Checks on light SBOTTOM Analysis

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1 Introduction

The ALEPH Collaboration presented at last LEPC [1] a preliminary result by Mario Antonelli [2] about an excess on $e^+e^- \to b\bar{b}$ (56 events against 34 expected) in which the B decays semileptonically. This was found compatible with a signal coming from a sbottom ($\tilde{b}$) with low mass (3.6 GeV) and a lifetime of about 1 ps.

This short note describes a light sbottom dedicated analysis aimed to improve the selection based on standard SUSY ntuples ([2]).

In the first part I try and reproduce M.Antonelli's results, using basically the same set of cuts (with some differences....); then, I try to improve the selection mostly for what concerns electron identification.

2 Data sample

I use data taken in 1998–1999 at the energies:

Energy	$\mathcal{L}$ (nb^{-1})
189	174205
192	28923
196	79834
200	86298
202	42008
	411268

Table 1: Integrated luminosities and energies. Cards were obtained from P.Azzurri, and require good events for all physics groups.

Monte Carlo samples As I will show in a moment, only $q\bar{q}$ MCs are relevant to this analysis. I use 189 GeV MC available at CERN through scanbook; for energies greater than 189 GeV I use the MC production done in Pisa and not yet in scanbook, for a total of 2.5 million events.

Moreover, I use WW events at 196 GeV, $\tau\bar{\tau}$ at 189 GeV, $\gamma\gamma$ at 196 GeV and ZZ at 200 GeV.

The signal has been simulated by M.Antonelli, and amounts to roughly 3300 events of sbottoms with $M = 3.6\ GeV$ and $\tau = 1\ ps$.

Energy	Events	σ (nb)
189 $b\bar{b}$	50000	.0194
189 $c\bar{c}$	50000	.0201
189 $s\bar{s}$	50000	.0198
189 $d\bar{d}$	50000	.0198
189 $u\bar{u}$	50000	.0201
192 $b\bar{b}$	100000	.0188
192 $c\bar{c}$	100000	.0196
192 $s\bar{s}$	100000	.0192
192 $d\bar{d}$	100000	.0192
192 $u\bar{u}$	50000	.0196
196 $b\bar{b}$	150000	.0179
196 $c\bar{c}$	150000	.0186
196 $s\bar{s}$	150000	.0183
196 $d\bar{d}$	150000	.0183
196 $u\bar{u}$	150000	.0187
200 $b\bar{b}$	150000	.0170
200 $c\bar{c}$	150000	.0177
200 $s\bar{s}$	150000	.0173
200 $d\bar{d}$	150000	.0173
200 $u\bar{u}$	150000	.0177
202 $b\bar{b}$	100000	.0165
202 $c\bar{c}$	100000	.0172
202 $s\bar{s}$	100000	.0169
202 $d\bar{d}$	100000	.0169
202 $u\bar{u}$	100000	.0173

Table 2: Energies, number of events and cross sections for MCqq.

3 Preselection

Hadronic (CLAS16) events are forced to 2 jets, and the most energetic lepton is selected in each thrust hemisphere.

Lepton id criteria at this stage are:

- Electrons: $R_T > -3$; $-3 < R_L < 3$.
- Muons: QMUIDO flags 11 and greater than 12 (muon chambers and/or HCAL).

In the preselection the following requirements are needed:

- $THRUST > .975$
- $|\cos\theta_{THRUST}| < .95$
- $\log_{10}(BTAG) < -0.2$ (Probability smaller than 80%)
- number of good charged tracks from EF greater than 7
- Sum of the energy of the two jets greater than 55% of energy of LEP.

After these cuts, the number of selected events is:

	189	192	196	200	202	Tot
DT	184	27	82	66	35	394
MCqq	148	26 70	76	36	22.2	356.7
WW						1.2
$\tau\bar{\tau}$						0.1
ZZ						1.2

Table 3: Selected events after preselection.

A small excess is present at this stage.

4 Selection

Other cuts are added to improve the selection:

- the leptons are required to have opposite charges.
- the energy of the most energetic lepton is required to be in excess of 2% the cm energy, while the other in excess of 1% of cm energy.
- a tighter BTAG is asked : $\log_{10}(BTAG) < -1.7$.
- the aplanarity is required to be small: $|\Delta\phi - 180°| < 8°$.
- $|\cos\theta_{THRUST}| < .7$

With these cuts, the selected events are

	189	192	196	200	202	Tot
DT	23	2	10	10	5	50
MCqq	14.8	2.8	6.8	7.3	3.5	35.1
WW						0.07
ZZ						0.05

These cuts mostly reproduce the ones used by M.Antonelli; in particular, ALL the events selected by Mario in data are selected here, with a few more (on the same datasets, Mario selects 39 events with an expected bkg of 23.9). Since I use a different MC production, the comparison cannot be done on MC events.

If I look at the type of selected leptons, the excess is present mainly in case of at least one selected electron:

Pair	DT	MC
ee	22	13.3
$\mu\mu$	7	5.2
μe	21	16.6

Table 4: Selected events by lepton pairs.

5 Improved cuts

Since the excess seems to be there mainly for electrons, it may be worth looking better at them. The cuts used in preselection are standard for LEP 2 analyses, but are a bit too loose for leptons with very small momenta, as those selected here.

I try to improve the selection using the dE/dx information for electrons, where available. Unluckly, dE/dx from pads was never calibrated at LEP 2 and turns out to be completely unusable (see figure 1).

I propose 4 sets of "selection" cuts for electrons:

1. "Mario's": use standard

$$-3 < R_L < 3 \quad R_T > -3$$

2. dE/dx: use above cuts for ECAL, and then if dE/dx (wires only!) is available (this means at least 50 isolated wires), cut at

$$\frac{R_i - R_{exp}}{\sigma} > -2$$

   At the preselection level, 32% of electron candidates (data) do not have dE/dx information.

3. Stronger ECAL cuts: apply standard HF cuts, with no dE/dx

$$-1.8 < R_L < 3 \quad R_T > -1.6$$

4. Stronger ECAL cuts plus dE/dx

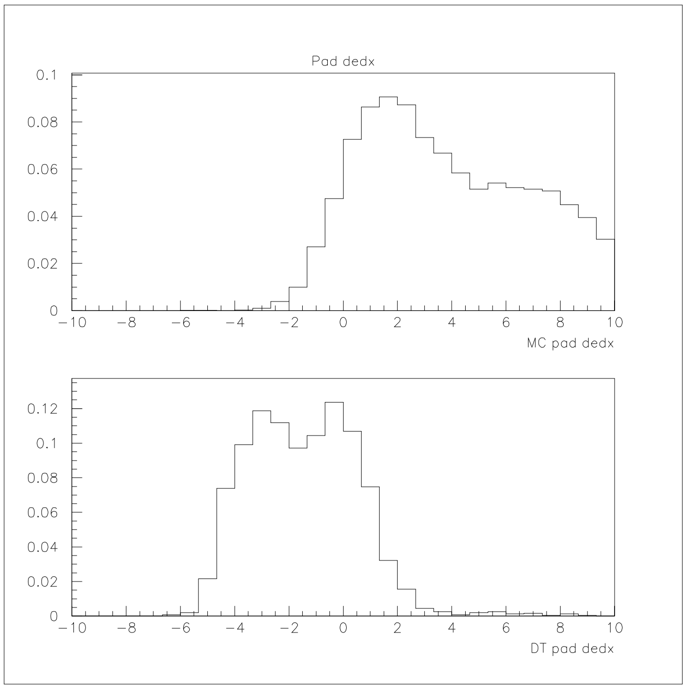

Figure 1: Pad dE/dx for MC and DT. The estimator is not calibrated at LEP 2.

Cut		189	192	196	200	202	Tot
	DT	14	2	7	7	4	34
dE/dx (cut 2)	MCqq	11	2	6	6	3	27.0
	WW						0.07
	ZZ						0.05
	DT	14	1	6	7	4	32
ECAL (cut 3)	MCqq	9	2	5	5	2	22.6
	ZZ						0.05
	DT	11	1	4	5	3	24
dE/dx (cut 4)	MCqq	8	2	4	4	2	19.6
ECAL	ZZ						0.05

Table 5: Selected events after full selection, with the improved cuts.

The excess decreased on the electron side if the dE/dx cut is applied.

Cut	Pair	DT	MC
	ee	14	8.6
dE/dx (cut 2)	$\mu\mu$	7	5.2
	μe	13	13.2
	ee	8	5.6
ECAL (cut 3)	$\mu\mu$	7	5.2
	μe	17	11.7
	ee	6	4.3
ECAL (cut 4)	$\mu\mu$	7	5.2
dE/dx	μe	11	10.0

6 Electron efficiencies

To estimate systematic uncertainties on electron identification, I use mostly–pure electrons from gamma conversions, using a technique similar to the one used at LEP 1 [3].

I am not going to repeat here how it works, nevertheless it allows the selection of electrons without using ECAL or dE/dx with a purity of about 98%.

The measured efficiencies in DT and MC, together with the correction to be applied to MC events, are shown here:

Cuts	Eff DT	Eff MC	Correction
"Mario's" (cut 1)	90.3%	89.7%	0.993
dE/dx (cut 2)	90.2%	88.9%	0.985
ECAL (cut 3)	80.2%	78.9%	0.983
dE/dx with ECAL (cut 4)	80.0%	78.1%	0.976

The uncertainties are always smaller than 3%.

7 Signal efficiencies

The same analysis has been performed on the signal sample produced by Mario. These are the efficiencies, together with the expected number of events in the hypothesis of $\sigma = 200\ fb$ (from Mario's talk [2])

Cuts	ϵ	Expected number
Preselection	60%	49
Preselection + cut 2	55%	45
"Mario's" (cut 1)	35%	29
dE/dx (cut 2)	33%	27
ECAL (cut 3)	31%	25
dE/dx with ECAL (cut 4)	30%	25

8 Check on same–sign events

The present analysis searches for opposite–sign leptons from sbottom decays. A low signal efficiency is instead expected if I look at same–sign leptons; thus looking at these events can clarify problems in the Monte Carlo simulation.

Here are the results asking for exactly the same cuts as in the reference analyses, but asking for same–sign leptons:

Cut	DT	MCqq	MC$\tau\bar{\tau}$	ZZ	Signal eff.
Cut 1	34	34.2	0.02	0.1	5%
dE/dx (cut 2)	26	27.2	0.02	0.1	4%
ECAL (cut 3)	25	21.6	0.02	0.05	2%
ECAL + dE/dx (cut 4)	21	19.1	0.02	0.05	2%

No significant discrepancy is found.

9 Limits on sbottom cross section

Since I still have a small excess, I can try two approaches:

- try to measure the cross section for sbottom production
- put a limit on cross section for sbottom production

In the first approach, I consider the number of events in excess and, using efficiency and integrated luminosity, I can estimate the cross section as

$$\sigma = \frac{N}{\epsilon \mathcal{L}}$$

When considering the limit, I calculate the confidence level of a simple fluctuation of the background B gives N events, and then the confidence level for the presence of a signal which gives also S selected events. The 95% CL for S where N events are selected events and B are expected as background, is

$$\frac{CL_{B+S}}{CL_B} = (1 - 0.95)$$

I calculate both for the various cuts that can be used:

Cuts	DT	bkg MC	S	ϵ	Meas σ (fb)	Excl σ (fb)
Preselection	394	359.2	69.4	60%	141	243
Preselection + cut 2	220	221.8	29.7	55%	7	131
"Mario's" (cut 1)	50	35.1	28.3	35%	103	196
dE/dx (cut 2)	34	27.0	18.4	33%	52	136
ECAL (cut 3)	32	22.8	20.3	31%	72	159
dE/dx with ECAL (cut 4)	24	19.5	14.7	30%	37	118

Here I added also the cut on dE/dx at preselection level, just to show that it makes disappear the small excess seen there.

The best limit comes from the analysis using all the cuts; moreover, the measured values are always within a couple of sigmas with respect to the statistical background fluctuations.

The CL limits just presented are only due to background statistical fluctuations; thus, the limits are due to be increased when systematics effect will be taken into considerations.

10 Systematic uncertainties

I had no time to perform a full calculation of systematic errors. Nevertheless, the error which seems to me more critical in the analysis (since is where we see the excess) is the one due to electron–id, which was estimated smaller than 3%.

Other "fast" checks are possible. I select 2–jet events with high THRUST values, and compute the efficiency for the BTAG cut in DT and MC; the ratio of efficiencies $\epsilon_{DT}/\epsilon_{MC} = 0.92$, giving an estimate of 8% for the systematic error on B–tagging.

If I assume a total systematic error of about 10%, the CL limits as above become:

Cuts	S	Excl σ (fb)
Preselection	104	421
Preselection + cut 2	48	212
"Mario's" (cut 1)	32	222
dE/dx (cut 2)	21	154
ECAL (cut 3)	23	181
dE/dx with ECAL (cut 4)	16	129

11 Conclusions

I am not going to draw any real conclusion, since this analysis was only meant to be a further check, and a lot of similar analyses are being done right now.

From what I have found, even if I still see a small excess in data, this does not seem enough to indicate the presence of a sbottom signal with $\sigma = 200\ fb$.

12 Plots

I put in this section a few plots comparing Data and Monte Carlo (qq) distributions, mainly at full selection level. The explanations are in the captions.

References

[1] G. Taylor, LEPC Open Session, July 20th 2000.

[2] M. Antonelli, Thursday Meeting Presentation, July 18th 2000.

[3] "Measurement of the inclusive b semileptonic branching ratio", ICHEP2000, Osaka.

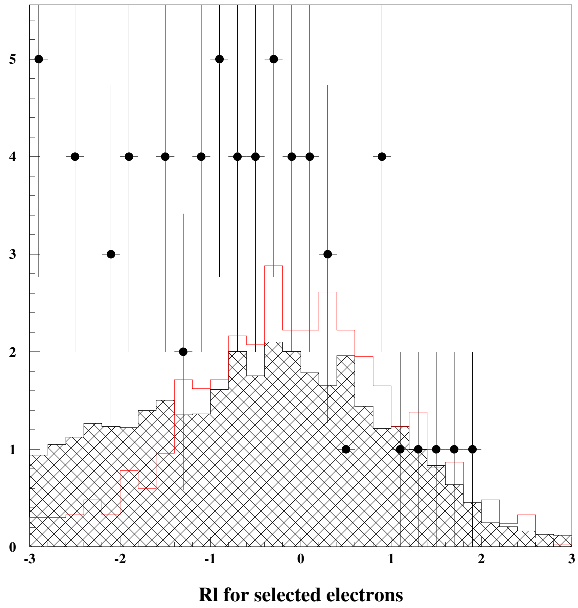

Figure 2: R_L for electrons selected with cuts 1. The grayed histogram is expectation from MCqq, the empty one the expectation from sbottom signal with the same normalization as MCqq.

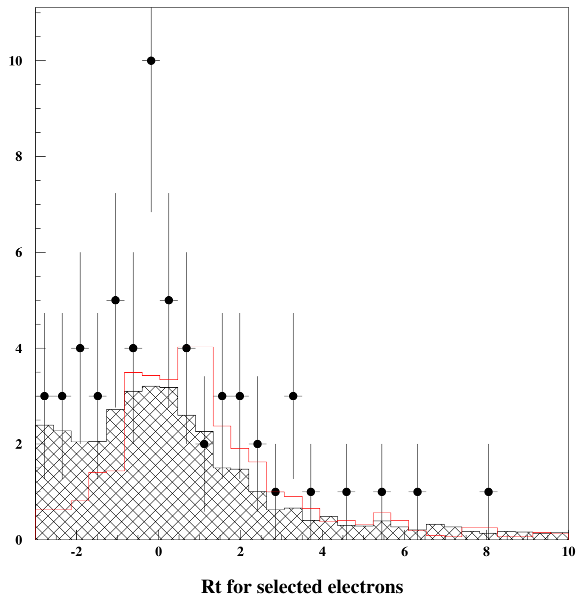

Figure 3: R_T for electrons selected with cuts 1. The grayed histogram is expectation from MCqq, the empty one the expectation from sbottom signal with the same normalization as MCqq.

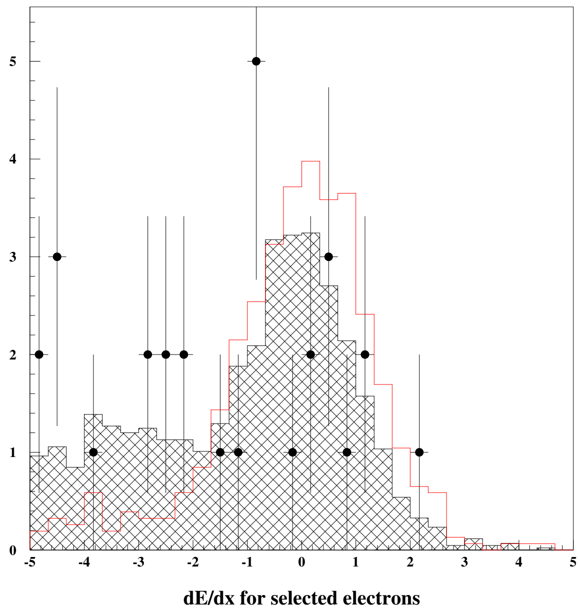

Figure 4: dE/dx for electrons selected with cuts 1. The grayed histogram is expectation from MCqq, the empty one the expectation from sbottom signal with the same normalization as MCqq.

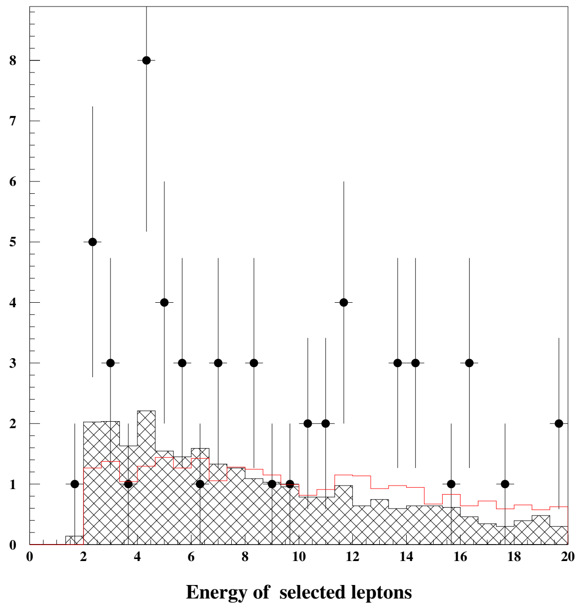

Figure 5: Momentum for leptons selected with cuts 2. The grayed histogram is expectation from MCqq, the empty one the expectation from sbottom signal with the same normalization as MCqq.

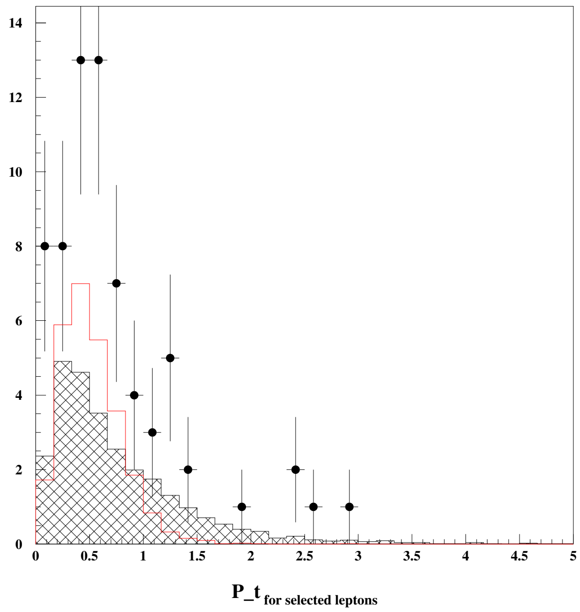

Figure 6: Transverse momentum for leptons selected with cuts 2. The grayed histogram is expectation from MCqq, the empty one the expectation from sbottom signal with the same normalization as MCqq.

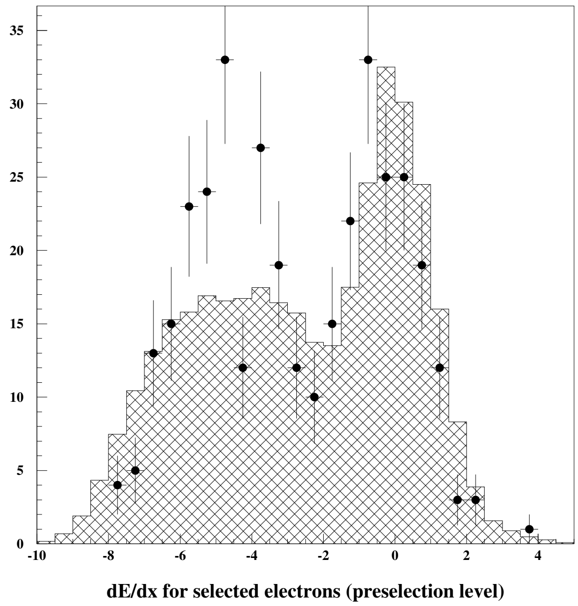

Figure 7: dE/dx for preselected electrons. Data seems to account for a larger number of fake electrons.