

# SUPERKEKB MAIN RING TUNNEL MOTION

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# SuperKEKB Main Ring

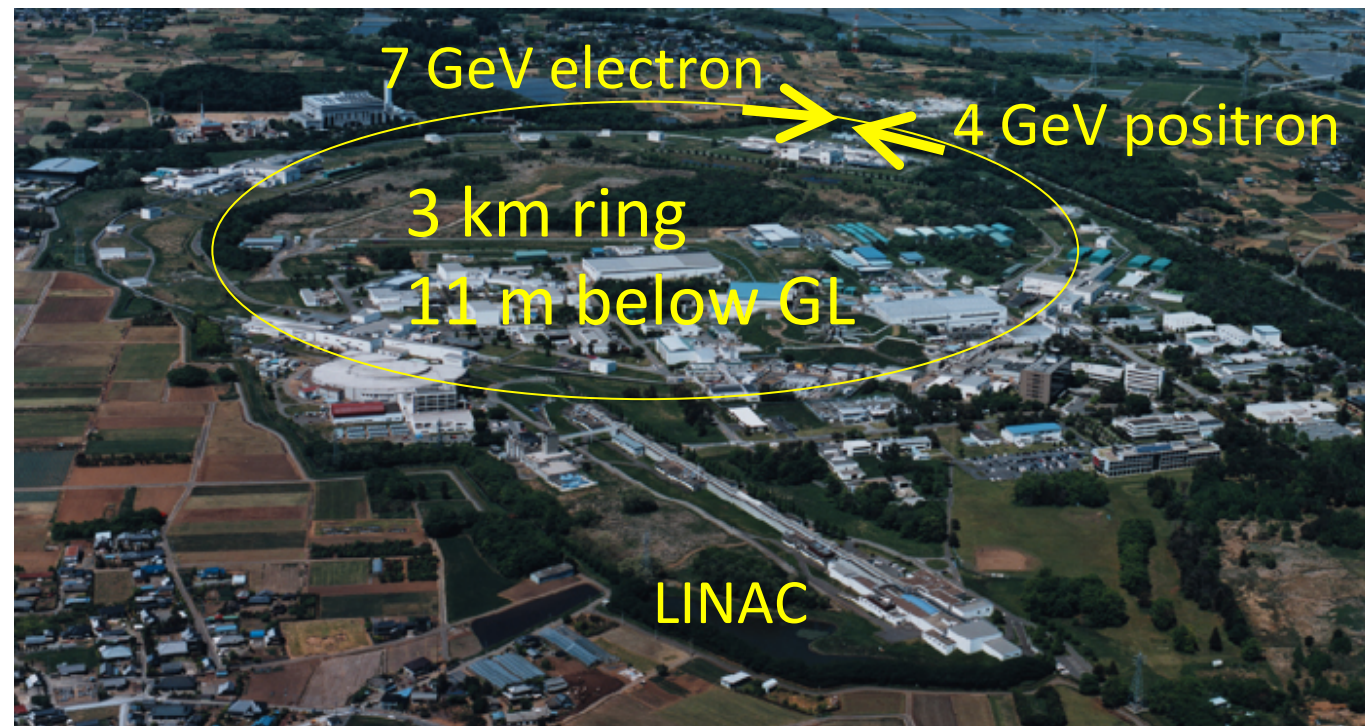
The tunnel was originally built for  
TRISTAN (1986~1995)

And then reused for

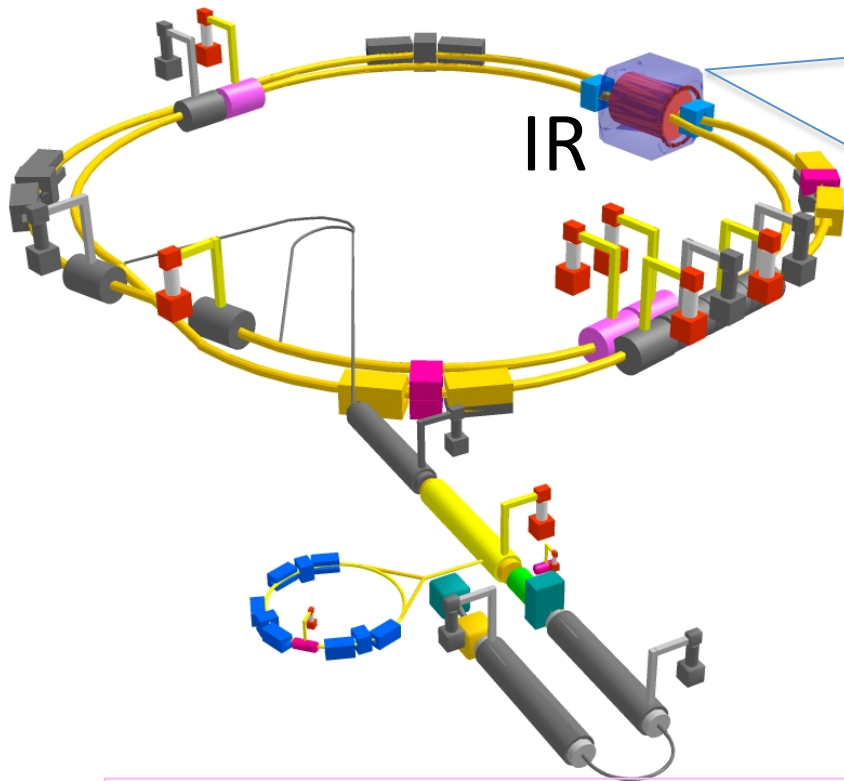
➔ KEKB (1998~2010, ended before the big earthquake.)

And again for

➔ SuperKEKB (under construction)



# SuperKEKB Main Ring



To collide  $\sigma_y = 60$  nanometer beams, precise magnet alignment is needed.

& stable environment  
Temperature  
Tunnel motion ...

1<sup>st</sup> beam circulation is expected to be sometime late next year.  
Construction everywhere  
not only in the tunnel but also above the tunnel... (next page)



# Construction of the new facility buildings & beam transport line

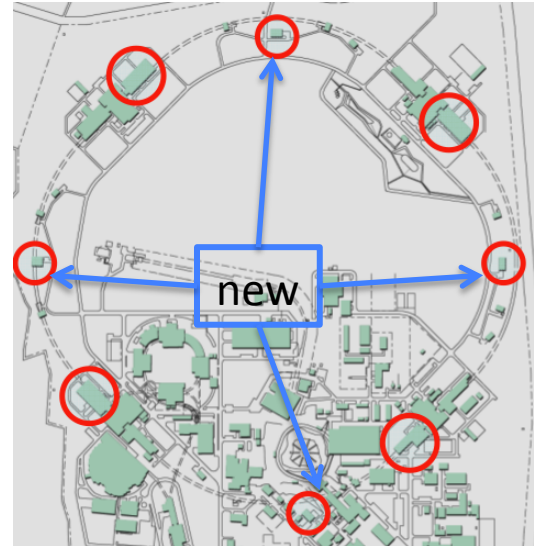
# of magnets is increased by 20 % for SuperKEKB.

Cooling water for magnets:

4 pump systems for KEKB, each ~3600 l/min. They were operated at ~100% capacity level.

The PS buildings are already very crowded.

We requested additional space & power distribution facilities.



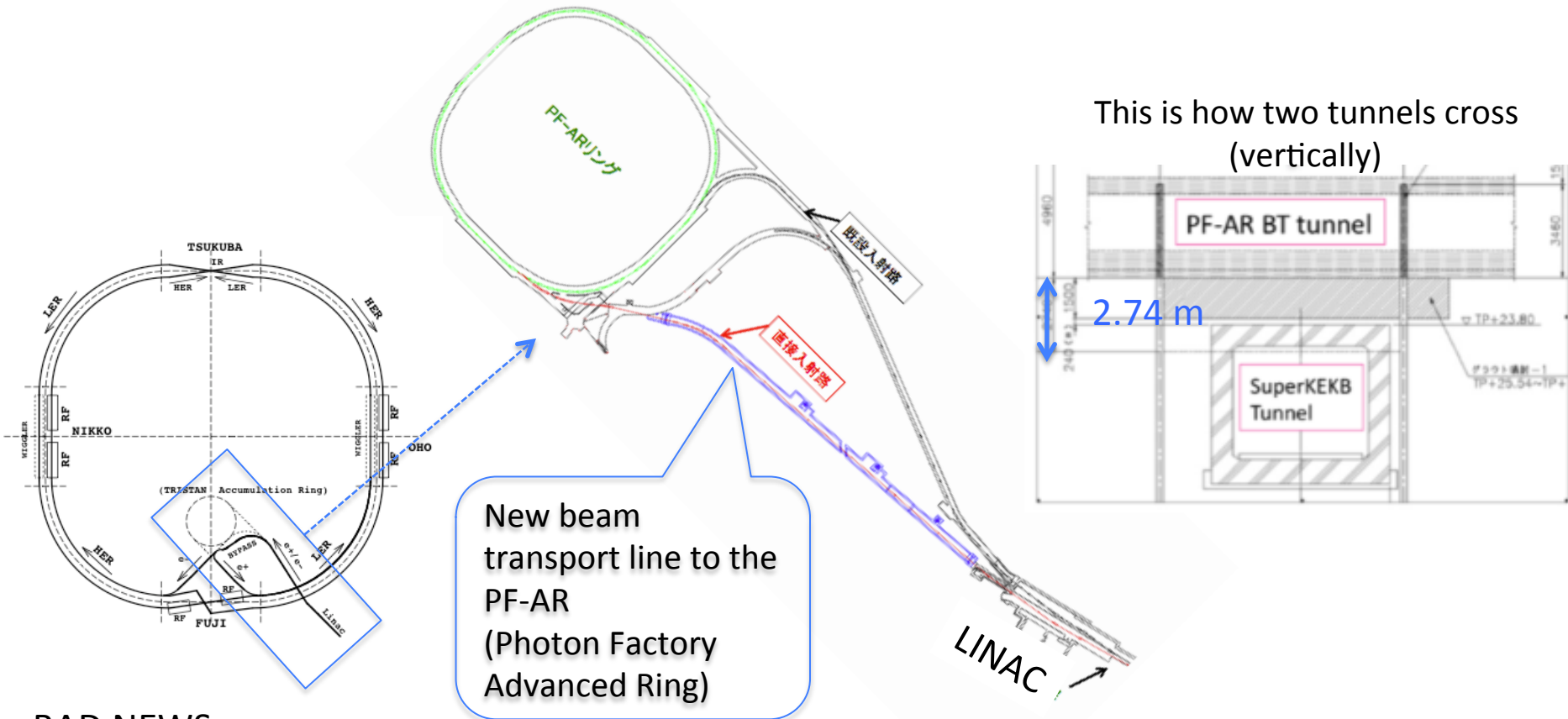
## GOOD NEWS

➔ 4 new pump systems and 4 power buildings for power supplies are being built.

## BAD NEWS

➔ Construction takes place at the same time as the survey and 1<sup>st</sup> round alignment work in the tunnel.

# Construction of the new facility buildings & beam transport line



## BAD NEWS

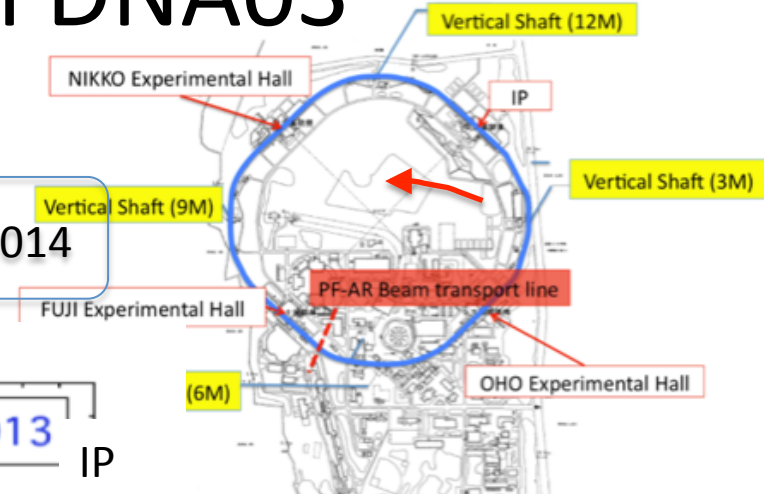
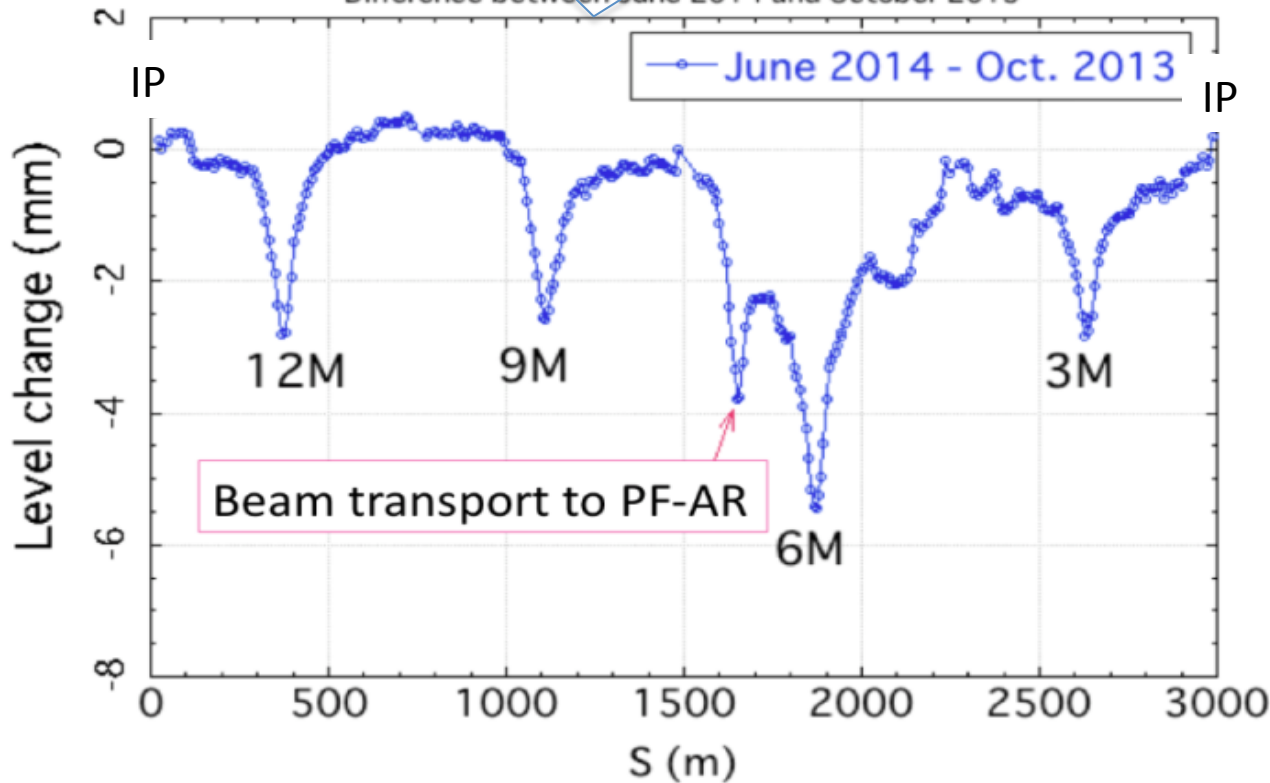
➔ Construction takes place at the same time as the survey and 1<sup>st</sup> round alignment work in the tunnel.

# Effects of the facility buildings seen by level survey with DNA03



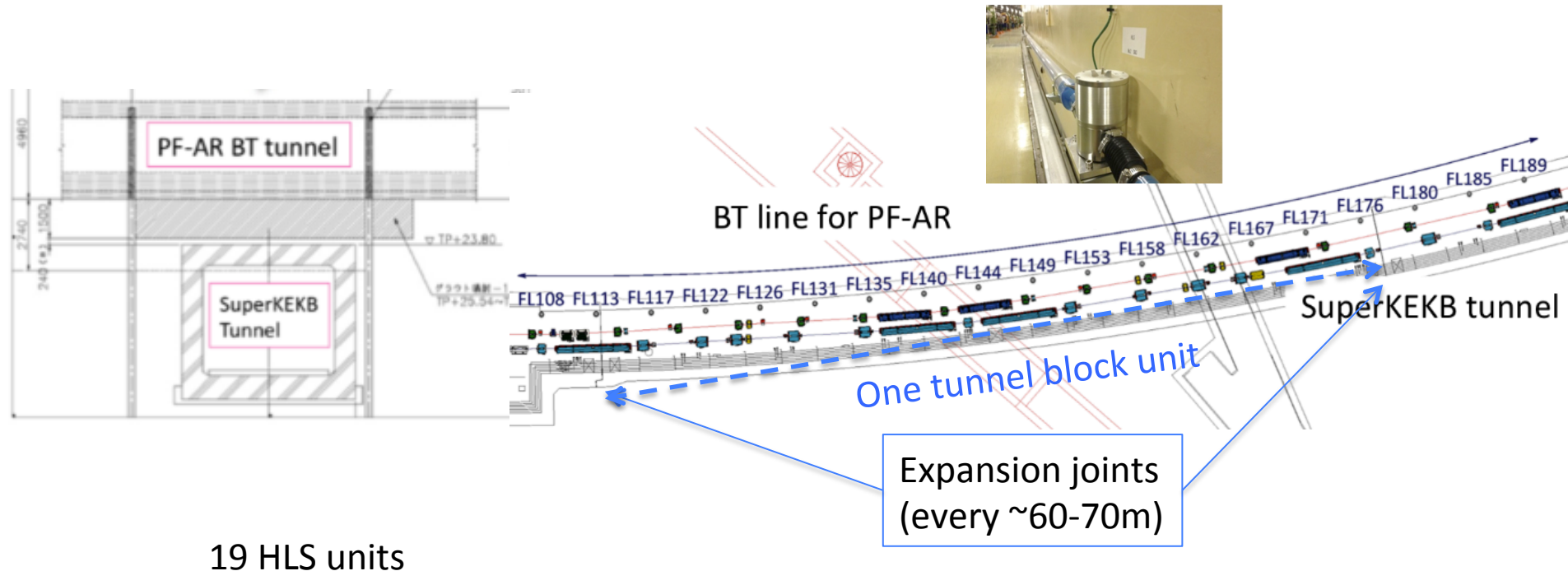
$\Delta$  Level between Oct.2013 and June 2014

Difference between June 2014 and October 2013

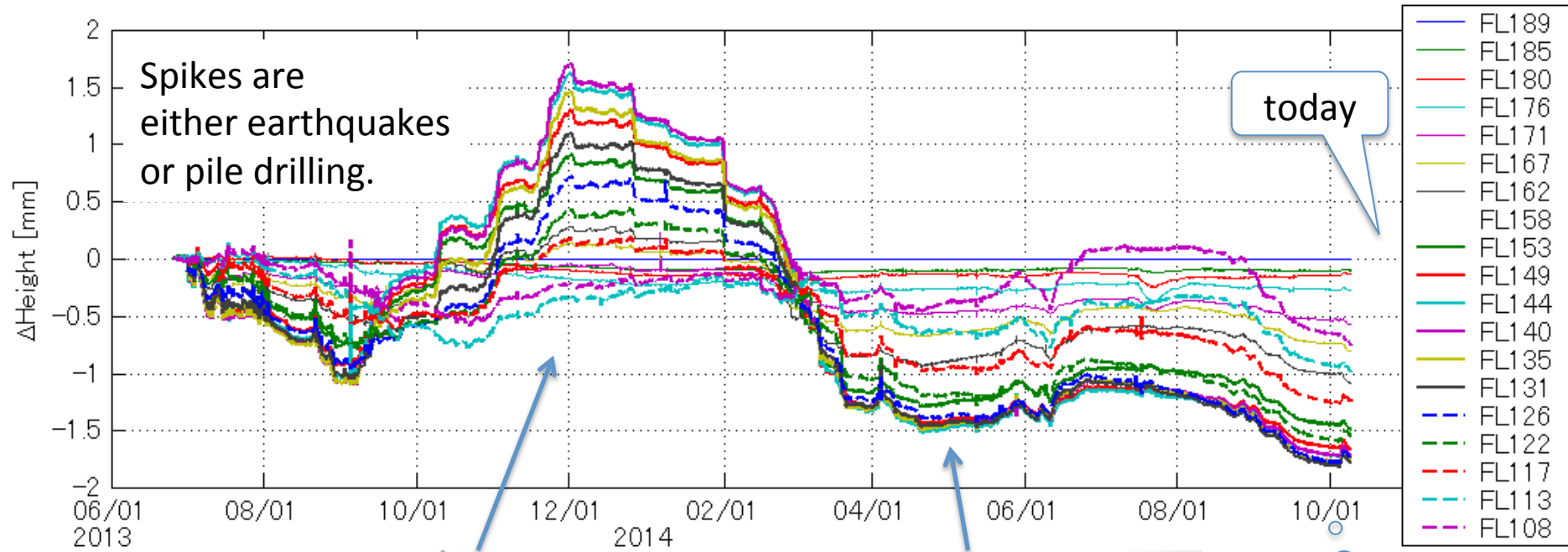


Vertical shaft at the 12M site. Ground water removal is carried out by turbine pumps (deep well method).

# Effects of the new BT line to the PF-AR monitored by HLS



# Effects of the new BT line to the PF-AR monitored by HLS



Dec. 2013: Removal of the soil

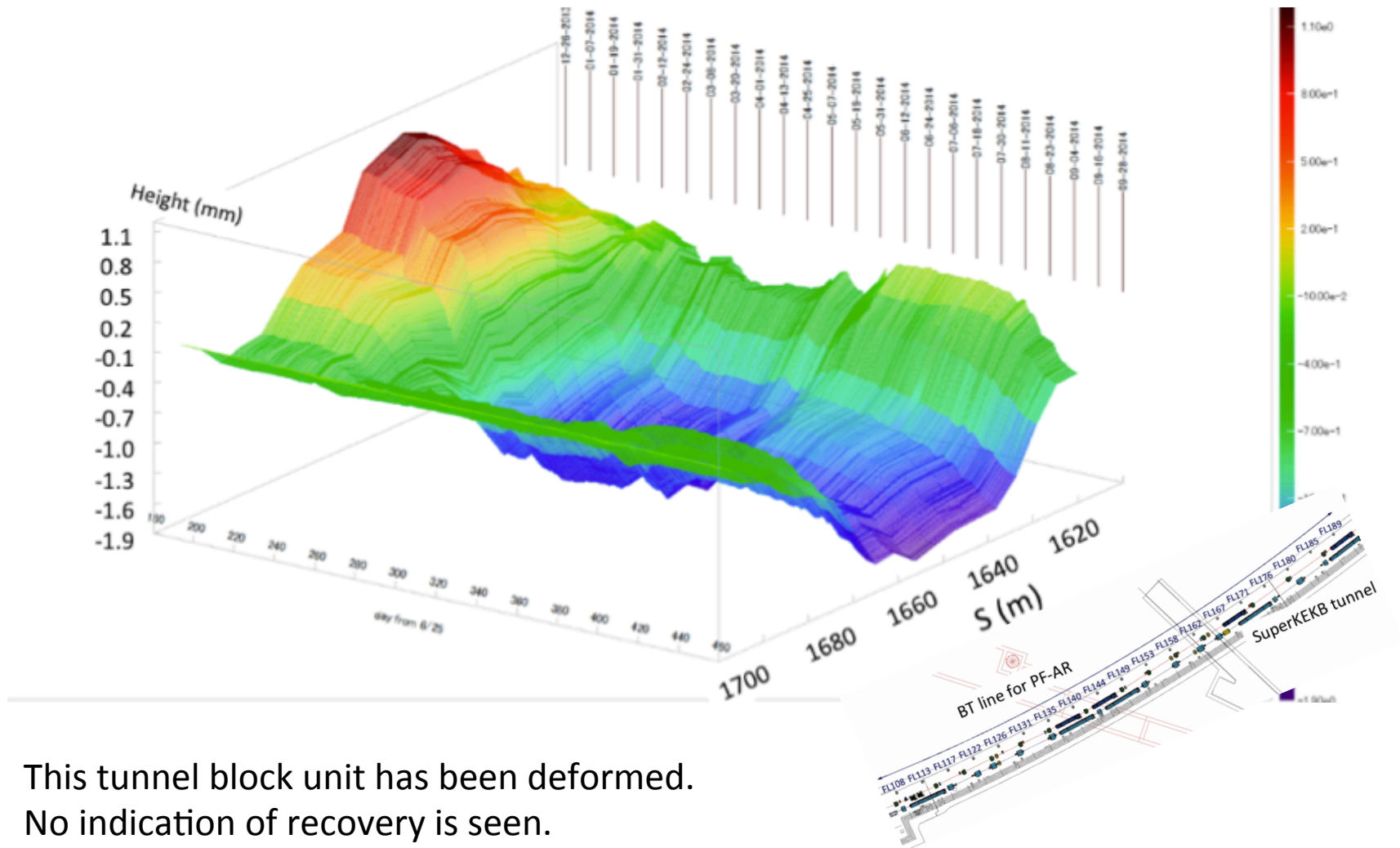


May 2014: Refilling of the soil

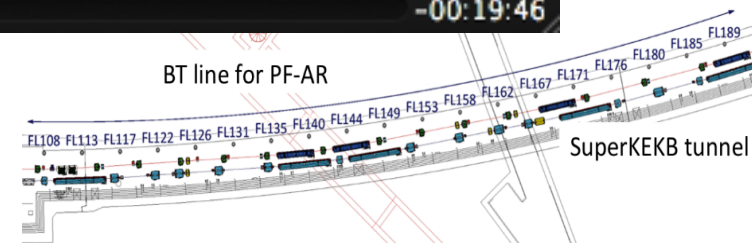
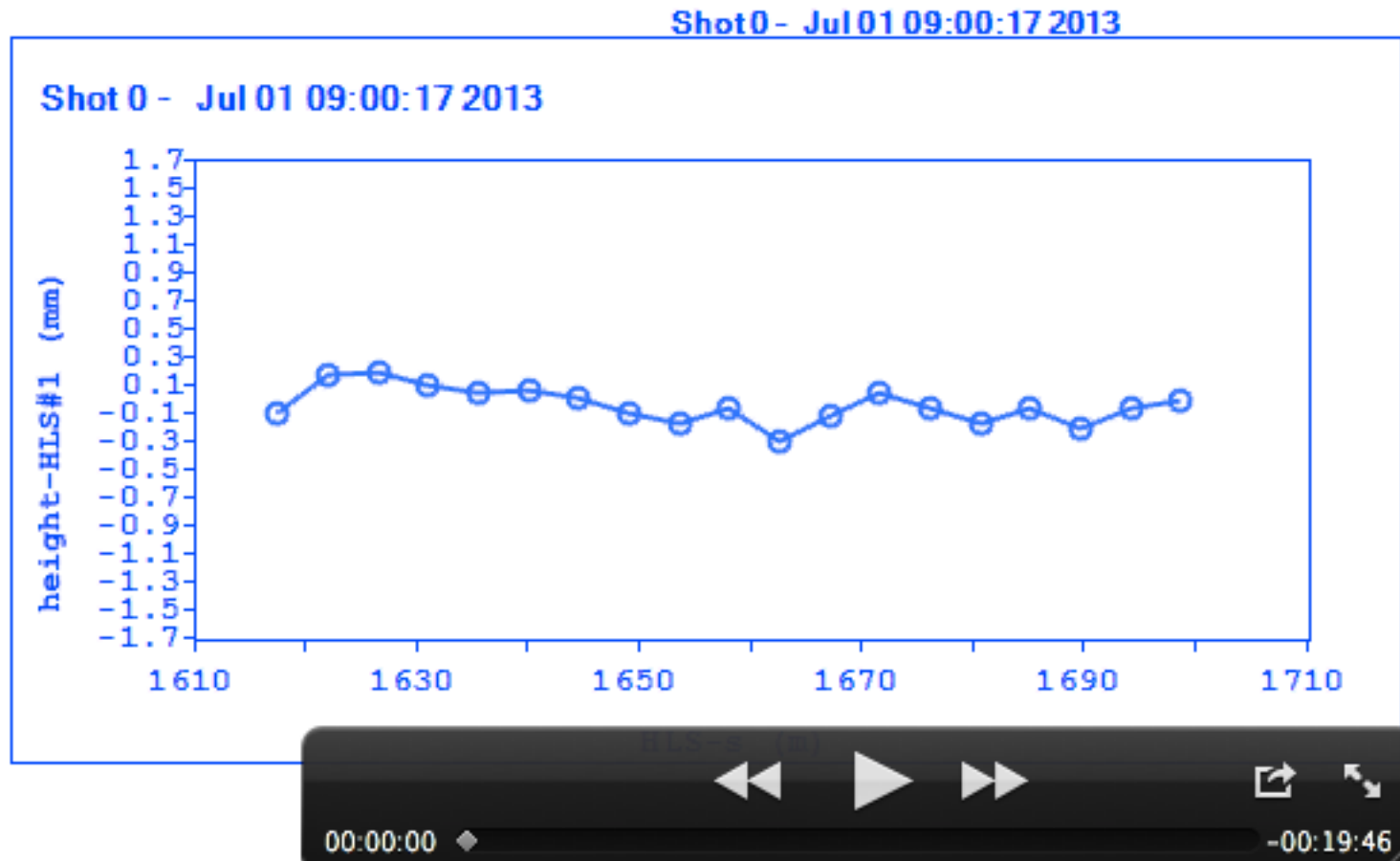
Still  
sinking,  
why??



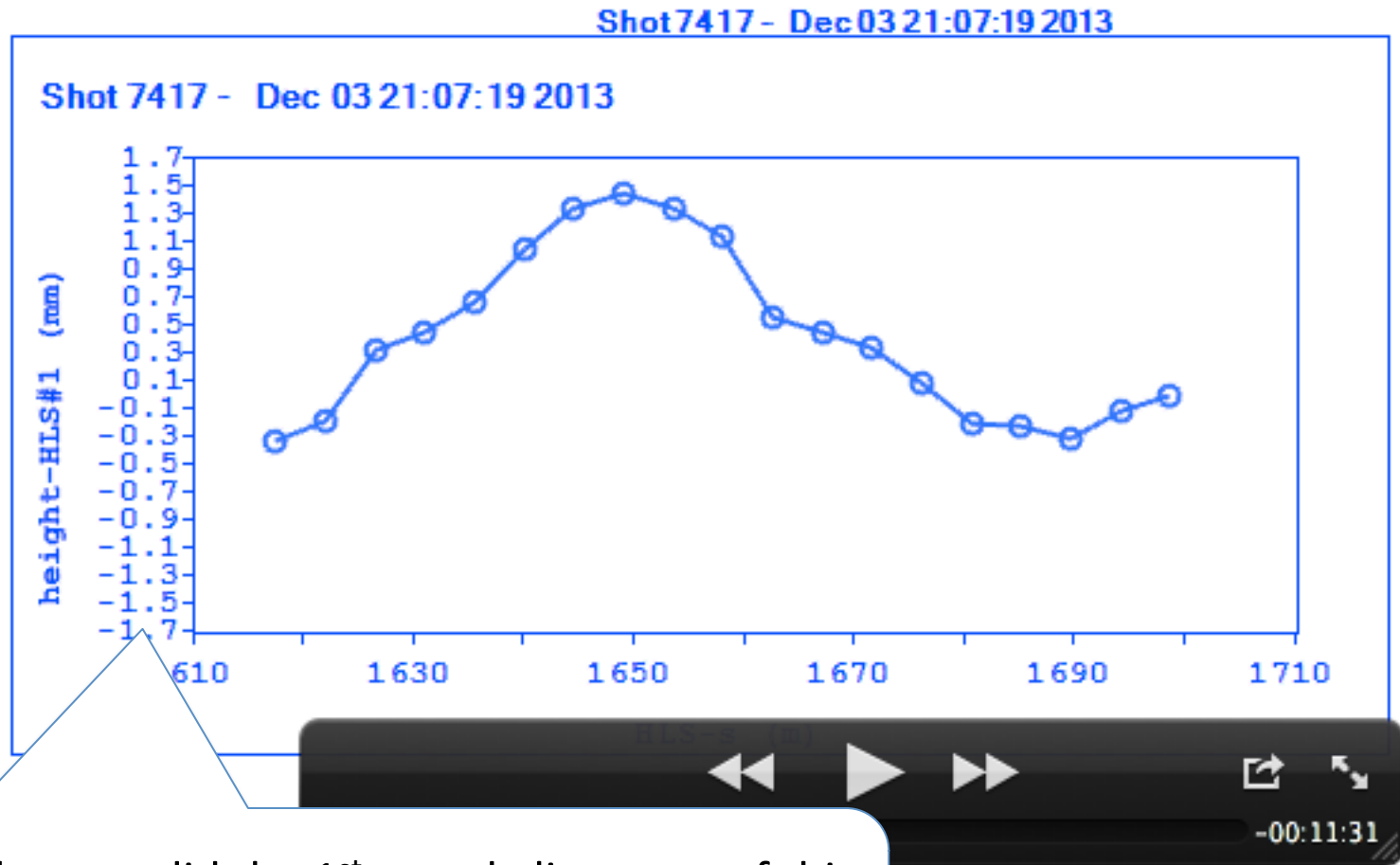
# Effects of the new BT line to the PF-AR monitored by HLS



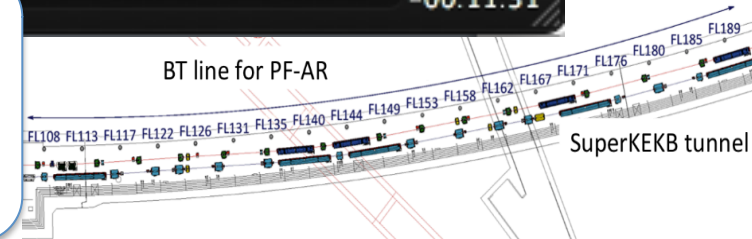
# Effects of the new BT line to the PF-AR monitored by HLS



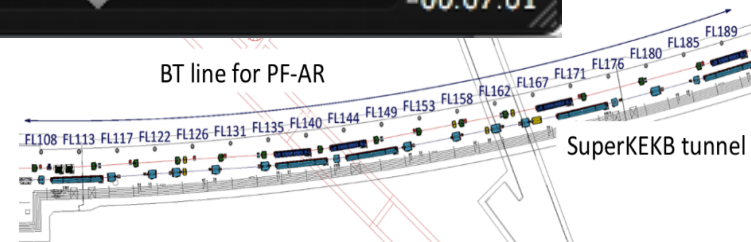
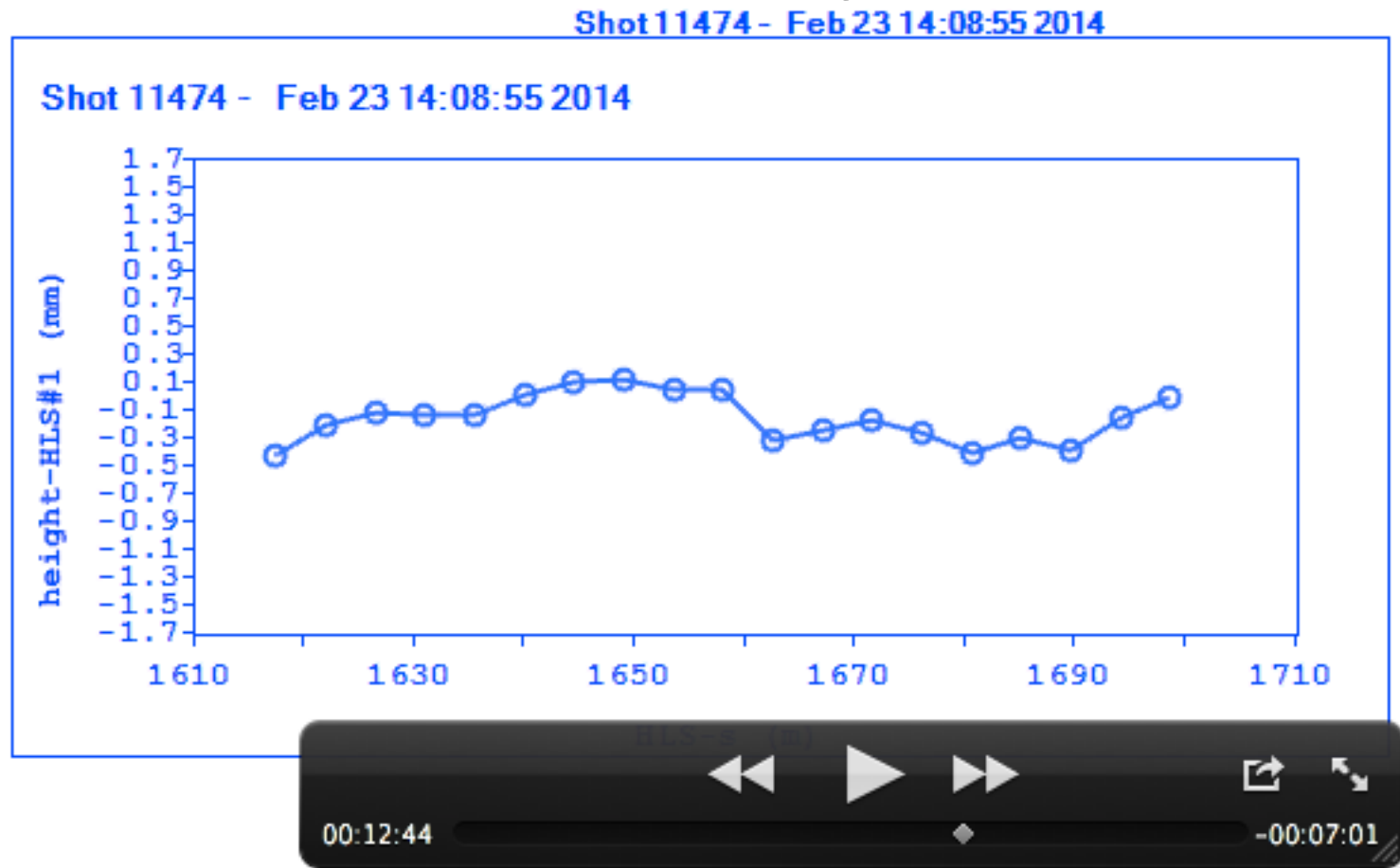
# Effects of the new BT line to the PF-AR monitored by HLS



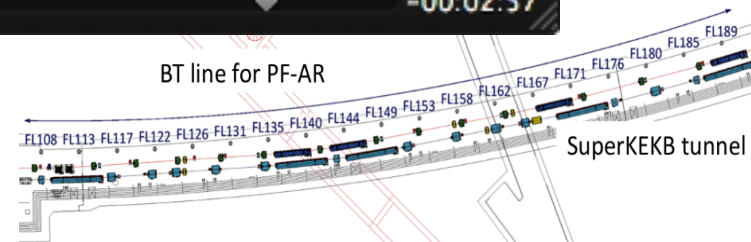
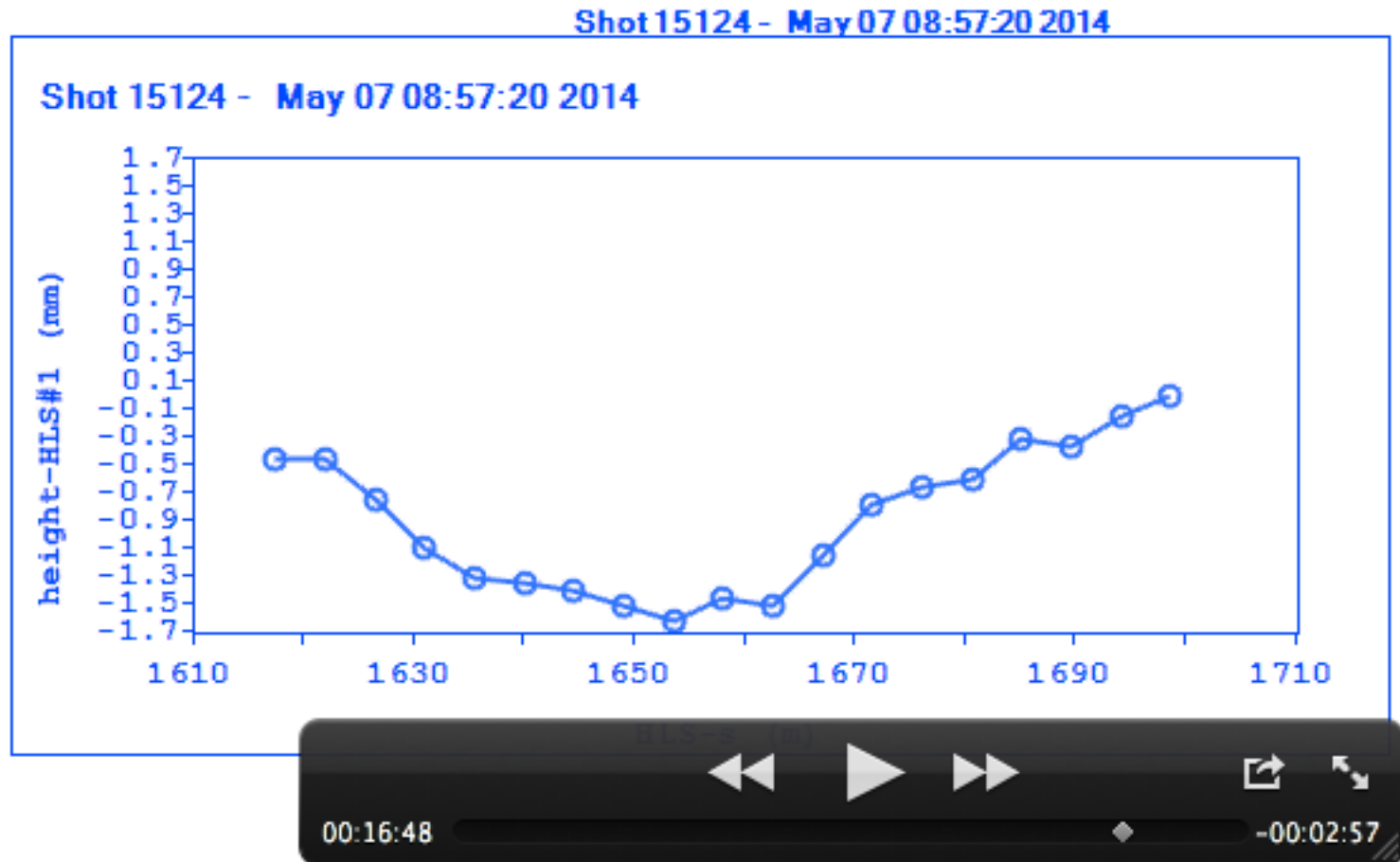
This is when we did the 1<sup>st</sup> round alignment of this section, mainly to smooth out misalignment caused by the big earthquake but...



# Effects of the new BT line to the PF-AR monitored by HLS

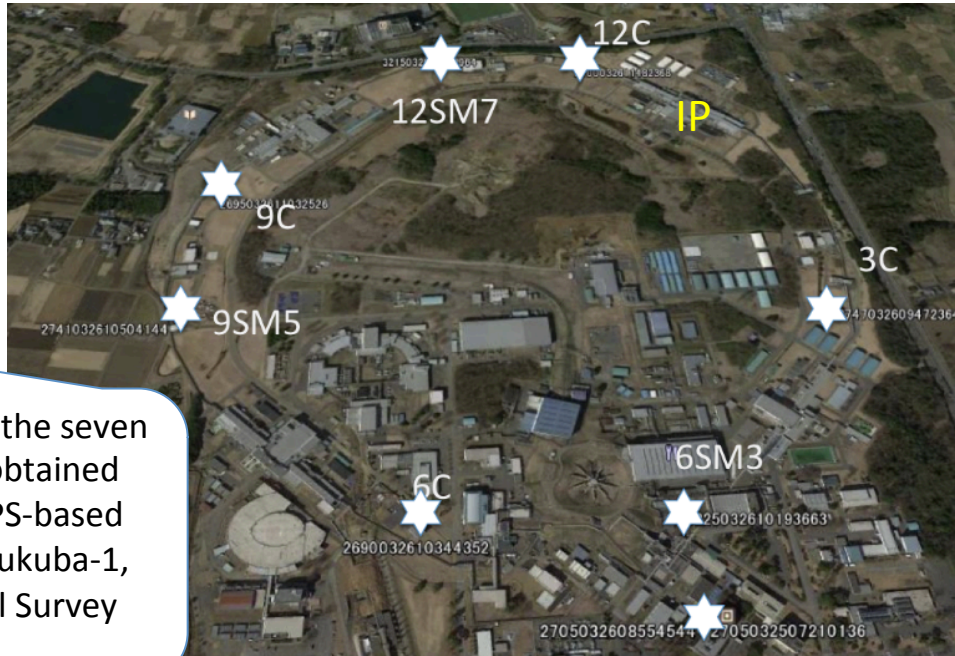


# Effects of the new BT line to the PF-AR monitored by HLS

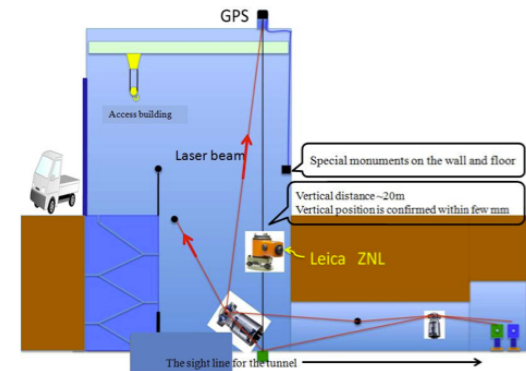
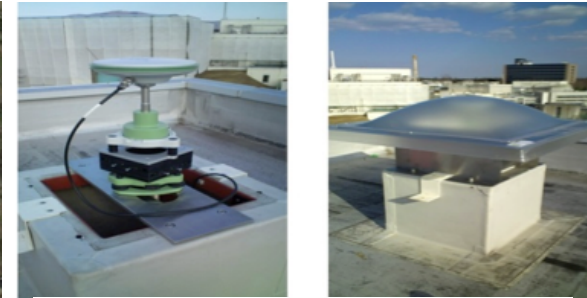




# GPS data



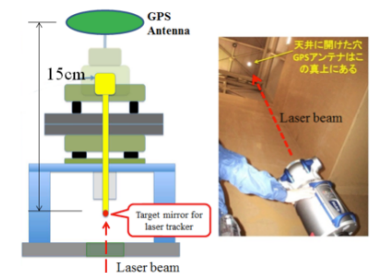
The coordinates of the seven GPS antennas are obtained using one of the GPS-based control stations, Tsukuba-1, at the Geographical Survey Institute (GSI).



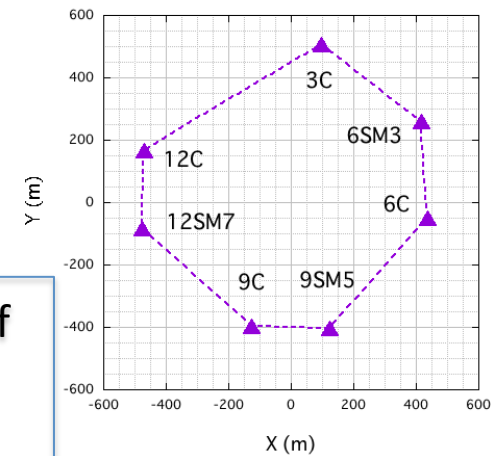
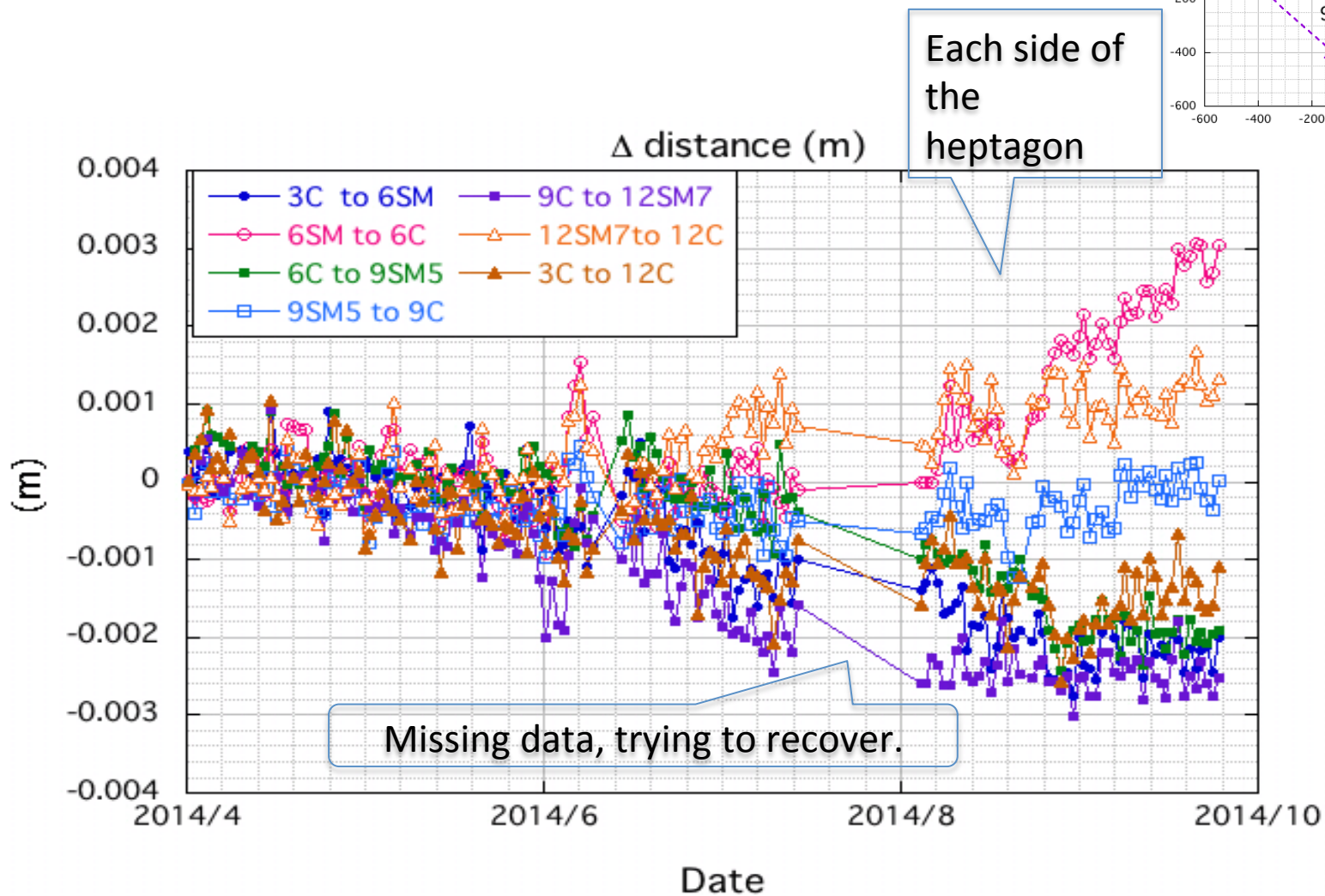
A GPS network system was installed in 2012, after the Great East Japan Earthquake struck Japan in 2011:

- (1) to connect the tunnel survey network to the surface network
- (2) to monitor long-term ground and building motion.

7 GPS antennas (Leica, GS10) are placed on the roofs of buildings called, going clockwise from near the IP: 3C, 6SM3, 6C, 9SM5, 9C, 12SM7 and 12C.

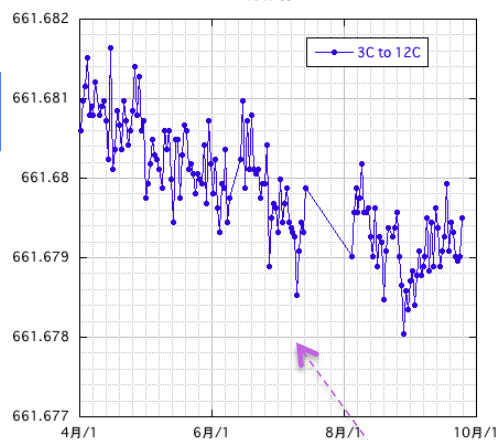


# GPS data

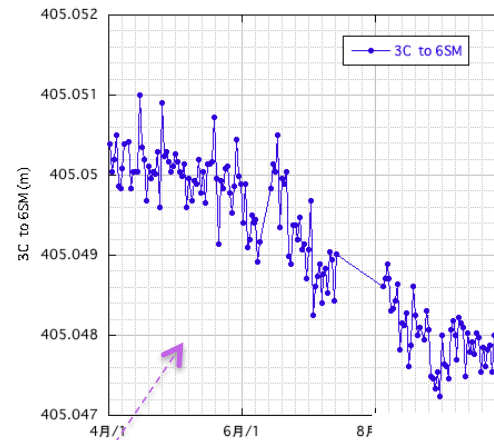


$\Delta$  slope distances

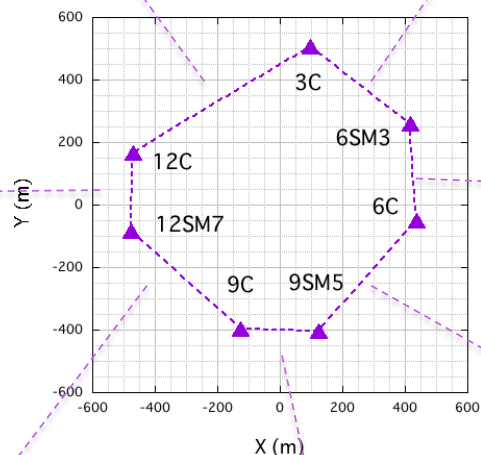
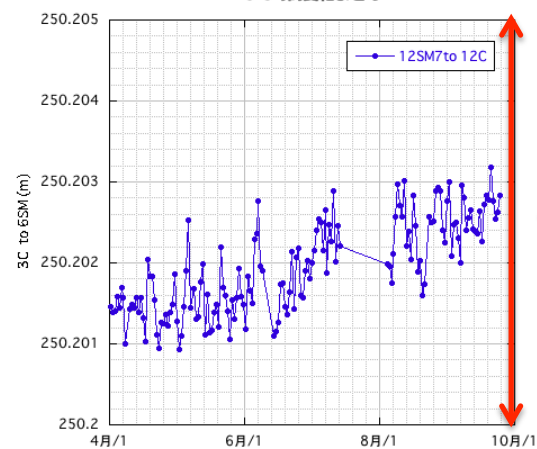
GPS時間変化まとめ



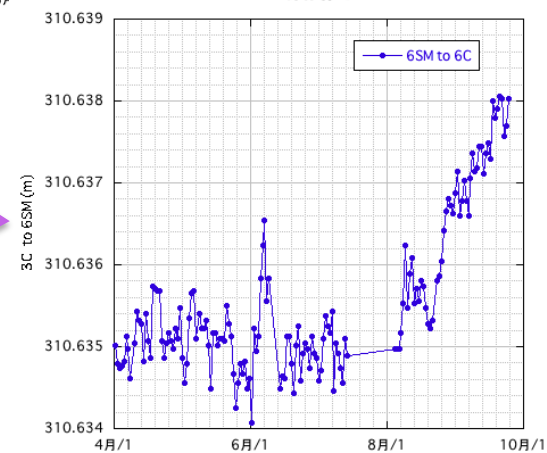
GPS時間変化まとめ



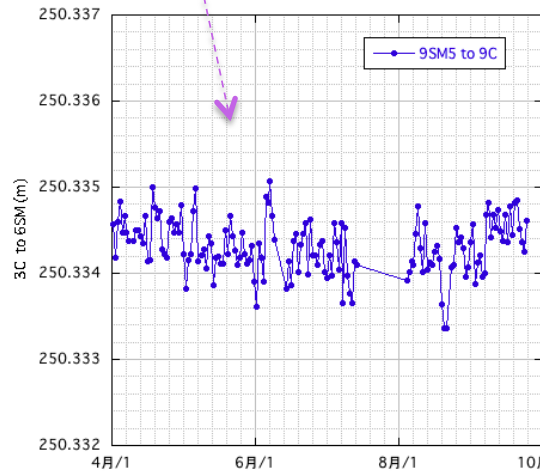
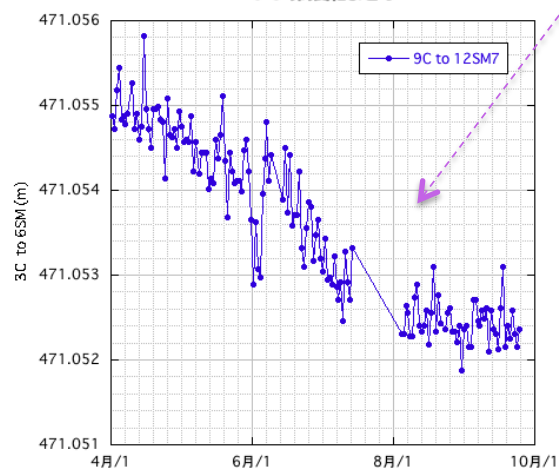
GPS時間変化まとめ



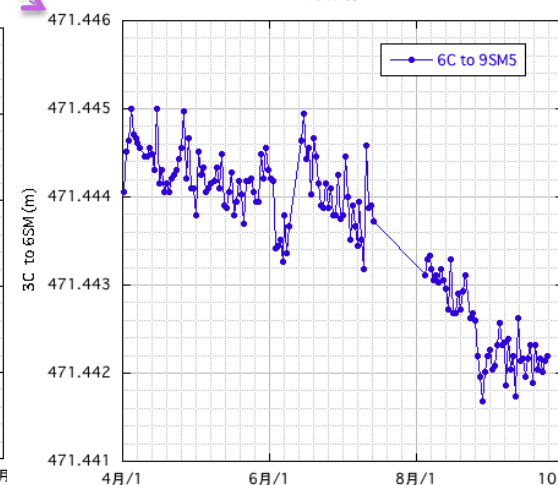
GPS時間変化まとめ



GPS時間変化まとめ

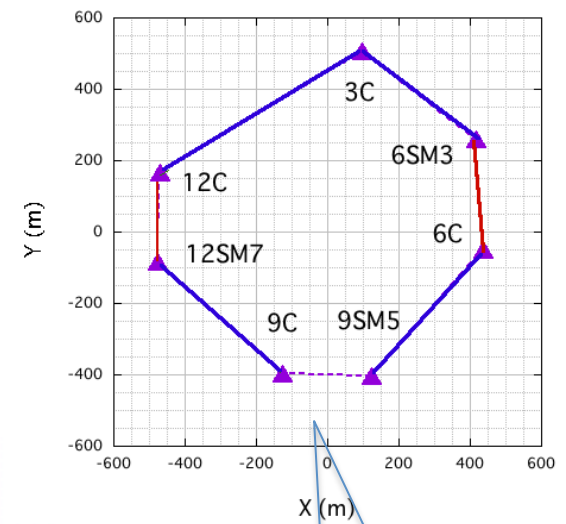
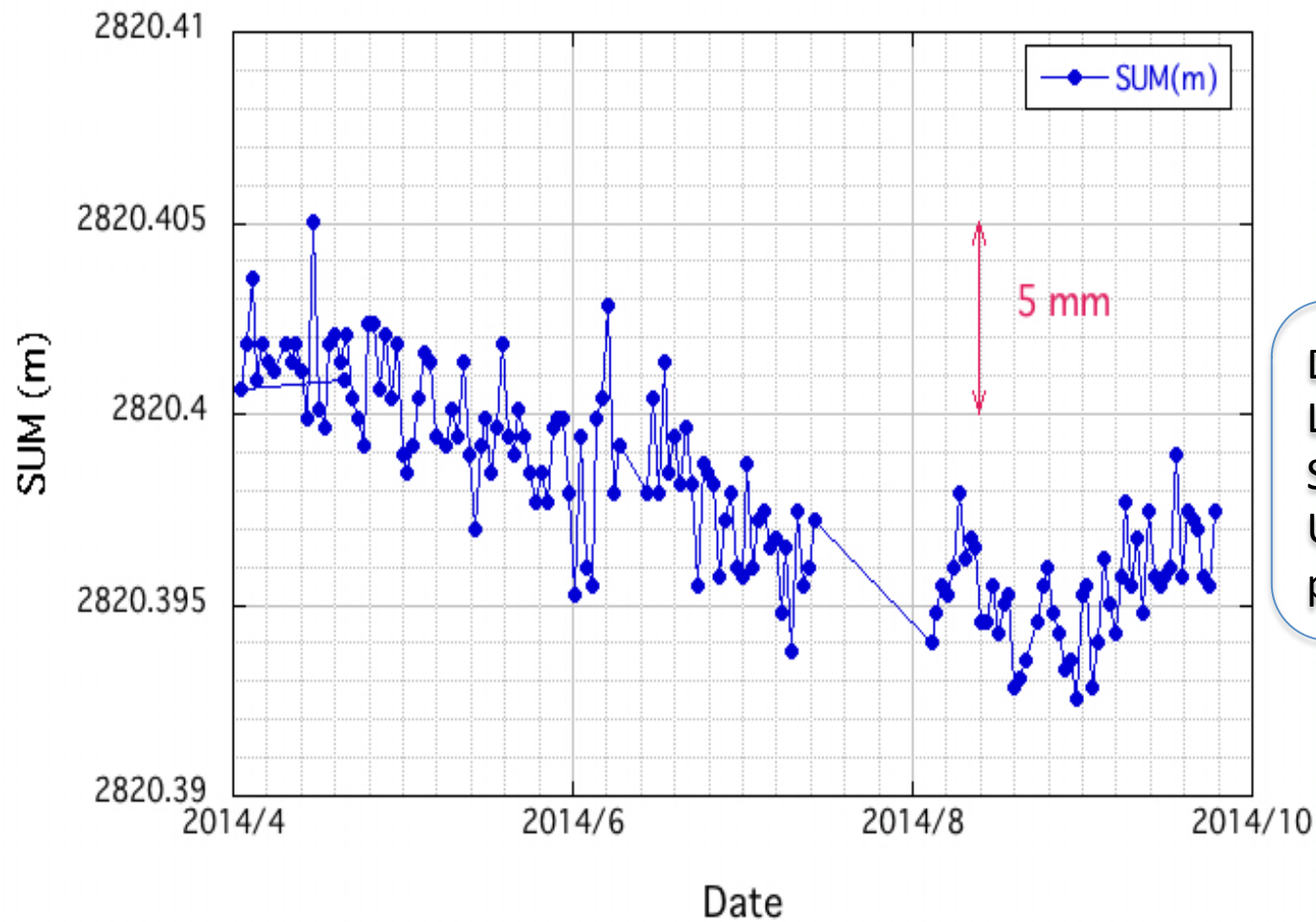


GPS時間変化まとめ





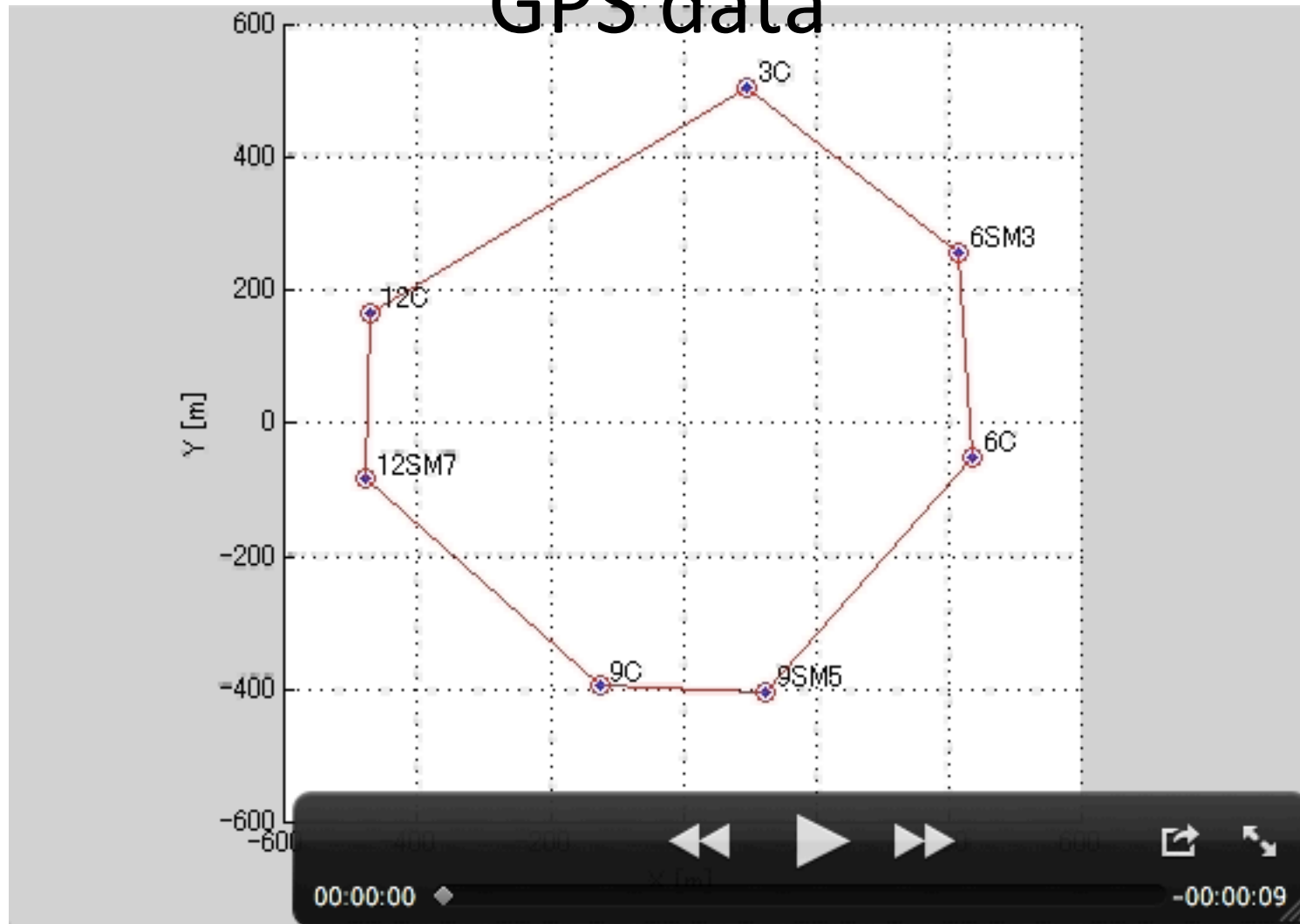
$\Delta$  sum of slope distances



Distance became  
Longer (red)  
Shorter (blue)  
Unchanged (dotted  
purple)

Slope distances observed by the GPS antennas

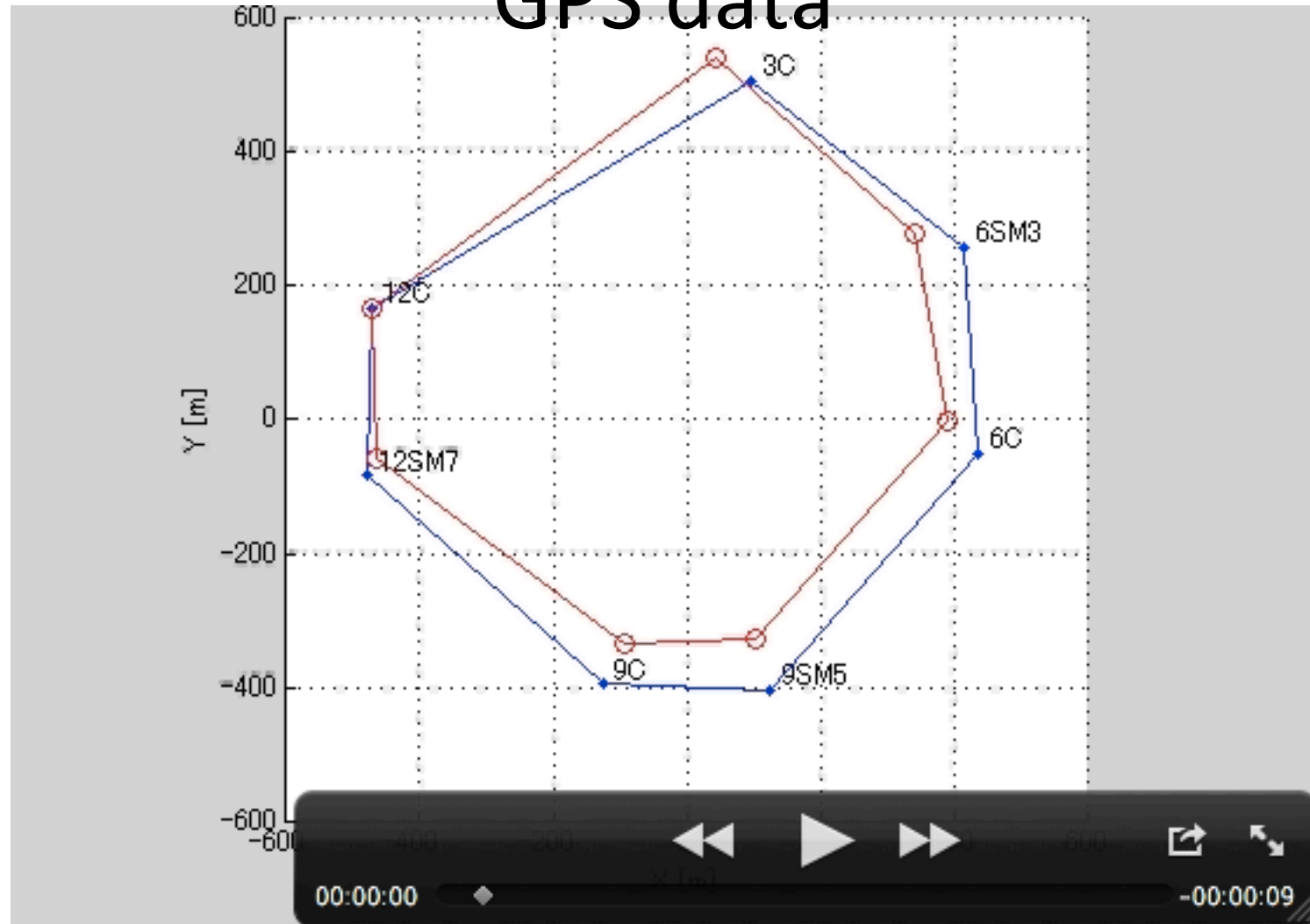
## GPS data





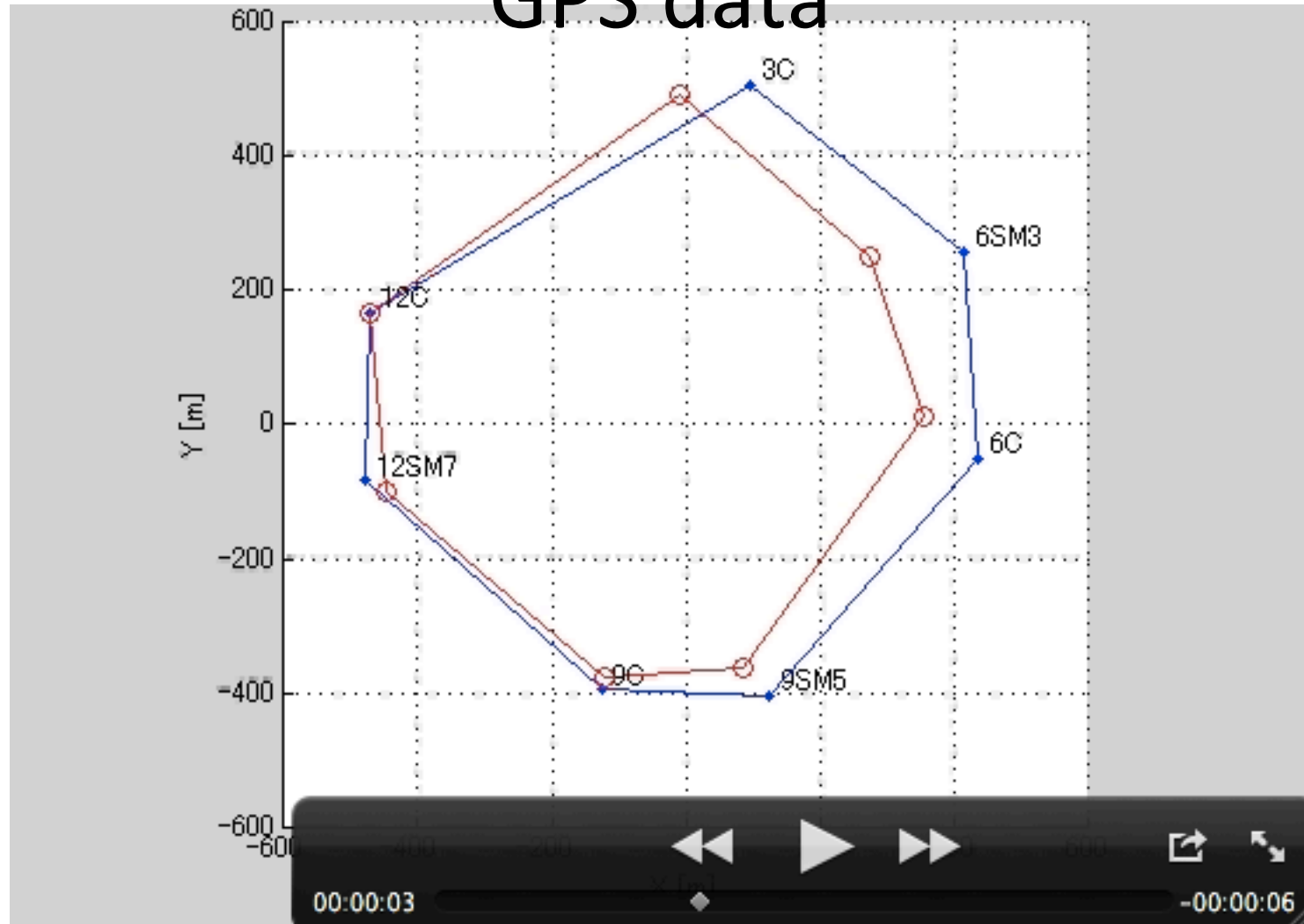
Slope distances observed by the GPS antennas

# GPS data



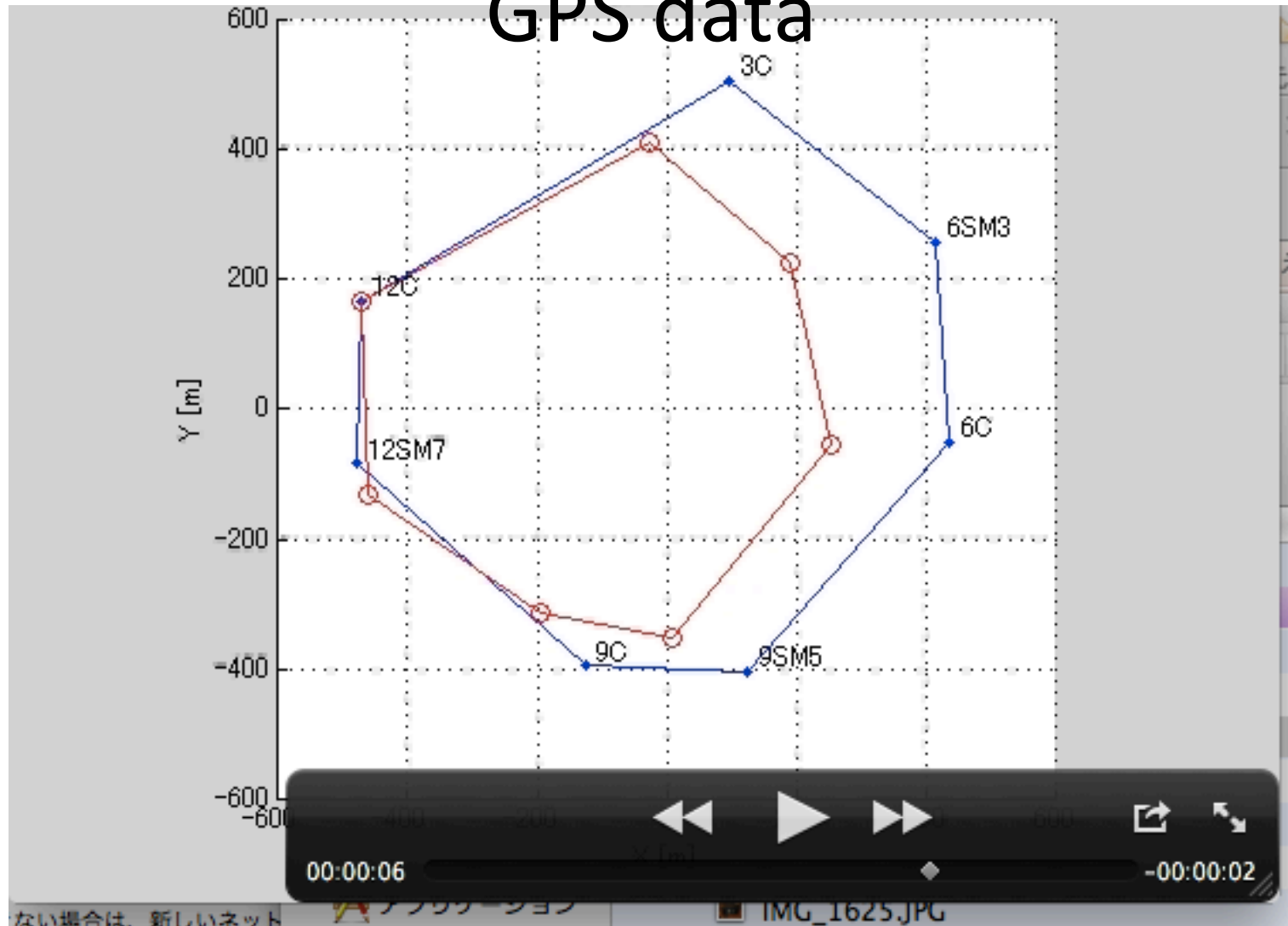
Slope distances observed by the GPS antennas

# GPS data



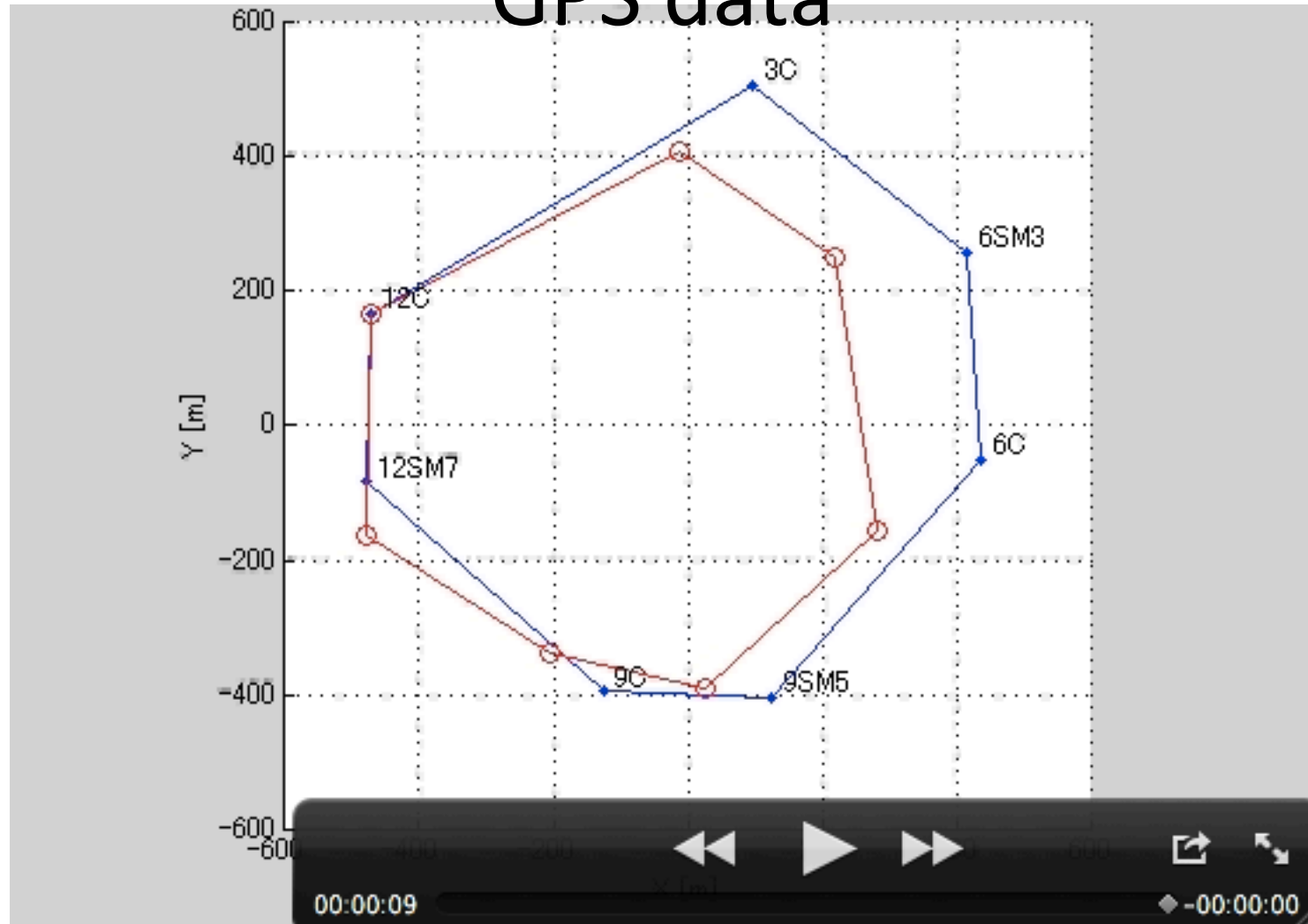
## Slope distances observed by the GPS antennas

### GPS data

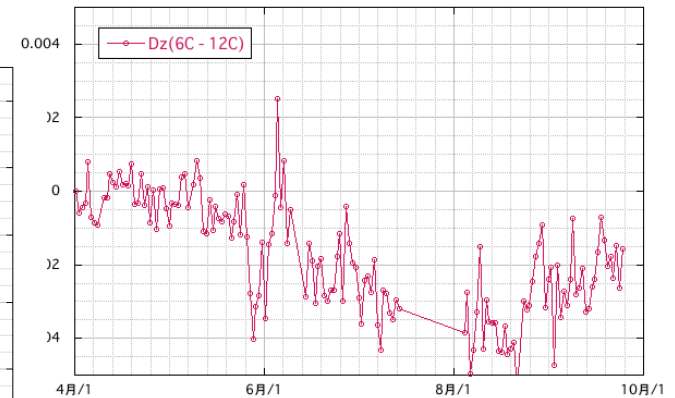
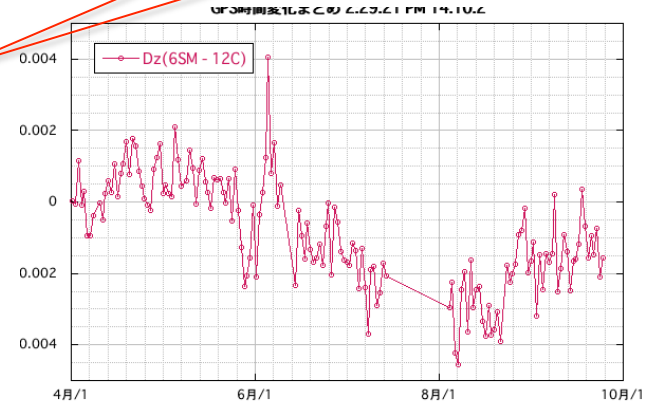
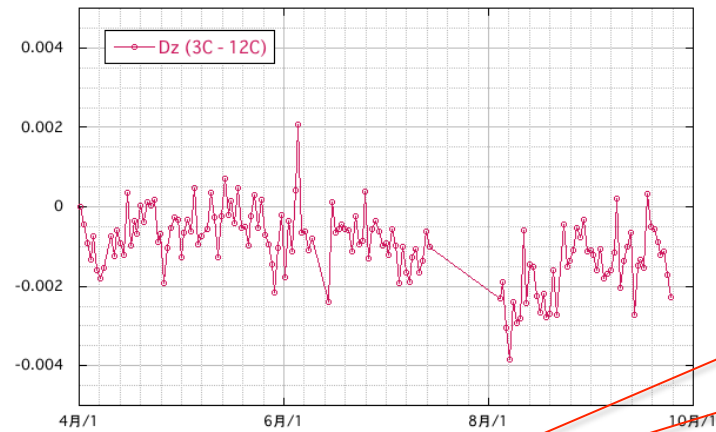
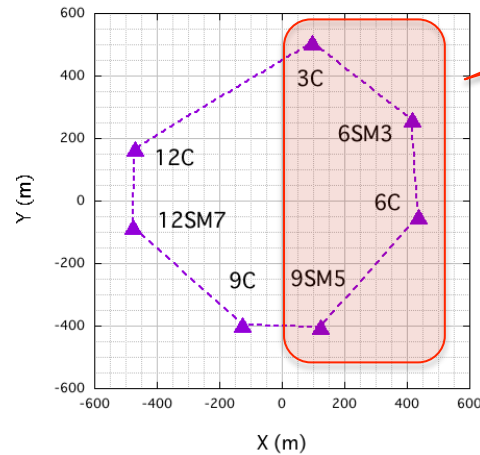
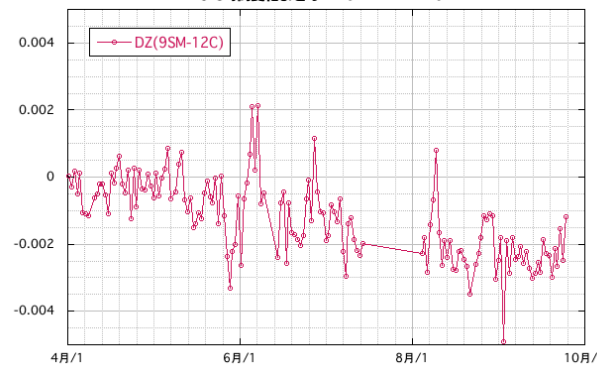
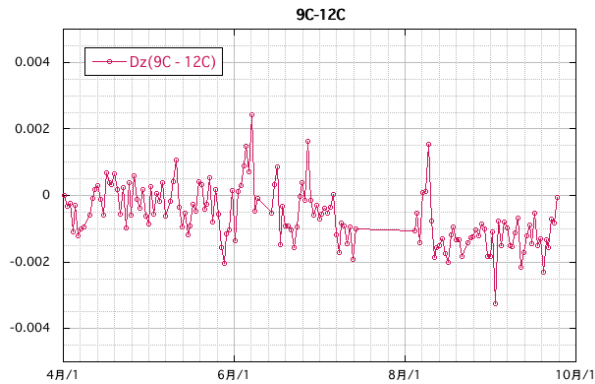
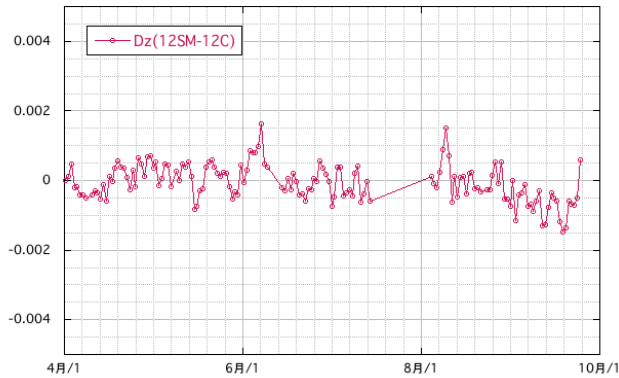


Slope distances observed by the GPS antennas

# GPS data



# GPS data $\Delta$ level w.r.t. 12C antenna



Sinking?



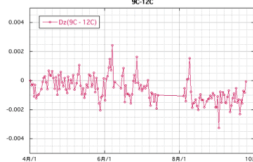
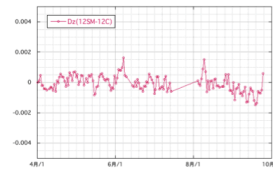
# GPS data

It is probably too early to say this has some connections to the yearly sinking of the south part of the SuperKEKB tunnel.

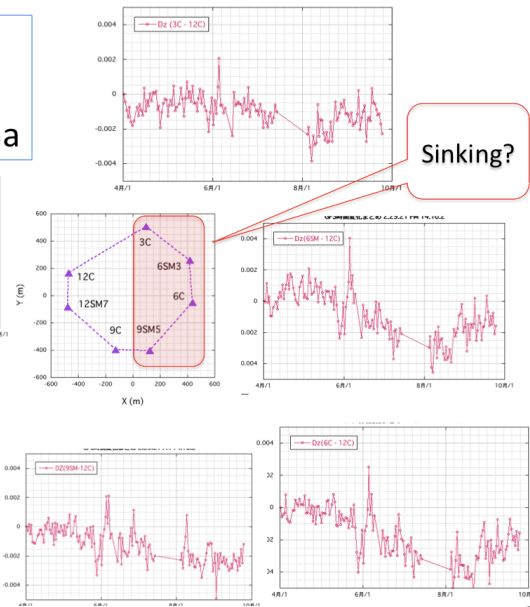
But it could be related.

Further investigation will be carried out.

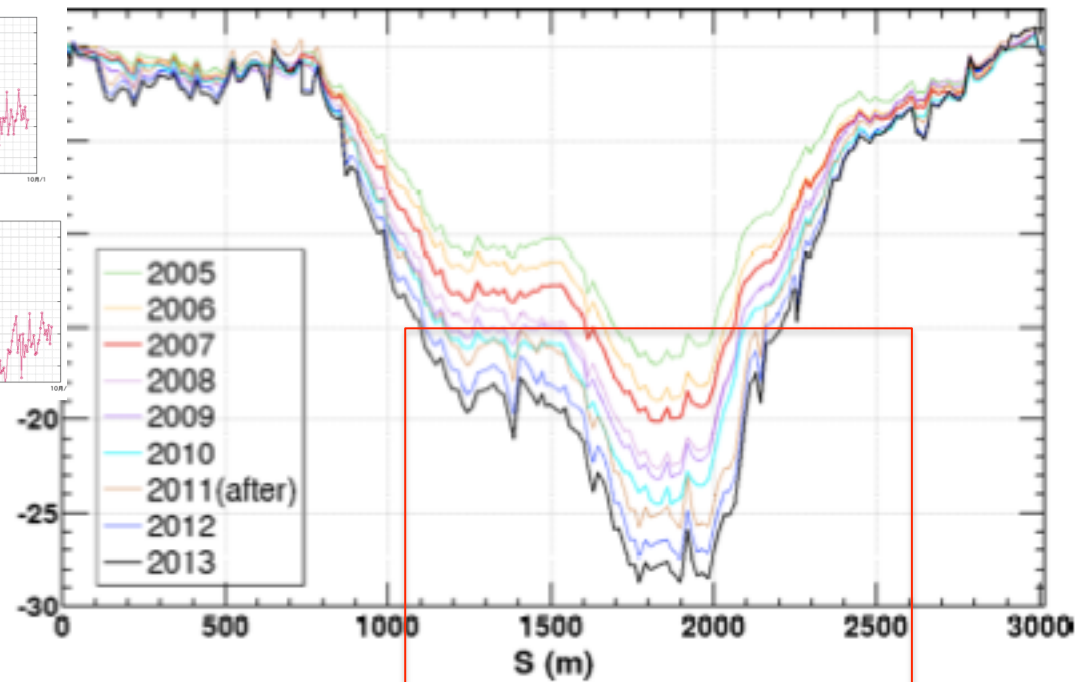
GPS data  
 $\Delta$  level  
w.r.t. 12C antenna



GPS data

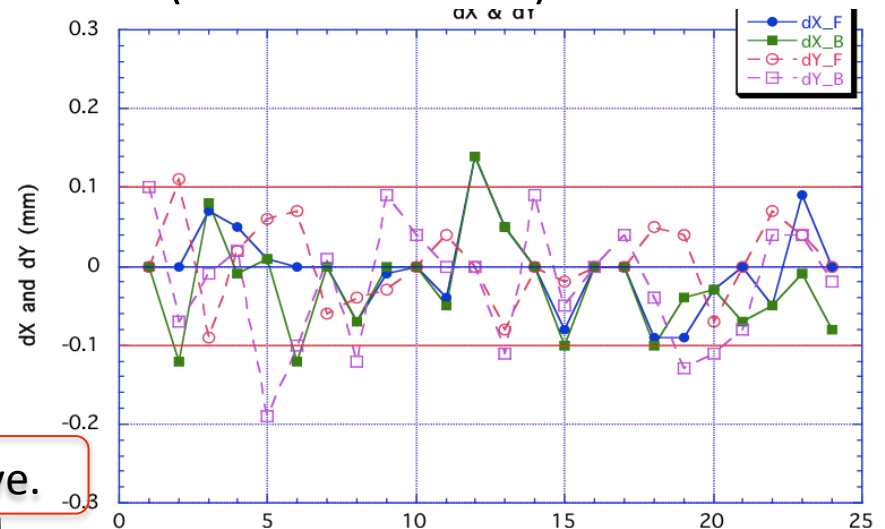


Sinking?

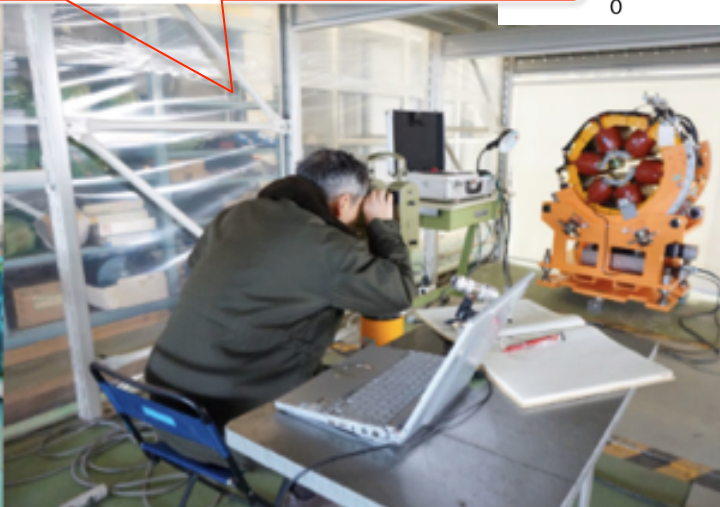
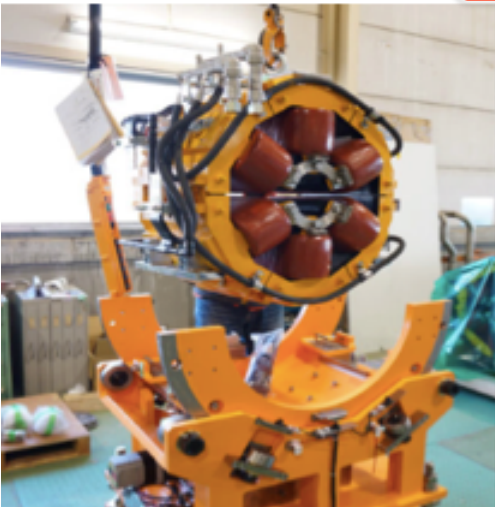


# Other SuperKEKB activities

- Large angle precision tilting tables for 24 sextupole magnets (R. Sugahara et al)
- Self-leveling floor for the movable table at the IP (H.Yamaoka et al)



Ryuhei Sugahara, still active.



Stretched hair cross wires, which indicates the magnet center.



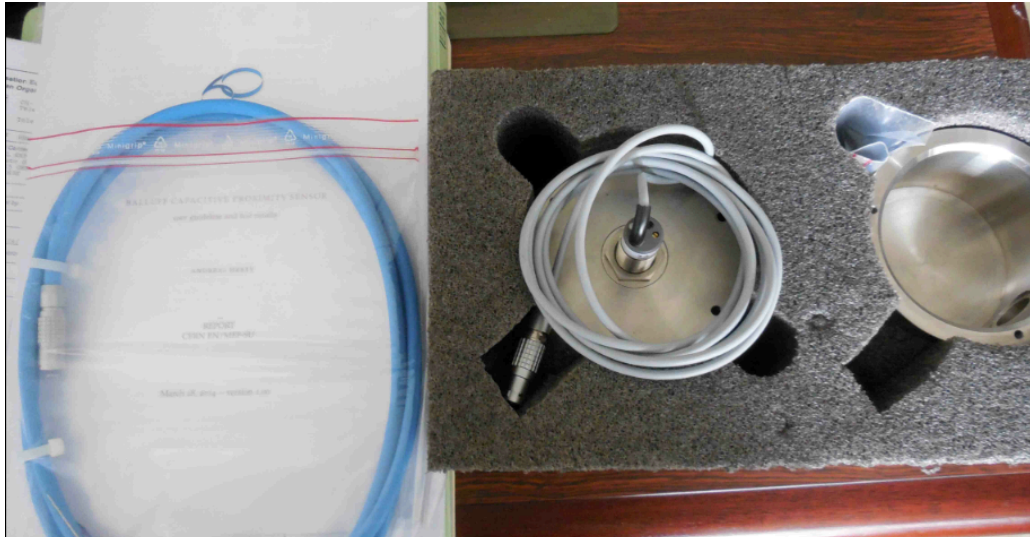
# Summary

- Effects of the construction of new facility buildings along the SuperKEKB tunnel were observed by surveying the tunnel level markers using a DNA03 → As large as ~6 mm over 8 months.
- Continuous monitoring of tunnel level variation is carried out in the south arc section of the SuperKEKB tunnel, the area where the new beam transport tunnel is excavated, by 19 HLS units.
- Correlation between tunnel motion and the type of construction work (excavating, refilling and so on) is seen.
- Re-alignment of the magnets is obviously needed, the timing of the final alignment is crucial. We may have a conflict between the construction schedule and the optimal timing for alignment.
- We hope to increase the number of HLS units to cover a wider area of the SuperKEKB tunnel as the effects of such construction is large.

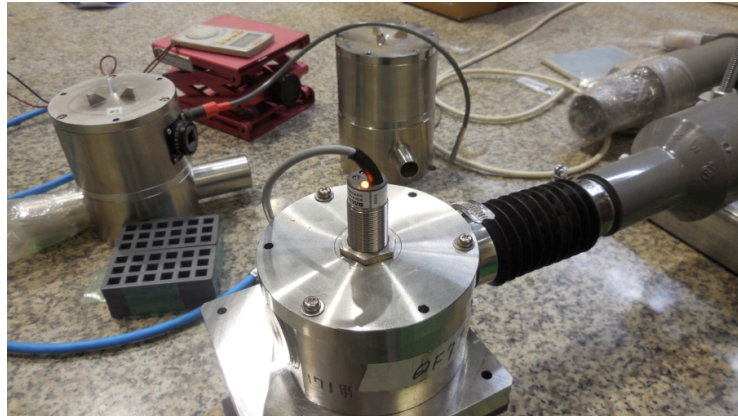
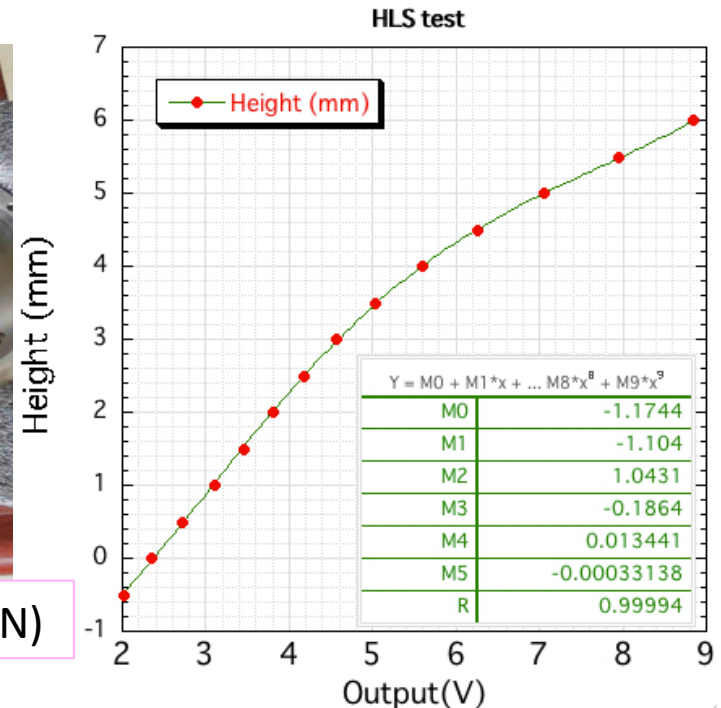


# Test of Balluff capacitive sensor

Seeking the possibility to get more (less expensive) HLS units to cover larger area



Many thanks to Dominique, Helene and Andrea (CERN)



# Summary

- Recent GPS data obtained using 7 GPS antennas along the SuperKEKB tunnel are presented.
- GPS data are stable enough to see a variation of a few millimeters when a daily average is taken.
- The GPS data indicate a drift of the tunnel circumference and level change, though further investigation is needed.
- We may have a conflict between the construction schedule and the optimal timing for alignment.

