# VXRE Reconstruction Software Manual

Version 1.7.8

#### **3D INDUSTRIAL IMAGING**

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VXRE Reconstruction software reconstructs 3D volume using multiple 2D X-ray projection images with geometry information. The basic reconstruction process is based on FDK filtered back-projection algorithm for 3D Cone-beam CT. Major features are like the following.

- Hardware Requirements
- Install and Launch VXRE
- Import Wizard
  - Projection Files, Geometry Parameter Setting, Volume Cube Setting
- 3D Cone Beam CT Reconstruction
  - FDK-filtered back projection
- Export Slices
- Main UI
  - ◆ Projection View, CT Geometry View, Recon Result View
- Basic Features
  - Noise Reduction and Dark/Bright field correction
  - Outside FOV Boundary Artifact Correction
  - Offset CT Mode
  - ◆ Oblique CT Mode
- Advanced Features
  - CT Value Calibration (Hounsfield Calibration)
  - CT Geometry Correction (Detector Offset/Tilt angle)
  - Custom Geometry XML Generation
  - RAR (Ring Artifact Reduction)
  - MAR (Metal Artifact Reduction for Dental CT)
- Appendix
  - Project file format
  - Command line & UDP remote commands

## • Hardware Requirements

	Minimum Requirements	Recommended
OS	Windows Vista,7,8 (64bit)	Windows 7,8,8.1 (64bit)
CPU Memory	At least 2 GB (at least twice as big as the data size)	At least 6 GB (at least three times as big as the data size)
Graphics Card (GPU)	Graphics cards compatible with DirectX 10 or higher	Graphics cards compatible with DirectX 11 and Nvidia CUDA with GPU memory at least twice as big as the data size
CPU	Intel i3 Dual Core or higher	Intel i5 Quad Core or higher
HDD	At least 2GB free space	At least 2GB free space

#### • Install and Launch VXRE

- Download latest VXRE install package and unzip the file.
- Click 'Setup\_VXRE\_V\_x.x.x.official.exe' file, then installation process will begin.
- After the installation is done, click VXRE icon on the desktop to launch the VXRE software.







• Click VXRE icon on desktop.

#### • Import Wizard

- For the CT reconstruction, various parameter values (input file information, CT geometry parameters and volume cube information) should be set for correct reconstruction process.

- Parameter setting can be done by two different ways. By using import wizard (this section) or by using project file. For the latter method, please refer to 'Project file format for reconstruction parameters' section in this manual.

- By using import wizard, user can set many parameters step-by-step process. For launching import wizard window, please click 'Import Wizard' button in the top toolbar.



## **Import Wizard**

Use Import Wizard to easily set input Projection Files, CT Geometry and Volume Cube Information.

- Import Wated

   Xrey Projection Files

   Detector Size (pkels)

   Image resolution

   With ELE

   Height 608

   Detector Files

   Detector Files

   Detector Size (pkels)

   Image resolution

   With ELE

   Height 608

   Detector Files

   Detector Files

   Add Projection Files

   Add Directory

   Remove All

   Number of Projections : 0
- Import Wizard 1: Setting input projection files (Step1)

# ✤ Setting Input Projection Files

- 1. Click the Import Wizard button to open the Import Wizard window.
- 2. Click 'Add Projection Files' or 'Add Directory' button to open the Opening Files window.
- 3. Select X-ray Projection images or a folder name.

• Import Wizard 1: Setting input projection files (Step2)



# Setting Input Projection Files

4. If you want to delete unwanted files, select them by mouse drag and click 'Remove Selections' button.

• Import Wizard 1: Setting input projection files (Step3)

Xay Projection Files       Detector Size (pixels)         C/CTDATA, PROJECTION/20120820-190628-down/projection/ViewImage0002raw       Width 615       Height 600         C/CTDATA, PROJECTION/20120820-190628-down/projection/ViewImage002araw       Width 615       Height 600         C/CTDATA, PROJECTION/20120820-190628-down/projection/ViewImage002araw       Width 615       Height 600         C/CTDATA, PROJECTION/20120820-190628-down/projection/ViewImage002araw       Detector Size (pixels)         C/CTDATA, PROJECTION/20120820-190628-down/projection/ViewImage002araw       Vertical 0.200       Vertical 0.200       Image Format         C/CTDATA, PROJECTION/20120820-190628-down/projection/ViewImage0012raw       Vertical 0.200       Vertical 0.200       Image Format         C/CTDATA, PROJECTION/20120820-190628-down/projection/ViewImage0012raw       Vertical 0.200	Import Wizard	
CyCTDATA_PROJECTION/20120820-190628-down/projection/NewImage0000.raw       Image resolution         CyCTDATA_PROJECTION/20120820-190628-down/projection/NewImage0002.raw       Width @16 * Height @00 *         CyCTDATA_PROJECTION/20120820-190628-down/projection/NewImage0003.raw       CyCTDATA_PROJECTION/20120820-190628-down/projection/NewImage0005.raw         CyCTDATA_PROJECTION/20120820-190628-down/projection/NewImage0005.raw       Detector Pitch (mm)         CyCTDATA_PROJECTION/20120820-190628-down/projection/NewImage0005.raw       Detector Pitch (mm)         CyCTDATA_PROJECTION/20120820-190628-down/projection/NewImage0007.raw       The format         CyCTDATA_PROJECTION/20120820-190628-down/projection/NewImage0007.raw       The format         CyCTDATA_PROJECTION/20120820-190628-down/projection/NewImage0007.raw       The format         CyCTDATA_PROJECTION/20120820-190628-down/projection/NewImage0007.raw       The format         CyCTDATA_PROJECTION/20120820-190628-down/projection/NewImage0017.raw       The format         CyCTDATA_PROJECTION/20120820-190628-down/projection/NewImage0015.raw       CyCTDATA_PROJECTION/20120820-	Xray Projection Files	Detector Size (pixels)
CyCTDATA_PROJECTION/20120820-190628-down/projection/ViewImage0023.raw       Sincodiming micri       Microbiological and the second seco	Xray Projection Files         C/CTDATA_PROJECTION/20120820-190628-down/projection/ViewImage0000.raw         C/CTDATA_PROJECTION/20120820-190628-down/projection/ViewImage0001.raw         C/CTDATA_PROJECTION/20120820-190628-down/projection/ViewImage0003.raw         C/CTDATA_PROJECTION/20120820-190628-down/projection/ViewImage0003.raw         C/CTDATA_PROJECTION/20120820-190628-down/projection/ViewImage0004.raw         C/CTDATA_PROJECTION/20120820-190628-down/projection/ViewImage0005.raw         C/CTDATA_PROJECTION/20120820-190628-down/projection/ViewImage0005.raw         C/CTDATA_PROJECTION/20120820-190628-down/projection/ViewImage0007.raw         C/CTDATA_PROJECTION/20120820-190628-down/projection/ViewImage0009.raw         C/CTDATA_PROJECTION/20120820-190628-down/projection/ViewImage0009.raw         C/CTDATA_PROJECTION/20120820-190628-down/projection/ViewImage0017.raw         C/CTDATA_PROJECTION/20120820-190628-down/projection/ViewImage0011.raw         C/CTDATA_PROJECTION/20120820-190628-down/projection/ViewImage0011.raw         C/CTDATA_PROJECTION/20120820-190628-down/projection/ViewImage0011.raw         C/CTDATA_PROJECTION/20120820-190628-down/projection/ViewImage0013.raw         C/CTDATA_PROJECTION/20120820-190628-down/projection/ViewImage0013.raw         C/CTDATA_PROJECTION/20120820-190628-down/projection/ViewImage0015.raw         C/CTDATA_PROJECTION/20120820-190628-down/projection/ViewImage0015.raw         C/CTDATA_PROJECTION/20120820-190628-down/projection/ViewImage0015.raw	Detector Size (pixels) Image resolution Width 616  Height 608  Detector Pitch (mm) Physical size of single pixel Horizontal 0.200  Vertical 0.200  Image Format Image Format IRAW Data Type : Unsigned 16bit  Image Flip : No Flip  Header Skip (byte) : 0  Detector Pice Projection Smoothing Projection Smoothing
	C-/CTDATA_PROJECTION/20120820-190628-down/projection/ViewImage0022.raw C-/CTDATA_PROJECTION/20120820-190628-down/projection/ViewImage0023.raw C-/CTDATA_PROJECTION/20120820-190628-down/projection/ViewImage0025.raw C-/CTDATA_PROJECTION/20120820-190628-down/projection/ViewImage0025.raw C-/CTDATA_PROJECTION/20120820-190628-down/projection/ViewImage0025.raw C-/CTDATA_PROJECTION/20120820-190628-down/projection/ViewImage0028.raw C-/CTDATA_PROJECTION/20120820-190628-down/projection/ViewImage0028.raw C-/CTDATA_PROJECTION/20120820-190628-down/projection/ViewImage0029.raw C-/CTDATA_PROJECTION/20120820-190628-down/projection/ViewImage0029.raw C-/CTDATA_PROJECTION/20120820-190628-down/projection/ViewImage0031.raw C-/CTDATA_PROJECTION/20120820-190628-down/projection/ViewImage0031.raw C-/CTDATA_PROJECTION/20120820-190628-down/projection/ViewImage0031.raw C-/CTDATA_PROJECTION/20120820-190628-down/projection/ViewImage0031.raw C-/CTDATA_PROJECTION/20120820-190628-down/projection/ViewImage0031.raw C-/CTDATA_PROJECTION/20120820-190628-down/projection/ViewImage0031.raw C-/CTDATA_PROJECTION/20120820-190628-down/projection/ViewImage0031.raw C-/CTDATA_PROJECTION/20120820-190628-down/projection/ViewImage0031.raw C-/CTDATA_PROJECTION/20120820-190628-down/projection/ViewImage0031.raw C-/CTDATA_PROJECTION/20120820-190628-down/projection/ViewImage0031.raw C-/CTDATA_PROJECTION/20120820-190628-down/projection/ViewImage0031.raw C-/CTDATA_PROJECTION/20120820-190628-down/projection/ViewImage0031.raw C-/CTDATA_PROJECTION/20120820-190628-down/projection/ViewImage0031.raw	Smoothing http://weuan       Kernel Size :       2       Attribution       Calibration:       No (Calibrated)       Bright (Gain) Calibration File:       Dark (Offset) Calibration File:   Browse

# **\*** Setting Input Projection Files

- 5. Set detector image resolution and pitch values. (e.g. 1024x1024,
- 0.2mm x 0.2mm)
- 6. Set detector image format. (e.g. Raw file format, 16bit data type)
- 7. Set Projection Smoothing filter (If the projection image has noise, apply median filter.)
- 8. Set Detector Calibration images.
  - $\rightarrow$  Set Bright (Gain) image and Dark (Offset) image file path.
- 9. Click 'Next' button.

0	Import Wizard			The lands	
Γ					Info
	Distance from Source to Object (mm): X-ray Scan Start Anole (deoree) :	430.000	Distance from Source to Detector (mm) : X-rav Scan Total Angle (degree) :		-Dist from Source to Object : Distance from x-ray source to volume cube center.
	Rotation Direction   Clockwise	• Anti-Clockwise	Rotation Method: O Source/Detector	Object (Volume)	-Dist from Source to Detector : Distance from x- ray source to detector center. -Rotation Direction : Rotate direction around Z- axis
	Advanced Geometry Parameter Setting Horizontal detector offset (mm) : Rotation axis tilt angle (degree) :	0.000 ÷	Vertical detector offset (mm) : Oblique Tilt Angle (degree) :	0.000 \$ 0.000 \$	-Detector offset : Detector offeset value along horizontal/vertical direction. (Only the horizontal value affect construced result.) -Rotation axis tilt angle : 0 means no tilt. other value means X-ray rotation (Z) axis is tilted.
	Use Custom Geometry XML file :			Browse	-Oblique Tilt Angle : Source/Detector rotation value along Y-axis. -Custom Geometry XML file : Using custom
	Object Volume Cube Setting Volume Cube Size (Pixels) : Wi	idth 600 🛟			geometry input, any arbitrary geometry settings (Rotational, Planar, Non-regular, etc.) are possible.
	Volume Cube Offset (Pixels) :	( 0.000 🛟	Y 0.000 ÷ Z	0.000	- Border Correction : Correct border artifact when object is larger than FOV.
		dth 0			- Auto Pitch Calculation : When checked, Volume Cube Pitch values will be calculated automatically.
	Boarder Correction		☑ Auto	Pitch Calculation	<ul> <li>Min/Max Recon Value for Normalization : Reconstructed 32bit float volume data will be normalized to user defined min/max value. When</li> </ul>
		No	<ul> <li>Kernel Size Width/Height:</li> </ul>	2	auto is checek, min/max values will be automatically calculated from the recon volume.
				Auto	
					< <u>B</u> ack <u>F</u> inish Cancel

#### • Import Wizard 2 : Setting geometry parameters

# \* Setting Geometry Parameters

- 1. Set up basic geometry parameters:
  - Source to Object distance
  - Source to Detector distance
  - Rotation Direction (CW or CCW)
  - Source/Detector rotation vs. Object rotation
- 2. Set up advanced geometry parameters:
  - set detector offset (Horizontal detector offset value is important)

Import Wizard			Time features -	
				Info
				-Dist from Source to Object : Distance from x-ray
		X-ray Scan Total Angle (degree) :		-Dist from Source to Detector : Distance from x-
Rotation Direction 🕥 Clockwise 🕻	anti-Clockwise	Rotation Method: ③ Source/Detector	Object (Volume)	-Rotation Direction : Rotate direction around Z-
Advanced Geometry Parameter Setting			0.000	-Detector offset : Detector offeset value along horizontal/vertical direction. (Only the horizontal
Honzontal detector offset (mm) : Rotation axis tilt angle (degree) :		Vertical detector offset (mm) : Oblique Tilt Angle (degree) :		value affect reconstruced result.) -Rotation axis tilt angle : 0 means no tilt. other value means X-ray rotation (Z) axis is tilted.
Use Custom Geometry XML file :				-Oblique Tilt Angle : Source/Detector rotation value along Y-axis.
Object Volume Cube Setting				-Custom Geometry XML file : Using custom geometry input, any arbitrary geometry settings (Rotational, Planar, Non-regular, etc.) are parsitile
Volume Cube Size (Pixels) : Wid	th 600 🗘	Height 600 🗘 Depth	600 🛟	
	0.000 ‡	Y 0.000 🐥 Z	0.000 🛟	- Border Correction : Correct border artifact when object is larger than FOV.
Volume Cube Pitch (mm) : Wid				- Auto Pitch Calculation : When checked, Volume Cube Pitch values will be calculated automatically.
Boarder Correction		V Auto	o Pitch Calculation	<ul> <li>Min/Max Recon Value for Normalization : Reconstructed 32bit float volume data will be normalized to user defined min/max value. When</li> </ul>
		<ul> <li>Kernel Size Width/Height:</li> </ul>		auto is checek, min/max values will be automatically calculated from the recon volume.
			8 🗖 Auto	
				< <u>B</u> ack <u>Einish</u> Cancel

#### • Import Wizard 3 : Volume cube setting

# **\*** Setting Volume Cube

- 1. Set Volume Cube Size. (e.g. 600x600x600)
- 2. Set Volume Cube Pitch.
  - size of a single voxel in mm
  - Or set 'Auto Pitch Calculation' check box for automatic pitch calculation
- 3. Click 'Finish' button.

#### • 3D Cone Beam CT Reconstruction

- To start CT reconstruction, click 'Do 3D Reconstruction' button in the top toolbar.

- Input projection (x-ray) images will be reconstructed as a 3D volume slices using FDK based filtered back-projection algorithm.

- When Nvidia graphics card is installed on the PC, the reconstruction process will be accelerated using CUDA technology.



# **\*** CT Reconstruction Process

1. Click 'Do 3D Reconstruction' button

2. After the reconstruction process finished, recon result view tab will be activated.

#### • Export Slices

- After CT reconstruction, user can export (save) the reconstructed 3D volume data to slice files.

- Volume slices will be saved as 16bit and 4 different types are supported (Dicom DCM, RAW, TIFF, PNG format).



# **\* Export Slices**

- 1. Click 'Export Slices' button.
- 2. Create New folder where the volume slices will be saved.
- 3. Select file format and click 'save' button.



#### • Main UI : Open Project

#### Open Project file which contains all the parameters for CT reconstruction

- Parameter setting can be done without 'Import Wizard' when project file which contains all the parameters for CT reconstruction is prepared.

- When user click 'Open Project' button, a pop-up window will appear.
- Choose .xml project file with frame directory (which contains 2D projection images).
- By using the information from .xml file, 2D x-ray projection images will be loaded.

- The content of sample .xml file is shown above, including its relevant information such as Source to Detector distance, Source to object center, detector size, projection image information, etc. For more information about project file format, please refer to 'Project file format for reconstruction parameters' section in this manual.

VXRE CT Reconstruction v1.3.8		
Reconstruction Recon Result		
Import Wizard         Open Project         Swee Project         Do 3D Reconstruction         Export Slices	Recon Result Simulation Widget	
Projection View		Scan Geometry + Detector Parameters Reconstruction Par   Distance from Source to Object (mm)  601.110
		Distance from Source to Detector (mm) 912.000 🛟
		X-ray Scan Start Angle (default : 0 degree)
		X-ray Scan Total Angle (default : 360 degree)
		Rotation Direction 💿 Clockwise 🕤 Anti-Clockwise
		Center Offset for Short Scan Mode (mm) 0.000
Threshold Lower:	Oblique Tilt Angle : (default : 0 degree)	
Threshold Upper:	Rotation Method:  Source and Detector Rotation Patient(Sample) Rotation	
	Summary	
Change Volume Output Directory Volume Folder Name (ex. Volume): Volume	-distance from source to detector (mm): 912	
	-detector onset (pate) ; 1.5, 0 -detector pixel pitch (mm) ; 0.4, 0.4 -Tomography Angle (Degree) ; 90	

#### • Main UI : Projection Image View

- After loading project file, the first projection image will be visualized on projection view.

- See other projection images by changing the image number of spin box control or by using the slider.

- Change the contrast of the projection image by adjusting 'Threshold Lower' and

'Threshold Upper' sliders.

Invert the projection image result (White→Black, Black→White) by using the 'Invert
 Projection Display' check box.

🙆 VXRE CT Reconstruction v1.7.8	– 🗆 X
P . Reconstruction Recon Result	
Import Wizard Open Project Save Project 3D Reconstruction Export Slices Recon Result Launch 3D Viewer Geometry Correction	
Projection View	Scan/Detector Param Volume/Recon Param Extra
	Distance from Source to Object (mm) 601.110 Distance from Source to Detector (mm) 912.000 X-ray Scan Stat Angle (default : 0 degree) 0.000 X-ray Scan Total Angle (default : 360 degree) 360.000 Rotation Direction O Clockwise Anti-Clockwise Tomography Angle (default : 90 degree) 90.000 Detector Center Offset for Offset CT Mode (mm) 0.000 Detector Parameters Detector Pizze (Pixels) : U 512 V 512 Detector Pitch (mm) : U 0.8000 V
143 Colique Tilt Angle : (default : 0 degree)	Detector Offset (Pixels) : U 0.000 + V 0.000 +
Threshold Uwer: Rotation Method:  Source and Detector Rotation O Patient(Sample) Rotation	
Output Setting (Only applicable in UDP or CMD mode) Summary	
DATA_PROJECTION/VXRE_test_data_brkt       Change Volume Output Directory         Volume Folder Name (ex. Volume):       slice         Program Files/VX3D2/Platform/VX3D.exe       Change 3D Viewer EXE path	Data Type :     UShort16     Image Flip :     No Flip       Noise Reduction :     Image Apply Smooth (Median) Filter       Horizontal Strength     1     Vertical Strength     1

#### • Main UI : CT Geometry View (3D View)

- Current CT Geometry will be shown in geometry view as 3D lines and cube.

- If you change geometry parameters on right panel, CT Geometry view will get values and update immediately.

- Purple sphere represents the position of X-ray source position and the yellow rectangle represents the detector plate.

- The blue box between the two represents the object (patient) region.

- The size and position of the geometry object are adjusted automatically, based on the information from the .3dii file.

- Rotate the geometry object by left-clicking on CT geometry view and zoom-in and out object by mouse wheel operation.

• Main UI : Right Panel (Scan Geometry/Detector Parameter)



Right panel : Scan Geometry Parameter

- Modify CT geometry related settings such as distance from source to object, distance from source to detector, X-ray scan start/total angles on the right panel.

- Choose either clockwise or counter-clockwise as the rotating direction of source and detector plate on 'Rotation Direction'.

- 'Tomography angle' determines vertical movement of source and detector. For most cases, user doesn't need to modify this value. (The value from project file will be used.)

- For offset CT scan case (detector is shifted horizontally to shot bigger objects than detector size), please adjust 'Detector Center Offset CT Mode' slider to set the appropriate value.

Detector Parameters
Detector Size (Pixels) : U 512 + V 512 +
Detector Pitch (mm) : U 0.8000 + V 0.8000 +
Detector Offset (Pixels) : U 0.000 + V 0.000 +
Detector Rotation Tilt Angle (degree) : 0.000
Num of Projections 400 🗘 Pixel Depth (bit) : 16 🗘
Data Type : UShort16 ▼ Image Flip : No Flip ▼
Noise Reduction : 🗹 Apply Smooth (Median) Filter
Horizontal Strength 1 🗘 Vertical Strength 1 🗘

Main UI : Right Panel (Detector Parameters)

**Right panel : Detector Parameters** 

- Set the parameters related to the detector plate on 'Detector Parameters' panel.

- Possible parameters for setting are detector size in pixel, detector pitch in mm, vertical/horizontal offset in pixel, number of projections to be used for reconstruction process. Moreover, it is possible to flip the image. Possible options are no flip, horizontal flip, vertical flip, and flip both.

- Smooth filter to reduce noises in projection images can be set in the last row. Check the 'Apply Smooth Filter' check box and set the filter kernel size. (e.g. when W=1 and H=1, the kernel size will be 3x3.)

Scan/Detector Param	Vo	lume/Rec	on Par	am	Extra	
Volume Size (Pixels) :						
W 512 🗘	Н	512	*	D	512	* *
Volume Offset (Pixels						
X 0.000 🗘		0.000	*	Z	0.000	* *
Volume Pitch (mm) :						
W 0.527289	н	0.52	7289	D	0.52	7289
					Auto P	litch
Volume File Format :		Dicom	16bit s	slices	(*.dcm)	
Minimum Recon Valu	ie fo	r Normal	lization			800.0
Maximum Recon Val	ue fo	or Norma	lizatior			0.08
		Auto	o Min/I	Max I	Normaliz	ation
Post Processing 3D :	I	No		•	W 2	*
Boundary Correct	tion	(when ob	ject is	large	r than FC	OV)

Main UI : Right Panel (Volume/Recon Parameters)

Right panel : Volume/Reconstruction parameters

- Change the setting for reconstructed 3D volume such as volume size, pitch, data type and file format on 'Reconstruction Parameters' panel.

- Volume Pitch shows a size of single voxel. It can be set manually or automatically. (When click 'Auto Pitch' button, volume pitch values will be calculated and set automatically based on current FOV.)

- When 'Auto Min/Max Normalization' check box is checked, reconstructed volume's value will be normalized to minimum/maximum of the entire volume automatically.

- Otherwise, it will be normalized by the user-defined min/max value range.

- In 'Post Processing 3D' combo-box, user can select the type of post-processing filter (Mean or Gaussian filter in 3D) which will be applied to the reconstructed volume before saving to slice files. The size of filter can be adjusted in the 'W' parameter.



Right panel : 'Out-Of-Core' mode

- When the size of volume is too big and cannot be fitted into the GPU memory (e.g. if the volume has 1024x1024x1204 resolution, it needs 4GB GPU memory because VXRE uses 32bit floating point precision for the reconstruction process), the reconstruction process should be done in 'Out-Of-Core' mode.

- When 'Out-Of-Core' mode check box is checked, the volume data will be divided into multiple subsets (each subset data will be fitted into GPU memory) and the reconstruction process will be applied to each subsets one-by-one.

VXRE CT Reconstruction v1.3.8		
Reconstruction Recon Result		
Save Project Export Slices Return to main tab		
Recon Result View		
		A. Select Current Active Preset to load preset. B. To start a new calibration, select material lype to calibrate . C. Draw rectangle on Result View using Mouse Right Batton. D. Aber finishing calibrations for all types, press Save as Current Preset button. Current Active Preset: N/A Save as Current Preset Select Material ① 1.Set Air ② 2.Set Water ③ 3.Set Third Material (Optional) 1.Air 1.Air 1.Air 1.Air Rectangle ROI (Region Of Interest) pixel counts N/A Mean Value: N/A SkdDev: N/A
Windowing for result view		3.Third Material (Optional)
Z Slice No.	Adjust threshold slider to separate the metal Click 'Metal Correction Reconstruction' button, Accelerated accelerate acceleration and the second state of the second s	Vse Third Rectangle ROI (Region Of Interest) pixel counts N/A
ThresholdL:	(to run metal corrected reconstruction using Projection completion method)	Mean Value: N/A StdDev: N/A
ThresholdU:	High Value Threshold: 0.130005	
0.059303	Show High Value Threshold Do Metal Artifact Reduction	

#### • Main UI : Recon Result View



- After the reconstruction, 3D volume data will be shown in Recon Result View as 2D axial slices.

- Adjust 'Z Slice No.' slider to change current volume slice.
- Change slice bright/contrast by changing threshold sliders.

Basic Features : Dark/Bright field correction



X-ray projection image

Linearized, Calibrated image

- When detector dark and bright field images are available, detector calibration (linearization) can be done using those images.

- Please set dark/bright images in detector calibration menu inside import wizard panel, or set dark/bright file name inside project file.

## • Basic Features : Outside FOV (Field Of View) Boundary Artifact Correction



Before the correction

After the correction

- When the object's size is larger than FOV (Field Of View) of CT scan geometry, artifacts will appear at the object boundaries.

- Set 'Boundary Correction' check box in import wizard panel or Main UI's right panel to correct those artifacts.

- 'Boundary Correction' feature can slow down the reconstruction process, please turn on this feature only when the object is larger than FOV.

VXRE CT Reconstruction v1.3.8	(A. R. A.)	
Reconstruction Recon Result		
Import Wizard Open Project Save Project Do 3D Reconstruction Export Slices	Recon Result Simulation Widget	
Projection View		Scan Geometry + Detector Parameters Reconstruction Par
0       Invert Projection Display         Threshold Lower:       Invert Projection Display         Threshold Lower:       Invert Projection Display         Reconstructed Volume Output Setting       C/CTDATA_PROJECTION_RF/F0VIS0v80         C/CTDATA_PROJECTION_RF/F0VIS0v80       Change Volume Output Directory         Volume Folder Name (ex. Volume):       Volume         ogram Files/W3D_20/PlatformVX3Dexe       Change Siera Viewer EXE path	Apply         detector         center         offset         offse	Distance from Source to Object (mm) 430.000  Distance from Source to Detector (mm) 530.000  X-ray Scan Start Angle (default : 0 degree) X-ray Scan Total Angle (default : 360 degree) 560.000  Clockwise Anti-Clockwise Tomography Angle (default : 90 degree) 94.800  Detector Direction  Clockwise Anti-Clockwise Tomography Angle (default : 90 degree) 94.800  Detector Center Offset for Offset CT Mode (mm) 52.000  Detector Parameters Detector Parameters Detector Pitch (mm) : U 0.200  V 0.200  Detector Offset (Pixels) : U 5.000  V 0.000  V 0.000  V 0.00

#### • Basic Features : Offset CT mode support

- Offset CT mode scan support: adjust 'Detector Center Offset' slider in projection view to shot big size object using small size detector.

	VXRE CT Reconstruction v1.3.8	×
Reconstruction Recon Result		
Import Wizard         Open Project         Save Project         Do 3D Reconstruction         Export Sices	Recon Result Simulation Widget	
Projection View		Scan Geometry + Detector Parameters Reconstruction Par 4
		Distance from Source to Object (mm) 215.769 🗘 —
888888666		Distance from Source to Detector (mm) 504.326 🛟
		X-ray Scan Start Angle (default : 0 degree)
		X-ray Scan Total Angle (default : 360 degree) 360.000 🗘 💳
		Rotation Direction OClockwise O Anti-Clockwise
		Detector Center Offset for Offset CT Mode (mm)
	Focal Length (mm) : 504.326 Det Centre Offset (pixels) : 510.0, 512.0 Det centre of for effective : 0.0 72 - 00.00	
Threshold Lower:	Oblique 1ilt Angle : (default : 0 degree) -36.000	
Threshold Upper: -	Rotation Method: O Source and Detector Rotation O Patient(Sample) Rotation	
Reconstructed Volume Output Setting	Summary	Data Type : Unsigned 16b Image Flip : No Flip 💌
CTDATA_PROJECTION/VXRE_test_data02 Change Volume Output Directory	-distance from source to detector (mm) : 504.326 -distance from source to object (mm) : 215.769	Smooth filter Median 🔻 W 2 🛟 H 2 🛟
Volume Folder Name (ex. Volume): slice	-detector width, height (pxel) : 1024, 1024 -detector offset (pixel) : -2, 0 -detector pixel pixel (pxp) : 0.003, 0.087	
nBrowser EX/Program/ZoomBrowsezexe Change Siera Viewer EXE path	-Tomography Angle (Degree) : 90	

### • Basic Features : Oblique CT mode support

- For Oblique CT, adjust 'Object Tilt Angle' slider to set tilted angle value.
- Both of X-ray source and detector will be rotated together.
- If you want to move X-ray source and detector separately, refer to 'Custom Geometry

XML Generation' section in this manual.

- Siera Reconstruction v1.0.1 🔙 Siera 🗸 **Recon Result** Import Images Save MNRI Export Slices Do 3D Reconstruction Siera Reconstruction v1.0.1 Siera truction Renain tab Export Slices -Third Material B. Draw rectange on Result View using Mouse Right Button. C. After finishing calibration for all types, set active preset combo and press save button. Air Rectangle ROI (Region Of Inte Rectangle ROI (Region Of Interest) pixel cour 🔲 Use Third Rectangle ROI (Region Of Interest) pixel c 1 I I Ð
- Advanced Features : CT Value Calibration (Hounsfield Calibration)

CT Value (HU) Calibration

- After the reconstruction is finished, change the 'Reconstruction' view to 'Recon Result' view by clicking 'Recon Result' tab button.

On Recon Result view, you can calibrate CT value to Hounsfield Unit value. For example, HU value is set as -1000 HU in the air region, and 0 HU in the water region.
To calibrate the CT value to HU value, first choose 'Current Active Preset' by clicking the combo box. Currently six CT value presets are supported. If N/A is selected, calibration will not be applied.



**Current Active Preset Combo Box** 

- To calibrate CT value for Air, press '1.Set Air' button and draw a rectangle on the desired air region using the right mouse button. This yellow rectangle represents the ROI (Region Of Interest) of air. The mean CT value of selected ROI will be calculated and set as CT Value automatically. It is also possible to modify CT value to any desired value.

- Repeat the same process for Water calibration. The blue rectangle represents the ROI of water. Its mean value will be set as CT Value as well.

- Calibration for any third material is optional.

- Click 'Save as Current Preset' button after calibration, to save the calibrated preset as current active preset. Whenever any current active preset is chosen among the combo box, its saved setting will be automatically loaded.

- Calibrated preset will be saved to the following path.

→ 'C:\Users\\*\*\*\Documents\VXRE\CTValuePreset.ini'.



• Advanced Features : CT Geometry Correction (Detector Offset/Tilt angle)

#### Find Correct Detector Offset Parameter using CT Geometry Correction feature

- User can correct detector offset and tilt angle by using 'CT Geometry Correction'.

- When 'Geometry Correction' button is clicked in the top toolbar, CT geometry correction window will be shown.

- 'Auto Estimation' feature will find detector horizontal offset automatically using only center slice reconstruction. User can check differents result using 'Range Bar' slider.

• Advanced Features : Custom Geometry XML Generation (Experimental)



- User can specify arbitrary position/orientation of source/detector/cube for each projection angle. If CT scanner has stationary mis-alignment which can be measured, exact CT geometry values for each projection angle can be set using custom XML file.

- For this feature, click 'Simulation Widget' button in the top toolbar.

- In 'Generate Geometry Elements' tab, set parameters and click 'Generate Rotational CT 'button.

- Generated custom geometries will be displayed in the table view.
- Click 'Save Table to XML' button to save generated geometries.

custom geoxmi + ×
<pre>k2yml version="1.0" encoding="UTE-8"&gt;&gt;</pre>
<pre></pre>
<pre>GeoElement id="1" srcPosition="430.0.0" detleftTon="-20061.6.60.8" detDirecl="0.1.0" detDirecV="0.01" cubeOrigin="-40.9540.9540.95" cubeDirecl="</pre>
<pre>&lt;GeoFlement id="2" srcPosition="429.935, -7.50453, 0" detleftTon="-201.045, -58.1001, 60.8" detDirecl="0.0174524, 0.999848, 0" detDirecV="0.0, -1" cubeOrigin="-44&lt;/pre&gt;</pre>
<pre>&lt;GeoElement id="3" srcPosition="429.738, -15.0068, 0" detLeftToo="-202.028, -54.5826, 60.8" detDirecU="0.0348995, 0.999391, 0" detDirecV="0, 0, -1" cubeOrigin="-44&lt;/pre&gt;</pre>
<pre>&lt;GeoElement id="4" srcPosition="429.411, -22.5045, 0" detLeftTop="-202.95, -51.0484, 60.8" detDirecU="0.052336, 0.99863, 0" detDirecU="0.0, -1" cubeOrigin="-40.95&lt;/pre&gt;</pre>
<pre>&lt;GeoElement id="5" srcPosition="428.953, -29.9953, 0" detleftIon="-203.81, -47.4987, 60.8" detDirecU="0.0697565, 0.997564, 0" detDirecV="0.0, -1" cubeOrigin="-40.&lt;/pre&gt;</pre>
<pre>&lt;GeoElement id="6" srcPosition="428,364, -37,477, 0" detLeftTop="-204,608, -43,9344, 60.8" detDirecU="0,0871557, 0.996195, 0" detDirecU="0, 0, -1" cubeOrigin="-40,&lt;/pre&gt;</pre>
<pre>&lt;GeoElement id="7" srcPosition="427.644, -44.9472, 0" detLeftTop="-205.343, -40.3569, 60.8" detDirecU="0.104528, 0.994522, 0" detDirecV="0, 0, -1" cubeOrigin="-40.&lt;/pre&gt;</pre>
<GeoElement id="8" srcPosition="426.795, -52.4038, 0" detLeftTop="-206.016, -36.767, 60.8" detDirecU="0.121869, 0.992546, 0" detDirecV="0, 0, -1" cubeOrigin="-40.5</td>
<pre>&lt;GeoElement id="9" srcPosition="425.815, -59.8444, 0" detLeftTop="-206.627, -33.1659, 60.8" detDirecU="0.139173, 0.990268, 0" detDirecV="0, 0, -1" cubeOrigin="-40.&lt;/pre&gt;</pre>
<GeoElement id="10" srcPosition="424.706, -67.2668, 0" detLeftTop="-207.174, -29.5547, 60.8" detDirecU="0.156434, 0.987688, 0" detDirecV="0, 0, -1" cubeOrigin="-40</td>
<pre>&lt;GeoElement id="11" srcPosition="423.467, -74.6687, 0" detLeftTop="-207.658, -25.9345, 60.8" detDirecU="0.173648, 0.984808, 0" detDirecV="0, 0, -1" cubeOrigin="-46&lt;/pre&gt;</pre>
<GeoElement id="12" srcPosition="422.1, -82.0479, 0" detLeftTop="-208.079, -22.3064, 60.8" detDirecU="0.190809, 0.981627, 0" detDirecV="0, 0, -1" cubeOrigin="-40.5</td>
<pre>&lt;GeoElement id="13" srcPosition="420.603, -89.402, 0" detLeftTop="-208.437, -18.6716, 60.8" detDirecU="0.207912, 0.978148, 0" detDirecV="0, 0, -1" cubeOrigin="-40.&lt;/pre&gt;</pre>
<GeoElement id="14" srcPosition="418.979, -96.729, 0" detLeftTop="-208.731, -15.031, 60.8" detDirecU="0.224951, 0.97437, 0" detDirecV="0, 0, -1" cubeOrigin="-40.95</td>
<pre>&lt;GeoElement id="15" srcPosition="417.227, -104.026, 0" detLeftTop="-208.962, -11.3858, 60.8" detDirecU="0.241922, 0.970296, 0" detDirecV="0, 0, -1" cubeOrigin="-46&lt;/pre&gt;</pre>
<GeoElement id="16" srcPosition="415.348, -111.292, 0" detLeftTop="-209.128, -7.73722, 60.8" detDirecU="0.258819, 0.965926, 0" detDirecV="0, 0, -1" cubeOrigin="-46</td>
<pre>&lt;GeoElement id="17" srcPosition="413.343, -118.524, 0" detLeftTop="-209.232, -4.08625, 60.8" detDirecU="0.275637, 0.961262, 0" detDirecV="0, 0, -1" cubeOrigin="-46&lt;/pre&gt;</pre>
<GeoElement id="18" srcPosition="411.211, -125.72, 0" detLeftTop="-209.271, -0.43404, 60.8" detDirecU="0.292372, 0.956305, 0" detDirecV="0, 0, -1" cubeOrigin="-40.</td>
<pre>&lt;GeoElement id="19" srcPosition="408.954, -132.877, 0" detLeftTop="-209.247, 3.21832, 60.8" detDirecU="0.309017, 0.951057, 0" detDirecV="0, 0, -1" cubeOrigin="-40.&lt;/pre&gt;</pre>
<GeoElement id="20" srcPosition="406.573, -139.994, 0" detLeftTop="-209.159, 6.86968, 60.8" detDirecU="0.325568, 0.945519, 0" detDirecV="0, 0, -1" cubeOrigin="-40.</td>
<pre>&lt;GeoElement id="21" srcPosition="404.068, -147.069, 0" detLeftTop="-209.007, 10.519, 60.8" detDirecU="0.34202, 0.939693, 0" detDirecV="0, 0, -1" cubeOrigin="-40.95&lt;/pre&gt;</pre>
<GeoElement id="22" srcPosition="401.44, -154.098, 0" detLeftTop="-208.792, 14.165, 60.8" detDirecU="0.358368, 0.93358, 0" detDirecV="0, 0, -1" cubeOrigin="-40.95,</td>
<pre>&lt;GeoElement id="23" srcPosition="398.689, -161.081, 0" detLeftTop="-208.513, 17.8068, 60.8" detDirecU="0.374607, 0.927184, 0" detDirecV="0, 0, -1" cubeOrigin="-40.&lt;/pre&gt;</pre>
<pre>&lt;GeoElement id="24" srcPosition="395.817, -168.014, 0" detLeftTop="-208.17, 21.4431, 60.8" detDirecU="0.390731, 0.920505, 0" detDirecV="0, 0, -1" cubeOrigin="-40.5&lt;/pre&gt;</pre>
<pre>&lt;GeoElement id="25" srcPosition="392.825, -174.897, 0" detLeftTop="-207.764, 25.0729, 60.8" detDirecU="0.406737, 0.913545, 0" detDirecV="0, 0, -1" cubeOrigin="-40.&lt;/pre&gt;</pre>
<GeoElement id="26" srcPosition="389.712, -181.726, 0" detLeftTop="-207.295, 28.6951, 60.8" detDirecU="0.422618, 0.906308, 0" detDirecV="0, 0, -1" cubeOrigin="-40.</td>
<pre>&lt;GeoElement id="27" srcPosition="386.481, -188.5, 0" detLeftTop="-206.762, 32.3085, 60.8" detDirecU="0.438371, 0.898794, 0" detDirecV="0, 0, -1" cubeOrigin="-40.95&lt;/pre&gt;</pre>
<GeoElement id="28" srcPosition="383.133, -195.216, 0" detLeftTop="-206.167, 35.9121, 60.8" detDirecU="0.453991, 0.891007, 0" detDirecU="0, 0, -1" cubeOrigin="-40.</td>
<pre>&lt;GeoElement id="29" srcPosition="379.667, -201.873, 0" detLeftTop="-205.509, 39.5047, 60.8" detDirecU="0.469472, 0.882948, 0" detDirecU="0, 0, -1" cubeOrigin="-40.&lt;/pre&gt;</pre>
<pre>&lt;GeoElement id="30" srcPosition="376.086, -208.468, 0" detLeftTop="-204.788, 43.0853, 60.8" detDirecU="0.48481, 0.87462, 0" detDirecV="0, 0, -1" cubeOrigin="-40.95&lt;/pre&gt;</pre>
<GeoElement id="31" srcPosition="372.391, -215, 0" detLeftTop="-204.005, 46.6528, 60.8" detDirecU="0.5, 0.866025, 0" detDirecV="0, 0, -1" cubeOrigin="-40.95, -40.95</td>
<pre>&lt;GeoElement id="32" srcPosition="368.582, -221.466, 0" detLeftTop="-203.16, 50.2061, 60.8" detDirecU="0.515038, 0.857167, 0" detDirecV="0, 0, -1" cubeOrigin="-40.5&lt;/pre&gt;</pre>
<pre>&lt;GeoElement id="33" srcPosition="364.661, -227.865, 0" detLeftTop="-202.253, 53.7441, 60.8" detDirecU="0.529919, 0.848048, 0" detDirecV="0, 0, -1" cubeOrigin="-40.&lt;/pre&gt;</pre>
<pre>&lt;GeoElement id="34" srcPosition="360.628, -234.195, 0" detLeftTop="-201.284, 57.2657, 60.8" detDirecU="0.544639, 0.838671, 0" detDirecV="0, 0, -1" cubeOrigin="-40.&lt;/pre&gt;</pre>
<pre>&lt;GeoElement id="35" srcPosition="356.486, -240.453, 0" detLeftTop="-200.254, 60.7699, 60.8" detDirecU="0.559193, 0.829038, 0" detDirecV="0, 0, -1" cubeOrigin="-40.&lt;/pre&gt;</pre>
<pre>&lt;GeoElement id="36" srcPosition="352.235, -246.638, 0" detLeftTop="-199.163, 64.2555, 60.8" detDirecU="0.573576, 0.819152, 0" detDirecV="0, 0, -1" cubeOrigin="-40.&lt;/pre&gt;</pre>
<pre>&lt;GeoElement id="37" srcPosition="347.877, -252.748, 0" detLeftTop="-198.011, 67.7216, 60.8" detDirecU="0.587785, 0.809017, 0" detDirecV="0, 0, -1" cubeOrigin="-40.&lt;/pre&gt;</pre>

- Generated XML file contains custom geometry information for each projection angle (refer to above figure).

- User can view and modify parameters to arbitrary values in the XML file.



- The custom geometry XML file can be used as an input for the reconstruction.

- Set 'Use Custom Geometry XML file' check box and click 'Load' button to load the XML file.

- After the XML loading, reconstruction process will use xml data for the reconstruction.

(Basic/Advanced Geometry Parameter Setting will be ignored.)

B VXRE CT Reconstruction v1.5.8		- 🗆 X
2 _ Reconstruction Recon Result		
http://www.angle.com/angle	Recon Result Launch 3D Viewer Geometry Correction	
Projection View		§metry + Detector Parameters         Reconstruction Parameters         ▶           Volume Size (Pixels) :         W         512         +         H         512         +         D         512         +         Nolume Offset (Pixels) :           X         0.000         +         Y         0.000         +         Z         0.000         +         X         0.000
	Accel Length (smil) : 1015-014 Der Center: Offert (solid) : 2540, 2560 Detector: Ster (smil) : 130, 741000, 741000, 741000, 741000, 741000, 741000, 741000000000000000000000000000000000000	Auto Pitch         Volume File Format:       Dicom 16bit slices ('.dcm))         Minimum Recon Value for Normalization:       =0.008         Maximum Recon Value for Normalization:       =0.008         Image: Auto Min/Max Normalization       =0.008         Image: Auto Min/Max Normalization       =0.008         Post Processing 3D:       No       ■       W       2         Image: Boundary Correction (when object is larger than FOV)        Boundary Correction (when object is larger than FOV)
0  Threshold Lower:  Invert Projection Display Threshold Upper:	Oblique Tilt Angle : (default : 0 degree)           0.000         •           Rotation Method:         •           Source and Detector Rotation         •	RAR (Ring Artifact Reduction) Settings Use RAR (Ring Artifact Reduction) Defective Columns : (ex. 200,300 or 200–1000)
	Summary -distance from source to detector (mm) : 1015.91 -distance from source to object (mm) : 409.406 -detector offset (pise) : 312, 512 -detector offset (pise) : -2, 0 -detector offset (pise	100-400 Filter Size (RAR Strength) : (Weak «> Strong) 15 • Etc Settings • Out-OF-Core Mode (Use when volume size is too big)

#### • Advanced Features : RAR (Ring Artifact Reduction)

- Even though the detector calibration was applied using dark/bright images, projection images couldn't be calibrated perfectly in some cases. It will result in ring artifacts in the reconstructed volume.

- By using RAR (Ring Artifact Reduction) feature, ring artifacts can be reduced in the reconstructed volume.

RAR (Ring Artifact Reduction) Settings
✓ Use RAR (Ring Artifact Reduction)
Defective Columns : (ex. 200,300 or 200~1000)
100~400
Filter Size (RAR Strength) : (Weak <> Strong)
15 🗘 🛑

Projection Image (ex. 512x512)



- To use RAR (Ring Artifact Reduction) feature, check 'Use RAR' check box in the right panel inside 'Reconstruction Parameters' tab.

- RAR needs two kinds of parameters. First, 'Defective Columns' parameter should be set. It will restrict the region where the RAR will be applied (RAR will be applied only to the columns specified by this parameters in projection images).

- Another parameter is 'RAR Strength' parameter. It controls how much RAR effect will be applied. Large value results in strong RAR effect, but subtle details can be blurred.



**Before RAR** 

After RAR



Advanced Features : MAR (Metal Artifact Reduction)

Result view after initial reconstruction

- VXRE has MAR (Metal Artifact Reduction) feature for Medical/Dental CT.

- If the patient has dental filling or metal pins near the soft/bone tissue, reconstructed volume will show metal artifact near metal regions.

 After the initial (normal) reconstruction, 'Metal Artifact Reconstruction' feature will be enabled. Current implementation supports metal artifact reduction algorithm using
 Projection completion method. - In result view, check 'Set High Value Threshold' check box to enable metal correction feature. Then adjust high value (value for metal area) threshold slider to separate the metal region (Metal area will appear as red color in the result view).

- Click 'Metal Artifact Reduction' button to run metal corrected reconstruction using Projection completion method. Metal corrected result will be shown in result view.





Left : Metal regions appear as red colr

Right : Metal corrected reconstruction result

#### Appendix : Project file format

- xml project file is a text file which contains parameters for the reconstruction. - The following lines show a single parameter and corresponding its meaning. <GeometryMode> : geometry mode (ConeBeam, ParallelBeam, FanBeam) <FOD> : Distance from X-ray source to Object center (mm) <FDD> : Distance from X-ray source to Detector center (mm) <StartAngle> : Start angle (degree) <ScanAngle> : Total scan angle (e.g. 360 degree) <ProjCount> : Number of total projection images <ProjStart> : Index of first projection image (e.g. 0) <TomoTheta> : Tomography angle (e.g. 90 degree) <TiltAngle> : Oblique tilt angle (degree) <RotDirection> : Object (or Source/Detector) rotation direction (CW or CCW) <RotMethod> : 0=Source/Detector rotation, 1=Object rotation <DetSizeU> : Detector Width (pixels) <DetSizeV> : Detector Height (pixels) <DetPitchU> : Detector pitch in horizontal direction (mm) <DetPitchV> : Detector pitch in vertical direction (mm) <DetOffsetU> : Detector offset in horizontal direction (mm) <DetOffsetV> : Detector offset in vertical direction (mm) <DetRotAngle> : Detector rotation tilt angle (degree) <DetCenterOffset> : Detector center offset for half beam mode (mm) <ImgFlipU> : Flip projection image horizontal direction (0 or 1) <ImgFlipV> : Flip projection image vertical direction (0 or 1) <ImgCropBorders> : Crop projection image border pixels (pixel) <ImgSkipHeader> : Skip header in projection image (byte) <BitDepth> : Bit depth of the projection image <DetDarkValue> : Detector (Projection image) offset constant value <DetBrightValue> : Detector (Projection image) air constant value <DetBrightAuto> : 'air value' will be estimated from the first projection image <ImgFormat> : Projection image format (UShort16, Short16, Byte8 or Float32) <ImgScaleValue> : This value will be multiplied when loading projection images

<CubeSizeX> : Reconstruction volume width (pixels) <CubeSizeY> : Reconstruction volume height (pixels) <CubeSizeZ> : Reconstruction volume depth (pixels) <CubePitchX> : Reconstruction volume pitch in x direction (mm) <CubePitchY> : Reconstruction volume pitch in y direction (mm) <CubePitchZ> : Reconstruction volume pitch in z direction (mm) <CubeOffsetX> : Reconstruction volume offset in x direction (pixels) <CubeOffsetY> : Reconstruction volume offset in y direction (pixels) <CubeOffsetZ> : Reconstruction volume offset in z direction (pixels) <CubeFlipX> : Reconstructed slice flip along x direction (0 or 1) <CubeFlipY> : Reconstructed slice flip along y direction (0 or 1) <CubeFlipZ> : Reconstructed slice flip along z direction (0 or 1) <PreProcessFilterType> : Smooth filter type for projection images (No, Median) <PreProcessFilterW> : Half kernel width for the projection smooth filter <PreProcessFilterH> : Half kernel height for the projection smooth filter <PostProcessFilterType> : Post processing filter for recon volume (No, Mean, Gaussian) <PostProcessFilterSize> : Half kernel size for post processing filter <BoundaryCorrection> : Boundary correction for outside FOV object (true, false) <ReconValueMinMaxAuto> : 3D will be normalize to volume min/max (true, false) <ReconValueMinValue> : Minimum recon value for normalization <ReconValueMaxValue> : Maximum recon value for normalization <projFolderName> : Folder name which contains projection images <SliceFolderName> : Folder name where recon volume will be written <ProjNameFormat> : Projection image name format (e.g. %04d.raw → 0000.raw, 0001.raw,…) <DarkFrameName> : File name of dark (offset) image for detector correction <BrightFrameName> : File name of bright (air) image for detector correction <CTValuePreset> : Set current 'CT Value Calibration' preset (0,1,2...,etc.) <CTValuePresetUseThird> : Use third material during 'CT Value Calibration' <UseRAR> : Turn on/off RAR (Ring Artifact Reduction) (true, false) <RARDefectColumns> : Set defective columns for RAR (e.g. 100~1000) <RARStrength> : Set RAR strength <MARMinMetalRatio> : Set minimum metal ratio for MAR mode 2 <MARMode> : Set MAR mode (1=MAR mode1, 2=MAR mode2)

< Parameter name in xml project file format >

Appendix : Command line & TCP remote commands

#### [Main UDP command channel]

```
"C:\Users\***\Documents\communication.txt"
-re_log_path
   : Change log file path for command line commands
-re load project "C:\CTDATA\project.xml"
   : Open a project file
-re recon
   : Do 3D Reconstruction
-re recon mar
  : Do 3D Reconstruction using MAR
-re_recon_mar_reuse
   : Do 3D Reconstruction using MAR (Re-use non-MAR recon volume if exist.)
-re save dcm
  : Save reconstructed data as dcm
-re_easy_mode_recon "C:\CTDATA\project.xml"
   : run '-re_load_project', '-re_recon', '-re_save_dcm' and load dcm using VX3D
-re show
   : Show VXRE GUI
-re hide
  : Hide VXRE GUI
-re close
  : Close VXRE process
```

[Idle Check command channel]

-re\_check\_idle
 : true if VXRE is in idle, false if running recon or saving DICOM files
-re\_cancel\_recon
 : cancel the 3D Reconstruction progress

#### < CMD/TCP commands >

- VXRE supports CMD commands and TCP-based commands for remote control

- Each TCP commands are same with Command line method.

- TCP Server in VXRE : VXRE runs TCP server for network communication and opens

6670 port (default value, can be changed in UI) and listen TCP client request.

Scan/Detector Param Volume/Recon Param Extra				
TCP Server Se	tting			
TCP Port :	6670	Restart Server		
Log Out :				
tcp server started with port 6670 [2728] client connected				
R] -re_recon				
wj -re_recon received				
W] -re_recon true				

< TCP Server Setting UI >

When VXRE receives a TCP command, it will return a immediate message (ex. '- re\_recon' received → '-re\_recon received' will be returned). After processing the command, it will return final return message (ex. '-re\_recon true' will be returned).
If VXRE receives '-re\_check\_idle' TCP command, it will return '-re\_check\_idle true' (when idle) or '-re\_check\_idle false' (when doing recon or saving files).
When using command line commands, return values will be saved to the following path

as a log file.  $\rightarrow$  'C:\Users\