**Cooling particles with microbunching electrons**

**Abstract:**

In the 1980s, Derbenev suggested that electron instabilities, such as the Free Electron Laser, could create collective space charge fields strong enough to cool high energy particles. Here we discuss a modified electron cooling scheme using the microbunching instability as the amplifier. A simple analytical model illustrates the cooling mechanism and simulations show cooling rates for realistic LHC-like parameters. Finally, we can consider the advances necessary to cool muons.

**Summary:**

Traditional cooling methods have difficulty cooling high-energy, bunched beams. The wide bandwidth of a free electron laser (FEL) allows coherent electron cooling (CeC) [1] to achieve faster cooling rates, but for LHC scale machines, even an EUV FEL bandwidth is not sufficient. In the time domain, the small FEL bandwidth manifests as periodic density spikes, of which only one contributes to cooling; ideally, a wide-bandwidth amplification process would create just the single spike needed to cool each hadron. An alternative approach is to use the Longitudinal Space Charge (LSC) Microbunching Instability (MBI) as the amplifier [2]. For LSC-MBI, space charge from an initial density modulation produces an energy modulation, which a dispersive region then converts back into an amplified density modulation. To drive CeC from MBI, a hadron's Coulomb field produces an initial electron energy modulation (as for other CeC schemes) and a dispersive region then converts the energy modulation from each hadron into a single density spike. Finally, as in other CeC methods, each density spike adjusts the energy of its corresponding hadron in a kicker. Driving CeC from MBI offers two benefits. First, the instability creates only a single density spike for each hadron, maximizing the bandwidth of the amplifier. The large amplifier bandwidth is crucial for cooling high density, bunched beams, such as those at LHC. Second, the scheme is relatively simple, consisting only of drift and dispersive regions. Reaching the cooling rates necessary for muon beams is a more challenging problem, and we consider the necessary advances to apply CeC to muons.

[1] V.N. Litvinenko and Y.S. Derbenev, Phys. Rev. Lett., 102, 114801 (2009)

[2] D. Ratner, Phys. Rev. Lett., 111, 084802 (2013)