# Optical Alignment System for Muon Tracker

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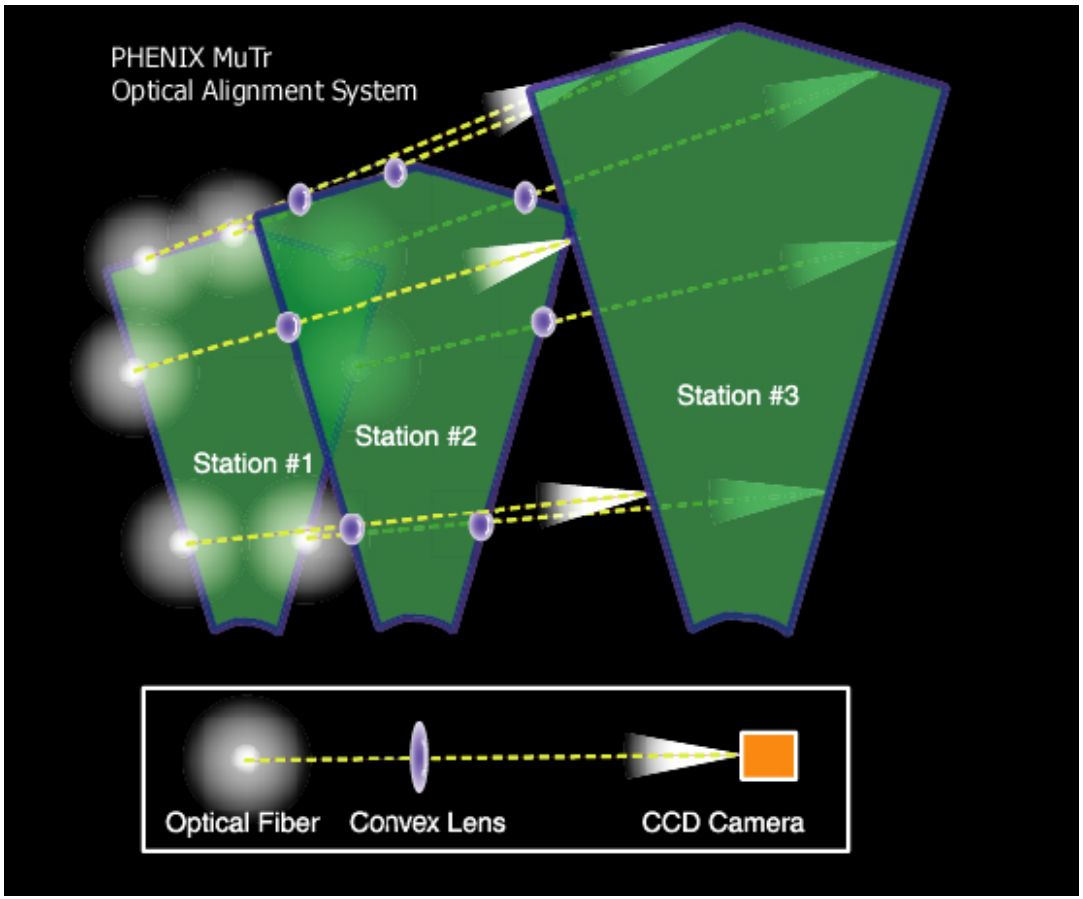
1. Hardware
2. Learned from RUN3/4
3. Upgrade
4. Plan and Summary

# Optical Alignment Sytem




Configuration

Light Source（station1）

- Single 150W Halogen light per
- Optical fiber to station1

Focusing lens(station2)

- 1cm convex lens

CCD camera (station3)

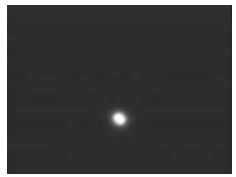
- effective area 8.8×6.6 mm
- Number of pixels 768× 498
- Pixel size 11.0×13.0 μm

Total 7optics/Octant * 8 Octant/Arm * 2Arm = 112

# Data flow

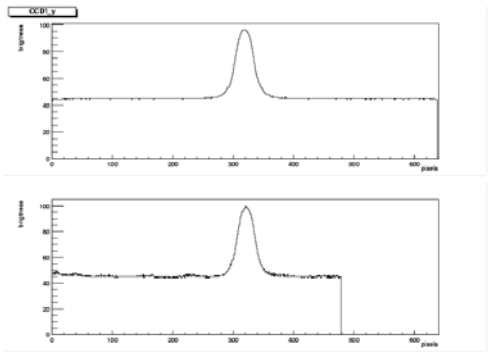
CCD Camera

Getting spot image



DAQ PC

・Taking CCD camera image each 30 min.
・Making light intensity histogram for each X and Y projection.



Online PC

・Fit histogram and measure peak position

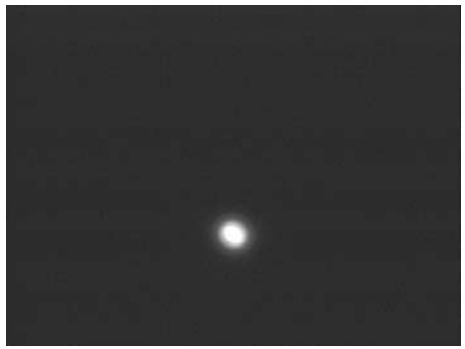
# Position correction of Muon Tracking Chamber

1. Measurement of peak position of light image.
2. Make a model of motion of each Octant with parameters.
3. Position correction
4. Evaluation of correction.

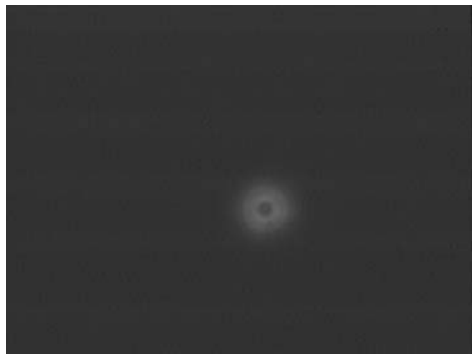
Done by Takashi Watanabe as Master Thesis work

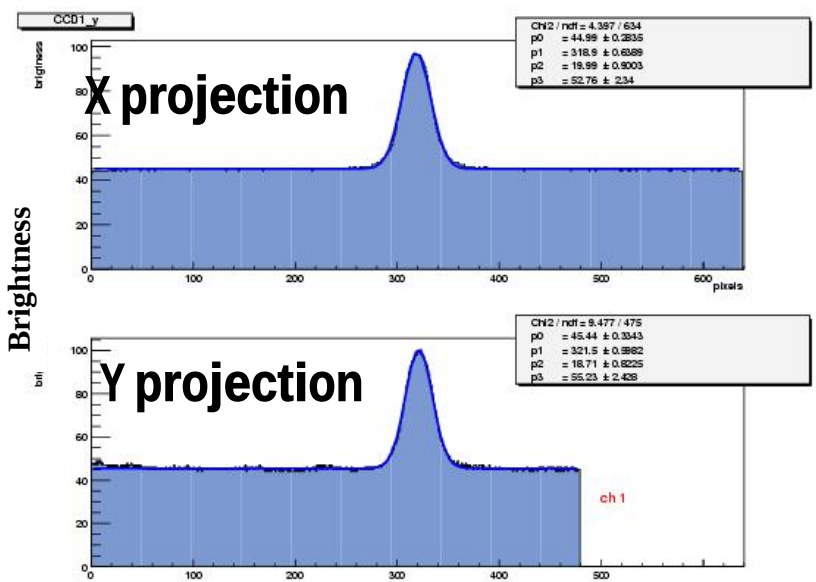
# Measurement of peak psotion

Sharp image



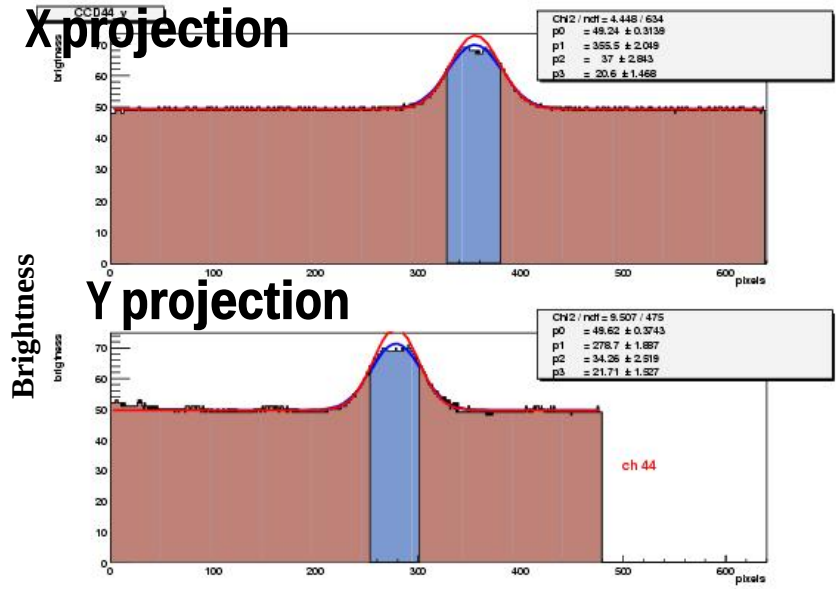
Out focus Image






**gauss fit**

pixel

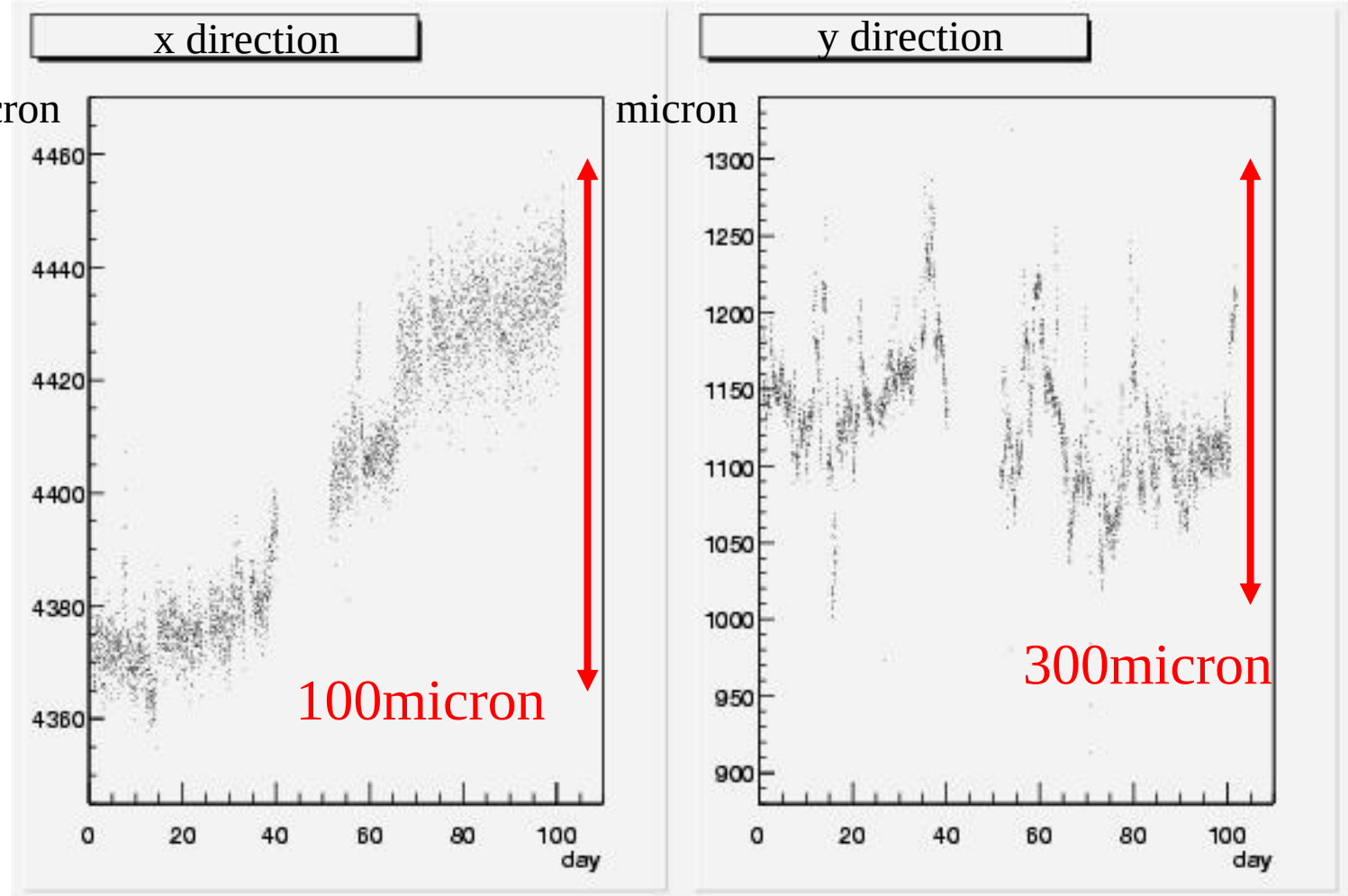



**window fit**

pixel

# Long term movement

North octant4 CCD4




Long Term movement：50～300 micron meter
on single CCD camera

# Movement Model without expansion

Consider half octant as rigid body

$$f_i = \begin{pmatrix} \text{Rot}\ (\phi_x, \phi_y, \phi_z) \end{pmatrix} \begin{pmatrix} x_i \\ y_i \\ z_i \end{pmatrix} + \begin{pmatrix} \Delta X \\ \Delta Y \\ \Delta Z \end{pmatrix}$$

$$\sim \begin{pmatrix} \phi_z x_i + \\ \end{pmatrix} + \quad y_i +$$

**Rotation**

**Position on Octant**

**Displacement in PHENIX**

**Look at the movement on X and Y**

**Ignore rotation along X and Y axis**

$x_i$ … position

$S = \text{Sum}(f_i - x_i)^2$

**Center of gravity of camera on octant**

$+ \Delta$ …

**Peak position in camera**

$+ \Delta Y - \delta y_i)^2$

Minimize S wi… …cement

# Movement model with expansion

$\Delta \mathbf{r} = \alpha(t)\mathbf{r}$: **Isotropic expansion**

$$\mathbf{f}_i = \begin{pmatrix} \text{Rot}(\phi_x,\phi_y,\phi_z) \end{pmatrix} (1+\alpha) \begin{pmatrix} x_i \\ y_i \\ z_i \end{pmatrix} + \begin{pmatrix} \Delta X \\ \Delta Y \\ \Delta Z \end{pmatrix}$$

$$\mathbf{f}_i = \begin{pmatrix} (1+\alpha)x_i - \phi_z y_i + \Delta X \\ \phi_z x_i + (1+\alpha)y_i + \Delta Y \end{pmatrix}$$

: Movement of Model

$$x_i = \begin{pmatrix} x_{0i} + \delta x_i \\ y_{0i} + \delta y_i \end{pmatrix}$$

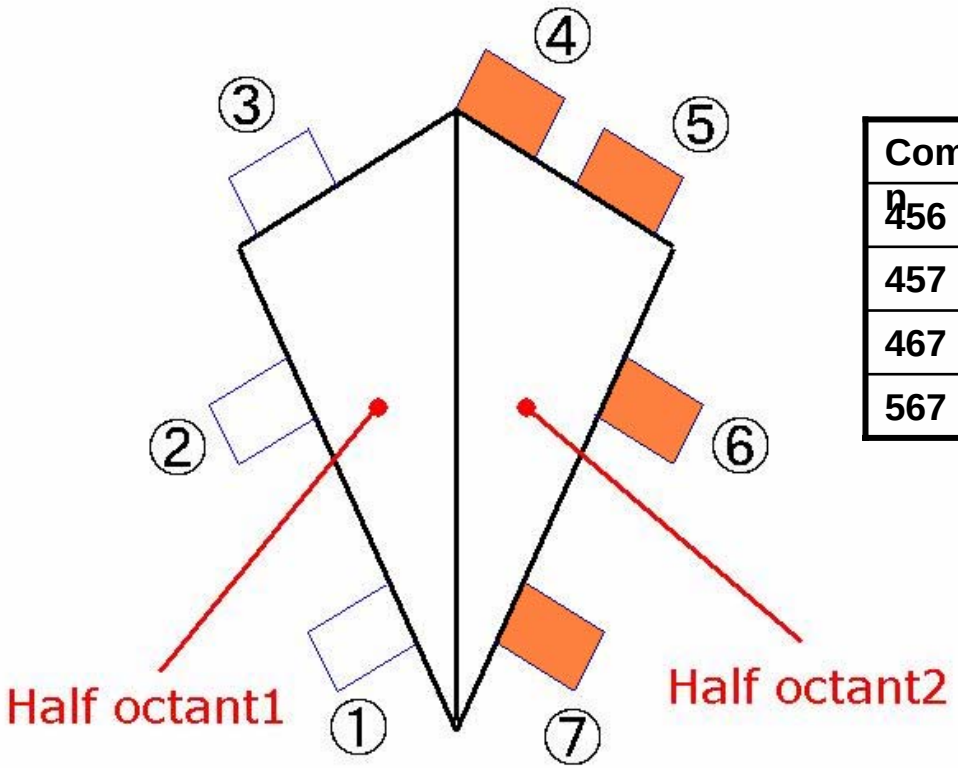
: Image position

$$S = \text{Sum } |f_i - x_i|^2$$

$$= \text{Sum } \{(\alpha x_{0i} - \phi_z y_{0i} + DX - \delta x_i)^2 + (\phi_z x_{0i} + \alpha x_{0i} + \Delta Y - \delta y_i)^2\}$$

Minimize S

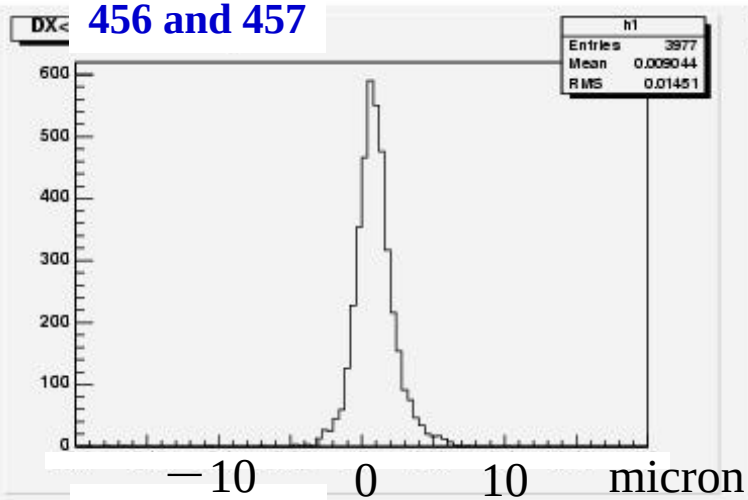
# Camera Combination

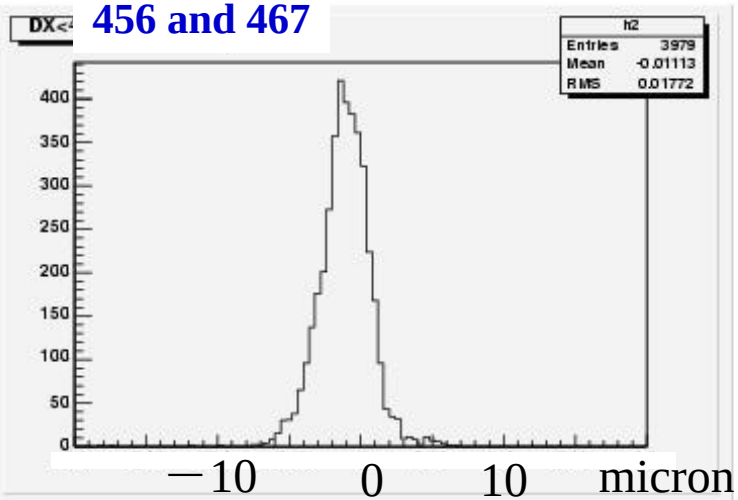


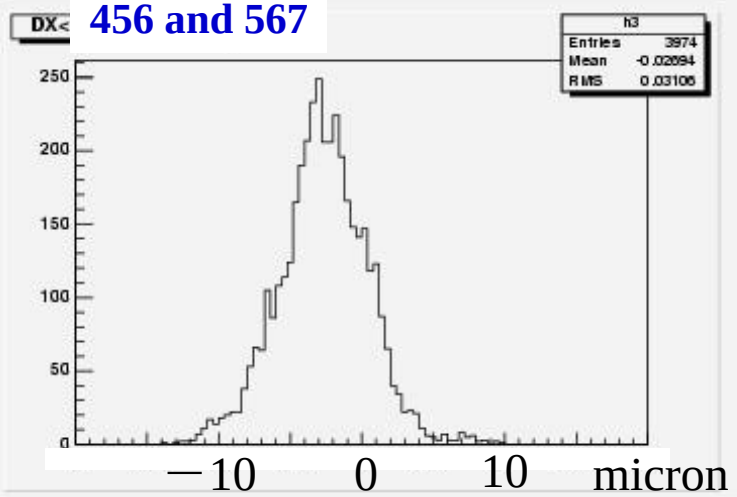

| Combination | CCD4 | CCD5 | CCD6 | CCD7 |
|---|---|---|---|---|
| 456 | ○ | ○ | ○ | |
| 457 | ○ | ○ | | ○ |
| 467 | ○ | | ○ | ○ |
| 567 | | ○ | ○ | ○ |

- Use North Arm, octant4, CCD4、5、6、7
- Evaluate by comparing different camera configuration

# Correction comparison on Δx




Correction evaluation

Displacement on X : 9~ 27 micron

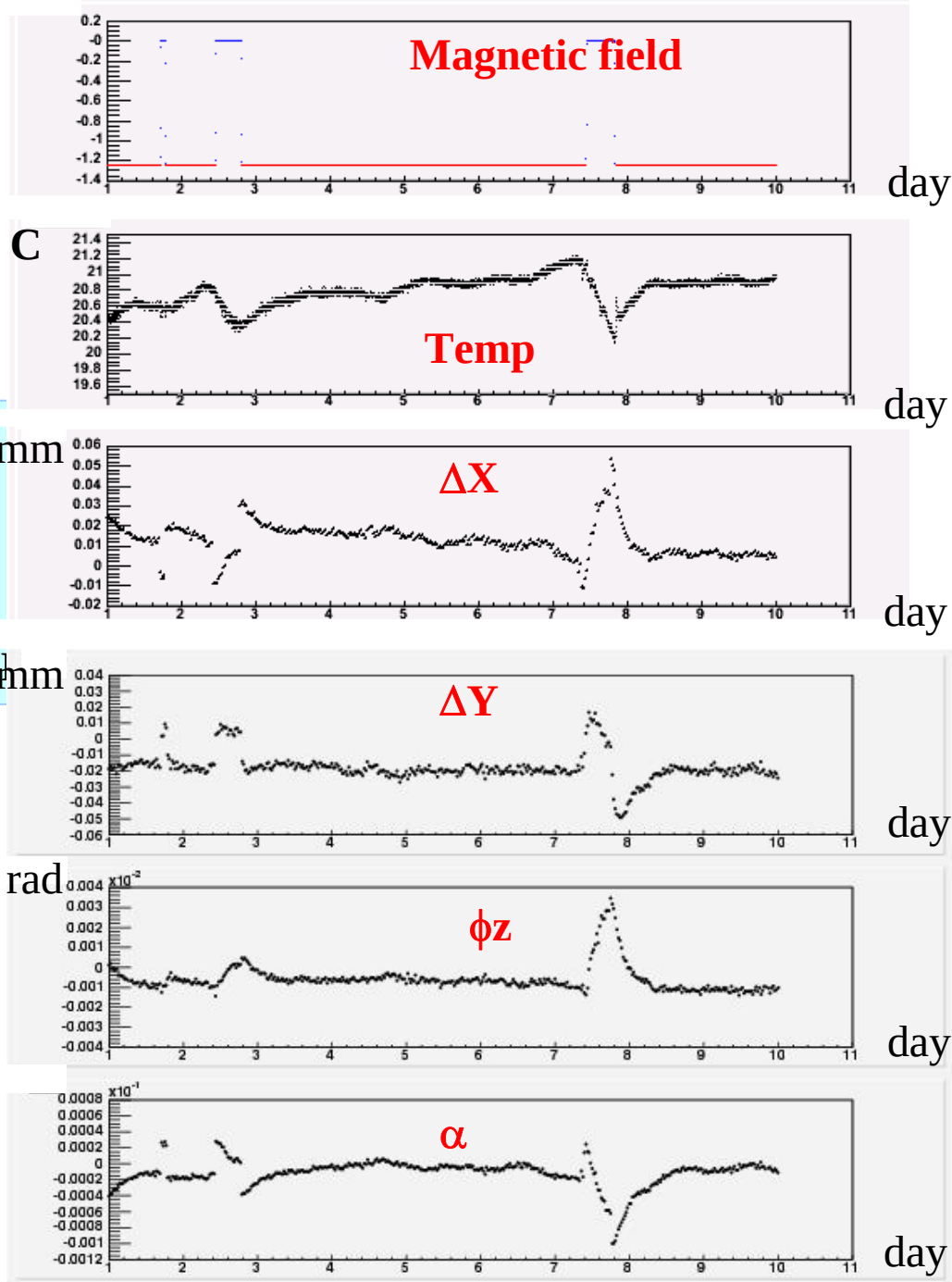
Y : 5~ 24 micron

Rotation along Z axis : 4- 15 micro rad

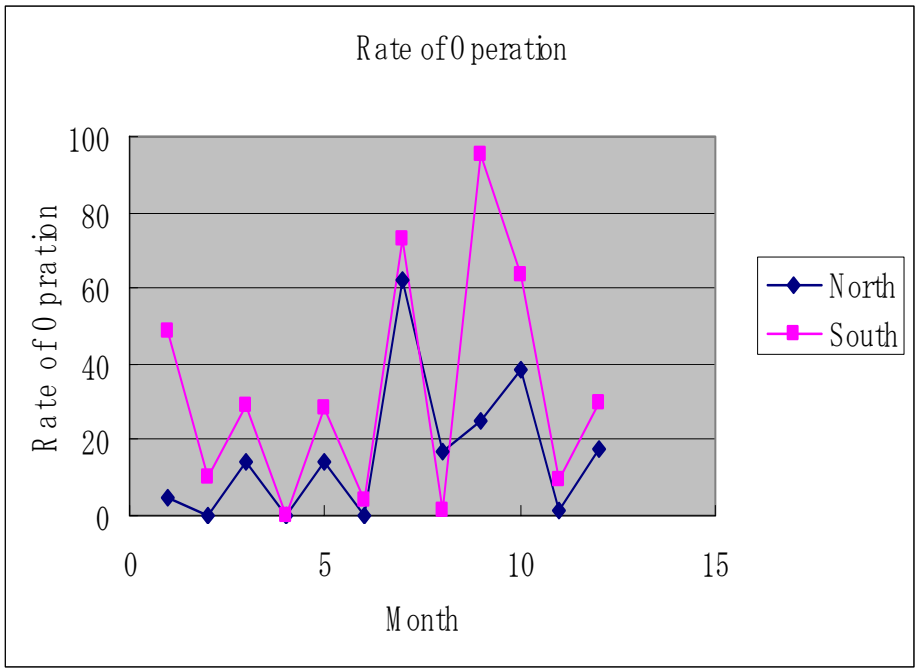
Expansion : 2 ~ 15* 10^-6

# Temperature and Magnetic field dependence

- Temperature changes after magnetic field change
- Magnetic field moves chamber



# RUN4




Data acquisition is not stable.

Pay attention by MuTr expert shift or PHENIX shift.

| | North | South |
|---|---|---|
| Good | 24 | 12 |
| Recoverable | 16 | 23 |
| No Image | 16 | 21 |

Good: good accuracy of peak

Recoverable : not good accuracy

No Image : No image at all

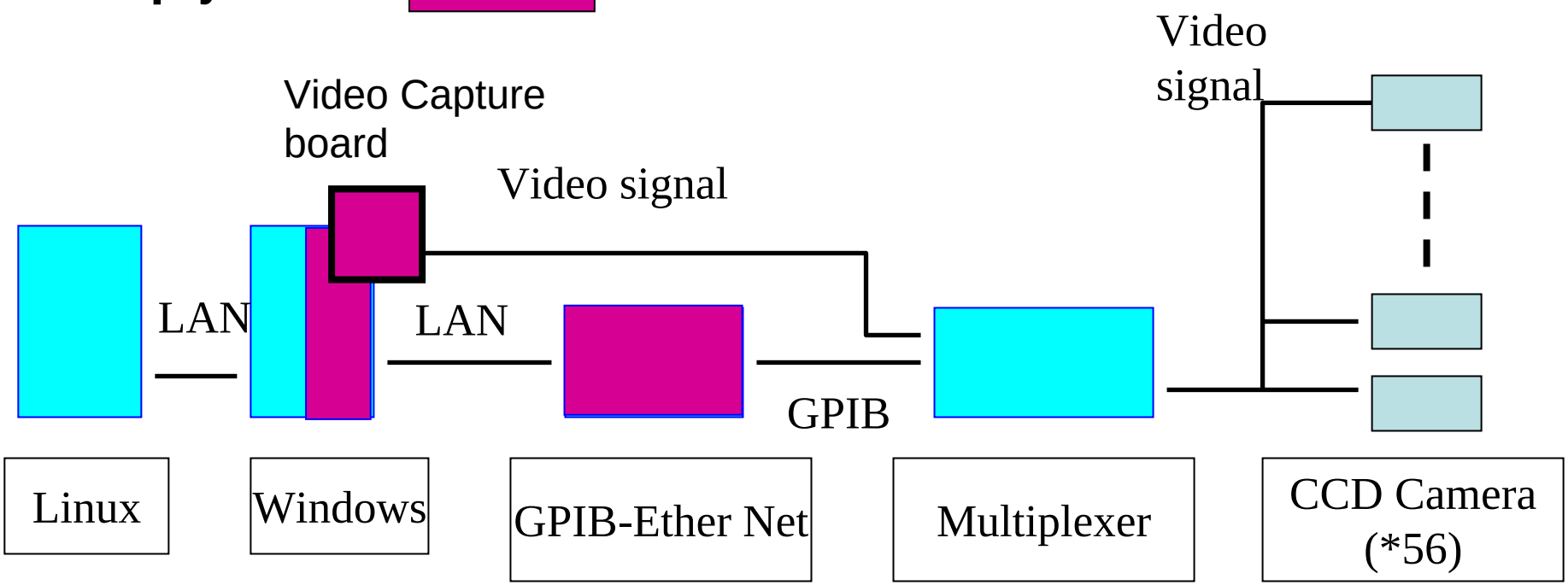
# How to Improve

- No Image : Need to access the area inside magnet. -> Not this year.
- Recoverable: Take more picture, integrate them and then get sharper image.

- Replace DAQ system from GUI operation base to Labview base.

# Daq system

Labview




Save data

Take pictures,
Integration
Make projection

Change cameras

# All of components for prototyping are build at RIKEN

| | | |
|---|---|---|
| | Initialize system | few msec |
| | Check hardware | few sec |
| **Executed 56 times** | Change camera | 50 msec for 1ch |
| | Take pictures | 110 msec for 1ch, 1 picture |
| | Integrate pictures | 40 msec for 1ch, 1 picture |
| | Make projection | 40 msec for 1ch |
| | Save to file | 20 msec for 1ch |
| | Close system | few msec |

**Large contribution**

Take N pictures for all camera…

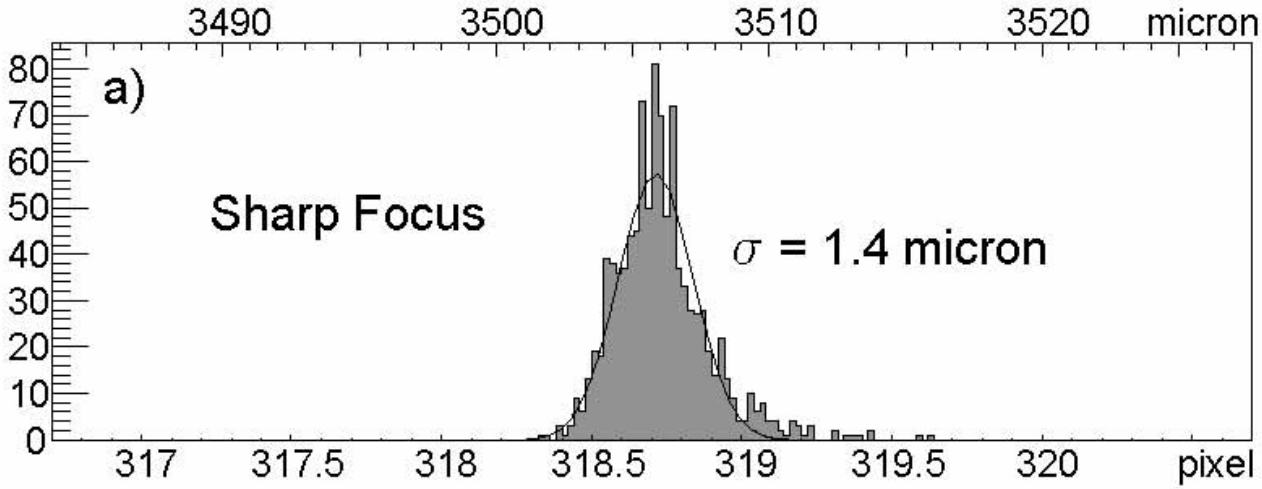
$$T = 8.09N + 5.06 + \text{few (sec)}$$

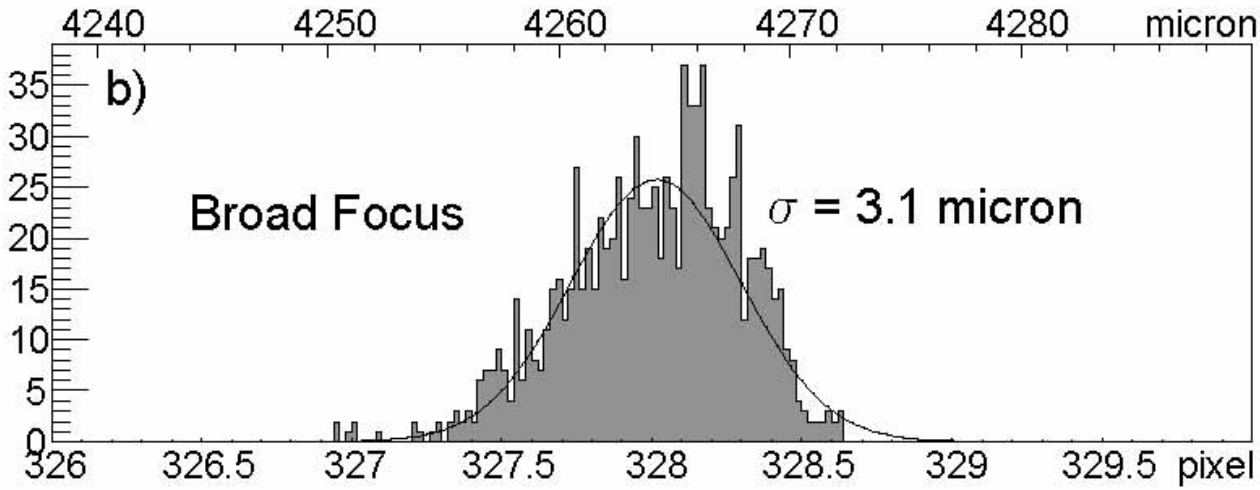
(N < 73, T < 10 min.)

# Plan and Summary

- *Young* **Hiroki** will build Labview based system at RIKEN and move it to BNL at Aug.
- Looking OASYS will be shift duty.
- OASYS analysis data will be implemented in the  geometry database and then improve J/PSI mass resolution.

# Performance




Taking 1000 images from same camera for 30 minutes.

# Temperature and Expansion