Specification of Requirements

Appendix 2

Central Denmark Region
Danish Centre for Particle Therapy, DCPT

1 General requirements

The Proton Treatment Planning System (PTPS) must be designed in accordance with good principles, and the system must be robust and reliable. The system must be able to continue production even after failure in server hardware components.

The maintenance and service of the servers and clients must be easy and flexible supported by server and client virtualization, fast and secure backup and archive routines.

For efficient and flexible deployment and user access the system must be remotely accessible and in situations where needed the applications must also be able to run on standard hospital PC's.

1.1 Minimum requirements

- The PTPS must be a redundant system with duplicated hardware installed in two separated server rooms. If hardware in one server room is not working because of fatal failure, the duplicated hardware must be in operation within four hours (describe how this is fulfilled)
- Server software and client must be hosted in a virtual environment (eg. Citrix or VM-Ware) (describe how this is fulfilled)
- It must be possible to backup and archive patient data on external media (describe how this requirement is fulfilled)
- The PTPS clients must be accessible remotely (eg. via Citrix)
- The PTPS application must be able to run on standard hospital PC's with Microsoft Windows OS version 7 or higher, if necessary with dedicated graphic card.
- The applications must be able to run on computers with active antivirus software.
- The PTPS must accept Danish characters and support Danish keyboards.
- All installation/setup and documentation manuals must be electronically available, as well as tech tips and other technical documentation.

2 Segmentation tools

A high patient throughput at DCPT requires a high efficiency in the target and normal tissue delineation effectuated by e.g. scripting. In order to avoid improper treatment, structures generated e.g. by Boolean functions should preferably be automatically updated if the underlying structure is changed.

Advanced treatment planning and image guided adaptive proton therapy demands handling of multi-modality imaging and 4D imaging. The Proton Treatment Planning System (PTPS) must make available flexible tools for structure contouring on CT, PET, MRI and CBCT including delineation on one image using information from other images registered to the image. Automatic contouring using SUV on PET images will be positively evaluated. Multiple algorithms and flexibility for rigid registration of images (CT-CT or CT-other modalities) are preferable. It is to be positively evaluated if the naming of the registrations is unique and descriptive as well as automatic registration between one image and a series of images is preferred.

In order to perform dose accumulation, the PTPS should support flexibility in the selection of the rigid registration used for dose propagation. Rigid and deformable registration should be available for structure propagation.

In the interest of retrospective data handling, as many details as possible should be available from the rigid registration matrix.

The availability of beam specific PTVs taking inhomogeneities into account will be positively evaluated.

2.1 Minimum requirements

- The PTPS must provide tools for import and segmentation of 4D CT, CBCT, DWI MRI, DCE MRI, 4D MRI, PET and 4D PET
- The PTPS must provide tools for rigid registration of CT images to CBCT, PET and MR images

2.2 Evaluation criteria

1. **Contouring tools (flexibility):** Describe the contouring tools, e.g. HU/grey scale based contour delineation, creation of Boolean structures, post processing of structures (remove holes, remove small contours, reduce number of points etc.), delineation in all three orthogonal planes, etc.
2. **Contouring, scripting (functionality)**: Does the PTPS provide possibility of scripting of structure generation? If yes, describe the functionality.
3. **Contouring, update (functionality)**: If a structure is changed, will contours based on this structure, e.g. contours created by Boolean algorithms involving the structure, be automatically updated? If yes, describe the functionality.
4. **Contouring, PET (flexibility):** Specify tools specific for contouring PET images. E.g. does the PTPS support auto contouring using e.g. SUV values? If so, describe which SUV values are supported, e.g. SUV max.
5. **Contouring, MRI (flexibility):** Specify tools specific for contouring MRI images. E.g. describe possibility to contour in transvers, sagittal or coronal planes.
6. **Registration, algorithms (functionality):** Specify algorithms for rigid registration (e.g. grayscale, volume based, point based etc.). Describe the possibility to select multiple user defined regions of interest (ROIs) for a registration.
7. **Registration, tools, and features (flexibility):** Describe the tools and features for rigid registration of images. E.g. is the naming of the registration unique and descriptive? Is it possible to select/deselect rotation, roll and pitch separately? Is it possible to perform automatic registration between one image and multiple selected images (e.g. planning CT and daily CBCTs)?
8. **Registration, dose propagation (functionality)**: In case of multiple online/offline rigid registrations, will the user be able to select the registration which should be used for dose propagation? If so, describe the functionality.
9. **Registration, output (flexibility):** Specify data available for the user from the registration (e.g. transformation matrix, coordinates for structures, volume changes, Dice coefficient, etc.)
10. **Registration, contouring (functionality):** Describe the possibility to delineate on one image using information from multiple registered images (e.g. delineation on one image while fused/registered to a second image).
11. **Registration, contour propagation (functionality):** Describe contour propagation from one image to deformedly registered images (e.g. copy of a structure, deformable propagation). Also describe how the history of the contour is tracked to e.g. show from which image the contour originates. Describe the possibility to automatically propagate contours from one image to multiple registered images.
12. **Beam specific PTV generation (functionality):** Is it possible to create beam specific PTV? Describe the functionality. Is it e.g. possible to take lung density into account when planning spot positions?

3 Planning tools

The Proton Treatment Planning System (PTPS) must support the treatment delivery of Pencil Beam Scanning (PBS) using the Varian ProBeam Proton Therapy System. Treatment planning using state of the art proton pencil beam scanning techniques must be provided. To assure high level of patient treatment quality and flexibility, effective tools to perform optimization, including robust optimization, should be available.

Since DCPT is expected to deliver the most forefront treatment and drive the development of new advanced PBS based proton delivery techniques, a large variety and flexibility of optimization methods and spot delivery techniques should be supported.

At DCPT the Varian ProBeam System will be commissioned with two beam tunings with different spot sizes. This feature must also be handled effectively by the PTPS. Since range shifters and apertures or blocks also will be used the PTPS should be able to handle these.

The referral of patients will for large part be based on comparative dose planning (photon vs. proton). Photon dose planning must therefore also be supported.

3.1 Minimum requirements

- The PTPS must provide tools for treatment planning using PBS at the Varian ProBeam system
- The PTPS must provide tools for treatment planning using photons including dynamic wedges, IMRT and VMAT and electrons. Import of user specific beam data from the Varian TrueBeam must be supported
- The PTPS must provide tools for robust optimization

3.2 Evaluation criteria

13. **Optimization, techniques (flexibility):** Specify PBS techniques supported (e.g. SFUD, distal edge tracking, IMPT etc.).
14. **Optimization, constraints (flexibility):** Specify which types of constraints are supported in the optimization mentioned above (e.g. min, max, mean, EUD, min/max to a specified volume, dose fall off, multiple constraints/line dose, etc.).
15. **Optimization, process (flexibility):** Describe the optimization process and features (e.g. direct access to DVH parameters during optimization, visualization of fulfillment of clinical goals, calculation of intermediate dose if necessary, possibility to edit fluence etc.). Also describe criteria apart from dose distribution that can be included in the optimization (e.g. smoothness, speed of treatment delivery etc.). (Robust optimization is evaluated separately)
16. **Optimization, spot location (flexibility):** Describe how energy layer spacing is set (e.g. automatic according to an algorithm, can it be customized as a parameter for IMPT etc.). Describe if changes in spot parameters are possible (e.g. spot spacing, spot location/out of grid, spot size).
17. **Optimization on top of primary dose distribution (functionality):** Can the optimization of a new dose plan be made as an additional dose on top of a primary/former dose distribution? If so, describe the functionality (e.g. can the primary/former dose distribution be imported from another TPS?)
18. **Dose painting by numbers (functionality):** Does the PTPS support dose painting by numbers using functional and molecular imaging to determine a voxel by voxel dose? If so, describe the functionality.
19. **Robust optimization, algorithms (flexibility):** Specify algorithms used for robust optimization (e.g. minimax, mean, hybrid, user defined).
20. **Robust optimization, options (flexibility):** Specify options available for robust optimization (e.g. isocenter shift, density change, a full 4DCT scan, additional CT/CBCT scans, specified positional changes in contours, isocenter position, etc.).
21. **Spots with low weight (functionality):** Describe how the PTPS handles spots with low weight (e.g. if the MU is lower than the ProBeam minimum MU are the spots rejected? Is it possible to edit spot weight or delete spots manually? Is the minimum MU per spot included during the optimization process?)
22. **Spot delivery, scan path (functionality):** Does the PTPS support minimization of scan path e.g. by spot sorting? If so, describe the functionality.
23. **Spot pattern (flexibility):** Describe default spot patterns (e.g. hexagonal, square, etc.). Is it possible to have user defined spot positions?
24. **Accessories (functionality):** Describe how the PTPS handles accessories like range shifters, blocks and ripple filters for different snouts and snout-skin distances. Which materials are supported? Describe the degrees of freedom and limitations, e.g. if accessories are plan specific or may be changed between fields.
25. **Biological optimization (functionality):** Does the PTPS support biological optimization? If so, specify algorithms used for biological optimization (e.g. LQ model, user defined). Does the system support user specified data?

26. **Multiple beam tunes (functionality):** Describe how the PTPS supports planning with multiple beam tunes. Is it possible to have two beam tunes per plan, per field, per energy layer?
27. **Customizable plans (functionality):** How does the PTPS support generation of plans with a high degree of user-control such as user-defined number of protons in a given spot, user-defined spot spacing, spot pattern, layer spacing, spot sequence, etc. (eg. as a research option)?

4 Evaluation tools

The recruitment of patients for treatment at DCPT will for a large part be based on comparisons between photon and proton plan proposals. The objective is to offer proton treatment when the comparison demonstrates a reduced risk of adverse effects for normal tissue, without deteriorating the target coverage.

Therefore the PTPS should have informative, efficient, and user friendly tools for evaluating plans, and for comparing plans, also based on biological response modeling. Because of the cooperative organization of the referrals to DCPT, plans or dose matrices imported from a referring oncological center should be possible to evaluate and compare in an equal manner.

Robustness of a proton plan towards uncertainties related to Stopping Power Ratio (SPR) calibration, isocenter position, intra fractional motions, and inter fractional organ changes is crucial in the clinical decision process, and appropriate tools to address this is positively evaluated.

Biological response models should preferably include normal tissue complication rate, tumor control rate, variable LET dependent RBE and risk for radiation induced secondary cancer risk.

Treatment plans should preferably be evaluated in terms of practical realization at the treatment gantry. An example of this is a tool to check for collisions and the support of the quality assurance work of DCPT, e.g. generation of patient specific QA plans for specific test devices and dose calculation based on log files from the beam delivery at the Varian ProBeam. The latter will both serve as the dose status in case of partially delivered beams, and as a method to validate the quality of the beam delivery.

4.1 Minimum requirements

- The TPS must provide dose volume histograms and dose distribution analysis tools.
- The TPS must have tools to compare two or more plans.
- The TPS must provide tools to analyze the robustness of the plan towards uncertainties; this must include uncertainties related to SPR calibration and isocenter position.

4.2 Evaluation criteria

28. **Dose plan comparison (flexibility):** Describe the tools for to evaluate and compare the dose distributions of two or more treatment plans.
29. **Evaluation of imported treatment plans or doses (functionality):** Describe how imported treatment plans or doses from third party PTPS can be evaluated. Eg. can the evaluation be done with functionality similar to the evaluation of plans generated with the PTPS?
30. **Biological modeling (functionality):** Does, the PTPS have tools for evaluation based on modeling of biological response? If so, describe the biological models used in the tools. Response parameters like normal tissue complication rate, tumor response probability, etc., should be accessible and editable.
31. **Biological modeling of secondary cancer (functionality):** Describe how the PTPS may be used to estimate the risk for radiation induced secondary cancer.
32. **Robustness (functionality):** Describe tools of the PTPS to evaluate the robustness of a proton plan to uncertainties related to SPR calibration, isocenter position, intra fractional motions, and inter fractional organ changes.
33. **Ranking of plans (functionality):** Describe tools of the PTPS to perform an automatic ranking of two or more plans based on user defined decision protocols.
34. **LET evaluation (functionality):** Describe tools of the PTPS to evaluate the LET distribution of a plan, and to compare LET distributions between two or more plans.
35. **Collisions (functionality)**: Does the PTPS support check for collisions? If so, describe the functionality.
36. **Tools for patient specific QA (functionality):** Describe tools for generating patient specific QA plans.
37. **Log file based dose calculation (functionality):** Describe tools for calculating the dose distribution from the accelerator log file of a delivered beam.

5 Motion management

The DCPT patient case mix includes several indications with significant target and risk organ motion such as treatments in the thorax and abdomen. Organ motion is a challenge for PBS treatment planning and delivery due to interplay effects between pencil beam motion and organ motion. The Proton Treatment Planning System must provide tools to account for respiratory motion by use of images obtained at multiple points during the respiration cycle, e.g. a 4DCT scan.

A smooth workflow for planning on 4DCT is preferred, including automation of as many steps in the planning process as possible. In order to evaluate the effect of organ motion, the PTPS should provide tools for dose propagation to all phases of e.g. a 4DCT scan. Additionally, it is preferable if the organ motion can be included in robust optimization.

The PTPS must support motion mitigation features of the Varian ProBeam System.

At present, a range of motion mitigation methods are being investigated in the particle therapy community including breath hold gating, respiratory gating, rescanning, tracking, retracking, spot size variations, phase controlled spot delivery, motion-robust scan patterns, and ripple filters. Effective organ motion management may require simultaneous application of several methods, and the optimum motion mitigation strategy may depend on the individual patient. Consequently, the PTPS should support as many motion mitigation methods as possible to ensure optimal treatment of the large variety of moving targets in the DCPT patient case mix.

To maintain high efficiency, repainting as a parameter for plan optimization is preferred.

5.1 Minimum requirements

- **Repainting:** The PTPS must support layer repainting.
- **4DCT:** In case of targets subject to respiratory induced motion, the PTPS must provide tools for taking the respiratory motion into account, based on images including 4DCT images. All phases of the 4DCT scan must be co-registered and handled as a single set of images.

5.2 Evaluation criteria

38. **Motion management (flexibility):** Describe which motion management techniques are supported by the PTPS (e.g. respiratory gating, breath hold gating, rescanning). Describe how the techniques are supported.
39. **Tools for 4DCT treatment planning (functionality):** Describe the tools for treatment planning based on 4DCT (e.g. automatic generation of MIP, automatic selection of mid-ventilation phase, and automatic propagation of contours from one phase to all phases).
40. **4DCT dose (functionality):** Describe how the PTPS supports dose calculation at all phases (e.g. by dose/structure propagation. Can individual weighted summation be performed?)
41. **4DCT robust optimization (functionality):** Can robust 4DCT optimization be used to minimize the interplay effects? If so, describe how the PTPS allows inclusion of 4DCT images in the robust optimization.
42. **4DCT, gating (functionality):** Is it possible to include in the optimization only selected 4DCT phases used for gating? If so, describe the functionality.
43. **4DCT repainting (functionality):** Does the PTPS supports inclusion of repainting as a parameter for plan optimization (e.g. to optimize delivery time). If so, describe the functionality.
44. **Rescanning (functionality):** Describe how the PTPS handles rescanning (e.g. isolayer, scaled rescanning, phase controlled, volumetric, combination of the techniques, user defined etc.).

6 Physics

The exploitation of the potential high conformity of the dose to the target in proton therapy is sensitive to the accuracy of calculation and optimization of dose in the process of treatment planning. The PTPS should provide beam models and calculation engines to meet the demand for accuracy. These models should preferably have been experimentally validated, and include special issues like handling of accessories, edge scattering on cut blocks, Bragg peak degradation due to inhomogeneities, non-organic implants, and the use of Dual Energy CT –data for optimized determination of Stopping Power Ratio.

Evaluation of the LET distribution provides information of the biological robustness of treatment plans and ideally the LET distribution will be considered in the optimization of the dose distribution.

For evaluation of patient safety the capability of modeling of neutron doses is wanted for.

The DCPT ProBeam System will be commissioned with two beam tunings (giving different spot sizes at the isocenter), which must be handled by the PTPS in a flexible way.

6.1 Minimum requirements

- **Beam modeling:** The PTPS must be able to model the actively scanned pencil beams generated by the specific Varian ProBeam system installed at DCPT.
- **Single energy CT:** The PTPS must be able to handle single energy CT scanner specific look up tables for mapping of CT numbers to relevant interaction quantities for the dose calculations algorithms. The look up tables should be editable.

6.2 Evaluation criteria

45. **Beam models (flexibility):** Describe the various calculation engines for proton therapy (e.g. pencil beam convolution, Monte Carlo simulation) provided by the PTPS
46. **Monte-Carlo calculation (functionality):** Does the PTPS provide dose calculations by Monte-Carlo method for protons? If so, describe the implementation of Monte-Carlo calculation and provide data demonstrating the performance if possible.
47. **Dose optimization methods (functionality):** Describe to what extend the various beam models can be used in robust and biological optimization.
48. **Beam models, non-organic implants (functionality):** Describe how the PTPS calculation engines handle non-organic implants like metal, Kevlar, silicone implants etc. If possible - provide documentation for experimental validation.
49. **Accessories (functionality):** Describe how the PTPS calculation engines handle accessories like range shifters, blocks and ripple filters for different snouts, snout-skin distances, materials and geometries. Provide documented experimental validation if possible.
50. **Dual energy CT (functionality):** Describe how the PTPS handles data from a dual energy CT scanner, and how the data may be converted into SPR information for the dose calculation algorithms.
51. **LET distributions, calculation (functionality):** Does the PTPS provide calculation of LET distribution? If so, describe how the PTPS calculates LET distributions (e.g. dose averaged and/or fluence averaged distributions), both for the entire plan and for each individual treatment beam.
52. **LET distributions, optimization (functionality):** Does the PTPS provide optimization of LET distribution? If so, describe how the PTPS optimizes LET distributions.
53. **Neutron dose (functionality):** Does the PTPS provide modeling of neutron dose? If so, describe tools to model and evaluate the dose contribution from neutron radiation to the patient (e.g. from neutrons in the primary beam, and from secondary neutrons generated in the patient).
54. **Beam models, multiple beam tunes (flexibility):** Describe how two beam tunes will be handled in the beam modeling (e.g. are the beam tunes handled as two different machines?)
55. **Beam modeling (flexibility):** Describe how the beam models are generated for the PTPS. Is it done by the user alone - or by the tenderer based on the user measurement? Describe the service/support provided by the tenderer during the beam modeling.

7 Adaptive Radiotherapy (ART)

Adaptive Radiotherapy (ART) involves adaptation of the treatment plan to anatomical changes during the treatment course. ART may also compensate for a sub-optimal accumulated dose delivered so far. ART is based on images (e.g. CT, CBCT, MRI, PET) acquired during the treatment course, and the PTPS should support the use of the additional information in these images for smooth plan adaptation.

The core feature to be provided by the PTPS in relation to ART is Deformable Image Registration (DIR). High quality DIR is mandatory. Nevertheless, knowing the uncertainties in DIR it also becomes important to be able to monitor, evaluate and control the DIR used for adaptation. This can be done if the PTPS provides tools for visualization, evaluation and user interaction of and with the registration.

For photon radiotherapy, ART has proven to be an effective tool to reduce the disagreement between the planned and the actually delivered dose distribution. For proton therapy, the dosimetric consequences of anatomical changes are even more important, and the need for a high level of adaptation is expected. The PTPS must therefore support an efficient, effective and safe workflow including aspects of ART such as treatment evaluation using CBCT, contour propagation, dose recalculation, dose mapping, dose accumulation, and treatment re-planning with inclusion of the dose delivered so far.

In e.g. treatment in the pelvis the inter fractional changes in anatomy will dictate the plan of the day to be selected for a plan library. The PTPS must support plan selection libraries, where daily pre-treatment imaging is used for online selection of the most suitable plan from a plan library.

7.1 Minimum requirements

- **Deformable image registration (DIR):** The PTPS must provide tools to perform DIR between two CT images and between CBCT and CT images.
- **Contour propagation:** The PTPS must provide tools to propagate contours between deformedly registered images.
- **Dose recalculation:** The PTPS must provide tools to recalculate doses from the same plan on additional CT images deformedly registered to the planning CT.

7.2 Evaluation criteria

57. **DIR, algorithm (flexibility):** Specify the deformable image registration algorithms available. Describe if the algorithms are based on grayscale, anatomical structures, preservation of mass, etc. If possible, provide data demonstrating the performance.
58. **DIR, parameters and visualization (flexibility):** Specify parameters available from the DIR, e.g. translations, rotations, volume changes. Describe the tools to visualize deformed structures and not deformed structures on the original image and on the target image.
59. **DIR, evaluation (flexibility):** Describe evaluation tools for the DIR (e.g. point evaluation for manually selected points and self-consistency checks by back-and-forth mapping or circular mapping through e.g. 4DCT phases).
60. **DIR, user interaction (flexibility):** Describe the possibility of user interaction in the DIR (e.g. one or multiple regions of interest, select structures/regions not to be deformed, manual input to drive the DIR algorithm, etc.).
61. **DIR, Deformation Vector Field (functionality):** Is the DVF accessible? If so, describe how. Describe the possibility to generate and use a mean DVF from multiple DIRs (e.g. in order to estimate a mean anatomy from several CBCT scans).
62. **DIR, multiple registrations (flexibility):** Can the PTPS handle multiple registrations between the same two images (e.g. an online and an offline registration between a CBCT and a plan CT)? If so, describe the functionality (e.g. can the user freely select the registration to use for e.g. contour propagation, dose mapping and accumulation?).
63. **Dose calculation, CBCT (functionality):** Can dose calculation be performed using CBCT images? If so, describe the functionality (e.g. how will the HUs be propagated from a plan CT to the CBCT or visa versa?).
64. **Dose mapping (functionality):** Does the PTPS support deformation of dose based on DIR? If so, describe the functionality.
65. **Dose accumulation (functionality):** Does the PTPS support dose accumulation? If so, describe the functionality (e.g. will the dose be accumulated on the planning CT?)
66. **Plan adaptation based on accumulated dose (functionality):** Can the accumulated dose be used in optimization of an adapted plan? If so, describe the functionality.
67. **Plan selection library (flexibility):** Describe how to create a plan selection library (e.g. how can the library be based on information gained from inter fractional changes detected by imaging modalities, e.g. CT, CBCT, PET, and MRI?).

8 Automation, workflow and data integrity

To ensure efficient, consistent, user independency and safe workflows in DCPT, the PTPS must maintain data integrity and provide tools for automation.

Automation includes the use of templates, automated segmentation, automated dose planning, and scripting. And also Multi Criteria Optimization should be provided.

Data integrity is important for maintaining both efficiency and patient safety. The PTPS should be designed to prevent redundant data and to ensure unique relations between data.

As DCPT will have close collaborations with other treatment centers about treatment plan candidates and it is important that the import and export of images, structures, plans, doses etc. is seamless.

8.1 Minimum requirements

- **Templates:** The PTPS must be able to use various predefined templates/protocols to automate the treatment planning process (this could e.g. include, but is not limited to: names and types of structures, fractionation, location of isocenter, field geometry, optimization criteria, plan objectives, etc.)
- **Segmentation:** The PTPS must provide tools for automation of segmentation based on CT or MRI images
- **Scripting:** The software must feature the possibility to create and execute user-defined scripts allowing for customizable automation of various procedures.

8.2 Evaluation criteria

68. **Templates (flexibility):** Describe the possibility to create and use templates for treatment planning (e.g. for structures, treatment gantry, isocenter, beam angles, prescription, optimization, evaluation, isodoses, DRR, etc.)
69. **Automatic segmentation (flexibility):** Specify models used for automatic segmentation (e.g. atlas based). Describe the workflow and the possibility of user interaction and customization (e.g. addition of patients/structures to the atlas). Describe possibility to use images from other imaging modalities than CT, e.g. MRI.
70. **Automatic treatment planning (functionality):** Is the PTPS able to base a treatment plan on a library of best-case plans from similar cases (by diagnose and/or anatomical site) in order to optimize the planning process and quality? If so, describe the functionality.
71. **Scripting (flexibility):** Describe how scripting can be used to support efficient workflow and automate various tasks involved in image registration, segmentation, treatment planning, optimization and evaluation. If any of the described scripts are delivered by the tenderer as part of this tender, this needs to be specified.
72. **Multi Criteria Optimization (functionality):** Does the system support Multi Criteria Optimization? If so, describe the functionality.
73. **Databases (functionality):** Describe the database or databases used in the PTPS to store and organize data. In general terms specify which database stores which data? Giving special attention to safety for the patient and to prevent unintended events, how do the tenderer organize data to ensure minimum redundancy, maintaining unique relations between patient ID, images, dose plans, registrations, etc. across databases including the Aria database?
74. **Aria -> PTPS (flexibility):** Describe the transfer of images obtained during treatment together with related treatment parameters from Aria to the PTPS. Describe the workflow when transferring the images including manual procedures and how related data is transferred and stored (e.g. date and time stamps, related fraction number, on-line registration information, treatment machine, couch positions, match to reference CT, applied shifts and rotations etc.)? How does the PTPS assign a unique patient ID to the data and relate it to the patient ID in the Aria database? If the PTPS includes more than one database, describe the same transfer between databases inside the PTPS.
75. **Data export (functionality):** Describe how the PTPS manages export of data for sending e.g. scans, structures, plans and dose matrices to other Danish centers. Is it possible to use different export filter settings?
76. **Data import (functionality):** Describe how the PTPS manages import of data (e.g. scans, structures, plans, and dose matrices) from other Danish centers with various contouring software and treatment planning systems. Is it possible to use different import filter settings?

9 Research, education and training

The overall vision for DCPT is to deliver the highest quality of proton beam treatment of cancer and to conduct frontline research. An extensive research program is planned, with the main areas being outlined in the DCPT project proposal from 2012.

In brief, the research in DCPT will encompass basic, translational and clinical studies within biology, imaging, physics and oncology integrated within the existing translational research environment in radiation oncology at Aarhus University Hospital. Clinical protocols and clinical research will also be conducted by the Danish Multidisciplinary Cancer Groups; DMCG.dk to support the development of evidence for Proton Therapy. It is expected that 85 % of patients treated at the DCPT will be selected by treatment planning comparison using normal tissue complication probability models.

DCPT will have a research room equipped with a horizontal beam, capable for pencil beam scanning, dedicated to physics and biology studies. The biology studies will include irradiation of tumors and normal tissues in small and large animals and irradiation of cell lines in vitro.

Aarhus University Hospital has a long history of teaching, training and educating the different professional groups within radiotherapy. The hospital is hosting the national teaching course on radiotherapy for Danish oncologists, as well as one of the two educational centers for radiation therapists (RTTs) in Denmark. Aarhus University has a dedicated program for medical physics integrated in the basic physics degree, and radiographers and medical physicists also receive their clinical training at the hospital. These activities will be extended to include proton therapy.

The Department of Oncology has since 2007 hosted a Radiotherapy Learning Centre with an installation of VERT, a 3D virtual reality simulation system (Vertual Ltd, www.vertual.eu), and an IT lab with non-clinical installations of the OIS and TPS that mirror the workflow of the clinical installations. A new Learning Centre is being built with the same 3D virtual reality system and now including 3D simulation of the Varian ProBeam System and with the Varian Aria OIS.

Apart from supporting research, the tenderer must also support the implementation of the PTPS at DCPT by making available application training and preferably provide resources for continuous educational training, knowledge exchange, and access to resources at reference centers.

The tenderer must also support future features of the Varian ProBeam System, and the tenderer is asked to disclose their strategy and collaboration with Varian about the synchronization of development of new features.

Advanced research features of the PTPS must also be described.

9.1 Minimum requirements

- **Research projects:** The tenderer must be prepared to participate in collaborative research and development projects within one or more fields of proton therapy and treatment planning.
- **Application training:** The tenderer must provide on-site application training of all relevant staff (radiographers, RTTs, physicists, physicians). Application training includes training in tools, procedures and operations required for segmentation, treatment planning, plan evaluation, data transfer, treatment evaluation, and adaptation.
- **Technical training:** The tenderer must provide training of relevant staff (IT-engineers). Training must include system installation, setup, administration, and optimization. Training for third party virtualization software must also be included.

9.2 Evaluation criteria

77. **Structure and management (flexibility):** Describe in general terms the foreseen structure and management of collaborative research projects between the tenderer and DCPT.
78. **Potential research projects (flexibility):** Give examples of potential synergistic collaborative research projects between the tenderer and DCPT.
79. **Learning Center (flexibility):** How will the tenderer support the learning center? (Eg. will the tenderer make available PTPS licenses for non-clinical educational use and training?)
80. **Continuous educational programs (flexibility):** Does the tenderer in addition to application training offer continuous educational programs (on-site training, e-learning, webinars, teaching courses, etc.)? If so, describe available programs including learning objectives, contents and potential associated costs.
81. **Knowledge exchange (flexibility):** Does the tenderer support various means of knowledge exchange between costumers (e.g. user groups, user meetings, workshops, script exchange sites, online fora and/or other means of exchange of best practice with other users)? If so, describe the means provided and potential associated costs.
82. **Reference centers (flexibility):** Does the tenderer provide reference centers to assist during commissioning and clinical start? If so, describe the configuration of delivery system and OIS of the centers, the clinical workload of

the installed PTPS, and which services DCPT can expect from the reference centers (e.g. email consultations, site visits, practical hands-on training, any time limitations of reference service, etc.).

83. **Support of future functionalities (flexibility):** Describe the tenderer's strategy and the collaboration with Varian to ensure that new functionalities of the Varian ProBeam system will be supported in future versions of the PTPS.
84. **Advanced research features: (flexibility):** Describe if and how any advanced research features, that are not yet clinically released, are included in this tender.
85. **Small animals (flexibility):** Describe features, tools etc. that support dose planning and treatment of small animals like rodents and mini-pigs.