Flemming Videbæk

From the Niels Bohr Institute
to RHIC

For me, an extremely fruitful collaboration!

- Low energy nuclear physics major directions: reactions and spectroscopy

- Tools: Coulomb excitation (COULEX)—understanding level schemes and EM transition rates
- Distorted Wave Born Approximation DWBA—calculating reaction rates using nuclear optical potential

- NBI is where these came together with the matchmakers Ole Hansen (Copenhagen) and Lee Grodzins (MIT) on sabbatical leave

Timeline:

- Sept. 1972 We meet at Niels Bohr Institute – FV student of Ole Hansen

  I leave Europe for MIT Grodzins group in Dec 1972

  FV and MIT collaborate with Doug Cline (Rochester) on Coulomb-nuclear interference with FV doing DWBA calculations using DWUCK at NBI
- Sept. 1974 – Dec. 1975 Visiting Scientist in Lee Grodzins heavy-ion group

  We begin program of heavy-ion reactions at BNL Tandem Van de Graaff
- 1975-1985 – Return to NBI
- Jan. 1985–Dec. 1989 Argonne Nat. Lab

  initially Nuclear Chemistry – with Sheldon Kaufman, then Nuclear Physics joining effort on E802 with Ole Hansen at BNL
- Dec. 1989–present – at BNL

Nuclear Physics A
Volume 207, Issue 3, 18 June 1973, Pages 433-455

The interference of Coulomb and nuclear excitation in the scattering of ^{16}O from ^{58}Ni, ^{88}Sr and ^{142}Nd

P.R. Christensen [a], I. Chernov [†], E.E. Gross [a, ††], R. Stokstad [a, †††], F. Videbæk [a]

Nuclear Physics A
Volume 256, Issue 2, 12 January 1976, Pages 301-311

Coulomb-nuclear interference and nuclear reorientation in the scattering of $^{16, 18}$O by ^{58}Ni and ^{64}Ni

F. Videbæk, P.R. Christensen, Ole Hansen, K. Ulbak

University of Rochester Tandem Van de Graaff

VOLUME 33, NUMBER 8 PHYSICAL REVIEW LETTERS 19 AUGUST 1974

Polarization in Heavy-Ion Inelastic Scattering in the Coulomb-Nuclear Interference Region

S. G. Steadman, T. A. Belote, R. Goldstein, and L. Grodzins

Laboratory for Nuclear Science, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139*

and

D. Cline and M. J. A. de Voigt

Nuclear Structure Research Laboratory,† University of Rochester, Rochester, New York 14627

and

F. Videbæk

The Niels Bohr Institute, University of Copenhagen, Copenhagen, Denmark

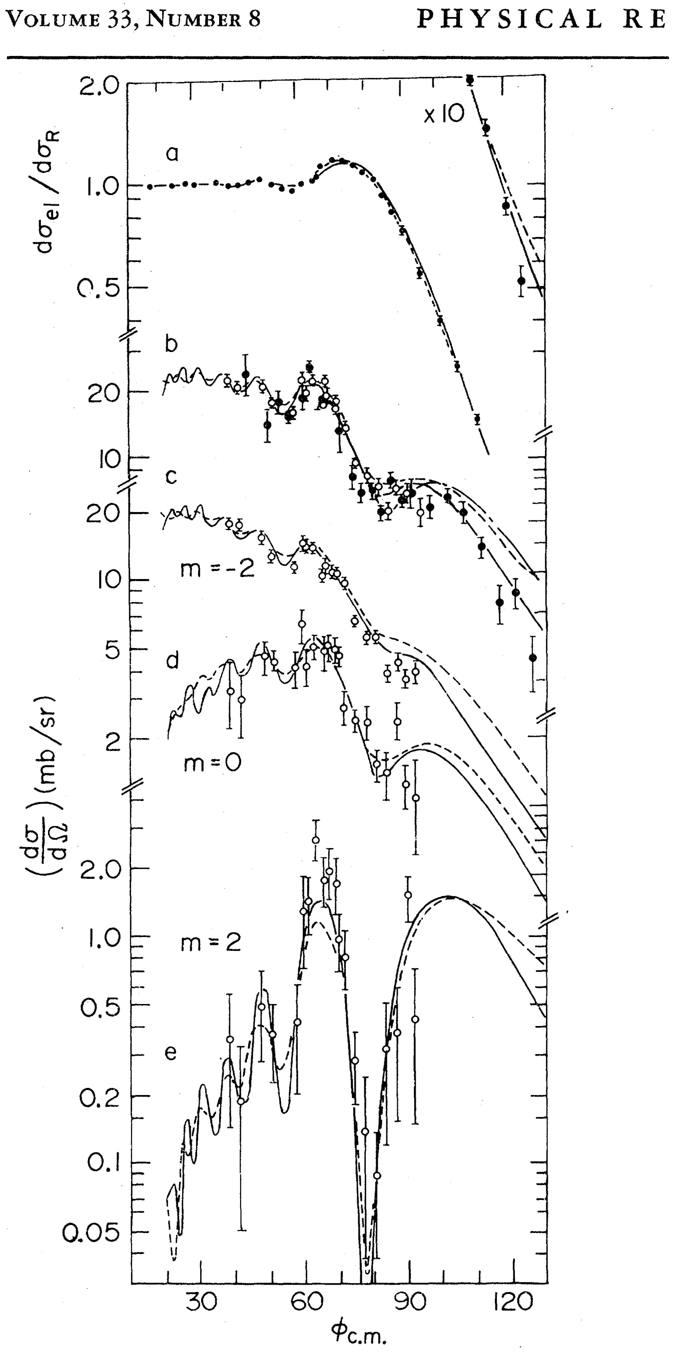
(Received 10 July 1974)

The polarization in the region of Coulomb-nuclear interference has been determined from the γ-ray correlation following excitation of the 856-keV 2^+ state in ^{56}Fe by 43-MeV ^{16}O ions. Elastic and inelastic scattering cross sections were also measured. Dramatic interference effects are observed in the transition amplitudes which can be reproduced by coupled-channel distorted-wave calculations.

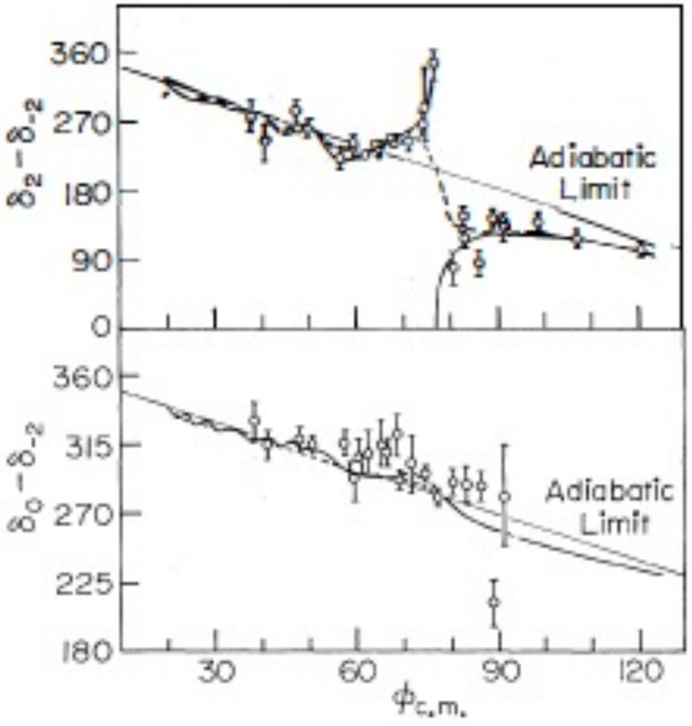
^{56}Fe(^{16}O,^{16}O'γ) with 43 MeV ^{16}O beam energy as function of cm scattering angle. Measure γ rays in coincidence with inelastically scattered ^{16}O ion exciting the ^{56}Fe 2+ state at 856 keV. See strong Coulomb-nuclear interference. Experiment performed at Univ. of Rochester MP Tandem Van de Graaff accelerator. Scattered ^{56} Fe ion detected from 15^{o} to 110^{o} by 2 position-sensitive Si detectors in focal plane of Enge split-pole spectrograph. Scattered ^{16}O ions detected in 4 surface-barrier Si detectors. γ-rays detected in coincidence array of six 3" x 3" NaI (Tl) detectors in upper hemisphere.

Solid lines show distorted wave coupled-channel calculations using optical potential obtained from fit to elastic scattering. Dashed lines show DWBA predictions.

(a) Elastic scattering/Rutherford scattering
(b) Inelastic scattering cross section to ^{56}Fe 2+ state
(c) –- (e) *M*-substate populations of the 2+ state



Relative phases of the transition amplitudes to the 2+ state as a function of the c.m. scattering angle



BNL Tandem Van de Graaff

VOLUME 38, NUMBER 7 PHYSICAL REVIEW LETTERS 14 FEBRUARY 1977

Fragment Spin Orientation Following Deep-Inelastic Scattering*

K. Van Bibber, R. Ledoux,† S. G. Steadman, F. Videbæk,‡ and G. Young
Laboratory for Nuclear Science, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139

and

C. Flaum
Brookhaven National Laboratory, Upton, New York 11973
(Received 3 December 1976)

K. Van Bibber's thesis expt.

Yields of discrete γ transitions in coincidence with deep-inelastic fragments identified in a particle telescope have been measured as a function of Q value and Z from the scattering of ^{16}O with ^{27}Al at 100 MeV. The anisotropies in the γ-particle angular correlations indicate a high degree of spin alignment in the fragments. This, as well as the deduced value of the internal angular momentum, is consistent with sticking of the fragments prior to scission.

[4] T. M. Cormier, A. J. Lazzarini, M. A. Neuhausen, A. Sperduto, K. Van Bibber, F. Videbæk, G. Young, E. B. Blum, L. Herreid, and W. Thoms, Phys. Rev. C 13, 682 (1976).

Flemming with
Joel Karp at
BNL Tandem VdG
control room

Jan. 1976

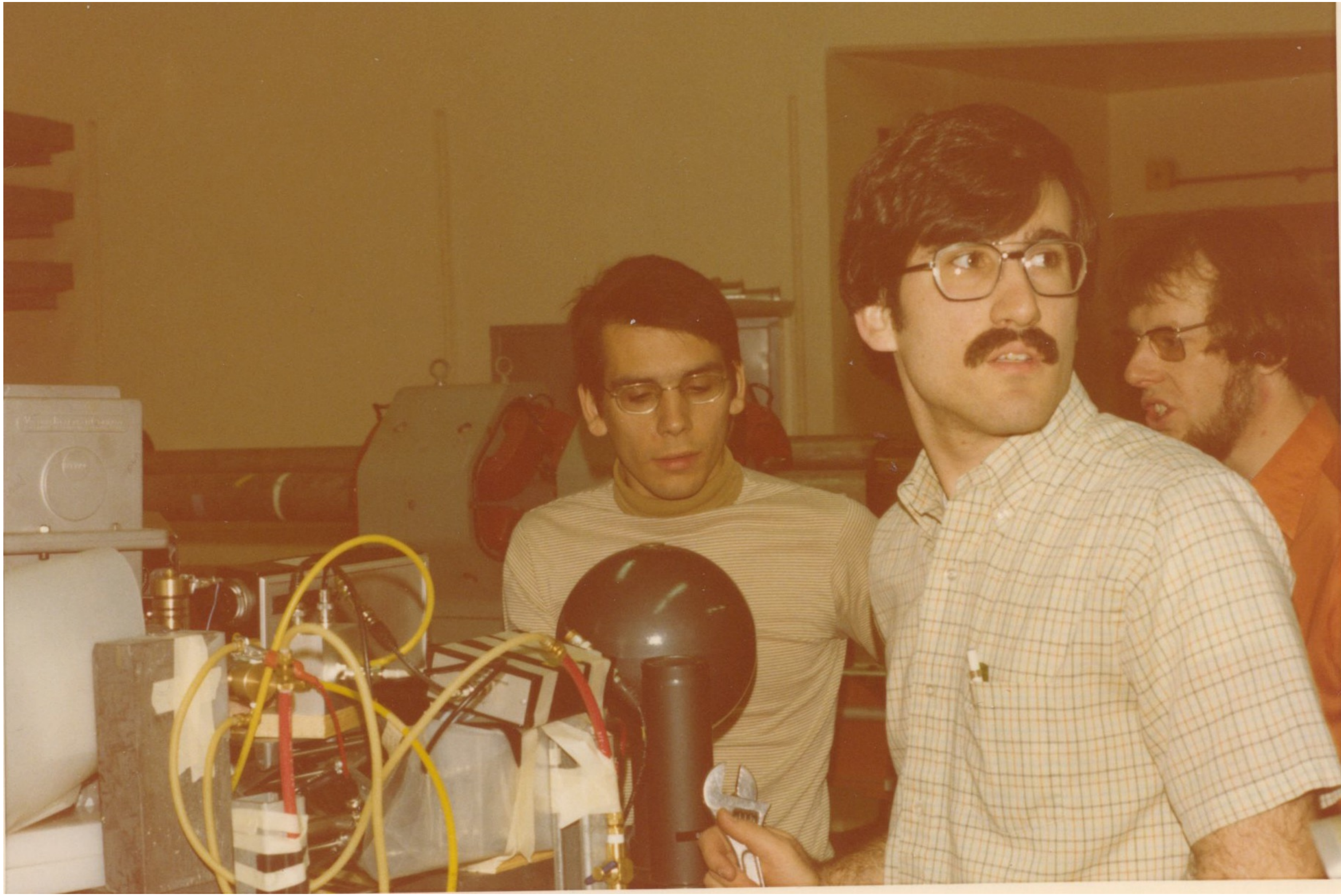
Joel is now Prof.
of Radiology
at Univ. of Penn.

Picture courtesy of
F. Videbaek

Glenn Young,
Karl Van Bibber,
and SGS at BNL
Tandem VdG.
Jan. 1976

Karl is now Prof. at UC Bk Dept. of Nucl. Eng. & Exec. Assoc. Dean of Engineering

Picture courtesy of
F. Videbaek



Glenn Young and SGS
Setup at BNL Tandem VdG for Karl's thesis exp.

Jan. 1976

Glenn Division Director at ORNL, most recently at Jefferson Lab, now retired.

Picture courtesy of
F. Videbaek

BNL Tandem Van de Graaff 220 Citations

PHYSICAL REVIEW C VOLUME 15, NUMBER 3 MARCH 1977

Elastic scattering, transfer reactions, and fission induced by ^{16}O ions on ^{181}Ta and ^{208}Pb†

F. Videbæk,* R. B. Goldstein, L. Grodzins, and S. G. Steadman
Laboratory for Nuclear Science, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139

T. A. Belote
University of Massachusetts, Boston, Massachusetts 02116

J. D. Garrett*
Brookhaven National Laboratory, Upton, New York 11973
(Received 7 July 1976)

Total cross sections for the quasielastic and fission channels in reactions of ^{16}O on ^{181}Ta and ^{208}Pb were measured as a function of the incident energy near the Coulomb barrier. For ^{208}Pb, the fission and quasielastic components account for essentially all of the total reaction cross sections as deduced from the elastic scattering. However, for ^{181}Ta, the fission and quasielastic components account for only about 25% of the total cross section as deduced from elastic scattering. The fission fragment angular distributions for ^{208}Pb are analyzed with a simple statistical approach yielding an effective moment of inertia at the saddle point compatible with the liquid-drop-model prediction. Fission excitation functions for ^{181}Ta are described reasonably well by a statistical evaporation code.

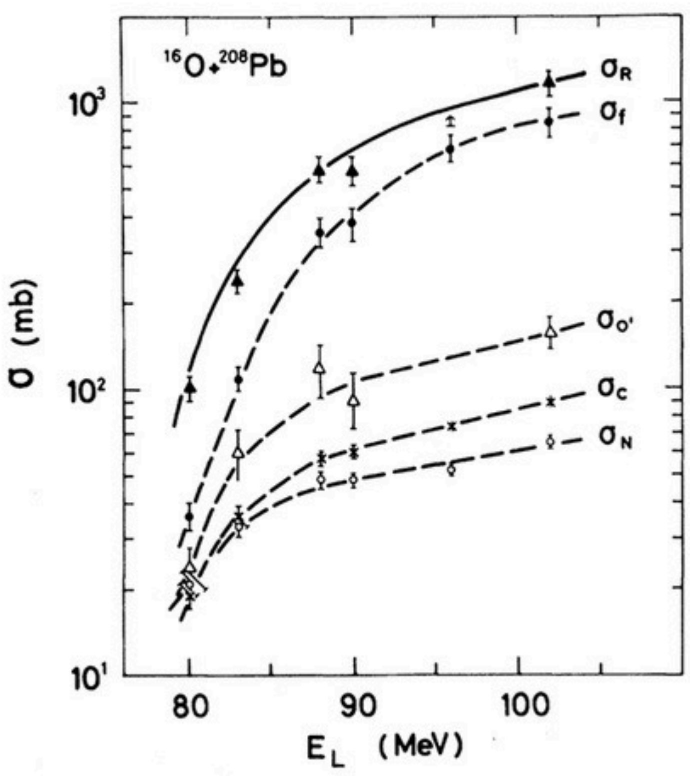
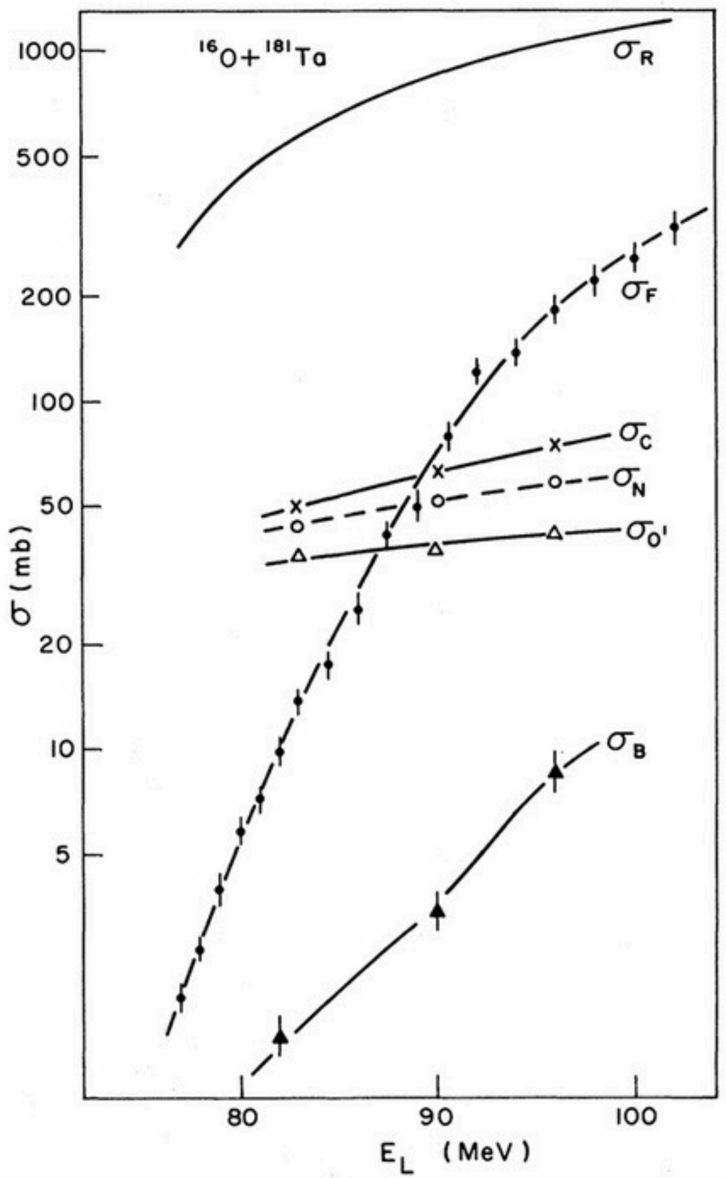


FIG. 17. Total cross sections measured for the various quasielastic processes and fission induced by ^{16}O on ^{208}Pb as a function of the incident energy. σ_f, σ_O, σ_N, and σ_C are designated by solid circles, open triangles, open circles, and crosses, respectively. The 82 and 94 MeV quasielastic cross sections are from Ref. 4. The experimental quasielastic and fission cross sections shown are summarized in Table I. The curves shown with the quasielastic and fission cross sections are only to guide the eye. Also shown is a comparison between the total cross sections measured in the quasielastic plus fission channels (solid triangles) and the reaction cross section, σ_R, predicted from the optical model—see Table II.



LBL Bevalac 49 citations

PHYSICAL REVIEW C VOLUME 46, NUMBER 4 OCTOBER 1992

Intermediate mass fragment emission in Fe+Au collisions

T. C. Sangster, H. C. Britt, D. J. Fields, L. F. Hansen, R. G. Lanier, M. N. Namboodiri, B. A. Remington, and M. L. Webb*
Lawrence Livermore National Laboratory, Livermore, California 94550

M. Begemann-Blaich,[†] T. Blaich,[‡] M. M. Fowler, and J. B. Wilhelmy
Los Alamos National Laboratory, Los Alamos, New Mexico 87545

Y. D. Chan, A. Dacal,[§] A. Harmon,** J. Pouliot,[††] and R. G. Stokstad
Lawrence Berkeley Laboratory, Berkeley, California 94720

S. Kaufman and F. Videbaek[‡‡]
Argonne National Laboratory, Argonne, Illinois 60439

Z. Fraenkel
Weizmann Institute of Science, 76100 Rehovot, Israel

G. Peilert, H. Stöcker, and W. Greiner
Institut fur Theoretische Physik der Universität, Frankfurt, Germany

A. Botvina and I. N. Mishustin
Institute for Nuclear Research, Moscow 117312, Russia
(Received 14 October 1991)

Experimental results are presented on the charge, velocity, and angular distributions of intermediate mass fragments (IMFs) for the reaction Fe+Au at bombarding energies of 50 and 100 MeV/nucleon. Results are compared to the quantum molecular dynamics (QMD) model and a modified QMD which includes a Pauli potential and follows the subsequent statistical decay of excited reaction products. The more complete model gives a good representation of the data and suggests that the major source of IMFs at large angles is due to multifragmentation of the target residue.

BNL AGS

272 citations

VOLUME 64, NUMBER 8 PHYSICAL REVIEW LETTERS 19 FEBRUARY 1990

Kaon and Pion Production in Central Si + Au Collisions at 14.6*A* GeV/*c*

T. Abbott,[4] Y. Akiba,[7] D. Alburger,[2] D. Beavis,[2] R. R. Betts,[1] L. Birstein,[2] M. A. Bloomer,[10] P. D. Bond,[2] C. Chasman,[2] Y. Y. Chu,[2] B. A. Cole,[10] J. B. Costales,[10] H. J. Crawford,[3] J. B. Cumming,[2] R. Debbe,[2] E. Duek,[2] J. Engelage,[3,9] S. Y. Fung,[4] L. Grodzins,[10] S. Gushue,[2] H. Hamagaki,[7] O. Hansen,[2] S. Hayashi,[7] S. Homma,[7] H. Z. Huang,[10] Y. Ikeda,[8],[a] S. Katcoff,[2] S. Kaufman,[1] K. Kimura,[8] K. Kitamura,[6],[b] K. Kurita,[5] R. J. Ledoux,[10] M. J. Levine,[2] Y. Miake,[2,11] R. J. Morse,[10] S. Nagamiya,[5] J. Olness,[2] C. G. Parsons,[10] L. P. Remsberg,[2] M. Sarabura,[10],[c] A. Shor,[2],[d] P. Stankus,[5] S. G. Steadman,[10] G. S. F. Stephans,[10] T. Sugitate,[6] M. J. Tannenbaum,[2] M. Torikoshi,[7],[e] J. H. van Dijk,[2] F. Videbaek,[1] M. Vient,[4],[f] P. Vincent,[2],[g] E. Vulgaris,[10],[h] V. Vutsadakis,[10] W. A. Watson, III,[2],[i] H. E. Wegner,[2] D. S. Woodruff,[10] Y. D. Wu,[5] and W. A. Zajc[5]

(E-802 Collaboration, Brookhaven National Laboratory)

[1] *Physics Division, Argonne National Laboratory, Argonne, Illinois 60439-4843*
[2] *Brookhaven National Laboratory, Upton, New York, 11973*
[3] *Space Sciences Laboratory, University of California, Berkeley, California 94720*
[4] *University of California, Riverside, California 92507*
[5] *Columbia University, New York, New York 10027 and Nevis Laboratory, Irvington, New York 10533*
[6] *Hiroshima University, Hiroshima 730, Japan*
[7] *Institute for Nuclear Study, University of Tokyo, Tokyo 188, Japan*
[8] *Kyushu University, Fukuoka 812, Japan*
[9] *Lawrence Livermore National Laboratory, Livermore, California 94550*
[10] *Laboratory for Nuclear Science, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139*
[11] *Department of Physics, University of Tokyo, Tokyo 113, Japan*

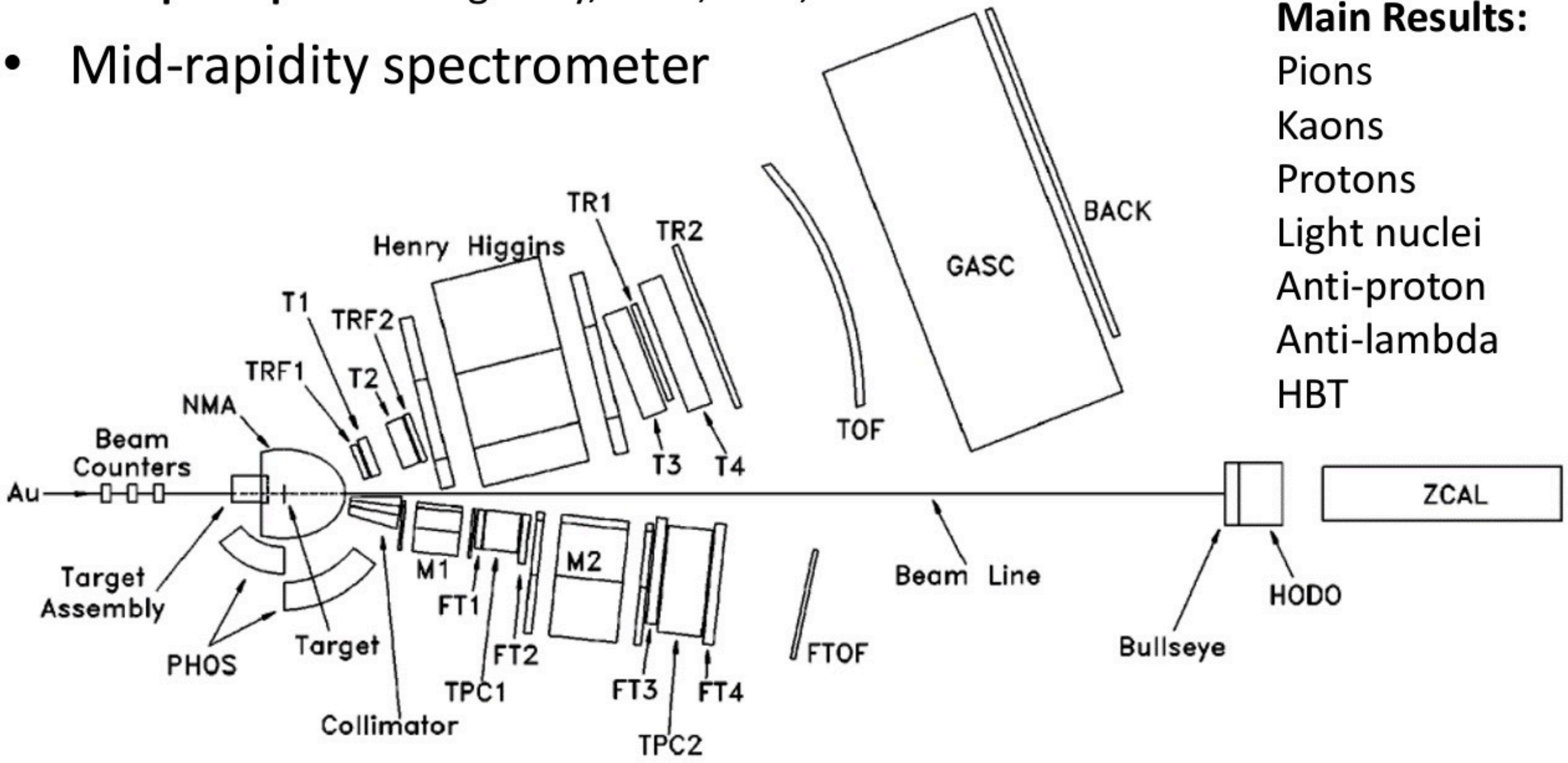
(Received 20 October 1989)

Semi-inclusive spectra of $\pi^{\pm}$, $K^{\pm}$, and p have been measured near midrapidity for central collisions of 14.6*A*-GeV/*c* ^{28}Si with ^{197}Au nuclei. The invariant cross sections are all well fitted by exponential distributions in transverse mass, within the measured ranges. The π and K cross sections can also be fitted by Boltzmann distributions. From integrated yields, at midrapidity, the kaon/pion yield ratios are $(19.2 \pm 3)\%$ for K^+/π^+ and $(3.6 \pm 0.8)\%$ for K^-/π^-; the π^+/π^- ratio is 1.00 ± 0.04.

E802/E859/E866/E917 Experiment

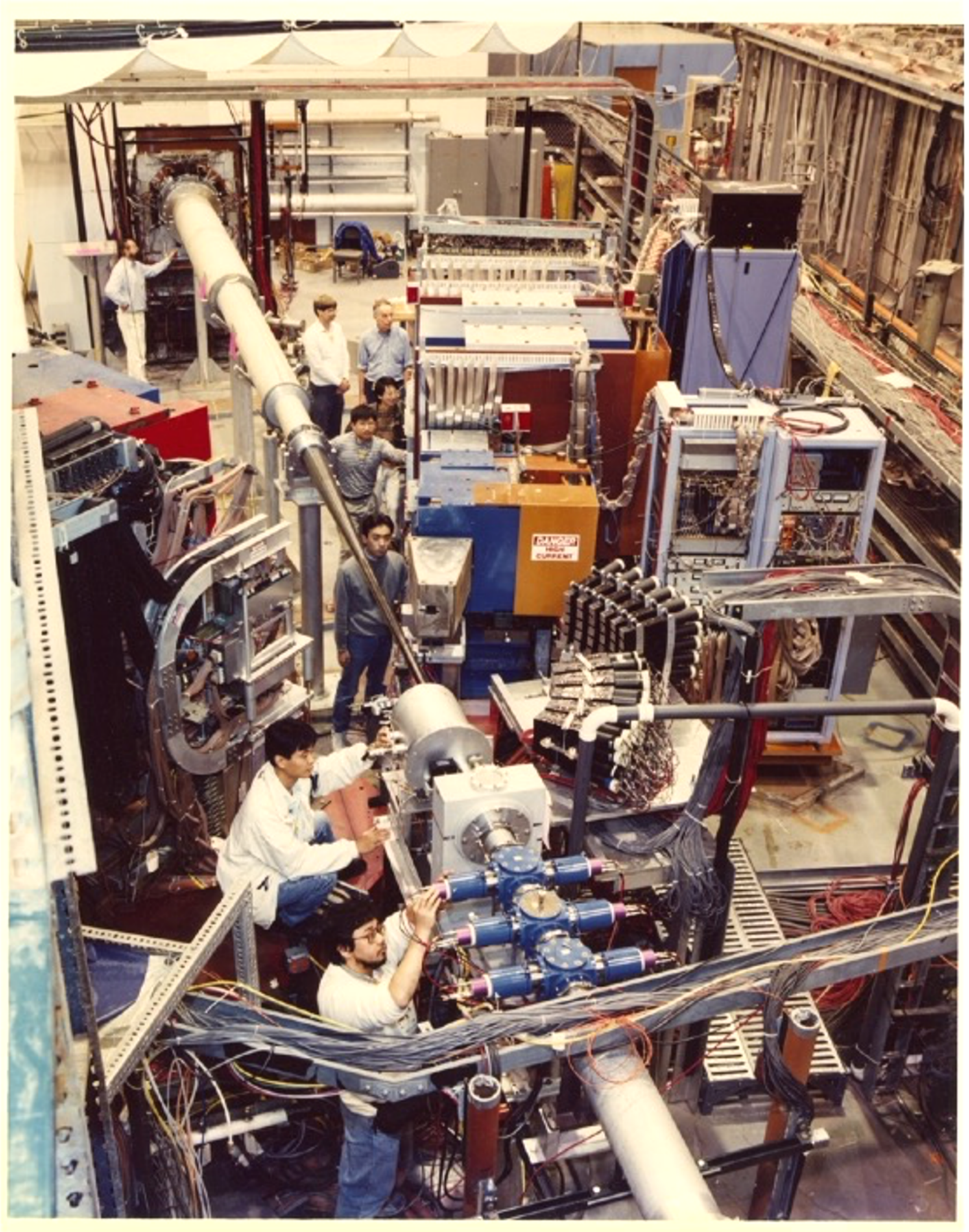
E802 – **Spokesperson:** Chellis Chasman, Shoji Nagamiya
E859 -- **Spokesperson:** Ledoux, Robert J.; Remsberg, Louis P.; Zajc, William A.
E866 -- **Spokesperson**: Chasman, Chellis; Hamagaki, Hideki; Steadman, Steve G.
E917 -- **Spokesperson:** Mignerey, Alice; Seto, R.K.

- Mid-rapidity spectrometer



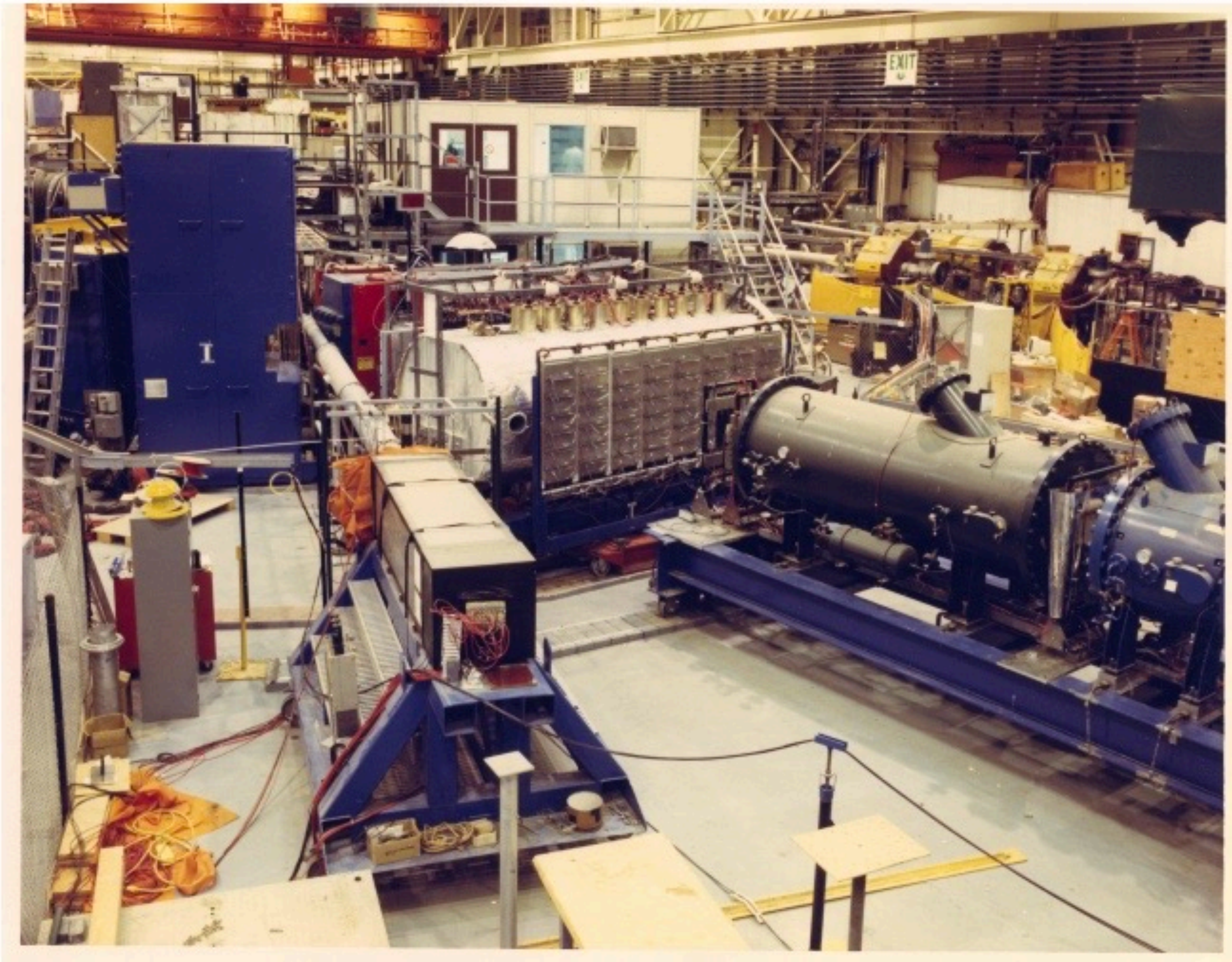
Main Results:
Pions
Kaons
Protons
Light nuclei
Anti-proton
Anti-lambda
HBT

Thanks to
Dan Cebra



AGS E802/E859/E866/E917 spectrometer

Pictures courtesy of F. Videbaek



In summary, we have measured the first momentum distributions for identified charged particles produced in high-energy nucleus-nucleus collisions. We find that the invariant cross sections for the produced particles within a given rapidity interval for central collisions can be described as having an exponential or Boltzmann dependence in transverse mass. The integrated pion distributions have a rather broad dependence in rapidity, but are peaked about a rapidity intermediate between the participant $y_{\text{c.m.}}^{\text{geom}}$ and $y_{\text{c.m.}}^{NN}$. The observed ratio of K^+/π^+ is considerably enhanced compared with ratios observed in similar kinematic regions in p-p collisions.

$$dN/dy \propto (x^{-2}+x^{-1}+0.5)\exp(-x)\,, \qquad (1)$$

with $x=(m_0/T)\cosh(y-y_0)$, where m_0 is the rest mass of the emitted particle and T is the temperature of the source with rapidity y_0. A satisfactory fit with Eq. (1) for the pion data in Fig. 3 is possible for $y_0=1.46$ and any $T>125$ MeV. The solid curve in Fig. 3 is a fit to dN/dy for the pion data with $T=125$ MeV, consistent[15] with the measured values of T_B shown in Fig. 2.

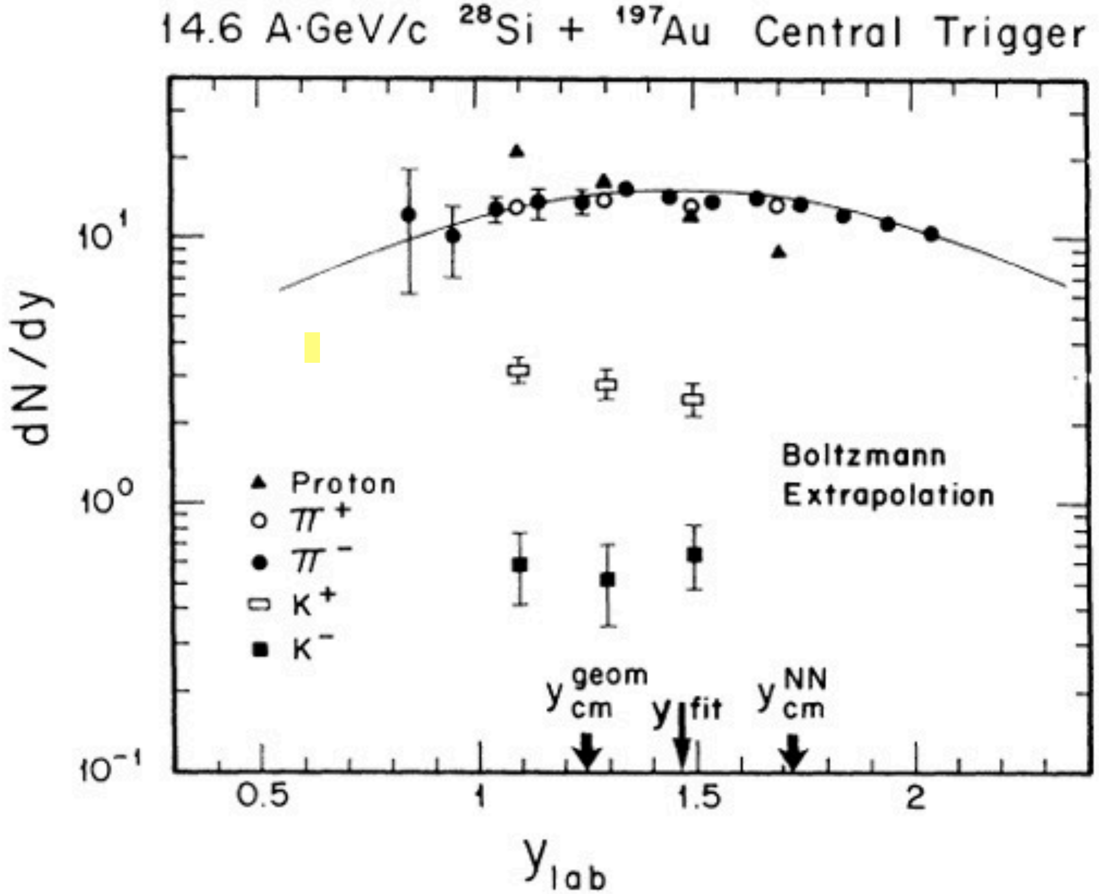


FIG. 3. Rapidity distributions dN/dy per trigger. The errors shown are relative errors only; there is an overall uncertainty of $\pm 10\%$ due to the absolute normalization. The solid curve shows the fit with Eq. (1), for a source located at $y_{\text{fit}}=1.46$ and $T=125$ MeV.

E866

RAPID COMMUNICATIONS

PHYSICAL REVIEW C VOLUME 57, NUMBER 2 FEBRUARY 1998

Particle production at high baryon density in central Au+Au reactions at 11.6A GeV/c

L. Ahle,[8] Y. Akiba,[5] K. Ashktorab,[1] M. D. Baker,[8] D. Beavis,[1] H. C. Britt,[7] J. Chang,[3] C. Chasman,[1] Z. Chen,[1] C.-Y. Chi,[4] Y. Y. Chu,[1] V. Cianciolo,[7,8] B. A. Cole,[4] H. J. Crawford,[2] J. B. Cumming,[1] R. Debbe,[1] J. C. Dunlop,[8] W. Eldredge,[3] J. Engelage,[2] S.-Y. Fung,[3] J. J. Gaardhoje,[9] E. Garcia,[13] M. Gonin,[1] S. Gushue,[1] H. Hamagaki,[5] A. Hansen,[9] L. Hansen,[9] R. S. Hayano,[10] G. Heintzelman,[8] S. Homma,[5] E. Judd,[2] H. Kaneko,[6] J. Kang,[12] E.-J. Kim,[12] A. Kumagai,[11] K. Kurita,[11] J.-H. Lee,[1] M. J. Levine,[1] J. Luke,[7] Y. Miake,[11] A. Mignerey,[13] D. Morrison,[8] B. Moskowitz,[1] M. Moulson,[4] C. Muentz,[1] S. Nagamiya,[4] M. N. Namboodiri,[7] C. A. Ogilvie,[8] J. Olness,[1] S. Park,[8] L. P. Remsberg,[1] P. Rothschild,[8] H. Sako,[5] T. C. Sangster,[7] R. Seto,[3] J. Shea,[13] K. Shigaki,[10] R. Soltz,[7,8] S. G. Steadman,[8] G. S. F. Stephans,[8] T. Sung,[8] M. J. Tannenbaum,[1] J. H. Thomas,[7] S. Tonse,[7] S. Ueno-Hayashi,[11] F. Videbæk,[1] F. Wang,[4] Y. Wang,[4] Y. Wu,[4] H. Xiang,[3] G. H. Xu,[3] K. Yagi,[11] D. Zachary,[8] W. A. Zajc,[4] F. Zhu,[1] and Q. Zhu[3]

Semi-inclusive proton and pion distributions from central Au+Au reactions at 11.6A GeV/c have been measured. The proton rapidity distribution shows significantly increased stopping compared to lighter systems, providing strong evidence for the formation of a state of matter with baryon density substantially greater than normal nuclear matter. Unlike reactions at this energy induced by lighter heavy ions, at low m_t-m_0 the proton invariant spectra deviate from a single exponential shape and become flatter, while π^- spectra are found to rise faster than the π^+ spectra. [S0556-2813(98)50402-5]

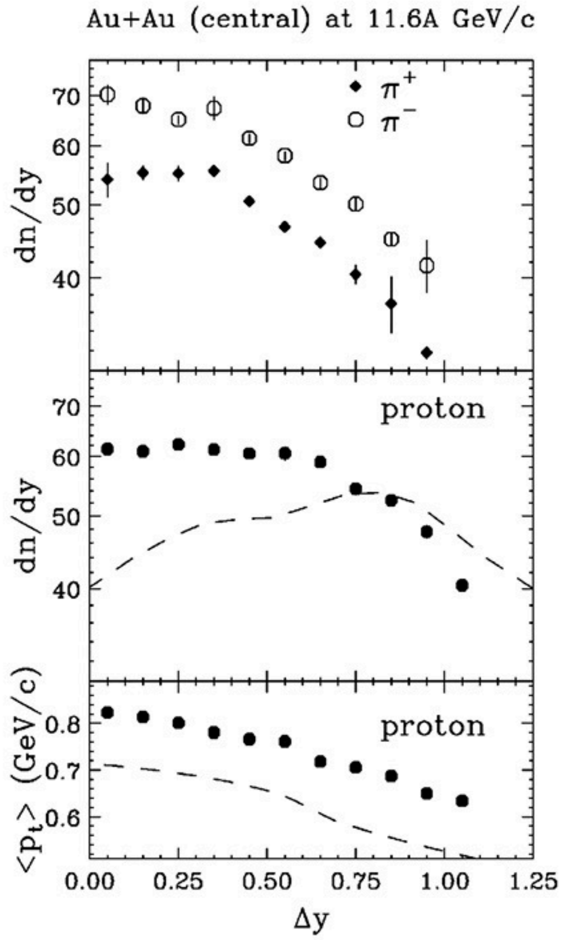


FIG. 3. Rapidity distribution of dn/dy (upper and middle pa els) and mean transverse momentum (lower panel) for pions a protons in central Au+Au reactions, where Δy is the absolute d ference of the measured rapidity of the spectra from the cent rapidity $y_{nn}=1.6$. The open circles in the figure are for π^-, and t solid squares for π^+. Protons are plotted with solid round poir For comparison, the dotted lines are for protons in central Si+ reactions at 14.6A GeV/c. (The dn/dy for Si+Al is scaled by factor of 197/27=7.3, the mass ratio of the two reactions.) The er bars are statistical only, either shown or smaller than the data poi

In summary, spectra are measured for the identified hadrons in central Au+Au reactions at 11.6A GeV/c. Unlike the Si+Al results, the rapidity distribution for protons has a maximum around midrapidity, indicating a large degree of stopping and hence strong evidence for high baryon density. Model calculations indicate that the density is increased by about a factor of about 8, and that the lifetime of the high density region is correspondingly longer. It is also found that the proton transverse mass spectra are considerably flatter in central rapidities and at low m_t than in other reactions using lighter ions. This nonexponential shape and large mean p_t for protons may be evidence for collective flow but further analysis of the deuteron and triton spectra is needed to confirm this conclusion. The much more pronounced rise in the π^- spectra than in π^+ at low m_t suggests the presence of a large final-state Coulomb interaction.

Even before RHIC Flemming had a distinguished career in heavy-ion physics.