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Poster #80: 3D spatial analysis of fluorescence foci from z-stack microscopy using cell reconstruction

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Bacteria encode diverse anti-phage defense systems, yet how their components are spatially organized during infection remains poorly understood. Three-dimensional multichannel fluorescence microscopy can resolve the spatial relationship between phages and fluorescently labelled defense components. However, this information is often lost during analysis when z-stacks are collapsed into maximum-intensity projections, obscuring their relationships to each other and to cellular structures.
We present an implemented workflow for geometry-aware analysis of infection- and defense-associated fluorescence in individual bacterial cells. The workflow combines 2D cell segmentation, three-dimensional reconstruction of cell volumes using radially symmetry, and foci detection on individual z-slices. Slice-wise detections are linked into 3D foci using spatial parameter.
These measurements enable us to address questions central to phage-host interactions: how bacterial immune systems are coordinated in space and time, where are phage-associated activities accumulated, whether defense components are recruited to infection sites, and how host-response signals co-localize relative to the cell envelope. This three-dimensional analysis aims to offer insights of spatially resolved, single-cell dynamics of phage infection and organization of bacterial antiviral defenses.

Reference #1

Popp, P. et al. Molecular basis of the Druantia anti-phage defense system. BioRxiv (2026)

Reference #2

Popp, P. et al. Structure and mechanism of the Zorya anti-phage defence system. Nature (2024)

Reference #3

Baybay EK, et al. Pomegranate: 2D segmentation and 3D reconstruction for fission yeast and other radially

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