This paper studies the detection of chipless frequency-coded tags. The detection exploits a temporal separation that allows obtaining the identification (ID) with only one measurement. In this way, the flexibility of reading of this type of chipless tags is clearly improved, which is highly expected for future real implementation. This temporal separation is possible when the tag presents a long-time signature, longer than the backscattering wave corresponding to the surrounding objects. A technique based on the short-time Fourier transform (STFT) is used to differentiate the useful parts of the signal, which contain the tag ID. Up to now, this was done by using a calibration process based on two measurements at least to remove coupling and clutter contribution. With the proposed approach the acquisition of the tag ID is direct, and it is not necessary to have further information such as the measurement of the environment without the tag. A study on the time duration of several frequency-coded tags is performed based on simulations and measurements. The study shows that this approach can be used with classical depolarizing chipless tags already proposed in the literature. It is proven that the proposed approach is useful to detect the tag response with a single measurement.