Preliminary study to optimise the irradiation condition for future application in small animal CT

M. G. Bisogni, P. Delogu, C. Carpentieri, M. E. Fantacci,

M. Quattrocchi, V. Rosso, A. Stefanini

rtimento di Fisica “E. Fermi” Universita’ di Pisa e INFN Sezion
Pisa

mariagrazia.quattrocchi@pi.infn.it

Outline

- ✓Introduction
- ✓Acquisition system description and characterization
- ✓Optimization of the equalization process
- ✓Influence of the energy window on the image quality
- ✓Conclusions

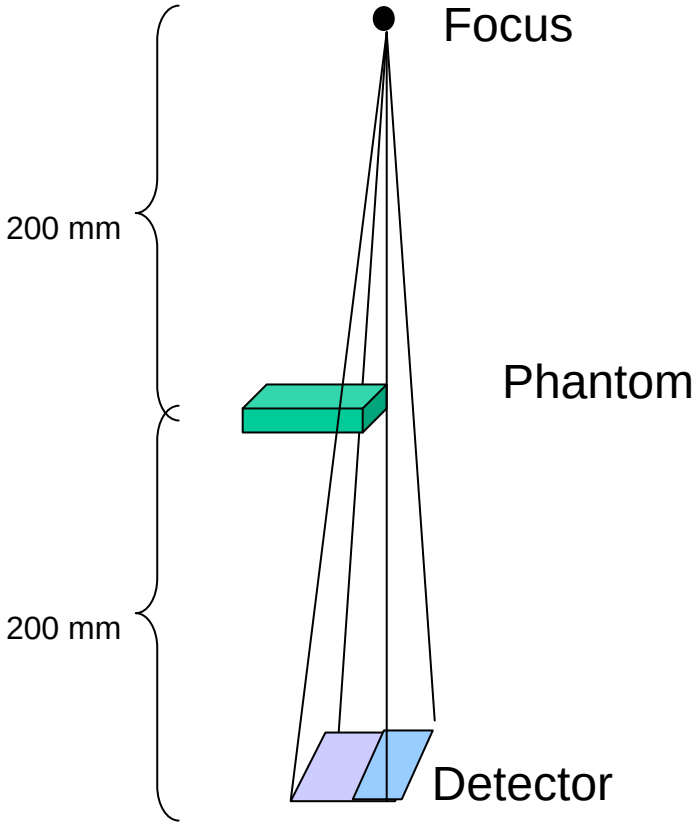
Introduction

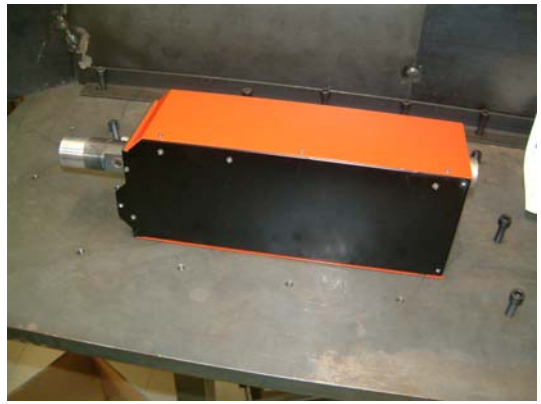
The goal of this work is to optimise the set-up to enhance the signal-to-noise ratio in CT for small animal:

Reduce of the structured noise on the detector;

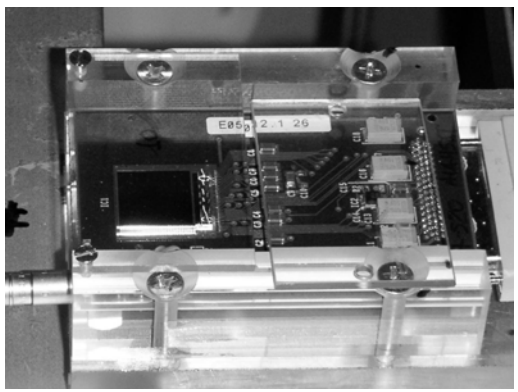
Find the optimum photon energy for a given sample and material

Experimental set-up

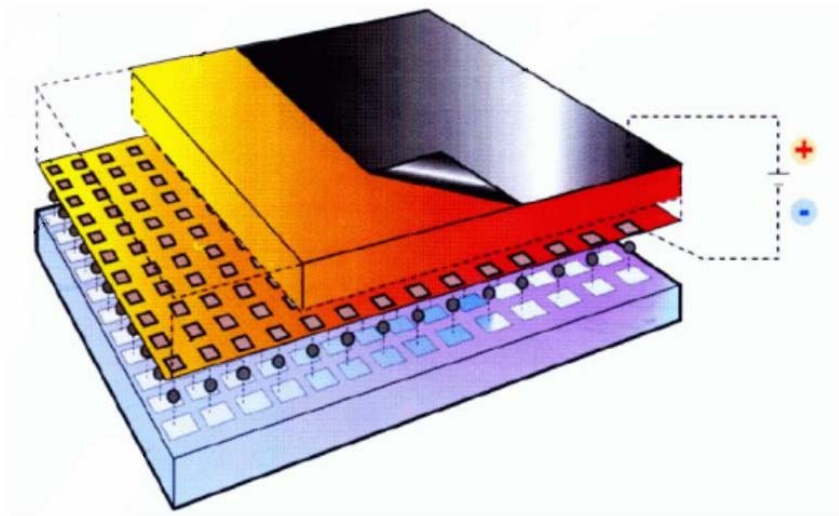




- X-ray source: Hamamatsu 60KVFMX
  - –Tungsten anode, beryllium window (150 μm thick)
  - –0 up to 60 kV voltage
  - –10 isowatts power
  - –30 μm focus size



MPX2 read-out chip

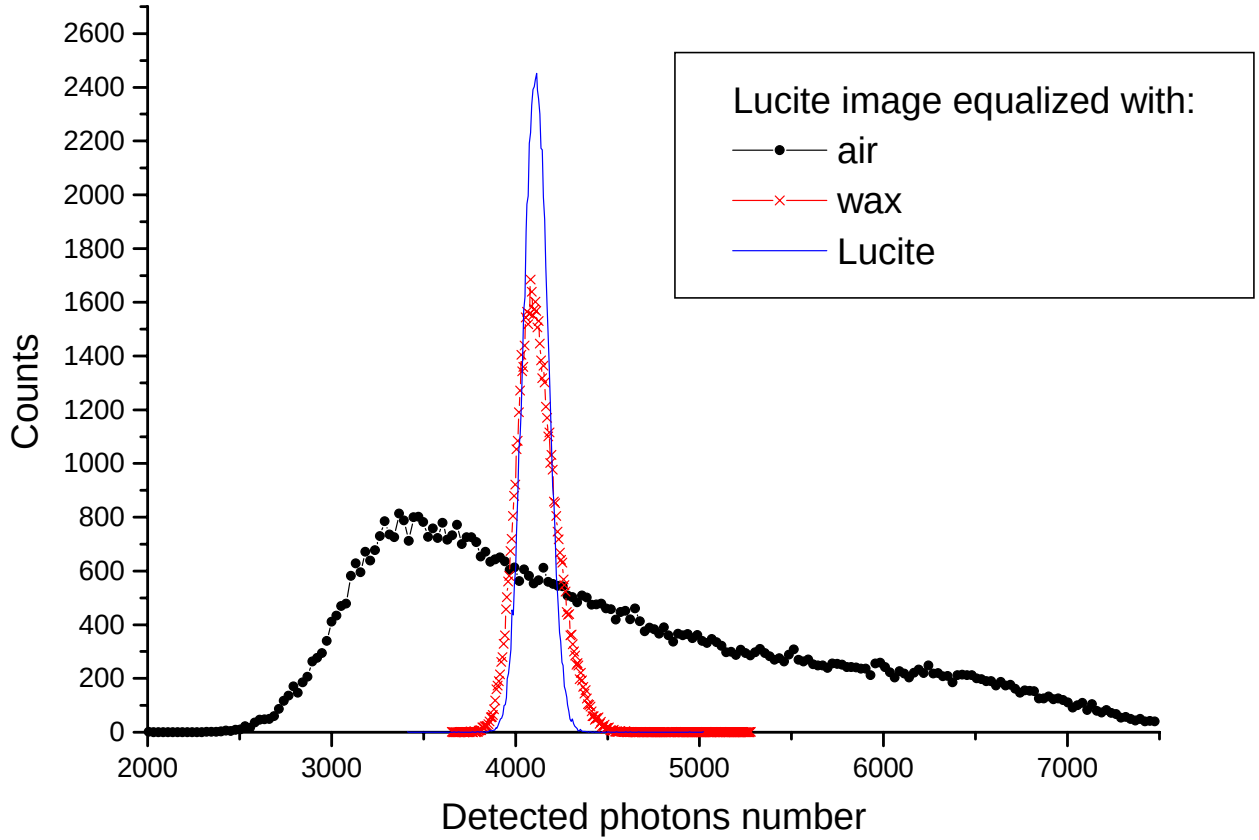


Detector 300 μm Si
Canberra

- 256 x 256 square pixel matrix (size 55 μm)
- 13 bit pixel counter
- Max. count rate per pixel 1 MHz
- Electronic noise (sigma) 105 e-
- Window threshold discriminator (low and high level)
- 8bit conf. reg. (mask, enable, 3-bit thrs. adj. per each discriminator)
- Radiation tolerance <200 krad (10 keV X-ray)

Optimization of the equalization process

Lucite image equalized using three high statistical images



Counts distribution on the lucite image equalized by flat fields acquired with different materials

Optimization of the equalization process

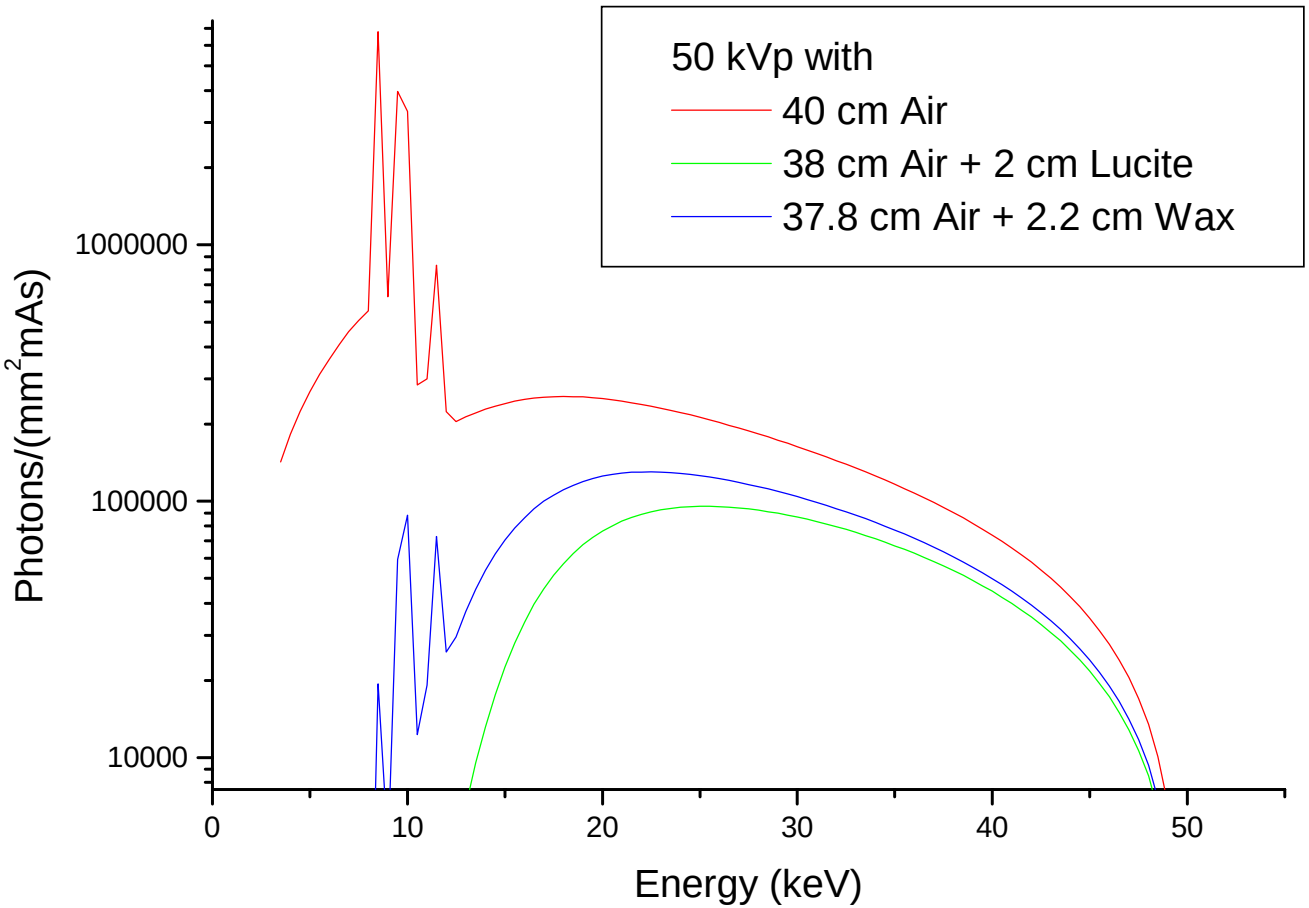
σ of the counts distribution on equalized images

Image / Flat field	Air	Wax	Lucite
Air	82	1036	1133
Wax	783	70	111
Lucite	847	114	68

… To have a good equalization we have to use flat field acquired with the same material

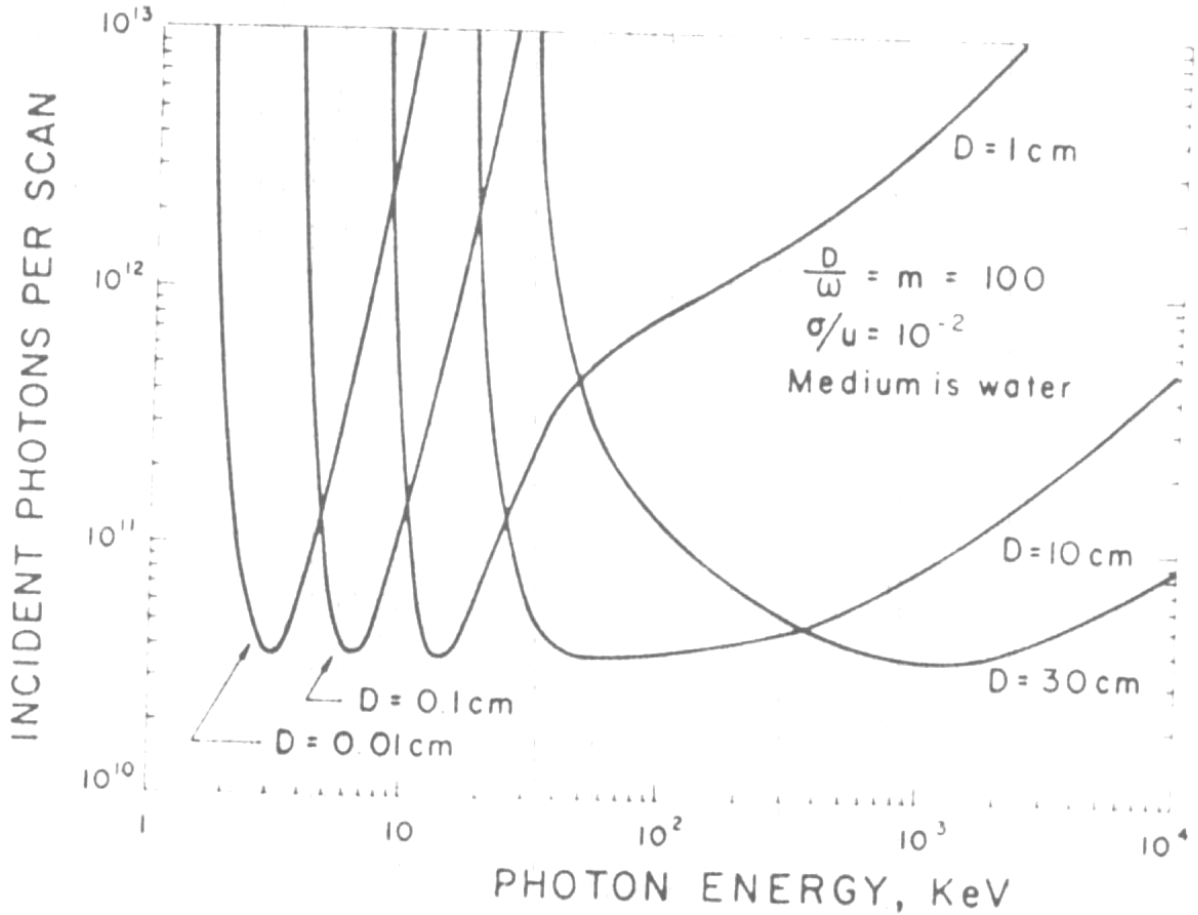
Optimization of the equalization process

Simulated spectra



R. Birch, M. Marshall and G. M. Ardran, *Catalogue of Spectral Data for Diagnostic X-rays* (The Hospital Physicists' Association, London, 1979

Incident photon energy optimization

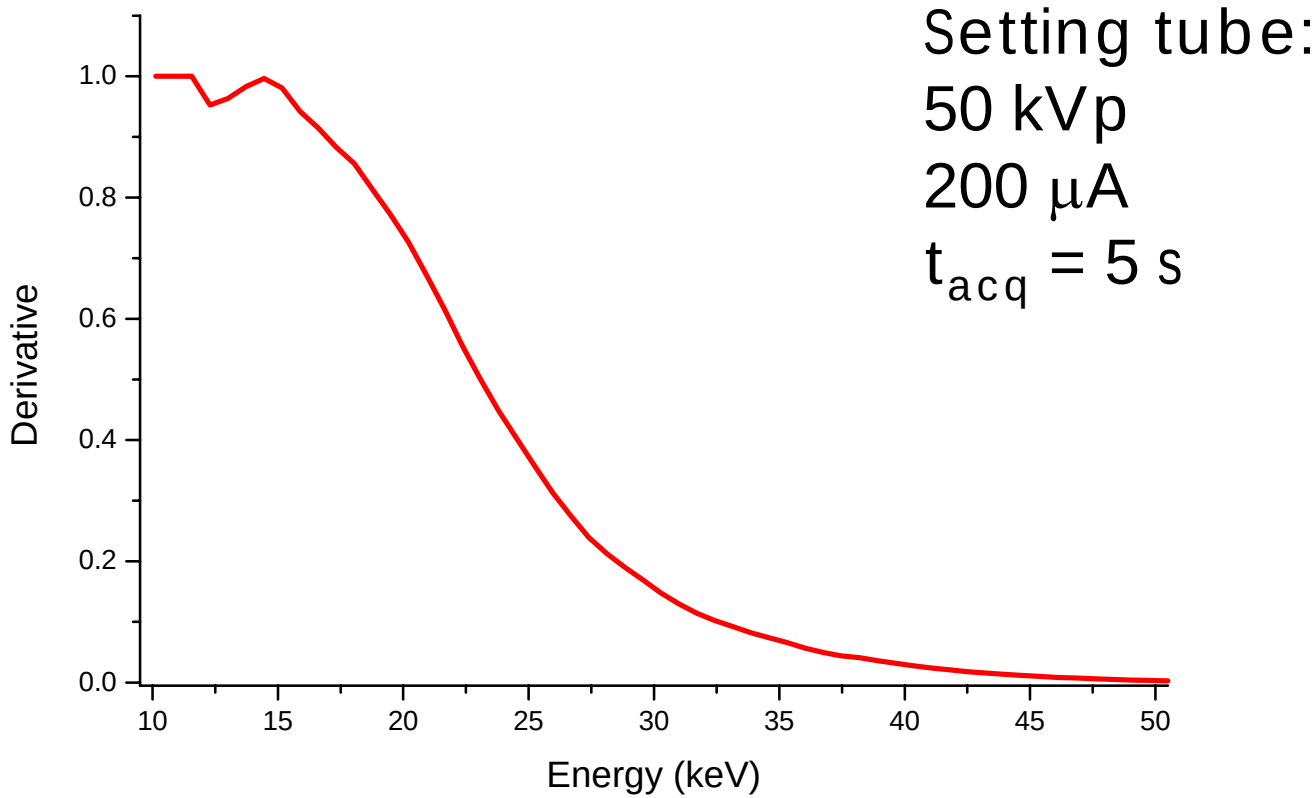


$$\mu = \frac{2}{D}$$

Optimum energies for x-rays transmission tomography of small samples
L. Grodzins
NIMA 206 (1983) 541-545

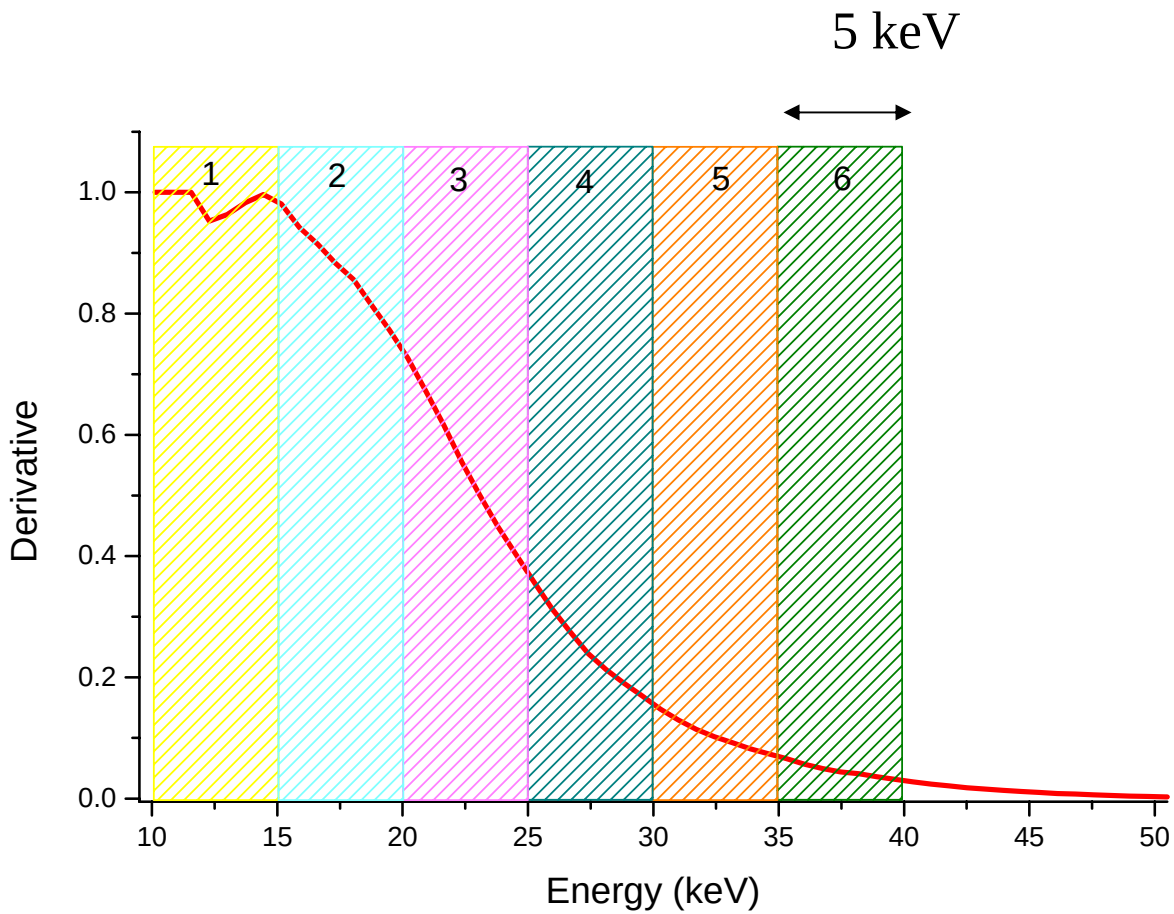
Incident photon energy optimization

…as our detector sees the incident spectrum

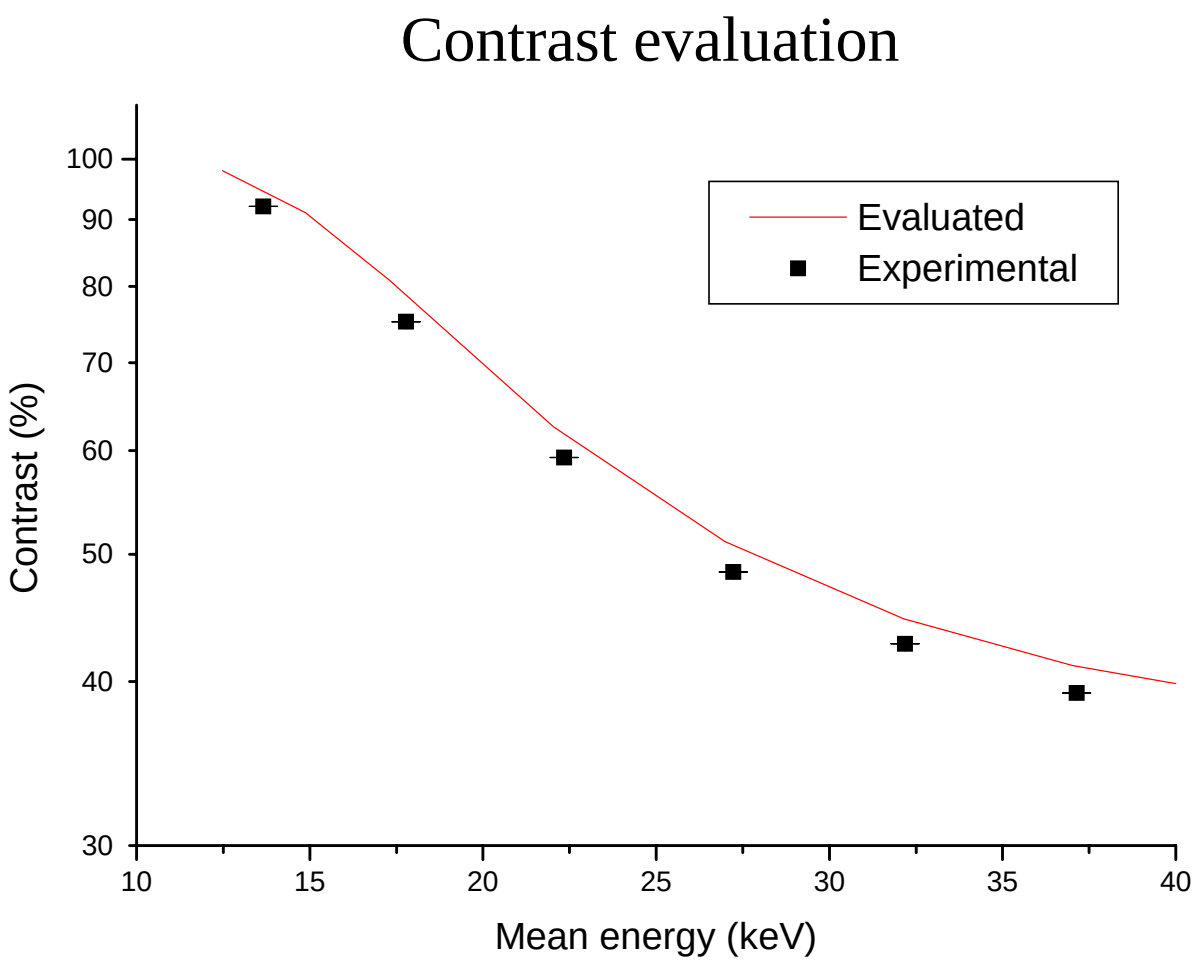


Setting tube:
50 kVp
200 μA
t_{acq} = 5 s

Incident photon energy optimization



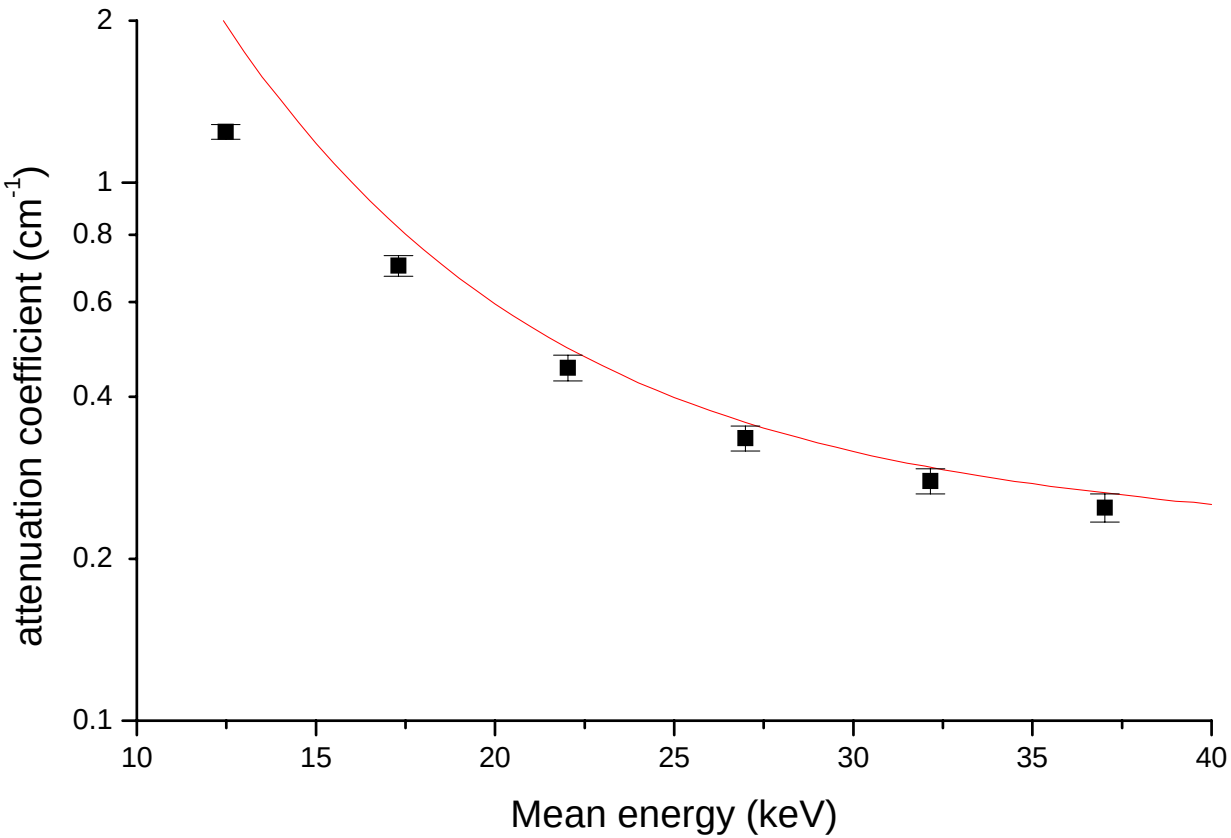
Incident photon energy optimization



Different images have the same photon number in air

Incident photon energy optimization

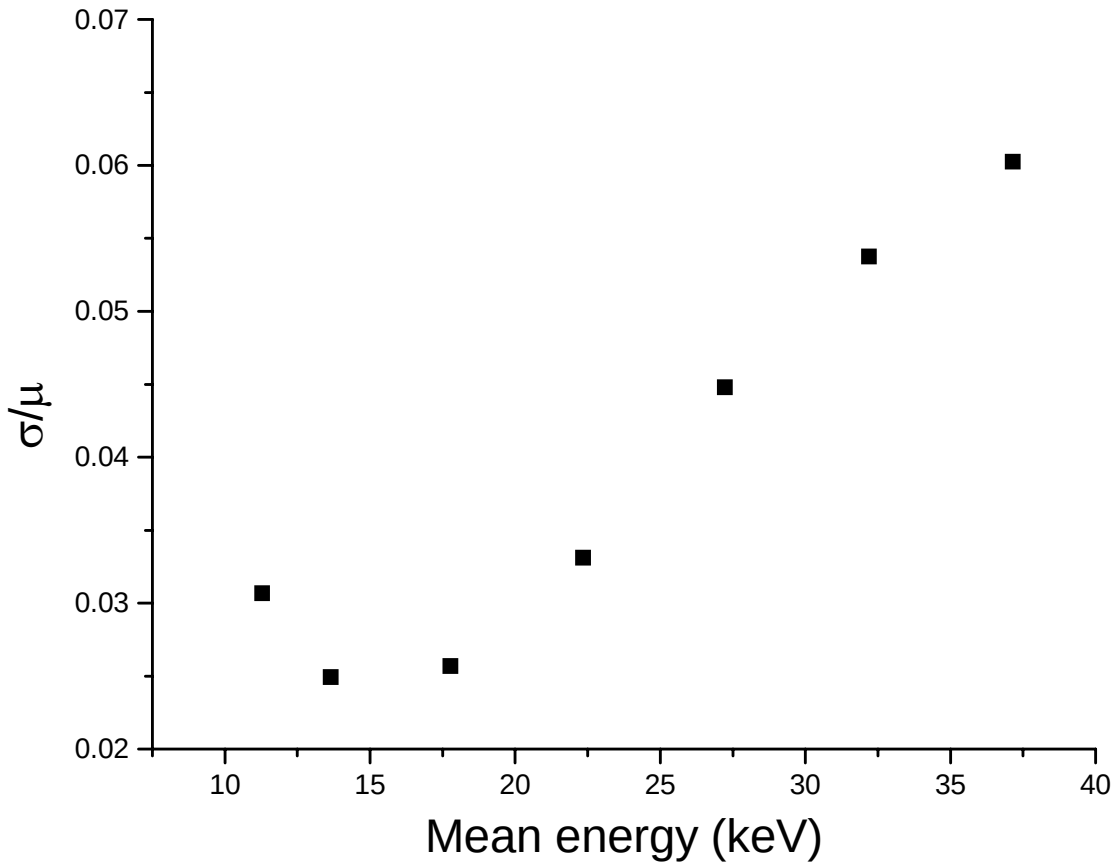
Attenuation coefficient evaluation



Berger M J and Hubbell J H 1987 *XCOM: Photon Cross Sections on a Personal Computer, NBSTIR 87-3597* (National Institute of Standards and Technology, Gaithersburg, MD).

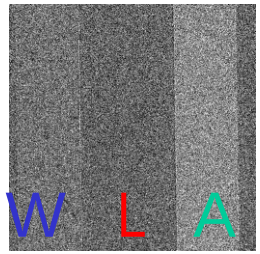
Incident photon energy optimization

Coefficient of variation of the linear attenuation coefficient

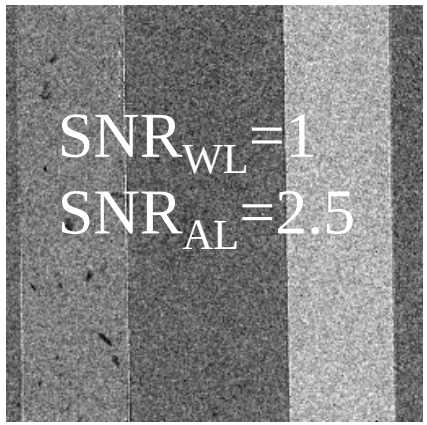


Different images have the same photon number in air

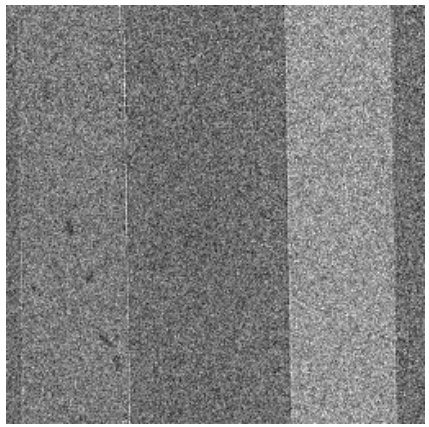
Incident photon energy optimization



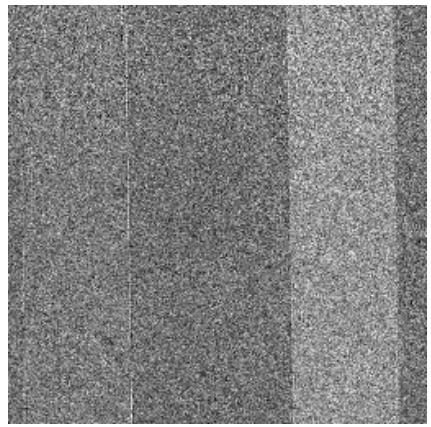
SNR_{WL}=0.3
SNR_{AL}=0.9



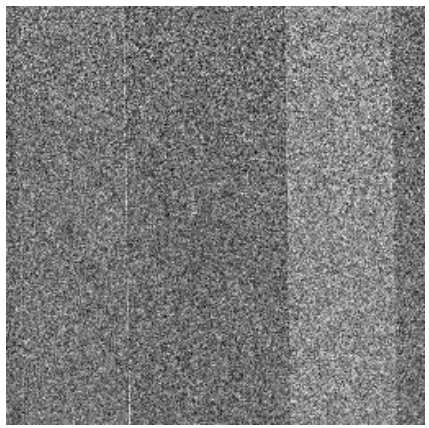
10 – 15 keV



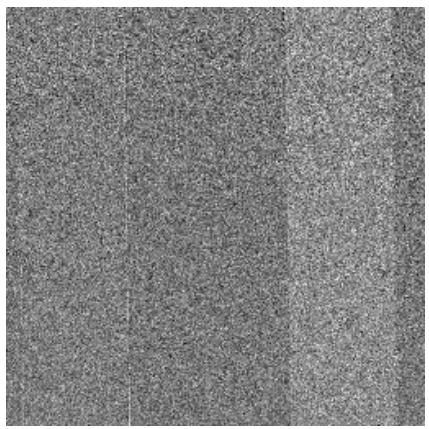
15 – 20 keV



20 – 25 keV



25 – 30 keV



30 – 35 keV

35 – 40 keV

Different images have the same incident photon number

Conclusions

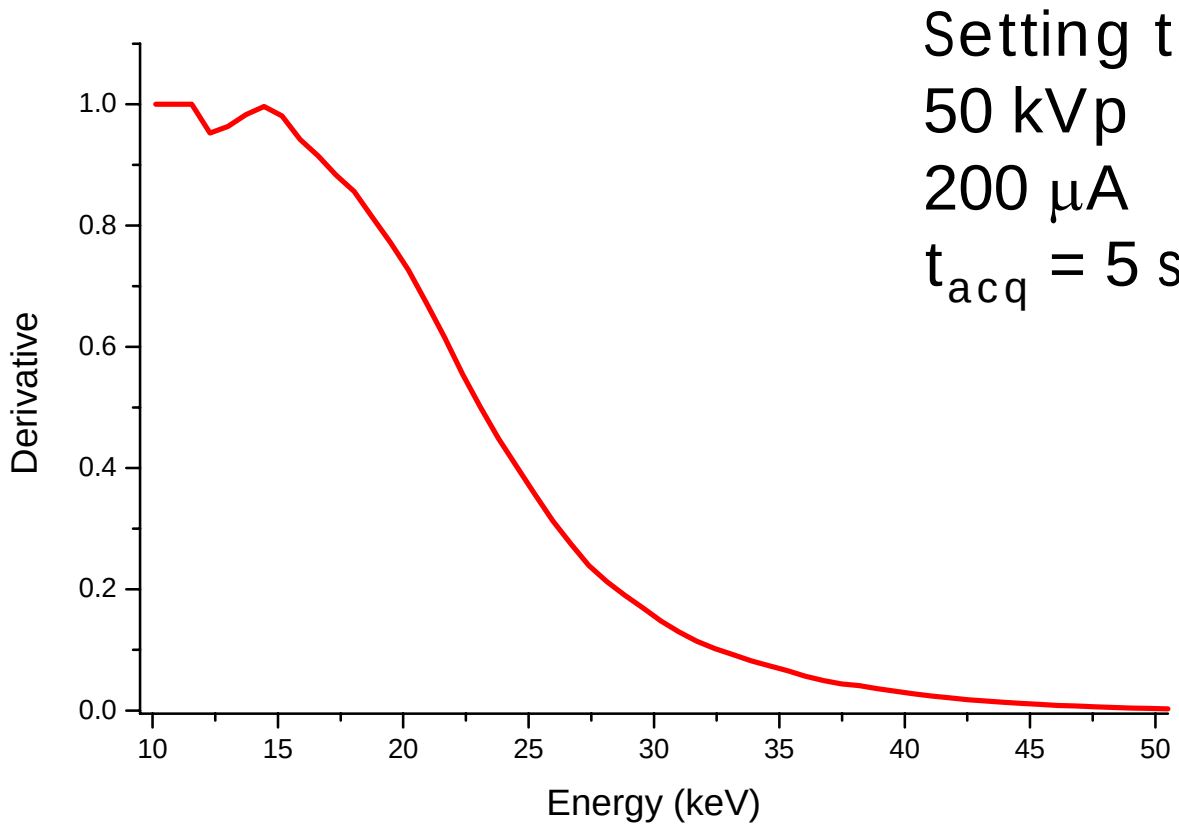
•The equalization depends on the incident spectrum and on the phantom materials: in our case, the best equalization is obtained by using flat field acquired with the same material as the used phantom

•For 2 cm thick Lucite, experimentally the coefficient of variation of the linear attenuation coefficient has a minimum in the energy window between 12.5 – 20 keV as expected (16 keV)

•The images obtained applying the energy window show a SNR dependences upon energies as expected and the potentiality of this acquiring mode has to be still investigated

Energy calibration

…as our detector sees the incident spectrum



Aggiungere spettro simulato

Energy optimization