Guidelines for formulation of PET-CT Specifications

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Latest technology whole body Positron Emission Tomography system with integrated multi-slice spiral CT scanner designed for providing volume measurements of metabolic and physiological processes using positron emitters, as well as for producing accurate structural and anatomical fusion images and making attenuation maps for attenuation correction. The CT should also be completely able to function as a full CT machine.
The system should have capability for simultaneous data acquisition, processing, image reconstruction & analysis and fusion and co-registration of PET with CT images.

Manufacturer should provide the details regarding:

1. Manufacturer / Supplier Information
2. Model of the Equipment
3. Product Literature
4. Acquisition & Processing Software Version
5. Where Marketed
6. CE Mark (MDD)

1. PET scanner features:

All specifications must comply with NEMA Standards Publication NU2-2007 Performance Measurements, without altering instrument parameters.

The scanner must have a detection configuration of a continuous ring around the patient. It must not have "gaps" of detection of areas of decreased sensitivity around the ring of detection.

The scanner must have low power laser lines orthogonally mounted on the gantry for patient alignment. The laser should be mounted in such a way that the patient can be positioned from either side of the gantry/patient bed.

Specify the front end shielding

Identify back end shielding

2. Patient Aperture:

Specify the size of patient aperture with the transmission source in place.

(a). Diameter (cm)
(b). Length (cm)

3. Slice Separation:

The (center-to center) separation between slices acquired simultaneously without any axial motion must not exceed 5 mm.

4. Detector Assembly:

i. Specify the Crystal material: (BGO, LSO or LYSO)
ii. Specify the size of the crystal (mm): Length, width and depth

iii. Specify the number of crystals:

iv. Specify the number of crystals per PMT:

v. Specify the number of PMT's:

vi. Specify the geometric arrangement of the detectors (Diagram):

vii. Specify the number of detector rings:

viii**.** Specify the number of detector block:

ix. Specify the Number of crystal per detector block:

x. Specify the ring diameter (cm):

xi. Specify the axial FOV, mm:

xii. Specify the number of image planes:

xiii. Specify the plane spacing:

5. **DETECTOR PERFORMANCE**:

i. System sensitivity (cps/Bq/ml)
ii. Scatter fraction (%):
iii. Activity at which 50% dead time loss in coincidence counts occurs (MBq):
iv. Peak singles count rates (kcps):
v. Activity at which peak singles counts occurs (MBq):
vi. Peak coincidence counts rate(kcps):
vii. Activity at which peak coincidence counts occurs (MBq):
viii. Peak NEC (kcps):
ix. Activity at which peak NEC is achieved (MBq):
x. Scatter correction: Give method used

6. Resolution (mm):

i. Transaxial (FWHM) : 1 cm rad, statny: $\leq$5
: 10 cm rad, statny: $\leq$6

ii. Axial (FWHM) : 1 cm radius : ≤5
: 10 cm radius: ≤6

7. Energy Resolution (%):≤15%

8. Uniformity: ≤5% variation

9. Detection Configuration:

The scanner must have a detection configuration of a continuous ring around the patient. It must not have "gaps" of detection or areas of decreased sensitivity around the ring of detection.

10. Patient Alignment:

The scanner must have low power laser lines orthogonal mounted on the gantry for patient alignment. The laser should be mounted in such a way that the patient can be positioned from either side of the gantry from either side of the patient bed.

11. GANTRY:

i. Specify the H x W x D, cm:

ii. Specify the Weight, kg:

iii. Specify the Patient port diameter, cm:

iv. Patient positioning: Laser

v. Transmission source: CT attenuation correction with additional feature

12. Imaging Table Features:

i. Precision bed with low attenuation carbon fibre pallet and minimum sag of the patient table top. It should be able to bear up to 200 kg patient weight.

ii. The horizontal motion of the patient bed must be electrically motorized and computer controlled with an independent operator control option as well. Operator controls accessible from both sides of the patient must be provided for both horizontal and vertical movements.

iii. A digital readout of the horizontal and vertical position of the bed must exist and must be located near the aperture controls for the bed to provide ease in positioning.

iv**.** Horizontal movement should be ≥ 180 cm and Vertical movement between 60 -110 cm.

v. Paediatric pallet, Headrest, Armrests, Knee-leg support are to be provided.

13. IMAGE RECONSTRUCTION:

i. Image uniformity:

Total uniformity:
inter slice uniformity :

ii. Coincidence window, nsec:

14. COMPUTER SYSTEM (DICOM Compliant):
(Acquisition and processing workstation with following features)

A. CPU:

i. Specify the Processor speed (GHz):
ii. Specify the Operating system: preferably Windows based
iii. Specify the Random Access Memory:
iv. Specify the word length, bits:
v. Specify the video memory, MB:
Vi. Ports: 1 serial, 4 USB behind and 2 USB in the front

B. STORAGE:

i. Specify the hard disk storage capacity :
ii.DVD drives with writing facility.
iii. Archival system with 1.5 tera byte storage capability with possibilities to retrieve and analyse multiple studies simultaneously with spare disc.

C. Specify ADC Resolution bits:

D. Specify the ADC throughput KHz:

E. Camera ports number: Network

F. Dual Isotope input: required

G. INPUT/OUTPUT:

i. Display monitor: LCD
ii. Specify the Size, cm :
iii.What is the maximum resolution of the screen (pixels):
iv. What is the maximum number of distinct steps in colour scale:
v.How many colour scale are supplied as standard:
vi.Can the user create an additional colour scale:
vii. Can each displayed image modality use a different colour scale Independently of the colour scales used for the others modalities:
viii. Can the display levels be adjusted independently for each image On the screen:
ix. Can user specified free text be displayed on the screen:

x. Can upper and lower display levels be specified as:
Actual counts:
Present of maximum in the current image:
Present of maximum in the complete dynamic sequence:

xi. Printer: Camera for B/W as well as colour hardcopy on paper and transparency – dry chemistry type and one network laser printer.

xii. ROI Control : mouse and keyboard

xiii. Hard copy : DICOM or PostScript

H. Operating Features:

i. Simultaneous acquisition and processing: Required
ii. Acquisition matrix: 1K x 1K
iii. ECG gating: Required
iv. Respiratory Gating needed

I. Application Software:

i. Capability for simultaneous data acquisition and processing.

ii. Software for Data Collection, Reconstruction of images for Co-registration, 3-D volume reconstruction with 3-D fusion, MIP, whole body acquisition. Attenuation correction, quality control software and a latest version of DICOM facilities for clinical applications at the time of shipment, reconstruction (FBP, 3-D OSEM).

iii. System management software for computerized calibration, diagnostics and administration of the patients' records. Database management is also required.

iv. Quality Control Software for scanner calibration (for all scanner performance parameters).

v. Other Data Processing software should include:

a. Fully integrated processing & Reconstruction
b. CT Based attenuation correction
c. Volume rendering and virtual endoscopy.
d. Model based 3-D scatter correction
e. Iterative reconstruction methods
f. 3-D prospective reconstruction with iterative scatter correction

vi. Latest Emory Cardiac Toolbox PET – SPECT soft ware

vii. Computer aided diagnosis software for neurological applications with quantification ability (SISCOM or equivalent software)

viii. Provision to make DICOM/PDF/JPEG/AVI/MPEG digital output. Software for CT/PET/MRI fusion and provision for multiple phases in 3D demonstration and treatment planning system.

ix. PET DICOM 3.0 or higher version must be implemented. It should have the ability to import MR/CT DICOM Data.

J. Data Acquisition:

i. Acquisition Modes: Acquisition in 3D modes must include Static, Whole Body, Dynamic and Gated acquisition provisions. 3D whole Body acquisition protocols with prospective 3-D reconstruction algorithm. Iterative reconstruction technique should also be available

ii. Acquisition Protocols: The acquisition program should support pre-programmed scan protocols with acquisition and reconstruction parameters and patient information with simple, dynamic editing of parameters. These parameters would include all information necessary to acquire data on the PET scanner (e.g. scan duration, patient information, frame/list mode, bed motion), as well as information necessary for reconstruction.

iii. Whole body Acquisition: Multi bed acquisitions (e.g. for the purpose of whole body oncology studies) should advance the bed from one position to the next automatically.

iv. Dynamic Frame Mode Acquisition: The acquisition set-up software must support multi-frame acquisitions of different (arbitrary) frame duration's with no loss of data between frames.

v. Automatic Acquisition Start: The option to start an acquisition automatically must be provided.

vi. Reconstruction Start: Image reconstruction should simultaneously start for the acquired images while acquisition is still in process.

vii. Reconstruction Time: The time for reconstruction of a uniform phantom with corrections for normalization scatter, and calculated attenuation applied must be less than 10 sec/frame for filtered back projection and < 2 min / frame for OSEM iterative reconstruction.

viii. Pixel Size: The user should have the capability to specify the pixel size for reconstruction. The reconstruction program should support reconstruction in image sizes of at least 128x128 or higher.

ix. Scatter Correction: A scatter correction technique that is space variant and adjusts for patient geometry must be included. Scatter correction must be provided based on scan of the actual patient whose scan is being corrected and processed automatically.

x. ECG gating and respiratory gating should be part of the offer and are to be provided with necessary software. Acquisition matrix: 1K x 1K

xi. Dual Isotope input is also required

K. DATABASE MANAGEMENT: Required.

L. PROGRAMMING LANGUAGE: Basic or C

M. NETWORKING:

i. LAN architecture: Ethernet
ii. Communication protocols used: TCP/IP, DICOM

N. DICOM 3.0 COMPLIANCE: NM, SC, SCU/SCP query/retrieve, modality work list, performed procedure step.

O. Modality Work list: Required

P. Query/Retrieve: Required

Q. POWER REQUIREMENTS: Standard

R. HEAT OUTPUT, W (BTU/hr): 220 (750)

15. SITING REQUIREMENTS: To be given

16. **ENVIRONMENTAL REQUIREMENTS**:

i. Operating temp range, °C (°F): give the details

ii. Humidity, %: give the details

iv. Cooling, BTU/hr: give the details

17. POWER REQUIREMENTS: To be given separately for PET & CT

18. CT Specifications:

i. MODEL:
ii. Supplier Information:
iii. Product literature:
iv. Where Marketed:
v. CE Mark (MDD) :

19. TYPE: Multislice CT (Mentioned the number of slices):

20. DETECTOR:

i. Specify the Total detector width, z-axis, mm:

ii. Specify reconstructed slice width options, mm:

iii. Specify optional min slice width, mm:

iv. Specify the standard Rotation times, sec, 360°:

v. Specify the optional min rotation time, sec:

21. PERFORMANCE:

A. Specify the high-contrast spatial resolution:

B. MTF kernel (i.e., bone, body): bone

C. 0% MTF, lp/cm: 20

D. 10% MTF, lp/cm: 15

E. 15% MTF, lp/cm: 10

F. Specify the Slice sensitivity profile:

i. FWHM of SSP at 0.5 mm:
ii. FWHM of SSP at 1 mm:
iii. FWHM of SSP at 2 mm:

G. Low-contrast resolution**,**

mm at % at ≤20 mGy (2 rads): 3 mm at 0.3% at 2 rads

Noise, % at ≤25 mGy (2.5 rads): 0.3% at 25 mGy (2.5 rads)

22. GANTRY:

i. Specify the gantry dimensions, H x W x D, cm:

ii. Specify the gantry weight, kg:

iii. Specify the gantry aperture, cm:

iv. Specify the scan localizer:

23. X-RAY TUBE:

i. Specify the heat storage, MHU:

ii. Specify the heat dissipation rate, KHU/min:

iii. Specify the tube cooling:

iv. Specify the tube focal spots, mm:

v. Specify the expected tube life, scan sec and maximum mA:

vi. Specify the Maximum scan time at maximum mA, sec:

24. X-RAY GENERATOR:

i. Specify the kW output:

ii. Specify the kVp range:

iii. Specify the mA range:

25. PATIENT TABLE:

A. Specify the range of movement:

(i) Vertical, cm:
(ii) Longitudinal, cm:
(iii)Scannable range, cm:

B. Specify the max load capacity (accuracy, mm), without restrictions, kg:

26. RADIATION DOSE:

i. Dose modulation technique: Required

ii. Paediatric specific dose control: Required

iii. Prospective ECG gating: Required

iv. Retrospective ECG editing: Required

v. Axial cardiac: Required

vi. Low dose cardiac (axial acquisition): Required

viii. Arrhythmia correction: Required

27. Clinical applications and functionality with following features required:

i. Coronary artery calcification scoring

ii. Quantification

iii. Respiratory gating

iv. Highest achievable temporal resolution: $\leq$0.1

v. Cardiac, perfusion, lung analysis, CT colonography, Denta Scan, CT angiography:
vi. Ventricular output

vii. Myocardial evaluation

viii. Lung nodule assisted reading

ix. Lung nodule CAD

x. Lung function analysis

xi. Virtual colonoscopy assisted reading

xii. Virtual colonoscopy CAD

xiii. Vessel analysis (noncardiac)

xiv. Brain perfusion

xv. Z-axis coverage for brain perfusion

xvi. Auto bone removal

xvii. Body perfusion

xviii. CT/MR fusion, functional CT brain perfusion, virtual colonoscopy, stereotaxis, AVA stenosis, stent planning, bone mineral analysis, cardiac imaging, cardiac scoring, Cardiac LV/RV, EP planning, SmartmA-3-D dose modulation, ECG dose modulation with optional cardiac.

28. IMAGE RECONSTRUCTION:

A. **COMPUTER SYSTEM (Acquisition and processing workstation with following features)**:

a. CPU:

(i) Specify the processor speed (GHz):
(ii) Specify the operating system: preferably Windows based
(iv) Specify the memory (RAM):
(v) Specify the word length, bits : preferably 64 bits
(vi) Specify the video memory, MB :
(vii) Ports: 1 or more serial, 4 USB

b. Specify the Scan FOVs, cm:

c. Specify the reconstruction matrices:

d. Specify the max reconstruction rate, (512 x 512), ips:

f. Real-time partial image reconstruction: Required

g. Specify the no. of online images:

h. Archival storage should be: MOD, DVD, CD

i. Image sharing: DVD, USB

B. SYSTEM INTEGRATION:

i. DICOM Ready: Required

ii. CT image storage SCU/SCP: Required

iii. Enhanced CT storage SCU/SCP: Required

iv. ECG waveform SCP/SCU: Required

v. Modality work list SCU: Required

vi. Query/Retrieve SCU and SCP: Required

vii. Storage commitment SCU: Required

viii. Modality performed procedure step SCU: Required

C. IMAGE PROCESSING:

i. Standard or optional: Standard

ii. Remote access to raw image data: Required

iii. Remote access to clinical applications: Required

iv. DICOM 3-D image export: Required

29. Year completed after first machine sold:

30. Number of installations & company profile: Company should preferably be manufacturer of the equipment and in case non-manufacturing vendors (third party supplier) are allowed to participate the same should be mentioned clearly in bid document. In case of third party supplier the liabilities of principal manufacturing company and third party supplier needs to be clearly demarcated and ensured.

32. Peripherals / Accessories: As per requirement

i. Latest dual-head pressure injector.

ii. Connecting tubing for dual injection system

iii. ECG gating device & necessary electronics to enable gated cardiac acquisition with ECG print out facility.

iv. Phantoms for CT & PET Quality Assurance, 3-D phantom (Germanium-68) Calibration Sources and 2 Rod sources (calibrated for the date of installation).

v. Two germanium orbiting rods for attenuation correction.

vi. 18 to 20 cm cylindrical phantom of polymethyl methacrylate or polythene for Spatial resolution, sensitivity, scatter fraction, count-rate losses and randoms, uniformity test in PET.

vii. Cylindrical phantom for iso-exposure counters at different distance from CT.

viii. MTF test tools and interpretation tools.

ix. Dosimetery Phantom (32 cm body and 16 cm head) for CT.

x. Acrylic uniformity phantom

xi. X-ray film densitometer.

xii. LiF TLD -100 ribbons and TLD holders.

xiii. Voltage divider with kv and mA.

xiv. On site remote service diagnostic capabilities.

xv. A 3 phase input/output UPS with Steal Maintenance Free (SMF) batteries for the complete system including CT with minimum 45min. backup at full load should be provided.

xvi. Hard copy recorder: Film image hard copy recorder with 20cm x 25.4 cm and 35 mm formats with 12 bit tonal resolution-dry chemistry type.

xvii. DICOM dry laser film camera with docked in processor and dual film format.

xviii. Network color laser printer with at least 16 million colors and 1200 dpi spatial resolution with accessories including workstation, digital, DICOM compatible, Networking, Dicom software for A3/A4,Lamination system and---- years supply of all consumables namely color toners, drum, imaging system, glossy paper and lamination roll.

xix. Umax powerlook 2100 A3 size scanner with optical resolution: 800dpix1600dpi across full A3 bed, max resolution: 9600dpi, max scanning area 304.8x431.8 mm, max optical density: 3.4D and scan method single pass.

xx. ------nos. Duo-2- core (processor speed: 2.8 GHz or more) or latest specifications workstation fully loaded with all processing softwares

xxi. Two non invasive vital sign monitors (for monitoring of HR, BP, ECG, Saturation etc.)

xxii. Fully equipped crash cart with resuscitation kit.

xxiii. ------nos. laptop (Duo-2-core with processor speed 2.8 GHz) based remote processing workstation/console and image review station.

xxiv. Remote dial-up diagnostic and logging facilities.

xxv. One Defibrillator with ECG monitor.

xxvi. Two beta/gamma radioisotope calibrator

xxvii. One Anthromorphic Phantom(whole body)

xxviii. One TLD reader with annealing unit with accessories like TLD pellets.

xxix. One Transport trolleys and transport containers for transporting FDG.

xxx. Radiation survey meters

xxxi. Contamination monitors

xxxii. Gun monitors

xxxiii. Pocket dosimeters

xxxiv. Area zone monitors

xxxv. One Anthromorphic Thorax Phantom

xxxvi. Tools (hardware and software) for PET/CT guided brain biopsy.

xxxvii. Complete hardware and software tools for radiotherapy planning and execution.

xxxviii. Dehumidifier for 30-40° temperature

xxxix. Glucometer

xl. Infusion pump.

xli. Automatic blood pressure measuring apparatus.

xlii. Electronic weighing machine with 200 kg.

xliii. 12 leads ECG machine.

33. Guarantee/ Warranty for complete system:

i. The complete system should have a guarantee including the radioactive reference source, crystals, detectors and x-ray tubes replacement for a period of five years after the satisfactory commissioning and handing over of the equipment.

ii. Comprehensive maintenance contract for whole system including x-ray tube replacement as and when required and accessories for a period of five years after the expiry of warranty period.

iii. The peripherals / accessories, electronics/electrical consumables (leads, probes, batteries etc), 3-D phantom source and rod sources, air conditioning units and batteries of UPS will also form part of the warranty and thereafter CMC. Services, repairs and maintenance of all third party items will be the sole responsibility of primary manufacturer. Replacement /replenishment of the coolant for gantry will also form the part of warranty as well as CMC.

iv. At least 95% uptime should be maintained during warranty as well as CMC period.

v. After sale service to be available locally in city with availability of an on site engineer.

vi. The CMC contract shall be executed after the warranty period; however, rates shall be fixed from now.

vii. The manufacturer would be required to quote for CMC value which would commence from sixth year onwards till 10^{th} year.