Lepton Production from Charm Decay in Nuclear Collisions at $\sqrt{s} = 200$ GeV and 5.5 TeV per Nucleon [*]

S. Gavin[†], *P. L. McGaughey*[‡], *P. V. Ruuskanen*[§] *and R. Vogt*

Dilepton production provides an important tool for measuring the temperature of the high density matter produced in the early stages of a relativistic heavy-ion collision [1]. In high energy pp interactions, the continuum in the dilepton mass range above $M \sim 2$ GeV is dominated by the Drell-Yan process and by semileptonic decays of charm mesons. This production can be addressed using perturbative QCD. In contrast, the lower mass region arises from soft processes, for which theory offers little guidance. We therefore hope to find a signal of thermal dilepton production at masses $M \sim 2-3$ GeV where *i*) the thermal contribution can still be sizable and *ii*) the background is calculable.

We compare the predictions of dilepton production from a simple thermal model with the hard 'background' from heavy quark pair, $Q\overline{Q}$, decays and Drell-Yan production at RHIC and LHC nucleus-nucleus collision energies, $\sqrt{s} =$ 200 GeV and 5.5 TeV in the nucleon-nucleon center of mass. This background is now calculated to next-to-leading order (NLO), shown to agree with pp and $p\overline{p}$ data [2], and is no longer dependent on arbitrary phenomenological 'K factors'. The remaining uncertainties in the NLO perturbative approach are well defined and likely rather small [2]. We also calculate the invariant mass and transverse momentum distributions of the lepton pairs and use these distributions to illustrate how thermal and hard dileptons can be distinguished in an experiment. In addition, we introduce the dilepton contribution from B meson decays, and discuss the effects of nuclear shadowing on the initial production.

We find that hard charm quark production and decay dominates the continuum below the Υ mass. In particular, the charm signal is more than an order of magnitude above the optimistic thermal dilepton and thermal charm rates for $M > 2$ GeV. Thus the isolation of thermal signals will not be straightforward.

To experimentally enhance the thermal signal, one can count only those lepton pairs with a small separation in rapidity. Lepton pairs from charm decays typically occur with a large rapidity gap, absent in Drell-Yan and thermal pairs. Together with like-sign subtraction, rapidity gap cuts can essentially remove the uncorrelated charm and greatly suppress the correlated charm background. The finite acceptance of a real detector can serve this purpose. Then at least one of the $D\overline{D}$ decay leptons may be outside the finite detector acceptance. In particular, relatively few high mass lepton pairs from uncorrelated $D\overline{D}$ decays will be detected, significantly reducing the uncorrelated yield even before like-sign subtraction. We show that the acceptance window of PHENIX/RHIC and ALICE/LHC can enhance the signal from thermal charm decays to the point of measurability by rejecting pairs with large gaps. However, charm production remains the dominant source of dileptons in heavy-ion collisions, even with acceptance cuts, for $M < 6-8$ GeV. Since charm cannot be removed simply by the finite detector acceptance, charm measurements are crucial.

[1] R. Vogt, B.V. Jacak, P.L. McGaughey and P.V. Ruuskanen, Phys. Rev. **D49** (1994) 3345.
[2] P.L. McGaughey *et al.*, Int. J. Mod. Phys. **A10** (1995) 2999; S. Gavin *et al.*, Int. J. Mod. Phys. **A10** (1995) 2961.

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[†]Physics Department, Brookhaven National Laboratory
[‡]Los Alamos National Laboratory
[§]Department of Physics, University of Jyväskylä, Jyväskylä, Finland