Statement of Interest

for low-energy kaon-nuclei interaction studies

at the DAΦNE Collider of LNF-INFN

by the AMADEUS Collaboration

10th November 2015

Studies of kaon-nucleon/nuclei interactions provide extremely valuable information for understanding low-energy QCD in the non-perturbative regime in the strangeness sector. Since the strange quark has its mass in between light and heavy quark masses, the strangeness study is the ideal "instrument" to obtain information about the interplay between the spontaneous and explicit chiral symmetry breaking mechanisms which, together with the Higgs mechanism, give the mass of the baryonic matter in the Universe. The kaon-nuclei interaction studies are vital to develop theories, such as chiral perturbation theory, or other effective theories, including potential models, and also strongly contribute to the advance of lattice calculations.

Hot topics, such as the structure of neutron stars and the role strangeness might play, and even the possible contribution of strangeness to the dark sector of the Universe (strange dark matter), could strongly benefit from experimental studies of low-energy kaon interactions in nuclear matter. On the strength and details of these interactions it depends whether the (core of) neutron stars might harbor exotic phases associated with strangeness and if strange matter (such as strangelets) could contribute to the dark matter sector of the Universe, presently very hot topics, especially after the recent discovery of two-solar-mass neutron stars.

Experimental studies of low-energy kaon-nuclei interactions is, consequently, extremely important and timely, having high impact in particle and nuclear physics, astrophysics and cosmology.

In this context, the DAΦNE collider provides a kaon source with unique characteristics: an almost monochromatic low-energy (127 MeV/c) positive/negative kaon "beam", having very low energy spread (less than 1%), with low hadronic background, delivered in a back-to-back configuration with the opposite charge kaon "beam". By using this beam the following

processes deriving from low-energy kaons interacting with nuclei can be studied, either for the first time or in order to perform the most precise measurements up to date (the list given below is a limited list):

1) From the processes involving stopped kaons in a nuclear target (such as deuterium, He3,4 or heavier targets) one can: investigate the strength of the interaction of kaons with one, two and more nucleons; study the possible existence of so-called deeply bound kaonic nuclei, in Λp/d/t final channels; study of the Λ(1405) resonance in all final channels; study possible modification to the hyperon masses in nuclear matter; perform studies in hypernuclear physics, as neutron-rich hypernuclei or non-mesonic decays.

2) From processes involving in-flight low-energy kaon interactions, one can: extract cross sections of kaon interactions in nuclear matter at momenta lower than 100 MeV/c going into various final channels – experimental data presently non-existent; perform Λ(1405) studies at higher invariant masses.

A successful preliminary feasibility study of the capacity of DAΦNE and of a spectrometer to perform unique investigations in this sector was performed in the framework of the AMADEUS-KLOE Collaboration: AMADEUS Step 0 (Hyperfine Interact. 234 (2015) 1-3, 9-15; Acta Phys. Polon. B46 (2015) 1, 203-215).

For the future we would like to propose a dedicated experiment, in an optimal configuration, both from the machine side in relation to the needs of the scientific program, as well as from the detector point of view, i.e. the AMADEUS spectrometer. We plan to present to the LNF and INFN a proposal for a dedicated experiment requiring some fb^{-1} of data, in order to perform new unique measurements in the strangeness sector, with implications going from particle and nuclear physics, to astrophysics and cosmology.

The following groups, having consolidated experience and complementary skills in the field of particle and nuclear physics experiments performed at various facilities in the world, as well as in detector construction, are expressing their interest to participate in AMADEUS, in the construction, installation and running of the experiment.

1) Stefan Meyer Institute for Subatomic Physics, Austrian Academy of Sciences, *Austria* (Prof. Johann Zmeskal)
2) University of Victoria, *Canada* (Prof. George Beer)
3) Institute of High Energy Physics, Chinese Academy of Sciences, IHEP/CAS, *China* (Prof. Hai-Bo Li, Prof. Yu-Bing Dong, Prof. Mei Huang, Prof. Ping Wang, Prof. Qiang Zhao)
4) Institute of Theoretical Physics, Chinese Academy of Sciences, ITP/CAS, *China* (Prof. Bing-Song Zou, Prof. Shan-Gui Zhou, Prof. Feng-Kun Guo)
5) Institute of Modern Physics, Chinese Academy of Sciences, IMP/CAS, *China* (Prof. -Jun Xie, Prof. Xu Cao)

6) University of Zagreb, *Croatia* (Prof. Damir Bosnar)
7) II. Physikalisches Institüt Justus-Liebig-Universität Gießen, *Germany* (Prof. Kai-Thomas Brinkmann)
8) Physikalisches Institüt der Universitaet Heidelberg, *Germany* (Prof. Dr. Norbert Herrmann)
9) Institut fuer Kernphysik, Universitaet Mainz, *Germany* (Prof. Josef Pochodzalla)
10) Excellence Cluster 'Origin and Structure of the Universe', and Technische Universitaet Muenchen, *Germany* (Prof. Laura Fabbietti)
11) Institüt fur Kernphysik Universitaet Münster, *Germany* (Prof. Dr. Alfons Khoukaz)
12) Indian Institute of Science Education and Research - Bhopal, *India* (Dr. Somnath Choudhury)
13) LNF-INFN, *Italy* (Dr. Catalina Curceanu)
14) INFN-Torino, *Italy* (Dr. Daniela Calvo, Dr. Alessandra Filippi)
15) Politecnico Milano, *Italy* (Prof. Carlo Fiorini)
16) Kyoto University, *Japan* (Dr. Hiroyuki Fujioka)
17) RIKEN, *Japan* (Dr. Shinji Okada)
18) Tohoku University, Sendai, *Japan* (Prof. Hirokazu Tamura)
19) Jagiellonian University, Krakow, *Poland* (Prof. Pawel Moskal)
20) Institute of Experimental Physics, University of Warsaw, Warsaw, *Poland* (Prof. dr. hab . Tomasz Matulewicz)
21) IFIN-HH, Bucharest, *Romania* (Dr. Mario Bragadireanu)
22) Lund University, *Sweden* (Dr. Hideyuki Tatsuno)