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NOTES ON VISIT TO BROOKHAVEN ON 6TH, 7TH SEPTEMBER 1960.

A.G.S.

The synchrotron has worked some time ago and is at present undergoing modifications to improve various components and circuits. Major work is connected with the magnet power supply, in particular the servo control of the liquid rheostat in the motor rotor circuit, which has not been satisfactorily designed by the maker.

Changes are also in progress with the RF system, particularly the driver station and the removal of undesirable phase shifts and jumps during acceleration.

The next trial is scheduled for Friday 9th and it appears everything will be ready in time.

According to Mrs. Blewett the machine worked amazingly well despite the early state of the circuitry and equipment. However, injection was impossible without some powering of the sextupole lenses. The beam vs time traces show no loss during acceleration, and the various controls were claimed to be rather uncritical.

EXPERIMENTAL EQUIPMENT.

Some bending magnets and rectangular aperture quadrupoles have already been delivered. There is some disappointment in the latter as they consume even more power than expected. The maximum gradient is about 400 G/cm - the aperture 15 x 60 cm and the power consumption figures are not definite but are variously quoted at 400 to 500 KW. The length is about 3 feet.

The solid state power supplies are delivered. Their regulation is to 0.5 o/oo over 8 hours in current. The range is 20 o/o on taps but for short term over a factor of 3 in current. There are 3 sizes of 175 KW (2 KA) 300 KW (2 KA) and

and 600 KW (4 KA). They are very bulky due to air cooling and Chris will try to get more details as to circuits. The problems of space and cabling seem to be much as we have discussed.

They are made by ACME Electric Co., Cuba NY. and may be operated in parallel or 2 or 3 in series.

Some study is going into the possibility of using transistors for parallel shunt regulators for use in the case where two magnets excited in series are to be used with different currents.

COSMOTRON.

The cosmotron seems to be in serious operation, though there are difficulties from the rebuilding due to the fact that it is operating very near to a resonance Small perturbations, such as thermal changes or the presence of an experimenter's magnet can cause the machine to sit on the 2/3 resonance. It is proposed to put magnetic shielding in the straight sections. Interesting beam studies are in progress which Chris will report.

EXPERIMENTAL.

There is a quasi permanent beam layout - which is in a diagram which I have given to B. de Raad. Most external beams originate from three extracted beams which contain some 40 magnetic components and a 10 ft electrostatic separator. The new experimental hall is very well filled - the whole machine is covered by concrete shielding and each beam is completely surrounded by shielding so that the background in the hall is quite tolerable even for a bubble chamber. The normal best circulating beam current is 1.5 x 10^{11} protons per pulse and extraction efficiency is 50 o/o at best but more usually 20 - 25 o/o.

The major experimental work is as follows .

Beam 1 : is split at a thin target to give a low intensity π^- beam which after analysis goes to a propane bubble chamber.

The main beam strikes a 1/3 mean free path target to give forward pion production. After analysis these pions strike another 1/3 mean free path target (hydrocarbon). From this the neutral products are filtered by a sweeping magnet to permit such studies as the properties of θ_2^o in a hydrogen bubble chamber (14").

Beam 2 : The ejected beam is used to produce forward pions which after the electrostatic separator can go into a hydrogen bubble chamber (20"). The π^+ beam is obviously interesting.

Beam 3 : is not in operation yet. Will be used with a large counter experiment involving time of flight apparatus and Čerenkov counters. Intend to study, for example, K distribution in pp interactions.

It is possible to work usefully at these energies with $\sim$50 pions into the chambers.

The separator is similar to the Berkeley model in principle. Has a round tank $\sim$1 m diameter, 10 feet long and can run with $\pm$ 400 kV over 20 cm. Plates $\sim$ 50 cm wide. Evapor-ion pumps. Was actually operating with about 8 cm gap and I will find out more details soon.

I have discussed with Swartz some beam profile indicators. These are simply segmented in chambers with an array of 8 x 8 made by aluminising a mylar sheet with segments about 1 cm^2 and with a spacing of about 2 cm between the sheets. Electrometer tubes are used with $R \sim 10^{10}$ ohms $C \sim 10^{-10}$ farads at input (1 sec RC). With 10^7 particles per segment can get useful indication. More advanced model has grid in front of collector segment to remove difficulties which arise due to charge up of mylar with heavy pulse. Operating voltage 500 $\rightarrow$ 20 volts according to intensity (10^{10}/segment max.). Beam location possible to 1 cm.

Have also used 1/4 " x 5 " diam. disc from a Na I crystal viewed with television camera. Sensitive to 10^9 particles, but unfortunately serious contamination of the beam compared with mylar foil device. Best sensitivity comes by use of periscope and eye. With practice can see profile of beam of 10^6 particles over few cm^2. May try array consisting of 1/4" square strips of Na I 4" long and optically insulated from each other, in conjunction either with TV or maybe PM's. Solid state detectors seem also to be useful and are just being developed. Solid state glow lamps are used for the display of the profile indicators. Will try to get drawings.

Have seen with Roberts set up with image converter and 4 stages of image intensifiers. Will be used in Čerenkov set up with a scintillator say 20 cm diam by 20 cm long. An f:1.5 lens of about 8" focal length (already in use) will image the Čerenkov cone onto the first Iconoscope. The diameter of the image is a measure of the Čerenkov angle and thus β and position may be determined. Also possible to gate as max. time constant in circuit, will be about 2 nanoseconds due to persistence of phosphor. Hopes to obtain a resolution in β of better than 10^{-4}. In fact 3×10^{-5} should be possible.

The tubes are expensive. Set up worth ∼$ 40000 (5" diam Iconoscope ∼$ 5000). Has three f:0,75 lenses in the intensifiers ∼$ 1500 each and the f:1.5 lens has been especially made. May work in a few months and originally was intended for filament scintillator array until thought of Cerenkov arrangement.

MISCELLANEOUS.

Last month the hydrogen liquefier of the Cosmotron group put out 17000 litres liquid hydrogen. Very beautiful liquid gas containers for 1000 litres on wheels. Have seen propane cylinders for 300 lbs from Lee, Detroit which cost $ 80 each approx., (marked 300 HC).

Convenient digital clocks (for bubble chamber information) from Parabam. Digital unit removable for distant mounting or multiplication.

There are 12", 14", 20" liquid hydrogen bubble chambers.

The 80" will be finished in two years.

There is a 30" chamber under construction for either hydrogen or propane. Have seen the magnet and body. Two gas Cerenkov counters are similar to that of von Dardel.

$$\text{Resolution is } \frac{\Delta\beta}{\beta} \sim 0.0005.$$

RESEARCH PROGRAMME FOR A.G.S.

Cool gave a talk for visiting foreign scientists, mostly Russians.

If all the propositions already put forward were accepted there is already a programme for five years. There will be a careful screening of all experiments by a joint committee of the physics department and the machine group.

They will commence at first with a few months at a time.

The present programme may be classified as follows.

1. Extension to higher energies of data on σ_{total}, $\sigma_{elastic}$, $\sigma_{anihilation}$, and $\sigma_{charge\ exchange}$ for $\pi^{\pm}$, $K^{\pm}$ and $p^{\pm}$. This will involve 2 liquid hydrogen targets 10' long by 1' diam as **well** as smaller ones.

2. Study of properties of antihyperons. $\bar{p} + p \rightarrow \bar{\Lambda}^{o}, \bar{\Sigma}, \bar{\Xi}$
From CERN results large intensities of $\bar{p}$ are expected.

3. Study of $K^{-} + p \rightarrow \Xi^{0}$ and $\theta_2^{0} + p \rightarrow \Xi$ for which large flux is expected.

4. Study of electromagnetic phenomenon for instance electromagnetic form of π by scattering off electrons.

$\pi + e \rightarrow \pi + e$ can reach momentum transfers of $\sim$ 150 mev/c with A.G.S. With

$\mu + p \rightarrow \mu + p$ momentum transfer up to 1 Gev/c.

So far no anomalous results have been observed up to 200 Mev/c.

5. Have plans for neutrino experiments similar to our own.

6. General search for short lived new particles.

7. Emulsion experiments e.g. $\pi^{-} + p \rightarrow \pi^{o}$. By measuring gap spacing can determine lifetime of π^{o}. Hyperfragments may be studied similarly.

However it is expected that the most interesting results will come from experiments which have not been planned yet.

Apparatus : 2 groups are working on scintillation fibre chambers. ($\sim$15 x 15 x 30 cm).

Spark chambers for neutrino detectors and to observe polarisation of decay products of hyperons.

The 30" bubble chamber will be used with freon in the neutrino experiment.

The electrostatic separators will have 30 metres of electrodes, fields up to 70 kV/cm, power supplies of $\pm$ 600 kV)just like ours).

DUBNO.

Blokhintsev gave a talk about Dubno. Staff is 2500. Has Council of 12 which he is "happy to report, meets once per year". Five laboratories.

1. High Energy Physics (10 Gev machine) 900 staff, V. Veksler
2. Nuclear Research (680 Mev cyclotron) 600 staff, Dzhelepov
3. Nuclear Reactions (120 Mev heavy ion machine),120 staff, Flerov
4. Neutrino Physics (Reactor) 100 staff, Frank
5. Theoretical Physics and Computer 100 staff, Bogoliubov

The establishment is more similar to CERN than to Brookhaven. There is no secret work.

VEKSLER LABORATORY.

Veksler Laboratory has studied in π, N reactions how N moves in c.m.s. Independently of no of π generated momentum goes within 60° cone. and N goes backward (7 Gev/c beams).

Transverse momentum of N $\sim$ 400 Mev/c.

$$\pi^{-} + p \rightarrow \Lambda^{0} + K^{0}$$
$$\Sigma^{0}$$
$$\Xi$$

Angular distribution of K strongly forward, Λ and Ξ strongly backward. Region of interaction $\sim$ $\sim 10^{-14}$ cm. Sharp rise in K and $\bar{K}$ production with energy.

$\Lambda^{0} \rightarrow p + \pi$ large assymetry in c.m.s., p backwards.

D particle. Good search in last year. 4 coplanar cases found. 15 non coplanar cases. Could be

$$K^{+} + N \rightarrow K^{0} + \pi^{+} + n$$

Or

$$D \rightarrow \pi + K^{0}$$

In 4 cases m = 1400, 800, 800, 900

No definite conclusions, may be it indicates there are cases of non elastic charge exchange. Now looking in hydrogen bubble chamber where charge exchange is excluded.

REORGANISATION AT BROOKHAVEN.

There are now two departments connected with the high energy machines. The accelerator department and physics department, made roughly by dividing staff into two classes - those prepared to contribute to the services and development of the laboratory, as well as doing research - and those wanting only to do research. The respective departments are obvious. There is no difficulty in finding staff for the physics department. Considerable difficulty for the other. Even more so in chemistry and biology.

The accelerator department will operate the machines and facilities, and will allow staff free research, machine time to be competed for on same basis as other parties.

General control will be achieved by personnel ceiling.

The physics department will develope detectors.

C.A. Ramm

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