Spectral microtomography using the MARS-CT

LIST OF PARTICIPANTS

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AIM OF THE PROJECT

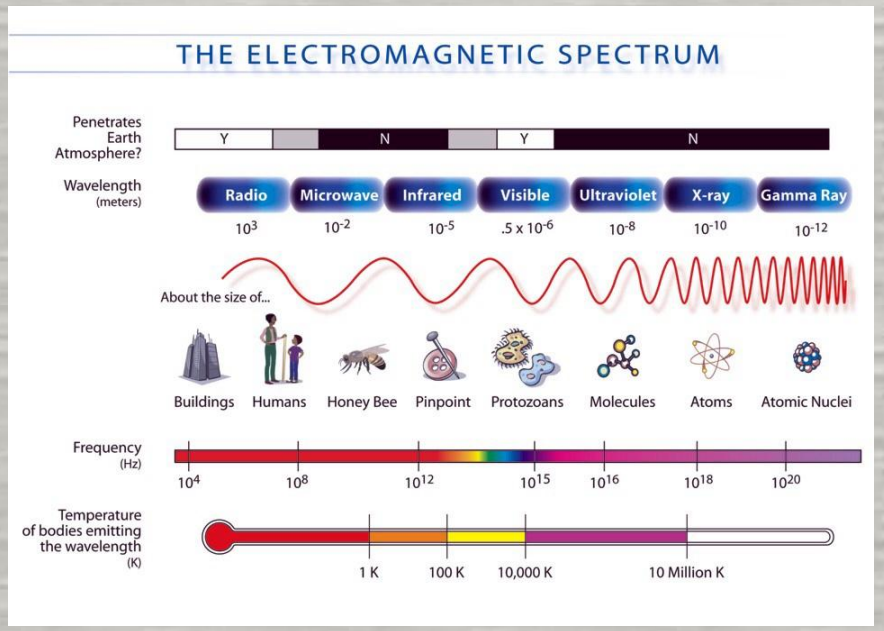
- Objectives:

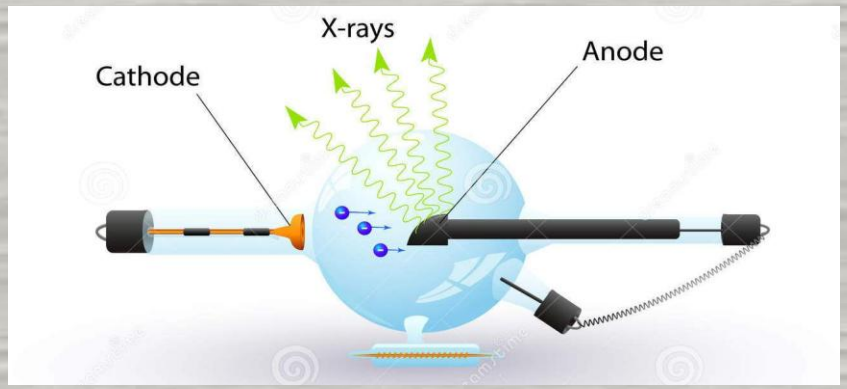
1) Visualization of unknown object
2) Material identification

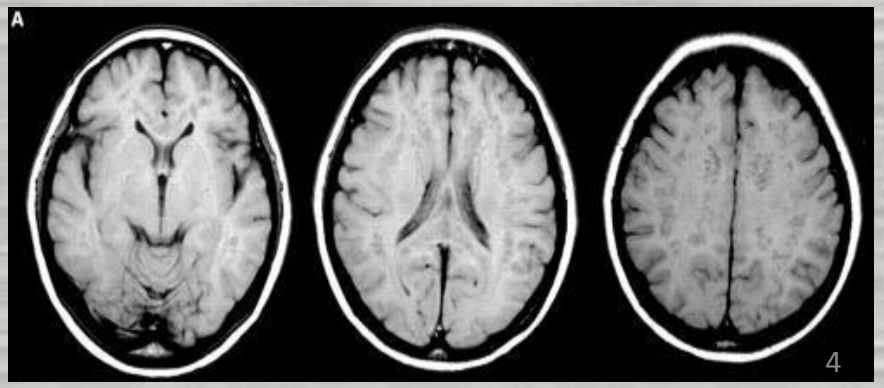
   using spectral computed tomography.

- Possible applications:
  - In the biomedical research (tissue identification, new X-ray contrast media in diagnostics, study of drug delivery etc.)
  - In the geophysical studies (ore composition, oil core permeatability etc.)

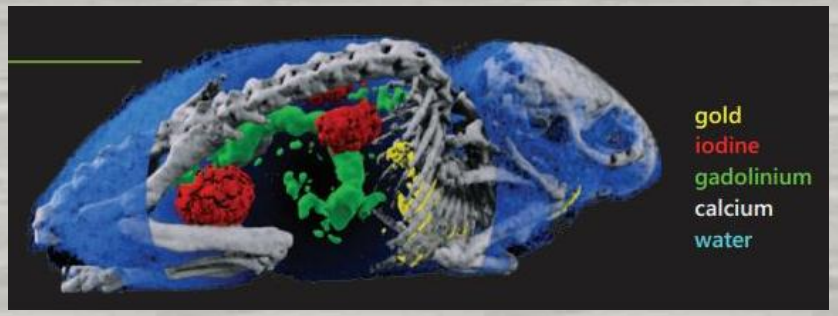
COMPUTED TOMOGRAPHY



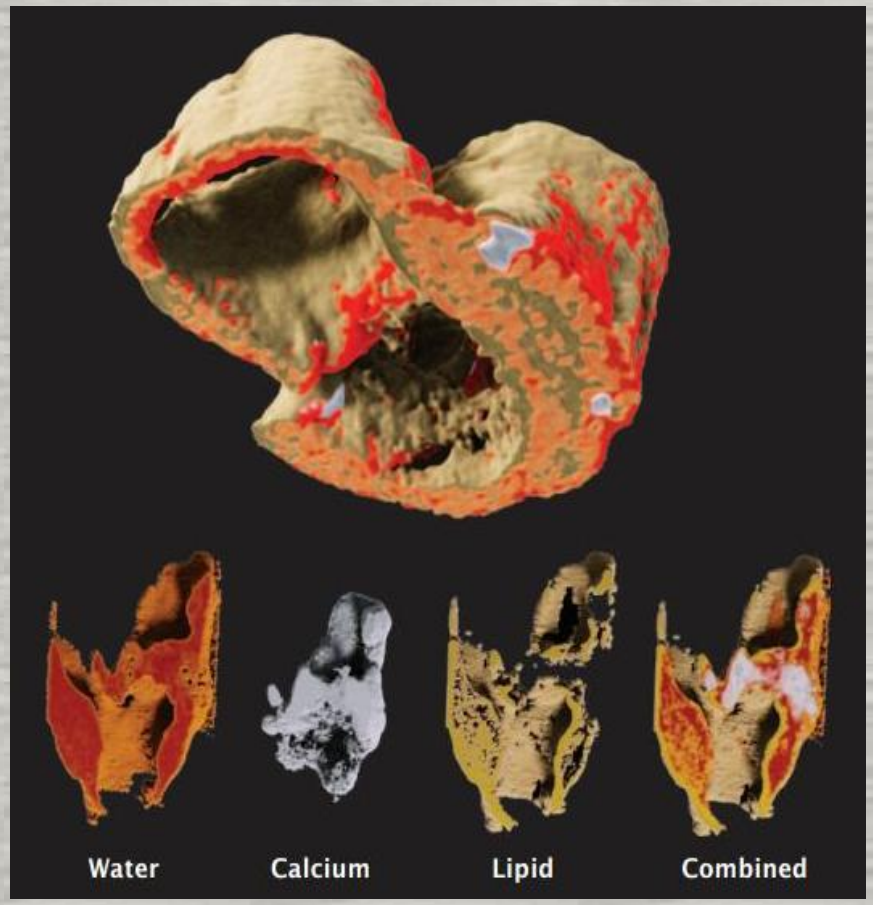




MICRO-CT

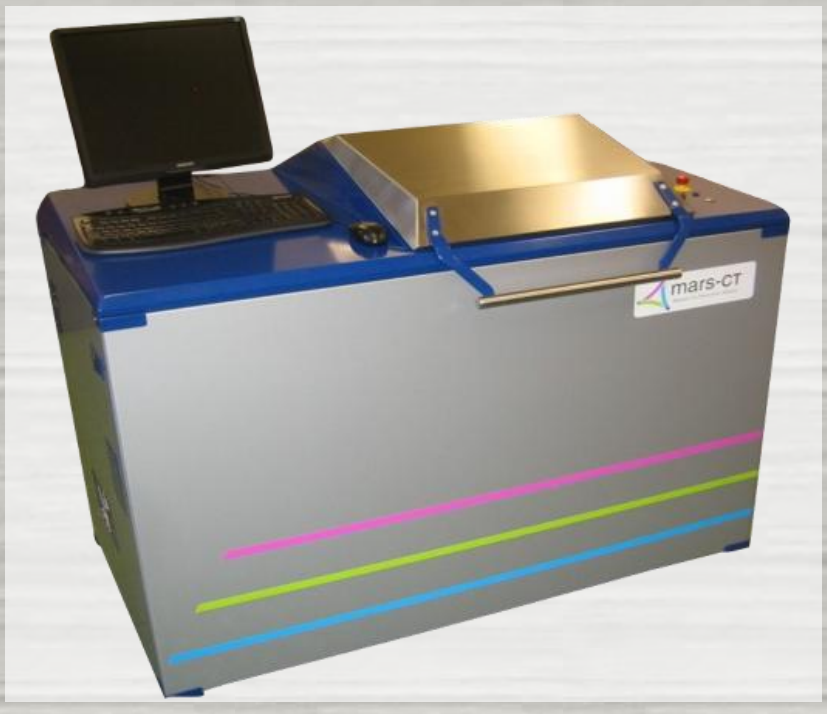


Multiple targeted agents



Spectral imaging of atherosclerosis

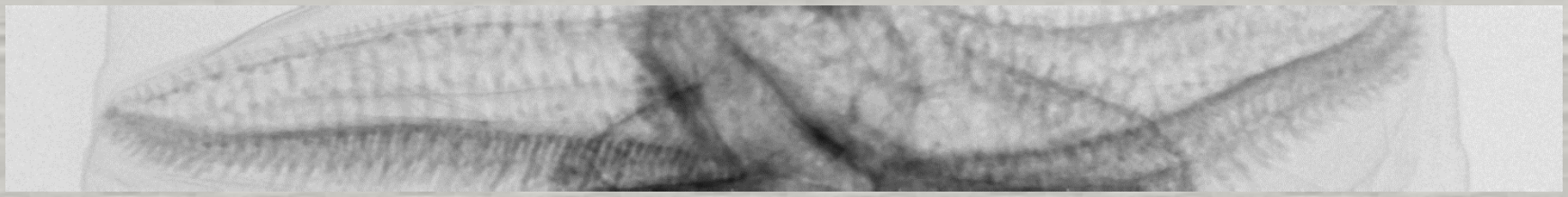
MARS SCANNER SPECIFICATIONS

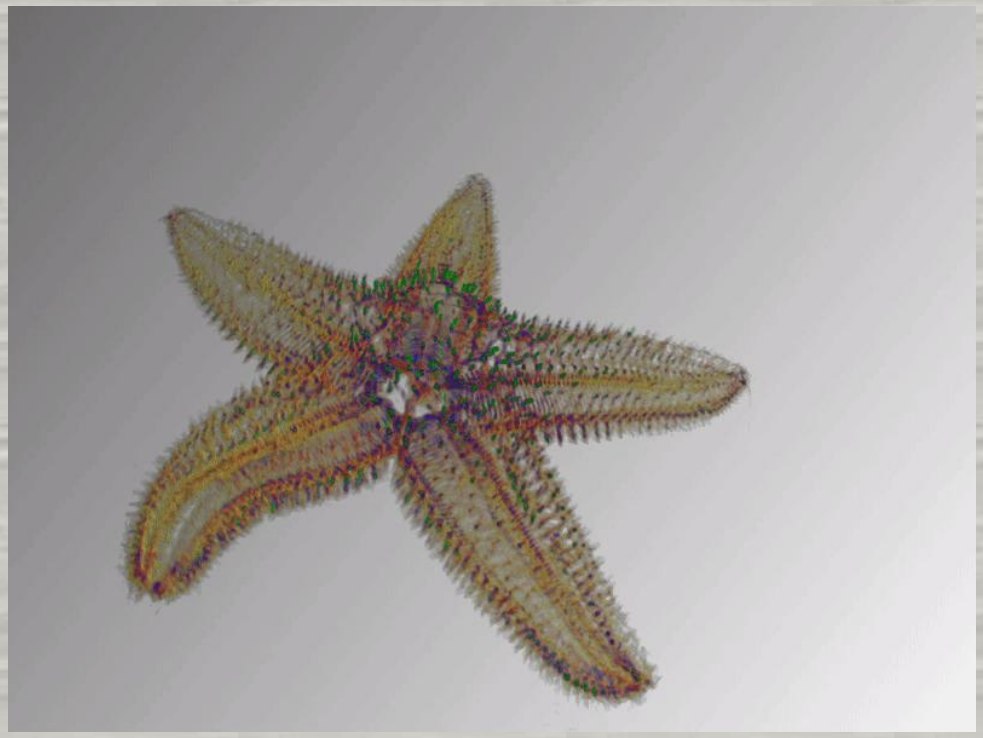


*General view of the MARS (**M**edipix **A**ll **R**esolution **S**ystem) microtomograph located at the Laboratory of Nuclear Problems of JINR*

- Gallium arsenide-based 1 mm-thick Timepix detector + Fitpix readout interface
- 65536 pixels in 256×256 array, 14.1×14.1 mm^2 active area.
- 1 energy threshold per pixel
- Microfocus X-ray tube (120 kVp, 350 uA, >70 um focal spot)
- The gantry is surrounded by the lead shield.
- The scan procedure is fully automatic.
- The sample stays motionless.
- The size of a sample may be up to the diameter of 10 cm and up to the length of 30 cm.
- The bias voltages for the sensor were 700V and 500V respectively.

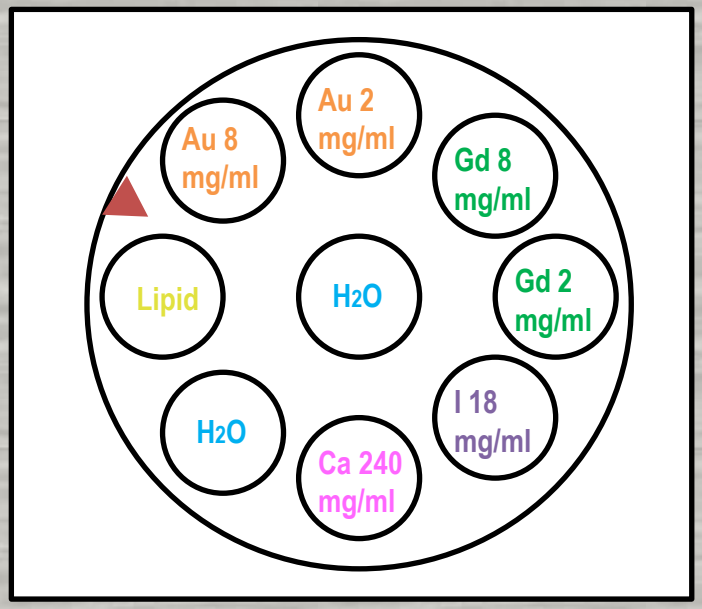
1) VISUALIZATION OF UNKNOWN OBJECT



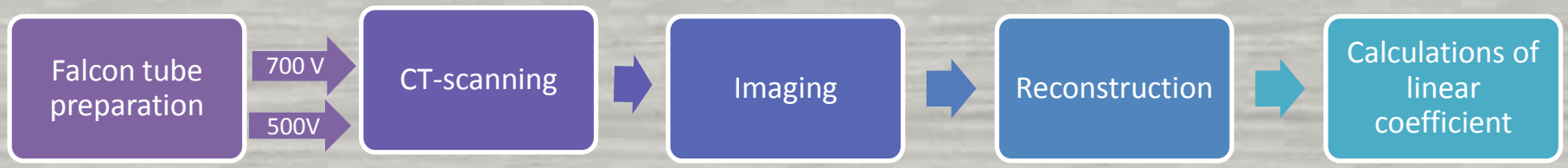


2) MATERIAL IDENTIFICATION

Phantom with 9 falcon tubes containing different materials



Schematic top-view of the 9 falcon tubes

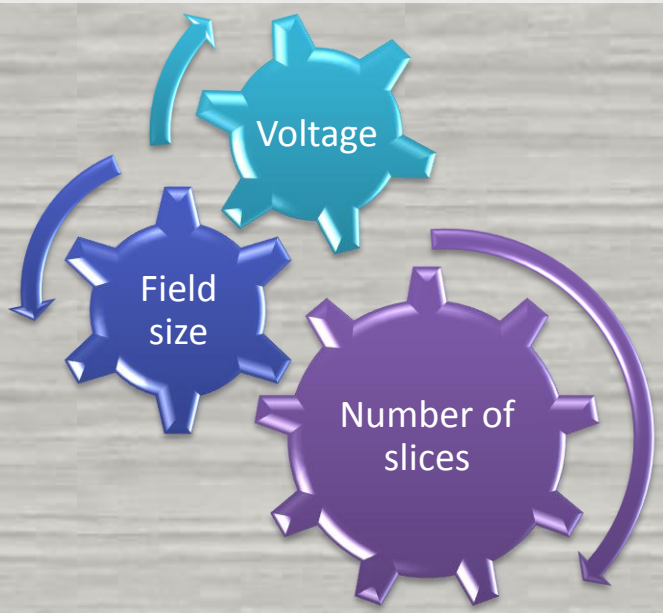


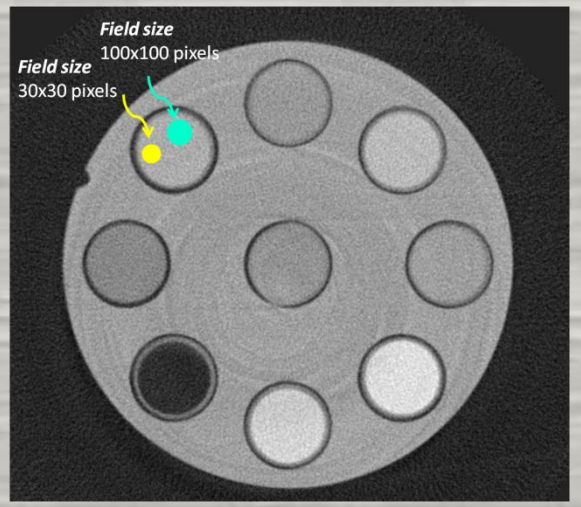
The process of material identification

SPECTRAL IMAGES–RESCALING AND DATA ANALYSIS

- 16 bit Dicom reconstructed images were convert to 32 bit by “ImageJ” software.
- The CT attenuation values were measured for each material in all thirteen energy bins.

Different parameters

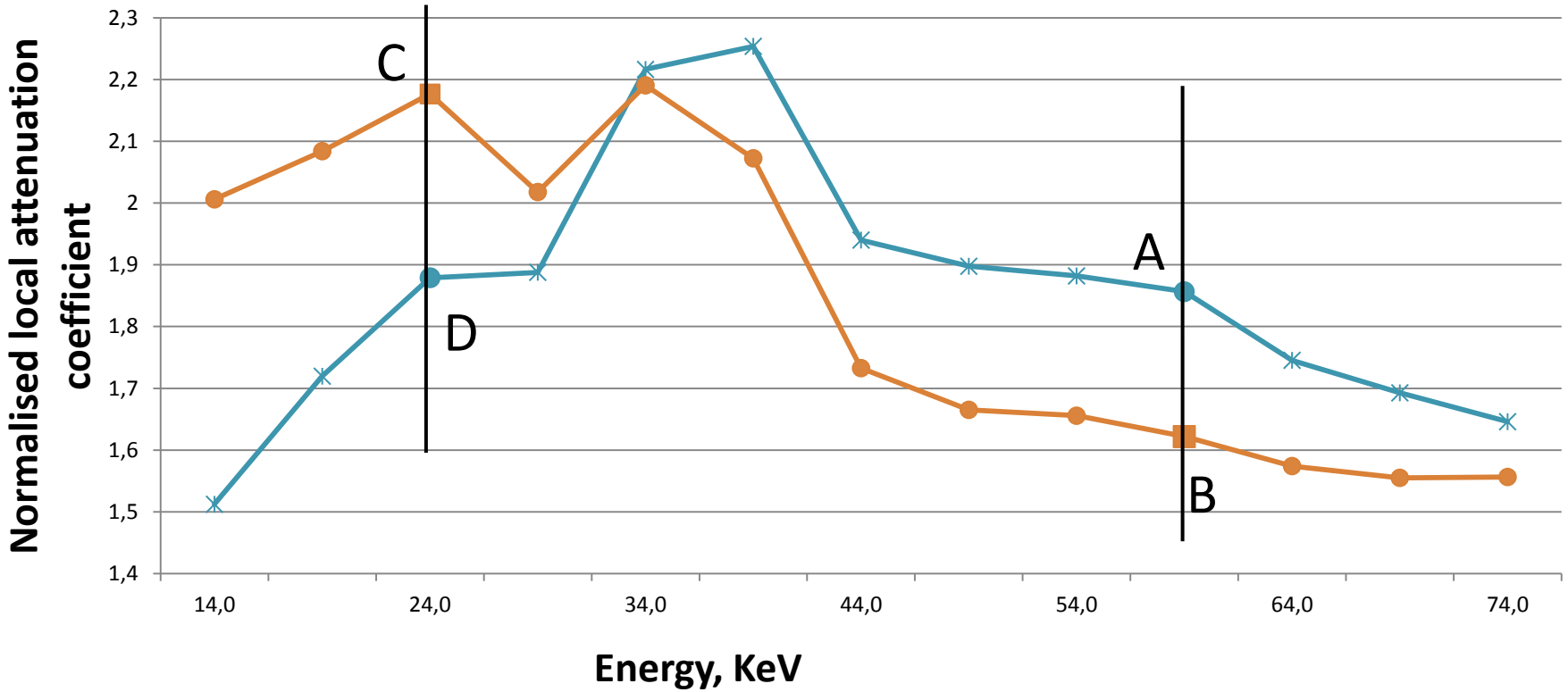




The transverse CT image with thirteen energy bins

RESULTS

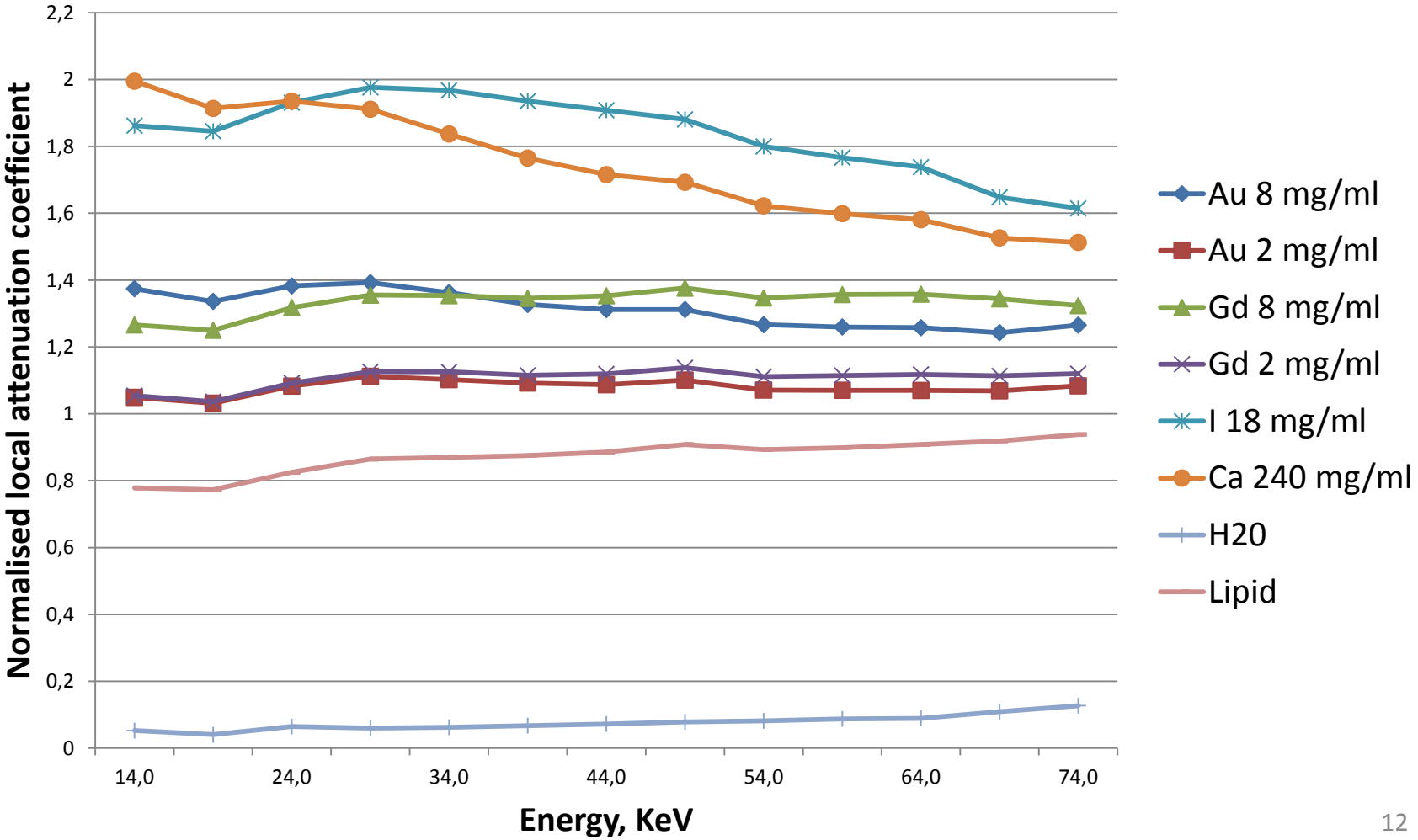
DESCRIPTION OF CALCULATIONS



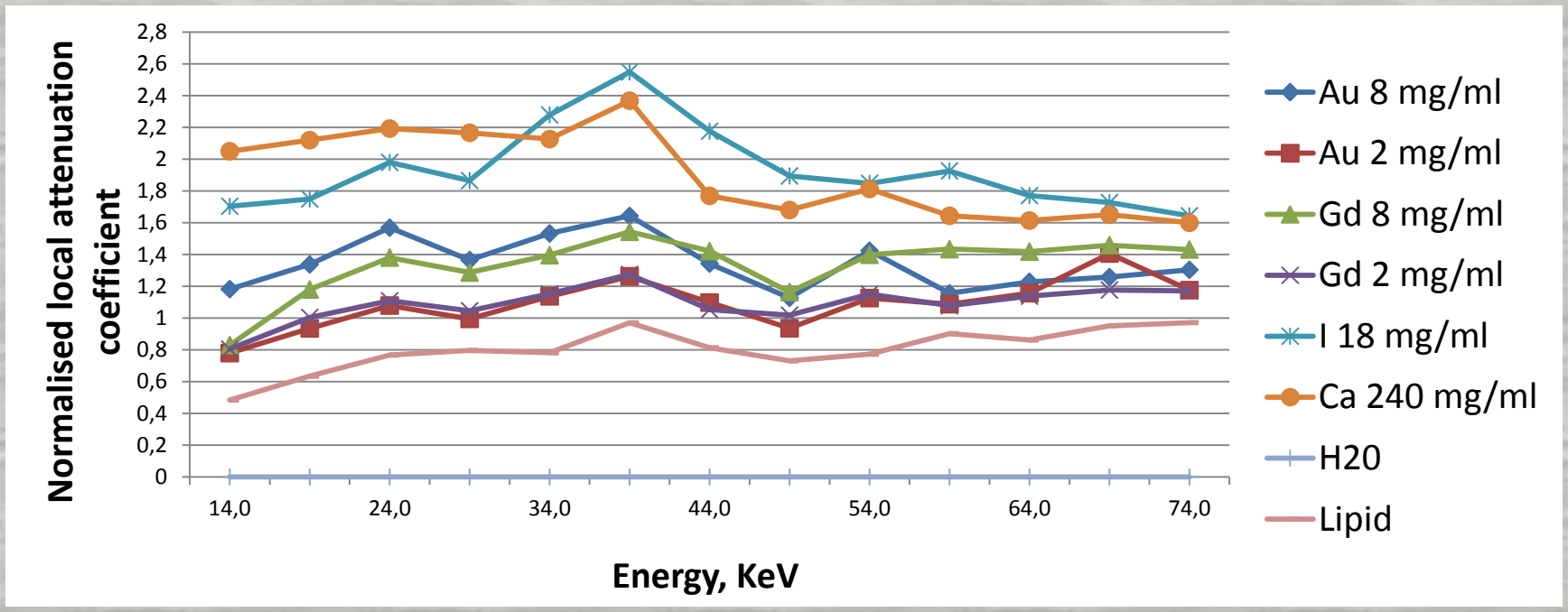
$$d = \sqrt{(A-B)^2+(C-D)^2+\cdots+(\ldots-\cdots)^2}$$

d -Deviation between to curves for tow bias voltages

700 V |100x100 (150-170 slices)



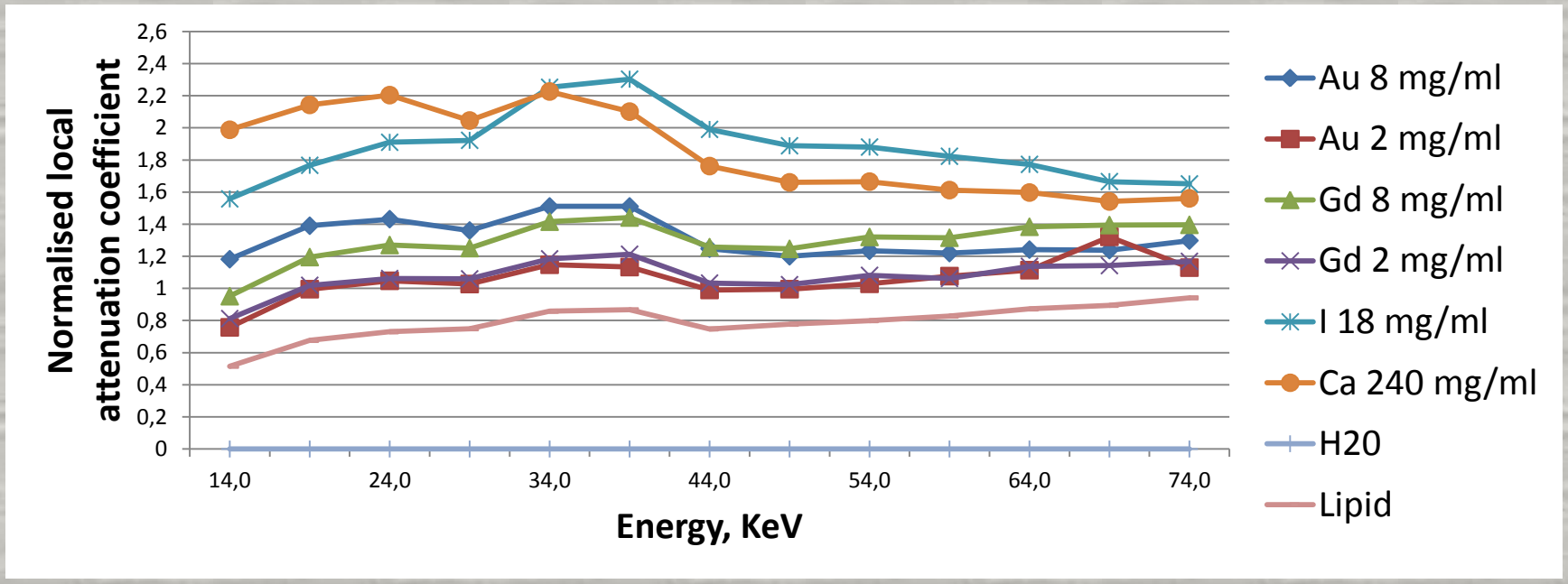
CASE (1) **500 V** |30x30 (#120 slice)



The table of values parameter of d

Material	Tube 1	Tube 2	Tube 3	Tube 4	Tube 5	Tube 6	Tube 7	Tube 8
Au8	0,79	1,73	1,14	1,64	1,81	1,60	5,41	2,65
Au2	0,83	0,64	0,89	0,47	2,89	2,82	4,20	1,39
Gd8	0,62	1,30	0,65	1,24	2,03	2,00	5,12	2,27
Gd2	0,79	0,65	0,83	0,51	2,83	2,76	4,27	1,46
I18	2,79	3,75	2,89	3,70	0,87	1,05	7,57	4,74
Ca240	3,06	4,09	3,33	4,03	1,58	1,07	7,76	5,04
Air	4,88	3,97	4,85	3,95	7,02	6,94	0,00	2,94
Lipid	1,77	0,85	1,69	0,79	3,88	3,84	3,21	0,44

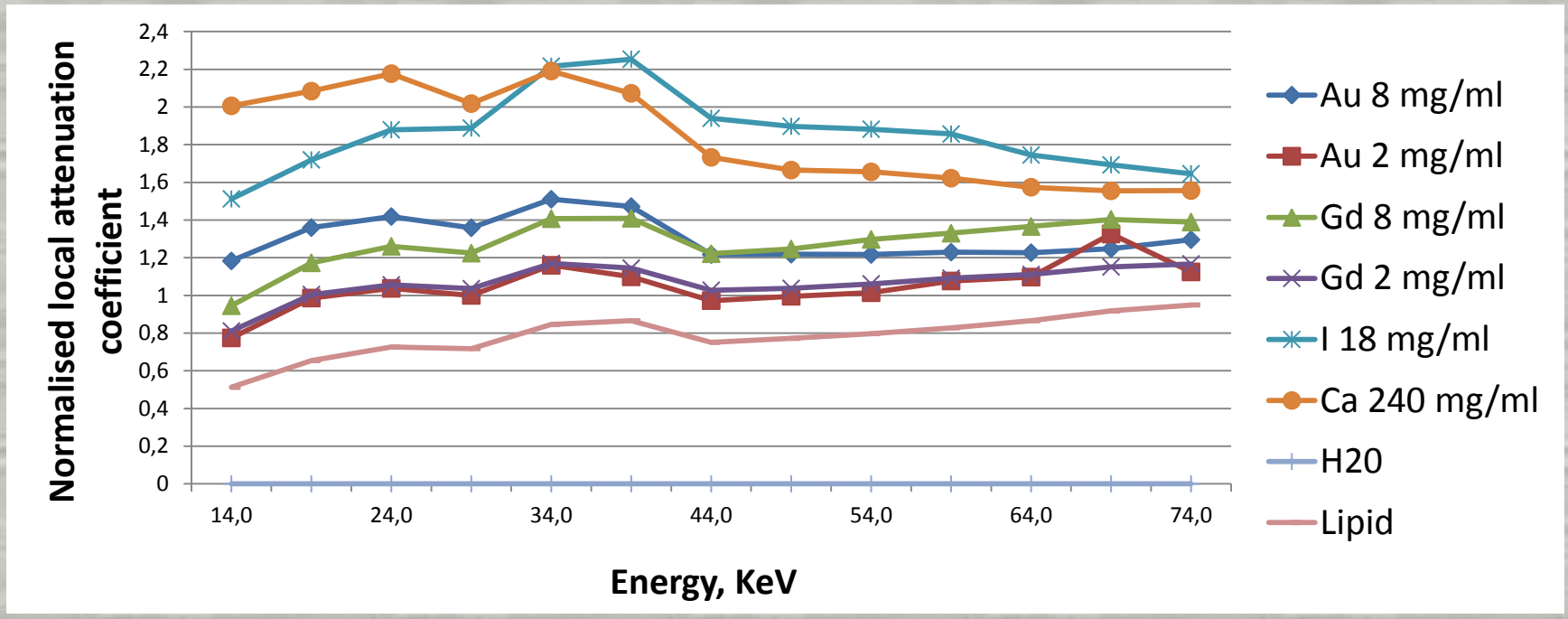
CASE (2) **500 V** |100x100 (#120 slice)



The table of values parameter of d

Material	Tube 1	Tube 2	Tube 3	Tube 4	Tube 5	Tube 6	Tube 7	Tube 8
Au8	0,79	1,77	1,08	1,67	1,56	1,40	5,41	2,67
Au2	0,64	0,60	0,65	0,47	2,65	2,63	4,20	1,41
Gd8	0,56	1,36	0,59	1,28	1,78	1,83	5,12	2,30
Gd2	0,60	0,63	0,58	0,52	2,58	2,58	4,27	1,48
I18	2,89	3,84	3,00	3,75	0,94	1,18	7,57	4,78
Ca240	3,15	4,16	3,39	4,06	1,62	1,15	7,76	5,07
Air	4,75	3,84	4,69	3,90	6,80	6,75	0,00	2,87
Lipid	1,62	0,70	1,50	0,73	3,65	3,66	3,21	0,42

CASE (3) **500 V** |100x100 (120-130 slices)



The table of values parameter of d

Material	Tube 1	Tube 2	Tube 3	Tube 4	Tube 5	Tube 6	Tube 7	Tube 8
Au8	0,82	1,80	1,12	1,70	1,51	1,33	5,41	2,69
Au2	0,60	0,62	0,63	0,49	2,58	2,57	4,20	1,43
Gd8	0,57	1,39	0,63	1,31	1,70	1,76	5,12	2,32
Gd2	0,56	0,65	0,55	0,53	2,51	2,51	4,27	1,50
I18	2,92	3,87	3,05	3,78	1,01	1,21	7,57	4,80
Ca240	3,18	4,18	3,44	4,10	1,70	1,20	7,76	5,09
Air	4,72	3,81	4,65	3,86	6,73	6,69	0,00	2,86
Lipid	1,58	0,68	1,46	0,69	3,57	3,59	3,21	0,44

CONCLUSION

1) The multi-energy spectral CT system has the ability to discriminate nine materials from each other. The addition of a color spectrum to the spatial resolution provided by MARS-CT scanner gives significantly more information.
2) The highest voltage that the detector can withstand is 700 V, and this may result in producing a good quality image. On the other hand, as we decrease the voltage to 500 V, it gives lower quality.
3) In the terms of field size, it doesn't make any difference for the results.

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