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CT: Feasibility and Accuracy

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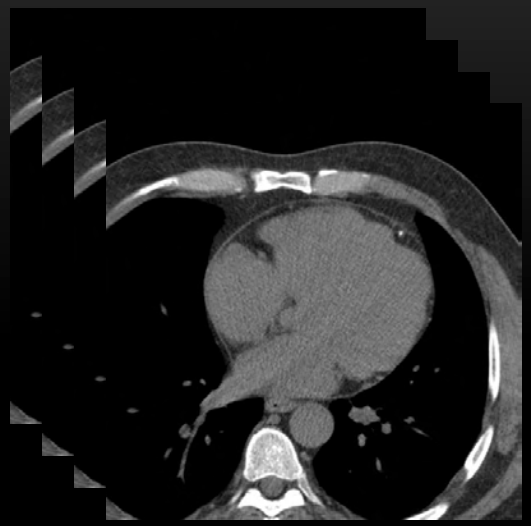
Coronary CTA in 2013

Using modern scanners, coronary CTA should be technically feasible in a wide range of patients with a minimum of radiation and contrast

Prospective ECG-Triggered Cardiac CT



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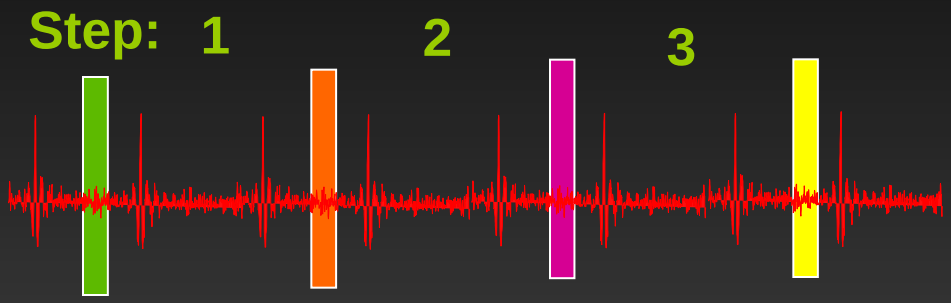
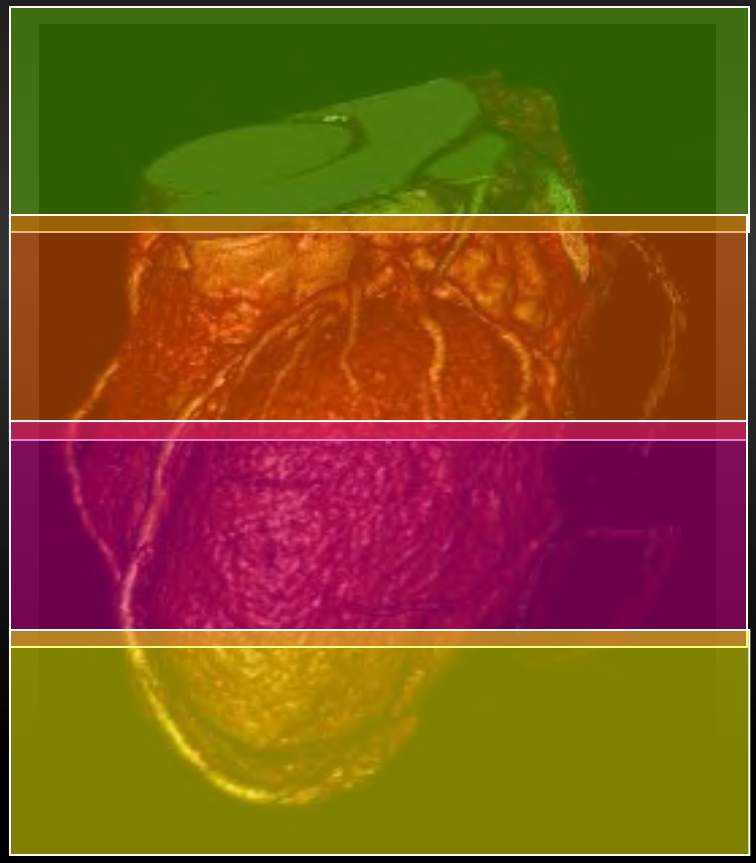
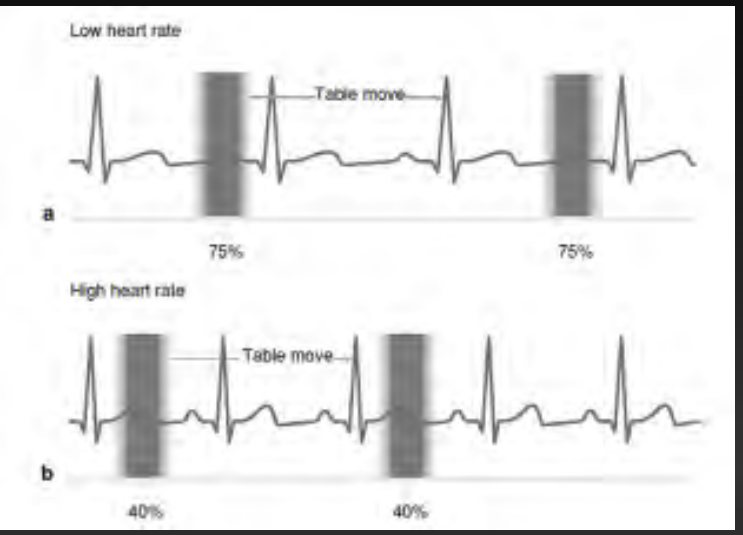
Prospective ECG-Triggered Axial Scan

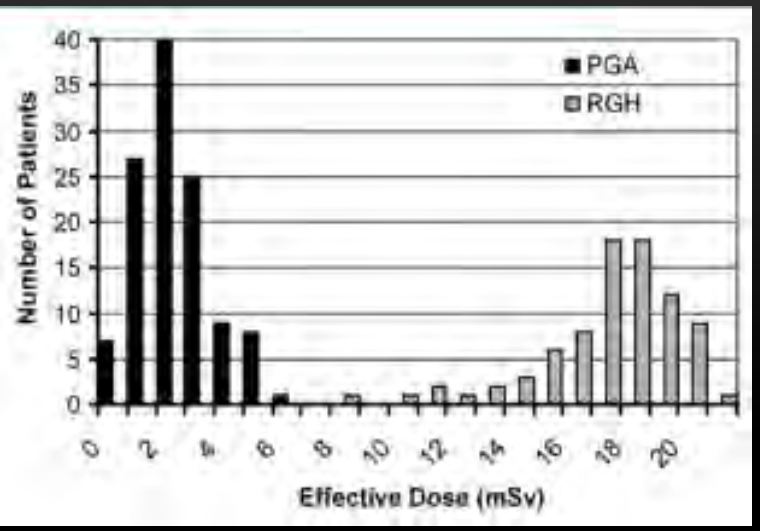


***Step & Shoot Cardiac* scan**



Prospective CCT





- *X-ray tube is OFF during most of the scan!*
- *Gantry rotation speed more important than in helical CT*
  - Helical cardiac CT uses "oversampling" of data, to allow multi-cycle reconstruction
  - "Virtual" temporal resolution may be faster than gantry speed
  - In sequential (prospective) cardiac CT , there is no oversampling
  - Temporal resolution is entirely dependent on gantry speed

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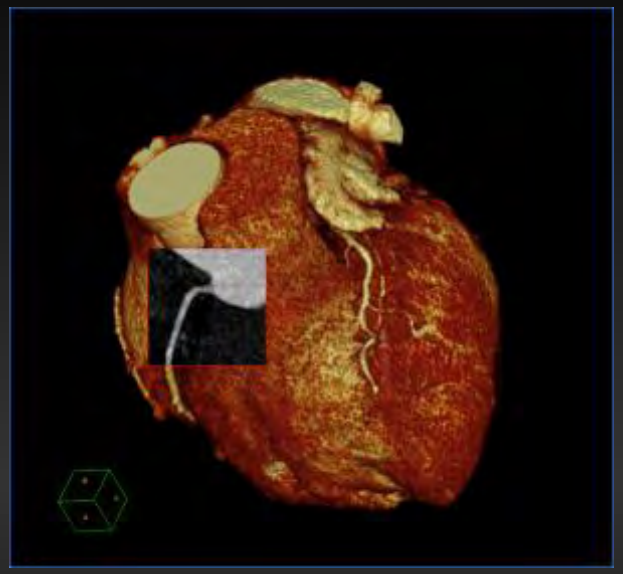
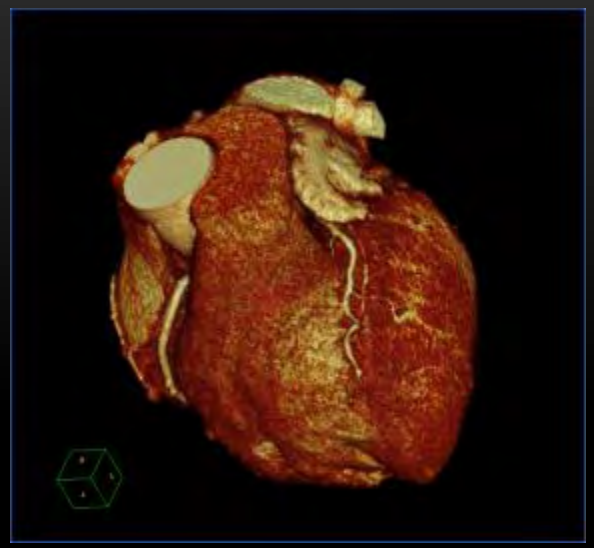
Same Image Quality; Much Lower Dose





1-4 mSv

(vs. 12-18 mSv
for helical cardiac CT
and 6-8 mSv
for standard
chest CT)

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Key Elements of Prospective CT

1. Tube Power
2. Coverage
3. Gantry Speed

Tube Power Overcomes Obesity

Step & Shoot Scan

- Mrs G – 55 y.o. woman with chest pain
- 5’8” (1.7 m) 285 lb (130 kg) BMI 43.4
- 80 mL contrast
- 120 kV 993 mA 560-deg sc angle 420 mAs
- HR 59
- CTDI 38.6 DLP 601.1 Eff Dose 8.4 mSv

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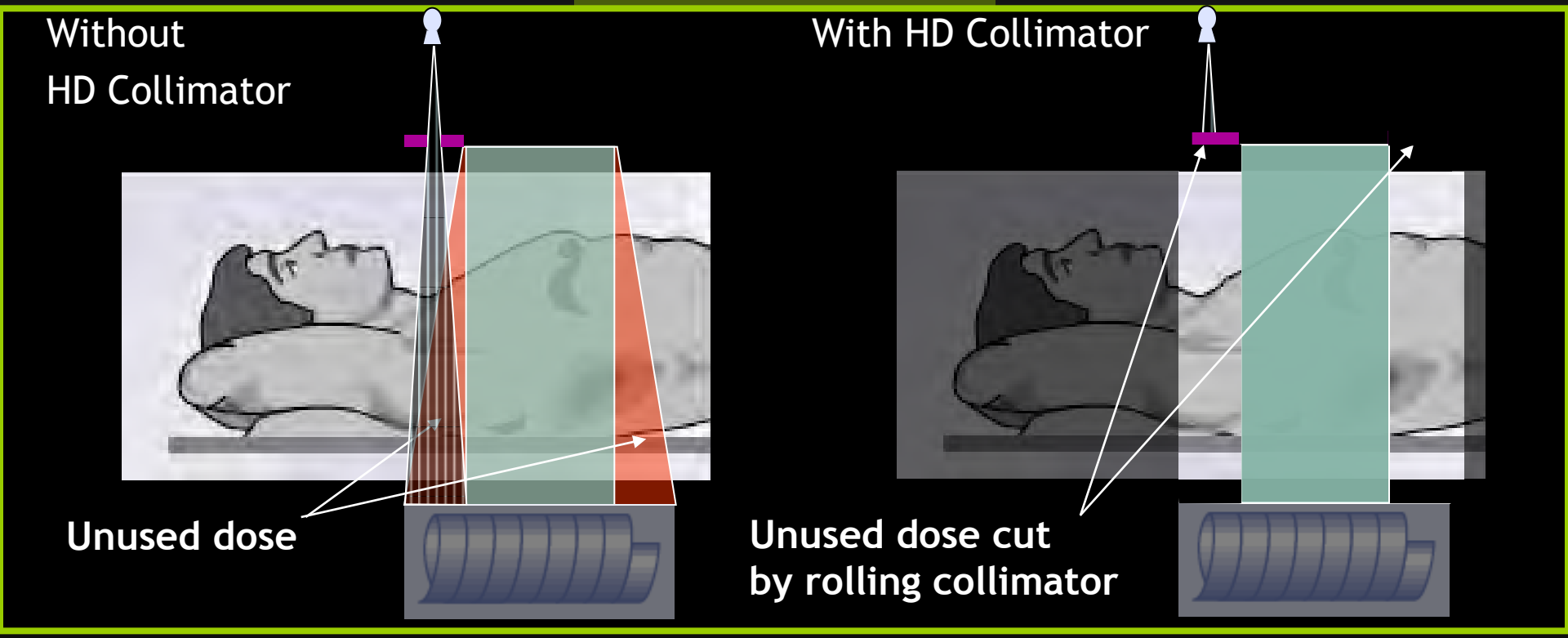
Step & Shoot Coronary CTA

Dose Only Where Needed

Helical Dynamic Collimation to Reduce Overscanning



Courtesy Mani Vembar, PhD

Key #2: Detectors & Coverage

16x16 elements

Nano-Panel™

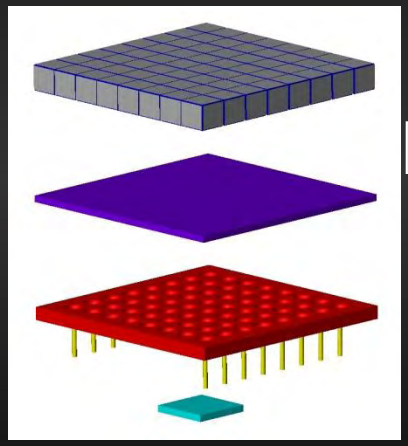
Detector module

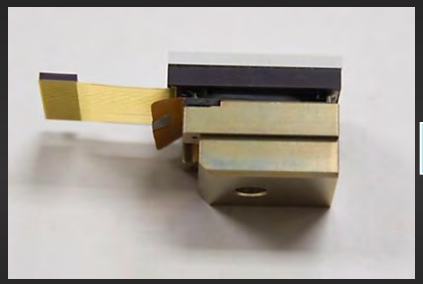
* Expandable to 16 cm

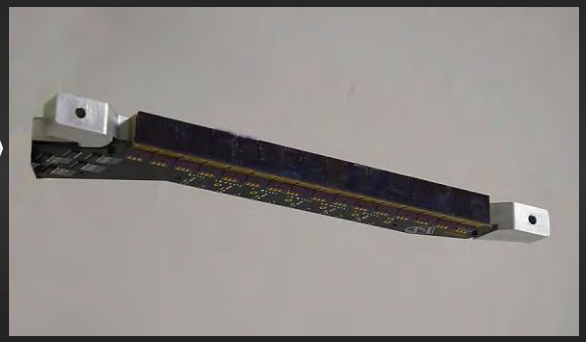
Scintillator

Photodiode

Electronics







Detectors are 0.625 mm in width

128 rows x 0.625 mm = **80 mm** of coverage

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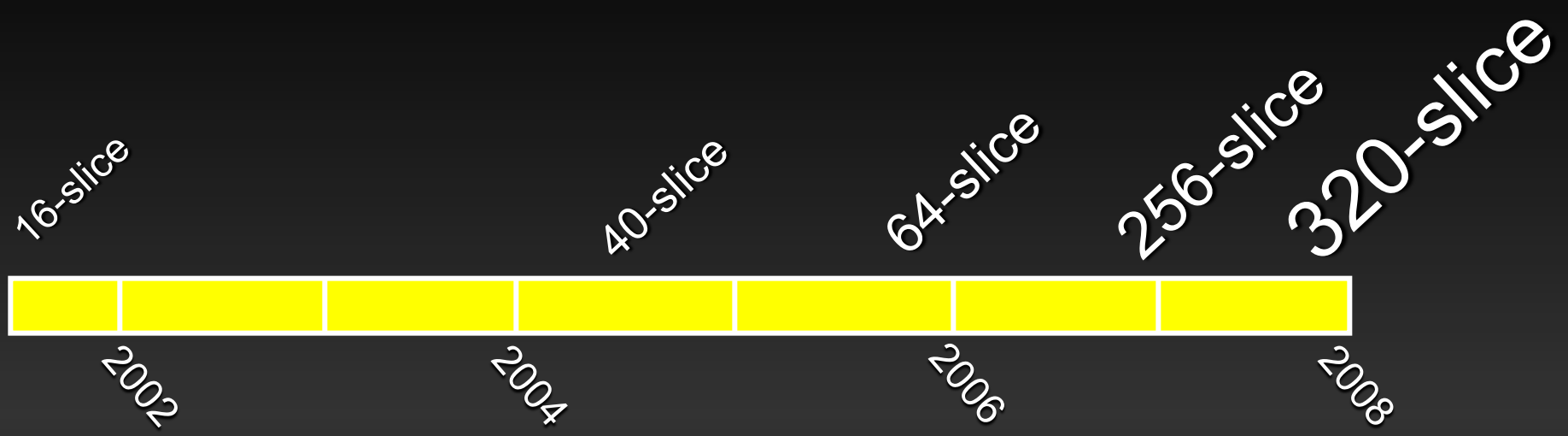
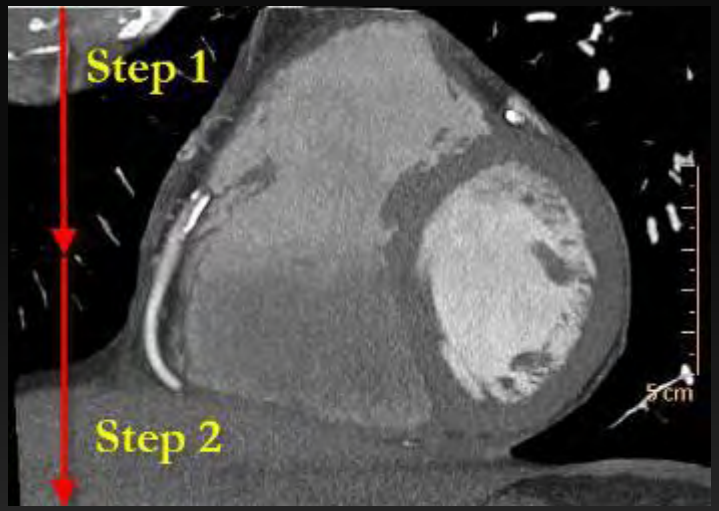
Increasing Detector Rows = Increased Z-Axis Coverage

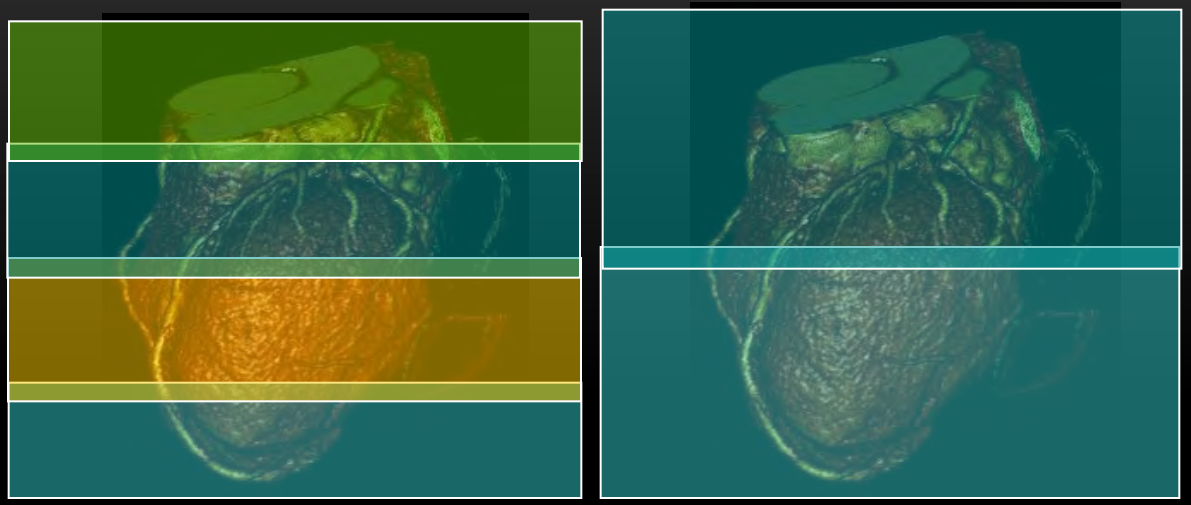


- Increased z-axis coverage = shorter scan duration
  - Shorter breath holds
  - Fewer heart beats
  - Less contrast

Coverage



- Larger coverage:
  - 80 mm
- For a typical cardiac scan (120 mm)
  - Two axial shots
  - 3 Heart beats
  - 4-5 second scans
- Less vulnerability to irregularity / arrhythmia
- More reliable performance in scan after scan



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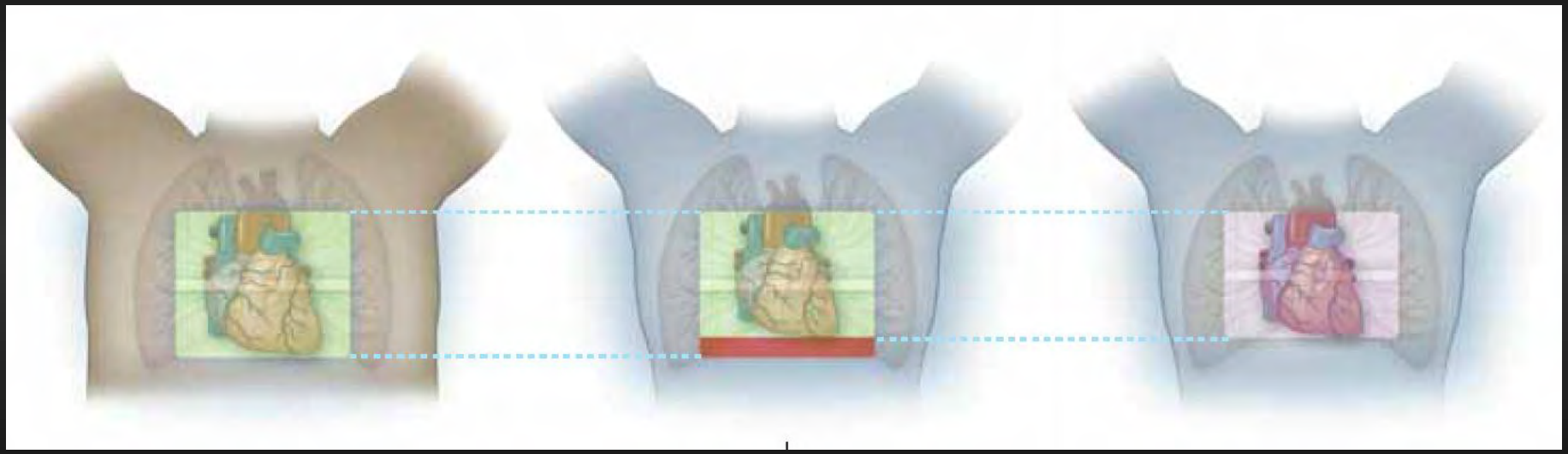
Dose Only When Needed

Adaptive Axial Collimation



Walker MJ, Olszewski ME, Desai MY, et al. IJCVI 2009

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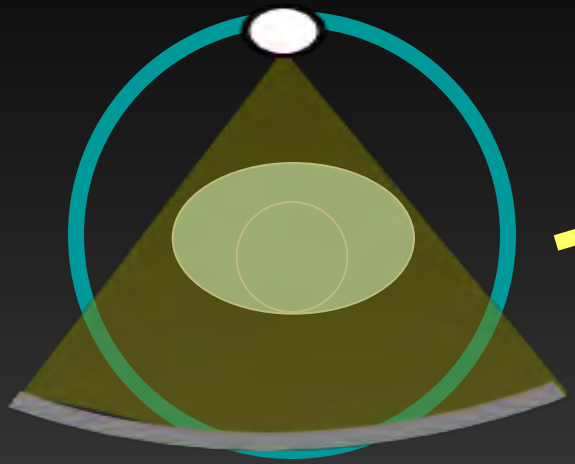
Key #3: Gantry Speed



500 ms

420 ms

370 ms

330 ms

270 ms

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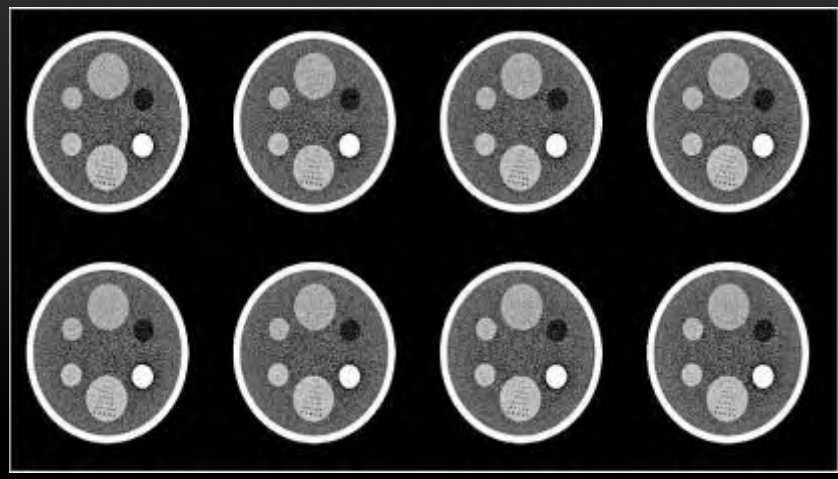
Benchmark Speed

- ***Air Bearing System***
  - *Completely new and innovative breakthrough technology*
- 270 msec per rotation
- 220 rpm
  - vs. 180 rpm at 330 ms/rotation (30%)
- Preserved geometric integrity



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High speed = Better temporal resolution

250 ms **210 ms** **165 ms**

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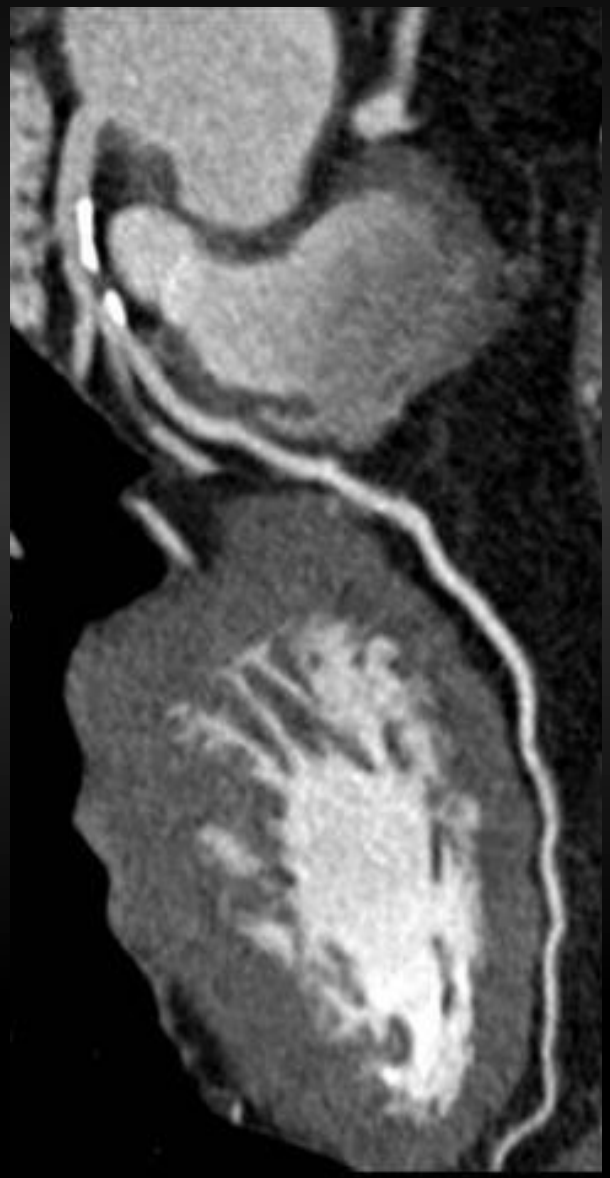
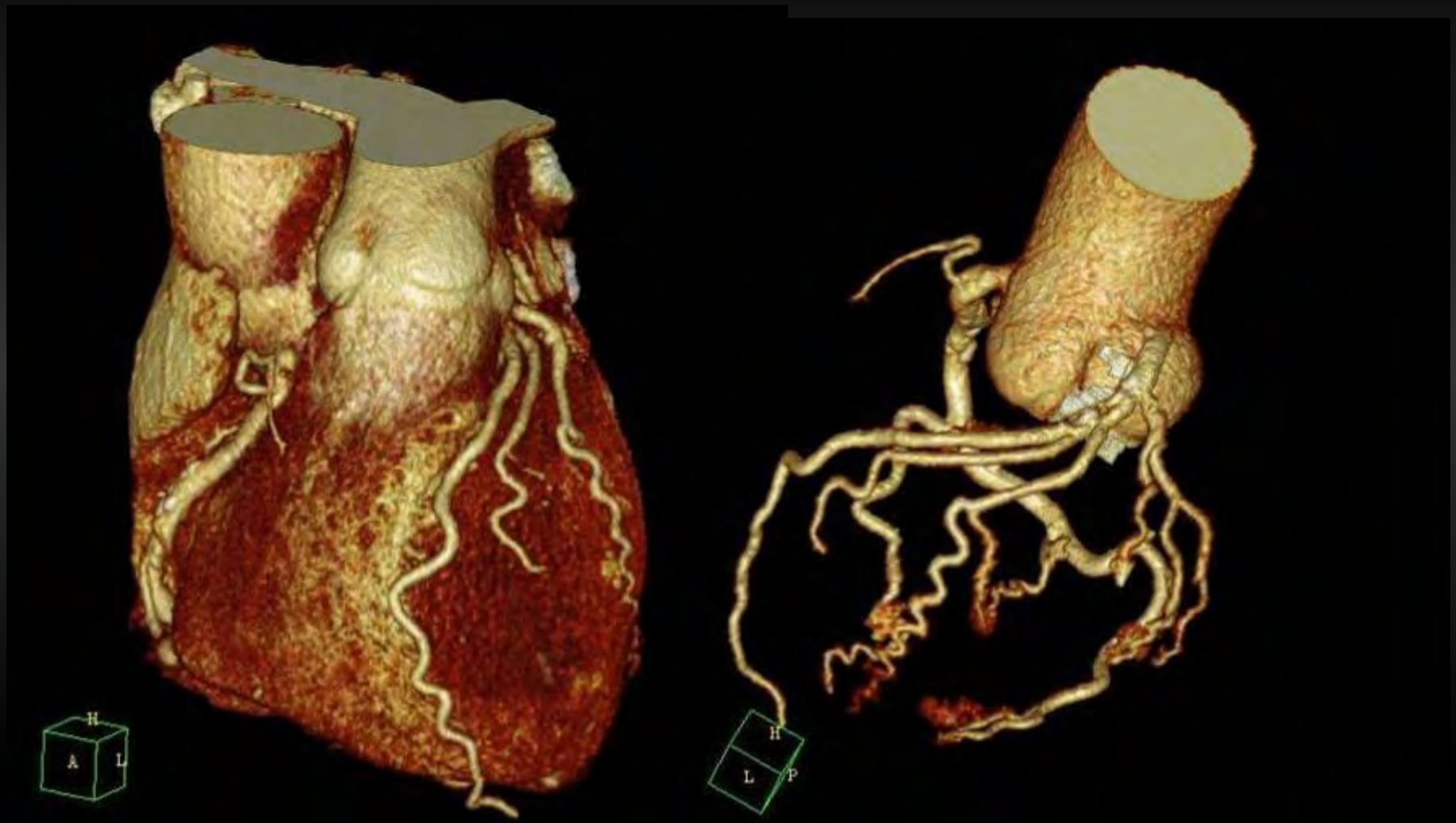
Step & Shoot Cardiac CT

Heart Rate 79 bpm



Step & Shoot Cardiac CT

Heart Rate 79 bpm



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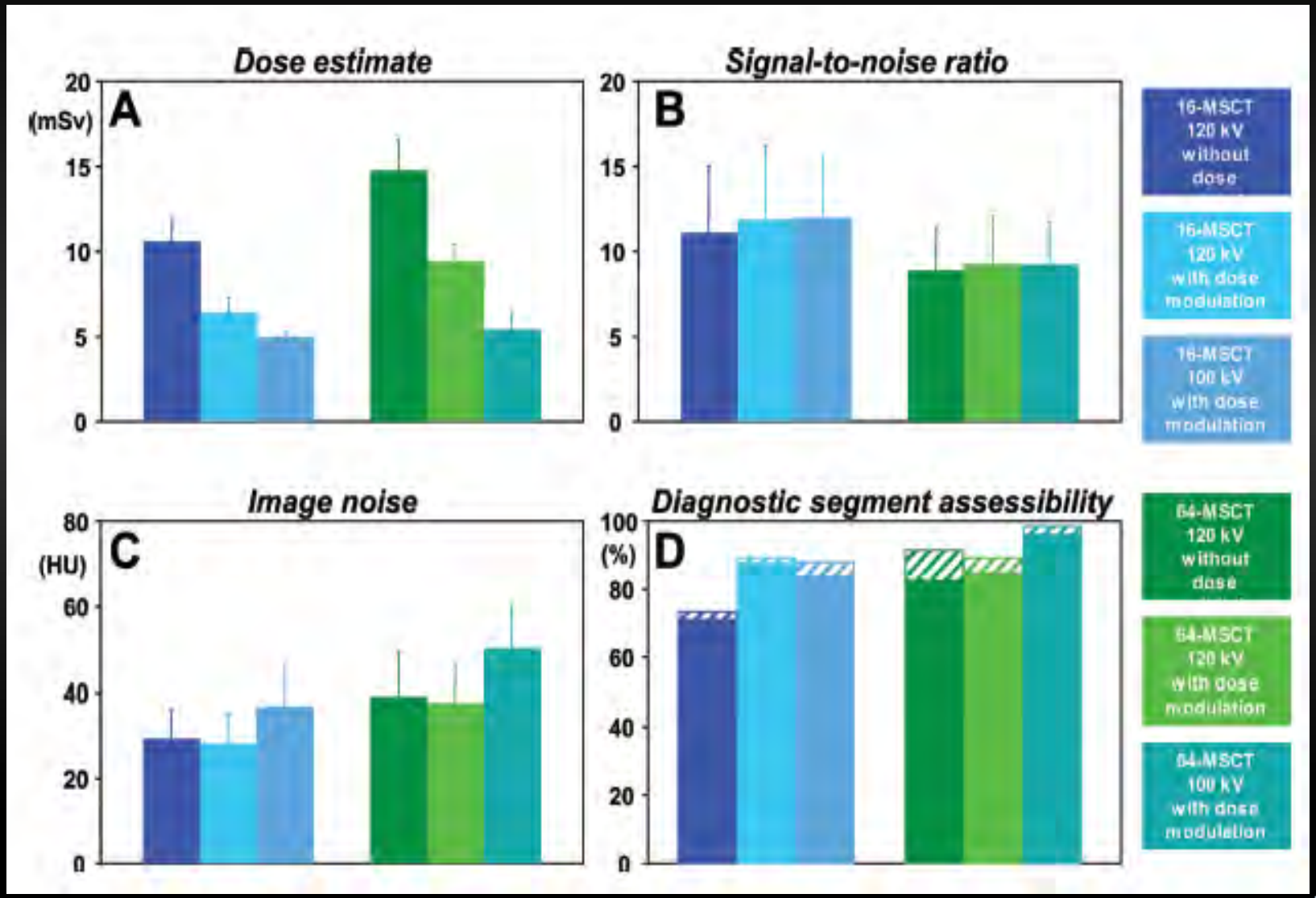
Keys to Prospective Cardiac CT

- The best prospective cardiac CT will be performed by a scanner that offers the *combination* of…
  - **wide detector coverage** *and*
  - **high-speed gantry rotation** *and*
  - **strong x-ray tube power**
- This permits *reliable* helical *and prospective* (step & shoot) cardiac scanning and delivery of high quality images with only a minimum of contrast and radiation exposure

100 kV Scanning
Reduces Radiation Exposure



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Step & Shoot – Radiation Dose

- Mrs. F 61 y.o. woman
- Dyslipidemia and family history of CAD
- 5’1” 126 lb (57 kg)
- 100 kV* 709 mA 560-deg sc angle 300 mAs

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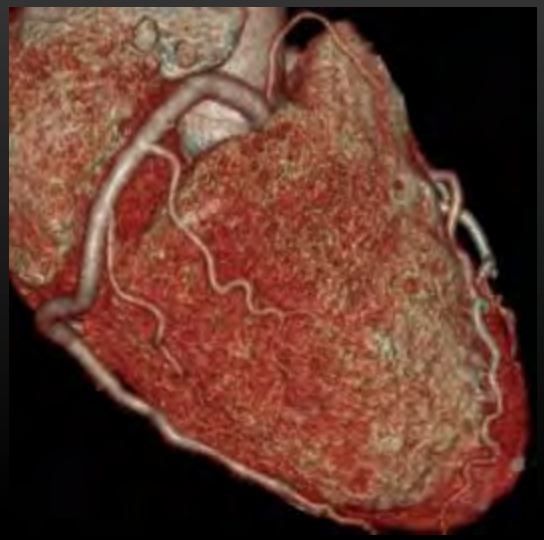
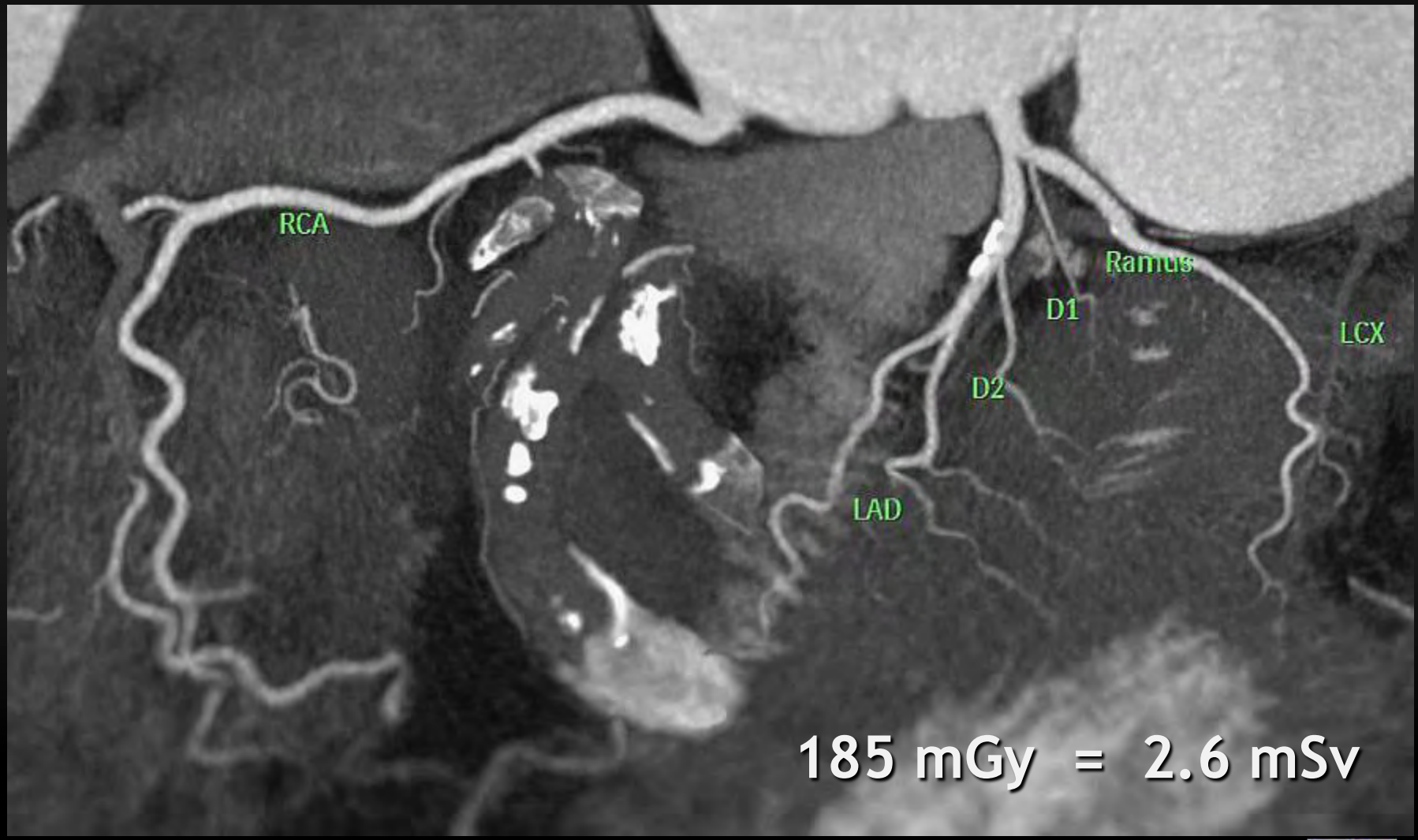
Step & Shoot Coronary CTA



2D Map & Dose



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Step & Shoot CT

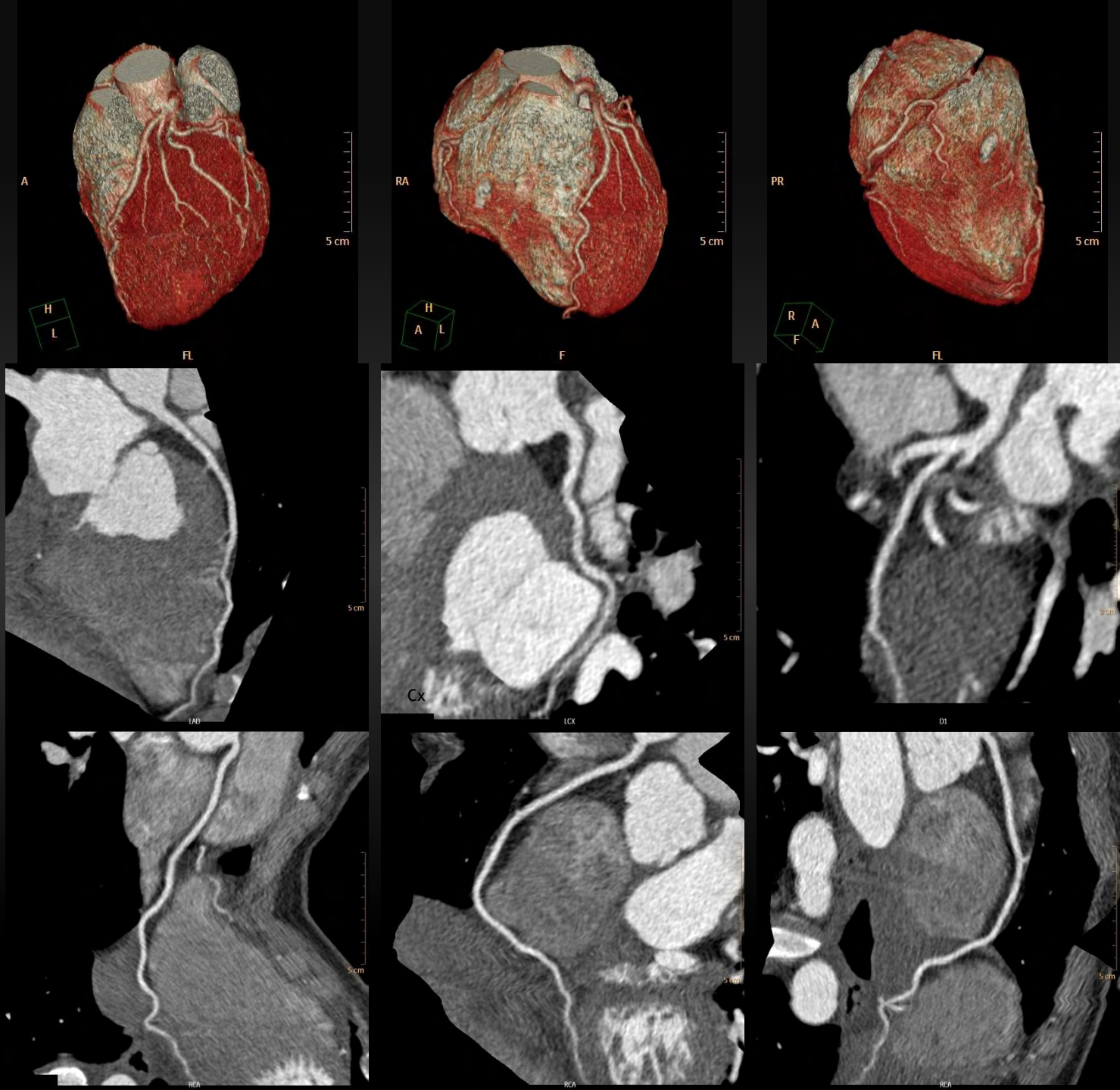
Low Radiation Dose

- 27 y.o. woman (60 kg) with acute episode of dyspnea
- Evaluation at outside hospital
  - CT scan & echo: cardiomyopathy; no pulmonary embolus
- Referred to coronary CTA

Step & Shoot
Cardiac CT
iCT

100 kV
200 mAs

1.4 mSv



Iterative Image Reconstruction

- First major update to image reconstruction method since inception of CT in 1970's
- Driven by desire to minimize radiation exposure
- Advanced reconstruction algorithm makes multiple "passes"
- Results in lower image noise
- Permits scanning with lower x-ray exposure while preserving image quality

How does iDose^4 work?

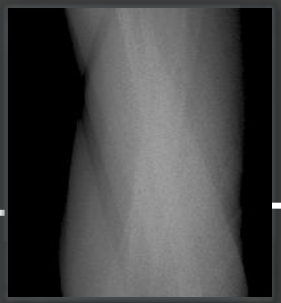
Projection space (raw data)

- Each projection examined for points likely caused by noisy measurements
- Iterative diffusion process wherein noisy data is penalized while edges are preserved
- Signal streaking & bias errors are prevented

Image space (pixels)

- Structural & data-dependent noise models used to iteratively eliminate quantum image noise while preserving underlying edges associated with the anatomic model
- Multi-frequency noise removal maintains noise power spectrum

Data variation analysis



Update projections

Noise Model

Model selection

N

Structured Model

Based on local anatomy

Multi-frequency model of *noise removal*

Optimized Model?

Y

Acquisition

(Noise Optimized) Images

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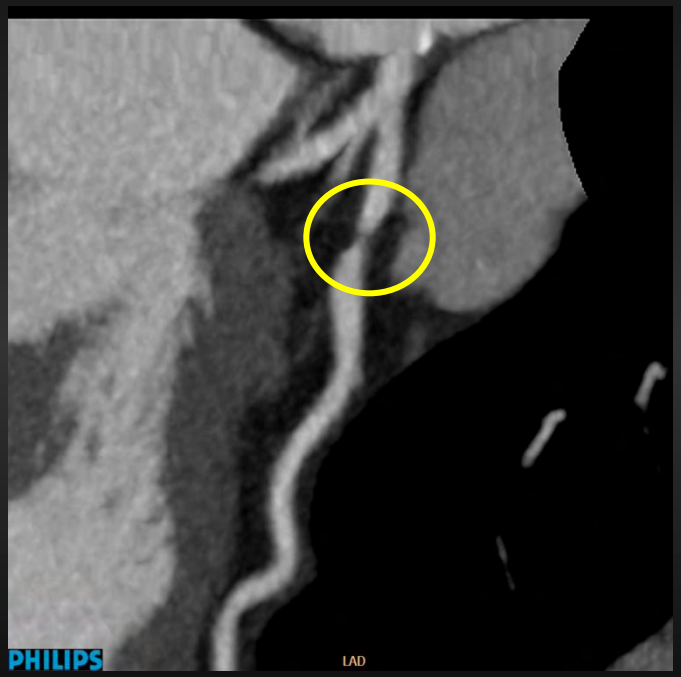
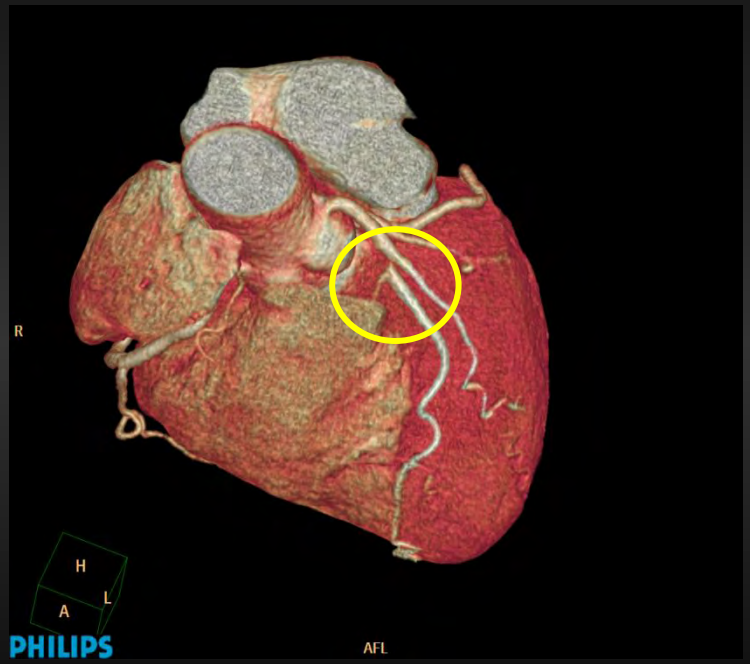
Low Dose Imaging on Brilliance iCT

Step & Shoot Cardiac using iDose^4





100 kVp, 150 mAs, 13.4 cm coverage
DLP: 95.2, estimated radiation dose: 1.3 mSv

Courtesy: Dr. Guy Weigold, Washington Hospital Center

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Blooming Artifact Reduction via iDose^4

Standard Reconstruction
Standard Kernel

Iterative Reconstruction Technique
Sharp Kernel

Courtesy Mani Vembar, PhD

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Additive Dose Sparing Technology

Minimize scan range

Lower tube voltage

Prospective, sequential scanning

Lower tube current + iterative reconstruction

Routine Cardiac CT with <1 mSv

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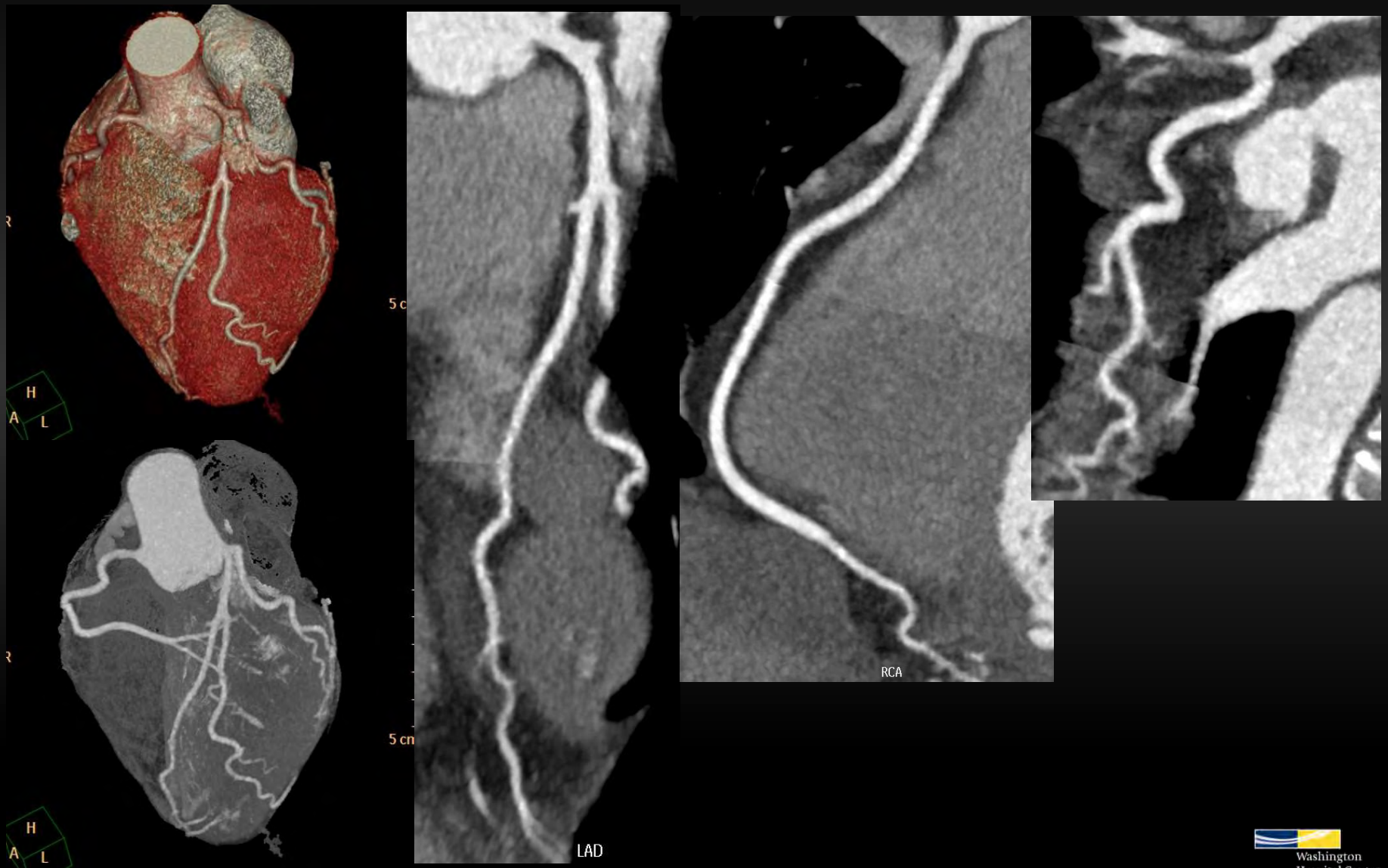
Cardiac CT using < 1 mSv



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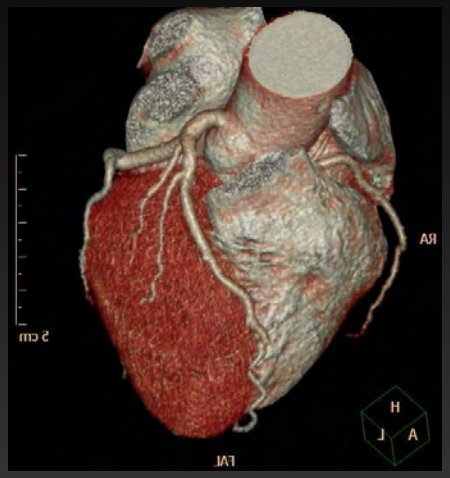
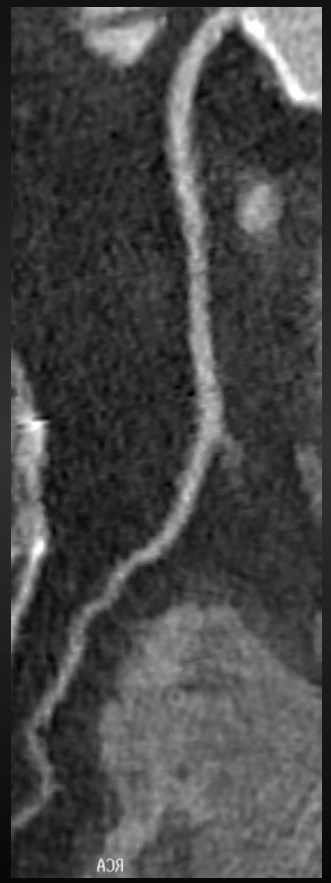
Cardiac CT using < 1 mSv





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Low Dose Imaging on Brilliance iCT

Step & Shoot Cardiac using iDose^4

100 kVp, 100 mAs, 10.9 cm coverage
DLP: 64, estimated radiation dose: 0.9 mSv

Courtesy: Seirei Yokohama Hospital, Japan

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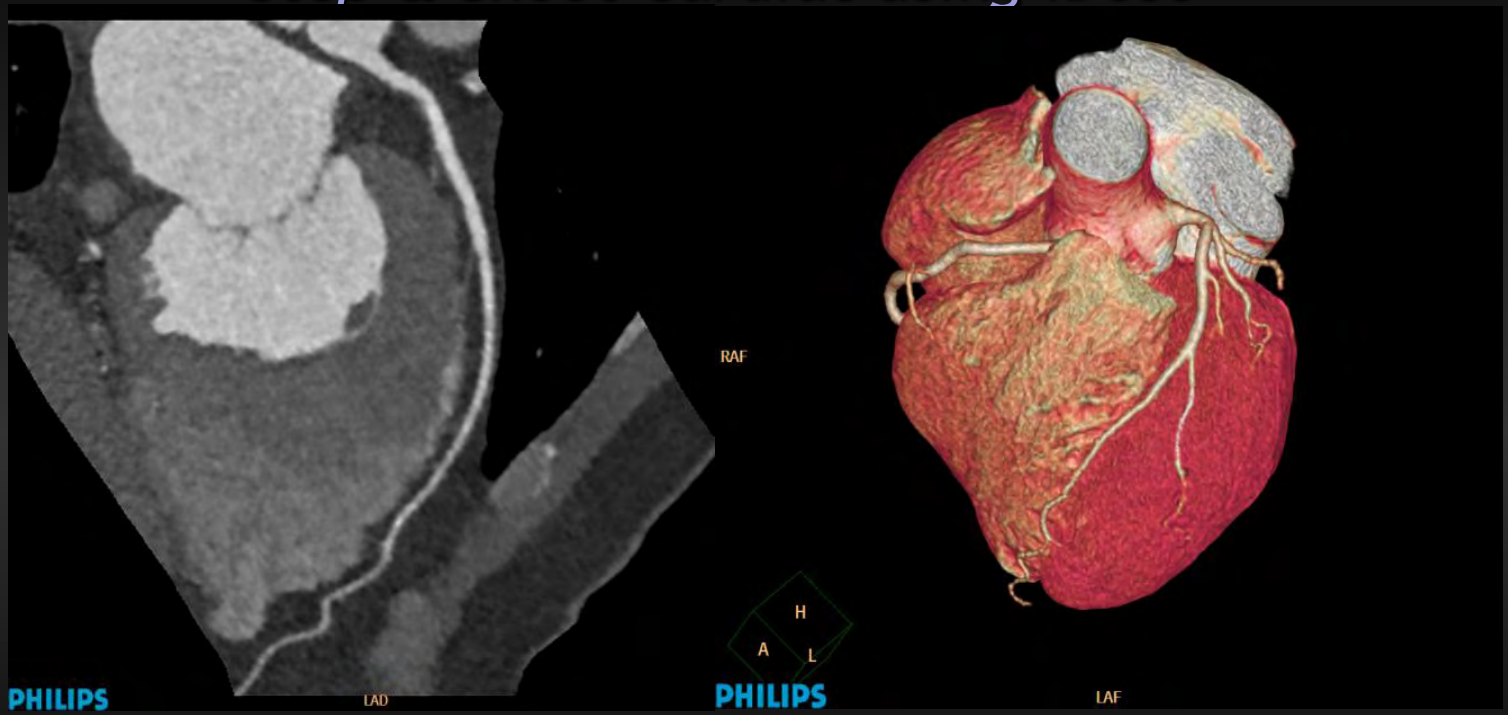
Low Dose Imaging on Brilliance iCT

Step & Shoot Cardiac using iDose^4



100 kVp, 75 mAs, 10.9 cm coverage
DLP: 40.9, estimated radiation dose: 0.5 mSv

Courtesy: Dr. Harvey Hecht Lenox Hill Hospital, New York

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Key Elements of High Speed, Low Dose Cardiac CT

1. Tube Power
2. Coverage
3. Gantry Speed

Essential Requirements for Reliable Prospective Scanning

4. Dose Sparing Hardware
5. Iterative Reconstruction

Additional Requirements for Further Dose Reduction

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IMPLICATIONS OF LOW DOSE CT

Scan Characteristics and Results

(n=235)

	%
S&S CTA	27
Helical CTA	5
S&S CS/CTA	56
Helical CS/CTA	9
Any S&S	85
Contrast (mL)	64
Exposure (mSv)	3.3
Exposure (mSv)	5.3
Adverse event	0 (n=0)

	%
None	55
Minimal	20
Mild	6
Non-Significant	81
Moderate /Borderline	5
Severe	4
Occluded	<0.5

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CT-STAT: Most patients don't have significant disease

- No significant stenosis: 297/361 (82%) pts
  - 262 (72.6%) discharged
  - No (0/297) ACS at 6 months f/u
- Severe stenosis : 27 (8%) pts
  - ICA in 24 → revasc in 13 (54%) (9 PCI, 4 CABG)
- Borderine stenosis : 23 (6%) pts
- CT uninterpretable : 14 (4%) cases
  - MPI in these 37

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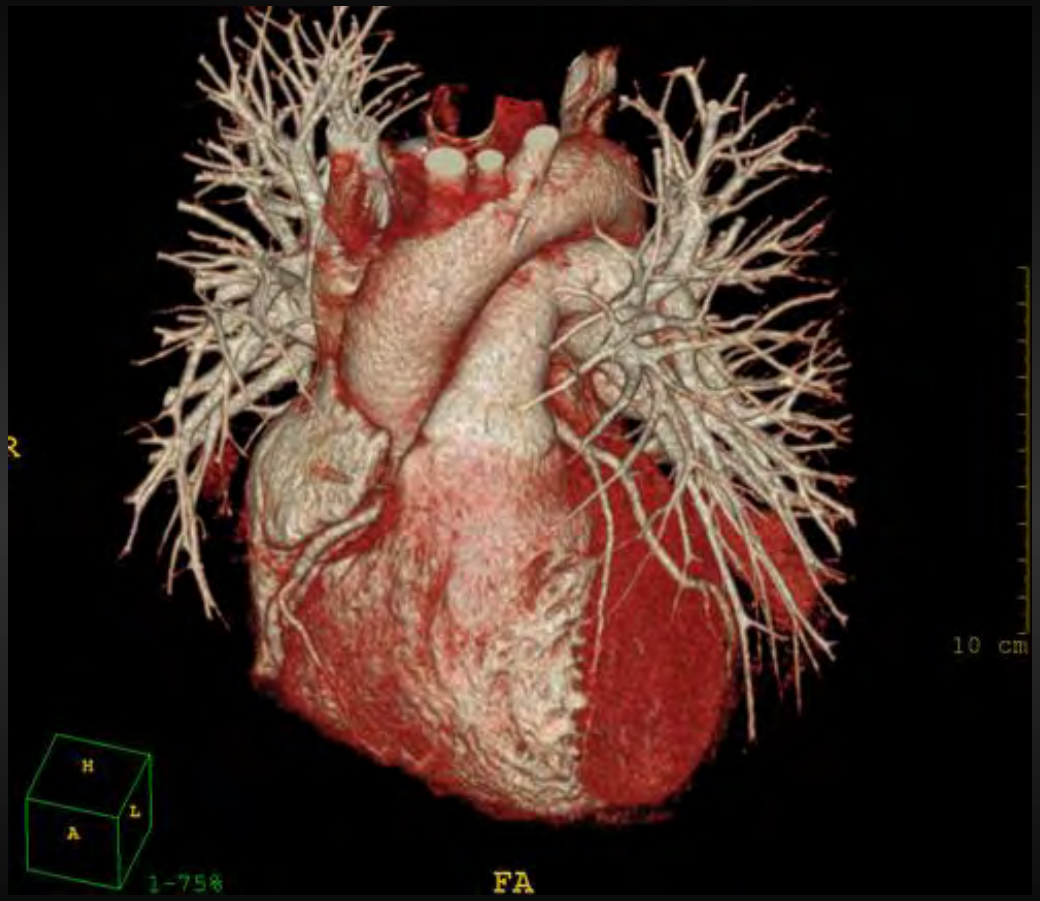
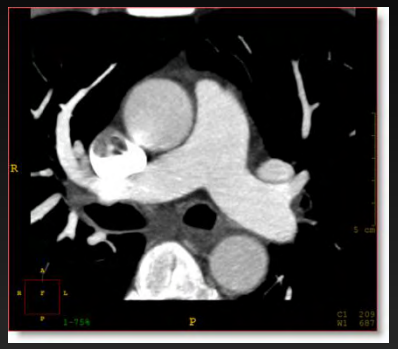
Future Application – Triple Rule Out





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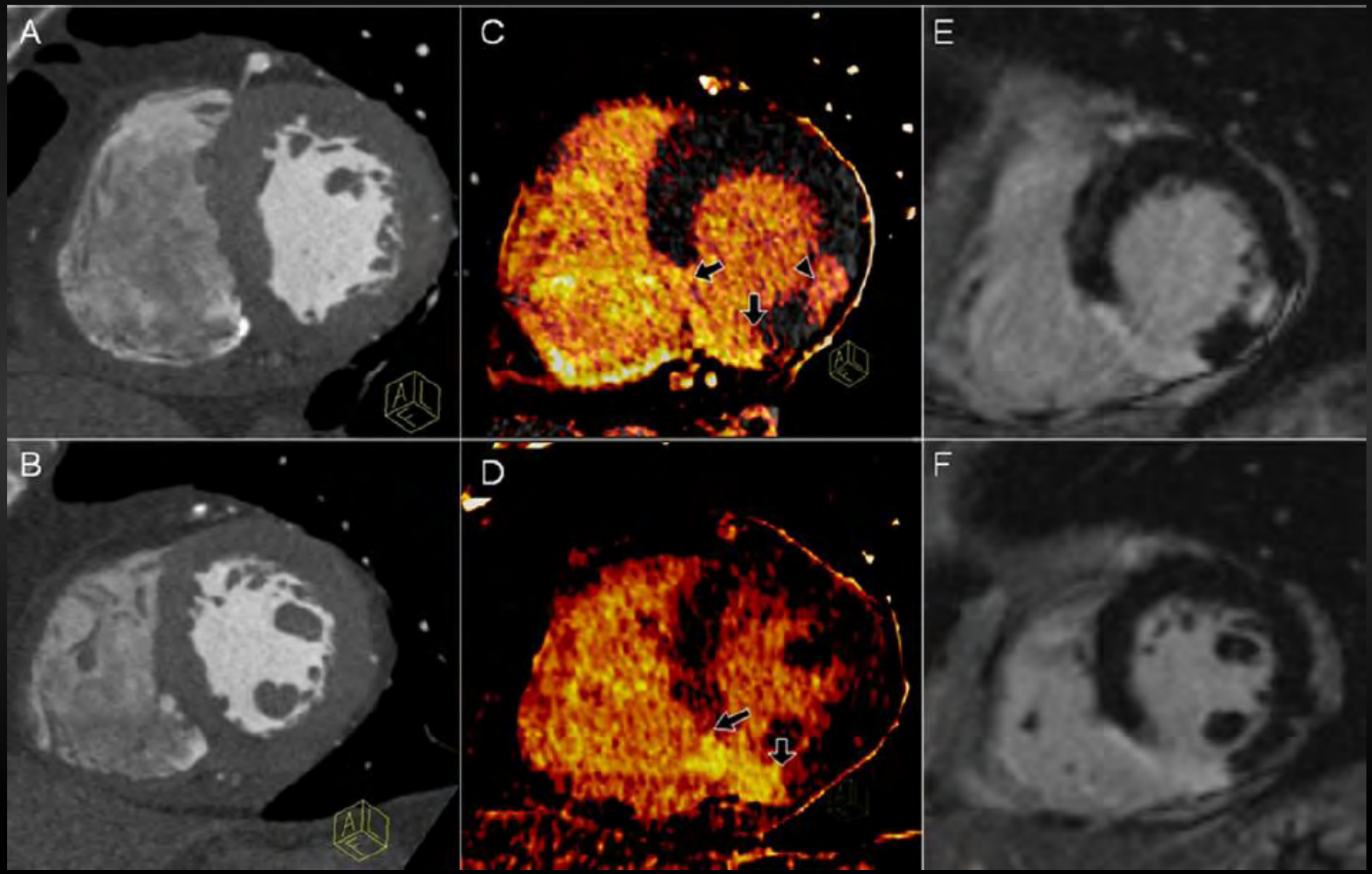
Future Application – Scar Imaging



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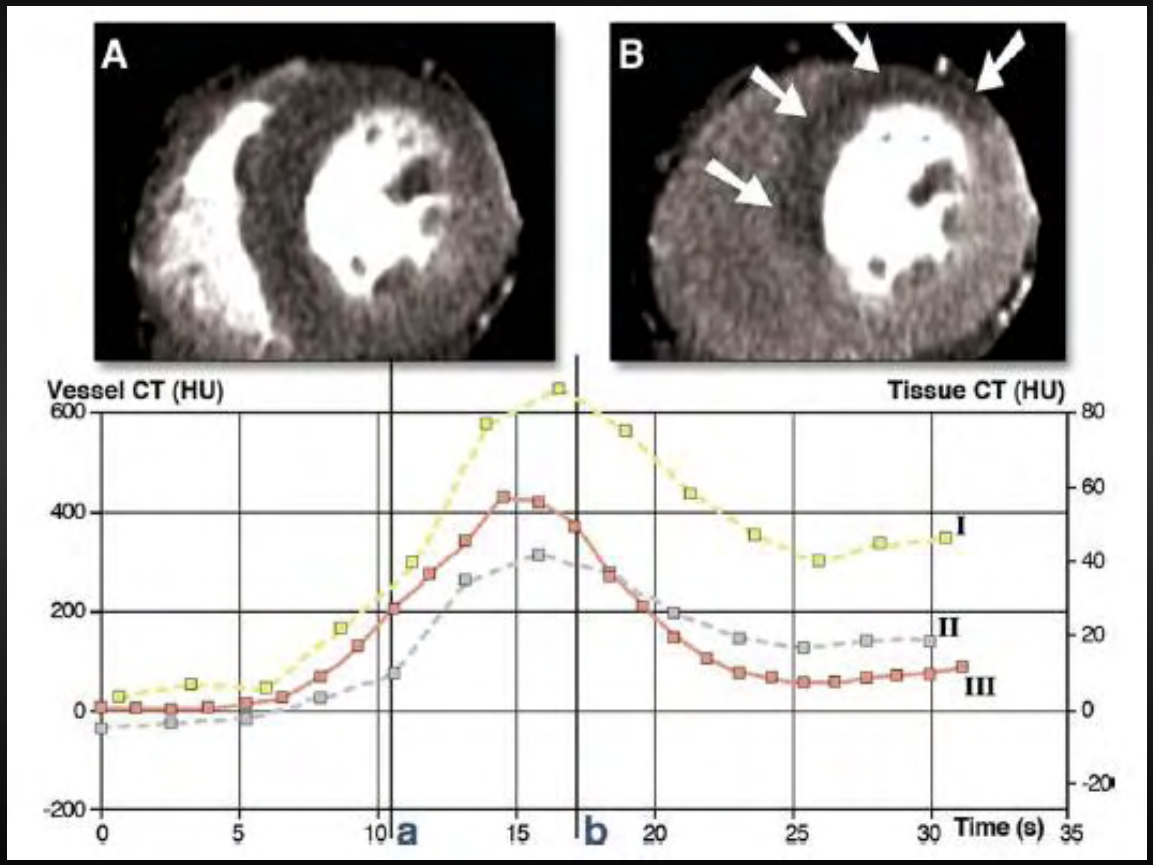
Future Application – Dynamic Perfusion Imaging



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Flexibility Will Be Key

- With new applications & increasing role of CT, becomes even more important for scanners to be ***flexible*** in order to handle ALL clinical scenarios:
  - Not just manage high heart rates for coronary imaging, but also wide coverage for triple rule out and whole heart imaging
  - Not just wide coverage but also high speed
  - High tube power for best step and shoot and obese pts