 data for 0.08±0.008 expected

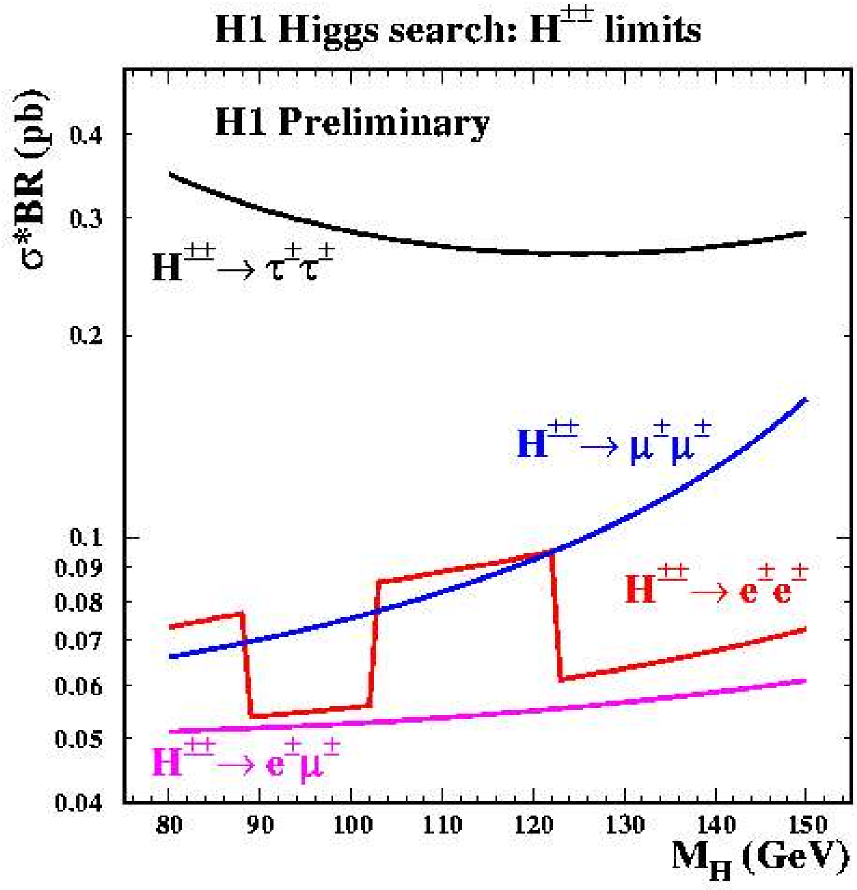
M>100 GeV: 0 data

⇒ also consistent with SM

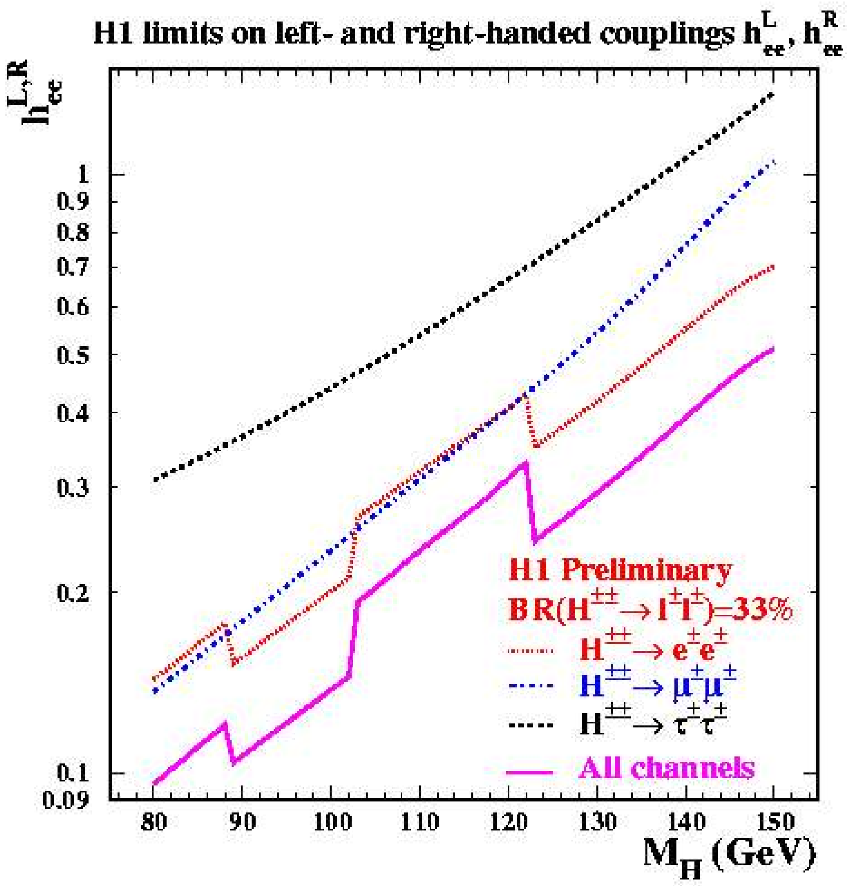
Backup: Doubly Charged Higgs

HERA I 1996-2000

Sigma x Branching Ratio

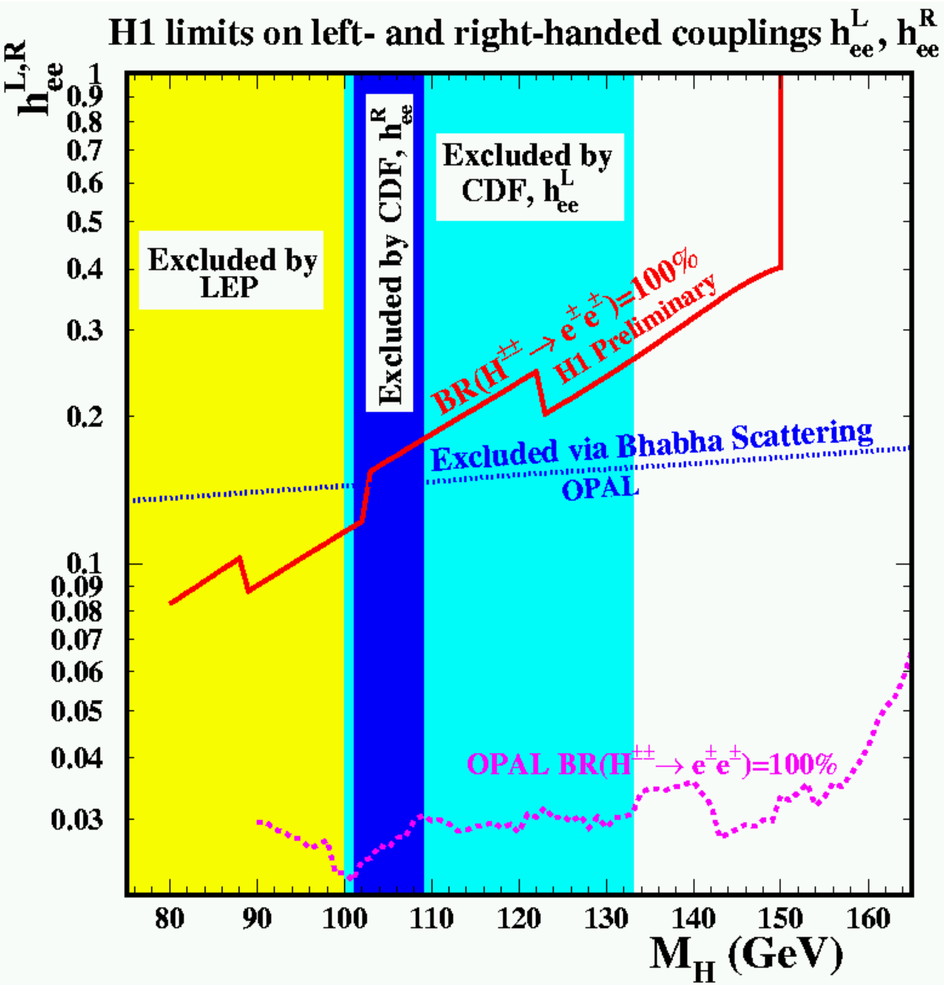


Democratic Couplings



Backup: Doubly Charged Higgs

HERA I 1996-2000

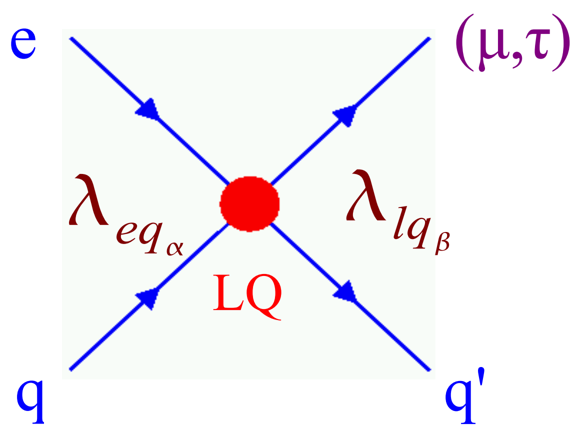


⇒ excess of high mass multi-electrons cannot be explained by doubly charged Higgs hypothesis

Backup: Lepton Flavor Violation

ZEUS Collab., DESY-05-016 (1/2005), submitted to EPJ

- <u>high mass limit M > s:</u>



four fermion contact IA

- α,β generation indices
- limits set on (1/TeV²):

$$\frac{\lambda_{eq_\alpha}\lambda_{lq_\beta}}{M^2_{LQ}}$$

e → τ ZEUS $e^\pm p$ 94-00 F=0

$\alpha\beta$	$S^L_{1/2}$ $e^-\bar u$ e^+u	$S^R_{1/2}$ $e^-(\bar u+\bar d)$ $e^+(u+d)$	$\tilde S^L_{1/2}$ $e^-\bar d$ e^+d	V^L_0 $e^-\bar d$ e^+d	V^R_0 $e^-\bar d$ e^+d	$\tilde V^R_0$ $e^-\bar u$ e^+u	V^L_1 $e^-(\sqrt{2}\bar u+\bar d)$ $e^+(\sqrt{2}u+d)$
1 1	$\tau\to\pi e$ 0.4 1.8	$\tau\to\pi e$ 0.2 1.5	$\tau\to\pi e$ 0.4 2.7	$\tau\to\pi e$ 0.2 1.7	$\tau\to\pi e$ 0.2 1.7	$\tau\to\pi e$ 0.2 1.3	$\tau\to\pi e$ 0.06 0.6
1 2	1.9	$\tau\to Ke$ 6.3 1.6	$K\to\pi\nu\bar\nu$ 5.8×10^{-4} 2.9	$\tau\to Ke$ 3.2 2.1	$\tau\to Ke$ 3.2 2.1	1.6	$K\to\pi\nu\bar\nu$ 1.5×10^{-4} 0.8
1 3	*	$B\to\tau\bar e$ 0.3 3.2	$B\to\tau\bar e$ 0.3 3.3	$B\to\tau\bar e$ 0.13 2.6	$B\to\tau\bar e$ 0.13 2.6	*	$B\to\tau\bar e$ 0.13 2.6
2 1	6.0	$\tau\to Ke$ 6.3 4.1	$K\to\pi\nu\bar\nu$ 5.8×10^{-4} 5.2	$\tau\to Ke$ 3.2 2.3	$\tau\to Ke$ 3.2 2.3	2.1	$K\to\pi\nu\bar\nu$ 1.5×10^{-4} 0.9
2 2	$\tau\to 3e$ 5 10	$\tau\to 3e$ 8 5.6	$\tau\to 3e$ 17 6.5	$\tau\to 3e$ 9 3.4	$\tau\to 3e$ 9 3.4	$\tau\to 3e$ 3 5.5	$\tau\to 3e$ 1.6 2.1
2 3	*	$B\to\tau\bar eX$ 14 8.1	$B\to\tau\bar eX$ 14 7.8	$B\to\tau\bar eX$ 7.2 5.5	$B\to\tau\bar eX$ 7.2 5.5	*	$B\to\tau\bar eX$ 7.2 5.5
3 1	*	$B\to\tau\bar e$ 0.3 7.8	$B\to\tau\bar e$ 0.3 7.2	V_{ub} 0.12 2.5	$B\to\tau\bar e$ 0.13 2.5	*	V_{ub} 0.12 2.5
3 2	*	$B\to\tau\bar eX$ 14 11	$B\to\tau\bar eX$ 14 10	$B\to\tau\bar eX$ 7.2 4.2	$B\to\tau\bar eX$ 7.2 4.2	*	$B\to\tau\bar eX$ 7.2 4.2
3 3	*	$\tau\to 3e$ 8 15	$\tau\to 3e$ 17 14	$\tau\to 3e$ 9 8.1	$\tau\to 3e$ 9 8.1	*	$\tau\to 3e$ 1.6 8.1

Backup: RPV SQUARKS (mSUGRA)