



**Wydział
Fizyki**

POLITECHNIKA WARSZAWSKA

Laser sensor locating the magnetic field indicator inside the main magnet of the BM@N detector

Supervisors:

prof. nzw. dr. hab. inż Adam Kisiel
mgr. inż. Krystian Roślon

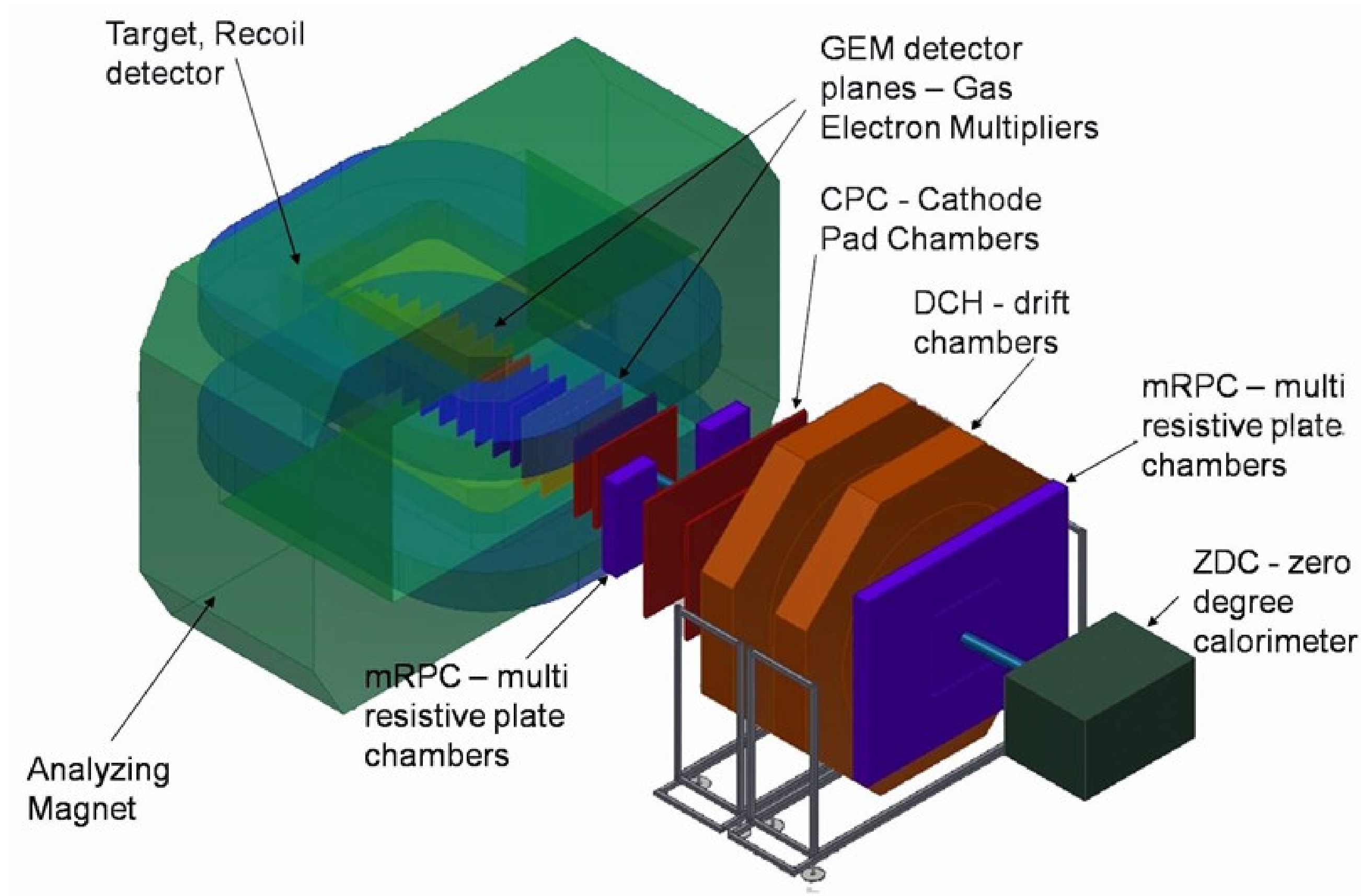
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**Politechnika
Warszawska**



Detector BM@N



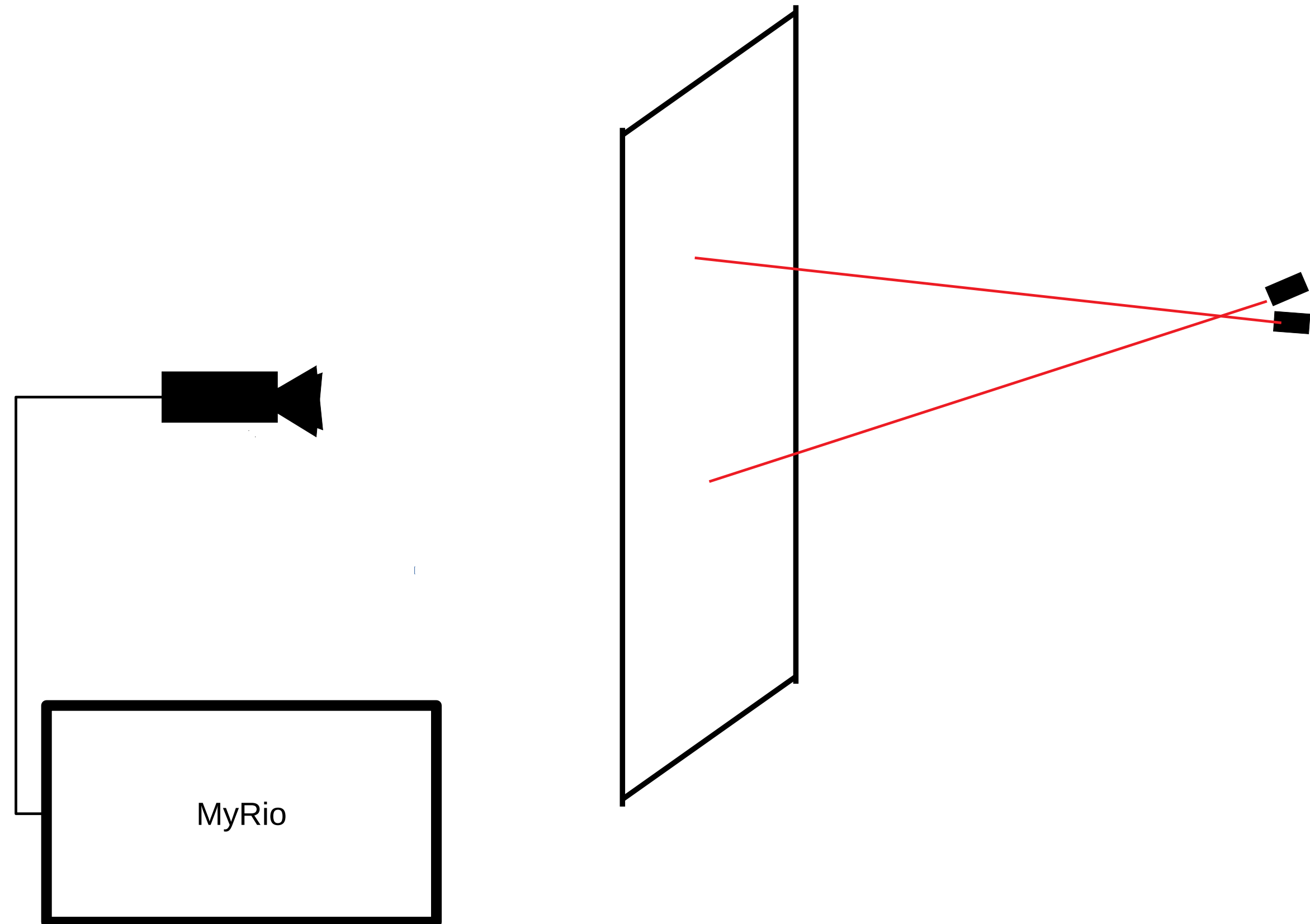
source: nica.jinr.ru/ru/projects/bman.php

Magnetic field scanner

Elements of the project:

- Magnetic field indicator- Konrad Krawczyk
- Positioning system – Jakub Sękulski
- Position sensor

Laser sensor locating the magnetic field indicator

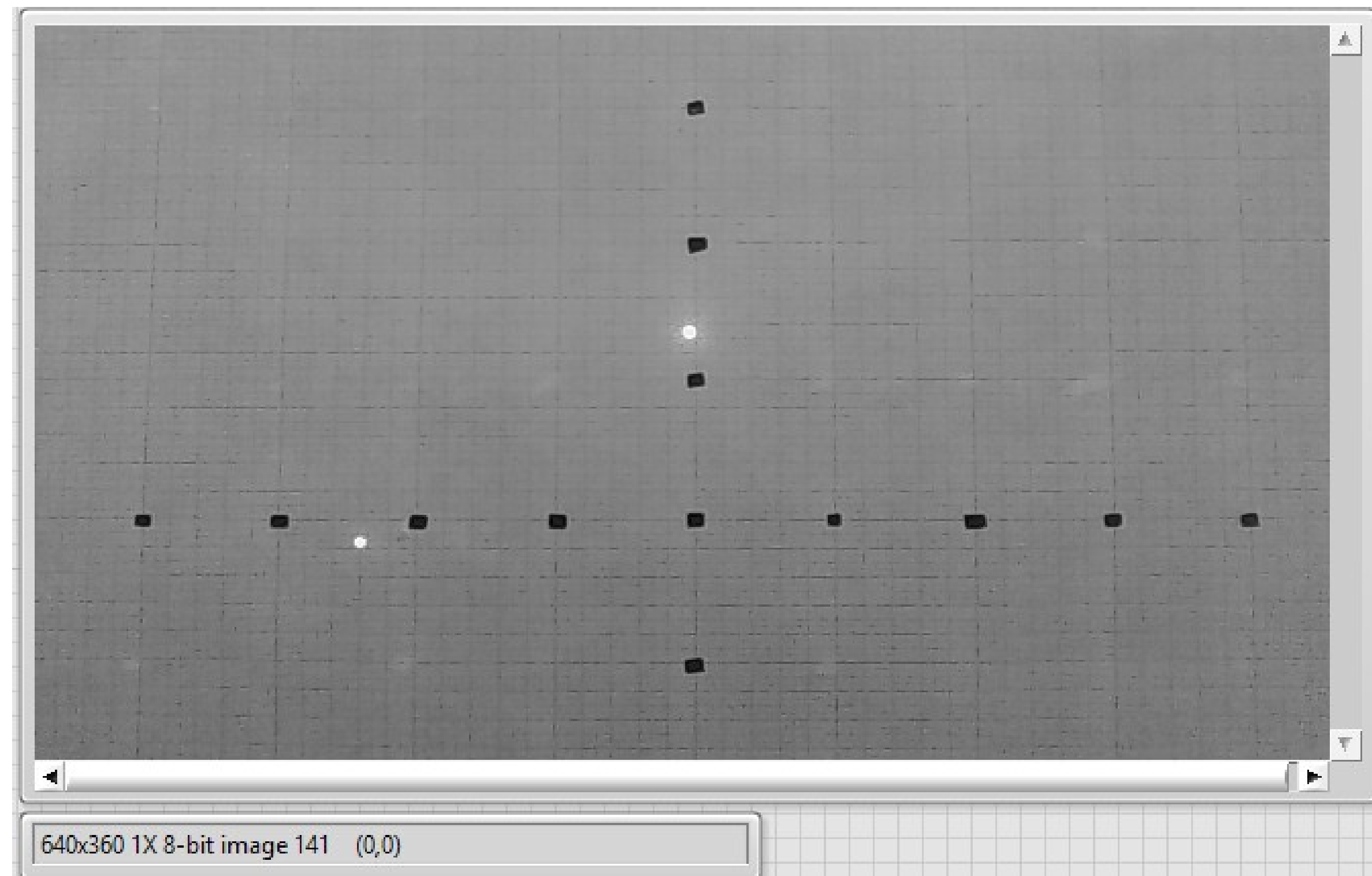


Scheme of the program in LabView

- 1) Downloading the image from a digital camera
- 2) Image segmentation
- 3) Data selection and determining the position of dots
- 4) Changing units from pixels to centymeters
- 5) Determining the position of indicator
- 6) Recording data

1) Downloading the image

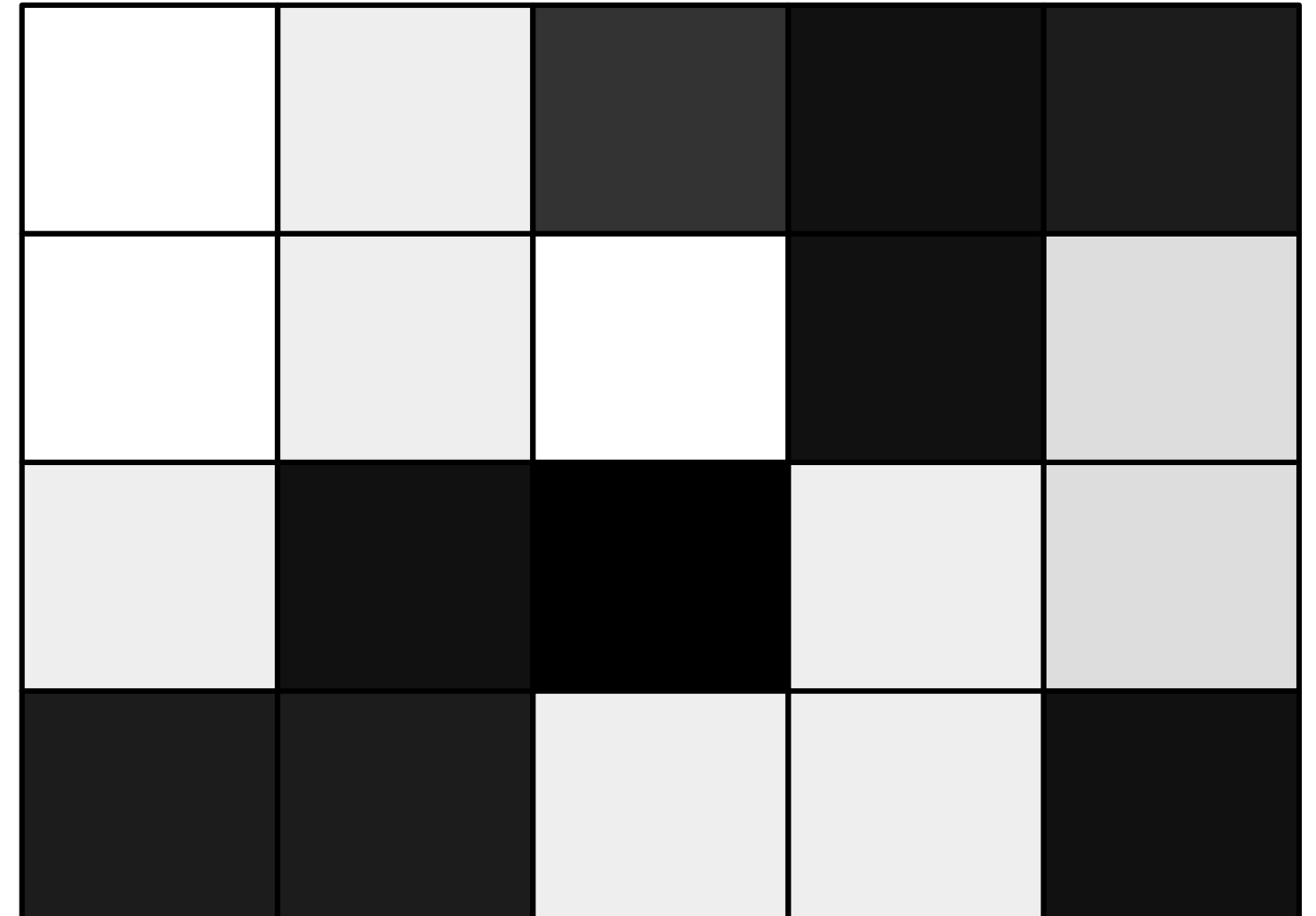
- Used drivers: NI-IMAQdx
- Image as a 2D array of bytes 360/640



2) Image segmentation

Converting the image into pixel segments with given parameters.

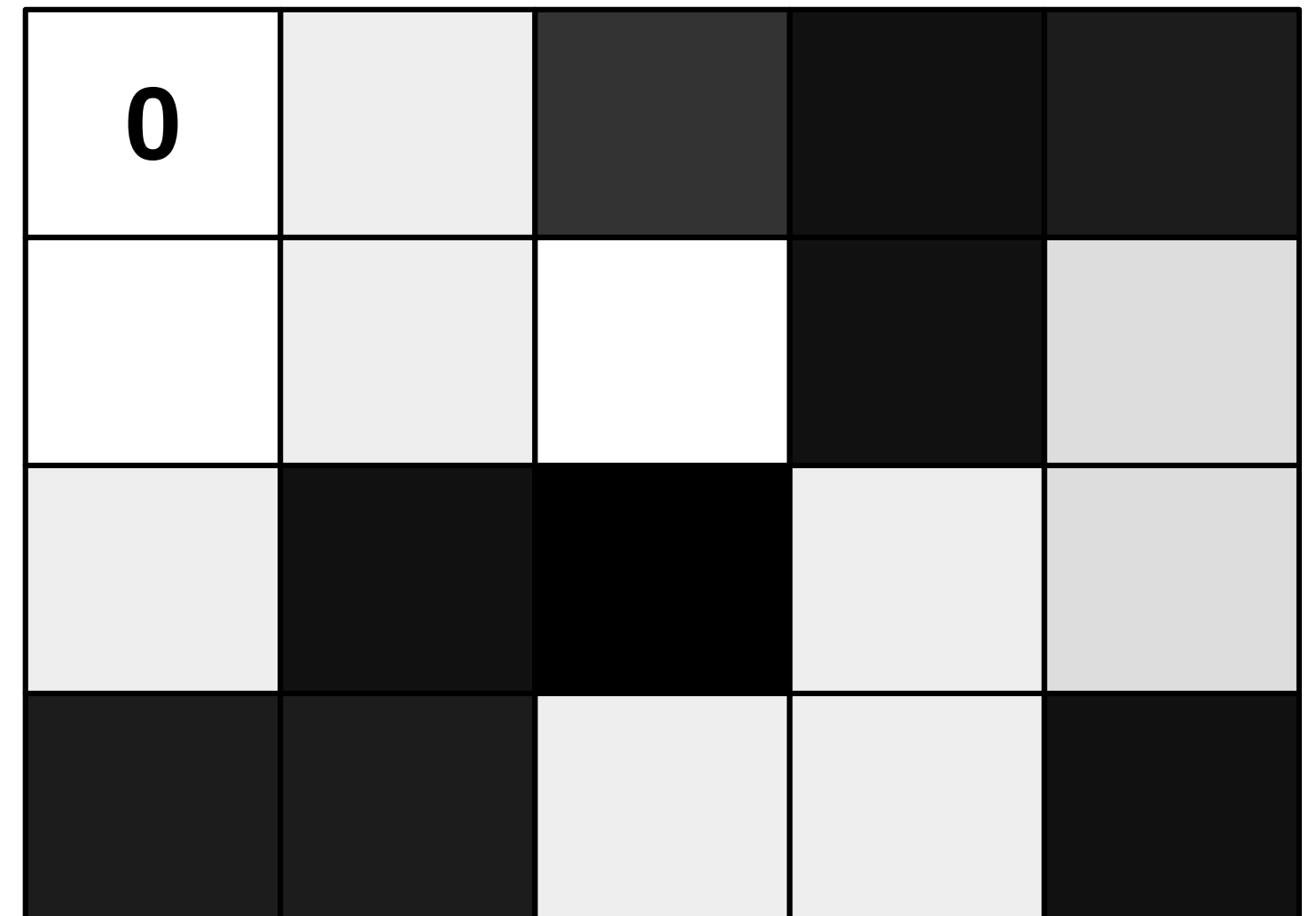
For each pixel it is checked whether its value is greater (or smaller) than the critical value.



2) Image segmentation

Converting the image into pixel segments with given parameters.

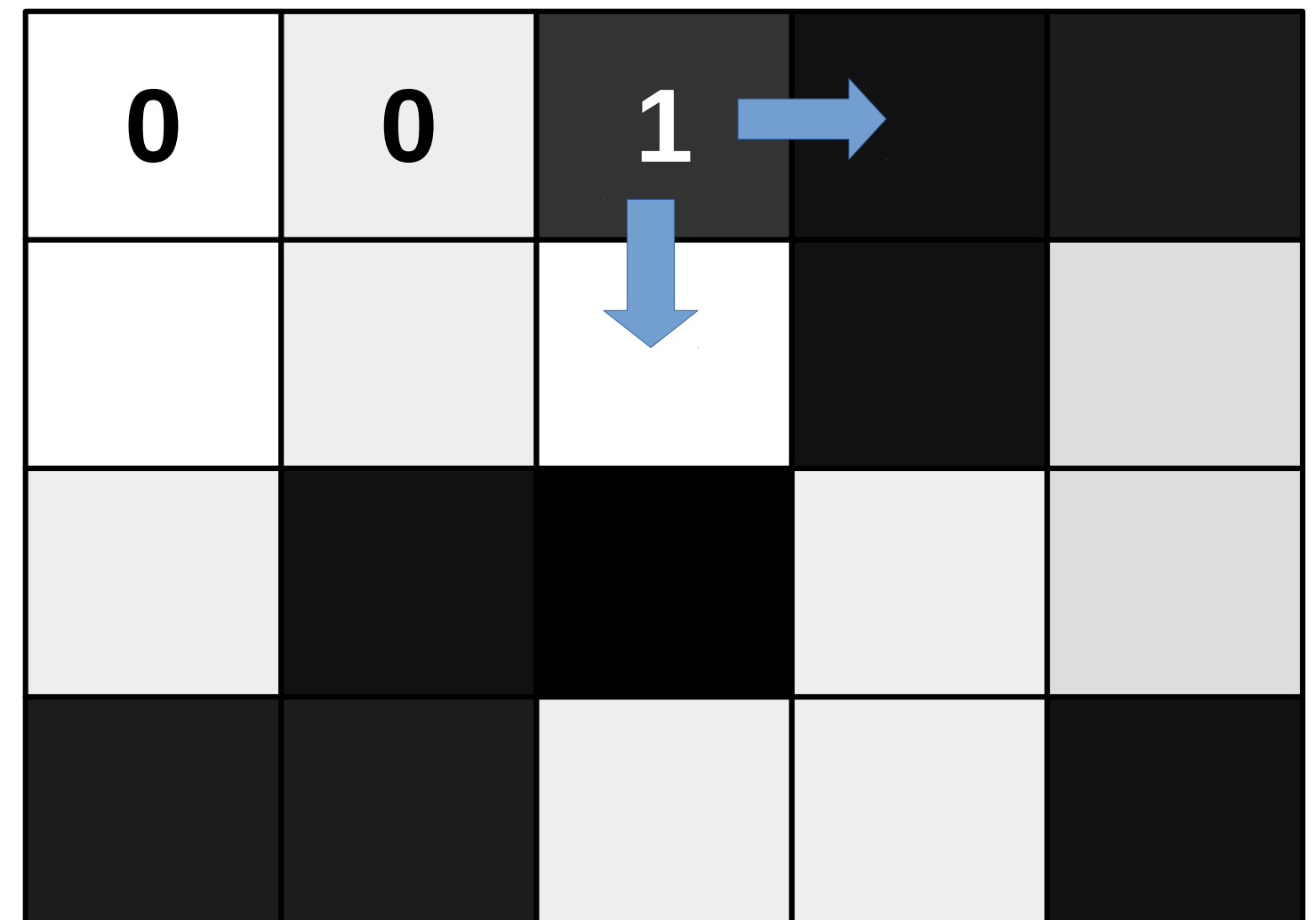
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0	0	1	1	
		0		

2) Image segmentation

Converting the image into pixel segments with given parameters.

For each pixel it is checked whether its value is greater (or smaller) than the critical value.

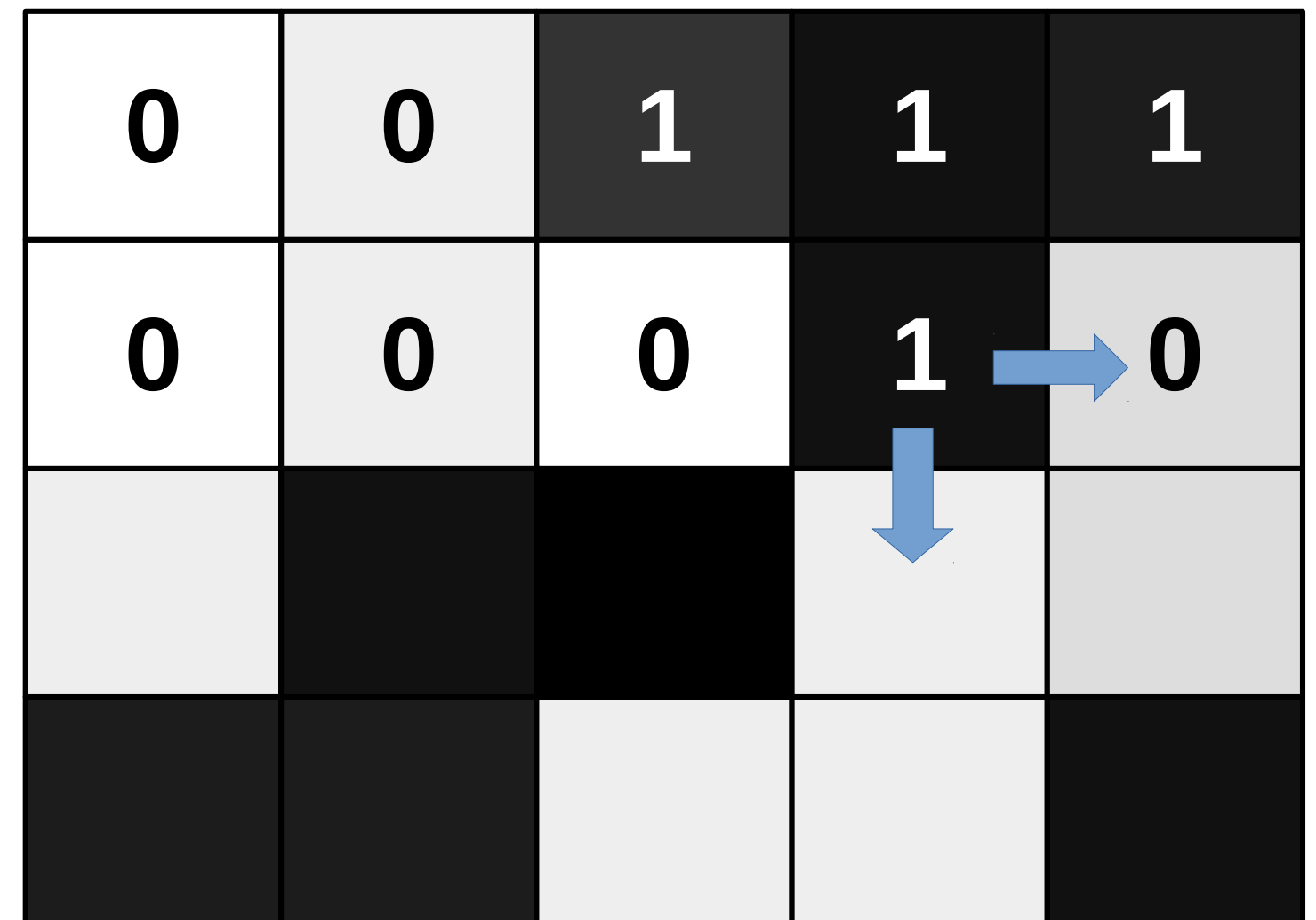
0	0	1	1	1
		0	1	

2) Image segmentation

Converting the image into pixel segments with given parameters.

For each pixel it is checked whether its value is greater (or smaller) than the critical value.

0	0	1	1	1
0	0	0	1	0



2) Image segmentation

Converting the image into pixel segments with given parameters.

For each pixel it is checked whether its value is greater (or smaller) than the critical value.

0	0	1	1	1
0	0	0	1	0
			0	

2) Image segmentation

Converting the image into pixel segments with given parameters.

For each pixel it is checked whether its value is greater (or smaller) than the critical value.

0	0	1	1	1
0	0	0	1	0
0	2	2	0	0
	2			

2) Image segmentation

Converting the image into pixel segments with given parameters.

For each pixel it is checked whether its value is greater (or smaller) than the critical value.

0	0	1	1	1
0	0	0	1	0
0	2	2	0	0
3 → 2				

2) Image segmentation

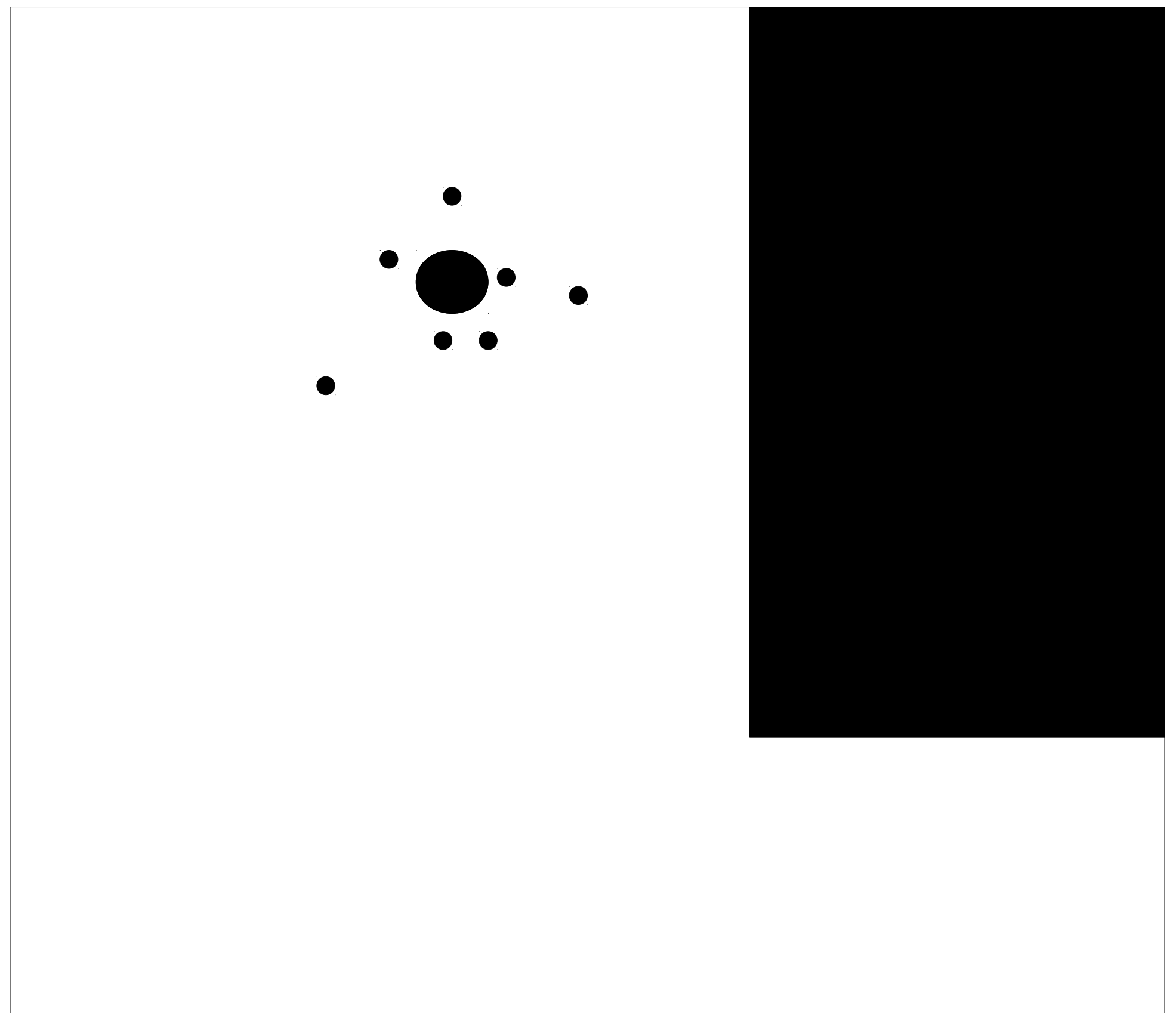
Converting the image into pixel segments with given parameters.

For each pixel it is checked whether its value is greater (or smaller) than the critical value.

0	0	1	1	1
0	0	0	1	0
0	3	3	0	0
3	3	0	0	4

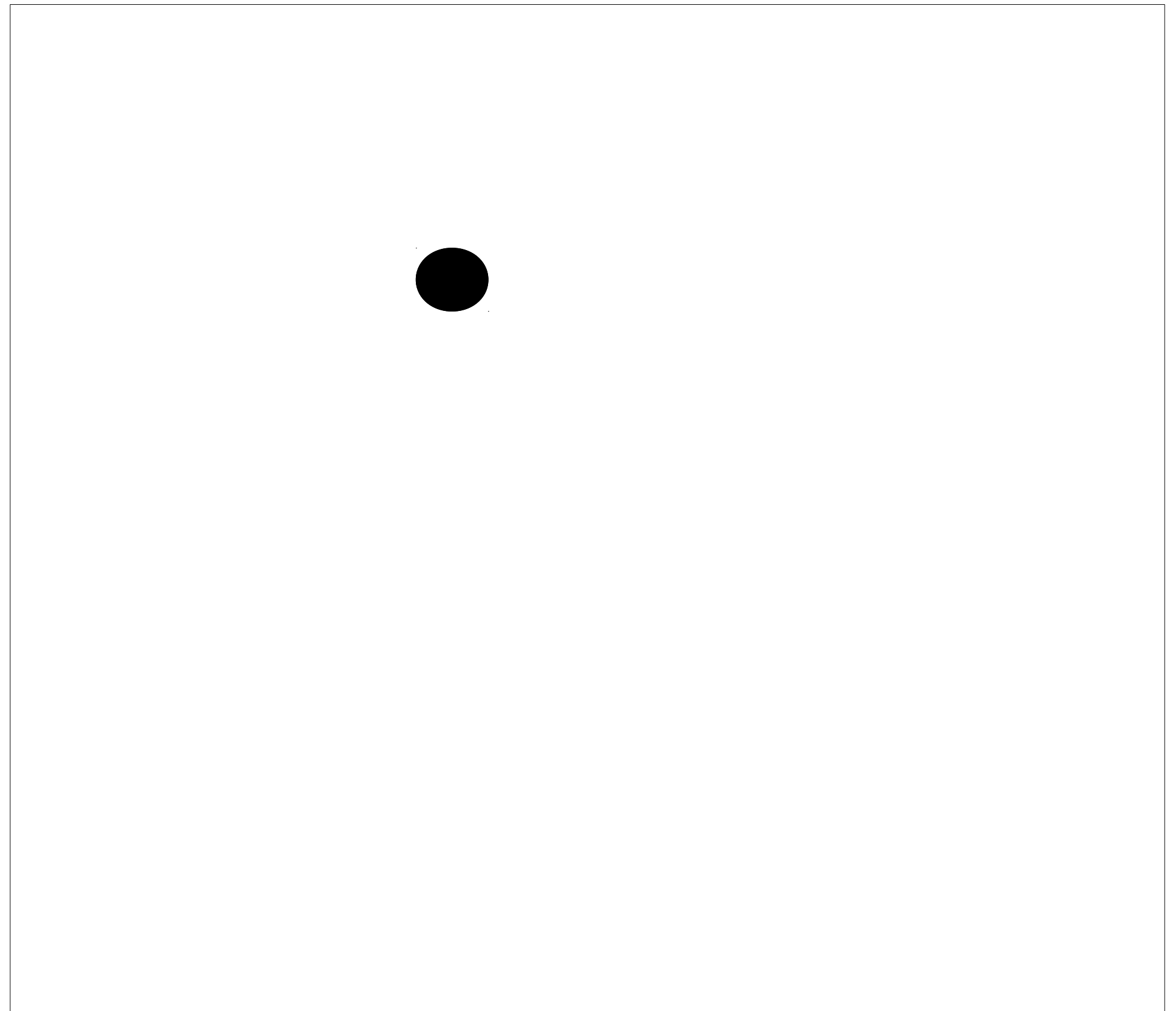
3) Data selection and determining the position of dots

To avoid distortions, all groups of pixels are selected in size

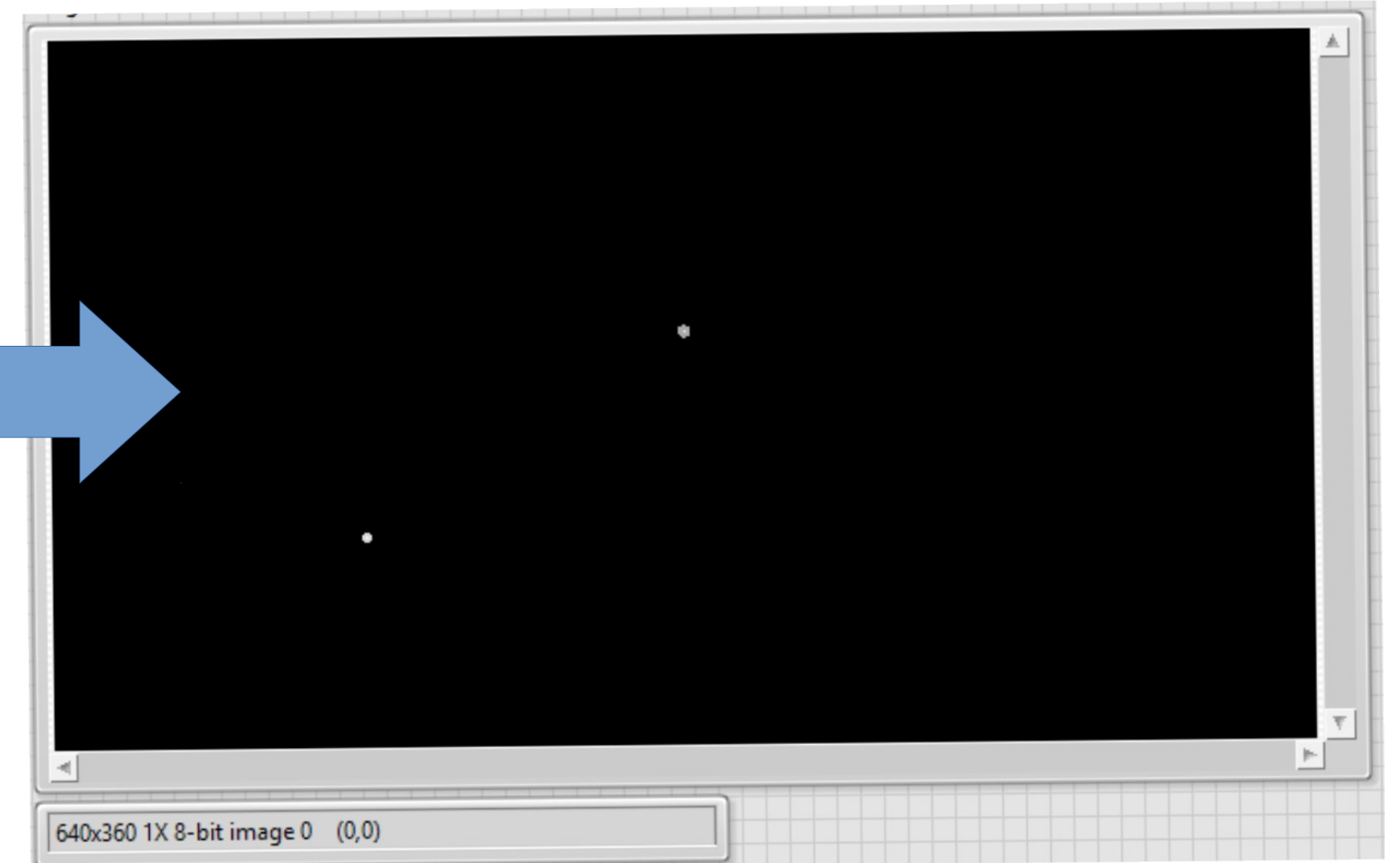
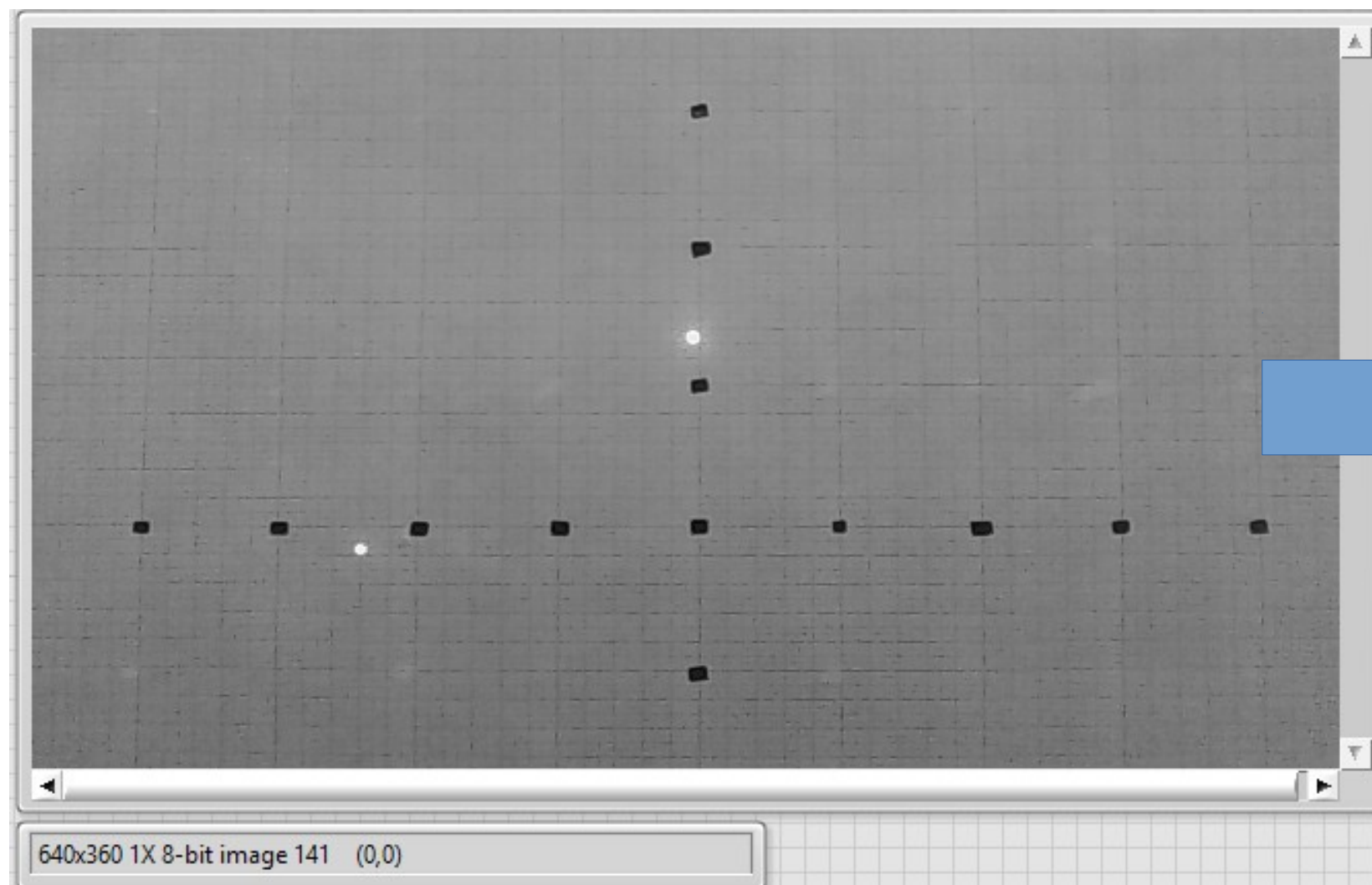


3) Data selection and determining the position of dots

To avoid distortions, all groups of pixels are selected in size



3) Data selection and determining the position of dots



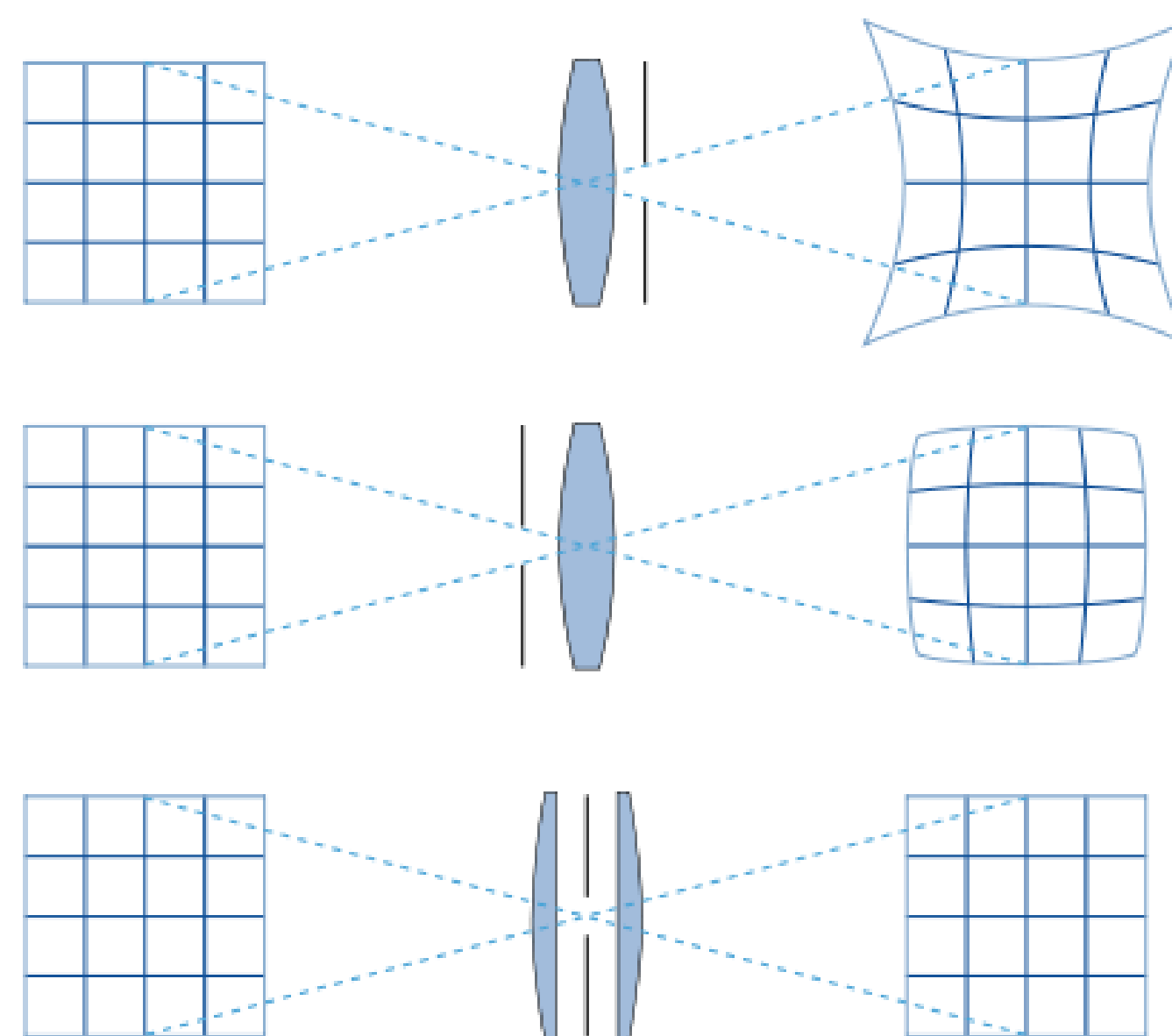
X,Y of points [pix]

0	-6,139	19,39
0	-168	-83,62

4) Changing units from pixels to centymeters

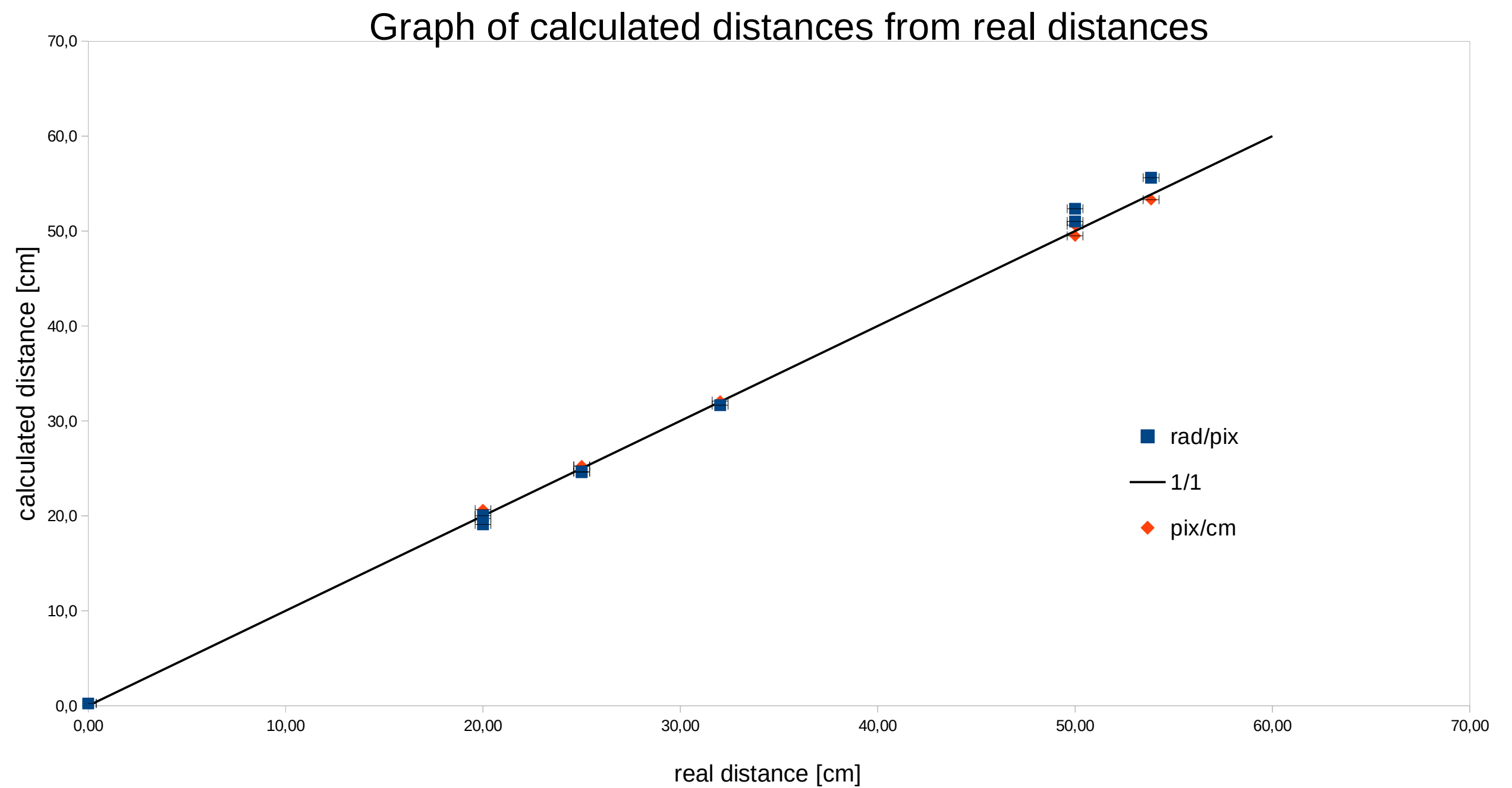
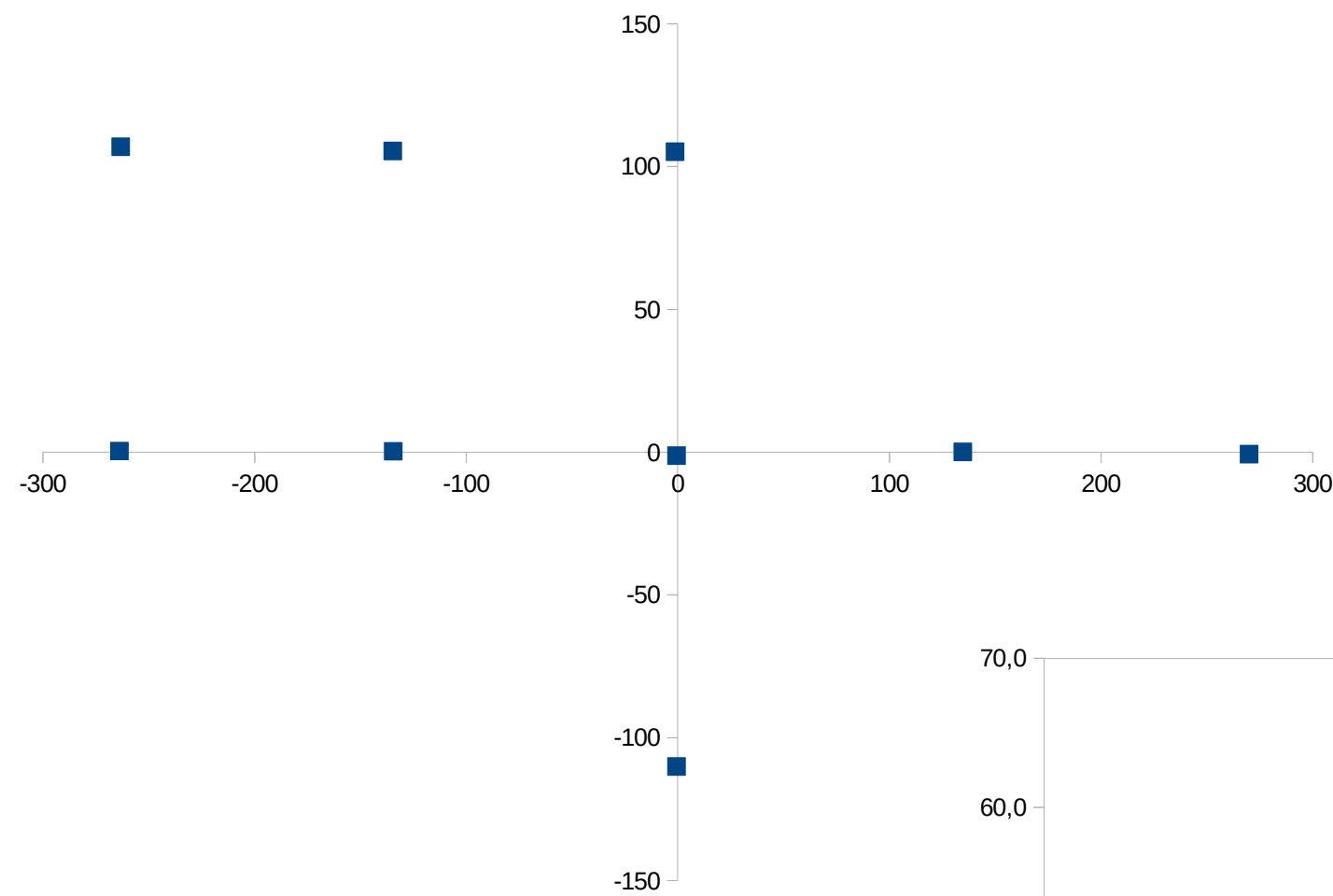
Interpretation of distance in pixels

- As constant angle
- As constant distance in centimeters

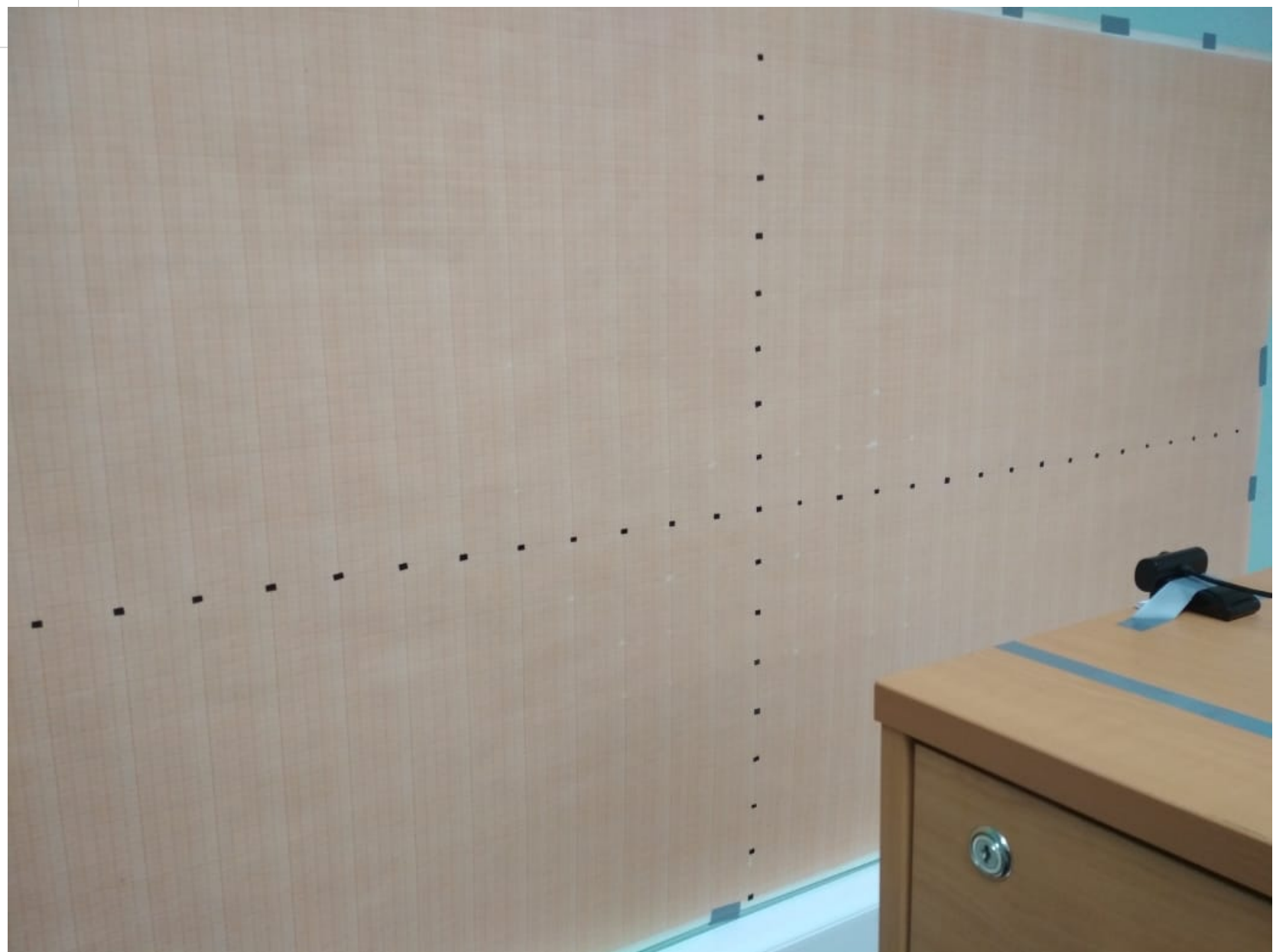
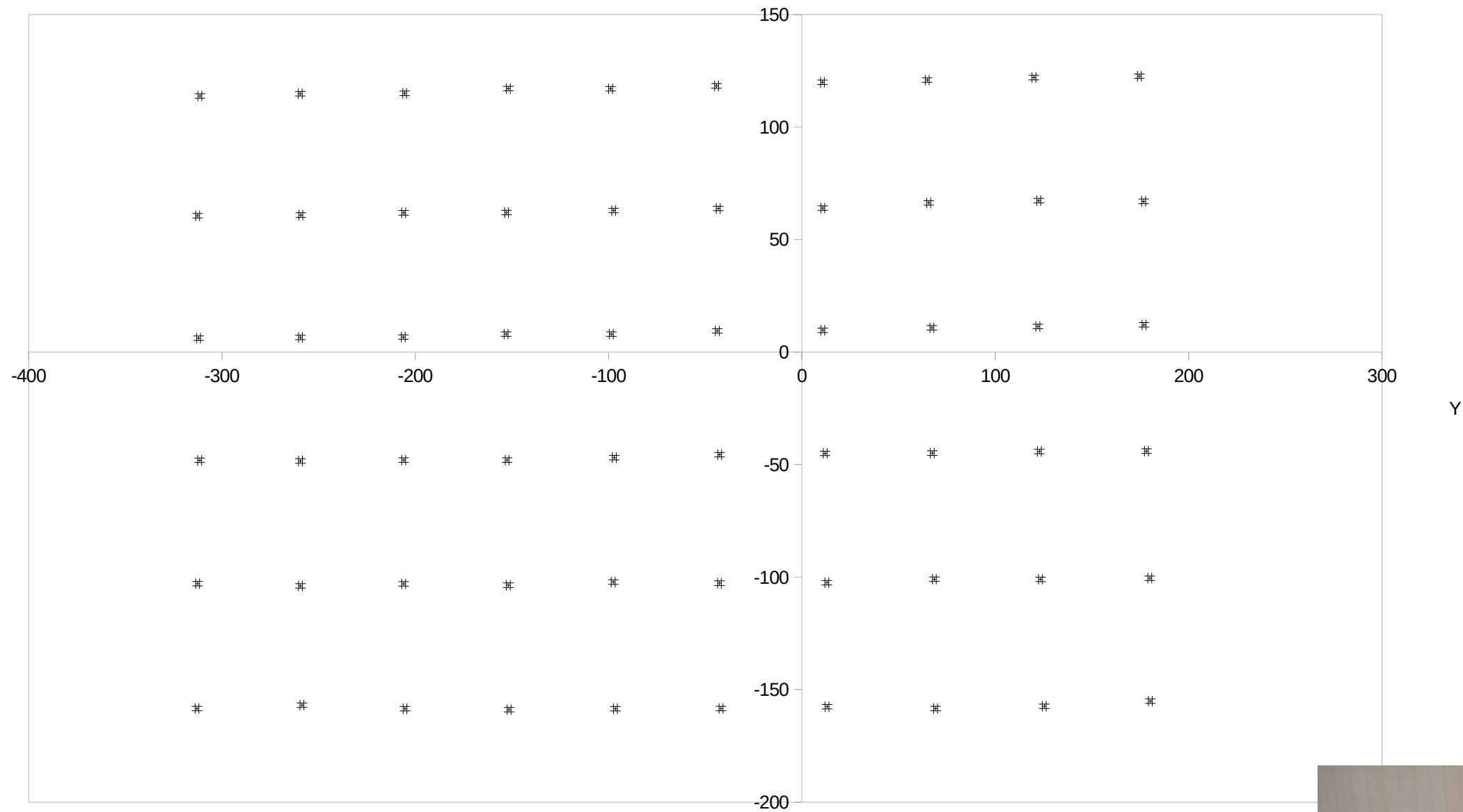


Distortion – source: Wikipedia

4) Changing units from pixels to centymeters

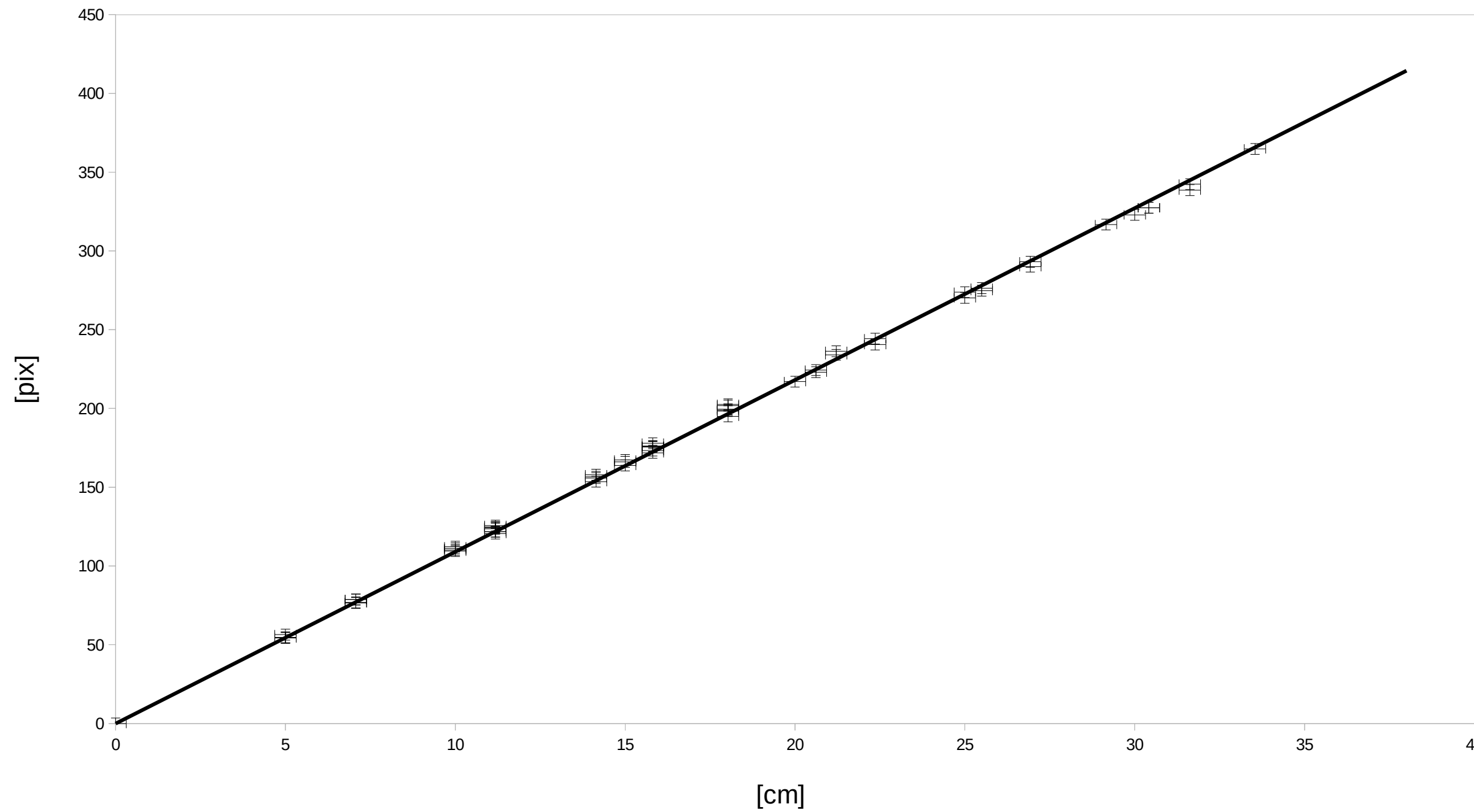


4) Changing units from pixels to centimeters

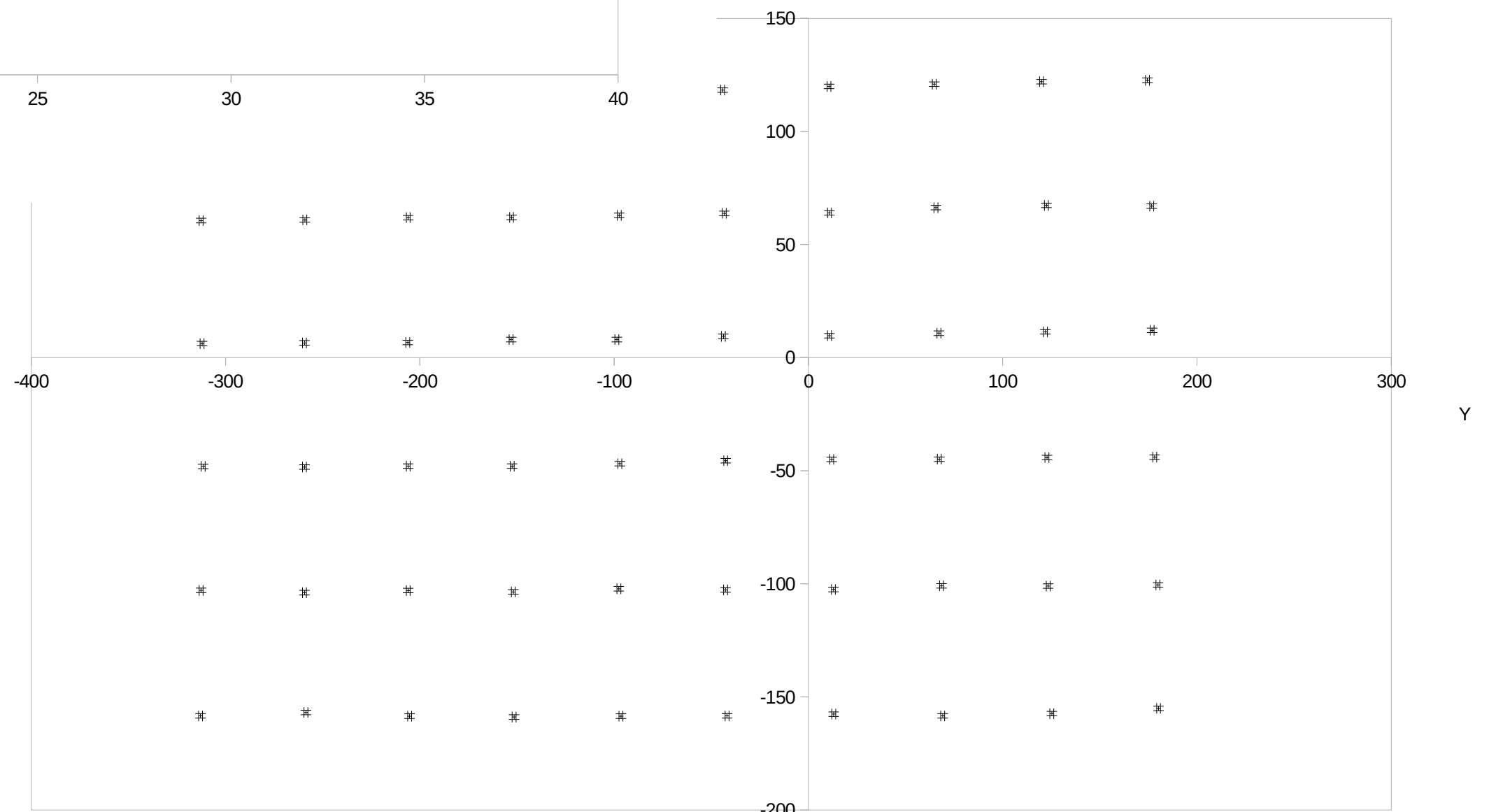


4) Changing units from pixels to centymeters

Distances in pixels from real distances

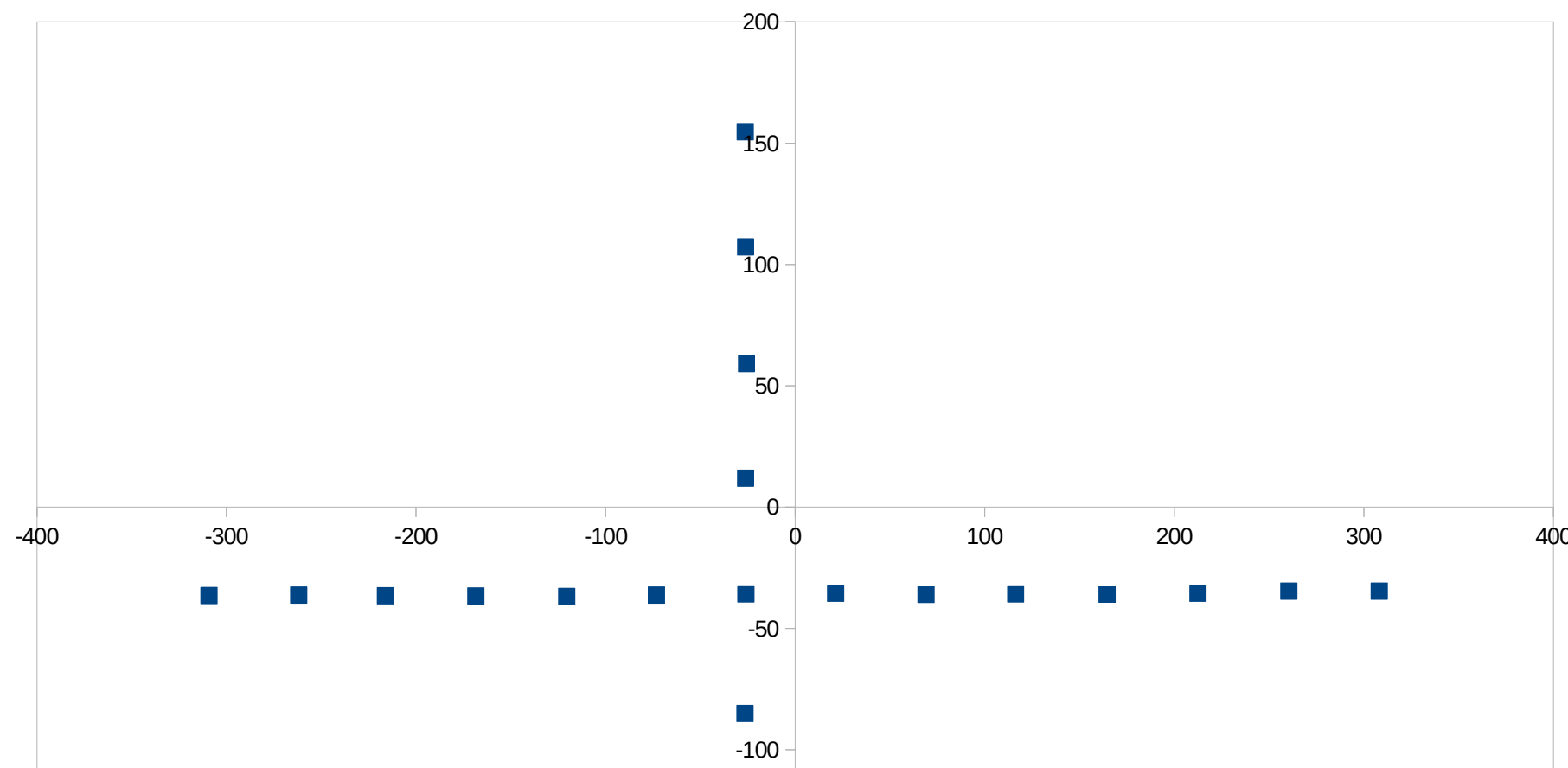


Chi² on the level of 0,98 accuracy

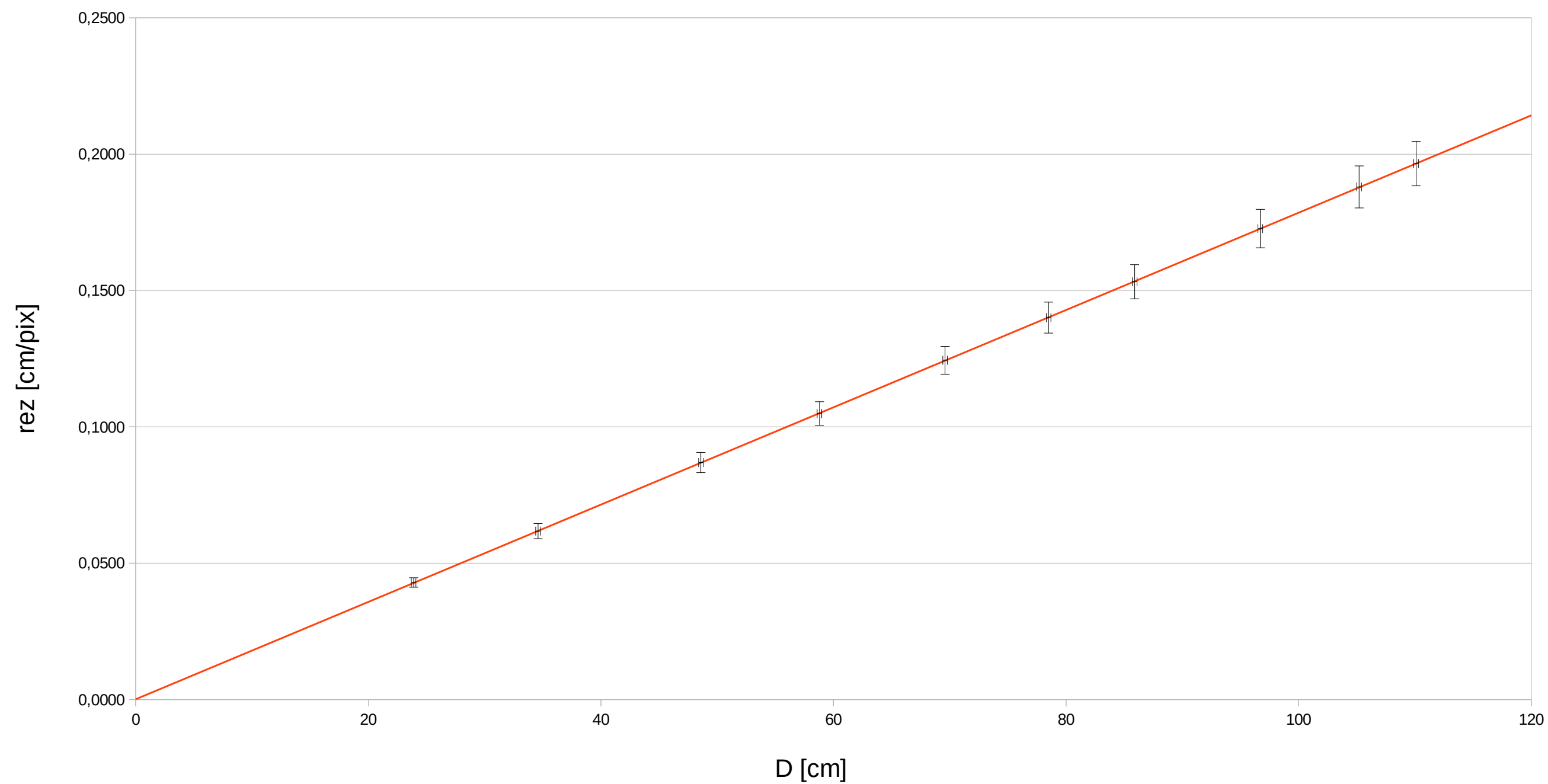


4) Changing units from pixels to centymeters

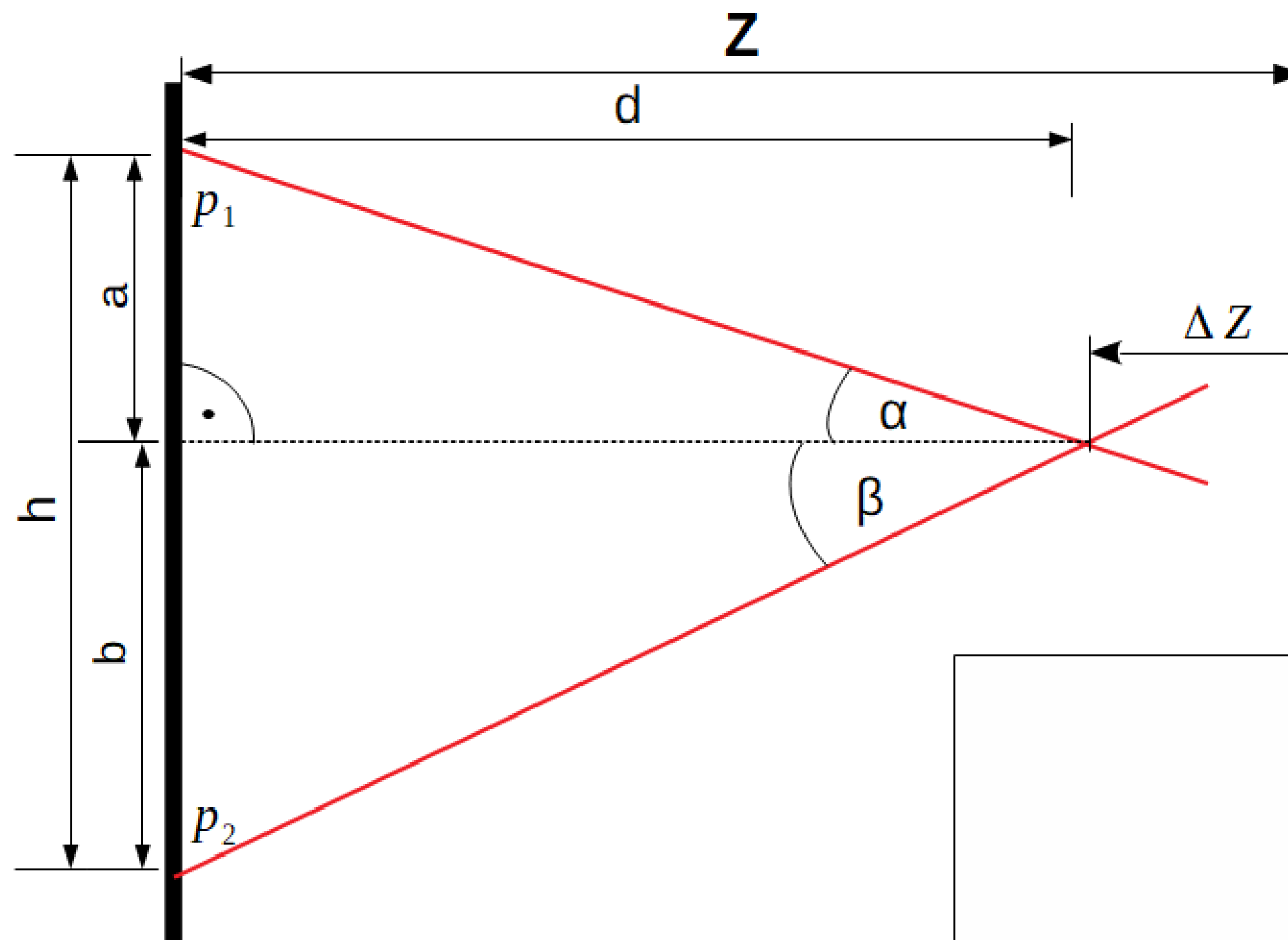
The dependence of image resolution on the distance from camera to the screen was determined by repeated measurement of known value for different distance



Graph od resolution cm/pix from distance



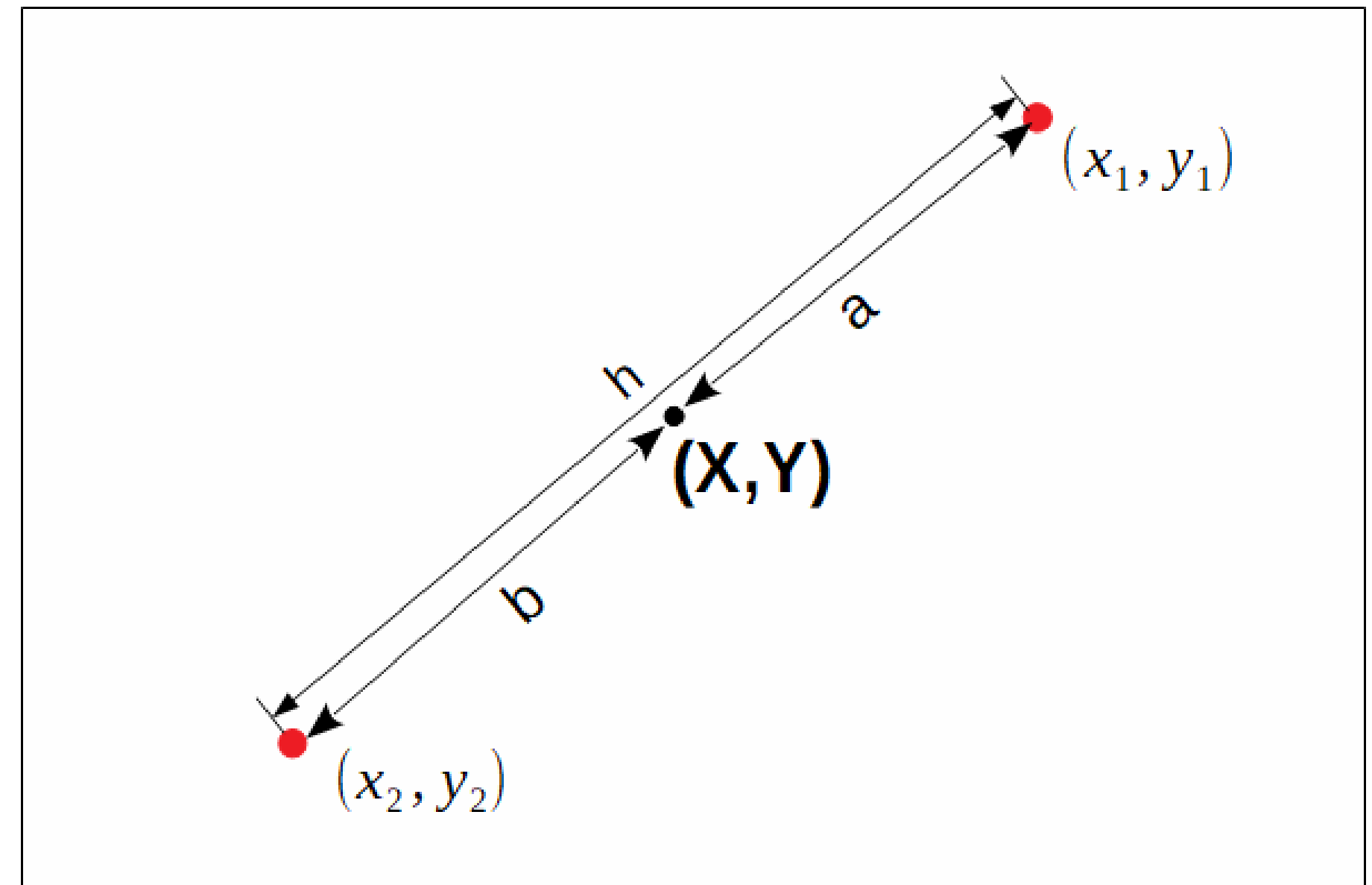
5) Determining the position of indicator



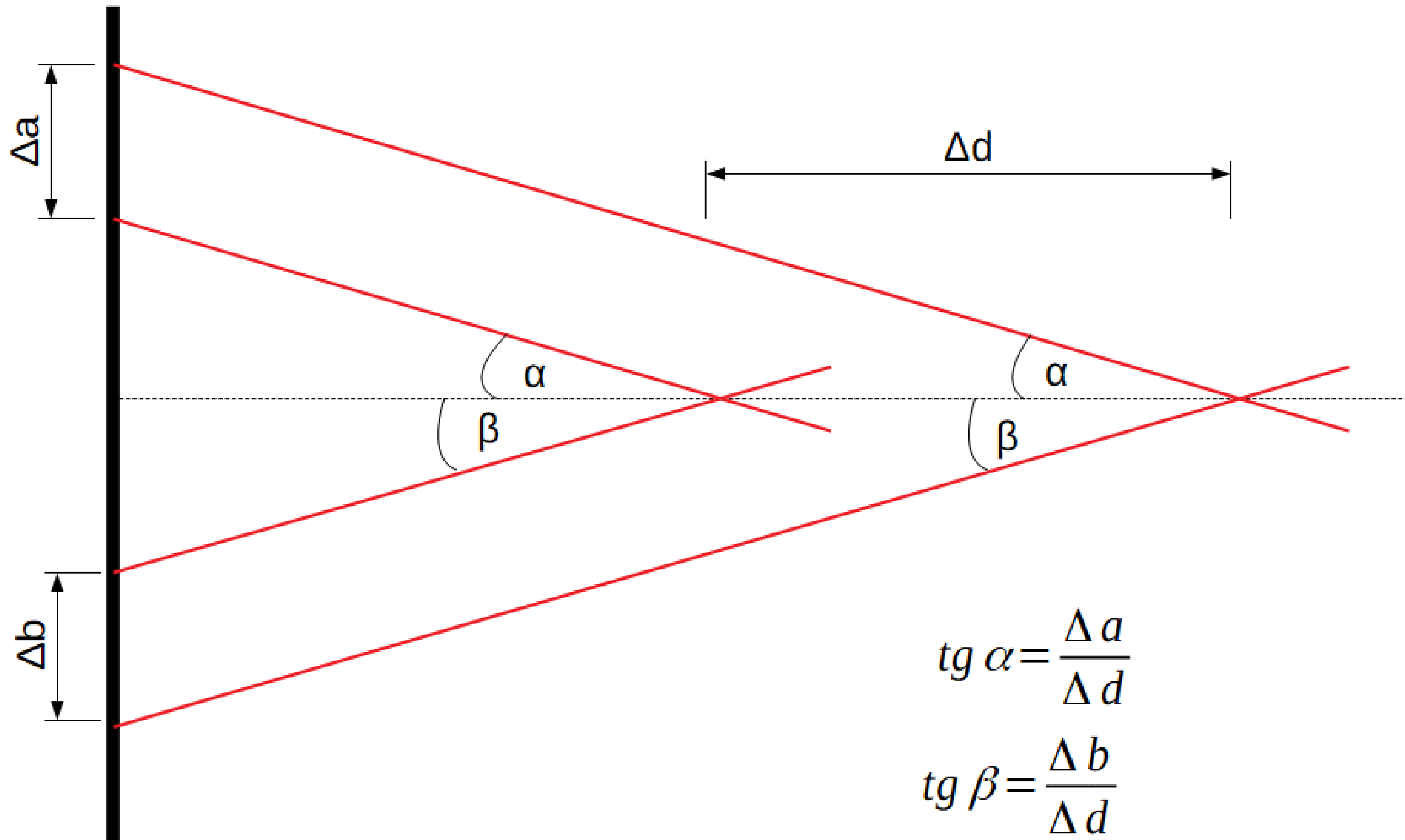
$$X = x_1 - (x_1 - x_2) \frac{\operatorname{tg} \alpha}{\operatorname{tg} \alpha + \operatorname{tg} \beta}$$

$$Y = y_1 - (y_1 - y_2) \frac{\operatorname{tg} \alpha}{\operatorname{tg} \alpha + \operatorname{tg} \beta}$$

$$Z = \frac{h}{\operatorname{tg} \alpha + \operatorname{tg} \beta} + \Delta Z$$



5) Wyznaczenie położenia czujnika – kalibracja



Goals to be achieved

- Teoretical model using three lasers beams to reduce sensitivity to angle changes
- Estimation of the impact of the system on the magnetic field
- System integration with other elements of the scanner
- Determination of measurement uncertainty

The End