Jumpstart Processing and Liquid Surfaces (J-PLS) Scope Definition **Rev 4**

This WBS contains all of the work scope necessary to utilize experimental equipment from APS, refurbish and modify them as necessary, procure new components, and install them as a complete end station, ready for commissioning on port 12-ID at NSLS-II, as follows:

- J-PLS Experimental equipment Installation
    - includes the design, development, and installation effort to refurbish and modify existing equipment as necessary, procure new components, and installation of a complete end station, as follows:
        - Conceptual, preliminary and final design reviews
        - Procurement or manufacture of granite tables, slides and screws, machined plates to support:
            - Enhanced crystal tilt stage from the APS/LSS
            - Enhanced sample stage from the APS/LSS
            - New sample stage detector arm for supporting the detectors for:
                - X-ray reflectivity
                - Small Angle X-ray Scattering (SAXS)
                - Wide Angle X-ray Scattering (WAXS)
        - Acquisition of the SAXS beam stop, vibration isolation, flight paths, beam position monitoring, multiple translation stages, supports and miscellaneous hardware.
        - Existing Huber rotation stages will be used, tested, and refurbished as required.
        - Procurement of two new area detectors
            - X-ray reflectivity
            - WAXS
            - An existing area detector will be repurposed for SAXS
        - Installation of all end station components into hutch 12-ID-B.
        - Experimental safety review, or equivalent, prior to commissioning the instrument.

- J-PLS Controls and EPS
    - Includes the design, development, installation, and testing of all controls needed for the J-PLS experimental equipment, as follows:
        - Development of control/server rack configurations and associated cabling.
        - Development of motion control, including configuration and tuning
        - Development of cable study to incorporate new CAT-6 and EPS cables.
        - Procurement and installation of network switch and Linux IOC server.
        - Procurement and installation of new controls cables, as applicable.
        - Procurement and installation of replacement motors and motor connectors for experimental equipment and gear reducers (as required)

        - Procurement and installation of I/O controllers needed to integrate the instrumentation in the end station.
        - Development of diagnostic controls, such as cameras and webcams.
        - Development and testing of vacuum control IOC for flight paths
        - Development and testing of timing IOC.
        - Development and testing of controls to support in-situ/operando measurements.
        - Development of instrumentation to control the end station including operator consoles, network hardware, and disk storage for all of the instrumentation, serial to Ethernet connections, and camera controllers.
        - Controls integration and testing of the end station detectors.
        - Labor to interface with accelerator controls and SMI beamline controls and EPS.
        - Labor to implement, integrate, test, and commission this equipment through successful completion of the beamline's IRR and taking of first light.

- Control Station
    - Includes the design, procurement, and installation of J-PLS furniture and required electrical/ITD infrastructure, as follows:
        - Development of control station layout.
        - Procurement and installation of chairs, desks, partitions and mains wiring/ethernet connections mounted on this equipment.
        - Procurement and installation of standard computer workstations and associated computer hardware.
        - Procurement and installation of monitors and larger overhead TVs.

- Data Acquisition Management (DAMA)
    - Develop basic configuration that allows users to carry-out reflectivity and grazing incident geometry measurements.
    - Develop geometry
        - Define liquid geometry code. This will be used both in liquid and polymer instrument modes.
        - The geometry is used to calculate the grazing incident (alpha_i) and exit (alpha_f) angles and the in-plane detector angle (2-theta) from reciprocal space positions. About 10-15 motors must move to change to a different reciprocal space position.
        - Scans are required both in motor space and in reciprocal (HKL) space. In the control program, such as Bluesky, it is simplest to use variables H, K, and L rather than q_x, q_y and q_z where q_x, q_y, q_z) = (a*,b*,c* dot (H,K,L), i.e. q_x* a* x H. Each HKL corresponds to a specific alpha_i, alpha_f, 2-theta

position. The basic transformation is given by

$$q_{x,y,z} = \frac{2\pi}{\lambda}\begin{bmatrix} \cos(\alpha_f)\cos(2\theta_f) - \cos(\alpha_i) \\ \cos(\alpha_f)\sin(2\theta_f) \\ \sin(\alpha_f) + \sin(\alpha_i) \end{bmatrix}$$

This must be modified to include a sample rotation (azimuthal angle) which is required for solid samples. For a given HKL, the reverse transformation, to angle space, is required. Both alpha_i and alpha_f are psuedo motors.

The algebra for calculating the angular rotations of the deflecting crystal to get a specific alpha_i is represented by a series of matrix rotations. This may not require a reverse transformation. Once alpha_i is known, then one calculates the sample position to intercept the beam which is being tilted downward. This is based on the wavelength and the distance between the rail and the crystal tilting stage. The algebra must take into account that the two rails (crystal tilting and sample chamber) are not truly perpendicular and that the incident beam may have a finite angle with respect to plane of the earth. The crystal deflection calculation code already exists as part of the geometry code in SPEC and the DAMA Group will be provided with appropriate python code to carry-out these transformations.

- Scans are often carried out along paths in reciprocal space, The most generalized scan should take a linear path between, (H,K,L)_start to (H,K,L)_end. One should also have the ability to take 2D mesh scans and arc scans at fixed |(H,K,L)|.
- To extract x-ray reflectivity data from 2D detector scans, post processing operations are required. Some of the existing areaDetector modules maybe be suitable with slight modifications.
  - During post processing to provide the user with analyzable data, each detector pixel will have to be mapped into a specific point in reciprocal space, based on alpha, beta, 2-theta, and the distance to the detector. In the post processing one would like to either specify a region in reciprocal space to integrate over or alternative to integrate over a specified number of channels.
  - Two additional 2D detectors will have to be incorporated, one for SAXS and the other for wide angle scattering. Again, each pixel will have to be mapped to a distinct point in reciprocal space.

- Scope Exclusions:
  - Excluded from this scope is the ID source, front-end, safety and shielding systems that were previously installed as part of construction of the SMI beamline, beamline optics and diagnostics, vacuum systems, and controls for the SMI photon delivery system. Also excluded are hutches, utilities and interfaces to the facility infrastructure. Control of measurement chambers and processing equipment have not been included in the present scope.