

Reducing acquisition time and radiation damage through data-driven experimental design in spectro-microscopy



Science and Technology Facilities Council



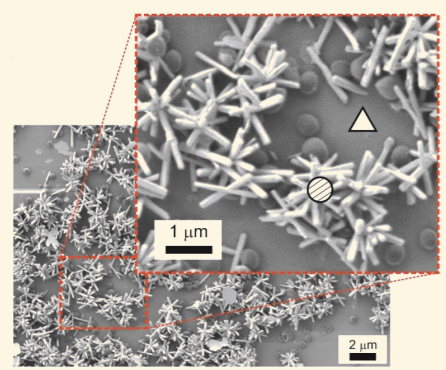
Mathematical Institute

LORENZO LAZZARINO

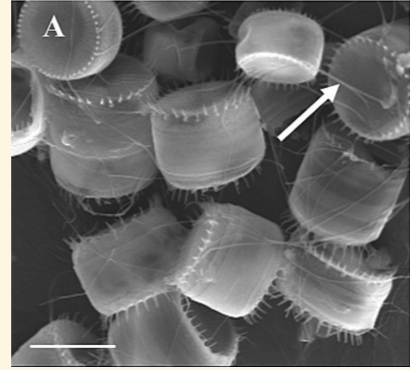
M. MEIER, B. SHUSTIN, H. AL DAAS, AND P. QUINN

CONTEXT

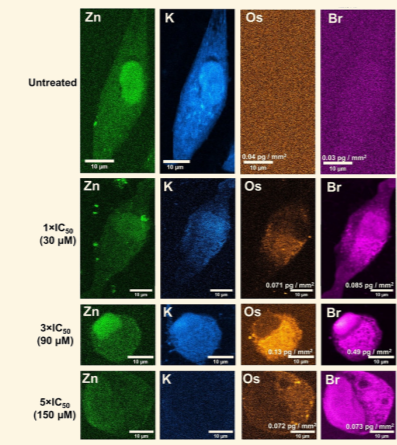
WE TRY TO IMAGE THE SPACIAL AND SPECTRAL MAKE-UP OF A SAMPLE ...



EVOLUTION OF ZNO NANORODS IN WASTEWATER (GOMEZ-GONZALEZ ET AL., 2019)

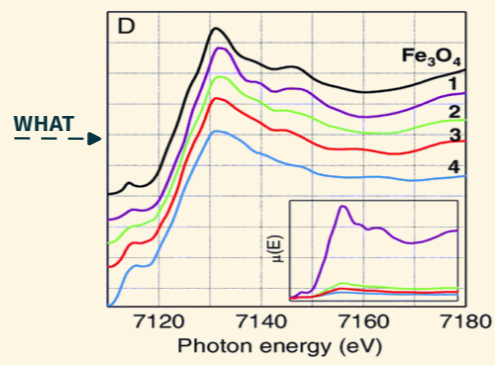
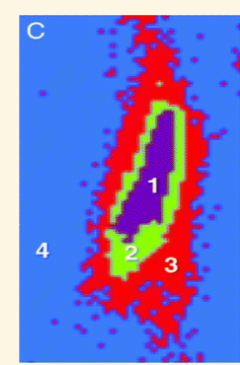
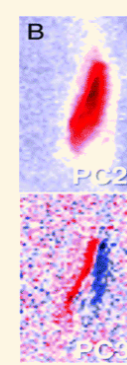
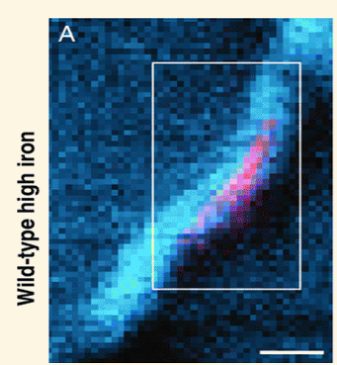


IMPACT OF NANOPARTICLES IN RIVER WATER (YALLOP ET AL., 2025)



TRACKING REACTIONS IN CANCER CELLS (BOLITHO ET AL., 2021)

... IDENTIFYING WHAT MATERIAL IS WHERE

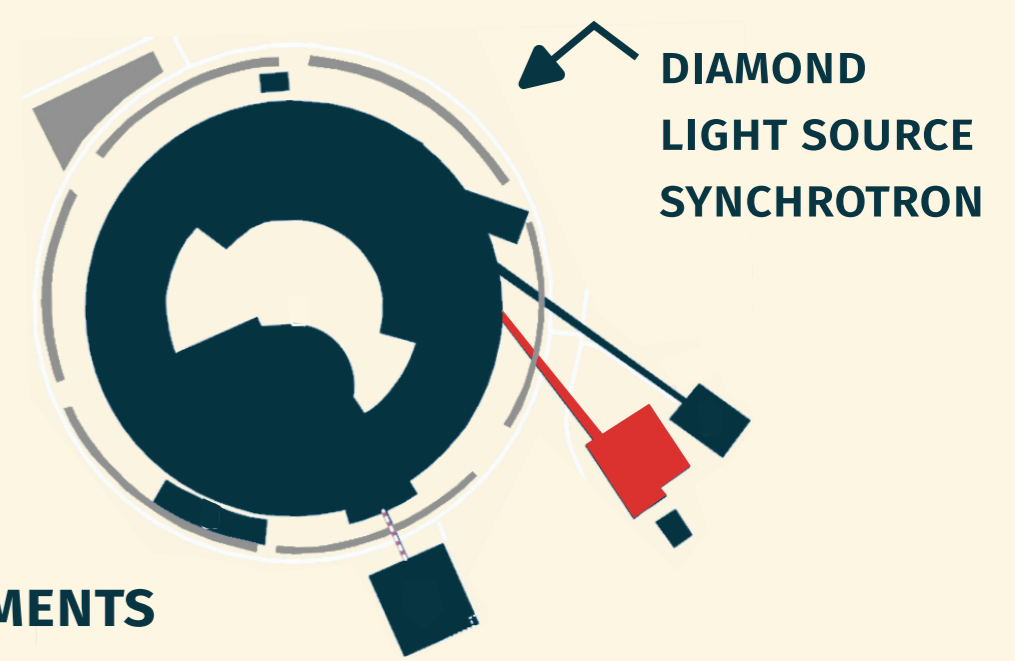


HETEROGENEITY OF IRON SPECIES IN MAGNETOTACTIC BACTERIA (CHEVRIER ET AL., 2022)

STANDARD APPROACH: MEASURE ALL PIXELS FOR ALL ENERGIES

OBSTACLES

- TYPICAL EXPERIMENTS TAKE 5 HOURS, SOME EXPERIMENTS TAKE UP TO 20 HOURS
- APPROXIMATELY £10,000 PER DAY OF EXPERIMENTS
- SAMPLES ARE SIGNIFICANTLY DAMAGED DURING EXPERIMENTS



IDEA

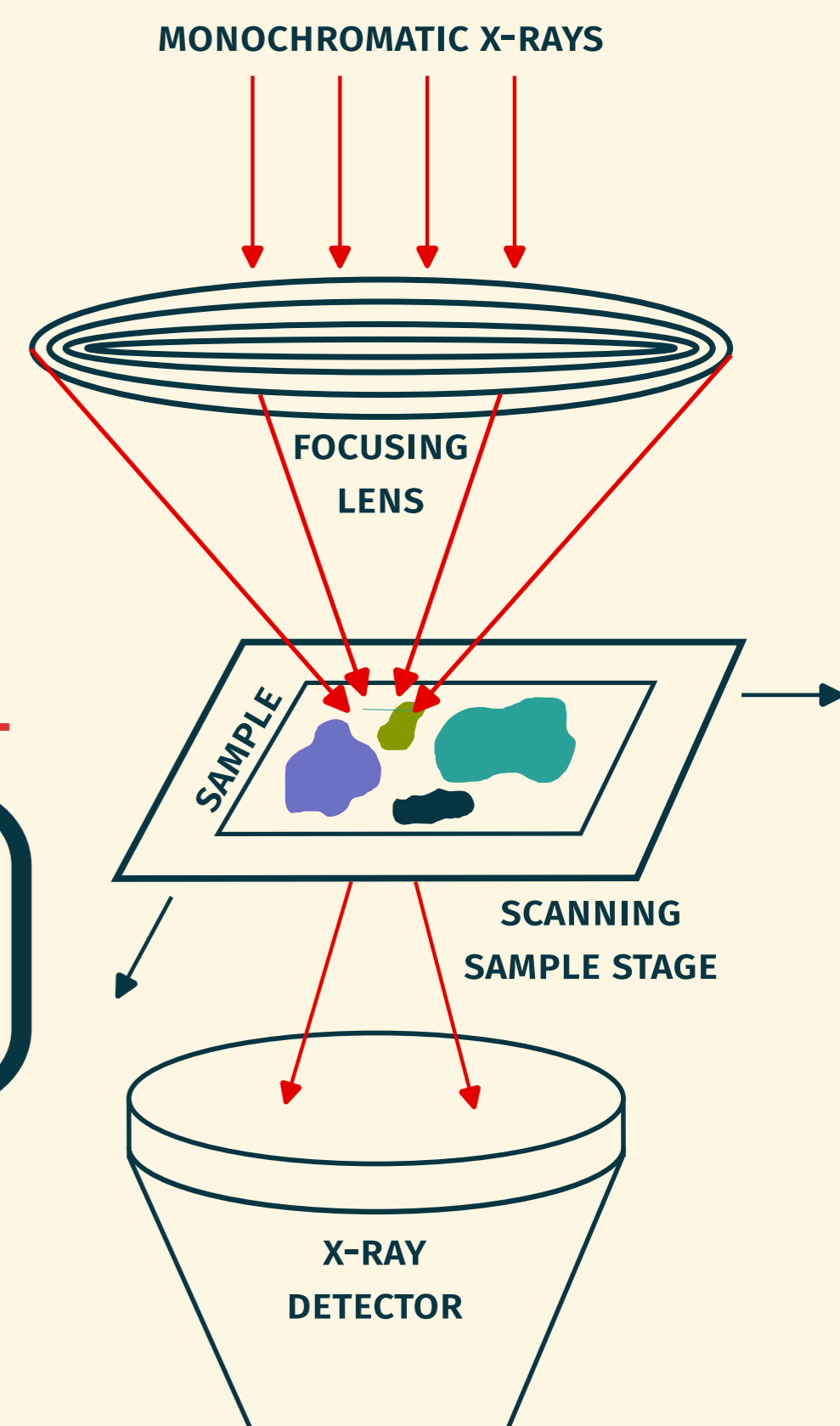
- THERE IS REDUNDANCY IN THE MEASUREMENTS
- SOME PARTS OF THE SAMPLE ARE MORE IMPORTANT
- SOME ENERGIES ARE MORE IMPORTANT

OUR APPROACH

REDUCES TIME

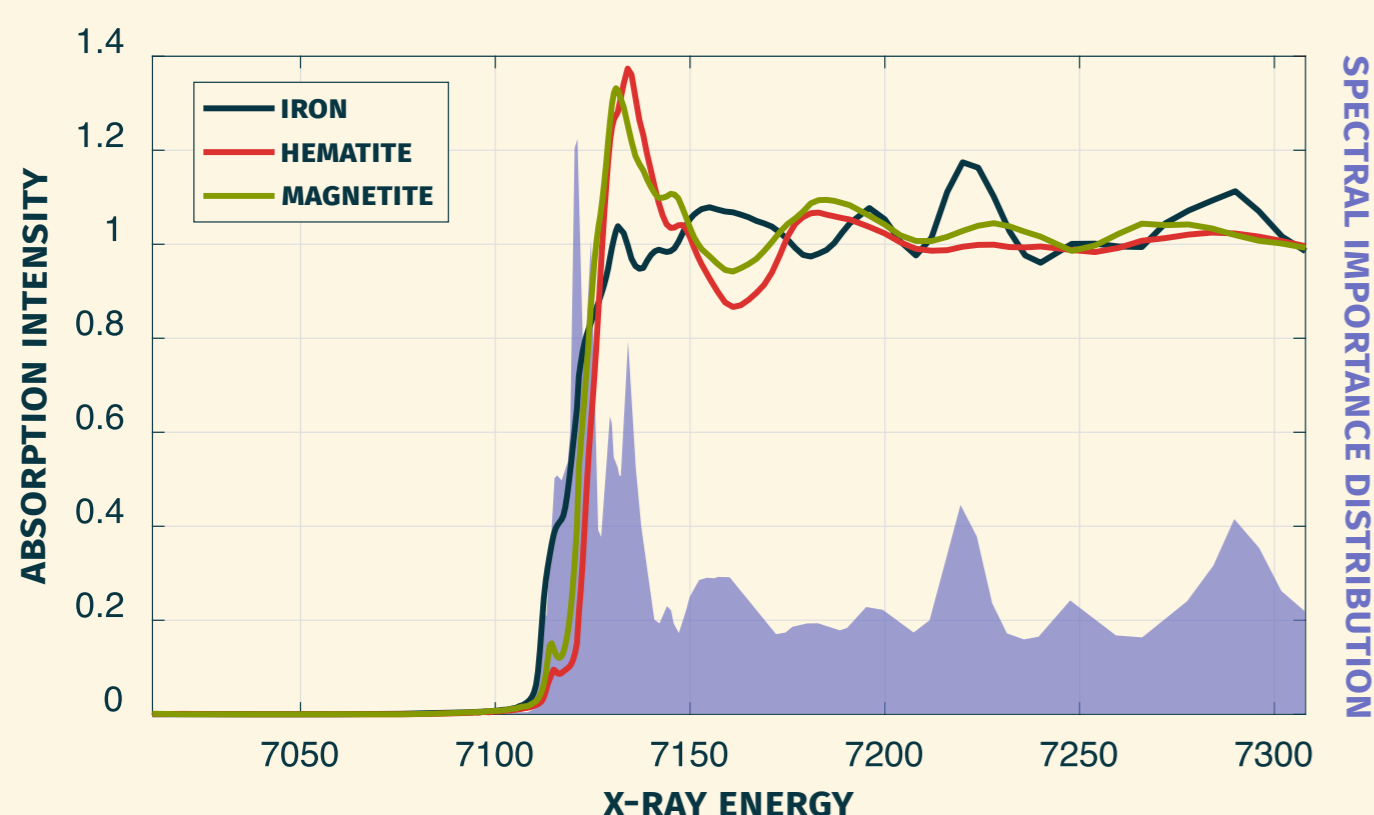
SAFEGUARDS MATERIALS

EXPANDS POSSIBILITIES



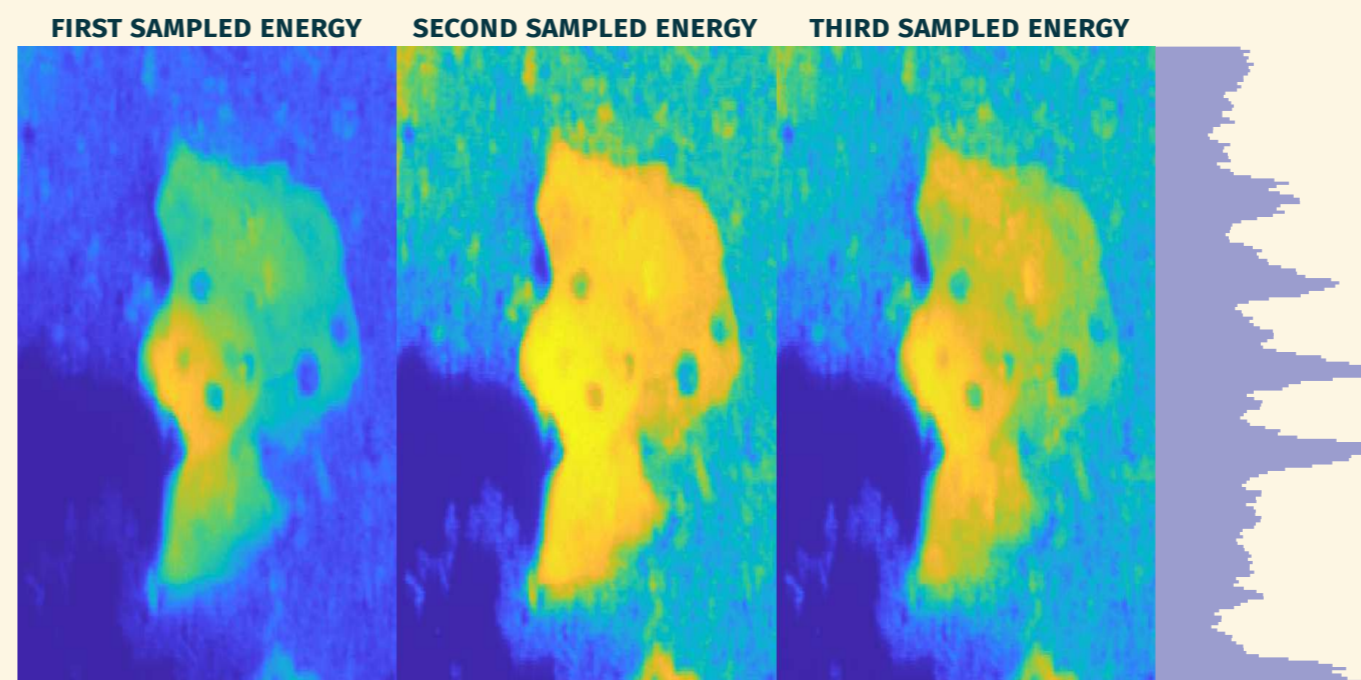
STEPS

1 IDENTIFY SPECTRAL IMPORTANCE SCORES



RANDOMLY SAMPLE FROM IMPORTANCE DISTRIBUTION AND MEASURE FOR FEW ENERGIES

2 IDENTIFY SPATIAL IMPORTANCE SCORES

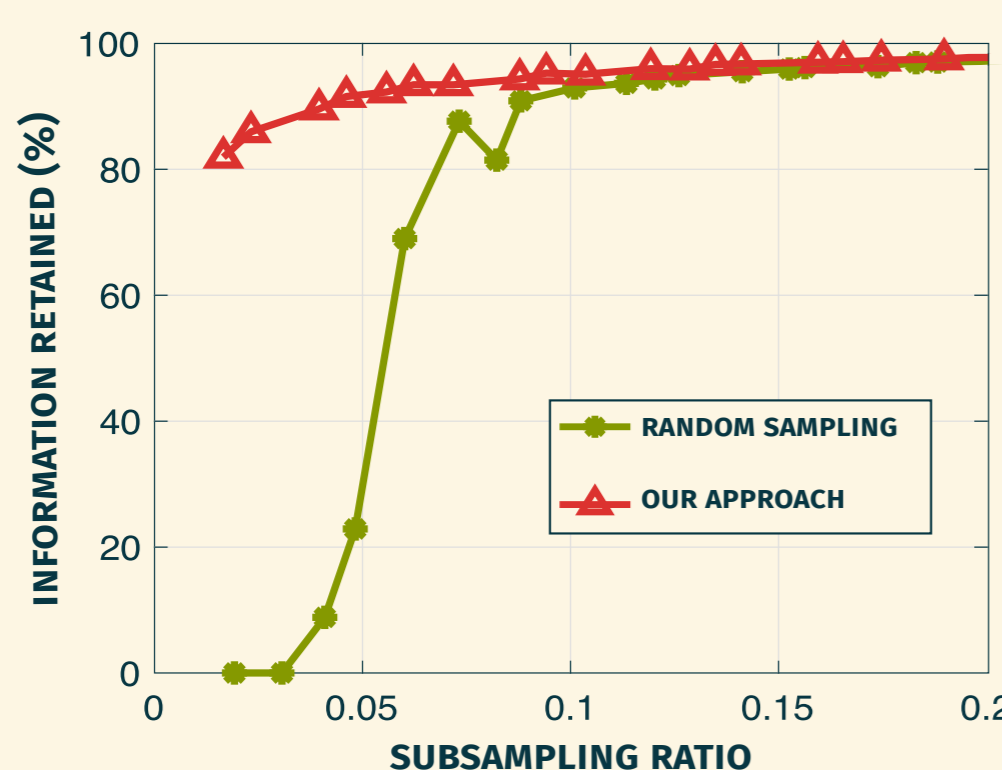


3 MEASURE BASED ON IMPORTANCE

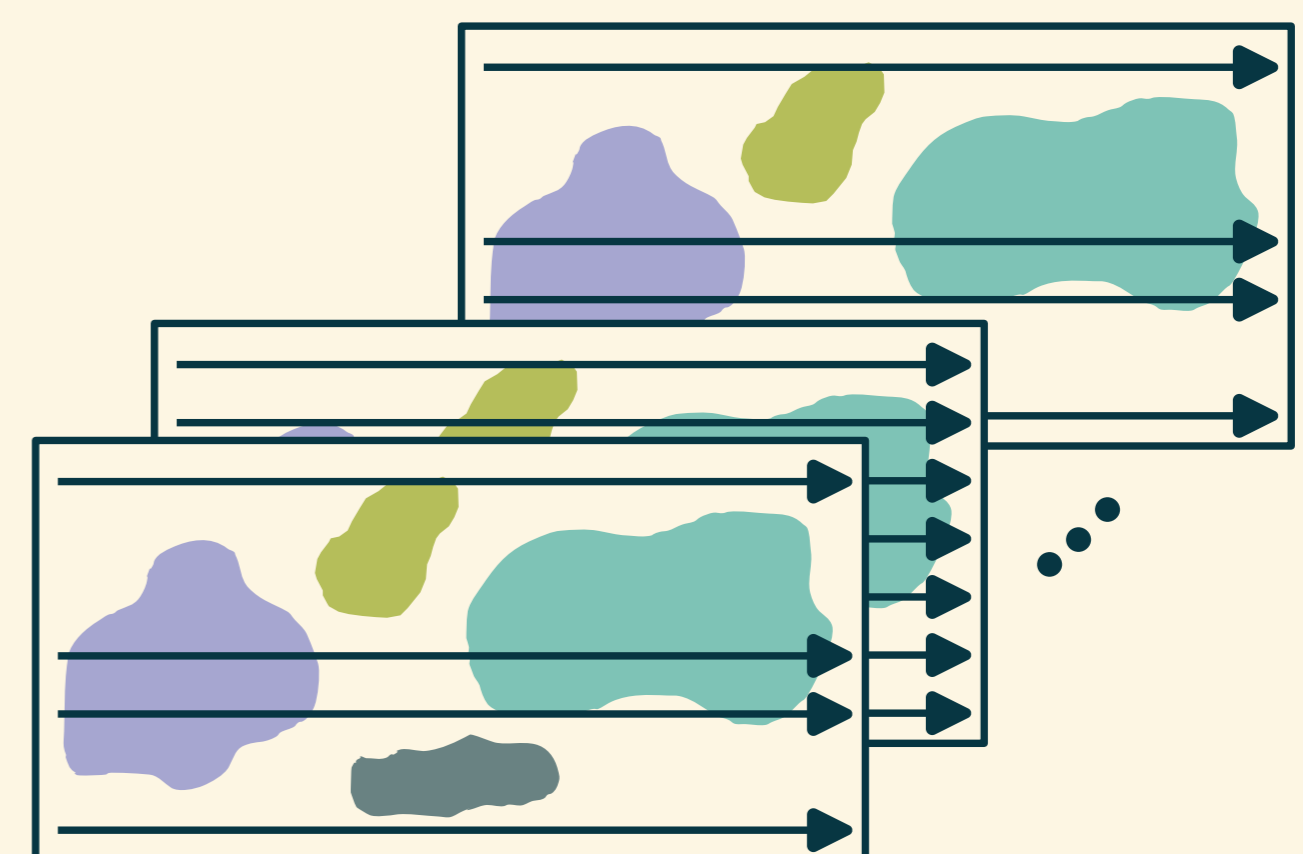
MATHEMATICAL GUARANTEES - CUR APPROXIMATION

$$C \approx U^{-1} R$$

RECOVER FULL DATA-SET



4 ANALYSIS



2-4% MEASUREMENTS
↓
90% INFORMATION

OUR APPROACH IS

- BEING IMPLEMENTED FOR THE DIAMOND LIGHT SOURCE SYNCHROTRON
- A GENERAL FRAMEWORK EASILY ADAPTABLE TO OTHER EXPERIMENTS SUCH AS SPECTRO-PTYCHOGRAPHY AND DIFFUSE X-RAY SCATTERING