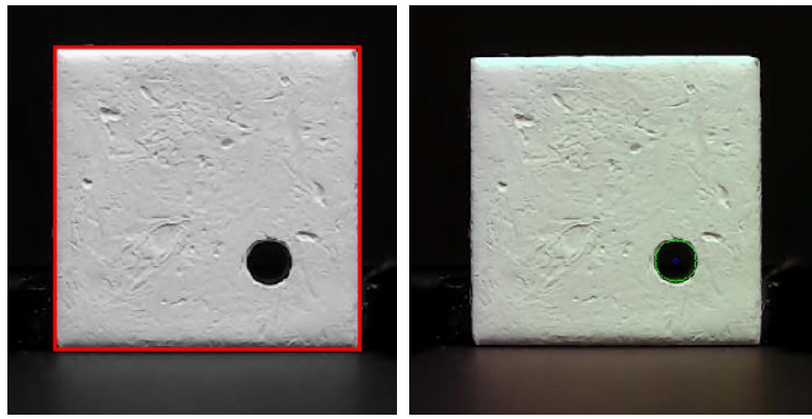
scintillator cubes image analysis

2019.12.10 Mao Tani

what is my work

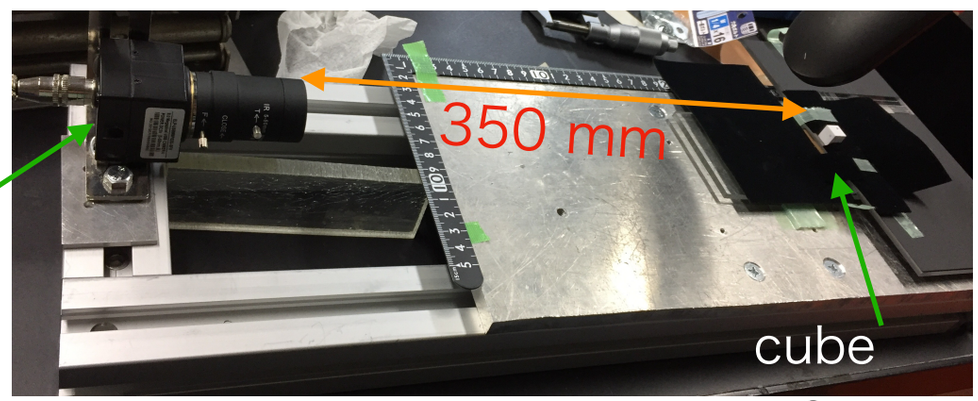
- Quality check of scintillator cubes for super-FGD.

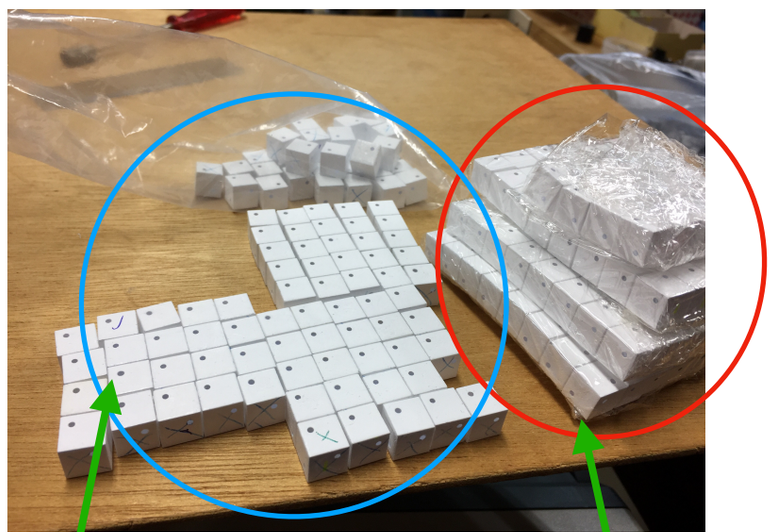
- Take pictures of cubes, then get the information of cube size, position and radius of hole.



- I checked 70 good + 70 bad cubes before (these are already distinguished by manual quality check in Russia).

previous system

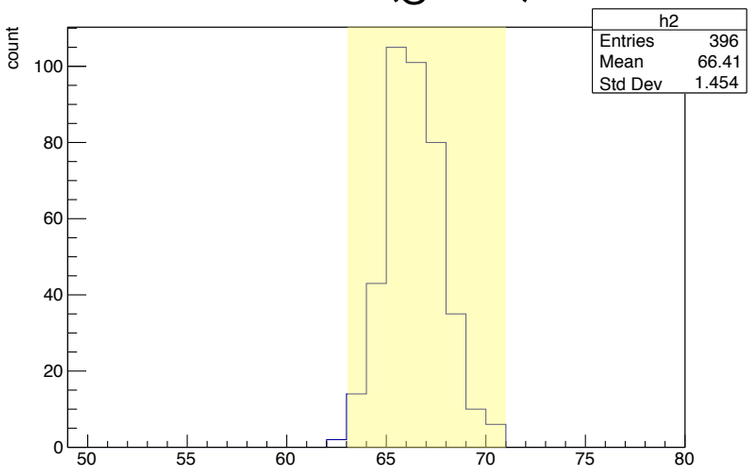




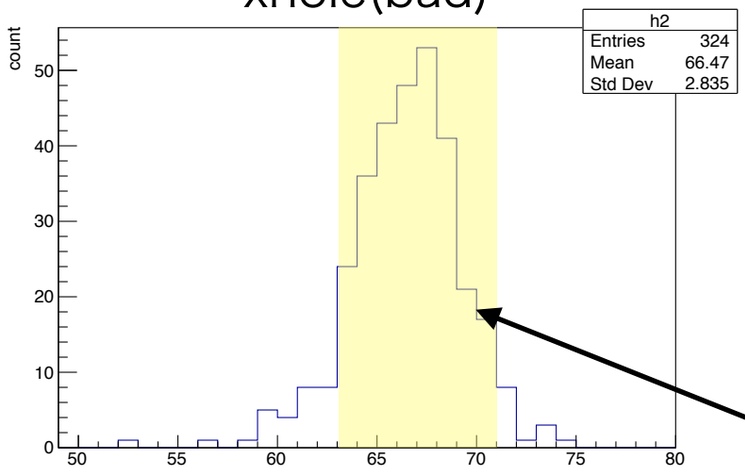
analysis of good / bad cubes (previous theme)

- each 70 good / bad cubes analysis
  - get distribution about cube size, position and radius of hole
  - cut the bad-cube distribution referring to good cubes' one.

xhole(good)

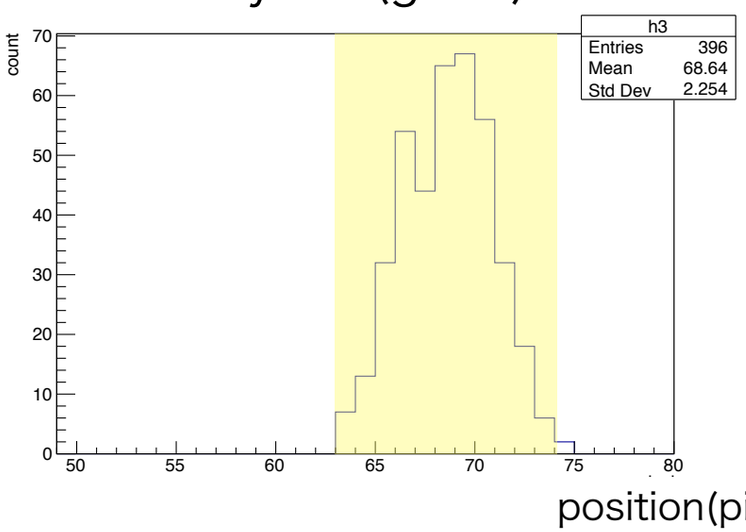


xhole(bad)

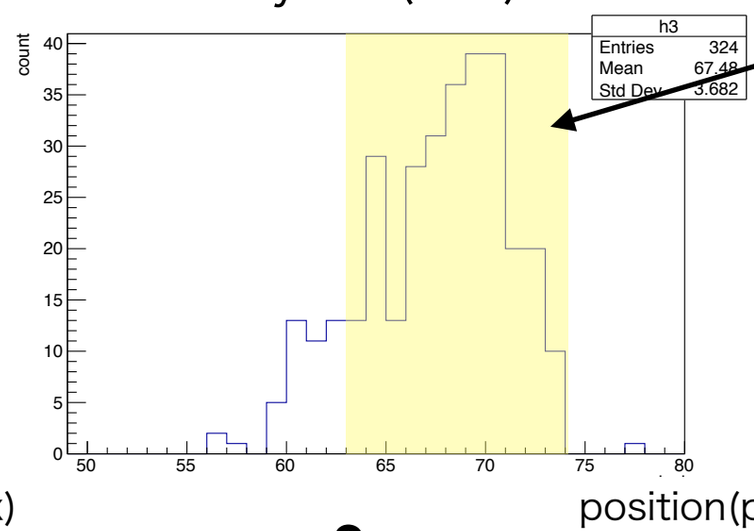


ex) distributions about position of hole

yhole(good)



yhole(bad)



decide the cut area comparing good and bad distribution.

good : 70 cubes -> 62 cubes

bad : 70 cubes -> 15 cubes

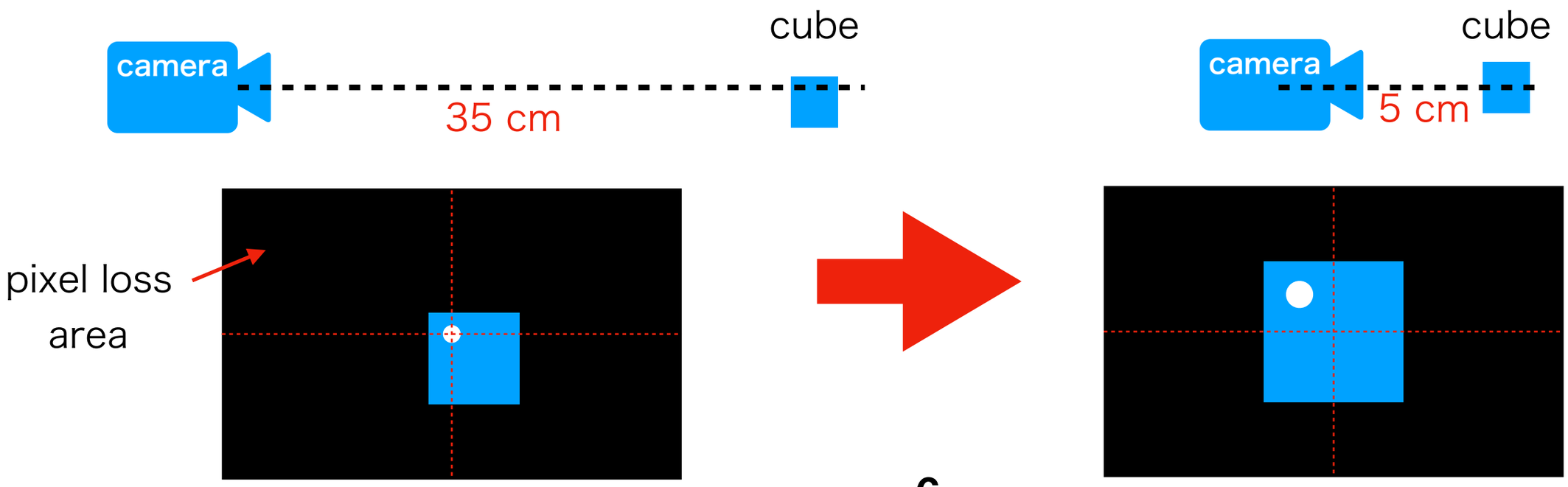
Today's topic

- Improvement of photographic system
  - change the geometry, focal distance
    - Introduce extender (rear converter)
    - Introduce LED ring light
- Improvement of analysis codes
- Plan of three-dimension photographic system

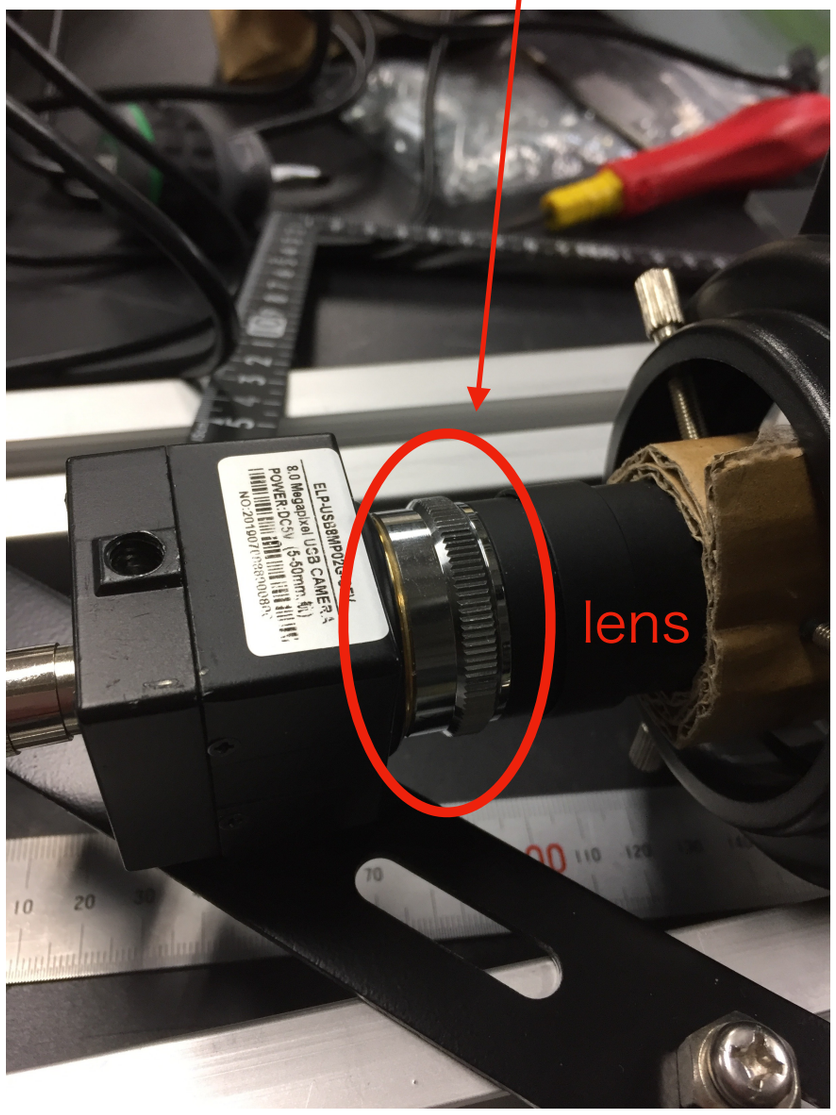
Improvement of photographic system

focal distance

- To reduce the influence of parallax (視差) inside of the hole, images have been taken at long range (~35 cm).
- However, in this manner there are much pixel loss.
- Changed the focal range (35 cm → 5 cm).
  - We were focused on the center of hole (left) before, now the lens axis is set to the center of cube surface (right)

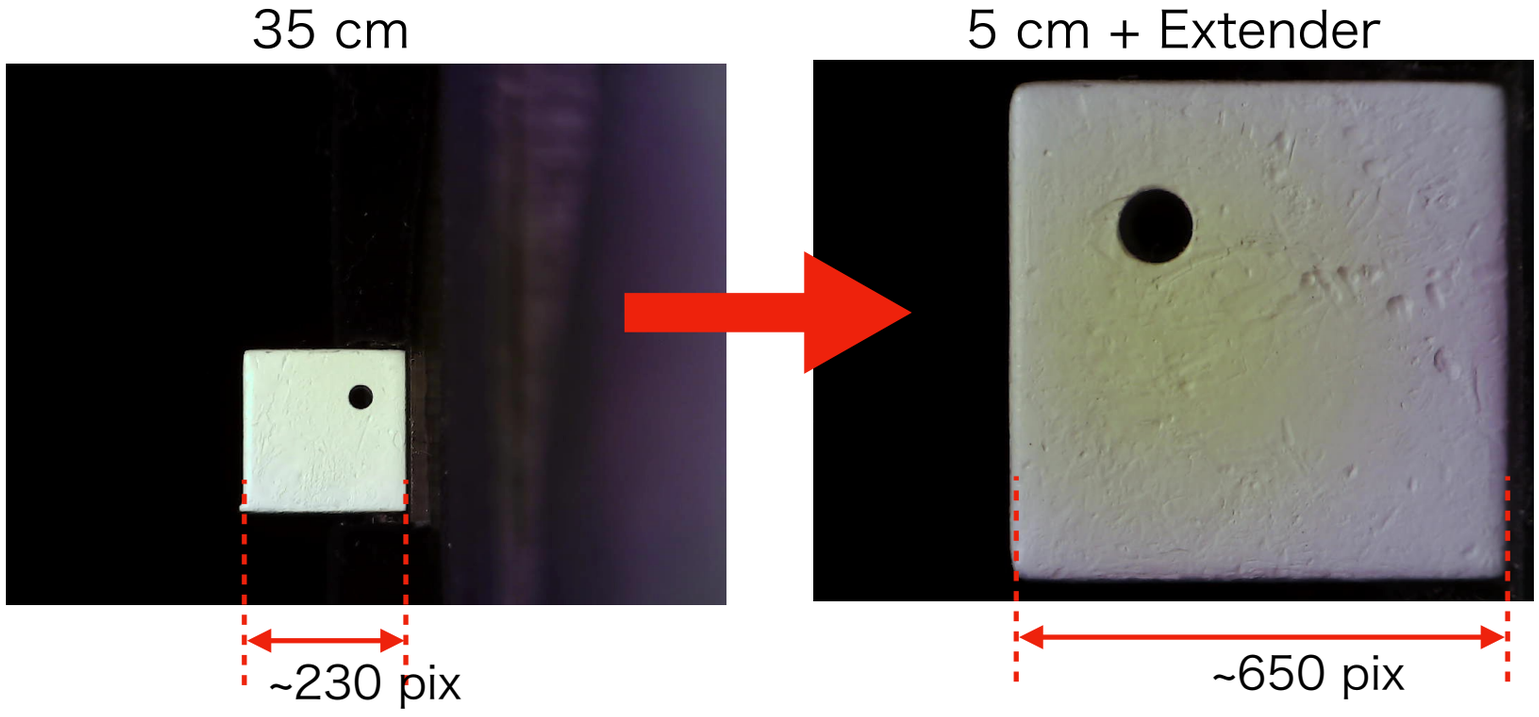


Extender (rear converter)



- By using extender, the image of cube got more enlarged.

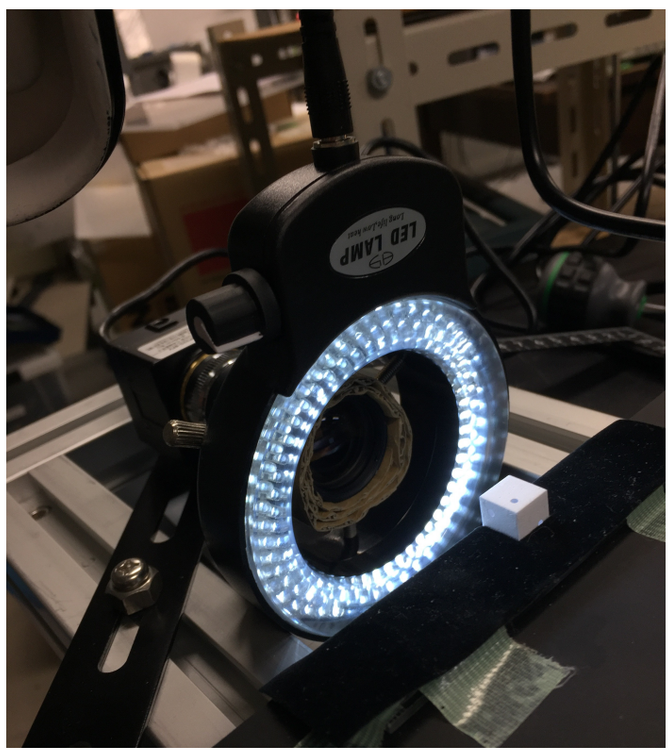
X2 TV EXTENDER JAPAN



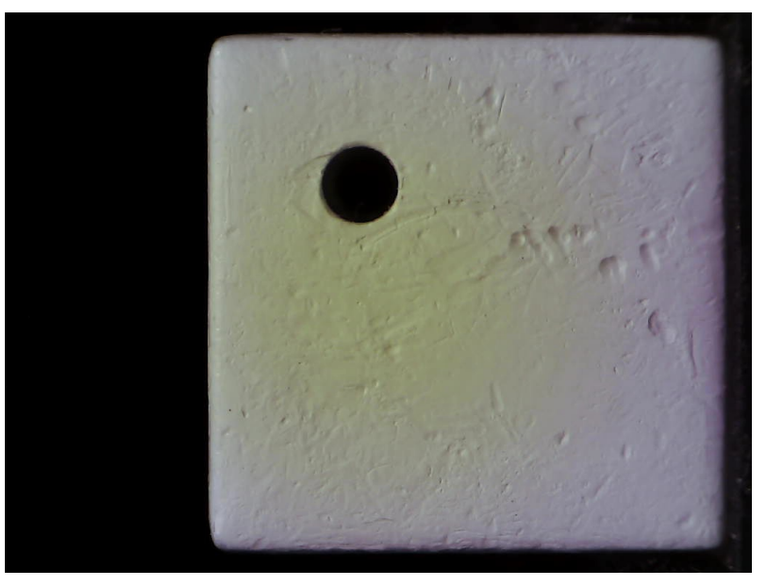
ring light

- As a light source, a desk lamp was used before, but now we started to use LED ring light to shine the whole surface equally.

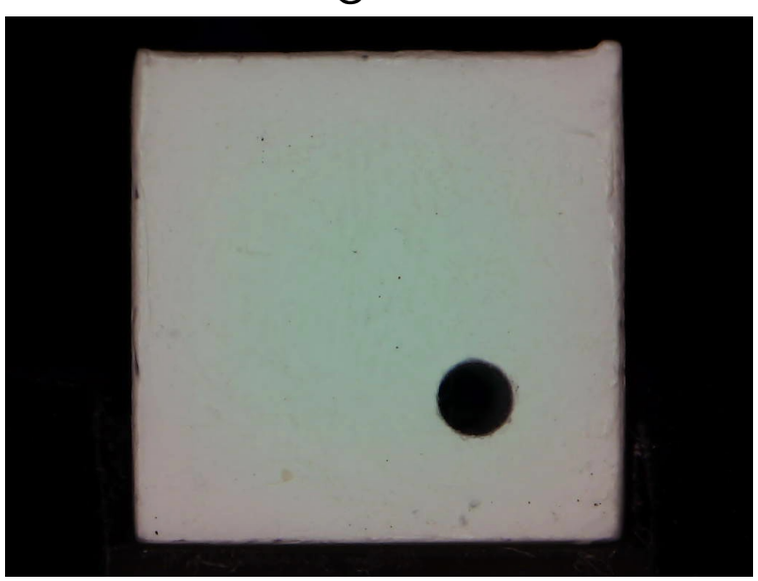
- By using ring light, bumps on the surface got unnoticeable, which stood out with the desk lamp. Similarly, contours got independent of the direction of light.



蛍光灯



ring LED



Improvement of analysis codes

Improvement of accuracy of hole detection

- Previously we have detected holes automatically with the function ‘Hough Circle’ in openCV that is a library of python : (0 or 255)

  1. binarization (0 or 255)

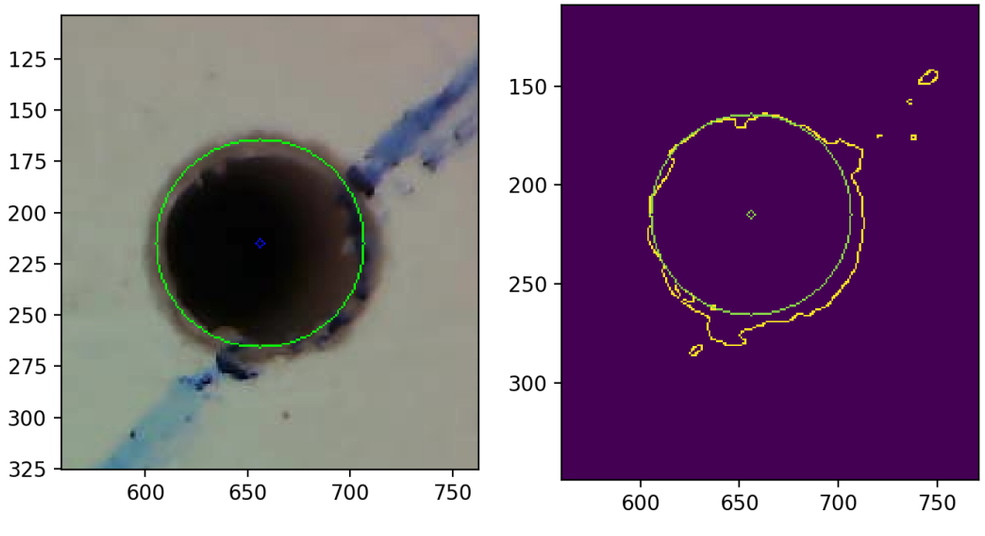
     need to decide threshold value (~100)

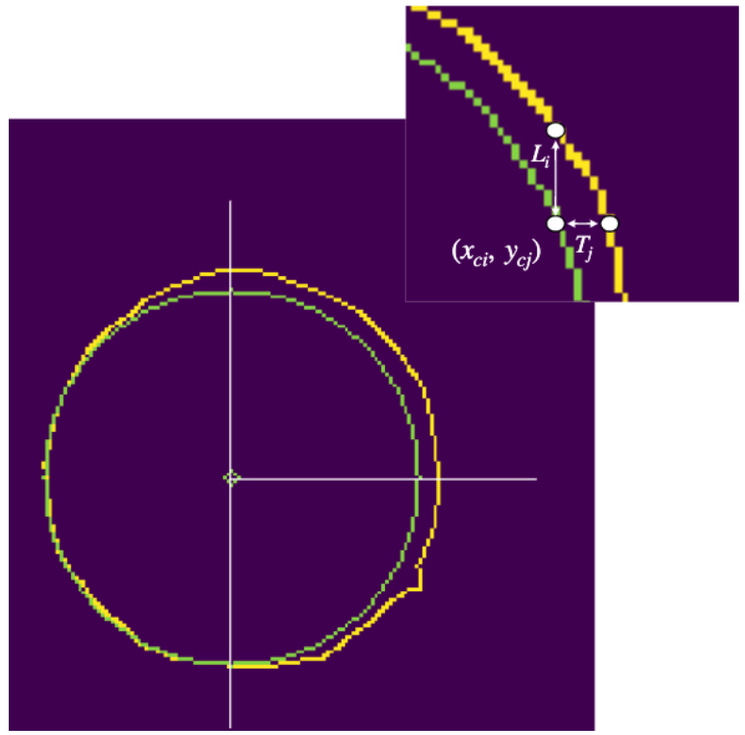
  2. edge detection

  3. automatic circle detection

- Improve the hole-detection accuracy with certain correction.

Hough Circles





green : detected circle

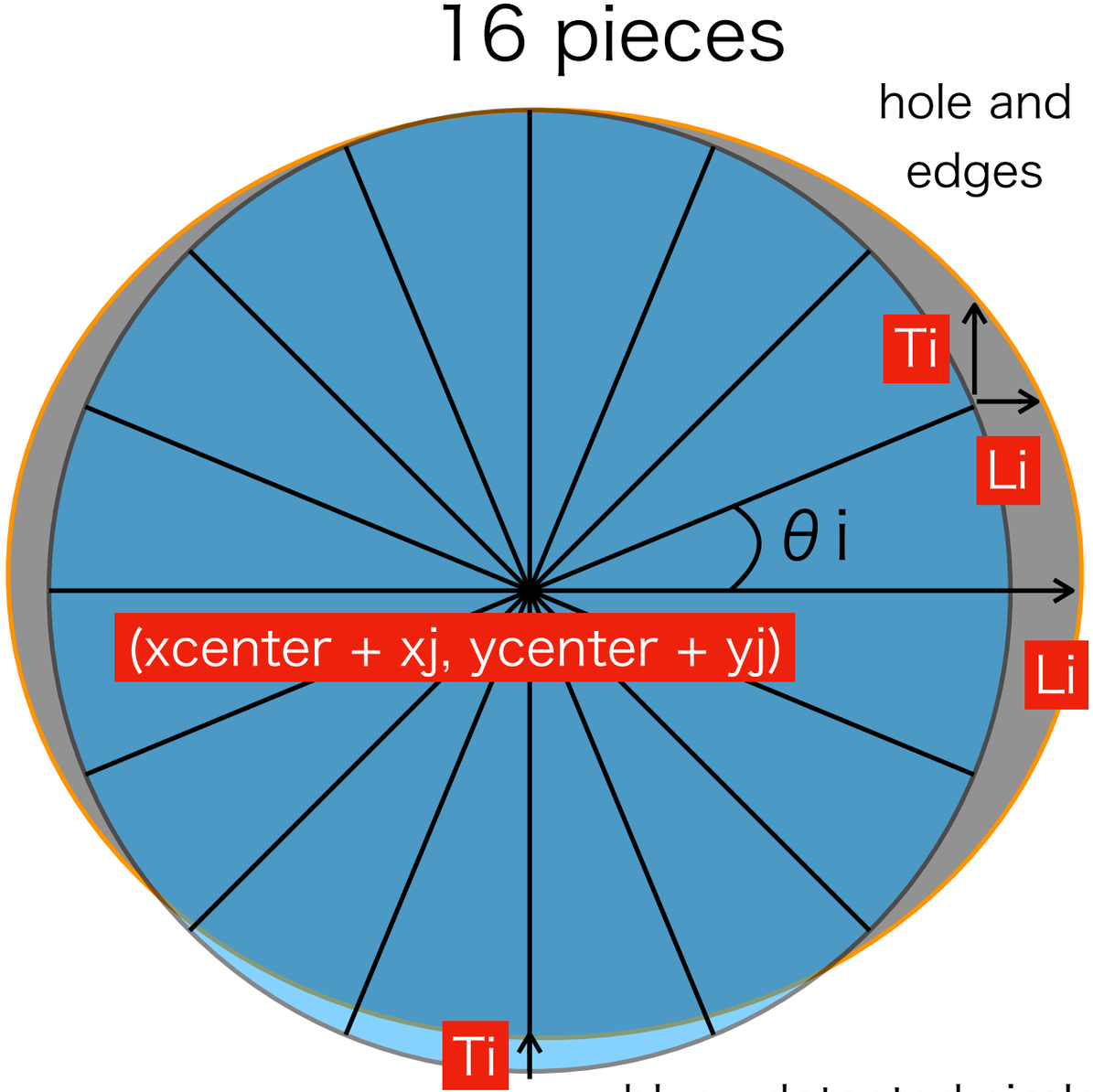
yellow : edges of hole

minimization of distance between circle and edge

- equally devide the circumference (into 12 ~ 16 pieces)
- sum the longitudinal and lateral distance to edge : E = Σ(Ti+Li)
  - use only Li, Ti for θi = 0 or π, θi = π/2 or 3π/2 respectively.
  - if there are some edges in the same direction, use the farther one.
- move the center of hole one by one (xj, yj), and increase the radius by 1, minimize E = Σ(Ti+Li).

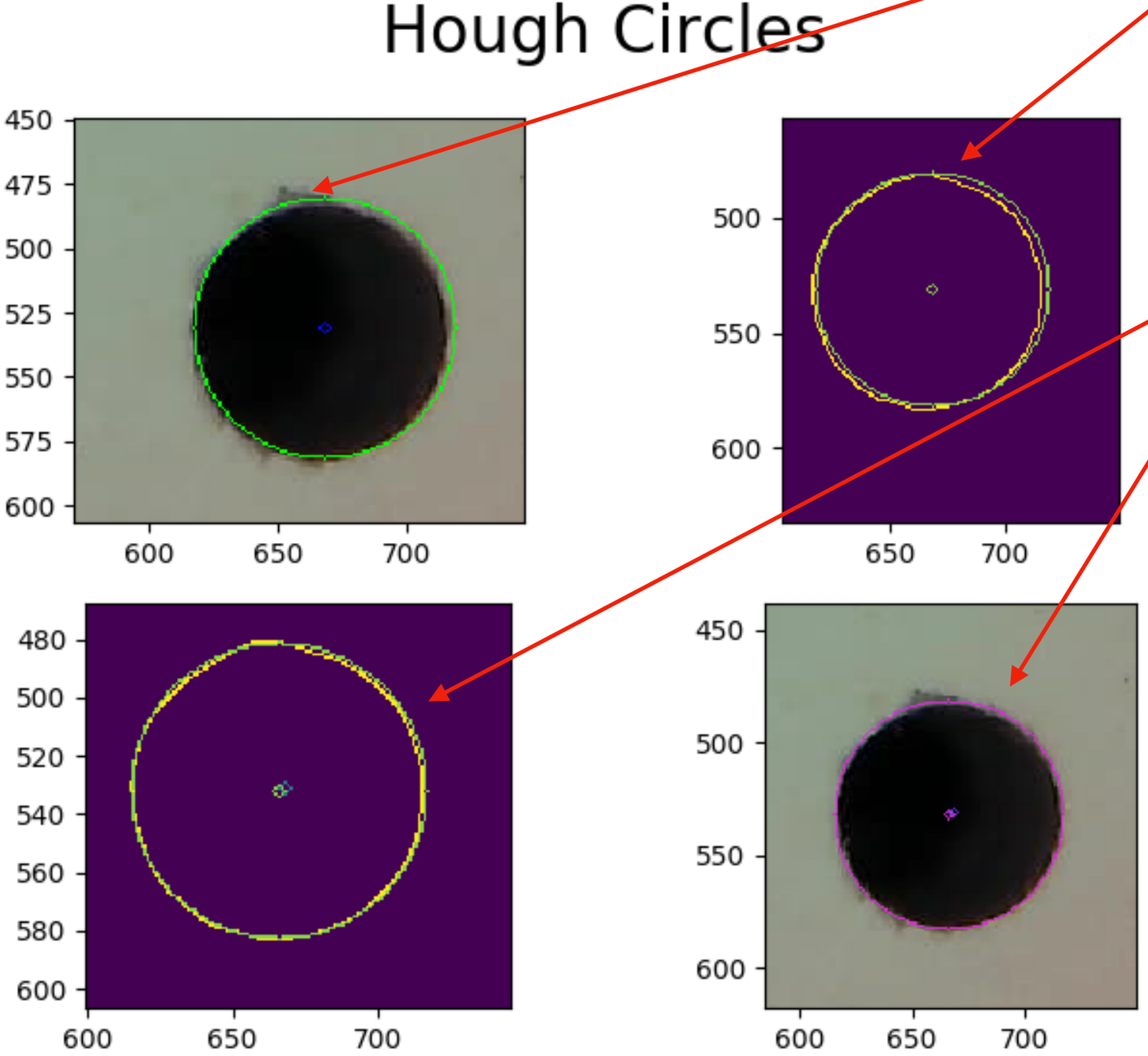
search area : $-5 \le x_j \le +5,\ -5 \le y_i \le +5$

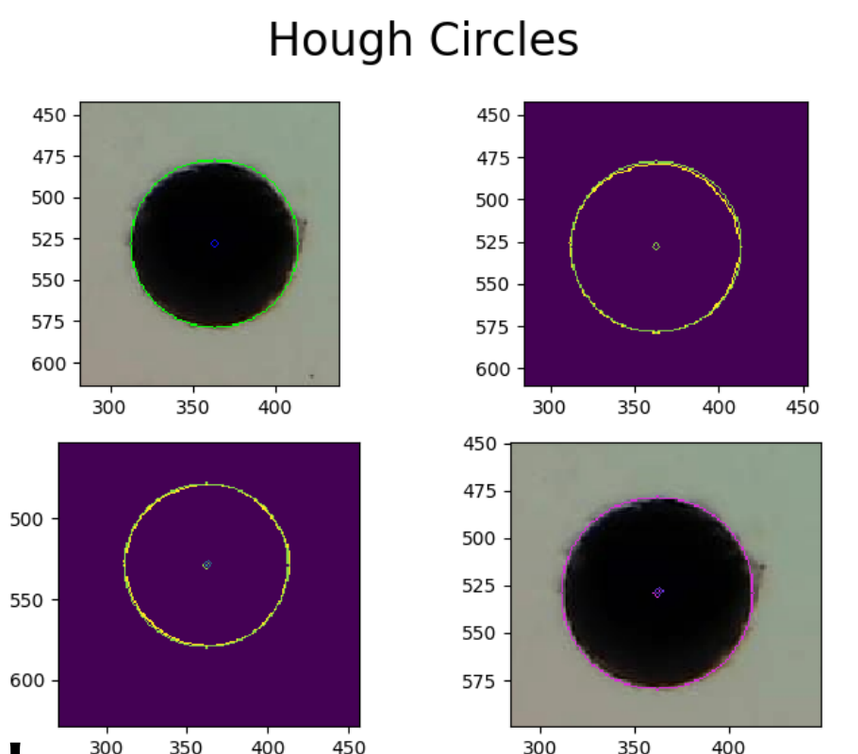
search radius : $r = r_0 + \delta r,\ 0 \le \delta r \le 5$



Example of ‘good’ hole

- upper row : detect hole by Hough circle transformation (green) (yellow : edge)
- bottom : edge (yellow) , circle after E minimization (green and pink)



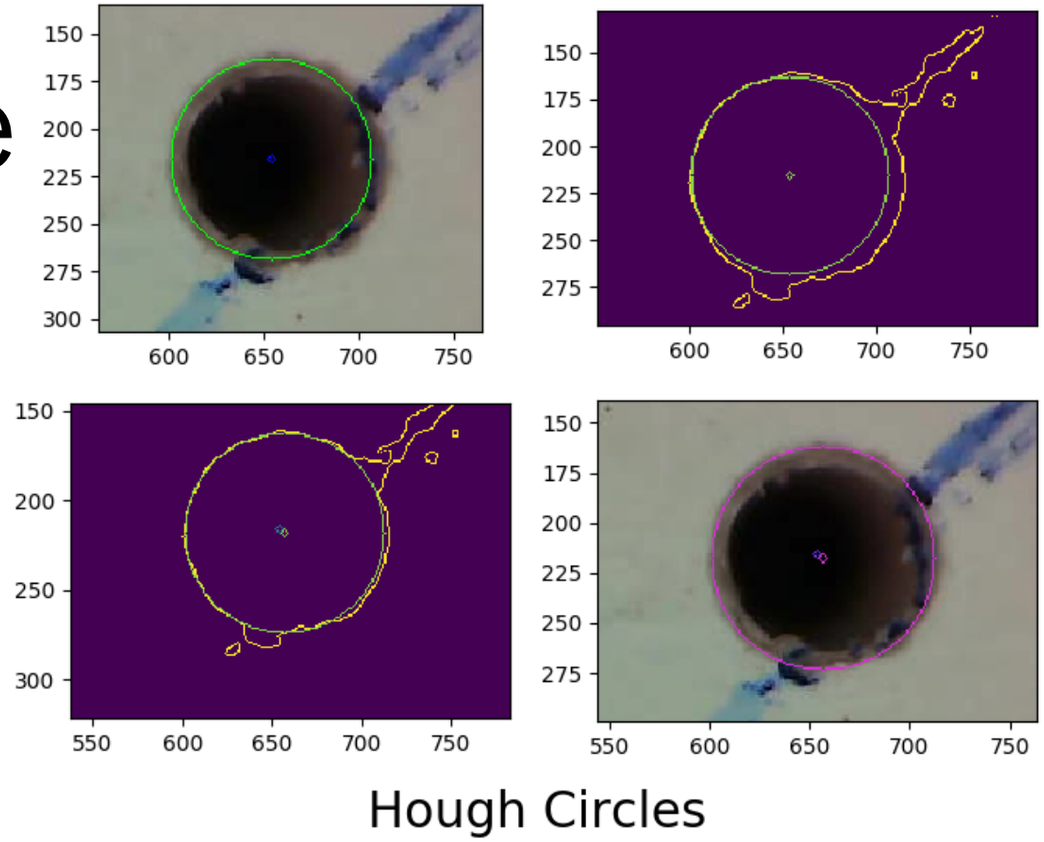


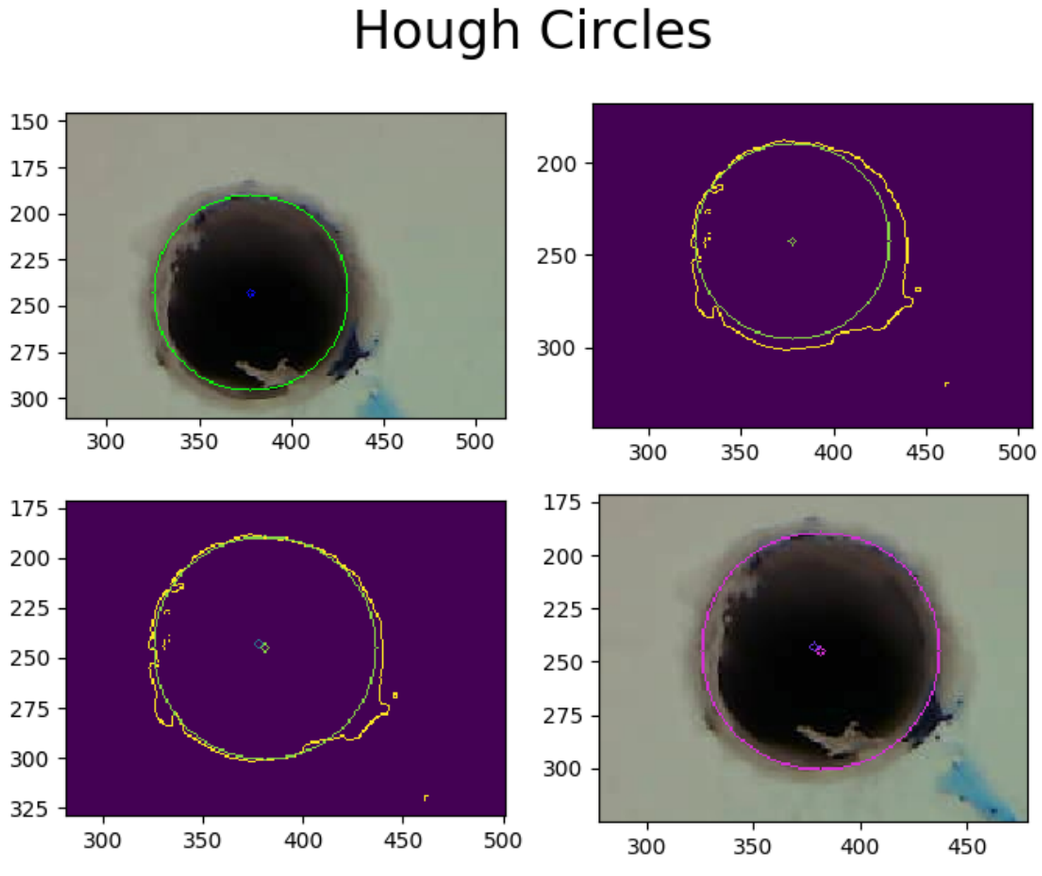
for ‘good’ hole, this corrections succeed

Example of ‘bad’ hole

- If there is a ‘good’ edge, we get accurate center of hole by correction.

- Since we have to scan for many times, it takes time (~ 5 sec)

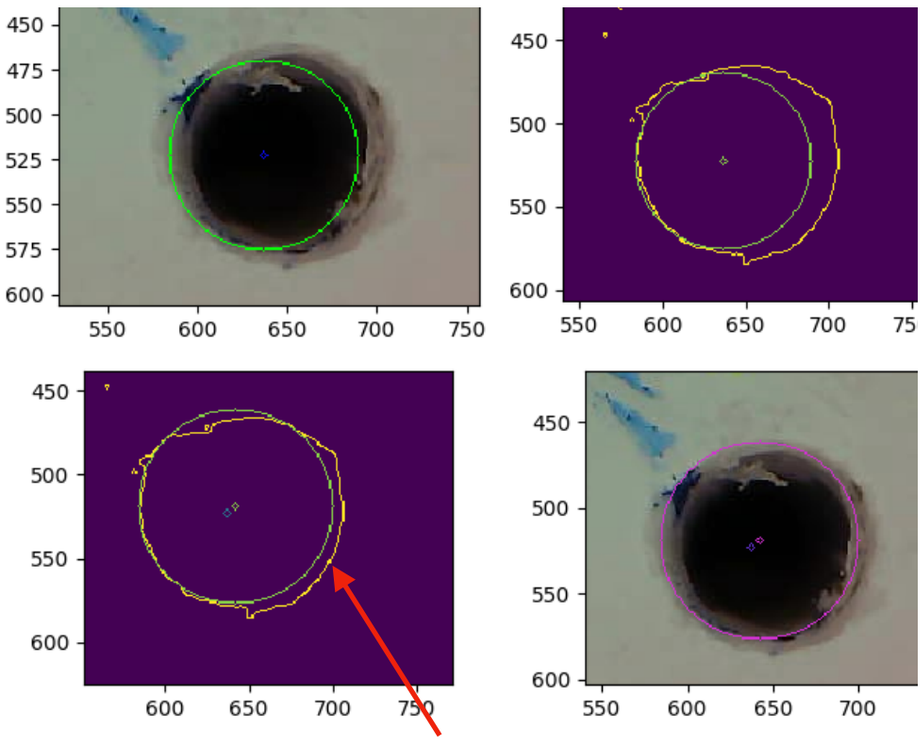




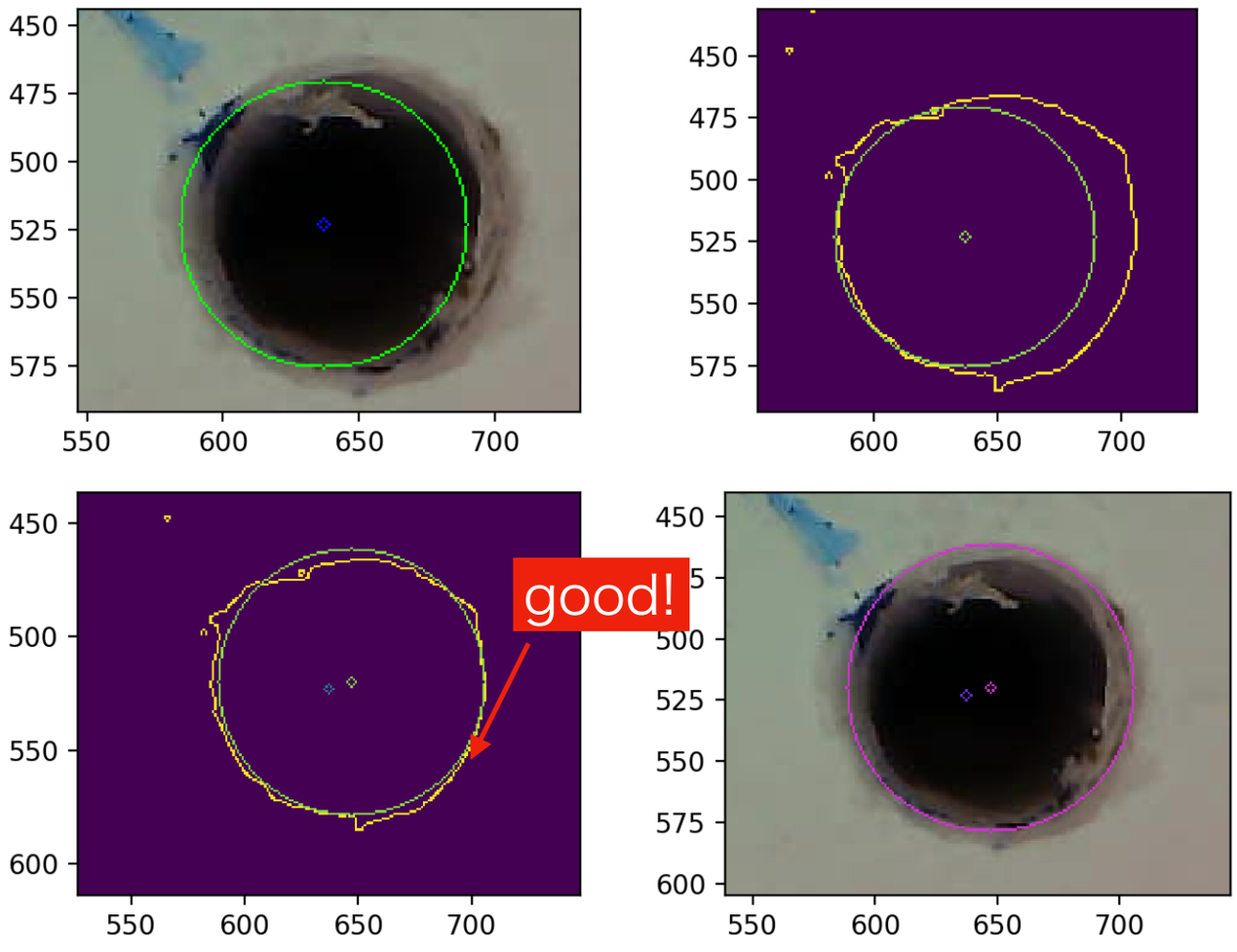
upper row : before correction
bottom row : after correction
(for each image matrix)

Example that could not get ideal center

for big edge, it is difficult
to correct the circle.



- enlarged the search area, then succeeded (bottom image)
- center (xcenter+9, ycenter-4), radius r = r0+6



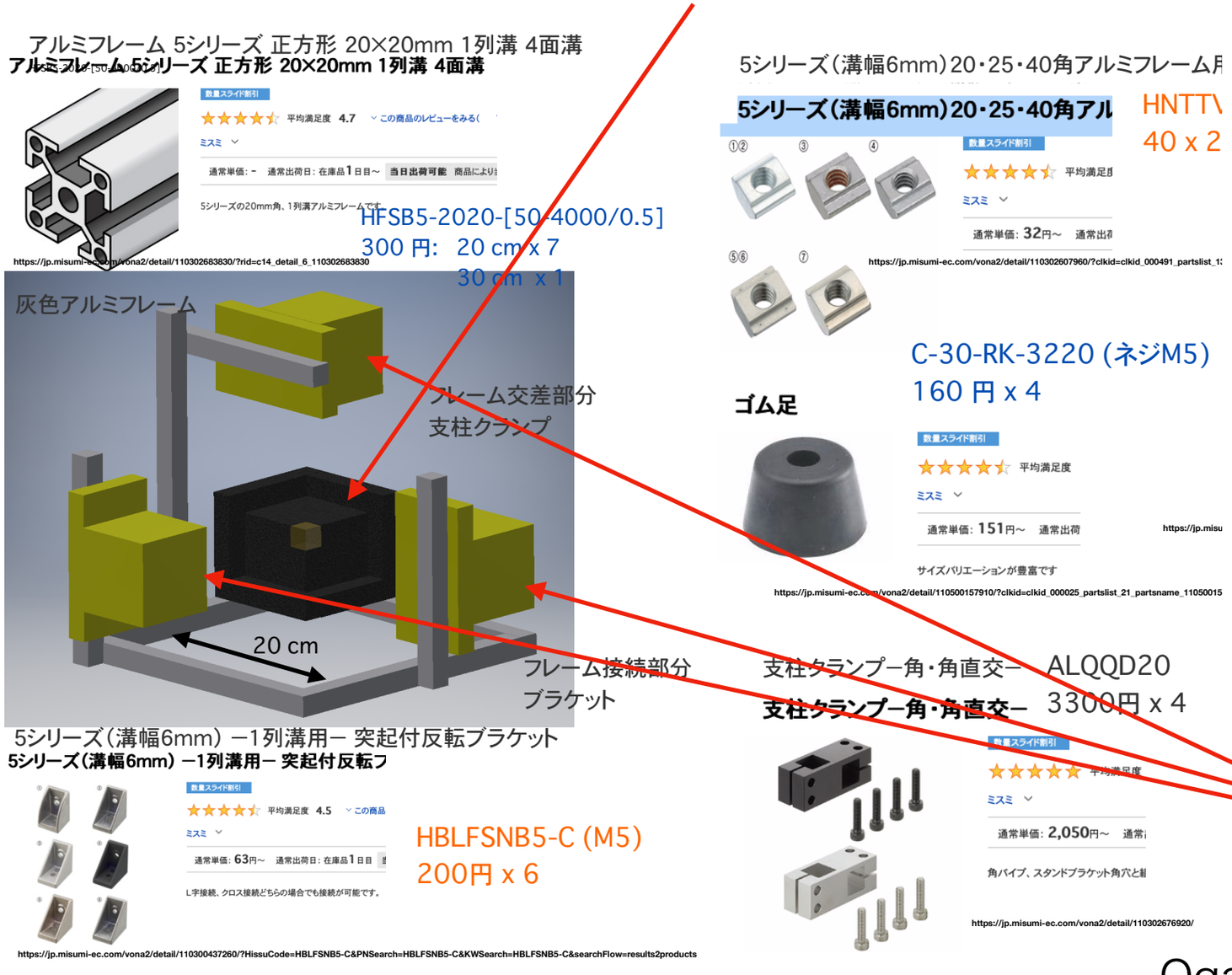
upper row : before correction
bottom row : after correction
(for each image matrix)

because of increment of scan area it takes more time (~25 sec)

plan of 3 dimensional photography jig

photography jig

- we will make a 3 dimensional photography jig (left image)



- order photography platform and camera box

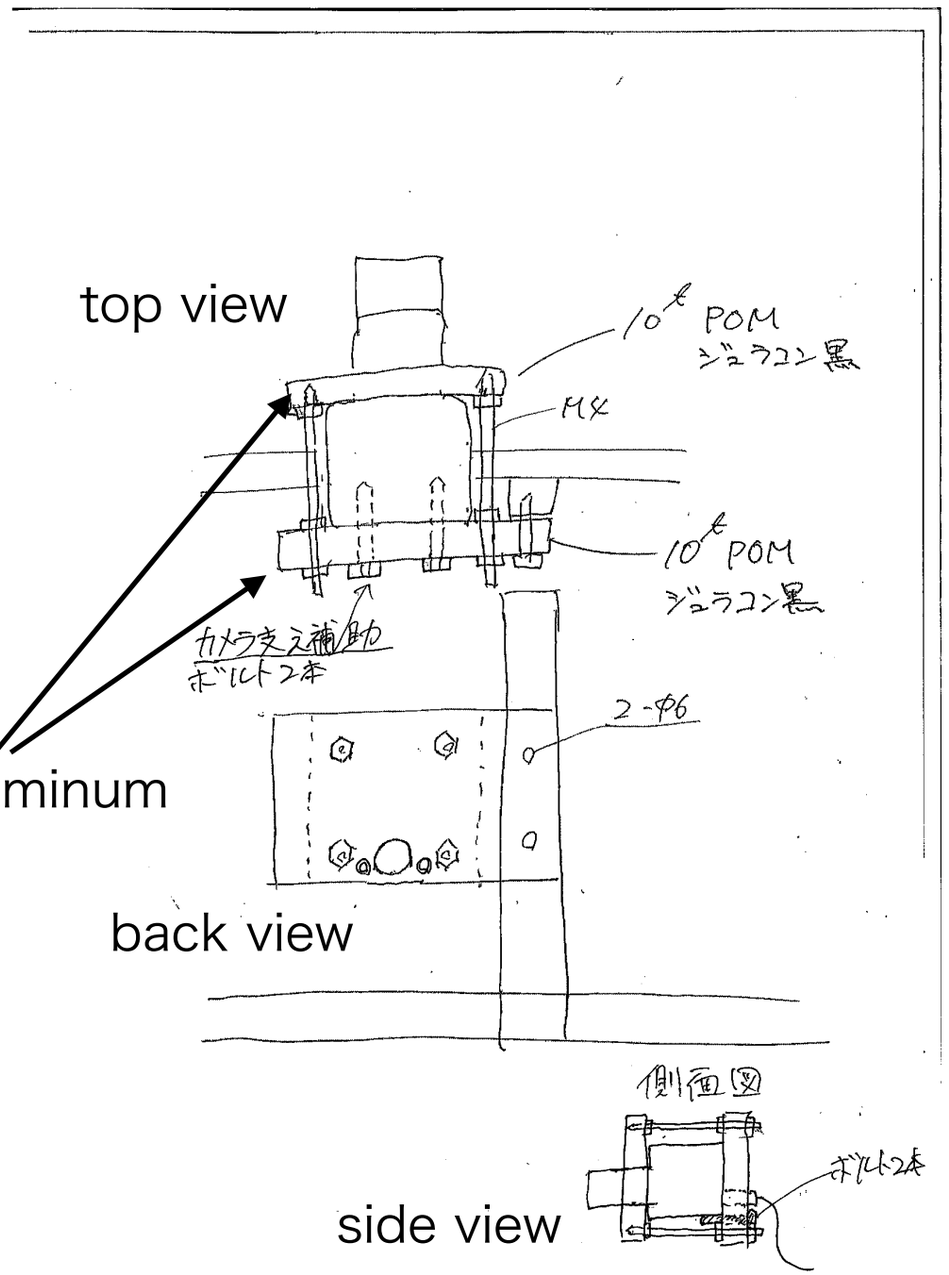
camera box

Ogawa-san's slide

camera box

body of this camera is not a rectangluar, but this area protrudes.

backside and frontside look parallel, so consider such a camera jig (right image)



conclusion

- improved photographic system and equipments
- succeed to correct the detected hole of cube
- going to make a new photography jig