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Probing the R-ratio on the lattice

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The ratio of the cross sections for $e^+e^- \to hadrons$ and $e^+e^- \to \mu^+\mu^-$ at c.o.m energy E, i.e. $R(E)$, is an extremely interesting observable. Its measurements are used in dispersive analyses of the leading hadronic vacuum polarization (HVP) contributing to the muon $g-2$, and the results of these analyses for a certain window observable are in significant tension with those coming from recent accurate lattice computations. It is thus very important to determine $R(E)$ from first-principles and compare it with experiment. In this talk we study $R(E)$ through a smearing in energy with different kernels $f(E)$. Indeed, by changing the shape of the smearing kernel one obtains an infinite number of observables, $R[f]$, that probe $R(E)$ in different ways. In particular, choosing $f(E) = \exp(-Et)$ yields the Euclidean lattice correlator of two electromagnetic hadronic currents. This is a primary quantity from the lattice viewpoint, which we compare with its experimental counterpart directly obtained from the measured $R(E)$. We also use a recently proposed method for extracting smeared spectral densities from Euclidean lattice correlators in order to compute $R[f]$ for smearing kernels f chosen as Gaussians of different width and central energy. Our still preliminary numerical results are obtained using state-of-the-art ETMC ensembles with $N = 2+1+1$ dynamical quark flavours at three values of the lattice spacing ($\geq$ 0.06 fm), large volumes and physical pion mass.

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