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High Energy Heavy Ion Experiments

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November 1994

Lawrence Livermore National Laboratory

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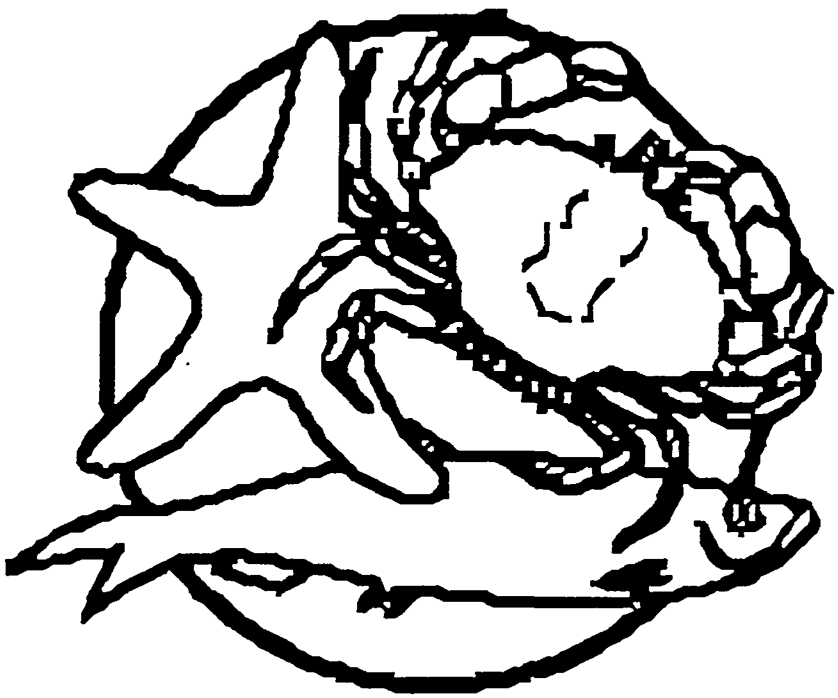
High Energy Heavy Ion Experiments



Eleventh International Conference on
Ultra-Relativistic Nucleus-Nucleus Collisions
9-13 January 1995

Quark Matter '95 Monterey, California, USA

Large Experiments at the Brookhaven AGS

- E802: ^{16}O, ^{28}Si, p
- E859: ^{28}Si
- E866: ^{197}Au
- E810: ^{16}O, ^{28}Si
- E891: ^{197}Au
- E864: ^{197}Au
- E814: ^{16}O, ^{28}Si, p
- E877: ^{197}Au
- E895: ^{197}Au
- E858: ^{28}Si
- E878: ^{28}Si, p, ^{197}Au
- E896: p, ^{197}Au

Small Experiments at the Brookhaven AGS

- E793 (EMU02): ^{28}Si
- E882: ^{28}Si, ^{197}Au
- E806 (WA87): ^{28}Si
- E883: ^{197}Au
- E808 (EMU07): ^{28}Si
- E868 "KLMM": ^{197}Au
- E815 (EMU01): ^{16}O, ^{28}Si
- E863: ^{197}Au
- E819 (NA40): ^{28}Si
- E862: ^{197}Au
- E825: ^{28}Si
- E844: ^{28}Si
- E847 (EMU08): ^{28}Si
- E875: ^{197}Au
- E869 "UHIC": ^{197}Au

Collider Experiments at RHIC

- STAR: ^{16}O, ^{28}Si, p, ^{197}Au
- PHENIX: ^{16}O, ^{28}Si, p, ^{197}Au
- PHOBOS: ^{16}O, ^{28}Si, p, ^{197}Au
- BRAHMS: ^{16}O, ^{28}Si, p, ^{197}Au

Contents

PREFACE

We hope you enjoy this book. It is intended to be a supplement to the presentations at the Quark Matter 95 Conference. The book is pattered on the original document which was edited by Evert Stenlund and was distributed at the QM93 conference. The inside covers of this book contain a block diagram of the major heavy ion experiments at CERN and Brookhaven. The blocks show the family history of each experiment and a summary of the beams provided to the experiments; while relationships between CERN and Brookhaven experiments are indicated in parentheses. The underlined experiment names are included in this book and you can find them by consulting the table of contents.

November 11, 1994
Livermore, California — Jim Thomas
Berkeley, California — Peter Jacobs

ALICE - A Large Ion Collider Experiment

Athens, Bari-Politecnico, Bari-Uni., Beijing, Bergen, Bhubaneswar, Birmingham, Calcutta, Catania, CERN, Chandigarh, Cracow, Dubna, Frankfurt, Geneva, GSI, Heidelberg-MPI, Heidelberg Uni. Jaipur, Jammu, Kharkov, Kiev, Kosice, Legnaro, Lund, Marburg, Minsk, Messina, Moscow INR, Moscow Kurchatov, Moscow ITEP, Nantes-SUBATECH, Novosibirsk, Oak Ridge, Orsay, Oslo, Padua, Prague, Protvino, Rehovot, Rez, Rome, St. Petersburg, Utrecht/NIKHEF, Turin/INFN-HEP, Turin/INFN-NP, Warsaw, Wuhan, Zagreb

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World Wide Web: http://www1.cern.ch/ALICE/welcome.html

Physics Goals:	hadrons, photons, leptons around midrapidity
Beams:	from p to Pb, $\sqrt{s} \approx 6$ TeV/A
Targets:	symmetric systems or equal Z/A

Physics Summary

ALICE is a general purpose experiment planned for the CERN LHC to investigate heavy ion collisions at a c.m. energy of ≈ 6 TeV/A. It will address a majority of the known observables sensitive to QGP formation in final states containing hadrons, di-electrons or photons. It will measure the flavour content and phase space distribution event-by-event and is designed to cope with the highest particle density anticipated for Pb-Pb collisions at the LHC (i.e. $dN/dy_{ch} = 8000$).

Lay-out

- large warm solenoid (e.g. the magnet of the L3 detector at LEP), field > 0.2T
- central acceptance $(90 \pm 45)^\circ$ ($|\eta| < 0.9$) over the full azimuth
- inner tracking system (r = 7.5 - 50cm) with five planes of high resolution detectors (Silicon-pixels, -drift chambers, -strips or MSGC's)
- large central TPC (r = 1 - 2.5m) for tracking and dE/dx
- PID array (r between 3 and 4.5m) of either TOF or RICH detectors
- single arm e.m. crystal calorimeter ($PbWO_4$, r = 6m, area = 25m^2)
- Zero Degree Calorimeter (centrality trigger)
- large acceptance multiplicity array ($|\eta| < 5$)

Under study are an additional muon spectrometer, large acceptance e.m. calorimeters (FEC, NEC, BARC in the figure below) and forward detectors for some specific topics in pp collisions.

Major R&D efforts

- Silicon pixel detectors (CERN RD19)
- Silicon drift chambers (INFN DSI)
- MSGC's (CERN RD28)
- TPC with good double track resolution (CERN RD32)
- fast proximity focusing RICH with solid photo-cathode (CERN RD26)
- TOF: Pestov spark counters, PPC's, cheap PM's
- dense scintillating crystals ($PbWO_4$)

Selected Publications

"ALICE Letter of Intent, CERN/LHCC/93-16", 1st March 1993.

"The ALICE heavy ion experiment at the CERN LHC" J. Schukraft, Nucl. Phys. **A566** (1994) 311c.

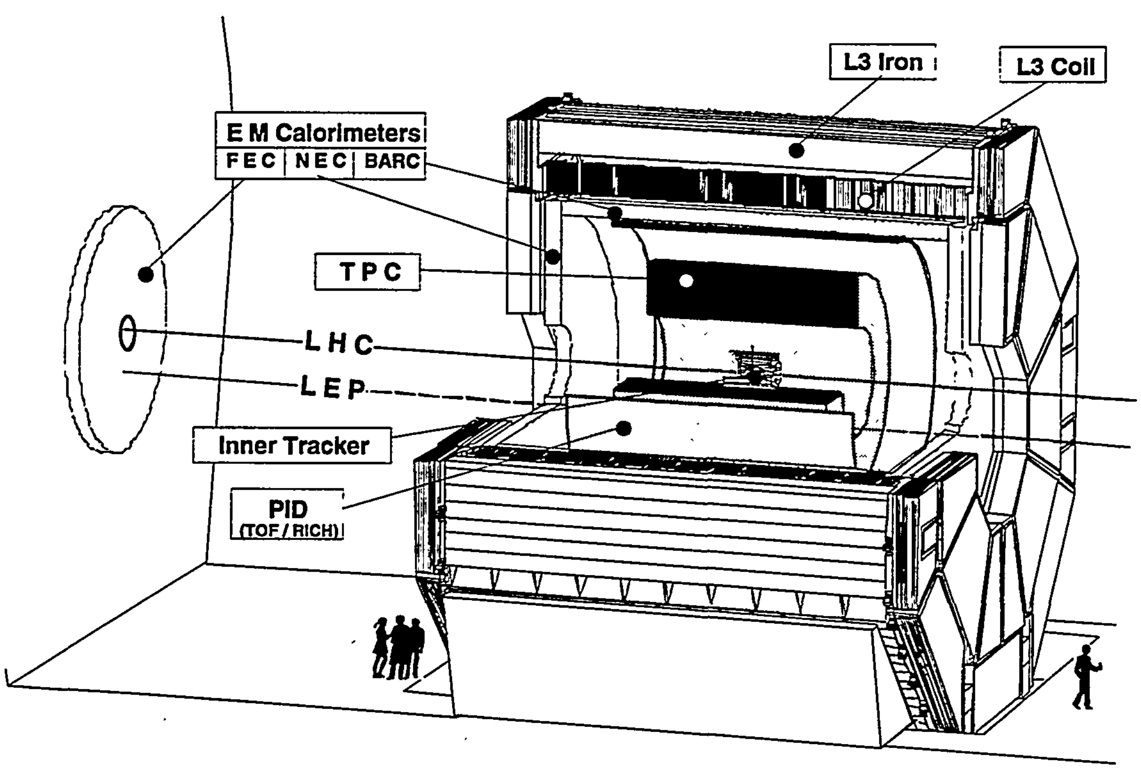

Figure 1: Three-dimensional view of the ALICE detector

The BRAHMS experiment at RHIC

BNL-CRN(Strasbourg)-Beijing-NBIAFG(Copenhagen)
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World Wide Web Home Page
http://rsgi01.rhic.bnl.gov/export1/brahms/WWW/brahms.html

Physics Goals:	Charged hadron spectra in a wide rapidity range
Beams:	Au, Si, p at $\sqrt{s} = 200$ GeV/A

Physics Summary

The BRAHMS experiment at RHIC is designed to measure charged hadrons over a wide range of rapidity and transverse momentum for all available beams and energies. One of the physics goals is to study the reaction mechanism of the relativistic heavy ion reactions at RHIC energies. The properties of stopping will be studied through the net baryon distributions. The expansion and freeze-out characteristics of the hot nuclear system formed in the reaction will be established by studying the spectral shapes and particle abundances. At higher p_t values (1-2.5 GeV/c) the measurements will give insight into the earlier reaction phases through the properties of the hadron spectra at higher p_t values (1-2.5 GeV/c). Some information of space-time properties of system will be obtained from interferometry measurements in a limited rapidity and p_t range. Another goal is to look for evidence of the QGP phase transition as it may manifest itself in the final hadronic stages e.g. through study of the $< p_t >$ dependence with centrality, and the strange particle production via K^+ and K^-, both in the relatively baryon free mid-rapidity region and in the baryon rich fragmentation region.
These goals are achieved using two small solid angle spectrometers which operate from $2^o - 20^o$ and $20^o - 90^o$, respectively. The rapidity range will be from 0 to 4 and the p_t up to 2.5 GeV/c for most of this y range. The centrality of the collisions will be obtained from a multiplicity array.

Selected Publications

"The BRAHMS experiment at RHIC"" F.Videbæk,Nucl.Phys.A566(1994)299c

"Conceptual Design Report for BRAHMS " D. Beavis *et al.*, BNL-1994, unpublished

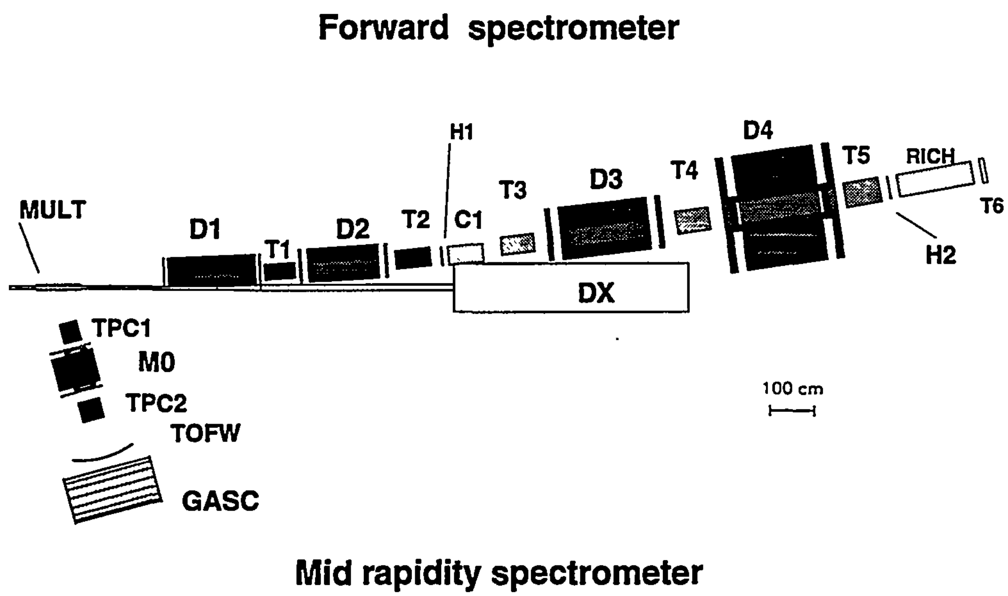

Figure 2: Top View of the BRAHMS Spectrometer

Figure Details

D1 D2 D3 D3	Forward Dipole magnets
T1 T2 T3 T4 T5	Tracking detectors
H1 H2	high resolution TOF Hodoscopes
C1	Segmented Gas Cherenkov
RICH	RICH detector
T6	Back counter for RICH
M0	Mid-rapidity Magnet
TPC1 TPC2	Mid-rapidity TPC's
TOFW	Mid-rapidity TOF-wall with segmentation 225
GASC	Segmented Gas Cerenkov Counter
MULT	Multiplicity detector
DX	RHIC beam line magnet

E793 – Study of Fragmentation and Search for Exotic Particle Production

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Physics Goals:	Study of Fragmentation and Search for Anomalons and Fractional Charges
Beams:	Si at 14.5 A GeV
Targets:	Cu and Pb

Experiment Description

E793 uses CR-39 plastic track-etch detectors to record projectile fragments produced in interactions of ^{28}Si beams with Cu and Pb targets. We exposed two stacks of the plastic detectors interleaved with Cu and Pb targets to a beam of 14.5 A GeV ^{28}Si at a density of ~ 1000 cm^{-2}. Fragments with $Z \geq 6$ were identified in CR-39 detector with a charge resolution of $\sigma_Z \sim 0.14$ charge unit. Data were taken by automatically scanning the sheets with a computer-controlled microscope and using automated image-processing techniques to fit the ellipses to the intercepts of etchpit mouths with the surfaces.

Physics Summary

In this series of experiments, we studied charge-changing interactions for 14.5 A GeV ^{28}Si and secondary beams. We searched for anomalons with extremely short mean-free-path and fractionally charged composites.

1. Study of Fragmentation Processes

We studied interactions of nuclear breakup, electromagnetic dissociation, and nuclear charge pickup for 14.5 A GeV ^{28}Si beams. We also measured the cross sections for fragmentation of secondary beams with $6 \leq Z \leq 14$. In addition, we measured the transverse momentum distribution of projectile fragments produced in interactions of 14.5 A GeV ^{28}Si with Cu and Pb targets.

2. Search for Composites with Anomalously Short Mean-Free-Path

We conducted a search for anomalons with extremely short mean-free-path which might be created in collisions of 14.5 A GeV ^{28}Si with Cu and Pb targets. Stringent limits were placed on the production cross section for objects with anomalously short mean-free-path.

3. Search for Fragments with Fractional Charges

We also searched for fractionally charged composites among projectile fragments. An upper limit was placed on the production cross section for composited fragments with factional charges.

Selected Publications

"Interactions of projectile fragments at 14.5 A GeV: A search for anomalons", Y. D. He, P. B. Price, and W. T. Williams, Phys. Lett. B **252** (1990) 331–335.

"Behavior of nuclear projectile fragments produced in collisions of 14.5 A GeV ^{28}Si with Pb and Cu targets", P. B. Price and Y. D. He, Phys. Rev. C **43** (1991) 835–848.

"Search for fractional charge states in high-energy heavy fragments produced in relativistic heavy-ion collisions", Y. D. He and P. B. Price, Phys. Rev. C **44** (1991) 1672–1674.

Related Experiments

E882

E802 - Particle Production at Extreme Baryon Densities

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UC Berkeley(SSL)-UC Riverside-Tokyo

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World Wide Web Home Page: http://suntid.bnl.gov:8080/bnl.html

Physics Goals:	Inclusive spectra with global event characterization
Beams:	Si, O, p at 14.5 GeV/A
Targets:	Al, Cu, Ag, Au

Physics Summary

E802 measures semi-inclusive double differential particle cross sections with global event characterization to find consequences of the high baryon densities produced in nucleus-nucleus reactions. Beams of ^{28}Si, ^{16}O, and p are used at a momentum of 14.5 GeV/c per nucleon from the BNL AGS on targets of Al, Cu, Ag, and Au. Particle spectra for p, $\pi^{\pm}$, $K^{\pm}$, and pbar are measured in a magnetic spectrometer and particle identification is done with Cerenkov and time of flight counters in the approximate interval $0.5 \leq y \leq 2.1$. The experiment also has three gobal variable characterizing detectors: the Target Multiplcity Array, the ZCAL forward energy calorimeter, and the lead glass neutral energy array which can be used alone or in conjunction with each other to measure their correlations. In addtion, these detectors can be used to restrict the spectrometer data by providing centrality or peripherality cuts on the multiplicity, the forward going energy, and neutral transverse energy. Some 2-π correlation data were also obtained.

Selected Publications

"A Single Arm Spectrometer Detector System for High Energy Heavy Ion Experiments", T. Abbott *et al.*, Nucl. Instrum. Meth. A **290** (1990) 41-60.

"Kaon and Pion Production in Central Si+Au Collisions at 14.6 GeV/c", T. Abbott *et al.*, Phys. Rev. Lett., **64** (1990) 847-850.

"Bose-Einstein Correlations in Si+Al and Si+Au Collisions at 14.6 GeV/c", T. Abbott *et al.*, Phys. Rev. Lett., **69** (1992) 1030-1033.

"Azimuthal Asymmetries of Particles Emitted in Relativistic Heavy-Ion Collisions", T. Abbott *et al.*, Phys. Rev. Letts **70** (1993) 1393-6.

"Intermittency Central Collisions of ^{16}O+A at 14.6A GeV/c" T. Abbott *et al.*, Phys. Letts. B (accepted).

"Charged Hadron Distributions in Central and Peripheral Si+A Collisions at 14.6 A·GeV/c" T. Abbott *et al.*, Phys. Rev. C **50**, (1994) 1024-47.

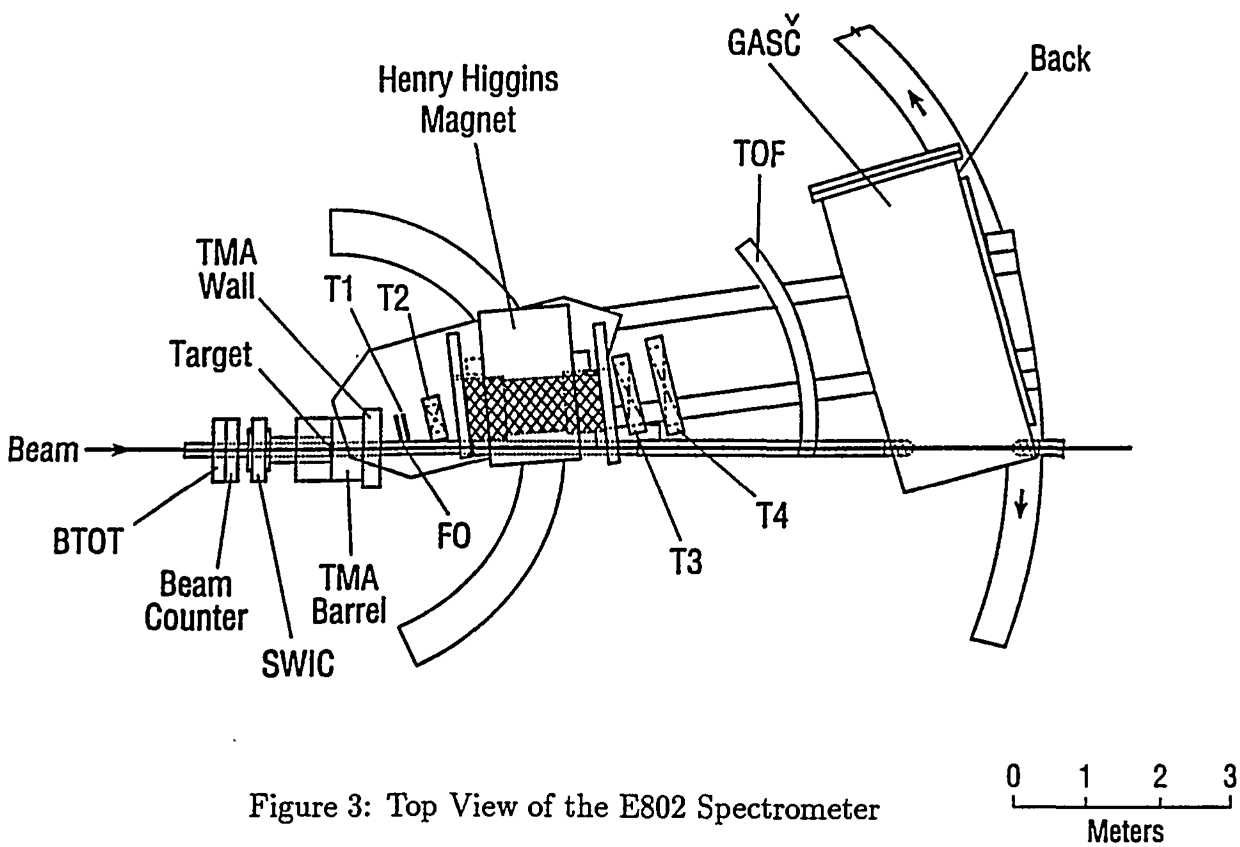

Figure 3: Top View of the E802 Spectrometer

Figure Details

UDEW, BTOT, BVETO	Beam Counters (not all shown)
TMA Wall and Barrel	Target Multiplicity Array
PBGL	Lead Glass Array (not shown)
ZCAL	Zero Degree Calorimeter (not shown)
T1, T2, T3, T4	Drift Chambers
TOF	Time of Flight Wall with 160 elements
GASC and Back	Segmented Gas Cerenkov Counter with Back Pad Chamber
CC	Cerenkov Complex for Particle ID at high p (not shown)
SWIC	Beam Diagnostic Ion Chamber

Related Experiments

E859, E866

E814 - Study of Fragmentation and Transverse Energy and Particle Production in Ultrarelativistic Nuclear Collisions

BNL-GSI-McGill-Albuquerque-Pitt-São Paulo-Stony Brook-Wayne State-Yale

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Physics Goals:	Particle spectra with emphasis at low p_t with global event characterization
Beams:	Si, O, p at 14.6 AGeV
Targets:	Al, Cu, Sn, Pb

Physics Summary

E814 peripheral collision studies included measurements of projectile fragmentation and projectile inelastic scattering with about 1 MeV excitation energy resolution, demonstrating the importance of the giant dipole resonance for these phenomena. Central collision studies included measurements of the distribution of E_t and charge particle multiplicity and studies of associated baryon and meson spectra with emphasis on low to intermediate transverse momenta. These data were used to demonstrate the large degree of stopping achieved in the collisions. Furthermore, the size and resonance content of the fireball formed in the collisions were determined by measurements of particle-particle correlations, and by precise studies of the shape of pion spectra at low p_t.

Selected Publications

Energy Flow and Stopping in Relativistic Heavy Ion Collisions at Elab/A=14.6 GeV, J. Barrette et al. the E814 Collaboration, Phys. Rev. Lett. 64(1990)1219

Baryon Distributions in Ultra-Relativistic Nucleus-Nucleus Collisions, J. Barrette et al., the E814 Collaboration, Z. Physik C59(1993)211

Measurement of Transverse Energy Production in Reactions with Si and Au Beams at Relativistic Energy: Towards Hot and Dense Hadronic Matter, J. Barrette et al., the E814/E877 collaboration, Phys. Rev. Lett. 70(1993)2996

J. Barrette et al., the E814 collaboration, Evidence for Expansion of a Hot Fireball from Two-Pion Correlations for Si+Pb Collisions at AGS Energy, Phys. Lett.

B333(1994)33

Electromagnetic Dissociation of Relativistic ^{28}Si into $p+^{27}Al$, J. Barrette et al, The E814 Collaboration, Phys. Rev. C45(1992)2427

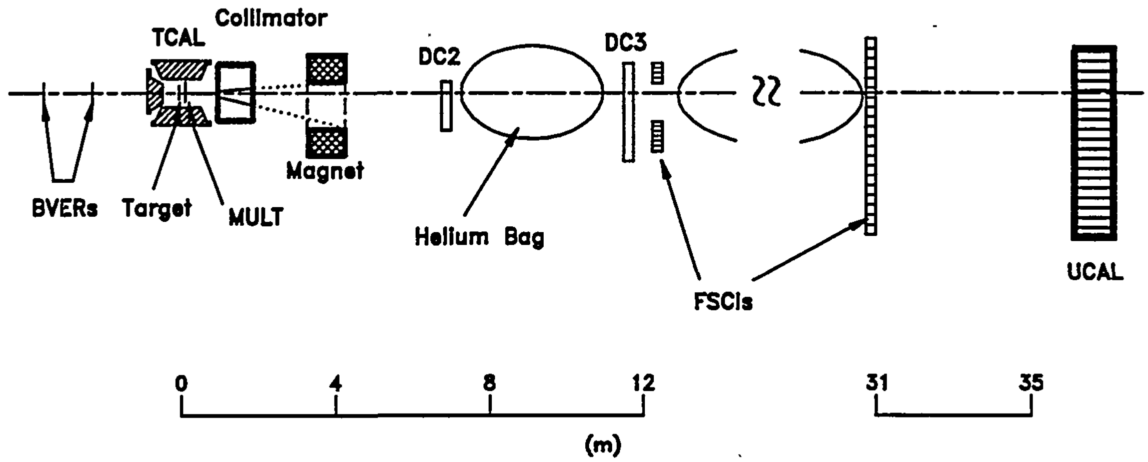

Figure 4: Top View of the E814 Detector

Figure Details

BVER	Beam Vertex Detector
TCAL	Target Calorimeter
PCAL	Participant Calorimeter
DC2/3	Drift/Pad Chambers
MWPC	Multi-wire Proportional Chambers
FSCI	Scintillator Hodoscopes
UCAL	Uranium Calorimeters

Related Experiments

E877

E844 - Measurement of Angular Distributions for Fragments in the Target Rapidity Region

Brookhaven National Labortory and Oregon State University

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Physics Goals:	Multi-fragmentation Angular Distributions ^{37}Ar, ^{127}Xe
Beams:	Si at 14.5 GeV/c
Targets:	Au

Physics Summary

Angular distributions have been measured for typical light (Ar-37) and heavy (Xe-127) products from the fragmentation of gold by 13.6-GeV/nucleon Si-28 ions. Preliminary results from the April 1992 running period are compared with existing data at Bevalac energies in the accompanying figure. Projectile rapidity, y, rather than its mass is expected to be the dominant variable determining the shape of a distribution. The E844 results, shown as filled points, indicate only small changes in the Xe-127 angular distribution between y=1.85 and y=3.44, consistent with the hypothesis of limiting fragmentation. In contrast, those for Ar-37 suggest a significantly increased supression of fragments at forward angles for the y=3.44 projectile. These results confirm the integral F/B measurements of AGS E-825 which indicated an enhanced "backsplash" for light multifragmentation products which was not expected on the basis of existing studies of p-nucleus collisions up to 400 GeV or of nucleus-nucleus interactions at Bevalac energies. Unfortunately, technical problems led to loss of some E844 data, particularly for Ar-37 at forward angles, and additional measurements are anticipated.

Selected Publications

"Unusual Backward Emission of Multi-Fragmentation Products in Ultra-Relativistic Nucleus-Nucleus Collisions", W. Loveland, K. Alkelett, M. Bronikowski, Y.Y. Chu, J.B. Cumming, P.E. Haustein, S. Katcoff, N.T. Porile, and L. Sihver, Phys. Rev. **C37**(1988)1311-1313.

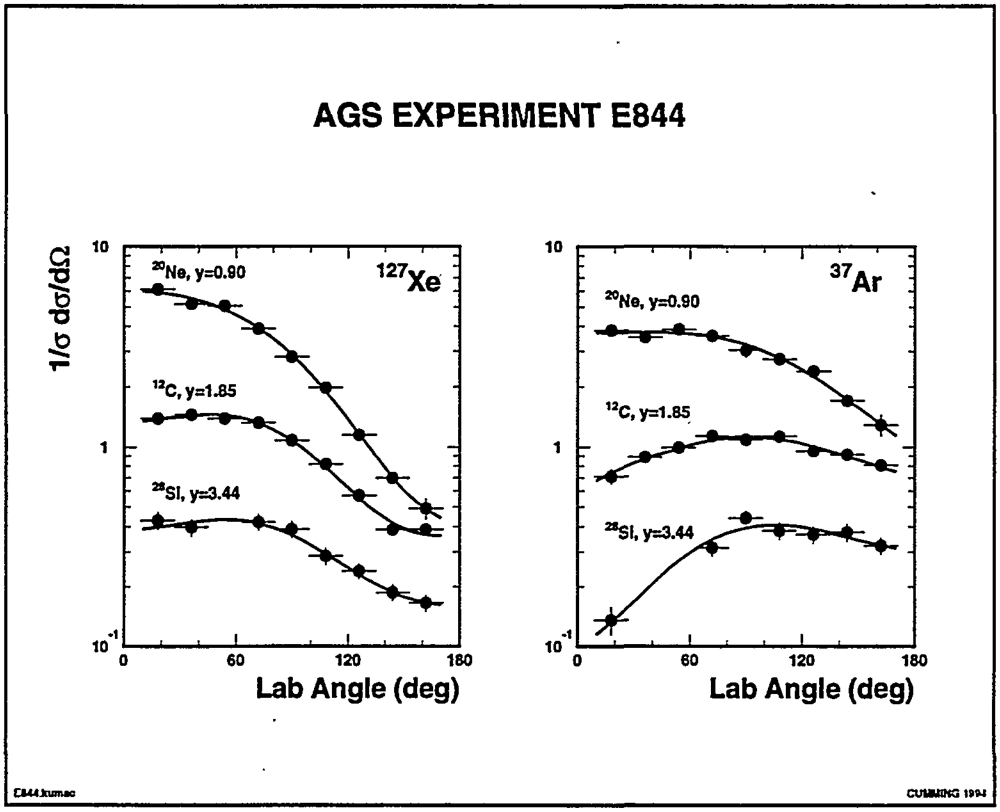

Figure 5: Evolution of angular distributions of Xe-127 and Ar-37 from the fragmentation of gold by heavy ions as a function of projectile rapidity, y. Filled points from AGS experiment E-844 are compared with existing data at Bevalac energies. Smooth curves indicate general trends. Note that the upper and lower data sets for each product are displaced by a factor of three from central set to simplify the display.

Related Experiments

E825

E858-Study of Negative Particle Production near Zero degrees

Brookhaven National Laboratory, Columbia University,
University of California at Berkeley-Space Science Laboratory,
University of California at Los Angeles,
KEK-PS Department, Johns Hopkins University,
Lawrence Berkeley Laboratory, Louisiana State University
University of Tokyo, Waseda University

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Physics Goals:	Investigate antideuteron and rare particle production
Beams:	Si at 14.7 A GeV/c
Targets:	Au, Al, Cu

Physics Summary

AGS experiment E858 is a study of negative particle production near zero degrees from Si+A targets designed to measure the production cross section of antideuterons. 106 hours of 14.7 A GeV/c Si beam were taken in June 1990 on targets of Al, Cu, and Au and the negative rigidities were scanned from 1.5 GV to 8.4 GV using the A1 beam line as a spectrometer. Over 10^8 π^- were integrated in the spectrometer at each of five settings for the Au target, leading to new sensitivity limits on the production of new particles. The π^-, K^-, and $\overline{p}$ rigidity spectra were measured to statistical accuracies of better than 1% for Si+Au and to 3% for the Al and Cu targets. The results showed a significant depletion of the $\overline{d}$ compared to a simple coalescence calculation based on the measured $\overline{p}$ spectrum. The results from this experiment also included the first π^- measurements from heavy ion collisions at rapidities bracketing the beam rapidity.

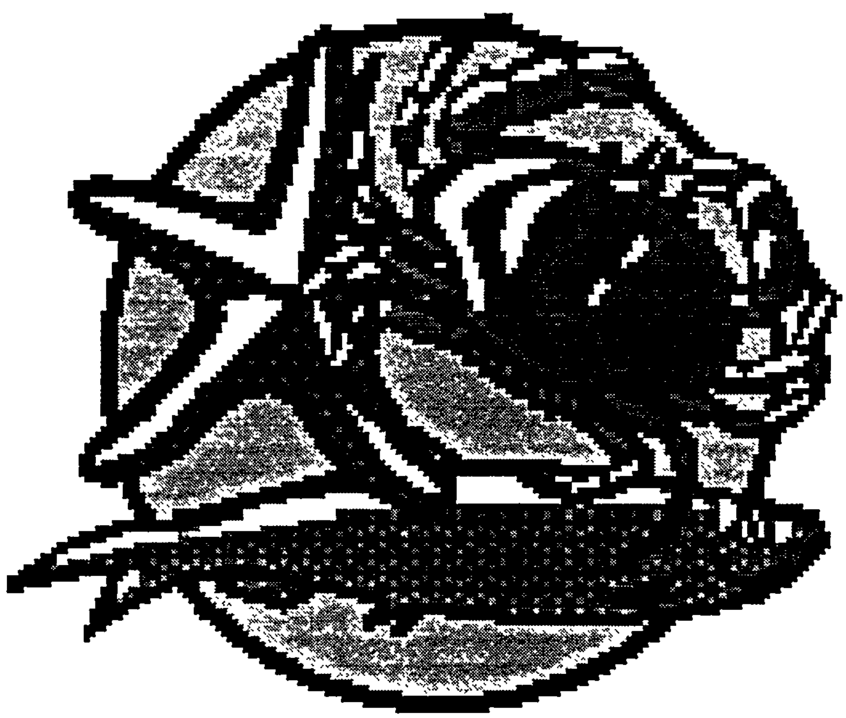
Selected Publications

"$\overline{p}$ and $\overline{d}$ Production in Relativistic Heavy Ion Collisions: Results of BNL-E858" Paul Stankus for E858 collaboration, Nuc.Phys.A 544, 603c (1992).

"Measurements at 0° of Negatively Charged Particles and Antinuclei Produced in Collision of 14.6 A GeV/c Si on Al, Cu, and Au Targets" M.Aoki et al., PRL 69, 2345 (1992).

Related Experiments

E864, E878, E886, E896



E859 - Extended Measurements of Particle Momentum Distributions and Two Particle Correlations

ANL-BNL-Columbia-INS(Tokyo)-Kyoto-Kyushu-LLNL
MIT-NYU-UC Berkeley(SSL)-UC Riverside-Tokyo-Tsukuba

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World Wide Web Home Page: http://suntid.bnl.gov:8080/bnl.html

Physics Goals:	Inclusive spectra, two-particle correlations
Beams:	Si at 14.5 GeV/A
Targets:	Al, Cu, Ag, Au

Physics Summary

E859 extends the semi-inclusive particle cross section measurements of E802 over a larger kinematic range, and to include rare particles. High precision two-particle correlation measurements are also performed. This is accomplished by the addition of a second-level trigger for online momentum determination and particle identification to the E802 magnetic spectrometer. Also, a set of Phoswich scintillator detectors are added for semi-inclusive cross sections measurements in the target rapidity region.

Selected Publications

"Bose-Einstein Correlations of Kaons in Si+Au Collisions at 14.6A GeV/c", Y. Akiba *et al.*, Phys. Rev. Lett., **70** (1993) 1057-60.

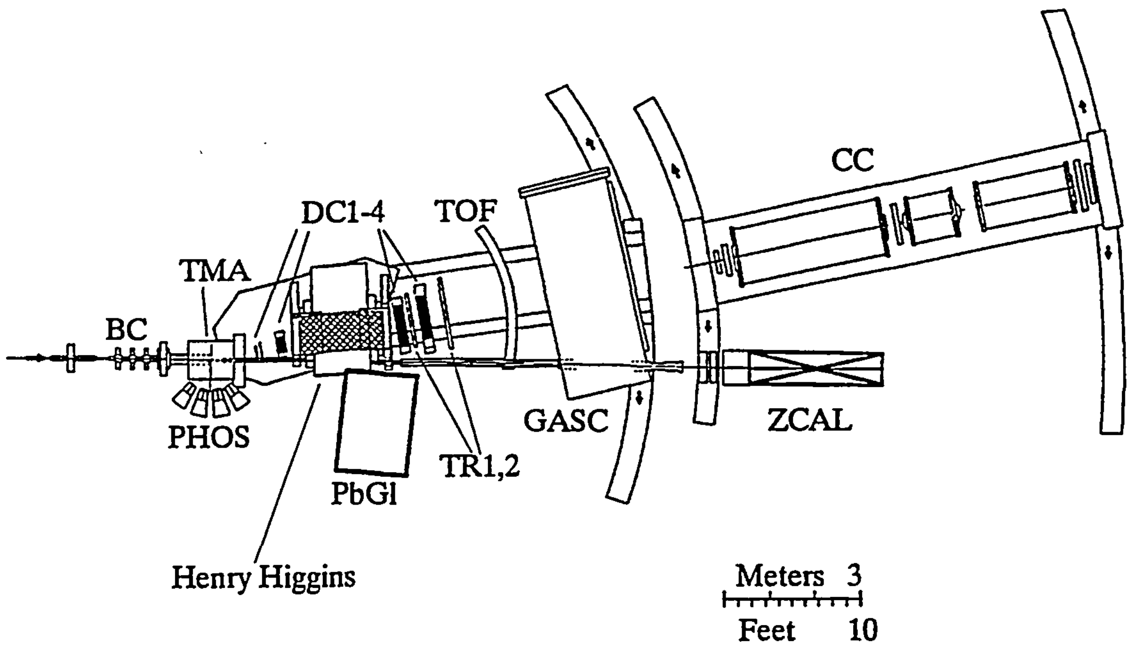

Figure 6: Top View of the E859 Apparatus

Figure Details

BC	Beam Counters
TMA	Targe Multiplcity Array
PHOS	Phoswich Array
Henry Higgins	Spectrometer Magnet
PBGL	Lead Glass Array
ZCAL	Zero Degree Calorimeter
DC1-4	Drift Chambers
TR1,2	Trigger Wire Chambers
TOF	Time of Flight Wall
GASC	Segmented Gas Cerenkov Counter
CC	Cerenkov Complex for Particle ID at High p

Related Experiments

E802, E866

E862 - Electromagnetic Dissociation of Co-59 and Au-197 by Au-197

BNL-Iowa State

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Physics Goals:	Electromagnetic dissociation cross sections
Beams:	Au at 10.2 GeV/A
Targets:	Co, Au

Physics Summary

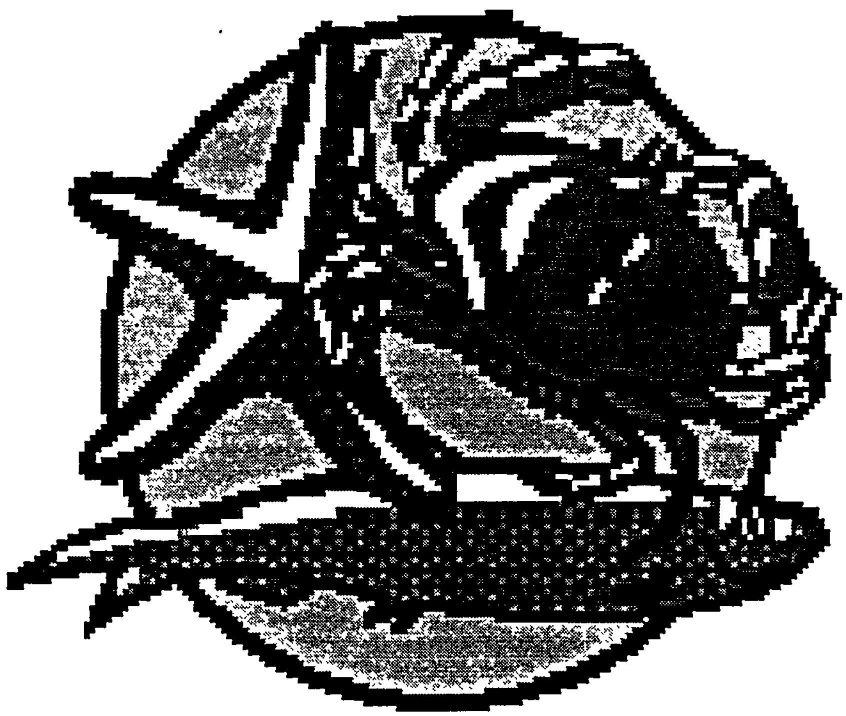
The purpose of E862 is to measure the electromagnetic dissociation (ED) cross sections for the one- and two-neutron removal reactions of 10.2 GeV/nucleon Au beams from the BNL AGS on targets of Co and Au. ED is a process occurring when relativistic heavy ions interact by an exchange of virtual photons. The usual result is the excitation of an E1 or E2 giant resonance. For heavy nuclei the most common mode of deexcitation is by the emission of one or more neutrons. The ED process is expected to become of the order of 60 barns for the colliding Au beams expected for RHIC and is the primary process leading to the degradation of RHIC beams. In the experiment Au and Co targets of several thicknesses were bombarded in the Au beam. Yields of nuclides of interest were measured using gamma-ray spectroscopy. In a low intensity run the beam particles were counted using a simple 2-element telescope. The measured Au one-neutron removal cross section was then used as an internal standard to measure other cross sections. Data taking is complete and data analysis is in progress.

Selected Publications

"Electromagnetic Dissociation by a 10.2 GeV/n Au Beam", L. Ewell *et al.*, Bull. Amer. Phys. Soc., **39** (1994) 1196.

Related Experiments

E819



E864 - Rare Composite Objects and Novel Forms of Matter

BNL-Iowa State-Ames(ISU)-Massachusetts(Amherst)-MIT-Penn State
Purdue-Yale-Wayne State-U Bari(Italy)

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World Wide Web Home Page:
file://osf.physics.yale.edu/www_info/e864/doc.index.html

Physics Goals:	Strangelets, Anti-matter & High Mass States
Beams:	Au at 14.5 GeV/A
Targets:	Al, Cu, Pb

Physics Summary

High acceptance, high sensitivity study of massive (mass $\geq$ 4 GeV) states produced in high energy Au-Au collisions. Includes searches for strangelets, measurements of known nuclear states, and measurements of antimatter. The design sensitivity for strangelets is 3x 10^{-11} of the total interaction cross section. The sensitivity for nuclear states should allow measurements of coalescence yields up to mass 14 and the sensisitivity for antimatter should allow observation of mass 3.

Selected Publications

[Technical reports in preparation.]

Related Experiments

BNL E814, BNL E878, BNL E886, CERN NA52

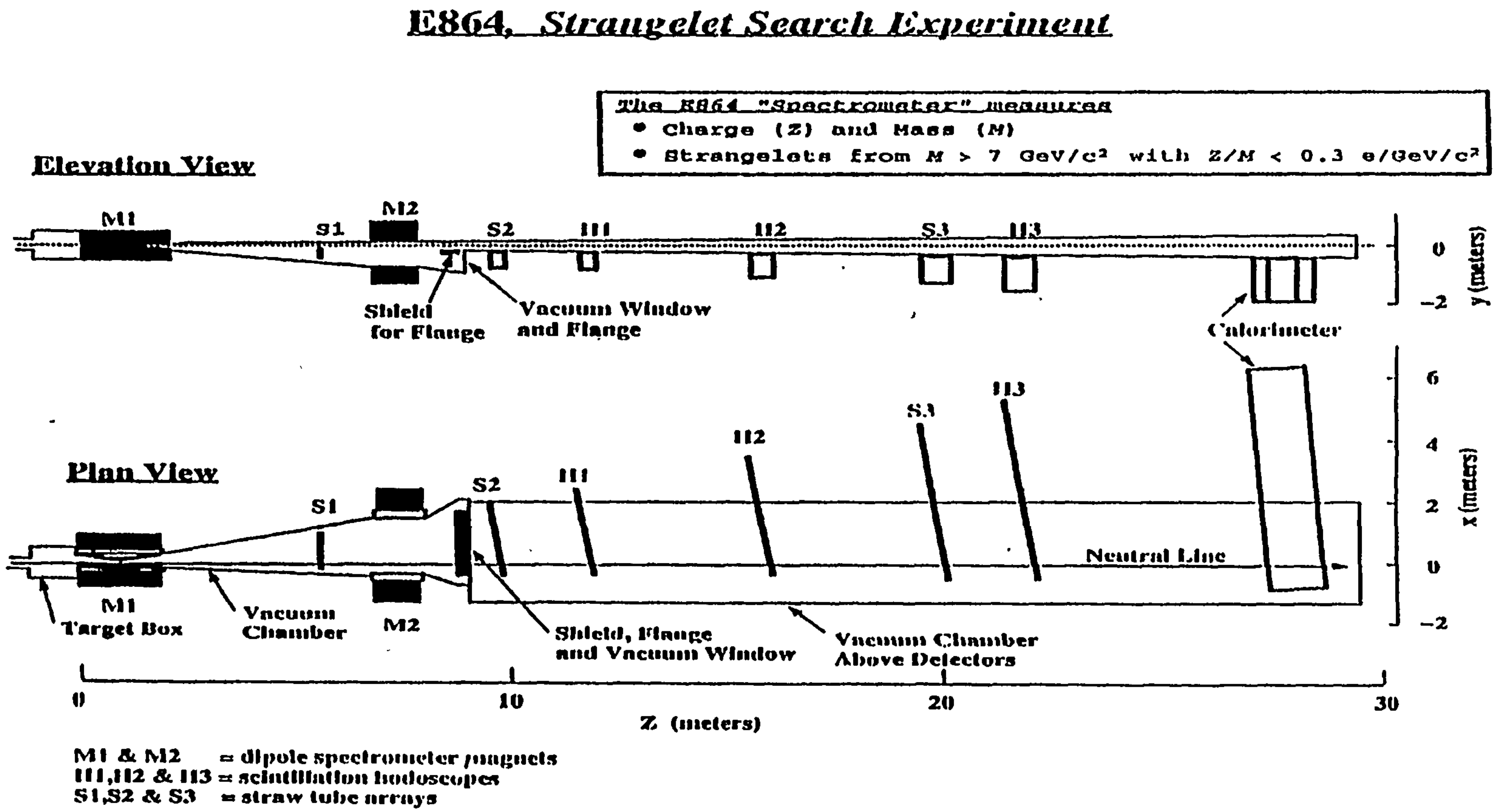

Figure 1: Top View of the E864 Spectrometer

E866 - Particle Production at High Baryon Densities Using the Au Beam

ANL-BNL-Columbia-Hiroshima-INS(Tokyo)-Kyushu-LLNL-MIT-
NYU-UC Berkeley(SSL)-UC Riverside-Tokyo

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World Wide Web Home Page: http://suntid.bnl.gov:8080/bnl.html

Physics Goals:	Inclusive spectra with global event characterization
Beams:	Au at 11.5 GeV/A
Targets:	Al, Cu, Ag, Au

Physics Summary

Experiment 866 is an extension of E802/E859 for use with the Au beam at the BNL AGS. As with the previous experiments, its scientific goals are semi-inclusive particle spectra and 2-particle correlations with centrality cuts. It uses the E802/E859 spectroemter for $20° < \theta < 60°$ where the multiplicity with the Au beam is similar to that for the Si beam. In the forward direction, a new small spectrometer is being built to cover the high multiplicity region $6° < \theta < 20°$. The phoswich detector has been extended to somewhat beyond the target rapidity region with increased segmentation.

Experiment 866 had its first gold beam in the spring of 1992. That run together with the 1993 shakedown run has provided preliminary data on p, $\pi^{\pm}$, $K^{\pm}$ inclusive spectra and neutral transverse energy distributions.

Selected Publications

"Global Transverse Energy Distributions in Si+Al, Au at 14.6*A* GeV/c and Au+Au at 11.6*A* GeV/c", Phys. Letts. **B332** (1994) 258-264.

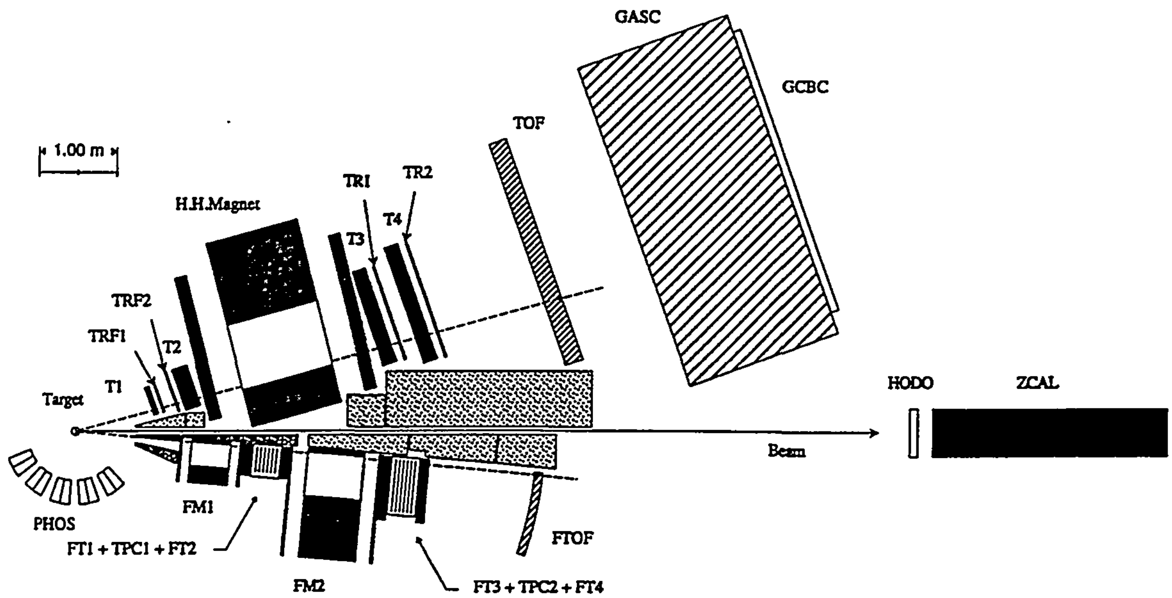

Figure 8: Top View of the E866 Spectrometer

Figure Details

PHOS: Phoswich Array
HODO: Hodscope Array
ZCAL: Zero Degree Calorimeter

Upper Spectrometer: E802/859 Spectrometer for use $20° < \theta < 60°$
T1,T2,T3,T4: Drift Chambers
TRF1,TRF2,TR1,TR2: MWPC
TOF: Time of Flight Wall
GASC and GASCBC: Segmented Cerenkov Counter and Back Pad Chamber
HH: Spectrometer Magnet

Lower Spectrometer: New Forward Spectrometer for use $6° < \theta < 20°$
FT2,FT2,FT3,FT4: Drift Chambers
TPC1,TPC2: Time Projection Chambers
FTOF: Time of Flight Wall
FM1,FM2: Spectrometer Magnet

Related Experiments

E802, E859

BNL Exp 868 Multifragmentation of 10.6 AGeV gold nuclei

U. of Minnesota, LSU, Krakow, Moscow
(The KLMM collaboration)

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Co-Spokesperson: W. Wolter
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Physics Goals:	Inclusive study of interactions of gold nuclei in emulsions
Beams:	Au at 10.6 GeV/A
Targets:	Emulsion; H, C, N, Ag, Br

Physics Summary

Exp 868 consisted of the exposure of a number of stacks of nuclear emulsions to the 10.6 AGeV gold beam. The incident nuclei were aligned paralllel to the plane of the emulsions and their tracks were thus confined to a single pellicule. Interactions were located by along the track scanning and a mean free path consistent with that deduced from the results of Exp 869 was determined. The resulting sample of some 1000 interactions has minimal bias and can be compared with similar results obtained at lower energies. For each interation it was possible to determine the number and charge of all the fragments heavier than helium emitted, the numbers of alpha particles, the number of fast singly charged particles, and the number of slow particles emitted from the target. The angles of emission could be measured with high precision and hence the pseudorapidities determined.

Selected Publications

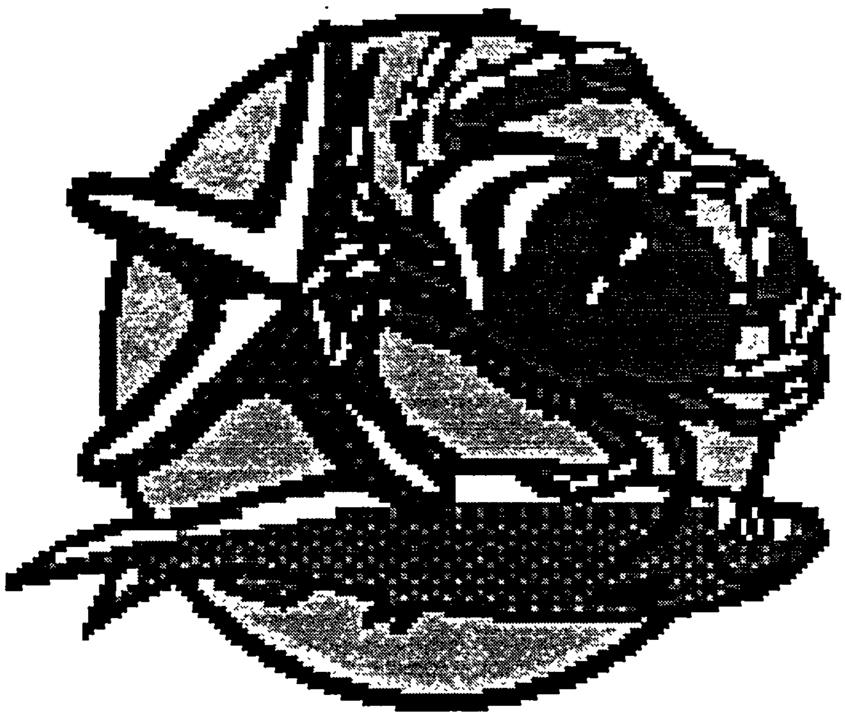
"Interactions of 10.6 GeV/nucleon gold nuclei in nuclear emulsion", M. L. Cherry *et al.*, Z. Phys. C **62**, 25 – 29 (1994)

"Some preliminary results from the new 10.6 GeV/nucleon gold beam at Brookhaven", C. Jake Waddington, Int. J. Mod. Phys. E **2**, 739-766 (1993).

"Particle production and fragmentation processes in heavy ion interactions in emulsion", R. Holynski, Nucl. Phys. A **556**, 191c (1994).

Related Experiments

EMU-07



The Production of Leading Fragments by Heavy Nuclei

U. Minnesota - Washington U., St Louis - Caltech
UHIC Collaboration

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Physics Goals:	Production of heavy fragment nuclei in many targets
Beams:	Kr,Ag,Xe,La,Ho and Au at 0.5-1.4A GeV
	Au at 10.6 A GeV
Targets:	H, CH2, Li, C, Al, Cu, Sn, Pb.

Physics Summary

An array of plastic Cherenkov counters, parallel plate ion chambers and MWPCs has been used to study the interactions of numerous beams of heavy relativistic ions in a wide variety of targets. The charges of nuclei incident on the array have been verified in detectors placed in front of an automated target changer. Incident nuclei and produced heavy fragments from the targets are examined by the downstream detectors. These measure signals that depend on the sum of the squares of the charges of all the particles produced in an interaction. So long as there is a "leading" fragment, with a charge that is not more than 20 to 30 charges less than that of the projectile, its charge is determined uniquely. The charge resolution obtained from the Č and I detectors is between 0.12 and 0.16 of a charge unit, which is even adequate to resolve the very small number of nuclei undergoing charge pickup from the very large number of incident nuclei that do not interact. Basically similar versions of this array have been used to exmine the interactions of the projectiles listed above in some or all of the listed targets. Some 2100 partial cross sections for the production of heavy fragments have been determined.

Selected Publications

"Charge-pickup by heavy relativistic nuclei", B. Ṡ. Nilsen *et al.*, Phys.Rev. C **50**, 1065-1076 (1994).

"Some preliminary results from the new 10.6 GeV/nucleon gold beam at Brookhaven", C. Jake Waddington, Int. J. Mod. Phys. E **2**, 739-766 (1993).

"Determination of the cross sections for the production of fragments from relativistic nucleus-nucleus interactions, Parts I and II", J. R. Cummings *et al.*, Phys. Rev. C **42** 2508 and 2530 (1990)

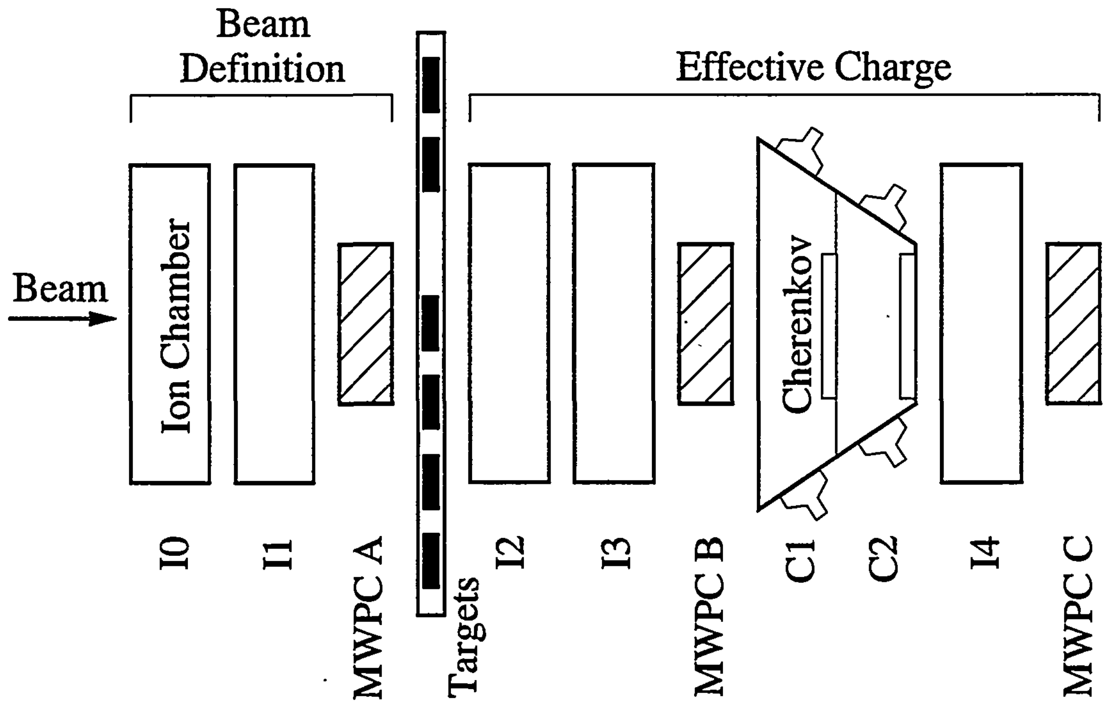

Figure 9: Schematic diagram of the detector array used in Exp. 869 at BNL to study high energy gold nuclei. Five ion chambers, I-0 to I-4, and two Cherenkov counters C-1 and C-2 were interspaced with three multiwire proportional counters, MW. Targets were moved in and out of the beam by the target holder

Related Experiments

HEAO-C3

EMU08/E847/E875 - Particle Production

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Physics Goals:	Particle production at relativistic energies
Beams:	^{32}S and ^{16}O at 200A GeV
	^{16}O at 60A GeV (EMU08)
	^{28}Si at 14.5A GeV (E847)
	^{197}Au at 10.6A GeV (E875)
Targets:	H, C, N, O, Ag, Br (emulsion)

Physics Summary

We investigated the multifragmentation of ^{197}Au at 10.6A GeV in nuclear emulsion. A power-law behavior has been found in the charge distribution of fragments with $Z = 1 - 25$. A rise and fall in the average multiplicity of IMFs is also observed in the data. Two independent souces of helium particles are found through the study of their transverse momenta (P_t): one source with low P_t and the other one with high P_t. The high P_t helium particles should give rise to a bounce-off effect, and consequently the flow of nulear matter at AGS energy. This is what is exacly found in for the fragments of charge $Z \geq 2$ in ^{197}Au-emulsion collisions using the technique of azimuthal correlation function of particle pairs.
Through the technique of multifractal G_q moments, we studied the dynamical fluctuations of produced shower particles in ^{197}Au-emulsion interactions. Multifractal structures are revealed in these data. The results are compared with those of ^{32}S and ^{28}Si data obtained from SPS and AGS, respectively. For the ^{197}Au and ^{28}Si ions, an interesting observation, known as the squeeze-out effect, has been made from the azimuthal angle distributions of charged pions with respect to the reaction plane as determined by the projectile fragments of charge $Z \geq 2$. We did not find this effect for the ^{32}S beam at 200A GeV from the SPS.

Selected Publications

"Intermediate-Mass-Fragment Emission by ^{197}Au Projectile at Relativistic Energy in Nuclear Emulsion" P. L. Jain, G. Singh and A. Mukhopadyay, Phys. Rev. C, August 1994.

"Production of Helium Fragments in ^{197}Au-Emulsion Collisions at 10.6A GeV" G. Singh and P. L. Jain, Z. Phys.**A4** (1994) 99-104.

"Collective Flow by the Azimuthal Correlation of Projectile Fragments in Relativistic Heavy Ion Collisions" G. Singh and P. L. Jain, Phys. Rev. **C49** (1994) 3320 -3323.

"Squeeze-out of Pion Emission in Relativistic Heavy-Ion Collisions" P. L. Jain and G. Singh, Mod. Phys. Lett. **A9**, (1994) 1445-1452.

"Nuclear Collectice Flow in ^{197}Au-Emulsion Interactions at 10.6A GeV" P. L. Jain, G. Singh and A. Mukhopadyay, submitted 1994.

E877 - Study of Transverse Energy and Particle Production in Ultrarelativistic Au+Au Collisions

BNL-GSI-INEL Idaho-McGill-Pitt-São Paulo-Stony Brook-Wayne State

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Physics Goals:	Flow, particle spectra and correlations with global event characterization
Beams:	Au at 11.4 A GeV
Targets:	Al, Cu, Au, U

Physics Summary

E877's physics goals include measurements of the distribution of E_t and charge particle multiplicity and studies of associated baryon and meson spectra with emphasis on low to intermediate transverse momenta. With the calorimetry both the centrality and the reaction plane can be identified on an event by event basis. Therefore, particle transverse momentum spectra can be measured with respect to the reaction plane. Furthermore, the size, lifetime and resonance content of the fireball formed in the collisions is determined by measurements of particle-particle correlations, and by precise studies of the shape of pion spectra at low p_t. Finally, a search is made for signals of possible chiral symmetry restoration during the collision through measurements of K^+ and K^- transverse momentum spectra at low p_t.

Selected Publications

Measurement of Transverse Energy Production in Reactions with Si and Au Beams at Relativistic Energy: Towards Hot and Dense Hadronic Matter, J. Barrette et al., the E814/E877 collaboration, Phys. Rev. Lett. 70(1993)2996

J. Barrette et al., the E877 collaboration, Observation of Anisotropic Event Shapes and Transverse Flow in Au+Au Collisions at AGS Energy, Phys. Rev. Lett. (October 1994)

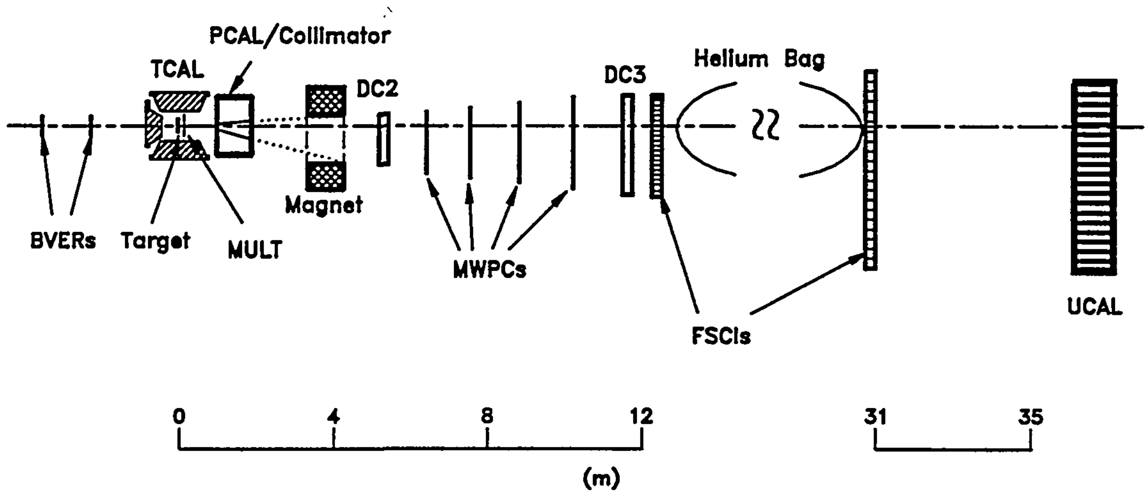

Figure 10: Top View of the E877 Detector

Figure Details

BVER	Beam Vertex Detector
TCAL	Target Calorimeter
PCAL	Participant Calorimeter
DC2/3	Drift/Pad Chambers
MWPC	Multi-wire Proportional Chambers
FSCI	Scintillator Hodoscopes
UCAL	Uranium Calorimeters

Related Experiments

E814

E878-Investigation of Antinucleus Production and a Search for New Particles in Nucleus-Nucleus Collisions at the AGS

Brookhaven National Laboratory, Columbia University,
University of California at Berkeley/Space Science Laboratory,
University of California at Los Angeles,
KEK-PS Department, Johns Hopkins University,
Lawrence Berkeley Laboratory, University of Tokyo,
Universities Space Research Association,
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World Wide Web Home Page: http://aquila.lbl.gov/bnl878/home_e878.html

Physics Goals:	Investigate antideuteron and rare particle production
Beams:	Au at 11.6 A GeV/c, Si at 14.7 A GeV/c, p at 24 GeV/c
Targets:	Au, Al, Cu

Physics Summary

E878 is a follow on experiment to E858, an investigation of antideuteron production in Si+Al, Cu and Au interactions, in which high statistics measurements of π^-, K^-, and $\bar{p}$ spectra at 0^o were made and new limits on the production of stable negative particles were set. Integral to the design of both these experiments was the need to handle high beam rates to achieve good sensitivity coupled with excellent particle identification to reject background. With these goals in mind, we implemented a double focusing system outfitted with four PMT-based scintillator detectors for redundant TOF, threshold Cerenkov detectors to downscale low mass particles and drift chambers for tracking. Improved capabilities for E878 include a Cerenkov based, high rate multiplicity counter to provide centrality information, improved tracking and the ability to tune to positive and negative rigidities. E878 utilized beams of 14.6A GeV/c Si and 10.8A GeV/c Au on various targets (Al, Cu, Au) with the beamline (A3) tuned to varying rigidities (1.5 GV to 20 GV). Over 10^{11} Au and 10^{13} Si ions were integrated in the spectrometer where $\pi, K, p, d, t, {}^3He$ and ${}^4He$ rigidity spectra of statistical accuracies of better than 1% are expected and new upper limits for the production both positively and negatively charged exotic particles will be set. In addition, measured centrality-dependent production cross sections will allow us to address several physics topics of interest, e.g. $\bar{p}$ production and annihilation and its dependence on the system geometry; and coalescence of light nuclei, with its dependence on system geometry and implications on source size and hydrodynamic flow.

Selected Publications

"Rapidity Distributions of Antiprotons in Si+A and Au+A Collisions", B.S.Kumar, Nucl.Phys A566 (1994)439.

"High-rate Multiplicity Detector for Relativistic Heavy-Ion Collisions" J.K.Pope et al., (submitted to NIM, 1994).

"Search for New Meta-stable Particles Produced in Au + Au Collisions at 10.8 A GeV/c", J.L.Nagle (to be published).

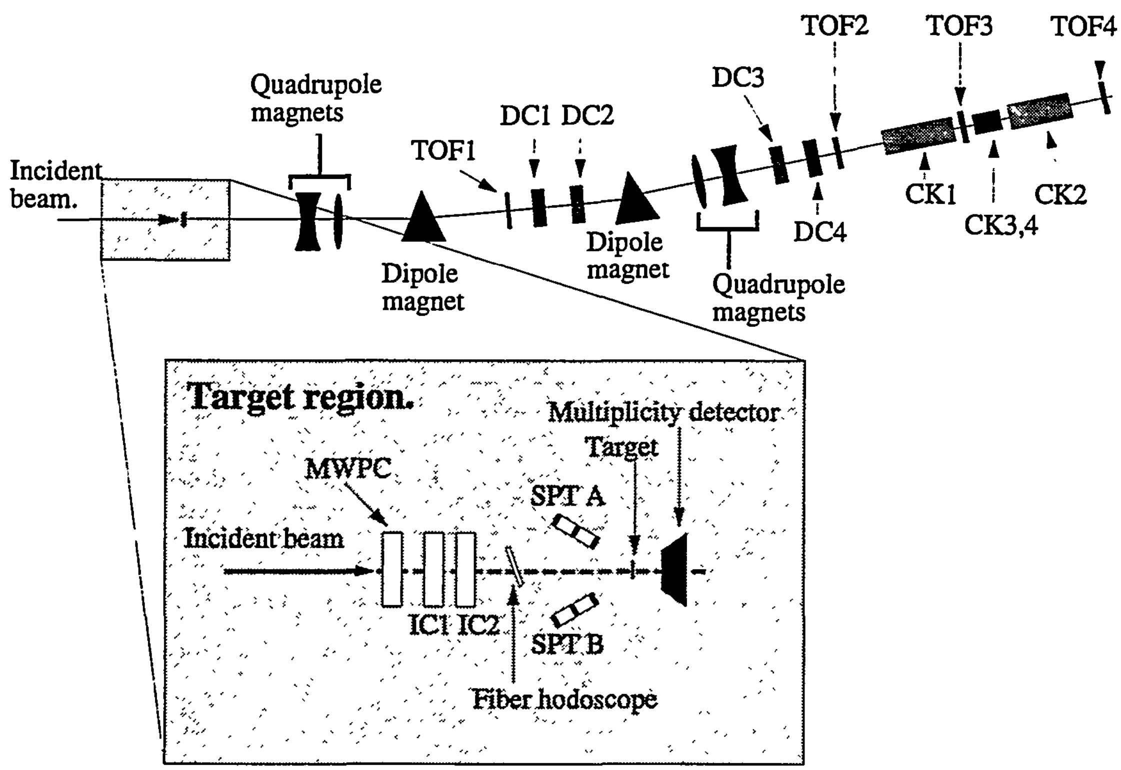

Figure 11: E878 Experimental Layout

Related Experiments

E858, E864, E886, E896

E882-A – Measurement of Charge-Changing Cross Sections for Au Ions

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Physics Goals:	Cross Sections for Nuclear Fragmentation, Electromagnetic Dissociation, Charge Pickup, and Electron Capture and Stripping
Beams:	Au at 11.4 A GeV
Targets:	CH_2, C, Al, Fe, Cu, Sn, and Pb

Experiment Description

Using a novel phosphate glass track-etch detector BP-1 and an automated scanning system, E882-A carried out a series of small-scale experiments. We exposed several stacks of the glass detectors interleaved with various targets to a beam of 11.4 A GeV ^{197}Au at a density of ~ 1000 cm^{-2}. Fragments with $Z \geq 68$ were identified in BP-1 detector with a charge resolution of $\sigma_Z \sim 0.1$ charge unit. Data were taken by automatically scanning the sheets with a computer-controlled microscope and using automated image-processing techniques to fit the ellipses to the intercepts of etchpit mouths with the surfaces.

Physics Summary

We measured the cross sections for several interesting charge-changing interactions in peripheral collisions of 11.4 A GeV ^{197}Au nuclei with various targets. The main topics studied are nuclear charge pickup reaction, nuclear spallation, electromagnetic dissociation, and electron capture and stripping processes. We also measured the cross sections for fragmentation of secondary beams with $68 \leq Z \leq 80$.

1. Charge Pickup Reaction

We established that the charge pickup cross section scales with target mass as $\sim A_T^{0.37}$. We found that the projectile dependence is more rapid than linear, and not inconsistent with the quadratic dependence as found at ~ 1 A GeV. We discovered that the cross section for charge-changing fragmentation of the secondary beams with $Z = 80$ formed in charge pickup is enhanced roughly by a factor of two compared to that for a Au ion.

2. Nuclear and Electromagnetic Spallation

We discovered that the large Coulomb barrier for Au reduces the electromagnetic contribution σ_{em} in a Pb target to only $\sim$ 18% of nuclear contribution σ_{nuc}, compared with $\sim$ 70% for 14.5 A GeV ^{28}Si and $\sim$ 120% for 200 A GeV ^{32}S. With σ_{em} taken to be $\propto Z_T^{1.8}$, σ_{nuc} can be fitted with $\sigma_{nuc} = \alpha(A_P^{1/3} + A_T^{1/3} - b)^2$, with $b = 0.83$ and $\alpha = 59$ mb, essentially the same as found at energies of $\sim$ 1 A GeV.

3. Fragmentation of Secondary beams

We observed an enhancement in total charge-changing cross sections for secondary beams compared to those for stable beams with similar charges. The amount of enhancement depends on the target in which the secondary fragments are produced, being 10 to 30% for light targets and up to 80% for a Pb target. We found an enhancement in partial cross sections for breakup into visible charge loss channels.

4. Electron Capture and Stripping Processes

The measured electron capture cross section in BP-1 glass is consistent with the prediction of radiative capture, and with the calculation of the vacuum capture. However, the measured cross section for stripping differs from the prediction by a factor of 2. We set an upper limit for vacuum capture which constrains recent non-perturbative calculations. In 1994 run we are measuring the cross section for electron capture and loss processes in C, Al, Cu, and Au. The experimentally determined target dependence will enable us to measure the vacuum capture contribution. Since the vacuum capture is expected to become the dominant electron-capture process at high energies, it could intrinsically limit the beam lifetime for future heavy ion colliders such as RHIC. Our measurements are of interest for RHIC.

Selected Publications

"Measurement of cross section for charge pickup by 11.4 A GeV gold ions", Y. D. He and P. B. Price, Phys. Lett. B **298** (1993) 50–53.

"Measurement of cross sections for electron capture and stripping by highly relativistic ions", A. J. Westphal and Y. D. He, Phys. Rev. Lett. **71** (1993) 1160–1163.

"Response of BP-1 phosphate glass track-etch detector to relativistic heavy ions", Y. D. He, A. J. Westphal, and P. B. Price, Nucl. Instrum. Meth. B **84** (1994) 67–76.

"First measurement of charge-changing cross sections for 11.4 A GeV ^{197}Au in various targets", Y. D. He and P. B. Price, Nucl. Phys. A **566** (1994) 363c–366c.

"Nuclear and electromagnetic fragmentation of 2.25-TeV ^{197}Au", Y. D. He and P. B. Price, Z. Phys. A **348** (1994) 105–109.

Related Experiments

E793, E882-B

E882-B – Search for Strangelets and Other Exotic Objects

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Physics Goals:	Search for Short-lived Exotic Composites
Beams:	Si and Au at $\sim$ 10 A GeV
Targets:	Pb

Experiment Description and Physics Summary

In this series of experiments, we search for production of various short-lived exotic objects in high energy heavy ion collisions.

1. Search for Abnormally Ultradense Nuclear Matter

A detector system consisting of 17 sheets of BP-1 phosphate glass and a 1.27-cm Pb target was exposed to 3.5×10^9 ions of ^{197}Au at 11.4 A GeV in 1992. This experiment was designed to search for the production of abnormally dense nuclei suggested by Lee and Wick and others. Exploiting one of the useful features of the BP-1 detector – that its sensitivity can be tuned by suitable choice of chemical etchants – we can set the detector to be sensitive only to $Z/\beta > 82$. In 10^9 interactions, we observed none of such composites emitted within an angle of 140 mrad to the beam direction, which led us to set an upper limit of $\sim$ 20 nb for the production cross section for abnormally dense nuclear matter.

2. Search for Strange Quark Matter

We have conducted an exploratory search for strangelets and other exotic composites using the beam of $\sim$ 10 A GeV ^{197}Au ions in 1993. Our setup consisted of a Pb target, 3 tracking chambers, each contained 25 sheets of CR-39 track-etch detectors, inside a magnet of 1.5 T at C5 beamline. The total fluence reached 10^9 Au ions in $\sim$ 20 hours of run. The purpose of the experiment was to search for negatively highly charged ($|Z| \geq 6$) and short-lived ($\tau \sim 10^{-9}$ sec) exotic fragments produced at mid-rapidities in 10 A GeV ^{197}Au + Pb collisions. The experiment will reach a sensitivity of 10^{-8}/interaction. The short lifetime to which this experiment is sensitive makes it complementary to other experiments at the AGS. The scanning and measurement are in progress.

2. Search for Dirac Magnetic Monopole Production

We will expose a detector module to $10^{11} - 10^{12}$ Au ions in 1994 run. The detector module will consist of 12 sheets of 10 cm $\times$ 10 cm $\times$ 0.1 cm BP-1 glass detectors and a 1.5 cm thick Pb target. With this setup, we will search for magnetic monopole production in high-energy nucleus-nucleus collisions. The production of Dirac magnetic monopole pairs in e^+e^-, pp, and AA collisions has been speculated about by many authors. Extensive searches for monopole pair production in e^+e^- and pp have been performed at various energies and upper limits to its production cross section have been placed. In all these collisions, the monopole pairs are expected to be produced via Drell-Yang mechanism. Moreover, in heavy-ion collisions the thermal production of monopole pairs has been predicted. We estimate that our detector is sensitive to a magnetic monopole with $n = 2$ and with various possible masses. This experiment will be the first search for monopole pair production in heavy ion collisions. Given a fluence of 10^{11} ions, a sensitivity of 10^{-35} cm^2 in its production cross section is expected. This sensitivity is well below the extrapolation of Drell-Yang cross section for pair production.

This setup will also allow us to search for ultradense nuclear composites with $Z/\beta > 82$ and $\tau \sim 10^{-10}$ sec in central collisions. Given a fluence of 10^{11} Au ions, we could reach a limit that is three orders of magnitude lower than previously achieved.

Selected Publications

"Sensitivity study of CR-39 plastic track detectors", Y. D. He and P. B. Price, Nucl. Tracks Radia. Meas. **20** (1992) 491–494.

"Search for abnormal nucleus production in heavy-ion collisions", Y. D. He and P. B. Price, Phys. Rev. C **48** (1993) 647–650.

Related Experiments

E793, E882-A

E883 - Fragmentation of Au-Projectiles at AGS Energies

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Physics Goals:	Spallation Reactions, Multifragmentation, Search for non integer charged fragments
Beam:	Au at 10.6 A GeV
Targets:	CH_2, C, Al, Cu, Ag, Pb

Physics Summary

This experiment investigating nuclear fragmentation for Au projectiles is a continuation of earlier experiments WA87 and E806 (see QM-93 booklet). It is based on two types of nuclear track detectors: the plastic material CR-39 (registration threshold $Z \geq 6$ for relativistic fragments) and the glass BP-1 (registration threshold $Z \geq 73$ for relativistic fragments). Stacks of these detectors are combined with different targets. Experiments with good statistics are possible due to the completely computerized analysis of the track detectors. Total and partial charge changing fragmentation cross sections are measured. Vertices of intermediate mass fragments which are produced in multifragmentation interactions are reconstructed. The excellent charge resolution of CR-39 allows to search for fragments with fractional charge.

Status of Analysis

Spallation and Electromagnetic Dissociation

Total and elemental charge changing cross sections for reactions $\Delta Z = +1, -1, -2, -3$ were measured for ^{197}Au ions colliding with different targets. Our results confirm the data of Waddington et al. (E869) and disagree with the data of He and Price (E882). We determined electromagnetic dissociation cross sections which are in good agreement with calculated values.

Non Integer Charged Fragments

11830 tracks of fragments with charges $6 \leq Z \leq 12$ were analyzed in detail. No candidate for fractional charge was detected, i.e. the production probability of fractional charged fragments is less than $2.5 \cdot 10^{-4}$ at a confidence level of 95%.

Multifragmentation

The results of our multifragmentation experiment at AGS energies significantly differ from those of a comparable experiment performed at 1 A GeV at LBL BEVALAC. As predicted by the statistical Berlin model fission is suppressed at higher excitation energies, whereas the contribution by multifragmentation events increases. Furthermore, the charge of intermediate mass fragments produced by multifragmentation decreases with increasing excitation energies.

Selected Publications

"Multifragmentation experiments using plastic nuclear track detectors", W. Heinrich, E. Winkel, G. Rusch, J. Dreute, and B. Wiegel, Proc. Int. Workshop XXII, Hirschegg, p.30 (1994).

" Response of BP-1 to ^{197}Au heavy ions at 11.3 GeV/nucleon", S.E. Hirzebruch, G. Rusch, E. Winkel, and W. Heinrich, Nucl. Instr. Meth. **B74** (1993) 519–522.

"Charge changing interactions of ^{197}Au at 10 GeV/nucleon in collisions with targets from H to Pb", S.E. Hirzebruch, E. Becker, G. Huentrup, T. Streibel, E. Winkel, and W. Heinrich, to be submitted to Phys. Rev. C.

Related Experiments

WA87, E806, E882, E896

E891 - Search for QGP

BNL-LBL-Rice U.-CCNY

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Physics Goals:	Strangeness enhancement in Au-Au Collisions
Beams:	Au
Targets:	Au

Physics Summary

The e891 program is for studying Au-Au collisions at the AGS by measuring the angles and momenta of charged tracks, K's and Λ's using TPC's and trigger dectectors from E-810. In order to handle the higher track multiplicities produced by Au beams, a modified geometric arrangement of the TPC modules will be used.

This program will allow us to look for anomalous behavior in rapidity (pseudorapidity) distributions, multiplicity, strangeness enhancements, $P_{\perp}$, energy flow, possibly observe Hanbury-Brown and Twiss effects and other new phenomena. These observations will be on an event by event basis so that particularly interesting classes of events can be selected and added together to search for new effects (like strangelets) implying a QGP or other new states of matter in a manner which tends to maximize signal to background ratios.

Selected Publications

"Results from E-810 Concerning Strange Particles and Strangelet Search", R.S. Longacre *et al.*, Quark Matter '93, Proceedings Tenth International Conference on Ultra-Relativistic Nucleus-Nucleus Collisions, Borlange, Sweden, June 20-24, 1993, Eds. E. Stenlund, H-A. Gustafsson, A. Oskarsson and I. Otterlund, (North Holland, 1994) 167c-174c. Nucl. Phys. A**566** (1994) 167c-174c.

"Recent Results from E-810", K.J. Foley (for the E-810 Collaboration), Proceedings of Quark Matter 1991, Nucl. Phys. A**544** (1992) 335c-342c.

"Ξ^- Production in Heavy Ion Collisions at the AGS", S.E. Eiseman *et al.*, Phys. Lett. B**325** (1994) 322-326.

"Transverse Momentum Distributions of π^- from 14.6 $\times A$ GeV/c Silicon Ion Interactions in Copper and Gold", S. Ahmad *et al.*, Phys. Lett. B**281** (1992) 29-32.

"Rapidity Distributions and Nuclear Transparancy in Heavy Ion Collisions", S.E. Eiseman *et al.*, Phys. Lett. B**292** (1992) 10-12.

"Rapidity Distributions of K_s and Λ's Produced by 14.6 GeV/c *Si* and *Pb* Targets", S.J. Lindenbaum (for the E-810 Collaboration), paper submitted to the 26th International Conference on High Energy Physics (ICHEP 92), August 6-12, 1992, Dallas, Texas. BNL 47886.

"Rapidity Distributions of K_s^0's and Λ's Produced by 14.6 $\times A$ GeV/c *Si* Beams on *Si* and *Pb* Targets", S.E. Eiseman *et al.*, Phys. Lett. B**297** (1992) 44-48.

"Neutral Strange Particle Production at the AGS", A.C. Saulys (for the E-810 Collaboration), Proceedings of Heavy-Ion Physics at the AGS: HIPAGS '93 Conference, Cambridge, Massachusetts, 13-15 January 1993, Eds. G.S.F. Sjtephans, S.G. Steadman, and W.L. Kehoe, (1993) 196-203.

"Systematics of Hadronic Production from *Si* and *Pb* Targets with 14.6 $\times A$ GeV/c *Si* Beams", A.C. Saulys *et al.* Proceeding of the XIII Particles and Nuclei International Conference (PANIC '93), Perugia, Italy, 27 June-3 July 1993, Ed. Alessandro Pascolini, (1994) 691-694.

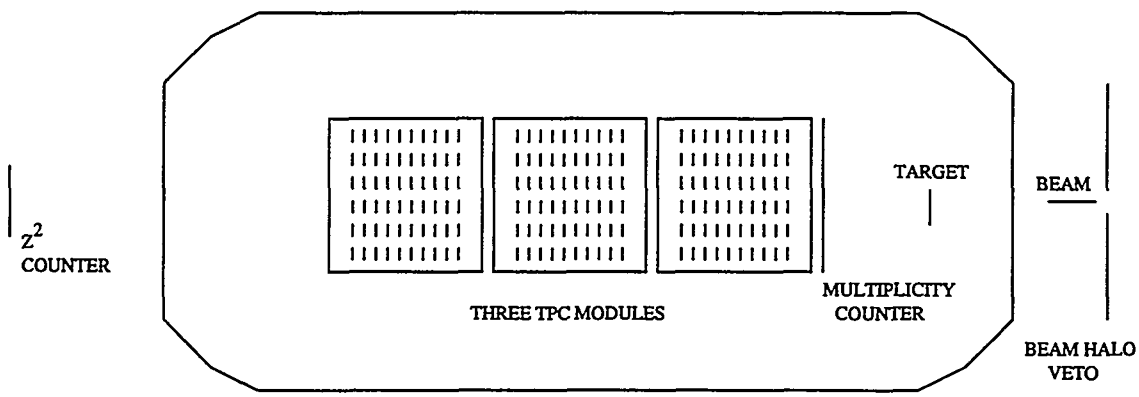

Figure 12: E-891 Plan View

Figure Details

The MPS magnet with three TPC modules, Au target and associated trigger devices.

Related Experiments

E810

E895 - Exclusive Study of Nuclear Collisions using 2-10A GeV Au Beams.

Kent State-LBL-LNLL-Purdue-SUNY Stony Brook
Texas A&M-UC Davis-UT Austin-INFN Catania(Italy)

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Physics Goals:	Exclusive Study, Flow, Critical Behaviour
Beams:	Au at 2-10A GeV
Targets:	Al, Cu, Hydrogen

Physics Summary

E895 will carry out a systematic and exclusive measurement of the energy and mass dependence of particle production, correlations, and collective (flow) effects in Au+Au,Cu collisions. An important objective is to determine the highest compression achievable in nuclear matter and to study its properties. E895 will search for an exotic Equation of State, that is new physics such as Resonance Matter, Exotica, and QGP. Also, E895 will conduct high statistics study of nuclear multifragmentation using inverse kinematics Au + p collisions.
The four-momentum of light mass particles ($\pi^{\pm}$, K°_{s}, $K^{\pm}$, Λ, Ξ^{-}, n, p, d, $\bar{p}$) and composite fragments ($Z = 2$ to $Z = 79$) will be measured on an event-by-event basis over a large fraction of 4π acceptance. The bulk of the data will be acquired from a state of the art Time Projection Chamber (TPC) built and used at LBL by the EOS collaboration. Projectile fragments will be identified in a multiple ionization sampling device called MUSIC and a time of flight (TOF) wall. Neutron measurements will be made using a scintillator barrel detector called MUFFINS. This experimental arrangement will allow an examination of events in fine detail and, simultaneously measure many observables.

Selected Publications

"Exclusive Study of Nuclear Collisions at the AGS", E895 Collaboration, LBL-PUB-5399,(1994).

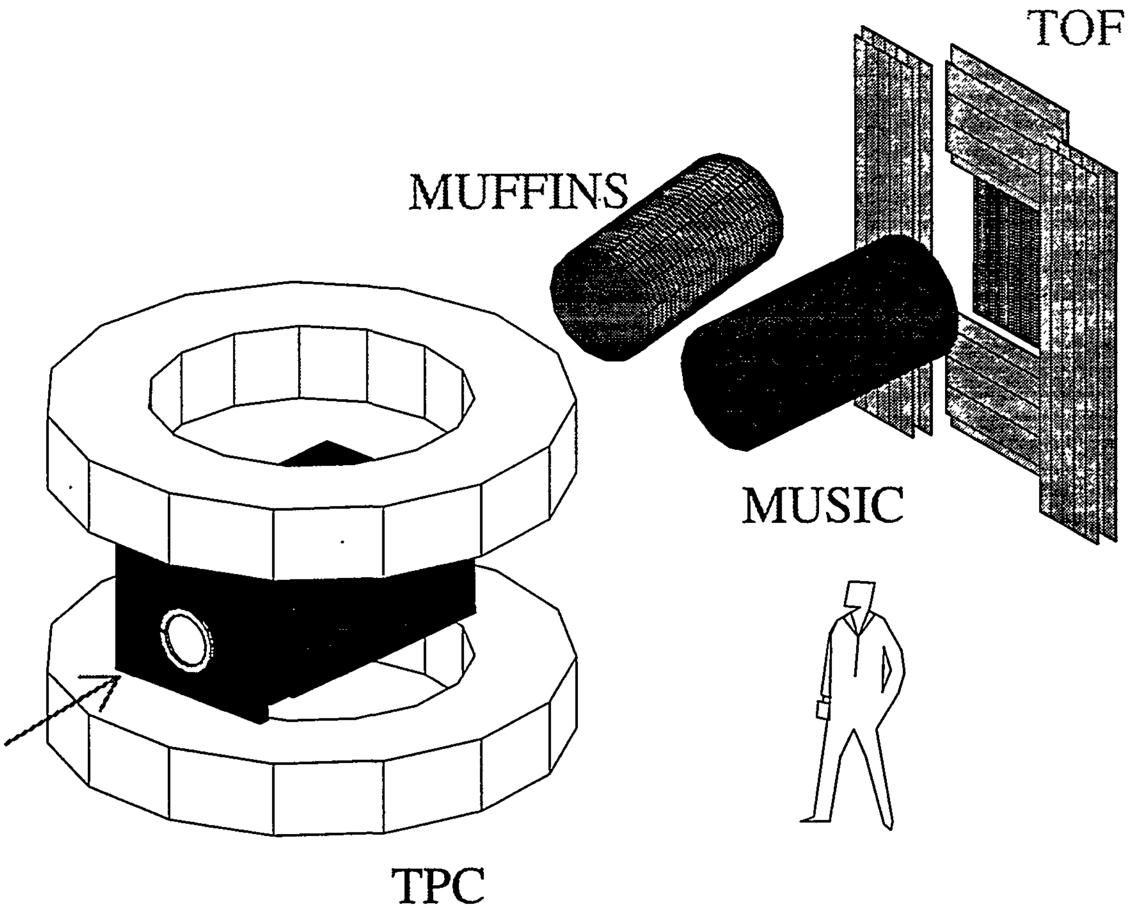

Figure 13: Schematic layout of the Experiment

Figure Details

TPC	EOS Time Projection Chamber
MUSIC	Multiple Ionization Chamber
MUFFINS	Neutron Spectrometer
TOF	Time of Flight Wall

E896-A Search for a Short-Lived H_o Di-baryon and a Study of Hyperon Production in 11.6 A GeV/c AuAu Collisions

University of California at Berkeley/Space Science Laboratory,
University of California at Los Angeles, Brookhaven National Laboratory,
University of Catania, CERN, Johns Hopkins University,
Lawrence Berkeley Laboratory, Ohio State University,
Universities Space Research Association, University of Texas,
Wayne State University, Yale University

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World Wide Web Home Page: http://aquila.lbl.gov/bnl896/home_e896.html

Physics Goals:	Search for short-lived H_o dibaryon; Study of hyperon production
Beams:	p at 30 GeV/c and Au at 11.6 A GeV/c
Targets:	Au

Physics Summary

Experiment E896 will search for the H_o di-baryon state and for new states of nuclear matter in nucleus-nucleus collisions at the AGS. This experiment enhances the existing AA program at both BNL and CERN by extending the search into regions of short lifetime, ($\approx \tau_\Lambda/2$), and complements the existing double strangeness exchange program by offering access to a new doorway channel, the coalescence of two Λ^os. The detector is capable of unambiguously identifying the topological signature of unstable particle decays as well as the rigidity of each charged decay particle, affording a sensitive search for new metastable states and investigation of the properties of known strange particle states. The experimental setup includes a 5 Tm sweeping magnet to remove charged secondaries immediately downstream of the target, followed by a distributed drift chamber in an analyzing magnet downstream of the sweeping magnet. In addition, a small array of silicon drift detectors will be placed inside the sweeping magnet to detect H_o candidates, Λ^o hyperons, and multiply-strange charged baryons. The main feature of the experiment is the

ability to detect secondary vertices corresponding to decay lifetimes from less then half the lifetime of the Λ^o to approximately two orders of magnitude longer in which an unambiguous decay topology ($H \rightarrow \Sigma^- p$) can be measured. An array of neutron counters (MUFFINS) located downstream of the tracking detector provides redundant momentum information on the neutron from the Σ^- decay.

Selected Publications

"A Proposal to the BNL AGS: To Search for a Short-Lived H_o Di-Baryon, Short-Lived Strange Matter, and to Investigate Hyperon Production in 11.6 A GeV/c AuAu Collisions", The E896 Collaboration, (1994).

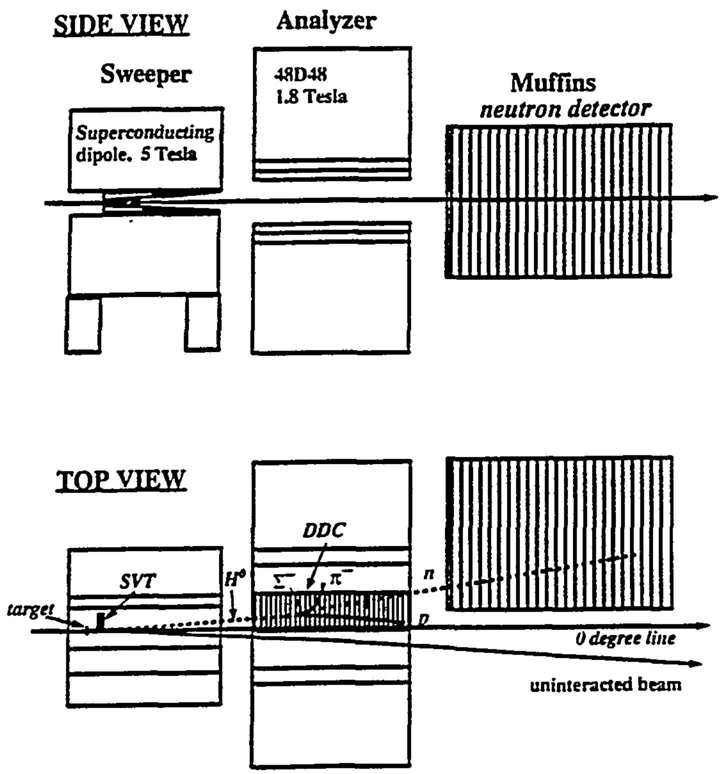

Figure 14: E896 H_o Search Experimental Layout

Figure Details

DDC	Distributed Drift Chamber
SVT	Silicon Vertex Tracker
MUFFINS	Neutron Time of Flight Detector

Related Experiments

E858, E878

EMU01

Almaty - Beijing - Bucharest - Chandigarh - Changsa - Dubna - Jaipur - Jammu - Kosice - Linfen - Lund - Marburg - Moscow - St Petersburg - Seattle - Sydney - Tashkent - Wuhan - Yerevan

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Collected data:

200 A GeV/c:	O+Em (S+C), S+Em (S+C), S+Au (C), S+Ag (C)	at CERN SPS	EMU01
160 A GeV/c:	Pb+Em (S+C), Pb+Pb (C)	at CERN SPS	EMU12
60 A GeV/c:	O+Em (S+C)	at CERN SPS	EMU01
14.6 A GeV/c:	O+Em (S+C), Si+Em (S+C), Si+Au (C)	at BNL AGS	E815
11.6 A GeV/c:	Au+Em (S+C), Au+Au (C), Au+Ag (C)	at BNL AGS	E863
4.5 A GeV/c:	O+Em (S), Si+Em (S)	at Dubna	-

S=stack C=chamber

Physics Summary

Experiment based on the emulsion technique. Ordinary horizontally exposed stacks(S) and vertically exposed emulsion chambers(C). Chamber data measured with semiautomatical systems and stack data measured with conventional methods. Centrality criterion based on forward charge flow, i.e. the number of charges found in a narrow forward cone. In chambers only particles emitted within 30° ($\eta \geq 1.3$) are measured and only central events are recorded. Both methods have very good angular resolution and an efficiency close to 100%.
Emission angles and azimuthal angles for all particles. Categorization of particles into: shower paticles, mainly produced pions; grey particles, mainly knock-out protons from the target; black particles, mainly singly and doubly charged fragments evaporated from the target; and projectile fragments.

Selected Publications

"Limiting Fragmentation in Oxygen Induced Emulsion Interactions at 14.6, 60 and 200 A GeV." M. I. Adamovich *et al.*, Phys. Rev. Lett. **62** (1989) 2801.

"Scaling Properties of Charged Particle Multiplicity Distributions in Oxygen Induced Emulsion Interactions at 14.6, 60 and 200 A GeV." M. I. Adamovich *et al.*, Phys. Lett. **223B** (1989) 262.

"Slow Target Associated Particles Produced in Ultrarelativistic Heavy-Ion Interactions." M. I. Adamovich *et al.*, Phys. Lett. **262B** (1991) 369.

"On Intermittency in Heavy Ion Collisions and the Importance of γ-Conversion in a Multi-Dimensional Intermittency Analysis." M. I. Adamovich *et al.*, Nucl. Phys. **B388** (1992) 3.

"Rapidity Density Distributions and their Fluctuations in Violent Au-Induced Nuclear Interactions." M I Adamovich *et al.*, Phys Lett **322B** (1994) 166.

Related Experiments

EMU01 and EMU12 at CERN
E815 and E863 at BNL

NA34/3 - Dimuon production at low mass

Bari Univ-INFN, CERN, Kosice Phys.Ins., Montreal Univ., Moskow Lebedev Inst., Moskow Phys.Eng. Inst., Roma Univ-INFN, Saclay CEN DAPNIA, Torino Univ-INFN

Spokesperson: Georges London
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Physics Goals:	Dimuon production per charged particle
Beams:	p, S at 200 GeV/A
Targets:	W

Physics Summary

The HELIOS/3 experiment was designed to study virtual photons, detected as muon pairs, at low transverse mass. In this way the dimuon production was studied from threshold up to the J/psi mass at all pt. Data from interactions of p and ^{32}S at 200 GeV/c per nucleon on a tungsten target were collected in 1990 at the CERN SPS. A comparison of the dimuon mass spectra between p-W and ^{32}S-W is therefore possible. The HELIOS/3 set-up consists of a muon spectrometer based on a large superconducting dipole magnet, scintillator hodoscopes and MWPC's, a hadron absorber made of Al_2O_3 followed by iron. Between the target and the absorber, two silicon ring detectors of suitable granularity measured the event multiplicity in the dimuon acceptance.

Selected Publications

"Dimuon and vector-meson production in p-W and S-W interactions at 200 GeV/c/nucleon", M.A.Mazzoni, Proc. of QM 93 Conf., Nucl. Phys. **A566**, 95c.

"Dimuon continuum production in p-W and S-W interaction at 200 GeV/c/A (pagina 531)", J. Bystricky, Proceedings of the International Europhysics Conference on High Energy Physics (HEP 93), 531, J. Carr, M.Perrottet Editors, Editions Frontieres.

"Vector meson production in p-W and S-W interactions at 200 GeV/c/A", M.Masera, Proceedings of the International Europhysics Conference on High Energy Physics (HEP 93),529, J. Carr, M.Perrottet Editors, Editions Frontieres.

"Dimuon production below mass 2.5 GeV/c2 in p-W and S-W interactions at 200 GeV/c/A", M.Masera, 27th International Conference on High Energy Physics (ICHEP 94) Glasgow, UK 20-27 July 1994

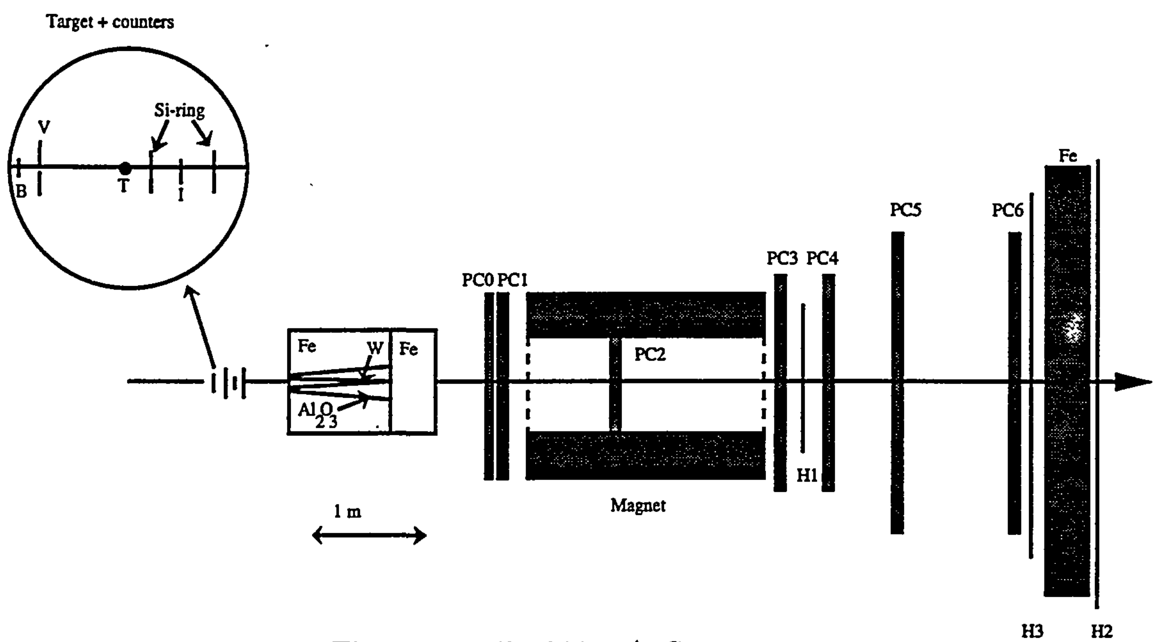

Figure 15: The NA34/3 Spectrometer

Figure Details

B, V, I	Beam and Interaction Counters
Si-ring	Silicon Multiplicity Counters
PC0-PC6	Proportional Chambers
H1-H3	Trigger Hodoscopes

Related Experiments

NA34/2

NA35 - Study of Relativistic Nucleus–Nucleus Collisions

Athens-Bari-Cracow INP-GSI-Frankfurt-Freiburg-LBL-Marburg-
MPI Munich-Warsaw INS-Warsaw IEP-Washington-Rudjer Boskovic Inst

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World Wide Web Home Page: http://hpna49-1.cern.ch/

Physics Goals:	Large acceptance: charged hadrons, strange particles
Beams:	S, O, d, p at 200 GeV/A
Targets:	C, S, Cu, Ag, Au

Physics Summary

Determines for each event the charged-particle multiplicity, the proton and pion rapidity distributions, the charged-pion transverse momentum distribution, the charged particle momentum correlations,the energy flow, and strange-particle production. Studies the stopping power of nuclear matter with different nuclear targets, and searches for evidence of formation of quark matter or quark-gluon plasma.

Selected Publications

"Neutral Strange Particle Production in Sulphur-Sulphur and Proton- Sulphur collisions at 200 Gev/nucleon", J. Bartke *et al.*, Z. Phys. **C48**, 191 (1990).

"Study of Energy Flow in Sulphur- and Oxygen-Nucleus Collisions at 60 and 200 Gev/nucleon", J. Baechler *et al.*, Z. Phys. **C52**, 239 (1991).

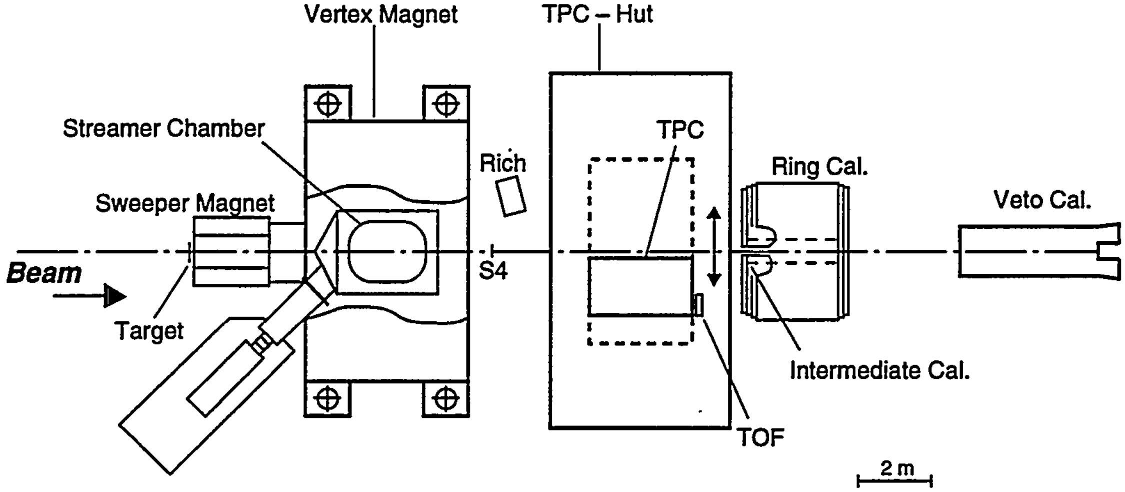
"Production of charged Kaons in Proton-Nucleus and Nucleus-Nucleus Collisions at 200 Gev/nucleon", J. Baechler *et al.*, Z. Phys. **C58**, 367 (1993).

"An Investigation of Intermittency in Proton-Gold,Oxygen-Gold, Sulphur-Gold and Sulphur-Sulphur Interactions", J. Baechler *et al.*, Z. Phys. **C61**, 551 (1994).

"Charged Particle Spectra in Central S+S Collisions at 200 Gev/nucleon", J. Baechler *et al.*, Phys. Rev. Lett. **72**, 1419 (1994).

Related Experiments

NA5, NA49



LAYOUT OF EXPERIMENT NA 35
Run April 1992

NA36 - Strange Particle Production

Bergen-Birmingham-CERN-Creighton-CMU-HEPHY-Krakow
LBL-Madrid-Santiago-Strasbourg

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Physics Goals:	Measurement of strange baryons
Beams:	S, p at 200 GeV/A
Targets:	S, Fe, Cu, Ag, Pb

Physics Summary

NA36 has measured the production of singly and doubly strange baryons and anti-baryons in nucleus-nucleus and proton-nucleus collisions. The NA36 experiment consists of a Time Projection Chamber (TPC) which is situated in a 2.7 Tesla magnetic field. Strange particle decays are reconstucted via their charged decay modes in the TPC. The production of Λ, $\overline{\Lambda}$, Ξ^- and $\overline{\Xi}^+$ have been measured in S+Pb and p+Pb collisions. The S+Pb data were acquired with a mixed central interaction trigger, minimum bias trigger and beam trigger. Central collisions were selected by a cut in the energy signal summed over the central blocks of the forward calorimeter. This cut corresponds to a maximum impact parameter of approximately 9 *fm*. Some data were also acquired with lighter targets.

Selected Publications

"A measurement of cross-sections for S interactions with Al, Fe, Cu, Ag and Pb at 60 and 200 GeV/*c* per nucleon.", E. Andersen *et al.*, Phys. Lett. B **220** (1989) 328-332.

"Target dependence of central rapidity Λ production in Sulfur-Nucleus collisions at 200 GeV/*c* per nucleon.", E. Andersen *et al.*, Phys. Rev. C **46** (1992) 727-735.

"Strangeness production at mid-rapidity in S+Pb collisions at 200 GeV/*c* per nucleon.", E. Andersen *et al.*, Phys. Lett. B **294** (1992) 127-130.

"Multplicity dependence of strangeness production in S+Pb collisions at 200 GeV/*c* per nucleon", E. Andersen *et al.*, Phys. Lett. B **316** (1993) 603-607.

"Production of Λ, $\overline{\Lambda}$, Ξ^- and $\overline{\Xi}^+$ particles in S+Pb collsions at 200 GeV/*c* per nucleon", E. Andersen *et al.*, Phys. Lett. B **327** (1994) 433-438.

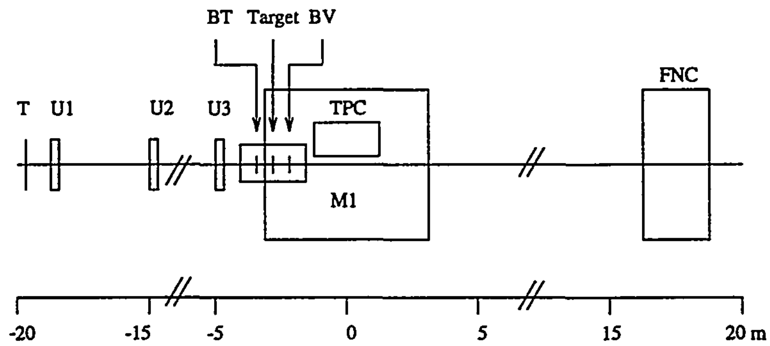

Figure 16: Side View of the NA36 Spectometer

Figure Details

T	Scintillator
U1, U2, U3	Multiwire Proportional Chambers
BT, BV	Silicon Detectors, Beam Tag and Beam Veto
TPC	Time Projection Chamber
M1	Magnet
FNC	Forward Neutral Calorimeter

NA 38 - Muon Pair and Vector Mesons Production with O and S beams

Annecy – Clermont-Ferrand – CERN – Lisbon
Lyon – Orsay – Palaiseau – Strasbourg

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Contactman : Peter Sonderegger
CERN, Division PPE, CH - 1211 Genève 23, Switzerland
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World Wide Web Home Page: http://lyoinfo.in2p3.fr/eiexp/NA38.html

Physics Goals:	Yields versus energy density
Beams:	S, O, d, p at 200 GeV*A
Targets:	U, W, Cu, Al, C

Physics Summary

Experiment NA 38 detects muon pairs from the mass continuum and from vector mesons decays ($\rho, \omega, \phi, J/\psi$ *and* ψ') up to an invariant mass of 7 GeV/c^2. It studies, on an event by event basis, the behaviour of the different components of the mass spectrum as a function of energy density estimated from the transverse energy measured by an electromagnetic calorimeter. The apparatus is designed to work up to 10^8 ions/burst. Acceptance in mass, rapidity and transverse momentum of the muon pair is 10% with a rapidity coverage between 2.8 and 4.0. A "multiple target" system (20% of an interaction length) provides vertex and spectators reinteractions identification. The electromagnetic calorimeter measures transverse energy with a resolution better than 5% for central interactions and covers a rapidity range between 1.7 and 4.1. A "beam hodoscope" detects and identifies the incoming ion and quartz Cerenkov counters identify the incident beam and monitor its position on the targets.

Selected Publications

Transverse energy distributions in nucleus-nucleus collisions at 200 GeV/nucleon. Phys. Lett. B251 (1990) 472

Study of J/ψ production in p-U, O-U and S-U interactions at 200 GeV per nucleon. Phys. Lett. B255 (1991) 459

Transverse momentum of J/ψ produced in p-Cu, p-U, ^{16}O-U and ^{32}S-U collisions at

200 GeV per nucleon. Phys. Lett. B262 (1991) 362

J/ψ and muon-pair cross-sections in proton-nucleus and nucleus-nucleus collisions at 200 GeV per nucleon. Phys. Lett. B270 (1991) 105

ϕ, ρ and ω production in p-U, O-U and S-U reactions at 200 GeV. Phys. Lett. B272 (1991) 449

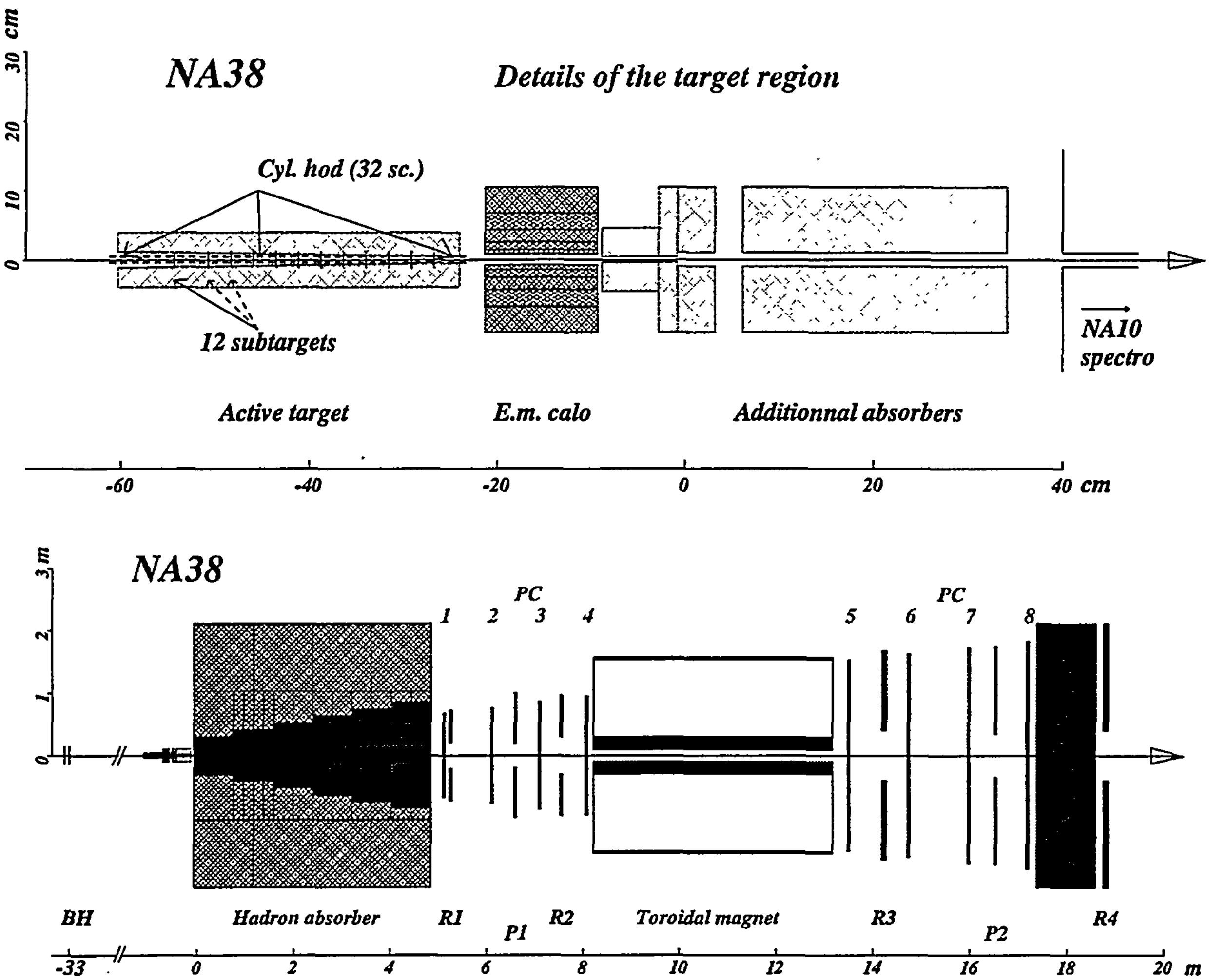

Figure 17: Lay-out of the NA 38 detector

Figure Details

R1,R2,R3,R4,P1,P2	Scintillation hodoscopes
PC1 to PC8	Multi-wire proportional chambers
BH	Beam hodoscope

Related Experiments

NA 50

NA44 - A Focussing Spectrometer for one and two Particles

BNL-CERN-Copenhagen-Columbia-Creighton-Hiroshima
Los Alamos-Lund-Nantes-Ohio-Texas A&M-Tsukuba

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E-Mail: franz@cernvm.cern.ch FAX: (41)-227678350

World Wide Web Home Page: http://www.cern.ch/NA44/Welcome.html

Physics Goals:	HBT and Inclusive Spectra at Midrapidity
Beams:	p ,S, Pb at 450, 200, 160 GeV per Nucleon
Targets:	Be, S, Ag, Pb

Physics Summary

The NA44 Experiment uses a focussing spectrometer with good time-of-flight and momentum resolution to study single particle inclusive spectra and multiparticle correlations (particle interferometry, also called "HBT") of identified pions, kaons and protons in pp (p-Be), p-A and A-A collisions. One of the physics aims is to study single particle spectra and particle composition as a function of transverse momentum for different beam and target combinations. Furthermore particle interferometry with high statistics in the region of small momentum difference is used to study detailed aspects of the space-time evolution in dense hadronic matter, ultimately to look for signatures of a quark-gluon plasma.

Selected Publications

"Identified pion interferometry in heavy-ion collisions at CERN" , H.Beker *et al.*, Phys. Lett. B **302** (1993) 510-516.

"Kaon interferometry in heavy-ion collisions at the CERN SPS" , H.Beker *et al.*, in press Zeitschrift f. Physik, CERN-PPE/94-75

"m_T dependence of boson interferometry in heavy ion collisions at the CERN SPS" , H. Beker *et al.*, submitted to Phys. Rev. Lett., CERN-PPE/94-119

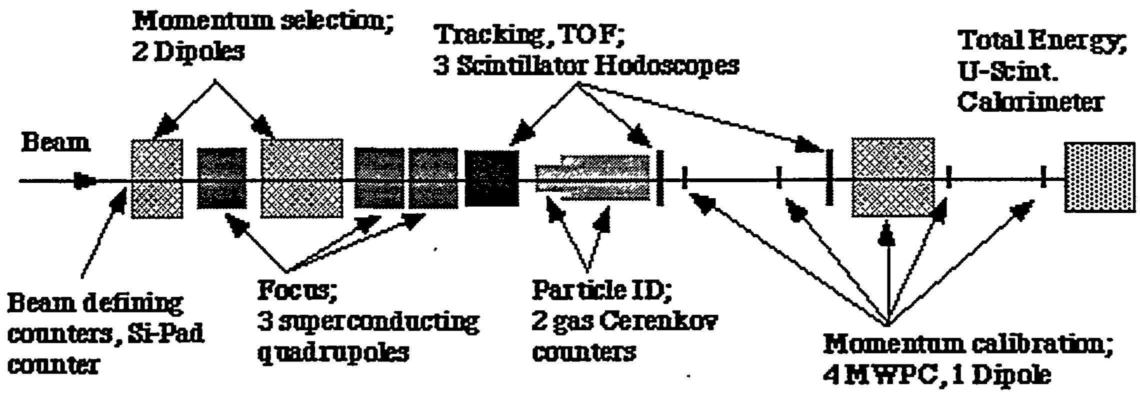

Figure 18: Top View of the NA44 Spectrometer

Related Experiments

E802, E859, E866, NA35

CERES/NA45 Electron-Pair and Photon Production p-p, p-A and A-A Collisions at the SPS

BNL - CERN - JINR, Dubna - MPI Heidelberg - Politecnico di Milano
University of Heidelberg - Weizmann Institute, Rehovot

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E-Mail: sks@cernvm.cern.ch
FAX: 41 - 22 - 767 8350

World Wide Web Home Page: http://ceres6.physi.uni-heidelberg.de

Physics Goals:	Electron-pair and photon production
Beams:	p 450 GeV, S 200 GeV/u, Pb 160 GeV/u
Targets:	Be, Au, Pt

Physics Summary

CERES is an experiment dedicated to the measurement of electron-positron pairs and direct photons produced in hadron and nuclear collisions, at CERN SPS energies. Its main goal is to systematically study the pair continuum in the mass region from 50 MeV/c^2 up to ~2 GeV/c^2, and the vector mesons ρ, ω and ϕ. Due to the absence of final state interactions, these observables are considered as unique probes for studying the dynamics of ultrarelativistic heavy-ion collisions, and in particular the hot early stages where a quark-gluon plasma is expected to be formed. The apparatus also allows high-statistic studies of high-p_t pions and of QED pairs produced in distant nuclear collisions.
CERES has measured e^+e^--pairs emitted in p-Be and p-Au collisions at 450 GeV and in S-Au collisions at 200 GeV/nucleon and direct photons in S-Au collisions at 200 GeV/nucleon. These measurements will be extended with the 160 GeV/nucleon Pb beams which are becoming available at CERN.

Layout

- two Ring-Imaging Cherenkov detectors (RICH) – one situated before, the other after a short superconducting double solenoid.
- two silicon radial-drift chambers located closely downstream of the target.
- a pad chamber located behind the spectrometer.

The spectrometer covers the region $2 < \eta < 2.6$ near mid-rapidity with 2π azimuthal symmetry

Selected Publications

"The CERES RICH detector system" R. Baur *et al.*, Nucl. Instrum. Meth. **A343** (1994) 87-98.

"In-beam experience from the CERES UV-detectors: Prohibitive spark breakdown in multi-step parallel-plate chambers as compared to wire chambers" R. Baur *et al.*, Nucl. Instrum. Meth. **A343** (1994) 213-240.

"First results of the CERES electron pair spectrometer from p-Be, p-Au and S-Au collisions" R. Baur *et al.*, Nucl. Phys. **A566** (1994) 87-94.

"Measurement of electromagnetically produced e^+e^- -pairs in distant S-Pt collisions" R. Baur *et al.*, Phys. Lett. **B332** (1994) 471-476.

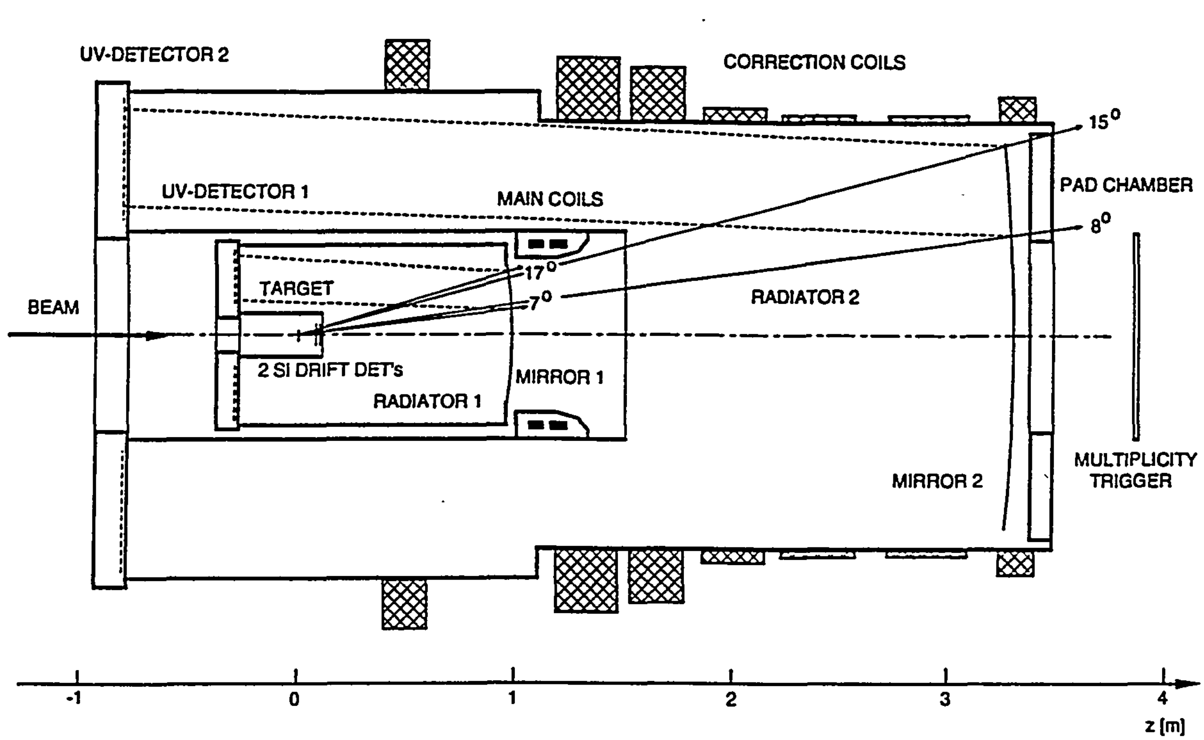

Figure 1: Layout of the CERES spectrometer

NA49 - Large Acceptance Hadron Detector for Pb-beams

Athens-Berkeley(LBL)-Birmingham-Budapest-CERN-Cracow-Darmstadt(GSI)-Davis-Frankfurt-Freiburg-Marburg-Munich(MPI)-Seattle-Warsaw(INS)-Warsaw(U)-Zagreb

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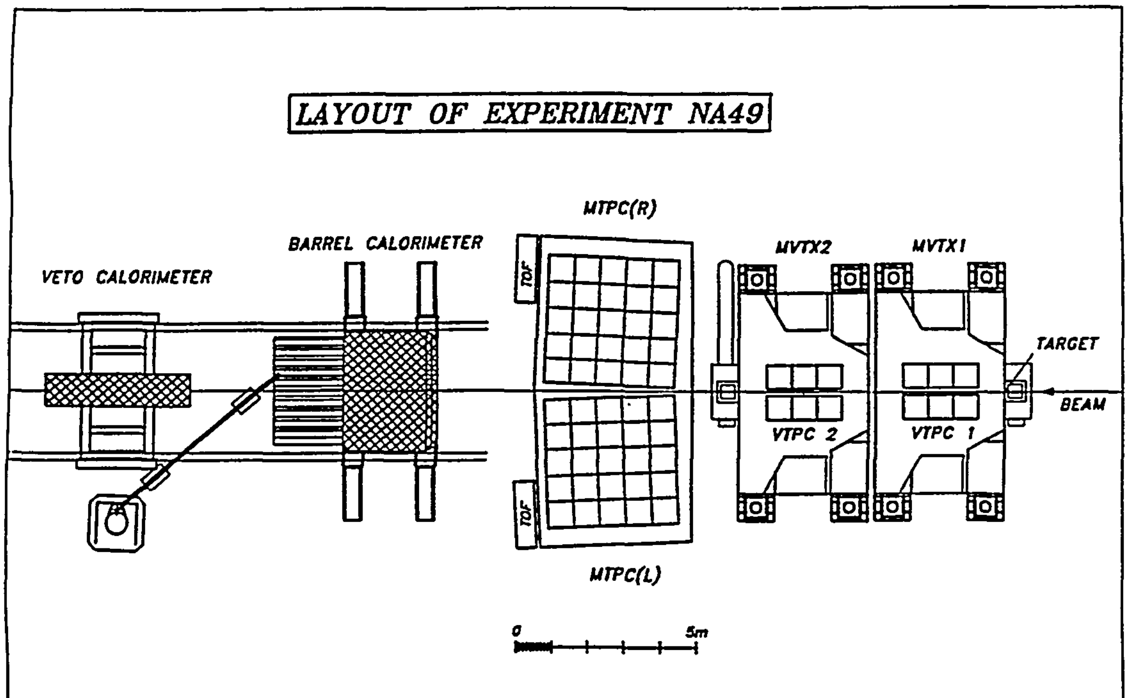
World Wide Web Home Page: http://hpna49-1.cern.ch/NA49.html

Physics Goals:	Charged Hadrons and Neutral Strange Particles
Beams:	p, Pb at 160 GeV/A
Targets:	light, Pb

Physics Summary

This experiment intends to investigate the new physics offered by SPS lead (Pb) beams and will study the production of charged hadrons ($\pi^\pm$, $K^\pm$, p, $\bar{p}$) and neutral strange particles (ϕ, K^0_s, Λ, $\bar{\Lambda}$) in a search for the deconfinement transition predicted by Lattice QCD. Special emphasis will be placed upon an event–by–event analysis of global observables like $\pi^-\pi^-$ Bose–Einstein correlations, the mean transverse momentum or temperature T derived from pion p_T spectra, the K/π ratio at midrapidity, and the rapidity distribution of the net baryon number density derived from the proton and antiproton rapidity spectra. All these observables should be sensitive to the transition to a deconfined phase during the collision. It is the outstanding new feature of high energy Pb+Pb collisions that such observables can be studied at the event–by–event level, if a large acceptance detector system is employed which identifies on the order of 800-1000 hadrons per central collision. This implies an azimuthal coverage of more than 50% in one hemisphere of kinematical phase space. Due to the reflection symmetry about midrapidity (y=2.9) in Pb+Pb collisions, one hemisphere contains all physics information. We have chosen to cover the phase space forward of midrapidity in order to obtain approximately complete azimuthal coverage with minimum detector sizes.

A combination of two 4.2 Tm dipole vertex magnets, in either "sweeper–rebender" or "sweeper–sweeper" configuration, accomplishes appropriate track density distributions for charged particle identification and tracking at 10 m and for neutral strange particle decay detection at 5 m downstream of the target. The main detector components are four Time Projection Chambers, one within each vertex magnet and two large ones downstream in the field–free region, two Time of Flight walls adjacent to the large TPCs, and downstream calorimetry for E_T measurements and triggering on forward energy. Particle idenitification is accomplished two ways: energy loss in the large TPCs, and the combination of time of flight and momentum determination.



Experiment NA49 Large Acceptance Hadron Dectector for an Investigation fo Pb-induced Reactions at the CERN SPS

Figure 20: Top View of NA49

Figure Details

MVTX	Vertex Magnet
VTPC	Vertex Time Projection Chamber
MTPC	Main Time Projection Chamber
TOF	Time of Flight

Related Experiments

NA35

NA 50 - Muon Pair and Vector Mesons Production with Pb ions

Annecy – Bucharest – Cagliari – Clermont-Ferrand – Cracow – CERN
Lisbon – Lyon – Moscow – Orsay – Palaiseau – Strasbourg – Torino

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World Wide Web Home Page: http://lyoinfo.in2p3.fr/eiexp/NA50.html

Physics Goals:	Yields versus energy density
Beams:	Pb at 160 GeV*A
Targets:	Pb

Physics Summary

Experiment NA 50 detects muon pairs from the mass continuum and from vector mesons decays ($\rho, \omega, \phi, J/\psi$ *and* ψ') up to an invariant mass of 7 GeV/c^2. It studies, on an event by event basis the behaviour of the different components of the mass spectrum as a function of energy density, multiplicity and impact parameter estimated from the transverse energy measured by an electromagnetic calorimeter and the responses of a silicon strip detector and a "very forward calorimeter". The apparatus is designed to work up to 5 10^7 Pb ions/burst. Acceptance in mass, rapidity and transverse momentum of the muon pair is 8% for the J/ψ and 1.2% for the ϕ. The rapidity coverage is in the range between 2.7 and 3.9. A "multiple target" system (20% of an interaction length) provides vertex and spectators reinteractions identification. Multiplicity is measured with 5% resolution within the rapidity interval 1.6, 4.0. Transverse energy is measured with a resolution better than 5% for central interactions and covers a rapidity range between 1.5 and 2.3. The number of spectators is measured and allows direct estimate of centrality. A quartz "beam hodoscope" detects and identifies the incoming ion and quartz Cerenkov counters monitor the beam position on the targets.

Selected Publications

Study of muon pairs and vector mesons produced in high energy Pb-Pb interactions. CERN/SPSLC 91-55, SPSLC/P 265-Rev, November 1991.

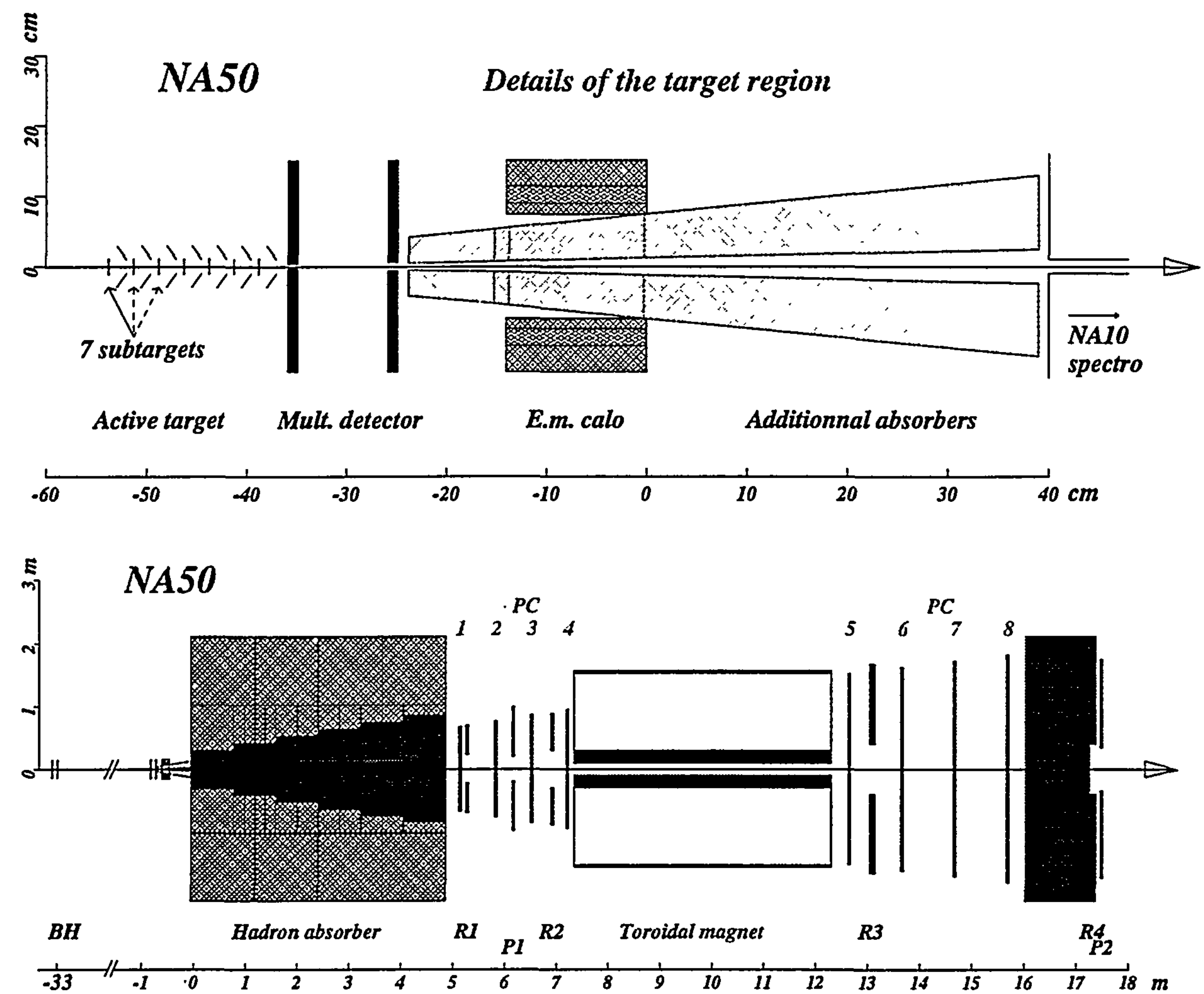

Figure 21: Lay-out of the NA 50 detector

Figure Details

R1,R2,R3,R4,P1,P2	Scintillation hodoscopes
PC1 to PC8	Multi-wire proportional chambers
BH	Quartz Beam "hodoscope"

Related Experiments

NA 38

NA52 - Strangelet and Particle Search in Pb-Pb Collisions

Bern Univ.•CERN•CRN,CNRS-IN2P3 Strasbourg•Helsinki Univ.
LAPP,CNRS-IN2P3 Annecy•Stockholm Univ.

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Physics Goal:	Search for long-lived massive strange matter
Beam:	Pb at 160·A GeV/c
Target:	Pb

Physics Summary

The NA52 experiment will search for long-lived massive strange matter particles, *strangelets*, in Pb-Pb collisions at a beam momentum of 160 GeV/c per nucleon. It intends to look for both, positively and negatively charged massive objects with a low charge to mass ratio at 0^0 production angle, using the H_6-beamline in the North Experimental Area at CERN as a charged-particle spectrometer.

The strangelets will be identified by the measurement of their rigidity R in the spectrometer, their velocity, and their charge. The velocity will be determined from the time-of-flight (TOF) measurements provided by TOF scintillation counter hodoscopes positioned along the beam spectrometer. The $\mathrm{d}E/\mathrm{d}x$ information from the TOF counters will be used for the charge measurement. A hadron calorimeter will complement the momentum information from the spectrometer with an independent energy measurement, thus providing redundancy for effective background rejection. The interesting charge and mass range ($|Z|/m < 0.2$, $10 < m < 40\,\mathrm{GeV}/c^2$) of the strangelets can be covered quite effectively by two settings of the beam spectrometer with the rigidities R = 100 GV and R = 200 GV. With a distance of 524 m between the production target and the last counters in the beam spectrometer, the strangelets should have a lifetime $\gamma\tau > 2 \cdot 10^{-6}$ s in order to be detected. The aim of the experiment is to reach a detection sensitivity of 10^{-9} to 10^{-10} per interaction.

The NA52 experiment further intends to investigate particle production in Pb-Pb collisions with emphasis on *antibaryon* (antiproton, antideuteron, ...) production by measuring their production yields over more than 3 units of rapidity each and at production angles from 0 to 12 mrad. The particles will be identified by means of differential and threshold Čerenkov counters and by TOF measurements.

Selected Publications

"Proposal for a Strangelet and Particle Search in Pb-Pb Collisions", NEWMASS Collaboration, CERN / SPSLC **P 268**, March 13, (1992).

"Strangelet Search in S-W Collisions at 200·A GeV/c", contributed paper to the Quark-Matter '93 Conference, Borlänge, Sweden (1993).

"Strangelet Search in S-W Collisions at 200·A GeV/c", K. Borer *et al.*, Phys. Rev. Lett., **72**, N10 (1994) 1415-1418.

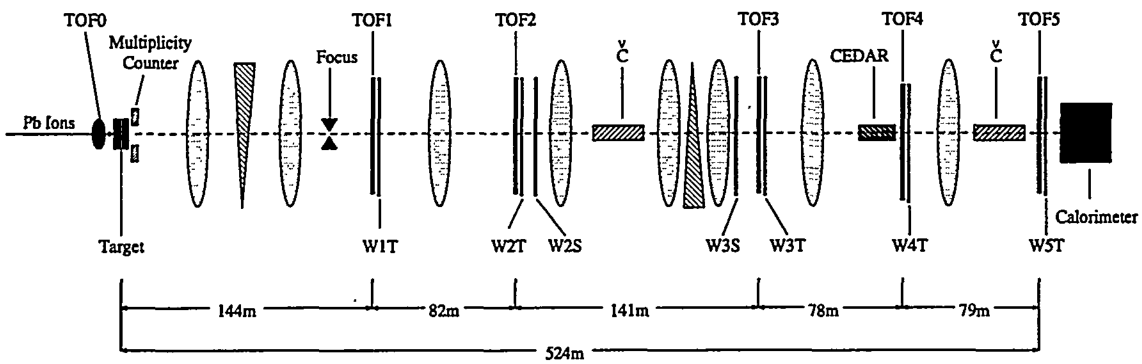

Figure 22: NA52 Experimental Setup

Figure Details

TOF0	Quartz Counter
TOF1, TOF2, TOF3, TOF4, TOF5	Time-of-flight Counter Hodoscopes with 8 slabs
W1T, W2T, W3T, W4T, W5T	Multiwire Proportional Chambers with x, y and v planes
W2S, W3S	Multiwire Proportional Chambers with x, y planes
Č	Threshold Čerenkov Counter
Calorimeter	Hadron Calorimeter

Related Experiments

E814, E858, E864, E878, E882, E886

NA53 - Electromagnetic Dissociation of Co-59 and Au-197 by Pb-208

BNL-Iowa State

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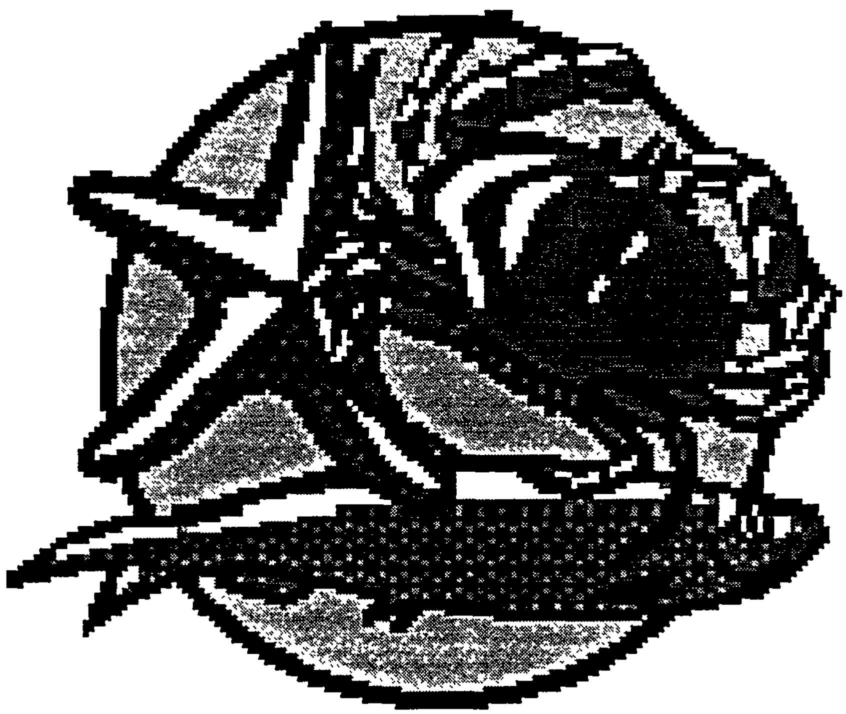
Physics Goals:	Electromagnetic dissociation cross sections
Beams:	Pb at 160 GeV/A
Targets:	Co, Au

Physics Summary

The purpose of NA53 is to measure the electromagnetic dissociation (ED) cross sections for the one- and two-neutron removal reactions of 160 GeV/nucleon Pb beams from the CERN SPS on targets of Co and Au. ED is a process occurring when relativistic heavy ions interact by an exchange of virtual photons. The usual result is the excitation of an E1 or E2 giant resonance. For heavy nuclei the most common mode of deexcitation is by the emission of one or more neutrons. The ED process is expected to become of the order of 60 barns for the colliding Au beams expected for RHIC and is the primary process leading to the degradation of RHIC beams. Our calculations indicate that the ED cross section for one-neutron removal for Pb on Au should be about 26 barns at SPS energies. In the experiment very thin targets of Au and Co will be bombarded in the Pb beam. The bombardments will be carried out upstream from and parasitic to the NA50 experiment. The number of beam particles incident on the target will be counted using the NA50 beam monitors. The activity from the bombarded targets will be measured using gamma-ray spectroscopy in order to determine the yield of the one- and two-neutron removal reactions and various fragmentation reactions. The first measurements will be carried out in December 1994.

Related Experiments

NA40



PHENIX - Search for Leptonic, Photonic, and Hadronic Signatures of QGP at RHIC

Alabama, BARC(Bombay), BNL, UC Riverside, CIAE, Chung-ang, Columbia, Florida State, Georgia State, Hiroshima, INEL, IHEP(Beijing), IHEP(Protvino), IMP(Landzou), INR(Moscow), INS(Toyko), ITEP(Moscow), Iowa State, JINR(Dubna), KEK, Korea, Kurchatov, Kyoto, LLNL, LANL, Louisiana State, Lund, McGill, MIT, Münster, NIRS, SUNY Stony Brook, ORNL, Peking, PNPI(St.Petersberg), São Paulo, Seoul National, Soong-Sil, Tennessee, Tokyo U., Tokyo UAT, Tsukuba, Vanderbilt, Yale

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World Wide Web Home Page:
http://rsgi01.rhic.bnl.gov/~phenix/phenix_home.html

Physics Goals:	Detect and Characterize Quark Gluon Plasma
Beam-Beam:	Au, I, Cu, Si, O, p at 100 A·GeV, p at 250 GeV

Physics Summary

The primary goals of PHENIX are to detect the QGP and to measure its properties. The PHENIX strategy is to perform a systematic investigation of leptonic, photonic, and hadronic signatures and to look for a simultaneous anomoly attributable to QGP formation. The important physics topics include deconfinement (Debye screening), chiral symmetry restoration, thermal radiation of hot gas, nature of the phase transition, strangeness and charm production, jet quenching, and space-time evolution. Because the physics of interest involves many different kinds of particles, particle identification is very important. The PHENIX approach is to identify and measure leptons, photons, and hadrons as a function of energy density in both A + A and p + A collisions. Lepton pairs (dielectrons and dimuons) are measured to study various properties of vector mesons, such as the mass, the width, and the degree of yield suppression due to the formation of the QGP. The effect of thermal radiation on the continuum is studied in different regions of rapidity and mass. The $e\mu$ coincidence is measured to study charm production, and to help understand the shape of the continuum dilepton spectrum. Photons are measured to study direct emission of single photons and to study π^0 and η production. Charged hadrons are identified to study the spectrum shape, production of antinuclei, the ϕ meson (via K^+K^- decay), jets, and two-boson correlations. The measurements are made down to small cross sections to allow the study of high p_T (transverse momentum) spectra, and J/ψ and Υ production. Recognizing that some of the potential QGP signatures involve rare processes and small effects, PHENIX is designed to be a detector capable of taking data at the highest luminosities expected at RHIC.

Selected Publications

"PHENIX Conceptual Design Report (CDR)", The PHENIX Collaboration, Presented at DOE/RHIC Review, BNL, January 1993 (Informal Report).

"PHENIX Conceptual Design Report (CDR) Update", The PHENIX Collaboration, Presented at DOE/RHIC Review, BNL, November 1993 (Informal Report).

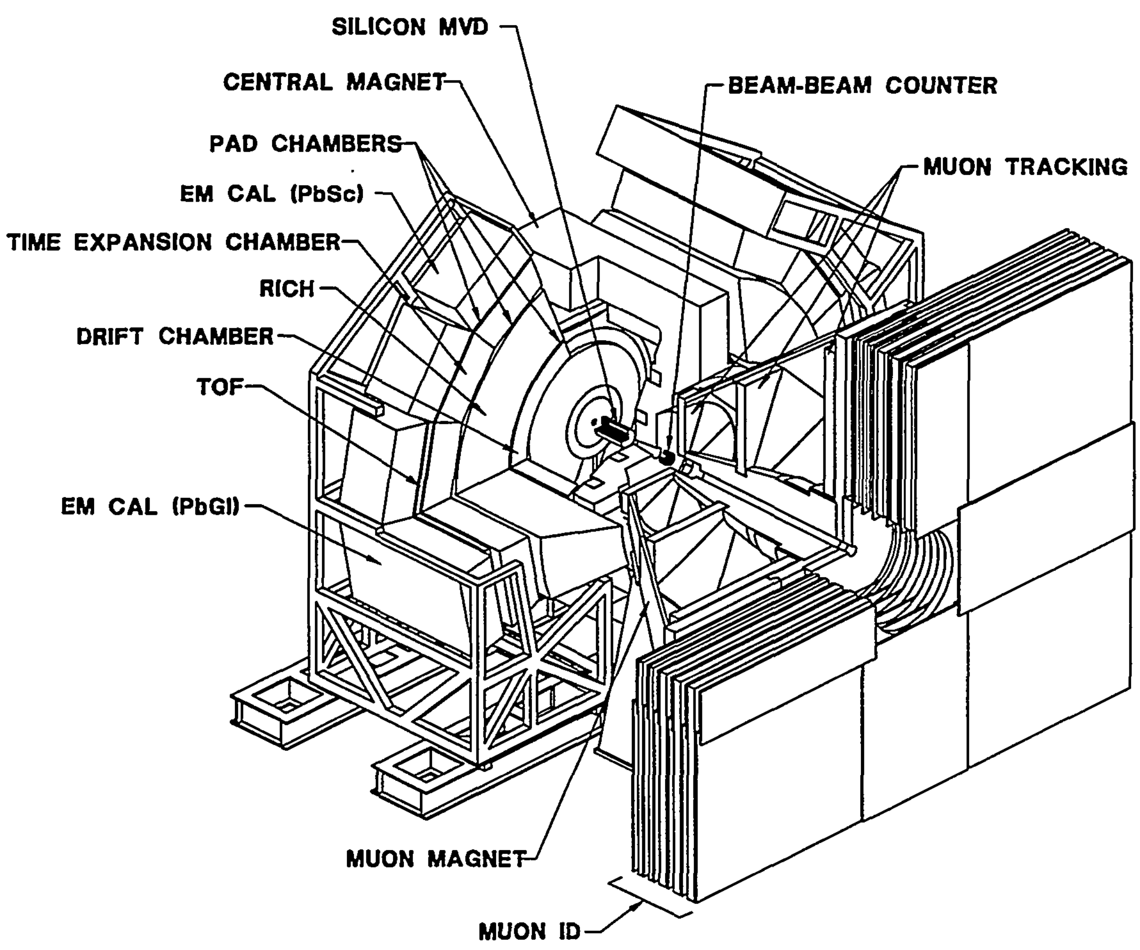

Figure 23: The baseline PHENIX Detector, showing the location of the two large magnets (central and muon) and the many detector subsystems used for both particle identification and tracking.

PHOBOS

Argonne National Laboratory-Brookhaven National Laboratory
Institute for Nuclear Physics, Krakow-Jagiellonian University, Krakow
Massachusetts Institute of Technology-Oak Ridge National Laboratory
University of Illinois at Chicago-University of Maryland-Yale

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Physics Goals:	Study nuclear matter at extremes of energy and baryon density; search for the Quark-Gluon Plasma; study nature of confinement and the QCD vacuum.
Beams:	p + p, p + Au, and Au + Au at 100 GeV/A

Physics Summary

The aim of the PHOBOS research program is to obtain a better understanding of QCD, the nature of confinement and the QCD vacuum, through a study of matter at extreme energy density. In particular to search for possible evidence for a phase transition to a Quark-Gluon Plasma in heavy-ion collisions at RHIC energies. In searching for signs of new physics, the following will be studied with the PHOBOS detector:

1. Event-by-event pseudorapidity and azimuthal distributions of charged particles and photons over the full solid angle. (The primary aim here will be to identify events with abnormally large multiplicity or fluctuations.)

2. Particle ratios (π, K, p, ϕ, Λ) and Pt distributions near mid-rapidity. [π/K separated up to 550 MeV/c by dE/dx and up to 1150 MeV/c by time of flight.]

3. Particle correlations, in particular Bose-Einstein correlations.

4. Mass and width of $\phi \rightarrow K^+K^-$.

The particular strengths of PHOBOS are:

1. Coverage down to very low Pt's (~35 MeV/c).

2. Very high data rate and capability to analyze a very large number of events. This allows data to be taken in an unbiased way (no restrictive trigger).

3. Flexible design which allows reconfiguration of detector, should multiplicity of most interesting events be much higher than expected.

Selected Publications

"The PHOBOS Experiment at RHIC and AGS", B. Wyslouch, Proc. Quark Matter '93, Nucl. Phys. A566 **94** 305c.

"Low Pt Physics and Compact Detectors at RHIC and LHC", W. Busza, Proc. NATO Advanced Study List on Particle Production in Highly Excited Matter, Il Ciocco, (1992) 149.

"Conceptual Design Report", MIT Laboratory for Nuclear Science, (1994).

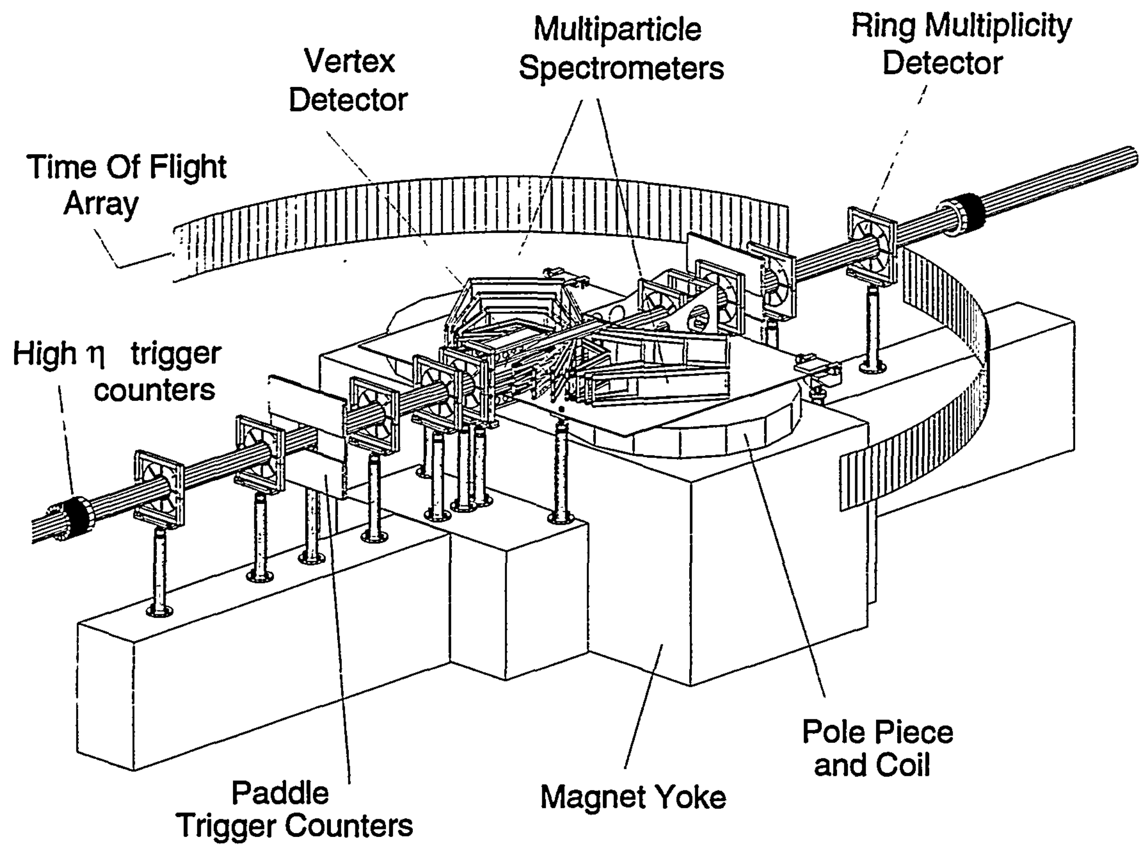

Figure 24: A Schematic of the PHOBOS Experiment (top magnet yoke removed)

Figure Details

The PHOBOS detector consists of two major components. The first is a double-arm multiparticle spectrometer used to measure identified particles at low Pt, over approximately one unit of rapidity at mid-rapidity. The second is an array of silicon detectors designed to measure the full azimuthal distribution of charged particles and photons over almost the entire rapidity range available at RHIC.

The Solenoidal Tracker At RHIC (STAR)

Argonne National Laboratory, University of Arkansas,
Ruder Boskovic Institute (Zagreb), Brookhaven National Laboratory,
University of California (Berkeley), University of California (Davis),
University of California (Los Angeles), Carnegie Mellon University,
City College of New York, Creighton University, University of Frankfurt,
Institute of High Energy Physics (Protvino), The Johns Hopkins University,
Kent State University, Laboratory of High Energy–JINR (Dubna),
Lawrence Berkeley Laboratory, Massachusetts Institute of Technology,
Max-Planck-Institut für Physik (Munich), Michigan State University,
Moscow Engineering Physics Institute, University of Notre Dame,
Ohio State University, Particle Physics Laboratory–JINR (Dubna),
Purdue University, Rice University, Universidade de Sao Paulo,
Texas A&M University, University of Texas (Austin), Warsaw University,
Warsaw University of Technology, University of Washington,
Wayne State University, Weizmann Institute of Science

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World Wide Web Home Page: http://rsgi00.rhic.bnl.gov/star/starlib/doc/www/welcome_star.html

Physics Goals:	Search for quark-gluon plasma formation; study of strongly interacting matter at high energy density
Colliding Beams:	AA interactions, protons to ^{197}Au at 100 GeV/A ; polarized protons at $\sqrt{s}$ up to 500 GeV

Physics Summary

The Solenoidal Tracker At RHIC (STAR) is designed to search for signatures of quark-gluon plasma formation and to investigate the behavior of strongly interacting matter at high energy density. The emphasis is on the measurement and correlation of global observables on an event-by-event basis and the use of hard scattering of partons to probe the properties of high density nuclear matter. To fulfill the physics objectives, the experiment will provide tracking, momentum analysis, and particle identification of most of the charged particles at mid-rapidity ($dn/d\eta \approx 1000$). The baseline STAR detector utilizes a time projection chamber

(TPC) in a solenoidal magnetic field of 0.5 T, covering approximately 4 units of the central rapidity ($-2 \leq |\eta| \leq 2$). The cylindrical TPC is four meters in diameter. Ionization charge produced along particle trajectories is drifted 2.1 meters to each of two end plates, where induced signals and arrival times are read out on a total of $\approx$ 136,500 cathode pads. Particle identification in the TPC will be accomplished via dE/dx in the $1/\beta^2$ region. A central trigger barrel (CTB) surrounding the TPC, and veto calorimeters in the region of the beam insertion magnets will provide the information necessary for a collision geometry trigger by measuring the multiplicity at mid-rapidity and the energy carried forward, respectively. A portion of the central trigger barrel will be instrumented with a highly segmented time of flight (TOF) array having a resolution of $\approx$ 100 picoseconds. For particles within the acceptance of the TOF array, the maximum momentum for π/k separation will be extended from $\approx$ 0.7 GeV/c to 1.3 GeV/c, and for k/p separation from $\approx$ 1 GeV/c to 2.4 GeV/c.

A silicon vertex tracker (SVT) coupled with the TPC will locate the position of the primary vertex to high accuracy, improve the momentum and dE/dx resolutions, and locate secondary vertices to an accuracy of better than 100μm. The SVT will consist of $\approx$ 200 silicon drift detectors (SDD) arranged in three concentric barrels around the interaction point. The improved vertex resolution will make it possible to measure the decay of baryons and anti-baryons having multiple strangeness (e.g. $\Xi^{\pm}$, Ω^{-}) whose yield is sensitive to the strangeness density reached in nucleus-nucleus collisions.

An electromagnetic calorimeter (EMC) surrounding the central trigger barrel will be used to trigger on local ($d^2E_t/d\eta d\phi$) and global (E_t) transverse energy, and to measure jets, direct photons, and leading π^0 production. Correlation of the information from the EMC and central trigger barrel detector systems will also enable STAR to trigger on events exhibiting unusual pion isospin abundances (Centauro events) which have been suggested as a signature of exotic nuclear matter in nucleus-nucleus collisions at high energy.

External time projection chambers (XTPC) located in the forward regions will be used to study the transfer of energy between projectile rapidity and midrapidity by following the fate of the incident baryons rescattered in the collision. These chambers extend the pseudorapidity coverage of STAR from $|\eta| \leq 2$ to $|\eta| \leq 4.5$. A high granularity preshower photon multiplicity detector (PMD) covering the same acceptance as the XTPC detector in one of the forward directions will allow the measurement of photon multiplicities and isospin fluctuations (N_γ/N_{ch}) forward of midrapidity in order to search for events with an excess of thermal photons and events with anomalous isospin which may result from the presence of a disoriented chiral condensate.

Selected Publications

"The Conceptual Design Report for the Solenoidal Tracker At RHIC", The STAR Collaboration, LBL **PUB-5347** (1992).

"STAR Project Conceptual Design Update", The STAR Collaboration (1993).

"The STAR Experiment at the Relativistic Heavy Ion Collider", J. W. Harris et al., Nuclear Physics **A44** (1994) 277c-286c.

"Experimental Equipment for RHIC: Description of Baseline Detectors; Proposal for Additional Experimental Equipment", T. Ludlam, J. Harris, S. Nagamiya (1994).

"The Electromagnetic Calorimeter for the Solenoidal Tracker AT RHIC - A Conceptual Design Report", The STAR EMC Collaboration, LBL **PUB-5380** (1993).

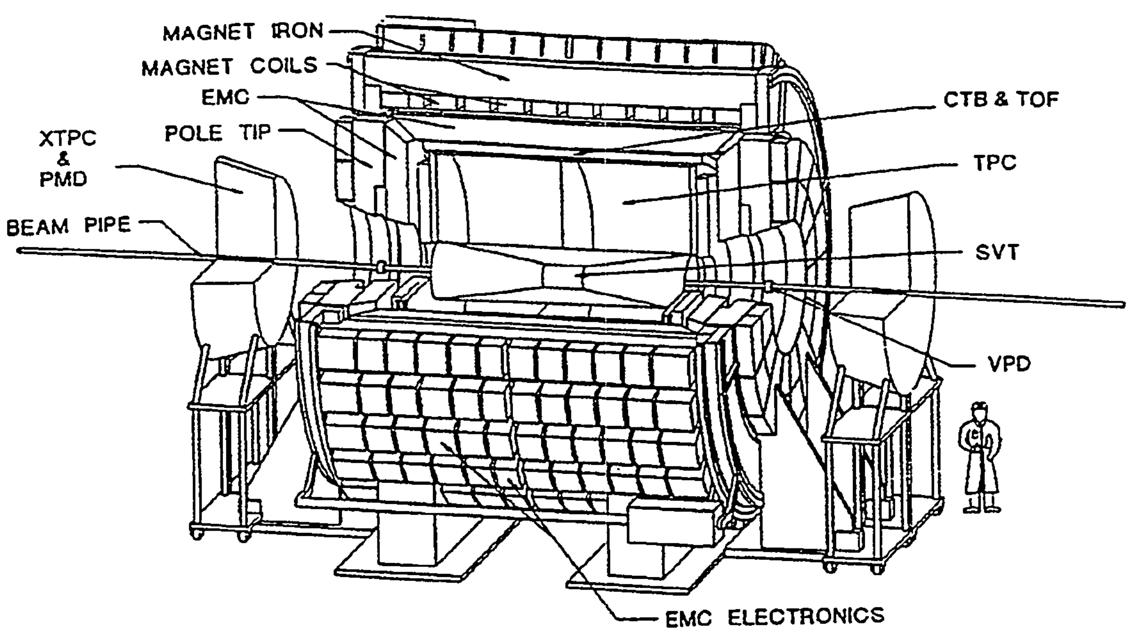

Figure 25: Schematic layout of the STAR experiment

Figure Details

VPD	Beam-Beam Interaction Counters
CTB/TOF	Central Trigger Barrel/Time of Flight Counters
SVT	Silicon Vertex Tracker
EMC	Electromagnetic Calorimeter
TPC	Time Projection Chamber
XTPC	External Time Projection Chambers
PMD	Photon Multiplicity Detector

Related Experiments

EOS, E810, NA35, NA49

WA80 - Large Acceptance Photon, Meson, and Baryon Production

GSI – Kurchatov-Inst. – ORNL – Uni. Münster – LBL
Uni. Lund – Uni. Tennessee – KVI – BNL

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Physics Goals:	π^0, η, prompt γ spectra and target fragmentation
Beams:	S, O, p at 200 AGeV and O, p at 60 AGeV
Targets:	C, Al, S, Cu, Ag, Au

Physics Summary

The aim of the WA80 experiment is to study the reaction mechanisms of nuclear collisions in particular by detecting photons in a 3800 module lead glass spectrometer. Transverse momentum spectra of photons, π^0 and η at various centrality conditions have been extracted for $0.2 \leq p_\perp \leq 4.4$ GeV/c. The data show power-law shaped spectra and $m_\perp$-scaling is observed within the experimental uncertainties. The η/π^0-ratio is somewhat enhanced as compared to the values found in pp collisions. An uncertainty of 7% is reached in the γ/π^0-ratio at $0.5 \leq p_\perp \leq 2.5$ GeV/c. In a preliminary analysis a photon excess of 10-15% is observed over known hadronic sources.
One and two-dimensional intermittency has been studied by using the streamer tube detectors read out by 40,000 pads. No intermittency signal beyond that produced by folding the Fritiof event generator with a detailed model of the detector is observed. The target fragmentation region has been investigated by measuring pp, $\pi^+\pi^+$, as well as many particle azimuthal correlations. The data consistently suggest that the full target nucleus participates in the reaction and that pion absorption effects play an important role in the interactions with heavy target nuclei.

Selected Publications

"Multiplicity and Pseudorapidity Distributions of charged particles from ^{32}S induced interactions...", R. Albrecht *et al.*, Z. Phys. **C55** (1992) 539-548.

"Intermittency and Correlations in 200 AGeV S+S and S+Au collisions", from ^{32}S induced interactions...", R. Albrecht *et al.*, Phys. Rev. **C50** (1994) 1048-1064.

"Distributions of transverse energy and forward energy in ^{16}O- and ^{32}S-induced collisions...", R. Albrecht *et al.*, Phys. Rev. **C44** (1991) 2736-2752.

"Bose-Einstein correlations in the target fragmentation region in 200 AGeV ^{16}O+nucleus collisions", R. Albrecht *et al.*, Z. Phys. **C53** (1992) 225-237.

"Upper Limit for Thermal Direct Photon Production in Heavy-Ion Collisions at 60 and 200 AGeV", R. Albrecht *et al.*, Z. Phys. **C51** (1991) 1-10.

"Transverse momentum distributions of neutral pions from central and peripheral 16O+Au collisions at 200 AGeV", R. Albrecht *et al.*, Z. Phys. **C47** (1990) 367-375.

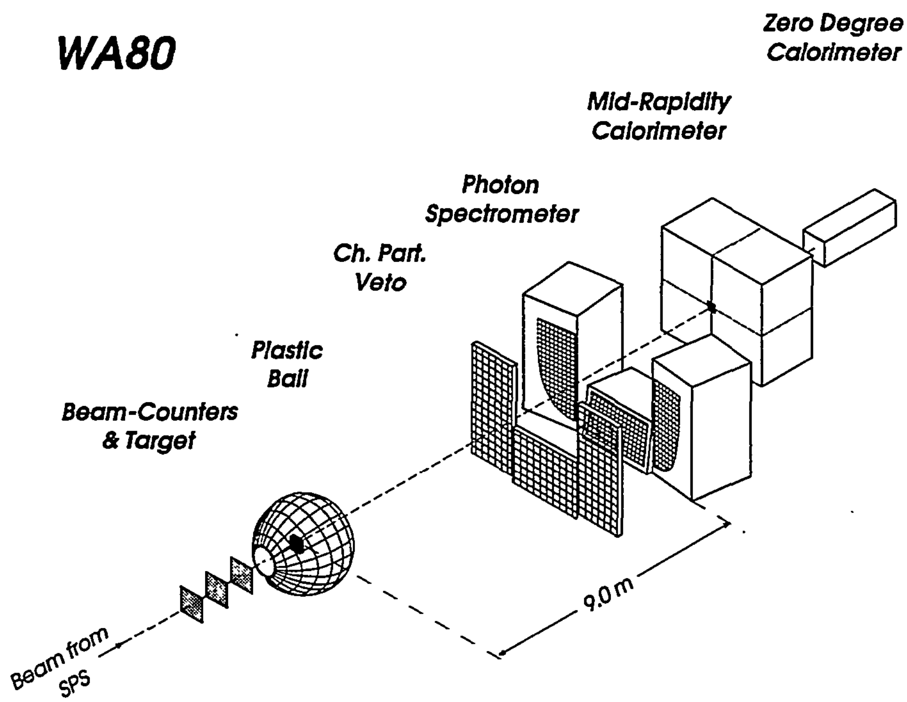

Figure 26: Perspective view of the WA80 experimental setup

Figure Details

Plastic Ball	Particle Identifying Spectrometer, p,d,t,He, P$-1.7 \leq \eta \leq 1.3$
Ch. Part. Veto	Streamer tube arrays, $1.5 \leq \eta \leq 4.4$ ($2.1 \leq \eta \leq 3.0$)
Photon Spectrometer	Lead Glass Arrays, $1.5 \leq \eta \leq 2.1$ ($2.1 \leq \eta \leq 3.0$)
Mid-Rap. Calo.	Sampling Pb-Fe Scint. Calo., $1.5 \leq \eta \leq 4.4$
Zero Degree Calo.	Sampling U-Scint. Calo., $\eta \geq 6.0$

Related Experiments

WA93, WA98

WA85 - Strange and Multistrange Particle Production at 200 GeV/c per Nucleon

Athens-Bari-Bergen-Birmingham-CERN-College de France
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Physics Goals:	Strange and multistrange particle detection
Beams:	S, p at 200 GeV/A
Targets:	W

Physics Summary

The WA85 experiment studies strange and multistrange baryon and antibaryon production in ultra-relativistic heavy ion interactions in the central rapidity and medium p_T region. Sulphur and proton beams have been used at 200 GeV/c per nucleon incident on a tungsten target. WA85 uses the OMEGA Spectrometer at CERN equipped with seven modules of MWPCs for track reconstruction and two arrays of silicon microstrips which sample the overall charged multiplicity in the central region. The MWPCs have been modified so that tracks with a p_T less than 0.6 GeV/c are not detected thus making it possible to take high statistics and have high reconstruction efficiencies in the difficult environment of heavy ion interactions. WA85 was the first experiment to produce results on Ξ^- and $\overline{\Xi^-}$ production and is the only heavy ion experiment to find Ω^- candidates. WA85 have published high statistic results on K^0, Λ, $\overline{\Lambda}$, Ξ^-, and $\overline{\Xi^-}$ spectra.

Selected Publications

"Λ and $\overline{\Lambda}$ Production in Sulphur-Tungsten Interactions at 200 GeV/c per Nucleon.", S. Abatzis *et al.*, Phys. Lett. **244B**, 130-134 (1990).

"Λ and $\overline{\Lambda}$ Production in ^{32}S+W and p+W Interactions at 200 A GeV/c.", S. Abatzis *et al.*, Nucl. Phys. **A525**, 445-448 (1991).

"Ξ, $\overline{\Xi}$, Λ, $\overline{\Lambda}$, Production in Sulphur-Tungsten Interactions at 200 GeV/c per Nucleon.", S. Abatzis *et al.*, Phys. Lett. **270B**, 123-127 (1991).

"Observation of Ω^- and $\overline{\Omega^-}$ in Sulphur-Tungsten Interactions at 200 GeV/c per Nucleon.", S. Abatzis *et al.*, Phys. Lett. **B316** (1993) 615-619.

"New Results from WA85 on Multistrange Hyperon Production in 200 A GeV/c S-W Interactions.", S. Abatzis *et al.*, Nucl. Phys. **A566** (1994) 225c-232c.

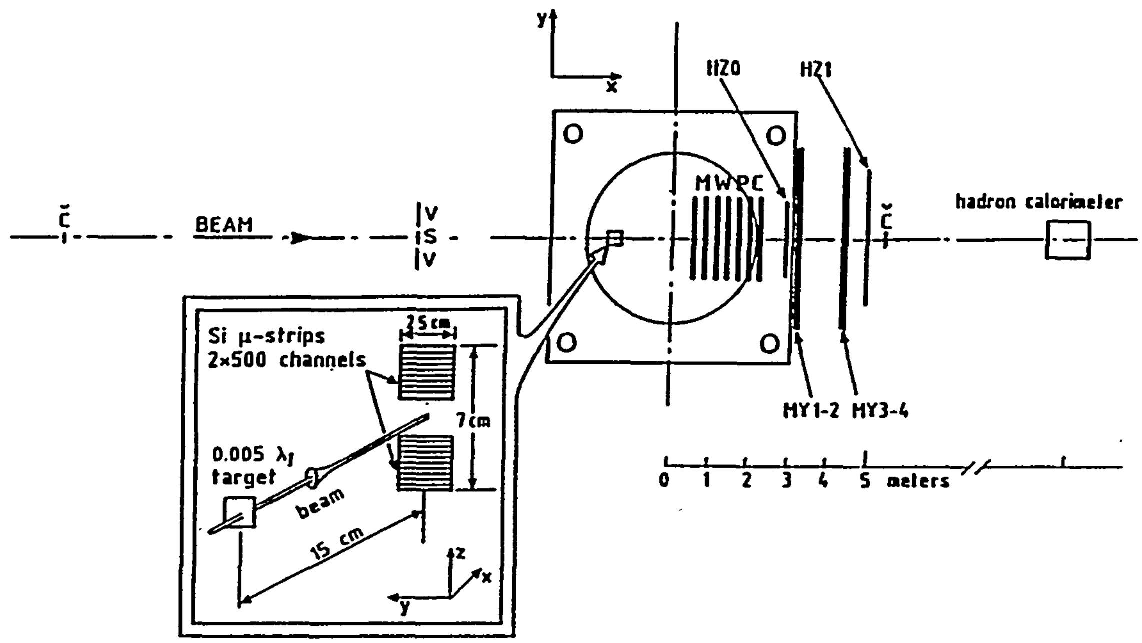

Figure 27: Layout of the WA85 Apparatus

Figure Details

Č	Beam Cerenkovs
Si	Two silicon microstrip arrays (512 channels each)
MWPC	Muliwire proportional chambers sensitive to tracks with $p_T > 0.6$ GeV/c
HZ0, HZ1	Scintillator hodoscopes

Related Experiments

WA94, WA97

WA93 - Spectrometer for Correlations between Photons and Hadrons

VECC(Calcutta)-U Panjab(Chandigarh)-U Geneva-GSI(Darmstadt)
U Rajasthan(Jaipur)-U Jammu-KVI(Groningen)-U Lund-MIT-U Münster
ORNL-RRC(Kurchatov Moscow)-U Tennessee(Knoxville)-U Utrecht
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Physics Goals:	Particle correlations and inclusive spectra
Beams:	S at 200 GeV/A
Targets:	Au

Physics Summary

The experiment combines two essential means of quark matter diagnosis: the measurement of photon production rates relative to charged particles or π^{o}'s, and the measurement of transverse momenta of charged and neutral particles and their correlations. The experimental setup consists of highly segmented lead glass arrays (3780 modules) at a distance of 9 m from the target covering the range 2<y<3. The detector allows to reconstruct the transverse momentum of π^{o}'s and η's. A preshower detector that can be operated in a hadron-blind mode complements the photon measurement in the range 3<y<5.5. The detector yields the number of photons and — to a limited extent — information on the total electromagnetic transverse energy. Charged particle tracking is achieved by a set of newly developed multistep avalanche chambers read out by CCD cameras downstream of the GOLIATH vertex magnet. Bose-Einstein correlations allow source size measurements up to 20 fm. The coverage is 2<y<4 for two field settings of $B \times L = 1$ and 2 Tm. Events of high energy density (central collisions) are selected by triggering on high E_T or low energy deposition at zero degree.

Selected Publications

"Proposal for a Light Universal Detector for the Study of Correlations between Photons and Charged Particles", CERN/SPSLC 90-14, SPSLC/P252 May, 1990.

"Large parallel plate avalanche chambers for multiparticle tracking", A.L.S. Angelis *et al.*, Nucl. Phys. A **566** (1994) 605c-610c.

"Photon Multiplicity Measurements in Nucleus-Nucleus Collisions at 200 A GeV", Y.P. Viyogi *et al.*, Nucl. Phys. A **566** (1994) 623c-628c.

WA93

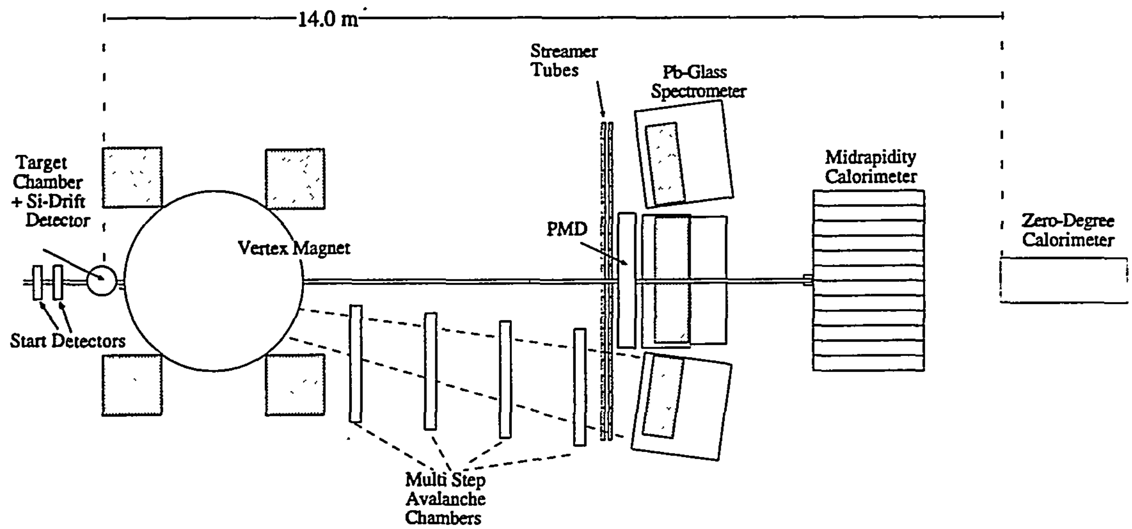

Figure 28: Top view of the WA93 experiment

Figure Details

Target Chamber + Si-Drift Detector (SDD)
Start Detectors
Vertex Magnet (GOLIATH)
Multi Step Avalanche Chambers (MSAC's)
Photon Multiplicity Detector (PMD)
Pb-Glass Spectrometer
Midrapidity Calorimeter (MIRAC)
Zero-Degree Calorimeter

Related Experiments

WA80, WA98

WA94 - Strange Particle Production in Sulphur-Sulphur Interactions

Athens-Bari-Bergen-Birmingham-CERN-Kosice-Legnaro-Madrid-Padua-College de France-Serpukhov-Strasbourg-Trieste

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Physics Goals:	Strange and multistrange particle spectra
Beams:	S, p at 200 GeV/A
Targets:	S

Physics Summary

The WA94 experiment is designed to study the production of baryons and antibaryons with 0, 1 and 2 units of strangeness in sulphur-sulphur interactions at 200 GeV per nucleon, and to compare the results with proton-sulphur interactions. It was performed using the CERN Omega Spectrometer with a ^{32}S beam at 200 GeV/c per nucleon incident on a tungsten target. The Omega Multi Wire Proportional Chambers (MWPCs) were modified to select only high p_T tracks; only a few tracks are recorded out of the several hundred produced in a central collision, making reconstruction of both strange and multi-strange baryons possible. Spectra have been measured for $\Lambda, \overline{\Lambda}, \Xi^-$, and $\overline{\Xi^-}$ particles, and ratios such as Ξ^-/Λ and $\overline{\Xi^-}/\overline{\Lambda}$ have been determined in the kinematic region $p_T > 1$ GeV/c and $2.5 < y_{lab} < 3.0$.

Selected Publications

"Strange Particle Production in Sulphur-Sulphur Interactions at 200 GeV/c per nucleon", S. Abatzis *et al.*, Nucl. Phys. **A566** (1994) 499-502.

"Strange Particle Production in Sulphur-Sulphur Interactions at 200 GeV/c per nucleon", S. Abatzis *et al.*, Proceedings of the International Conference on High Energy Physics (ICHEP'94) Glasgow, July 1994. Presented by O. Villalobos Baillie.

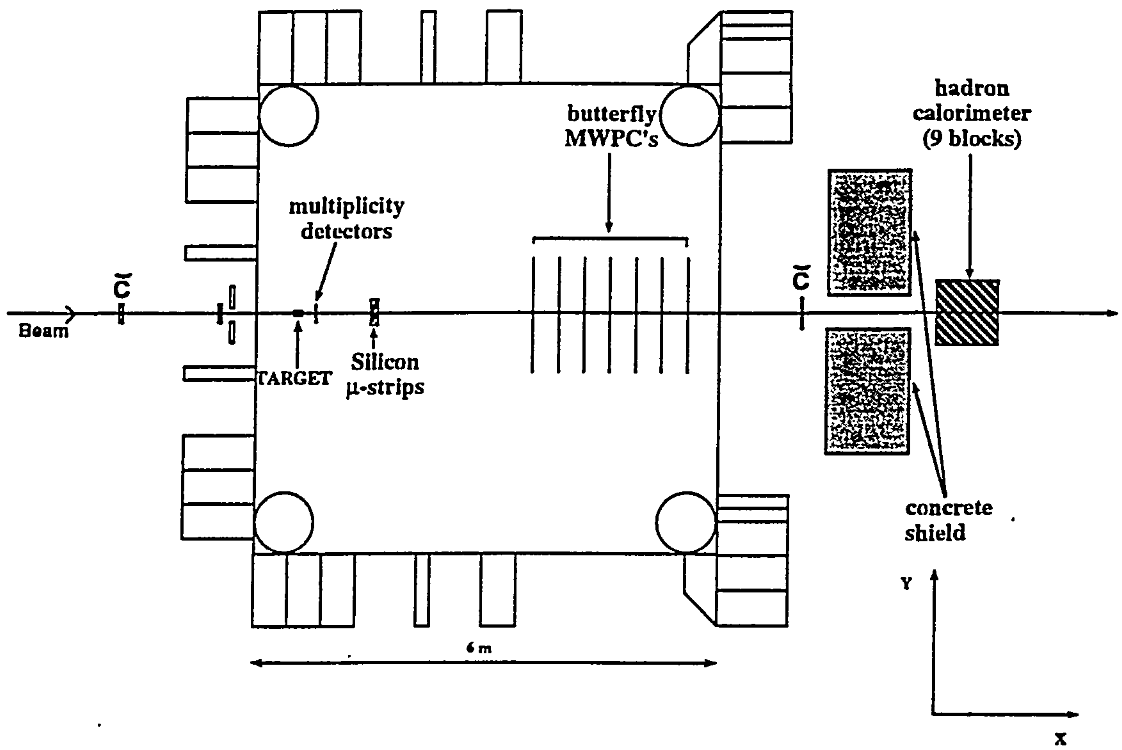

Figure 29: The WA94 Experimental Layout

Figure Details

The Omega Spectrometer, a 1.8T superconducting magnet, with:
(*a*) A thin sulphur target (1% interaction length).
(*b*) Silicon microstrips to sample the overall multiplicity in the central region.
(*c*) Seven MWPCs operated in the butterfly mode (as used by WA85).
(*d*) A forward hadron calorimeter which can be used in the trigger to select central interactions.

Related Experiments

WA85, WA97

WA97 - Strange Particle Production

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CERN-Genoa Univ./INFN-Košice Phys. Inst.-Legnaro Nat. Lab./INFN
Oslo Univ.-Padova Univ./INFN-Paris Collège de France
FZU-Inst. Phys. Acad. Sci. Prague-Prague TU-Rome Univ./INFN
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Physics Goals:	Strange particle spectra with $S = 1, 2, 3$
Beams:	Pb, p at 160 GeV/A
Targets:	Pb, Sn, Cu, S, C, Be

Physics Summary

WA97 aims to measure the spectra of strange particles and in particular of hyperons and antihyperons produced in ultrarelativistic lead-lead interactions and to compare them with those from proton initiated reactions. The experiment will cover the two central rapidity units down to transverse momenta of a few hundred MeV/c. The experimental setup will consist of: an array of multiplicity counters, a silicon based decay detector made of microstrips, pads and pixels, located in the CERN-OMEGA Spectrometer, an array of pad cathode MWPCs used as lever arm detectors and a zero degree hadron calorimeter. The possibility of using, as initially proposed, the OMEGA RICH followed by an array of MWPCs to identify protons is still under investigation.

Selected Publications

"First operation of 72k element hybrid silicon micropattern pixel detector array", E.H.M. Heijne *et al.*, Nucl. Instrum. Meth. A **349** (1994) 138.

"Experience with a 30 cm^2 silicon pixel plane in CERN experiment WA97", F. Antinori *et al.*, to be published in Proc. of the 6th Pisa meeting on advanced detectors, Frontier detectors for frontier physics, May 1994, in Nucl. Instrum. Meth. A.

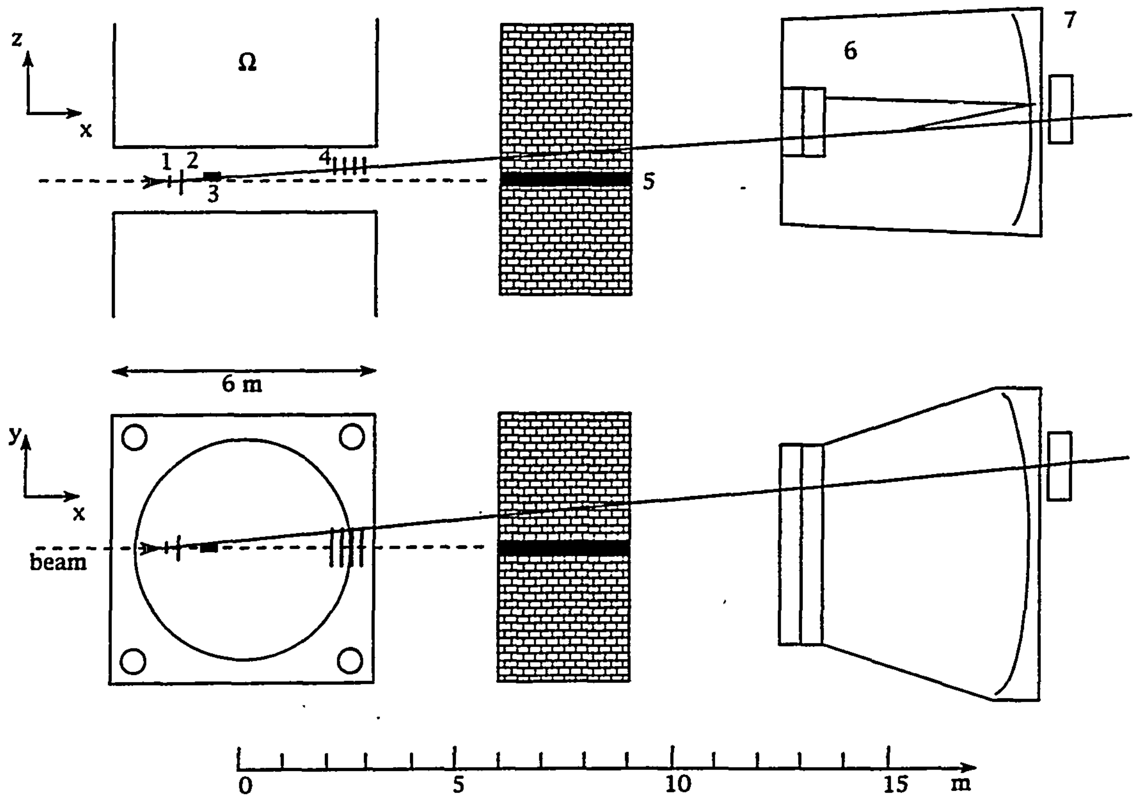

Figure 30: Side and top views of the WA97 Spectrometer

Figure Details

1 Target
2 Silicon multiplicity detectors
3 Telescope consisting of silicon microstrip, pad and pixel detectors
4 Lever arm pad chambers
5 Zero degree calorimeter
6 Omega RICH
7 Multiwire proportional chambers

Related Experiments

WA85, WA94

WA98 - Large Acceptance Hadron and Photon Spectrometer

VECC(Calcutta)-CERN-U Panjab(Chandigarh)-U Geneva-GSI(Darmstadt)
IOP(Bhubaneswar)-JINR(Dubna)-U Rajasthan(Jaipur)-U Jammu
KVI(Groningen)-U Lund-MIT-U Münster-NPI/ASCR(Řež/Prague)
ORNL-RRC(Kurchatov Moscow)-U Tennessee-U Utrecht
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Physics Goals:	Global event description and inclusive spectra
Beams:	Pb at 160 GeV/A, p at 200 GeV/A
Targets:	Pb

Physics Summary

The aim of the experiment is the high statistics study of photons, neutral hadrons and charged particles, and their correlations in Pb-Pb collisions. The photons are measured by a 10,000 module Lead Glass Spectrometer yielding high precision data on π° and η at midrapidity (with transverse momenta 0.3 GeV/c$<p_T<$4.5 GeV/c for π° and 1.5 GeV/c$<p_T<$4.0 GeV/c for η covering the "thermal" as well as the "hard scattering" regime beyond 3 GeV/c) and determination of the thermal and direct photon to π° ratio. The pad preshower Photon Multiplicity Detector allows, by comparing with the charged particle multiplicity measurement, to determine the photon enrichment in an event or event class. The charged particle setup contains a Multistep Avalanche Chamber tracking system with Silicon Drift Chambers to measure the multiplicities and the momenta, and a Time-of-Flight System for particle identification. This allows to correlate electromagnetic and charged hadronic data within event classes, yields high statistics transverse momentum spectra of identified hadrons as well as Bose-Einstein correlation data. Energy flow measurements are available with mid rapidity ($3.7<\eta<5.5$) and zero-degree calorimetry.

Selected Publications

"Proposal for a Large Acceptance Hadron and Photon Spectrometer", CERN/SPSLC 91-17, SPSLC/P260 May, 1991.

"Memorandum to the SPSLC: Tracking System for WA98", CERN/SPSLC 93-5,

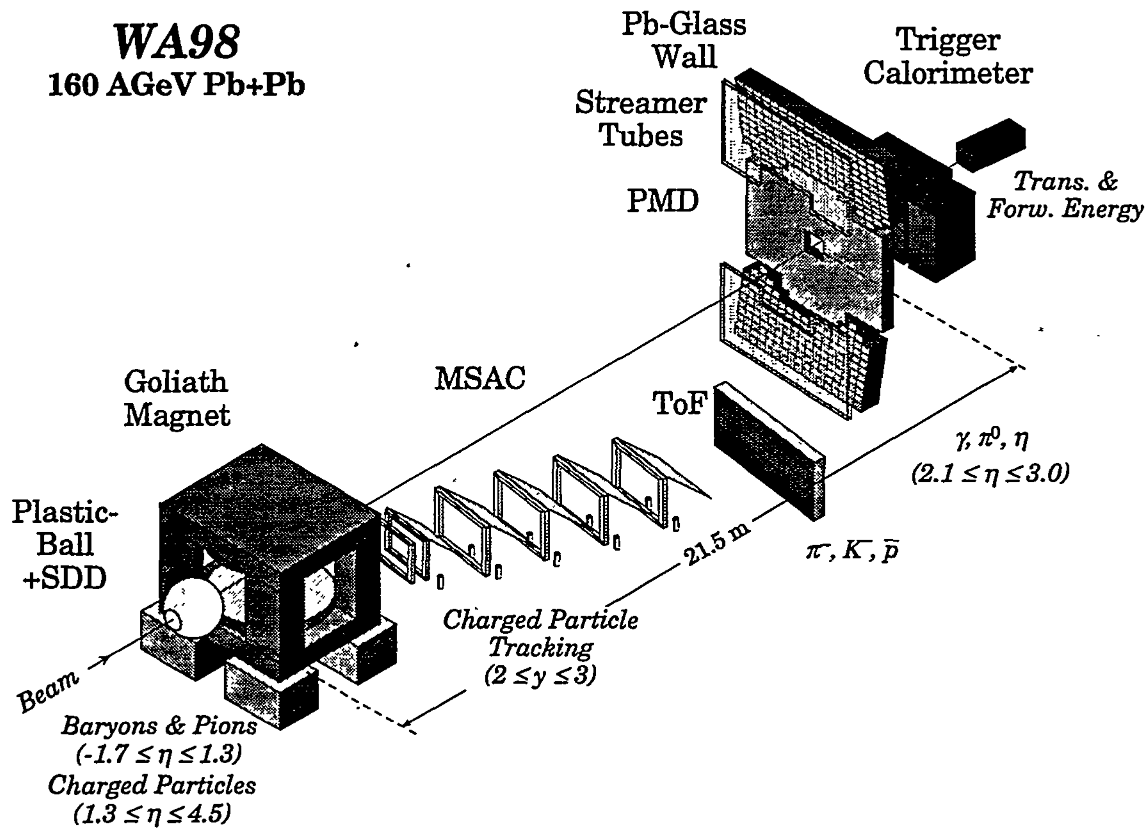

Figure 31: The WA98 Spectrometer

SPSLC/P260/Add.1 March, 1993.

Figure Details

Plastic Ball + Si-Drift Detector (SDD)
Vertex Magnet (GOLIATH)
Multi Step Avalanche Chambers (MSAC's) + Padchamber
ToF-Spectrometer
Photon Multiplicity Detector (PMD)
Pb-Glass Spectrometer
Hadron Calorimeter (MIRAC)
Zero-Degree Čerenkov Detector
Zero-Degree Calorimeter

Related Experiments

WA80, WA93

WA101 – Study of Various Processes with 160 A GeV Pb Beam

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Physics Goals:	Cross Sections for Nuclear Fragmentation, Electromagnetic Dissociation, Charge Pickup, and Electron Capture and Stripping
Beams:	Pb at 160 A GeV
Targets:	CH_2, C, Al, Cu, Ag, Sn, Au, Pb, and U

Experiment Description

In this series of experiments we will use BP-1 phosphate glass track-etch detectors, which measure ionic charges with remarkable resolution ($\sim$ 0.15 charge unit per surface) in a very small sampling distance ($\sim 20\mu$m). We plan to expose 10 stacks composed of BP-1 and several targets to the anticipated $\sim$ 160 A GeV ^{208}Pb beam at CERN when it first becomes available. After exposure, scanning and measurements will be made with an automated scanning microscope system.

Physics Summary

With this simple setup, we will measure cross sections for several interesting interactions in heavy ion collisions of $\sim$ 160 A GeV ^{208}Pb ions:

- nuclear charge pickup;
- nuclear and electromagnetic spallation;
- fragmentation of secondary beams produced in upstream targets;
- electron capture and stripping.

Measurements of the cross sections for these processes at Lorentz factor of 160 and with an ion beam as heavy as Pb will be fascinating.

New data of charge pickup will be useful for us to explore its underlying mechanism.

A measurement of the electromagnetic dissociation cross section will enable us to establish a clear picture for electromagnetic dissociation by heavy projectile nuclei.

It is of particular interest for us to study the charge-changing cross section for secondary beams, especially for Bi nuclei formed in charge pickup by 160 A GeV ^{208}Pb.

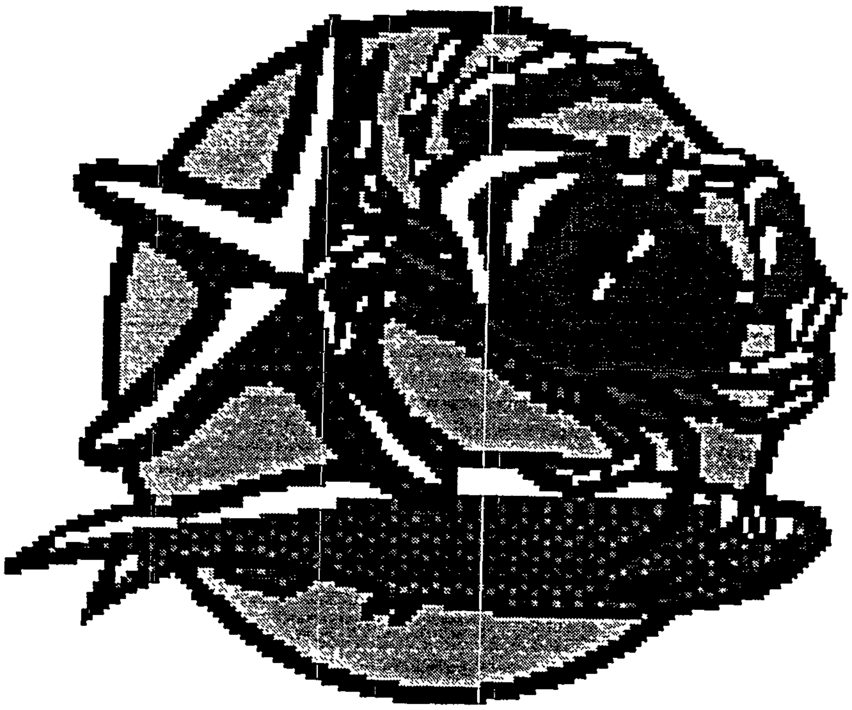
At higher Lorentz factor the capture cross section is dominated by vacuum capture. A measurement of cross section for electron capture with the $\sim$ 160 A GeV ^{208}Pb beam is crucial for resolving the question of the lifetime of colliding beams at RHIC. It is also interesting to measure cross sections for electron stripping, in order to predict lifetimes of stored beams of partially ionized ions. Our measurement will remove some of the uncertainties in the current calculation. The information our experiment will provide should thus be of great interest for RHIC.

Selected Publications

no paper has been submitted yet.

Related Experiments

EMU02



Large Experiments at the CERN SPS

NA34/2	^{16}O
NA34/3 "HELIOS"	^{32}S, p
NA38	^{16}O, ^{32}S, p
NA50	^{208}Pb
NA35	^{16}O, ^{32}S, p
NA49	p, ^{208}Pb
NA36	^{32}S, p
NA44	^{32}S, p, ^{208}Pb
WA80	^{16}O, ^{32}S, p
WA93	^{32}S
WA98	^{208}Pb
NA45	^{32}S, p, ^{208}Pb
WA85	^{32}S, p
WA94	^{32}S, p
WA97	p, ^{208}Pb
NA52	^{208}Pb

Small Experiments at the CERN SPS

EMU01 (E815)	^{16}O, ^{32}S
EMU12 (E863)	^{208}Pb
EMU02 (E793)	^{16}O, ^{32}S
WA101	^{208}Pb
EMU07 (E868)	^{16}O, ^{32}S
EMU13 "KLMM"	^{208}Pb
NA40 (E819)	^{16}O, ^{32}S
NA53 (E862)	^{208}Pb
EMU03	^{16}O, ^{32}S
EMU09	^{16}O, ^{32}S
WA87 (E806 & E883)	^{16}O, ^{32}S

Collider Experiments at the LHC

ALICE	^{16}O, ^{32}S, p, ^{208}Pb