PARTICLE DATA GROUP NOTES

Product Branching Ratios and Rescaling

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Product Branching Ratios

A new method of handling product branching ratios was introduced in the 1994 edition of RPP. If `ALBRECHT 92G` reports a product branching ratio

$$\mathrm{B}\left(B \to D_s^{\pm} \text{ anything}\right) \cdot \mathrm{B}\left(D_s^{\pm} \to \phi\pi^+\right) = 0.00292 \pm 0.00039 \pm 0.00031$$

we can encode in place of the `ALBRECHT 92G` value in the $B \to D_s^{\pm}$ anything branching ratio section (S041S14) the expression

$$\texttt{br\_product:} 0.00292 \pm 0.00039 \pm 0.00031, \ \texttt{S034 6}$$

where `S034 6` is the particle code and designator of the $D_s^+ \to \phi\pi^+$ mode. As the footnote for this value, we encode the expression

$$\texttt{\#br\_note\{S041S14 ALBRECHT 92G\}}.$$

The value of $\mathrm{B}(B \to D_s^{\pm}$ anything$)$ will automatically be calculated using the current PDG value for $\mathrm{B}(D_s^+ \to \phi\pi)$ and will be displayed as the `ALBRECHT 92G` value. A footnote which explains the conversion will be generated. The reader will see

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$\Gamma\left(D_s^{\pm} \text{ anything}\right)/\Gamma_{\text{total}}$ 　　　　　　　　 Γ_{139}/Γ

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT	NODE=S041S14
0.089±0.011 OUR AVERAGE					
0.084±0.014±0.010		[228] ALBRECHT 92G ARG		$e^+e^- \to \Upsilon(4S)$	
0.088±0.013±0.010	257	[229] BORTOLETTO90 CLEO		$e^+e^- \to \Upsilon(4S)$	
0.109±0.029±0.013		[230] HAAS 86 CLEO		$e^+e^- \to \Upsilon(4S)$	
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
0.120±0.031±0.014		[231] ALBRECHT 87H ARG		$e^+e^- \to \Upsilon(4S)$	

[228] ALBRECHT 92G reports [B$(B \to D_s^{\pm}$ anything$) \times$ B$(D_s^+ \to \phi\pi^+)$] $= 0.00292 \pm 0.00039 \pm 0.00031$. We divide by our best value B$(D_s^+ \to \phi\pi^+) = (3.5 \pm 0.4) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.　　　　NODE=S041S14;LINKAGE=C

[229] BORTOLETTO 90 reports [B$(B \to D_s^{\pm}$ anything$) \times$ B$(D_s^+ \to \phi\pi^+)$] $= 0.00306 \pm 0.00047$. We divide by our best value B$(D_s^+ \to \phi\pi^+) = (3.5 \pm 0.4) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.　　　　NODE=S041S14;LINKAGE=A2

[230] HAAS 86 reports [B$(B \to D_s^{\pm}$ anything$) \times$ B$(D_s^+ \to \phi\pi^+)$] $= 0.0038 \pm 0.0010$. We divide by our best value B$(D_s^+ \to \phi\pi^+) = (3.5 \pm 0.4) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value. 64 ± 22% decays are 2-body.　　　　NODE=S041S14;LINKAGE=A

[231] ALBRECHT 87H reports [B$(B \to D_s^{\pm}$ anything$) \times$ B$(D_s^+ \to \phi\pi^+)$] $= 0.0042 \pm 0.0009 \pm 0.0006$. We divide by our best value B$(D_s^+ \to \phi\pi^+) = (3.5 \pm 0.4) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value. 46 ± 16% of $B \to D_s X$ decays are 2-body. Superseded by ALBRECHT 92G.　　　　NODE=S041S14;LINKAGE=B

Other information can be included in the footnote after (or before) the automatically-generated portion as was done in footnotes 230 and 231 above.

The old method of handling product branching ratios was to display only the product branching ratio in the data block. The old method has been retained to avoid having to convert all old data.

Rescaling Branching Ratios

A new method of rescaling branching ratios to our current values has also been introduced. If BORTOLETTO 90 reports a "parent" branching ratio

$$\mathrm{B}\left(B^+ \to \overline{D}^0\, D_s^+\right) = 0.029 \pm 0.013$$

where they assumed a "daughter" branching ratio of

$$\mathrm{B}\left(D_s^+ \to \phi\pi^+\right) = 0.02$$

we can encode in place of the BORTOLETTO 90 value in the $B^+ \to \overline{D}^0\, D_s^+$ branching ratio section (S041R39) the expression

```
br_rescale: 0.029 ± 0.013, 0.02, S034 6
```

with footnote

```
#br_note{S041R39 BORTOLETTO 90}.
```

The reader will see

$\Gamma\left(\overline{D}^0 D_s^+\right)/\Gamma_{total}$			Γ_{24}/Γ	
VALUE	EVTS	DOCUMENT ID	TECN	COMMENT

NODE=S041R39

0.017±0.006 OUR AVERAGE

| 0.019±0.010±0.002 | | [66] ALBRECHT | 92G ARG | $e^+e^- \to \Upsilon(4S)$ |
| 0.017±0.007±0.002 | 5 | [67] BORTOLETTO90 CLEO | | $e^+e^- \to \Upsilon(4S)$ |

[66] ALBRECHT 92G reports $0.024 \pm 0.012 \pm 0.004$ for $\mathrm{B}(D_s^+ \to \phi\pi^+) = 0.027$. We rescale to our best value $\mathrm{B}(D_s^+ \to \phi\pi^+) = (3.5 \pm 0.4) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value. Assumes PDG 1990 D^0 branching ratios, e.g., $\mathrm{B}(D^0 \to K^-\pi^+) = 3.71 \pm 0.25\%$.

NODE=S041R39;LINKAGE=CA

[67] BORTOLETTO 90 reports 0.029 ± 0.013 for $\mathrm{B}(D_s^+ \to \phi\pi^+) = 0.02$. We rescale to our best value $\mathrm{B}(D_s^+ \to \phi\pi^+) = (3.5 \pm 0.4) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

NODE=S041R39;LINKAGE=A

Error Handling

The numerical arguments of br_product and br_rescale can be a value with two errors (statistical and systematic), with one error (combined statistical and systematic), or with no errors. The first argument can also be a limit. The input errors can be asymmetric. Before any computation is done, statistical and systematic errors are combined in quadrature, separately for positive and negative errors if both are present.

Error handling is similar for product branching ratios and for rescaling. The only difference is that in rescaling, the program must first calculate a product branching ratio by multiplying the experimenter's "parent" and "daughter" branching ratios and unfolding the error on the "daughter" branching ratio. In other words, if an experimenter reports a "parent" branching ratio

$$\mathrm{B}\left(B \to \overline{D}^0 D_s^+\right) = a \pm \alpha$$

where they assumed a "daughter" branching ratio of

$$\mathrm{B}\left(D_s^+ \to \phi\pi^+\right) = e \pm \epsilon$$

the program must form the product branching ratio and its error

$$\mathrm{B}\left(B \to \overline{D}^0 D_s^+\right) \cdot \mathrm{B}\left(D_s^+ \to \phi\pi^+\right) = p \pm \phi$$

$$= ae \pm ae \left[\frac{\alpha^2}{a^2} - \frac{\epsilon^2}{e^2}\right]^{1/2}$$

If the bracketed quantity is less than zero, zero is used. For asymmetric errors, the error $\phi^+[\phi^-]$ is obtained from the errors $\alpha^+[\alpha^-]$ and $\epsilon^+[\epsilon^-]$. The rest of the calculation and error handling is the same for a rescaled experiment as for an experiment which directly quotes a product branching ratio $p \pm \phi$.

All values in one data block which are obtained from product branching ratios or rescaling and which use the same PDG branching ratio will have a common percent systematic error. They will form a new type of "systematic error clump" in the RPP system, and their common percent systematic error will be handled by a new method as follows.

Consider the product branching ratio from the ith experiment

$$\mathrm{B}(\mathrm{mode}\ 1) \cdot \mathrm{B}(\mathrm{mode}\ 2) = \mathrm{p}_i \pm \phi_i$$

where ϕ_i is the total error, including combining statistical and systematic errors in quadrature if both are present in the input.

We divide the product branching ratio by the current PDG value

$$\mathrm{B}(\mathrm{mode}\ 2)_{\mathrm{PDG}} = b \pm \beta$$

to obtain

$$\mathrm{B}(\mathrm{mode}\ 1)_i = A_i \pm \sigma_i \pm \delta_i$$

where

$$A_i = p_i/b\ ,\ \ \sigma_i = \phi_i/b\ ,\ \ \delta_i = A_i\left(\beta/b\right)$$

The $\sigma_i^+[\sigma_i^-]$ error is obtained from the $\phi_i^+[\phi_i^-]$ error, whereas the $\delta_i^+[\delta_i^-]$ error is obtained from the $\beta^-[\beta^+]$ error since we divide by the current PDG value. In printing the values and errors, we determine the number of significant digits to display by subjecting

$$\max\left[\min\left(\sigma_i^+, |\sigma_i^-|\right),\ \min\left(\delta_i^+, |\delta_i^-|\right)\right]$$

to the PDG rules of rounding, examining the number of digits that follow the decimal point, and applying that number to the other three errors and to the central value.

The percent systematic errors δ_i/A_i are all equal to β/b, the percent error of the current PDG value. Therefore the δ_i are correlated so that the values cannot be averaged as if they were independent. A similar problem exists when we average experiments with a common systematic error Δ as described on page 1180 of the 1994 edition of RPP. The difference in the new case discussed here is that rather than δ_i being a constant Δ, the percent systematic error δ_i/A_i is constant.

A similar treatment to the one described on page 1180 of the 1994 edition of RPP can be derived for this case. One could first average the $A_i \pm \sigma_i$ and then divide the results by $b \pm \beta$. One obtains, however, the same result by averaging $A_i \pm (\sigma_i^2 + \Delta_i^2)^{1/2}$, where

$$\Delta_i = \sigma_i \left(\delta_1/A_1\right) \sum_k \left(A_k/\sigma_k^2\right) \Big/ \left[\sum_j \left(1/\sigma_j^2\right)\right]^{1/2} .$$

The formula for Δ_i assumes symmetric errors. For asymmetric errors, it isn't clear to us that there is an analogous method. We evaluate $\Delta_i^+[\Delta_i^-]$ using $\sigma_i^+[\sigma_i^-]$, $\delta_i^+[\delta_i^-]$, $\sigma_k^+[\sigma_k^-]$ and $\sigma_j^+[\sigma_j^-]$, which should provide a reasonable approximation.

The existing common systematic error treatment described on page 1180 of the 1994 edition suffers from the same lack of a method for asymmetric errors. In that case, the program used only the positive systematic errors in past RPP editions. This lack is fixed for the 1994 edition by the same method as described above (even though none of the old type of systematic error clumps have asymmetric errors).

We need to augment the discussion of common systematic errors and to add a discussion of rounding before publishing the 1996 edition.