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Proposal*

# A study of $\bar{p}p$ reactions in BEBC at 25,50 and 100 (?) GeV/c

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Summary: We propose to take 50,000 pictures at antiproton momenta of 25,50 and (hopefully) 100 GeV/c (i.e. 150,000 pictures). The aim is to test the feasibility of annihilation studies at high momenta and to examine inclusive and exclusive $\bar{p}p$ reactions, especially in relation to pp data at corresponding energies

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* Subsequent to letter of intent CERN/SPSC/I 73-32

Proposal

Study of $\bar{p}$ p reaction in BEBC at 25, 50 and 100 (?) GeV/c

Athens, Democritus, Liverpool, Vienna

Studies of the antiproton annihilation process have shown it to possess certain features which are unique in hadronic interactions namely

1) high transverse momentum for the outgoing pions,

2) high multiplicity distributions with moments unlike those of other hadronic processes,

3) inclusive distributions for all $\bar{p}$ p data which do not fit with current theoretical schemes, the discrepancy being caused by the annihilation component.

These properties may be associated with the absence of leading particles, baryon exchange or some other unknown mechanism. Many of the features associated with (2) appear to be similar to those observed in $e^+e^-$ annihilation. Since all three properties listed above are s-dependent their study should be pushed to as high an energy as possible.

One great problem, however, is associated with the study of annihilations at great energies, namely that the total annihilation cross sections appear to fall like $s^{-0.6}$ which implies cross sections of $\sim$5 mb at 50 GeV/c and $\sim$3.5 mb at 100 GeV/c. The total $\bar{p}$ p cross section is 40 mb at these momenta.

Since the annihilation cross section is known to roughly equal the difference of $\bar{p}$ p and p p total cross sections a start on investigating the feasiblity of annihilation studies may be made by comparing $\bar{p}$ p and p p interactions. We propose to take:

1) 50,000 pictures at 25 GeV/c,

2) 50,000 pictures at 50 GeV/c,

3) 50,000 pictures at the highest possible antiproton momentum.

Although the document CERN/SPSC/7 73-4 refers to an upper limit of 75 GeV/c for separated $\bar{p}$ beams to BEBC we understand from private conversations that the limit is set, not by problems of separation (CERN/D.Ph.11/BEAM 73-5), but by the avaiable flux and that there is reasonable confidence to achieve 80-90 GeV/c. We therefore hopefully designate our top momentum as 100 (?) GeV/c.

We propose to compare our data with p p reactions at comparable momenta. Preliminary p p data from Serpukhov and NAL already exist at these momenta and clearly more refined information will exist by the time BEBC operates in conjunction with the SPS. However since NAL has no immediate plans for an R.F. beam, $\bar{p}$ p studies at CERN may well offer unique opportunities.

Regardless of the problems of separating the annihilation components, three runs of 50,000 pictures will give us certain physics which can be usefully exploited. A pessimistic list would include:

1) charge multiplicities and topological cross sections ,

2) inclusive reactions-problems of particle ambiguities may well be helped here by exploiting the charge conjugate nature of the $\bar{p}$ p system - in principle one need only look at particles travelling backwards in the c-system,

3) exclusive channels, especially of the diffractive dissociation type

$$\bar{p}\ p \longrightarrow \bar{p}\ (p\ \pi^+\pi^-)$$
$$\bar{p}\ (p\ 2\pi^+2\pi^-) \quad .$$

More ambitiously a start on the physics of the annihilation process may prove possible. Studies with $\bar{p}$ with incident momenta up to 10 GeV/c at Liverpool have shown that the events with highest prong numbers are always from annihilations, and a straight difference of prong cross sections between $\bar{p}$ p and p p yields a substantial portion of the total annihilation cross section. At 50 and 100 GeV/c with 10 tracks per picture and a fiducial region 2 metres long we expect the following numbers of events.

| | | 50 GeV/c | 100 GeV/c |
|---|---|---|---|
| 2 prongs | $\sim$ | 45,000 | $\sim$ 36,000 |
| 4 | $\sim$ | 33,000 | $\sim$ 24,000 |
| 6 | $\sim$ | 24,000 | $\sim$ 24,000 |
| 8 | $\gtrsim$ | 15,000 | $\sim$ 24,000 |
| 10 | $\gtrsim$ | 10,000 | $\gtrsim$ 10,000 |

Thus a minimum programme for the annihilation processes could well be :

4) annihilation cross sections and topological cross sections at higher multiplicities by $\bar{p}$ p, p p differences,

5) examination of the properties of systems with highest multiplicities (probably pure annihilation).

If the external hadron identifier behind BEBC functions successfully then systems with lower multiplicities should be separable into inelastic (antiproton present) and annihilation processes (the separation may also behelped by the occurence of slow (identifiable) protons in BEBC)
Thus the ultimate ambition is

6) A systematic study of the mechanisms of the annihilation process.

If stage (6) is reached and the data prove to be interesting, then a request for further film would be made at a later data.

Two of the groups are already equipped with automatic measuring machines and a third will be added by 1977. BESSY scanning tables will also be obtained (Liverpool already has two). The Liverpool laboratory has considerable experience in the handling of antiproton data at high energies.