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Abstract

The objective of the PODIUM project is to develop a user-friendly online tool to calculate the radiation dose to workers. This is done by combining positioning information from individual staff members using tracking by 3D cameras, information on the radiation field and the geometry of the room and dose calculation by means of Monte Carlo simulations or a simplified 'look-up' approach.

The aim of WP 3 is to develop the user-friendly online tool to calculate the radiation worker dose. The requirements of this tool were already defined in D9.101. Based on these requirements a web application, the Dosimetry online Calculation Application (DCA), has been developed. The technical modules for the staff tracking and dose calculation have been integrated with the DCA through the use of a runner and module specific wrappers. This deliverable describes the characteristics of the DCA and has the detailed manual as an annex.

TABLE OF CONTENT

I. INTRODUCTION 5
II. MAIN CHALLENGES 5
III. TECHNICAL ASPECTS 5
IV. GENERAL PROCESS FLOW 7
V. CURRENT LIMITATIONS AND OUTLOOK 7

ANNEX DCA MANUAL 1
INTRODUCTION 4
ACCESS TO THE APPLICATION 6
DASHBOARD 8
USER PROFILE AND SETTINGS 9
CONFIGURATION 10
PROCEDURE CREATION 18
DOSE CALCULATION 24
DOSE MONITORING 26
ANNEX I - DOSE CALCULATION APPROACHES 28
ANNEX II - DOSE CALCULATION RUNNER 29
ANNEX III - UPLOAD OF OFF-LINE PROCEDURES 30
ANNEX IV - SUPPORTED RDSR 32
ANNEX V - LOCALIZATION 36
GLOSSARY 36

I. Introduction

Within PODIUM the different partners worked on several challenges such as staff tracking, definition of the workplace geometry, definition of the radiation source and calculation of the staff doses. But in the end it was of course also needed to combine all these developments in a way such that staff doses can be calculated by non-specialists in a user-friendly way. To do this it was required to develop a web application, the Dosimetry online Calculation Application (DCA) that connects with the different technical modules for staff tracking and dose calculation. The development of the DCA and the integration with the different technical modules was not straightforward and involved several challenges.

II. Main challenges

Firstly, it was needed to define the requirements for the DCA. Which functionalities should be included? How should the screens look like? How should the DCA interact with the technical modules? The requirements were defined in the beginning of the project and were reported in D9.101.

After defining the DCA requirements a suitable software developer had to be found. The developer had to be sufficiently flexible in order to accommodate our evolving requirements. Furthermore, we also had to stay within the foreseen budget. The original idea was to work with an external IT company in Belgium by subcontracting through SCK•CEN. However, due to limited flexibility and high prices of the Belgian IT companies, it was decided to go for another approach. A software developer, Ariel von Barnekow, was hired through UPC and was dedicated to the DCA development. This turned out to be an efficient approach, because Ariel was very much involved in the project and able to join the PODIUM meetings and assisted also with the development and integration of the technical modules.

During the actual development the biggest challenge was to align the teams working on the different technical modules. The input and output data and the data format need to be consistent between the different modules in order to integrate them with the DCA. Furthermore, also translating from what the scientists want to what the software developer can implement involved quite some effort.

III. Technical aspects

The technical aspects of the software will not be discussed in detail, as this is outside the scope of this deliverable. Only the general idea will be sketched. The development of the DCA and the integration of the technical modules required the use of a large variety of different technologies. An overview of the used technologies is shown in figure 1. The structure of the software is shown schematically in figure 2. The users interact with the DCA through the web application. The DCA and the corresponding database are hosted on a dedicated server at UPC together with an API for runner authentication and for retrieving data from and uploading data to the database. The runners for the dose calculation modules are running on a separate server at UPC. Computationally demanding calculations can be run through Secure Shell Connection (SSH) on the UPC computer cluster. The runners for the staff tracking run on a local computer at the workplace. The communication of the web application, the dose calculation server, the tracking server and the computer cluster with the DCA server goes through Hypertext Transfer Protocol Secure (HTTPS).

Figure 1: Technologies used for the development of the DCA and the integration of the technical modules

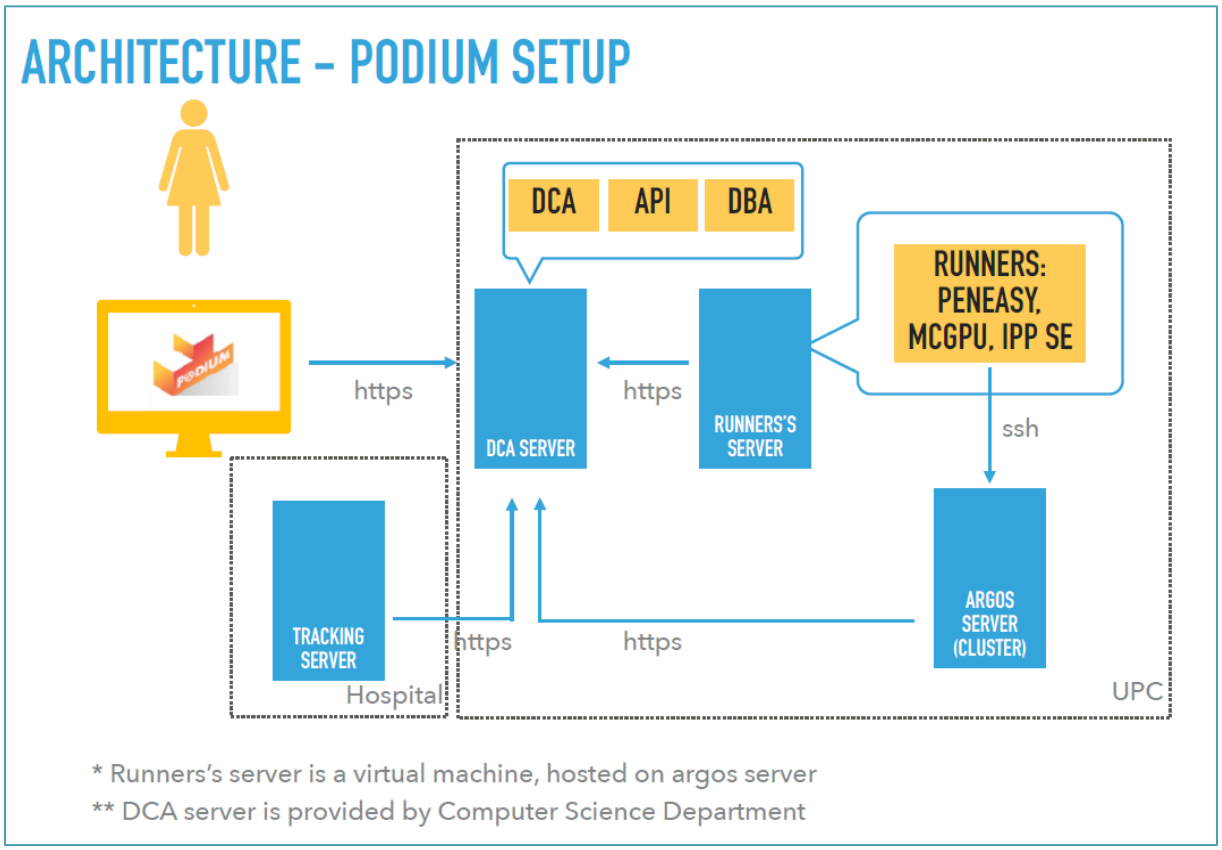


Figure 2: Schematic representation of the software architecture

IV. General process flow

The DCA is based on different user profiles, each which its particular responsibilities and possibilities:

- Monitored worker: See personal doses
- Procedure operator: Create new procedures, start/stop procedures
- Radiation protection expert: See worker doses
- Dose calculator: Launch dose calculations
- Administrator: Data management

Before a procedure can be created, the workplace, radiation source, procedure type and worker data need to be defined. When all these data are available, a procedure can be created. The procedure can be started once the connection with the staff tracking runner is established. After stopping the procedure and making sure that the radiation source history is uploaded, the dose of the monitored worker for the procedure can be calculated. The doses of previous procedures can be consulted afterwards.

All the details of the process flow are included in the DCA manual in annex of this deliverable.

V. Current limitations and outlook

The different features of the DCA were tested extensively by test cases in hospitals. However, as the DCA and the tracking and dose calculation modules were still under development during the project, these tests were always partial. Therefore, it is planned to test now the complete process flow with the final version of the DCA and the tracking and dose calculation modules by tracking staff in interventional radiology in Belgian and Swedish hospitals after the project. But no big issues are expected here because of the previous partial tests.

The DCA developed during the PODIUM project is a prototype to proof the feasibility of the PODIUM approach. In the future the functionalities of the DCA can be extended in different ways:

- Currently, the DCA is targeted towards the use in hospitals for interventional radiology. In the future the DCA should be extended towards other user cases such as neutron workplace fields. The DCA is made in a modular way such that its use can in the future be extended towards other applications relatively easily.

- Currently, the DCA does not yet calculate doses in real-time. The problem is that the data from the X-ray console cannot be obtained in real-time. Therefore, the X-ray data need to be uploaded manually after a procedure using the RDSR file and only then the dose for the procedure can be calculated. By collaboration with manufacturers it should be investigated how direct communication with the X-ray system can be established. This will then also allow moving towards real-time dose calculation.

- Currently, the doses can be consulted by clicking on the procedure of interest. However, for the future it would be useful to have data grids with filters and graphs to allow more detailed investigation of worker doses over time.

Annex DCA manual

PODIUM

DOSIMETRY ONLINE CALCULATION APPLICATION

USER MANUAL

2019.12.19

USER MANUAL

ANNEX DCA MANUAL **1**

INTRODUCTION **4**

INSTALLATION OPTIONS 4
ROLES 5
Features by role *5*

ACCESS TO THE APPLICATION **6**

LOGIN 6
LOGOUT 6
USER REGISTRATION 7
PASSWORD RECOVERY 7
ACCOUNT CONFIRMATION 8

DASHBOARD **8**

USER PROFILE AND SETTINGS **9**

LANGUAGE AND REGION 9
PASSWORD CHANGE 9

CONFIGURATION **10**

WORKPLACE DETAILS 10
Room *10*
Radiation Source Machines (C-Arm) *11*
Room objects *11*
Protections *12*
Procedure Types *13*
TRACKING SYSTEM INSTALLATION 14
DOSE CALCULATION INSTALLATION 14
GRANTING ACCESS TO USERS 16

PROCEDURE CREATION **18**

TURN ON TRACKING SYSTEM COMPUTER 18
Launch tracking system application *18*
PROCEDURE CREATION 18
PROCEDURE CONNECTION 20
Procedure debug Information *22*
PROCEDURE MONITORING 22
FINISH THE TRACKING SYSTEM SESSION 22
RDSR FILE UPLOAD 23

DOSE CALCULATION **24**

CALCULATE MONITORED WORKER DOSES 24
MARK AS COMPLETED 25

DOSE MONITORING **26**

VIEWING OWN DOSES 26
VIEWING WORKER DOSES 27

ANNEX I - DOSE CALCULATION APPROACHES **28**

IPP SE *28*

MCGPU IR *28*
Penelope/ PenEasy IR *28*

ANNEX II - DOSE CALCULATION RUNNER **29**

Technical details *29*

ANNEX III - UPLOAD OF OFF-LINE PROCEDURES **30**

ANNEX IV - SUPPORTED RDSR **32**

RDSR FILE FORMATS 32
Supported RDSR file formats *32*
Other RDSR file formats *33*
ANONYMIZATION 33
Anonymization tools *33*
Excel format *33*
Comparative *34*
LIST OF RDSR FIELDS 35

ANNEX V - LOCALIZATION **36**

GLOSSARY **36**

Introduction

PODIUM-DCA is an online dosimetry application based on computer simulations, which will calculate the occupational ionizing radiation doses, without the use of physical dosimeters. The operational quantities, protection quantities and radio-sensitive organ doses (e.g. eye lens, brain, extremities, etc.) are assessed based on the use of modern technology such as personal tracking systems, flexible individualized computational phantoms, scanning of geometry set-up and Monte Carlo computer simulations.

This document covers the installation and usage of PODIUM Online Dosimetry Calculation Application, from now on called DCA.

Installation options

DCA is composed of three different components:

1. Tracking system
2. Web application
3. Dose Calculation system

The first component, a motion tracking system, needs to be installed in the room where the radiation source is installed. It will be used during procedures to monitor and store the worker positions.

The second component, the web application, will be used to introduce the information required to calculate the doses, control the tracking system, launch the dose calculation system and display the doses. This component is provided as a *cloud service* or can be installed on your facilities (self-hosted).

The third component, the dose calculation system, will calculate the doses of your workers. This component is provided as a *cloud service* or can be installed on your facilities.

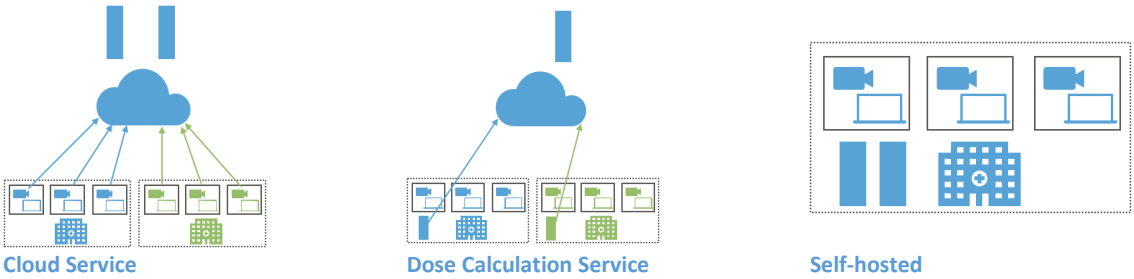


Figure 1 Installation options

To sum up PODIUM-DCA can be obtained as:

1. Cloud Service: which requires a simpler setup on your facilities, although you will have to send data to PODIUM servers.
2. Dose Calculation Service: you will only use PODIUM servers to calculate doses. Anonymized data will be sent to PODIUM-servers.
3. Self-hosted: all components will be installed in your facilities.

Roles

PODIUM-DCA is targeted to different types of users: the staff of the hospital working with X-Rays, *Monitored Worker (MW),* the *radiation protection experts (RP)* (who controls monitored worker doses) and the *manager* from the hospital (MG) (who configures the application and grants access to the different users).

Moreover, three support roles are also provided: *Procedure Operator (PO)*, to restrict the staff that can introduce procedure information, *Dose Calculation Expert (DC)* and *Image Processing Expert (IP)* which provide access to details related to the connection of the dose calculation and the tracking system.

Every user of the application can have one or more roles, usually manager users have all the roles, so they can access to all the features to the application. Some of these roles can be merged into one person if wanted.

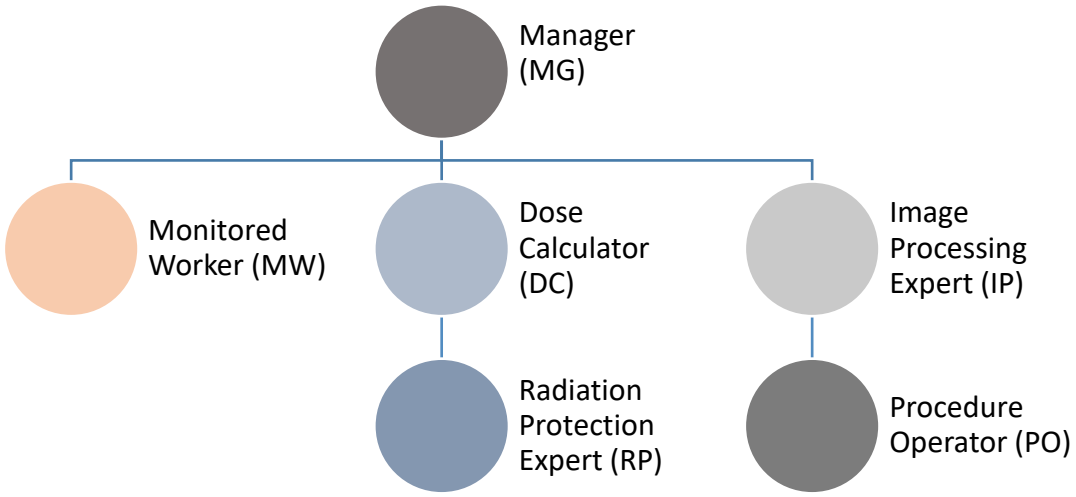


Figure 2 Role hierarchy

Features by role

The table below defines the features of DCA available for each role. If a user has more than one role they will have access to the features provided by each of them.

	MW	PO	IP	DC	RP	MG
Login	X	X	X	X	X	X
Modify profile	X	X	X	X	X	X
Modify preferences	X	X	X	X	X	X
Be tracked	X					
View own doses	X					
View others doses					X	X
Create a procedure		X	X	X	X	
Edit non-started procedure		X	X			
Delete non-started procedure		X	X			
Track procedure		X	X			
Upload RDSR		X				
Calculate Doses				X	X	
Manage workplace						X

Access to the application

All users with an account on PODIUM-DCA will need the URL of the website and their credentials to access to it. For example (these credentials will not grant access to the website):

DCA URL: https://podium.cs.upc.edu
Username: *demo*
Password: *demo*

The URL of DCA will be defined during DCA cloud service acquisition or when doing the installation at the institution; the user credentials will be defined by a *Manager* or by the user itself as it is explained below.

Login

The login page (Fig 3) will be displayed to all users if they have not introduced their credentials or if their session has expired.

This page is displayed using the language requested by the browser, if it is available on DCA. Otherwise, it will be displayed in English.

After introducing their credentials users will see their Dashboard, the information displayed there will be defined by their roles.

Logout

In order to close the session, the user needs to click on its profile icon (top-right corner; Fig 4)), and click on **Logout,** this option is available for all users after login in the system. If access to DCA is done from a shared computer closing the session is important.

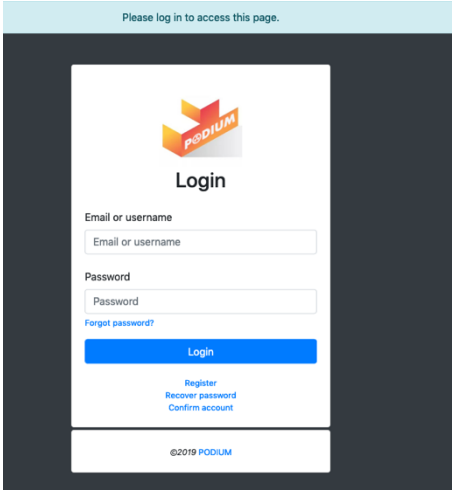


Figure 3 Login page

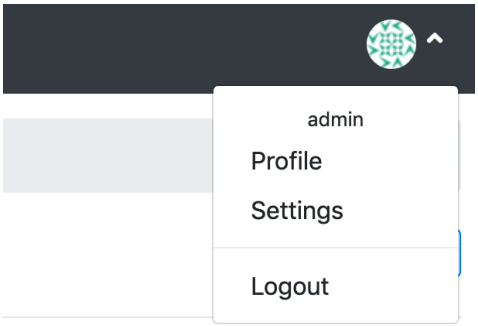


Figure 4 User menu option with logout

User Registration

If enabled, users can register themselves, otherwise an admin user should create their account. Registration can be accessed using the link from the bottom of the login page.

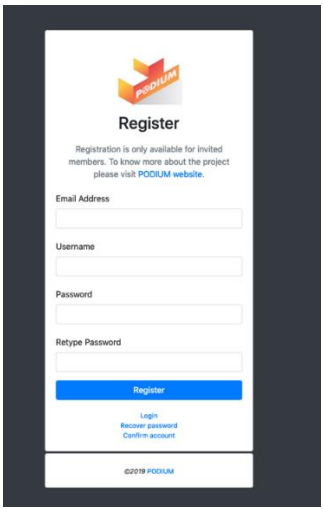


Figure 5 Registration page

After filling the form an email will be sent to the registration email address containing a link to confirm the account.

Once confirmed, the user will be able to login to his account.

System administrators can define the roles, for the new users, by default. The default role is *Monitored Worker (MW)*.

Password recovery

note: this feature may not be available on all DCA instances as it can be disabled by system administrators.

If users forget their password they can use Forgot Password/Recover Password to set a new one. This will display them the recover form.

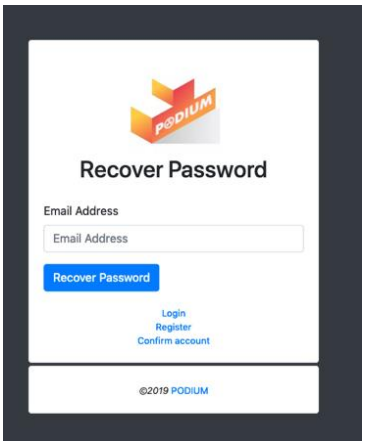


Figure 6 Password recovery

After filling the recovery form an email will be sent to the email of the user. It will contain a link to set a new password.

Account confirmation

note: this feature may not be available on all DCA instances as it can be disabled by system administrators.

Users registered by themselves or users created by an administrator may be requested to confirm their account. Users will have to click a link received to their email account or copy the URL to their browser. The administrator may choose if a created account needs to be confirmed or not.

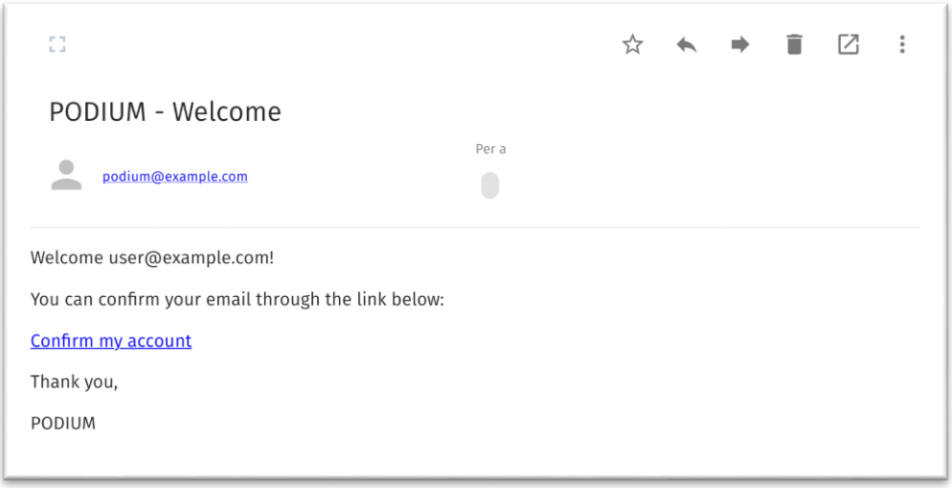


Figure 7 Confirmation email

If the confirmation link has expired, or the user has not received the email, they can request a new confirmation email by using the Account confirmation link from the login page.

Dashboard

After login, users will see their dashboard. There, users can see their roles, a quick start guide and have access to their profile and settings and all the different features available for their roles.

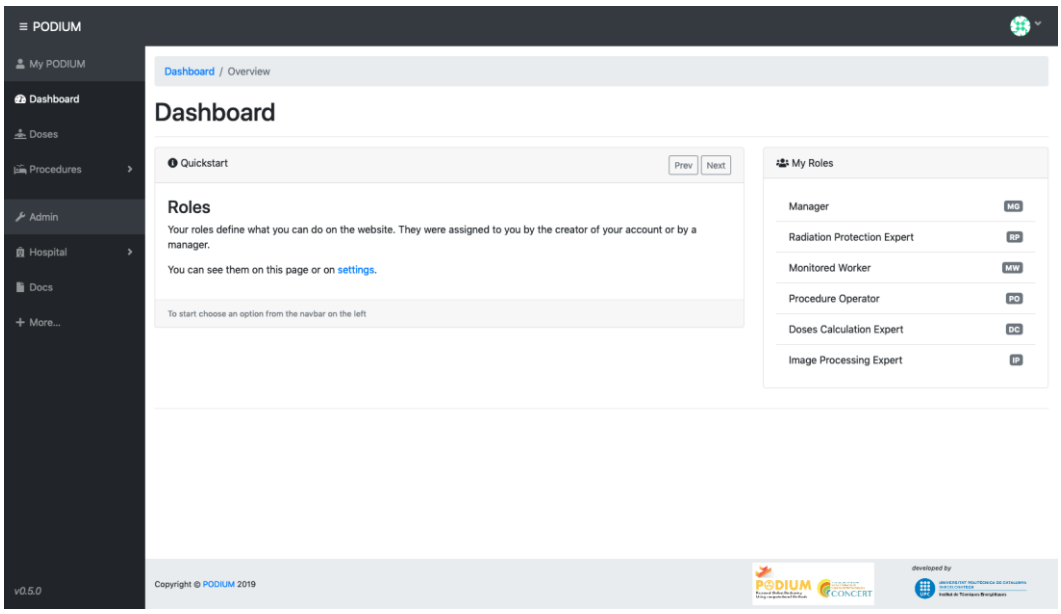


Figure 8 Dashboard for admin users

User Profile and Settings

All users have a profile and a user settings page. They are accessible through the user avatar image in the upper right corner of the screen.

Some of the profile information is shared among other DC and RP users, while other information is kept private to the users and managers, like the user email and birth year.

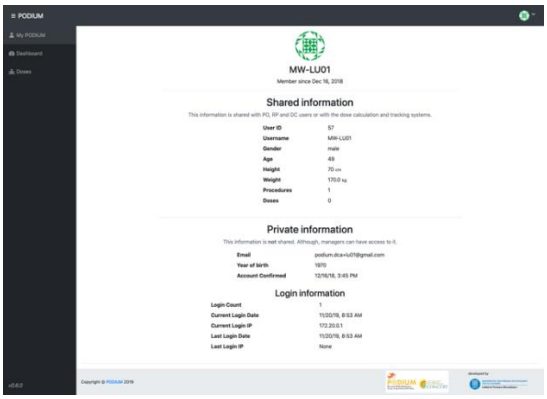


Figure 9 User profile

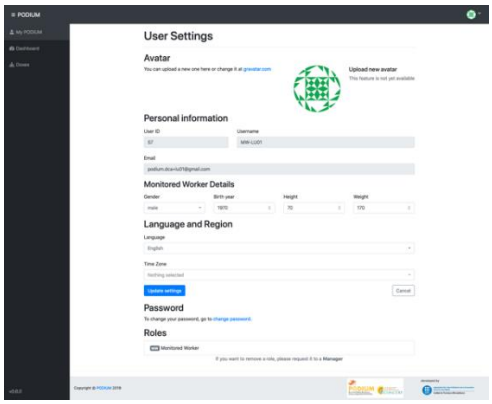


Figure 10 User settings

Under user settings, users will be able to define/update their monitored worker details (gender, birth year, height and weight) and set their preferred language and time zone.

In this page, users have access to change their password.

Language and Region

Users can configure the language of DCA and the time zone this way they can see the content using their preferred language and date format.

Password Change

All users can change their password, this option is accessible through their user settings, to change the password users must introduce the old one and twice the new one.

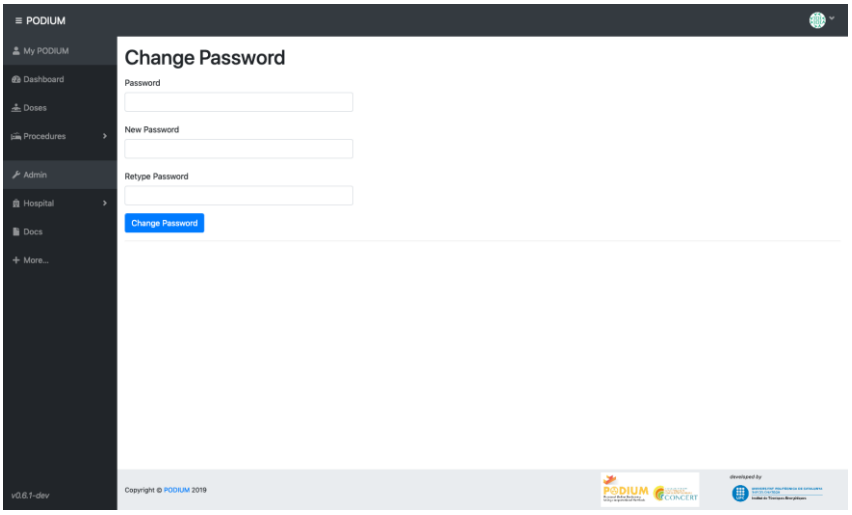


Figure 11 Change password form

Configuration

Role Required: Manager (MG)

Manager (MG) users have access to the DCA administration area. This area allows to configure DCA to adapt it to a specific workplace, setting the environment and the members.

Workplace details

Dose calculation requires information about the workplace, like the equipment available and characteristics. All the data required are aimed either to do the dosimetry calculation or to help workers understand where doses come from.

Room

Rooms are composed by a radiation source, C-arm, a set of relevant objects for the dosimetry calculation, for example a ceiling shielding and a set of geometry properties.

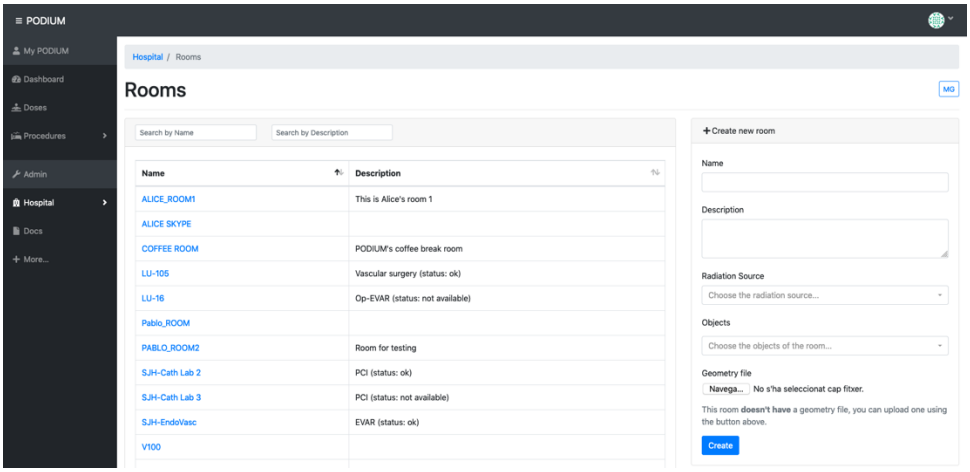


Figure 12 Room listing and creation

Radiation sources and objects from different rooms may have the same characteristics, in this case they can be reused.

Room geometry file

The geometry proprieties are stored in a text file. This file is in JSON format and contains the variables to represent the minimal geometry necessary for the dosimetry calculation:

- Distance Floor to Isocenter (mm): the distance from the floor to the isocentre in millimetres.

The file containing this information can be created using a text editor and it must contain the variables identifiers and its values, for example:

```
{
    "dfi": 1080
}
```

Figure 13 Room geometry file example

Radiation Source Machines (C-Arm)

Each room contains a single radiation source (C-arm), this machine is identified by a name, usually the manufacturer name, a description and optionally a specification file.

The specification file contains behaviour specific details of the radiation source.

If your institution has more than one machine of the same model, only the first one needs to be introduced into the system.

Room objects

Together with the radiation source, rooms may have ceiling shielding or movable objects used during procedures which may have effect on the dose received by the staff.

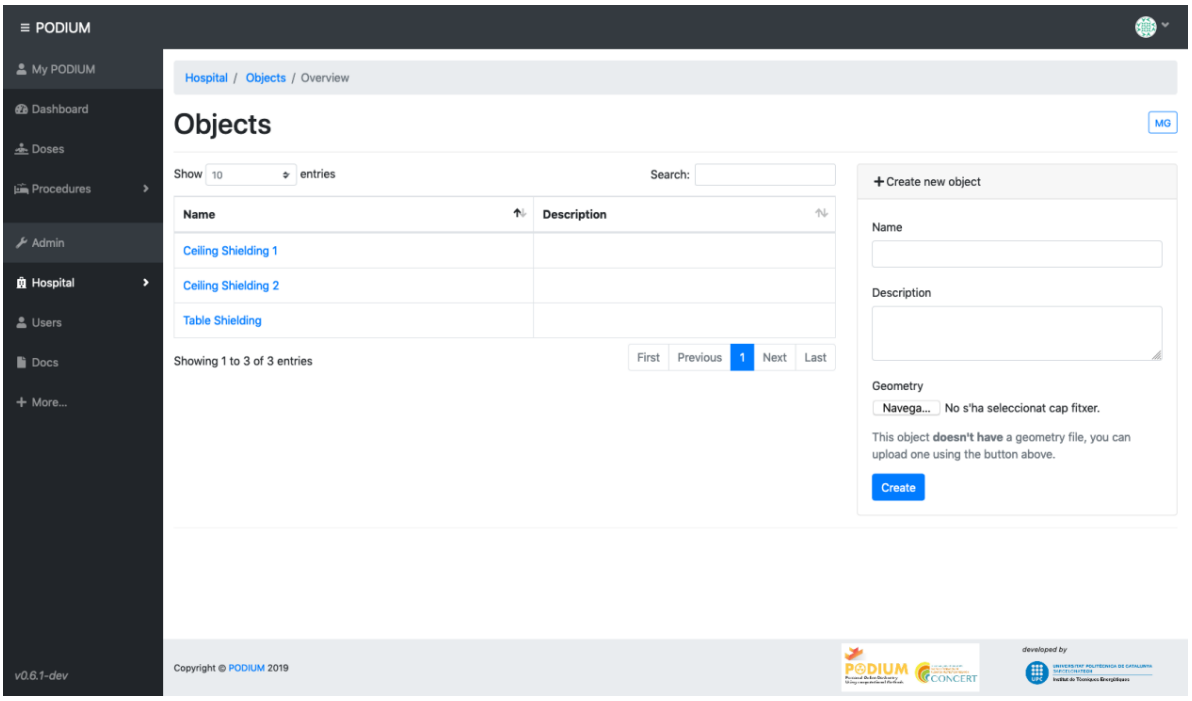


Figure 14 List of objects

These objects can be created on the website by specifying its name and a description.

The geometry file contains relevant data of the object in order to calculate its influence in the dose calculation. Its basic shape representation is usually enough (width, height and thickness) and its material. For example, a shielding of 0.5mm lead equivalent thickness:

- Thickness: 2cm
- Equivalent thickness: 0.5mm Pb
- Width: 40 cm
- Height: 50 cm

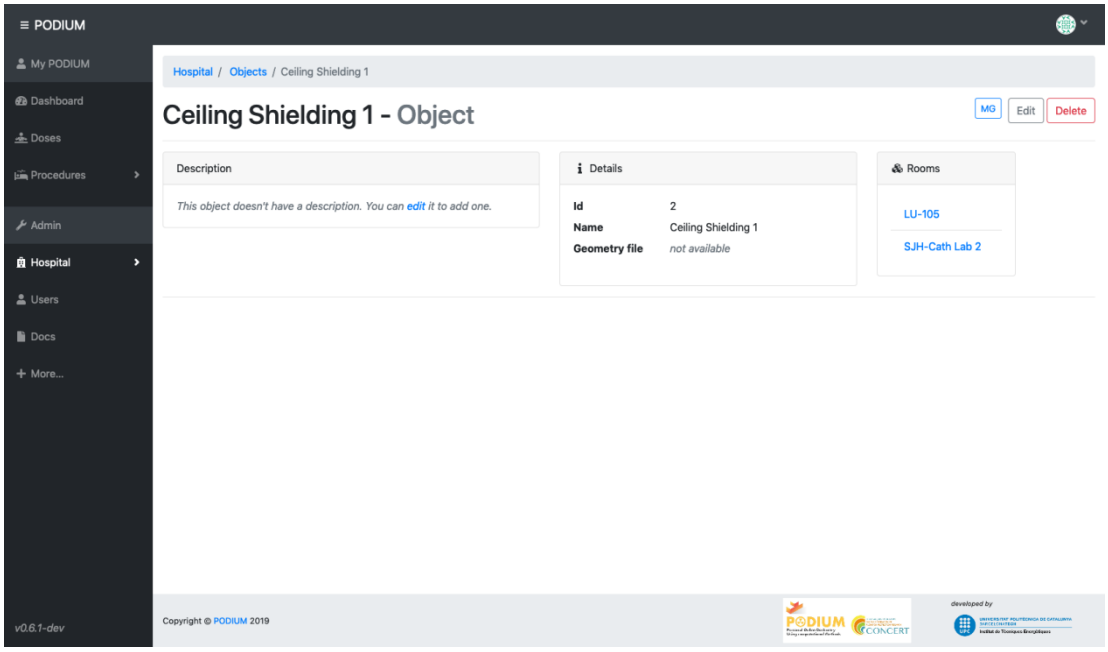


Figure 15 Object details

Room creation

Once the radiation source and the objects of the room are available in the system, the room can be created. If one of the objects is missing or replaced, it can be edited afterwards to reflect the changes after creation.

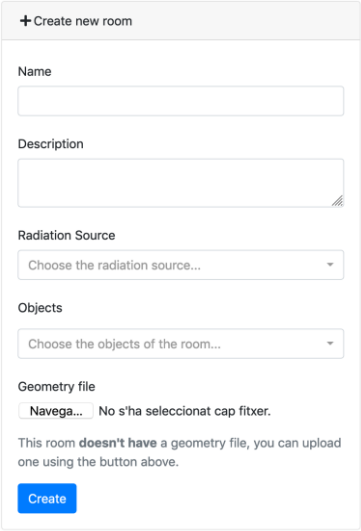


Figure 16 Room creation

The room details page is displayed just after it is created, displaying there the information required to configure the tracking system communication with DCA.

Once created rooms can be edited, and deleted only if they have not been used in any procedure.

Protections

During procedures staff members can wear different personal protection elements, like lead cap, lead apron … These protections need to be created in DCA, specifying its name, description and geometry.

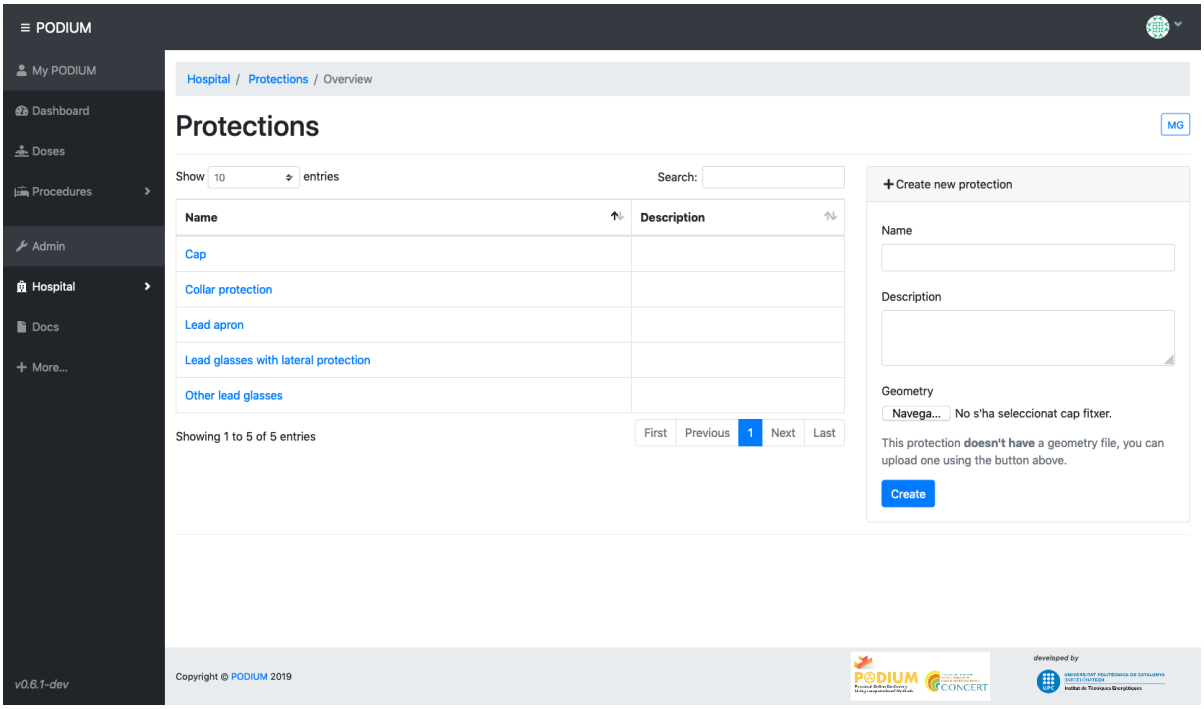


Figure 17 Protections

Procedure Types

In order to identify a procedure and help the staff to recognize it, a type of predefined procedure is associated to it. The types available are created by the managers of DCA.

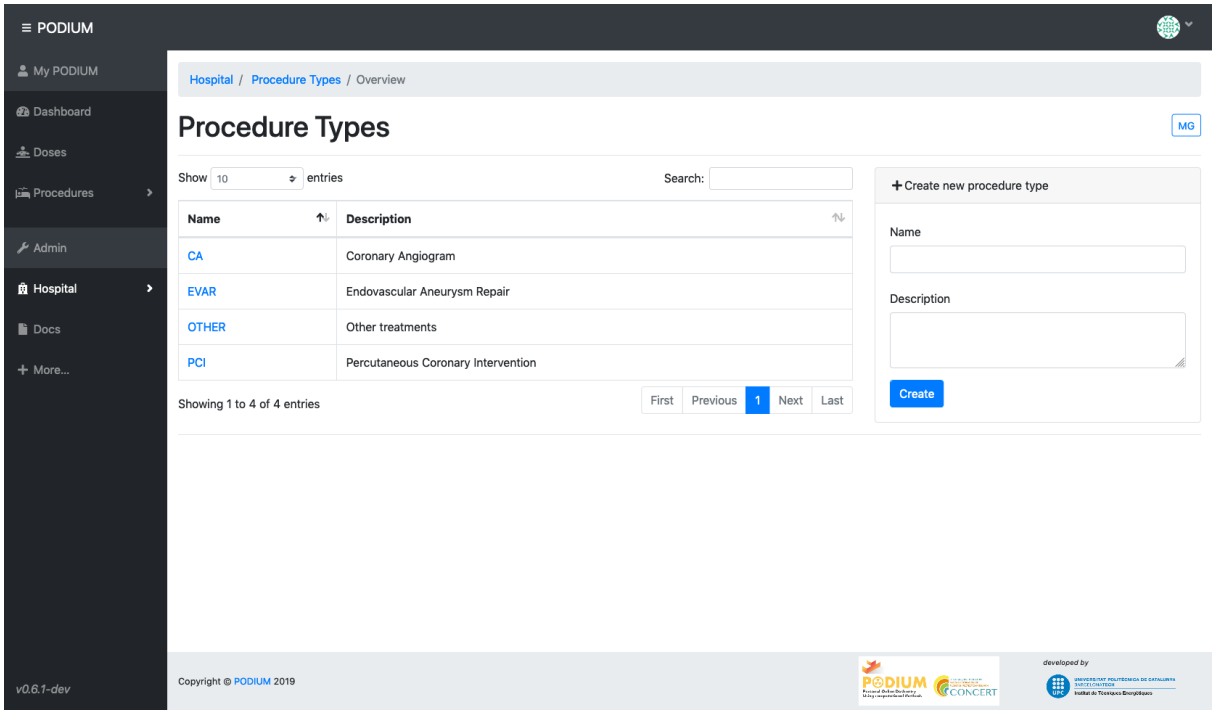


Figure 1 Procedure Types

Tracking System Installation

The first time the tracking system is turned on it will ask to configure the connection with DCA.

The configuration of the connection will ask for:

- URL: the URL of the PODIUM-DCA instance
- Room Registration Token: the token provided during the room creation to register the tracking system. This information is available to Managers of PODIUM-DCA, in the details of each Room, see image below, when the tracking system has not been registered.

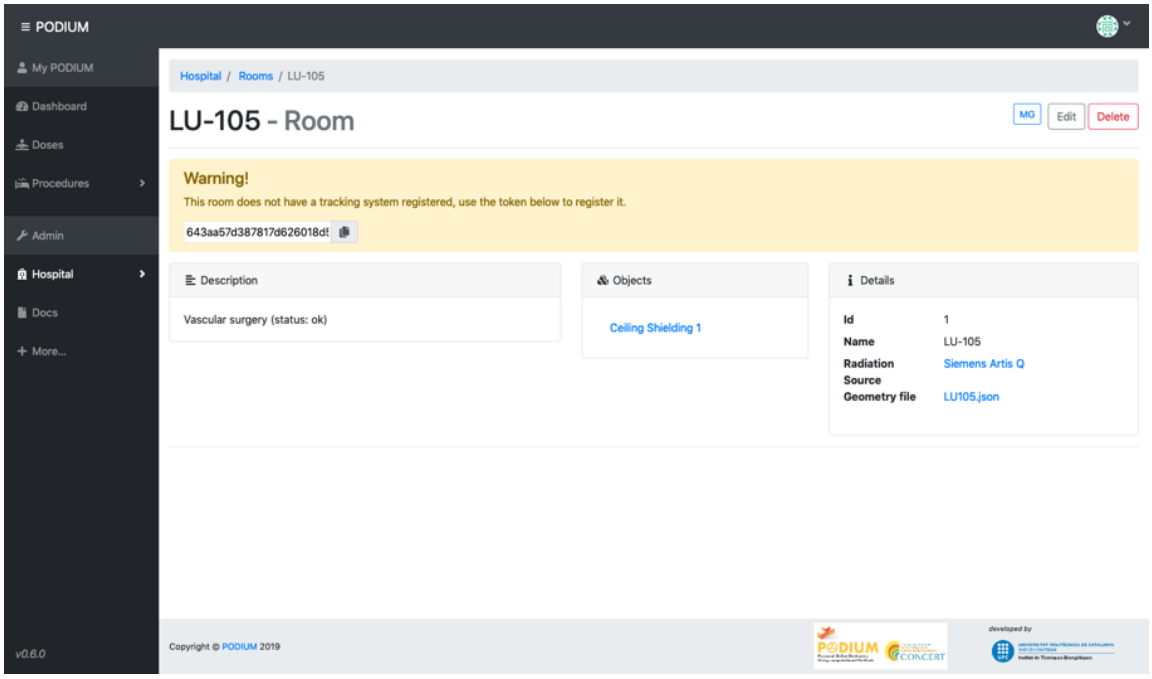


Figure 2 Room without registered tracking

The room registration token can be copied using the button next to the token displayed in the yellow area. This token can only be used once, afterwards it will not be displayed

note*: Manager users can see always the runner token at *More...* → *Runner

The steps to configure the tracking system depend on the system installed, either single-camera or multi-camera system. The instructions can be found in the corresponding system user manual.

Dose Calculation Installation

The dose calculation is done by a separate component of DCA, like the tracking system. DCA can be configured to use one or more dose calculation approaches (see Annex I). Each approach is associated to a Dose Calculation Runner (see Annex II).

To configure a new approach, a runner needs to be created by a manager and the token of it needs to be provided to the dose calculation during installation. DCA needs at least one Dose Calculation system, when more than one is provided Dose Calculators can choose which one they want to use.

Manager can see the existing runners, view their details, and create new ones.

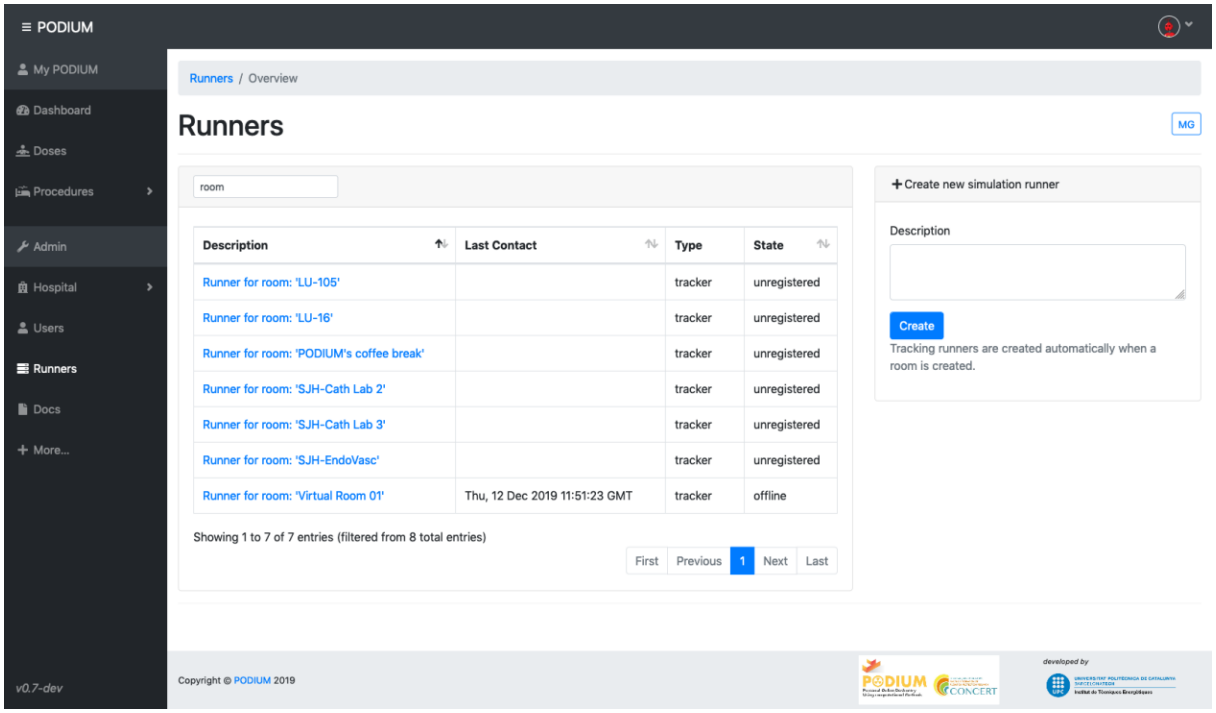


Figure 3 Dose Calculation Runner list and creation

The creation form allows creating new simulation runners, tracking runners are created automatically when a new room is created. For this manager has to introduce the description of the runner. Once created its details can be viewed, which include the token.

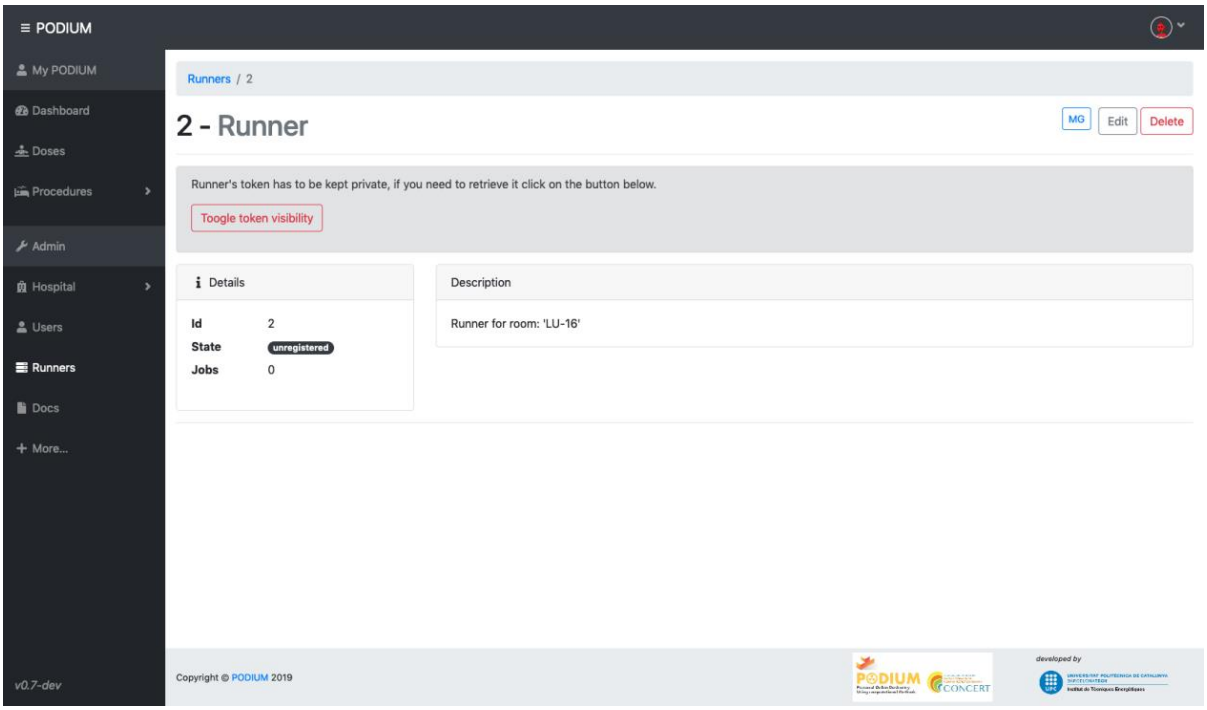


Figure 4 Runner details

From the details page runners can be edited or deleted.

Granting access to users

Each user has to have its own account. For this, *Managers* can create an account for each user or allow user registration when installing DCA. Account creation is done at *Users.*

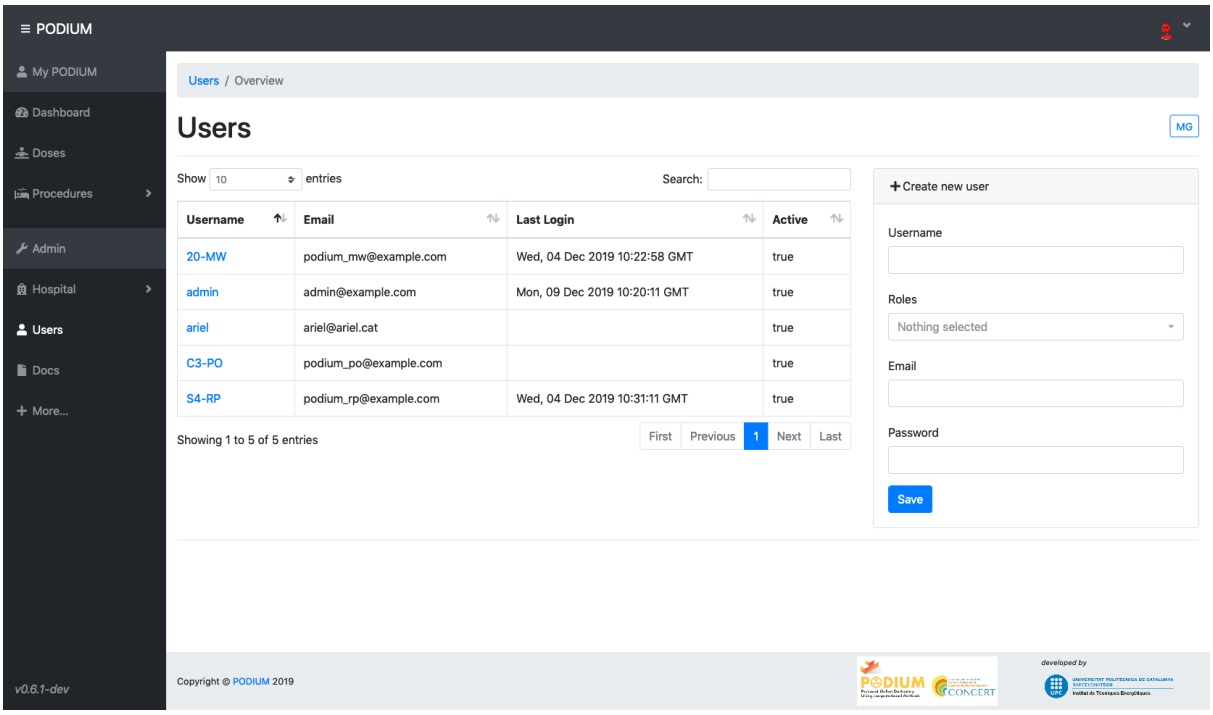
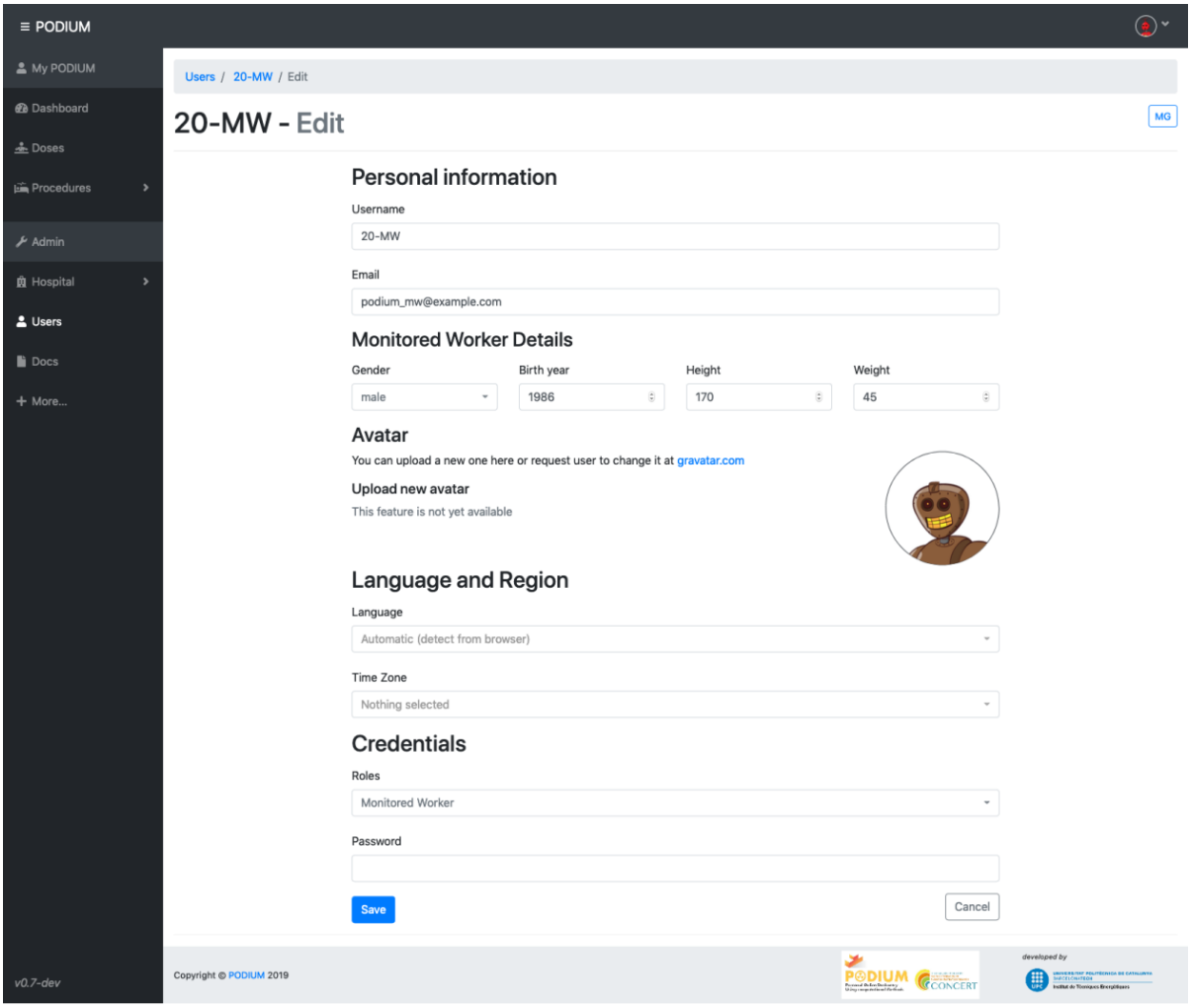


Figure 5 Users management

In order to create a user, the form needs to be completed with:

- **Username**: the name of the user on the system (it is visible by other users)
- **Roles**: the roles granted to the user, one or more.
- **Email**: the user email, it will be used to recover password, or send confirmation email.
- **Password**: the password for the user.

Optionally, a manager user can set the gender, weight, height and birth year of the user after creating it, by entering in edit mode. Otherwise, if it is a monitored worker, a Procedure Operator will have to introduce them before starting monitor them on a procedure.



- **Gender**: gender of the user, required in order to participate in procedures. If empty, Procedure Operator will have to introduce it.
- **Weight**: weight of the user in kg, required in order to participate in procedures. If empty, Procedure Operator will have to introduce it.
- **Height**: height of the user in cm, required in order to participate in procedures. If empty, Procedure Operator will have to introduce it.
- **Birth year**: birth year of the user, required in order to participate in procedures. If empty, Procedure Operator will have to introduce it.
- **Lang Code**: the language code for the user, if blank the default language will be used.
- **Time zone**: the time zone for the user, if blank the default time zone will be used.

Procedure creation

Role Required: Procedure Operator (PO)

Turn on tracking system computer

If the tracking system computer is off, turn it on and login with your institution credentials.

Check that tracking system time is accurate:

If there is an internet connection:

- From your browser, visiting https://time.is
- From the command line (*cmd.exe*): *w32tm -stripchart -computer:us.pool.ntp.org -dataonly -samples:5*

If the tracking system is not connected to internet, check the time with another clock.

Tip:

The best way to maintain system date and time accurate is using a NTP server. In some cases this may be blocked by the company's firewall. If it is the case, contact your IT department or try Time Sync Tool.

Launch tracking system application

After checking machine time, follow the tracking system manual to start the program. Once it is waiting for a connection from DCA follow this manual again.

Procedure Creation

To track the positions of the staff to later calculate their doses, a new procedure has to be created. For this a *Procedure Operator (PO)* has to:

- Login into your PODIUM instance
- Click on Procedure
- Click on Start new
- Fill the Create Procedure form

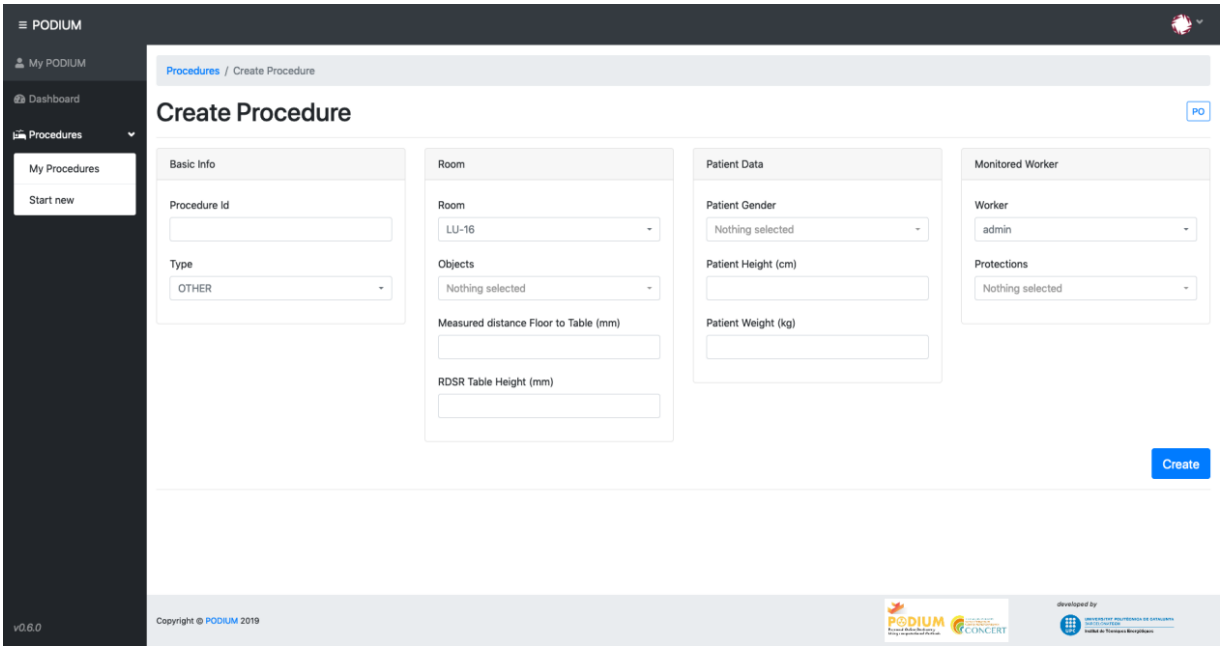


Figure 6 Procedure creation

The procedure form requires introducing:

- Procedure ID: the identifier will relate this procedure with the companies systems to allow staff to recognize it (monitored workers will see it when viewing doses)
- Type: the type of procedure that will be done.
- Room: the room name where the procedure occurs.
- Objects: the list of objects, which may have effect on the doses, that will be used.
- Measured distance Floor to Table (mm): the distance in millimetres from the floor to the table, at the beginning of the procedure.
- RDSR table height (mm): the table height value displayed on the screen, corresponding to the measured distance Floor to Table.
- Patient Gender: the gender of the patient
- Patient Height: the height of the patient in centimetres, if the exact height is not available introduce an approximate one.
- Patient Weight: the weight of the patient in kg
- Worker: the user name of the monitored worker
- Protections: the list of protections the monitored worker is wearing.

After clicking on Create, if the monitored worker has not introduced their birth year, gender, height or weight in its profile, the procedure operator will have to do it before continuing with the procedure.

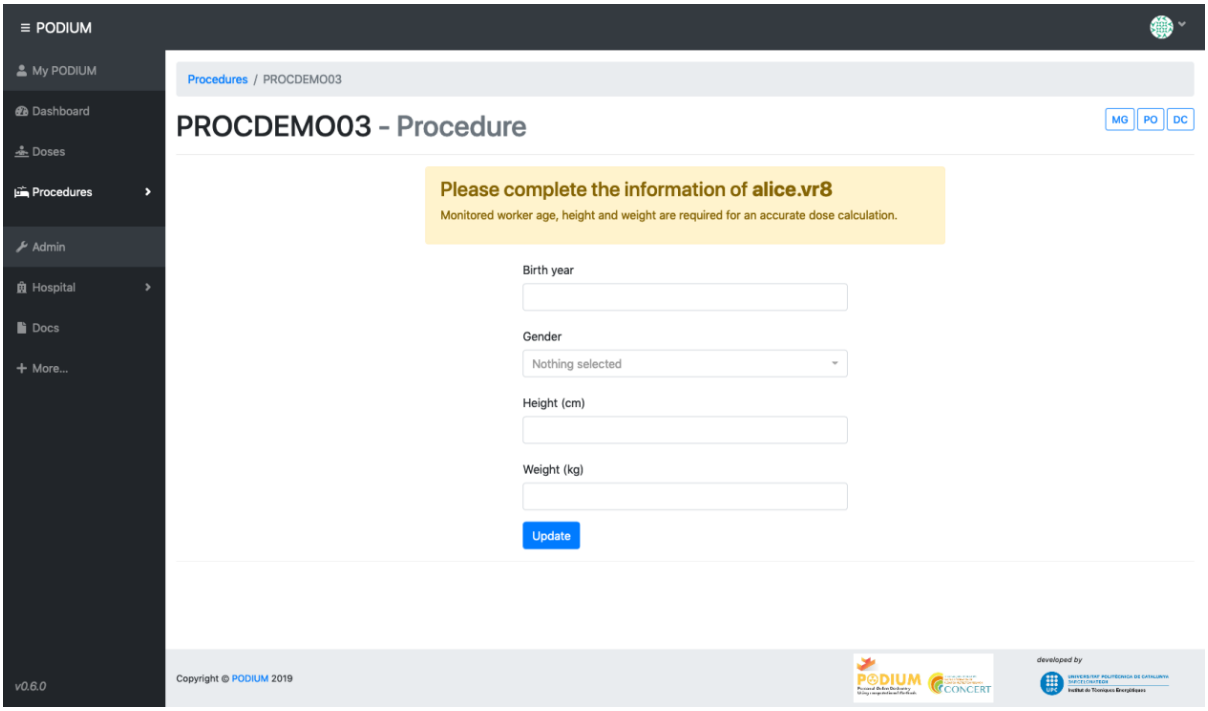


Figure 7 Introduction of monitored worker details

Otherwise, the procedure details page will be displayed. There, it can be reviewed and if necessary edited or deleted. If everything is correct the connection with the cameras may start.

Procedure Connection

After creating a procedure, it has to connect with the cameras. If the camera system is not detected by DCA, either because it is off or it could not reach DCA, the warning message from below will be displayed:

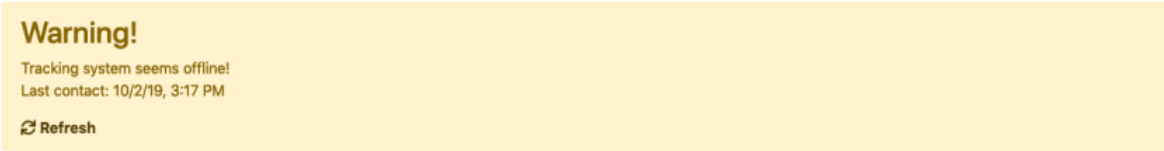


Figure 8 Tracking system offline

In this case, check the tracking system and when everything is fine use the refresh link from the message to reload the page and see the connect button as is displayed below.

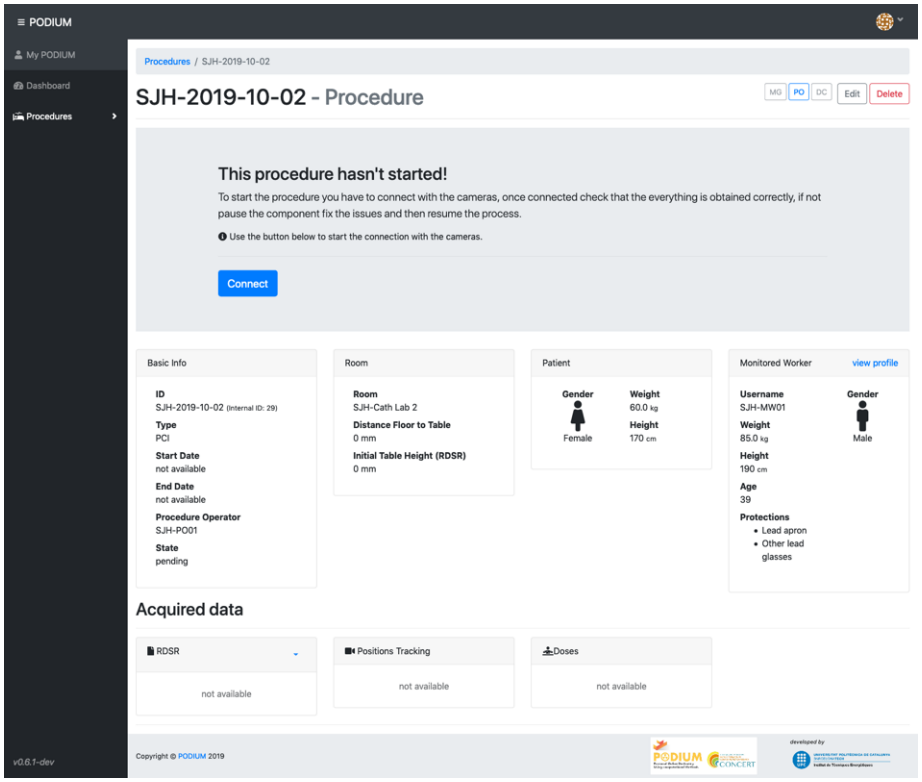


Figure 9 Procedure waiting connection with tracking system

Each step of the procedure displays a different help message to the PO. After connecting with the tracking system, the PO will have to check whether the tracking system recognizes the monitored worker properly. Afterwards, they will be able to start the tracking recording.

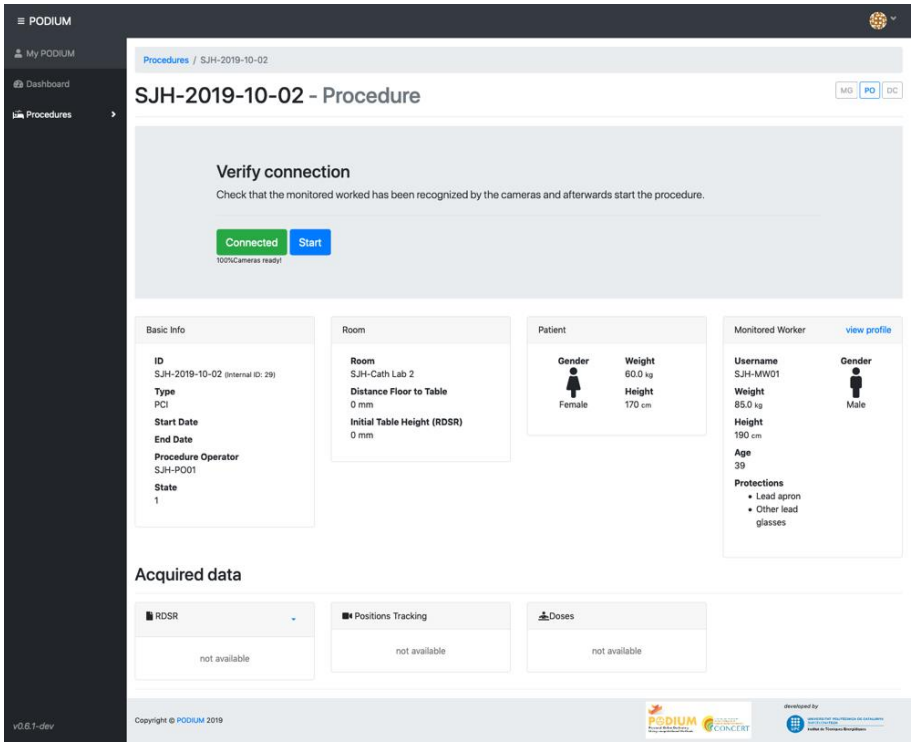


Figure 10 Procedure waiting start of recording

Procedure debug Information

Managers, Image processing Expert and Dose Calculator have access to an extended view of the procedure details. There they can see the state of the runners and in-course or past tasks.

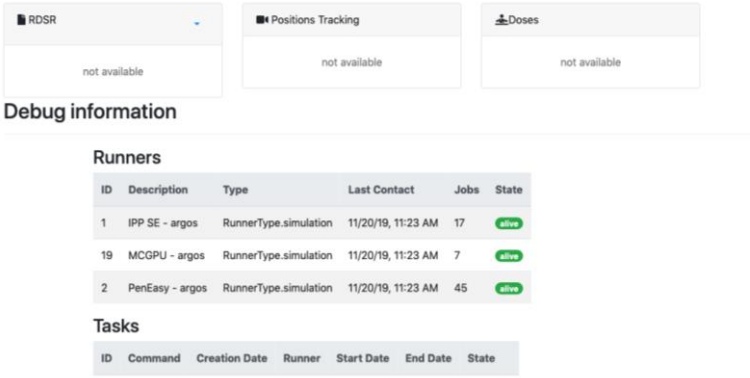


Figure 11 Runners and tasks debug information

Procedure Monitoring

While the procedure/intervention is in course, the Procedure Operator has to monitor the tracking system.

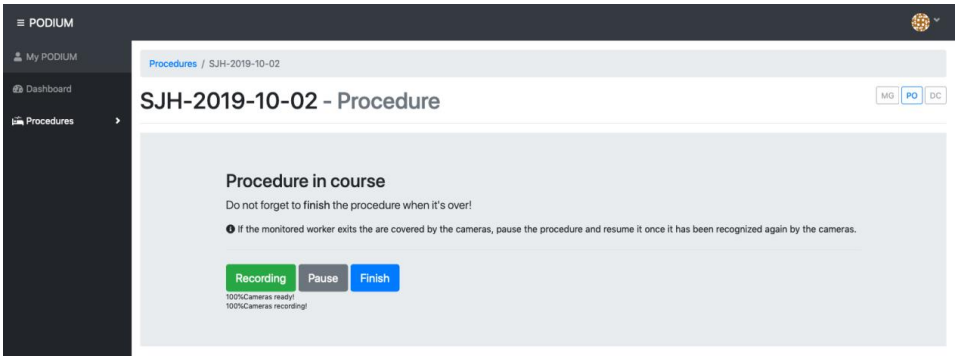


Figure 12 Control options while procedure is in course

Once the procedure finishes, or once it will no longer use the X-Ray machine. Press the finish button from the website.

Finish the tracking system session

Once the procedure is finished, the tracking system will upload the tracking file to DCA. This may take some time. Check whether the data has been uploaded before turning of the tracking system.

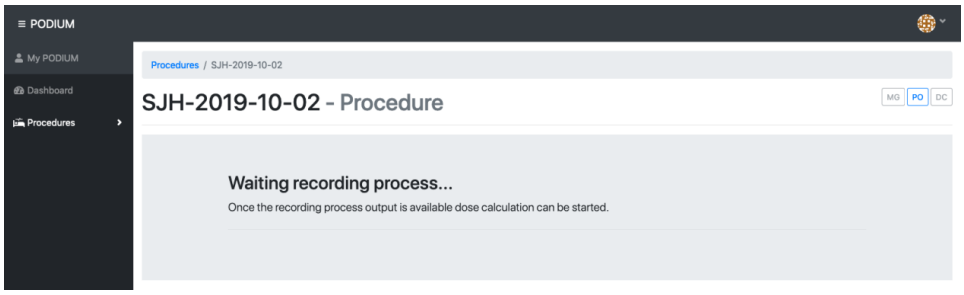


Figure 13 Procedure waiting recording process output

RDSR file upload

The last step to be done by the Procedure Operator is to extract the RDSR file, in one of the supported formats, from the radiation source machine and anonymize it (see *Annex IV - Supported* RDSR for more information). Afterwards, it has to be uploaded to PODIUM-DCA.

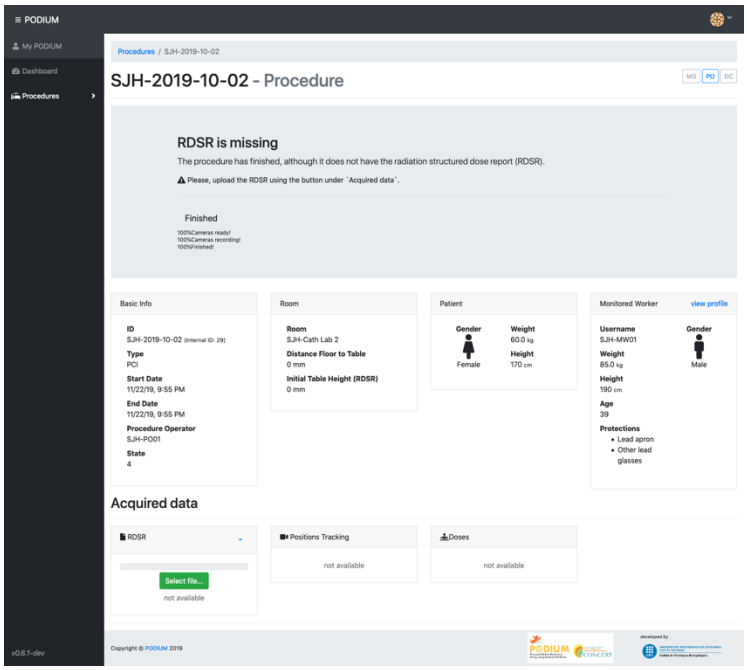


Figure 14 RDSR file can be uploaded using the green 'Select file…' button

Dose calculation

Role required: **Dose Calculator (DC)**

Calculate monitored worker doses

Once a procedure has finished (a Procedure Operator (PO) has uploaded the RDSR and the tracking system has uploaded the recorded positions) a *Dose Calculator* will see it at *Procedures → Simulate*.

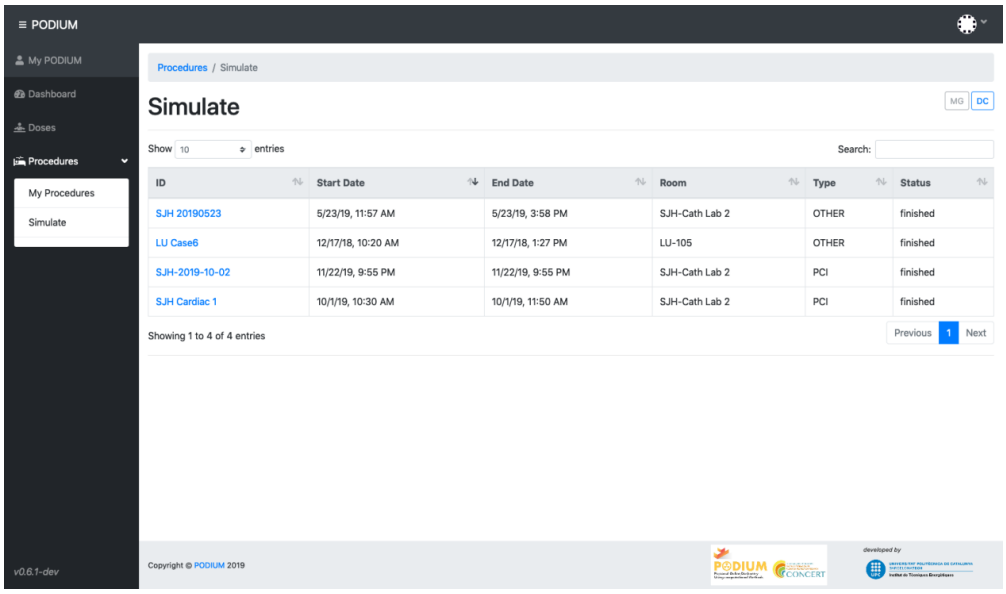


Figure 15 Listing of procedures to simulate

There a *Dose Calculator* will be able to launch the dose calculation, later the results will be available for the monitored worker and all the Radiation Protection Experts. If there is more than one calculation approach available DC can choose the one to use.

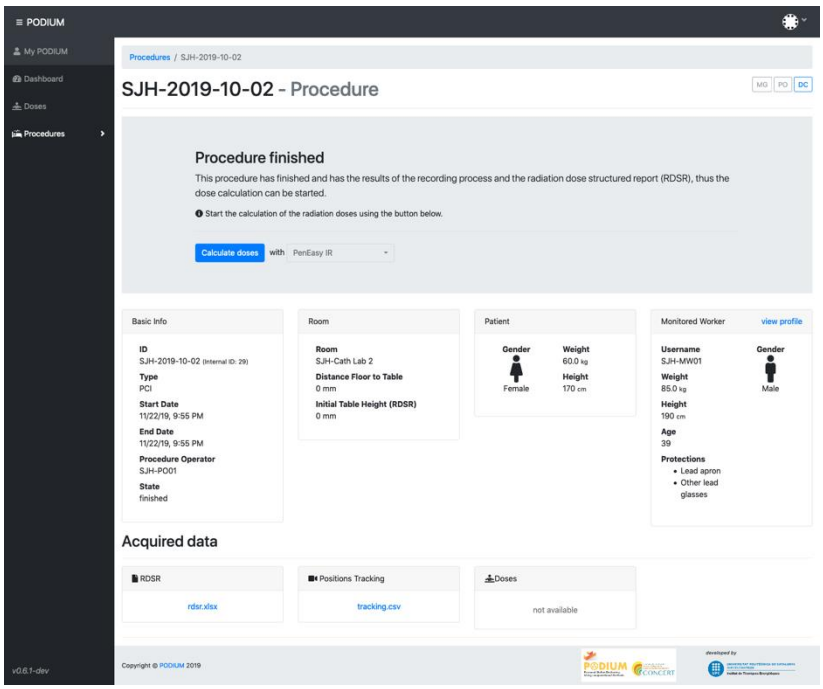


Figure 16 Procedure view for Dose Calculator

PODIUM Cloud Service offers several tools for different dose calculation approaches, these are explained in detail at Annex I: Dose Calculation Approaches.

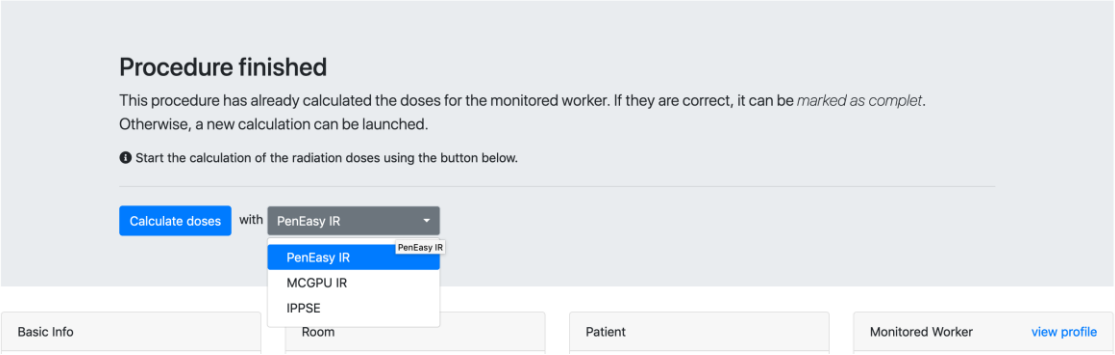


Figure 17 Calculate doses selecting approach

Doses can be calculated multiple times either with the same approach or using different approaches. This can be used to compare the different approaches.

Mark as completed

Once the doses have been calculated, DC can mark the procedure as completed. This will remove the procedure from the simulate page.

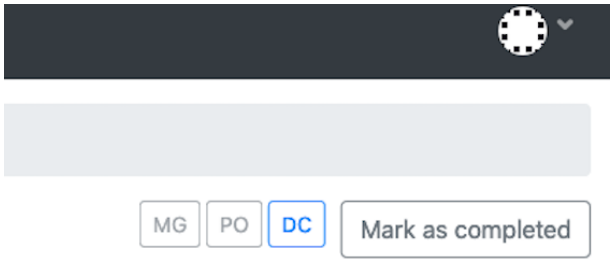
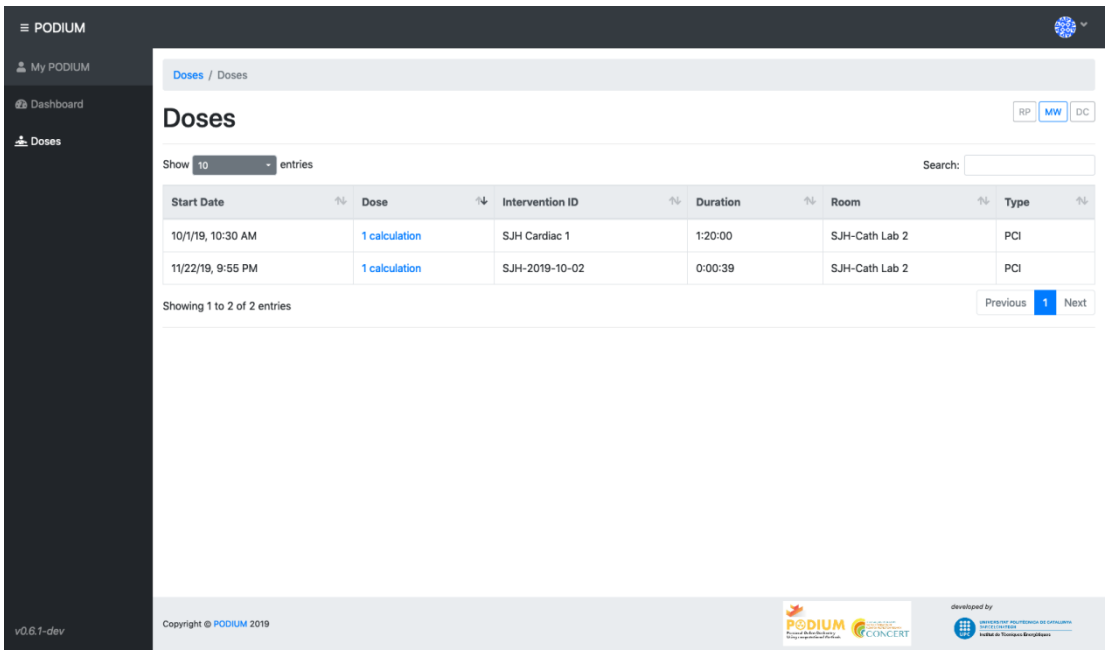


Figure 18 Mark as completed button

Dose monitoring

Viewing own doses

All monitored workers can view their own doses. They are displayed in a list by procedure where the total accumulated dose can be found.



Depending on the calculation system, workers may see one or more quantities from Effective dose, Hp(10), Hp(0.3) or Hp(0.07). Other organ doses are not displayed yet but they could be shown if required.

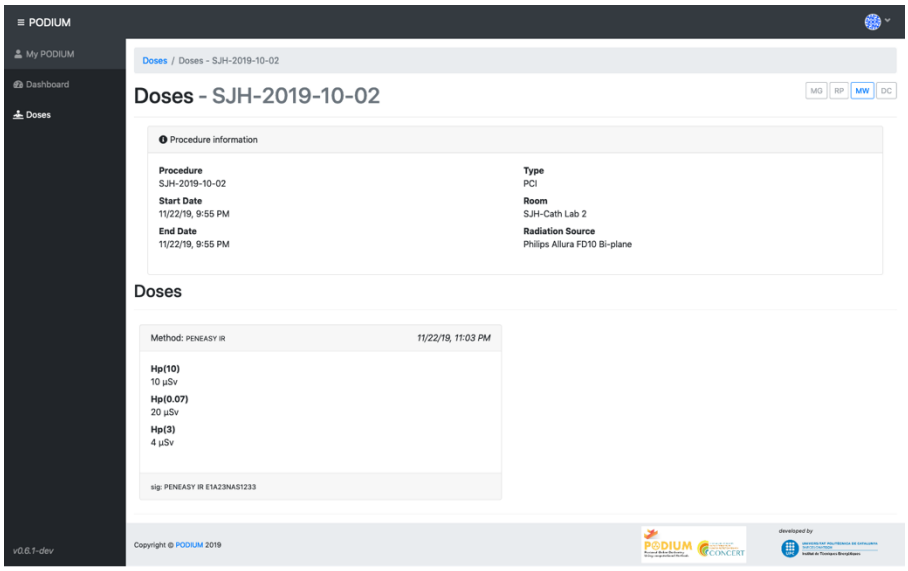


Figure 19 Dose details for a monitored worker

Viewing worker doses

Radiation Protection Experts can see the doses for all the monitored workers. They can list the doses of all the users or filter them by user.

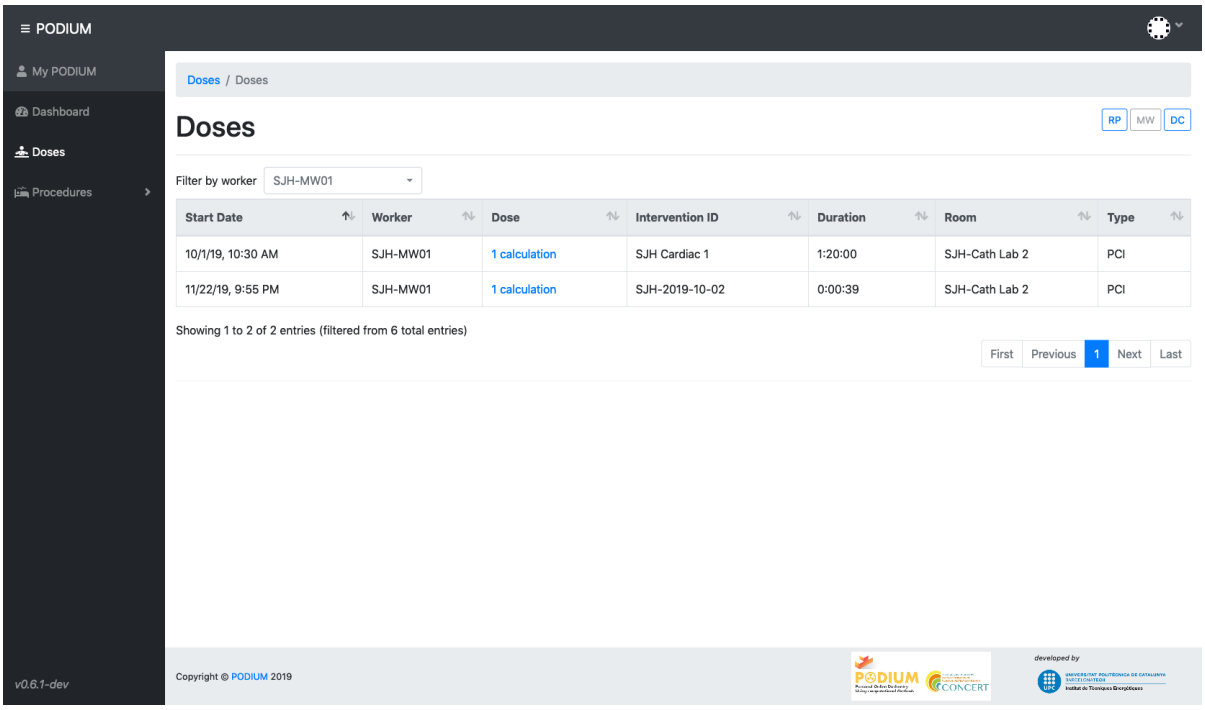


Figure 20 Dose listing after applying a filter by user

When viewing the doses of a user, the user name and avatar of the monitored worker is displayed.

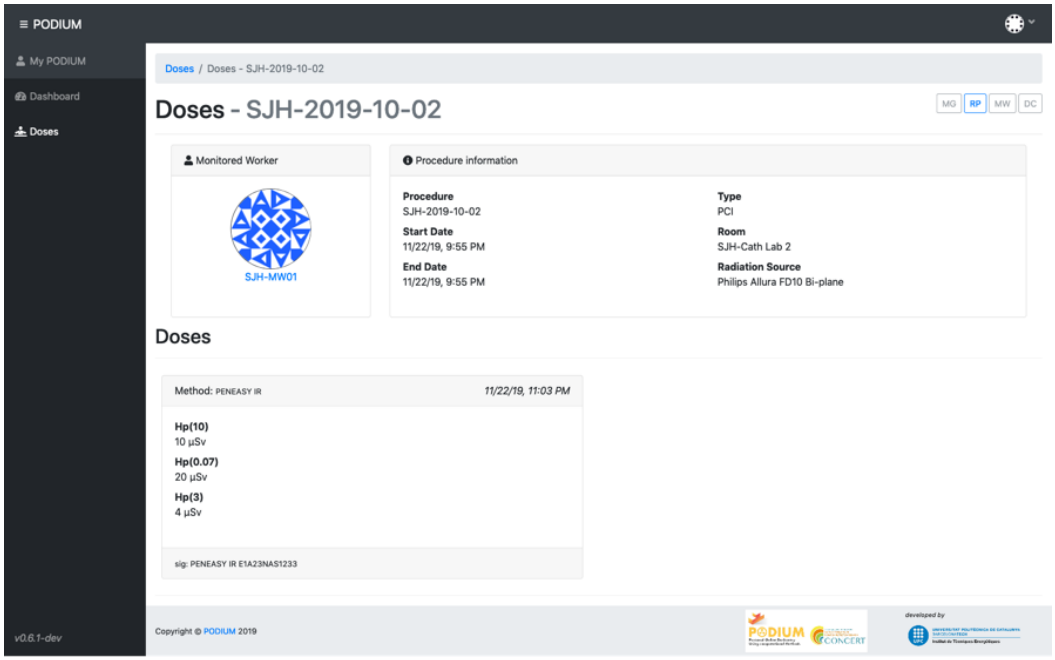


Figure 21 Dose details for a user RP

Annex I - Dose Calculation Approaches

IPP SE

One of the approaches that can be used to calculate the dose received by the monitored worker is to use look-up tables based on two sets of tables from previously calculated Monte Carlo simulations: the source tables and the Dose Conversion Coefficient (DCC) tables. These data are integrated within a software, IPP_SE, which is based on the Interactive Posture Program developed in PODIUM WP2. The software convolutes the irradiation parameters from the RSDR, defining the scatter field, with the tracking information coming from the camera module, and provides dose estimates for effective doses, (peak) skin doses, eye lens doses, and simulated Hp(10).This approach requires less time to obtain the doses for a monitored worker, although it approximates the real case to one of its precalculated results.

MCGPU IR

MCGPU-IR is based on MC-GPU (Badal 2009). The code implements a massively multi-threaded Monte Carlo simulation algorithm for the transport of X-rays in voxelized geometries using the computational power of commodity Graphics Processing Unit (GPU) cards. More details about MCGPU-IR are given in D9.107.

MCGPU-IR provides absorbed dose at a voxel level, the absorbed dose in the different specified organs in the voxelized phantom, $H_p(10)$ and the effective dose for the monitored worker.

Penelope/ PenEasy IR

PENELOPE/penEasyIR is based on PENELOPE v2014 (Salvat 2014), a standard general-purpose Monte Carlo (MC) code and penEasy (Sempau 2011), a general-purpose main program for PENELOPE. Photon transport is simulated by means of the standard, detailed simulation scheme.

To speed-up the simulation process in the interventional radiology field; PENELOPE/penEasyIR implements the variance reduction technique, *detection forcing*, and simplifies the geometry of the problem. More details about PENELOPE/penEasyIR are given in D9.107. PENELOPE/PenEasyIR provides the photon energy fluence distribution at a given position and subsequently ICRP fluence to dose conversion coefficients are automatically applied to obtain the operational quantities: $H_p(10)$, $H_p(3)$, $H_p(0.07)$ for the monitored worker.

Annex II - Dose Calculation Runner

A dose calculation runner is an external application which is used to obtain procedure's information from PODIUM-DCA, calculate the doses of the monitored workers and then upload them to DCA.

Technical details

Runners use PODIUM-DCA API to interact with PODIUM-DCA's server. This communication uses a secure connection (HTTPS). API requires runners to authenticate themselves using a private key and only allows them to access to a subset of the database from DCA.

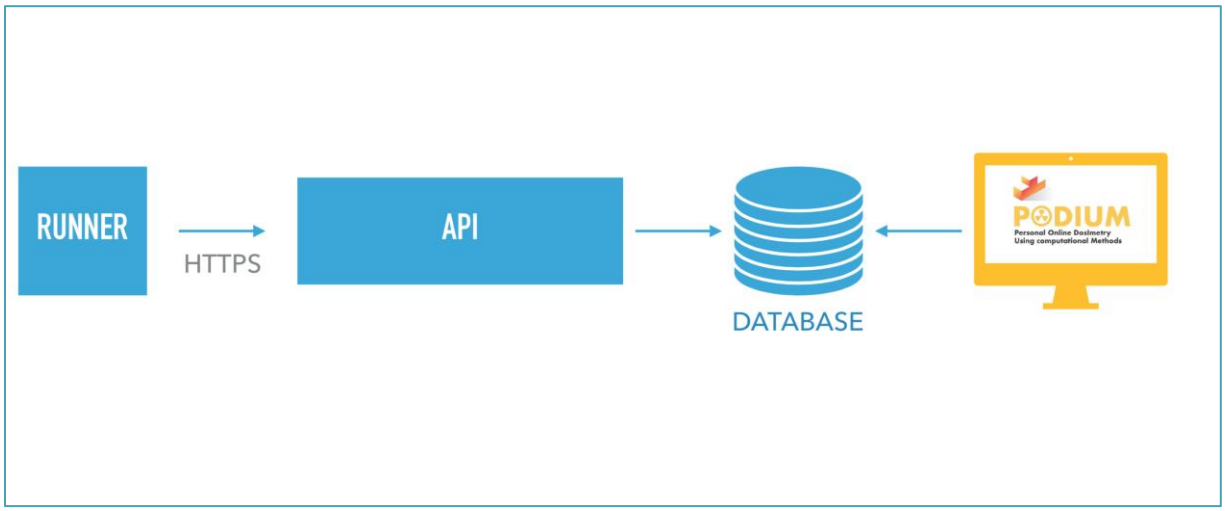


Figure 22 Runner communication with PODIUM-DCA

Each runner contacts with PODIUM-DCA periodically in order to check if it has to do a new calculation, if so it will retrieve the necessary information. For dose calculation runners this subset is:

- Procedure details (only the ID of the worker is shared)
- Tracking file
- RDSR
- Room geometry
- Object geometry

Finally, once the calculation has finished it will upload the doses to DCA.

Annex III - Upload of Off-line procedures

Introduced on PODIUM-DCA v0.5.1

Tracked offline procedures can be uploaded to DCA manually.

They must meet the following requirements:

- RDSR: it has to be a valid RDSR (see supported RDSR files)
- Tracking: tracking file must contain only one person and coordinates must be referenced to the isocentre.
- Patient sex, height and weight is known or can be approximated (required by the dose calculation).
- Worker height, weight and age or can be approximated (required by the dose calculation).

Moreover, this section assumes worker, room, objects, worker protections and radiation source were already created on the website as explained on the installation section.

If the procedure meets these requirements, a Manager can upload the procedure by creating a new procedure at *More… → Procedure → Create and filling the formulary*.

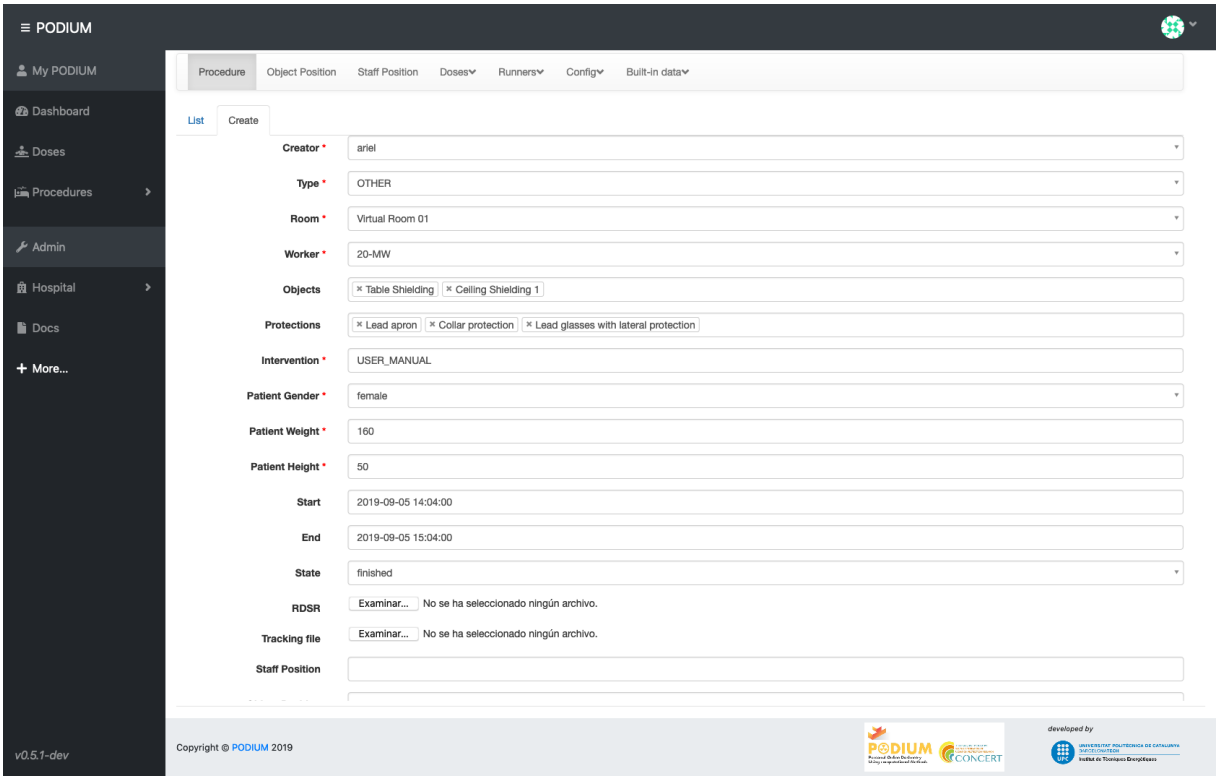


Figure 23 Offline procedure upload

The form will have the following fields:

- **Creator**: the person creating the formulary.
- **Type**: the type of procedure (to choose from a list). The types of procedures can be defined following the instructions from Procedure Types.
- **Room**: the room where the procedure occurred (this will define the radiation source used)
- **Worker**: The worker tracked (be sure it has the age, weight and height defined, see)
- **Objects**: the objects tracked during the procedure (to choose from a list). The available objects can be defined following the instructions from Room objects.
- **Protections**: the personal protections ward by the worker tracked (to choose from a list). The available objects can be defined following the instructions from Protections.
- **Intervention**: the unique identifier used to recognize the procedure by the Procedure Operator and Monitored Workers.
- **Patient Gender**: the sex of the patient (will be used during the dose calculation)
- **Patient Weight**: the weight of the patient (will be used during the dose calculation)
- **Patient Height:** the height of the patient (will be used during the dose calculation)
- **Start:** the date and time when the procedure started.
- **End**: the date and time when the procedure finished.
- **RDSR**: select the RDSR file from your computer files.
- **Tracking File**: the tracking file from your computer files

The following fields <u>should</u> remain empty:

- Staff position
- Object position
- Doses
- Tasks

Annex IV - Supported RDSR

PODIUM-DCA has been tested with different X-Ray machines and hospitals, how the information is extracted and which data is included depends on the machine and the system used to retrieve it. This section covers the content expected to find and the supported file formats.

RDSR file formats

DCA supports the standard format for communication and management of medical imaging, DICOM and also a spreadsheet (Excel) based format.

Supported RDSR file formats

DICOM

DICOM files usually have **.dcm** as extension, which is the recommended extension by RFC3240, other extensions can be .sr (from structured report). Other extensions will not be allowed by DCA.

If you are not sure if a file is a DICOM, you can try to find the type of the file from using `file` command from Mac Os or Linux terminal and executing:

```
file --mime-type [path to your file]
application/dicom
```

***note: file* uses file extensions and the file content to detect the correct type of the file, even if it has a wrong extension.**

Microsoft Excel™

DCA has support for RDSR spreadsheets, either in Excel 97 (.xls) or Excel 2010 (.xlsx) format. The format of the spreadsheet is based on the files generated by Philips DoseWise.

The spreadsheet has to contain one row for each event and the columns will represent each of the required fields for the dose calculation approaches. The spreadsheet can contain other columns or charts.

If the spreadsheet contains more than one sheet, the first one has to contain a list of the studies and the second one the dose events. Only the first study of the first page is recognized by PODIUM-DCA.

MULTIVALUE COLUMNS

DICOM provides multivalue fields, in order to represent them in a spreadsheet a low-level approach has been chosen. These values are stored using a list notation, where each list starts with [and ends with], and all the element separated by commas. If the element is a text it is wrapped by double-comas and if they are present they need to be escaped using a ‘ \’ . For example:

[“Copper or Copper Compound”, “Aluminum or Aluminum Compound”]

[0.4, 1.0]

ALTERNATIVE COLUMN LABELS

In addition of DICOM supported tags, the spreadsheet can use the names from the table below to identify them.

Spreadsheet Label	DICOM Equivalent
Gender	Patient's Sex
Serial Number	Series Number
StudyInstanceUID	Study Instance UID
SeriesInstanceUID	Series Instance UID
System Name	Device Model Name

Other RDSR file formats

Some Picture Archiving and Communication System (PACS) do not provide access to DICOM files, in those cases they may allow export the information somehow or not.

XML

Extensible Markup Language (XML) (.xml extension) is **unsupported**, although if the xml file was generated using DCM toolkit, it can be converted back to DICOM with xml2dcm. The converted file is supported.

Anonymization

PODIUM-DCA stores RDSR without modifying them, if you want to remove personal information before uploading them you will have to anonymize them.

Anonymization tools

DICOM

To anonymize a DICOM, you can use:

- **PODIUM-RDSR**:
  The RDSR reader/exporter developed for PODIUM which can also anonymise Excel RDSR files.
- **Rubo DICOM Anonymizer** (commercial, free)
  https://www.rubomedical.com/dicom_anonymizer/index.html
- **DICAT DICOM Anonymization Tool** (open source, free)
  https://github.com/aces/DICAT
- **dcmodify** (from DCM toolkit): https://support.dcmtk.org/docs/dcmodify.html
  dcmodify can edit data from DICOM files when executed with `*-m PatientName=edited*`.

Excel format

remove patient/Machine information

For RDSR files in spreadsheet format patient and machine information can be removed by just deleting the columns that contain these information.

Once the patient and machine information is removed, the file will still contain some metadata related to the creator and the last editor. The next section explains how to remove this information.

Remove excel metadata

Excel™ file format contains some metadata with last editor and creator information. As example this is the information found in one Excel RDSR file of PODIUM (with the author and last editor names edited):

> samples/sjh_20190523_rdsr.xls: Composite Document File V2 Document, Little Endian, Os: Windows, Version 6.1, Code page: 1252, Author: **Jack Byrne**, Last Saved By: **Emma Murphy**, Name of Creating Application: Microsoft Excel, Create Time/Date: Tue Oct 26 08:19:36 2010, Last Saved Time/Date: Thu May 30 12:48:23 2019, Security: 0

This information can be removed using:

- **PODIUM-RDSR** using anonymize, which will also anonymize the data.
- **Libre Office/Open Office**: using *Reset Properties* under *File* → *Properties…* → *General*. Data needs to be anonymized manually.
- **PowerShell + Microsoft Office**: bulk removal can be done using Powershell as described on Use PowerShell to Remove Personal Information from Excel.

Comparative

	DICOM	EXCEL	GUI	Multiplatform	Free	Easy to use	Format conversion	Bulk processing
PODIUM RDSR								
Rubo DICOM Anonymizer								
DICAT DICOM Anonymizer								
Dcmtoolkit								
Libre Office / Open Office								
PowerShell + MS. Office								

List of RDSR Fields

The table below lists the fields required from the DICOM standard and the alternatives if they are not present.

	Required	*Observations*
DateTime Started	X	Two different date formats are supported, with or without milliseconds precision.
Distance Source to Detector	X	
Distance Source to Isocenter	X	
Final Distance Source to Detector (optional)	X	
KVP	X	
Reference Point Definition	X	
X-Ray Filter Material	X	This can be a multi-value field
X-Ray Filter thickness Maximum		This is a multi-value field
Collimated Field Area		Alternatives: Dose Area Product
Dose Area Product		
Dose (RP)		
Positioner Primary Angle	X	
Positioner Secondary Angle	X	
Bottom Shutter		Alternatives: Dose Area Product, Collimated Field Area
Left Shutter		
Right Shutter		
Top Shutter		
Table Height Position	X	The value of this field is referred to an unknown position, the distance of the table from the floor needs to be introduced for each procedure before starting it.
Table Lateral Position	X	
Table Longitudinal Position	X	

ANNEX V - localization

DCA is written in English as base and it has been translated to different languages

Language	Version Introduced	Percentage translated	Last update
Catalan	V0.2	100 %	V0.6
Spanish	V0.2	100 %	V0.6
Dutch	V0.3	3 %	

If your institution is interested in another language, it can be extended to support it. Or you can help to translate it. Current version is around 1950 words in 395 different messages.

Glossary

C-arm
An imaging scanner intensifier, named of its configuration.

Geometry file
A file containing the geometry of a room or object with the properties necessary to calculate the radiation propagation through it.

Isocentre
The point where the three rotation axes of the radiation source (c-arm) converge.

RDSR
Radiation Dose Structured Report, usually a DICOM file reporting the usage of the radiation source machine.

Tracking file
A file containing the position and posture of a monitored worker, or more than one monitored worker, during a procedure.