Dynamics of the Radial Flow of Strange Particles

R. A. LACEY[(1)], N. N. AJITANAND[(1)], J. M. ALEXANDER[(1)], M. ANDERSON[(5)], D. BEST[(*3)], F.P. BRADY[(5)], T. CASE[(3)], W. CASKEY[(5)], D. CEBRA[(5)], J.L. CHANCE[(5)],P. CHUNG[(1)], B. COLE[(10)], K. CROWE[(3)], A. C. DAS[(2)], J.E. DRAPER[(5)], A. ELMAANI[(1)], M.L. GILKES[(1)], S. GUSHUE[(1,8)], M. HEFFNER[(5)], A.S. HIRSCH[(6)], E.L. HJORT[(6)], L. HUO[(12)], M. JUSTICE[(4)], M. KAPLAN[(7)], D. KEANE[(4)], J.C. KINTNER[(11)], J. KLAY[(5)], D. KROFCHECK[(9)], J. LAURET[(1)], C. LAW[(1)], M.A. LISA[(2)], H. LIU[(4)], Y.M. LIU[(12)], R. MCGRATH[(1)], Z. MILOSEVICH[(7)], G. ODYNIEC[(3)], D.L. OLSON[(3)], S. Y. PANITKIN[(4)], C.PINKENBURG[(1)], N.T. PORILE[(6)], G. RAI[(3)], H.G. RITTER[(3)], J.L. ROMERO[(5)], R. SCHARENBERG[(6)], L. SCHROEDER[(3)], B. SRIVASTAVA[(6)], N.T.B STONE[(3)], T.J.M. SYMONS[(3)], J. WHITFIELD[(7)], T. WIENOLD[(*3)], R. WITT[(4)], L. WOOD[(5)], AND W.N. ZHANG[(12)]
(E895 COLLABORATION)

[(1)] *Depts. of Chemistry and Physics, SUNY Stony Brook, New York 11794–3400*
[(2)] *Ohio State University, Columbus, Ohio 43210*
[(3)] *Lawrence Berkeley National Laboratory, Berkeley, California, 94720*
[(4)] *Kent State University, Kent, Ohio 44242*
[(5)] *University of California, Davis, California, 95616*
[(6)] *Purdue University, West Lafayette, Indiana, 47907–1396*
[(7)] *Carnegie Mellon University, Pittsburgh, Pennsylvania 15213*
[(8)] *Brookhaven National Laboratory, Upton, New York 11973*
[(9)] *University of Auckland, Auckland, New Zealand*
[(10)] *Columbia University, New York, New York 10027*
[(11)] *St. Mary's College, Moraga, California 94575*
[(12)] *Harbin Institute of Technology, Harbin, 150001 P. R. China*

The radial flow of strange hadrons (K_s^0's and Λ's) can serve as an important probe for reaction dynamics and the properties of high-density nuclear matter. The E895 collaboration has performed a comprehensive set of radial flow measurements for the Au + Au system spanning a broad range of beam energies and impact parameters. First results obtained from these measurements for K_s^0's and Λ's are presented. They suggest the possibility of a different freeze-out time for strange and non-strange hadrons.

1 Introduction

The study of collective motion in relativistic heavy ion collisions can provide crucial information about the nuclear equation of state (EOS), phase transitions, and reaction dynamics[1,2,3,4,5,6]. Extensive investigations of the radial flow of non-strange hadrons have been made[7,8,9,10,11,12,13]. However, the dy-

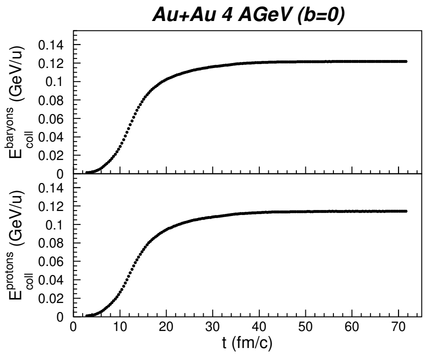

Figure 1: Time evolution of the radial flow of baryons (top panel) and protons (bottom panel).

namics of radial flow is still not very well understood. Currently, it is not completeley settled as to whether or not radial flow develops at an early or late stage in a nuclear collision. Similarly, it is not clear if the freeze-out of different particle species – during the expansion phase – results from simultaneous or squential processes.

Fig. 1 shows the time development of radial flow obtained from the BEM model[4] for all baryons and protons emitted in central 4 AGeV Au + Au collisions. The Figure suggests that radial flow requires a relatively long time ($\sim$ 30 fm/c) to develop to its maximum value. If particles are emitted during this time, it may be possible to probe the dynamic evolution of radial flow. Model calculations suggest that the time scale for freeze-out of strange and multi-strange particles may be much shorter than that for non-strange particles[14,15]. If this is indeed the case, then such particles could serve as probes for the dynamical development of radial flow in heavy ion reactions. In this contribution, we investigate this notion by way of measurements of the radial flow of K_s^0's and Λ's.

2 Results

Details of the experimental setup as well as the methods employed to identify and select K_s^0's and Λ's have already been presented in this symposium[16,17].

Quantitative estimates of the radial flow for K_s^0's and Λ's have been obtained by assuming a spherically symmetric expanding-emitting source at mid-rapidity. If this source expands with a velocity, β, then the transverse mass,

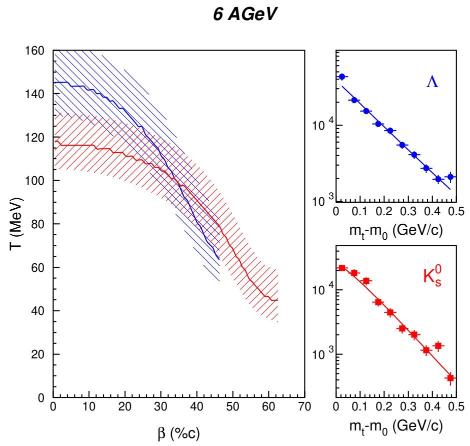

Figure 2: T and β values (left panel) extracted from fits to our m_T spectra for Λs and K^0_ss (right panel), see text.

m_T, distributions for K^0_s's and Λ's can be characterized by the expression[7,10]:

$$\frac{1}{m_T^2}\frac{dn}{dm_T} \propto e^{-\gamma m_T/T}\left[\frac{sinh\alpha}{\alpha}\left(\gamma + \frac{T}{m_T}\right) - \frac{T}{m_T}cosh\alpha\right], \qquad (1)$$

where $\alpha = \beta\gamma p/T$ and $\gamma = (1-\beta^2)^{1/2}$. T is the freeze-out temperature for the particles. We have used this expression to carry out fits to the experimentally measured m_T spectra (for Λ's and K^0_s's) and have extracted β and T for several beam energies. Fig 2 shows representative results for the 6 AGeV measurement. The dark solid curves in the left panel represent the chi-squared minima for fits to the m_T spectra shown in the right panel of the Figure. The hatched regions represent the associated uncertainties. All points on the solid curves (left panel Fig. 2) represent equally acceptable fits to the m_T spectra shown in the right panel. This being the case, it is necessary to impose further constraints for the extraction of the freeze-out values for T and β. We assume a common freeze-out condition for Λ's and K^0_s's and take the crossing point of the two curves as a good estimate for the value of T and β at freeze-out. It should be emphasized here that the crossing of these two curves is a necessary requirement for the above assumption of a common freeze-out condition. Another approach is to assume a common freeze-out (for Λs and K^0_ss) and use the mass dependence of slope parameter obtained from the m_T spectra to extract β and T[11,12]. Within error bars, both approaches yield similar values for T and β.

The extracted values for T and β at 4 and 6 AGeV are summarized in

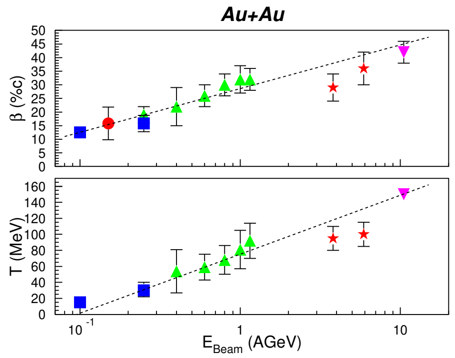

Figure 3: Excitation functions for β (top panel) and T (bottom panel). The stars represent our values for strange hadrons.

Fig. 3 (stars). The other symbols in the Figure represent a compilation of flow values for non-strange hadrons in Au + Au collisions. A comparison of these flow values for strange and non-strange particles suggests somewhat smaller freeze-out temperatures and radial velocities for the Λ's and K_s^0'. A smaller radial flow velocity for Λ's and K_s^0' is compatible with the notion that these particles may be emitted during the time required for full development of radial collective flow in the emitting system. If this is indeed the case, then these particles could serve as probes for the expansion dynamics.

In order to test whether or not strange and non-strange hadrons freeze-out with the same values of T and β, we have caried out fits to the m_T spectra for protons and compared them to those for K_s^0, and Λ's. The preliminary results obtained from this comparison do not indicate any common values in β and T for protons, K_s^0's and Λ's, implying that these particles may not all be produced in an instantaneous freeze-out scenario. This conjecture will be further tested in our ongoing analysis.

Acknowledgements

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