Accelerated 3D Isotropic mecho-UTE using CG-SENSE
& Deep Learning-Based Denoising Reconstruction (DLR)

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Acknowledgement to:
Mr. Mitshuhiro Bekku
Canon Medical Systems, Japan

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109TH SCIENTIFIC ASSEMBLY AND ANNUAL MEETING
ANNUAL MEETING: NOV. 26–30
TECHNICAL EXHIBITS: NOV. 26–29

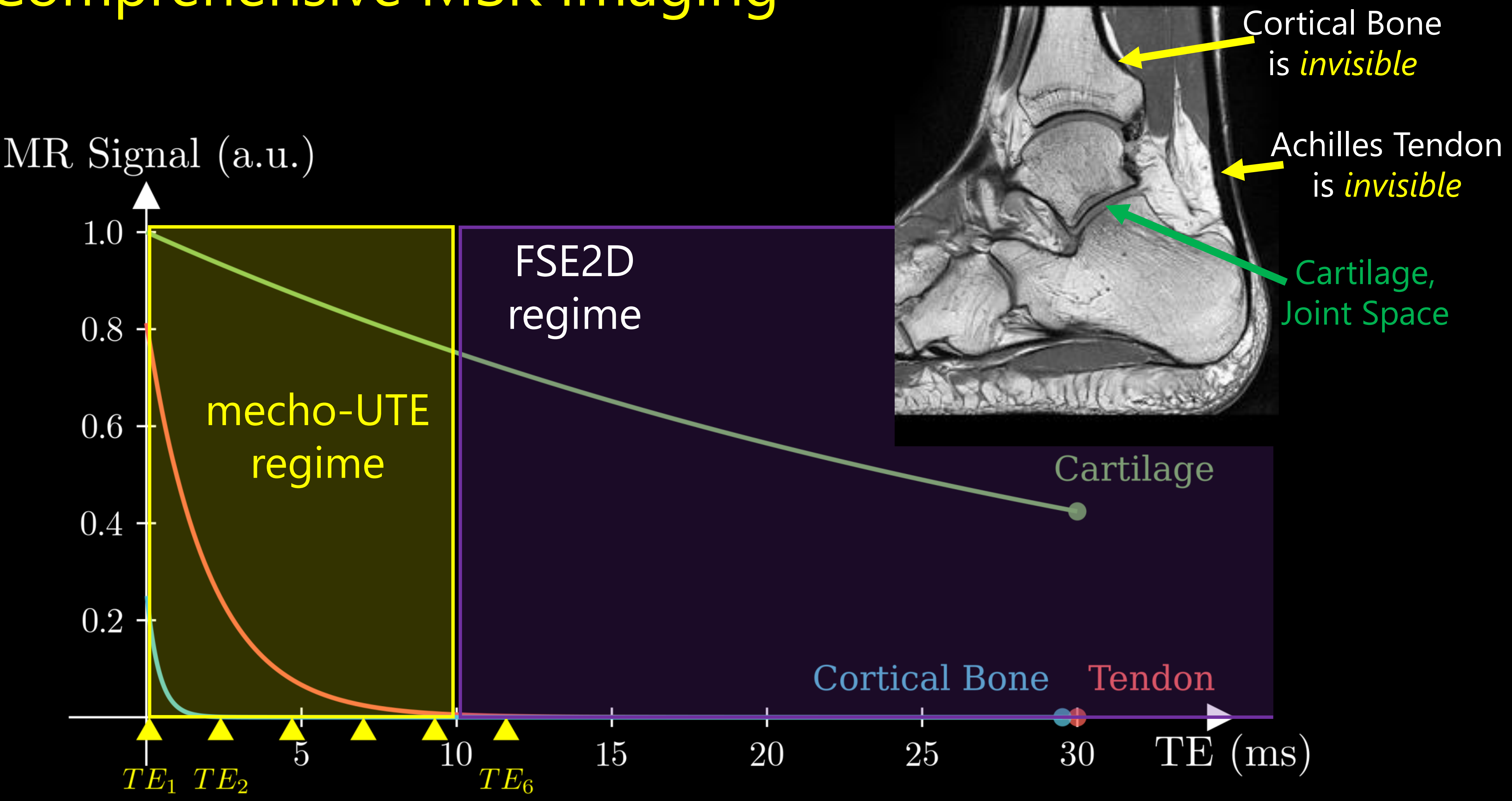
Declaration of Financial Interests or Relationships

Speaker Name: Hung P. Do, PhD MSEE

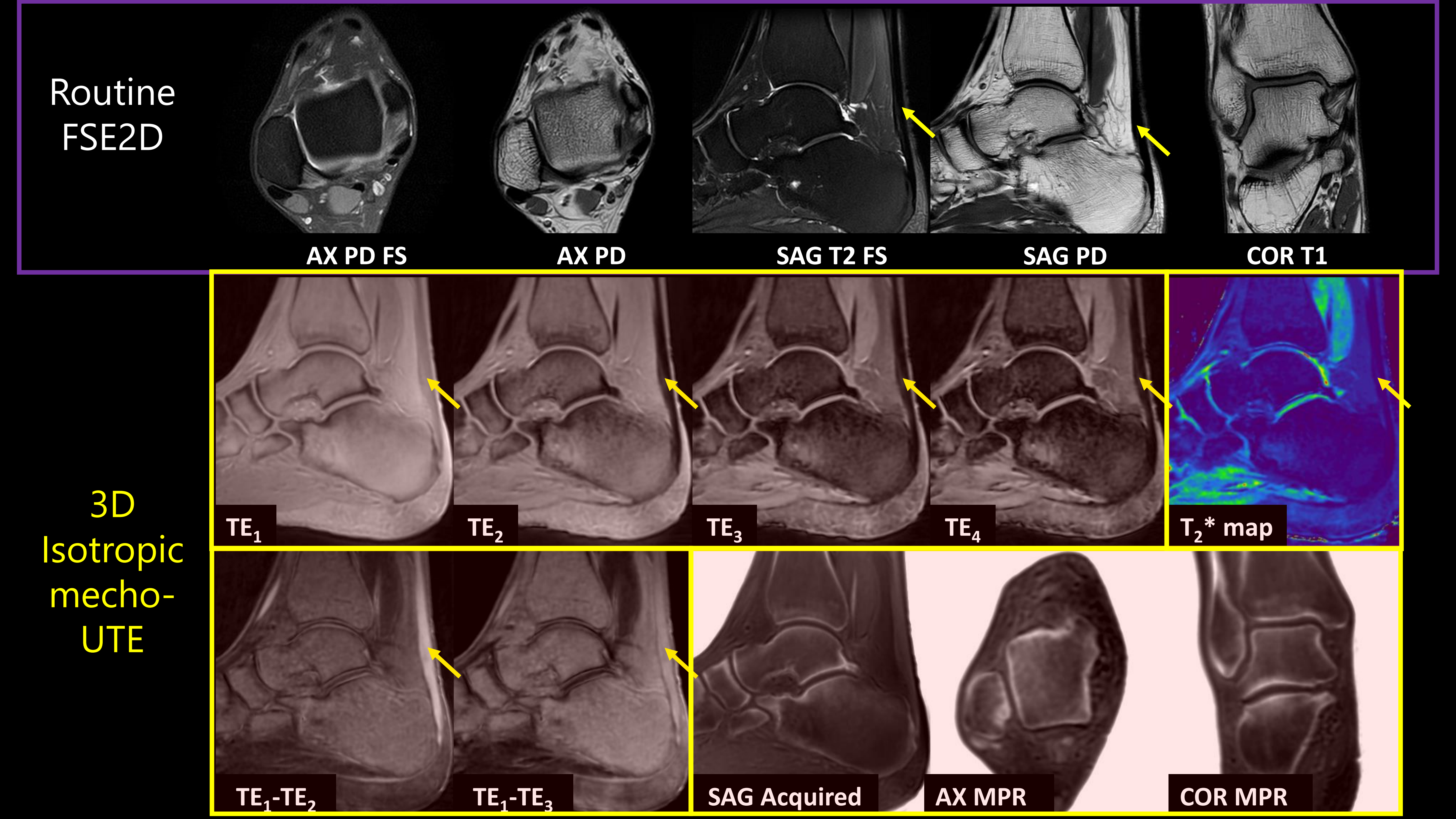
Company Name: Canon Medical Systems USA, Inc.

Type of Relationship: Employer

Comprehensive MSK Imaging



Hennig et al., Magn Reson Med. 1986;3:823-833.

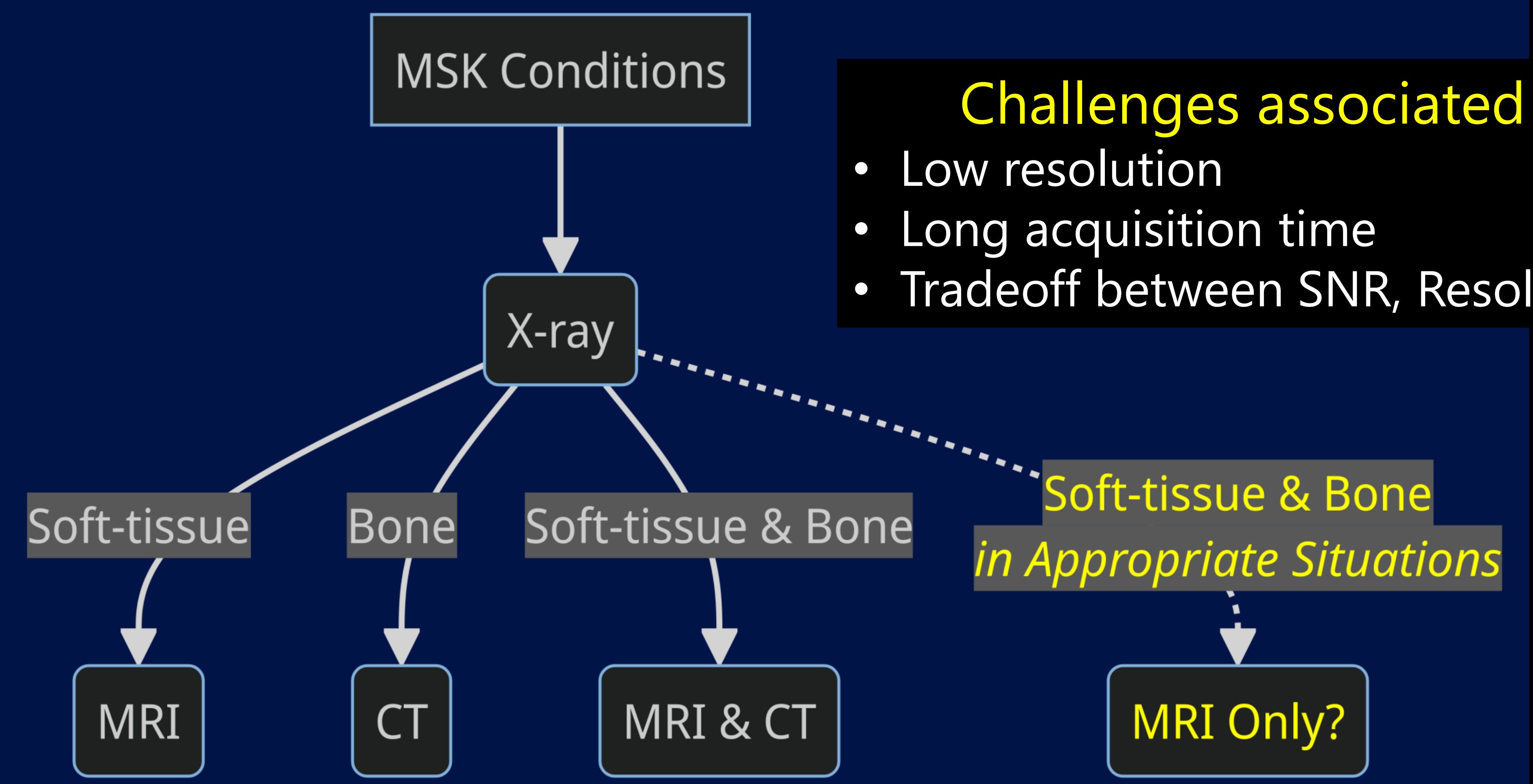


Routine FSE2D
AX PD FS
AX PD
SAG T2 FS
SAG PD
COR T1
3D Isotropic mecho-UTE
TE1
TE2
TE3
TE4
T2* map
TE1-TE2
TE1-TE3
SAG Acquired
AX MPR
COR MPR

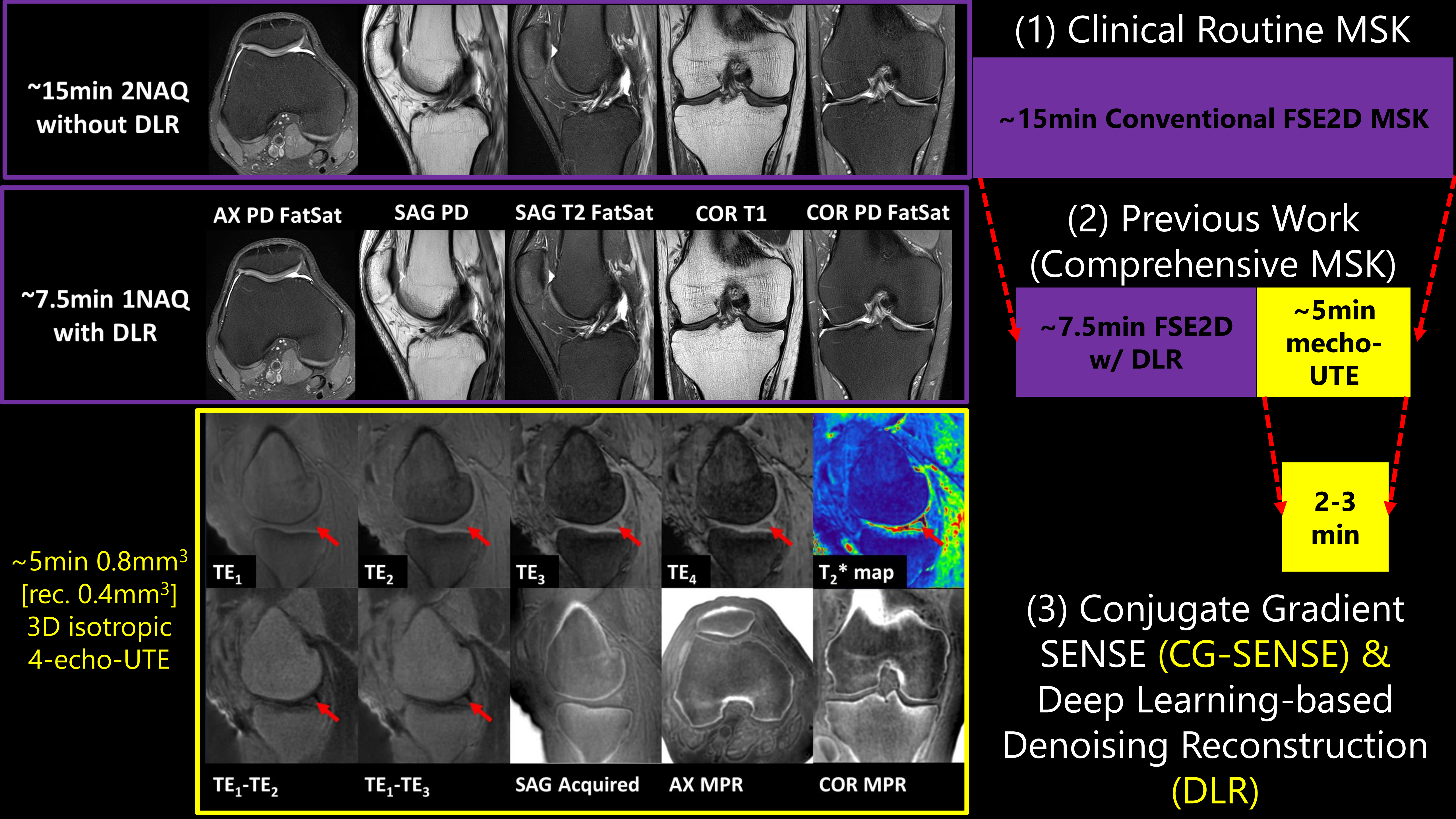
Goal: Improve IQ and Accelerate mecho-UTE using CG-SENSE and DLR, allowing it to be acquired in clinically relevant scan time

Challenges associated with UTE/ZTE

- Low resolution
- Long acquisition time
- Tradeoff between SNR, Resolution, and Scan time



Beaman et al., J Am Coll Radiol 2022;19:S473-S487.
Florkow et al., J Magn Reson Imaging 2022;56(1):11-34.



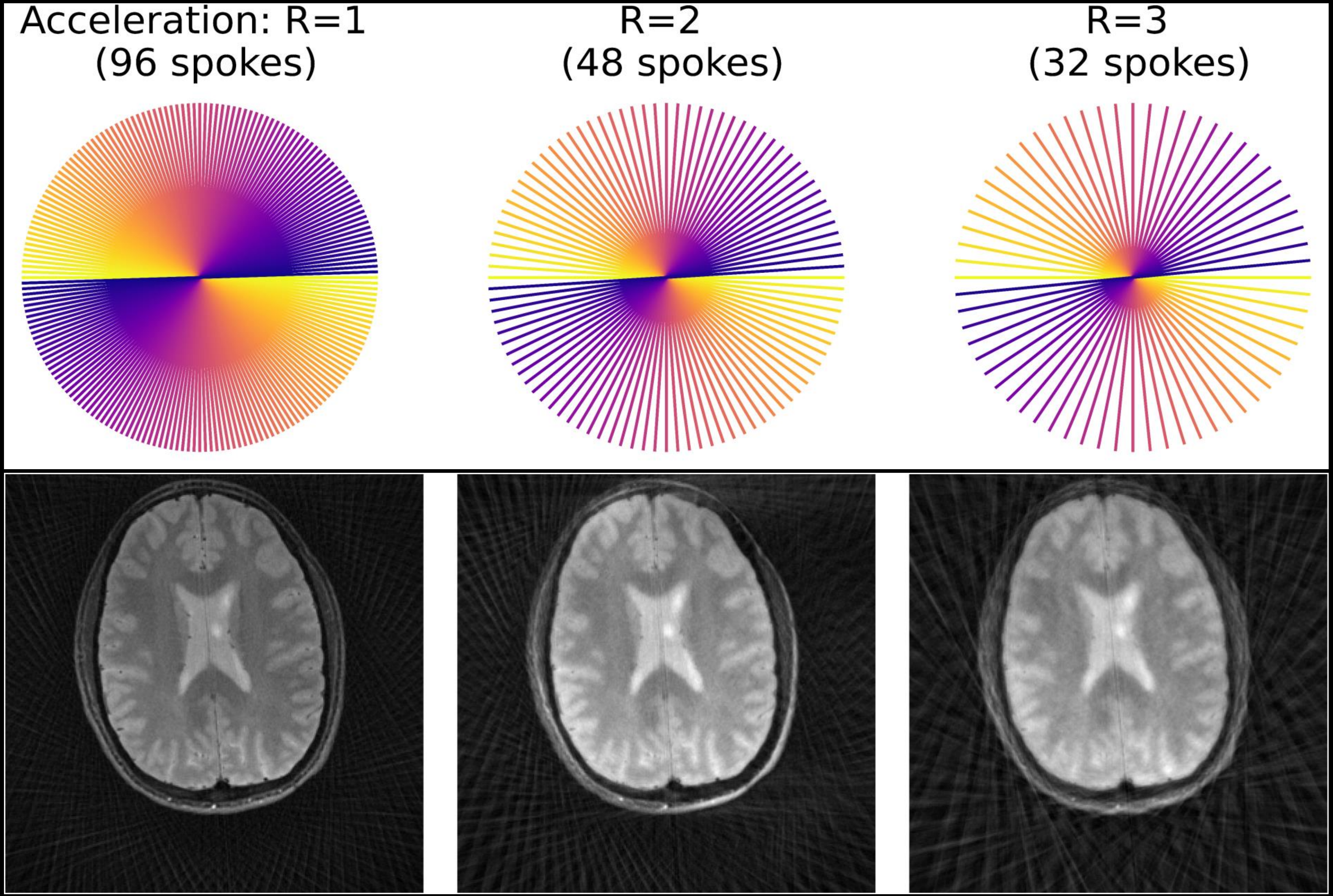
(1) Clinical Routine MSK
~15min Conventional FSE2D MSK
(2) Previous Work (Comprehensive MSK)
~7.5min FSE2D w/ DLR
~5min mecho-UTE
2-3 min
(3) Conjugate Gradient SENSE (CG-SENSE) & Deep Learning-based Denoising Reconstruction (DLR)
~15min 2NAQ without DLR
~7.5min 1NAQ with DLR
AX PD FatSat
SAG PD
SAG T2 FatSat
COR T1
COR PD FatSat
~5min 0.8mm³ [rec. 0.4mm³] 3D isotropic 4-echo-UTE
TE1
TE2
TE3
TE4
T2* map
TE1-TE2
TE1-TE3
SAG Acquired
AX MPR
COR MPR

CG-SENSE

Conjugate Gradient SENSE: Parallel Imaging for arbitrary k-space

Radial kspace trajectories

Gridding reconstruction

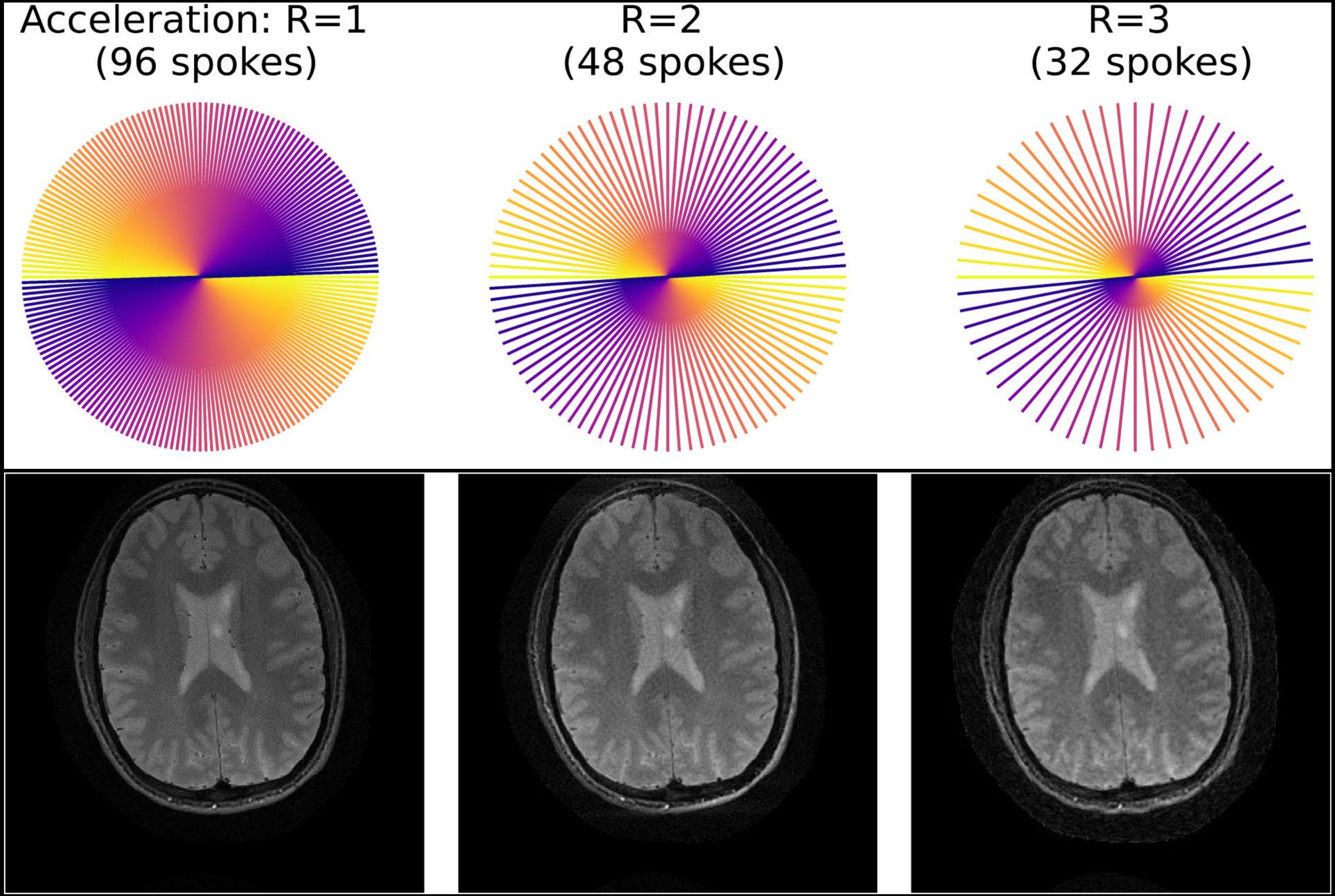


Pruessmann et al., Magn Reson Med. 2001;46:638-651.
Maier et al., Magn Reson Med. 2021;85:1821-1839.

CG-SENSE

Conjugate Gradient SENSE: Parallel Imaging for arbitrary k-space

Radial kspace trajectories



CG-SENSE reconstruction

Pruessmann et al., Magn Reson Med. 2001;46:638-651.
Maier et al., Magn Reson Med. 2021;85:1821-1839.

Methods

Healthy Subjects (1 Shoulder and 4 Knees) were scanned using a
Vantage Galan 3T MRI (Canon Medical Systems, Tochigi, Japan)

5-min mecho-UTE

3-min mecho-UTE

2-min mecho-UTE

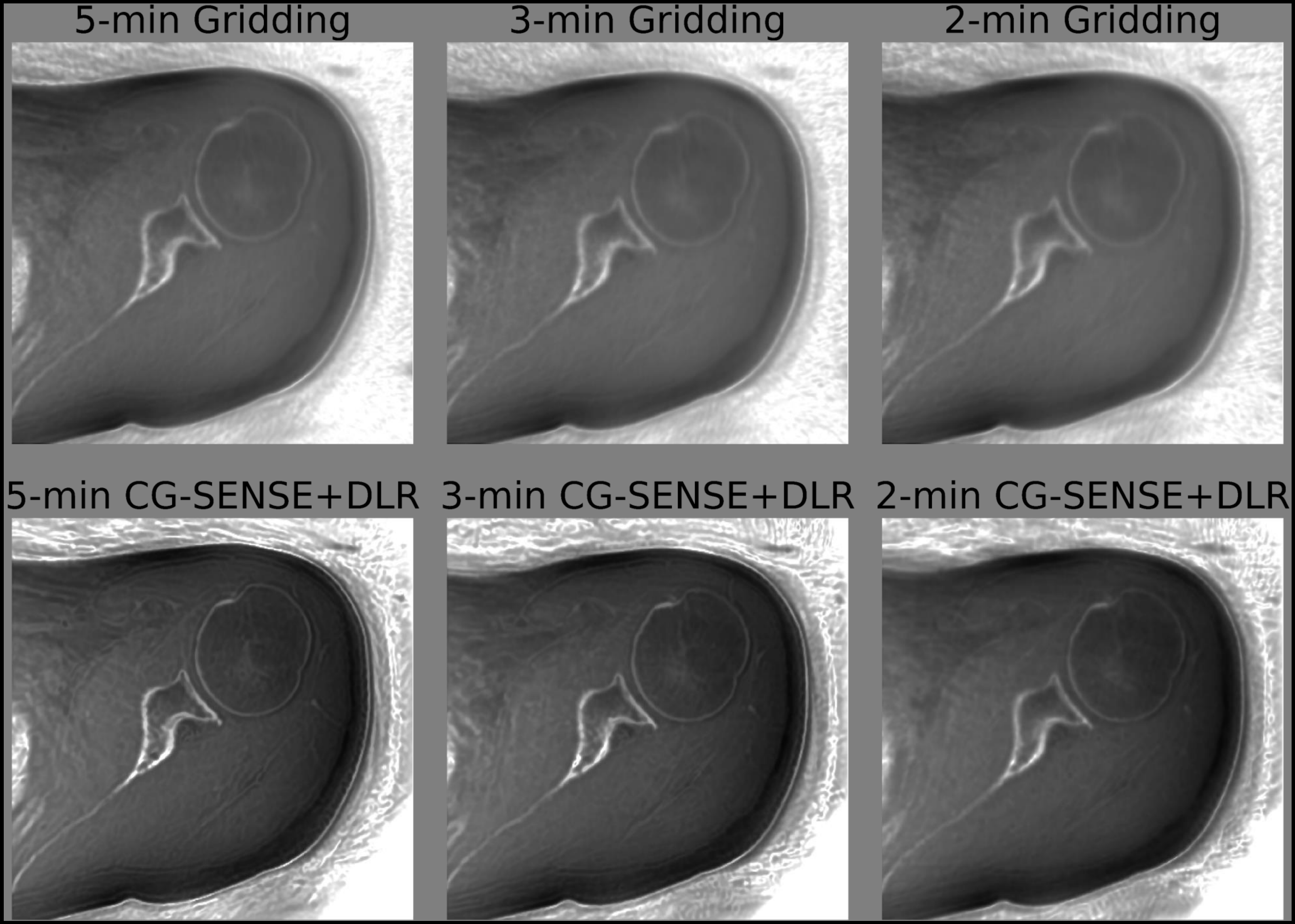
Each was reconstructed:

- Gridding *i.e., conventional recon*
- CG-SENSE & DLR

Qualitative and Quantitative comparisons:

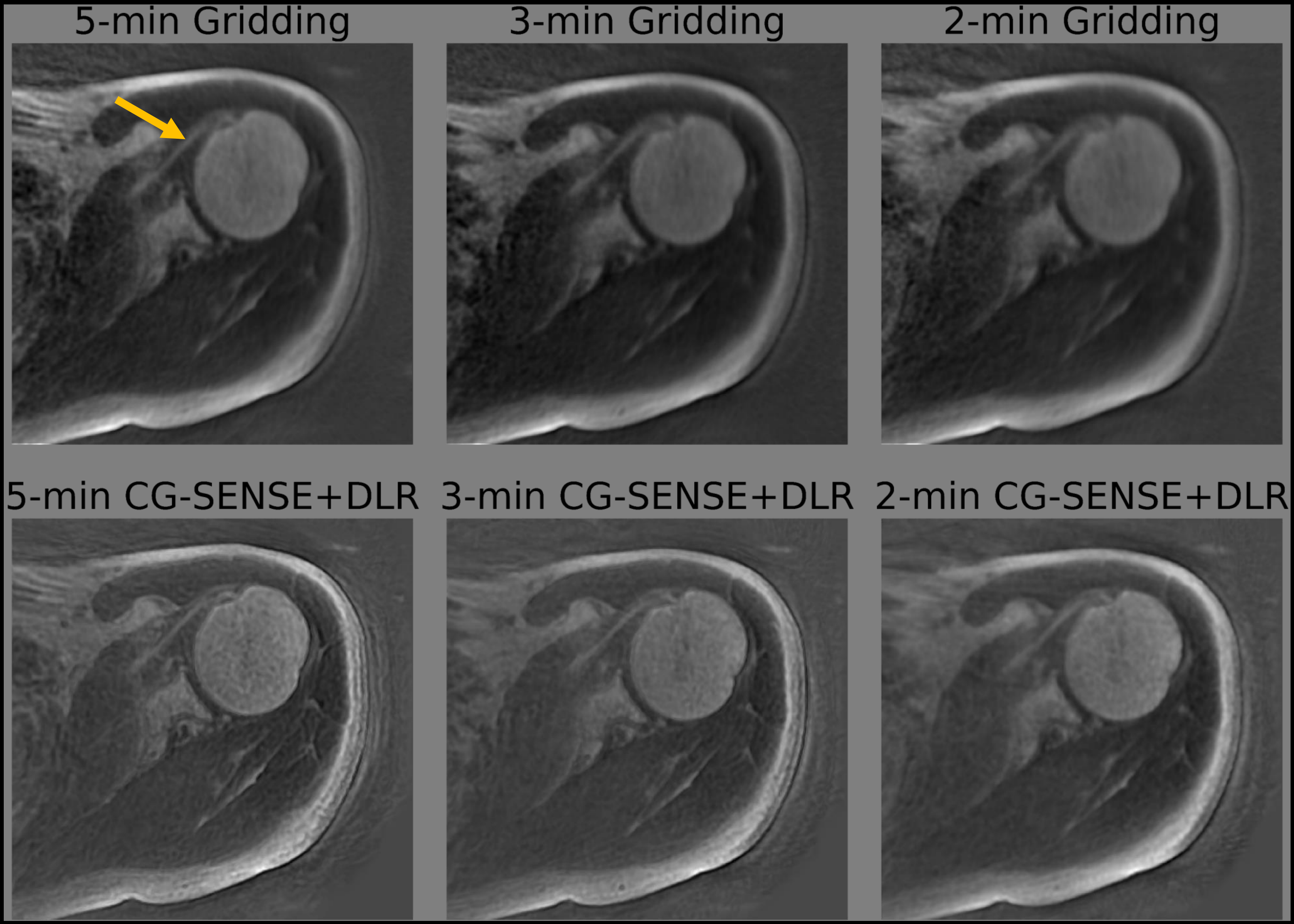
- Visual inspection
- Image Resolution: *Full-Width at Half-Maximum (FWHM)*
- Image Sharpness: *Relative Edge SHarpness (RESH)*
- Tendon's Quantitative T2* Values

CT-like Images



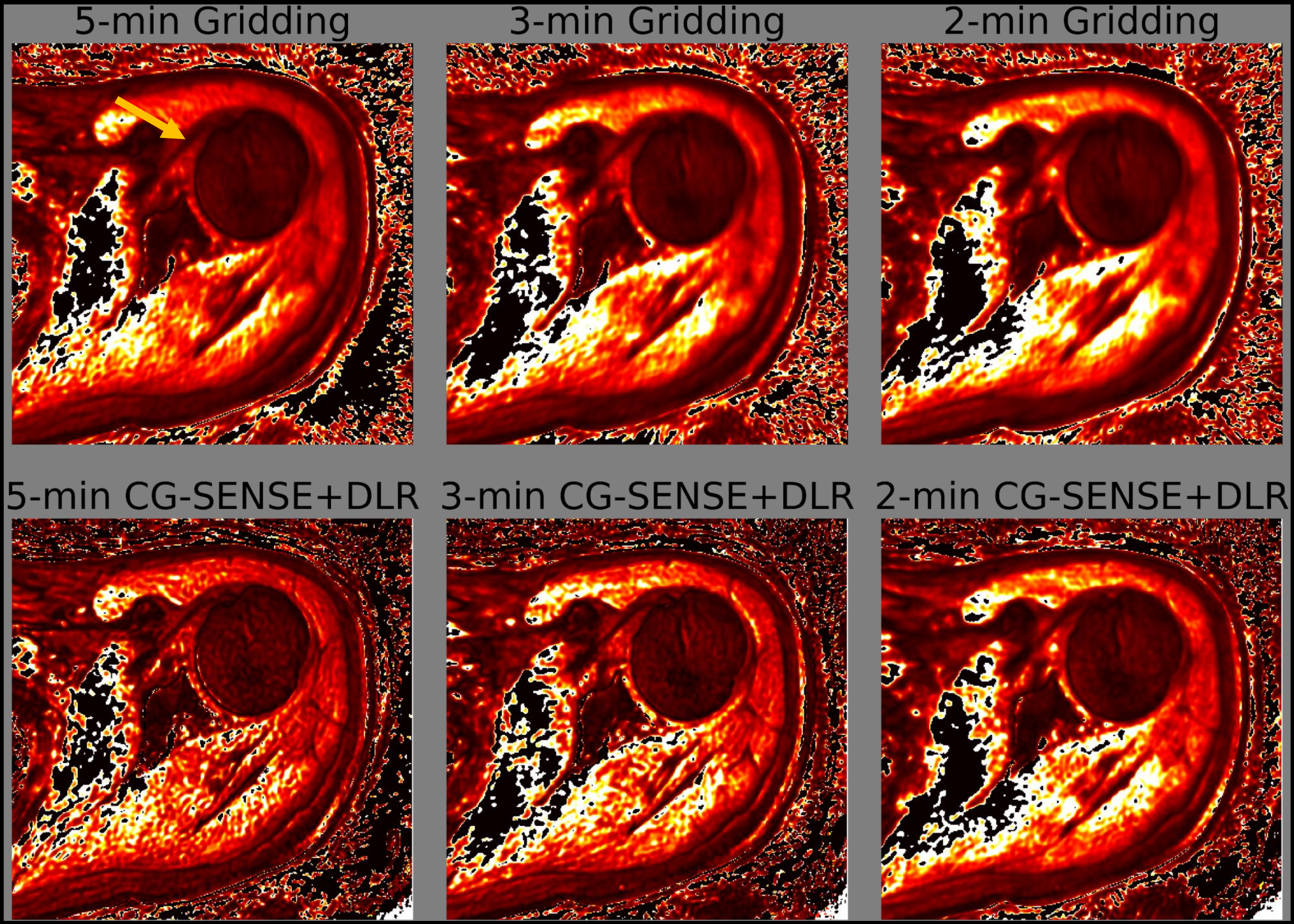
Arrow is pointing to Tendon

Visualization of Ultrashort-T2* Tissues

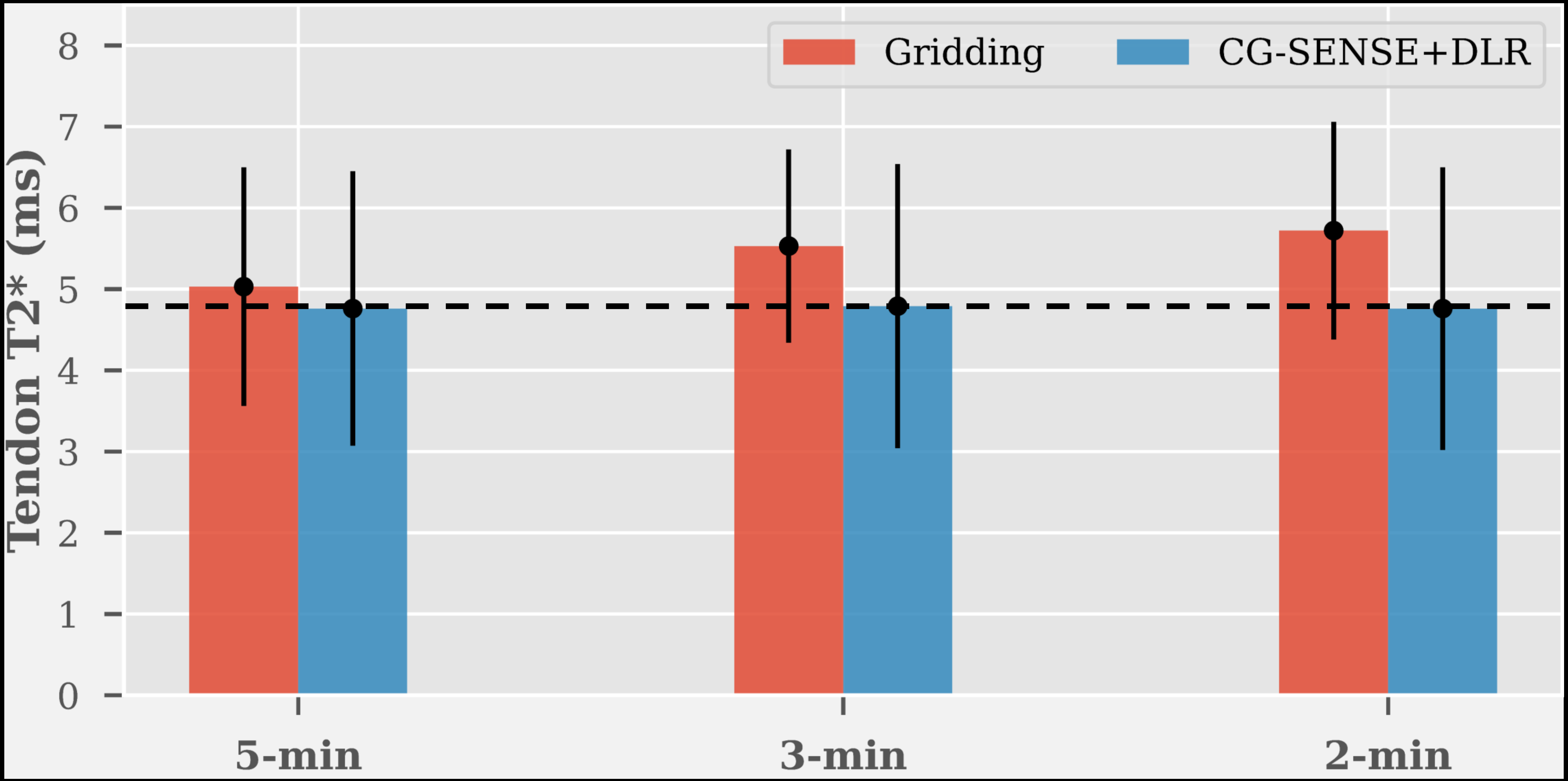


Arrow is pointing to Tendon

Quantitative T2* Maps

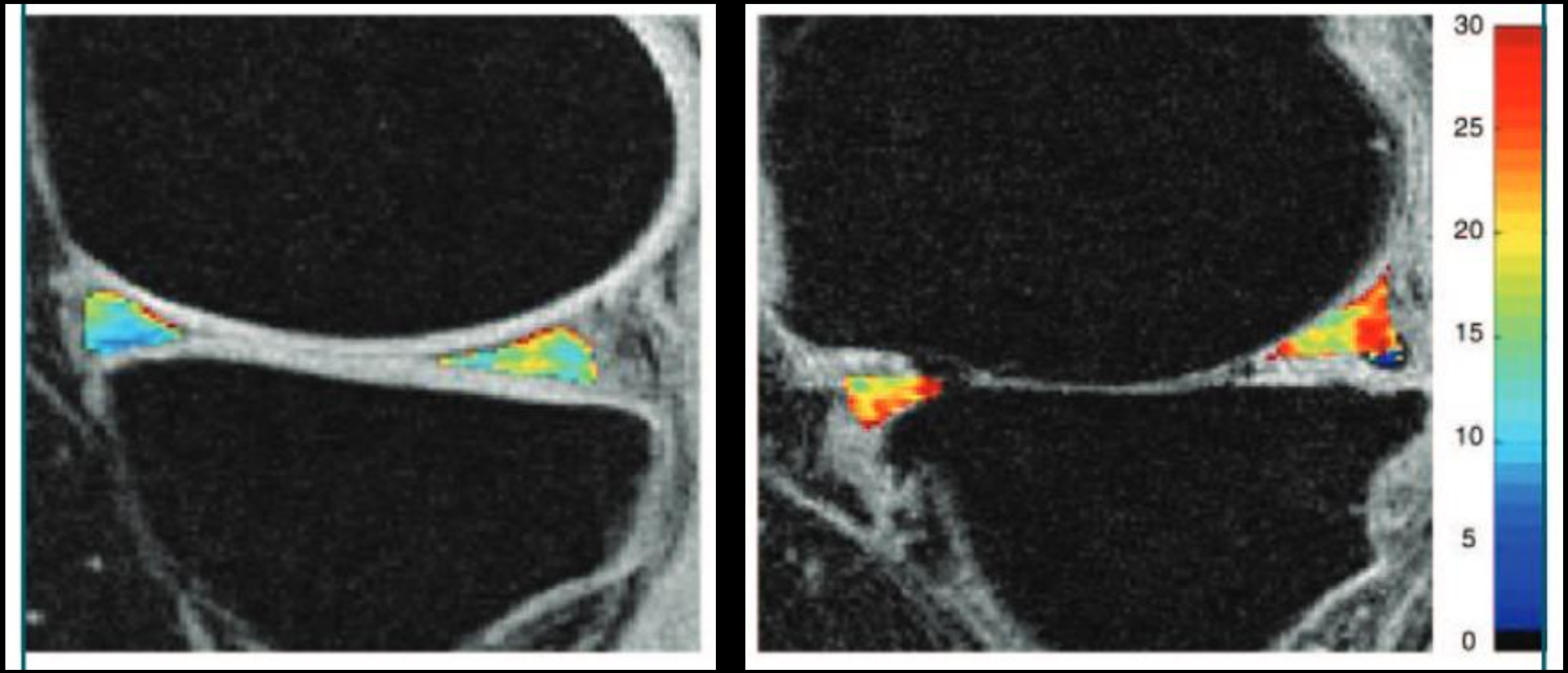


Tendon's Quantitative T2* Measures



T2* Elevations associated with Disease

Healthy Control | Patient with osteoarthritis (OA)

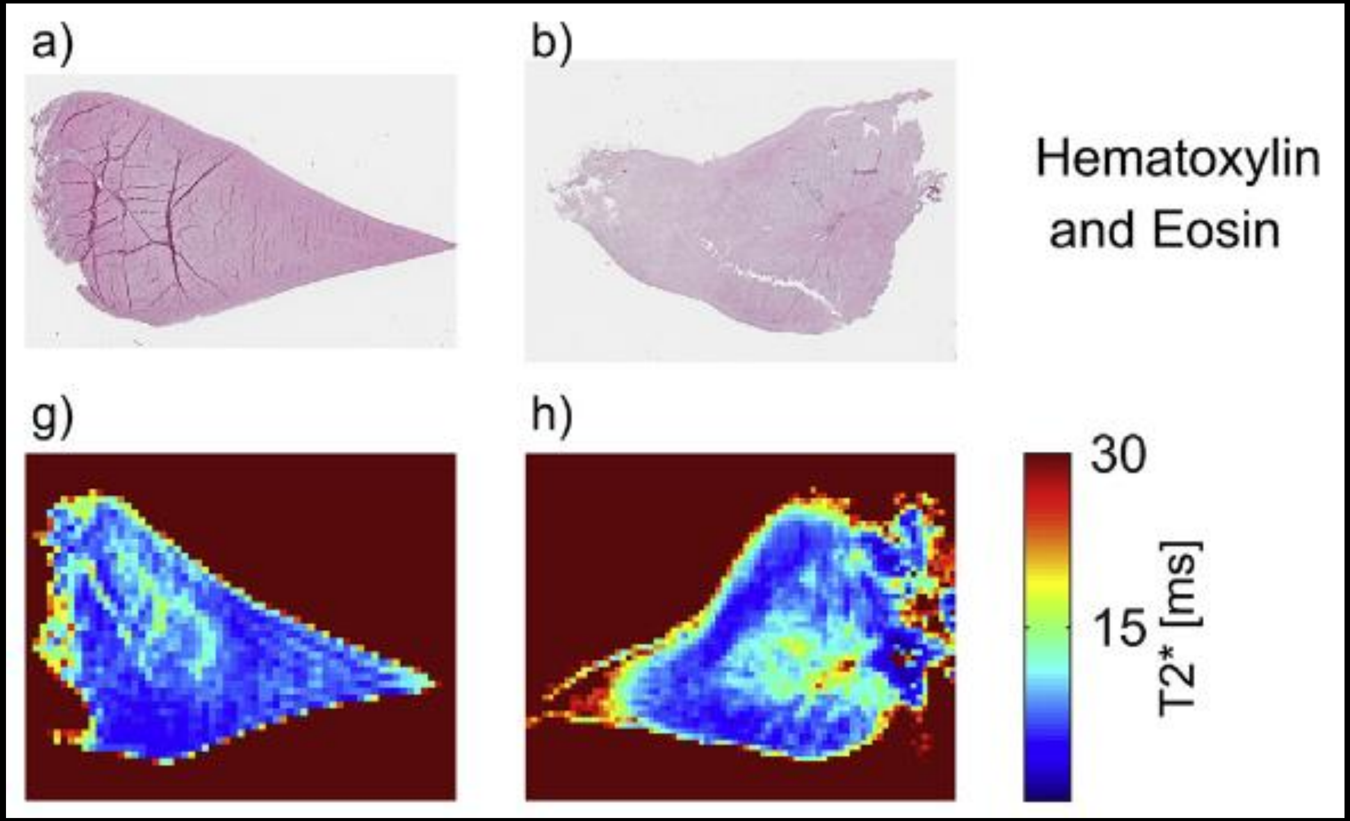


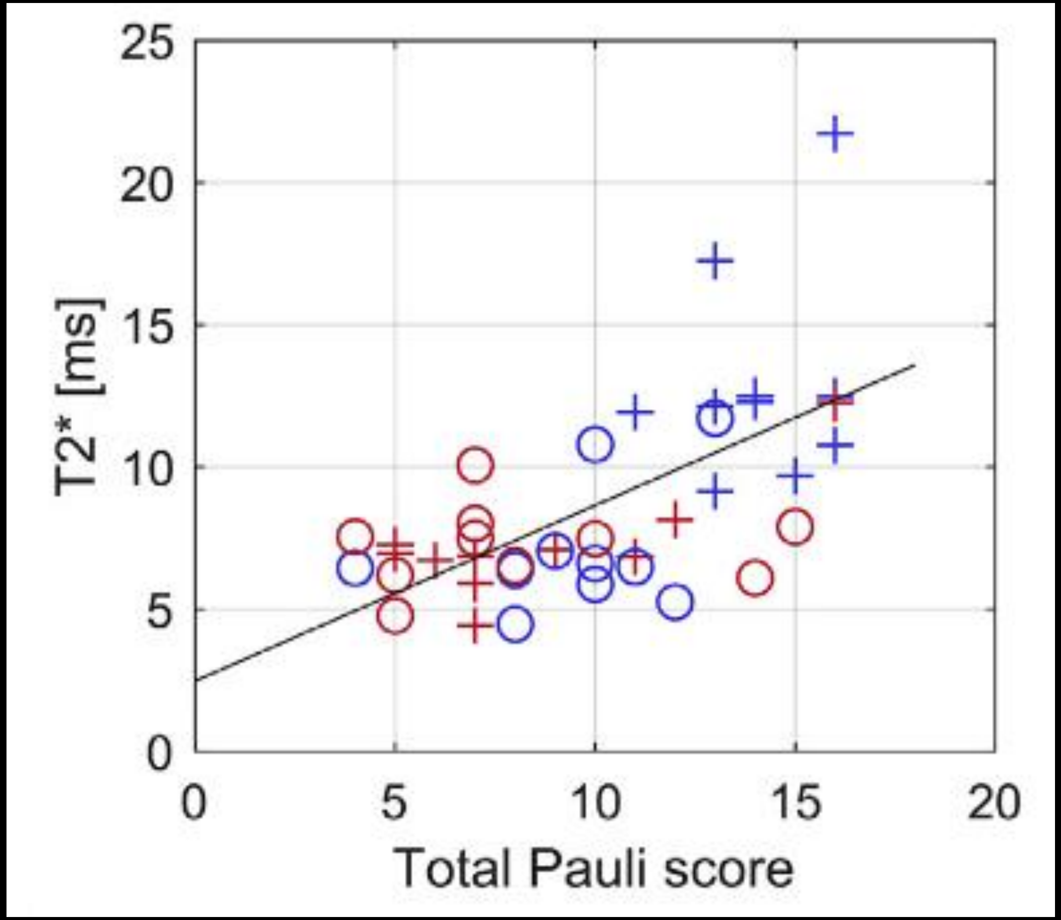
Rauscher et al., Radiology: Volume 249: Number 2—November 2008

T2* Elevations associated with Disease

Normal
Score = 4

Degenerated
Score = 13

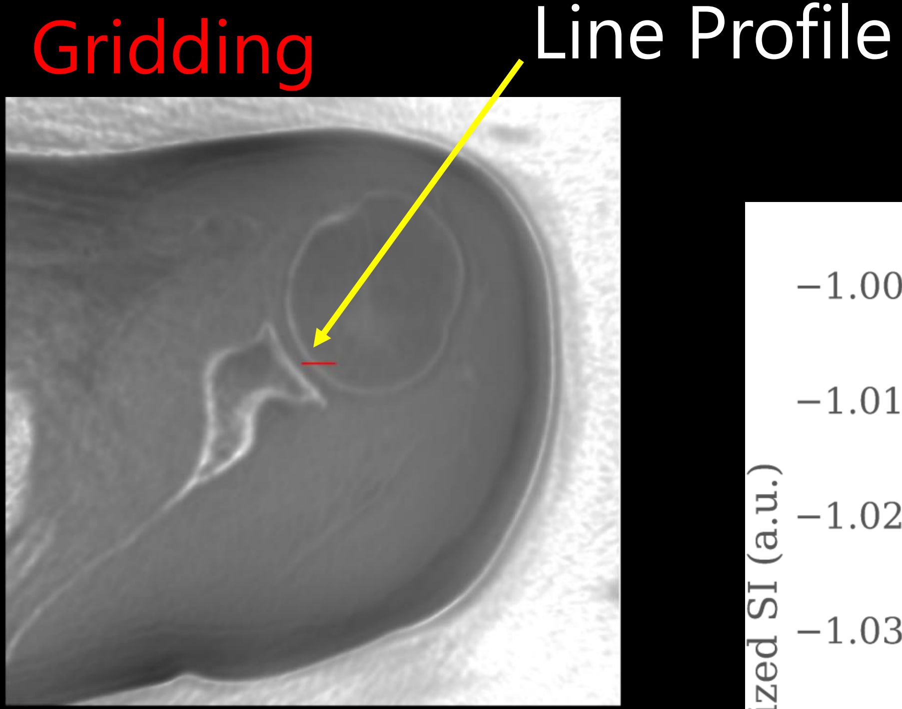




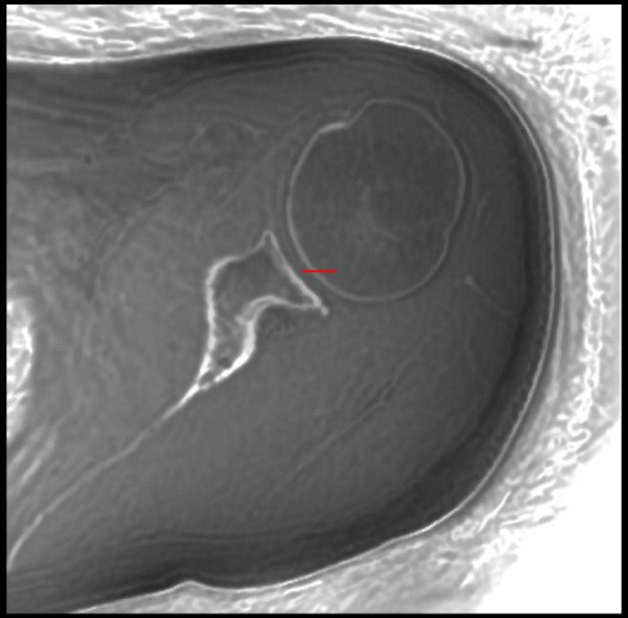
Einarsson et al., Osteoarthritis and Cartilage Open 2 (2020) 100061

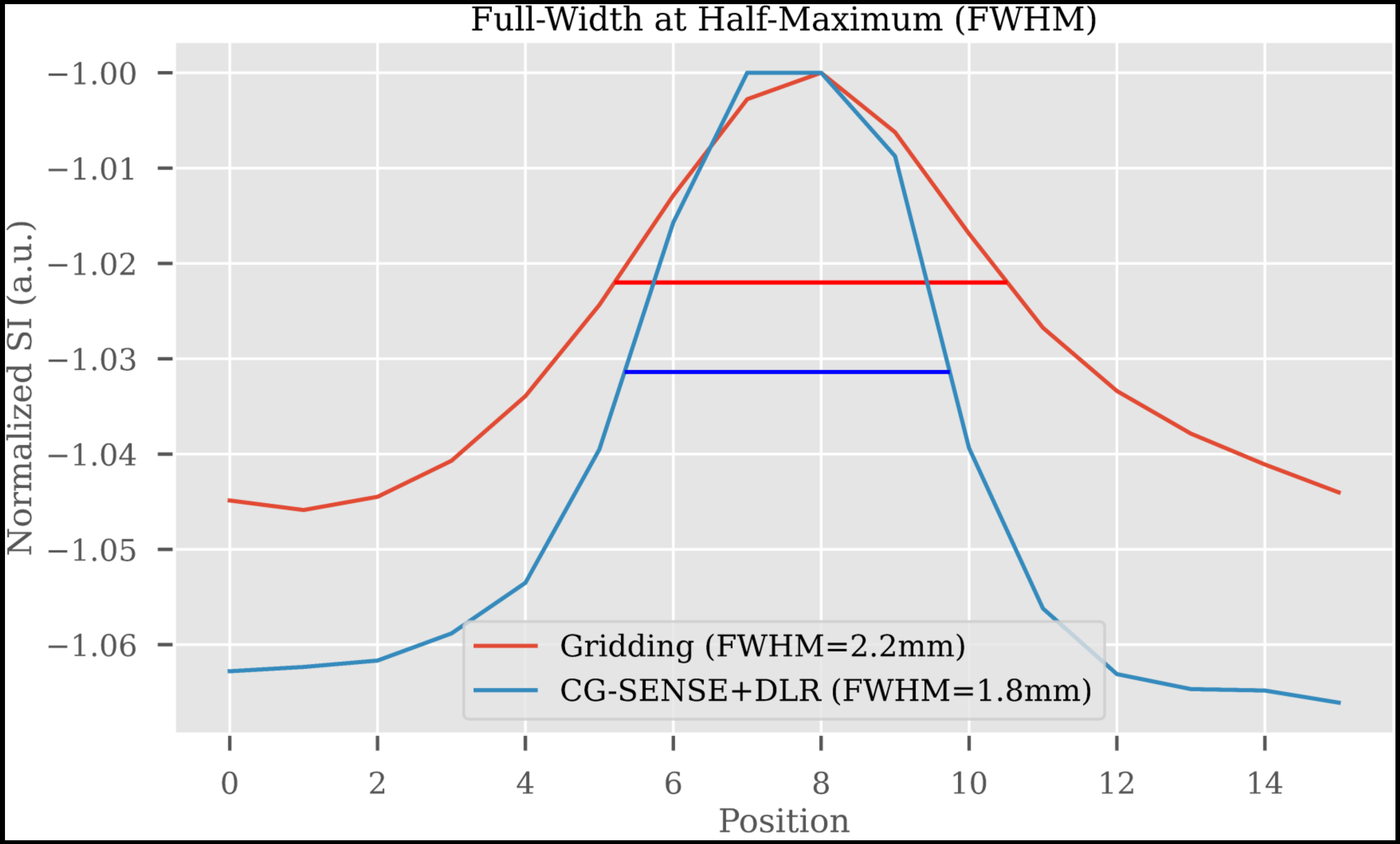
Quantify Resolution

Gridding

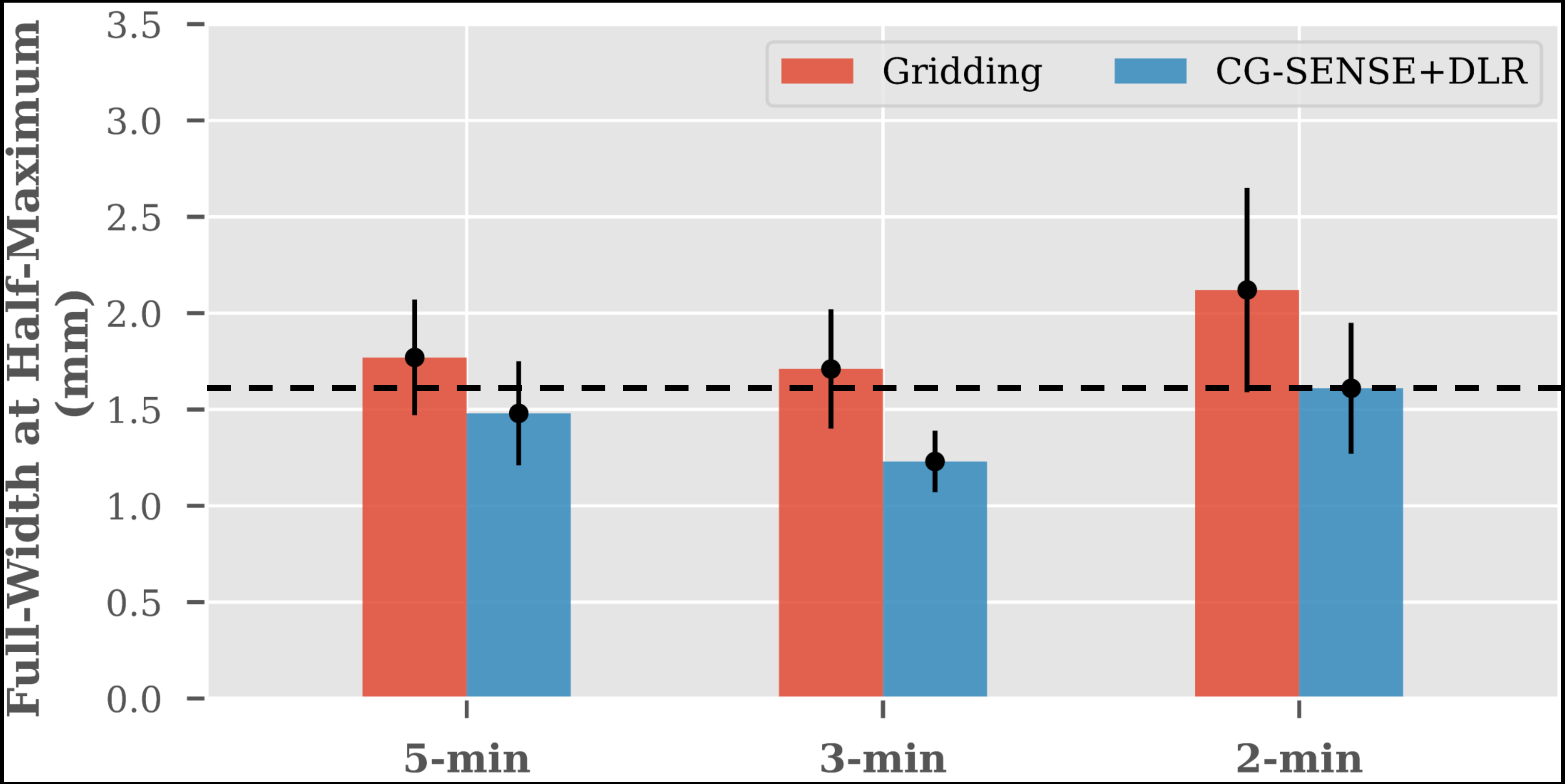


CG-SENSE+DLR



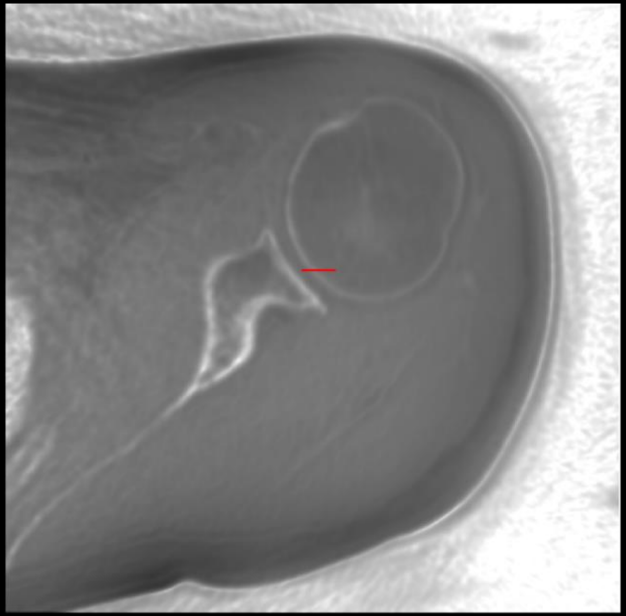


~23% higher Resolution with CG-SENSE+DLR

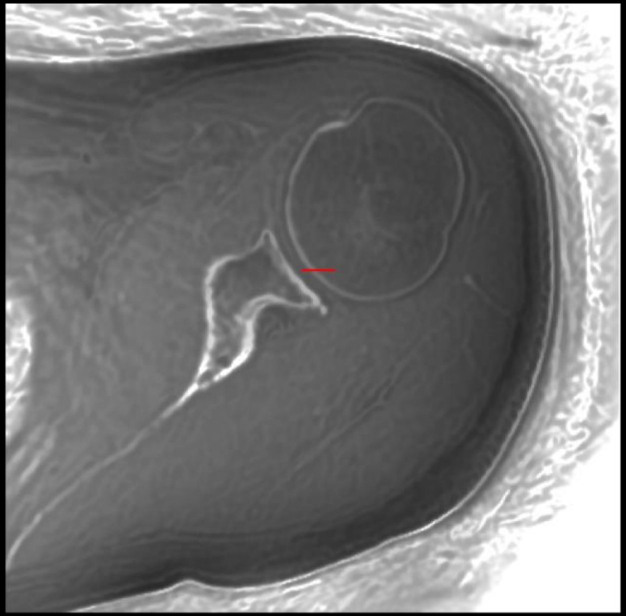


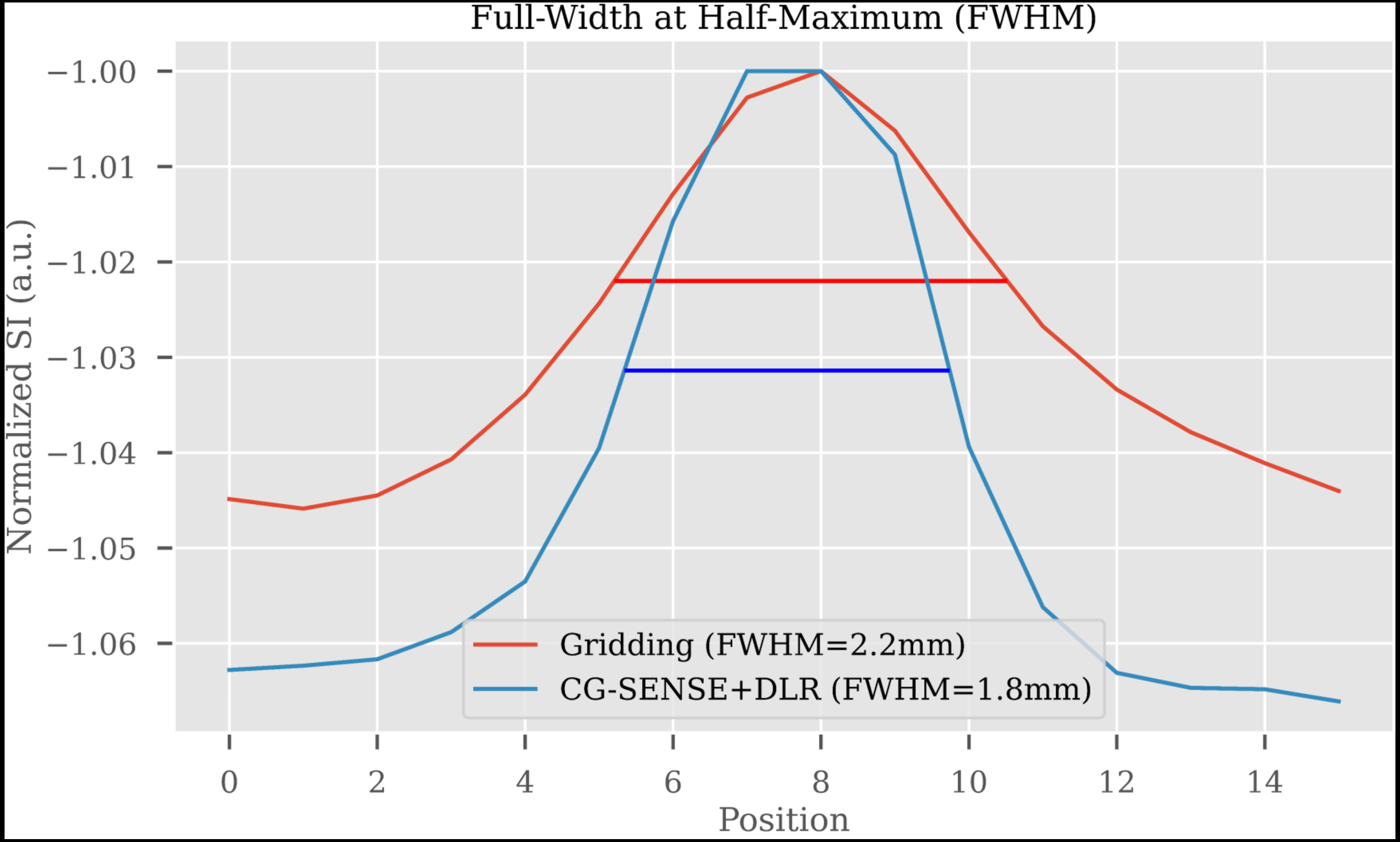
Quantify Image Sharpness using Relative Edge Sharpness (RESH)

Gridding



CG-SENSE+DLR

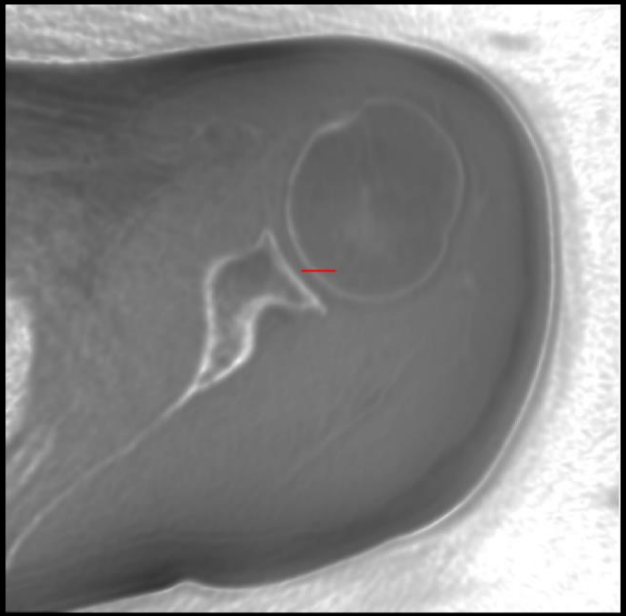




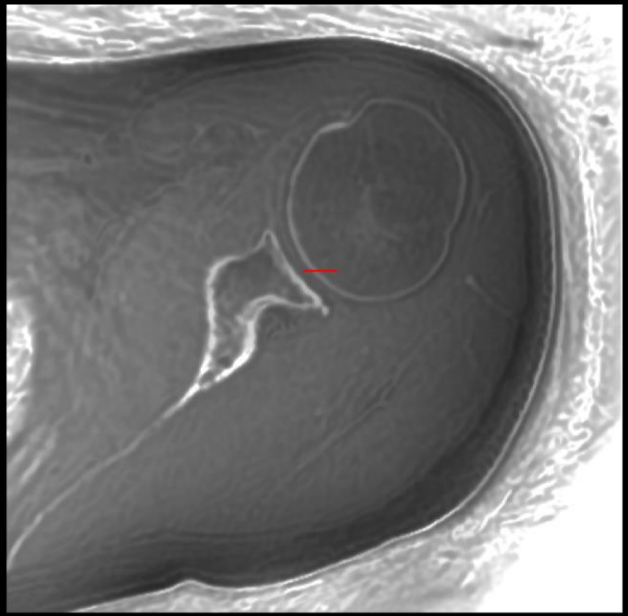
Lebel et al., ArXiv200806559

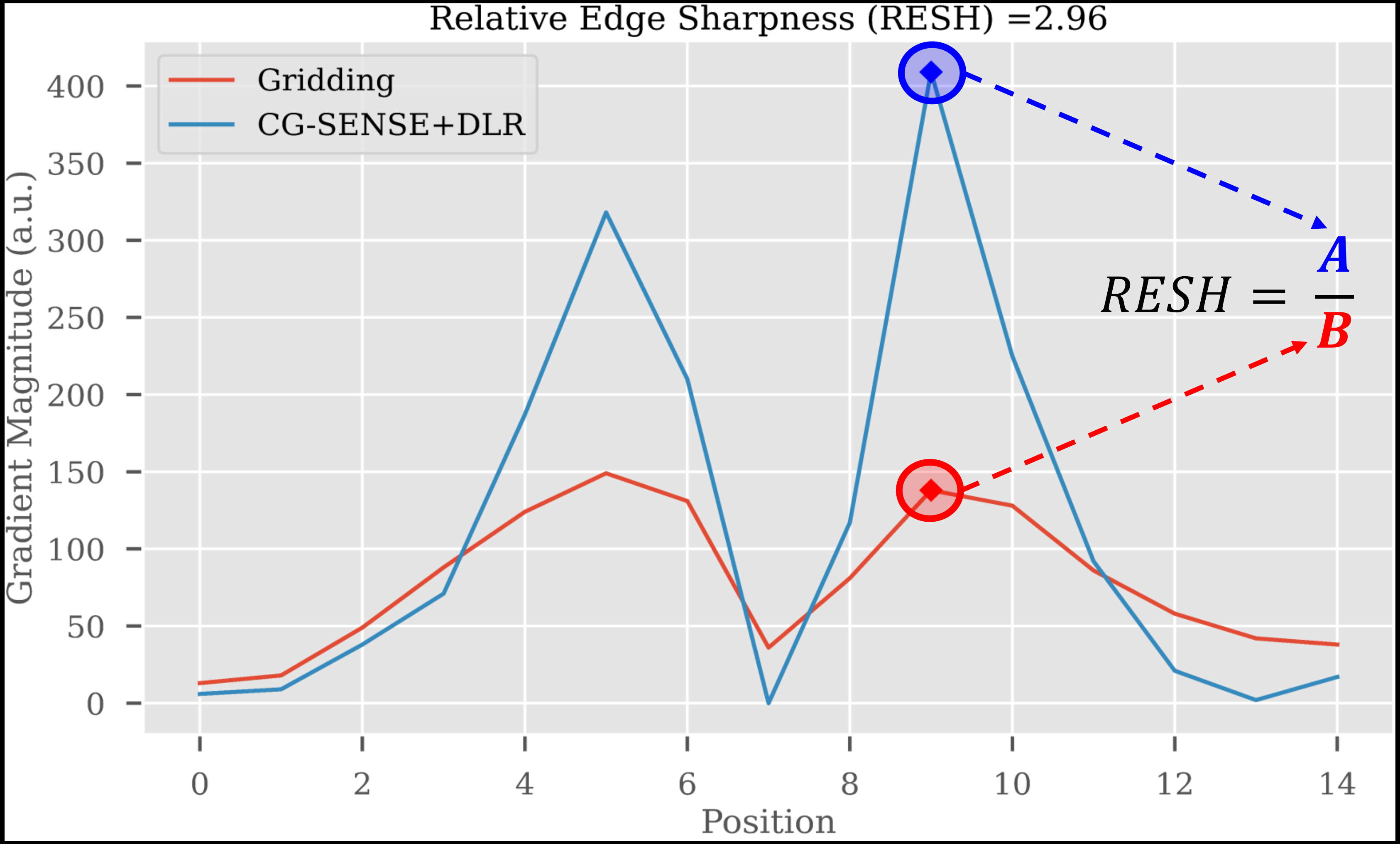
Quantify Image Sharpness using Relative Edge Sharpness (RESH)

Gridding



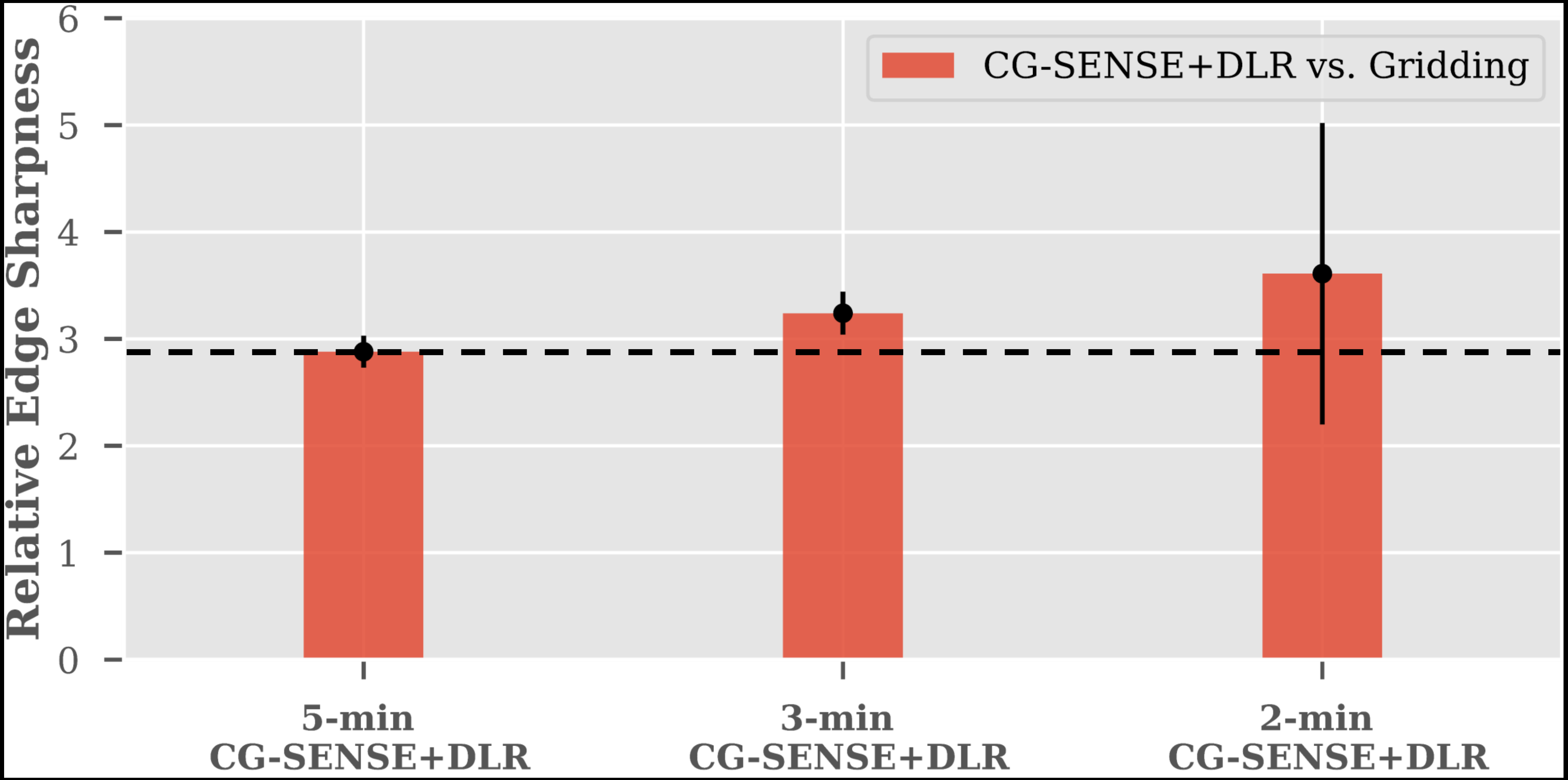
CG-SENSE+DLR



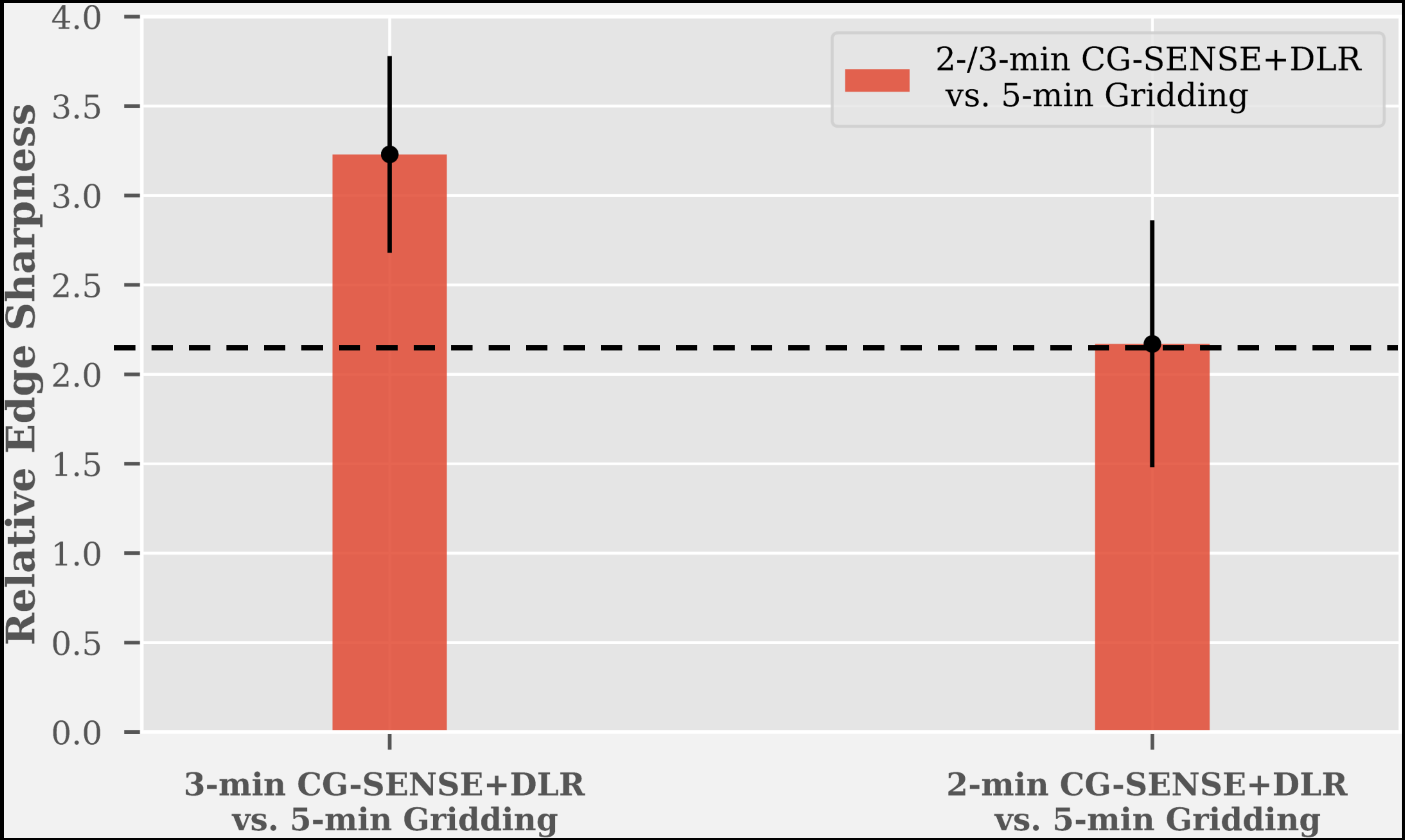


Lebel et al., ArXiv200806559

~3X higher Image Sharpness with CG-SENSE+DLR



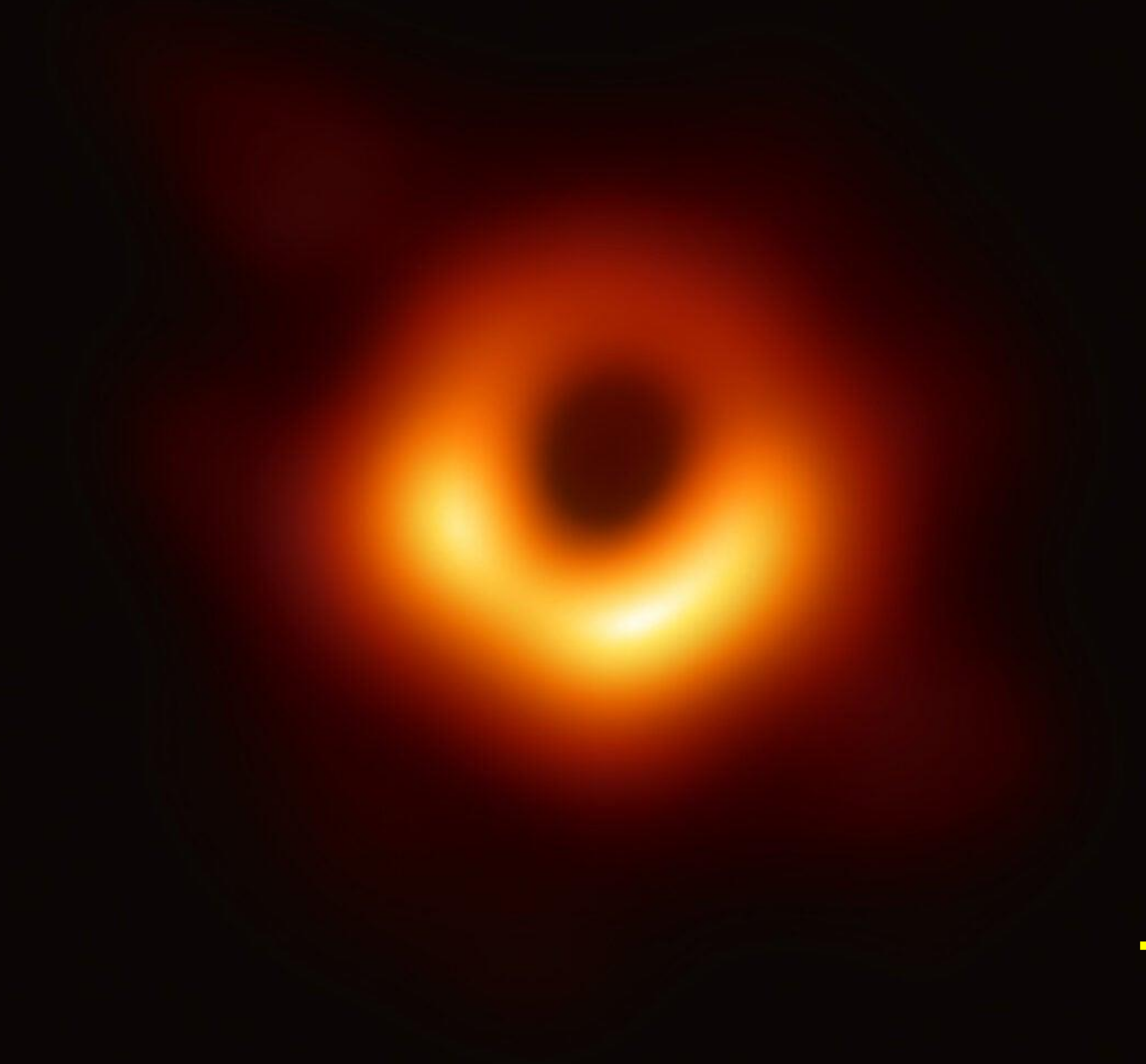
~3X higher Image Sharpness with CG-SENSE+DLR



Conclusion

- CG-SENSE+DLR *improves resolution and image sharpness* compared to conventional gridding reconstruction.
- CG-SENSE+DLR enables *3- and 2-min mecho-UTE* with *higher resolution and image sharpness* vs. *5-min mecho-UTE* with conventional Gridding reconstruction.
- Routine FSE2D+mecho-UTE may enable *one-stop-shop for MSK Imaging.*
- Future work will focus on
  - *(1) head-to-head comparison with CT* in patients
  - *(2) further improving resolution using DL-based super-resolution*

"See the Unseeable[1]" *The first-ever image of a black hole*

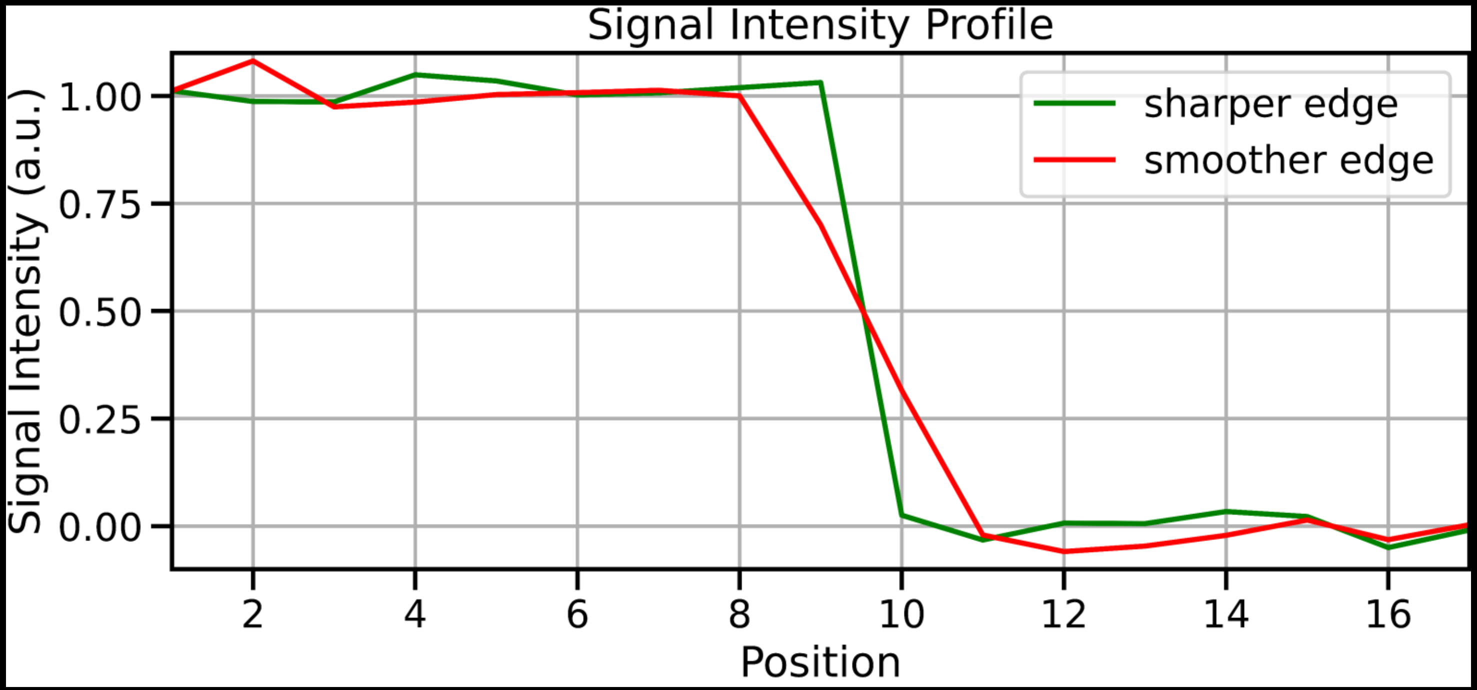


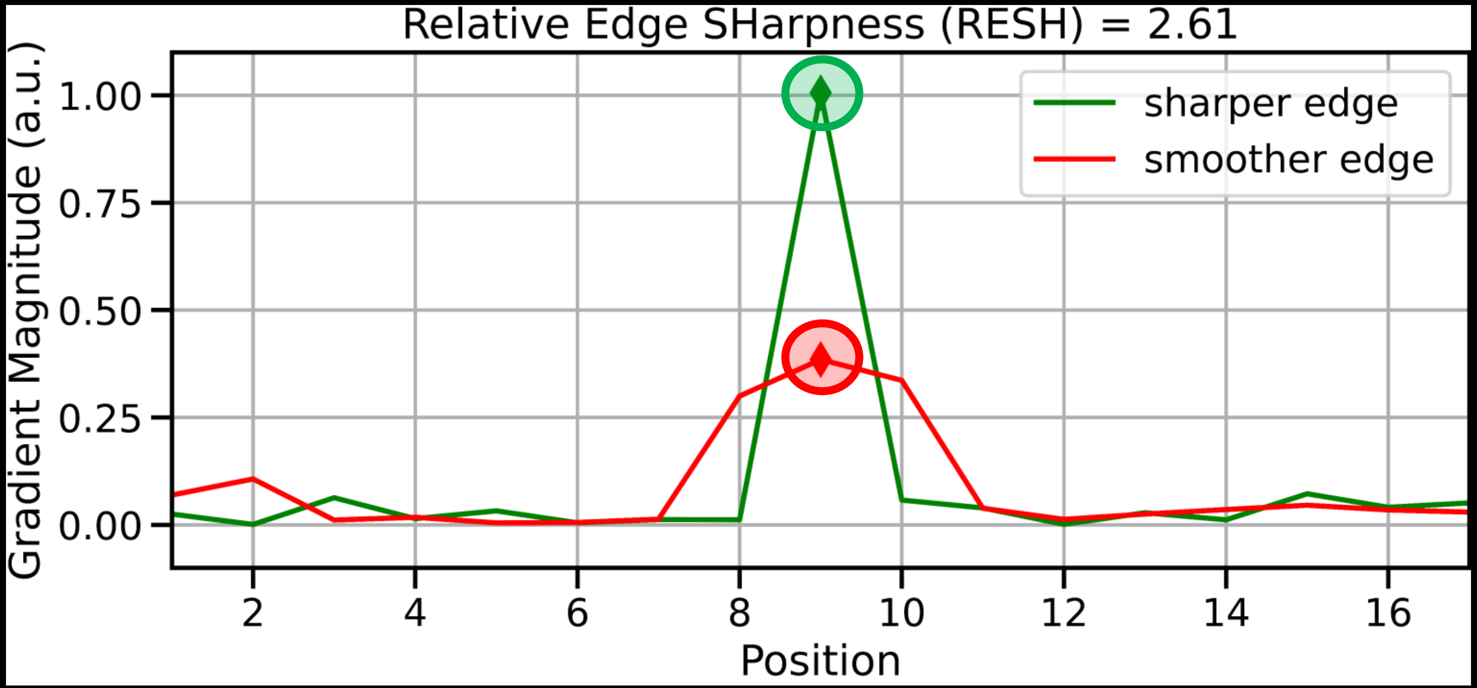
Thank you!

[1]. https://news.harvard.edu/gazette/story/2019/04/harvard-scientists-lead-team-revealing-black-hole/

Quantify Image Sharpness

using Relative Edge Sharpness (RESH)





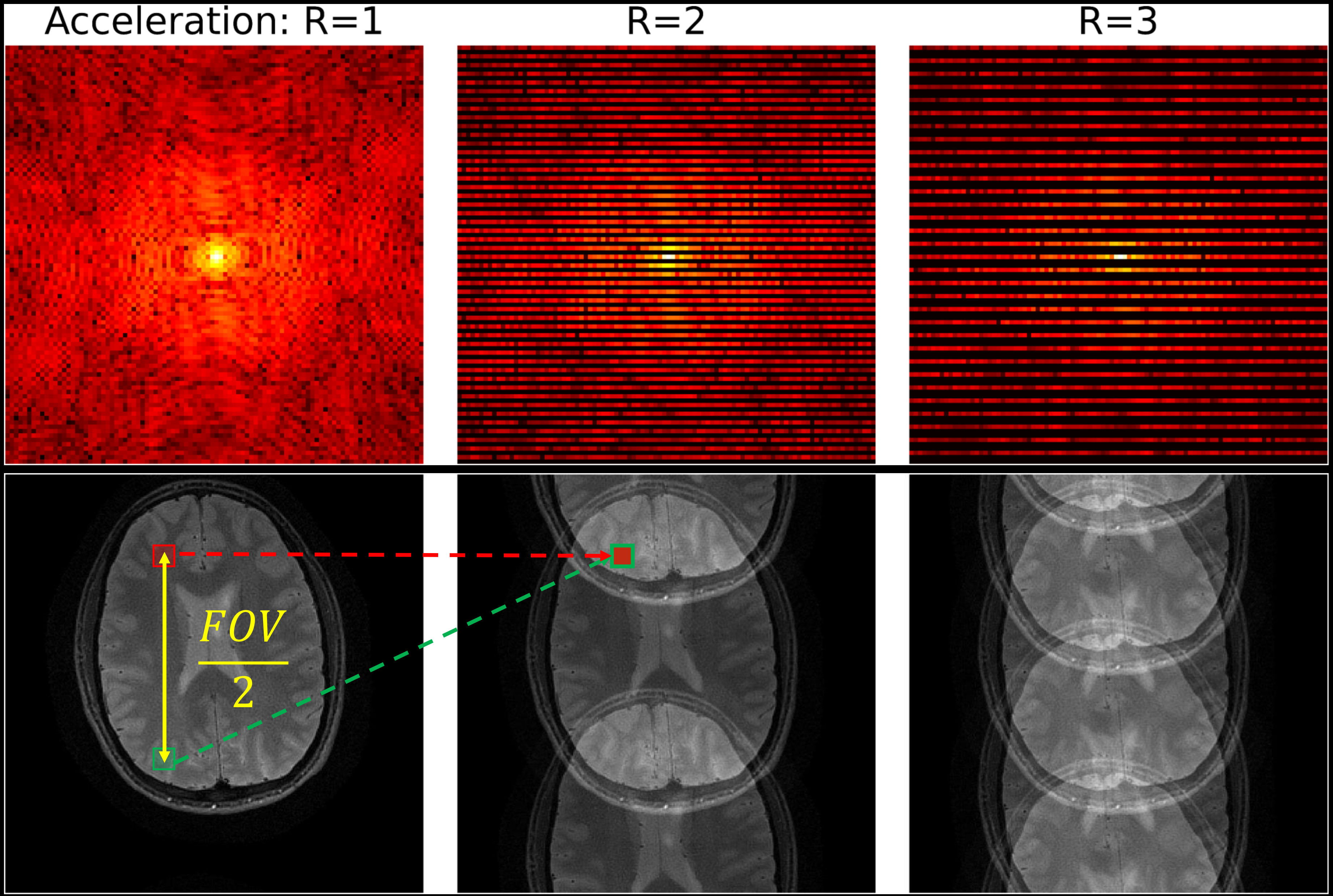
Lebel et al., ArXiv200806559

SENSE

Sensitivity Encoding: Parallel Imaging for Cartesian k-space

Cartesian kspace

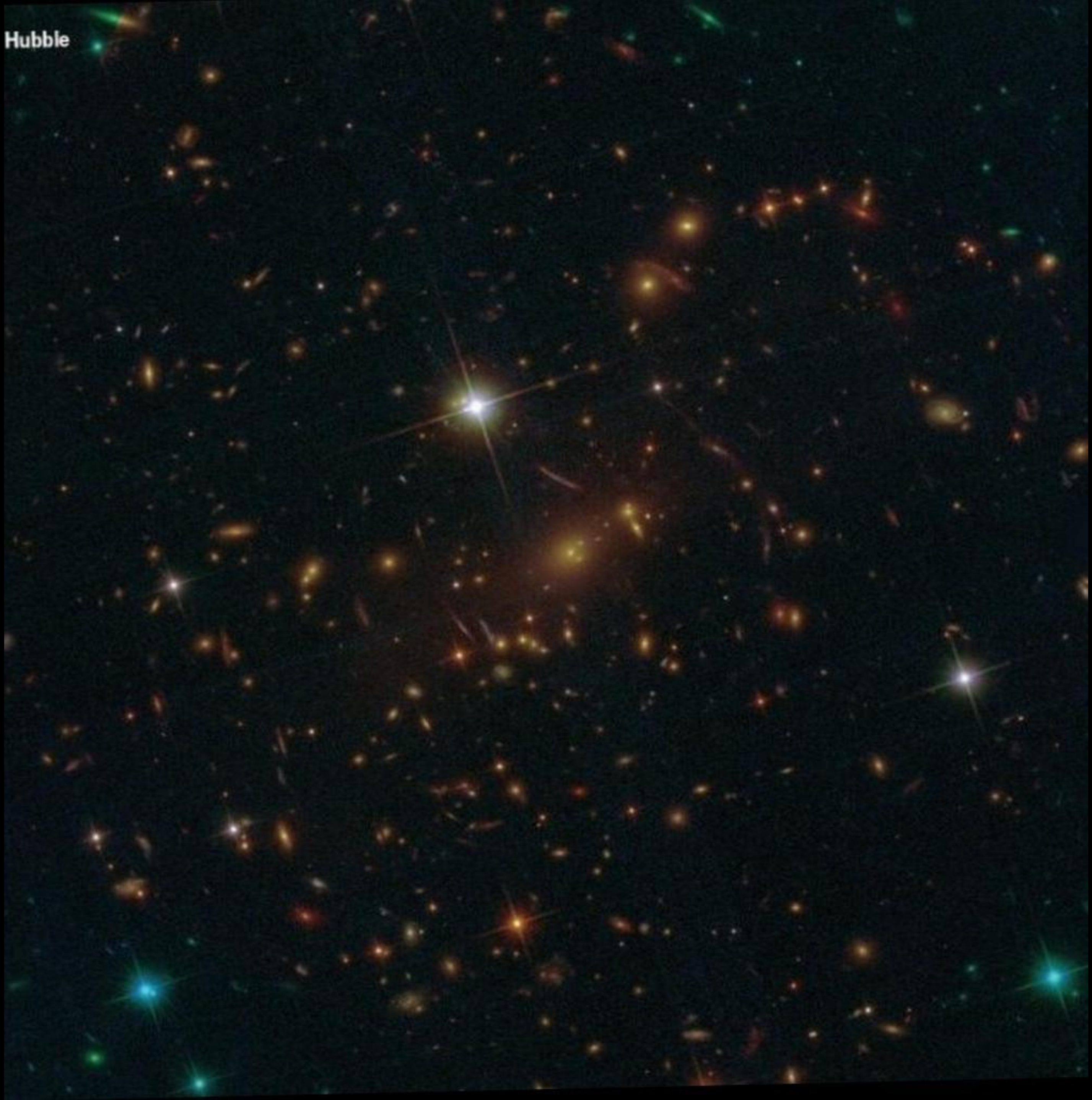
Cartesian image space



Pruessmann et al., Magn Reson Med. 1999;42:952-962.

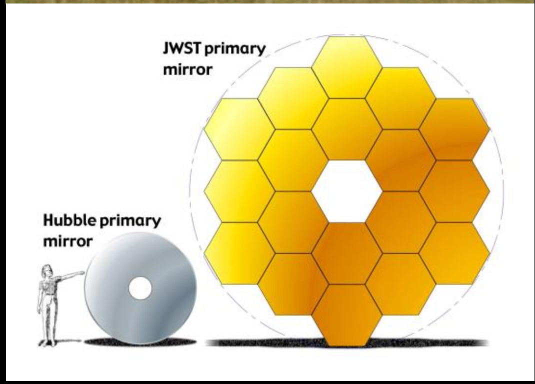
Hubble
(prior to 2022)

- esahubble.org/images/opo0318c/
- science.nasa.gov/mission/hubble/observatory/hubble-vs-webb/
- en.wikipedia.org/wiki/Webb%27s_First_Deep_Field
- en.wikipedia.org/wiki/Hubble_Space_Telescope
- en.m.wikipedia.org/wiki/File:JWST_people.jpg



Hubble
(prior to 2022)

James Webb (2022)
>6X light-gathering power



- esahubble.org/images/opo0318c/
- science.nasa.gov/mission/hubble/observatory/hubble-vs-webb/
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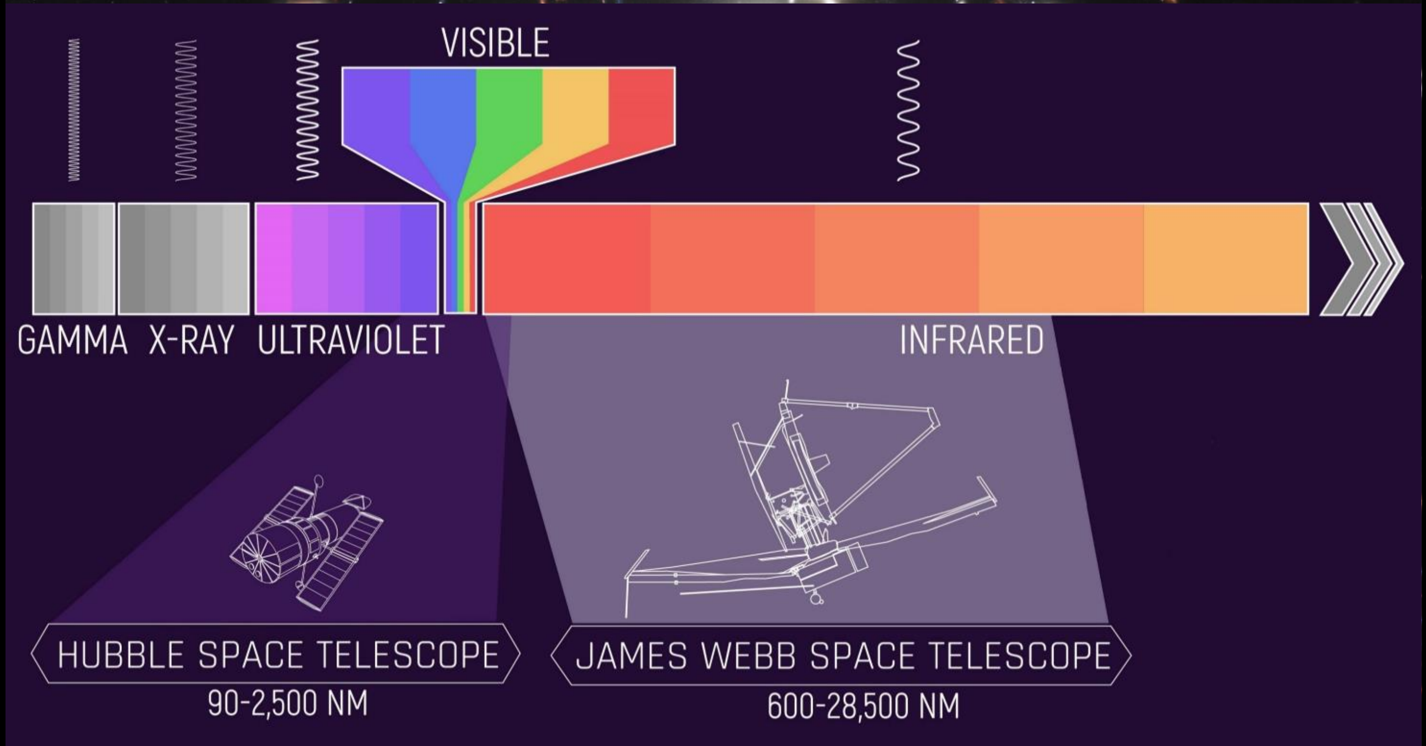

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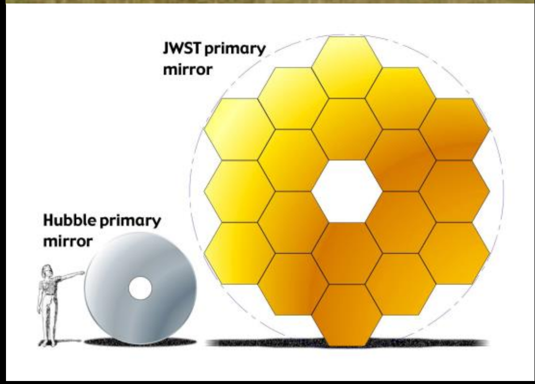

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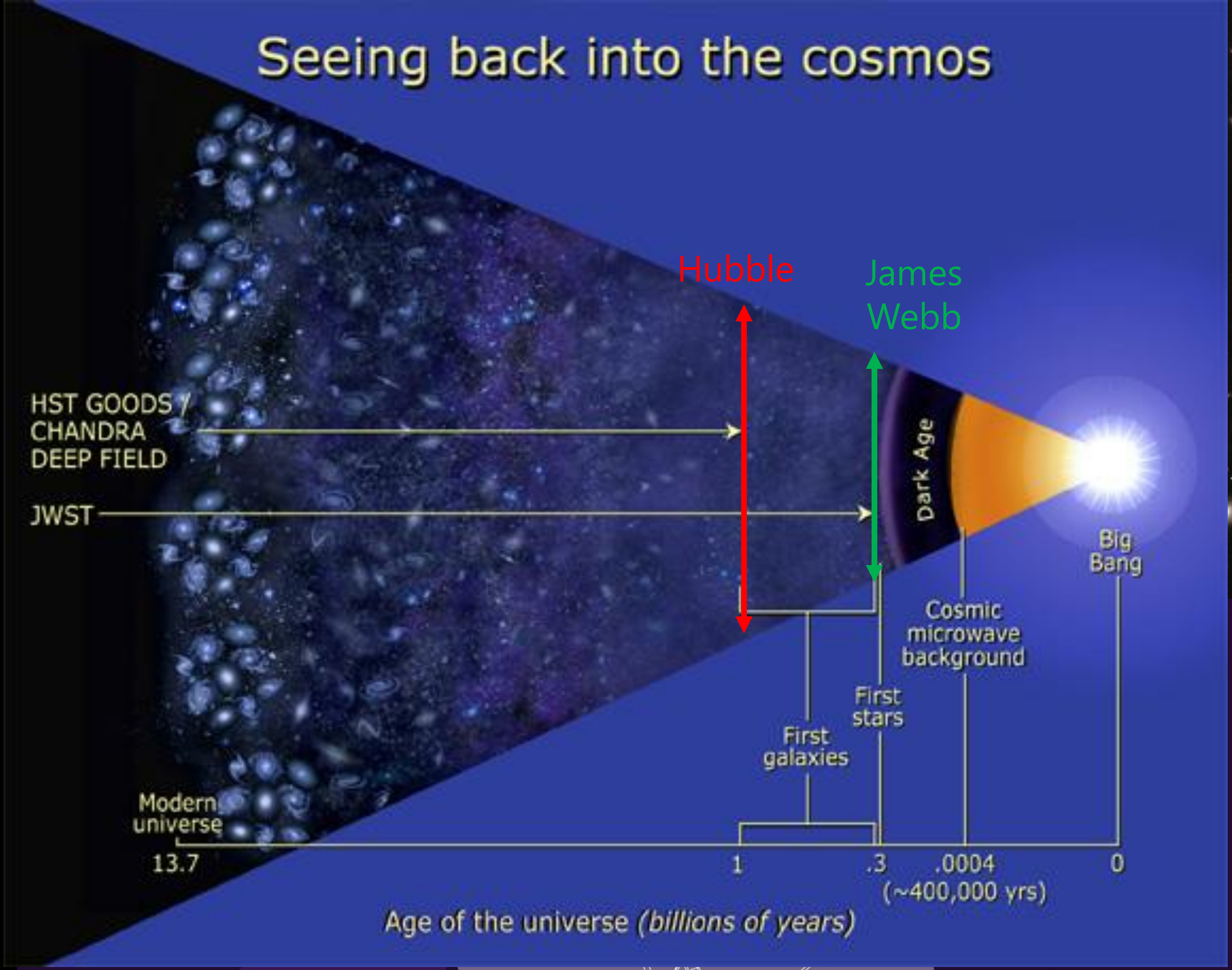

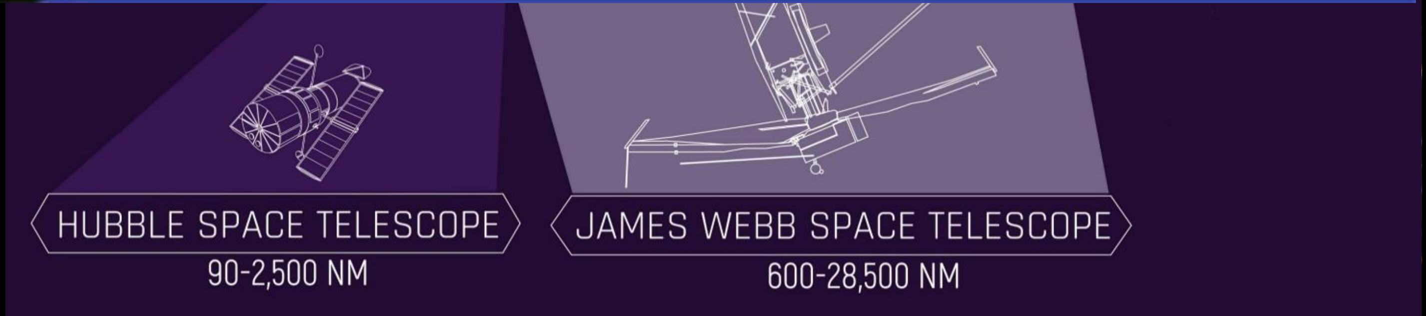

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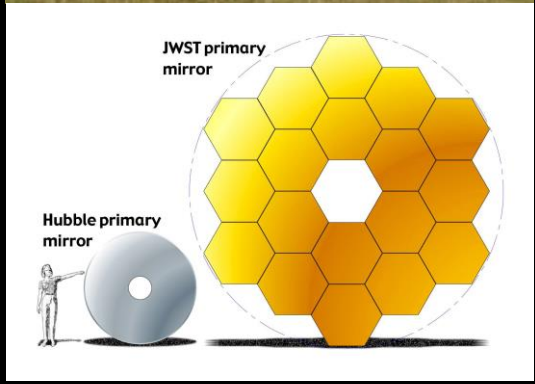

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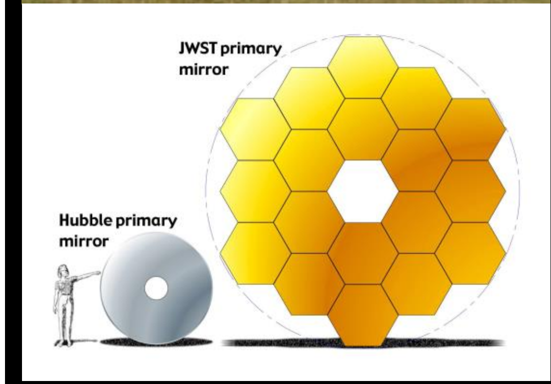
PHYS.ORG

New research puts age of universe at 26.7 billion years, nearly twice as old as previously believed

July 13 2023, by Bernard Rizk

James Webb (2022)
>6X light-gathering power



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