Heavy Charged Lepton Searches

**Charged Heavy Lepton MASS LIMITS**

**Sequential Charged Heavy Lepton ($L^\pm$) MASS LIMITS**

These experiments assumed that a fourth generation $L^\pm$ decayed to a fourth generation $\nu_L$ (or $L^0$) where $\nu_L$ was stable, or that $L^\pm$ decays to a light $\nu_\ell$ via mixing.

See the “Quark and Lepton Compositeness, Searches for” Listings for limits on radiatively decaying excited leptons, i.e. $\ell^* \rightarrow \ell \gamma$. See the “WIMPs and other Particle Searches” section for heavy charged particle search limits in which the charged particle could be a lepton.

<table>
<thead>
<tr>
<th>VALUE (GeV)</th>
<th>CL%</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
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<td>ACHARD</td>
<td>01B</td>
<td>L3</td>
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<td>ALEP</td>
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<td>2 AHMED</td>
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<td>JADE</td>
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<td>none 4--14.5</td>
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<td>&gt; 0.490</td>
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<td>ROTEH</td>
<td>69</td>
<td>RVUE</td>
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</table>

1 ACCIARRI 96G assumes LEP result that the associated neutral heavy lepton mass $> 40$ GeV.
2 The AHMED 94 limits are from a search for neutral and charged sequential heavy leptons at HERA via the decay channels $L^- \rightarrow e\gamma$, $L^- \rightarrow \nu W^-$, $L^- \rightarrow eZ$; and $L^0 \rightarrow \nu\gamma$, $L^0 \rightarrow e^- W^+$, $L^- \rightarrow \nu Z$, where the $W$ decays to $\ell\nu_\ell$, or to jets, and $Z$ decays to $\ell^+\ell^-$ or jets.
3 RILES 90 limits were the result of a special analysis of the data in the case where the mass difference $m_{L^\pm} - m_{L^0}$ was allowed to be quite small, where $L^0$ denotes the neutrino.
into which the sequential charged lepton decays. With a slightly reduced $m_{L^{\pm}}$ range, the mass difference extends to about 4 GeV.

4 STOKER 89 (Mark II at PEP) gives bounds on charged heavy lepton ($L^{\pm}$) mass for the generalized case in which the corresponding neutral heavy lepton ($L^{0}$) in the SU(2) doublet is not of negligible mass.

5 ABE 88 search for $L^{+}$ and $L^{-}$ → hadrons looking for acoplanar jets. The bound is valid for $m_{L^{\pm}} < 10$ GeV.

6 ADACHI 88b search for hadronic decays giving acoplanar events with large missing energy. $E_{cm} = 52$ GeV.

7 Assumes associated neutrino is approximately massless.

8 ADEVA 85 analyze one-isolated-muon data and sensitive to $\tau < 10$ nanosec. Assume $B(\text{lepton}) = 0.30$. $E_{cm} = 40$–47 GeV.

9 BARTEL 83 limit is from PETRA $e^{+}e^{-}$ experiment with average $E_{cm} = 34.2$ GeV.

10 BERGER 81 is DESY DORIS and PETRA experiment. Looking for $e^{+}e^{-} \rightarrow L^{+}L^{-}$.

11 BRANDELIK 81 is DESY-PETRA experiment. Looking for $e^{+}e^{-} \rightarrow L^{+}L^{-}$.

12 AZIMOV 80 estimated probabilities for $M + N$ type events in $e^{+}e^{-} \rightarrow L^{+}L^{-}$ deducing semi-hadronic decay multiplicities of $L$ from $e^{+}e^{-}$ annihilation data at $E_{cm} = (2/3)m_{L}$.

Obtained above limit comparing these with $e^{+}e^{-}$ data (BRANDELIK 80).

13 BARBER 80 looks for $e^{+}e^{-} \rightarrow L^{+}L^{-}$, $L \rightarrow \nu_{L}X$ with MARK-J at DESY-PETRA.

14 ROTHE 69 examines previous data on $\mu$ pair production and $\pi$ and $K$ decays.

### Stable Charged Heavy Lepton ($L^{\pm}$) MASS LIMITS

<table>
<thead>
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<th>VALUE (GeV)</th>
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<td>• • • We do not use the following data for averages, fits, limits, etc. • • •</td>
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<td>&gt;28.2</td>
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<td>ADACHI 90C TOPZ</td>
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<td>none 18.5–42.8</td>
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<td>&gt;26.5</td>
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<td>DECAMP 90f ALEP</td>
<td></td>
</tr>
<tr>
<td>none $m_{\mu}$–36.3</td>
<td>95</td>
<td>SODERSTROM90 MRK2</td>
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</table>

15 ADACHI 90C put lower limits on the mass of stable charged particles with electric charge $Q$ satisfying $2/3 < Q/e < 4/3$ and with spin 0 or 1/2. We list here the special case for a stable charged heavy lepton.

### Charged Long-Lived Heavy Lepton MASS LIMITS

<table>
<thead>
<tr>
<th>VALUE (GeV)</th>
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<td>none 0.55–4.5</td>
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<td>BUSHNIN 73 CNTR</td>
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<tr>
<td>none 0.2–0.92</td>
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<td>BARNA 68 CNTR</td>
<td>–</td>
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<td>none 0.97–1.03</td>
<td>18</td>
<td>BARNA 68 CNTR</td>
<td>–</td>
<td>Long-lived</td>
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</table>

16 ANSORGE 73b looks for electron pair production and electron-like Bremsstrahlung.

17 BUSHNIN 73 is SERPUKOV 70 GeV $p$ experiment. Masses assume mean life above $7 \times 10^{-10}$ and $3 \times 10^{-8}$ respectively. Calculated from cross section (see “Charged Quasi-Stable Lepton Production Differential Cross Section” below) and 30 GeV muon pair production data.

18 BARNA 68 is SLAC photoproduction experiment.
Doubly-Charged Heavy Lepton MASS LIMITS

<table>
<thead>
<tr>
<th>VALUE (GeV)</th>
<th>CL%</th>
<th>DOCUMENT ID</th>
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<tr>
<td>none 1–9</td>
<td>90</td>
<td>19 CLARK</td>
<td>81 SPEC ++</td>
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19 CLARK 81 is FNAL experiment with 209 GeV muons. Bounds apply to \( \mu^p \) which couples with full weak strength to muon. See also section on “Doubly-Charged Lepton Production Cross Section.”

Doubly-Charged Lepton Production Cross Section

<table>
<thead>
<tr>
<th>VALUE ((\text{cm}^2))</th>
<th>EVTS</th>
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<td>&lt;6. \times 10^{-38}</td>
<td>0</td>
<td>20 CLARK</td>
<td>81 SPEC ++</td>
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</table>

20 CLARK 81 is FNAL experiment with 209 GeV muon. Looked for \( \mu^+ + n \rightarrow P_{\mu}X, P^{0+} + P^{0+} \rightarrow 2\mu + \nu \). Above limits are for \( \sigma \times \text{BR} \) taken from their mass-dependence plot figure 2.

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AKRAWY 90O PL B252 290 M.Z. Akrawy et al. (OPAL Collab.)
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BEHRENDE 88C ZPHY C41 7 H.J. Behrend et al. (CELO Collab.)
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