NA-MIC - Mario Negri Institute
External Collaboration

Luca Antiga
Medical Imaging Unit
Bioengineering Department
Mario Negri Institute
Bergamo, Italy

MARIONEGRI
ISTITUTO DI RICERCHE FARMACOLOGICHE

Mario Negri Institute

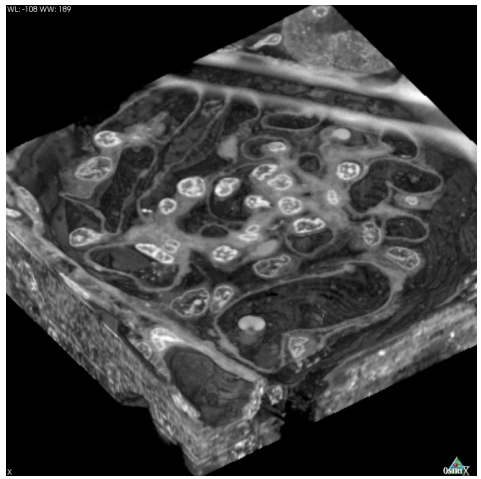
Departments

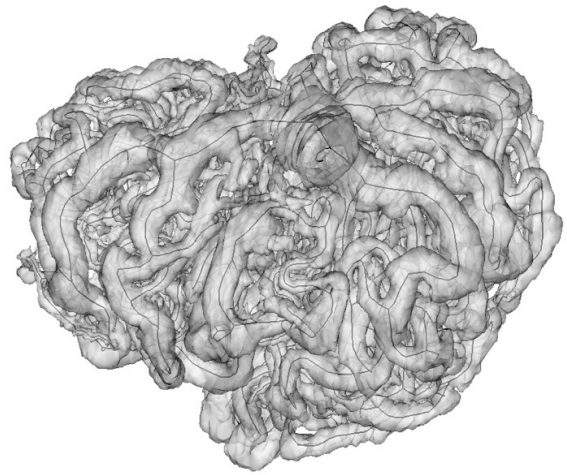
Bioengineering
Cardiovascular Research
Environmental Health Sciences
Epidemiology
Molecular Biochemistry and Pharmacology
Molecular Medicine
Neuroscience
Oncology
Public Health
Renal Medicine

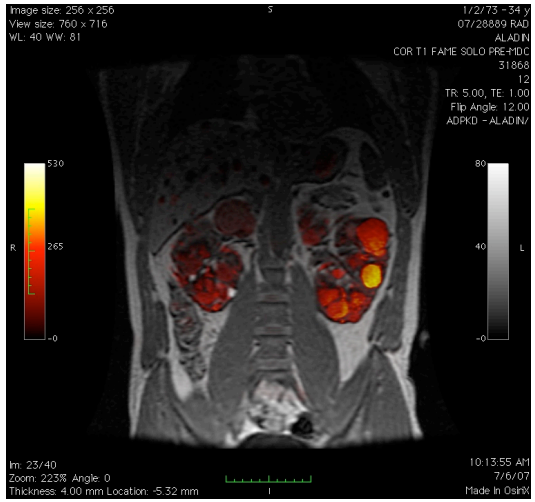
MARIONEGRI
ISTITUTO DI RICERCHE FARMACOLOGICHE

Medical Imaging Unit (Bioengineering Department)

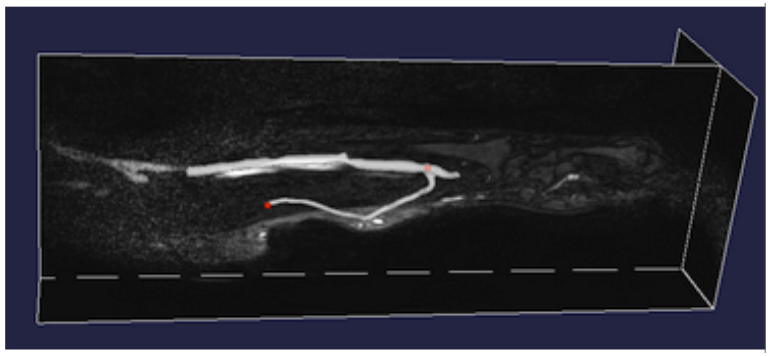
Imaging and quantification of kidney physiopathology

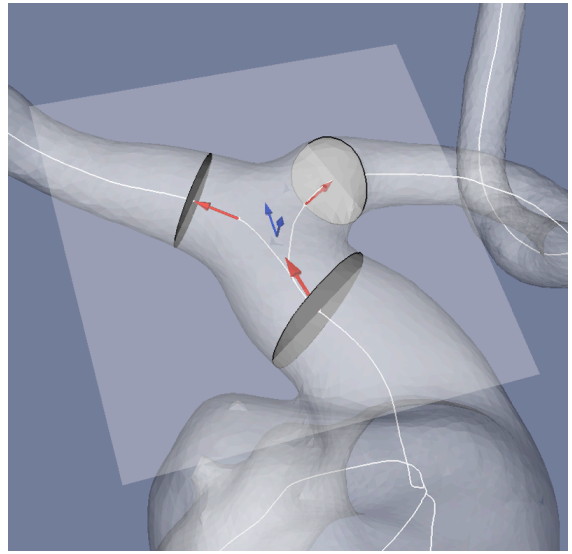


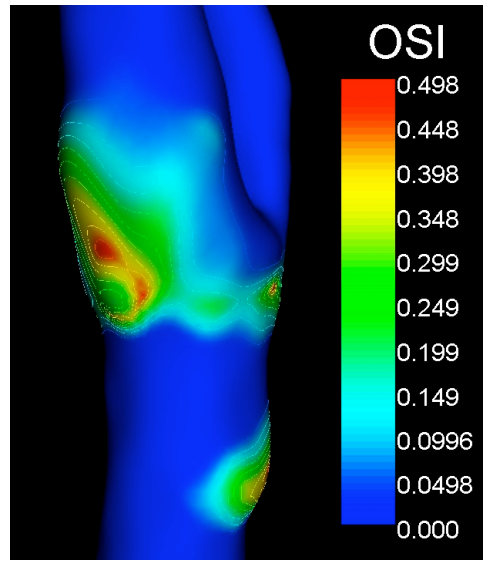




Hemodynamics and vascular disease



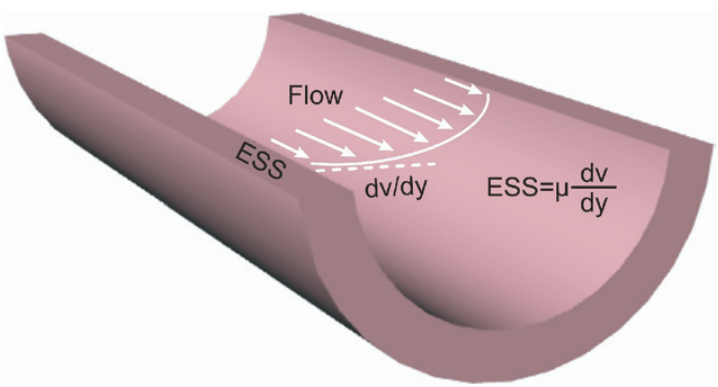


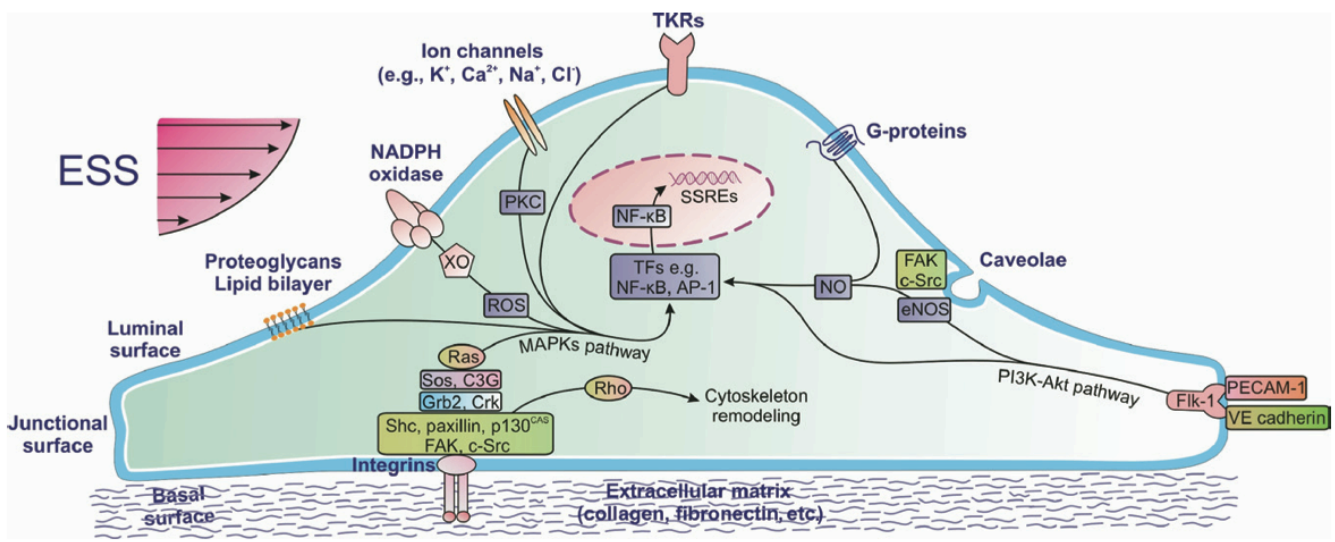


Hemodynamics involved in several vascular pathological processes

- atherosclerosis
- cerebral aneurysms
- extra-cerebral aneurysms (AAA, ...)
- intimal hyperplasia (grafts, bypasses, vascular access for HD, ...)

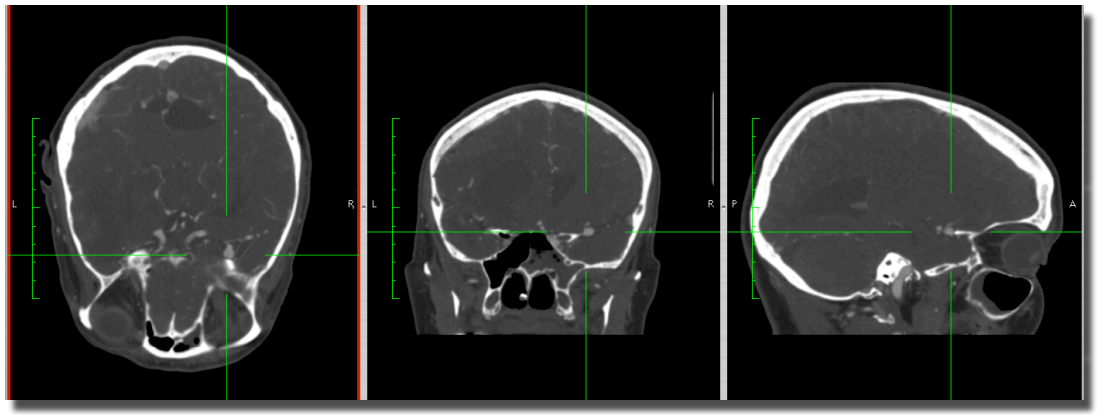
through the action of pressure, wall shear stress...

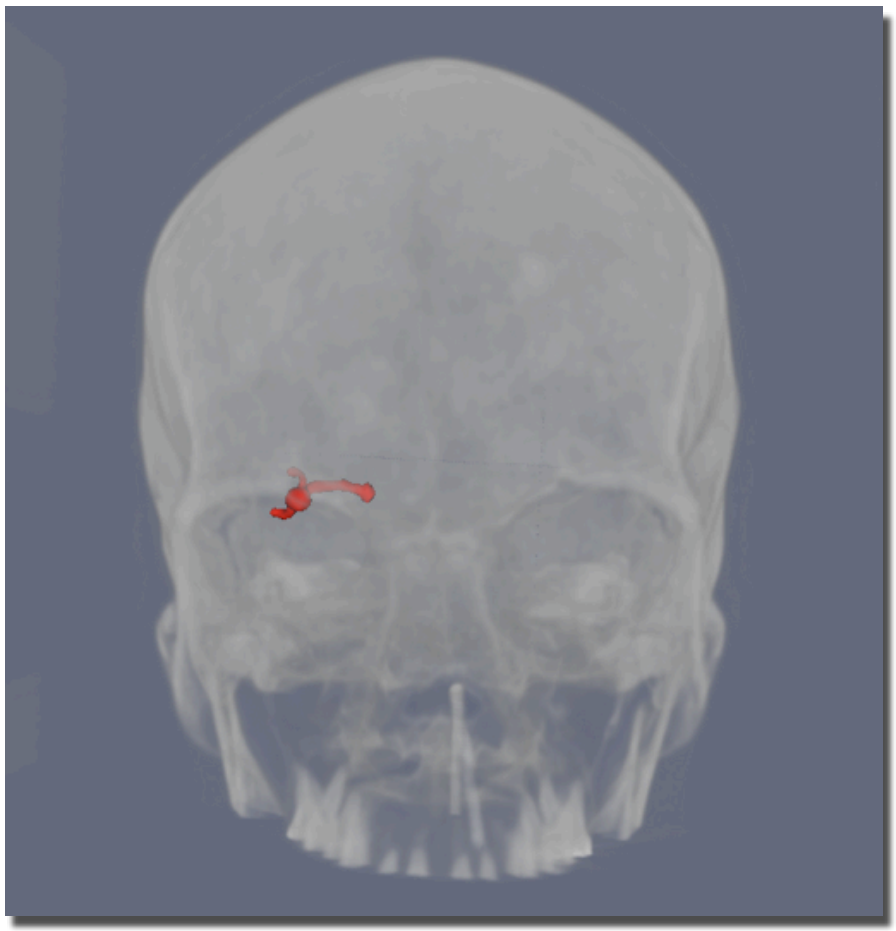




Chatzizisis et al, J Am Coll Card (2007)

Image-based computational hemodynamics





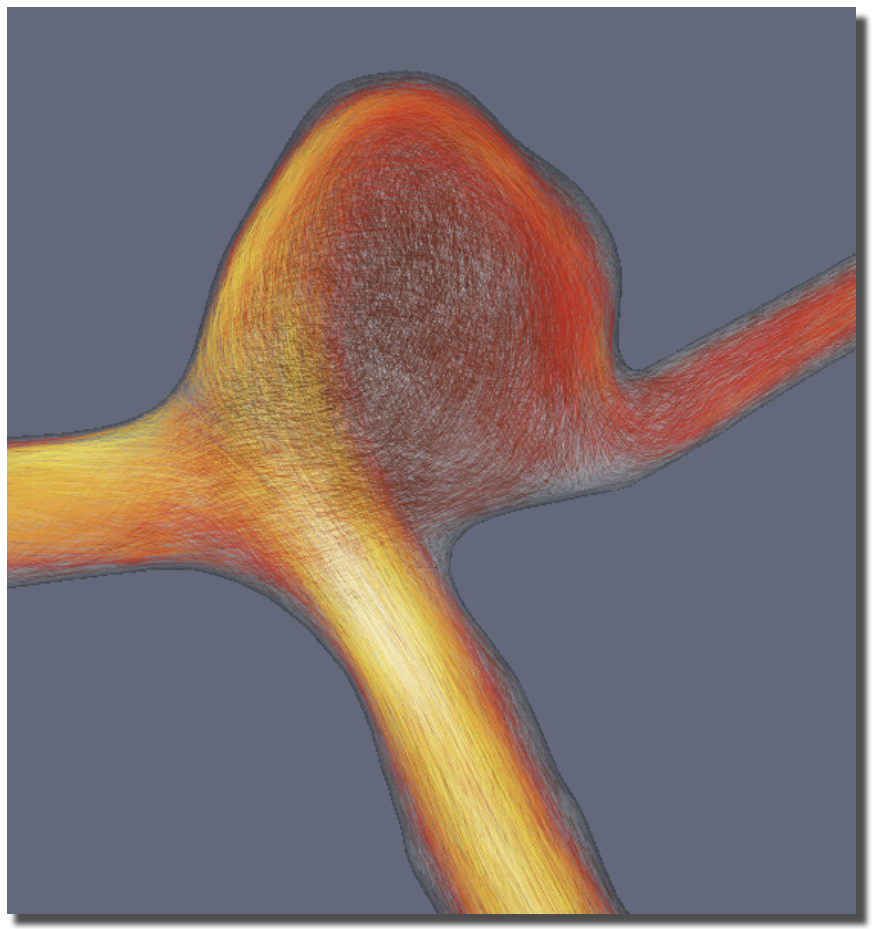


Image-based computational hemodynamics

Important to get the geometry right.

Streamlined tools needed for the generation of unstructured grids from images, for the numerical approximation of Navier-Stokes equations (using finite elements, finite volumes, ...).

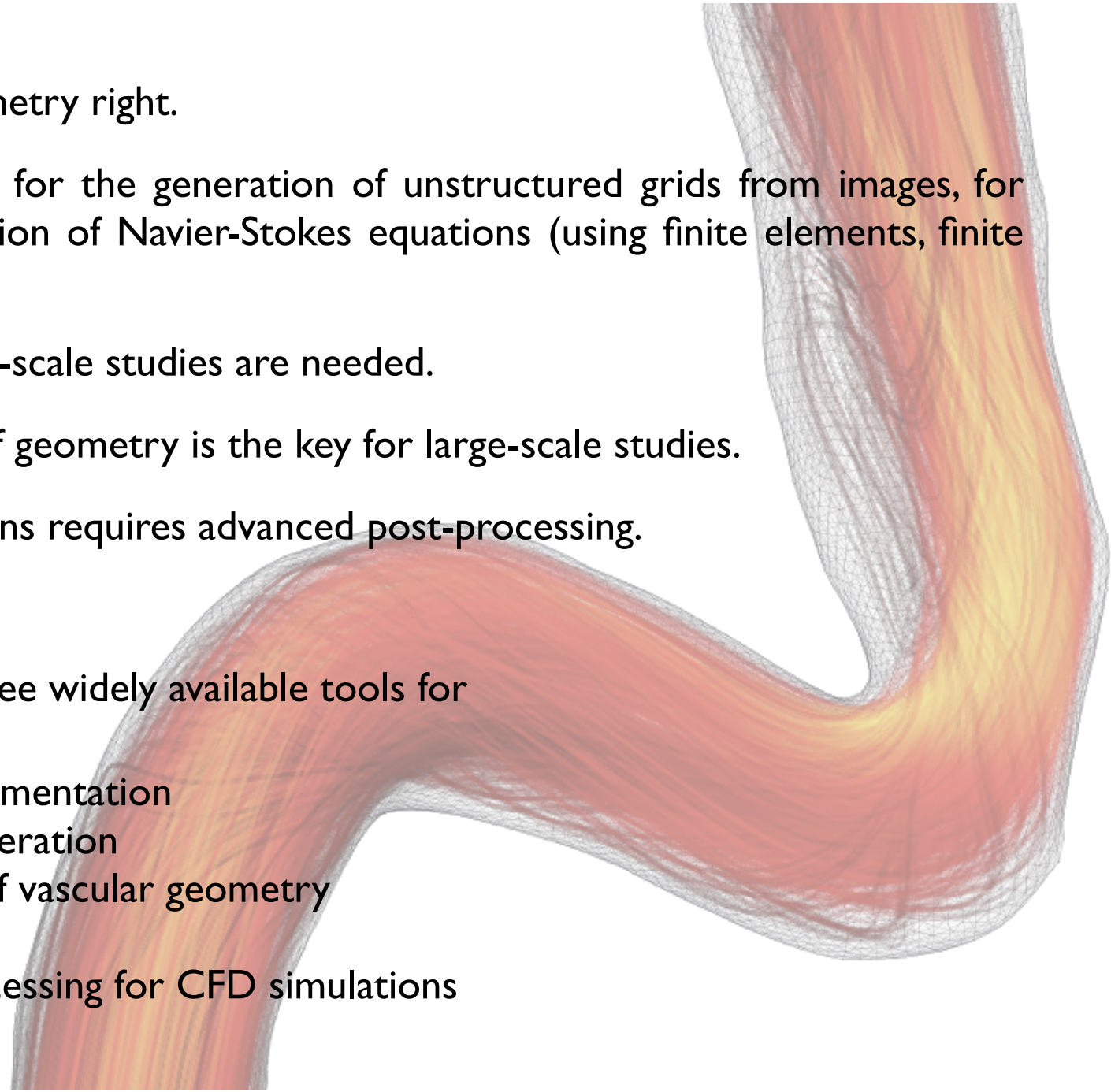
At the present stage, large-scale studies are needed.

Robust characterization of geometry is the key for large-scale studies.

Data analysis on populations requires advanced post-processing.

Effort: providing a set of free widely available tools for

- image segmentation
- mesh generation
- analysis of vascular geometry
- CFD
- post-processing for CFD simulations



The Vascular Modeling Toolkit

www.vmtk.org

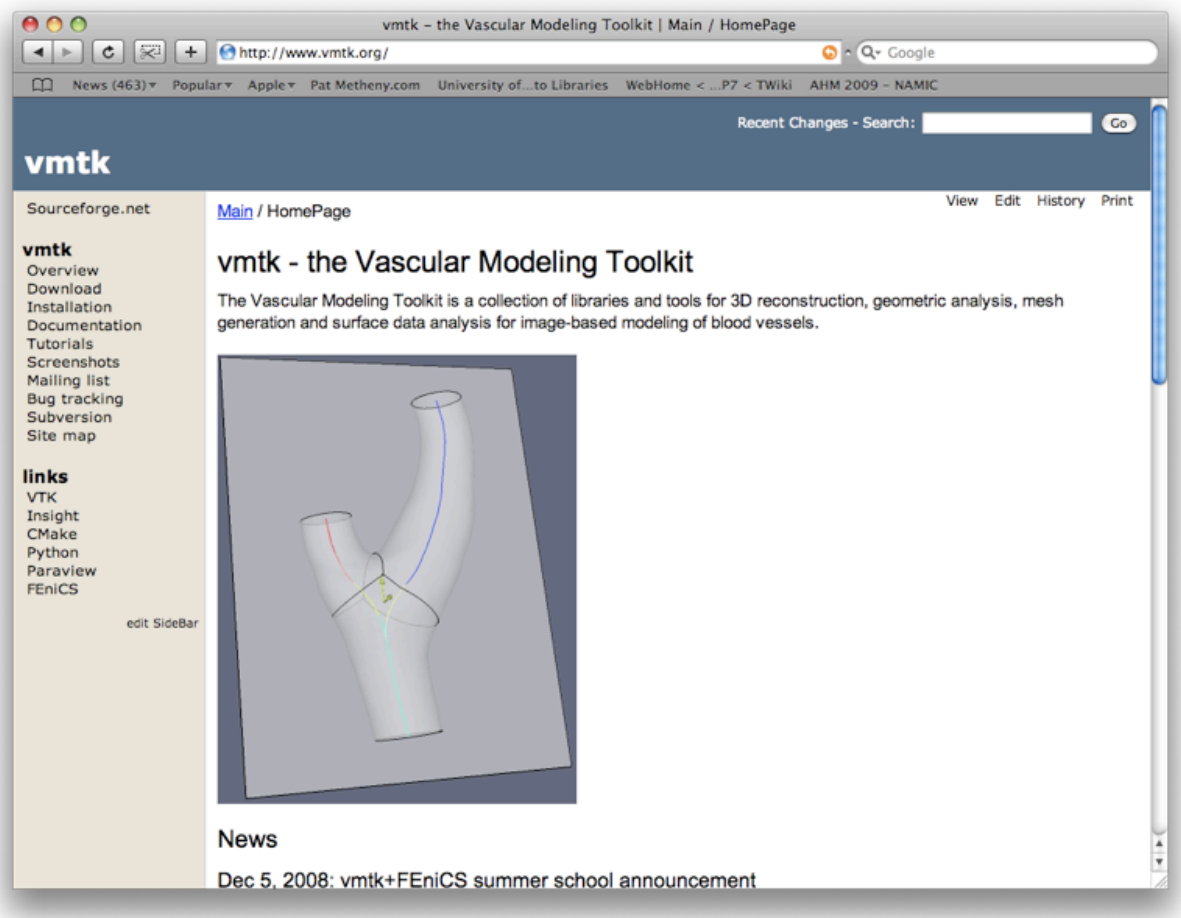
Countries		Pages	Hits
United States	us	15630	27802
Canada	ca	2909	4686
Netherlands	nl	2373	4207
Germany	de	1569	2803
Italy	it	1133	2118
Great Britain	gb	1041	1843
China	cn	1035	1886
Switzerland	ch	851	971
Unknown	ip	821	1313
Japan	jp	332	553
Norway	no	330	564
Australia	au	326	683
France	fr	303	526
Ireland	ie	244	590
Greece	gr	243	376
European country	eu	190	305
Spain	es	147	404
Austria	at	129	257
Brazil	br	102	335
Belgium	be	90	336
Singapore	sg	80	161
Portugal	pt	75	206
Argentina	ar	75	114
Sweden	se	69	184
Israel	il	65	142
Others		356	880

Jul 2008 - Dec 2008

Luca Antiga, Mario Negri Institute
David Steinman, University of Toronto

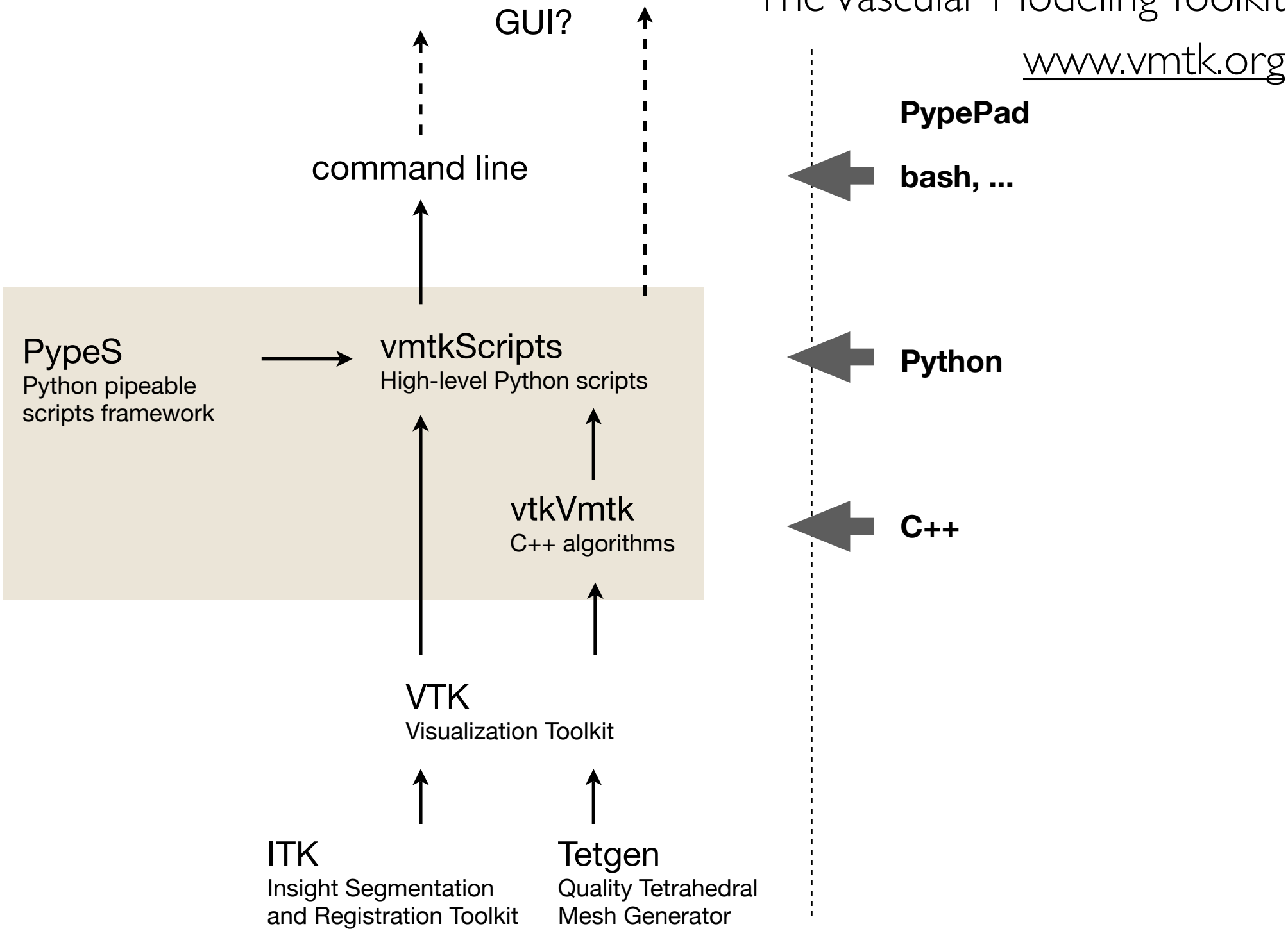
based on VTK, ITK

BSD license



The Vascular Modeling Toolkit

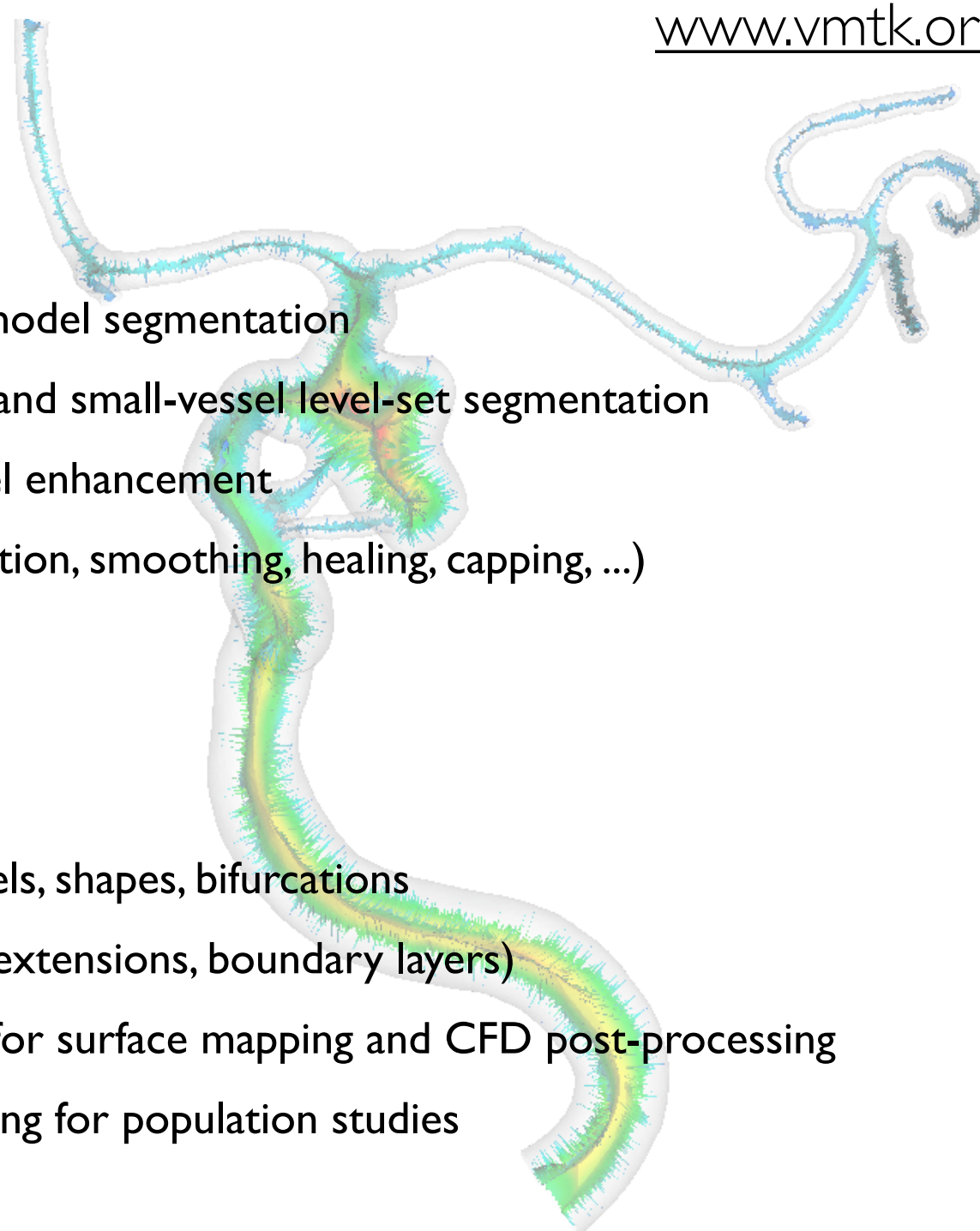
www.vmtk.org



The Vascular Modeling Toolkit

www.vmtk.org

Features:



- Level-set and deformable model segmentation
- Smart branch initialization and small-vessel level-set segmentation
- Image processing and vessel enhancement
- Surface processing (decimation, smoothing, healing, capping, ...)
- Surface remeshing
- Volume meshing (Tetgen)
- Centerline computation
- Geometric analysis of vessels, shapes, bifurcations
- CFD pre-processing (flow extensions, boundary layers)
- Finite element framework for surface mapping and CFD post-processing
- Surface mapping and patching for population studies

The Vascular Modeling Toolkit

www.vmtk.org

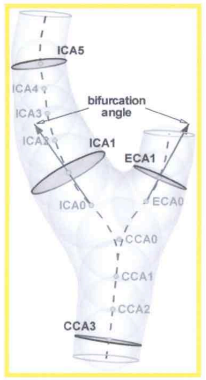
Geometric risk hypothesis for atherosclerosis

Volume 39, Number 8, August 2008
ISSN 0039-2499
http://stroke.ahajournals.org

American Heart Association. | American Stroke Association.
Learn and Live.

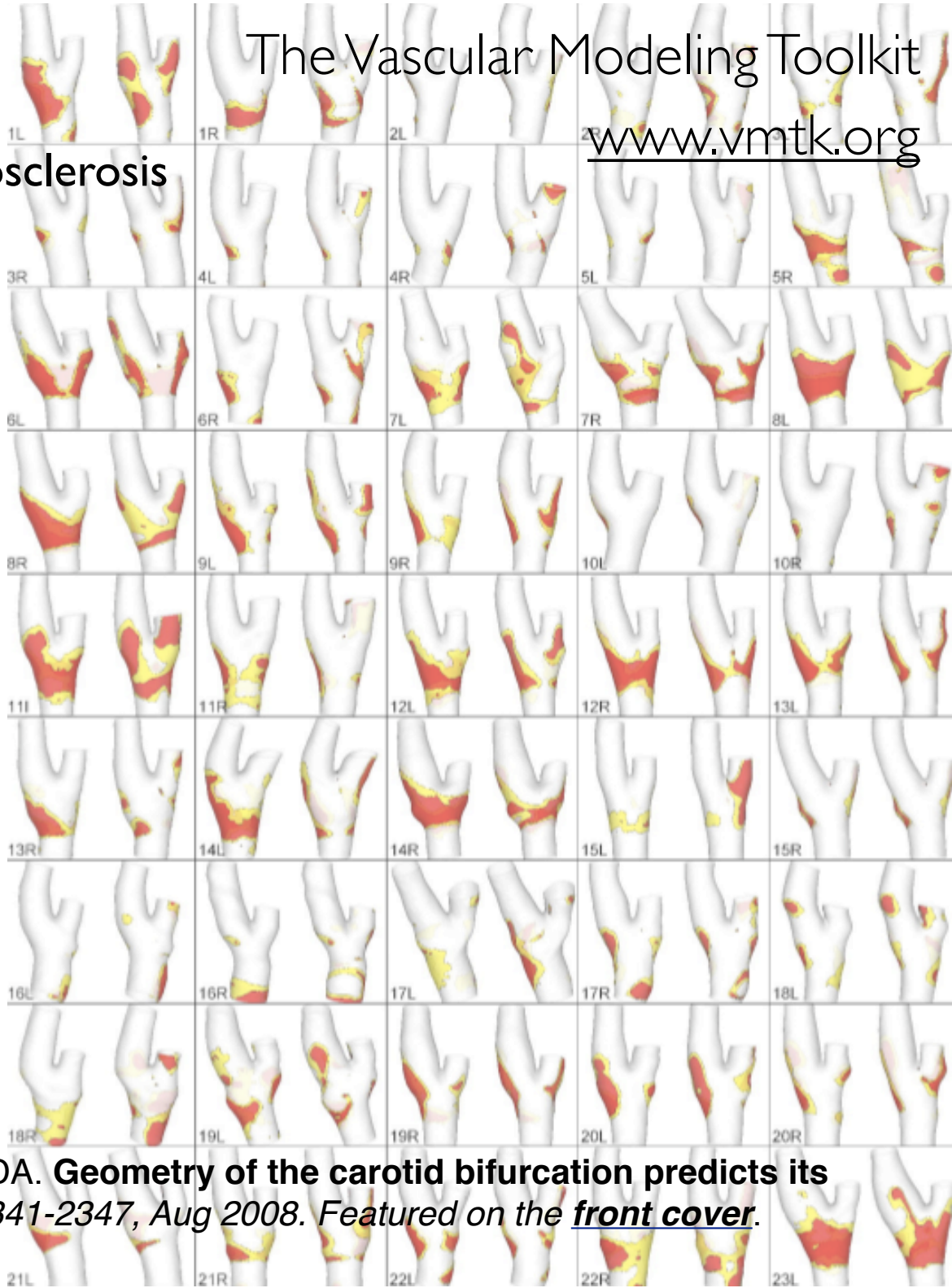
Stroke

JOURNAL OF THE AMERICAN HEART ASSOCIATION



Potential Geometric Risk Factors for Carotid Atherosclerosis

■ Editorial
Community Outreach for Stroke Education
■ Original Contributions
Stroke and Socioeconomic Position
Stroke Mortality in England From 1979 to 2004
Trends in Stroke Incidence and Vascular Risk Factors
Genetic Factors for Stroke
DWI Lesions in TGA and CVD CME
Cytokines and Recurrent Stroke
Serum Calcium in Acute Stroke
Diagnostic Accuracy of MRA for ICA Disease
Hemorrhagic Transformation in Ischemic Stroke Patients
Infarct Growth in DEFUSE Study
LAMS in Large Arterial Occlusions
Hemostatic Risk Factors for Intracerebral Hemorrhage
Plasma VEGF Levels in Patients Treated for Cerebral AVMs
Biomarkers for Stroke Etiology
Coiling of Aneurysms: Clinical Long-Term Follow-Up
Prestroke Mobility Predicts Poststroke Outcomes
Predicting Functional Outcome in ICH: The FUNC Score
Stroke Outcome in Those Over 80
Variables Associated With Stroke Fatality
Predictors of Death and Stroke in Pro-CAS
The Beauty Shop Stroke Education Project
Lesion Volume and Capacity to Consent in Stroke Trials
Carotid Geometry Predicts Disturbed Flow
DTI Characterizes WM Injury in Neonatal HI Rat Model
Microemboli, BBB Disruption and Cognitive Impairment
Postconditioning Inhibition of Post-I/R Apoptosis
D1Rs Depress EPSCs in Spiny Neurons After Ischemia
■ Research Letters
Postpartum Cervicocephalic Artery Dissection
Postural Dependency of Right to Left Shunt
Identification of Vertebrobasilar Variants
Early BBB Changes as Predictors of tPA-Related SICH
DWI Before IV tPA Thrombolysis Predicts Poor Outcome
Acute Ischemic Stroke Therapy With Intracranial Stent
■ Comments, Opinions, and Reviews
Large Artery Intracranial Occlusive Disease
■ Emerging Therapies
EXPRESS TIA Study
■ Cochrane Corner
Organized Inpatient Care for Stroke
Vinpocetine for Acute Ischemic Stroke
■ Letters to the Editor★
■ Corrections★



Lee SW, **Antiga L**, Spence JD and Steinman DA. **Geometry of the carotid bifurcation predicts its exposure to disturbed flow.** *Stroke, 39(8): 2341-2347, Aug 2008. Featured on the **front cover**.*

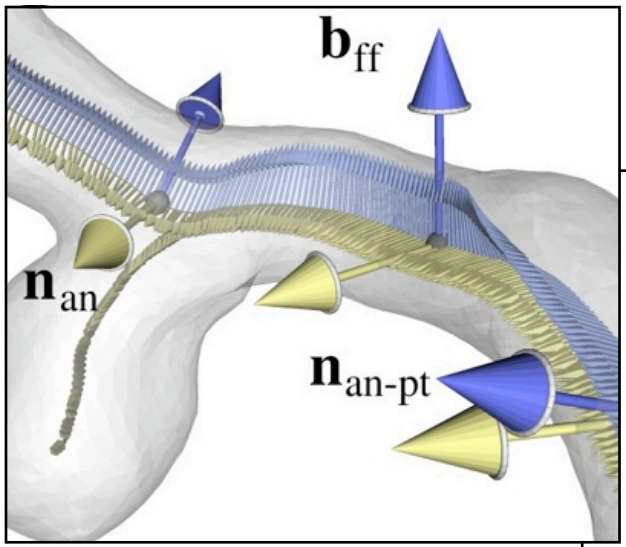
The Vascular Modeling Toolkit

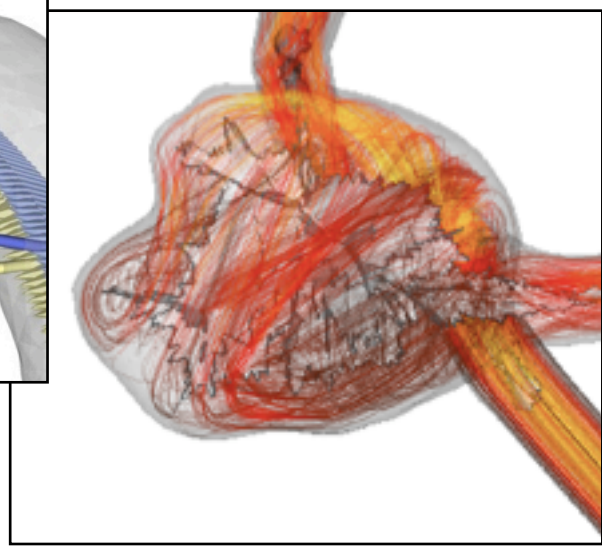
www.vmtk.org

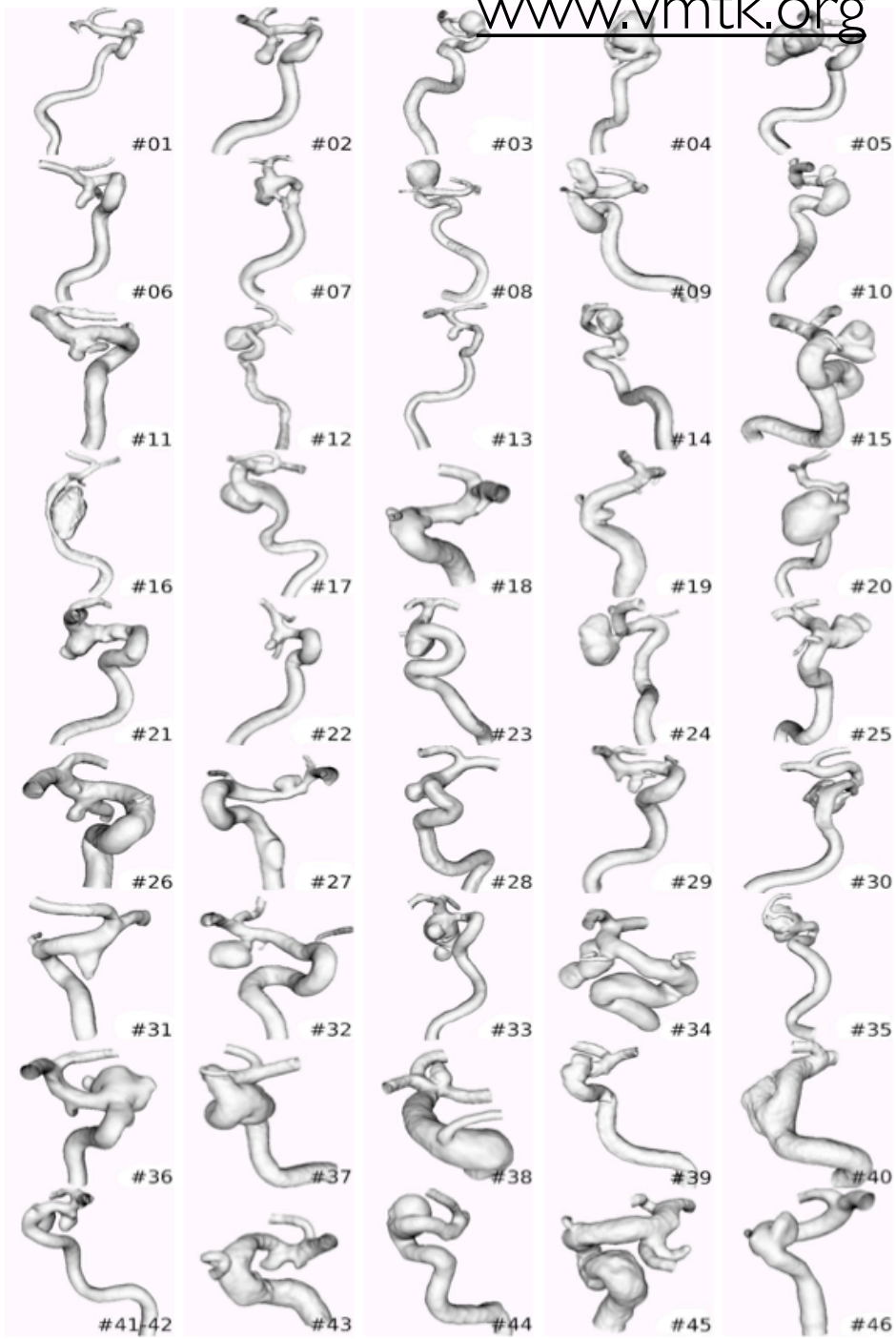
Aneurisk project

Location	cases
MCA	35
ACA	34
ICA	65
BAS	19
Tot	165

Third largest database of cerebral aneurysmal geometries.

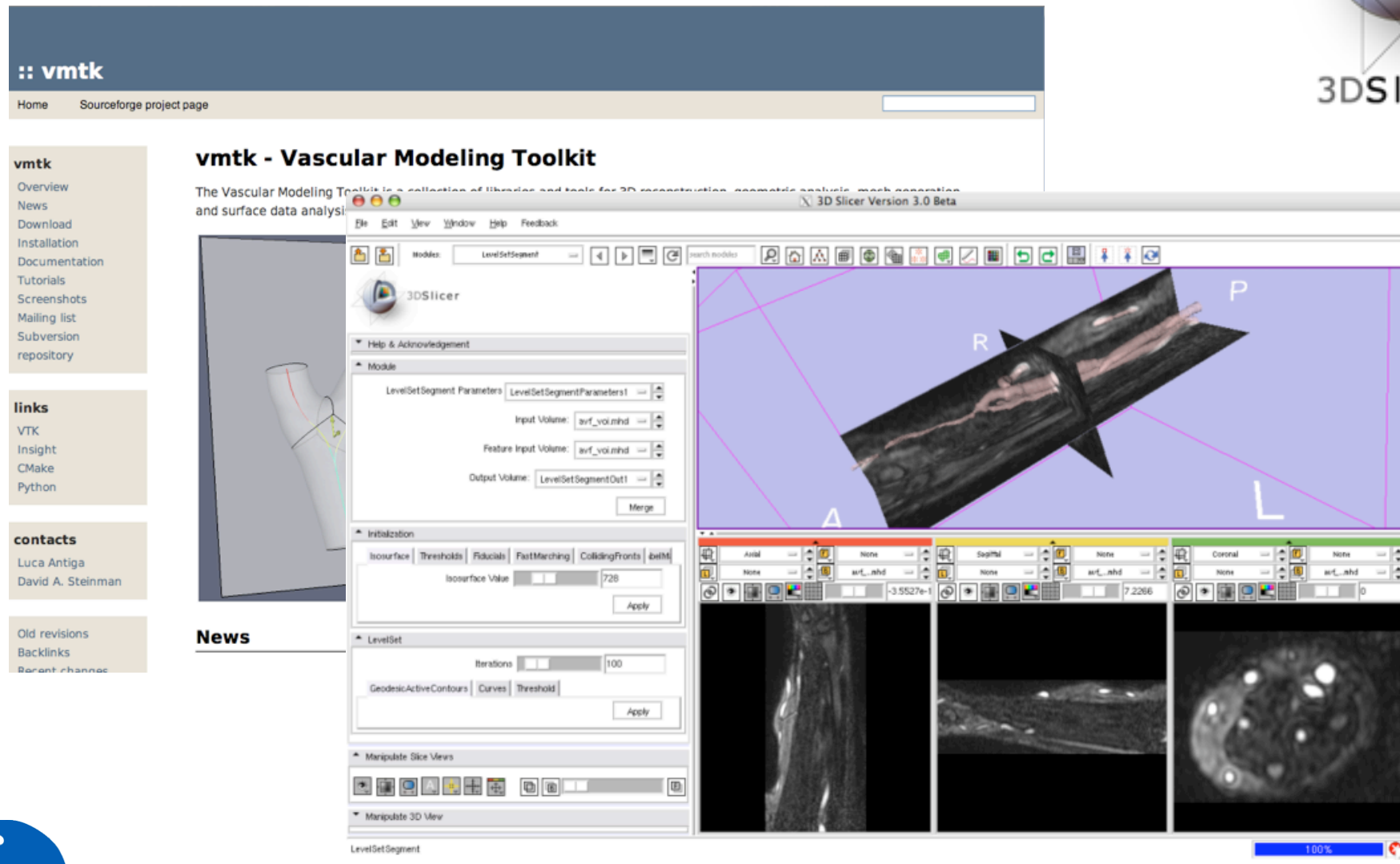






With Marina Piccinelli, Alessandro Veneziani,
MathCS, Emory University

vmtk Slicer integration



NA-MIC
National Alliance for Medical Image Computing

Summary of past and ongoing projects at project weeks

vmtk Slicer integration

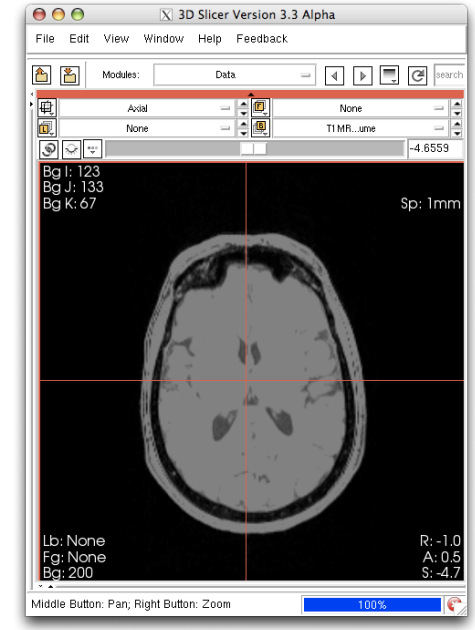
- automated generation of command line modules for non-interactive vmtk tasks (done)
- vmtk C++ code in Slicer as a library (done)
- interactive Slicer modules for segmentation, etc. (with Daniel Haehn) (in progress)
- vmtk Slicer as a NITRC project (to do)

Summary of past and ongoing projects at project weeks

Engineering core:

- Python interface and modules (with Dan Blezek) (done)
- Reference system issues for orientation-unaware command-line modules (done)
- Breakout sessions: AHM 2008, AHM 2009

```
>>> from Slicer import slicer
>>> scene = slicer.MRMLScene
>>> node = scene.GetNodeByID('vtkMRMLScalarVolumeNode1')
>>> arr = node.GetImageData().ToArray()
>>> type(arr)
<type 'numpy.ndarray'>
>>> arr.max()
367
>>> arr[arr>200] = 200
>>> node.Modified()
```

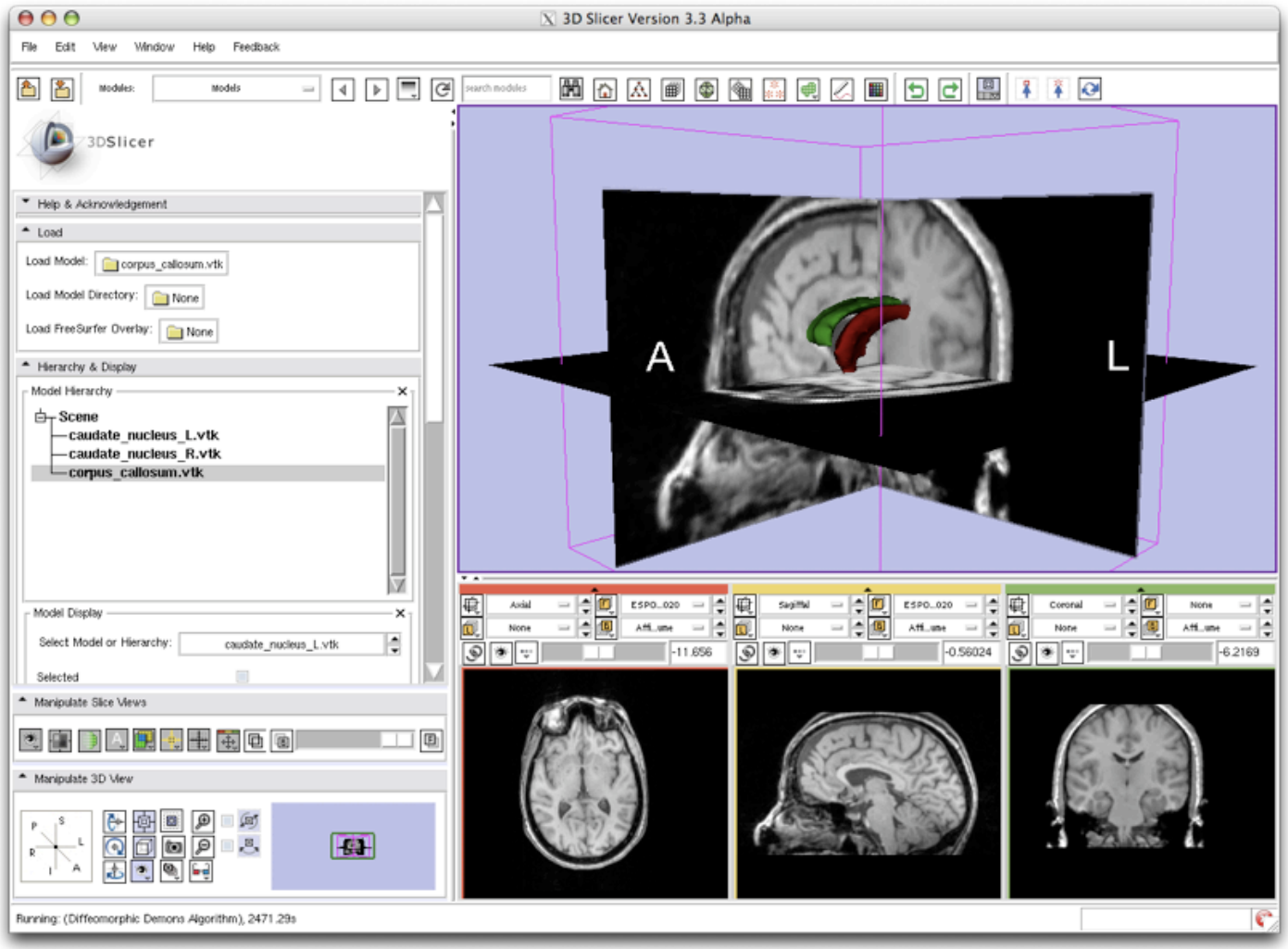


Ongoing projects back home

With Roberto Foroni, University of Verona:

Pre-operative planning and intra-operative visualization platform for minimally-invasive neurosurgery

- Registration (affine, diffeomorphic demons), segmentation (EM), vessel extraction (enhancement, EM, level sets)
- Integrated visualization
- Slicer layout customization
- Workflows

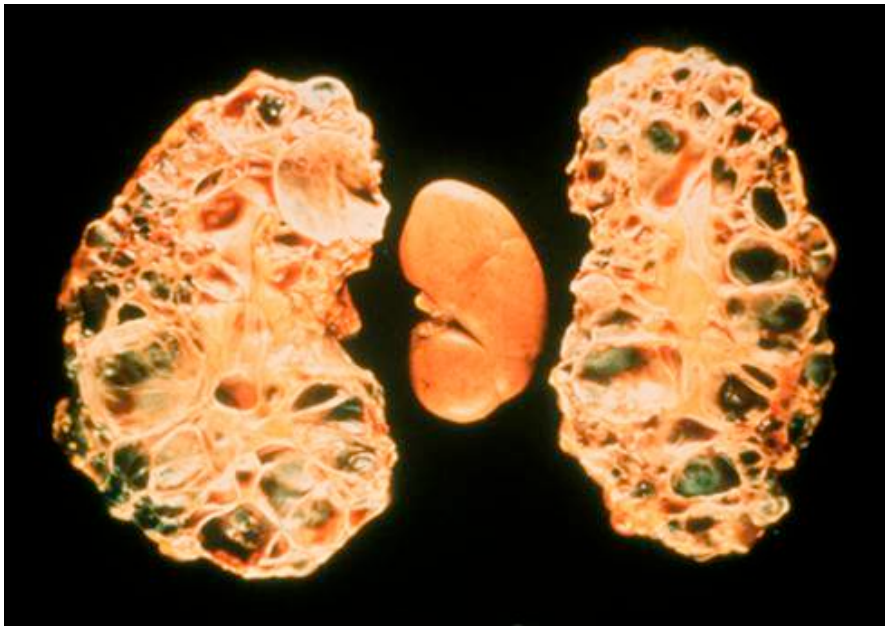


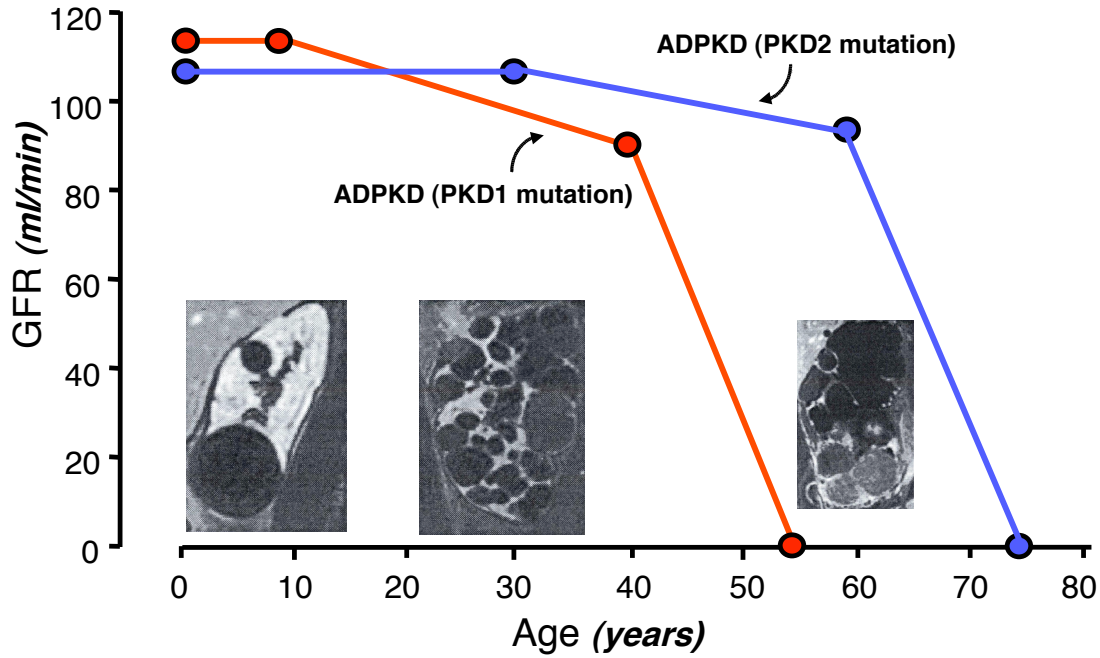
Ongoing projects back home

Mario Negri Institute:

Image quantification in autosomal dominant polycystic kidney disease (ADPKD)

- ADPKD: responsible for the majority of ESRD among hereditary kidney diseases, currently no treatment available
- currently at the Mario Negri Institute: 3 clinical trials on treatment with imaging endpoints (MR and CT)
- identified imaging evidence for key components for functional loss (Antiga et al, CJASN 2006; Caroli, ASN 2008)



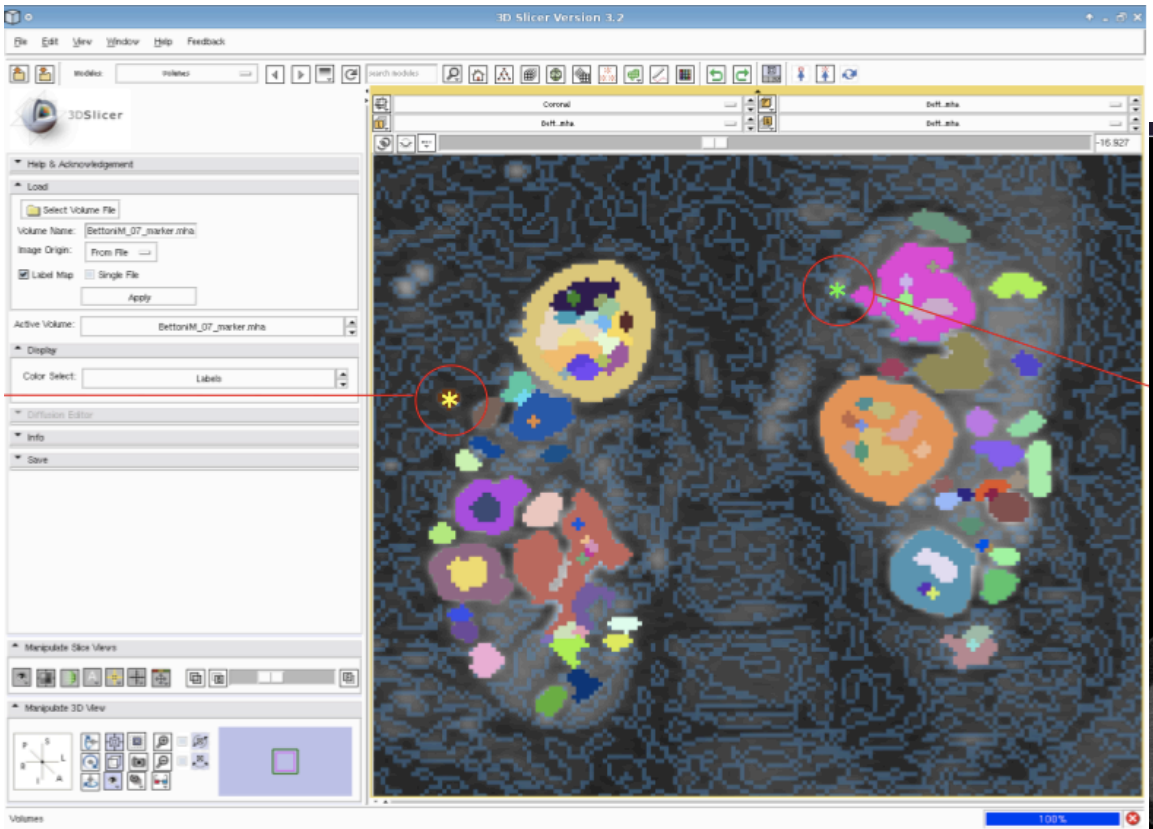


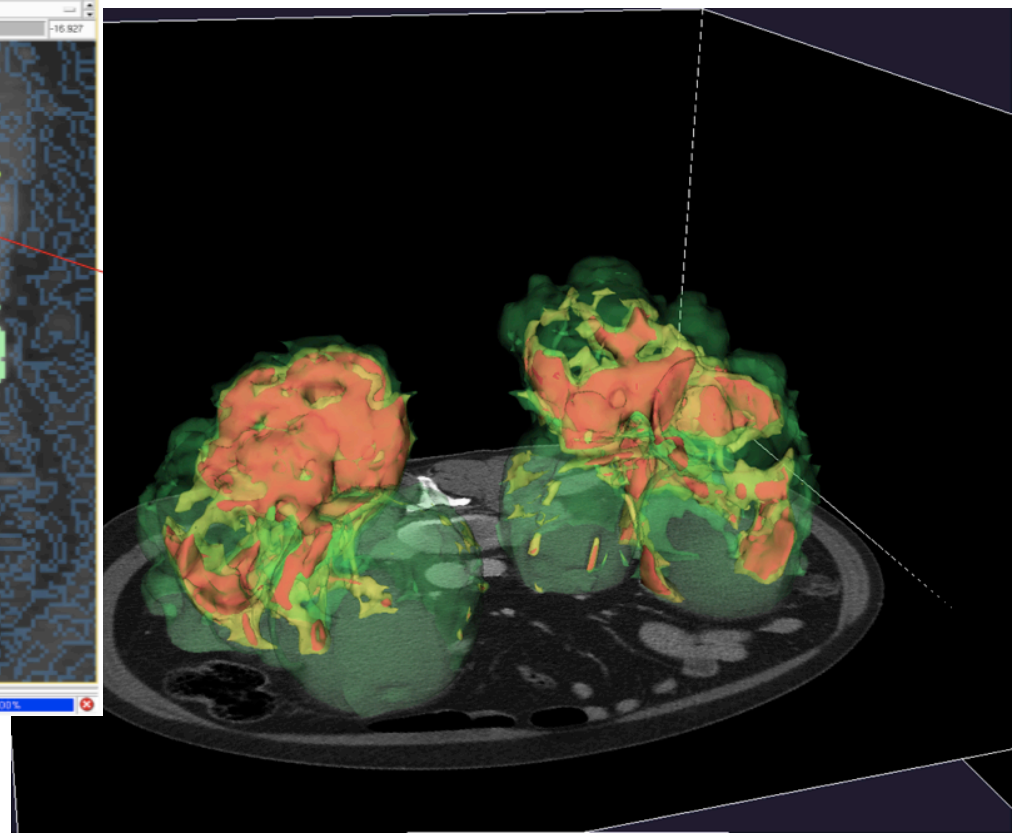
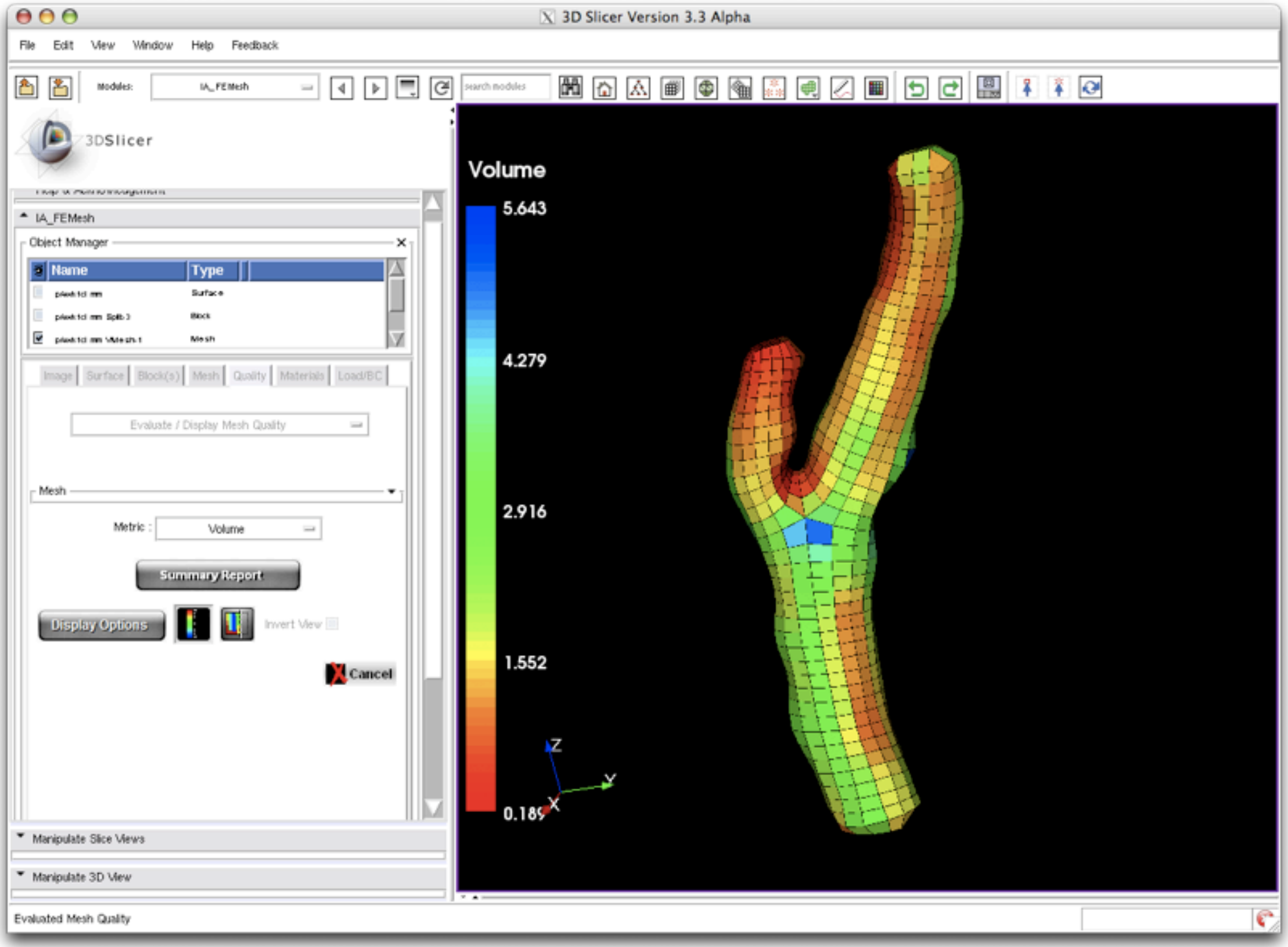
Ong et al, Kidney Int 2005

Ongoing projects back home

Mario Negri Institute:

- Slicer as a platform for image quantification in autosomal dominant polycystic kidney disease (ADPKD)
- Image analysis methodology has been developed (ITK)
- A complete set of Slicer modules will be created during the next months





Last slide: Meshing module!