



# AAPM Low Dose CT Grand Challenge

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Presented at ADSA Workshop, 5/15/2018

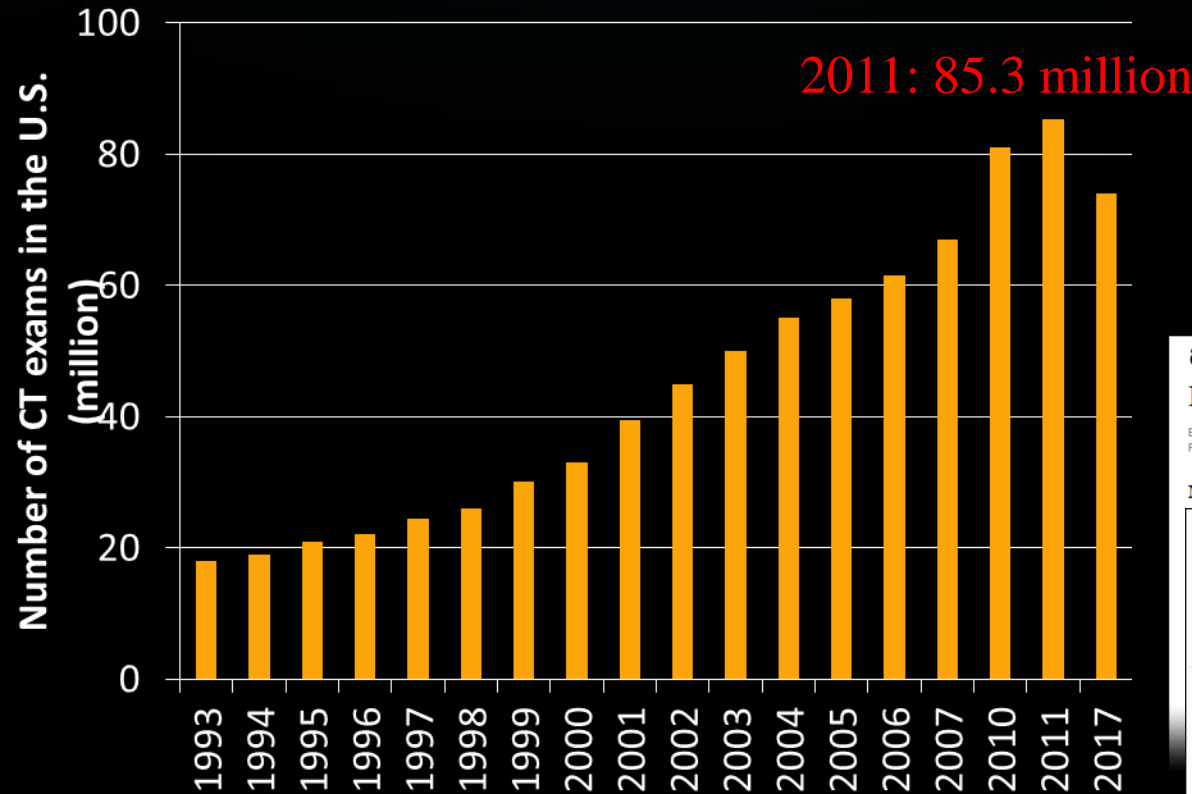
# On behalf of our team at Mayo Clinic

- Principle Investigator of the Project
  - Cynthia H. McCollough, PhD
- Co-leaders
  - JG Fletcher, MD
  - Lifeng Yu, PhD
  - Shuai Leng, PhD
  - Rickey Carter, PhD
  - David Holmes III, PhD
- Trainees
  - Baiyu Chen, PhD
  - Kyle McMillan, PhD
  - Chi Ma, PhD
- Staff
  - Tammy Drees
  - Greg Michalak, PhD
  - Alice Huang
  - Kris Nunez
  - Shane Dirks

# Overview

- ▶ A Grand Challenge for low-dose CT was held by Mayo, NIH and AAPM
  - Global participation to test reconstruction algorithms
  - Top performing sites identified
- ▶ A vendor neutral standard CT projection data format (DICOM-CT-PD) was developed.
- ▶ A patient CT projection data library was developed and will become publicly available.

# Public Concerns on Radiation Exposure from Clinical CT



The NEW ENGLAND JOURNAL of MEDICINE

REVIEW ARTICLE

CURRENT CONCEPTS

Computed Tomography — An Increasing Source of Radiation Exposure

David J. Brenner, Ph.D., D.Sc., and Eric J. Hall, D.Phil., D.Sc.

The New York Times

Report Links Increased Cancer Risk to CT Scans

By THE ASSOCIATED PRESS  
Published: November 29, 2007

Millions of Americans, especially children, are needlessly getting

USA TODAY

Study: Unnecessary CT scans exposing patients to excessive radiation

CNN.com /health

Study: CT scans raise cancer risk

updated 7:45 p.m. EST, Wed November 28, 2007

Researchers say they're not trying to

Study: Increased Use of CT Scan Poses Cancer Risk

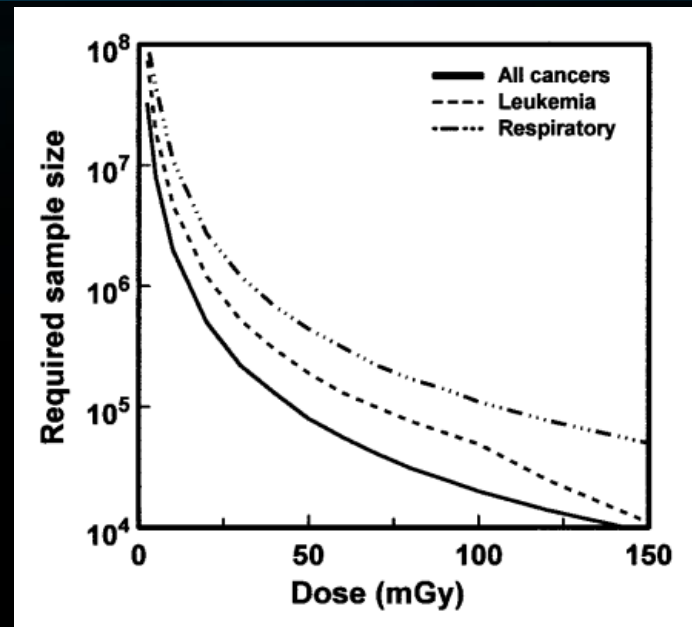
Thursday, November 29, 2007

Associated Press

Source: IMV Medical Information Division

# Initiative on radiation dose reduction in clinical CT

- ▶ Risk of low-dose radiation is hypothetical and unproven. Even if exists, it is extremely low.
  - BEIR VII report: “At doses of 100 mSv or less, statistical limitations make it difficult to evaluate cancer risk in humans.”
  - Extremely hard to investigate!
  
- ▶ However, ALARA is still the guiding principle. Maximizing benefit/risk ratio is always the right thing to do!
  
- ▶ NIH’s “Sub-mSv CT” initiative calls for development of new technologies to lower patient doses



Brenner et al,  
 PNAS 2003;  
 100: 13761-  
 13766

## The Summit on Management of Radiation Dose in Computerized Tomography: *Toward the Sub-mSv Exam*

Bethesda North Marriott Hotel and Conference Center | Bethesda, Maryland  
 February 24-25, 2011

### Agenda

This is an NIH, CIBR sponsored and FDA, ACR, and ACC supported conference focused on transforming CT technology and its use to achieve minimal public health risks from radiation exposure. A specific goal is to identify the technological steps and associated research required to reduce the routine CT exam dose to less than one mSv. Additional goals in the near term are improving our understanding and management of radiation exposure and defining steps to achieve best practices.

# Motivation and Purpose of the Grand Challenge

- ▶ Image reconstruction has a huge impact on dose efficiency
- ▶ A large number of reconstruction algorithms all over the world. It is important to determine which algorithm is the best
- ▶ This is a challenging task since it requires clinically relevant evaluation using a common set of projection CT data from patient scans
- ▶ In 2016, we decided to have a grand challenge to evaluate CT reconstruction algorithms
  - for the specific task of detecting metastatic liver lesions
  - using a common set of 25% dose patient data with proven pathology
  - on an international scale
  - using radiologist as human observers to evaluate diagnostic performance



# Low Dose CT Grand Challenge



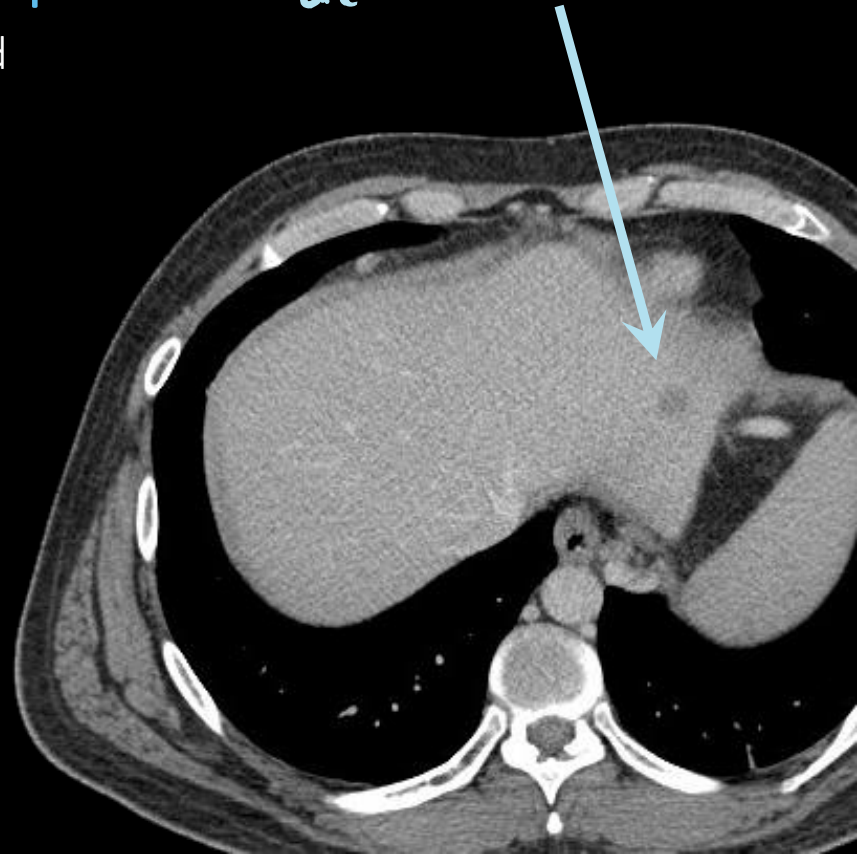
AMERICAN ASSOCIATION  
of PHYSICISTS IN MEDICINE



MAYO CLINIC

- Image reconstruction and denoising experts
  - Test your algorithm against others in the field
- Using real patient projection data
  - In vendor-neutral format
  - w/ and w/o pathology
- Winners announced at AAPM 2016
  - Free meeting registration
  - Participation in a low dose CT session
  - Manuscript co-authorship

*Come find me  
at a lower dose*



# Major Challenges to have the Grand Challenge

- ▶ Lack of access to projection data from patient CT scans
  - CT raw data format is proprietary information of vendors
- ▶ Lack of patient reference dataset
  - With pathology labelled and validated
  - With multiple dose levels
- ▶ Human observer evaluation is time consuming!



# An open data format for CT projection data (DICOM-CT-PD)

## Extended DICOM

### Header

(0008,0060) Modality

...

(7029,1010) Number of Detector Rows

...

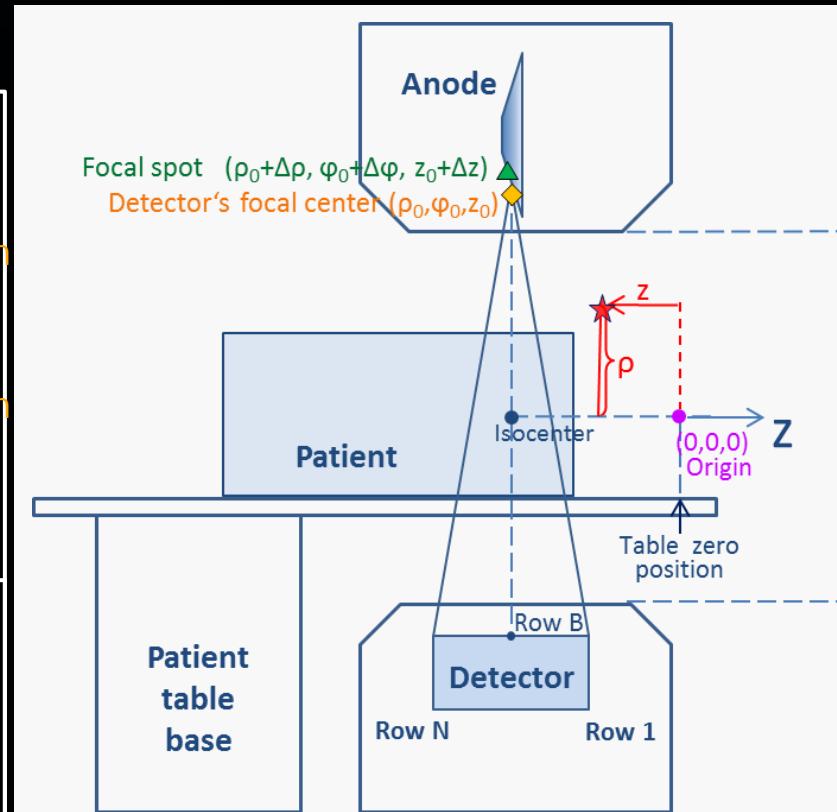
(7037,100A) Type of Projection Geometry

Private tags in  
HEADER to  
store  
CT acquisition  
geometry

### Image

(7FE0,0010) Projection data

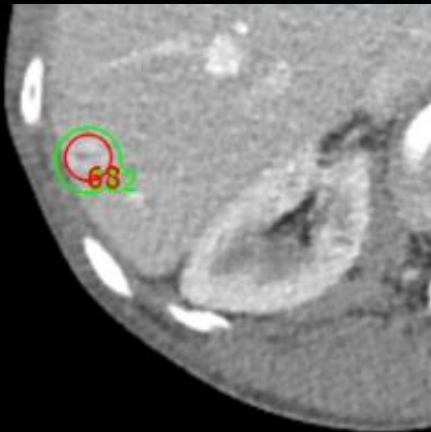
IMAGE to  
store  
projection  
data



(a) Right side view of a CT scanner

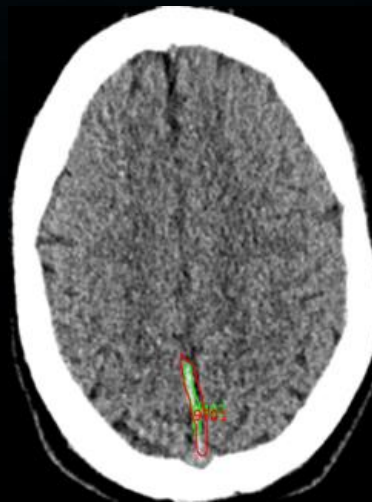
# Patient CT Projection Data Library

Metastatic liver lesion



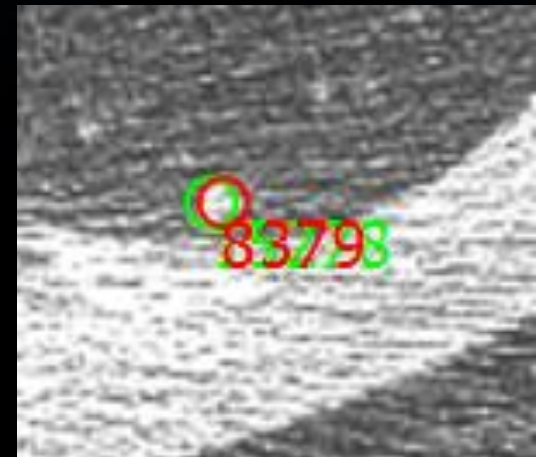
50 GE  
50 Siemens  
50 Philips  
Multiple dose levels

Cause of acute neurologic deficit



50 GE  
50 Siemens  
50 Philips  
Multiple dose levels

Indeterminate lung nodule

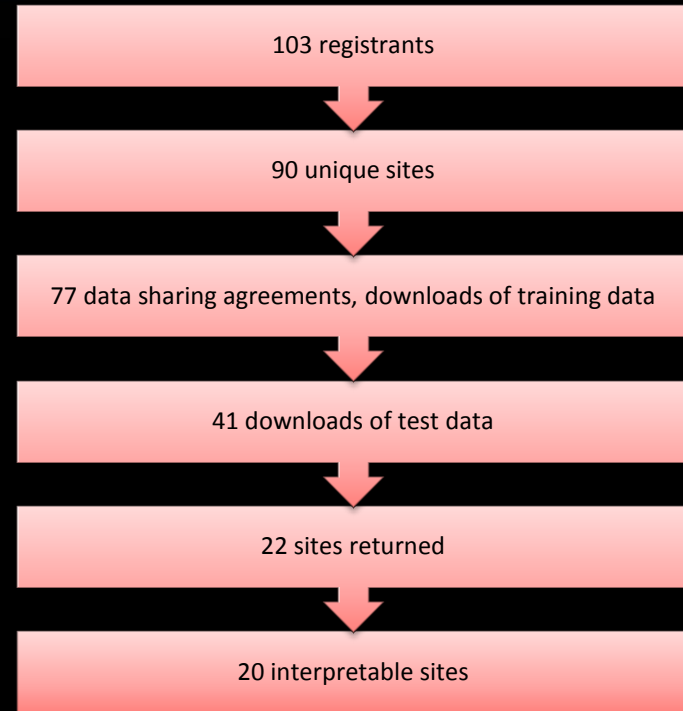
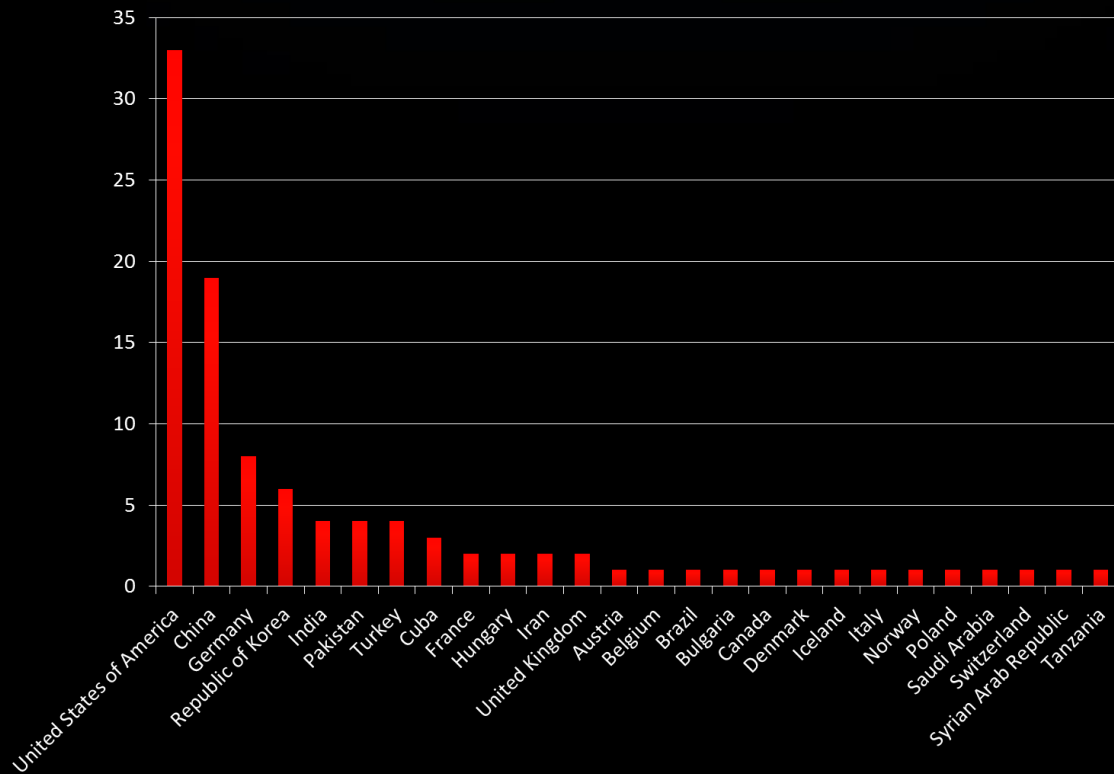


50 GE  
50 Siemens  
50 Philips  
Multiple dose levels

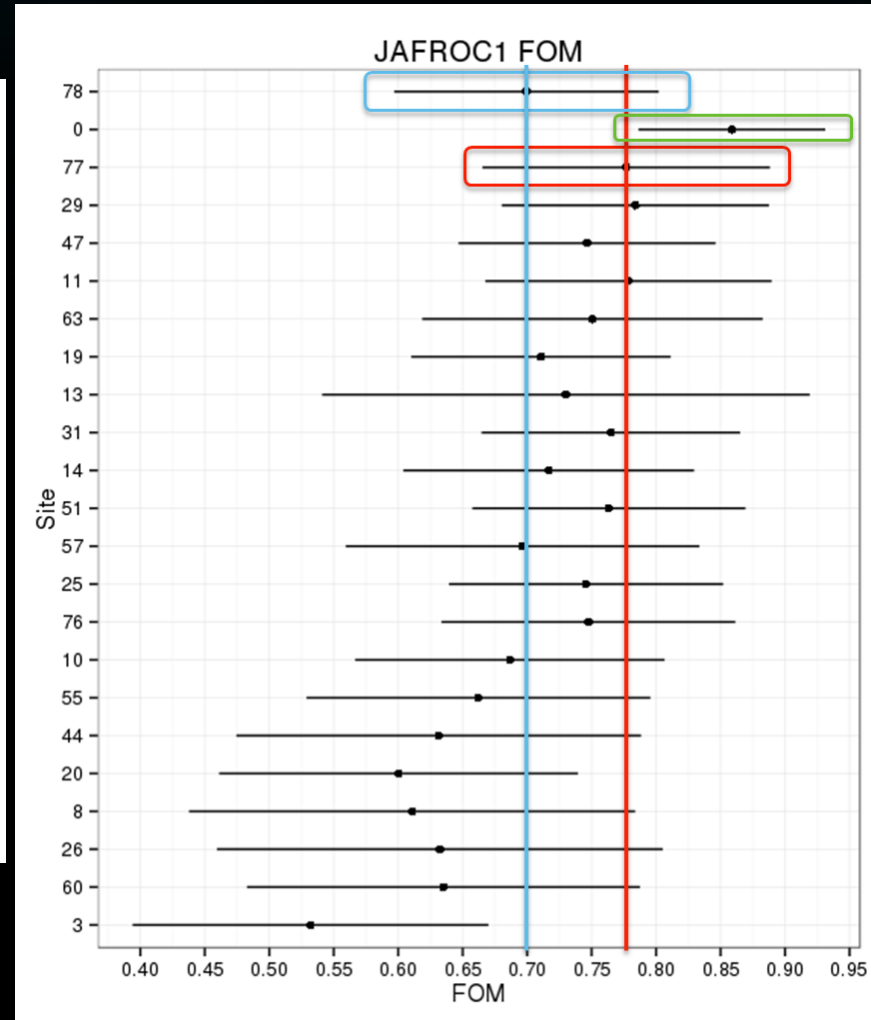
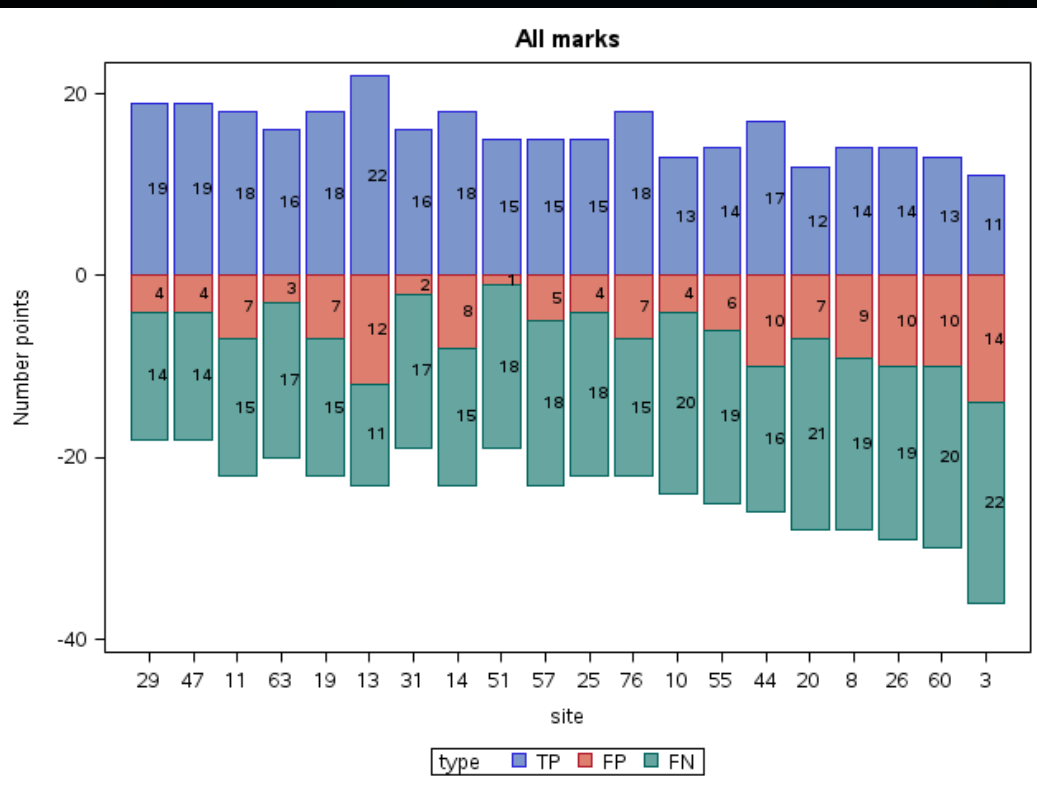
- ▶ Liver Cases used in this Challenge:
  - 10 training (full dose and 25% dose) and 20 testing (only 25% dose)

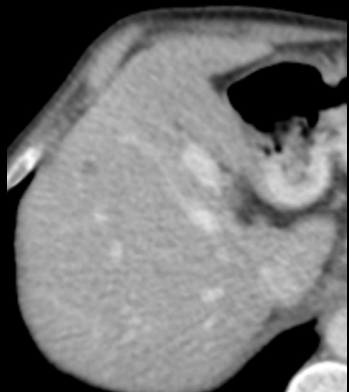
# Global participation

26 countries represented by 103 registrants



# Lesion detection rates and performance by site

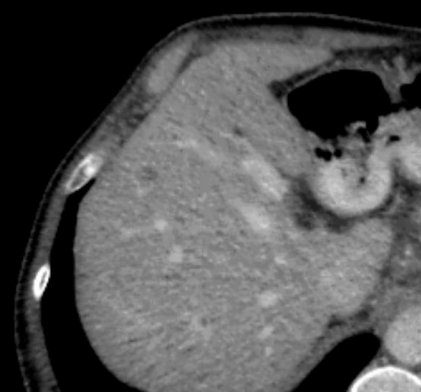




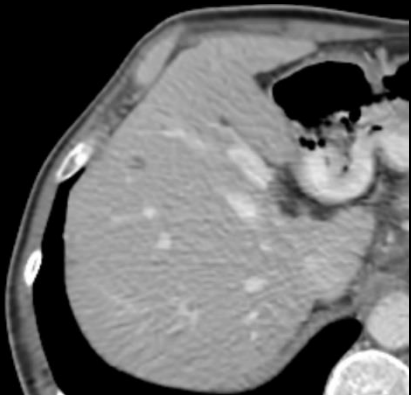
**1<sup>st</sup> – Site 29 (+)**



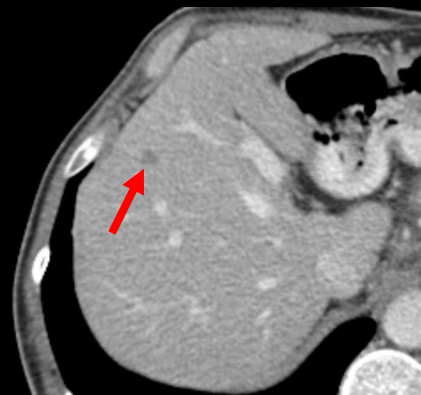
**2<sup>nd</sup> – Site 47 (+)**



**3<sup>rd</sup> – Site 11 (-)**



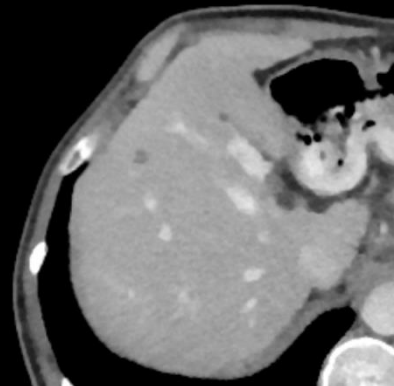
**4<sup>th</sup> – Site 63 (+)**



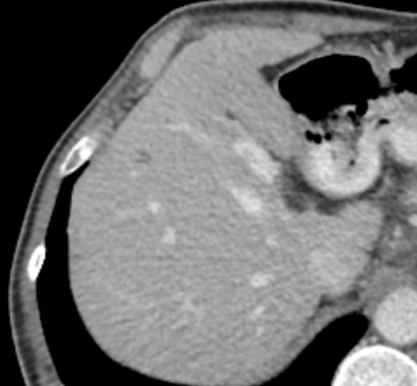
**Routine dose**



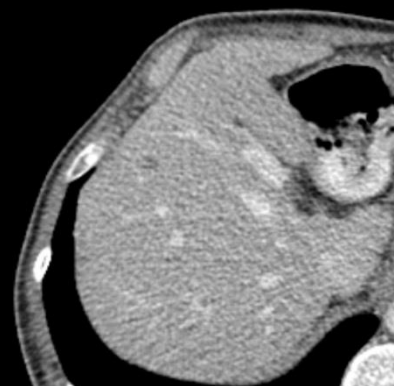
**5<sup>th</sup> – Site 19 (-)**



**6<sup>th</sup> – Site 13 (+)**



**7<sup>th</sup> – Site 31 (+)**

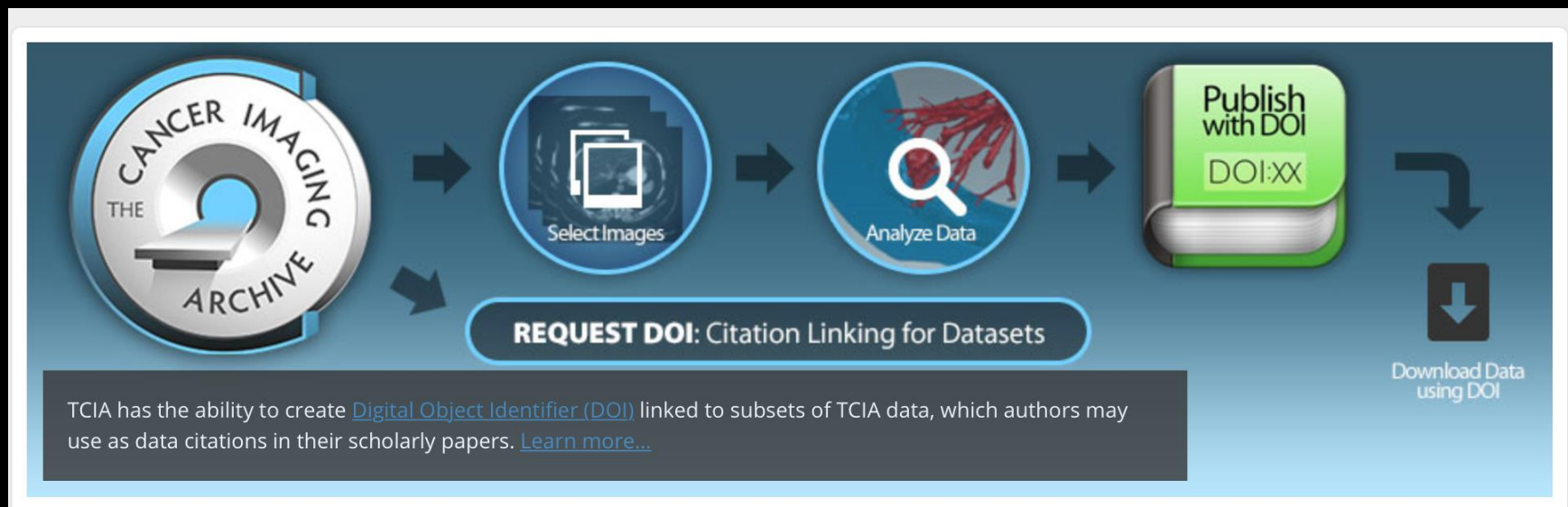


**Quarter dose FBP**

# Ongoing work

## NCI The Cancer Imaging Archive (TCIA)

- ▶ Deidentifies and curates large collection of medical images for public use, organized by disease or anatomy
- ▶ Supports DICOM and other metadata
- ▶ We will be first to provide projection data





# Summary

- ▶ A Grand Challenge for low-dose CT image reconstruction was successfully held by Mayo, NIH and AAPM.
- ▶ A vendor neutral standard CT projection data format (DICOM-CT-PD) was developed.
- ▶ A patient CT projection data library was developed and will be distributed through NCI-TCIA .