

## Breakout Session 2: Track B

# Inline Image Reconstruction of Dynamic 3D Data Using a GPU-enabled Cloud Implementation

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# Inline image reconstruction of dynamic 3D data using a GPU-enabled cloud implementation

Adrienne Campbell-Washburn, PhD

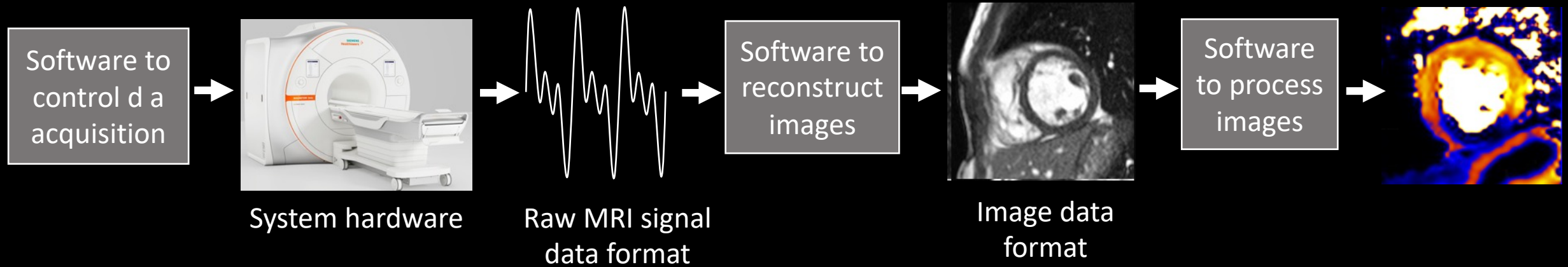
Ahsan Javed, PhD

Rajiv Ramasawmy, PhD

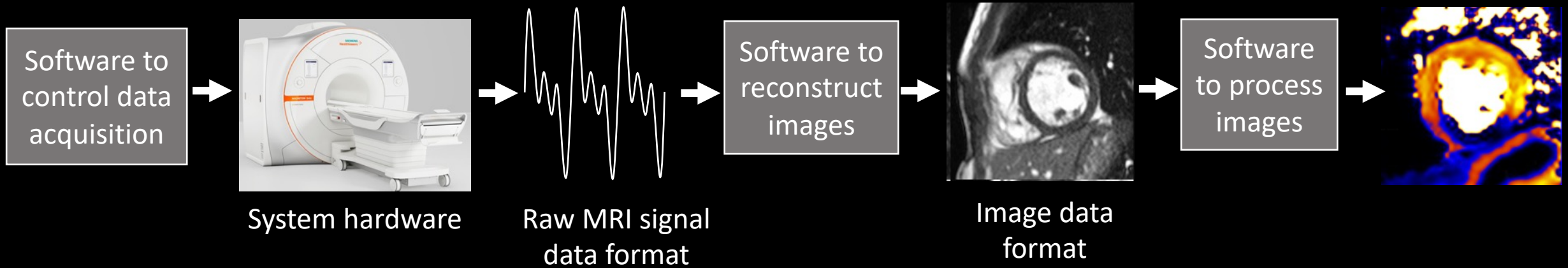
NHLBI/NIH DIR

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# Engineering behind an MRI system

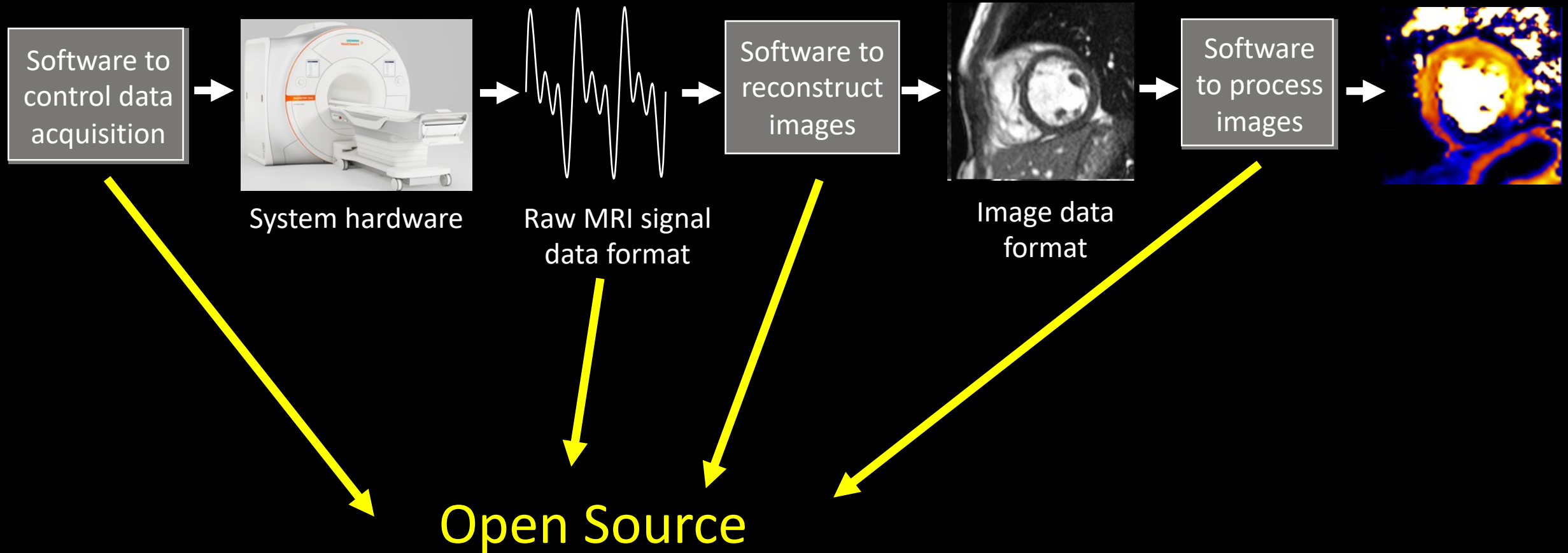


# Engineering behind an MRI system



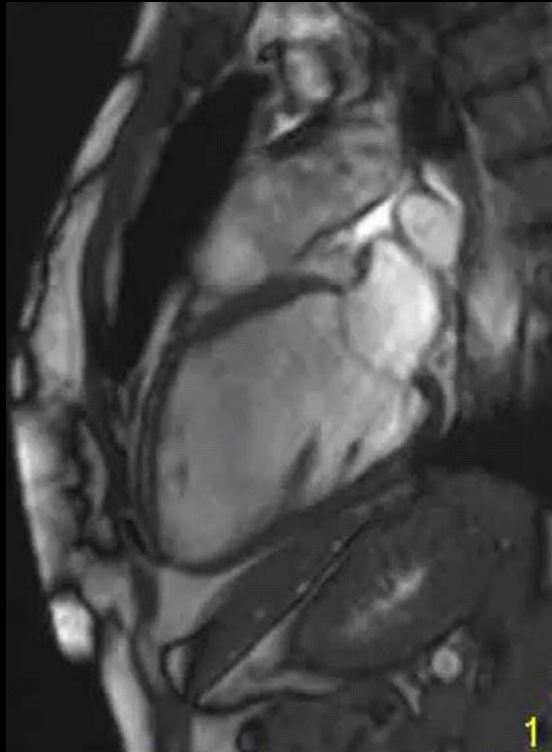
**Vendor Proprietary**

# Engineering behind an MRI system



# For example

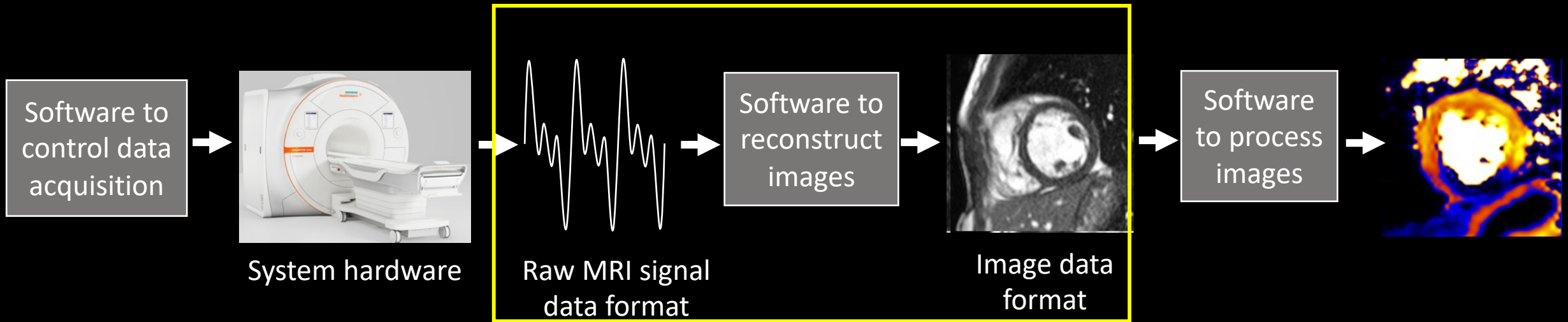
Vendor software



Custom software



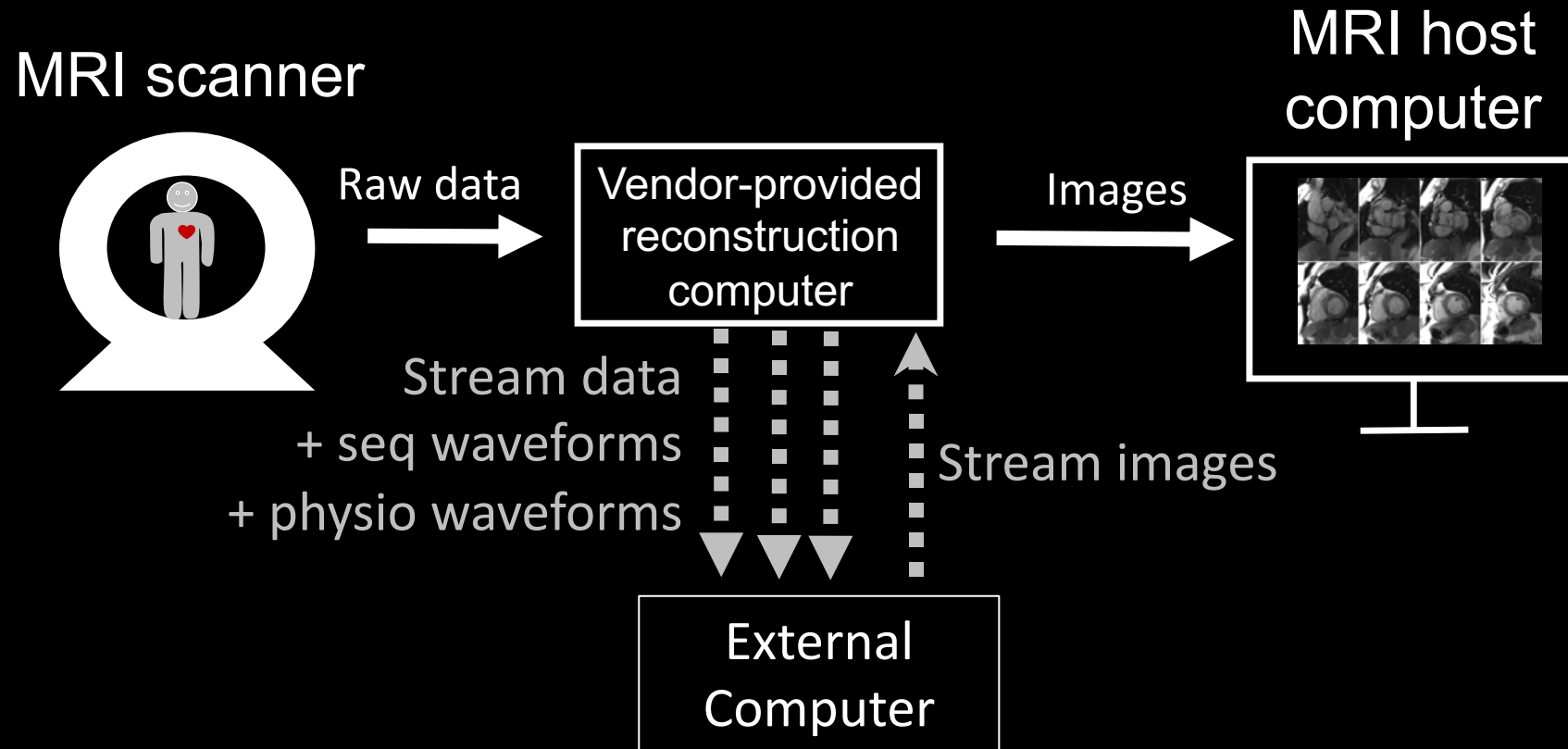
# Engineering behind an MRI system



## Why use custom software?

- Development of advanced reconstruction algorithm
- Increase computational power
- Data interpretation with knowledge of exact algorithm details
- To be vendor agnostic and share algorithms

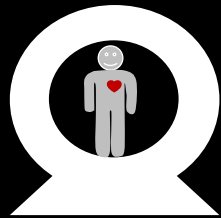
# Gadgetron: open-source inline advanced recon





# Gadgetron in the Cloud

MRI scanner



Raw data

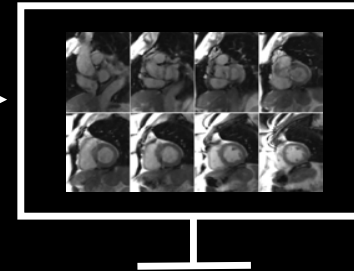


Vendor-provided  
reconstruction  
computer

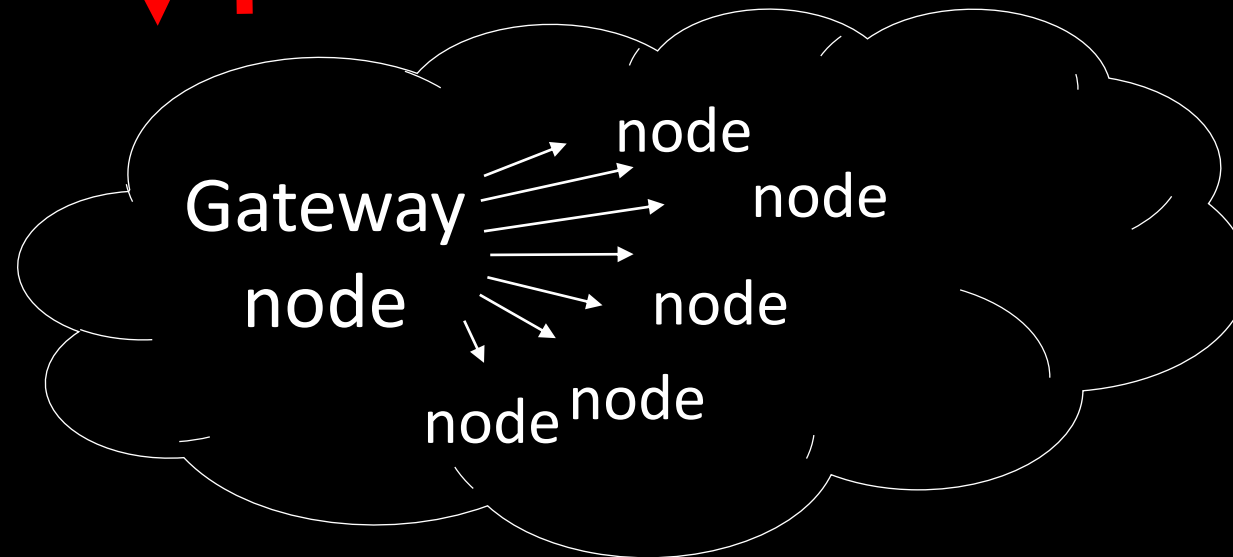
Images



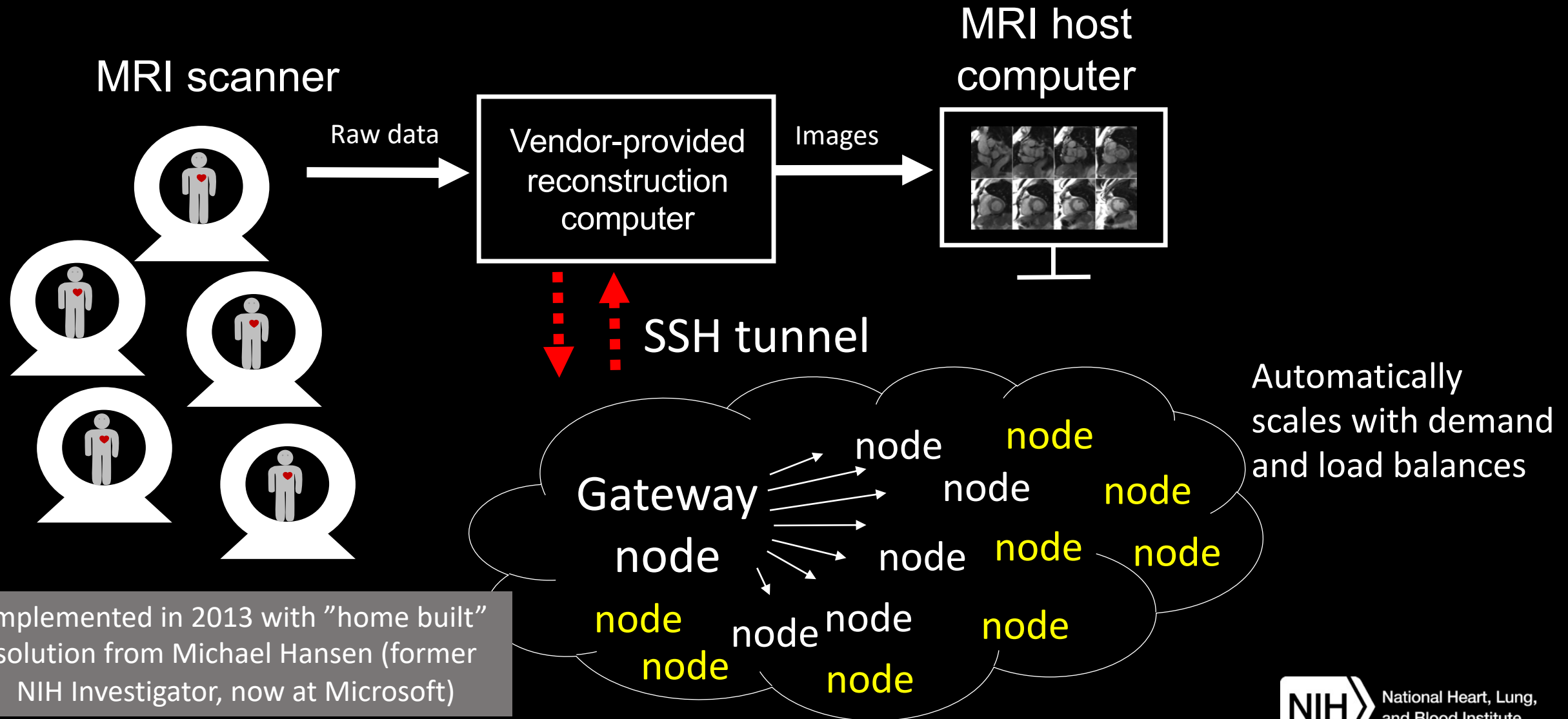
MRI host  
computer



SSH tunnel

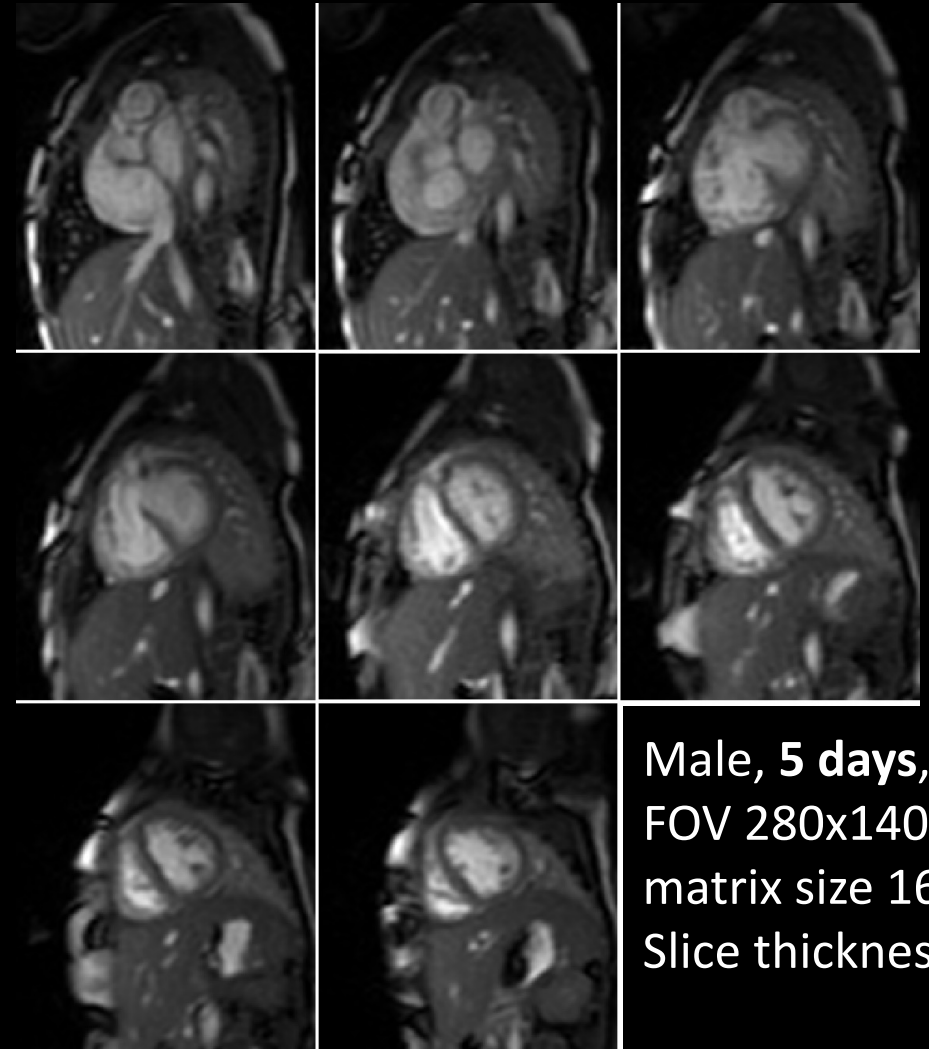
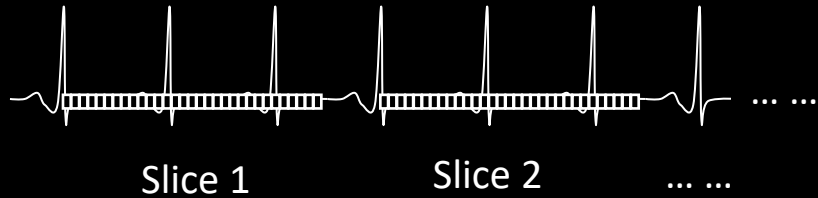
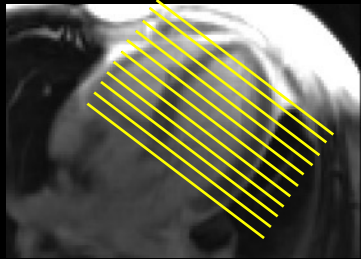


# Gadgetron in the Cloud



Implemented in 2013 with "home built" solution from Michael Hansen (former NIH Investigator, now at Microsoft)

# Example: Free-breathing cardiac cine



- Complex reconstruction, with motion correction and retrospective gating
- Worst case recon time = 2min x 13 slices = 26 min
- Instead, data streamed to the cloud for reconstruction
- Data from every slice gets its own computing nodes
- Waiting time = 1-2min after all slices acquired

Male, 5 days,  
FOV 280x140mm<sup>2</sup>,  
matrix size 160x120  
Slice thickness 4mm

## STRIDES proposal:

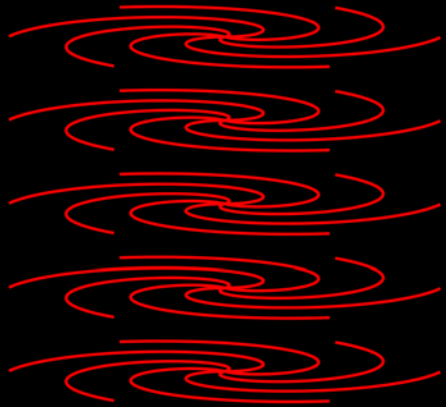
Inline image reconstruction of dynamic 3D data  
using a GPU-enabled cloud implementation

### Goals:

- Extend the Gadgetron cloud capabilities from CPU-based computation to GPU-based computation
- Apply GPUs for advanced imaging applications that require computational power beyond what is available currently.

# Free-breathing 3D pulmonary imaging

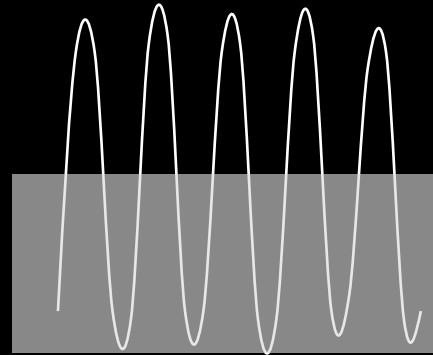
Continuous, free-breathing  
3D stack-of-spirals



8.5 minutes data acquisition

+

Respiratory navigator



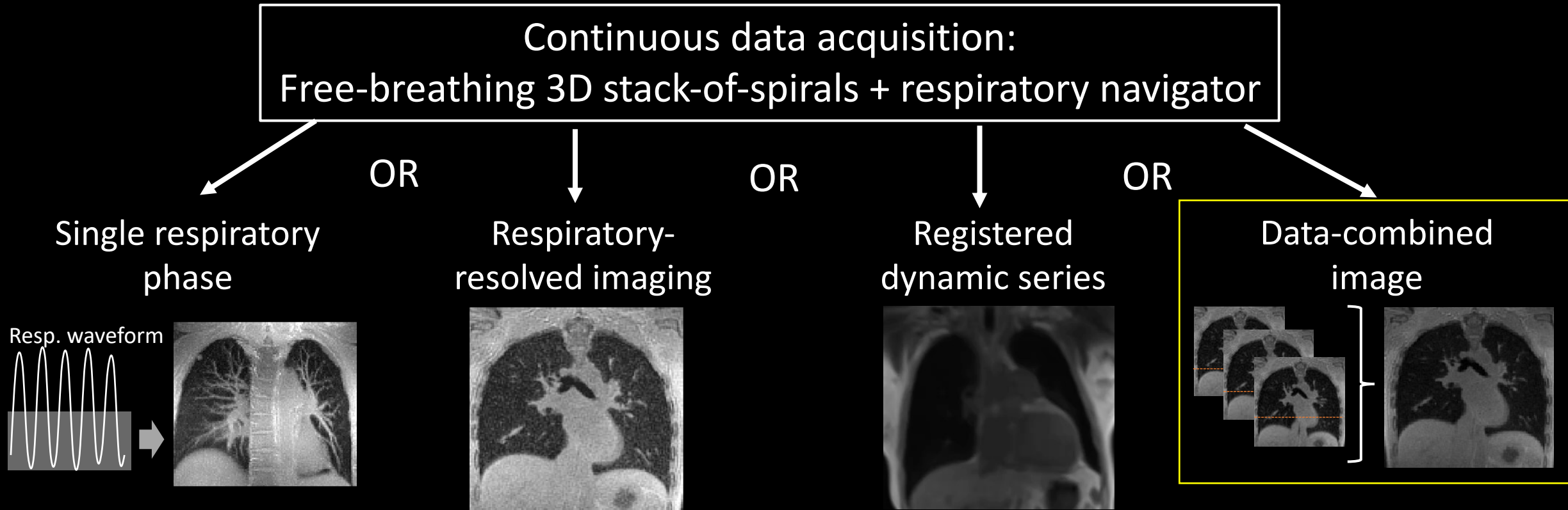
3D pulmonary imaging



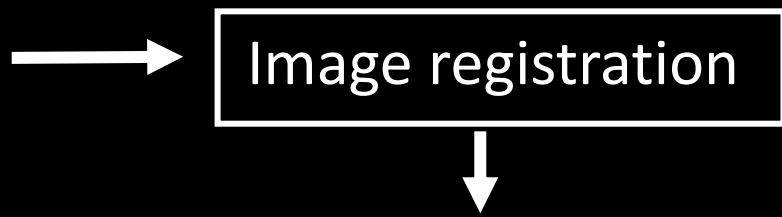
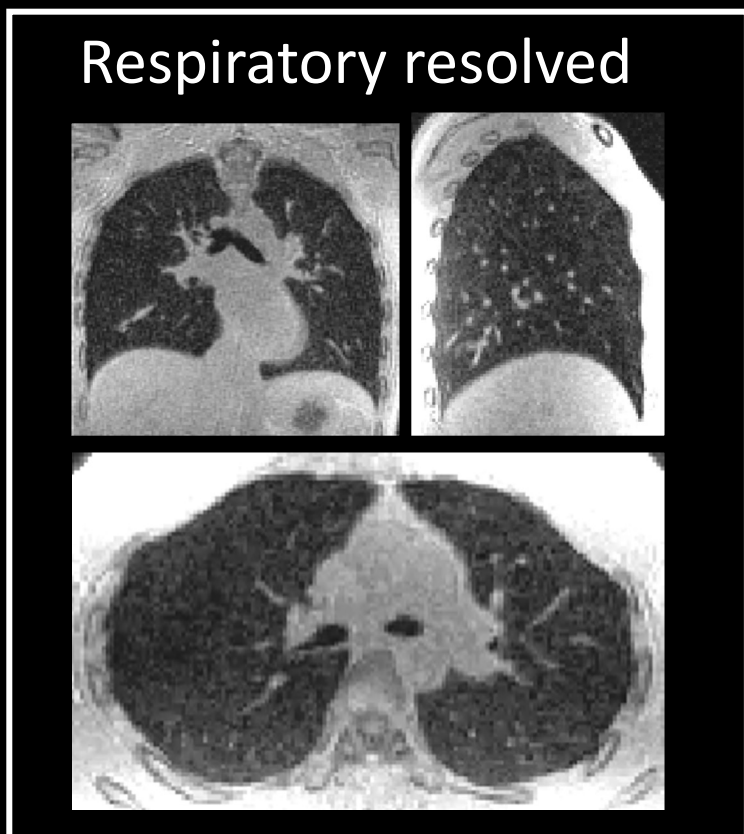
Single respiratory phase

Data size: 40GB  
Memory: 512 GB RAM  
3x Nvidia Quadro RTX 8000  
Recon time: 4 minutes

# Extending the image reconstruction framework



# “iCoMoCo” Iterative concomitant field and motion corrected reconstruction



iCoMoCo

$$\arg\min_X \sum_{n,k}^{N_c K} \left\| W_k \sum_p^P (D_p F C_p) S_n M_k X - d_{n,k} \right\|_2^2 + \lambda_s TV_s(X)$$

Demodulation frequencies

Motion fields

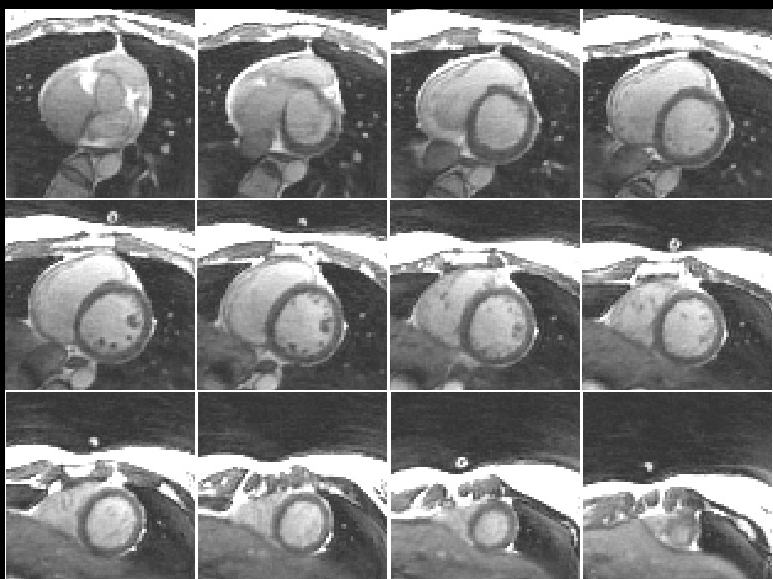
Concomitant field MFI weights



Data size: 22GB  
 Memory: 1TB RAM  
 4x Nvidia A100 80 GB GPUs  
 Recon time: 15 minutes\*

# Ongoing work

## 3D cardiac applications



Data size: 16 GB

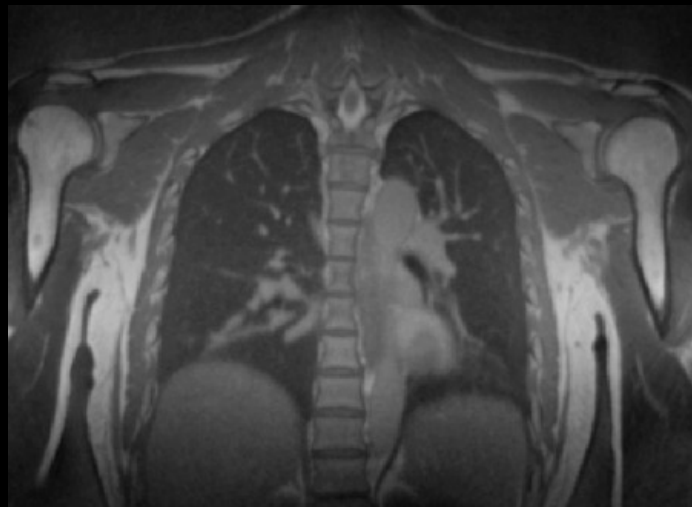
Intermediate Image size: 8 GB

Memory: 1TB

4-8x Nvidia A100 80 GB GPUs

Recon time: 15 minutes

## Higher resolution



Data size: 37 GB

Intermediate Image size: 15 GB

+ Maintain 3 copies for iterative algorithm

Memory: 1TB

8x Nvidia A100 80 GB GPUs

Recon time: 15 minutes

Our GPU  
requirements  
keep growing



# Roadblocks with AWS

- Desired GPUS (A100 or H100 80GB) were rarely available in our VPC
  - Iterative technical development not possible
  - Availability on-demand for patient imaging is required for our application
- Next steps:
  - Try a non-managed account to remove VPC restrictions =

# Acknowledgements

Laboratory of Imaging Technology (NHLBI DIR):



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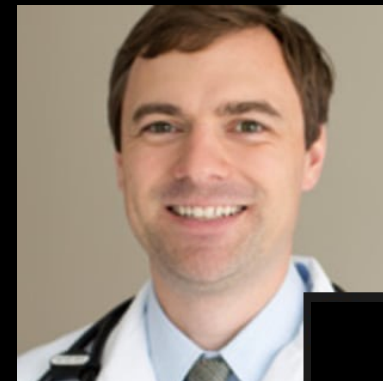
The main people working on this project



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