

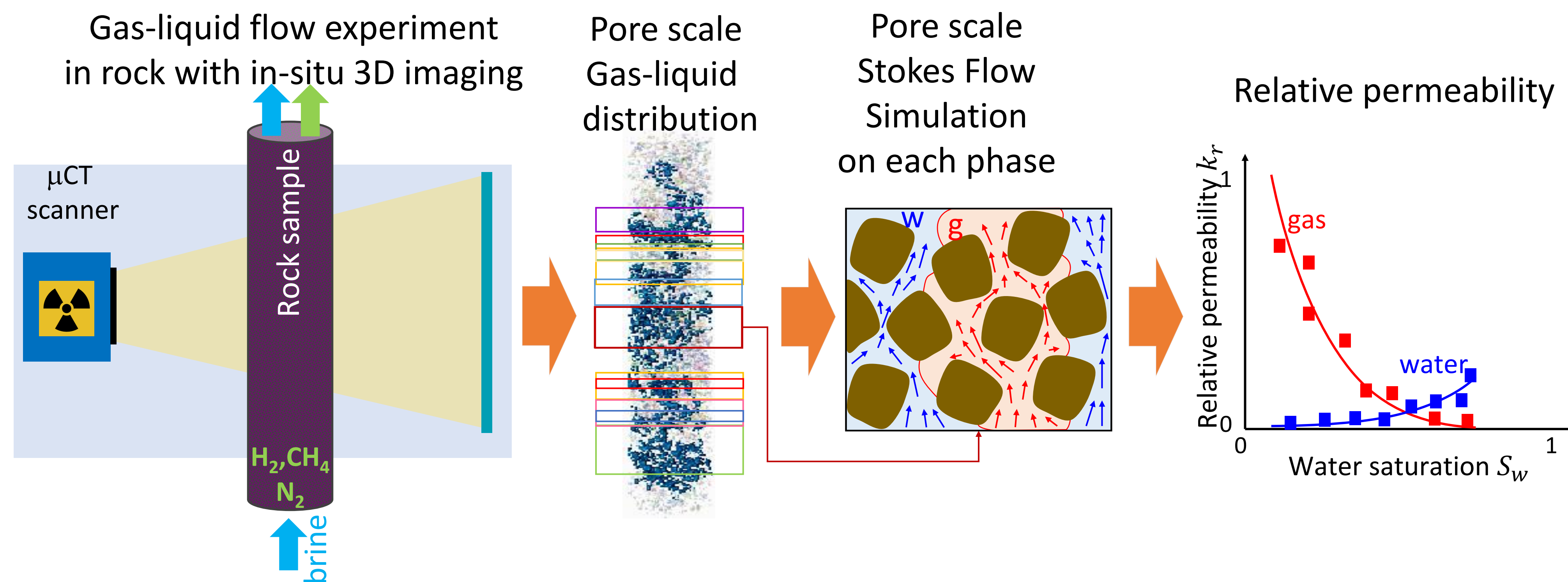


Automating the computation of relative permeability from micro-CT flow experiments

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Context & Data



Motivation

- One fixed segmentation
- Scattered parameters
- Manual workflows
- Subjective selections
- No batch processing
- Unscalable
- 30+ GB volumes

Manual workflow:
 No batch processing · No reproducibility · No standardized process · Extremely time intensive · **Variability across results**

Software Transition

Segment	Current Software	Automated Pipeline
1. μ CT images	Avizo	Python – ahds, PyVista
2. Segmentation	Fiji, Avizo	Avizo
3. CC	Avizo	Python – cc3d, scipy
4. Simulations	GeoDict	Python - MPLBM-UT ⁴
5. Computations	Python	Python, DuckDB

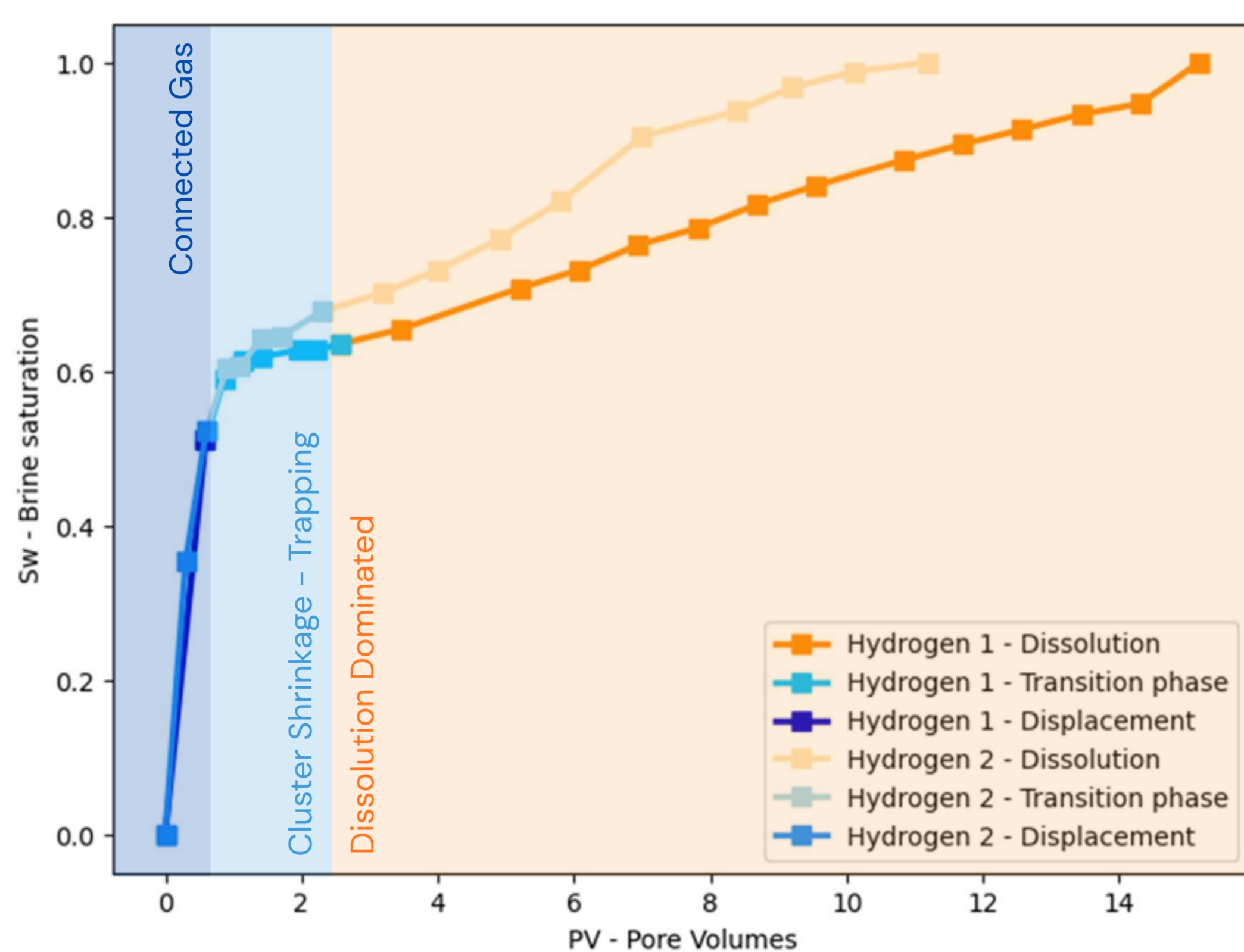
Post-processing Steps

From .raw files to relative permeability and Corey curves

Step	Description
1. Micro CT images (.raw)	Image reconstruction, 3D map of slices
2. Segmentation	Preprocessing, Watershed method, Labelling
3. Connected Components	Gas cluster identification*, Relevant metrics, Tracking
4. Simulations	Stokes and Darcy flow, Minkowski functionals
5. Computations	Relative permeability, Diagrams, Corey Curves

Automated Processing
 Controlled input data, Parameters, Sensitivity Assessment, Data Provenance

Connected Components



Regime Boundary

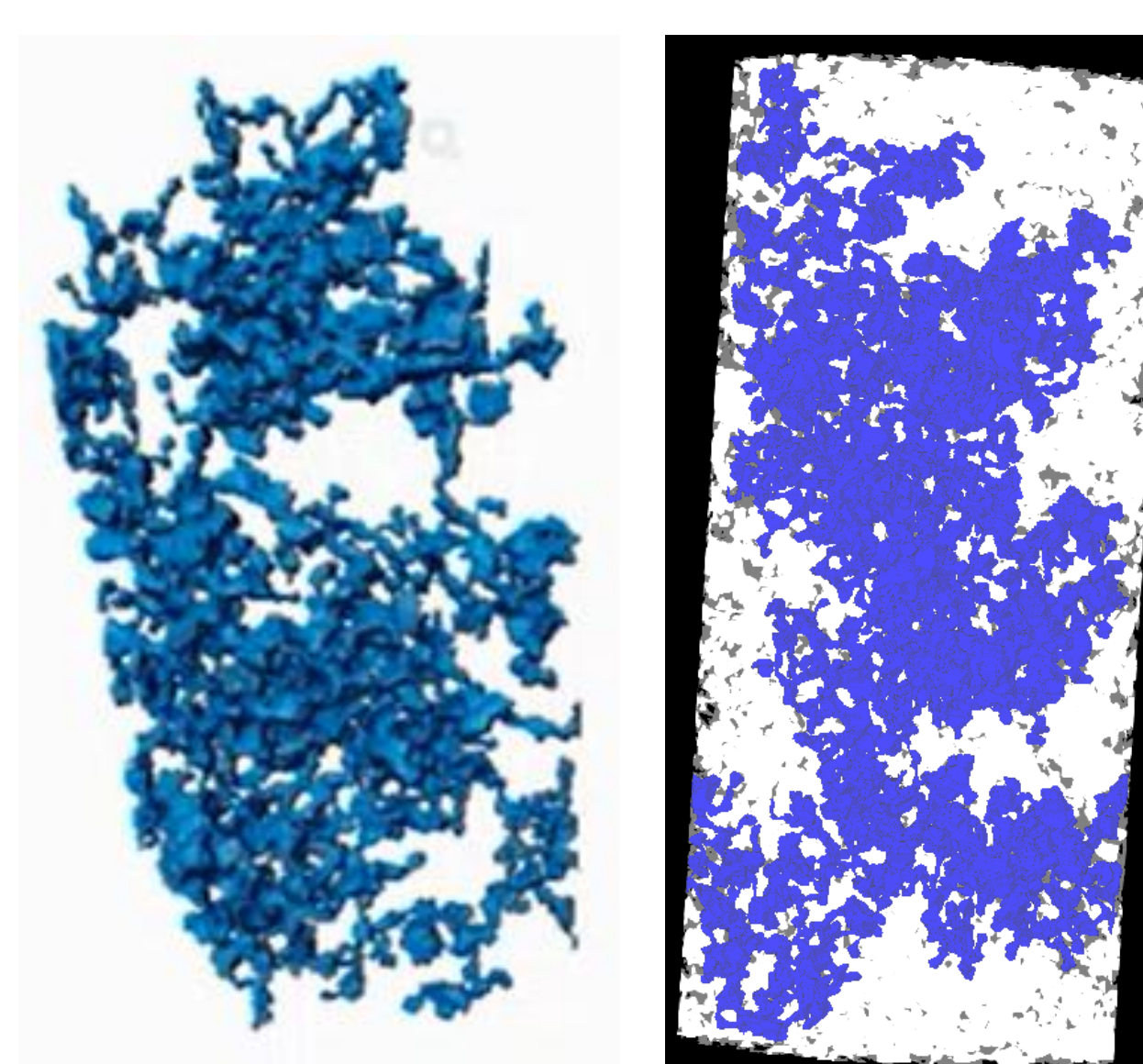
Displacement = mobile gas
 Transition = trapping
 Dissolution = excluded

Boundary Selection

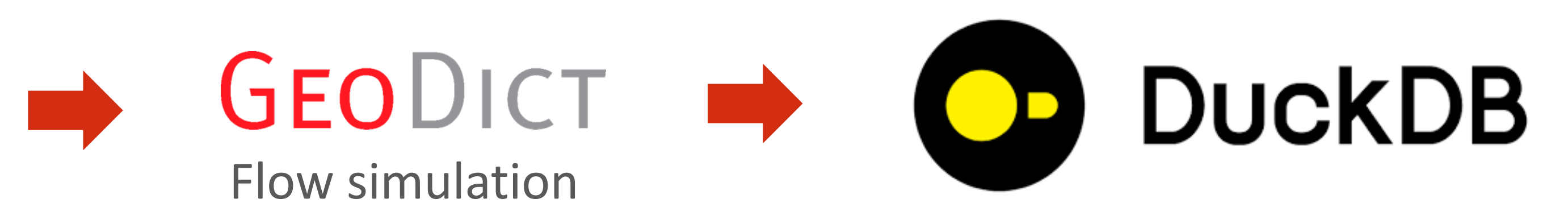
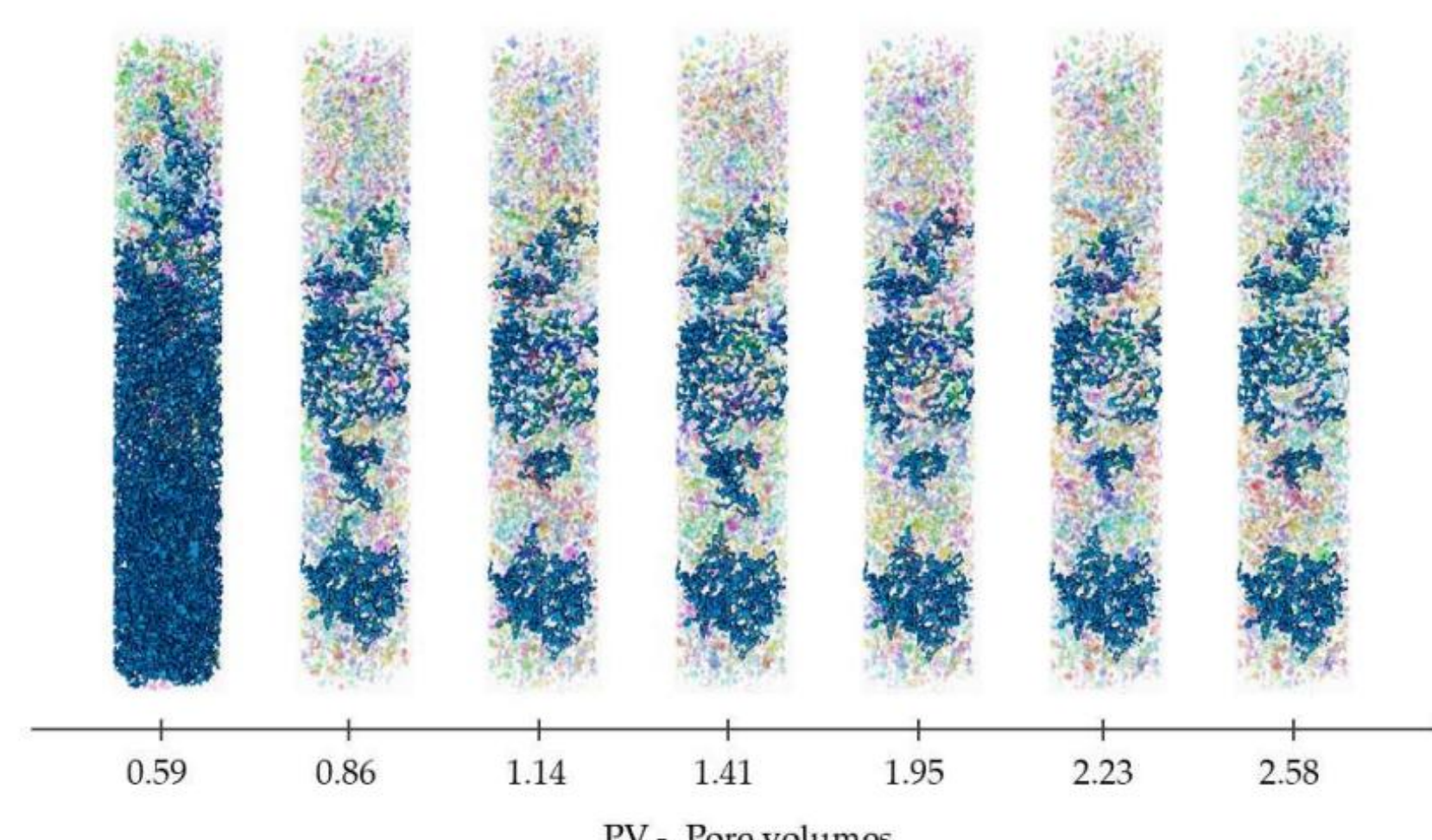
Fit 3 straight line segments (one per regime)
 Test all configurations → choose breakpoint s.t. total sum of squared errors is *minimized*:

$$SSE_{total} = SSE_1 + SSE_2 + SSE_3$$

What design principles for a provenance-aware data-management and analysis pipeline best support reproducibility, scientific transparency, and effective interrogation of pore-scale flow processes derived from time-resolved micro-CT imaging?

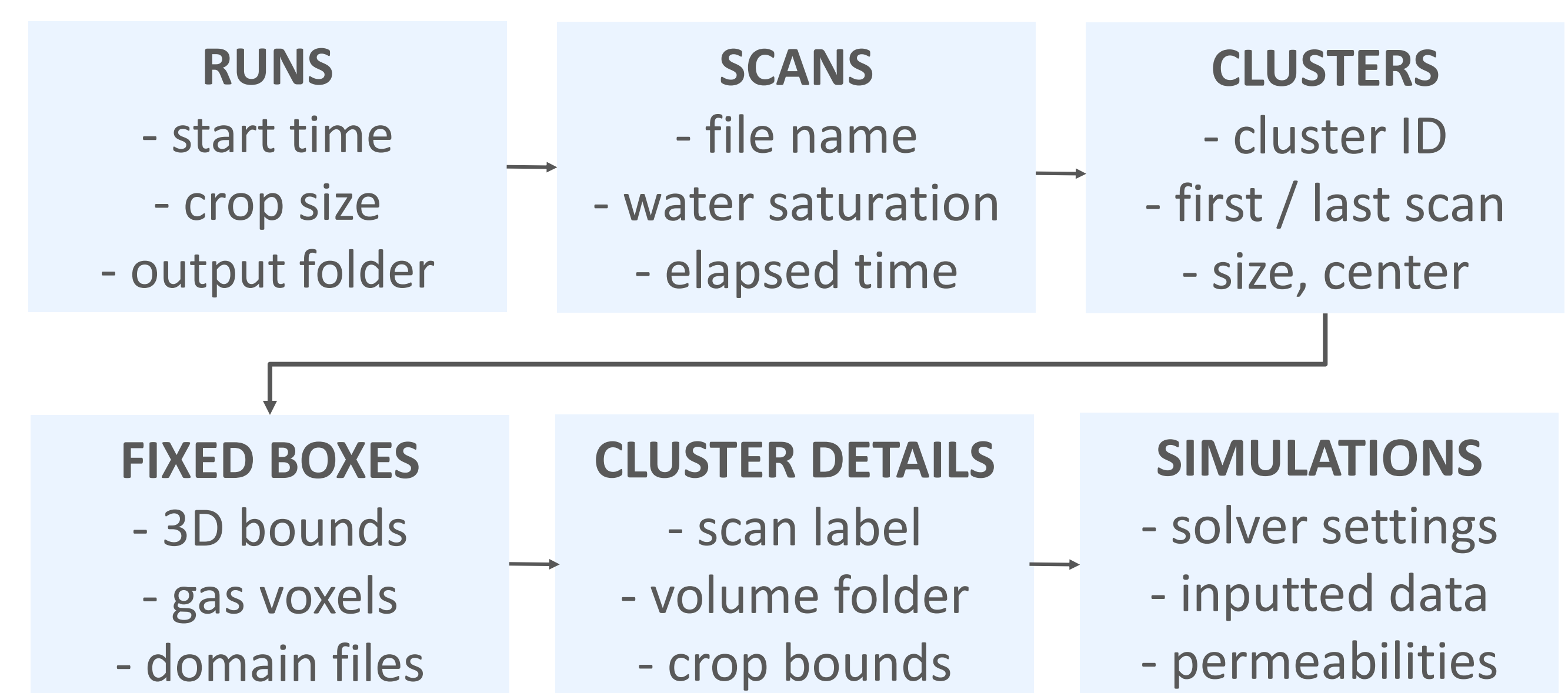


Largest connected cluster visualized



Every relative permeability must be **traceable** to experiment, image, scan, cluster, box, and solver

Database Structure



References:

1. Berg et al. (2022). Relative Permeability as stationary process. Physics of Fluids 34, 092011.
2. Gao et al. (2024). Petrophysics 64 (03), 368–383, 2023.
3. Parente et al. (2026). International Journal of Hydrogen Energy 229, 154730, 2026
4. Santos, J. E., et al. (2022). MPLBM-UT: Multiphase LBM library for permeable media analysis. SoftwareX, 18, Article 101097