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THE TRIUMF KAON FACTORY – AN OVERVIEW

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Summary

TRIUMF has been awarded $11M for a one-year pre-construction Engineering Design and Impact Study of the KAON Factory. This will enable prototypes of many accelerator components to be built and the design of the accelerators and the layout of the experimental areas to be reviewed. The building and tunnel designs will be finalized, environmental, legal and economic impact studies carried out, and international involvement pursued further.

Introduction

The TRIUMF Kaon-Antiproton-Otherhadron-Neutrino Factory has been described in full in the original proposal[1]. The basic aim is to accelerate a 100 μA beam of protons to 30 GeV, roughly 100 times more than available at present. This would provide correspondingly more intense – or pure – beams of secondary particles (kaons, pions, muons, antinucleons, hyperons and neutrinos) for particle and nuclear physics studies on the "precision frontier", complementary to the "energy frontier". Major areas of investigation would be

- rare decay modes of kaons and hyperons
- CP violation
- meson and baryon spectroscopy
- meson and baryon interactions
- neutrino scattering and oscillations
- quark structure of nuclei
- properties of hypernuclei
- K^+ and $\overline{p}$ scattering from nuclei.

Experience with the pion factories has already shown how high beam intensities make it possible to explore the "precision frontier" with results complementary to those achievable at the "energy frontier". A notable example was the setting of a lower limit of 380 GeV on the mass of any right-handed W-boson by a muon decay

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measurement[2] at TRIUMF in 1982. Others include improved confirmation of muon-electron universality and the first observations of the muonium Lamb shift and of the breakdown of charge symmetry in neutron-proton scattering.

For kaon decay Figure 1 illustrates the improved branching ratios attainable for selected channels, pushing up the mass limits on various exotic particles. A

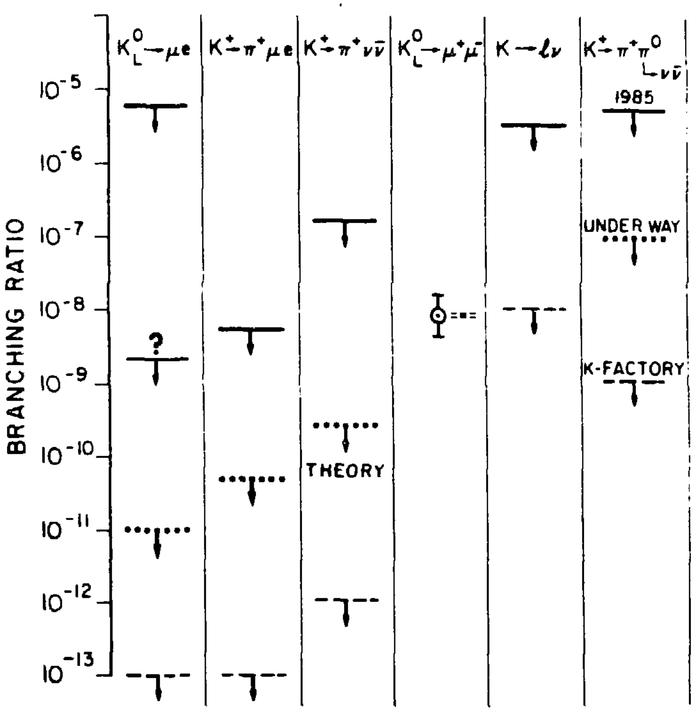

Fig. 1. Branching ratios for selected kaon decay channels showing limits attainable with a KAON Factory.

comprehensive justification of the physics case for K factories may be found in the three proposals so far published[1,3,4] and in the proceedings of the recent international conferences at Mainz[5], Lake Louise[6] and Rockport[7]. Papers summarizing the physics case are given later in these proceedings by Ng[8] (particle physics), Bryman[9] (rare decays) and Kitching[10] (nuclear physics). To obtain the most up-to-date assessment a number of workshops have been organized by TRIUMF this year on KAON Factory physics topics – and are listed in Table I.

Table I. KAON Factory Workshops

Topic	Location	Date
Rare Kaon Decays and CP violation	TRIUMF	Nov 30-Dec 3 1988
Spin Physics	TRIUMF	Feb 15-16 1989
Hadron Spectroscopy	TRIUMF	Feb 20-21 1989
Neutrino Physics	Montreal	May 14 1989
Physics at the KAON Factory	Bad Honnef, W. Germany	June 7-9 1989
Hypernuclear Physics at the KAON Factory	KEK, Japan	June 17-18 1989
Spin and Symmetries	TRIUMF	June 30-Jul 2 1989
Users Workshop	TRIUMF	July 10-11 1989
Low Energy Muon Science at Large Accelerators	TRIUMF	July 19-21 1989
Intense Hadron Sources and Antiproton Physics	Turin, Italy	Oct 18-20 1989

Accelerator Design

The TRIUMF H^- cyclotron, which routinely delivers 150 μA beams at 500 MeV, would provide a ready-made and reliable injector. It would be followed by two fast-cycling synchrotrons interleaved with 3 storage rings, as follows:

A	Accumulator:	accumulates cw 450 MeV beam from the cyclotron over 20 ms periods
B	Booster:	50 Hz synchrotron; accelerates beam to 3 GeV; circumference 214 m
C	Collector:	collects 5 Booster pulses and manipulates longitudinal emittance
D	Driver:	main 10 Hz synchrotron; accelerates beam to 30 GeV; circumference 1072 m
E	Extender:	30 GeV stretcher ring for slow extraction for coincidence experiments

This arrangement allows the B and D rings to run continuous acceleration cycles without flat bottoms or flat tops. The use of a Booster permits a smaller normalized emittance and hence reduces the aperture and cost of the Driver magnets for a given space charge tune shift. The use of a Booster also simplifies the rf design by separating the requirements for large frequency swing and high voltage (33% and 600 kV respectively for the Booster, and 3% and 2550 kV for the Driver). These high rf voltages are associated with the high cycling rates; the use of an asymmetric magnet cycle with a rise 3 times longer than the fall in the Driver reduces the voltage required by one-third, and the number of cavities in proportion. In the Booster the saving is less because more voltage is needed for bucket creation.

Figure 2 shows a proposed site layout together with cross-sections through the tunnels, with the Accumulator above the Booster in the small tunnel, and the Collector and Extender rings above and below the Driver in the main tunnel. Identical lattices and tunes are used for the rings in each tunnel. This is a natural choice providing structural simplicity, similar magnet apertures and straightforward matching for beam transfer. Further details of accelerator design and prototype construction are given in a separate paper in these proceedings.[11]

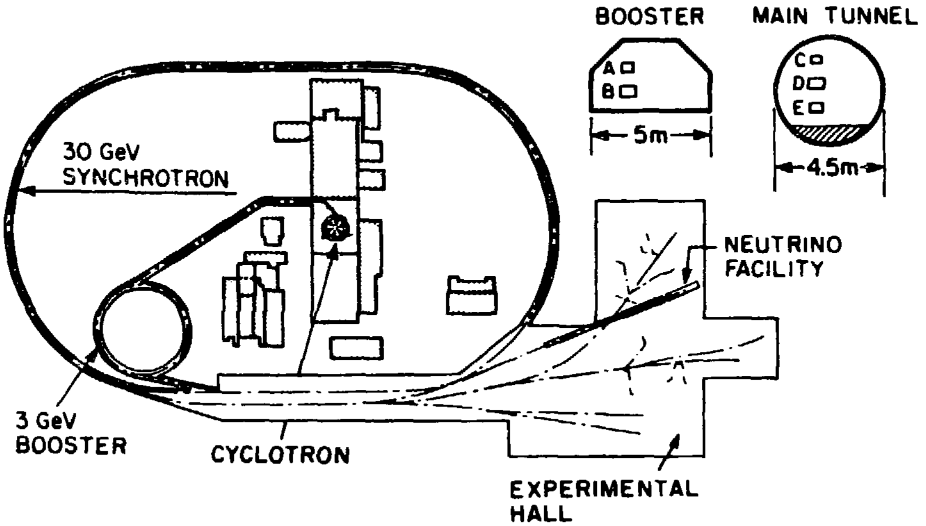

Fig. 2. Possible site layout together with cross sections through the tunnels

Experimental Areas and Targets

The revised experimental area layout proposed by Doornbos and Beveridge[12] (Fig. 3) is summarized later in these proceedings by Gill.[13] The slow extracted proton beam will be shared between two lines each with two production targets. Each target will feed at least two forward K^- and $\bar{p}$ channels, and in some cases backward μ channels. A dedicated line and area is provided for polarized proton beams and the neutrino production target and area are now incorporated in the main hall for better crane access. Target development includes both modification of an existing rotating graphite target (driven and cooled by water) for tungsten, and the construction of a prototype target rotated by a flexible cooling line.

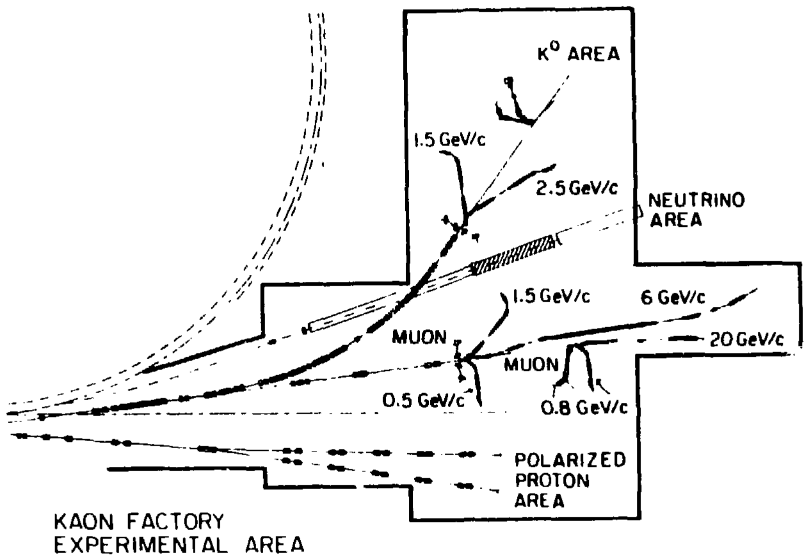

Fig. 3. Proposed experimental area layout.

Status of the Project

Following technically favourable reviews of the proposal by the funding agencies, the governments of Canada and British Columbia in 1987 instituted supplementary studies on economic benefits, broader national management (the four founding universities have now been joined by the Universities of Manitoba, Montreal, Regina and Toronto) and international involvement. Exploratory discussions abroad at the end of 1987 (see below) indicated a potential for ~$200M (Cdn) in international contributions - about one third of the total cost of $571M. Furthermore the Province of British Columbia has given approval in principle to the funding of the buildings and tunnels ($92M).

The most recent development has been the joint funding by the federal and provincial governments of an $11M pre-construction Engineering Design and Impact Study. This began in October 1988 and is planned to take 15 months. It will enable prototypes of the major components to be built, the cost estimates to be updated, the international contributions to be better defined and various impact studies to be carried out. The various projects are listed below, together with the names of the group leaders and other engineers and physicists involved.

Project Leader	A. Astbury
Accelerator Design	M.K. Craddock; R. Baartman, S. Koscielniak, G.H. Mackenzie, J.R. Richardson, R.V. Servranckx and U. Wienands
Systems Integration	E.W. Blackmore; G. Clark, M. Zanolli (CERN)
RF Systems	R. Poirier; R. Burge, T. Enegren
Magnets	A.J. Otter; C. Haddock, P. Schwandt (IUCF)
Magnet Power Supplies	K. Reiniger;
Beam Pipe & Vacuum	C.J. Oram
Kickers	G. Wait; M. Barnes
Controls	D. Dohan; W.K. Dawson, B. Frammery (CERN), D. Schultz (LANL)
Shielding & Safety	I.M. Thorson; D. Axen (U.B.C.)
Cyclotron Beam Extraction	M. Zach; G. Dutto, R.E. Laxdal, J. Pearson
Experimental Areas	J. Beveridge; J. Doornbos, G. Stinson
Targets	T.A. Hodges
Science Workshops	P. Kitching (Univ. of Alberta)
International Consultations	P. Dyne (ISTC); E.W. Vogt
Project Management	G. Ritchie; G. Ridout (UMA Spantec Ltd); V.K. Verma
Building Design	Company to be appointed
Tunnel Design	Company to be appointed
Services & Power	Company to be appointed
Industry Development	D. Williams; A. Stretch (Monenco Ltd.); J. Carey
Economic Assessment	Company to be appointed
Legal Studies	Company to be appointed
Environmental Studies	Company to be appointed

International Consultations

A Canadian delegation visited West Germany, Italy, Japan and the U.S.A. in late 1987 to explore the potential for international participation in the KAON Factory. Each country agreed to consider supplying components for construction, and indeed the possibility of support is being explicitly allowed for in the planning scenarios of both Germany and Italy. In the U.S.A. the DOE and NSF requested advice from NSAC, which set up a subcommittee under Prof. H. Feshbach. This has recently completed its report, which characterizes the Canadian proposal as "a conservative design" and "cost-effective". In all it appears that there is a potential for about $200M (Cdn) – or one-third of the total cost – in international contributions. Besides the countries mentioned above, Belgium, Britain, France, Israel and the People's Republic of China have all expressed interest in participating in experiments and in some cases in accelerator design and construction. International consultations will now continue more formally under the aegis of the pre-construction study with a first round of visits scheduled for April and May 1989 to begin identifying suitable items to be supplied. E.W. Vogt's paper[14] at the end of these proceedings will give more details of these initiatives.

Conclusion

The pre-construction Engineering Design and Impact Study now under way, funded by the Canadian federal and provincial governments, is a wide-ranging one intended to cover all aspects of the project scientific, engineering, environmental, legal and economic including international involvement. It is expected to be complete by the end of 1989, leaving the way clear for final approval of the project in 1990.

TRIUMF has benefitted from a long history of collaboration with Japanese scientists and institutions. It has gained not only from the experience brought to Canada by Japanese individuals, but also from direct contributions of hardware - most recently a long superconducting solenoid for an improved muon channel. We attempt to run a user-friendly laboratory and certainly hope that Japanese scientists experience comparable benefits in working at TRIUMF. For the future, the Japanese Hadron Project and the TRIUMF KAON Factory even though they are largely complementary - clearly offer enhanced opportunities for collaboration to our mutual benefit (Gill[15], D'Auria[16]).

References

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