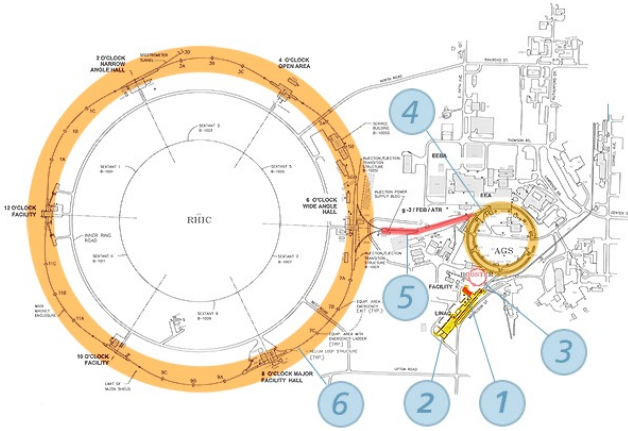
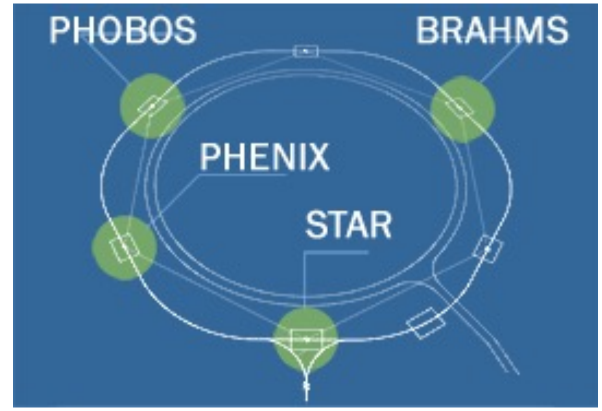




Flemming Videbaek - The Quiet Man

Flemming Videbaek's Retirement Celebration
February 11, 2022

W.A. Zajc
Columbia University

Thanks to: Wit Busza, Craig Sangster, Jens Jørgen Gaardhøje, Tim Hallman, Brant Johnson, Dave Morrison, Shoji Nagamiya, and Glenn Young

This work was supported by the United States Department of Energy Grant DOE-FG02-86ER-40281

Testimonials

Brant Johnson: Flemming is such a nice guy that it is hard to roast him.

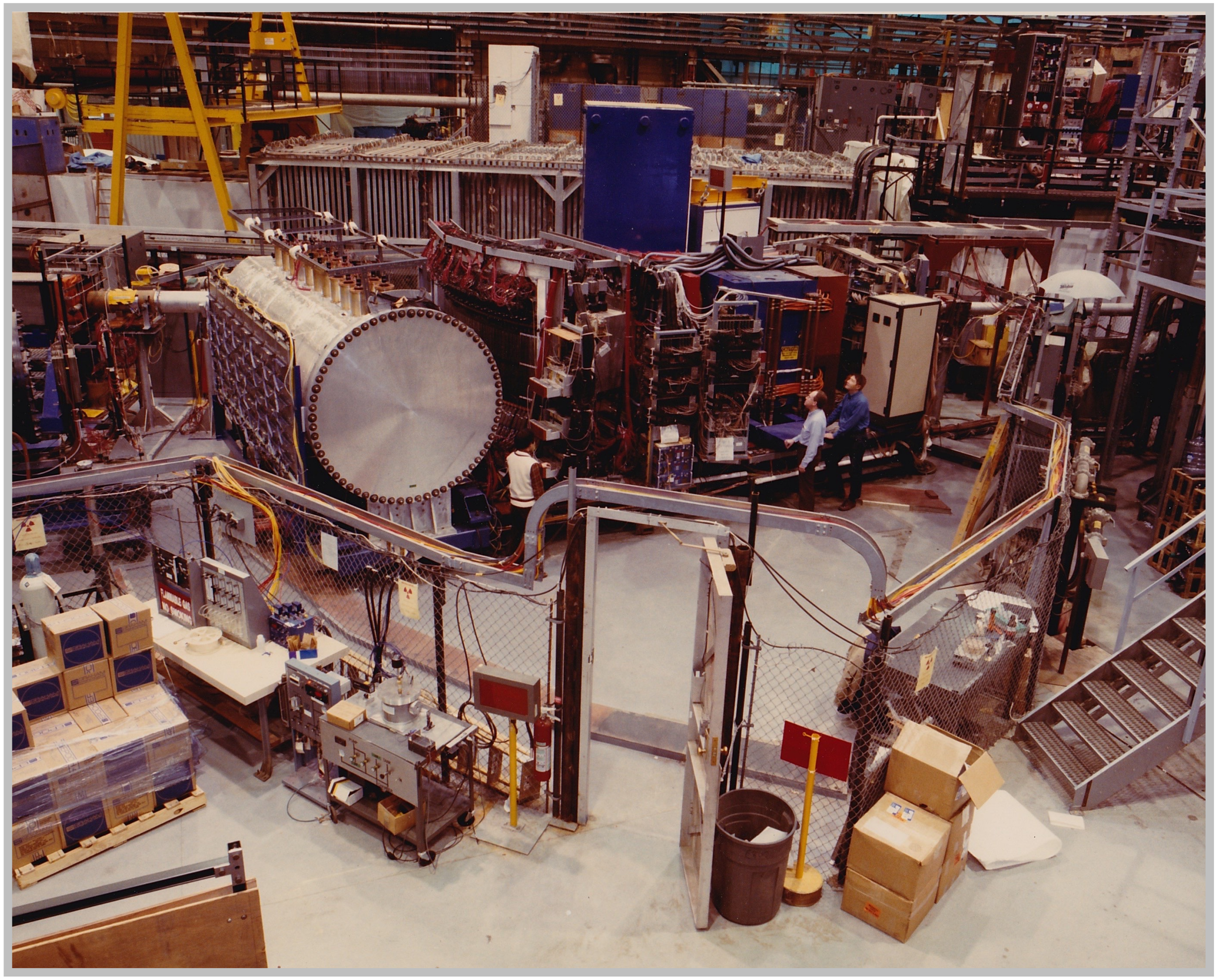
Shoji Nagamiya: I was surprised to hear that he is already retiring. Please give my best regards to him.

Ed O'Brien: Flemming is such a nice and even-keeled guy that I can not think of any entertaining anecdotes relating to Flemming.

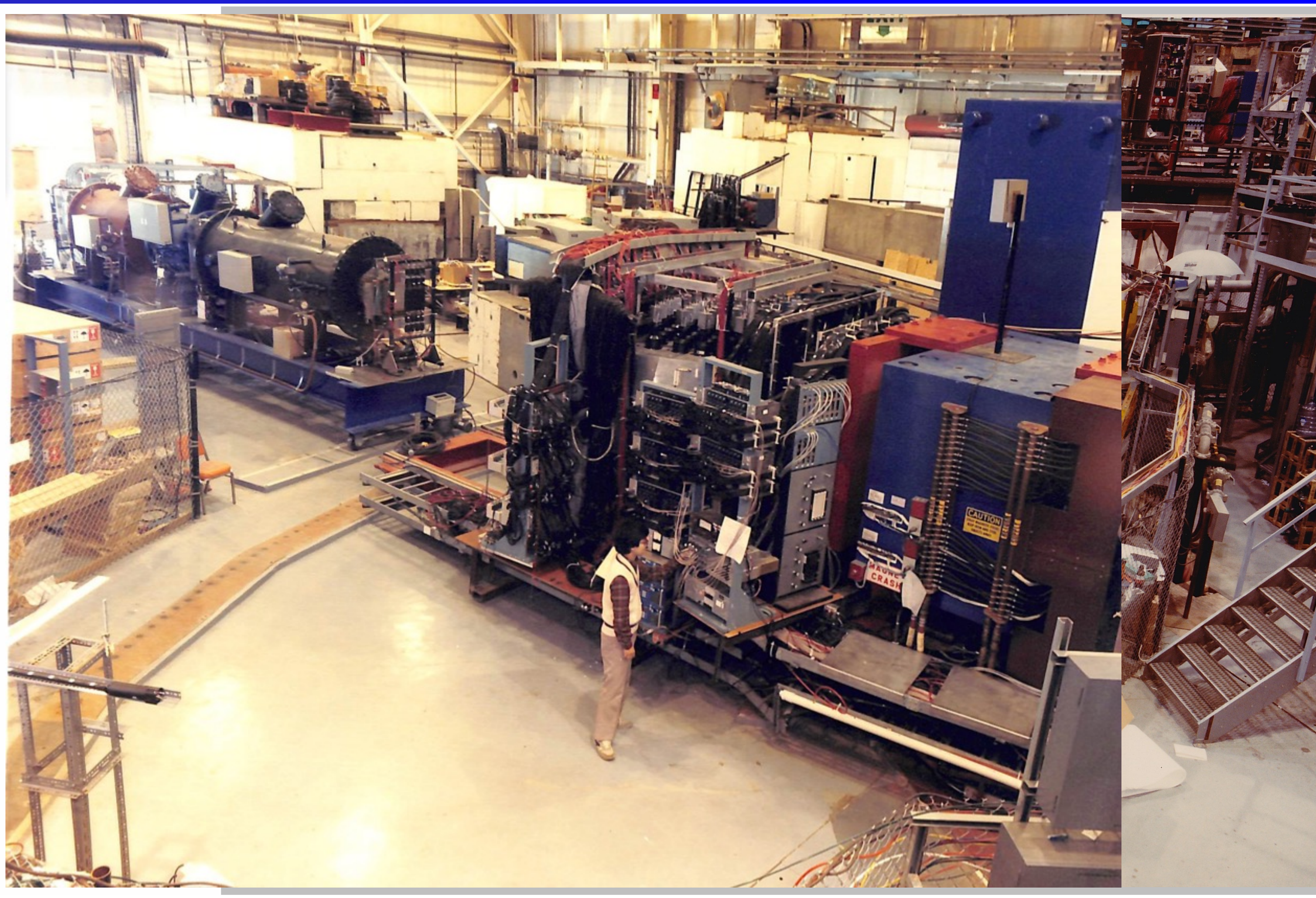
Craig Sangster: My memory of Flemming was irreverent humor and good nature. But no Flemming anecdotes come to mind. I hope he is healthy and happy and ready to do something fun.

Wit Busza: All that I can think of is that he is a quiet and nice guy!

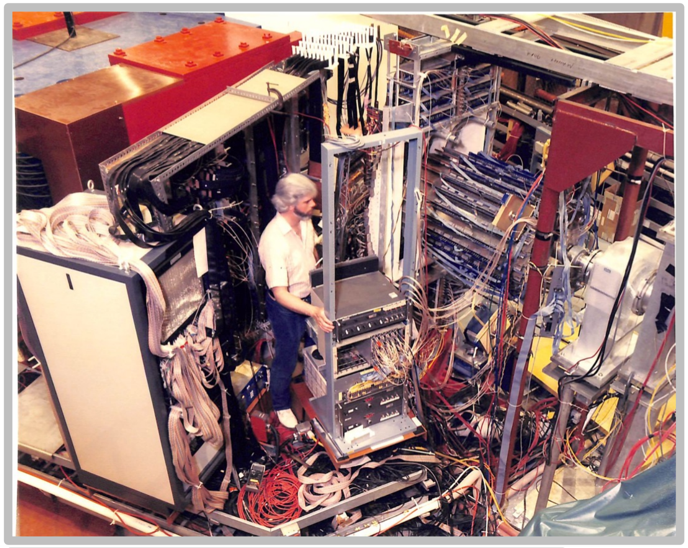
E802 Experiment

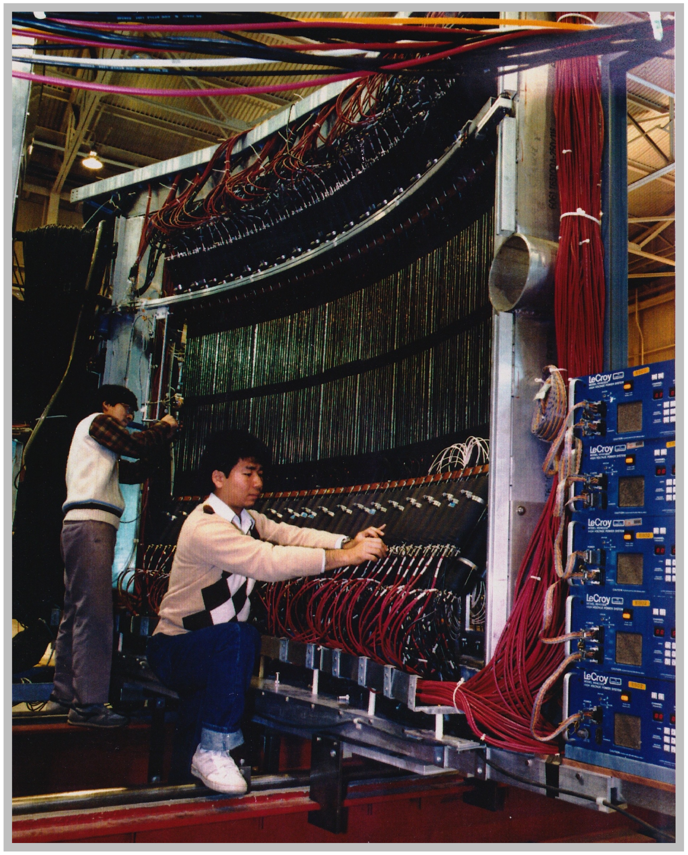


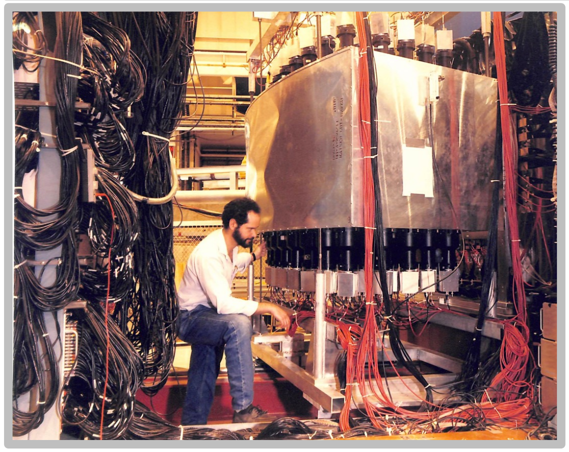
E802 Experiment



E802 Experiment







E802 Collaboration

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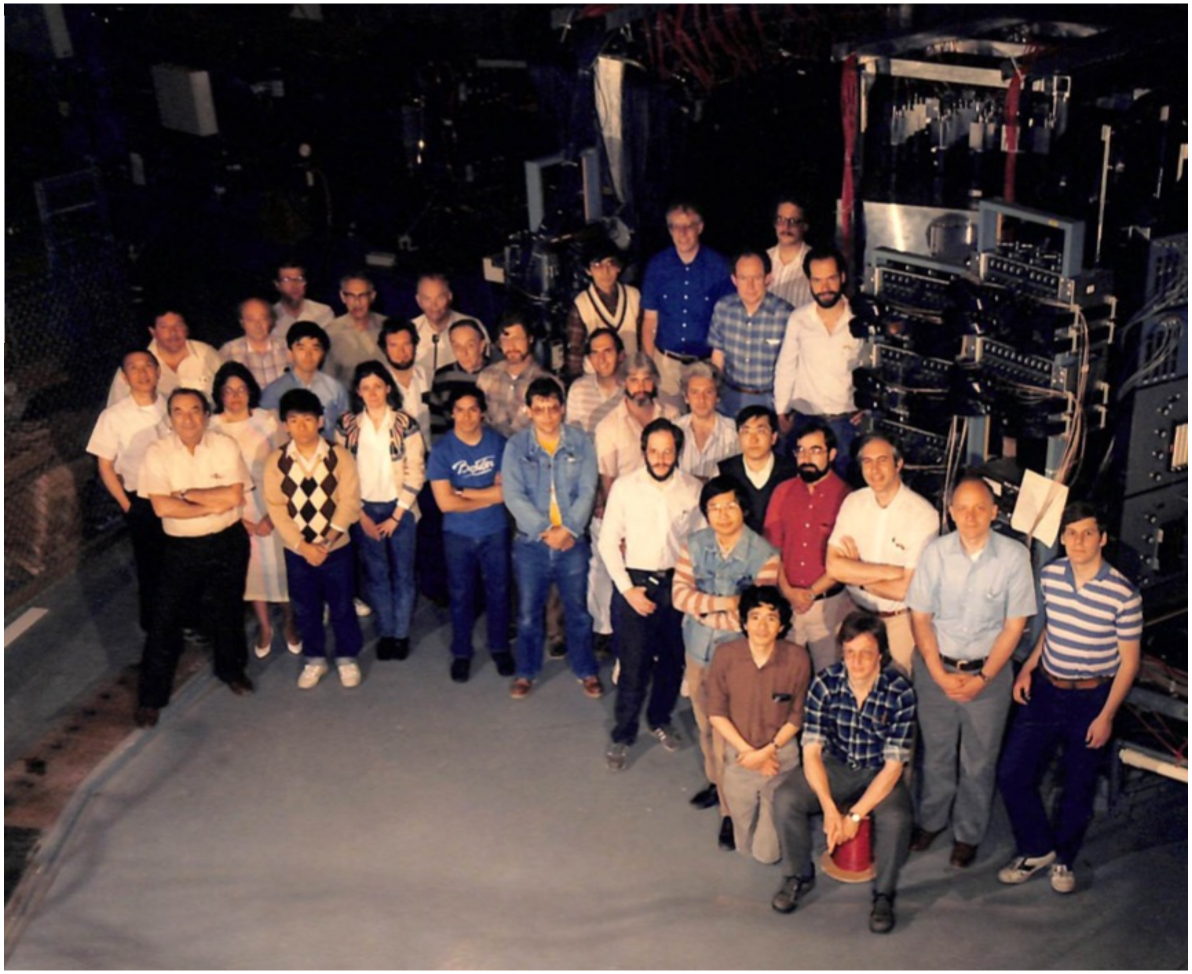

45 Joint Publications with Flemming

Our First Joint Publication - 1987

Volume 197, number 1,2 PHYSICS LETTERS B 22 October 1987

MEASUREMENT OF ENERGY EMISSION FROM O+A AND p+A COLLISIONS AT 14.5 GeV/*c* PER NUCLEON WITH A LEAD-GLASS ARRAY

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Received 20 July 1987

The first data from a ^{16}O beam of total energy 232 GeV at the BNL Tandem-AGS are reported. A lead-glass array covering the laboratory pseudo-rapidity interval $1.25<\eta<2.44$ recorded the energy emitted from ^{16}O interactions in Au, Cu, and Mylar and from proton interactions in Au. The shapes of the energy spectra imply that a nucleon loses most of its energy in the first few collisions. Consequently a simple description of the observed $^{16}O+Cu$ and $^{16}O+Au$ spectra as a properly weighted convolution of the observed p+Au spectrum is obtained. It is shown that ^{16}O nuclei at this energy can be substantially stopped by nuclei of the size of Cu. An estimate of the energy density for central collisions is given.

High energy nucleus–nucleus collisions open up the possibility of creating nuclear matter in conditions of high temperature and density. Under such conditions there are theoretical expectations that a new state of matter, the quark–gluon plasma (OGP) may be formed [1]. Models of the dynamical evolution of such systems indicate that the thermodyn-

[1] JSPS Fellowship for Japanese Junior Scientists.
[2] On leave of absence from Comision Nacional de Energia Atomica, Buenos Aires, Argentina.
[3] On leave of absence from University of Toko.
[4] Deceased.

Volume 197, number 1,2 PHYSICS LETTERS B 22 October 1987

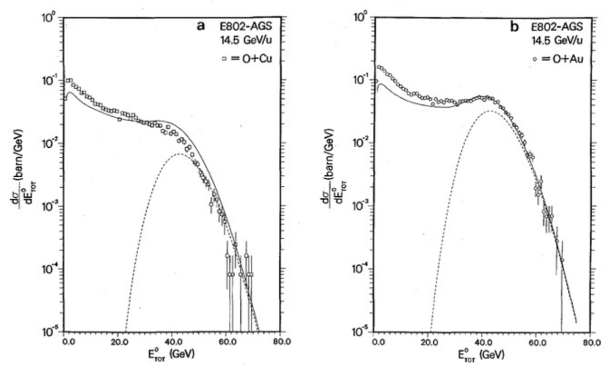

Fig. 3. Measured E^0_{TOT} spectra for ^{16}O interactions on Cu (a) and Au (b) together with the sum of 1- to 16-fold convolutions of the measured p+Au spectrum weighted according to the probability for 1, 2, ..., 16 of the projectile nucleons to interact in the target (solid line). The dashed line shows the contribution of the 16-fold convolution, the case in which all 16 projectile nucleons interact.

squared, $[R(Au)-R(^{16}O)]^2/[R(Cu)-R(^{16}O)]^2$, a factor of ≈ 5, which is close to the factor of ≈ 6 observed.

An estimate of the total transverse energy emitted for central collisions can be made from the data in fig. 1. A value of $E^0_{TOT}=50$ GeV, roughly 18 times the average for p+Au collisions, is taken to represent the energy observed in the PbGl for central $^{16}O+Cu$ or $^{16}O+Au$ collisions. In order to find the true energy from neutral-meson emission a correction must be made for the fraction of the signal arising from charged hadrons. this fraction is estimated [#3] to be 0.5, which results in a neutral energy emission of 25 GeV. The standard assumption is that the total energy is 3 times the neutral, which implies a total energy emission of 75 GeV into the pseudo-rapidity interval $-0.5<\eta<0.7$. If the transverse energy density in pseudo-rapidity is constant in this interval, the appropriate $\langle \sin\theta \rangle$ is 0.29, which gives a transverse energy of 22 GeV or $dE_t/d\eta=18$ GeV. The Bjorken formula [4,7], although it may not be appropriate in this domain, then gives an energy density of 0.7 GeV/fm^3 for a

[#3] A rigorous correction for the charged hadron component of the PbGl signal cannot be made with the information from the present experiment. An estimate based on systematics of p–p and p–A data, however, can be made. From ref. [19] it is estimated by averaging charged pion data that $dn/dy=0.5$ and $\langle p_T \rangle = 0.33$ GeV/c for π^0 production at 14.5 GeV/c in p–p collisions. The value of $\langle \sin\theta \rangle = 0.29$, then gives $\langle E_{TOT}(\pi^0)$, p–p$\rangle = 0.7$ GeV for the PbGl array. The ratio of dn/dn for p+Au to that for p+p can be estimated from the systematics of negative particle data at 200 GeV in ref. [13] by extrapolation from the p+Ar and p+Xe data. The ratio is estimated to be 2.0. This ratio is then applied to the 14.5 GeV p–p estimate, yielding $\langle E_{TOT}(\pi^0)$, p+Au$\rangle = 1.4$ GeV as compared to the observed value $\langle E^0_{TOT} \rangle = 2.73$ GeV. The hadronic correction is thus estimated as ≈ 0.5. The correction estimated above is consistent with the upper bound of $2\times 0.5/(\langle p_T \rangle/\langle \sin\theta \rangle + 2\times 0.5) = 0.5$ obtained from the PbGl response and the ratio $[n(\pi^+)+n(\pi^-)]/n(\pi^0)=2$.

Our Last Joint Publication - 2003

PHYSICAL REVIEW C **68**, 034908 (2003)

Further observations on midrapidity E_T distributions with aperture corrected scale

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In a previous publication [T. Abbott *et al.*, E802 Collaboration, Phys. Rev. C **63**, 064602 (2001); **64**, 029901(E) (2001)], measurements of the A dependence and pseudorapidity interval ($\delta\eta$) dependence of midrapidity E_T distributions in a half-azimuth ($\Delta\phi=\pi$) electromagnetic calorimeter were presented for p+Be, p+Au, O+Cu, Si+Au, and Au+Au collisions at the BNL-AGS. The validity of the "nuclear geometry" characterization versus $\delta\eta$ was illustrated by plots of the $E_T(\delta\eta)$ distribution in each $\delta\eta$ interval in units of the measured $\langle E_T(\delta\eta)\rangle_{p+\mathrm{Au}}$ in the same $\delta\eta$ interval for p+Au collisions. These plots, with aperture corrected scale in the physically meaningful units of number of average observed p+Au collisions, were nearly universal as a function of $\delta\eta$, confirming that the reaction dynamics for E_T production at midrapidity at AGS energies is governed by the number of projectile participants and can be well characterized by measurements in apertures as small as $\Delta\phi=\pi, \delta\eta=0.3$. A key ingredient in these analyses is the probability p_0 for no signal to be detected in a given aperture $\delta\eta$ for the fundamental p+Au collision. In fact the measured $\langle E_T(\delta\eta)\rangle_{p+\mathrm{Au}}$ is biased and the true $\langle E_T(\delta\eta)\rangle^{\mathrm{true}}_{p+\mathrm{Au}}$ for the detector aperture is the measured value times $1-p_0$. The issues and merits of measuring the $E_T(\delta\eta)$ distribution in units of $\langle E_T(\delta\eta)\rangle_{p+\mathrm{Au}}$ or $\langle E_T(\delta\eta)\rangle^{\mathrm{true}}_{p+\mathrm{Au}}$ in the same $\delta\eta$ interval are presented and discussed. This method has application at RHIC, where p-p data could be used as the reference distribution for two participants. The E_T distributions for $B+A$ collisions, with $E_T(\delta\eta)$ scale normalized by $\langle E_T(\delta\eta)\rangle^{\mathrm{true}}_{p\text{-}p}$ in the same aperture for p-p collisions, would then be given directly in the popular unit "per participant-pair" [K. Adcox *et al.*, PHENIX Collaboration, Phys. Rev. Lett. **86**, 3500 (2001); I. G. Bearden *et al.*, BRAHMS Collaboration, Phys. Lett. B**523**, 227 (2001); B. B. Back *et al.*, PHOBOS Collaboration, Phys. Rev. C **65**, 031901(R) (2002); C. Adler *et al.*, STAR Collaboration, Phys. Rev. Lett. **89**, 202301 (2002)].

DOI: 10.1103/PhysRevC.68.034908 PACS number(s): 25.75.−q, 12.38.Mh, 13.60.Le, 13.85.Hd

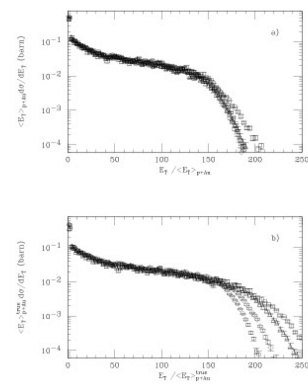


FIG. 2. (a) Measured distributions for Au+Au [1] at 14.6A GeV/c on the four $\delta\eta$ intervals, $\delta\eta=1.30$ (circles), 0.966 (diamonds), 0.624 (triangles), 0.378 (squares), with $E_T(\delta\eta)$ scales normalized by the measured $\langle E_T(\delta\eta)\rangle_{p+\mathrm{Au}}$ on the same interval. (b) Measured distributions for Au+Au on the four $\delta\eta$ intervals, with $E_T(\delta\eta)$ scales normalized by the true $\langle E_T(\delta\eta)\rangle^{\mathrm{true}}_{p+\mathrm{Au}}$ on the same interval.

ber of projectile participants because of bias in the measured spectrum. Perhaps this should have been obvious from Eqs. (3) and (10).

IV. THE MEASUREMENTS

The measured E_T distributions from Ref. [1] for Au+Au, corrected[1] to 14.6A GeV/c, are shown in Fig. 2(a) with the $E_T(\delta\eta)$ scale normalized by the measured $\langle E_T(\delta\eta)\rangle_{p+\mathrm{Au}}$ and in Fig. 2(b) with the $E_T(\delta\eta)$ scale normalized by $\langle E_T(\delta\eta)\rangle^{\mathrm{true}}_{p+\mathrm{Au}}$. By comparing Figs. 2(b) and 1(b), it is easy to see from the distributions of the data and WPNM in units of $\langle E_T(\delta\eta)\rangle^{\mathrm{true}}_{p+\mathrm{Au}}$ that the data largely follow the WPNM, but, as noted in Ref. [1], systematically vary from the WPNM predictions as a function of $\delta\eta$. The data in the $\delta\eta=0.966$ aperture are closest to the WPNM, while the larger $\delta\eta$ spectrum is below the WPNM and the smaller $\delta\eta$ spectra are increasingly above the WPNM. Nevertheless, the data in Fig. 2(b) all closely follow the w_n distribution to ~160 units and above the knee exhibit a larger fluctuation, the smaller the aperture, just like the model. On the other hand, comparison of Figs. 2(a) and 1(a), the distributions of the data and WPNM with the $E_T(\delta\eta)$ scale in units of the measured $\langle E_T(\delta\eta)\rangle_{p+\mathrm{Au}}$, reveals that the small systematic variations of the data from the WPNM produce data distributions which overlap entirely over the whole measured range for the largest three $\delta\eta$ intervals, with the smallest $\delta\eta$ interval deviating slightly only in the upper tail. This spectacular empirical scaling law was perhaps understated in Ref. [1] with the description that the upper percentiles of the data distributions showed "small-observed variation" as a function of $\delta\eta$, "significantly less than would be expected" in the WPNM. It is worth remarking that the empirical scaling illustrated in Fig. 2(a) would likely have been missed if we had followed in Ref. [1] the correct procedure for normalizing the $E_T(\delta\eta)$ scales outlined in the present work. It is also worth noting that empirical scaling behavior of E_T distributions in disagreement with the WNM was seen in α-α collisions at $\sqrt{s_{NN}}=31$ GeV at the CERN ISR [10].

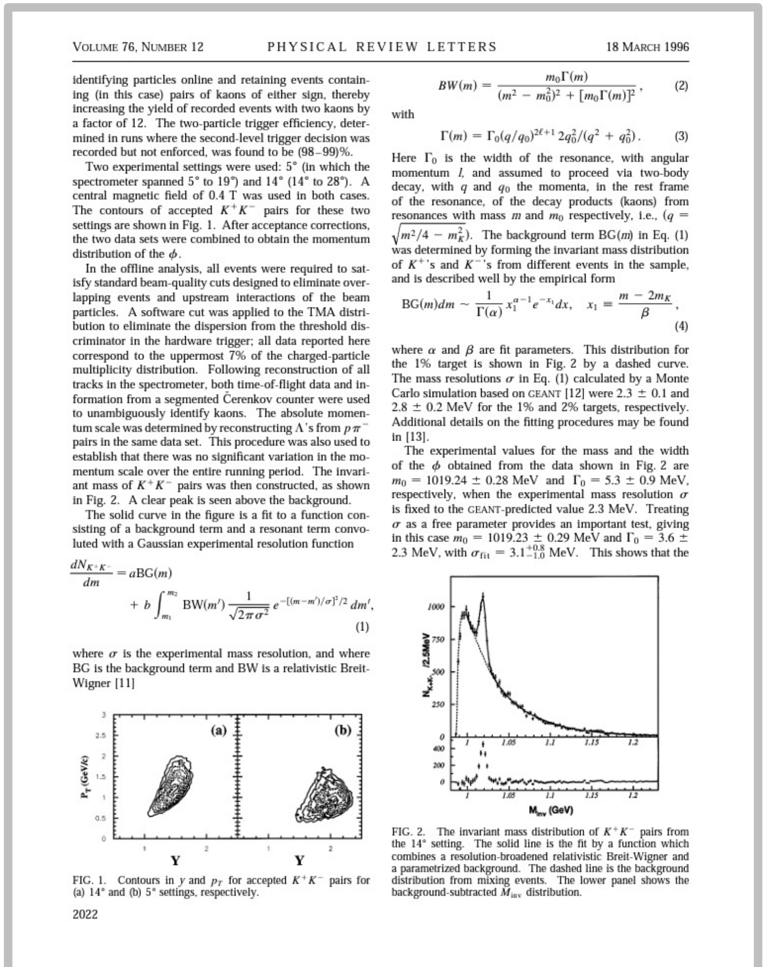
V. CONCLUSIONS

The procedure for obtaining E_T distributions with aperture corrected scale outlined in Ref. [1] is amended in the present work by using the true $\langle E_T\rangle^{\mathrm{true}}$ for the reference distribution in the aperture, rather than the observed $\langle E_T\rangle$, to normalize the E_T scale in the same aperture for $B+A$ collisions. The measured $\langle E_T\rangle$ is biased because only a fraction $1-p_0$ of the reference collisions produce a signal on the aperture, so that $\langle E_T\rangle^{\mathrm{true}}$ for the reference distribution is related to the measured $\langle E_T\rangle$ by $\langle E_T\rangle^{\mathrm{true}}=(1-p_0)\langle E_T\rangle$. As demonstrated in Figs. 1(b) and 2(b), normalizing the scale of the measured $E_T(\delta\eta)$ distribution for Au+Au collisions by $\langle E_T(\delta\eta)\rangle^{\mathrm{true}}$ in the same aperture for the reference distribution really does give results which can be read directly in physically meaningful units (projectile participants for the present discussion) up to the top 5 percentile without recourse to external centrality definition or correction of the E_T spectra for limited aperture and calorimeter response. For the data at AGS energies, the reference distribution used was p+Au, which at midrapidity was shown [1] to represent the E_T distribution of a projectile participant. At higher energies, such as at RHIC, p-p data could be used as the reference distribution for two participants. The E_T distributions for $B+A$ collisions with E_T scale normalized by $\langle E_T\rangle^{\mathrm{true}}$ in the same aperture for p-p collisions would then be given directly[2] in the popular unit, "per participant-pair." Of course, one should also keep alert for possible additional unexpected empirical scaling laws for E_T distributions.

[1] T. Abbott *et al.*, E802 Collaboration, Phys. Rev. C **63**, 064602 (2001); **64**, 029901(E) (2001).
[2] K. Adcox *et al.*, PHENIX Collaboration, Phys. Rev. Lett. **86**, 3500 (2001); I.G. Bearden *et al.*, BRAHMS Collaboration, Phys. Lett. B **523**, 227 (2001); B.B. Back *et al.*, PHOBOS Collaboration, Phys. Rev. C **65**, 031901(R) (2002); C. Adler

E802 → E859

- Augmented E802 spectrometer with trigger chambers and a Level II trigger system to perform online particle identification



VOLUME 76, NUMBER 12 PHYSICAL REVIEW LETTERS 18 MARCH 1996

identifying particles online and retaining events containing (in this case) pairs of kaons of either sign, thereby increasing the yield of recorded events with two kaons by a factor of 12. The two-particle trigger efficiency, determined in runs where the second-level trigger decision was recorded but not enforced, was found to be (98–99)%.

Two experimental settings were used: 5° (in which the spectrometer spanned 5° to 19°) and 14° (14° to 28°). A central magnetic field of 0.4 T was used in both cases. The contours of accepted K^+K^- pairs for these two settings are shown in Fig. 1. After acceptance corrections, the two data sets were combined to obtain the momentum distribution of the ϕ.

In the offline analysis, all events were required to satisfy standard beam-quality cuts designed to eliminate overlapping events and upstream interactions of the beam particles. A software cut was applied to the TMA distribution to eliminate the dispersion from the threshold discriminator in the hardware trigger; all data reported here correspond to the uppermost 7% of the charged-particle multiplicity distribution. Following reconstruction of all tracks in the spectrometer, both time-of-flight data and information from a segmented Čerenkov counter were used to unambiguously identify kaons. The absolute momentum scale was determined by reconstructing Λ's from $p\pi^-$ pairs in the same data set. This procedure was also used to establish that there was no significant variation in the momentum scale over the entire running period. The invariant mass of K^+K^- pairs was then constructed, as shown in Fig. 2. A clear peak is seen above the background.

The solid curve in the figure is a fit to a function consisting of a background term and a resonant term convoluted with a Gaussian experimental resolution function

$$\frac{dN_{K^+K^-}}{dm} = a\mathrm{BG}(m) + b\int_{m_1}^{m_2} \mathrm{BW}(m')\frac{1}{\sqrt{2\pi\sigma^2}}e^{-[(m-m')/\sigma]^2/2}\,dm', \quad (1)$$

where σ is the experimental mass resolution, and where BG is the background term and BW is a relativistic Breit-Wigner [11]

$$BW(m) = \frac{m_0\Gamma(m)}{(m^2-m_0^2)^2+[m_0\Gamma(m)]^2}, \quad (2)$$

with

$$\Gamma(m) = \Gamma_0(q/q_0)^{2\ell+1}2q_0^2/(q^2+q_0^2). \quad (3)$$

Here Γ_0 is the width of the resonance, with angular momentum l, and assumed to proceed via two-body decay, with q and q_0 the momenta, in the rest frame of the resonance, of the decay products (kaons) from resonances with mass m and m_0 respectively, i.e., ($q = \sqrt{m^2/4 - m_K^2}$). The background term BG(m) in Eq. (1) was determined by forming the invariant mass distribution of K^+'s and K^-'s from different events in the sample, and is described well by the empirical form

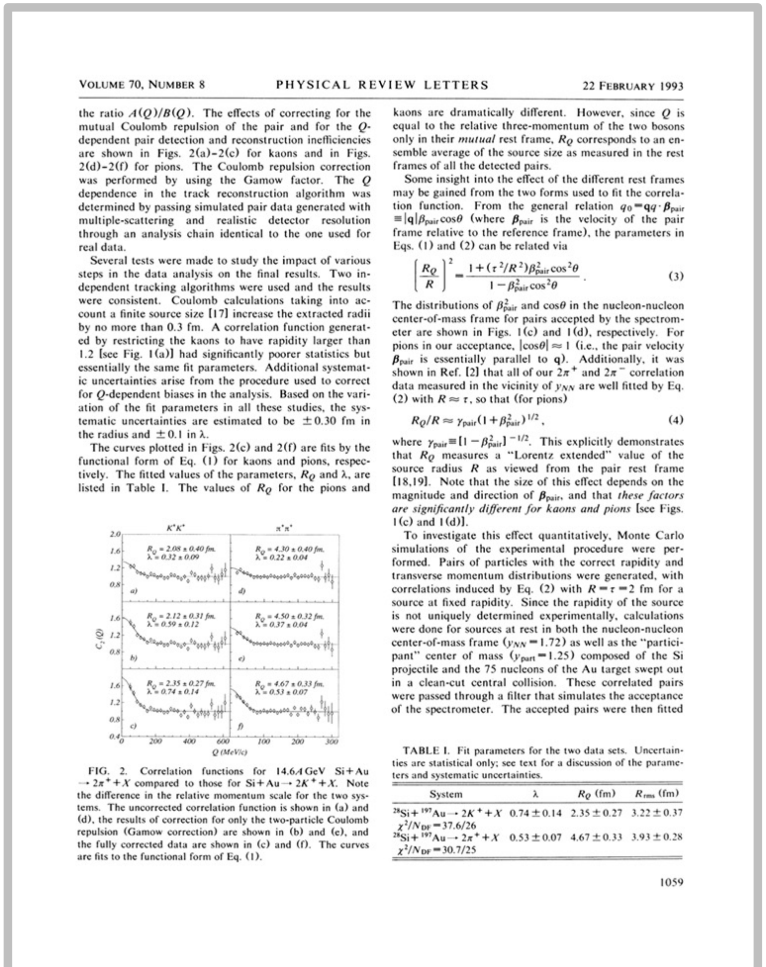
$$\mathrm{BG}(m)dm \sim \frac{1}{\Gamma(\alpha)}x_1^{\alpha-1}e^{-x_1}dx, \quad x_1 = \frac{m-2m_K}{\beta}, \quad (4)$$

where α and β are fit parameters. This distribution for the 1% target is shown in Fig. 2 by a dashed curve. The mass resolutions σ in Eq. (1) calculated by a Monte Carlo simulation based on GEANT [12] were 2.3 ± 0.1 and 2.8 ± 0.2 MeV for the 1% and 2% targets, respectively. Additional details on the fitting procedures may be found in [13].

The experimental values for the mass and the width of the ϕ obtained from the data shown in Fig. 2 are $m_0 = 1019.24 \pm 0.28$ MeV and $\Gamma_0 = 5.3 \pm 0.9$ MeV, respectively, when the experimental mass resolution σ is fixed to the GEANT-predicted value 2.3 MeV. Treating σ as a free parameter provides an important test, giving in this case $m_0 = 1019.23 \pm 0.29$ MeV and $\Gamma_0 = 3.6 \pm 2.3$ MeV, with $\sigma_{\mathrm{fit}} = 3.1^{+0.8}_{-1.0}$ MeV. This shows that the

FIG. 1. Contours in y and p_T for accepted K^+K^- pairs for (a) 14° and (b) 5° settings, respectively.

FIG. 2. The invariant mass distribution of K^+K^- pairs from the 14° setting. The solid line is the fit by a function which combines a resolution-broadened relativistic Breit-Wigner and a parametrized background. The dashed line is the background distribution from mixing events. The lower panel shows the background-subtracted M_{inv} distribution.



VOLUME 70, NUMBER 8 PHYSICAL REVIEW LETTERS 22 FEBRUARY 1993

the ratio $A(Q)/B(Q)$. The effects of correcting for the mutual Coulomb repulsion of the pair and for the Q-dependent pair detection and reconstruction inefficiencies are shown in Figs. 2(a)–2(c) for kaons and in Figs. 2(d)–2(f) for pions. The Coulomb repulsion correction was performed by using the Gamow factor. The Q dependence in the track reconstruction algorithm was determined by passing simulated pair data generated with multiple-scattering and realistic detector resolution through an analysis chain identical to the one used for real data.

Several tests were made to study the impact of various steps in the data analysis on the final results. Two independent tracking algorithms were used and the results were consistent. Coulomb calculations taking into account a finite source size [17] increase the extracted radii by no more than 0.3 fm. A correlation function generated by restricting the kaons to have rapidity larger than 1.2 [see Fig. 1(a)] had significantly poorer statistics but essentially the same fit parameters. Additional systematic uncertainties arise from the procedure used to correct for Q-dependent biases in the analysis. Based on the variation of the fit parameters in all these studies, the systematic uncertainties are estimated to be ± 0.30 fm in the radius and ± 0.1 in λ.

The curves plotted in Figs. 2(c) and 2(f) are fits by the functional form of Eq. (1) for kaons and pions, respectively. The fitted values of the parameters, R_Q and λ, are listed in Table I. The values of R_Q for the pions and kaons are dramatically different. However, since Q is equal to the relative three-momentum of the two bosons only in their *mutual* rest frame, R_Q corresponds to an ensemble average of the source size as measured in the rest frames of all the detected pairs.

Some insight into the effect of the different rest frames may be gained from the two forms used to fit the correlation function. From the general relation $q_0 = \mathbf{q}q\cdot\boldsymbol{\beta}_{\mathrm{pair}} \equiv |\mathbf{q}|\beta_{\mathrm{pair}}\cos\theta$ (where $\boldsymbol{\beta}_{\mathrm{pair}}$ is the velocity of the pair frame relative to the reference frame), the parameters in Eqs. (1) and (2) can be related via

$$\left(\frac{R_Q}{R}\right)^2 = \frac{1+(\tau^2/R^2)\beta_{\mathrm{pair}}^2\cos^2\theta}{1-\beta_{\mathrm{pair}}^2\cos^2\theta}. \quad (3)$$

The distributions of β_{pair}^2 and $\cos\theta$ in the nucleon-nucleon center-of-mass frame for pairs accepted by the spectrometer are shown in Figs. 1(c) and 1(d), respectively. For pions in our acceptance, $|\cos\theta| \approx 1$ (i.e., the pair velocity $\boldsymbol{\beta}_{\mathrm{pair}}$ is essentially parallel to $\mathbf{q}$). Additionally, it was shown in Ref. [2] that all of our $2\pi^+$ and $2\pi^-$ correlation data measured in the vicinity of y_{NN} are well fitted by Eq. (2) with $R \approx \tau$, so that (for pions)

$$R_Q/R \approx \gamma_{\mathrm{pair}}(1+\beta_{\mathrm{pair}}^2)^{1/2}, \quad (4)$$

where $\gamma_{\mathrm{pair}} \equiv [1-\beta_{\mathrm{pair}}^2]^{-1/2}$. This explicitly demonstrates that R_Q measures a "Lorentz extended" value of the source radius R as viewed from the pair rest frame [18,19]. Note that the size of this effect depends on the magnitude and direction of $\boldsymbol{\beta}_{\mathrm{pair}}$, and that *these factors are significantly different for kaons and pions* [see Figs. 1(c) and 1(d)].

To investigate this effect quantitatively, Monte Carlo simulations of the experimental procedure were performed. Pairs of particles with the correct rapidity and transverse momentum distributions were generated, with correlations induced by Eq. (2) with $R = \tau = 2$ fm for a source at fixed rapidity. Since the rapidity of the source is not uniquely determined experimentally, calculations were done for sources at rest in both the nucleon-nucleon center-of-mass frame ($y_{NN} = 1.72$) as well as the "participant" center of mass ($y_{\mathrm{part}} = 1.25$) composed of the Si projectile and the 75 nucleons of the Au target swept out in a clean-cut central collision. These correlated pairs were passed through a filter that simulates the acceptance of the spectrometer. The accepted pairs were then fitted

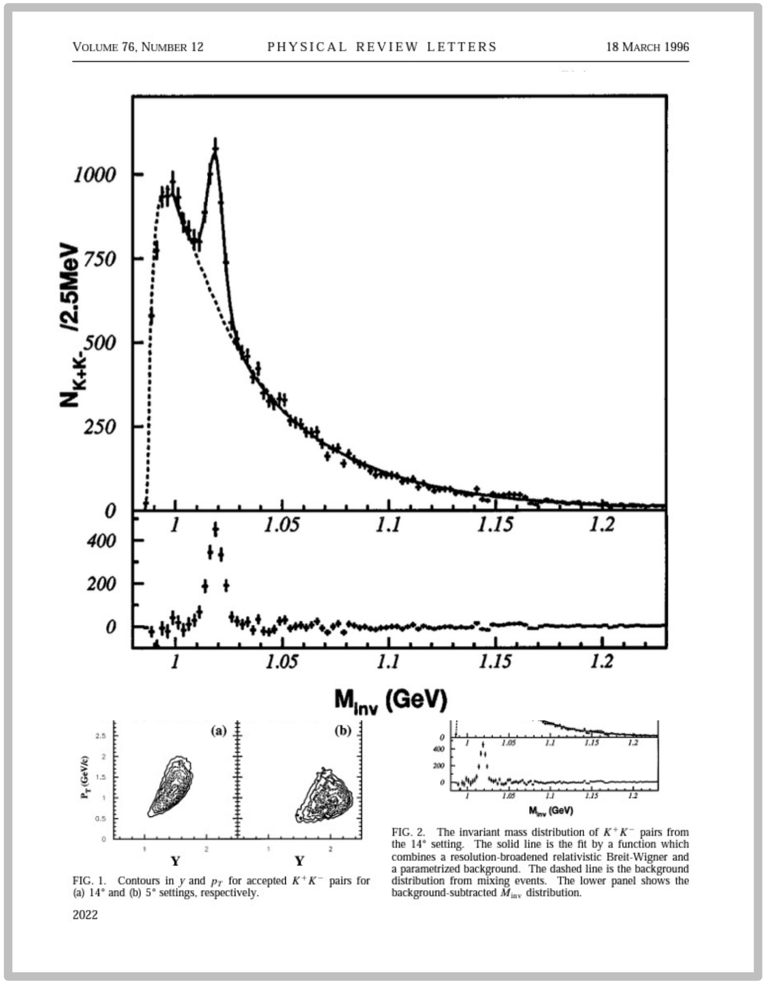
FIG. 2. Correlation functions for 14.6A GeV Si+Au → $2\pi^+ + X$ compared to those for Si+Au → $2K^+ + X$. Note the difference in the relative momentum scale for the two systems. The uncorrected correlation function is shown in (a) and (d), the results of correction for only the two-particle Coulomb repulsion (Gamow correction) are shown in (b) and (e), and the fully corrected data are shown in (c) and (f). The curves are fits to the functional form of Eq. (1).

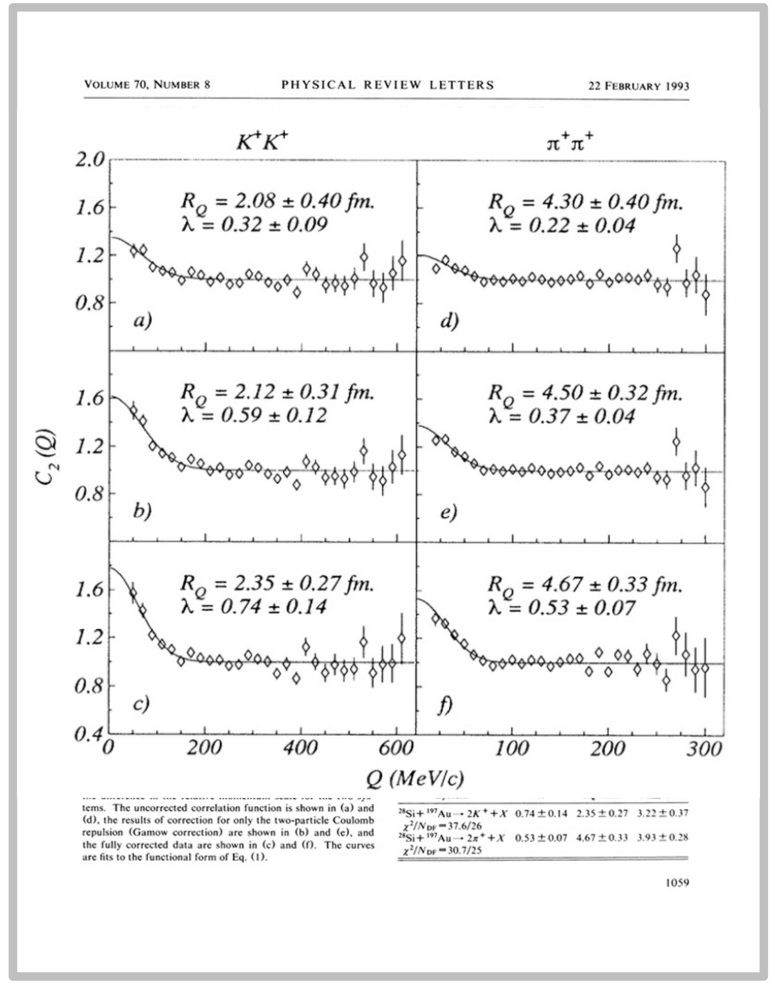
TABLE I. Fit parameters for the two data sets. Uncertainties are statistical only; see text for a discussion of the parameters and systematic uncertainties.

System	λ	R_Q (fm)	R_{rms} (fm)
^{28}Si+^{197}Au → $2K^+ + X$ $\chi^2/N_{\mathrm{DF}} = 37.6/26$	0.74 ± 0.14	2.35 ± 0.27	3.22 ± 0.37
^{28}Si+^{197}Au → $2\pi^+ + X$ $\chi^2/N_{\mathrm{DF}} = 30.7/25$	0.53 ± 0.07	4.67 ± 0.33	3.93 ± 0.28

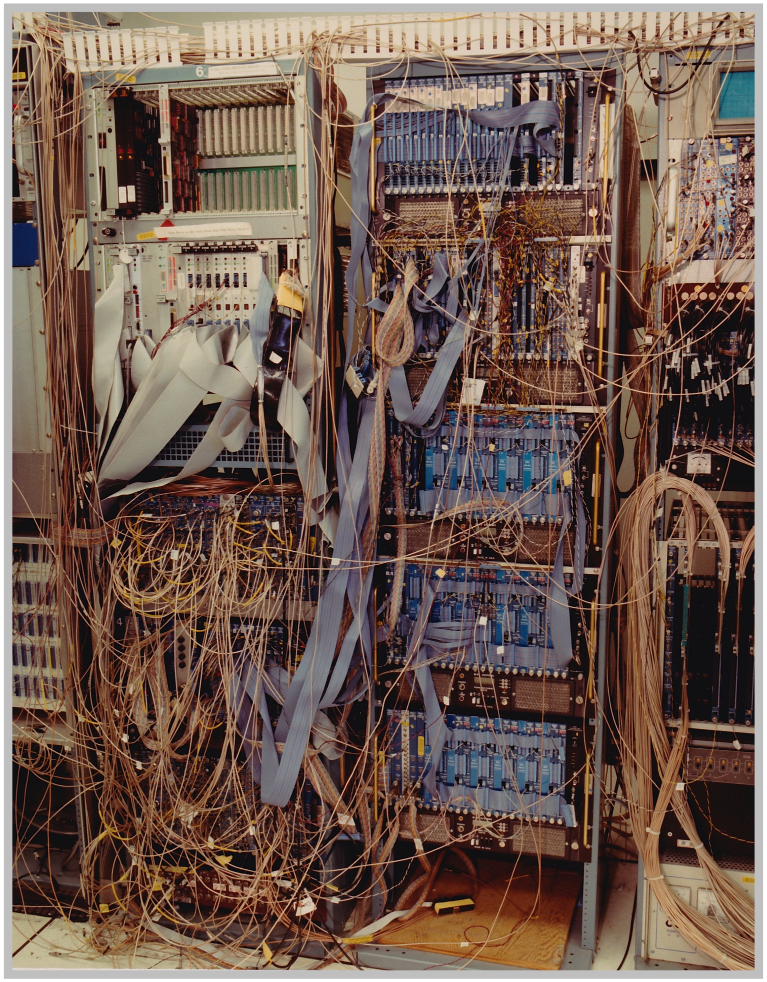
E802 → E859

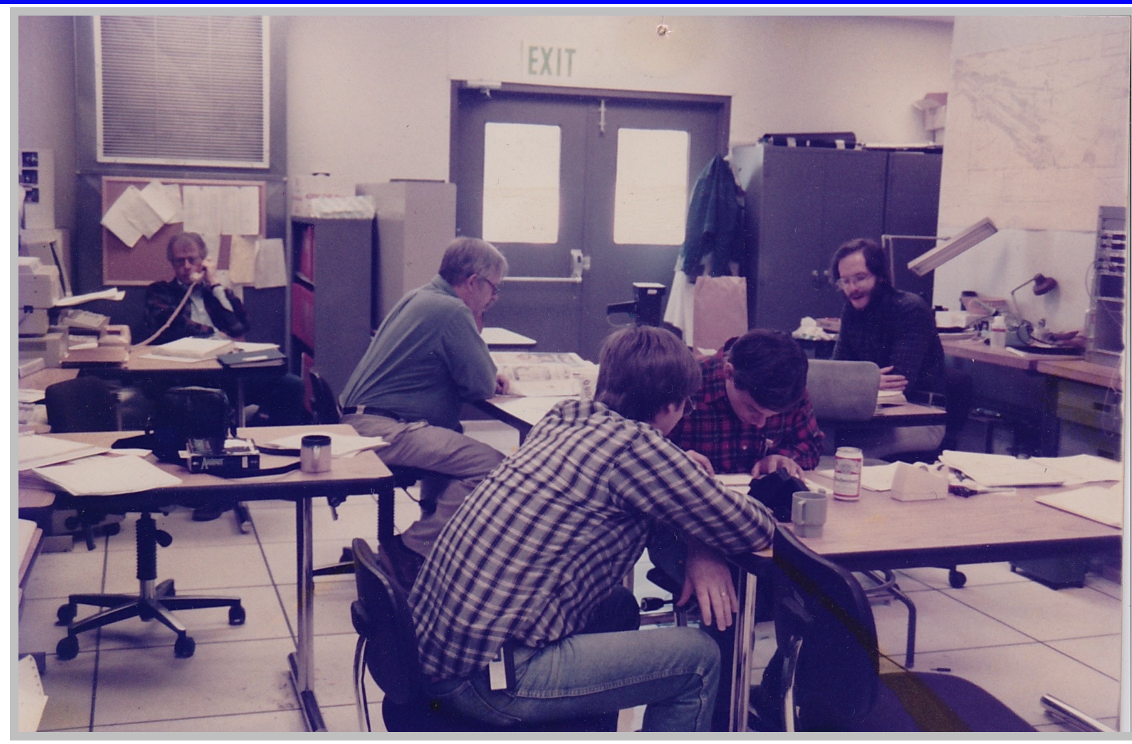
- Augmented E802 spectrometer with trigger chambers and a Level II trigger system to perform online particle identification





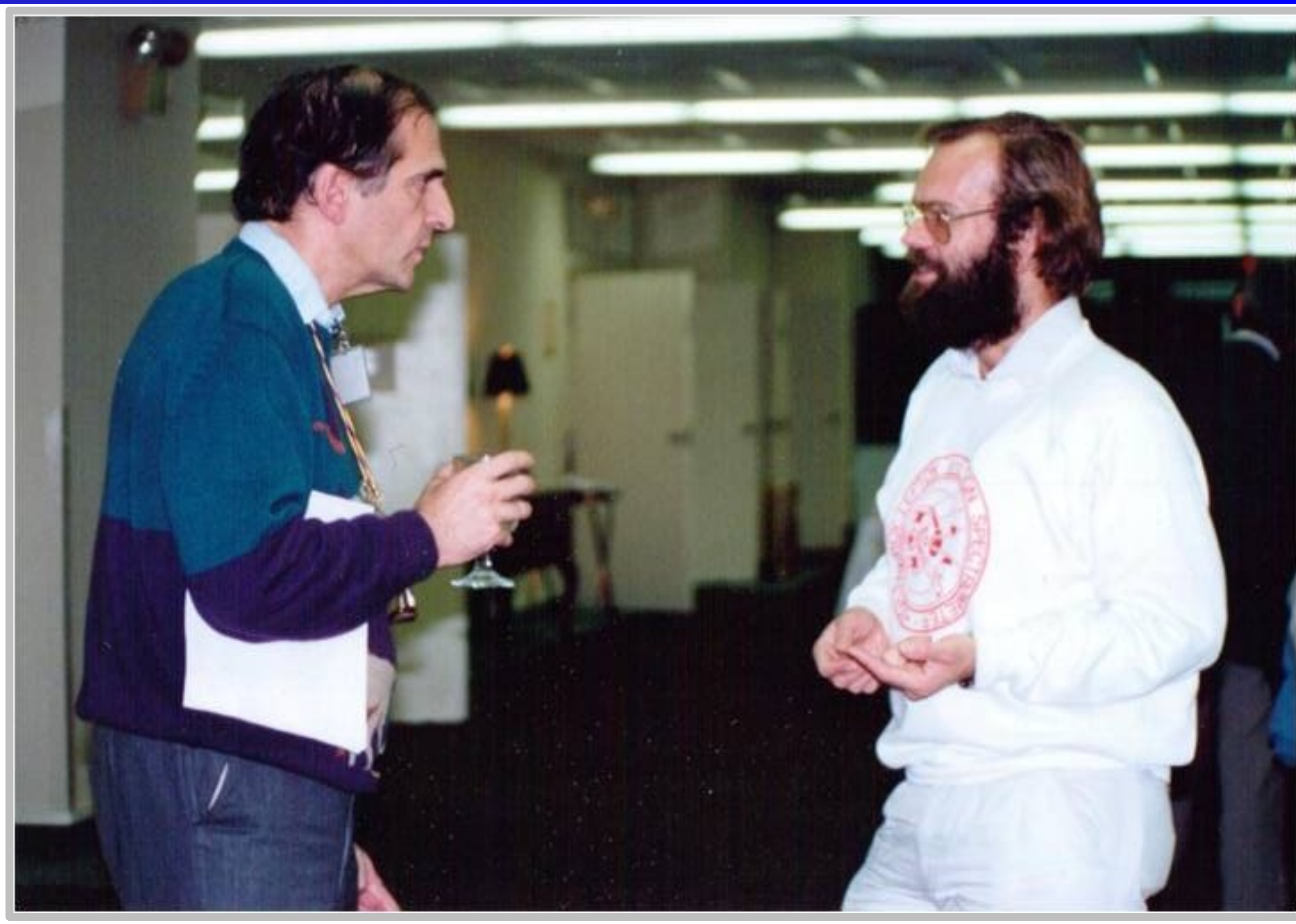
It Was a Different Era





Quark Matter 1991

Flemming, Is This Flemming?



Something Else Was Going on 1991…

RHIC !

RHIC Bulletin
Brookhaven National Laboratory January 1990

Time for RHIC

A Message from the Director

N.P. Samios
Brookhaven National Laboratory

The history of modern physics has shown again and again that great scientific discoveries come as the result of a sequence of timely developments. Ideas stimulate experiments, word of new results spreads, and large numbers of highly motivated scientists soon recognize a window of understanding whose curtain might be drawn back as a result of their efforts. In an era when the horizons of our scientific knowledge are expanding at a rapid pace, rich new opportunities for research emerge when their time is right, and good scientists seize the moment. The Relativistic Heavy Ion Collider offers such an opportunity and its time is now.

The field of "quark matter" research was virtually non-existent as recently as ten years ago. The ideas for this new field of investigation grew out of the discovery of quarks, of the understanding of "asymptotic freedom" — the realization that quarks are confined in hadrons — and the development of QCD as a theory of strong interactions. The idea quickly developed that the properties of nuclear matter — of the most basic nuclear structure — can be profoundly altered in high energy collisions, not only to reveal new particles, but also a new form of matter in which the properties of quarks are no longer hidden away inside the particles we used to call elementary. These ideas have spawned a search for new discoveries which calls for beams of nuclei accelerated to the highest attainable energies.

Brookhaven has been in the forefront of this research, utilizing its Tandem Van de Graaff accelerator to inject ions into the AGS, where accelerated beams of heavy ions now share the research schedule with those of high

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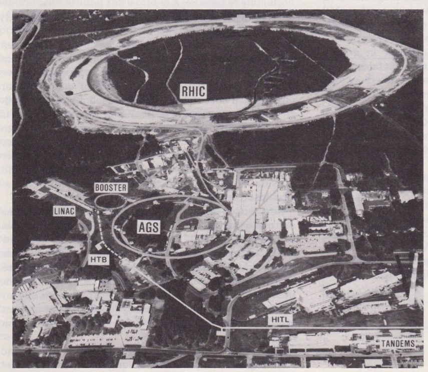

The RHIC Layout

The complex of accelerators which will make up the RHIC facility are shown in this aerial view of a portion of the Brookhaven site, looking north. Ion beams originating in the Tandem Van de Graaff accelerator, at the lower right in the picture, are transported through a long transfer line and injected into the Alternating Gradient Synchrotron (AGS). For experiments being carried out now, these beams are accelerated in the AGS to an energy of 14.6 GeV per nucleon and then extracted and sent down each of three different beam lines to experimental detectors housed in the large building seen jutting out to the northeast of the AGS ring. In these so-called "fixed target" experiments, a pulsed beam of

(Continued on page 3)

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(Continued on page 3)

RHIC Bulletin July 1992

RHIC Bulletin
Brookhaven National Laboratory
Volume III, Number 2
July 1992

$42.7 Million Contract to Grumman to Build RHIC Dipole Magnets

On Tuesday, June 23, Brookhaven signed a 42.7 million dollar contract with Grumman Aerospace Corporation's Electronics Systems Division, to buy 373 superconducting dipole magnets for RHIC. This is the single largest procurement for the RHIC project, which is being funded by the U.S. Department of Energy and has a total project budget of $509 million, including research and development, construction and start-up costs.

At the contract signing, held in the RHIC tunnel with a prototype superconducting dipole magnet as a backdrop, RHIC Project Head Satoshi Ozaki said, "We are pleased to have Grumman join us in our endeavor to build this world-class Relativistic Heavy Ion Collider. Grumman's outstanding reputation in high-tech manufacturing bodes well for success." Ozaki also applauded the commitment exhibited by Grumman's management and the production team. John Harrison, President of Grumman's Electronics Systems Division, spoke of how their magnet work will fit into the corporation's strategies in such areas as transportation and lithography.

The dipole magnets to be built by Grumman will have the job of guiding the heavy ions as they circulate in opposite directions around two intersecting rings built in a tunnel 3.8 kilometers (2.5 miles) in circumference. A total of 1,700 superconducting magnets will be needed for RHIC, 1,200 of them to be built by industry and the rest by Brookhaven. Four types of magnets will be used: dipoles, quadrupoles, sextupoles and assorted special magnets. Of these, the system of dipoles being undertaken by Grumman represents the largest single effort. The readiness for construction of the RHIC magnets is the fruit of Brookhaven's long-standing research and development work on superconducting magnets. In his remarks at the signing ceremony, Ozaki said, "We have mastered the art of building superconducting magnets, as demonstrated by our success in designing and building magnets for RHIC, as well as for the Superconducting Super Collider."

(Continued on page 2)

The dipole-magnet contract signing took place in the RHIC tunnel, on the floor of the eight o'clock experimental hall. At the signing table were: (seated, from left) Albert Verderosa, President, Grumman Space and Electronics Group; John Harrison, President, Grumman Electronics Systems Division; Renso Caporali, Chairman of the Board and Chief Executive Officer of Grumman; BNL Director Nicholas Samios; RHIC Project Head Satoshi Ozaki; AUI Vice President Jerome Hudis; and BNL Associate Director Parke Rohrer.

RHIC Bulletin July 1992

"In the meantime, two small detectors for RHIC have been given preliminary approval to prepare conceptual designs. These experiments, each with total cost less then $5M, are designed to complement the large detectors by focusing on specific apparatus that can be put in place relatively quickly and complete data taking in about a year of operation."

DETECTOR UPDATE:

*STAR Poised for Construction
*PHENIX Nearing Final Design
*"Small" Experiments in the Queue

Meeting a mid-June deadline, the two large detector collaborations have submitted design reports which culminate six months of physics discussion and engineering effort following the go-ahead given last December by the RHIC Detector Technical Advisory Committee [see January 1992 edition of the Bulletin]. This was also a period of hard-nosed grappling with the realities of budgets and schedules as both the STAR and PHENIX groups prepare for a construction phase that will get them on the air in five years.

The STAR collaboration has completed its conceptual design report. This report, which provides a detailed description of the technical design, and a plan for the required funding and manpower, will form the basis for initiating construction of the detector. The STAR detector (see box) is a cylindrical device based on a solenoid magnet and a large time projection chamber (TPC) for tracking and particle identification. The physics emphasis is on the measurement of hadron production over a large solid angle in the central rapidity range, with the ability to correlate global observables on an event-by-event basis in a search for signatures of quark-gluon-plasma formation, and to use hard scattering of partons as a probe of the properties of high density nuclear matter.

The STAR TPC will be augmented by a 3-layer silicon vertex tracker (SVT), utilizing the silicon drift technique, for improved momentum measurement and detection of secondary decay vertices. while not part of the initial construction phase, the SVT will be developed through its prototype phase as part of the RHIC R&D effort, and constructed thereafter using other resources. The initial STAR construction phase will cost about 35 million dollars (FY 1992 $), of which $31.3M will come from RHIC project funds, and the remainder from other resources within the collaboration. An electromagnetic calorimeter, for which outside funding is being sought, would be used to trigger on transverse energy and measure jet cross sections.

With this detector configuration the major physics goals of STAR will be accomplished. A time-of-flight system surrounding the TPC for particle identification at higher momenta and external time projection chambers at forward angles, outside the magnet, to extend the rapidity coverage, are identified as potential upgrades.

Last December the newly formed PHENIX collaboration presented its first attempt to define a detector configuration capable of fulfilling a mandate to explore the physics signals carried by leptons and photons. These are the so-called penetrating probes: electromagnetic particles whose characteristic spectra may reflect the thermodynamic conditions and particle states that prevail during the earliest stages of the formation of high density nuclear matter in RHIC collisions. During the ensuing months the PHENIX consortium has consolidated its resources, defined a management structure for the collaboration, and done extensive design and simulation work to optimize its many-faceted detector. The Preliminary Conceptual Design Report submitted by PHENIX gives a detailed discussion of the group's physics goals, and a status report of the technical design. For PHENIX, this document represents a significant milestone on the way to a final conceptual design report in October or early November.

Based on an axial magnetic field in the central rapidity region, with a forward muon arm, the PHENIX plan describes a detector system capable of measuring thermal and resonance spectra with electron pairs, muon pairs, and photons, as well as hadron production in the selected solid angle. The "Basic" version of the detector is designed to address the key physics goals on day-one, and its ultimate configuration will be matched to the available financial resources of the collaboration. The "standard" version includes upgrades to the Basic version's subsystems, as well as expansion of its capabilities via the addition of new detector subsystems.

More than half of the scientists and engineers that make up the PHENIX collaboration are from foreign countries, and it is expected that a substantial portion of the funding resources for the construction of the detector will come from these sources. Like STAR, PHENIX will have a base construction budget of $31.3M (FY 92 $) from the DOE RHIC construction project. The contribution to the Basic detector from foreign collaborators is expected to be approximately $15-20M, from Japan, Russia, and China.

Both the STAR and PHENIX documents will be reviewed by the Technical Advisory Committee in mid-August. The emphasis of this 3-day meeting will be on the STAR Conceptual Design Report, which should become the basis for initiating construction of this detector. For PHENIX, this will be a mid-course review that should put the group on track for a final conceptual design report in the Fall. The Laboratory's High Energy and Nuclear Physics Program Advisory Committee, meeting in September, will review the research plans of both groups as they move toward the construction phase.

In the meantime, two small detectors for RHIC have been given preliminary approval to prepare conceptual designs. These experiments, each with total cost less then 5 million dollars, are designed to complement the large detectors by focussing on specific measurements, with apparatus that can be put in place relatively quickly and complete data taking in about a year of operation.

The two small detectors currently under consideration are illustrated in the accompanying figure. PHOBOS, of almost table-top dimensions, is to consist of two spectrometer arms utilizing silicon pad and strip detectors, and two small high-field (4 Tesla) superconducting magnets. This detector will measure and identify very soft (low-momentum) hadrons, whose production in RHIC collisions may have anomalous features related

(Continued on page 6)

RHIC Bulletin July 1992

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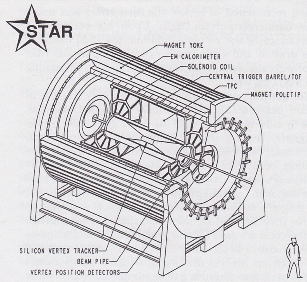
STAR Collaboration: Spokesman: J. Harris, LBL
Technical Director: J. Marx, LBL

Collaborating Institutions: Argonne National Laboratory; Rudjer Boskovic Institute, Zagreb; Brookhaven National Laboratory; UC-Berkeley; UC-Davis; UC-Los Angeles; Carnegie Mellon Univ.; Creighton Univ.; Univ. of Frankfurt; Johns Hopkins Univ.; Kent State Univ.; Lawrence Berkeley Laboratory; CCNY; Univ. of Notre Dame; Univ. of Pittsburgh; Institute of High Energy Physics, Protvino, Russia; Purdue Univ.; Rice Univ.; Texas A&M Univ.; Warsaw Univ., Poland; Warsaw Univ. of Technology, Poland; Wayne State Univ.; Univ. of Washington; Weizmann Institute of Science, Rehovot, Israel.

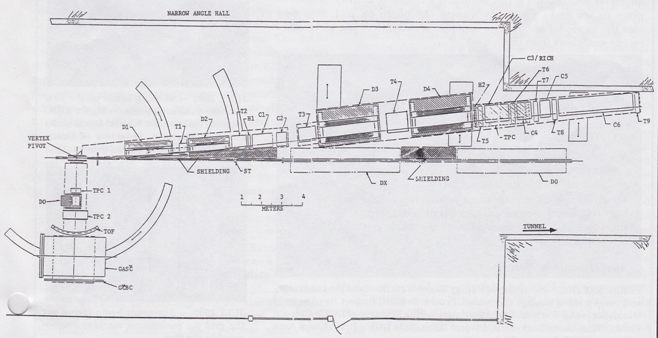


Forward Angle and Midrapidity Hadron Spectrometer

The spectrometer is shown as it would appear if installed in the two o'clock (narrow angle) hall. The magnets labelled DX and D0 are part of the machine lattice.

Spokesman: F. Videbaek, BNL

Collaborating Institutions: Brookhaven National Laboratory; CRN Strasbourg; CIAE-Beijing; NYU; Texas A&M; UC-Berkeley.



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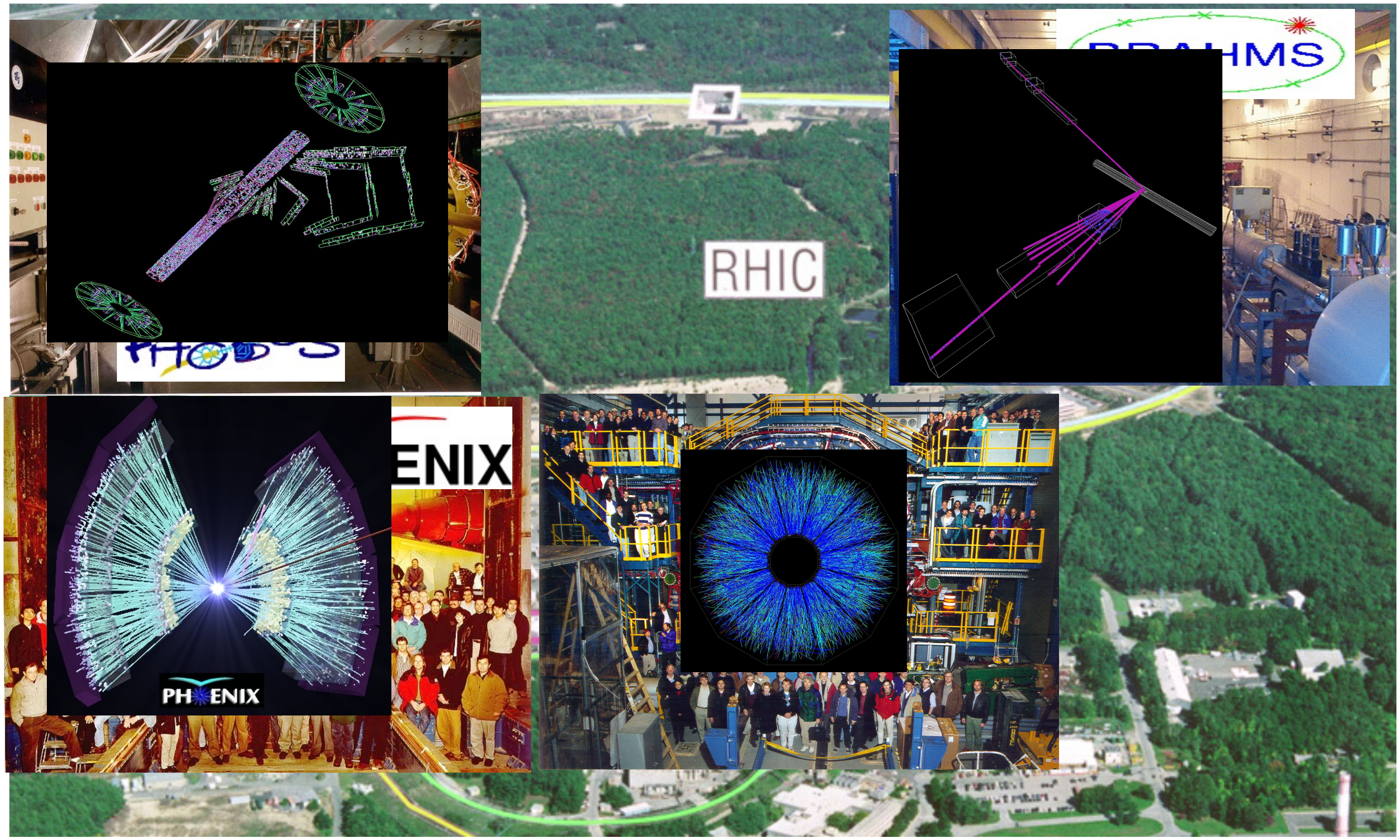
2000 !



From Tim Hallman

I always found Flemming to be a gentlemen first despite the fierce competition we were in when he was Spokesperson of BRAHMS, and --where you and I were willing to mix it up on occasion-- I never saw that kind of aggressiveness from him. He was also very skillful in extracting the full measure of what BRAHMS could do scientifically, and in working hard to keep BRAHMS relevant and productive, despite continually being in the same bath tub with two elephants.

Post BRAHMS I found him to be a very capable technologist and project leader; someone you could rely on for sober, no BS assessments, and straight forward hard, grinding work to get things done.

2001 - First BRAHMS Publication

Flemming Videbaek April 7, 2001 at 11:55 AM

Brahms publication

To: Thomas Kirk, Thomas Ludlam, "Bill Zajc", & 2 more Details

Reply-To: Flemming Videbaek

Dear Colleagues:

I am happy to announce that BRAHMS has prepared and completed its internal review of the first publications from last year's data run, and is planning to submit the paper the Physical Review Letter on or about April 16. The title and abstract are given below.

Title

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Antiproton to proton ratios in Au+Au collisions at $\sqrt{s_{NN}}=130$ GeV as
function of rapidity and centrality
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Abstract:

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Measurements with the BRAHMS detector of the antiproton to proton ratio at central
($y\approx 0$ and $y \approx 0.7$) and forward ($y\approx 2$) rapidities for three
different collision centralities, for Au+Au reactions at $\sqrt{s_{NN}}=130$ GeV are
presented. For collisions in the centrality range ($0-40\%$) $N(\bar{p})/N(p) = 0.62
\pm 0.06$   at $y \approx 0$,  0.59$\pm$0.05 at $y\approx 0.7$ and $0.44 \pm   0.04$
at $y \approx 2$. The ratios are found to be nearly   independent of collision
centrality and transverse momentum. The $N({\pi}^-)/N({\pi}^+)$  ratio has been
determined to be near unity for three rapidity  values ($y \approx 0, 1$ and $3$).
The measurements demonstrate that the antiproton and proton rapidity densities vary
differently with rapidity, and indicate that a net-baryon free midrapidity   plateau
(Bjorken-limit) is not reached at this RHIC energy.
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Best regards,

Flemming

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2001 - First BRAHMS Publication

VOLUME 87, NUMBER 11 PHYSICAL REVIEW LETTERS 10 SEPTEMBER 2001

Rapidity Dependence of Antiproton-to-Proton Ratios in Au + Au Collisions at $\sqrt{s_{NN}} = 130$ GeV

I. G. Bearden,[7] D. Beavis,[1] C. Besliu,[10] Y. Blyakhman,[6] J. Brzychczyk,[4] B. Budick,[6] H. Bøggild,[7] C. Chasman,[1] C. H. Christensen,[7] P. Christiansen,[7] J. Cibor,[3] R. Debbe,[1] J. J. Gaardhøje,[7] K. Grotowski,[4] K. Hagel,[8] O. Hansen,[7] A. Holm,[7] A. K. Holme,[12] H. Ito,[11] E. Jakobsen,[7] A. Jipa,[10] J. I. Jørdre,[9] F. Jundt,[2] C. E. Jørgensen,[7] T. Keutgen,[8] E. J. Kim,[5] T. Kozik,[4] T. M. Larsen,[12] J. H. Lee,[1] Y. K. Lee,[5] G. L. Løvhøiden,[12] Z. Majka,[4] A. Makeev,[8] B. McBreen,[1] M. Murray,[8] J. Natowitz,[8] B. S. Nielsen,[7] K. Olchanski,[1] J. Olness,[1] D. Ouerdane,[7] R. Płaneta,[4] F. Rami,[2] D. Röhrich,[9] B. H. Samset,[12] S. J. Sanders,[11] R. A. Sheetz,[1] Z. Sosin,[4] P. Staszel,[7] T. F. Thorsteinsen,[9,*] T. S. Tveter,[12] F. Videbæk,[1] R. Wada,[8] A. Wieloch,[4] and I. S. Zgura[10]

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(Received 28 April 2001; published 24 August 2001)

Measurements, with the BRAHMS detector, of the antiproton-to-proton ratio at midrapidities and forward rapidities, are presented for Au + Au reactions at $\sqrt{s_{NN}} = 130$ GeV, and for three different collision centralities. For collisions in the 0%–40% centrality range, we find $N(\bar{p})/N(p) = 0.64 \pm 0.04_{(stat)} \pm 0.06_{(syst)}$ at $y \approx 0$, $0.66 \pm 0.03 \pm 0.06$ at $y \approx 0.7$, and $0.41 \pm 0.04 \pm 0.06$ at $y \approx 2$. The ratios are found to be nearly independent of collision centrality and transverse momentum. The antiproton and proton rapidity densities vary differently with rapidity, and indicate a significant degree of collision transparency, although a net-baryon free midrapidity plateau (Bjorken limit) is not yet reached.

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The reaction mechanism between heavy ions at high energies is expected to evolve from full stopping to complete transparency with increasing collision energy. In the case of full stopping, the baryons of the colliding nuclei will be shifted from the rapidity of the incident beam to midrapidity ($y \approx 0$), leading to the formation of a central zone with a significant excess in the number of baryons as compared to antibaryons (net-baryon density). In the case of full transparency, also called the Bjorken limit [1], the baryons from the interacting nuclei will, after the collision, also be shifted from the beam rapidity, but midrapidity will be devoid of original baryons. In this region, the net-baryon density is zero and the energy density is high. Almost complete stopping is observed for Au + Au reactions at AGS energies ($\sqrt{s_{NN}} \approx 5$ GeV). In reactions between lead nuclei at SPS energies ($\sqrt{s_{NN}} = 17$ GeV), transparency begins to set in, and systematics suggest that maximum baryon density occurs at energies intermediate between AGS and SPS (see, e.g., [2,3]). The situations of maximum baryon density and of vanishing net-baryon density at midrapidity give rise to entirely different initial conditions for the possible creation of a deconfined quark-gluon system.

The rapidity dependence of the antiproton to proton ratio in collisions between Au nuclei at the Relativistic Heavy Ion Collider (RHIC), Brookhaven National Laboratory, is investigated for $\sqrt{s_{NN}} = 130$ GeV, the highest center of mass energy yet achieved in collisions between heavy nuclei in the laboratory. The data were collected with the BRAHMS detector during the final two weeks of the first RHIC run, where the beam luminosity reached ≈10% of the nominal design value. We present measurements of the $N(\bar{p})/N(p)$ ratios at rapidities y(proton) ≈0, 0.7, and 2 as a function of collision centrality and transverse momentum together with $N(\pi^-)/N(\pi^+)$ ratios at $y(\pi) \approx 0, 1$, and 3. The measurements provide the first particle ratios over an extended rapidity range at RHIC energies and contribute to understanding the stopping mechanism at RHIC and the degree of transparency in the collisions. We find that, while the pion ratios are close to unity, the measured antiproton to proton ratio decreases from $0.64 \pm 0.04_{(stat)} \pm 0.06_{(syst)}$ at $y \approx 0$ and $0.66 \pm 0.03_{(stat)} \pm 0.06_{(syst)}$ at $y \approx 0.7$ to

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FV **Flemming Videbaek** April 7, 2001 at 11:55 AM
Brahms publication
To: Thomas Kirk, Thomas Ludlam, "Bill Zajc", & 2 more Details
Reply-To: Flemming Videbaek

Dear Colleagues:

I am happy to announce that BRAHMS has prepared and completed its internal review of the first publications from last year's data run, and is planning to submit the paper the Physical Review Letter on or about April 16. The title and abstract are given below.

Title

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Antiproton to proton ratios in Au+Au collisions at $\sqrt{s_{NN}}=130$ GeV as
function of rapidity and centrality
```

Abstract:

```
Measurements with the BRAHMS detector of the antiproton to proton ratio at central
($y\approx 0$ and $y \approx 0.7$) and forward ($y\approx 2$) rapidities for three
different collision centralities, for Au+Au reactions at $\sqrt{s_{NN}}=130$ GeV are
presented. For collisions in the centrality range ($0-40\%$) $N(\bar{p})/N(p) = 0.62
\pm 0.06$   at $y \approx 0$,  0.59$\pm$0.05 at $y\approx 0.7$ and $0.44 \pm   0.04$
at $y \approx 2$. The ratios are found to be nearly   independent of collision
centrality and transverse momentum. The $N({\pi}^-)/N({\pi}^+)$  ratio has been
determined to be near unity for three rapidity  values ($y \approx 0, 1$ and $3$).
The measurements demonstrate that the antiproton and proton rapidity densities vary
differently with rapidity, and indicate that a net-baryon free midrapidity   plateau
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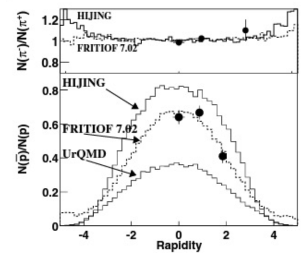

FIG. 3. Comparison of the measured $N(\bar{p})/N(p)$ (lower panel) and $N(\pi^-)/N(\pi^+)$ (upper panel) ratios to model predictions. The data shown are for 0%–40% central events and integrated over the transverse momentum range shown in Fig. 2. The three model calculations (HIJING, FRITIOF, and UrQMD) are shown for comparison. See text for details.

in the ratio over the next unit of rapidity is larger than observed in $A + A$ collisions at lower energies, but is very similar to the $p + p$ result at roughly half the c.m. energy [11]. The observed magnitude of the antiproton to proton ratio at $y \approx 0$ and 0.7 suggests that in the measured collisions a high degree of transparency is obtained leading to a region with low net-baryon density around midrapidity covering at least ±1 units of rapidity. The $y = 2$ result of a significantly smaller antiproton to proton ratio shows that the net baryon poor plateau does not extend to $y = 2$, an observation that provides a severe test for theoretical model descriptions of the collision mechanism.

In Fig. 3, we compare the measured ratios to calculations using the HIJING model [12], the FRITIOF 7.02 string model [13], and the UrQMD cascade model [14] using the same centrality cuts as in the data analysis. Hyperon decays have not been included in the calculations shown, but affect the results by less than 5%. All three models reproduce the observed pion ratios well. FRITIOF reproduces our $N(\bar{p})/N(p)$ ratios, while overpredicting (by ≈30%) the charged particle yield at $\eta \approx 0$ [15]. This is due to a significant degree of stopping in the model. On the other hand, HIJING, which describes the overall charged particle yields at $\eta \approx 0$, fails in describing the antiproton to proton ratio. This feature of the model is related to the small stopping of the projectile baryons. The UrQMD model, which is not a partonic model, underpredicts the ratio by nearly a factor of 2. None of the models offer a consistent description of the observed features in this energy regime.

In summary, the BRAHMS experiment has measured the ratio of positive and negative pions and protons at midrapidities and forward rapidities. We find that the pion ratios are close to unity as would be expected at these energies. We find, however, that for central collisions at $\sqrt{s_{NN}} = 130$ GeV the ratio of antiprotons to protons is still significantly below unity at midrapidity and decreases towards forward rapidity. In addition, the reactions at the present energy evidence the highest antiparticle/particle ratios thus far observed in energetic nucleus-nucleus collisions. The rapidity dependence serves as an indicator of baryon number transport to the central region. Although there is evidence for transparency in the reaction and the onset of the decoupling of the net-baryon rich fragmentation region from the net-baryon poor central region, the present result demonstrates that there is still a significant contribution from participant baryons over the entire rapidity range.

The BRAHMS Collaboration wishes to thank the RHIC team for their support. This work was supported by the Division of Nuclear Physics of the Office of Science of the U.S. Department of Energy, the Danish Natural Science Research Council, the Research Council of Norway, the Jagiellonian University Grant, the Korea Research Foundation Grant, and the Romanian Ministry of Education and Research.

*Deceased.

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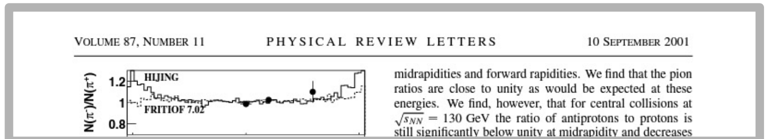

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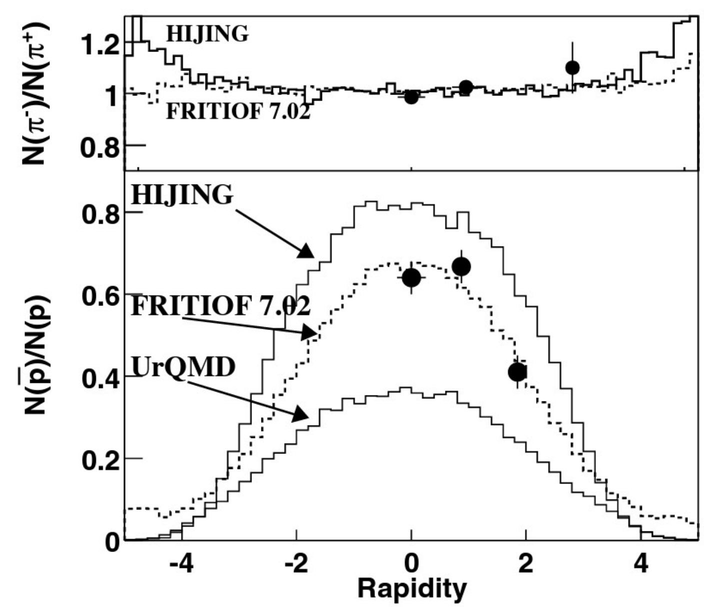

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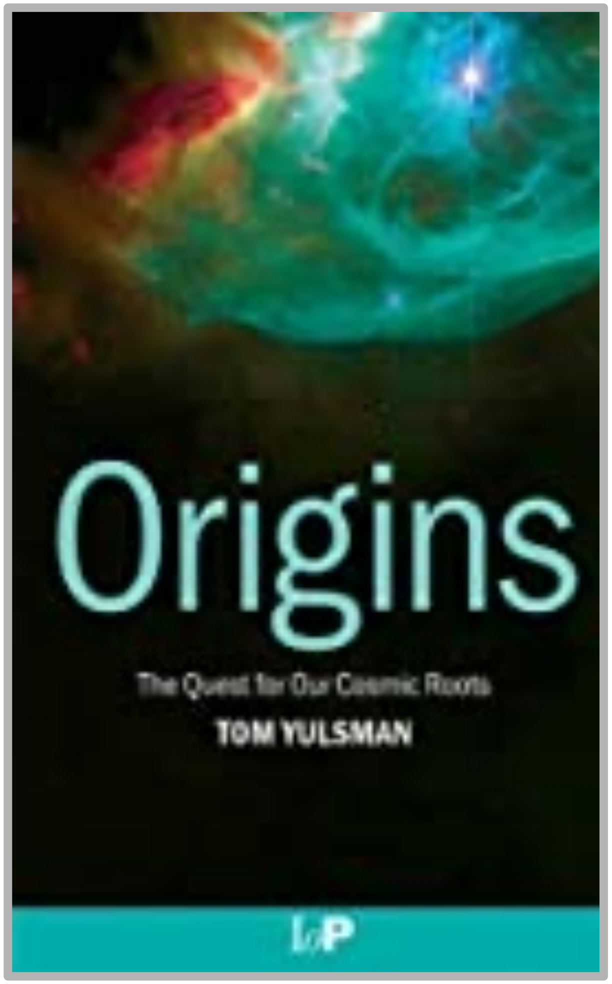
2002



Hot Big Bang

Moreover, "PHENIX looks at a smaller region than STAR and thus produces a finer-grain picture," Young says. With this fine detail, PHENIX can identify, for example, individual gamma rays and determine their energy. STAR can only measure the total energy contributed by gamma rays to the fireball.

Finally, there is BRAHMS (the Broad Range Hadron Magnetic Spectrometer). "With BRAHMS, we can look closely, very accurately, from a few angles," Flemming Videbaek says. "It's like moving the microscope around." The detector measures the momentum, energy and other characteristics of only a small number of particles emerging from a specific set of angles during each collision. And it's the only detector that looks at the fireball along the line of flight of colliding gold ions, which means it's the only one with a very good view of the actual collision region itself.

2003 - BRAHMS Data → Landau Hydrodynamics !?!

William A. Zajc 7/23/03
RE: two or three items for H/P PWG tomorrow (...
3 recipients Details

Dear Paul:

I was struck (more like dumbfounded) by the Gaussian dn/dy distributions from BRAHMS you display on Slide #2 (this also shows I have not been paying enough attention to the data from other experiments).

Why dumbfounded? Because the Landau hydrodynamic model of 1953(!) predicted that. (Technically, it's an approximate solution to that model that predicts Gaussian dn/dy's .) That approximation makes a definite prediction for the width of the Gaussian:

\sigma^2 = log(\sqrt(s) / 2m_P) = y_{BEAM} - log(2)

Ever skeptical, I was not expecting much when I decided to calculate a few points:

y	dn/dy
0	300.0 <-- normalization point
1	269.5
2	195.4
3	114.4
4	54.0
5	20.6
6	6.3

For an ab initio prediction, it works ridiculously well (not perfectly, to be sure; one can always fine-tune this by playing with leading-particle effects). Surely someone must have already noticed this?

For details, it's easiest to consult

P. Carruthers and M. Duong-Van, Phys. Rev. D8, 859 (1973), and references therein.

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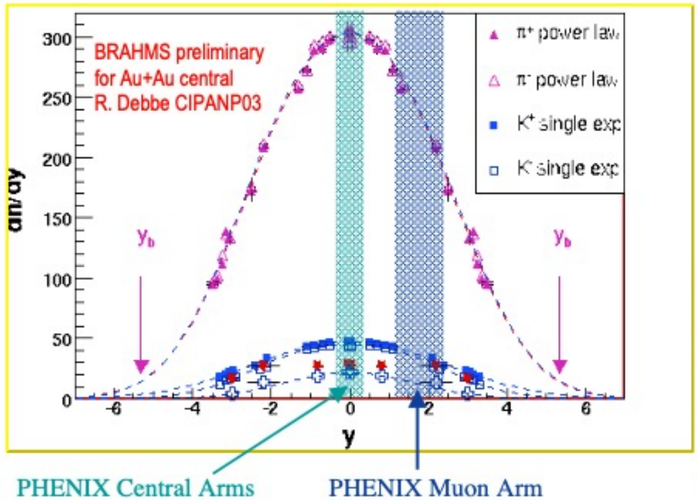
Why is this interesting?



BRAHMS measurement shows dN/dY (~ dE_T/dY) created energy density is Gaussian in Y, and drops by almost factor of x2 between central rapidities and muon arm rapidities. Don't be fooled by dN/dη, which shows a plateau; dN/dY is the real thing.

If RHIC A+A shows strong jet quenching signal but SPS A+A does not, where does it turn on in between?
Bjorken energy densities differ only by factor about x2
-> Motivation for RHIC energy scan

Drawback to beam energy scan: changing two things at once, both created medium energy density *and* parton energy spectra

Better to change only one thing: looking at high rapidity changes ε_{Bj} but leaves everything else close to the same.

We can scan almost x2 in ε_{Bj} ,purely *within* A+A central collisions at one root{s}, if we can reconstruct spectra of hadrons into PHENIX muon arms.

2003 - BRAHMS Data → Landau Hydrodynamics !?!

William A. Zajc 7/23/03
RE: two or three items for H/P PWG tomorrow (...
3 recipients Details

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\sigma^2 = log(\sqrt{s} / 2m_P } = y_{BEAM} - log{2} X

Ever skeptical, I was not expecting much when I decided to calculate a few points:

y	dn/dy
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1	269.5
2	195.4
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For an ab initio prediction, it works ridiculously well (not perfectly, to be sure; one can always fine-tune this by playing with leading-particle effects). Surely someone must have already noticed this?

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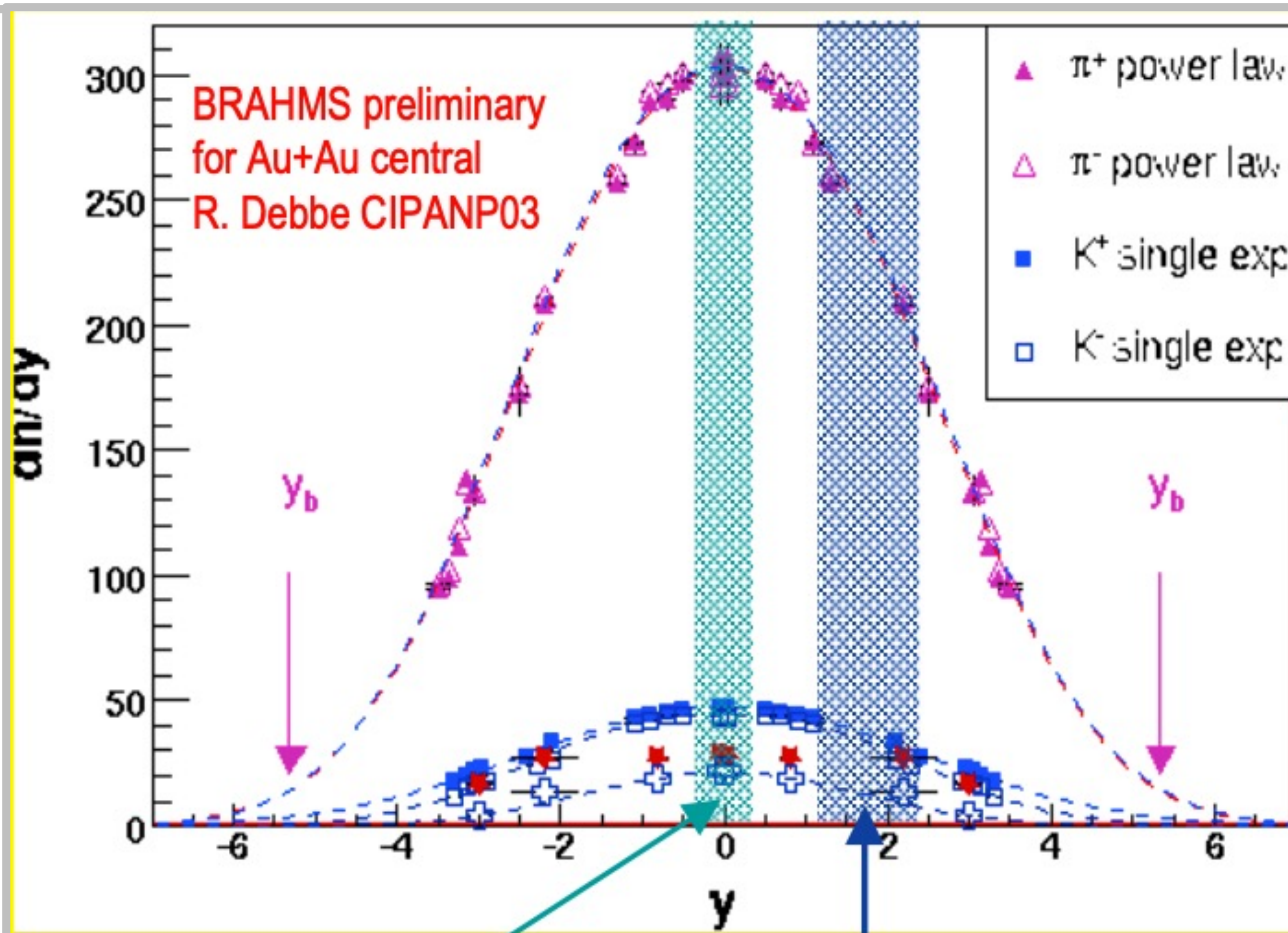

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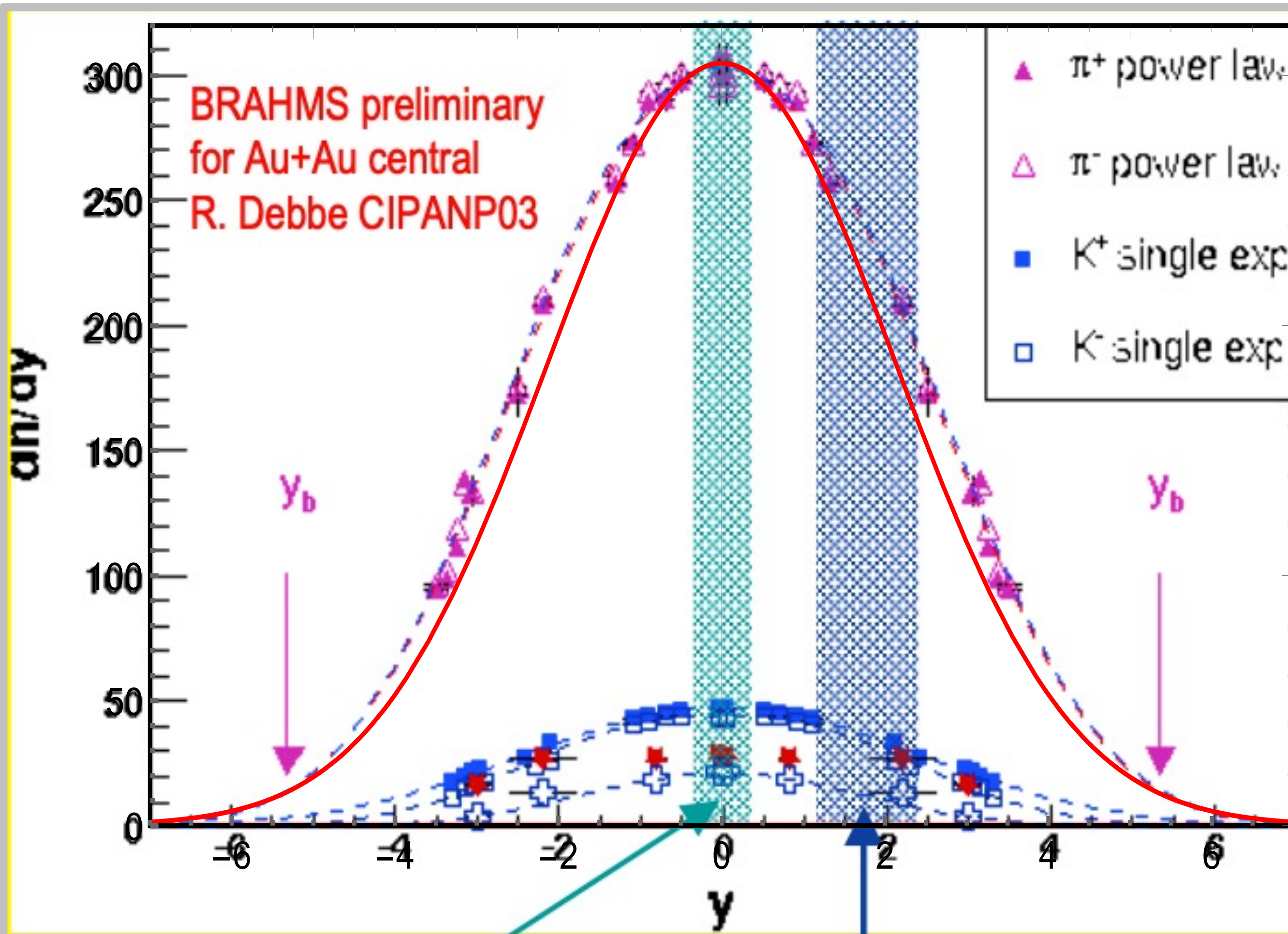

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PRL **94,** 162301 (2005) PHYSICAL REVIEW LETTERS week ending 29 APRIL 2005

Charged Meson Rapidity Distributions in Central Au + Au Collisions at $\sqrt{s_{NN}} = 200$ GeV

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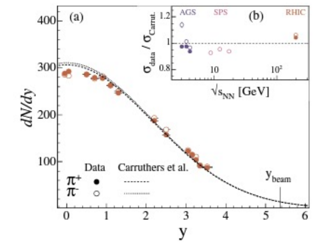

FIG. 4 (color online). Comparison $dN/dy(\pi)$ and Landau's prediction at $\sqrt{s_{NN}} = 200$ GeV (a), and ratio $\sigma_{N(\pi)}/\sigma_{\text{Carrut.}}$ as a function of $\sqrt{s_{NN}}$ (b). Errors are statistical.

furthermore interesting to note that in central Au + Au collisions at $\sqrt{s_{NN}} = 200$ GeV, the original baryons lose 2 rapidity units on average from the initial value $y_b = 5.36$ [3]. Not only is the degree of transparency significantly different between AGS and RHIC, but the relative rapidity loss $\langle \delta y \rangle / y_b$ is about half lower [3].

On the basis of Landau's original hydrodynamic, Bjorken [2] proposed a scenario in which yields of produced particles would be boost invariant within a region around midrapidity. In that approach, reactions are described as highly transparent leading to a vanishing net-baryon density around midrapidity and particle production from pair creation from the color field in the central zone. This would result in a flat distribution of particle yields around $y = 0$. As mentioned, collisions at RHIC are neither fully stopped nor fully transparent, although a significant degree of transparency is observed. Consequently the overall dN/dy distribution of pions is expected to consist of the sum of the particles produced in the boost-invariant central zone and the particles produced by the excited fragments. The fact that the observed distributions are flatter at midrapidity and wider than those predicted by the Landau-Carruthers model might point in this direction.

In summary, we have measured transverse momentum spectra and inclusive invariant yields of charged meson $\pi^{\pm}$ and $K^{\pm}$. The ratios of strange to nonstrange mesons K/π are well reproduced by the hadron gas statistical model [6] that assumes strangeness equilibration at midrapidity. The excess of K^+ over K^- yields at higher rapidities can be explained by the increasing baryochemical potential μ_B with rapidity. The widths of the pion rapidity distributions are in surprisingly good agreement with a hydrodynamic model based on the Landau expansion picture.

This work was supported by the division of Nuclear Physics of the Office of Science of the U.S. DOE, the Danish Natural Science Research Council, the Research Council of Norway, the Polish State Com. for Scientific Research, and the Romanian Ministry of Research.

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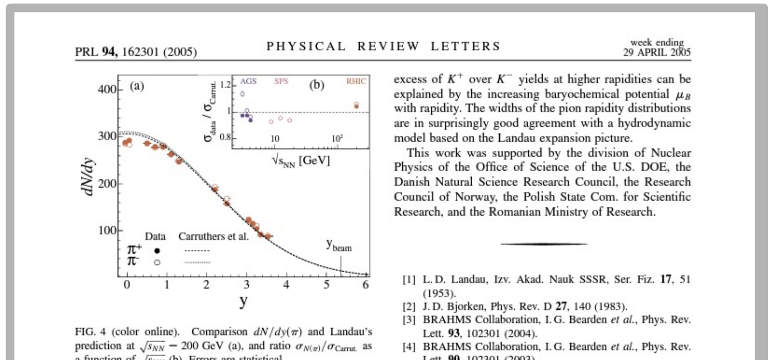
BRAHMS consists of two hadron spectrometers, a midrapidity arm (MRS) and a forward rapidity arm (FS), as

0031-9007/05/94(16)/162301(4)$23.00 162301-1



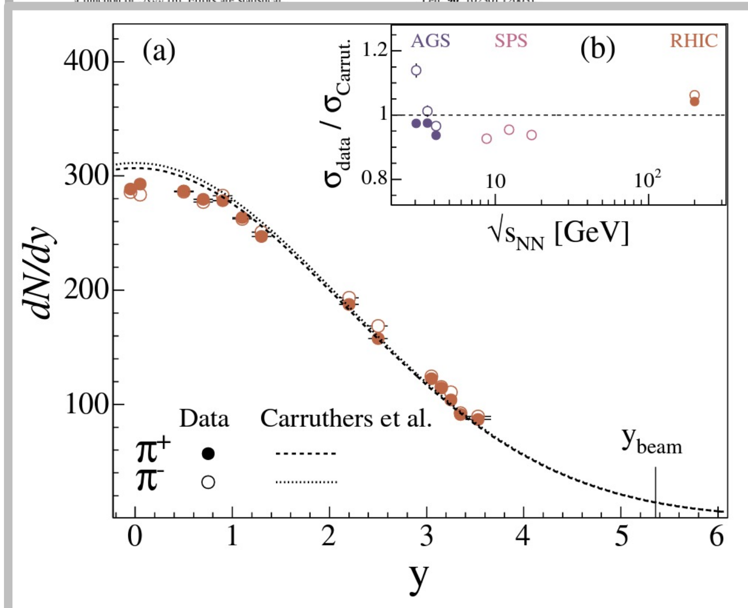
PRL **94,** 162301 (2005) PHYSICAL REVIEW LETTERS week ending 29 APRIL 2005

FIG. 4 (color online). Comparison $dN/dy(\pi)$ and Landau's prediction at $\sqrt{s_{NN}} = 200$ GeV (a), and ratio $\sigma_{N(\pi)}/\sigma_{Carrut.}$ as a function of $\sqrt{s_{NN}}$ (b). Errors are statistical.

excess of K^+ over K^- yields at higher rapidities can be explained by the increasing baryochemical potential μ_B with rapidity. The widths of the pion rapidity distributions are in surprisingly good agreement with a hydrodynamic model based on the Landau expansion picture.

This work was supported by the division of Nuclear Physics of the Office of Science of the U.S. DOE, the Danish Natural Science Research Council, the Research Council of Norway, the Polish State Com. for Scientific Research, and the Romanian Ministry of Research.

[1] L. D. Landau, Izv. Akad. Nauk SSSR, Ser. Fiz. **17**, 51 (1953).
[2] J. D. Bjorken, Phys. Rev. D **27**, 140 (1983).
[3] BRAHMS Collaboration, I. G. Bearden *et al.*, Phys. Rev. Lett. **93**, 102301 (2004).
[4] BRAHMS Collaboration, I. G. Bearden *et al.*, Phys. Rev. Lett. **90**, 102301 (2003).



RHIC’s Incredible Success

- 2000 – first collisions
- 2001 – major results from all 4 collaborations
- 2002 – first full-energy Au+Au run
- 2003 – d+Au control run

Contacts: Karen McNulty Walsh, (631) 344-8350 or Peter Genzer, (631) 344-3174 PRINT

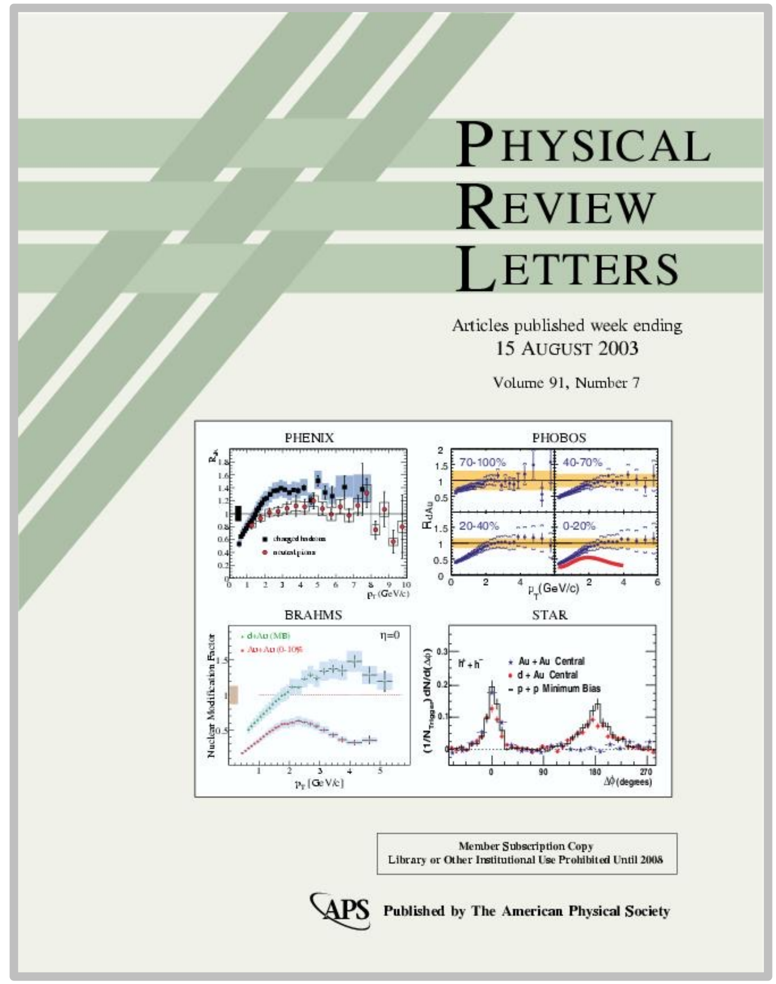
Exciting First Results from Deuteron-Gold Collisions at Brookhaven

Findings intensify search for new form of matter

June 11, 2003

UPTON, NY — The latest results from the Relativistic Heavy Ion Collider (RHIC), the world’s most powerful facility for nuclear physics research, strengthen scientists’ confidence that RHIC collisions of gold ions have created unusual conditions and that they are on the right path to discover a form of matter called the quark-gluon plasma, believed to have existed in the first microseconds after the birth of the universe. The results will be presented at a special colloquium at the U.S. Department of Energy’s Brookhaven National Laboratory on June 18 at 11 a.m., to coincide with the submission of scientific papers on the results to Physical Review Letters by three of RHIC’s international collaborations.

The scientists are not yet ready to claim the discovery of the quark-gluon plasma, however. That must await corroborating experiments, now under way at RHIC, that seek other signatures of quark-gluon plasma and explore alternative ideas for the kind of matter produced in these violent collisions.



Quark Matter 2004

Oakland – January 11-17

- New York Times article by Jim Glanz emphasizing “reluctance” to announce QGP discovery

Like Particles, 2 Houses of Physics Collide

By JAMES GLANZ
Published: January 20, 2004

OAKLAND, Calif., Jan. 14— MARCELLUS What, has this thing appear'd again to-night?

BARNARDO I have seen nothing.

-- "Hamlet," Act I, Scene 1

A bland and bulky conference center in this city's fogbound downtown was transformed in recent days into the Elsinore of particle physics. The ghost that continually appeared, disappeared and appeared again during a scientific meeting was not the shade of a murdered king but a puff of primordial matter with an otherworldly name: the quark-gluon plasma.

This drama, like the original, involved not only a clash of great forces but also what some saw as betrayal and a measure of revenge. It drew in a pair of renowned laboratories -- two great houses of physics -- that have avidly pursued what may be among the most important discoveries in science.

Most of all, the meeting was a forum for one of those institutions, Brookhaven National Laboratory, to play Hamlet, earnestly raising doubt after doubt about the meaning of its own data: the laboratory's scientists refused to acknowledge that they had created the plasma, even though it would be hard to find a physicist anywhere who seriously argued that the lab had blundered and failed in its quest.

Miklos, QM04: Why Haven’t You Declared Victory??

QM04 was a true missed opportunity for RHIC I believe… Talk after talk showed that RHIC had produced superb data of the highest quality and originality- yet the meeting left most people empty with no conclusions and conflicting uncertain outlook.

James Glanz of the New York Times in the attached article captured the quagmire and tragedy of our tale very well.

"Brookhaven National Laboratory, to play Hamlet, earnestly raising doubt after doubt about the meaning of its own data: the laboratory’s scientists refused to acknowledge that they had created the plasma, even though it would be hard to find a physicist anywhere who seriously argued that the lab had blundered and failed in its quest."

Miklos, 20-Jan-2004

Could we agree on this private list to cut the crap about "democratic voting" before we wind up as a case study in the "constructed tribal myth" school of (anti)-science historians? When statements of QGP formation move from PPT to PRL, then we will be in a position to declare victory.

Miklos, your multi-leg table is a persuasive set of arguments. Will it be submitted to a journal in the near future? If so, good- provided you can address the anticipated referee comments.

As I said in the second NYTimes piece, I think there is little doubt that we are making QGP. But I, along with many others, would like to see this move from hunches, "consistent with", "most economical description", "highly plausible" to some more specific statement in the refereed literature.

WAZ, 20-Jan-2004

Causality in the White Paper Process

- 12-Feb-04 Discussion SA, TH, WZ “RHIC Science Retreat”
- 20-Feb-04 TH, WZ discuss “white papers”, WZ message to phenix-ec-l
- 25-Feb-04 Spokesperson’s meeting, WZ charged to draft a process
- 27-Feb-04 Experiments invited to contribute ~15 page paper to RBRC Series
- 29-Feb-04 Draft process for WP’s distributed
- 02-Mar-04 Proposal to politely decline publication in RBRC Series
  - Unrealistic time scale (April 5)
  - Potential interference with existing WP process
- 04-Mar-04 Draft response circulated (7 AM); revised draft (3 PM)
-
- (Extraordinary period of work, writing, negotiations)
- 30-Sep-04 Nuclear Physics A selected as publication venue
- 04-Oct-04 PHENIX WP posted to archive
-
- (Another extraordinary period…)
- 18-Apr-05 “Perfect Liquid” press release

Something I (Re)-Learned in Preparing This Talk

- Impetus to Nuclear Physics A for the White Papers came through Jens Jørgen Gaardhøje via Flemming

- Alas, APS journals…

FV **flemming videbaek** 7/12/04

Re: white paper question

To: Tim Hallman, Samuel H. Aronson, Hide

Cc: William A Zajc, Flemming Videbaek, Wit Busza, Mark Baker,

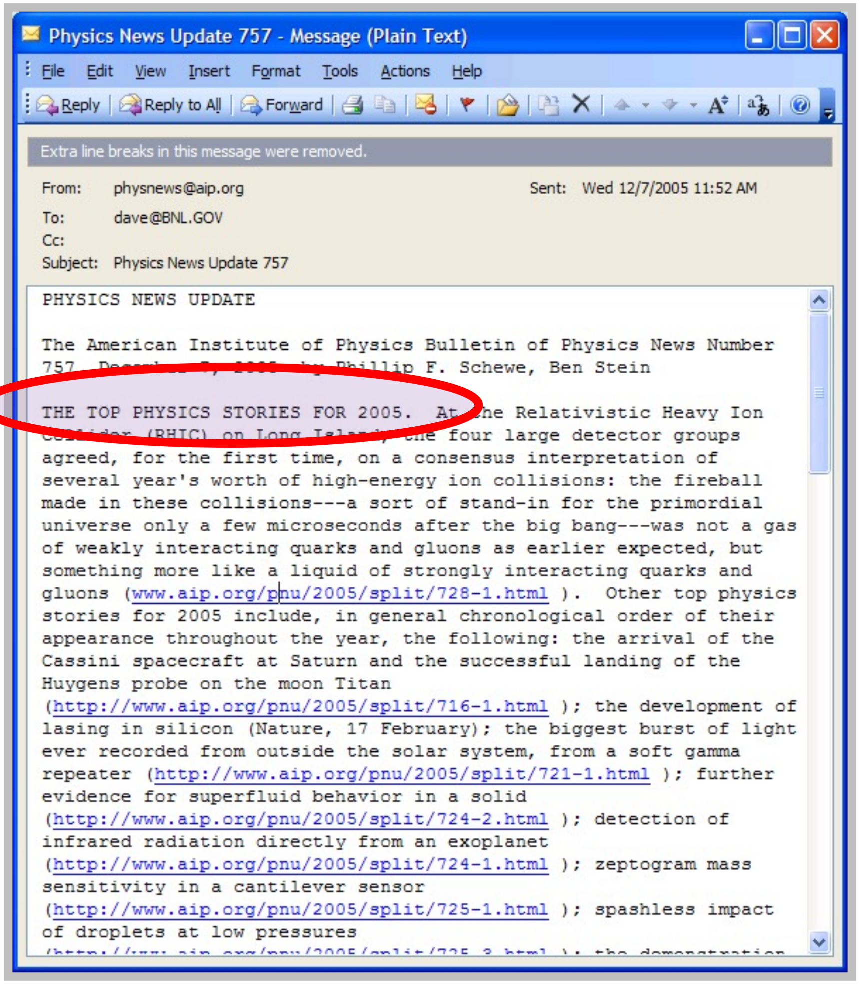
Reply-To: Flemming Videbaek

Dear All,

I think there is a need to understand where we are in this process. e.g. I
do not know what has happened with the
initiative by Brant in regards to PRC , but will like to know so we can
have
a good discussion on options.
Since we are targeting a date of mid August for a final product, it will
be
good to know the target audience and how to proceed.
For some additional information on this, independently of me, Jens
Jorgen
have talked toCarl Swartz from NPA which have said
they would be interested in these articles. From JJ's comments it also
seems
that the RBRC aka theorist have also approached NPA for their articles.
NPA
would , it seems, be willing to have seperate volume for the papers. So it
seems also from Tim's comments that there are indeed several options
available.

I encourage you to share information so the best can be made of
publishing
the whitepapers.
regards
flemming

AIP Physics Story of 2005



Physics News Update 757 - Message (Plain Text)

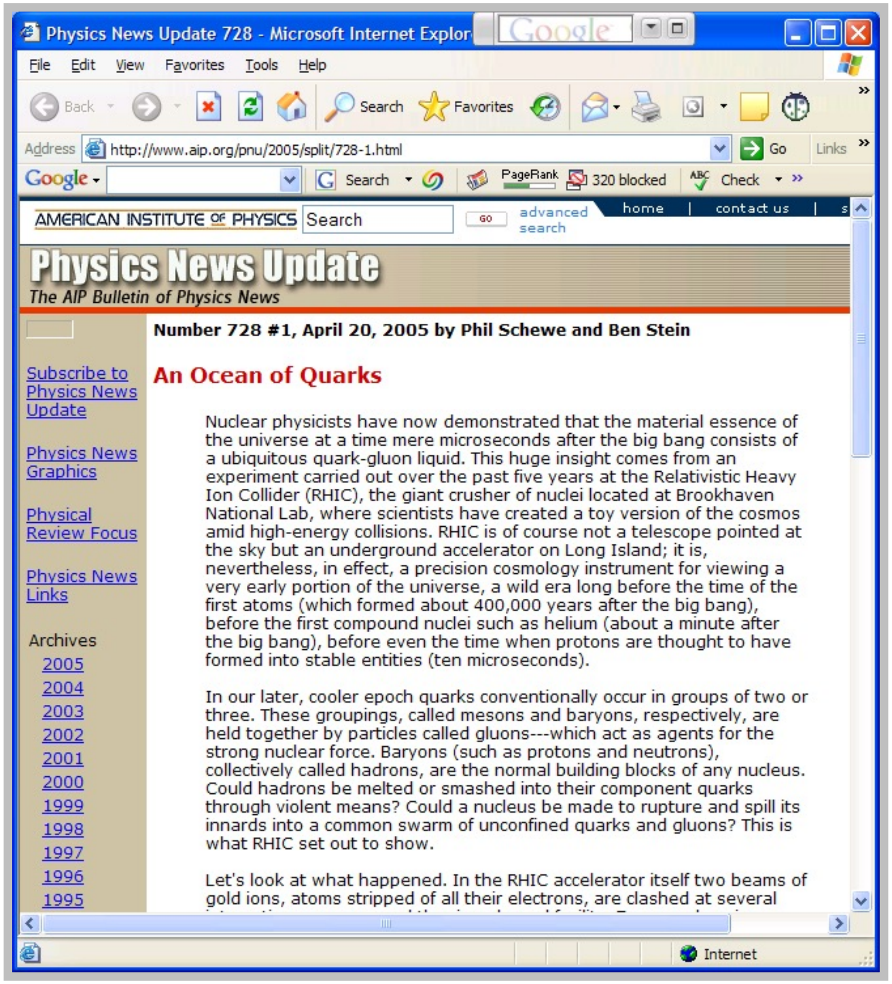
Extra line breaks in this message were removed.

From: physnews@aip.org Sent: Wed 12/7/2005 11:52 AM
To: dave@BNL.GOV
Cc:
Subject: Physics News Update 757

PHYSICS NEWS UPDATE

The American Institute of Physics Bulletin of Physics News Number 757 December 7, 2005 by Phillip F. Schewe, Ben Stein

THE TOP PHYSICS STORIES FOR 2005. At the Relativistic Heavy Ion Collider (RHIC) on Long Island, the four large detector groups agreed, for the first time, on a consensus interpretation of several year's worth of high-energy ion collisions: the fireball made in these collisions---a sort of stand-in for the primordial universe only a few microseconds after the big bang---was not a gas of weakly interacting quarks and gluons as earlier expected, but something more like a liquid of strongly interacting quarks and gluons (www.aip.org/pnu/2005/split/728-1.html). Other top physics stories for 2005 include, in general chronological order of their appearance throughout the year, the following: the arrival of the Cassini spacecraft at Saturn and the successful landing of the Huygens probe on the moon Titan (http://www.aip.org/pnu/2005/split/716-1.html); the development of lasing in silicon (Nature, 17 February); the biggest burst of light ever recorded from outside the solar system, from a soft gamma repeater (http://www.aip.org/pnu/2005/split/721-1.html); further evidence for superfluid behavior in a solid (http://www.aip.org/pnu/2005/split/724-2.html); detection of infrared radiation directly from an exoplanet (http://www.aip.org/pnu/2005/split/724-1.html); zeptogram mass sensitivity in a cantilever sensor (http://www.aip.org/pnu/2005/split/725-1.html); spashless impact of droplets at low pressures



Physics News Update 728 - Microsoft Internet Explorer

Address http://www.aip.org/pnu/2005/split/728-1.html

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Number 728 #1, April 20, 2005 by Phil Schewe and Ben Stein

An Ocean of Quarks

Nuclear physicists have now demonstrated that the material essence of the universe at a time mere microseconds after the big bang consists of a ubiquitous quark-gluon liquid. This huge insight comes from an experiment carried out over the past five years at the Relativistic Heavy Ion Collider (RHIC), the giant crusher of nuclei located at Brookhaven National Lab, where scientists have created a toy version of the cosmos amid high-energy collisions. RHIC is of course not a telescope pointed at the sky but an underground accelerator on Long Island; it is, nevertheless, in effect, a precision cosmology instrument for viewing a very early portion of the universe, a wild era long before the time of the first atoms (which formed about 400,000 years after the big bang), before the first compound nuclei such as helium (about a minute after the big bang), before even the time when protons are thought to have formed into stable entities (ten microseconds).

In our later, cooler epoch quarks conventionally occur in groups of two or three. These groupings, called mesons and baryons, respectively, are held together by particles called gluons---which act as agents for the strong nuclear force. Baryons (such as protons and neutrons), collectively called hadrons, are the normal building blocks of any nucleus. Could hadrons be melted or smashed into their component quarks through violent means? Could a nucleus be made to rupture and spill its innards into a common swarm of unconfined quarks and gluons? This is what RHIC set out to show.

Let's look at what happened. In the RHIC accelerator itself two beams of gold ions, atoms stripped of all their electrons, are clashed at several

Perfect Liquids, Perfect White Papers

- *Quark gluon plasma and color glass condensate at RHIC? The Perspective from the BRAHMS experiment,*
  Nucl.Phys. **A757** (2005) 1-27, nucl-ex/0410020

- *Formation of dense partonic matter in relativistic nucleus-nucleus collisions at RHIC: Experimental evaluation by the PHENIX collaboration,*
  Nucl.Phys. **A757** (2005) 184-283, nucl-ex/0410003

- *The PHOBOS perspective on discoveries at RHIC,*
  Nucl.Phys. **A757** (2005) 28-101, nucl-ex/0410022

- *Experimental and theoretical challenges in the search for the quark gluon plasma: The STAR Collaboration's critical assessment of the evidence from RHIC collisions,*
  Nucl.Phys. **A757** (2005) 102-183, nucl-ex/0501009

Cumulative citations exceed 11,000


Brookhaven National Laboratory search U.S. DEPARTMENT OF ENERGY

RHIC
Brookhaven National Laboratory's Relativistic Heavy Ion Collider

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Contacts: Karen McNulty Walsh, (631) 344-8350 or Peter Genzer, (631) 344-3174

RHIC Scientists Serve Up 'Perfect' Liquid

New state of matter more remarkable than predicted — raising many new questions

Monday, April 18, 2005

TAMPA, FL — The four detector groups conducting research at the Relativistic Heavy Ion Collider (RHIC) — a giant atom "smasher" located at the U.S. Department of Energy's Brookhaven National Laboratory — say they've created a new state of hot, dense matter out of the quarks and gluons that are the basic particles of atomic nuclei, but it is a state quite different and even more remarkable than had been predicted. In peer-reviewed papers summarizing the first three years of RHIC findings, the scientists say that instead of behaving like a gas of free quarks and gluons, as was expected, the matter created in RHIC's heavy ion collisions appears to be more like a *liquid*.

"Once again, the physics research sponsored by the Department of Energy is producing historic results," said Secretary of Energy Samuel Bodman, a trained chemical engineer. "The DOE is the principal federal funder of basic research in the physical sciences, including nuclear and high-energy physics. With today's announcement we see that investment paying off."

Secretary of Energy Samuel Bodman

"The truly stunning finding at RHIC that the new state of matter created in the collisions of gold ions is more like a liquid than a gas gives us a profound insight into the earliest moments of the universe," said Dr. Raymond L. Orbach, Director of the DOE Office of Science.

Also of great interest to many following progress at RHIC is the emerging connection between the collider's results and calculations using the methods of string theory, an approach that attempts to explain fundamental properties of the universe using 10 dimensions instead of the usual three spatial dimensions plus time.

"The possibility of a connection between string theory and RHIC collisions is unexpected and exhilarating," Dr. Orbach said. "String theory seeks to unify the two great intellectual achievements of twentieth-century physics, general relativity and quantum mechanics, and it may well have a profound impact on the physics of the twenty-first century."

Dr. Raymond L. Orbach

The papers, which the four RHIC collaborations (BRAHMS, PHENIX, PHOBOS, and STAR) have been working on for nearly a year, will be published simultaneously by the journal *Nuclear Physics A*, and will also be compiled in a special Brookhaven report, the Lab announced at the April 2005 meeting of the American Physical Society in Tampa, Florida.

These summaries indicate that some of the observations at RHIC fit with the theoretical predictions for a quark-gluon plasma (QGP), the type of matter postulated to have existed just microseconds after the Big Bang. Indeed, many theorists have concluded that RHIC has already demonstrated the creation of quark-gluon plasma. However, all four collaborations note that there are discrepancies between the experimental data and early theoretical predictions based on simple models of quark-gluon plasma formation.

Other RHIC News

- Energy Secretary Moniz Announces 2014 Ernest Orlando Lawrence Award Winners
- U.S.-CERN Agreement Paves Way for New Era of Scientific Discovery
- Sergey Belomestnykh Receives Particle Accelerator Science & Technology Award
- Into the Depths of the Electromagnetic Spectrum
- Giant Electromagnet Arrives at Brookhaven Lab to Map Melted Matter
- Explorations of Quarks and Gluons in *Scientific American*
- Relativistic Heavy Ion Collider Smashes Record for Polarized Proton Luminosity at 200 GeV Collision Energy
- A Tale of Two Colliders, One Thesis, Two Awards—and a Physics Mystery

The Press Event at April 2005 APS Meeting

QM11 in Annecy

Since That Time…

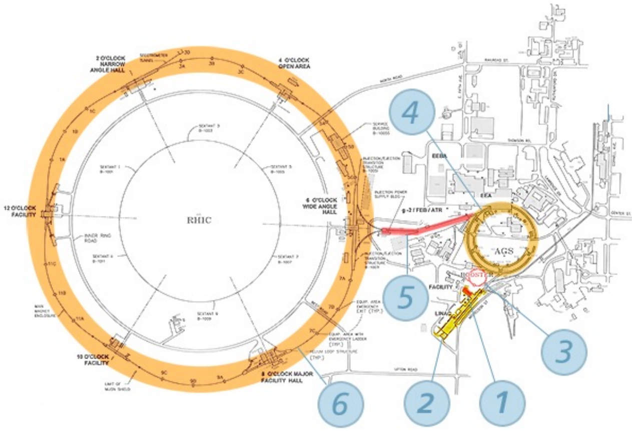
- Flemming's physical insight, calm demeanor, and good humor have served him, STAR, sPHENIX and RHIC science so very well!

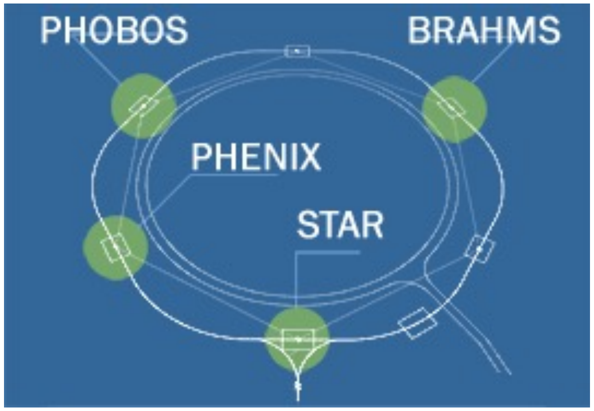
Flemming Videbaek • Physics Department

Flemming Videbaek has had a distinguished career in the field of relativistic heavy ion collisions—the near-light speed collisions of the nuclei of heavy atoms such as gold that scientists use to explore the fundamental building blocks of visible matter and the strong nuclear force. He is receiving a Science and Technology Award for his leadership role in the construction and installation of the Heavy Flavor Tracker upgrade to the STAR experiment at the Relativistic Heavy Ion Collider (RHIC).

Flemming Videbaek

Flemming served as spokesperson of RHIC's BRAHMS experiment, one of the original four RHIC detectors, from its conceptual design in 1991 through its contributions to RHIC's discoveries of jet quenching and the strongly interacting, "perfect" liquid quark-gluon plasma. After joining STAR in 2008, he coordinated the multi-institutional effort to build and install a $15 million silicon detector—the first at a collider to use ultra-thin monolithic active pixel sensors—to track particles made of heavy quarks. He continues to improve the detector's ability to reveal important insight into the properties of the quark-gluon plasma—a top research priority for RHIC.





Flemming, wishing you all the best
in your well-deserved retirement !!!

This work was supported by the United States Department of Energy Grant DOE-FG02-86ER-40281