Arbitrary Two-Dimensional Mapping Scan Utilizing the Sardana Framework

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Background

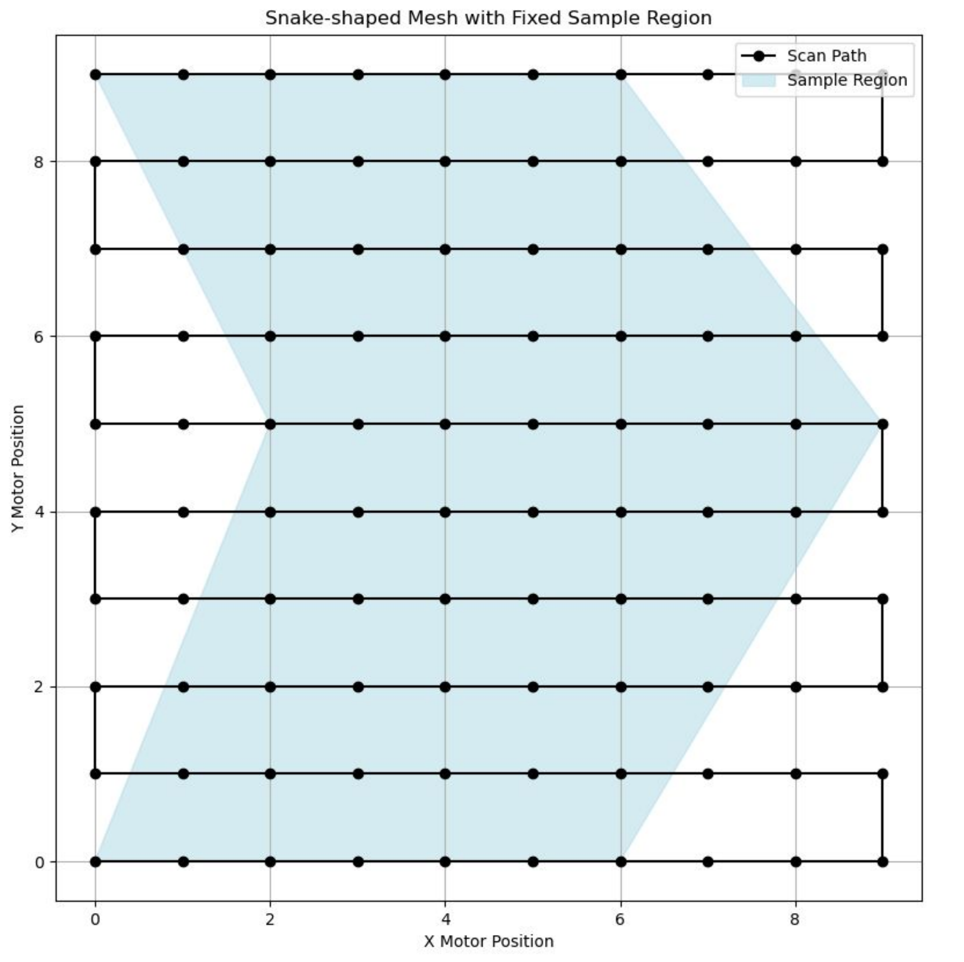
Advanced materials such as energy materials, catalysts, and biological materials like bone have complex hierarchical structures spanning several length scales where chemical elements are organized in a spatial heterogeneous fashion. To understand such materials, it is essential to be able to map the structure and elements within them. 2D micro X-ray diffraction/small-angle X-ray scattering (μXRD/SAXS) and micro X-ray fluorescence (μXRF), available at MAX IV, are particularly well-suited for this purpose.

Motivation

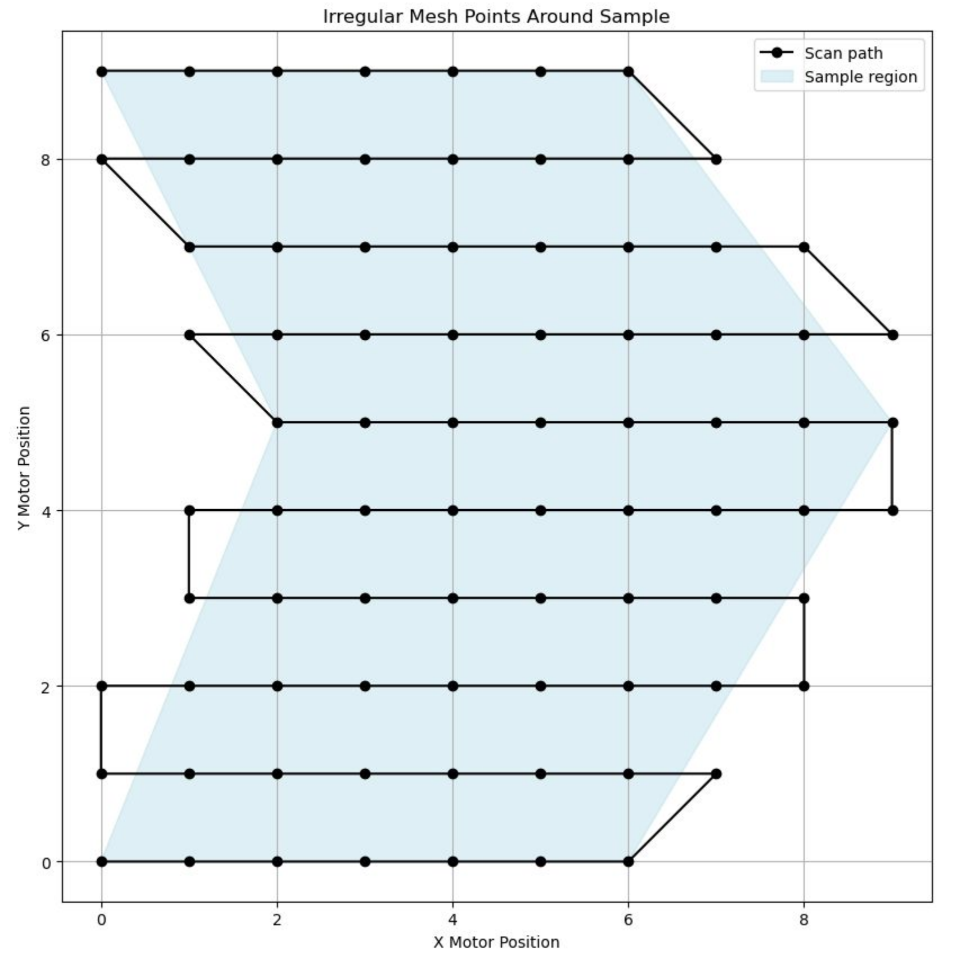
The 2D mesh mapping scan consists of a sequence of linear scans. For competitive speed it is essential to keep overhead to a minimum.

The current implementation at MAX IV enable efficient mapping over large sample areas but are constrained to rectangular scan geometries. This limitation leads to inefficiencies when targeting arbitrarily shaped regions of interest, resulting in prolonged scan times due to the inclusion of irrelevant surrounding areas.

Purpose



Snake-shaped Mesh with Fixed Sample Region
Scan Path
Sample Region
Y Motor Position
X Motor Position
0
2
4
6
8



Irregular Mesh Points Around Sample
Scan path
Sample region
Y Motor Position
X Motor Position
0
2
4
6
8

Irregular mesh continuous scan

The scan macro is capable of executing a mesh scan over arbitrarily defined mapping regions. It exacts the scan regions from a user-provided input file and generates a table of motor positions, which is then passed to the detectors and trigger gate controllers.

```
Door_B304A_ct [2]: imeshct?
Syntax:
        imeshct <mapping_file>

meshct for irregular scanning area. Scan
information are defined in a json file which
should include:
m1_start_pos(list), m1_final_pos(list),
m1_nr_interv(list), m2_start_pos(float),
m2_final_pos(float), integ_time(float),
latency_time(float), motor1(string),
motor2(string)

Parameters:
mapping_file : (String) The path for mapping
info json file
```

mapping_file.json


```
{
  "Region01":{
    "m1_start_pos": [0, 1, 0.5],
    "m1_final_pos": [1, -0.2, 1.5],
    "m1_nr_interv": [15, 10, 5],
    "m2_start_pos": 0,
    "m2_final_pos": 1
  },

  "Region02":{
    "m1_start_pos": [0, 1],
    "m1_final_pos": [1, -0.2],
    "m1_nr_interv": [15, 10],
    "m2_start_pos": 2,
    "m2_final_pos": 3
  },
  "integ_time": 0.1,
  "latency_time": 0.1,
  "motor1": "pd_sam_y",
  "motor2": "pd_sam_x"
}
```

Prepare irregular mesh scan

Coarse scan

↓

Segmentation of the interested area

↓

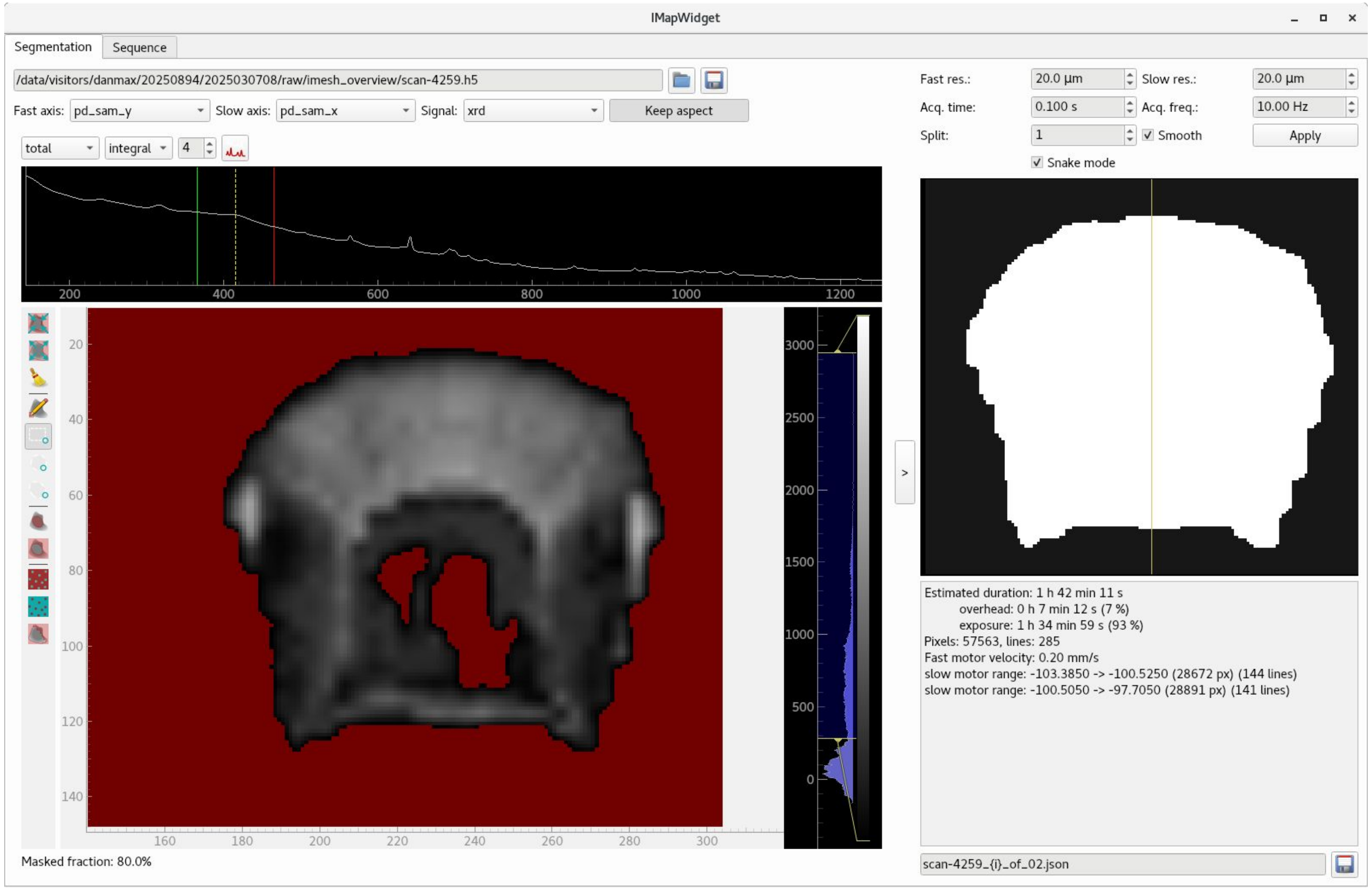
Imesh parameters (integration, resolution)

↓

Split scans

↓

Scan sequence



Preliminary test with different shapes of samples

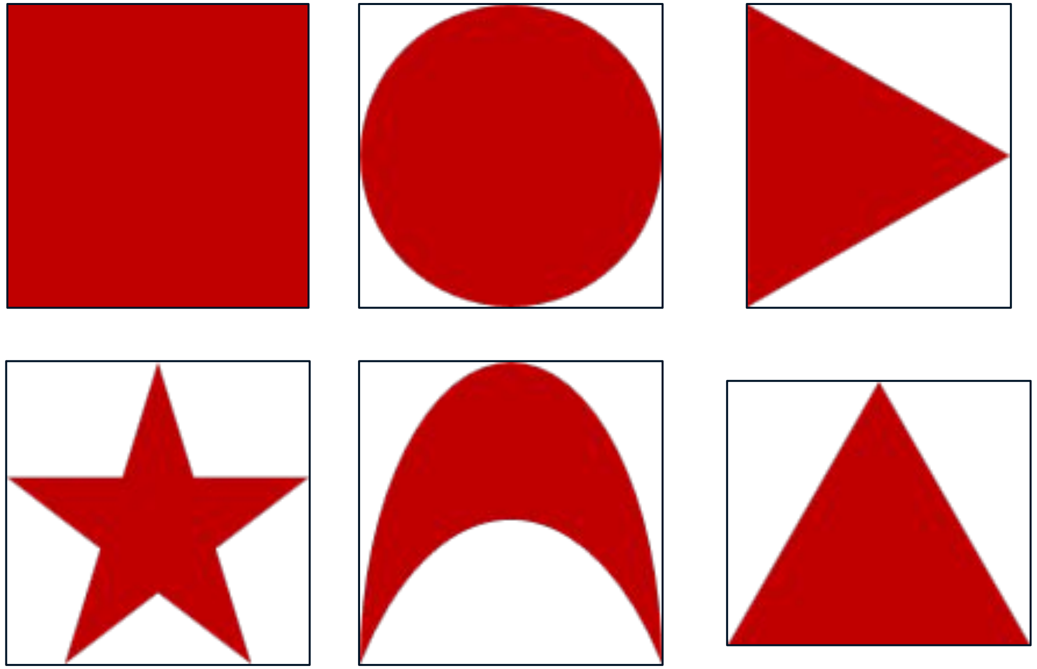
Setting:

Resolution: 50 um
Frequency: 50 Hz
Scanning trajectory: snake motion

Detectors:
Pilatus, Alba electrometer, Xspress 3 mini

Synchronization:
PandABox hardware synchronized

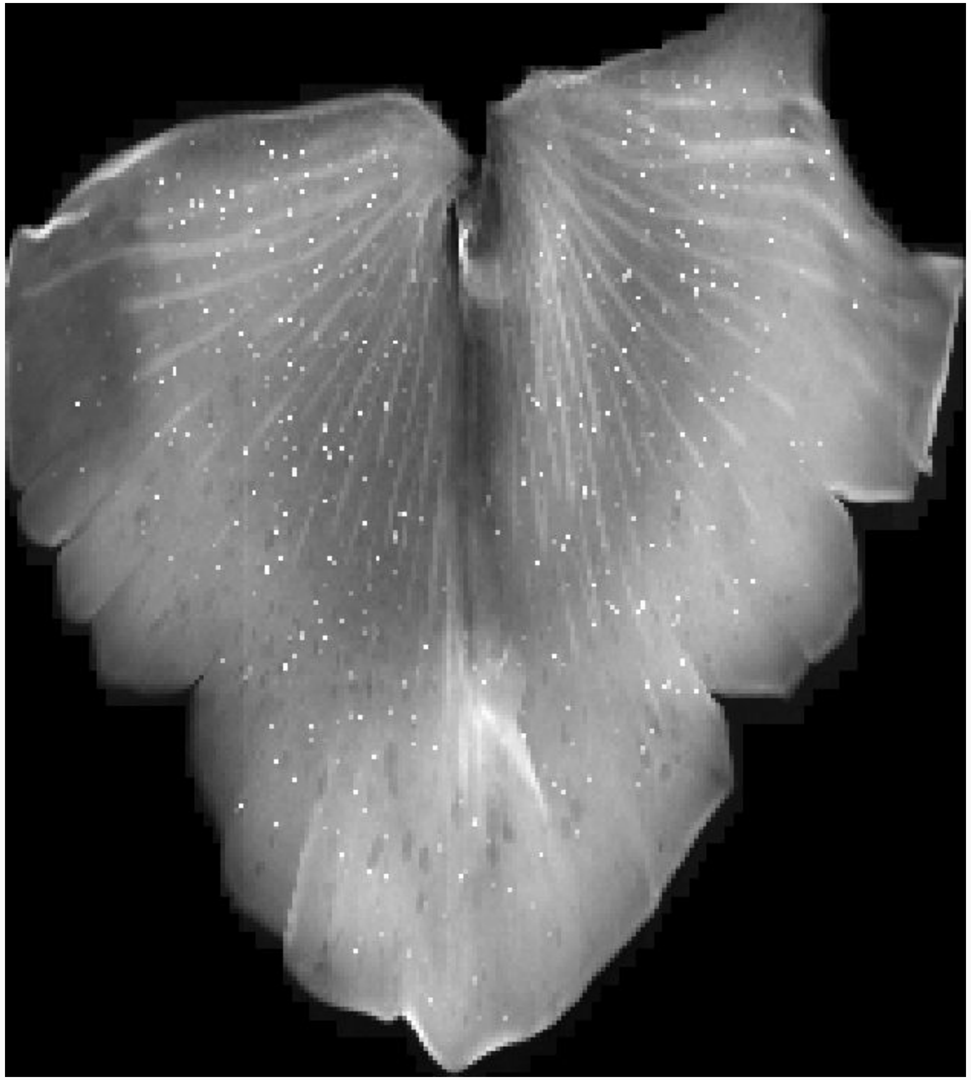
Scanning stage:
Icepap controlled Owis motors

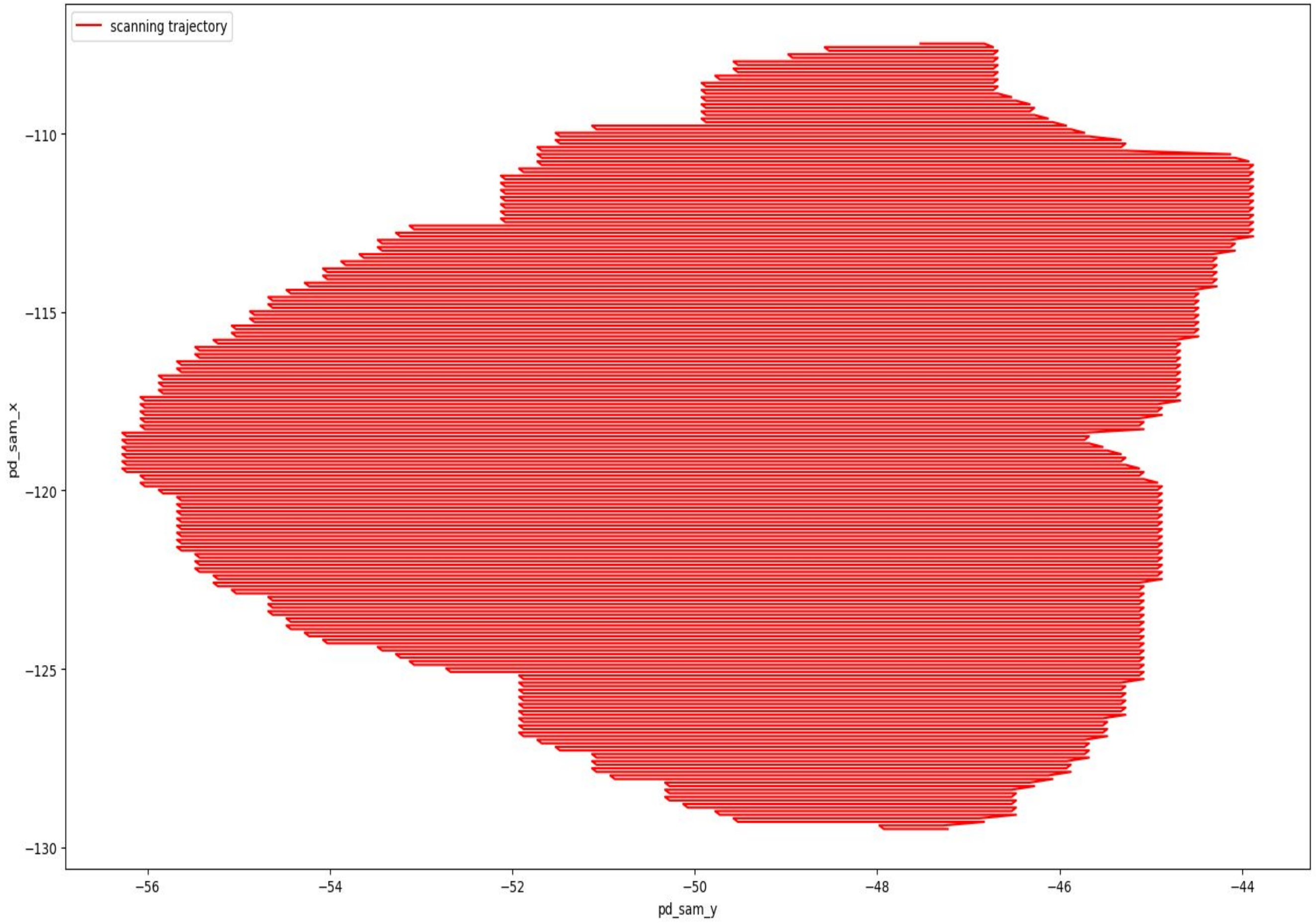


Each sample scanning is composed of 6 scans in sequence to avoid generating one large data file.

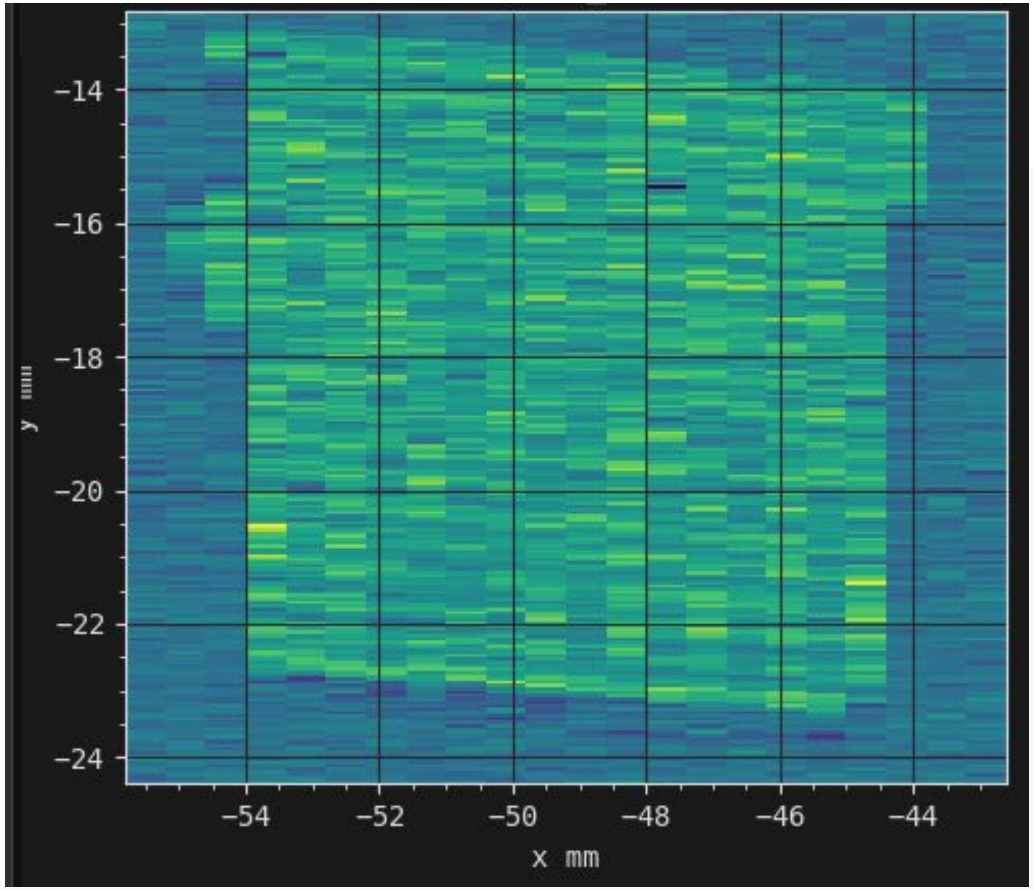
imeshct measurement duration benchmark				
Sample shape(area)	meshct duration	Estimated duration	imeshct duration	Comparison
Square (100%)	1 h 41 min 15 s	1 h 39 min 30 s	1 h 38 min 2 s	96.8 %
Circle (79.8%)	1 h 40 min 50 s	1 h 24 min 1 s	1 h 23 min 4.61 s	82.4 %
Moon (47%)	1 h 49 min 39 s	0 h 54 min 55 s	54 min 9.71 s	49.4%
Star (34.6%)	1 h 54 min 25 s	0 h 48 min 54 s	48 min 44.42 s	42.6 %
Triangle 1 (51.2%)	1 h 53 min 36 s	0 h 52 min 11 s	52 min 35.86 s	46.3 %
Triangle 2 (51.2%)	1 h 49 min 58 s	0 h 50 min 27 s	50 min 34.96 s	46.0 %
Pineapple (60.2%)	0 h 54 min 33 s	0 h 34 min 6 s	33 min 13.41 s	60.9 %

Pineapple outer shell

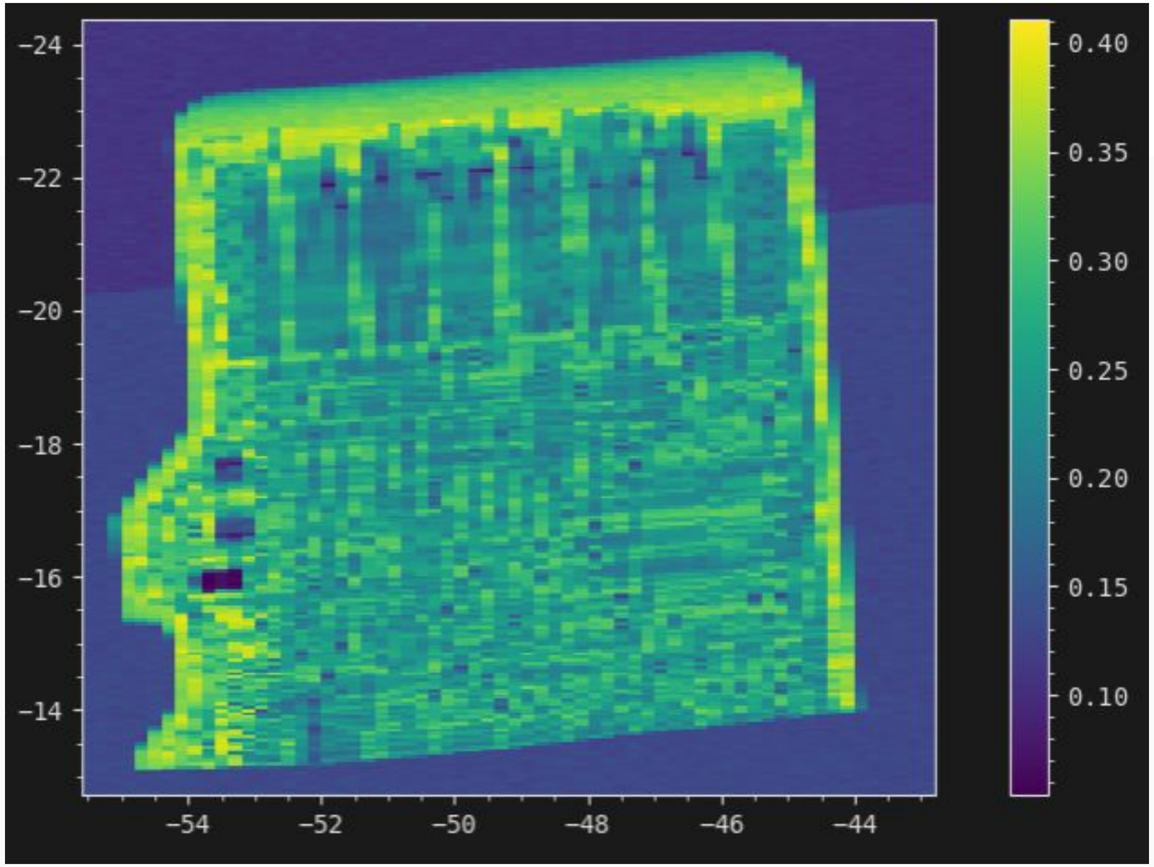




SD Card



Conventional meshct scan



Irregular meshct scan

Conclusion

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- The reduction in scan time is proportional to the decrease in sample area relative to the original rectangular scan region
- It significantly enhance the efficiency of high-resolution structural and compositional mapping workflows.
- All detectors are only armed once in the beginning of the scan to save more overhead between scanning lines.

Future

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- The complicated implementation for passing the synchronization description to the Sardana controllers for detectors could be improved with the new feature that allows transmission of multiple synchronization description directly to Sardana.
- It will be valuable to compare it with the mesh scans with parameterized trajectory solution in IcePAP(ongoing).