



ONTARIO  
BRAIN  
INSTITUTE

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ONTARIEN  
DU CERVEAU

WELCOME TO BRAIN CENTRAL

# Brain-CODE

Machine Learning for Medical Imaging Consortium

March 19th 2021



Ontario

Funding provided, in part,  
by the Government of Ontario

# The Ontario Brain Institute accelerates discovery and innovation, benefitting both patients and the economy.



## COLLABORATIVE RESEARCH

OBI is an active partner in the funding, fielding and dissemination of research. Championing high impact research programs, OBI accelerates innovation with the goal of better patient outcomes.

Through the development and use of a state-of-the-art informatics platform designed to store, manage and analyze findings, OBI's Brain-CODE is a "shared brain" for researchers in Ontario and beyond.



## COMMERCIAL INNOVATION

OBI partners with research and industry to co-ordinate commercialization and application of brain-related technologies. Through access to funding and support OBI and its partners have created a track-record of success in nurturing and accelerating innovation.

Programs like ONtrepeneurs and NERD help de-risk investment in neurotechnologies bridging the funding gap between research and private capital to ensure validated brain-related technology.



## CONNECTED CARE

A focus on impact, means improving the lives of those affected by brain disorders. OBI creates new connections between patient groups, researchers, clinicians and other stakeholders, benefiting patients today and for generations to come.

To ensure scale and efficiency OBI funds and manages six Integrated Discovery Programs – neurodegenerative disorders, neurodevelopmental disorders, cerebral palsy, depression, concussion and epilepsy. These programs provide evidence-based care back to patient groups, delivering real-world application and positive impact.



# Collaborative research




CP-NET  
Childhood Cerebral Palsy  
Neuroscience Discovery Network

**CEREBRAL PALSY**



EPLINK  
THE OBI EPILEPSY PROJECT

**EPILEPSY**



POND NETWORK  
Province of Ontario Neurodevelopmental Disorders

**NEURO-  
DEVELOPMENTAL  
DISORDERS**



CAN-BIND

**DEPRESSION**



ONDRI

**NEURO-  
DEGENERATIVE  
DISEASES**



CONNECT

**CONCUSSION**



# Our data opportunity

Data Modalities

Neuroimaging

Clinical

Genomics

Proteomics

Patient Outcomes

Cerebral Palsy

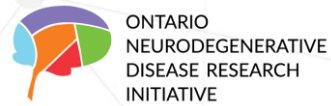
Epilepsy

Neurodevelopmental  
Disorders

Neurodegeneration

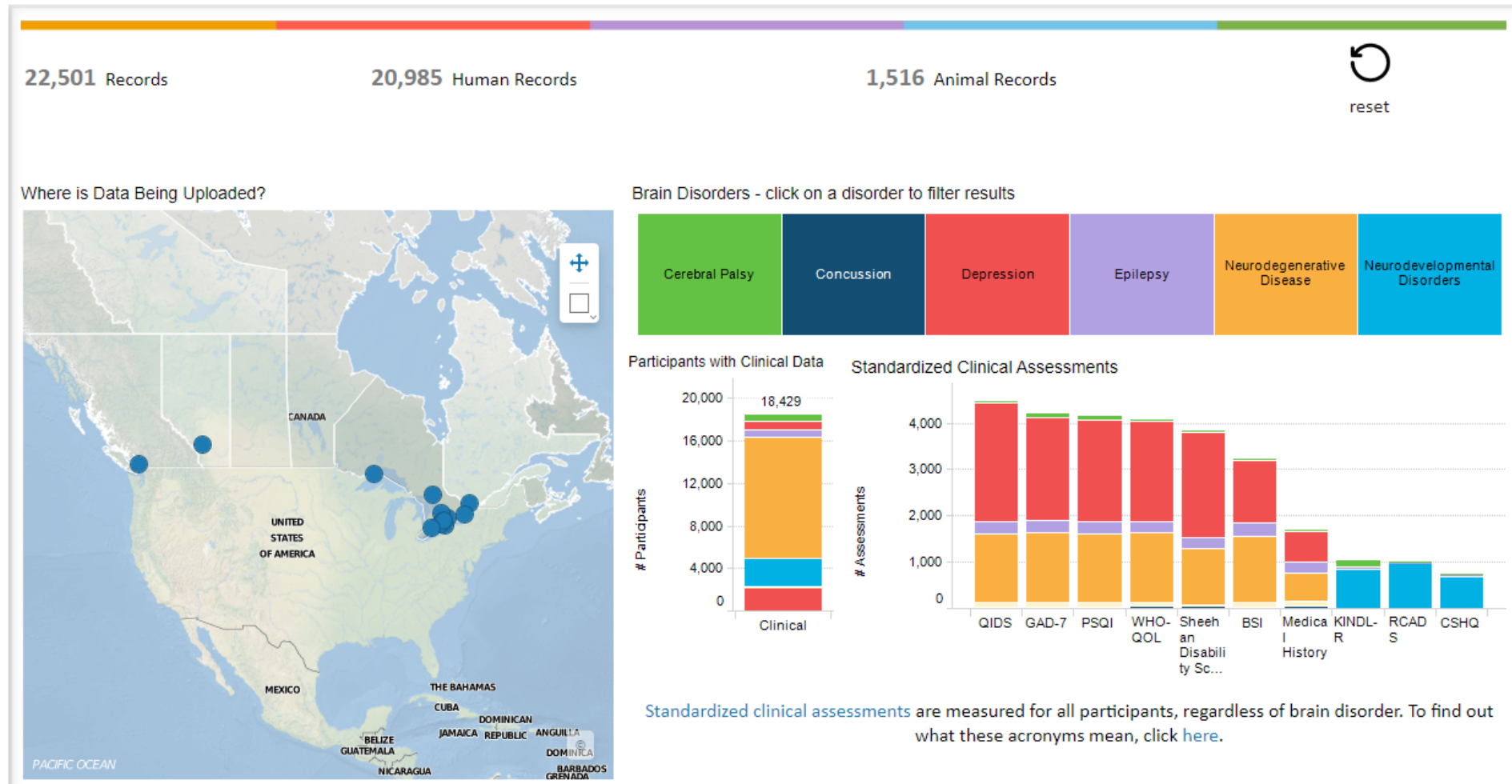
Depression

Concussion





# What data is in Brain-CODE?

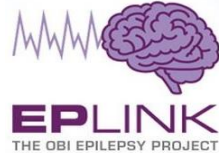




# Imaging Data on Brain-CODE



**CEREBRAL PALSY**



**EPILEPSY**



**NEURO-  
DEVELOPMENTAL  
DISORDERS**



**DEPRESSION**



**NEURO-  
DEGENERATIVE  
DISEASES**



**CONCUSSION**

- 4000+ imaging sessions on Brain-CODE
- Protocols are IDP-specific but usually contain structural T1 and T2, DTI, fMRI (resting state/task-based), etc.
- ONDRI uses Canadian Dementia Imaging Protocol (CDIP)



OBI•Brain-CODE

**indoc**  
CONSORTIUM

**indoc**  
RESEARCH

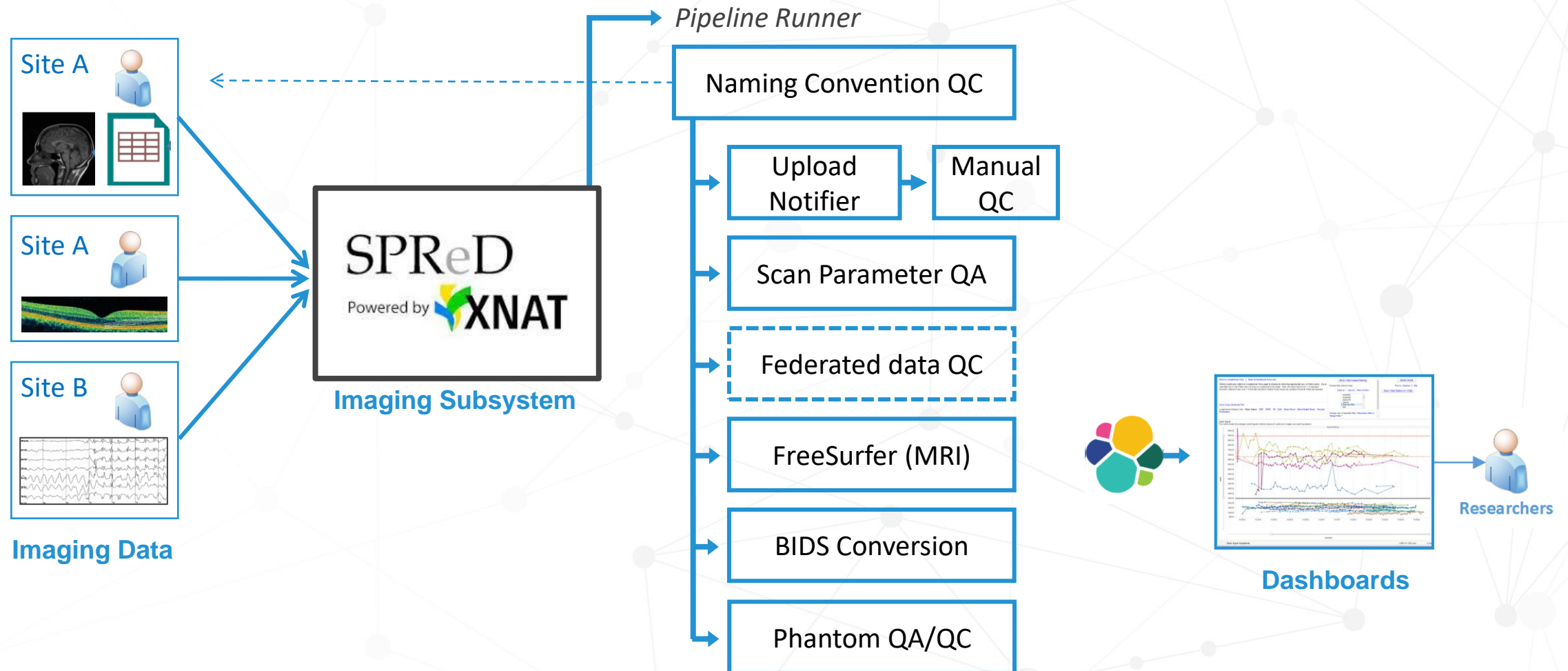
**Baycrest**  
Rotman Research Institute

Electronic  
Health  
Information  
Laboratory

Centre for  
Advanced  
Computing



# Imaging Pipelines





# Imaging QA/QC

Scanner variance is an issue



MR phantoms to characterize/track variance



LEGO phantom

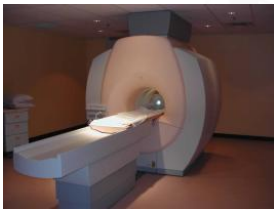


fBIRN phantom

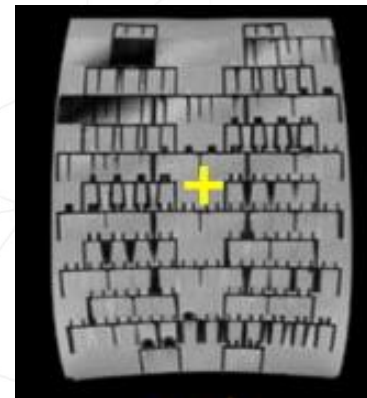


# Imaging QA/QC

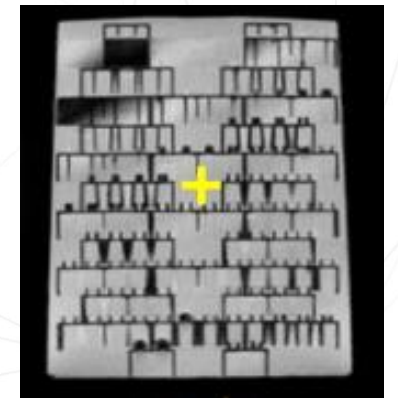
Scanner variance is an issue



LEGO phantom to reduce image distortion



raw image



distortion corrected

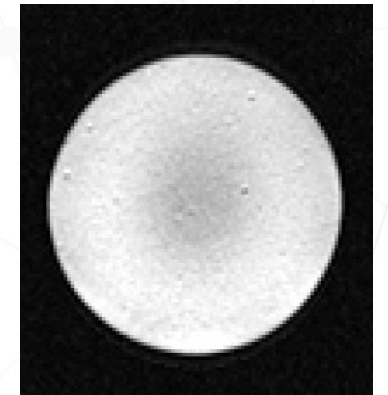


# Imaging QA/QC

Scanner variance is an issue



fBIRN phantom to track scanner performance





# Imaging QA/QC

## fBIRN QA dashboard

### Longitudinal View

Time-series plots of all QA reports are summarized on this page.

[Overview of dashboard](#) || [Navigational tips](#)

[Cross-Sectional View](#) | [FWHM](#)  
[Statistical Index](#) | [Site Info.](#)

[Show / Hide Custom Filtering](#)

Plot by: [Scanner](#) || [Site](#)

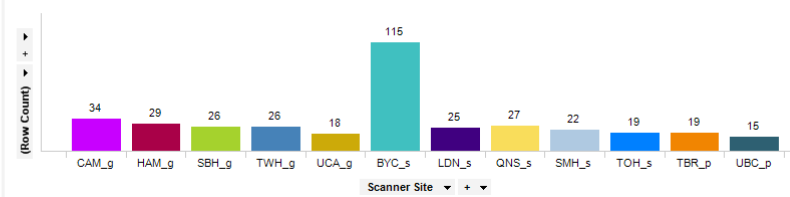
[Show / Hide Outliers \(+/- 3\\*SD\)](#)

Scans w/ Parameter Deviations:

False  
 True

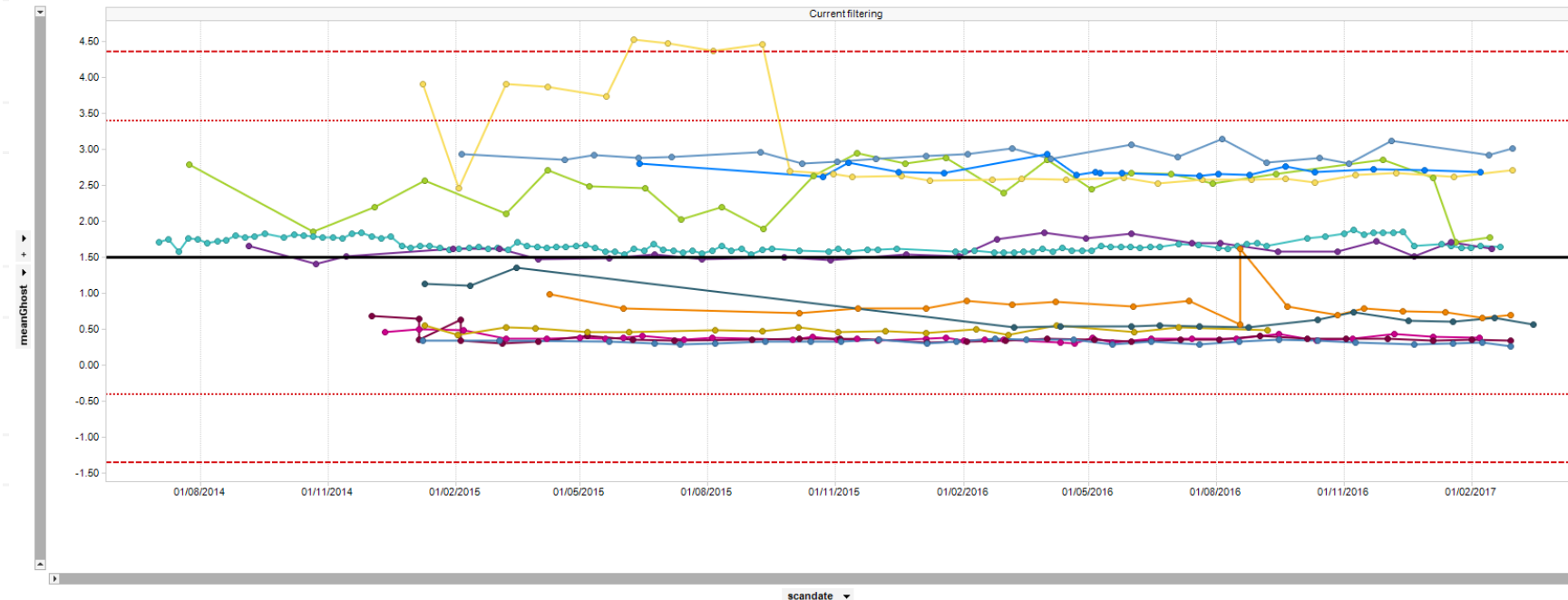
Choose filter option here:

### Count of uploaded & analyzed scans



### Mean Ghost

Ghost metrics are calculated for each volume by taking a dilated mask ("original mask") of the data, and shifting it by N/2 voxels in the appropriate axis to create a "ghost mask". The mean intensities of those voxels in the ghost mask and not in the original mask is the "Mean Ghost" value.

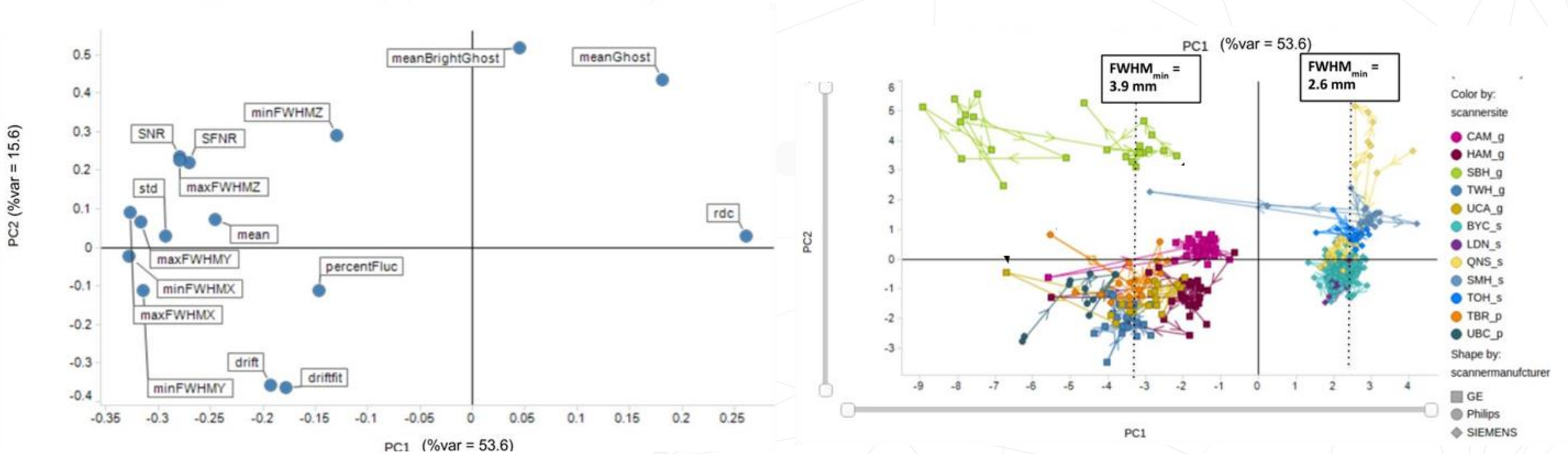


fBIRN phantom data aggregated across sites



# Imaging QA/QC

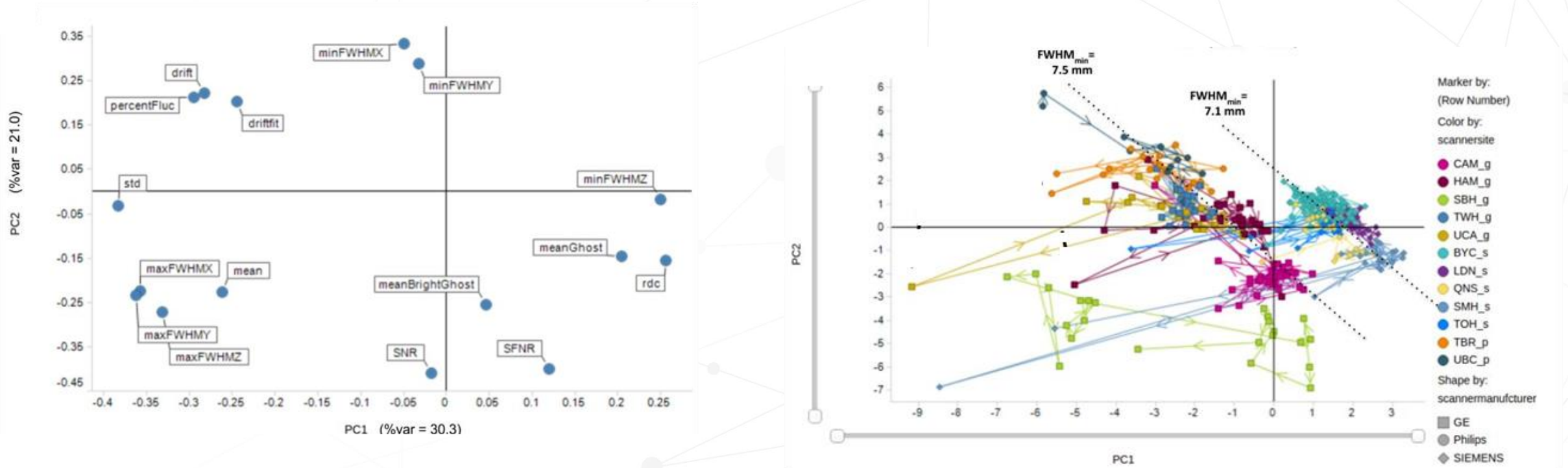
## PCA of fBIRN results





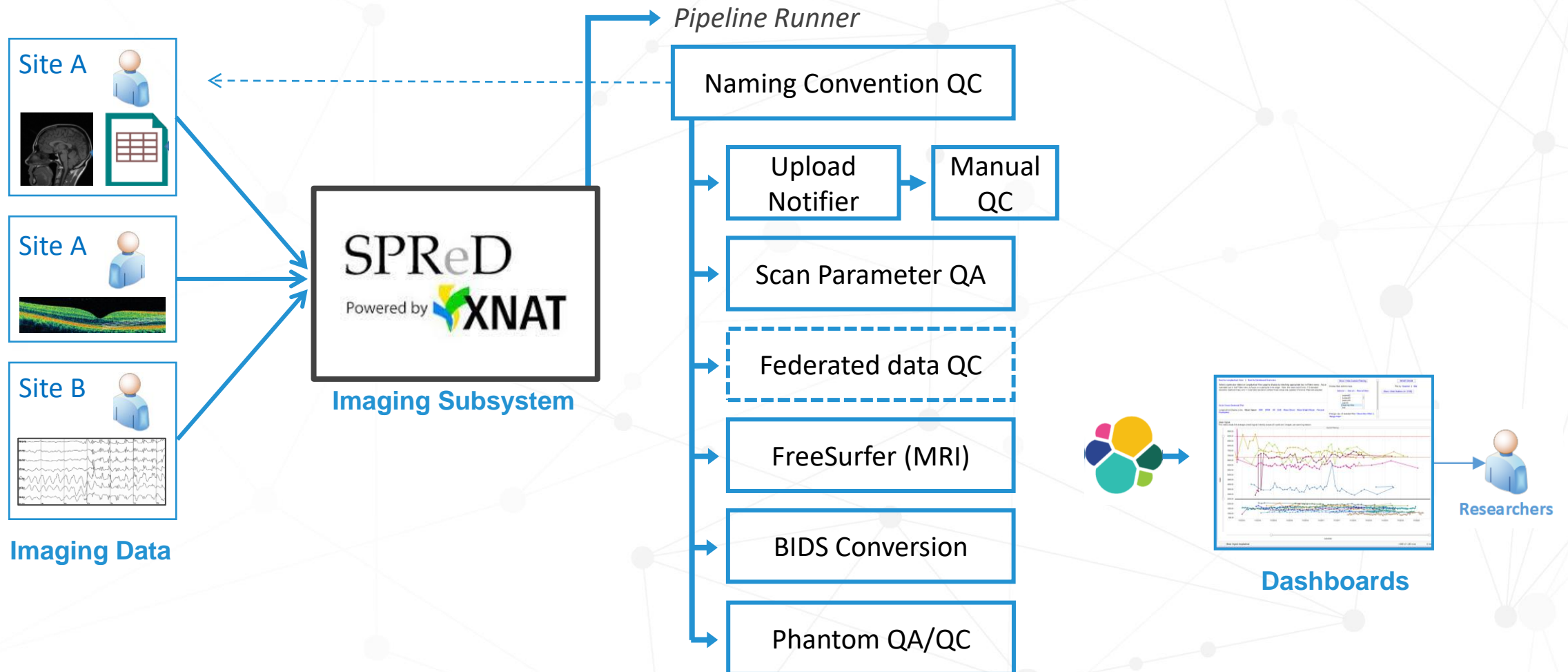
# Imaging QA/QC

## PCA of fBIRN results after voxel smoothing





# Imaging Pipelines



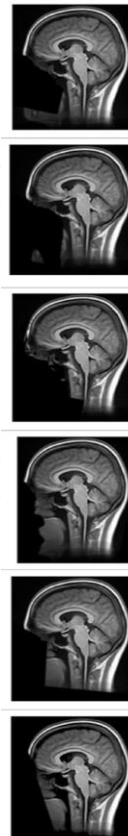
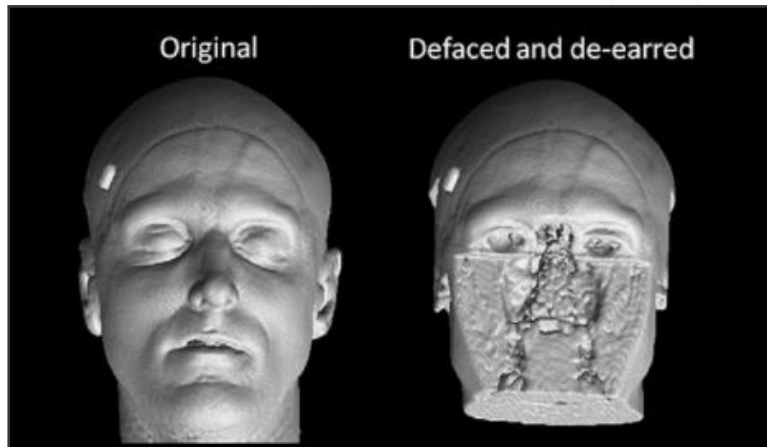


- Using BrainCODE database to validate new tools/approaches:

## Multisite Comparison of MRI Defacing Software Across Multiple Cohorts

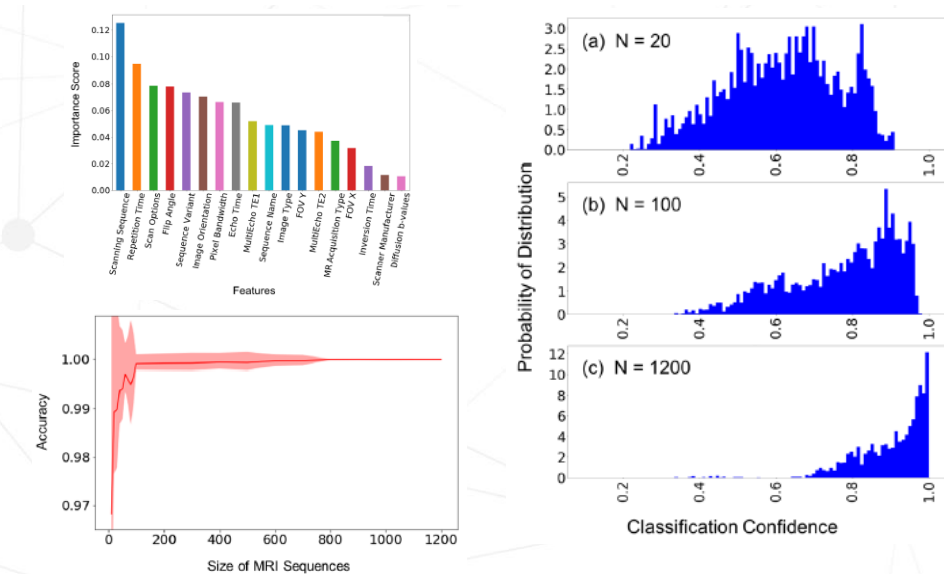
Front. Psychiatry, 24 February 2021 | <https://doi.org/10.3389/fpsyt.2021.617997>

Athena E. Theyers<sup>1\*</sup>, Mojdeh Zamyadi<sup>1</sup>, Mark O'Reilly<sup>2</sup>, Robert Bartha<sup>3</sup>, Sean Symons<sup>4</sup>, Glenda M. MacQueen<sup>5</sup>, Stefanie Hassel<sup>5</sup>, Jason P. Lerch<sup>6</sup>, Evdokia Anagnostou<sup>7</sup>, Raymond W. Lam<sup>8</sup>, Benicio N. Frey<sup>9,10</sup>, Roumen Milev<sup>11</sup>, Daniel J. Müller<sup>12,13</sup>, Sidney H. Kennedy<sup>13,14,15,16</sup>, Christopher J. M. Scott<sup>17,18,19</sup>, Stephen C. Strother<sup>1,20</sup>, on behalf of The ONDRI Investigators and Stephen R. Arnott<sup>1</sup>



## Magnetic Resonance Imaging Sequence Identification using a Metadata Learning Approach

Shuai Liang<sup>1,2</sup>, Derek Beaton<sup>1</sup>, Stephen R. Arnott<sup>1</sup>, Tom Gee<sup>2</sup>, Mojdeh Zamyadi<sup>1</sup>, Robert Bartha<sup>3</sup>, Sean Symons<sup>4</sup>, Glenda M. MacQueen<sup>5</sup>, Stefanie Hassel<sup>5</sup>, Jason P. Lerch<sup>6</sup>, Evdokia Anagnostou<sup>7</sup>, Raymond W. Lam<sup>8</sup>, Benicio N. Frey<sup>9,10</sup>, Roumen Milev<sup>11</sup>, Daniel Mueller<sup>12,13</sup>, Sidney H. Kennedy<sup>13,14,15,16</sup>, Christopher J.M. Scott<sup>17,18,19</sup>, The ONDRI Investigators, Stephen C. Strother<sup>1</sup>



# CP-NET Clinical Database

## Introduction and Neuroimaging Platform

# Neuroimaging Platform



- **Data size:** De-identified neuroimages have been collected for 625 participants and uploaded to SPReD (Brain-CODE)
  - 246 for Hemiplegic CP (Phase 1)
  - 379 for all CP subtypes (Phase 2 & 3)
- **Modality:** Mostly MRI sessions
- **Source:** Neuroimaging acquired for clinical purposes, if available
  - Preferably an MRI taken 0-28 days from birth or 4 months to 2 years post-injury
  - No new brain scans are taken specifically for the purpose of this study
- **Scoring:** >95% of the images have been scored by a radiologist at SickKids to classify each case into distinct neuropathology phenotypes
  - Brain structures affected, pattern of injury indicating age at onset (fetal, preterm, term) and mechanism of injury (malformation, ischemic, infection, inflammation, vascular, other)