Systematics on lifetime measurments

We propose the following text (latex format). latex abbreviations are defined using the standard lhcb latex defintion file.

The particle decay times are measured from the distance between the primary vertex and secondary decay vertex in the VELO. The accuracy with which this distance is known is dependent on the precision with which the relative position along the beam line (z axis) of the LHCb modules is
determined.\\
There are two contributions to this systematic uncertainty. First there is the precision with which the VELO modules were assembled. This has been
determined during a survey at the time of assembly to be 100~\mum~ of the measurement of the baseplate over the whole length of the VELO \cite{bib:VELOPerformance}.
\begin{equation}
\sigma_{\text{survey}} = \frac{100\times10^{-3}~\text{mm}}{1000~\text{mm}} = 0.01 \%.
\end{equation}
The second contribution originates from track-based alignment \cite{bib:alignKalman, bib:alignVELO, bib:alignVELOResult}. This is mostly determined by the first two modules on the track since the following modules are weighted down due to multiple scattering effects. So in principle the z-scale
uncertainty is obtained comparing the z module position from the track-based alignment with the metrology (20~\mum) divided by the spacing between two modules (30~mm).
However since the signal tracks have some spread in z within the VELO, they do not all hit the same module first (see Fig.\ref{fig_zpos}). The RMS
of this distributions (100~mm) is a measure for the effective spread of the tracks. Therefore the resulting uncertainty from tack-based alignment is
given by
\begin{equation}
\sigma_{\text{track}} = \frac{20\times10^{-3}~\text{mm}}{100~\text{mm}} = 0.02 \%.
\end{equation}
\begin{figure}
\centering
\includegraphics[width=0.6\linewidth]{./plots/ct/zpos_first_hit.eps}
\caption{z-position of the first hit on each track used in this analysis.\label{fig_zpos}}
\end{figure}
For the overall z-scale systematic we add the two contributions in quadrature and end up with
\begin{equation}
\sigma_{z\text{-scale}} = 0.022 \%.
\end{equation}
This is directly translated into a relative uncertainty on \Dms. Therefore the systematic uncertainty on \Dms that we assign to the z-scale is
± 0.004 ps^{-1}.

\bibitem{bib:alignKalman}{W.~Hulsbergen, ``The global covariance matrix of tracks fitted with a Kalman filter and an application in detector alignment'', Nucl.\ Instrum.\ Meth.\ A {\bf 600} (2009) 471 [arXiv:0810.2241 [physics.ins-det]]. %%CITATION = NUIMA,A600,471;%% }
\bibitem{bib:alignVELO}{ S.~Viret, C.~Parkes and M.~Gersabeck, ``Alignment procedure of the LHCb Vertex Detector'', Nucl.\ Instrum.\ Meth.\ A {\bf 596} (2008) 157 [arXiv:0807.5067 [physics.ins-det]]. %%CITATION = NUIMA,A596,157;%% }
\bibitem{bib:alignVELOResult}{ S.~Borghi {\it et al.}, ``First spatial alignment of the LHCb VELO and analysis of beam absorber collision data,'', Nucl.\ Instrum.\ Meth.\ A {\bf 618} (2010) 108. %%CITATION = NUIMA,A618,108;%% }
\bibitem{bib:VELOPerformance}{LHCb VELO grou},``Performance of the LHCb VELO, to be submitted to JINST''}

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