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Beam-based measurements of the plasma decay constant

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The evolution of plasmas on timescales much longer than the beam-plasma interaction time is of interest for potential high repetition rate applications. In the AWAKE experiment, a terawatt-class laser is used to ionize a ten meter-long Rb vapor during or before the transit of a 400 GeV proton beam. The proton beam is modulated by the plasma through a process called the Self-Modulation Instability (SMI). The modulation occurs at the plasma frequency, which is proportional to the square root of the plasma density. In this experiment, we scan the laser timing from zero (coincident with the beam) to tens of microseconds ahead of the beam. At each point, we measure the modulation frequency on the proton beam and deduce the plasma density, and from this information we are able to extract a decay constant from the plasma.

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