ADVANCED WHITE MATTER IMAGING VISUALIZATION FOR RADIOSURGERY IN ELOQUENT BRAIN AREAS

G.K. RICCIARDI - R.I. FORONI

M Longhi, C Lemonis, E Zivelonghi, PM Polloniato, FB Pizzini, C Cavedon, M Ganau, F Sala, A Nicolato

Neurosurgery, Neuroradiology, Medical Physics,
Verona University Hospital Italy

NO DISCLOSURES

Verona Interactive Neurosurgical Imaging Laboratory

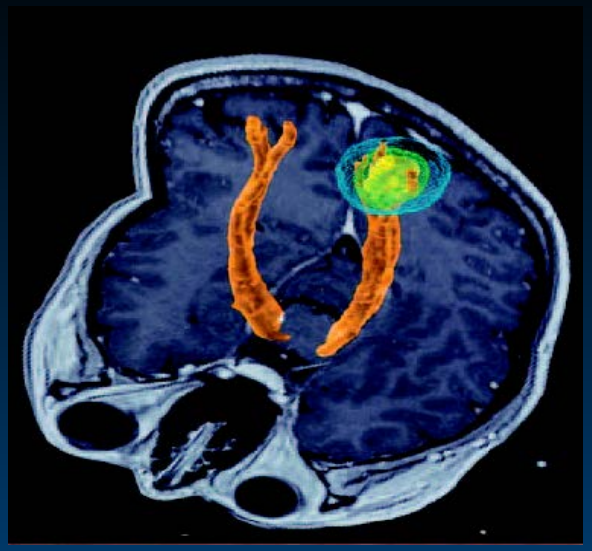
RADIO-SURGICAL PLANNING WITH TRACTOGRAPHY

RADIOSURGERY Vs SURGERY

- GREATEST ADVANTAGE
  - NO BRAIN SHIFT
- GREATEST DISADVANTAGE
  - NO INTRAOPERATIVE NEUROPHISIOLOGY

COMMON ENEMY : MRI DISTORSION

Maruyama K, IJROBP 2008



- The internal capsule was considered more sensitive than other regions, probably due to higher fiber concentration
- The tolerable dose of the CST resulted greater than that previously reported
- 5% risk of motor complications was related to a maximal dose of 23 Gy

Integration of CST Reduces Motor Complications After AVM's Radiosurgery

Koga T, Shin M, Maruyama K, et Al.

Department of Neurosurgery. The University of Tokyo Hospital

JRBOP (Int J Rad Onc Biol Phys 2011)

GROUPS	CST-T	N° pts	Obliteration rate at 4 yrs	Morbidity
A	No CST	28	69 % n.s.	18 %
B	CST Yes	24	76 % n.s.	4 % P 0.021

DO YOU THINK INTEGRATION OF TRACTOGRAPHY IN GKRS PLANNING CAN BE USEFUL?

1. YES

1. NO

2. ?

Diffusion-Tensor Imaging Tractography of the Corticospinal Tract for Evaluation of Motor Fiber Tract Radiation Exposure in Gamma Knife® Radiosurgery Treatment Planning

R.I. Foroni[a], *G.K. Ricciardi*[b], *F. Lupidi*[a], *A. Sboarina*[a], *A. De Simone*[a], *M. Longhi*[a], *A. Nicolato*[a], *F. Pizzini*[b], *A. Beltramello*[b], *M. Gerosa*[a]

[a]Stereotactic Unit, Neurosurgery Department, and [b]Neuroradiology Section, Neurosurgery Department, University Hospital, Verona, Italy

Karger, 2010, vol 7, pp 128–138

CST OUR RESULTS 2013

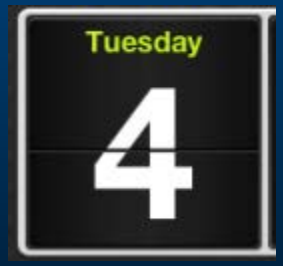
GROUPS	STUDY TYPE	N° pts	Obliteration rate at 3 yrs (median)	Morbidity
A	**EXPOSURE EVALUATION**	**18**	**72 % n.s.**	**12 %**
B	**TP MODIFICATION**	**18**	**70 % n.s.**	**6 %**

METHOD

Day before radiosurgery:
DTI and fiber tracking with 3-T MR

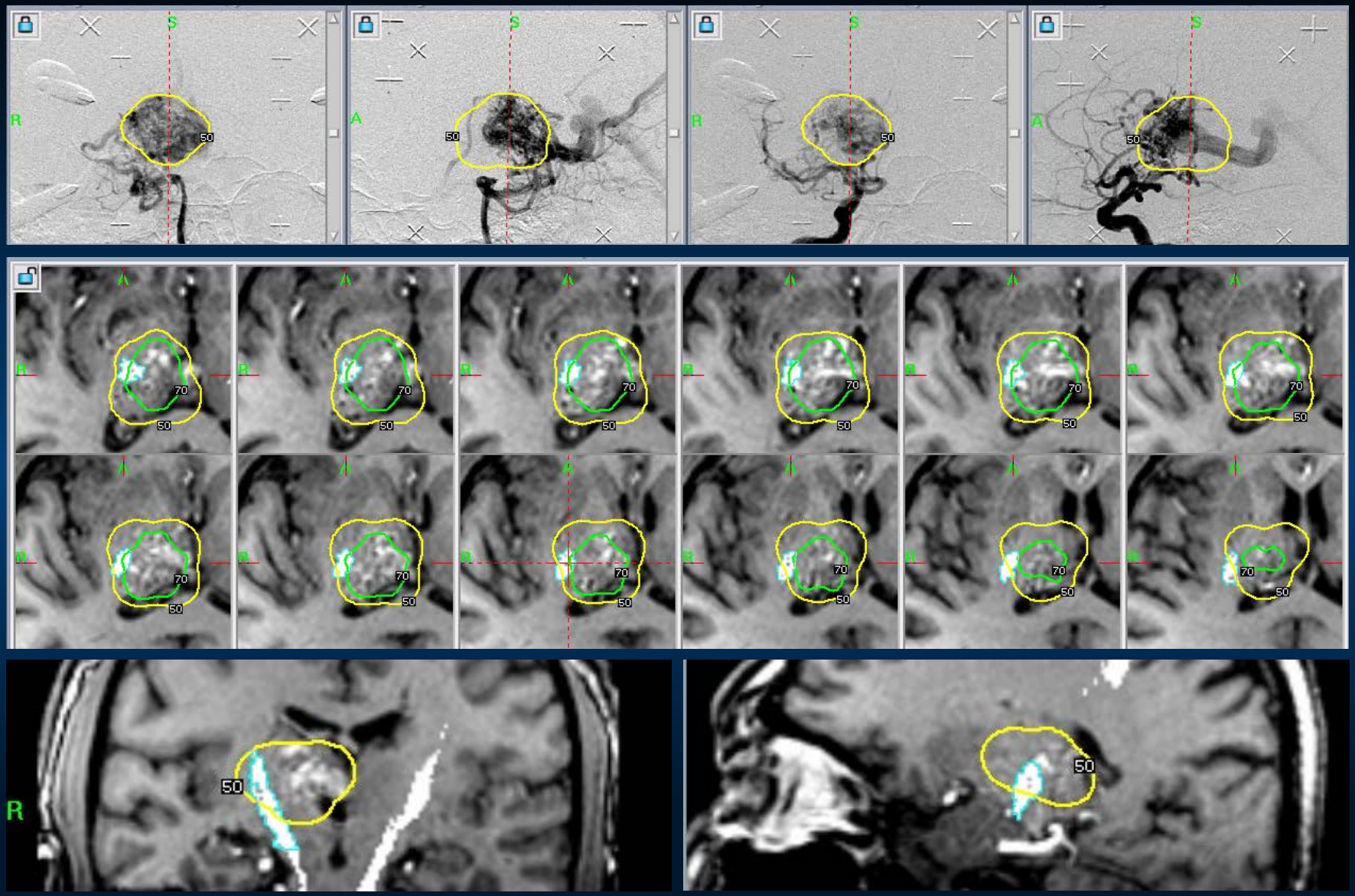
- ✓ **T1-weighted volumetric dataset (1x1x1)**
- ✓ **30 gradient DTI :**
  - ➢ Single-channel coil
  - ➢ NO Distorsion Correction
- ✓ **Tracking:**
  - ➢ Seed - Target ROIs = M1 cortex – CP
  - ➢ Not-ROI = basal ganglia, posterior brain stem

Radiosurgery Day
Stereotactic Leksel Frame 1-T MR



- ✓ **CE T1 volumetric dataset (1x1x1), axial T2 no gap, MRA**
- ✓ **Stereotactic Catheter Angiography**
- ✓ **Image registration: 3T CST DTI / 3T 3D-T1 / 1T CE 3D-T1**

Visualization of DTI-TTRACTOGRAPHY of CST during treatment planning



TECHNICAL IMPROVEMENTS

30 gradients → 60 gradients (HARDI)

LOW SENSITIVITY → HIGH SENSITIVITY (b-VALUE)

(15')

DTI MODEL → SPHERICAL DECONVOLUTION (2h)

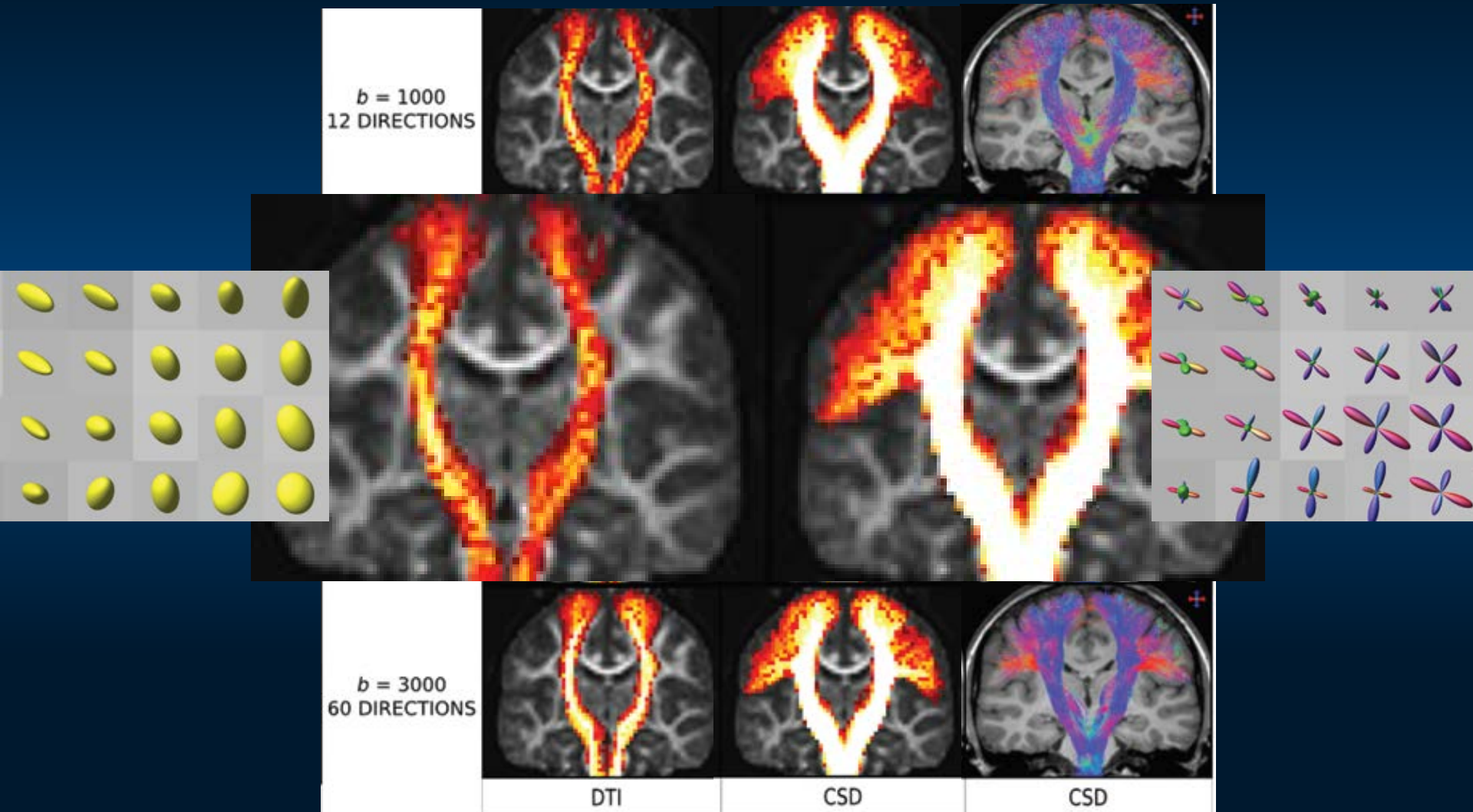
MINIMAL PRE-P. → EXTENSIVE PREPROCESSING (1h)

Verona Interactive Neurosurgical Imaging Laboratory

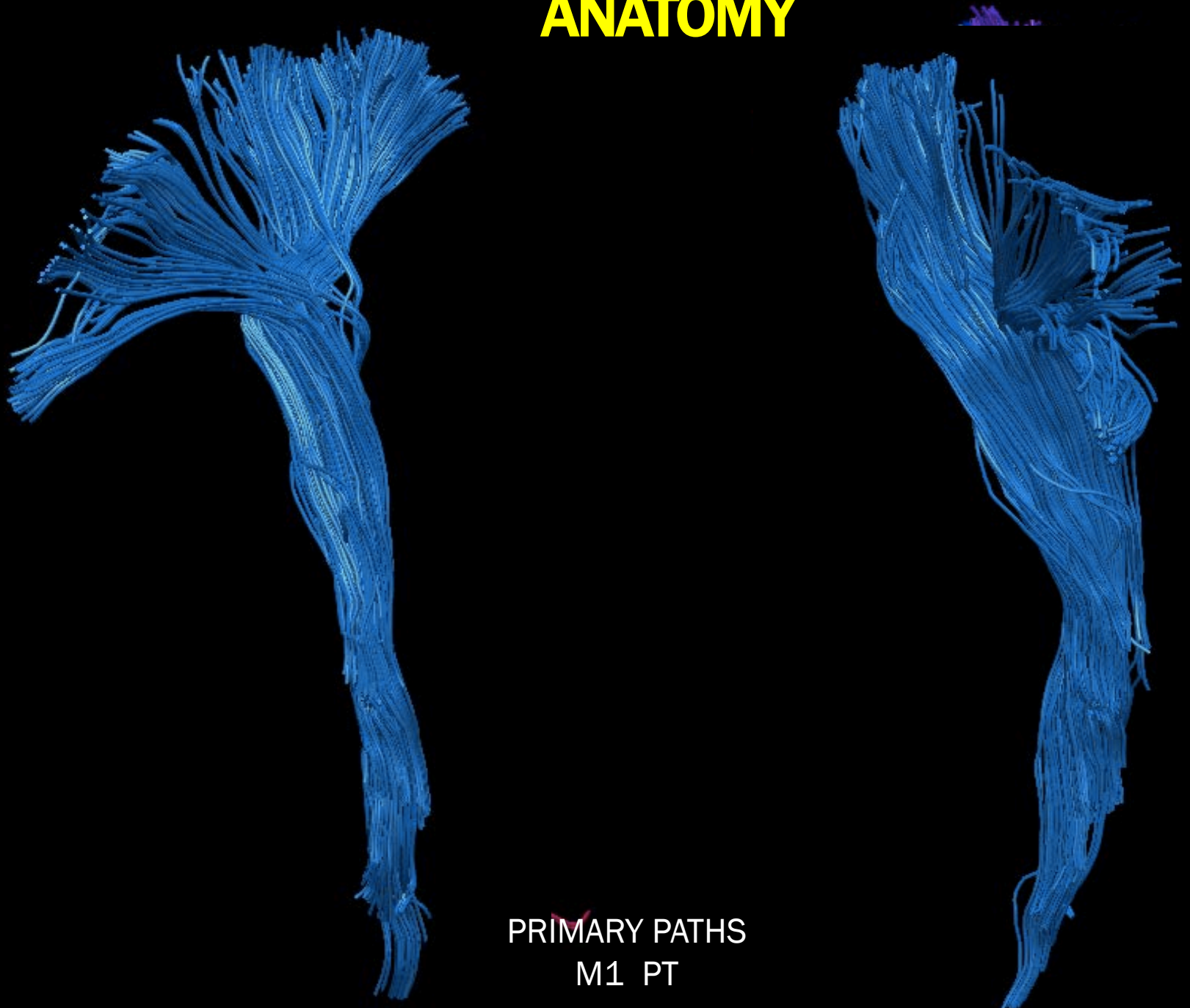
SPHERICAL DECONVOLUTION

Farquharson et al. JNS 2013

Tractography: why we need to move beyond DTI

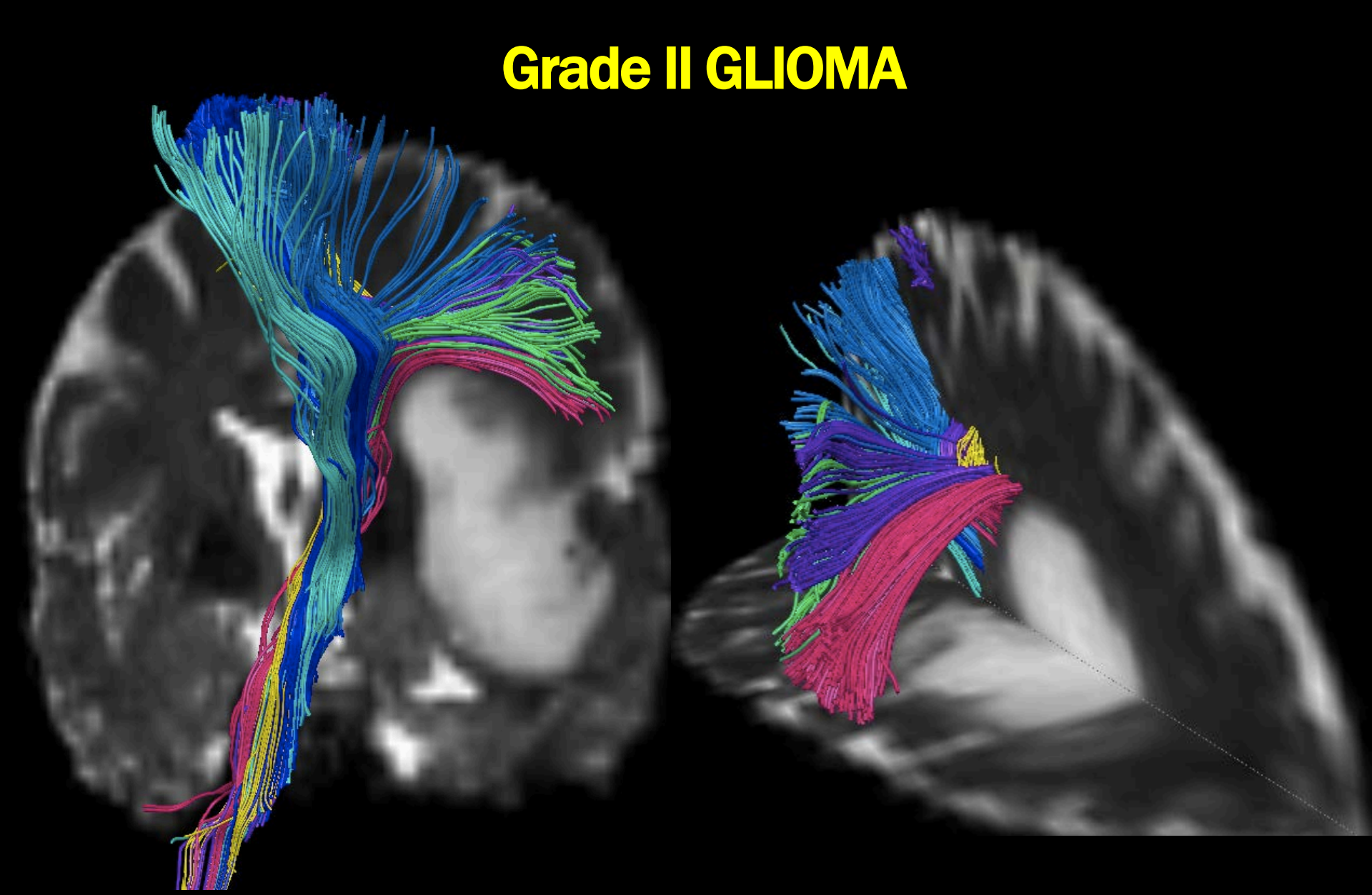


ANATOMY



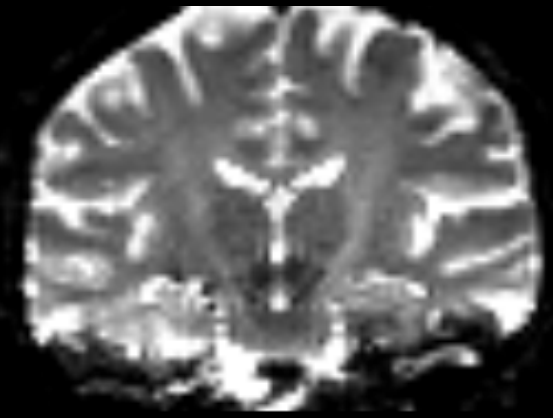
PRIMARY PATHS
M1 PT

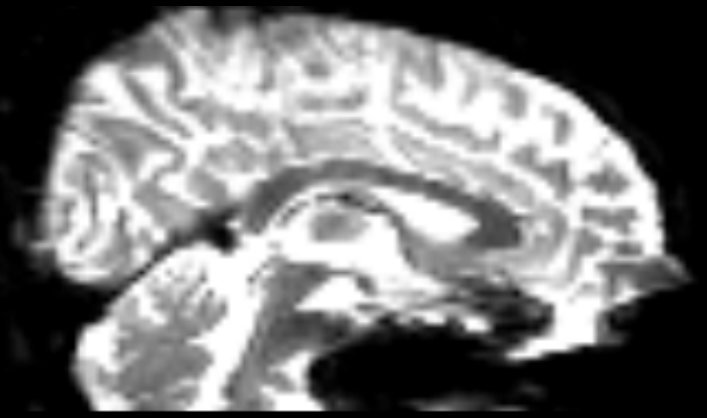
Grade II GLIOMA



We verified accuracy and selectivity of fibers reconstruction
with Spherical Deconvolution (SD) algorithms
by means of intraoperative neurophysiology (IoN) mapping and clinical outcome

PREPROCESSING





MATHEMATICAL

DISTORTION CORRECTION

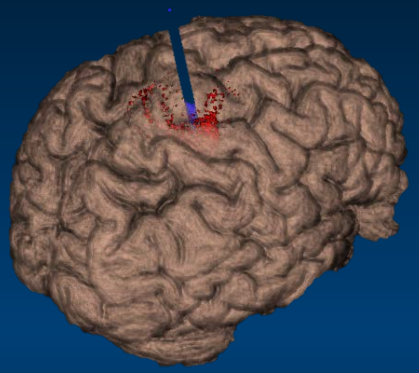
FMIRB FSL: TOPUP & EDDY

CASES WITH SD TRACTOGRAPHY

SURGERY

LGG & HGG	123
AVM's	15
METS	9

With IoN



RADIO-SURGERY

	CONVENTIONAL DTI	ADVANCED SPHERICAL DECONV.
AVM's	37	16

RESULTS

FIBRE BUNDLES

(STREAMLINES)

NUMBER of TRAJECTORIES

↑ 27% (SD 8)

VOLUME of BUNDLES

↑ 33% (SD 11)

PRECISION in TRACT LOCATION

↑ 20% (SD 7)

RESULTS

INTRA-OPERATIVE RESULTS

Intra-operative Neurophysiology

(Precision and Speed)

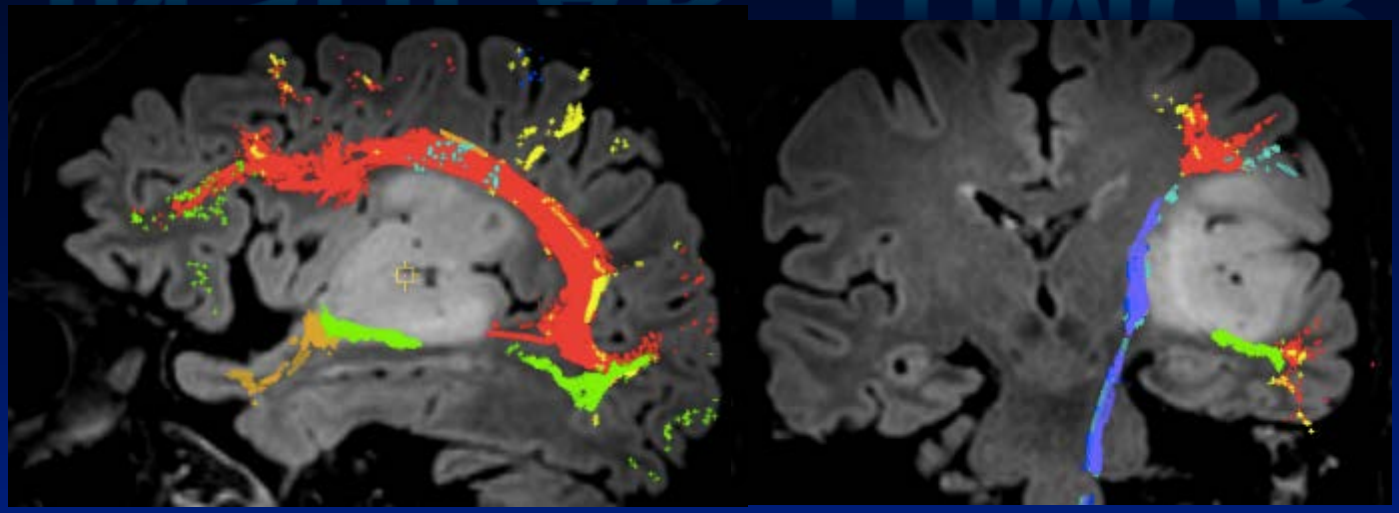
↑ 20%

Intra-opearative Neuropsycology

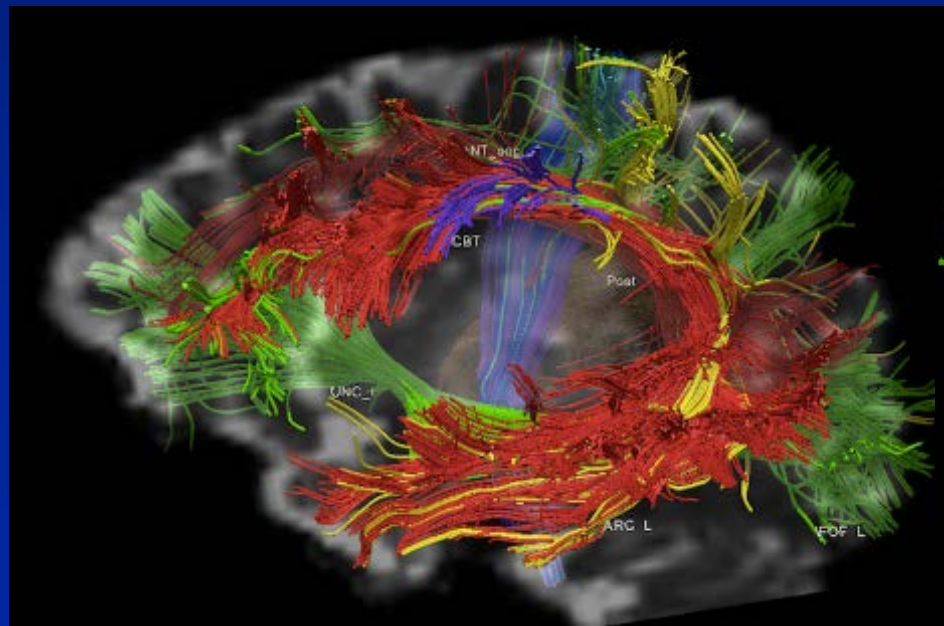
(Speed)

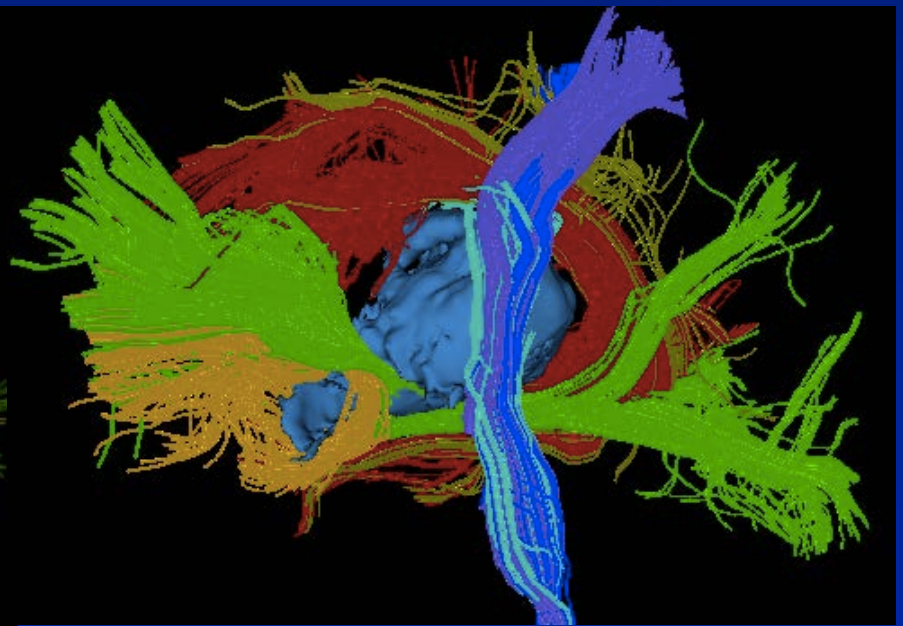
↑ 12%

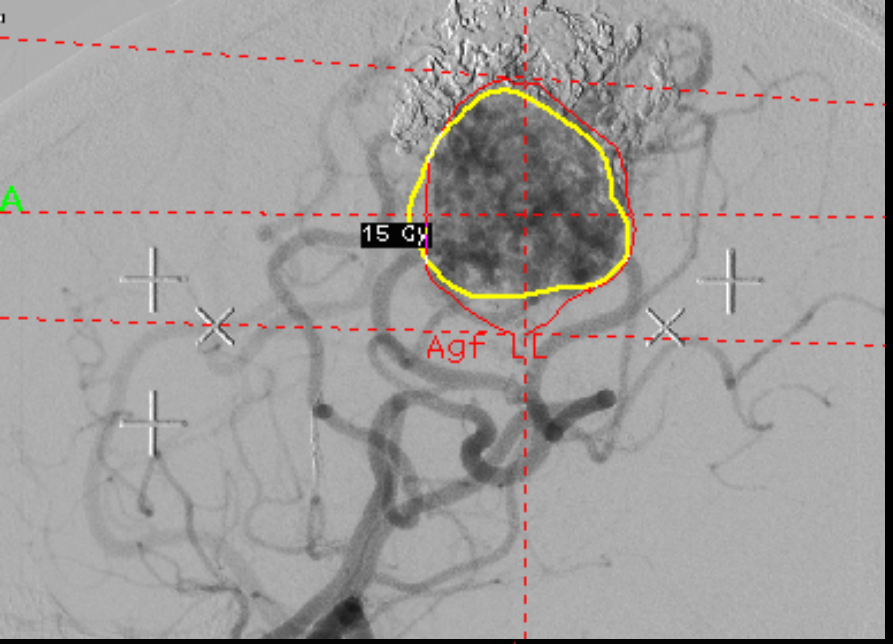
INSULAR TUMOR

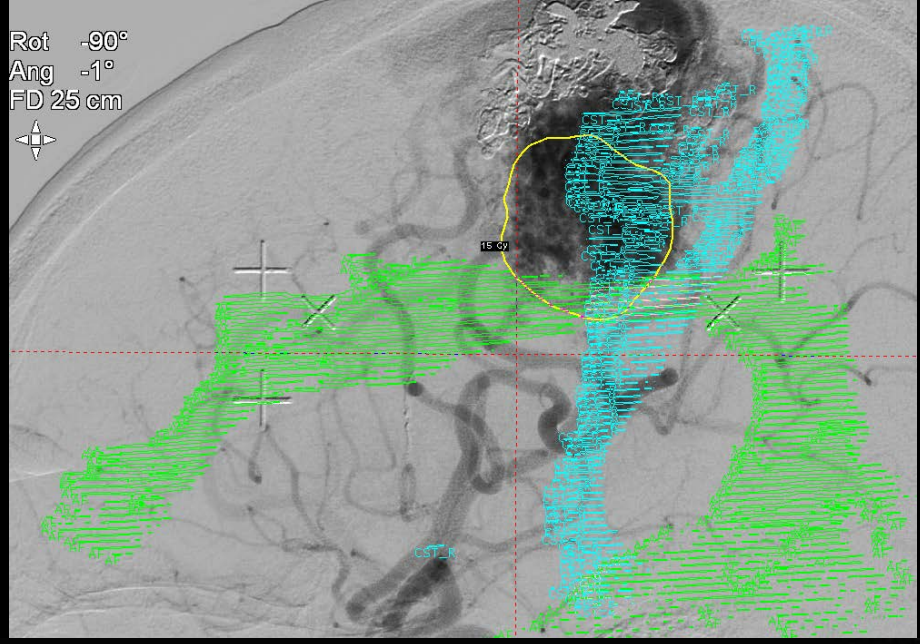


■Arc. ■SLF CST-CBT ■ IFOF ■ UNC

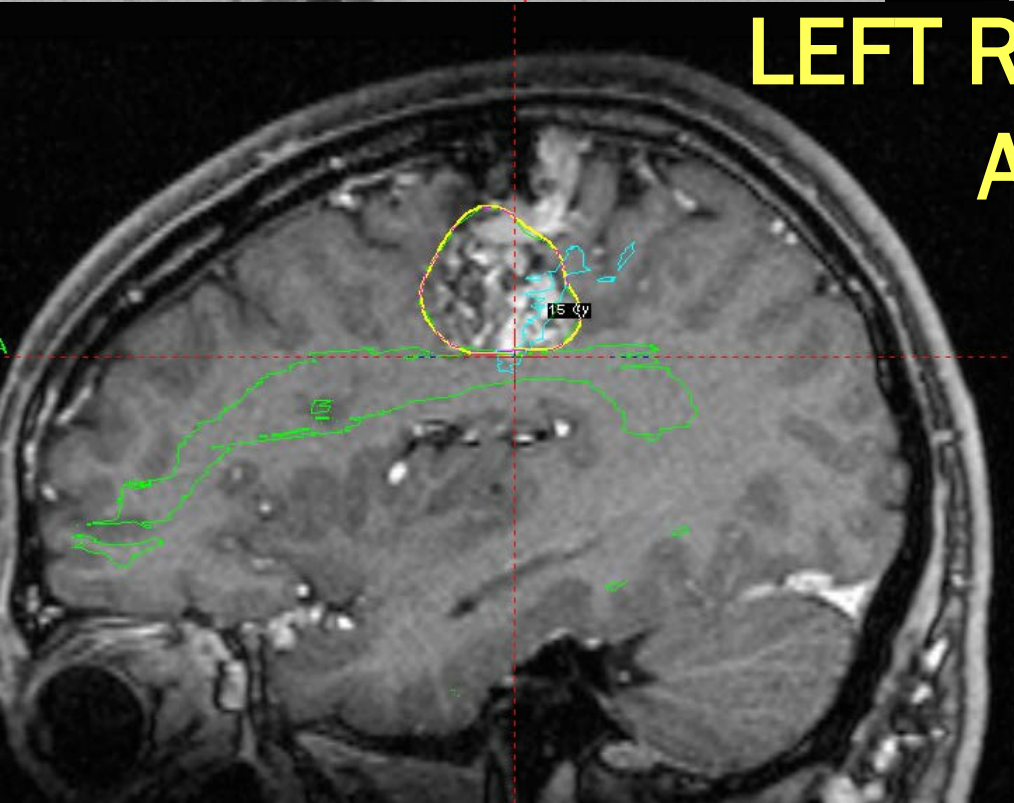


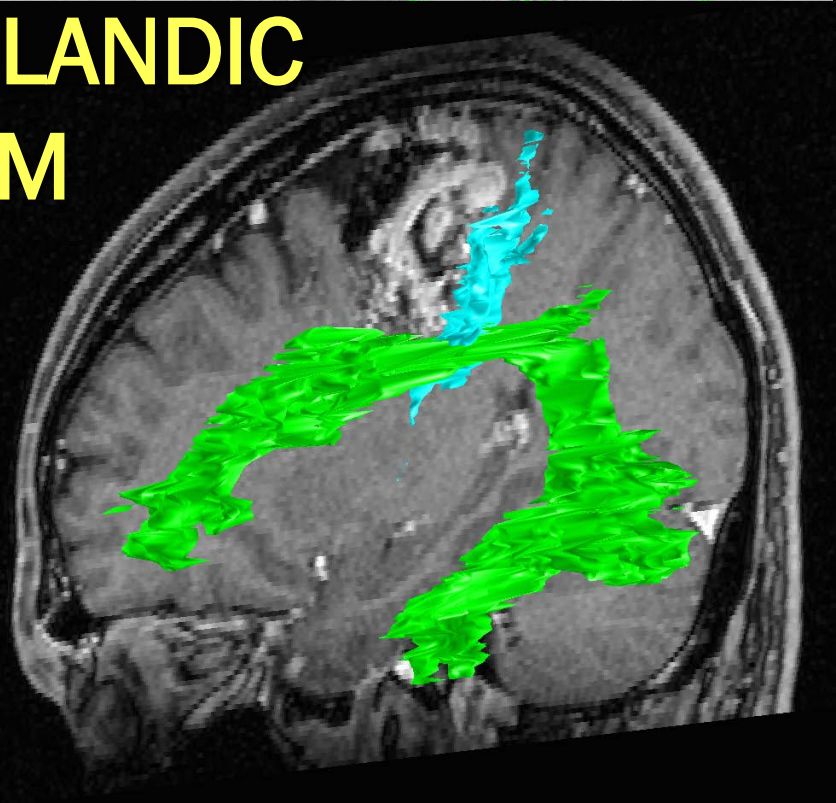


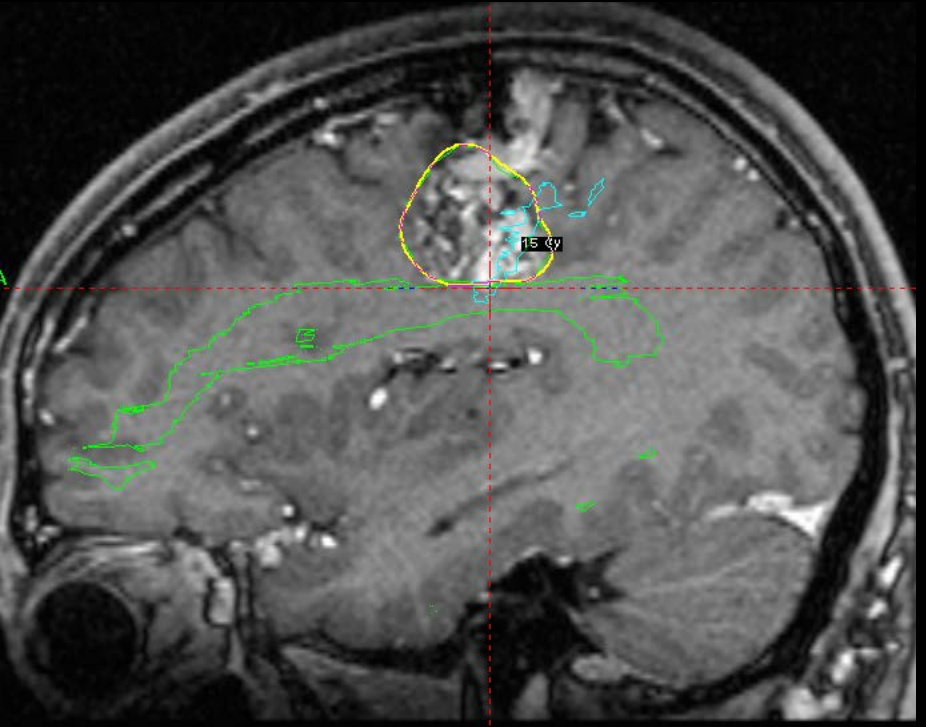


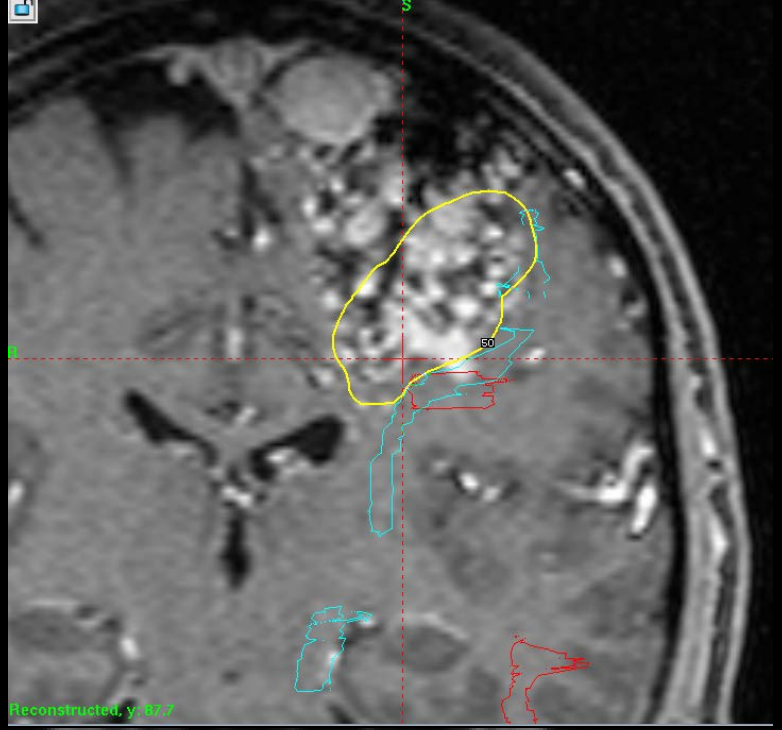


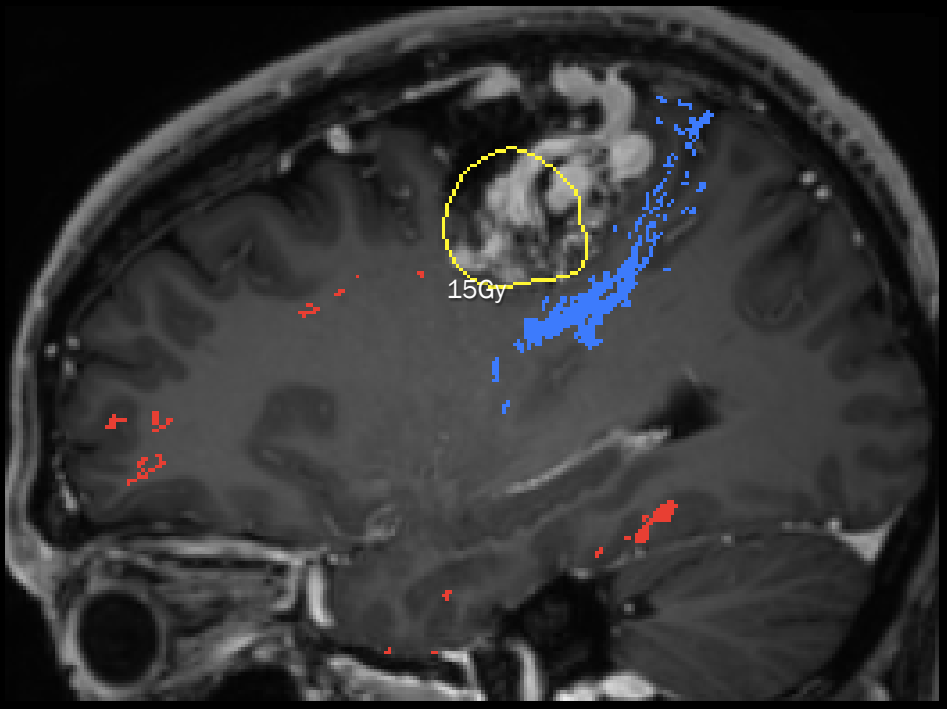
LEFT ROLANDIC AVM

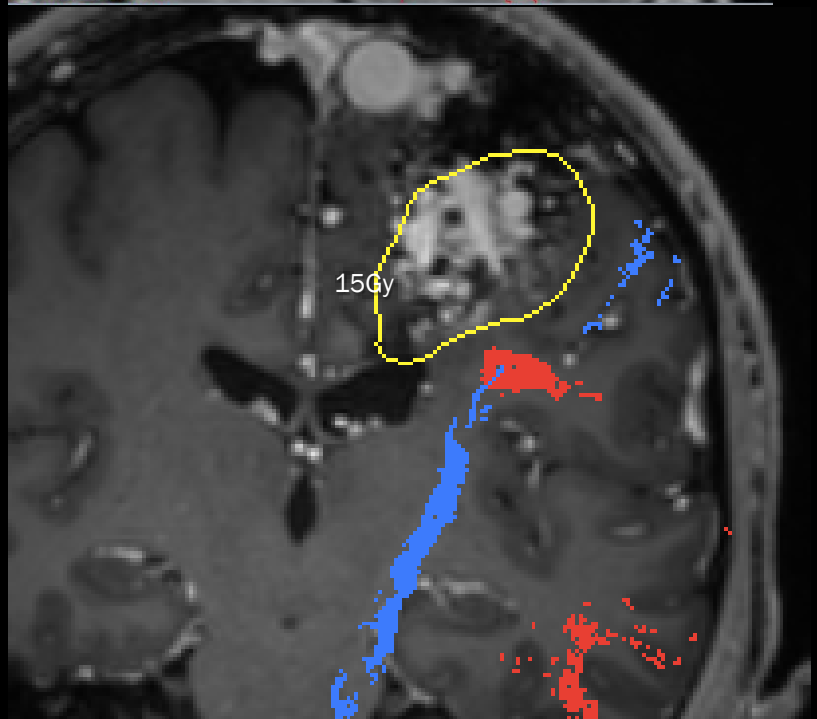


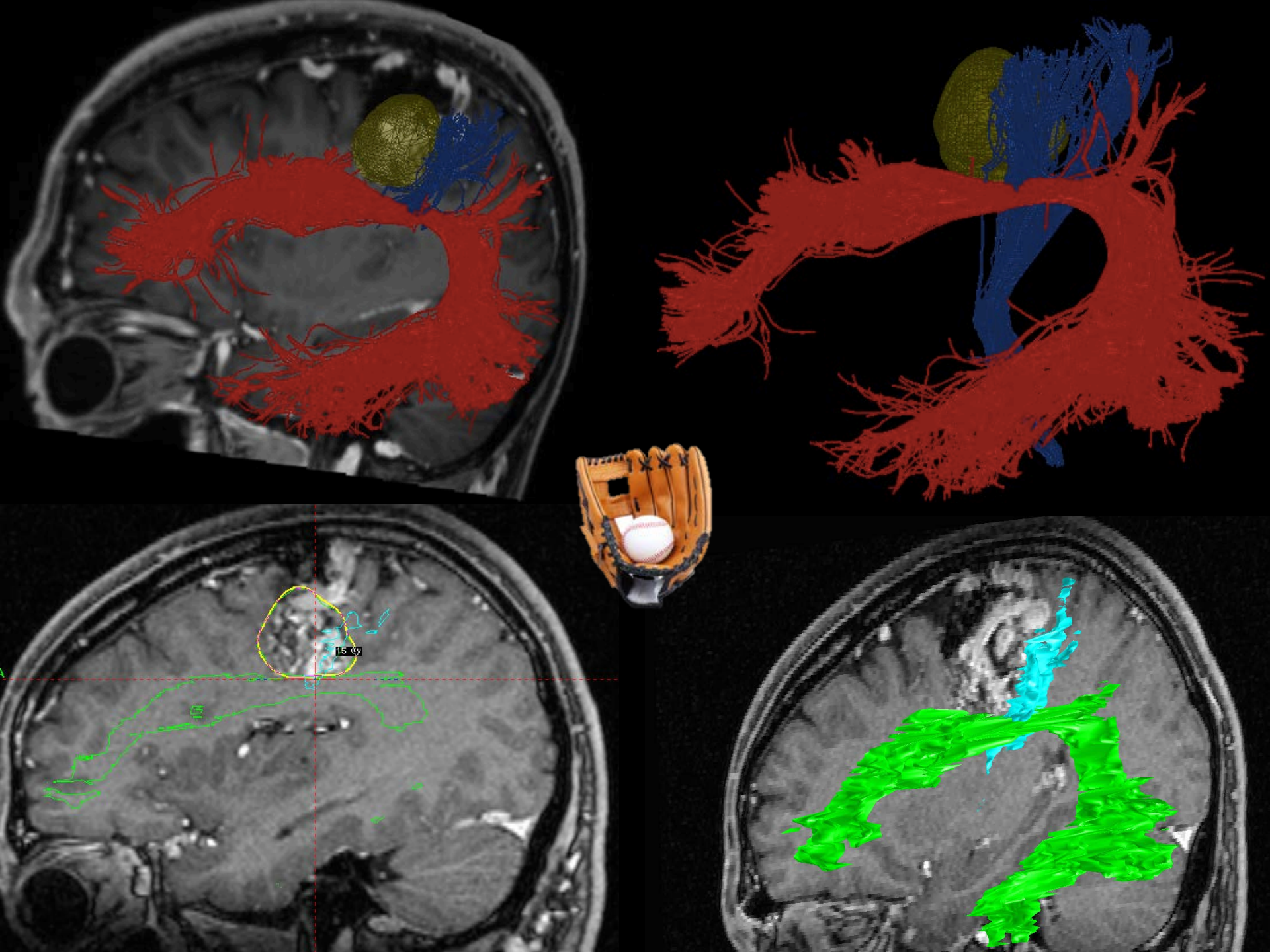



15 Gy

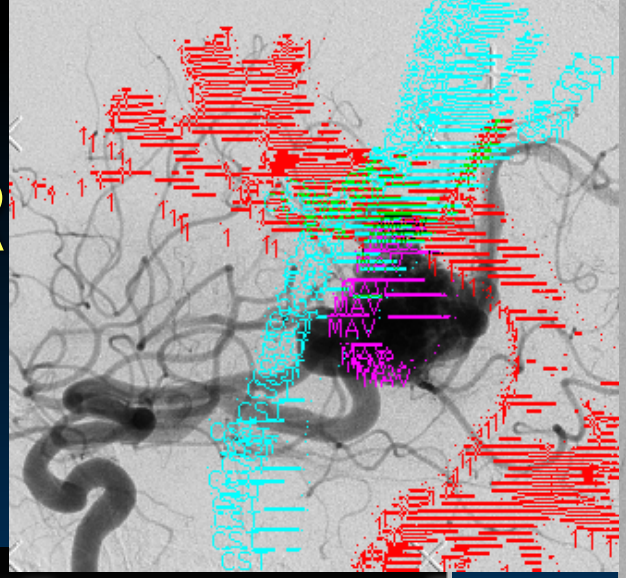

50
Reconstructed, y: 87.7

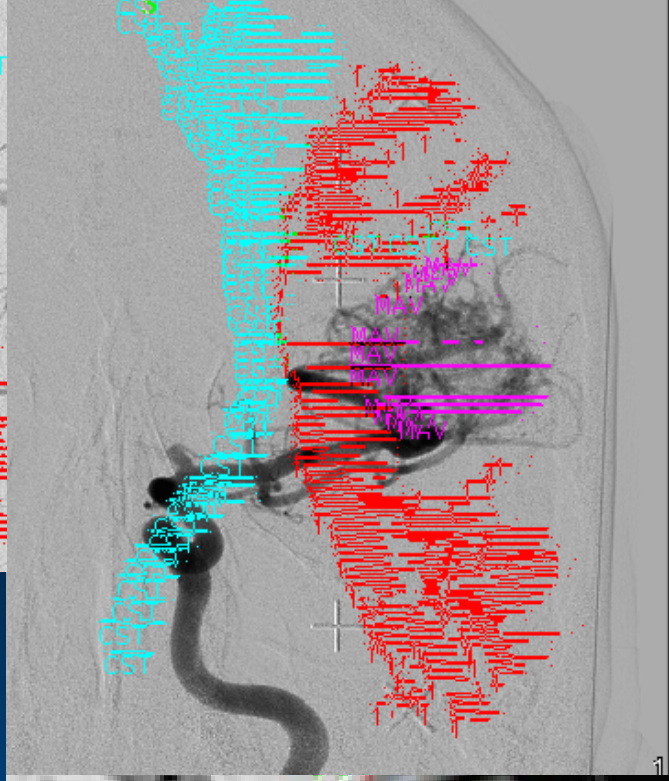

15Gy

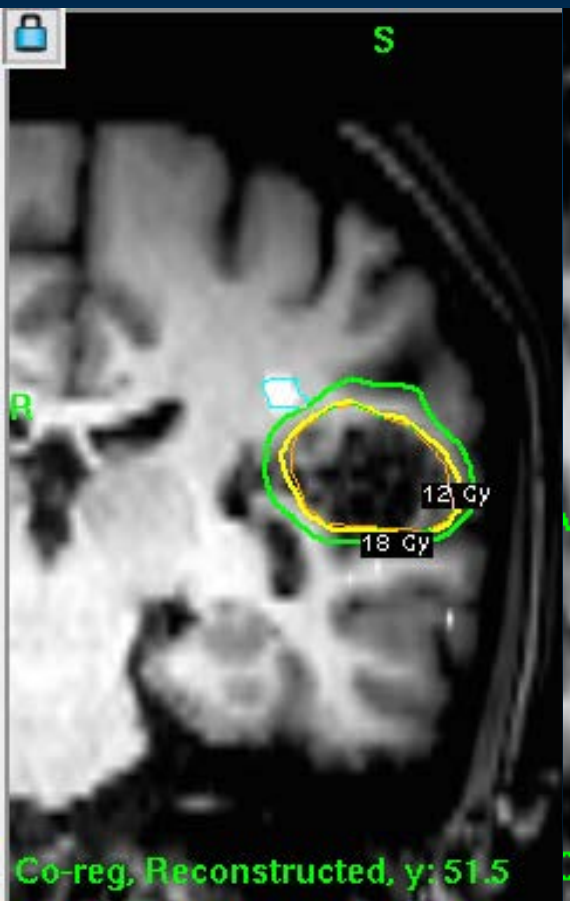

15Gy

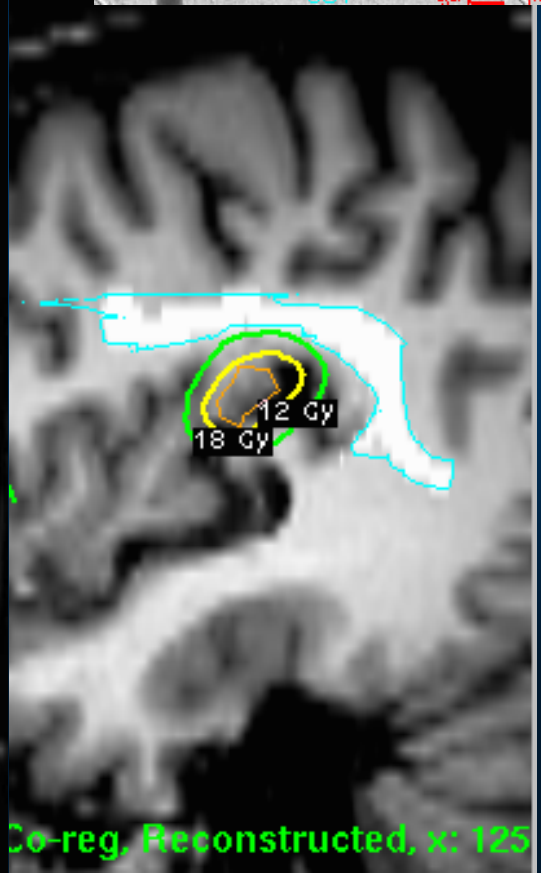

15 Gy

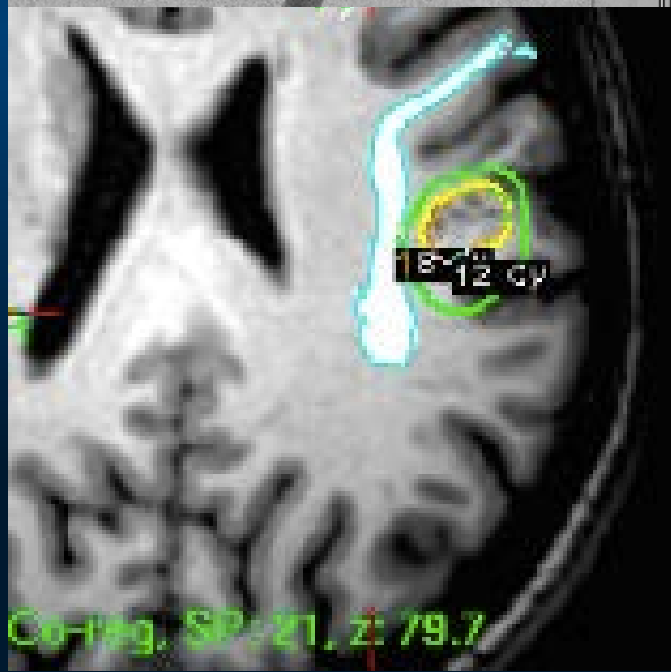
LEFT INSULAR REGION AVM

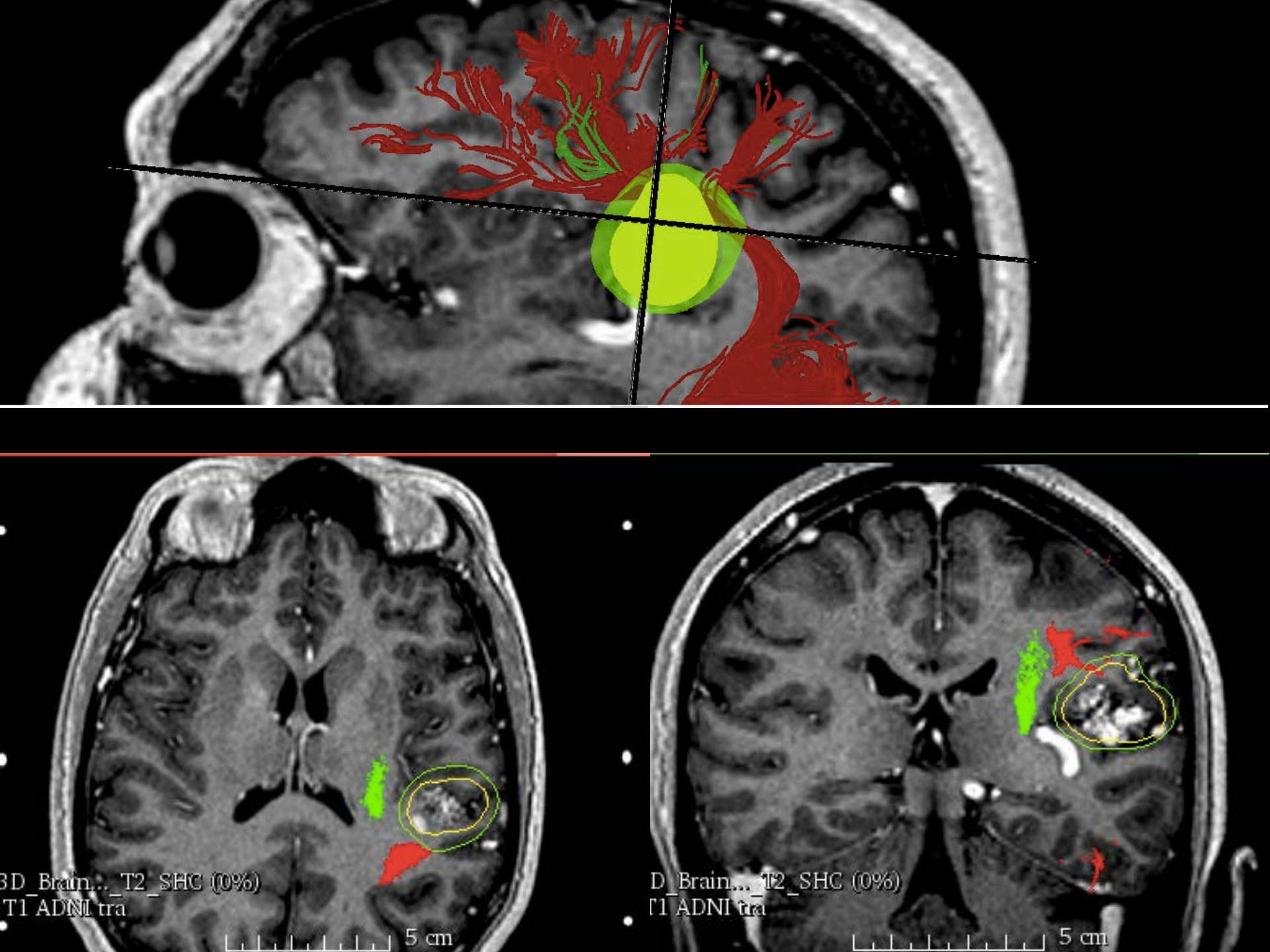











3D_Brain..._T2_SHC (0%)
T1 ADNI tra
5 cm
D_Brain..._T2_SHC (0%)
T1 ADNI tra
5 cm

CONCLUSIONS

Advanced Acquisition protocols, new Algorithms and Image Correction

Enhanced Tractography of White Matter Tracts

IoN techniques Validated our new Pipeline

GKRS preliminary experience

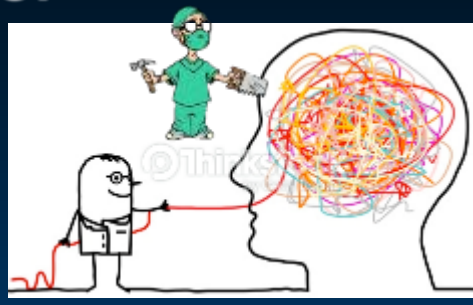
MULTIDISCIPLINARY TEAM

Neuroradiolgists:

GK Ricciardi
FB Pizzini

Neurosurgeons:

A Nicolato
M Longhi



Phisicist:

RI Foroni
E Zivelonghi

Bio-Informatics:

C Lemonis