

# Deep Learning based 3D Volume Segmentation for Few View X-ray Computed Tomography

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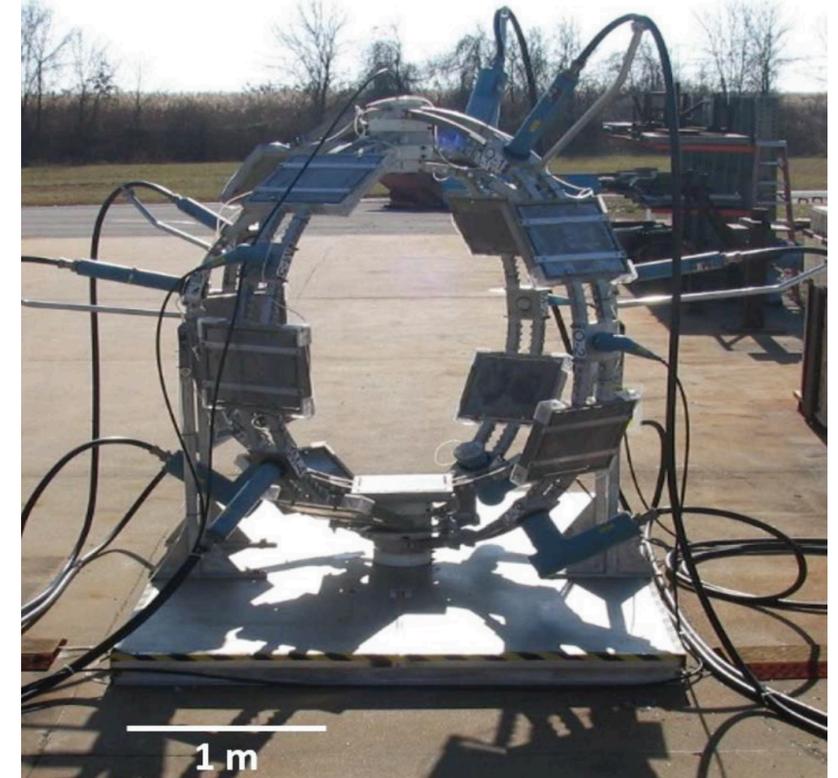
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# PROBLEM: 3D volume from very few 2D images

- Only a few projection images, in the order of 5-20, are available for 3D reconstruction and segmentation in few view X-ray computed tomography (CT)
- Applications:
  - Flash X-ray CT, where images are acquired simultaneously by multiple pairs of X-ray sources and detectors
  - Limited dose CT, where X-ray dosage delivered to object must be limited
  - Dynamic CT, where object composition or density change quickly over time

A flash X-ray system

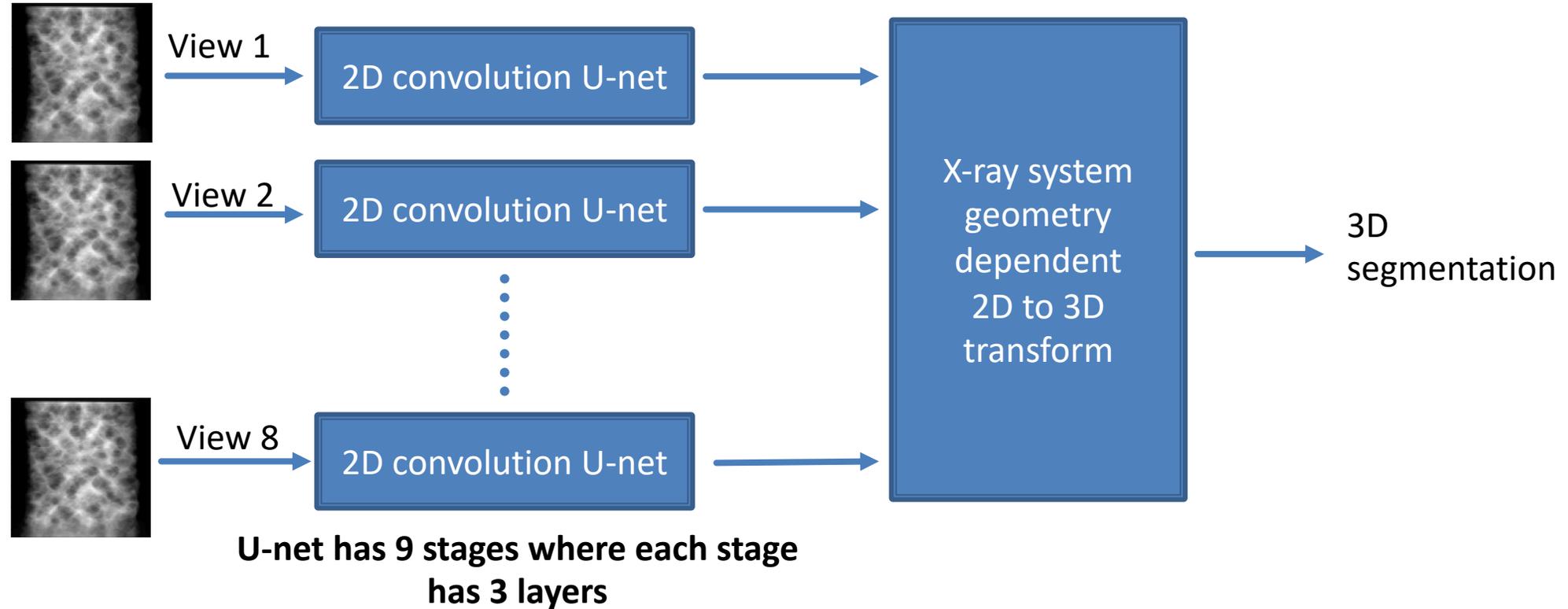


*M. B. Zellner et al., "Development of a multi-energy flash computed tomography diagnostic for three dimensional imaging of ballistic experiments", in AIP Conference Proceedings, vol. 1979, no. 1, p. 160032, 2018*

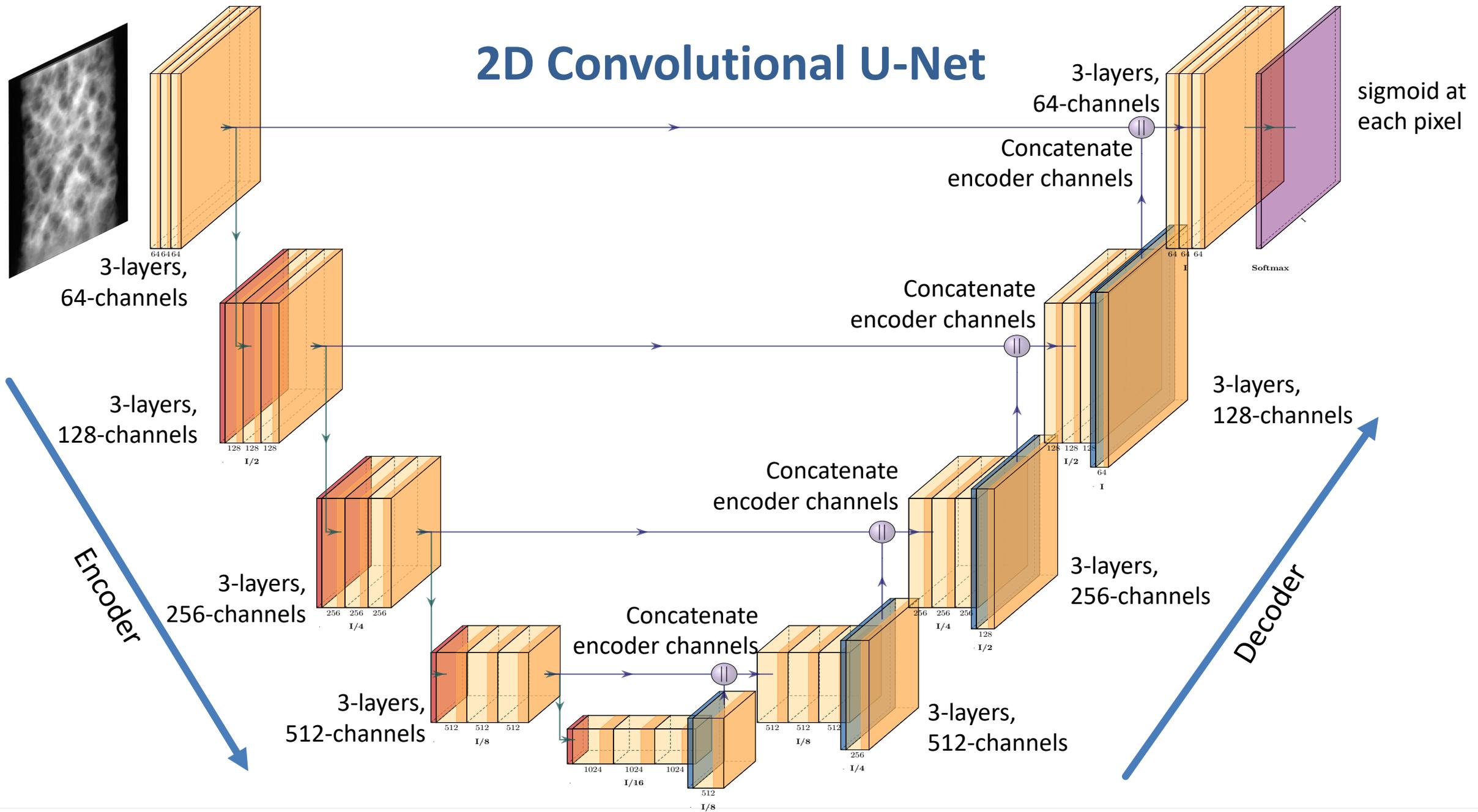
# SOLUTIONS: State-of-the-art and our approach

- State-of-the-art approach to reconstruction is to use filtered back projection (FBP) or other regularized iterative algorithms
  - Result in substantial artifacts in case of few-view CT
- Our solution is a new neural network architecture for 3D segmentation from few view 2D projection images
  - Applicable to any X-ray system geometry
  - Currently, capable of 128x128x128 segmentation with scope for further increase
  - Memory efficient and can be trained on single GPU
  - Small changes in system configuration will not need re-training

# Neural Network Architecture

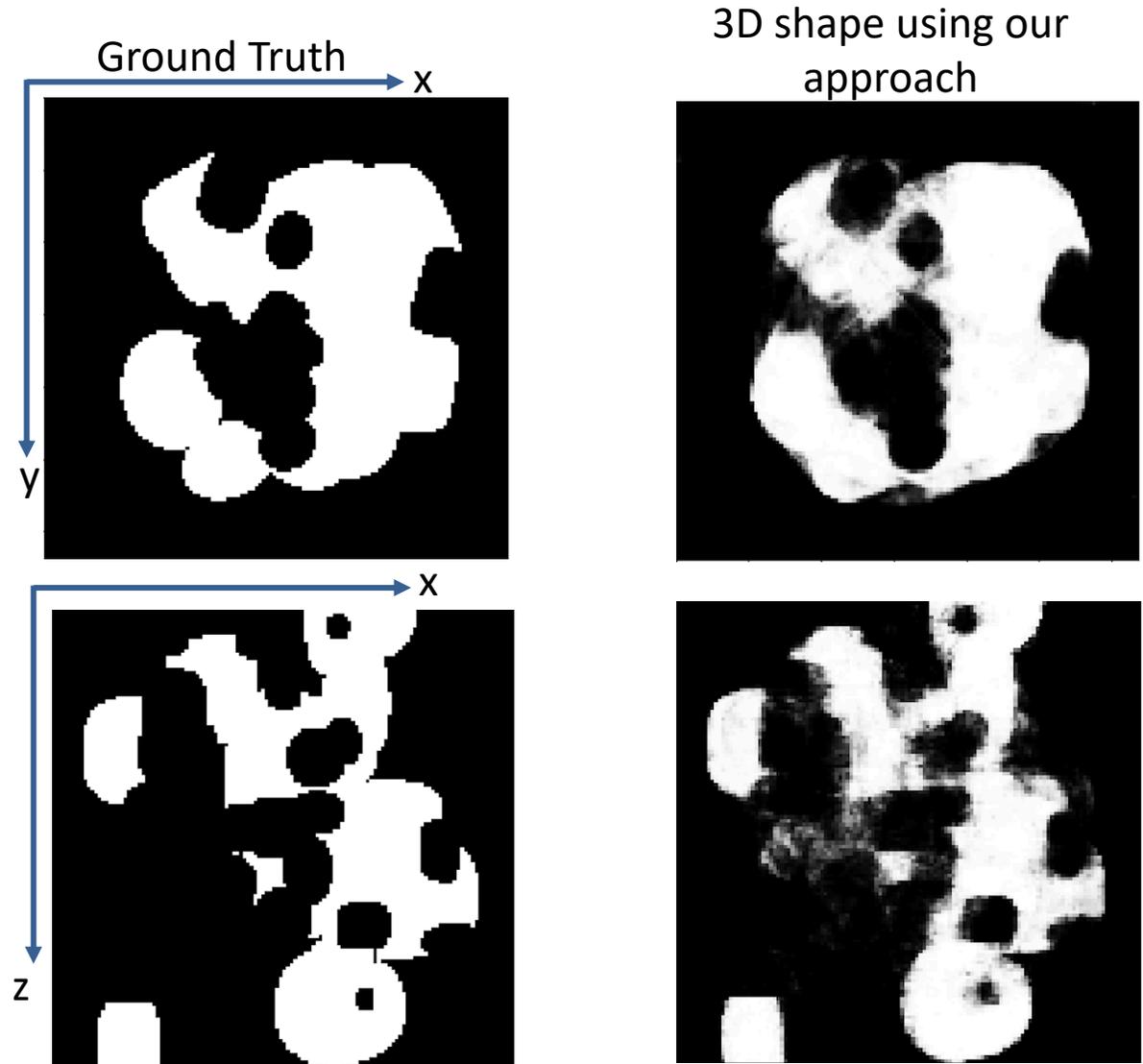


# 2D Convolutional U-Net



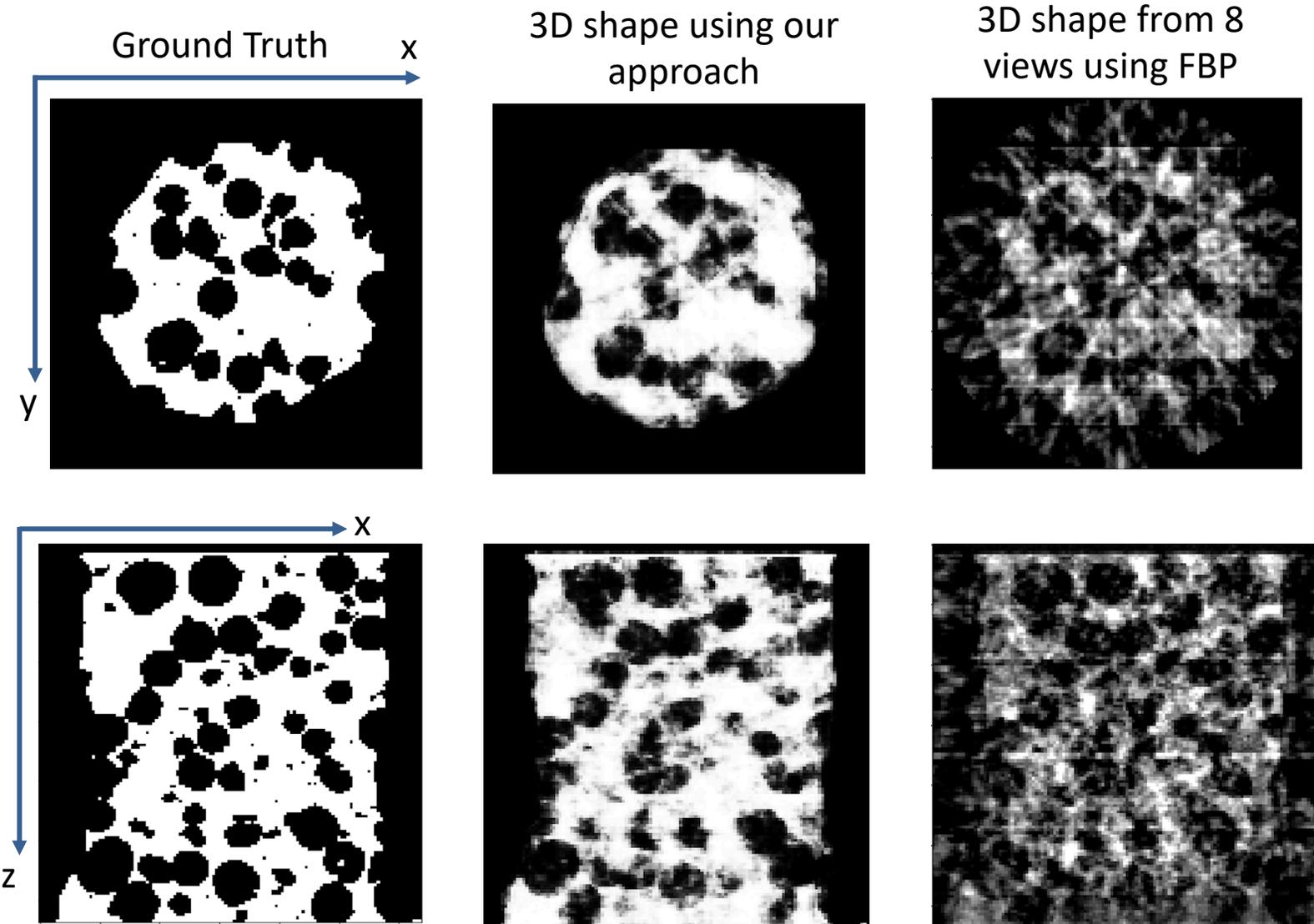
# Parallel Beam X-ray CT: Training with 8-View Simulated Data

- Training for 3D 128x128x128 segmentation using simulated data that is made to look like a foam
- Trained for 100 epochs with batch size 4 using 10000 simulated samples on a Nvidia Quadro P6000 GPU
- Simulated data generated by mixing together ellipsoids and rounded edge cuboids
- Projection data at 8-views was generated using Livermore Tomography Tools (LTT)



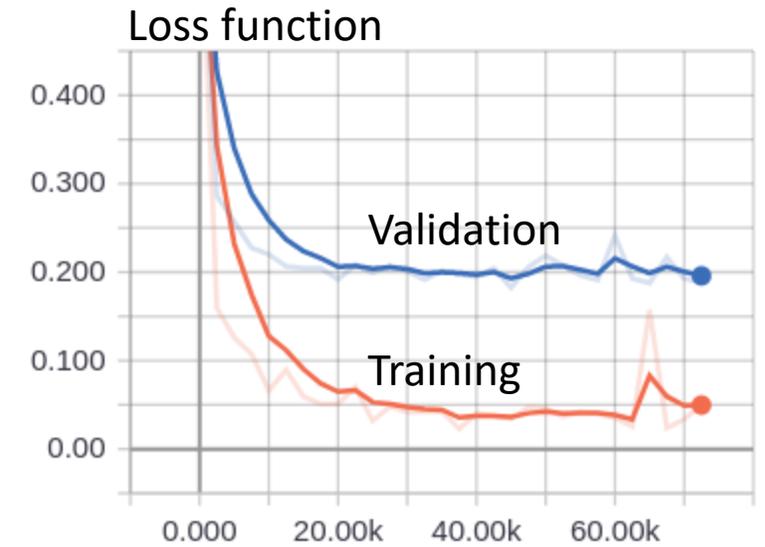
# Parallel Beam X-ray CT: Validation with 8-View Real Data

- Validation using real foam data
- 3D 128x128x128 segmentation from just 8-views
- FBP (standard approach) results in severe streak artifacts

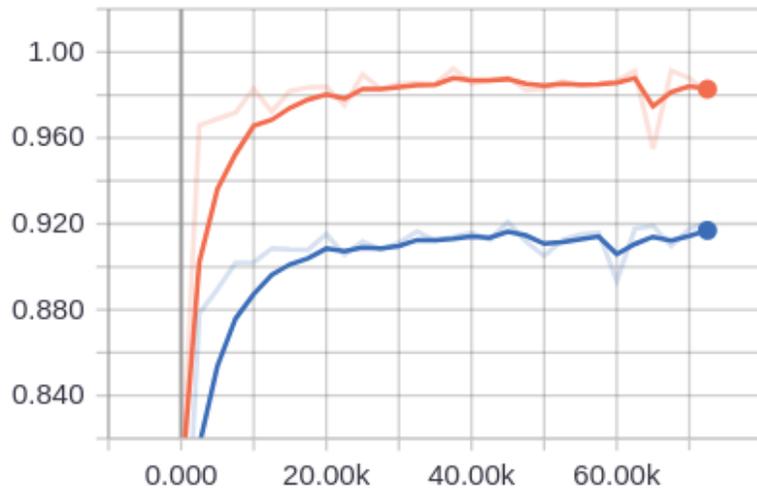


# Overfit to Training Data

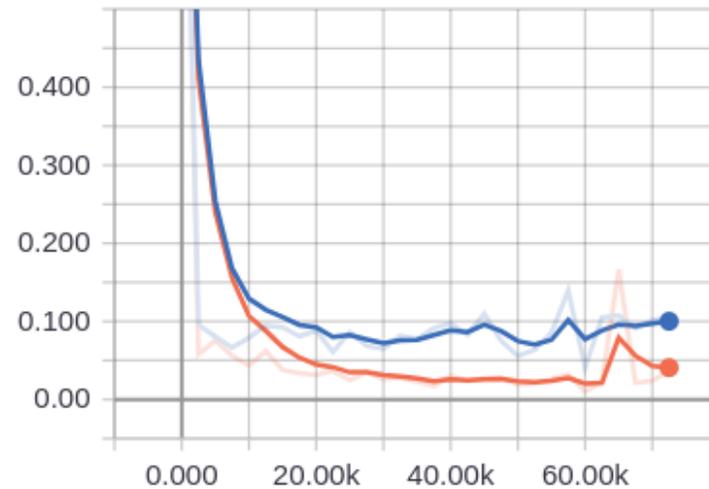
- The gap between training and validation curves proves overfitting to simulated training data
- There is also underfitting since there is scope for further reduction in training loss



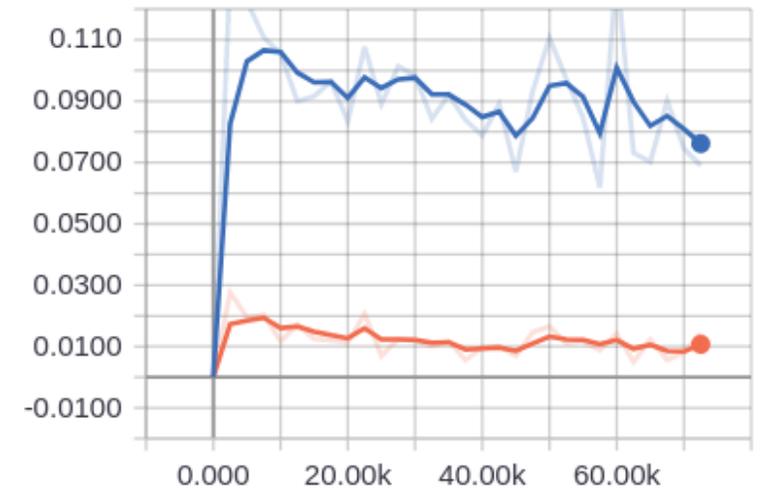
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tag: metrics/accuracy



false\_negative\_rate  
tag: metrics/false\_negative\_rate

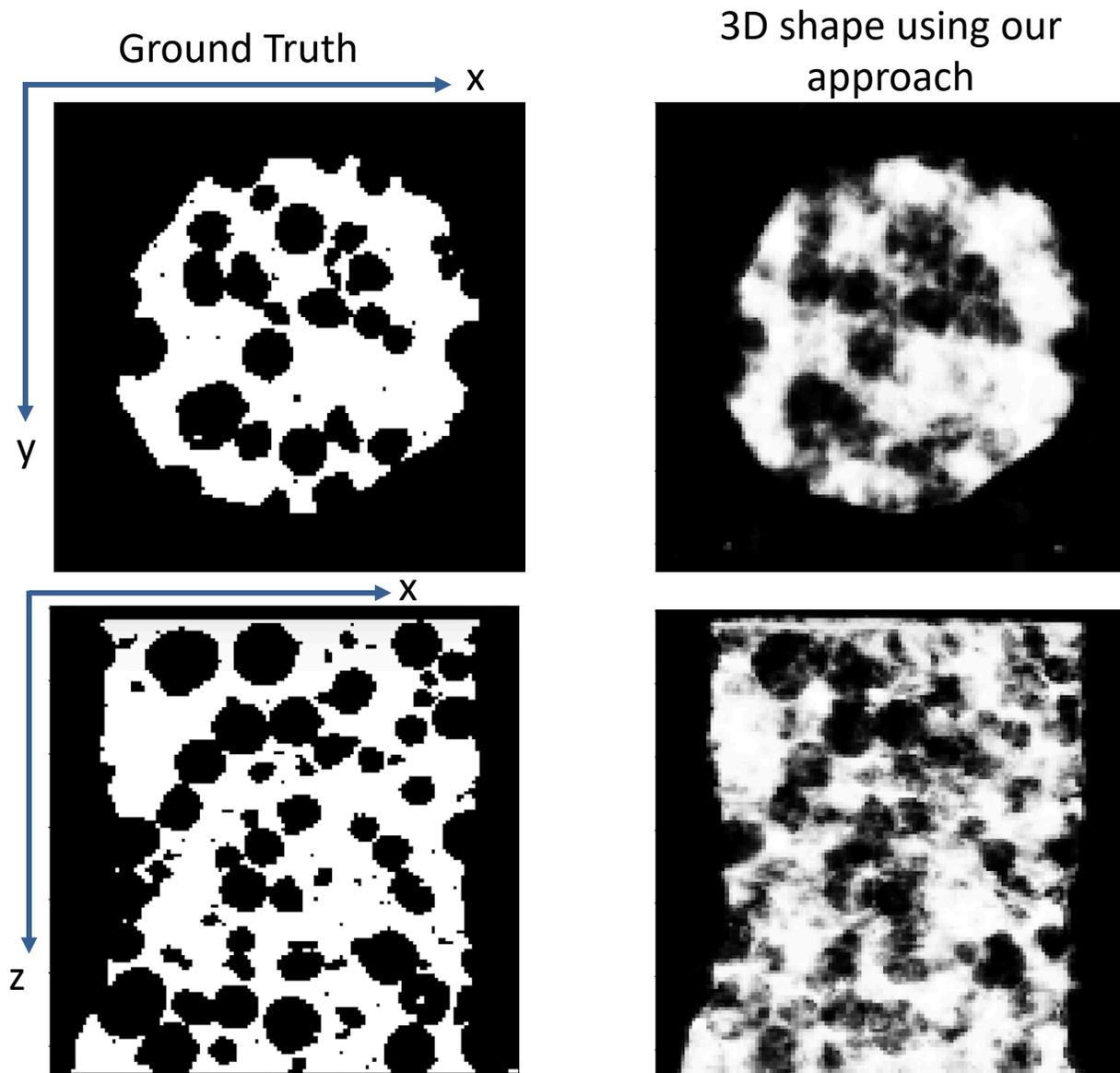


false\_positive\_rate  
tag: metrics/false\_positive\_rate



# Cone Beam X-ray CT: Testing with 8-View Real Data

- Testing using real cone beam foam data
- 3D 128x128x128 segmentation from just 8-views
- Trained for 100 epochs with batch size 6 using 10000 simulated samples on a Nvidia Quadro P6000 GPU
- Next Steps:
  - Irregular geometry
  - Extend to 256x256x256



# Thank you!

# Questions?



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