

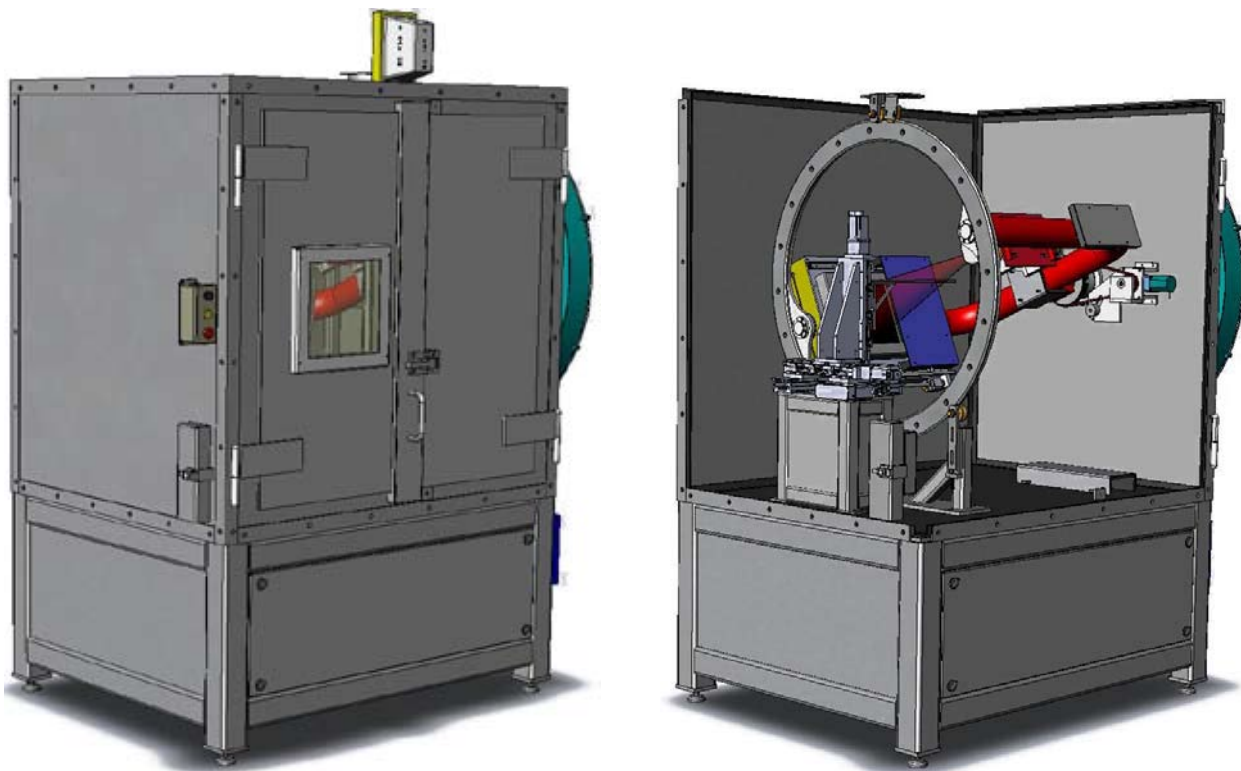
## X-RAD 225CX

### Image Guided Biological Irradiator System

Technical Specifications (updated Sept 09)

The X-RAD 225Cx Small Animal Image Guided Irradiator provides a high accuracy cone beam CT imaging system and a high dose delivery therapeutic X-ray source into a single platform. This self shielded system consists of the following items:

#### Item 1. Shielded Cabinet:



- Cabinet Dimensions: 88" h x 72" w x 48" d (224cm h x 183cm w x 122cm d)
- Cabinet Weight: 5000 lbs (2275 kg)
- Large specimen loading door provides easy access inside chamber
- 12" (30cm) leaded glass observation window
- HT Cable Management System
- Ventilation Port located on roof to allow air exchanges inside cabinet
- User Entry Port for inserting small tubing or cables into Irradiation Chamber
- X-RAYS ON Warning Light on roof of cabinet (magnetically relocatable)
- Shielded for 225 kV with exterior leakage less than 1  $\mu$ Sv/hr at 10 cm
- Cabinet meets safety requirements of US Federal Regulation 21 CFR sub chapter J

ITEM 2. X-Ray Unit:



- GE TITAN 225kV, Ultra High Stable 4500 Watt Power Supply
- Comet MXR 225/22 metal ceramic, dual filament design. Power: (640W/3000 W) Focal spot: (d=1mm/d=5.5mm)
- ISOVOLT TITAN E Microprocessor Controlled Operators Console
- 10m HT Cable (15m optional)
- 3000 Watt Water to Air Cooling Pump (closed loop).
- All necessary interconnect cables
- Applicator & Filter Holder mounted to X-Ray Tube
- Filtration: Interchangeable slides; (2) HVL's provided (additional values available as options)
- Collimator Set

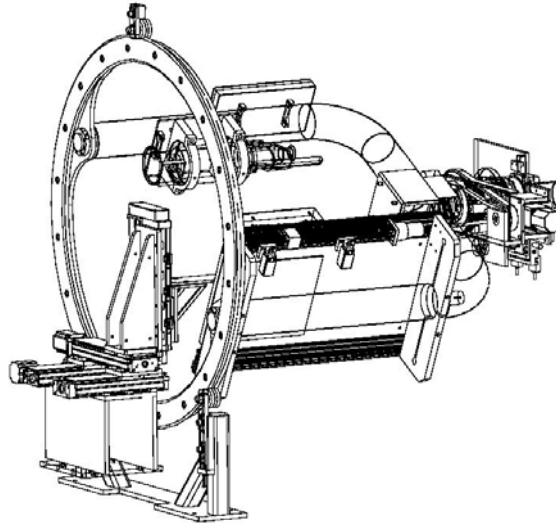
We provide a set of (12) long cones with the following specifications:

- All cones will be 23 cm in length providing a 7cm cone to isocenter distance.
- Fixed cones will be provided in the following sizes (at 30cm SSD):
  - Circles (diameter): 1 mm, 2.5 mm, 5mm, 1 cm, 1.5cm, 2.5cm
  - Squares: 1x1 cm, 2x2cm, 4x4cm
  - Rectangles: 1x3cm, 3x4cm
- A modifiable Field Shaping Collimator will also be provided. The user can change the field size by cutting an opening in a blank lead sheet. Any field shape up to 10x10cm can be created.



- Irradiation Energy: 20-225 kVp (nominal)
- Dose Rate: 10-400 cGy/min
- Beam Orientation: Fixed, Dynamic (0 - 360°)
- Maximum Dose Gradient ( $d_{80-20}$ ): 0.2 mm
  - Dose gradient(0.2 mm) was based on MC calculations of what would be achievable. It is a little bit too optimistic.
  - The dose gradients I have measured (EBT Film in solid water) are as follows:
  - With a 2cm surface collimator and large focal spot (collimator within 2cm of the top of the solid water)
  - Penumbra (80-20) from 0.5 mm - 0.75 mm (at depths in solid water from 0-2cm). I know that I have previously measured penumbra as small as 0.3mm, but I can't pull this out of my data right now. The uncertainty in those values is about 0.1 mm. With the collimators that Pete is proposing, the object will be ~7-8 cm from the collimator, so the penumbra would be a bit larger. Of course a sharper gradient could be achieved with the small focal spot, but due to tube loading, the dose rate with the small focal spot is about 20% of that with the large focal spot.

### ITEM 3. 4-Axis Motion System:



#### Rotational Stage:

- Supports Tube Assembly & Imaging Plate axially
- IG Targeting Precision (unambiguous targets): +/- 0.5 mm
- Servo Controlled drive with high accuracy relative positioning encoder
- Very smooth 0-360 rotation
- Rotation Speed, Adjustable 0.1 to 3 RPM
- Positioning Accuracy: better than 6 arc minute resolution
- Rotational limit and home detection proximity switches
- Primary beam attenuator mounted behind imaging plate
- Parker Daedal multi-axis motion controller programming

#### X-Y-Z Specimen Positioning Stage:

- High precision X-Y-Z motion with relative position encoders on all axis
- Load Capacity: more than 10lbs (4.5 kg)  
There is no perceptible change in performance from no load to stated full load
- Table Travel: Better than 20mm all directions
- Positional accuracy: 82  $\mu\text{m}$
- Positional Repeatability:  $\pm 20$  micron
- Positioning Velocity, Adjustable: Up to 36mm/sec
- Vertical Stage has brake
- Travel limit and home detection proximity switches
- Parker Daedal multi-axis motion controller programming

### ITEM 4. Imaging Hardware & Specifications:

- Perkin Elmer XRD 0820 AN3 ES
- Active pixels: (1024 x 1024)
- Pitch: 200  $\mu\text{m}$
- Total Area: 20 cm x 20 cm
- Capture Speed: 15 fps (30 fps @ 2x2 binning)



- Scintillator: CsI
- Shutter Protected (shutter covers sensor grid and electronics during high energy exposures)
- Volumetric Imaging Resolution: 0.2 mm (nominal)
- Volumetric Field of View: 100 mm diameter cylinder of 100 mm length
- Minimum Acquisition Time: 20 seconds
- CT Noise: 50 HU at 0.2 mm voxel resolution  
 CT Noise - at first glance the quoted number (50HU) looks reasonable. Of course, noise would be specified for a particular technique, but I just pulled up a CBCT scan of our image quality phantom that was taken at 70kVp, 0.5 mA, 535 frames (this is probably a ~3 cGy image). It looks like 1 standard deviation within a region of 50x50 pixels (1cmx1cm) in the center of an acrylic plate is about 20HU.
- Geometric Linearity: 0.5 mm over 100 mm
- Typical Imaging Dose: 1-10 cGy (center of 30 mm subject)

#### ITEM 5. Pilot V1.1 Imaging Software & Workstation

Image Acquisition and Reconstruction, 3D alignment and Targeting Software (Developed in collaboration with Princess Margaret Hospital of the University Health Network).

- Workstation - Pentium 4 Quad Core CPU, Windows XP Pro OS
- Basic Data Management including Researcher Study, Specimen specific items and ability to import new treatment protocols
- Scan/Target/Treat capabilities including:
  - Cone Beam CT (CBCT)
  - Fluoroscopic scan
  - Quick-treat capability
- Calibration application "PilotCal", with the ability to do:
  - Flood calibrations
  - Projection Maps, to get isocenter/flexmaps
  - Export utility, to export system and research data
- Image review
- Image export
- Energy and current x-ray unit control
- Full study review
- Comprehensive User's Manual
- One year of support and updates

#### SYSTEM WARRANTY

X-ray Power Supply (GE)	12 Months
Manipulators	12 Months
X-ray Tube	21 Months or 2000 Hours (pro-rated)
Cabinet workmanship and Safety Interlock Circuitry	24 Months
X-Ray Imaging Detector	12 Months