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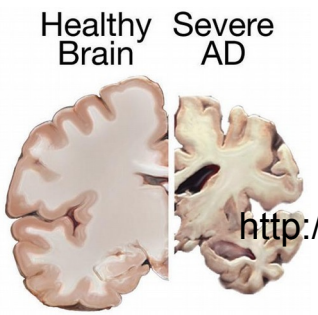
Brain images data mining: what's next?

CERN openlab "IT in Healthcare" Workshop
Geneva, Tuesday, 11 November 2014

Numbers and facts about Dementia

- ~35M people have dementia today. ~70M by 2030 and ~115M by 2070.
- When a diagnosis is made, it often comes at a relatively late stage of the disease.
- Alzheimer's disease is the most common cause of dementia (up to 70% of cases).
- Current drugs can in the best hypothesis just slow down the progression of the disease.
- Currently there is no cure.



http://www.who.int

Twin Labs

Brescia, Italy

IRCCS
CENTRO SAN GIOVANNI DI DIO FATEBENEFRATELLI – BRESCIA
Centro Nazionale per lo Studio e la Cura
della Malattia di Alzheimer e Malattie Mentali

Geneva, Switzerland

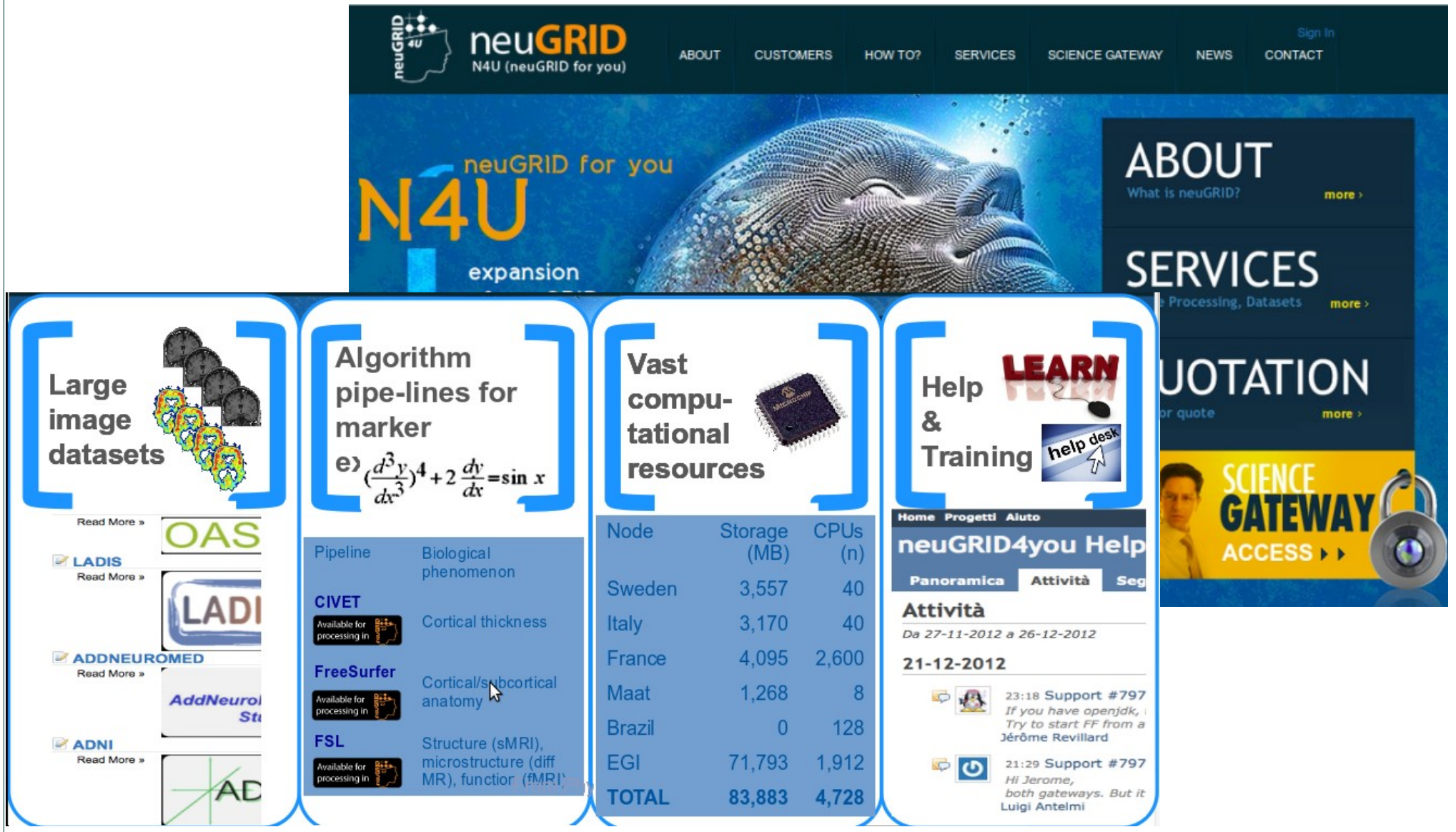
Laboratory of Neuroimaging of Aging

HUG
Hôpitaux Universitaires de Genève

High Performance Computing

High Performance Computing

neuGRID: a grid-based image analysis environment

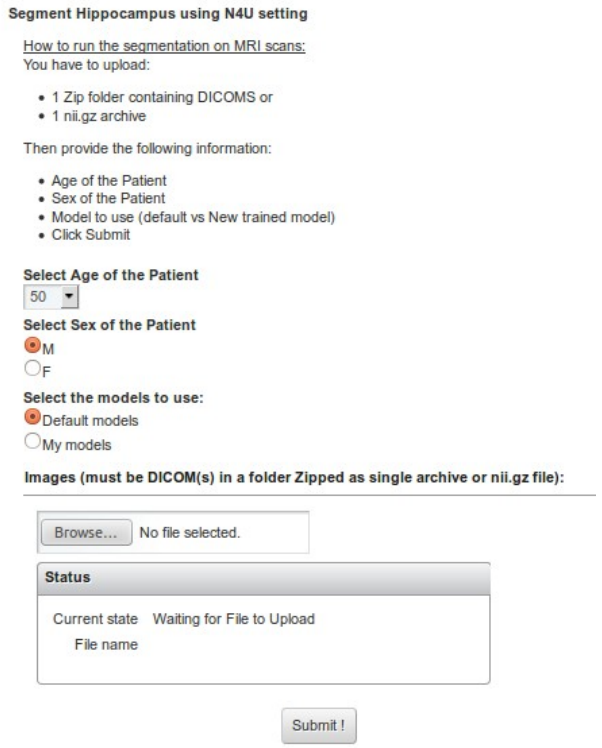


neuGRID

Graphical Interface

Single case analysis

Physician oriented



Command Line Interface

Parallel processing

Research Oriented

Report for Clinicians

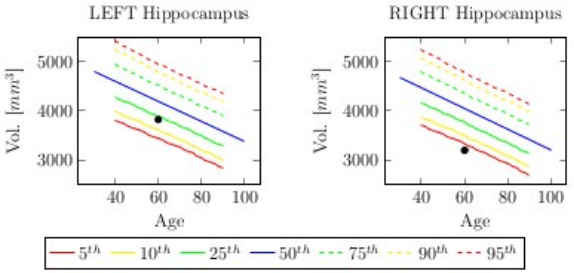
ACM-AdaBoost Report

Subject info

Patient ID: TestImageDICOMS **Sex:** M **Age:** 60

ACM-AdaBoost[1] Results

Model: wl3-75k-v2.0
Left Volume: 3822 mm^3 **Right Volume:** 3194 mm^3



Every colored line represents the *Prediction Percentile* for the hippocampus volume of a **non**-pathological subject.

[1] J. H. Morra, Z. Tu, L.G. Apostolova, A.E. Green, C. Avedissian, S.K. Madsen, N. Parikshak, X. Hua, A.W. Toga, C.R. Jack, M.W. Weiner, P.M. Thompson. *Validation of a fully automated 3D hippocampal segmentation method using subjects with Alzheimer's disease mild cognitive impairment, and elderly controls.* Neuroimage, 43 (2008), 1:59-68.

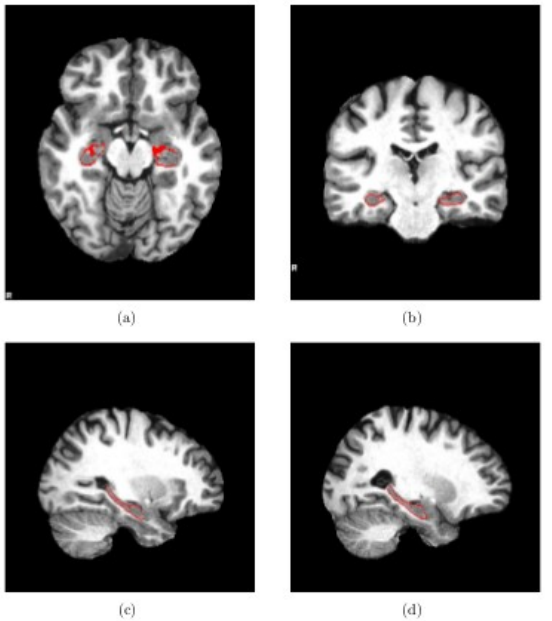


Figure 1: Segmentation of the brain scan registered to the ICBM-152 template. The letter "R" identifies the Right direction. (a) Axial view. (b) Coronal view. (c) Sagittal view centered on the Right Hippocampus. (d) Sagittal view centered on the Left Hippocampus.

Scientific achievements

alzheimer's association AAIC 14

Neuroscience Campus Amsterdam

The hippocampal boundary shift integral is 70% more reproducible than FreeSurfer, manual and other hippocampal atrophy measurement algorithms

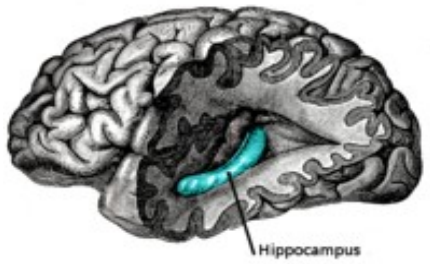
Keith S Cover[a], Ronald A van Schijndel[a], Adriaan Versteeg[a], Kelvin K Leung[b], Emma R Mulder[a], Remko A de Jong[a], Pieter J Visser[a], Baptiste Grenier[c], Jérôme Revillard[c], David Manset[c], Alberto Redolfi[d], Bob W van Dijk[a], Hugo Vrenken[a], Nick C Fox[b], Frederik Barkhof[a]

[a]VU University Medical Center, Amsterdam [b]UCL, London [c]gnubila, France [d]IRCCS San Giovanni di Dio Fatebenefratelli, Brescia, Italy (Contact: Keith@kscover.ca)

neuGRID 4U

VU medisch centrum

vrije Universiteit amsterdam



Conclusions

- MAPS-HBSI is roughly 70% more reproducible, based on BTB, than FreeSurfer, manual and the other algorithms
- ADNI1 post processing does not introduce significant noise based on the left-right symmetry of annualised PVC scatter plots
- The improved atrophy measurement is a step closer to hippocampus atrophy as a biomarker for individuals in AD

Biomarkers

2011: New Criteria for AD diagnosis

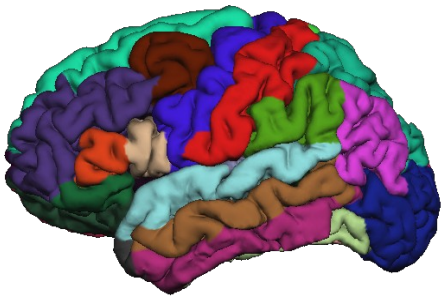
Alzheimer's & Dementia 7 (2011) 280–292

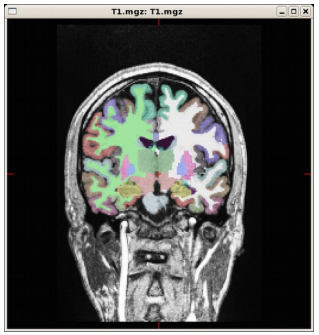
Toward defining the preclinical stages of Alzheimer's disease: Recommendations from the National Institute on Aging-Alzheimer's Association workgroups on diagnostic guidelines for Alzheimer's disease

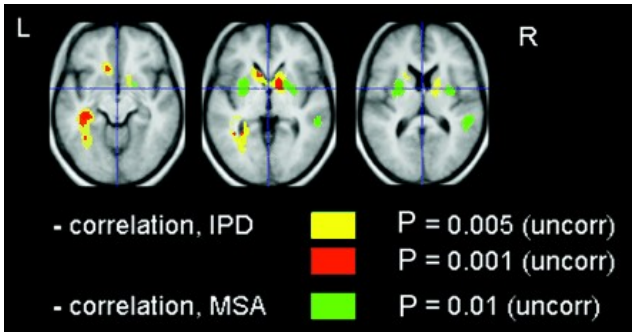
- Preclinical AD: a new concept that indicates that changes in the brain, can be detected before there are any clinical symptoms
- changes in the brain can begin 10 or more years before clinical symptoms like memory loss appear.
- Research must focus on finding early disease biomarkers.

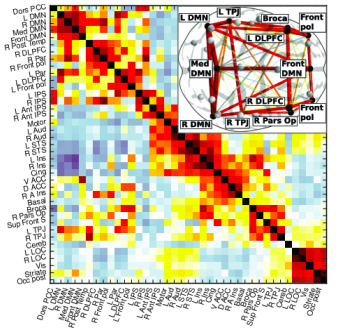
What we are currently able to measure: the biomarkers

- Geometry (MRI)
- Functionality (fdg-PET, fMRI)
- Amyloid load (CSF, amy-PET)
- Pattern of atrophy/functionality

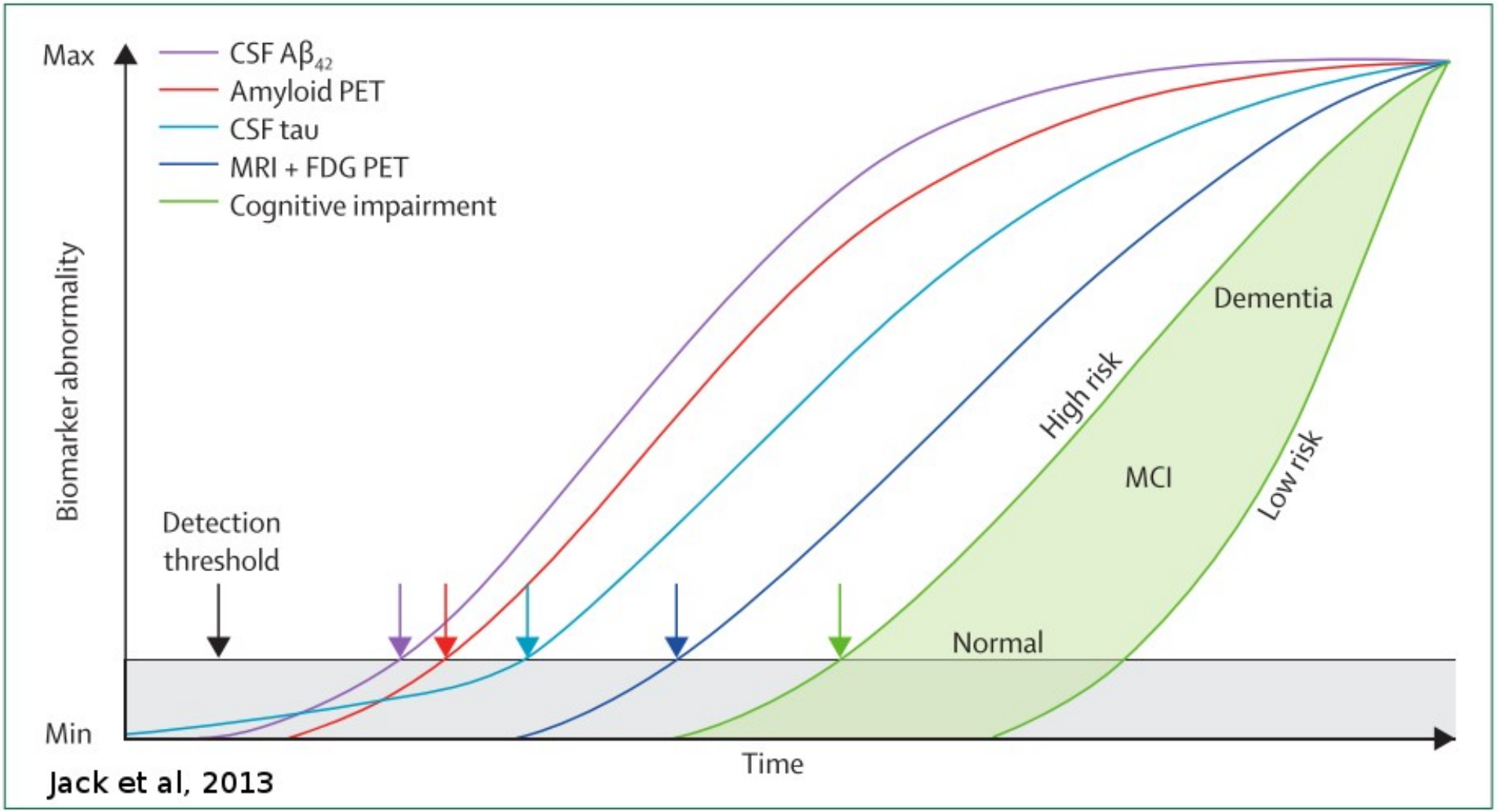








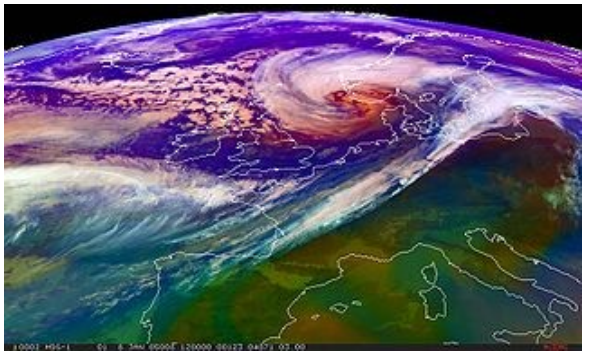
Hypothetical model of dynamic biomarkers



Tough Problems

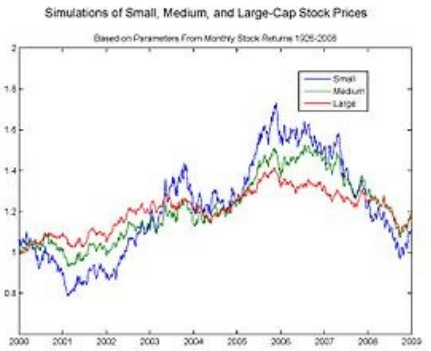
Navier-Stokes

$$\rho\left(\frac{\partial v}{\partial t}+v\cdot\nabla v\right)=-\nabla p+\nabla T+f$$



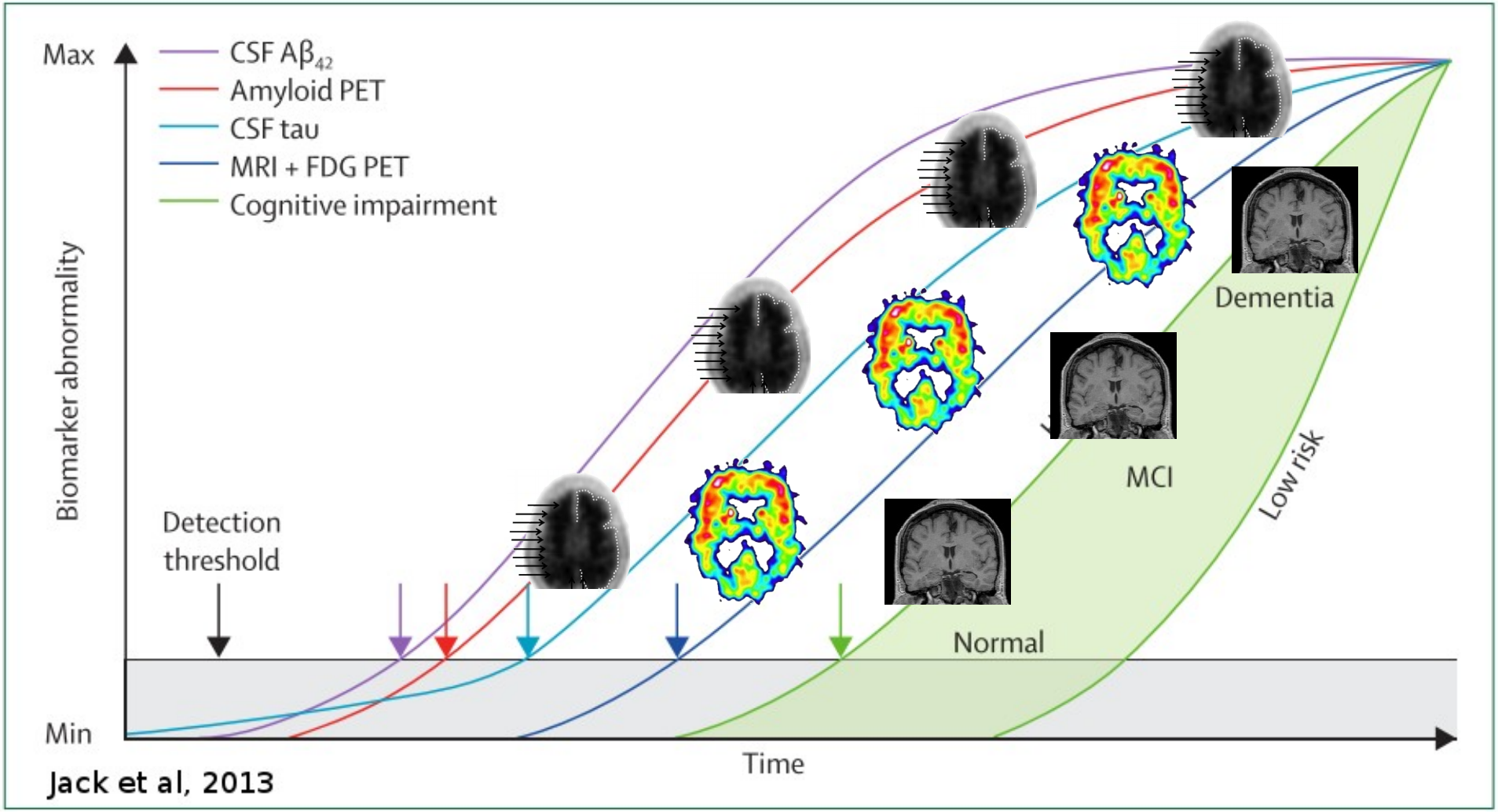
Black-Scholes

$$\frac{\partial V}{\partial t}+\frac{1}{2}\sigma^2 S^2\frac{\partial^2 V}{\partial S^2}+rS\frac{\partial V}{\partial S}=rV$$



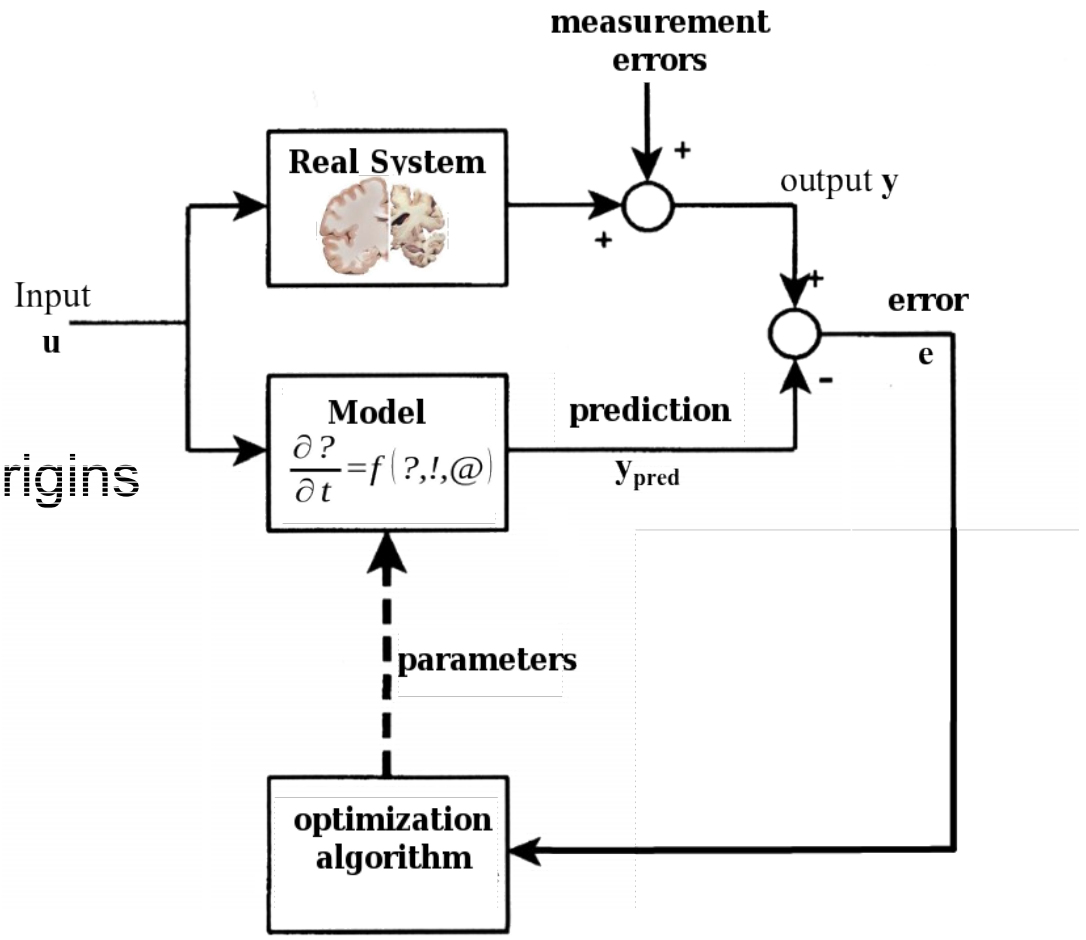
The Challenge:

$$\frac{\partial ?}{\partial t} = f(?,!,@)$$



Advantages of a quantitative model

- Quantify disease dynamics
  - Disease tracking (pharma)
  - Early diagnosis (clinicians)
- Identify drugs that works
  - Short-term end-points
- Personalized medicine
- Test hypothesis on disease origins
  - Tau vs Beta debate



$$\frac{\partial ?}{\partial t} = f(?, !, @)$$