RF-SEPARATED BEAM FOR A BUBBLE CHAMBER IN AREA 1 (15-45 GeV)

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ABSTRACT

We have made a conceptual design of a low-energy rf-separated hadron beam for a bubble chamber of intermediate size, which would operate in area 1 and require only low proton intensity. It uses the transmission target proposed with the muon channel. No attempt was made to make the beam attractive for counters. Instead the emphasis was on low intensity use compatible with the muon experiments.

It appears desirable that purified bubble-chamber beams be available at NAL in the momentum range from 15 to above 100 GeV/c. This range would overlap the regions to be covered at BNL/CERN (up to 20 GeV/c kaons) and at Argonne (10 GeV/c kaons) and extend to the maximum energies consistent with existing separation techniques.

It would not be prudent to cover this entire energy range in a single beam. It is the maximum kaon momentum p_{max} that determines the length of an rf separated beam, and the separable yields cut off sharply above p_{max}, because of separator field limits, and below 0.5 p_{max} because of decay losses. Furthermore, below 0.5 p_{max} the separator control problems would become marginal. As a rough rule of thumb one may say that for kaons and antiprotons the momentum ranges are

$$0.5\, p_{max} \lesssim p_k \lesssim p_{max}$$

$$0.5\, p_{max} \lesssim p_{\bar{p}} \lesssim 1.2\, p_{max} .$$

Accordingly NAL should ultimately construct two rf-separated beams, one for low energies and one for high energies, with momentum intervals

$$20 \lesssim p_k \lesssim 40 \text{ GeV/c} \quad \text{(low energy)}$$

and

$$50 \lesssim p_k \lesssim 100 \text{ GeV/c} \quad \text{(high energies).}$$

Of these two the low-energy beam might be constructed first. It would be approximately 300 m long whereas the high-energy beam would be longer than 1000 m. For bubble-chamber use the low-energy beam could be pushed, with special precautions, as low as 15 GeV/c momentum.

We consider here a low-energy separated beam for a bubble chamber in area 1. The beam proposed for counters[1] in area 2 serves as a model. We note in passing a suggestion that a bubble chamber of intermediate size could share the spill in the counter beam in area 2, if one is willing to accept over the time span of several years the rather severe operational compromises and program choices involved in such sharing. For the purpose of defining the targeting parameters and layouts for area 1, however, we use as a working hypothesis that a low-energy beam will be a first step toward construction of a high-energy beam to a large chamber, which could not be located anywhere else but area 1.

BEAM DESIGN

In Table I we summarize a conceptual beam design for area 1. It is an adaptation of the design proposed for counters in area 2. In making this adaptation we did not feel constrained to optimize the system transmission to make the beam attractive for counters too. The emphasis is on low-intensity use compatible with the muon experiments proposed for the first target in area 1.

The target angle is 20 mrad and the input triplet is far enough away from the target to avoid interference with the muon beams. The bending angles are 2° per bend (3 such bends assumed), and the momentum resolution would be ~0.15% assuming a 1 mm wide, short target. Yields are shown in Fig. 1 for parasitic operation, assuming only 10^{11} proton interactions in the target, per pulse, per 0.1% momentum bite. In deriving the fluxes from the estimates for the counter beam, we are not only using a lower beam acceptance of 1 μsr, but we assume that for high beam purity one will have to provide such tight collimation of images that an additional factor of four is lost on collimators. Nevertheless, even allowing for some optimism in the yield estimates, there will be ample flux for parasitic (low intensity) operation in the 20-40 GeV region. Pions can be separated from protons up to 80 GeV, provided that one can ignore the kaon background.

Table I. RF-Separated Beam for Bubble Chamber.

Momentum Regions	15-40 GeV/c	kaons
	15-45 GeV/c	antiprotons
	20-80 GeV/c	pions, protons
Beam Length	280 meters approx.	
Separator: Deflector Spacing	115 meters	
Wavelength	3.75 cm	
Transverse Momentum	5 MeV/c per deflector	
Target	1×1 mm^2, tungsten	
Viewing Angle	20 mrad	
Solid Angle	10^{-6} sr	
Momentum Resolution	0.15%	
Bending Angles	2° (three such bends assumed)	
Required Proton Intensity	$\leq 10^{11}$ interactions per pulse	

If this beam line were ultimately used for the high-energy separated beam to the large chamber (required deflector spacing ~700 m, beam length 1.1 km), the yields would be lower by approximately two orders of magnitude, unless one made the following adjustments: 1) The targeting angle would have to be smaller (13 mrad may be adequate) and 2) one may have to consider committing about 3×10^{11} interactions in the target to the bubble chamber. The necessary target angle change may make it impossible to operate simultaneously with the muon experiments, but this needs further study.

SEPARATOR

The bubble chamber would require only a short pulse separator (spill ~100 μsec long). The rf frequency is 8 GHz to save space in the separator stage. The beam employs three deflectors, the outside ones being spaced 115 m apart. The maximum transverse momentum imposed by each deflector is assumed to be 5 MeV/c as in the area 2 design. The somewhat cumbersome design of the conventional deflectors for area 2 would of course be adequate, but they could be simplified: the deflectors might be shorter (say 3 m) and use higher instantaneous rf power at the low bubble-chamber duty cycle. Superconducting deflectors could be pulsed too by "force-feeding" them with filling times of ≈1 msec.

SUMMARY

We have analyzed a conceptual design of a low-energy rf-separated hadron beam (20-40 GeV kaons) for a bubble chamber of intermediate size which will operate parasitically in area 1. It uses the first area 1 target together with the muon beam. The target angle is 20 mrad. No attempt was made to make the beam attractive for counters too.

REFERENCE

[1]H. Foelsche, RF Beam of Long Duty Cycle (20-50 GeV), National Accelerator Laboratory 1968 Summer Study Report SS-26, Vol. III.

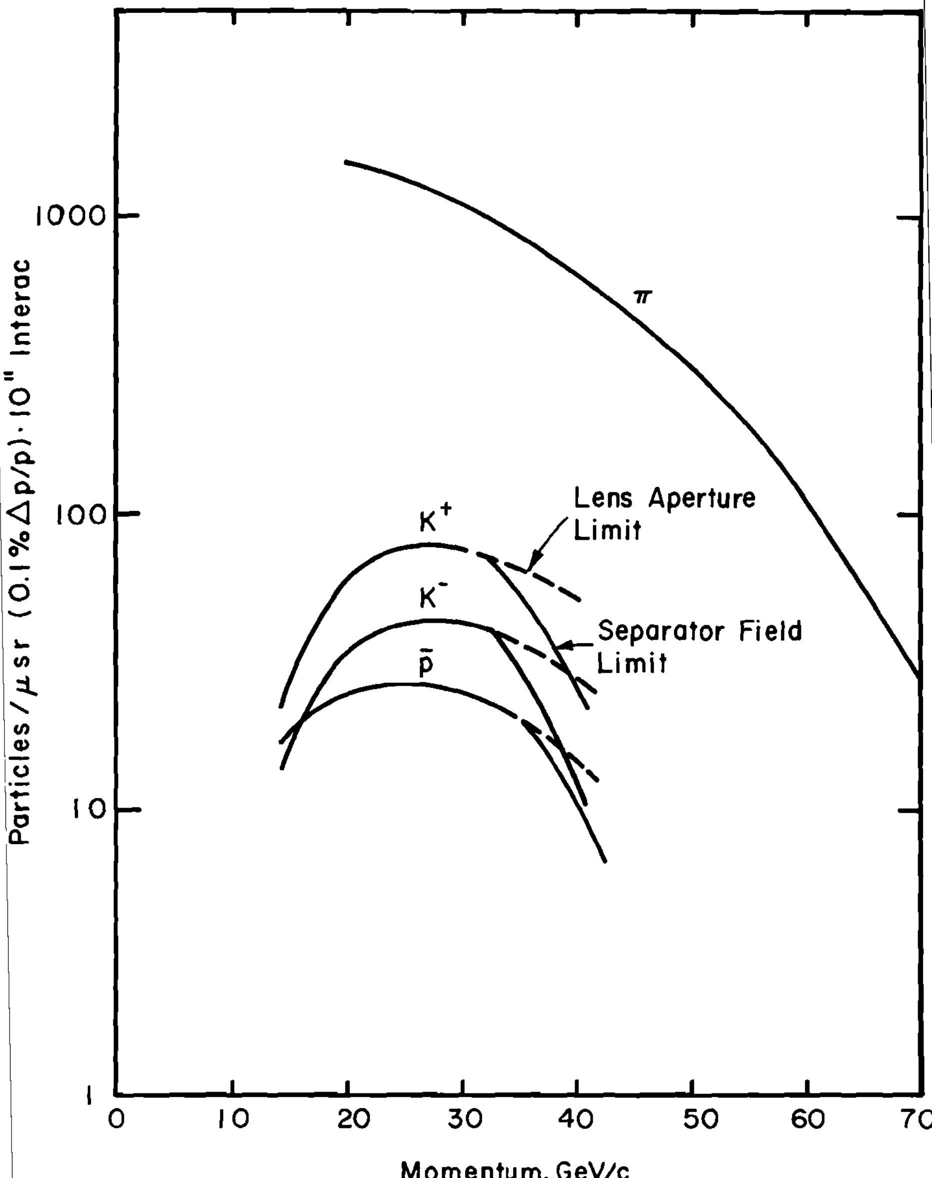

Fig. 1. Yield of separated beam.