PROGRESS REPORT ON SPECIAL BEAMS

FOR

15' BUBBLE CHAMBER AS OF SEPTEMBER 25, 1974

Item 2. Tagging System: Progress very good.

Both Cerenkov counters are completely built and installed, although neither of them has been tested yet.

PWC's are under construction. The three small ones for Enclosure 115 have been sub-contracted to be built at ORNL. The six large ones are being built at Fermilab. The G10 board is here, the artwork has been done, and the etching is in progress. The electronics is essentially all here and a large part is already assembled. It is not clear when the wire winding will be done, but it is hoped that everything will be completed before December 31, 1974.

The re-programming of the PDP-9 program for the 30" bubble chamber tagging system for use on the PDP-11 is essentially complete. In the re-programming, its use with the 15' bubble chamber was taken into account and it is estimated that about a week's effort will be required to implement it for the 15' bubble chamber after the new PWC's are installed and working.

Item 3. Experimentation With Enrichment Schemes Using

Present Beams: Progress has been poor to moderate. Tests done so far have been scanty but quite successful. Many enrichment schemes still to be tested need additional equipment.

One significant item of progress was that Neale wrote up and published his ideas. They have been distributed as Fermilab Report FN-259, dated June 24, 1974. He gives the results of computations with various beam designs and flux enrichment estimates. In addition, he gives a design for a compact "Enriched Particle Beam Facility" proposed to be installed in Enclosure 100, where the present N3/N5 hadron target is located.

Here I will give the progress on each scheme in the same sequence as the schemes are given in FN-259 for the three general areas of (a) particle filtering, (b) multiple targetting, and (c) target halo. I will also mention some of the proposals with which I am familiar but the list of proposals is not exhaustive. There are undoubtedly many more.

(a) Particle Filtering:

Neale has suggested a 40-meter long deuterium filter just downstream of Enclosure 103 to obtain enriched beams of π^+ and K^+ over a large momentum range.

Tests on this so far, done in Spring 1974, consisted of enriching a positive 200 GeV/c beam by using 12 feet of water and 1.5 feet of polyethylene in Enclosure 103. The ratio π^+/p went from 0.053 to 0.387 - an improvement of about 7. The ratio of μ^+/π^+ in the chamber was about 0.5. No significant improvement in K^+/π^+ was observed. Further tests are needed to understand what is happening to the K^+ mesons.

There have been discussions with CERN about the possibility of CERN building a deuterium or helium filter, but action awaits the results of further experiments with water.

(A group involving Cambridge, Aachen, and Bonn have requested a K^+ run with the 15-foot bubble chamber (Proposal 334).)

(b) Multiple Targetting:

(1) Double targetting in Enclosure 100 for p, π^+, K^- enrichment.

(i) Low momentum proton beams may be obtained by placing a second target in the flux of neutrals from the first target.

Tests done so far with 300 GeV/c protons on the first target produced beams of 100 GeV/c and 60 GeV/c consisting of 95% and 85% protons, respectively, corresponding to enrichment factors of about 20.

(ii) Positive pion beams may be obtained by sweeping away positives and focusing negatives from the first target onto a second target (see Figure 9 of FN-259).

No tests of this scheme have been made. It requires pulsed quadrupoles and two new target stations in Enclosure 100. (See Item 5 discussion below.)

(iii) Negative Kaon beams may be obtained by sweeping away positives and focusing negatives with momentum close to incident proton momentum (expected to be mostly Σ^-) onto the second target.

No tests of this scheme have been made. It requires the pulsed quadrupoles and two new target stations. (See Item 5 below.)

(A collaboration involving Cambridge, Birmingham, CERN, and Florida State are requesting a K^- run with the 15-foot bubble chamber (Proposal 333).)

(iv) High energy enrichment of beams by elastic scattering may be exploited using composition differences at particular values of t. Need to be able to select particles produced at large angles at the second target.

No tests of this have been attempted.

(2) Triple targetting in Enclosure 100 for $\bar{p}$, K^+, and K^- enrichment:

(i) The sequence here is to use primary protons on the first target, select and refocus a negative beam on the second target, and then sweep out the charged secondaries and retarget the neutrals on the third target. This should produce a positive beam rich in K^+ or a negative beam rich in K^- and $\bar{p}$.

No tests of this have been made. This scheme requires high field pulsed dipoles which have not been ordered. Also, a primary flux of about 10^{12} incident protons may be required for reasonable final fluxes so the target area may have to be hardened.

(3) Retargetting near the bubble chamber:

(i) Neutral beams consisting of n, $\bar{n}$, and K^0's can be produced by retargetting p, K, or π's near the bubble chamber (see Figure 16 of FN-259) and sweeping charged particles vertically into collimators.

No tests of this scheme have been made. Sweeping dipoles and collimators are necessary in Enclosure 113.

(Two proposals have been submitted to do experiments with such beams in the 15' chamber. Proposal P-65 from BNL, Vanderbilt and Florida State requests a 20 to 60 GeV/c K^0p experiment. Proposal P-303 from Michigan proposes an np exposure to study neutron diffraction dissociation.)

(ii) A beam rich in Σ^- could be sent into the bubble chamber by selecting high momentum negatives from a target on which protons are incident near the bubble chamber.

No tests of this scheme have been made. It requires pulsed dipoles, pulsed quadrupoles, and other standard components to be placed between Enclosure 115 and the bubble chamber.

(Proposal P-214 from Cambridge involves use of this scheme to do a Σ^-p experiment.)

(c) Target Halo Beams (particularly $\bar{p}$'s from $\bar{\Lambda}^0$ decay and π^+ from K^0_S decay):

(i) Antiproton beams can be produced by a sequence in which the primary protons are aimed down the beam channel and then intercepted by the target, then the charged particles are swept out of the beam line, and only decay products originating beyond the sweeping dipole enter the downstream beam where they appear as a diffuse virtual source back at the target. By using beam line collimators and vernier dipole magnets specific parts of the halo with the highest $\bar{p}/\pi^-$ ratios can be selected.

A test of the most essential part of this idea has been made and it was very successful. During the last week of August, using 300 GeV/c primary protons on the target, a study was begun of the yield of π's, K's, and $\bar{p}$'s in the 100 GeV/c negative beam as a function of angle using the Cerenkov counter in the N3 line. This was the beginning of a systematic program to study yields as a function of momentum and angle. However, when the production angle magnets were set to large angles or set to sweep all the charged particles out of the beam line, the $\bar{p}$ flux was found to be about 1.5 $\bar{p}$'s/10^{11} protons on target with $\bar{p}$'s comprising 28% of the beam.

In FN-259, Neale had predicted that one could obtain about 25% $\bar{p}$'s and about 10 $\bar{p}/10^{11}$ protons on target if the targetting technique described therein were used.

Although not yet optimized, it is clear that even now the $\bar{p}$ flux is sufficient for a $\bar{p}$ bubble chamber exposure.

(A proposal (P-311) to study the $\bar{p}p$ interaction in the 30-inch bubble chamber had already been approved by the Program Advisory Committee even before the above test was completed. The experiment will be done by a collaboration involving Cambridge, Fermilab, and Michigan State. There are also 15' chamber proposals from Purdue requesting a $\bar{p}p$ exposure at 40 GeV/c (P-282) and from Tohoku University requesting $\bar{p}p$ at 100-150 GeV/c (P-83A).)

(ii) π^+ beams could be obtained by the same technique discussed above except that the π^+'s would be coming from K^0_s and $\bar{\Lambda}^0$ decays.

No test of this scheme has been made.

Item 4. Design of Higher Acceptance System and Study Existing Beams: Progress here has been moderate to good.

(a) Neale has designed a higher acceptance beam and it is discussed in his FN-259. At 200 GeV/c it will yield flux increases by a factor of ≥10. However, it requires two high gradient pulsed quadrupoles in Enclosure 100 and two 3Q52 quadrupoles in Enclosure 103.

(b) Studies of the existing N3 and N5 lines have continued, off and on, when time was available, during July and August. Improvements were made in instrumentation and controls. Various components were better aligned to beam line. Vacuum pipe was finally installed on most of the N5 beam line. Quadrupole settings were optimized for minimum spot sizes at collimators. By the middle of August the transmission was better than 90% for the N5 line up to Enclosure 115 and the N3 line up to Enclosure 112. The N5 line quadrupoles in Enclosure 115 which were limiting transmission were replaced by a large aperture quadrupole in September. The N3 transmission is limited by the small aperture dipoles in Enclosure 112 but replacements have been requested.

More study and adjustments will be necessary before the beam lines are fully acceptable and fully commissioned.

Item 7. Comparison With Conventional RF Separators:

No work has been done on this, since the idea was to compare with the enriched beam schemes after they were attempted. However, Lach has published a report on the work with superconducting RF separators and has proposed a new experimental area with such a separated beam (TM-493, May 22, 1974).

Item 1: TST for 15-Foot Bubble Chamber:

As far as I know, no additional work has been done on this at Fermilab. However, there have been two offers to build TST's for the 15' chamber (by Leutz and Kenney). In addition, of course, it might be possible to use the ANL 12' chamber TST.

(There is a proposal (P-309) from Wisconsin to do a 486 GeV/c π^-p experiment with a TST in the 15' chamber.)

Item 5. Regarding Acquisition of Pulsed Quadrupoles and Dipoles:

We had recommended that the Lab "go slow" on acquiring pulsed magnets until the enrichment schemes were shown to work with standard magnets. However, since standard quadrupoles and/or their power supplies could not be obtained for use in Enclosure 100, the Neutrino Section went ahead and ordered the pulsed quads from Rutherford Lab - estimated cost is about $12,000. Unfortunately the order was delayed unreasonably long and only recently left Fermilab (about September 25). As a result, several of the more interesting enrichment schemes have not been tested yet.

Item 6. Study of Fast Photomultipliers:

I know of no work being done on this.

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