EVENT PARAMETERS - FIXED TARGET

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This subgroup has focussed on detectors for fixed target experiments which have full azimuthal coverage. The general scope of the working group was to consider 1) the configuration of an idealized detector, and 2) various configurations of practical detectors that could be implemented on a relatively short time scale. The second category includes possible upgrades and modifications of existing experimental facilities. Beams of both 15 GeV/A sulphur at the AGS and 200 GeV/A oxygen at the SPS were considered.

The first conclusion reached regarding the idealized detector was that a magnetic field is necessary. Both solenoids and dipoles were considered, as well as combinations of the two. Behavior of simulated events was studied in the various magnetic fields. It was concluded that a reasonable solenoid could effectively cover only the target rapidity region and as such was not cost-effective even in the case of an "idealized" detector. Thus a dipole was chosen with the field determined by the beam energy.

Practical detectors and upgrades considered were 1) upgrade of the BNL Multiparticle Spectrometer (MPS); 2) upgrade of the Plastic Ball Non-Magnetic CERN SPS experiment; and 3) a streamer chamber.

The event parameters which could be measured with the detectors considered are indicated in Table I. Total multiplicity is an invaluable quantity to characterize the impact parameter of the collision. Gross structure in the hadronization phase change from the QGP might show up in fluctuations in pseudorapidity ($dN/d\eta$) or rapidity (dN/dy) distributions of the particles in an event. The energy available in the c.m. would be characterized by both the number (neg. multiplicity) and energy ($\pi^\pm$ energy) of the produced particles. Centauro-like events would be characterized by anomalous π^0 energy. Hard collisions would give large calorimetrically measured perpendicular energy ($E_\perp$) and particles with high $P_\perp$. Stopping and equilibration, hydrodynamic flow, or unexpected jets could all be investigated by more detailed shape analyses. The size of the emitting regions could be studied by the particle correlations.

EHP

Table I

Event Parameter	Idealized Detector	MPS III	Non-Magnetic	Streamer Chamber
Multiplicity:				
Neg	X	X		X
Total	X	X	X	X
dN/dn	X	X	X	X
dN/dy:				
Neg.	X	X		X
Others	X			
π^+ energy	X			
π^0 energy	X		X	
$E_{\perp}$	X		X	
$P_{\perp}$	X	X		X
Shape: equilibration	X	X	X	X
flow	X	X	X	X
jets	X	X	X	X
Particle corr: π^-	X	X		X
K, $\bar{P}$	X	X		
Others	X			

Idealized Detector

The Idealized Dipole-Detector (Fig. 1) consists of a small target surrounded by a cube of CCD detecting planes which serves as a vertex detector and multiplicity counter within the uniform field region of the magnet. Immediately downstream of this is a silicon counter serving as a beam veto. Also within the magnetic volume is a highly segmented tracking chamber with dE/dx capability and 3 dimensional read-out. The target, vertex detectors and tracking chamber are surrounded by electromagnetic calorimeters and time of flight detectors for particle identification from 180° to 20° . All this is azimuthally surrounded by a hadron calorimeter which also serves as the return yoke of the dipole coils. Downstream of the magnet, covering the forward direction to an angle of about 20° are 3-dimensional tracking chambers, and a ring imaging cerenkov detector (RICH) for identification of the high momentum particles. Finally, also covering the forward 20° are electromagnetic and hadron calorimeters, and a TOF hodoscope.

Figure 1. Idealized detector.

Figures 2 and 3 show a typical central event at 15 GeV/A tracked through the idealized dipole detector. The pattern reconstruction is simpler if one starts in the non-bend plane (Fig. 2) where the tracks are straight lines and then goes to the bend plane (Fig. 3).

Figure 2. 15 GeV/A ^{16}O + Au central collision tracked in the non-bend plane.

Figure 3. Same event in the bend plane with a field of 0.5 Tesla.

At 200 GeV/A (Fig. 4 and 5) the problem is much more difficult. A system like the European Hybrid Spectrometer might be necessary. This uses a series of dipole magnets spaced down the beam line dispersing higher and higher rapidity intervals.

Figure 4. 200 GeV/A $^{16}\text{O} + \text{Au}$ central collision tracked in the non-bend plane.

Figure 5. Same event in the bend plane with a field of 1.5 Tesla.

MPS III

A prime example of existing equipment that could be modified for heavy ion physics is the BNL Multiparticle Spectrometer (MPS). Two AGS beams are currently available to the MPS, one of which (the HEUB) is produced at 0° from the A target station and can easily be modified to transport primary beam particles. In addition, the MPS operates at a user facility so the equipment has been built with frequent changes of experiment in mind—a necessary feature for the short heavy ion program since the MPS will use it's conventional beams for the rest of the year.

The spectrometer is based on a large dipole C magnet with a pole area of $15' \times 6'$ and a gap height of $4'$. The current detectors, 49 narrow cell drift chambers with projective measurements, were designed to operate in pion and proton beams of $\sim 2 \times 10^6$ per second in order to measure events of relatively low multiplicity (<10). We have examined the improvements needed to handle nucleus-nucleus collisions with an incident beam of ~ 15 GeV/A, with a goal of full measurement of charged particle multiplicity near the target, tracking of the charged particles in the MPS magnet and particle identification of at least the forward negative particles; for particle identification purposes we have assumed the use of two existing threshold Cerenkov hodoscopes and a time-of-flight hodoscope currently being constructed for MPS Experiment 771.

A possible setup is shown in Fig. 6. The major changes are threefold:

- 1) Construct a two-layer cube of CCD's to surround the target. Tests with minimum ionizing particles have given a spatial resolution of $5 \mu\text{m}$ and two particle resolution of $50 \mu\text{m}$, hence a $1 \text{ cm} \times 1 \text{ cm}$ plane has effectively 40,000 independent elements. This detector gives n and $dn/d\eta$ for all charged particles. Since the CCD's are live during readout, we will use pulsed magnets to kick the beam into an upstream beam stop when an event is selected for readout.

Figure 6. Plan for MPS III. The target would be surrounded by a CCD cube with a Si beam veto 10 cm downstream.

2) Replace the current MPS chambers with true 3D devices. A prime candidate is the TPC, possibly a series of thin planar modules similar in structure to those used in RICH counters or possibly a larger gas volume of similar design to a conventional TPC.

3) Add large drift chambers with true 3D readout in the field-free region downstream of the MPS. The straight line tracks will help in disentangling the curved tracks in the MPS field.

A small detector ≈ 10 cm downstream of the target will be set to veto on non-interacting beam particles; this will eliminate background events from interactions in the detectors. In order to get information on target fragments, three calorimeters will be set up downstream of the other detectors. They will cover 0° production for neutrals, protons, and fragments with $Z/A = 1/2$. These will play a major role in trigger selection.

Non-Magnetic Detector

The nonmagnetic detector (Fig. 7) consists of a square tube, a CCD cube, and a calorimeter box, surrounding the target, that will be able to determine the energy and the emission angles of all the charged particles produced in the target. All other parameters are extracted by calorimetry which gives up to 10% accuracy or even separating individual particles. A detector of the Plastic Ball type is used to measure the energies of the particles emitted backwards in the laboratory. The forward hemisphere is completely covered with a suitable arrangement of sampling calorimeters, with both electromagnetic and a hadronic sections. About 1200 towers covering 48 m^2 , 20×20 cm with a depth of 80 cm, have been used for this design.

Figure 7. Plan for a non-magnetic system consisting of a square tube and a wall of calorimeters. The target is also surrounded by a CCD cube.

The arrangement is well suited for applications over a large energy range (from AGS up to SPS energies) and seems to be the only obvious design that will be able to cope with the tremendous multiplicities expected from the collisions of heavier ions.

Besides the measurement of the pseudorapidity distributions, and of the amount of energy put into the production of charged and neutral pions, this detector will be well suited to study shape parameters and to investigate phenomena connected with high transverse energy.

Streamer Chamber

To estimate an adequate size for the chamber, and a minimum magnetic field, we use as a guide the multiple-tracking efficiency attained in the Bevalac streamer chamber for central 1 A GeV U + U collisions: $1.3 \times 0.6 \times 0.4 \text{ m}^3$ and $B = 13 \text{ kG}$. For charged particle multiplicities of about 160 in the forward lab hemisphere, acceptance losses plus track reconstruction failures are less than 15%. Typically, $\Delta P/P$ is about 3 to 10% and measurement time is about a few hours for a full event.

At worst, avoidable multi-track problems scale with the length of the chamber parallel to the beam and other multi-track inefficiencies scale with the area of the chamber projected onto the camera plane. We used the HIJETA data to estimate whether the magnetic field produces sufficient dispersion of the forward-going tracks to counteract the Lorentz boost effect. Momentum resolution is generally not a problem, since it scales with segment length to the fourth power.

The overall conclusion is that for 15 A·GeV S + Au, where HIJETA predicts central trigger events with charged particle multiplicities of about 220, a chamber of length 2m, with $B = 15 \text{ kG}$, is adequate. The chamber would be 0.6 m parallel to the field and 0.8 m in the remaining dimension. For 200 A·GeV O + Au, we do not recommend a conventional streamer chamber, but a holographic chamber might be possible.

R&D

The CCD vertex detector is a completely untested device for heavy ions. Much R&D will be needed. RICH detectors are being built but have not yet proved themselves at these high multiplicities. This development must be watched carefully. There are several choices for the 3D tracking chambers. A careful study to make a choice followed by R&D is necessary. A new development in the calorimetry of soft hadrons is very much needed. Other items which need prototype studies are the thin TPC's, the Si beam anti, and the TOF barrel. The pattern recognition problem requires software development in parallel to the other development projects.

Conclusions

We have concerned ourselves with fixed target experiments with full azimuthal coverage. The planned MPS III and SPS non-magnetic experiments are fairly close to the ideal magnetic and non-magnetic configurations described here. It appears that fixed target 15 GeV/A Au + Au experiments look very difficult. At 200 GeV/A only calorimetry looks feasible, even for 160 .