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# Preliminary results on New Particle Searches at $\sqrt{s} = 183$ GeV

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## Abstract

A brief status of the searches for new particles is presented based on 6.1 $\mathrm{pb}^{-1}$ of data collected at $\sqrt{s} \simeq 183$ GeV. The observed event rates are consistent with the Standard Model expectations. All quoted result are preliminary.

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# 1 Higgs Searches and Four Jets Analysis

A search for the Standard Model Higgs Boson is performed using analysis approach described in [1]. Two candidates are selected in the $\mathrm{Hq\bar{q}}$ channel with 1.21 expected from the Standard Model processes, one (see Fig. 1) in $\mathrm{H}\nu\bar{\nu}$ with 1.15 expected, one in the $\mathrm{He^+e^-}$ channel with 0.38 expected and no candidates in the $\mathrm{H}\mu^+\mu^-$, $\mathrm{H}\tau^+\tau^-$ and $\tau^+\tau^-\mathrm{q\bar{q}}$ channels with 0.5, 0.05 and 0.07 expected events, respectively. Combining these results with those recently published leads to a new lower Higgs mass limit of 72 GeV at 95% confidence level (Fig. 2).

A study of hadronic events with high jet multiplicity has been performed similar to the one described in [2]. Seven events are selected with 9.32 expected from the standard processes. One event falls in the mass window of $105 \pm 4$ GeV for the sum of two dijet masses with 0.51 events expected. The distributions of the sum of dijet masses are presented in Figure 3 for the smallest and the second smallest mass difference between jet pairs.

# 2 SUSY searches

Analysis has been performed for slepton, stau and chargino production, taking into account all chargino decay channels. To cover all possible final states 27 different selections are used as described in reference [3]. In each channel the analysis is carried on for three ranges of mass difference ($\Delta\ M$=$M_{\chi^\pm}$ - $M_{\chi^0}$).

We select in total 8 events; the results are presented in Tables 1 and 2. Table 1 includes sleptons and stops, and Table 2 shows chargino decay channels. Efficiencies of the $\tilde{l}\tilde{l}$ and $\tilde{t}\tilde{t}$ selections are $\sim$ 55 % for low $\Delta M$, $\sim$ 62 % for medium $\Delta M$ and $\sim$ 55 % in high $\Delta M$ regions. Efficiencies of chargino selections are $\sim$ 30 % for low $\Delta M$, $\sim$ 45 % for medium $\Delta M$ and $\sim$ 30 % for high $\Delta M$.

Table 1: Summary of $\tilde{l}\tilde{l}$ and $\tilde{t}\tilde{t}$ analysis.

| | low $\Delta M$ | | medium $\Delta M$ | | high $\Delta M$ | |
|---|---|---|---|---|---|---|
| | Bckg | Data | Bckg | Data | Bckg | Data |
| $\tilde{e}\ \tilde{e}$ | 0.04 | 1 | 0.28 | 0 | 1.14 | 2 |
| $\tilde{\mu}\ \tilde{\mu}$ | < 0.01 | 0 | 0.08 | 0 | 0.69 | 0 |
| $\tilde{\tau}\ \tilde{\tau}$ | 0.08 | 2 | 0.28 | 1 | 0.57 | 1 |
| $\tilde{t}\ \tilde{t}$ | 1.52 | 3 | 1.74 | 1 | 0.82 | 0 |

Figure 4 shows an event that is selected as $\tilde{e}\ \tilde{e}$ candidate with high $\Delta M$. There are two electrons detected and large transverse imbalance. A preliminary result on chargino mass limit is shown in Figure 5, where the calculation is performed for $\Delta M = 10$ GeV giving the limit of 85.4 GeV (95% C.L.). In the deep gaugino region ($\mu = -500$, $\tan\beta = 1.41$ and $\mathrm{m_0} = 500$ we almost reach the kinematic limit: $M_{\chi^\pm} > 90.9$ GeV.

Table 2: Summary of chargino analysis.

| | low $\Delta M$ | | medium $\Delta M$ | | high $\Delta M$ | |
|---|---|---|---|---|---|---|
| | Bckg | Data | Bckg | Data | Bckg | Data |
| *hadrons* | 0.97 | 0 | 0.82 | 0 | 0.33 | 0 |
| *lepton + jet* | < 0.01 | 0 | 0.81 | 0 | 0.47 | 0 |
| *leptons* | < 0.01 | 1 | 0.04 | 1 | 0.16 | 0 |
| $\tau\tau$ | < 0.01 | 2 | 0.08 | 1 | 0.24 | 0 |
| $\tau$ + *jet* | < 0.01 | 0 | < 0.01 | 0 | < 0.01 | 0 |

# 3 Search for Excited Leptons

We have searched for charged excited leptons $e^*$, $\mu^*$ and $\tau^*$ in $e^+ e^-$ collisions at $\sqrt{s} = 182$ GeV using the 6.1 pb$^{-1}$ of data collected by the L3 detector at LEP. The analysis is similar to that described in our previous paper [4].

Excited leptons can be produced either in pairs ($e^+e^- \rightarrow l^*l^*$) or singly ($e^+e^- \rightarrow ll^*$). Effective Lagrangian and lowest order cross sections can be found in references [5] and [6]. An excited lepton is expected to decay immediately into its corresponding standard lepton and a photon with a 100% branching ratio if its mass is smaller than that of the W. For higher mass, the decays $l^* \rightarrow Zl$ and $l^* \rightarrow W\nu$ are allowed and the branching ratio of $l^* \rightarrow l\gamma$ is a function of $m_{l^*}$ [6].

For the pair production of excited leptons, the event selection requires two leptons and two photons. For at least one of the two possible $l - \gamma$ permutations, $m_1(l_1, \gamma_1)$ and $m_2(l_2, \gamma_2)$, must be smaller than 10 GeV and their mean value must be greater than 50 GeV. No events pass the selection. The main background is due to the radiative dilepton production. A total of 0.24 $ee\gamma\gamma$ events are predicted from the BHAGENE3 Monte Carlo, and less than 0.1 $\mu\mu\gamma\gamma$, and $\tau\tau\gamma\gamma$ events from KORALZ. The detection efficiency for the signal is estimated to be 60% for $e^*e^*$, 57% for $\mu^*\mu^*$ and 54% for $\tau^*\tau^*$. Taking into account the luminosity, the efficiency, the branching ratio and the production cross section, we determine the lowest mass limits at 95% confidence level to be 89.1 GeV for $e^*$, 88.9 GeV for $\mu^*$, and 88.7 GeV for $\tau^*$.

For the single production of excited leptons, the event selection requires a photon and at least one lepton. The invariant mass $m(l, \gamma)$ must be greater than 70 GeV. A total of 21 $ee\gamma$ events pass the selection. The invariant mass distribution does not show any structure and the number of selected events is compatible with the expected background from the radiative Bhabha events. One $\mu\mu\gamma$ event is selected. It is consistent with the expected background of radiative return to the Z. Eight events pass the initial cuts for the $\tau\tau\gamma$ channel, consistent with background from radiative Bhabhas. The detection efficiency for the signal is estimated to be of the order of 70% for $ee^*$, 54% for $\mu\mu^*$ and 42% for $\tau\tau^*$, and depends on the mass of the excited lepton. Taking into account the luminosity, the efficiency, the branching ratio and the production cross section, the upper limit of the coupling constant $\lambda/m_{l^*}$ at 95% C. L. as a function of $m_{l^*}$ is shown in Figure 6.

# 4 Limits on deviations from QED

The possible deviations from QED are parametrised in terms of effective Lagrangians, and their effect on the observables can be expressed as a multiplicative correction term to the QED differential cross-section. All data samples collected by L3 in the centre-of-mass energy range 130 GeV $< \sqrt{s} <$ 183 GeV have been included in the following analysis (see Figure 7). Depending on the type of parametrisation two general forms are considered:

$$\frac{d\sigma}{d\Omega} = \left(\frac{d\sigma}{d\Omega}\right)_{QED} \left(1 + \frac{s^2}{\alpha}\frac{1}{\Lambda^4}\sin^2\theta\right) \tag{1}$$

and

$$\frac{d\sigma}{d\Omega} = \left(\frac{d\sigma}{d\Omega}\right)_{QED} \left(1 + \frac{s^3}{32\pi\alpha^2}\frac{1}{\Lambda'^6}\frac{\sin^2\theta}{1+\cos^2\theta}\right) \tag{2}$$

which depend on the centre-of-mass energy, the polar angle $\theta$ and the scale parameter $\Lambda$ which has dimension of energy. A simpler and more standard way of parametrising the deviations from QED is the introduction of the cut-off parameters $\Lambda_\pm$ [8]. The differential cross-section can be obtained from equation 1 by replacing $\Lambda^4$ by $\pm(2/\alpha)\Lambda^4_\pm$.

Limits on the different scale parameters have already been set in our previous publications [7]. However, since the sensitivity to possible deviations from QED increases rapidly with the centre-of-mass energy they are improved with the present data. In order to quantify the possible deviations from QED we define, for each sample at a given centre-of-mass energy, a likelihood for the different hypotheses of $\Lambda$ in terms of the observed polar angle of the event ($\theta_i$) and the total number of observed events ($N_0$) as:

$$L(\lambda_p) = \frac{1}{\sqrt{2\pi}\sigma(\lambda_p)} exp\left(\frac{-(N_o - N_t(\lambda_p))^2}{2\sigma^2(\lambda_p)}\right) \prod_{i=1}^{N_o} f(\cos\theta_i|\lambda_p) \tag{3}$$

In this expression $\lambda_p$ stands for the parameter under consideration ($1/\Lambda^4$ or $1/\Lambda'^6$); $N_t(\lambda_p)$ is the total number of expected events, $\sigma(\lambda_p)$ the statistical error on the number of expected events and $f(\cos\theta_i|\lambda_p)$ the probability density function of the polar angle $\theta$. The choice of $\lambda_p$ as a parameter has the advantage of giving, to a good approximation, a parabolic shaped log-likelihood around the maximum. The estimated parameters from all data samples collected by L3 in the centre-of-mass energy range 130 GeV $< \sqrt{s} <$ 183 GeV are:

$$\begin{aligned} \frac{1}{\Lambda^4} &= \left(-0.03^{+\,0.09}_{-\,0.08}\right)\, 10^{-11} \quad \mathrm{GeV}^{-4} \\ \frac{1}{\Lambda'^6} &= \left(-0.13^{+\,0.24}_{-\,0.23}\right)\, 10^{-16} \quad \mathrm{GeV}^{-6} \end{aligned}$$

consistent with no deviations from QED. To determine the confidence levels the probability distribution is normalised over the physically allowed range of the parameters. At the 95% C.L. the following limits are obtained:

$$\begin{aligned} \Lambda &> 899 \quad \mathrm{GeV} \\ \Lambda_+ &> 221 \quad \mathrm{GeV} \\ \Lambda_- &> 213 \quad \mathrm{GeV} \\ \Lambda' &> 535 \quad \mathrm{GeV} \end{aligned}$$

Another way to study possible deviations from QED is to postulate the existence of an excited electron ($e^*$) of mass $m_{e^*}$ which couples to the electron and the photon via magnetic interactions. To describe this interaction two different phenomenological Lagrangians are used; one with a magnetic interaction [9]:

$$\mathcal{L} = \frac{e}{2\Lambda_{e^*}} \overline{\Psi}_{e^*} \sigma^{\mu\nu} \Psi_e F_{\mu\nu} + h.c. \tag{4}$$

and another one with a magnetic interaction where only left-handed or right-handed fermions are involved [10]:

$$\mathcal{L} = \frac{e}{2\Lambda_{e^*}} \overline{\Psi}_{e^*} \sigma^{\mu\nu} (1 \pm \gamma^5) \Psi_e F_{\mu\nu} + h.c. \tag{5}$$

In both cases $\Lambda_{e^*}$ is related to the effective scale of the interaction and $m_{e^*}$ is the additional mass parameter. Fixing the interaction scale $\Lambda_{e^*}$ to $m_{e^*}$ we obtain

$$\frac{1}{m_{e^*}^4} = \left(-0.09^{+0.23}_{-0.22}\right) 10^{-9} \quad \mathrm{GeV}^{-4}$$

for the first case and

$$\frac{1}{m_{e^*}^4} = \left(-0.23^{+0.61}_{-0.79}\right) 10^{-9} \quad \mathrm{GeV}^{-4}$$

for the second one. From them we derive the 95% C.L. lower limits of:

$$m_{e^*} > 223 \quad \mathrm{GeV}$$

and

$$m_{e^*} > 167 \quad \mathrm{GeV}$$

respectively.

# References


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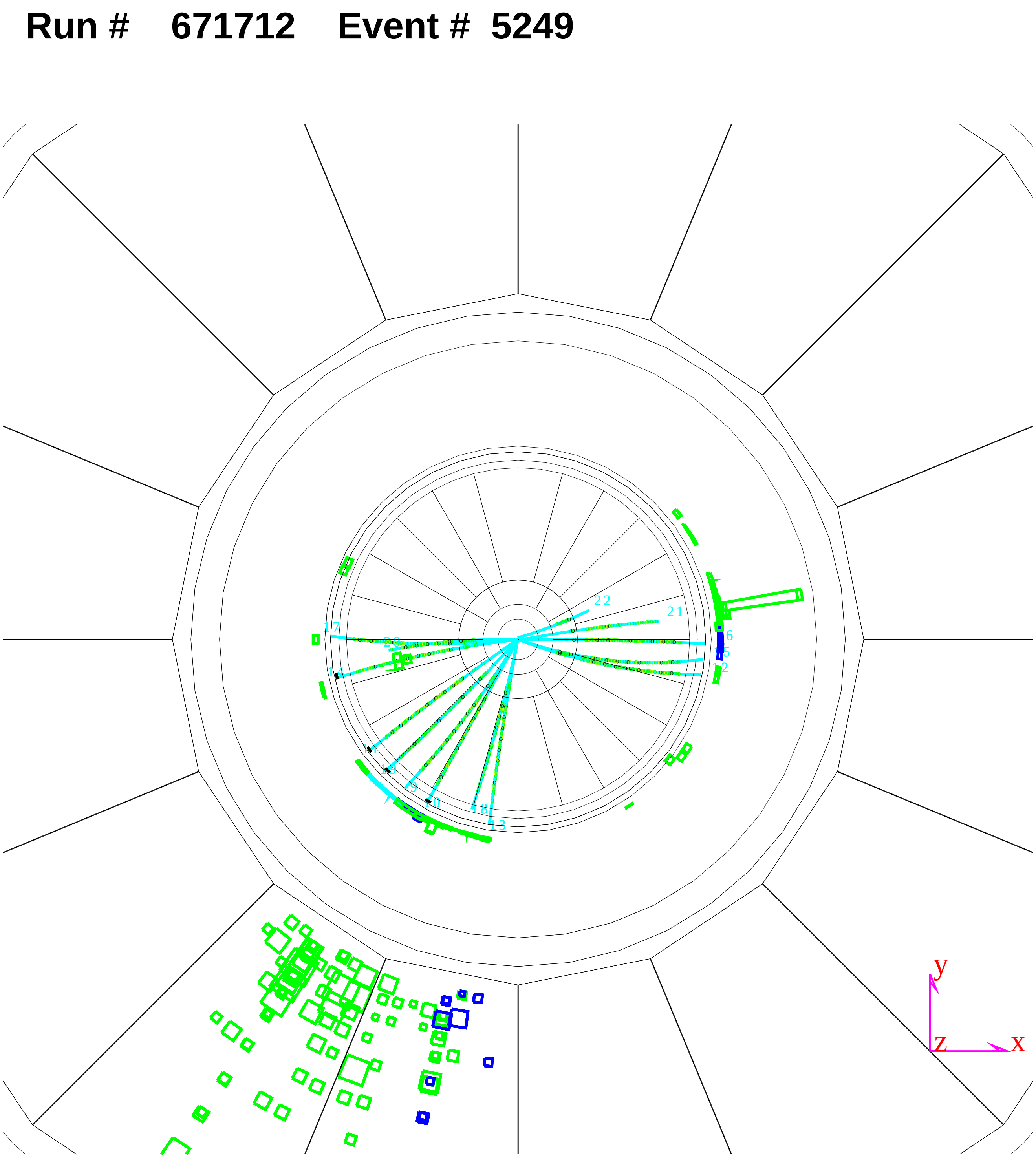


Figure 1: A $H\nu\bar{\nu}$ candidate event. The invariant mass $M_{\mathrm{j-j}}$ is measured to be 81 GeV.

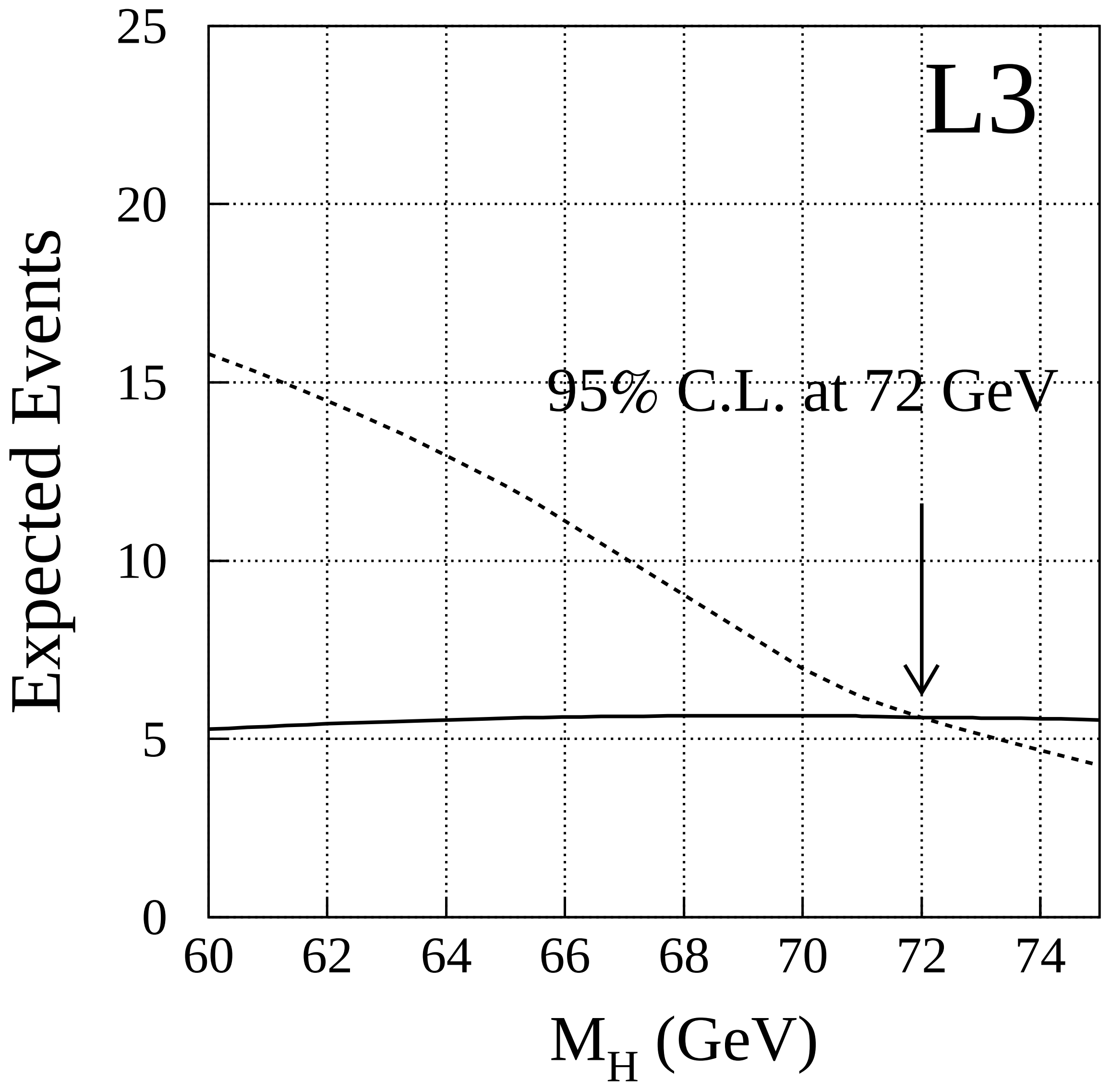


Figure 2: The number of expected Higgs signal events (dashed line) and the number of signal events excluded at 95% confidence level as functions of the Higgs boson mass.

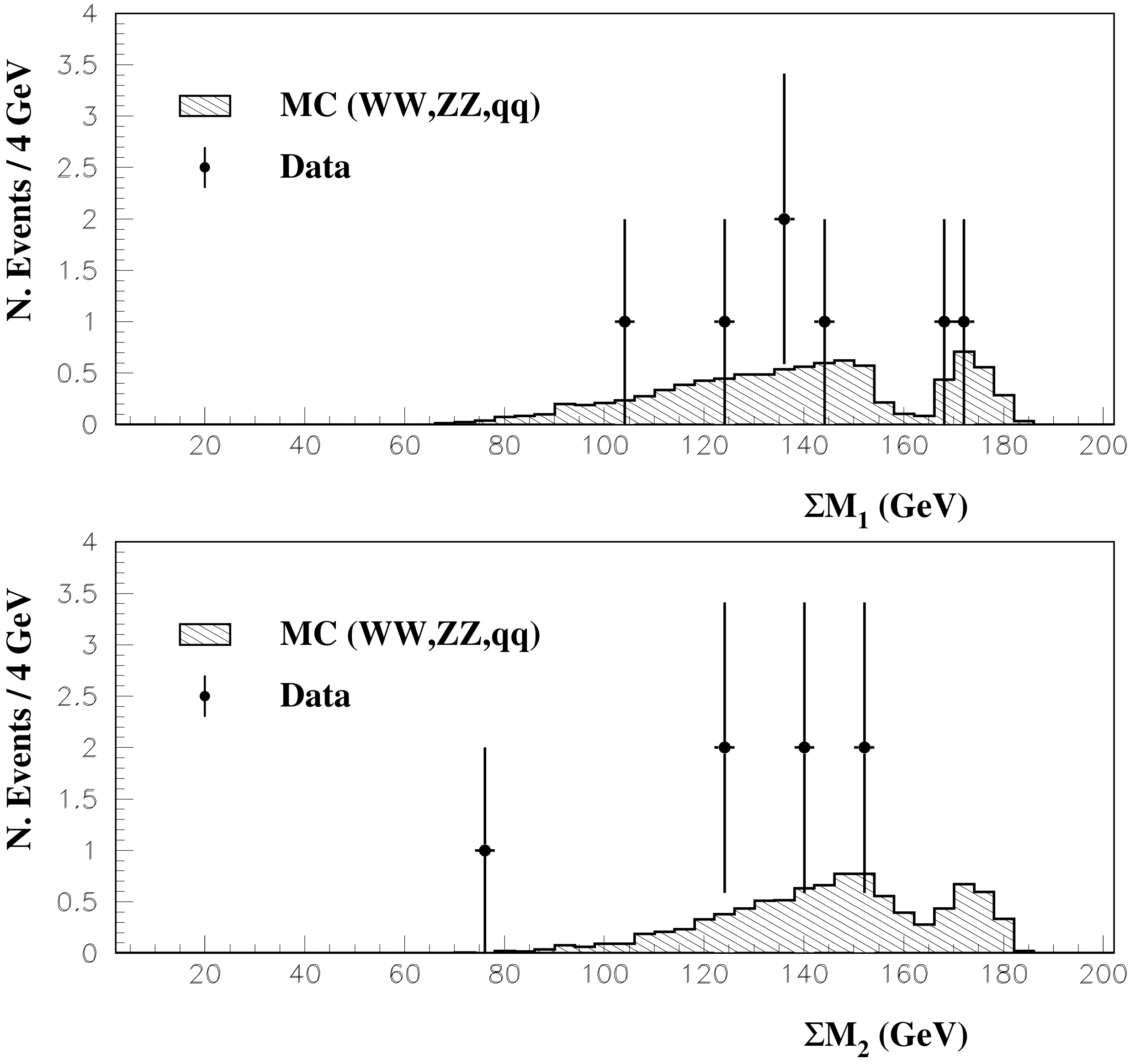


Figure 3: The distributions of the sum of dijet masses for (a) smallest dijet mass difference, (b) second smallest dijet mass difference.

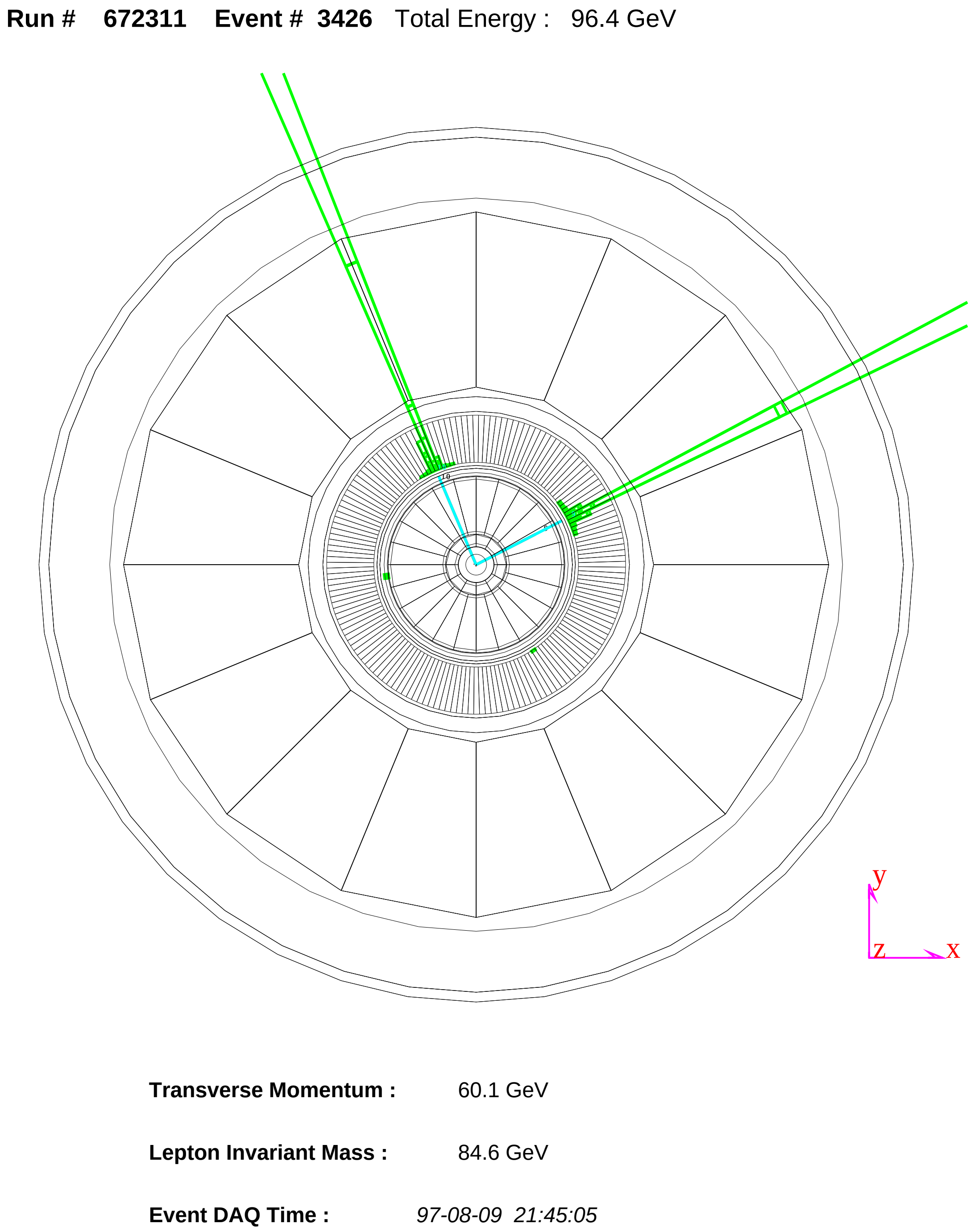


Figure 4: A $\tilde{e}\,\tilde{e}$ candidate event.

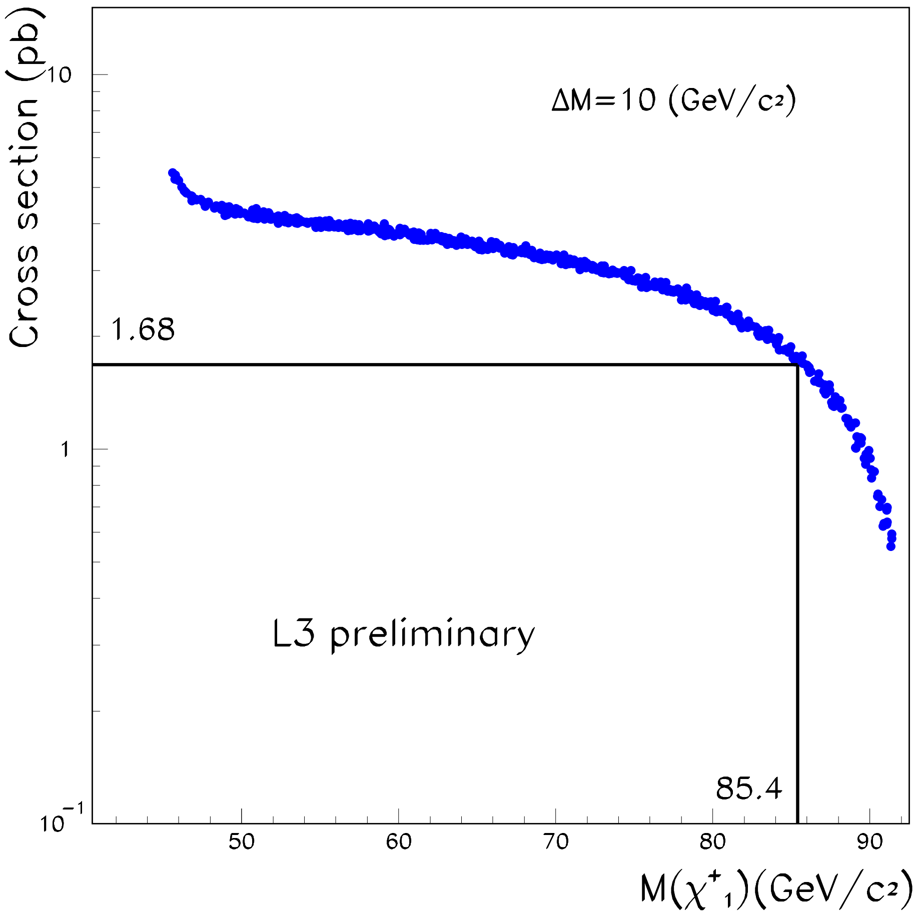


Figure 5: Chargino exclusion for $\Delta M = 10$ GeV. Each dot corresponds to the chargino production cross sections and specific choice of the parameters. Cross sections larger than 1.68 pb are excluded.

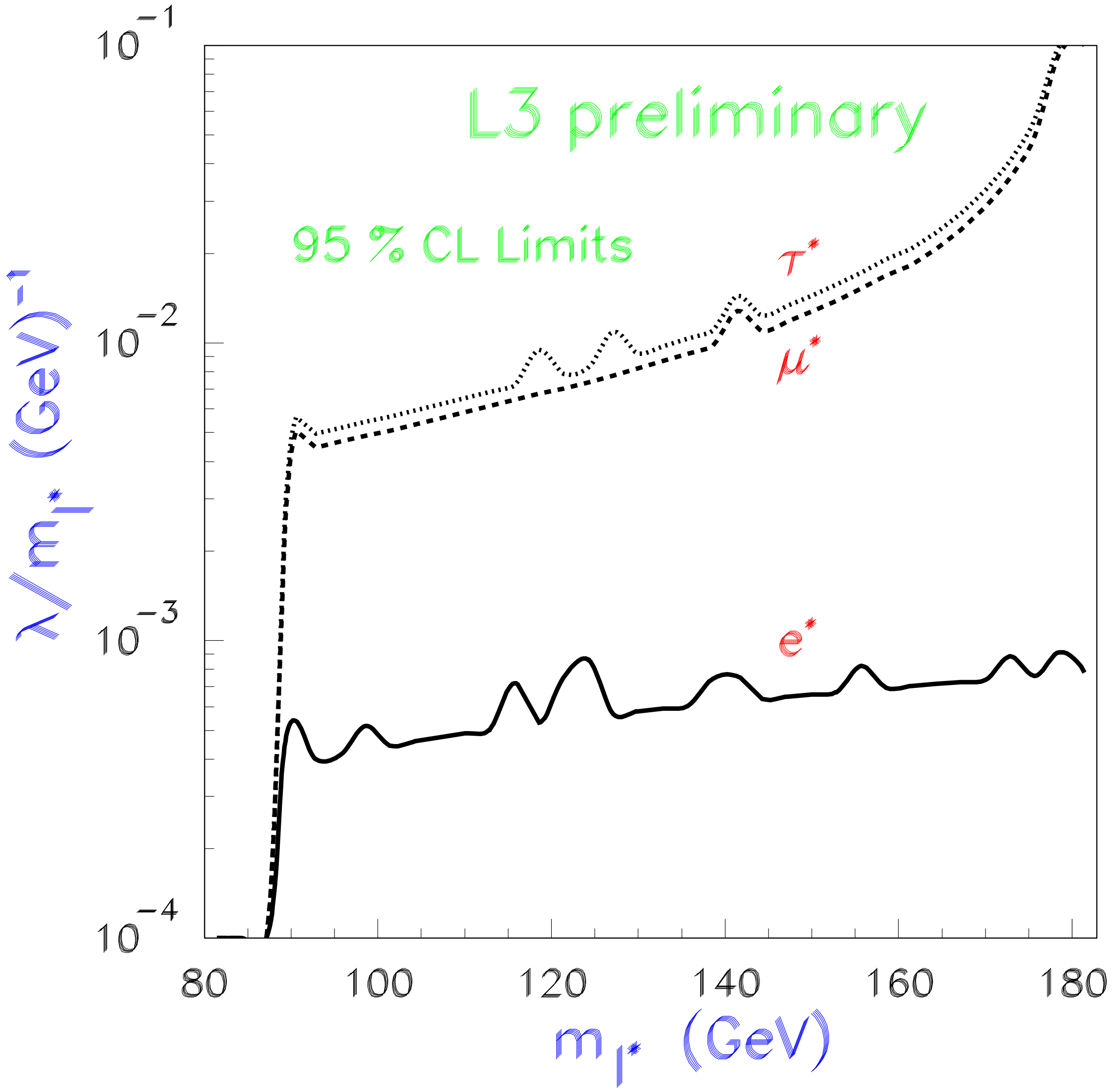


Figure 6: Upper limit of the coupling constant $\lambda/m_{l^*}$ at 95% C. L. as a function of $m_{l^*}$.

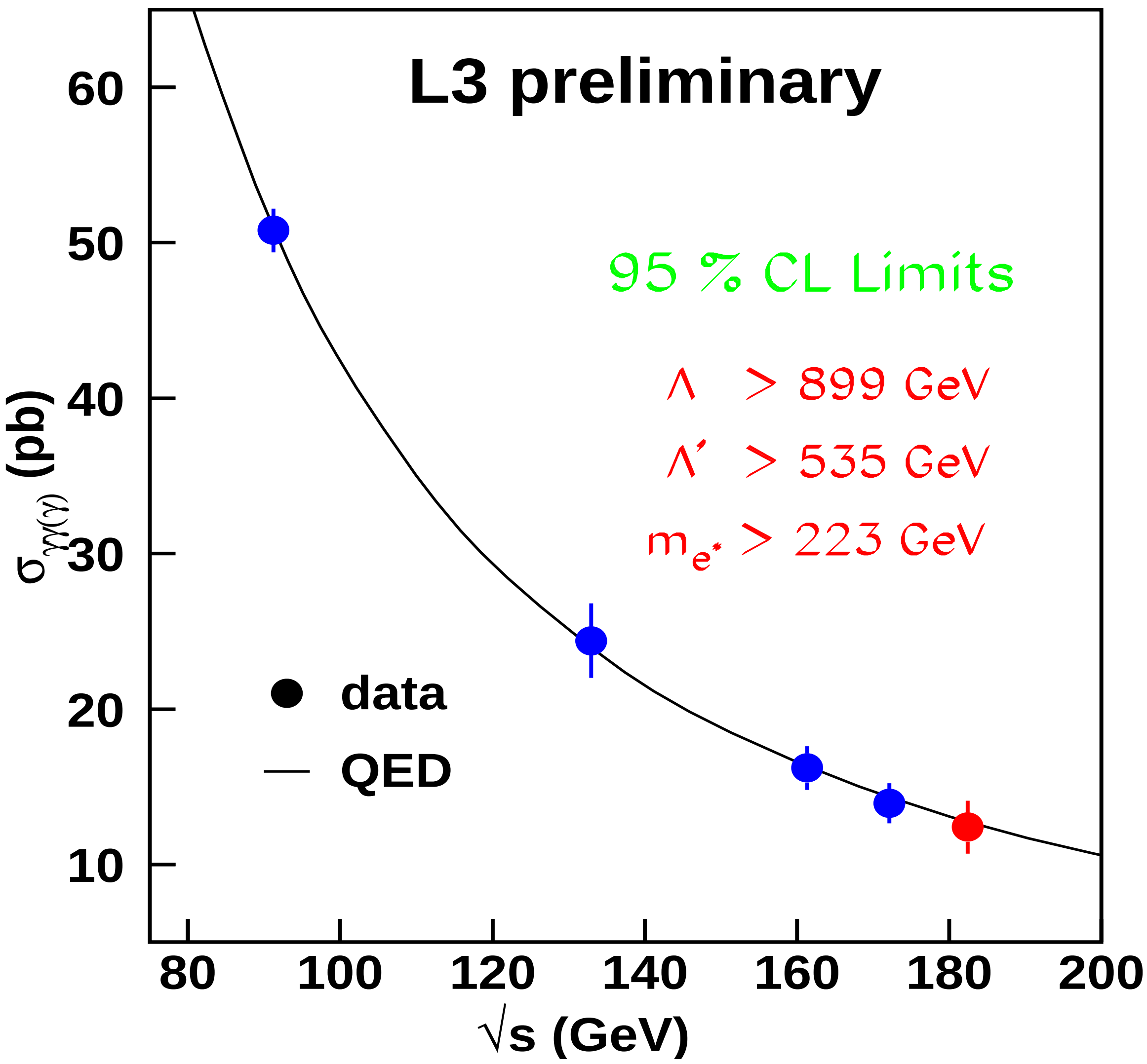


Figure 7: Combined limits on QED deviations and measured cross-sections as function of the centre-of-mass energy for $\theta_\gamma$ between 16° and 164° compared with the QED prediction.