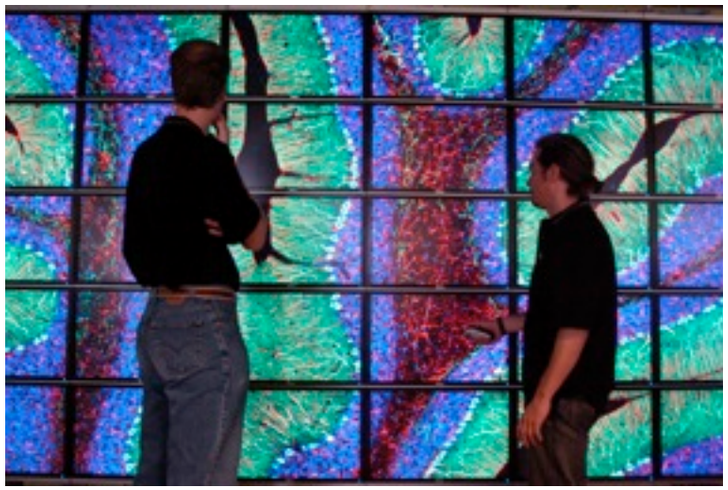
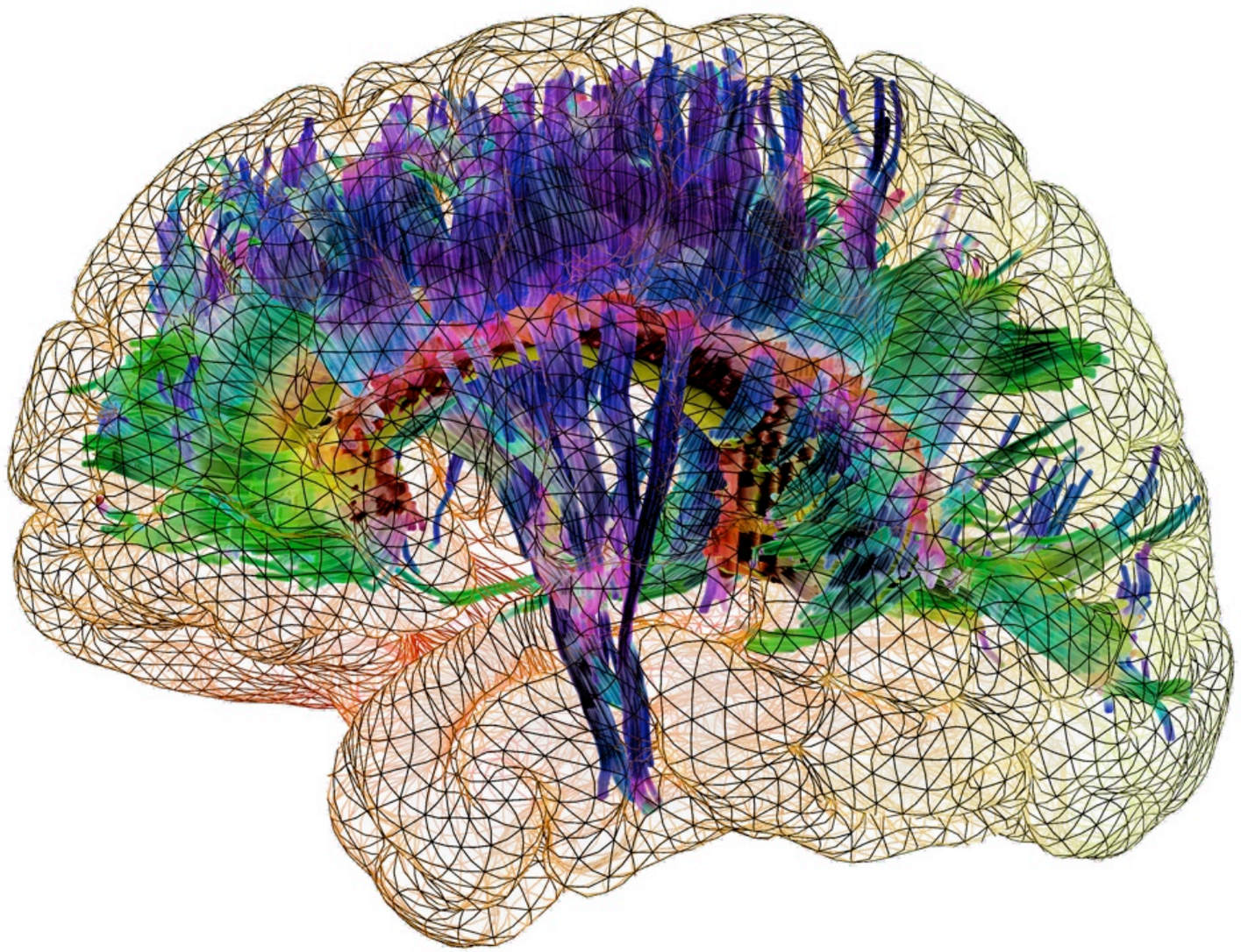
CBRAIN

An International Computing Platform for Neuroimaging
Dr. Alan C. Evans' Laboratory

BIC Lecture, Feb 2012

by Marc-Etienne Rousseau





neuro canarie

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Summary

- What is CBRAIN?
  - What is it for?
  - Who uses it and how much?
  - A Few Special Projects
- What can it do for you?
- Can I get access? Can I get involved?

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Funded by CANARIE

CANADA'S ADVANCED RESEARCH AND INNOVATION NETWORK

http://www.canarie.ca

Canadian Brain Imaging Research Network

2009-2010

Global Brain Imaging Research Network

2010-2012

What is CBRAIN?

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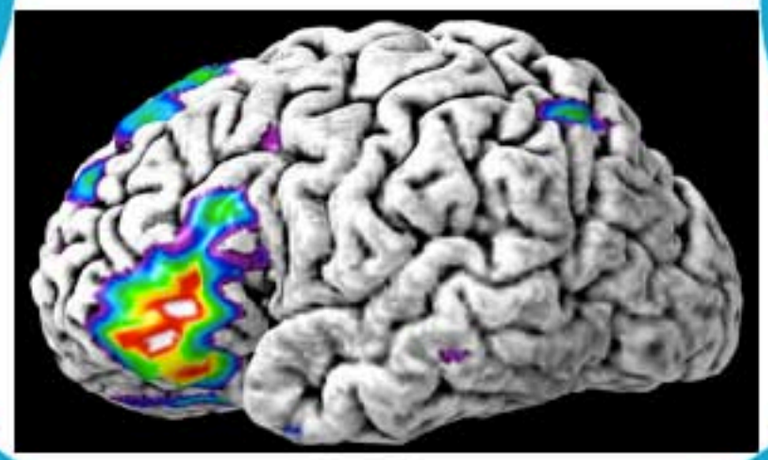
What is Neuro-Imaging?

Clinical Expertise

Physical Sciences

Basic Neuroscience



Imaging Technology

High Performance Computing

3 Tesla MRI

Brain Imaging Techniques:

- Magnetic Resonance Imaging (MRI)
- Functional MRI (fMRI)
- Position Emission Tomography (PET)
- Magnetoencephalography (MEG)

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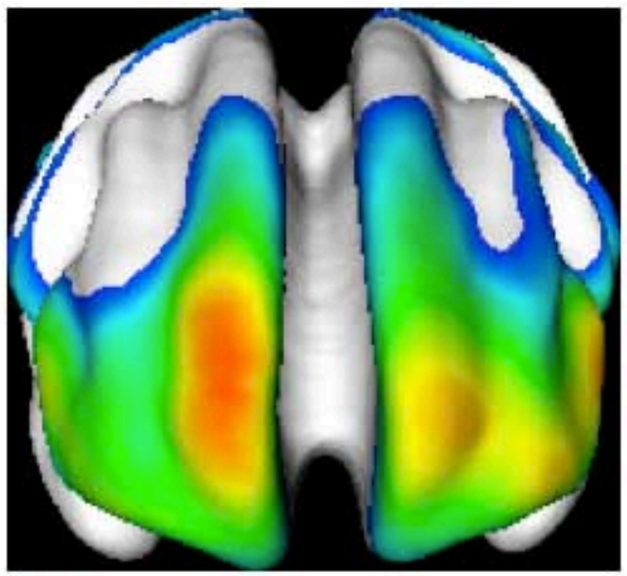
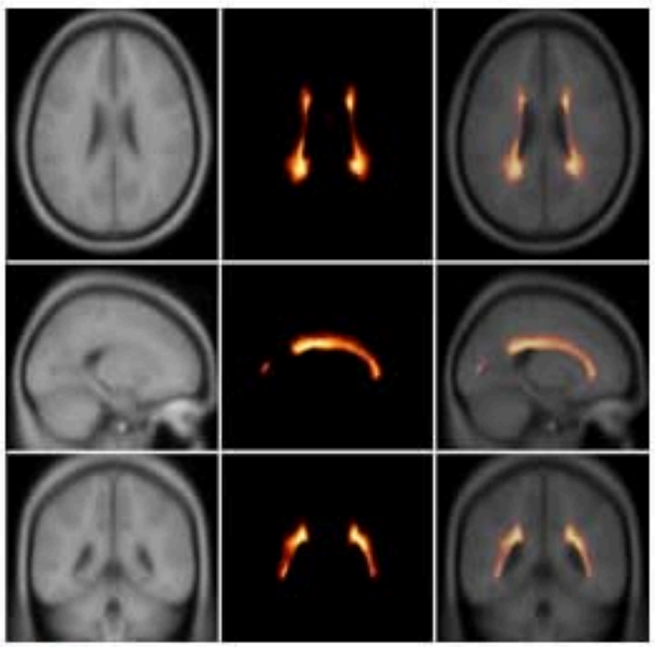
Neuro-Imaging Applications

Population Studies:

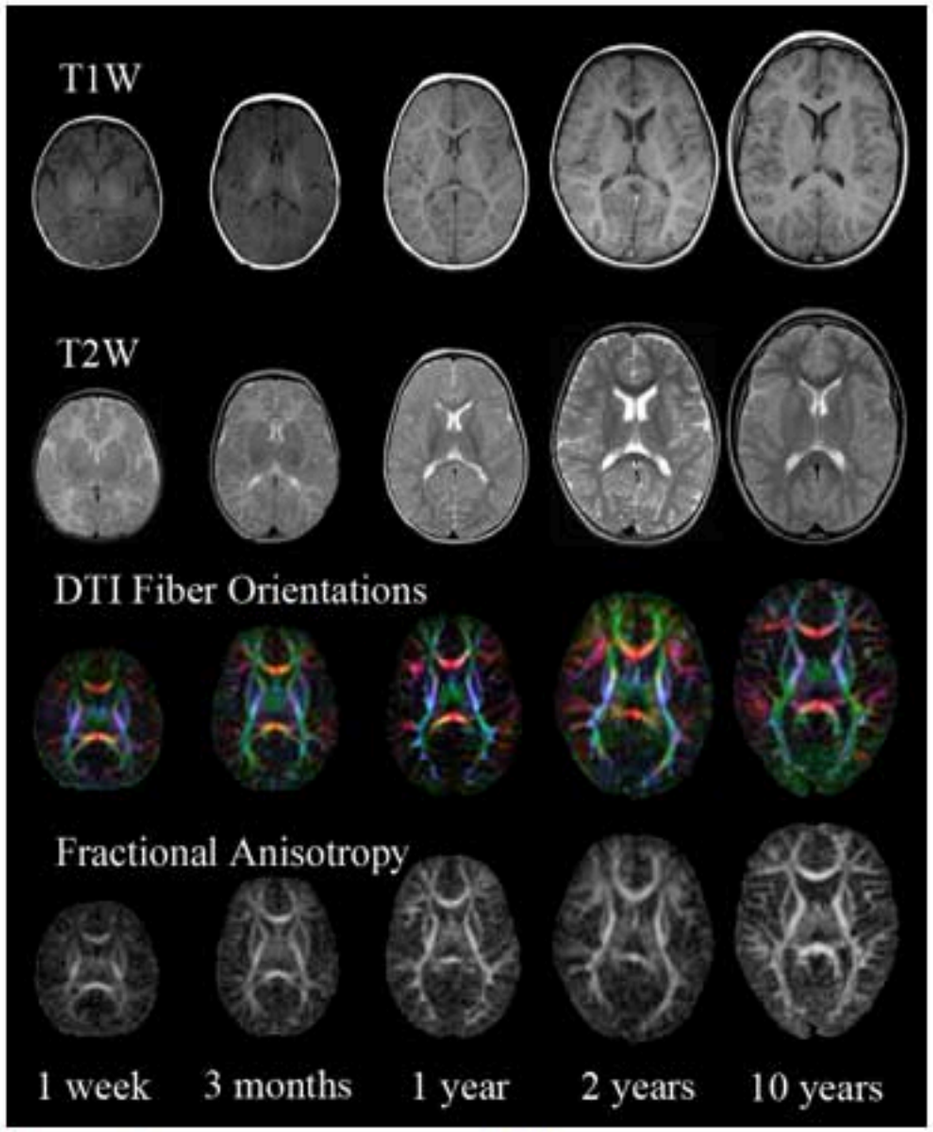
- Alzheimer's Disease
- Multiple Sclerosis
- Autism
- Schizophrenia
- Normal brain development



Alzheimer loss of cortical thickness

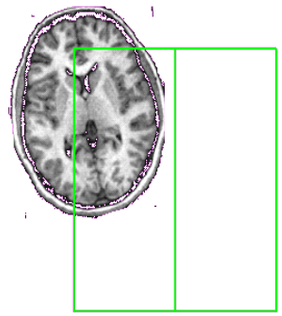


Multiple Sclerosis lesions

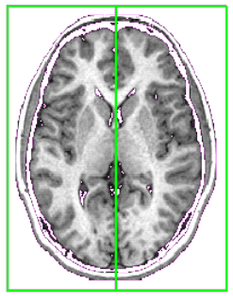


Normal Brain Development in Children

A Processing Pipeline: CIVET



"Native" T1-weighted MRI

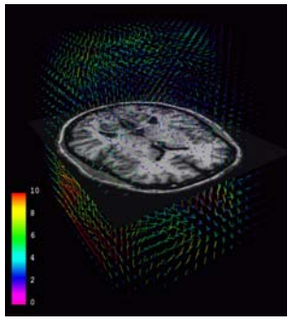


Registered MRI

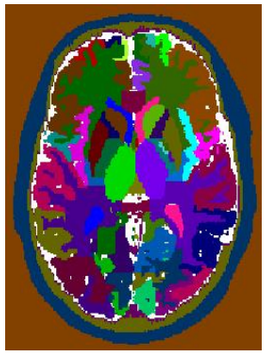
Classification

Subject brain with its cortical surface

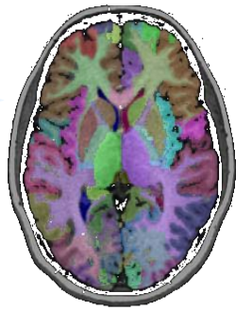
Template brain, in stereotaxic space



Deformation field



Atlas defined on template brain, in stereotaxic space



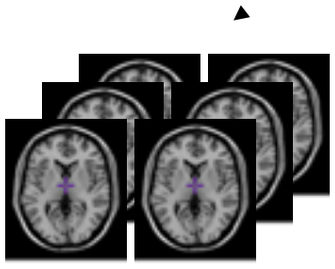
Automatic segmentation

- Hundreds of MRI per study
- GBs of data
- Thousands of CPU hours

Removing Obstacles to Compute

Scientist

Vancouver
Montreal

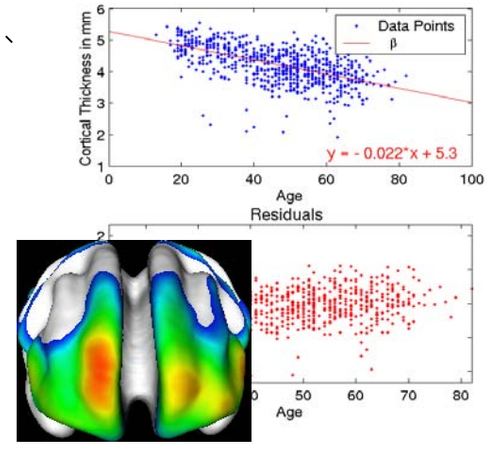


Data

Vancouver & Montreal
10 GB

Computing

Sherbrooke
4000 CPU hours



Results

Vancouver & Montreal
100GB

Challenges: Users

Most Neuroscientists are not IT experts

- Don’t want to deal with networks, HPC processing, UNIX, etc.
- Just want to use specific tools with their data and get the results.
- They want to share, but they want to control their data.
- Research requirements are unclear and unstable.

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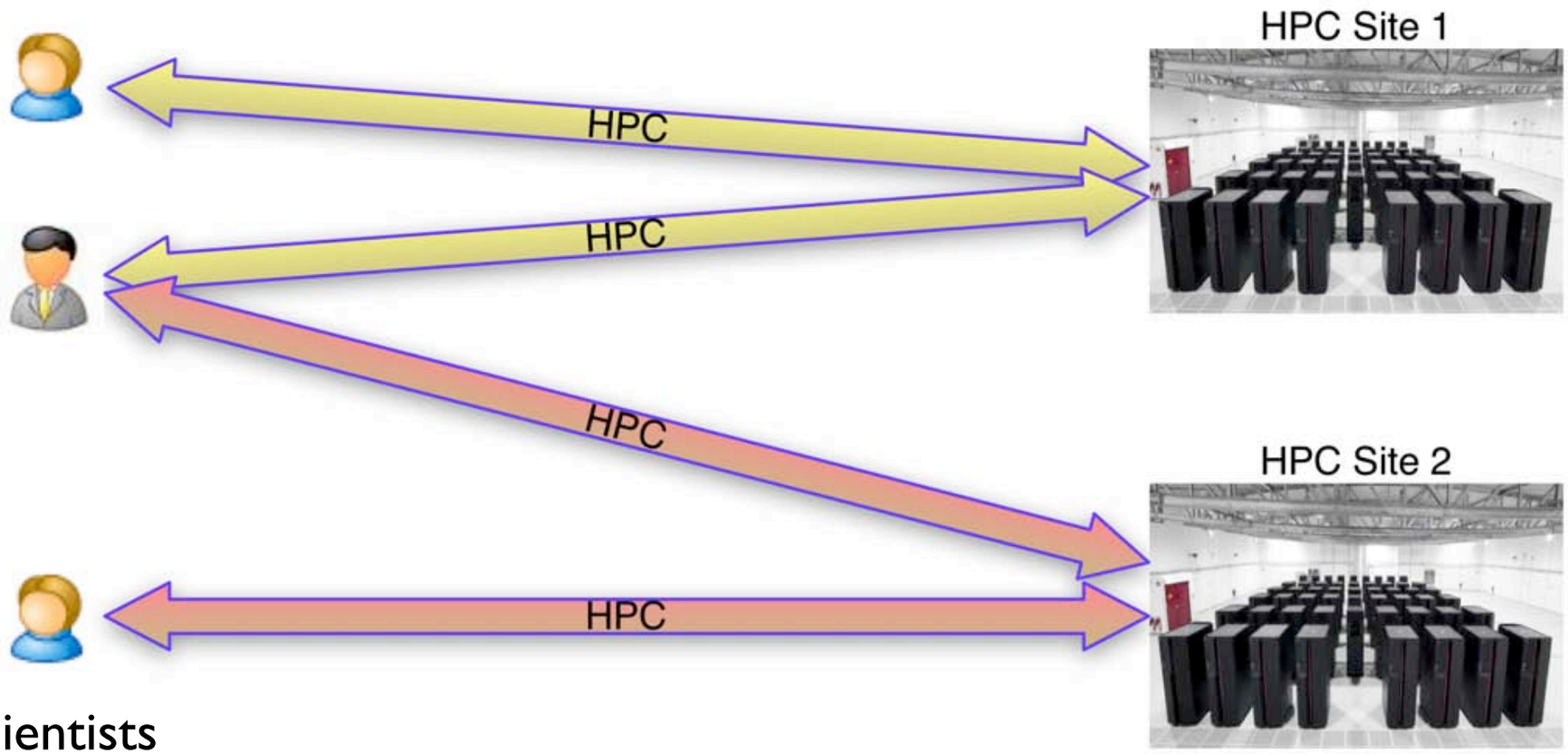
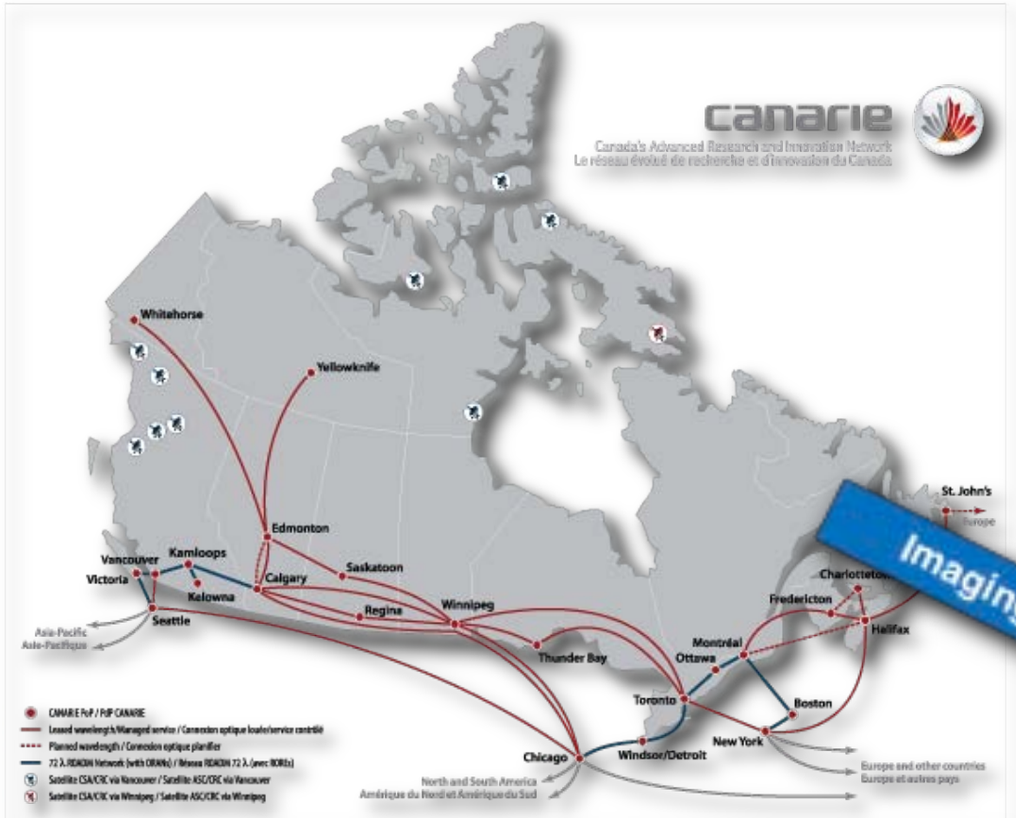
Challenges: Heterogeneous HPC

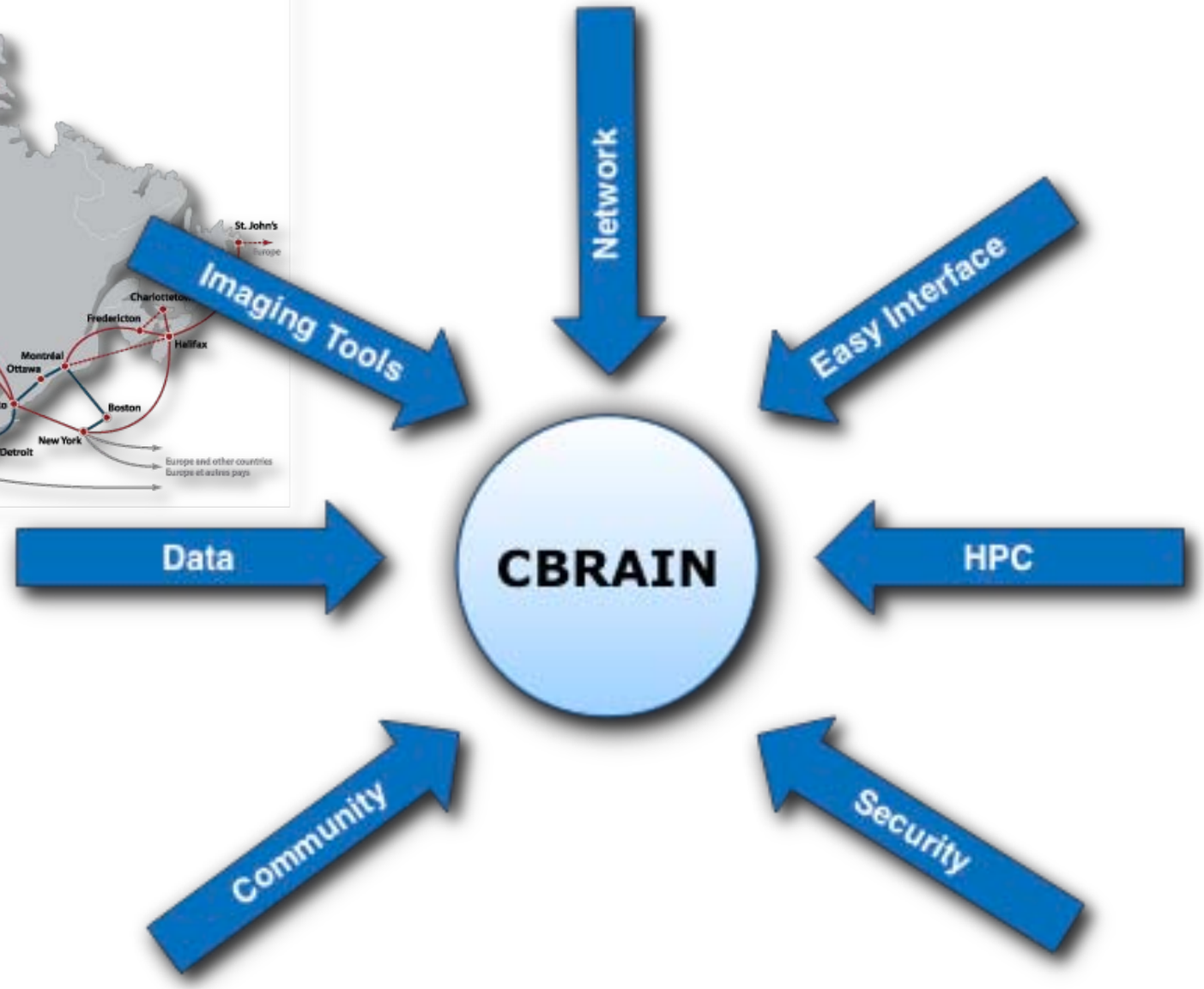
compute • calcul
CANADA



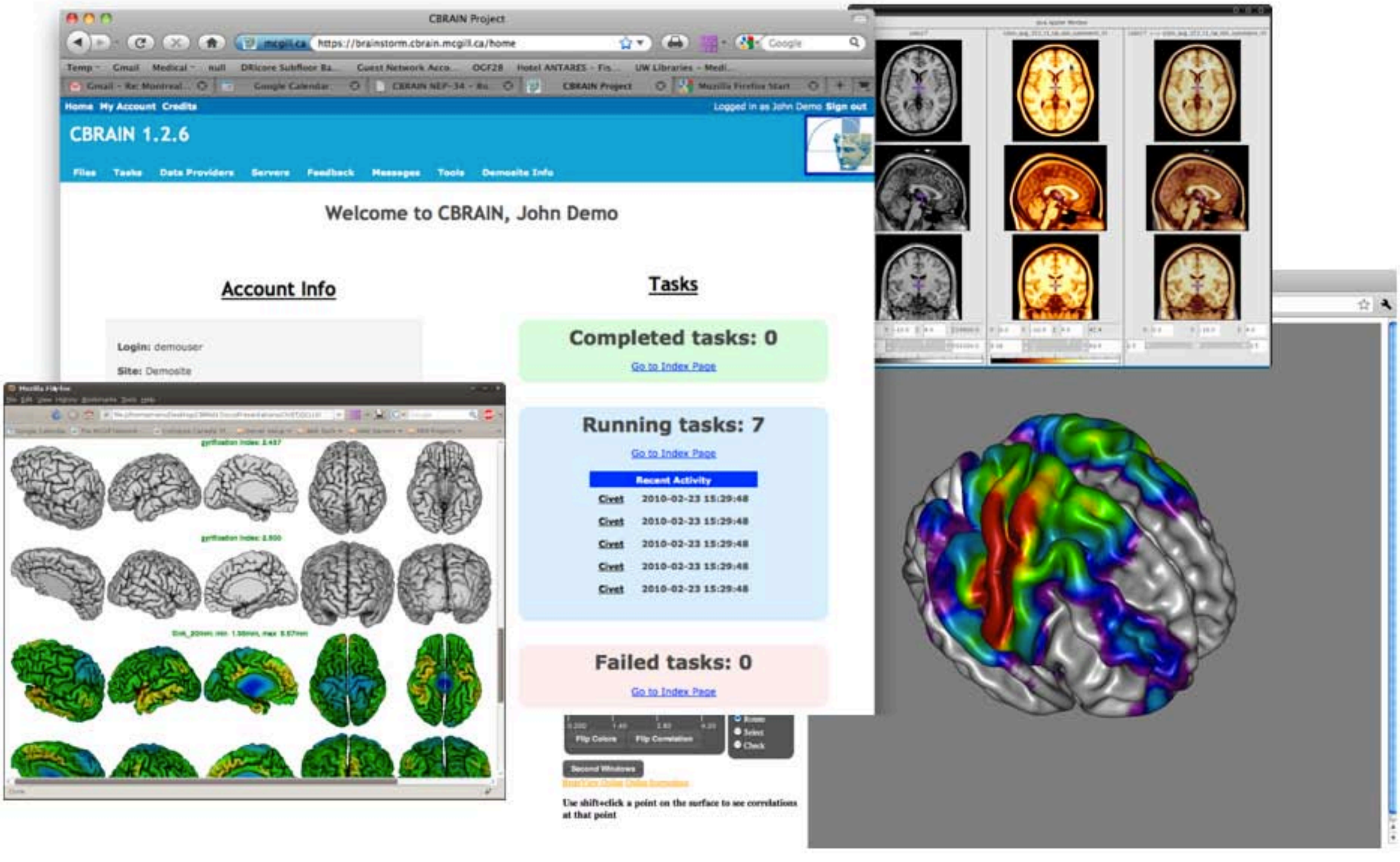
Scientists
With HPC expertise

CBRAIN: An Integrative Platform



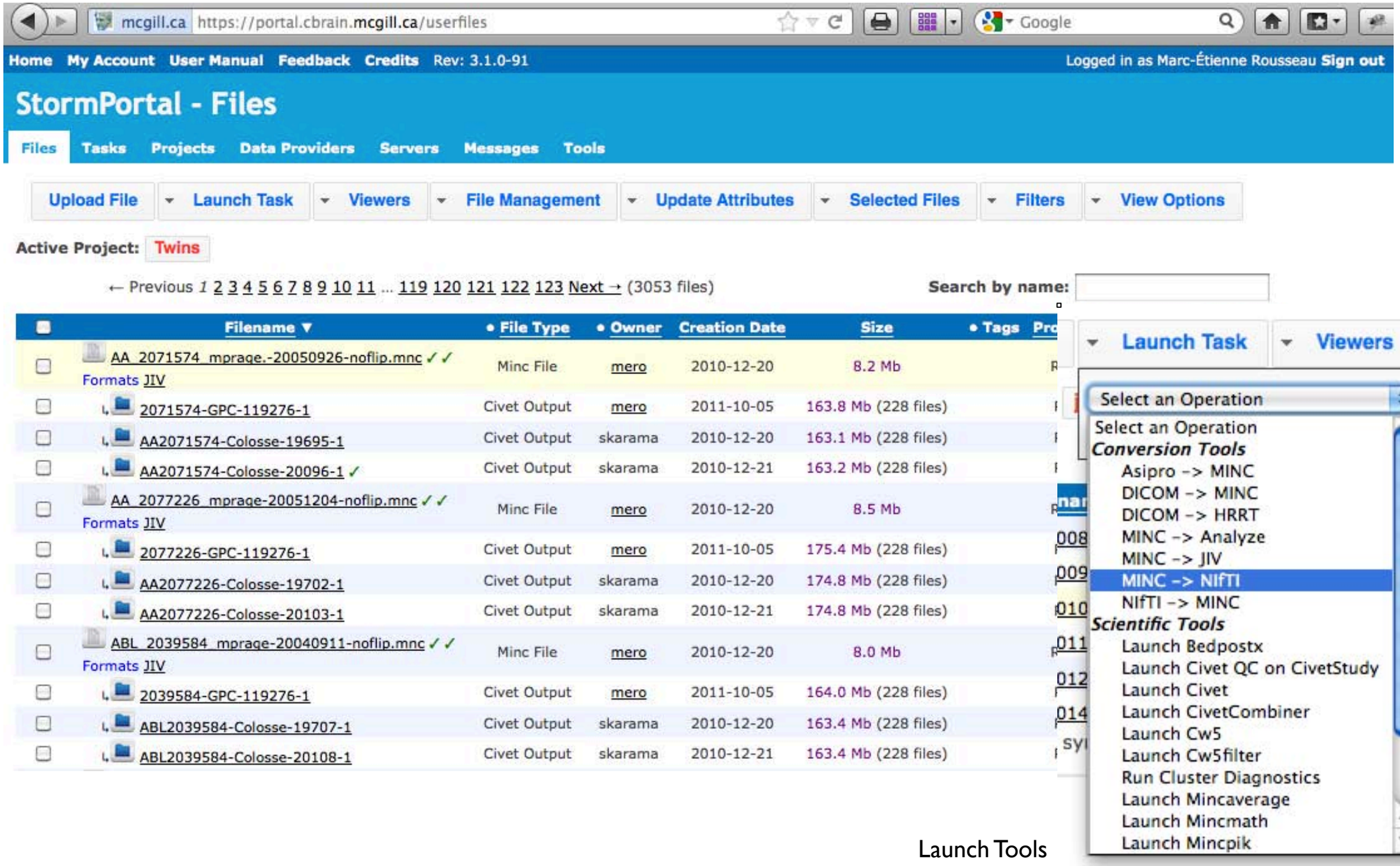


CBRAIN: Simple Web Interface



CBRAIN: Simple Web Interface

File & Project Management (inputs & results)



Launch Tools

CBRAIN: Simple Web Interface

Tool configuration

Task Parameters (Help) :

Pipeline Options

Template: 1.00

Model: icbm152nl

CIVET options

Interpolation: trilinear

N3 distance: 0

Degrees of freedom for linear registration: 9

Do NOT build surfaces: ☐

Thickness method: tlink and kernel size: 20

Resample surfaces: ☑

Combine surfaces: ☐

VBM Options

Process VBM files: ☐

Blurring kernel size in mm for volume: 8

Run symmetry tools: ☐

Keep cerebellum in VBM maps: ☑

MINC file input list

Launch CIVET?	T1 name	
☑	AA_2071574_mprage.-20050926-noflip.mnc	pret

Compute Job status and Management

mcgill.ca https://portal.cbrain.mcgill.ca/tasks

Google

Home My Account User Manual Feedback Credits Rev: 3.1.0-91 Logged in as Marc-Étienne Rousseau Sign out

StormPortal - Tasks

Files | Tasks | Projects | Data Providers | Servers | Messages | Tools

For Queued Tasks | For Running Tasks | For Failed Tasks | For Completed Tasks | Terminating And Cleaning Up | Archiving | Filters | View Options

Active Project: Twins

Currently in Batch View (1401 tasks)

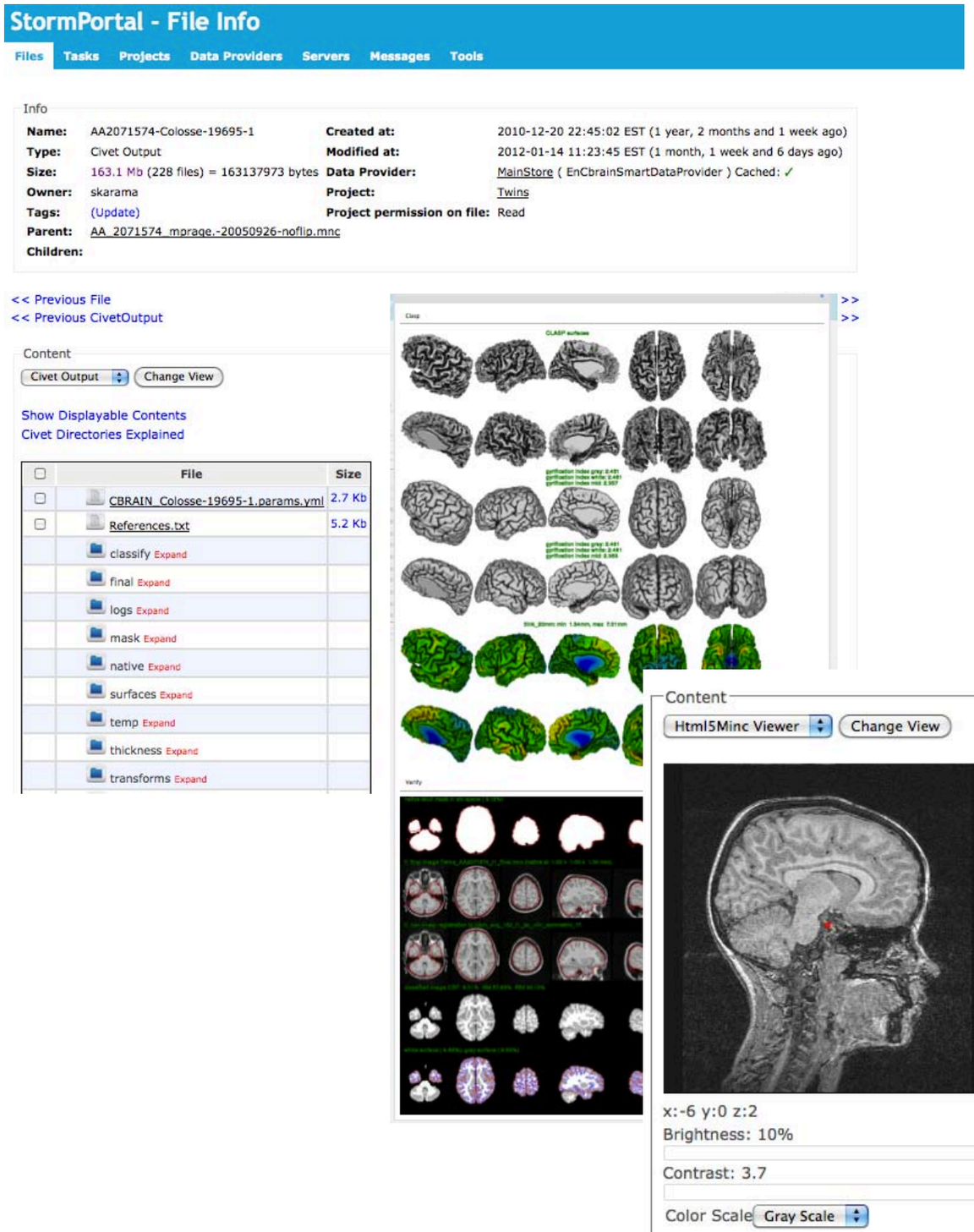
☐	• Task Type	Description	• Owner	• Execution Server	• Current Status	Run Number	Workdir Size	Time Submitted	Last Upd
☐	Civet (Go to Batch)	N3_150mm_Spline	skarama	200 jobs launched at 2010-12-21 21:50:02 EST		200 x Failed			
☐	Civet	N3=150	skarama	Colosse	Completed	1	∇	2010-12-21 11:56:09 EST	2012-01-12 16
☐	Civet (Go to Batch)	N3=150	skarama	200 jobs launched at 2010-12-21 11:35:41 EST		200 x Completed			
☐	Civet (Go to Batch)	N3=150	skarama	200 jobs launched at 2010-12-21 10:29:13 EST		200 x Completed			
☐	Civet	N3=200	skarama	Colosse	Completed	1	∇	2010-12-21 09:45:53 EST	2012-01-12 13
☐	Civet (Go to Batch)	N3=200	skarama	200 jobs launched at 2010-12-21 09:43:52 EST		200 x Completed			
☐	Civet (Go to Batch)	N3=200	skarama	199 jobs launched at 2010-12-20 16:12:07 EST		199 x Completed			
☐	Minc2jiv		skarama	MindStorm	Completed	1	∇	2010-12-20 15:55:53 EST	2012-01-11 22
☐	Minc2jiv (Go to Batch)		skarama	200 jobs launched at 2010-12-20 15:54:03 EST		200 x Completed			
☐	Minc2jiv (Go to Batch)		skarama	199 jobs launched at 2010-12-20 15:53:20 EST		199 x Completed			

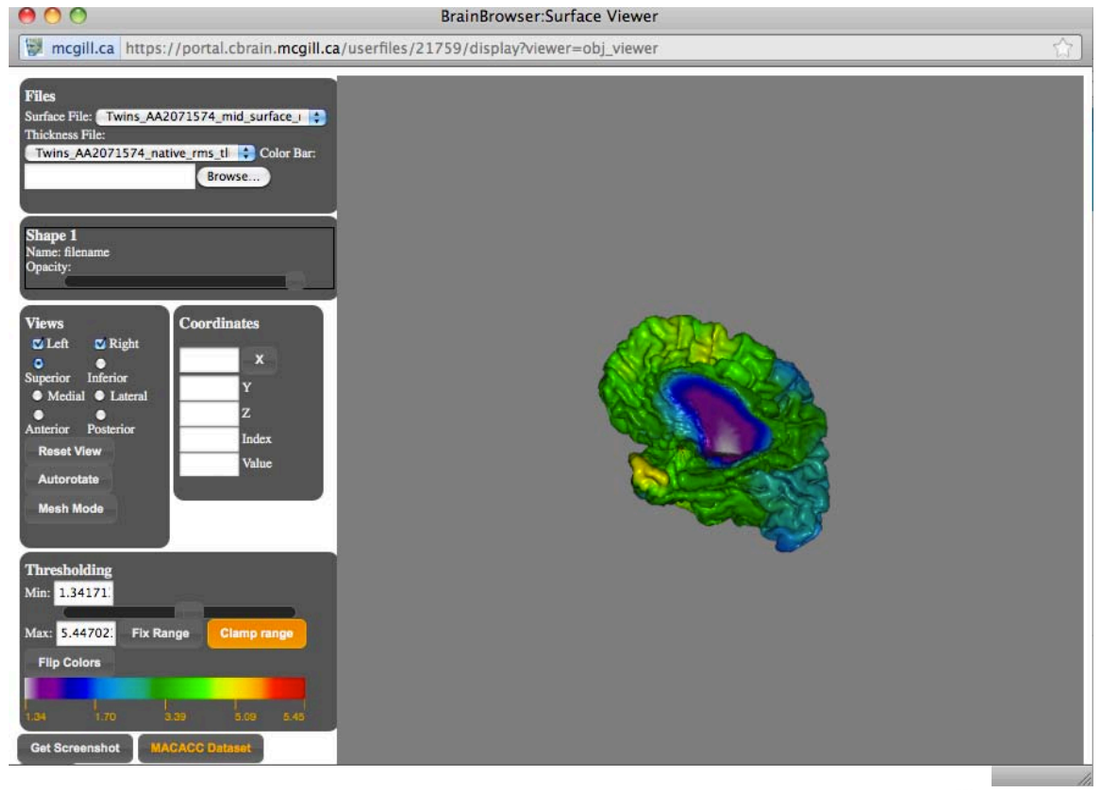
Workdir archiving status symbols: ◇: On Cluster ∇: As File

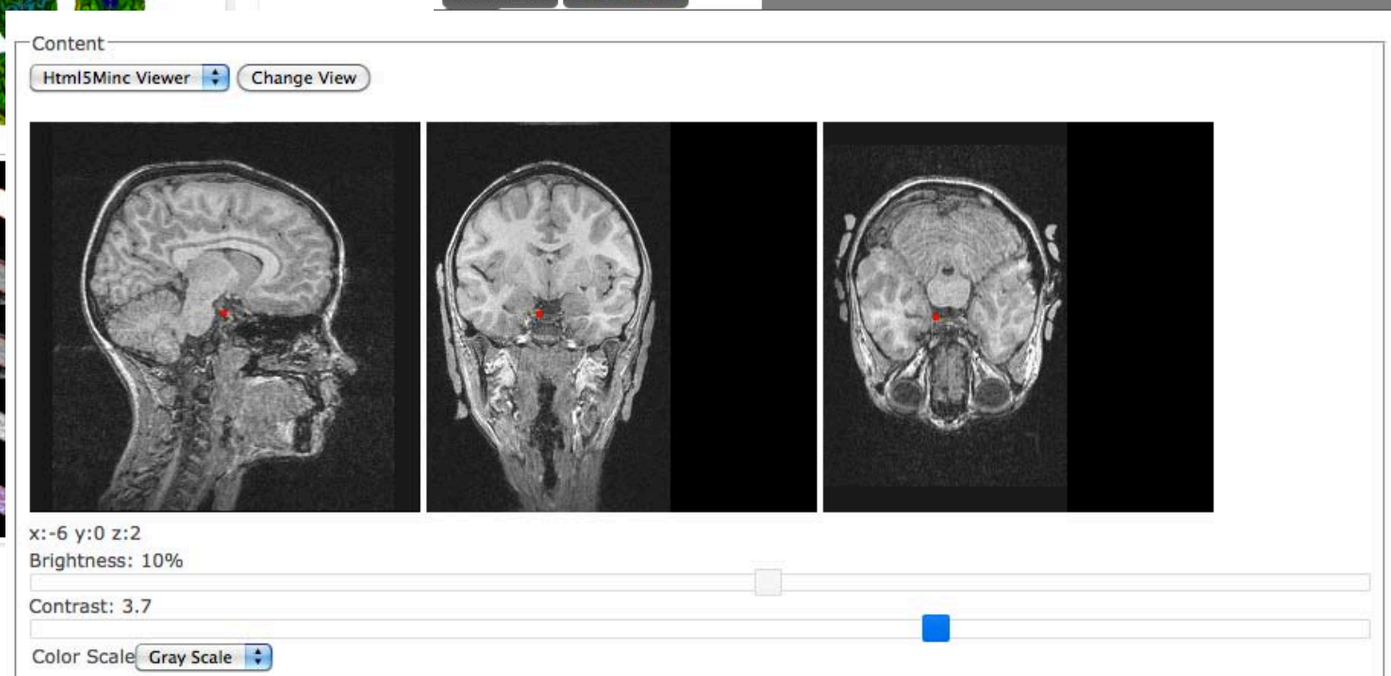
Powered by CBRAIN

CBRAIN: Simple Web Interface

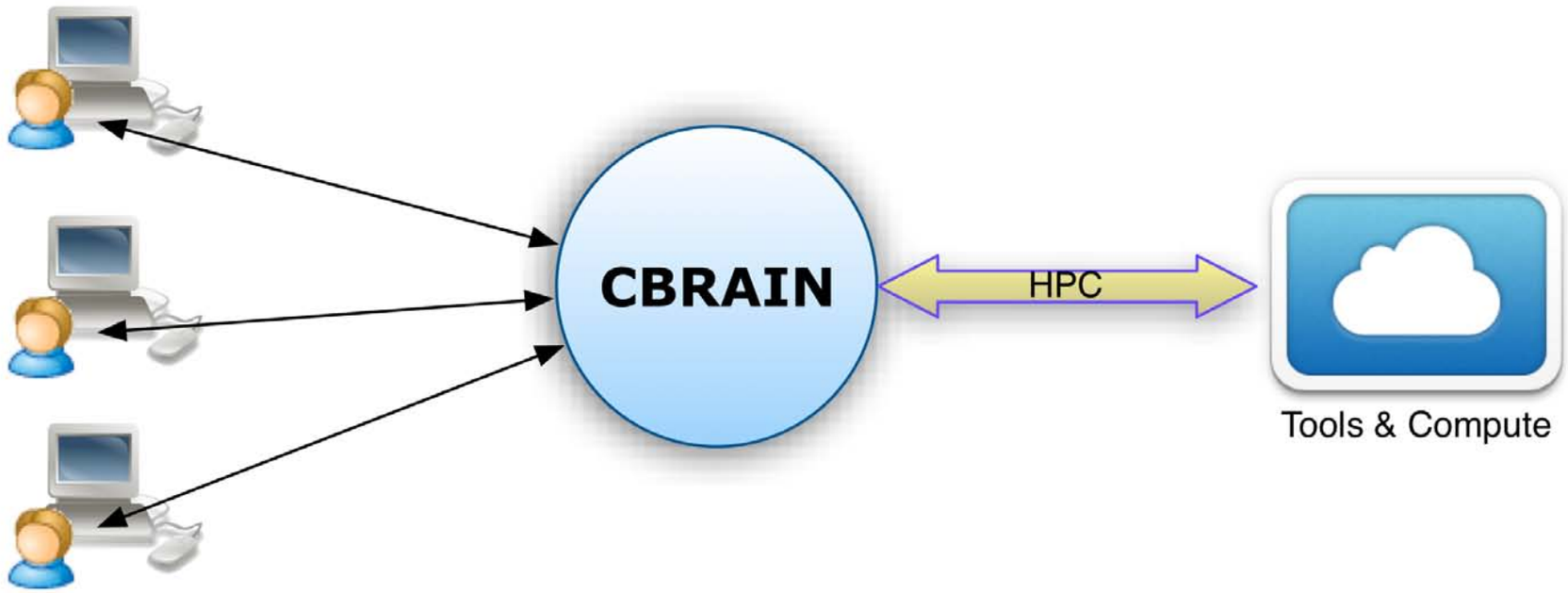
Results, QC, Provenance and Visualisation



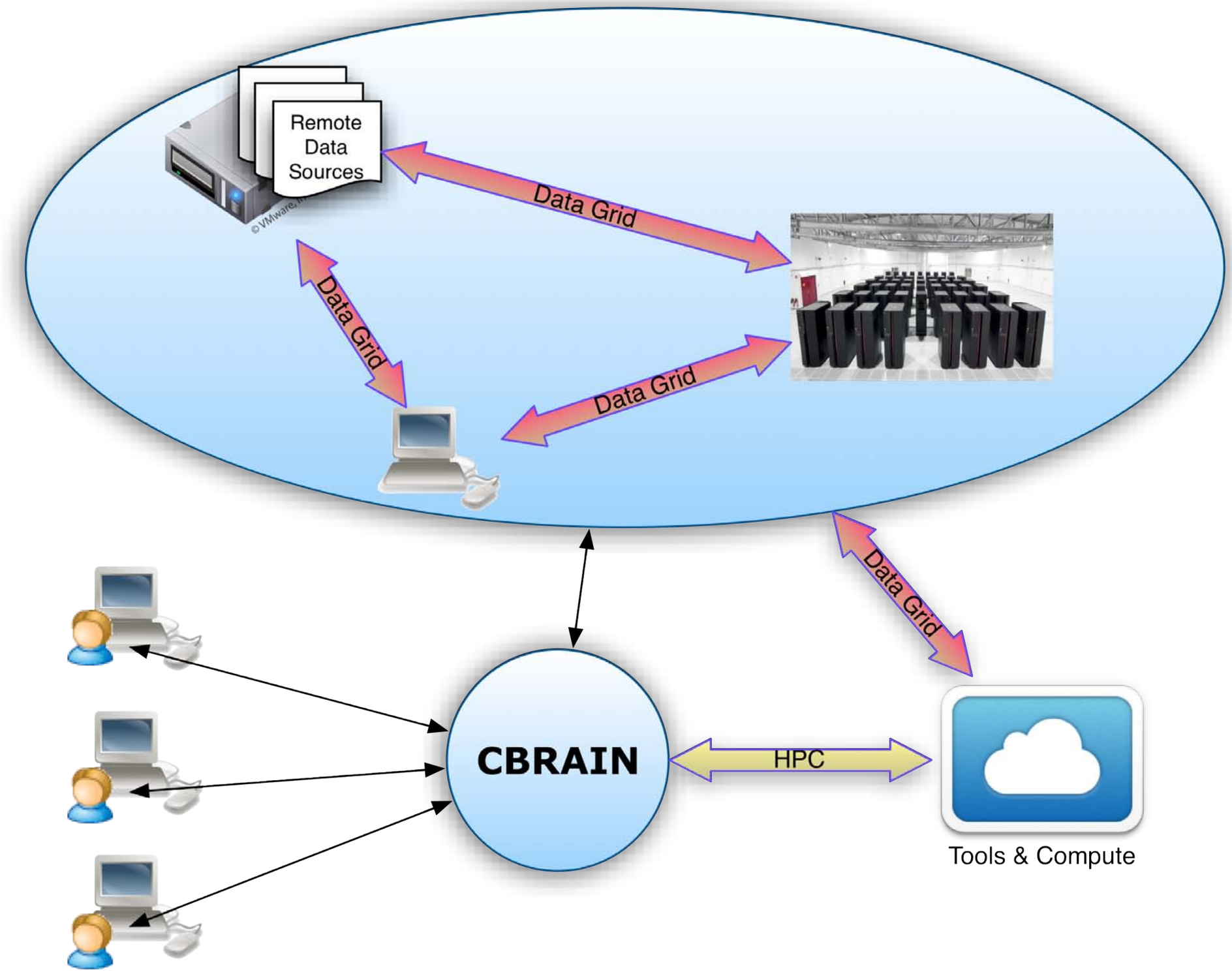




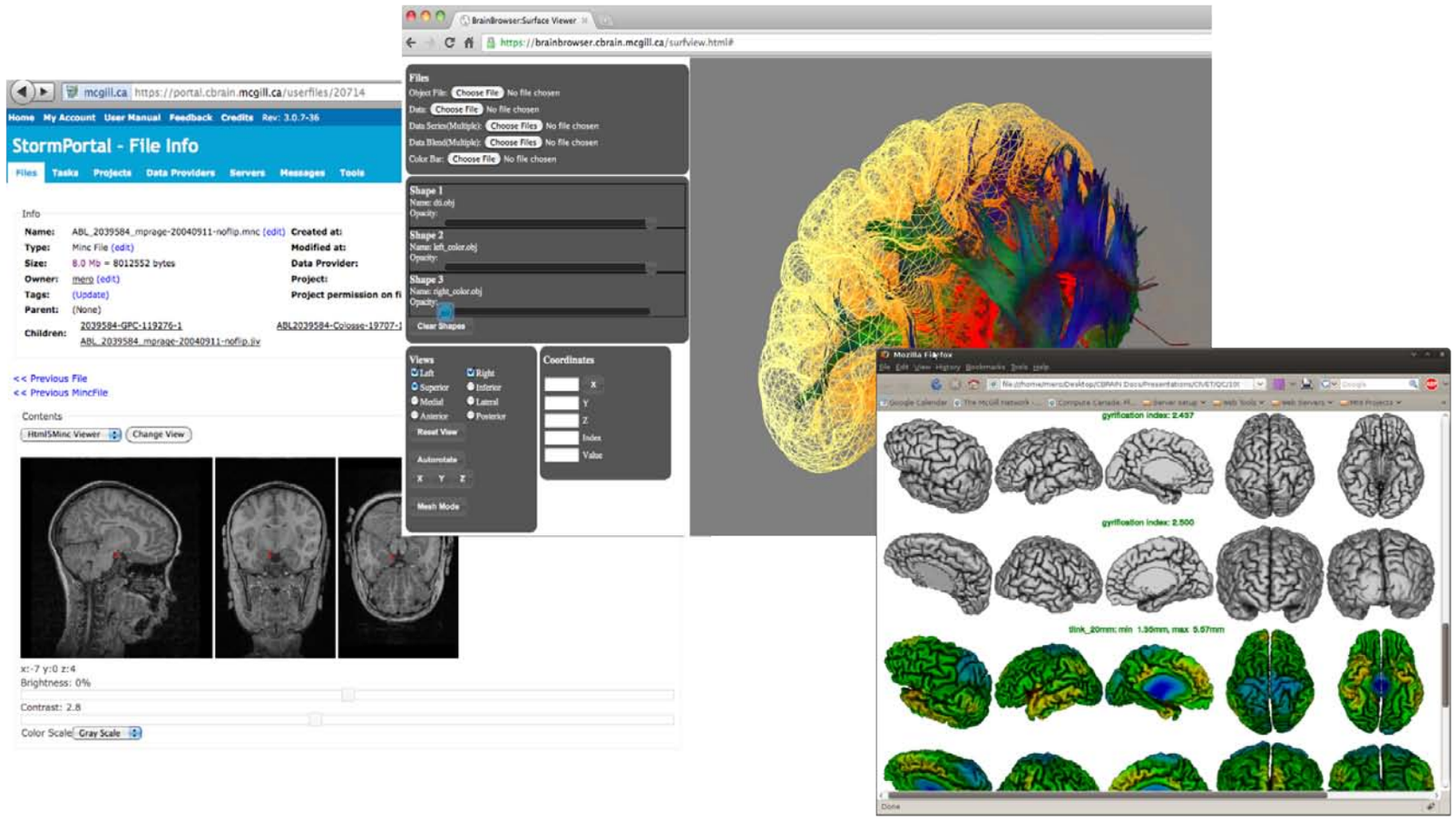
CBRAIN
Transparent Compute Access

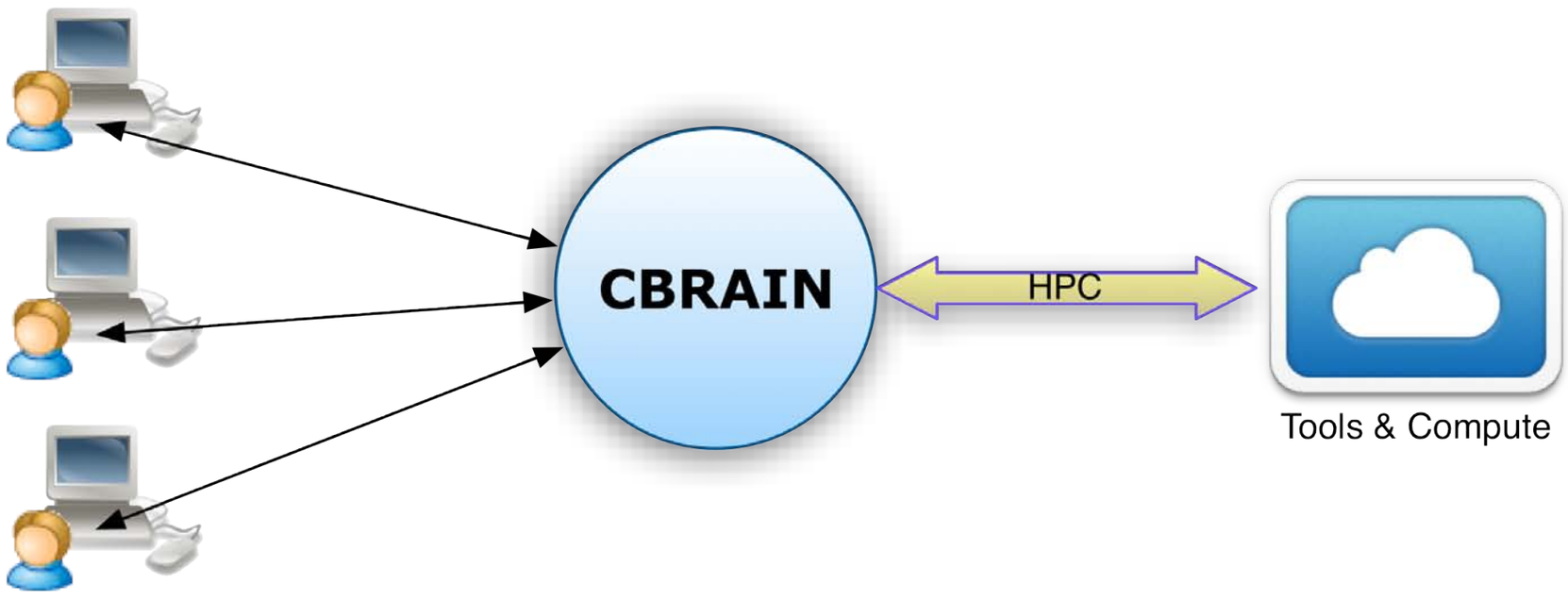


Transparent Data Grid

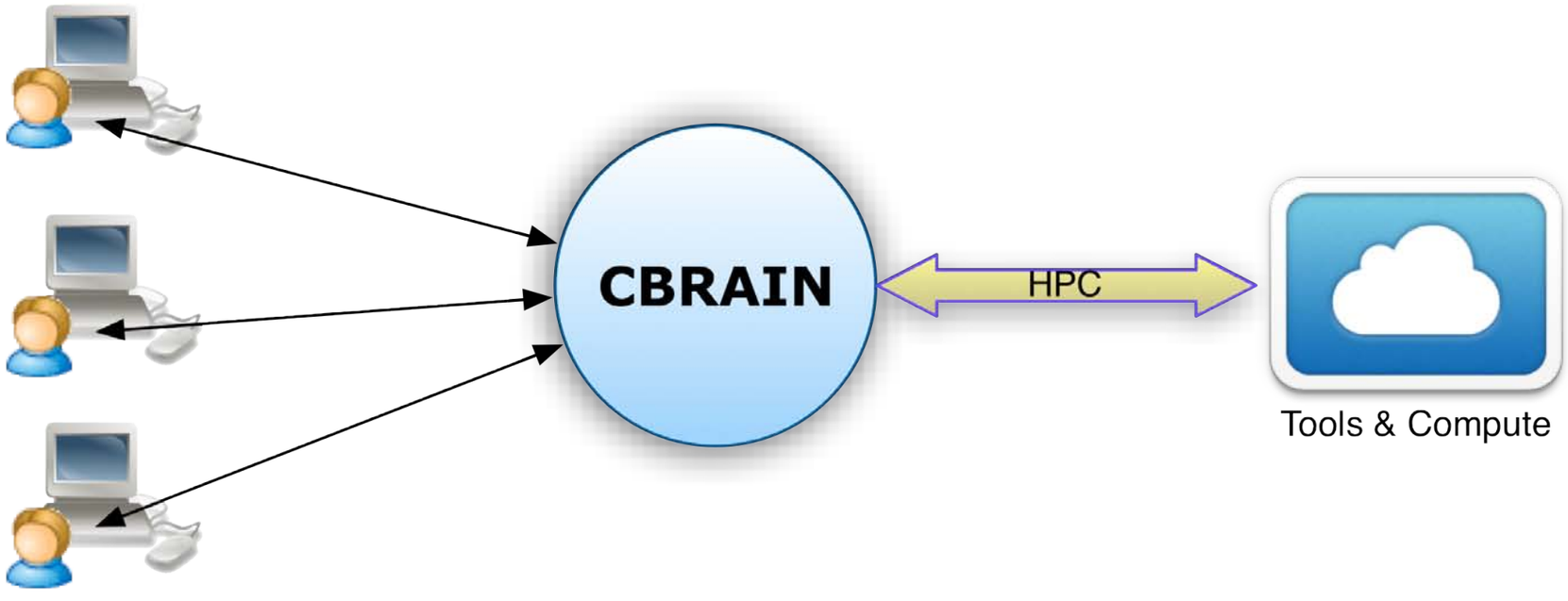


Interactive Scientific Visualisation

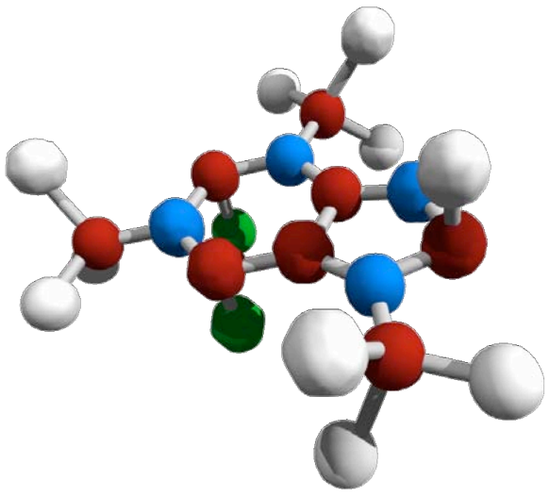


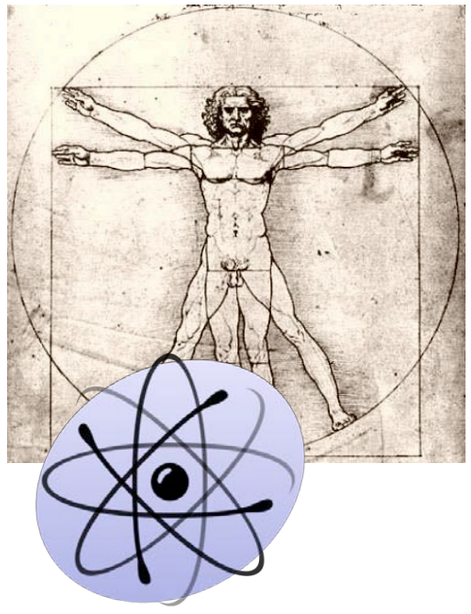


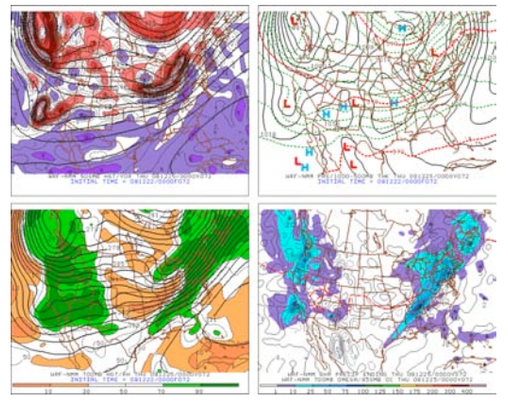
Community Portal

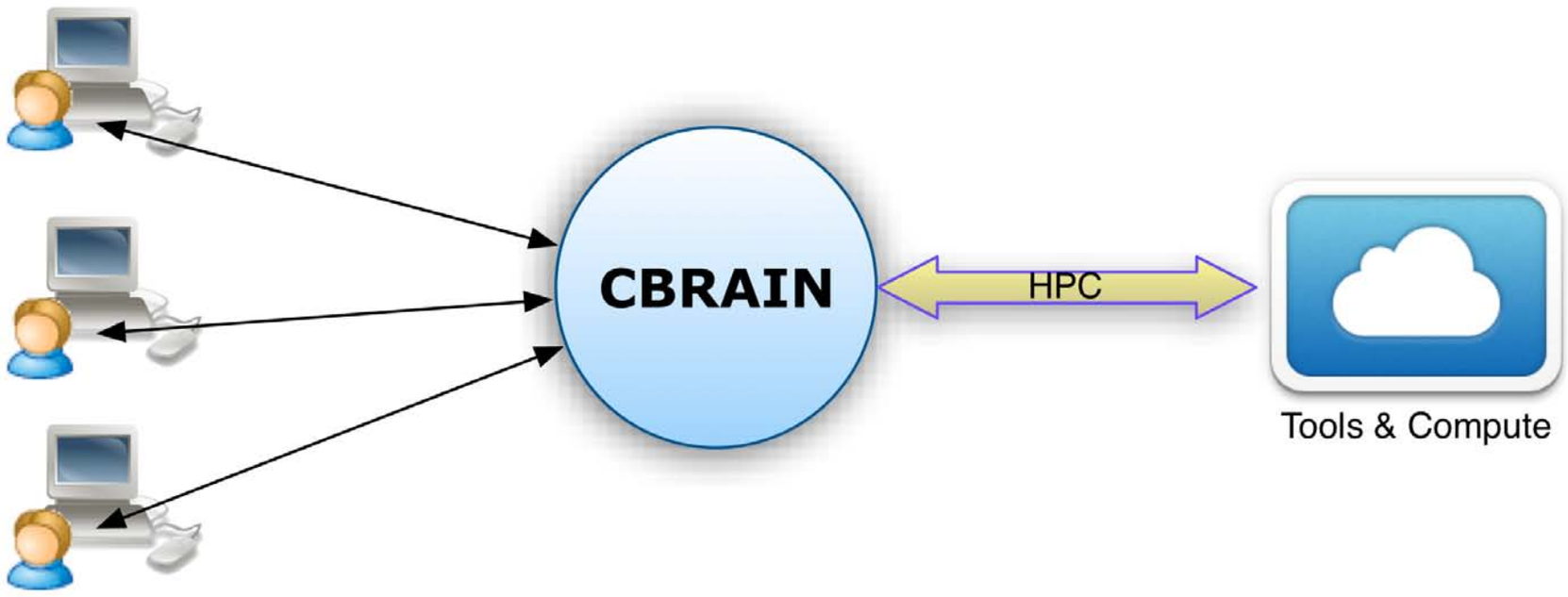


Generic Research Platform



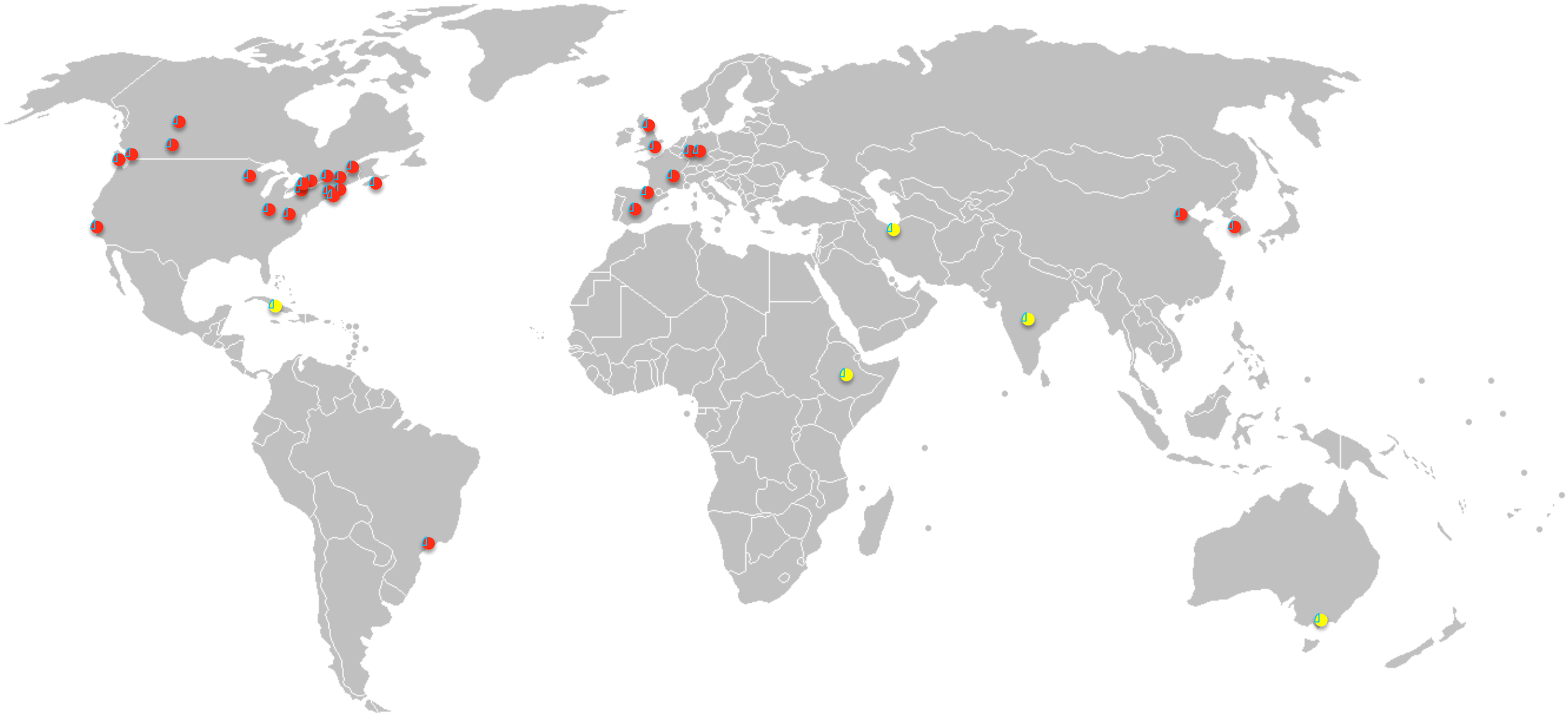






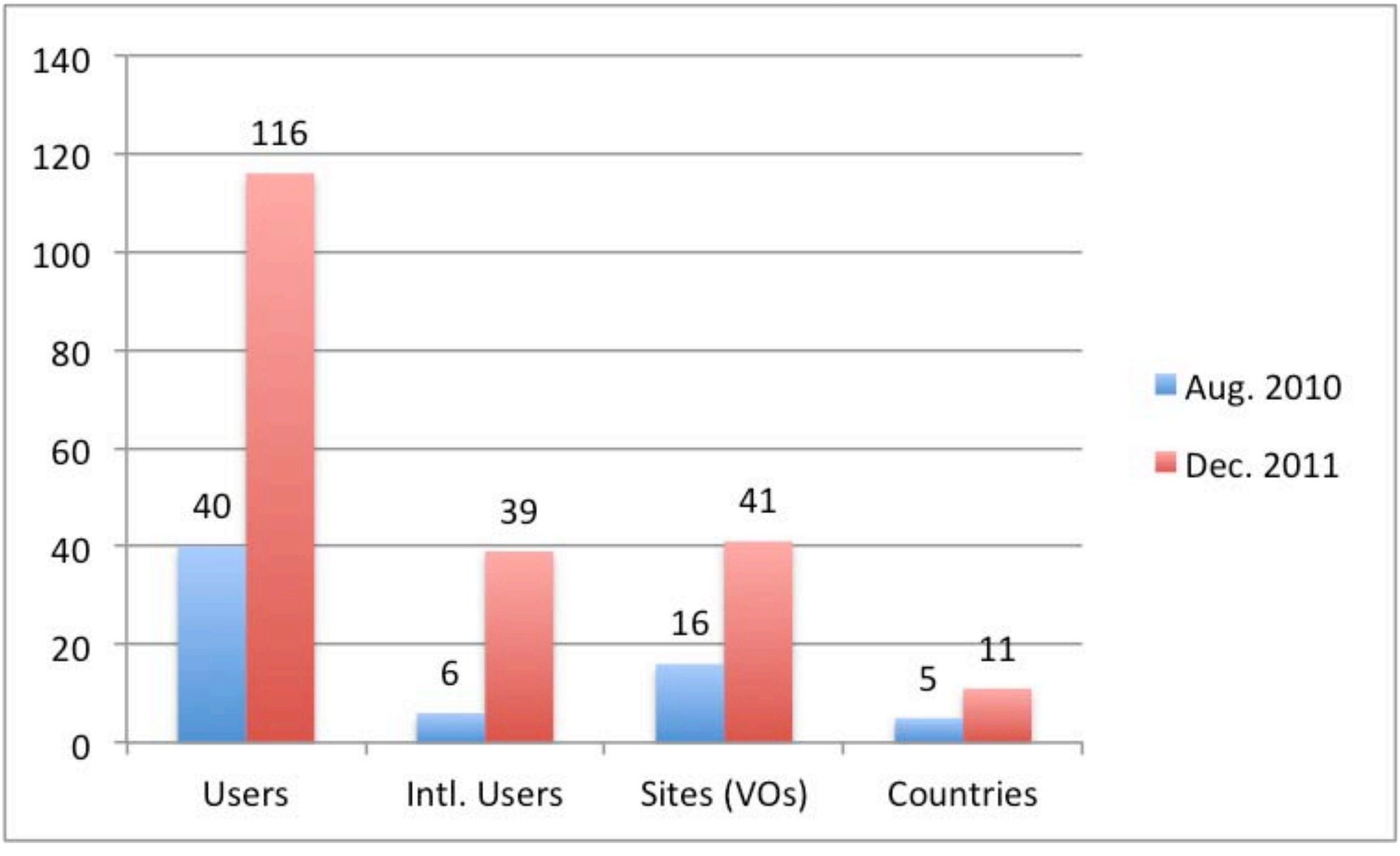
CBRAIN
International Platform

Current Worldwide Distribution
CBRAIN Users



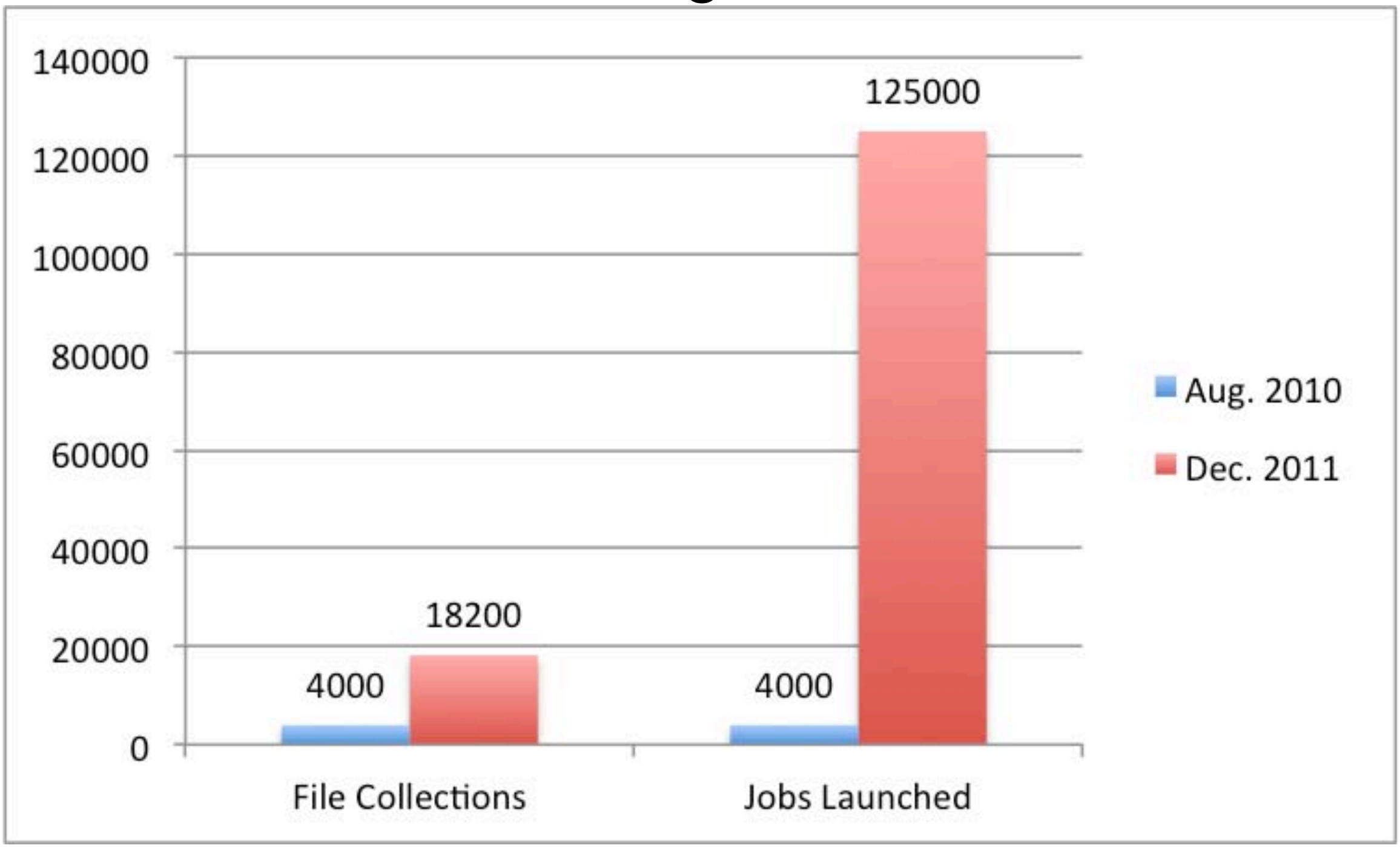
CBRAIN Platform Statistics

Membership



CBRAIN Platform Statistics

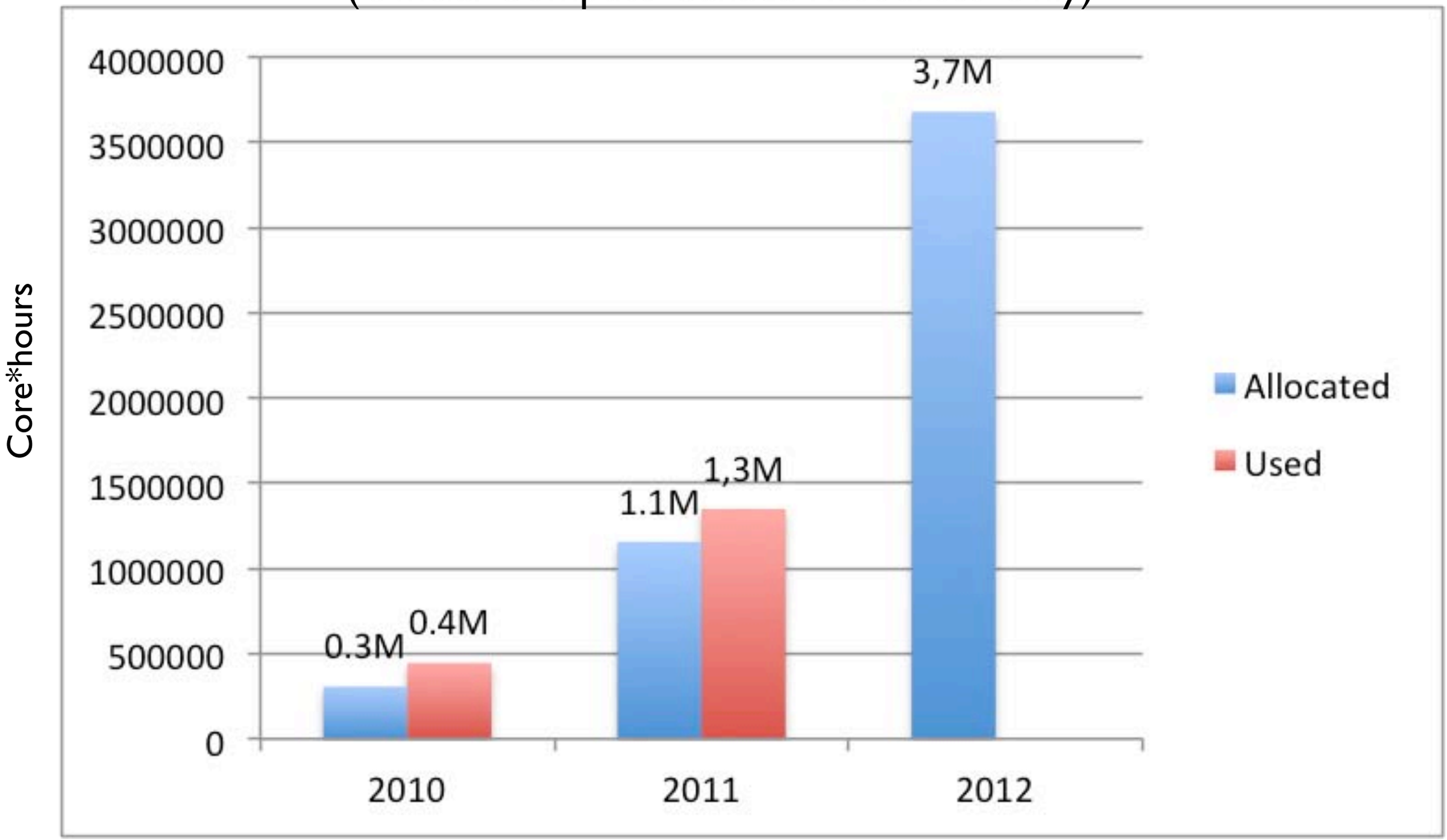
Usage



CBRAIN Platform Statistics

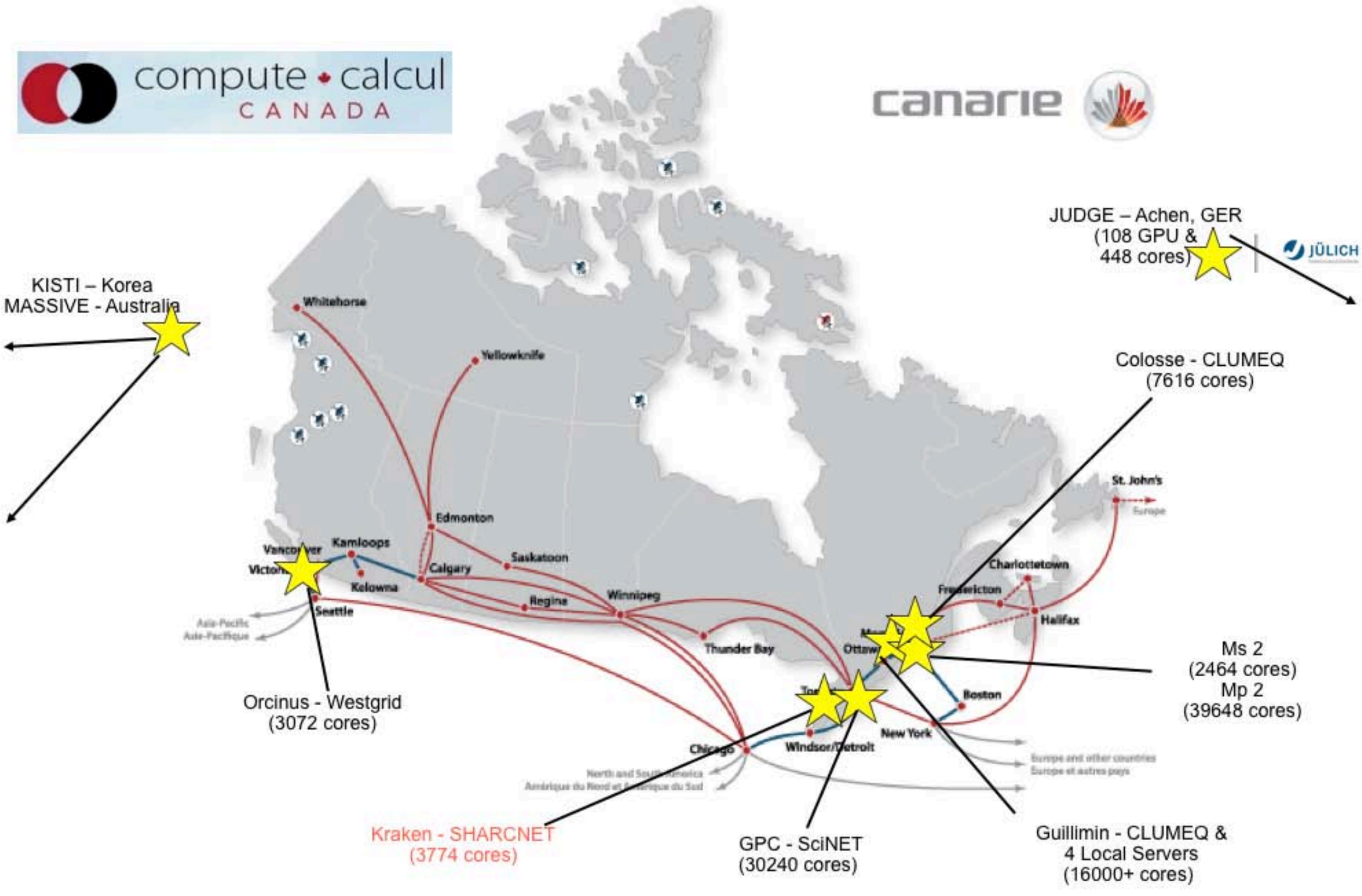
Workload

(Official Compute Canada Resources Only)



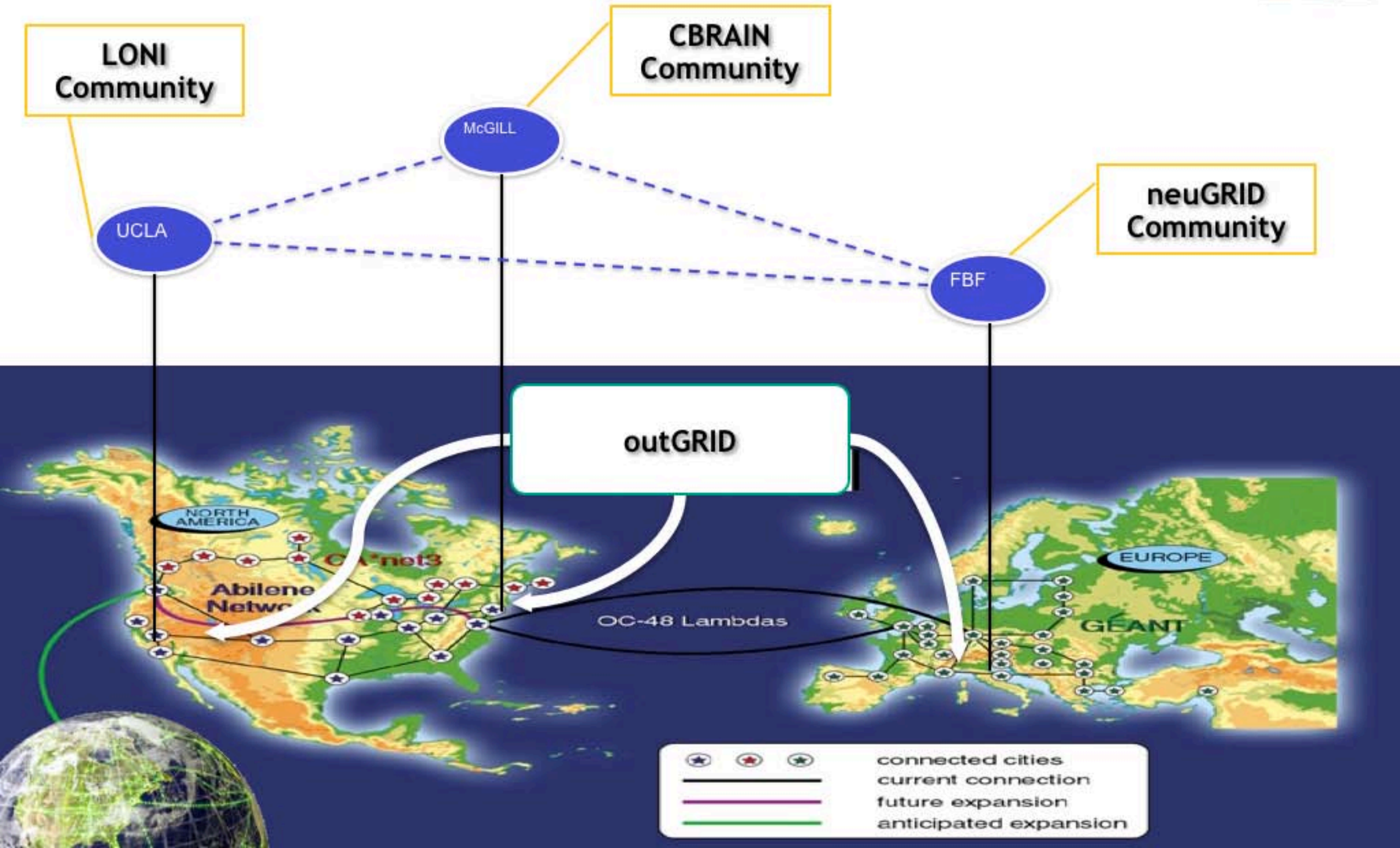
HPC Integration 2012

(11 compute installations, 80,000+ core)

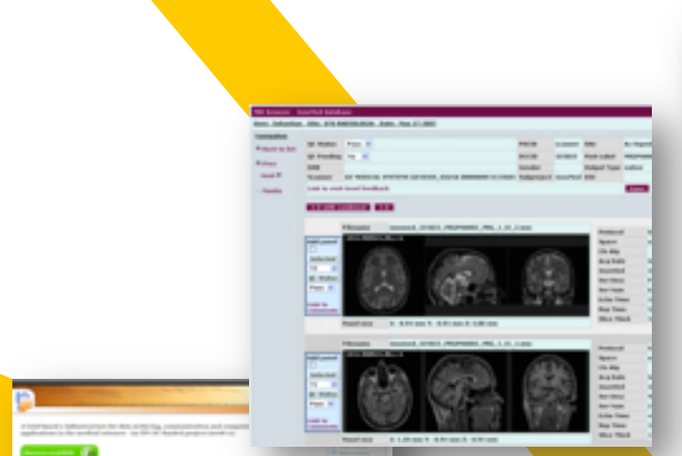


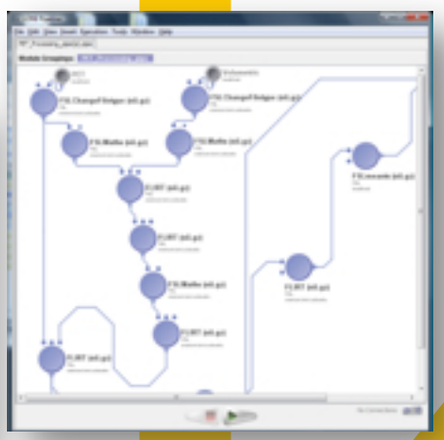
Infrastructures

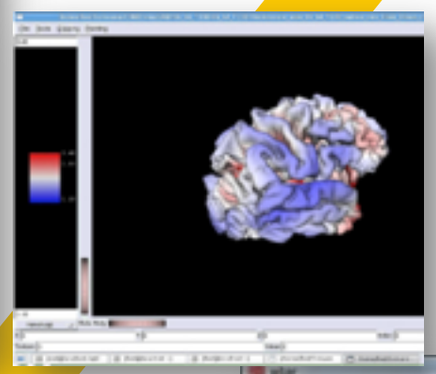
Continental Access for Communities

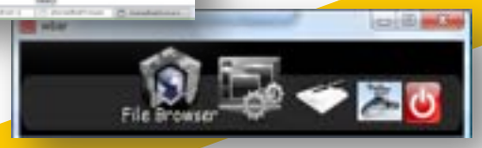


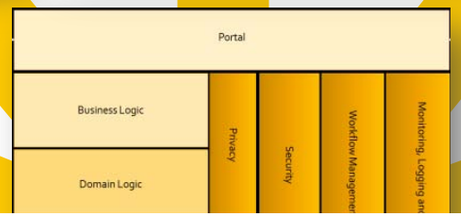
Grand Vision







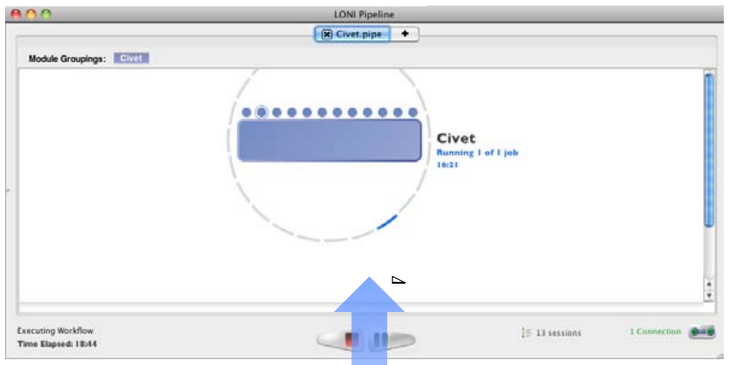




outGRID

outGRID – GBRAIN

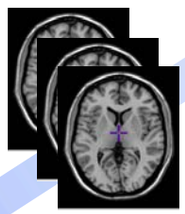
(EGI Tech Forums 2011, Lyon: Best live demonstration)

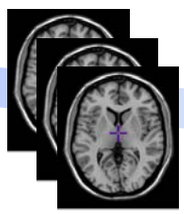


LONI Client:

- NeuGrid Module
- CBRAIN Module
- LONI Module

LONI Servers





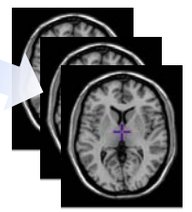
France

CIVET
One HPC

WS CBRAIN

Canada

CIVET – Freesurfer
on CBRAIN Cloud

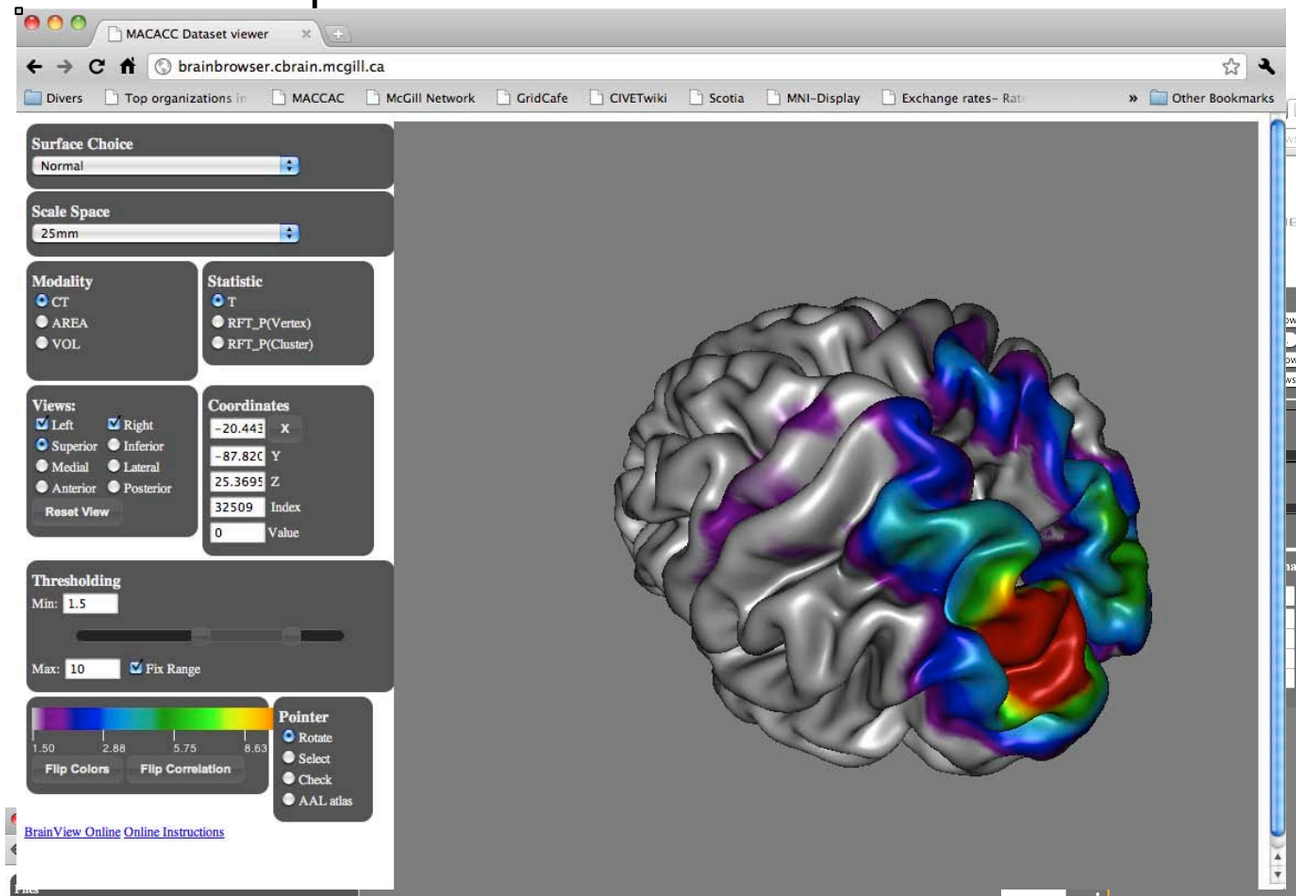


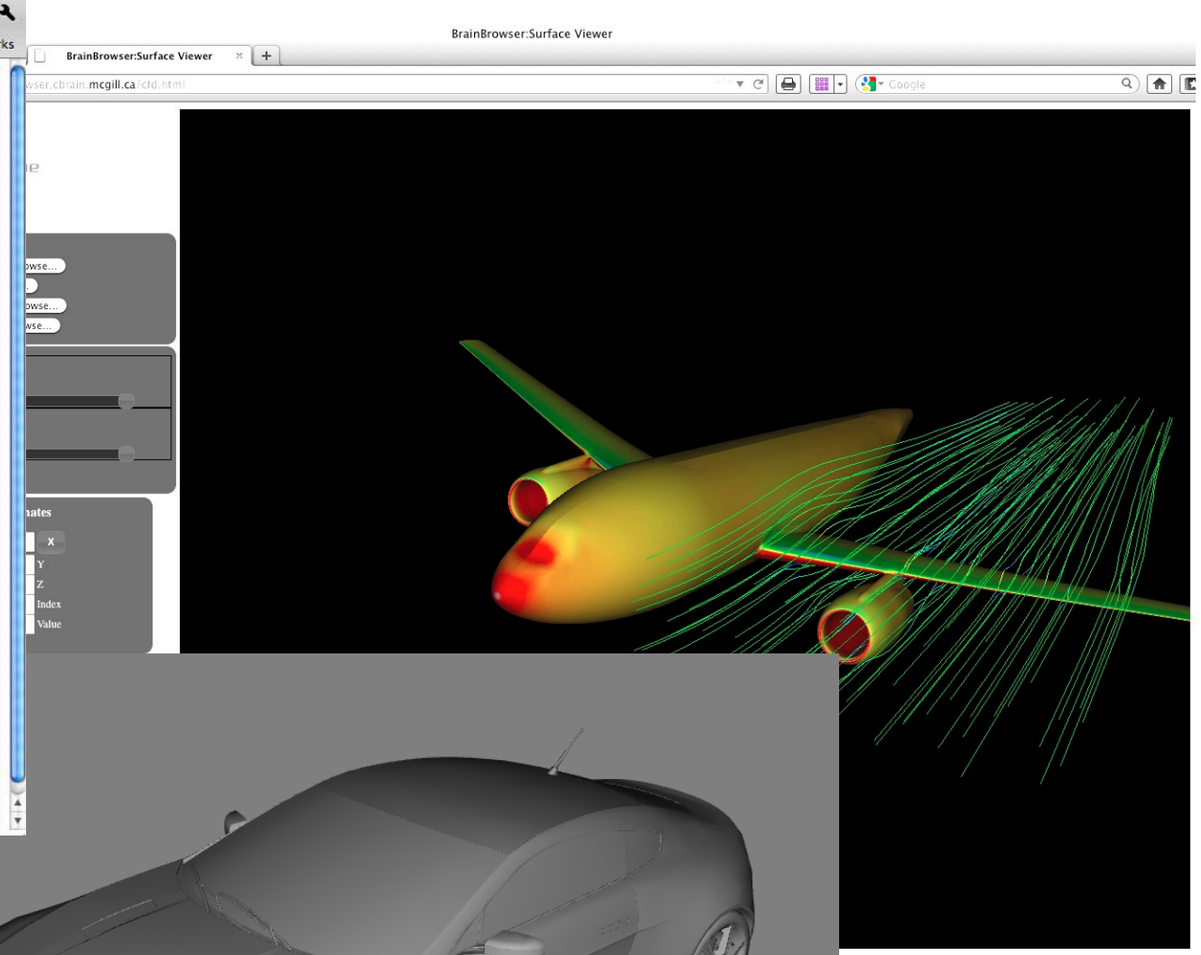
USA

Freesurfer
One HPC

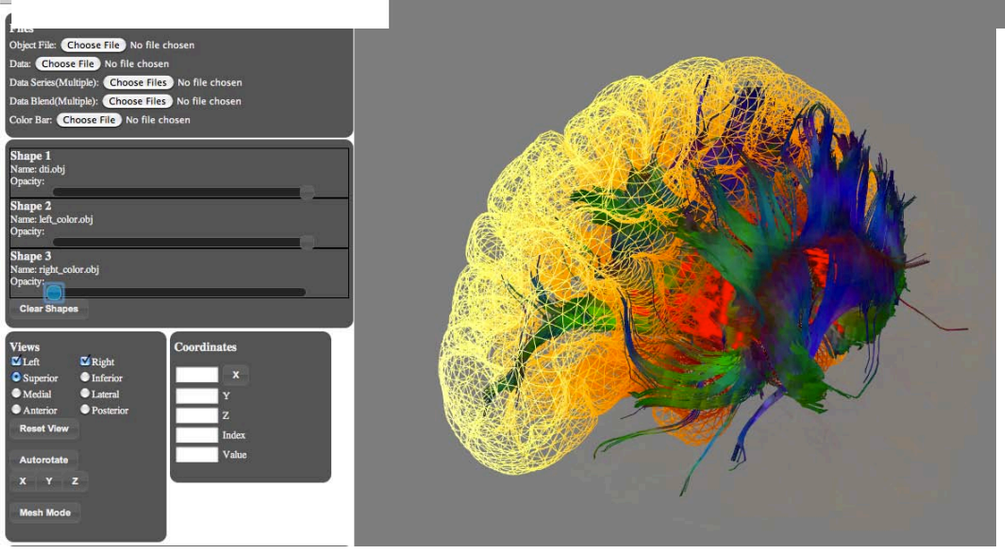
BrainBrowser – Web3D
Planes, brains and automobiles

MACCAC Maps

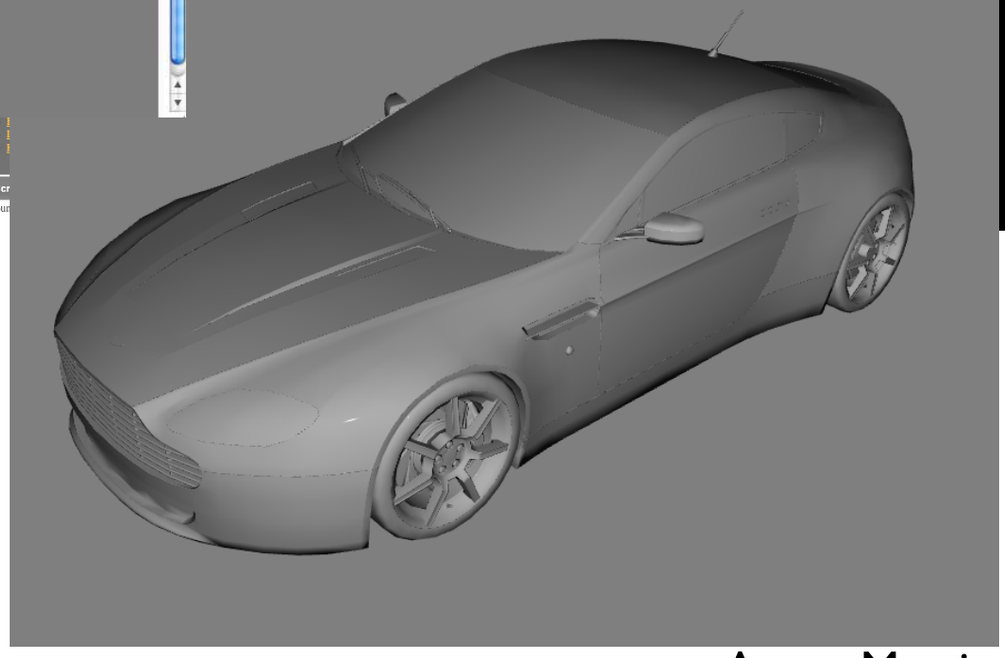




DLR-F6 Model



Mesh and Fibertracks



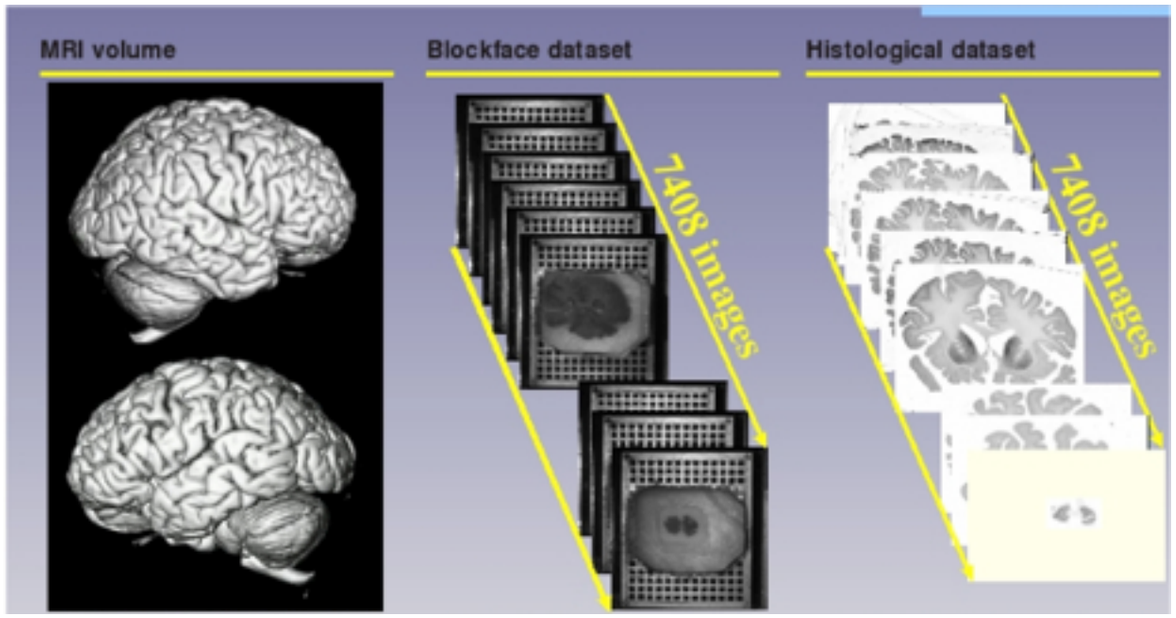
Aston Martin

McGill

Big Brains

- Drs. Zilles & Amunts -

Post-Mortem High-Resolution Histology



Julich, Germany. Dr. Karl Ziles

- 1TB of data per brain
- 7408 Slices
- 11500x8800 pixels

- Animal studies will generate a few dozens per year

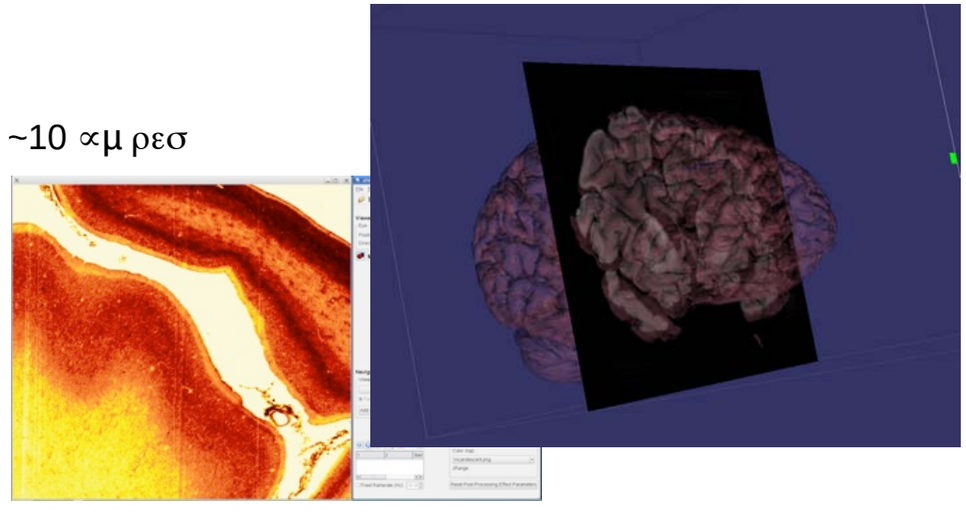
- Rip & Tear correction
  ~5000 CPU hours

- Non-linear slice alignment, 50 iterations
  ~370,000 CPU hours

- Conversion: 1TB 3D data structure
  HPC ~160 CPU hours

- Full brain view

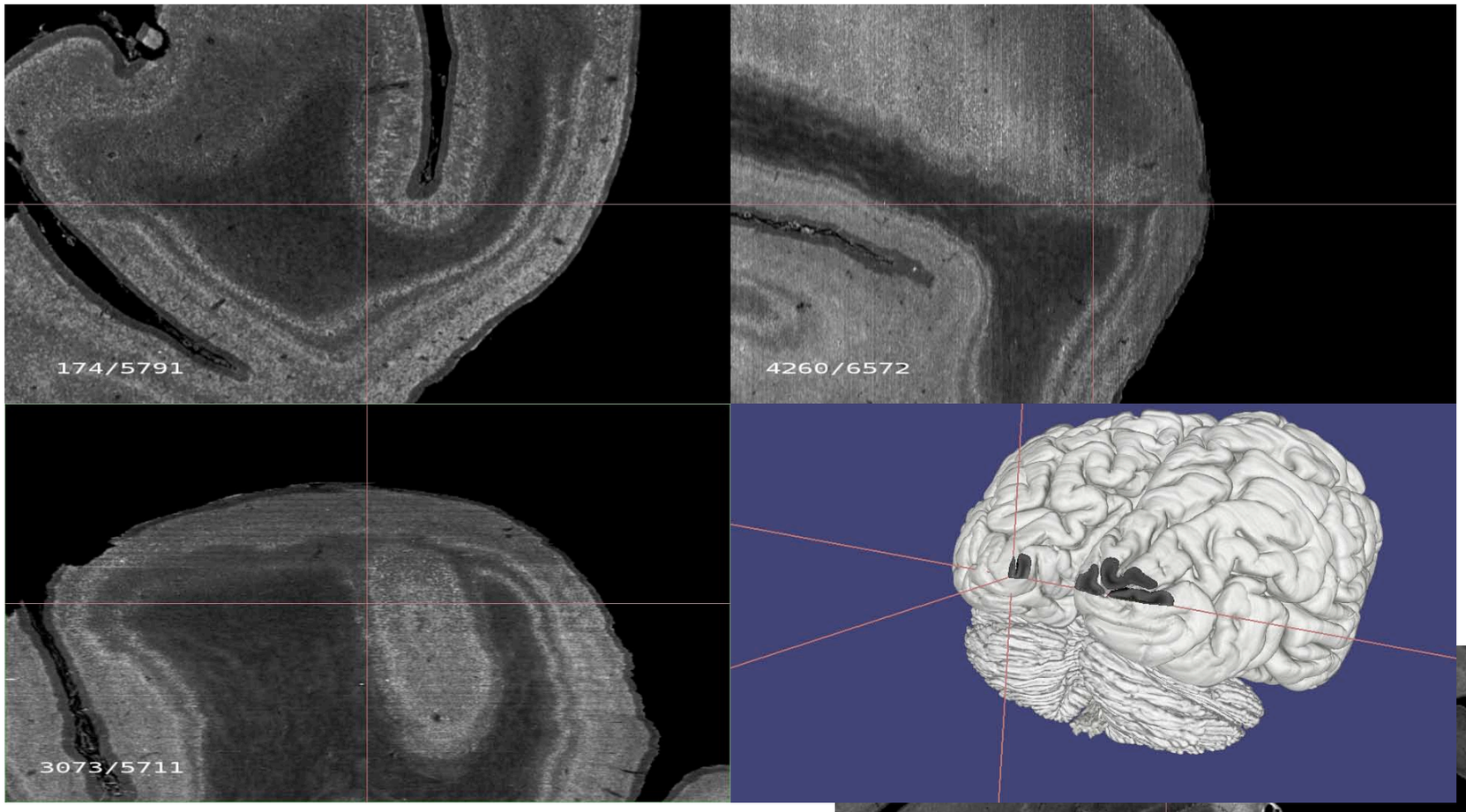
~10 ∝μ ρεσ



Goal: Collaborative, Real-Time 3D Visualization

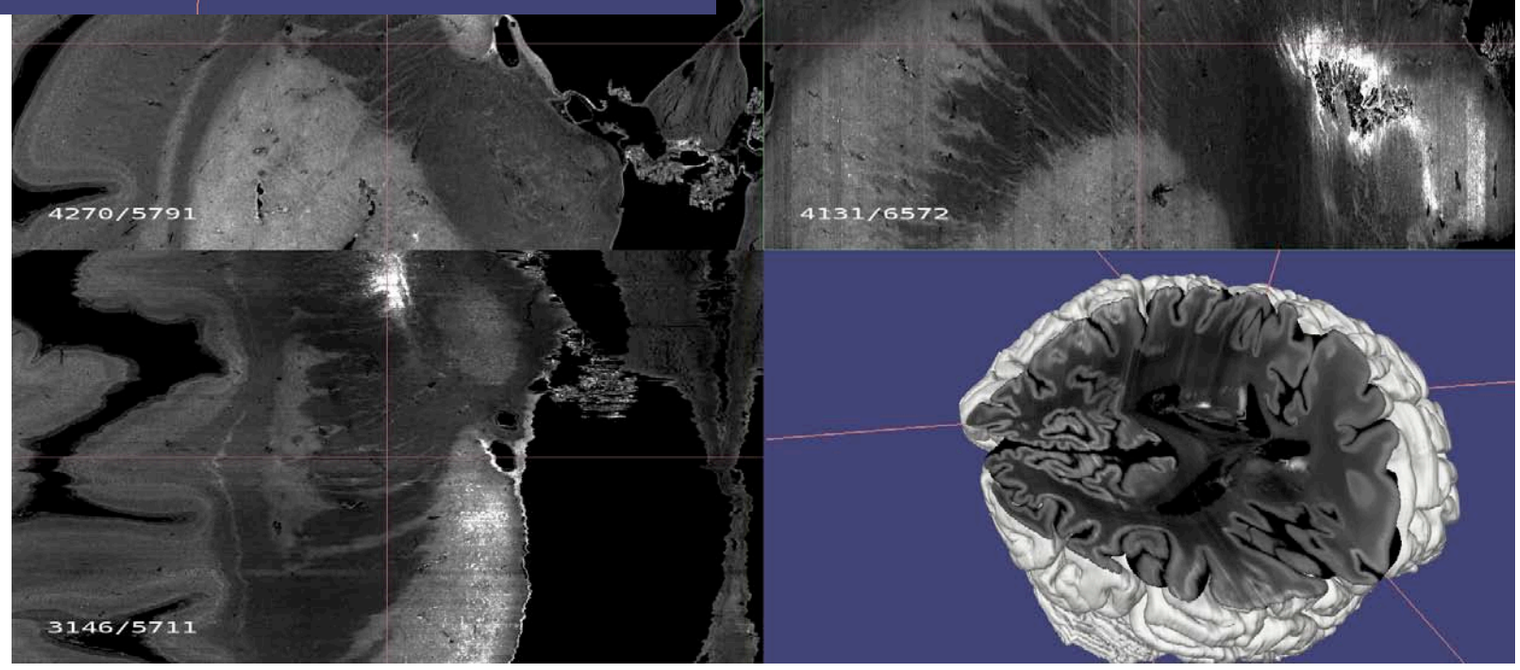
Big Brains – Atelier3D

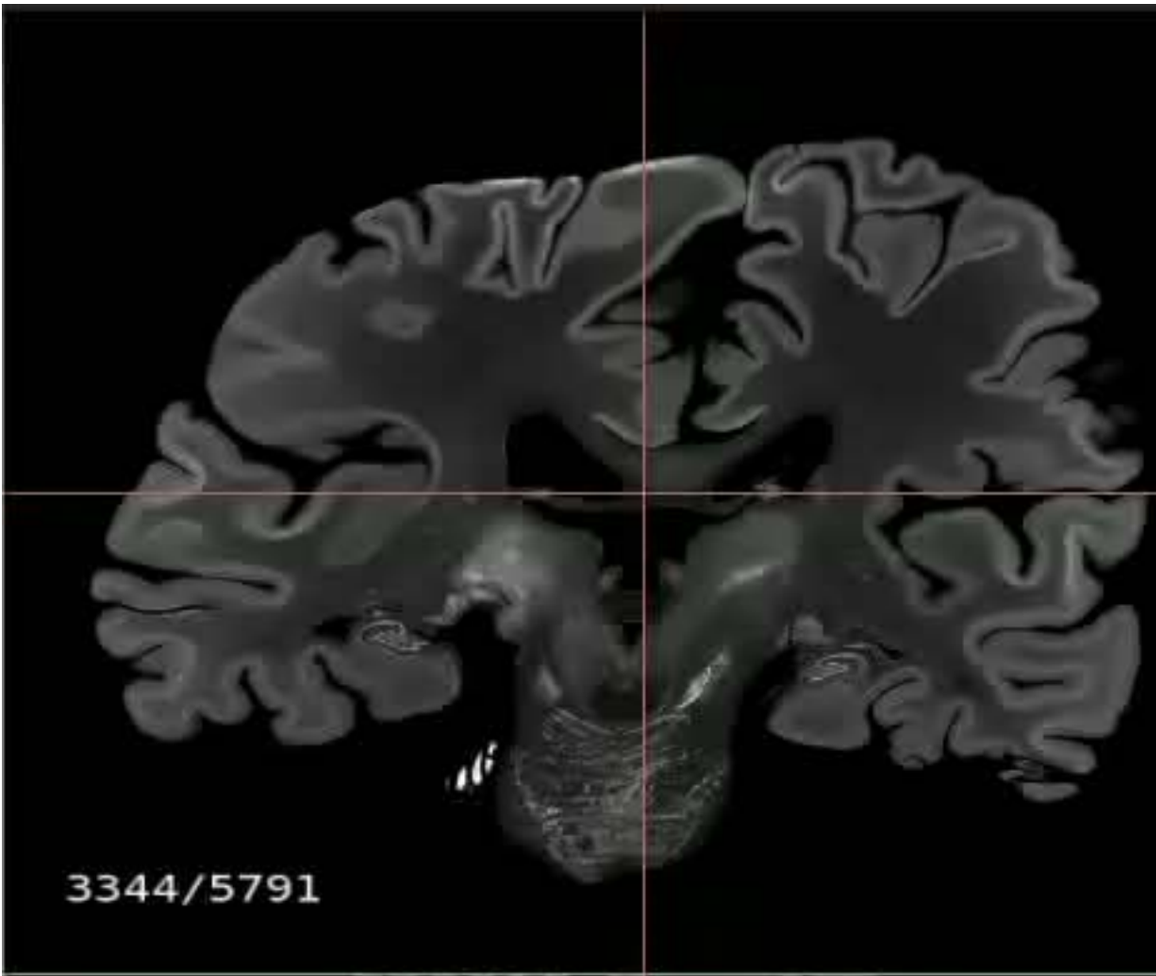
Histology – Neuroimaging – HPC – Modeling/Visualisation



Atelier3D

VIT - NRC

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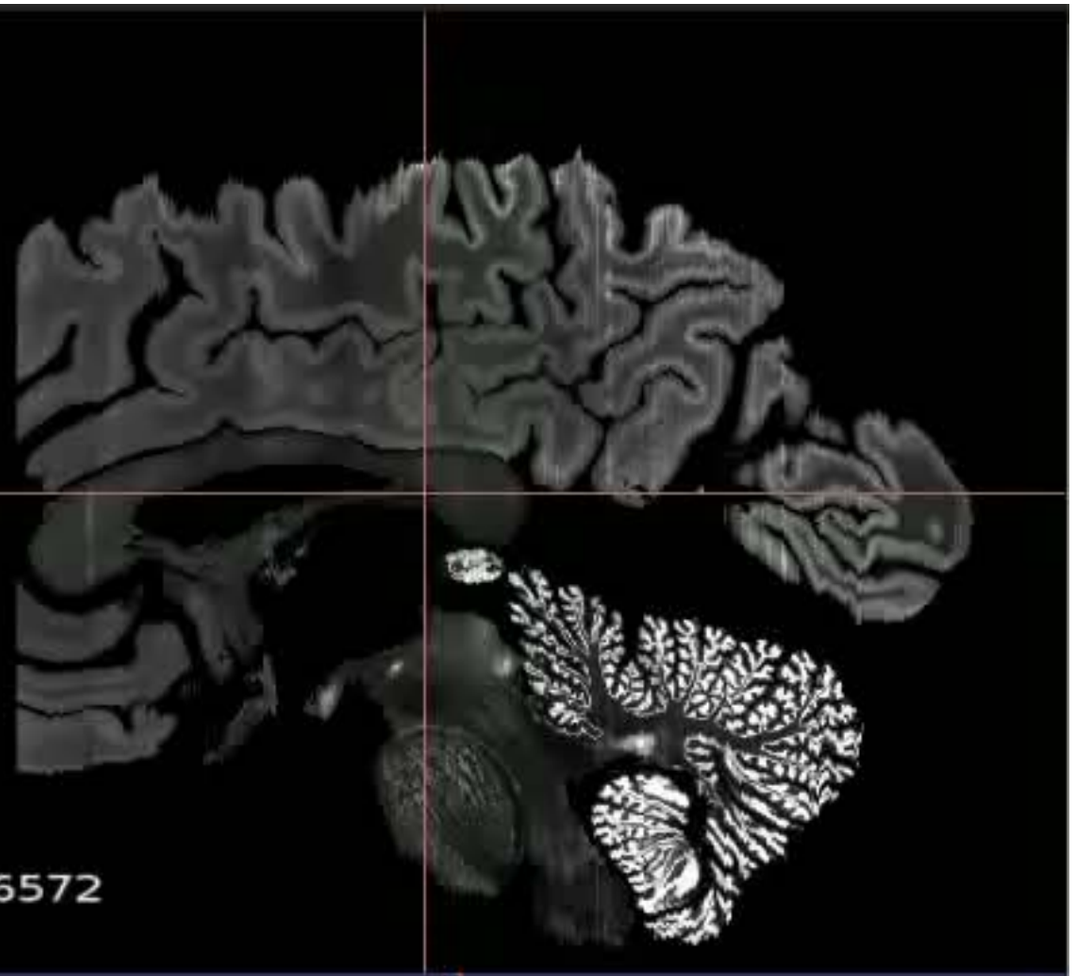
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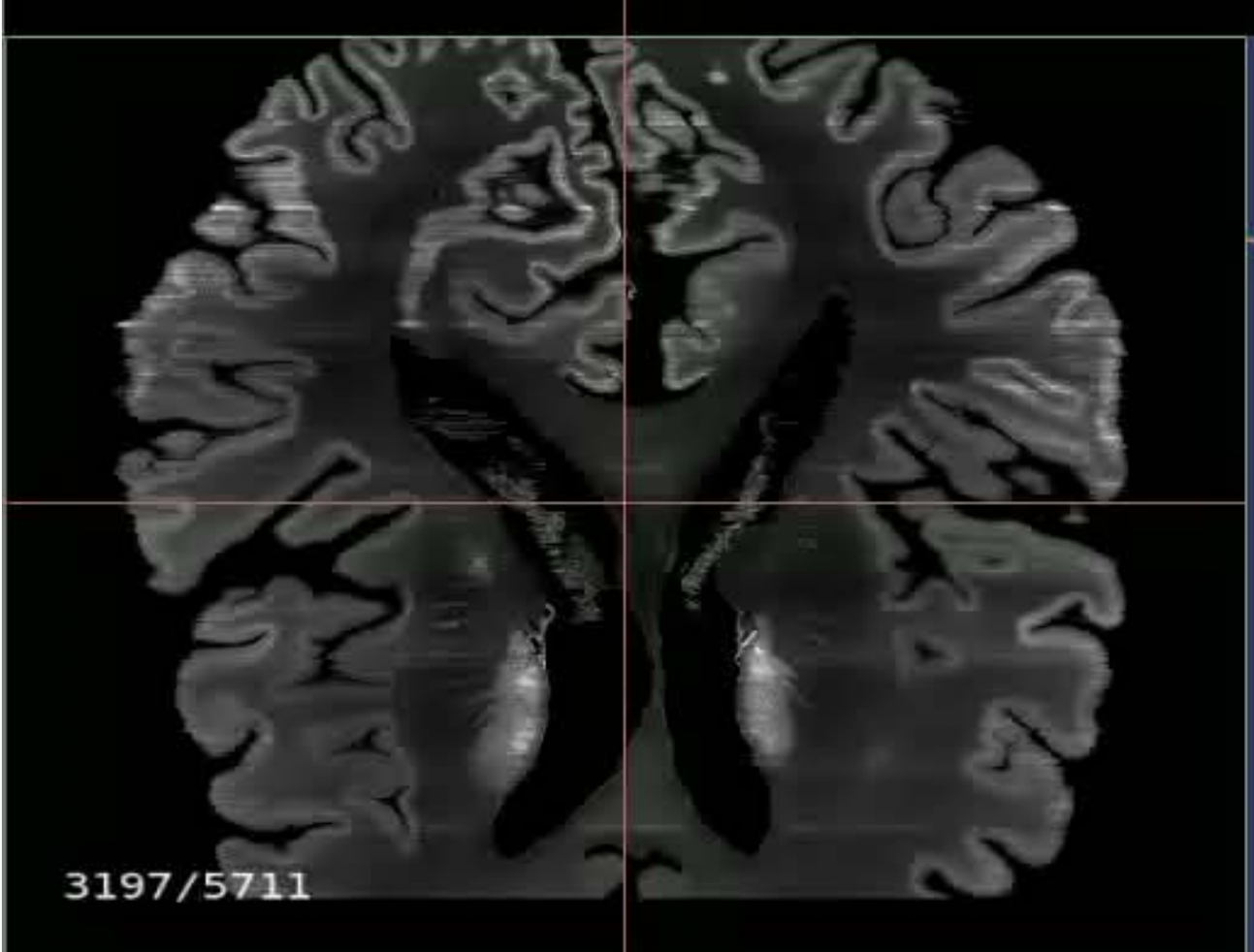
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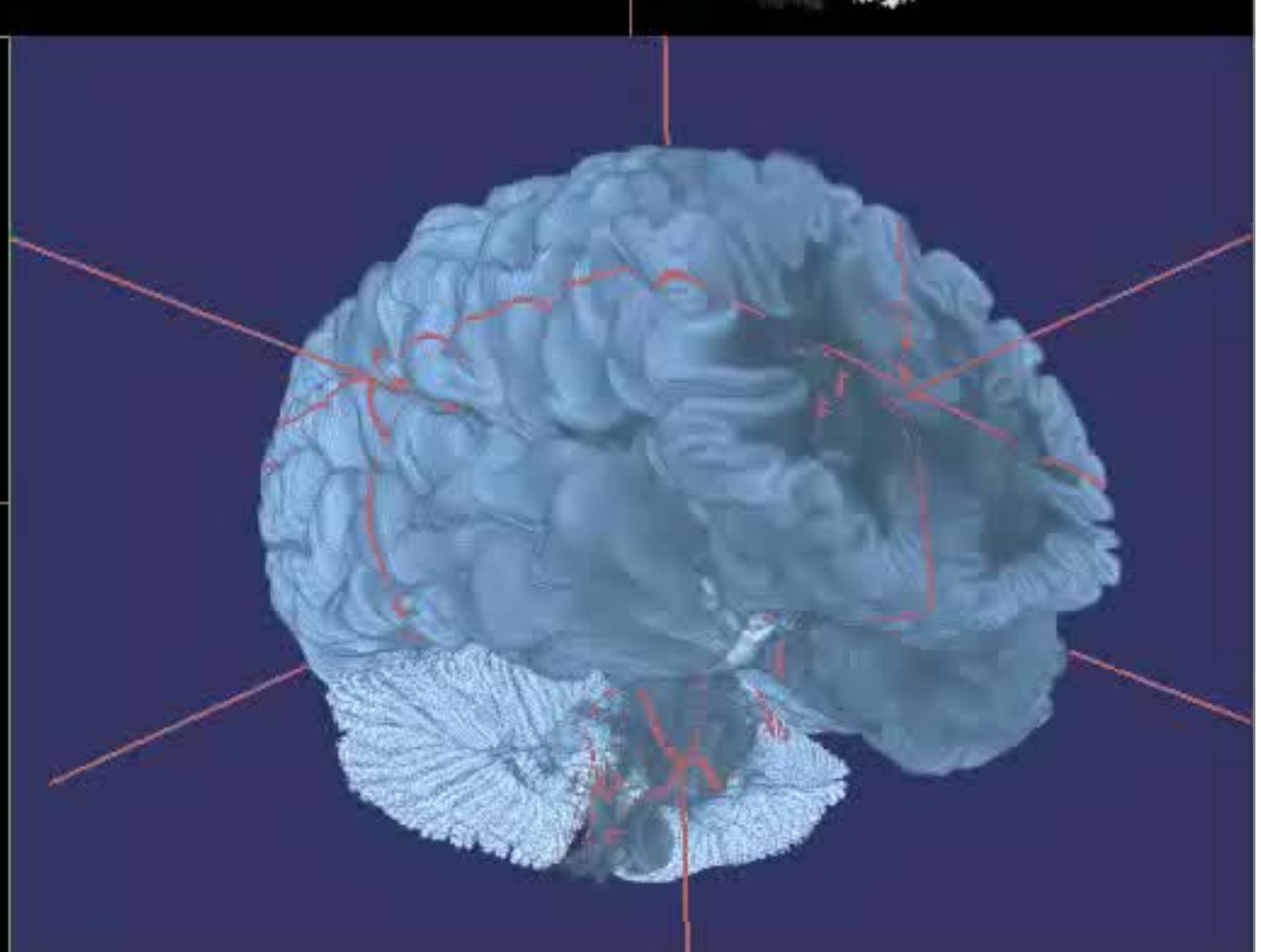
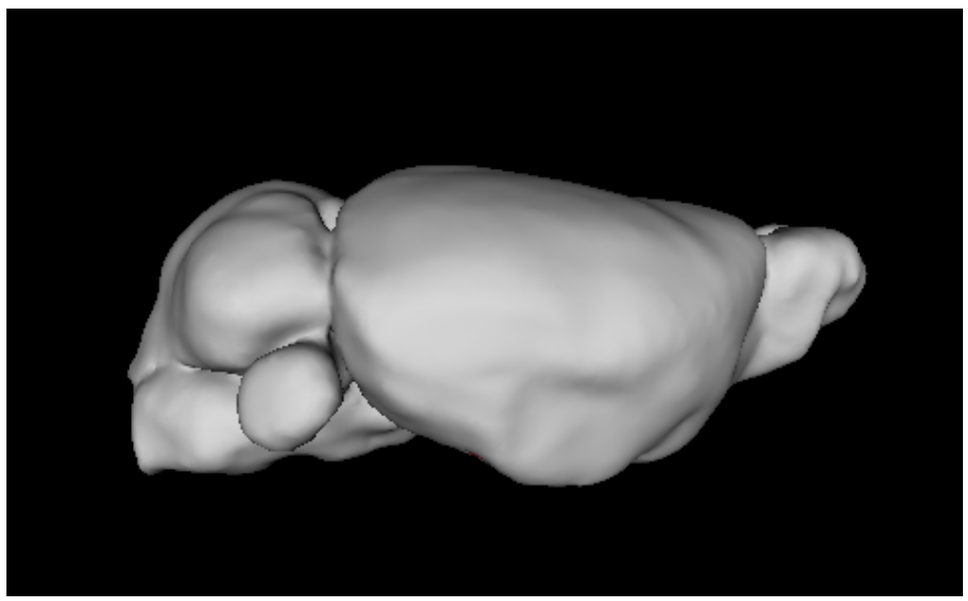
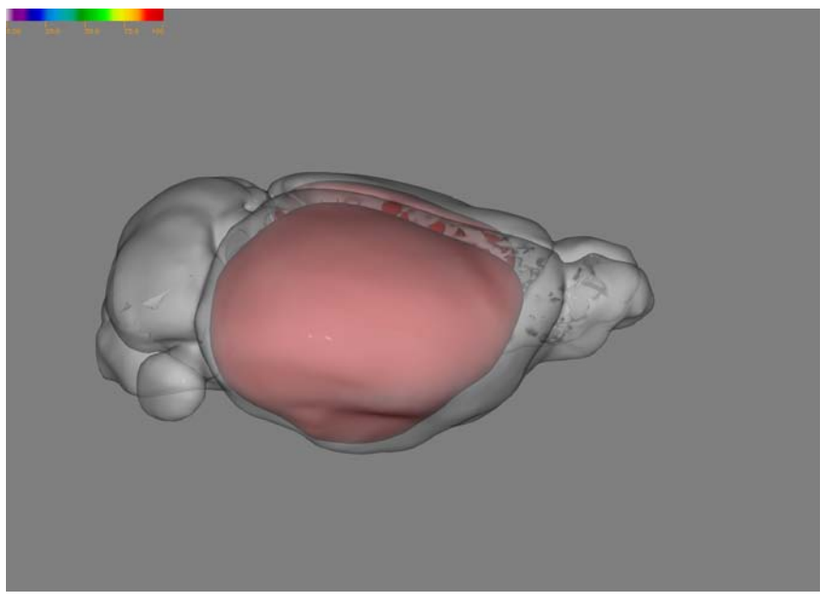


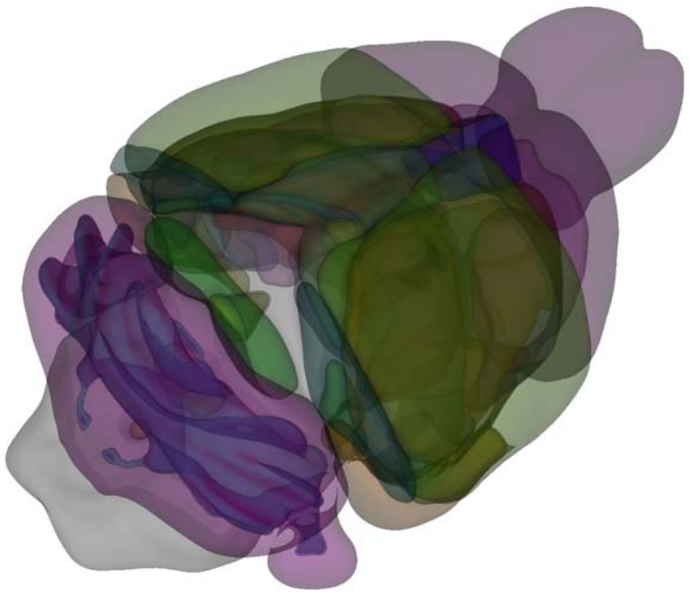
Large Animal Datasets (Dr. Bedell)

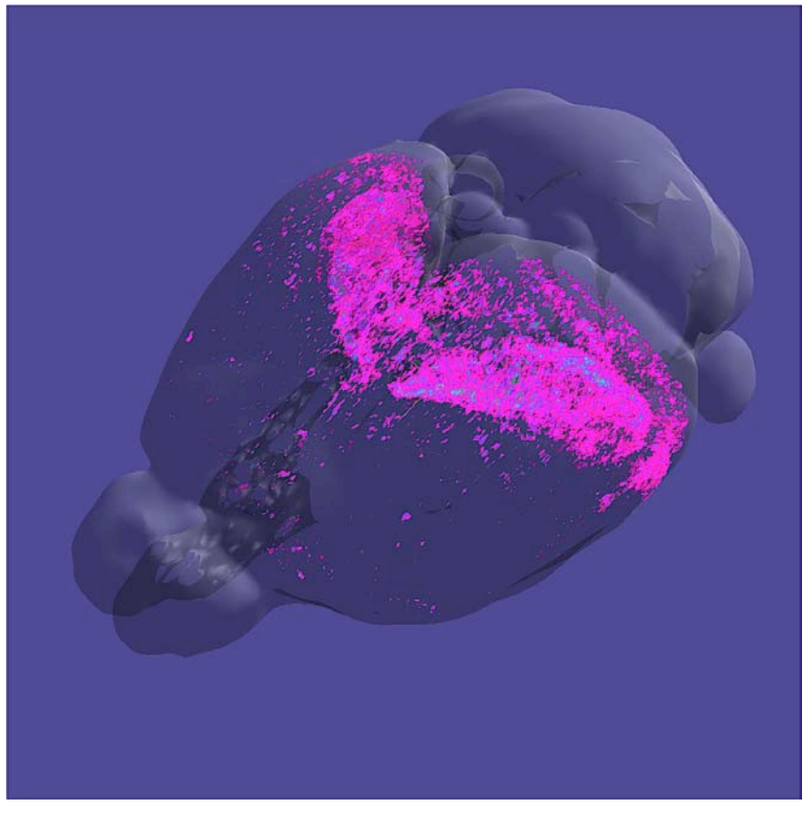
CBRAIN
BrainBrowser





Atelier 3D

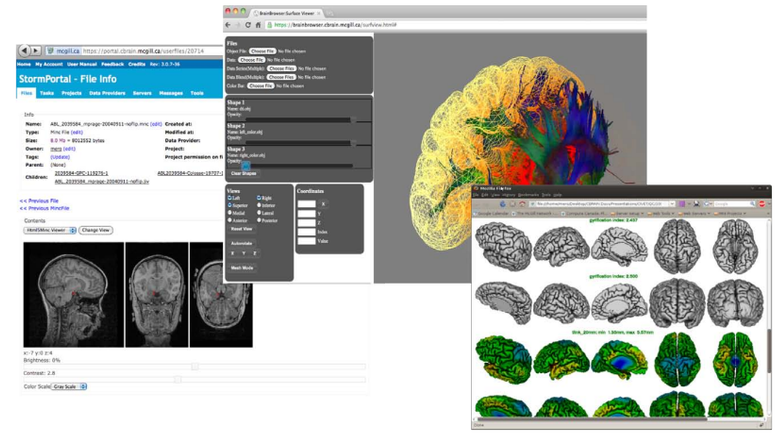


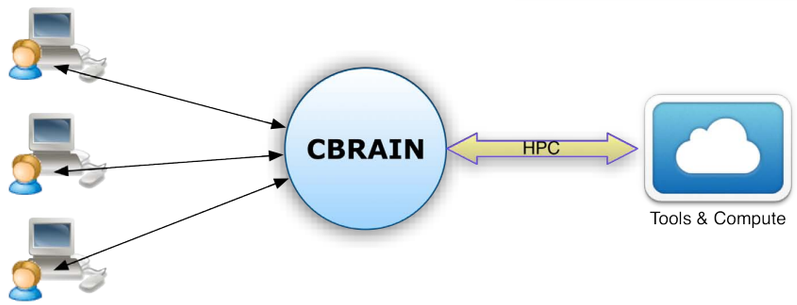


What can CBRAIN do for you?

Typical Usage

- Access to pre-installed tools, converters, pipelines.
- Access to large amounts of compute power (project speedup).
- Long distance collaborations / data sharing.
- Web based visualisations.
- Do things you could not easily do before!





Illustrative Performance Comparison

NIH-Pediatric-Obj1: up to 3 visits per subject

866 CIVET pipeline runs to generate cortical thickness maps
Input: 866 x 3 x 5Mb = 15Gb
Output: 866 x 250 Mb = 211Gb

Cluster	Total CPU-hrs	Maximum Performance		Typical Performance	
		# cores	Execution time	# cores	Execution time
mammouth-ms2 (RQCHP -Sherbrooke)	866 x 4 = 3464	~500	3hr	176	17hr
CLUMEQ-Krylov (McGill)	866 x 6 = 5196	~90	2.5d	24	9d
BIC (MNI)	866 x 8 = 6928	~100	3d	40	7d

In general, studies which use to takes 1 week to 1 month now take 1 day.

McGill

Available Tools

Based on Community requests!

Come talk to us, we will see what we can do.

CIVET

NIAK (Dr. Bellec)

FSL (some tools)

Minc tools (some tools)

FreeSurfer recon-all

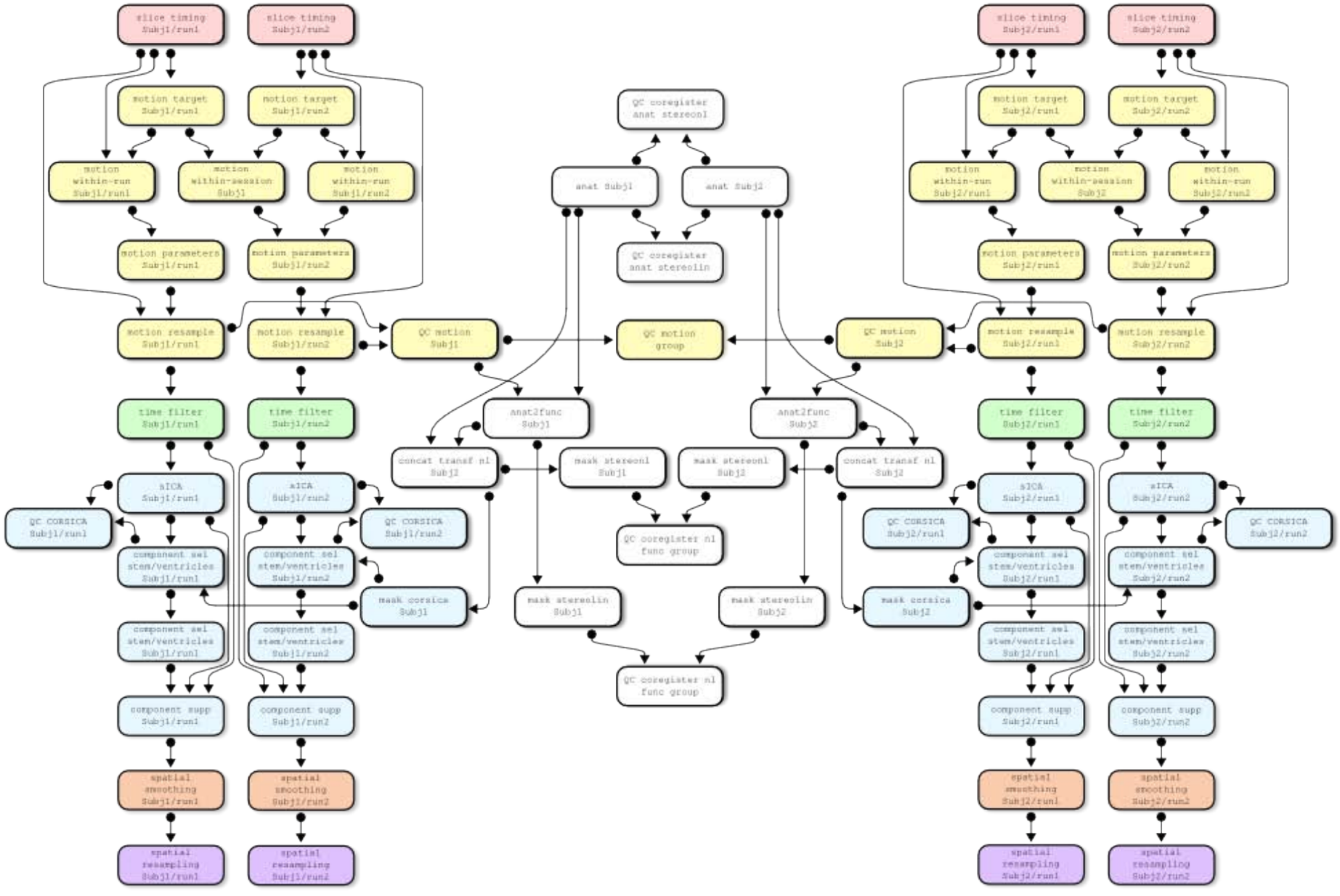
SPM Batch

Format conversion (minc, nifty, dicom, analyze…)

Cw5

Can the tools be complex?

Dynamic Flowchart for fMRI pre-processing (NIAK) – 2 subjects



A Few CBRAIN Related Publications

NeuroImage

Volume 55, Issue 2, 15 March 2011, Pages 462–467

Patterns of cortical thickness and surface area in early Parkinson's disease

Thomas Jubault[a, b], Jean-François Ga
C. Evans[d], Oury Monchi[a, b]

[a] Unité de Neuroimagerie Fonctionelle, Institut U
[b] Département de Radiologie, Université de Mor
[c] Département de Psychologie, Université du Qu
[d] McConnell Brain Imaging Centre, McGill Unive
[e] Montreal Neurological Institute, McGill Universi
[f] Movement Disorders Unit, McGill University He

Received 20 August 2010. Revised 30 Novembe

http://dx.doi.org/10.1016/j.neuroimage.2010.12.(

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Integration of a neuroimaging processing pipeline into a pan-canadian computing grid

S. Lavoie-Courchesne[1,2,3], P. Rioux[3], F. Cl
T. Sherif[3], M.-E. Rousseau[3], S. Das[3], R. A
C. Craddock[4,8], D. Margulies[5,8], C. Chu[6,8
A. C. Evans[3], P. Bellec[1,2,8]

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[6]Section of Functional Imaging Methods, Laboratory of
Bethesda, USA
[7]Mind, Brain Imaging and Neuroethics Unit, Institute of
Ottawa Health Care Group, University of Ottawa, Ottaw
[8]The Neurobureau Research Institute, Chicago, USA

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Abstract. The ethos of the neuroimaging field is quickl resources, including both imaging databases and processi represents a large volume of datasets and as neuroimagin heterogeneous, computationally intensive tools, such oper challenges. This motivates the design of novel dedica describe here an interface between PSOM, a code-oriented CBRAIN, a web-oriented platform for grid computing. a PSOM-compliant pipeline for preprocessing of structur imaging into CBRAIN. We also showed the capacity of thi database by processing close to 1000 subjects released a This pilot experiment demonstrates the feasibility of our computing solution for high-throughput processing in the

1. Introduction

With most modern scientific projects relying heavily on compute research software prototypes is of central importance at the very of published results by independent research groups [1]. I dissemination raises a number of domain-specific computationa

(i) **Complex multi-stage processing.** Neuroimaging data number of preprocessing steps before a scientifically mean These steps can include such operations as non-linear real

JPCS 2011 – HPCS 2011

FOCUS ON NEUROINFORMATICS

Virtual imaging laboratories for marker discovery in neurodegenerative diseases

Giovanni B. Frisoni, Alberto Redolfi, David Manset, Marc-Étienne Rousseau, Arthur Toga and Alan C. Evans

Abstract | The unprecedented growth, availability and accessibility of imaging data from people with neurodegenerative conditions has led to the development of computational infrastructures, which offer scientists access to large image databases and e-Science services such as sophisticated image analys algorithm pipelines and powerful computational resources, as well as three-dimensional visualization ar statistical tools. Scientific e-infrastructures have been and are being developed in Europe and North Am that offer a suite of services for computational neuroscientists. The convergence of these initiatives represents a worldwide infrastructure that will constitute a global virtual imaging laboratory. This will pr computational neuroscientists with a virtual space that is accessible through an ordinary web browser, image data sets and related clinical variables, algorithm pipelines, computational resources, and statis and visualization tools will be transparently accessible to users irrespective of their physical location. S an experimental environment will be instrumental to the success of ambitious scientific initiatives with societal impact, such as the prevention of Alzheimer disease. In this article, we provide an overview of t currently available e-infrastructures and consider how computational neuroscience in neurodegenerativ disease might evolve in the future.

Frisoni, G. B. *et al. Nat. Rev. Neurol.* 7, 429–438 (2011); published online 5 July 2011; doi:10.1038/nrneurol.2011.99

Introduction

Research in neurodegenerative diseases is undergoing a radical transformation brought about by extraordinary growth in the volume, availability and accessibility of clinical and research imaging data, both in the form of public releases and within virtual research organizations. Traditional neuroimaging research typically involved small to mid-sized locally collected data sets ranging from dozens to hundreds of scans. Only a few imaging laboratories have the technical expertise and computational resources required to merge multiple large data sets and explore scientific questions relating to larger populations. Not only do neuroscientists face a steep learning curve to grasp their own particular computing ecosystem, in terms of operating system environment, basic scripting, programming, remote data transfers and remote computing, but also, because of divergence in the basic information technology (IT) setup, the principles of one ecosystem often do not adapt well to other laboratories. The commonplace replication and idiosyncrasies of toolsets and infrastructures among many sites greatly increases the complexity and overheads for neuroimaging projects, leading to issues such as the need to locally support IT-related technical staff, and difficulties in coordinating multisite studies.

Open access to large data sets, pioneered in genetics and physical sciences, has been implemented successfully by various initiatives in the neuroimaging field, such as the Alzheimer's Disease Neuroimaging Initiative (A and the NIH Pediatric Database (NIHPD).[2] Sinc all researchers who subscribe to these databases ha able to obtain full access to images and clinical dat people with varying degrees of cognitive deteriorati were originally collected to identify biomarkers of initiation and progression.[3,4] Currently, a number to very large data sets can be found in the public d and freely downloaded, such as the 1000 Func Connectomes Project,[5] the Human Imaging Da (HID),[6] the Open Access Series of Imaging S (OASIS),[7] the Bipolar Disorder Neuroimaging Da (BiND),[8] Multisite Imaging Research In the Ana Depression (MIRIAD),[9] and Efficient Longitudinal of Depression in the Elderly (ELUDE).[10]

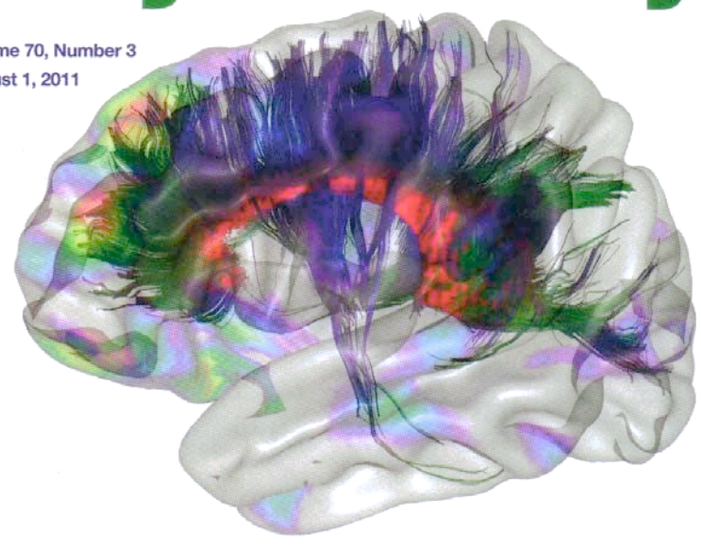
The gap between the pace of data generation a capability to extract clinically or scientifically r information is rapidly widening. Sophisticated algo are available, and more are being developed, that al extraction of biologically relevant markers from and clinical data requiring heavy computatio instance, the extraction of the three-dimensional thickness map, a marker of neurodegeneration, high-resolution structural MRI scan can take b 30 min and 22 h per scan on a single-core comput extraction of functional connectivity networks c 20–120 min. At present, relatively few imaging labo worldwide have the expertise and resources re for such sophisticated high-throughput comput

Competing interests
The authors declare no competing interests.

Nature reviews. Neurology, 2011 Jul 07; 7(8):429-38

Biological Psychiatry

Volume 70, Number 3
August 1, 2011



Genotype, Circuits, and Cognition in Autism and Attention-Deficit/Hyperactivity Disorder

ISSN 0006-3223
www.sobp.org/journal
Official Journal of the Society of Biological Psychiatry

Selected Conferences and Press

SIGGRAPH 2011, Vancouver, Canada, Bird of a Feather: WebGL session, Invited Speaker, **BrainBrowser**.

EGI User Forum 2011, Vilnius, Lithuania, Invited Speaker, **GBRAIN Project (a CANARIE NEP Project)**.

MICCAI 2011 Workshop High Performance and Distributed Computing for Medical Imaging, Toronto, Canada, Invited Speaker, The CBRAIN Neuroimaging Platform.

Canadian Research Data Summit 2011, Invited Speaker. Dialogue on developing a common vision. Ottawa, Canada, The CBRAIN Neuroimaging Platform.

HPCS 2011, Montreal, Canada, Invited Speaker, **CBRAIN: Canadian Neuroinformatics Platform**.

Best Poster at HPCS 2011, Montreal, Canada. Sébastien Lavoie-Courchesne, P. Rioux, T. Sherif. S. Das, N. Kassis, J. Doyon, R. Adalat, M.E. Rousseau, A.C. Evans, P. Bellec, Integration of a neuroimaging pipeline prototype into a pan-canadian computing grid.

Best Live Demonstration at EGI Technical Forums 2011, Lyon, France.
http://gridtalk-project.blogspot.com/2011/09/win-win-win.html and article http://www.isgtw.org/visualization/hat-trick-alzheimer%E2%80%99s-grand-challenge

Rapport Annuel RISQ 2009-2010: Le Project CBRAIN

Colloque RISQ 2009: Highest Satisfaction level (from public vote)

CBRAIN technologies produced a cover page for Ducharme & al in **Biological Psychiatry** (see Publication: Biol Psychiatry. 2011 Aug 1;70(3):283-90. Epub 2011 Apr 30.)

Gigabits on the Brain. Ottawa Citizen, Business Frontpage.
http://www.ottawacitizen.com/business/Gigabits+brain/3691533/story.html

CANARIE opens the “ultra-fast lane”. Telemanagement.
http://www.tele-management.ca/content/23481-canarie_opens_the_%E2%80%9Cultra_fast_lane%E2%80%9D

OGF-28 Sessions 2010, Munich GER, Invited Speaker. CBRAIN/GBRAIN Projects.

Selected 2011 Publications

Frisoni G. B., Redolfi A., Manset D., Rousseau M. E., Toga A., Evans A. C. **Virtual imaging laboratories for marker discovery in neurodegenerative diseases.** Nature reviews. Neurology, 2011 Jul 07; 7(8):429-38

Ducharme S, Hudziak JJ, Botteron KN, Ganjavi H, Lepage C, Collins DL, Albaugh MD, Evans AC, Karama S; Brain Development Cooperative Group. **Right anterior cingulate cortical thickness and bilateral striatal volume correlate with child behavior checklist aggressive behavior scores in healthy children.** Biol Psychiatry. 2011 Aug 1;70(3):283-90. Epub 2011 Apr 30.

Lavoie-Courchesne, S. Rioux P., Chouinard-Decorte P., Sherif T., Rousseau M.-E., Das S., Adalat R., Doyon J., Craddock C., Margulies D., Chu C., Lyttelton C., Evans A.C., Bellec P. **Integration of a neuroimaging processing pipeline into a pan-canadian computing grid.** Journal of Physics: Conference Series HPCS 2011**, accepted.**

Gong G, He Y, Chen ZJ, Evans AC. **Convergence and divergence of thickness correlations with diffusion connections across the human cerebral cortex.** Neuroimage. 2011 Aug 22. [Epub ahead of print]

Gong G, He Y, Evans AC**. Brain connectivity: gender makes a difference.** Neuroscientist. 2011 Oct;17(5):575-91. Epub 2011 Apr 28.

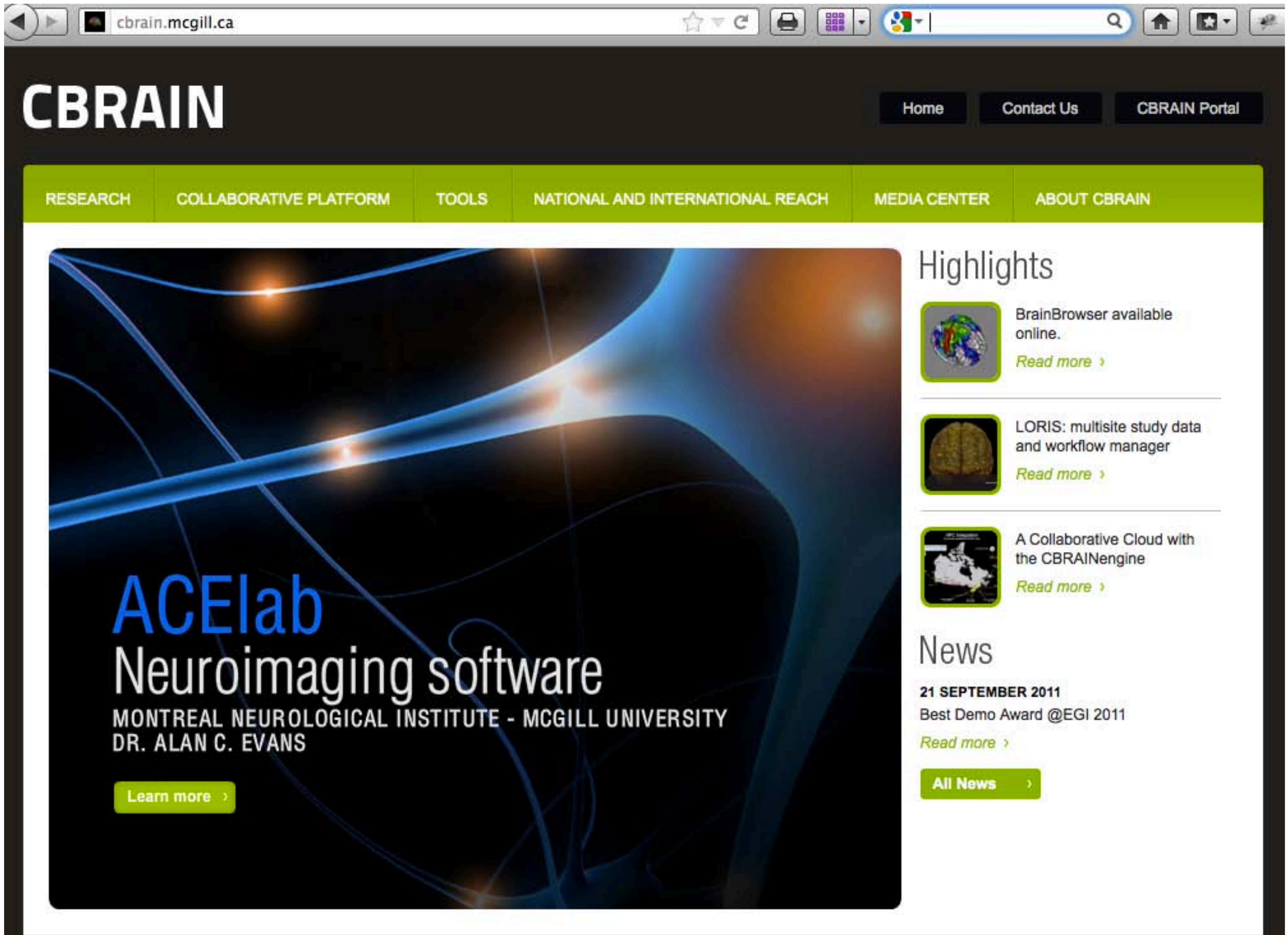
Ganjavi H, Lewis JD, Bellec P, MacDonald PA, Waber DP, Evans AC, Karama S; Brain Development Cooperative Group. **Negative associations between corpus callosum midsagittal area and IQ in a representative sample of healthy children and adolescents.** PLoS One. 2011;6(5):e19698. Epub 2011 May 19.

Operation and Support

- Compute Canada Support (3.7M hours for 2012)
- Creation of a Center for Neuroinformatics
- CFI Application
    - 5 PB Datacenter, part of Compute Canada environment
    - Obtained Server Room support for 5 years from McGill
    - Obtained Compute Canada and CLUMEQ-ETS support
- Partner Projects
    - Small contracts to support specific CBRAIN projects (Julich, outGRID…)
- CANARIE & Compute Canada next round (in 2012
    - National Research Platform Initiative.

Can I get access?
Can I get involved?

cbrain.mcgill.ca



Contact Our Team

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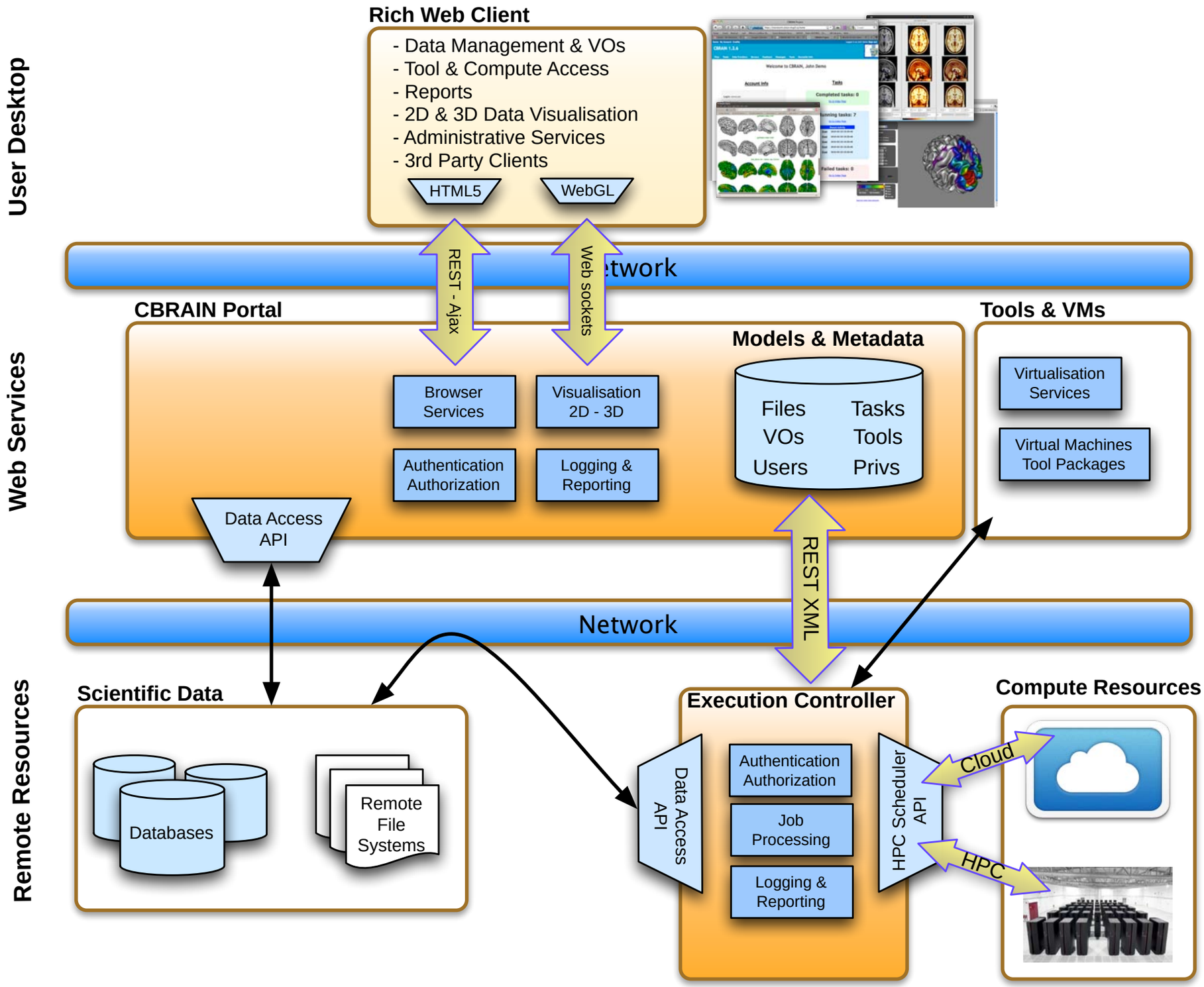
Project Manager:

Reza Adalat – reza.adalat@mcgill.ca

CBRAIN Architecture



CBRAIN Project Team & Partners

Alan Evans

Reza Adalat

Pierre Rioux

Tarek Sherif

Nicolas Kassis

Natacha Beck

Tien Duc Nguyen

Claude Lepage

Louis Borgeat (NRC)

Lindsay Lewis

Hartmut Molhberg, Timo Dickscheid (Drs. Zilles – Amunts)

All ACE Lab members

Mathieu Desrosiers (UdeM)

Pierre Bellec (UdeM)

Sébastien Courchenes-Lavoie (UdeM)

Participating Research Centers

Montreal Neurological Institute, McGill University (Lead)
Principal Investigator: Alan Evans
Program Manager: Reza Adalat
System Architect: Marc Rousseau
Developers: Pierre Rioux, Tarek Sherif, Angela McCloskey, Samir Das, David Brownlee
McGill Office of Technology Transfer (OTT): Francoys Labonte
Canada National Research Council: Louis Borgeat
Consultants: Rosanne Aleong, Claude Lepage, Pierre Bellec, Andrew Janki, Robert Vincent

Rotman Research Institute, University of Toronto
Principal Investigators: Stephen Strother and Randy MacIntosh
Developers: Anda Pacurar, Anita Oder, Jacques Waller

Robarts Research Institute, University of Western Ontario
Principal Investigators: Ravi Menon and Mel Goodale
Developers: Martyn Klassen, Ronghai Tu

Unité de Neuroimagerie Fonctionnelle, Université de Montréal
Principal Investigators: Julien Doyon and Rick Hoge
Developer: Mathieu Desrosiers

Division of Neurology, University of British Colombia
Principal Investigators: Jon Stoessl and Max Cynader
Developers: Ryan Thomson, Nasim Vafai

CBRAIN acknowledges the contributions of IBM Canad Jonathan Harlap and Sebastian Muehlboeck.

canarie

Contact Our Team

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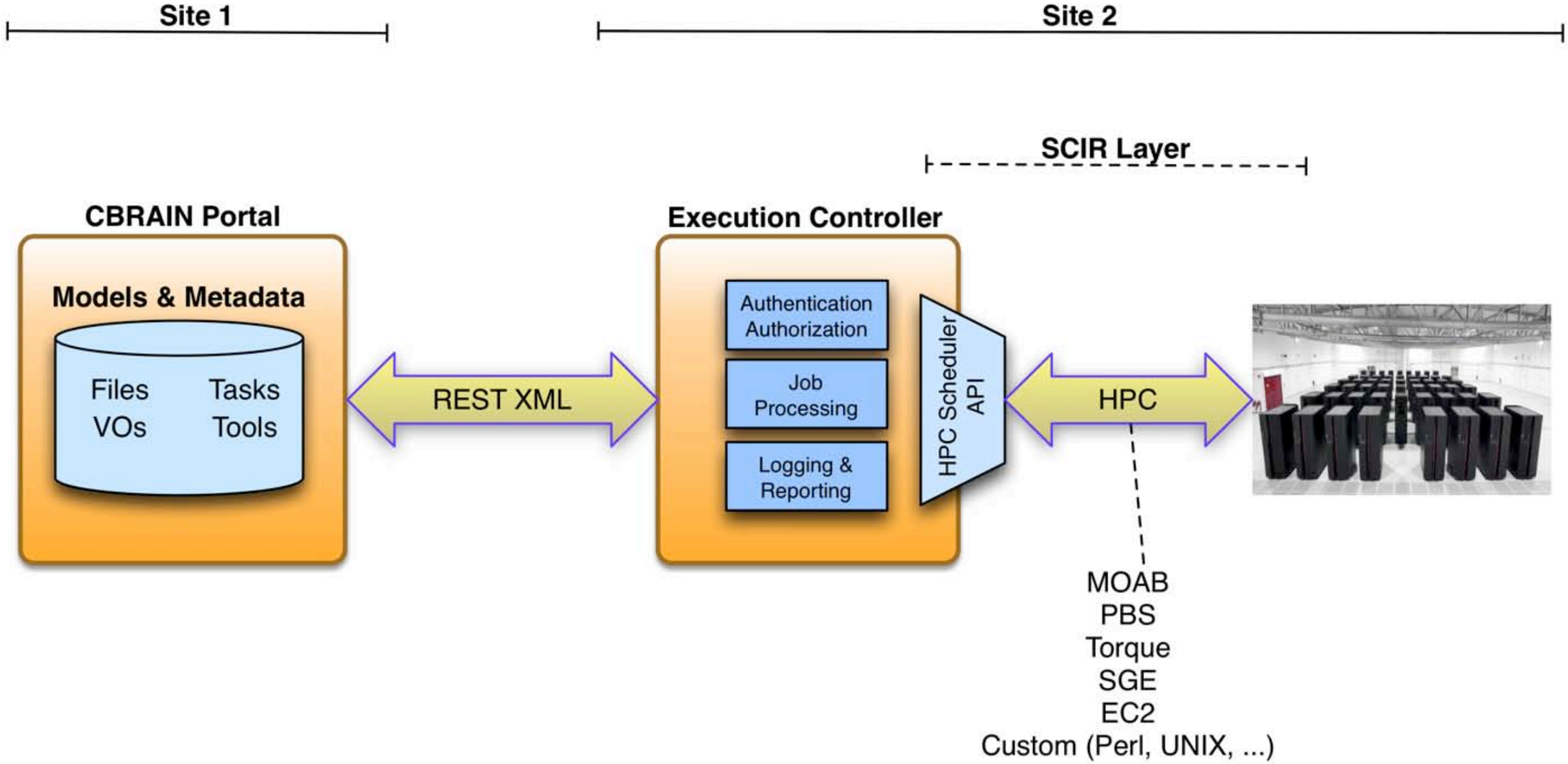
Reza Adalat – reza.adalat@mcgill.ca

CBRAIN
Technical Overview

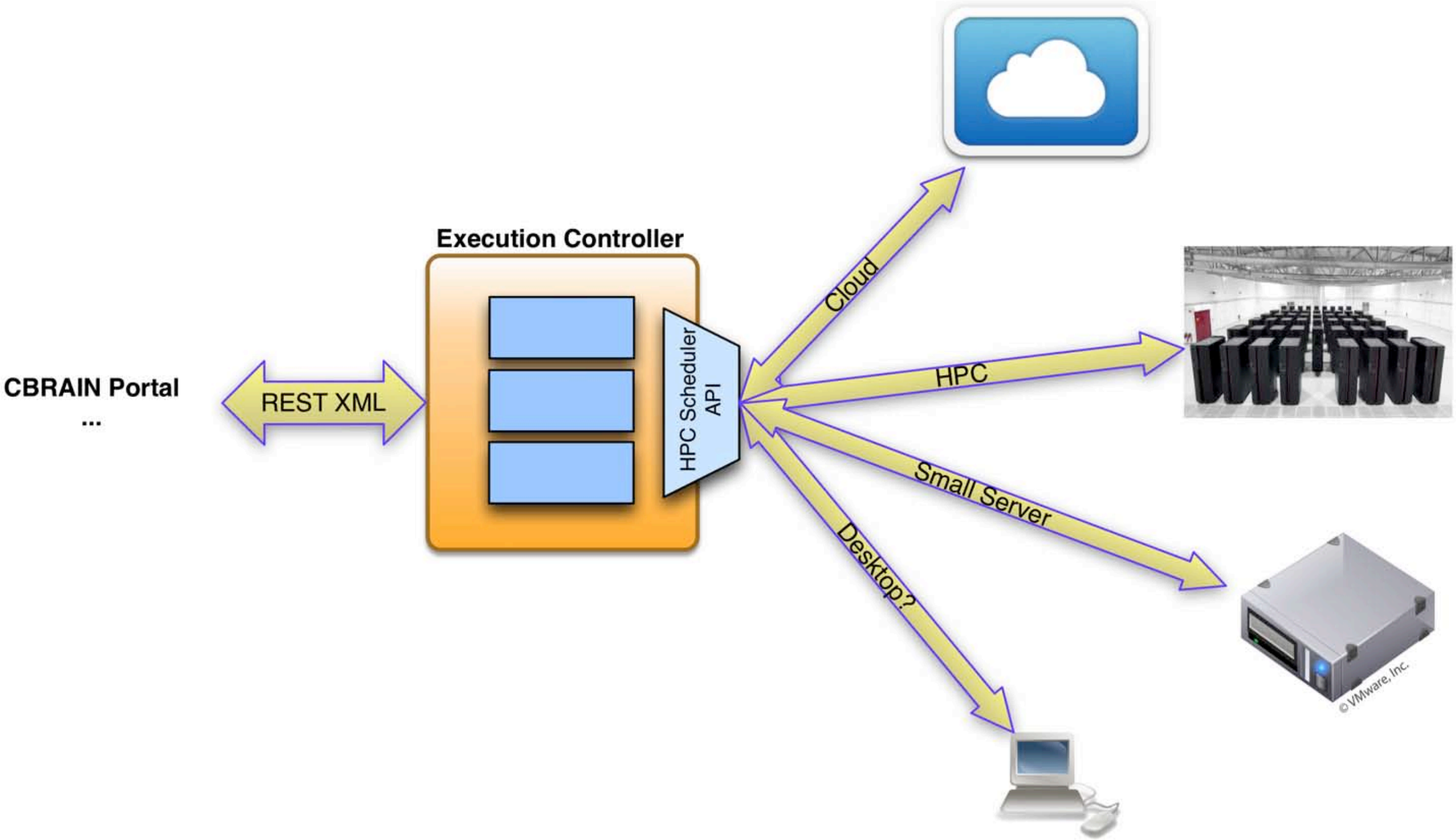
McGill

HPC Scheduling

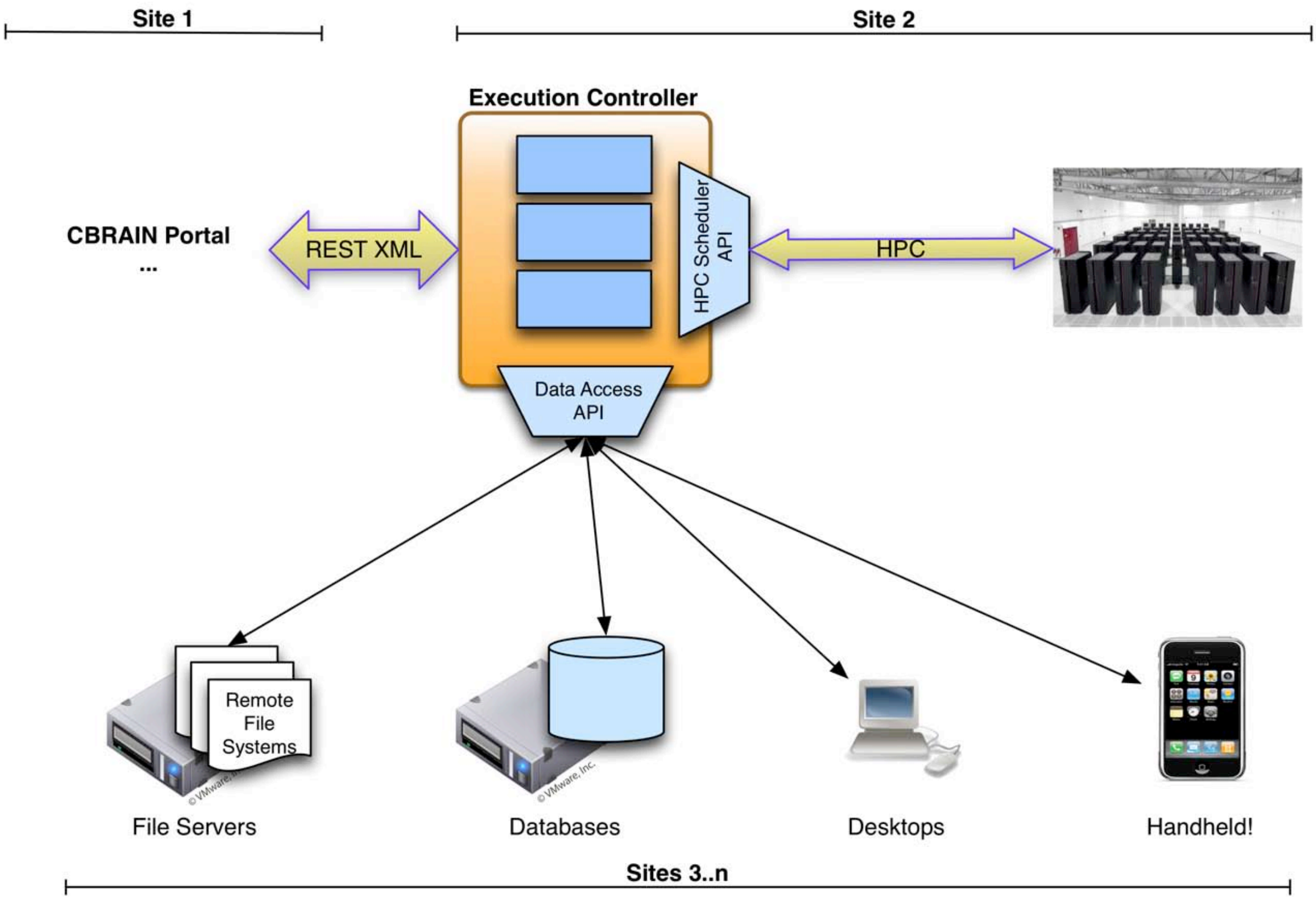
(SCIR: Simple Cluster Interface in Ruby)



Flexible Resource Access



Flexible Data Access

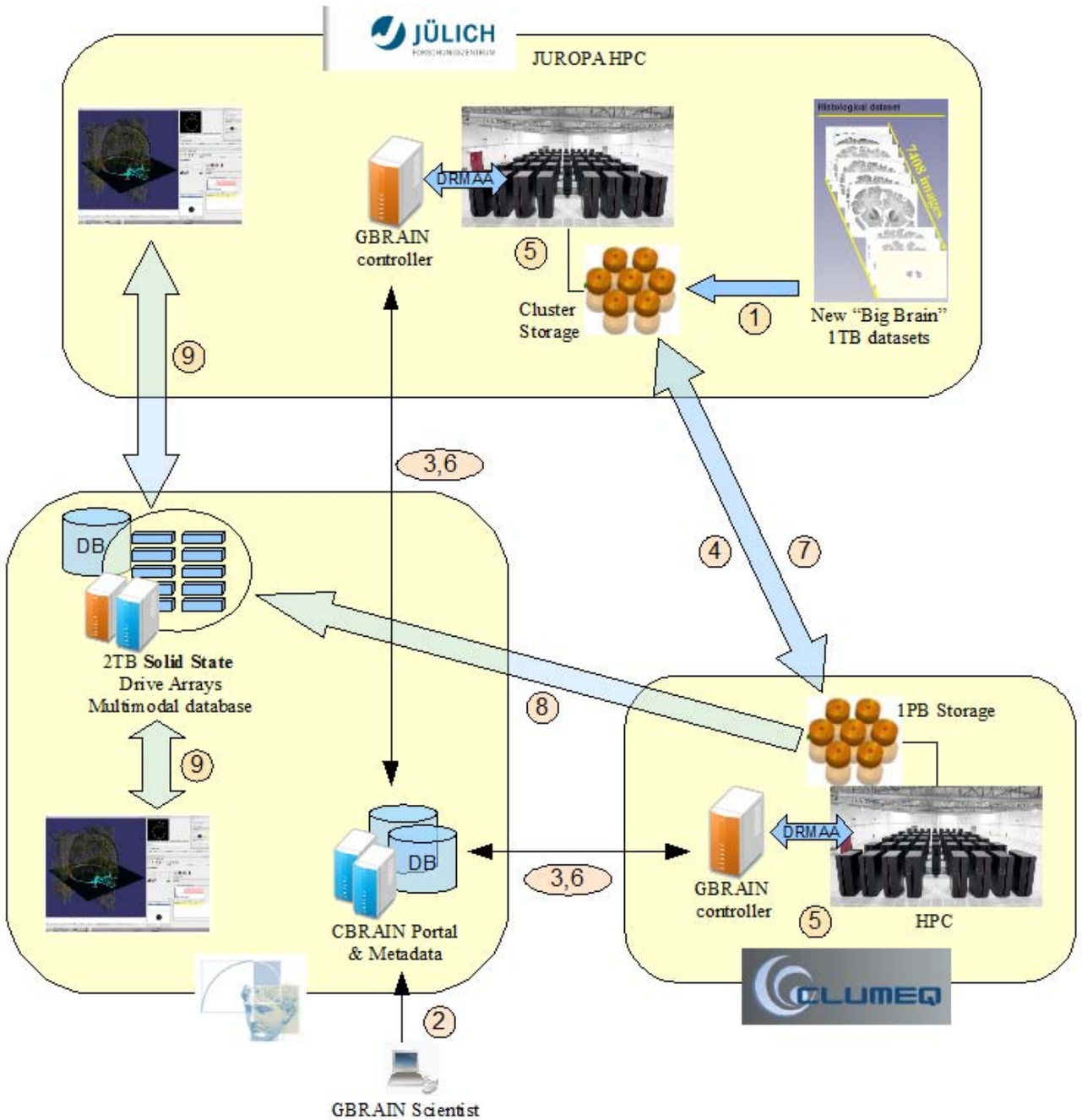


Julich Forschungszentrum, Germany

Large dataset assembly pipeline (current and future Big Brains)

Remote visualization of Big Brains (A3D)

MRI study



Operations in 2012