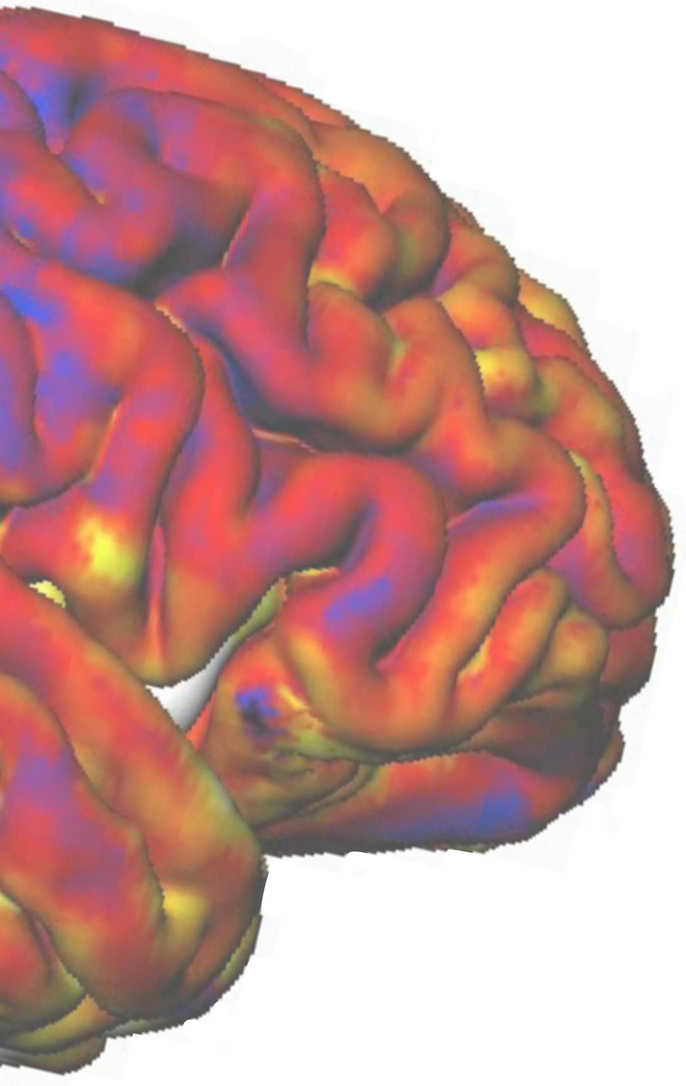
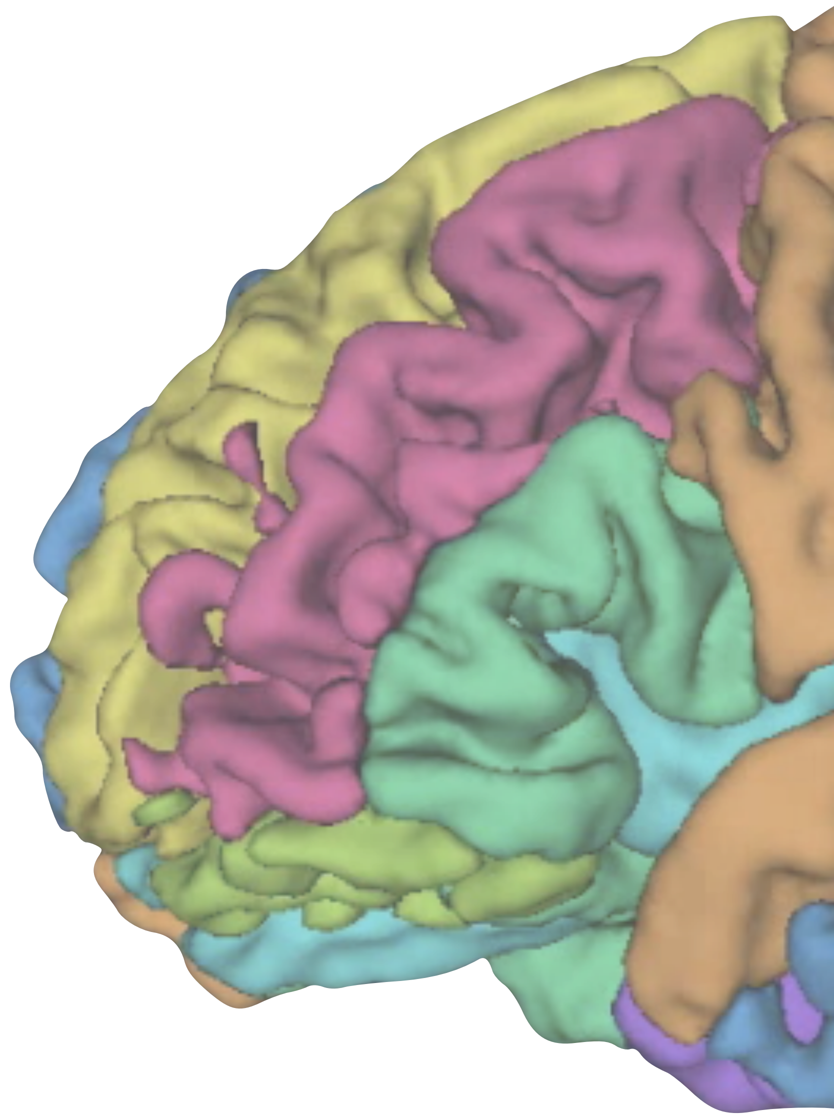
Quantitative Neuroradiology

Machine Learning for Improved Patient Care





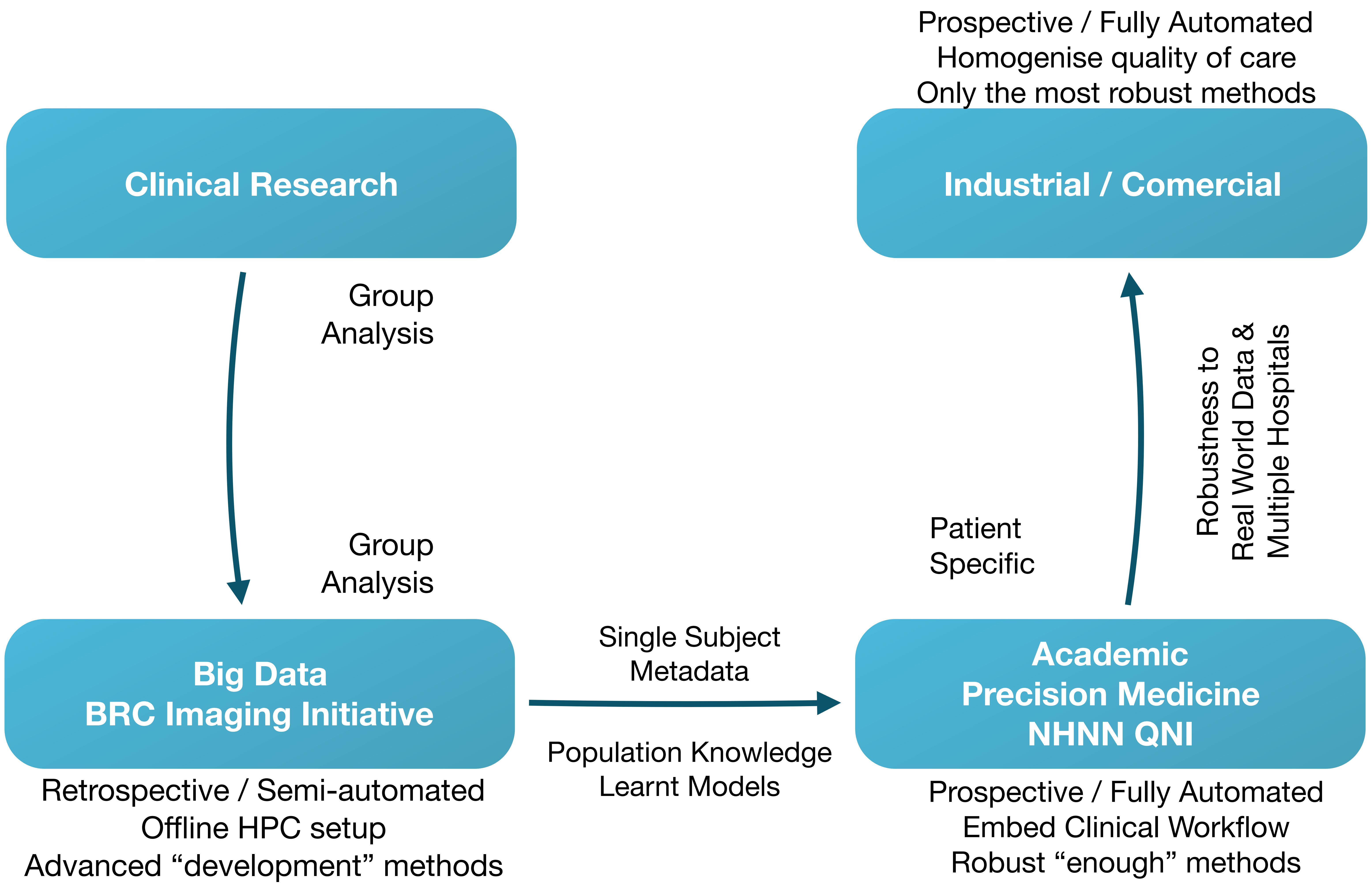
M. Jorge Cardoso

TRANSLATIONAL IMAGING GROUP

UCL

Image Analysis

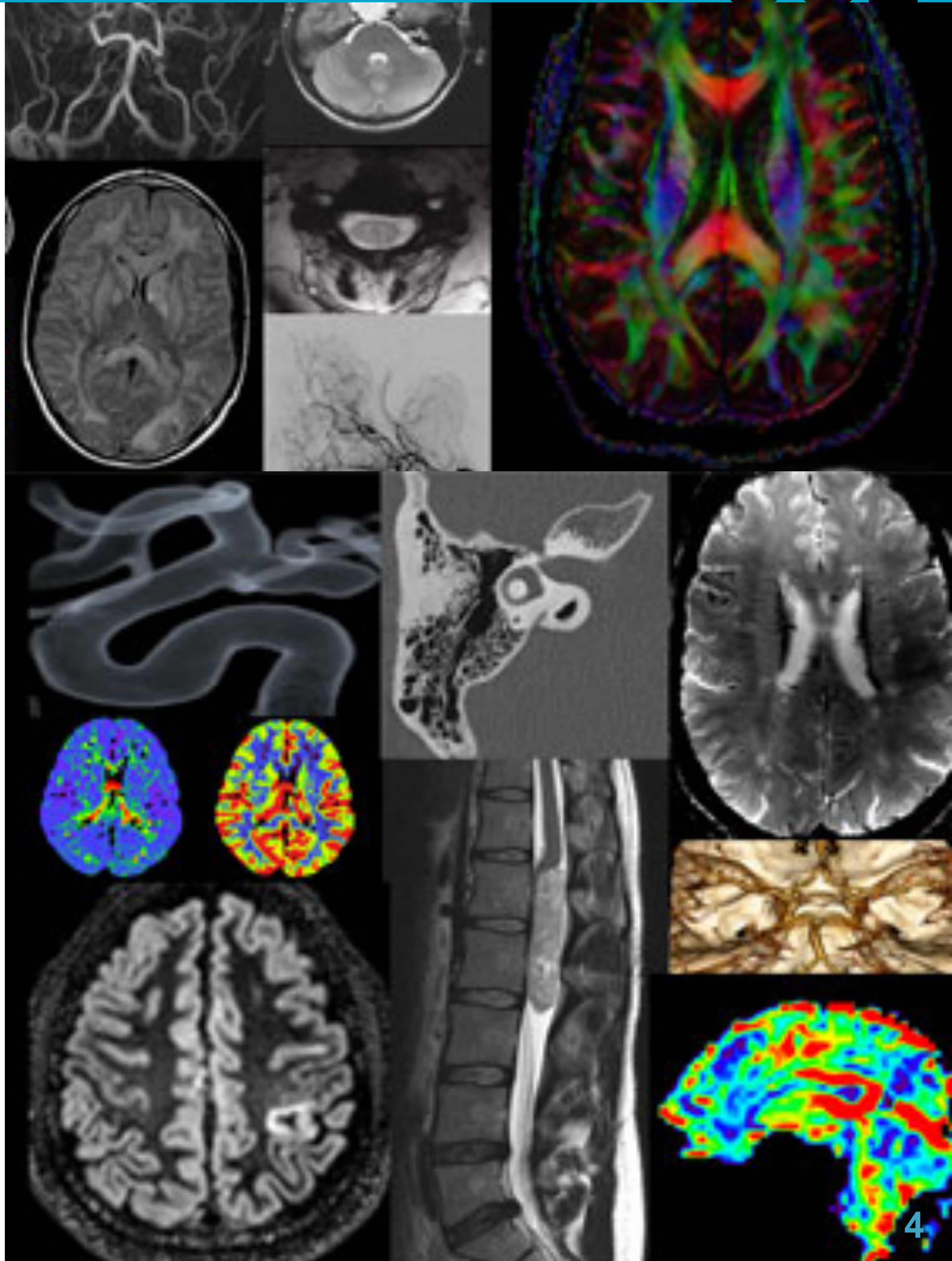
UCL TIG Translational Pathway



Classic Neuroradiology

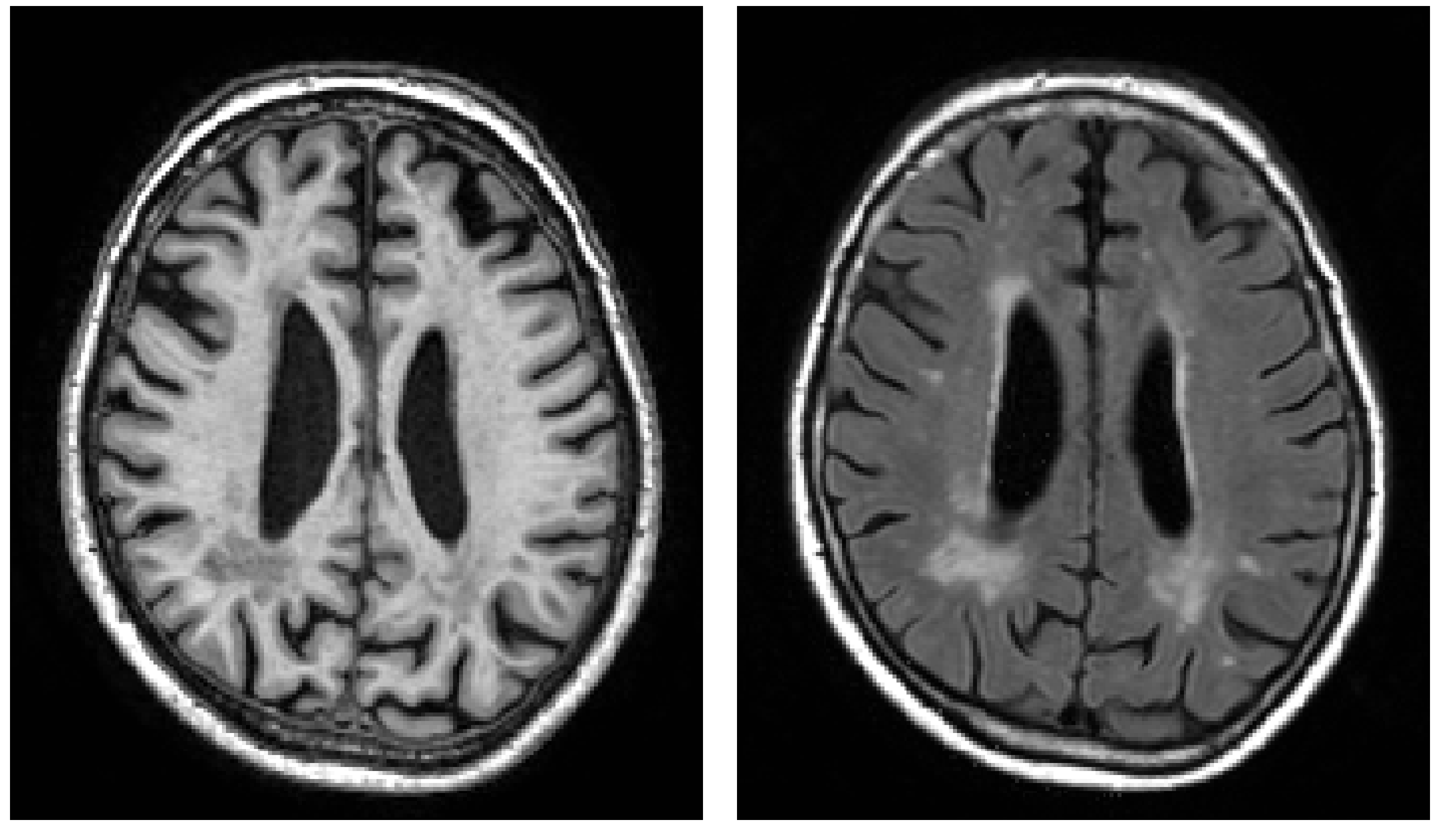
- Neuroradiologists interpret or "read" the acquired images and produce a report of their findings and impression or diagnosis.
- Referring physician reinterprets the findings against symptoms to obtain the final integrated diagnosis.

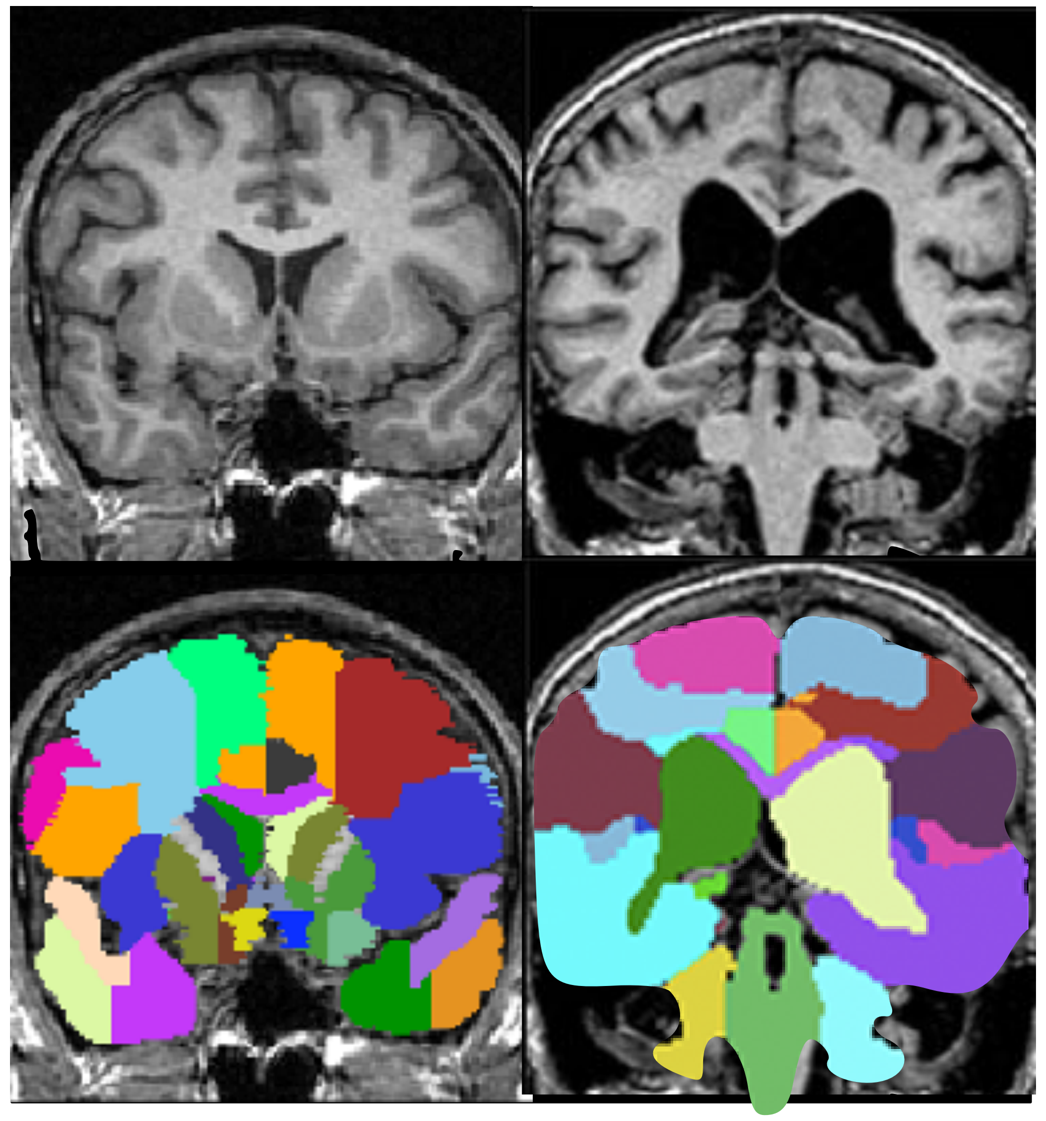
- Neuroradiology has a problem:
  - MRI & CT increase 10-12% per year compounded
  - Radiologists increase 1-3% per year
  - Limited NHS funding, no increase in training rates, escalating data complexity



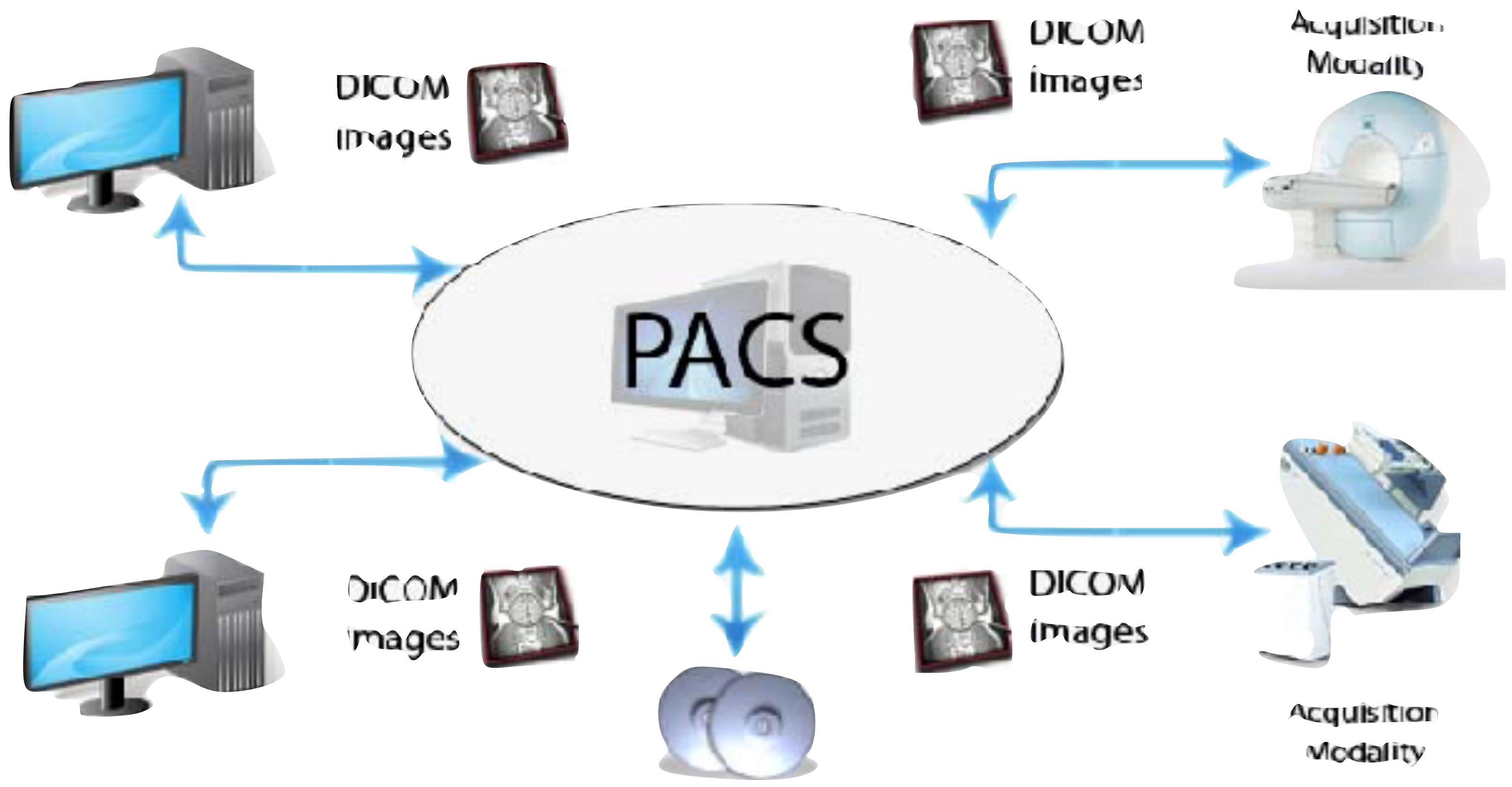
Challenges of quantitative neuroradiology

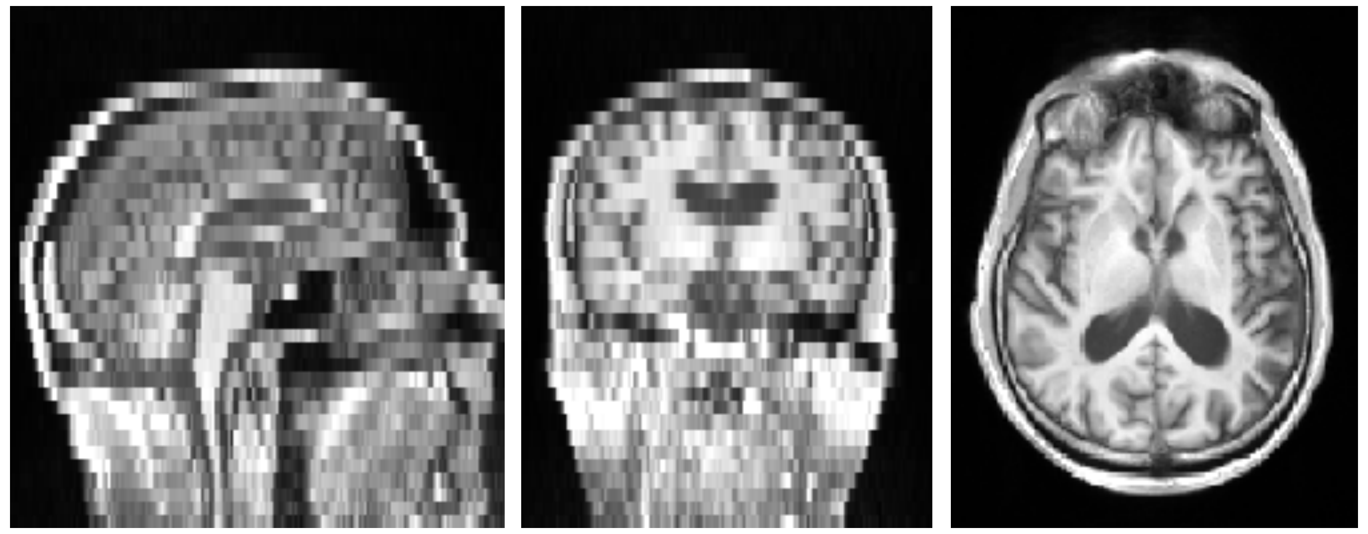
- Normally small training datasets
- Very variable input data
- Accuracy is paramount
- Speed is not important (with exceptions)
- Ability to extrapolate
- Problem specific solutions
- No ground truth
- Large unstructured data
- Ethics and clinical adoption





- **300.000 sessions - +2.5M Volumes**
  - Many images & follow-up data
  - 2.5M Volumes
  - 14k “different” sequences
  - 15+ different scanners
  - From 0.5 - 7T (mostly 1.5T and 3T)
- **RIS - Radiological reports**
- **CDR - ICD-10 codes**
- **Blood tests**



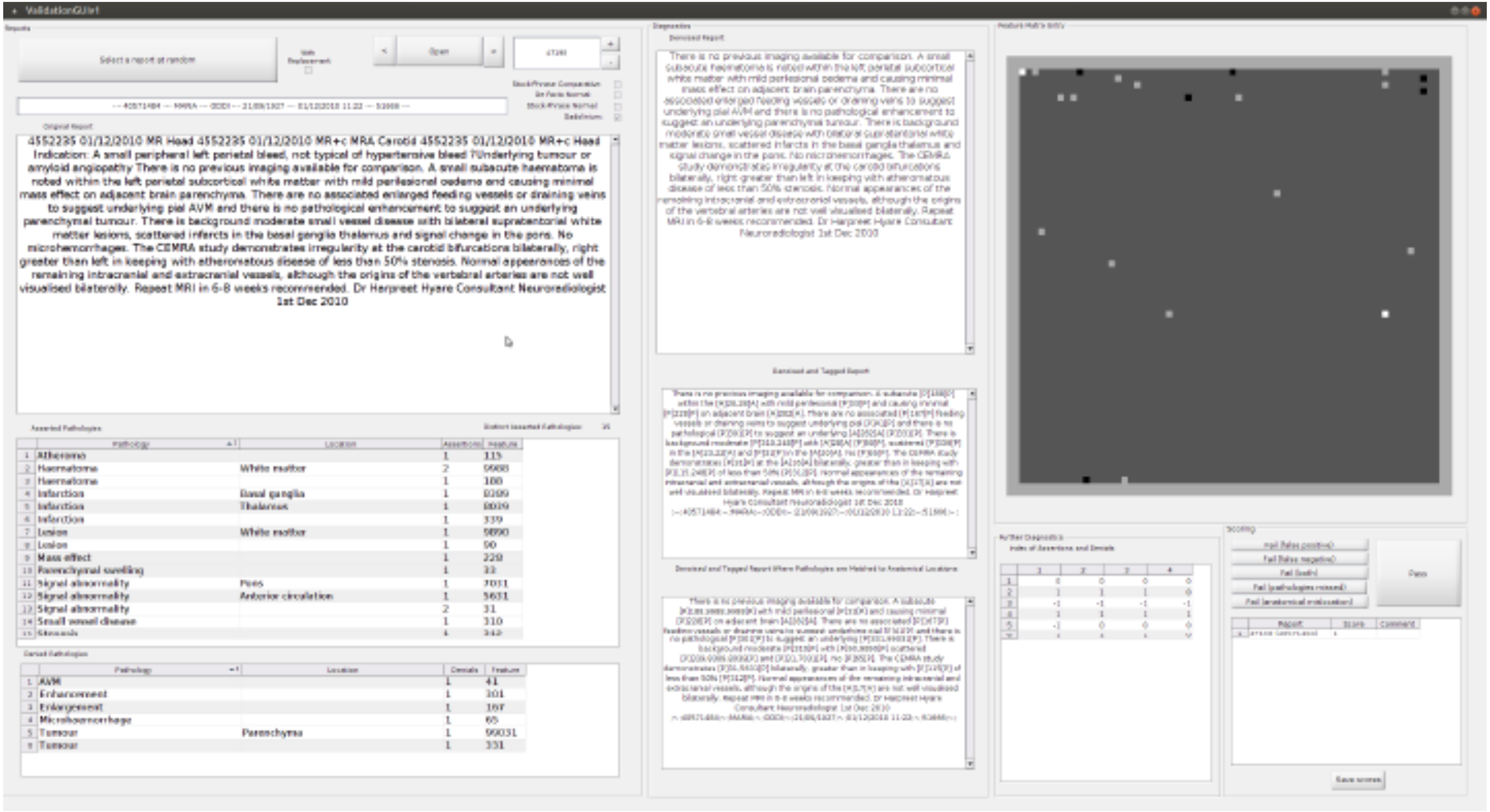


- **What questions can we ask?**
  - Epidemiology and learning disease structure
  - Service optimisation:
    - Workflow: Triage, Prioritisation, Recall
    - Managmment: Auditing, Bed usage, Cost-code optimisation, etc.
  - Surveillance/Diagnosis/Prognosis

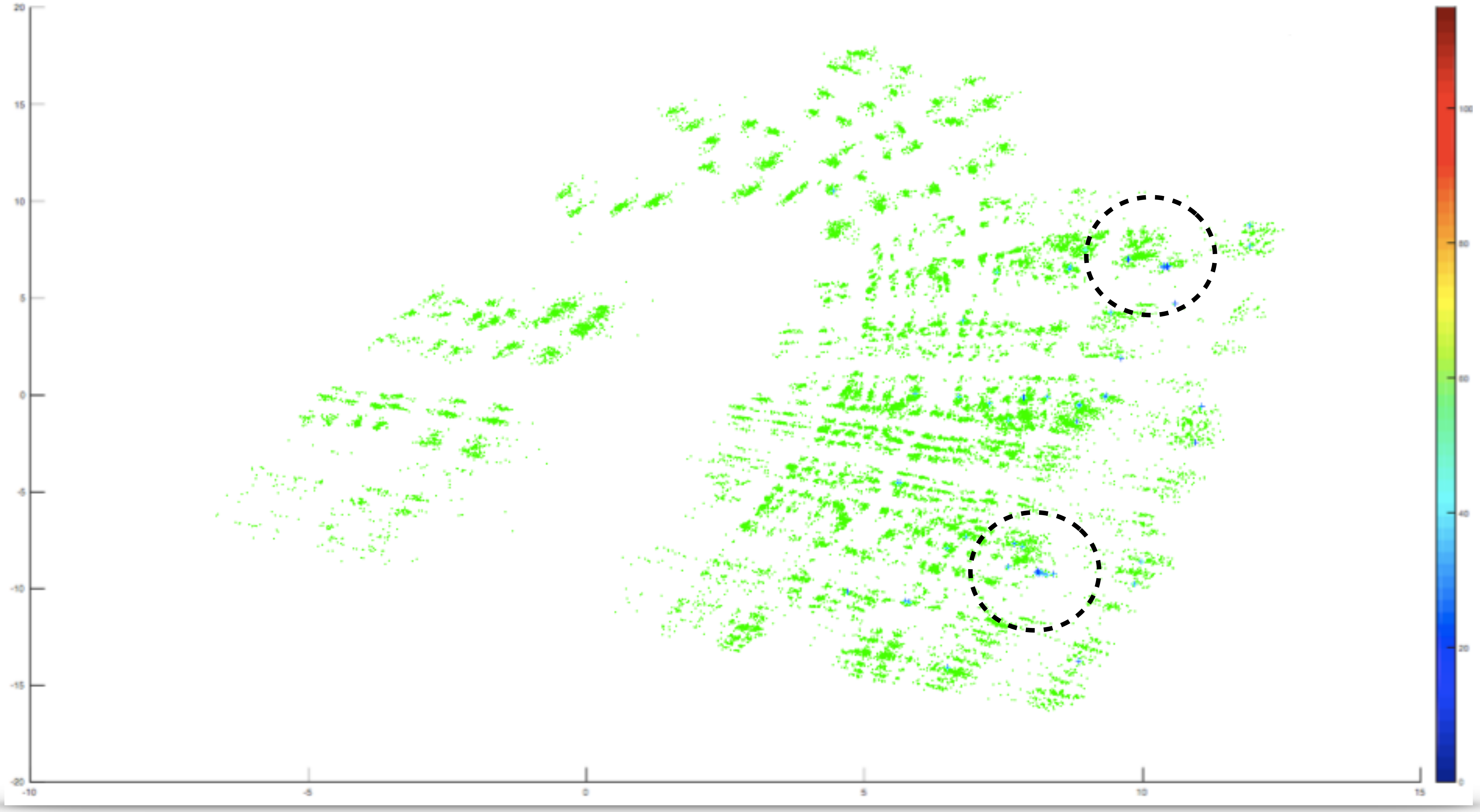
How do we learn from an unbalanced pool of pathologies given

a largely non-overlapping set of sequences?

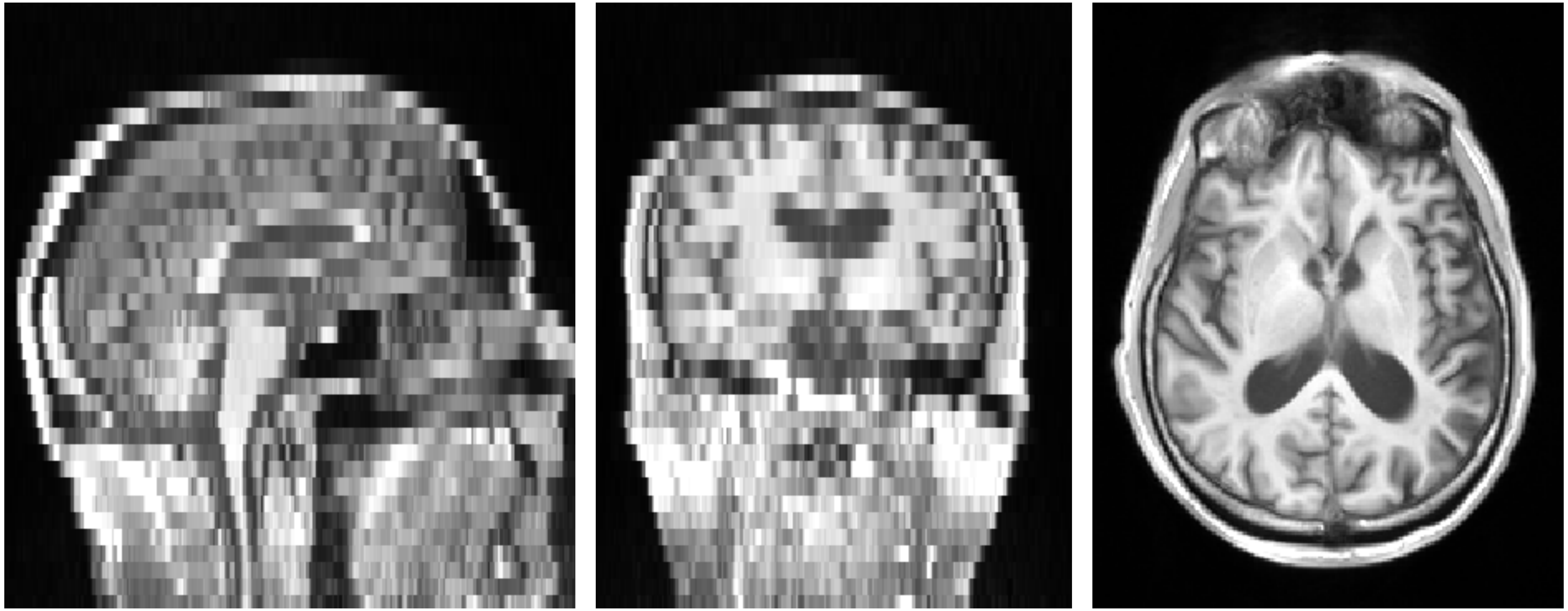
Parameterising Clinical Reports



- Deep Autoencoding - Low dimensional (2D) projection of Rad Report vs “Ataxia”
  - Reporting is consistent with regards to “appearance” and non-trivial (Cerebellum vs Sensory)

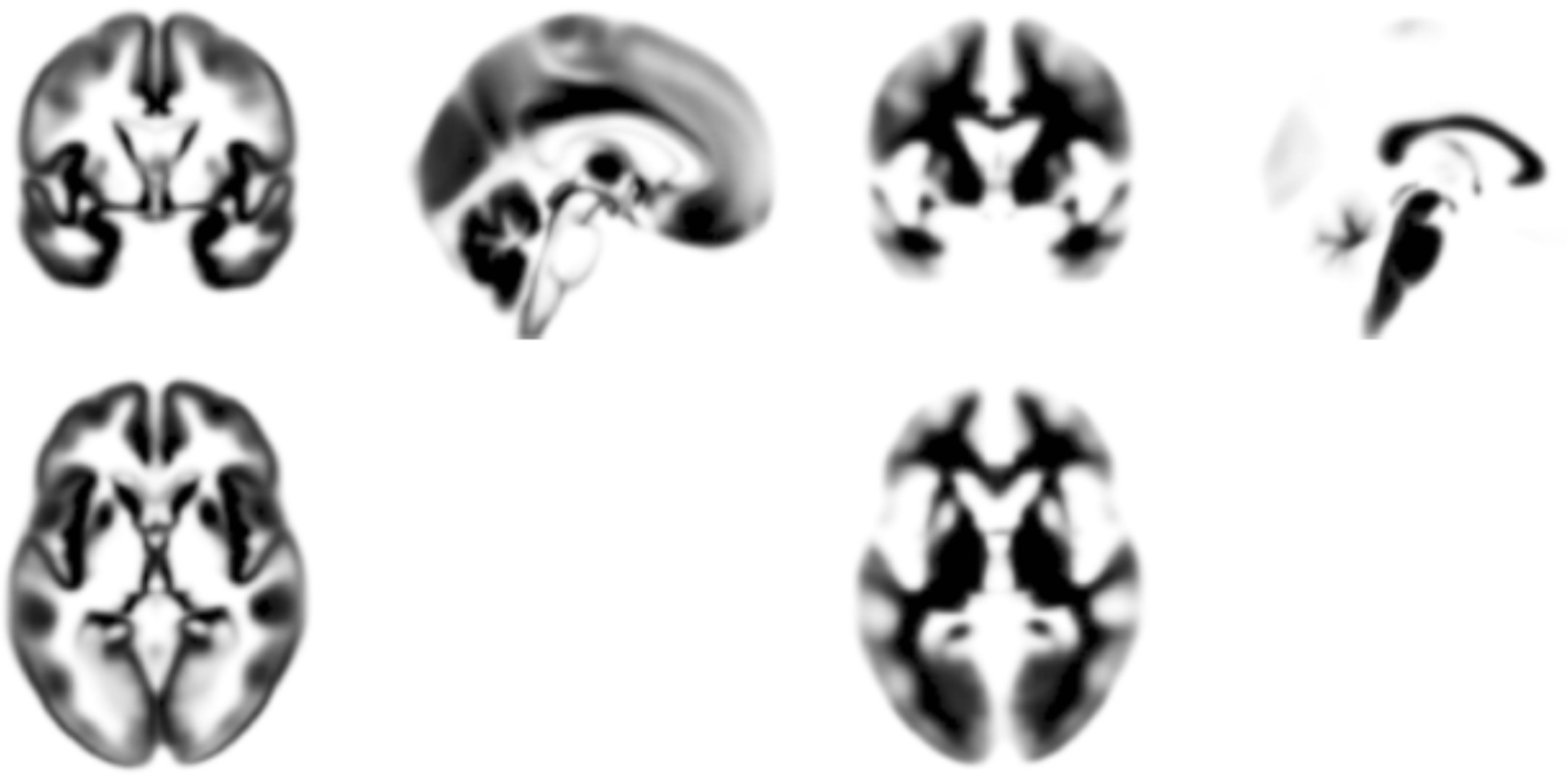


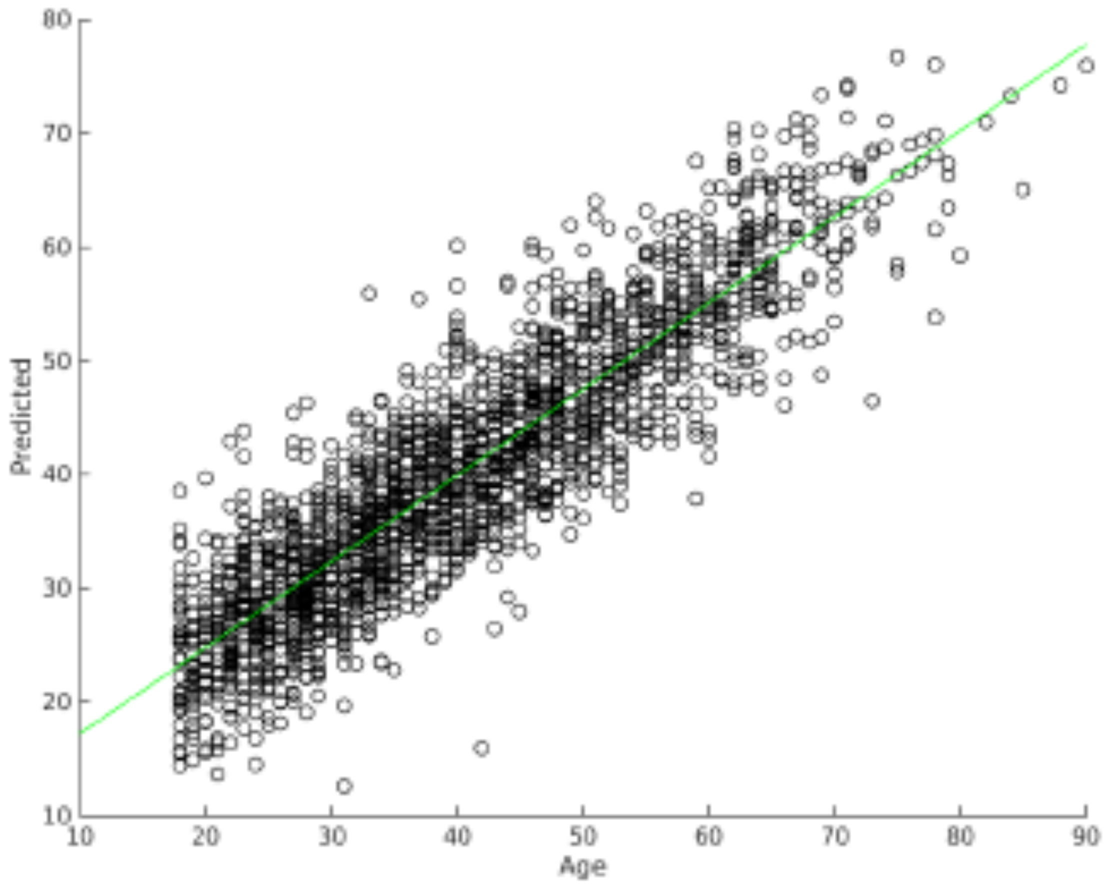
- 20000 radiologically normal → 6207 Asserted Normals
- Do standard Neuro pipelines work?
  - … with this “beautiful” data



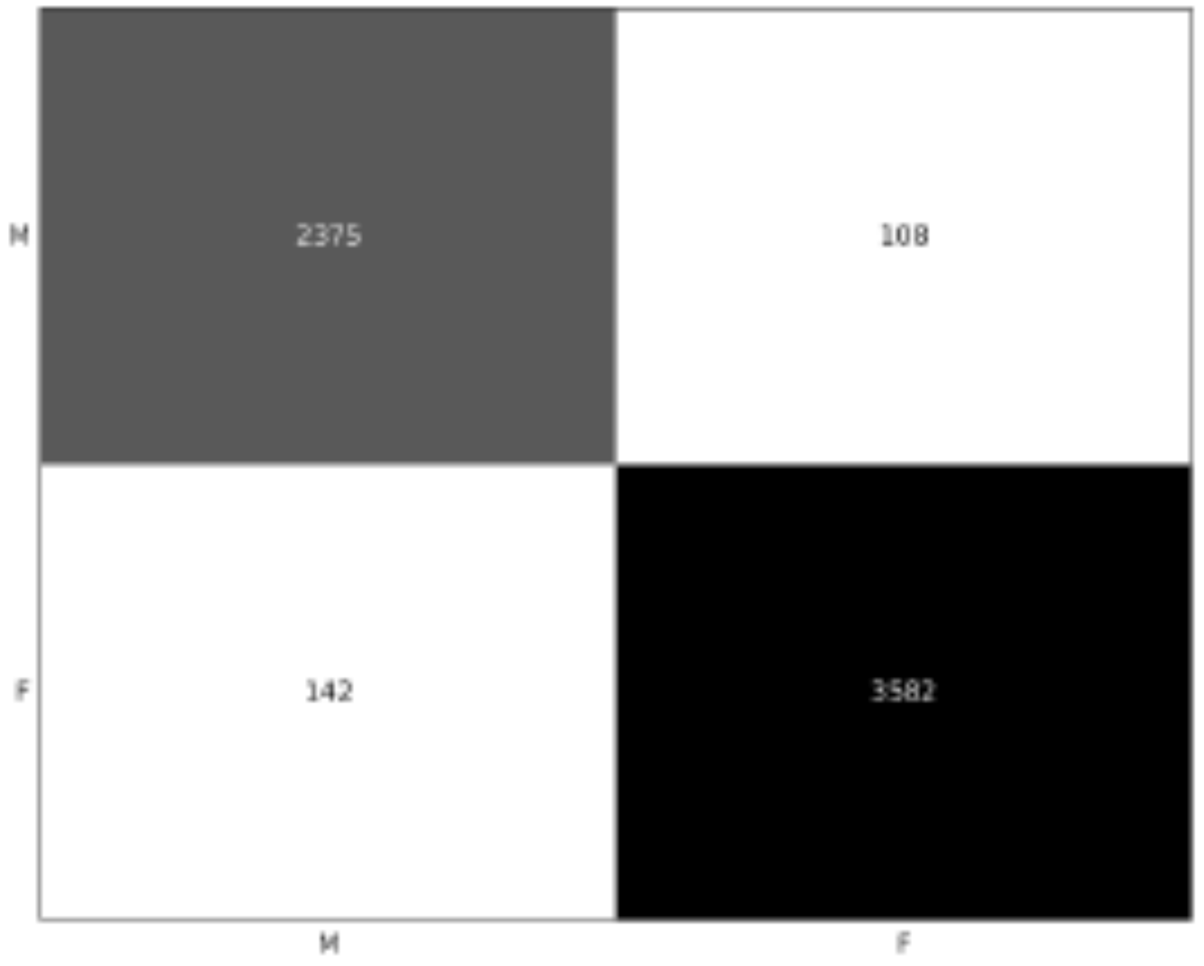
Population Analysis

- 40000 radiologically normal
  - 6207 Asserted Normals





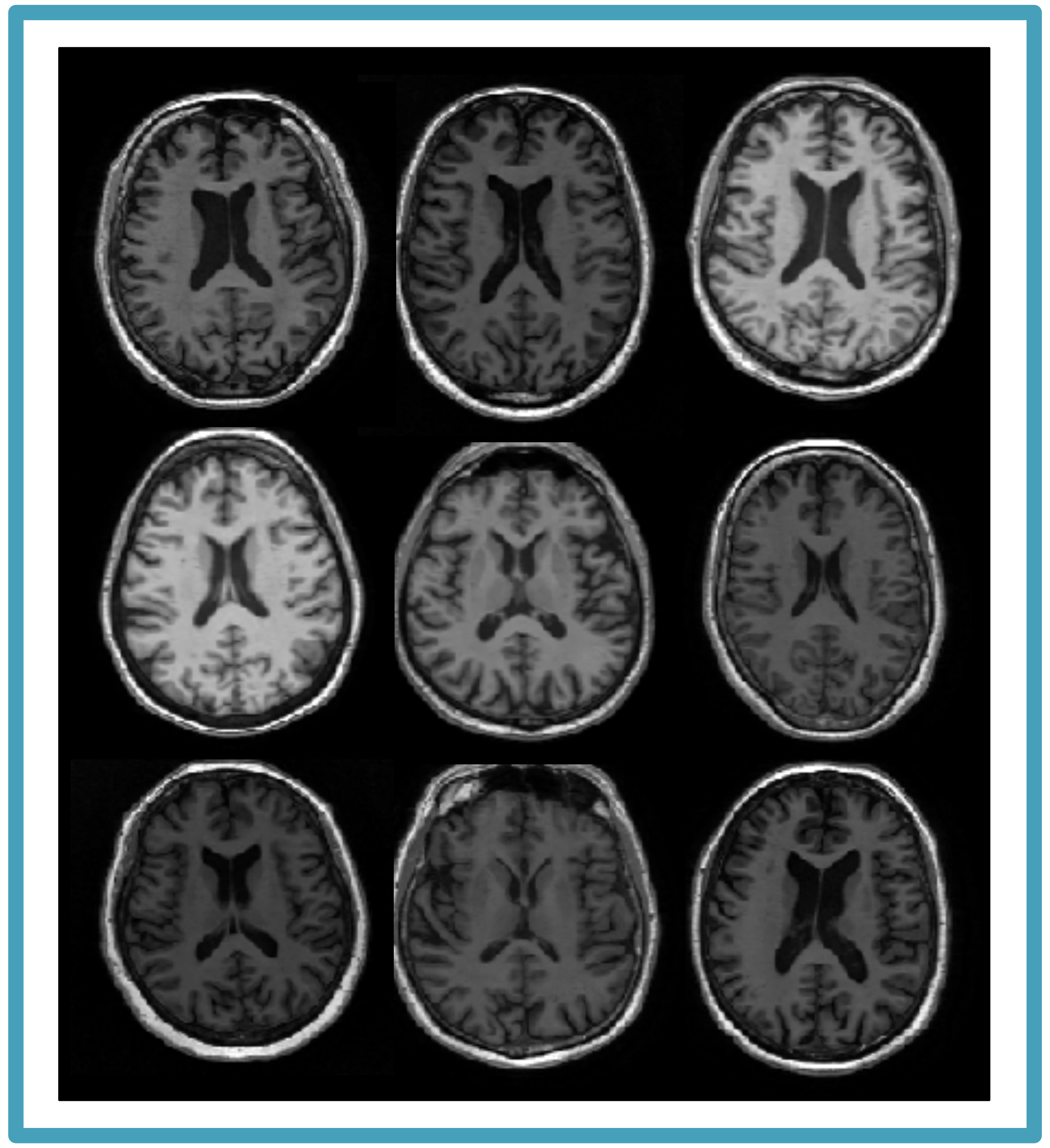
Age: R=0.897, RMSE=6.246 years



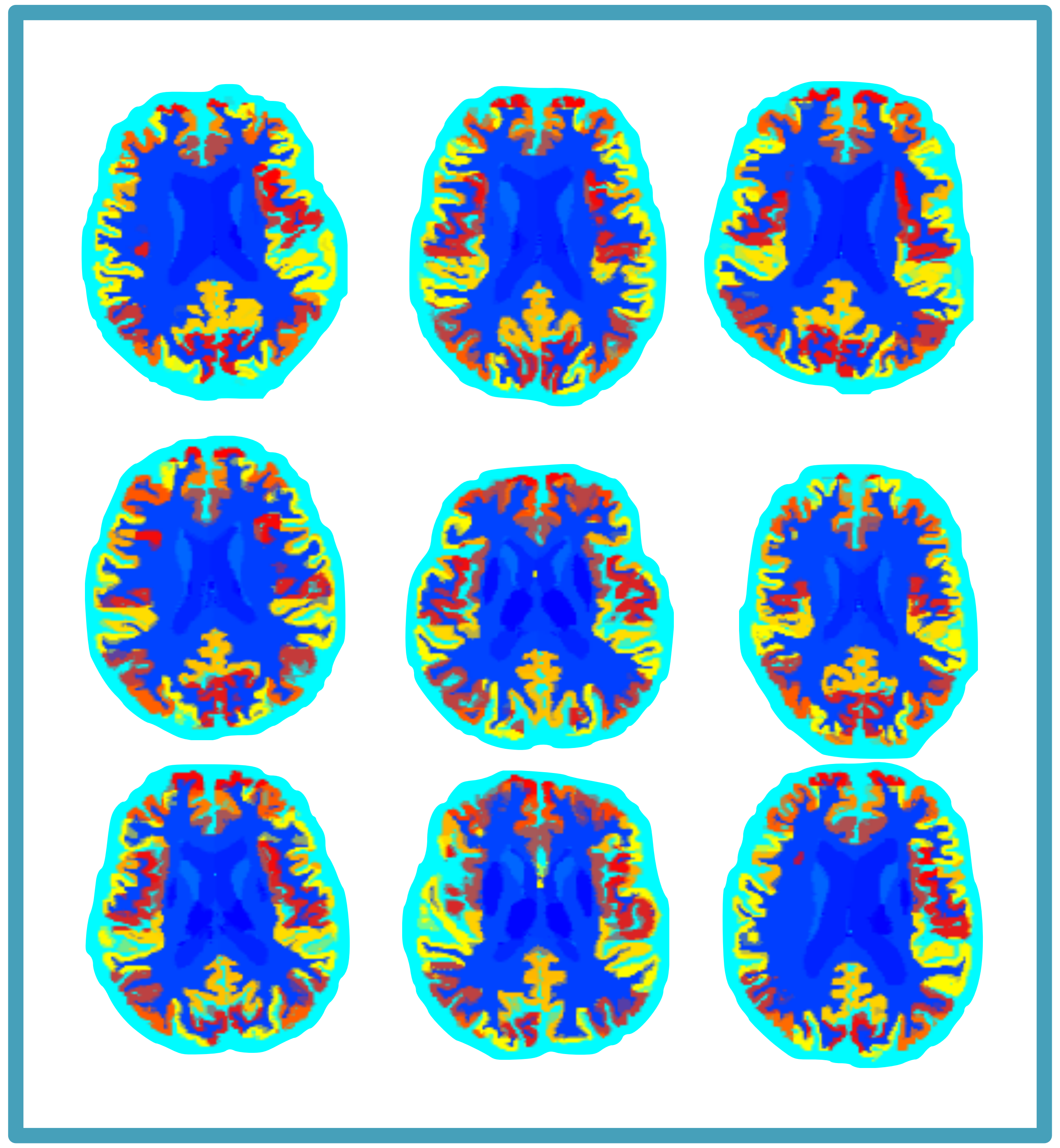
Sex: 95.97% accuracy

- 40000 radiologically normal
  - 6207 Asserted Normals
- Region statistics

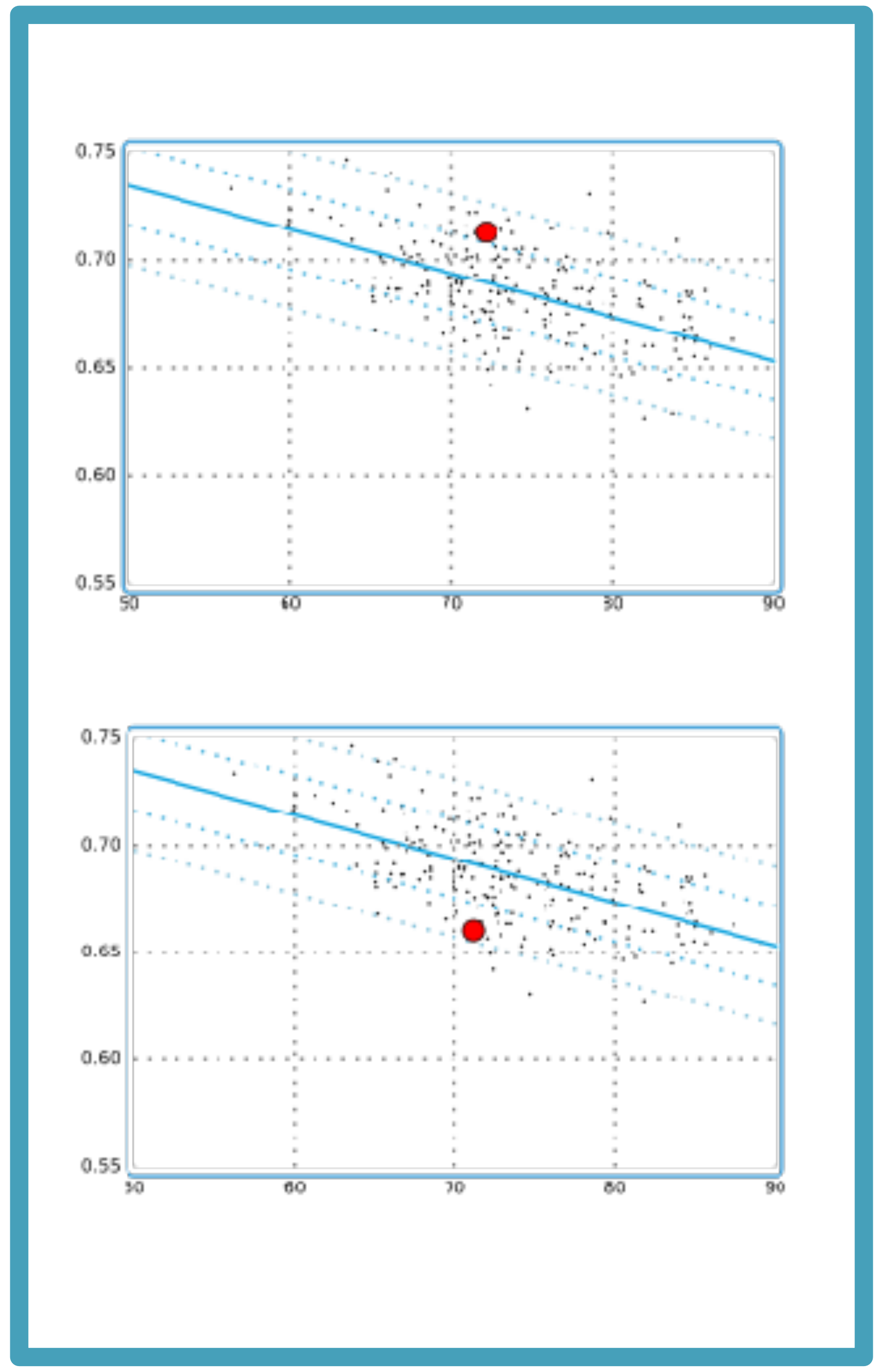
MRI Imaging



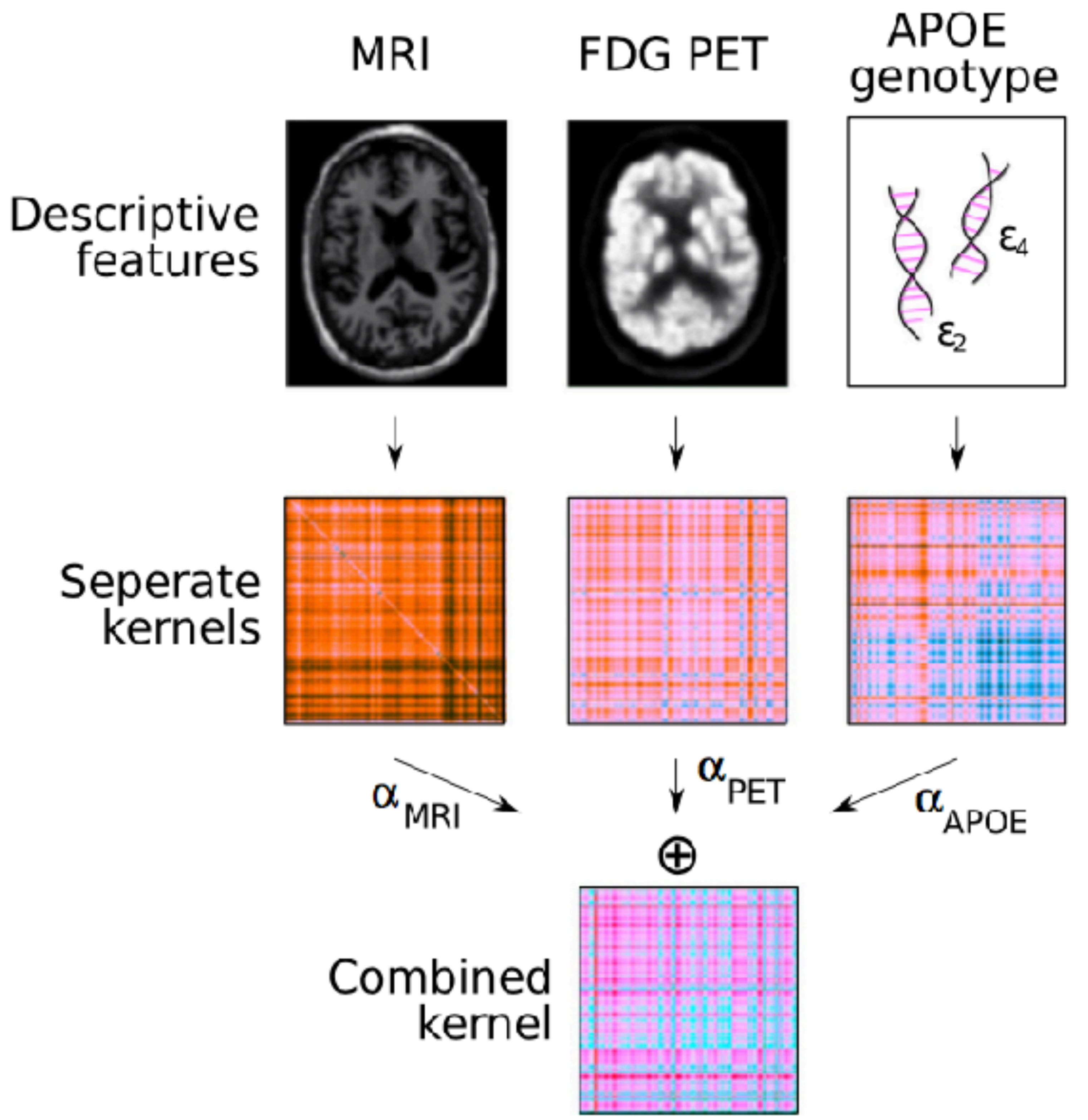
Delineation

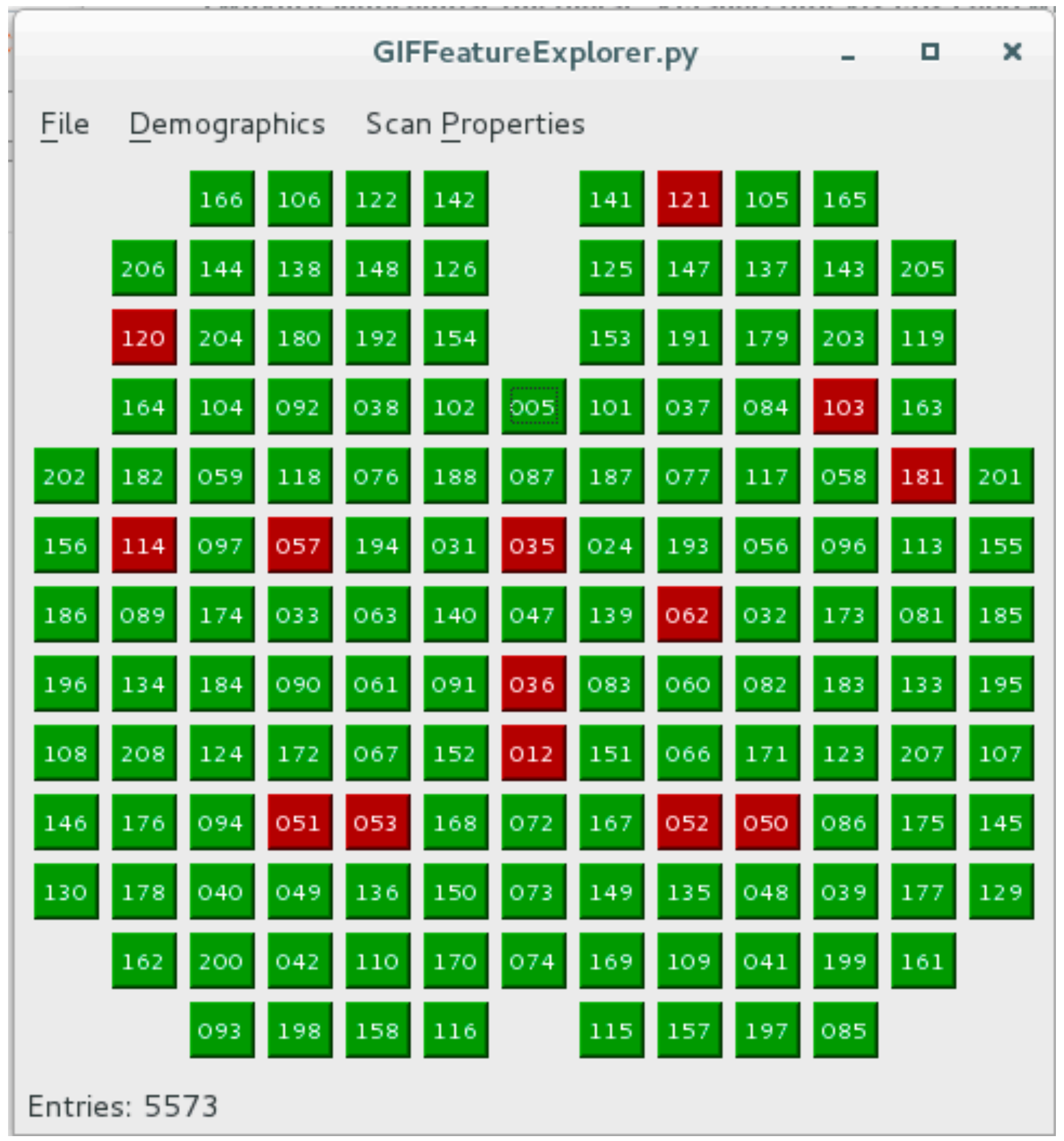


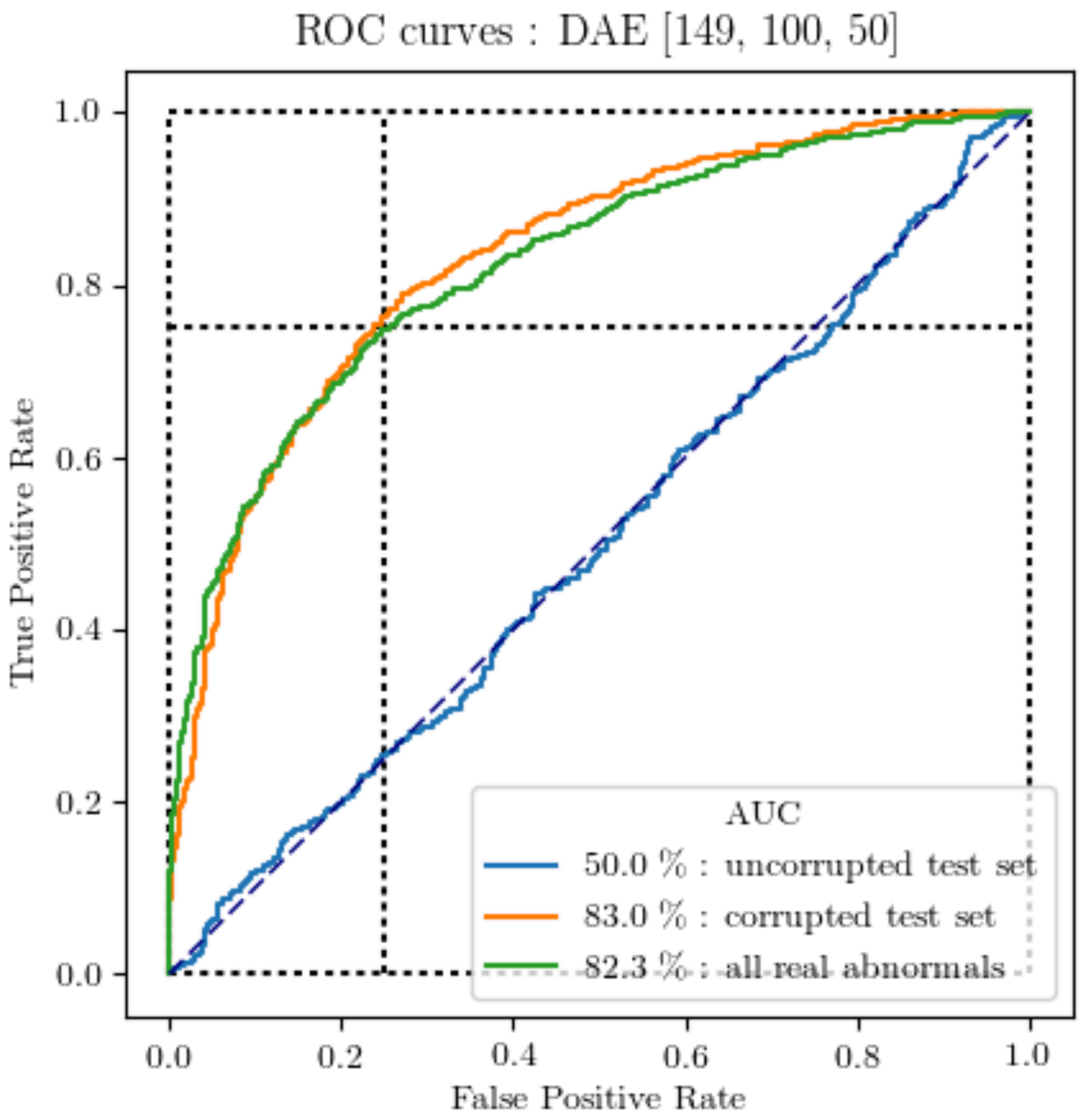
Population Distribution



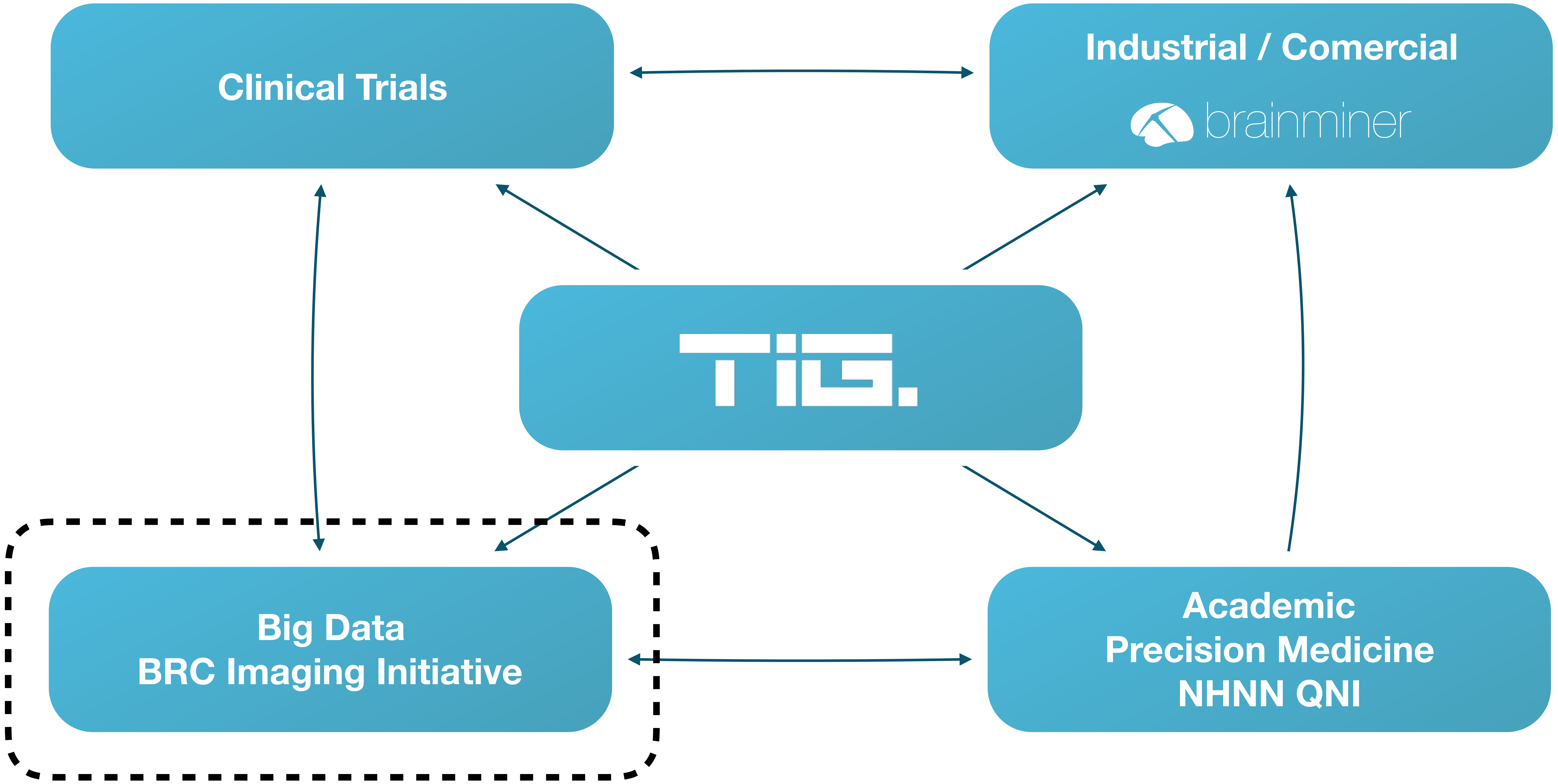
- Gaussian process (GP) - Probabilistic classification/predictions
- Variational/Denoising Auto-encoders for abnormality detection





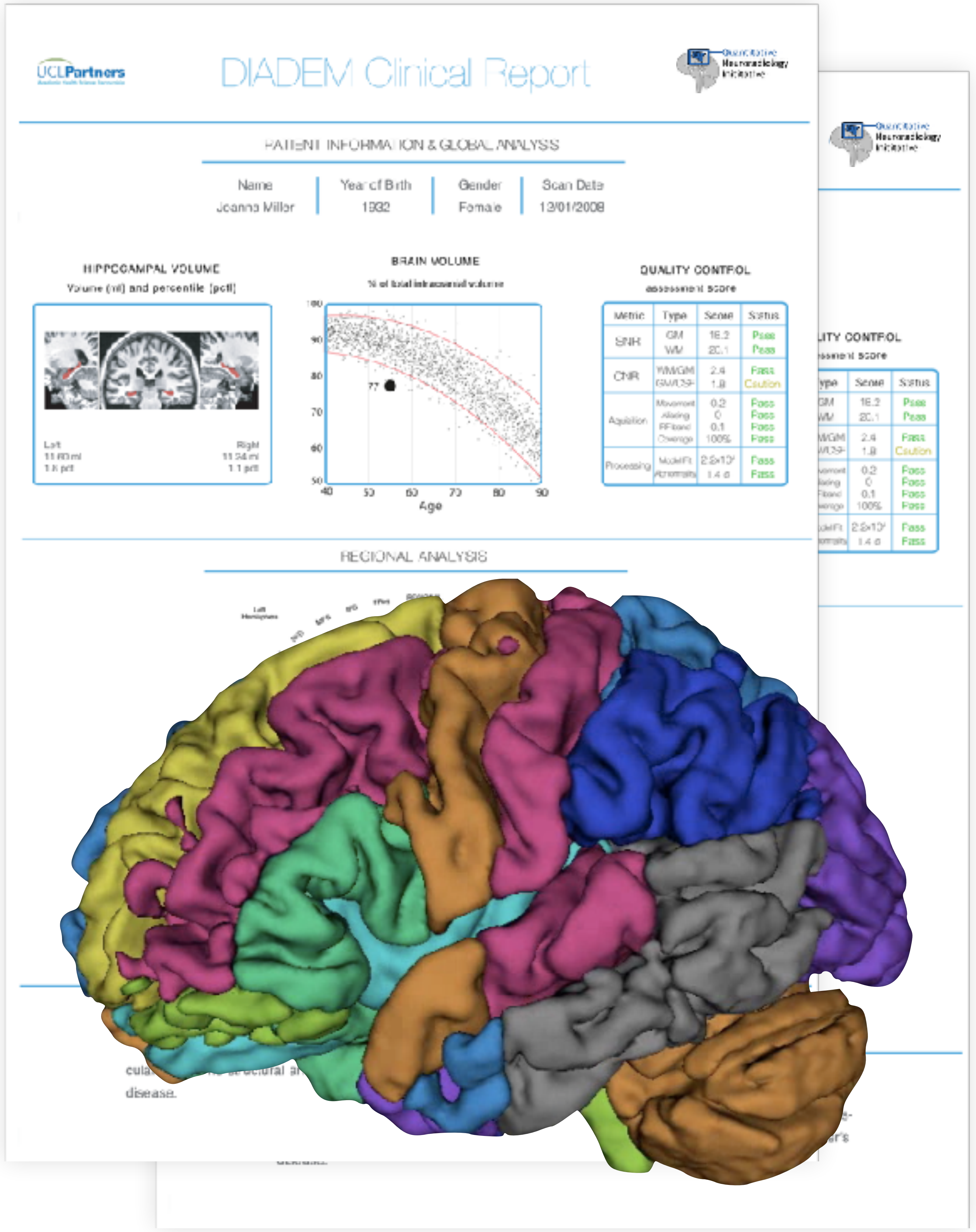


UCL TIG Translational Pathway



Quantitative Neuroradiology Initiative

- Patient-specific phenotyping tools for clinical data
- The Data
  - Can be low resolution (slice thick. 3/5/7mm)
  - Artefacts
  - Inconsistent scanning parameters
    - 1400 different “sequences”
  - Inconsistent availability of modalities
- Homogenising data acquisition across sites
  - Quality Control/Assurance, data identification
- Extracted metadata is integrated into a clinical report
- Collaboration with ION & NHNN



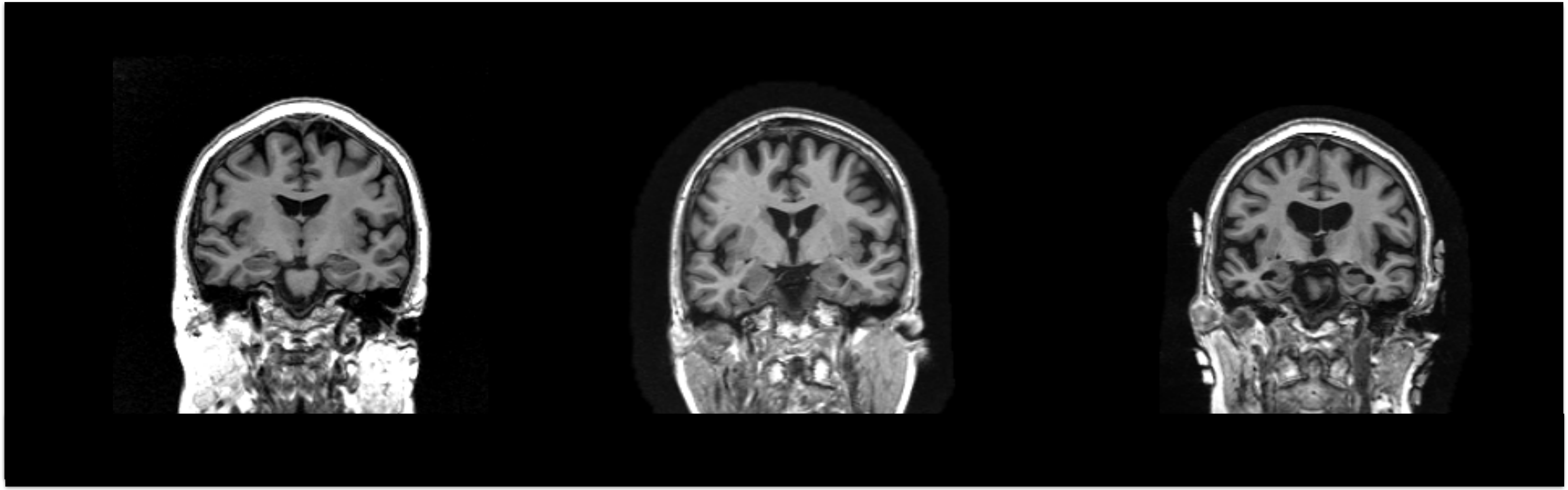
Translation to Clinical Usage

1 - Image Acquisition

2 - Automated quality control & biomarker estimation

3 - Automated clinical report & comparison to healthy population

4 - Quantitative neuroradiology & improved patient care



Healthy

Early Alzheimer's Disease

Alzheimer's Disease

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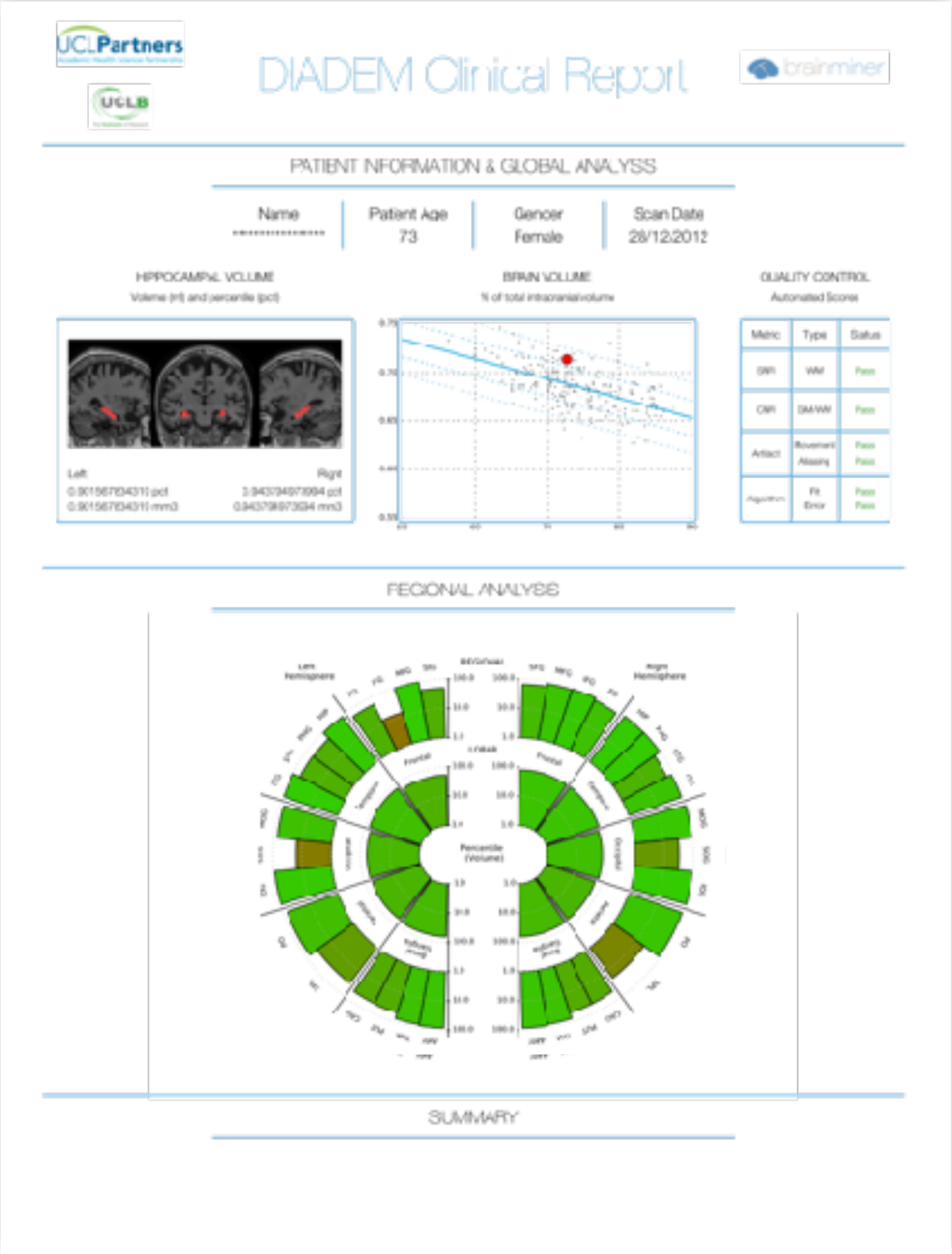

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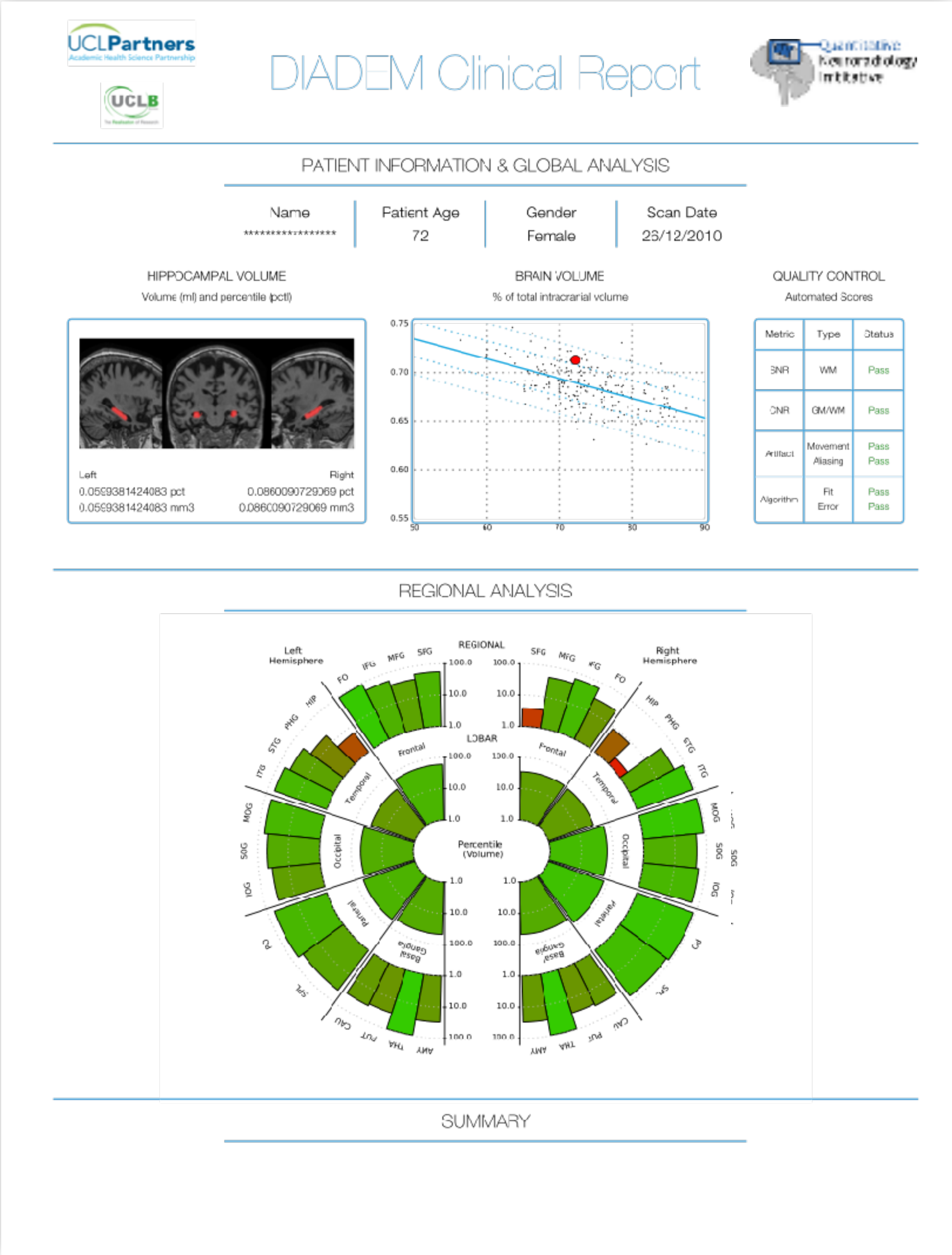
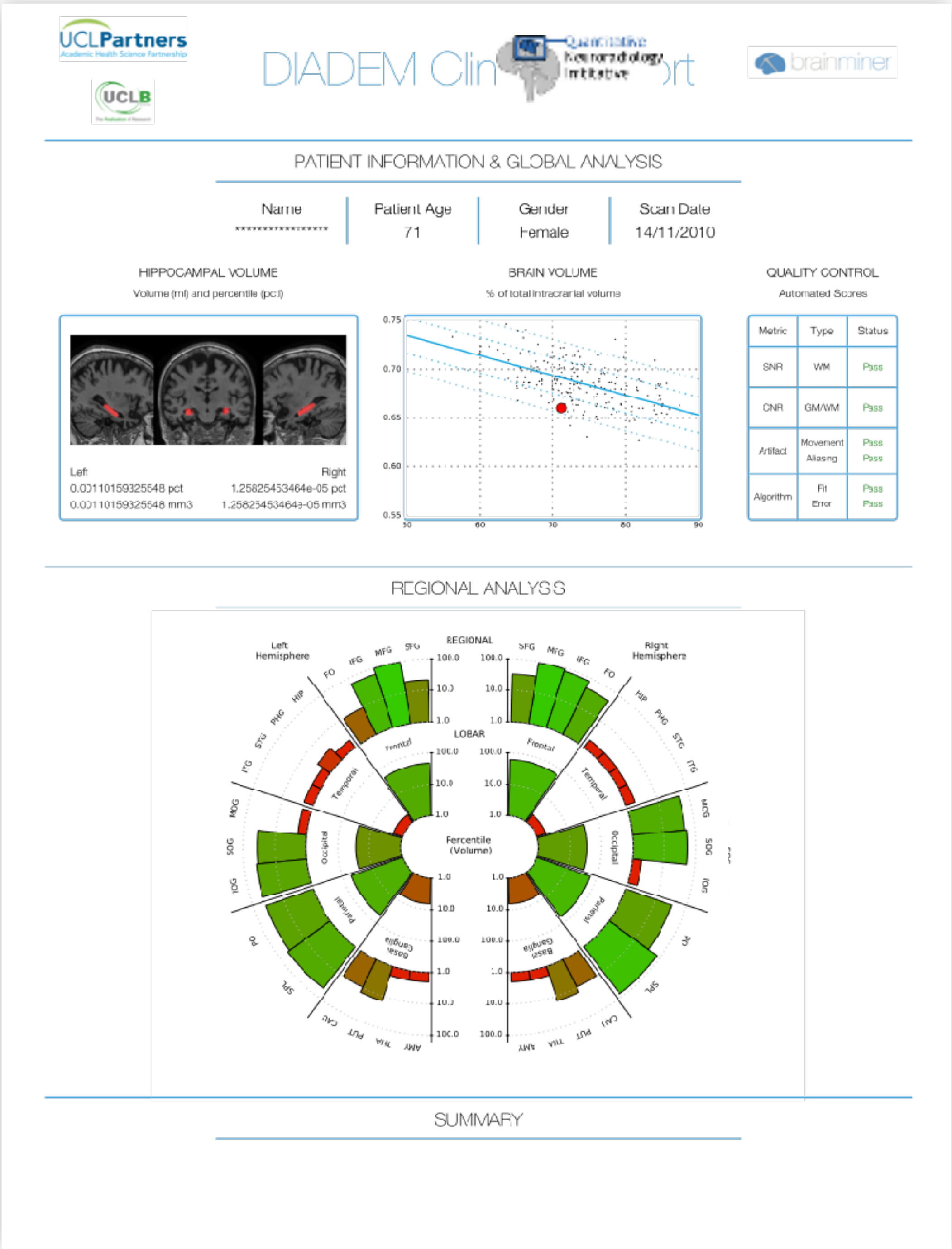


Early Alzheimer's Disease



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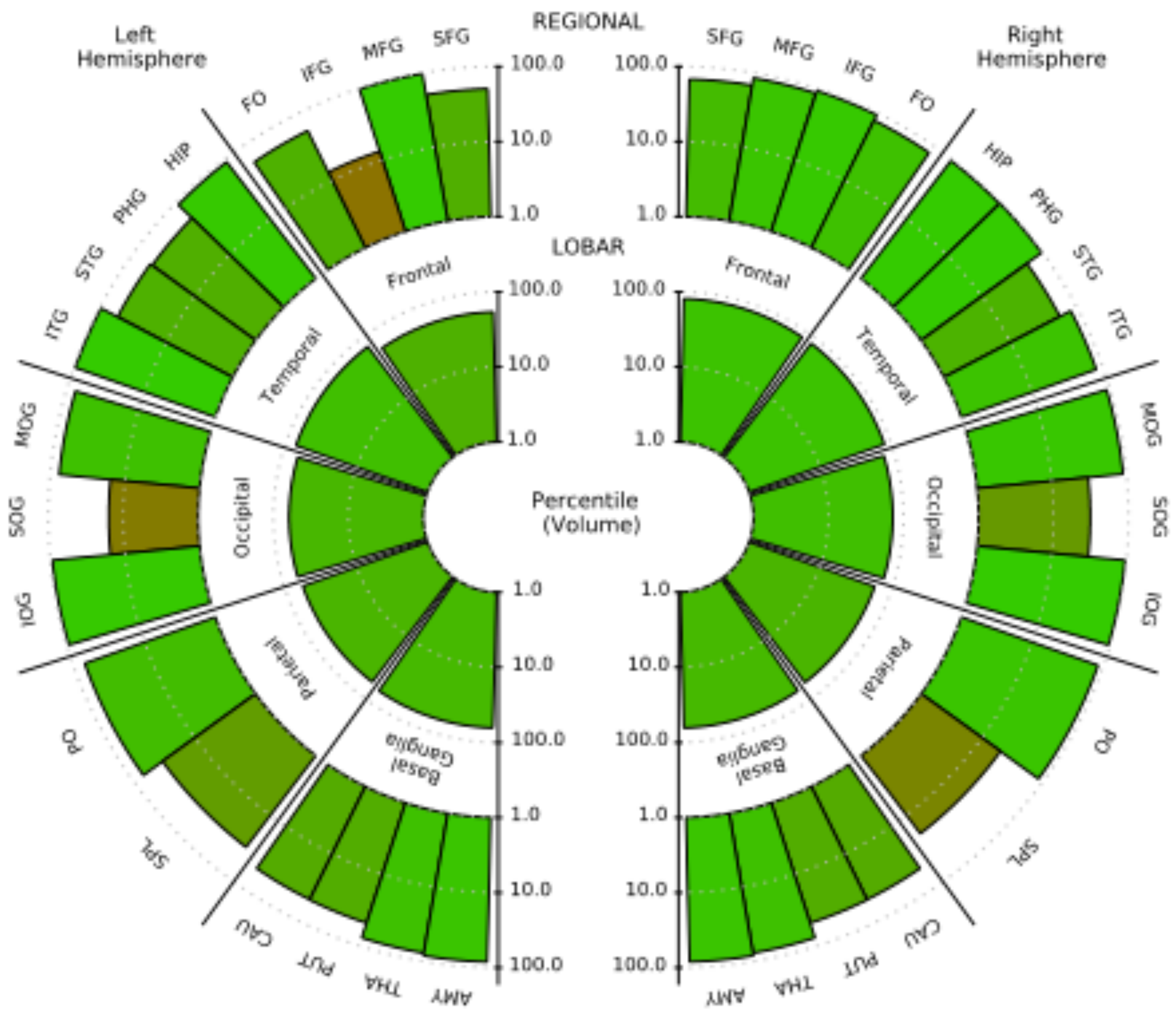

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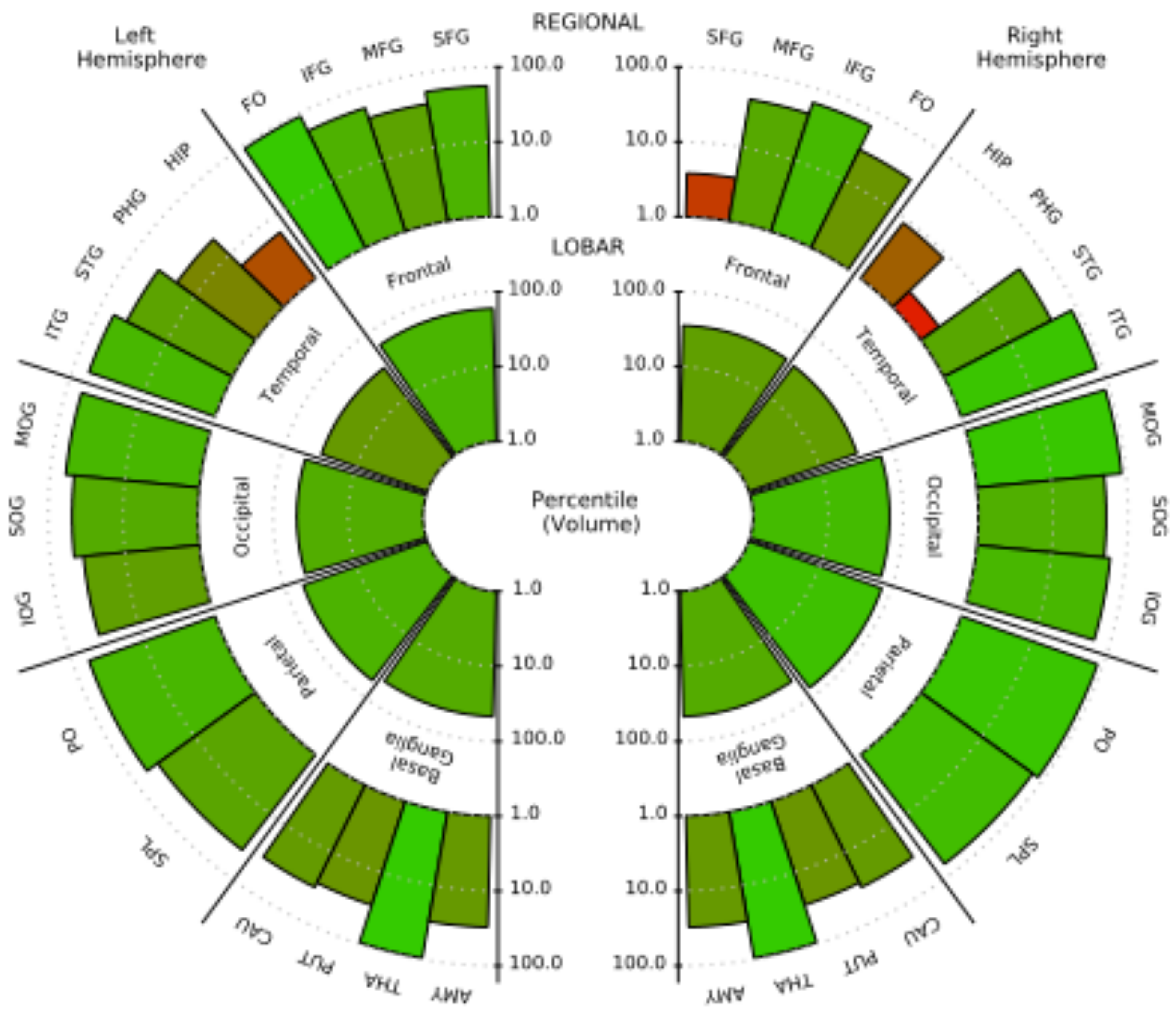

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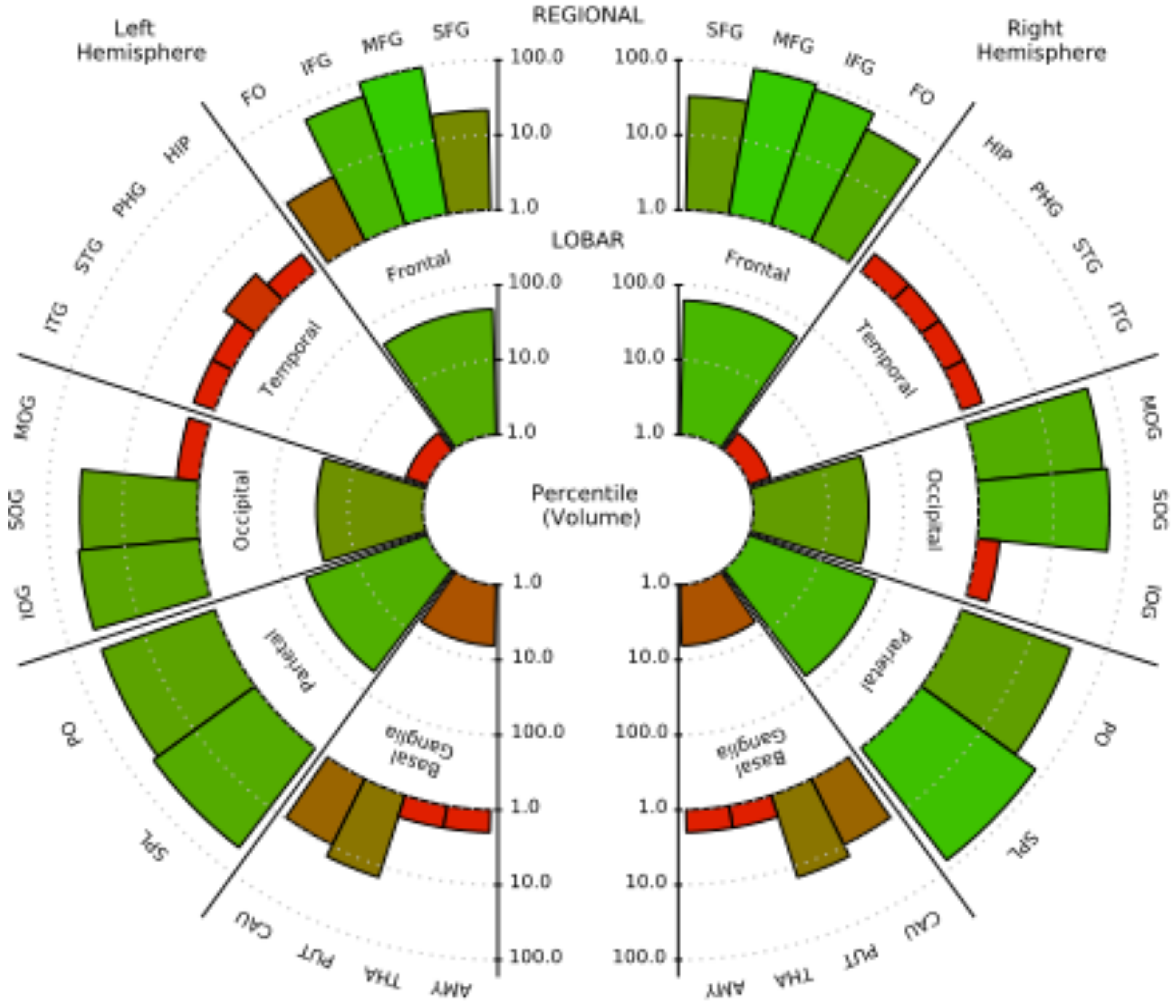
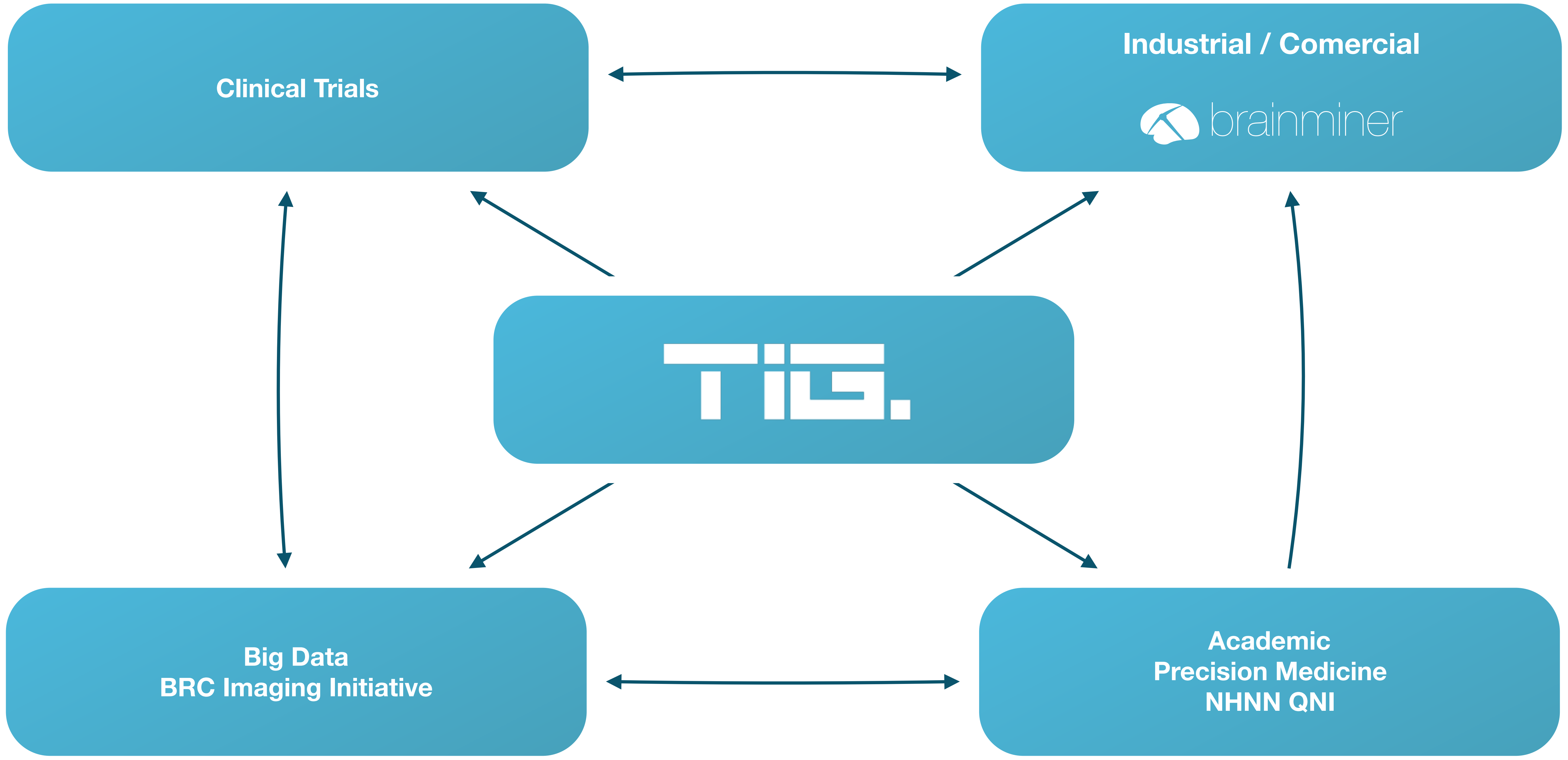


Alzheimer's Disease

Translation to the Real World

- Translation to Clinics: Neuroradiological workflow
  - Deploy results into reporting platform
    - Disease specific biomarkers
    - Available at reporting time (HPC)
  - Push to patient health care record
    - Available to referring physician
    - Retrievable for longitudinal analysis
- Translation to industry: BrainMiner
  - UCL spinoff
  - Translate TIG/QNI beyond UCL
  - SBRI award £1.1M
  - Build CE marked/FDA approved software



Questions?

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