



# *AAPM Computed Tomography Automatic Exposure Control Education Slides*

Many of the terms used in these slides can be found in the CT  
Terminology Lexicon

<http://www.aapm.org/pubs/CTProtocols/documents/CTTerminologyLexicon.pdf>

*Last Updated 2021-12-06*



## Disclaimer

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- Screen captures are **examples** of a common (or latest) software version only and all software versions are not represented
- The information contained herein is current as of the date shown on the title slide
- The master version of these slides is located at:
  - <https://www.aapm.org/pubs/CTProtocols/documents/GeneralAECEducationSlides.pdf>
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## *Vendor Specific Slide Details*

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- The presence of a vendor name in the title of the slide indicates that the slide is vendor specific slide
- White text is used throughout to indicate vendor specific language



## *Motivation*

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- These slides are provided to aid in understanding the factors that affect performance of Automatic Exposure Control, specifically image quality and radiation dose, in CT studies



# Outline

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- Effect of CT localizer on AEC
- Image quality reference parameter for AEC
- Effect of patient size on AEC
- Effect of scanned anatomy
- Effect of first or expected reconstruction settings
- Advanced AEC features



## *Effect of CT Localizer*

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- The CT localizer(s) provide the initial data to inform the behavior of the AEC
- The apparent size of the patient on the localizer(s) or the measured attenuation are used to set the initial dose level for the exam
- The localizer(s) may also be used to adjust the longitudinal or angular tube current modulation
- The use of multiple localizers and the order of their acquisition may affect the behavior of the system's AEC



## *Effect of CT Localizer – Siemens Healthineers*

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- If only one localizer is acquired, the choice of the localizer (AP vs. Lateral vs. PA) impacts AEC calculations
  - Newer Software Version (Somaris 7 VBxy, Somaris X, etc.) – Choice of localizer affects AEC calculations only slightly, as long as patient is centered properly.
  - Older Software Version (Somaris 7 VAxy and all Somaris 5) – Choice of localizer impacts AEC calculations.



## *Effect of CT Localizer – Siemens Healthineers*

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- If two localizers are acquired, the order of the localizer (AP + LAT vs LAT + AP) does not impact AEC calculations
  - Except on older systems Somaris 5, where only the latest topogram will be used for AEC calculations





## Effect of CT Localizer – Siemens Healthineers

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- Newest changes to dual topogram AEC system eliminate the inconsistencies between single and dual topo modes of previous Somaris 7 software versions
  - AP/PA<sup>(1)</sup> topogram is used to calculate the water-equivalent patient diameters (WED)
  - LAT<sup>(1)</sup> topogram is used only for geometric correction of patient position
- The migration of protocols from the previous Somaris 7 VAxy version to any VBxy version requires an adaption<sup>(2)</sup> of the Quality Reference mAs values.

*(1) Applies to protocols with preferred topogram direction AP. In protocols preferred topogram direction is LAT, the WED calculation is based on the LAT topogram and the AP/PA topogram is used only for geometric correction of patient position.*

*(2) For more detailed information on suggested adaptations please check out the link:*

<https://pep.siemens-info.com/en-us/-i-syngo-i-ct-vb10-software-update-care-dose-4d-dual-topogram-job-aid>



# Effect of CT Localizer – Siemens Healthineers

- Table below summarizes the Somaris 7 dual topogram behavior across VAxy and VBxy software versions

	VAxy (except VA62)	VA62, VBxy	
<b>Organ characteristic</b>	All	Shoulder, Thorax, Abdomen, Pelvis, Extremities, Vascular Head, Vascular Body, Runoff, Perfusion Body, Cardio, Respiratory	Brain, Neck, Spine, Osteo
<b>Preferred topogram direction</b>	n.a.	AP/PA	LAT
<b>AP/PA topogram</b>	Calculation of WED in AP direction	Calculation of WED in AP and LAT directions	Patient center profile for correction of WED calculation
<b>LAT topogram</b>	Calculation of WED in LAT direction	Patient center profile for correction of WED calculation	Calculation of WED in AP and LAT directions

- In Somaris 5, only the latest topogram is used. SomX: behavior is the same as Som7 VBxy in the table.



## *Effect of CT Localizer – Siemens Healthineers*

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- The scanning parameters (e.g. tube voltage, mA) of the localizer impact AEC calculations
  - Somaris 5 and Somaris 10 scanners – Tube voltage has an effect on the AEC calculations. The recommendation is to match the Localizer and scan voltage.
  - mA & Voltage and use of tin filter do not play a role as long as the localizer quality is sufficient. This is achieved using the default protocols supplied with the scanners.



## *Effect of CT Localizer* – Siemens Healthineers recommendations

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- For head/neck/spine/osteo exams it is recommended to use:
  - One LAT localizer
- For all other (chest/abdomen/pelvis/etc.) exams \* it is recommended to use:
  - One AP localizer

\* For default Dual Source Dual Energy scan protocols on Definition Flash and Drive it is recommended to use LAT + AP localizers



## *Effect of CT Localizer – Siemens Healthineers*

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- **Mis-centering of the patient impacts AEC calculations**
  - If using AP + Lateral or Lateral only, there is only a minimal impact on the AEC calculations
  - If using AP/PA topogram the impact of mis-centering on AEC calculations is potentially high.
- **Once the patient mis-centering has been corrected, it is recommended that a new localizer be acquired for accurate AEC calculations**
  - If using AP + Lateral or Lateral only, there is no need to repeat acquisition.



## *Effect of CT Localizer – Siemens Healthineers*

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- If the prescribed CT scan range exceeds the range of the acquired localizer, the AEC algorithm uses the same technique for the scan range beyond the localizer as the closest z location included in the localizer



## *Image quality reference parameter for AEC*

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- The image quality reference parameter for AEC is generally a measure of image quality in the reconstructed images
- The image quality reference parameter for AEC has a unique relationship with both tube output and patient size
- Specifically, the Image quality reference parameter is used together with the patient attenuation profile (as estimated by the CT localizer) to determine the tube output for a particular exam
- The operation of the AEC may be independent of the reconstruction parameters, or related to them



## *Image quality reference parameter for AEC – Siemens Healthineers*

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- The primary image quality reference parameter for AEC for this manufacturer is called Quality Reference mAs.
- The same reference patient size is used by the AEC for adults and pediatric protocols.
  - Reference patient is 75 kg





## *Effect of image quality reference parameter for AEC – Siemens Healthineers*

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- The tube output (i.e., effective mAs) has a linear relationship with the image quality reference parameter for AEC (all other factors being equal)



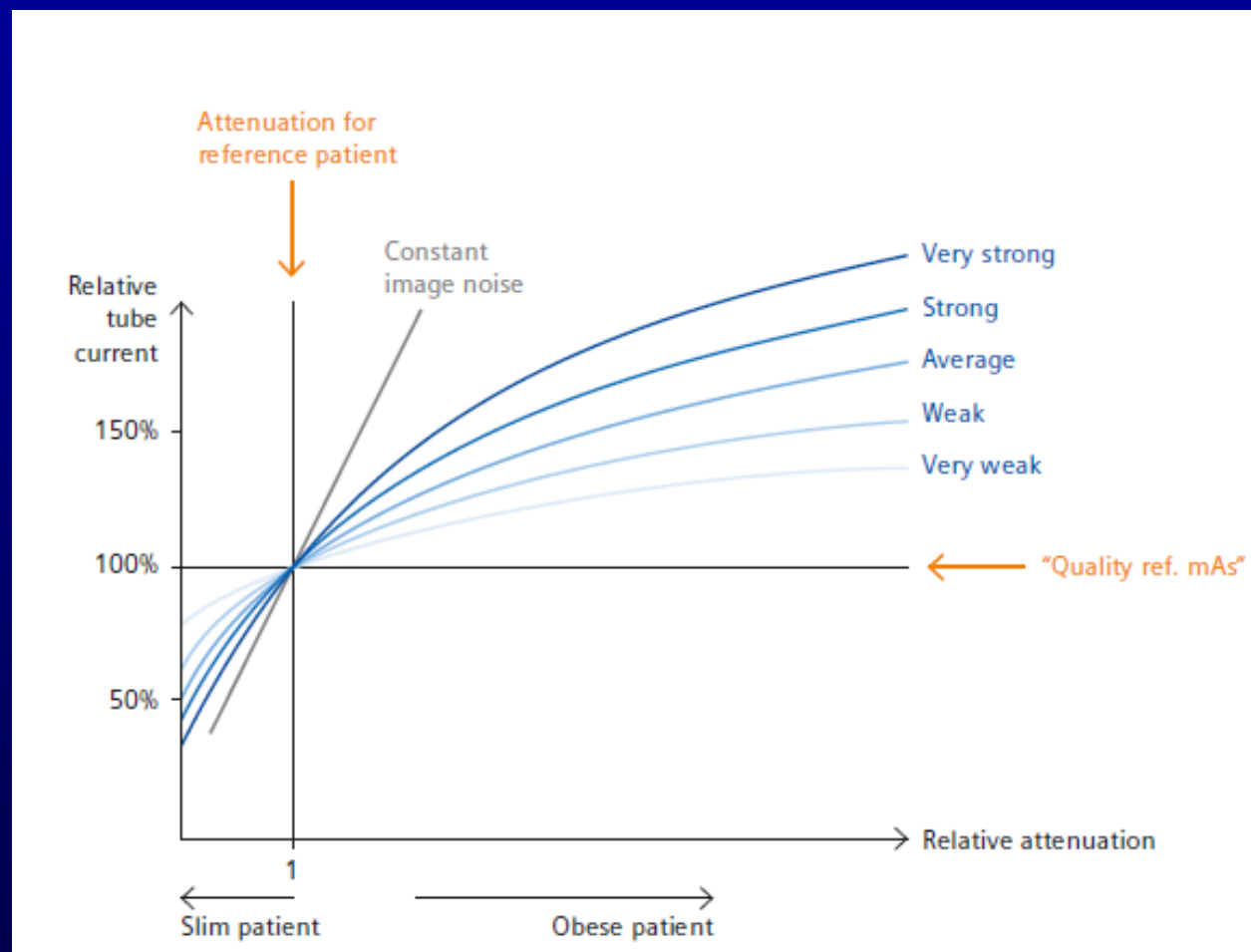
## *Effect of patient size – Siemens Healthineers*

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- The tube output (i.e., effective mAs) has the following relationship with the size of the patient (all other factors being equal):
  - Exponential increase of effective mAs with WED
  - The gradient of the exponential rise is lower than the attenuation increase observed in the scanned field of view. This way, image noise is higher for larger patients, and lower for smaller patients



# Effect of image quality reference parameter for AEC – Siemens Healthineers



For more information on AEC, Care Dose 4D, please refer to <https://pep.siemens-info.com/en-us/care-dose-4d>



## *Effect of scanned anatomy – Siemens Healthineers*

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- The tube output (i.e., effective mAs) is dependent of the organ or anatomy being scanned (all other factors being equal)
  - Organ specific water equivalent reference diameters & Organ specific AEC curves are automatically used when using the appropriate default protocols



## *Effect of first or expected reconstruction settings – Siemens Healthineers*

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- The tube output (i.e., effective mAs) is independent of the first/expected reconstruction for that protocol (all other factors being equal)



## Advanced AEC Features Outline

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- AEC in cardiac exams
- Unusual attenuation profiles
  - Head/Neck exams (strategy to handle abrupt change of attenuation profile)
  - Extremity exams
  - Neonates and very small children
  - Metal/Foreign objects within Scan FOV
  - Obese patients
- Automatic tube voltage selection
- Organ based tube current modulation



## *AEC in cardiac exams – Siemens Healthineers*

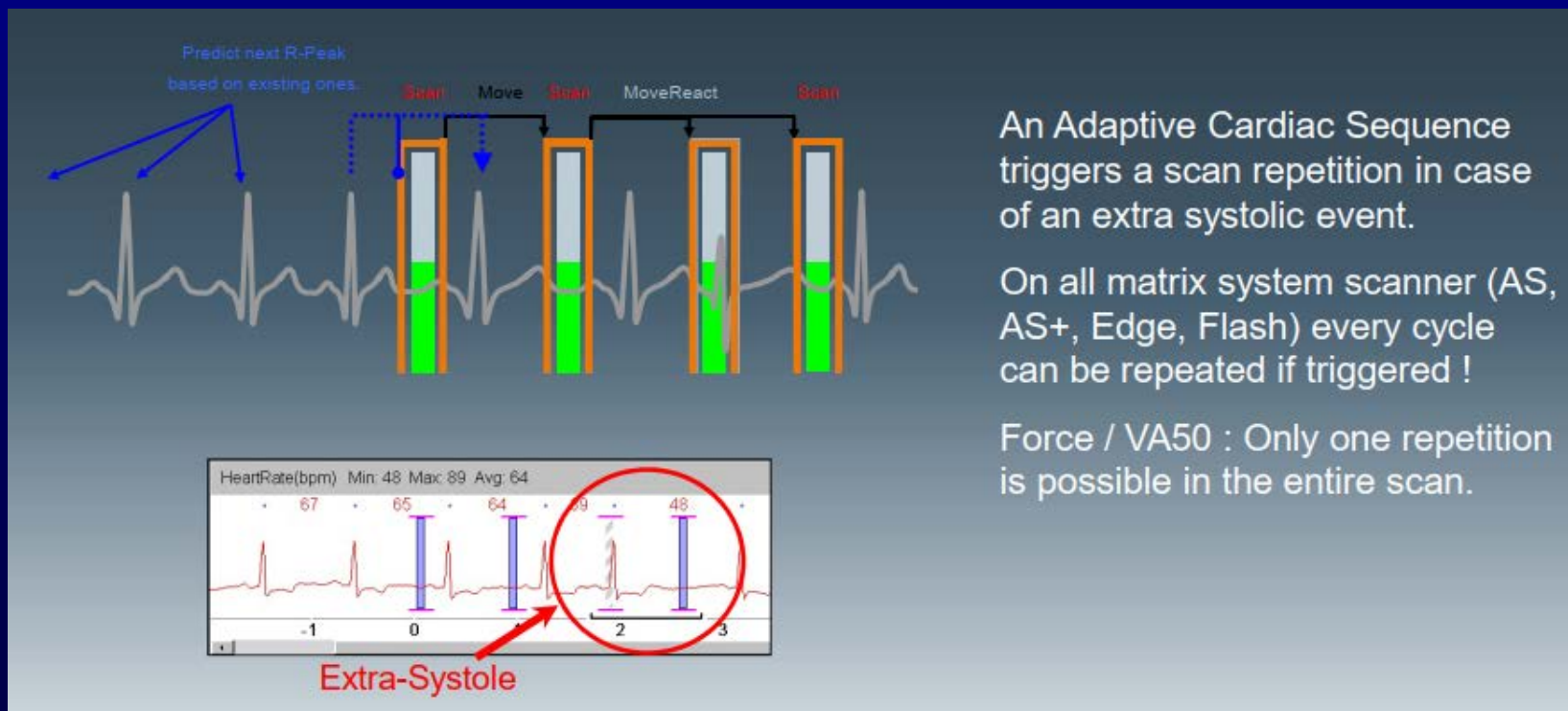
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- ECG-based tube current modulation is available:
  - Somaris 7: Standard Cardiac no TCM – still adjusts to patient body weight
  - Somaris 7: Cardiac Chest Pain protocol – Z-axis modulation
  - Somaris 10: Z-axis modulation all the cardiac modes
  - X.cite scanners: Z-axis and angular modulation



## AEC in cardiac exams – Siemens Healthineers

- In Prospective Triggering Mode with table movement:
  - There is an option for tube current modulation at selected cardiac phase range, both for spiral and sequential acquisitions
  - There is Adaptive triggering to handle irregular heart beat.







## *AEC in cardiac exams – Siemens Healthineers*

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- In Retrospective Gating Mode with table movement:
  - there is option for tube current modulation at selected cardiac phase range
    - the reduction of tube current is fixed at 20% (or 4% using MinDose)



## *AEC in cardiac exams – Siemens Healthineers*

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- Cardiac acquisition without table movement (i.e. using wide beam collimation) is not available



## *Unusual attenuation profiles – Siemens Healthineers*

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- For head/neck exams, there is no specific recommendation for scanning craniocaudal or caudocranial for best AEC dose modulation
  - Siemens default head/neck exams have AEC on
- To achieve ideal image quality/dose performance, there are dedicated AEC parameter settings for head/neck exams.
  - Neck exams have dedicated AEC modulation curves
  - Also can be selected for different organs (attached in the next slide)



# Dose Configuration Screenshot – Siemens Healthineers

The screenshot displays the Siemens Healthineers Clinical Configuration interface. The main window is titled "Dose Configuration" and is divided into three tabs: "Modulation", "Report", and "Alert". The "Modulation" tab is active, showing a table of organ characteristics and their corresponding dose modulation settings for three patient types: Child, Adult Slim, and Adult Obese. The table is titled "CARE Dose4D configuration: mAs adaption to patient size".

Organ Characteristics	Child	Adult Slim	Adult Obese
Brain	Average	Average	Average
Neck	Average	Average	Average
Shoulder	Average	Average	Average
Thorax	Average	Average	Average
Abdomen	Average	Average	Average
Spine	Average	Average	Average
Pelvis	Average	Average	Average
Extremities	Average	Average	Average
Cardio	Average	Average	Average
Osteo	Average	Average	Average
Head/Vascular Head	Average	Average	Average
AngioBody	Average	Average	Average
Respiratory	Average	Average	Average
Runoff	Average	Average	Average

At the bottom of the configuration window, there are three buttons: "Save", "Cancel", and "Set Default Values". The interface also shows a sidebar on the left with various configuration options like "Examination Configuration", "Diagnose", "Installation", "Technical Configuration", "Quality Assurance", and "Clinical Configuration". The top of the window displays the Siemens Healthineers logo, user information (Blake, Angelique), and system status (Free (Restricted Remote Access)).

test is pending



## *Unusual attenuation profiles – Siemens Healthineers*

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- The following are clinical scenarios where achieving desired image quality/dose performance can be challenging with the use of AEC:
  - Scanning neonates and very small children
    - User can select strength of AEC modulation curves independently for pediatric patients
  - There are Metal/Foreign objects within scan FOV
    - Recommend not to use protective shielding for topogram – remove other objects glasses, belts, etc
  - Extremity exams:
    - Lower extremity
      - only angular modulation for Somaris 7; for 10 there is angular and z-axis modulation
    - Upper extremity with arm(s) raised up above the shoulder
      - only angular modulation for Somaris 7; for 10 there is angular and z-axis modulation
    - Upper extremity with arms(s) kept down aside the torso:
      - No special feature available



## *Unusual attenuation profiles – Siemens Healthineers*

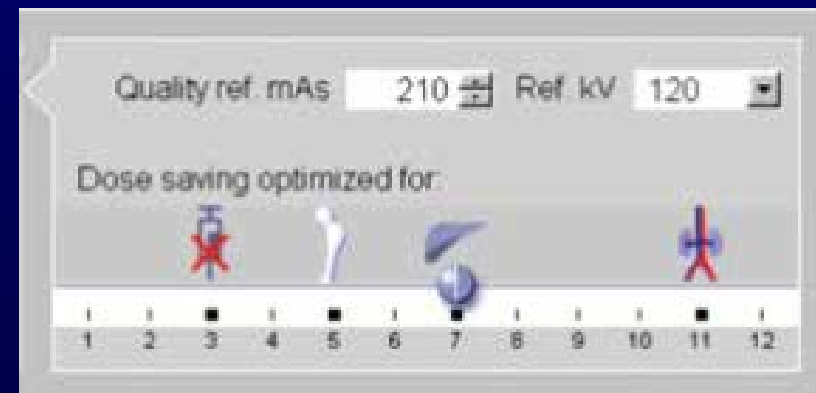
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- For scans where the tube power limitations are reached using AEC, automatic adjustment of the scanning parameters is available
  - FAST Adjust
    - adapt the pitch factor
    - reduce maximum mAs value per scan range to protect from tube overheat



## Automatic Tube voltage selection – Siemens Healthineers

- Automatic tube voltage selection based on the CT localizer scan(s) is available
  - All the scanners have it except:
    - Scanners with Somaris 5
    - go.Up, go.Now (FAST kV)
- Automatic tube voltage selection algorithm is dependent on whether contrast media is used for the exam
  - CARE kV slider





## *Automatic Tube voltage selection – Siemens Healthineers*

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- The parameters that specifically control the automatic tube voltage selection include:
  - Quality reference mAs
  - Reference kV
  - Clinical task/Exam type (CAREkV “slider bar”)



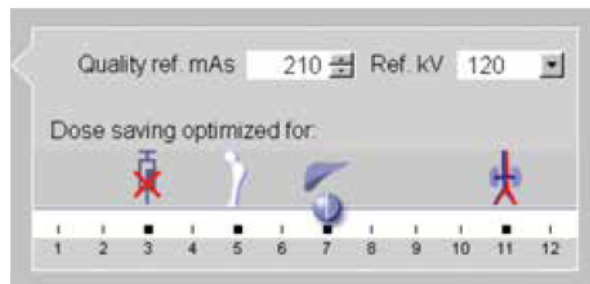


# Automatic Tube voltage selection – Siemens Healthineers



Configure the **“Quality reference mAs”** and **“Reference kV”** according to your clinical needs. Define values that you would use for a standard sized adult patient weighing 75 kg. Siemens standard protocols that come along with the system are a good starting point.

Select the exam type by setting the slider **“Dose saving optimized for”**. For CT Angiography examinations the slider should be positioned at 11, for non-contrast enhanced scans at 3. For contrast enhanced scans of parenchymatous organs such as the liver, a setting in between (7) is recommended.



In the Scan Protocol Assistant, you can define the minimum and the maximum value for the kV setting which CARE kV should use for optimization for a specific scan range.



Position the patient into the iso-center of the scanner to ensure that CARE Dose4D and CARE kV function optimally.

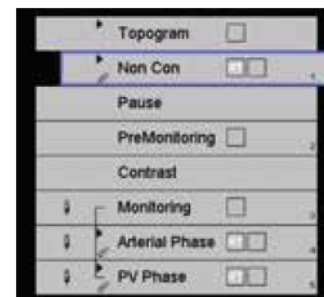
Ensure the topogram is long enough to cover the entire planned scan range.



Select 'On' in the CARE kV drop-down menu of the Scan Card.



If you need to perform subsequent acquisitions with the same kV, e.g., in case of multiphase exams, you can force CARE kV to use the same kV by linking the series. The optimization is then done by considering all linked acquisitions.



The “chain-link” icon indicates the linked acquisitions within one series. The same kV setting will be chosen.



## *Automatic Tube voltage selection – Siemens Healthineers*

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- The tube voltage is automatically selected based on the patient attenuation profile and exam type using the following principle:
  - Lowest radiation dose for a specified (depending on the “slider bar” selection) contrast to noise ratio without exceeding the tube power limits
- The tube voltage (and radiation dose) vs patient size (effective or water equivalent diameter) profile of the automatic tube selection parameter depends on the scanner



## *Automatic Tube voltage selection – Siemens Healthineers*

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- The user is allowed to disable specific tube voltages for each exam using automatic tube voltage selection



## *Organ based tube current modulation – Siemens Healthineers*

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- Organ-based tube current modulation is available on all the scanners
- The change in tube output (i.e. effective mAs) for projections over the organ of interest is -80%
- There is compensation in tube output for projections outside the “organ of interest” range



## *Organ based tube current modulation – Siemens Healthineers*

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- If organ-based modulation is activated for a CT scan, the total tube output per rotation (mAs) is the same as without organ-based modulation with other scanning conditions kept the same:
  - Exception with Somaris 7 systems, depending on the patient's attenuation profile and the scan direction, total tube output may be slightly increased in thorax examinations
- When organ-based modulation is enabled, there is restriction on other scanning techniques (i.e. rotation time, pitch):
  - Pitch cannot exceed 0.6
- Organ-based modulation is available for the following exam types:
  - Thoracic examination (breast dose reduction)
  - Head Exam (eye dose reduction)



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