ALEPH 92-174
PHYSIC 92-156
A. Falvard et al.
2.12.1992

Are the Heavy Flavour Leptonic Results P_T dependent?

A. Falvard, P. Perret, F. Saadi
Université Blaise Pascal, ClermontII/IN2P3

Several groups have participated to the production of results about Electroweak b and c physics. This is done through the measurements of $\Gamma(Z \rightarrow b\bar{b}, c\bar{c})$, A_c and A_b. Important related parameters as b and c fragmentation, $BR(b \rightarrow l)$, $BR(b \rightarrow c \rightarrow l)$ have also been extracted. Large efforts have been done to standardize and cross-check the analysis at the level of data and MC samples, event selection, lepton-id, p_t definition, etc...[1]. During the general HF Meeting (28/10/92), the results from the various analyses have been collected[2][3][4][5][6]. Unfortunately, despite the large coordination inside our working group, the amount of work to do before this meeting to finalize results was too large and time was too short to provide a coherent presentation of all the results. Essentially one point was not clarified and needed more work: are the results p_t dependent?

The aim of this note is to present some additional informations and comments to complete the discussion. In the first part we will discuss more specifically the case of $B\bar{B}$ Mixing which is a very good example of the confusion which appeared during the General HF Meeting. Due to the possible size of the investigated effect we will work with the sum of electron and muon samples for '90 and '91 data in order to include the largest possible statistics. Additionnal work has been done with e and μ separately and with '90 and '91 data which doesn't invalidate our conclusions. This discussion will be mainly done with the Pascal's global analysis [6] which offers the ability to analyze the data in very different configurations. In particular this flexibility allows very easily to degenerate the analysis to a high-p_t counting method.

1 An example of apparent inconsistency: the $B\bar{B}$ Mixing.

The question arises when you compare the two following results:

$$\text{Global analysis } (p_t > 0.\ \text{GeV/c})[6] \ : \ \chi = 0.127 \pm 0.0133\ (stat.)$$
$$\text{Counting analysis } (p_t > 1.25\ \text{GeV/c})[4] \ : \ \chi = 0.101 \pm 0.016\ (stat.)$$

In our Mixing paper using only '90 data [7], the same comparison gives:

$$\text{Global analysis } (p_t > 0.\ \text{GeV/c}) \ : \ \chi = 0.132 \pm 0.022\ (stat.)$$
$$\text{Counting analysis } (p_t > 1.25\ \text{GeV/c}) \ : \ \chi = 0.120 \pm 0.030\ (stat.)$$

While the results of '90 are statistically consistent with no p_t dependence, the crude comparison of the results obtained with '90 and '91 data looks like a confirmation that the χ measurement is p_t dependent. *But the situation is not so simple* and we would like now to give more inputs for the discussion.

1.1 Do we expect a p_t dependence of the $B\bar{B}$ Mixing?

This question was investigated by F. Prulhière [8]. Conceptually we can expect a variation of χ with p_t due to the difference between the $BR(D^+ \rightarrow l)$, $BR(D^0 \rightarrow l)$, $BR(D_s \rightarrow l)$, $BR(c\text{−baryon} \rightarrow l)$. The results are summarized in an ALEPH-note[9]. The main point for our discussion is that essentially no p_t dependence is expected when χ is measured by a standard dilepton analysis. This is shown in 1 (part of the table 1 in [9]) which gives the difference with respect to p_t between the true mixing and the measured one (let us note that in this study the p_t was computed in the lepton included in the jet). The small variations for $p_t > 0.6$ GeV/c are only statistical. At low p_t we expect a small decrease of χ but this region has a small weight in the measurement of χ.

$P_t >$	0.4	0.6	0.8	1.0	1.2
$\chi_{true} - \chi_{meas}$	0.0039	0.0001	0.0012	0.0008	0.0018

Table 1: Difference between the true mixing and the measured mixing in a typical dilepton analysis.

1.2 Do we really see a p_t dependence of the $B\bar{B}$ Mixing?

When you come back to the '90 Mixing [7] paper and look at page 244 at the end of paragraph 4 you find that the analysis in the $(Prob_1, Prob_2)$ plane done in the high p_t region gives a value of the mixing identical to the result of the high p_t counting method :

$$\chi = 0.120 \pm 0.024 \text{ instead of } 0.120 \pm 0.030.$$

The gain in statistical error is due to the fact that the analysis in the $(Prob_1, Prob_2)$ plane manages the $(b \to l)(b \to l)$ contribution in a better way than a simple counting method. What is the situation when you do the same thing in the Pascal's analysis?

- '90 Data.

$$\text{Global analysis } (\mathrm{p_t} > 0.\ \mathrm{GeV/c}) \ : \ \chi = 0.137 \pm 0.024\ (stat.)$$
$$\text{Global analysis } (\mathrm{p_t} > 1.25\mathrm{GeV/c}) \ : \ \chi = 0.113 \pm 0.026\ (stat.)$$

- '91 Data.

$$\text{Global analysis } (\mathrm{p_t} > 0.\ \mathrm{GeV/c}) \ : \ \chi = 0.121 \pm 0.016\ (stat.)$$
$$\text{Global analysis } (\mathrm{p_t} > 1.25\ \mathrm{GeV/c}) \ : \ \chi = 0.128 \pm 0.019\ (stat.)$$

You see that no universal tendency exists with respect to the question of a possible decrease of χ measurement with p_t. Adding '90 and '91 data you get χ=0.1274±0.0133 for $p_t > 0.$ GeV/c and χ=0.1216±0.0153 for p_t >1.25 GeV/c which is statistically perfectly consistent with no p_t dependence.

The last point is to understand why these results are different from the high p_t value given in reference [4]. A trivial reason can be pointed out: the values of $BR(b \to l)$ and $BR(b \to c \to l)$ used in these two analysis are different. In the global analysis these numbers are extracted from the fit whereas in [4] $BR(b \to l)$=0.105 is taken from [3] and $BR(b \to c \to l)$=0.097 from CLEO. Pascal did the exercice to compute χ by fixing all the parameters to the Monte-carlo values ($BR(b \to l)$=0.104 and $BR(b \to c \to l)$=0.099. Then χ ($p_t > 0.$ GeV/c)=0.108 ± 0.013 which is less that 0.5 σ away from the result in [4]. Then we see that most of the effect is simply due to the different BR's in the two analysis. Let us note that in the Mixing paper[7], Dave Cinabro and Pierre Henrard used the same BR's.

Then our conclusion about mixing is that on the basis of '90 and '91 statistics we have no evidence that the measured $B\bar{B}$ Mixing is p_t dependent. It is also clear that the measurement of χ cannot be decorrelated from the measurement of $b \to l$ and $b \to c \to l$, which is conceptually the aim of the global analysis.

1.3 Last remark on χ.

Looking at the evolution of the statistical error on the mixing value with p_t (table 2), we can see that the global fit essentially gains information from $p_t > 0.75$ GeV/c. To imagine a significant variation of χ when going from $p_t > 0$ GeV/c

$P_t >$	0.	0.25	0.5	0.75	1.0	1.25	1.5	1.75	2.0
σ (%)	1.3	1.31	1.32	1.32	1.35	1.54	1.77	1.92	2.88

Table 2: Statistical error on χ with respect to p_t in the global fit.

to $p_t > 1.25$ GeV/c, we need a very large variation of χ between 0.75 GeV/c and 1.25 GeV/c. This looks very unreasonnable and in fact as seen in the previous section is not confirmed by the analysis of data.

As an exercice you can look at this variation of the error on χ when you use a counting method at high p_t (table 3). You can see that the counting method

$P_t >$	0.	0.25	0.5	0.75	1.0	1.25	1.5	1.75	2.0
σ (%)	3.77	3.27	2.32	1.74	1.51	1.57	1.70	1.96	2.88

Table 3: Statistical error on χ with respect to p_t in the counting method.

essentially converges to its best value for $p_t > 1.0$ GeV/c (1.25 GeV/c is optimum due to the systematics). You cannot gain anything by going to lower cut on p_t since you cannot distinguish the statistical fluctuations of the background from the mixing signal in the low p_t region in a simple counting method. Then looking at p_t variation of χ by looking as low p_t cut as for instance $p_t > 0.5$ GeV/c is meaningless in the counting method. This is not the case of the global analysis which treates correctly the various contributions to the dilepton sample.

2 Is the $\Gamma(Z \to b\bar{b})$ value P_t dependent?

The analysis in ref. [2] measures $\Gamma(Z \to b\bar{b})$ and relies on single and double tag $b\bar{b}$ events. It is by construction independent of any physical input on b branching ratios (to $b \to l$, $b \to c \to l$, $b \to J/\psi$, $b \to X + (\pi^0$ or $\eta \to Y + l))$, b fragmentation, lepton efficiencies for leptons coming from any b decays, hadron misidentification in $b\bar{b}$ events, $b \to l$ modelisation and other more marginal effects. There are only two inputs taken from the Monte-Carlo:

- C is the ratio of the probability to tag the two b quarks of the same event and the probability squared to tag one b quark. In the fiducial volume selected in the analysis, we expect $C = 1$. We have verified that

C is not p_t dependent (see [2]) which means that the details of the b physics don't influence the result, as expected.

• The other input is the number of single tag events produced by light quarks, including $c\bar{c}$ events. Here it is not trivial that our simulation reflects the reality. A wrong p_t dependence of these backgrounds would reflect in the measurement of $\Gamma(Z \rightarrow b\bar{b})$. We don't expect large effects.

Figure 1 summarizes all the results. No dramatic p_t effect is seen in these plots and the results are statistically very consistent with no p_t dependence.

3 Looking for a p_t dependence.

The global analysis of single lepton, opposite and same side dileptons [6] has been redone to look for a possible p_t dependence of the results. In order to remain consistent on the full p_t range we don't try to extract any information on charm which has been fixed. Then the p_t dependence of 4 parameters has been investigated: $\Gamma(Z \rightarrow b\bar{b})$, $BR(b \rightarrow l)$, χ, A_b (not corrected by χ). A large section has been previously devoted to the discussion on χ. Figure 2 gives the p_t variation of these 4 quantities. No significant variation is observed.

4 Conclusions.

We have looked for p_t dependence of the leptonic results and find no significant evidence. This question will be rediscussed when '92 data will be analyzed.

References

[1] D. Abbaneo *et al.* - ALEPH Note 92-101.

[2] F. Saadi - Talk Given to the General HF Meeting on 27 October 1992.

[3] L. Bellantoni - Talk Given to the General HF Meeting on 27 October 1992.

[4] D. Abbaneo - Talk Given to the General HF Meeting on 27 October 1992.

[5] F. Ligabue - Talk Given to the General HF Meeting on 27 October 1992.

[6] P. Perret - Talk Given to the General HF Meeting on 27 October 1992.

[7] D. Decamp *et al.* - Phys. Let. B258 (1991) 236.

[8] F. Prulhière - PhD Thesis, Clermont PCCF T 9208.

[9] F. Prulhière - P_t dependence and $B^0\bar{B}^0$ mixing. ALEPH-Note (~~to appear~~). 92-168

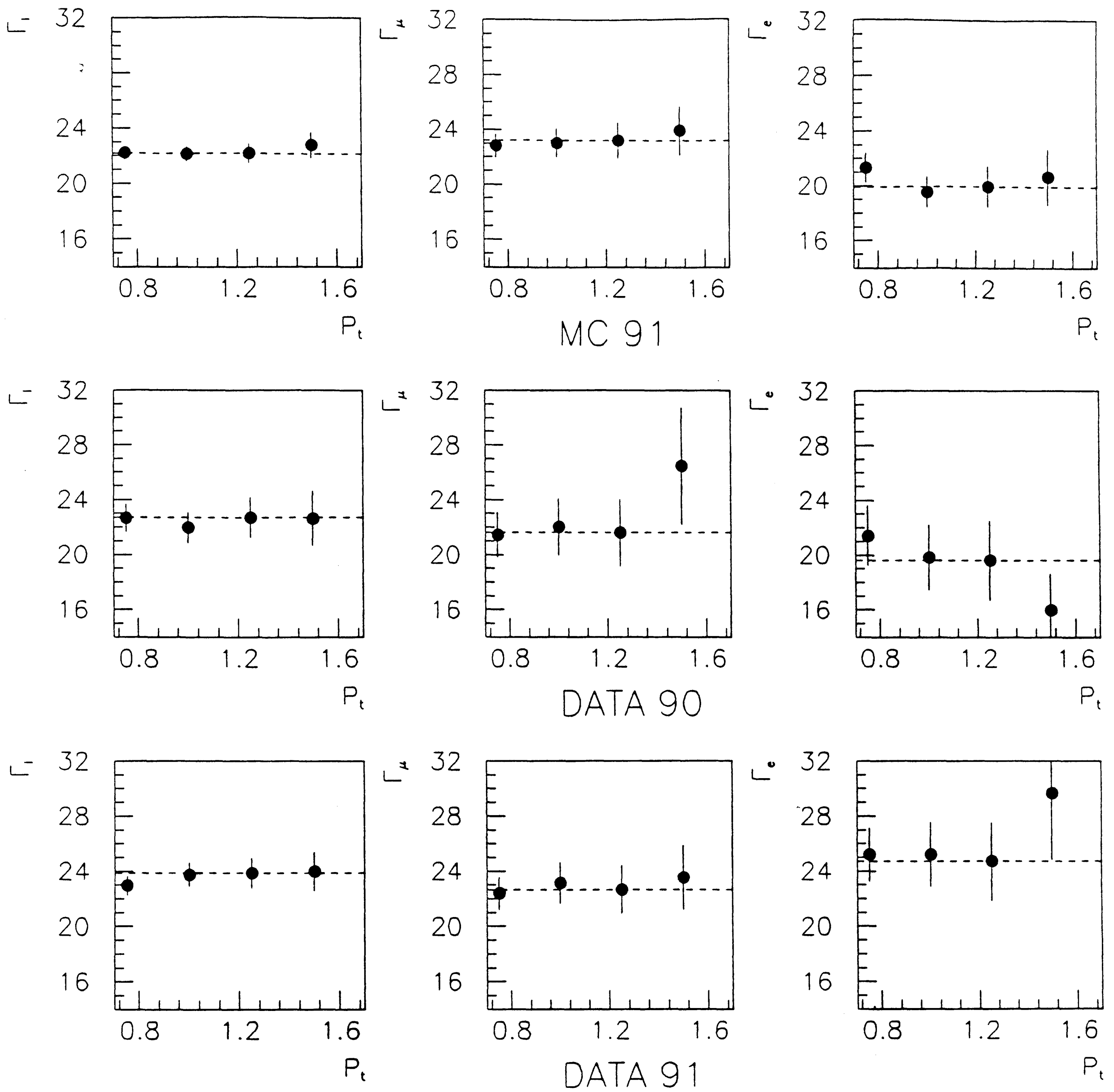

Figure 1 - For both a Monte carlo sample, '90 and '91 data, gives the measurement of Γ_b with respect to p_t. Three figures are shown: All leptons, μ alone and e alone.

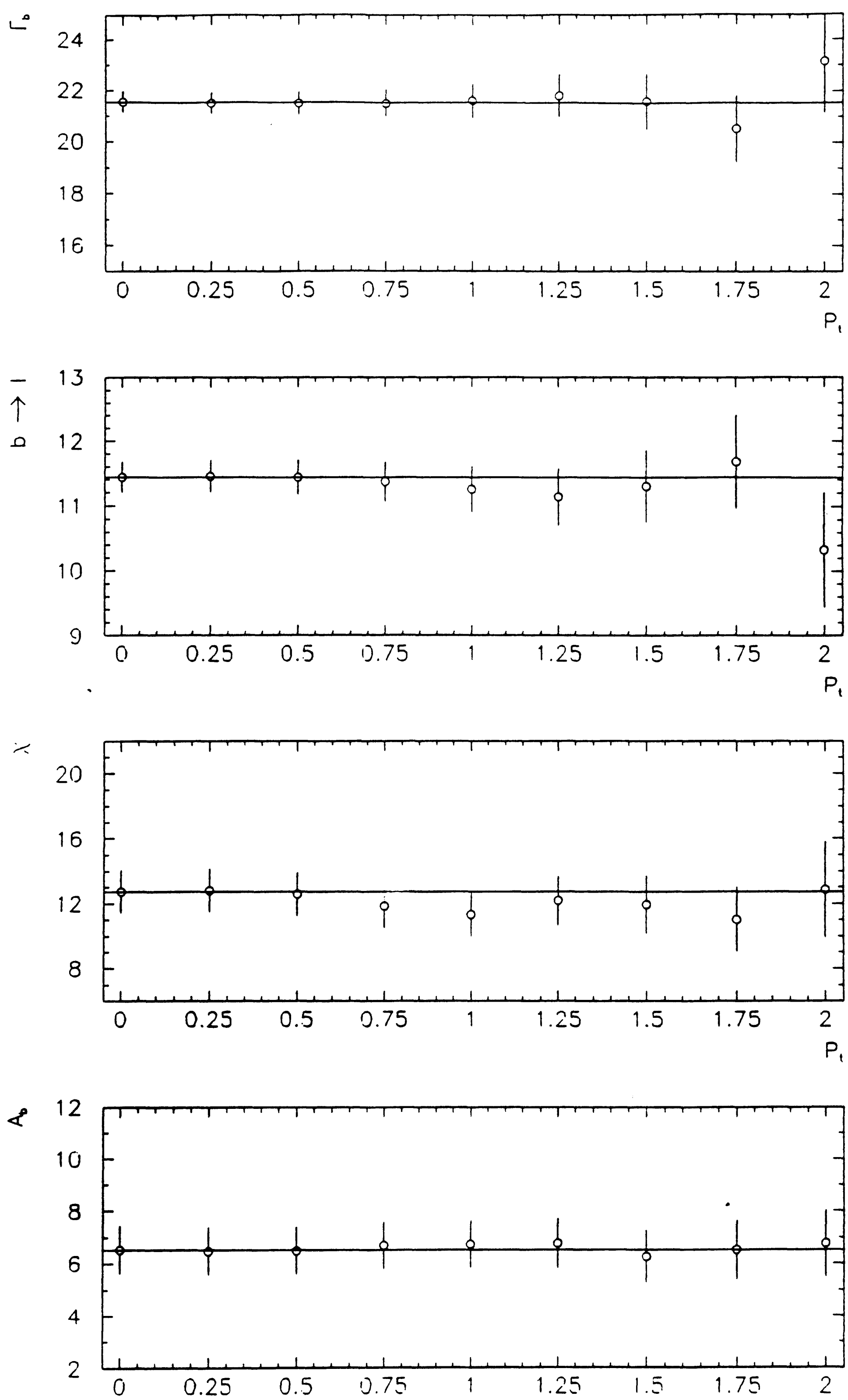

Figure 2 - For the global lepton analysis variation with the p_t cut of the 4 measured parameters.