

# Magnet Alignment

## ATF2 survey 2012

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ATF2 Technical Review

April 3, 2013 at KEK 2-goukan

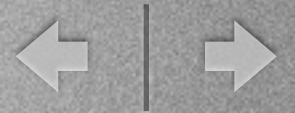


## contents

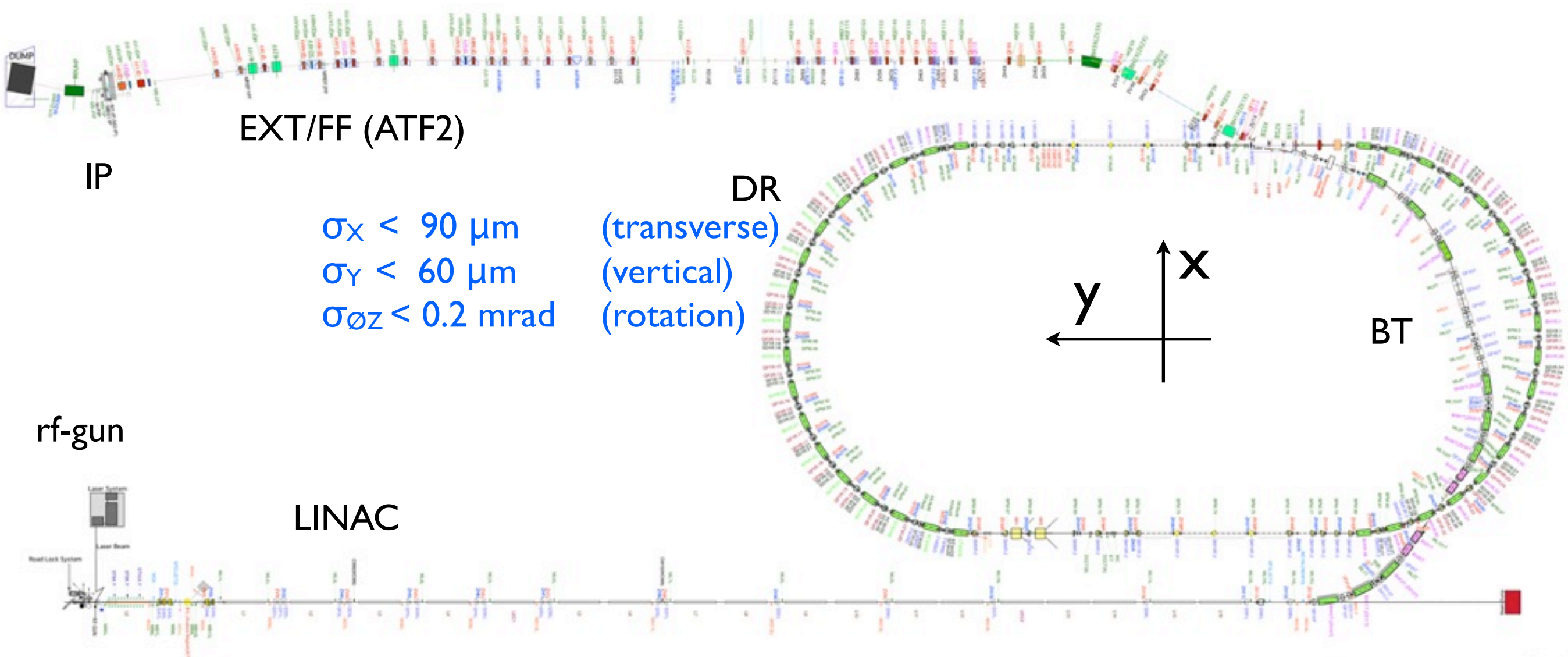
- Operation was stopped by the 3.11 earthquake.
- Rough alignment for linac to DR (June, 2011) :Order ~0.5mm  
=> It let the test beam pass to ATF2
- Second alignment for DR and survey for ATF2 (September, 2011) :Order ~0.1mm  
=> Restart beam study
- alignment for ATF2 :Order ~0.1mm  
(Quadruple magnets aligned from October, 2011)  
(Bend/Sext magnets aligned from January, 2012)
- Repeating survey for DR and EXT/FF  
(April, May, Sep., Oct., 2012)



# ATF



- Origin of alignment coordinates is a center of DR.
- SETTING ACCURACY  
DR Alignment tolerance was evaluated beam tracking simulation.







# Alignment tools

using by ..

- Bubble Level & Digital Tilt meter (Roll & Pitch)
- Alignment / Rotating Laser
- Laser Tracker (3D spacing survey) & Portable CMM

ACCURACY

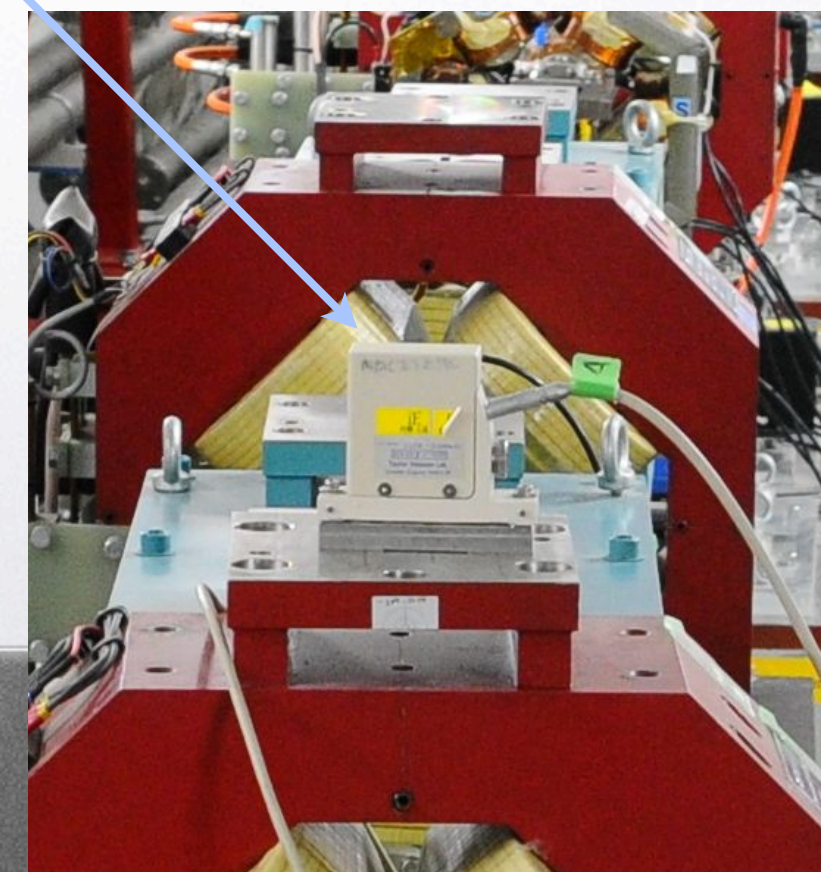
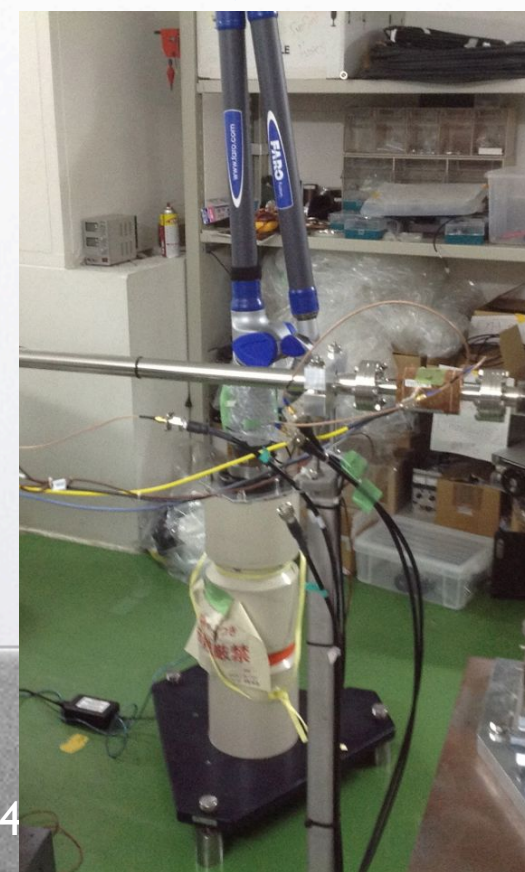
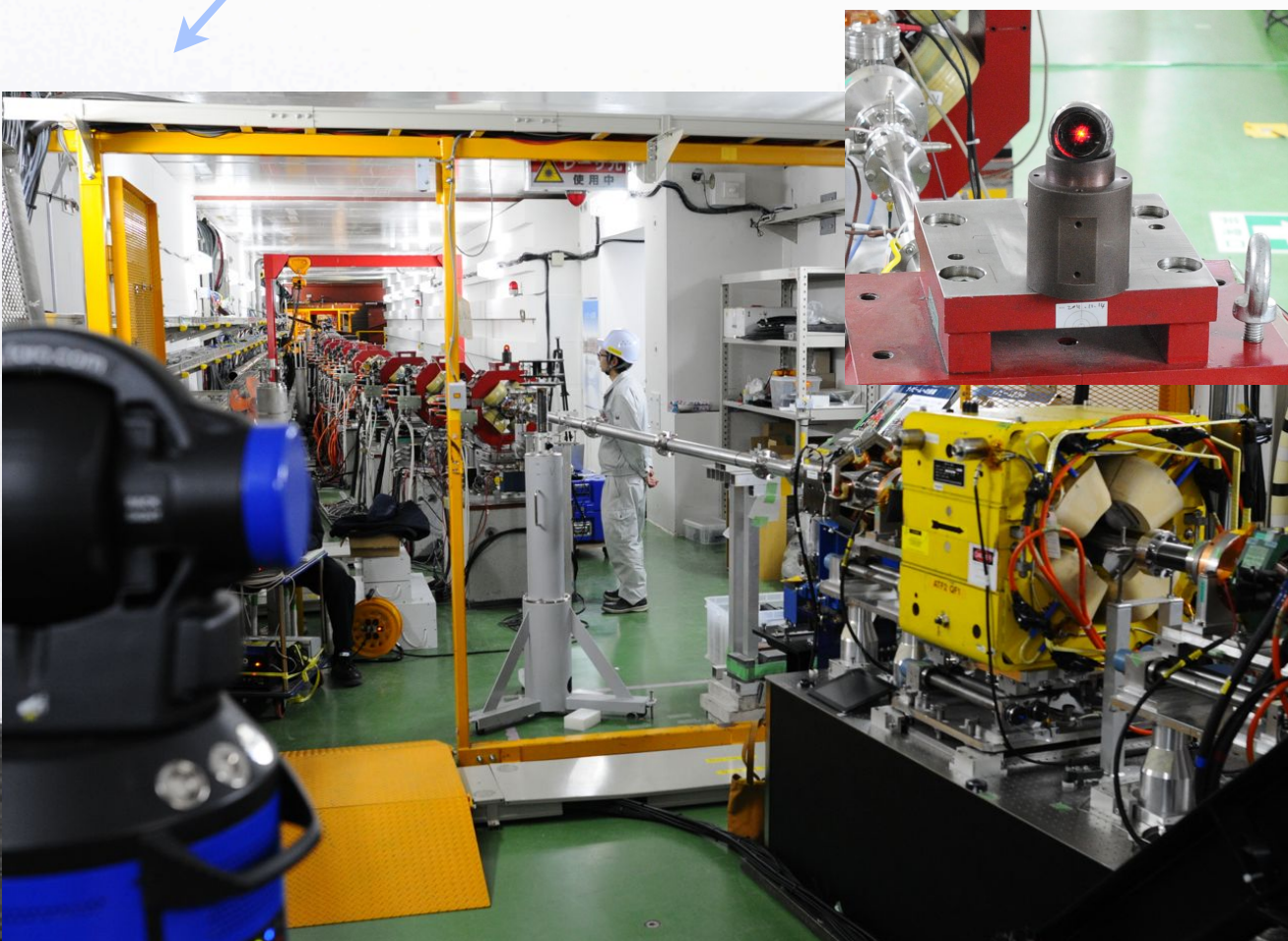
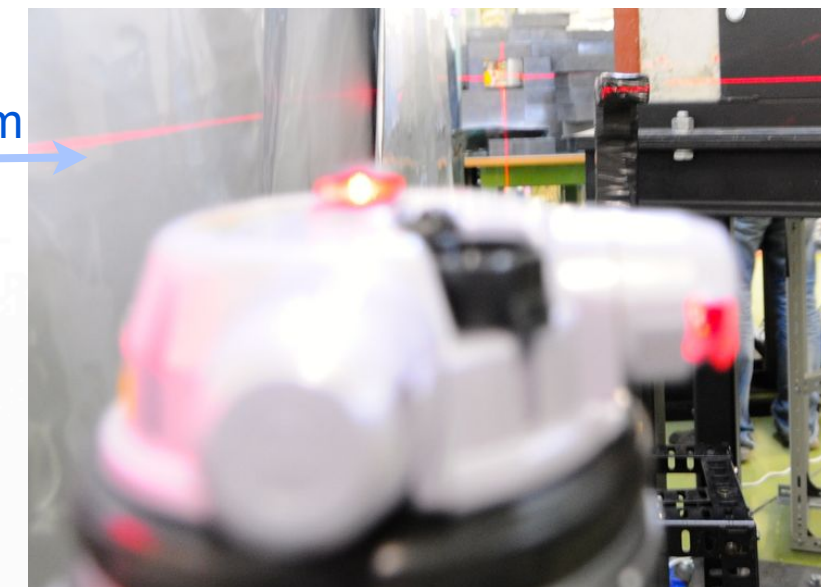
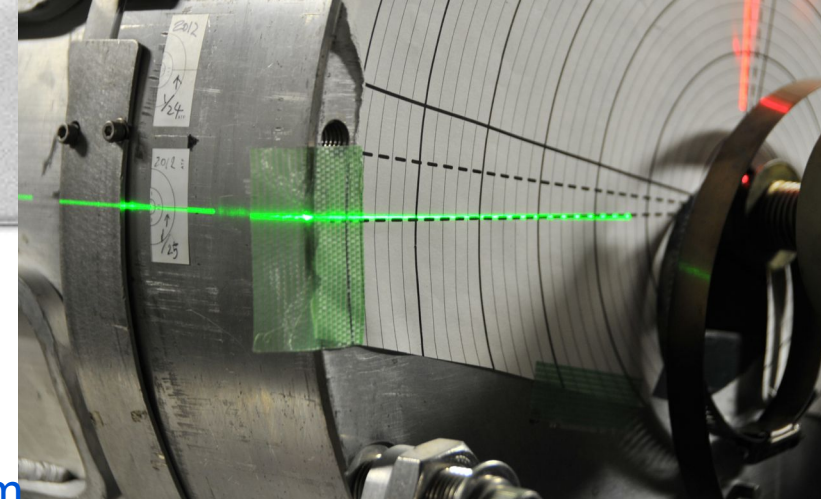
$\approx 0.002 \text{ mm/m}$

$\approx 0.1 \text{ mm/10m}$

$\approx 0.1 \text{ mm/3m}$

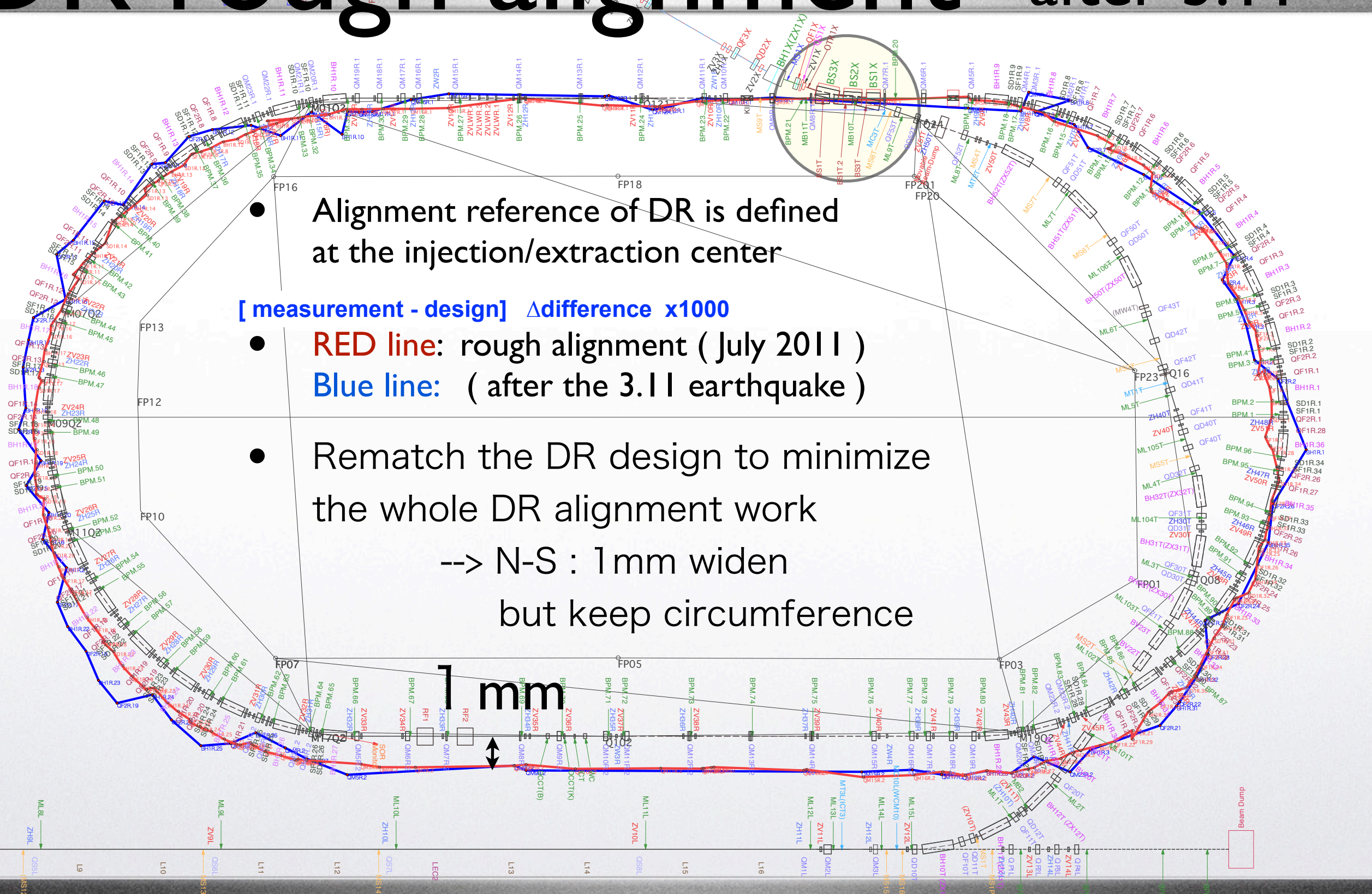
Rotating Laser  
 $\approx 0.15 \text{ mm/10m}$

Alignment Laser  
 $\approx 0.3 \text{ mm/10m}$





# DR rough alignment after 3.11



- Alignment reference of DR is defined at the injection/extraction center
- [ measurement - design ]  $\Delta$ difference x1000
- **RED line:** rough alignment ( July 2011 )
- **Blue line:** ( after the 3.11 earthquake )
- Rematch the DR design to minimize the whole DR alignment work  
--> N-S : 1mm widen  
but keep circumference





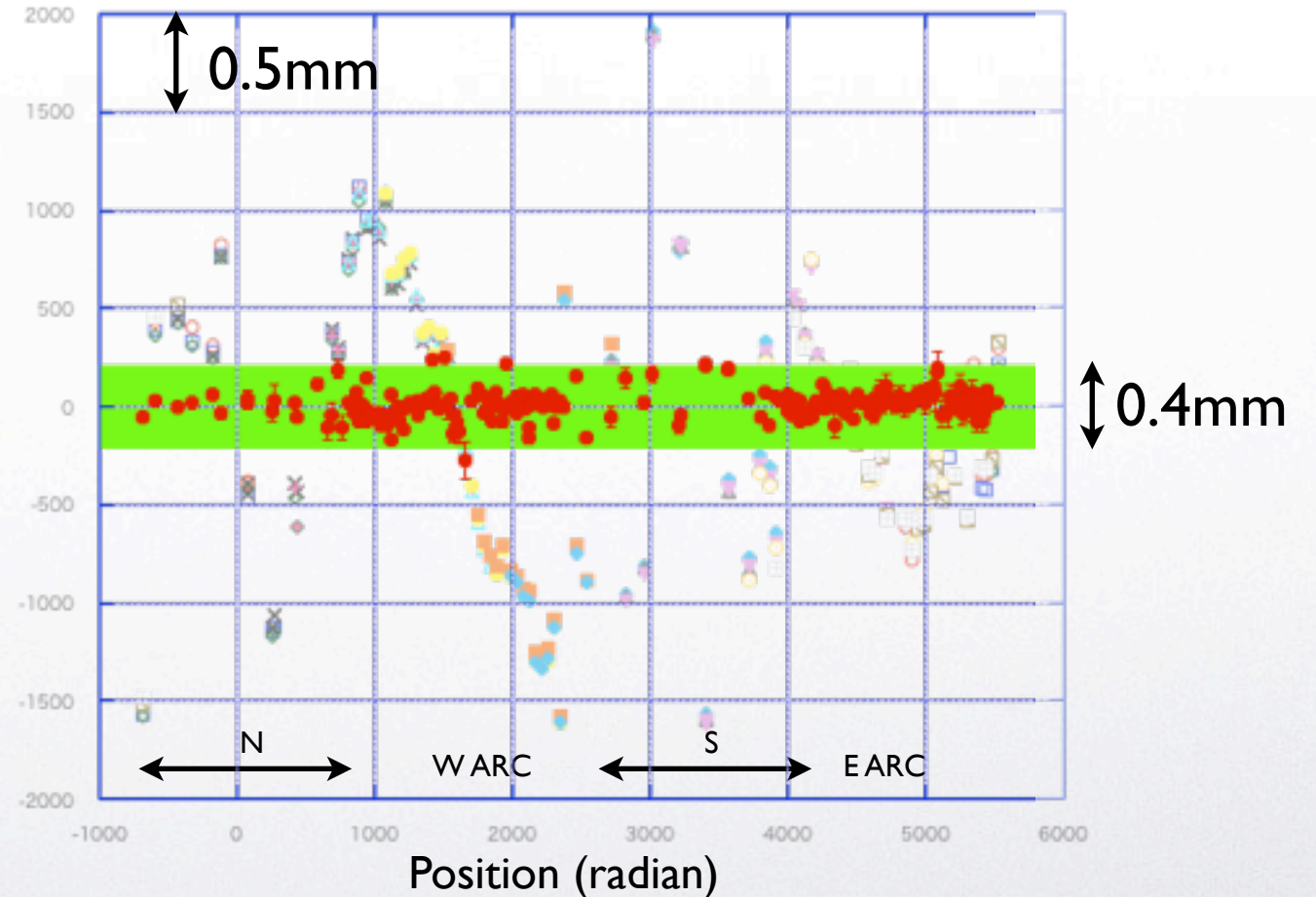
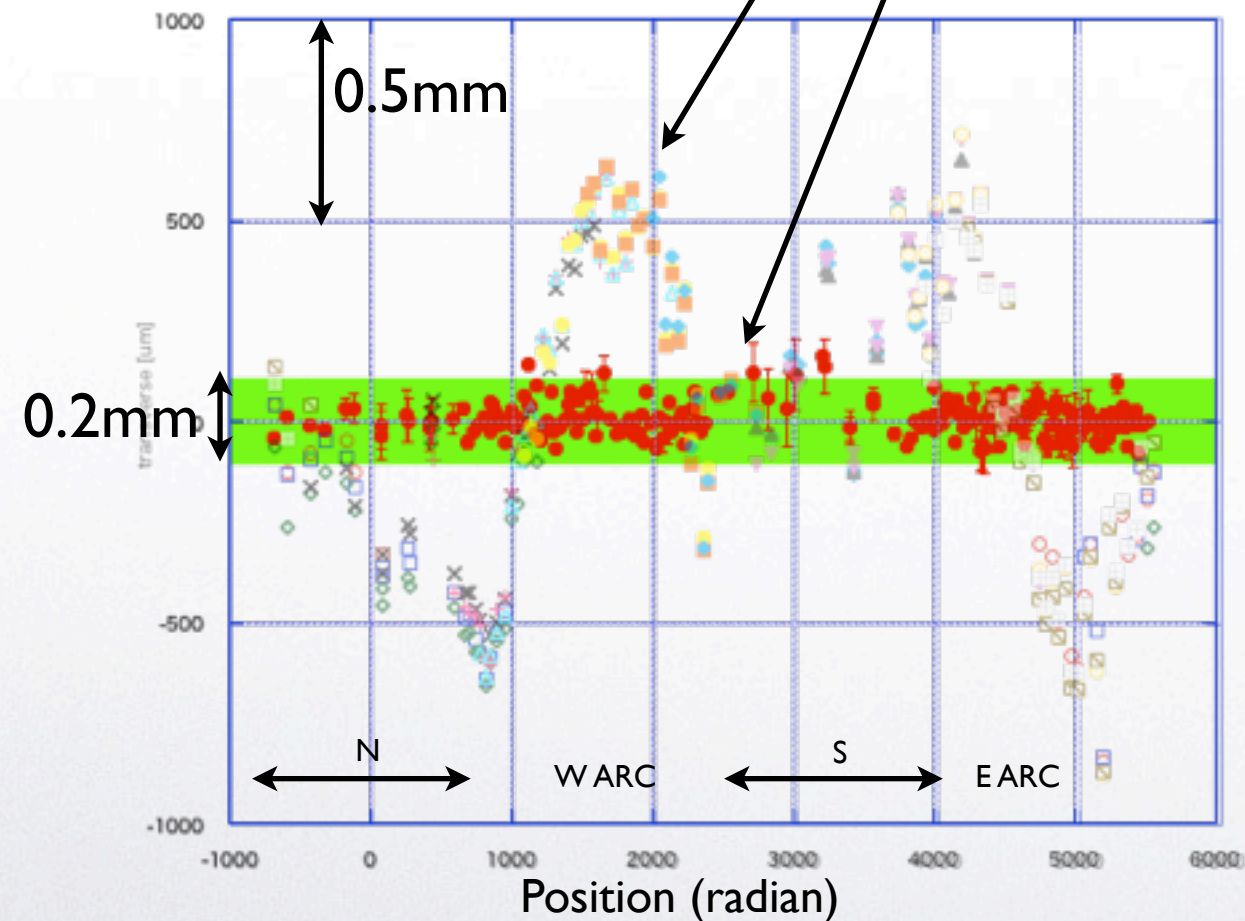
# DR alignment



- rough alignment ( June 2011 )
- after fine alignment ( ● september 2011 )

## Transverse

## Longitudinal



● Transverse  $\pm 0.15\text{mm}$

● Longitudinal  $\pm 0.27\text{mm}$

RMS: 0.05mm

RMS: 0.08mm

- DR alignment performed in October, 2011.





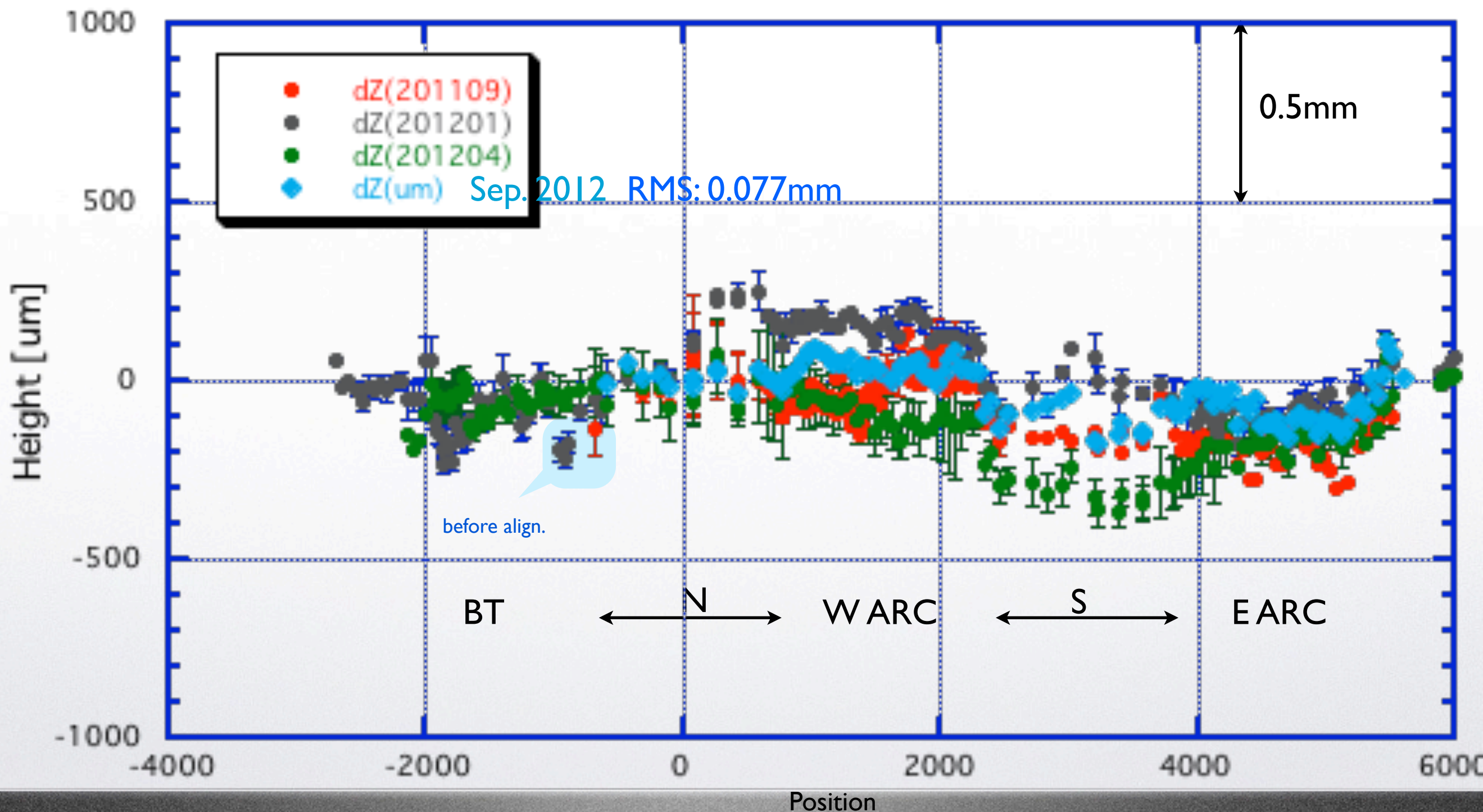
# DR survey

Sep.'11~Sep.'12



## Height (Vertical)

survey of DR-all Height



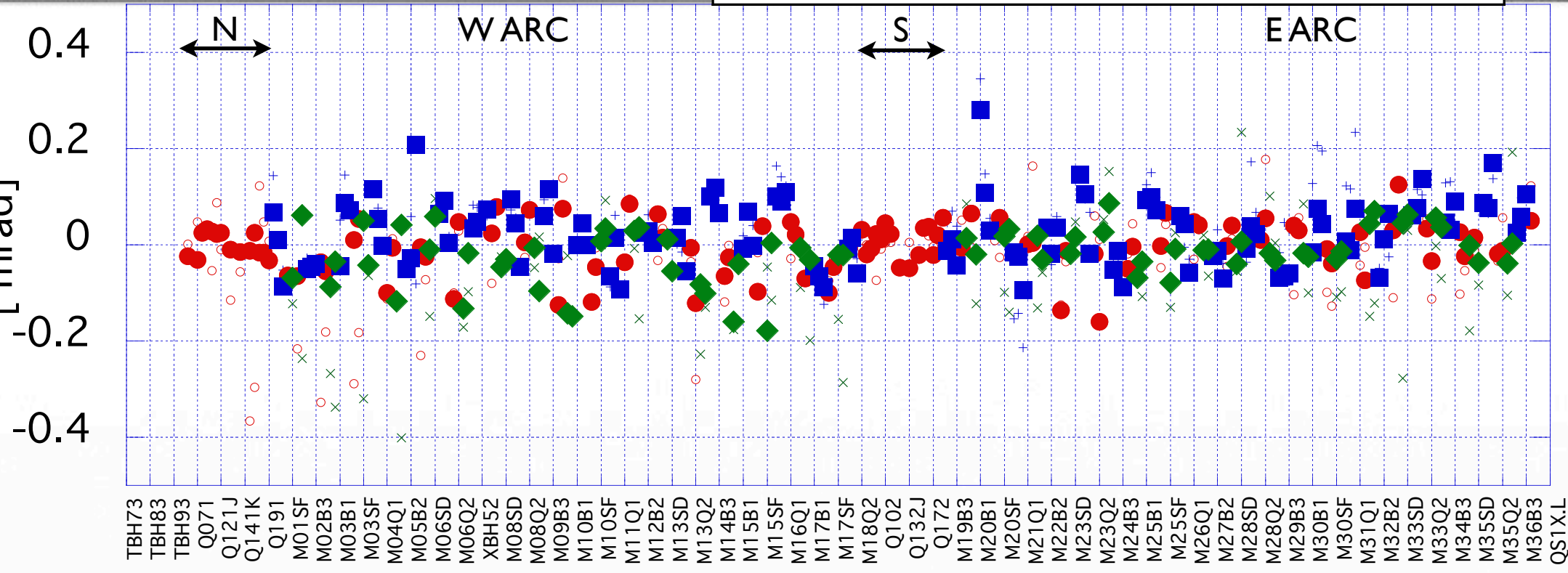




# DR Roll/Pitch

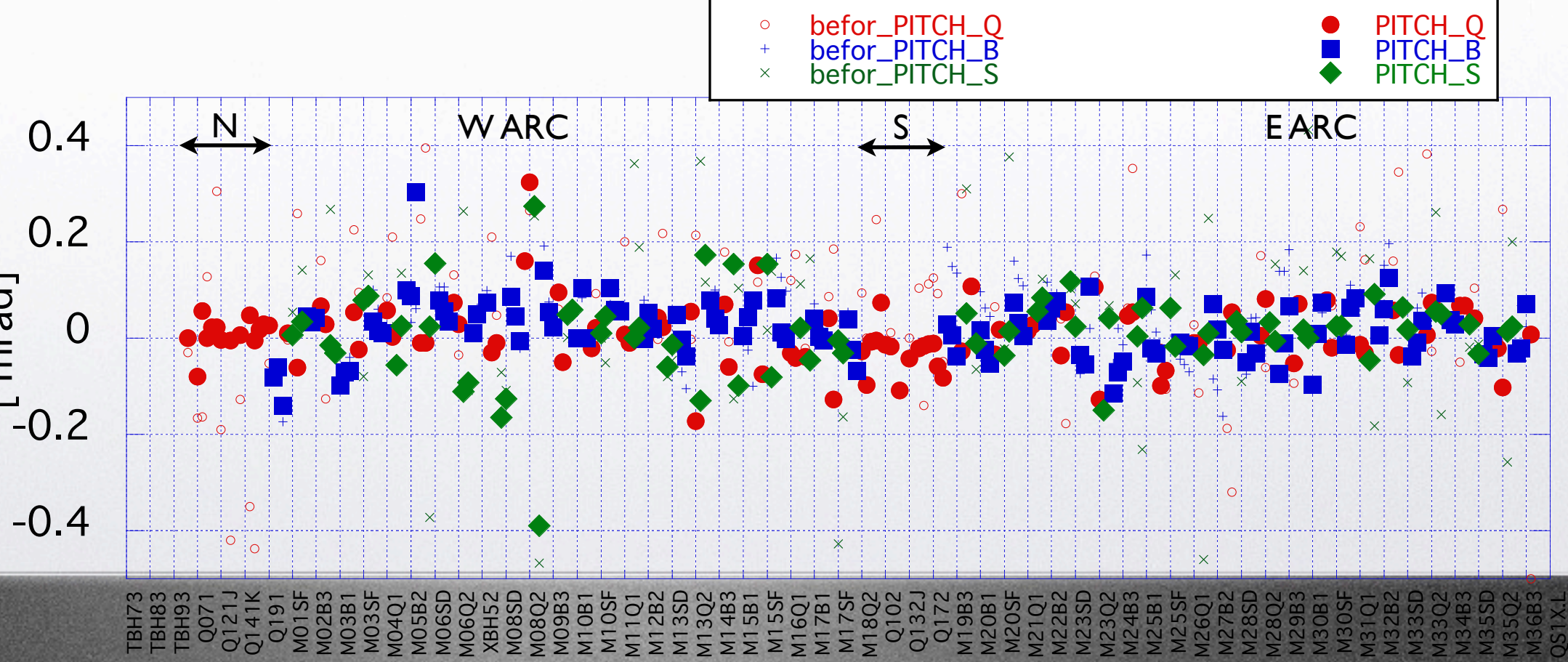
● Roll

[ mrad]



● Pitch

[ mrad]







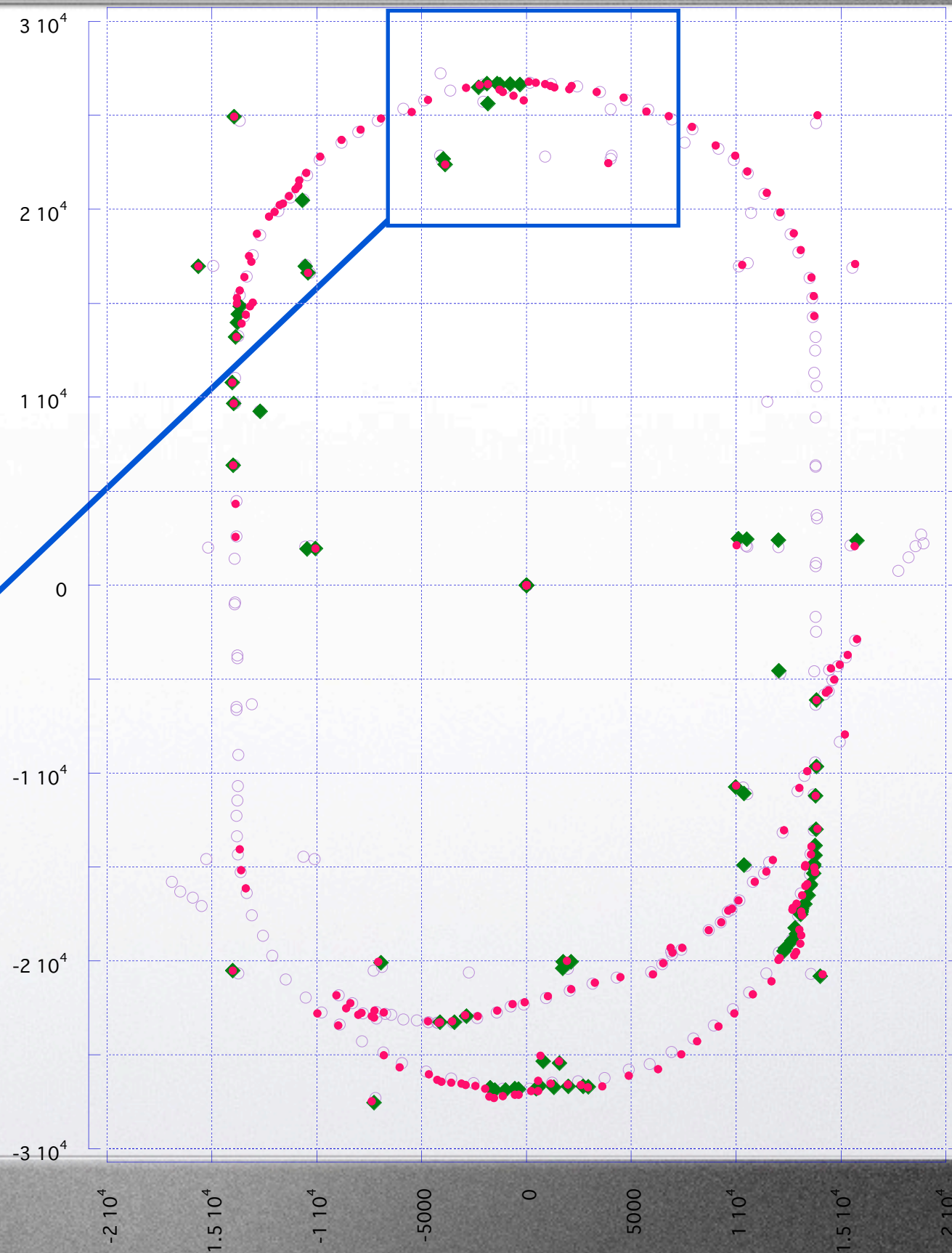
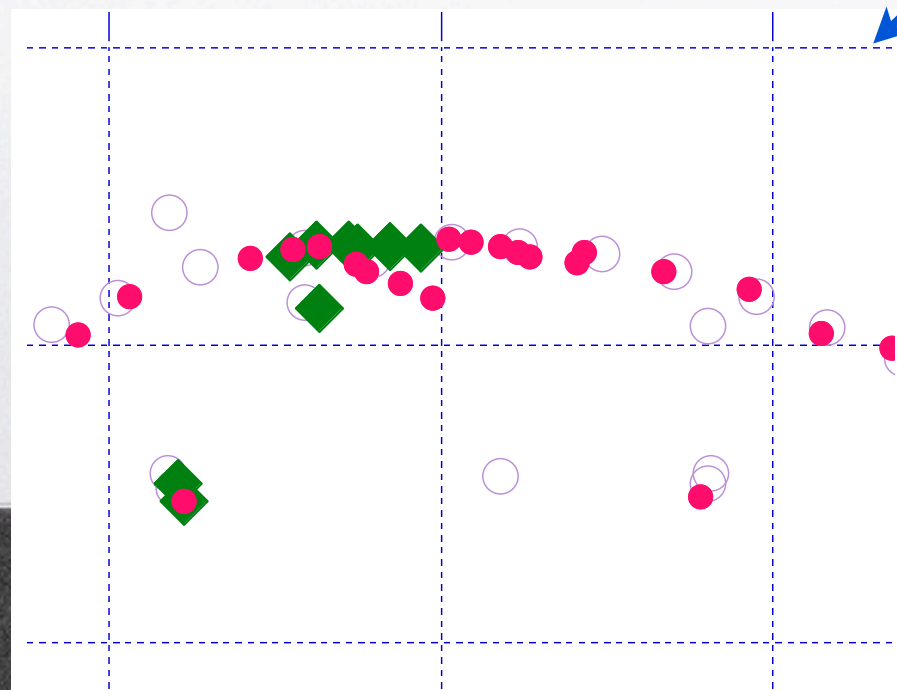
# DR alignment after 12.07.2012



[ measurement - design ]  $\Delta$ difference x1000

- Red dots : 10th Dec 2012  
(after Dec. 7th 2012 earthquake)
- Green dots : after alignment

same table of magnets were shifted.

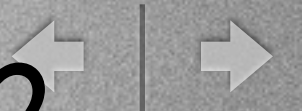






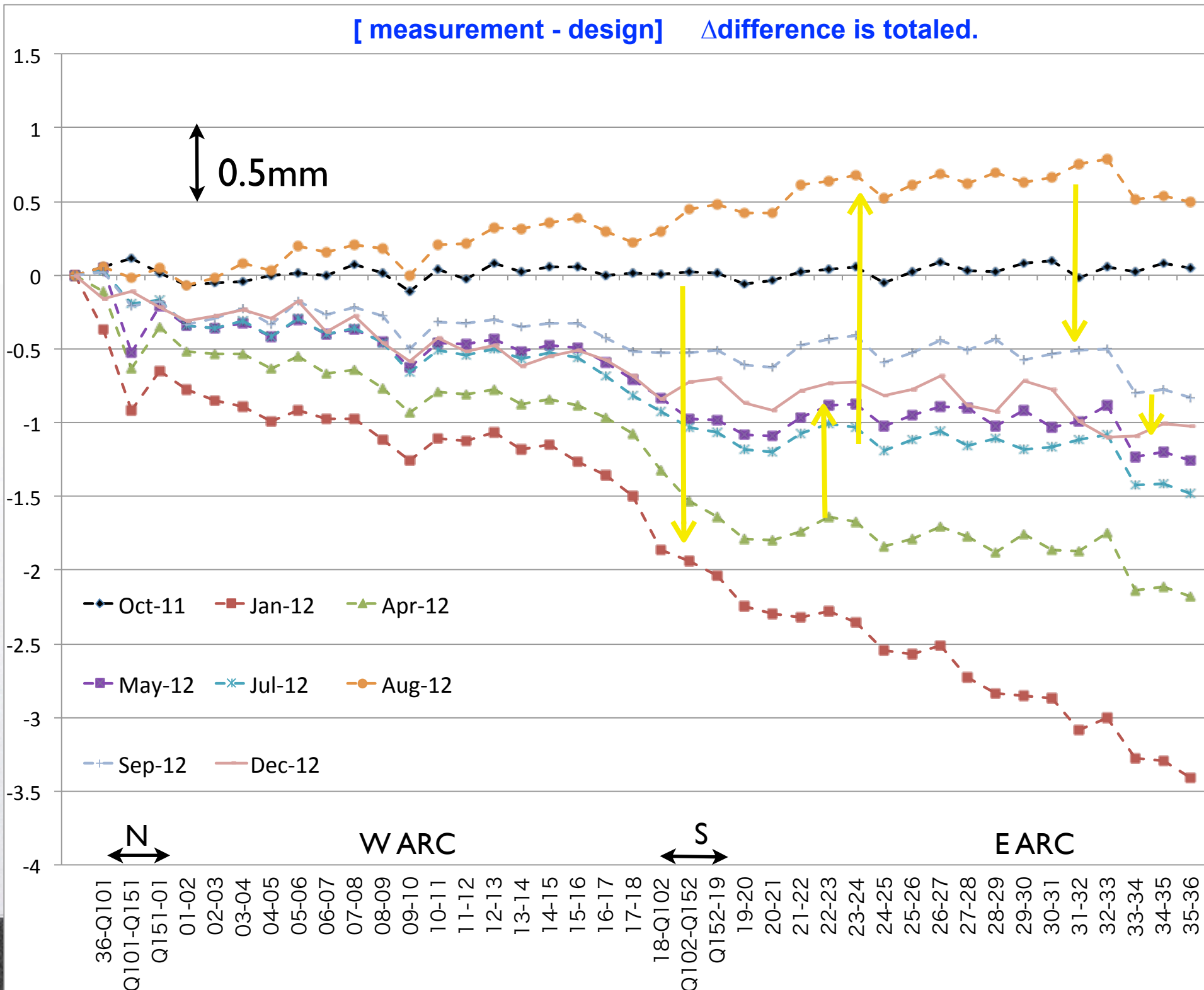
# DR survey

Oct.'11~Dec.'12



## circumference

[ measurement - design ]  $\Delta$ difference is totaled.



(Bend to B distance) sum

- +0.1mm Oct '11 Operation
- - 3.4mm Jan '12 Maintenance
- - 2.2mm Apr '12 Operation
- - 1.3mm May '12 Operation
- - 1.5mm Jul '12 Operation
- +0.5mm Aug '12 Maintenance
- - 0.8mm Sep '12 Maintenance
- - 1.0mm Dec '12 Operation /120m

10 integration value of each deviation





- **ATF2**



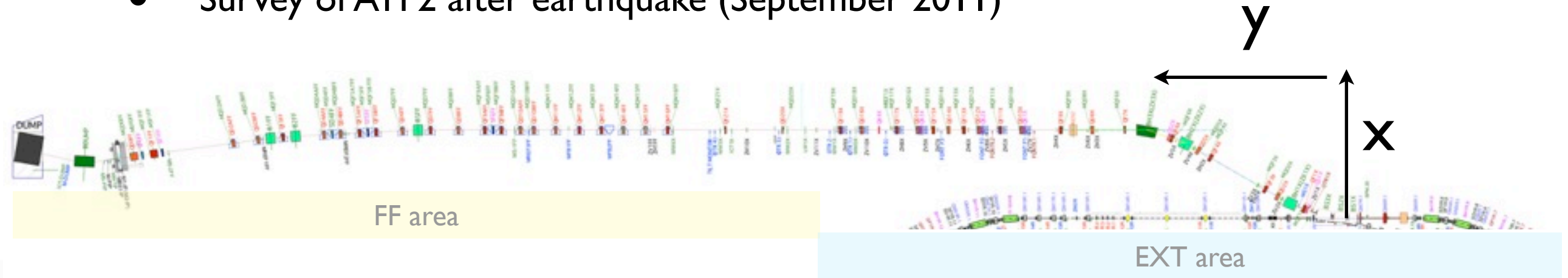




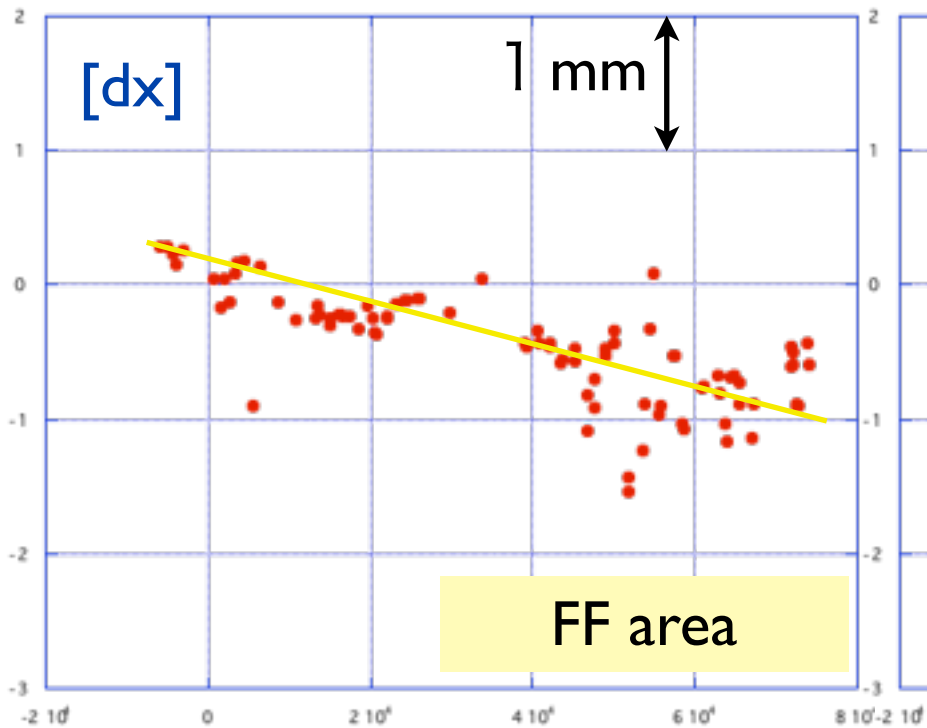
# EXT/FF(survey)

after 3.11

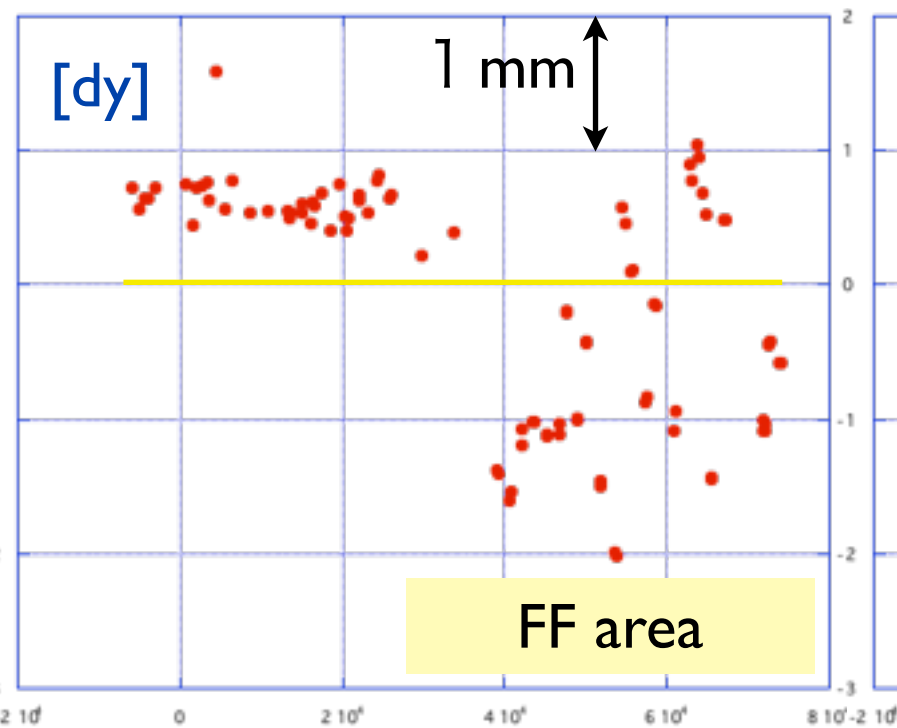
- Survey of ATF2 after earthquake (September 2011)



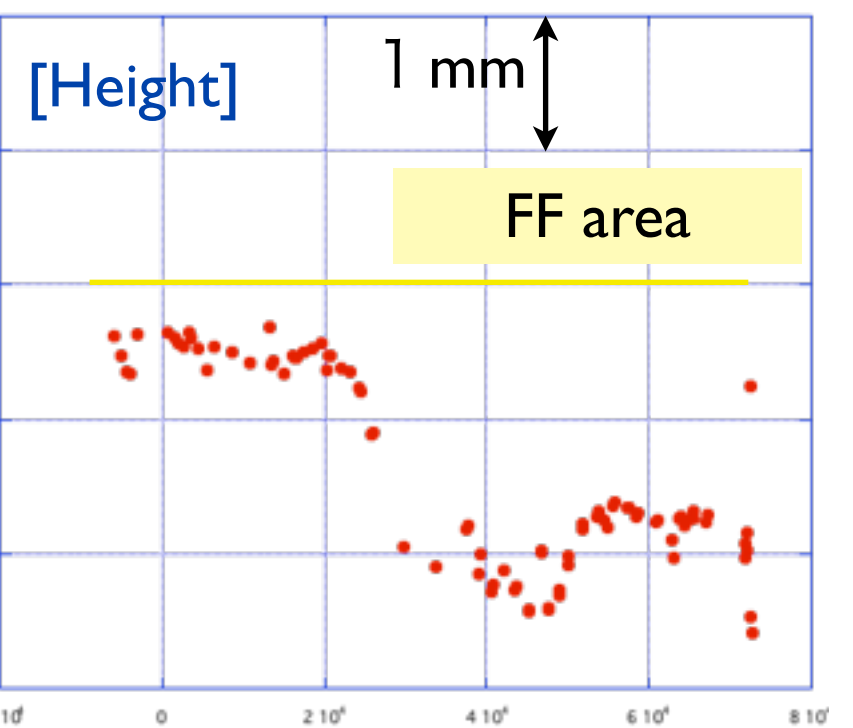
( $\approx$  Transverse)



( $\approx$  Longitudinal)



(Height)



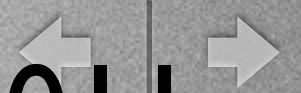
Y position [mm]



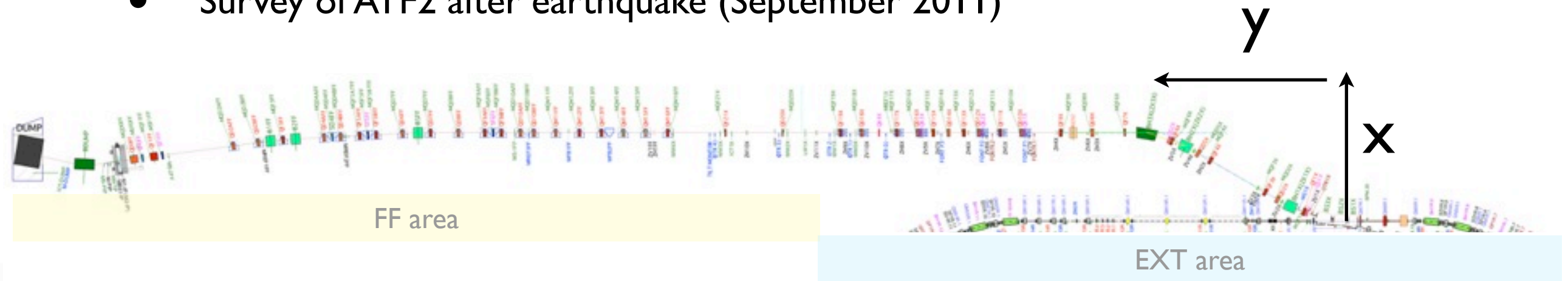


# EXT/FF(alignment)

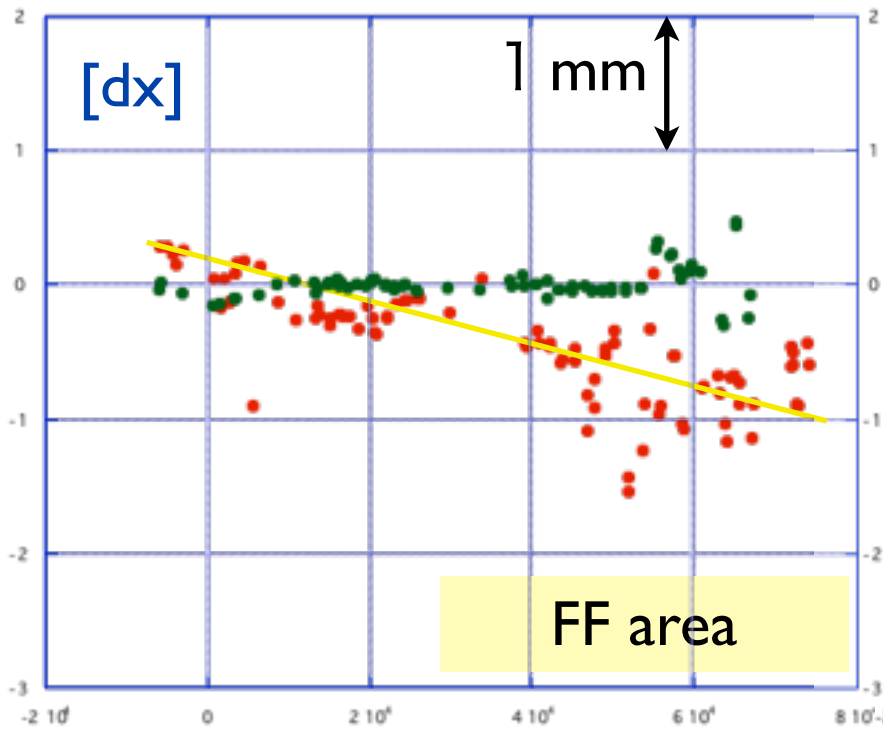
Dec. 2011



- Survey of ATF2 after earthquake (September 2011)

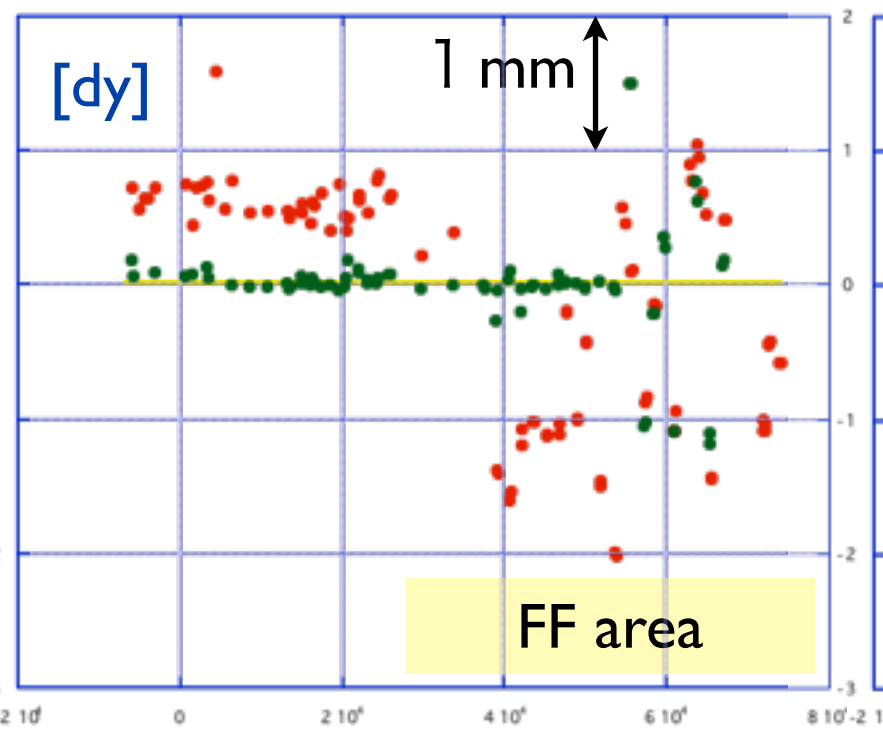


( $\approx$  Transverse)

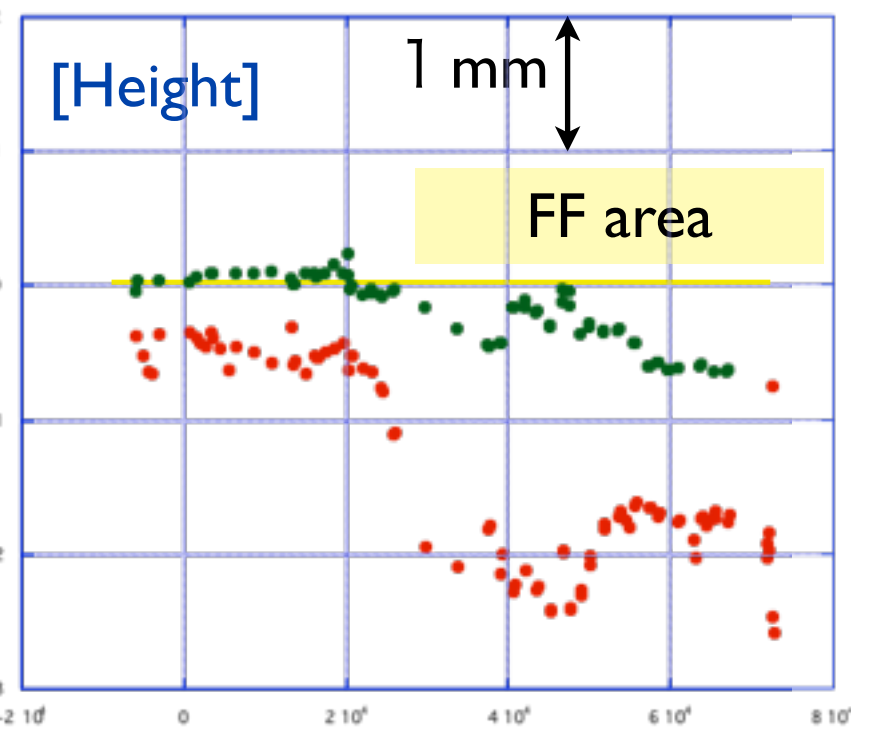


Y position [mm]

( $\approx$  Longitudinal)



(Height)



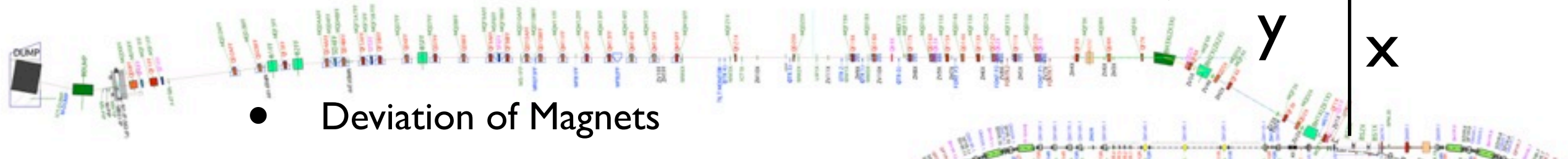
- before alignment
- Survey result in December by new ATF2 design





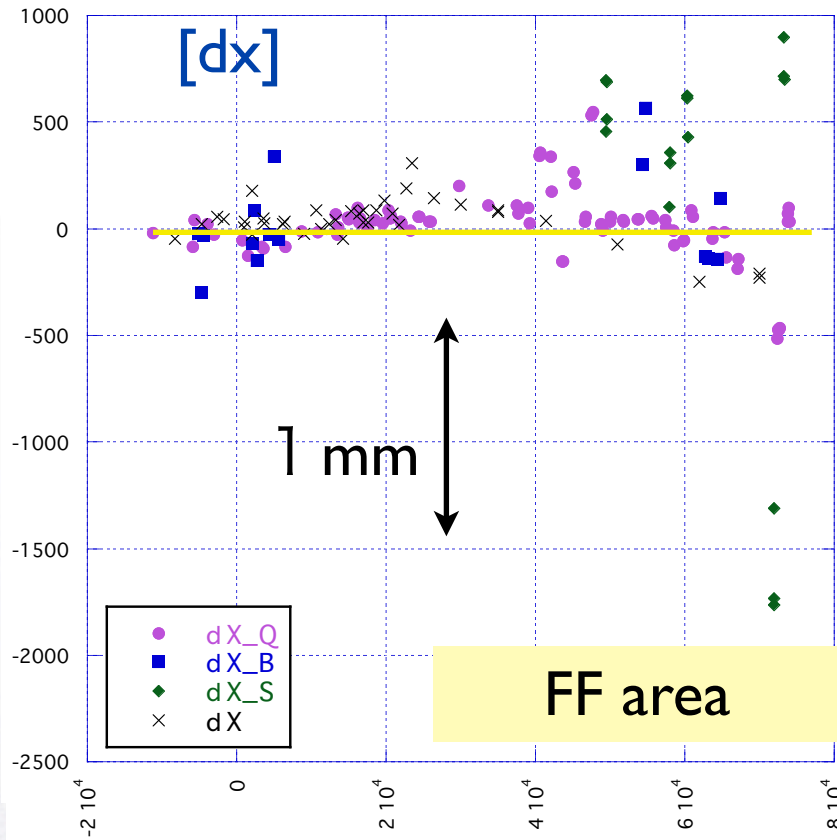
# EXT/FF(survey)

May '12

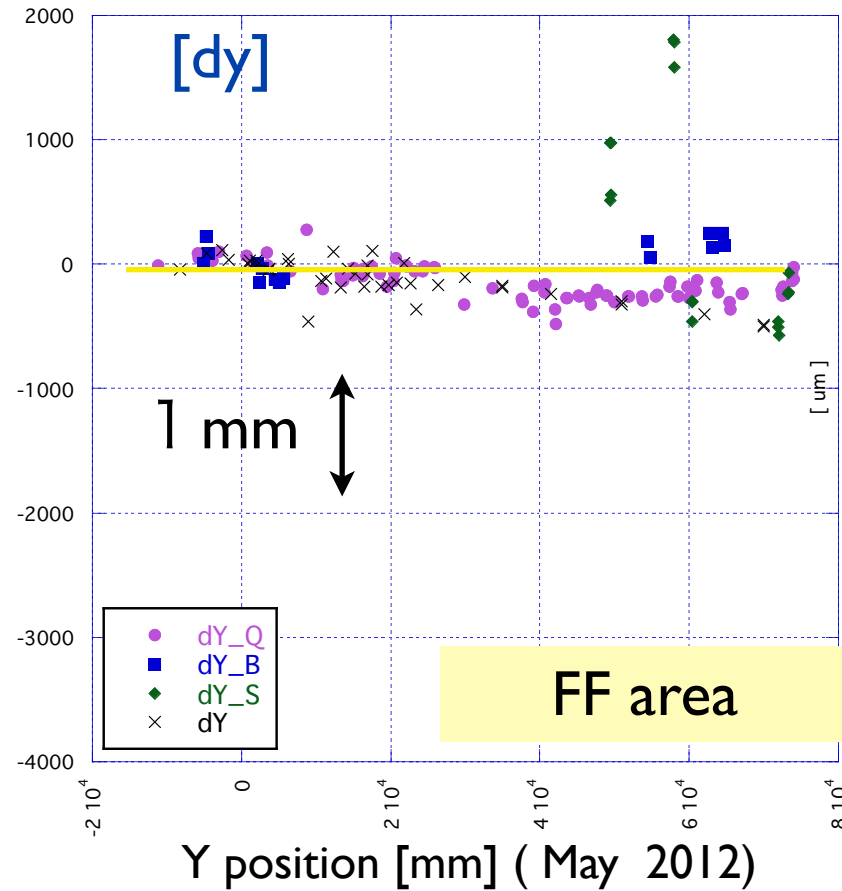


● Deviation of Magnets

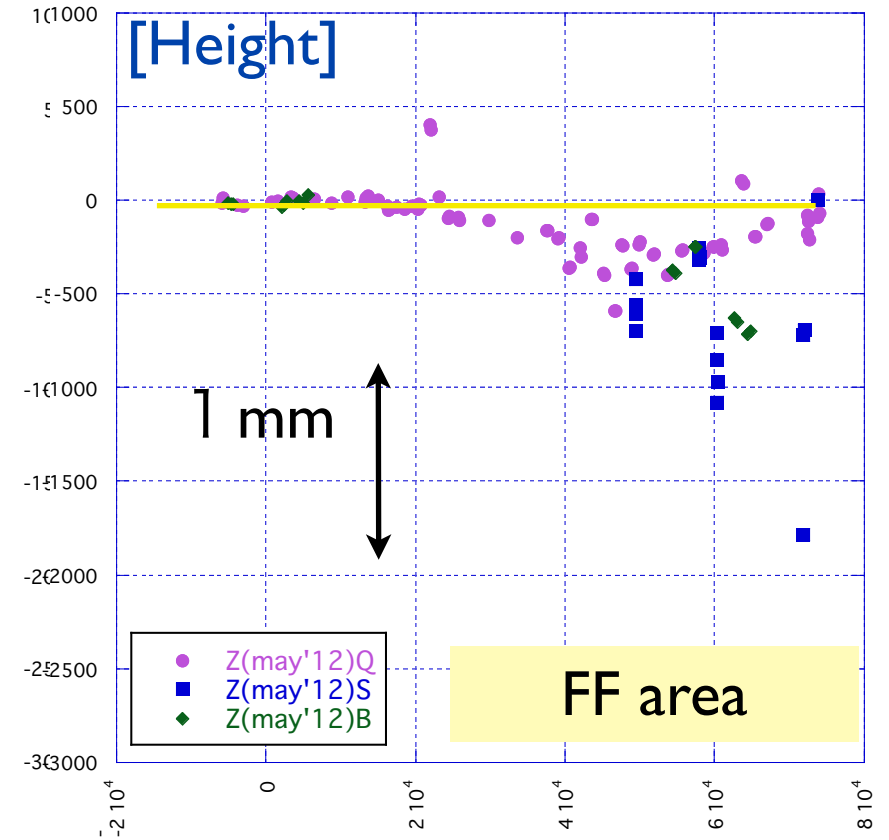
EXT-FF measurement ( was SET to FFMover)



( $\approx$  Transverse)  $Q_{mag\_RMS}$ : 0.169mm



( $\approx$  Longitudinal)  $Q_{mag\_RMS}$ : 0.205mm



(Height)  $Q_{mag\_RMS}$ : 0.218mm





# EXT/FF ROLL&PITCH

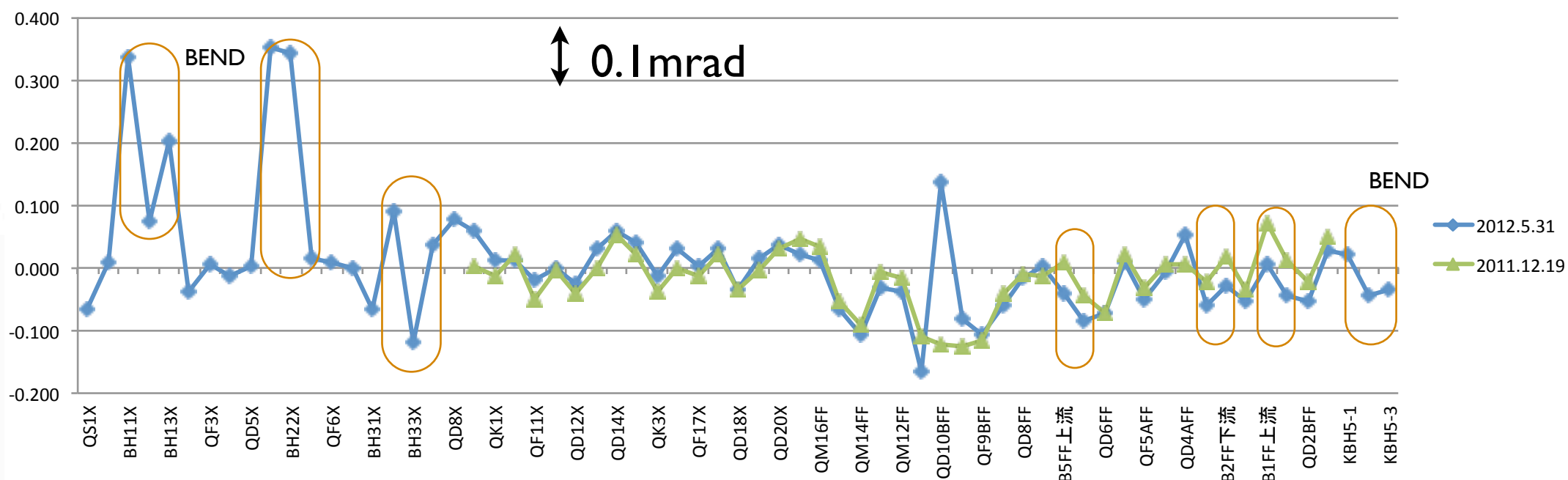


Roll&Pitch after the earthquake were out of range !!

Alignment of ATF2 was started in Oct '11

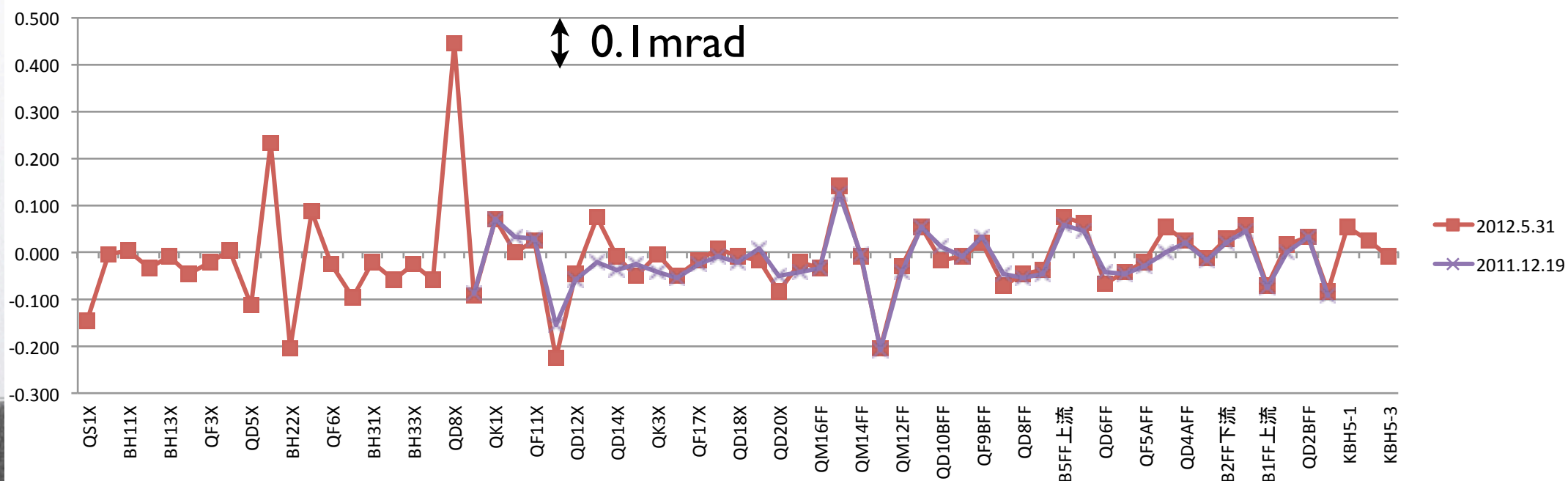
- Roll
  - Dec '11
  - May '12

ROLL



- Pitch
  - Dec '11
  - May '12

PITCH





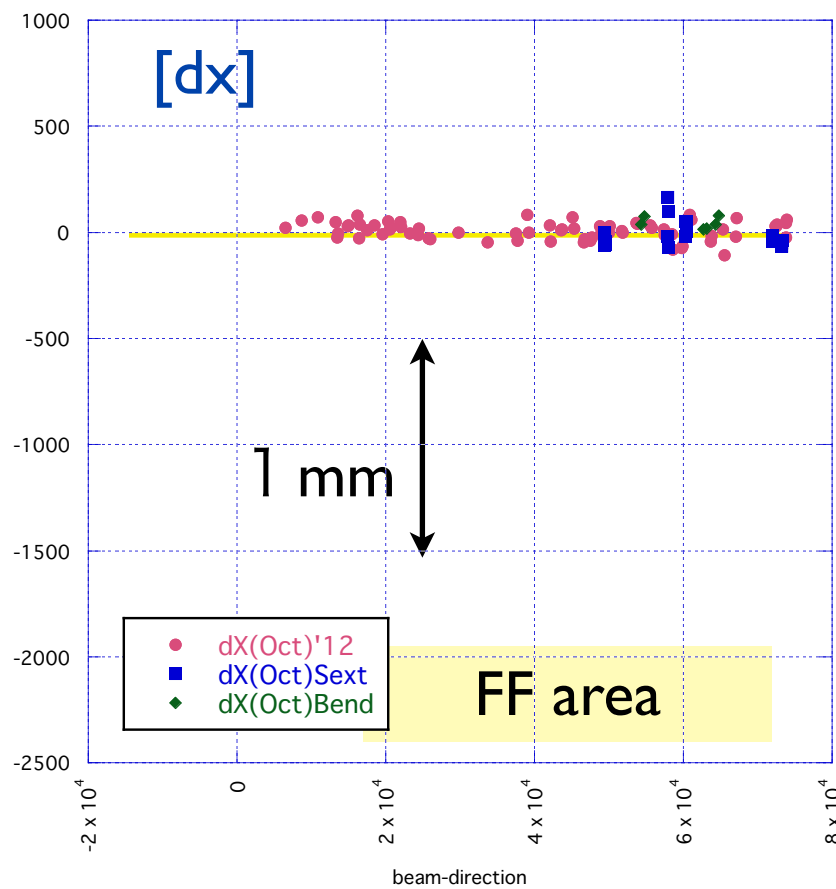


# EXT/FF

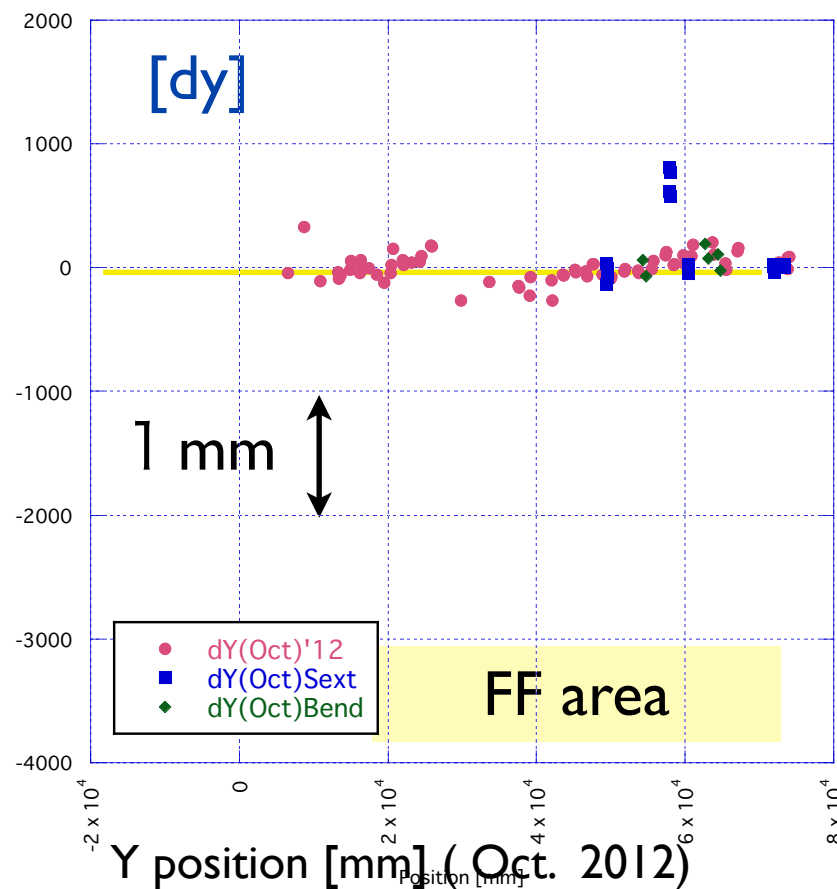
Oct '12



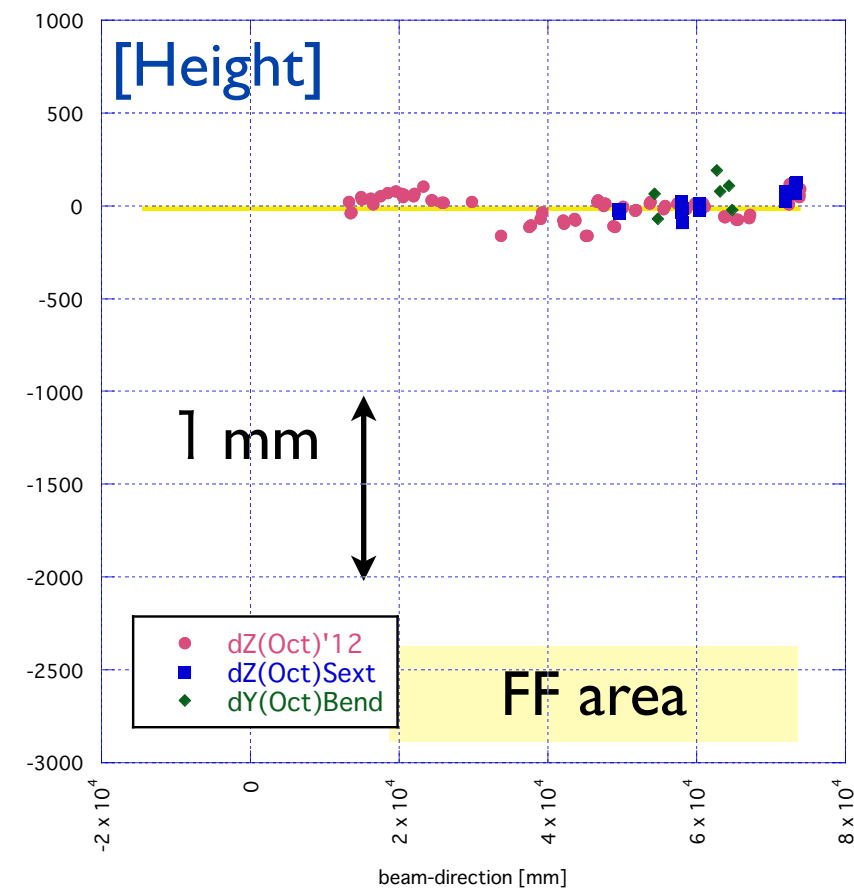
- Deviation of Magnets (Oct '12)



( $\approx$  Transverse)  $Q_{mag\_RMS}$ : 0.041mm



( $\approx$  Longitudinal)  $Q_{mag\_RMS}$ : 0.105mm



(Height)  $Q_{mag\_RMS}$ : 0.064mm

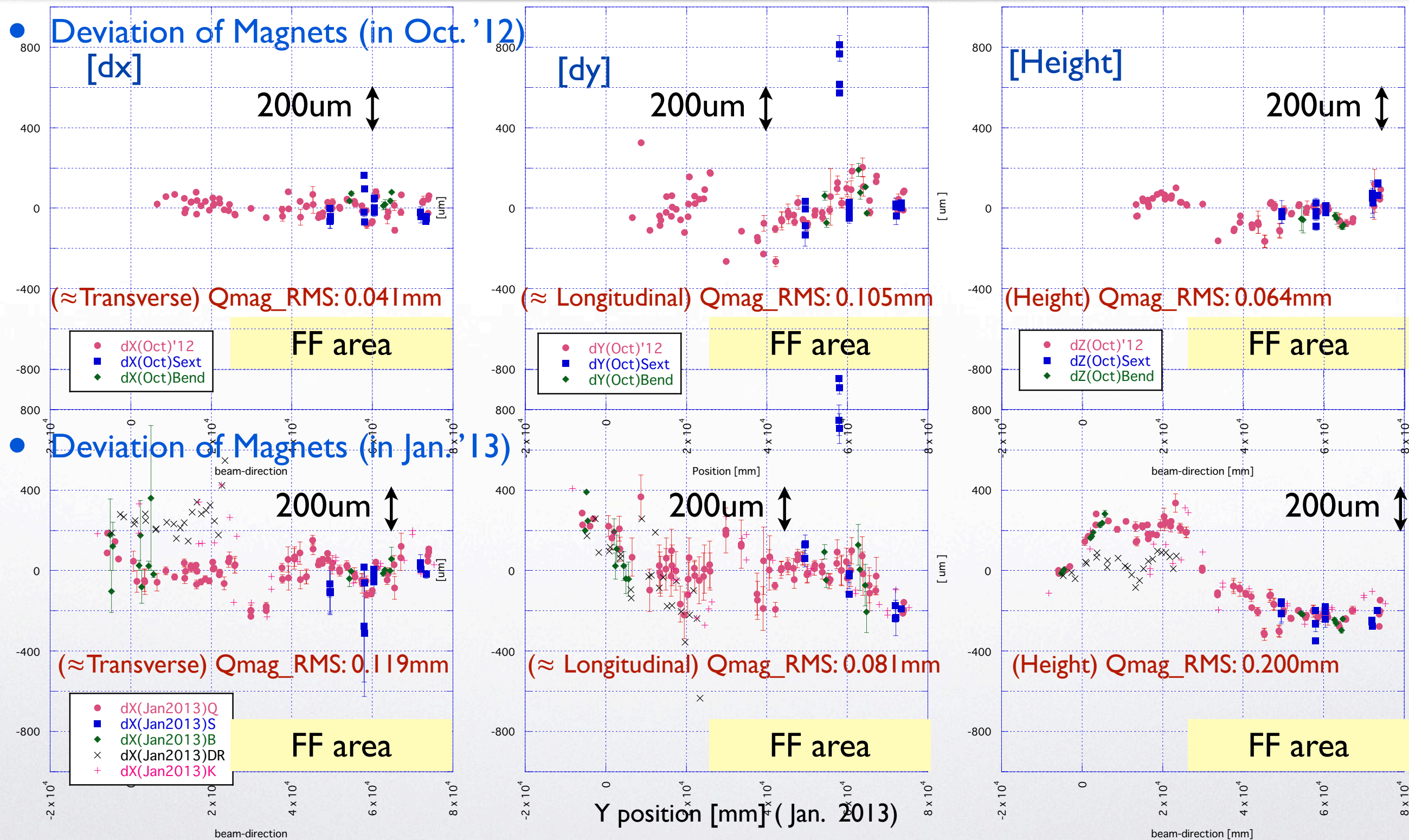
- Alignments for SD4, SF5, SD6, SFI, SD0, QFI, QD0
- Nov. 11th~ replaced for QFI





# EXT/FF(survey)

zoom

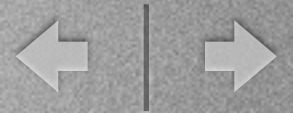


- The difference of the beam direction is changing.
- I think that length became short.

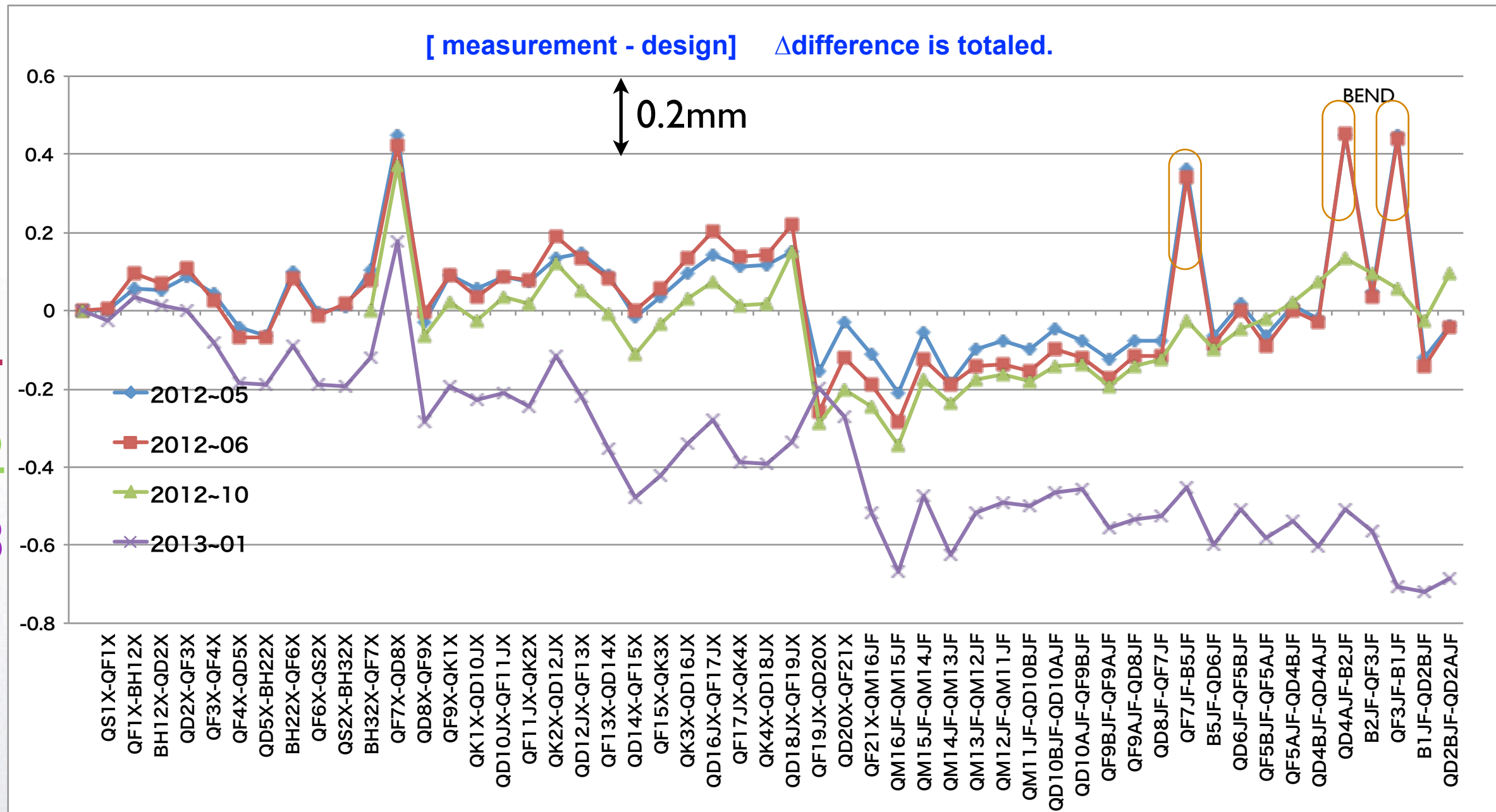




# EXT/FF (QS1X ~ QD2A)



## length of the beam line



May '12  
June '12  
Dec. '12  
Jan. '13

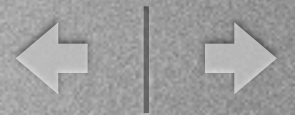
What makes difference. Total length was shorten 0.7mm / 80mm

- Earthquake in 7th December ?
- Temperature ?





# summary



- We had huge work for alignment at the 3.1 I.
- The survey for DR/ATF2 has been repeated every season.
- It seems that DR & ATF2 has a seasonal variation.

## issues

- The alignment was done under the magnets were off.  
(cooled down)





# おわり



- Thanks for your attention!

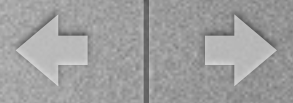




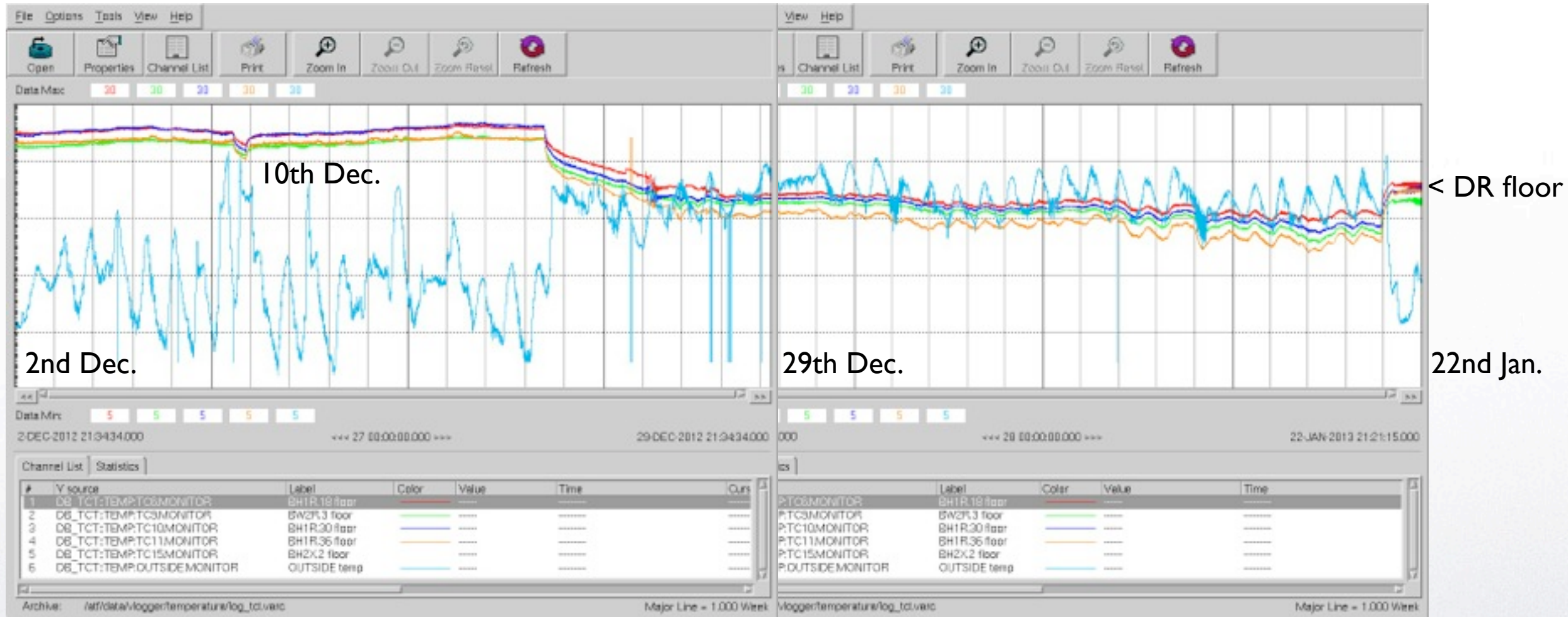




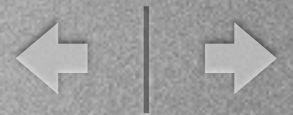
# Temperature



- Temperature of the floor of DR







# ● Circumference

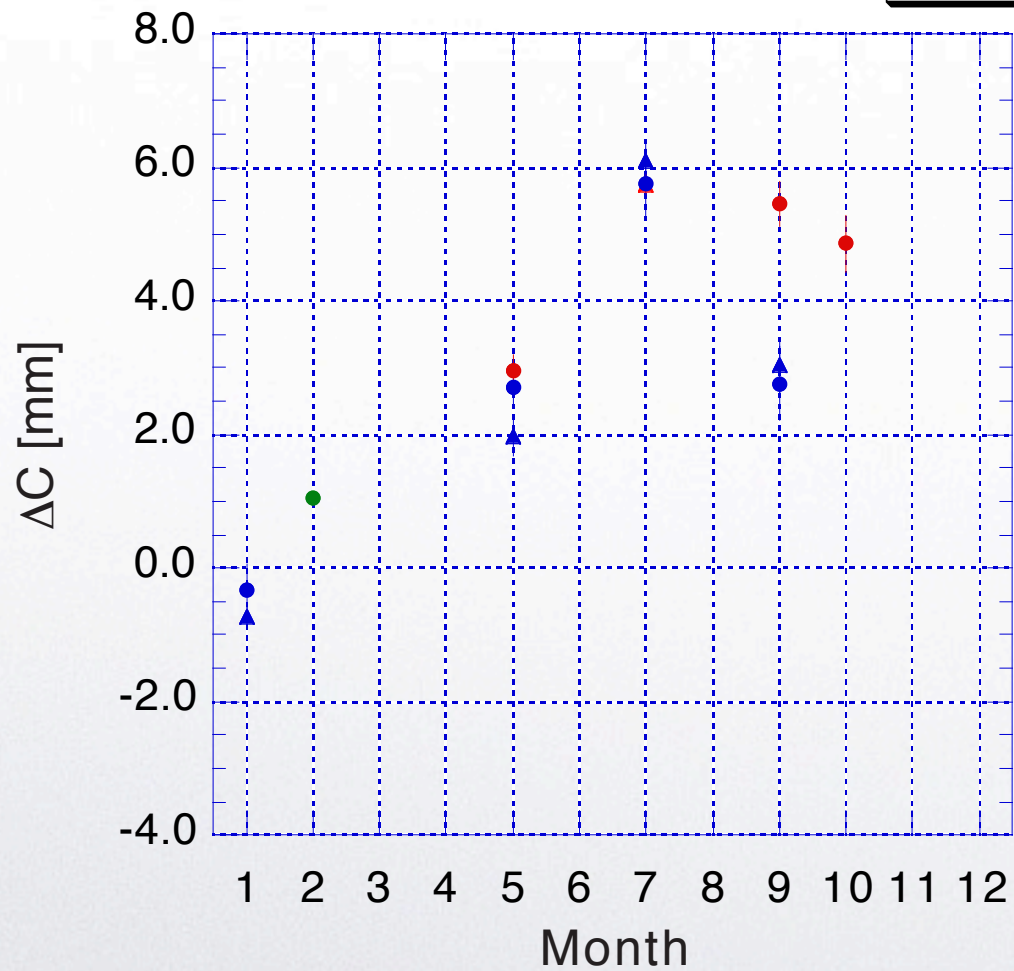
コンクリート膨張率  
 $0.58 \sim 1.5 \times 10^{-5} \cdot ^\circ\text{C}$

$(dL = 6\text{mm}) / 120\text{m}$   
 $= \text{mm} / 20 \times 1000$   
 $= 1/20000$   
 $= 5 \times 10^{-5}$

$D \times \pi = 120\text{m} + 6\text{mm}$   
 $dD = 0.006 / \pi$   
 $= 19.1 \times 10^{-5}$

DR Circumference

- ▲ 97 HEX
- ▲ 98 HEX
- 97 B-B
- 98 B-B
- 99 B-B



6mmの変化分は、

一直線であれば、  
 3~5 °C 相当

真円であれば、  
 13~21 °C 相当

MITO Temperature

- 97
- 98
- 99

