Letter of Intent for a
Transnational Access to the MAMI and MESA facilities at JGU Mainz /Germany

Acronym: **TNA_MZ**
Project leader: **Prof. Dr. Achim Denig**

1. Research objectives

The **Mainz Microtron (MAMI)** electron accelerator, operated by the Institute of Nuclear Physics of Johannes Gutenberg University (JGU) of Mainz, delivers continuous-wave electron beams with energies from 180 MeV to 1.6 GeV. It features unpolarized and polarized electron sources, an injection linac, three race-track microtrons, and a harmonic double-sided microtron. MAMI stands out with its 100 µA of beam intensity, up to 85% of beam polarization, and an absolute energy resolution of 10^{-4}. Major experiments include the A1 high-resolution spectrometer setup and the large-acceptance A2 experiment, which is located at the tagged-photon beamline of MAMI and which consists of the the Crystal Ball and TAPS calorimeters. The combination of a high-intensity electron beam with its outstanding beam conditions together with the experimental facilities A1 and A2 make MAMI to a premier facility for low-energy particle, hadron, and nuclear physics research. Highlights of the recent past include searches for dark photons, world-class measurements of form factors, electric and magnetic charge radii and polarizabilities of protons and neutrons as well as the measurement of single-spin asymmetries of nuclei. In addition to the A1 and A2 facilities, a dedicated test beam area (X1) for detector development and beam monitoring exists at MAMI and has been instrumental for detector developments at Mainz and for many external facilities, not the least for the FAIR facility at GSI Darmstadt. The X1 area has also been used very successfully for the generation of coherent X-rays and more recently for the production of positrons.

Over the past decade, the Institute of Nuclear Physics has been preparing a second accelerator facility, namely the **Mainz Energy-Recovering Superconducting Accelerator (MESA)**, with beam intensities exceeding MAMI by one order of magnitude. MESA is therefore a unique accelerator for intensity frontier experiments at low energies. MESA will begin operation in 2026 and will be able to run in parallel to MAMI. MESA’s three experiments (see below), which are currently being finalized, will support a long-term and highly impactful research program in subatomic physics for the years to come. MESA will operate in two modes. In the extracted-beam mode, delivering up to 155 MeV polarized electrons at 150 µA to the targets of the P2 spectrometer, luminosities above 10^{39} cm^{-2} s^{-1} will be achieved. The second beam mode of MESA is the highly-innovative energy-recovery (ERL) mode, providing a beam of up to 105 MeV with a beam intensity of >1 mA. At the MAGIX experiment, for the first time in accelerator physics, a high-intensity ERL beam will be operated in conjunction with a thin gas jet target for physics experiments, thereby reaching luminosities of at least 10^{35} cm^{-2} s^{-1}. After passing the gas jet target, the beam is decelerated back to injection energy via cryostat re-injection, enabling exceptionally clean conditions for precision experiments, from astrophysical cross-section measurements to nucleon form factor studies and BSM particle searches. In the extracted-beam mode, the 155 MeV polarized electron beam will interact with hydrogen targets for the P2 experiment, measuring the proton’s weak charge with unprecedented precision and probing new physics scales of up to 50 TeV by a precision determination of the weak mixing angle. Parity-violating asymmetry studies with nuclear targets will furthermore allow to determine the neutron-skin thickness of nuclei, constraining the equation of state, and thus improving our understanding of neutron stars. The P2 collaboration is also considering a determination of the weak charge of ^{12}C. The P2 beam dump can finally be used as a target for the hypothetical production of dark sector particles. A dedicated calorimeter, the DarkMESA experiment, will be placed behind the beam dump, providing world-leading sensitivity for light dark-matter particles.

The MESA facility is a flagship project of the newly approved Cluster of Excellence PRISMA^{++} (starting in 2026 for 7 years), while both MAMI and MESA build the basis for the Collaborative Research Center CRC1660 (approved in 2024 with the first funding period running up to 2028).

2. Connection to Transnational Access infrastructures (TAs) and / or Virtual Access projects (VAs)

not applicable

3. Estimated budget request

The total budget of the TNA to MAMI is calculated on the basis of

- **Trips to Mainz**: we have assumed 172 trips to Mainz with an average number of days spent at Mainz (per trip) of 6 days
  → assuming an average price per trip of 320 € and an average per diem per day of 125 €, this corresponds to **a total amount of travel costs of 184.040 €**

- **Unit costs**: the unit cost per beam hour corresponds to approximately 130 € (final estimate to be done); we are assuming that about 10% of the total number of beam hours at MAMI and MESA will be devoted to TNA users
  → we calculate the access to MAMI to amount to 1800 hours, which gives a **total amount of unit costs of 234.000 €**

We hence request a total amount of 424.040 €, which is the sum of travel and unit costs (plus 6.000 € for travel costs associated with the Program Advisory Committee for MAMI/MESA).

A table summarizing the above-mentioned estimates can be found here:

Unit of access	Unit cost (EUR)	Min. quantity of access	Estimated number of users	Estimated number of days spent at the infrastructure	Estimated number of projects
beam hour	130,00	1800	95	1032	14

4. Participating and partner institutions

The cooperation partners of the MAMI and MESA experiments are listed here:

A1 / MAGIX collaborations: Univ. of Edinburgh/UK, Univ. of Kattowice/Poland, Univ. of Ljubljana/Slowenia, Univ. of Zagreb/Croatia

A2 collaboration: Univ. of Edinburgh/UK, Univ. of Glasgow/UK, Univ. of Pavia/Italy

X1 collaboration: Univ. of Ferrara/Italy, ESRF Grenoble/France, IJCLab Saclay/France, Paul Scherrer Institute/Switzerland, Hellenic Mediterranean University/Greece

P2 collaboration: IJCLab Saclay/France, Univ. of Manitoba/Canada, Univ. of Indiana/USA

The preparation of beam times as well as the analysis of the data taken at MAMI and MESA requires in almost all cases close collaborations with theory groups. As a part of the publication process, we foresee visits of theory groups from the following institutions: Univ. of Barcelona/Spain, Tallin/Estland, Cagliari/Italy, Liverpool/UK, Trento/Italy, Zurich/Switzerland, Pittsburgh/USA, ETH Zurich/Switzerland, Chalmers U./Sweden, U. Jerusalem/Israel, and Oak Ridge Laboratory/USA.