Some comments on the subjects discussed (or not) at the workshop

In fact there was a point missing all along our discussions: what is the significance of the "problems" once uncertainties on theoretical expectations and experimental results are included?

About the suppression of j=1/2 states relative to j=3/2

Alain says that this is essentially a factor 10.

Consider only for the moment the Dπ channel. In non-leptonic decays there is not a fair agreement between Belle and BaBar (preliminary) results on D^*_0 production in $B^0 \rightarrow$anti-$D^0\ \pi^+\pi^-$. Using the values quoted in Thomas presentation and correcting for the branching fraction of the D^*_2 (41±2 %) and of the D^*_0 (2/3) into $D^0\ \pi^+$, the following values are measured:

Channel	BaBar	Belle
$B(B^0 \rightarrow D^*_2\,\pi^-) \times 10^4$	4.4 ± 1.0	5.2 ± 0.9
$B(B^0 \rightarrow D^*_0\pi^-) \times 10^4$	3.2 ± 1.8	0.90 ± 0.44
$B^0 \rightarrow D^*_2\,\pi^- / B^0 \rightarrow D^*_0\,\pi^-$	1.3 ± 1.0	6 ± 3

It is difficult to draw « firm » conclusions from these measurements. Even for Belle, which seems to be the more significant, values are compatible with a large (factor 10) or a small (factor 2) suppression. Personally I think that present or future measurements of this channel require more statistics and a better control of the different components present in the Dalitz plane.

In $B^0 \rightarrow$anti-D π lν, BaBar and Belle experiments agree on the rate. Once the contribution from the D^*_2 is removed it remains a branching fraction of 0.42 ± 0.06 % for the broad component. This value is similar to the measured decay branching fractions of the B^0 into D_1 or D^*_2. If these events are interpreted as coming from the decay of D^*_0 mesons there is contradiction with theoretical expectations.

But, if one believes that these $B^0 \rightarrow$anti-D π lν events are real and if one believes in factorization, independently of their origin (D^*_0, non resonant, other, ..), these D π events should be also present in non leptonic B^0 decays. We are thus left with a contradiction unless:

- factorization is violated (seems unlikely for these type of decays with pion emission);
- the Dπ component in non leptonic events is not made only by the D^*_0 and other contributions have to be added;
- within uncertainties the problem is not clear;
- some (large) fraction of $B^0 \rightarrow$anti-D π lν events are in fact $B^0 \rightarrow$anti-D* π lν events

with the soft pion from the D* having escaped detection (Florian hypothesis).

To check the last possibility it would be nice if BaBar can produce D π mass distributions for events selected with a tighter cut on the missing mass to avoid leakage from soft pions. It can be noted that Belle has already used this type of selection and has observed a similar result as BaBar.

What about the $D^*\pi$ channel. In non-leptonic decays there is only a measurement from Belle of $B^0 \rightarrow D^{*0} \pi^+\pi^-$. It gives a small rate for the broad D_1 state, in agreement with expectations from theorists. This result is also consistent with the Belle measurement of the $B^0 \rightarrow$anti-D* π lν channel where they do not observe a broad component.

This last result is not in agreement with the BaBar result which measures (0.37± 0.10 %) for the broad D_1 component. Experimentally, between BaBar and Belle there is more than 3σ discrepancy on this channel and this has to be understood before any conclusion can be drawn.

What about uncertainties of theoretical expectations ? Alain has insisted on the fact that there is a large (1 order of magnitude) difference between measurements and theoretical expectations of j=1/2 states in B semileptonic decays, whereas there is agreement for j=3/2 states. For non leptonic decays he considers that data and expectations agree. I hope to have convinced you that non leptonic decay measurements have non-negligible uncertainties and can agree with every expectation. Belle and BaBar are not either in agreement (or missing).

Theoretical expectations must have also uncertainties attached. It is difficult to assess uncertainties on quark model predictions. The present result from LQCD:

$$\tau_{3/2}(w=1) = 0.52 \pm 0.03; \; \tau_{1/2}(w=1) = 0.29 \pm 0.02$$

corresponds to the ratio $\tau_{3/2} / \tau_{1/2} = 1.8 \pm 0.2$. Quoted uncertainties do not include all possible sources (infinite quark mass limit). It would be nice if a more realistic evaluation of uncertainties can be obtained.

The comparison between semileptonic and nonleptonic decays requires to evaluate the form factors at (q^2~0) whereas they have been computed at w=1 which corresponds to q^2 maximum. When comparing expected decay rates for j=1/2 and j=3/2 states one has to integrate over w and the shape of the form factor has some influence. The slopes of the two form factors are thus also playing an important role. What are the corresponding uncertainties on these quantities?

For illustration we quote simple expressions for non-leptonic decays rates obtained using factorization and considering that a single universal form factor is enough to describe the decays;

$$B(B^0 \rightarrow D_{3/2}\,\pi) \sim (1-r)^5(1+r)^7/16\,r^3 \;\; x\; \tau^2_{3/2}(1+r^2/2r),\; r = m_{D**}/m_B = 0.458$$

$$B(B^0 \rightarrow D_{1/2}\,\pi) \sim (1-r)^5(1+r)^3/2\,r^2 \; x\; \tau^2_{1/2}(1+r^2/2r),\; r = m_{D**}/m_B = 0.436$$

Form factors have to be evaluated at $w_0 = (1+r^2)/2r = 1.32$ and 1.37 respectively. Using the dependence of form factors given by Alain:

$$\tau^2 (w) = (2/(1+w))^{2\sigma} ; \sigma_{1/2} = 0.83; \sigma_{3/2} = 1.5$$

one gets:

$$B(B^0 \rightarrow D_{3/2}\,\pi) / B(B^0 \rightarrow D_{1/2}\,\pi) = (0.4246 \times 0.219 \times \tau^2_{3/2}(1)) / (0.1945 \times 0.421 \times \tau^2_{1/2}(1))$$
$$= 2.18 \times 0.52 \times 3.21$$
$$= 3.6$$

One can see that the ratio of the square of form factors computed at w=1 contributes a factor 3 only. The slope difference of form factors gives in fact a reduction of the ratio because the slope is expected to be higher for 3/2 than for ½ states and the rest comes from kinematics. The central value of the ratio is thus less than a factor 10 and all contributing terms have uncertainties:

- the ratio of form factors has from LQCD a 10% relative uncertainty which corresponds to 20% error on the square of this ratio. This is still an incomplete evaluation of contributing uncertainties;
- what is the uncertainty on the slopes?
- the kinematic term has also uncertainties because form factors are not universal.

In my opinion the factor 3.6 has at least 30% uncertainty.

Conclusions:
Once uncertainties are included in the comparison between experimental results and theoretical expectations there is not a significant discrepancy. Theorists must indicate more precisely what are the uncertainties on their evaluations to really demonstrate that there is a significant effect. It would be nice if experimentalists can clarify present significant differences between BaBar and Belle results.

About the contribution of radial excitations in B semileptonic decays

Using the yields measured by BaBar in the fragmentation of charm quarks to D_1, D_2^*, D' and $D^{*'}$ states observed in the $D^*\pi$ final state, I have argued that the branching fraction of the $D^{*'}$ into $D^*\pi$ cannot be small. Using a model for hadronization, I get 50 ± 10 %. The D*' can also decay to $D\pi$ at the relative branching fraction to $D^*\pi$ is also measured by BaBar. It is thus legitimate to expect a signal at the D*' mass in the $D^*\pi$ mass distribution in semileptonic or non leptonic events if one wants to explain multipion events in B semileptonic decays by radially excited states.

It would be nice also to evaluate the fraction of events with a radial excitation where the soft pion from the D* escapes detection, using fully simulated events B → $D^{(*)'}$ l ν. I don't know if a realistic generator exists for such events, that includes all angular correlations (?) for D*' → D* π and → D_1 π (and D_2^* π eventually).