DELPHI WEEK PRAGUE September 19-22, 2002

CHARGED $\ell^+\ell^-\ell'^+\ell'^-$ FINAL STATES AT LEP2

M. Begalli and L.M. Mundim
Universidade do Estado do Rio de Janeiro
M. E. Pol
Centro Brasileiro de Pesquisas Físicas

WITH THE NEW PROCESSING AND NEW MC

DATA AND MC SAMPLES

- All data 183 GeV $\leq E_{CMS} \leq$ 209 GeV (aprox 665 pb^{-1})
- 4 fermion WPHACT MC
- KORALZ for $\tau^+\tau^-\gamma$, KK2F for $\mu^+\mu^-\gamma$, KK2f for $q\bar{q}\gamma$ and BHWIDE for $e^+e^-\gamma$
- BDK for 2 photon processes
- CUT in generation for $|\cos(\theta)| \leq 0.98$, so inside *'4f-like'* region in WPHACT

PRE-SELECTION

- 4 charged tracks with p$\geq$ 2. GeV/c from vertex region (lepton candidates)
- 2 extra charged tracks if compatible with a γ conversion
- 2 more charged tracks with p$\leq$ 2.GeV/c from vertex region

FINAL CUTS

- total charge zero
- total charged energy $\geq 0.25\ E_{CMS}$ (anti-$\gamma\gamma$)
- not all four candidates in one hemisphere (anti-$\tau^+\tau^-\gamma$)
- at most one candidate only VD-ID (anti-rubbish)
- at least 3 tracks with p $\geq$ 6 GeV/c
- isolation angle between 2 any tracks $\geq 5\ ^\circ$

See figures 1, 2 and 3.

EXPECTED EVENTS

$\sqrt{s}$	Efficiency	N_{signal}	N_{total}	Data
182.7 GeV	14.3±0.2	3.45±0.06	3.90±0.07	3
188.6 GeV	14.8±0.3	10.00±0.18	12.39±0.20	14
191.2 GeV	14.9±0.3	1.62±0.03	1.82±0.03	1
195.5 GeV	14.9±0.3	4.62±0.08	5.27±0.08	5
199.5 GeV	15.3±0.3	5.15±0.09	5.97±0.09	8
201.6 GeV	14.7±0.3	2.36±0.04	2.72±0.04	3
205.0 GeV	15.2±0.3	4.79±0.09	5.32±0.10	7
206.5 GeV	15.3±0.3	8.15±0.15	9.58±0.15	7

For the background composition see figure 4

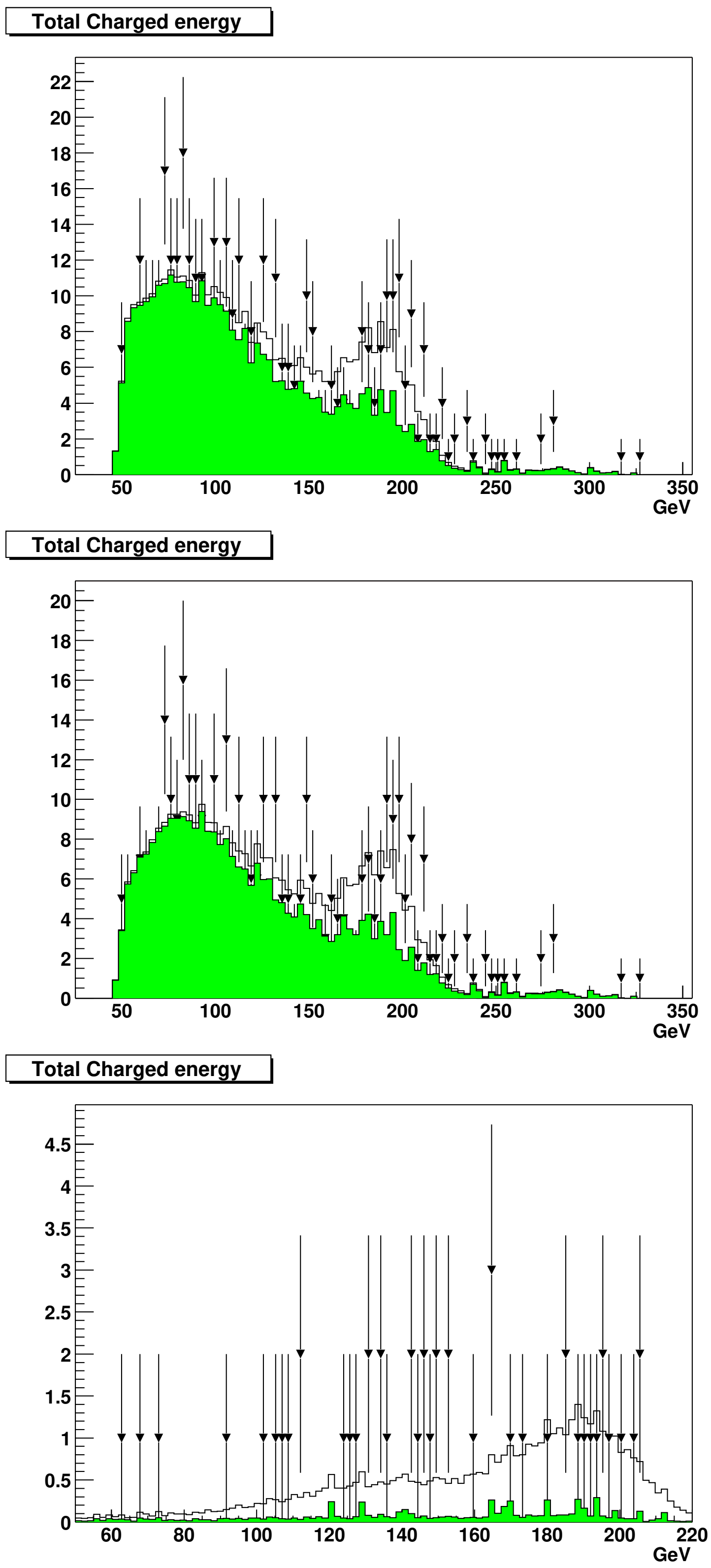


Figure 1: Total charged energy distributions. Top, before cuts in track momenta and isolation angle. Middle, after cut in track momenta is applied. Bottom, after both cuts are applied. Dots are the data, the histogram is the 4-lepton signal and the shaded histogram the background.

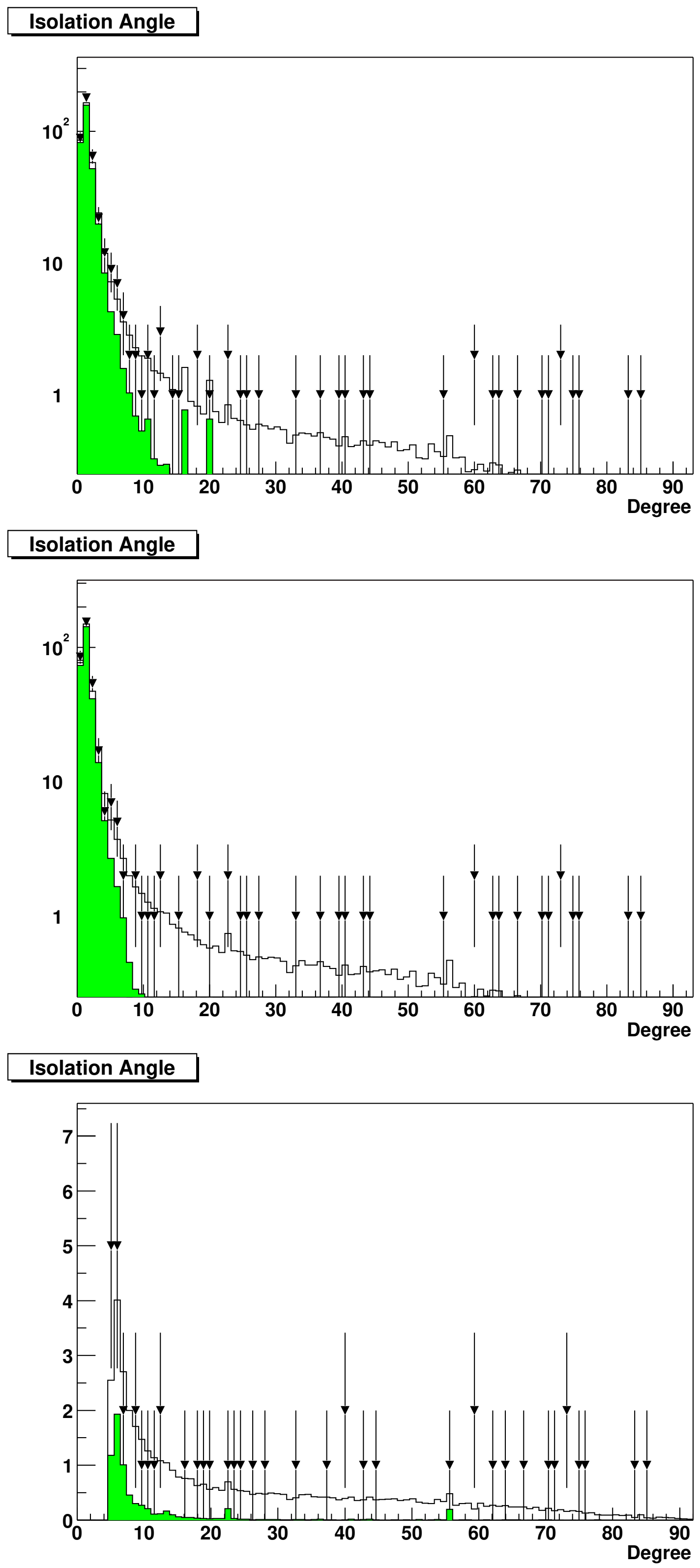


Figure 2: Isolation angle between nearest tracks distributions. Top, before cuts in track momenta and isolation angle. Middle, after cut in track momenta is applied. Bottom, after both cuts are applied. Dots are the data, the histogram is the 4-lepton signal and the shaded histogram the background.

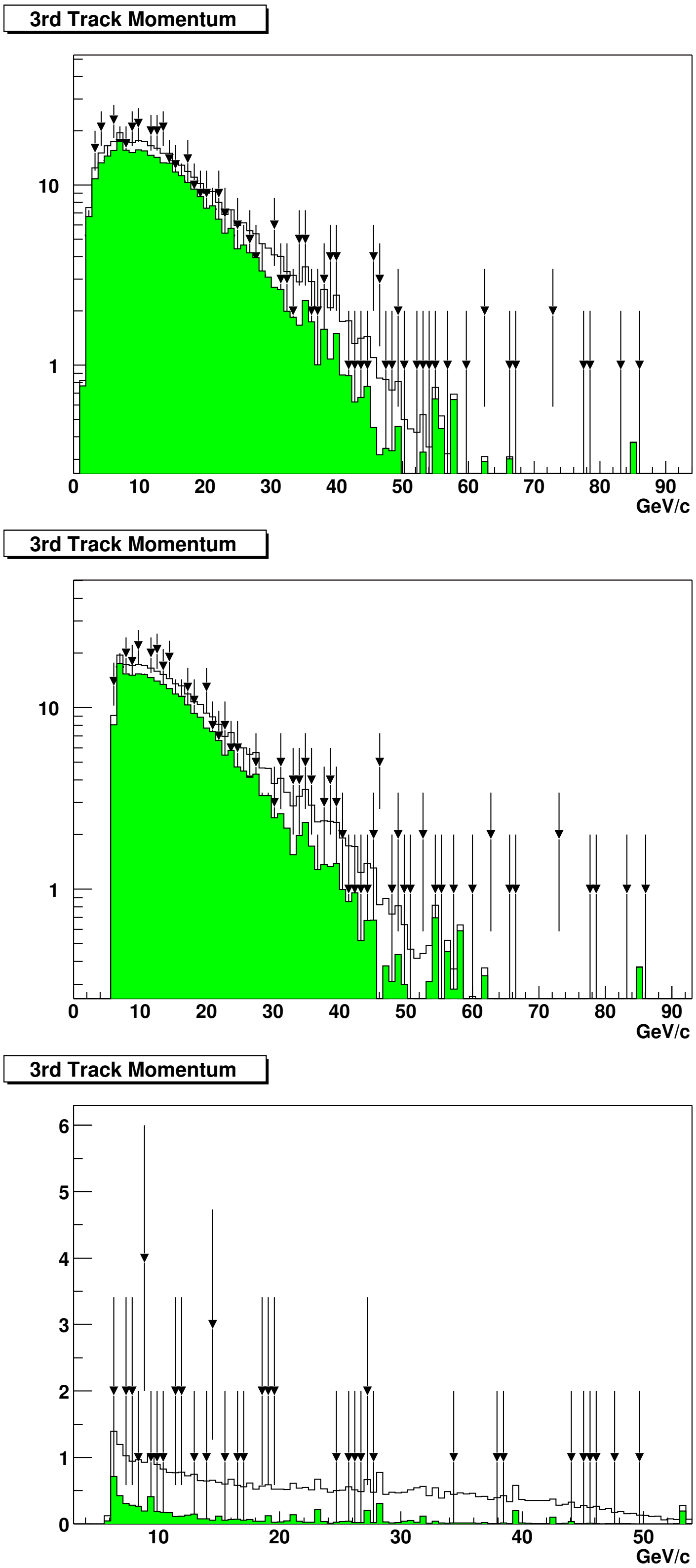


Figure 3: Momentum of the 3rd. most energetic track distributions. Top, before cuts in track momenta and isolation angle. Middle, after cut in track momenta is applied. Bottom, after both cuts are applied. Dots are the data, the histogram is the 4-lepton signal and the shaded histogram the background.

CROSS-SECTIONS

$$\sigma_{182.7GeV} = (0.33^{+0.24}_{-0.16} \pm 0.03)pb$$

$$\sigma_{188.6GeV} = (0.50^{+0.15}_{-0.12} \pm 0.04)pb$$

$$\sigma_{191.2GeV} = (0.21^{+0.29}_{-0.21} \pm 0.02)pb$$

$$\sigma_{195.5GeV} = (0.38^{+0.20}_{-0.15} \pm 0.03)pb$$

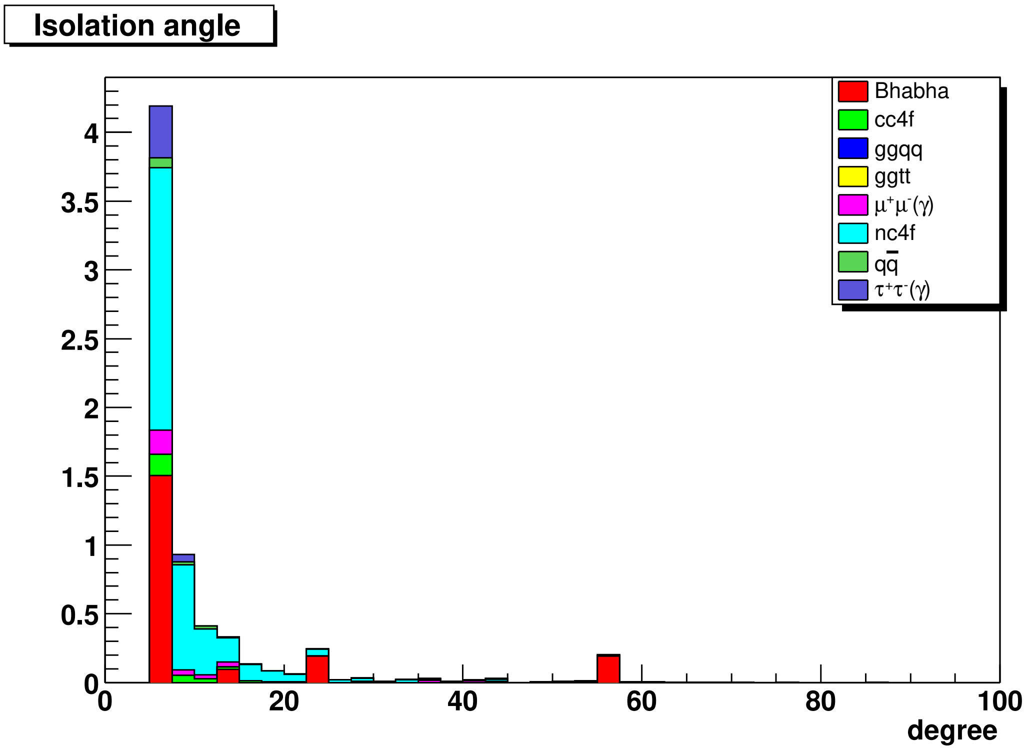
$$\sigma_{199.5GeV} = (0.56^{+0.22}_{-0.18} \pm 0.04)pb$$

$$\sigma_{201.6GeV} = (0.43^{+0.31}_{-0.21} \pm 0.03)pb$$

$$\sigma_{205.0GeV} = (0.52^{+0.22}_{-0.18} \pm 0.04)pb$$

$$\sigma_{206.5GeV} = (0.26^{+0.11}_{-0.09} \pm 0.02)pb$$

WPHACT : 0.44 pb (182.7 GeV) $\rightarrow$ 0.38 pb (206.5 GeV)



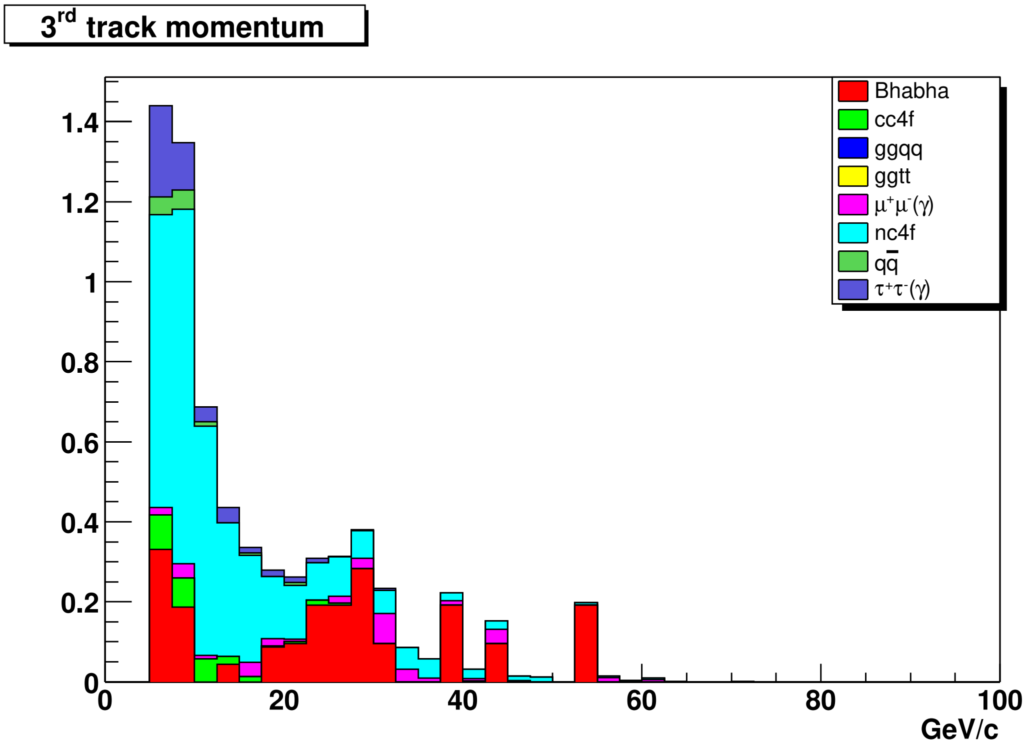


Figure 4: Background composition for the isolation angle between the two nearest tracks distribution(top) and for the momentum of the 3rd. most energetic track (bottom).

PARTICLE IDENTIFICATION

- DELPHI Muon ID + HAC $(E_{layer3}+E_{layer4})$ $(E_{layer1}+E_{layer2})$
- DELPHI electron ID + no hits in MUC + only 1st layer HAC
- PION ID : energy deposit in HAC, MIP in HPC(EMF), no hits in MUC

FINAL STATE

- An e^+e^- or $\mu^+\mu^-$ pair was identified, otherwise the four particles were assigned as τ decays and the final state $\tau^+\tau^-\tau^+\tau^-$.
- Once the first pair was identified, if the second pair was identified as e^+e^-, $\mu^+\mu^-$ or $\tau^+\tau^-$ $(\pi^+\pi^- + n\gamma)$ then the final state was identified.
- Once the first pair was identified, if the second pair had two different identified particles or if one or both were not identified, the second pair was assigned to be $\tau^+\tau^-$.
- In the case that the event had 3 identical particles and one not identified, two hypotheses were considered, that the 4 particles were identical and that there was a $\tau^+\tau^-$ pair.

FIT

- The 4-C fit was performed taking into account the two pairing possibilities for four identical particles.
- In the case of three electrons or muons, if the fourth particle was a pion the two possible pairings were considered for a final state $e^+e^-\tau^+\tau^-$or $\mu^+\mu^-\tau^+\tau^-$.
- In the latter case, if the fourth particle was not identified, four 4-C fits were done, corresponding to the two pairings of four identical particles and the two pairings with the $\tau^+\tau^-$ hypothesis.
- The possibility of having a photon from ISR lost in the beam pipe was also considered and the corresponding 3-C fits were done for each case.
- The fit having the best χ^2/NDF was selected and the masses of the two pairs were obtained, as well as the final state identification.

See figures 5, 6 and 7.

CROSS-TALK

	true $e^+e^-e^+e^-$	true $e^+e^-\mu^+\mu^-$	true $e^+e^-\tau^+\tau^-$	true $\mu^+\mu^-\mu^+\mu^-$	true $\mu^+\mu^-\tau^+\tau^-$	true $\tau^+\tau^-\tau^+\tau^-$
$e^+e^-e^+e^-$	6.44	0.00	0.28	0.00	0.00	0.00
$e^+e^-\mu^+\mu^-$	0.00	13.80	0.28	0.00	0.14	0.01
$e^+e^-\tau^+\tau^-$	3.25	1.49	3.17	0.00	0.02	0.07
$\mu^+\mu^-\mu^+\mu^-$	0.00	0.01	0.00	2.32	0.13	0.00
$\mu^+\mu^-\tau^+\tau^-$	0.00	4.00	0.05	0.42	1.56	0.05
$\tau^+\tau^-\tau^+\tau^-$	0.41	0.49	0.63	0.02	0.17	0.19

The purity of the identification is:

- 64% for $e^+e^-e^+e^-$
- 70% for $e^+e^-\mu^+\mu^-$
- 72% for $e^+e^-\tau^+\tau^-$
- 84% for $\mu^+\mu^-\mu^+\mu^-$
- 77% for $\mu^+\mu^-\tau^+\tau^-$
- 59% for $\tau^+\tau^-\tau^+\tau^-$

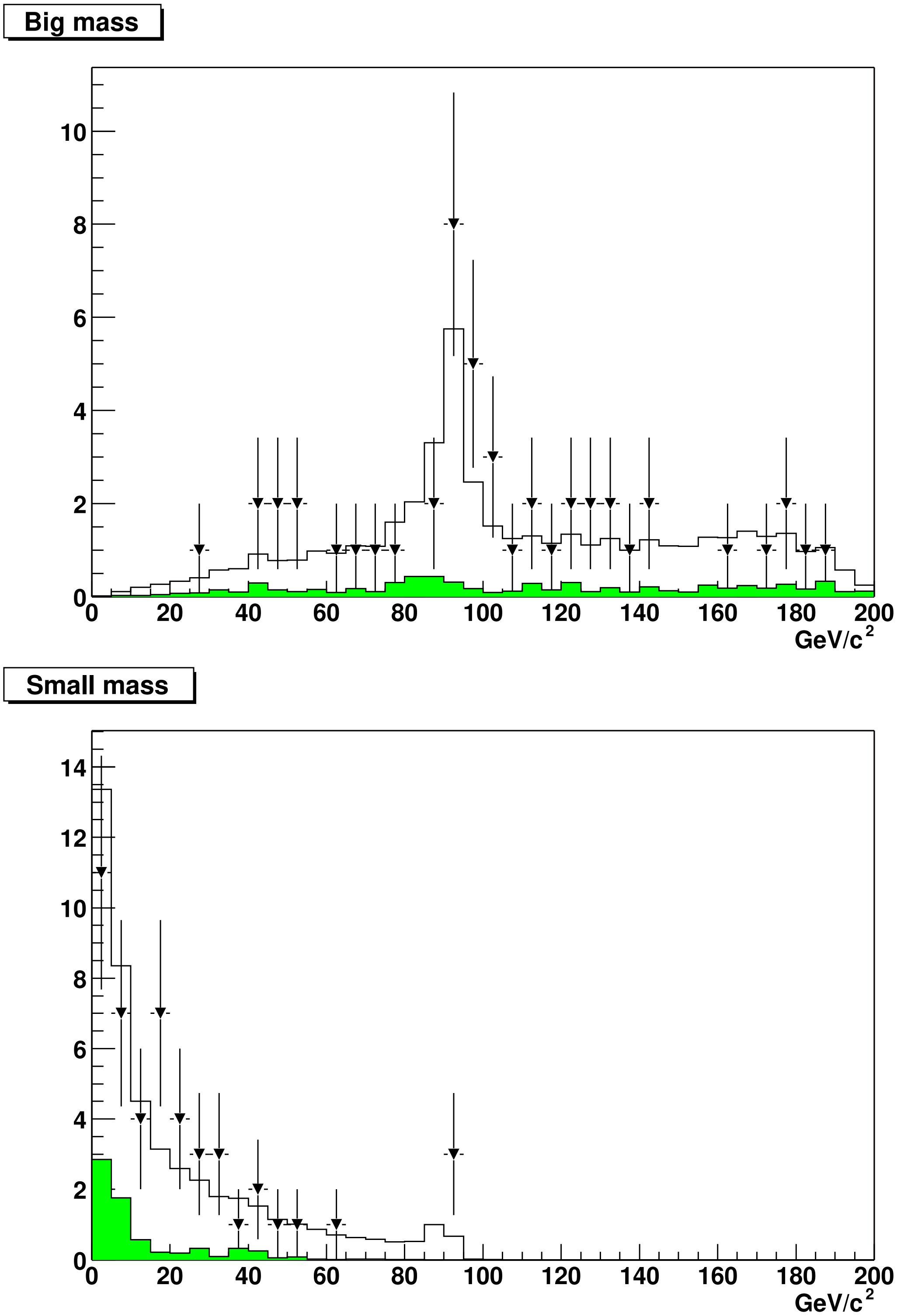


Figure 5: Fitted masses of the selected four leptons. Top plot: the mass of the pair with the biggest mass is shown. Bottom: the mass of the other pair is shown. The dots are the data and the histograms the predictions from Monte Carlo.

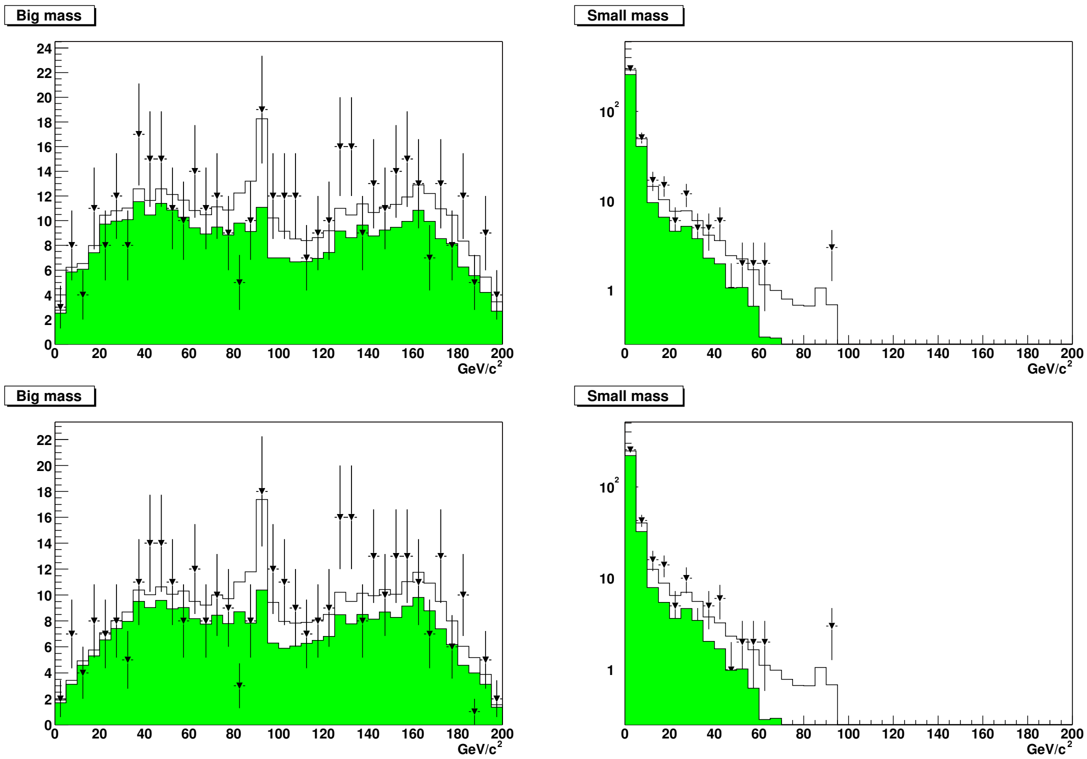


Figure 6: Fitted masses of the selected four leptons. Top plots: before cuts in track momenta and isolation angle. Bottom: before cut in isolation angle. The dots are the data and the histograms the predictions from Monte Carlo.

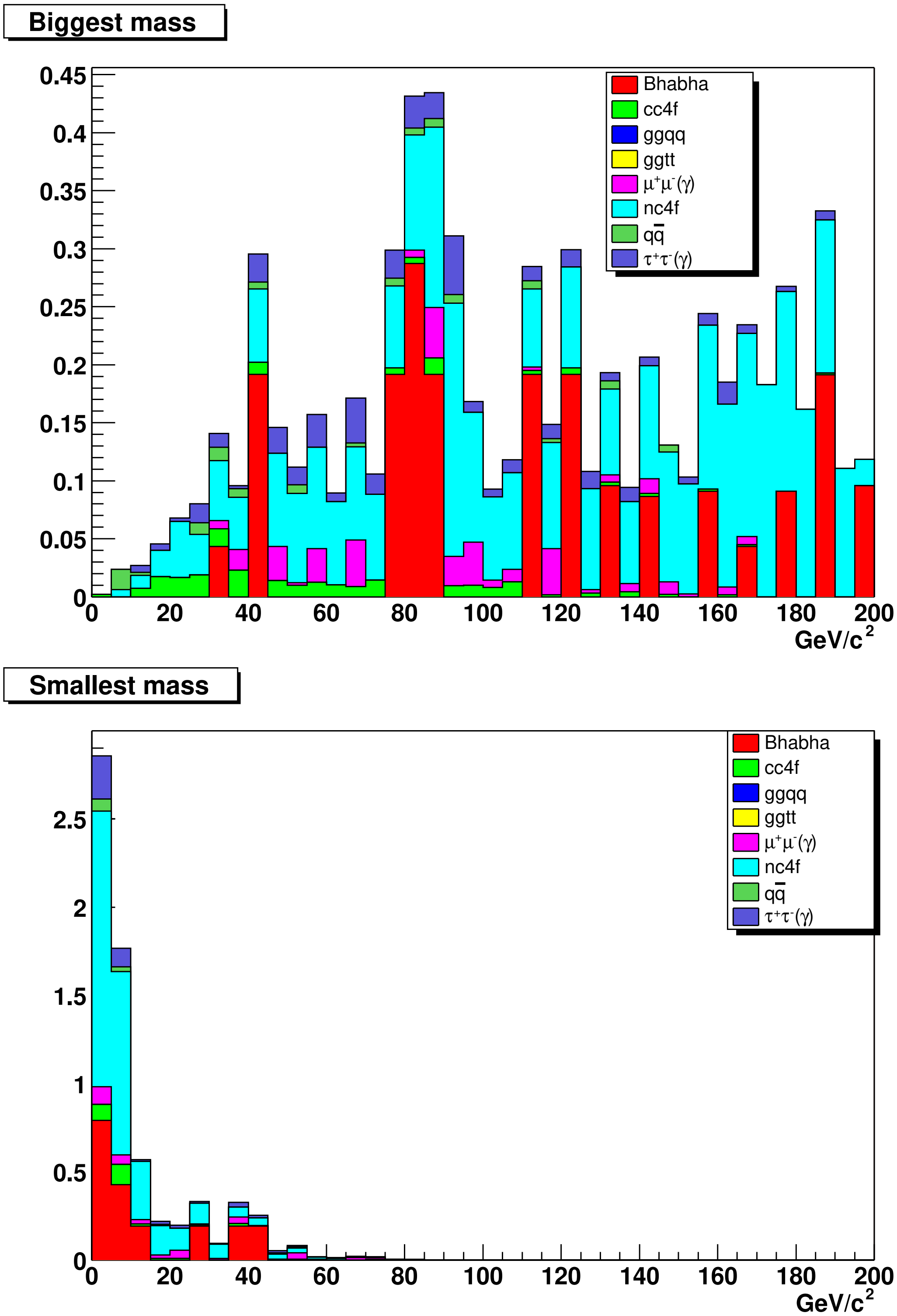


Figure 7: Fitted masses for the expected background. The background composition is shown after all cuts were applied.