1. Matrix factorization after standardizing columns of $G$

Let’s consider the difference in matrix $G$ from standardizing each of the columns. Let $\tau^{-1}$ be the $p$-vector of the column standard deviations, and $diag(\tau)$ is the $p \times p$ diagonal matrix of the inverse of those standard deviations.

\begin{equation}
G' = (G - 1_n\bar{G}^t)diag(\tau)
\end{equation}

where $\bar{G}$ is the $p$-vector of the column means of $G$, and $G'$ is the column-standardized matrix to which we apply PCA. Then,

\begin{equation}
(G - 1_n\bar{G}^t)diag(\tau) = \Lambda F
\end{equation}

\begin{equation}
G = \Lambda Fdiag(\tau^{-1}) + 1_n\bar{G}^t
\end{equation}

\begin{equation}
= (1_n\Lambda) \begin{pmatrix} G^t \\ Fdiag(\tau^{-1}) \end{pmatrix}.
\end{equation}

This implies that the means play the role of an additional factor that does not necessarily conform to the orthonormal constraint on $F$. It also implies that the $\Lambda$ will be scaled (because the $F$ are required to be orthonormal).