Microsoft

The Future of Diagnostic Imaging:
AI, Cloud Computing, and Intelligent Instruments



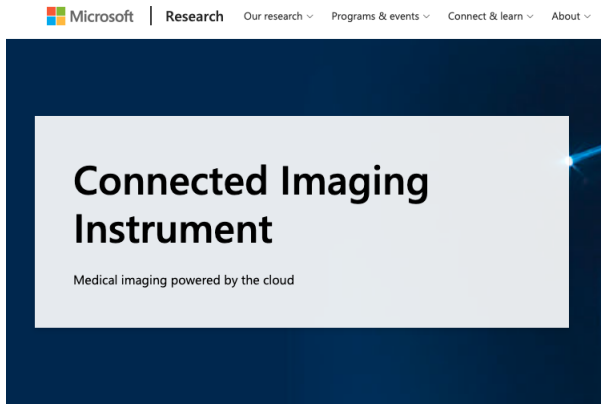
Joe Naegele, Principal Software Engineer

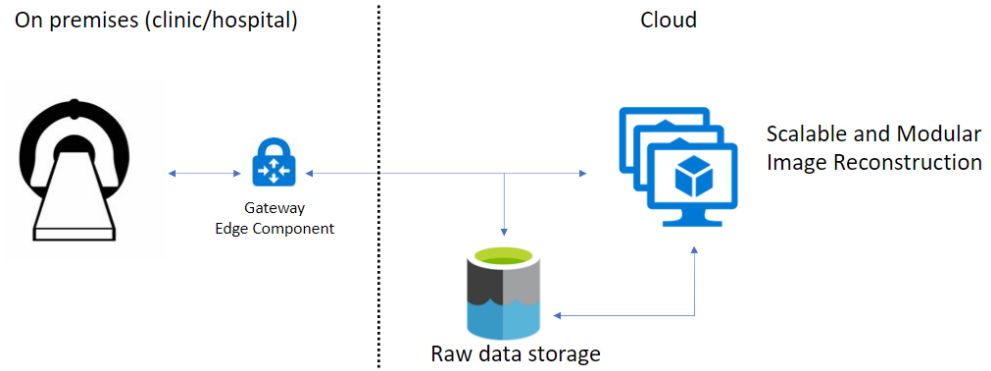
Microsoft Research, Health Futures

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Connected Instruments

- Reconsider the tradeoff between instrumentation and computation
- Which hardware components are truly essential?
- Which limitations can be addressed with scalable computation and AI?







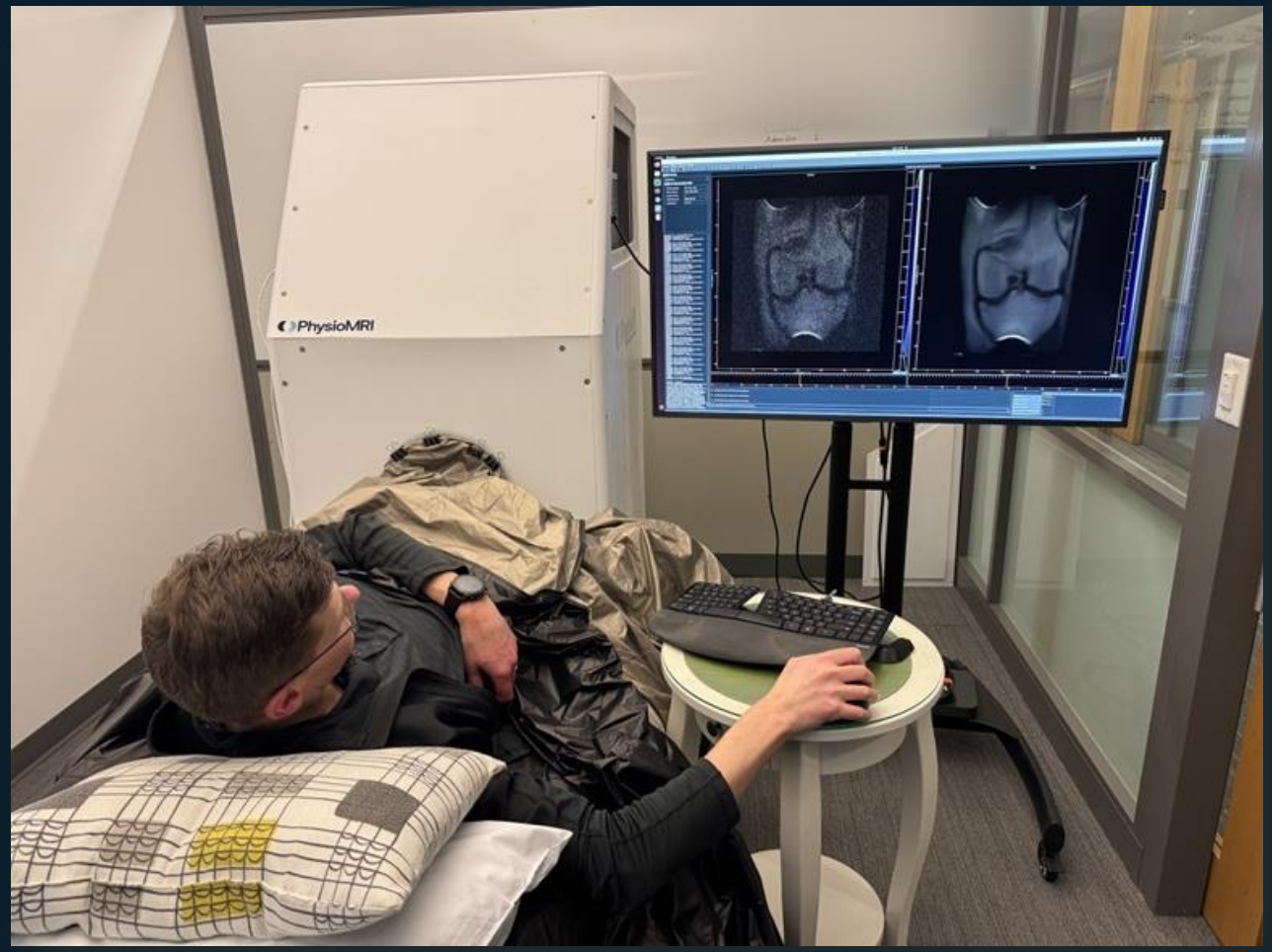
https://signalprocessingsociety.org/newsletter/2026/05/hardware-intelligence-how-ai-and-scalable-compute-enable-leaner-instruments

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Ultra-Low-Field MRI as our "Wind Tunnel"

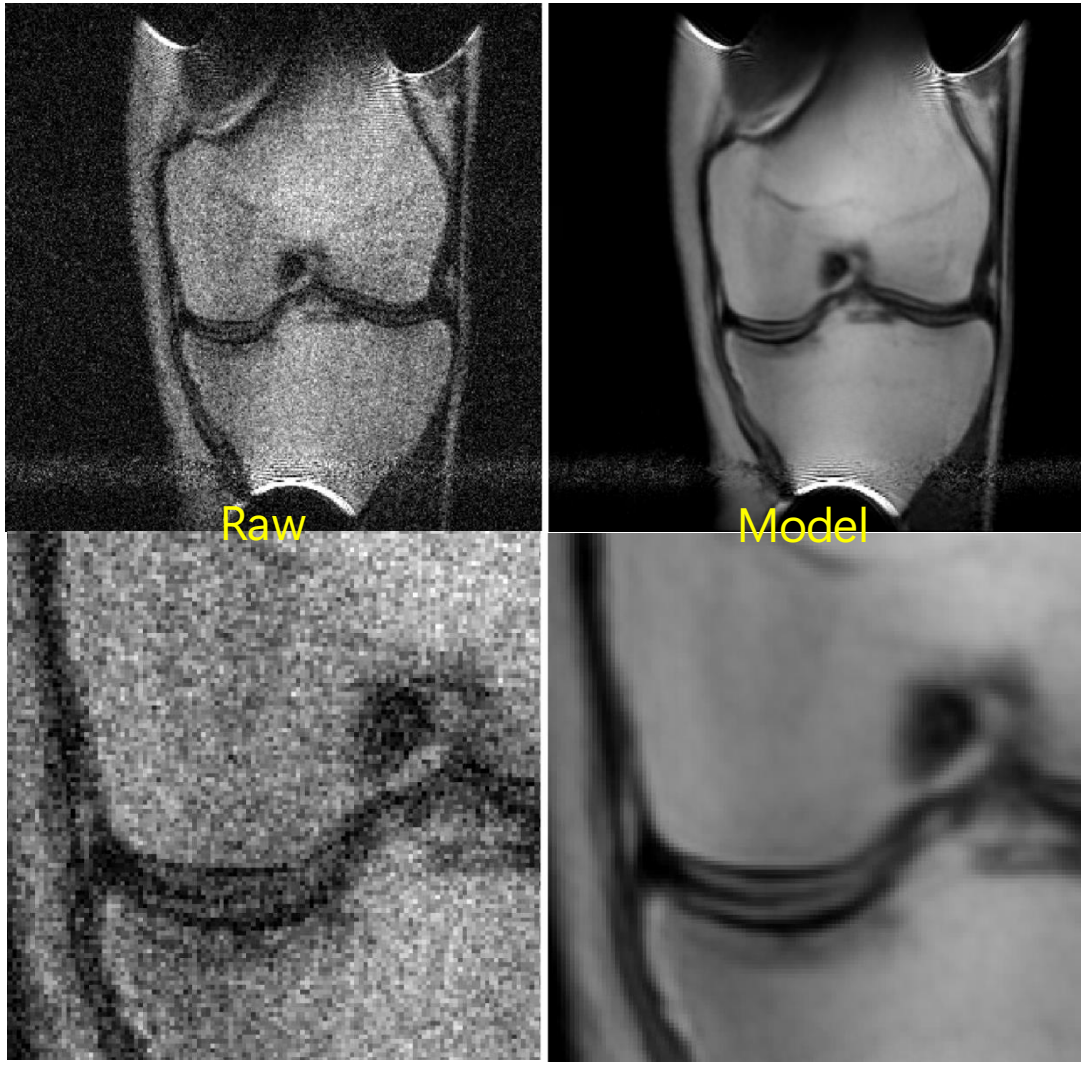
- Lower infrastructure requirements than conventional MRI
- Potential to bring imaging to new locations and populations
- Data challenges: single-channel, noisy, and susceptible to interference
- Reconstruction, denoising, and interference mitigation become essential





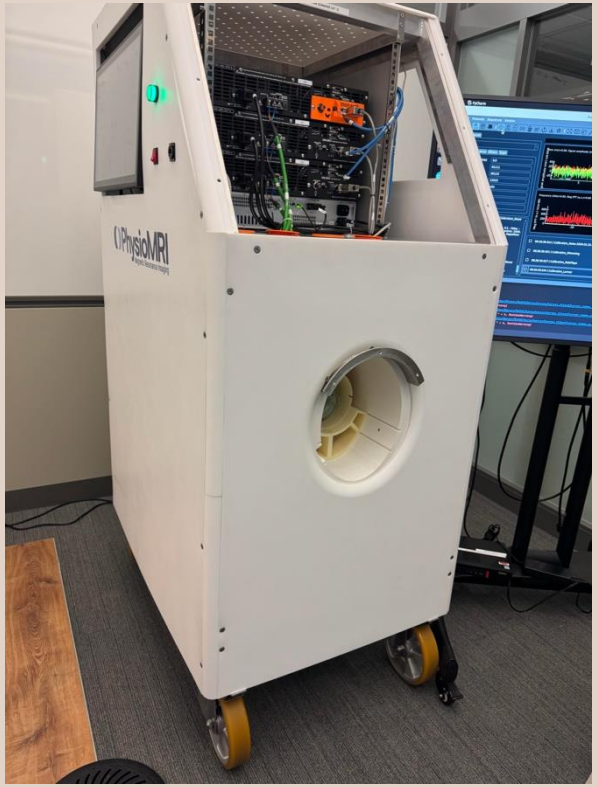
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Project Monarch



T1 Knee MRI acquired at MSR in the Tyger TEP environment

“ODIN”

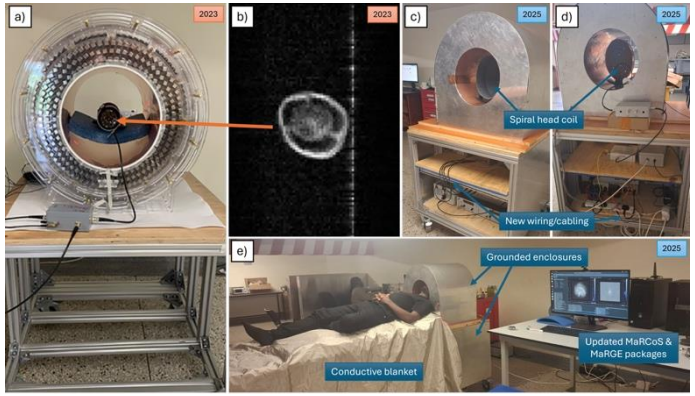


- 88mT MRI scanner
- Designed for extremity imaging
- Completely portable

Advanced, Point-of-Care imaging



"We only have one MRI imaging facility outside the capital city. Technology like this could finally bring imaging to places where it has never existed."
- Dr. Johnes Obungoloch, Dean of Faculty of Applied Sciences & Technology, Mbarara University

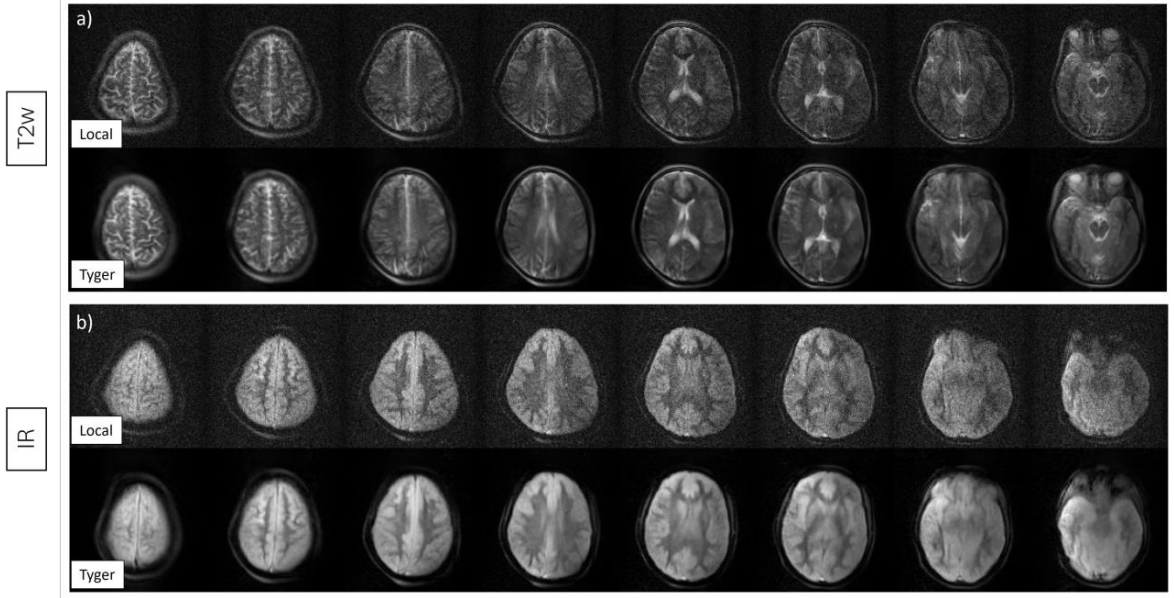


CSIC Consejo Superior de Investigaciones Científicas · Universitat Politècnica de València · i3M

NEXT MRI

PhysioMRI Magnetic Resonance Imaging

LUMC Leiden University Medical Center



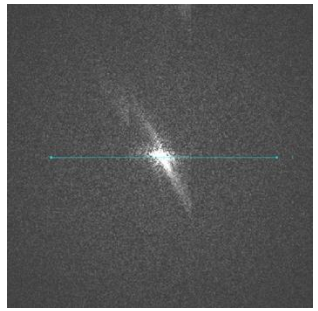
https://www.must.ac.ug/advancing-healthcare-musts-low-field-mri-project-gains-international-momentum/

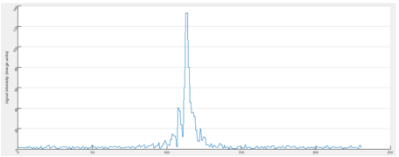
https://www.microsoft.com/en-us/research/story/when-mri-images-come-into-focus-how-tyger-scales-image-reconstruction/

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AI Image Reconstruction

Converting raw signal to images





Acquired signal



Imaging physics knowledge

- Protocol parameters
- System calibration

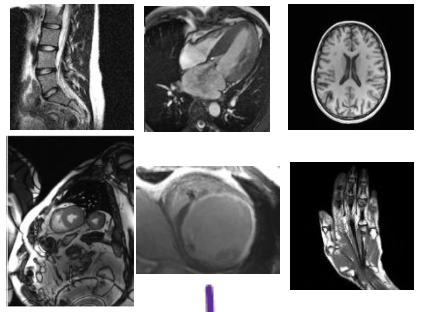
Reconstruction



Convert MR raw signal to image

- Allow fast acquisition
- Correct system/hardware imperfections
- Optimize tissue contrast
- High-performance computation

Imaging knowledge



Curated training data

- ~1.3 million MR raw signal data
- With good diversity

AI Training

Learning from previous scans

AI Model

AI model to improve image quality

- Remove noise
- Reduce artifacts
- Optimize tissue contrast
- Deploy/integration to Azure



Images for visualization and analysis

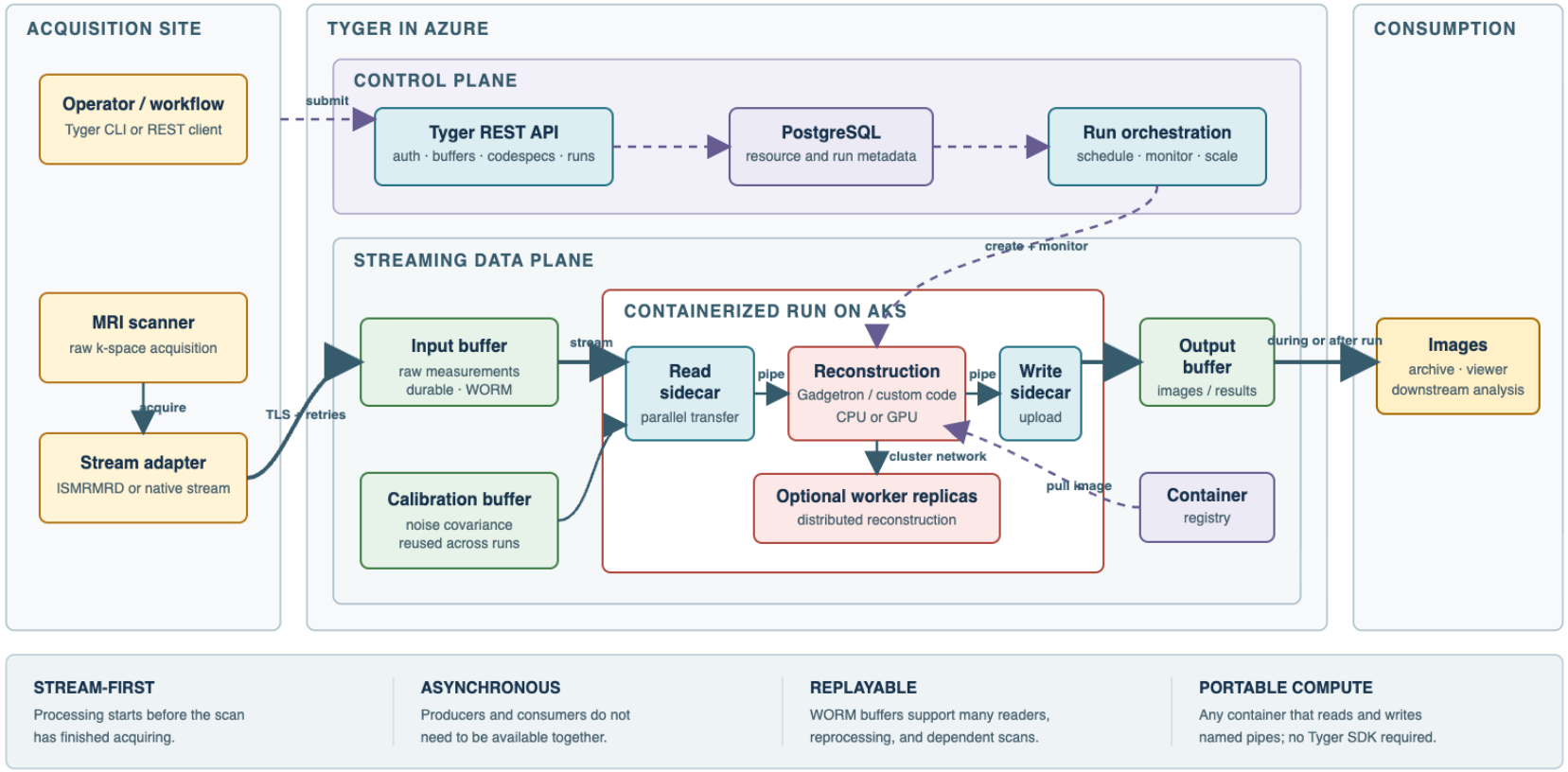
- Main output of the system
- Ready for radiological review
- Input to analysis

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Tyger: Open-Source Remote Signal Processing

https://microsoft.github.io/tyger/

- Tyger connects imaging devices to cloud services
- Raw acquisitions stream into containerized software
- High-performance computation and deep learning models reconstruct and enhance images
- Results are streamed to the imaging workflow



https://www.microsoft.com/en-us/research/video/accelerating-mri-image-reconstruction-with-tyger/

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Industry Trend

PHILIPS

Radiology without boundaries: a cloud transformation story

By Philips · September 08 2025 · 4 min read

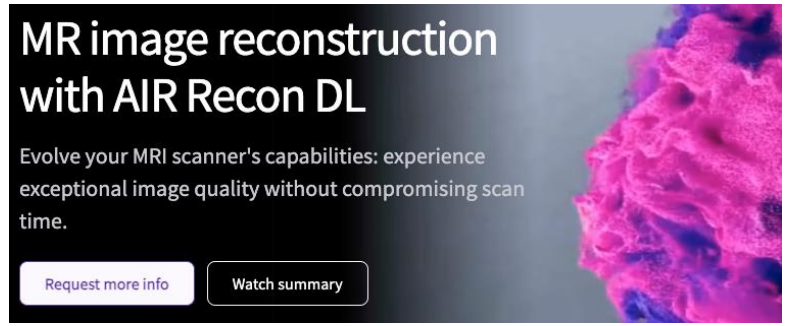
Customer story | Healthcare informatics | Diagnostic and clinical informatics

Radiology is no longer confined to reading rooms or hospital walls. Rising imaging volumes, evolving clinical demands, and the need for secure remote access put hospitals under pressure to deliver faster, scalable workflows. Traditional on-premises systems fall short. The way forward? Cloud technology offering innovation, flexibility, and collaboration without disruption.

Philips Reduces MRI Scan Time by 10x Using AWS Cloud Computing

Using AWS cloud computing and deep neural networks, Philips transforms medical image reconstruction from a time-consuming process to a scalable 40-second solution, enabling faster patient diagnosis and reduced wait times.

GE HealthCare



"The future of enterprise imaging depends on connected, cloud-enabled solutions that improve access, collaboration, and efficiency." - Scott Miller, CEO, Solutions for Enterprise Imaging, GE HealthCare

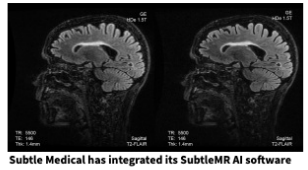
Siemens brings Subtle Medical's MR post-processing AI to Open Recon interface

by John R. Fischer, Senior Reporter | July 15, 2022

Artificial Intelligence | Health IT | Rad Oncology

Post | Share

Siemens Healthineers has integrated Subtle Medical's image-enhancement software for MR into the new reconstruction pipeline of its Open Recon interface.



Subtle Medical has integrated its SubtleMR AI software into Siemens' Open Recon interface to enhance MR post-processing. (Photo courtesy of Subtle Medical)

The Siemens platform adds third-party image reconstruction and post-processing solutions directly into the reconstruction process for images. Because of this, no extra steps are needed to export images, and the results are directly available on the scanner console.

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Low-Field MRI Is Already Clinical

- The deployed instrument continues to evolve through software updates
- Software-defined imaging is already a regulated clinical reality



Hyperfine Announces FDA Clearance of Optive AI™ Software, Introducing the Most Substantial Image Quality Improvement Ever for the Swoop® System

May 28, 2025 | PDF Version

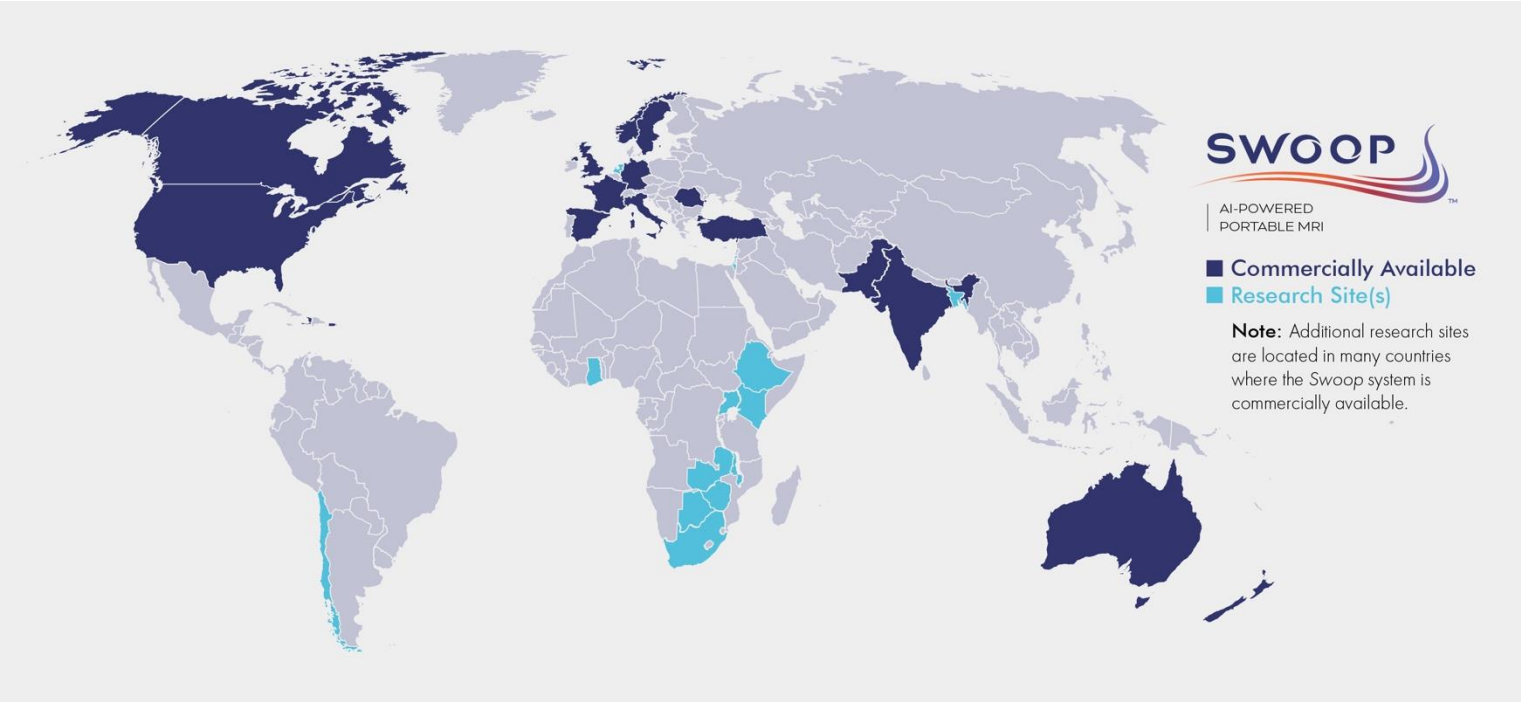
Hyperfine Announces FDA Clearance of the Next Optive AI™ Software, Further Enhancing Image Quality, Clinical Utility, and Ease of Use of the Swoop® System Across Care Settings

Aug 20, 2026 | PDF Version

"This latest advancement reflects our commitment to frequent Optive AI software updates that continuously expand the clinical value of the Swoop system and provide our customers with access to the most advanced portable brain MRI technology available…

This software is designed to improve performance today and is also architected for our ultra-low-field future."

- Tom Teisseyre, Chief Operating Officer of Hyperfine

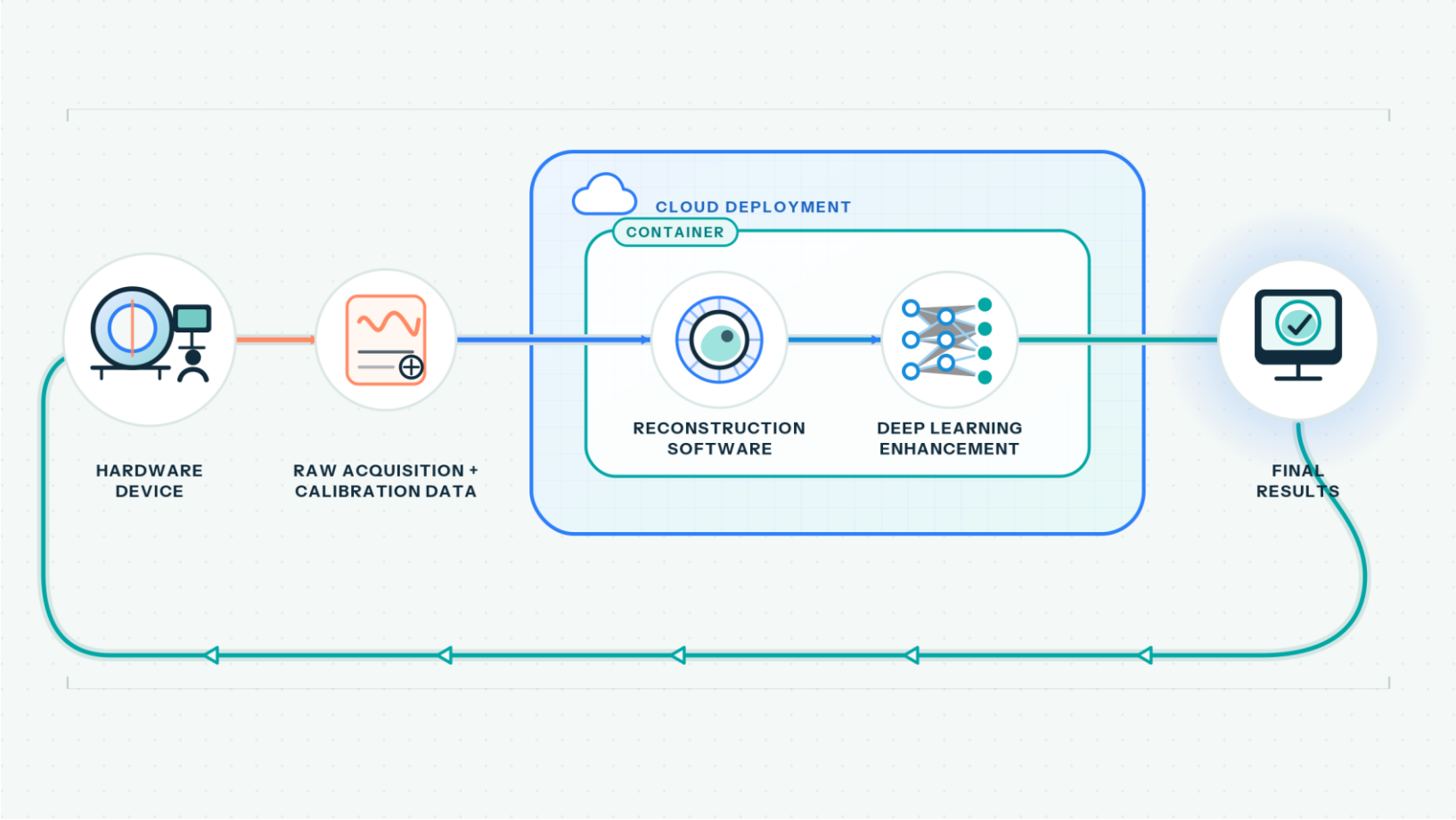


https://www.hyperfinemri.com/global

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Diagnostic Imaging Is Increasingly Software-Defined

- Future capabilities come from evolving software and computation
- Data crosses hardware, software, compute, and institutional boundaries
- The measurement chain is becoming critical infrastructure



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Software Can Change the Result

- Scanner hardware and apparent acquisition settings may remain unchanged
- Reconstruction or calibration software can still change the image or measurement
- Drift may be visible but impossible to attribute

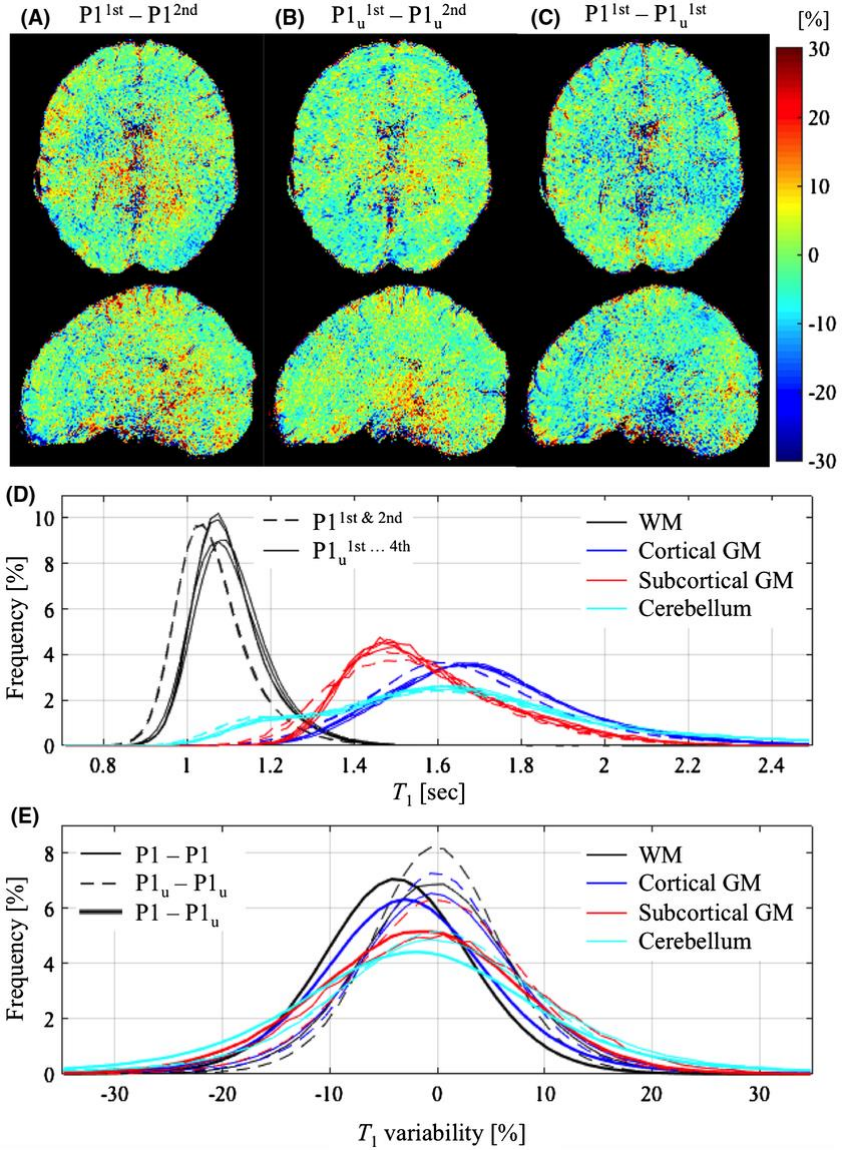


Figure 5a and 5b show T1 variability maps within P1 and P1u, i.e. before and after the software upgrade, respectively. An exemplar T1 variability map between P1 and P1u is shown in Fig. 5c.

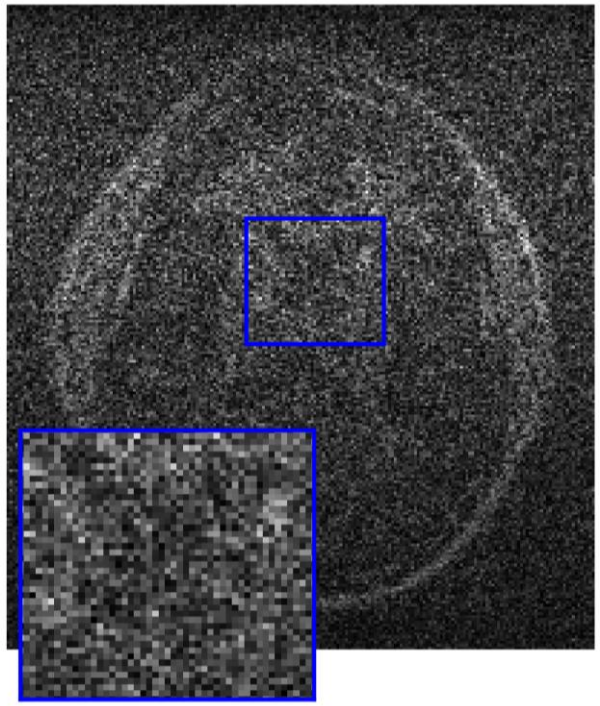
"Given that no hardware was changed and that the same sequence settings were used before and after the upgrade, these differences likely stem from the image reconstruction or the preparation steps before the acquisition (e.g. the way B1 is calibrated, the way optimal shim values are found, etc), which are not accessible to the end-users. This bias highlights the importance of software configurations of the scanner. For example, image reconstructions in multi-center study could be harmonized by using opensource, vendor-independent platforms (55) to alleviate such an inter-vendor bias"

Lee Y, Callaghan MF, Acosta-Cabronero J, Lutti A, Nagy Z. *Establishing intra- and inter-vendor reproducibility of T_1 relaxation time measurements with 3T MRI. Magn Reson Med.* 2018; 81: 454–465. https://doi.org/10.1002/mrm.27421

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AI Increases Capability *and Uncertainty*

- Deep Learning methods help overcome limitations of lower-cost instruments
- **SNRAware** uses quantitative noise information calculated during reconstruction
- The improved image is the result of acquisition plus a computational method



Raw, brain T1 at 50mT



Q-coil correction + SNRAware

Isotropic 1 mm^3 head T1 MRI image
Acquired at Leiden University Medical Center
using the Tyger TEP environment

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Denoising with SNRAware



Without SNRAware model

13x

signal quality improvement

Raw SNR was 2.68±1.31
Model SNR 30.9±14.4

With SNRAware model

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SNRAware

Improved Deep Learning MRI Denoising with Signal-to-Noise Ratio Unit Training and G-Factor Map Augmentation

Xue, Hui, et al.



Hugging Face | Search models, datasets, | Models

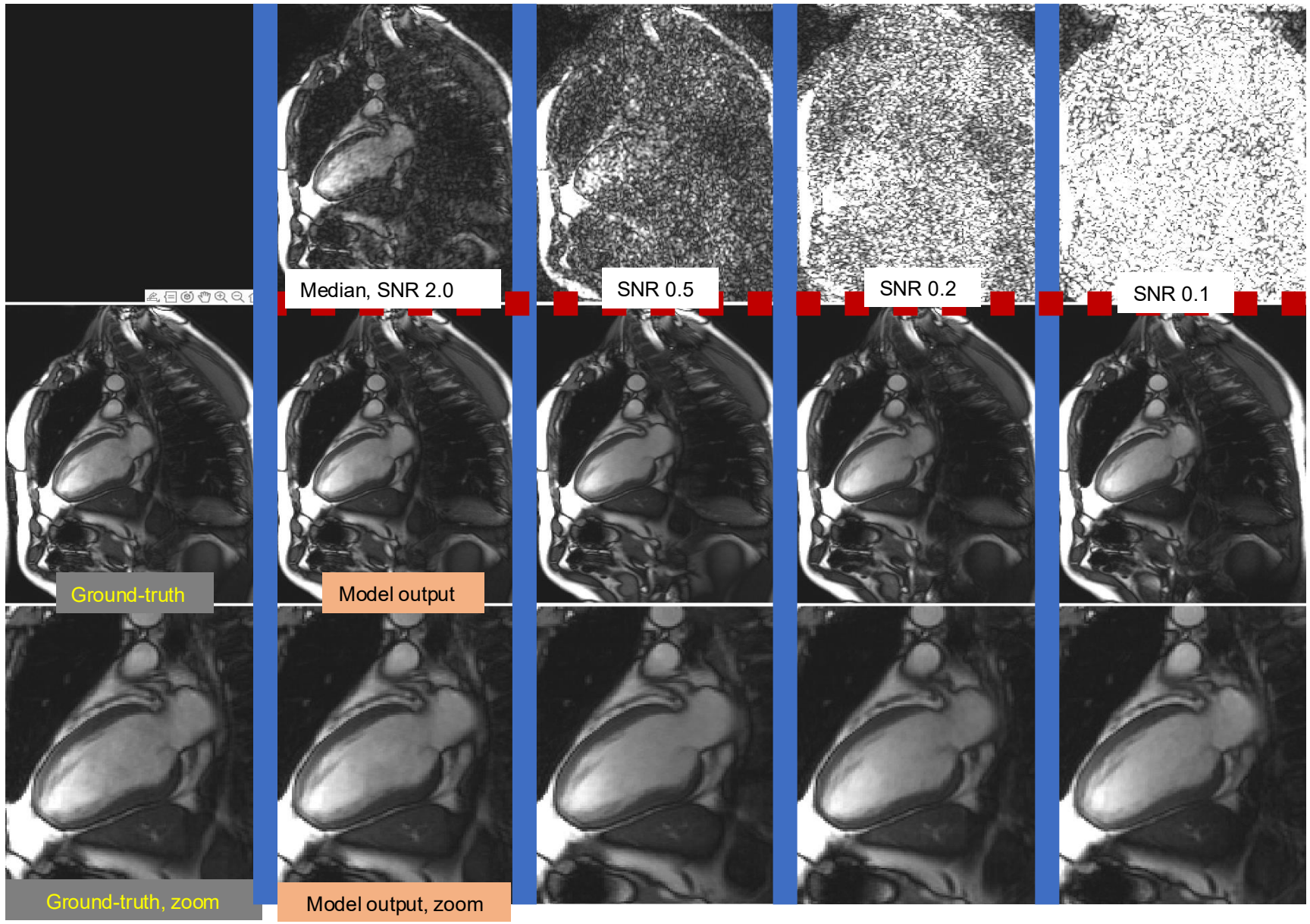
microsoft/SNRAware | Like 2 | Follow Microsoft 22.2k

English | License: mit

Model card | Files | Community

Model summary

Syntax	Description
Developer	Microsoft Research, Health Futures



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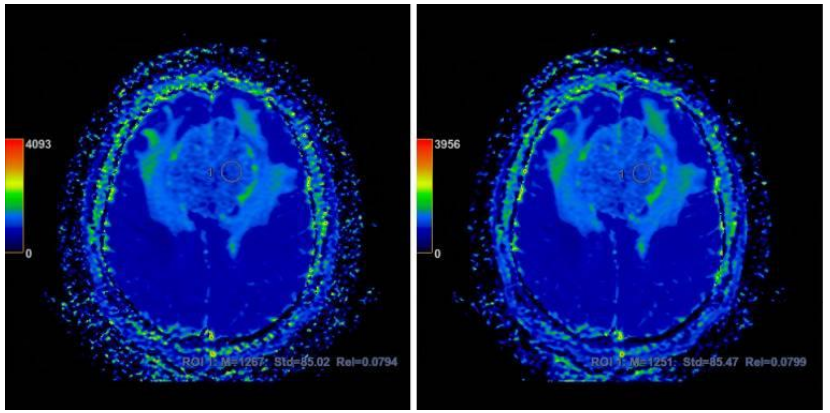
Shifting Biomarkers

- DL reconstruction can reduce apparent image noise
- It can also shift a quantitative biomarker

"… deep learning-based MRI reconstruction significantly improved the quality of diffusion-weighted images while also introducing a modest but statistically significant systematic shift in lesion ADC values…

These findings underscore the dual impact of DLR in neuro-oncologic diffusion imaging: it offers clear benefits for both qualitative and quantitative image quality metrics, while also introducing potential bias in quantitative ADC measurements."

Li QL, Gou XT, Wang XY, Jin R, Liu C, Yu RQ. Impact of deep learning-based MRI reconstruction on image quality and apparent diffusion coefficient measurements in patients with intracranial tumors: a prospective intra-individual study. *Quant Imaging Med Surg*. 2026;16(7):531. doi:10.21037/qims-2025-1-2768



Conventional reconstruction (left), Deep Learning reconstruction (right)

The two reconstruction methods showed a statistically significant difference in mean lesion ADC (t=2.974, P=0.004).

- Reconstruction should be treated as a controlled and traceable variable
- Competing methods should be compared against the same acquisition

"Quantitative IQMs offer a promising method for resource-efficient QC of AI-based MR reconstructions. Our study demonstrated that paired IQMs are highly sensitive to changes in image reconstruction performance and can be employed to monitor image quality over time."

White, O.A., Shur, J., Castagnoli, F. *et al.* Quantitative image quality metrics enable resource-efficient quality control of clinically applied AI-based reconstructions in MRI. *Magn Reson Mater Phy* **38**, 547–560 (2025). https://doi.org/10.1007/s10334-025-01253-3

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Not Just an MRI Problem

Deep Learning applied across...

Modalities:

- MRI
- CT
- PET
- SPECT
- Ultrasound
- Microscopy

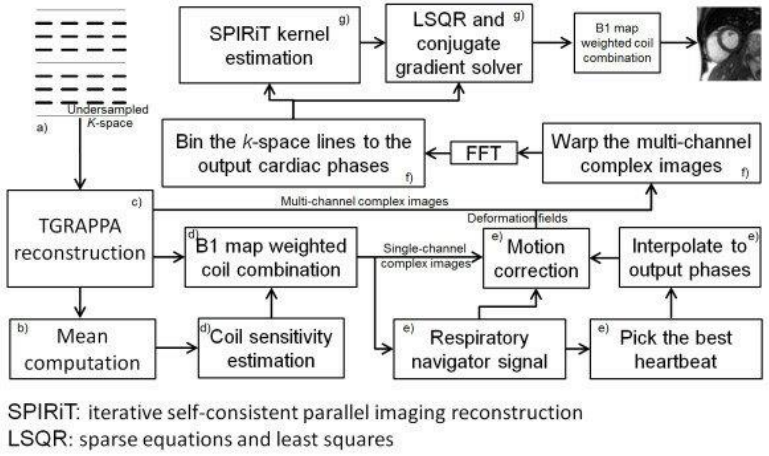
Applications:

- Reconstruction
- Motion correction
- Noise reduction
- Resolution enhancement
- Contrast improvement
- Accelerated imaging
- Low-dose imaging

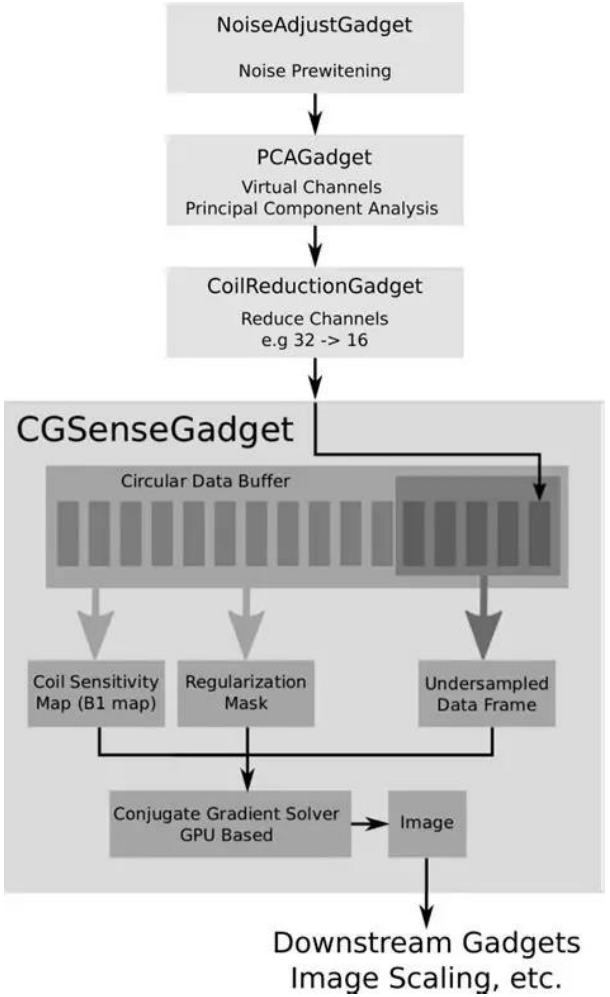
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The Image Is Not the Complete Record

- Raw signal data is rich
  - Multi-channel
  - Multidimensional
  - Complex-valued
- Reconstruction reduces and transforms the raw signal
- The finished image embeds decisions made in software



SPIRiT: iterative self-consistent parallel imaging reconstruction
LSQR: sparse equations and least squares



(Gadgetron Reconstruction Workflow Examples)

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The Measurement Problem

How does a measured value retain its meaning across:

- Instruments
- Vendors
- Locations
- Time
- New populations
- Software updates
- Evolving models & methods

Existing Challenges

More Challenges!

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Recommendations in the Literature

- System calibration data is needed for quantitative imaging, e.g. VFA T1 mapping

Keenan KE, Gimbutas Z, Dienstfrey A, Stupic KF, Boss MA, et al. (2021) **Multi-site, multi-platform comparison of MRI T_1 measurement using the system phantom**. PLOS ONE 16(6): e0252966. https://doi.org/10.1371/journal.pone.0252966

- Fixed, common reconstruction can improve inter-scanner consistency

Lo, W. C., Bittencourt, L. K., Panda, A., Jiang, Y., Tokuda, J., Seethamraju, R., Tempany-Afdhal, C., Obmann, V., Wright, K., Griswold, M., Seiberlich, N., & Gulani, V. (2022). **Multicenter Repeatability and Reproducibility of MR Fingerprinting in Phantoms and in Prostatic Tissue**. *Magnetic resonance in medicine*, *88*(4), 1818–1827. https://doi.org/10.1002/mrm.29264

- Shared raw-data infrastructure can support automated quality control

Dupuis, A., Boyacioglu, R., Keenan, K.E. *et al.* **Real-time automated quality control for quantitative MRI**. *Magn Reson Mater Phy* 38, 491–501 (2025). https://doi.org/10.1007/s10334-024-01205-3

- Standardizing *acquisitions* can improve harmonization of multi-center imaging data

Zholshybek N, Bastarbekova L. **Harmonizing multicenter quantitative imaging data: sources of variability, statistical solutions, and practical workflows in CT and MRI**. Explor Digit Health Technol. 2026;4:101185. https://doi.org/10.37349/edht.2026.101185

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Common Theme

Standardize the upstream imaging data.

The sequence parameters, raw acquisitions, and calibration information.

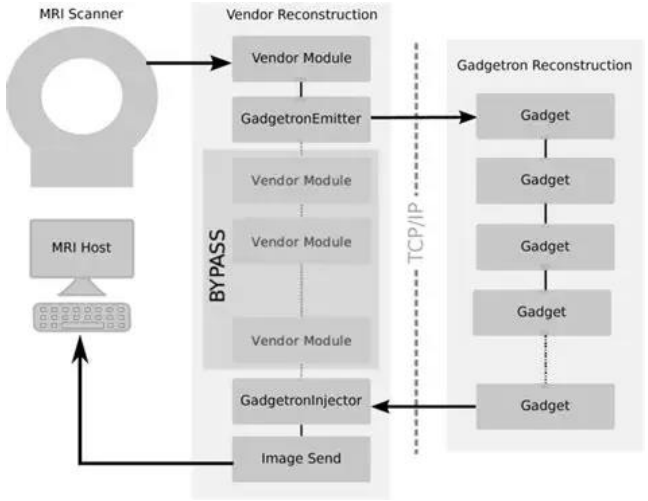
Require vendors to make it available.

That will allow us to evaluate reconstruction methods and AI against common evidence.

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Gadgetron

- Open-source framework for medical image reconstruction
- Expensive GPU-based reconstruction required shared compute, off-scanner



Moving reconstruction off the scanner created a data interface problem:

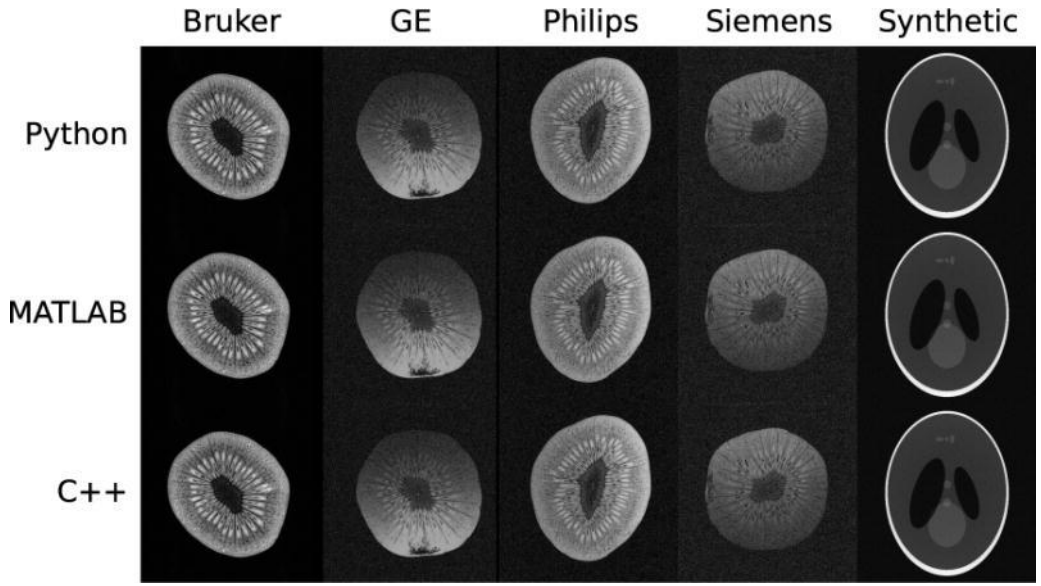
How can we connect instruments from different vendors to open-source reconstruction frameworks?

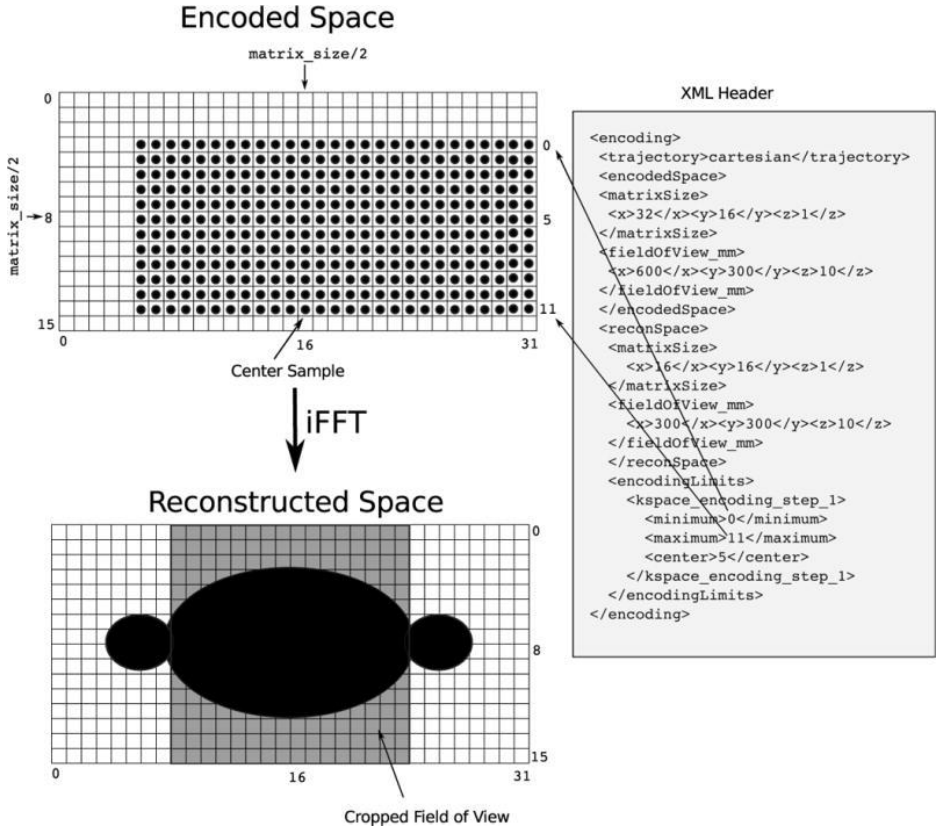
Hansen, M.S. and Sørensen, T.S. (2013), **Gadgetron: An open source framework for medical image reconstruction**‡. Magn Reson Med, 69: 1768-1776. https://doi.org/10.1002/mrm.24389

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ISMRMRD

- Open specification and format for raw MRI data
- Common interface for independent reconstruction
- Conversion tools for major vendors



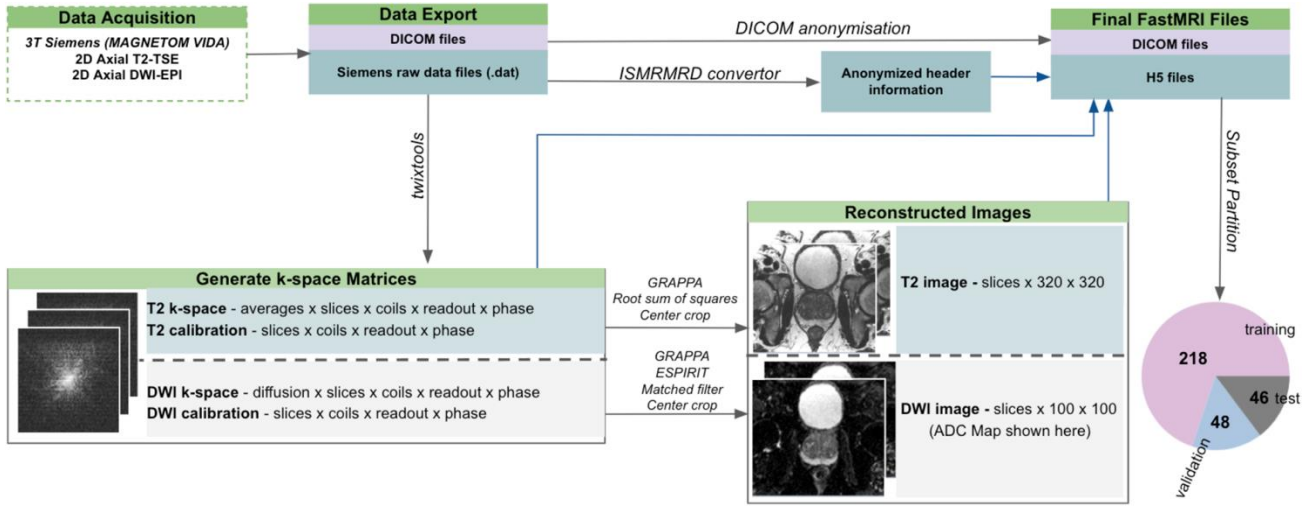


Inati, S.J., Naegele, J.D., Zwart, N.R., Roopchansingh, V., Lizak, M.J., Hansen, D.C., Liu, C.-Y., Atkinson, D., Kellman, P., Kozerke, S., Xue, H., Campbell-Washburn, A.E., Sørensen, T.S. and Hansen, M.S. (2017), **ISMRM Raw data format: A proposed standard for MRI raw datasets**. Magn. Reson. Med., 77: 411-421. https://doi.org/10.1002/mrm.26089

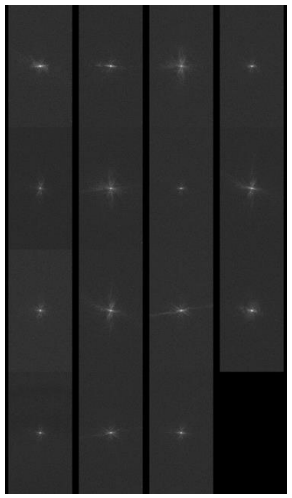
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Enabling Innovation

- fastMRI paired raw acquisitions in ISMRMRD format with corresponding images
- Deep Learning reconstruction must learn from acquisition data, not only pictures



Tibrewala, R., Dutt, T., Tong, A. *et al*. FastMRI Prostate: A public, biparametric MRI dataset to advance machine learning for prostate cancer imaging. *Sci Data* **11**, 404 (2024). https://doi.org/10.1038/s41597-024-03252-w



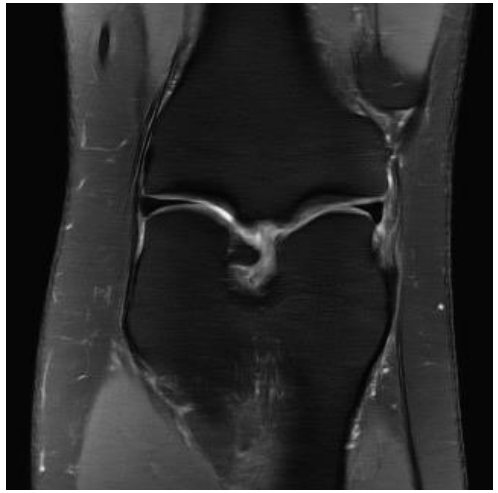
Raw k-space

+



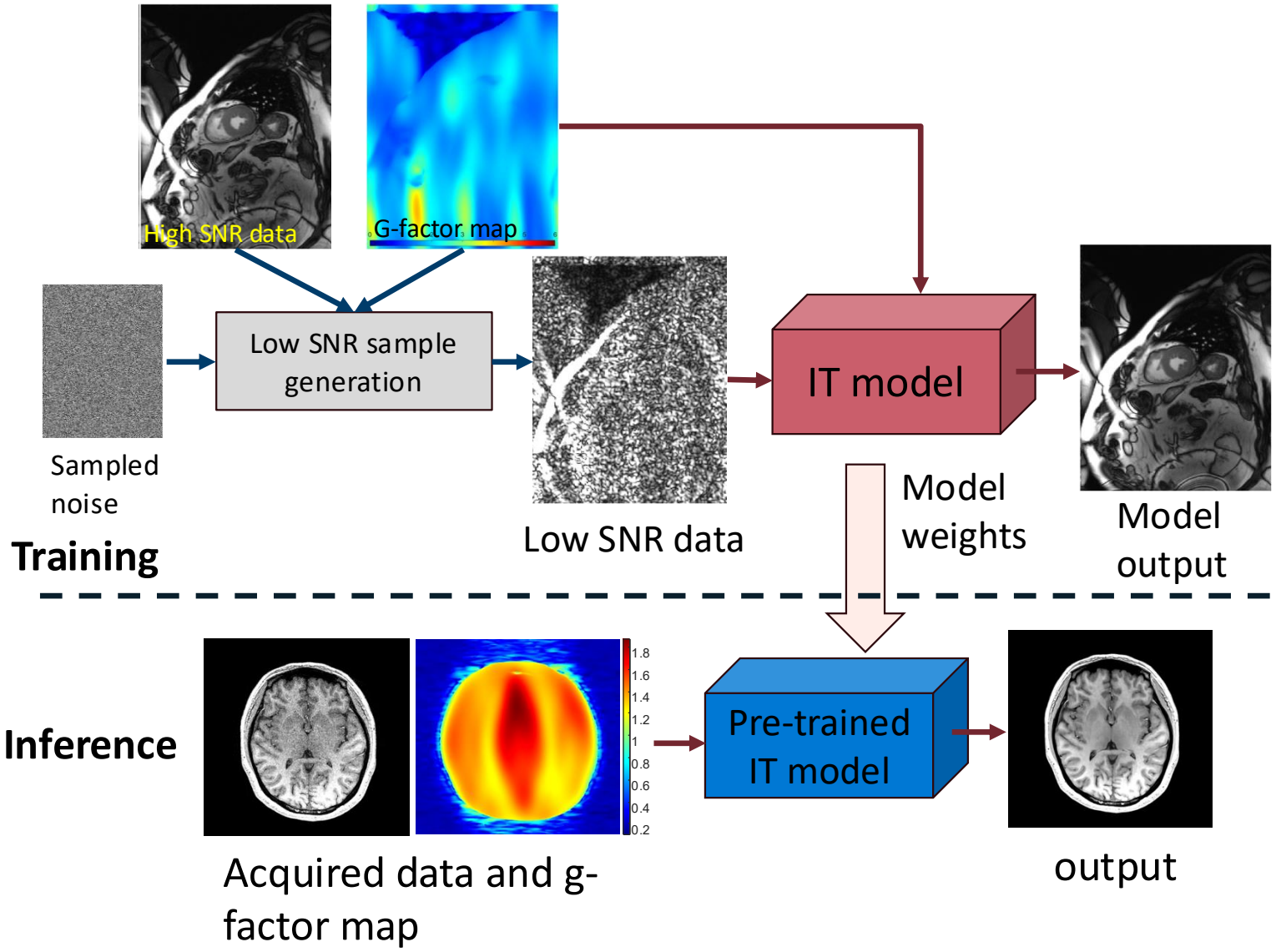
Ground Truth

Baseline Model Reconstruction



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SNRAware Training



- **Transformer model, tailored to imaging**
- **Large training dataset**: 3T cardiac retro-gated cine, 206,677 cine series
- **Dedicated training method** for MRI: SNRAware training method
- **Compute**: N=32 B200 GPU, ~12 days of training

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Lessons from ISMRMRD

https://microsoft.github.io/yardl/

Yardl

Define and Stream Instrument Data

A schema language and command-line tool that generates domain types and serialization code.

Get Started With Python | Get Started With C++ | Get Started With MATLAB | View on GitHub

Multiple Languages

Define your model in a simple YAML syntax and generate clean Python, C++, and MATLAB.

Multiple Formats

Supports writing to a compact binary format, NDJSON, or HDF5.

Stream-Oriented

Designed sending and receiving streams of typed data.

Useful Features

Support for multidimensional arrays, complex numbers, generics, unions, computed fields, and more.

MRD Examples:

```
Header: !record
  fields:
    version: long?
    subjectInformation: SubjectInformationType?
    studyInformation: StudyInformationType?
    measurementInformation: MeasurementInformationType?
    acquisitionSystemInformation: AcquisitionSystemInformationType?
    experimentalConditions: ExperimentalConditionsType
    encoding: EncodingType*
    sequenceParameters: SequenceParametersType?
    userParameters: UserParametersType?
    waveformInformation: WaveformInformationType*
```

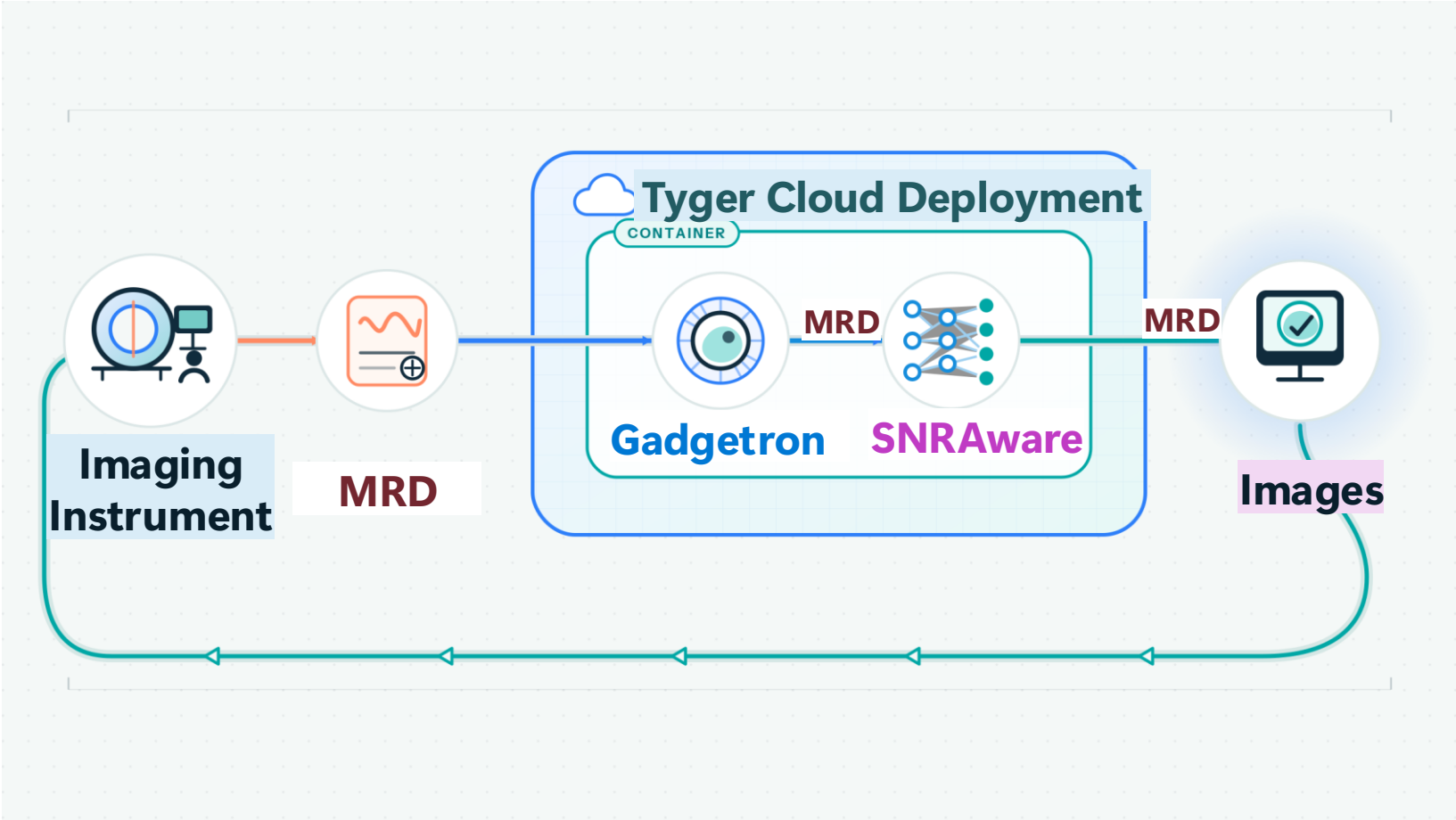
```
Acquisition: !record
  fields:
    # Acquisition header
    head: AcquisitionHeader
    # Raw k-space samples array
    data: AcquisitionData
    # Phase offset array as optional field
    phase: AcquisitionPhase?
    # Trajectory array
    trajectory: TrajectoryData
  computedFields:
    coils: size(data, "coils")
    samples: size(data, "samples")
    activeChannels: size(head.channelOrder)
    trajectoryDimensions: size(trajectory, "basis")
    trajectorySamples: size(trajectory, "samples")
```

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MRD2

https://ismrmrd.github.io/mrd/

- Successor to ISMRMRD
- Defines the semantic model for raw MRI data
- Backward compatibility and cross-language support
- Supports real-time streaming



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PET Standardization

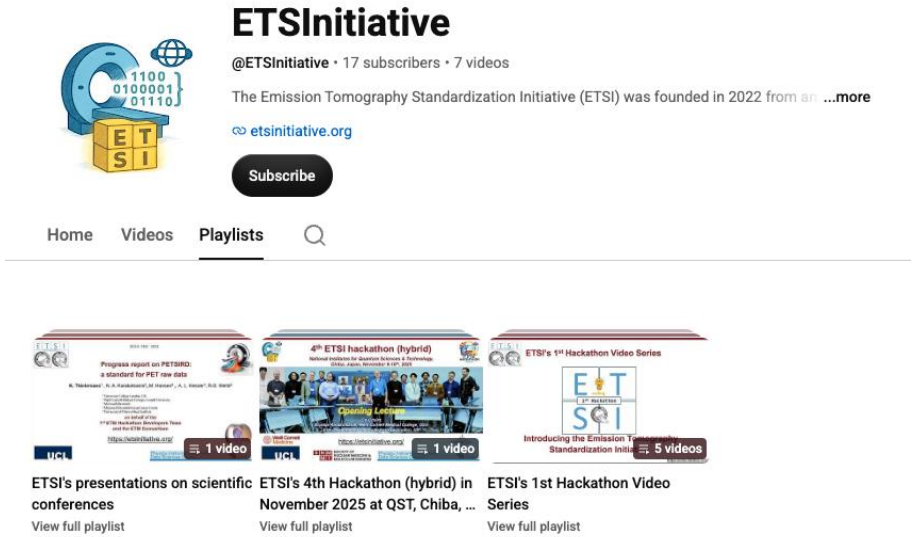
https://github.com/ETSInitiative/PETSIRD

- Parallel effort for raw PET imaging data
- Data model, reference datasets, conversion tools, and reconstruction research
- Evidence and experience for standards work

SOCIETY OF NUCLEAR MEDICINE & MOLECULAR IMAGING®

https://etsinitiative.org/





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Examples to Build Upon

Requirement	Purpose	Example
Semantic Modality Models	Define and capture raw signal, calibration, sequence parameters, trajectories, timing, geometry, etc.	MRD, PETSIRD
Fixed Reconstruction	Common software foundation for quality assurance (QA)	Gadgetron
Raw Data Infrastructure	Shared environment for comparing methods and results	Tyger
Vendor Support	Access to raw data and context	**??**
Conformance Tests	Verify interpretability of the data	**??**
Reference Datasets	Quantitative evaluation of methods and models	**??**

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The Future of Diagnostic Imaging

- Software-Defined Measurement Systems
  - An evolving measurement chain requires traceability, validation
- Portable and Low-Cost Hardware
  - Quantitative standards are essential for comparing data collected in this new paradigm
- AI-Enabled
  - Trustworthy AI depends on standardized, accessible data

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The Raw Data Connects the Instrument to the Result

Standards should make that upstream evidence accessible,
independently interpretable, and testable

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