EXPERIMENTAL EVIDENCE FOR HADRON DECONFINEMENT IN $\bar{p}-p$ COLLISIONS AT $\sqrt{s} = 1.8$ TeV IN THE FNAL CØ COLLIDER

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ABSTRACT

We have measured deconfined hadronic volumes, $4.4 < V < 13.0$ fm$^3$, produced by a one-dimensional (1D) expansion. The volumes are directly proportional to the charged particle pseudorapidity densities $6.75 < \frac{dN_c}{d\eta} < 20.2$. The hadronization temperature is $T = 179.5 \pm 5$ (syst) MeV. The hadronization energy density is $\epsilon = 1.10 \pm 0.26$ GeV/fm$^3$, corresponding to an excitation of $24.8 \pm 6.2$ quark-gluon degrees of freedom.

The deconfined hadronic matter has a threshold at $dN_c/d\eta = 7$. Hadronization for all events above the threshold occurs at a constant energy density and temperature. The temperature is constant to 1\% for $6.75 < \frac{dN_c}{d\eta} < 20.2$. If we treat all charged particles as pions then $1.57 \pm 0.25$ (stat) pions/fm$^3$ are emitted from the volume. We can relate this number of pions/fm$^3$ emitted from the volume $V$ to the number of gluons and quarks in the volume (see Fig.1).

\begin{equation}
\text{n(pions)} = \text{n(gluon)} + \frac{\text{n}(q) + \text{n}(\bar{q})}{2}
\end{equation}

We assume that two flavors of quarks and gluons are involved and that the number of quark and gluon degrees of freedom scale proportionally.

\begin{equation}
\text{n(pion)} = V \frac{G(T)1.202(kT)^3}{\pi^2 h^3 c^3}
\end{equation}
This corresponds to \( G(T) = 23.5 \pm 6.0\,\text{(stat)} \) quark-gluon degrees of freedom. Similarly all charged particles contribute to the freeze out energy \( E \).

\[
E(\text{freezout}) = V G(T) \frac{\pi^2 k^4}{30 \hbar^3 c^3 T^4}.
\]  

(3)

[ht] The freezeout energy density emitted by the volume \( V \) is \( \epsilon = 1.10 \pm 0.26\,(\text{stat}) \) GeV/fm\(^3\) and we obtain \( G(T) = 24.8 \pm 6.0\,(\text{stat}) \) quark-gluon degrees of freedom. In Fig.2. we compare our experimental results with Karsch’s lattice gauge calculation \([2]\), where \( \frac{\epsilon}{T^4} = \frac{\pi^2}{30} G(T) = 8.15 \pm 2.0 \) (stat).
References
