Content
(I) Dose Reduction and Dose Optimization Technologies
• Dose Right and Tube Current Modulation (Dose Right, Z-DOM, 3D-DOM)
• Special Acquisition Modes (Cardiac Dose Right, Prospective gating)
• Beam Filtration and Beam Shapers
• Eclipse Collimator and Clear Ray Collimator
• NanoPanel Elite Detector
• NEMA XR-25
  — Dose check
  — Dose structured reporting

(II) Advanced Reconstruction Technology
• iDose 4
• IMR (Iterative Model)

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Dose Right and Tube Current Modulation

Dose Right Index - Consistent IQ for Different Patient Size
Dose Right Index + Current Modulation - Consistent IQ for Different Patients and at Different Z-Locations

Dose Right Index – Definition (by Reference)

DRI=24
200 mAs @120 kV @ average patient size (29 cm)

Dose Right – How Does it Work

Exponential Adaptation to Patient size

Increase and Decrease in DRI (Dose Right Index) - Adults

<table>
<thead>
<tr>
<th>DRI</th>
<th>25cm</th>
<th>29cm</th>
<th>31cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>112</td>
<td>120</td>
<td>128</td>
</tr>
<tr>
<td>6+100mAs</td>
<td>102</td>
<td>114</td>
<td>126</td>
</tr>
<tr>
<td>6+200mAs</td>
<td>92</td>
<td>106</td>
<td>122</td>
</tr>
<tr>
<td>6+300mAs</td>
<td>82</td>
<td>95</td>
<td>112</td>
</tr>
<tr>
<td>1</td>
<td>142</td>
<td>150</td>
<td>160</td>
</tr>
<tr>
<td>1+100mAs</td>
<td>132</td>
<td>144</td>
<td>156</td>
</tr>
<tr>
<td>1+200mAs</td>
<td>122</td>
<td>134</td>
<td>146</td>
</tr>
<tr>
<td>1+300mAs</td>
<td>112</td>
<td>124</td>
<td>136</td>
</tr>
</tbody>
</table>

0
20
40
60
80
100

Current x Time [mAs]

0
10
20
30
40
50

Average Size [cm]
Z-Dose Modulation (Z-DOM)
Consistent IQ Along Patient Liver Detection Head Detection

3D-Dose Modulation (3D-DOM)
Reduction of Streak Artifacts Improve Noise Uniformity

3D-Dose Modulation vs. Z-DOM
- Reduction of Streak Artifacts
- Improve Noise Uniformity
Automatic Pitch/Rotation Time Algorithm

Basic equations:

\[ \text{scan time} = \frac{\text{scan length}}{\text{bed speed}} \]

\[ \text{bed speed} = \text{pitch} \times \text{collimation rotation time} \]

\[ mAs = \frac{mAs \times \text{rotation time}}{\text{pitch}} \]

Special Modulation Modes - Cardiac

Heart Cycle – The Heart is in Constant Motion

General motion profile:

- Relaxation: Heart is filled with blood
- Contraction: Heart 'pushes' blood to the body/Lungs

“Quiet phases”: Phases with relatively less motion

- End systolic ("40%")
- End diastolic ("75%"): Relaxation ⇒ Contraction

Cardiac Cycles

Reconstructing at Different Phases – ECG Gated
Special Modulation Modes
Cardiac Retrospective

- ECG triggered dose modulation in Helical/Spiral scans

Special Modulation Modes
Cardiac DoseRight - Prospective

- 20%

Special Modulation Modes
Cardiac Step and Shoot – Prospective Gating

- Low dose (3-5 mSv) diagnostic scan
  - Dose reduction up to 80% compared to standard retrospectively-gated spiral scans
  - Image quality comparable to that of standard retrospectively-gated spiral scans

- 3D axial cone beam reconstruction algorithm
- Real-time arrhythmia handling algorithms

Special Modulation Modes
Dose Reduction from ECG Dose Modulation – Dependency on HR

- Compared to ECG-gated spiral scans without dose modulation

Beam Filtration and Beam Shapers

**InteliBeam Filters**
**SmartShape Wedge (Bowtie) Filters**

- Filtration is optimized to increase low contrast and reduce skin dose and is done per protocol.

<table>
<thead>
<tr>
<th>Default scan protocol</th>
<th>Top position</th>
<th>HVL (mm Al equiv)</th>
<th>Wedge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult Head and Body</td>
<td>Full</td>
<td>8.7</td>
<td>Large</td>
</tr>
<tr>
<td>Cardiac</td>
<td>Full</td>
<td>8.7</td>
<td>Medium</td>
</tr>
<tr>
<td>Inlet</td>
<td>Half</td>
<td>7.4</td>
<td>Small</td>
</tr>
<tr>
<td>Thorax</td>
<td>Off-center</td>
<td>7.8</td>
<td>Open</td>
</tr>
</tbody>
</table>

Eclipse Collimator and Clear Ray Collimator

**Helical Dynamic Collimation to Reduce Over-Scanning**


Eclipse Collimator and Clear Ray Collimator

**2D Anti-Scatter Grid**
Clear Ray Scatter and Beam Hardening Correction

- Monte Carlo based scatter estimation
- Analytical Beam Hardening Correction
- Scatter correction is proportional to patient size

NanoPanel Elite New Tile Detector

Scintillator
- IGOS (Gd₂O₂S) High Quality Ceramic Scintillator
- Fast Response
- High Light Output
- Low Cross-Talk

PDA (Photo Diode Array)
- Back illuminated using thin and high purity silicon
- High Quantum efficiency.
- High Shunt Resistance
- Low Cross-talk

ASIC
- Very Low Noise
- Improved linearity over all the dynamic range
- Front End Electronics with 256 Channels

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iDose $^4$ - Advanced Reconstruction

iDose uses the raw data output from the NanoPanel detector to determine and remove noise while keeping structure intact.

*How it works*

Iterative reconstruction technique: How does it work?

iDose uses the raw data output from the NanoPanel detector to determine and remove noise while keeping structure intact.

**iDose $^4$ - Mode of Operation**

**Noise Reduction**

- Reduce noise according to iDose Level selection
- For each protocol the achievable iDose Level were determined
- No degradation in Resolution and Low Contrast (Tolerance: 10% in MTF10% and 1mm in Low Contrast)

**IQ Improvements**

- Keep the Dose Level the same and improve spatial resolution and Low Contrast

**Hardware Enabler**

- RapidView IR, Next Generation Intel Multi-Core Processors
- Up to 20 Images/sec

Comparison Full Dose / 50% Dose Reduction + iDose

Follow up with 50% Dose Reduction

<table>
<thead>
<tr>
<th>Dose Level</th>
<th>Compensating increase in noise reduction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12 %</td>
</tr>
<tr>
<td>2</td>
<td>16 %</td>
</tr>
<tr>
<td>3</td>
<td>20 %</td>
</tr>
<tr>
<td>4</td>
<td>24 %</td>
</tr>
<tr>
<td>5</td>
<td>28 %</td>
</tr>
<tr>
<td>6</td>
<td>32 %</td>
</tr>
<tr>
<td>7</td>
<td>36 %</td>
</tr>
</tbody>
</table>

PHILIPS

Courtesy TU Munich, Germany
Comparison Full Dose / 70% Dose Reduction + iDose

120 kV, 100 mAs (6.6 mGy) / 80 kV, 100 mAs (1.9 mGy) 70% Dose Reduction

Full Dose (6.6mGy) - FBP

70% Dose Reduction (1.9mGy) - iDose

Courtesy TU Munich, Germany

Improving Image Quality: Artifact Reduction

120kV, 700mAs, 6.4mGy, Prospective Gated Aortic CTA (Step & Shoot Complete)

FBP

iDose

Courtesy Cleveland Clinic, USA

Improving image quality in inherently noisy acquisitions

120kV, 280 mAs, 22.9mGy, Prospective Gated Cardiac CTA (Step & Shoot Cardiac)

FBP

iDose

Courtesy OHSU, USA
Knowledge-Based Iterative Reconstruction Technique

What makes this possible
- Fast and compact next-gen computing devices using GPU (under 3min for most protocols)

Integrated Workflow
- User has flexibility as to the final result.

Performance Evaluation

Low Contrast Detectability
- A measure of a person's ability to perform a particular task. The determination of a Low Contrast object
  - Influenced by all Physics IQ metrics (Noise, Resolution, Uniformity and CT number)
  - A statistical approach is needed
  - Human observer study, 4 Alternative Forced Choice (4AFC) Study was used
**Improve low-contrast detectability**

Revealing subtle differences

2.5 - 3.6x

Low-contrast Detectability Index

Low-contrast detectability was assessed using 4 AFC test on a reference abdomen phantom on the MITA CT IQ phantom. Data on file.

**High resolution Imaging**

Revealing fine detail

Standard Resolution MTF Measurements

FBP (Std Filter)  IMR (High-res setting)

GGO visualized on Chest CT with IMR

80 kVp, 10 mA/s, 0.2 mGy, 0.11 mSv

Chest X-ray 0.05 mSv
Standard Reconstruction
120 kVp, 300 mAs, 14.3 mGy, 1.8 mSv, < 2 min recon time

71 year old man with hemorrhagic lesions not seen on FBP

Non-calcified plaque visualization

Mixed plaque in LM / LAD in severe obese female: 130kg, 170cm, BMI 45
Step & Shoot scan!
Max tube settings 120kV, 300mAs

Courtesy: UCL, Belgium
Excessive noise hinders segmentation.

Pre-TAVI assessment
Entire ECG Gated Aorta with ONLY 40cc's of IV contrast
20cc @2cc/s + 20cc @ 1cc/s

Semmelweis Univ. Budapest

Video: Maimonides Medical Center
https://www.youtube.com/watch?v=X1u0Iu0bu0

TAVI scan with only 40cc of contrast
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