

Motion-Compensated Neuroanatomical Imaging

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Motion-compensated MRI sequences allow you to image subjects ***even if they move***, without discarding scans and rescanning.

There are two basic types of motion-compensation:

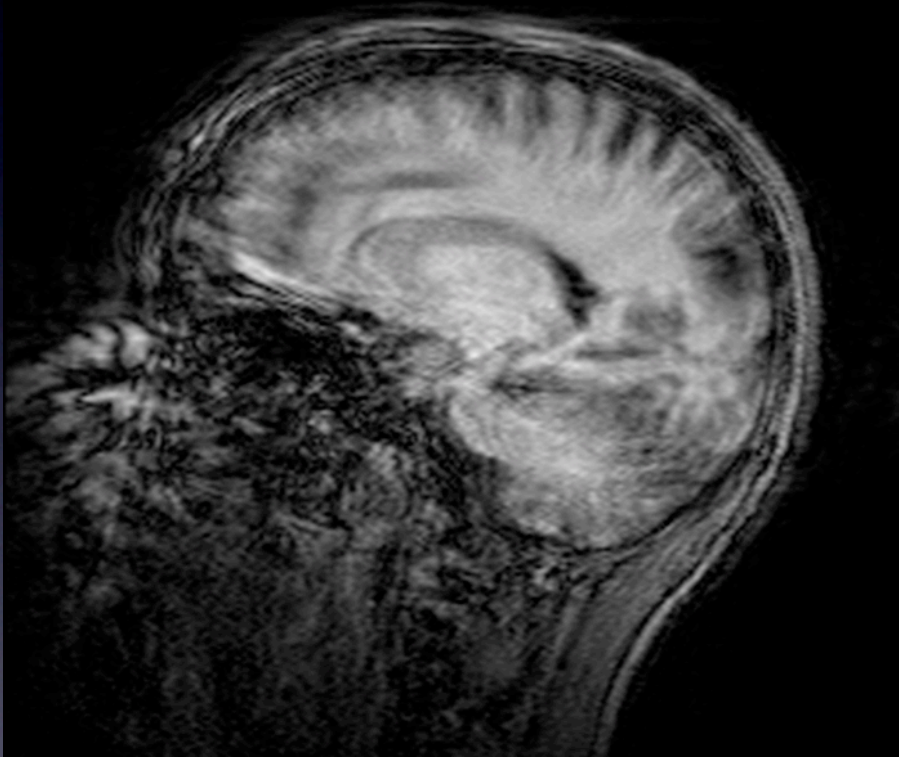
Retrospective

Post-process to estimate data that would have been measured if the subject hadn't moved.
Examples: PROPELLER, SNAILS

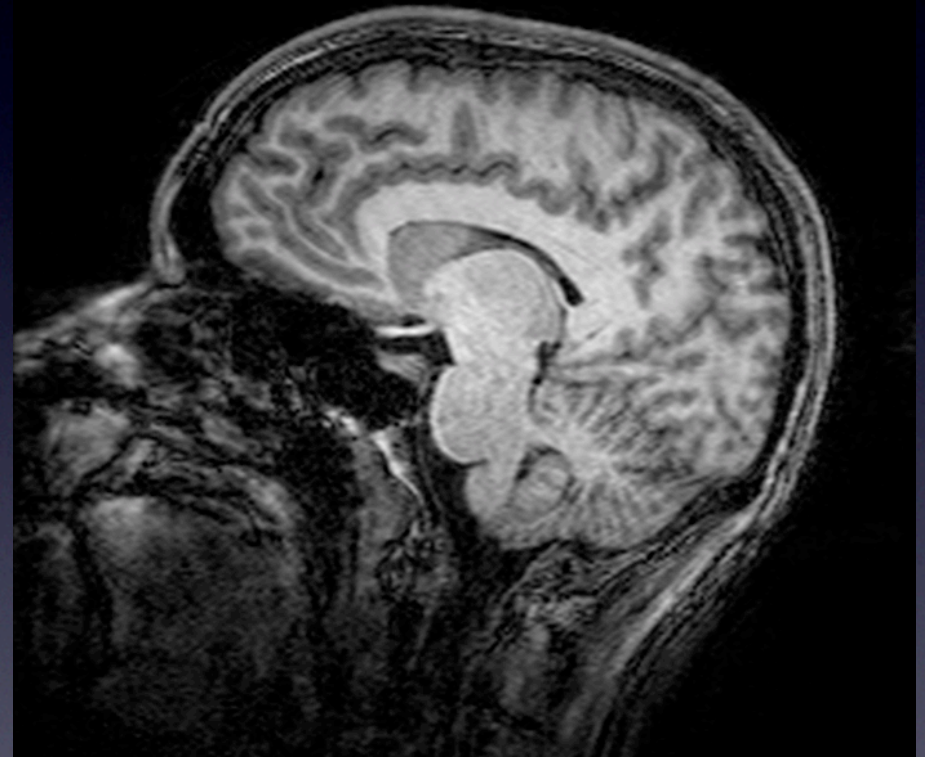
Prospective

Track the subject and alter the acquisition “on-the-fly” to account for subject motion.
Examples: PACE, vNavs, PROMO

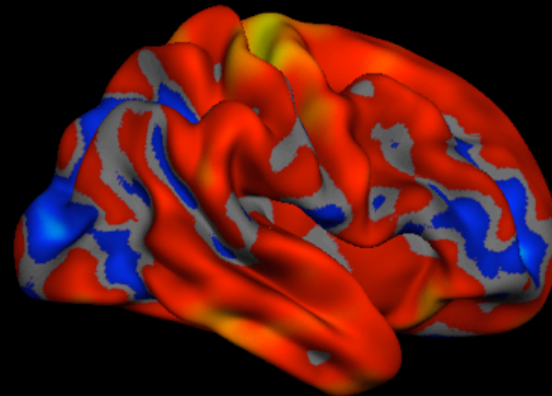
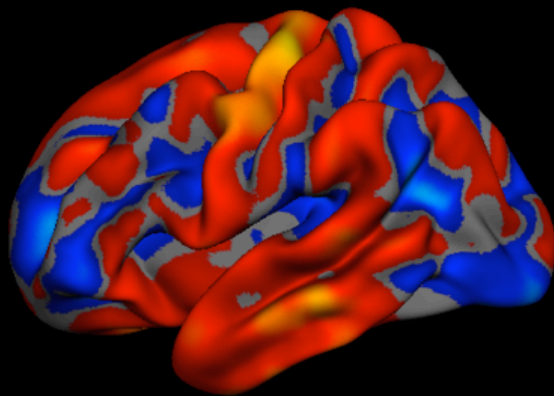
MPRAGE of subject prompted to
change position every 45 seconds



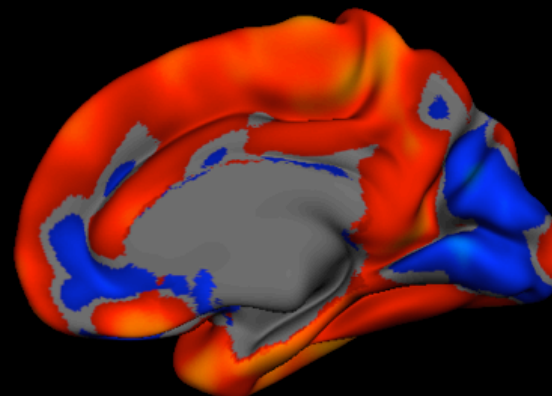
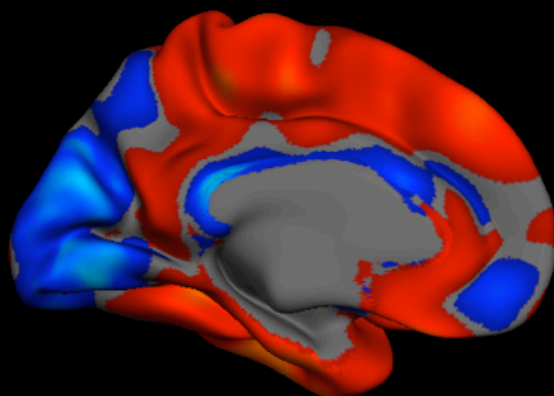
without prospective moco

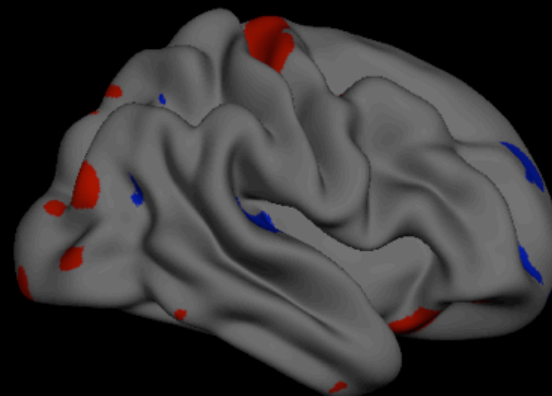
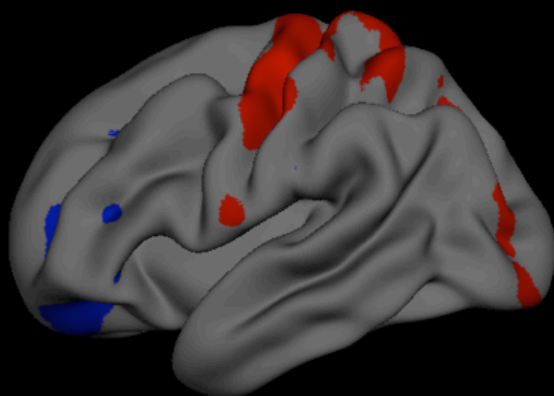


with prospective moco

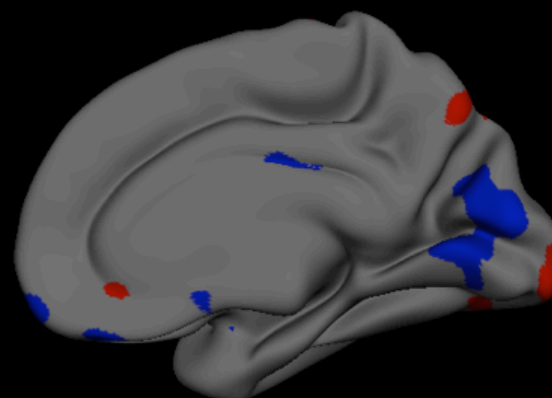
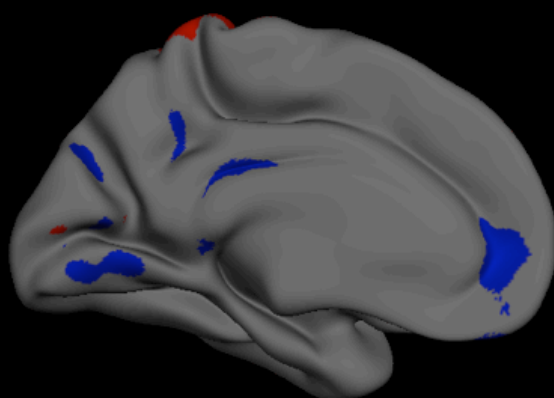


No Motion vs. Motion
Red/Yellow thinning, Blue thickening with motion
Yellow: 30% thinning





No Motion vs. Motion Correction Re-Aquisition
Red/Yellow thinning, Blue thickening with motion
Yellow: 30% thinning



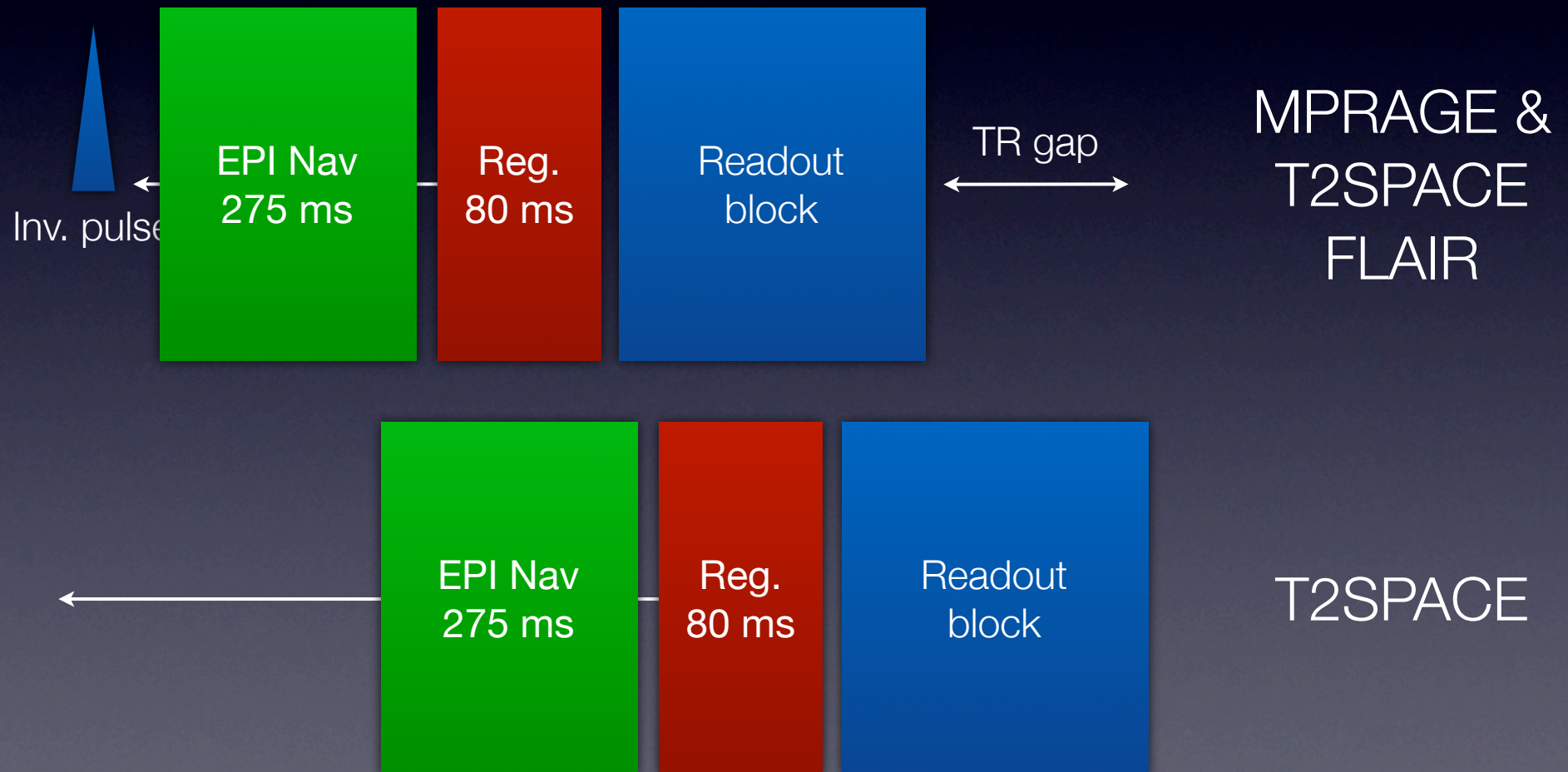
Who should use these sequences? Everyone!

- Our vNav sequences are available now on Siemens scanners (WIP 711).
- Other groups are developing similar techniques on GE scanners (e.g., PROMO).

Overview

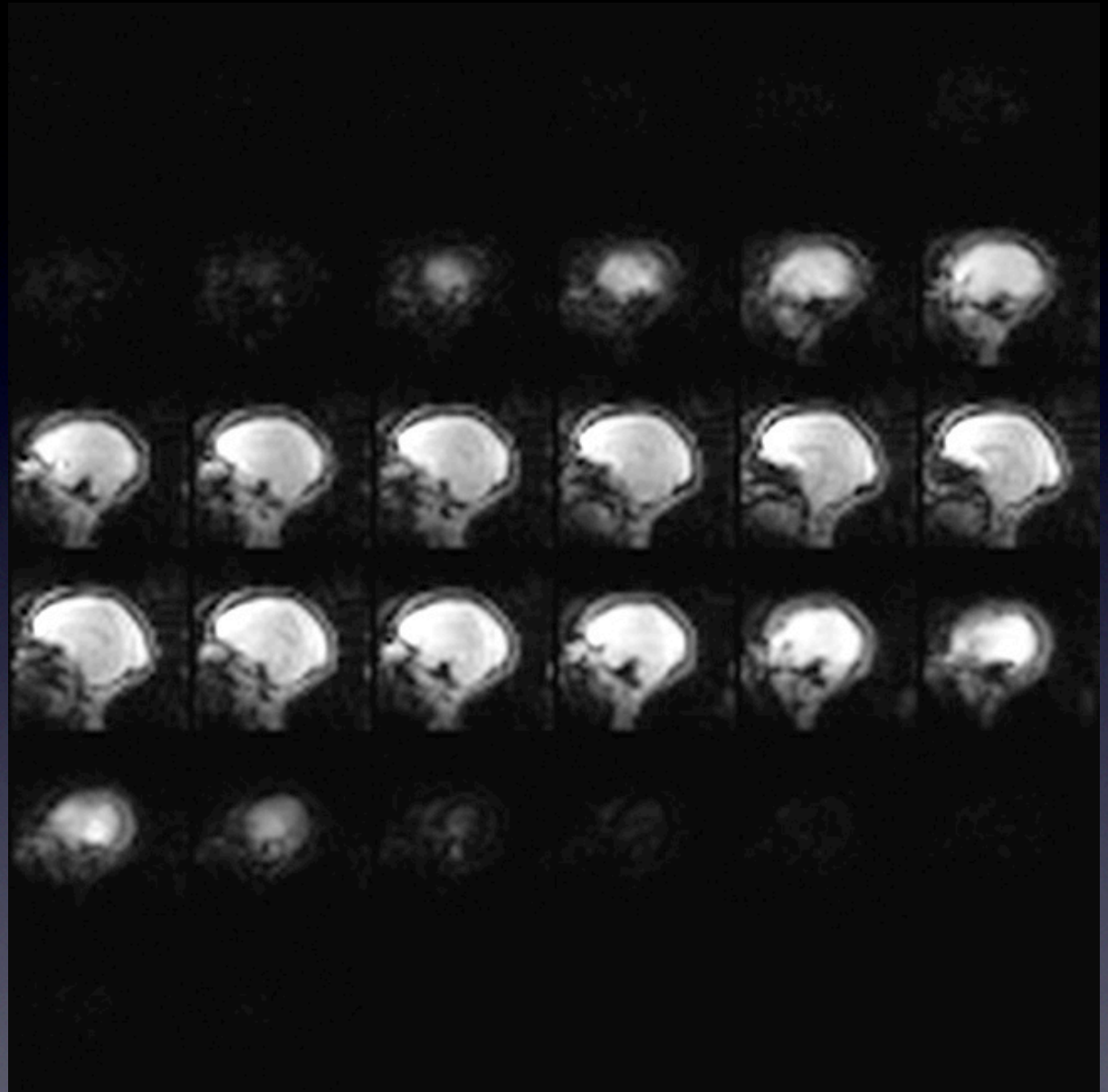
- **Following the subject:**
EPI-navigated prospective motion correction
- **More motion-resistance:**
automatic retrospective reacquisition
- **Using FreeSurfer for validation:**
longitudinal, cross-contrast analysis

A single TR
+ EPI Navigator
+ Registration and Feedback
= updated imaging coordinates

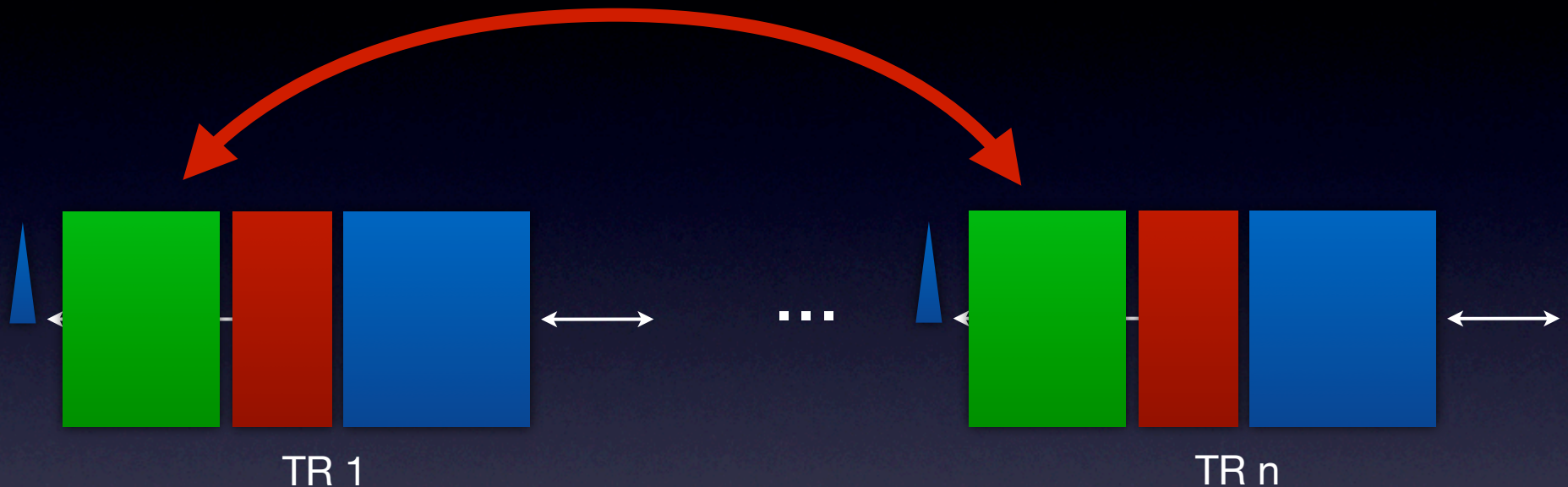


The Navigator

- 32^3 EPI
- 8 mm iso
- 256 mm FOV
- 25 shots
- TE 5.2 ms,
TR 11 ms
- ~ **275 ms**



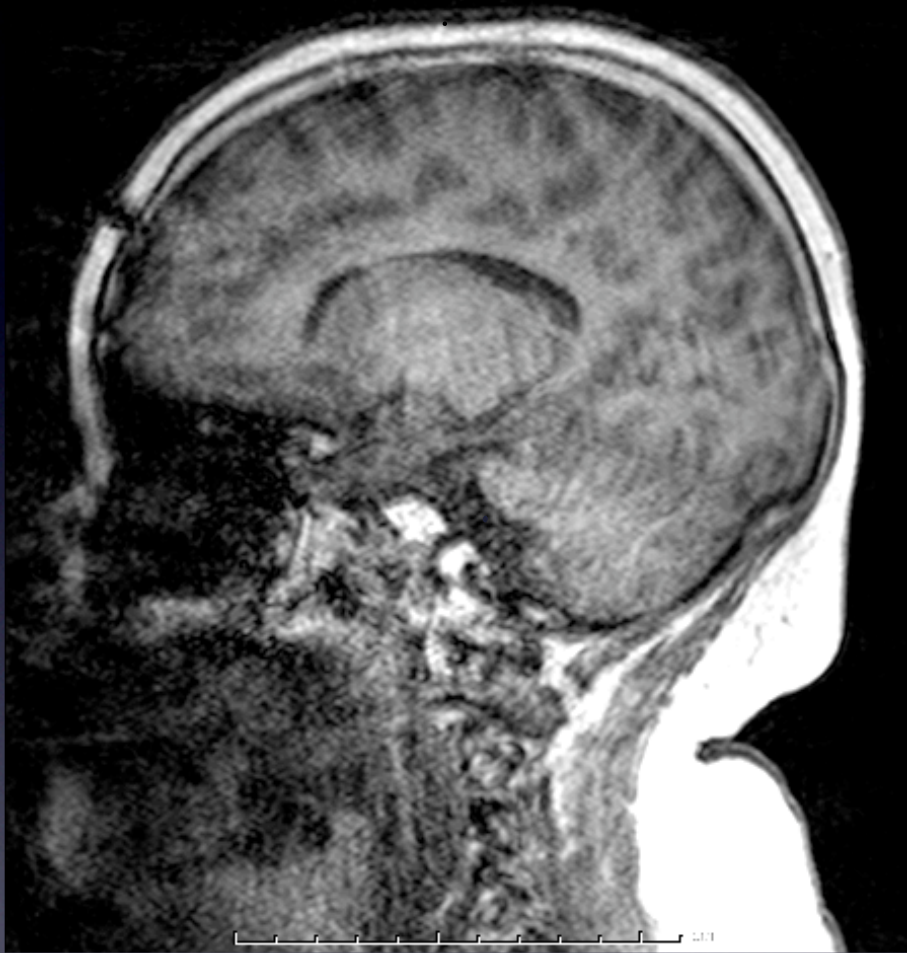
Register each EPI nav volume
back to first TR using Siemens'
PACE registration algorithm.



At 3T, observed variance of 50 microns with stationary subject (a pineapple).

Accuracy estimated to be **better than 300 microns** in real-world examples.

Unsedated pediatric multi-echo MPRAGE



without moco or navs



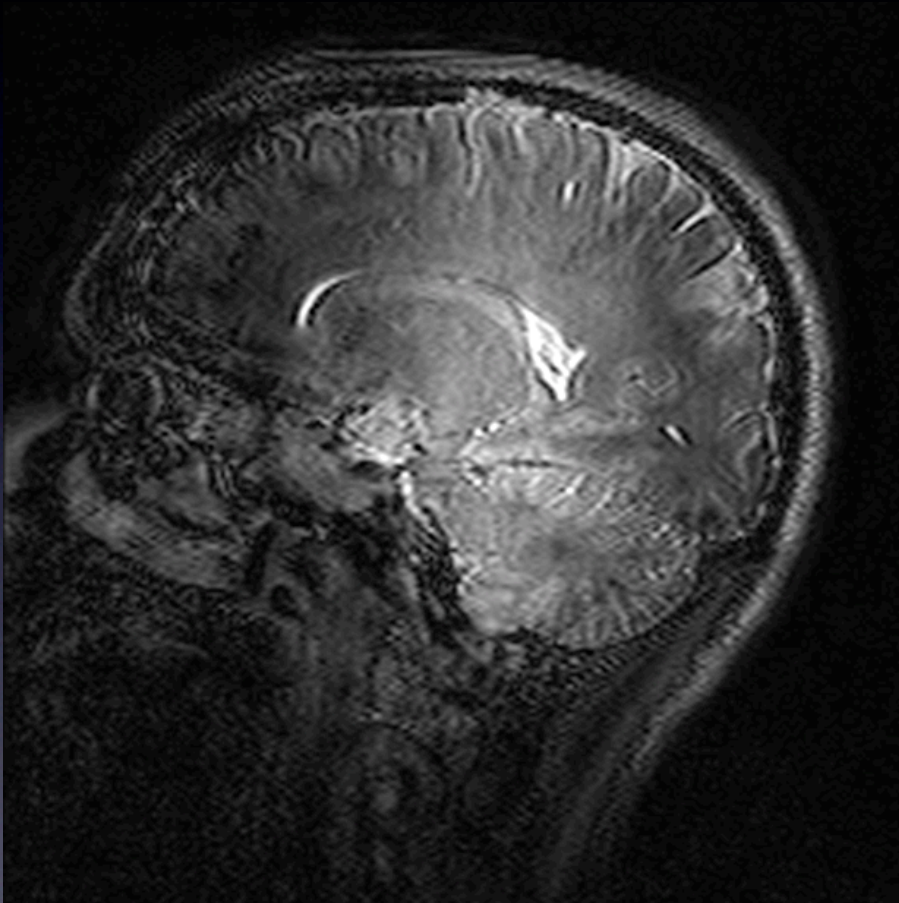
with navs and moco

Images courtesy of Ellen Grant, Children's Hospital Boston

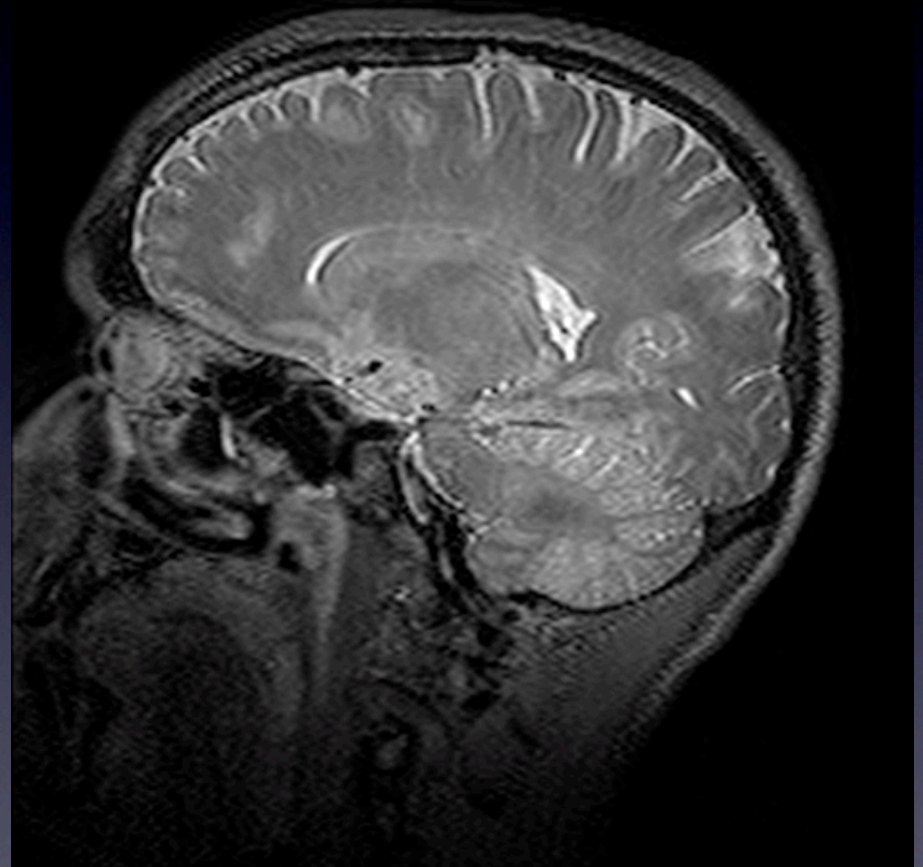
Overview

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T2SPACE corrupted by 20 seconds of free motion during acquisition of center of k-space

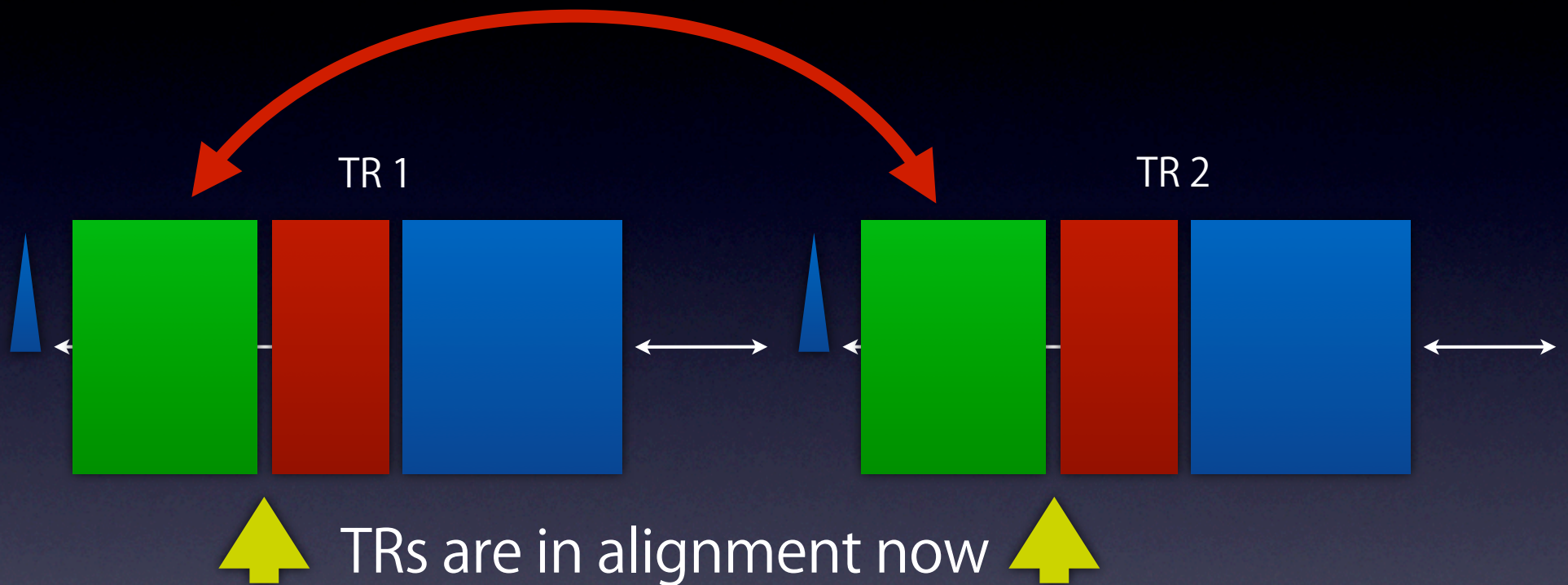


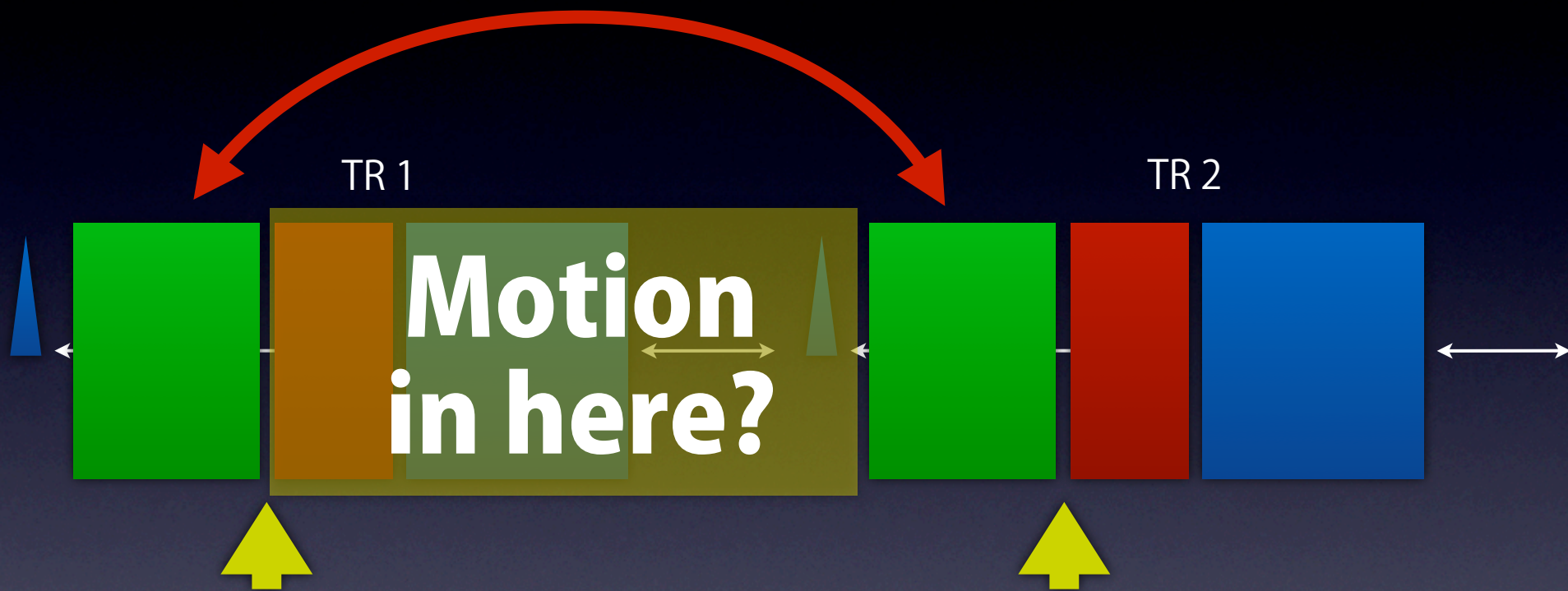
w/ moco
w/o reacquisition



w/ moco
w/ 10 TRs reacquired

Register each EPI nav volume
back to first TR using Siemens'
PACE registration algorithm.

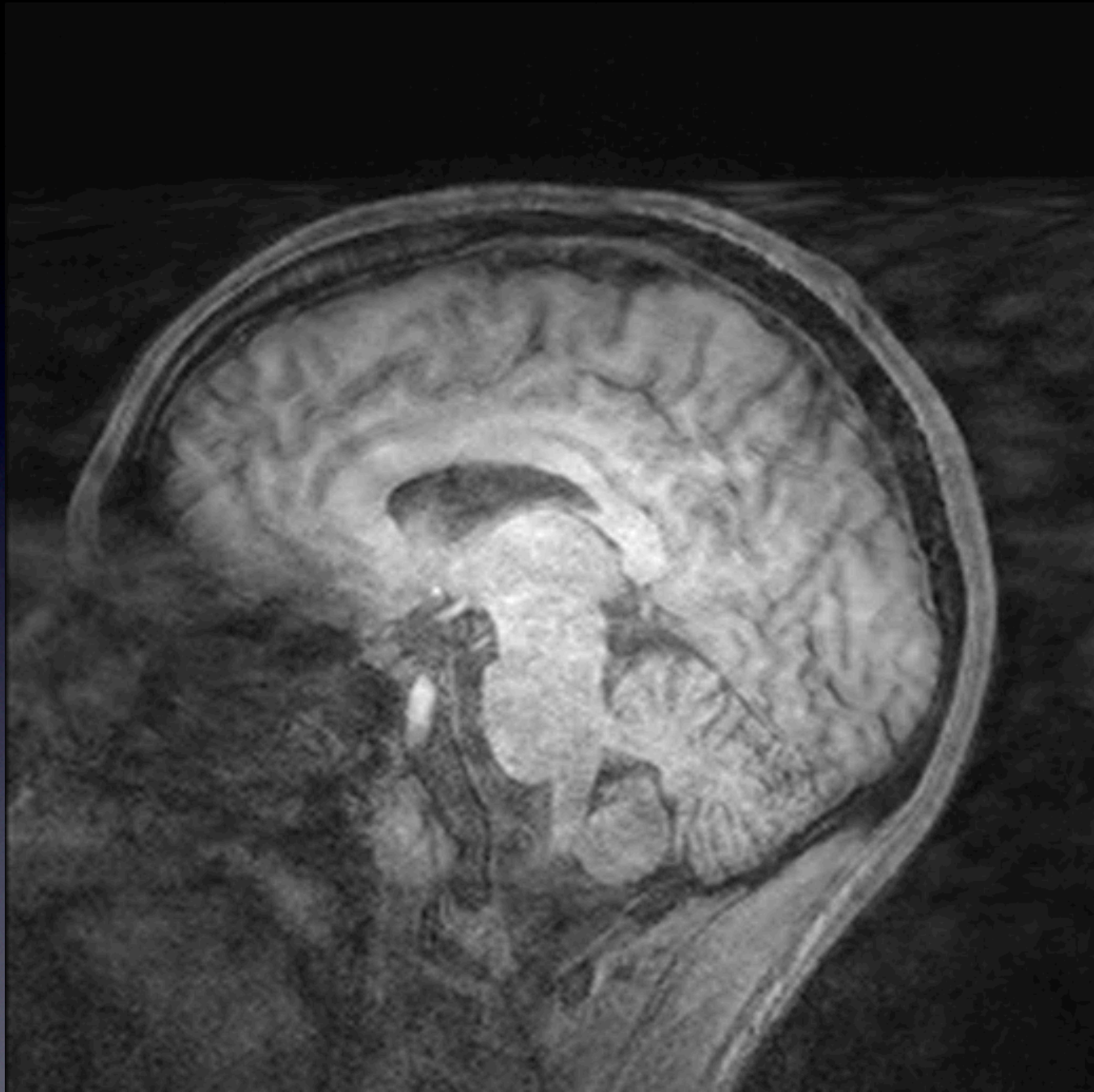




Users configure the number of TRs to reacquire as part of their protocol.

The screenshot displays a software interface with a top navigation bar containing tabs: 'Part 1', 'Part 2', 'Special', and an unlabeled tab. The 'Special' tab is currently selected. Below the tabs, the interface is divided by a vertical blue line. On the left side of this line, there are three settings: 'Add. scale factor' with a value of 1.0, 'Remeasure' with a value of 0, and 'Apply motion correction' with a checked checkbox. The 'Remeasure' field and its associated 'TRs' label are enclosed in a red rectangular box. On the right side of the vertical line, there is a horizontal green bar representing a scale from 0 to 1000, with the label 'Remeasure' positioned above it. At the bottom of the interface, there is a row of tabs: 'Routine', 'Contrast', 'Resolution', 'Geometry', 'System', 'Physio', 'Inline', and 'Sequence'.

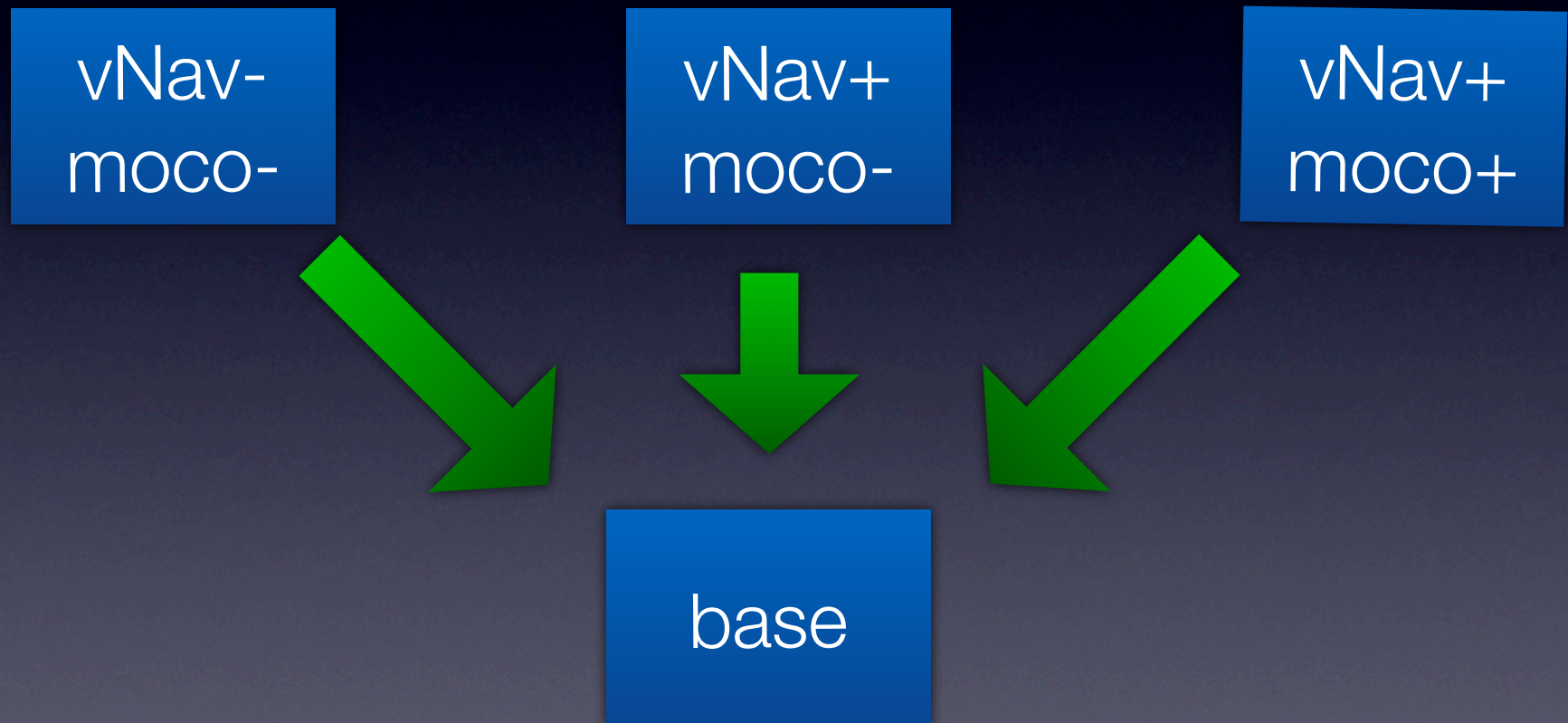
Part 1	Part 2	Special	
Add. scale factor 1.0			
Remeasure 0 TRs			
Apply motion correction <input checked="" type="checkbox"/>			
Remeasure 0 1000			
Routine	Contrast	Resolution	Geometry System Physio Inline Sequence



Overview

- **Following the subject:**
EPI-navigated prospective motion correction
- **More motion-resistance:**
automatic retrospective reacquisition
- **Using FreeSurfer for validation:**
longitudinal, cross-contrast analysis

“Longitudinal” analysis of same-subject, same-day, motion-free T1 scans without navigators, with navigators but without motion-correction, and with navigators and motion-correction.



longitudinal stream

“Longitudinal” analysis of same-subject, same-day, motion-free T1 scans without navigators, with navigators but without motion-correction, and with navigators and motion-correction.

vNav-
moco-

vNav+
moco-

vNav+
moco+

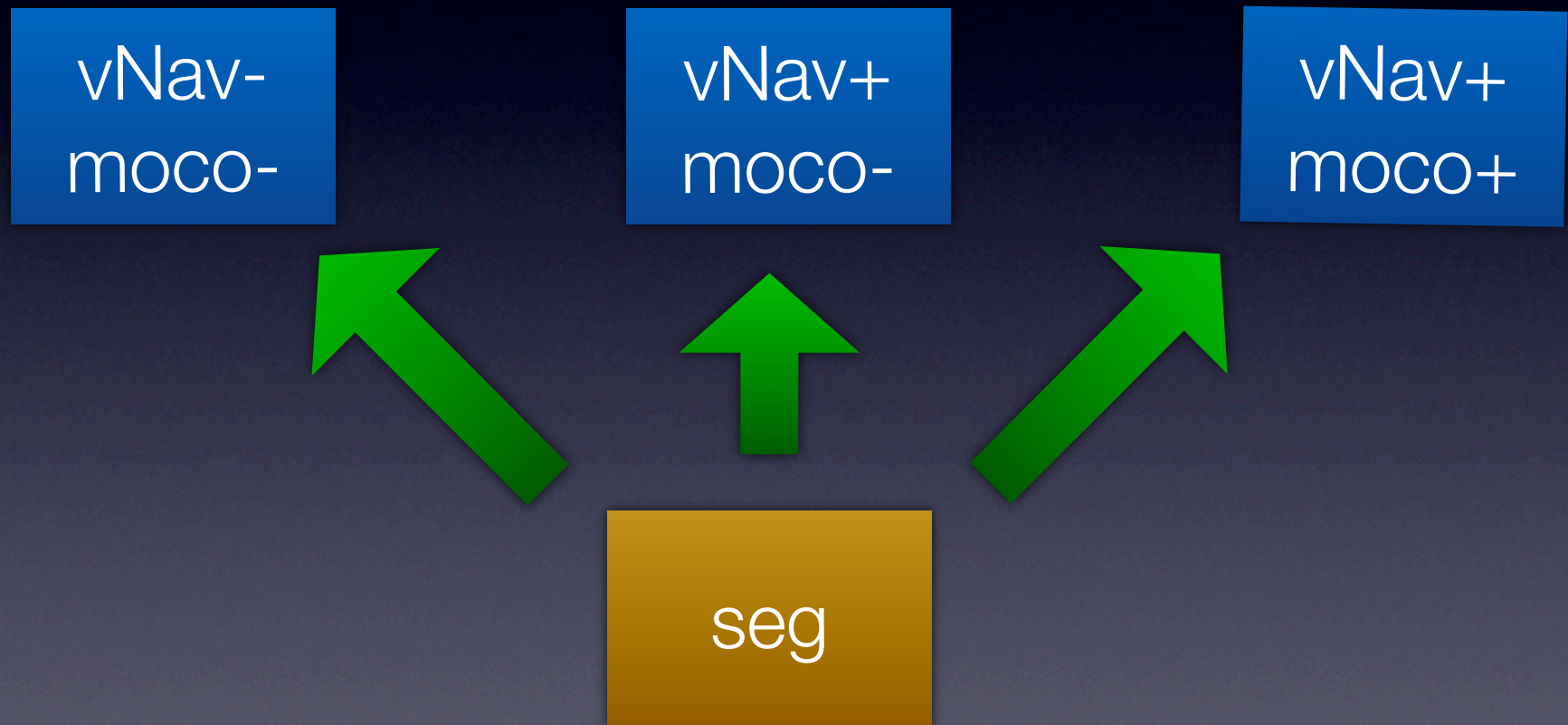
base



seg

longitudinal stream

“Longitudinal” analysis of same-subject, same-day, motion-free T1 scans without navigators, with navigators but without motion-correction, and with navigators and motion-correction.



now we have voxel-wise equivalence

Registration of same-subject, same-day, with-motion T1 scans to a fully segmented same-subject, same-day, without-motion T1 scan.

motion-
vNav-

motion+
vNav+

motion+
vNav-

Registration of same-subject, same-day, with-motion T1 scans to a fully segmented same-subject, same-day, without-motion T1 scan.

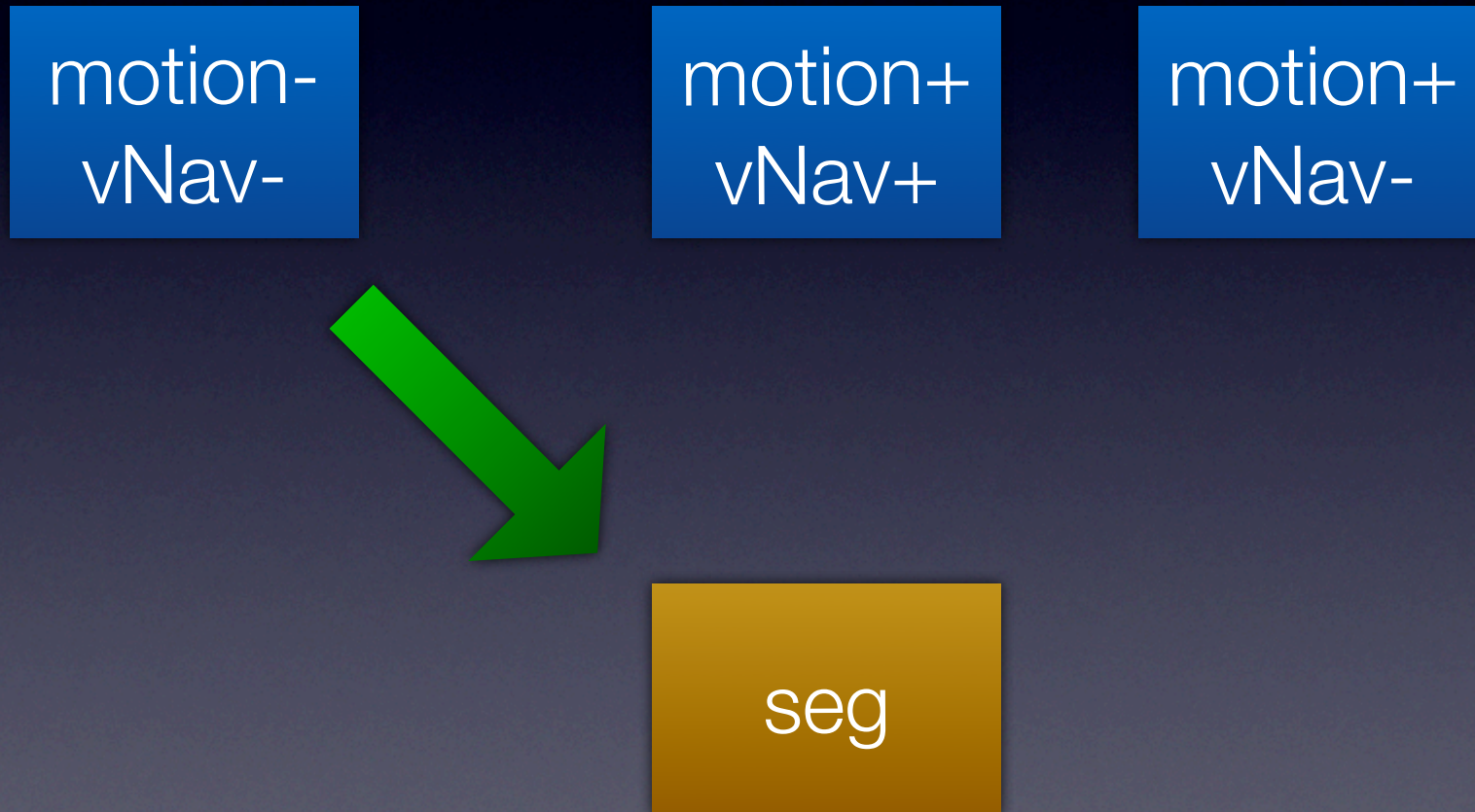
motion-
vNav-

motion+
vNav+

motion+
vNav-

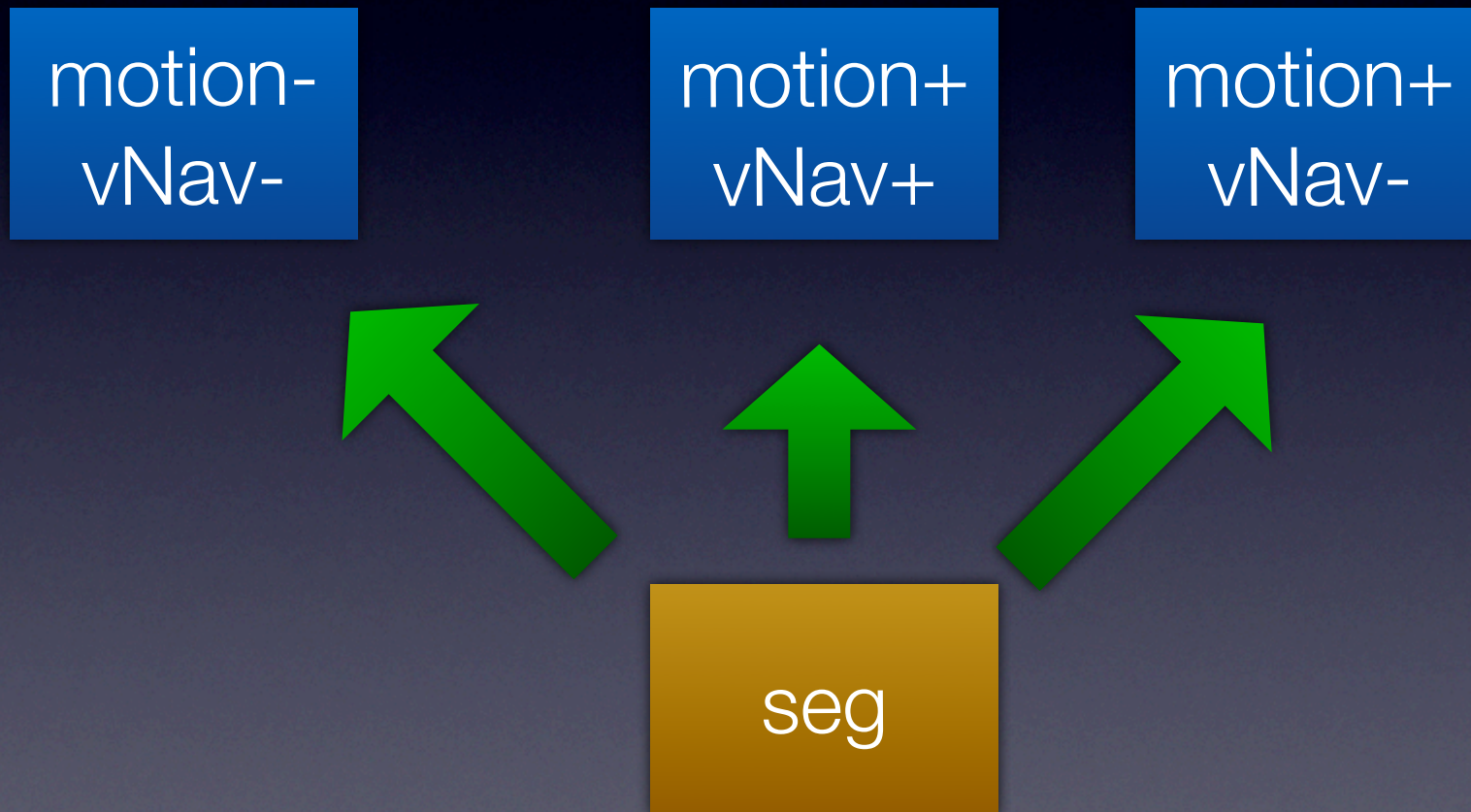
mri_robust_template

Registration of same-subject, same-day, with-motion T1 scans to a fully segmented same-subject, same-day, without-motion T1 scan.



cross-sectional stream

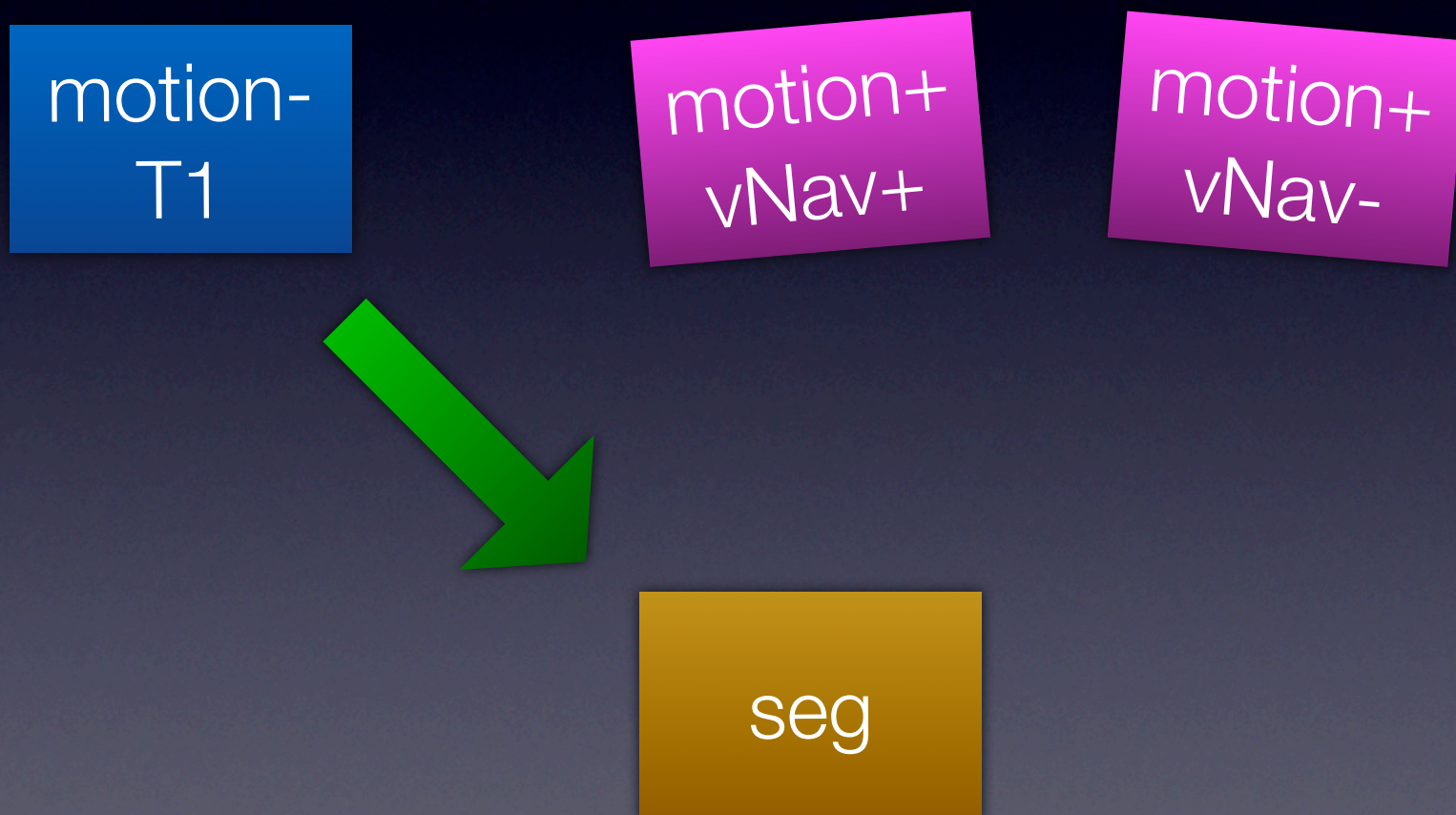
Registration of same-subject, same-day, with-motion T1 scans to a fully segmented same-subject, same-day, without-motion T1 scan.



now we have voxel-wise equivalence

We can use `mri_robust_register` to **extrapolate a segmentation** to a subsequent acquisition.

Cross-contrast registration of same-subject, same-day, with- and without-motion T2 scans to a fully segmented same-subject, same day without motion T1 scan.



cross-sectional stream

Cross-contrast registration of same-subject, same-day, with- and without-motion T2 scans to a fully segmented same-subject, same day without motion T1 scan.

motion-
T1

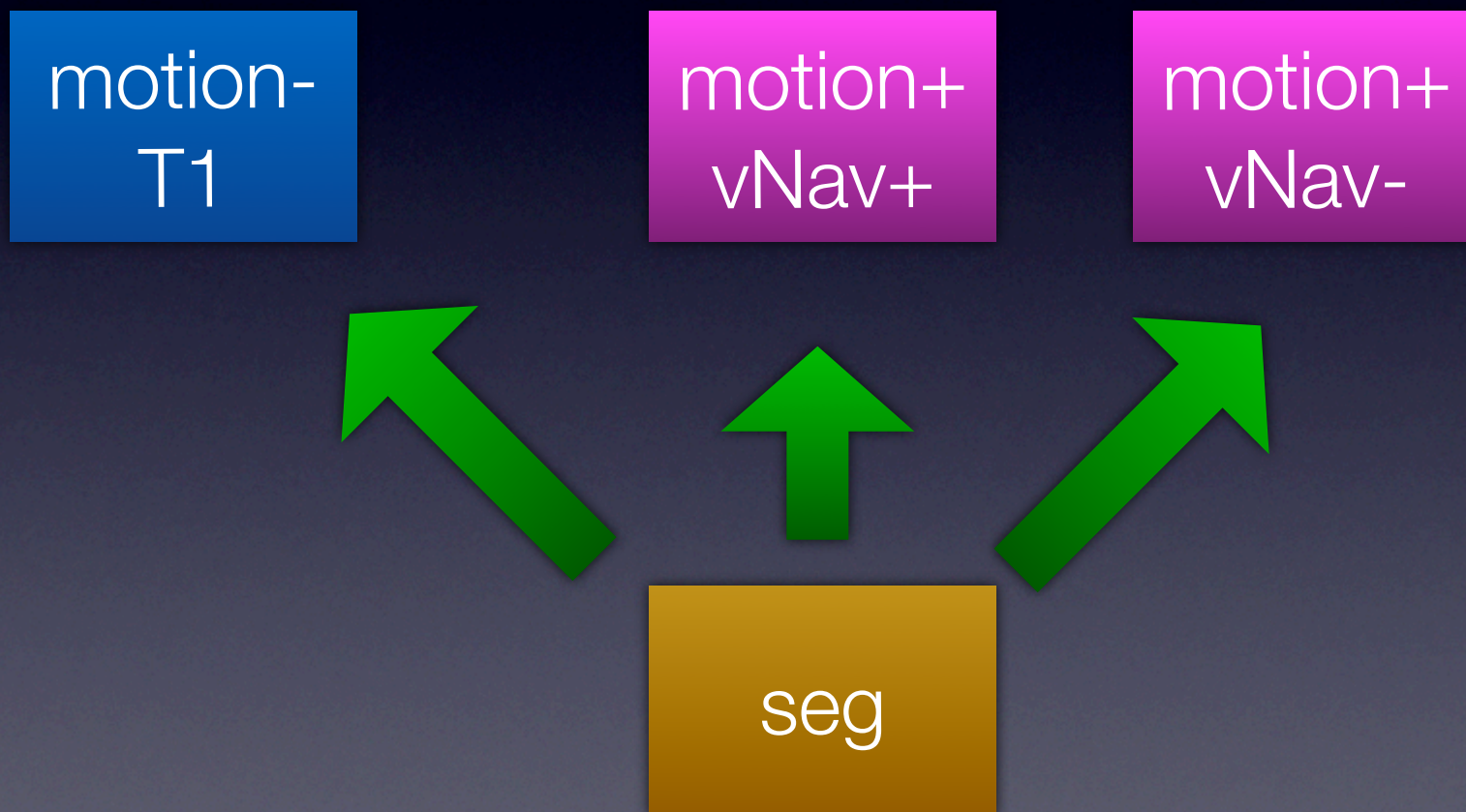
motion+
vNav+

motion+
vNav-

seg

bbregister

Cross-contrast registration of same-subject, same-day, with- and without-motion T2 scans to a fully segmented same-subject, same day without motion T1 scan.



now we have voxel-wise equivalence

We can use bbregister to **extrapolate a segmentation** to a subsequent acquisition with a different contrast.

Acknowledgements:

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