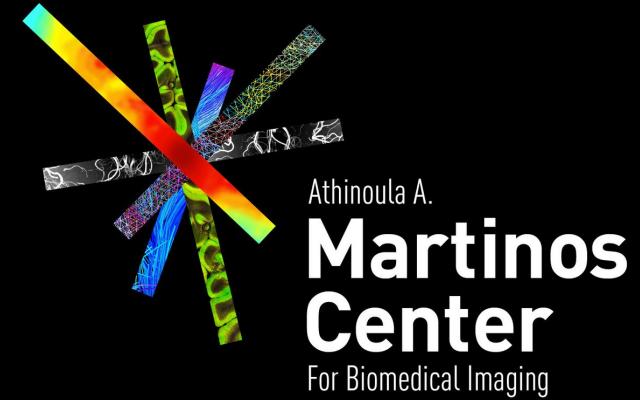




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A grayscale fetal brain MRI scan showing a cross-section of the fetal head with the brain visible inside.

A Deep Learning Approach for Image Quality Assessment of Fetal Brain MRI

Sayeri Lala, Nalini Singh, Borjan Gagoski, Esra Turk,
P. Ellen Grant, Polina Golland, Elfar Adalsteinsson



ISMRM 27TH ANNUAL MEETING & EXHIBITION

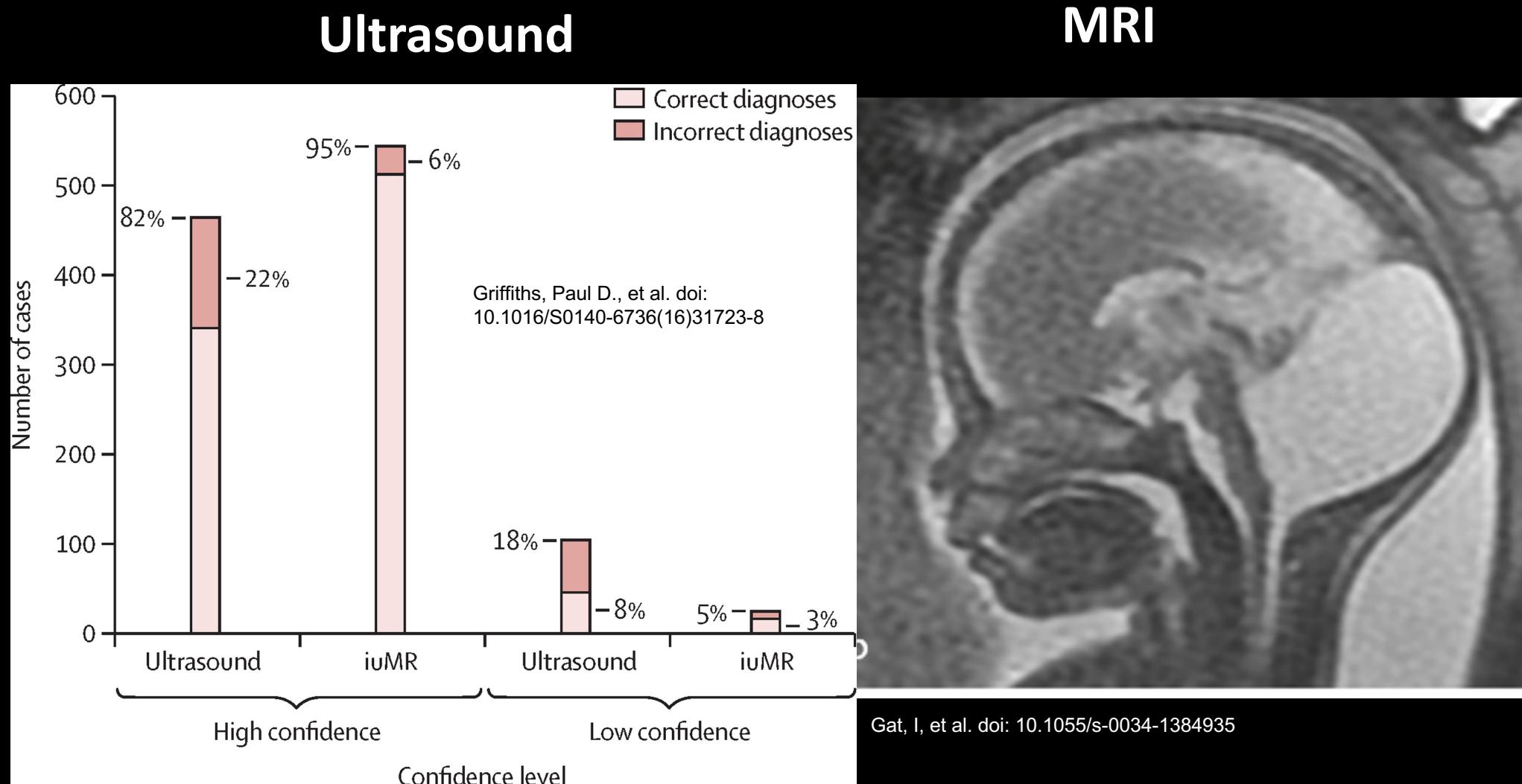
Palais des congrès de Montréal  Montréal, QC, Canada  11–16 May 2019

Declaration of Financial Interests or Relationships

Speaker Name: Sayeri Lala

I have no financial interests or relationships to disclose with regard to the subject matter of this presentation.

Fetal Brain MRI complements Ultrasound in diagnosing brain abnormalities

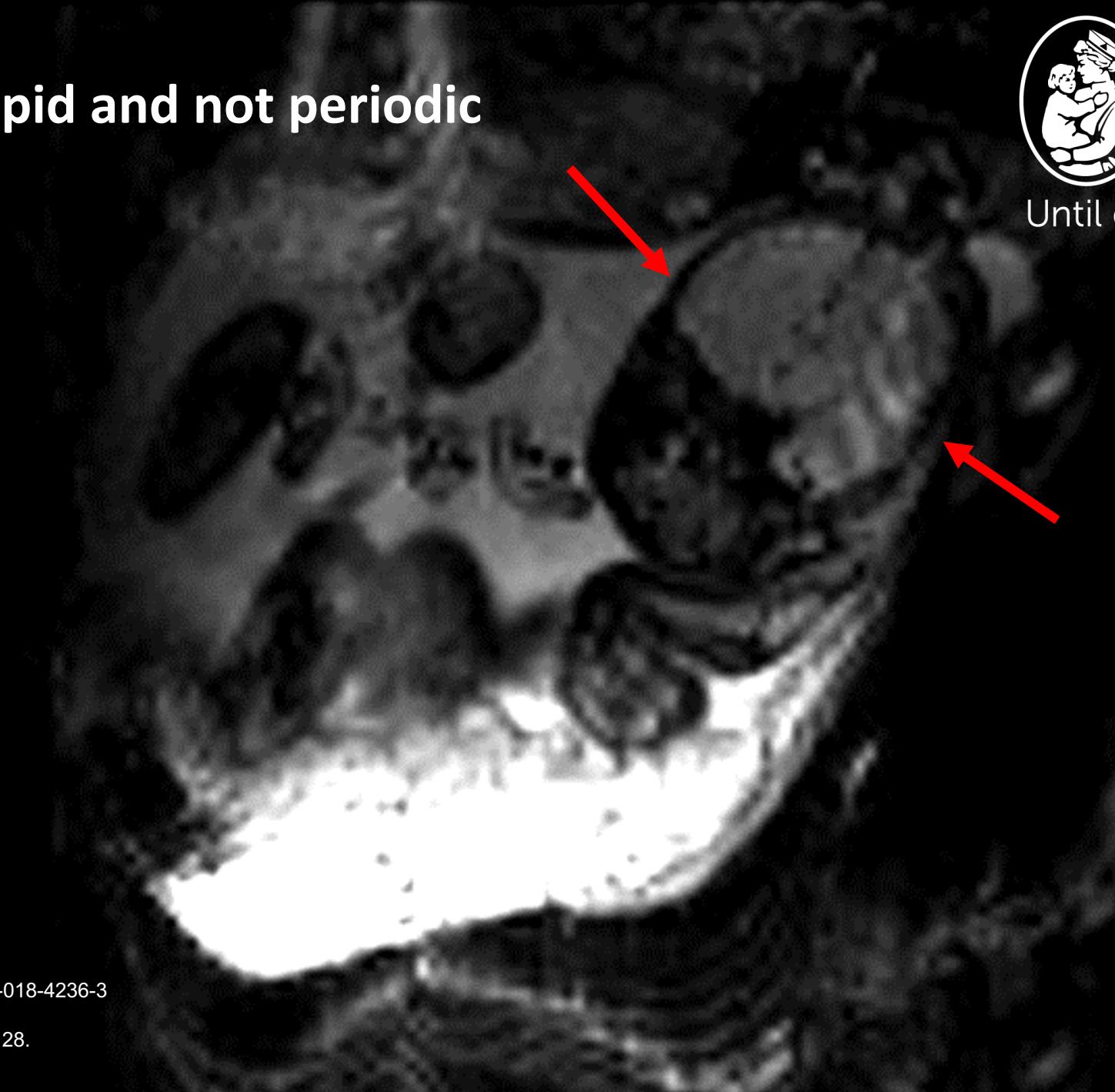




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Fetal motion is rapid and not periodic



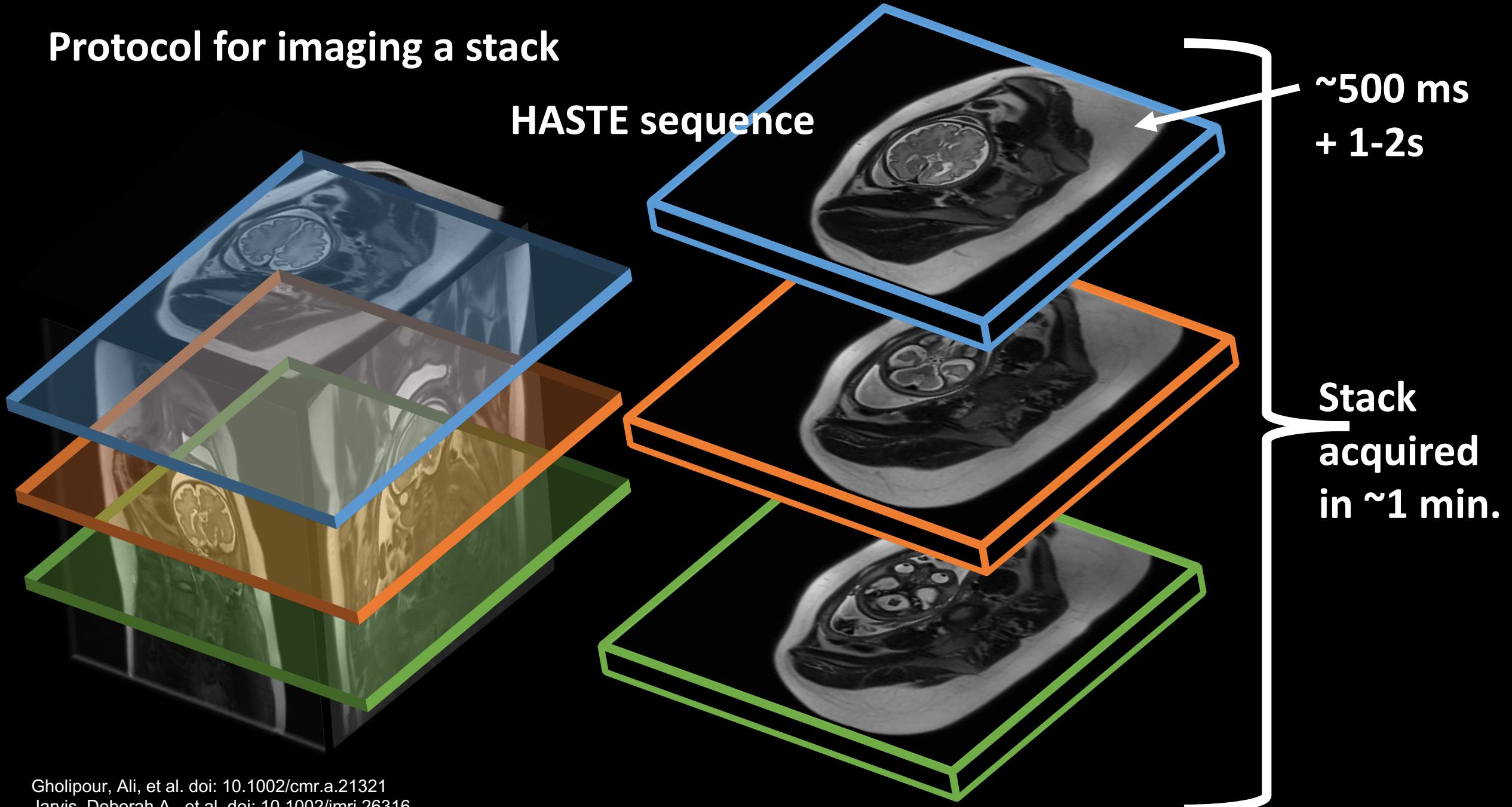
BOLD EPI

**Temporal
resolution: 3.5s**

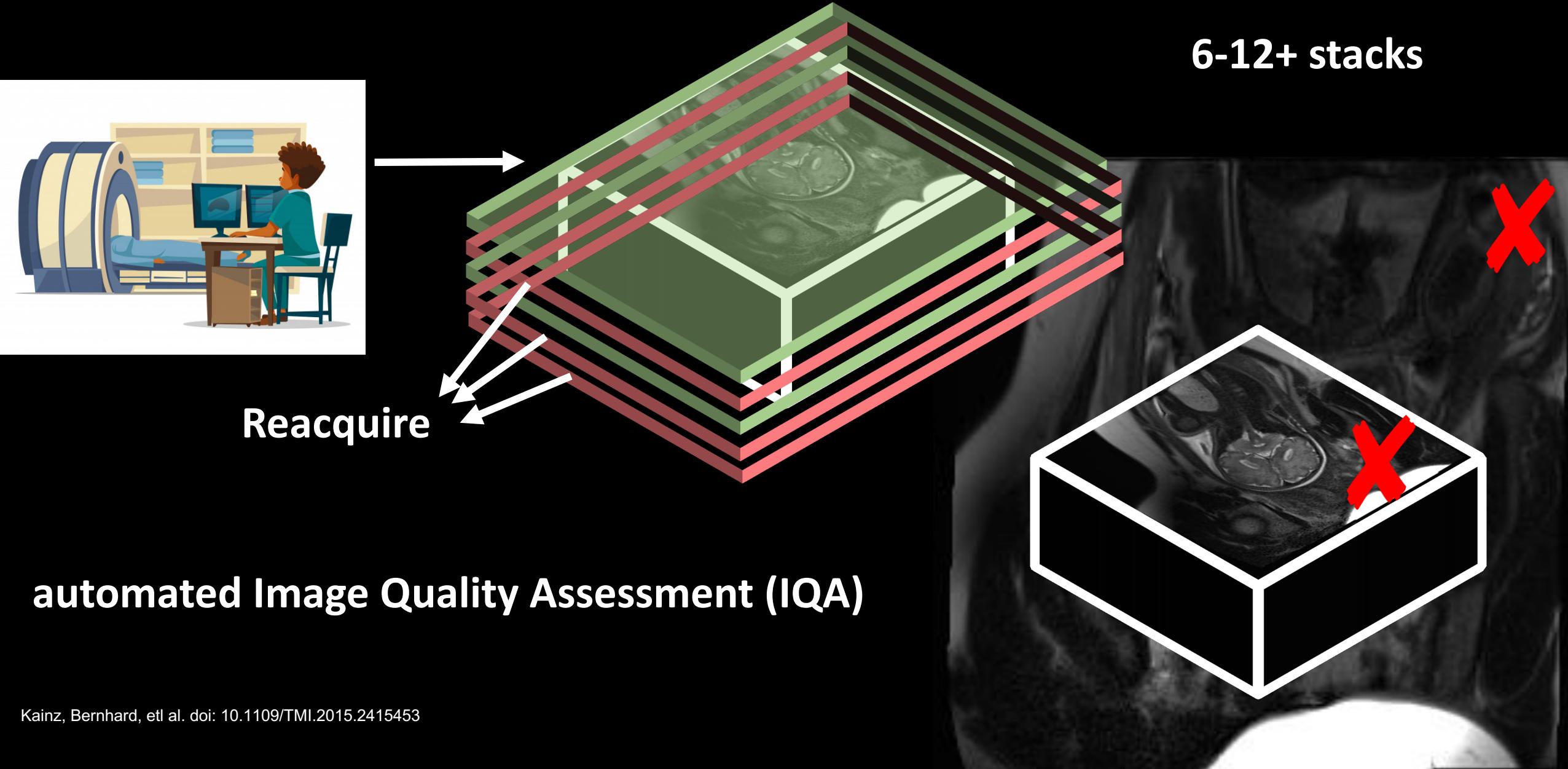
Protocol for imaging a T2W brain volume

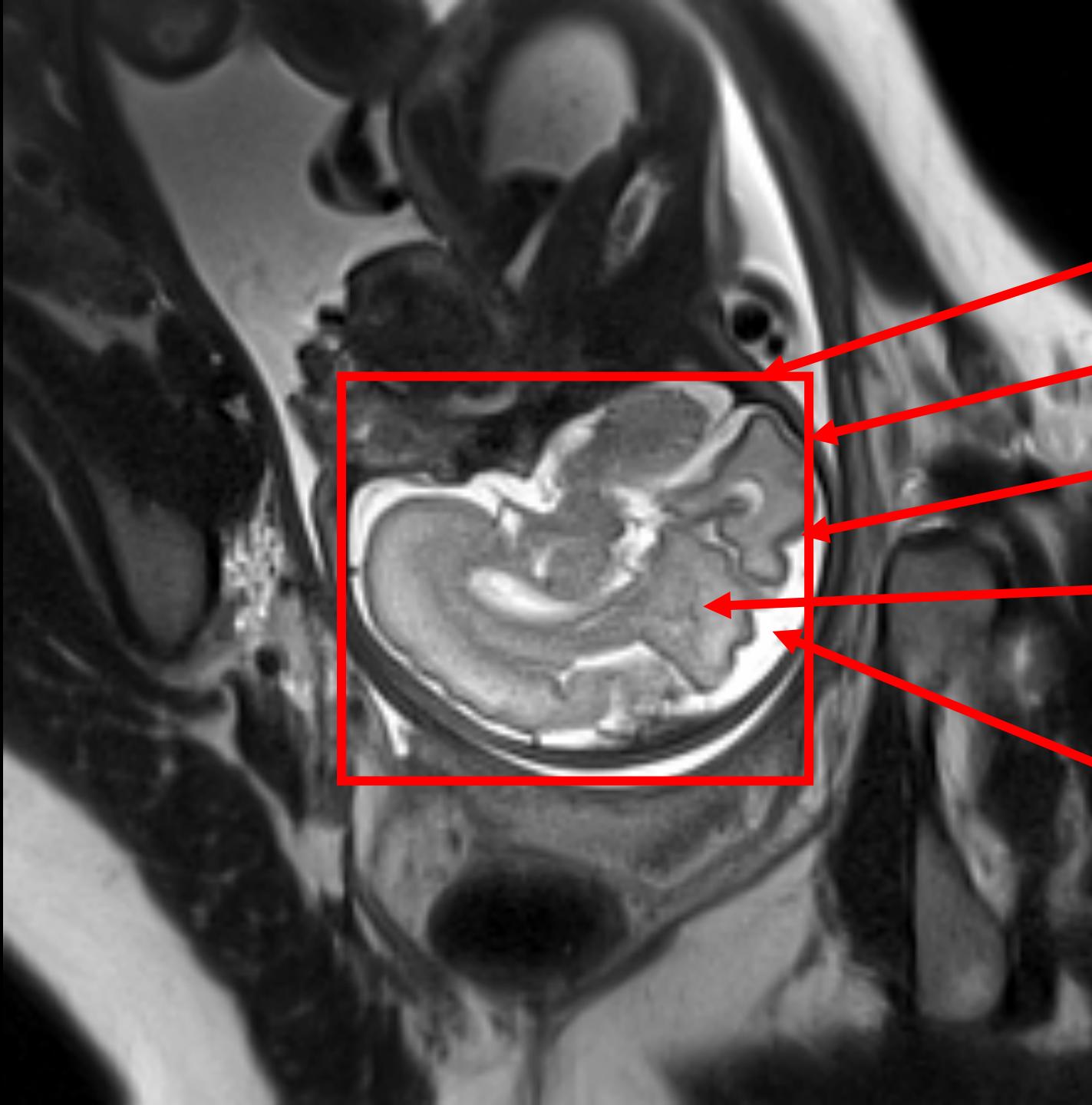


Protocol for imaging a stack



Challenges in T2W Fetal Brain MRI Clinical workflow





Scalp

Skull

Cortex

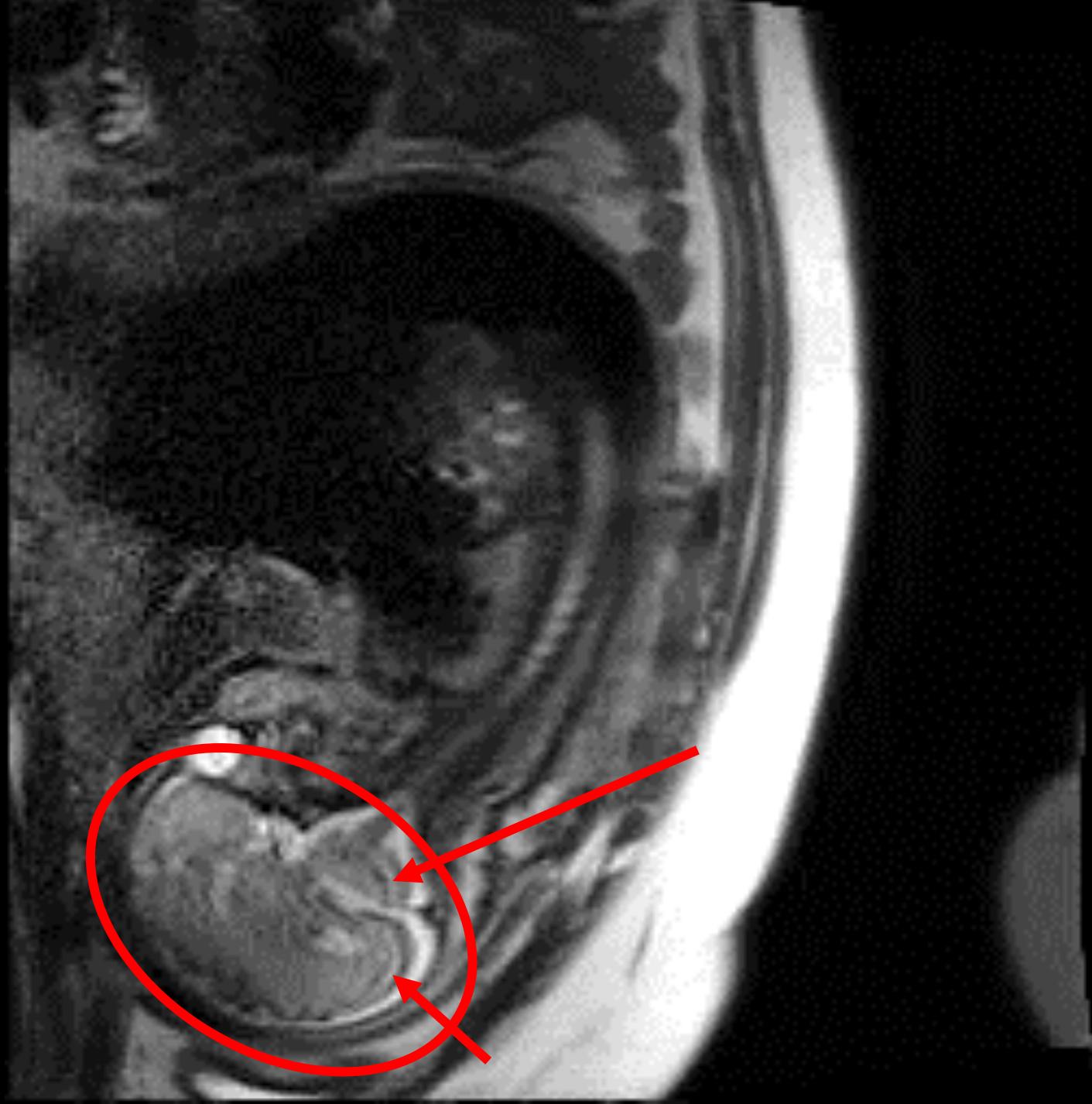
White matter

Cerebral
Spinal Fluid





Blurring



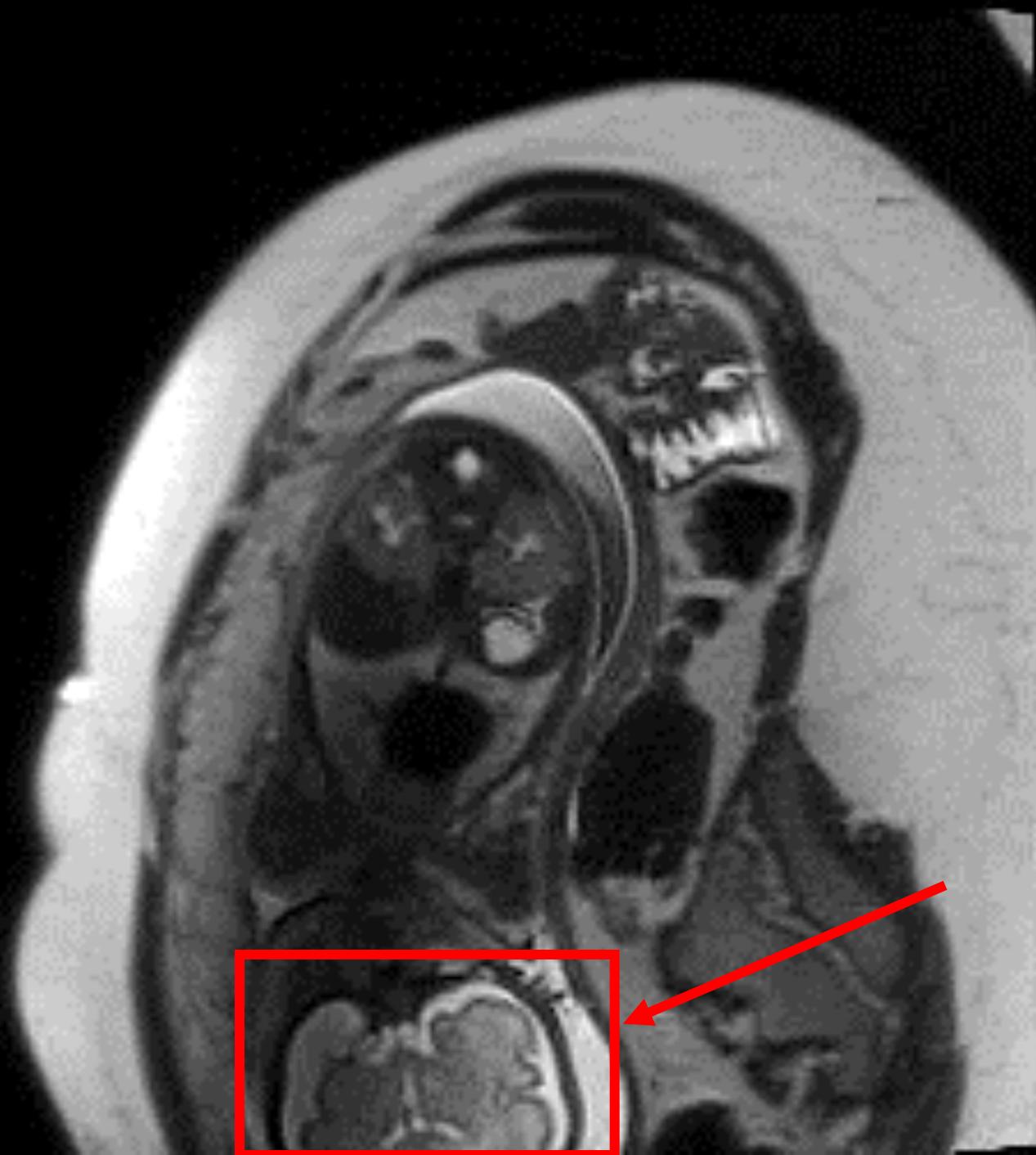


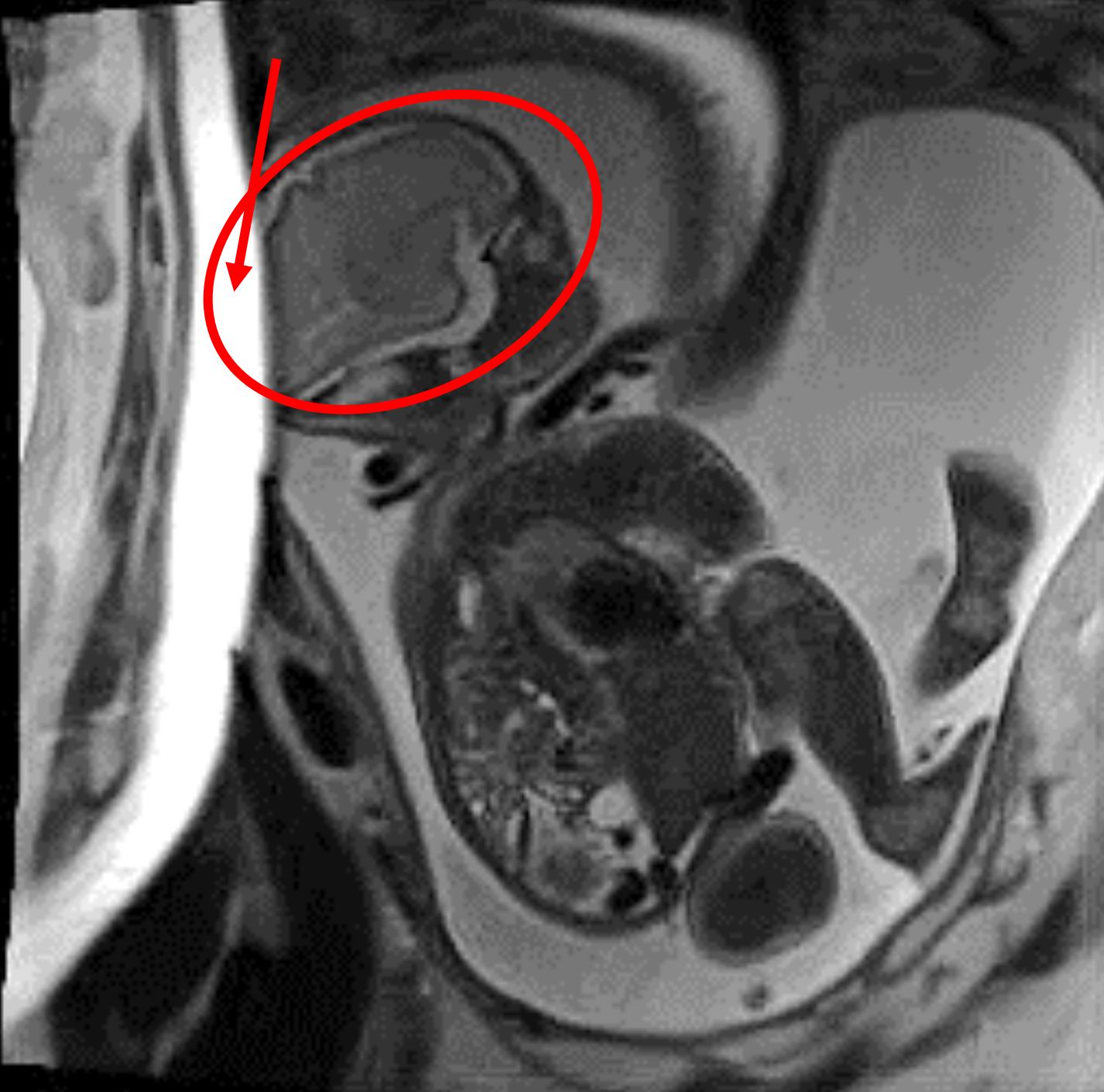
Non-uniform
signal void





Fetal brain not
in Field of View





✗

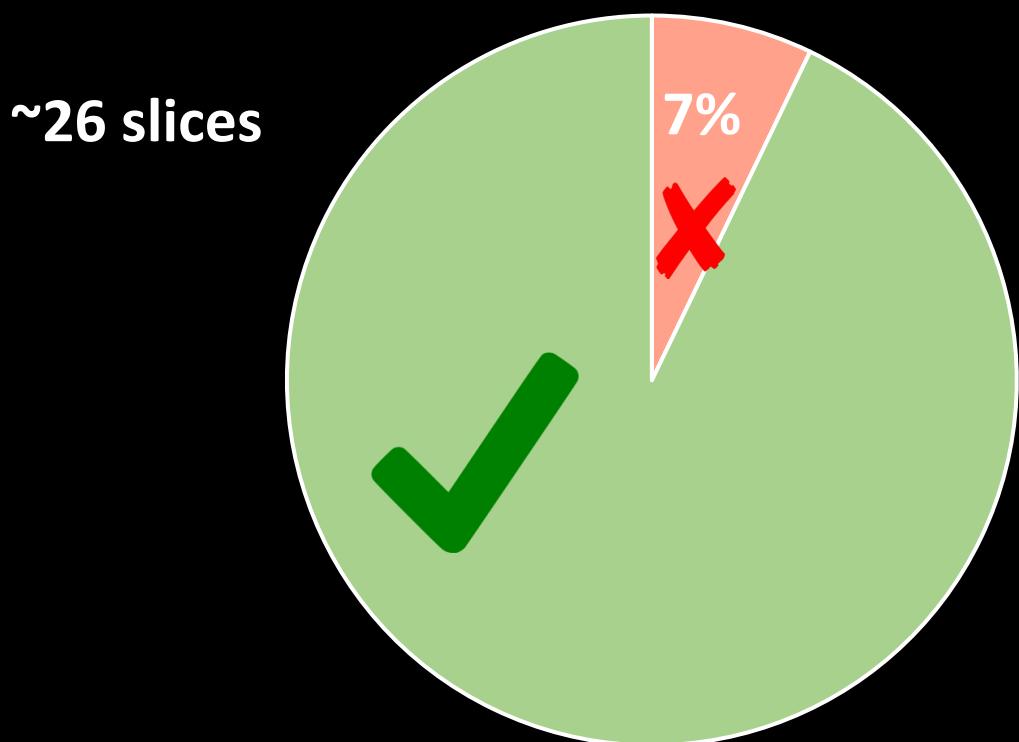
Aliasing

Dataset Characterization

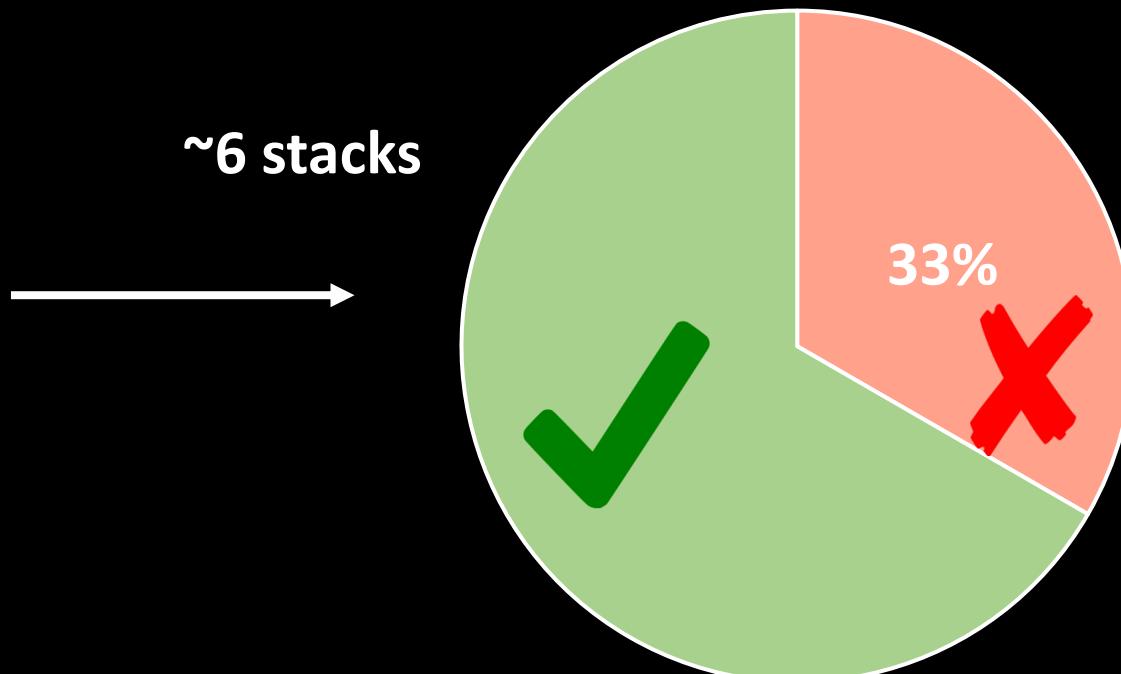
■ Non-diagnostic
■ Diagnostic

32 mothers with singleton healthy pregnancies

Average Slice Quality per Stack



Average Stack Quality per Subject



~26 slices

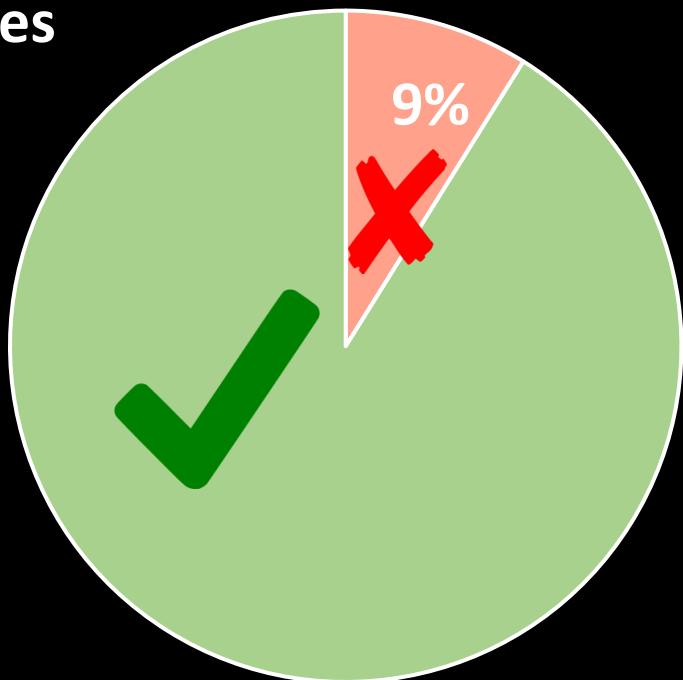
Dataset Characterization

32 mothers with singleton healthy pregnancies

■ Non-diagnostic
■ Diagnostic

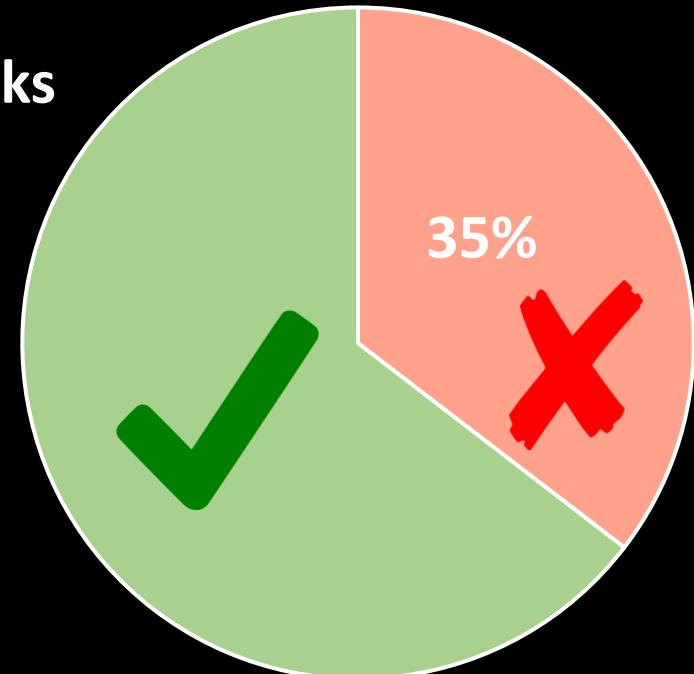
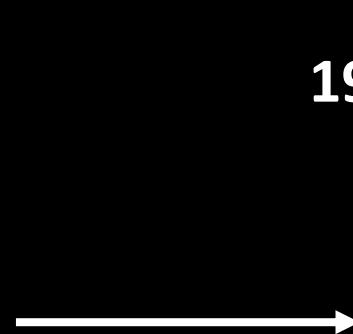
Slice Quality

4933 slices



Stack Quality

192 stacks



Dataset Characterization

32 mothers with singleton healthy pregnancies

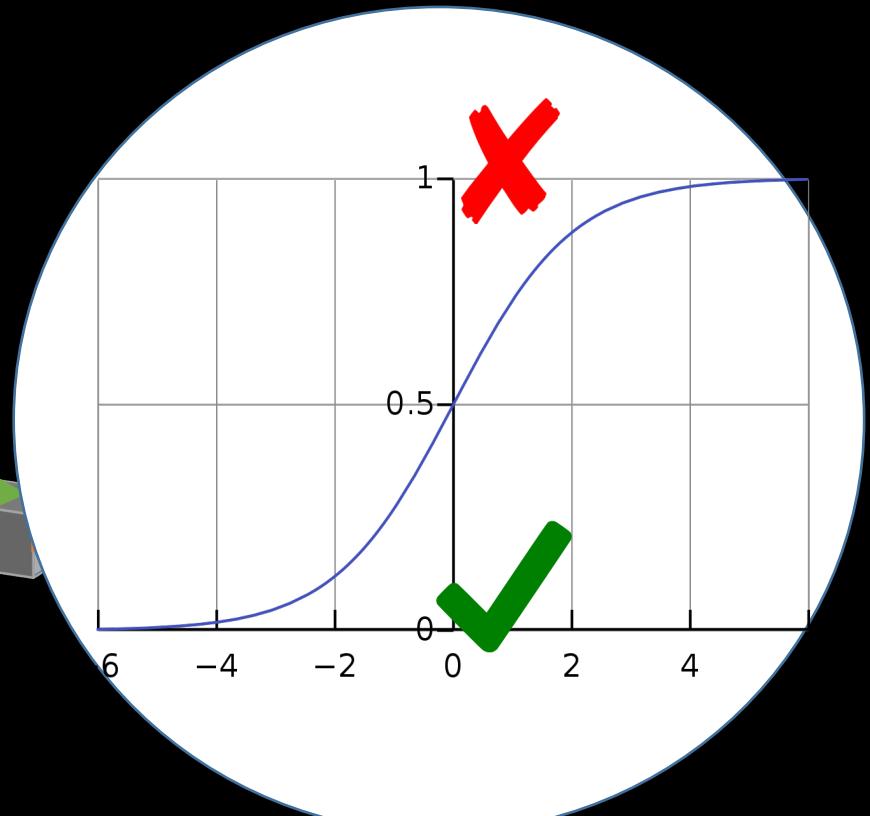
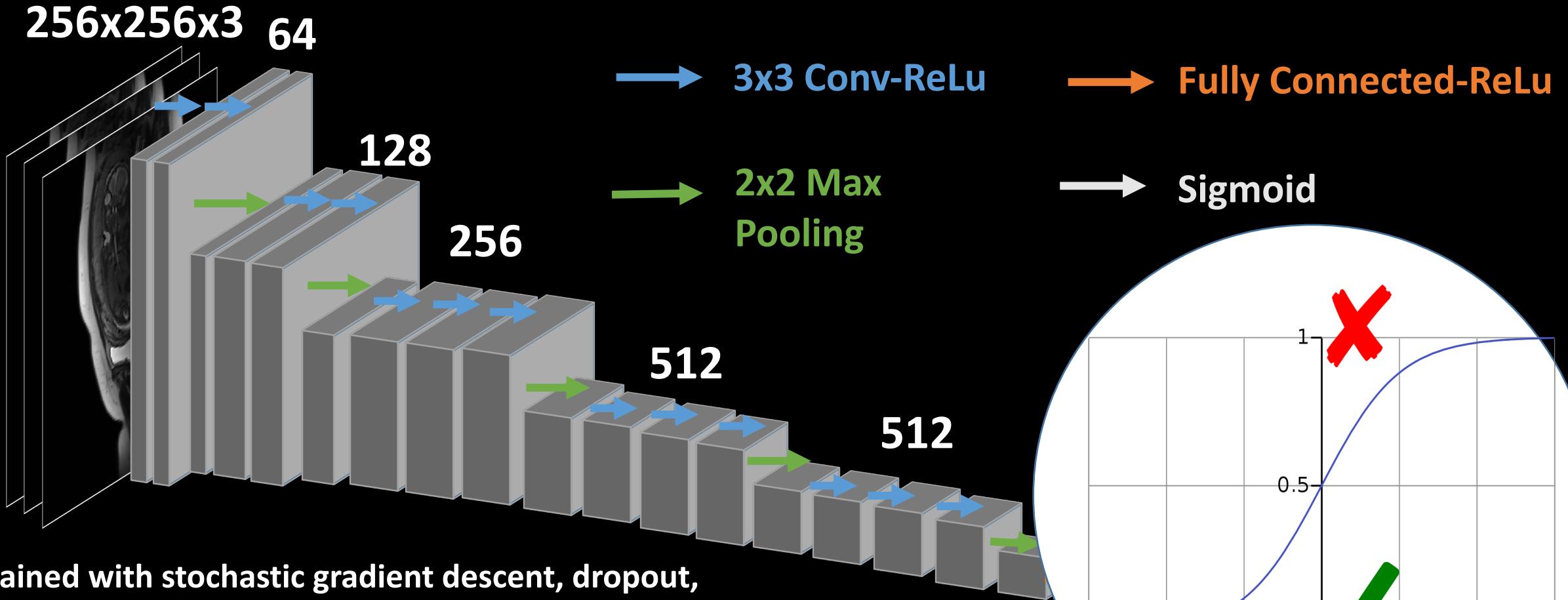


- Non-diagnostic
- Diagnostic

Slice imaging parameters

- HASTE sequence
- Echo Time of 115 ms
- Repetition Time of 1.6 s
- Field of view of 31cm
- Voxel size of $1.2 \times 1.2 \times 3 \text{ mm}^3$

Convolutional Neural Networks for IQA classifier



Simonyan, Karen, et al. arXiv preprint arXiv:1409.1556 (2014).

Esses, Steven J., et al. 10.1002/jmri.25779

Sujit, Sheeba J, et al. 10.1002/jmri.26693

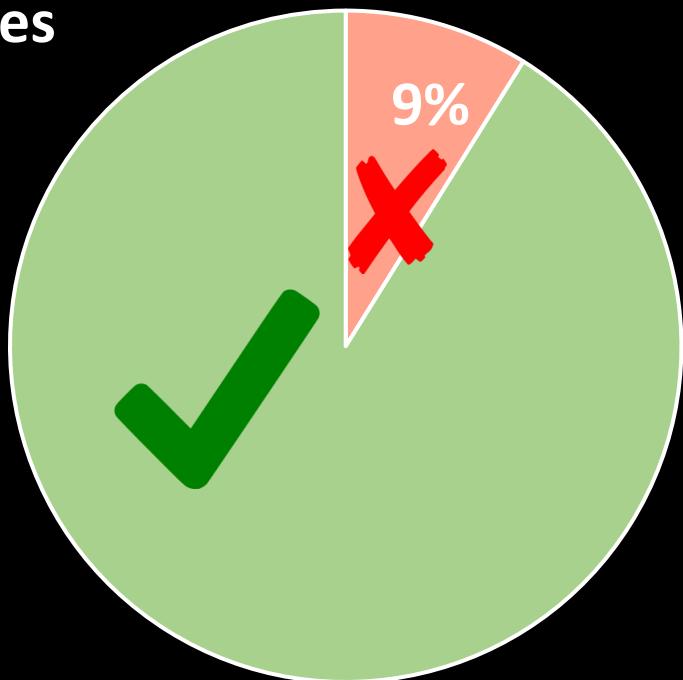
Li J, et al (2018) ISMRM-ESMRMB 2018.

Dataset Characterization

■ Non-diagnostic
■ Diagnostic

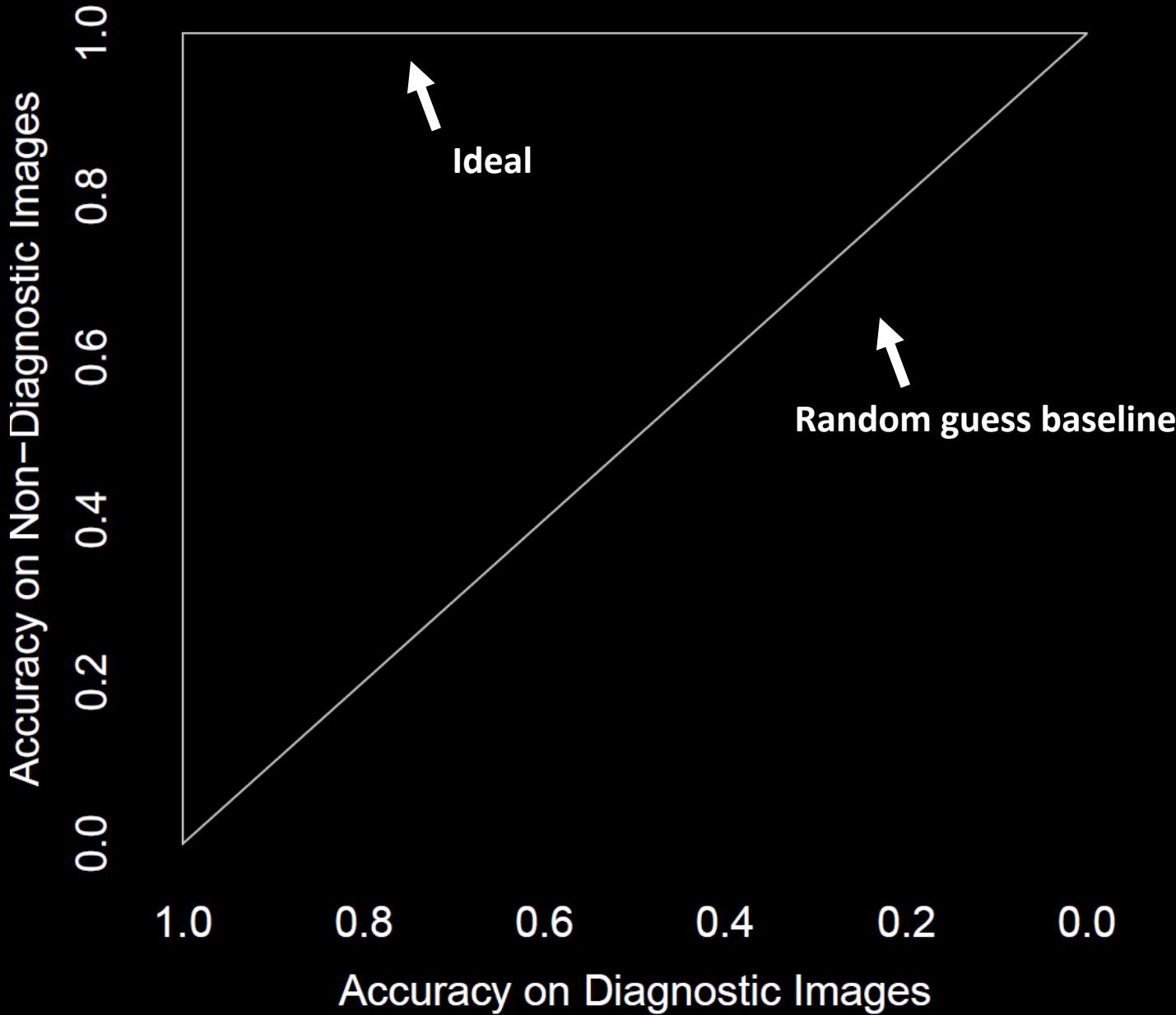
32 mothers with singleton healthy pregnancies

Slice Quality
4933 slices

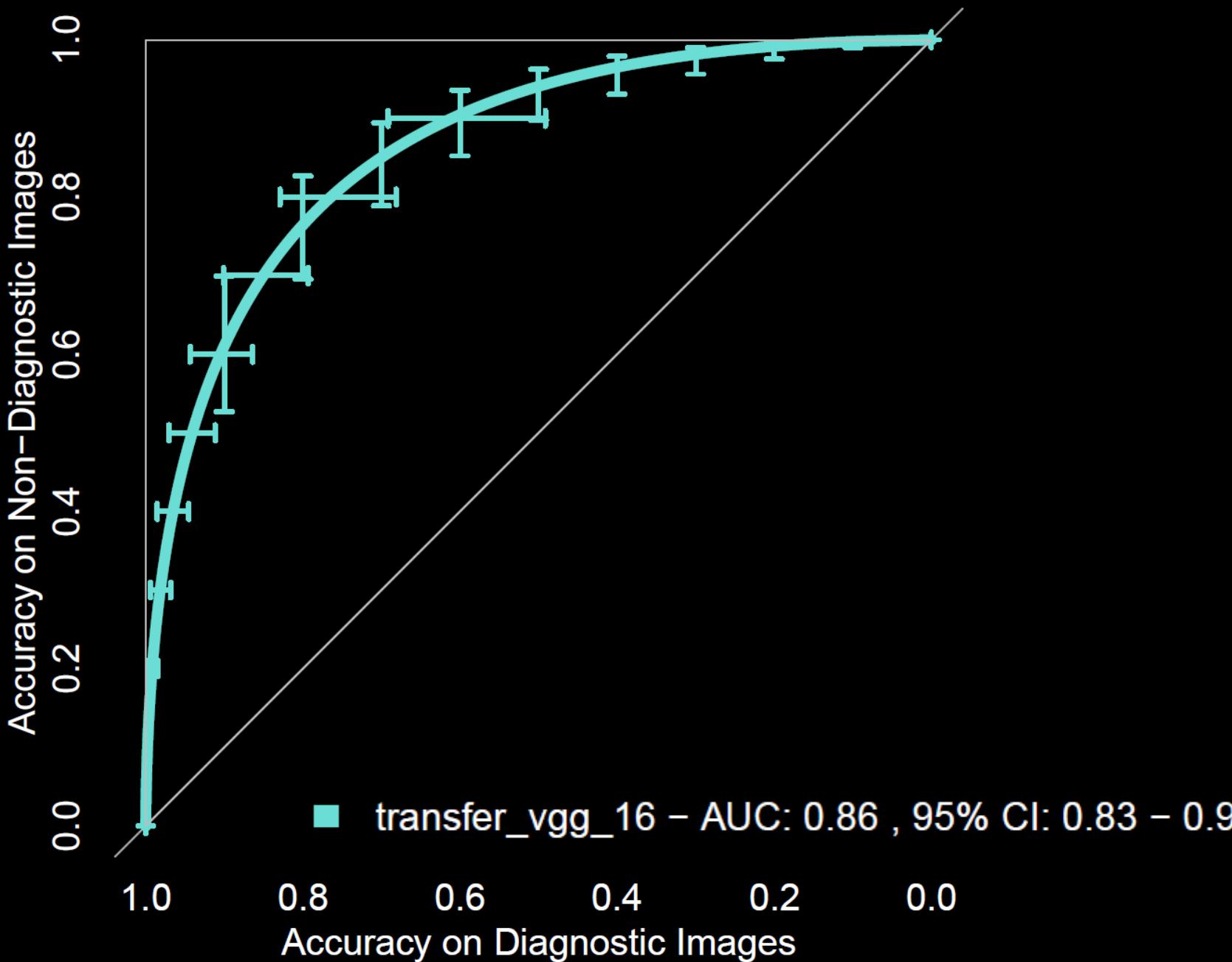


Dataset Partition	# subjects	# slice images	% Non-diagnostic quality
Train	19	2955	9
Validation	6	691	11
Test	7	1138	10

Test Set Receiver Operator Characteristic Curves

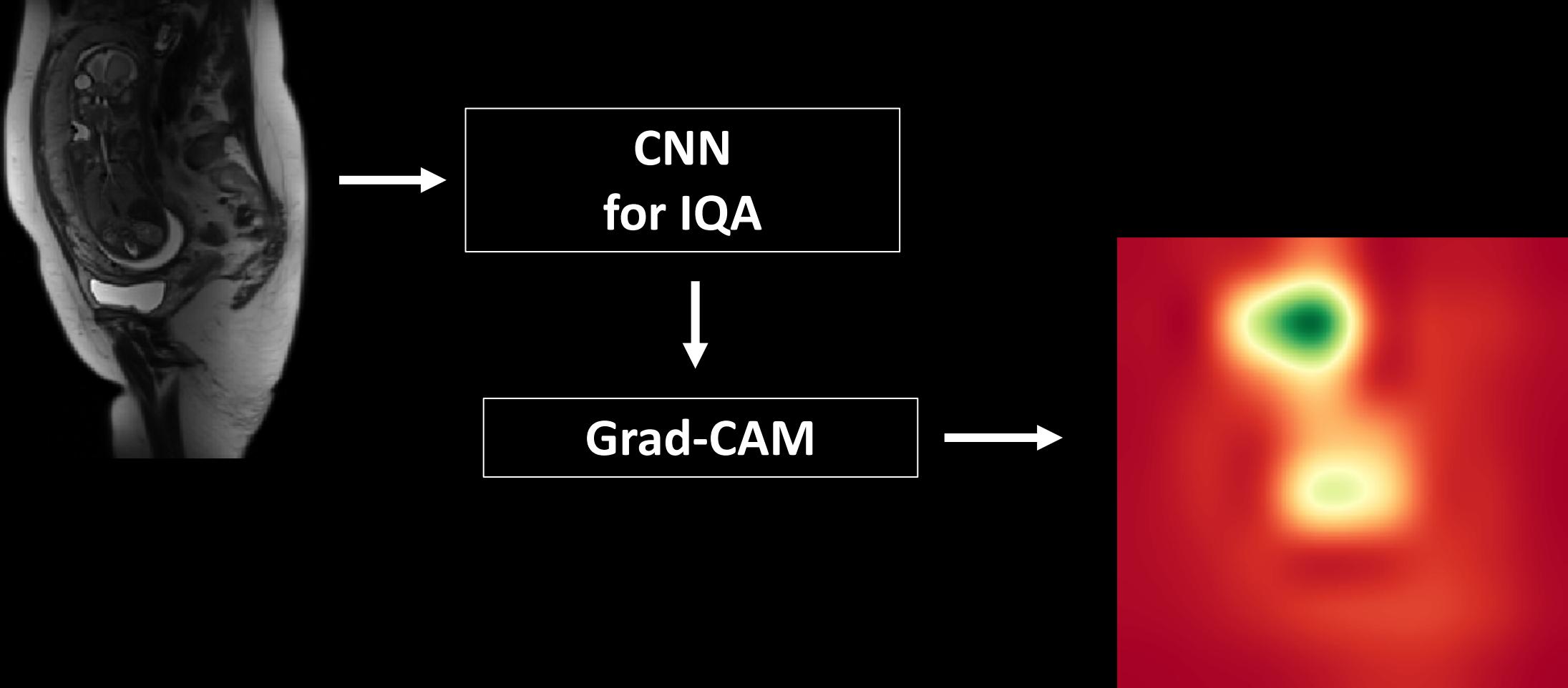


Test Set Receiver Operator Characteristic Curves



Grad-CAM for saliency maps

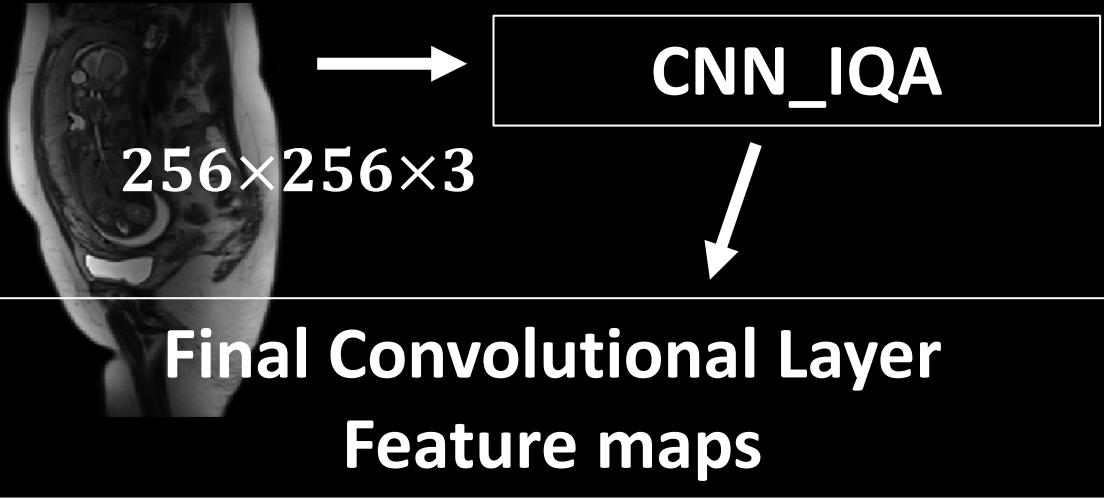
Selvaraju, Ramprasaath R., et al. arXiv: 1610.02391.
Adebayo, Julius, et al. arXiv:1810.03292.



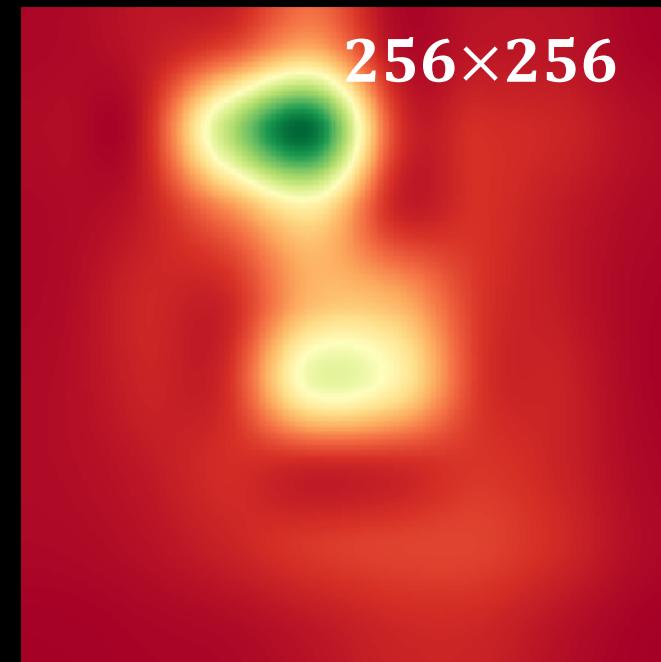
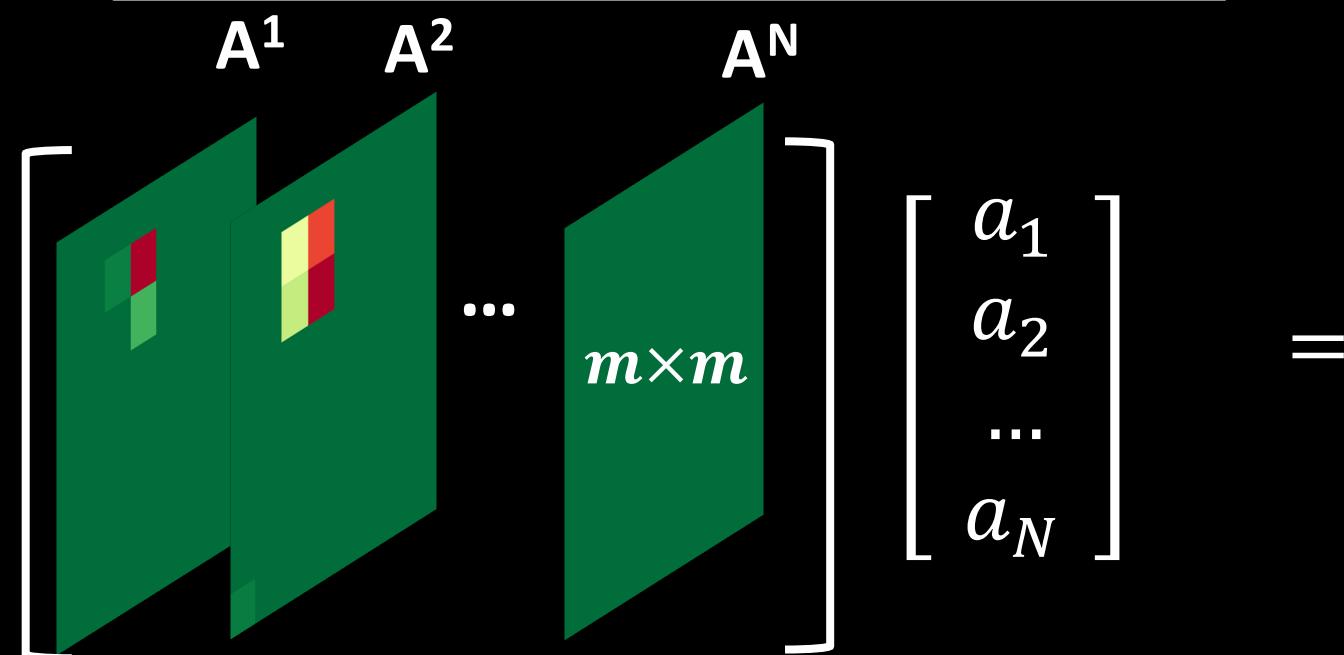
Normalized
Grad-CAM
activations

Selvaraju, Ramprasaath R., et al. arXiv: 1610.02391.
Adebayo, Julius, et al. arXiv:1810.03292.

Grad-CAM for saliency maps

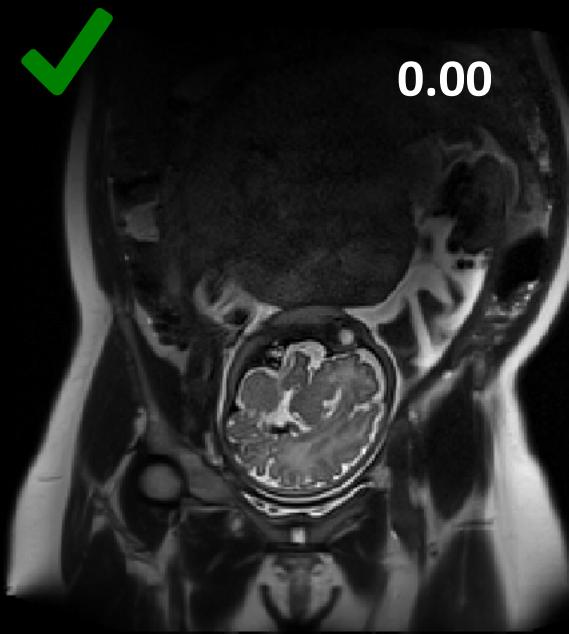


$$a_k = \frac{1}{Z} \sum_i \sum_j \frac{\partial y}{\partial A_{ij}^k}$$



Normalized
Grad-CAM
activations

True label

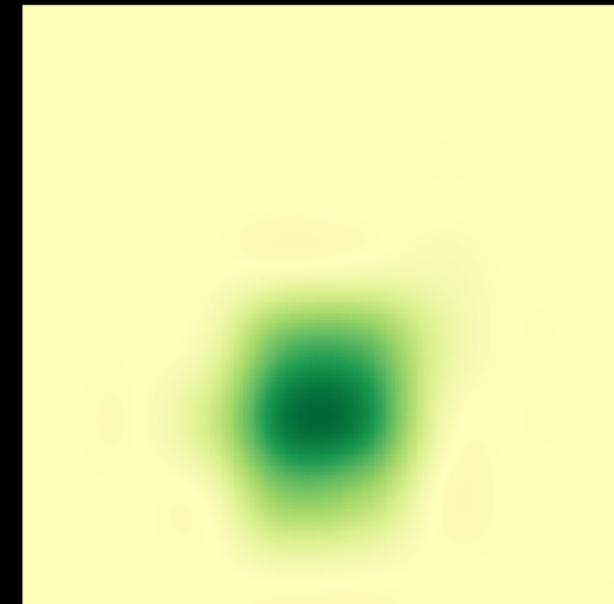


CNN_IQA
score and label

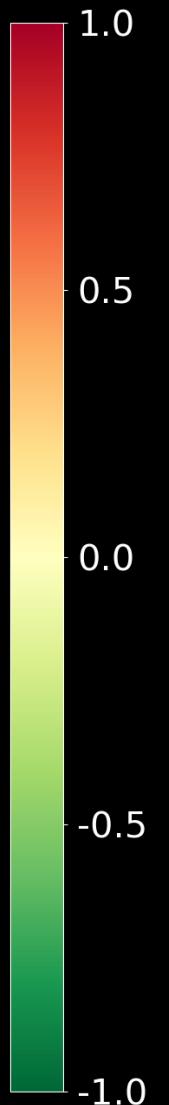
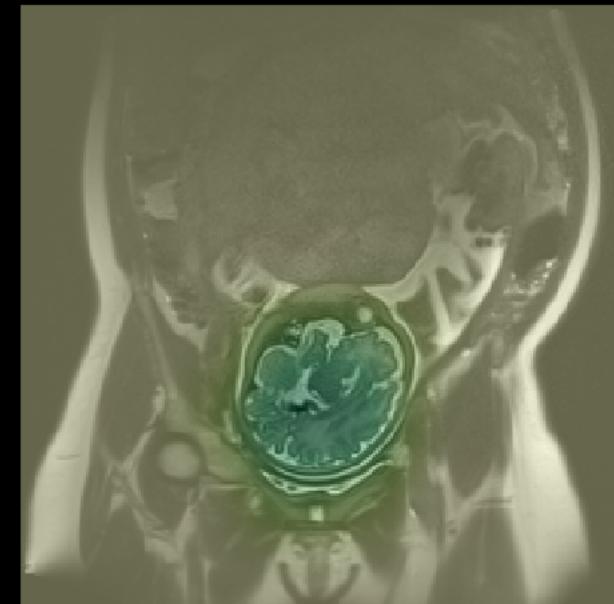
0.00



Grad-CAM



Grad-CAM overlaid



Normalized
Grad-CAM
activations

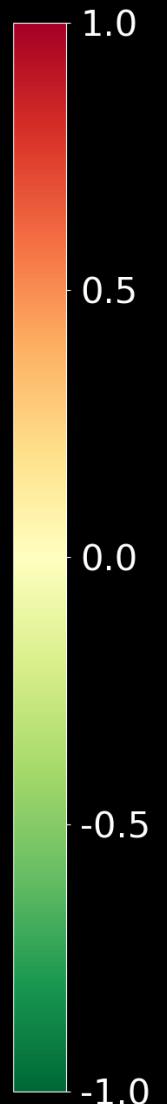
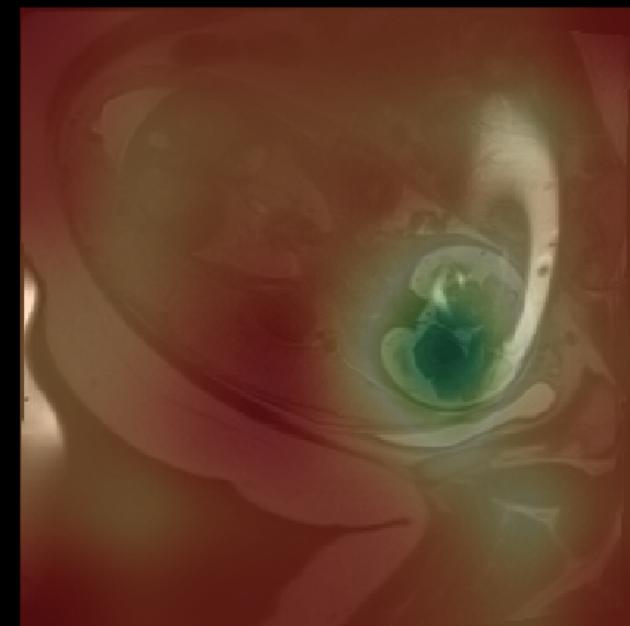
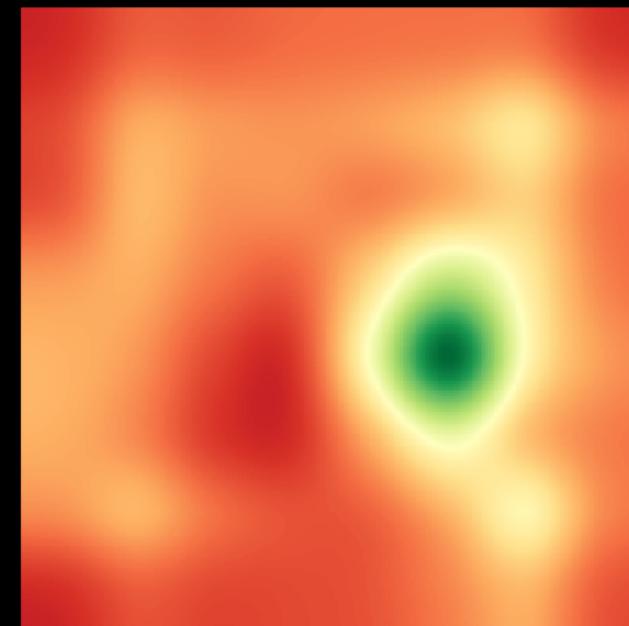
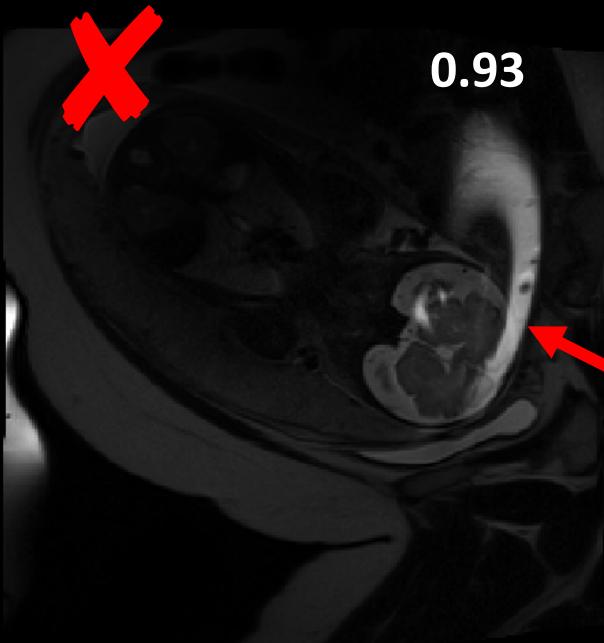
True label

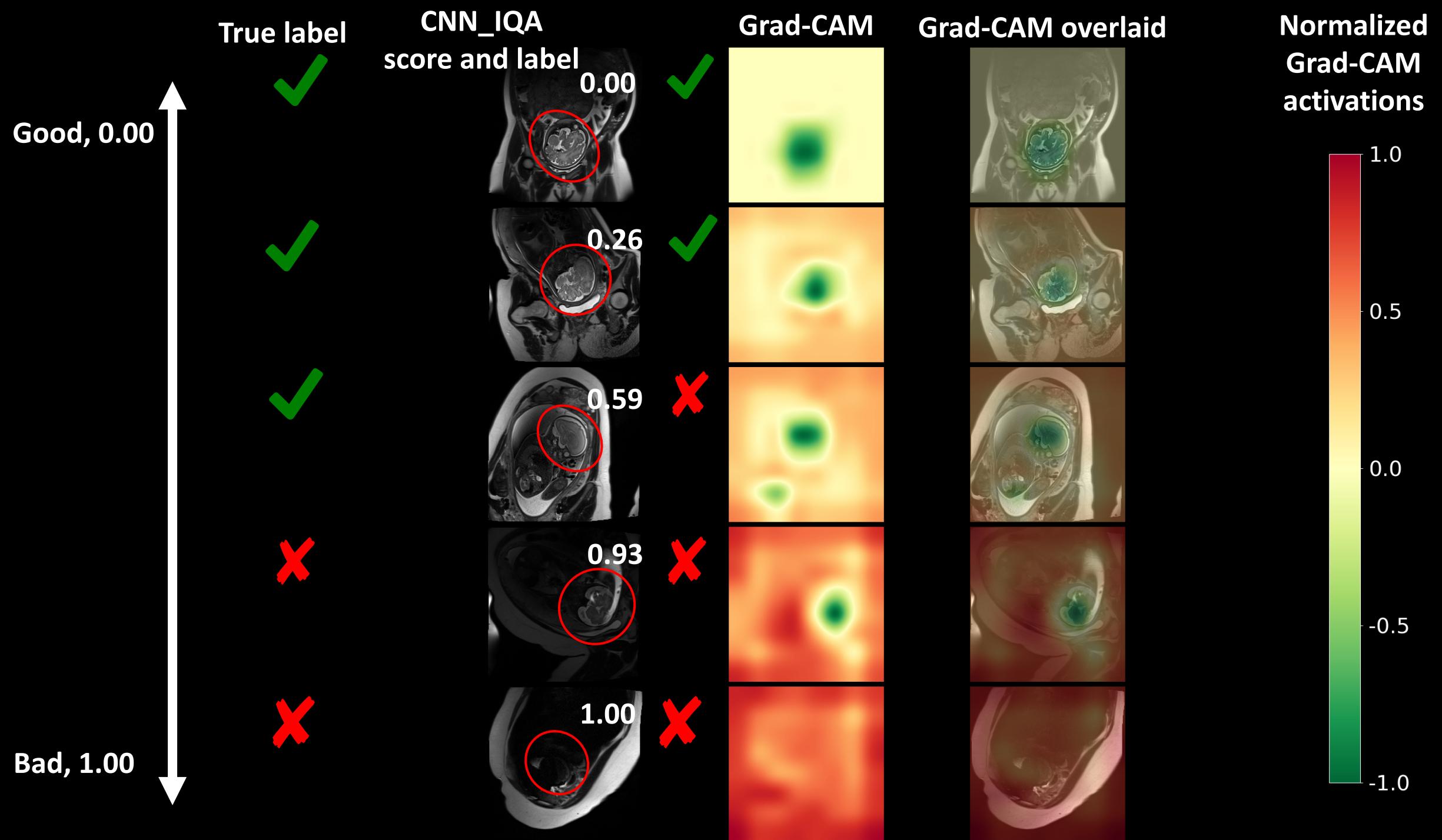
CNN_IQA
score and label

0.93

Grad-CAM

Grad-CAM overlaid



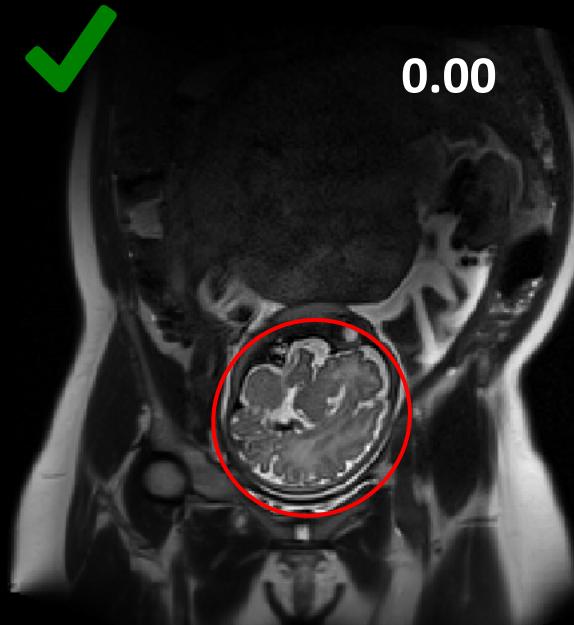


Normalized
Grad-CAM
activations

Insights from saliency maps

As classification score moves toward good quality, grad-CAM activations become negative and concentrated on the brain

True label

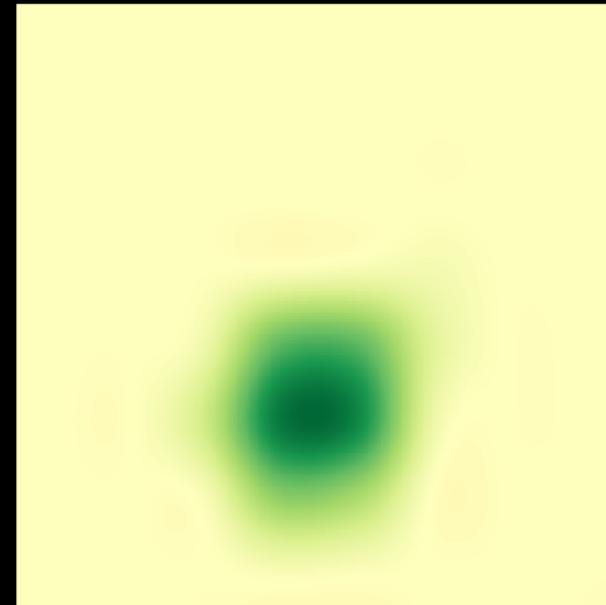


CNN_IQA
score and label

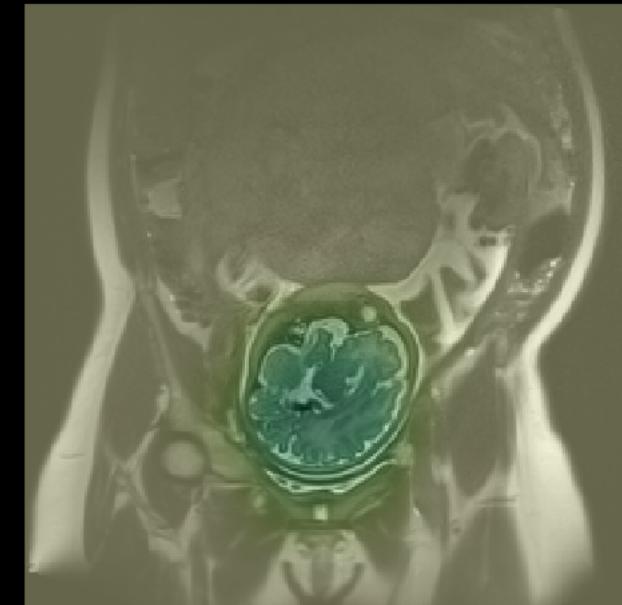
0.00



Grad-CAM



Grad-CAM overlaid



Normalized
Grad-CAM
activations

Insights from saliency maps

As classification score moves toward bad quality, grad-CAM activations become positive and diffuse over the image

True label



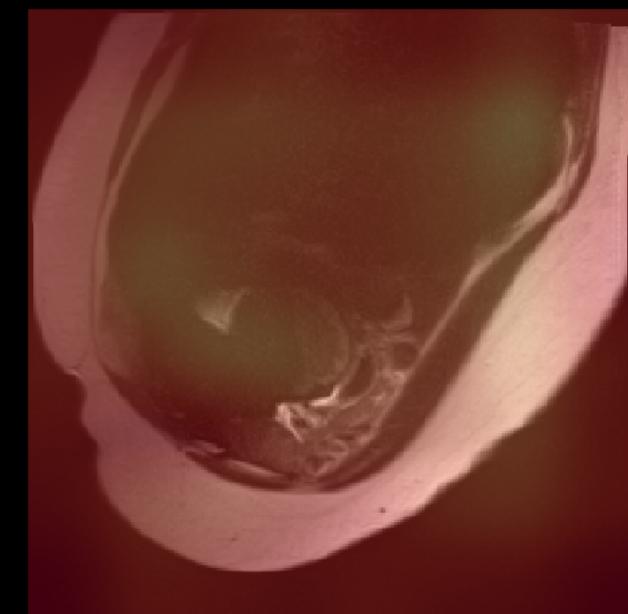
CNN_IQA
score and label

1.00



Grad-CAM

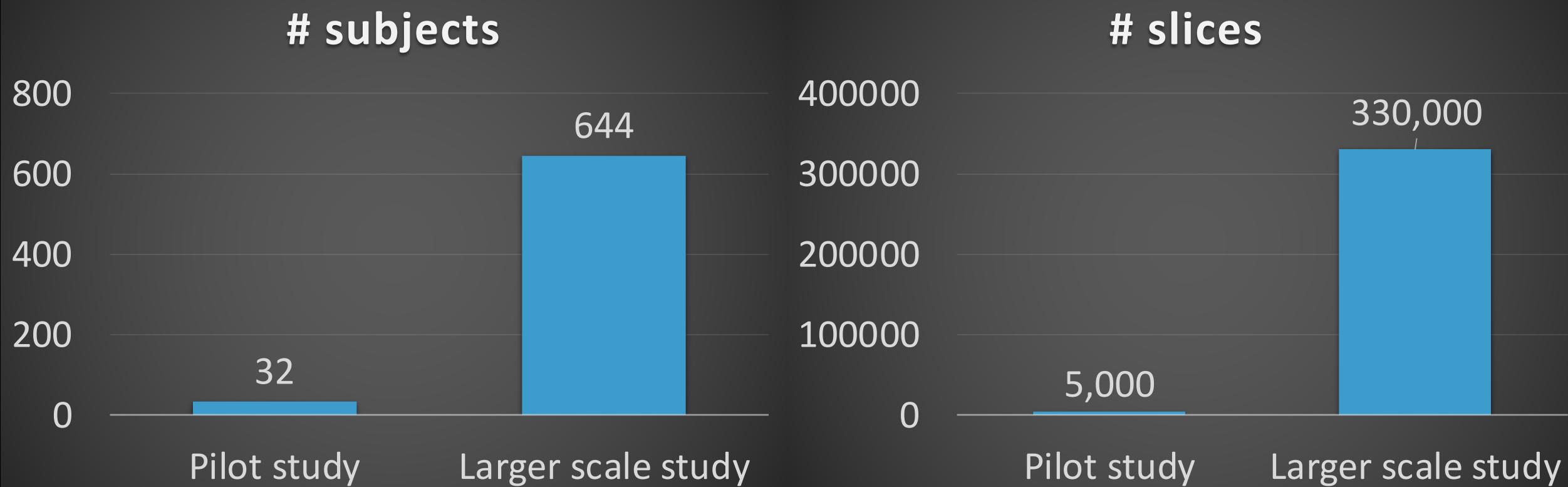
Grad-CAM overlaid



Summary and Next steps



- Trained and evaluated a CNN for T2W fetal brain MRI slice IQA
- Plan to scale experiments on larger, representative dataset



Summary and Next steps

- CNN image evaluation takes 20 ms on a GPU makes it feasible for low-latency detection during the scan
- Implement on the scanner
- Could be used towards improving current protocol and for automated slice prescription

Acknowledgments

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NIBIB 5T32EB1680

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