

Proposal for the US-Japan exchange program for studies of Hadron Structure and QCD (USJHPE)

Title of the Project: *Experimental studies of hadron spectroscopy at accelerator facilities.*

Applicant Institution: The George Washington University (GW), USA

Applicant name: Professor Igor Strakovsky

Host Institution: Research Center for Nuclear Physics (RCNP), Osaka University, Japan

Host Name: Professor Takatsugu Ishikawa

Expected total budget request: \$5,500

Tentative schedule: March-April 2023 (three weeks)

Narrative: The study of the spectrum of hadrons, the bound states of quarks and gluons generated by Quantum Chromodynamics (QCD), provides a powerful tool to understand this theory and to approach its open questions, such as the nature of quark and gluon confinement. In recent decades, a worldwide experimental program has produced large precision data sets that have allowed the detailed study of the baryon and mesons spectra, and the search for and study of “exotic” states consisting of quark and gluon degrees of freedom beyond the well-known (two or three quark states).

There are twofold aims of this proposal: Prof. Strakovsky is a co-spokesperson of the C12-19-001 experiment for JLab “*Strange hadron spectroscopy with secondary KL beam in Hall D*” and Prof. Ishikawa is a spokesperson of the P95 proposal for J-PARC “*Pion-induced phi-meson production on the proton.*”

C12-19-001 (KLF) experiment for Jefferson Lab Hall D got approval from JLab PAC48 in 2020 for 200 days. KLF project has firmly to setup secondary neutral kaon beam line, with flux of three order of magnitude higher than SLAC had, for scattering experiments on both proton and neutron (first time) targets. CEBAF will remain primarily a facility for fixed target electron scattering at the luminosity frontier. That is the first hadronic facility at JLab. One will measure differential cross sections and self-polarization of hyperons with the GlueX spectrometer to enable precise and model independent PWA to determine all resonances up to 2500 MeV in spectra of Λ^* , Σ^* , Ξ^* , and even Ω^{*-} . PDG2022 reports a quarter of predicted states by constituent quark models (CQM) and Lattice QCD. Then one intends to do a strange meson spectroscopy by studying pion-kaon interaction to locate pole positions in $I = 1/2$ and $3/2$ channels. The KLF will have a very significant impact on our knowledge of kaon-pion scattering amplitudes. It will certainly improve the still conflictive determination of heavy K^* 's parameters. The KLF has a link to ion-ion high energy facilities such as CERN and BNL and will allow understand the formation of our world in several microseconds after the Big Bang. Specifically, missed hyperons play a key role in this study.

The readiness review of the KLF experiment is scheduled for January/February 2023. Tentatively, JLab plans to install KLF in 2024–2025 and run experiments in 2025–2028.

J-PARC has charged kaon beams which are suitable for baryon spectroscopy study. That is a complimentary program to the JLab KLF program. Prof. Ishikawa will look for a way to contribute to the KLF program.

P95 will measure the cross sections for the $\pi^- p \rightarrow \phi n$ reaction to study the nucleon resonances coupling to the ϕ -meson and nucleon, which are expected to appear in the s -channel intermediate state of the reaction. One uses several incident negative-pion momenta from 1.6 to 2.4 GeV/ c and modified E16 spectrometer with large acceptance for detecting $K^+ K^-$ pairs from the ϕ decays. The high-intensity and high-momentum secondary beamline is expected to be constructed step-by-step. The requirement is the beam intensity of π^- s corresponding to the 400 W loss of the primary proton beam at the Lambertson magnet. The proposed experiment can be performed at an early stage of the beamline construction for 5 days for detector commissioning and 10 days for measurements.

There are threefold aims of this project. (i) Our knowledge about the ϕn branching fraction of baryons is insufficient and P95 data will provide an essential input for baryon spectroscopy for future development of CQMs and LQCD calculations. (ii) P95 threshold cross sections are essential for the phenomenological ϕn scattering length determination. Specifically, there are no threshold $\pi^- p \rightarrow \phi n$ cross sections. (iii) The new threshold J/ψ measurements may allow to help to solve a puzzle of existence of the exotic $P_c(4312)^+$ observed by LHCb recently.

Prof. Strakovsky will look for a way to contribute to the P95 program. He will give 2-3 seminars during his stay in Japan.

These plans will highly profit from the rich and productive environment at such a dedicated project and will without doubt help the field to align for prospects. The project will provide an essential part to understand the rich data which will be collected and to guide the development and analysis strategies of new planned experiments.

Expected total budget request

Airfare: Washington, DC USA to Osaka, Japan, and return: \$2,700

Local Transportation: \$500

Housing: (\$20/night at RCNP and J-PARC/KEK): \$450

Per-diem (\$70/day): \$1,470

Additional expenses: \$200

Total Budget request: \$5,500