



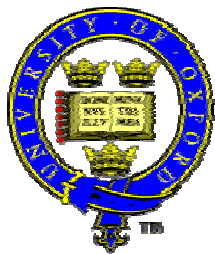
Digital Mammogram National Database

Professor Michael Brady FRS FREng

Medical Vision Laboratory

Oxford University

Chairman: Mirada Solutions Ltd





eDiamond aims

- construct a federated database of mammograms
- contribute to Grid middleware development
- contribute to HealthGrid development in UK, Europe
- aims to support the UK Breast Screening Program

Novel image analysis, federation of large data sets owned by hospitals, and levels of access to that data



Who is involved?

- IBM Hursley & Oxford e-Science Centre
 - Architecture, user requirements
- Mirada Solutions Ltd
 - Workstation, image normalisation
- Oxford University, KCL, UCL
 - Data mining, epidemiology, image analysis
- Breast screening centres
 - St. Georges, Oxford, Guy's, Edinburgh, W. Scotland



DIAMOND

end-user project goals

- Teaching tool for radiologists, radiographers
 - St George's Hospital
- Tele-diagnosis
 - Edinburgh Breast Screening Unit, W. of Scotland
- Algorithm development: data mining
 - Oxford Radcliffe Breast Care Unit
- Epidemiology
 - Guy's Hospital, London
- Quality control
 - Oxford Medical Vision Laboratory

Clinicians want to **use** the Grid & they profoundly wish to remain ignorant about how it works



UK Breast Screening – Today



Paper

Film

Began in 1988

Women 50-64
Screened
Every 3 Years
1 View/Breast

1.5M - Screened in 2001-02
65,000 - Recalled for Assessment
8,545 - Cancers detected
300 - Lives per year Saved



Scotland,
Wales,
Northern Ireland
England
(8 Regions)

92 Breast
Screening
Centres

Each centre sees
5K-20K images/yr

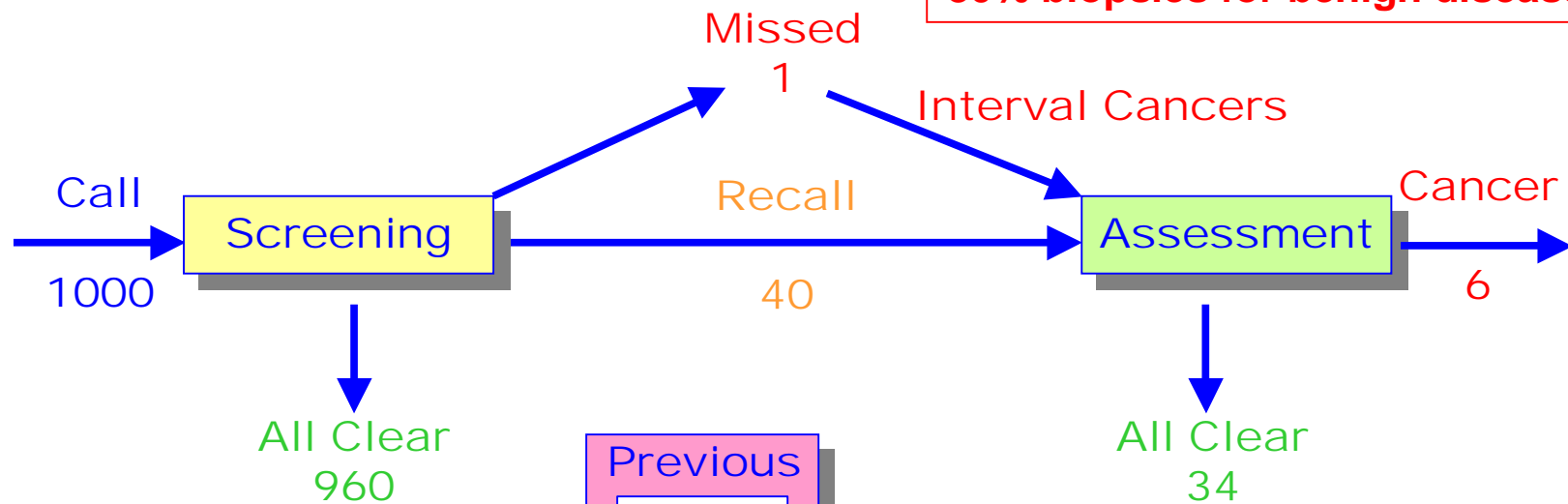


230 – Radiologists “Double Reading”

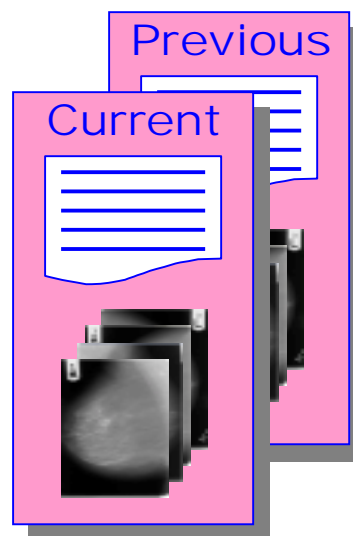
Statistics from NHS Cancer Screening web site

UK Breast Screening – Workflow

24% cancers missed at screening
80% biopsies for benign disease



~ 100 Breast Screening Programmes



Training

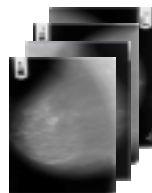
Epidemiology



UK Breast Screening – Challenges



Digital

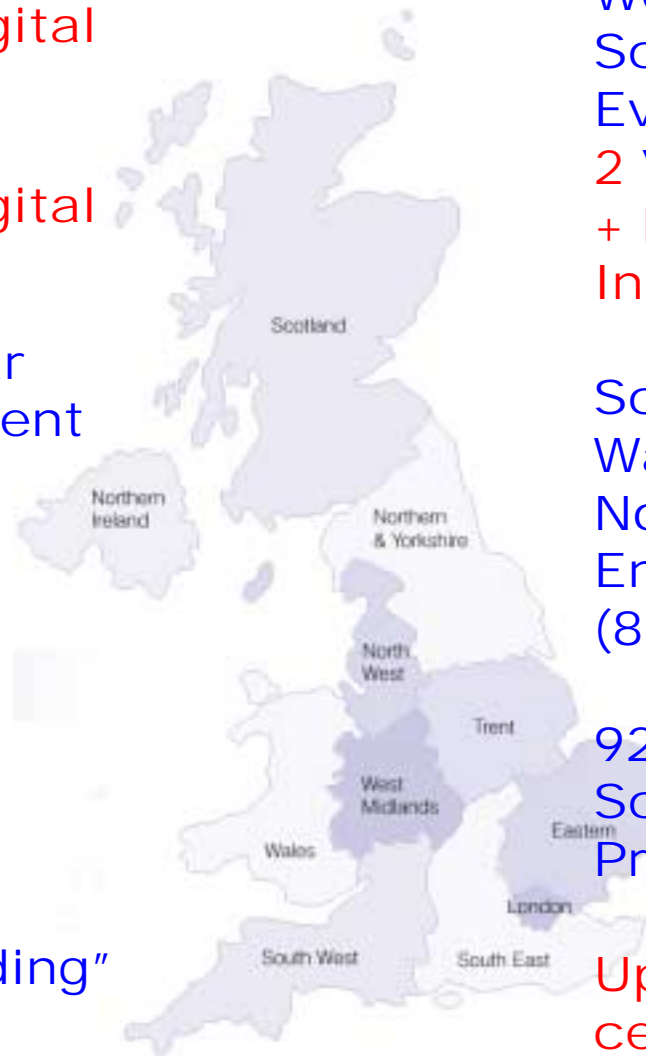


Digital

2,000,000 - Screened every Year
120,000 - Recalled for Assessment
10,000 - Cancers
1,250 - Lives Saved



230 - Radiologists "double Reading"
50% - Workload Increase



Women 50-70
Screened
Every 3 Years
2 Views/Breast
+ Demographic
Increase

Scotland,
Wales,
Northern Ireland
England
(8 Regions)

92 Breast
Screening
Programmes

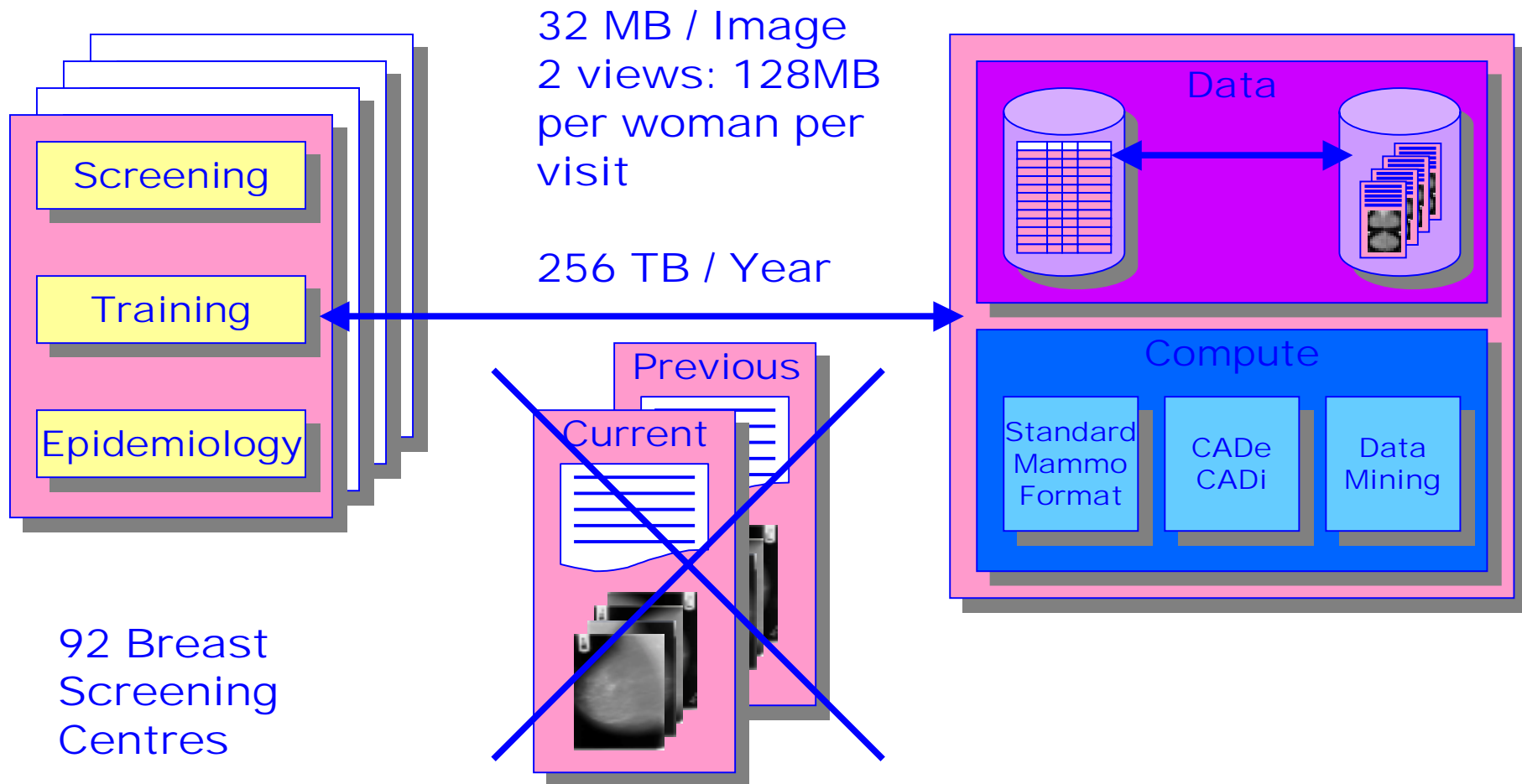
Up to 50K/yr per
centre



Scope of Project

Workstation

Grid

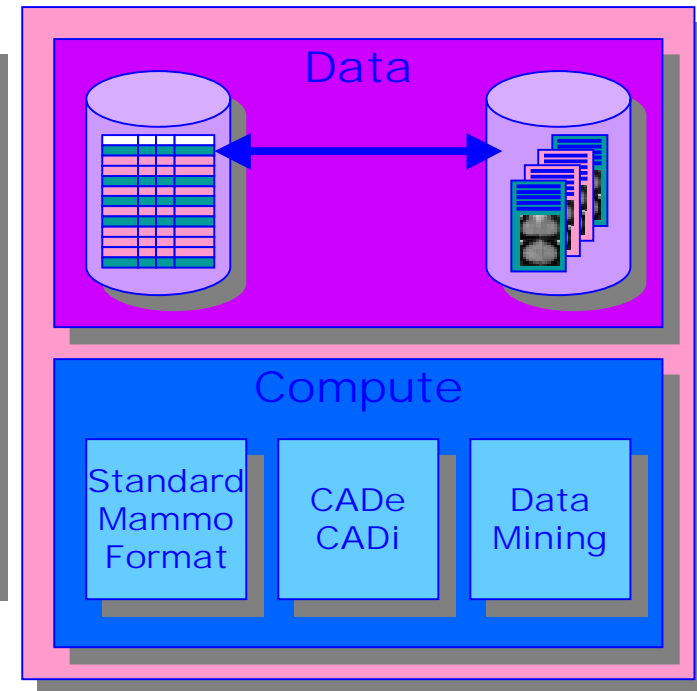
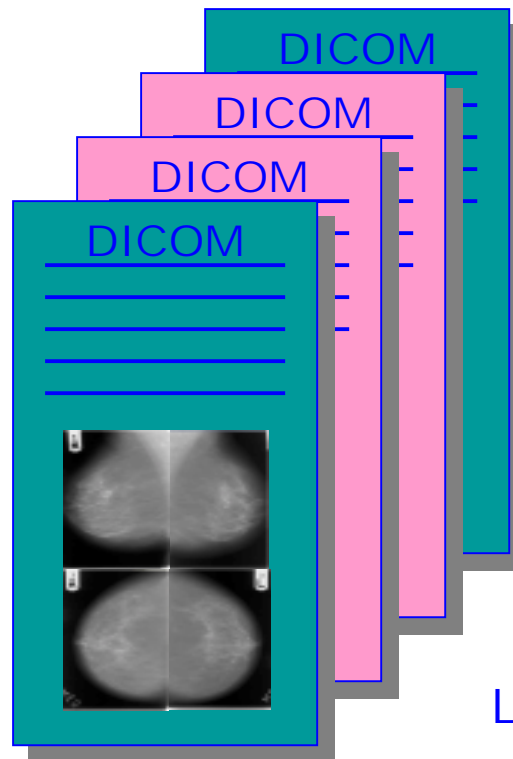


Metadata

Images

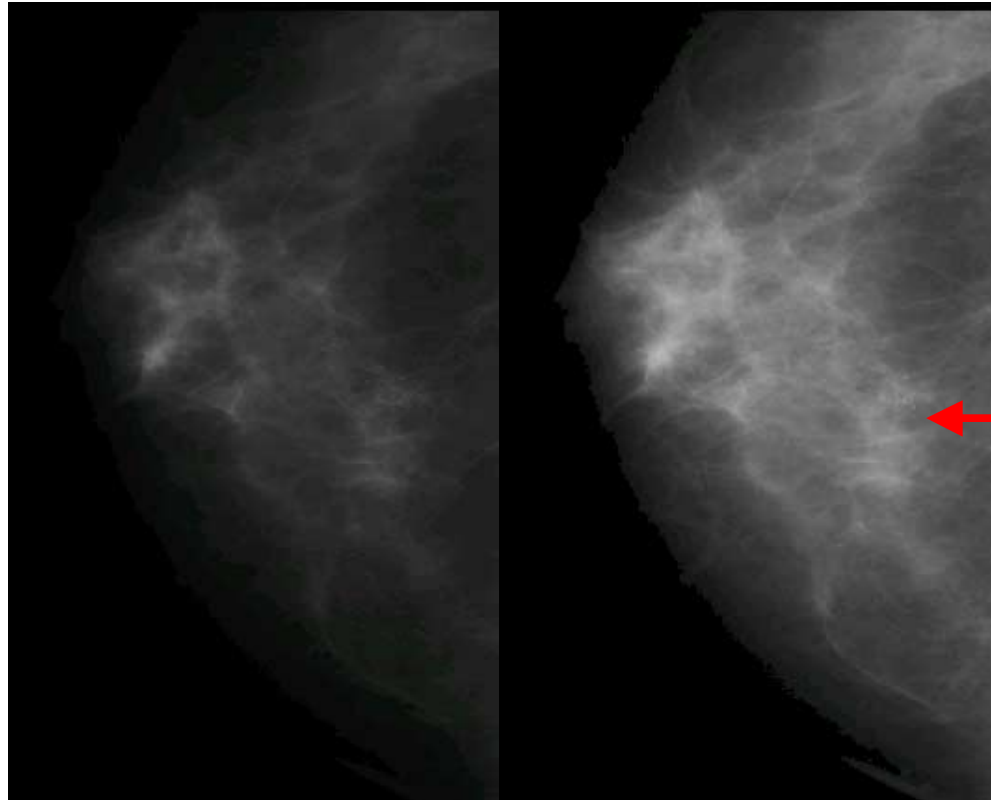
Grid

Patient	Age	...	Image
107258	55	...	1.dcm
236008	62	...	2.dcm
700266	59	...	3.dcm
895301	58	...	4.dcm
.....
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Logical View is One Resource

Challenge: imaging parameters



This image difference corresponds to a change of just 40 mAs in exposure. Often this parameter is poorly controlled

← Microcalcification cluster – barely visible on the poor contrast image

The **same** breast; the exposure time on the right is shorter than that on the left.



Meeting the challenge – Image Normalisation

Many variables greatly affect the appearance of a mammogram

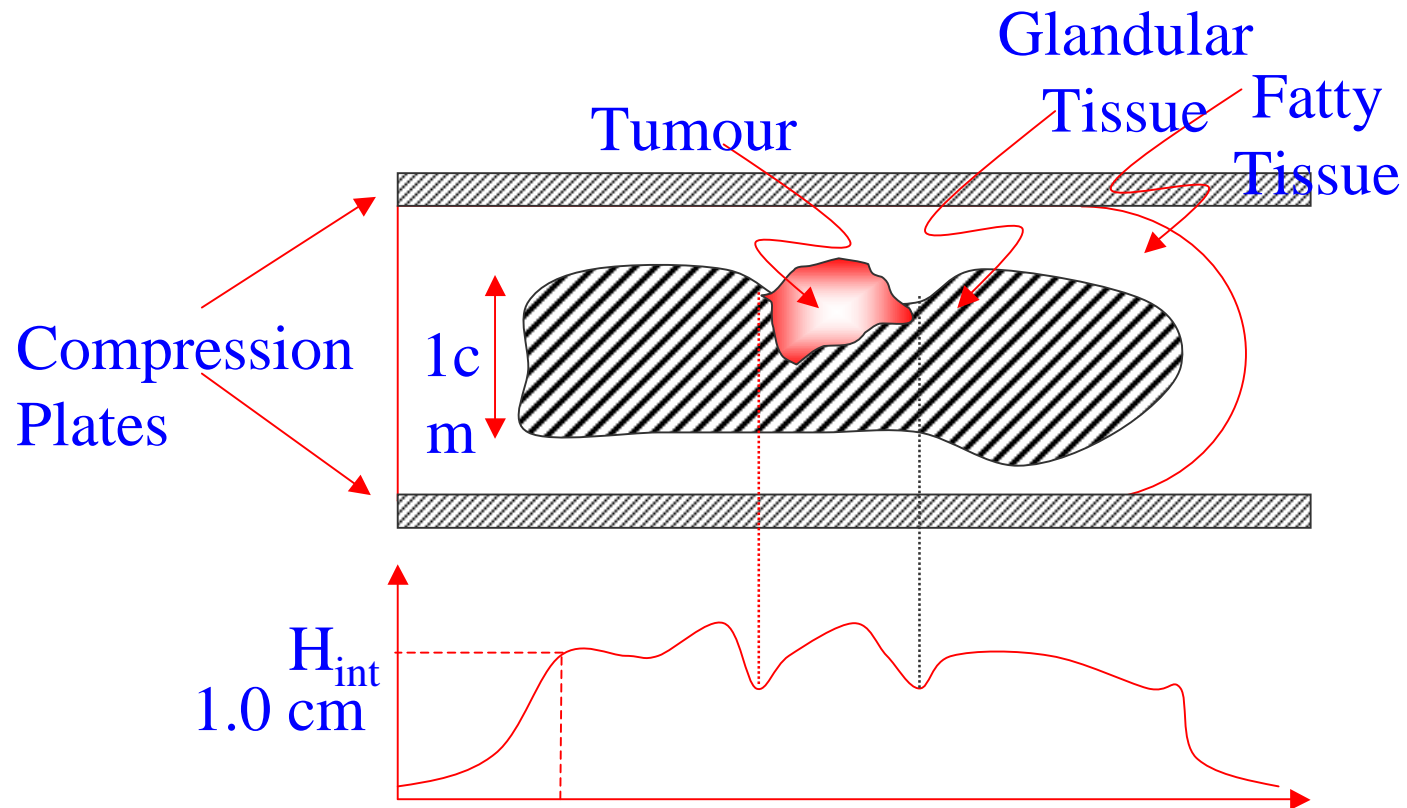
Woman's breasts:

distribution of dense tissue, tumours,
microcalcifications, ...

Chosen by the technician

Tube voltage, exposure time, AEC, ...

Solution is image “normalisation”: *Standard Mammogram Form - SMF*



A **quantitative** representation of breast tissue density

Main Menu

Processing Options

DICOM Settings

Acquisition Parameters

Archive

Quantification

SMF Quantification

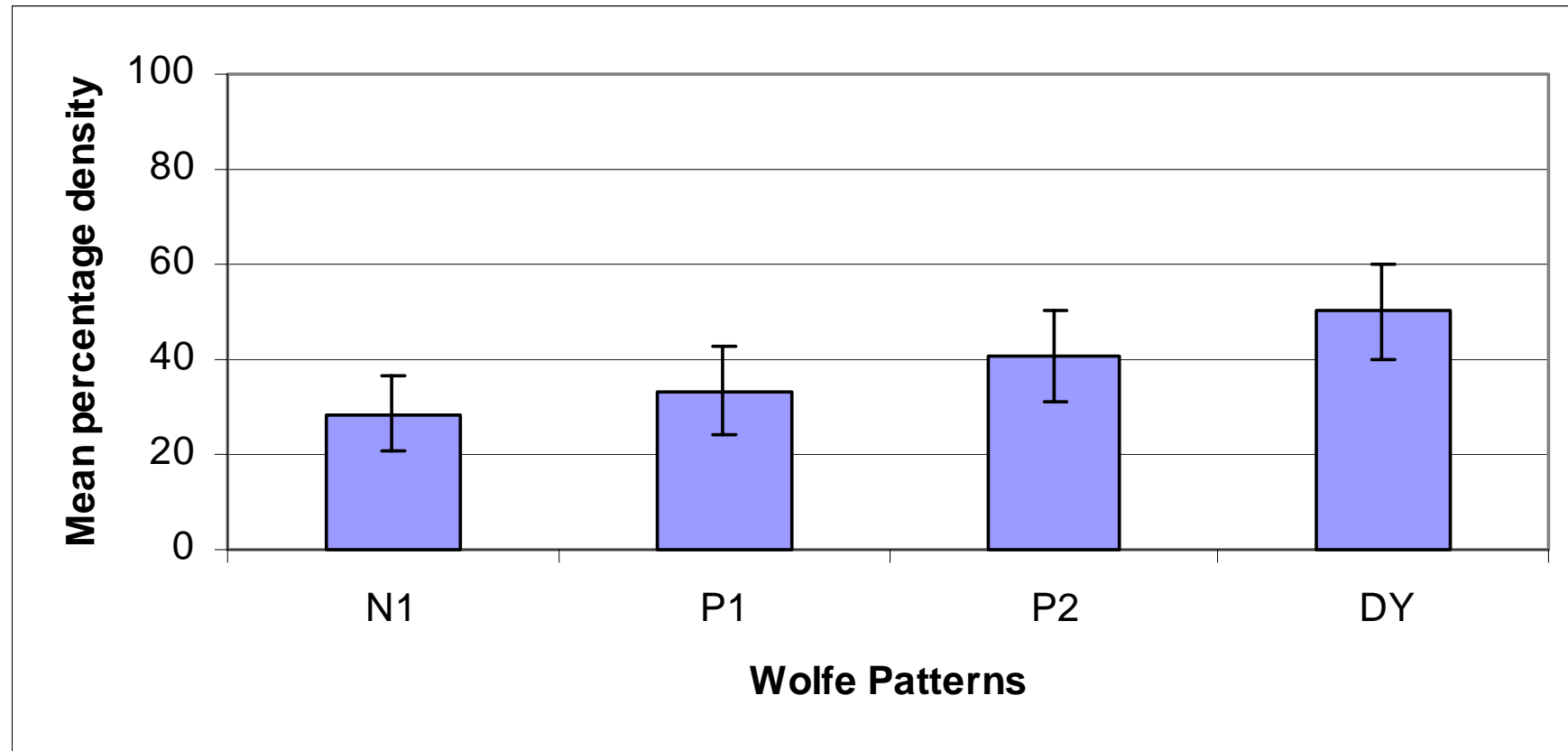
Native **kVp = 28**
Scatter Enh. **mAs = 150**
SMF Enh. **Breast compression = 5.5cm**
SenoForm **42% glandular (non-fatty) tissue**
651 cm³ glandular tissue volume
Estimated breast weight = 912g



Recent work (NEJM) demonstrates importance of quantitative estimates of breast density for assessing breast cancer risk.

SMF-enhanced (ideal image) digitized mammogram

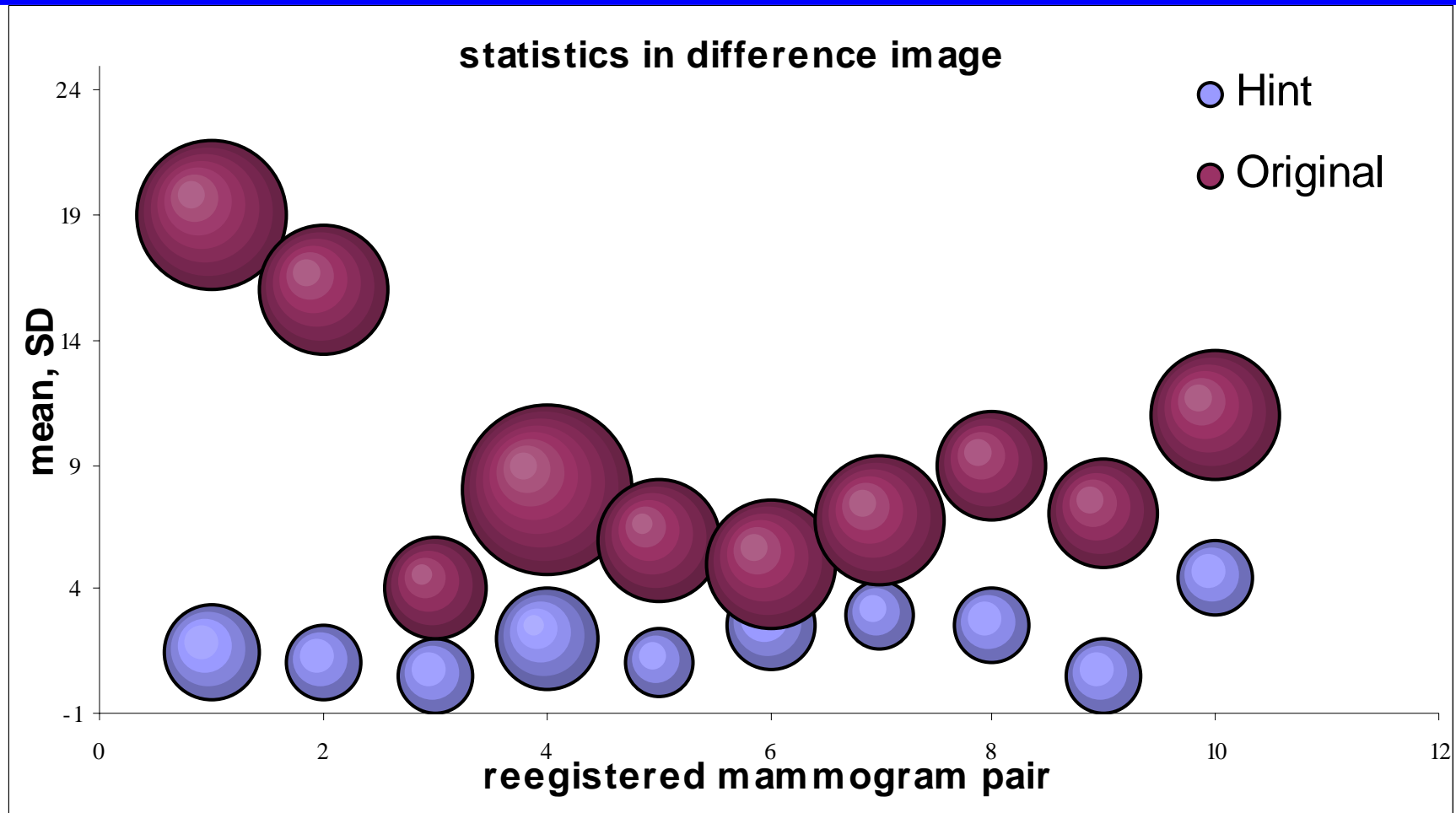
Wolfe vs. % SMF (n=629)



Qualitative assessment of risk → quantitative



Registration of two
mammograms is better using
SMF



Results for 10 pairs; SMF has lower mean, SD and variation in these

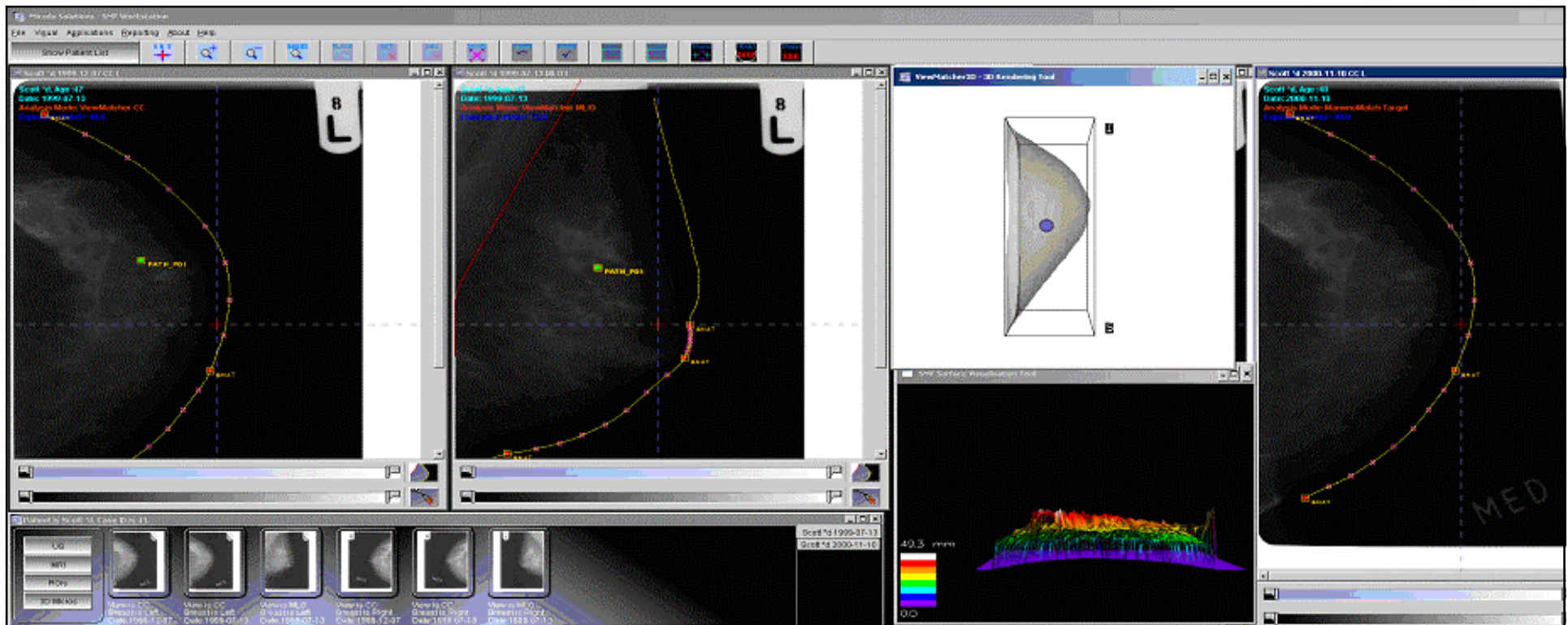
SMF Mammography Workstation

Optimal digital viewing and analysis....everytime!

*A multi-vendor visualization and diagnostic aid,
powered by Standard Mammogram Form (SMF) and featuring
quantification, 3D reconstruction, temporal registration and
reliable enhancement.*

Greater specificity in the diagnosis of breast cancer





Top left. Cranio-caudal image (plus breast boundary and marked feature

Top right. Mediolateral oblique image

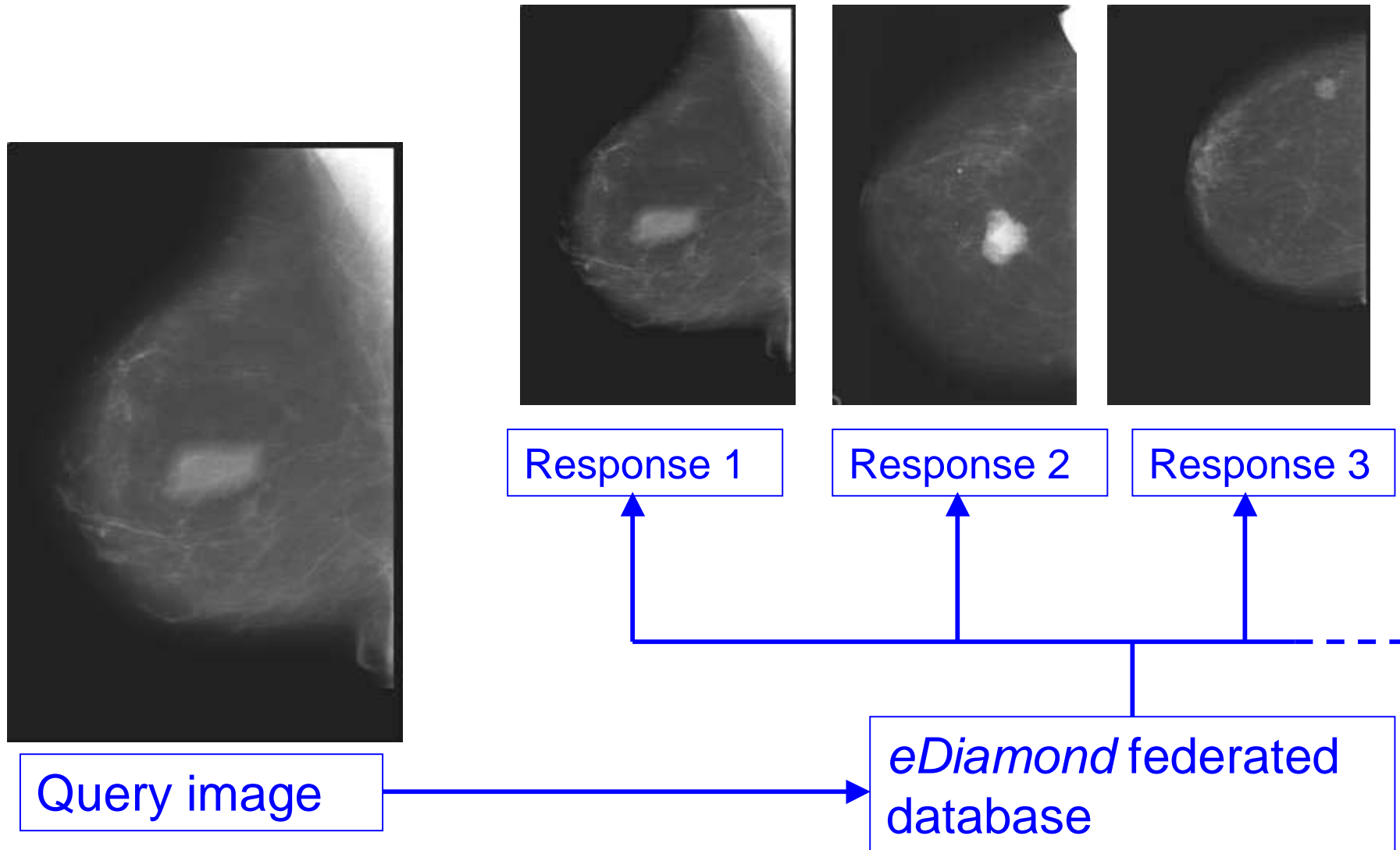
Bottom: image gallery & control panel

Top left. 3D reconstruction showing feature location

Bottom left. SMF viewed as dense tissue surface

Right. previous CC image registered to current CC

Image data mining: *FindOneLikelt*





Data mining from an SMF query image

- Texture features (dense tissue regions)
 - Learnt automatically from filter banks
- shape features (outline of masses)
 - Level sets, reaction-diffusion, topological relations
- intensity change features
 - Local energy & phase: Morphogenic signal & wavelets



Automated quality control

- Learn a model of normal variation of images from all centres bar one
- compile a mapping from SMF value (dense breast tissue) to imaging parameter choice
- compare to SMF value → imaging parameter choice in the remaining centre
- “women with denser breasts tend to be over-exposed at this centre”

For several years, I had wanted to find a way to gain the statistical power I needed for medical image analysis – the Grid offers the potential to provide it!

And, not just for medical image analysis ...

- mammograms are typical of medical images
 - many parameters (potentially) of interest
 - relatively few images gathered at each individual centre
- insufficient statistical power in the database garnered from a small number of centres
- The Grid provides the statistical power at acceptable bandwidth and with guarantees on secure image/data transmission

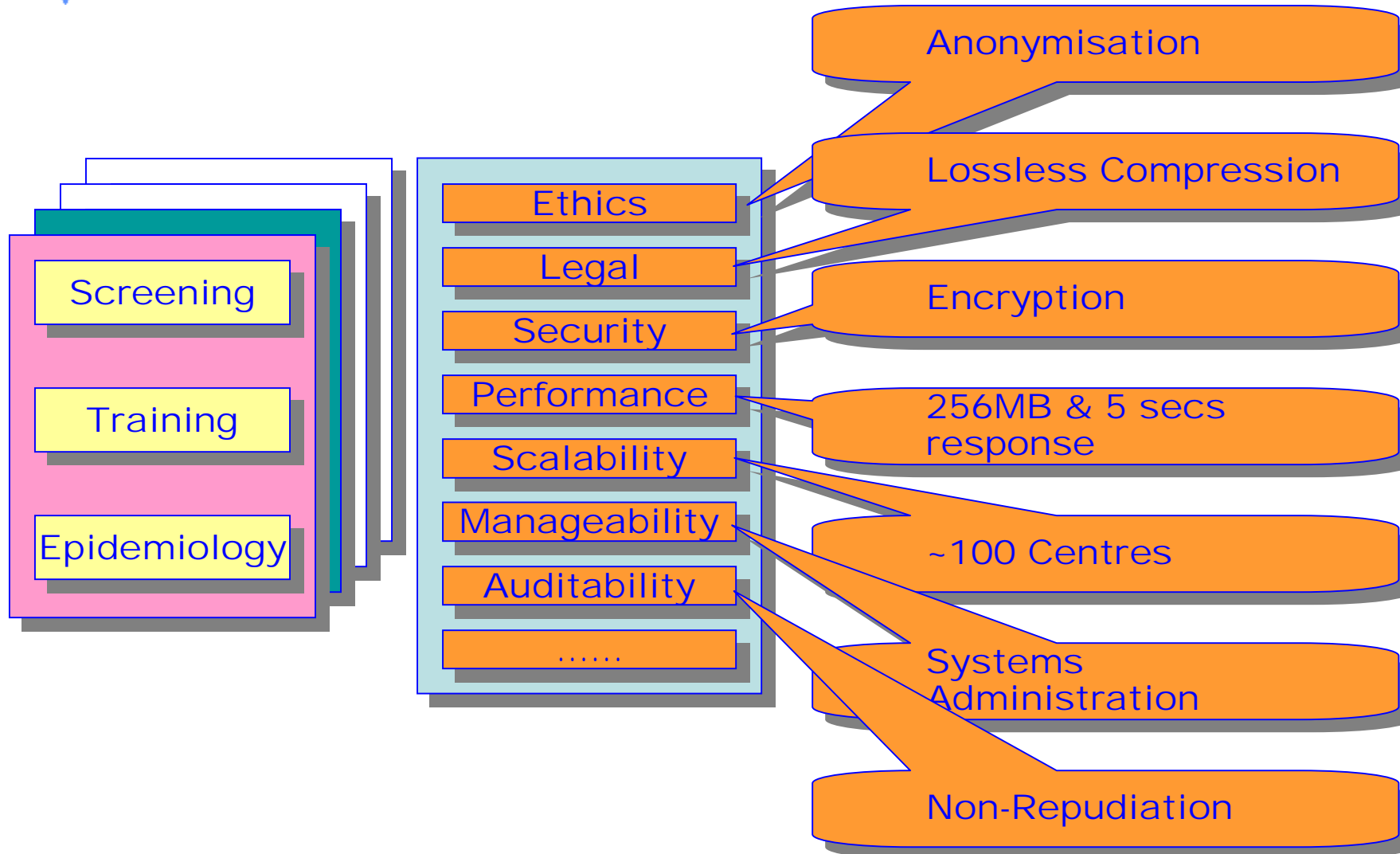


Ontology based on BIRADS

- Personal data
 - Family history, age, HRT, ...
- mammographic signs
 - Microcalcification, spiculations, patterns of dense tissue
- MRI signs: angiogenesis, permeability, tortuosity, ...
- ultrasound signs: elasticity
- PET signs: biochemical activity

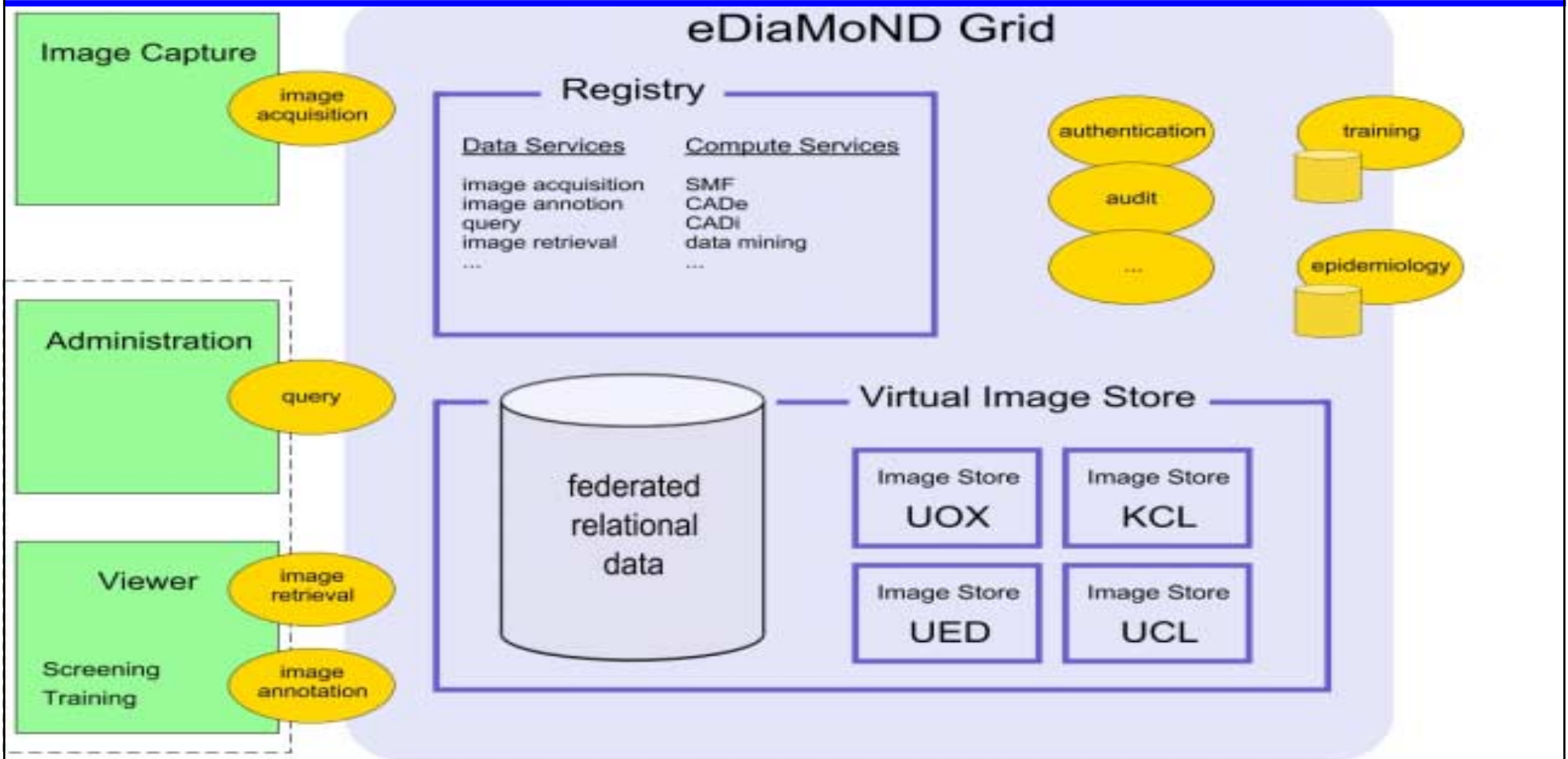


Challenges on communication and use



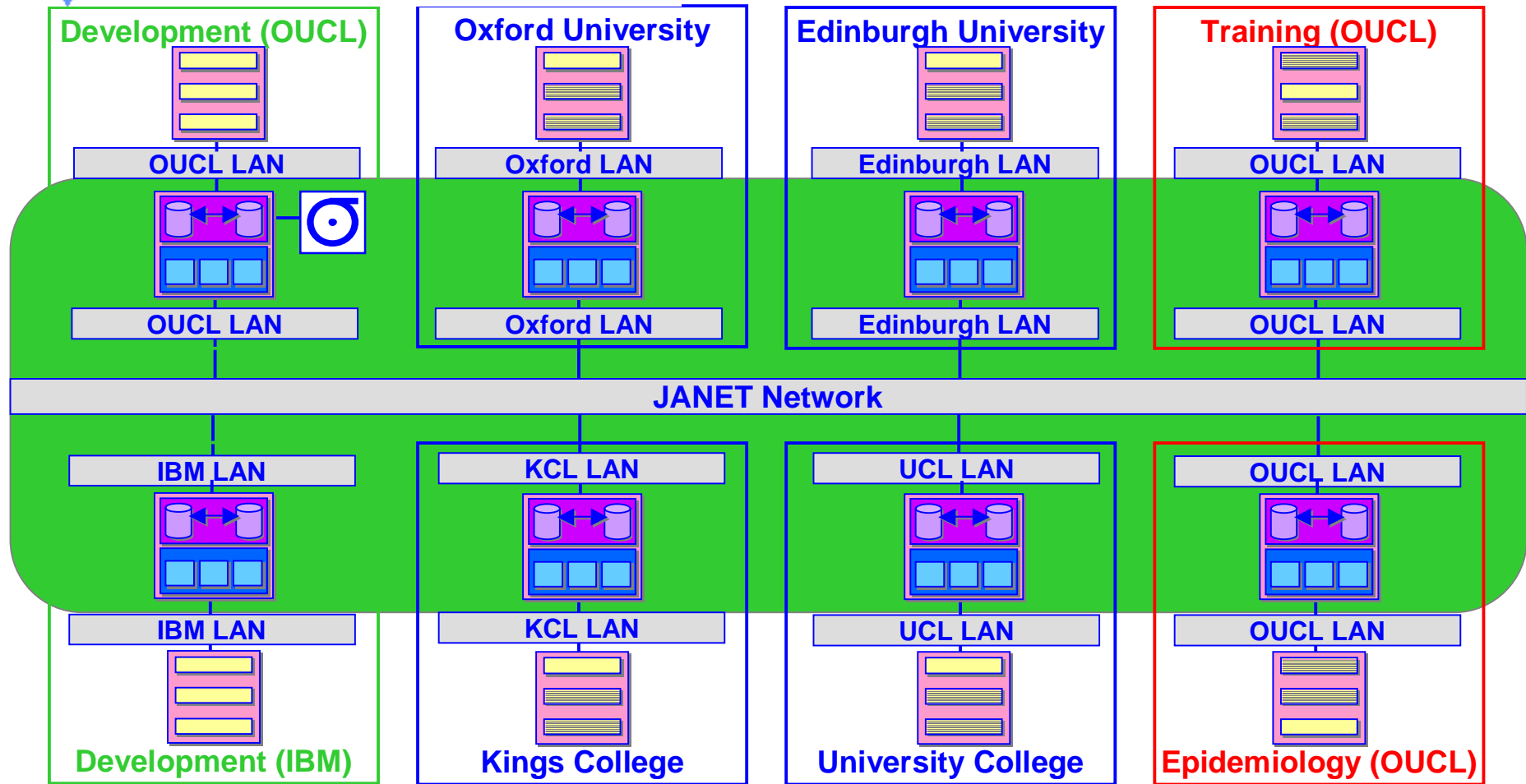


eDiaMoND Functional Model





Aim is to roll the project out to all 92 breast screening centres

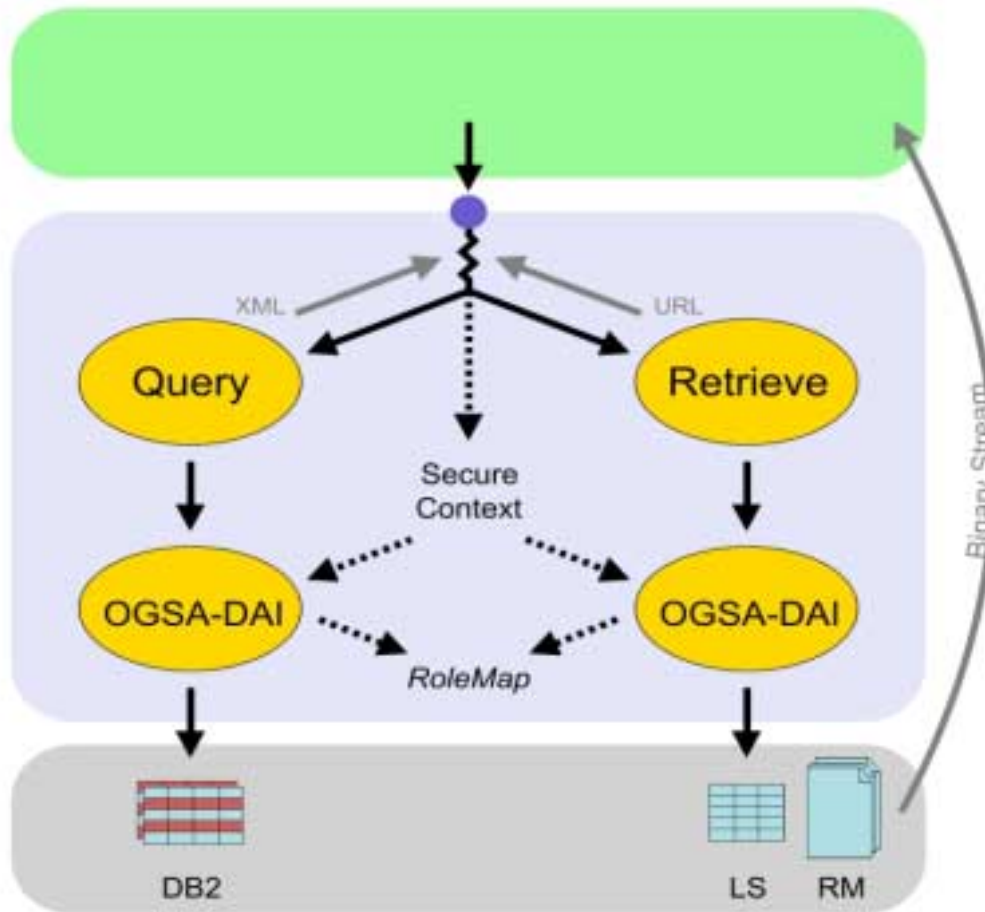


4 Breast Screening Centres

■ Grid Boundary



Single Image Server node



Two separate interactions with eDiaMoND shown: **Query** and **Retrieve**

The Grid Service Container authenticates requests, creates a secure context then transfers control to the called service.

eDiaMoND services are a façade for **OGSA-DAI** data services

OGSA-DAI services implement a **RoleMap** to map individuals to roles



DIAMOND

Beyond eDiamond

- The architectural infrastructure for eDiamond is not limited to mammograms or even cancer
- The only specialisation to mammography is image normalisation SMF, and the knowledge embodied in programs about masses, breast dense tissue and microcalcifications
- Medical image analysis is moving beyond diagnosis to monitoring disease progression and therapy, e.g.
 - molecular medicine
 - software-enhanced pharmaceuticals (eg Parkinson's)



... is a girl's best friend

e-Kitt