Evaluation and Comparison of Image Quality for Indirect Flat Panel Systems with CsI and GOS Scintillators

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Motivation

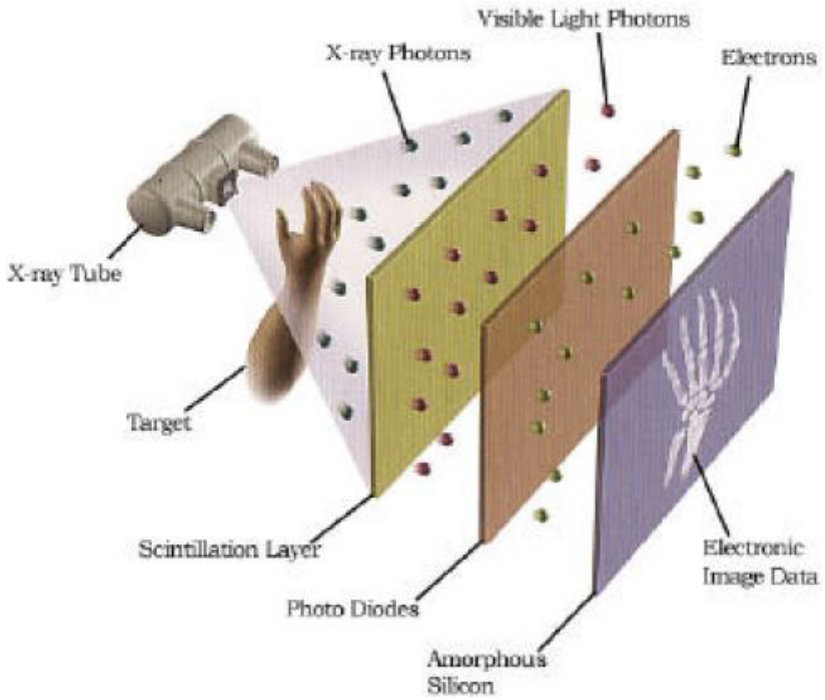
- There are ~5000 analog roentgen systems in Turkey
- Rapid conversion to digital radiography (DR) systems
- Large amounts of DR systems are purchased by the government
- Many options available from different manufacturers
- Objective image quality metrics and measurement protocols are required

Objectives of the work

- To compare flat panel digital radiography (DR) systems in terms of image quality with
  - cesium iodide (CsI) ← expensive
  - gadolinium oxysulfate (GOS) ← cheap

  scintillators
- Define a protocol for image quality measurements
- Find benchmark values for image quality metrics of DR systems

Anatomy of Flat Panel Detector Systems

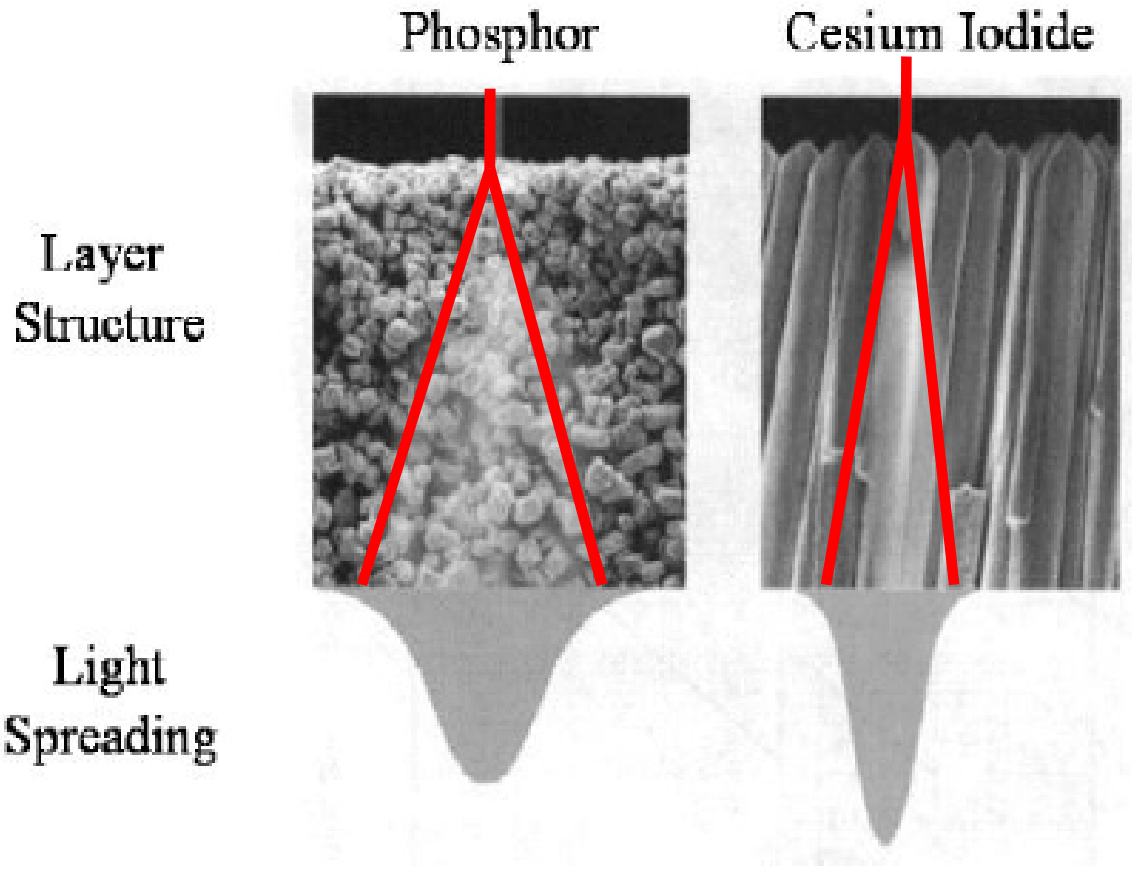


- Flat panel detectors are classified as:
  - Direct : converts x-ray directly into electronic signals
  - Indirect :
    - Scintillator: x-ray → visible light
    - Photodiode: visible light → electric charge
    - Thin film transistor (TFT): readout electric charge

Scintillator Types

- Scintillators have different types of crystals
- CsI and GOS scintillators are commonly used
  - GOS scintillators have granular particles similar to phosphor structures
  - CsI scintillators have needle structure that transport x-rays without spreading
- CsI scintillators are better than GOS in terms of image resolution and DQE
- Flat panel DR systems with CsI scintillators are more expensive compared to GOS

Scintillator Types



X-rays converted to visible light

Visible light scatters before reaching photodiodes

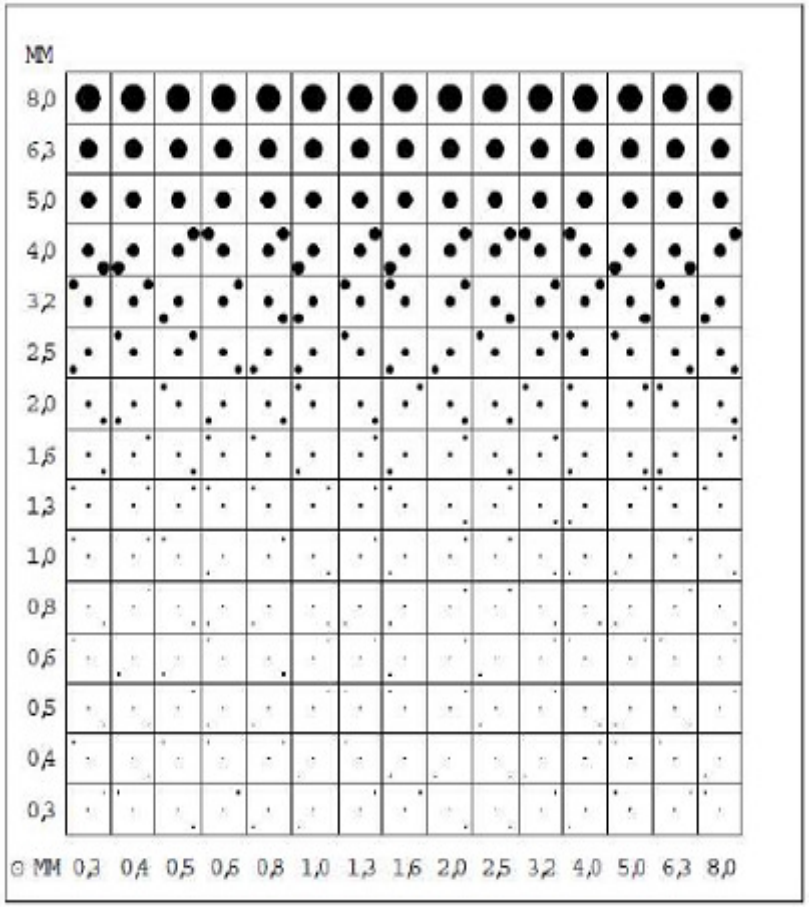
More spreading → higher FWHM → lower image resolution

Detector Quality Metrics

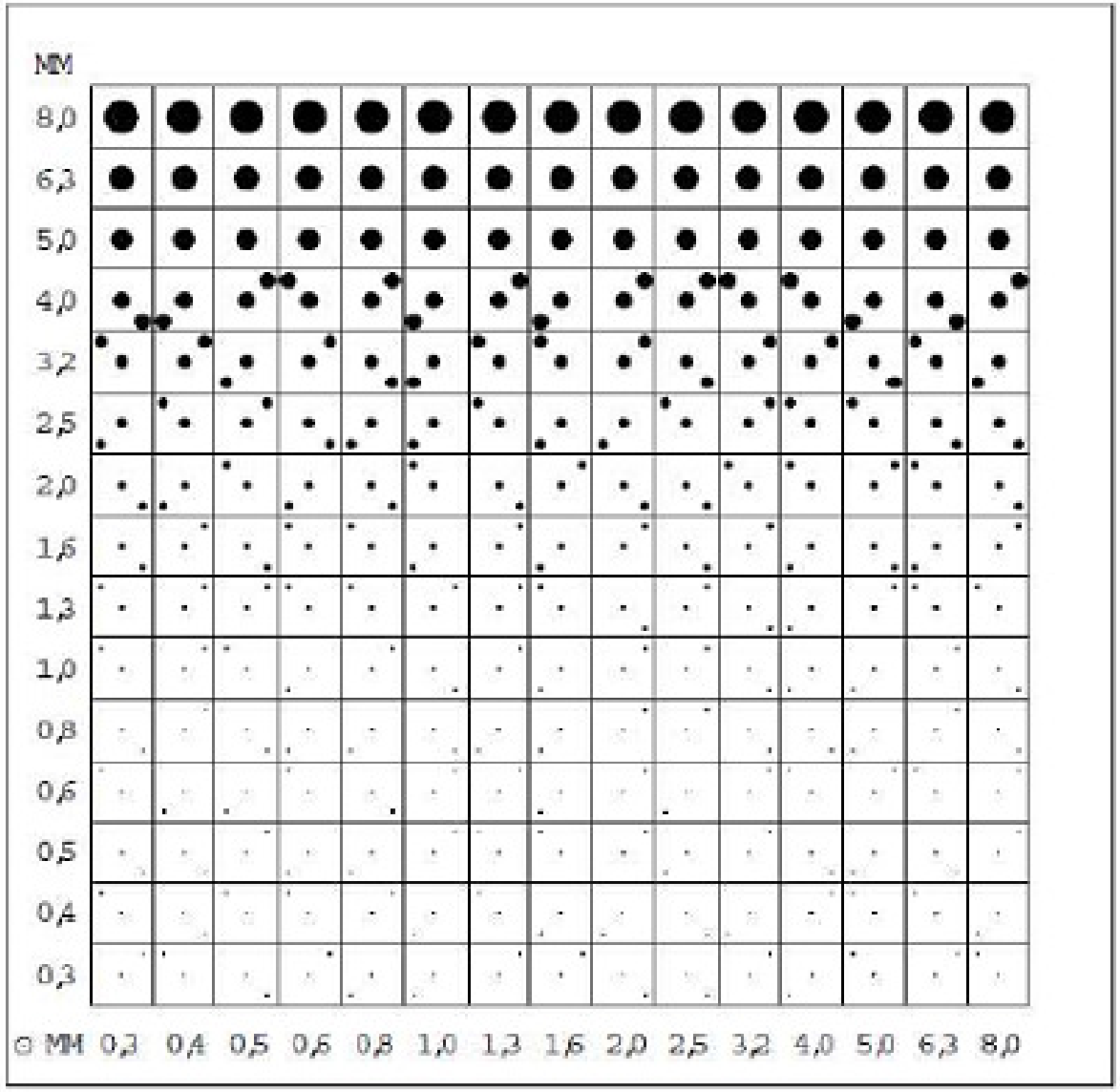
- There are many metrics for detector quality measurement
  - SNR – signal to noise ratio
  - MTF – modulation transfer function
  - NPS – Noise power spectrum
  - NEQ – Noise equivalent quanta
  - DQE – detector quantum efficiency
- Advantage: very detailed and informative
- Disadvantage:
  - hard and time consuming to compute in clinical environment
  - **Factors other than detectors are not measured**

Constrast Detail Phantom (CDRAD)

- Constrast detail phantom can be used to measure overall system performance.
- It shows the required contrast for detection at a given detail (resolution)
- Standard phantoms: CDRAD is commonly used.

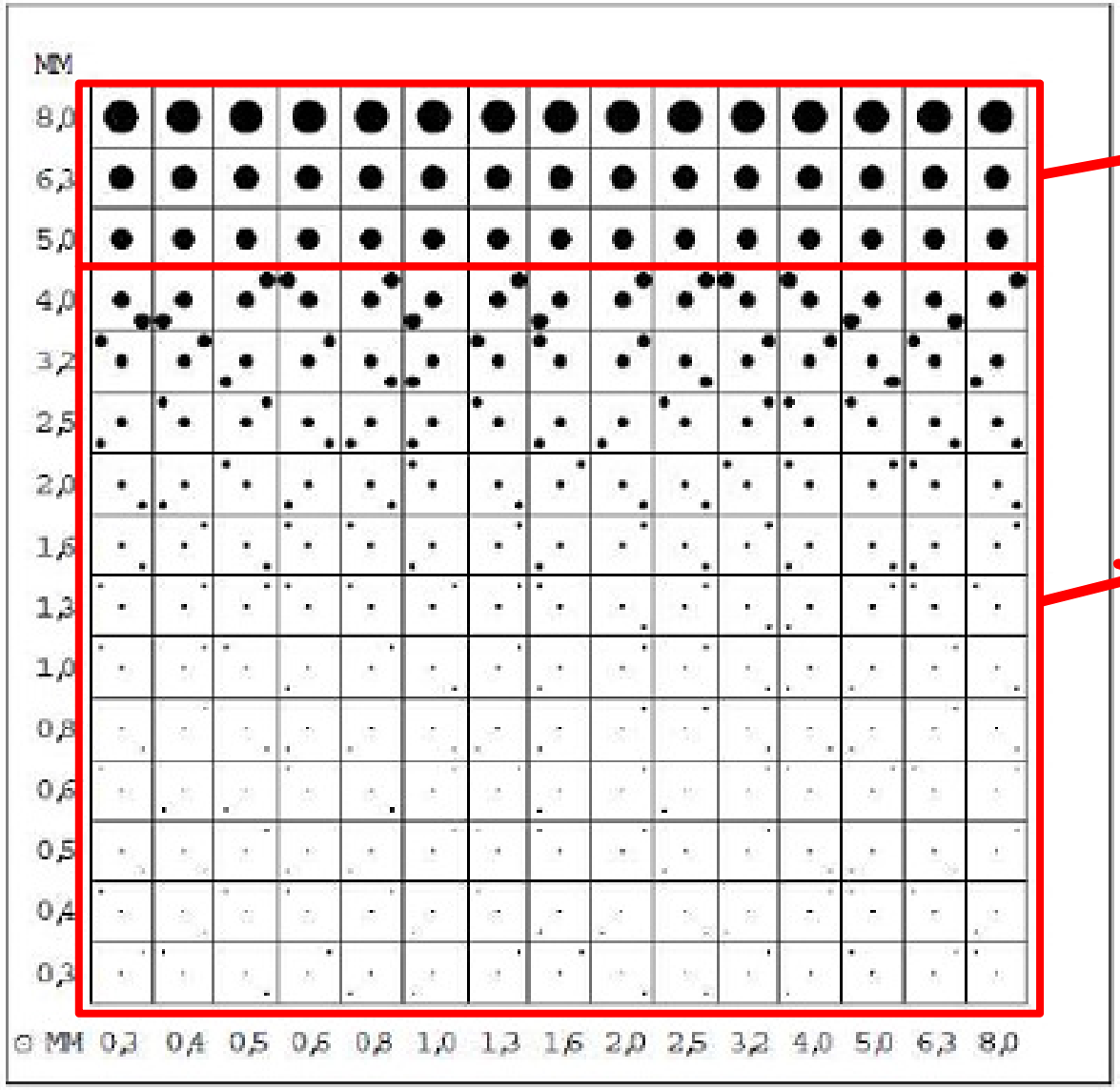


CDRAD Phantom



- constructed on a Plexi-glas tablet
- 225 cylindrical holes of varying diameters and depths
- Depths and diameters are sized 0.3 to 8.0 mm.
- The x-ray image will have 225 squares placed on a 15x15 grid.

CDRAD Phantom



- In the first 3 rows, a single hole

Each square has two holes: one in the middle of the square and another in one of the four possible corner of the square.

CDRAD Analyzer

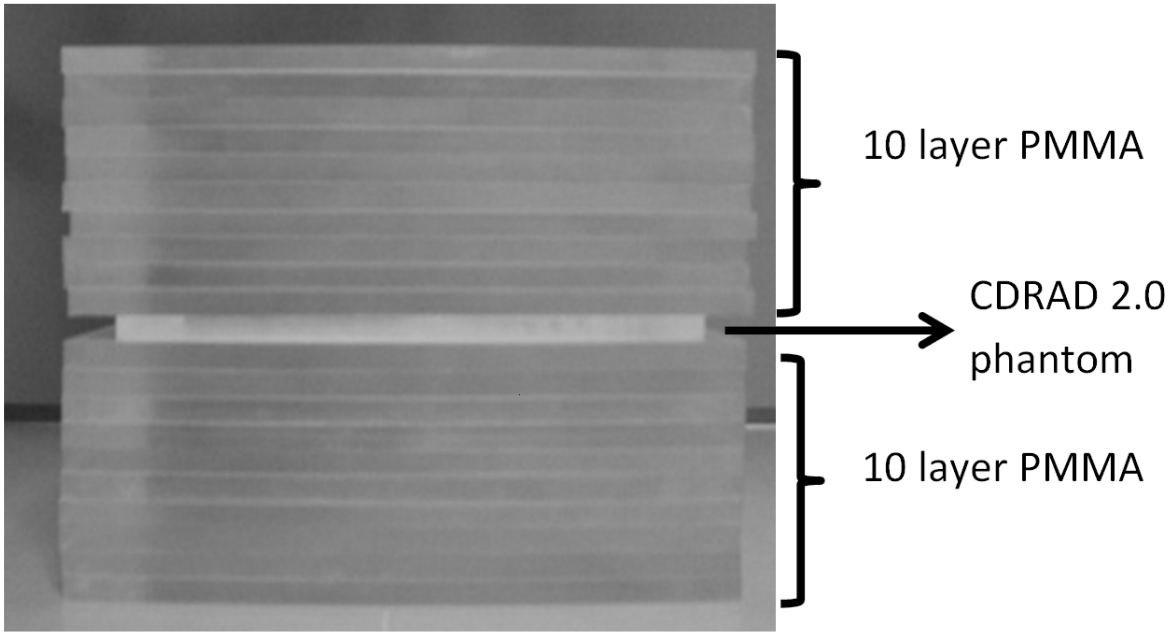
- CDRAD images are analyzed either by
  - radiologists (subjective)
  - software (objective) - CDRAD Analyzer
- They select the corner where they see a hole
- IQFinv metric is computed using the correctly detected detail at each constrast level

$$IQFinv = \frac{100}{\sum_{i=1}^{15} C_i \times D(i, th)}$$

- Inverted to have an increasing value for higher image quality

Method

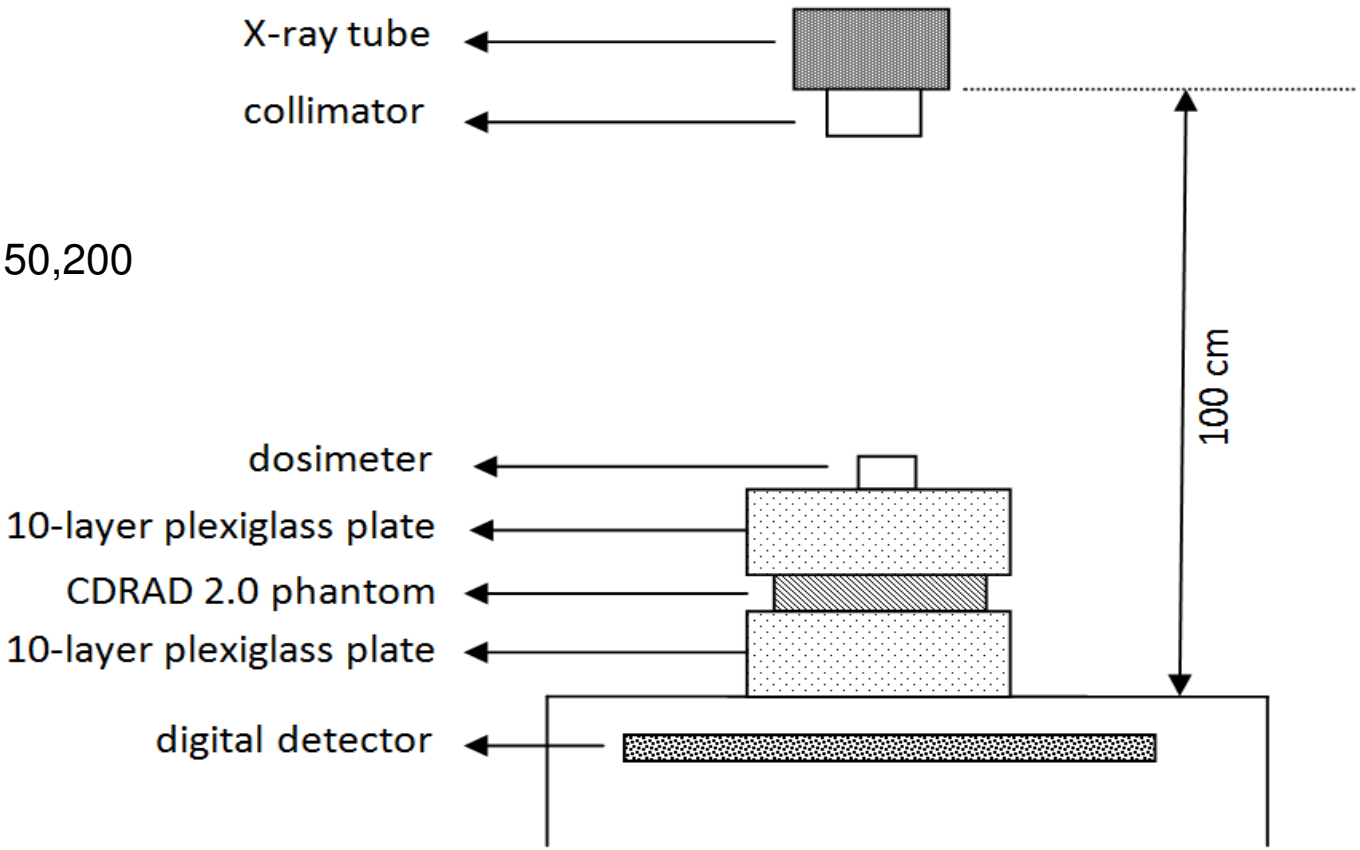
- Images were collected from 9 different panel systems: 6 different manufacturers.
- 4 with CsI and 5 with GOS scintillators
- 20 layers of PMMA for patient thickness



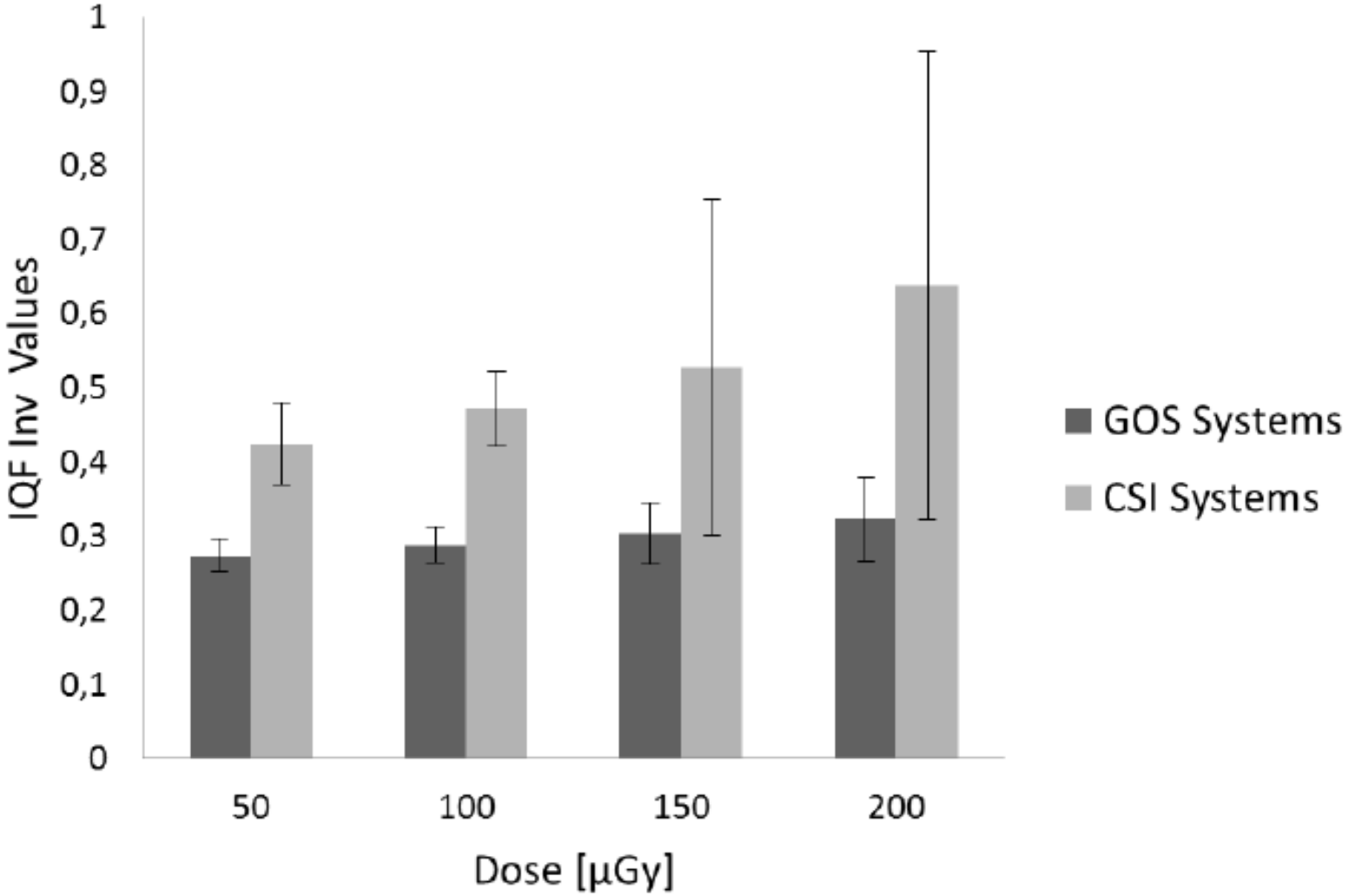
System Setup

Settings:

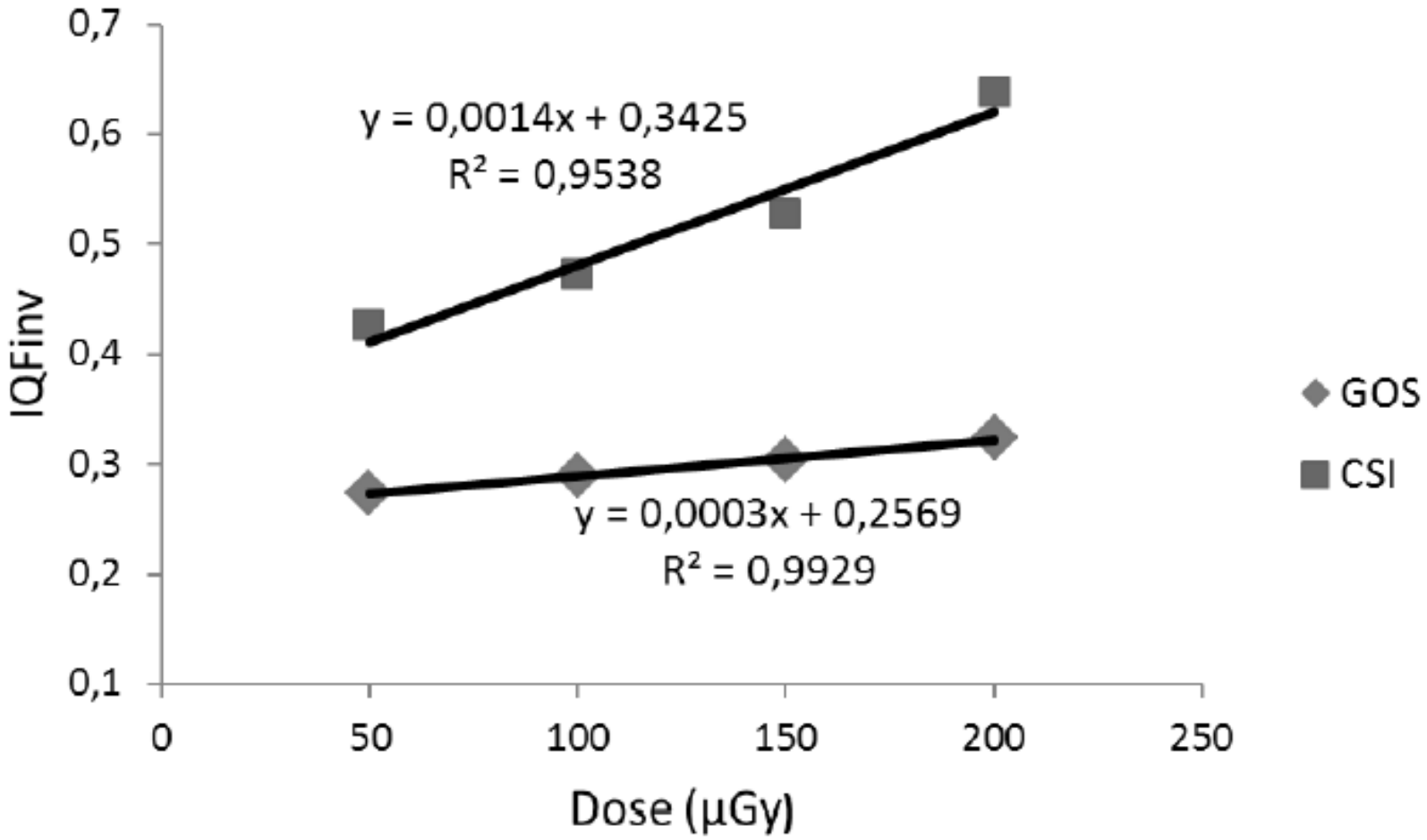
kVp : 80
AEC : closed.
SSD :100 cm
Dose : 50,100, 150,200 (µGys)



Results


1
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0
IQF Inv Values
50
100
150
200
Dose [µGy]
GOS Systems
CSI Systems

Results


0,7
0,6
0,5
0,4
0,3
0,2
0,1
IQFinv
y = 0,0014x + 0,3425
R² = 0,9538
y = 0,0003x + 0,2569
R² = 0,9929
0
50
100
150
200
250
Dose (µGy)
GOS
CSI