WP Number	1	1-48
WP Title	Hadron Probes of New Physics (Research, Develop, Training)	
Lead Beneficiary	INFN	

Objectives: Collect physics datasets to search for new physics signals in the hadronic sector. Move towards a tomography of the nucleon. Investigate strongly correlated fermionic systems. Search for new states of matter.

Description of Work and Role of Specific Beneficiaries / Partner Organisations

T4.1: Search for relativistic light dark matter (INFN, JLAB, ….).
Exploit the high-intensity CEBAF electron beam to produce and detect light dark matter. Search for a new gauge boson (heavy or dark photon) that could be the mediator of the interaction between the Standard Model and the Dark Sector using its leptonic decay in the HPS experiment. Search for signatures of dark-matter re-scattering in the BDX massive active volume after being produced by the interaction of the CEBAF beam with the dump..

T4.2: Exotic signals in hadronization (INFN, JLab).
Search for resonant evidences of new and exotic hadronic state created by the exchange of a quasi-real virtual photon between the high-intensity electron beam and nucleon targets with the CLAS12 detector. Highlight the role of the gluons in the hadron spectrum. Study the dependence on the hard probe scale (virtual photon momentum). Correlate with complementary study done at other accelerators.. Study the process of parton propagation and hadron formation in a cold nuclear matter.

T4.3: Investigate strongly correlated fermionic systems (UNIROMA, INFN, Nuclear Physics Institute/Czech Republic, Institute fur Kernphysik/Mainz, JLAB, BNL, Siracuse University, Stony Brook University, University of Virginia, Idaho State University, Florida International University, Tohoku University/Japan). Exploit the high intensity and high quality of the CEBAF beam combined to the high resolution Hall-A spectrometers to perform challenging electron-nucleus scattering experiments that investigate part per million parity violating processes and low rate hyper-nuclear production. Prepare and run the experiments in collaboration with the theoreticians to strengthen the physics cases both toward nuclear structure and neutron stars understanding. Study data to derive almost direct and unique information on ultra dense matter, e.g. neutron stars Equation of State (EoS). In particular investigate neutron skin and distribution in a neutron dense nuclear matter and Lambda-N interaction and the hyperon puzzle, two problems related to the mass and size of the neutron stars. Complement with such laboratory tests the modern multi-messenger investigation of the cosmic signals.

T4.4: Nucleon tomography at femto-scale (CNRS, GLASGOW, INFN, JLAB).
Perform deep-inelastic experiments to access the transverse spatial distribution of partons inside stable hadrons with high-resolution spectrometers in Hall-A and large-acceptance spectrometers in Hall-B at JLab. Perform multidimensional-multiscale imaging of the nucleon, the fundamental brick of the known matter. Study the implications for the proton radius puzzle, for the magnetic versus electric form-factor rebus; for the elusive partonic orbital momenta and collective motion.

T4.5: Strong-force dynamics in confined objects (INFN, JLAB, INT, ANL, BNL)
Perform deep-inelastic experiments with polarized electron beam and polarized nuclear targets combining two relevant scales: the hard virtual photon probe momentum and the intrinsic parton transverse momenta at the confinement scale. Study the strong-force dynamics in stable objects and during hadronization. Access partonic degrees of freedom and the relativistic correlations between motion and angular moments, i.e. spin-orbit effects.

Description of Deliverables:
D4.1 (M36): Scientific papers related to parton orbital motion and spin-orbit correlations
D4.2 (M36): Scientific papers related to newly bounded states
D4.3 (M48): Scientific papers on light dark matter searches
D4.4 (M48): Scientific papers related to neutron star EoS