EXOTICS AND HIGH Q^2 AT THERA

THERA MEETING
15/04/00

M. KUZE (KEK)
K. LONG (IC LONDON)
E. PEREZ (SACLAY)

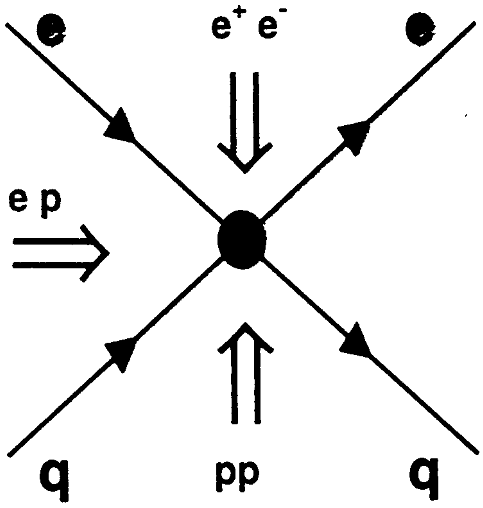
- CONTACT INTERACTIONS
- LEPTOQUARKS

STUDY PERFORMED BY A.F. ZARNECKI (WARSAW)

- R-PARITY VIOLATING SUSY
  (case of light $\tilde{b}$ and $\tilde{t}$)
- EXCITED FERMIONS
- SINGLE TOP PRODUCTION
- W PRODUCTION D. WATERS (OXFORD)

Contact Interactions

- "New Physics" processes (new bosons, compositeness) with characteristic E scale $\gg \sqrt{S}$: parametrised as a Contact Interaction :



Only Vector Terms considered :

$\mathcal{L}_{CI} = \Sigma \quad \eta_{ij}^{eq} (\bar{e}_i \gamma^\mu e_i)(\bar{q}_j \gamma_\mu q_j)$

$(i, j = L, R)$

η can be $= 0$, > 0 or < 0

Same formalism can be used in ep, e^+e^- and $p\bar{p}$ collisions

- CI interfere with Deep Inelastic Scattering (DIS)

$$\boxed{\mid \text{CI} \mid^2 + \text{Interference} \Longrightarrow \text{CI affect } d\sigma/dQ^2 \text{ (and } d\sigma/dx)}$$

Look for distorsion of Q^2 spectrum, set limits on Λ with $\eta = \pm 4\pi/\Lambda^2$

- Several Models considered (combinations of non vanishing η's) :

$VV, AA, VA \Rightarrow$ vector or axial currents
$LL, RR, LR, RL \Rightarrow$ pure chiral couplings
$U_i \Rightarrow$ 2 $\eta_{\alpha\beta}^{eu} \neq 0$, P conserving combinations
$X_i \Rightarrow$ same as U_i with $\eta_{\alpha\beta}^{eu} = \eta_{\alpha\beta}^{ed}$

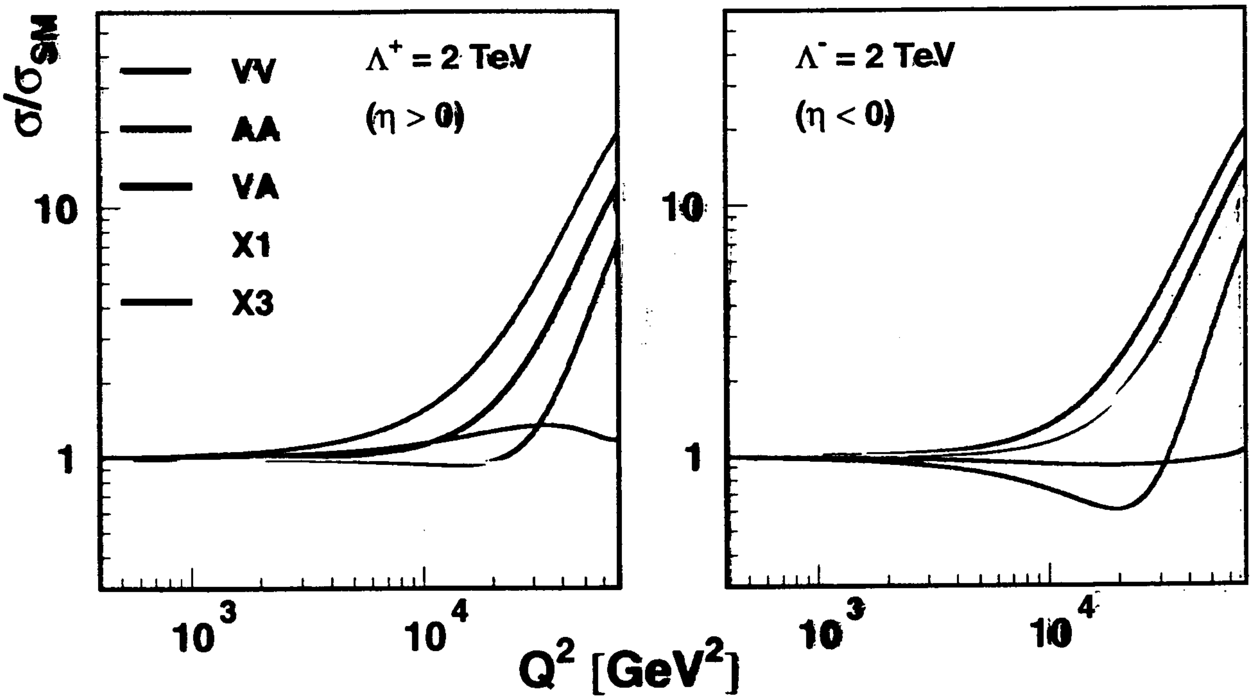
- Results can be translated into upper limits on heavy 1^{rst} generation LQs ($M_{LQ} \gg \sqrt{s}$) or on quark radius

- Can be used to look for virtual exchange of Kaluza-Klein modes of gravitons in models with large extra-dimensions

Contact Interactions

Illustration of the deformation of Q^2 spectrum in the HERA regime :

A.F. Zarnecki



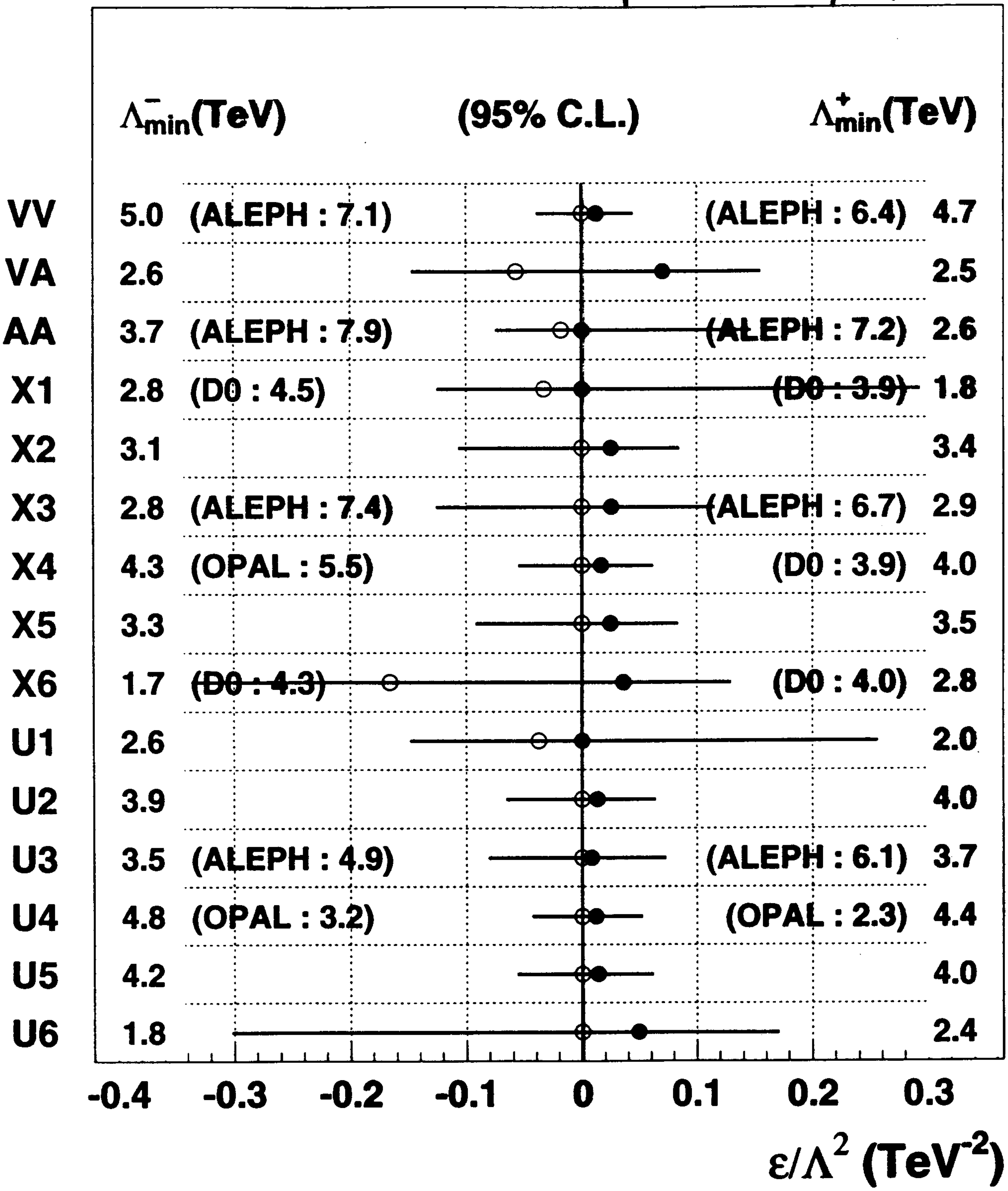
→ SENSITIVITY ON SCALE Λ (OR $\eta \hat{=} \pm 4\pi/\Lambda^2$)

OBTAINED VIA e.g. LOG-LIKELIHOOD OR

χ^2 FIT OF $d\sigma/dQ^2$

Contact Interactions : Status (EPS'99)

ZEUS 94-97 e^+p (~40 pb^{-1})



- CURRENT HERA LIMITS RANGE FROM 1.7 TeV TO 5 TeV
- NB: LEP RELIES ON FLAVOR SYMMETRY HYPOTHESIS

Contact Interactions : Prospects

A.F. Zarnecki

GLOBAL ANALYSIS BY A. ZARNECKI (EPJ C, Vol 11, (1999) 539.)
updated analysis with recent data (c ν and CC DIS)

CI Model	Current limits Global analysis		Future limits			
			HERA		TERA	
	Λ^- [TeV]	Λ^+ [TeV]	Λ^- [TeV]	Λ^+ [TeV]	Λ^- [TeV]	Λ^+ [TeV]
d_{LL}	23.4	8.6	3.0±0.4	2.6±0.5	7.1±1.2	5.8±1.3
d_{LR}	19.7	7.8	2.7±0.3	2.0±0.2	4.2±0.5	3.7±0.3
d_{RL}	7.7	20.5	2.1±0.2	2.5±0.3	3.6±0.3	4.2±0.5
d_{RR}	9.1	17.6	2.5±0.3	1.8±0.2	5.8±0.8	4.5±0.4
u_{LL}	14.9	11.5	5.2±0.9	5.2±0.9	9.6±2.1	10.2±1.8
u_{LR}	17.0	8.1	4.8±1.0	5.1±0.9	3.9±0.4	4.9±0.7
u_{RL}	7.4	18.4	3.7±0.8	4.4±0.7	4.0±0.4	4.5±0.5
u_{RR}	7.2	21.3	4.5±0.8	4.7±0.8	$\boxed{7.5\pm1.9}$	9.1±1.5
q_{LL}	26.2	11.3	4.0±1.0	4.6±0.8	5.3±0.5	8.8±1.3
q_{LR}	26.0	11.0	3.5±1.1	4.8±0.8	4.5±0.4	5.2±0.6
q_{RL}	10.6	27.5	3.3±0.9	4.6±0.7	4.4±0.4	5.4±0.7
q_{RR}	10.7	27.2	3.6±0.9	4.4±0.7	5.6±0.6	8.7±1.3
VV	8.3	14.5	7.6±1.4	7.8±1.3	$\boxed{8.6\pm2.8}$	12.3±2.1
AA	11.2	10.8	6.9±1.3	6.7±1.3	6.3±0.3	$\boxed{11.3\pm1.7}$
VA	5.8	6.3	4.1±0.4	4.0±0.4	$\boxed{8.2\pm0.8}$	$\boxed{8.5\pm0.9}$
$X1$	8.5	8.6	5.1±0.9	4.8±0.9	5.6±0.3	$\boxed{8.9\pm1.3}$
$X2$	6.7	10.8	5.1±1.1	5.7±0.9	5.7±0.7	9.5±1.5
$X3$	8.8	12.0	5.9±1.1	6.2±1.1	7.8±2.5	11.5±1.9
$X4$	6.2	10.0	5.9±1.3	6.4±1.1	5.2±0.4	6.6±0.8
$X5$	5.6	9.1	5.1±1.1	5.7±0.9	$\boxed{5.8\pm0.6}$	$\boxed{9.2\pm1.4}$
$X6$	6.8	5.4	4.5±0.9	4.8±0.8	$\boxed{8.6\pm1.2}$	$\boxed{5.8\pm0.4}$
$U1$	6.3	13.0	5.6±1.0	5.5±1.1	$\boxed{8.0\pm2.5}$	9.8±1.7
$U2$	7.3	15.6	6.0±1.0	6.0±1.0	$\boxed{9.8\pm2.2}$	10.5±1.9
$U3$	8.9	19.8	7.0±1.2	6.9±1.2	$\boxed{13.2\pm2.7}$	13.2±2.4
$U4$	5.2	8.5	6.4±1.2	6.5±1.1	4.7±0.5	6.0±0.8
$U5$	6.9	14.9	6.0±1.1	6.1±1.0	8.4±2.0	9.8±1.7
$U6$	11.9	5.8	4.7±0.9	4.9±0.9	9.0±1.5	6.1±1.6

$\not{P}$

P

HERA: 400 pb^{-1} e^-p
+ 400 pb^{-1} e^+p

THERA e^-p
500 × 1000 GeV
$\mathcal{L}$ = 100 pb^{-1}

- FOR MODELS VIOLATING PARITY: LIMITS FROM GLOBAL ANALYSIS ALREADY BETTER THAN LIMITS EXPECTED FROM HERA AND THERA
  → DUE TO VERY PRECISE APV MEASUREMENTS

- FOR MODELS CONSERVING PARITY

→ POSSIBLE DISCOVERY AT THERA IN MANY MODELS !

→ THERA CAN IMPROVE LIMITS FROM THE GLOBAL ANALYSIS IN 12 CASES OUT OF 30 ! (NB: limits in 10 years ?)

NB: FOR SOME MODELS, HERA WITH $2 \times 400\ pb^{-1}$ (e^- and e^+) DOES BETTER:
DUE TO HIGHER SENSITIVITY WITH e^+ IN THESE MODELS

$\boxed{\Lambda \text{ UP TO } \sim 14 \text{ TeV CAN BE PROBED AT THERA}}$

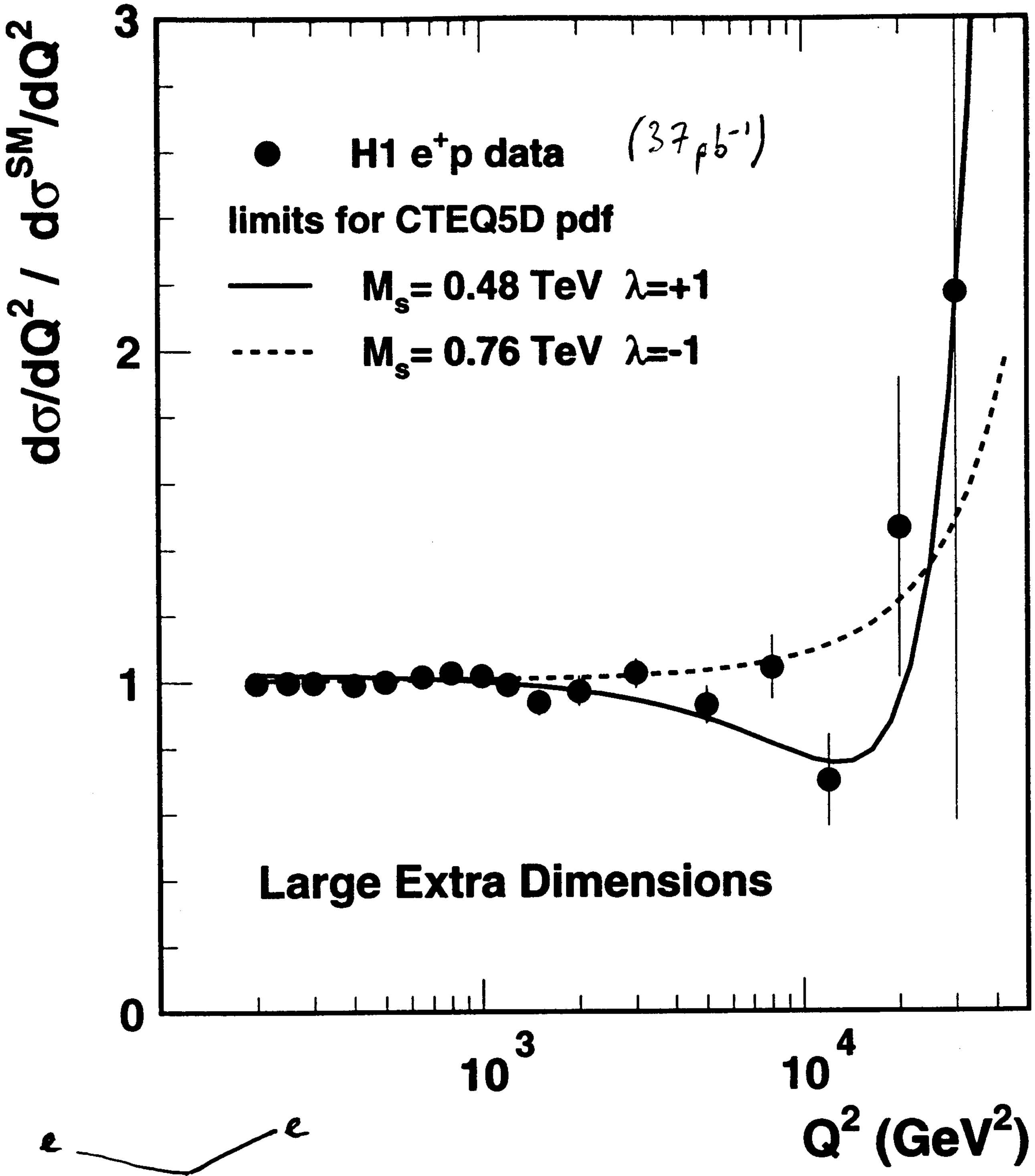
CRUDE ESTIMATE OF UPPER LIMIT ON QUARK RADIUS:

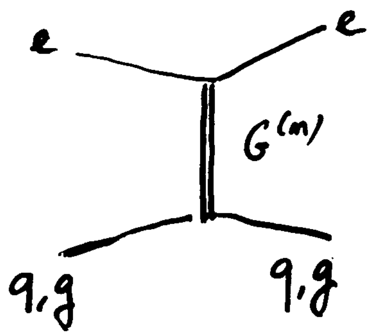
$R_q < \sim 5.\,10^{-17}$ cm

(complain to the speaker if this happens to be wrong...)

close to best indirect limit obtained from combined precise measurements of LEP and SLC (DESY 94-148, Spira, Zerwas et al)

Large Extra-Dimensions





C.i. ANALYSIS USED TO CONSTRAIN VIRTUAL EXCHANGES OF KALUZA KLEIN EXCITATIONS OF GRAVITONS IN MODELS WITH LARGE E-DIM (ADD)

REACH FOR THERA → NEXT MEETING H.U. MARTYN, J. SCHEINS
BUT WILL BE SEVERELY CONSTRAINED BY LHC...

Leptoquarks : BRW Model

$F=-2$	Prod./decay	$\beta(e^+q)$	$F=0$	Prod./decay	$\beta(e^+q)$
			Scalar Leptoquarks		
$^{1/3}S_0$	$e^+_R\bar{u}_R \to e^+\bar{u}$	1/2	$^{5/3}S_{1/2}$	$e^+_R u_R \to e^+u$	1
	$e^+_L\bar{u}_L \to e^+\bar{u}$	1		$e^+_L u_L \to e^+u$	1
$^{4/3}\tilde{S}_0$	$e^+_L\bar{d}_L \to e^+\bar{d}$	1	$^{2/3}S_{1/2}$	$e^+_L d_L \to e^+d$	1
$^{4/3}S_1$	$e^+_R\bar{d}_R \to e^+\bar{d}$	1	$^{2/3}\tilde{S}_{1/2}$	$e^+_R d_R \to e^+d$	1
$^{1/3}S_1$	$e^+_R\bar{u}_R \to e^+\bar{u}$	1/2			
			Vector Leptoquarks		
$^{4/3}V_{1/2}$	$e^+_L\bar{d}_R \to e^+\bar{d}$	1	$^{2/3}V_0$	$e^+_L d_L \to e^+d$	1
	$e^+_R\bar{d}_L \to e^+\bar{d}$	1		$e^+_R d_R \to e^+d$	1/2
$^{1/3}V_{1/2}$	$e^+_L\bar{u}_R \to e^+\bar{u}$	1	$^{5/3}\tilde{V}_0$	$e^+_L u_R \to e^+u$	1
$^{1/3}\tilde{V}_{1/2}$	$e^+_R\bar{u}_L \to e^+\bar{u}$	1	$^{5/3}V_1$	$e^+_R u_L \to e^+u$	1
			$^{2/3}V_1$	$e^+_R d_L \to e^+d$	1/2

Classification by Buchmüller-Rückl-Wyler (Phys. Lett. B191 (1987) 442., *Erratum* Phys. Lett. B448 (1999) 320.) under the following assumptions :

- gauge symmetry $SU(3)\times SU(2)\times U(1)$ (must be !)
- renormalizable interactions (must be !)
- L and B conserving (proton decay ..)
- pure chiral couplings (helicity suppressed π decays...)
- family diagonal (FCNC ...)
- couple only to SM fermions and gauge bosons (strong !)

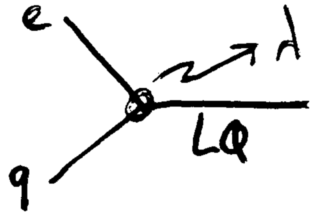
$\Longrightarrow$ 10 isospin families (5 scalars, 5 vectors)

In BRW : $\beta = BR(LQ \to e(\nu)q)$ is fixed (=1 or =0.5)

NB : Possible to relax some assumptions (see e.g. T. Rizzo)
$\Longrightarrow$ other possible decay modes, β variable

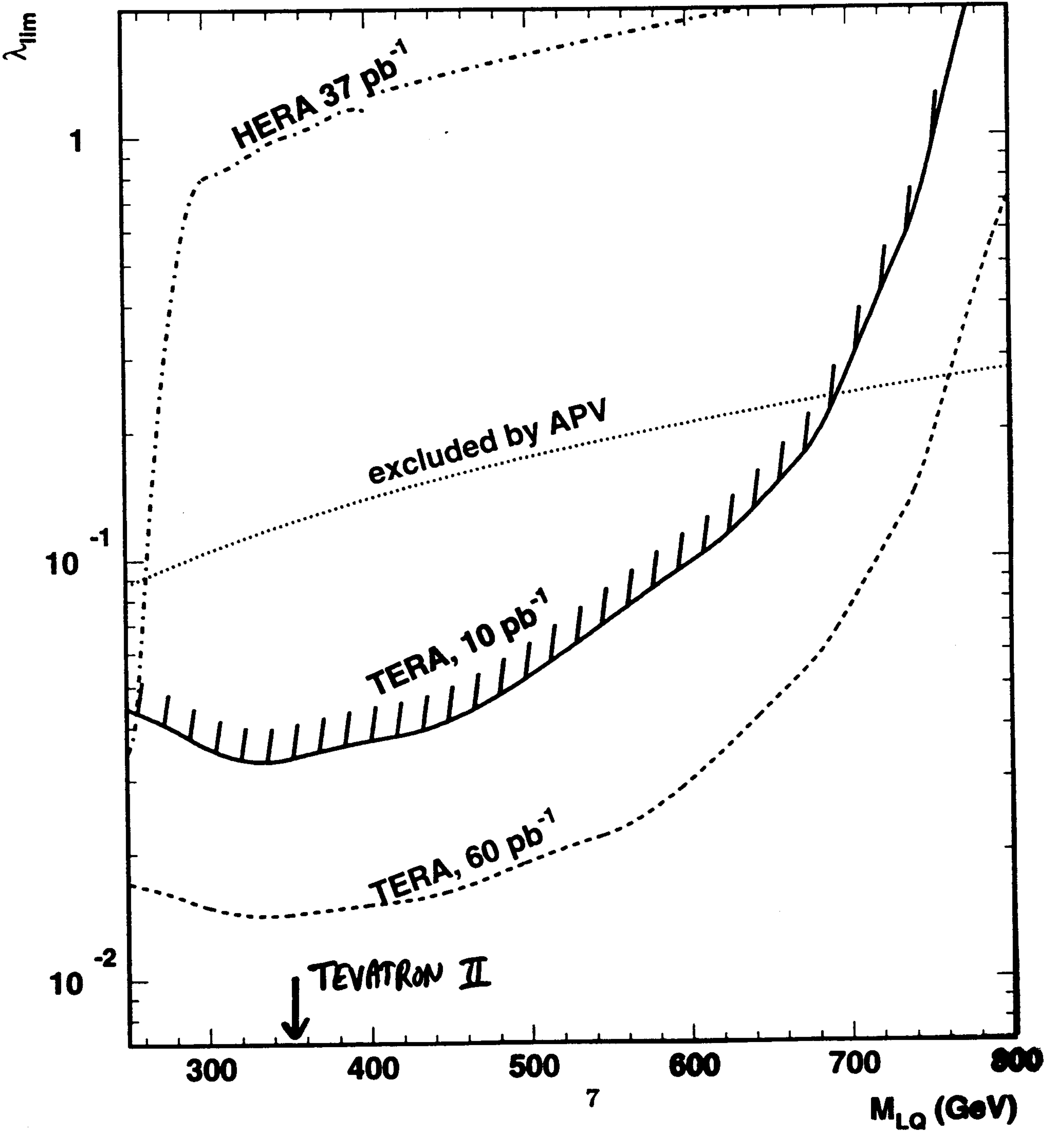
Leptoquarks : BRW Model

cf last meeting for e^+p running, at 250 × 820 GeV



250 GeV e^+ x 820 GeV p

LQ coupling to $e^+ + u$ (F = 0), $\beta_e = 1$

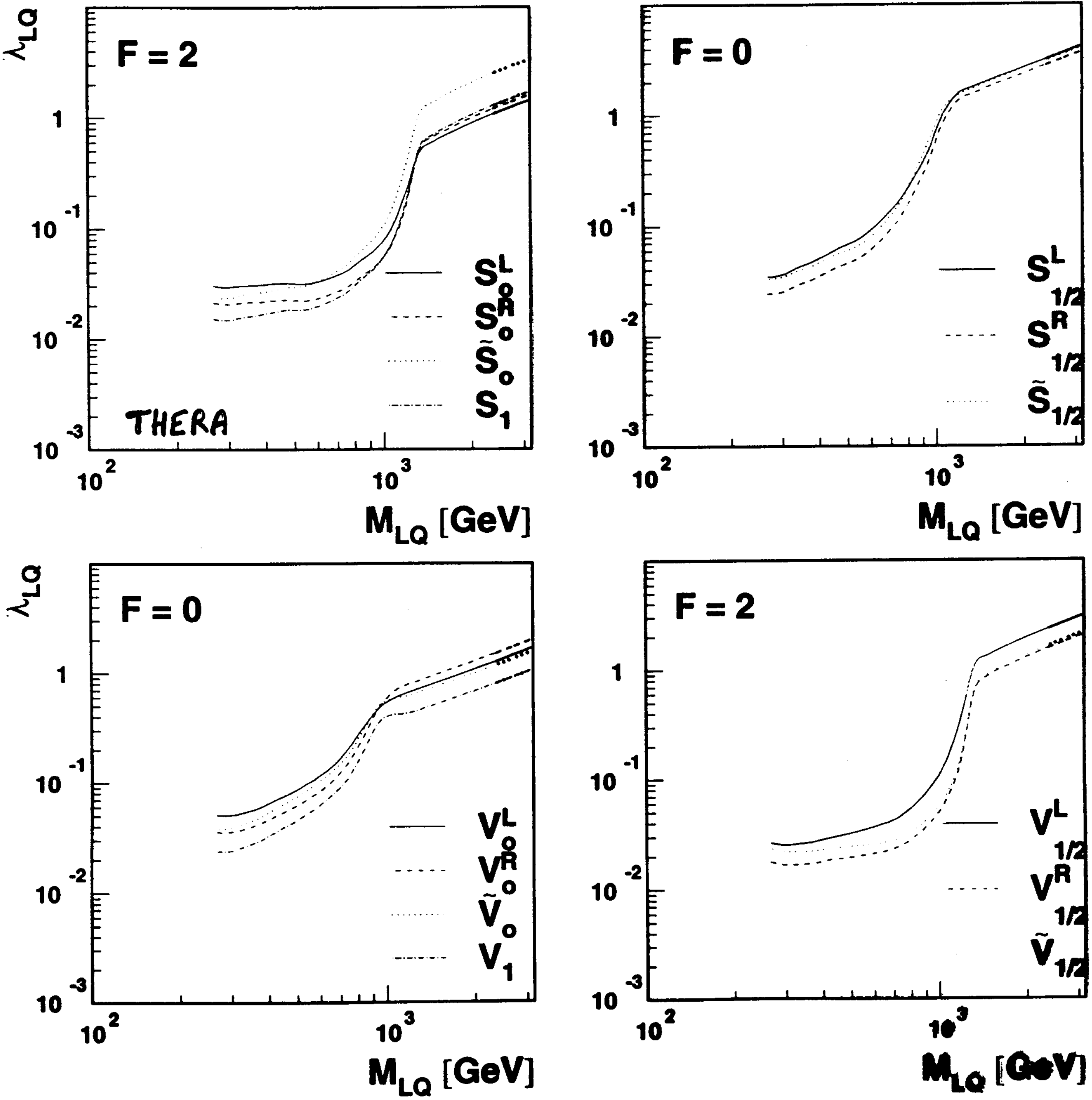


Leptoquarks : BRW Model

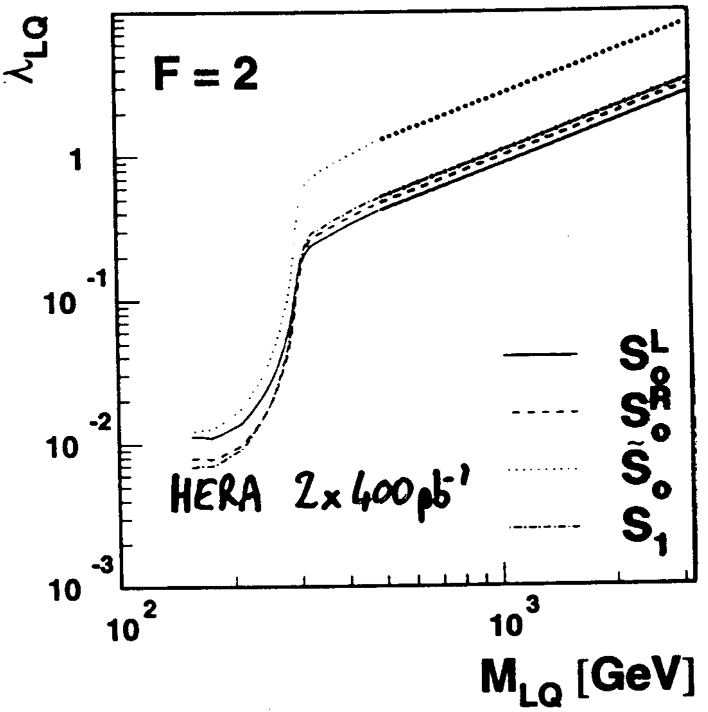
LIMITS ON BRW LQs FOR THERA, e^-p, 500 GeV x 1000 GeV
→ STUDY BY A. ZARNECKI

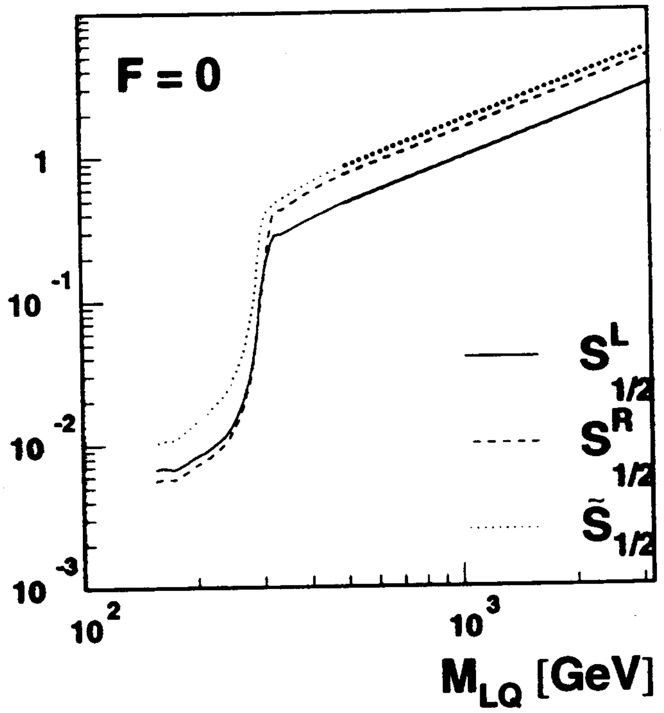
SENSITIVITY TO LQs WITH $M > \sqrt{s}$ BY VIRTUAL EXCHANGE (~ C.i.)
F=2 LQs BETTER SINCE e^-p COLLISIONS

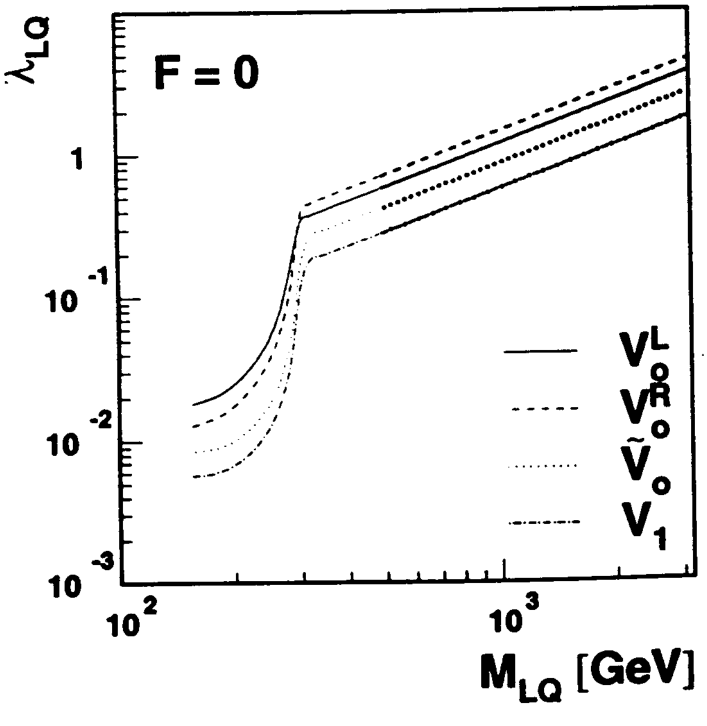
A.F. ZARNECKI

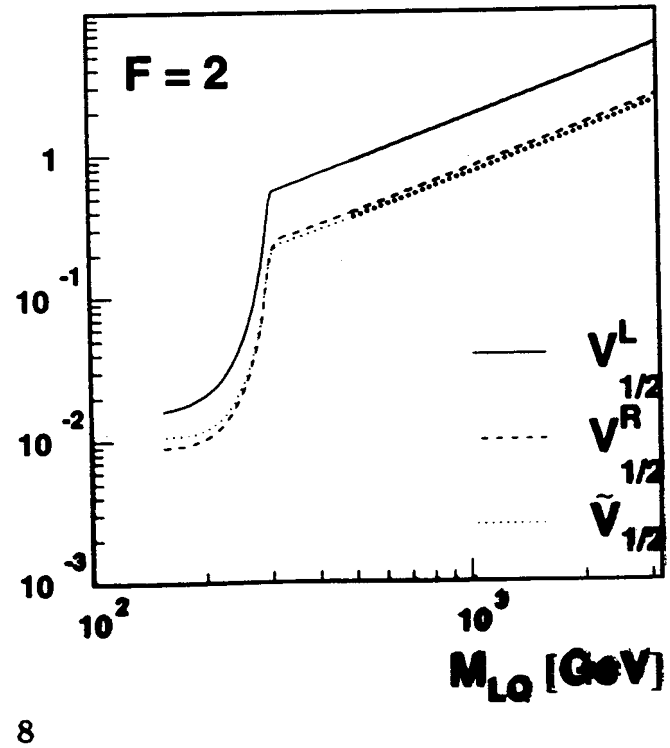


Leptoquarks : BRW Model









COMPARISON OF BOTH STUDIES FOR $M_{LQ} < \sqrt{s}$

CONFIG 1 : e^+p 250 GeV × 820 GeV $\mathcal{L} = 60\ fb^{-1}$
CONFIG 2 : e^-p 500 GeV × 1 TeV $\mathcal{L} = 100\ fb^{-1}$

- AT HIGH MASSES ($500 < M_{LQ} < 800$ GeV): BETTER LIMITS IN CONFIG 2 SINCE HIGHER $\sqrt{s}$

- FOR 300 GeV $< M_{LQ} <$ 500 GeV: ~ SAME SENSITIVITY

→ CONFIG 1 : $\sigma_{DIS}\ (Q^2 > 30\,000\ GeV^2) = 3$ pb
FOR LQ COUPLING TO e^+u, $M_{LQ} = 500$ GeV:
$$\sigma_{LQ} = \left(\frac{\lambda}{0.05}\right)^2 \times 0.72\ pb$$

→ CONFIG 2 : $\sigma_{DIS}\ (Q^2 > 30\,000\ GeV^2) = 10$ pb
(NB: ~ 7.6 pb with same energies but e^-
= EFFECT OF ⊕ γ/Z INTERFERENCE)
$$\sigma_{LQ} = \left(\frac{\lambda}{0.05}\right)^2 \times 1.26\ pb$$

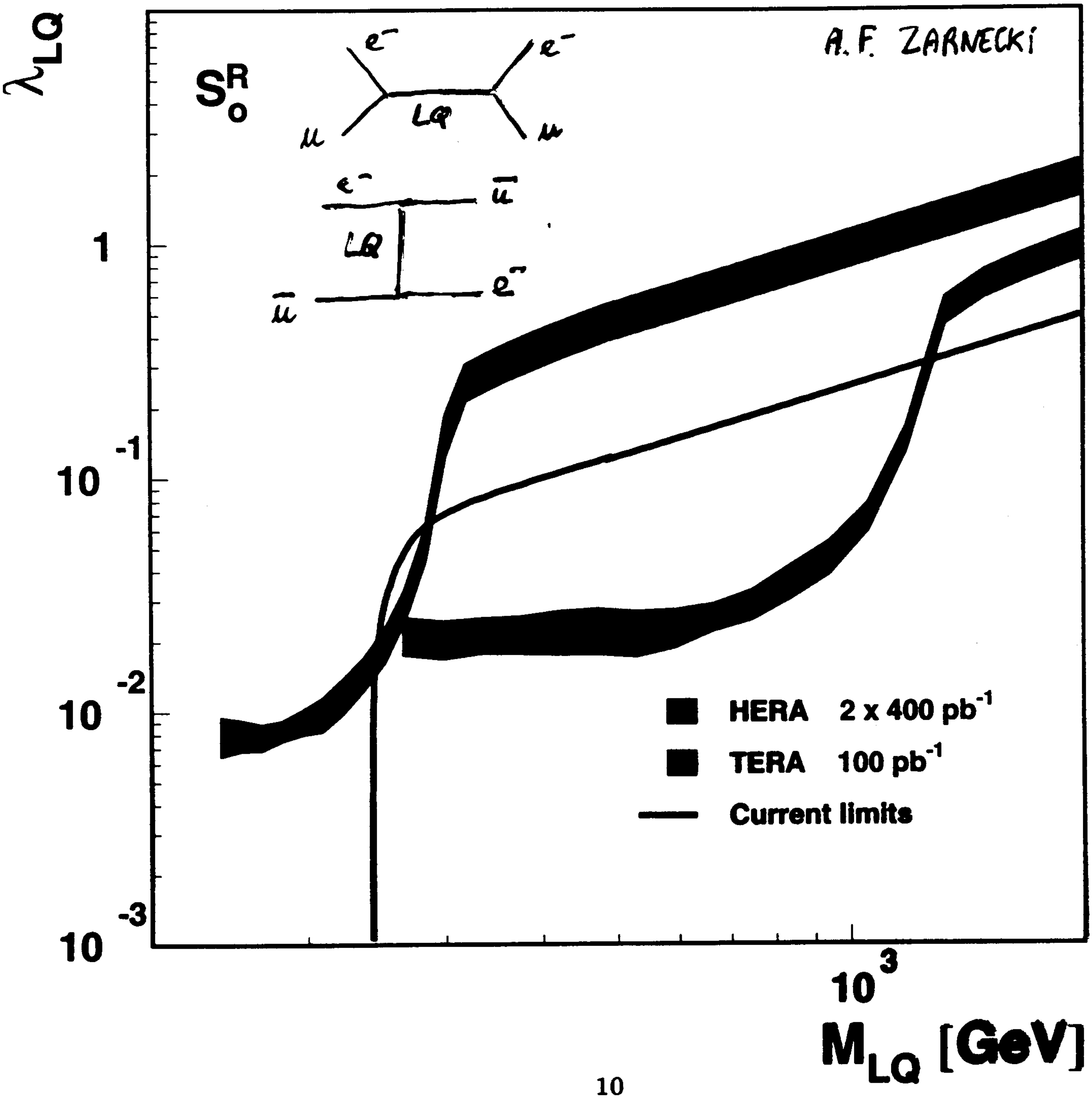
HENCE :
HIGHER σ_{LQ} IN CONFIG. 2
BUT HIGHER NC DIS BACKGROUND
BOTH EFFECTS ~ COMPENSATE

e^+p COLLISIONS PROVIDE A BETTER SENSITIVITY TO $F=0$ LQs THAN e^-p COLLISIONS FOR $|F|=2$ LQs.
DUE TO THE NEGATIVE γ/Z INTERFERENCE IN e^+p
AT HERA: DO NOT HAVE THIS EFFECT SINCE γ/Z INTERFERENCE CONTRIBUTES ONLY VERY CLOSE TO THE KINEMATIC LIMIT

Leptoquarks : BRW Model

COMPARISON OF HERA $(2\times 400\,pb^{-1})$, THERA $(e^-p,\ 500\times 1000,\ 100\,pb^{-1})$ AND CURRENT LIMITS

CURRENT LIMITS = RESULT OF GLOBAL ANALYSIS OF HERA, LEP, TEVATRON, APV, $e\nu$ SCATTERING, $e\mu$ UNIVERSALITY, UNIVERSALITY OF CC
↳ cf A.F. ZARNECKI hep-ph/0003271



Leptoquarks : BRW Model

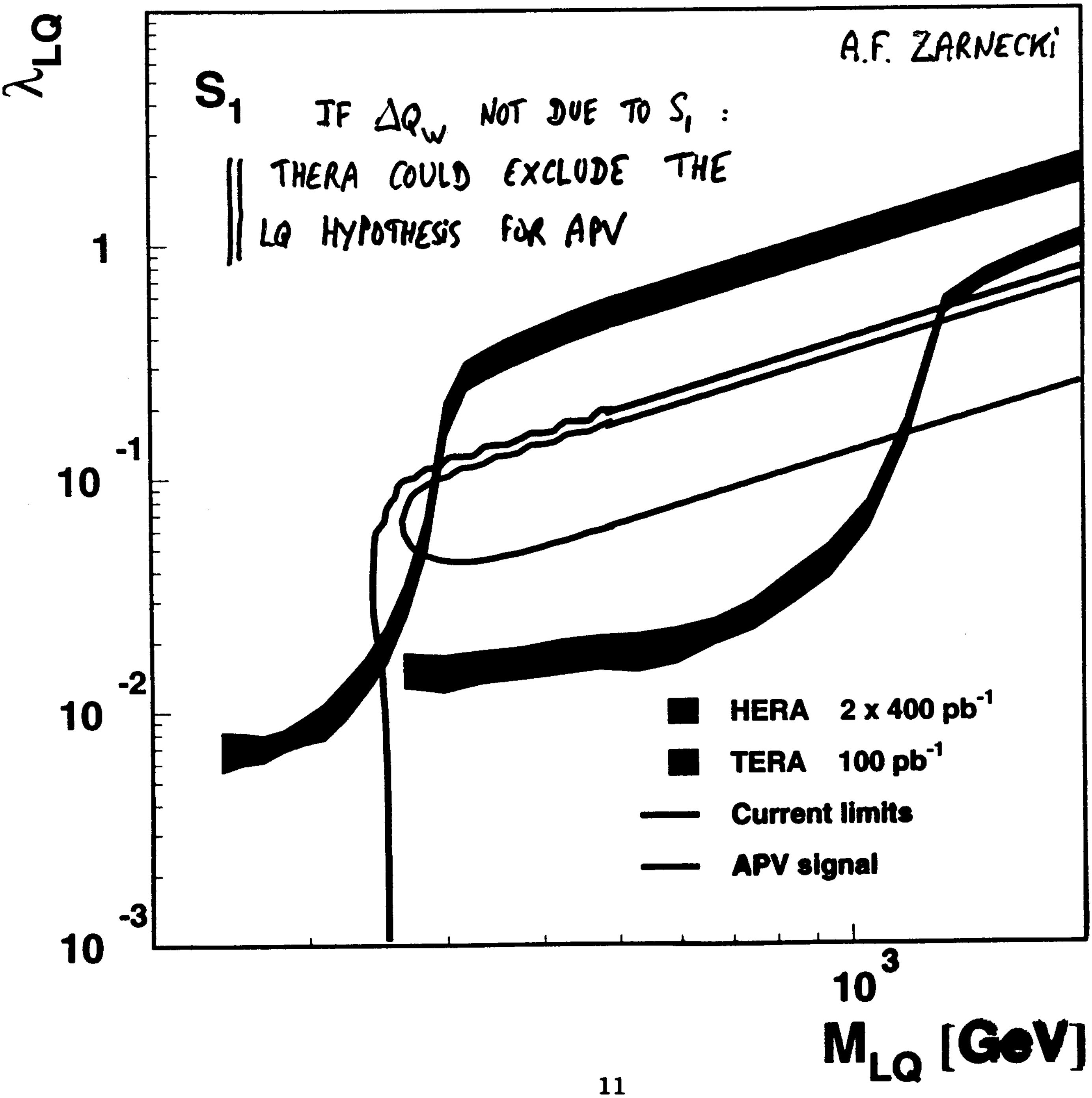
APV MEASUREMENTS IN ATOMS:

$Q_W^{MEASURED} - Q_W^{SM} = 1.13 \pm 0.46$ 2.5σ DISCREPANCY

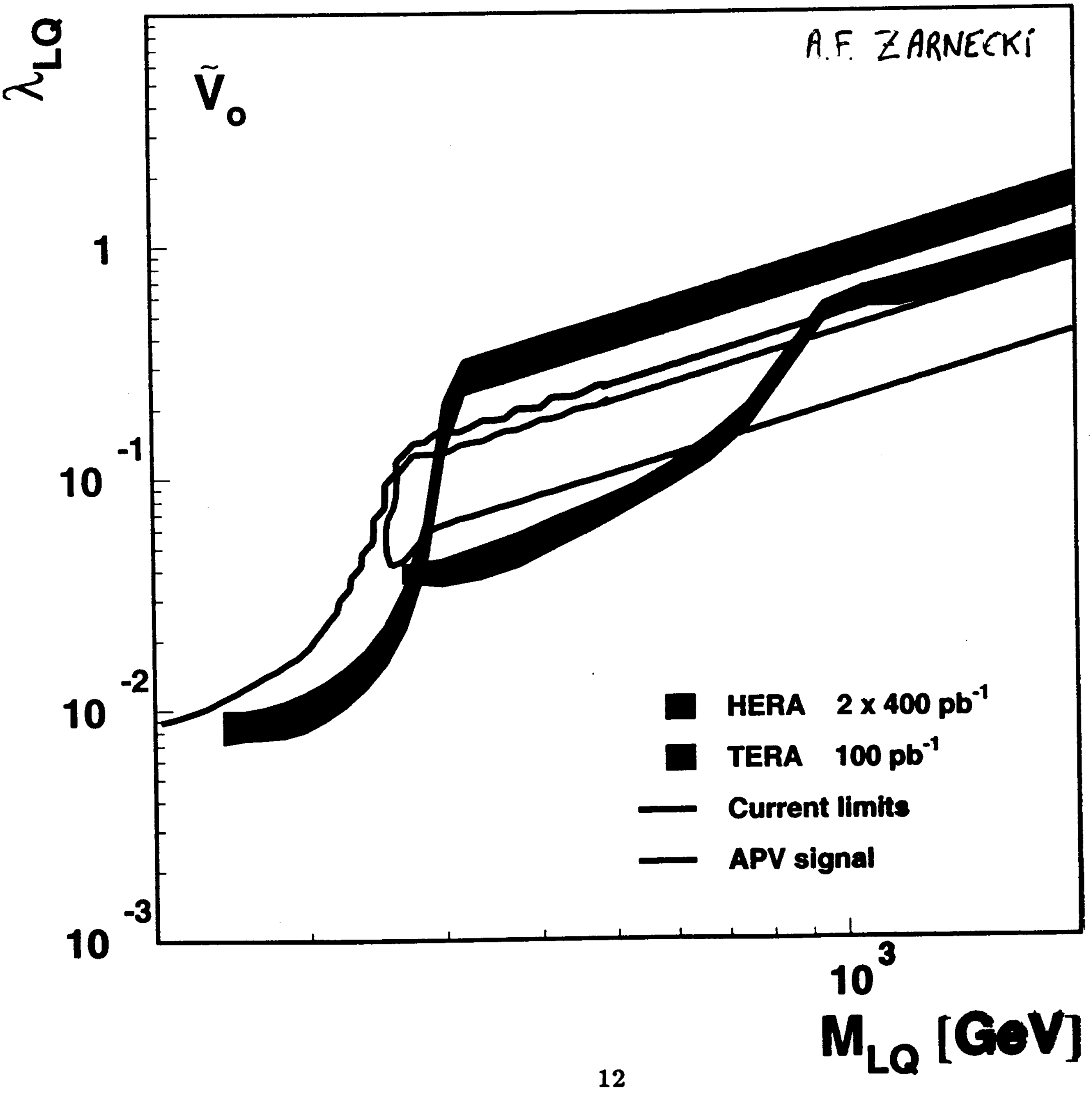
SOME LQs COULD ACCOUNT FOR THIS DISCREPANCY

cf A.F. ZARNECKI hep-ph/0003271

⇒ SHOWS THE "SIGNAL REGION" IN (λ, M) PLANE



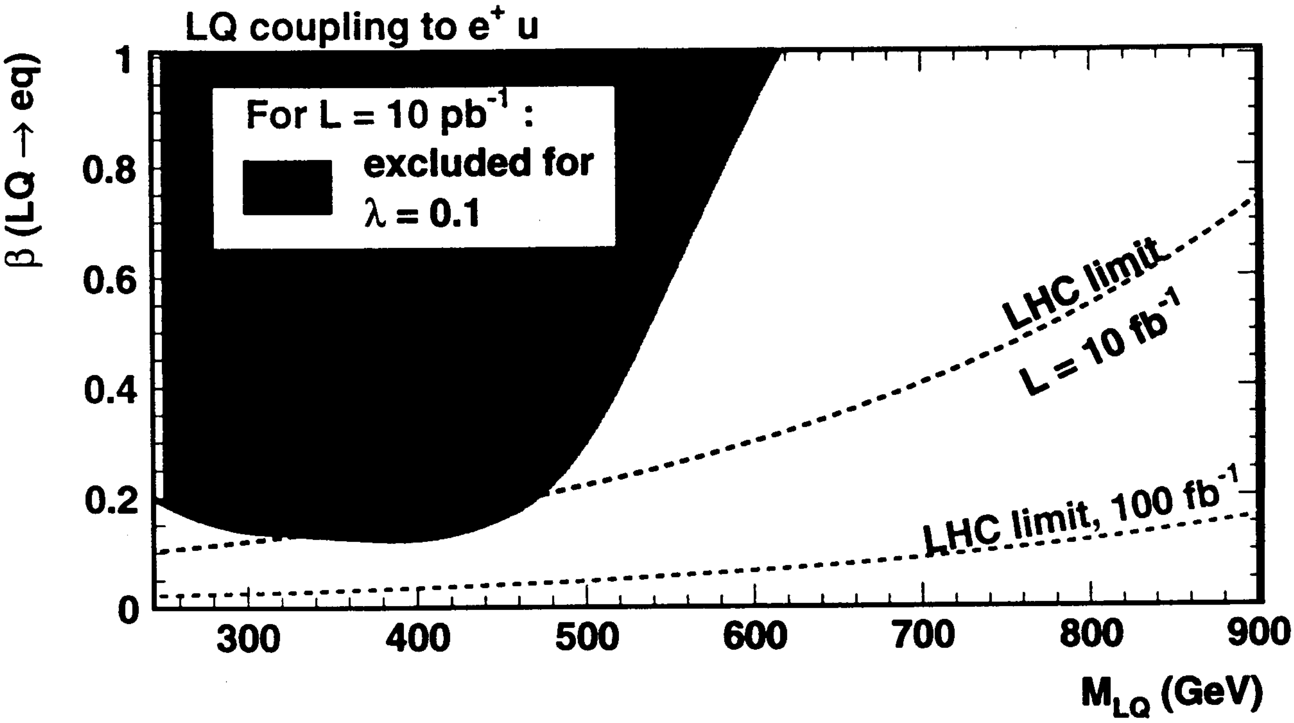
Leptoquarks : BRW Model

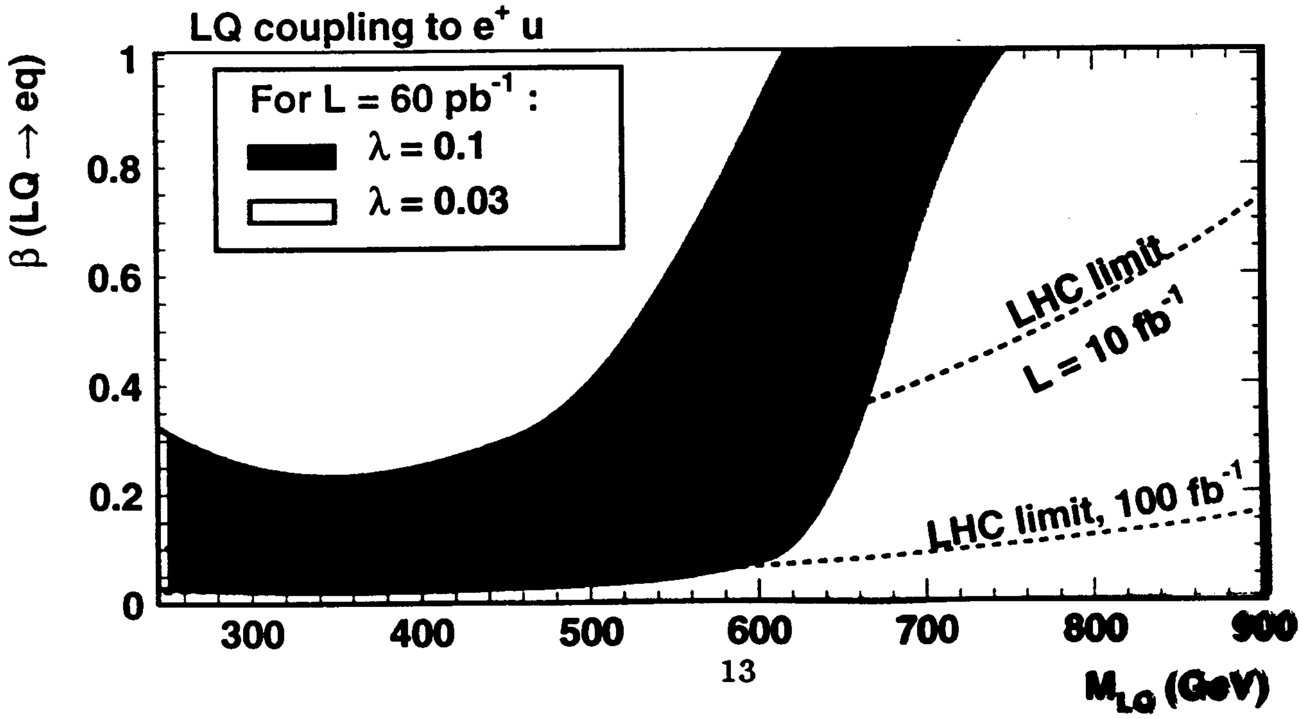


Leptoquarks : Generic Model

HOWEVER: IF NO LQ DISOVERED @ LHC, DIFFICULT TO SEE
IT AT THERA, UNLESS:
- λ QUITE HIGH (eg $\sim \alpha_{EM}$)
- AND $\beta = BR(LQ \to eq)$ SMALL $\to$ eg $\not{R}_p$ SUSY

250 GeV e^+ x 820 GeV p





STILL: if AN e·q RESONANCE is DISCOVERED BEFORE (e.g. @ LHC)

THERA : iDEAL MACHINE TO DETERMINE THE QUANTUM NUMBERS OF THIS RESONANCE

- ANGULAR (y) DISTRIBUTIONS → SCALAR / VECTOR
- e^-p / e^+p COLLISIONS → FERMION NUMBER F OF LQ ($F=0$: $e^-\bar{q}$ $F=2$: e^-q)
- e POLARISATION → CHIRAL STRUCTURE OF INTERACTION ($e^-_L q$ OR $e^-_R q$. could rule out R_p $\tilde{q}$ if e^-_R,
- p POLARISATION → FLAVOR STRUCTURE (e^-u OR e^-d SINCE $\Delta u > 0$ $\Delta d < 0$)

↳ NOT FEASIBLE AT pp COLLIDER!

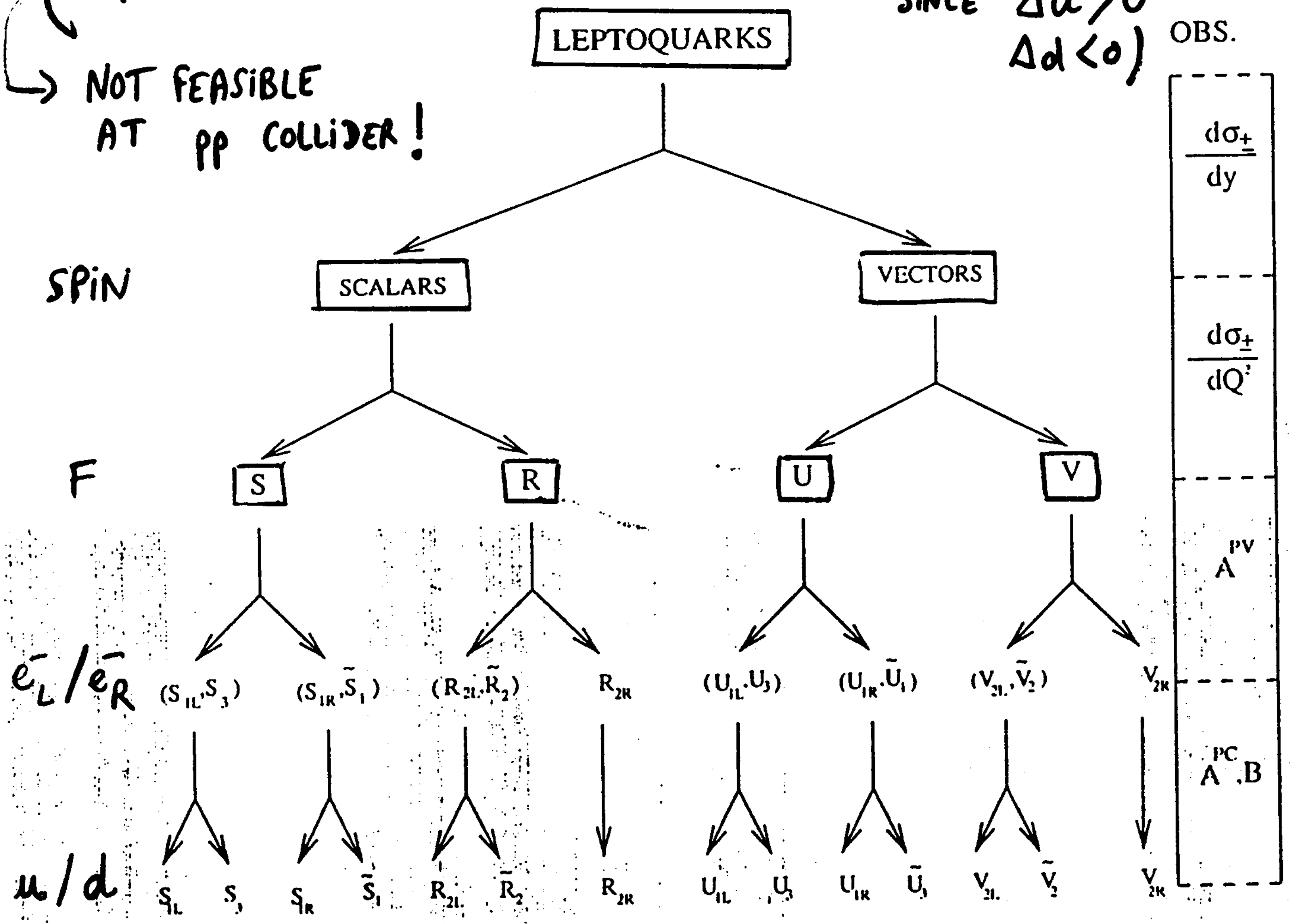


Figure 8: Schematic view for LQ identification.

↳ FROM J.M. VIREY et al
hep-ph / 9912272

CONCLUSIONS ON LEPTOQUARKS :

- TWO STUDIES MADE
  e^+p 250 GeV × 820 GeV
  e^-p 500 GeV × 1 TeV

  VERY WELL COMPATIBLE

- e^+p COLLISIONS PROVIDE BETTER SENSITIVITY ON LQs COUPLING TO e^+q (ie $F=0$) THAN e^-p COLLISIONS FOR LQs COUPLING TO e^-q (ie $|F|=2$)

  BUT ≠ LQs ARE PROBED IN EACH CASE

- THERA COULD EXTEND MUCH BEYOND THE "SIGNAL DOMAIN" OF APV MEASUREMENTS

- IN THE BRW MODEL ($BR(LQ \to eq) = 1$ OR $1/2$)
  → DIFFICULT TO DISCOVER A LQ IF NOT SEEN @LHC
  → HOWEVER THERA WOULD BE THE IDEAL MACHINE TO DISENTANGLE BETWEEN ≠ LQs

- A DISCOVERY POTENTIAL COULD A PRIORI REMAIN FOR LQs HAVING A SMALL $BR(LQ \to eq)$ (and large branching in channels "easy" for THERA, more difficult for LHC), ie LQs BEYOND THE BRW MODEL

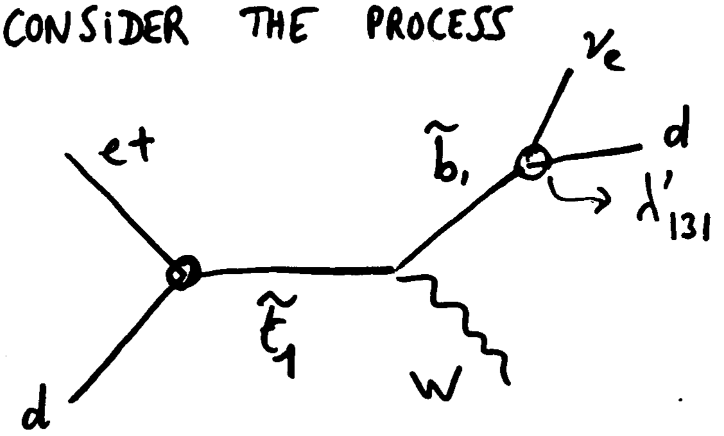
  e.g. $\tilde{q}$ IN $\not{R}_p$ SUSY ?

R-PARITY VIOLATING SUSY AT THERA ?

LHC: SHOULD PROBE $\tilde{q}/\tilde{g}$ UP TO ~ 2 TeV !
(up to ~ 600 GeV after 1st year)
TEVATRON Run III : up to ~ 450 GeV

COULD REMAIN A HOPE IF $\tilde{t}_1$ AND/OR $\tilde{b}_1$ MUCH LIGHTER THAN OTHER SQUARKS, AND if $\tilde{g}$ HEAVY ...

CONSIDER THE PROCESS



proposed by T. KON et al
(1998)

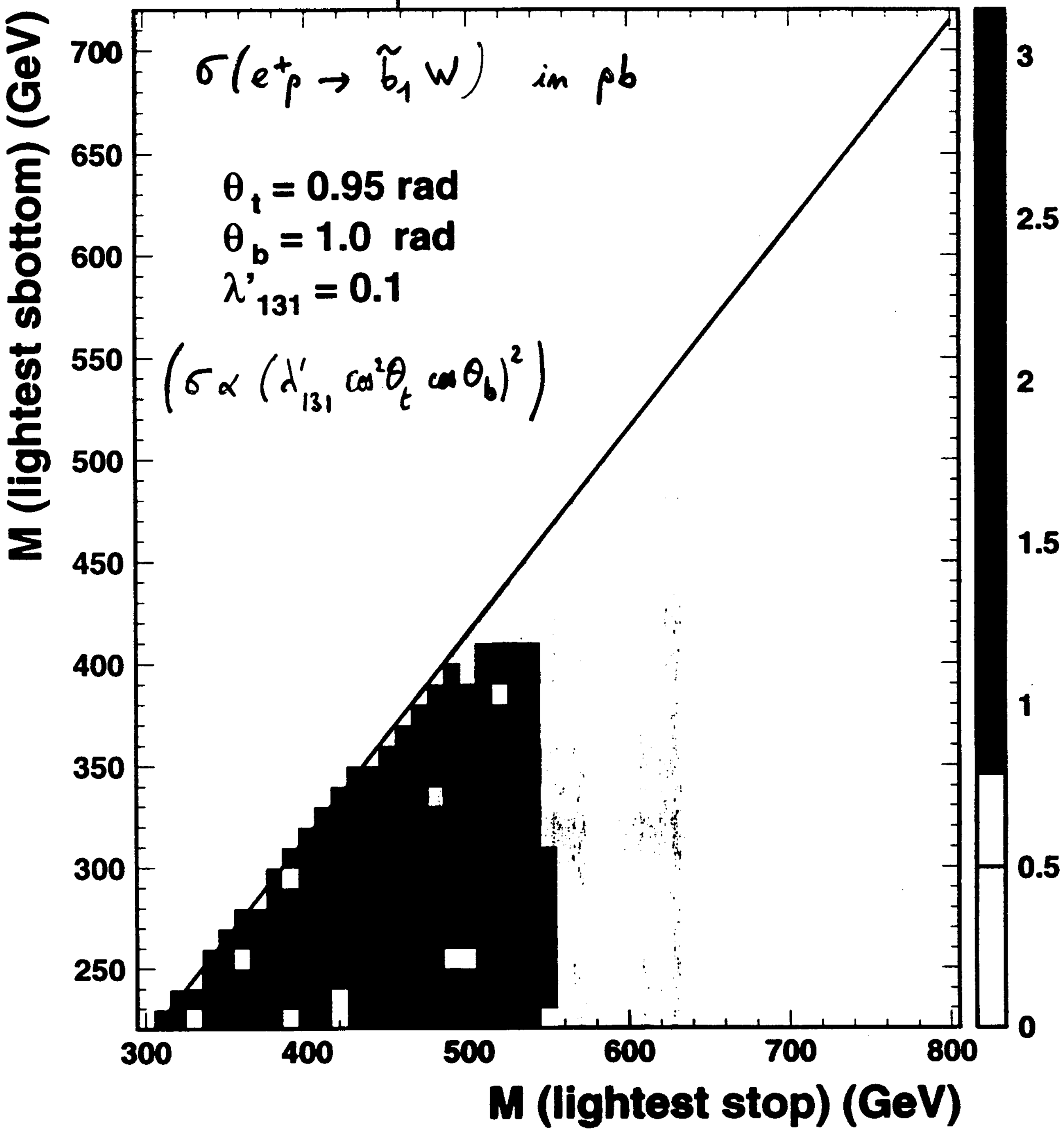
IF BR$(\tilde{b}_1 \to \nu_e d)$ HIGH : NOT EASY TO SEE IT AT LHC...

AT THERA : CHANNEL WHERE W → LEPTONS SHOULD BE EASY TO ANALYSE

FOR $\lambda'_{131} \sim 0.1$ (< CURRENT LIMIT FROM APV) :
SIZEABLE CROSS SECTION AT THERA FOR
(~ 1 pb)
$$\left\{ \begin{array}{l} \tilde{t}_1 \text{ UP TO } \sim 600 \text{ GeV} \\ \tilde{b}_1 \text{ UP TO } \sim 500 \text{ GeV} \end{array} \right.$$

MSSM PARAMETERS SO THAT $\chi_1^0 \sim 500$ GeV
$\chi_1^+ \sim 1$ TeV

THERA e^+p 500 GeV × 920 GeV



POTENTIAL OF LHC IF $\tilde{t}_1$ MUCH LIGHTER THAN OTHER $\tilde{q}$:

For $\tilde{t}_1 \sim 600$ GeV: $\sigma_{LHC} = \sim 0.2$ pb

$\Rightarrow$ LIKELY TO BE EXCLUDED WITH $\mathcal{L} = 100\ fb^{-1}$...
(background study needed..)

Beenaker, Plehn, Spira, Zerwas, Kramer DESY 97-214

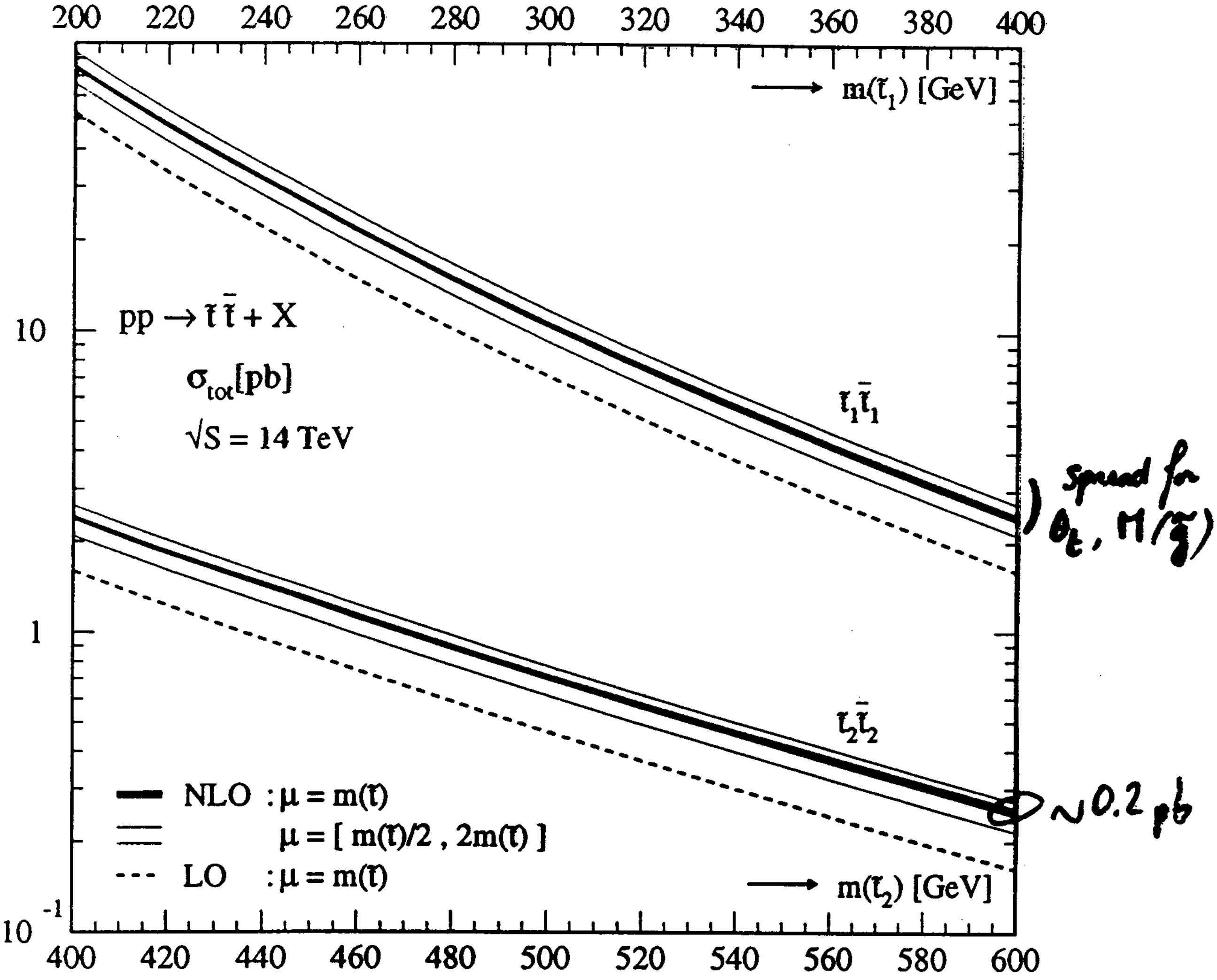
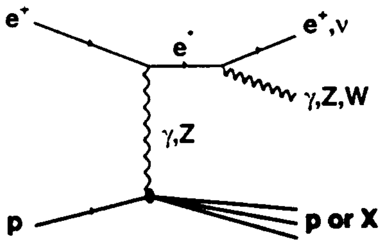


Figure 5: *The same as Fig. 4, but for the LHC. The SUSY mass spectrum is described in the text. The gluino mass is varied between 400 (600) and 900 GeV for $\tilde{t}_1(\tilde{t}_2)$-pair production.*

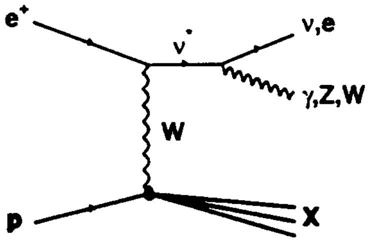
Excited Fermions

Fermions substructure ⇒ Excited l, q (only spin 1/2 considered)
In *ep* collisions : single production possible, followed by $f^* \to f(f') + V$
⇒ Search for fermion-boson resonance

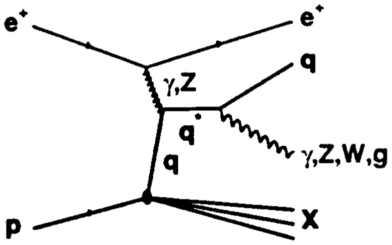
$\boxed{e^*}$



$\boxed{\nu^*}$

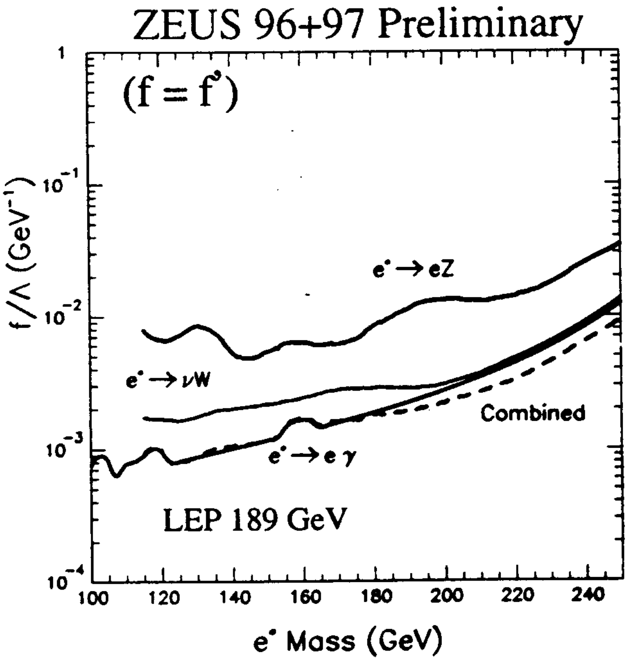


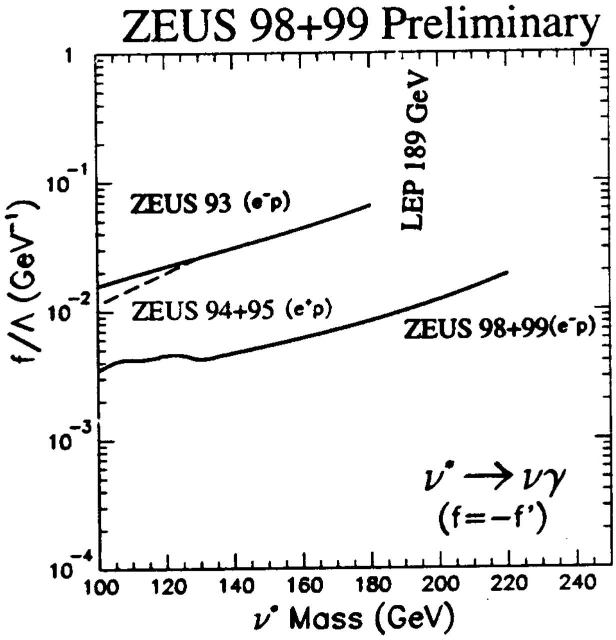
$\boxed{q^*}$



Phenomenological Model : **Hagiwara, Komaniya, Zeppenfeld**

$$\mathcal{L} = \frac{1}{\Lambda} \bar{f}^*{}_R \left[f\, SU(2)_L + f' U(1)_Y + f_s SU(3)_c \right] f_L$$





$$\boxed{\frac{f}{\Lambda} = \frac{1}{M(e^*)} \Longrightarrow M(e^*) > 229 \text{ GeV}}$$

$$\boxed{\frac{f}{\Lambda} = \frac{1}{M(\nu*)} \Longrightarrow M(\nu^*) > 161 \text{ GeV}}$$

- For q^*: will be very severely constrained at LHC
- For ν^* : better sensitivity with e^- than with e^+
  (σ(prod.ν^*) is $\sim$ 100 higher with e^-)
- For e^* and ν^* : no limits besides those obtained at the end of LEP2

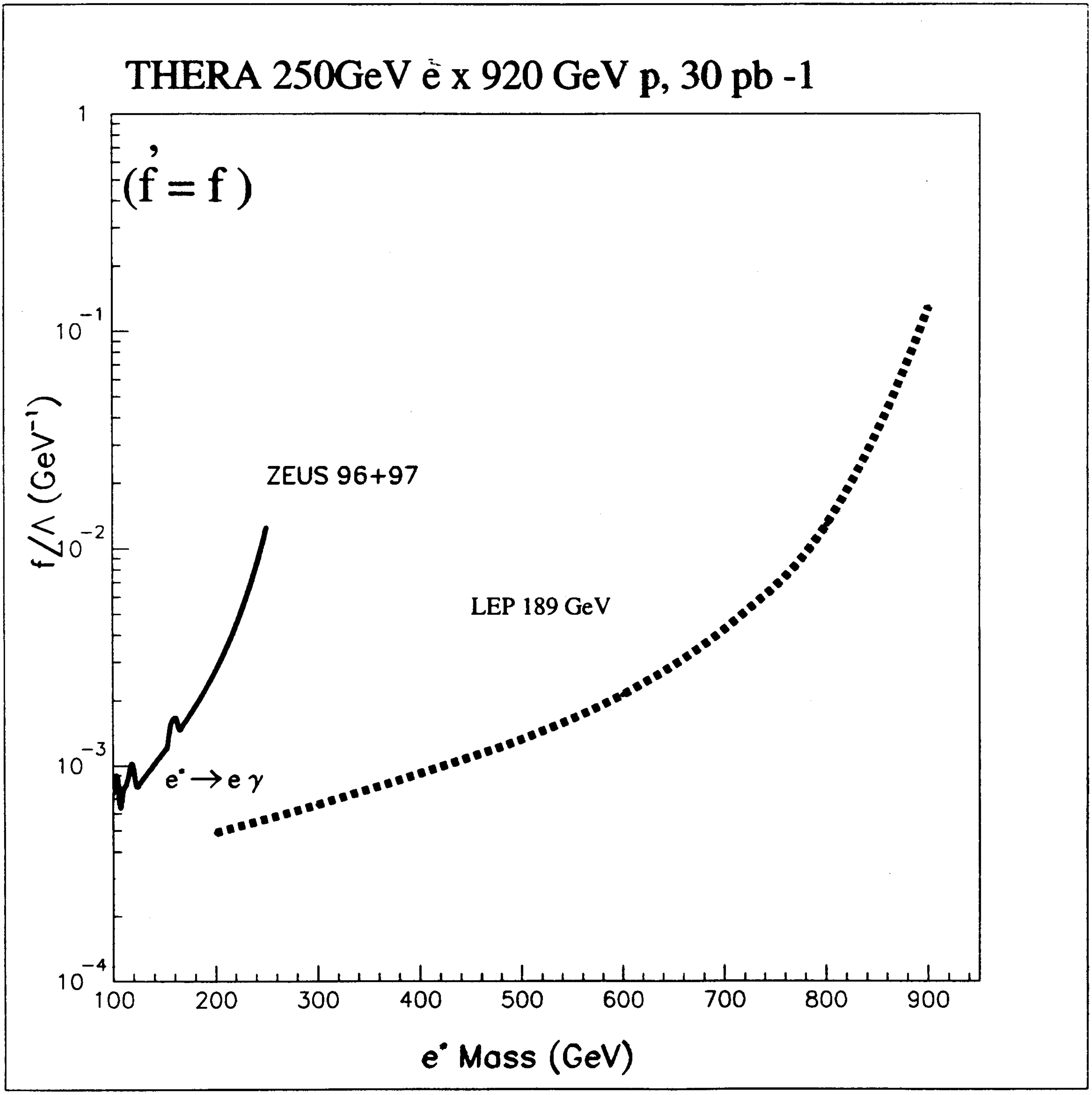
NB. NO LIMIT ON e^*/ν^* FROM TEVATRON ⇒ ASSUME NO LIMIT FROM LHC ?

$\boxed{\Rightarrow \text{Discovery Potential for THERA !}}$

simple assumptions

- Eff ~ 80%
- no bkgd.
- $B(e^* \to e\gamma) \sim 30\%$.

M. KUZE

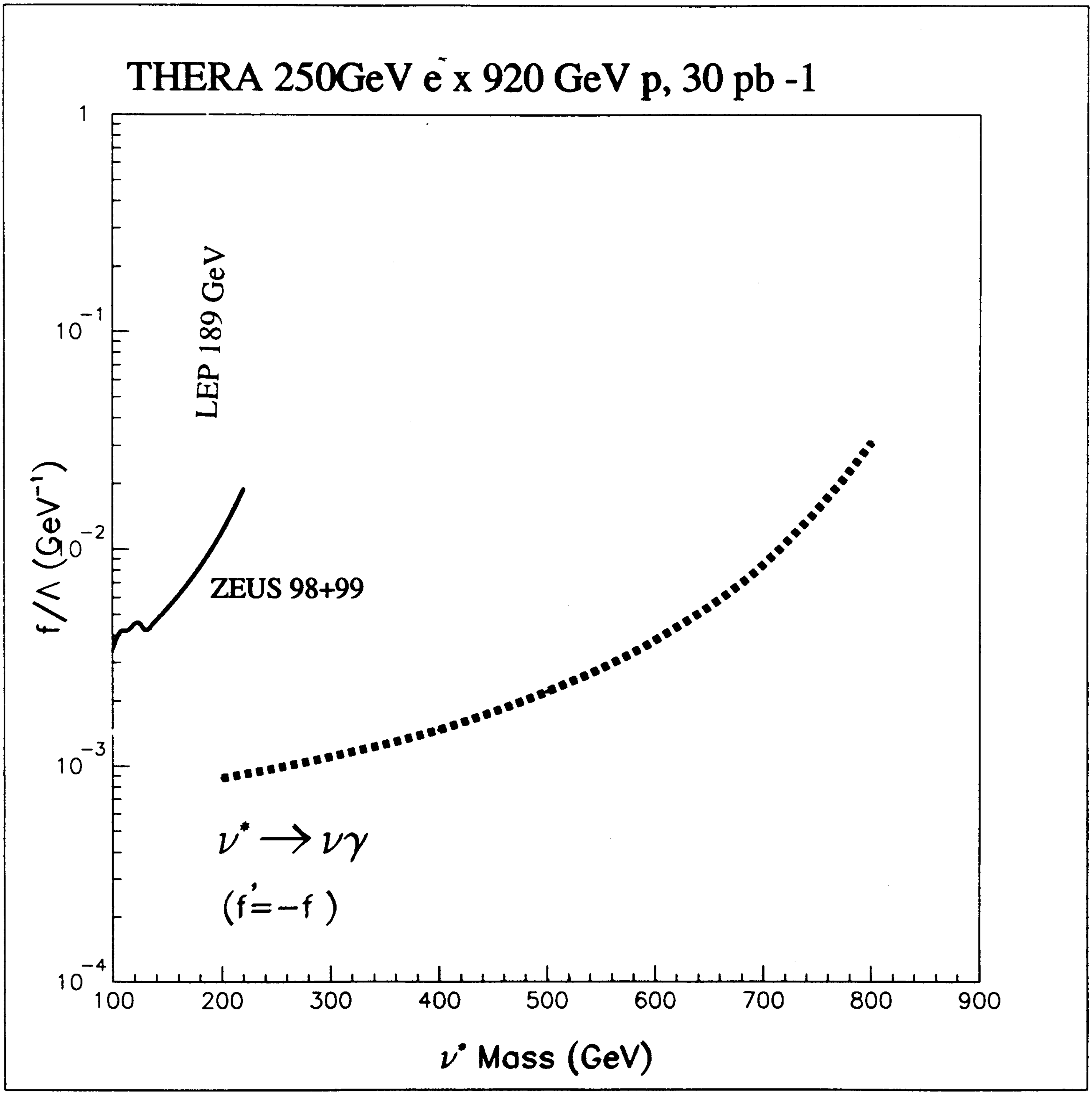


For $1/m_{e^*} = f/\Lambda$

$\rightarrow$ $m_{e^*} < 570$ GeV excluded (or found!)

- Eff ~ 80%
- no bkgd.
- $B(\nu^* \to \nu\gamma) \sim 30\%$

M. KUZE



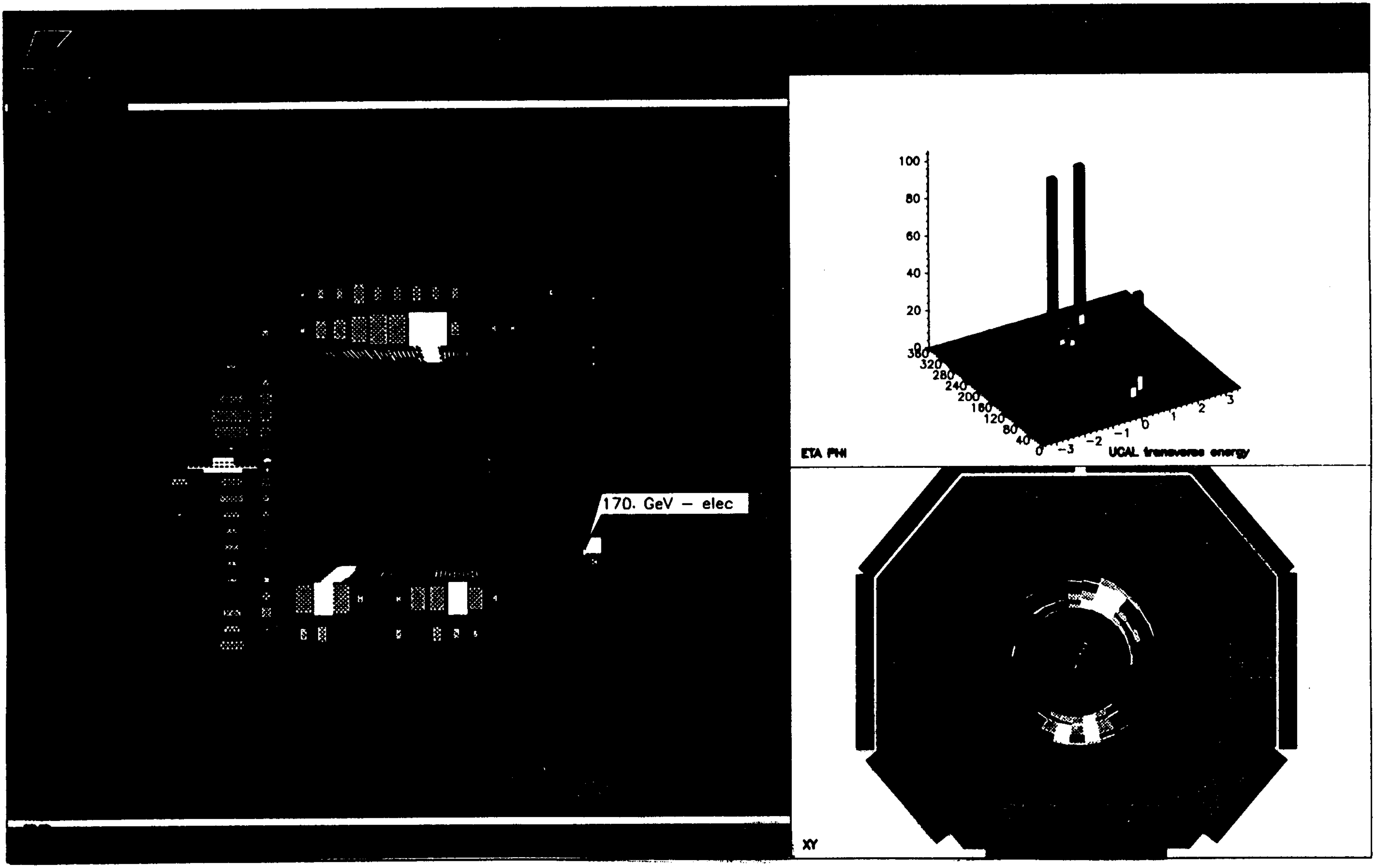
For $1/m_{\nu^*} = f/\Lambda$

$\rightarrow$ $m_{\nu^*} < 500$ GeV excluded (or found!)

$e^-p \rightarrow \nu^* X$
$\hookrightarrow eW \rightarrow eq\bar{q}$

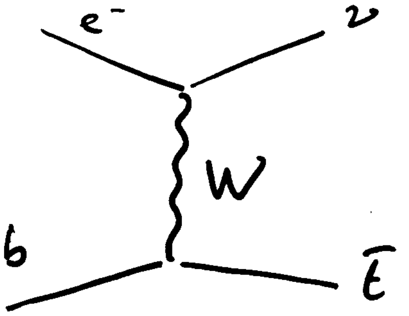
$M(\nu^*) = 400\,GeV$

$E - P_z = 482\,GeV$!



SINGLE TOP PRODUCTION AT THERA

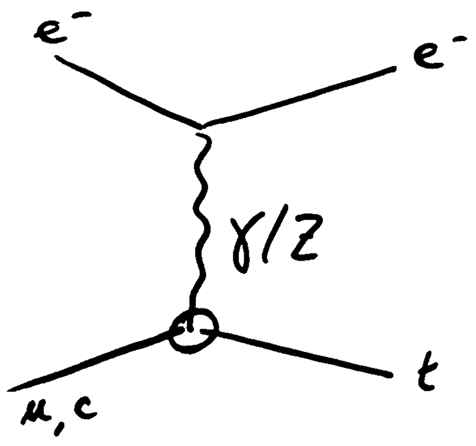
e^-p, 500 GeV × 920 GeV



$\sigma \sim 1$ pb

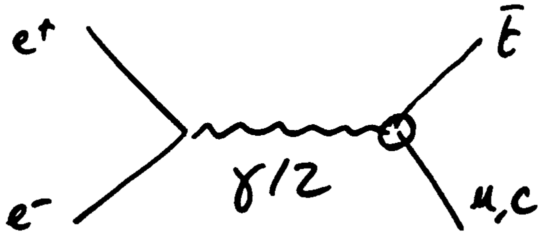
(large uncertainties)

Production via anomalous coupling to light quark(s) :



Interest for ep collisions first stressed by H. Fritzsch (hep-ph/9901411)

NB: EFFECT OF ANOMALOUS COUPLINGS LEADING TO FCNC TOP INTERACTIONS SEARCHED FOR AT LEP2:



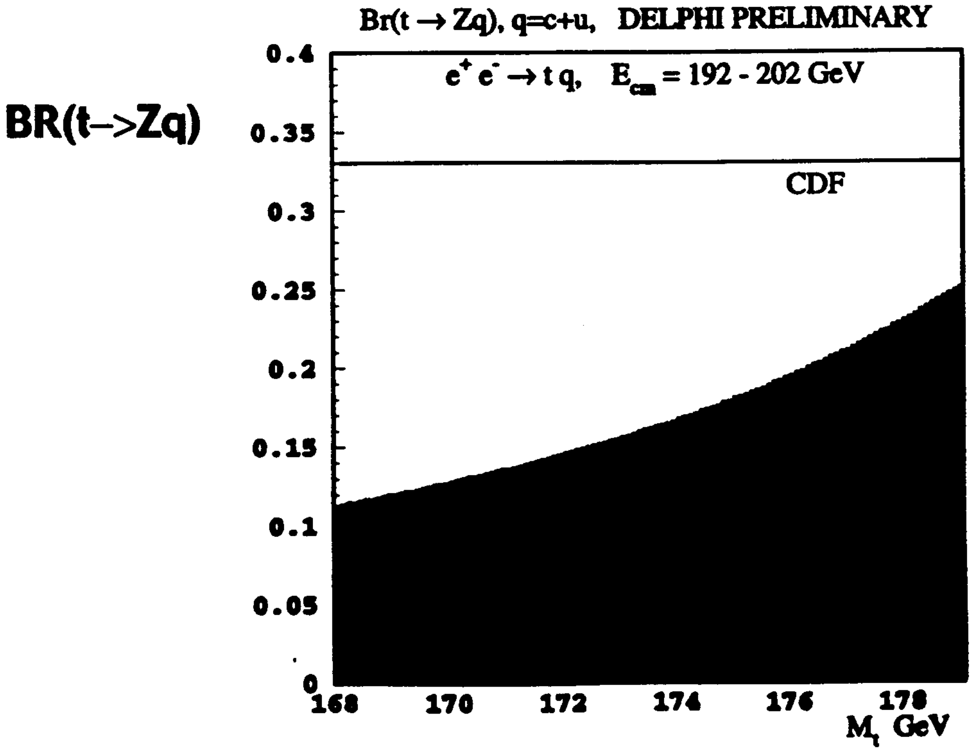
Search for FCNC processes : single top production

$$e e \to t c \to W b\, c \to q q b c$$
$$\to l \nu b c$$

When $E_{cm} > M(top)$ then this channel is kinematical accessible

	hadronic		Semileptonic	
E_{cm}	DATA	MC	DATA	MC
192	1	1.5	1	0.6
196	4	3.8	0	1.7
200	2	5.0	2	1.9
202	5	2.6	0	1.0

$$\sigma(ee \to tq) < 0.32 \text{ pb}$$



⇒ GENERAL LAGRANGIAN FOR TOP FCNC INTERACTIONS:
cf eg Hewett, Han PRD 60 (99) 074015

$$\mathcal{L} = e\,\bar{t}\,\frac{i\sigma^{\mu\nu}q_\nu}{\Lambda}\,\kappa_\gamma\, c\, A_\mu + \frac{g}{2c_W}\,\bar{t}\,\frac{i\sigma^{\mu\nu}q_\nu}{\Lambda}\,\kappa_Z\, c\, Z_\mu$$

$$+ \frac{g}{2c_W}\,\bar{t}\,\gamma^\mu (v_Z - a_Z\gamma^5)\, c\, Z_\mu$$

I take $\Lambda = m_t$ in the following

- ALSO COUPLINGS TO THE u QUARK !!

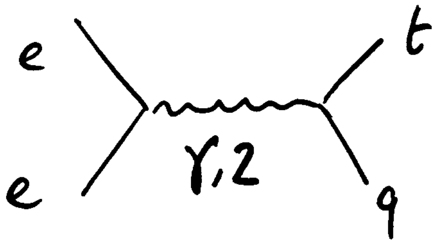
  mdr im Fritzsch: considered a specific model with $SU(2)_L \times SU(2)_R$ symmetry, dynamically broken
  → yields to a mass hierarchy for the couplings
  ⇒ $t\text{-}u\text{-}\gamma/Z \propto m_u \approx 0$

- MAGNETIC AND (v-a) COUPLINGS ALLOWED FOR Z

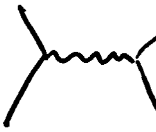
- ONLY MAGNETIC COUPLING κ_γ TO THE γ

PRODUCTION AT LEP AND HERA

Since $\sqrt{s_{ee}} > m_t$ single top production possible at LEP

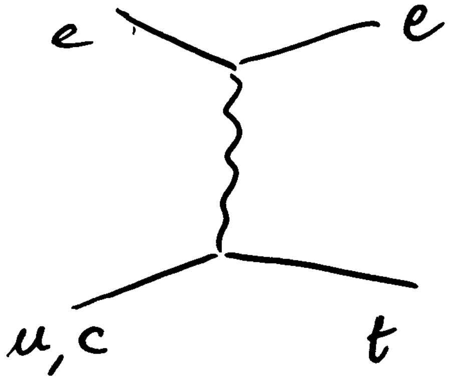


$$\sigma(\kappa_\gamma) \underbrace{>}_{\text{larger coupling to }\gamma} \sigma(\kappa_Z) \underbrace{> \sigma}(v_Z - a_Z)$$



$\kappa_Z q^\nu$

and $q^\nu \sim \sqrt{s}$



AT HERA :

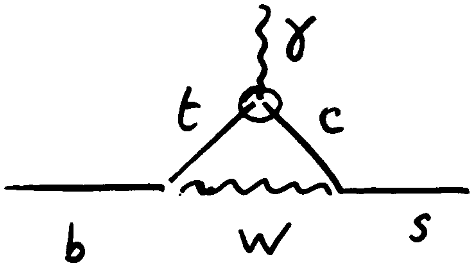
for the Z: $\sigma(v-a) \underbrace{> \sigma}_{\text{since } q^\nu \sim 0}(\kappa_Z)$

but $\sigma(\kappa_\gamma) \ggg \sigma(Z)$

$$\boxed{\text{HENCE: LEP AND HERA ARE MAINLY SENSITIVE TO THE SAME COUPLING } \kappa_\gamma}$$

EXISTING CONSTRAINTS

- from $b \to s\gamma$



USING CLEO RESULTS (95) : $10^{-4} < BR(b \to s\gamma) < 4.2\ 10^{-4}$

⇒ $|K_{\gamma,c}| < 0.1$ (Hewett et al., PRD 95)

ONLY CONSTRAINTS THE COUPLING TO THE c QUARK!

- from limits on $BR(t \to \gamma\ u/c)$

CDF: $BR(t \to c\gamma) + BR(t \to u\gamma) < \sim 3\%$

$$\boxed{\Rightarrow |K_{\gamma,c}| \text{ AND } |K_{\gamma,u}| < 0.3}$$

- Other constraints from $K_L \to \mu\mu$, $B \to \ell^+\ell^- X$, $\Delta m\,(K_L - K_S)$

↳ Constraints on v_Z, a_Z :

$$\begin{cases} g_{Z,L} = v_Z - a_Z < 0.05 \\ g_{Z,R} = v_Z + a_Z < 0.29 \end{cases}$$

(T. Han et al, NPB 454 (95) 527.)

CONSTRAINTS ON $\sigma(ep \to et)$ FROM LEP RESULTS

ALEPH, DELPHI AND L3 HAVE LOOKED FOR $ee \to t\, c/u$

eg | L3 (Moriond 00) using leptonic channel only:
| $\sigma(ee \to t\, c/u) < 0.2$ pb

→ WHAT IS THE UPPER BOUND ON $\sigma(ep \to et)$ WHICH CAN BE DERIVED FROM THIS LIMIT ?

I use $\left\{ \begin{array}{l} N_{expected} \text{ (mainly from WW)} \\ \varepsilon \text{ on signal} \end{array} \right.$

from ALEPH contributed paper @ EPS'99

and assume $N_{obs} = N_{exp}$

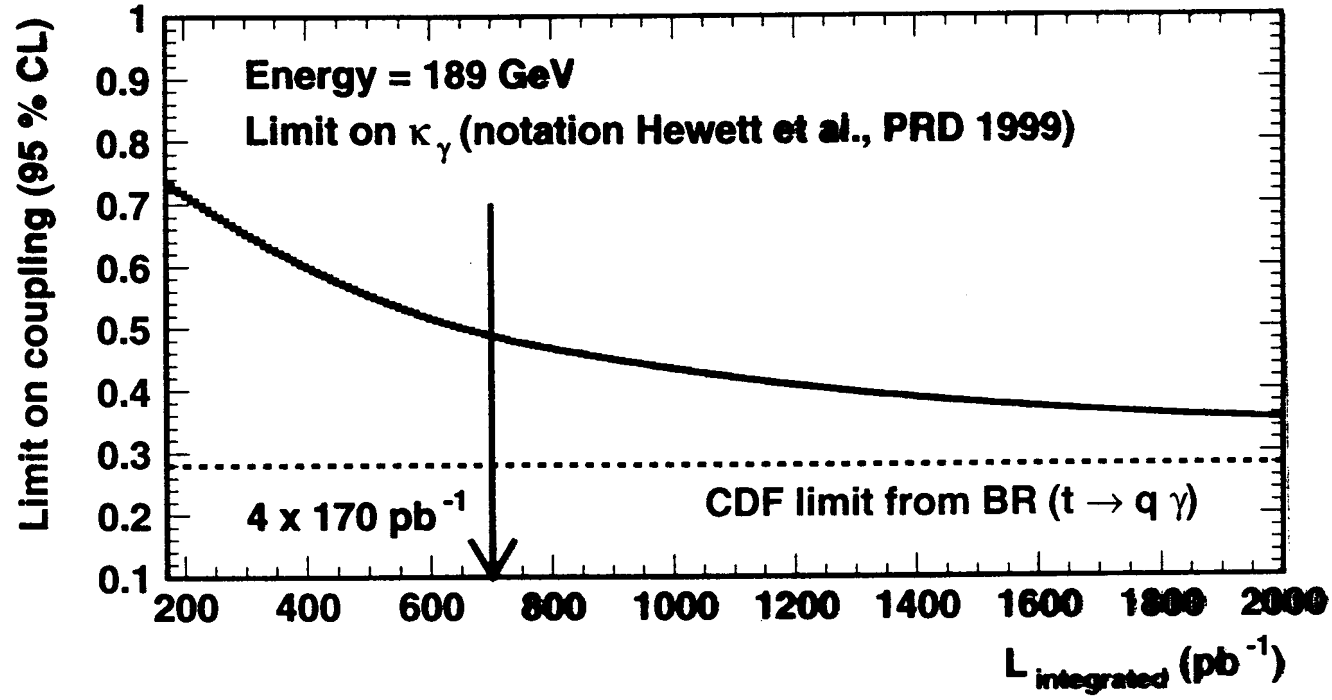
↳ expected limit on K_γ vs $\int \mathcal{L}$

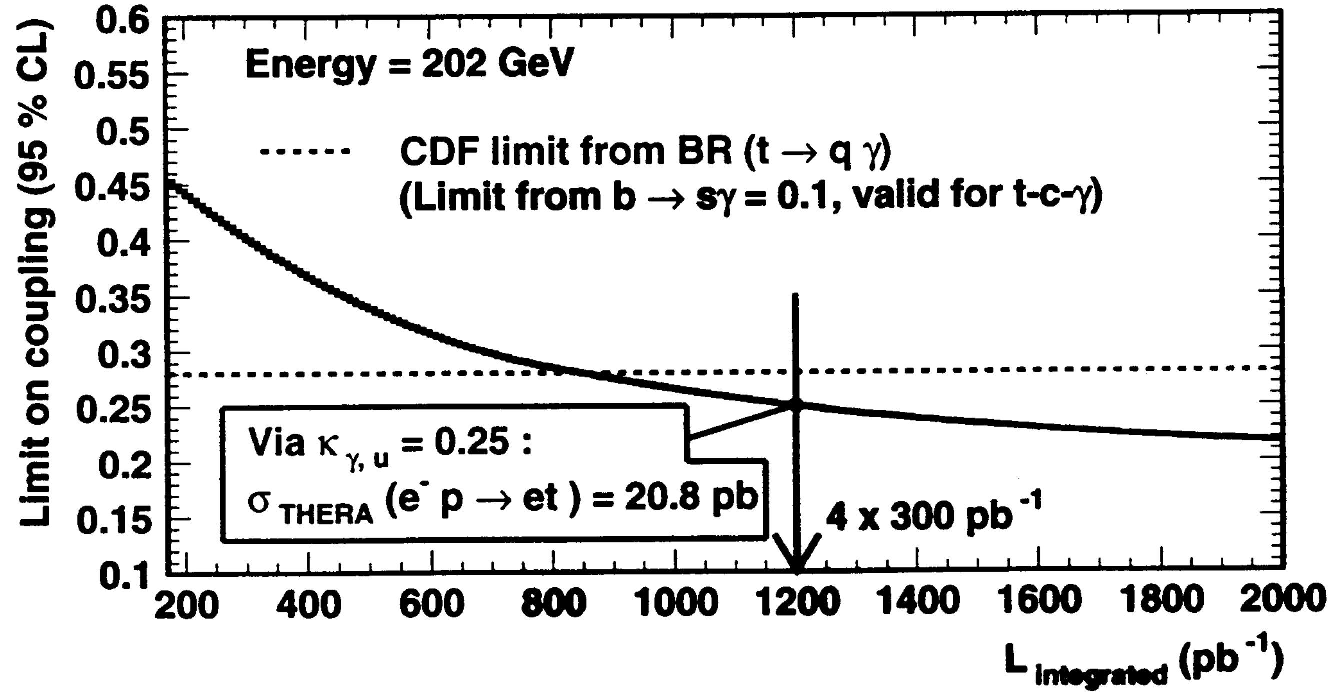
"COMBINING" THE FOUR LEP EXPERIMENTS :

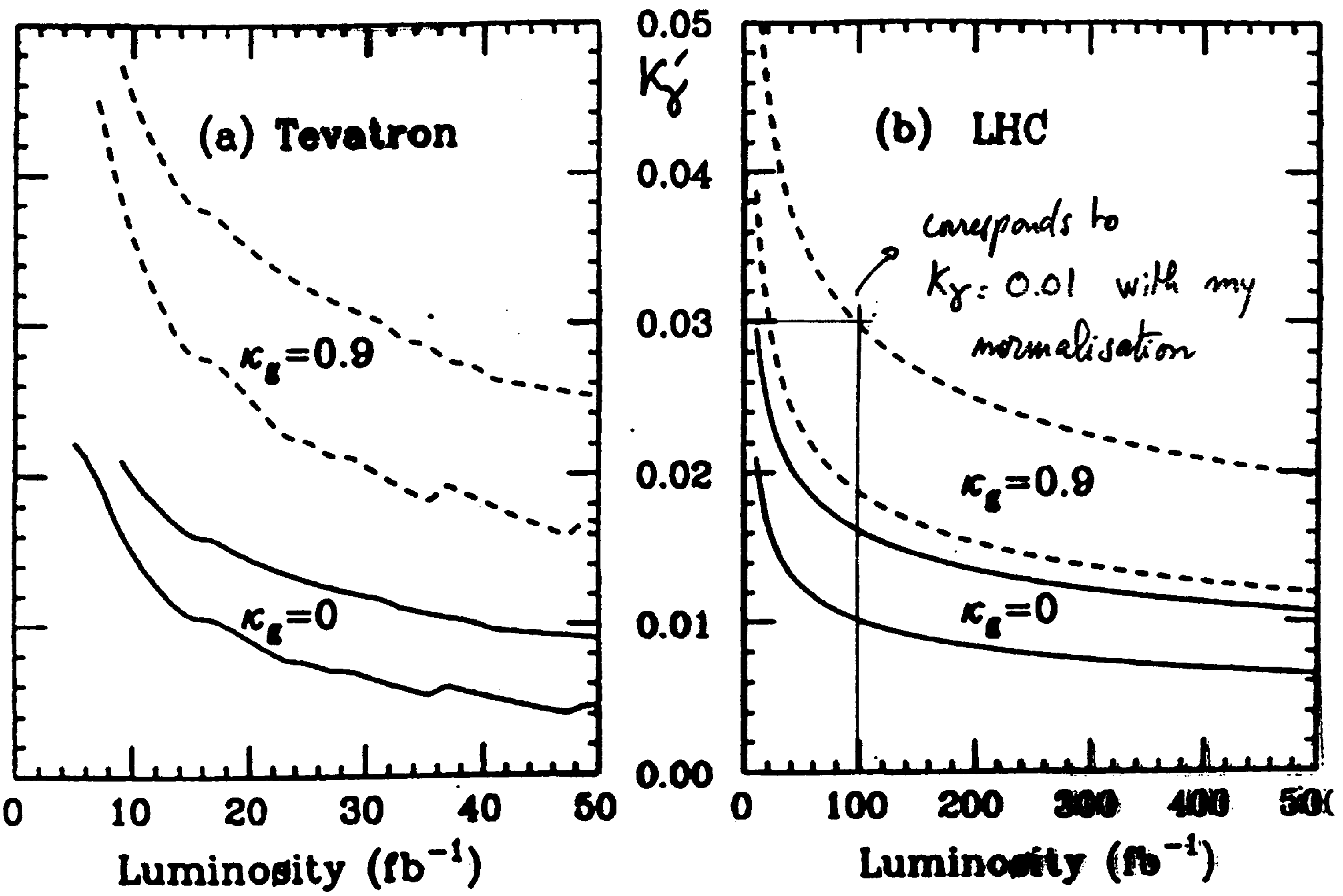
- with 170 pb^{-1}/exp @ 189 GeV : $|K_\gamma| < 0.5$
  not yet competitive with CDF limit
- with 300 pb^{-1}/exp @ 202 GeV (~ end of LEP 2)
  $|K_\gamma|$ up to 0.25 can be probed

$$\boxed{K_{\gamma,u} = 0.25 \Rightarrow \sigma_{THERA}(e^- p \to e^- t) \sim 21 \text{ pb}}$$

Constraints from LEP2 on $\sigma(t)$ at THERA







BUT : LHC WILL IMPROVE LIMIT ON BR $(t \to q\gamma)$!
T. Han et al, PRD 55 (1997) 7241.

LHC 100 fb^{-1} ⇒ $K_\gamma < 0.01$ (worst case)

WITH $K_\gamma = 0.01$: $\sigma_{THERA}(e^- p \to e^- t) = 3.4\ 10^{-2}$ pb !

⇒ VERY UNLIKELY TO OBSERVE TOP PRODUCTION VIA K_γ AT THERA IF LHC DOES NOT HAVE EVIDENCE FOR $K_\gamma \neq 0$!

W PRODUCTION AT THERA

D. WATERS, OXFORD

$\sigma(W)$ FROM EPVEC :

	HERA e^+p 27.5 × 920 GeV	THERA e^+p 250 × 920 GeV
W^+ (DIS)	0.39 pb	6.13 pb
W^- (DIS)	0.32 pb	4.89 pb
W^+ (RES)	0.15 pb	1.52 pb
W^- (RES)	0.12 pb	1.27 pb
TOTAL	~ 1 pb	~ 14 pb

⇒ EXPECT ~ 150 events $W \to e\nu$ per 100 pb^{-1}

SENSITIVITY TO ANOMALOUS COUPLING ?
STUDY IS UNDER WAY .... (D. WATERS)
↳ FALL MEETING

NB: D. WATERS AND U. BAUR EXPRESSED INTEREST IN CONTRIBUTING TO PROCEEDINGS

CONCLUSIONS

- CONTACT INTERACTIONS: EXISTING DATA LEAVE SOME ROOM FOR A DISCOVERY AT THERA IN MANY C.I MODELS

  Λ UP TO 14 TeV CAN BE PROBED AT THERA !

- LEPTOQUARKS :
  - → e^+ A PRIORI MORE SENSITIVE THAN e^- DUE TO NEGATIVE γ/Z INTERFERENCE
    (BUT ≠ LQs ARE PROBED)
  - → DIFFICULT TO DISCOVER A RESONANT LQ ($M_{LQ} < \sqrt{s}$) AT THERA IN SIMPLEST MODELS (LHC...)
    BUT THERA WOULD ALLOW TO DISENTANGLE ≠ LQs
  - → THERA COULD CONSIDERABLY EXTEND THE "SIGNAL REGION" IF ΔQ_W DUE TO A LQ

- $\not{R}_p$ SUSY : MAY BE SOME HOPE IF LIGHT $\tilde{t}$
  BUT SEEMS DIFFICULT

- SINGLE TOP VIA K_γ: DIFFICULT AFTER LHC !

- W PRODUCTION $\sigma \sim 15\,pb$
  SENSITIVITY TO ANOMALOUS COUPLINGS? UNDER WAY...

- EXCITED FERMIONS: THERE WILL BE NO LIMIT ON e^*, ν^* BESIDES THOSE OBTAINED AT THE END OF LEP2 !

THERA COULD DISCOVER (OR CONSIDERABLY EXTEND LIMITS ON) e^* / ν^*

eg $e^- p$ 250 x 920 GeV $\mathcal{L}$: 30 pb^{-1}

e^* UP TO 570 GeV FOR $\frac{1}{M_{e^*}} = \frac{f}{\Lambda}$

ν^* UP TO 500 GeV FOR $\frac{1}{M_{\nu^*}} = \frac{f}{\Lambda}$

e^* / ν^* : THE MAIN DISCOVERY POTENTIAL FOR THERA !

NB. COMMENT FROM ULI: CHECK WETHER LHC CAN REALLY NOT CONSTRAIN e^* / ν^* ?
IS THERE A GOOD REASON WHY NO LIMIT ON e^* / ν^* FROM TEVATRON ?