XSIT

Sordina **IORT** Technologies

IORT ECHO TPS

IORT ECHO TPS operating flow

Definition of the spatial reference system

3D real-time imaging (US or CT)

3D contouring & 3D planning

3D dose calculation & DVH evaluation

THE PRESENT:

More than 30.000[1] patients have been treated with IOeRT LINACS.

[1] Prof. Felipe Calvo, XX Congreso SEOR, Santiago de Compostela, 5-7 June 2019.

THE FUTURE:

The combination of 3D real time imaging, 3D real time dose calculation and image-guided docking significantly improves clinical practice.

IORT ECHO TPS allows:
- complete and accurate report of the executed treatment;
- the development of extra-breast clinical protocols that implement the current International Guidelines.

The system allows IOeRT team to discuss the optimal strategy for the intervention by using pre-operative DICOM imaging.

Image-guided docking

DVH re-evaluation: TPS validation

Treatment execution

DESCRIPTION and COMPARISON

IORT ECHO TPS description

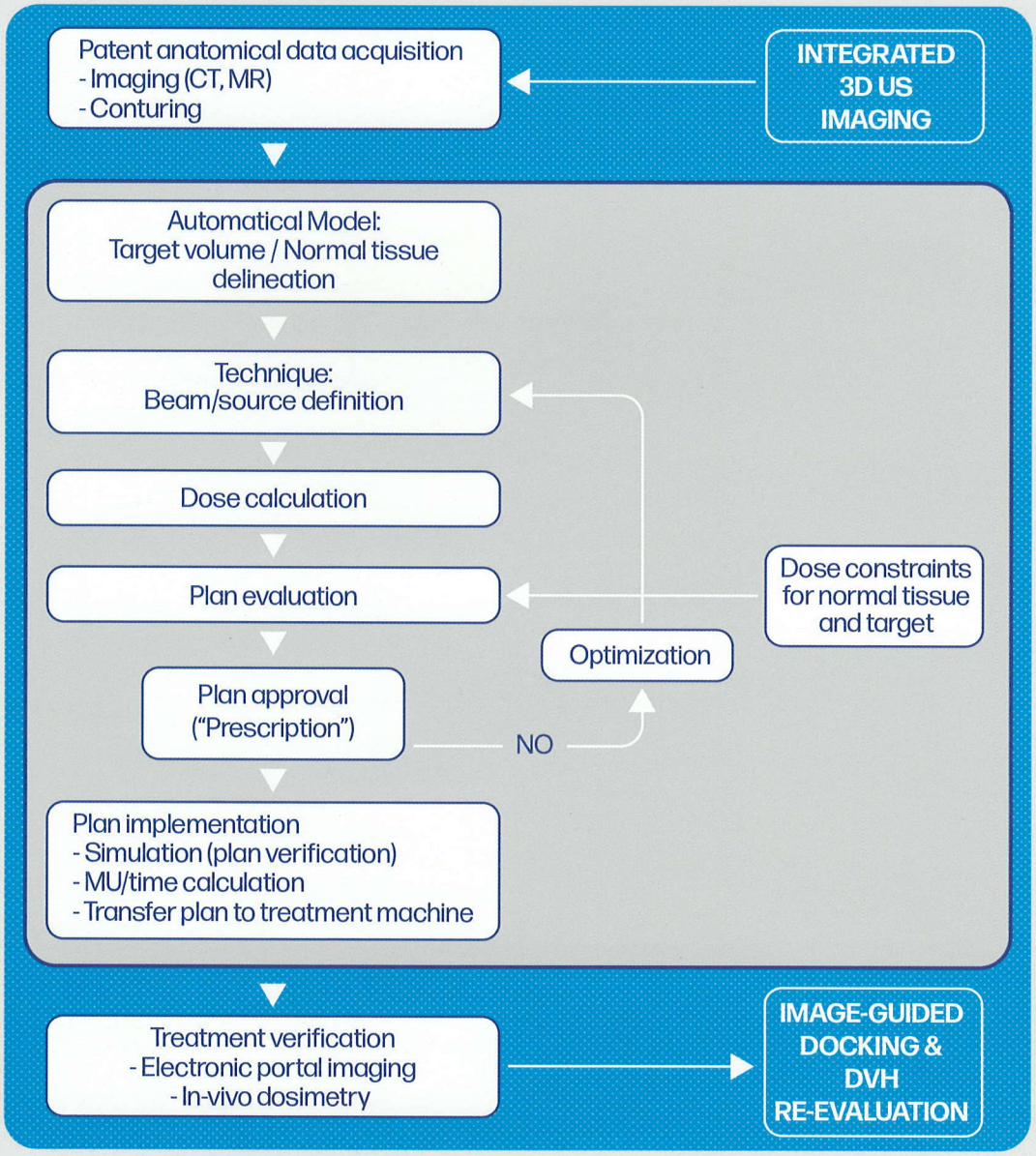
IORT ECHO TPS consists of:

- Tracking unit, the Optical tracker that is the reference system;
- Main Unit;
- US linear probes;
- Navigation, contouring and localization tools;
- Wireless Footswitch;
- Live-CT table (for CT mode only);
- Mechanical arm for applicator positioning.

IORT ECHO TPS tools are positioned in a Common Reference System.

IORT ECHO TPS is more than a STANDARD RT TPS

IORT ECHO TPS provides two additional functions respect a standard RT TPS:
- Imaging, both with US and CT;
- Image-guided docking: applicator positioning guidance and verification of treatment execution.



Reference:
IAEA HUMAN HEALTH SERIES No. 31 Accuracy Requirements and Uncertainties in Radiotherapy

STANDARD RT TPS

IORT ECHO TPS

As generally recognized, US imaging is successfully and widely used in clinical practice within interventional RT.

Imaging, planning and treatment are perfomed during the same session: precision and accuracy are thus greatly enhanced.

Once docking has been completed, DVH re-evaluated in order to precisely determine the dose effectively delivered to the patient.

3D REAL-TIME IMAGING: US and CT MODE

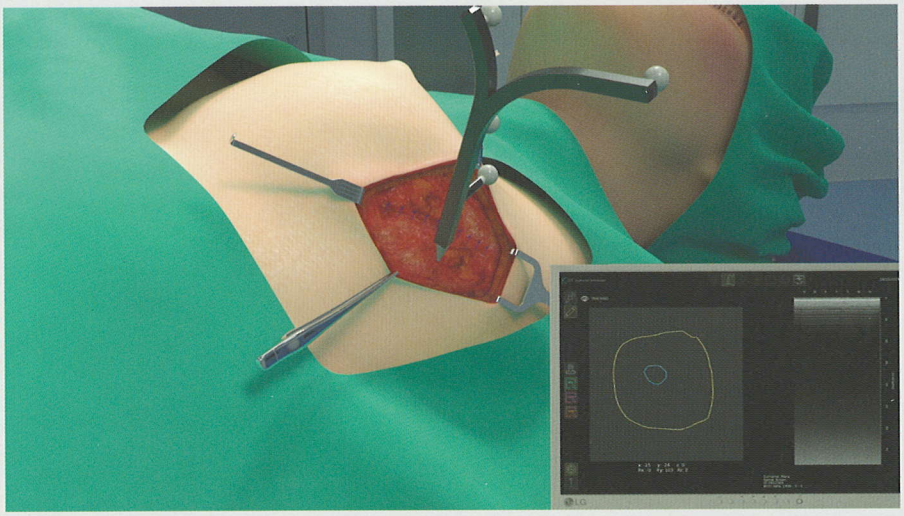
After entering the patient data and selecting the parameters of the treatment planning, the anatomical district to be treated has to be identified.

Subsequently, it is necessary to indicate the imaging mode to be used (US or CT). This section describes the US mode first, CT mode later. After tumor removal, the surgeon starts the tumor bed preparation.

TARGET DEFINITION and 3D US IMAGE ACQUISITION:

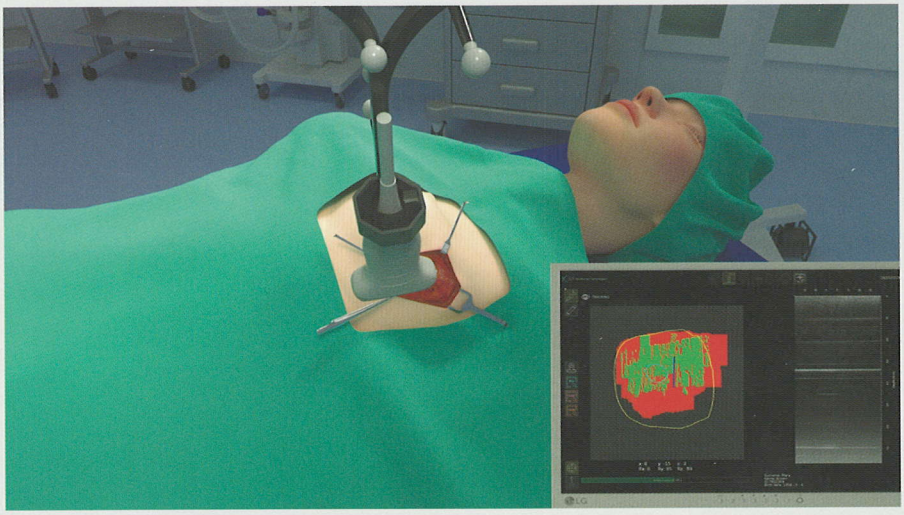
step 1:

By using a navigation tool equipped with special markers, the surgeon identifies the surface to be scanned and regions of interest (as planning target volume or PTV and organs at risk or OARs).



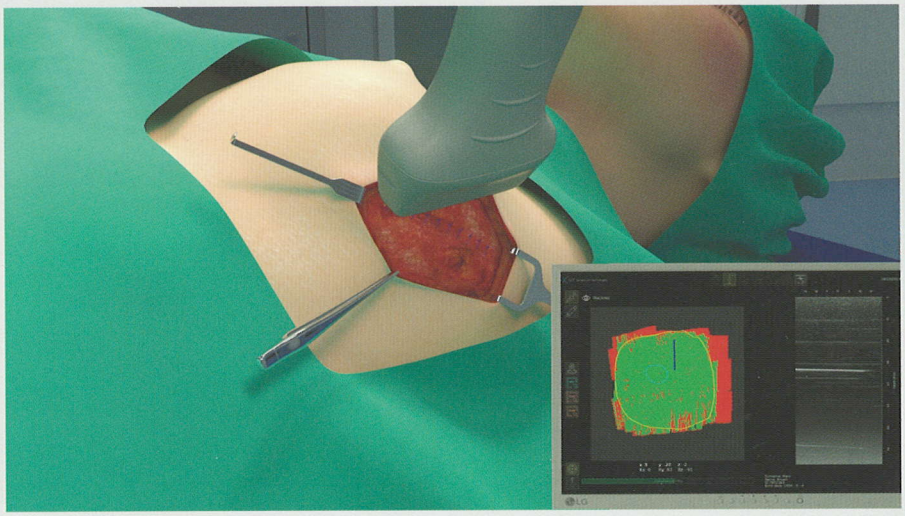
step 2:

By using a US probe - which is referenced in the space by means of an optical tracker - the surgeon acquires US images which are placed by the software in the correct position inside the surface previously identified.



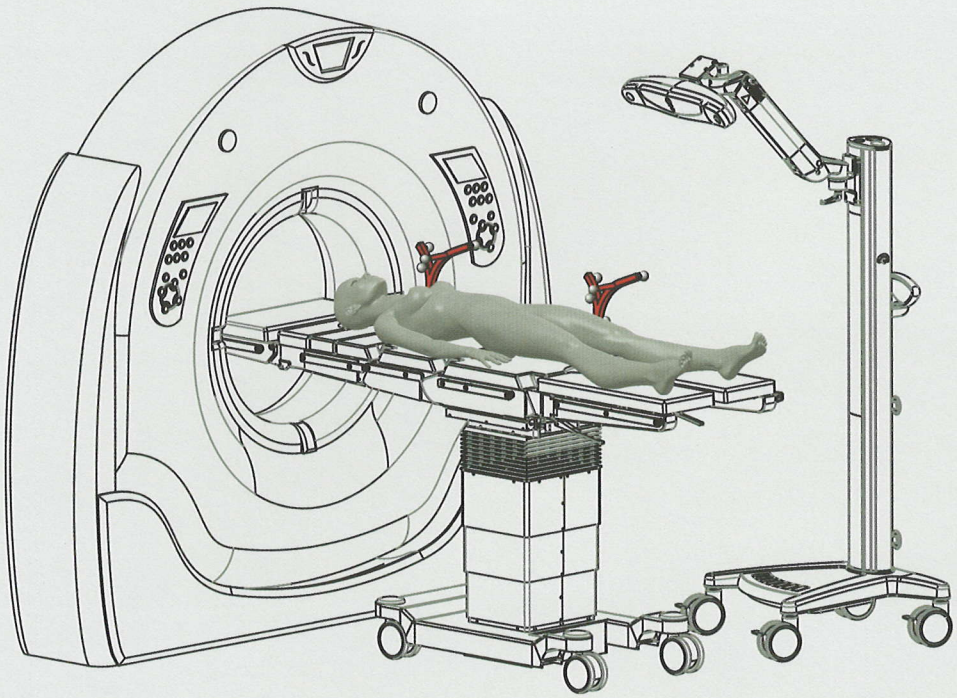
step 3:

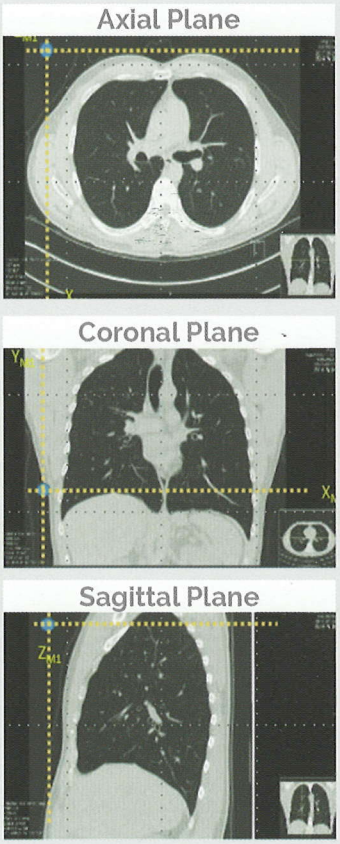
By summing up vectorially these referenced US 2D images, a 3D reconstruction of the target volume is performed. The image acquisition phase ends when each voxel has been correctly acquired. The whole process takes less than 2 minutes.



TARGET DEFINITION and 3D CT IMAGE ACQUISITION:

IORT ECHO TPS acquires DICOM images from any CT and/or CBCT imaging device.
CT image is referenced in the real space thanks to optical tracker, localization tools and "Live CT" table.





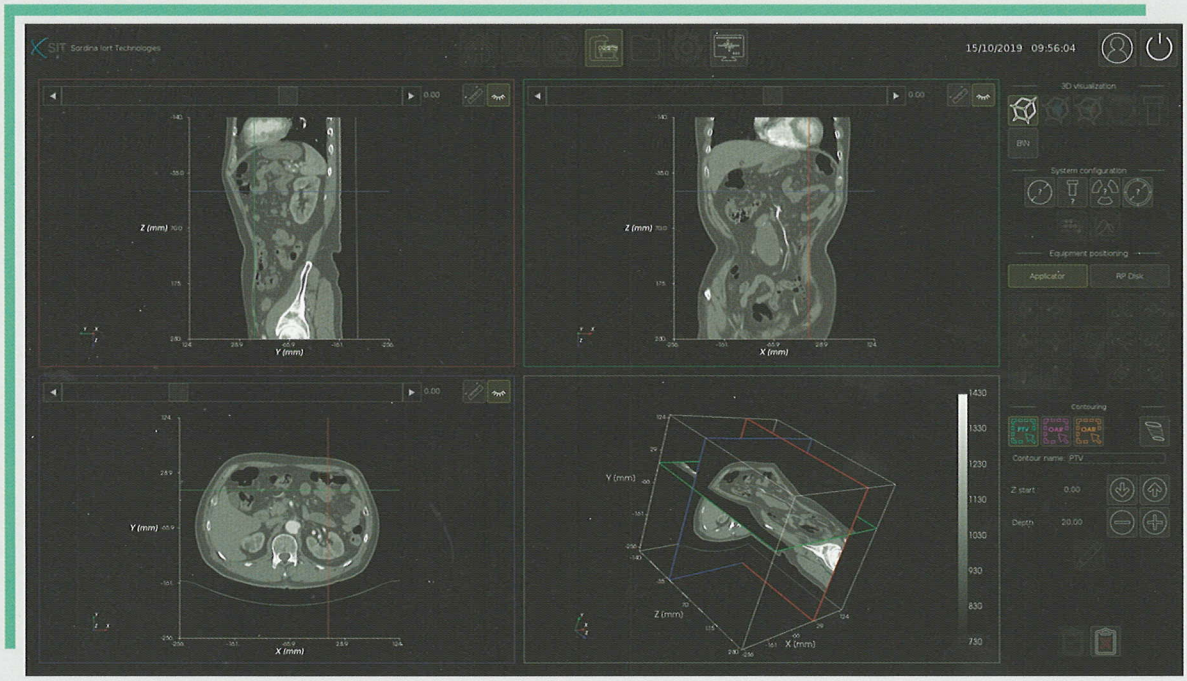


Fig. 1
3D target volume visualization.
3D image (bottom right) and the axial, coronal and sagittal planes view.

Once the target volume has been acquired, the 3D image viewer integrated into the system allows the target volume visualization in 3 orthogonal projections. The 3D image viewer allows the validation of the anatomical model.

3D CONTOURING and 3D PLANNING

DEFINITION AND CONTOURING OF REGIONS OF INTERESTS (PTV, OAR).

The first step consists of identifying PTV and at least one OAR.

Both in CT and US modes, these regions of interest (ROIs) can be either defined in each XY slice or drawn in a single one slice, then extruded for the desired thickness.

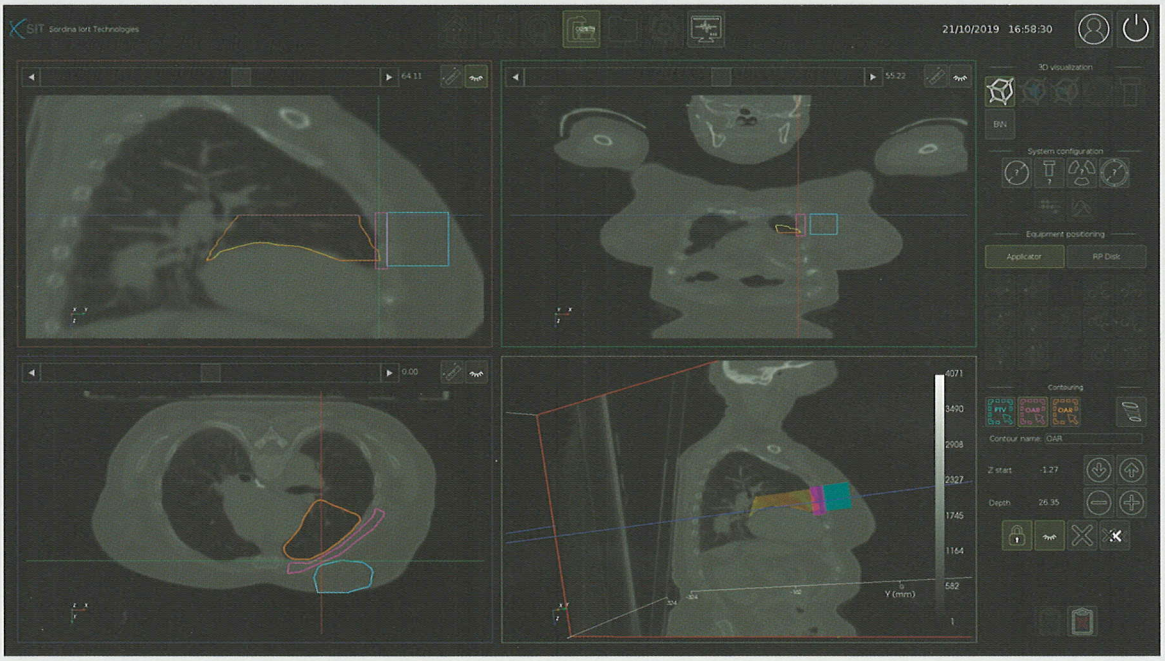


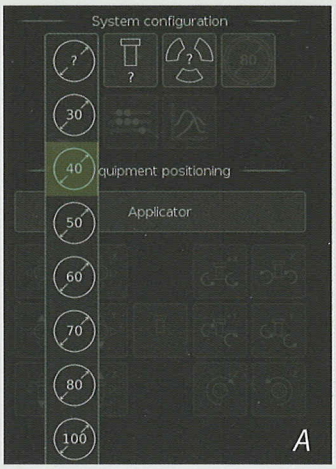
Fig. 2
Example of 3D contouring for an intra-operative CT image.

IDENTIFICATION OF TREATMENT PARAMETERS

Treatment parameters are:

- applicator diameter and bevel angle;
- applicator position respect to the target;
- electron beam energy.

Software allows the virtual applicator terminal positioning. In order to identify the optimal treatment modality, the virtual model of the applicator is moved respect to the target in the virtual environment thanks to its 6 degrees of freedom.



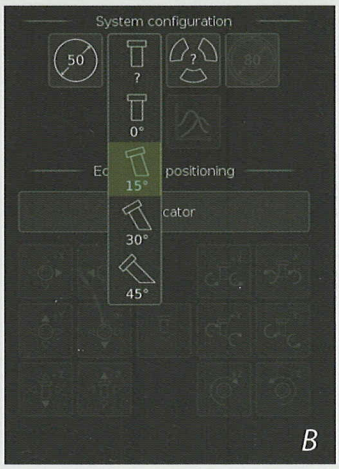
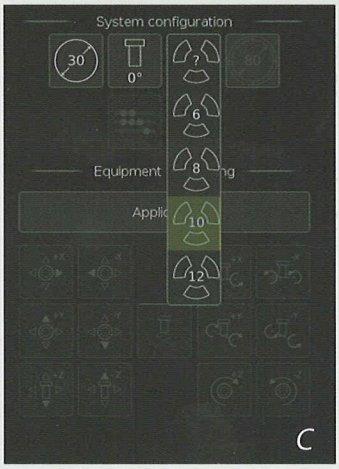


Fig. 3
Applicator size (A) and bevel angle (B) are chosen from a pre-defined list.



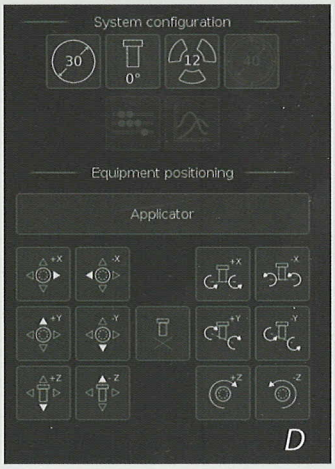


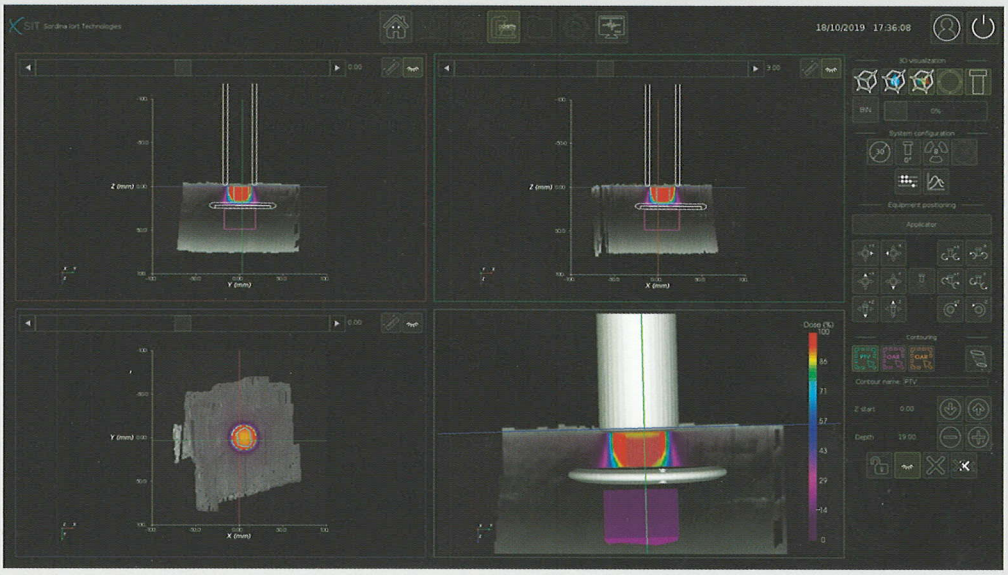
Fig. 4
Electron beam energy selection (C) and virtual applicator positioning menu (D).

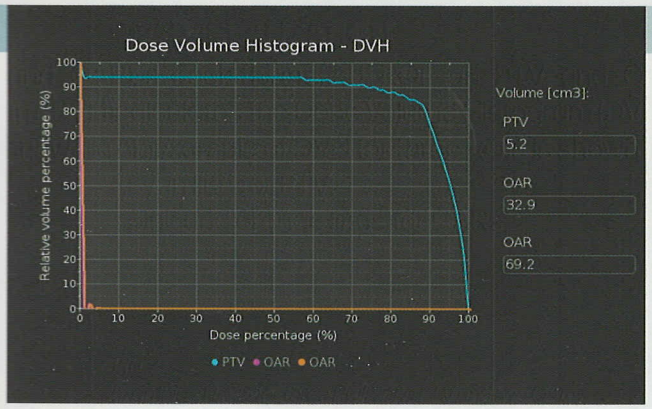
EXECUTION OF REAL TIME 3D DOSE CALCULATION

Once the applicator has been properly positioned, 3D dose calculation is performed.
The dose calculation algorithm is based on Monte Carlo simulation.
The dose distribution calculation can be iteratively repeated, modifying any parameters previously chosen, until the optimal condition for the treatment is obtained.

Fig. 5
Example of real time 3D dose calculation for a target volume based on intra-operative CT image.

Fig. 6
Example of real time 3D dose calculation for a target volume based on intra-operative US image. The radioprotection disc is clearly visible.





DVH VISUALIZATION

For each identified ROI (as PTV and OAR), the software calculates the Dose Volume Histogram (DVH).
An example of DVH for three ROIs is shown in Fig.7:
- cyan line for PTV;
- pink and orange lines for OARs.

Fig. 7
Example of DVH for three ROIs: one PTV and two OARs.

IMAGE-GUIDED DOCKING

IMAGE-GUIDED DOCKING PROCEDURE

It is crucial to guarantee that the dose is delivered exactly as per the plan approved.
IORT ECHO TPS has been designed in order to comply with this specification: IMAGE-GUIDED DOCKING represents the technological answer to this clinical need.
IMAGE-GUIDED DOCKING: the system "observes" the applicator terminal positioning in real time and gives a feedback to the user through an intuitive Human Machine Interface (HMI).
The position of the simulated applicator is shown in white colour in Fig. 8, the real one in red.

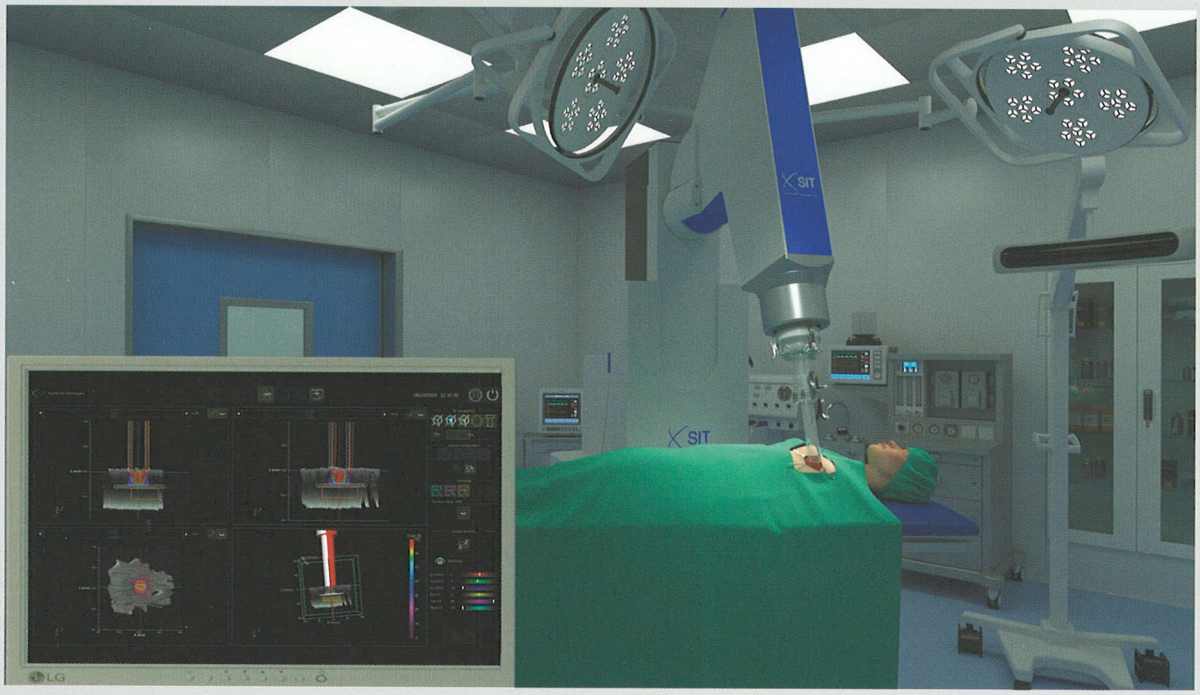
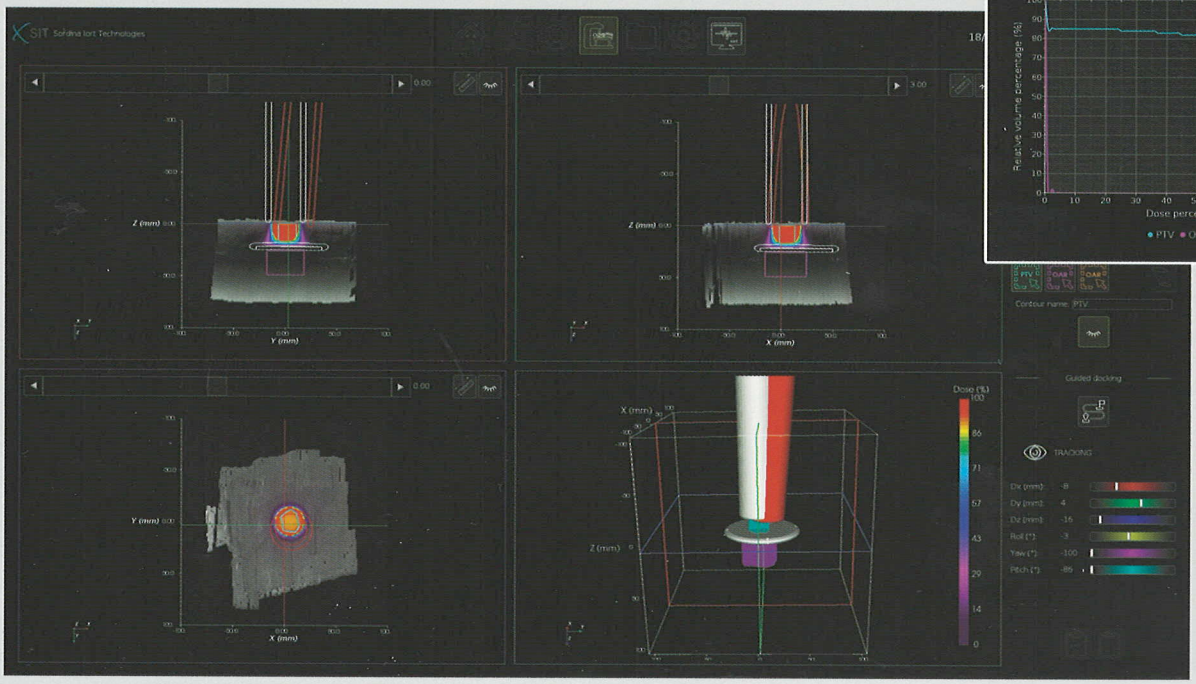


Fig. 8
Image guided docking is correctly performed.

DVH RE-EVALUATION AND TPS VALIDATION

After the docking process is over, and before the final plan validation, DVH are recalculated according the current position of the applicator.
Such feature guarantees that the dose which is delivered is exactly the dose which has been planned.



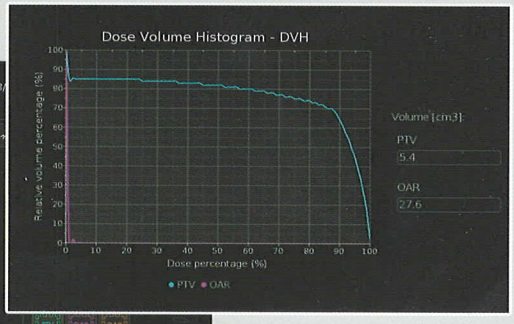


Fig. 9
Incorrect DVH generated by a not proper docking position.

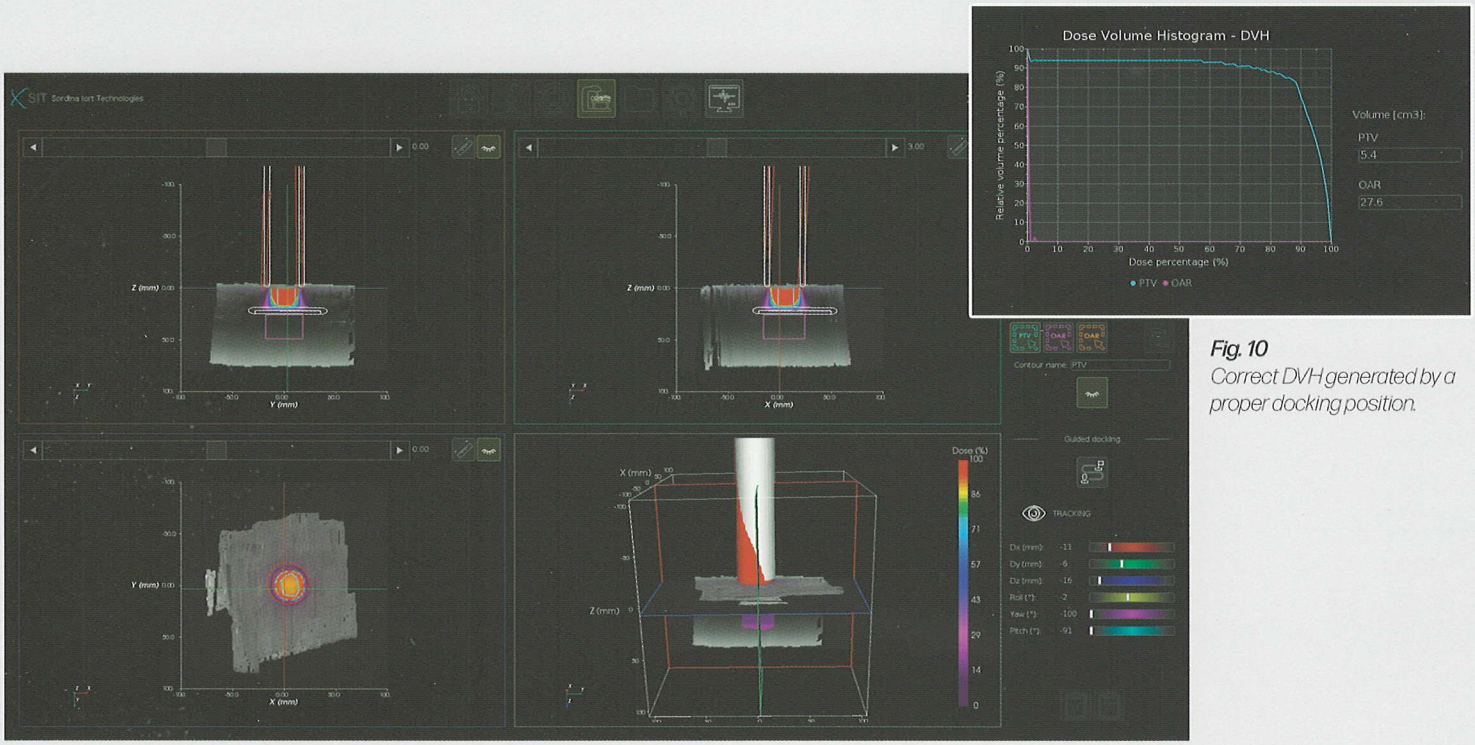


Fig. 10
Correct DVH generated by a proper docking position.

TREATMENT EXECUTION

By inserting the input values of prescribed dose (Gy) and isodose prescription (%), the number of monitor units (MU) is calculated and visualized.
Thanks to the high-dose rate of SIT accelerators, the irradiation time takes less than 1 minute.

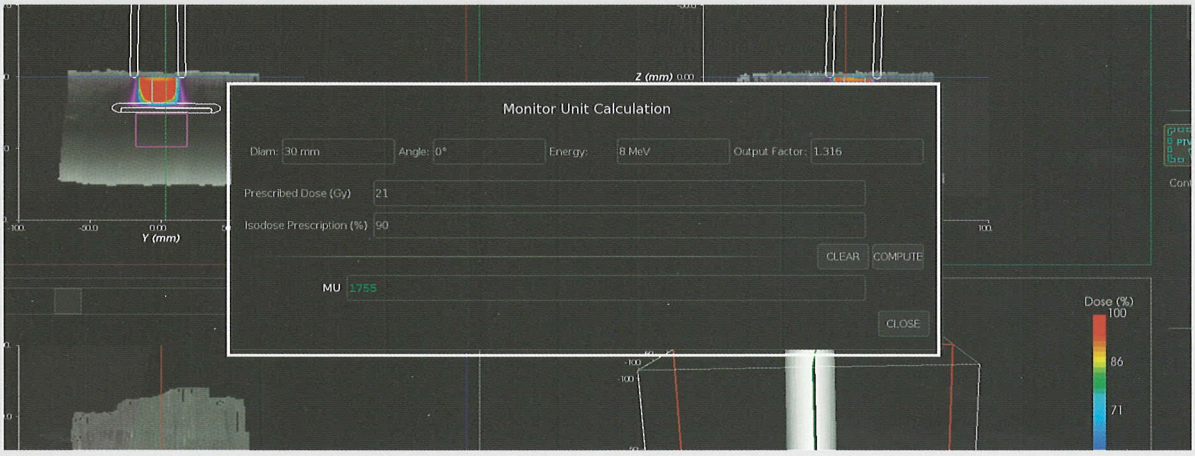
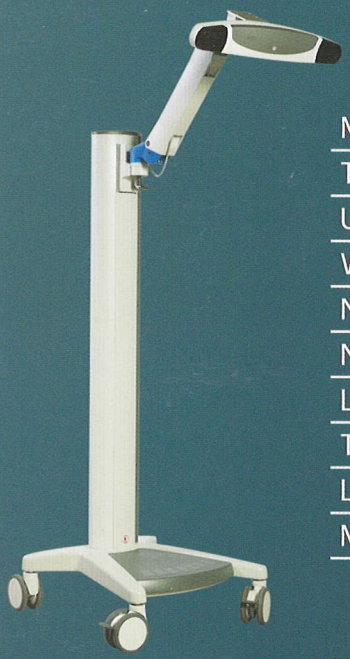


Fig. 11
Example of Monitor Unit Calculation.

TREATMENT REPORT

IORT ECHO TPS generates a complete Treatment Report including all the parameters mentioned below.
- Position and orientation of applicator;
- Applicator's diameter and bevel angle;
- ROIs both in 3D space and 3 orthogonal plans;
- DVH;
- Prescribed dose and isodose prescription;
- Calculated Number of Monitor Units.

Technical Features



- Main Unit
- Tracking Unit
- US probe: 40 mm or 25 mm
- Wireless footswitch
- Navigation Tool for US probe
- Navigation Tool for applicator terminal
- Localization Tool for operating table
- Tool for contouring
- Live-CT table
- Mechanical arm

- Plug & play installation
- TFT flat screen LCD 27" colour monitor
- RAM: 24 Gb
- Laser colour printer (A4 size)
- DICOM RT/3.0 compliant
- Imaging supported: US (integrated) and CT/MRI/PET-CT/PET-MRI
- Connectable with/on any standard record-and-verify and PACS
- Import/export DICOM images
- Dose calculation algorithm based on Monte Carlo Simulation

PATENT PENDING

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