Beam position monitor system (Pcal camera system)

17’8.29
F2FMT@Toyama Uni.

TAKAHARU SHISHIDO[1,2]

S. HAINO[3], Y. INOUE[2,3], N. KANDA[5], B. HSIEH[4] , T. TOMARU[1,2], T. YAMAMOTO[4], T. YOKOZAWA[5]

THE GRADUATE UNIVERSITY FOR ADVANCED STUDIES[1]
HIGH ENERGY ACCELERATOR RESEARCH ORGANIZATION (KEK)[1,2]
ACADEMIA SINICA, TAIWAN[3]
ICRR, THE UNIVERSITY OF TOKYO[4]
OSAKA CITY UNIVERSITY[5]

Outline

- Motivation of Beam position monitor
- Beam position monitor system
- Issues to be solved
- Resolution of camera and aberration
- Distortion of this system and analysis
- Results
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Motivation of Beam position monitor

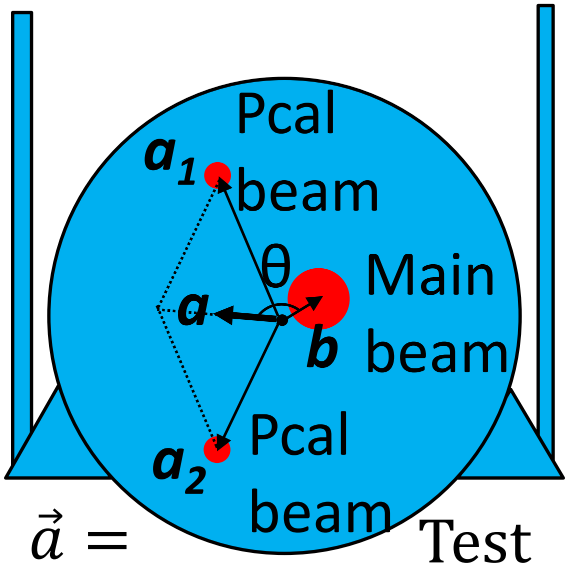
$$x(f) = \frac{2\,\mathrm{P}(f)\cos\theta}{c}\,\mathrm{S}(f)\left(1 + \frac{M}{I}(\boldsymbol{a}\cdot\boldsymbol{b})\right)$$

1%

Laser power — 0.7% ※ achieved by LIGO Pcal

Transfer function

Geometric factor — 0.5%



$\vec{a} = (\vec{a}_1 + \vec{a}_2)/2$

Requirement of calibration

Systematic error of mirror displacement is required within 1%.

Error on Geometric factor < 0.5%

→ beam position error < 2.5mm

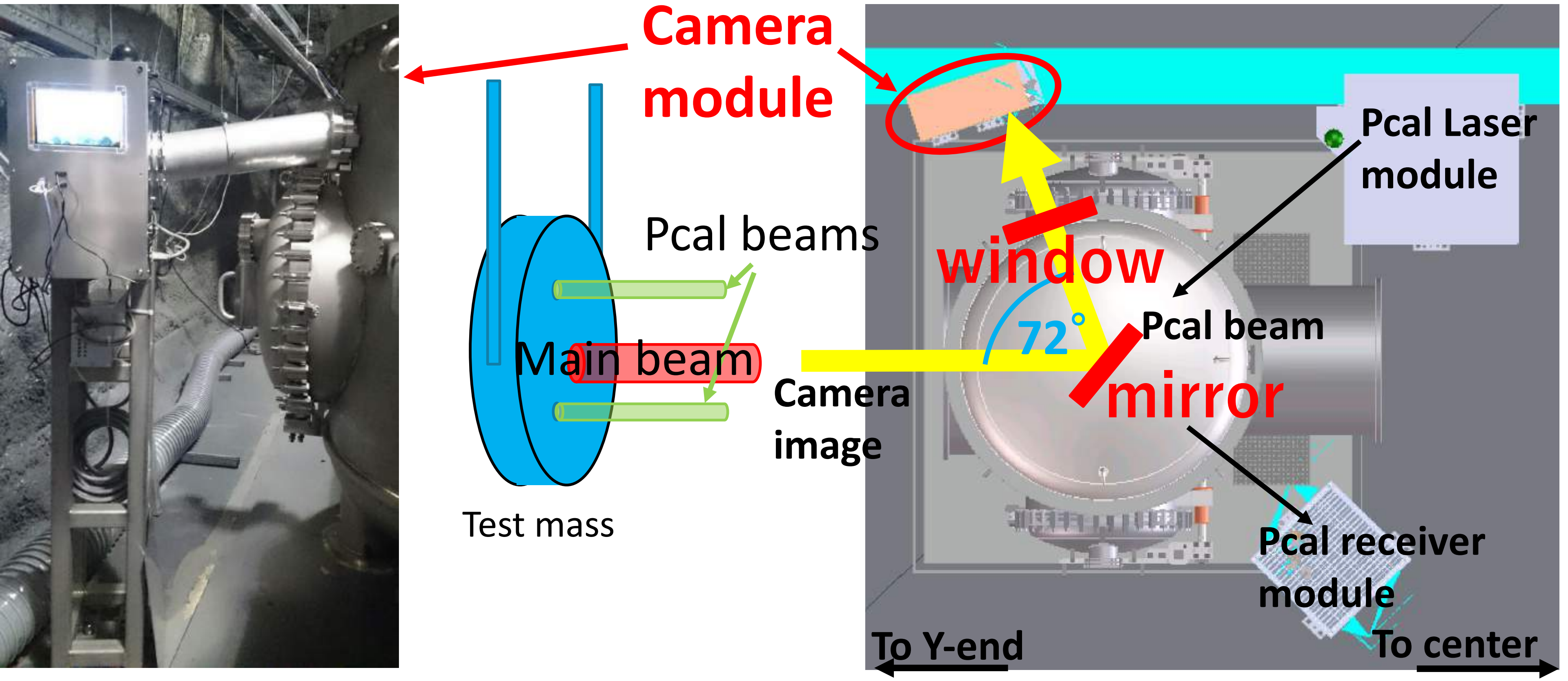
→We have to monitor beams position

Beam position monitor system

Purpose of this system

→ to monitor correct beam position toward ETM

to observe cryogenic ETM position and surface



To satisfy the requirement we study resolution and aberration.

Issues to be solved

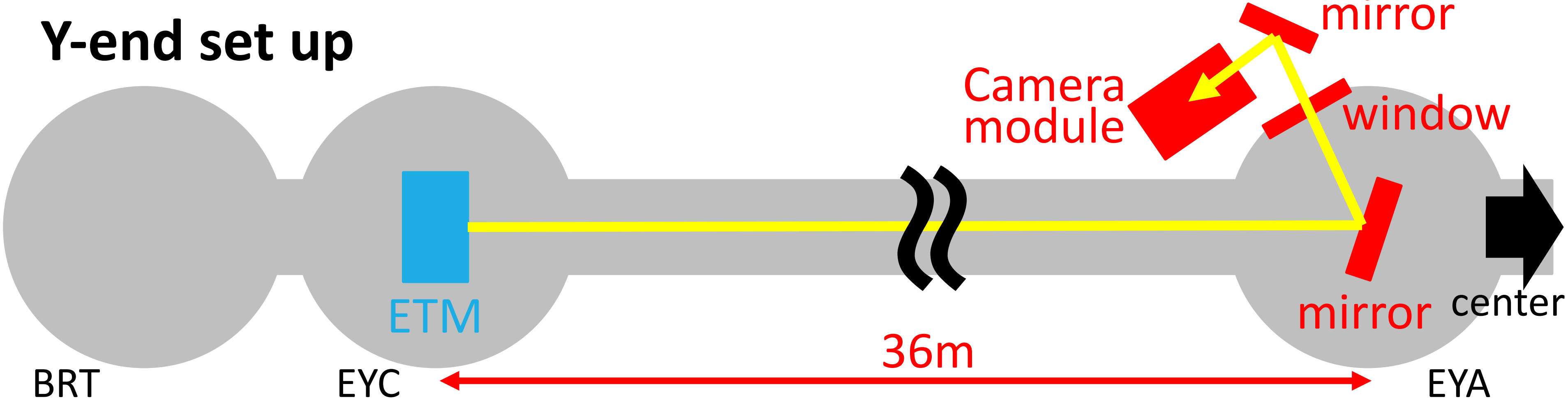
1. Images may be distorted by aberration of mirrors and window

→we have to evaluate the aberration

2. Pcal modules are 36m away from ETM so beam position may drift

→we have to monitor and control beam position

Y-end set up



Resolution of camera and aberration

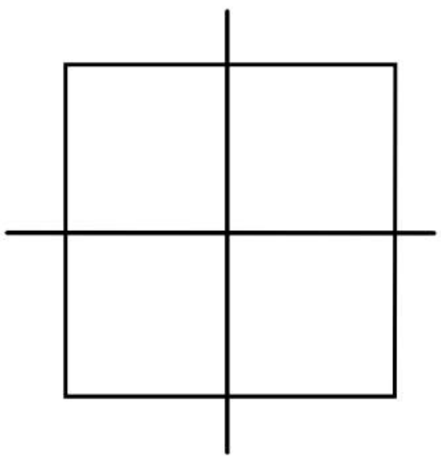
To restrain beam position error within ~2.5mm, we have to check camera resolution and aberration.

There are several kind of aberration, we focus on distortion.

▪distortion → one of the aberration to wrap an image

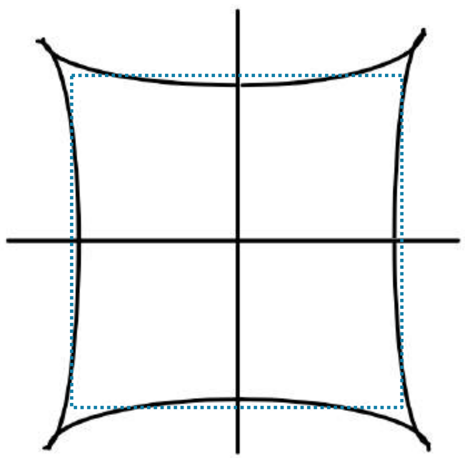
It is characterized by distortion number "D"

D=0



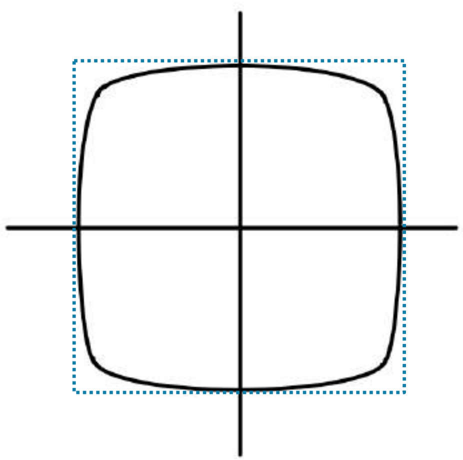
No distortion

D>0



Pincushion distortion

D<0

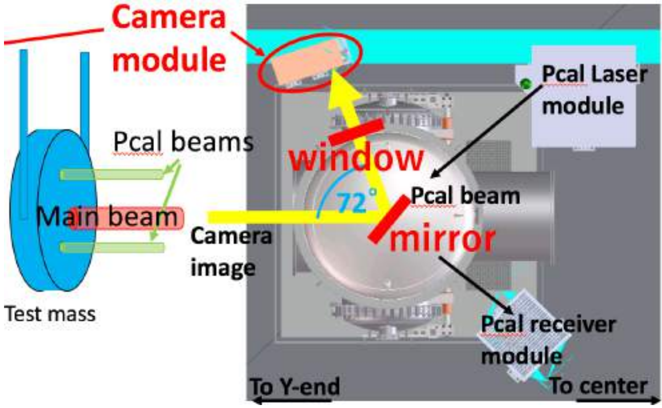


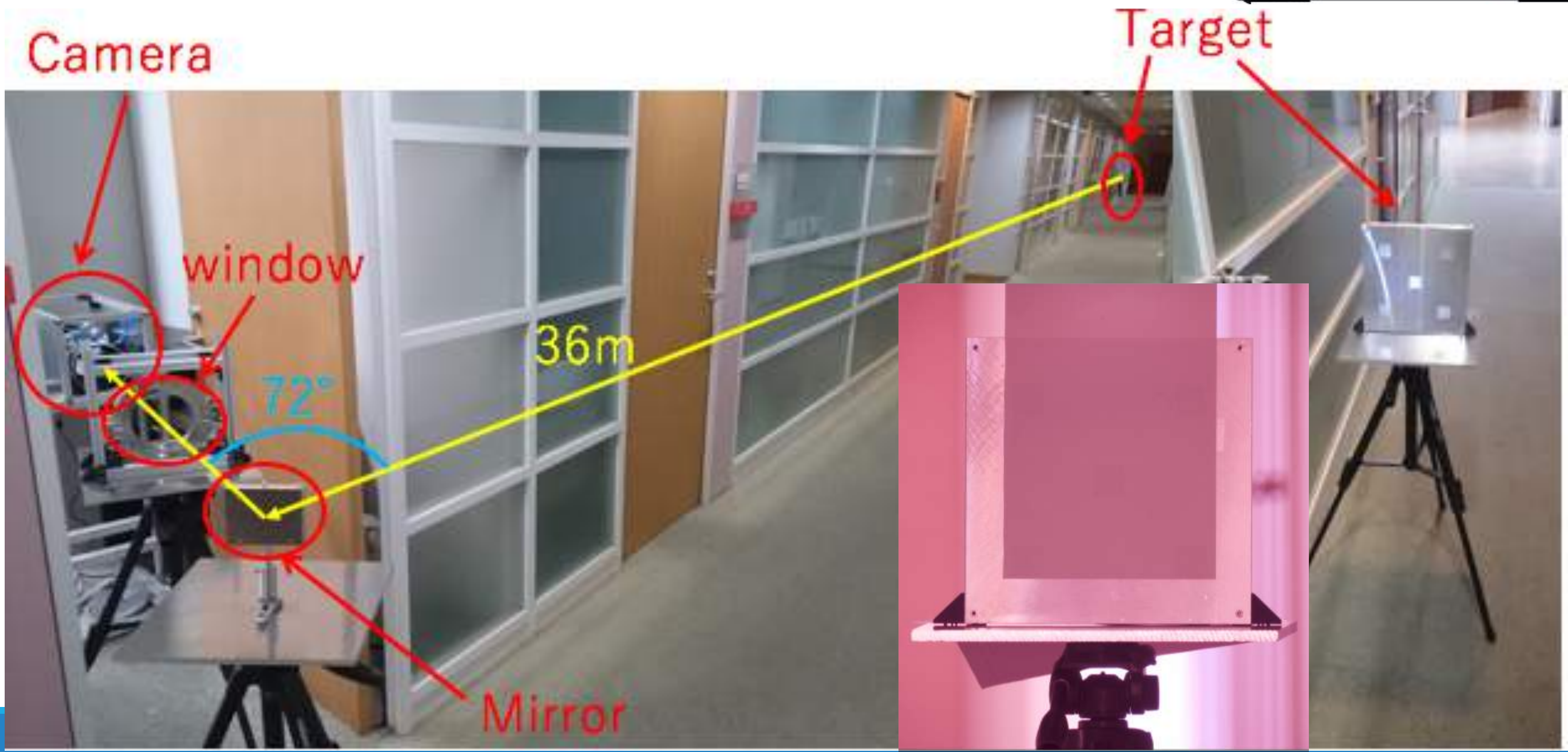
Barrel distortion

Set up for demonstration in KEK

This demonstration was held in KEK.

I put grid paper on the target and took a picture for analyzing this system distortion.





Distortion of this system and analysis

We analyze picture of grid taken by this camera system.

- Way of analysis

1. Pick up an intersection points

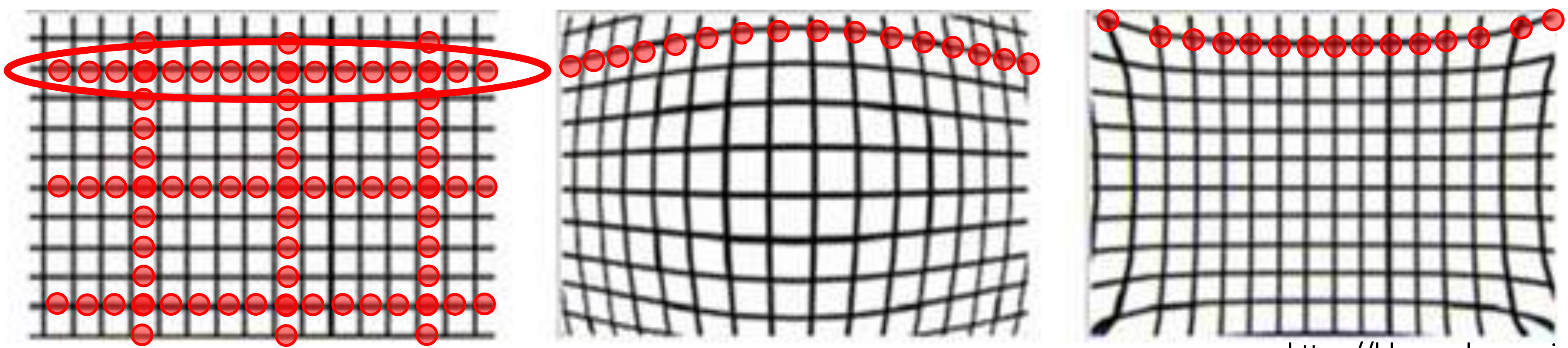
   ↓

2. fit line to them

   ↓

3. Calculate distortion number and slope

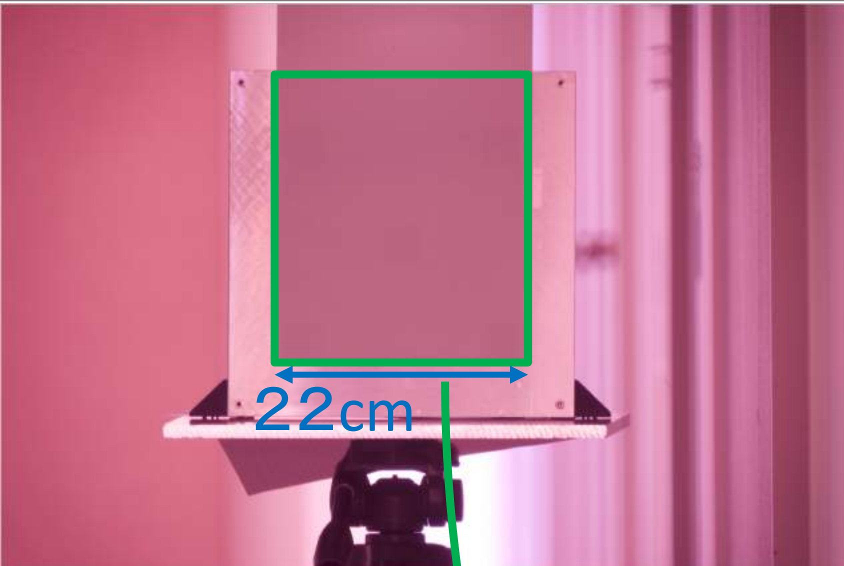
D=0 D<0 D>0

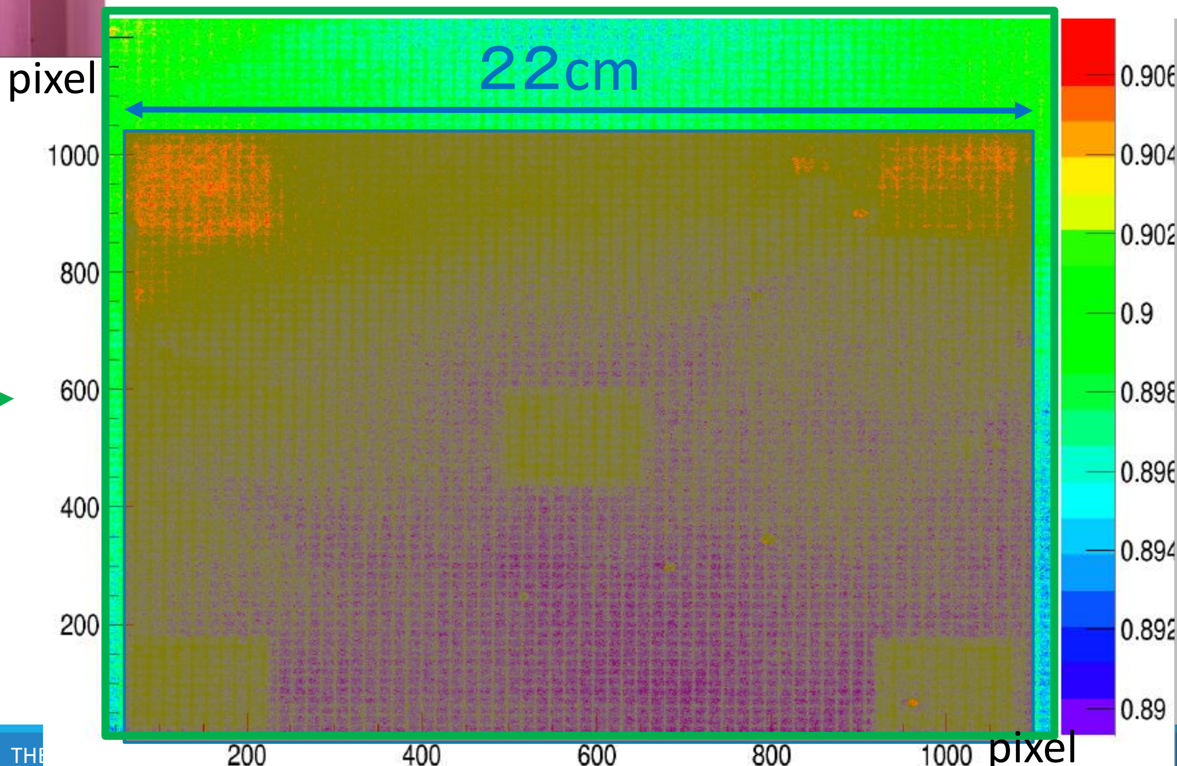


https://blogs.yahoo.co.jp/tomo_3ei/29163870.html

Results

I analyzed the area which cover ETM



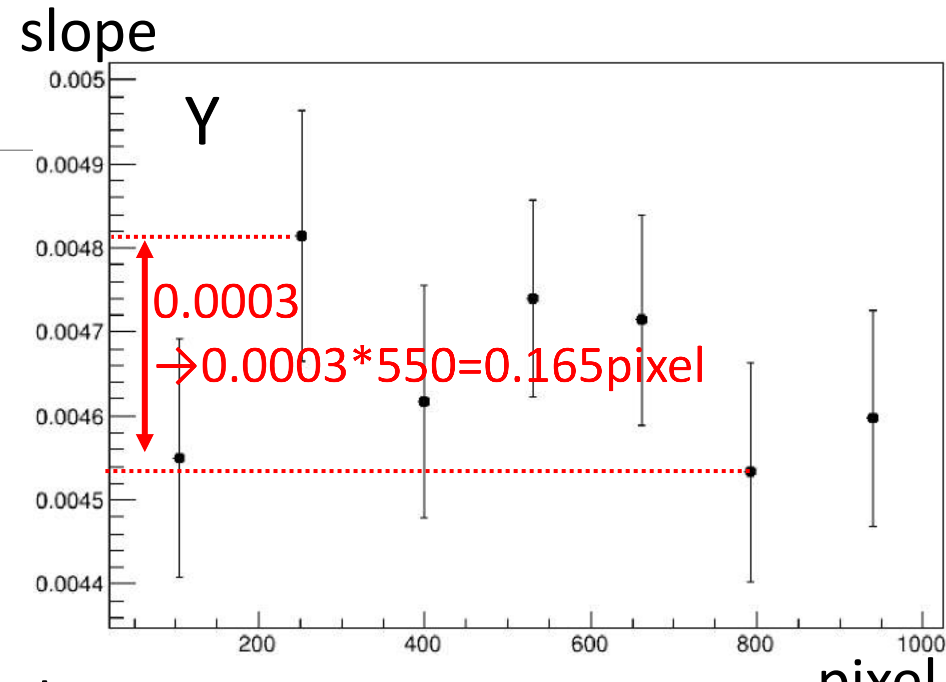


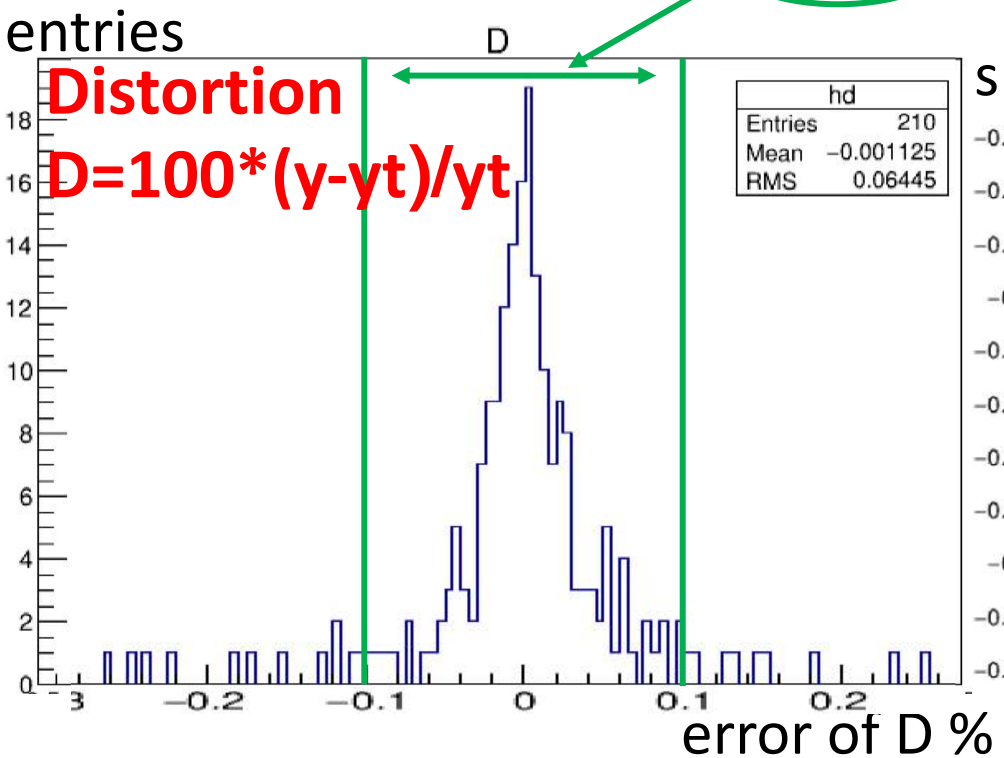
Results

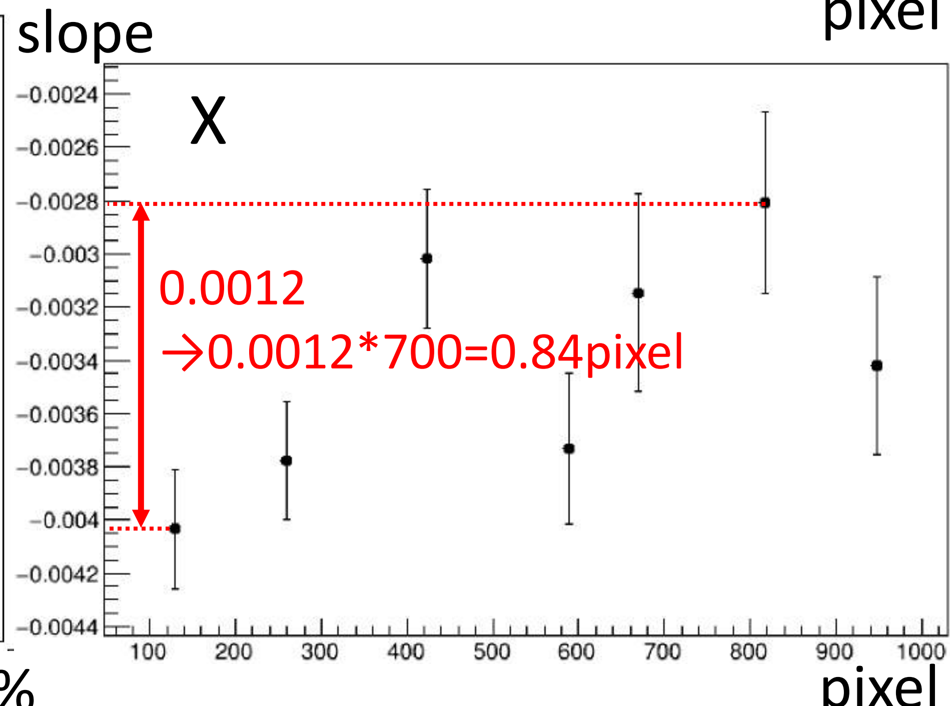
We calculate distortion number and slope of some points.

Both X and Y error are less than 1pixel (= 0.1mm)

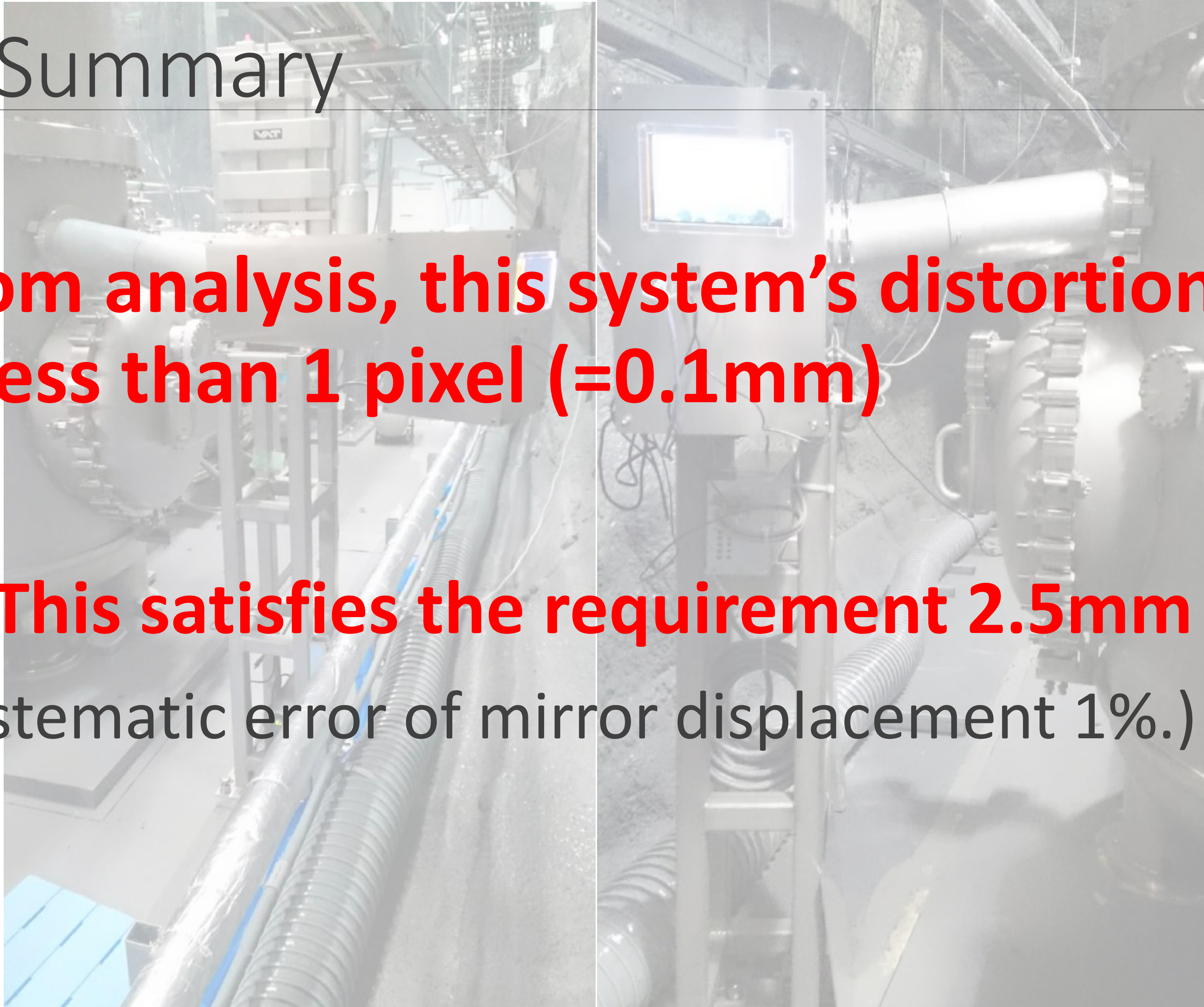
Most of D are within ±0.1%







Summary



From analysis, this system's distortion is less than 1 pixel (=0.1mm)

→ This satisfies the requirement 2.5mm

(Systematic error of mirror displacement 1%.)

Future work

1. Images may be distorted by aberration of mirrors and window

→ we have to evaluate the aberration

Distortion is small enough by demonstration test. Same analysis for ETM in Kamioka site.

2. Pcal modules are 36m away from ETM so beam position may drift

→ we have to monitor and control beam position

Thanks for listening.