

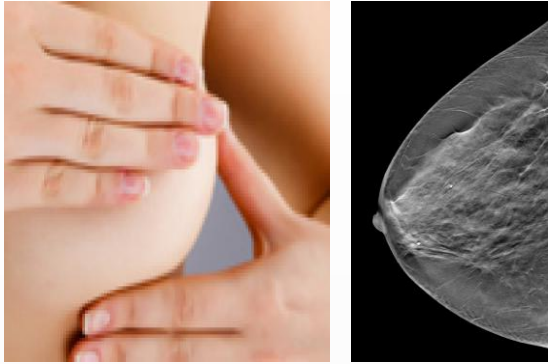
# Bio-Phantom Explorer

Software system for simulation of anthropomorphic models of mammary gland and tumor formations

for  
educational and research purposes and for industrial application

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According to the European Commission, one in every 8 women in Europe is affected by breast cancer\*, with cancer being diagnosed mechanically or with ultrasound and x-ray.

**Problem:** The results obtained are often inaccurate or the cancer is found at an advanced stage of development, which reduces the patient's chances of healing.



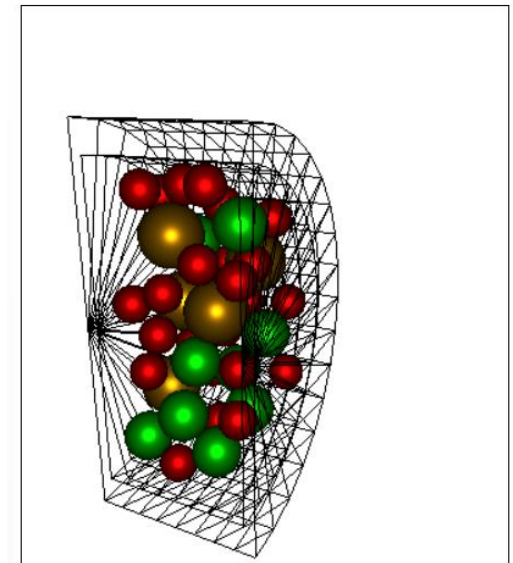
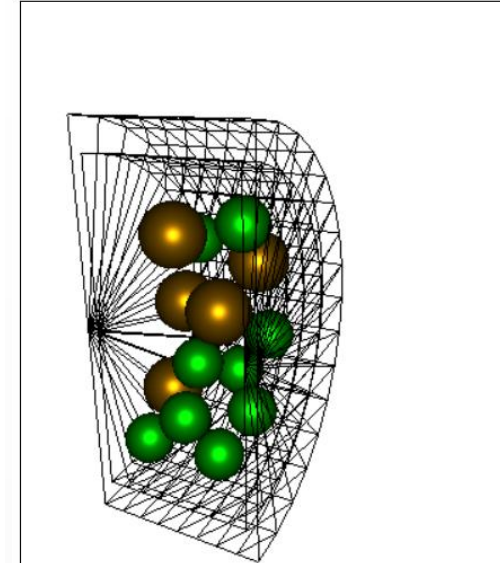
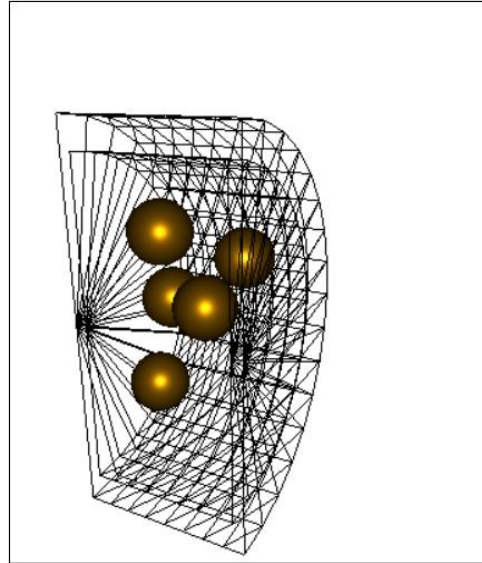
**Solution:** Bio-Phantom Explorer software technology that simulates 3D models of the mammary gland and identifies cancer tumours in them.



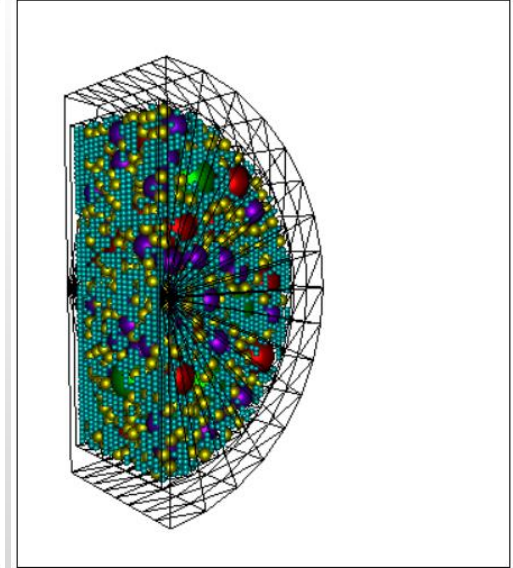
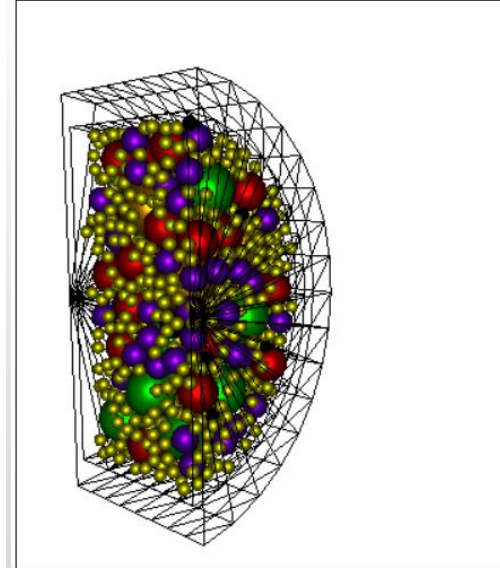
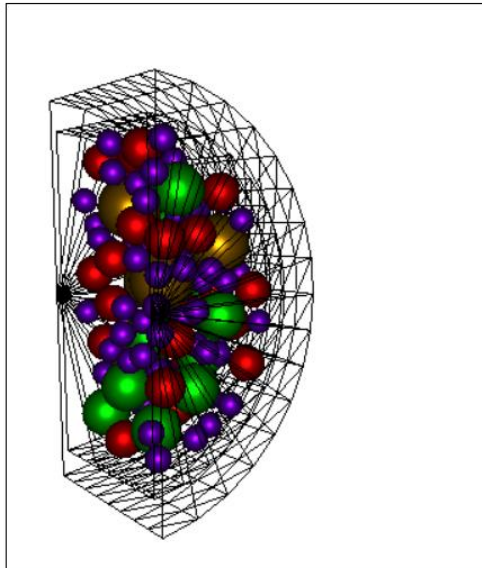
**Advantage:** The cancer tumour is identified at a very early stage of development, which greatly increases the patient's chances of healing.

[\\*http://ec.europa.eu/research/infocentre/article\\_en.cfm?&artid=48358&caller=FP](http://ec.europa.eu/research/infocentre/article_en.cfm?&artid=48358&caller=FP)

**1. Phase:** Development of a 3D computer model of a mammary gland that consists of two semi-cylinders, consecutively filled with 6 different types of spheres. The spheres have different sizes and colours, analogous to the different tissues in individual mammary glands.

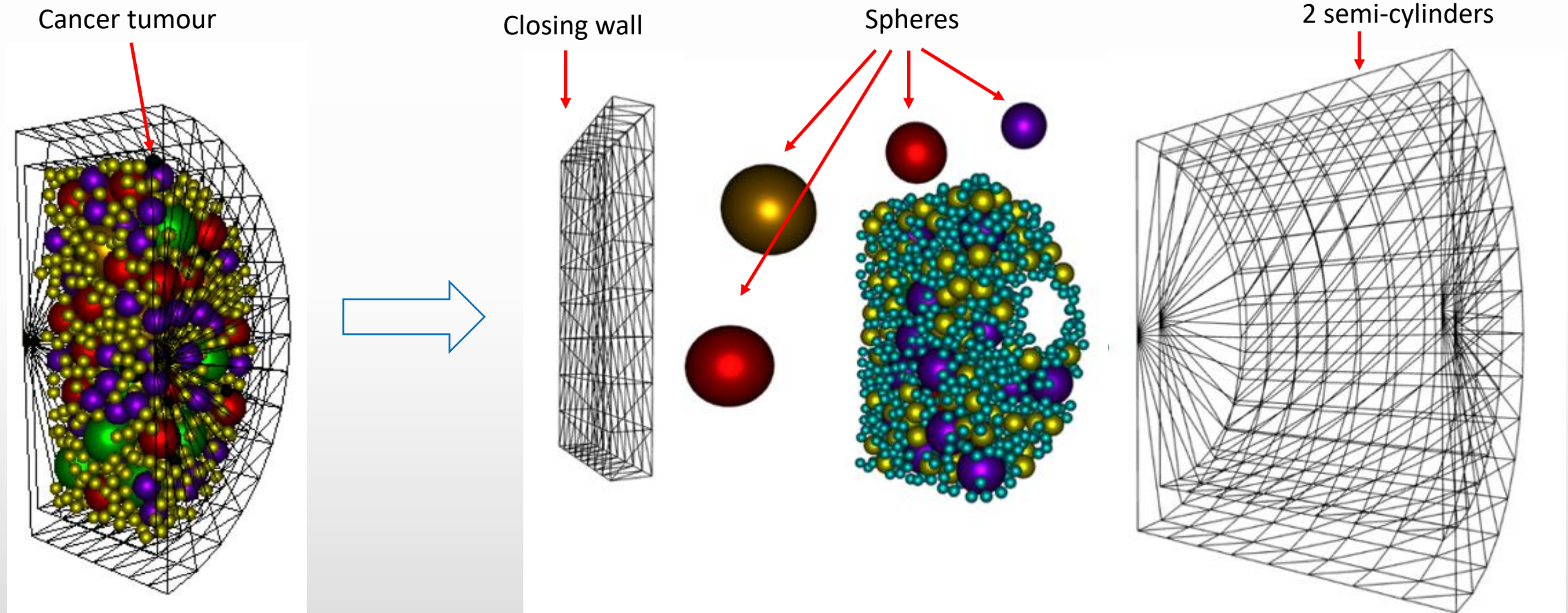


**2. Phase:** Computer simulation of irradiating the 3D model and thus obtaining X-ray images using the ray-tracing concept (slides 8 and 9).

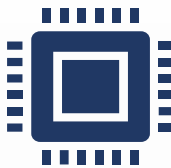
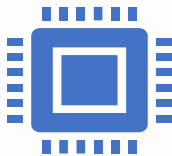
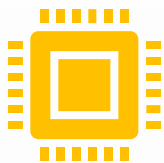




The main idea here is that the 3D model can be rotated and disassembled by the user, making it possible for the cancer tumour (black sphere) to be identified between the spheres.



The filling of the semi-cylinder is done not on one, but on 3 hardware platforms, thus generating a very large number of spheres in a very short time:



1. Core processor unit (CPU) with 8 cores    2. Graphic processor unit (GPU) with 640 cores    3. Graphic processor unit (GPU) with 1920 cores

Filling of the cylinder is done by the so-called random-fill algorithm using a matrix with a large number of processors. It get difficult to fill in the last stages when the free space is reduced.

Processor unit:	Cores@Clock rate:	Time: (16 000 spheres )	Time: (32 000 spheres)	Faster then single core: (16 000 spheres )	Faster then single core: (32 000 spheres )	Price**:
1. CPU – intel i7 6700K	<a href="#">8 cores@4.0GHz</a>	5 min. (300 sec.)	3 days	x 8	x 8	300 EUR
2. GPU – nVidia GTX960M	5 blocks x 128 cores@1097MHz	1,33 min. (80 sec.)	45 min.	X 50	X 96	200 EUR
3. GPU - nVidia GTX1070	15 blocks x 128 cores@1506MHz	0,33 min. (20 sec.)	6 min.	X 200	X 720	550 EUR

Advantages of using the GPU:

*\*\*Prices in Amazon for a high class CPU and GPU for the 1. quarter of 2018*

Filling the cylinder with spheres is done with 1920 processors in about 6 minutes, and with the classic single-processor mode it takes 12+ hours.

The price of the GPU is relatively low.

Coordinates of the spheres in the model

Risk Framework 20305 07.07.2017 Models v. 4.0 8005 14.04.2015 - [Item: User 007, User 007 -> Model: Phantom Visualizer, [12.07.2017...]

Phantom Data

Phantom Data Table

Number	object type	X	Y	Z	hiperb	rx	ry	rz
1	12,0000	-25,0000	0,0000	0,0000	0,0000	42,0000	40,0000	0,0000
2	12,0000	-25,0000	0,0000	0,0000	0,0000	50,0000	46,0000	0,0000
3	4,0000	5,4880	13,4100	7,2561	0,0000	7,9400	7,9400	7,9400
4	4,0000	-4,0850	3,0810	-8,9611	0,0000	7,9400	7,9400	7,9400
5	4,0000	-7,2620	-20,6770	-11,9874	0,0000	7,9400	7,9400	7,9400
6	4,0000	-13,4730	22,8590	-5,1741	0,0000	7,9400	7,9400	7,9400
7	4,0000	-11,9880	5,1790	5,9017	0,0000	7,9400	7,9400	7,9400
8	4,0000	-7,1170	-21,9050	11,9382	0,0000	6,3500	6,3500	6,3500
9	4,0000	-11,7530	26,8880	12,6729	0,0000	6,3500	6,3500	6,3500
10	4,0000	1,7040	-4,4330	12,0681	0,0000	6,3500	6,3500	6,3500
11	4,0000	-14,8460	-31,7010	6,6611	0,0000	6,3500	6,3500	6,3500
12	4,0000	1,6650	-16,0920	3,5731	0,0000	6,3500	6,3500	6,3500
13	4,0000	-11,6750	-9,6410	-0,7508	0,0000	6,3500	6,3500	6,3500
14	4,0000	-18,2720	-21,5160	-0,6392	0,0000	6,3500	6,3500	6,3500
15	4,0000	9,1350	-4,8850	-6,3787	0,0000	6,3500	6,3500	6,3500
16	4,0000	0,6940	18,7580	-7,3364	0,0000	6,3500	6,3500	6,3500
17	4,0000	-17,0590	-31,2790	-13,0121	0,0000	6,3500	6,3500	6,3500
18	4,0000	-12,4600	-8,6870	11,9382	0,0000	4,7600	4,7600	4,7600
19	4,0000	7,9390	-17,3630	15,0134	0,0000	4,7600	4,7600	4,7600
20	4,0000	-0,6990	26,5720	15,0594	0,0000	4,7600	4,7600	4,7600
21	4,0000	-16,9540	15,4160	14,5113	0,0000	4,7600	4,7600	4,7600
22	4,0000	-17,6690	-19,0590	14,5820	0,0000	4,7600	4,7600	4,7600
23	4,0000	10,9730	1,6370	14,0879	0,0000	4,7600	4,7600	4,7600
24	4,0000	-6,0770	16,3710	12,4574	0,0000	4,7600	4,7600	4,7600

Black spheres  
(cancer tumours)

Phantom Data

Phantom Data Table

Number	grid	grid	grid	grid	grid	Color	Name
136	0,0000	0,0000	0,0000	0,0000	0,0000	16 776 960,0000	none
137	0,0000	0,0000	0,0000	0,0000	0,0000	16 776 960,0000	none
138	0,0000	0,0000	0,0000	0,0000	0,0000	16 776 960,0000	none
139	0,0000	0,0000	0,0000	0,0000	0,0000	16 776 960,0000	none
140	0,0000	0,0000	0,0000	0,0000	0,0000	16 776 960,0000	none
141	0,0000	0,0000	0,0000	0,0000	0,0000	16 776 960,0000	none
142	0,0000	0,0000	0,0000	0,0000	0,0000	16 776 960,0000	none
143	0,0000	0,0000	0,0000	0,0000	0,0000	16 776 960,0000	none
144	0,0000	0,0000	0,0000	0,0000	0,0000	16 776 960,0000	none
145	0,0000	0,0000	0,0000	0,0000	0,0000	16 776 960,0000	none
146	0,0000	0,0000	0,0000	0,0000	0,0000	16 776 960,0000	none
147	0,0000	0,0000	0,0000	0,0000	0,0000	16 776 960,0000	none
148	0,0000	0,0000	0,0000	0,0000	0,0000	16 776 960,0000	none
149	0,0000	0,0000	0,0000	0,0000	0,0000	16 776 960,0000	none
150	0,0000	0,0000	0,0000	0,0000	0,0000	16 776 960,0000	none
151	0,0000	0,0000	0,0000	0,0000	0,0000	16 776 960,0000	none
152	0,0000	0,0000	0,0000	0,0000	0,0000	16 776 960,0000	none
153	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
154	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
155	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
156	0,0000	0,0000	0,0000	0,0000	0,0000	16 776 960,0000	none
157	0,0000	0,0000	0,0000	0,0000	0,0000	16 776 960,0000	none
158	0,0000	0,0000	0,0000	0,0000	0,0000	16 776 960,0000	none
159	0,0000	0,0000	0,0000	0,0000	0,0000	16 776 960,0000	none

# Application: desktop and web in the system Risk Framework

## Desktop application:

Risk Framework 21179 18.09.2018 Models v. 4.0/B005 14.04.2015 - [Item: User 007, User 007 -> Model: Phantom Visualizer, [27.9.2018 r.]]

User Item List Model View Reports Window Help

Phantom Visualizer

Phantom Visualizer

3D Visualizer

3D Visualizer for Objects

Phantom Data

Administration

**Phantom Visualizer**

**System data**

Finance center 001005

User ID User 007

System code User 007

System name User 007, User 007

Valuation date 28. 9. 2018 r.

Valuation currency EUR:EU

**Create Phantom**

Create Phantom Management

Create Phantom Visualize Phantom

**Container Parameters**

Container Radius [mm] 42.0000

Container Height [mm] 40.0000

Container Closing [mm] 3.0000

Wall Thickness [mm] 8.0000

Container Material plexiglas(lucite,PMMA)

Container Filling Material air

Filling coefficient 0.3080

Container Color (RGB) 16 711 680

**Sphere Parameters**

	Sphere Radius	Sphere Color	Total Number	Total Volume
Sphere Radius R1 [mm]	7.9400	12 615 680	5	10 484
Sphere Radius R2 [mm]	6.3500	65 280	10	10 725
Sphere Radius R3 [mm]	4.7600	16 711 680	25	11 294
Sphere Radius R4 [mm]	3.1750	8 388 863	84	11 262
Sphere Radius R5 [mm]	1.5900	16 776 960	675	11 365
Sphere Radius R6 [mm]	0.7900	65 535	5 509	11 377

Sphere Material water

Iterations 100000

Phantom Center at 0,0,0

**CUDA Parameters**

CUDA Blocks/Threads 128 128

Elapsed Time [sec] 56,4580

## Web application:

Risk Framework

Not secure | www.eurorisksystems.com:8080/RiskFramework/Session

System Settings

Phantom Visualizer 3D Visualizer 3D Visualizer for Objects Phantom Data Administration

**Phantom Visualizer**

**System data**

Finance center 001005

User ID User 007

System code User 007

System name User 007, User 007

Valuation date 27/09/2018

Valuation currency EUR:EU

**Create Phantom**

Create Phantom Management

Create Phantom Visualize Phantom

**Container Parameters**

Container Radius [mm] 20.0000

Container Height [mm] 40.0000

Container Closing [mm] 3.0000

Wall Thickness [mm] 8.0000

Container Material plexiglas(lucite,PMMA)

Container Filling Material air

Container Color (RGB) 0

**Sphere Parameters**

	Sphere Radius	Sphere Color
Sphere Radius R1 [mm]	7.9400	0
Sphere Radius R2 [mm]	6.3500	65280
Sphere Radius R3 [mm]	4.7600	0
Sphere Radius R4 [mm]	3.1750	0
Sphere Radius R5 [mm]	1.5900	0
Sphere Radius R6 [mm]	0.7900	65535

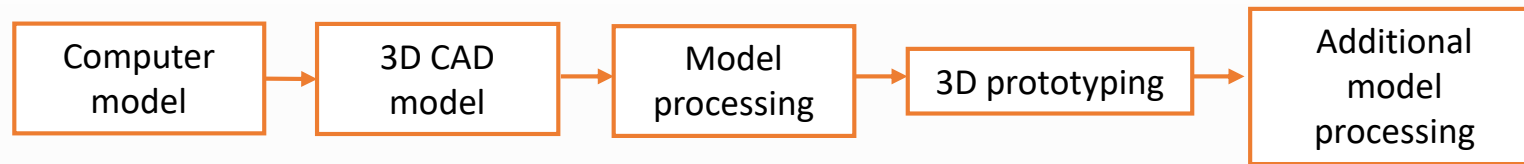
Sphere Material water

Iterations 100000

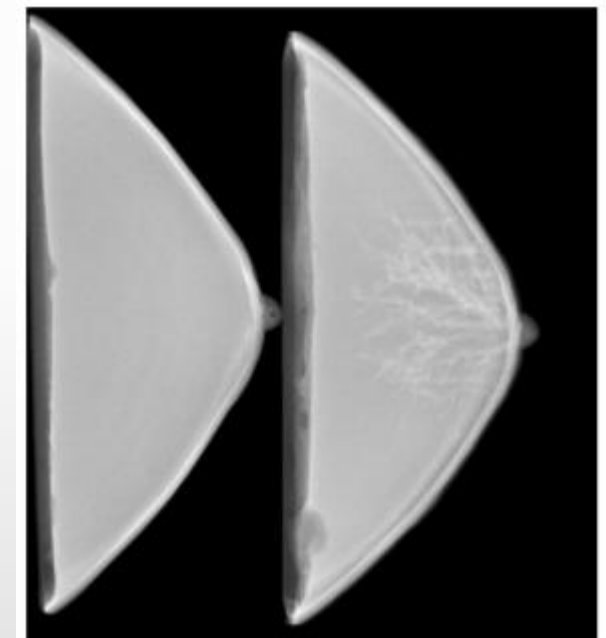
Phantom Center at 0,0,0

## Modelling and simulation of irradiation of the 3D model

Under construction. The idea is to obtain simulated X-ray images of a computer model using traditional and innovative geometry to produce an image. To this end, it is planned to use Monte Carlo techniques that sample the type of X-ray interaction in the model and the distance traveled. Physical anthropomorphic models are produced using 3D printers.\*



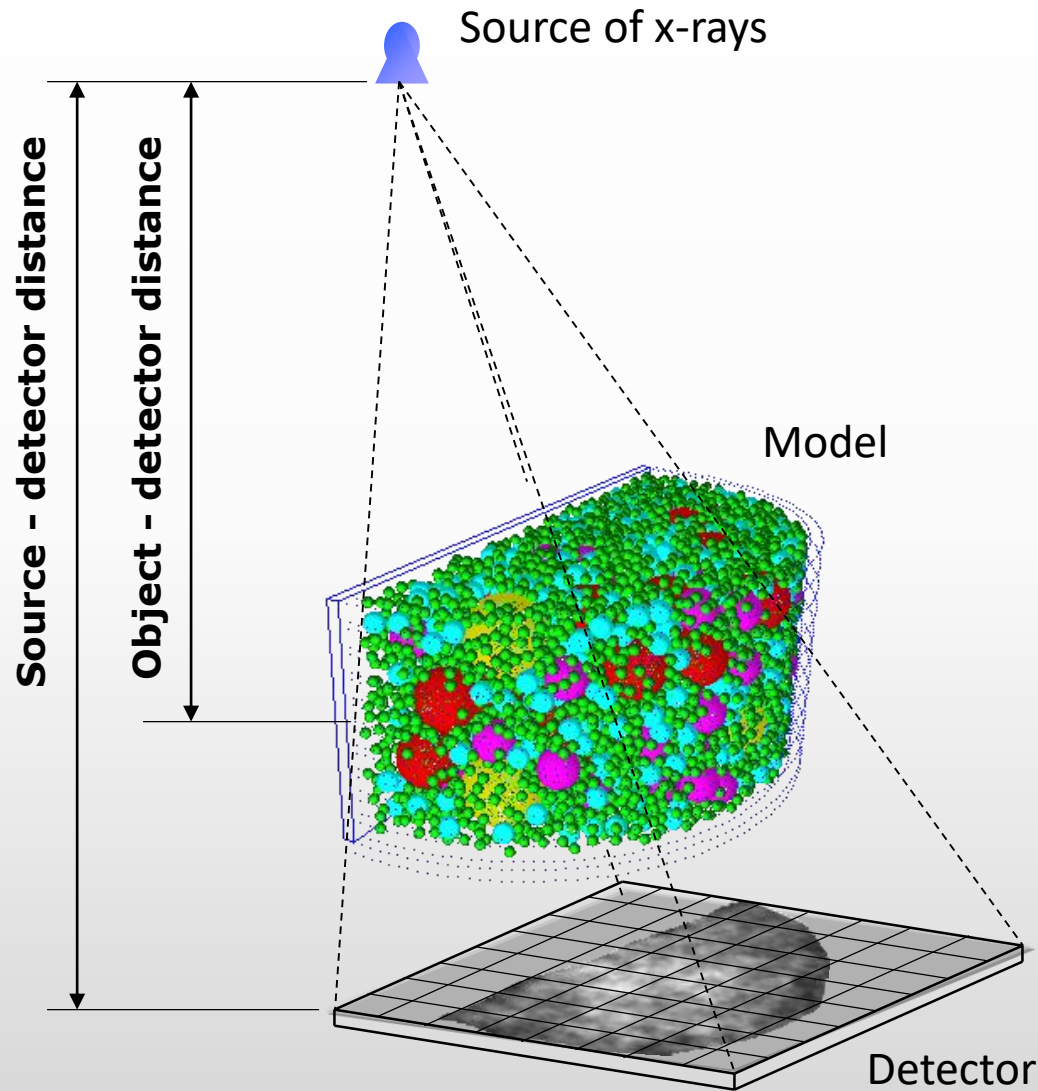
*Core stages in the development of physical phantoms of mammary gland.*



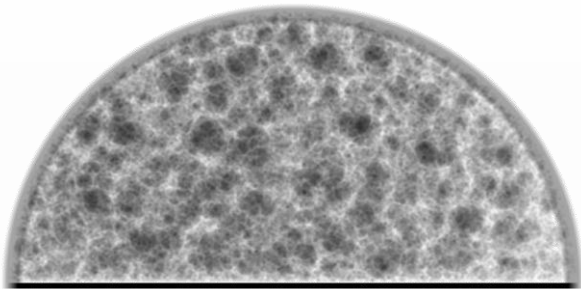
*Images of physical phantoms*

\* [https://zenodo.org/record/1065989/.../Ivanov\\_FOCHOS\\_2016.pdf](https://zenodo.org/record/1065989/.../Ivanov_FOCHOS_2016.pdf). Development and analysis of physical phantoms of a human breast for the purposes of X-ray diagnostics

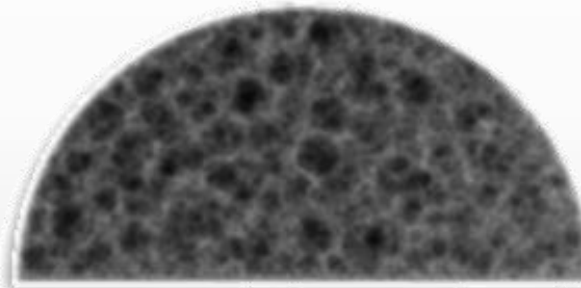




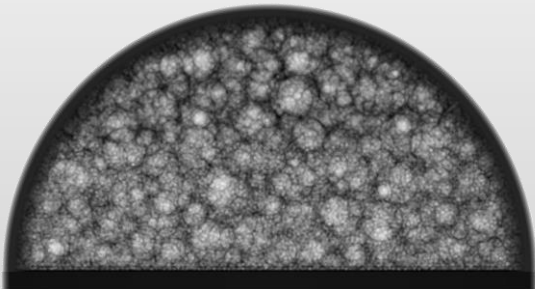
*Modeled planar images of a mammary gland model, composed of acrylic spheres placed in air.*



*Modeled planar images of a mammary gland model, composed of acrylic spheres placed in water.*



*Modeled planar images of a mammary gland model, composed of polyethylene spheres placed in air.*



# Thank you!



This project was also supported by the MaXIMA project: Three-dimensional Breast Cancer Models for X-ray Imaging, which received funding from the European Union's Horizon 2020 Research and Innovation Program under Grant Agreement Nr. 692097.

