Cardiac CT

Optimal Use of Evolving Scanner Technologies

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Disclosures

- Medical Advisory Board Member
  - Partners Imaging
- Consultant / Editing / Authoring (honoraria):
  - Perceptive Informatics
  - Amirsys, Inc.
- Research Funding
  - Bracco
  - BD

Contrast not FDA approved for coronary CTA or MRA

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Radiation Dose in Cardiac CT depends on

- Patient selection
  - Appropriate indications
- Patient preparation
  - Betablockers, breast displacement, positioning
- Acquisition mode selection
- Tube potential selection
- Tube current selection/modulation

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Tube Potential Selection

100 kV → 53% dose reduction (preserved image quality, thin patients)
Bischoff, et al. JACC Cardiovasc Imaging. 2009.

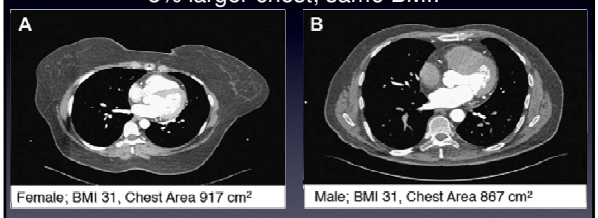
Recommendation

A tube potential of 100 kV could be considered for patients weighing ≤90 kg or with a BMI ≤ 30 kg/m^2; a tube potential of 120 kV is usually indicated for patients weighing >90 kg and with a BMI > 30 kg/m^2. Higher tube potential may be indicated for severely obese patients.

SCCT guidelines on radiation dose and dose-optimization strategies in cardiovascular CT.
Halliburton, Abbara, Chen, Gentry, Mahadevappa, Raff, Shaw, Hausleiter. JCCT. 2011; 5(4):198-224.

BMI ≠ Chest Size

8% larger chest; same BMI:



Ghoshhajra, et al. JCCT. 2011.

BMI ≠ Chest Size

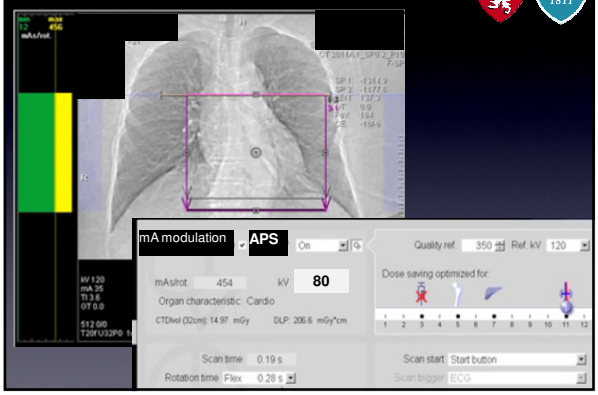
BMI

Chest Area	Underweight <18.5 kg/m²	Normal 18.5-24.99 kg/m²	Overweight 24.99-29.99 kg/m²	Obese ≥30.0 kg/m²
Large ≥842.9 cm²	0	0	15	43
Medium 712.9-842.6cm²	0	16	40	7
Small 543.8-712.6cm²	1	26	22	1
Very small <543.8 cm²	2	9	0	0

- 17.6% (32/182) potentially underdosed (BMI < corresponding chest area)
- 61.0% (111/182) concordant classes (BMI = corresponding chest area)
- 21.4% (39/182) potentially overdosed (BMI > corresponding chest area)

Ghoshhajra, et al. JCCT. 2011.

Automatic tube Potential Selection

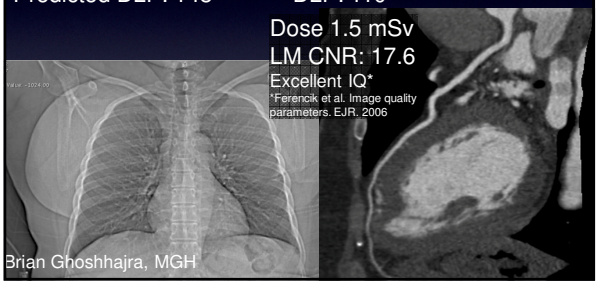


Mode: Prospective (axial-sequential)
5'5", 192 lbs: BMI 34.5

Default:
kV: 120 mAs: 292
Predicted DLP: 148

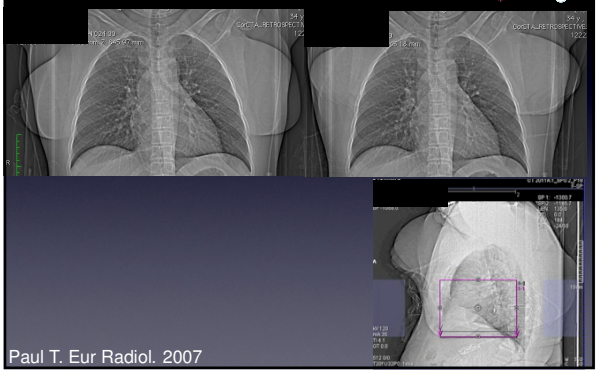
APS on:
kV: 100 mAs: 253
DLP: 110

Dose 1.5 mSv
LM CNR: 17.6
Excellent IQ*
*Ferencik et al. Image quality parameters. EJR. 2006



Brian Ghoshhajra, MGH

Some of the "BMI" can move!



Paul T. Eur Radiol. 2007

Cardiac CT – Unique Technical Aspects

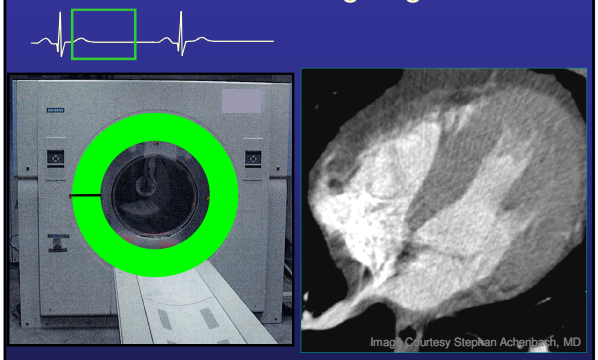
Data reconstruction

- Halve scan algorithm
- Multi segment algorithm

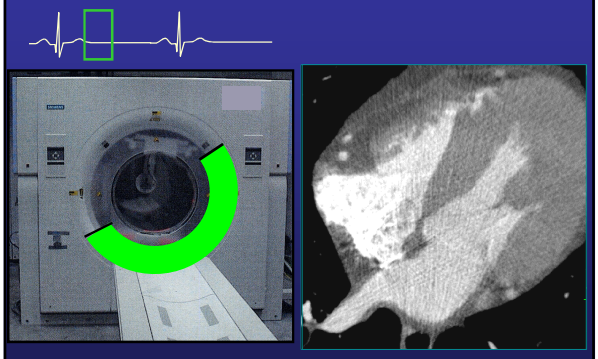
Cardiac Synchronization

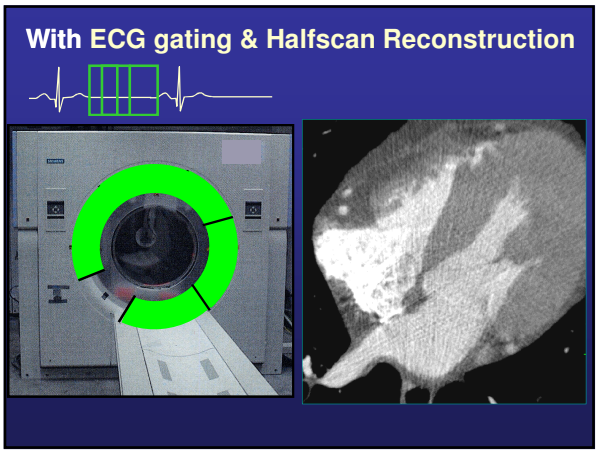
- Prospective triggering
- Retrospective gating

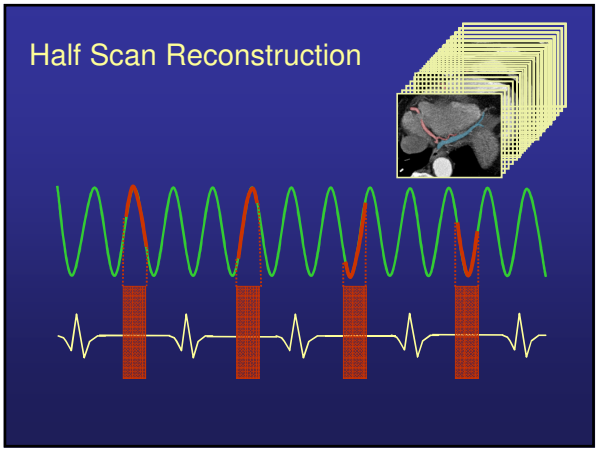
Without ECG gating

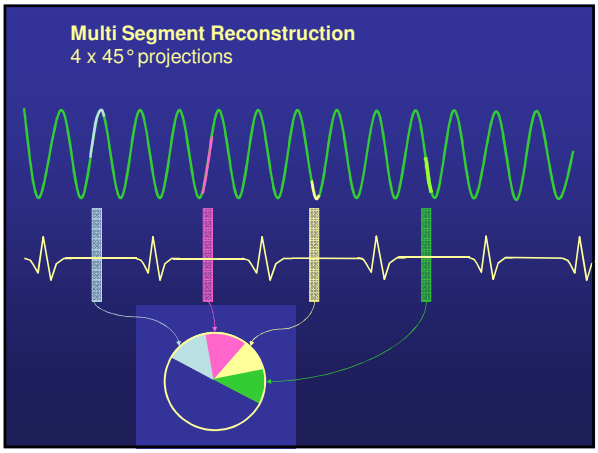


With ECG gating & Halfscan Reconstruction




With ECG gating & Halfscan Reconstruction


Half Scan Reconstruction


Multi Segment Reconstruction
4 x 45° projections

Acquisition Algorithms

- Prospective Triggering
  - Axial, stop and shoot
  - 'Padding', 'Adaptive', etc.
- Retrospective Gating
  - Helical, Tube Modulation
- Prospectively Triggered Helical Acquisition
  - High Pitch mode, requires DSCT

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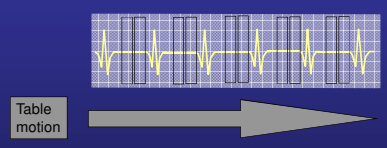
Retrospective Gating

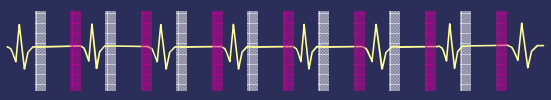


Higher radiation dose!

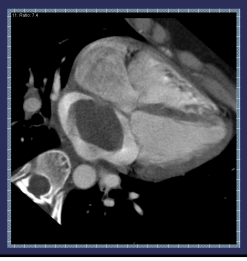
Allows multiple time points in R-R interval

Allows ECG editing

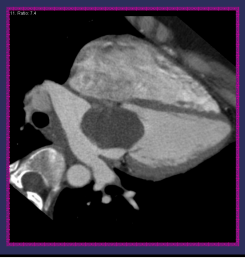
Retrospective gated MDCT



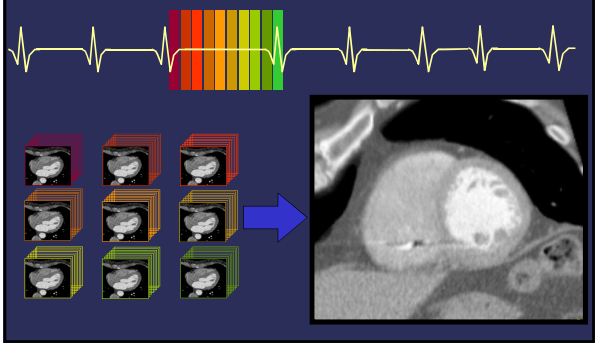
SYSTOLE



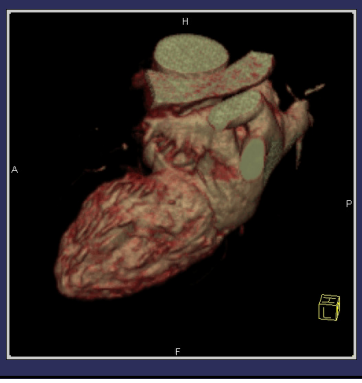
DIASTOLE



Multiple cardiac phases in one spatial location → cine images



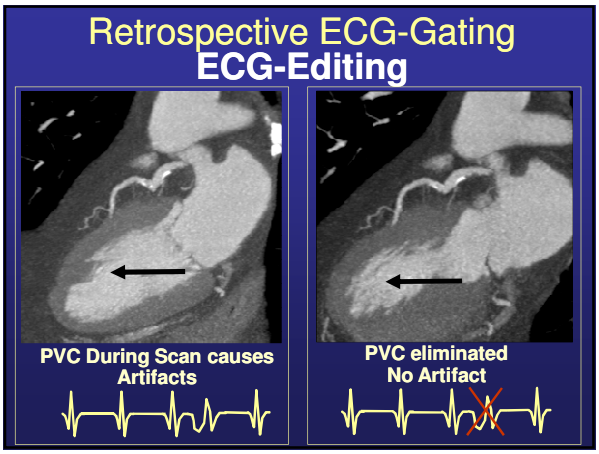
4D CT Ventriculogram



Dyskinesia in LAD Territory → acute MI

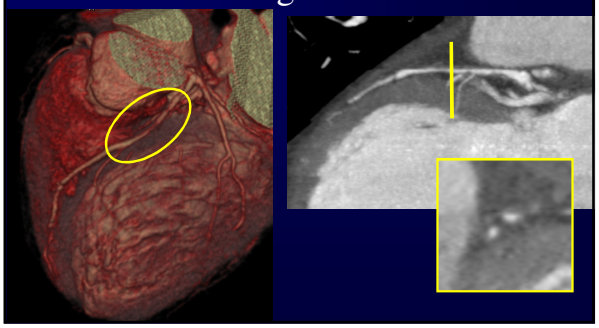
Abbara S, Soni AV, Cury RC. Evaluation of cardiac function and valves by multidetector row computed tomography. Semin Roentgenol. 2008 Apr;43(2):145-53

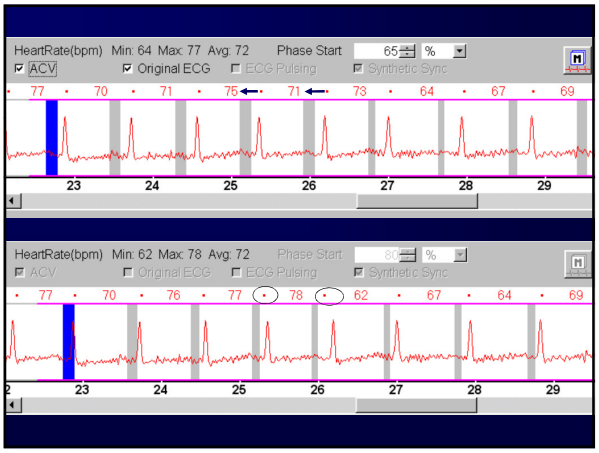
Retrospective ECG-Gating
ECG-Editing

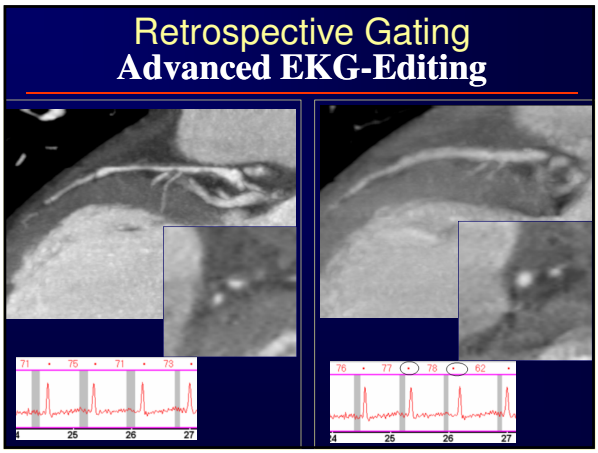


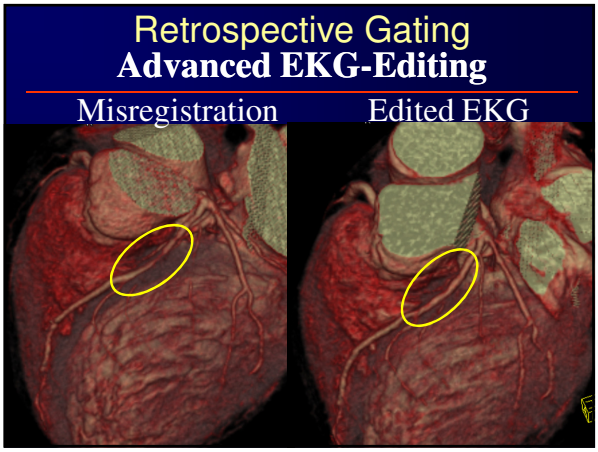
Retrospective Gating
Advanced EKG-Editing

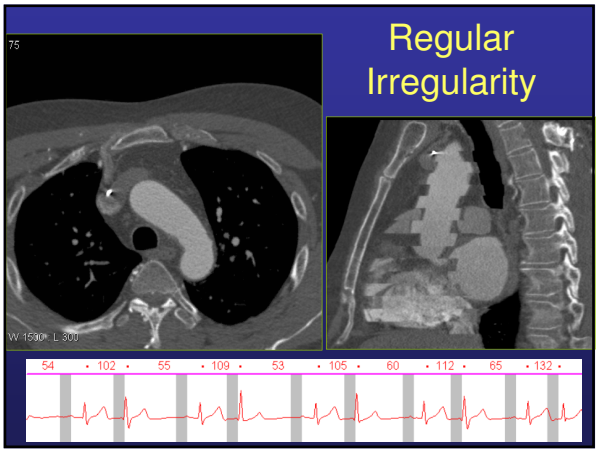
Misregistration

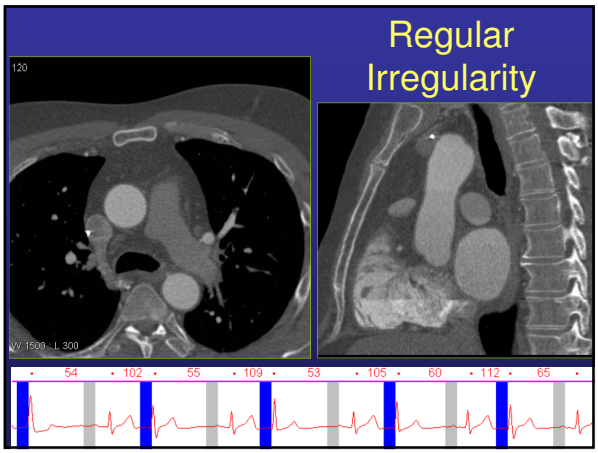


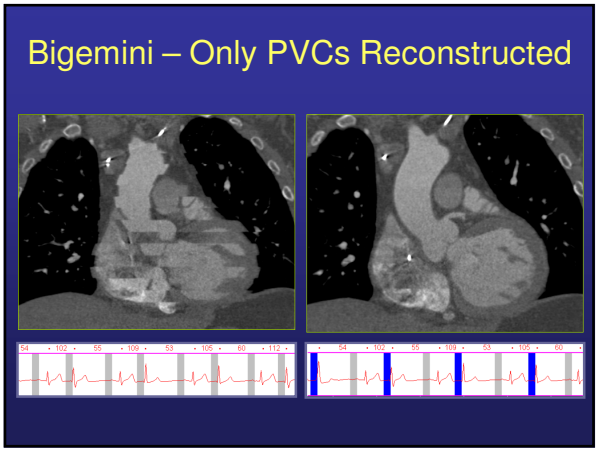


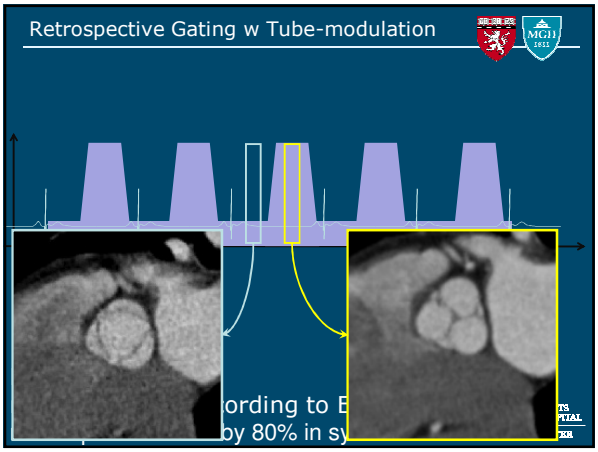

Retrospective Gating
Advanced EKG-Editing
71 75 71 73
25 26 27
76 77 78 62
25 26 27

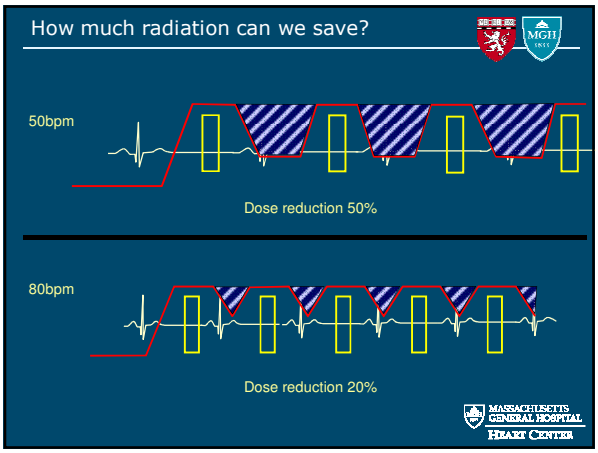

Retrospective Gating
Advanced EKG-Editing
Misregistration
Edited EKG


Regular
Irregularity
75
W 1500 L 300
54 102 55 109 53 105 60 112 65 132


Regular
Irregularity
120
W 1500 · L 300
54
102
55
109
53
105
60
112
65


Bigemini – Only PVCs Reconstructed


Retrospective Gating w Tube-modulation
ordering to E
by 80% in sy


How much radiation can we save?
50bpm
Dose reduction 50%
80bpm
Dose reduction 20%
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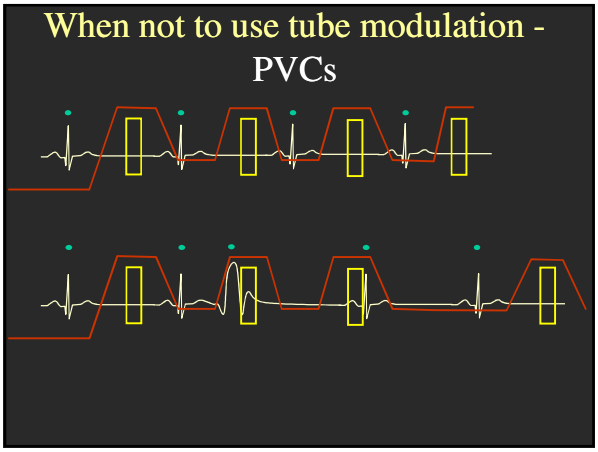
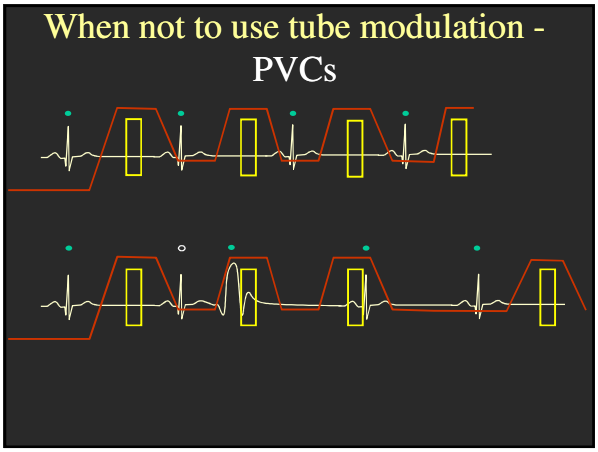
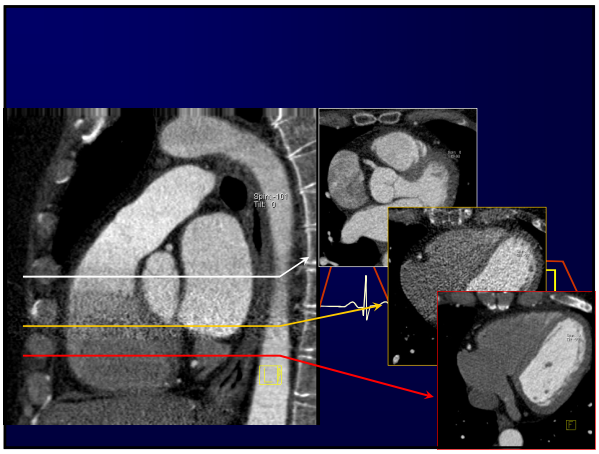
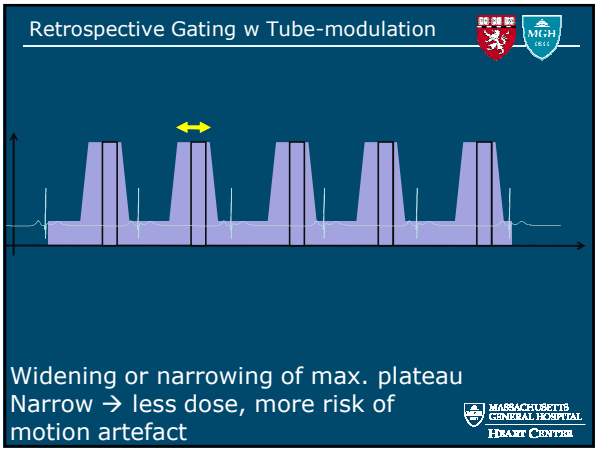

When not to use tube modulation - PVCs


When not to use tube modulation - PVCs




Retrospective Gating w Tube-modulation
Widening or narrowing of max. plateau
Narrow → less dose, more risk of motion artefact
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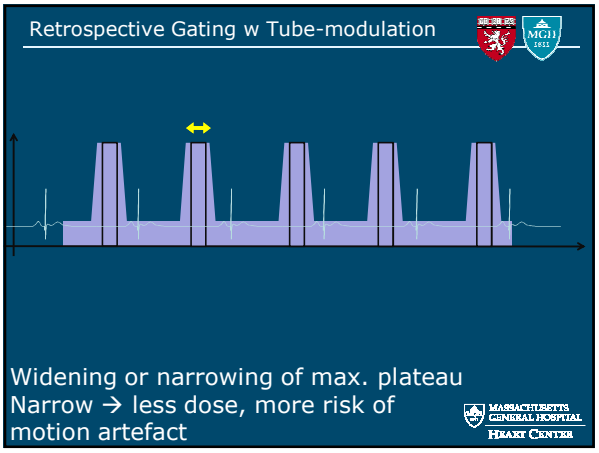
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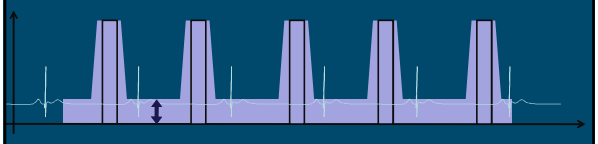
Retrospective Gating w Tube-modulation



Lowering of systolic tube output
Systolic reconstructions very noisy
May not get sufficient functional data

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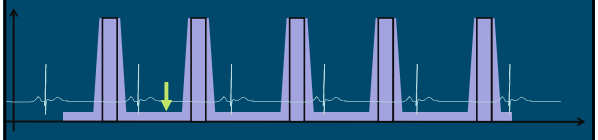
Retrospective Gating w Tube-modulation

Tube Current reduction in systole by ~96%



Lowering of systolic tube output
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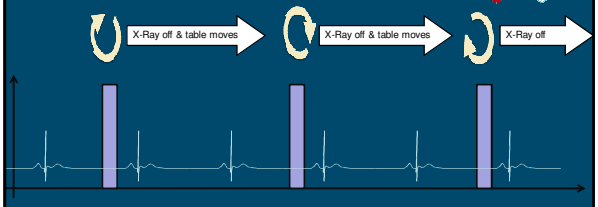
Prospective Triggering – Axial Sequential



Minimal dose
High risk for motion artifact

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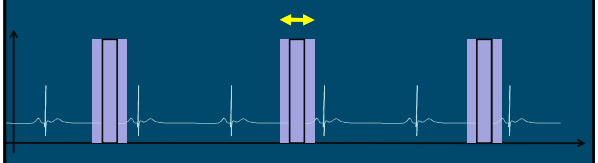
Prospective Triggering – Axial Sequential



Symmetric "padding"
Higher dose
Reduced risk for motion artifact

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Prospective Triggering – Axial Sequential

"Smart" algorythm senses premature beats and skips acquisitions
Reduces risk for motion artifact

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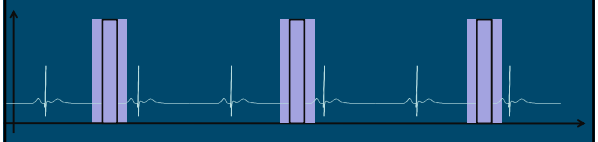
Prospective Triggering – Axial Sequential



Symmetric "padding"
Higher dose
Reduced risk for motion artifact

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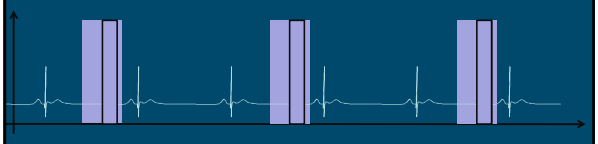
Prospective Triggering – Axial Sequential



User defined "padding"
Higher dose
Reduced risk for motion artifact

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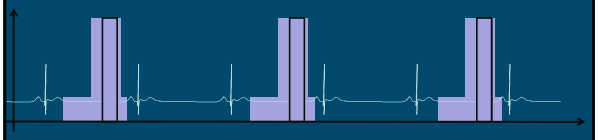
Prospective Triggering – Axial Sequential

Variable tube output Triggering



User defined "padding" at full dose
PLUS user defined low dose acquisition
May allow function
Reduced risk for motion artifact

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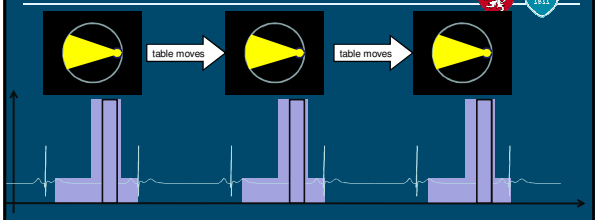
Prospective Triggering – Axial Sequential



User defined plateau at full dose
& user defined low dose acquisition
May allow function
Reduced risk for motion artifact

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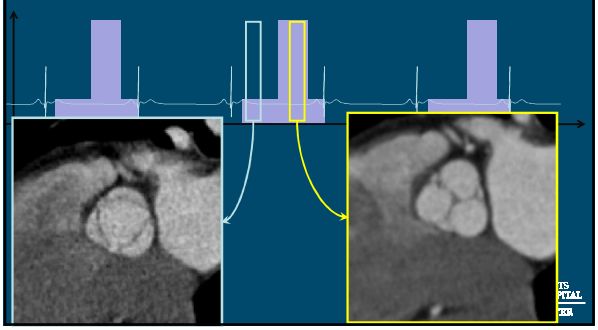
Prospective Triggering – Axial Sequential



High Pitch Mode

Pitch > **3** on Dual Source CT system

Second tube offset by 90° ('fills gap'), therefore image reconstruction is possible

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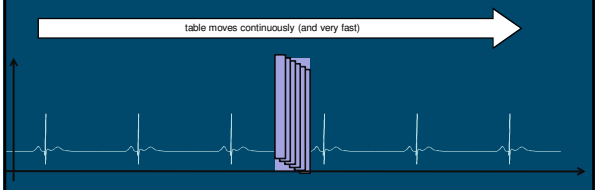
Prospective Triggered Helical Acquisition



Minimal dose
Excellent temporal resolution
Risk for motion artifact

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Types of iterative reconstructions

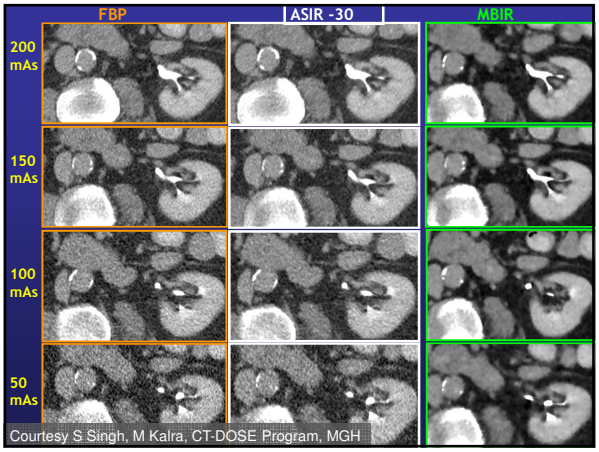
Available Today:

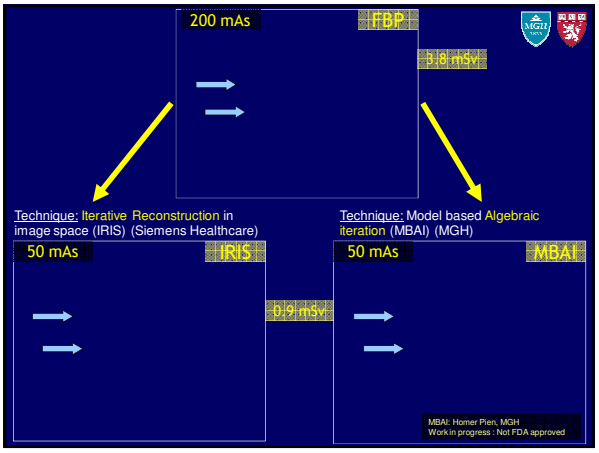
- ASIR Adaptive Statistical Iterative Reconstruction (GE)
- IRIS Iterative Reconstruction in Image Space (Siemens)
- iDose (Philips)
- AIDR Adaptive Iterative dose reduction (Toshiba)

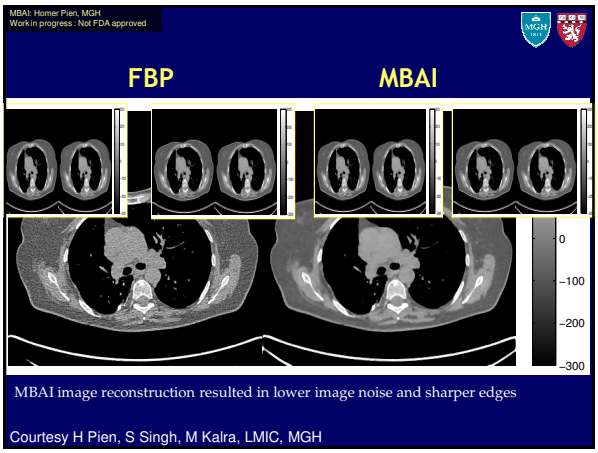
Work in progress

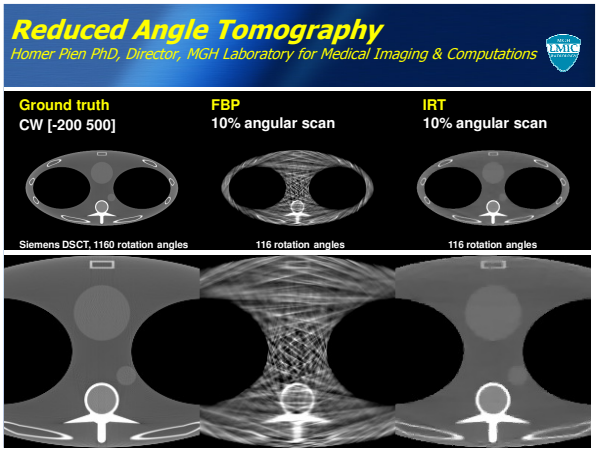
- MBIR Model Based Iterative Reconstruction (GE)
- MBAI Model Based Algebraic Iteration (© HH Pien, Mass General)
- SAFIRE Sinogram affirmed iterative reconstruction (Siemens)

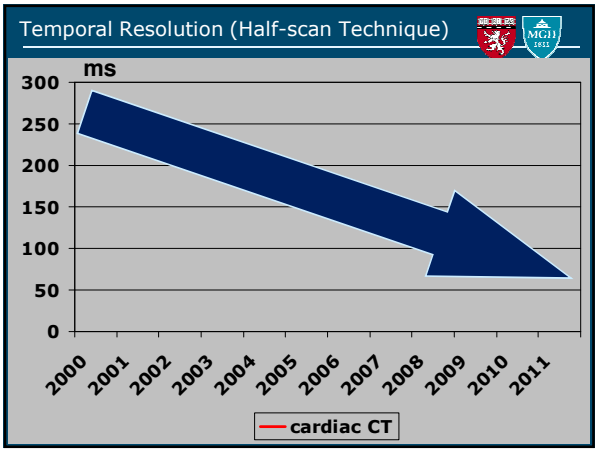
Courtesy S Singh, M Kalra, CT-DOSE Program, MGH

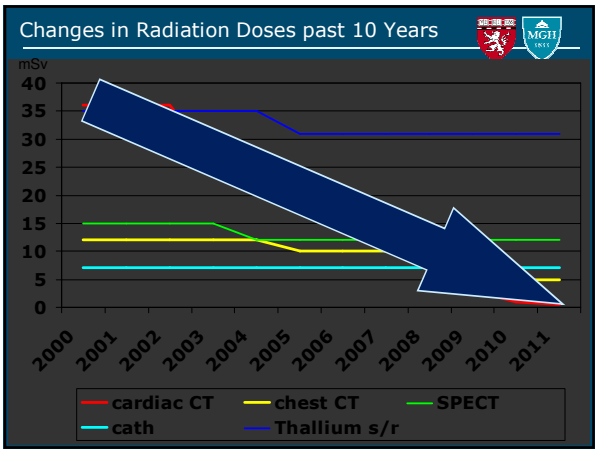


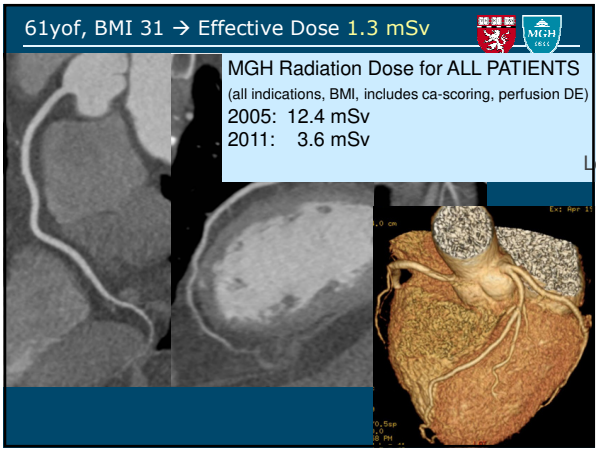



MBAI: Homer Pien, MGH
Work in progress : Not FDA approved
FBP
MBAI
0
−100
−200
−300
MBAI image reconstruction resulted in lower image noise and sharper edges
Courtesy H Pien, S Singh, M Kalra, LMIC, MGH


Reduced Angle Tomography
Homer Pien PhD, Director, MGH Laboratory for Medical Imaging & Computations
Ground truth
CW [-200 500]
FBP
10% angular scan
IRT
10% angular scan
Siemens DSCT, 1160 rotation angles
116 rotation angles
116 rotation angles


Temporal Resolution (Half-scan Technique)
ms
300
250
200
150
100
50
0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
cardiac CT





Thank you!

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