



NA-MIC

*National Alliance for Medical Image Computing*

*<http://na-mic.org>*

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# **Training & Validation Update**

**Sonia Pujol, PhD**  
**NA-MIC Training Core P.I.**

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# NA-MIC Training Core Effort

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Our mission:

- **Teaching effort** to accelerate the transfer of NA-MIC technology to the community
- **Validation effort** to investigate the comparative performances of algorithms





# 2011 NA-MIC Training Workshops

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## 12 workshops at 11 different national & international venues

- Harvard Medical School, Boston, MA. Feb-March, 2011
- Johns Hopkins, Baltimore, MD. April 2011
- SCI Institute, Utah. April 2011
- University of Western Ontario, London, Canada. June 2011
- OHBM 2012, Quebec City, Canada. June 2011
- AAPM meeting, Vancouver, Canada. August 2011
- UBC workshop, Vancouver, Canada. August 2011
- MICCAI 2011, Toronto, Canada. Sept. 2011
- Cranio-Maxillo Facial workshop, Cleveland. Nov. 2011
- SfN 2011, Washington, DC. Nov. 2011
- RSNA 2011, Chicago, IL. Dec. 2011



# NA-MIC Workshops

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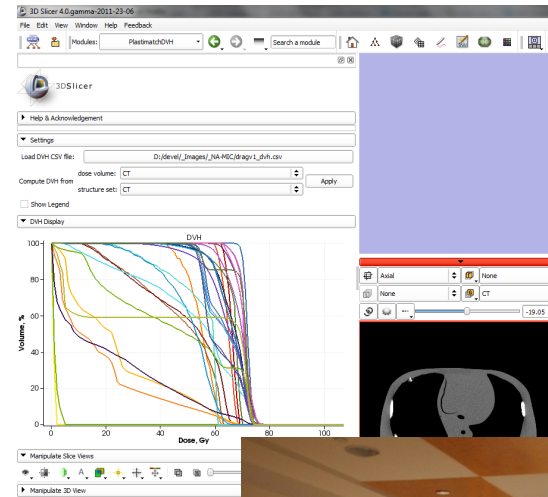
Hands-on workshops tailored for clinicians, clinical researchers, and scientists at national events, invited seminars, and international conferences ( MICCAI, RSNA, SfN...)





# AAPM 2011, Vancouver

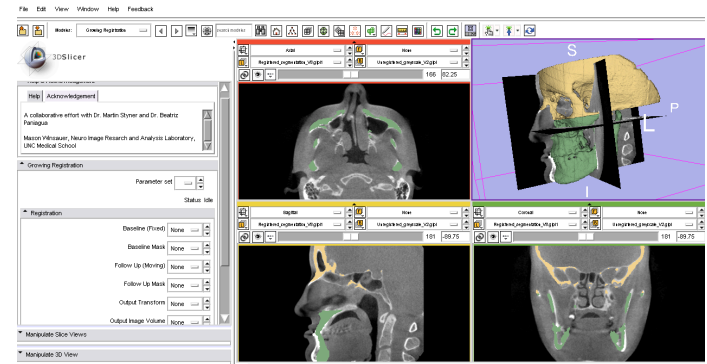
- Theme: 3DSlicer for radiotherapy research
- Gregory Sharp, MGH, Andras Lasso, Queen's University
- 20 participants





# 2011 Cranio-Maxillo Facial Workshop, Cleveland

- Theme: Slicer development in Orthodontics
- Beatriz Paniagua, UNC  
Tung Nguyen, UNC  
Lucia Cevidanes, U.Michigan



Joint Cephalometric Experts Group 2011 - 20 participants





# UBC 2011, Vancouver

- Theme: 3D Slicer for image-guided therapy research
- Andras Lasso and Tamas Ungi, Queen's University
- 21 participants

Image-guided therapy applications in Slicer 3.6

<p><b>ProstateNav</b></p> <ul style="list-style-type: none"><li>• Prostate biopsy</li><li>• Used on patients</li></ul>	<p><b>NeuroNav</b></p> <ul style="list-style-type: none"><li>• Neuro navigation</li><li>• Used on patients</li></ul>	<p><b>PerkStation</b></p> <ul style="list-style-type: none"><li>• Spine needle insertion with AR display</li><li>• Cadaver studies</li></ul>
<p><b>LiverAblation</b></p>	<p><b>IGTPanning</b></p>	
<p><b>MRABlation</b></p>	<p><b>IGTNavigation</b></p>	<p>...</p>










# SfN 2011 DTI workshop

- Full day event on DTI analysis
- Lectures & hands-on sessions on acquisition, analysis and interpretation of DT-MRI data
- 23 neuroscientists



**Society for Neuroscience**  
Neuroscience 2011 Meeting, Nov. 12-16, Washington, DC  
Satellite Workshop



## White Matter Exploration with Diffusion Tensor Imaging: Fundamentals and Perspectives

A Hands-On Workshop by the National Alliance for Medical Imaging Computing (NA-MIC)


The workshop will guide participants through the fundamentals of the acquisition, analysis and interpretation of DT-MRI data through a series of lectures and hands-on sessions with the participants running DT-MRI analysis on their own laptops, to provide a conceptual understanding of the underlying theory of Diffusion Imaging, and a practical experience of extracting relevant clinical information from DT-MRI data.

**Friday November 11, 2011**  
9:00 am – 5:30 pm

**Room 159A, Walter E. Washington Convention Center**  
Washington, DC

**Workshop Faculty**  
Sonia Pujol, PhD, Harvard Medical School  
Randy Gollub, MD, PhD, Harvard Medical School  
Anastasia Yendiki, PhD, Harvard Medical School  
Ipek Oguz, PhD, University of North Carolina

For registration and detailed agenda, please see:  
[http://wiki.na-mic.org/Wiki/index.php/SFN2011\\_Diffusion\\_Tensor\\_Imaging\\_Analysis\\_Workshop](http://wiki.na-mic.org/Wiki/index.php/SFN2011_Diffusion_Tensor_Imaging_Analysis_Workshop)





# Johns Hopkins Workshop

- Local Host: Prof. Rai Winslow, Director, Institute for Computational Medicine, JHU
- ICM Distinguished Seminar Series: Ron Kikinis, MD. “3DSlicer”
- Full-day workshop
  - Basics of DTI
  - White matter tractography for neurosurgical planning
  - OpenIGTLink

**NATIONAL ALLIANCE FOR MEDICAL IMAGE COMPUTING**

**Neuroimage Analysis Workshop**

Tuesday April 5, 2011  
8:00 am – 5:00 pm

Johns Hopkins University  
Baltimore, MD

**Workshop Faculty**

Ron Kikinis, M.D., Harvard University  
Sonia Pujol, Ph.D., Harvard University  
Nicole Auzoin, MSc, Harvard University

3DSlicer

**Clinical Goal**

The goal of this tutorial is to explore white matter fibers surrounding a tumor using Diffusion Tensor Imaging (DTI) Tractography.

White Matter tracts  
Tumor  
Ventricles

White Matter Exploration for Neurosurgical Planning  
Sonia Pujol, Ph.D. – Ron Kikinis, M.D.  
© NA-MIC ARR 2011

**INSTITUTE for COMPUTATIONAL MEDICINE**

Johns Hopkins Institute for Computational Medicine (ICM), a remarkable collaboration between Johns Hopkins School of Medicine and Whiting School of Engineering, is using powerful computational tools to transform the practice of medicine.

[More about our mission](#)



# Univ. Western Ontario, Canada

- Local Host: Prof. Terry Peters,  
Director, Robarts Imaging Institute
- Image Registration, Programming  
OpenIGTLink
- BIRC Lecture: “Open Source  
Platforms for Collaborative  
Research Examples from 3DSlicer.”  
Ron Kikinis, MD
- 63 participants







# Slicer booths

- **OHBM 2011** June 2011
- **BWH 2011 Resident Fair**  
Nov 2011
- **RSNA 2011 Slicer Booth**  
Nov 27-Dec 2, 2011

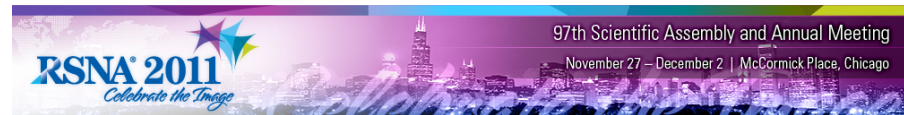


**HBM 2011** Quebec City, Canada

17<sup>th</sup> Annual Meeting  
of the Organization on Human Brain Mapping  
Centre des Congrès de Québec  
June 20-26, 2011



**BRIGHAM AND  
WOMEN'S HOSPITAL**  
A Teaching Affiliate of Harvard Medical School





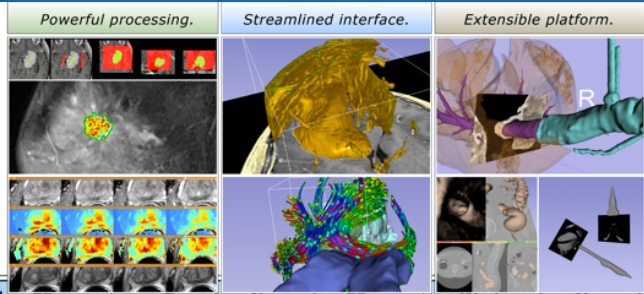
# RSNA 2011

- Largest medical conference in the world - 60,000 participants
- NA-MIC presence:
  - 2 hands-on courses
  - 54 hours demos at the 3DSlicer Booth
  - paper presentation on SPL Brain Atlas





# Slicer4 Premiere at RSNA 2011



NA-MIC and NAC at RSNA

Agenda

[edit]

[edit]

Sunday, November 27	Monday, November 28	Tuesday, November 29	Wednesday, November 30	Thursday, December 1	Friday, December 2
<p><b>8:00am-11:00am. 3D Slicer Exhibit</b>, Quantitative Imaging Reading Room, Lakeside Learning Center, Hall E</p> <p>-----</p> <p><b>11:00am-12:30pm. RSNA Refresher Course: Quantitative Medical Imaging for Clinical Research and Practice</b>. Room S401CD</p> <p>-----</p> <p><b>12:30pm-6:00 pm. 3D Slicer Exhibit</b> Quantitative Imaging, Lakeside Learning Center, Hall E</p>	<p><b>8:00am-11:00am. 3D Slicer Exhibit</b>, Quantitative Imaging Reading Room, Lakeside Learning Center, Hall E</p> <p>-----</p> <p><b>11:15am-11:45am. QIRR Theater Presentation</b>, Quantitative Imaging Reading Room, Lakeside Learning Center, Hall E</p> <p>-----</p> <p><b>12:15pm-1:15pm. Meet-The-Experts Session</b>, Quantitative Imaging Reading Room, Lakeside Learning Center, Hall E</p> <p>-----</p> <p><b>1:15pm-6:00 pm. 3D Slicer Exhibit</b>, Quantitative Imaging, Lakeside Learning Center, Hall E</p>	<p><b>8:00am-11:00am. 3D Slicer Exhibit</b>, Quantitative Imaging Reading Room, Lakeside Learning Center, Hall E</p> <p>-----</p> <p><b>12:30pm-2:00pm. RSNA Refresher Course: 3D Visualization for radiological applications</b>. Room S401CD</p> <p>-----</p> <p><b>12:30pm-6:00 pm. 3D Slicer Exhibit</b>, Quantitative Imaging, Lakeside Learning Center, Hall E</p>	<p><b>8:00am-12:15pm. 3D Slicer Exhibit</b> Quantitative Imaging Reading Room, Lakeside Learning Center, Hall E</p> <p>-----</p> <p><b>12:15pm-1:15pm. Meet-The-Experts Session</b>, Quantitative Imaging Reading Room, Lakeside Learning Center, Hall E</p> <p>-----</p> <p><b>1:15pm-6:00 pm. 3D Slicer Exhibit</b>, Lakeside Learning Center, Hall E</p> <p>-----</p> <p><b>4:30pm-6:00pm. RSNA Refresher Course: Lifecycle of an Imaging Biomarker: From Validation to Dissemination</b> Room S501ABC</p>	<p><b>8:00am-12:15pm. 3D Slicer Exhibit</b>, Quantitative Imaging Reading Room, Lakeside Learning Center, Hall E</p> <p>-----</p> <p><b>Session starts at 10:30 am - Talk at 11:10am-11:20am. RSNA Paper presentation: Publicly Available RadLex-linked Anatomy Atlases for Image Analysis, Informatics and Education</b> Room S402AB</p> <p>-----</p> <p><b>12:15pm-1:15pm. Meet-The-Experts Session</b>, Quantitative Imaging Reading Room, Lakeside Learning Center, Hall E</p> <p>-----</p> <p><b>1:15pm-6:00pm. 3D Slicer Exhibit</b>, Quantitative Imaging Reading Room, Lakeside Learning Center, Hall E</p>	<p><b>8:00am-12:45pm. 3D Slicer Exhibit</b>, Quantitative Imaging Reading Room, Lakeside Learning Center, Hall E</p>





# Slicer4 Premiere at RSNA – Behind the scenes

- July 19, 2011  
'Slicer4 review and Programming Sprint'
- RSNA 2011 targeted objectives and deadline for the first release of Slicer4

Events:Slicer4-Review-07-2011

Contents [hide]

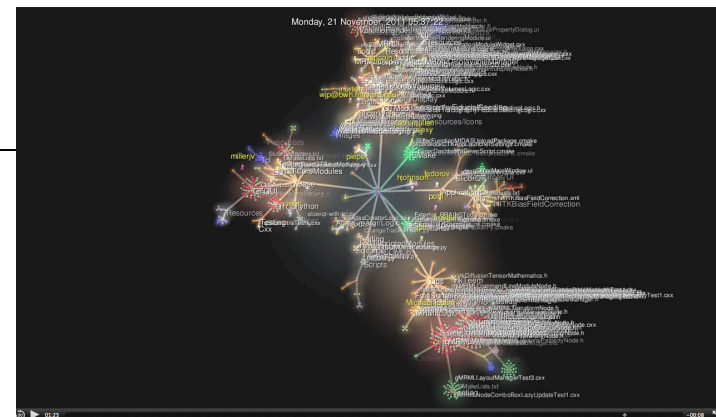
- 1 RSNA 2011 Targeted Objectives
  - 1.1 UI
  - 1.2 Under the hood
  - 1.3 Infrastructure
  - 1.4 Beginning Of The Rest
- 2 What
- 3 When
- 4 Who
- 5 Where
- 6 Why
- 7 Work on
  - 7.1 Full List
    - 7.1.1 UI
    - 7.1.2 Under the hood
    - 7.1.3 Infrastructure
    - 7.1.4 Completion
- 8 Agenda
- 9 Attending

RSNA 2011 Targeted Objectives

- ▀ Roadmap for the Slicer 4 release for the series of demos at the RSNA 3DSlicer Booth
- ▀ Most tasks need to be ready by end of September, to leave time to update tutorials, test and debug.
- ▀ List of open Mantis issues with RSNA Target

UI

- ▀ Main GUI Cosmetics
  - ▀ % face lift for the Slice viewers: reduce permanent non-image components. Reduce the number and depth of submenus. (J2) **done**
  - ▀ % Main Gui 3D viewers should have similar appearance to slice viewers (J2) **done**
  - ▀ % scenview and screenshot icons move to the icon bar at the top of the main gui. (J2-> Nicole) **done**
- ▀ Module Cosmetics
  - ▀ % Volume Rendering of (J2) (in progress)
  - ▀ % Models module of (J2) **done**
  - ▀ % Editor of, see picture to the right (Steve) (Done)
  - ▀ % Welcome Module of (Wendy)

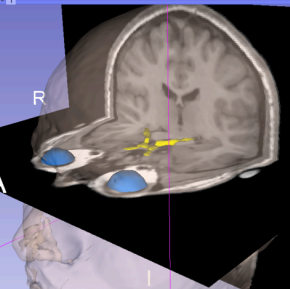
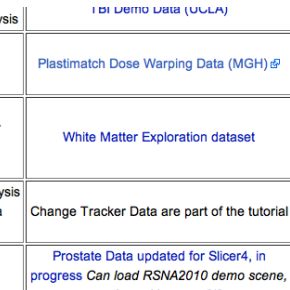
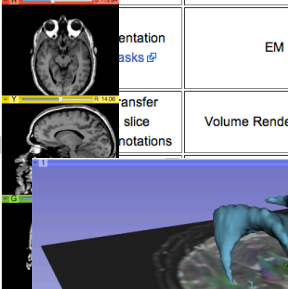
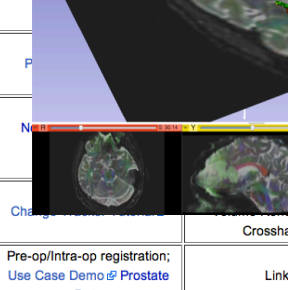


Slicer  
visual blog  
(S.Pieper)





# RSNA 2011: Slicer Booth

Nb	DEMO	Datasets	Notes	Tools	Slicer Modules
1	Data Loading and Visualization	<a href="#">Slicer3Visualization Data</a>	<a href="#">Slicer3Visualization Tutorial</a>	Compare View, Clipping, Save, Restore, Scene Views, Dicom studies sorting, Dicom networking (?)	Data, Volumes, Models, Scene Views
2	MRI-based topographic parcellation of human brain		<a href="#">Parcellation tasks</a>	EM Segmenter	EMSegmenter
3	Volume Render #1 Head		<a href="#">Transfer slice notations</a>	Volume Rendering and Annotations	Volume Rendering, Annotations, Scene Views
4	Volume Render #2 Abdomen				Volume Rendering, Annotations, Scene Views
5	Volume Render #3 Thorax				Volume Rendering, Annotations, Scene Views
6	Traumatic Brain Injury Case Analysis	<a href="#">IBI Demo Data (UCLA)</a>			BC Segmentation, Model Maker, Editor, Annotations, Scene Views
7	Radiotherapy	<a href="#">Plastimatch Dose Warping Data (MGH)</a>			Plastimatch Extension: DICOM/DICOM-RT Import, DICOM/DICOM-Export, B-Spine Deformable Registration, XFORMWARP Warping with transform Transforms,
8	White matter exploration for neurosurgical planning	<a href="#">White Matter Exploration dataset</a>			Volumes, Editor, Fiducials, Diffusion Tensor Estimation, Diffusion Tensor Tractography Fiducial
9	Longitudinal analysis of meningioma growth	Change Tracker Data are part of the tutorial	<a href="#">Change Tracker</a>	Crosshairs, BRAINSFit	Volume
10	Image-guided prostate interventions	<a href="#">Prostate Data updated for Slicer4, in progress Can load RSNA2010 demo scene, mostly working, see [1]</a>	Pre-op/Intra-op registration; <a href="#">Use Case Demo of Prostate Data</a>	Linked Viewing	
11	Brain Atlas	<a href="#">NAC Multi-modality MRI-based Atlas of the Brain</a>	Work in progress - atlases are being updated	Linked Viewing	
12	Abdomen Atlas	<a href="#">Knee Atlas</a>	Work in progress - atlases are being updated	Linked Viewing	
13	Knee Atlas Atlas	<a href="#">Abdominal Atlas</a>	Work in progress - atlases are being updated	Linked Viewing	Data, Volumes, Models, Scene Views

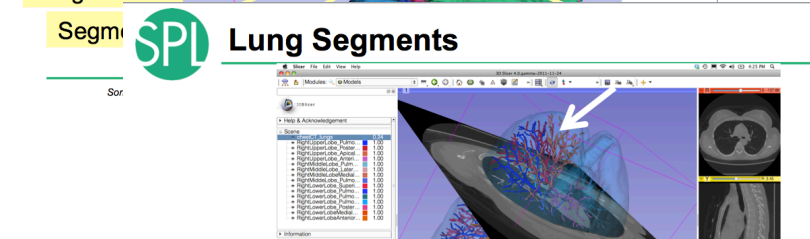
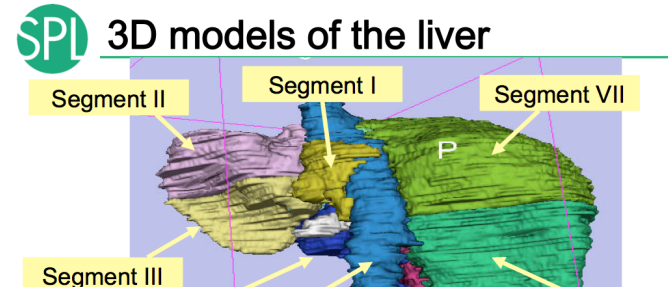
- 13 hands-on demos with pre-computed datasets
- ~10-20 visitors per day

“The 3D Slicer open source software platform for segmentation, registration, quantitative analysis and 3D visualization of biomedical image data”



# RSNA 3D Visualization Course

- 3D interactive visualization of liver & lung segments
- In Collaboration with Dr. Kitt Shaffer, Vice Chairman for Radiology Research, BU Medical Center
- 105 international attendees



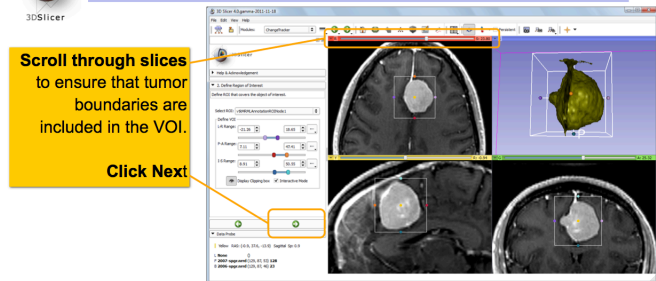
Slide 98



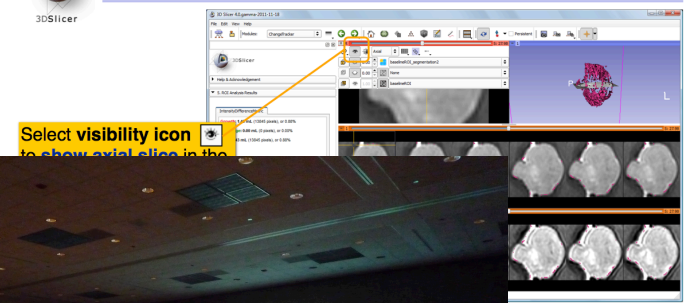
# RSNA Quantitative Imaging Course

- Slicer4minute, Change Tracker & PET/CT Fusion
- In Collaboration with Harvard Catalyst
- 120 participants

 **ChangeTracker: Step 2: Define a volume of interest**



**ChangeTracker: Results: change in pathology**

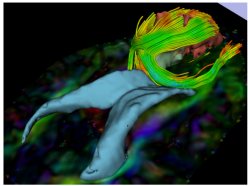




# Slicer Training Compendium

## Image Analysis Pipeline

The image analysis pipeline



described in this  
different algorithm  
algorithm for segmenting  
tumor parts, the  
algorithm for surface  
and the single tract  
streamline tract  
for tract generation

Sonia Pujol, Ph.D. — Ron Kikinis, M.D.

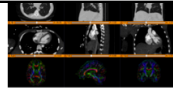
## Exploring Peritumoral White Matter Fibers for Neurosurgical Planning

Sonia Pujol, Ph.D.  
Ron Kikinis, M.D.

Surgical Planning Laboratory  
Harvard University

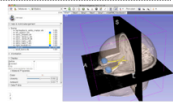
- New Slicer4 Compendium
- Development of new tutorials based on Clinical workflow: e.g., “White matter exploration for neurosurgical planning”
- Slicer tutorial contest

- The SlicerWelcome tutorial is an introduction to Slicer based on the Welcome module.
- Audience: First time users who want a general introduction to the software.



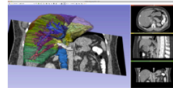
### SLICER4MINUTE TUTORIAL

- The Slicer4Minute tutorial is a brief introduction to the advanced 3D visualization capabilities of Slicer4.0.
- Audience: First time users who want to discover Slicer in 4 minutes.
- The Slicer4Minute dataset contains an MR scan of the brain and 3D reconstructions of the anatomy.



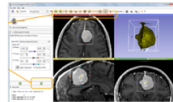
### SLICER4 3D VISUALIZATION OF DICOM IMAGES FOR RADIOLOGY APPLICATIONS

- The Slicer4RSNA course guides through 3D data loading and visualization of DICOM images for Radiology Applications in Slicer4.
- Audience: Radiologists and users of Slicer who need a more comprehensive overview over Slicer4 visualization capabilities.
- The Slicer4RSNAAdataset1 and Slicer4RSNAAdataset2 contain a series of MR and CT scans, and 3D models of the brain, lung and liver.



### SLICER4 QUANTITATIVE IMAGING TUTORIAL

- The Slicer4 Quantitative Imaging tutorial guides through the use for Slicer for quantifying small volumetric changes in slow-growing tumors, and for calculating Standardized Uptake Value (SUV) from PET/CT data.
- Audience: Radiologists and users of Slicer who need a more comprehensive overview over Slicer4 quantitative imaging capabilities.
- The PETCTFusion and Change Tracker datasets contain a series of MR, CT and PET data.

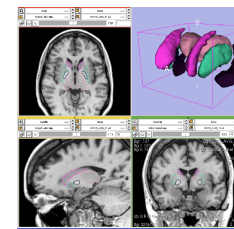
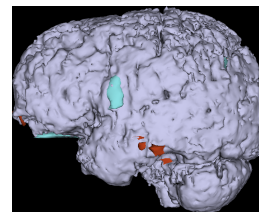






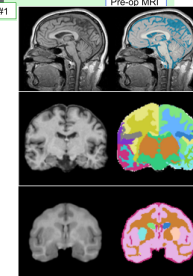
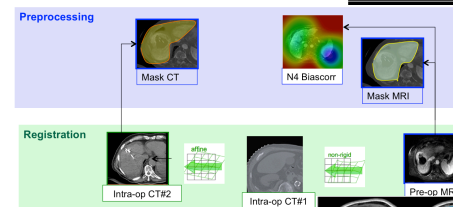
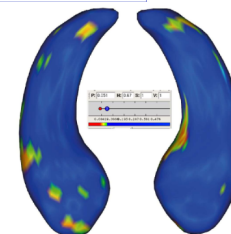
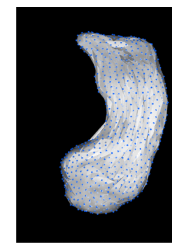
# Summer 2011 Tutorial Contest

- 8 tutorial submissions
- First prize winner: 'Automated Segmentation of TBI cases using ABC Segmentation' (Andrei Irima, Jack Van Horn, UCLA)



BRAINSCut Output example for sub-cortical structures

Select	Status	Name	Category	Description	HomePage
<input type="checkbox"/>	<input checked="" type="checkbox"/>	ABC			
<input type="checkbox"/>	<input checked="" type="checkbox"/>	ARCTIC	Cortical Thickness	ARCTIC is an e	
<input type="checkbox"/>	<input checked="" type="checkbox"/>	EMFiberClusteringModule	Tractography	An EM approa	
<input type="checkbox"/>	<input checked="" type="checkbox"/>	ExampleCommandLine	Examples	An example of	
<input type="checkbox"/>	<input checked="" type="checkbox"/>	ExampleLoadableGuiLessModule	Examples	An example of	
<input type="checkbox"/>	<input checked="" type="checkbox"/>	HammerRegistration	Work in Progress	HammerRegist	
<input type="checkbox"/>	<input checked="" type="checkbox"/>	LabelDiameterEstimation	Statistics		
<input type="checkbox"/>	<input checked="" type="checkbox"/>	platform-slicer	Developer Tools	This is an exa	
<input type="checkbox"/>	<input checked="" type="checkbox"/>	PythonTemplateScriptsModule	Developer Tools	This is an exa	
<input type="checkbox"/>	<input checked="" type="checkbox"/>	TofIsmcScripModule	Developer Tools	This is an exa	



```
Left DNI Diffusion:
baseLineOfNumber: 1
numberOfSlices: 23
gradientOfNumber: 1
0 [ 0.00000 0.00000 0.00000 ] 1
1 [ -0.48150 -0.11030 0.00000 ] 1
2 [ -0.48872 -0.73509 -0.14738 ] 1
3 [ -0.26569 -0.94191 -0.24181 ] 1
4 [ 0.09593 0.62494 0.05728 ] 1
5 [ -0.00000 0.00000 0.00000 ] 1
6 [ -0.48594 -0.11997 0.00000 ] 1
7 [ 0.73828 0.18209 0.05007 ] 1
8 [ 0.47739 0.73349 0.28724 ] 1
9 [ -0.33829 -0.94399 -0.18917 ] 1
10 [ -0.37444 -0.53845 0.78833 ] 1
11 [ -0.00000 -0.51399 0.05007 ] 1
12 [ 0.97183 0.18124 -0.18756 ] 1
13 [ 0.00000 0.18129 -0.48726 ] 1
14 [ -0.00000 0.73359 -0.05007 ] 1
15 [ -0.00000 0.94202 0.23611 ] 1
16 [ 0.48157 -0.51867 0.05007 ] 1
17 [ 0.22899 -0.51887 0.79848 ] 1
18 [ 0.22824 -0.17423 0.05007 ] 1
19 [ -0.62193 0.70708 -0.28728 ] 1
20 [ 0.30288 -0.94854 0.18986 ] 1
21 [ 0.15878 -0.94932 -0.25473 ] 1
22 [ 0.05766 -0.17089 0.48533 ] 1
23 [ 0.97922 -0.17246 0.09921 ] 1

=====
QC result summary:
=====
Image information check: PASS
Diffusion information check: PASS
File name check: PASS
Index name check: PASS
Gradient name check: PASS
```

→ Next Tutorial Contest: NA-MIC Summer Project Week 2012



# Slicer QA effort

2011 Summer Project Week Automated GUI Testing

**Contents [hide]**

- 1 Key Investigators
  - 1.1 Objective
  - 1.2 Approach, Plan
  - 1.3 Progress

**Key Investigators**

- Brigham and Women's Hospital: Sonia Pujol
- Isomics Inc: Steve Pieper
- Kitware: Jean-Christophe Fillon-Robin
- GE: Xiaodong Tao

**Objective**

The objective is to explore different solutions for automated GUI testing.

**Approach, Plan**

We'll generate automated tests using the Slicer3minute tutorial.

- Sikuli
- QtTesting libraries
- Directly calling GUI via PythonQt

**Progress**

- We have developed a sikuli script that runs automatically the different steps of the Slicer3minute tutorial using Slicer4: automated test example
- We reviewed the needs for the integrated test recording framework in VTK/Python (about 80% done, but is no the slicer4-to-do list)

2012 Project Week: Automated Testing

**Contents [hide]**

- 1 Key Investigators=
  - 1.1 Objective
  - 1.2 Approach, Plan
  - 1.3 Progress

**Key Investigators=**

- Brigham and Women's Hospital: Sonia Pujol
- Isomics Inc: Steve Pieper
- Kitware: Jean-Christophe Fillon-Robin, Benjamin Long

**Objective**

The objective is to implement automated GUI testing in Slicer4 based on QtTesting, to be able to perform nightly automated tutorial testing.

**Approach, Plan**

We'll generate automated tests for the Slicer4minute tutorial, and define associated metrics to measure the outcomes.

- Automated GUI testing of Slicer4
- First implementation at 2011 Summer Project Week using Sikuli
- On-going development with Kitware using QtTesting (JC, Benjamin Long)

Development of nightly automated tutorial testing



# Dissemination Update

## **12<sup>th</sup> Project Week: Salt Lake City, Utah, Winter 2011**

- 106 attendees: 20 academic institutions, 9 companies
- 59 Projects: Segmentation, Registration, IGT, Radiotherapy, Informatics, DTI, Engineering

## **13<sup>th</sup> Project Week: MIT, Summer 2011**

- 101 attendees: 17 academic institutions, 8 companies
- 61 Projects: TBI, Radiation Therapy, Huntington's Disease, Atrial Fibrillation, IGT, Segmentation, Registration, Tractography, Vessels, Engineering





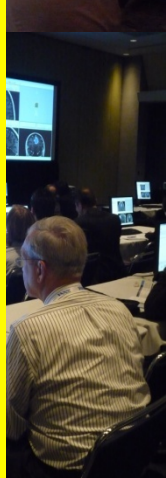
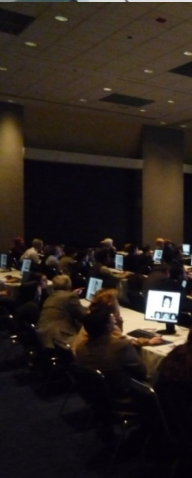


2011 outreach events:

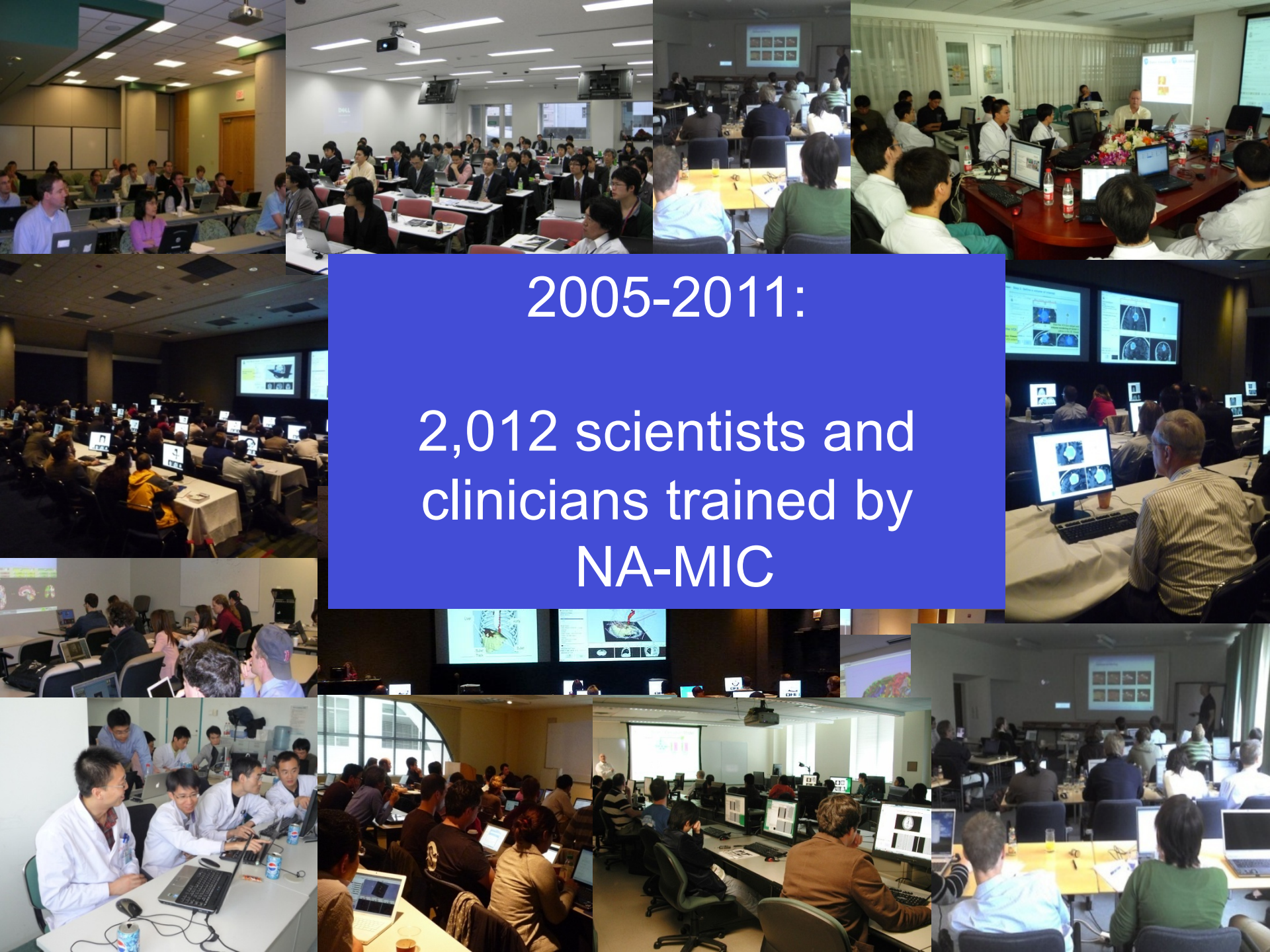
12 workshops

457 NA-MIC training workshop participants

207 NA-MIC project week participants







2005-2011:  
2,012 scientists and  
clinicians trained by  
NA-MIC



NA-MIC

*National Alliance for Medical Image Computing*

*<http://na-mic.org>*

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# **DTI Validation Update:**

## **Challenges in clinical transfer of DTI tractography**

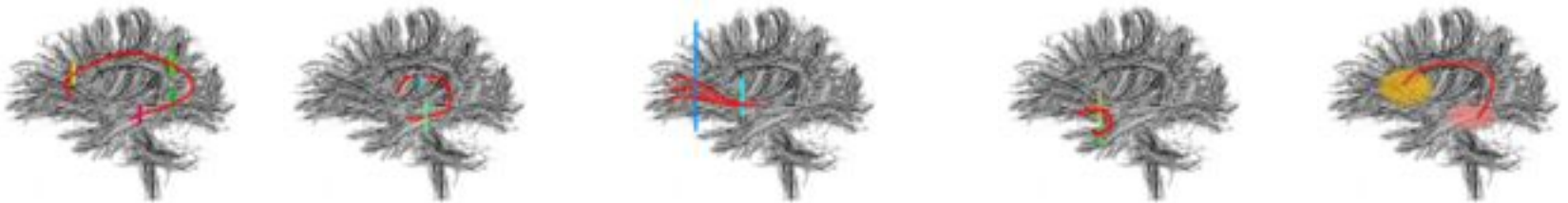
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# NA-MIC pilot initiative

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- Exploratory work on validation of DTI tractography
- Cross-comparison of tractography algorithms on major white matter fascicles

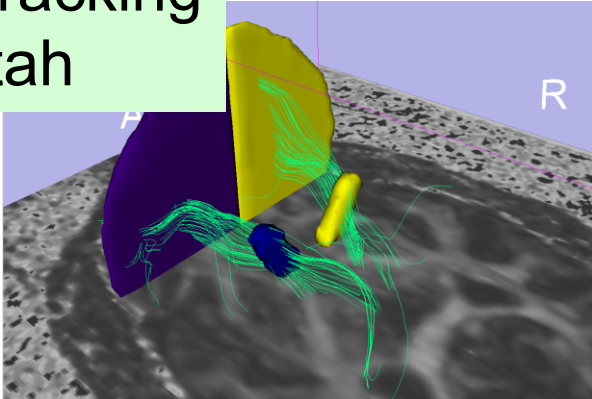




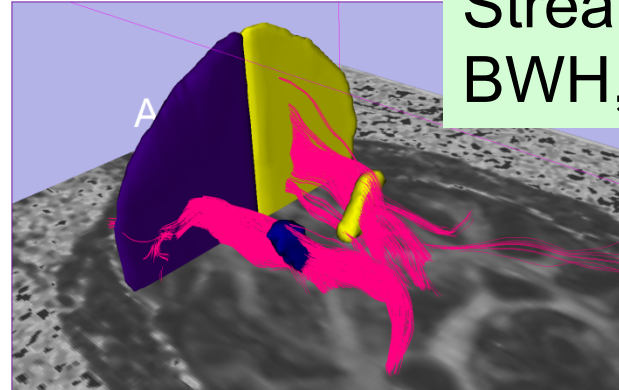


# Early Implementation

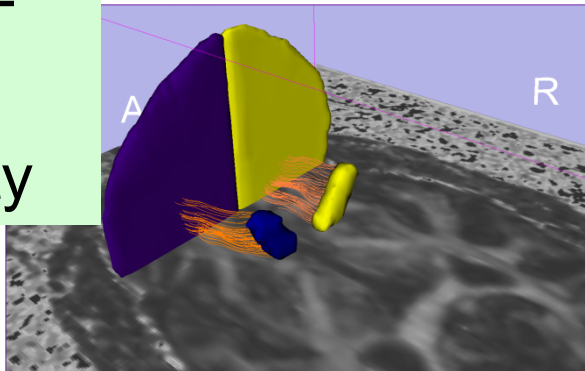
Fiber Tracking  
SCI, Utah



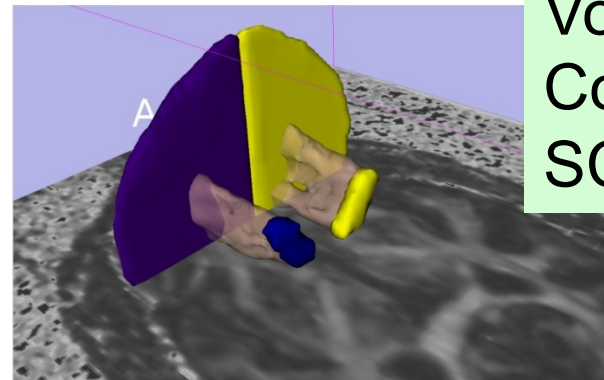
Streamline  
BWH, Harvard



GTRACT  
Iowa  
University



Volumetric  
Connectivity  
SCI, Utah



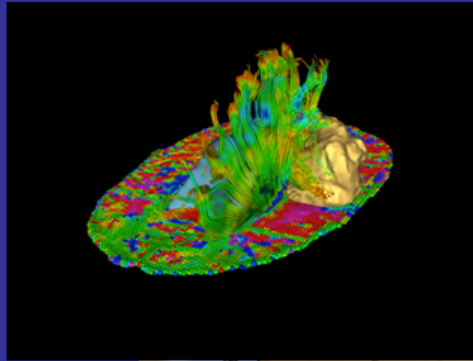
Pujol et al. ISMRM 2009





# MICCAI 2011 DTI Challenge

14<sup>th</sup> International Conference on Medical Image Computing and Computer Assisted Intervention



## DTI Tractography for Neurosurgical Planning: A Grand Challenge



**MICCAI 2011 Workshop**  
**Sunday September 18, 9am-6pm**  
**Westin Harbour Castle**  
**Toronto, Canada**

### Workshop Faculty

*Sonia Pujol, PhD, Surgical Planning Laboratory, Harvard Medical School*  
*Ron Kikinis, MD, Surgical Planning Laboratory, Harvard Medical School*  
*Alexandra Golby, MD, Brigham and Women's Hospital, Harvard Medical School*  
*Guido Gerig, PhD, The Scientific Computing and Imaging Institute, University of Utah*  
*Martin Styner, PhD, Neuroimage Research and Analysis Laboratory, University of North Carolina*  
*William Wells, PhD, Surgical Planning Laboratory, Harvard Medical School*  
*Carl-Fredrik Westin, PhD, Laboratory of Mathematics in Imaging, Harvard Medical School*  
*Sylvain Gouttard, MSc, The Scientific Computing and Imaging Institute, University of Utah*

National Alliance for Medical Image Computing

[http://www.na-mic.org/Wiki/index.php/Events\\_DTI\\_Tractography\\_Challenge\\_MICCAI\\_2011](http://www.na-mic.org/Wiki/index.php/Events_DTI_Tractography_Challenge_MICCAI_2011)



# Workshop Faculty

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- Sonia Pujol, BWH
- Ron Kikinis, BWH
- Alexandra Golby, BWH
- Guido Gerig, SCI Utah
- Martin Styner, UNC
- William Wells, BWH
- CF Westin, BWH
- Sylvain Gouttard, SCI Utah
- Arya Nabavi, Kiel Hospital, Germany



# Special Thanks

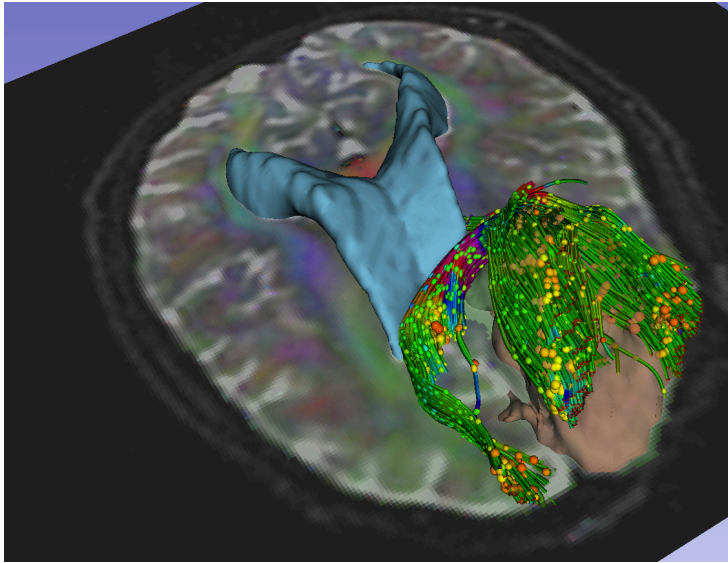
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- Hatsuho Mamata, BWH
- Isaiah Norton, BWH



# Tractography for neurosurgery

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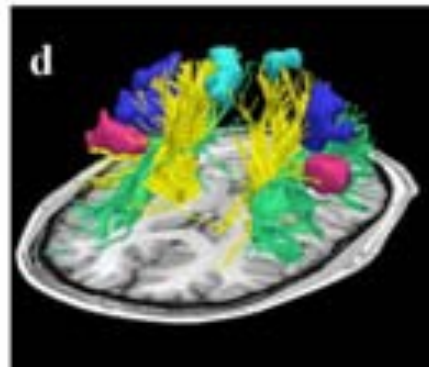
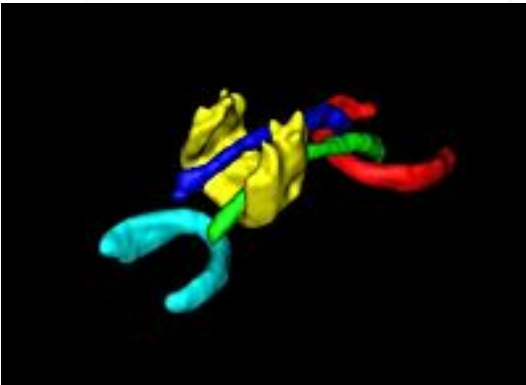
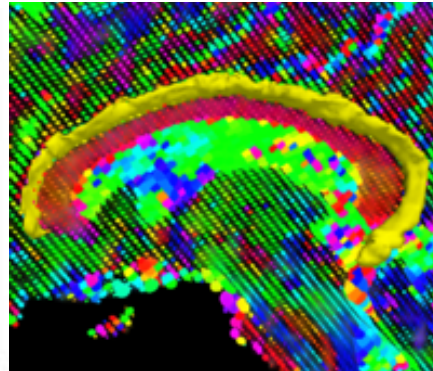
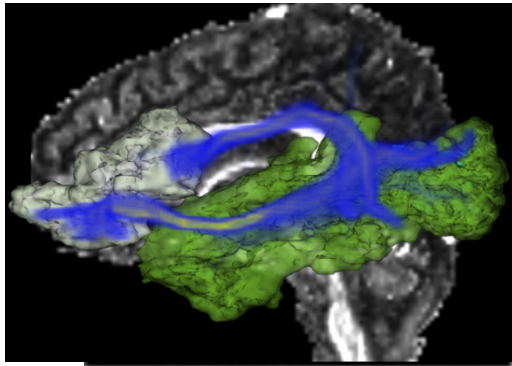
Tractography has the potential to bring valuable information to the neurosurgeon

- Spatial relationship between the tract and the tumor
- Demonstration of tract displacement
- Assessment of tumor infiltration



# Tractography Algorithms

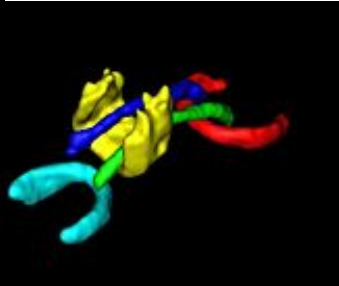
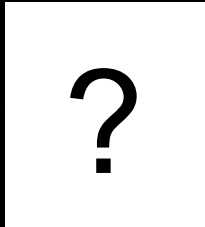
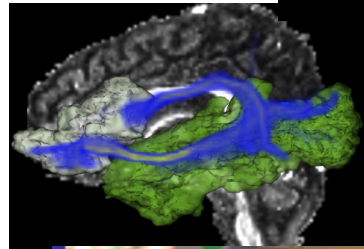
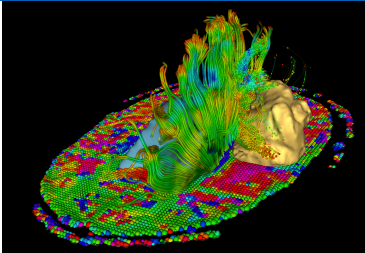
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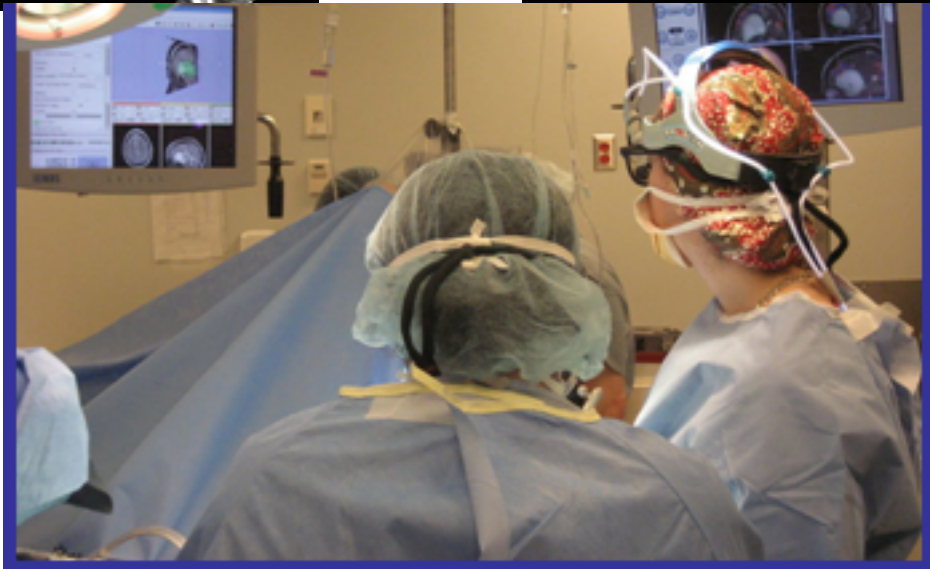
A wide variety of tractography techniques has been developed over the past decade (streamline, stochastic, volumetric, two-tensors...)



# How to choose ?



Neurosurgeons face the challenge of selecting the appropriate tractography method



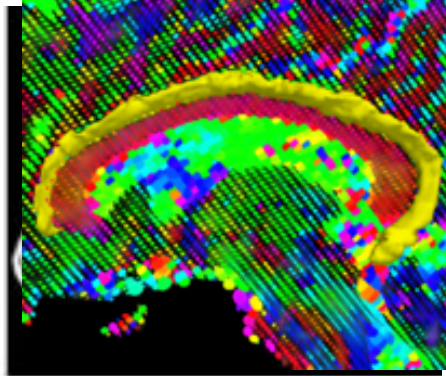
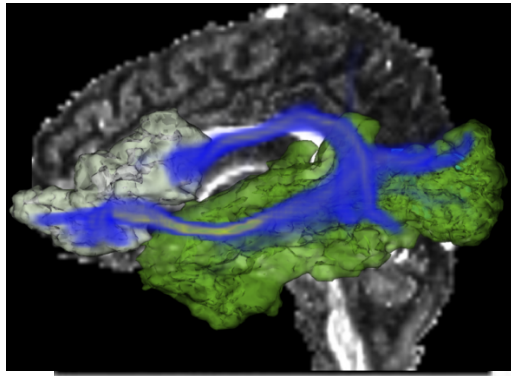
**Need for tool comparison**



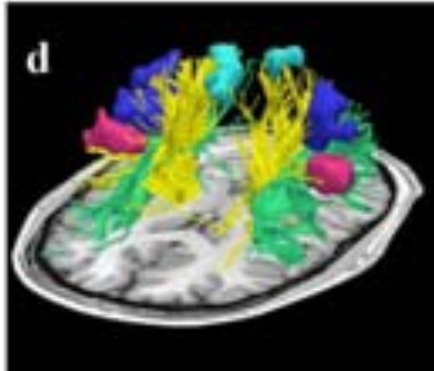
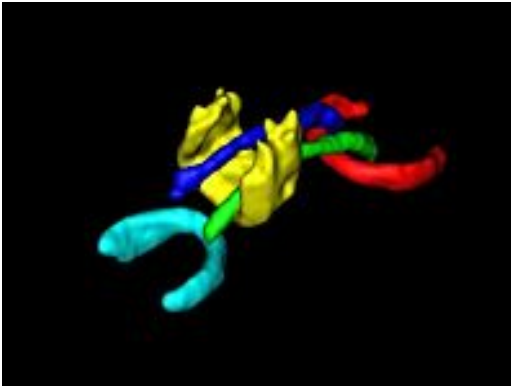


# Goal of the workshop

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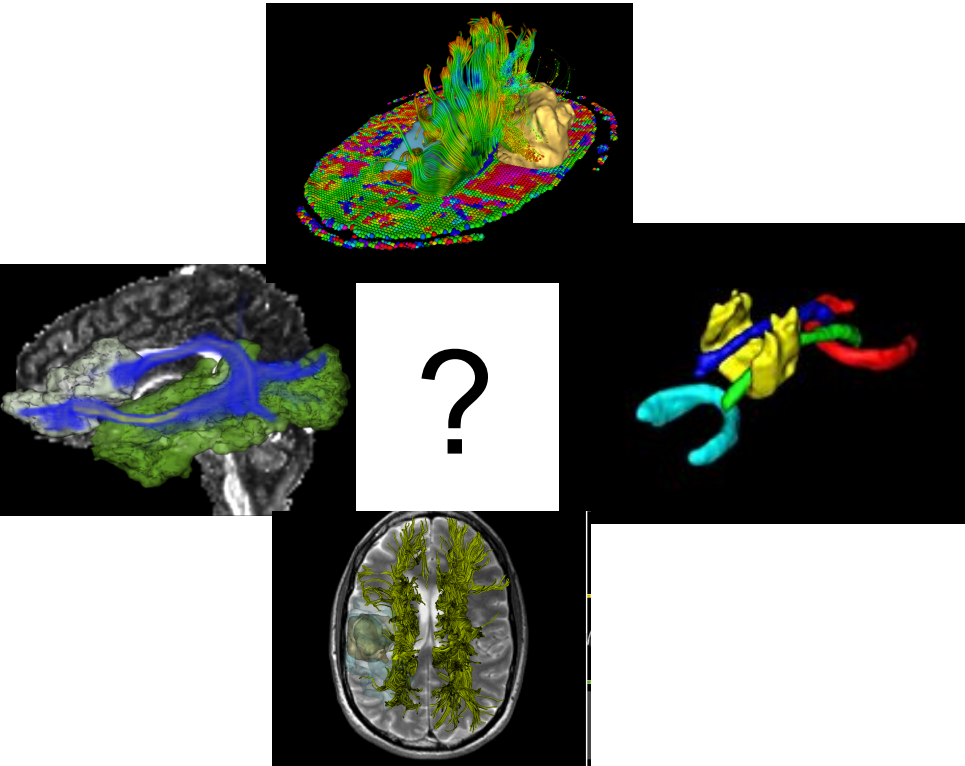
Qualitative and quantitative evaluation of multiple existing tractography algorithms





# How to compare?

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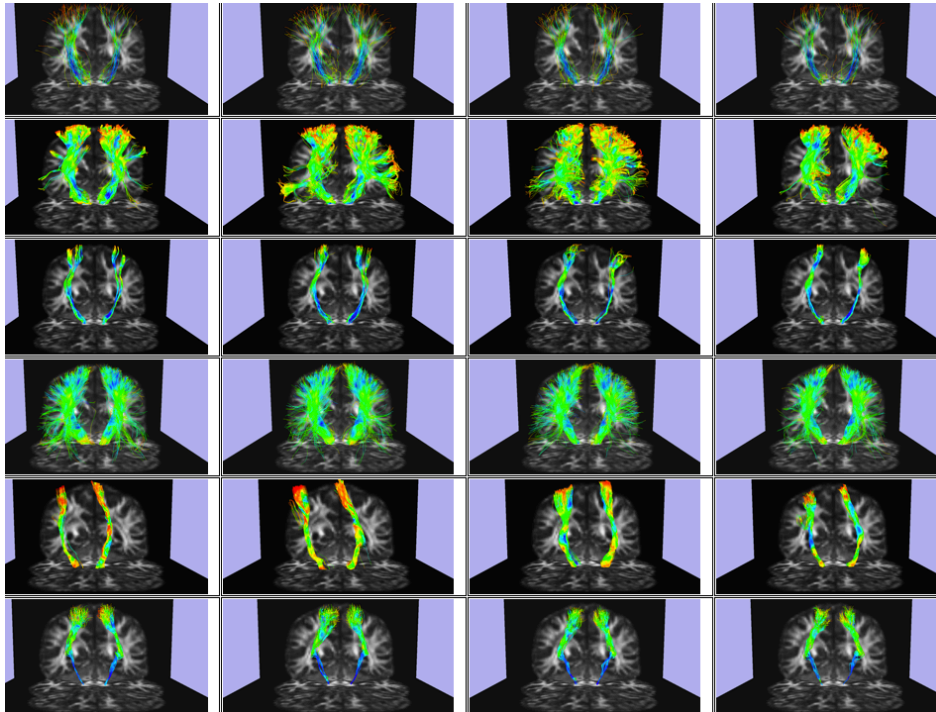


Many degrees of variability  
(patient, MR sequence, tumor location, etc..)





# How to compare?



Many degrees of variability

(patient, MR sequence, tumor location, etc..)



Standardized evaluation on a common set of data

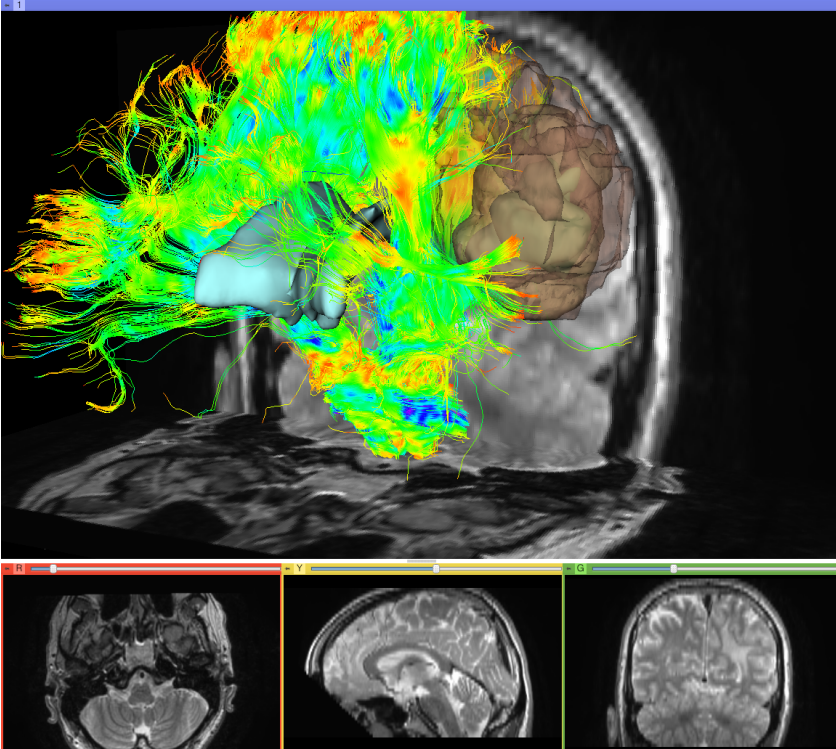


# How to compare?

Absence of ground truth

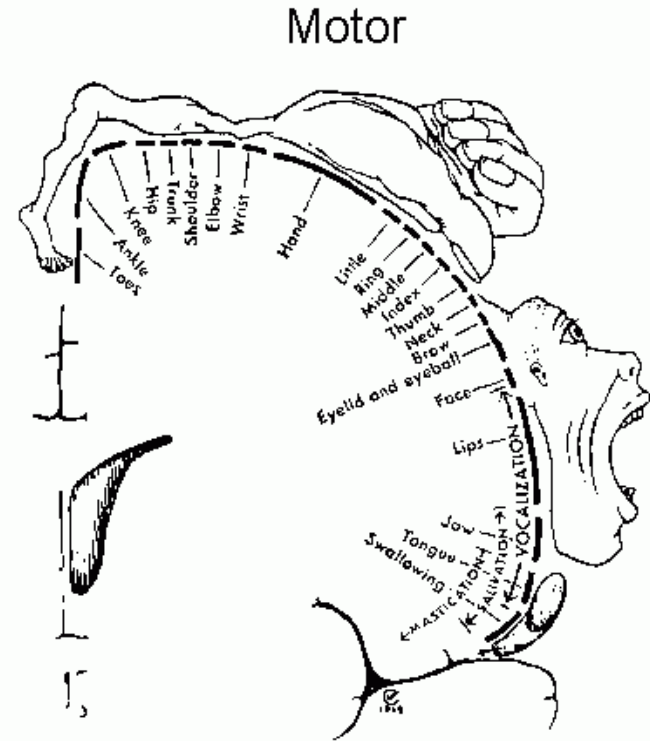
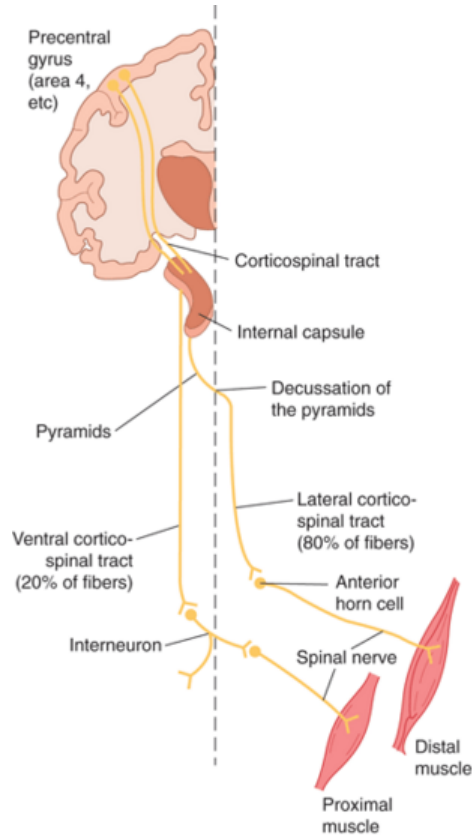


Combination of qualitative and quantitative criteria to get closer to the ground truth





# Corticospinal tract



(After W. Penfield and T. Rasmussen, 1950)

Source: Barrett KE, Barman SM, Boitano S, Brooks H: *Ganong's Review of Medical Physiology*, 23<sup>rd</sup> Edition: <http://www.accessmedicine.com>



# Workshop datasets

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- Four neurosurgical cases involving the CST
  - Patient1: Residual anaplastic oligoastrocytoma
  - Patient2: Anaplastic oligoastrocytoma
  - Patient3: Anaplastic oligodendroglioma
  - Patient4: Glioblastoma grade 4

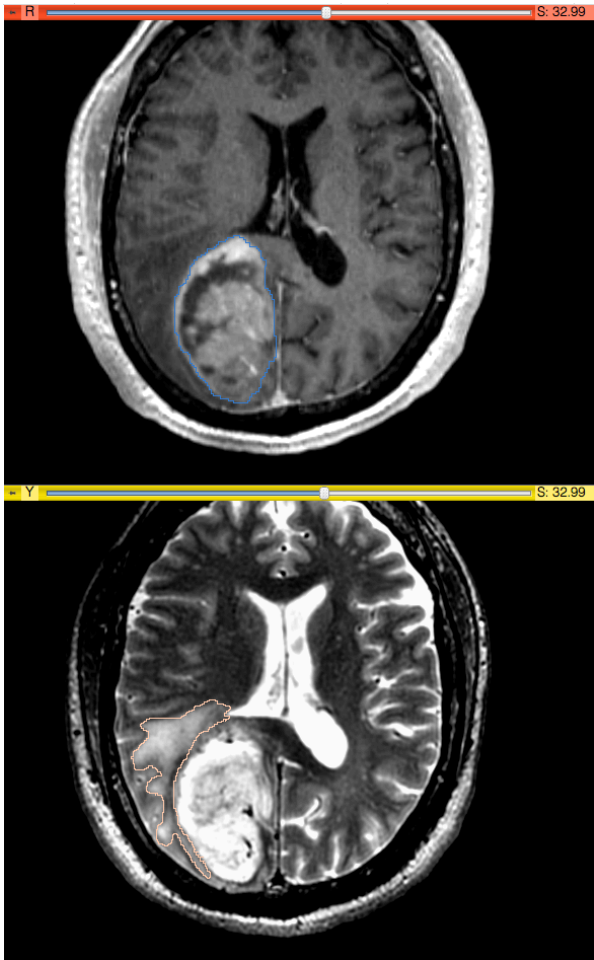
Cases provided by Dr. Alexandra Golby, neurosurgeon, BWH

- Two healthy subjects scanned twice on 5 different scanners

Datasets provided by Guido Gerig, Ph.D, SCI Utah



# Workshop Datasets



- Each dataset included T1-weighted, T2-weighted, Pre-op DWI and DTI
- Manual segmentation of tumor and edema on T1 and T2 images
- Review by expert neuroradiologist





# Evaluation Criteria

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## Two sets of metrics

- Qualitative assessment by clinicians and DTI experts
- Quantitative analysis based on five different metrics



# Quantitative evaluation

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**Metric 1:** Dice coefficient of overlap

**Metric 2:** Hausdorff distance

**Metric 3:** Fiber FA and MD profile along tract

**Metric 4:** STAPLE sensitivity score

**Metric 5:** STAPLE specificity score



# Clinical Evaluation Criteria

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**C1:** Anatomical correctness of the tract

**C2:** Presence of false positive-tracts

**C3:** Presence of false negative-tracts

**C4:** Correct depiction of the distance between the tract and the lesion

**C5:** Demonstration of tract displacement

**C6:** Demonstration of tumor infiltration

**→ critical to the neurosurgeon**



# MICCAI 2011 Workshop

- 8 international teams
- 10-hour long workshop
- 25 participants
- 352 corticospinal tracts generated
- 5,900 visits on challenge webpage



**DTI Tractography for Neurosurgical Planning: A Grand Challenge**

Welcome to the DTI Tractography for Neurosurgical Planning: A Grand Challenge workshop. The goal of the initiative is to provide neurosurgeons with an overview of the progress in the field of DTI Tractography for Neurosurgical Planning and to provide neurosurgeons with an overview of the progress in the field of DTI Tractography for Neurosurgical Planning.

**Overview**

Diffusion Tensor Imaging (DTI) Tractography has a crucial potential for neurosurgical planning since it provides a virtual representation of white matter pathways. This virtual representation can be used to plan neurosurgical procedures and to evaluate the performance of the tractography algorithms. The DTI Tractography Challenge workshop will give participants the opportunity to evaluate the performance of their tractography algorithms and to gain insights on the currently available paradigms for evaluating tractography results in the Operating Room. In the absence of ground truth.

**Faculty**

- Boris Poon, Ph.D., Surgical Planning Laboratory, Brigham and Women's Hospital, Harvard Medical School
- Ben Adams, M.D., Surgical Planning Laboratory, Brigham and Women's Hospital, Harvard Medical School
- Alexander Goh, Ph.D., Department of Neurosurgery, Brigham and Women's Hospital, Harvard Medical School
- Guohua Gao, Ph.D., The Scientific Computing and Imaging Institute, University of Utah
- Mark Spitzer, Ph.D., NeuroImage Research and Analysis Laboratory, University of North Carolina
- Wilson Velho, Ph.D., Surgical Planning Laboratory, Brigham and Women's Hospital, Harvard Medical School
- Christophoros Michos, Ph.D., Laboratory of Radiology and Imaging, Brigham and Women's Hospital, Harvard Medical School
- Frank Gantner, M.Sc., The Scientific Computing and Imaging Institute, University of Utah
- Paul Mollnes, M.D., Department of Neurosurgery, University Hospital Schleswig-Holstein, Kiel, Germany
- Mathias Marnett, M.D., Ph.D., Department of Radiology, Brigham and Women's Hospital, Harvard Medical School

**Workshop Agenda**

- 08:00-09:00: Start of the workshop
- 09:00-10:00: Morning remarks
- 10:00-10:30: DTI Tractography and
- 10:30-10:45: Presentation of the
- 10:45-11:00: Coffee break
- 11:00-11:15: Tractography Basics
- 11:15-11:30: Multiscale Science
- 11:30-11:45: Inviting remarks
- 11:45-12:00: Roundtable discussion
- 12:00-12:30: A Volunteer's Appl



[http://www.na-mic.org/Wiki/index.php/Events:\\_DTI\\_Tractography\\_Challenge\\_MICCAI\\_2011](http://www.na-mic.org/Wiki/index.php/Events:_DTI_Tractography_Challenge_MICCAI_2011)



# Challenge participants

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- UPenn, Philadelphia, USA
- INRIA Rennes, France
- Robarts Research Institute, Toronto, Canada
- Scientific Computing and Imaging Institute, Salt Lake City, USA
- University of Florida, USA
- Laboratory of Mathematics in Imaging, Boston, USA
- German Cancer Research Centre, Heidelberg, Germany
- UNC Chapell Hill, USA





# Tractography Algorithms

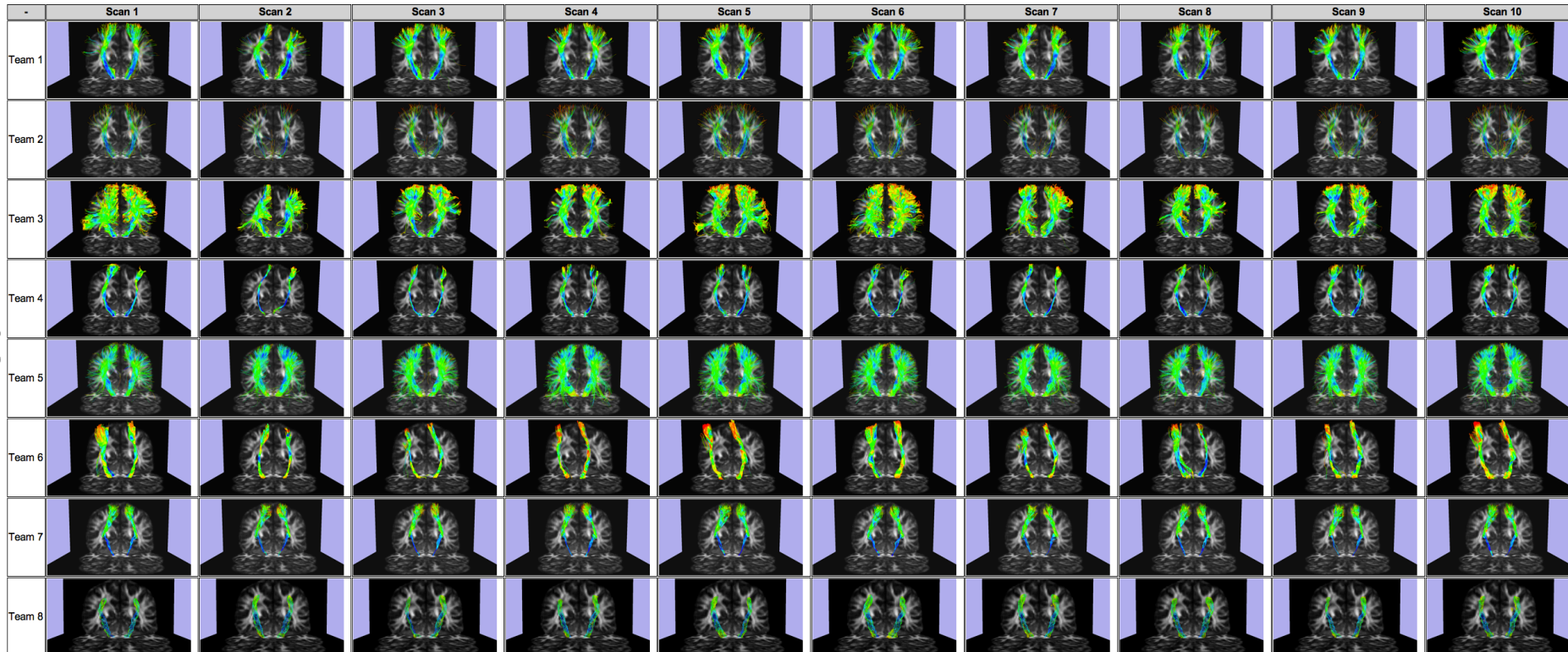
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1. Intrinsic Unscented Kalman Filter
2. Global Fiber tracking based on Finsler Distance
3. Automated Atlas-Based Seeding
4. Machine Learning & Particle Mass based tractography
5. Streamline tractography based on a multi-compartment model
6. Filtered Multi-tensor tractography
7. Volumetric Tractography
8. MITK Global Tractography



# Healthy subjects Results

## Scan



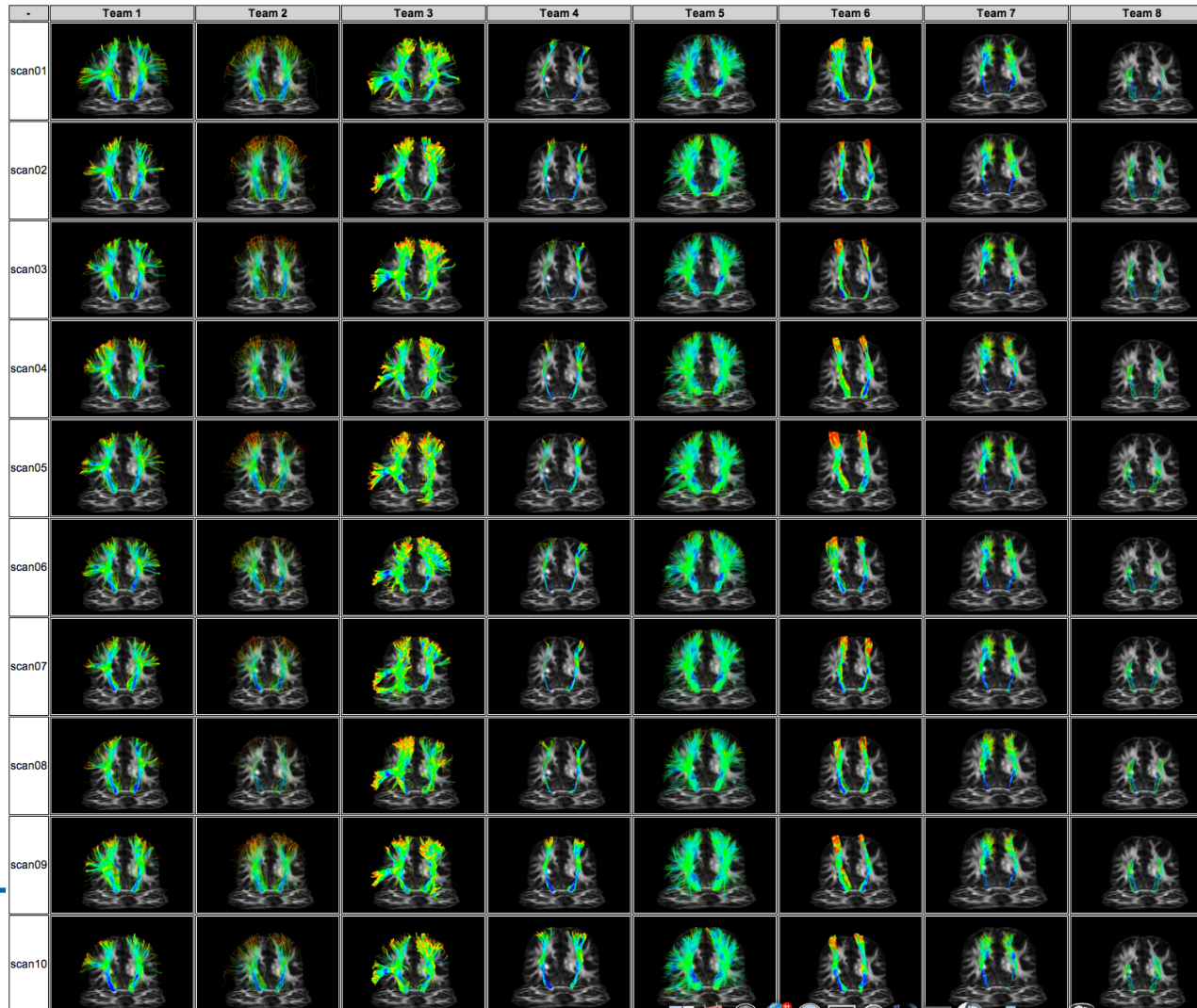


# Healthy subjects Results

## Team

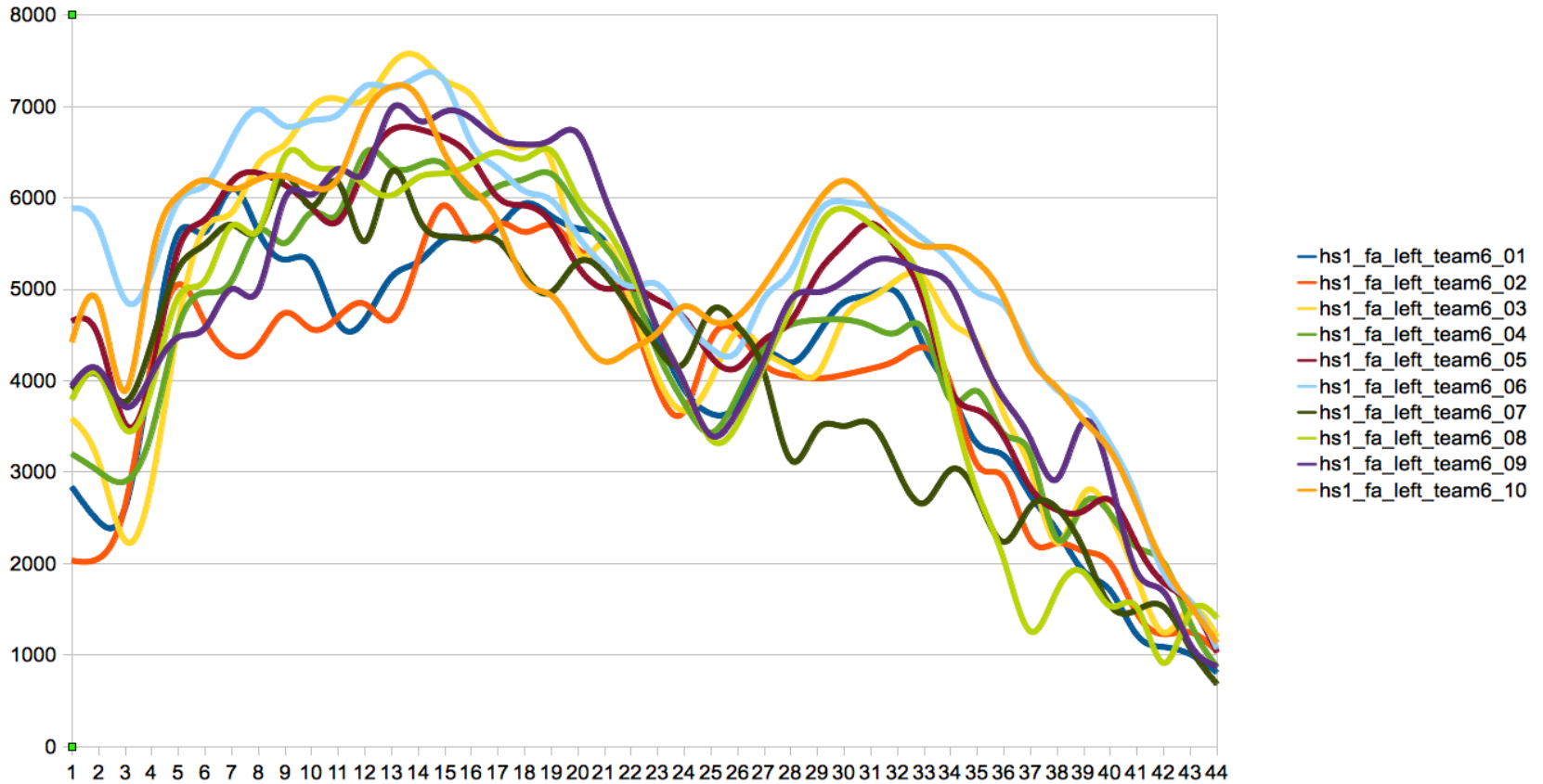
Healthy Subject 1 (For each scan, the images show the comparison across teams.)

## Scan





# FA profile example





# Results

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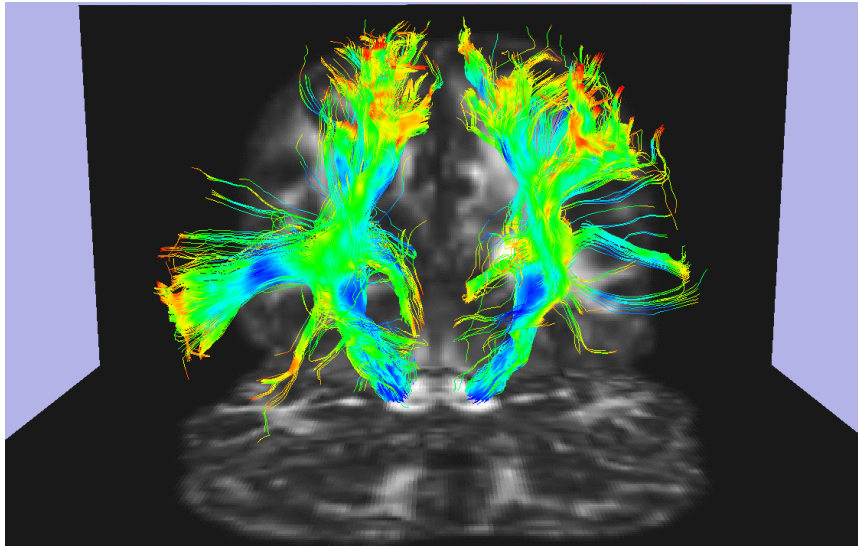
Mean(STD)	Healthy Subject 1	Healthy Subject 2
Dice's coefficient	0.45(0.17)	0.40(0.27)
Hausdorff Distance	1.95(0.97) mm	2.7(2.10) mm
STAPLE sensitivity	0.45(0.09)	0.42(0.08)





# Workshop Outcomes

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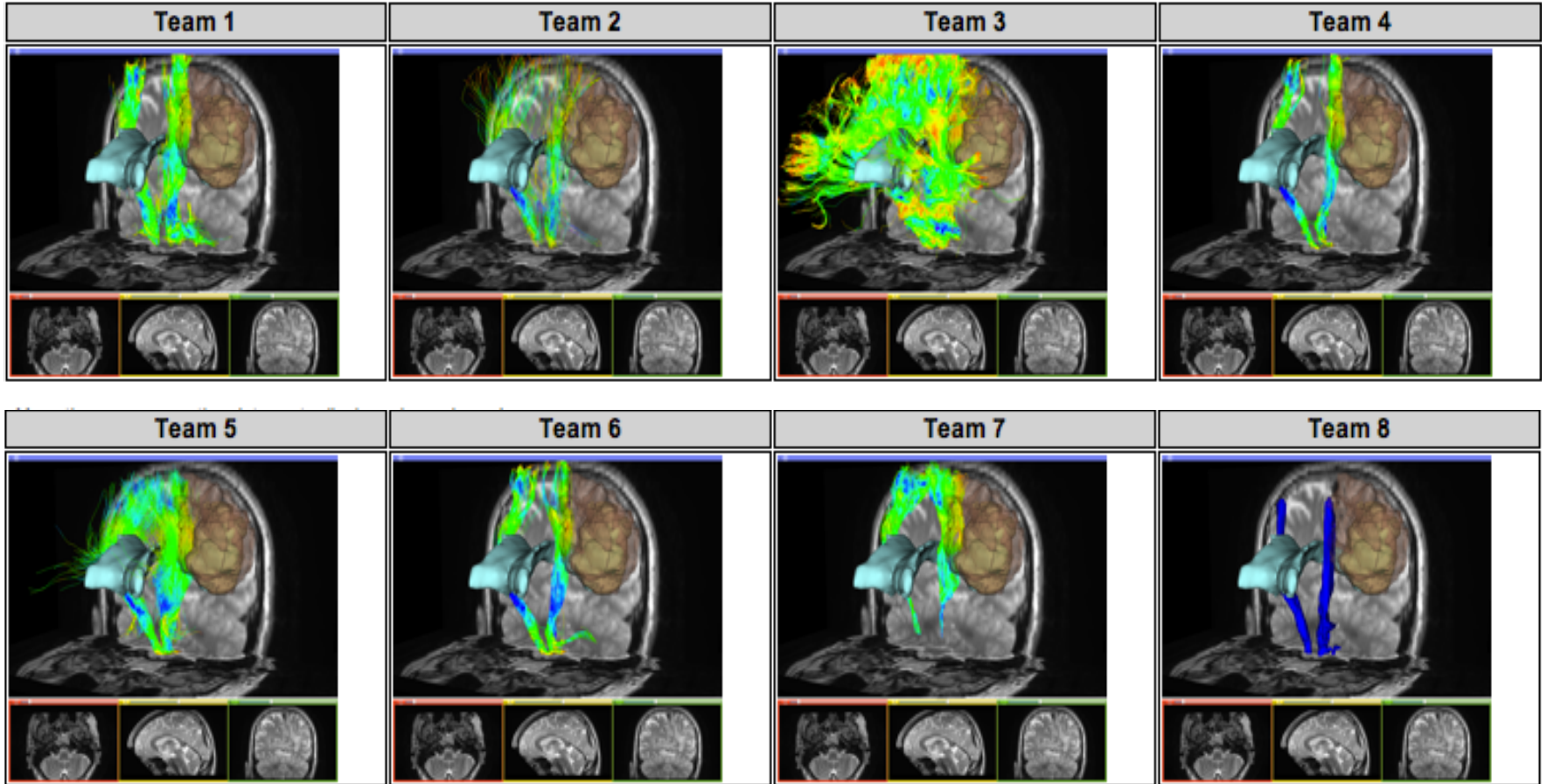


Healthy subject study

→ large **intra-  
algorithm** variability

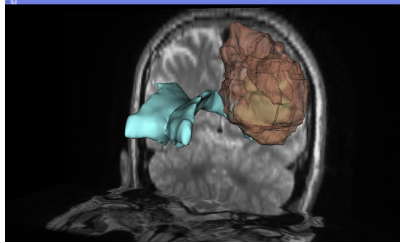


# Clinical Cases Results

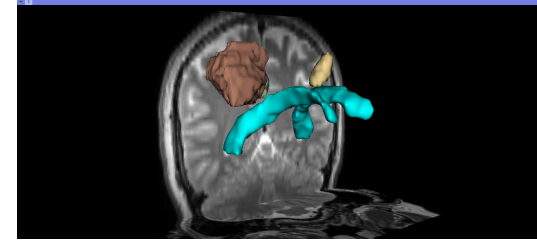
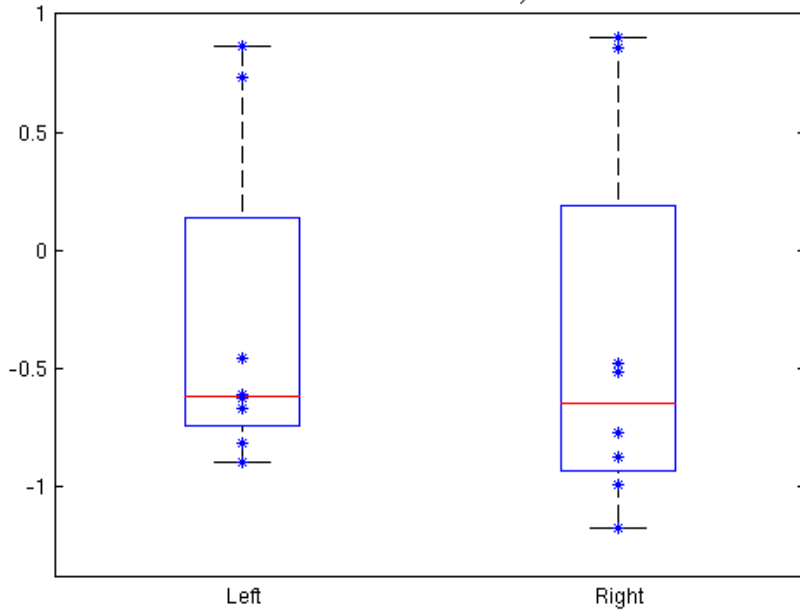




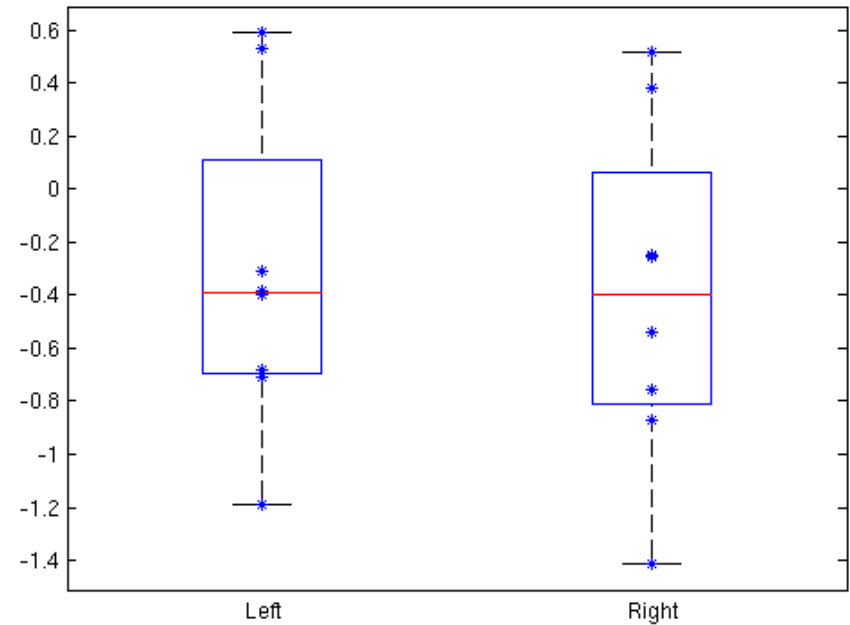
# STAPLE results



Patient 1 - Sensitivity



Patient 2 - Sensitivity

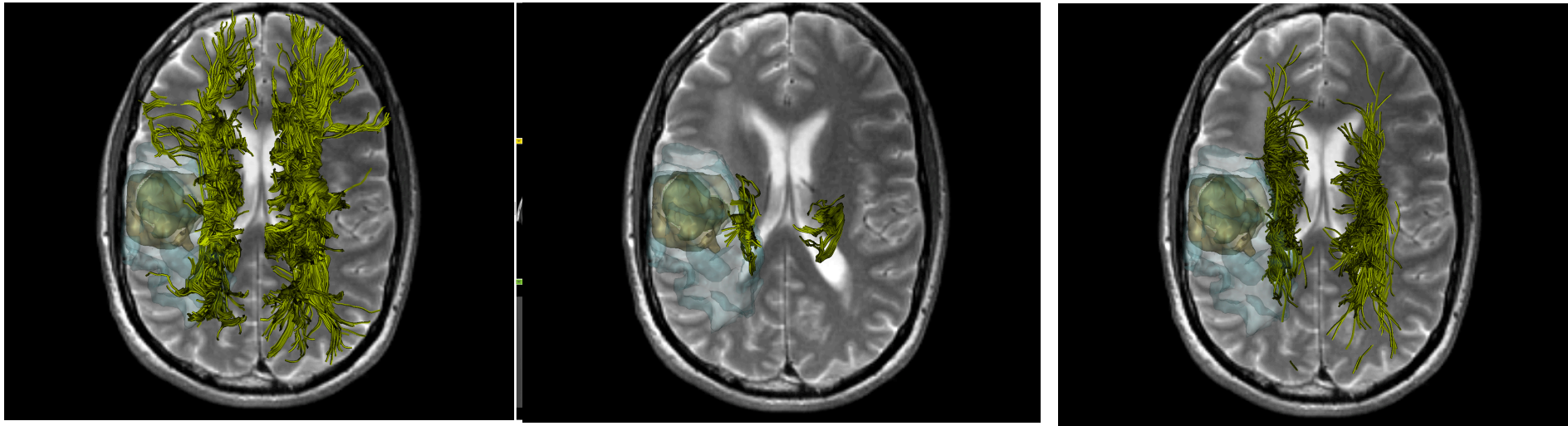


Weak agreement, large inter-algorithm variability



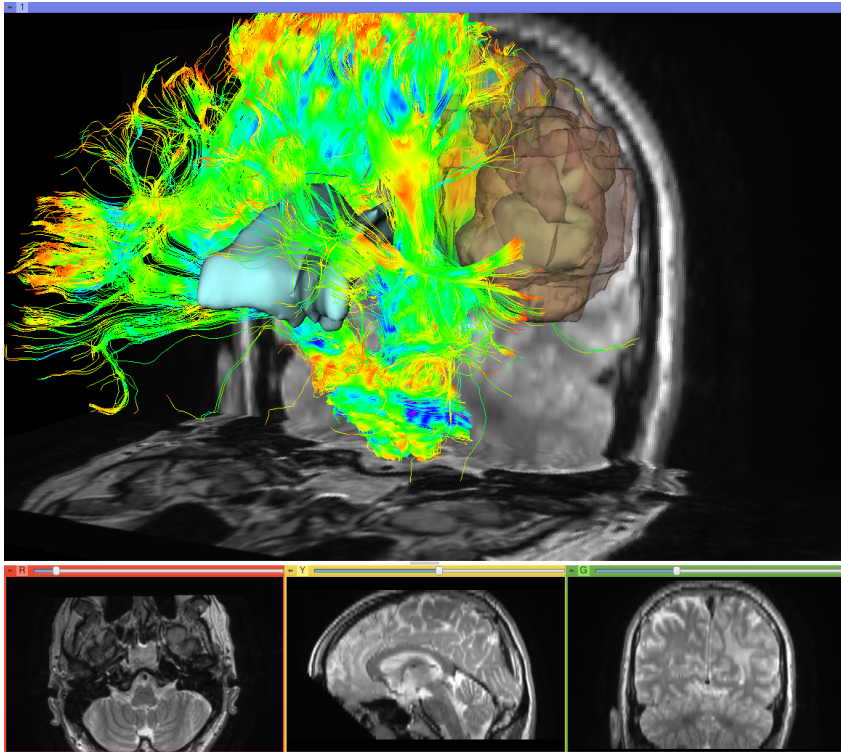
# Clinical cases results

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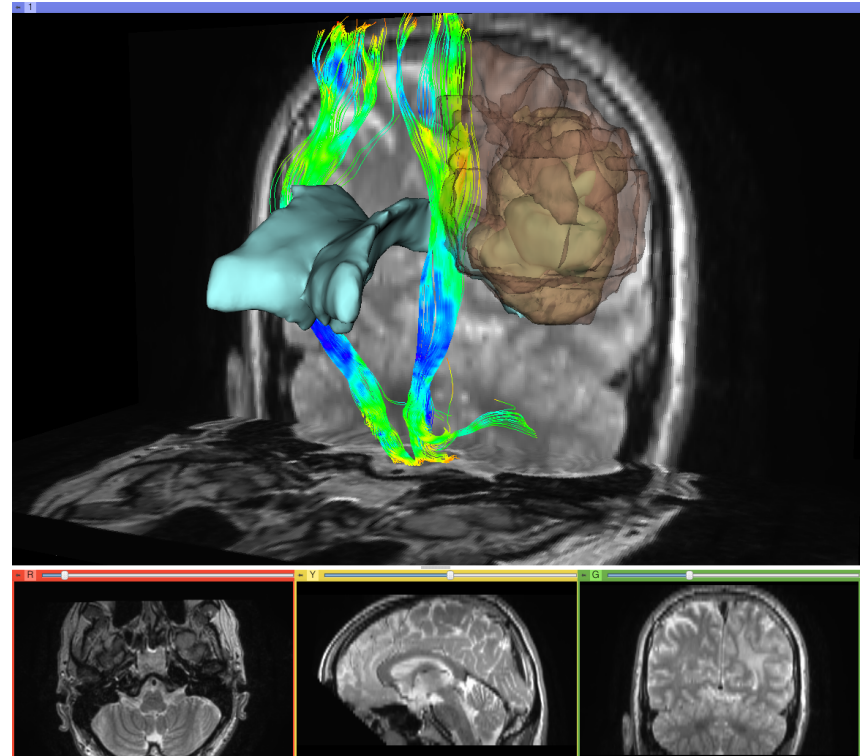




# CST reconstructions



FP



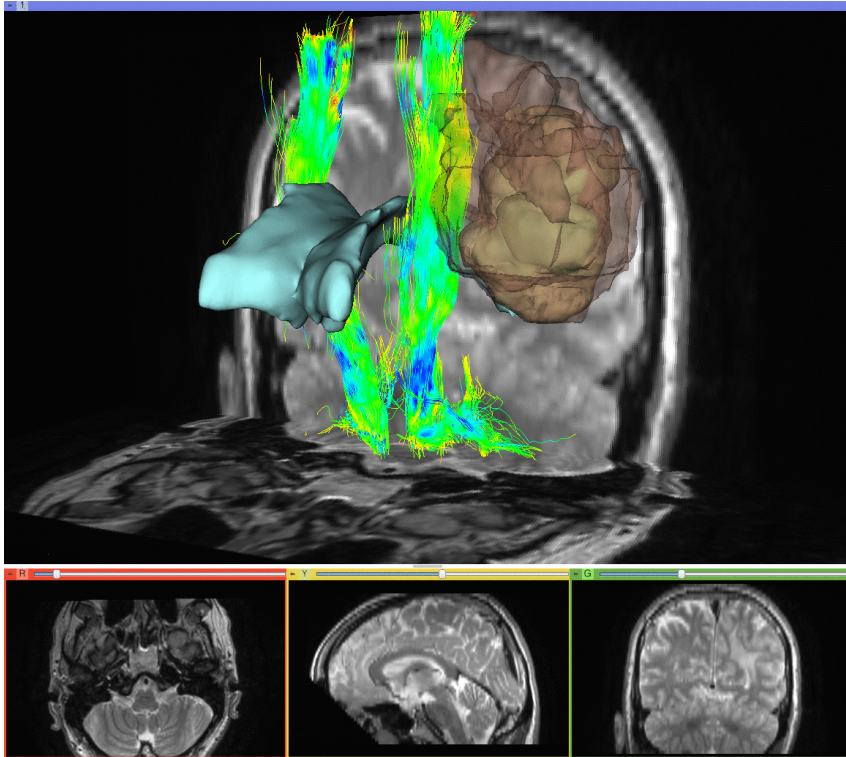
FN





# Clinical cases Results

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Neurosurgical cases study

→ large **inter-algorithm** variability



# Workshop outcomes

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- Large variability among tractography methods
- Quantitative metrics selected based on hypothesis of successful targeting of CST
- Opportunity for review and feedback from leading neurosurgeons
- Positive feedback from the MICCAI community



# Conclusion: the Challenge is the challenge!



$$\frac{\partial}{\partial x_i} \frac{\partial}{\partial x_k} A$$
$$\frac{\partial}{\partial x_k} \sqrt{A} + \frac{\partial}{\partial x_k} \sqrt{A_k} + \frac{1}{c} \frac{\partial}{\partial x_k} \frac{\partial}{\partial t} + \frac{1}{c^2} \frac{\partial^2}{\partial t^2} = \frac{4\pi}{c} J_k$$
$$-\nabla^2 A_k + \frac{1}{c^2} \frac{\partial^2 A_k}{\partial t^2} + \frac{\partial}{\partial x_k} \left( \vec{\nabla} \cdot \vec{A} + \frac{1}{c} \frac{\partial \phi}{\partial t} \right) = \frac{4\pi}{c} J_k$$
$$-\nabla^2 \vec{A} + \frac{1}{c^2} \frac{\partial^2 \vec{A}}{\partial t^2} + \vec{\nabla} \left( \vec{\nabla} \cdot \vec{A} + \frac{1}{c} \frac{\partial \phi}{\partial t} \right) = \frac{4\pi}{c} \vec{J}$$

```
doms::logPlus::logger::write(
  "logger::settings::doms::
  @Application::setLog( log );
  app::setOrganizationName( "Common
  app::setOrganizationDomain( "com
  app::setAppId( "testName", "test000" );
  @Settings::settings;
  @String::databaseDirectory;
  // set up the database
  if (argc > 1)
  {
    @String::directory( argc[1] );
    settings::setSetting( "databaseDirectory", directory );
    settings::sync();
  }
  if ( ! settings::value( "databaseDirectory", "" ) )
  {
    databaseDirectory = @String( "C:\\data\\db\\");
    settings::setSetting( "databaseDirectory", databaseDirectory );
    settings::sync();
  } else
  {
    databaseDirectory = settings::value( "databaseDirectory", "" );
  }
}
```

**GAP**



Image courtesy of Arya Nabavi, MD

Algorithm Development

Problem solving



# Bridging the gap

---

- After the challenge, each team received a 14-page document containing the qualitative evaluation by the clinical and DTI experts, and the values of the quantitative metrics
- Participants were invited to re-process the data using the reviewers' feedback







# DTI Challenge: Conclusion

- Appropriate reflection of the current state of the art in the field
- Submission to MICCAI 2012
- On-going learning effort for the community

