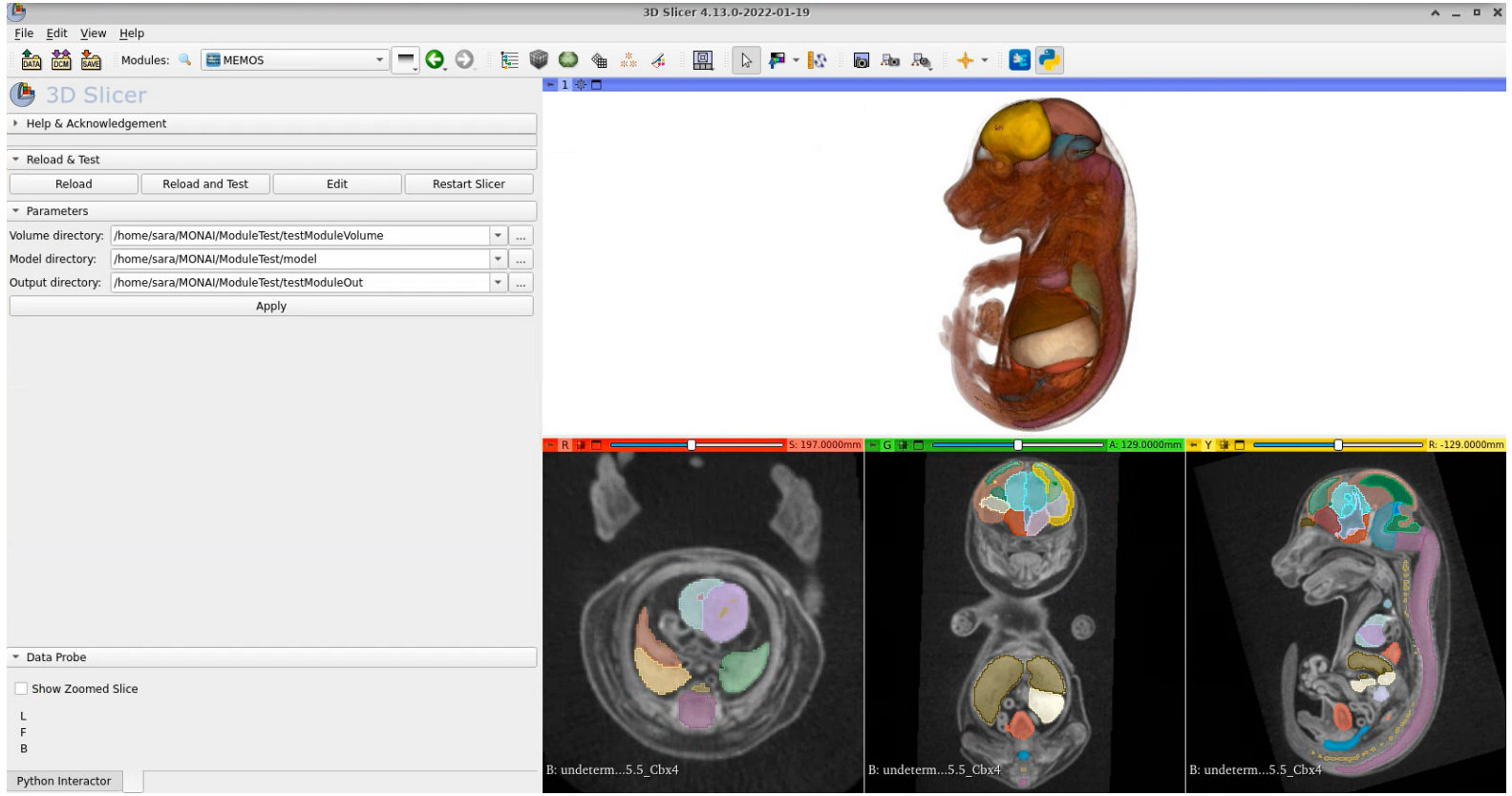
MEMOS: Mouse Multi-Organ Segmentation

Deep-learning enabled segmentation interface

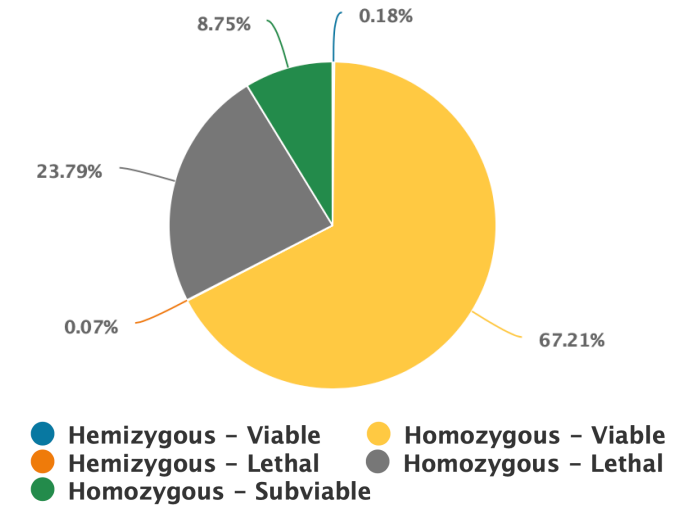
Sara Rolfe



Knockout mouse phenotyping project (KOMP2)

IMPC
International Mouse Phenotyping Consortium

- Generate a mouse null mutant for every protein-coding gene in the mouse genome
- Comprehensively phenotype each mouse mutant to determine developmental, physiological, and biochemical parameters
- Provide an important baseline for exploring gene function



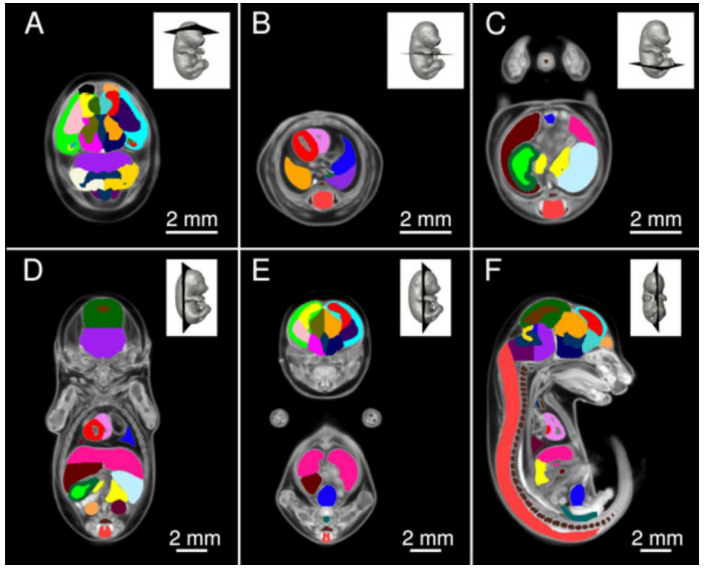
E14.5/15.5

E18

Lloyd, KC Kent. "A knockout mouse resource for the biomedical research community." Annals of the New York Academy of Sciences 1245.1 (2011): 24-26.

KOMP E15.5 Mouse embryo atlas

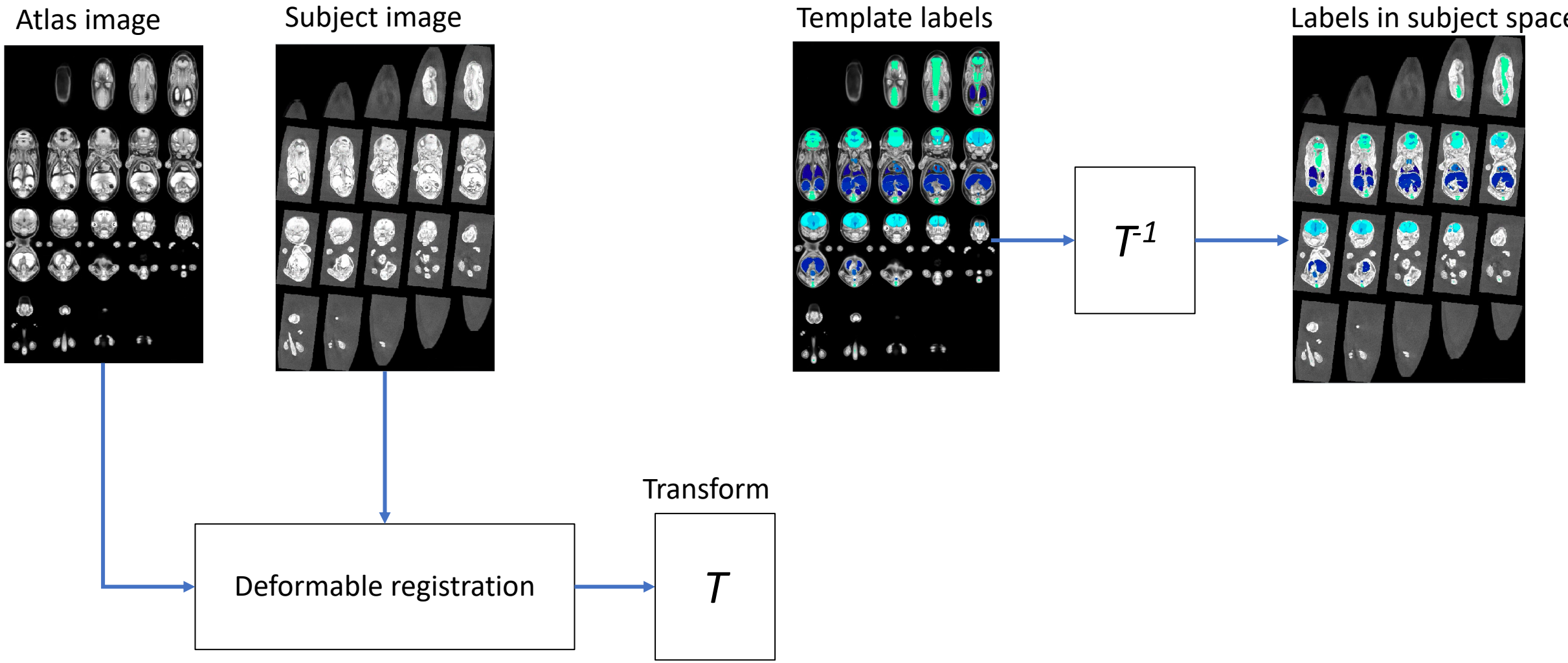
- Representative mouse embryo average 3D atlas
- 35 Micro-CT images of C57Bl/6J mouse embryos at E15.5 registered into a consensus average image
- 50 anatomical structures were segmented manually



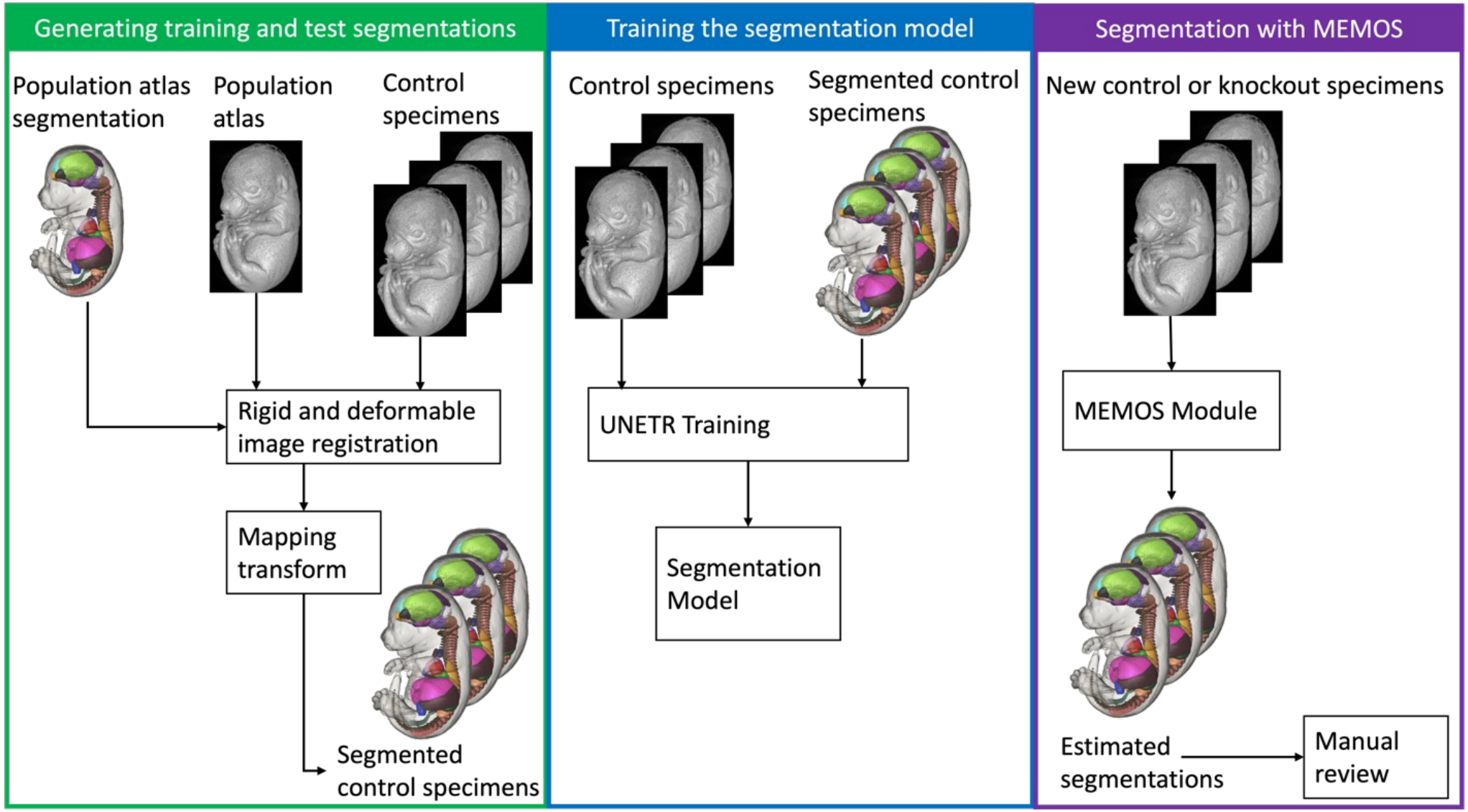
Sections through the mouse embryo atlas

Wong, M. D., Dorr, A. E., Walls, J. R., Lerch, J. P., & Henkelman, R. M. (2012). A novel 3D mouse embryo atlas based on micro-CT. Development, 139, 3248–3256. doi:10.1242/dev.082016

Atlas-based segmentation

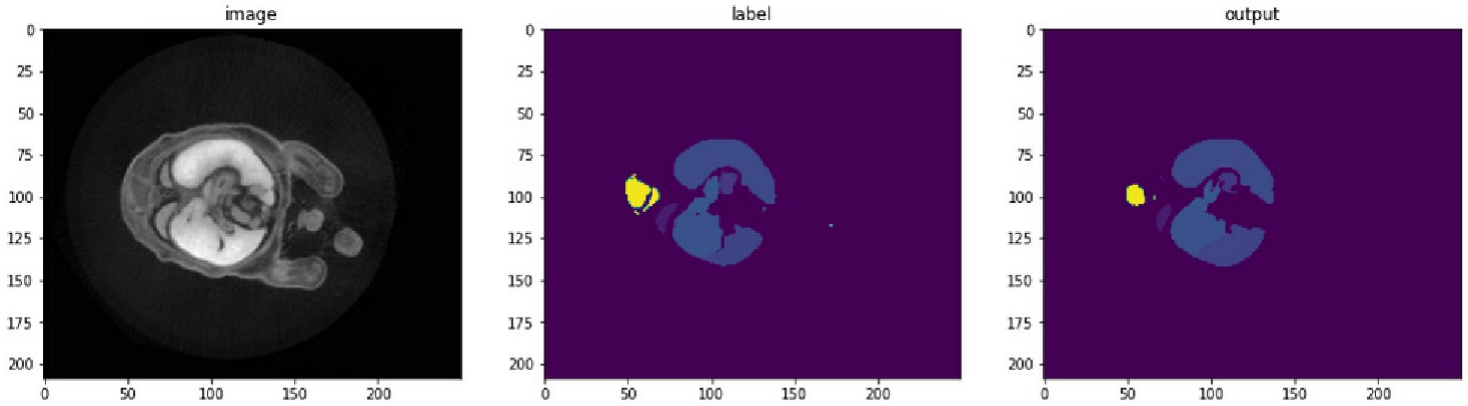


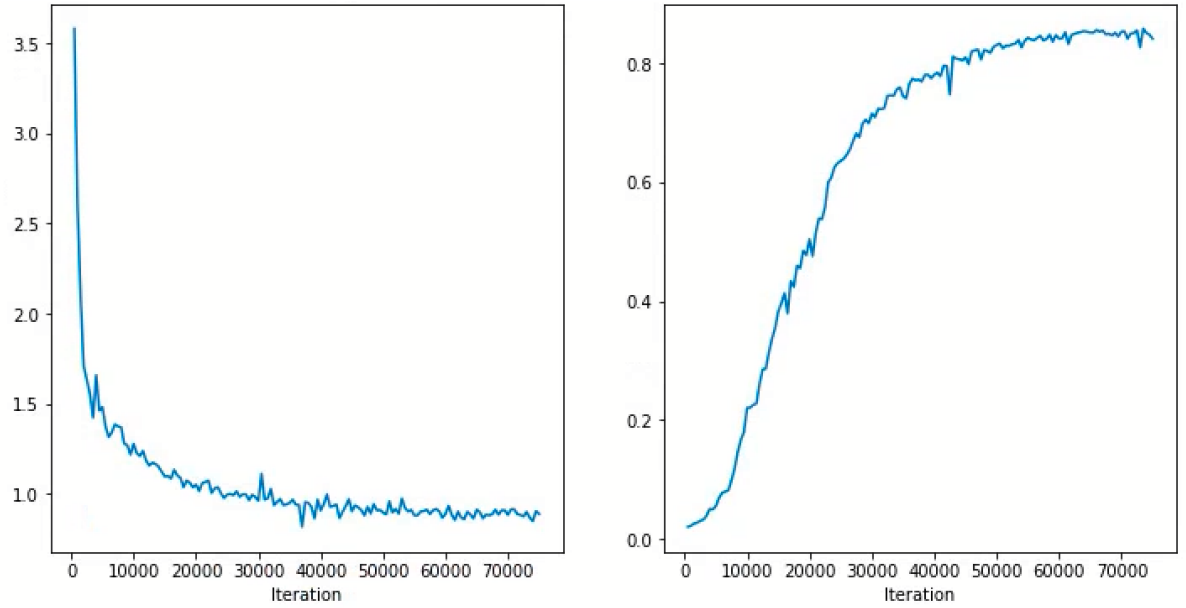
Building a deep learning model for segmentation



Training the UNETR model

- Training: 73
- Validation: 18
- 50 labeled segments
- Best average Dice coefficient score: 0.8585685





Average DICE score for 5 control specimen: 0.8

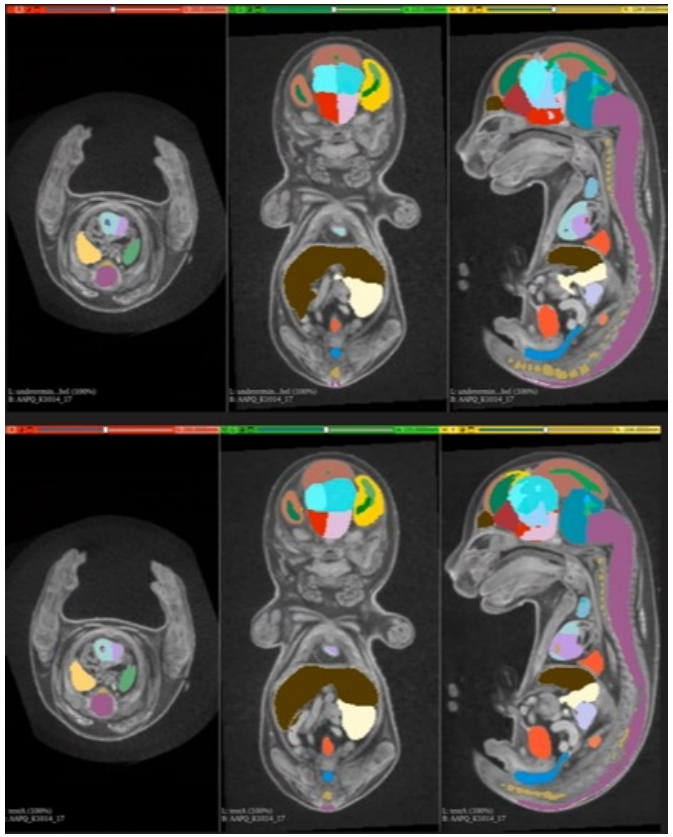
Segments with Dice coefficient >.85

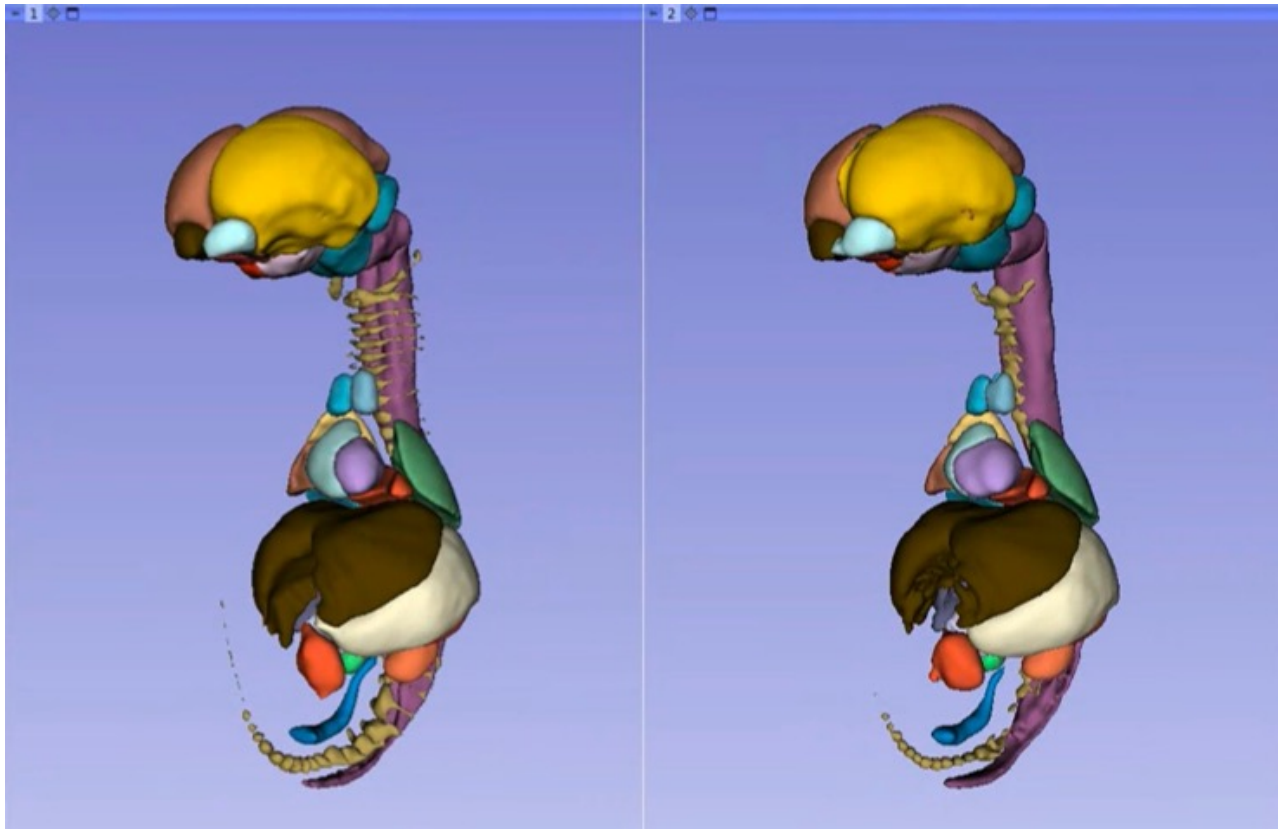
Segment	StDev	Average
left lung	0.01	0.93
left lobe of liver	0.01	0.91
medial lobe of liver	0.01	0.90
pons	0.01	0.90
medulla oblongata	0.02	0.90
caudal lobe	0.01	0.89
right hypothamalus	0.02	0.88
right thalamus	0.02	0.88
left thalamus	0.02	0.88
midbrain	0.02	0.87
stomach lumen	0.02	0.87
left hypothalmus	0.01	0.87
right lobe of liver	0.02	0.86
bladder	0.03	0.86
mesencephalic vesicle	0.02	0.86
cranial lobe	0.02	0.86
right striatum	0.02	0.86
left septal area	0.02	0.85
left striatum	0.03	0.85

Segments with Dice coefficient >.70

Segment	StDev	Average
rectum	0.04	0.69
right adrenal	0.05	0.69
left ventricle chamber	0.06	0.69
left lateral ventricle	0.03	0.66
right lateral ventricle	0.03	0.64
cerebral aqueduct	0.04	0.62
right ventricle chamber	0.23	0.54
vertebrae	0.04	0.50

Comparing to Dense Registration Results



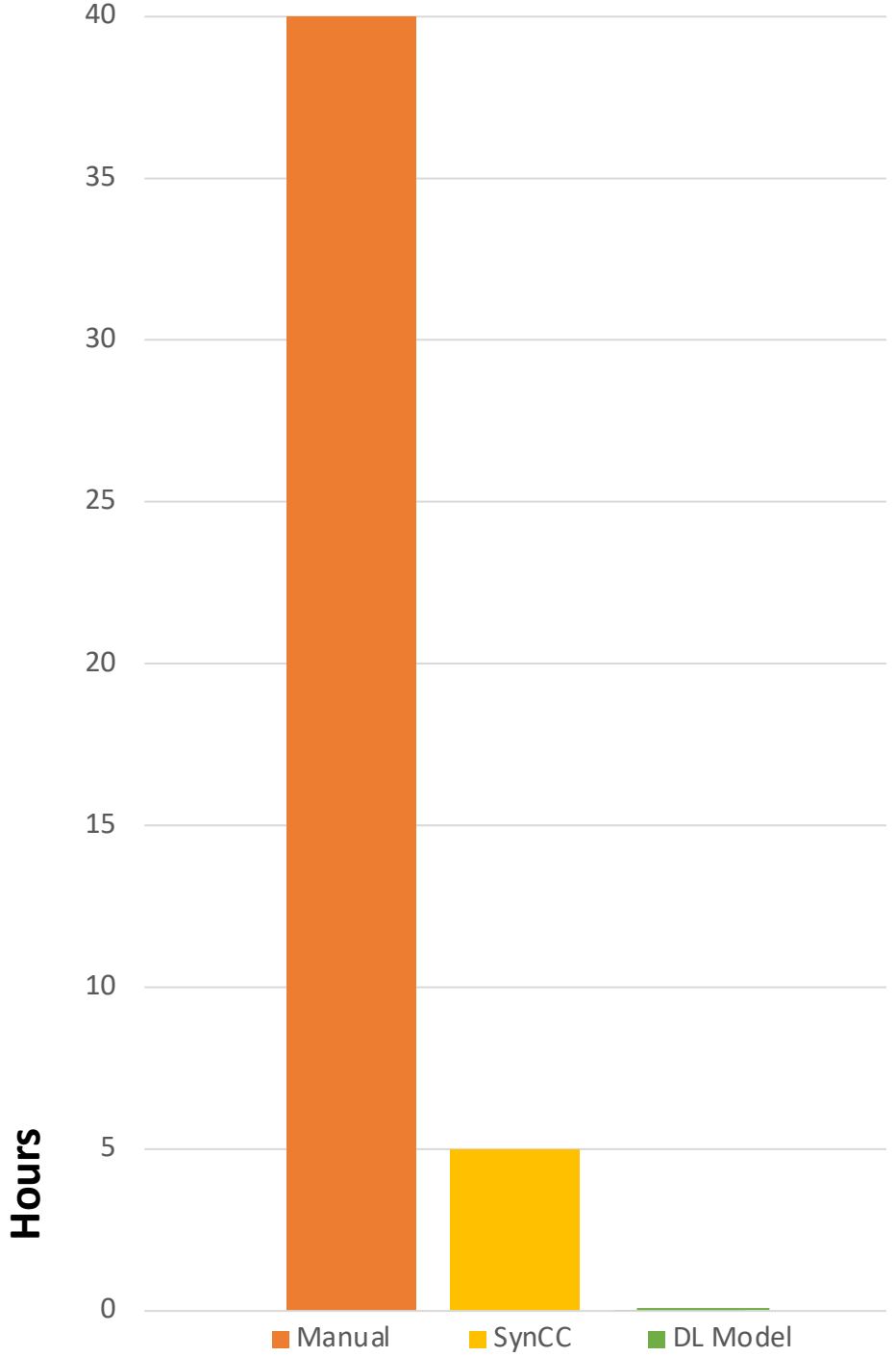


Registration transferred labels

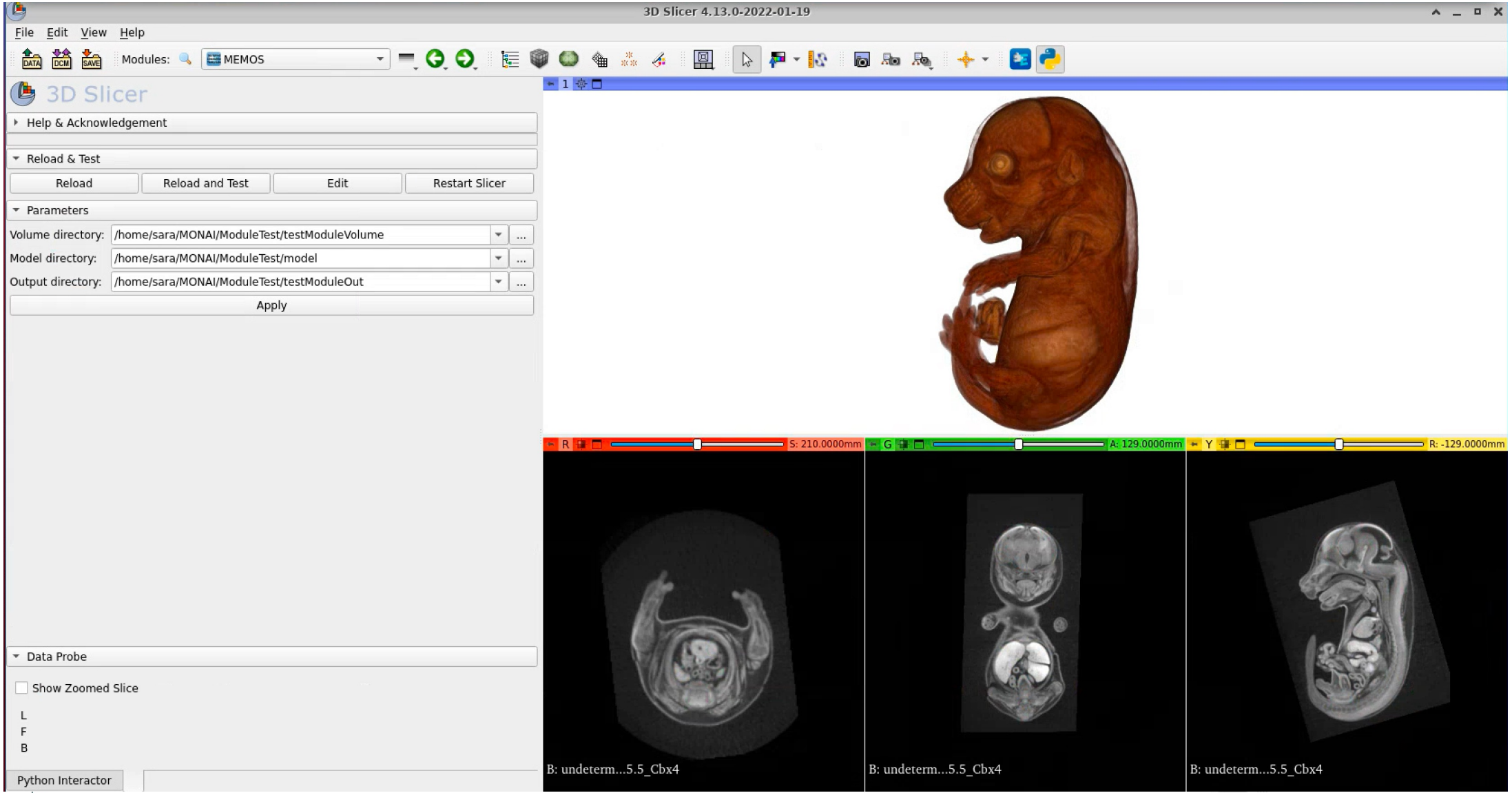
Deep learning estimated labels

Comparison of segmentation methods

- Training step of deep learning approaches is computationally expensive and usually requires labeled data
- After training, labeling of new images is fast
- For 3D labeling of fetal mouse organs
  - Manual: ~40 hours
  - Dense Registration (SynCC): ~6 hours
  - Deep Learning model: ~1-2 minutes



Automated Mouse Segmentation Demo



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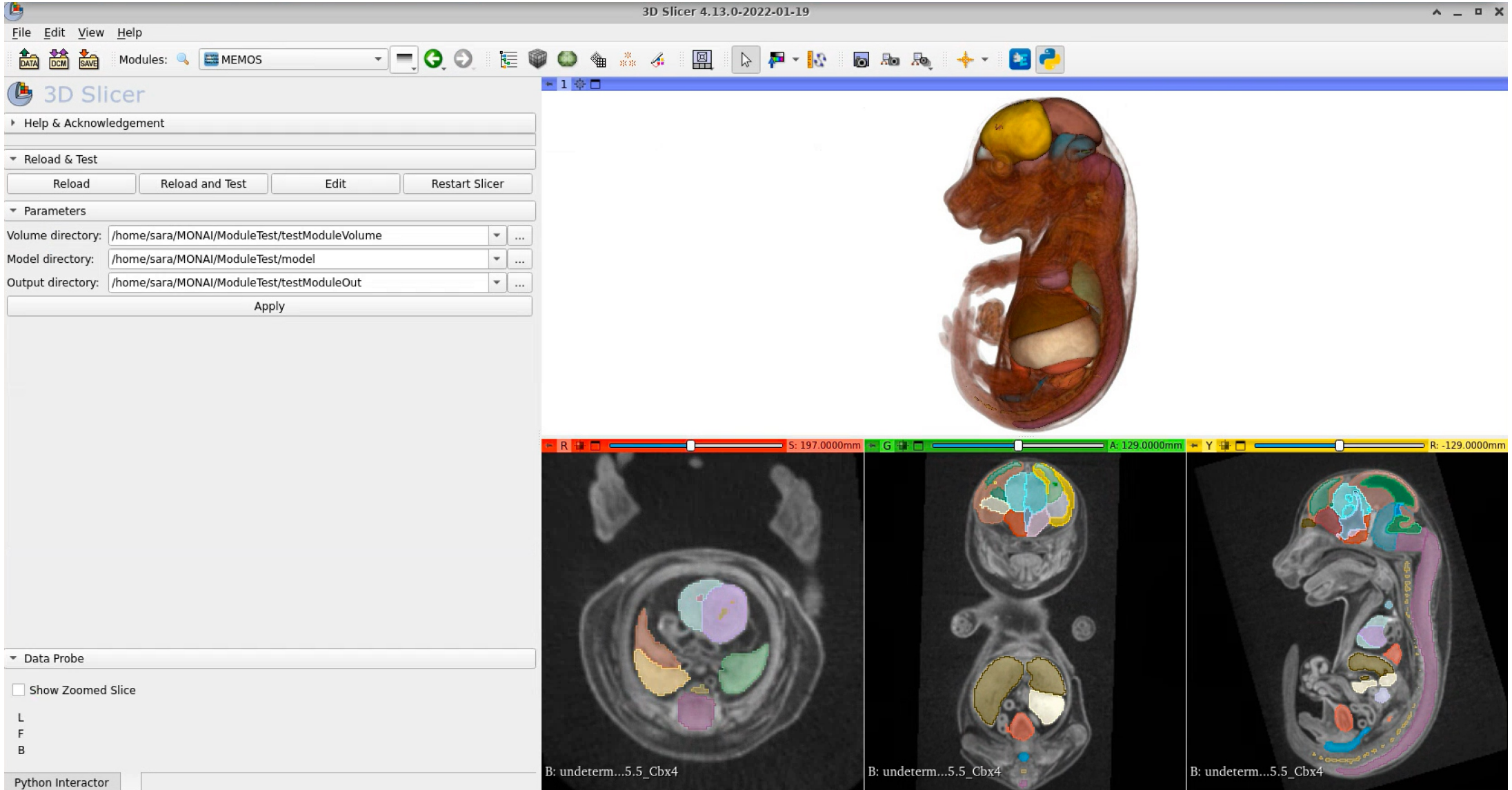
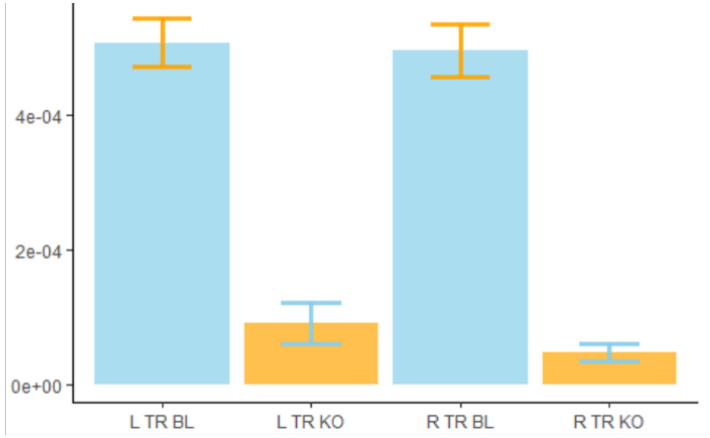
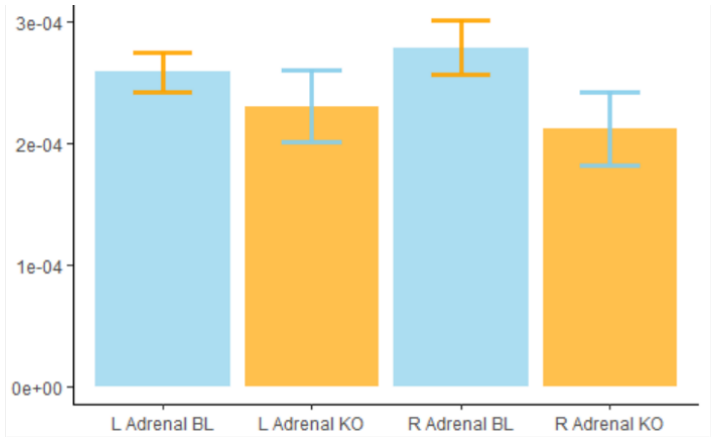


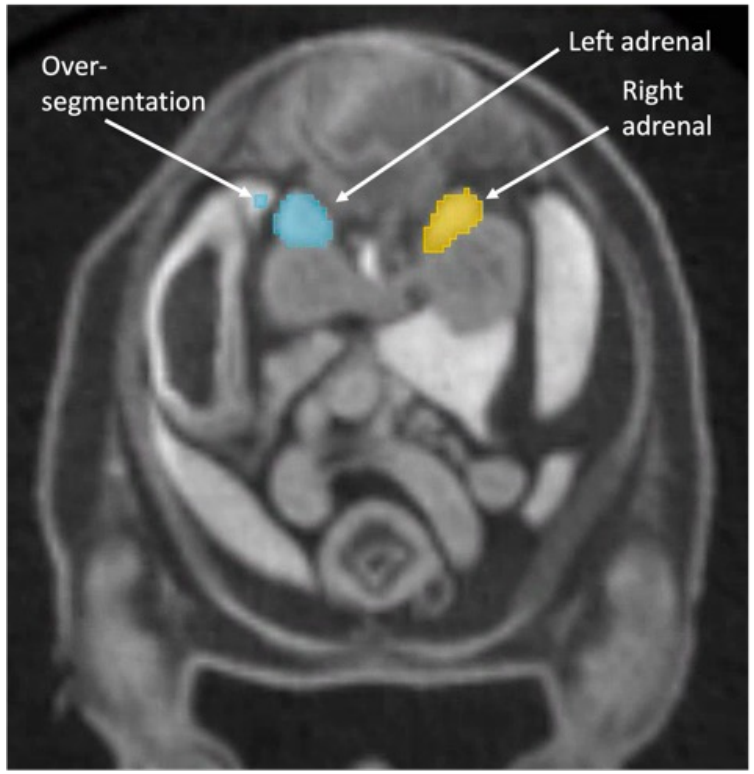
Application to KOMP2 Knockout lines



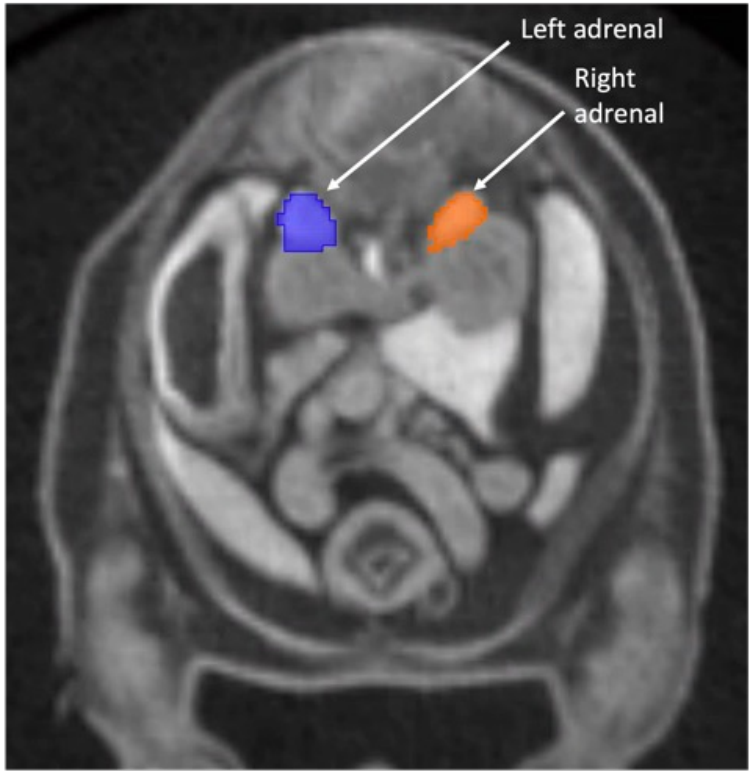
Volume differential for left and right thymic rudiment



Volume differential for left and right adrenals



MEMOS segmentation



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