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EXPERIMENTAL AREA DESIGN WORKING GROUP

SUMMARY

Chairman: E.W. Blackmore
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Participants

L. Agnew
J. Amann
J. Beveridge
R. Boudrie
G. Clark
J. Doornbos
H. Foelsche
D. Grisham
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J. McClelland
J. McGill
C. Oram
D. Werbeck
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Presentations

1. Jacob Doornbos, "Optimization of Secondary Channel Fluxes"
2. John McGill, "RF Separators in Secondary Beams"
3. Jack Beveridge, "Layout of Secondary Beams at KAON"
4. David Lee, "Neutral Kaon Decay Experiments"
5. Dick Boudrie, "Spectrometer Design"
6. Bill Louis, "Stopping Kaon Decay Experiments"
7. Ewart Blackmore, "Extrapolation of Brookhaven Experience to an AHF"
8. Don Grisham, "Remote Handling at an AHF"
9. George Clark, "Shielding and Beamline Engineering"
10. Hywel White, "Design of a Neutrino Beam"

1. Introduction

The charge to the working group on Experimental Areas concerned a number of topics related to the optimum layout of the experimental areas, the design of secondary channels and spectrometers, the floor space required for experiments and the impact of remote handling requirements on the site layout. The talks given by the various speakers provided useful information on these topics and the subsequent discussions, in particular on the operational considerations of running an experimental program at an AHF and the methods of beamline design and remote handling in the target areas resulted in a general concensus on the recommendations which are given below.

2. Layout of Experimental Areas

The main question concerning the experimental areas is the best way to share protons between the production targets to optimize the production of secondary beams. J. Doornbos summarized the various secondary channel front-end designs and showed a number of ways in which two or more channels could be combined at a production target[1]. Two general arrangements were compared, one with 3 in-line or sequential production targets and one with 2 proton lines each feeding 2 in-line production targets as shown in Fig. 1. A figure of merit for the different arrangements was determined based on available proton intensity, target absorption, channel momentum and production angle. The results are listed in Table 1. Using this comparison the in-line targets on a single proton line turns out to be the optimum as far as total kaon production per extracted proton is concerned although it is only 20-30% better than the alternatives. However this figure of merit does not include such factors as beam quality, coupling between channel operation, flexibility in staged installation and scheduling, access to experimental areas for experiment set-up and overall cost.

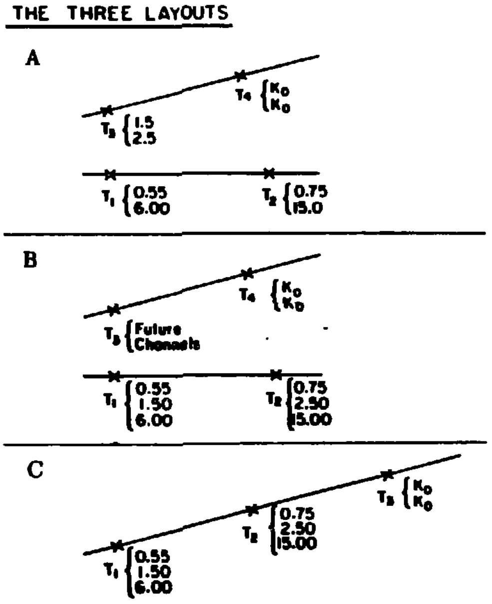

Fig. 1. Primary and secondary beam line arrangements used in study by J. Doornbos. The numbers at each target location indicate the channel momenta.

Target Lengths Used

	A cm	B cm	C cm
T1	3	3	3
T2	6	6	3
T3	3	0	6
T4	6	6	

The experimental area for the slow extracted beam (SEB) at the Brookhaven AGS at present consists of 4 proton lines, 8 production targets, 12 secondary channels and 17 locations for experimental setups. In addition there is a polarized proton beam area and a fast extracted beam for neutrino production. This sets the scale for the number of experimental beams required at an AHF. A single proton line feeding 3 in-line targets can at most provide 6 charged secondary kaon beams and one neutral beam. This does not appear sufficient for an international facility providing for an estimated 800 users. Although an additional proton line and target areas is costly it does seem to be a necessity.

Table 1. Comparison of figures of merit for arrangements A, B and C shown above. A and B1 have the proton beam equally shared and B2 has 2/3 going to T1/T2 and 1/3 to T4.

p (Gev/c)	A	B1	B2	C
0.55	1.00	0.66	0.88	1.32
0.75	0.77	0.51	0.67	0.73
1.5	1.00	1.00	1.34	2.00
2.5	1.00	0.77	1.02	1.11
6.0	1.00	0.75	1.00	1.61
15.0	0.77	0.77	1.02	1.11
K_o	0.77	1.39	0.93	0.84
K_o	0.77	1.39	0.93	0.84
Sum	7.08	7.24	7.79	9.56

Recommendation 1. In the layout of the experimental areas for an AHF plan for a second proton beamline even if not installed initially.

3. Kaon Beamlines and Spectrometers

John McGill discussed a new idea for rf separators for secondary beamlines. Present rf separators operate with a transverse field at gradients up to 3 MV/m using superconducting techniques. With the recent developments on superconducting accelerator cavities substantially higher gradients up to 15 MV/m are available in the longitudinal direction. By making use of the rf microstructure in the beam it is possible to use this field direction to separate particles. A possible design for a 6 GeV beamline would use 12 m of separator operating at 6 MV/m and at 60 MHz, the rf frequency of the extracted proton beam.

Dick Boudrie described the design and construction of the MRS spectrometer at LAMPF. Some of the parameters are maximum momentum 1.5 GeV/c, momentum acceptance 20%, resolution 0.2%, size 150 tons and total length to the focal plane of 7.1 m. The timetable for the optics and mechanical design were discussed. This spectrometer although not optimized for kaon experiments represents the type of device which would be required to support an AHF experimental program.

Much of the remaining discussion on kaon beamlines centered on the problems of designing front ends for high intensity. There are many optics designs of secondary channels which have been presented at previous workshops. The next step is a detailed engineering design of the beamline components taking into account the additional complexities of radiation-hard magnets, remote handling requirements, shielding and extra cooling due to the high thermal loads. The LESB2 channel at Brookhaven was described as an example of the types of components which should be considered. The magnets have large apertures and high field gradients which are obtained by using current densities in the coils up to 60 A/mm^2. For example the first quadrupole is a 12Q16 (aperture 30 cm) with a field gradient of 10T/m and the first dipole has a maximum field of 2.2T. Designs for radiation-hard magnets have to be developed which come close to matching these specifications. Copper conductors insulated by a hard-anodized aluminum sheaths[2] is an one possibility for high current densities and should be explored further.

Recommendation 2. Carry out a detailed engineering design of the components for the beamlines and target cell for a configuration in which two or more secondary channel front-ends are combined.

4. Floor Space for Experiments

E791 at Brookhaven ($K_L^0 \rightarrow \mu e$) was described by David Lee as an example of the beamline and detector requirements for an in-flight kaon decay experiment. The dimensions of the beamline, decay region, detector and beamstop are optimized for K^0 production with 28 GeV/c protons and the requirement to range out the muons. Going to 60 GeV would increase the floor area requirements in the longitudinal direction by about a factor of 2. A schematic layout of the components of such an experiment is shown in Fig. 2.

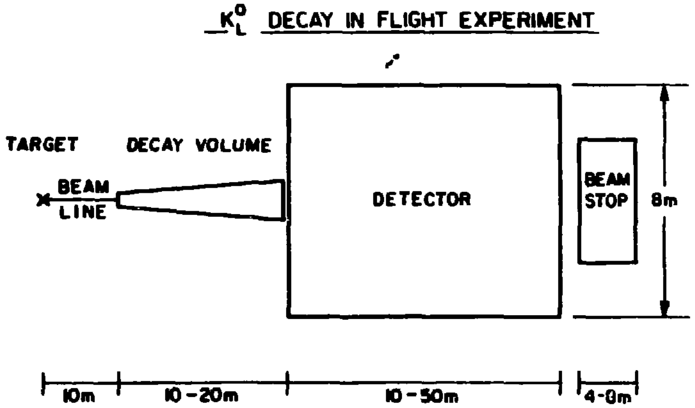

Fig. 2. Dimensions of components for an in-flight decay experiment. The largest dimensions refer to requirments for a 60 GeV experiment.

E787 at Brookhaven ($K^+ \rightarrow \pi\nu\bar{\nu}$) was described by Bill Louis as an example of a stopping kaon decay experiment. The footprint for this detector is about 8 m x 12 m. An extrapolation of this detector to AHF energies and intensities would not necessarily lead to larger floor area requirements. The most likely improvement would be to increase the magnetic field of the solenoid using a superconducting coil which would in fact lead to a smaller detector. The higher intensities would be handled by increasing the segmentation of the various components of the detector.

Hywel White presented a useful tutorial on how to build a neutrino beam at an AHF using the Brookhaven wide-band neutrino beam[3] for comparison. Some straightforward arguments provide the optimium length of decay section and shield thickness and the useful width of the detector. There are of course technical questions on the design of targets and pion horns which can operate at the required bean intensities and repetition rates. A neutrino facility could require the largest amount of real estate in the experimental area and provision should be made for this. However it is still an open question as to how the high flux of neutrinos will be used at an AHF with options ranging from using smaller, more highly segmented detectors to larger detectors at kilometer distances for oscillation experiments.

At a recent TRIUMF workshop a request was made to provide an rf separated beamline to the highest momentum available. For 15 GeV the length of such a beamline and its spectrometer would be at least 200 m and for 20-40 GeV this would increase to 300-500 m. This type of beamline should be allowed for in the layout of the experimental areas. A time-separated antiproton beam would require a similar or even longer length of beamline again depending on the design momentum.

Jack Beveridge presented the latest arrangement of the experimental areas for the TRIUMF Kaon Factory. The slow extracted proton beam is divided into two lines each feeding two production targets. Typically two charged kaon lines take off from each target in the forward direction with provision for low momentum pion and muon lines in the backward direction. The production targets and hot cell facilities are under a common crane coverage to ease the servicing of highly radioactive components.

Ewart Blackmore reviewed the evolution of the experimental areas and beamlines at Brookhaven. Flexibility in handling new designs of beamlines and detectors has been an important feature of their approach. This has been made easier by having an experimental area near grade level and sufficient space to expand.

Recommendation 3:* *Keep the experimental area floor close to grade level to minimize the cost and simplify future extensions to the building as new beamlines or facilities are required.

5. Remote Handling and Beamline Engineering

Don Grisham outlined the experience gained in installing and servicing components in the target areas at LAMPF where 1 MW of beam is routinely delivered. He proposed that similar techniques could be used in the target areas for the AHF as well as the extraction region of the main ring. George Clark described some of the ideas for the design of the target cells at KAON and also presented some preliminary costs and designs for shielding around the primary proton lines. During the subsequent discussions there developed a clear concensus on the remote handling philosophy in the high radiation areas:

- provide for vertical access to components
- reduce or eliminate vacuum connections
- move service connections to shielded regions above the components
- construct magnets and shielding as integral components

A typical section through a proposed target cell is shown in Fig. 3. One method of eliminating vacuum connections in high radiation areas as well as a significant part of the air activation problem is to put all of the components of a target cell, target, collimators, magnets and integrated shielding etc. in a large vacuum tank, sufficiently large so that an elastomer seal can be used for making the vacuum joint. There are two methods of servicing these components once the shielding is unstacked. For components which are less than about 10 tons it is practical to remove them in a shielded flask to nearby hot cells for repairs. For substantially heavier components, once access to these components is made available by removing shielding blocks, servicing by a remote manipulator such as the Monitor used at LAMPF seems most practical.

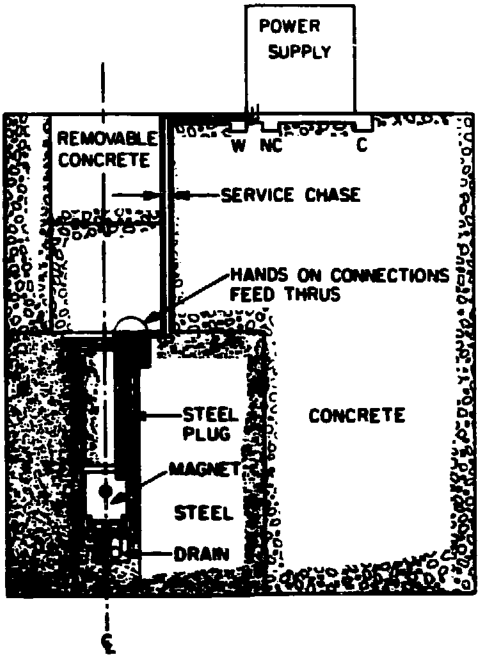

Fig. 3. Typical cross section through a primary beam line in the target cell region.

Any beamline region which receives more than 2 kW of continuous beam spill should be designed for remote handling from above. This includes the extraction regions[4] of the accelerator in those areas where beam is lost such as the extraction septa and collimators. As this servicing requires the use of an overhead crane it is most economical if the region is near grade level. This has site implications for the layout of the rings and experimental areas, in particular for the LAMPF AHF site where the topography of the mesas is quite varied.

Recommendation 4: Plan to have the extraction region accessible from above for remote servicing.

6. Topics for Further Study

1. Study the problems of beam transport after a thick production target. Try to understand the operation of the C-line at Brookhaven where there are sequential targets but with most of the beam on the downstream target obtained by steering a part of the beam around the upstream target.
2. Carry out a detailed engineering design of a target cell to investigate cost and other implications of various concepts eg placing the magnets in vacuum.
3. Develop designs for radiation hard magnets suitable for secondary channels with appropriate large apertures and field gradients.
4. Optimize the depth of the experimental hall by comparing the costs of shielding vs construction.
5. Develop new codes for particle production from thick targets in particular for optimizing targets and determining fluxes for neutrino production.

References

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