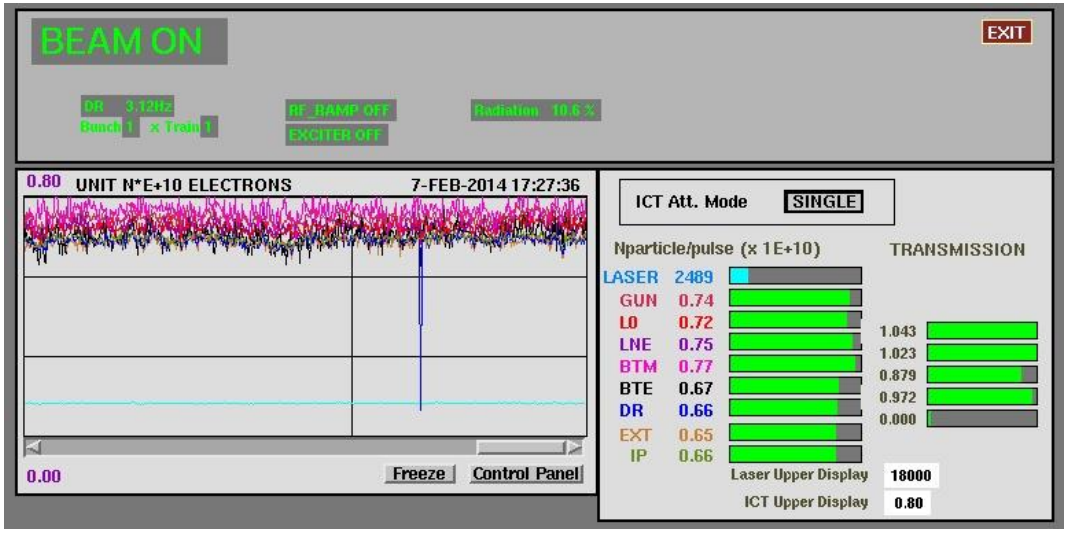
LINAC/DR stabilization and Monitor hardware improvement

17th ATF project meeting
2014/02/12 T.Naito

Contents

1. Linac stabilization
2. Multi-bunch/Multi-train operation
3. Hardware Troubles
4. DR circumference stabilization
5. Profile Monitor improvement and development
    1. XSR monitor
    2. YAG:Ce Screen monitor



The constant injection condition could keep a half day or more. (Feb. 2014)

Linac stabilization

1. Renewal of the klystron modulators
   #1~#4 completed(2013/June-Sep)
   #0 in progress
   The hardware bugs(HV PS) will soon be over.

2. Renewal of the cooling water system for the Linac accelerator components(2013/June-Sep)

3. Replace to new klystron (#0)
   The power drift come from the old klystron which was almost end of life.

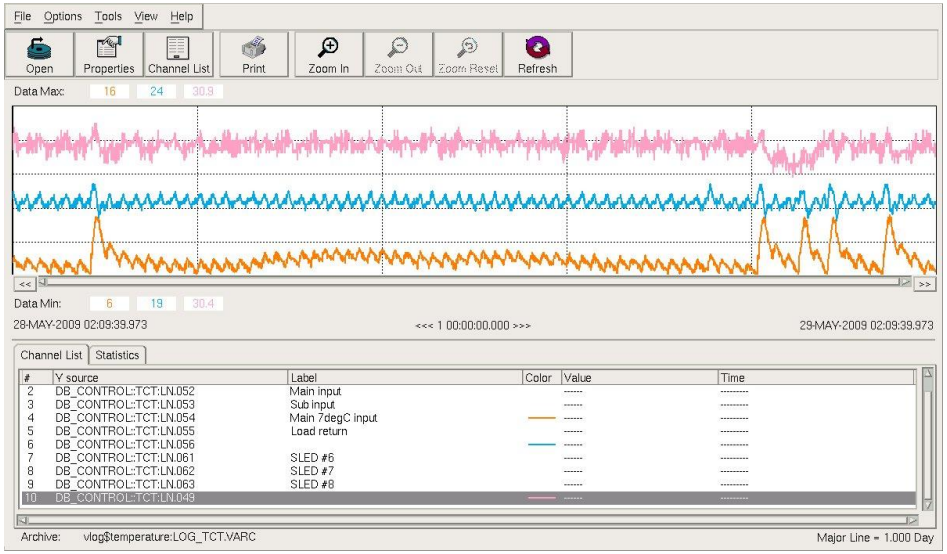
Renewal of the klystron modulators

Apr.2013

Jan.2014

Renewal of the cooling water system for the Linac accelerator components

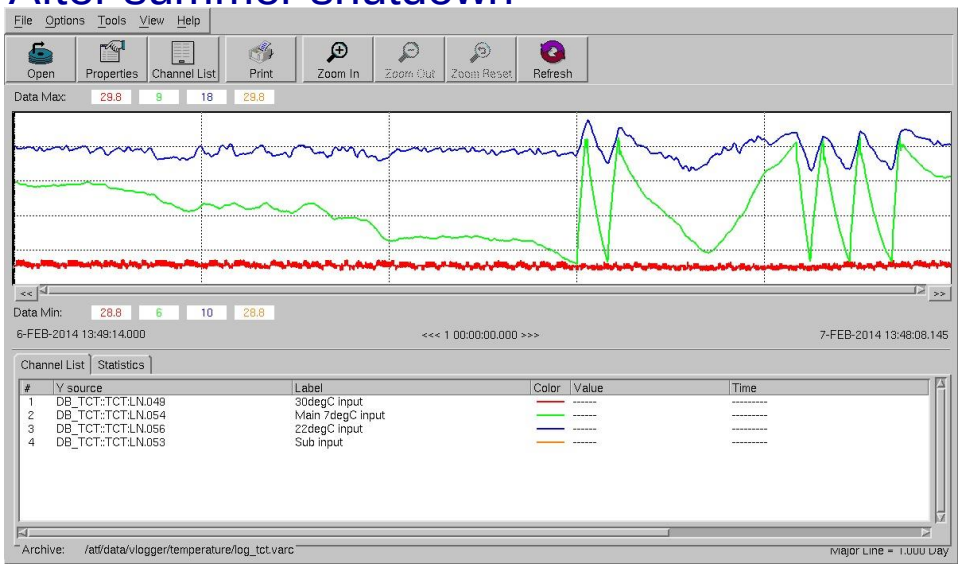
Before summer shutdown



Cooling water temperature 0.2℃/div

The previous system was very old and had troubled often.
The stability was not good which was caused by the energy drift of the linac.

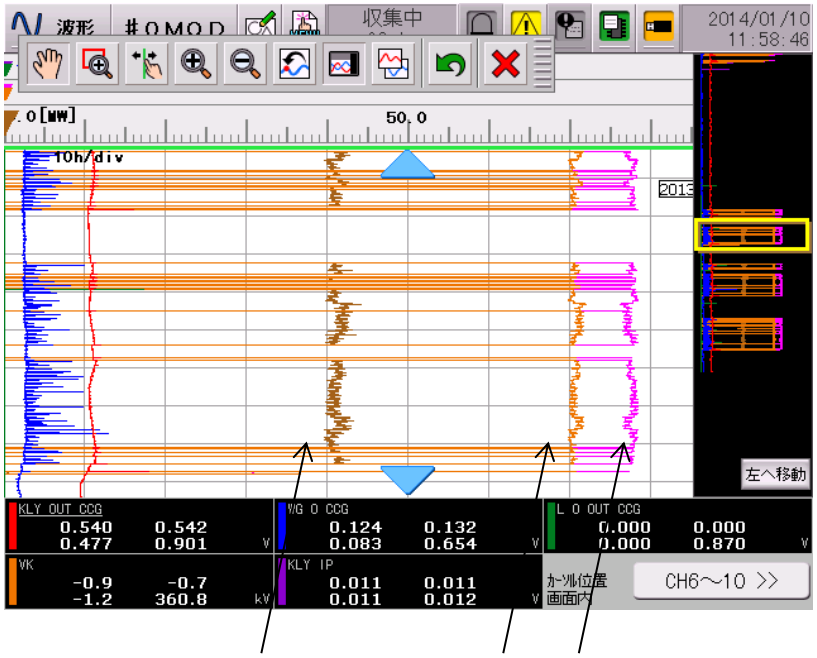
After summer shutdown



Cooling water temperature 0.2℃/div

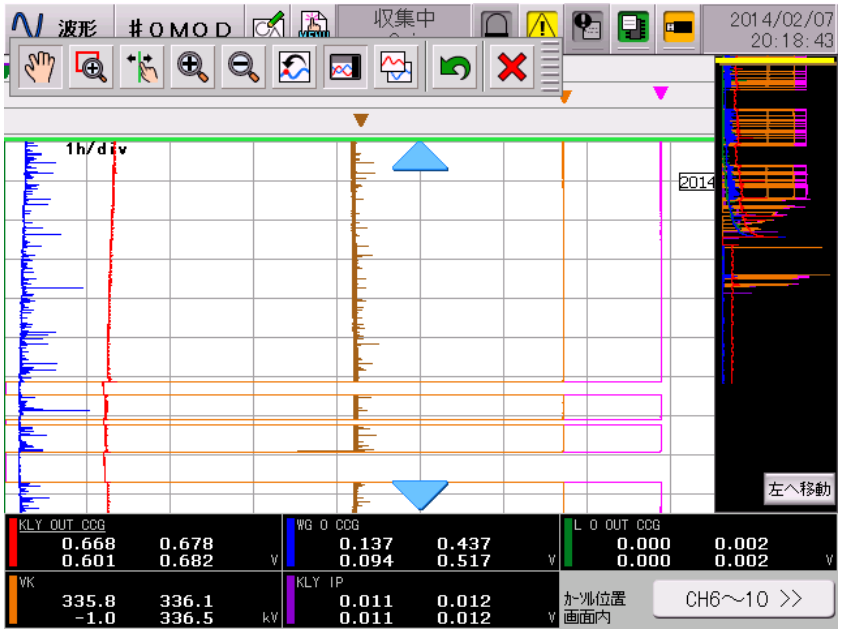
The temperature stability is less than 0.1℃ during all of the days.

Replace to new klystron (#0)



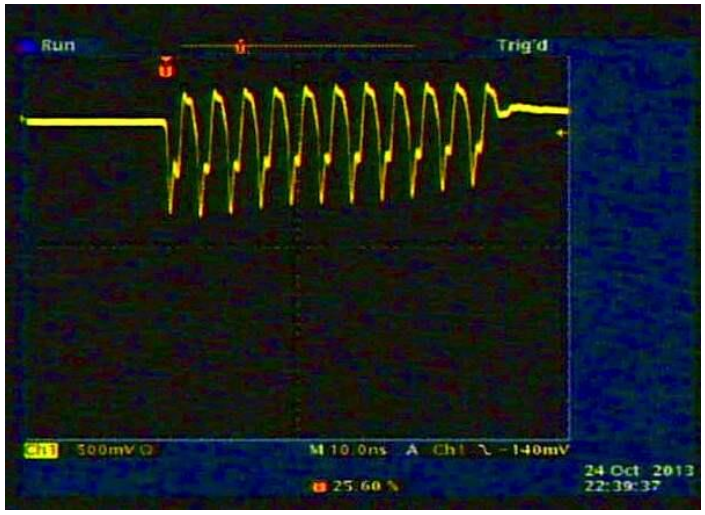
RFpower Vk Ik

Dec. 2013

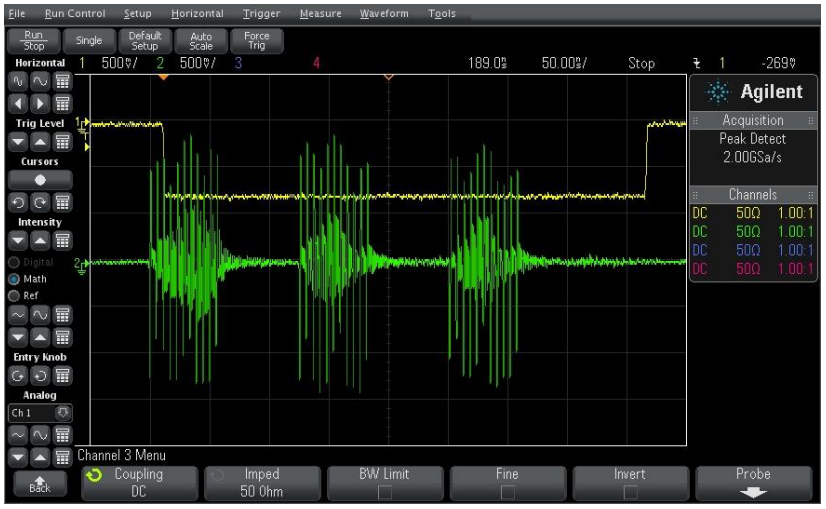


Jan. 2014
After replace #0 klystron

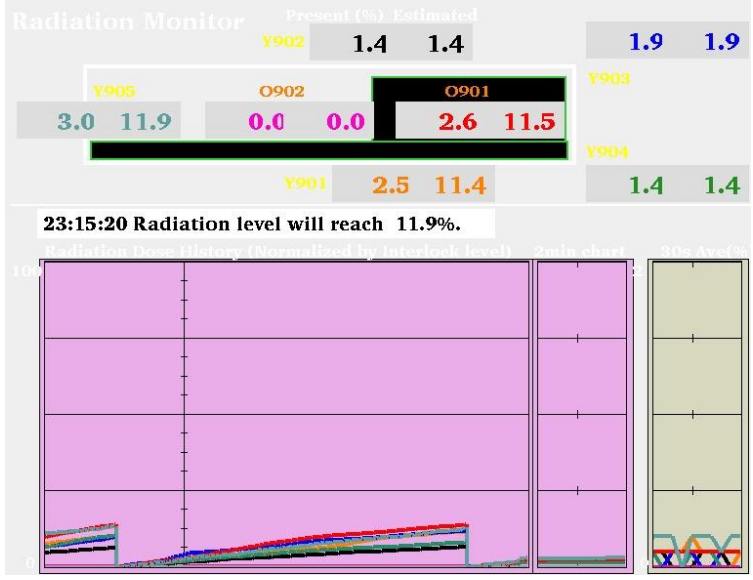
Multi-bunch, Multi-train operation For Radiation inspection(Oct, Nov/2013)



DR bunch intensities



Extracted bunches at ATF2



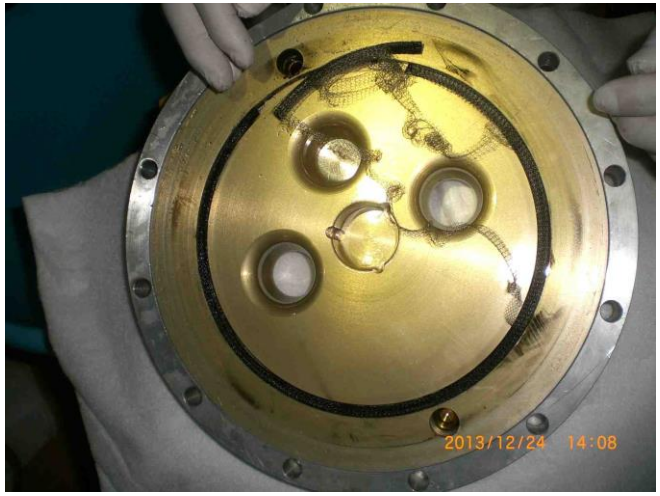
Multi-bunch(11 bunches with 5.6ns spacing) and multi-train(3 trains) operation was confirmed for the radiation inspection.

The stored current was over 40mA in the DR and the beam could extract to the ATF2. The radiation loss was small at the condition.

Troubles

1. *Injection kicker HV PS was broken(Dec/2013). After replaced the HV PS, we found the damaged dummy load. According to the instruction of J.W. Krzaszczak(SLAC), the dummy load was repaired.*
2. *The new installed HV PS of the modulator(fabricated by TDK-Lambda) had the hardware bugs(low noise immunity). We had to replace the troubled HV P.S. some times. The reason was found out, already.*
3. *The RF gun laser(5.6ns spacing) had trouble(Jan/2014). The spare laser(2.8ns spacing) was used for Jan/Feb operation.*

Injection kicker Trouble



The damage at the GND contact was found. The O-ring does not work to make the contact.

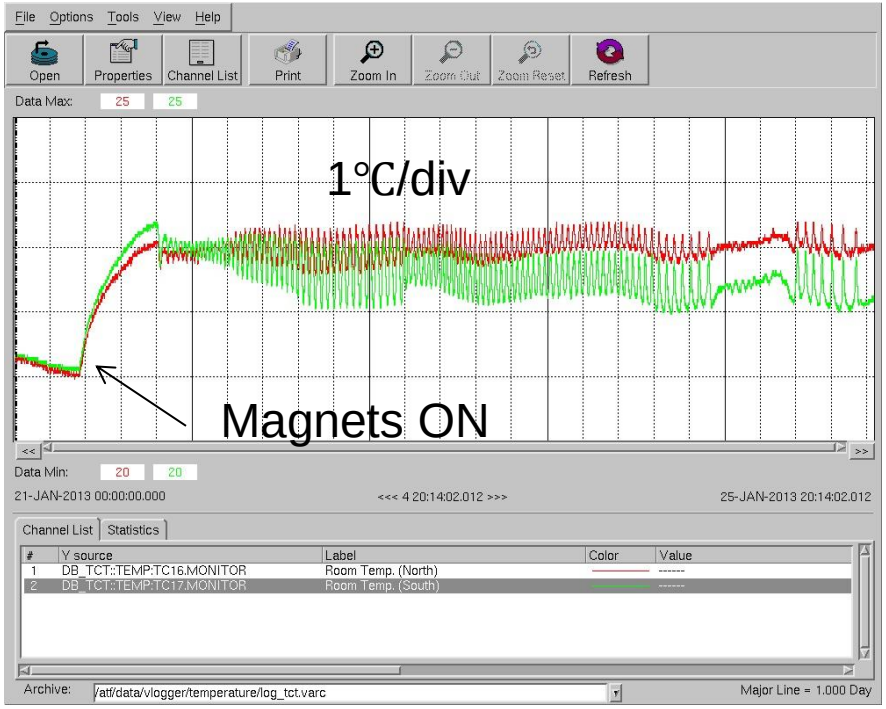
DR circumference stabilization

1. *DR tunnel temperature stabilization*
   The air conditioner censer location moved from the return to the output.

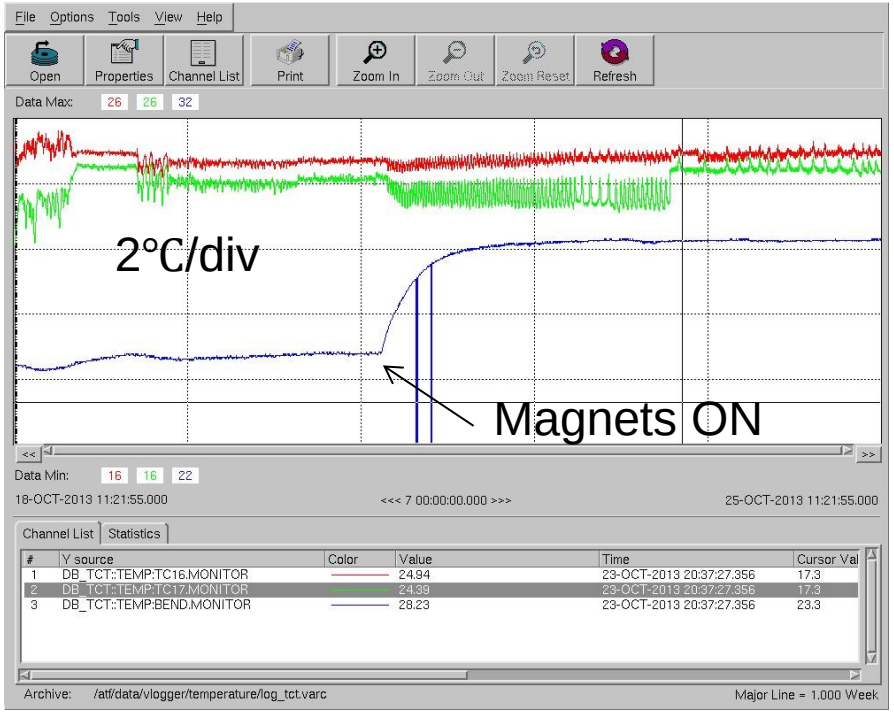
2. *Cooled air introduced to the DR Nakanoshima area.*

DR tunnel temperature stabilization

Before summer shutdown



After summer shutdown



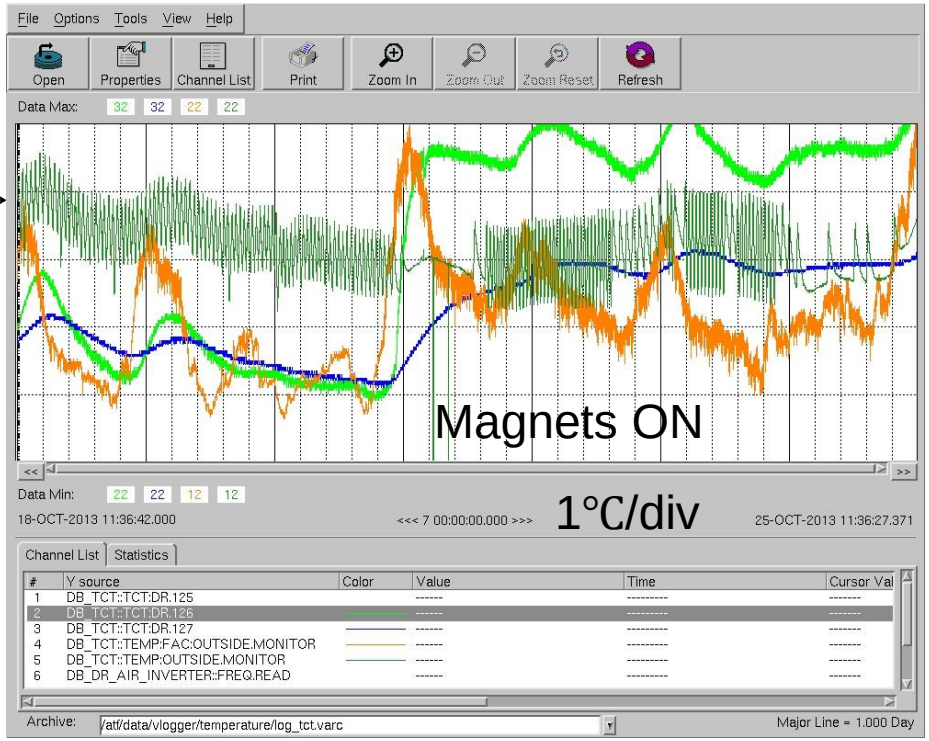
The Temperature in the tunnel was changed when the magnets were turned on. After moved the censer location, the temperature change was reduced.

Cooled air introduced to the DR Nakanoshima area

The previous air cooling was the outside air introduced Nakanoshima. The temperature was changed during day and night. The constant temperature air blow using a 45kW chiller, which was used at linac, was introduced.

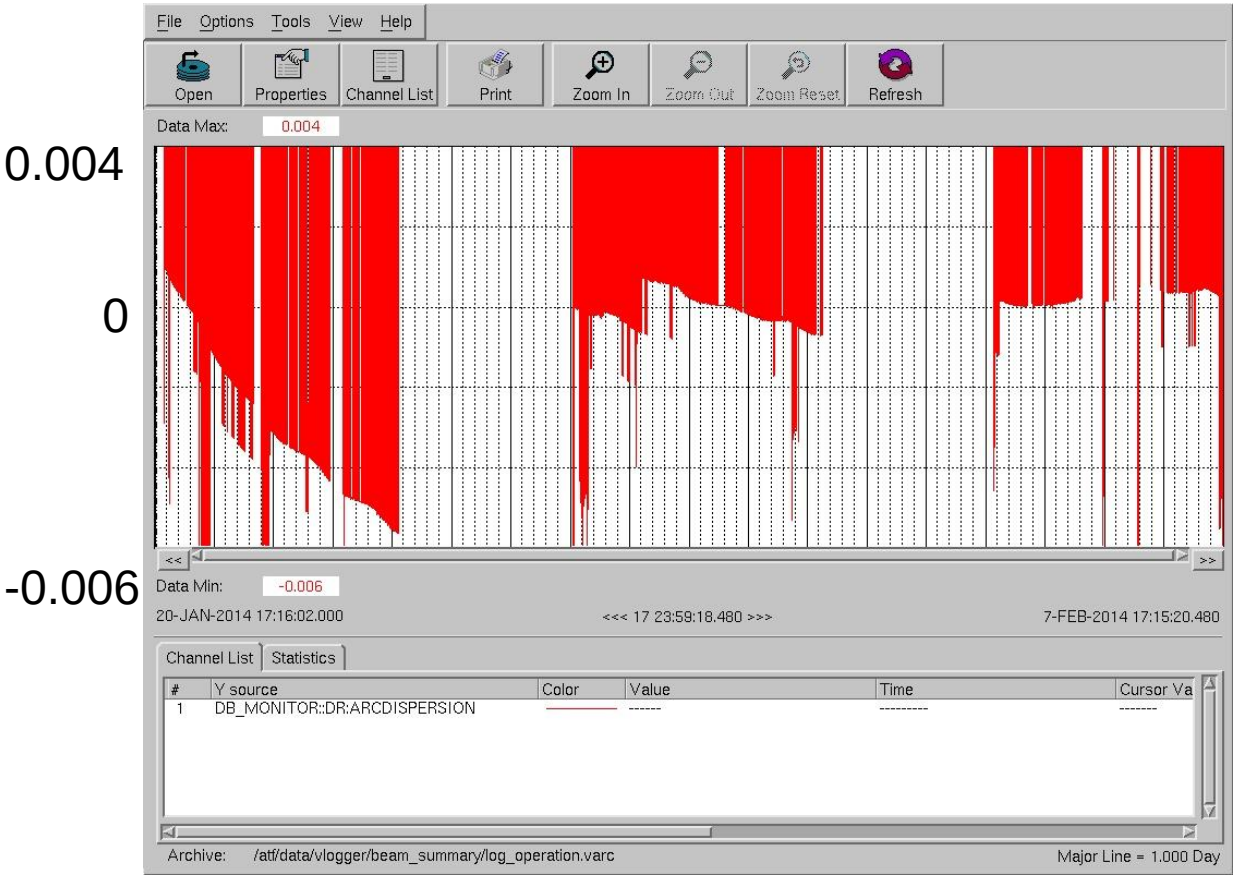
Cooled air(green) →

Nakanoshima floor(blue) →



10days trend of the temperatures

DR circumference



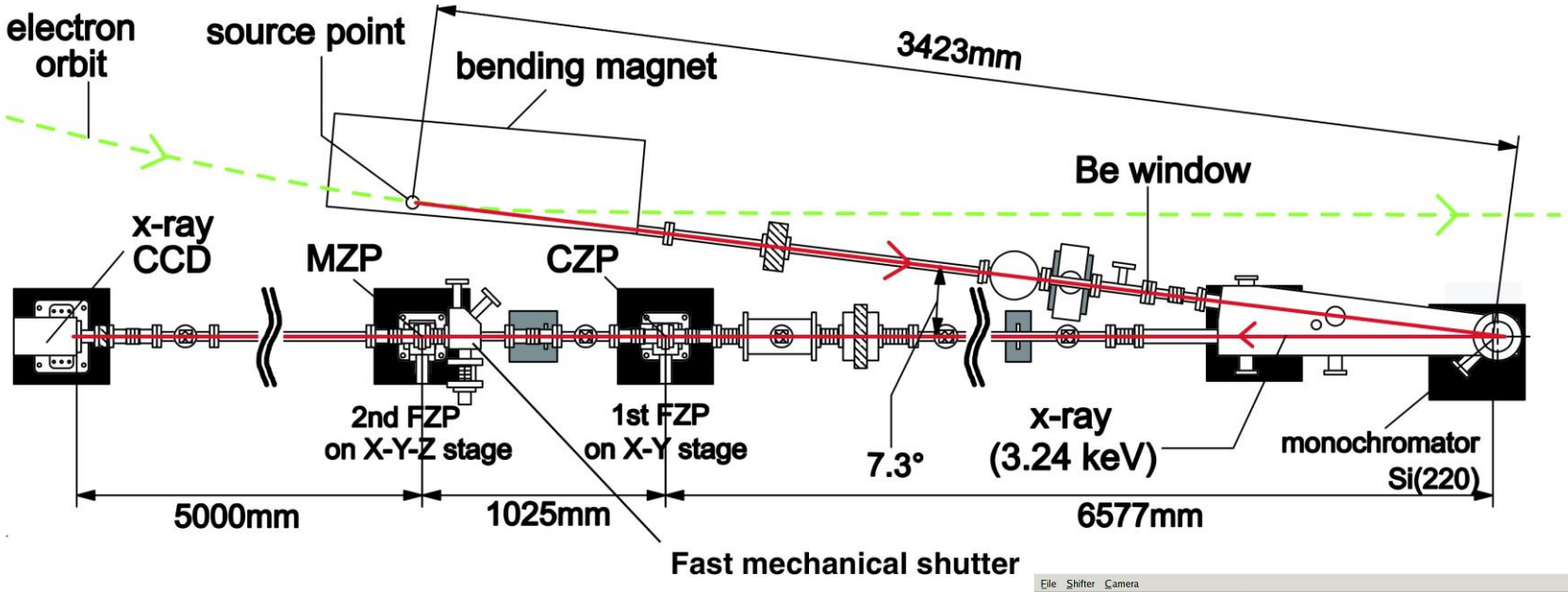
ΔE/E measurement at the DR

20/Jan/2014~7/Feb/2014

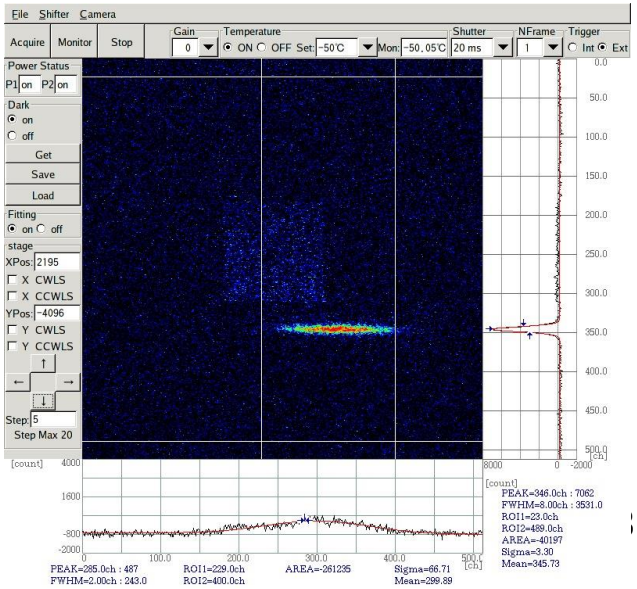
ΔF=1428.058-1428.030
=28kHz
ΔC=~3mm

The circumference changed 3mm during two weeks.
All of the power off during the winter shutdown and the cooling water temperature was reduced to prevent the frozen water trouble.

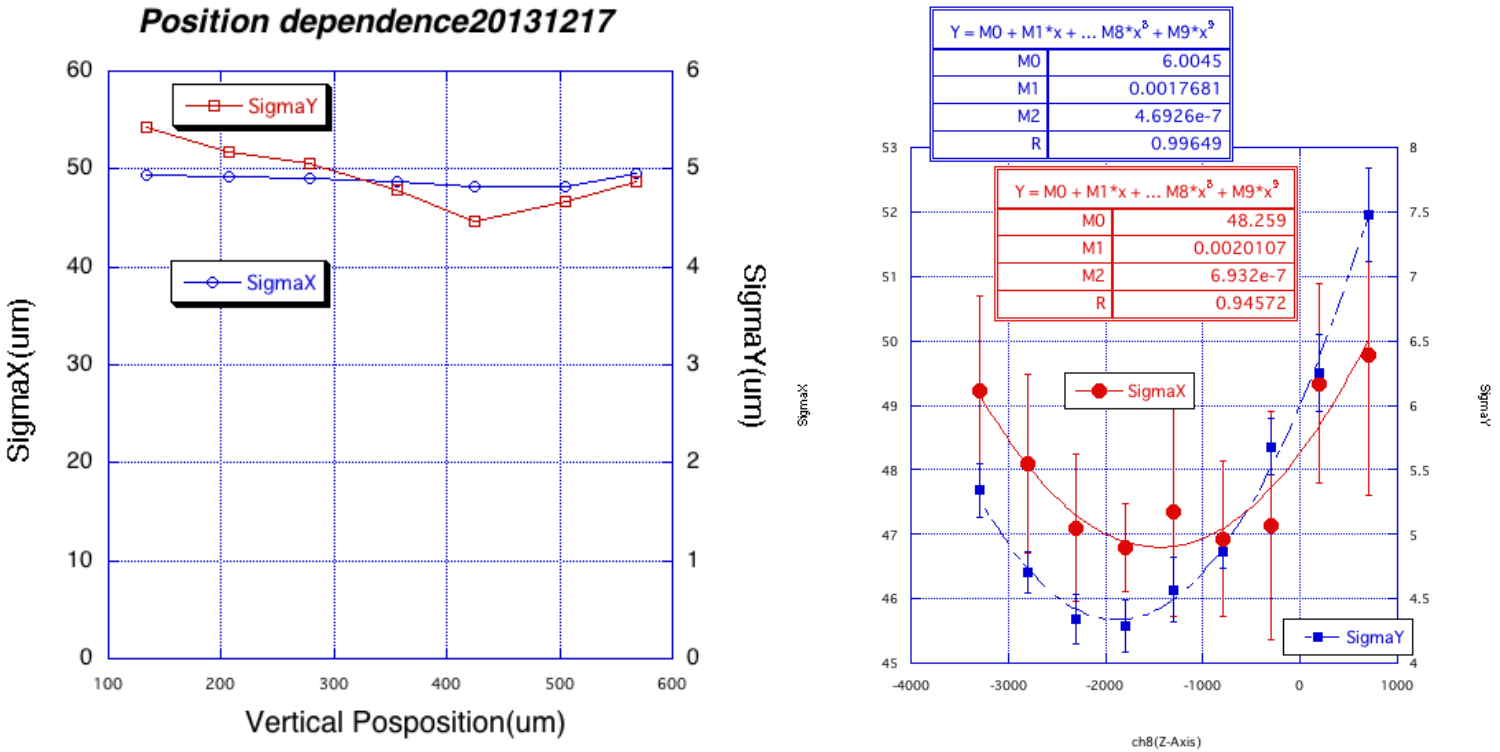
XSR monitor problem



We are using the XSR monitor to measure the emittance in the DR. The XSR monitor can get shot by shot beam size information. Recently, the vertical beam size less than 4*u*m was measured.

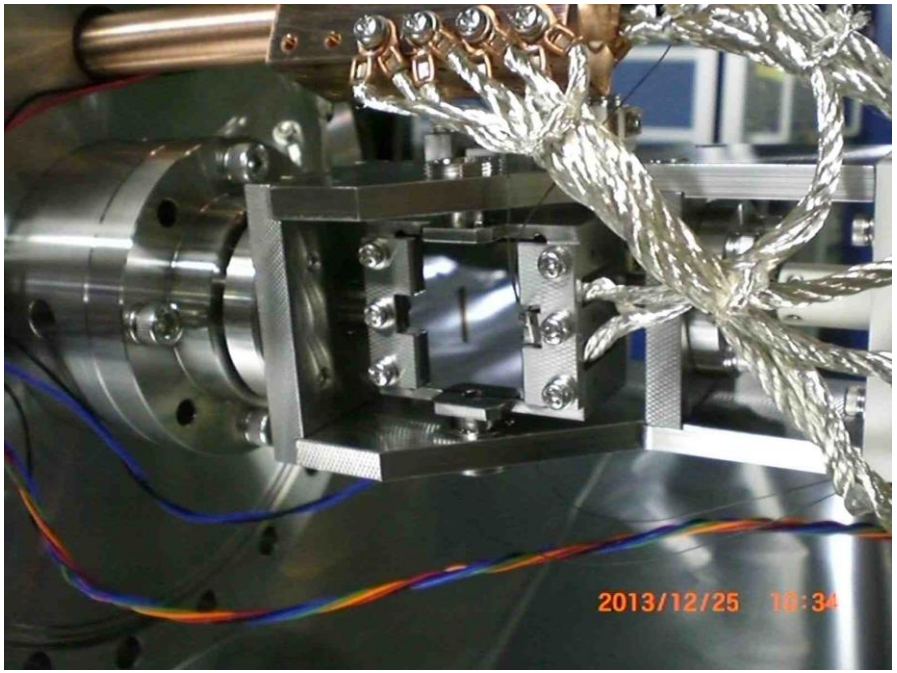


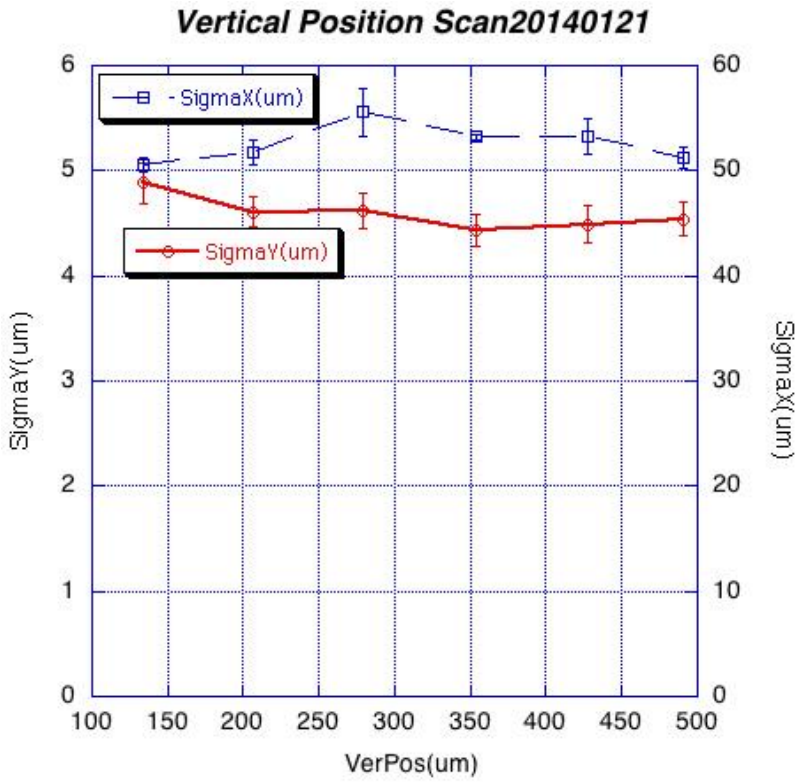
XSR monitor problem



The measured vertical beam size changed about 20% according to the vertical position. The focus scan result showed the evidence of the astigmatism of X-ray optical device. We suspected the deformation of the Si mirror which was replaced 3 years ago.

XSR monitor problem

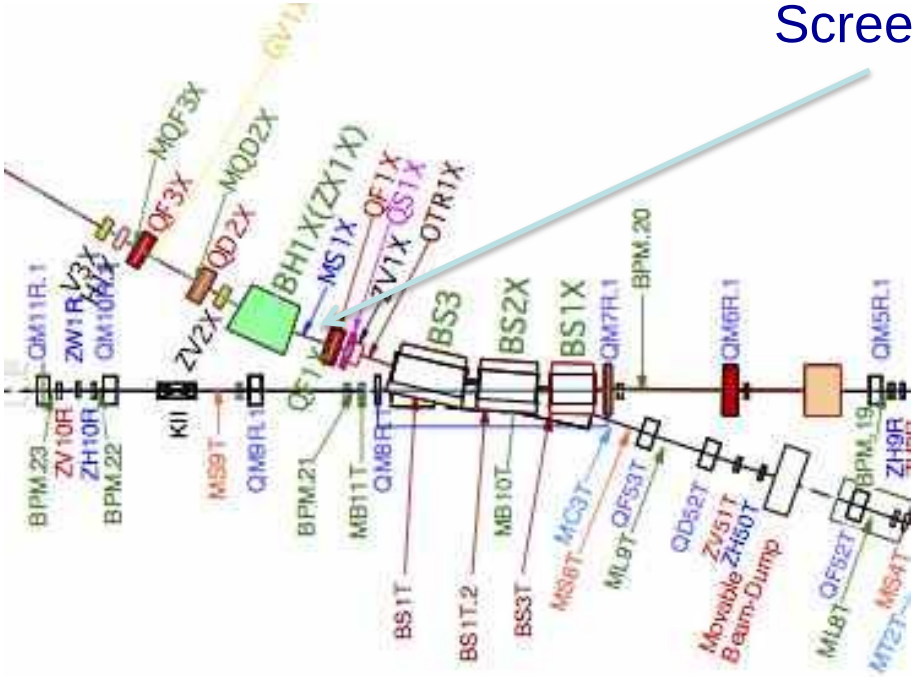


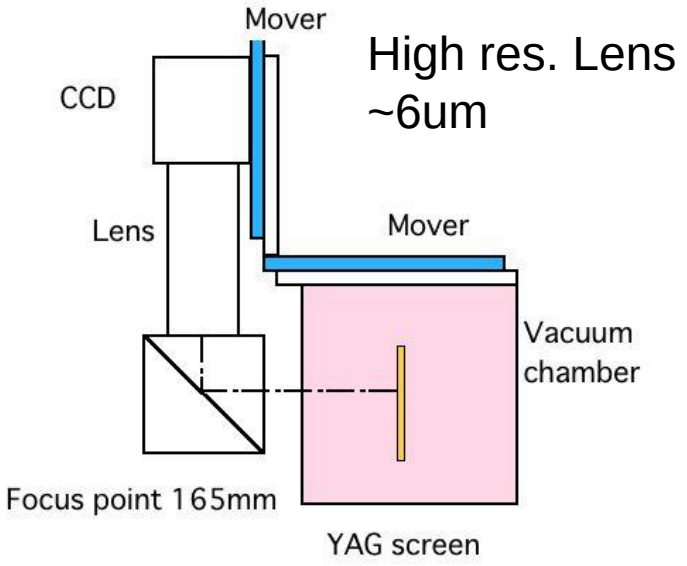


The Si mirror was replaced to previous one then the position dependence was almost cured.

MS1X YAG:Ce screen monitor

MS1X
Screen monitor





A new screen monitor using YAG:Ce scintillator was tested.
Purpose:
1)To measure the beam tilt at the exit of the DR
2)To measure the momentum spread
3)To measure the vertical beam size

A high resolution lens was adopted to the modified screen monitor chamber.

MS1X YAG:Ce screen monitor

YAG:Ce scintillator has following features,
1)high sensitivity(brightness) compared to OTR
2)higher resolution compared to phosphor screen
3)SR effect from the upstream can be avoided by the shutter timing

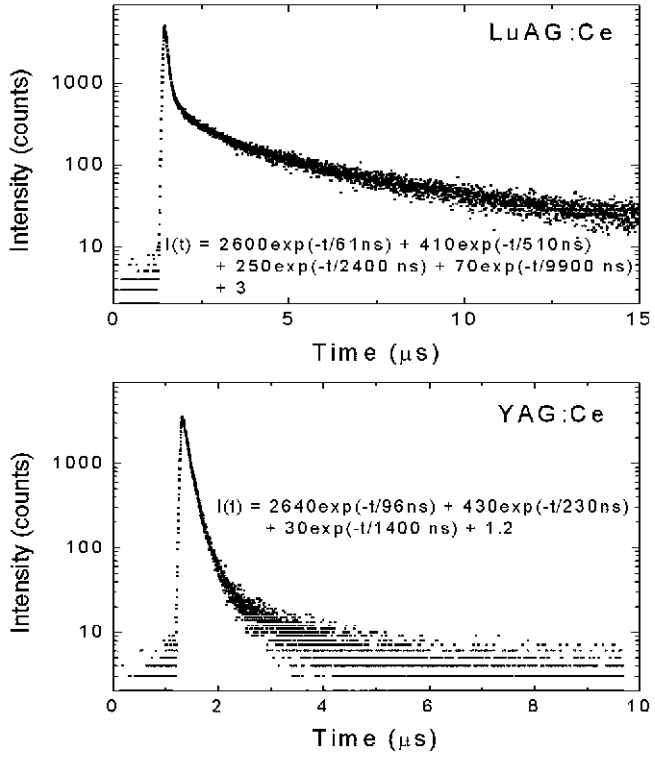
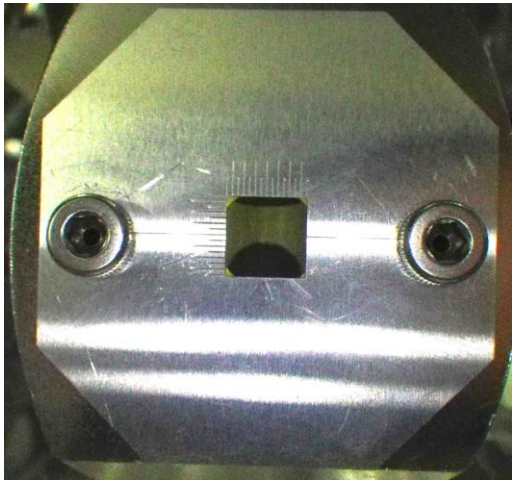
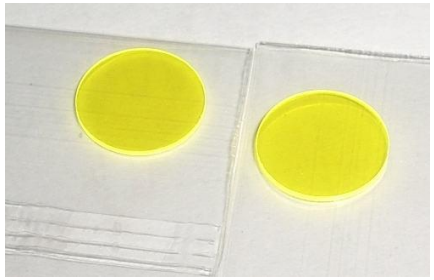


Fig. 5. Scintillation time profiles of LuAG:Ce and YAG:Ce crystals under excitation with 662 keV γ-rays from a ^{137}Cs source as measured in the time range of 20 μs and 10 μs, respectively. Experimental data are fitted by the function I(t) displayed in the figure.

The scintillation
Time ~100ns





100um thickness
YAG:Ce scintillator

MS1X YAG:Ce screen monitor

Beam size calculation from design parameters and measured emittance,

Betax = 2.2148 m

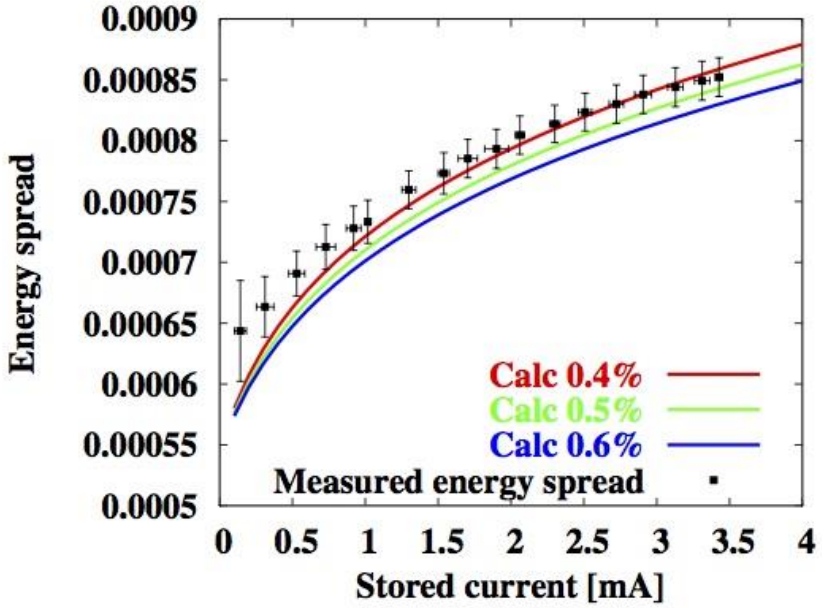
Betay = 8.5675 m

Etax = 0.4868 m

Emittancex(Ex) = 1.3 nm

Emittancey(Ey) =14pm

dp/p=0.0006



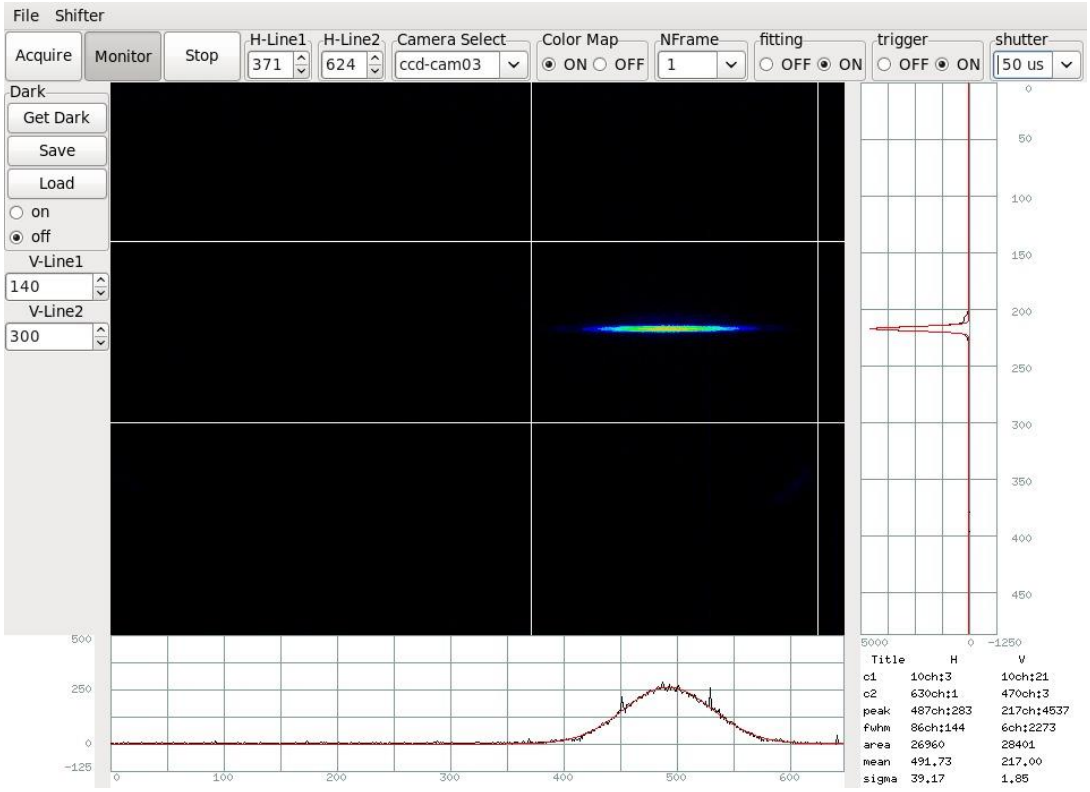
Example of energy spread meas.

$Sigmay = Ey \times Betay = (14\times10^{-12} \times 8.5675)^{1/2} = \underline{11um}$ $Sigmax = ((Ex \times Betax)^{1/2})^2 + (Etax \times dp/p)^2)^{1/2}$

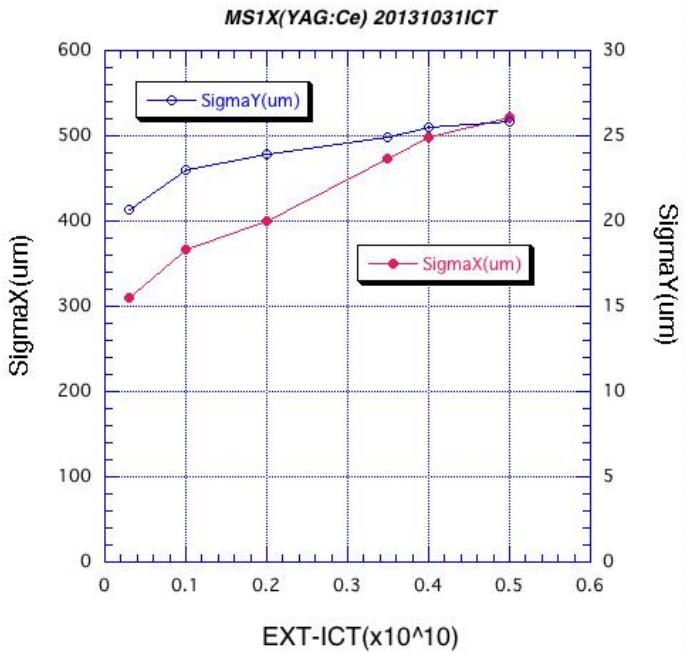
$= ((1.3\times10^{-9} \times 2.2148)^{1/2})^2 + (0.4868 \times 0.6\times10^{-3})^2)^{1/2}$

$= (53.6um^2 + 292um^2)^{1/2} = \underline{297um}$

MS1X YAG:Ce screen monitor



2013/10/31

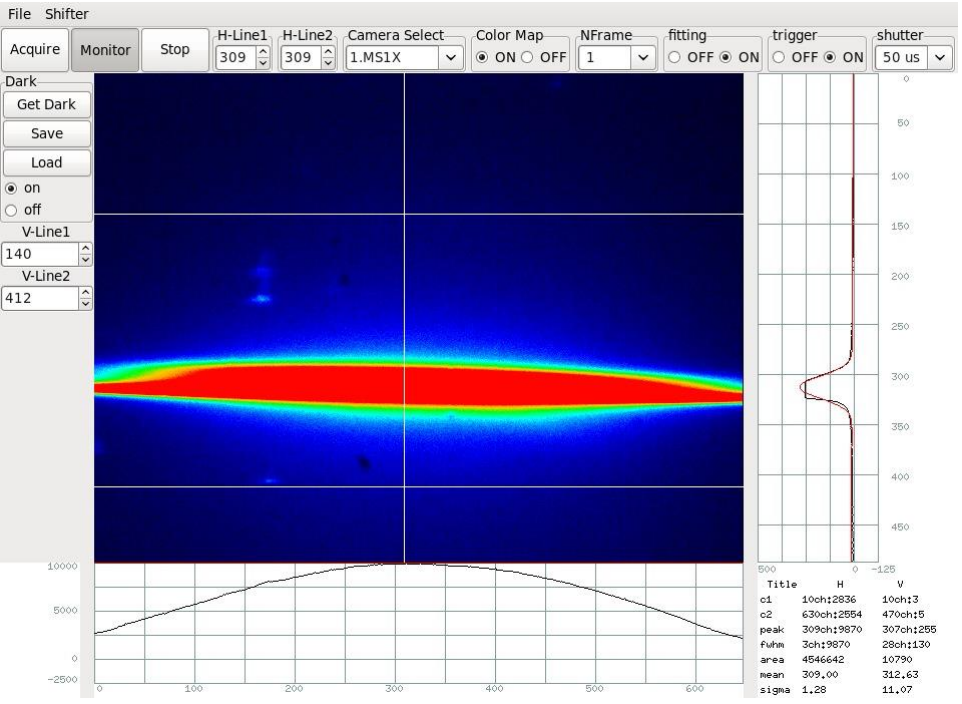


Ver 1.8ch x 11.5um/ch=20.7um

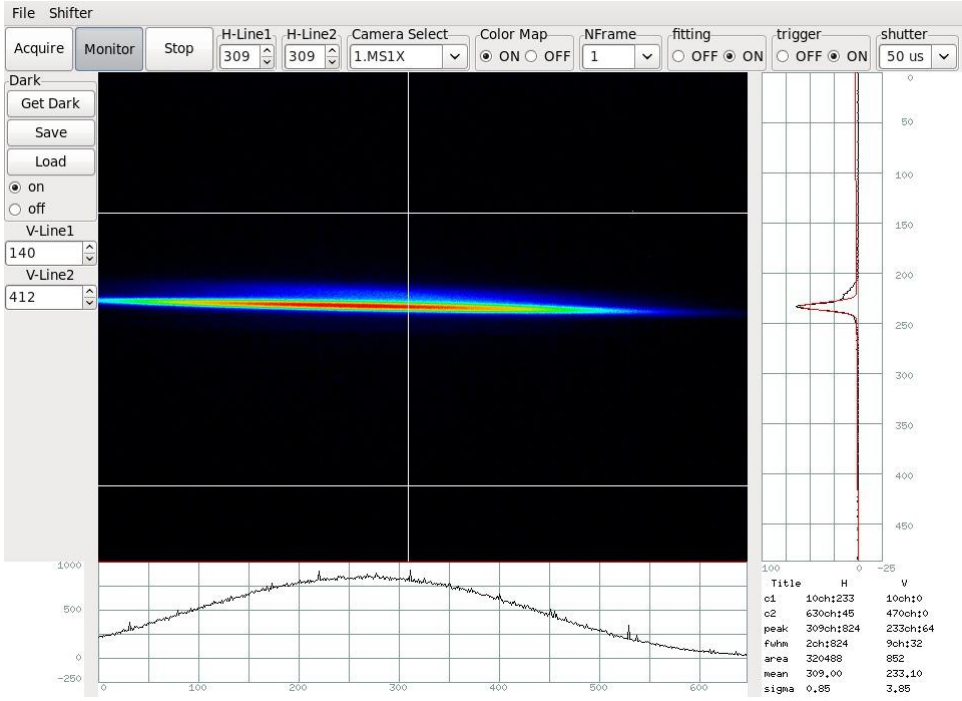
Hor 41ch x 8.1um/ch=332.1um

MS1X YAG:Ce screen monitor

Beam test 2013/11/22
The lens was replace to high magnification lens(6um resolution) and a optical filter(500nm/10nm band width) was installed to avoid the saturation.

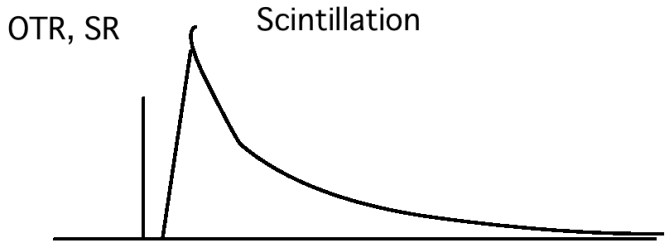


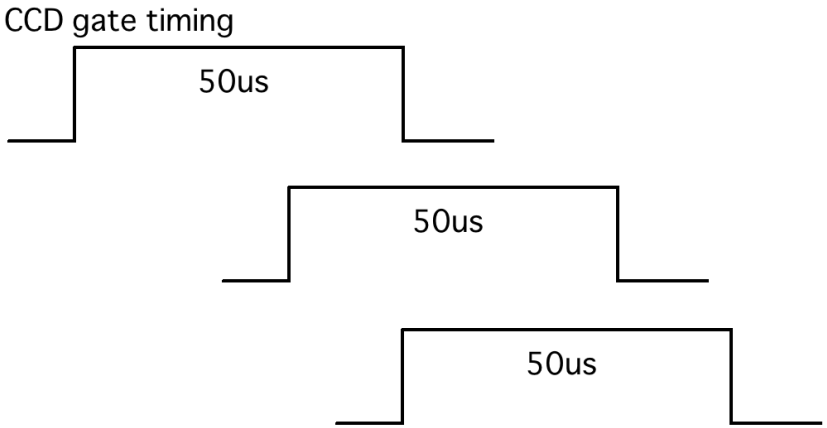
Without BPF
Trigger delay : 44.7us



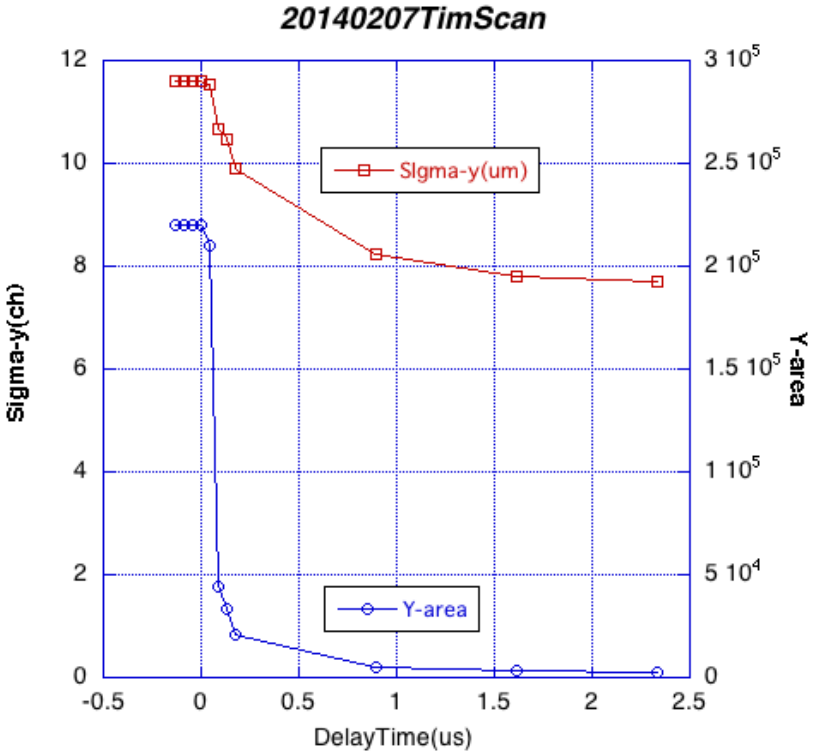
With BPF
Trigger delay : 44.7us

MS1X YAG:Ce screen monitor



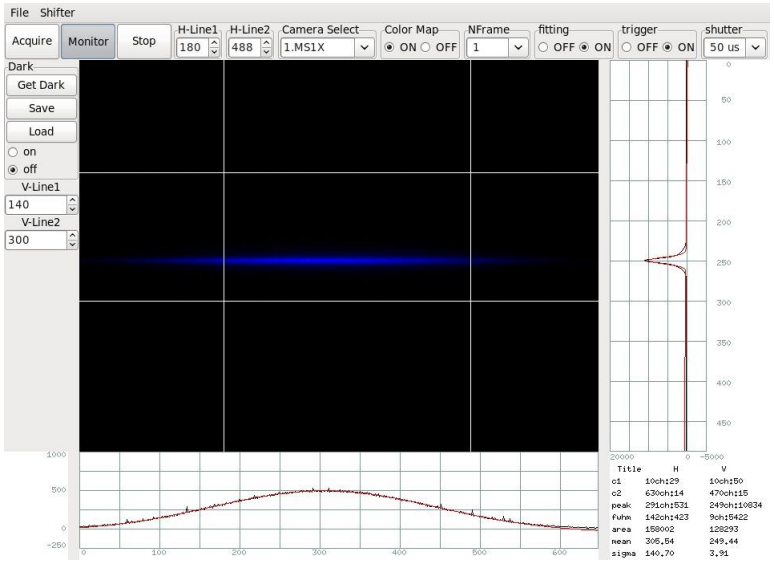


Exposure Timing
The CCD sees the OTR, SR from up stream and the scintillation light.
The OTR and the SR light can be avoided by the external trigger timing of the CCD.

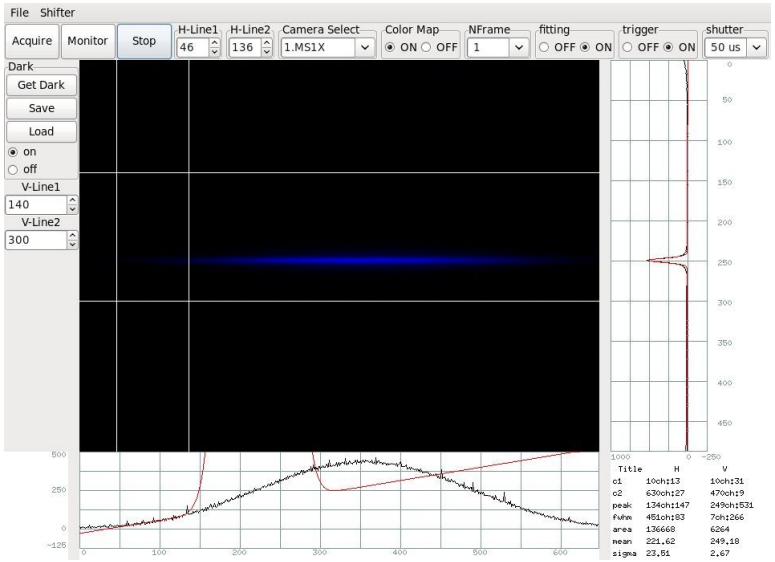


The shutter timing characteristics(electric shutter width 50us)

MS1X YAG:Ce screen monitor

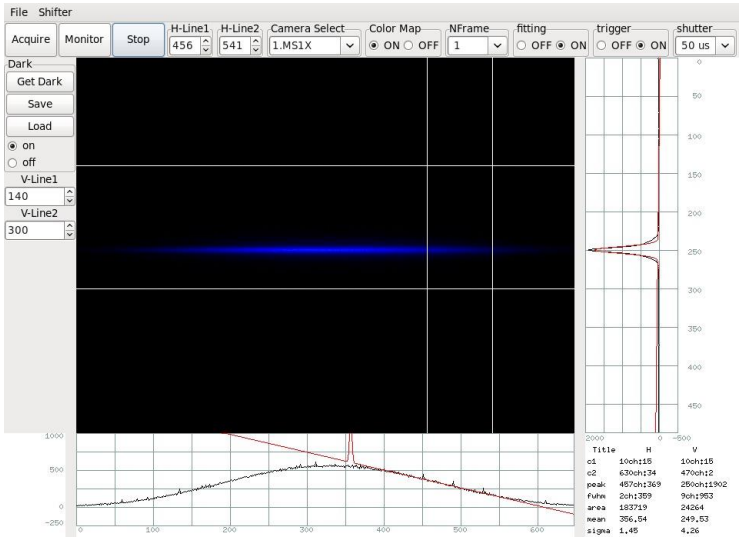


3.91ch x 7.4um/ch x 1/2=14.4um



2.67ch x 7.4um/ch x ½=9.88um

The vertical size was different for the left side and right side. The energy difference shows the different focus.



4.26ch x 7.4um/ch x 1/2=15.7um

Summary

1. To supply the stable beam to ATF2,
   a) The linac modulator renewal was completed (except for #0 modulator).
   b) The renewal cooling water system was completed.
   c) #0 klystron was replaced to new one.
2. Multi-bunch/Multi-train operation was carried out for the radiation inspection. Over 40mA of the stored current was operated without any serious radiation loss.
3. DR temperature stabilization was carried out. The effect is not clear.
4. XSR monitor – Si mirror was replaced to avoid the deformation of the optical system.
5. A screen monitor was tested using YAG:Ce scintillator.