EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

CERN-SPSC/2000-043
SPSC/M658
13 October, 2000

Memorandum

To: K. Königsmann, SPSC chairman
From: G. Barr, Coordinator of the HARP3 initiative
F. Dydak, HARP spokesperson
Subject: Use of the NA49 apparatus for the HARP3 initiative

We are writing to express the strong interest in utilizing the NA49 apparatus to obtain important information about pion and kaon production relevant to the calculations of the flux of atmospheric neutrinos.

A precise knowledge of the atmospheric neutrino beam at production is important for interpreting the measurements by SuperKamiokande and other, future, experiments of interactions of atmospheric neutrinos in terms of neutrino oscillations. The most important source of uncertainty at present in calculating the atmospheric neutrino beam is the limited knowledge of pion production by protons in interactions on light nuclei.

The HARP experiment at the CERN PS will measure production of pions and kaons up to proton momenta of 15 GeV/c with full coverage of phase space and for a variety of nuclear targets, including nitrogen and oxygen. Use of a helium beam is being considered for a second phase, HARP2, important to complement the measurements with protons.

Measurements at proton momenta beyond 15 GeV/c would be very desirable to cover fully the range of interaction energies relevant for atmospheric neutrinos. Unlike a mono-energetic accelerator beam, the primary cosmic-ray spectrum is a power-law extending up to very high energy. For the 'sub-GeV' neutrino sample at SuperKamiokande, for example, the most probable primary energy is about 20 GeV, but a broad distribution of interaction energies from a few GeV up to above 100 GeV are involved. For the 'multi-GeV' events, the relevant range of primary energies extends correspondingly higher. It would therefore be extremely desirable to complement the measurements expected from HARP by measurements at higher energy, and to close the gap to production experiments at still higher proton momenta, such as SPY, which measured pion and kaon production by 450 GeV/c protons.

We have contacted NA49 experts about the possibility of doing measurements with them to obtain pion production data relevant for improving the atmospheric neutrino flux computations. The preliminary conclusion is that the experiment can be done. Liquid nitrogen and oxygen will be used as targets (which will be recuperated, possibly with minor modifications, from the HARP experiment). No modification of the NA49 apparatus and the software is planned. Even with the moderate data acquisition speed of about 30 events per spill in NA49 a worthwhile amount of data can be collected in a few weeks of running.

This programme is supported by many HARP institutions who consider it important that the question of the atmospheric neutrino flux is satisfactorily resolved, in particular in view of forthcoming large magnetic detectors at the neutrino factory which will at the same time serve as powerful detectors for atmospheric neutrinos. For this programme of work, it is imperative that the absolute atmospheric neutrino flux will be known much better than known today. It is worthwhile to note that a variety of cosmic-ray experiments will establish a precise flux of primary protons and helium nuclei from outer space, the other ingredient for a precise atmospheric neutrino flux, on the same time scale.

Representatives of NA49 were confident that a core group of the NA49 collaboration would support the project, as such support is mandatory to provide the necessary know-how of operating the NA49 apparatus correctly and running the simulation and analysis programs. A number of NA49 members would join this initiative.

This programme could also find strong support from the MINOS collaboration who must measure precisely the pion yield of their neutrino target at 120 GeV/c proton momentum. Correspondingly, a number of MINOS members have expressed interest in joining this initiative.

Taking everything together including less than perfect data taking efficiency, the above programme could be successfully carried out within six to eight weeks.

In view of the HARP schedule the optimum time for HARP3 data taking would be in 2002 or in 2003. Data taking after 2003 appears impractical, however.

We cannot see another opportunity to obtain these important measurements this economically, and therefore urge the SPSC to support the continuation of NA49 operation beyond the currently approved programme. We would then commence a serious study of all practical aspects of the experiment, with a view to submitting a formal proposal in due time.