DELPHI Collaboration

DELPHI 2000-035 CONF 354
07 March, 2000

Update on the search for singly produced excited Leptons at LEP

S. Andringa, P. Gonçalves, A. Onofre,
R. Paiva, L. Peralta, M. Pimenta and B. Tomé
LIP-IST-FCUL Lisboa, Portugal

C. Matteuzzi
INFN Milano, Italy

Abstract

Preliminary results of the search for singly produced excited leptons with the DELPHI detector at LEP are reported. The data analysed correspond to an integrated luminosity of about 230 pb^{-1}, collected in 1999 at e^+e^- centre-of-mass energies ranging from 192 GeV to 202 GeV. Upper limits on the ratio of the coupling of the excited lepton to its mass (λ/m_{l^*}) as a function of the mass are given.

This note updates the search for excited leptons in DELPHI reported in [1, 2]. The analysis follows closely the previous one and therefore this note contains basically the updated results. The data were taken at centre-of-mass energies of 192 GeV, 196 GeV, 200 GeV and 202 GeV corresponding to integrated luminosities of approximately 26 pb^{-1}, 77 pb^{-1}, 84 pb^{-1} and 41 pb^{-1} respectively. All results are preliminary.

The single production of excited leptons could proceed via s-channel γ and Z^0 exchange. Important additional t-channel contributions would arise for excited electron and for excited electronic neutrino production. In this case the unexcited beam particle is emitted preferentially at low polar angle and often goes undetected in the beam pipe.

Excited leptons could decay by radiating a γ, Z^0 or W. The decay branching ratios are functions of the f and $f^{'}$ coupling parameters of the model [3]. The mean lifetime of excited fermions with masses above 20 GeV/c^2 is predicted to be less than 10^{-15} seconds in all the cases studied.

The process $e^+e^- \rightarrow \gamma\gamma(\gamma)$ can be used to probe compositeness at LEP and thus complement the excited electron direct searches in the mass region above the kinematic threshold [4].

Excited lepton events were generated according to the cross-sections defined in [3], involving γ and Z^0 exchange. The hadronization and decay processes were simulated by JETSET 7.4 [5]. The initial state radiation effect was included at the level of the generator.

In order to obtain the number of expected background events different programs were used to simulate the relevant SM processes. Four fermion events were generated using EXCALIBUR [6]. The processes $e^+e^- \rightarrow Z^0\gamma$ with $Z^0 \rightarrow f\overline{f}$ were simulated with PYTHIA [5] and KORALZ [7], for f=quark and f=μ,τ respectively. Final states originating from two-photon ("$\gamma\gamma$") physics were produced with the TWOGAM and the Berends,Daverveldt and Kleiss generators [8, 9]. BHWIDE [10] was used to simulate the Bhabha scattering, whilst the process $e^+e^- \rightarrow \gamma\gamma(\gamma)$ was produced using the generator described in [11]. Compton-like final states originating from a $e\gamma$ collision, with an electron going undetected in the beam pipe, were generated according to [12].

Generated SM and excited lepton events were passed through the full DELPHI simulation and reconstruction chain and processed by the same analysis program used for real data.

The event selection was performed in three stages. In the first level, very general selection criteria were applied and the events were classified according to the number of jets and of isolated leptons and photons. In the second level, differing selection criteria were applied to each topology. Finally, whenever possible, event flavour tagging was performed, based on the identification of the final state leptons and on other (topology dependent) characteristics of the event. Details on each selection level are given in reference [1]. Only small adjustments were made with respect to the previous analysis. At the different selection levels and topologies fair agreement between data and SM expectation was found.

The comparison between the numbers of excited lepton candidates and the expected background is shown in table 1, for the different excited lepton types and decay modes, revealing consistency with the SM expectations.

The efficiencies, including the trigger efficiency, were calculated for each final state topology at several mass points covering the relevant parameter phase space. The values shown in table 2 are average values for masses in the range 190 GeV–195 GeV.

The limits were computed, combining all 1999 data with the previous results obtained at 189 GeV [2], using the method described in [13]. In the single production of excited leptons the cross-sections are a function not only of the mass of the excited particle (m_{l^*}) but also of the ratio of the coupling of the excited lepton to its mass, λ/m_{l^*}. 95% confidence level (CL) upper limits on λ/m_{l^*} as a function of m_{l^*} were derived. Figures 1 and 2 show these limits for the excited leptons assuming $f = f'$ and $f = -f'$ respectively.

Figure 3 shows the limit on the excited electron production for $f = f'$ obtained by combining the result of the direct search (figure 1(a)) with the indirect result from the search for deviations in the $e^+e^- \to \gamma\gamma(\gamma)$ differential cross-section. We can thus extend the result to regions above the kinematic limit.

References

[1] DELPHI Coll., P. Abreu et al., E. Phys. J. C8 (1999) 41.

[2] S. Andringa et al., “Update on the search for excited fermions at LEP”, DELPHI note 99-71 HEP’99 CONF 258.

[3] K. Hagiwara, S. Komamiya and D. Zeppenfeld, Z. Phys. **C29** (1985) 115;
F. Boudjema, A. Djouadi and J.L. Kneur, Z. Phys. **C57** (1993) 425.

[4] S. Andringa et al.,“Determination of the $e^+e^- \to \gamma\gamma(\gamma)$ cross-section at centre-of-mass energies ranging from 189 GeV to 202 GeV”, submitted to Moriond EW’2000.

[5] T. Sjöstrand, Comp. Phys. Comm. **82** (1994) 74.

[6] F.A. Berends, R. Pittau, R. Kleiss, Comp. Phys. Comm. **85** (1995) 437

[7] S. Jadach, B.F.L. Ward and Z. Wąs, Comp. Phys. Comm. **79** (1994) 503.

[8] S. Nova, A. Olshevski and T. Todorov, “MONTE CARLO event generator for two photon physics”, DELPHI note 90-35 PROG 152.

[9] F. A. Berends, P. H. Daverveldt, R. Kleiss, Comp. Phys. Comm. **40** (1986) 271.

[10] S. Jadach,W. Placzek and B.F.L. Ward, UTHEP-95-1001.

[11] F.A.Berends and R.Kleiss, Nucl. Phys. **B186** (1981) 22.

[12] D.Karlen, Nucl. Phys. **B289** (1987) 23.

[13] A.L. Read, “Optimal statistical analysis of search results based on the likelihood ratio and its application to the search for the MSM Higgs boson at $\sqrt{s}$=161 and 172 GeV”, DELPHI note 97-158 PHYS 737.

$\sqrt{s}$ GeV	topology	excited lepton id.		
		e	μ	τ
192	$\ell^* \to \ell\gamma$	22 (20±1)	11 (8.4±0.4)	19 (13±1)
	$\ell^* \to \nu W$	6 (5.8±0.6)	2 (3.2±0.3)	1(1.5±0.2)
	$\ell^* \to \ell Z$	11 (13.5±0.7)	6 (9.6±0.5)	6 (7.6±0.5)
	$\nu^* \to \nu\gamma$	0 (0.1)		
	$\nu^* \to \ell W$	6 (5.2±0.6)	2 (2.6±0.3)	4 (2.8±0.3)
	$\nu^* \to \nu Z$	0(1.2±0.1)		
196	$\ell^* \to \ell\gamma$	51 (59±4)	22 (24±1)	50 (38±3)
	$\ell^* \to \nu W$	14 (17±2)	11 (9.7±0.8)	5 (4.6±0.7)
	$\ell^* \to \ell Z$	44 (41±2)	22 (29±1)	28(23±2)
	$\nu^* \to \nu\gamma$	2 (0.7)		
	$\nu^* \to \ell W$	12 (15±2)	9 (7.9±0.8)	8 (9±1)
	$\nu^* \to \nu Z$	1 (3.7±0.4)		
200	$\ell^* \to \ell\gamma$	62 (63±4)	27 (26±1)	45 (42±3)
	$\ell^* \to \nu W$	21 (22±2)	13 (13±1)	11 (7±1)
	$\ell^* \to \ell Z$	46 (52±3)	33 (31±1)	28 (24±2)
	$\nu^* \to \nu\gamma$	6 (1.7)		
	$\nu^* \to \ell W$	18 (20±2)	10 (11±1)	15 (14±1)
	$\nu^* \to \nu Z$	4 (4.3±0.5)		
202	$\ell^* \to \ell\gamma$	39 (30±2)	10 (12.5±0.5)	26 (20±2)
	$\ell^* \to \nu W$	10 (11±1)	5(6.5±0.5)	1 (3.5±0.5)
	$\ell^* \to \ell Z$	27 (25±1)	13(15.1±0.7)	13 (11.8±0.9)
	$\nu^* \to \nu\gamma$	1 (1.2)		
	$\nu^* \to \ell W$	9 (10±1)	4 (5.4±0.5)	6 (6.6±0.7)
	$\nu^* \to \nu Z$	1 (2.1±0.2)		

Table 1: Number of candidates for the different excited lepton decay channels and centre-of-mass energies. The SM expected background are displayed within parentheses.

topology	excited lepton id.		
	e	μ	τ
$\ell^* \to \ell\gamma$	30	60	19
$\ell^* \to \nu W$	20	30	21
$\ell^* \to \ell Z$	21	35	19
$\nu^* \to \nu\gamma$	35		
$\nu^* \to \ell W$	27	31	14
$\nu^* \to \nu Z$	15		

Table 2: Efficiency (in %) for the different excited lepton decay channels

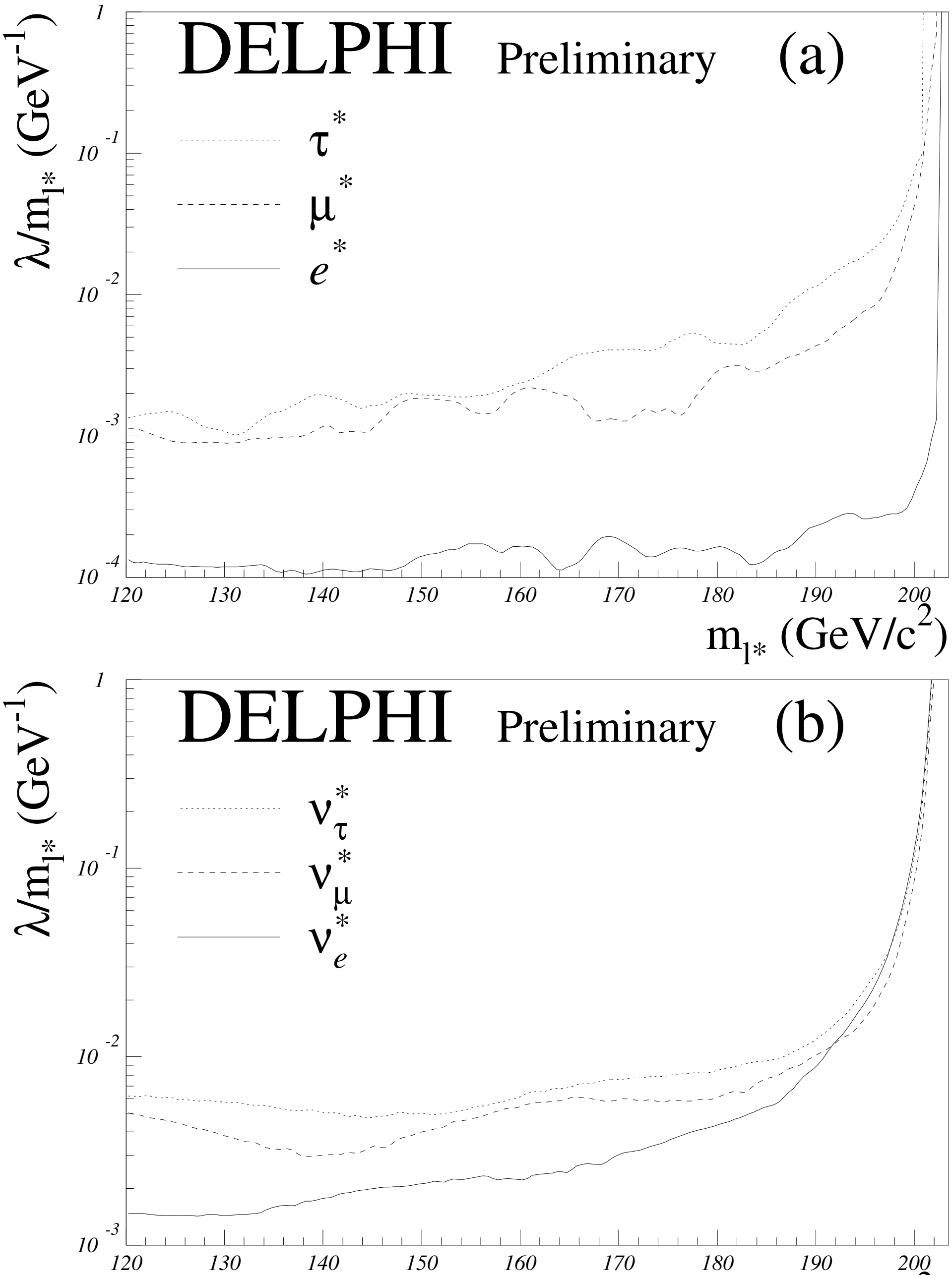

Figure 1: Limits on the single production of charged **(a)** and neutral **(b)** excited leptons assuming $f = +f'$. The lines show the upper limits at 95% CL on the ratio λ/m_{ℓ^*} between the coupling of the excited lepton and its mass as a function of the mass.

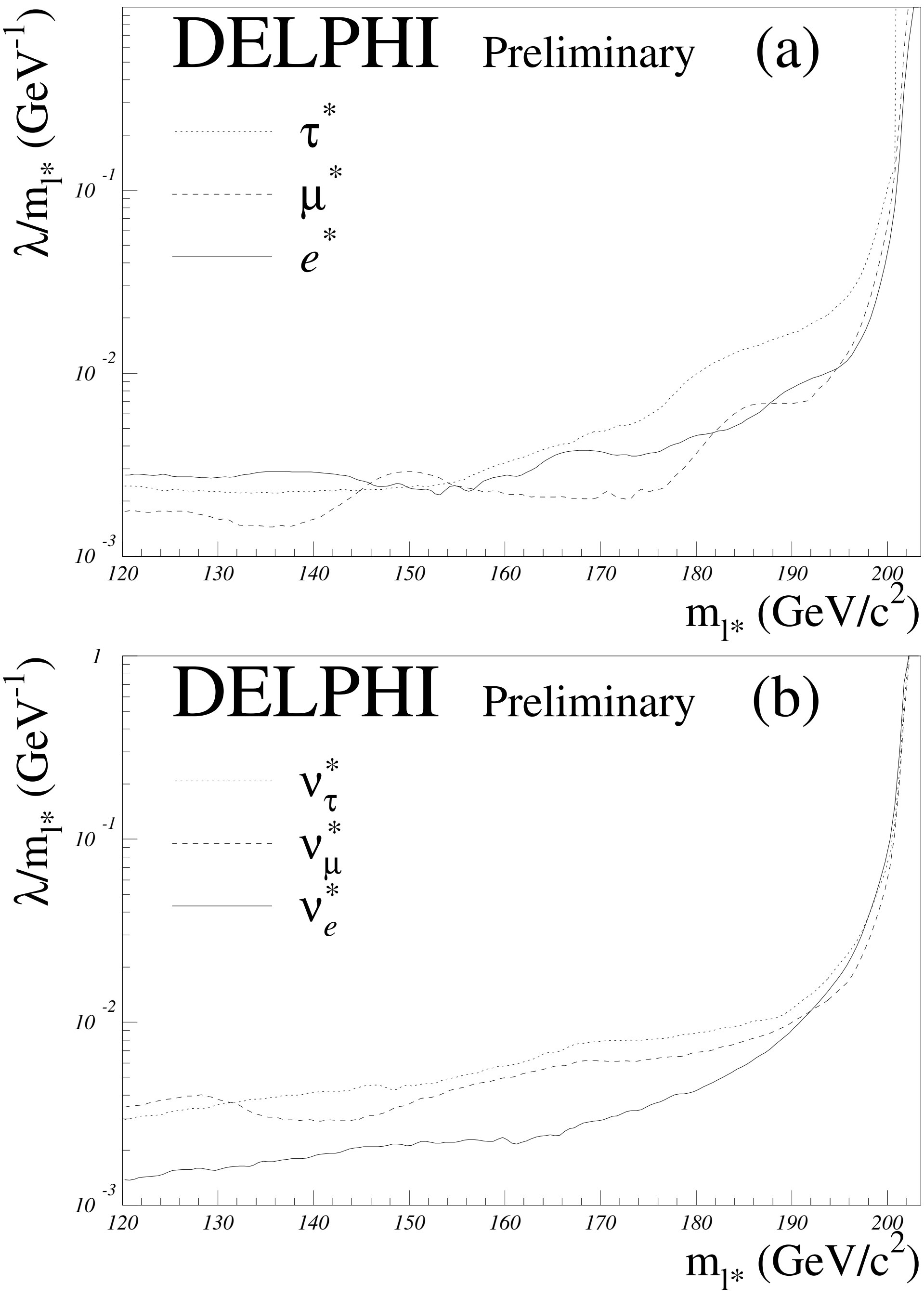

Figure 2: As figure 1, but for $f = -f'$.

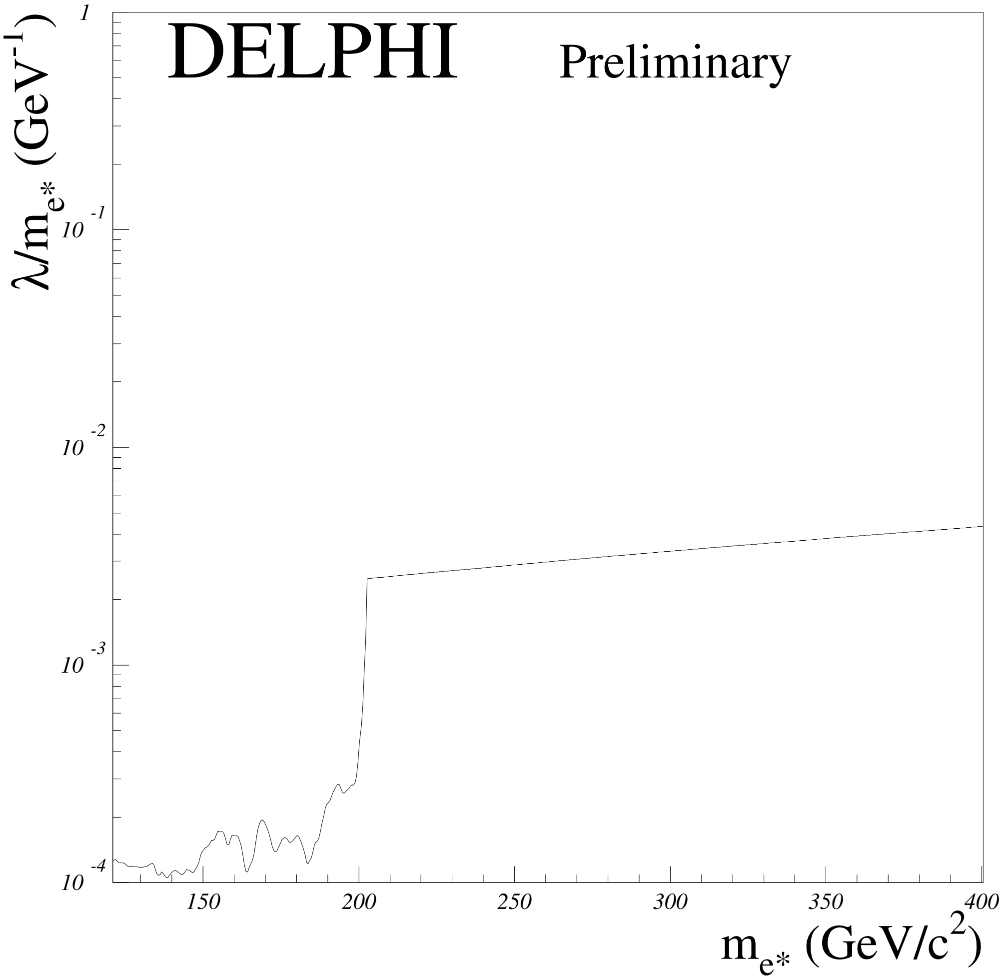

Figure 3: Combined excited electron limits for $f = f'$ from direct and indirect searches. The line shows the upper limits at 95% CL on the ratio λ/m_{e^*} as a function of the mass. Up to the kinematic limit the result is dominated by the single production direct search. Above this value the limit is the one coming from the indirect search using $e^+e^- \to \gamma\gamma$.