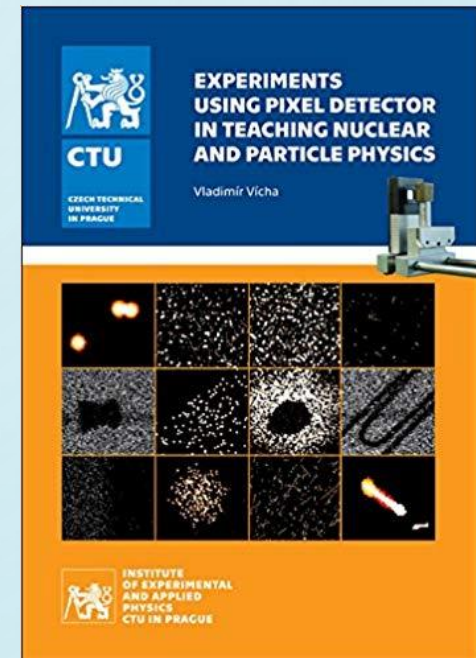


ELS XIPS MEDIPIX I TIMEPIX: DEL CERN A LES ESCOLES

Caracterització de Timepix per experiments al laboratori

A. LOBO (UNIVERSITAT BARCELONA)

- I. Experiments que es poden realitzar a la UB
- II. Experiments desenvolupats per instituts a Txèquia en col·laboració amb la universitat CTU





Characterization of the Timepix hybrid pixel detector for XRPD experiments

Author: Aniol Lobo Salvia

Advisor: Eugeni Graugés Pous

Facultat de Física, Universitat de Barcelona, Diagonal 645, 08028

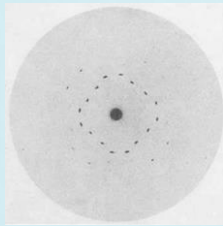
Barcelona, Spain.

I. INTRODUCTION: CRYSTALLOGRAPHY

Crystallography milestones

Up to now: 29 Nobel Prizes for 48 Nobel Laureates!

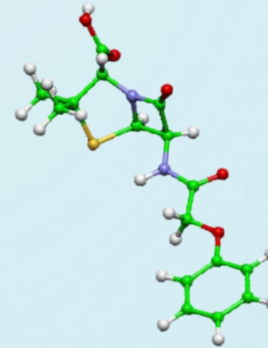
Max von Laue, Walter
Friedrich and Paul Knipping,
April 1912



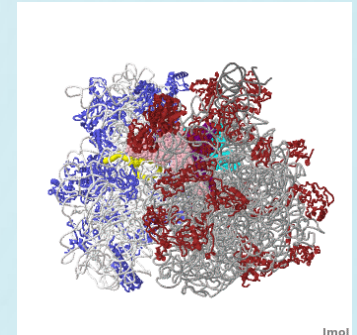
(1913–1916) W.H. Bragg
X-ray spectrometer and
powder diffraction



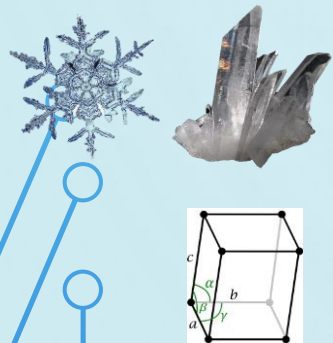
1945 Dorothy
Hodgkin Penicillin



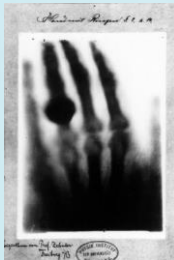
V. Ramakrishnan, T. A.
Steitz and A. E. Yonath
2009 Chemistry



Johannes Kepler (1571-1630)
Niels Stensen (1638-1686)
J.B.L. Romé de l'Isle (1736-1790)
René Just Haüy (1743-1822)
JF Christian Hessel (1796-1872)
Auguste Bravais (1811-1863)
Evgraf S. Fedorov (1853-1919)
Arthur Schoenflies (1853-1928)



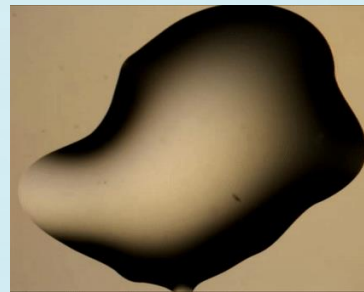
Roentgen,
1895



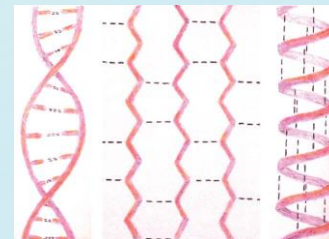
W.L. Bragg,
1913



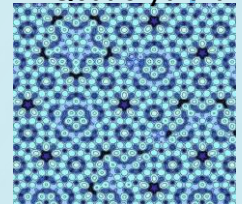
1946: Enzymes
Crystall growth



1962 F. Crick, J. Watson
and M. Wilkins DNA



2011
D. Shechtman
Quasicrystals



s.XV – s.XIX

1900

1920

1940

1960

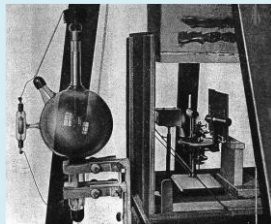
1980

2000

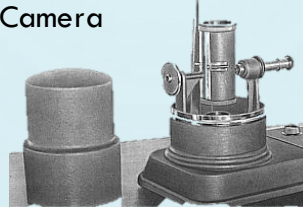
Technology evolution

Johannes Kepler (1571-1630)
 Niels Stensen (1638-1686)
 J.B.L. Romé de l'Isle (1736-1790)
 René Just Haüy (1743-1822)
 JF Christian Hessel (1796-1872)
 Auguste Bravais (1811-1863)
 Evgraf S. Fedorov (1853-1919)
 Arthur Schoenflies (1853-1928)

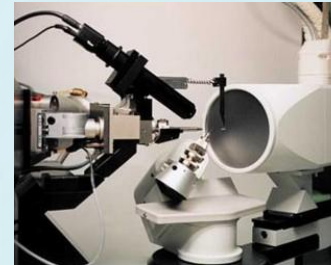
1912 M. Laue



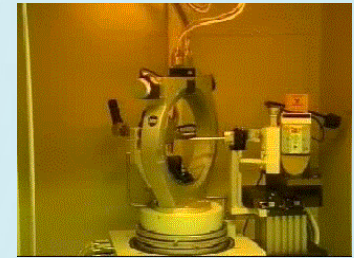
1924 Weissenberg
 Camera



Modern Diffractometer



Modern 4circle goniometer



X-ray tube



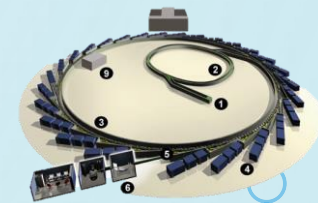
Diffractometers



Computers



Synchrotron X-ray



e⁻, n diffraction

s.XV – s.XIX

/

1900

1920

1940

1960

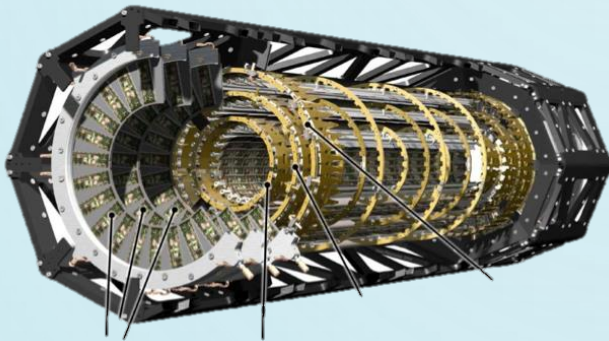
1980

2000

II. HYBRID PIXEL DETECTORS

From HEP to medical imaging

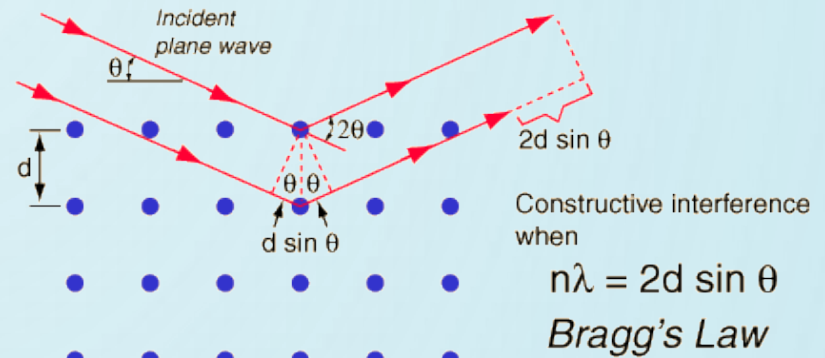
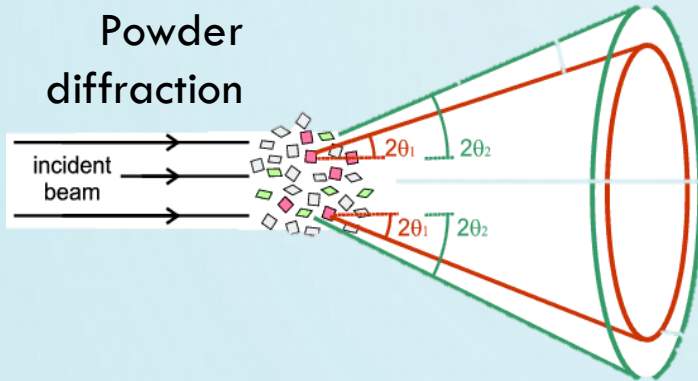
ATLAS tracker



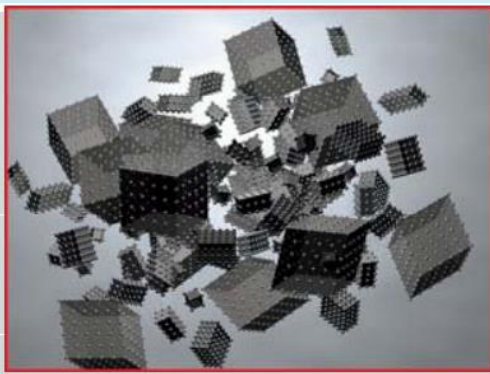
Minipix



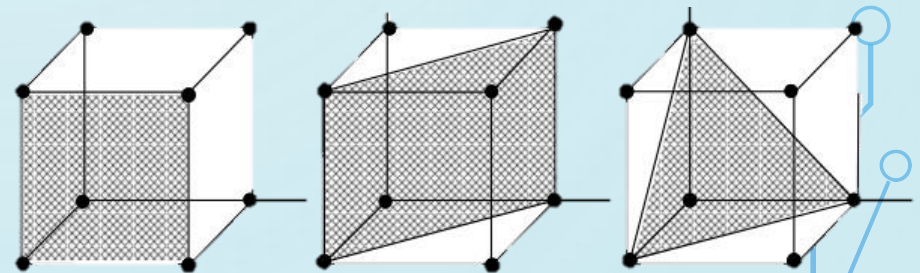
III. X-RAY POWDER DIFFRACTION



Powder

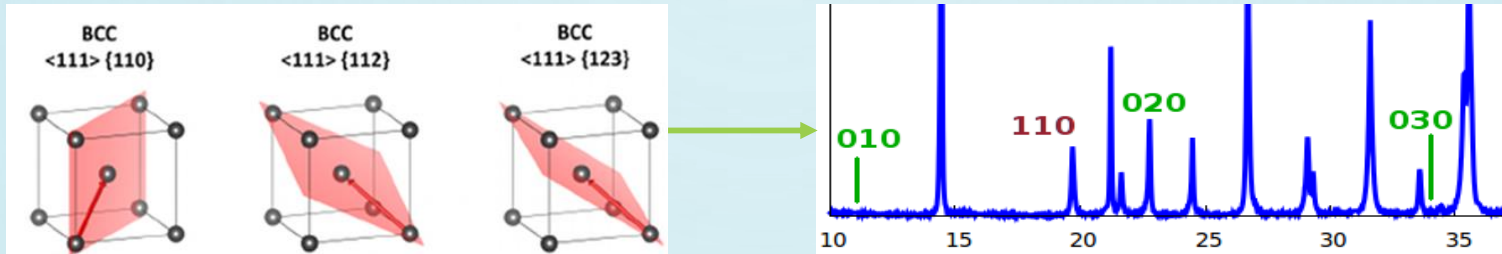


Crystal planes

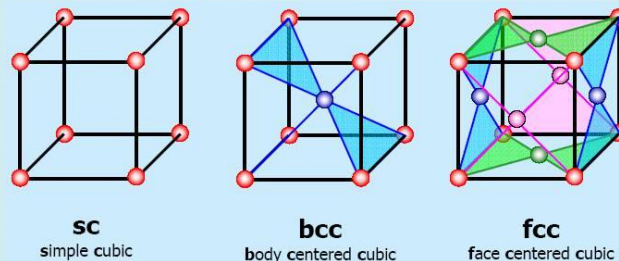


ORIGINAL OBJECTIVES “PRÀCTICA 9 LFM” (PHOTOGRAPHIC FILM)

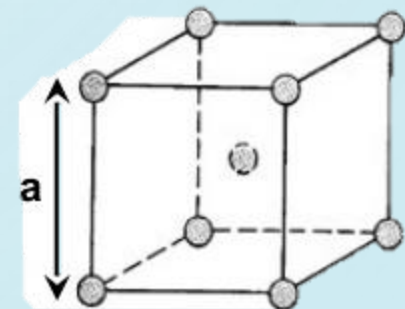
- Crystallographic planes indexing



- Structure determination (SC, BCC or FCC)



- Cell parameter determination ($a = 314,7 \text{ pm}$)



III. B) MATERIAL AND METHODS

PHYWE X-ray expert unit



X-ray tube

Diaphragm and monochromator

Mo sample

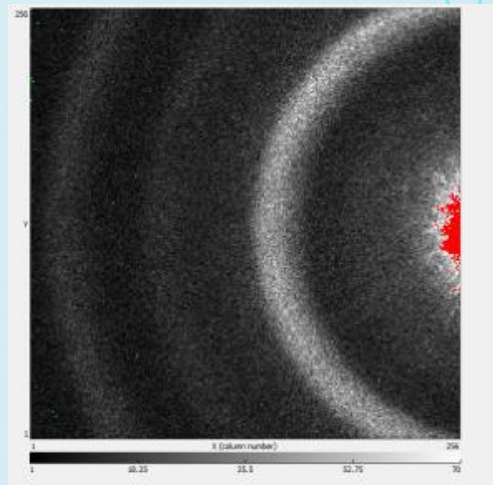
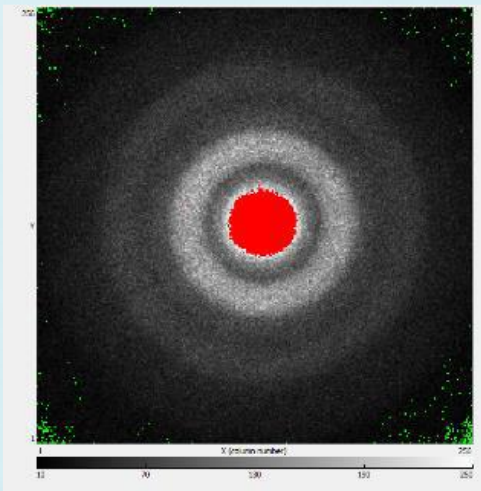
Detector (photographic film)



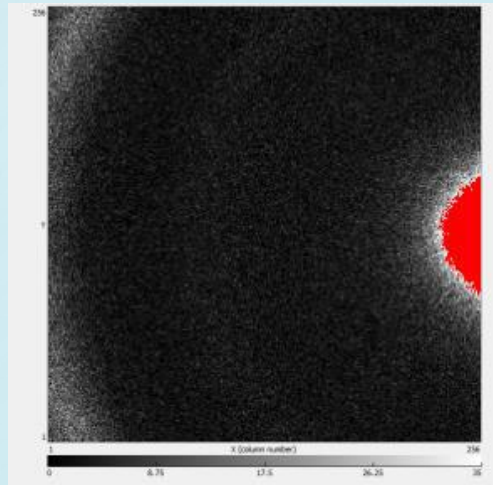
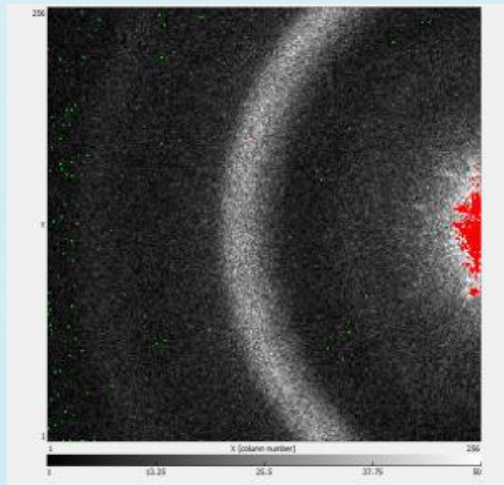
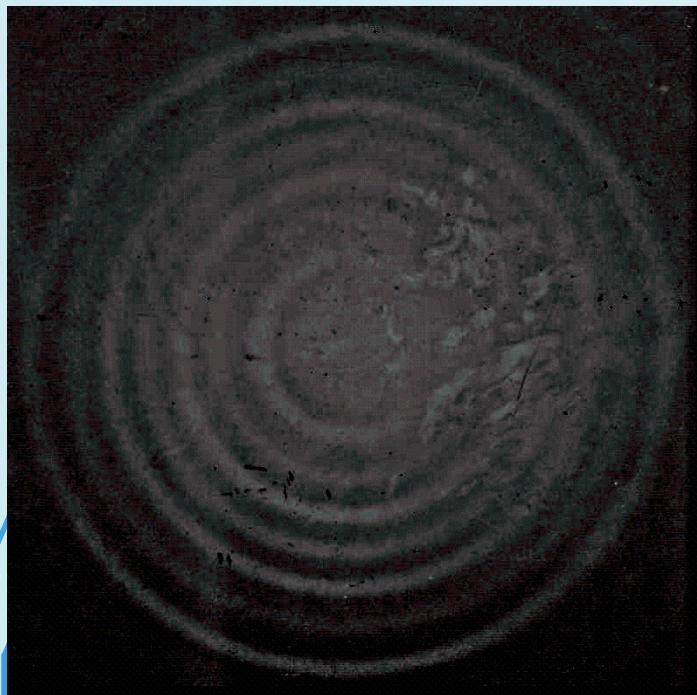
Detector (MiniPix)

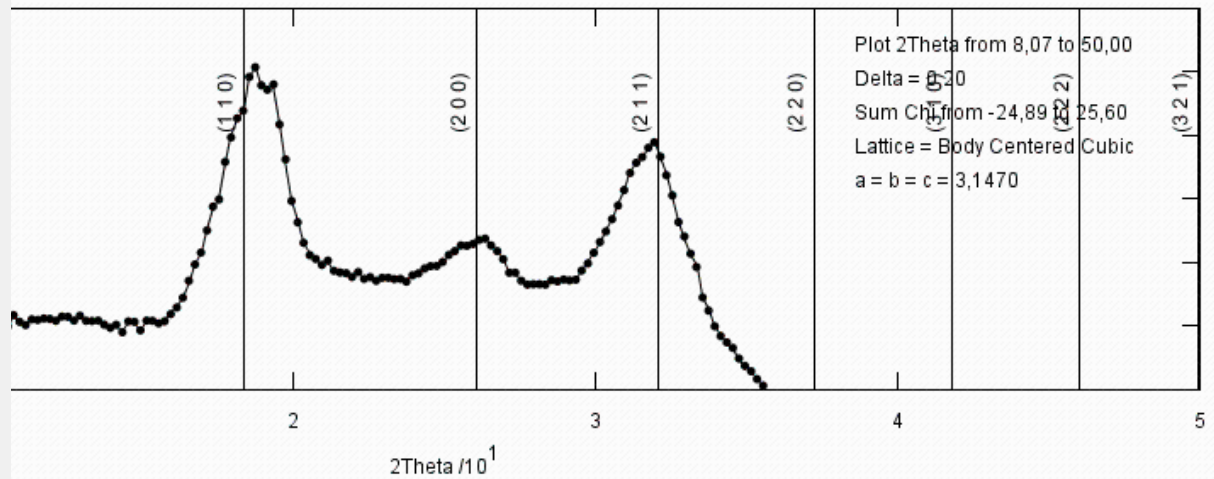
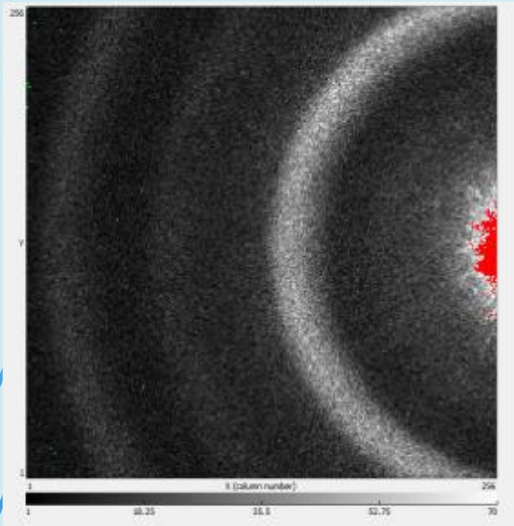
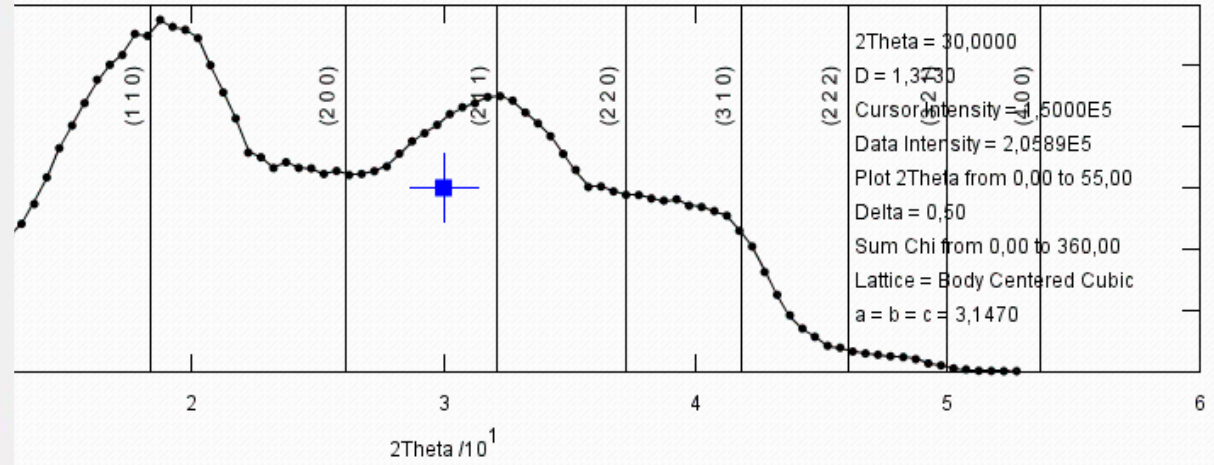
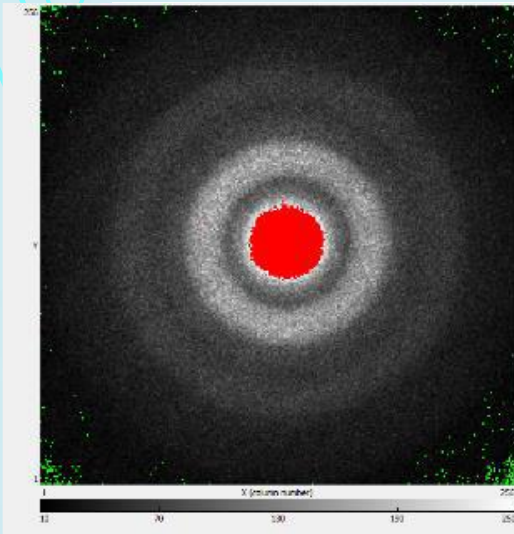
III. C) RESULTS AND DISCUSSION

MiniPix:



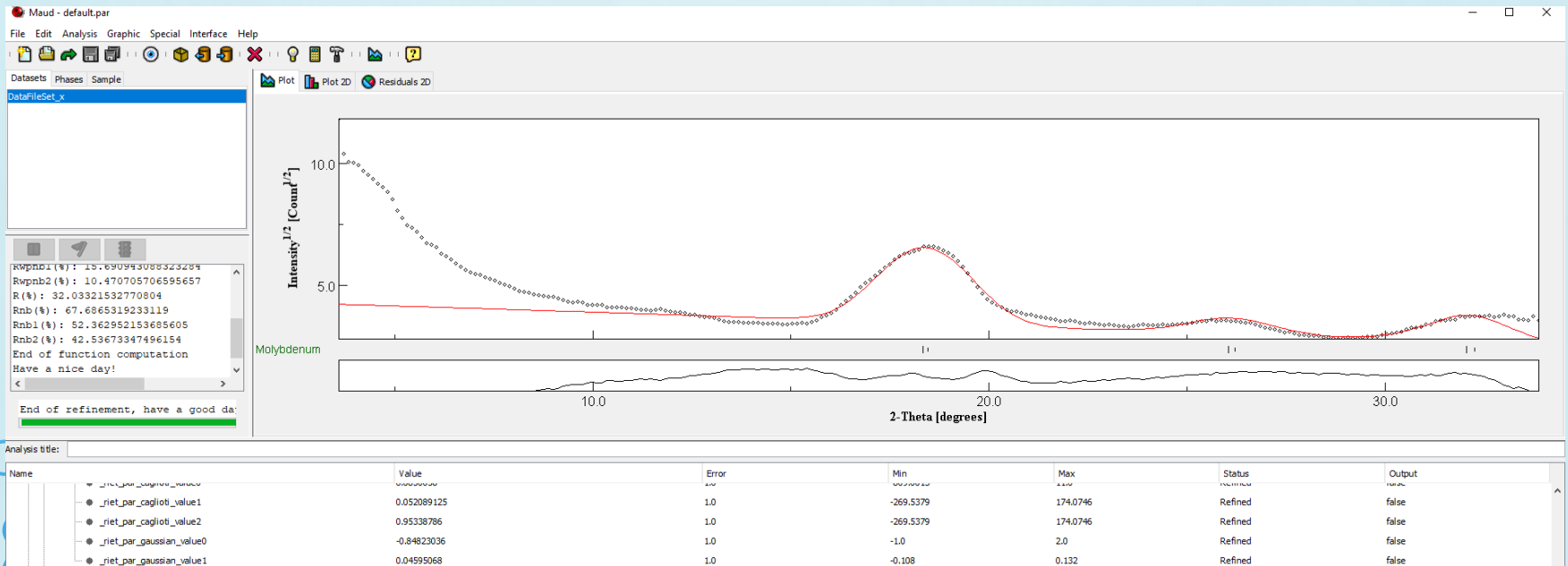
Photographic film:





Data analysis - software

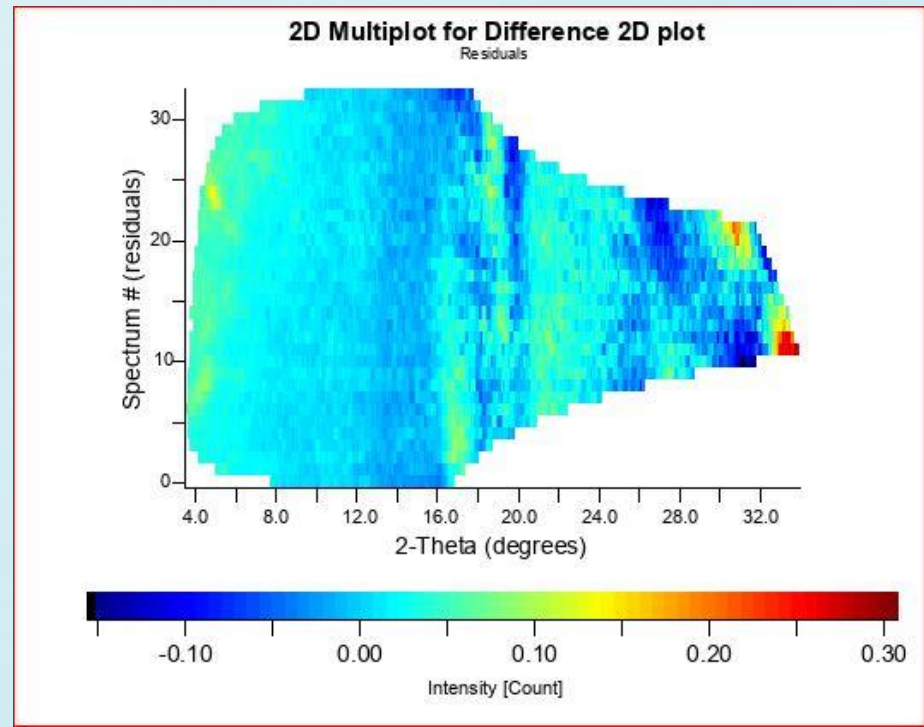
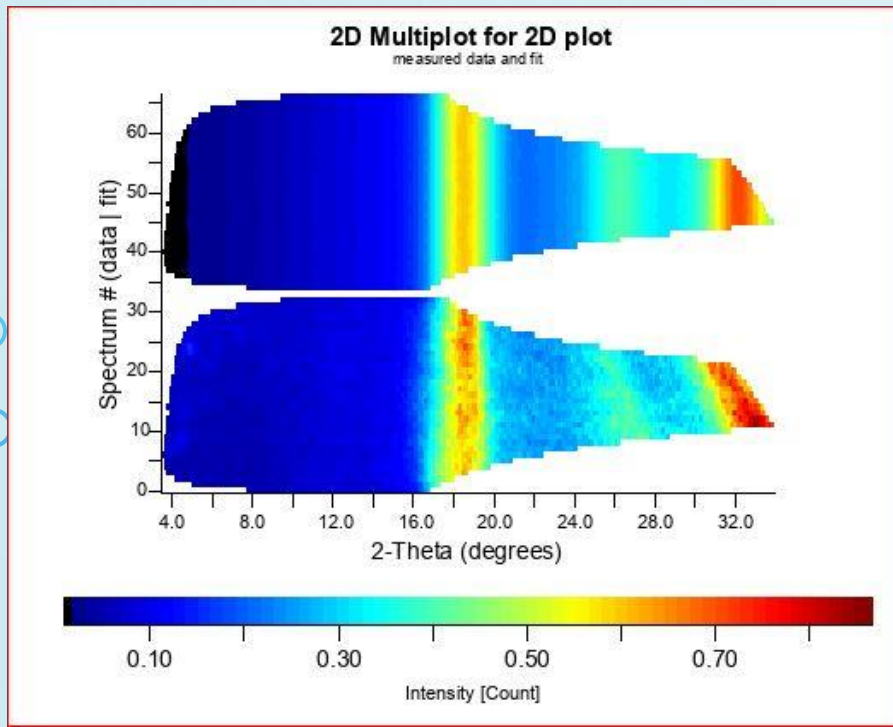
MAUD Rietveld refinement



- grain size
- strain

Data analysis - software


MAUD Rietveld refinement



- grain size
- strain

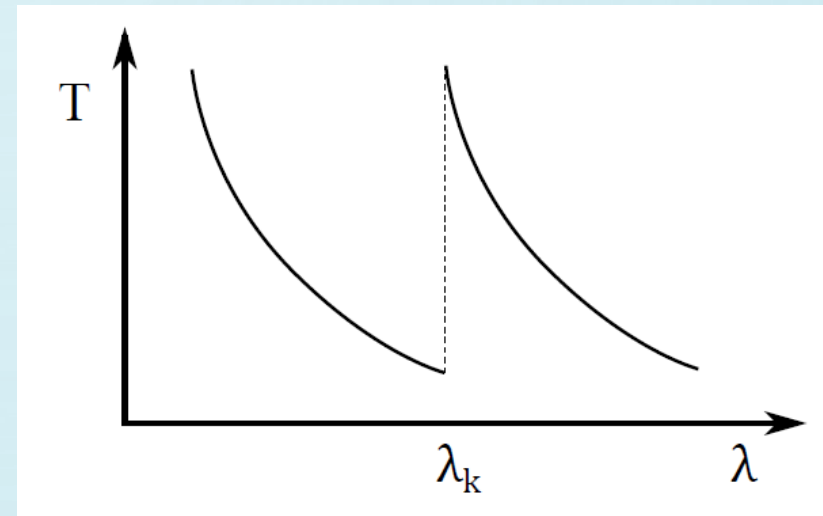
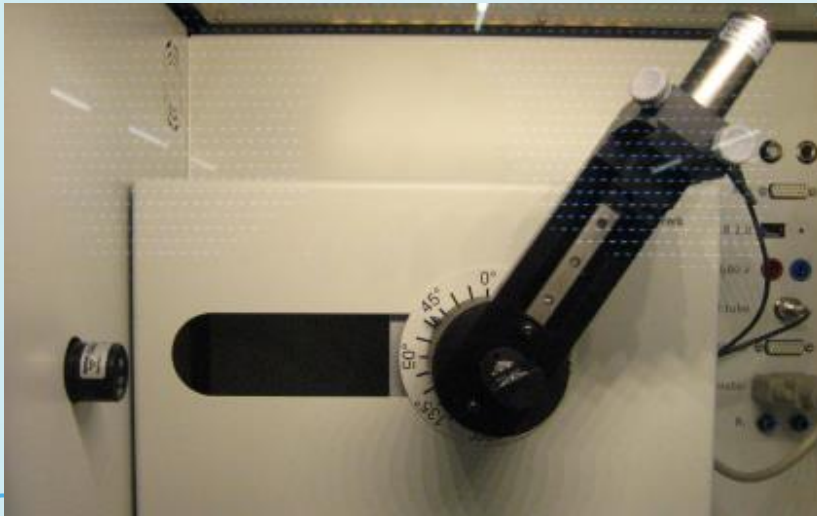
IV. CONCLUSIONS

- Timepix detector efficiency has been demonstrated
- Experimental setup error has been characterized
- Data analysis was performed
- Future perspectives were explored

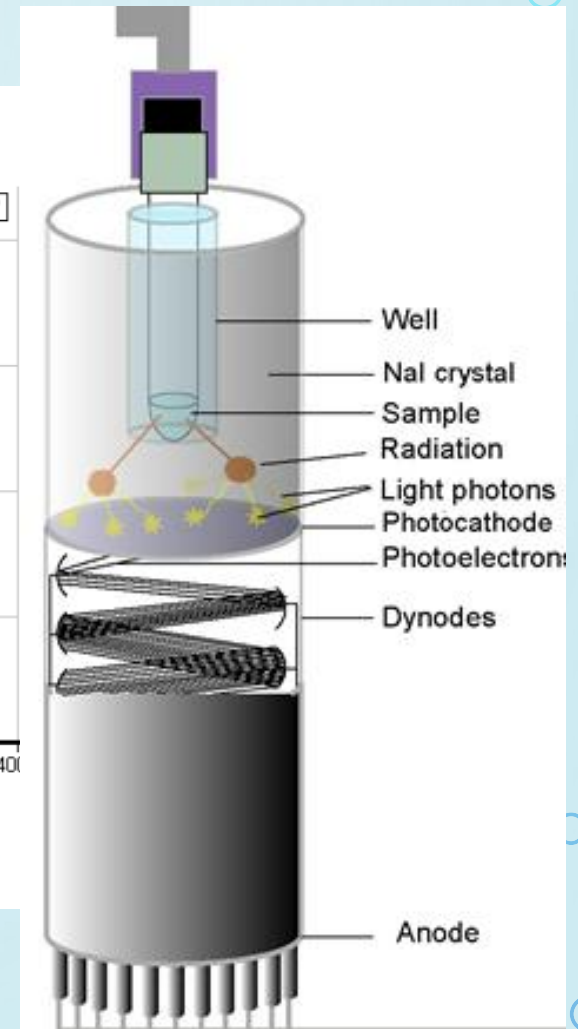
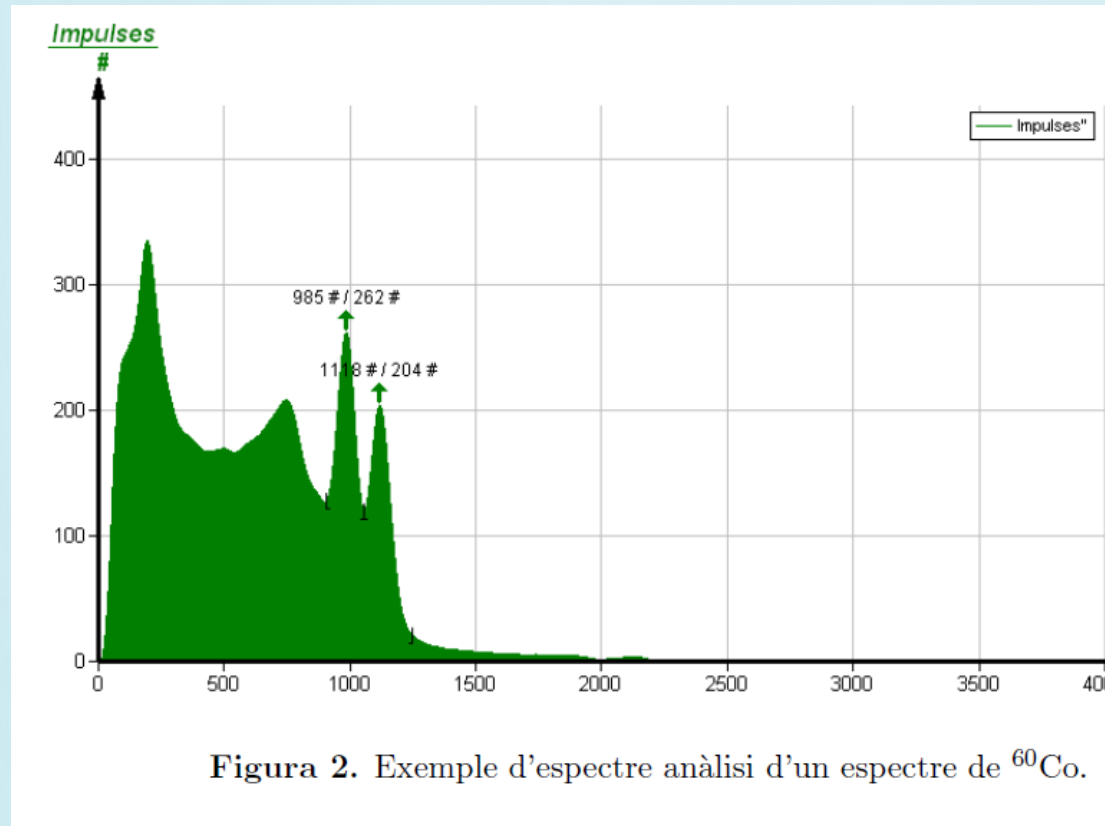
A decorative background featuring a light blue circuit board pattern with various lines and nodes. The pattern is most dense on the left side and fades towards the right. The text is centered in the upper half of the image.

EXPERIMENTS AMB EL MINIPIX REALITZABLES A LA UB

PRÀCTICA 1: ESPECTRES D'ABSORCIÓ: LLEI DE MOSELEY



PRÀCTICA 2: ESPECTROMETRIA GAMMA



PRÀCTICA 3: ABSORCIÓ DE RADIACIÓ BETA

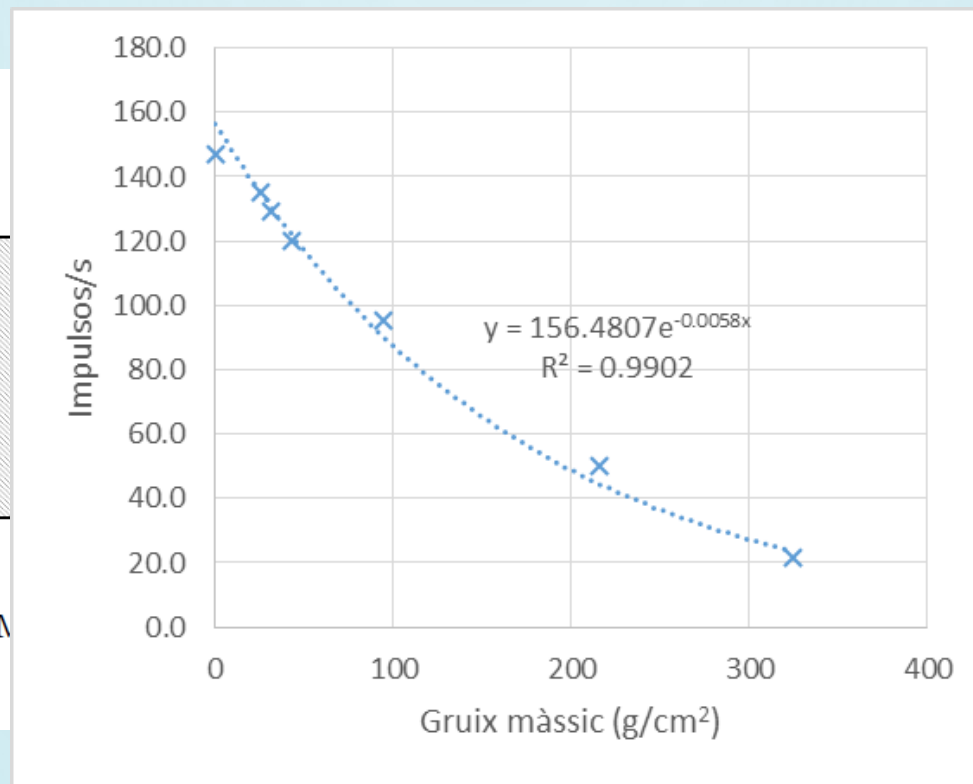
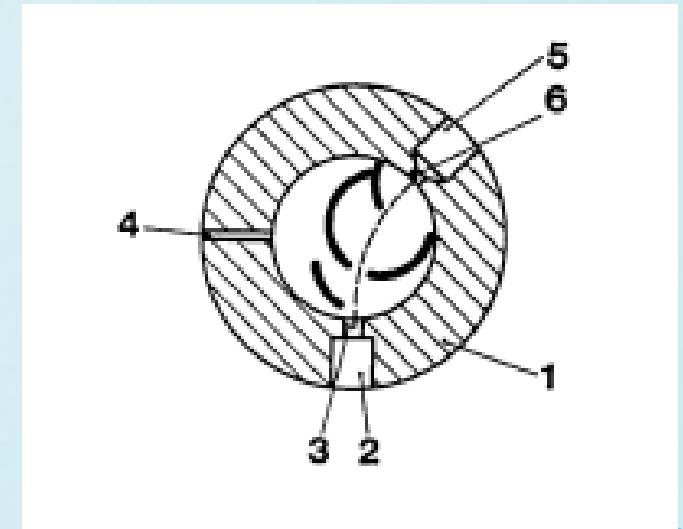
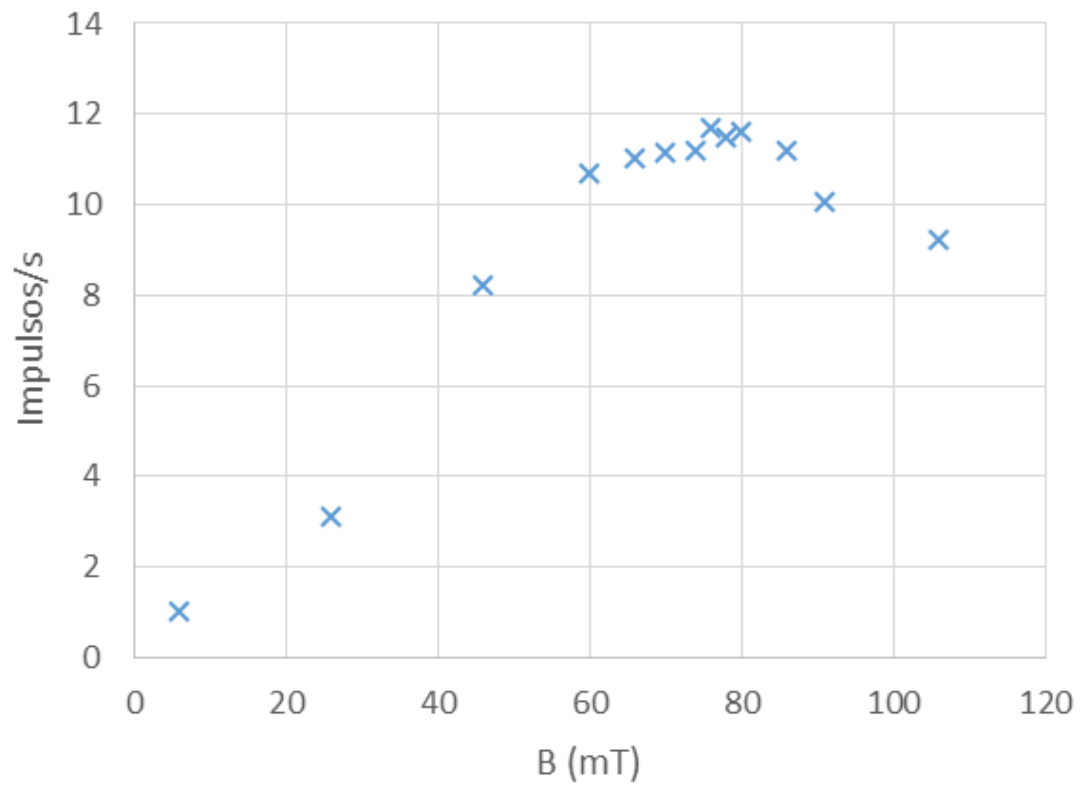


Figura 1. M

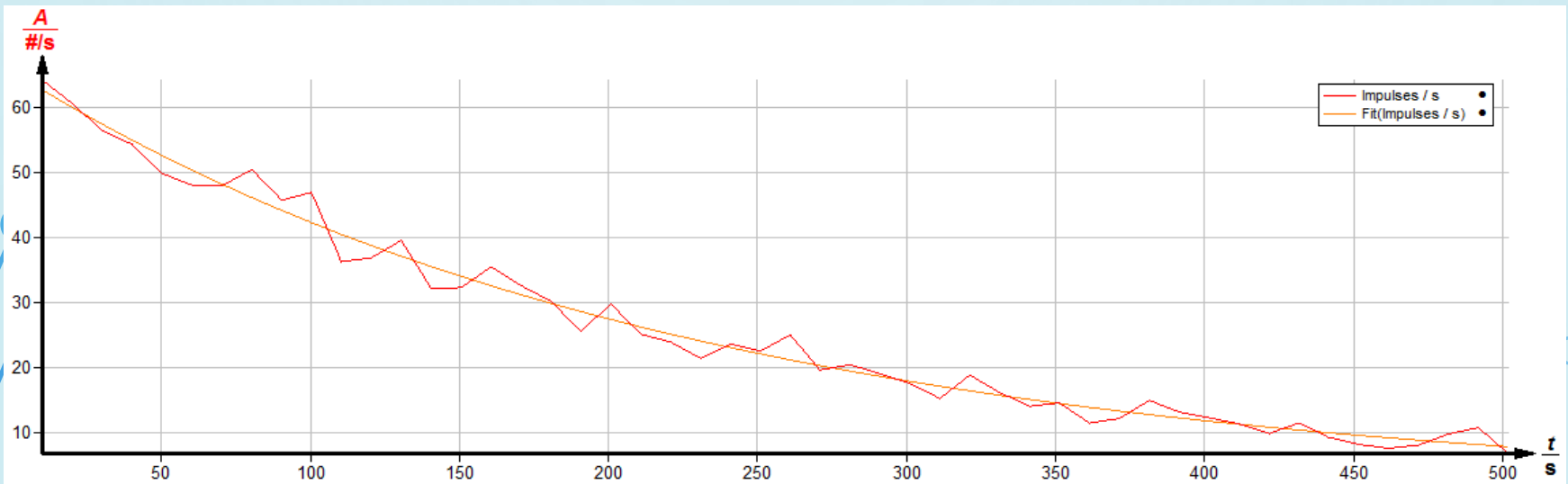
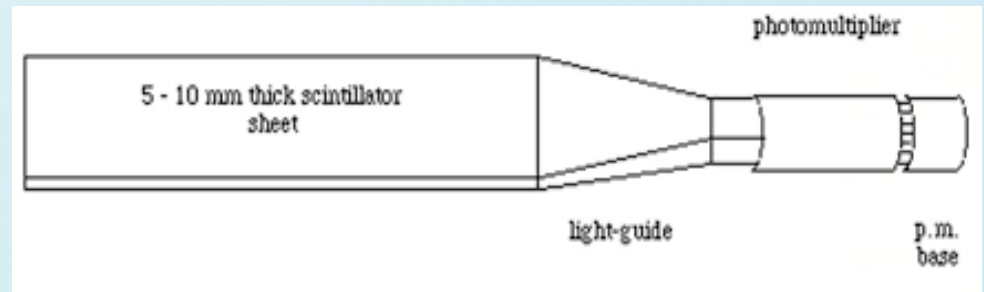
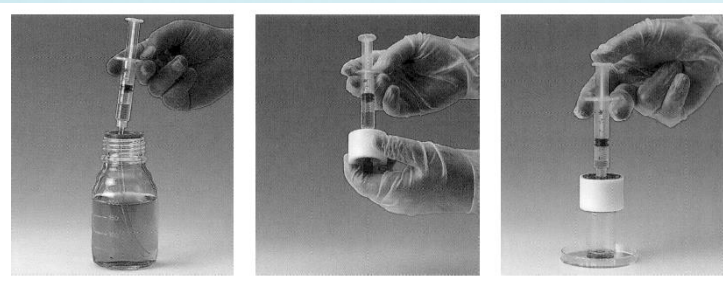
nissora de

PRÀCTICA 4: ESPECTROMETRIA BETA





PRÀCTICA 5: DETERMINACIÓ DE LA SEMIVIDA D'UN RADIONÚCLID



PRÀCTICA 6: ABSORCIÓ DE RADIACIÓ GAMMA

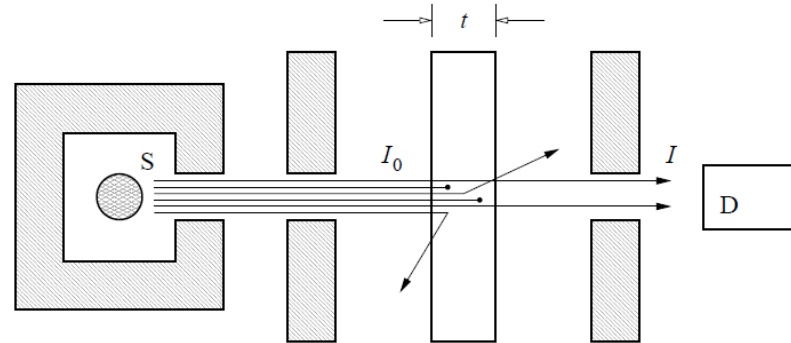
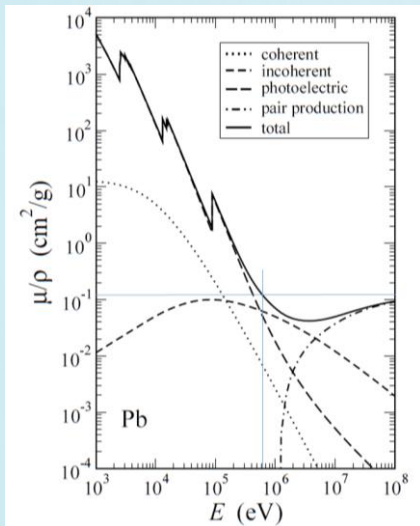
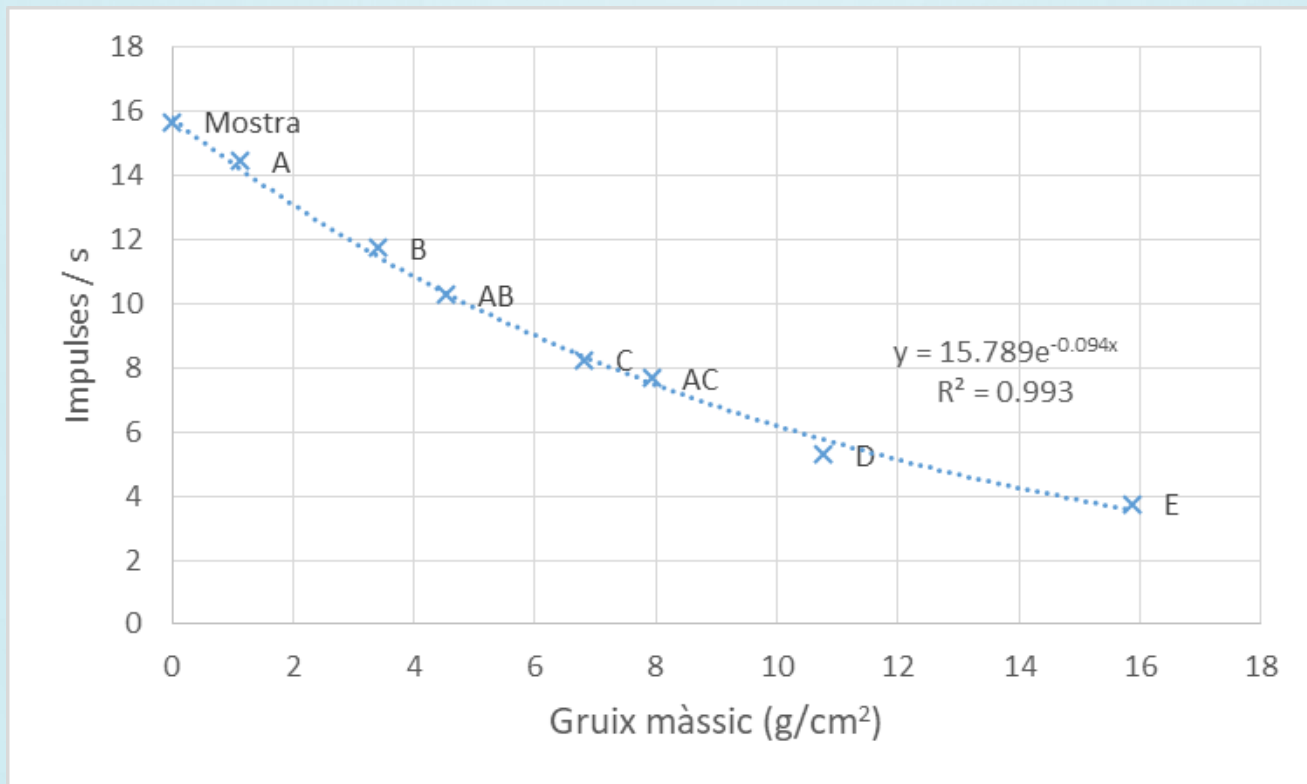


Figura 1. Muntatge experimental per mesurar coeficients d'atenuació. S: font emissora de radiació γ monoenergètica, D: detector.





PRÀCTIQUES DESENVOLUPADES PER INSTITUTS A TXÈQUIA AMB LA UNIVERSITAT CTU-IEAP



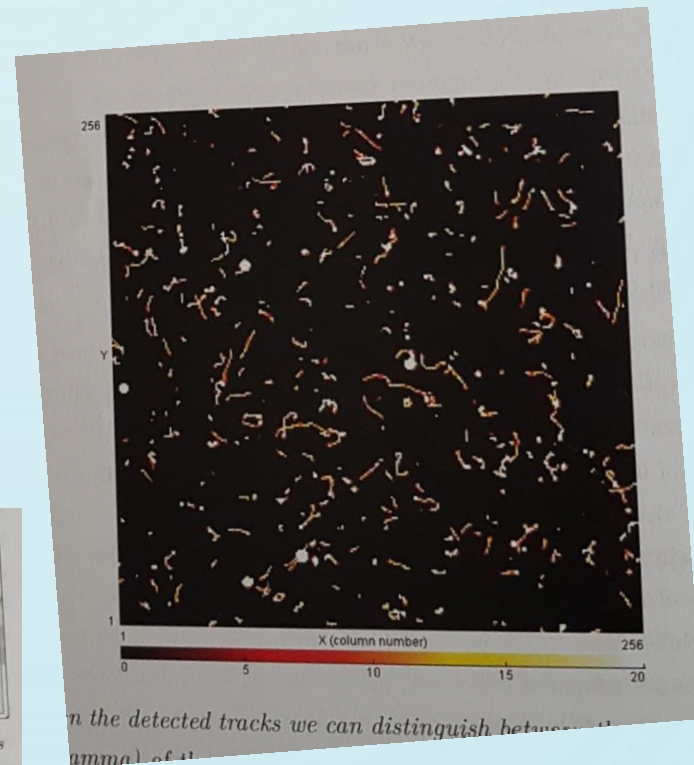
ÍNDEX

- Fonts de radiació d'objectes quotidians
 - 3.1 Vidre de bohèmia (Urani)
 - 3.2 Nucli de soldador (Tori)
 - 3.3 Fertilitzant (Potassi)
- Fonts de radiació homologades
 - 3.4 Fonts d'alfa i gamma d'americ
- 3.5 Radiació de fons natural
- 3.6 Dades del Timepix en altre col·laboracions e.g. ISS

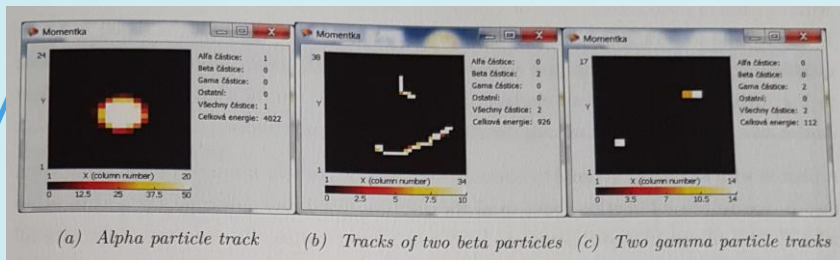
FONTS DE RADIACIÓ D'OBJECTES QUOTIDIANS

3.1 Vidre de bohèmia (Urani)

3.1.1 Visualització dels diferents tipus de radiació



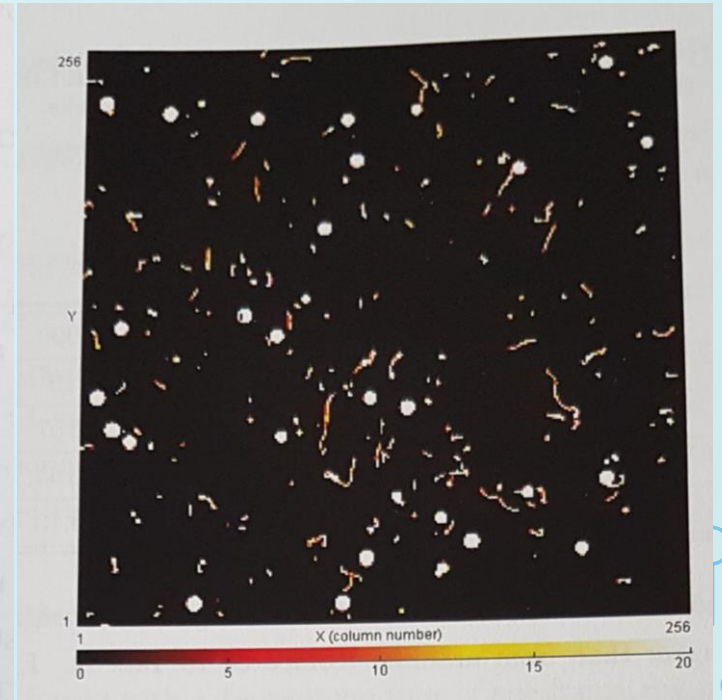
...n the detected tracks we can distinguish between ...
(alpha) of the



(a) Alpha particle track (b) Tracks of two beta particles (c) Two gamma particle tracks

3.2 Nucli de soldador (Tori)

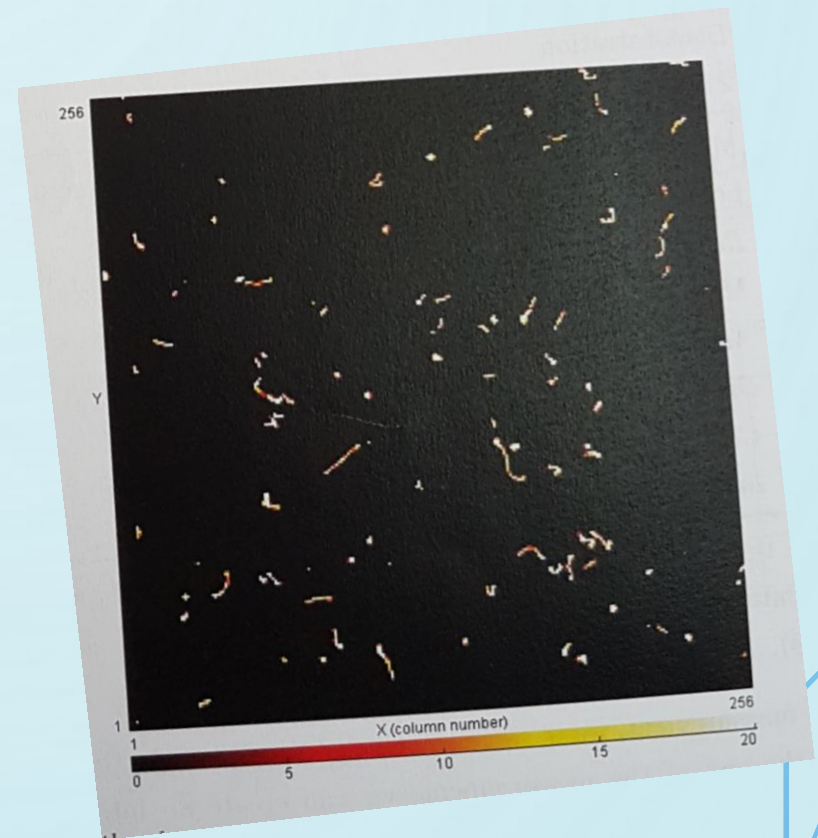
3.2.1 Visualització dels diferents tipus de radiació



Menor nombre de partícules, energies diferents

3.3 Fertilitzant (Potassi)

3.3.1 Visualització dels diferents tipus de radiació



Només radiació β, γ
Energia diferent

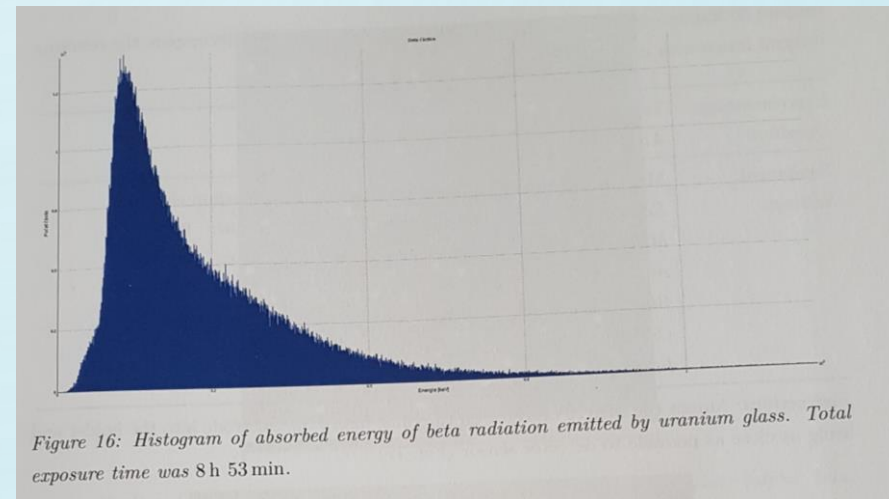
Energia i velocitat de les partícules alfa i beta

Table 1: Kinetic energies, speeds, and relative speeds of alpha particles emitted by uranium.

E_k [keV]	4022	2333	1839	2872	3152
v [m s^{-1}]	1.39×10^7	1.06×10^7	9.41×10^6	1.18×10^7	1.23×10^7
$\frac{v}{c}$ (relat)	0.04637	0.03533	0.03137	0.03919	0.04106
$\frac{v}{c}$ (classical)	0.04641	0.03535	0.03138	0.03922	0.04108
deviation [%]	0.09	0.06	0.04	0.07	0.06

Table 2: Kinetic energies, speeds, and relative speeds of beta particles emitted by uranium.

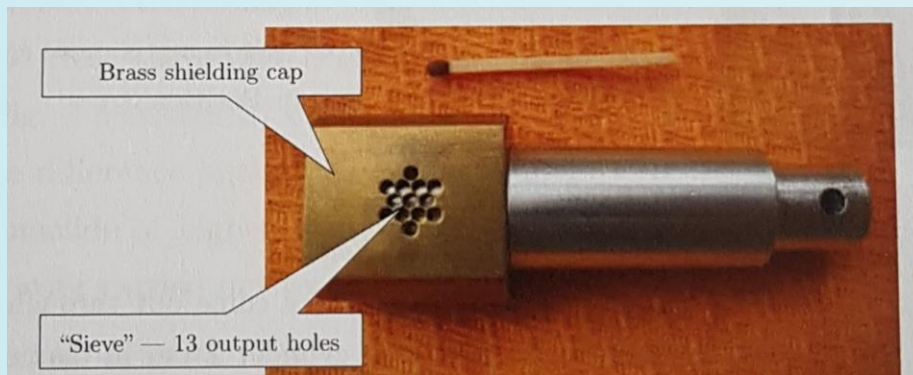
E_k [keV]	537	515	559	521	633
v [m s^{-1}]	2.62×10^8	2.60×10^8	2.64×10^8	2.61×10^8	2.68×10^8
$\frac{v}{c}$ (relat)	0.87	0.87	0.88	0.87	0.89
$\frac{v}{c}$ (classical)	1.45	1.42	1.48	1.43	1.57



FONTS DE RADIACIÓ HOMOLOGADES

Font α , γ d'americí 241

... contain the artificial radionuclide ^{241}Am and were approved by the State Office for nuclear safety (Czech Republic) as school educational equipment. The ŠZZ Alfa belongs to the category "insignificant..."

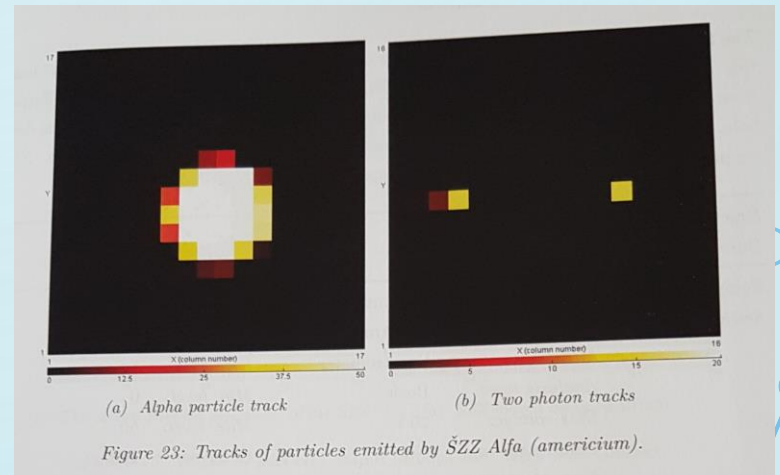
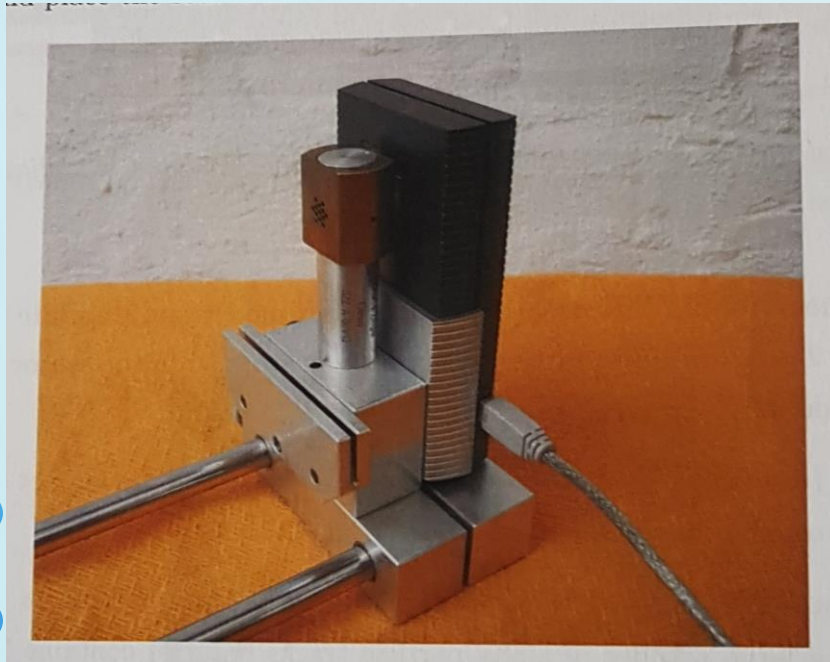
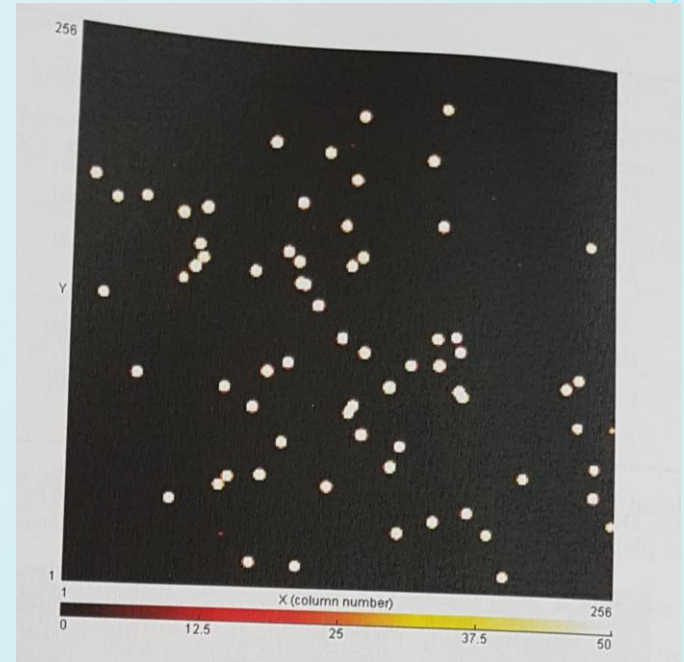
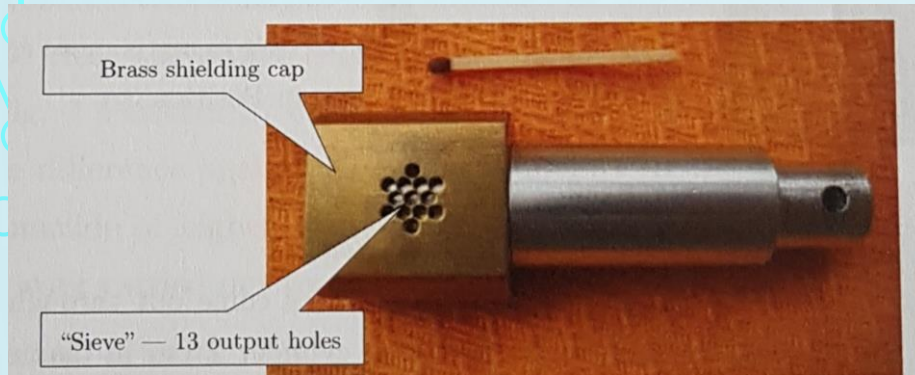


9,5 kBq, α , γ
“insignificant radiation source”,
Manipulat per professors o
alumnes

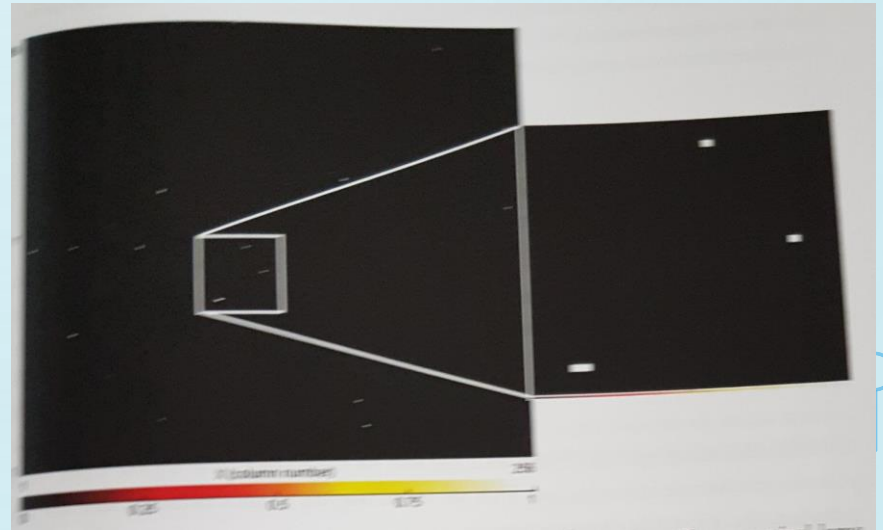


300 kBq, γ
“small source”
Manipulat per professors

Alfa i Gamma



Gamma



3.4 Fonts d'alfa i gamma d'americí

3.4.1 Visualització dels diferents tipus de radiació

3.4.2 Col·limació del feix de partícules

3.4.4;5 Naturalesa estadística del decaïment, Distribució de Poisson

Alfa:

3.4.3 Histograma de la mida de les traces de partícules alfa

3.4.6 Histograma d'energia α

3.4.7;8;10;20-22 Atenuació d' α a l'aire, abast, pic de Bragg

3.4.9 Influència del col·limador

3.4.11-19 Absorció per paper, film de plàstic, aigua, bombolles, ...

Gamma:

3.4.23 Visualització de traces

3.4.24 Histograma d'energies

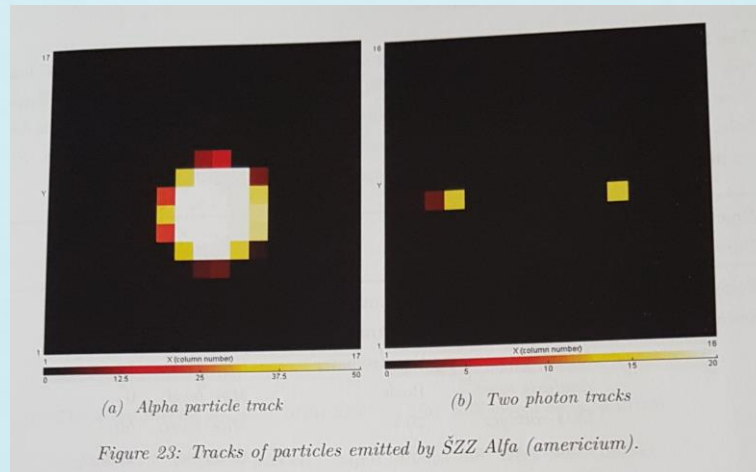
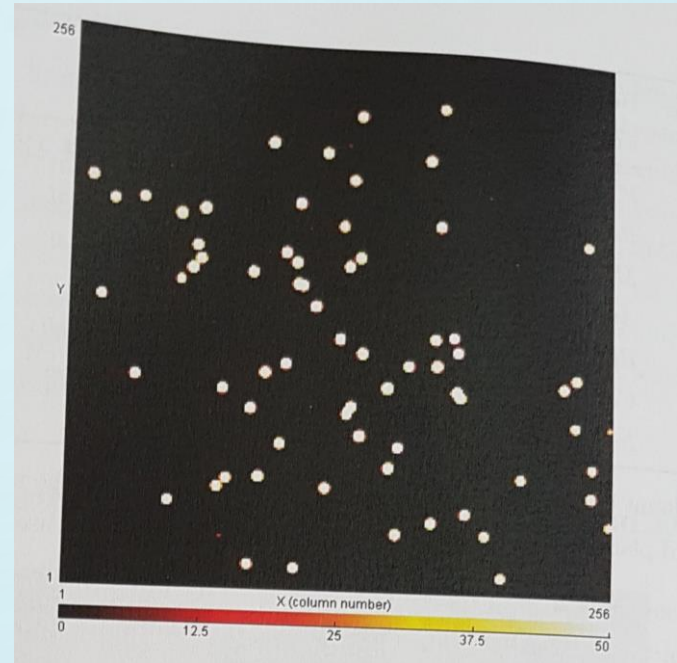
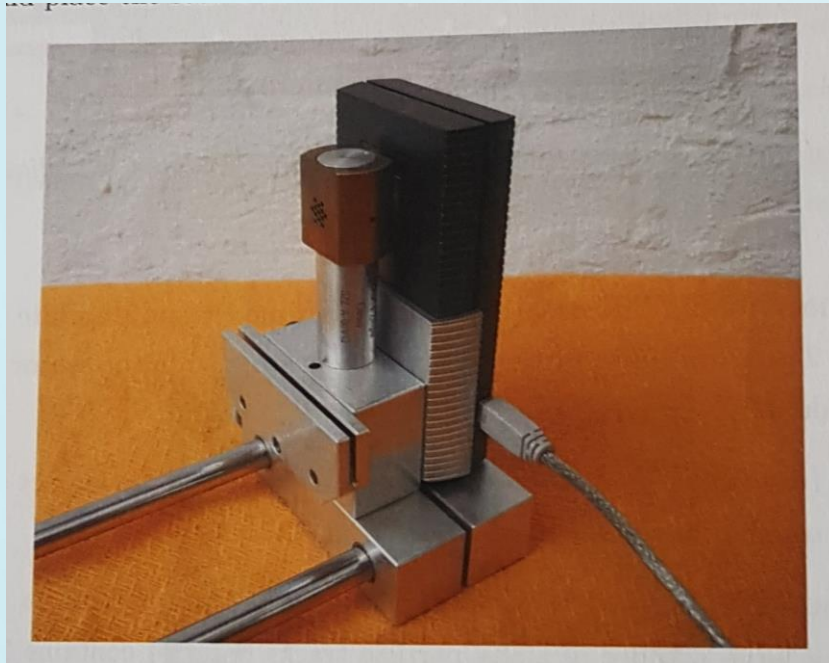
3.4.25-26 Dependència del # de traces i l'energia amb la distància

3.4.27 Absorció en metalls

3.4.28 Radiografia

3.4.29 Anàlisi per fluorescència

3.4.1 Visualització dels diferents tipus de radiació

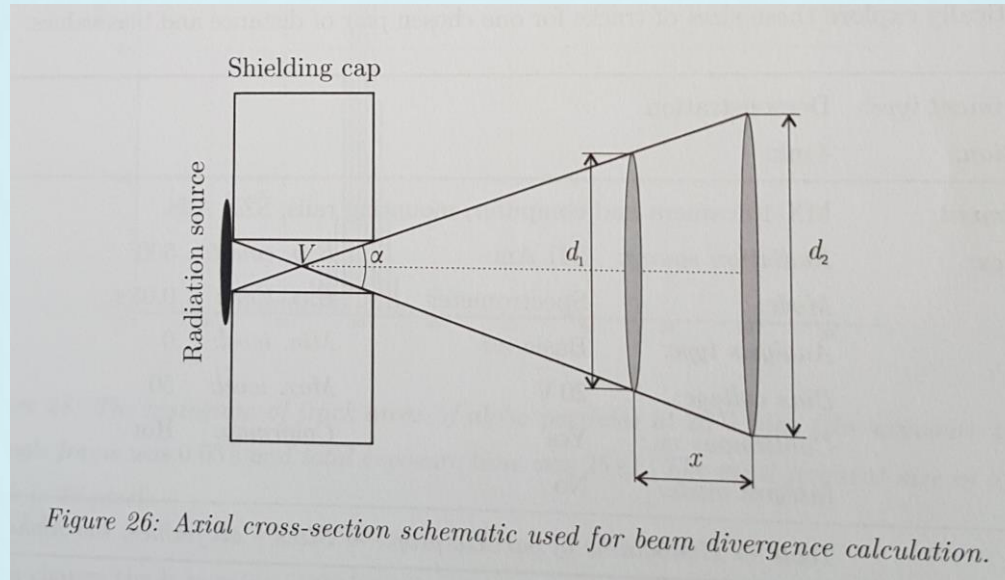


(a) Alpha particle track

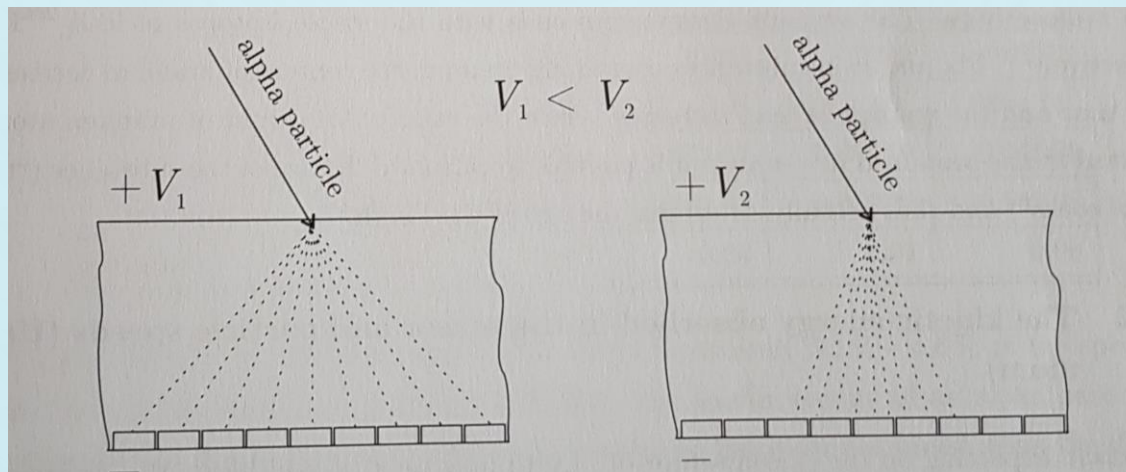
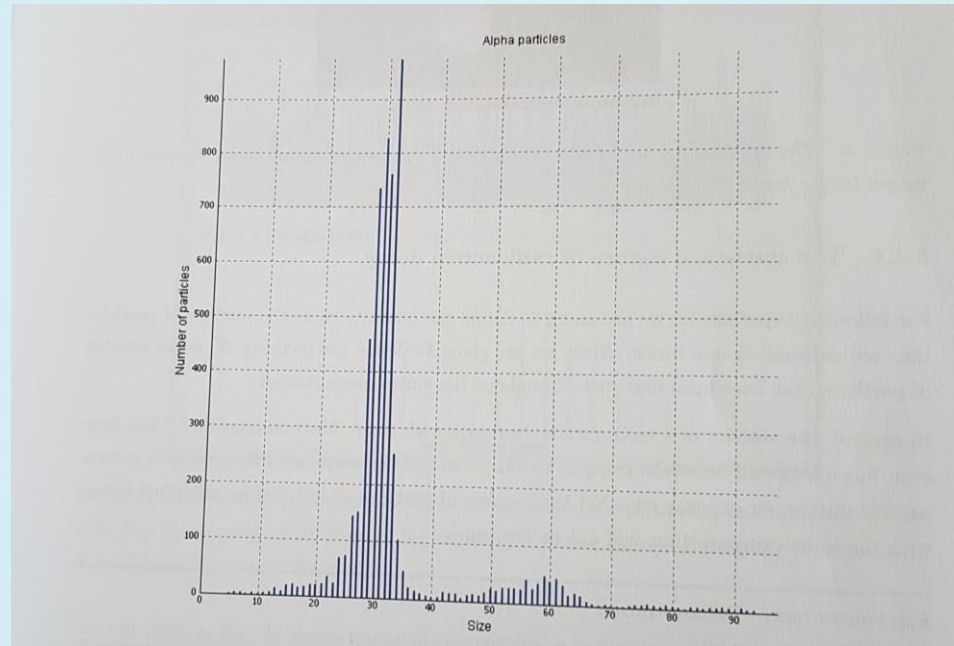
(b) Two photon tracks

Figure 23: Tracks of particles emitted by ŠZZ Alfa (americium).

3.4.2 Col·limació del feix de partícules



3.4.3 Histograma de la mida de les traces de partícules alfa



3.4.4;5 Naturalesa estadística del decaïment, Distribució de Poisson

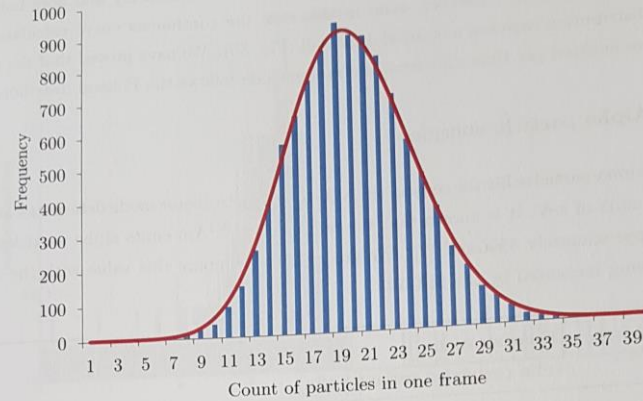


Figure 34: The histogram of n – the number of alpha particles in one frame constructed from measured data (column chart) and the graph of continuous functions whose points have been calculated from the equation for the Poisson distribution (equation (3) for $\lambda = 20$). During the measurement $N = 200\,300$ alpha particles were detected.

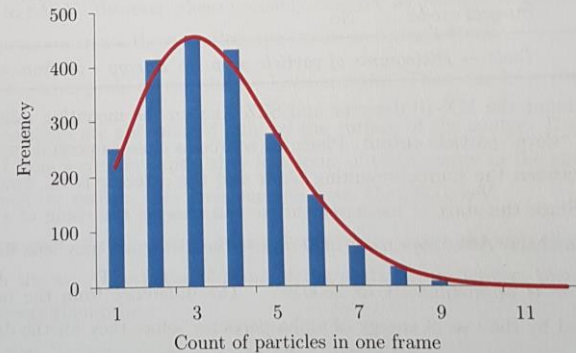
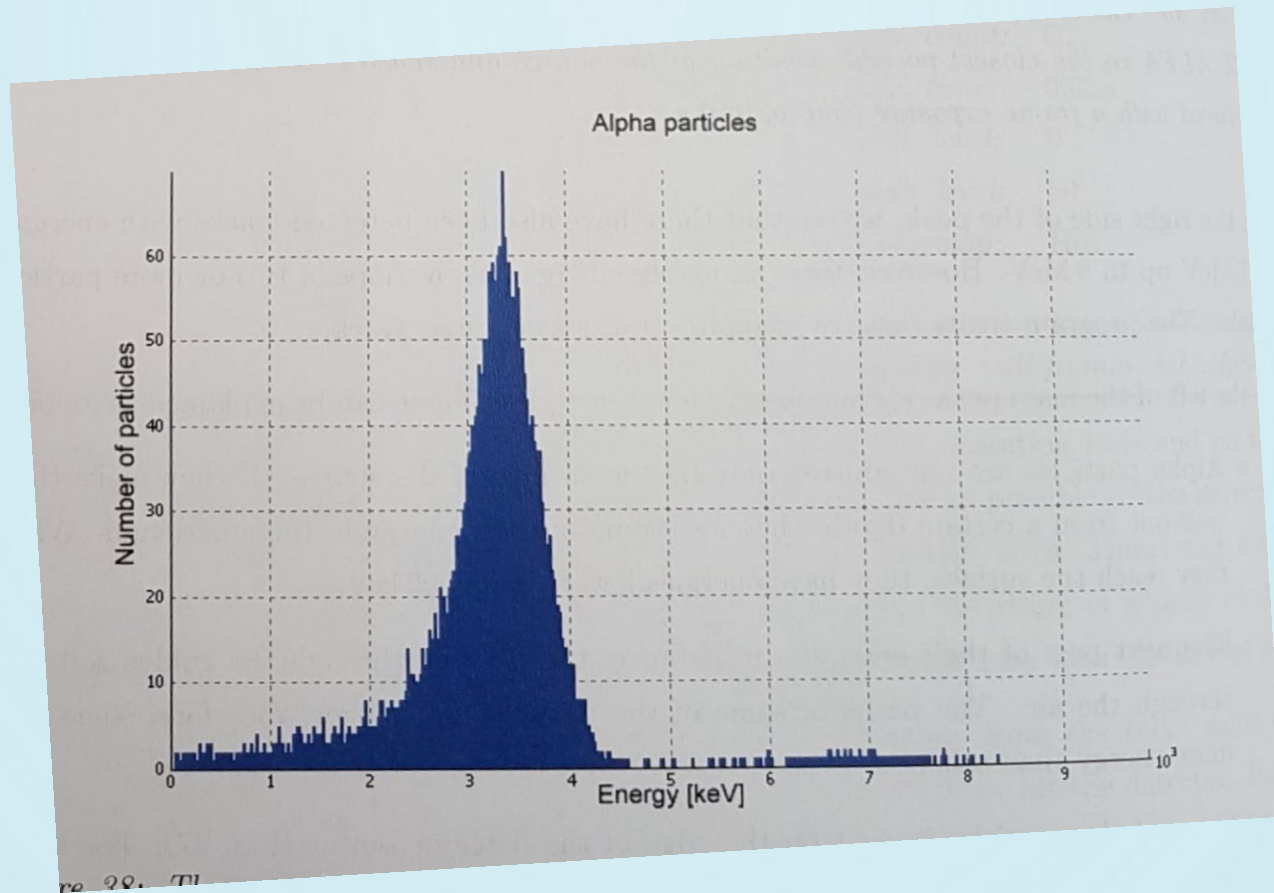


Figure 35: The histogram of n – the number of alpha particles in one frame constructed from measured data (column chart) and the graph of continuous functions whose points have been calculated from the equation for the Poisson distribution (equation (3) for $\lambda = 3.53$). During the measurement $N = 7437$ alpha particles were detected.

3.4.6 Histograma d'energia α



3.4.11-19 Absorció per paper, film de plàstic, aigua, bombolles, ...

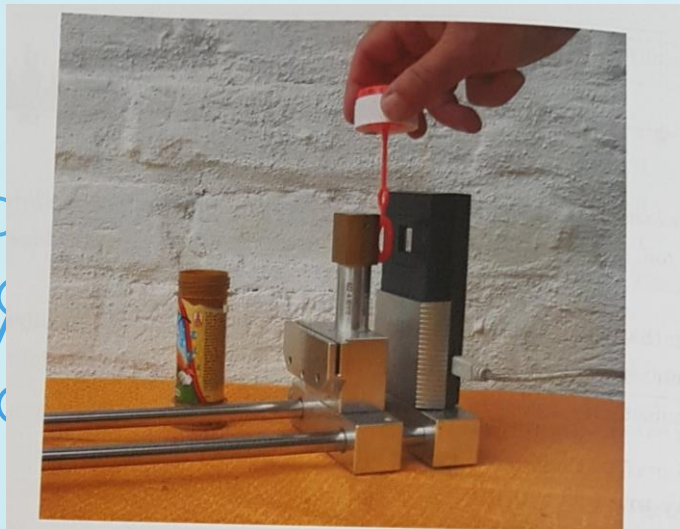
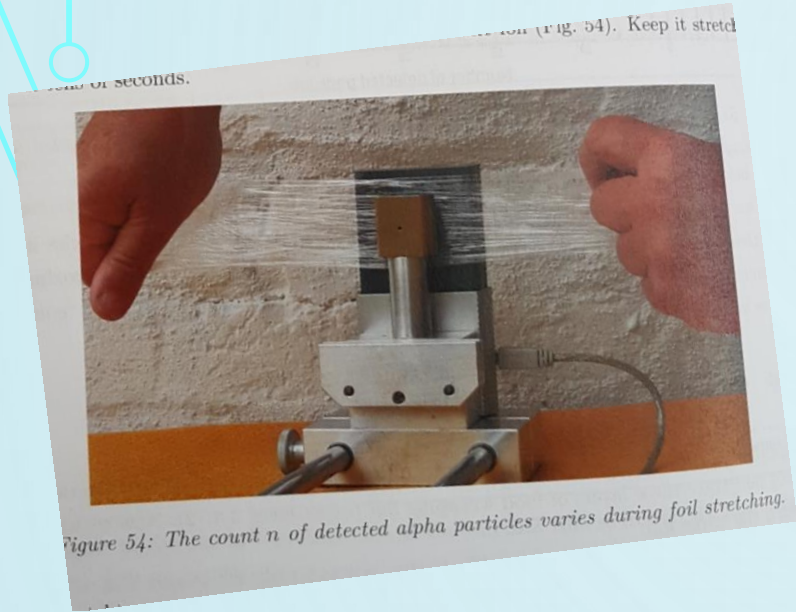


Figure 58: The setup for demonstration of the absorption of radiation in a water drop. The sensor is in the horizontal position, above it is a piece of food wrapping foil with a drop of water and above the center of the sensor is the radiation source. For a better visibility of the drop is the source in this picture placed higher than in actual measurement.

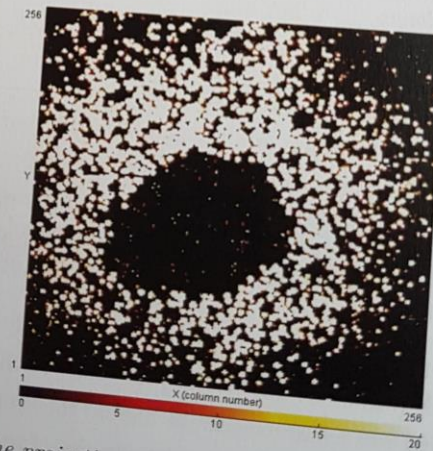


Figure 59: The projection of a water droplet on food wrapping foil.

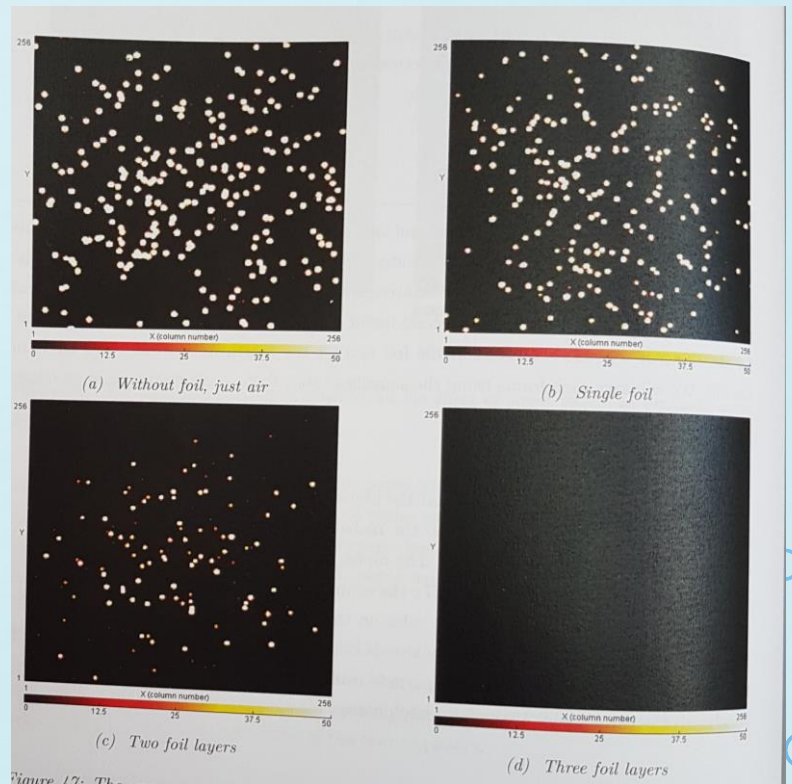
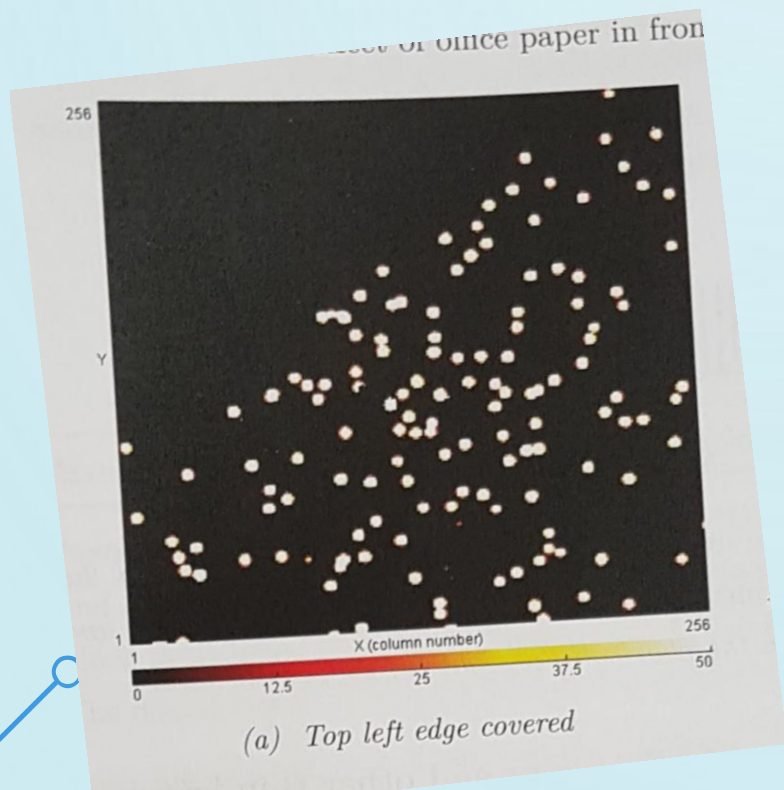
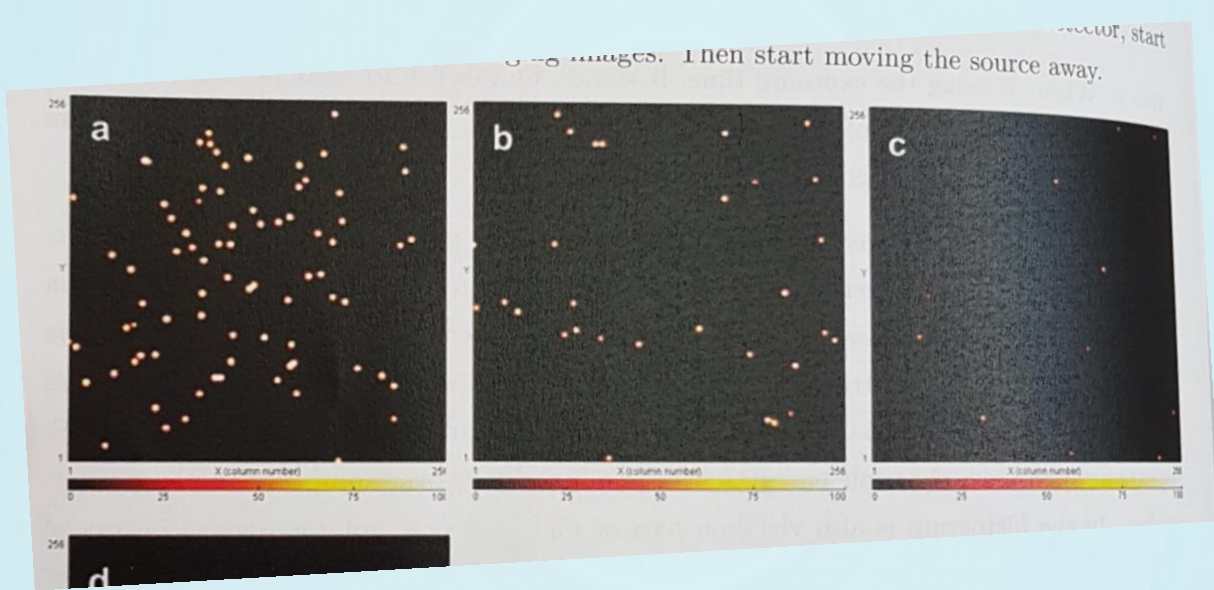


Figure 17: The

3.4.7;8;10;20-22 Atenuació d' α a l'aire, abast, pic de Bragg

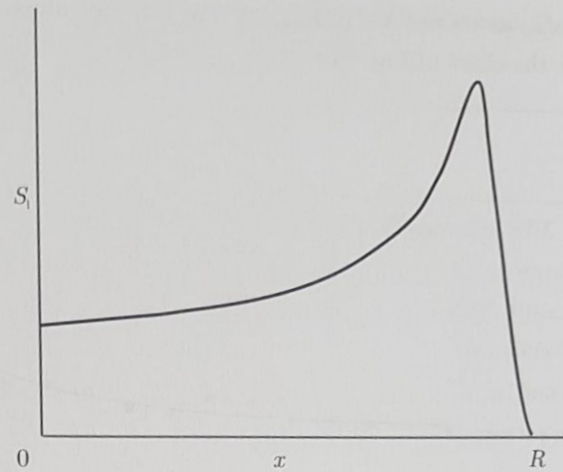
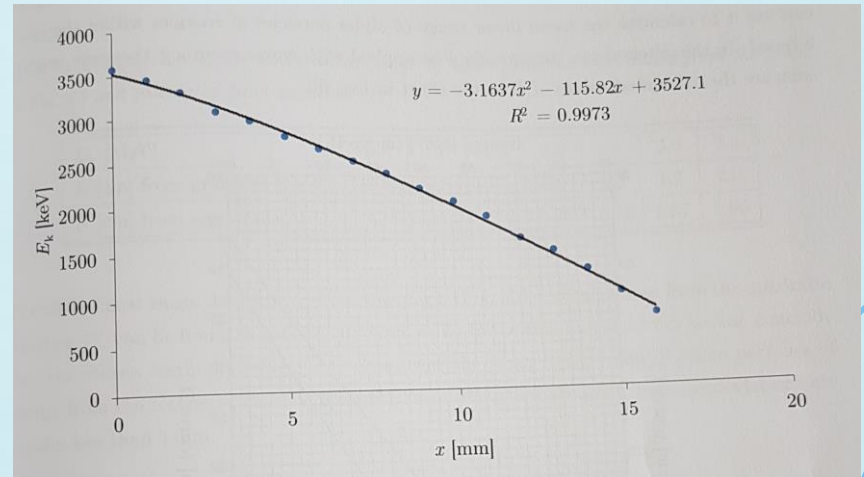
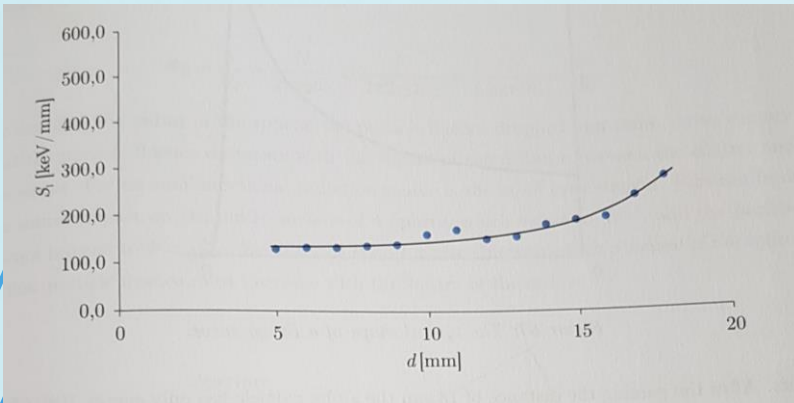
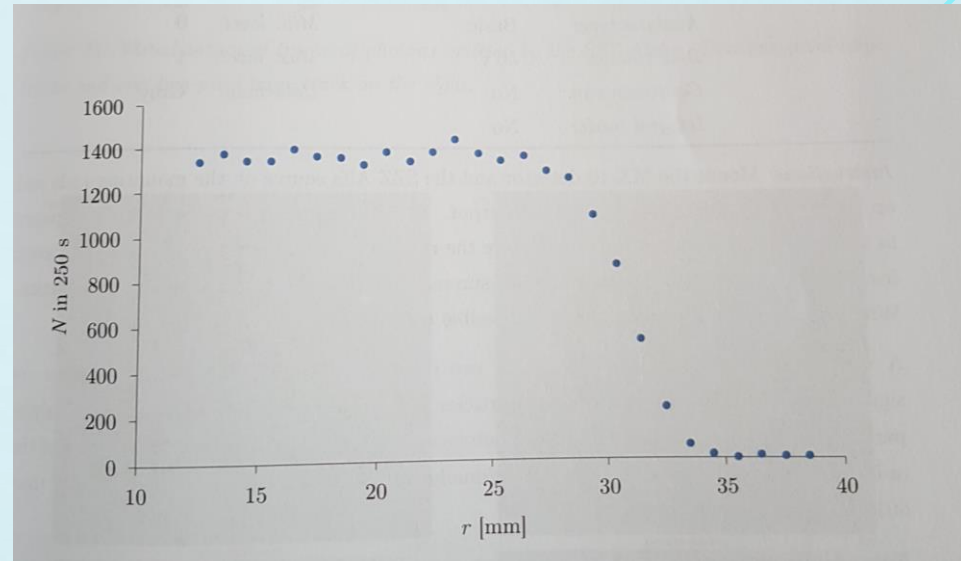
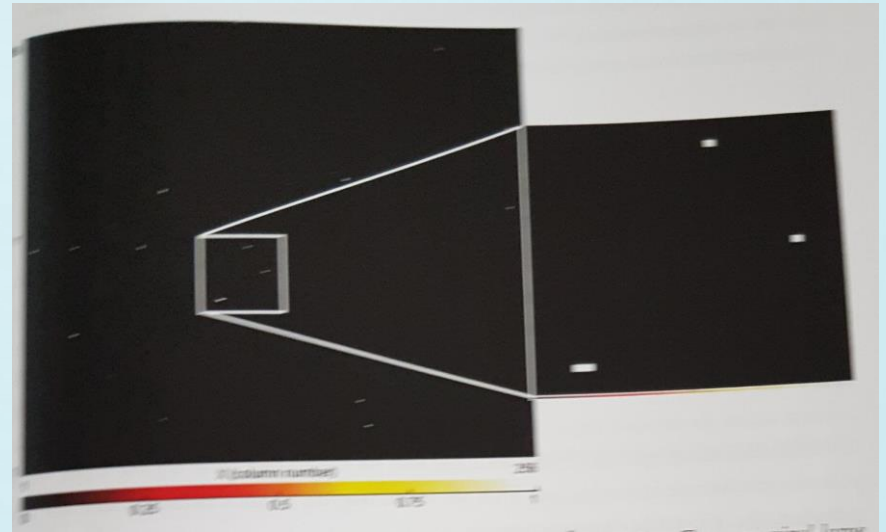


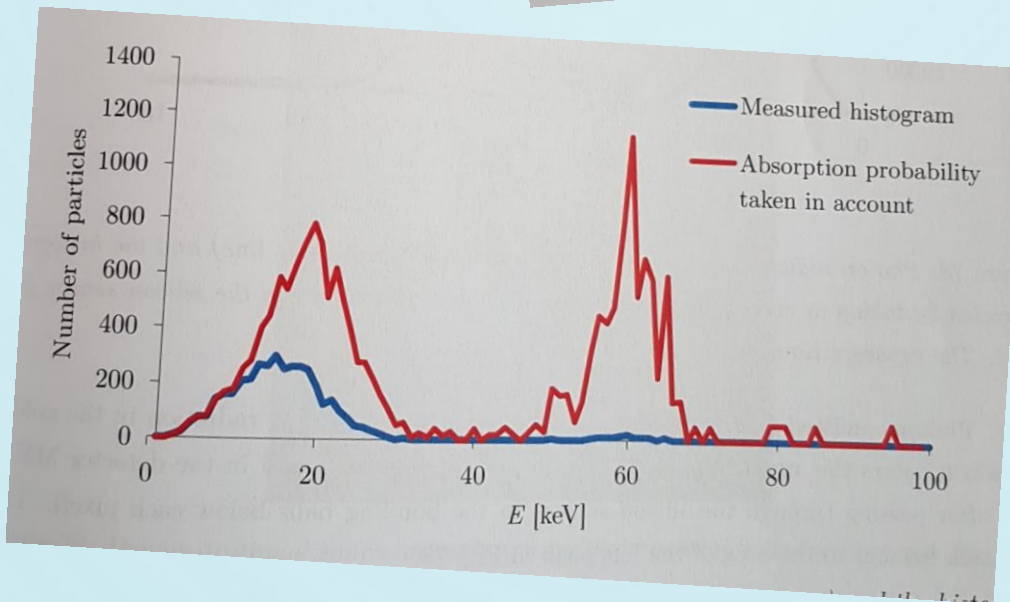
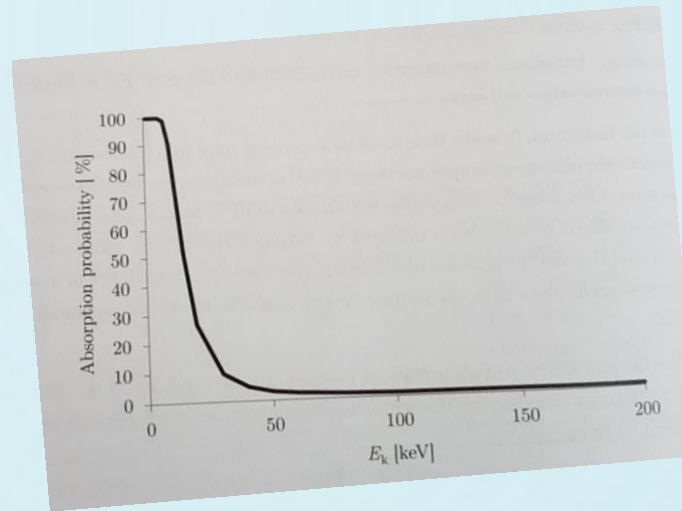
Figure 67: The typical shape of a Bragg curve.



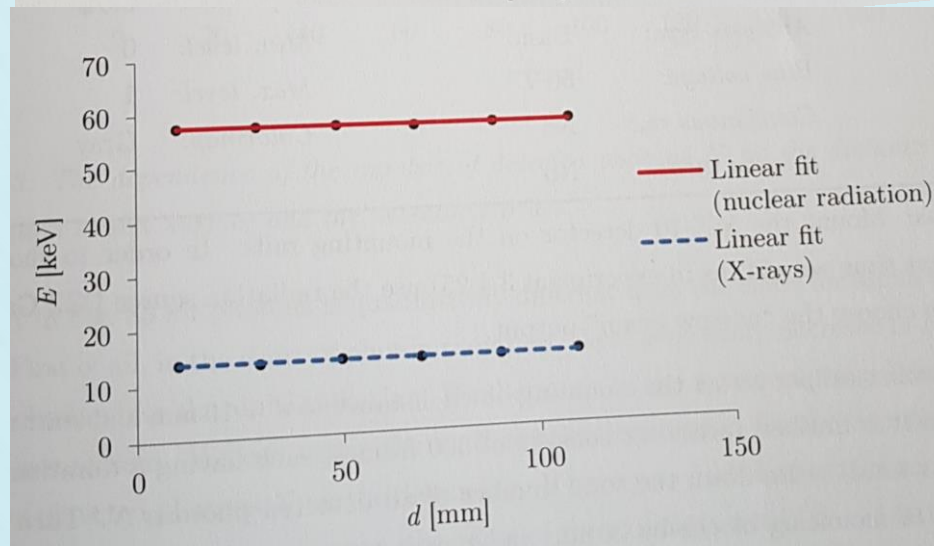
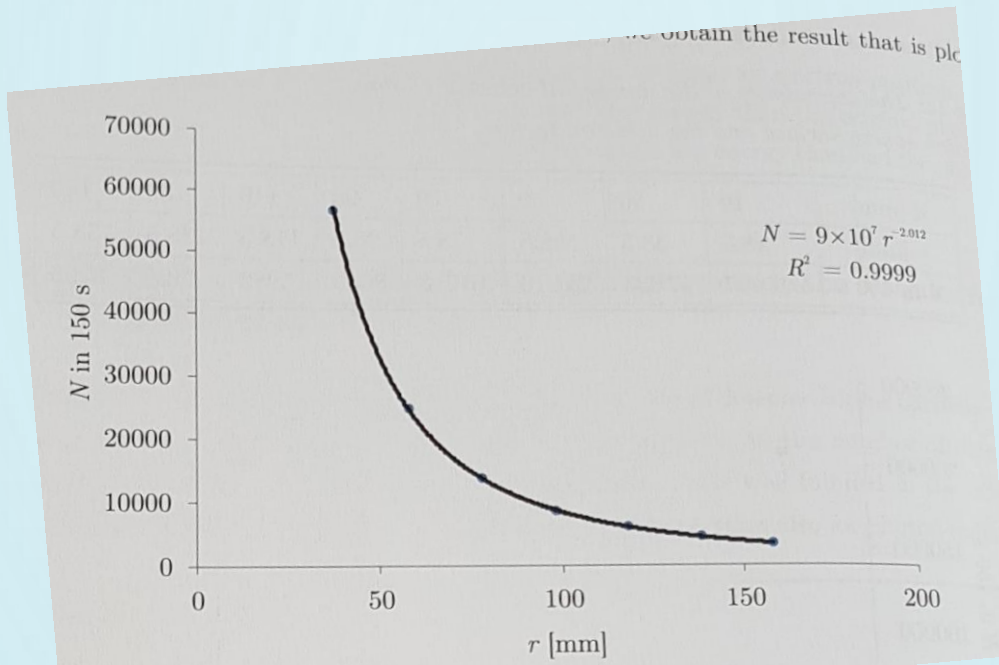
Gamma



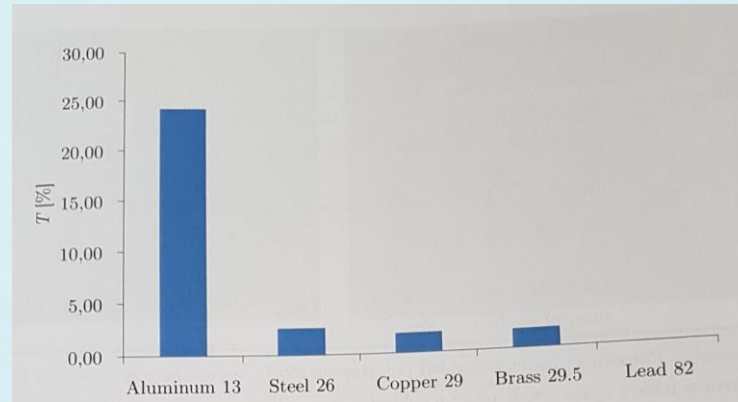
3.4.24 Histograma d'energies



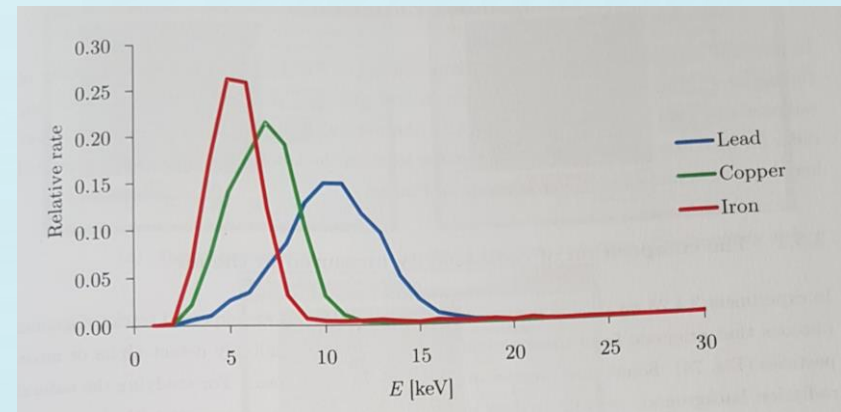
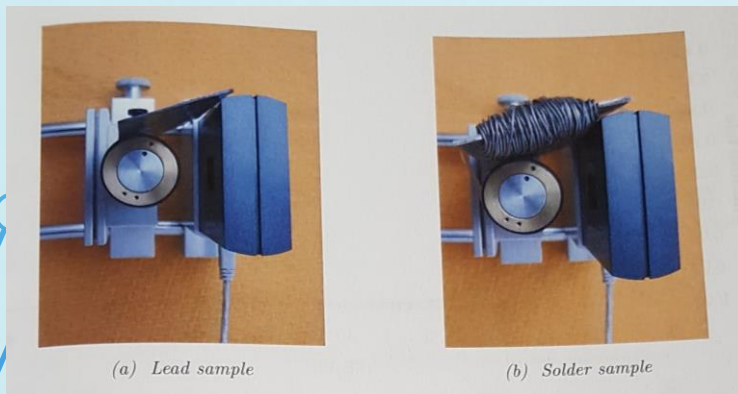
3.4.25-26 Dependència del # de traces i l'energia amb la distància



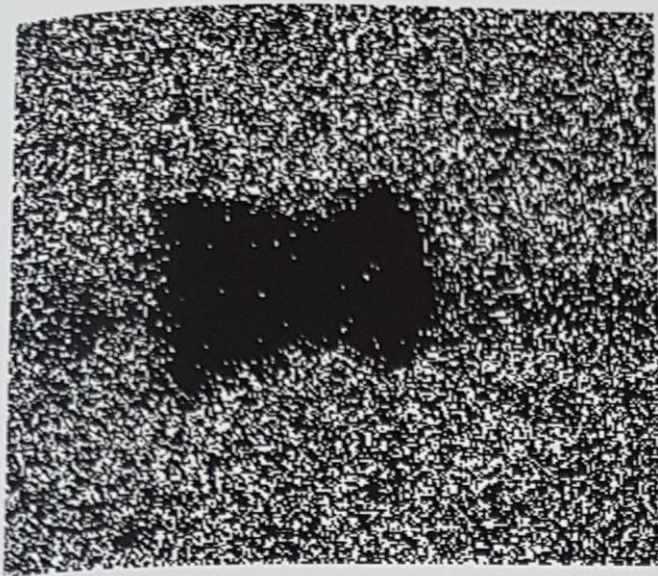
3.4.27 Absorció en metalls



3.4.29 Anàlisi per fluorescència



3.4.28 Radiografia



(a) Radiography



(b) Photography

3.5 RADIACIÓ DE FONTS NATURAL

3.5.1 Composició de la radiació de fons

3.5.2-4 Radó a l'ambient, filtració amb paper

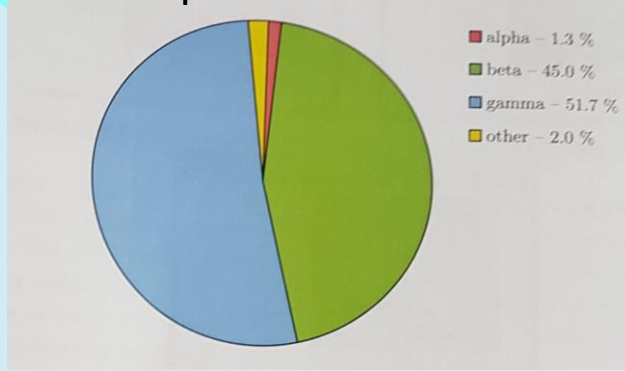
3.5.5 Decaïment exponencial

3.5.6-7 TV de raigs catòdics: raigs-X i radiació alfa

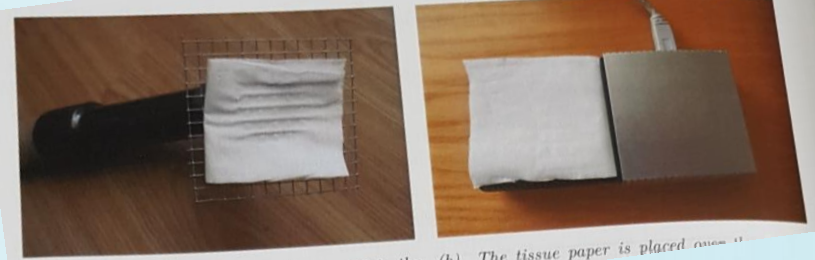
3.5.8-9 Raigs còsmics, trajectòria vertical

3.5.10-12 Radiació en vol d'avió: tipus, activitat, dosimetria

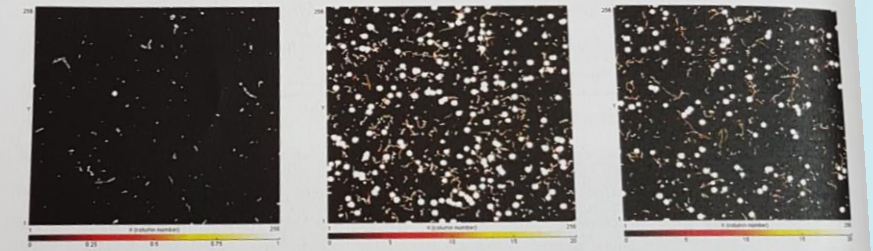
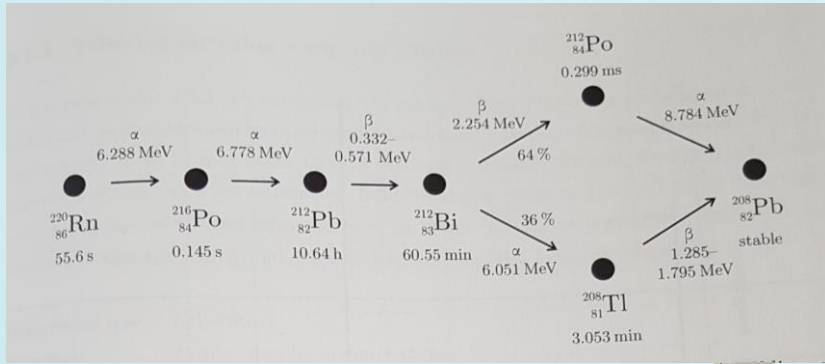
3.5.1 Composició de la radiació de fons



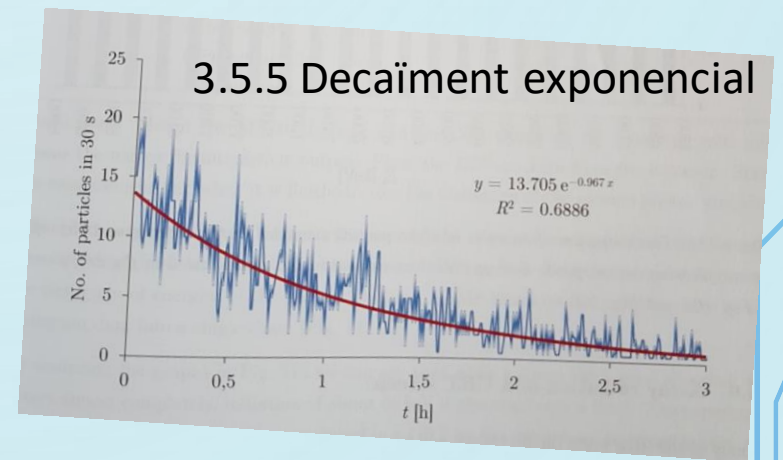
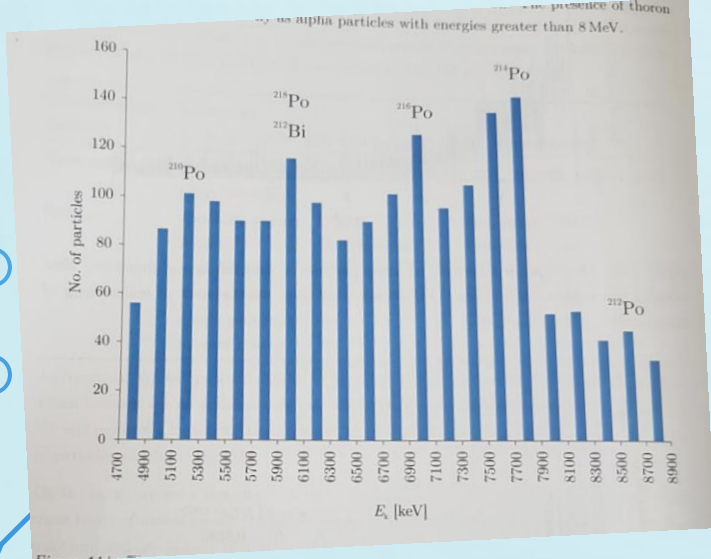
3.5.2-4 Radó a l'ambient, filtració amb paper



(a) Wire grid prevents sucking the paper into the nozzle. (b) The tissue paper is placed over the nozzle.



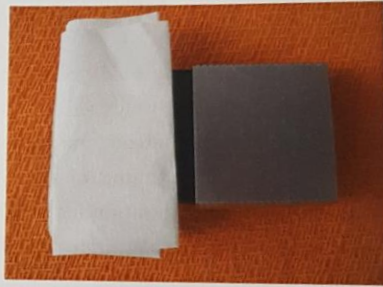
(a) Tissue paper before being used as air filter. (b) After filtering the air in a living room (200 m³). (c) After filtering the air used as air filter.



3.5.6-7 TV de raigs catòdics: raigs-X i radiació alfa

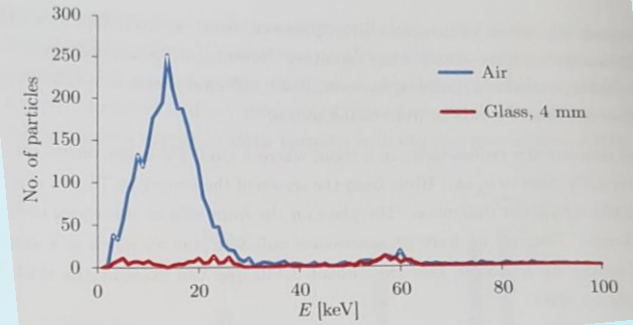


(a) The TV set with a CRT which has been the wiped with a tissue paper.



(b) The tissue paper placed over the sensor of MX-10.

Figure 113: The mesurement of alpha radioactivity near a CRT TV set



Histogram of energies of alpha particles

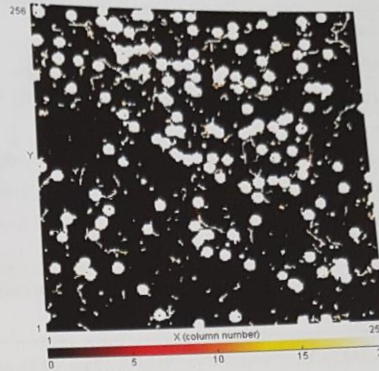
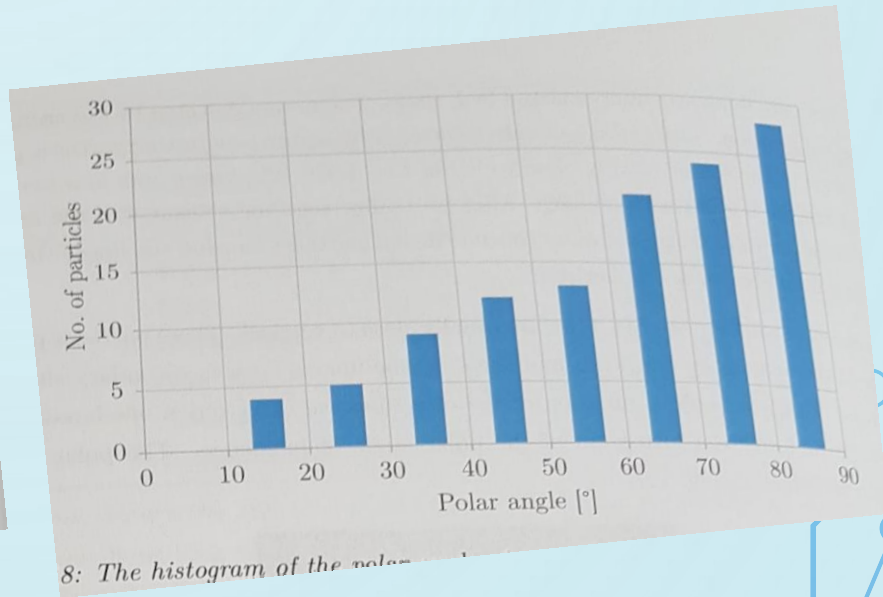
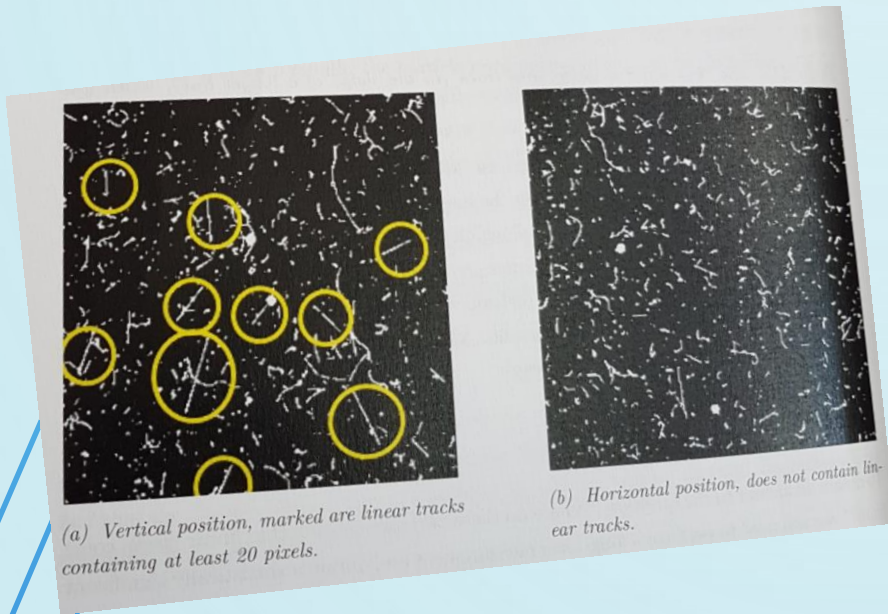
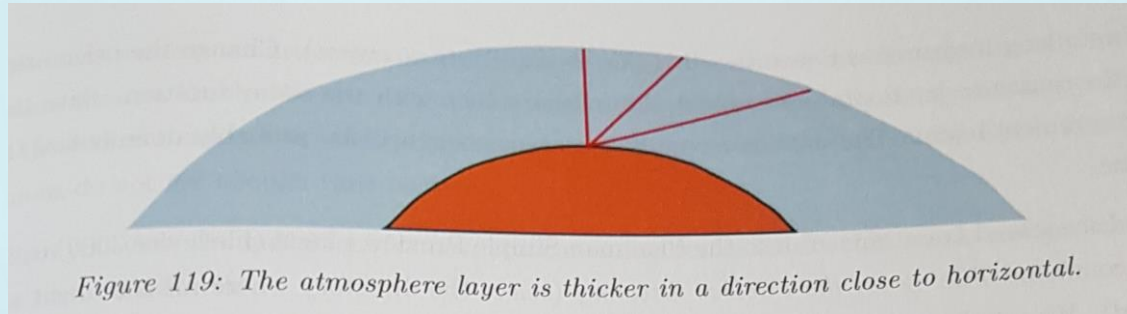
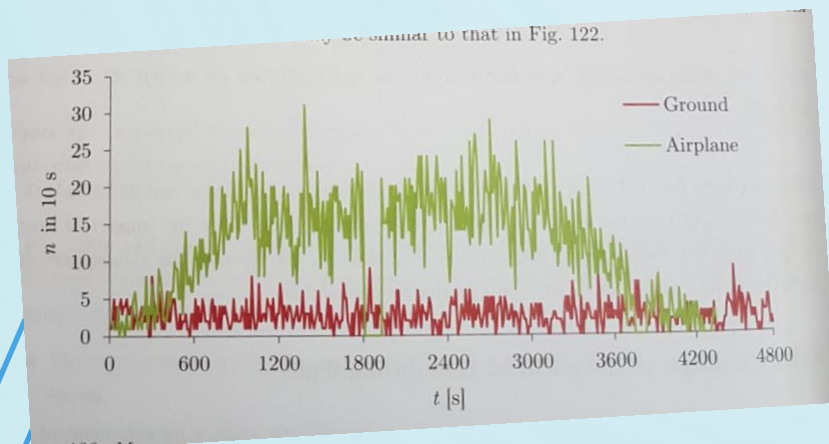
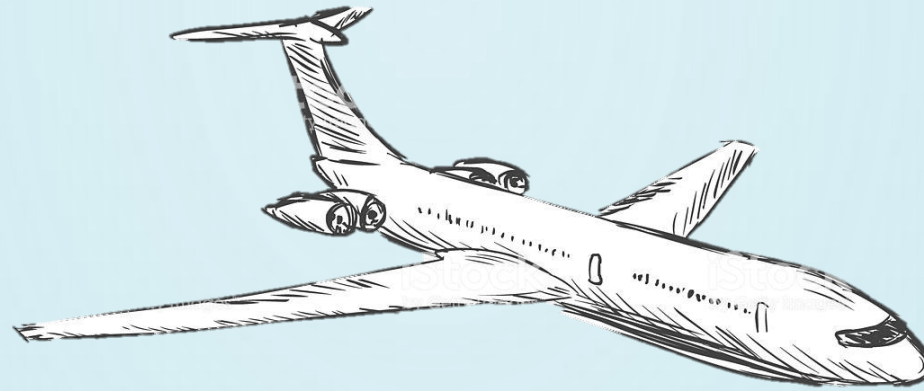


Figure 114: The radioactivity of a tissue paper, which was used to wipe a CRT TV screen. During the 10-minute measurement of radioactivity of the handkerchief were detected 301 alpha particles.

3.5.8-9 Raigs còsmics, trajectòria vertical



3.5.10-12 Radiació en vol d'avió: tipus, activitat, dosimetria



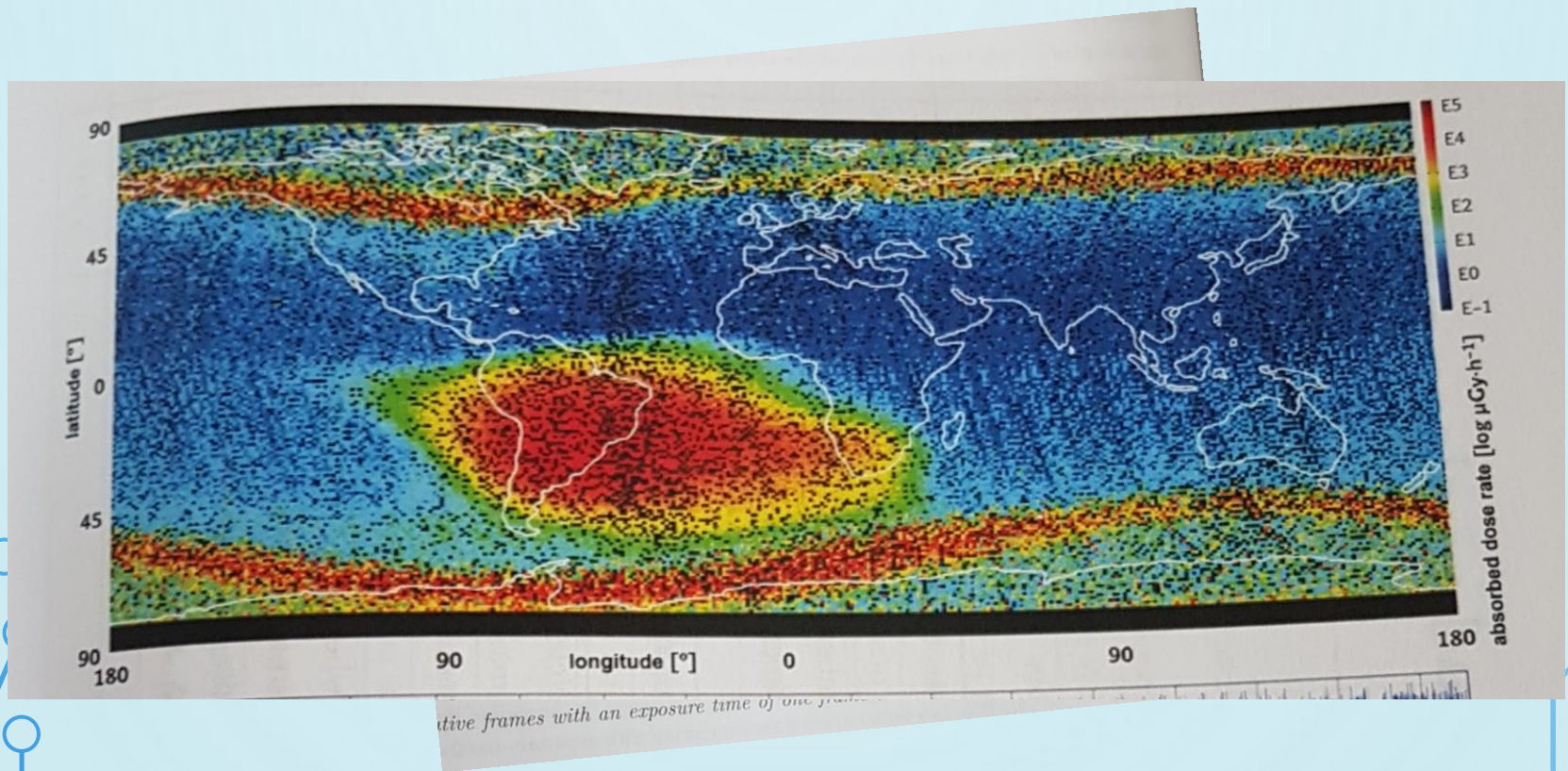
(a)



(b)

Figure 121: Interesting tracks with high absorbed energy, 14 552 keV on the left, 33 525 keV on the right.

3.6 DADES DEL TIMEPIX EN ALTRES COL·LABORACIONS e.g. ISS





The image features a light blue background with a subtle, large-scale pattern of concentric circles. In the four corners, there are decorative elements consisting of thin, light blue lines that resemble circuit traces or data paths, ending in small circles.

Thank you for your attention