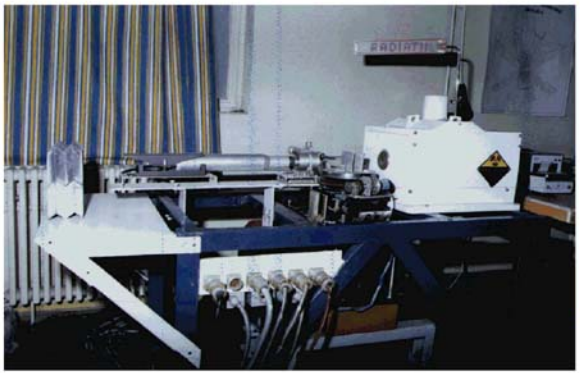
Tehnici de vizualizare, analiza si identificare materiale in Radioscopia si Tomografia cu Raze X "dual-energy" cu aplicatii in domeniul Securitatii si al Controlului Nedistructiv

ACCENT PRO 2000 S.R.L.

(AP2K - www.accent.ro)

Mihai IOVEA

CUPRINS



Primul
Tomograf
Industrial cu sursa
gama
din
tara

Sursa gama
Cs 137 (2 Ci)

(ICPE 1989)

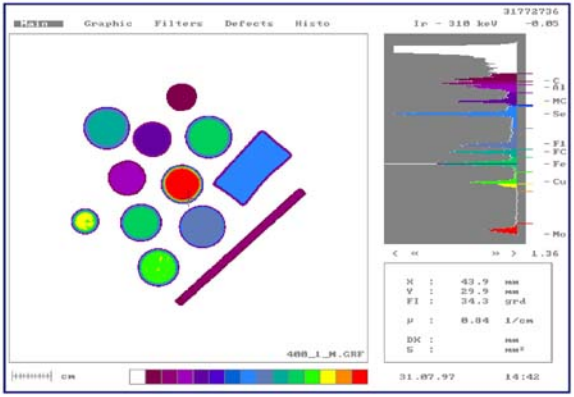
TOMORAY
Primul
Tomograf
Industrial
"dual-energy"

Sursa gama
Ir192 (20Ci)

(ICPE 1992)

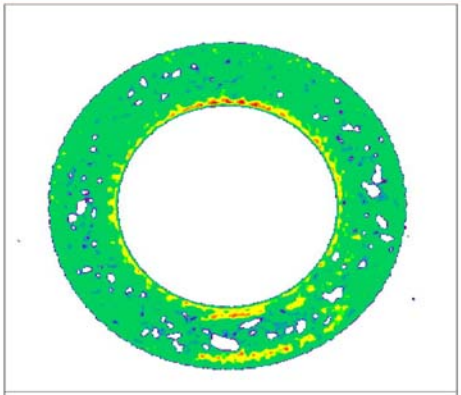
RAY- DENSIMAT
Masurarea
densitatii
cu precizie ridicata
(0,5 – 1,5 %)

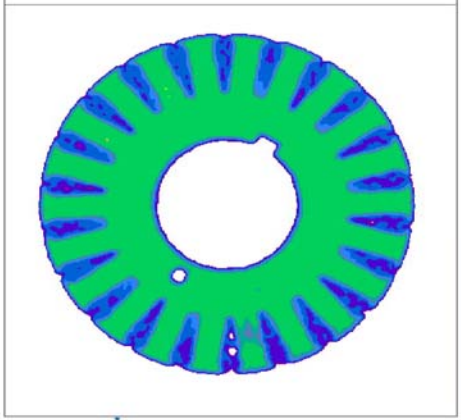
(ICPE – 1994)



TOMORAY
Identificarea
materialelor

(ICPE-1995)

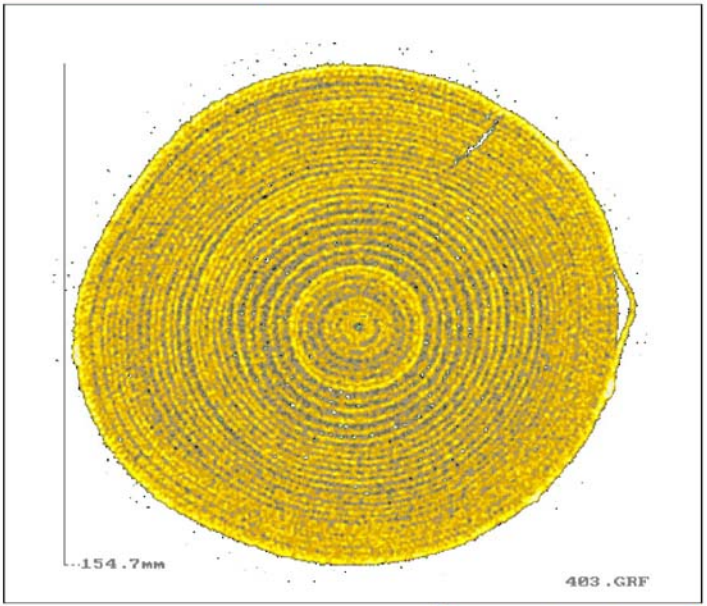




Rotor motor asincron

Diametrul: 90 mm
Pixel: 0.4 mm

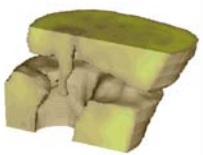
(ICPE 1994)



Trunchi de salcie

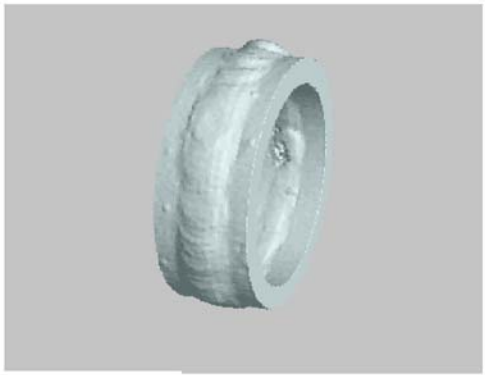
Diametrul: 155 mm
Pixel: 0.4 mm

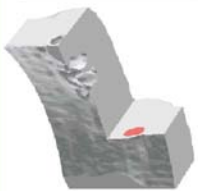
(ICPE 1995)

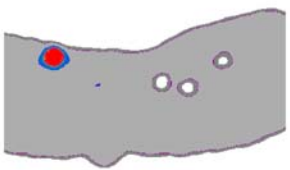


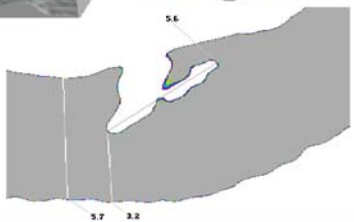
TOMORAY
Tomograme
2D si 3D

(ICPE 1995)

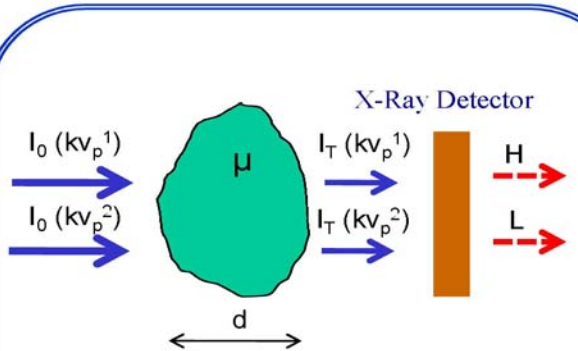




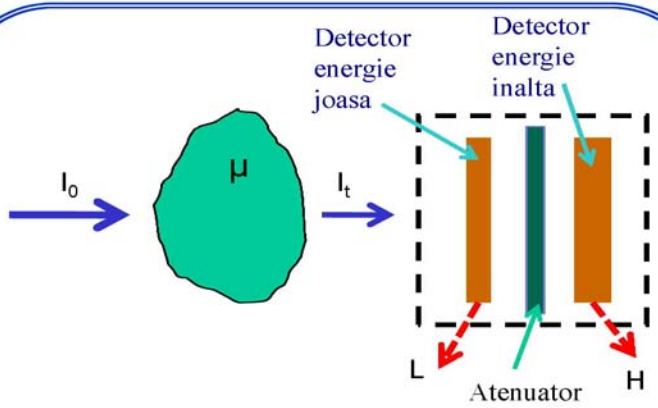




$$\ln\left(\frac{I_0}{I}\right) = \mu \times d$$



"Dual –energy" la doua valori kVp



"Dual – energy" simultan cu doi detectori

$$\mu(E) = \rho \cdot N_A \cdot \frac{Z_{eff}}{A} \cdot \left[a(E) + b(E) \cdot {Z_{eff}}^m \right]$$

$$Z_{effective} = \sqrt[m]{\left(\sum_i e_i \cdot Z_i^m \right)}$$

Tomografie "dual-energy"

$$\mu_L = \rho \times [\, a_L \times (Z_{eff})^k + b_L \times Z_{eff} + c_L]$$

$$\mu_H = \rho \times [a_H \times (Z_{eff})^k + b_L \times Z_{eff} + c_H]$$

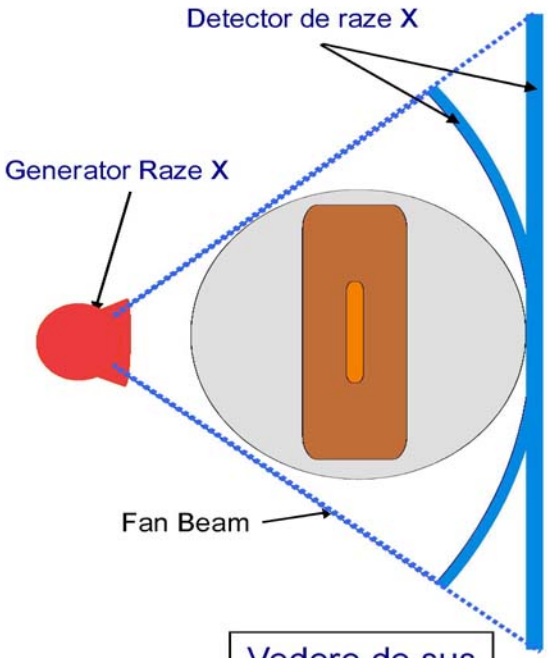
Z_{eff} ; ρ (Densitatea)

Radioscopie "dual-energy"

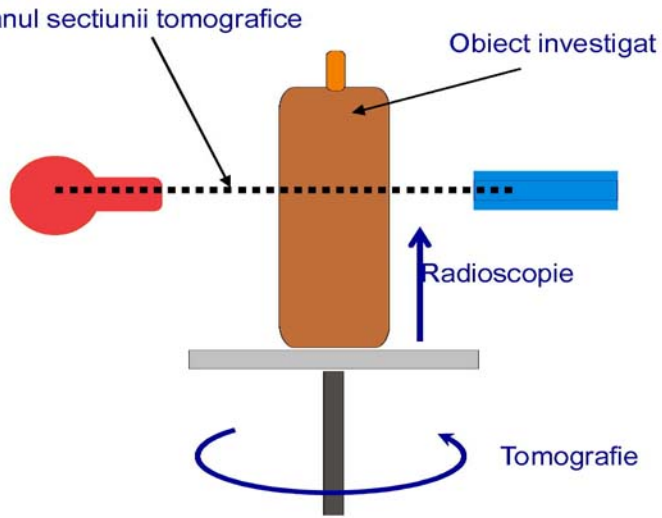
$$\ln (I_0 / I_t)_L = d \times \rho \times [\, a_L \times (Z_{eff})^k + b_L \times Z_{eff} + c_L]$$

$$\ln (I_0 / I_t)_H = d \times \rho \times [a_H \times (Z_{eff})^k + b_L \times Z_{eff} + c_H]$$

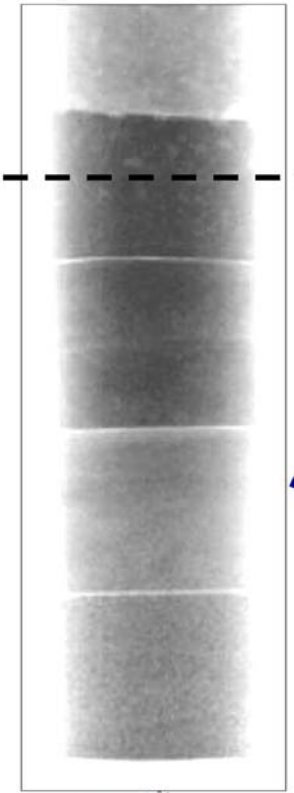
Z_{eff} ; Greutatea

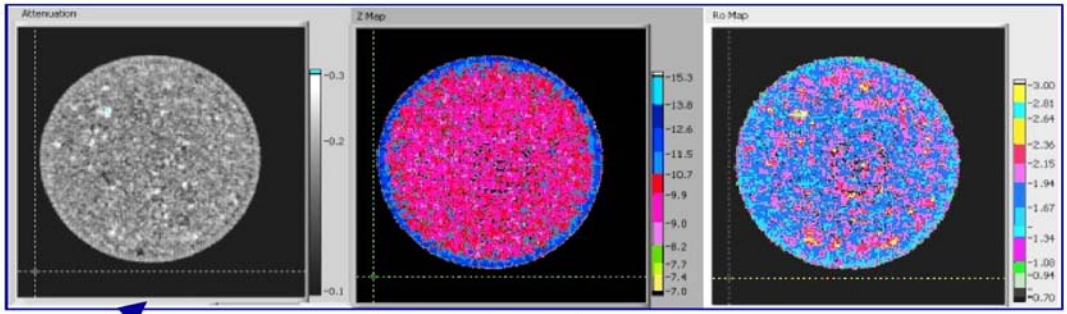


Vedere de sus



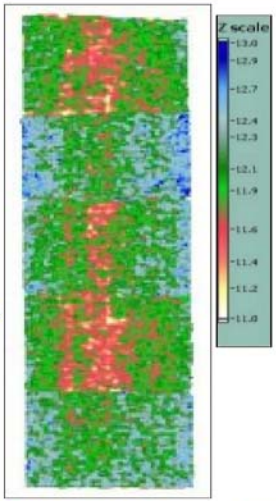
Vedere laterala





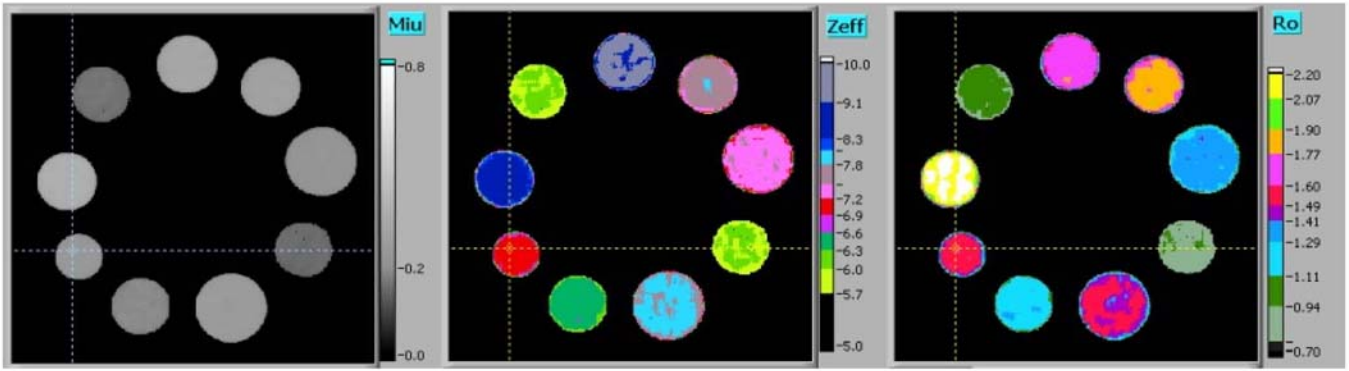
Tomografie "dual-energy"

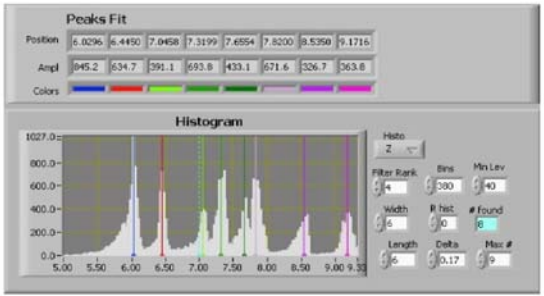
Radioscopie "dual-energy"

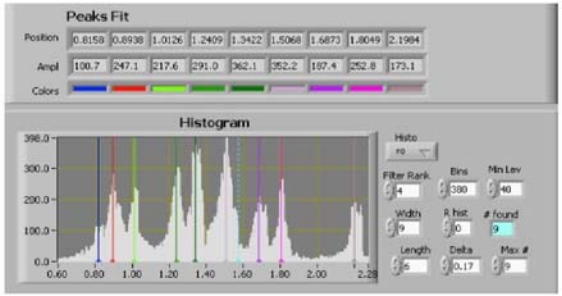


Distributia materialelor constituiente in Radioscopia si Tomografia cu raze X "dual-energy"

(AP2K 2003-2007)







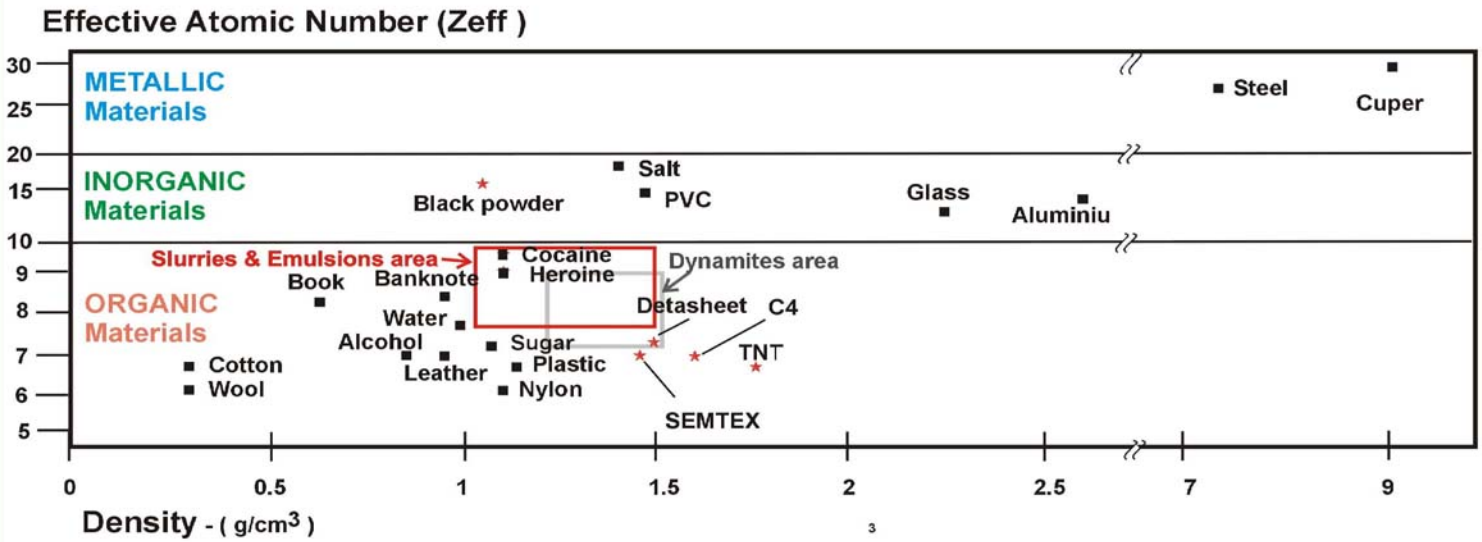
Tehnica "dual-energy" in Tomografia cu raze X aplicata la identificarea materialelor

(AP2K 2003-2007)

"TOMOEXP" - Echipament de Radioscopie si Tomografie cu Raze X "dual-energy" dedicat experimentelor privind identificarea explozivilor si dezvoltarea de aplicatii in NDT

- **160 kV / 3 mA, monobloc;**
- **2x240 fotodiode (1,5 mm) cu scintilatori in montaj "dual-energy" sau 1 x 1280 fotodiode (0,4 mm) cu scintilatori;**
- **Dimensiuni maxime obiect investigat: diametru: 40 cm, inaltime: 50 cm; greutate : 50 Kg**

(AP2K 2002-2007)

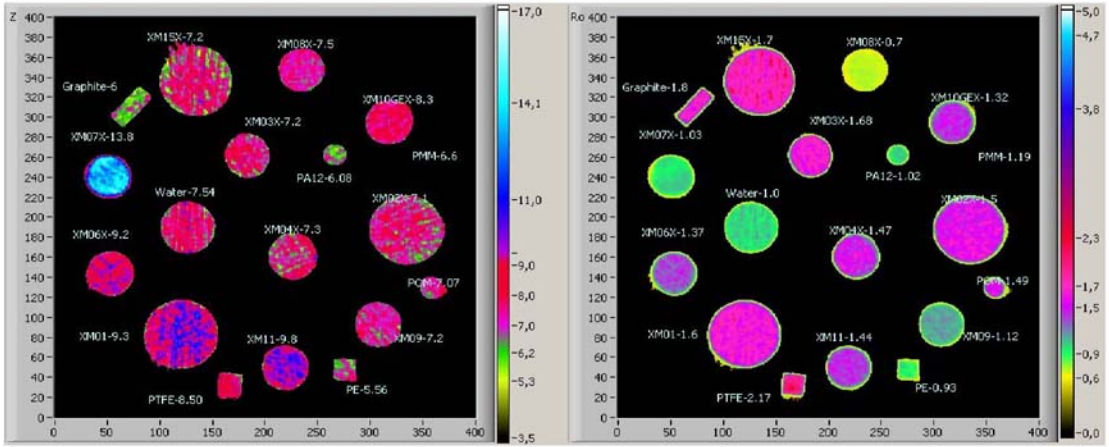


Densitatea si Numarul Atomic Effective ($Z_{efectiv}$) pentru explozivi si diverse materiale

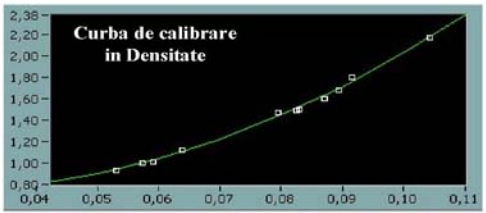
Etaloane/simulanti de materiale explozive destinate testarii sistemelor de detectie cu Raze X, concept dezvoltat la ***Lawrence Livermore National Laboratory*** si produse de firma ***XM Division of VanAken Int. - USA***

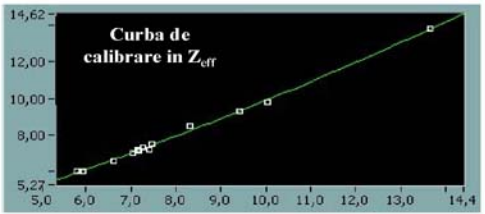
X-Ray Simulants Compared to Explosives and Powders

Explosive	Major Ingredients	Approximate Density (g/cc)	Approximate Average Effective Atomic Number (Z)
XM-08-X	*OUO*	0.7	7.5
Smokeless Powders	nitrocellulose	0.5 to 1.0	7.4 to 7.8
ANFO	ammonium nitrate	0.9	7.4
XM-07-X	*OUO*	1.03	13.8
XM-09GE-X	*OUO*	1.12	7.2
Black Powder	potassium nitrate	1.2	14.2
Commercial Slurries and Emulsions	ammonium nitrate *(higher Z nitrates)*	1.1 to 1.5	7.3 to 10.0
XM-10GE-X	*OUO*	1.32	8.3
XM-06-X	*OUO*	1.37	9.2
XM-11GE-X	*OUO*	1.44	9.8
Dynamites	nitroglycerine sodium nitrate *(higher Z nitrates)*	1.3 to 1.6	7.3 to 9.0
XM-05-X	*OUO*	1.45	7.3
Detasheet	PETN	1.47	7.2
SEMTEX H	RDX	1.47	7.1
SEMTEX 1A	PETN	1.47	7.2
XM-04-X1	*OUO*	1.47	7.3
TNT	TNT	1.51	7.1
XM-02-X1	*OUO*	1.50	7.1
Comp C-4	RDX	1.58	7.1
XM-01AL-X	*OUO*	1.60	9.3
Tritonal	TNT	1.65	9.1
XM-03-X	*OUO*	1.68	7.2
XM-15-X	*OUO*	1.70	7.2
Comp B	RDX	1.71	7.2
Octol	HMX	1.80	7.2



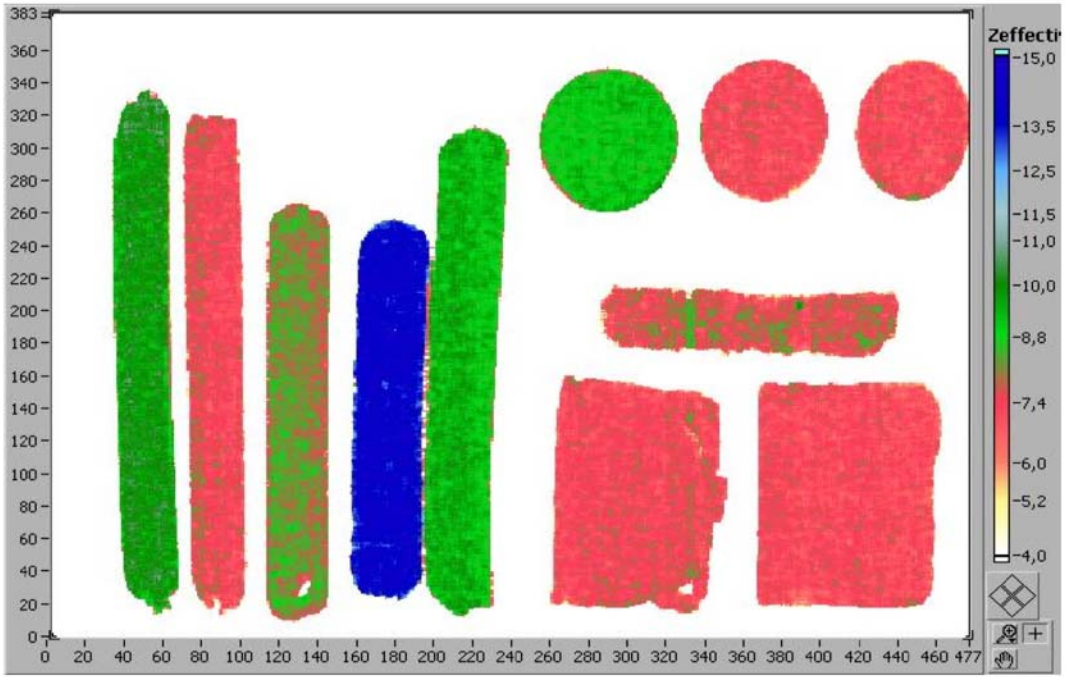
Calibrarea Tomografiei "Dual-energy"





Masurarea Z_{eff} si a Densitatii cu o eroare mai buna de ± 3% !

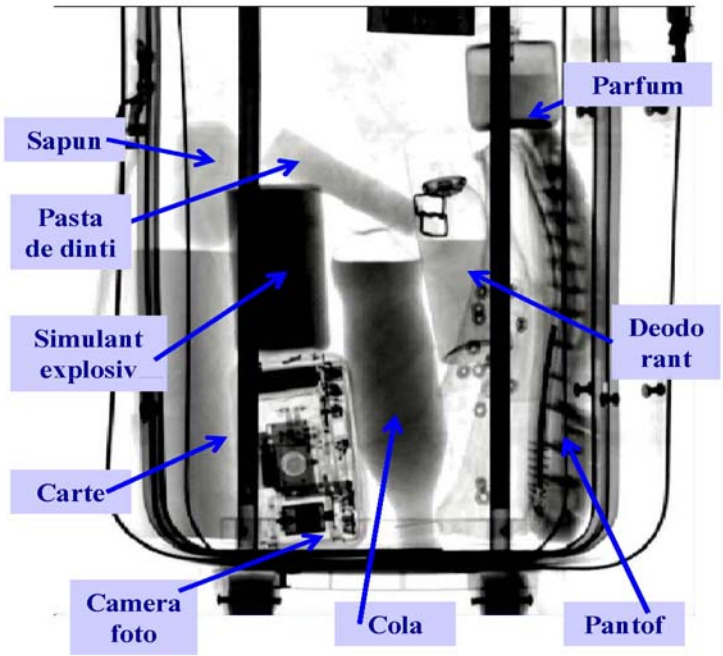
Masurarea etaloanelor in Tomografia "dual-energy" dupa calibrarea sistemului
(AP2K 2003 -2007)

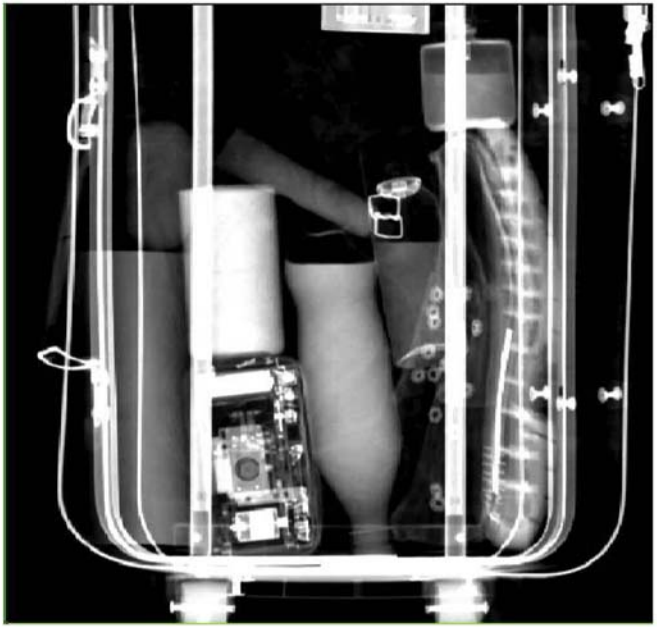


Z etalon	Error Z (%)
7,20	-1,32
7,30	1,92
7,20	-1,53
7,10	-1,22
9,30	1,75
7,20	1,42
7,50	-1,16
13,80	-1,23
9,80	-0,88
9,20	-1,73
8,30	1,76

Masurarea Z_{eff} cu o eroare mai buna de ± 2% !

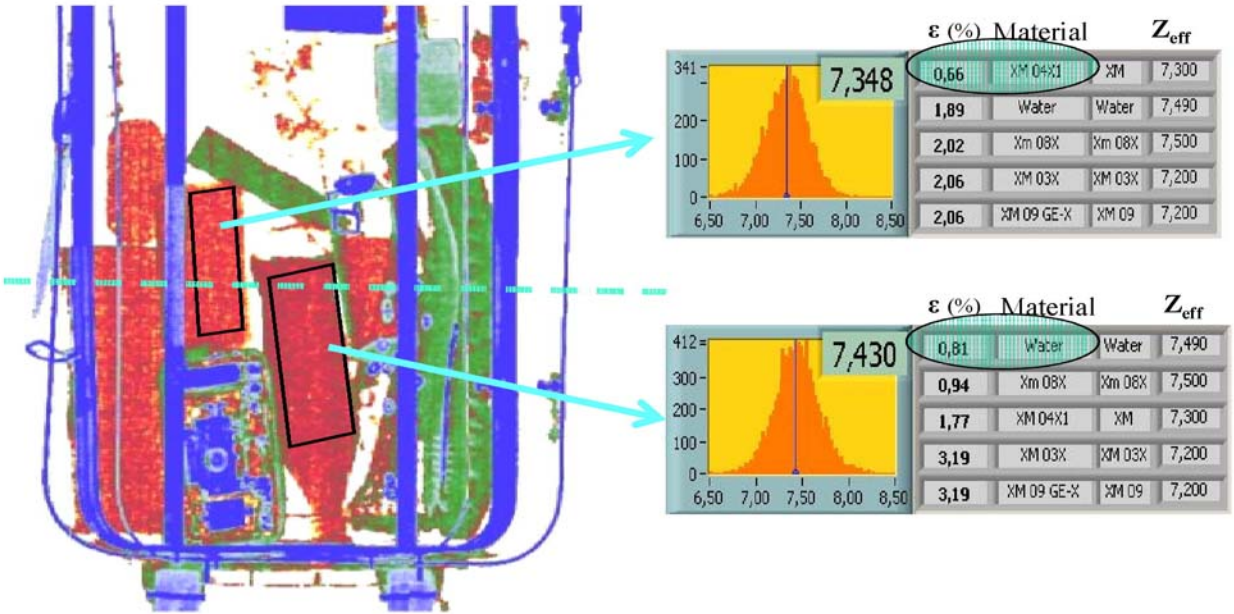
Valorile Densitatii si $Z_{efectiv}$ pentru simulantii de explozivi





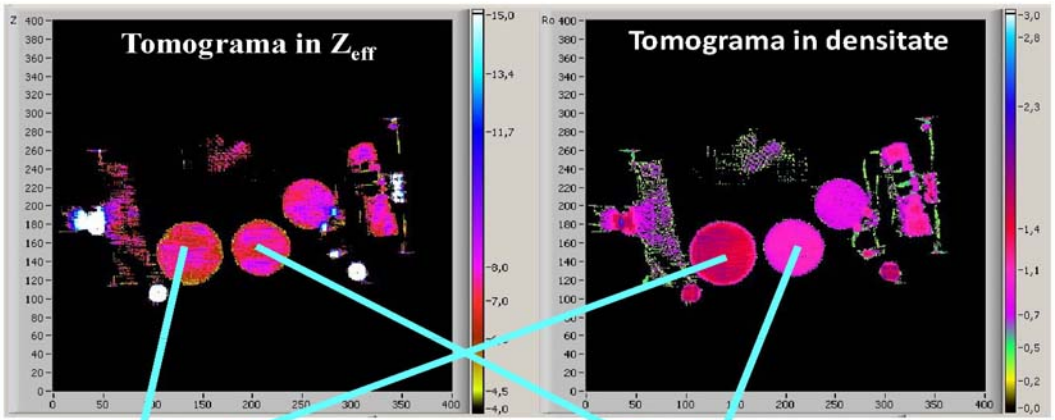
Radioscopie clasica a bagajului de test

(AP2K 2003 -2007)



Identificarea materialelor in Tomografia cu Raze X pa baza masurarii Numarului Atomic Efectiv si a Densitatii prin metoda "dual-energy"

(AP2K 2003-2007)

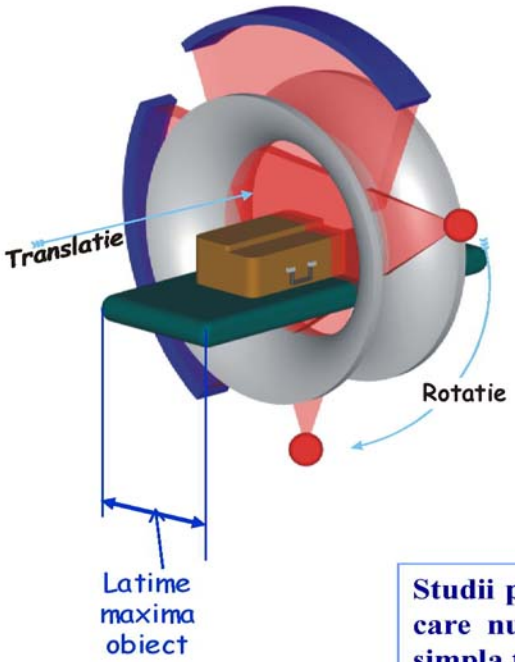


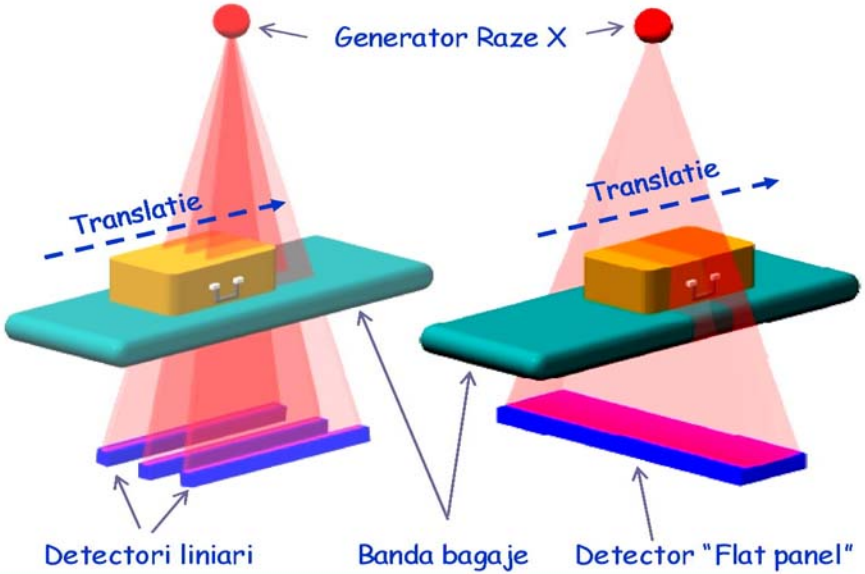
Tomograme "dual-energy" in valori **Z_{eff}** si **Densitate**

Full error(%)	Err Z(%)	Err Ro(%)	formula	abrev
1,4	0,4	-1,0	XM-04-XI	D4X1
3,4	-2,4	1,0	XM-02X	02X
4,1	-3,5	0,6	CH2O	POM
12,6	-0,9	11,6	XM-03X	03X
13,6	-0,9	12,7	15-X	15-X

Full error(%)	Err Z(%)	Err Ro(%)	formula	abrev
1,9	0,6	-1,3	H2O	H2O
11,5	-6,5	-5,0	C12H22O11	-
13,0	-3,4	9,5	XM-09GE-X	09GE
23,9	-23,6	0,3	C18H34O2N2	PA12
28,3	-13,8	14,5	C5H8O2	PMM

Rata extrem de scazuta de alarme FALS POZITIVE !



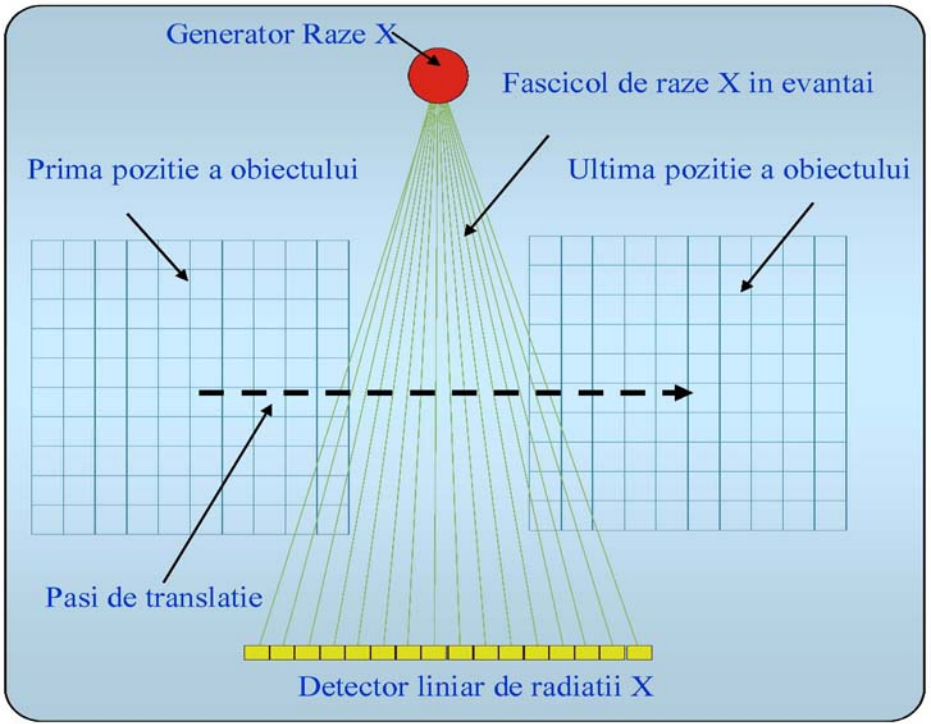


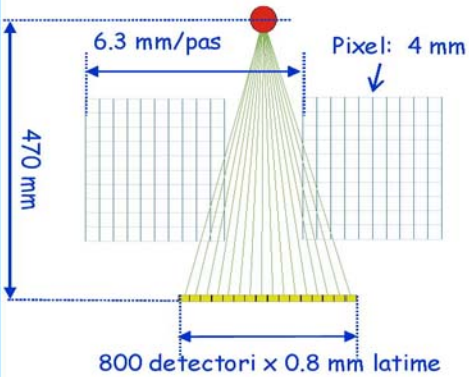
Studii privind realizarea unor algoritmi de reconstructie tomografica care nu necesita scanarea prin miscare de rotatie, bazati doar pe simpla translatie a obiectului

(AP2K 2007-2009)

Principiul algoritmului

- Obiectul investigat (reprezentat printr-o matrice 2D) este **translatat** prin fascicolul de radiatii colimat in forma de evantai;
- Practic, obiectul este translatat continuu iar imaginile se achizitioneaza succesiv la distante de un pas.
- Fiecare imagine reprezinta o proiectie in cadrul algoritmului;





Zgomot statistic: ± 2 %

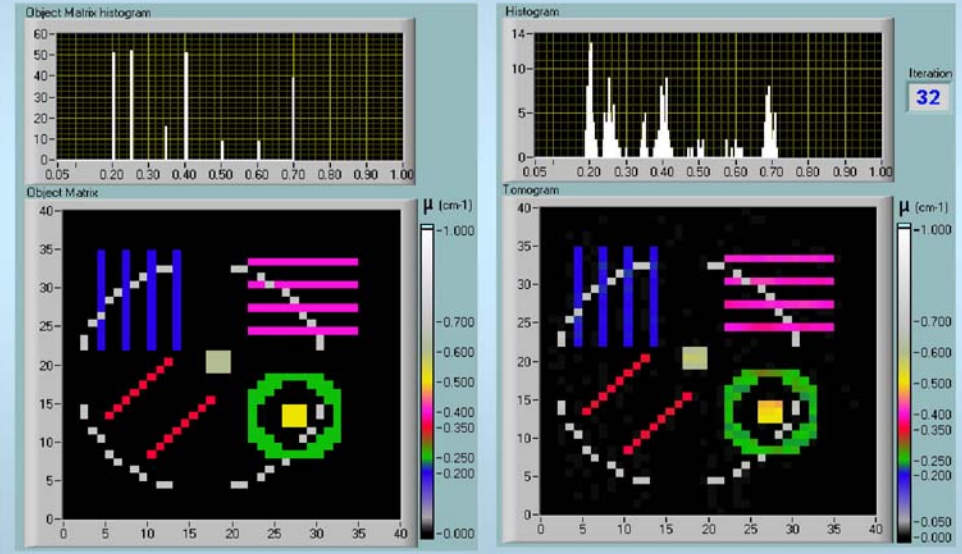
Imprastierea: 5 %

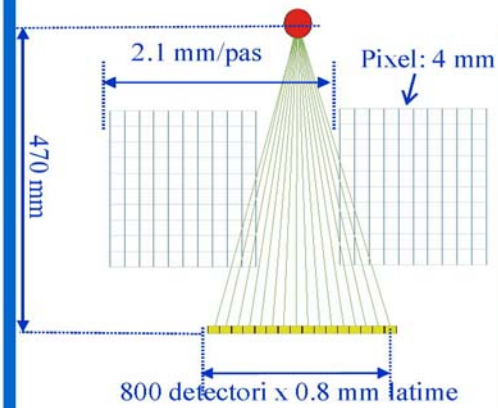
Numarul de proiectii (pasi)**: 50**

Durata unei iteratii: < 7 seconds

(AP2K 2007-2009)

Primul rezultat cu algoritmului iterativ obtinut pe date simulate





Zgomot statistic: ± 2 %

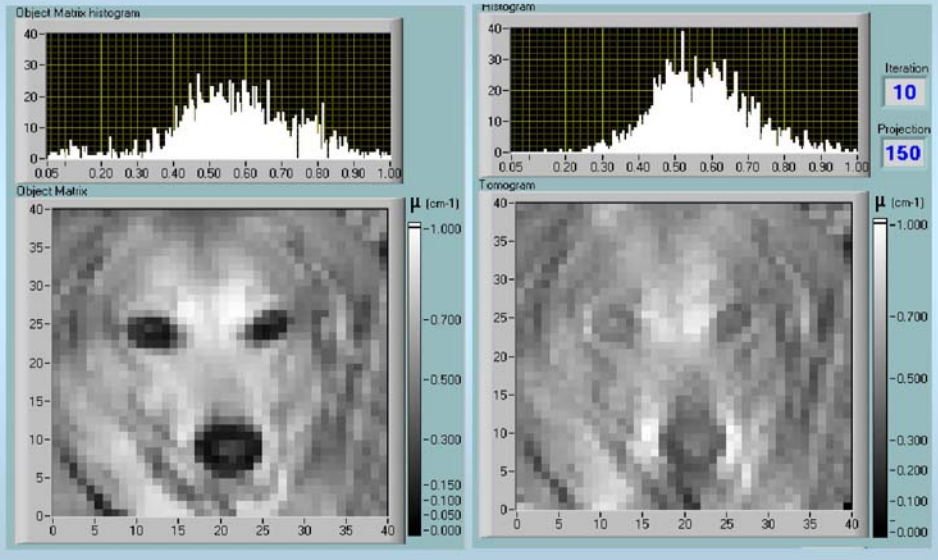
Imprastirea : 12 %

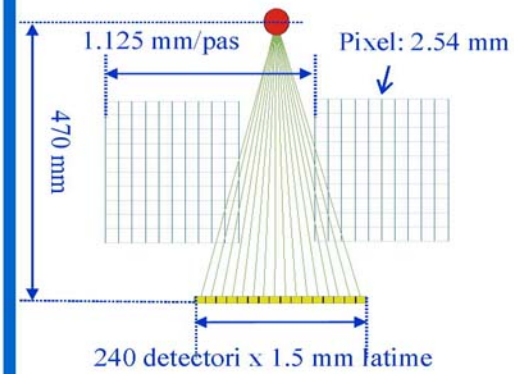
Numarul de proiectii (pasi): 150

Durata unei iteratii: 30 secunde

Dim. matrice: 40x40

Test simulat 2





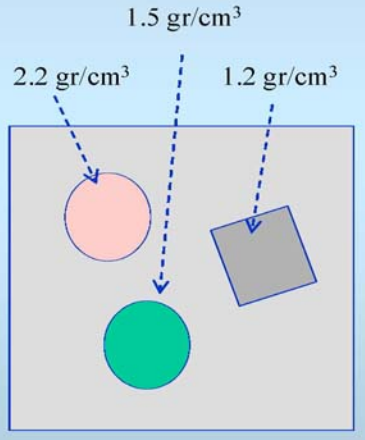
Numarul de Proiectii (pasi)**: 220**

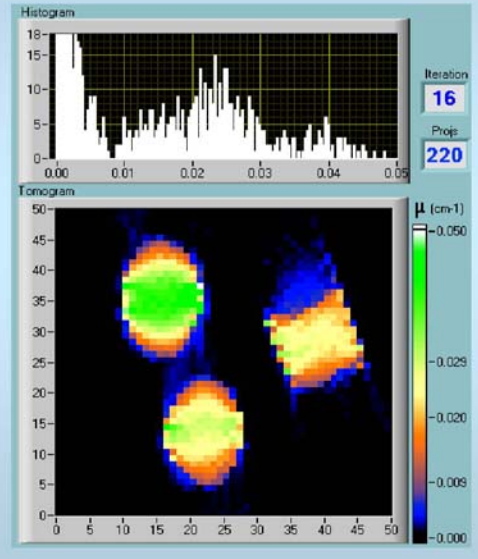
Timpul rulare o iteratie: 52 seconds

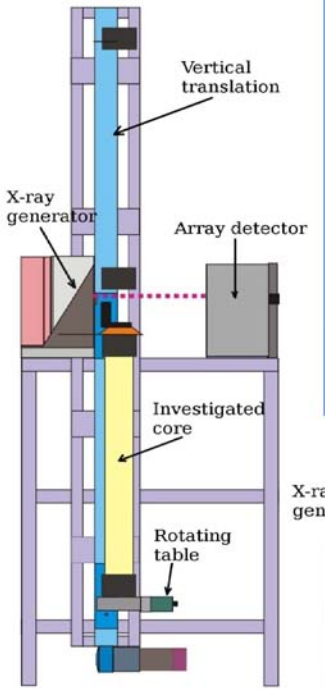
Matricea de reconstructie: 50 x 50

Timpul de achizitie: 20 seconds

Date experimentale

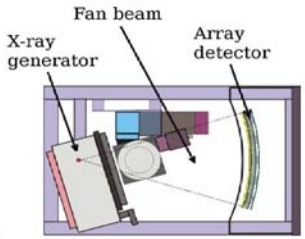






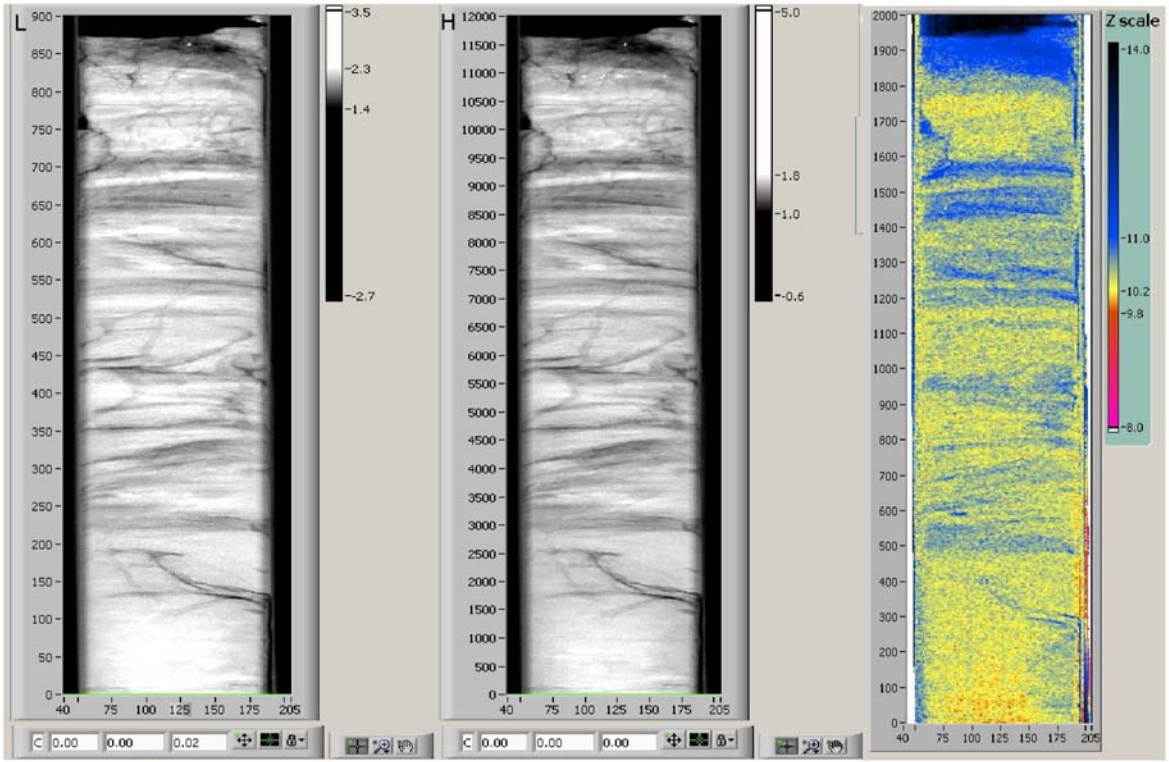
CORETOMO
Instalatie de de Tomografie/ Radioscopie dedicata analizei carotelor de foraj si mineralelor
- **160 kV/ 3mA**
- **2 x 240 detectori "dual-energy"**
- **Dim. carote: 1oo cm x 15 cm /10Kg**

(AP2K 2005-2007)



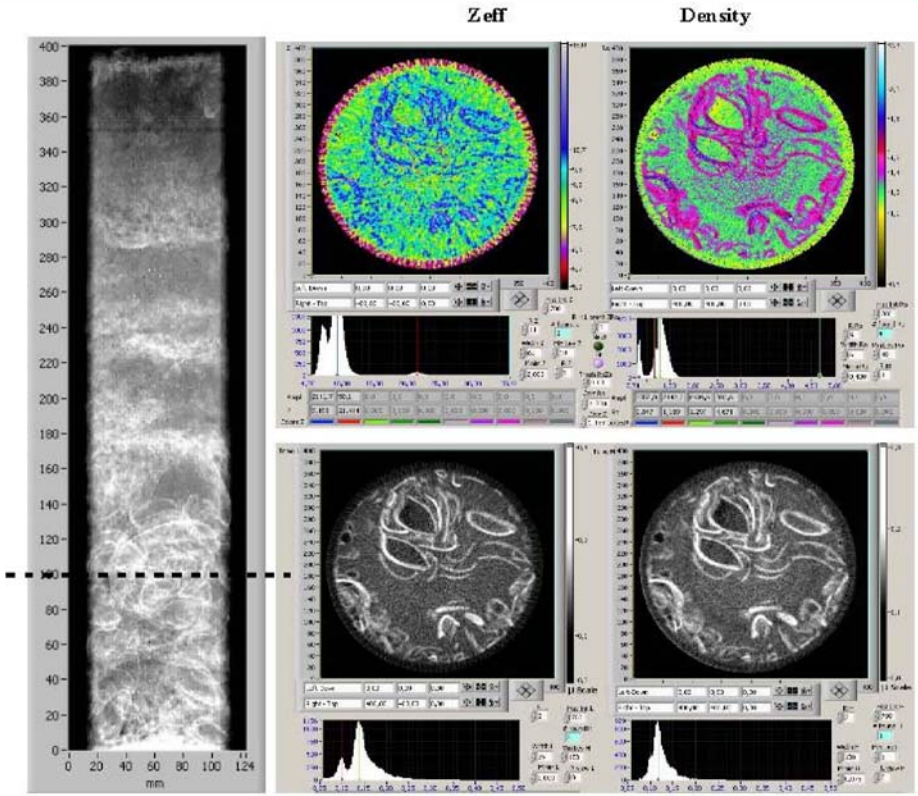
CORETOMO se poate instala in laborator sau la bordul navei de cercetari maritime *Mare Nigrum* apartinind Institutului GEOECOMAR

Proiect **C-D** realizat in parteneriat cu **Fac. de Fizica Bucuresti** si **GEOECOMAR**



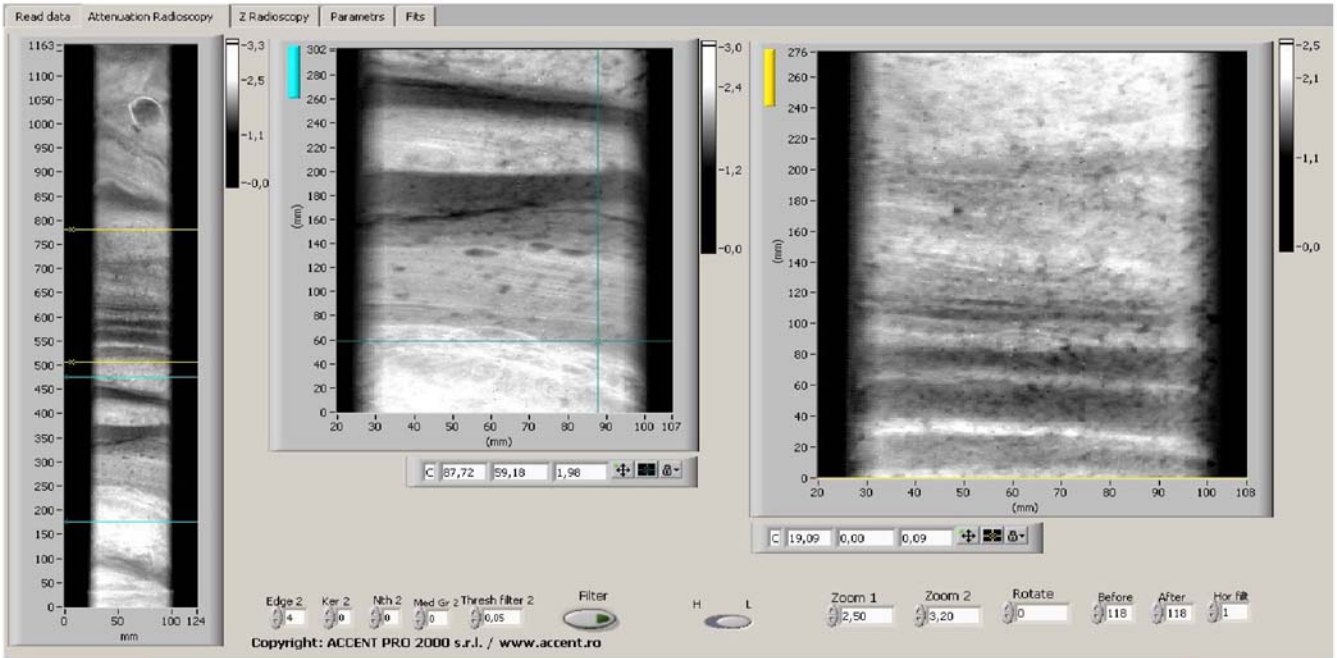
CORETOMO
Radioscopie clasica si "dual-energy" a unei carote de foraj realizata la bordul navei *Mare Nigrum* imediat dupa prelevarea acesteia

(AP2K 2008)



CORETOMO
Tomografie clasica si "dual-energy" a unei carote de foraj realizata la bordul navei *Mare Nigrum*

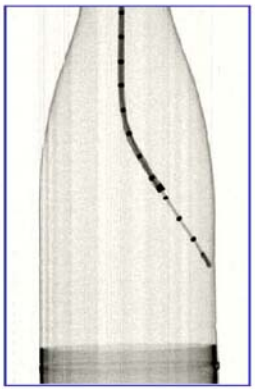
(AP2K 2008)

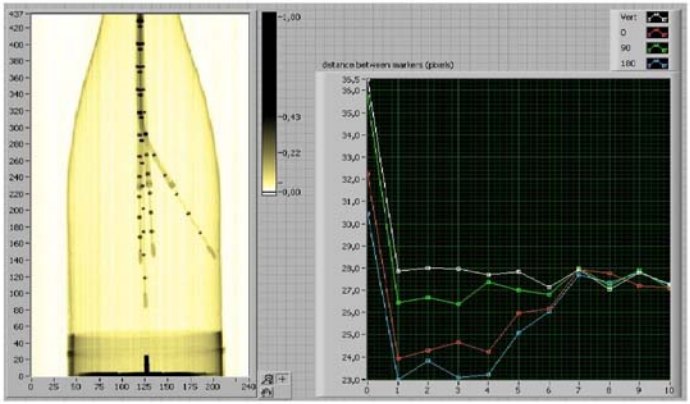


CORETOMO

Radioscopie clasica carota de foraj prelevata din Marea Neagra, cu magnificarea unor zone de interes, realizata la bordul navei *Mare Nigrum*

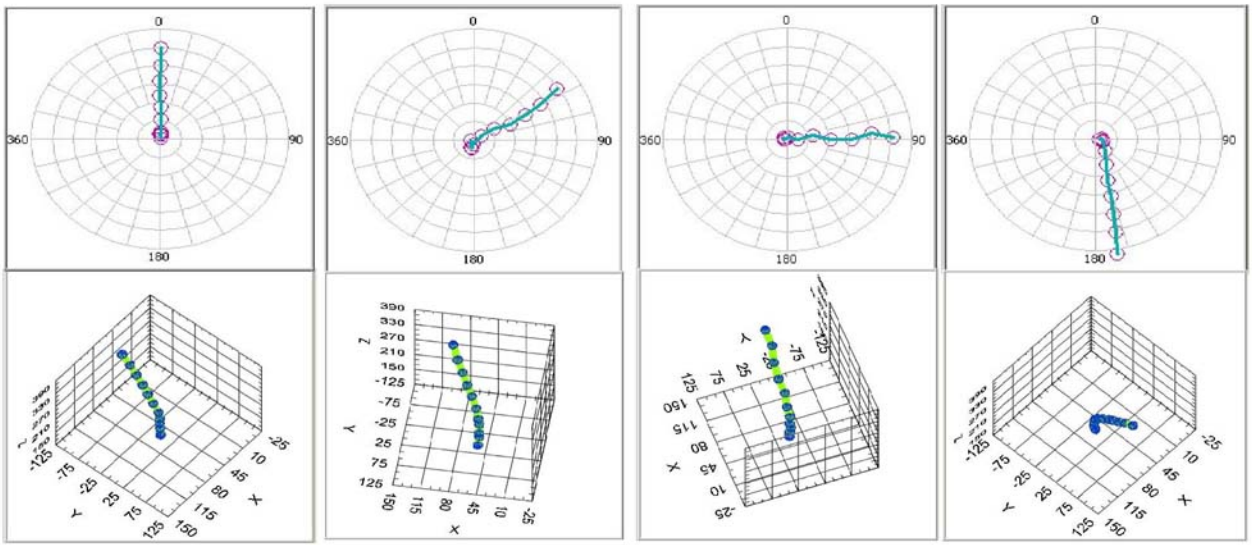
(AP2K 2008)





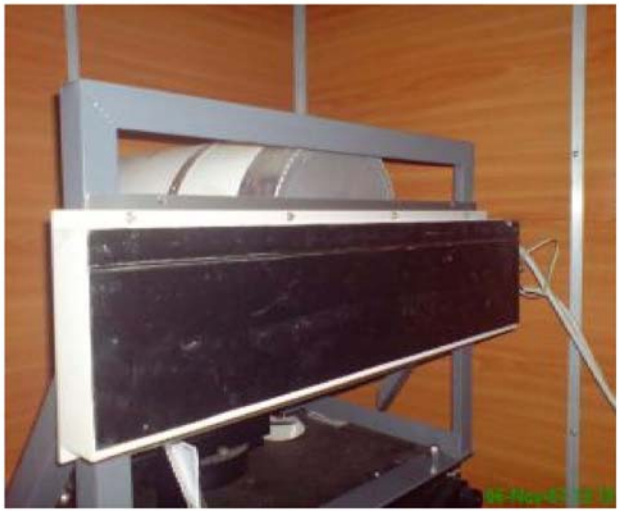
ALGORITM de determinare, dintr-o singura proiectie 2D, a pozitiei 3D a varfului cateterului pentru operatiile de injectare controlata a celulelor STEM in inima

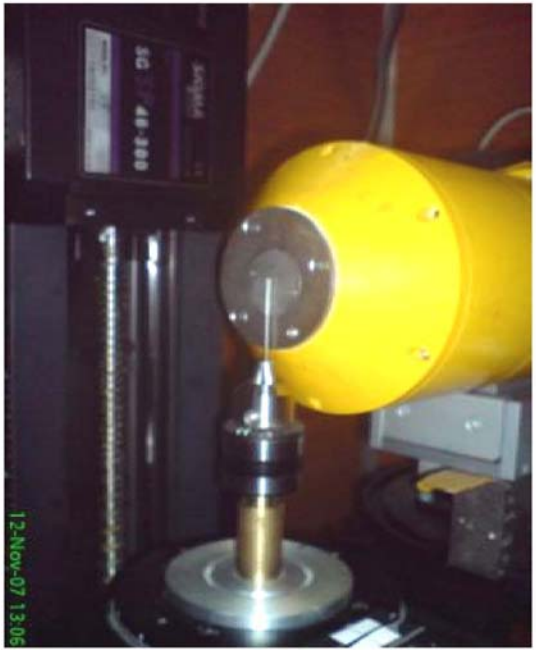
(AP2K 2007)



Rezultatele experimentale ale aplicarii ALGORITMULUI de determinare a pozitiei varfului cateterului pentru pozitiile acestuia situate la 0º, 60º, 90º si respectiv 180 º

(AP2K 2007)



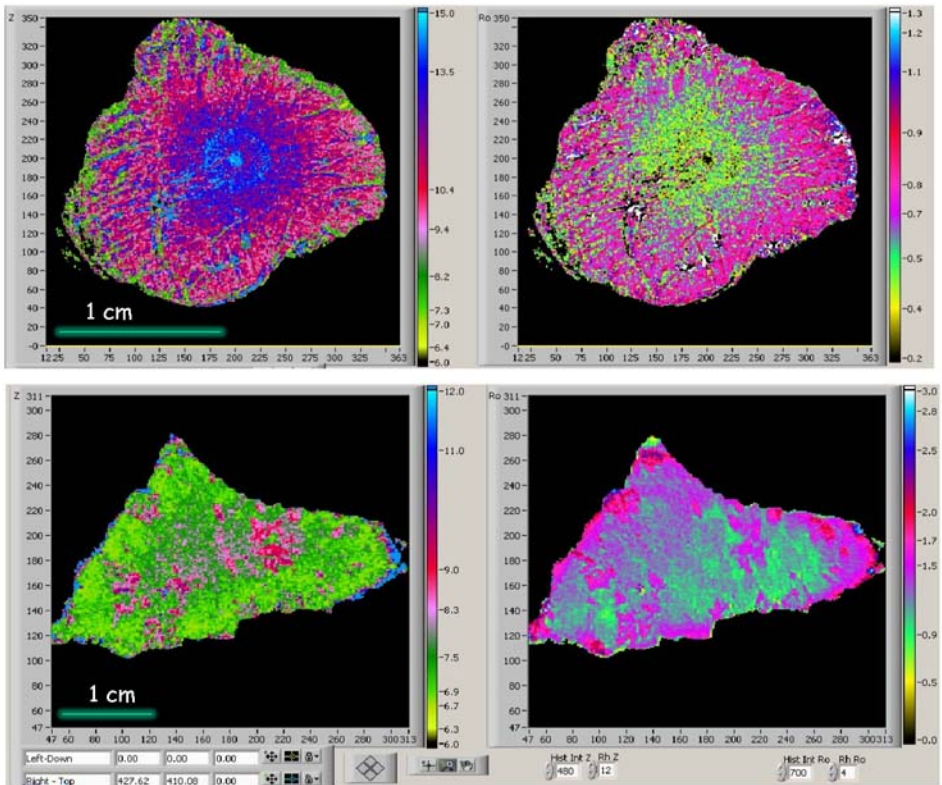


EXPERIMENT DE MICROTOMOGRAFIE "DUAL-ENERGY"

- **Detector:** Hamamatsu 1280 fotodiode de 0.4mm latime;
- **X-ray:** 160 kVp / 20W / 3µm pata focala;
- **Scanner:** 4 translatii + 1 rotatie.

(AP2K+INFLPR 2008)

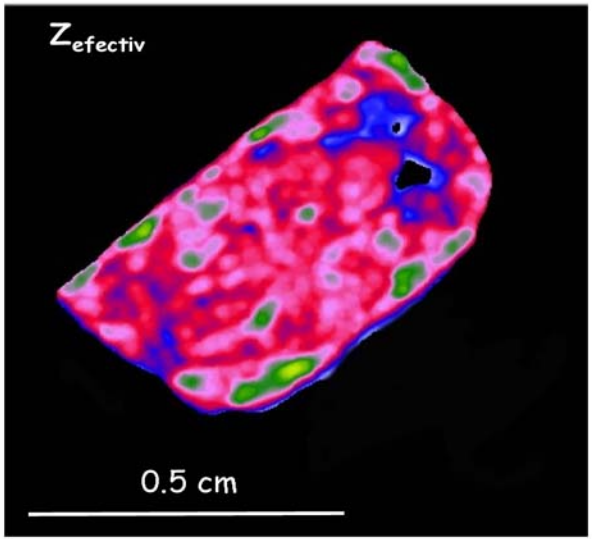
Proiect **C-D** realizat in parteneriat cu **INFLPR**

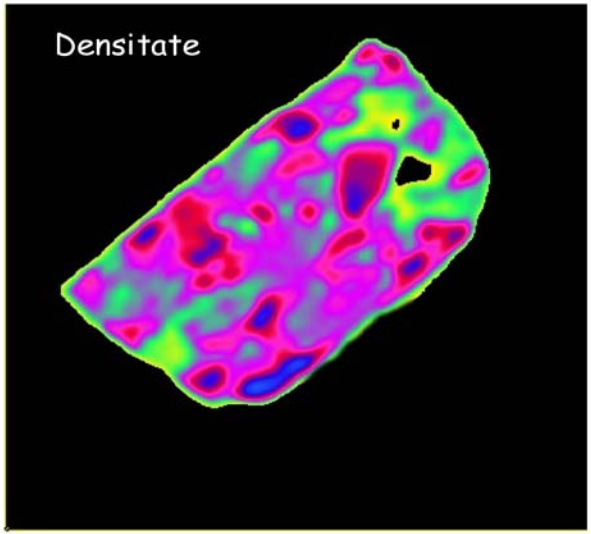


MICROTOMOGRAFIE "dual-energy" minerale (granati)

- **dimensiune pixel 40 µm si respectiv 13 µm**

(AP2K 2008)

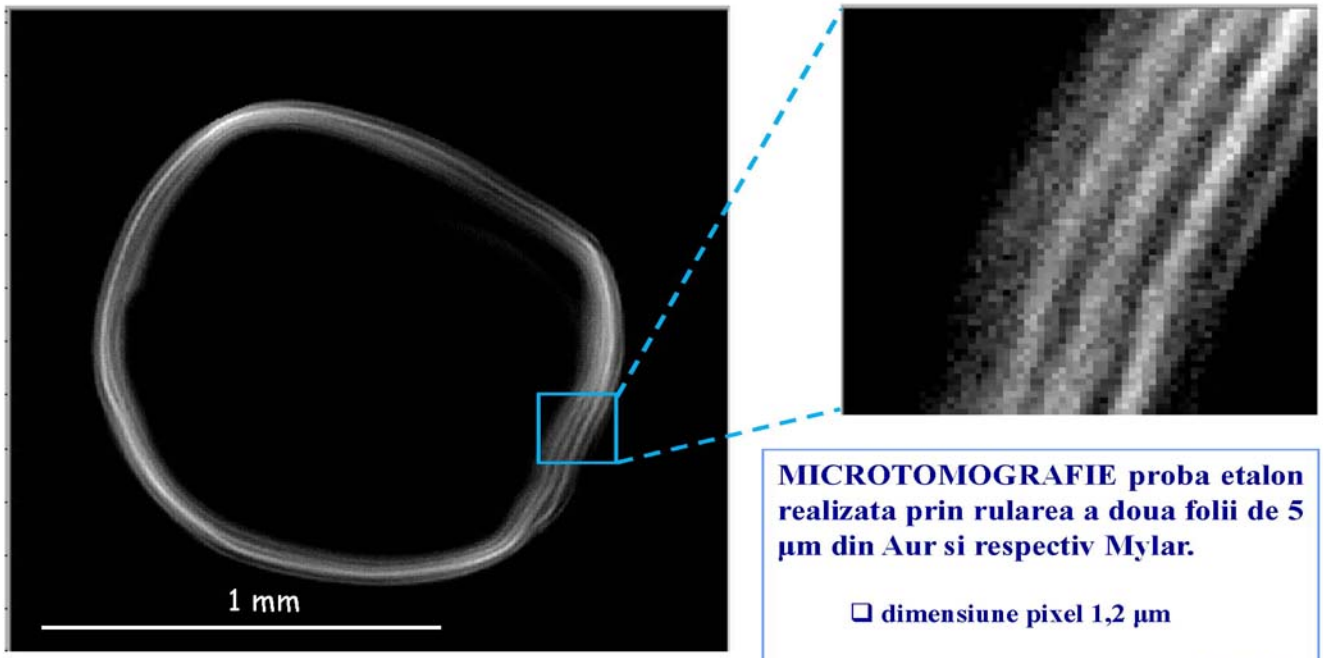




MICROTOMOGRAFIE "dual-energy" mostra supraconductor

- **dimensiune pixel 3 µm**

(AP2K 2008)



MICROTOMOGRAFIE proba etalon realizata prin rularea a doua folii de 5 µm din Aur si respectiv Mylar.

- **dimensiune pixel 1,2 µm**

(AP2K 2008)

DUALTOMO - Instalatie portabila autonoma de Tomografie si Radioscopie cu Raze X "dual-energy"

Sursa Raxe X : *ICM* (Belgia), 160 kV/ 0.5 mA, pata focala 0,7/0,5

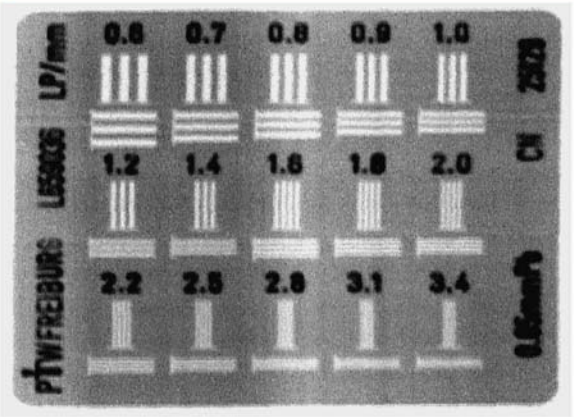
Flat Panel detector : 55 cm x 52cm, Detectori 0,4 mm (0,1 sau 0,05 mm);

Translatie independenta de 1 m pentru masa de rotatie si sursa de Raze X;

Obiect investigat: Diametrul : 60 cm, Inaltime: 55 cm, Greutate: 50 Kg

Proiect **C-D** realizat in parteneriat cu **Fac. de Fizica Bucuresti**

(AP2K 2008-2009)



DUALTOMO – Primele experimente

- **Indicator LPM**
- **Radioscopie bagaj**

(AP2K Iunie-Iulie 2009)

Dezvoltarea unei familii de Sisteme portabile de tomografie/radioscopie cu raze X

Realizarea unei familii de detectori 2D pentru aplicatii in imagistica cu Raze X

Studii privind dezvoltarea aplicatiilor bazate pe tehnicile "phase contrast" si "dark field" in imagistica medicala si industriala cu raze X

Combinarea imagisticii cu raze X pentru carote de foraj cu analiza locala de compozitie prin florescenta de Raze X si masuratori de permeabilitate magnetica

Studii privind realizarea unor algoritmi de scanare si reconstructie tomografica fara miscare de rotatie, cu aplicatii in domeniul controlului bagajelor si CND

Extinderea tehnicii "dual-energy" si "multi-energy" la energii inalte (6-9 MeV) cu aplicatii in cargo screening

Realizarea unor echipamente performante de Tomografie si Radioscopie cu costuri reduse destinate laboratoarelor de cercetare

Proiectul de rezerva, pentru supravietuire in cazul (foarte probabil de altfel) reduceri totale a fondurilor destinate proiectelor de C-D :

VA MULTUMIM PENTRU ATENTIE !

In continuare
va invitam sa vizitati Laboratorului de Tomografie computerizata din cadrul Facultatii de Fizica
pentru
o prezentare detaliata a echipamentelor si tehnologiilor prezentate !

Pentru detalii suplimentare
va rugam sa vizitati

www.accent.ro

sau sa ne contactati la

office@accent.ro