Common coordinate systems for the human body

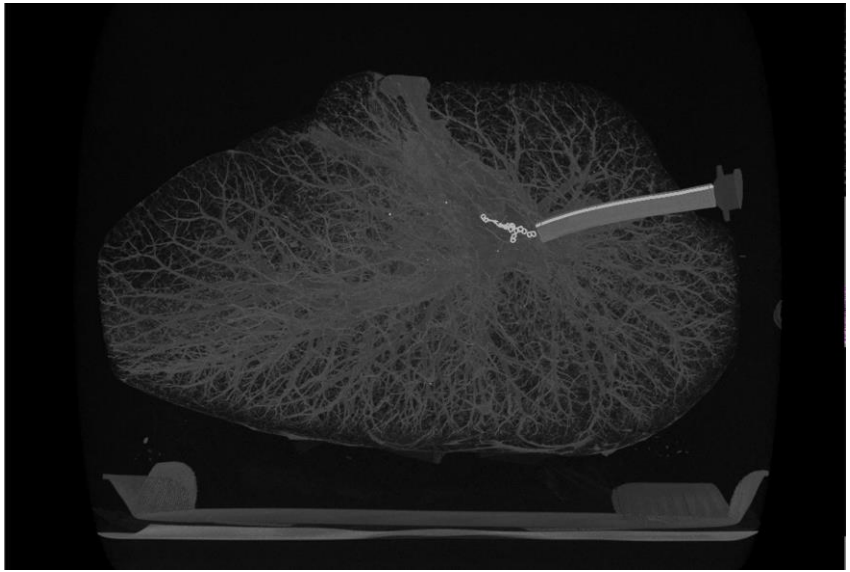
NYGC Mapping
Rahul Satija, John Marioni, Aviv Regev

Building a reference framework for HuBMAP

Question: How can we map across individuals to minimize inter-individual variation due to spatial differences?

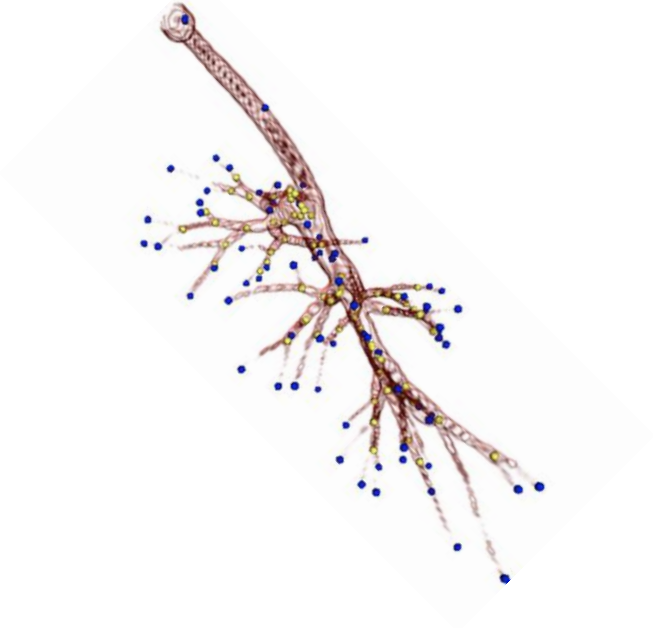
Chose the lung as a pilot to construct a Common Coordinate Framework.

High-resolution CT data available through collaboration with LungMAP

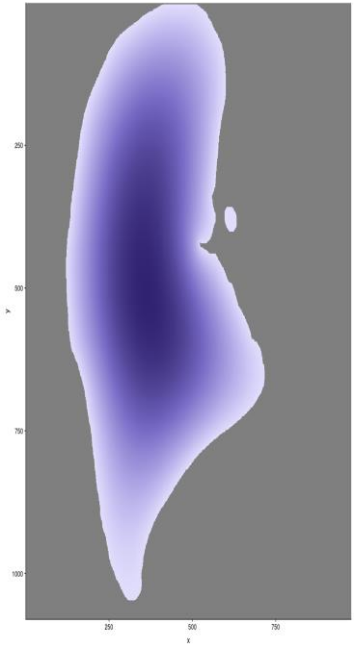


Progress in Year 1: Methods for CCF construction

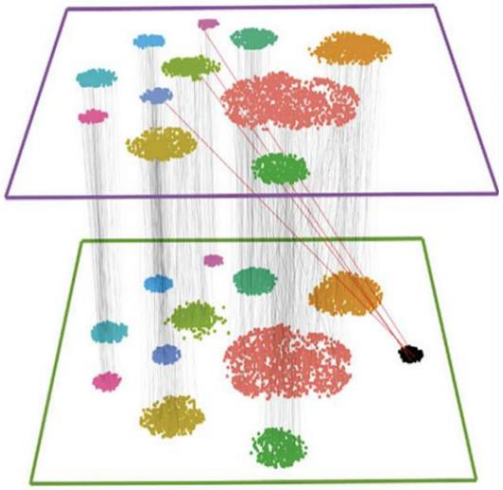
Internal spatial landmarks



Shape-based landmarks



Molecular landmarks



Next year’s deliverable

1. **Common Coordinate Framework (Lung)**
    - **Given a location in one sample, map to a corresponding position in another sample**
    - **Develop strategies for lung, can be generalized to other tissues**
    - **CCF Workshop (with MC-IU) in 2020**

1. **Molecular integration across individuals and technologies**
    - **Tools for the ‘harmonization’ of different HuBMAP and community datasets**
    - **Integrate and classify cells across experiments, modalities, and technologies**
    - **Demonstrate in lung and kidney, but methods will broadly apply to many tissues**

Collaboration with LungMAP and KULMAP: Gloria, James Hagood, Xin Sun

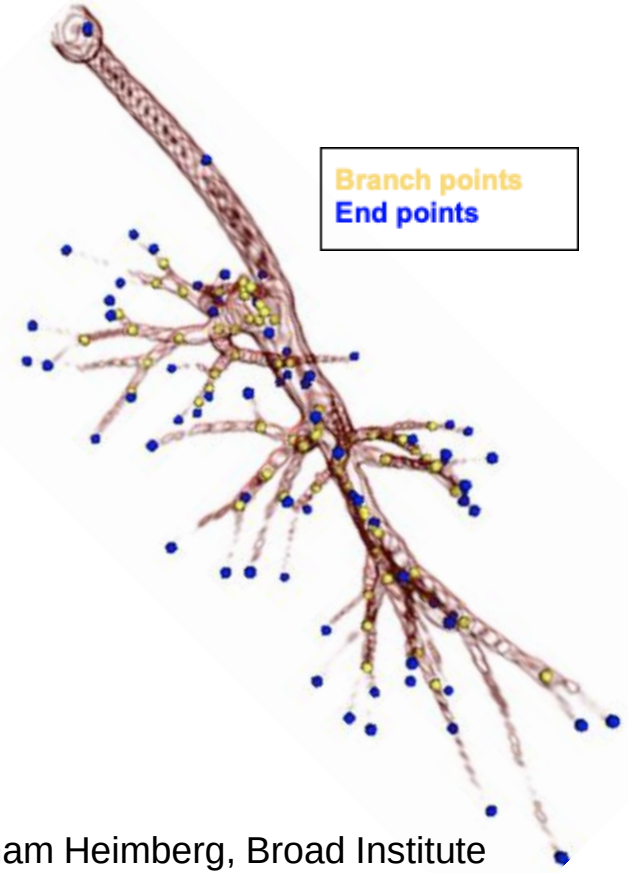
Internal spatial landmarks - Airway skeletonization

Airway cell studies: Airway-based coordinates are more important.

How can we consistently reference airway locations across individuals?

1. Segment airways in CT data
2. Detect branch points and endpoints
3. Align airway trees across individuals

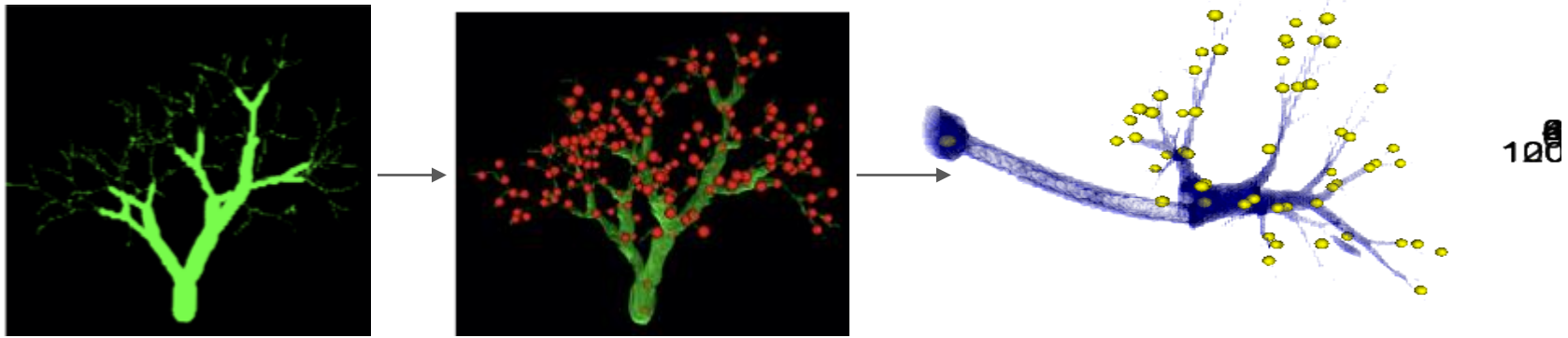
Problem: simple methods for branchpoint detection fail on lung CT data



Tommaso Biancalani & Graham Heimberg, Broad Institute

Internal spatial landmarks - Neural network

- Simulate lung branching
- Train Convolutional Neural Network (3D UNET) to detect branchpoints and endpoints
- Test on simulated data
- Run neural network on real lung data



Tommaso Biancalani & Graham Heimberg, Broad Institute

Poisson distance map

Distance from any given point inside a shape to the edge

- Random walk to edge of image
- Coordinate position represented by distance to the surface

Gorelick et al. IEEE Trans Patterns

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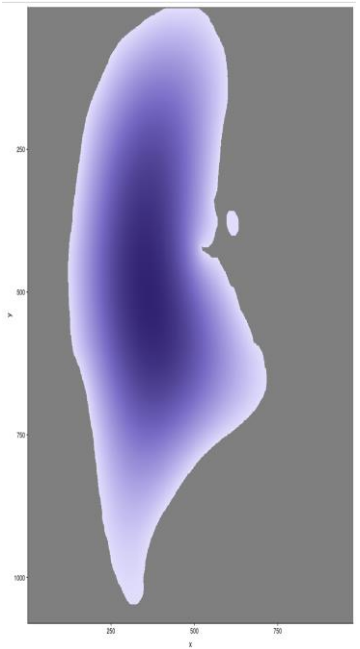
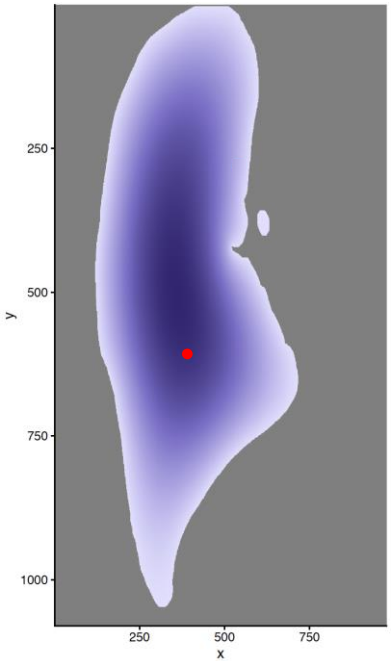


Gorelick et al. IEEE Trans Patterns

Poisson distance maps

Poisson Distance
(Lung 1)



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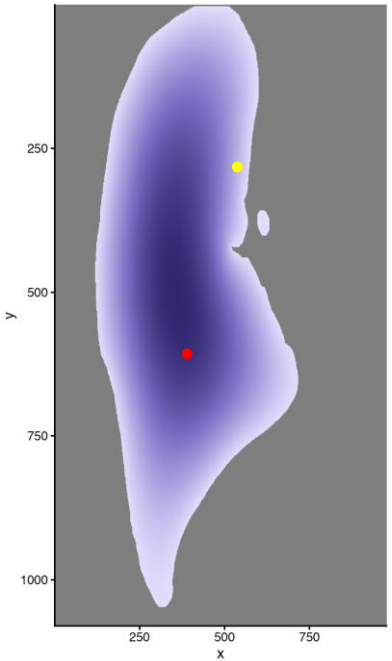
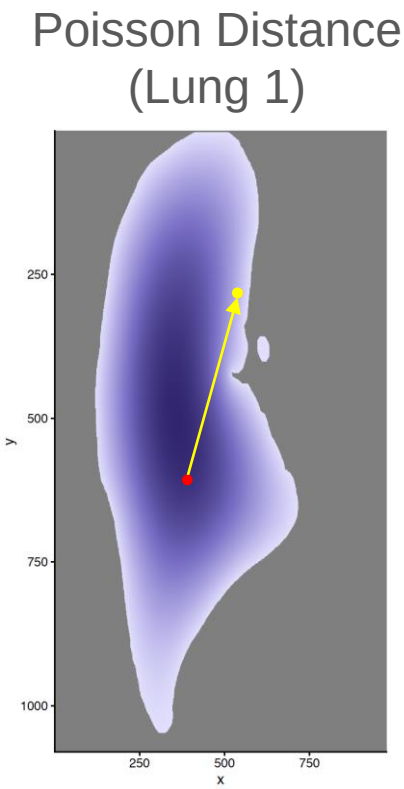
(Lung 1)



Poisson distance maps



Poisson distance maps

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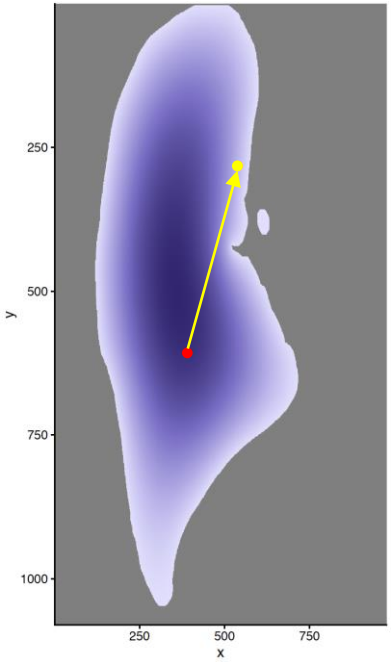
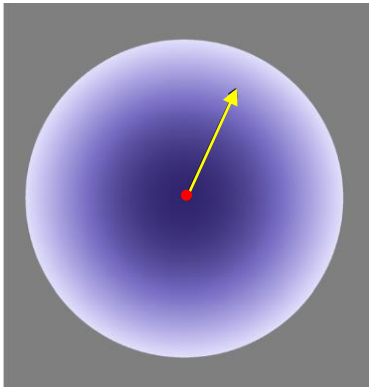
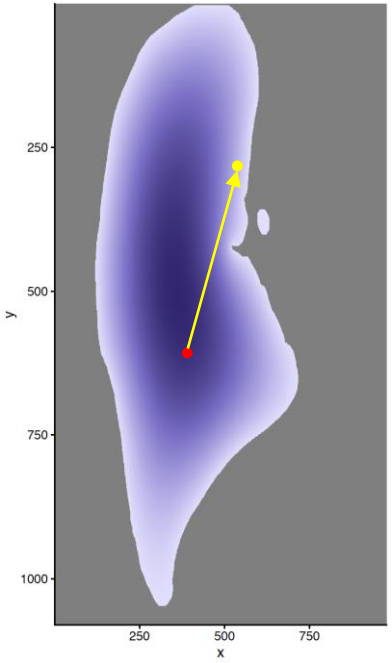


Poisson Distance Conformal Mapping



Poisson distance maps

Poisson Distance (Lung 1)



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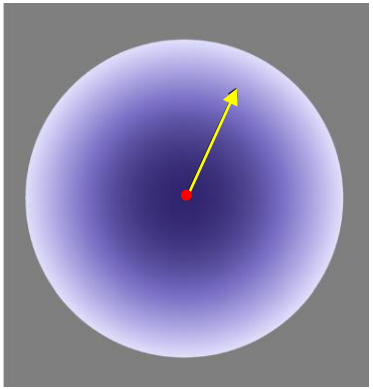
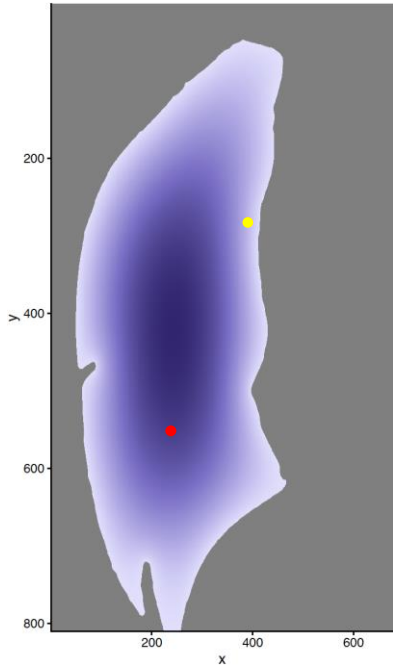
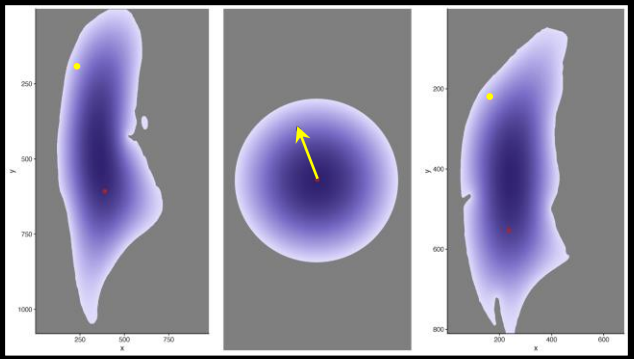
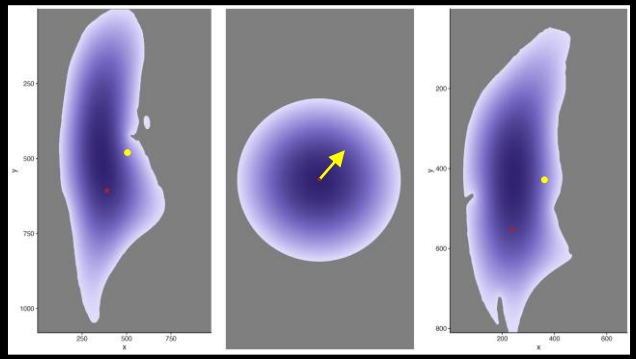
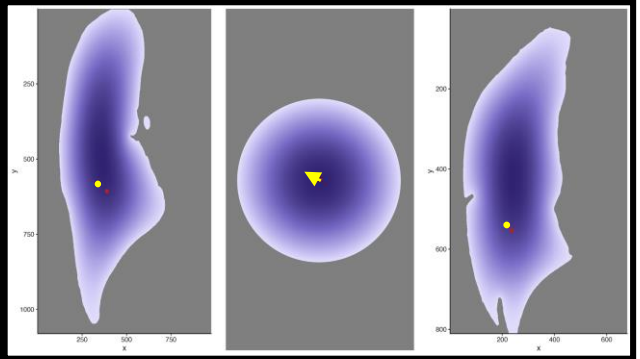
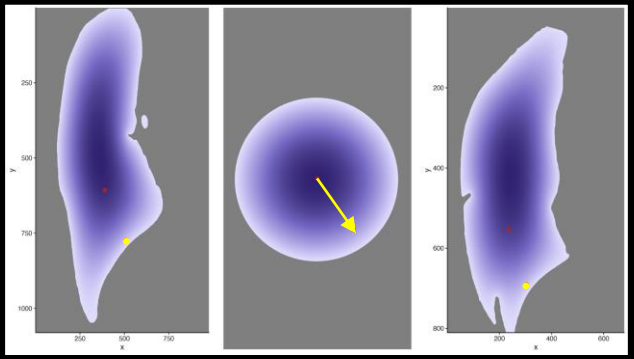
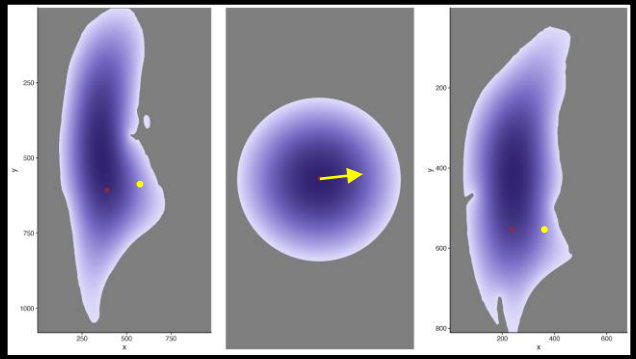
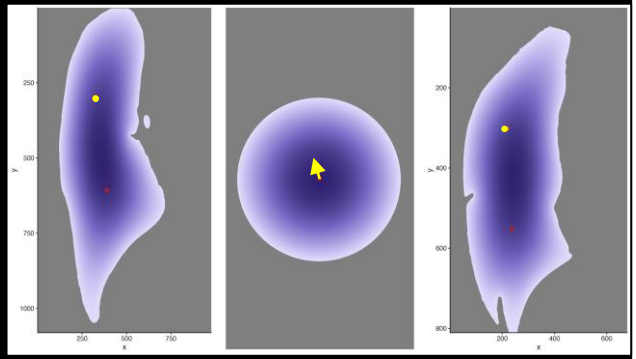


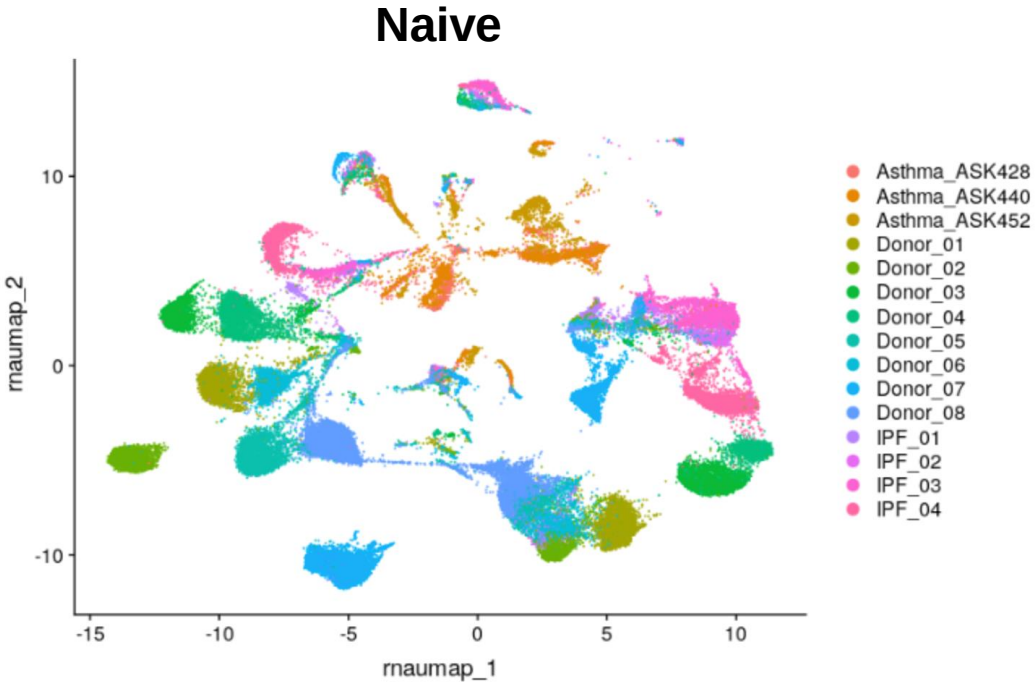
Poisson Distance (Lung 2)



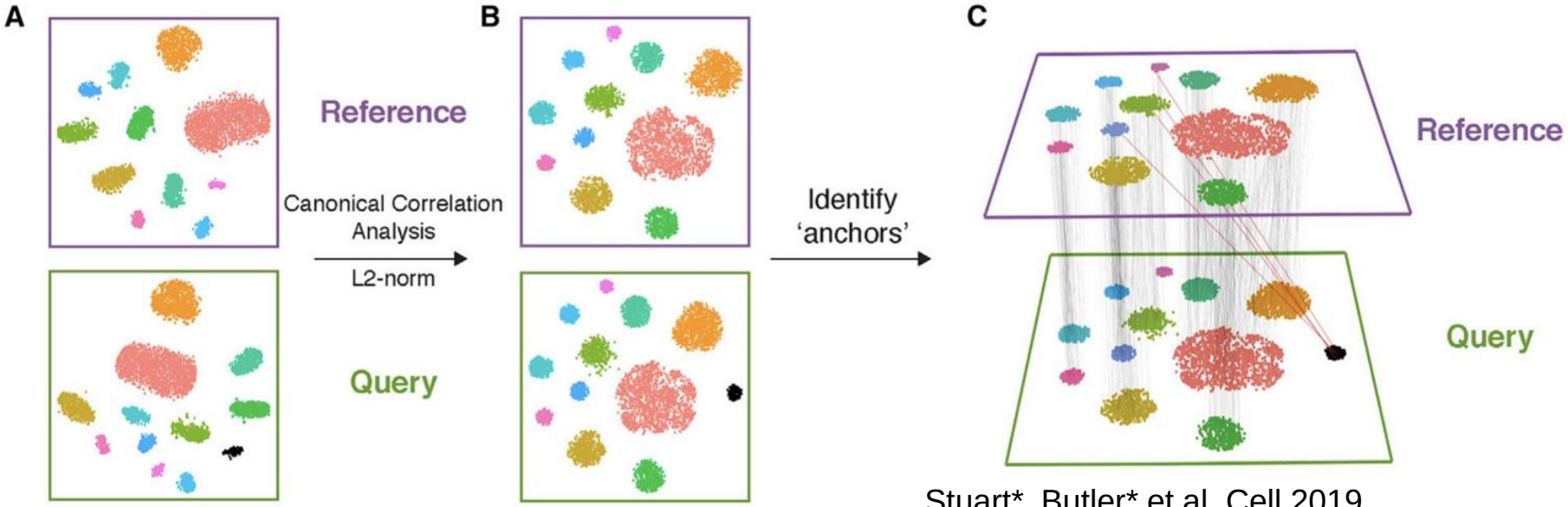
Single-cell molecular data for the human lung

Reyfman et al. 2019; Braga et al. 2019



Integration of single-cell molecular data

- Shared cell types create anchors
- Multiple datasets harmonized together
- Completely unsupervised



Stuart*, Butler* et al. Cell 2019

Single-cell molecular data for the human lung

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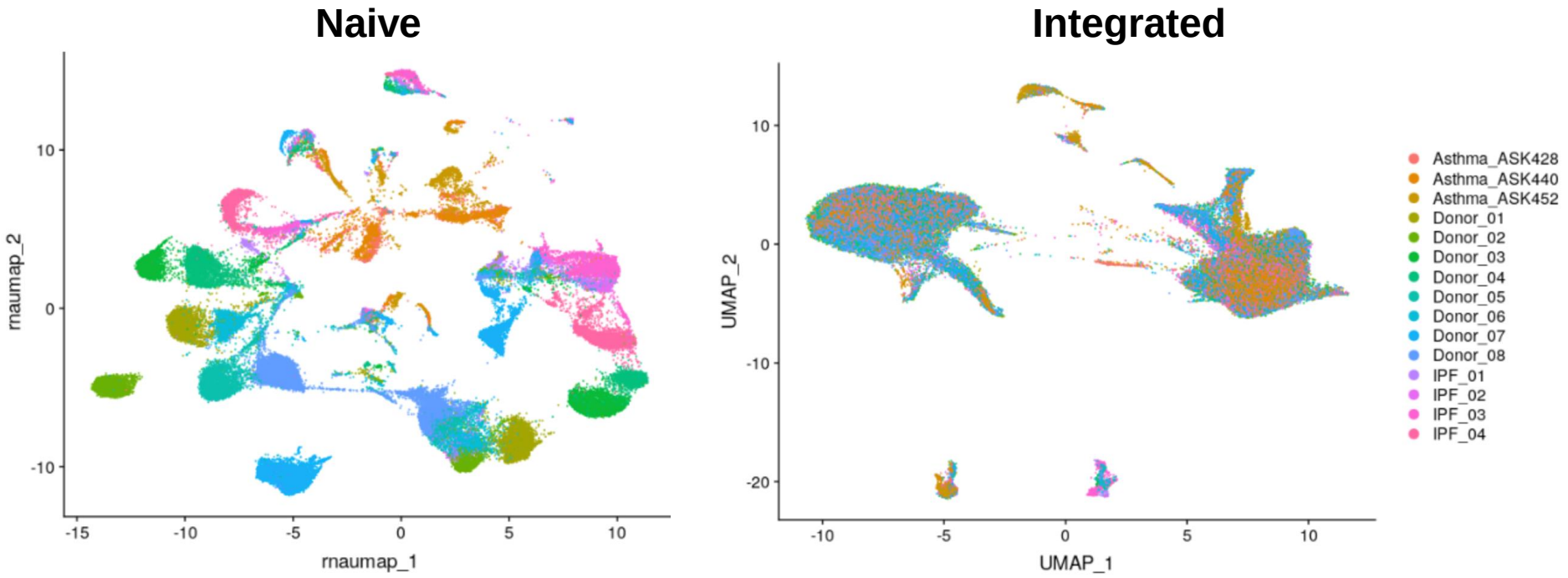
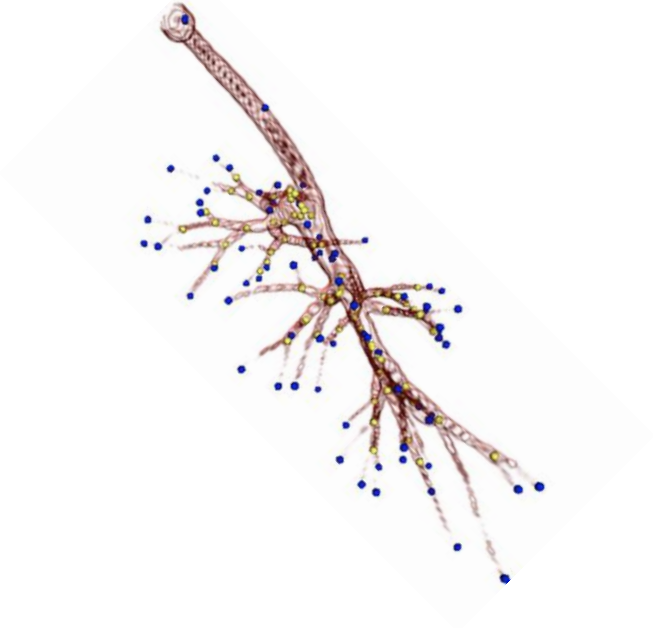
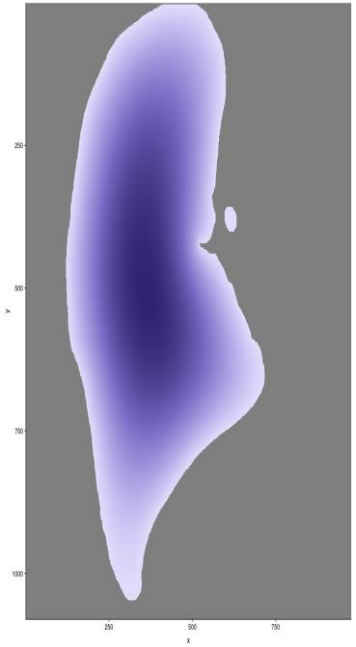


Collaboration with Sanjay Jain, Kun Zhang, Peter Kharchenko

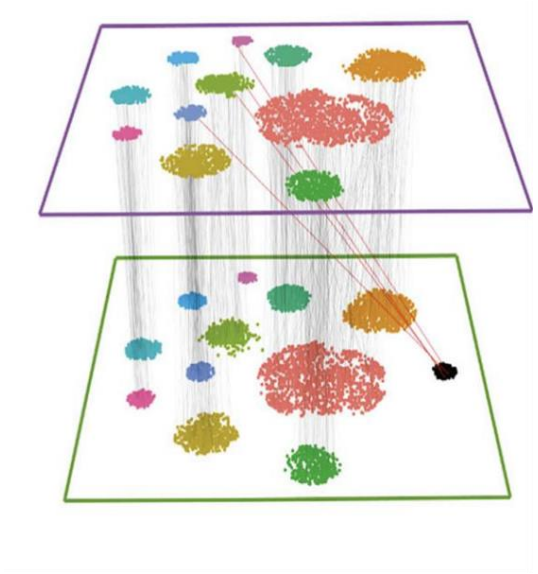
Internal spatial landmarks



Shape-based landmarks



Molecular landmarks



HuBMAP: HIVE Mapping Components (MC)

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  - Andrew Butler
  - Tim Stuart
- **EMBL / EBI**
  - Eyal Fisher
  - Shila Ghazanfar
- **Broad Institute**
  - Tommaso Biancalani
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HuBMAP
The Human BioMolecular Atlas Program

NEW YORK GENOME CENTER

EMBL-EBI

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