Brain Imaging: data management & processing

David Rodriguez Gonzalez
Fan Zhu

DIR & BRIC

SINAPSE collaboration

The following Universities are charitable bodies, registered in Scotland, with registration numbers as below.

Scottish Funding Council
Promoting further and higher education

UNIVERSITY of ABERDEEN SC013683

UNIVERSITY of DUNDEE SC015096

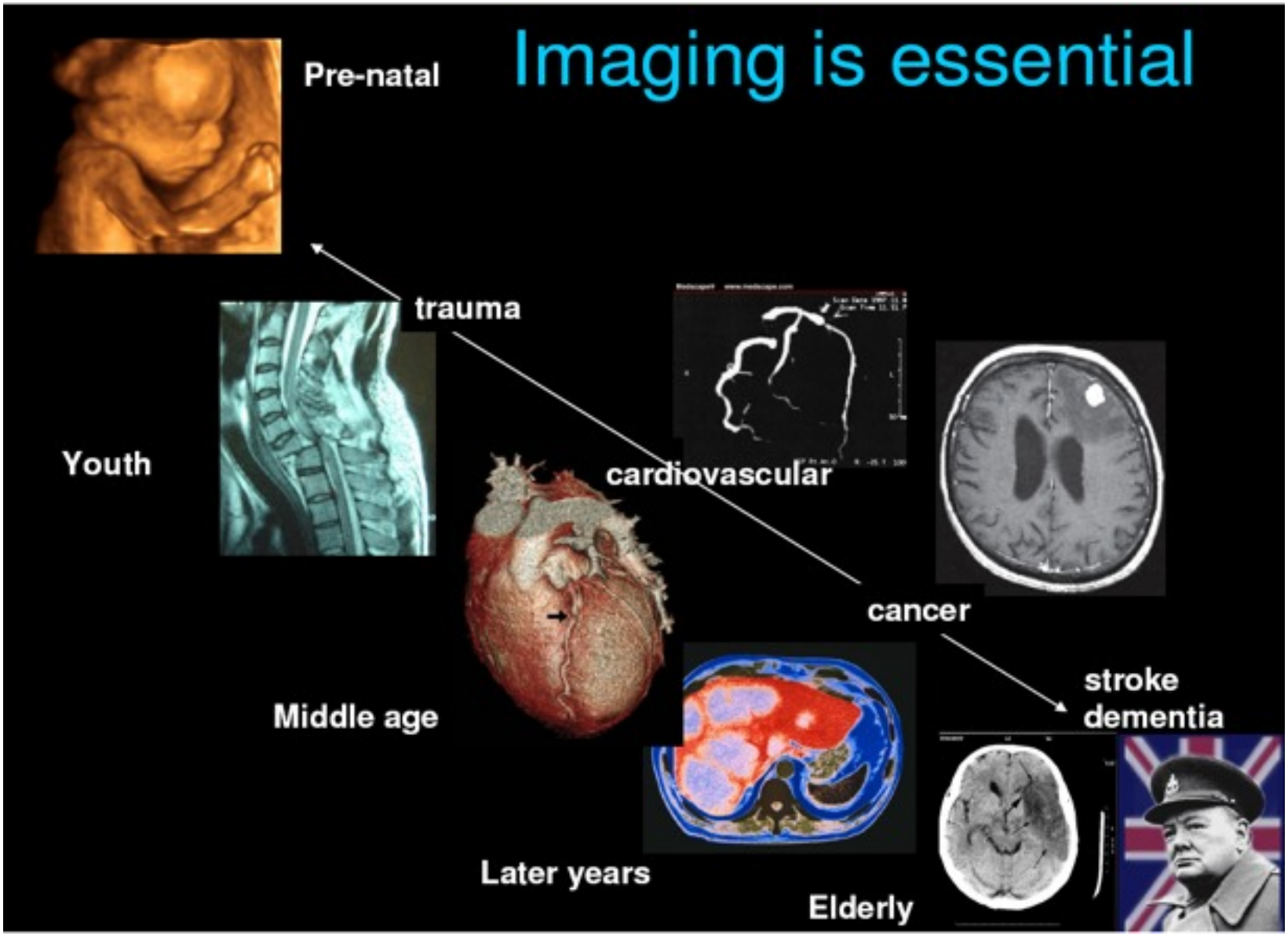
THE UNIVERSITY of EDINBURGH SC005336

University of Glasgow SC021474

University of St Andrews SC013532

UNIVERSITY OF STIRLING SC011159

Slide by J. Wardlaw

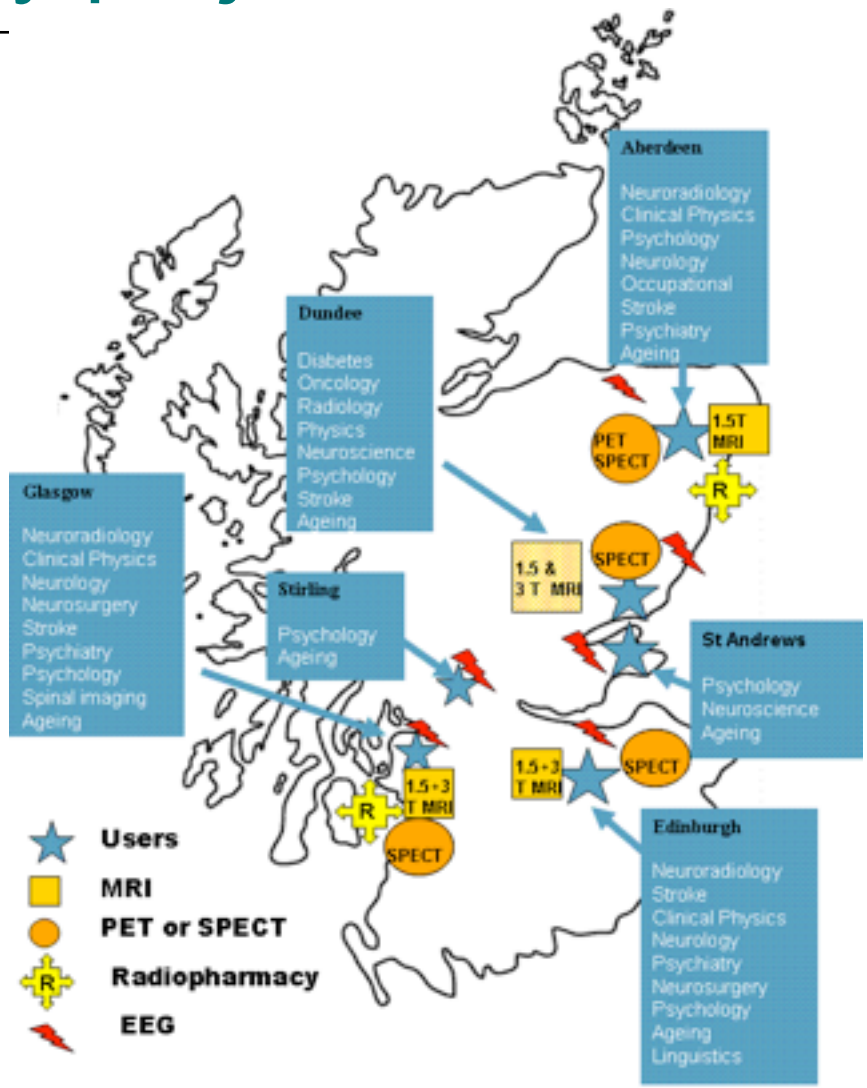


The SINAPSE Project

- Stands for ***Scottish Imaging Network: a Platform for Scientific Excellence***.
- Pooling initiative of six Scottish universities: Aberdeen, Dundee, Edinburgh, Glasgow, St. Andrews and Stirling.
- Main objectives:
  - develop imaging expertise,
  - support multi-centre clinical research in conjunction with the Clinical Research Networks,
  - improve the ability of neuroscientists to collaborate on clinical trials,
  - have a direct impact on patient health.

SINAPSE priority projects

- Stroke, the brain and the blood-brain interface
- Ageing brain to dementia
- Novel molecular imaging markers for major psychiatric disorders
- Innovative radiotracers for CNS inflammation



DIR involvement

- Information governance & data de-identification
  - Networking
  - Development of de-identification tool
- Data sharing infrastructure
  - Facilitating multi-centre studies
- Portal for brain imaging
  - Improving usability
- Image Analysis methods

Data in SINAPSE

- MRI:
  - T1, T2, perfusion, diffusion,
  - fMRI,
  - spectroscopy,…
- CT
- PET
- EEG
- Retinal Images

Images from SINAPSE, NIH and D. Clunie

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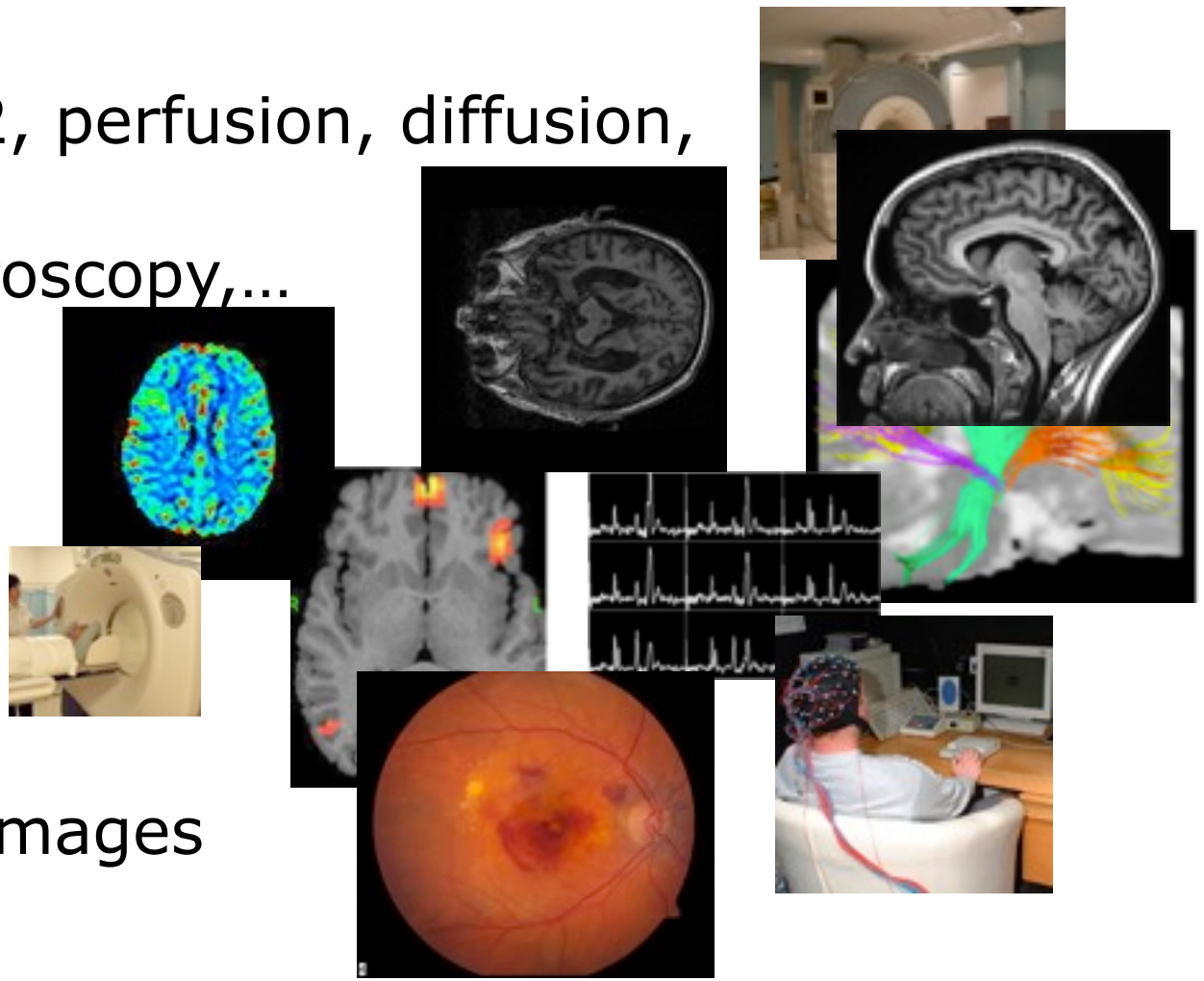


Images from SINAPSE, NIH and D. Clunie

Data Sharing

- Information governance and Privacy protection
  - MIDAS
  - DICOM Confidential
- Centralised storage
  - Server in ECDF (Edinburgh Computing and Data Facilities)
  - Storage space and databases
- Other: Portal & automatised QA

Data Protection Act

- UK's Data Protection Act (1998). Implements the European Community Data Protection Directive 1995.
- Establish individuals' rights on data held about them and obligations for organisations or people processing personal data.
- Personal data must be processed in a fair and lawful manner.
  - 8 DPA principles.
- Other legislation pieces apply to medical data.
  - Common law: duty of confidentiality.
  - Human Rights Act 1998 (article 8).

MIDAS meeting (18th March 2009)

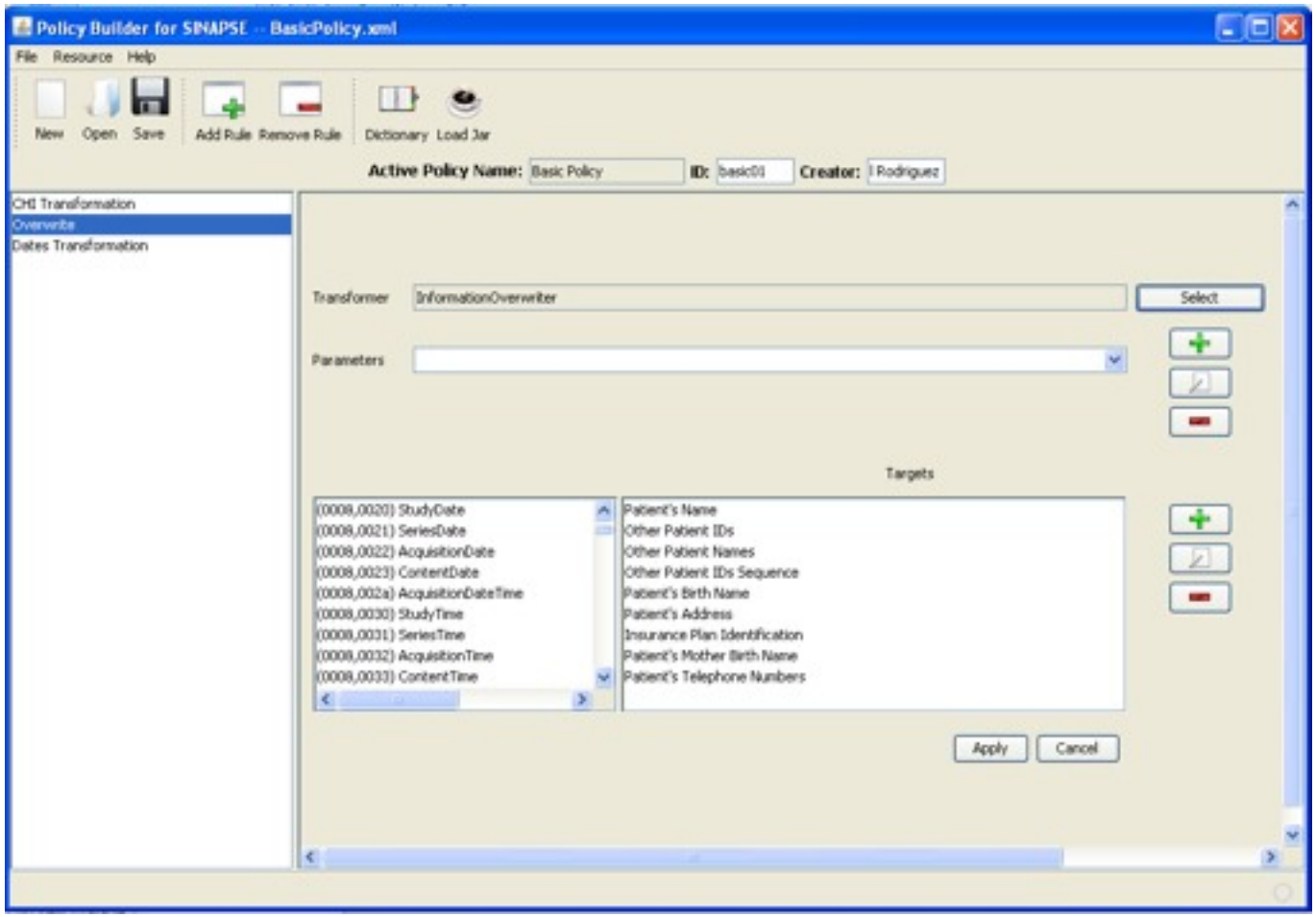
- **M**edical **I**maging **D**ata **A**ccess and **S**haring
- Hosted in the e-Science Institute
- Brought together representatives from the NHS Scotland & the universities
- Successful meeting with useful discussion
  - Came out with a roadmap for improving the data sharing between both sides
  - Report circulated between attendees
- Two follow-up meetings in September 2010 and March 2011

DICOM Confidential

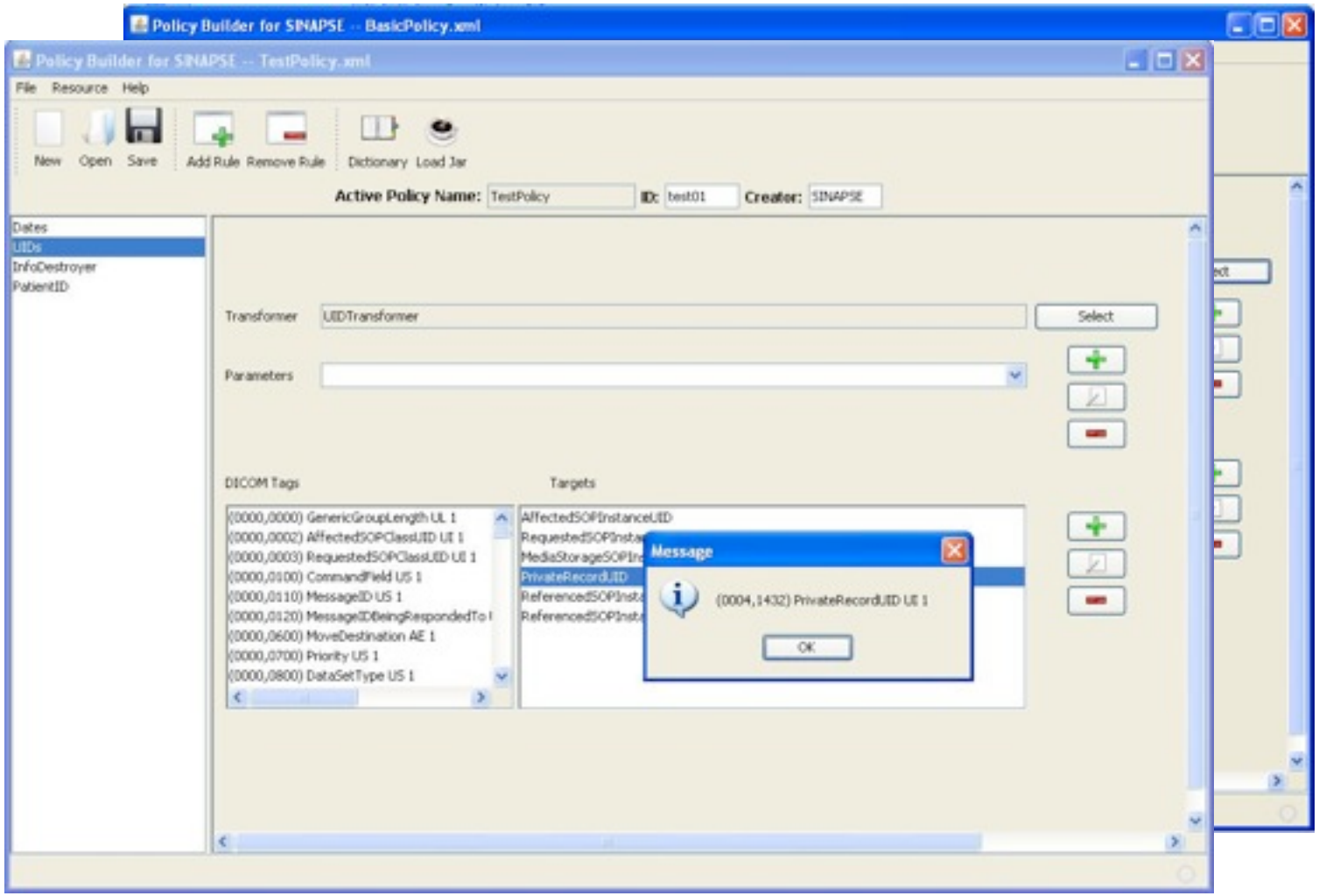
- A DICOM de-identification toolkit
  - Implemented in Java
  - Highly configurable
  - Configurable pipeline for chaining different operations
- Privacy Policies expressed in XML documents
  - PolicyEditor: a graphical policies creation tool
- Transformation classes distributed in signed jar files
- DICOM read/write through an interface that allows using different libraries
  - dcm4che2
  - pixelmed

Policy Editor

Policy Editor



Policy Editor



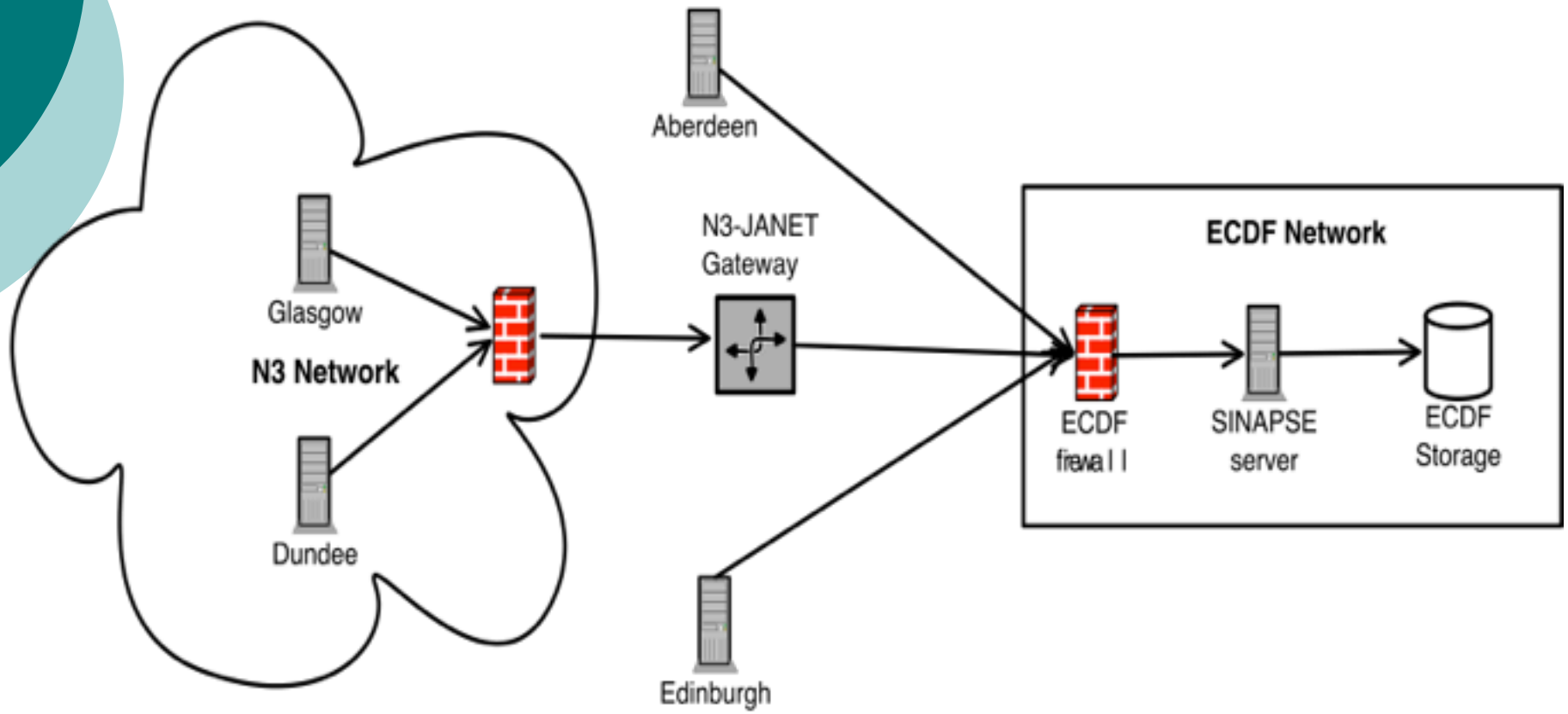
MRI QA in SINAPSE

- QA is used to monitor the performance of MRI scanners
  - particularly important in multicentre imaging studies
- Previous work in SINAPSE towards establishing a common QA protocol
  - 7 participant MR scanners in 4 centres
  - Framework for monitoring the quality of the data
  - It will facilitate the combination of data between centres

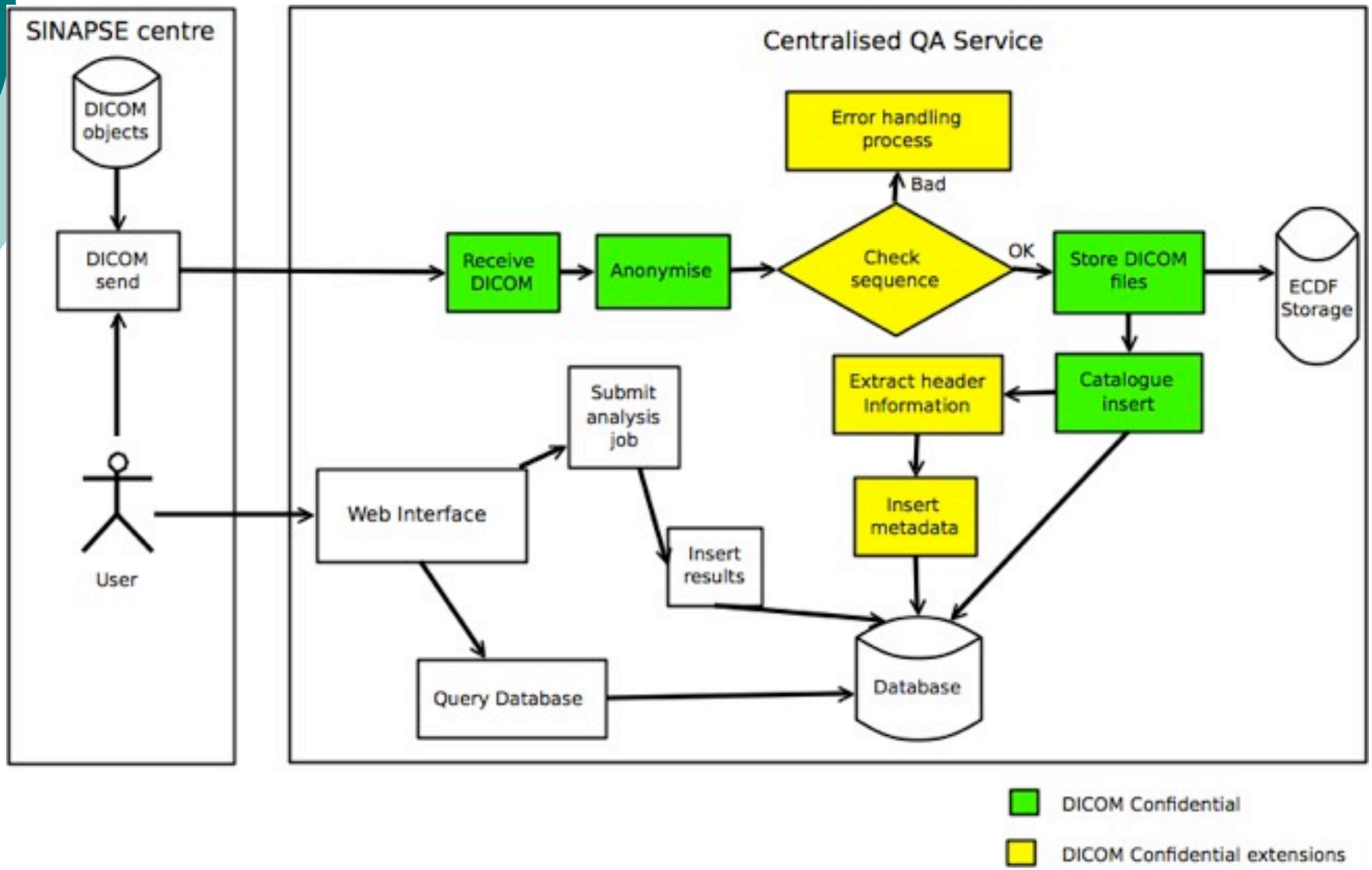
Motivation for an automatic system

- Remove the burden of some manual tasks currently being done in the centres
- Allow checking the correctness of the sequence parameters used
- Ensure the consistency of the software used for the analysis and
- Facilitate the reanalysis of the data
- Enforce (pseudo-)anonymisation policies across collaborations

Network Configuration

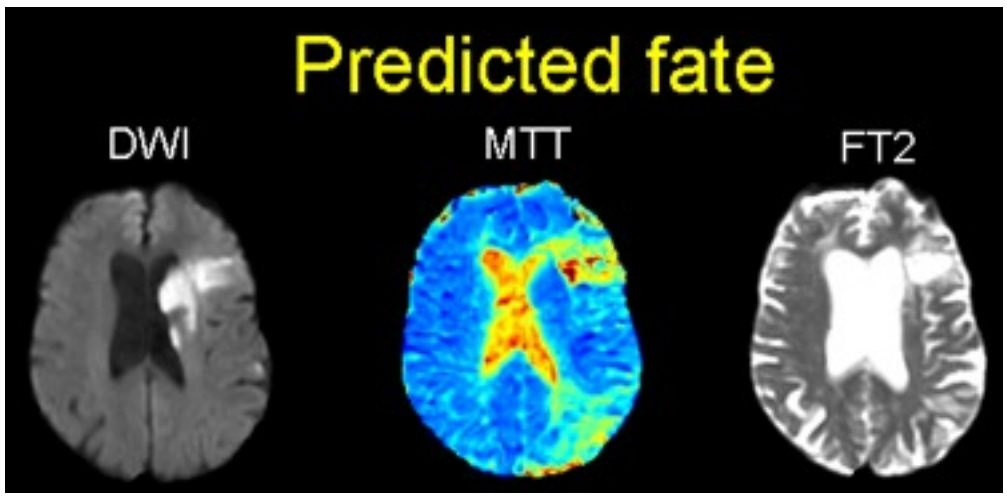


Automatised MRI QA flowchart



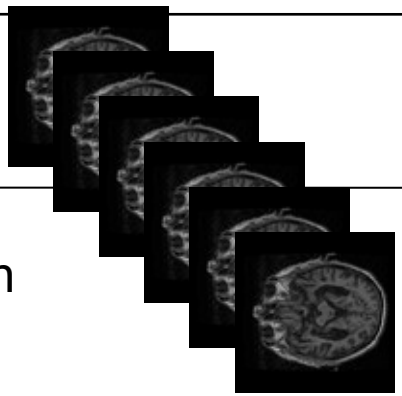
Example Image Analysis Application: Stroke

- Identifying the potentially salvageable tissue so that treatment can be delivered effectively



Example Image Analysis Application: Stroke

Acquisition



Storage & catalogue

original

De-Identification

Research Copy

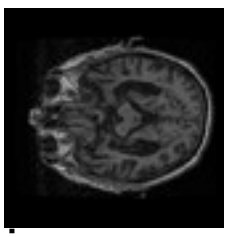
Reconstruction

Nifti Analyze

Nifti Analyze

Registration

ROIs selection



quantification

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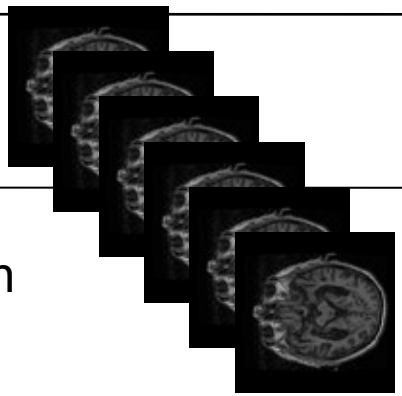

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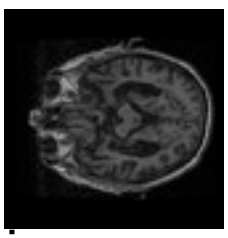

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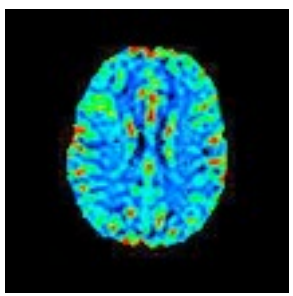
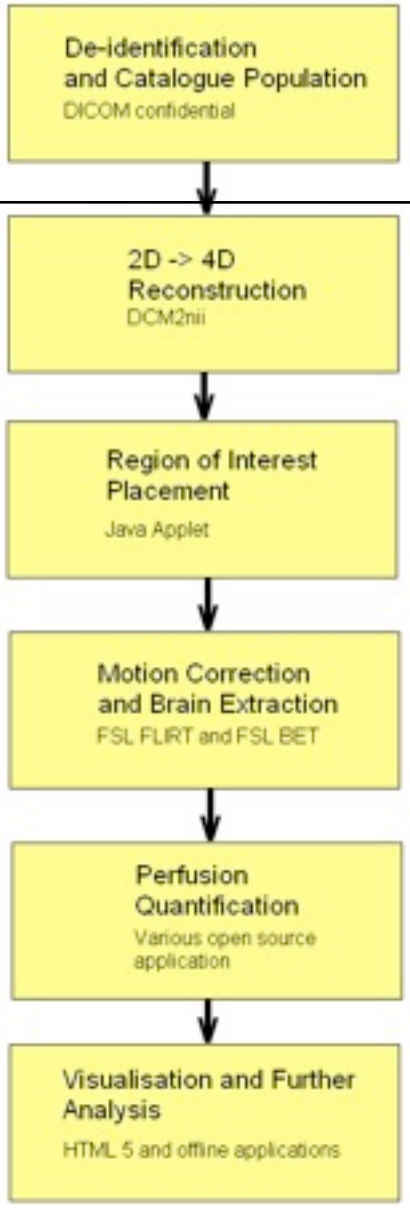


RapidBrain

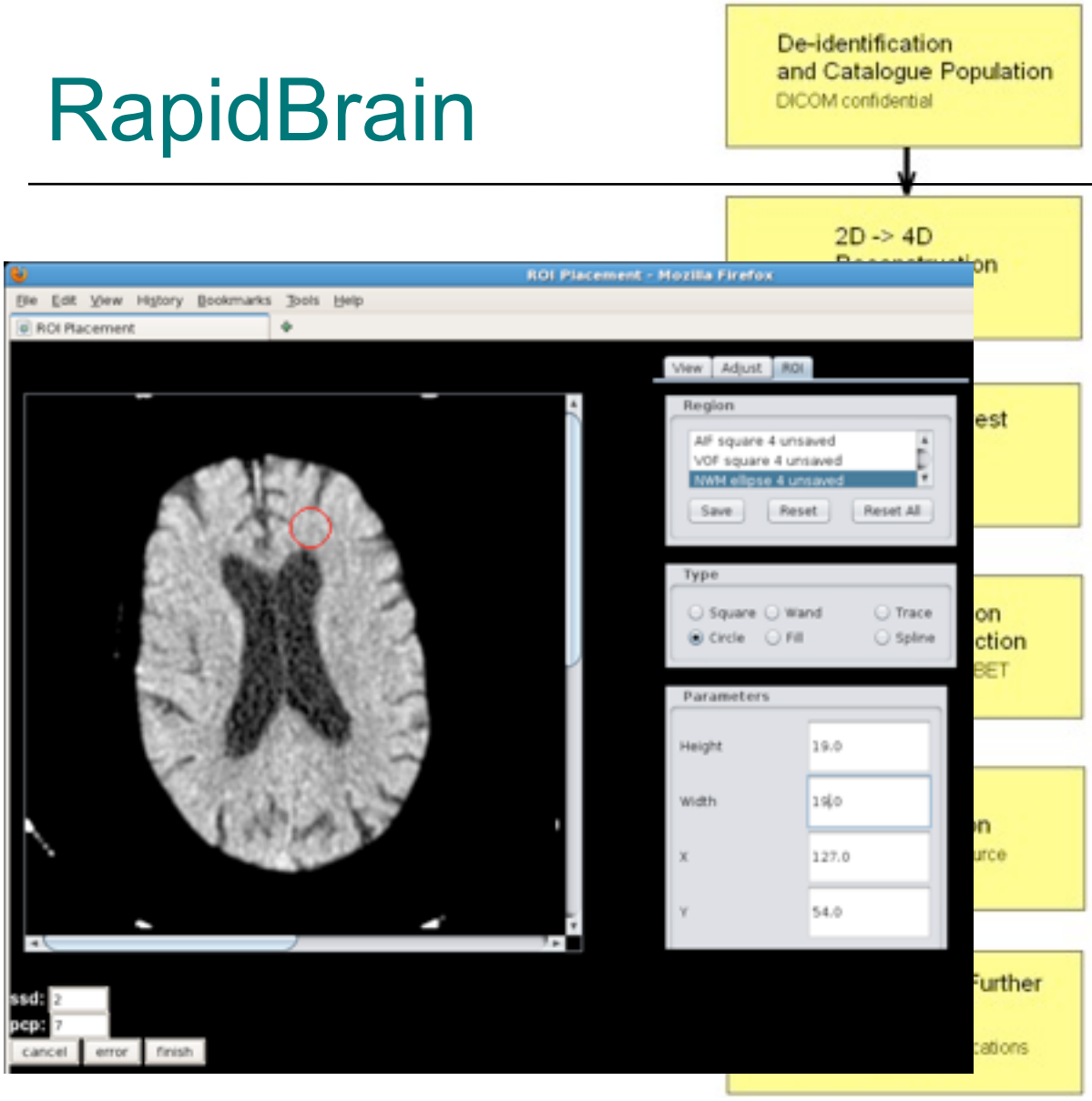
- In collaboration with ECDF and BRIC
  - A production portal at ECDF almost finished
- Brain perfusion image as example
- Main developments:
  - General solution for portal single sign-on authentication to the cluster
  - Databases: catalogue and application workflow support
  - Application specific portlets

RapidBrain

RapidBrain


De-identification
and Catalogue Population
DICOM confidential
2D -> 4D
Reconstruction
DCM2nii
Region of Interest
Placement
Java Applet
Motion Correction
and Brain Extraction
FSL FLIRT and FSL BET
Perfusion
Quantification
Various open source
application
Visualisation and Further
Analysis
HTML 5 and offline applications

RapidBrain


De-identification
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2D -> 4D
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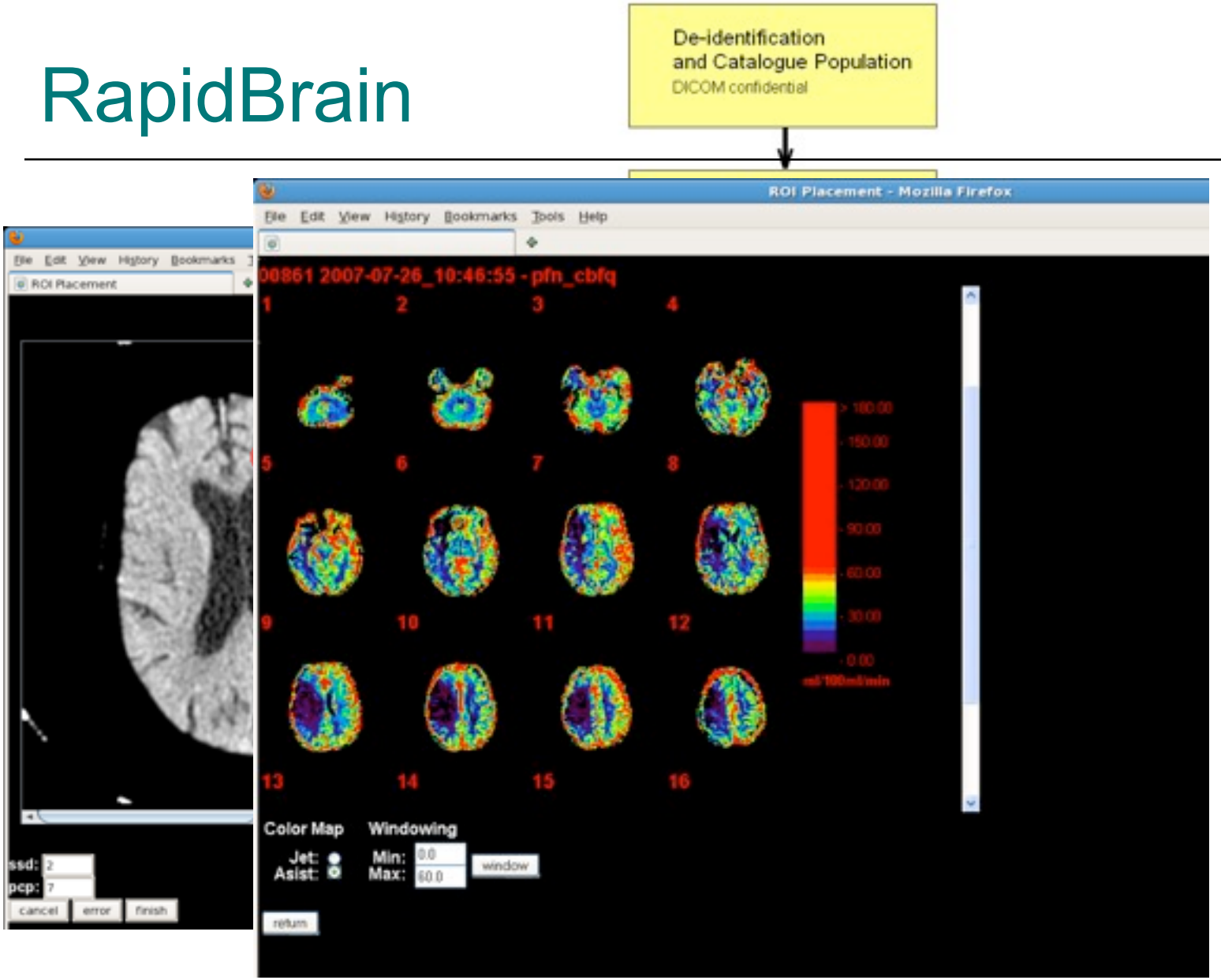
Further

RapidBrain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Perfusion Quantification

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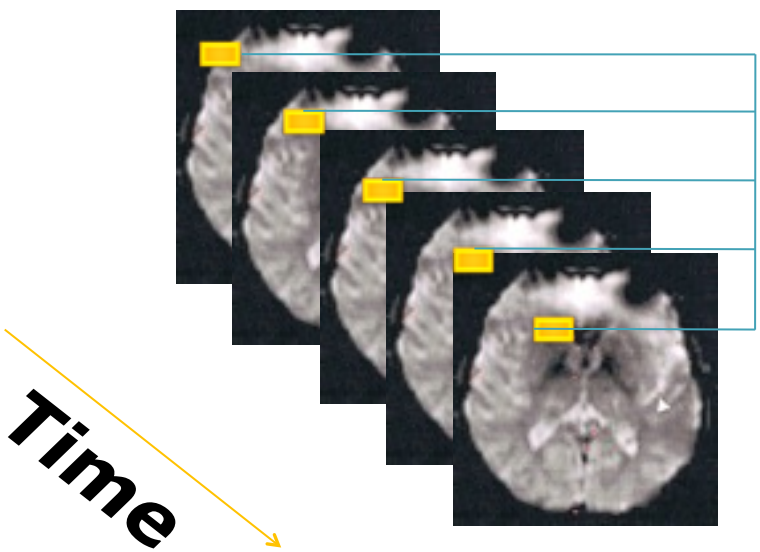
\+ Contrast Agent Injection

Perfusion Quantification



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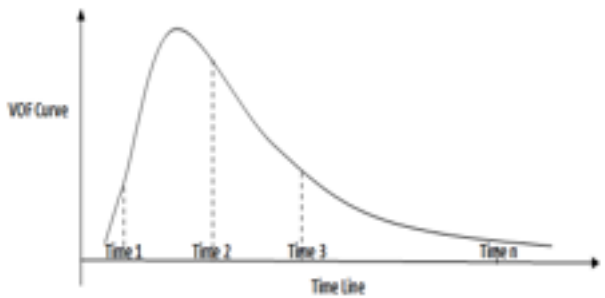

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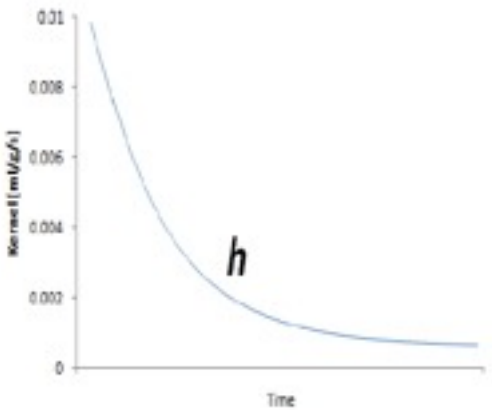

GPGPU implementation

- Results needed in quasi-real time if we want clinical application
  - Some methods like local AIFs take up to 20 minutes
- Deconvolution is ideally parallele as the processing of each voxel is independent

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GPGPU Speedup

Number of Voxels	Number of Time intervals	Overall Running Time	Parallel Version
CT 512*512*2	32	9 min	2.25 min
MR 128*128*15	80	24 min	8 min

Speed up factor: 3 - 4

Noise Reduction using GPR

- Low contrast-to-noise ratio
  - CT data especially
  - Gaussian noise
- Noise is enlarged in deconvolution
  - ill-conditioned problem

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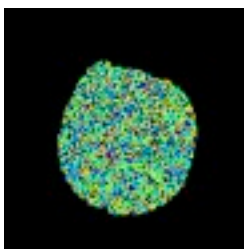

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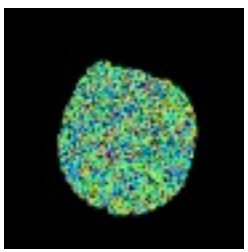

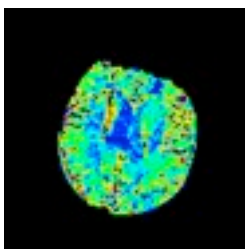

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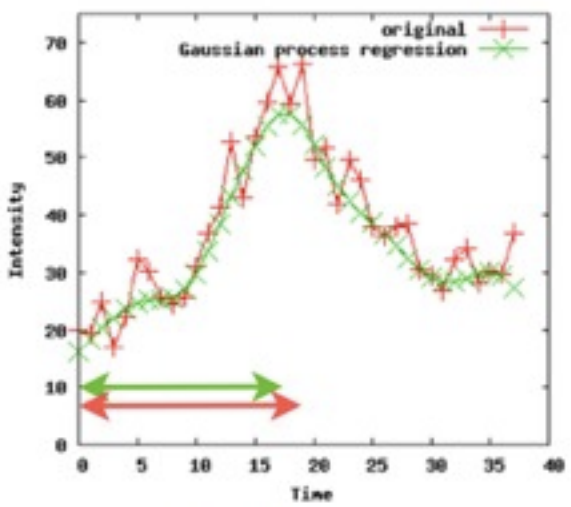
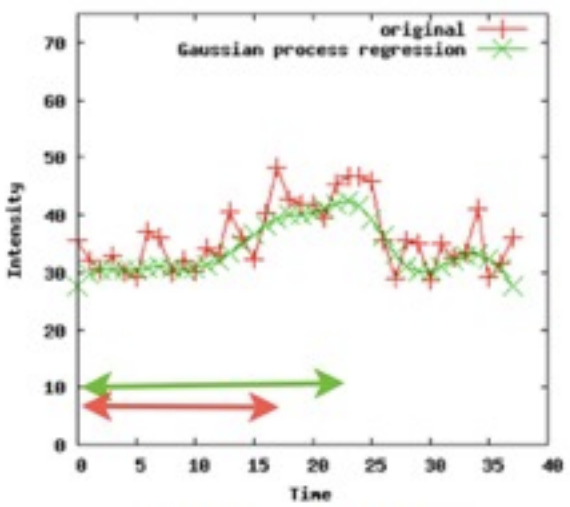
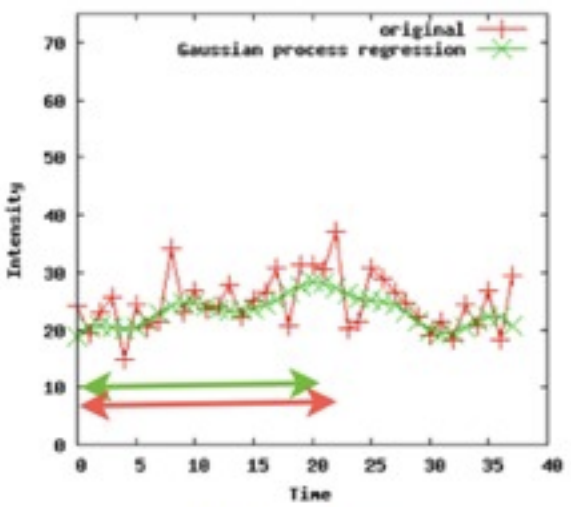


(a) Artery

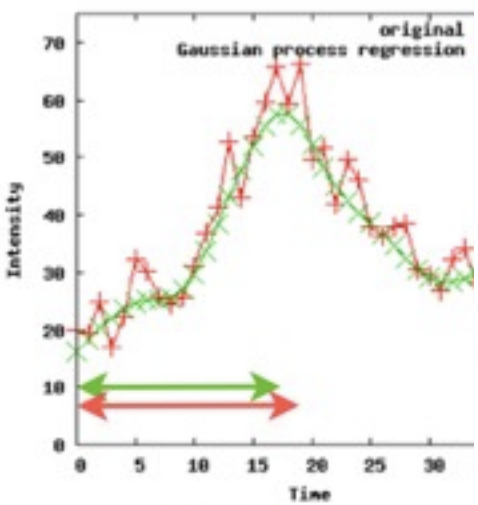


(b) Grey Matter



(c) White Matter

Noise reduction using GPR



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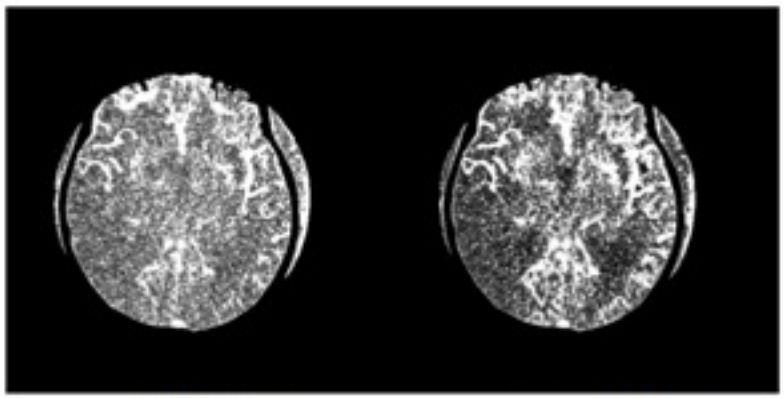
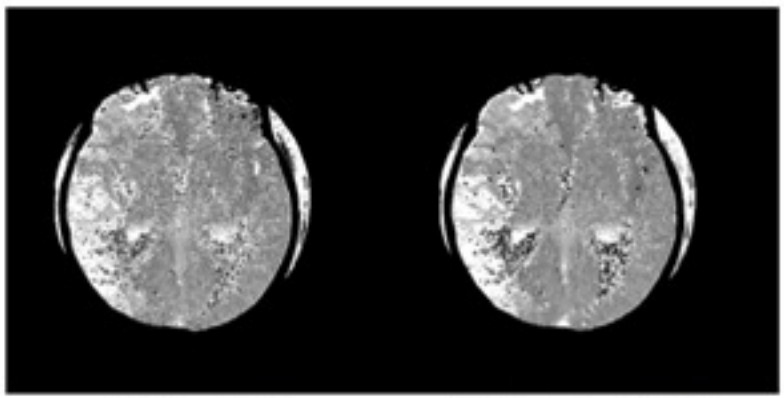
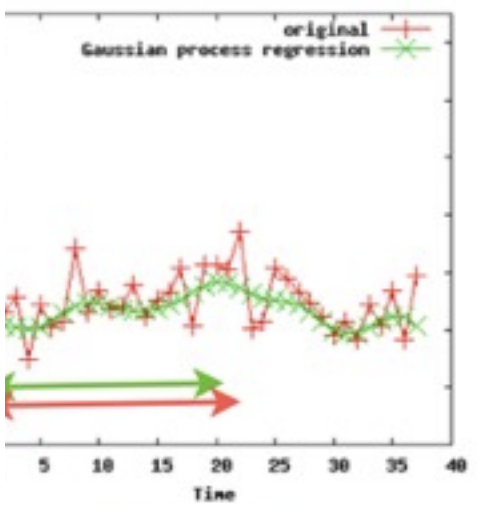


(a) Raw CBF (b) Denoised CBF



(c) Raw TTP (d) Denoised TTP



(c) White Matter

Questions