Human Neuroimaging on the Open Science Grid

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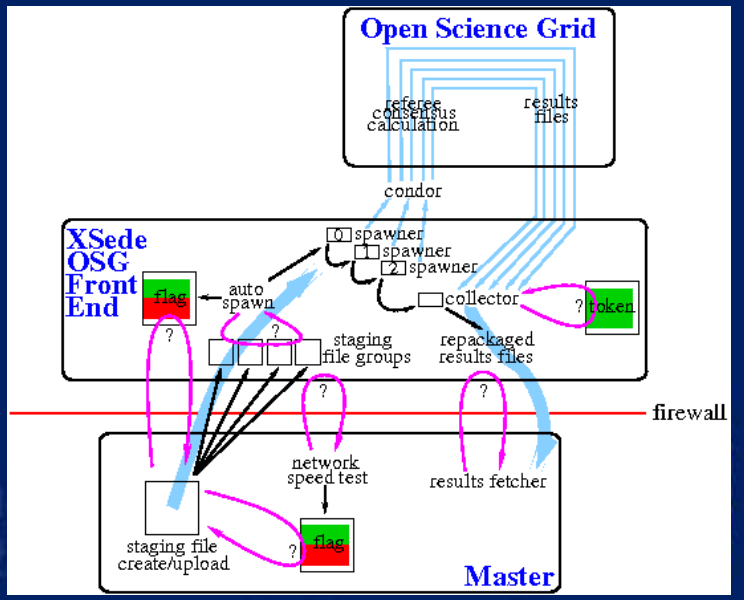
University of Pittsburgh

References may be found at
https://indico.fnal.gov/contributionDisplay.py?contribId=20&sessionId=6&confId=10571

Krieger et. al., Referee consensus: A platform technology for nonlinear optimization, ACM, 2013.
Krieger et. al., Very high resolution neuroelectric brain imaging realized by referee consensus processing. Intl J Advd Comp Sci, 2014.
Draft graphic explanation of the solver, 2015.
Tutorial: Freesurfer on the OSG



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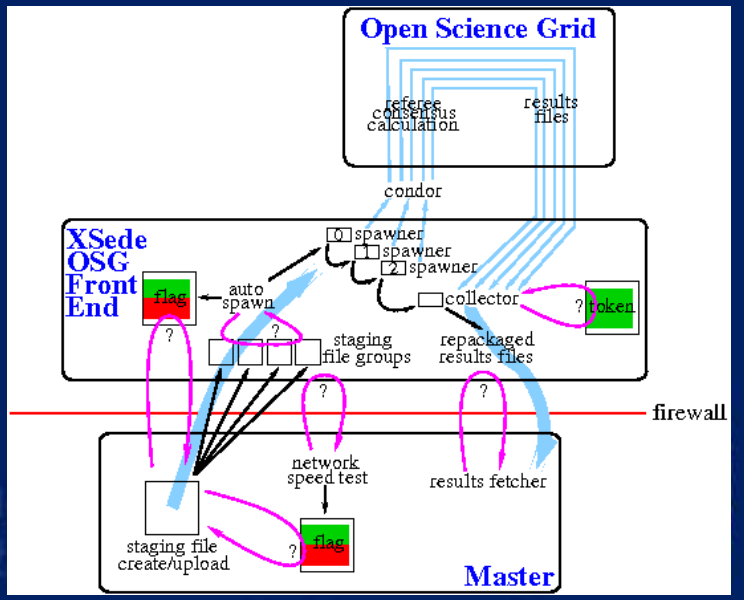

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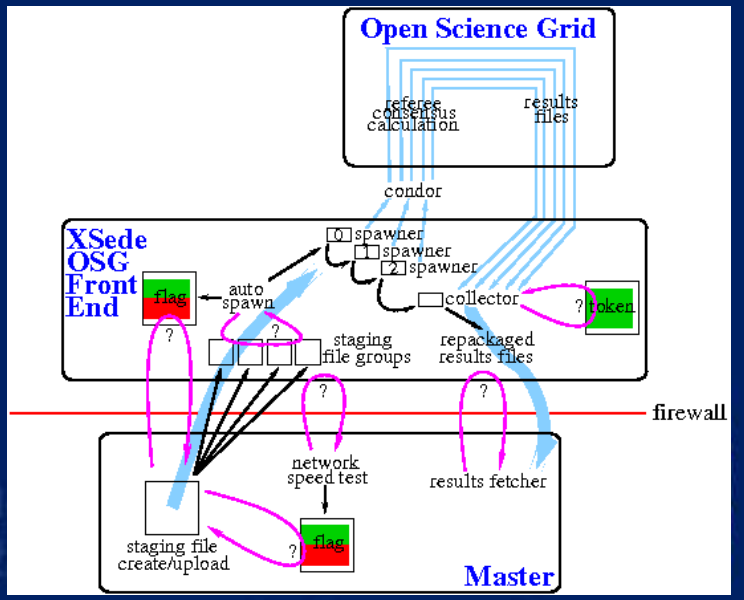
David Okonkwo, Jim Becker, Sue Beers, Mickey Collins, Anthony Kontos, Malcolm McNeil, Lisa Morrow, Nora Presson, Walt Schneider

Support: Dept. of Defense, Open Science Grid (NSF,DOE), XSede (NSF).



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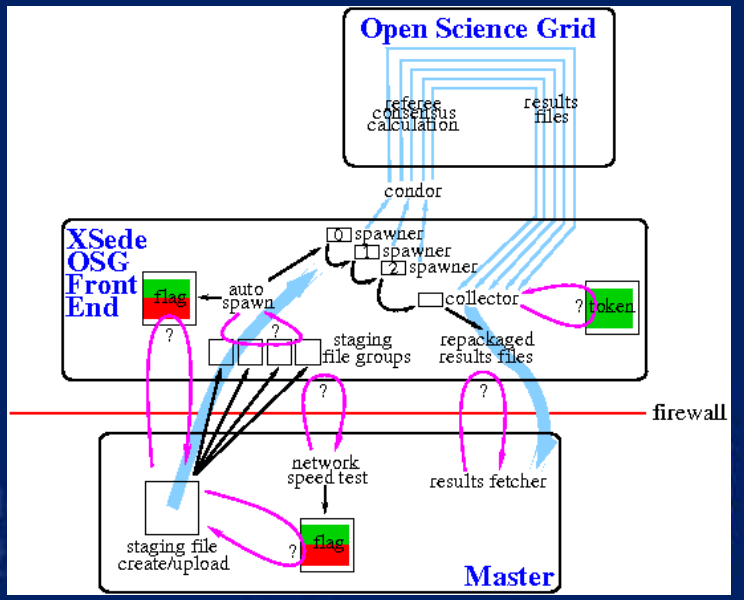

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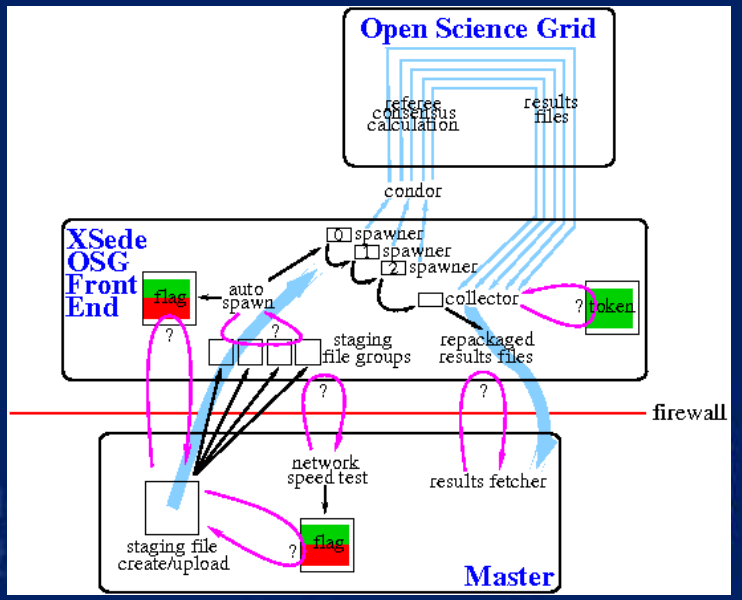
Mats Rynge, Mahidhar Tatineni, Frank Wurthwein, Miron Livny

San Diego Supercomputing Center, Open Science Grid (NSF,DOE), XSede (NSF).



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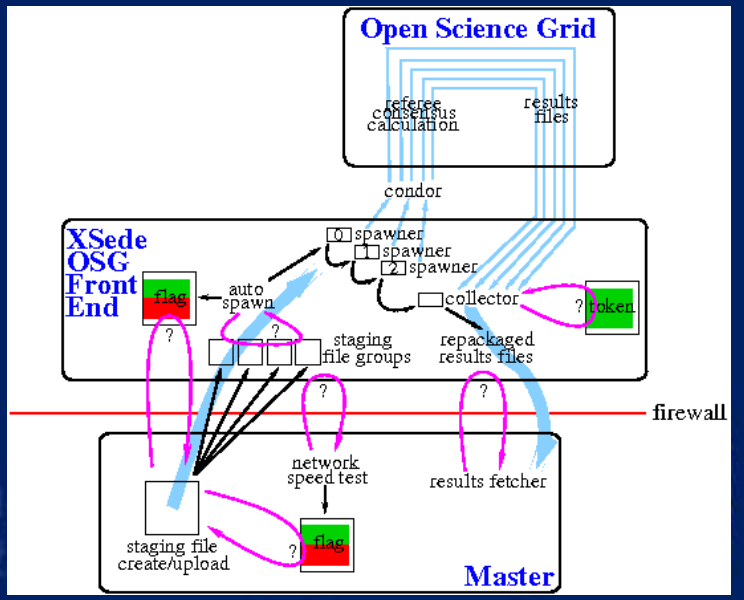

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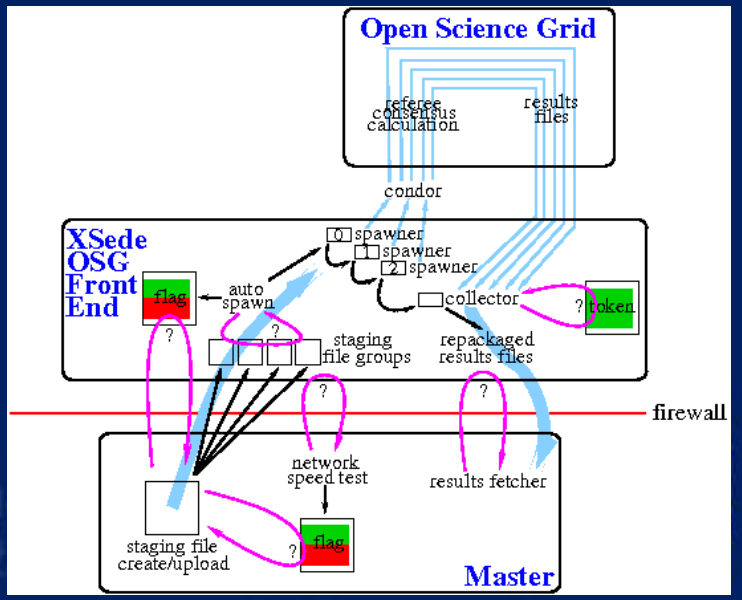

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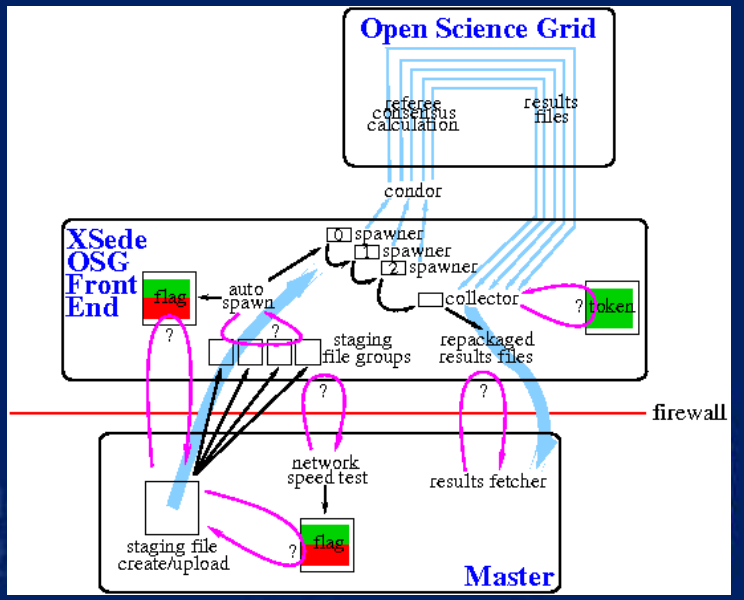

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- We further reduce those maps to numerical scores which may be formally tested for relationships with clinical measures derived from symptom inventories and neuropsychological testing.

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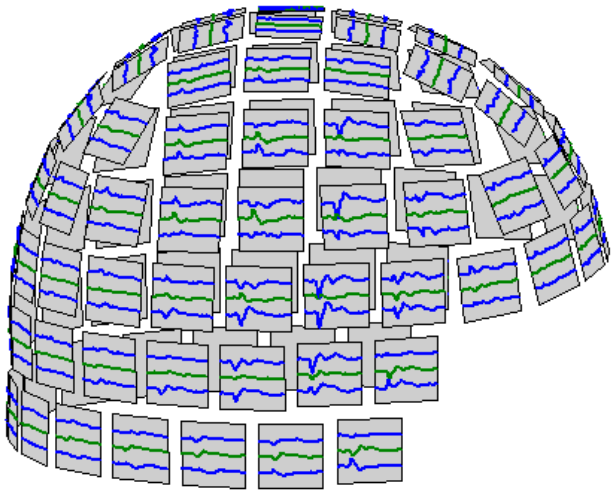
1. the brain is more widely activated during task performance than during rest.
2. The rate at which validated neuroelectric events occur within a given volume increases with activation.
3. The corresponding averaged current amplitude also increases with activation.

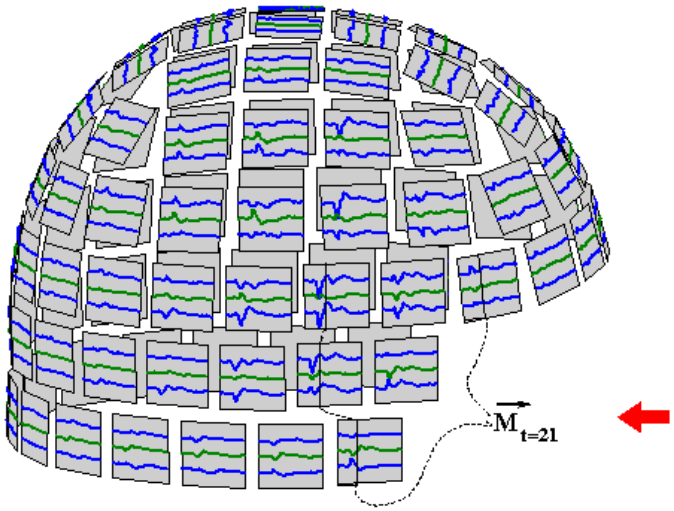
Inside the liquid helium dewar is an array of 102 1”x1” chips, each with 3 magnetic field sensors.

Hence the 3D “shape” of the magnetic field around the head is sampled at 102 points .



This 3D snapshot of the “shape” of the magnetic field is obtained 1000 times per second.

Each snapshot is a set of 306 measurements at a particular time and is designated: $\mathbf{M}_t$



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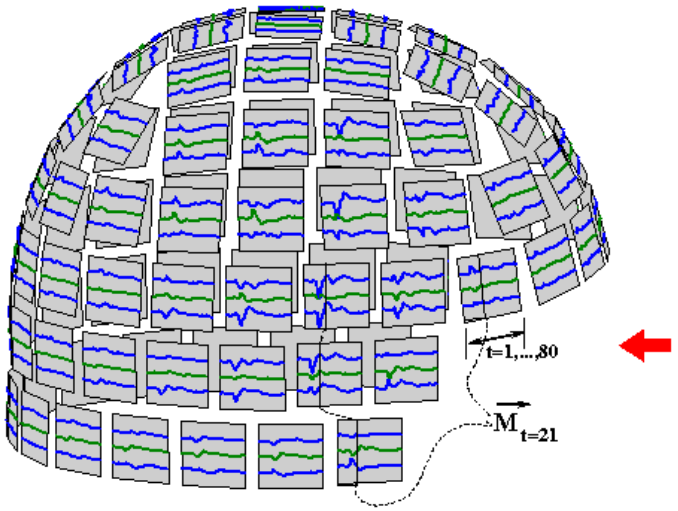
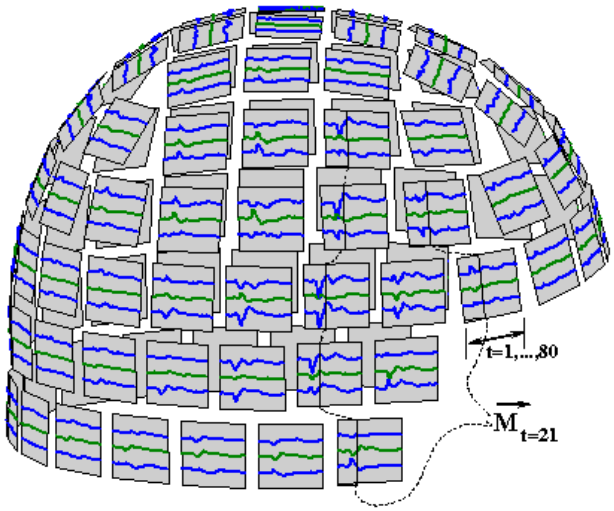
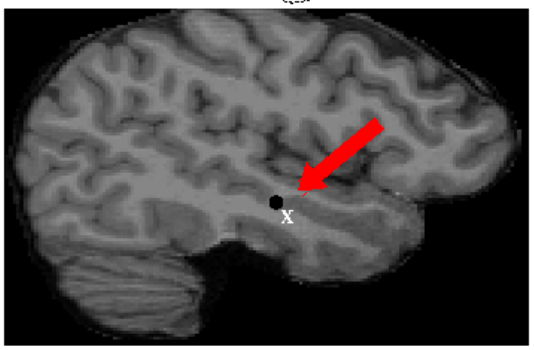
The referee consensus solver uses 80 snapshots at a time.



Given a specific location in the brain, **X,** the solver determines if an electric current at **X** is contributing significantly ($p < 10^{-12}$) to the shape of the magnetic field.





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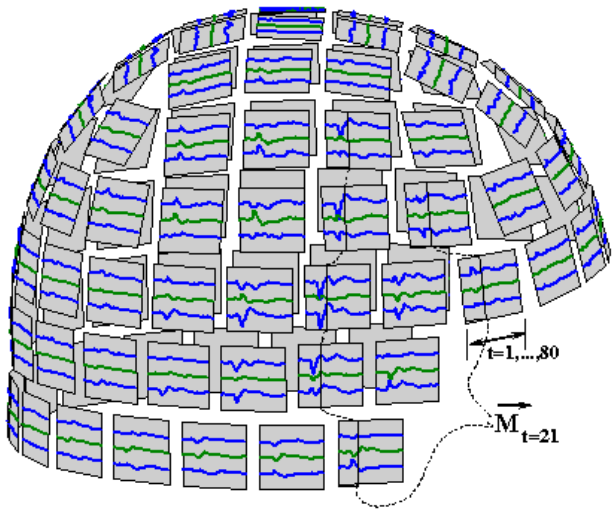
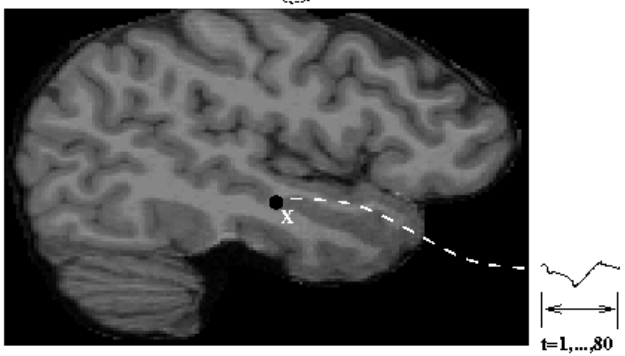
As part of this determination the procedure produces a high fidelity estimate of the time course of the electric current at **X**.





For each validated current source event, we have

- time marker … 1 msec resolution
- 3D location … ≈ 1 mm resolution
- 3D direction … 2 components: The radial component cannot be estimated.
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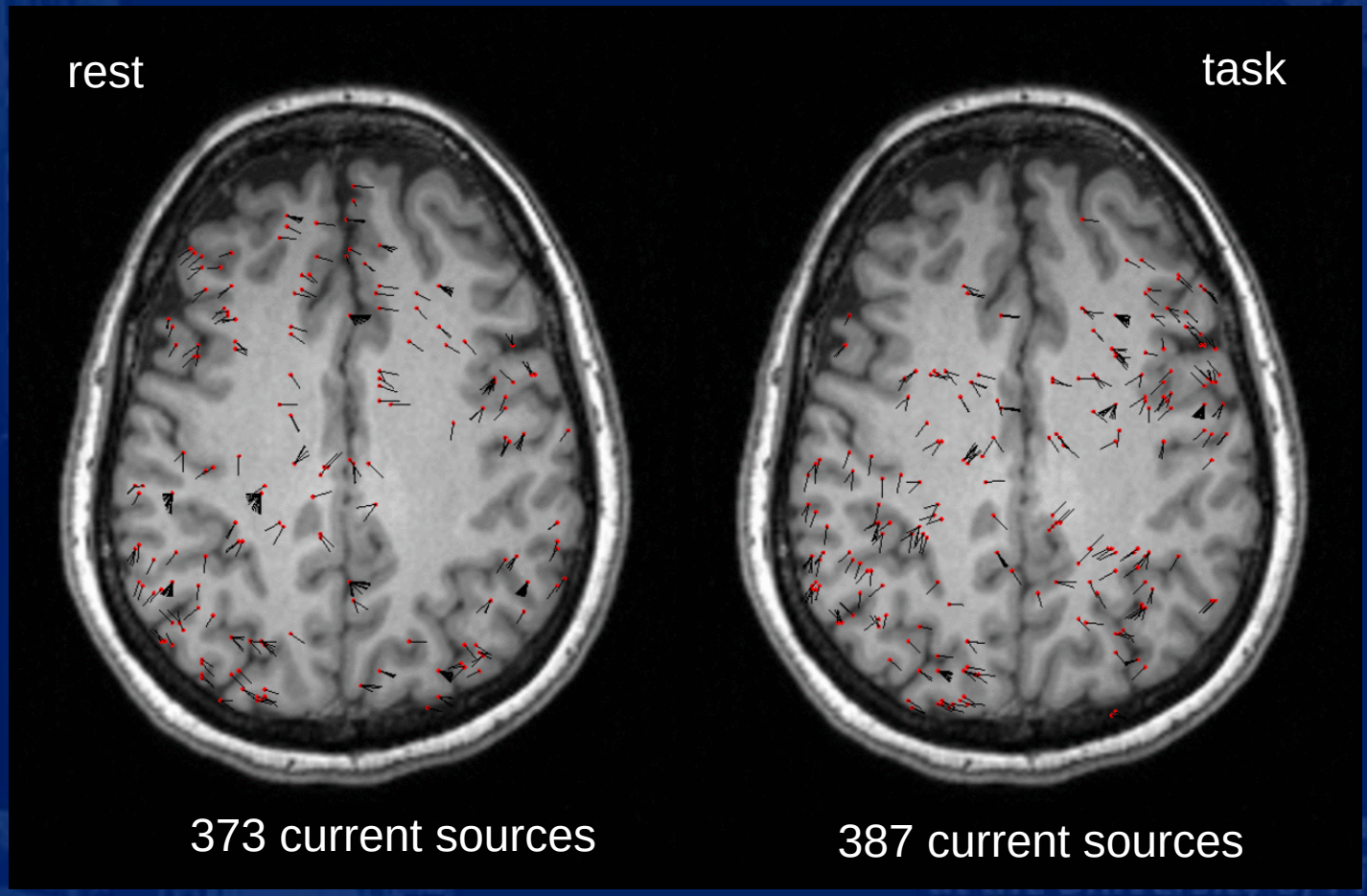
In principle comparable measurement resolution could be obtained with an array of 1,500,000 indwelling low impedance wires implanted in the brain on a 1 mm grid. That direct but unrealizable approach would extract more information since it would yield continuous recordings from each location.

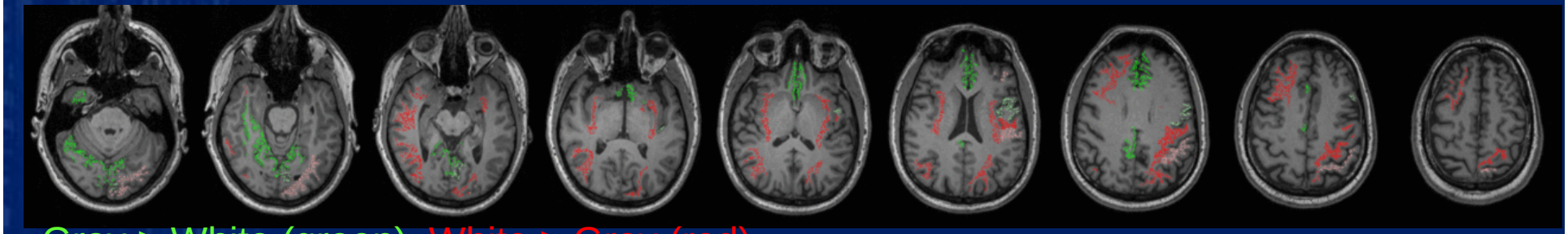
Each identified electrical current is flowing in a direction.

These typical neuroelectric current events were found in a 1 second MEG recording in a 1 mm thick volume.



Differential Activation – Gray/White

For each volunteer, we compare the activation of each cortical gray matter region with that of the adjacent white matter rim.



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- 34 gray/white pairs within each brain hemisphere
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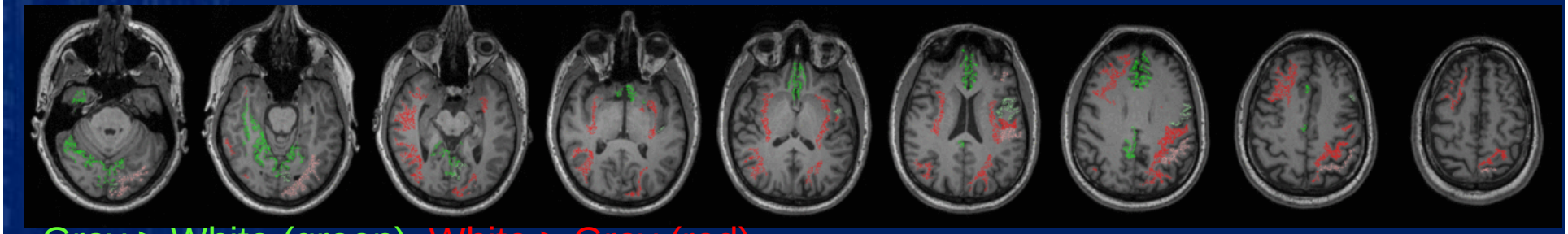

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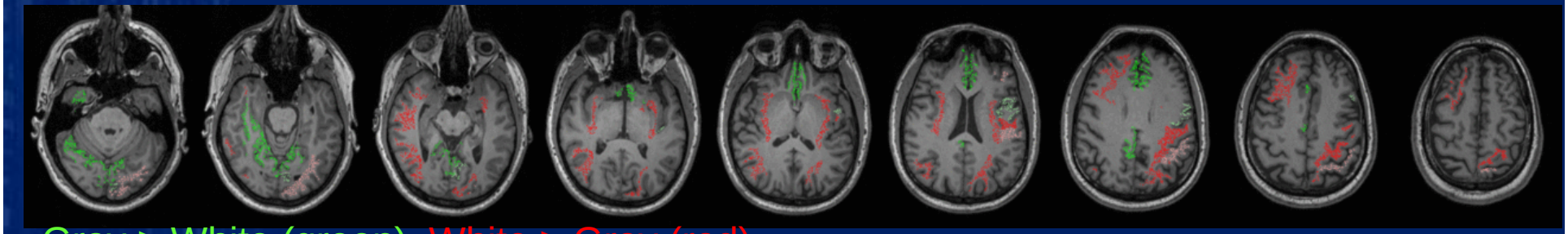

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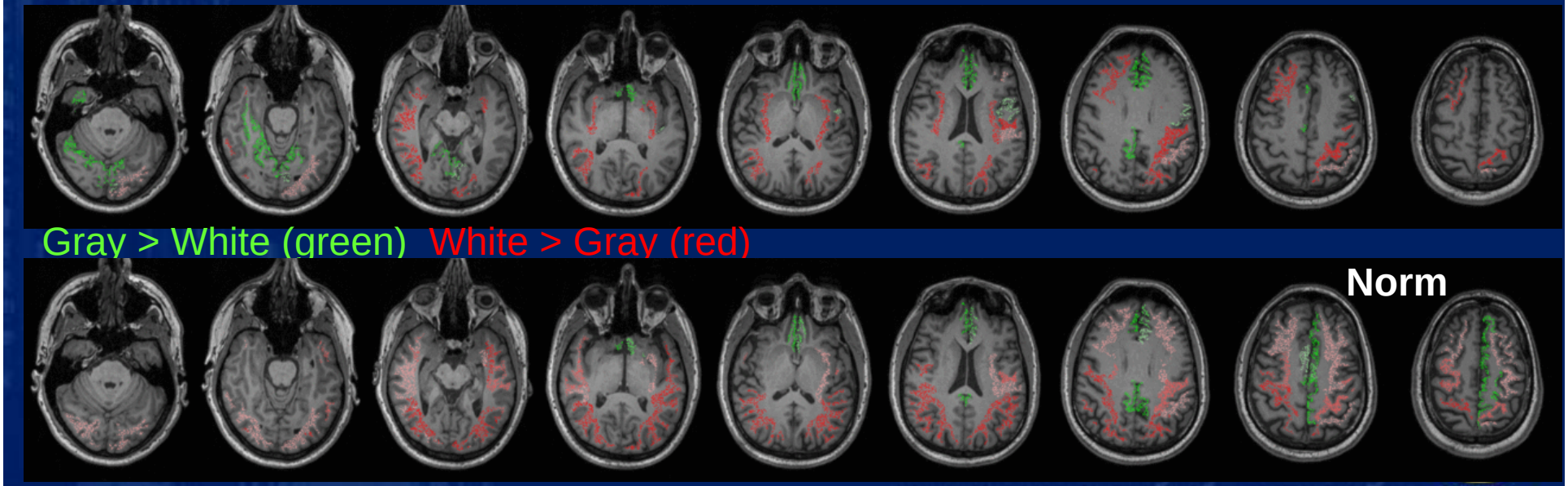

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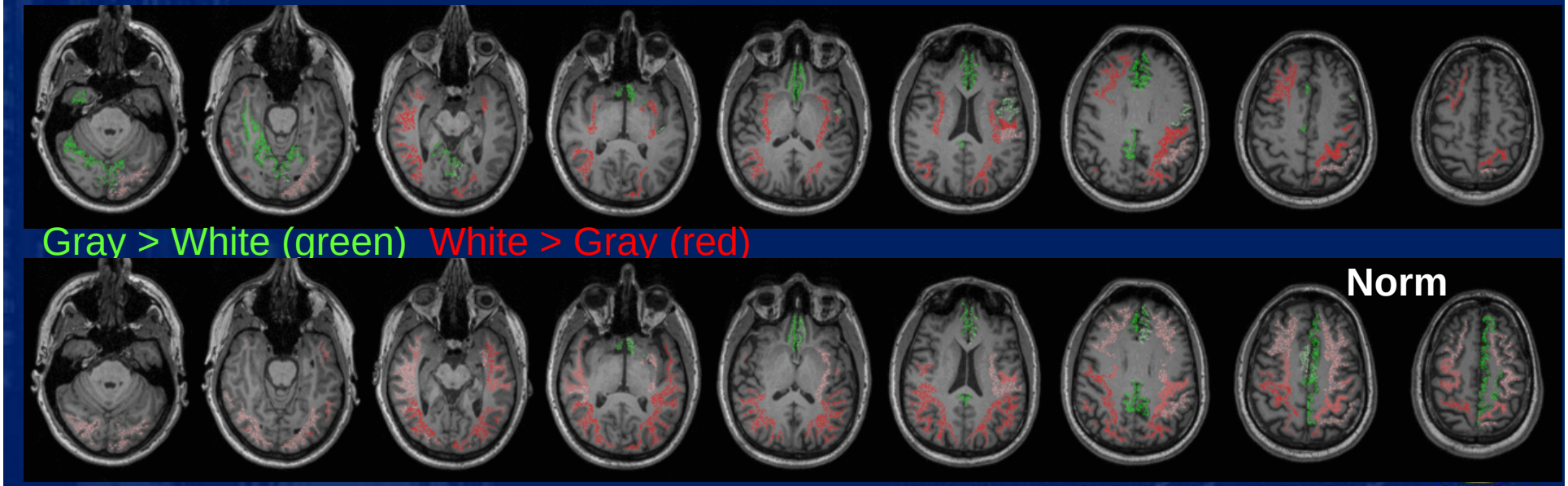
No comparable result is currently obtainable from any neuroimaging modality processed in any other way.



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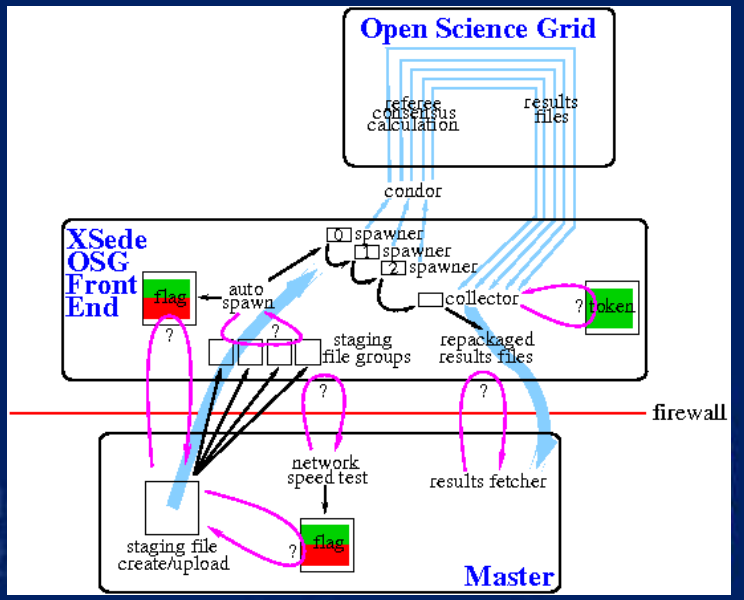

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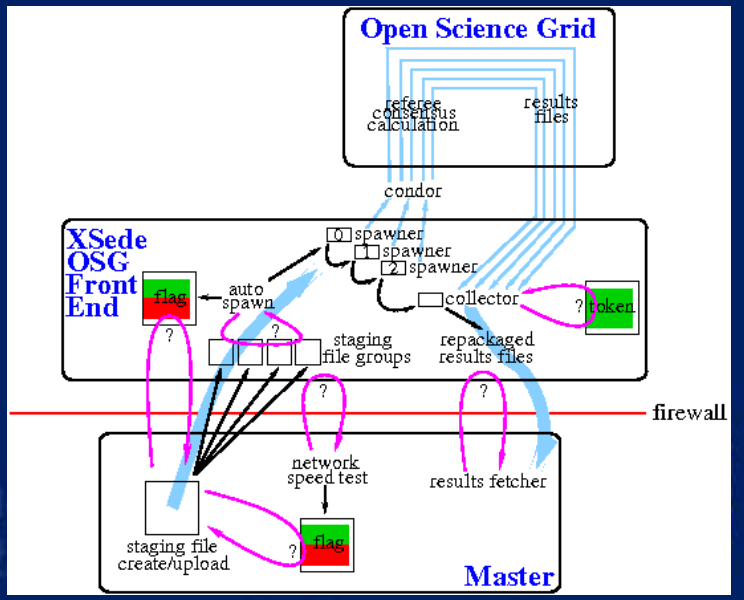

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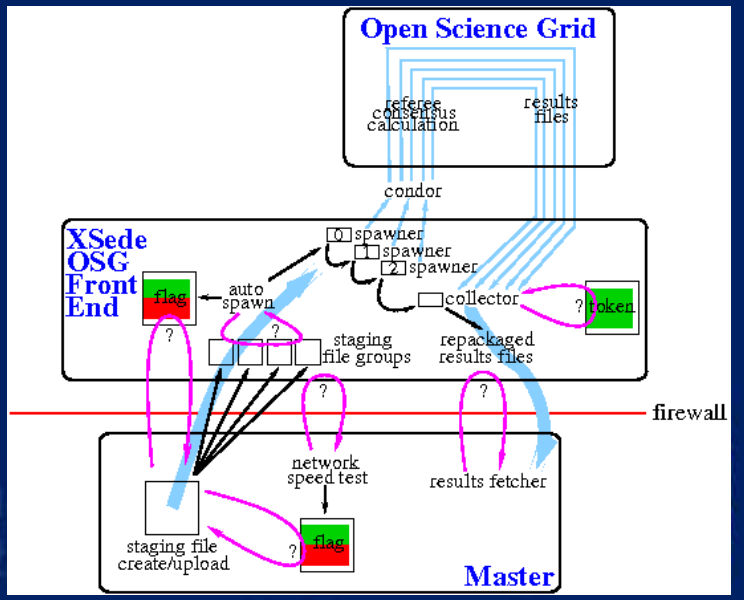

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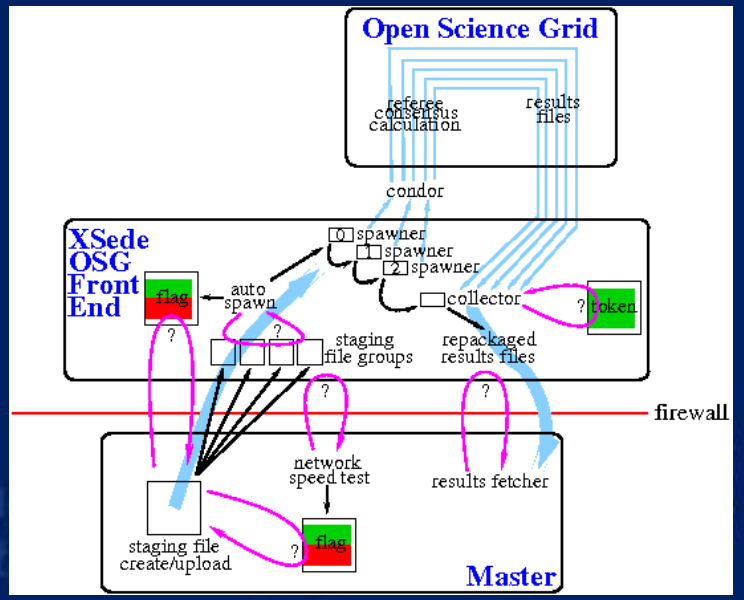

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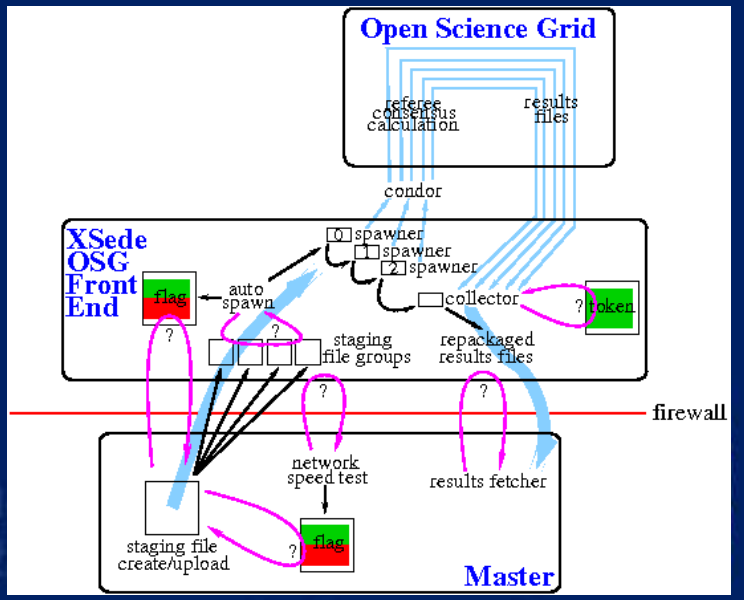

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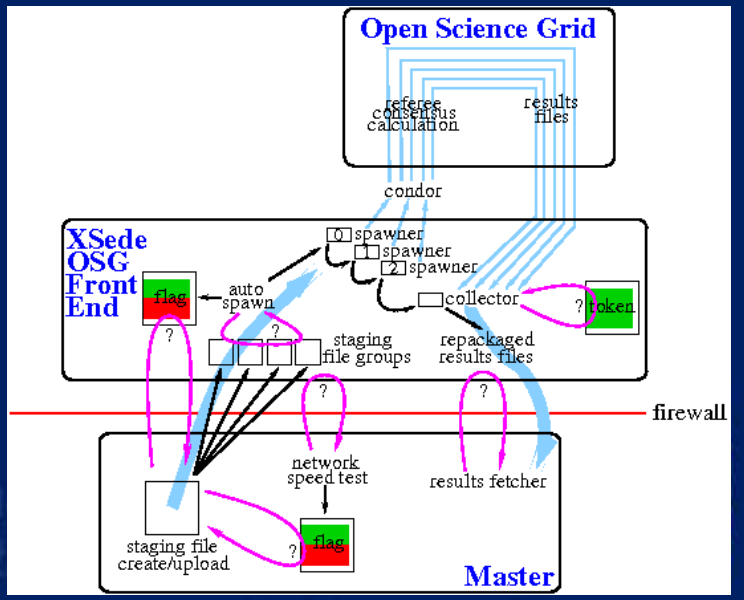

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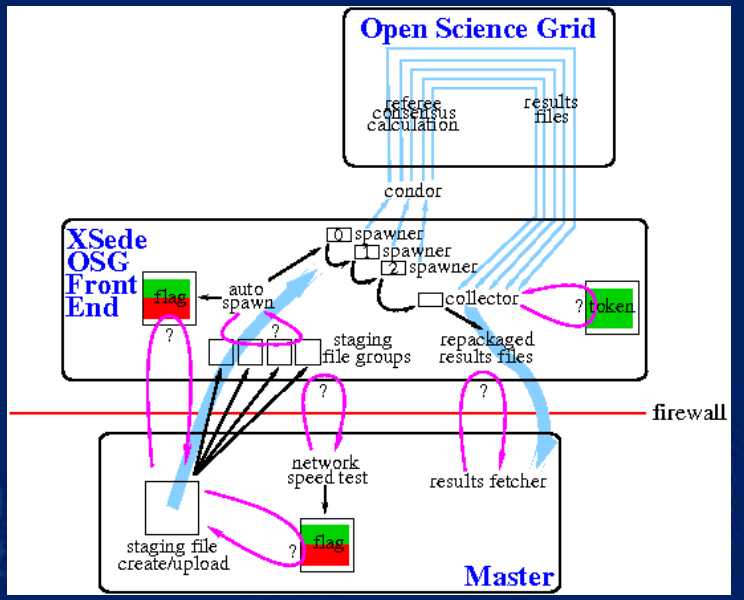
When added to the SUs we get from the opportunistic pool, this enables sufficient processing to provide reliable results for adjudication.



Comet booster for OSG condor pool

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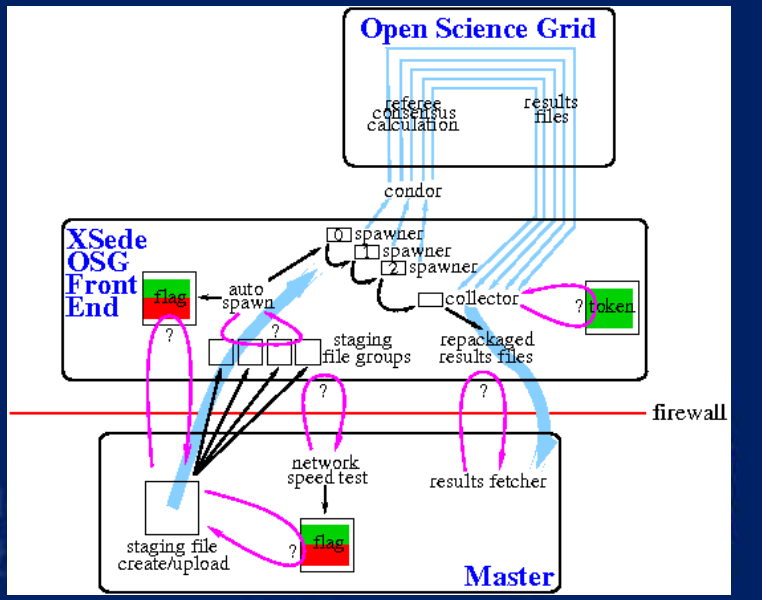

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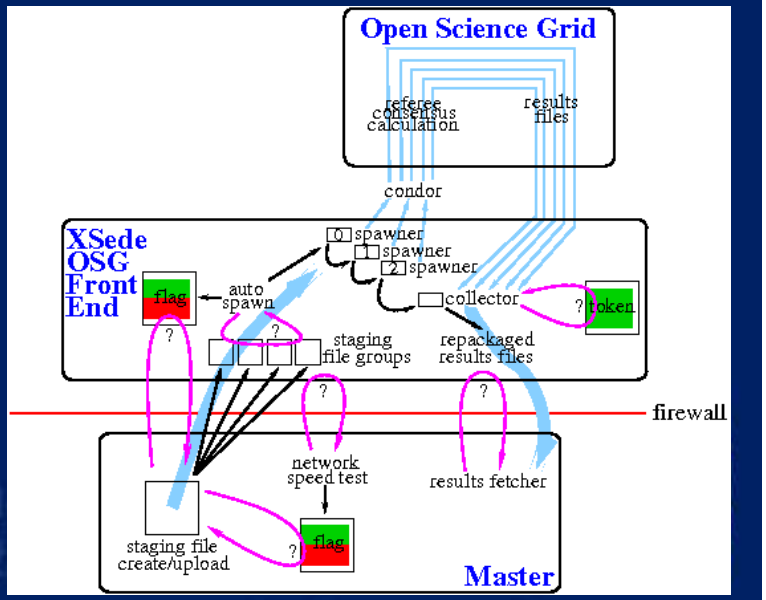

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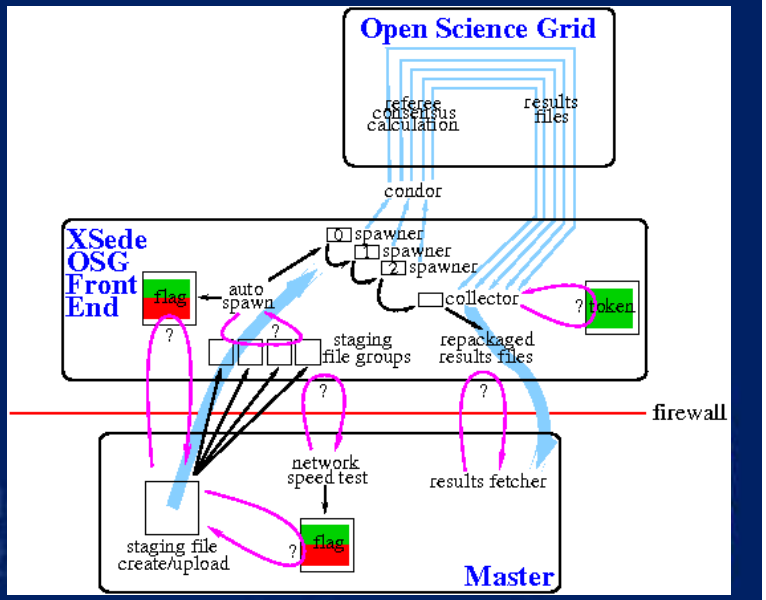

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3. Spawn glideins on Comet. The glideins will fall under XSede accounting.

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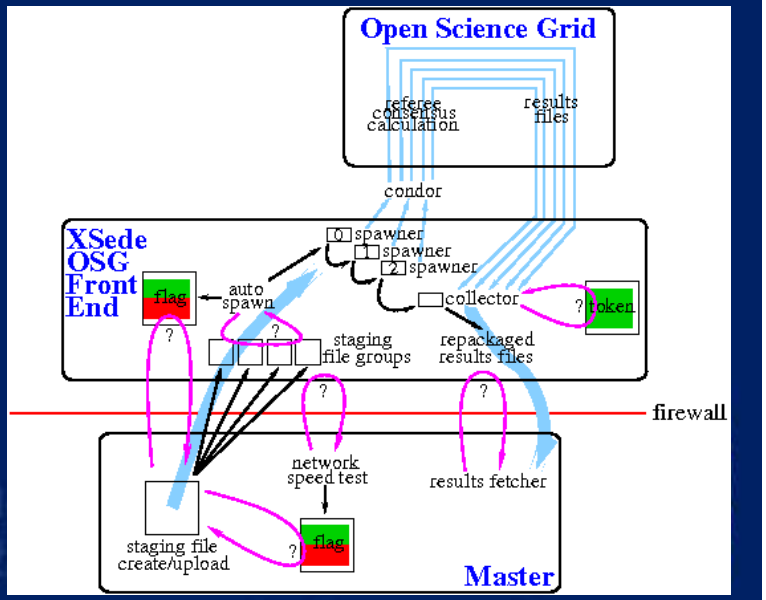
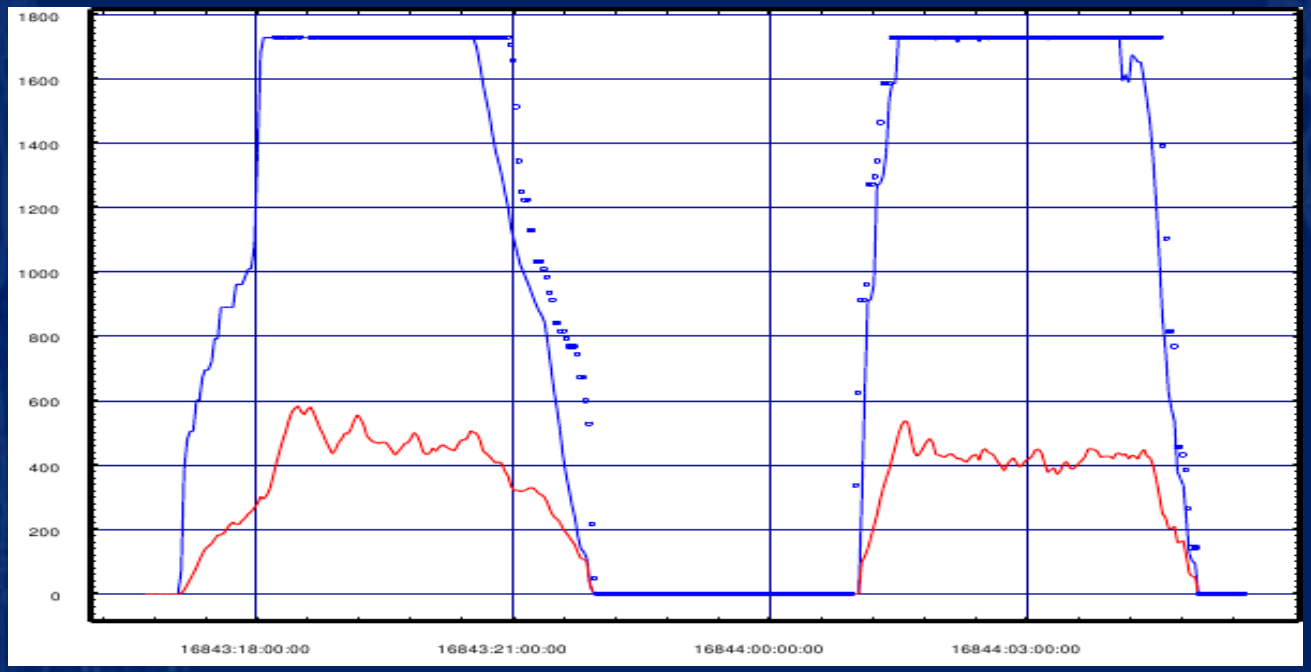
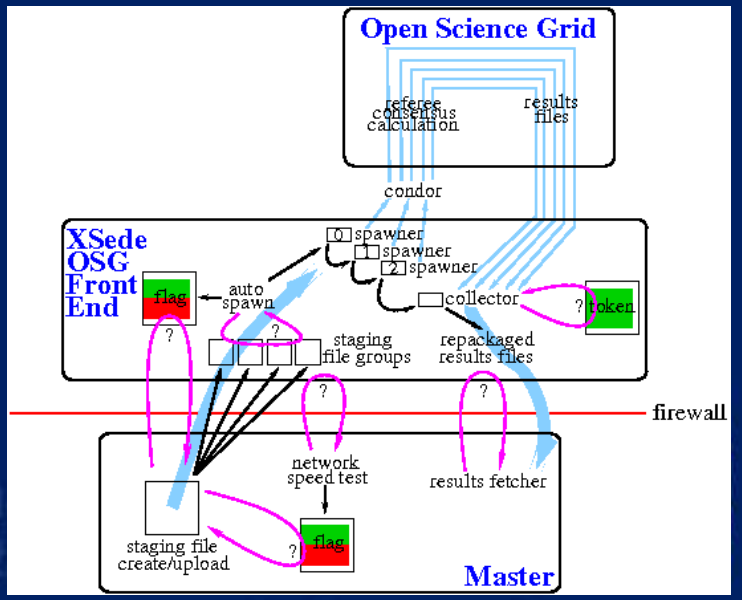


Comet booster for OSG condor pool Live Website



Blue line … # Jobs Running



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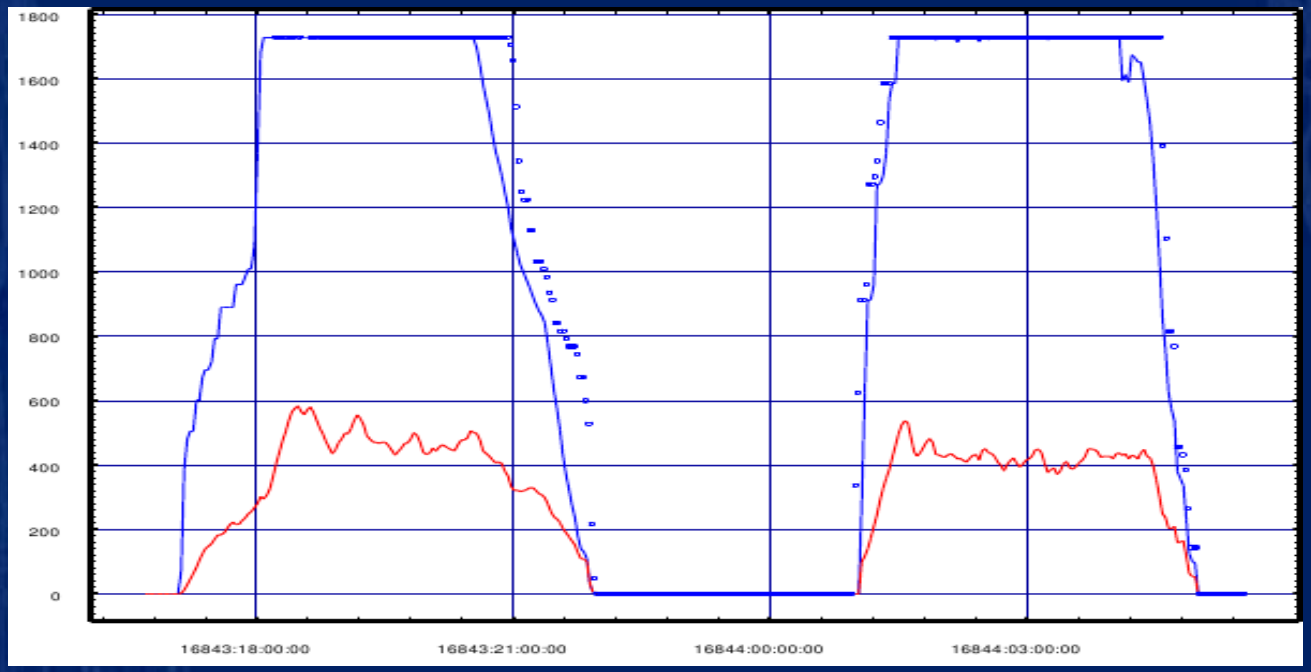

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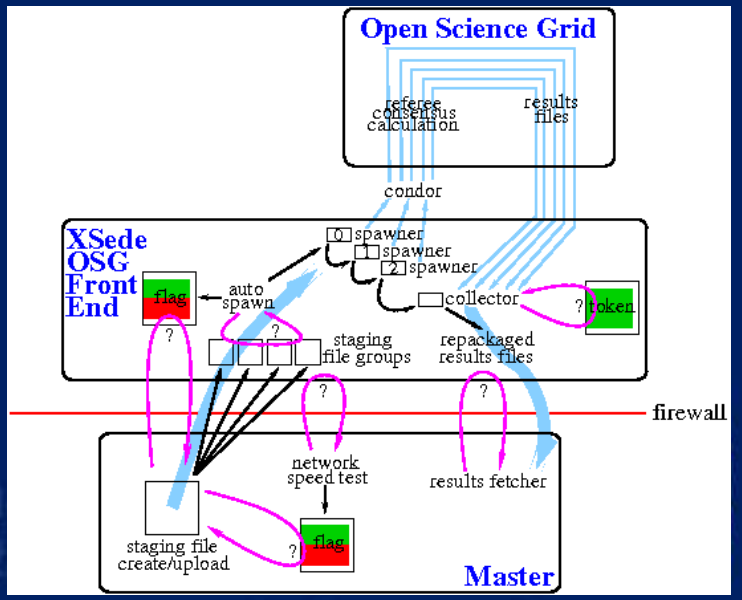
Blue dots … # Comet Glidein Job Slots



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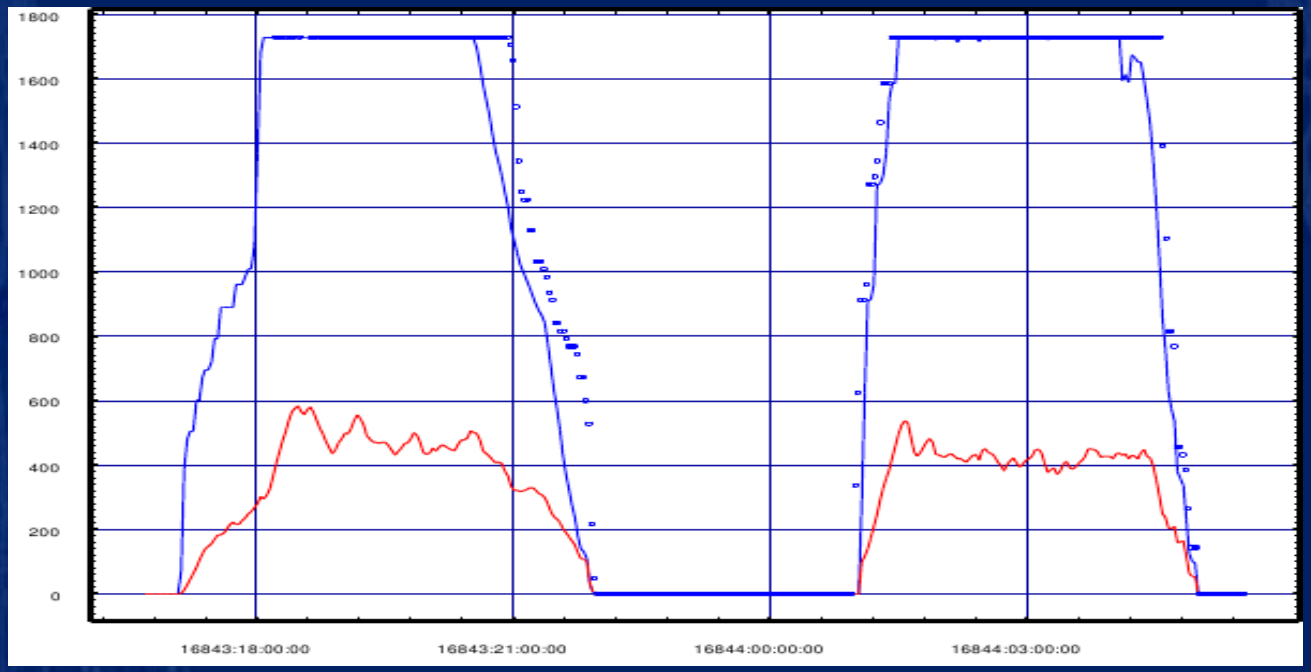

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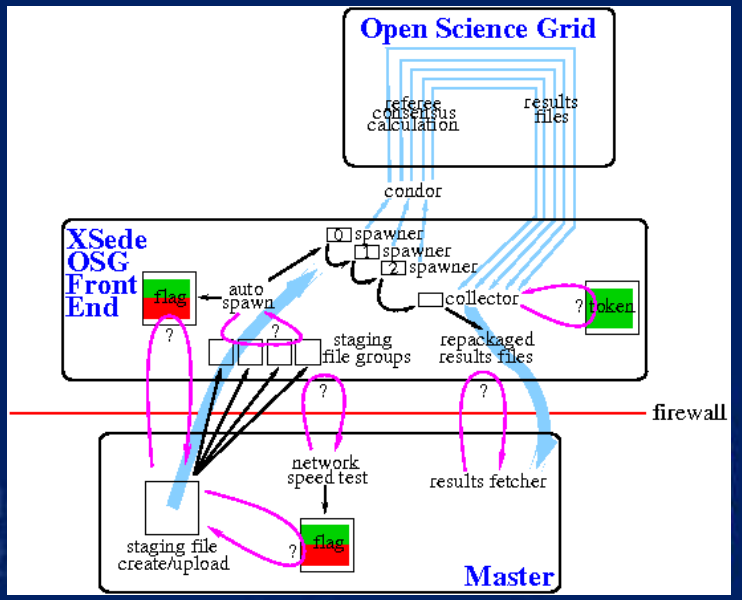
2 3-hour development runs.



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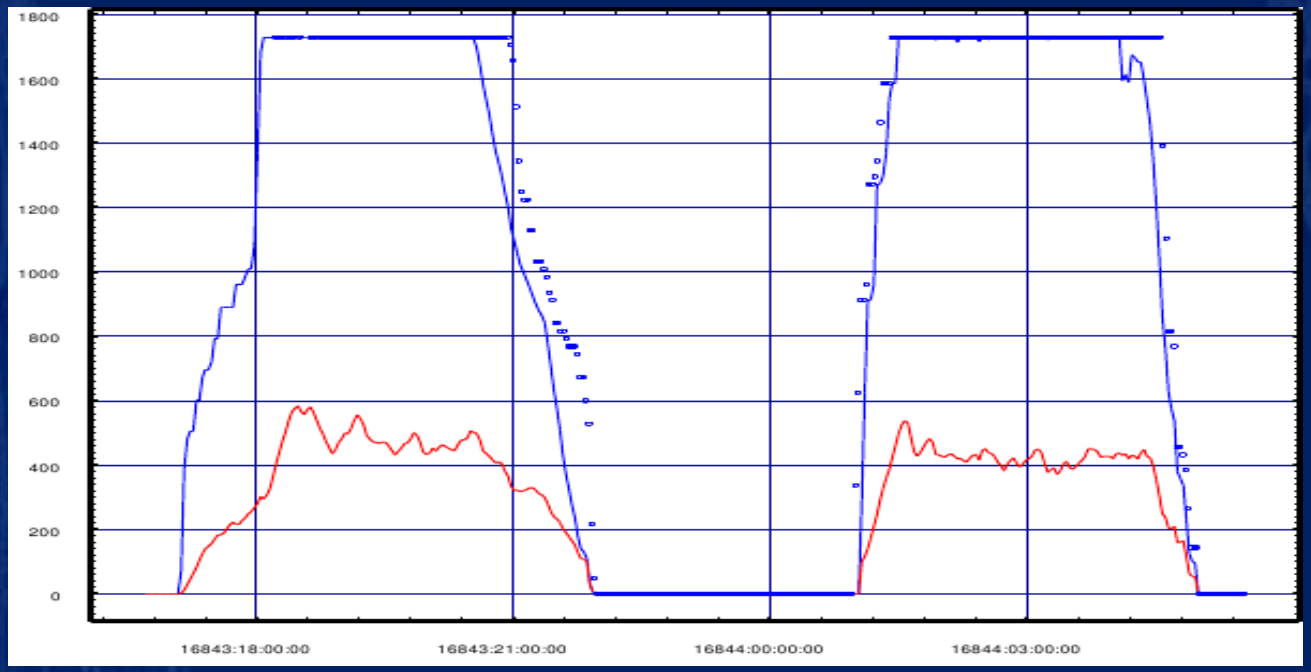

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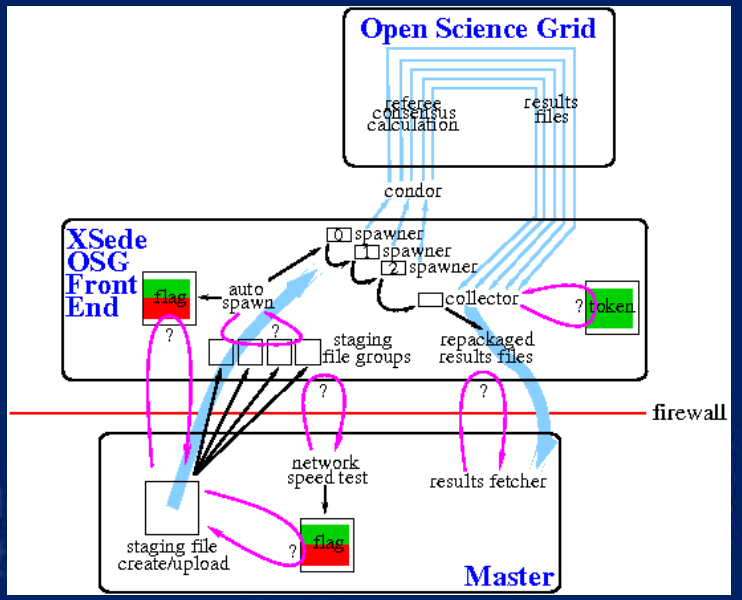

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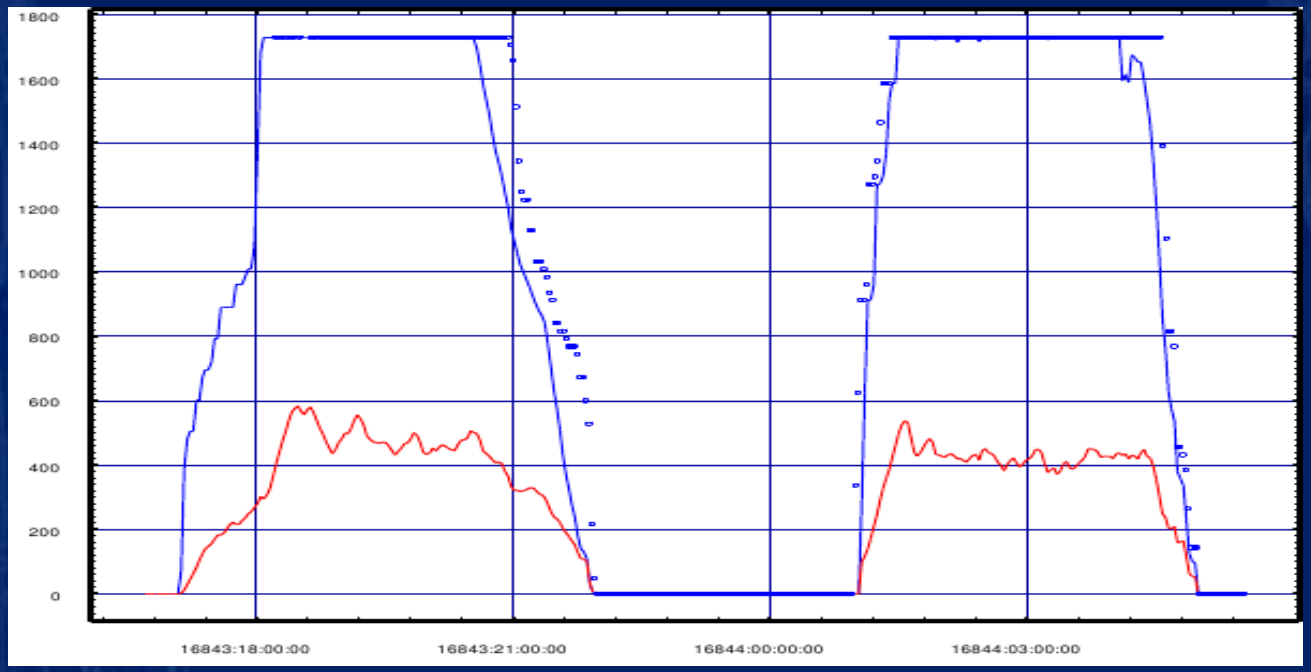

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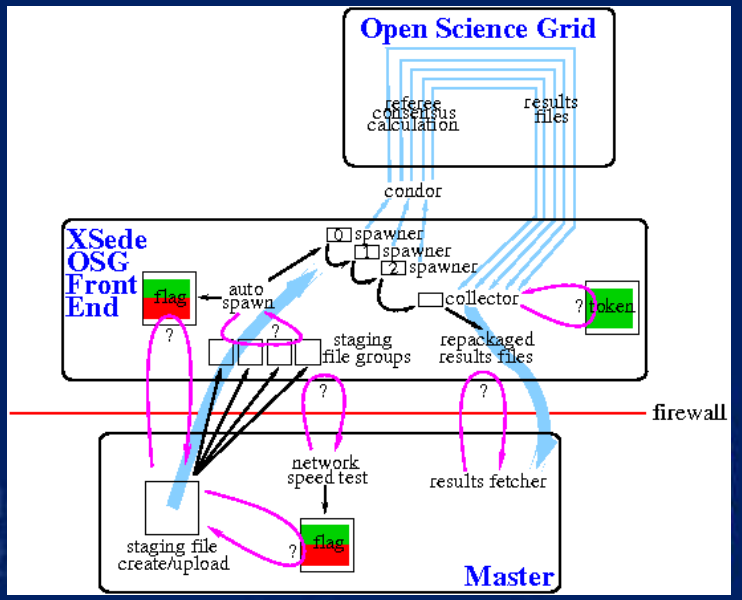
MIN_UNTIL_RETIREMENT was adjusted for the second run.



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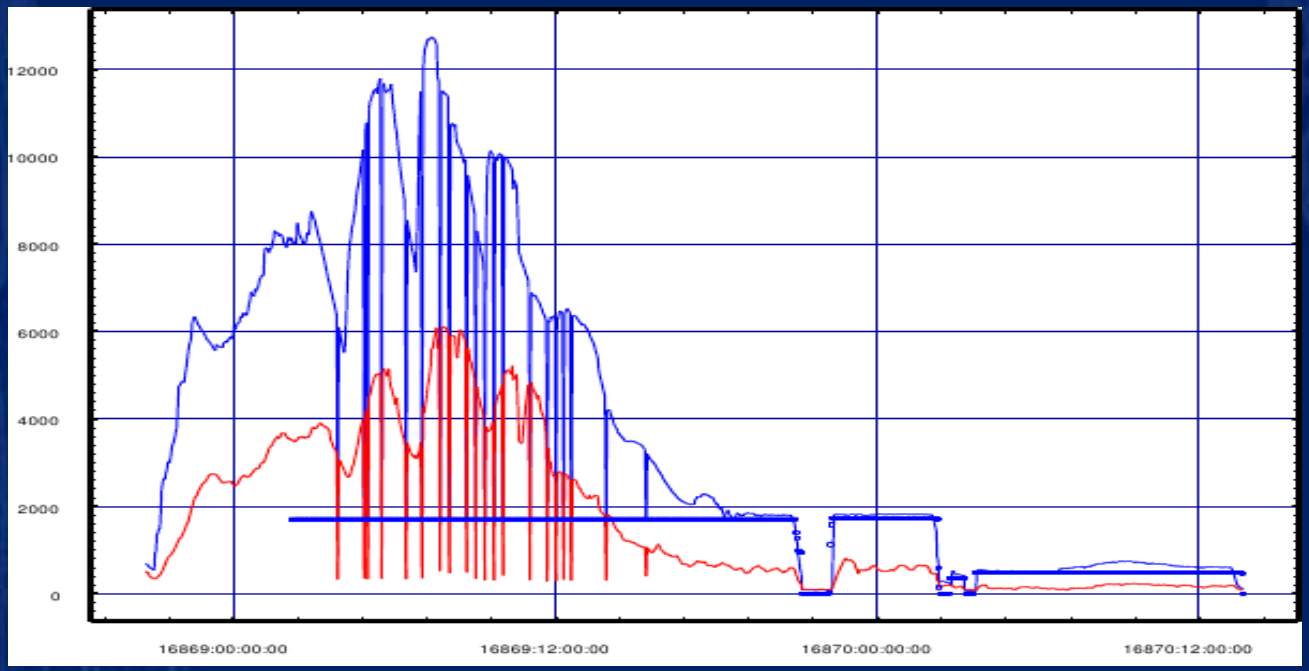

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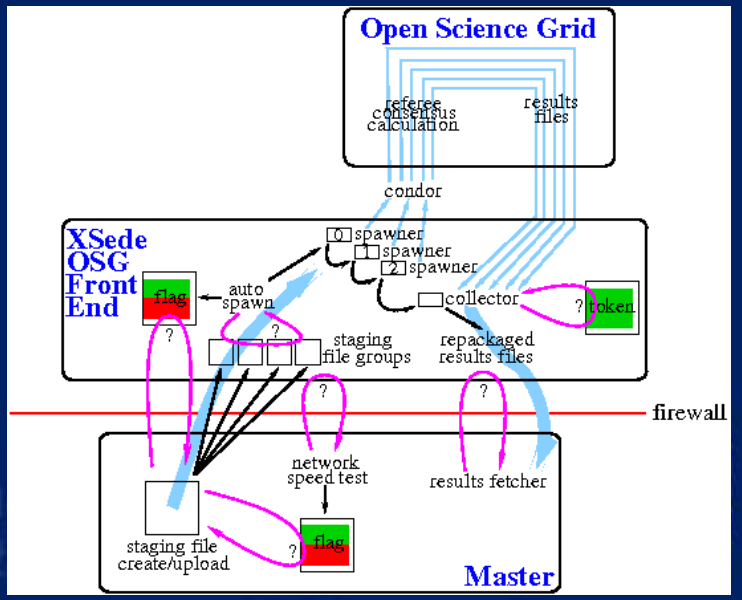

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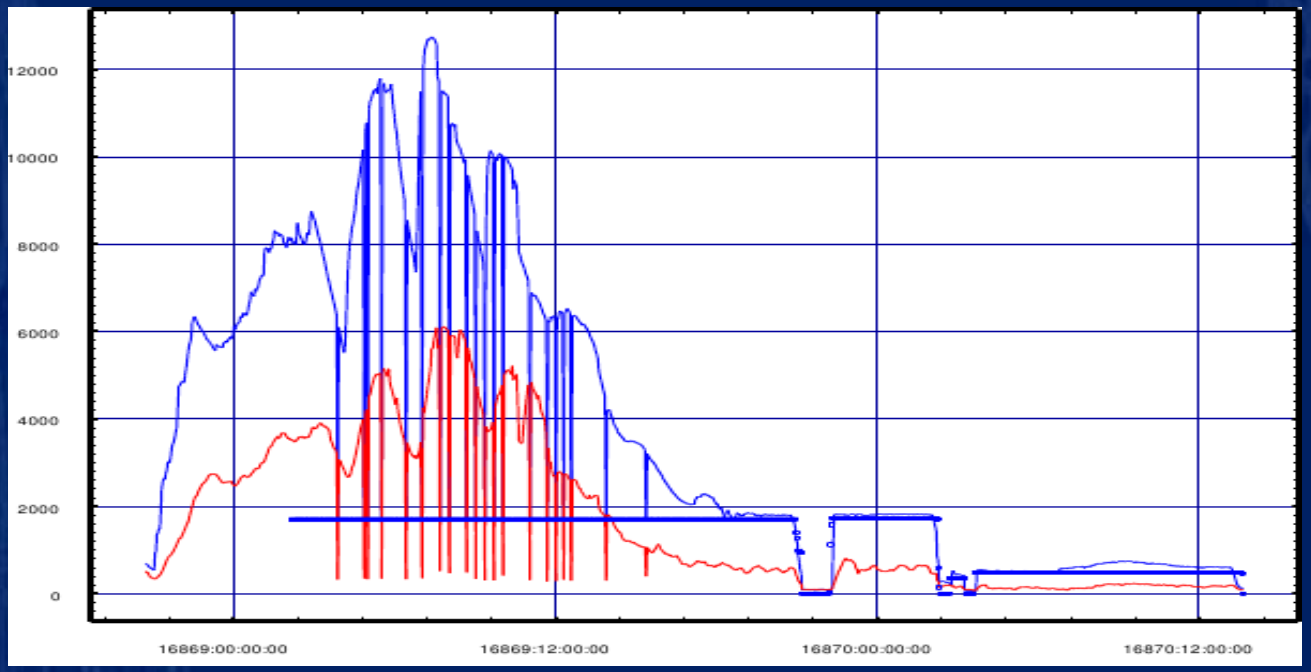

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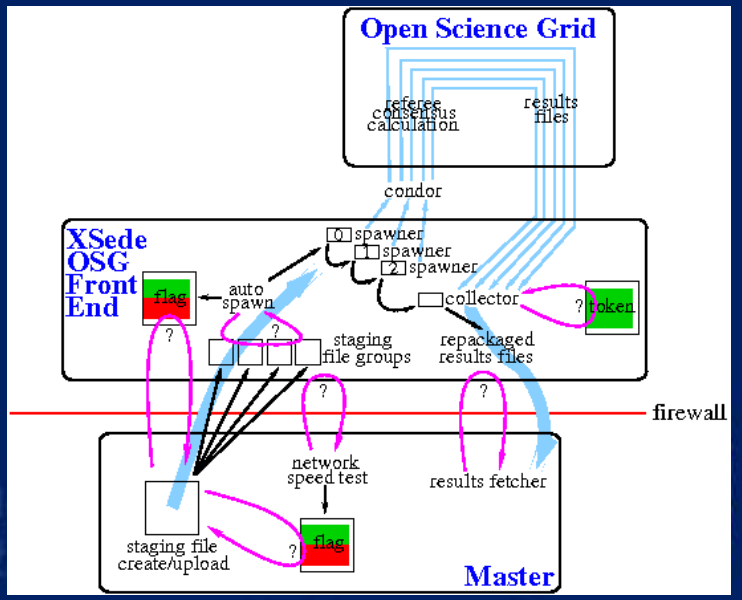
30-hour production run – 2 MEG's



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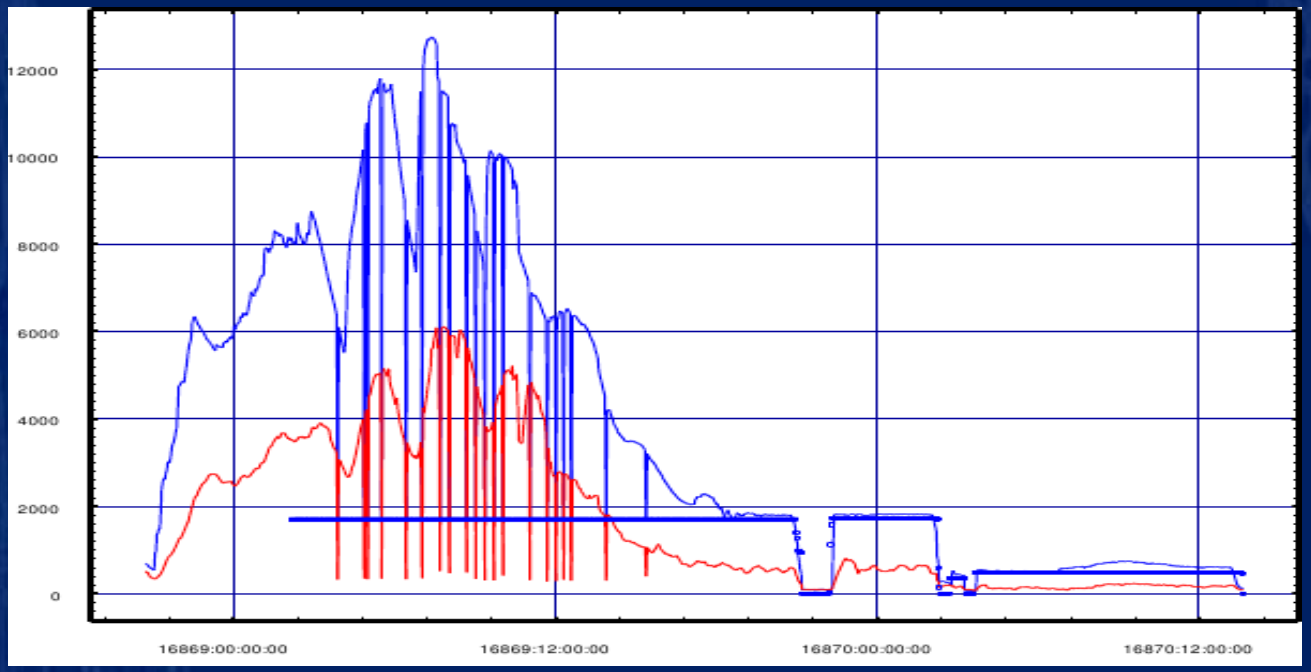

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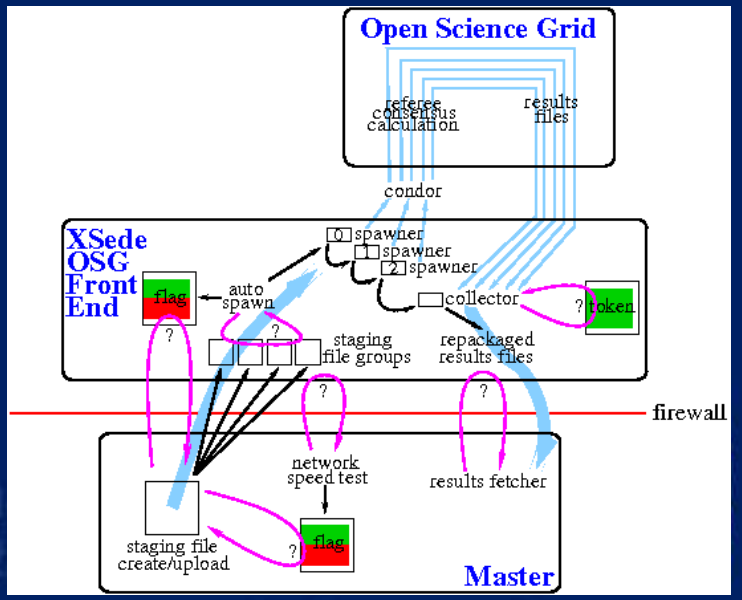
30-hour production run – 2 MEG's

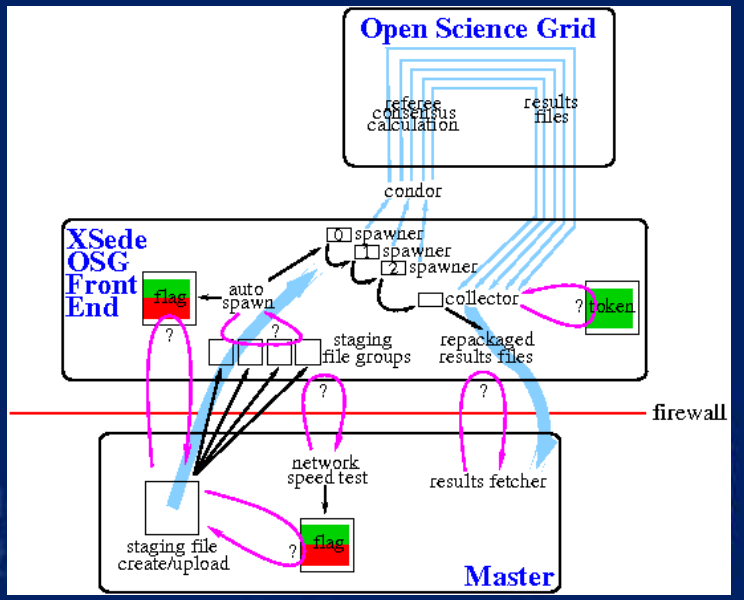
Opportunistic hours were high for 12 hours.



3

Human Neuroimaging on the Open Science Grid

1. Concussion and functional neuroimaging, a high value high demand use of the OSG.
2. Use of Comet to boost private OSG capacity for time sensitive job groups.
3. Freesurfer, a widely used brain image processing package, a high value low demand use of the OSG.



Freesurfer on the Open Science Grid

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The great majority of potential users have a modest need with consequently limited motivation.

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- Provide turn-key command line tools for one software package at a time.

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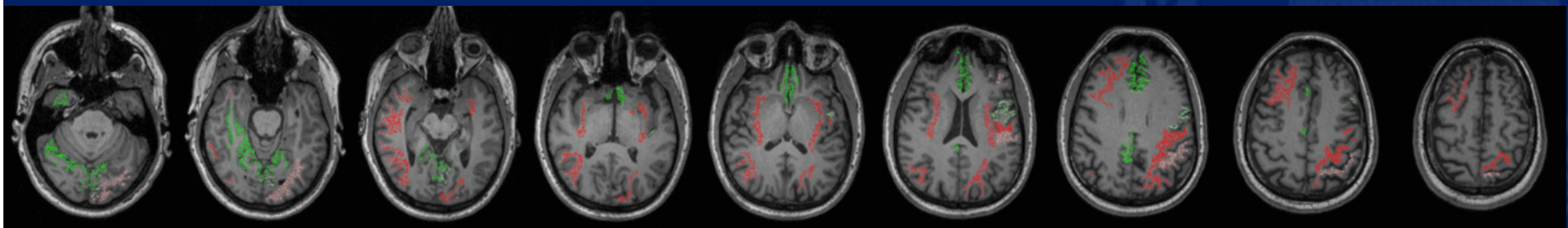
The great majority of potential users have a modest need with consequently limited motivation.

To reduce the start-up effort we are trying a simple approach:

- Provide turn-key command line tools for one software package at a time.
- We have selected a brain image processing application as a demonstration, Freesurfer (Martinos Biomedical Imaging Center, Harvard University).

Freesurfer on the Open Science Grid

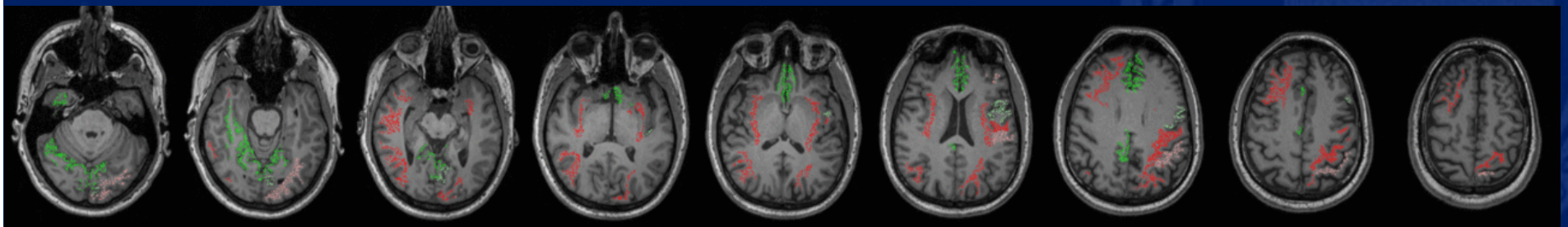


Cortical gray matter (green) vs adjacent white matter (red) differential neuroelectric activation. Regions identified with freesurfer.

The primary function of Freesurfer is readily adapted for execution on the Open Science Grid:

- Each job is fully independent.

Freesurfer on the Open Science Grid



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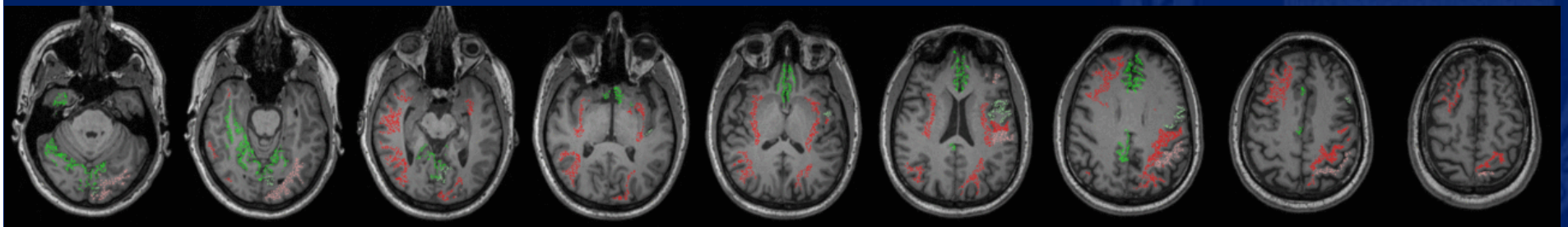

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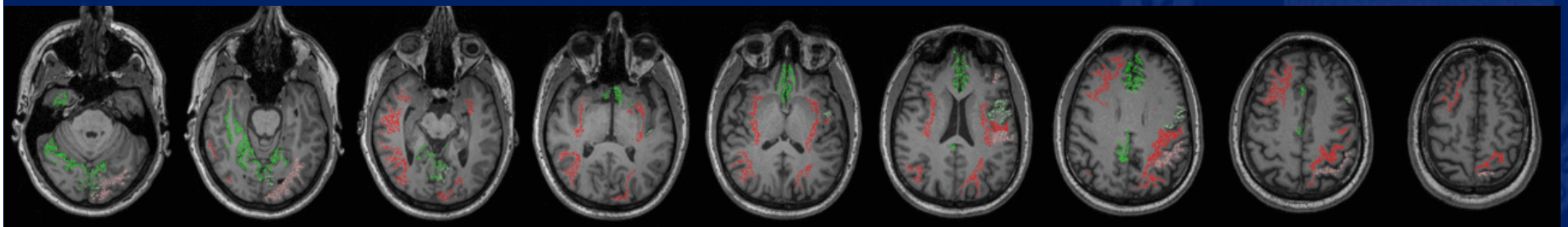
The primary function of Freesurfer is readily adapted for execution on the Open Science Grid:

- Each job is fully independent.
- Execution time: 16-24 hours (single core), 4-8 hours (multiple cores)
- Memory requirement: ~3 GBytes.

Freesurfer on the Open Science Grid



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- Input to each job: ~10 MBytes.

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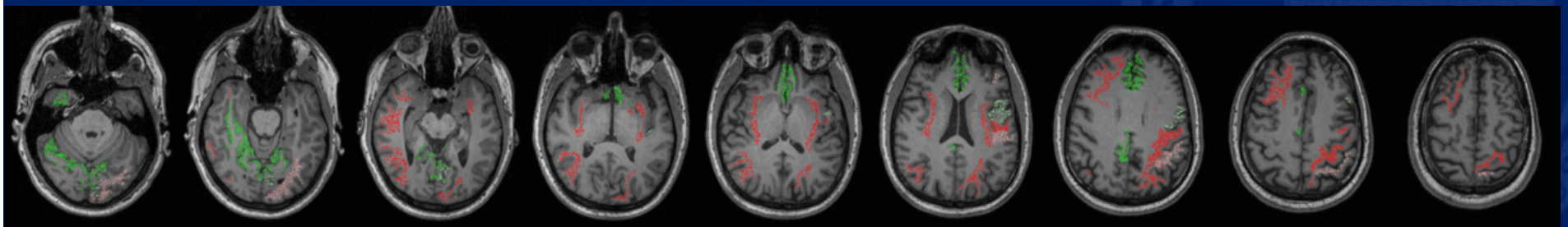

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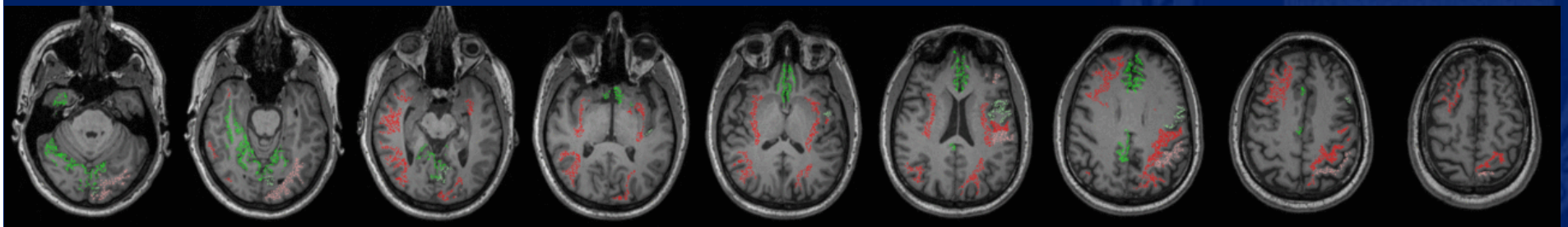
- Execution time: 16-24 hours (single core), 4-8 hours (multiple cores)
- Memory requirement: ~3 GBytes.
- Input to each job: ~10 MBytes.
- Output from each job: ~400 MBytes.

Freesurfer on the Open Science Grid



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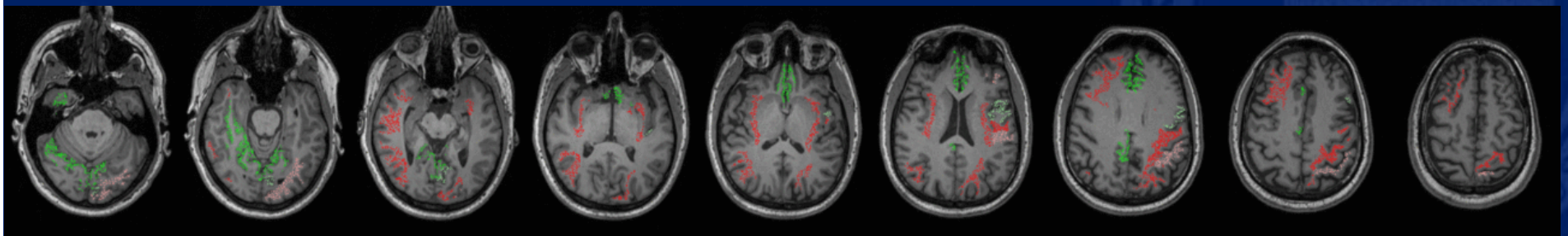

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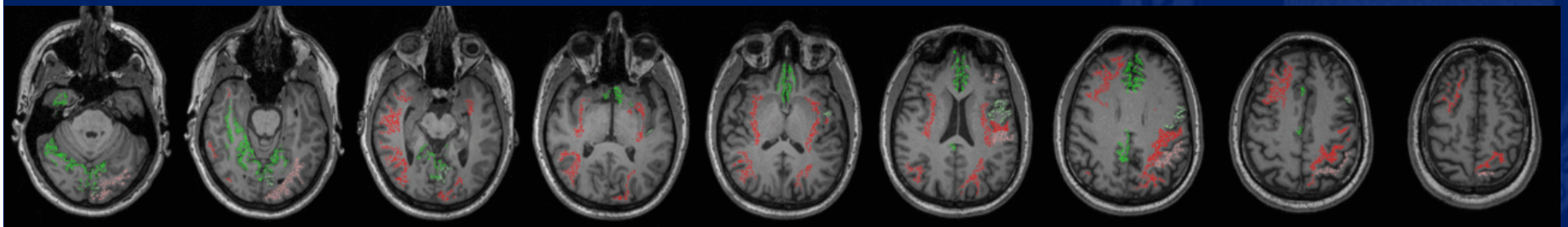
Many Freesurfer users lack sufficient computing resources and/or software expertise to install and maintain the package.

Freesurfer on the Open Science Grid



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There is a user base of at least 3,000 world-wide.

Freesurfer on the Open Science Grid

Our demonstration effort has produced turn-key command line tools usable either from the osgconnect remote client or from the osgconnect submit host:

Freesurfer on the Open Science Grid

```
fsurf –submit   –subject MRN_1 –dir INPUT_DIRECTORY                ;# 4-8 hours
fsurf –submit   –subject MRN_1 –dir INPUT_DIRECTORY –dualcore      ;# 11-16 hours
```

Our demonstration effort has produced turn-key command line tools usable either from the osgconnect remote client or from the osgconnect submit host:

- Submit a Freesurfer job to the grid.

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fsurf –list
fsurf –status   –subject MRN_1
```

Our demonstration effort has produced turn-key command line tools usable either from the osgconnect remote client or from the osgconnect submit host:

- Submit a Freesurfer job to the grid.
- Monitor job status.

Freesurfer on the Open Science Grid

```
fsurf –submit   –subject MRN_1 –dir INPUT_DIRECTORY                ;# 4-8 hours
fsurf –submit   –subject MRN_1 –dir INPUT_DIRECTORY –dualcore   ;# 11-16 hours
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fsurf –status    –subject MRN_1
fsurf –output   –subject MRN_1
fsurf –remove –subject MRN_1
```

Our demonstration effort has produced turn-key command line tools usable either from the osgconnect remote client or from the osgconnect submit host:

- Submit a Freesurfer job to the grid.
- Monitor job status.
- Fetch the results when complete.

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Benchmark testing has been completed for several data flows and for a range of core counts.

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Results will be validated for the range of RHEL versions running on the OSG including a very early and very recent one.

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Alpha user testing is complete.

Beta user testing and feedback will be by computer support people with little or no knowledge of the project.

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Alpha user testing is complete.

Beta user testing and feedback will be by computer support people with little or no knowledge of the project.

Final testing and feedback will be by members of the Freesurfer group.

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