Letter of intent: proposal template

Please specify an acronym, a project title and the name(s) of the project leader(s):

High Power Parity Targets (HPPT), High-power targets for parity-violating electron scattering
Project leaders:
Prof. Dr. Tyler Kutz (Institut für Kernphysik, Johannes Gutenberg-Universität Mainz)
Dr. habil. Michaela Thiel (Institut für Kernphysik, Johannes Gutenberg-Universität Mainz)

In the sections below, please provide details on *(2 pages max.):*

1. Research objectives

Parity-violating electron scattering (PVES) has developed into a well-established, general method for probing nuclear and nucleon structure, QCD, and performing precision tests of the Standard Model (SM). These are all experimental topics typically investigated using hadronic physics infrastructure. There are several large experimental collaborations with proposed or approved experiments at Jefferson Lab (JLab), USA (MOLLER, SoLID), MAMI/MESA, Germany (P2, A1), and at S-DALINAC, Germany. These experiments cover a wide experimental program including hadronic physics (axial form factors, model-independent extraction of proton d/u), nuclear physics (neutron skin thickness, nuclear isospin corrections to V_{ud}) and precision SM tests (weak charge of quarks, electrons, the proton, and carbon). Experimental setups for PVES also enable the measurement of beam-normal single-spin asymmetries, which are sensitive to the imaginary part of the hadronic two-photon exchange diagram.

PVES experiments measure parity-violating asymmetries between right- and left-handed electron beam helictites, which can be as small as parts per million down to tens of parts per billion, requiring high statistics (order 10^{20} events) and careful systematic control. To achieve the required rates, experiments use high beam currents on thick solid or liquid targets. The large deposited powers can quickly lead to degradation of the target, resulting in unstable luminosity and a severe reduction of experiment accuracy. This challenge is common to all PVES experiments.

We propose here the development of a system to raster the beam over the target in order to distribute power over a larger area of the target, reducing boiling effects (in liquid targets) or melting (in solid targets). The raster pattern must be carefully synchronized with the beam delivery from the accelerator, such that the same target area is swept in each beam helicity state. Such systems have been successfully implemented at JLab, and we propose to take advantage of the existing expertise at JLab to implement a beam raster system for MESA. This will improve the beam service and quality at MESA.

In addition, we propose to further improve the services provided at MESA through the development of a stable, flexible target system in order to switch between different physics programs without the installation of a new target system. For experiments with solid targets, the deposited beam power must be thermally transported out of the target to

cooled target frames. Multi-target ladders allow redundancy and the inclusion multiple target types for different physics measurements, calibrations, and systematic studies.

These methods will be critical to PVES program at the forthcoming MESA facility. The P2 experiment will measure the weak charge of the proton with 0.14% accuracy, as a high-precision test of the Standard Model. The MREX experiment will measure the weak radius of ^{26}Mg, reducing nuclear uncertainties in a super-allowed β-decay used for extractions of V_{ud} (testing CKM unitarity). Both of these experiments will require beam rastering, and the MREX measurement will require the development of a specialized, cryogenically cooled multi-target ladder compatible with magnesium targets.

The research objectives of this LOI are:
• Develop and construct a beam raster for P2 and MREX
• Begin development of MREX target ladders suitable for magnesium
• Participate in the experimental run of MOLLER at JLab

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

The PVES programs at P2 and JLab are highly complementary. JLab's upcoming MOLLER experiment will measure the weak charge of the electron, using a liquid hydrogen target and raster similar to the P2 apparatus. Part of this proposal will request funds for personnel to travel to JLab, participate in the MOLLER experimental run, and learn about the implementation of the MOLLER raster and target from JLab experts.

3. Estimated budget request

For personnel we request 1,25 FTE for three years to fund one PhD position (0,75 FTE) and one half postdoc position (0,5 FTE). This amounts to a total personnel cost of 300.000€ (at 240.000€ per FTE for three years). Further, we request 10.000€ for travel between Mainz and JLab.

Direct cost:	310.000,-€
Total request (+25% overhead):	**387.500,-€**

4. Participating and partner institutions

Institut für Kernphysik, Johannes Gutenberg-Universität Mainz, Germany
Helmholtz-Institute Mainz, Johannes Gutenberg-Universität Mainz, Germany
IRFU, CEA Saclay, France
University of Massachusetts Amherst, USA
University of Manitoba, Canada
Jefferson Laboratory, USA