NATIONAL CENTER FOR IMAGE-GUIDED THERAPY

SPL 25TH Anniversary

Clare Tempany MD

April 9th 2016

BWH

NIBIB National Institute of Biomedical Imaging and Bioengineering

AMIGO

NCIGT.ORG

Celebrate the past

MRT 1994

Ferenc & Len Holman

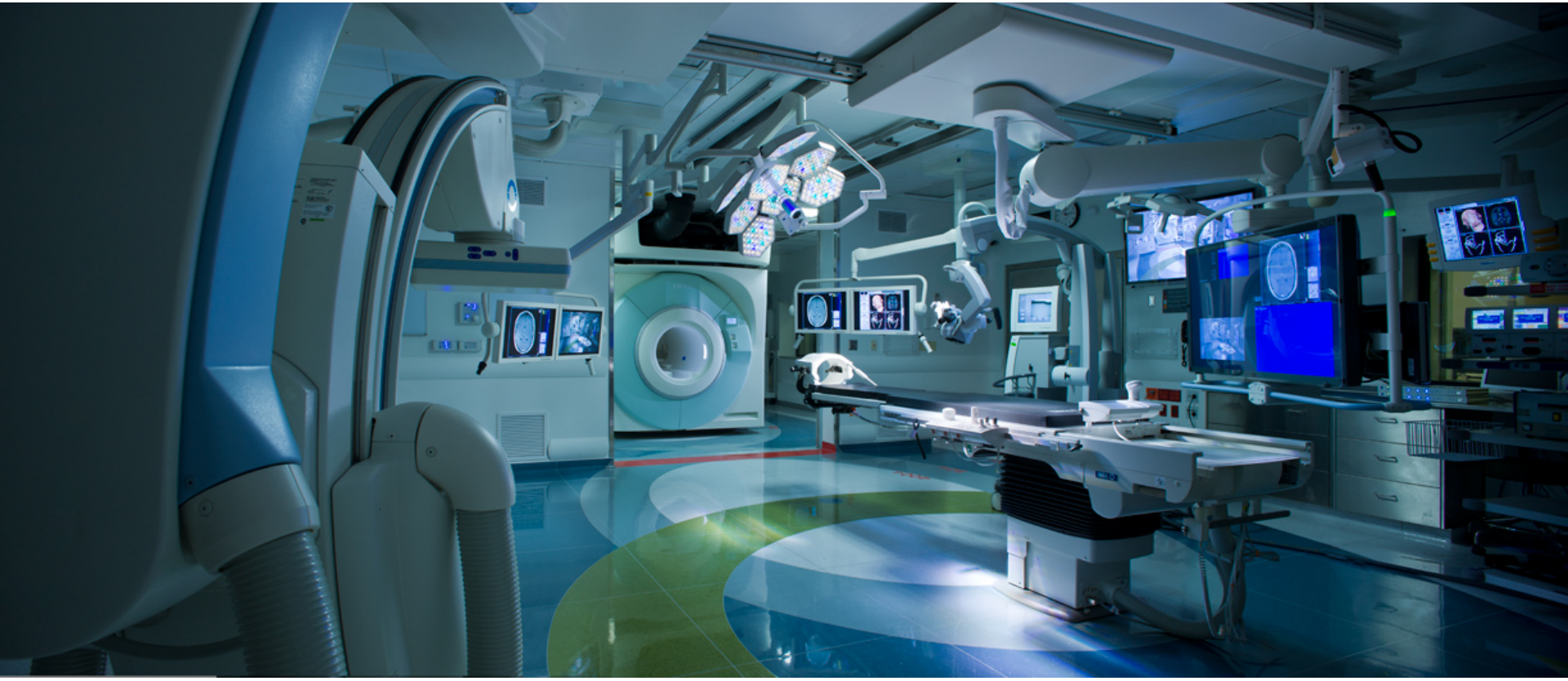
AMIGO 1ST CASE 2011

Abraham Levy NCRR/NIH, Ferenc, Rachel Rosenblum

AMIGO wins PIE award

Steven Seltzer, Ali, Kirby, Kemal, Janice, Dan
Alex, Tina, Angela, Ferenc, Clare, Rachel

Advanced Multimodality Image Guided Operating (AMIGO) Suite



Precise Localization of Tumor Boundaries for Therapy
Clinical Testbed for P41 EB015898 (PI Tempany)
National Center for Image-Guided Therapy

AMIGO History: A dream 20 years in the making

AMIGO represents the culmination of ground-breaking research at BWH in Image-guided Therapy (IGT) dating back to the early 1990's

1991

- BWH Image-guided Therapy program founded by Ferenc Jolesz
- Introduction of world's first inter-operative MR magnet: MRT 'double-donut'

1994

- BWH develops first MR-guided Focused Ultrasound (MRgFUS) system

2005

- Creation of NIH-funded National Center for Image Guided Therapy
- IGT applications expand to other advanced imaging modalities

2011

- AMIGO: First suite to offer the full array of advanced imaging modalities in one operating theater (MRI, PET/CT, 3D US, Fluoro, Angio)

MRT

MRgFUS

NCIGT

AMIGO

Since the early/mid-1990's, over 100 interoperative MRIs and close to 100 MRgFUS systems have been installed throughout the world

Training and technology dissemination: eg, 3D slicer

A clinical and translational test bed for multi-modal IGT

NIH Funded BTRC 2015
P41 NIBIB - Now

Funds 45+ people

PI

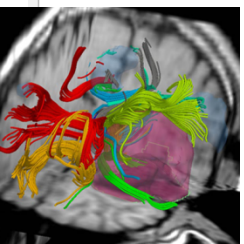
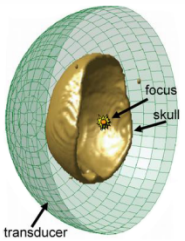
- Clare Tempany, MD

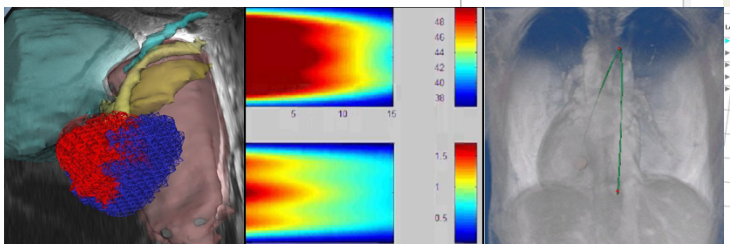
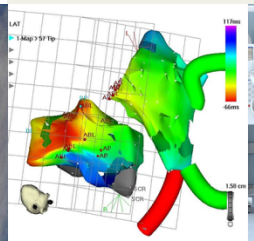
Executive Director

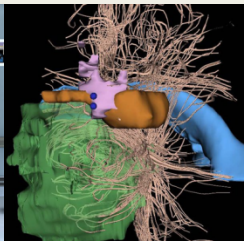
- Tina Kapur, PhD

TRD Cores

- Prostate (Tempany)
- Neurosurgery (Golby)
- Computation (Wells)
- Guidance (Hata)



State of the Science: A perspective

✧Great people: New grants in 2015-16

- ✧ 1. **Lauren O'Donnell:** U01CA199459-01 Open Source diffusion MRI technology for brain cancer research.
- ✧ 2. **Junichi Tokuda**: R01 EB 020667 Open IGTLink: A network communication interface for closed-loop image guided interventions
- ✧ 3. **Natalie Agar** R01 CA 201469-01 Evaluating mass spectrometry for intraoperative tissue characterization in breast conserving surgery.
- ✧ 4. **Kikinis/Fedorov** U24CA180918-03 Quantitative image informatics for cancer research

• Great work: New publications/presentations 2015-16

- ✧ 43 Medline Indexed Publications (17 with Collaborators)
- ✧ 50 Conference papers and abstracts at National and International Meetings

MAJOR IMPACT ON PATIENT CARE

1103 AMIGO patients

1103 Procedures in AMIGO 08/31/2011-04/08/2016

Neurosurgery — 187

- MR and Ultrasound Guided Brain Tumor Resections — 118
- MR Guided Deep Brain Stimulation Electrodes Placements — 28
- MR Guided Transsphenoidal Resections for Pituitary Tumors — 22
- MR Guided Laser Brain Tumor Ablations — 10
- MR Guided Skull Base Surgery — 5
- MR Guided Epilepsy Electrode Placement — 1
- AVM Repair using Angiography — 1
- Neurosurgery- Other — 2

Head and Neck Surgery — 26

- MR Guided Cryotherapy of Head & Neck Tumors — 10
- Parathyroidectomies/Hemithyroidecotmies — 5
- MR Guided Biopsy of Head & Neck — 5
- PET/CT Guided Biopsy of Tongue/Mouth/Neck — 3
- MR Guided Face Transplant Intervention — 2
- MR Guided Nerve Ablation — 1

Skeletal Biopsy & Ablation — 17

- MR Guided Cryoablation of Spine Tumor — 8
- MR Guided Cryoablation of Degenerative Spine Disease — 4
- PET/CT Guided Biopsy of Spine Tumor — 3
- MR Guided Biopsy of Femoral Tumor — 1
- Musculoskeletal MR Guided Cryoablation (Elbow) — 1

Thoracic Surgery, Biopsy, Ablation — 94

- Video Assisted Thoracoscopic surgeries (iVats) — 30
- Breast Conserving Surgery — 23
- PET/CT Guided Lung Biopsies — 18
- Cardiac EP Ablations — 7
- PET/CT Guided Microwave Ablations of Lung Tumors — 7
- PET/CT Guided Cryoablation of Metastatic Tumors — 5
- PET/CT Guided Cryoablations of Lung or Rib Tumors — 3
- MR Guided Cryoablation of Metastatic Tumors — 1

Abdominal Tumor Ablation & Biopsy — 307

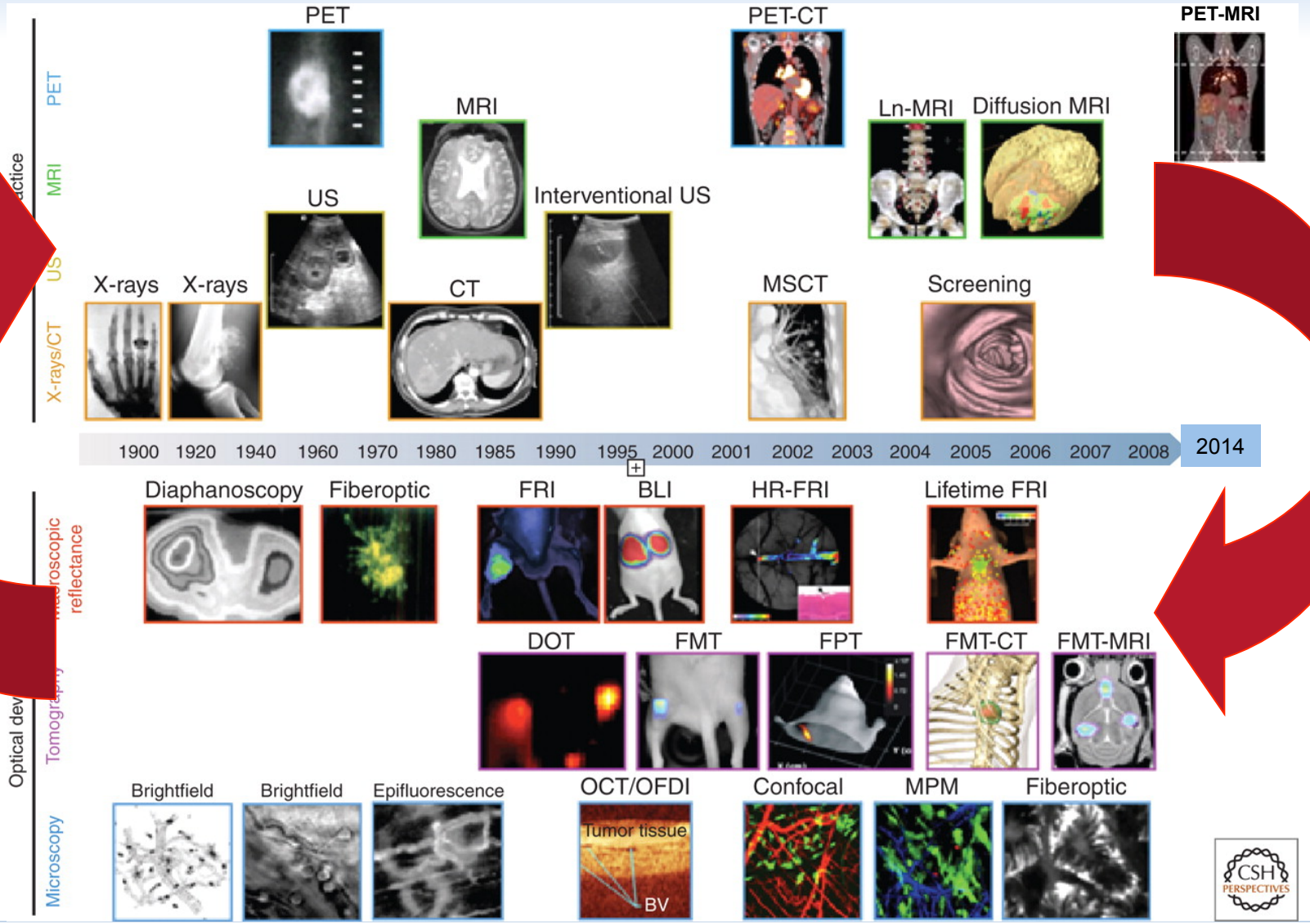
- MRI Guided Cryoablations of Liver or Kidney Tumors — 181
- PET/CT Guided Microwave Ablations of Liver or Kidney Tumors — 47
- PET/CT Guided Cryoablations of Liver or Kidney Tumors — 39
- MR Guided Biopsies of Liver or Kidney Tumors — 35
- PET/CT Guided Cryoablation of Retroperitoneal Mets — 2
- MR Guided Cryoablation and Biopsy of Retroperitoneal Mets — 1
- CT Guided Electroporation of Liver Metastases — 1
- PET/CT Guided Adrenalectomy — 1

Pelvic Biopsy, Ablation, Brachytherapy — 472

- MR Guided Prostate Biopsies — 358
- MR and Ultrasound Guided Gynecologic Cancer Brachytherapy — 92
- MR and Ultrasound Guided Prostate Brachytherapy — 8
- MR Guided Cryoablations of Prostate Tumors — 8
- MR Guided Biopsy & Cryoablation of Pelvis — 2
- MR Guided Biopsy of Penile Tumor, Perirectal Mass — 2
- PET/CT Guided Penile Biopsy — 1
- PET/CT Guided Cryoablation of Pelvic Tumor — 1

http://ncigt.org/pages/AMIGO
http://ncigt.org/amigoprocedures
https://www.youtube.com/watch?v=HNLB5Xcf3Co

Advances in imaging technologies used in oncology



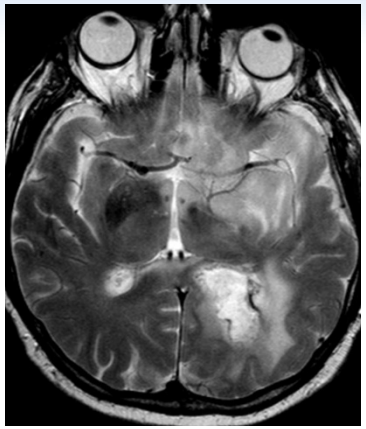
Adapted from Condeelis J , Weissleder R Cold Spring Harb Perspect Biol 2010;2:a003848

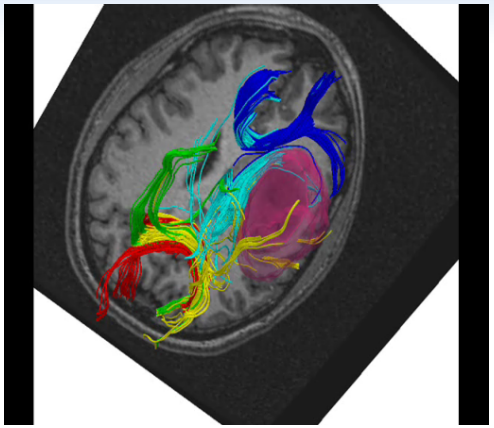
©2010 by Cold Spring Harbor Laboratory Press

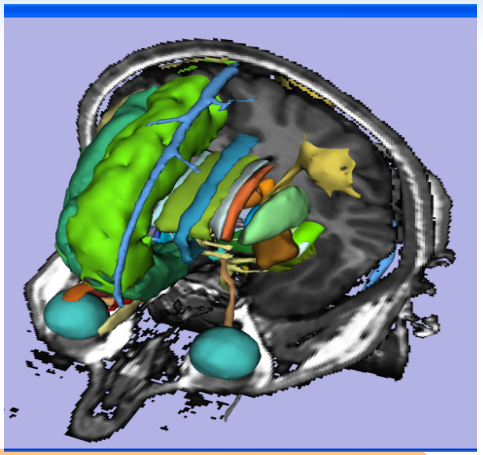
NCIGT.ORG

Courtesy of Annick D. Van den Abbeele, MD

Imaging Pipeline



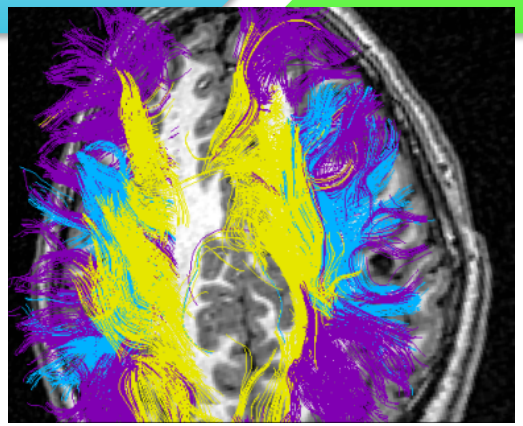


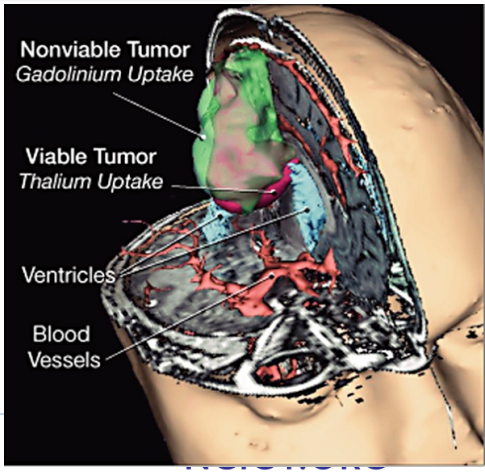


Images acquired

Image Processing

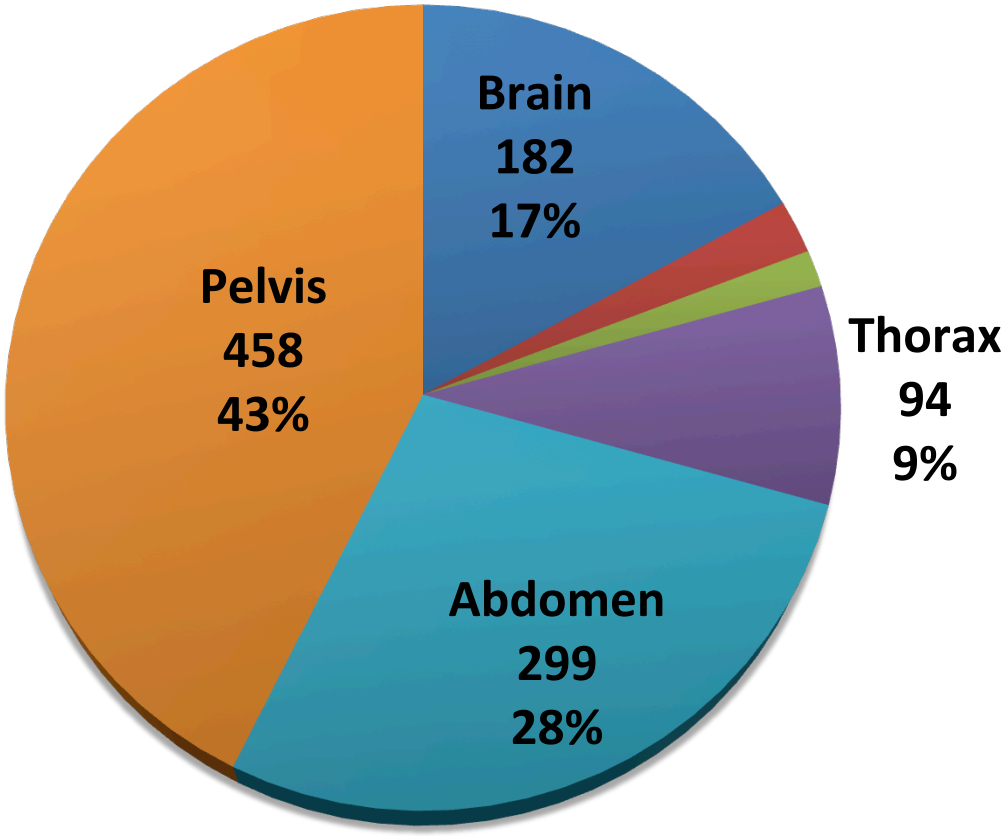
Data results/ Display

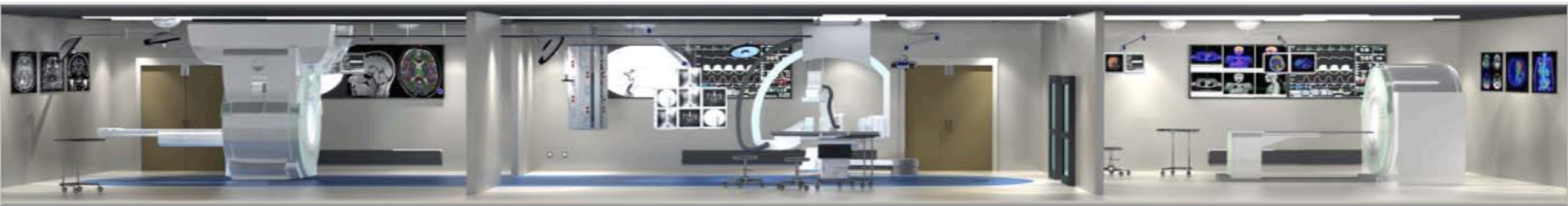




Lauren O'Donnell, Marek Kubicki, Martha E. Shenton, Mark E. Dreusicke, W. Eric L. Grimson, Carl-Fredrik Westin. A Method for Clustering White Matter Fiber Tracts.
AJNR 27(5):1032-1036, 2006

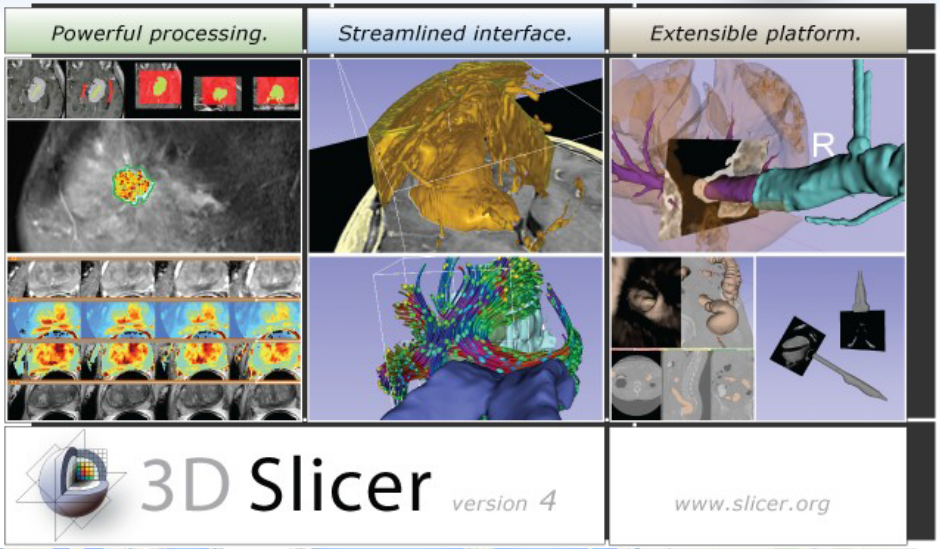
1072 Procedures
08/31/2011-03/11/2016

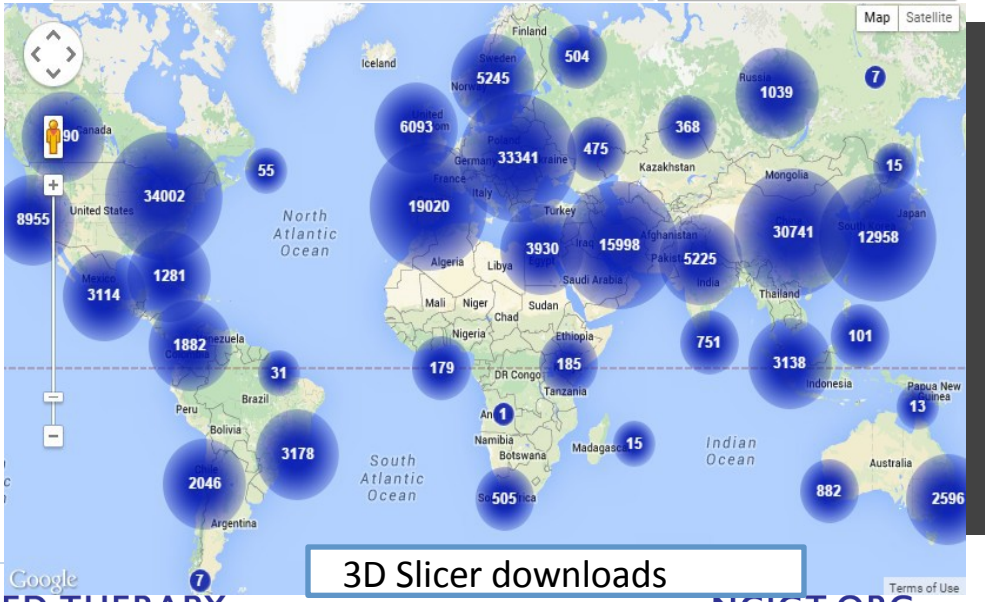




3D Slicer

- Medical image analysis and visualization platform
- Since 1997
- Multi million investment by NIH
- Professionally engineered core
- 1,000+ analysis functions
- Accelerating number of downloads
  - 1000 per week in 2015
  - 550 per week in 2012





3D Slicer downloads

www.slicer.org

MR guided prostate interventions at BWH

1995 MR guided prostate biopsy Transgluteal n=3 BWH/MGH first

1997-2007 **MR guided brachytherapy**
Transperineal in bore 0.5T n=70 BWH first

1999-2007 **MR guided prostate biopsy**
Transperineal in Bore n=50 BWH first

2001: **1R01AG019513-01 (PI Tempany)**
MR GUIDED PROSTATE CANCER DIAGNOSIS AND BRACHYTHERAPY n= 500

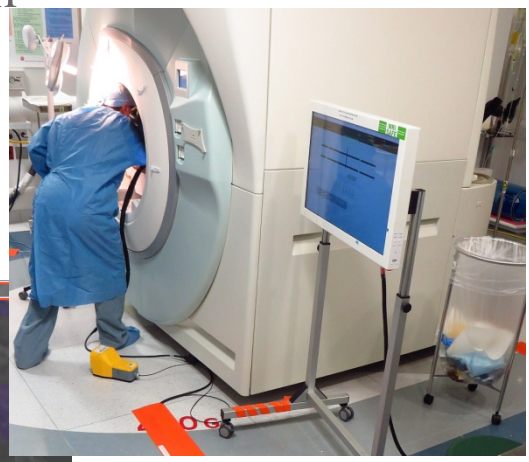
2005-present **P41 NCRR/NCI/NIBIB(Jolesz/Tempany-PROSTATE CORE**

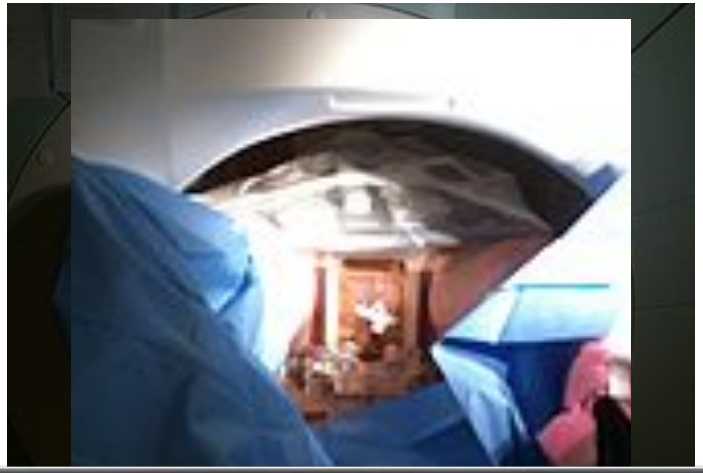
2006: **RO1 (Tempany) BRP NCI**

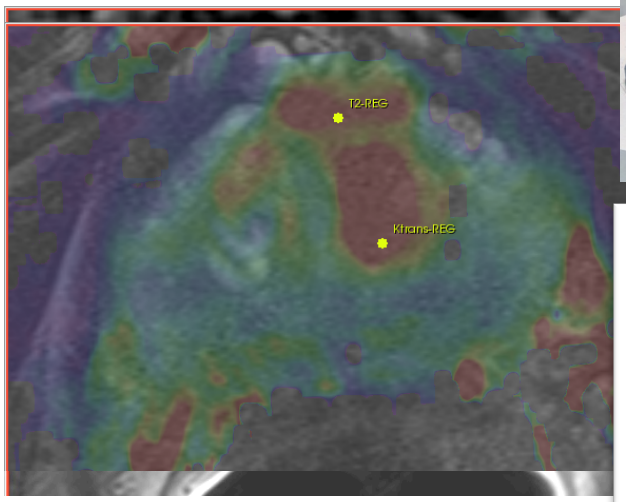
Now 18 years later MR targeted prostate biopsy is a routinely performed worldwide
Multiple approaches (TR/TP, in bore/out of bore), multiple devices/vendors, devices

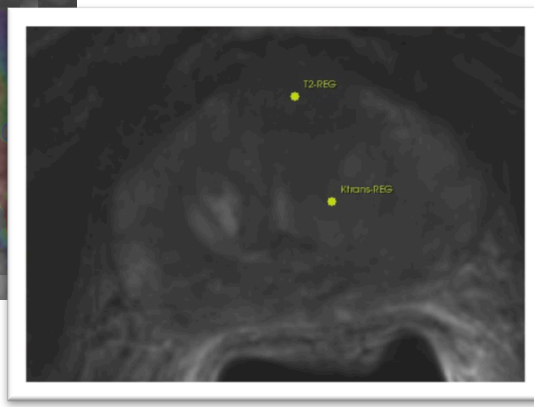
BWH 2014 MR guided prostate biopsy at 3T (wide bore-70 cm)

- Direct Transperineal sampling based on pre-biopsy MRI (Ecoil at 3T) to define targets
- Target sampling with 3D slicer, under IVCS- out patient
- Target MR abnormal areas
  - ✧ T2W/ADC/DCE
  - ✧ Site specific pathology

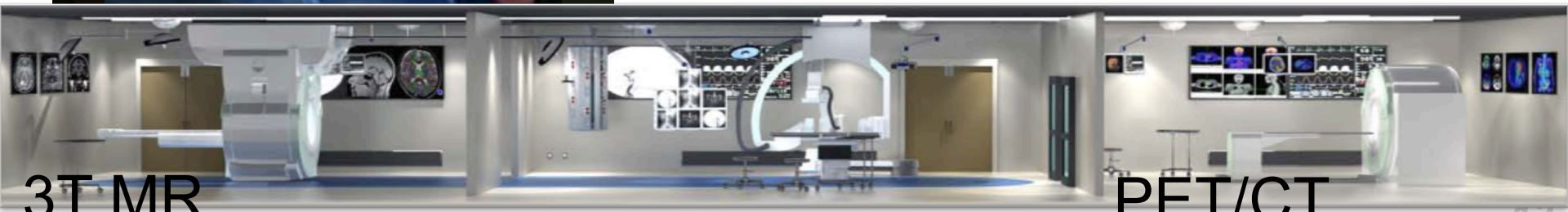








AMIGO



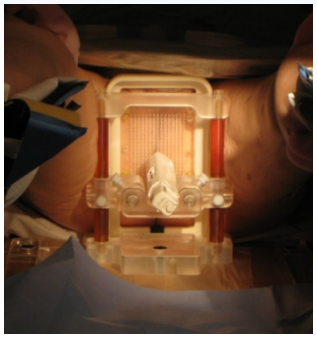
3T MR

PET/CT

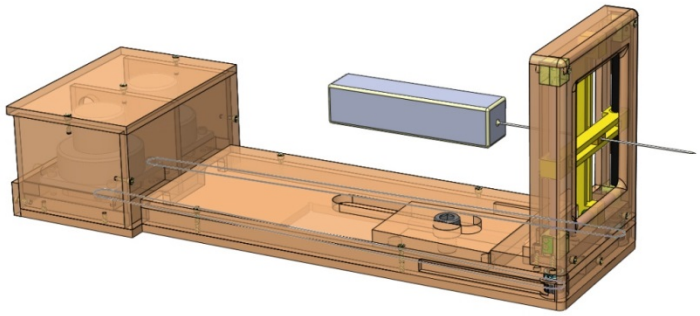
Smart Template and robot for MRI-guided Prostate Biopsy

NATIONAL CENTER FOR IMAGE-GUIDED THERAPY

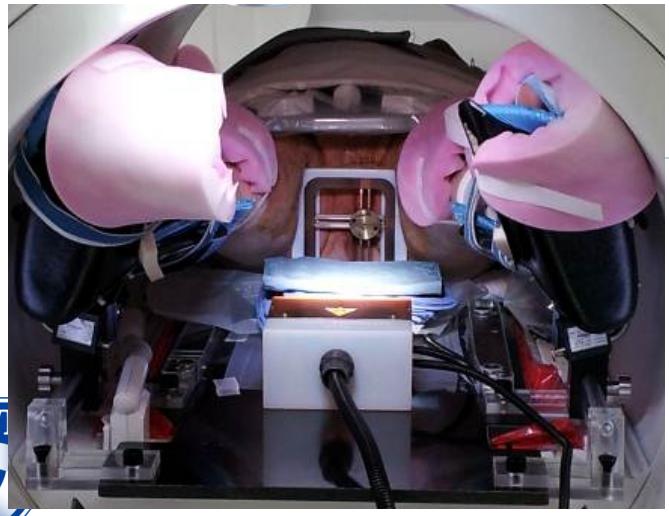
Intervention Stirrup



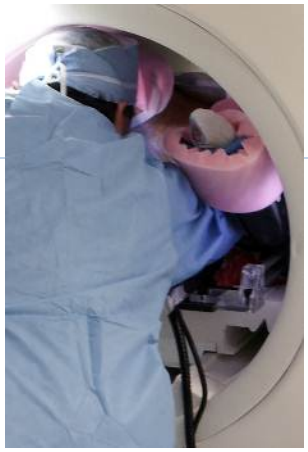
Manual Template

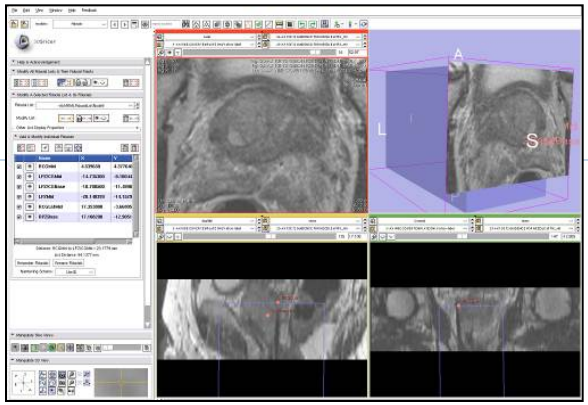


Smart Template



Clinical setup at AMIGO





3D Slicer ProstateNav

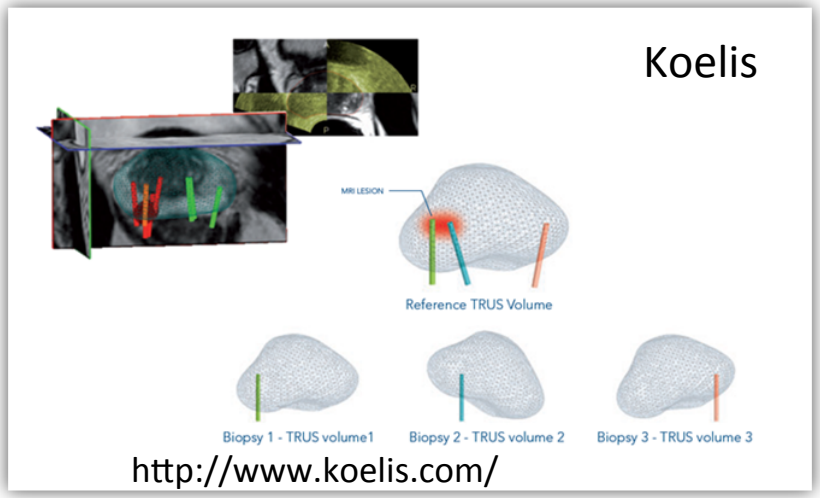
- No human communication error
- Unrestricted needle positioning

Song et al. IEEE Trans Biomed Eng. 2013

Overview of MR-US "fusion" biopsy systems
MR targeted US guided prostate biopsy

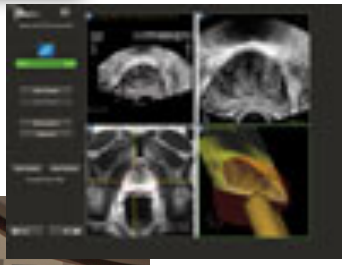
Artemis

http://www.eigen.com/products/artemis.shtml



http://www.koelis.com/

Uro nav



http://www.invivocorp.com/avs/UroNav.php

Look to the future

- Big Data, Deep Learning, Machine learning
  - Tools: Watson, 3DSlicer, MR fingerprinting

- Challenges and opportunities
  - Data sharing vs Research Parasites vs Symbiotic/Collaborative*
  - 2 new NIH initiatives

"Medicine is too important to be left to Doctors"
  - Issac Kohane P41 directors meeting March14th 2016
  - TED MED talk 2013

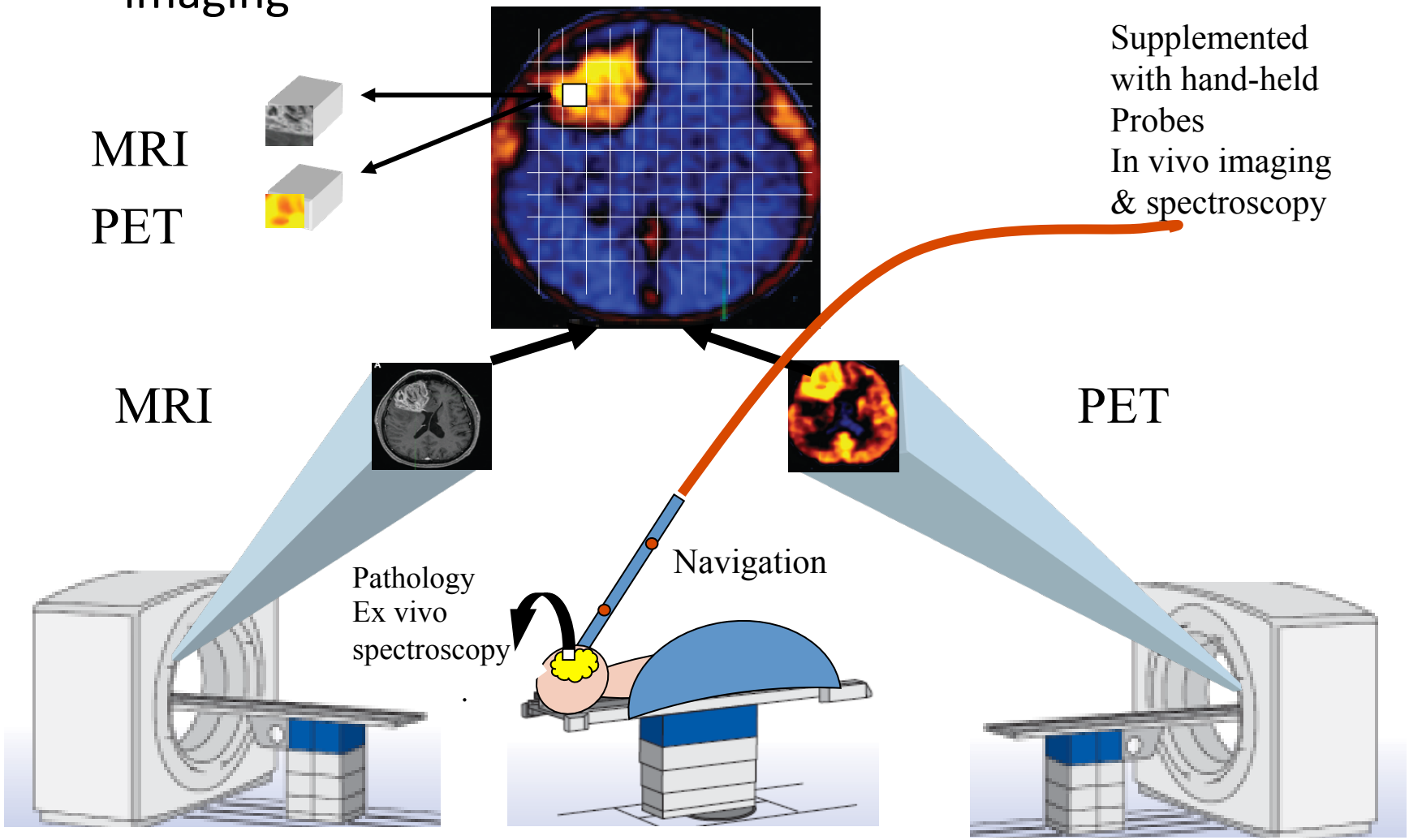
*D. Longo & J. Drazen NEJM

- Taichman DB, Backus J, Baethge C, et al. Sharing clinical trial
- data — a proposal from the International Committee of Medical
- Journal Editors. N Engl J Med 2016 January 20

Look to the future: Mega Trends

- High value-Low cost
  - Value-added: Experience/quality
  - Market differentiators
- Aging baby boomers
- Patient's driving the decisions: increased co-pays

Molecular imaging framework for AMIGO
Voxel specific tissue sampling for pathological validation of imaging



A validation of multimodal imaging MR-PET registration

Role of imaging

IMAGING

Quant Imaging

Phenome

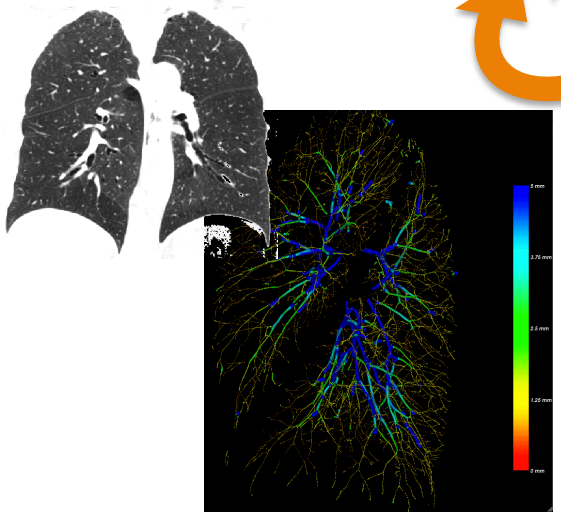
Genome

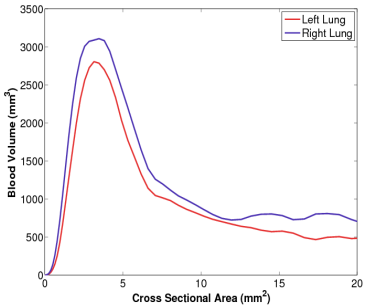
GWAS

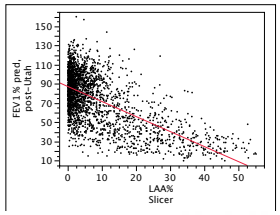
Clinical

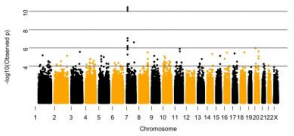
Drug Development

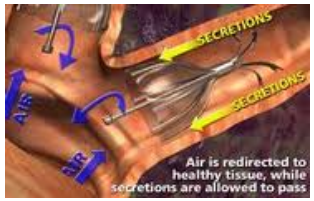
Therapy Planning











Courtesy Ron Kikinis

NIH BD2K 2012

- A trans-NIH initiative established to enable biomedical research as a digital research enterprise, to facilitate discovery and support new knowledge, and to maximize community engagement.
- 4major aims
  - To facilitate broad use of biomedical digital assets by making them discoverable, accessible, and *citable.*
  - To conduct research and develop the methods, software, and tools needed to analyze biomedical Big Data.
  - To enhance training in the development and use of methods and tools necessary for biomedical Big Data science.
  - To support a data ecosystem that accelerates discovery as part of a digital enterprise.

Cancer Moon shot NCI 2016

- Biden's $1B initiative
  - $195 M in 2016
  - $755 M in 2017-$680 to NCI/ $75M to FDA & $50 to VA

- NCI
  - Blue ribbon panel (n=28)
    - Scientific experts, cancer leaders, and patient advocates
    - Co-Chairs: Tyler Jacks (Koch/MIT), Eliz Jaffee (Kimmel/JHU) and Dinah Singer (NCI acting DD)
  - Report to NCAB 8/16.
  - FOA 8-10/16
  - Receipt of apps 1-3/17

Themes

- Highly sensitive approaches to detection
- Enhanced data sharing
- Single cell genomic profiling of cancer cells and cells in micro-environment.
- Cancer Vaccines
- Advances in Immunotherapy
- Pediatric cancers

Congratulations and Many Thanks

Looking forward to next 25!