Letter of intent for Transnational Access Funding to be held jointly between the Physikalisches Institute (PI) and the Helmholtz-Institut für Strahlen- und Kernphysik (HISKP) at the University of Bonn

Acronym: CEDAR (CEntre for Detector and Accelerator Research), Title: FTD-Hadron, Project leader: To be decided

1. Research objectives

Transnational Access is offered by Bonn University´s Forschungs- und Technologie-Zentrum Detektorphysik FTD (Research and Technology Centre Detector Physics), The Electron Stretcher Accelerator (ELSA) and the Bonn Isochronous Cyclotron. This is a unique infrastructure for hadron physics research, and is an integral part of the approved Excellence Cluster, *Colour Meets Flavour* (https://www.color-meets-flavor.de). The involved infrastructures include:

Research and Technology Centre Detector Physics (FTD)

The FTD research building provides a common infrastructure for detector research and development in high energy physics, hadron physics, and photonics. Key research areas of the FTD are chip design, Silicon pixel detectors, high-resolution calorimeters, organic scintillators, micropattern gas detectors, and optical antennas. It includes specialised equipment and large instruments for micro structuring, micro interconnections, micro X-ray inspection, and high resolution 3D coordinate measurements. Over four floors the FTD building features 2010m^2 of laboratory space, including a shielded underground laboratory and 360m^2 of category ISO 5–6 clean rooms.

In combination with the local accelerators, ELSA and the Cyclotron, this provides a unique research environment in Germany and Europe. It allows development and immediate tests of new detector technologies, including the production of calibration sources and radiation hardness tests at the cyclotron‘s proton/ion beams, and dedicated tests of detector response using the ELSA electron beam.

ELSA and associated hadron physics experiments

The Electron Stretcher Accelerator, ELSA delivers extracted cw electron beams with energies up to 3.2 GeV and, energy dependent, longitudinal spin polarisation of up to 80% with a macroscopic duty factor of typically 80%. The beam is used for hadron physics experiments as well as for detector tests which can operate in parallel. There are currently two major experiments set up for hadron physics research: CBELSA/TAPS (CB) and BGOOD. Double polarisation experiments using a spin-polarised target are the domain of the CB setup, which combines central (Crystal Barrel) and forward (TAPS) electromagnetic calorimeters for almost 4π acceptance. BGOOD uses a central calorimeter combined with a magnetic spectrometer (Open Dipole) in forward directions and is therefore ideal for final states of both charged and neutral mesons, in particular involving strange particles.

The new INSIGHT experiment is an integral part of the Excellence Cluster "Color meets Flavor" and represents also an important upgrade for both the BGOOD and Crystal Barrel photoproduction experiments at ELSA. INSIGHT will feature a unique combination of an almost complete angular coverage for high-resolution photon measurements, charged-particle detection and the ability to perform measurements using a polarized beam and a polarized target. For high resolution photon measurements the detector will reuse the main calorimeter of the CBELSA/TAPS experiment and in forward direction the PANDA Forward endcap consisting of 3856 $PbWO_4$ crystals. A new pixel vertex detector for charged particles installed in the space between the target and the calorimeter will measure the trajectories of charged particles with high precision and ensure good vertex resolution. A new forward spectrometer, consisting of several planes of high-resolution tracking detectors up- and downstream of a new dipole magnet and a forward time-of-flight wall will provide charged particle identification and momentum reconstruction. INSIGHT will enable unique possibilities in understanding strange and non-strange resonance spectra and states including their properties.

The TNA will facilitate both the analysis of data with CB and BGOOD, and the detector development, setup, commissioning of the INSIGHT experiment. After this commissioning phase is complete, the TNA will facilitate the subsequent data taking and analysis with INSIGHT.

Besides hadron physics research, the second important use of the electron beam is testing of detector components. This is possible either in combination with a hadron physics experiments or in a dedicated external electron beam line and test area. It allows flexible testing of detector components or complicated arrangements, e.g. polarimeters, either prepared in the FTD laboratories or brought in from third places. The usable electron currents range from “single electrons“ (i.e. ≃1 fA) to 100 pA.

The Bonn Isochronous Cyclotron

The cyclotron accelerates protons and light nuclei to energies up to 14 MeV per nucleon and offers several irradiation areas. The beam is mainly used for material investigations and detector tests, in particular tests of radiation hardness.

This has been used by many external institutions previously, working for example at ALICE, ATLAS and LHCb and will continue to be used during the TNA funding period. A neutron irradiation bay is currently under construction, with commissioning of the beamline starting this year and a third irradiation bay for IBA (ion beam analysis) is currently being planned. IBA beams are in demand for material studies, particularly for the development of nuclear fusion power and interdisciplinary applications, for example biology research.

2. Estimated budget request

The budget estimation is based upon the previous and successful TNA, *FTD Hadron*. Details can be found here: https://www.pi.uni-bonn.de/elsa-ftd/en. The request is split into four parts explained below. Over a four year period, the total budget is estimated as **902 800 €.**

- **Access Units (AU)**. An AU is defined as an hour of beam used by a member of TNA project, or one day's use at the FTD-Hadron infrastructure with no beam. For each AU, 100 € is supplied to ELSA or the cyclotron for operating costs. Over 4 years, 1750 AU is estimated for use at ELSA and FTD and an additional 1000 AU at the cyclotron. In total, this results in a budget of **275 000 €**.

- **Travel costs for TNA users.** This is estimated as 200 € per trip for transport costs, with an additional 120 € per night available for accommodation. It is estimating that for ELSA and the FTD, 20 users will each make three one week trips each of the four years (12 visits per user in total), which will cost 249 600 €. For the cyclotron, it is estimated that five users will make three trips, each three days per year (12 trips per user in total), costing 25 200 €. The total travel budget is therefore estimated as **274 800 €.**

- **A workshop to discuss the research and analysis of visiting institutions.**
  A successful workshop was held at the end of the previous TNA. Entitled *Exotic multi-quark states and baryon spectroscopy* (https://indico.hiskp.uni-bonn.de/event/513/). Estimated cost of **17 000 €**.

- **A paid position for an Access Manager to coordinate TNA**. Estimated 4 year salary as **336 000 €**.

3. Participating and partner institutions

Based upon existing collaborations, previous TNA, and new expressions of interest, we expect the following institutions to use the TNA (however not limited to):

National Science Center, Kharkov Institute of Physics and Technology, Kharkov, Ukraine.
Università di Roma "Tor Vergata", Dipartimento di Fisica, Rome, Italy.
INFN - Laboratori Nazionali di Frascati, Via E. Fermi, Frascati, Italy.
INFN Sezione di Roma, Rome, Italy.
INFN Sezione di Pavia, Pavia, Italy.
Institute for Nuclear Research of NASU, Kyiv, Ukraine.
School of Physics and Astronomy, The University of Glasgow, Glasgow, UK.
IJCLab Orsay, CNRS/IN2P3, Orsay, France.
Instituto de Fisica Corpuscalar, Universitat de Valencia, Valencia, Spain.
CERN, Geneva, Switzerland.
Dipartimento di Fisica, Università Di Torino, Turin, Italy.
INFN Sezione Di Torino, Turin, Italy.
Instytut Fizyki, Uniwersytet Jagiellonski, Cracow, Poland.
AGH, University of Science and Technology, Cracow, Poland.
IFJ, Institute of Nuclear Physics PAN, Cracow, Poland.
Uppsala Universitet, Institutionen för fysik och astronomi, Uppsala, Sweden.
Department of Physics and Chemistry (DiFC)-Emilio Segrè University of Palermo, Italy.
CEA, France.

The following institutions within Germany and also outside of Europe (not eligible for TNA funding) are anticipated to work with the TNA institutions towards the research objectives:

Department of Physics, Technische Universität München, Garching, Germany.
Fakultät für Physik und Astronomie, Universität Heidelberg, Heidelberg, Germany.
Department of Physics, Universität Münster, Münster, Germany.
GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany.
Fachgruppe Physik, RWTH Aachen University, Aachen, Germany.
Ludwig-Maximilians-Universität München, München, Germany.
Lamar University, Department of Physics, Texas, USA.
Department of Physics, Florida State University, Tallahassee, USA.