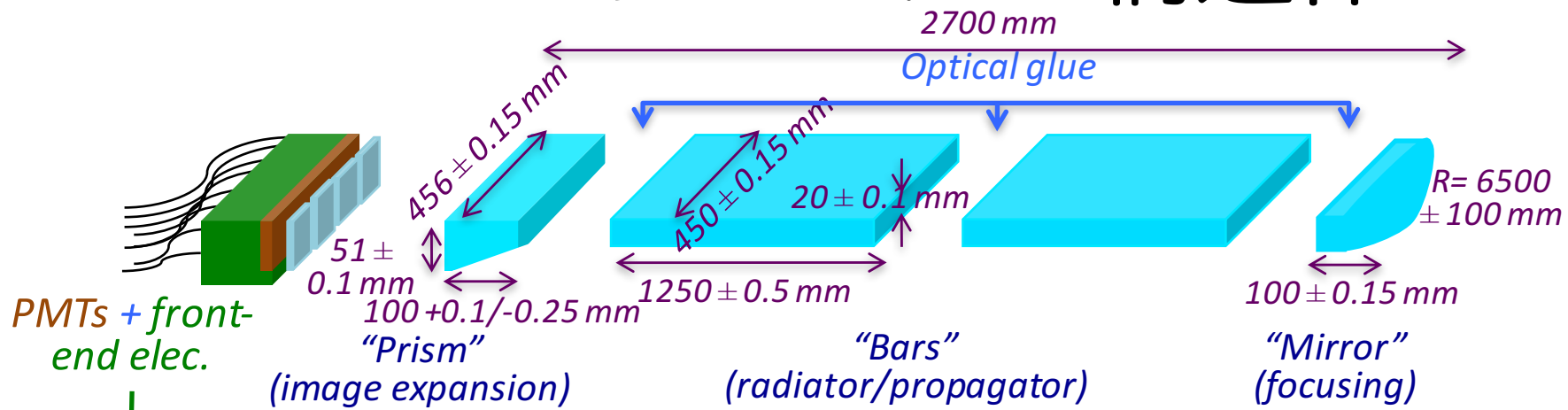


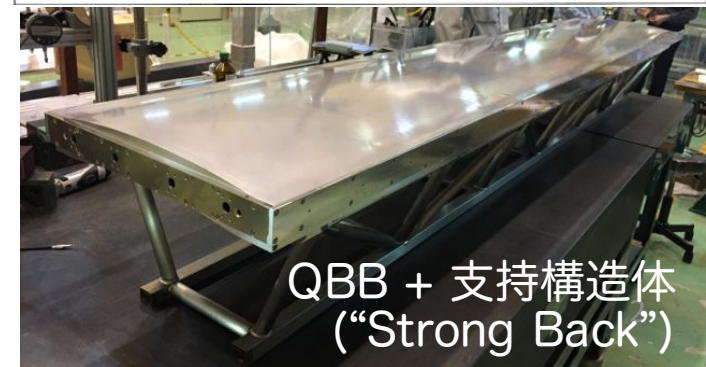
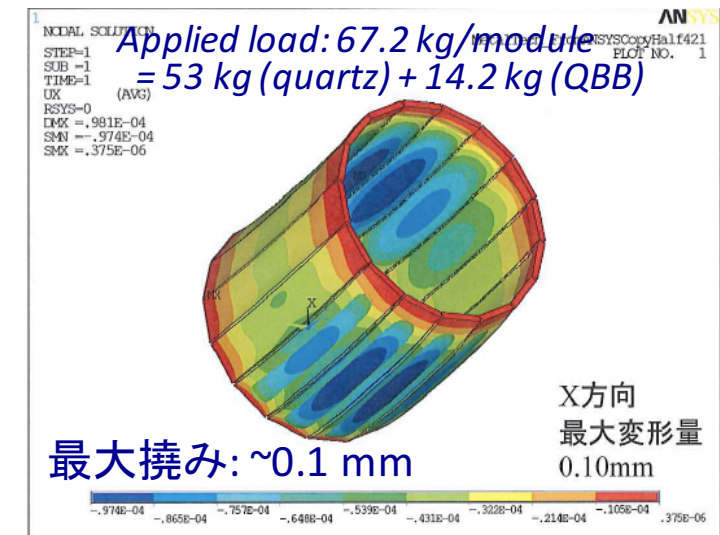
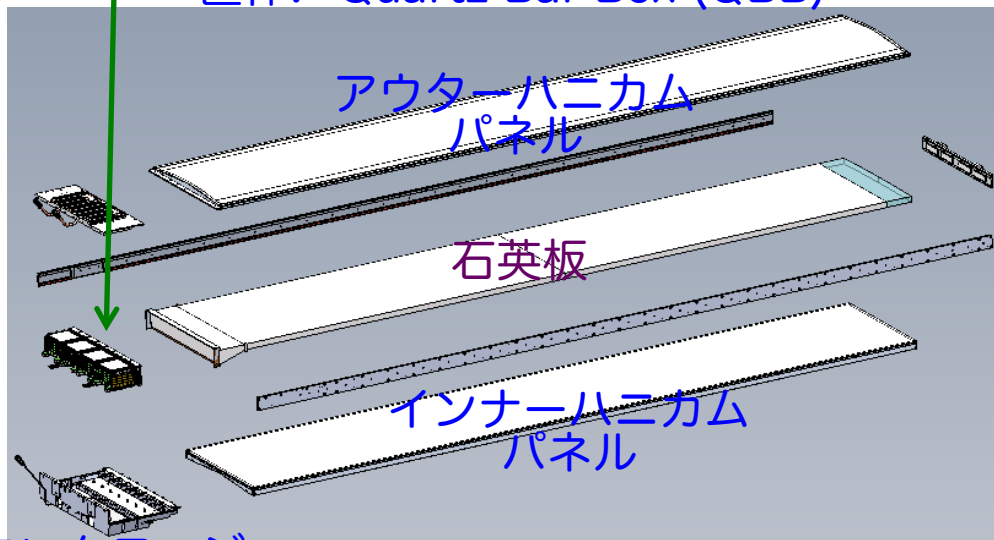
Module Transportation and Installation

J. Fast (PNNL), T. Kohriki (KEK),
K. Inami, R. Omori and K. Suzuki (Nagoya)

TOPモジュールと構造体



筐体: "Quartz Bar Box (QBB)"



要求仕様: TOPモジュールの撓みを0.5 mm以下に制御。

(輻射体の強度と検出器性能を保守的に考慮。)

2016.7.22

TOP Construction Review Meeting

Installation schedule

TOP module installation schedule

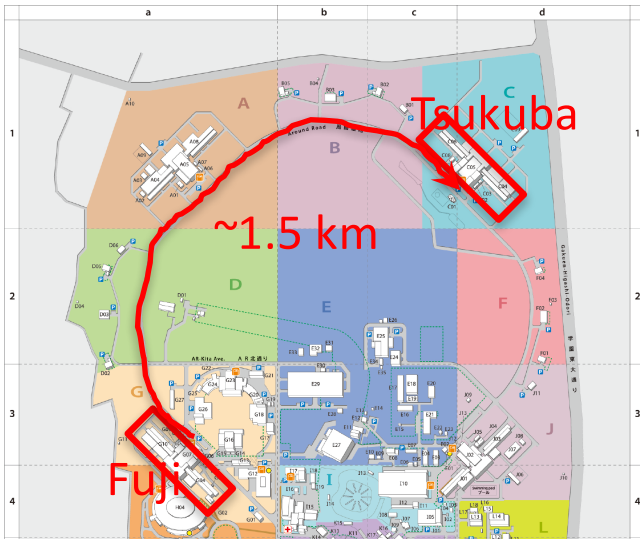
Month	Jan	February	March	April	April	May	June																												
Date	25	1	10	3	14	29	5	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	14	15					
Day of the week	Mon	Mon	Wed	Thu	Mon	Tue	Tue	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Tue	Wed			
M01																																			
S16																																			
M10	Move																																		
M03		Install																																	
M04		Move																																	
M09				Move																															
M06				Move																															
M08					Move																														
M13					Move																														
M05						Move																													
M07						Move																													
M14							Move																												
M02								Move																											
M15									Move																										
M12										Move																									
M11																																			
M16																																			
M17																																			
XY-stage reconfig. for S09-S12																																			
XY-stage reconfig. for S05-S08																																			
XY-stage reconfig. for S01-S04																																			
XY-stage reconfig. for S13-S16																																			
Z-beam insertion for S09-S15																																			
Z-beam insertion for S05-S09																																			
Z-beam insertion for S01-S04																																			
Z-beam insertion for S16																																			
Fwd IDS installation																																			
Installation iie removal																																			

- 1st module (M03) was installed on Feb. 10.
- Remaining 15 modules were installed in less than 3 weeks.
 - In Apr. 11-22 and May 9-11.
- 16 modules were joined together on May 12.
- Strong Backs removal was completed May 20.

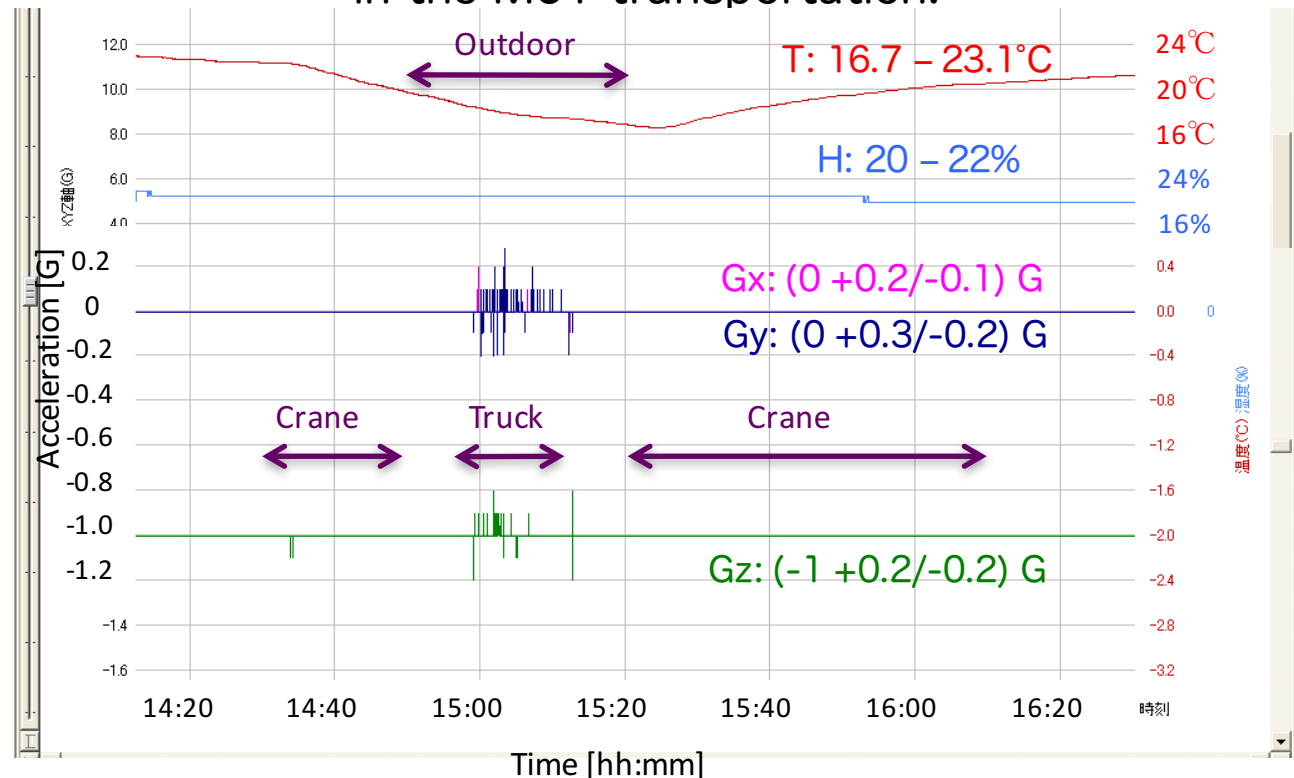
Module transportation

- From Fuji B4 to Tsukuba B4.
 - Using a transportation pallet, crane and truck (~1.5 km @ ~5 km/h).
 - Gently done for all modules.

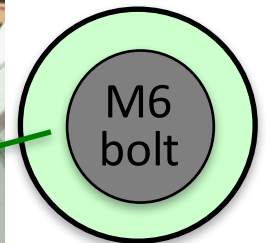
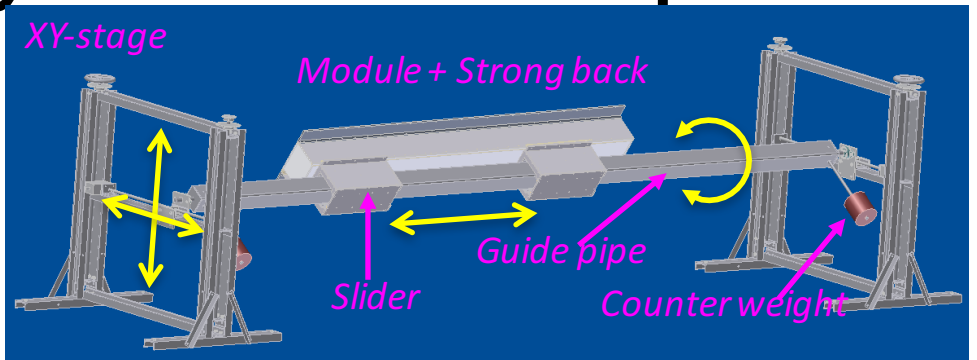
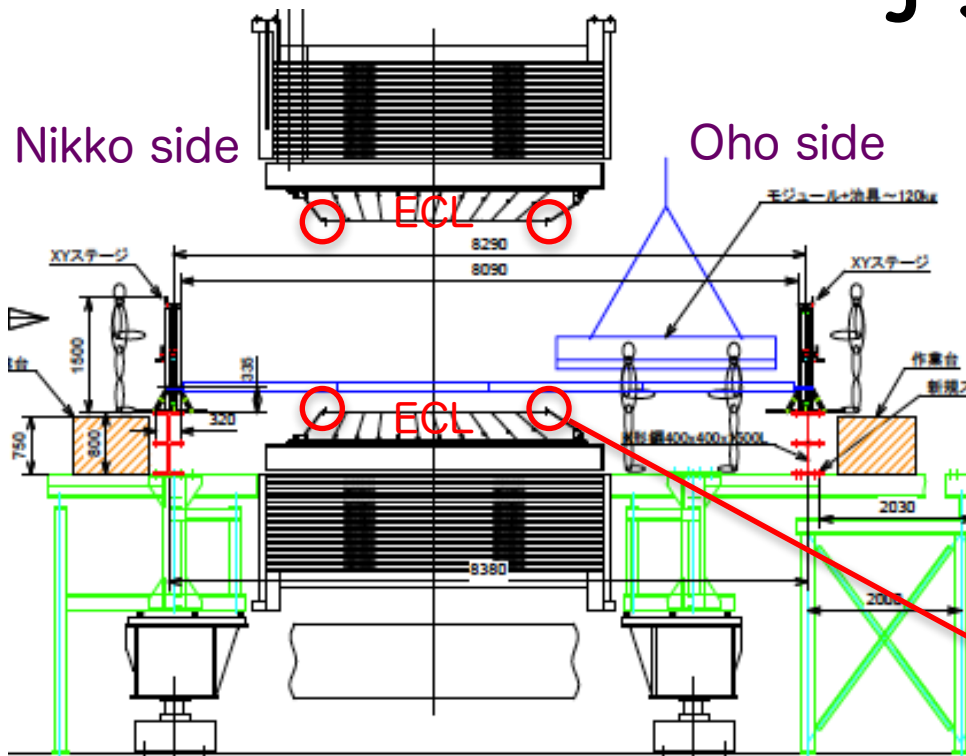
Temp. (T), Humidity (H) and Acceleration (G) in the M01 transportation.



~5 km/h

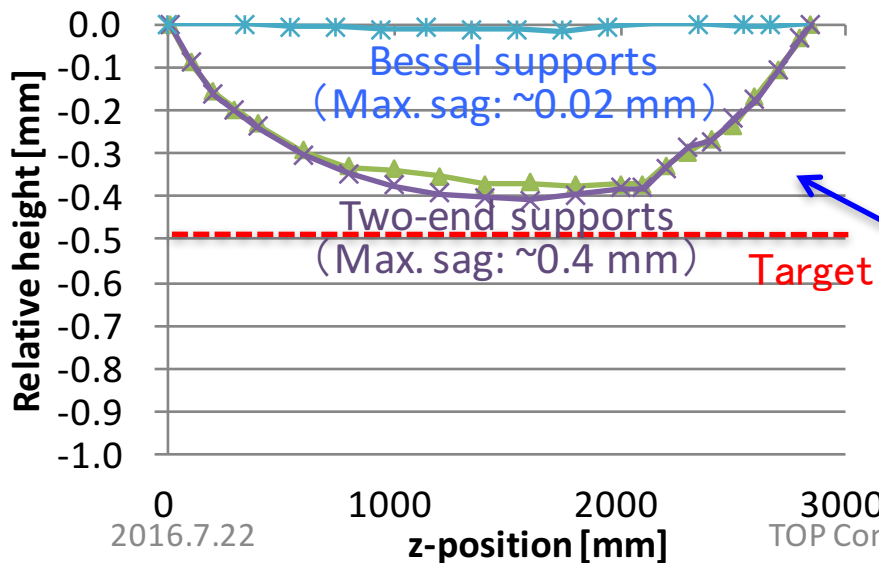
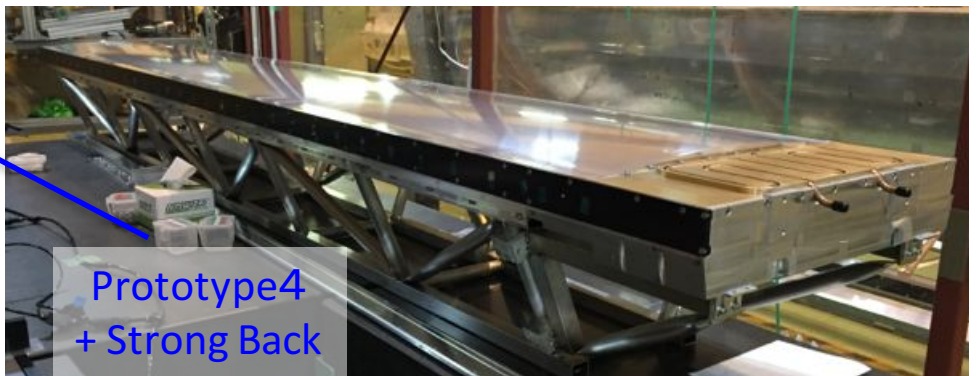


Installation jigs and set-up



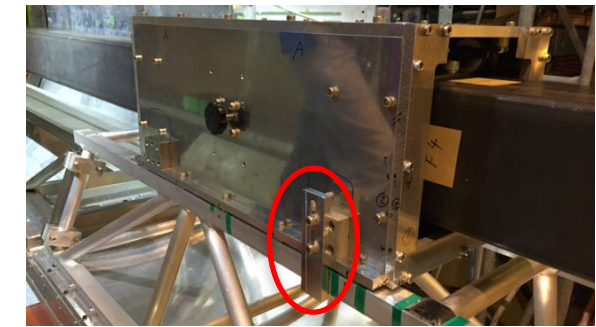
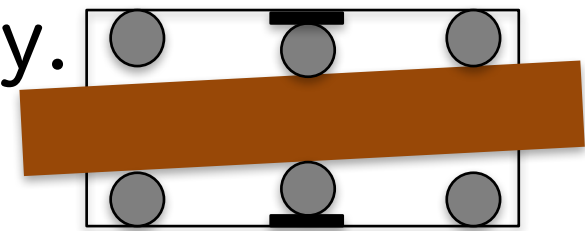
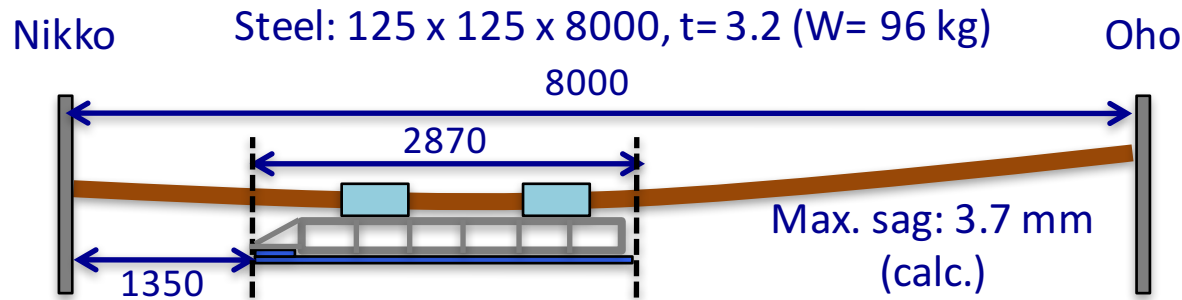
“ECL flange”
(H:70mm, T:4mm)

Positioning bushings
(accuracy: $\sim \pm 0.25$ mm)

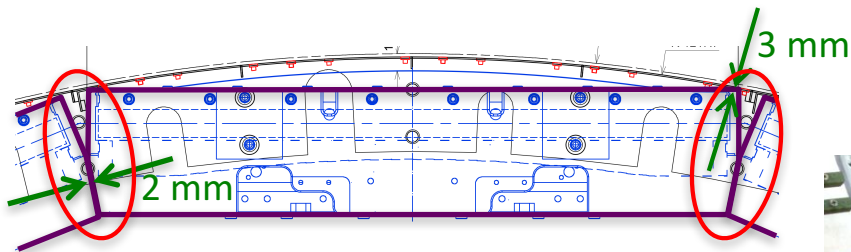


Challenges in the installation

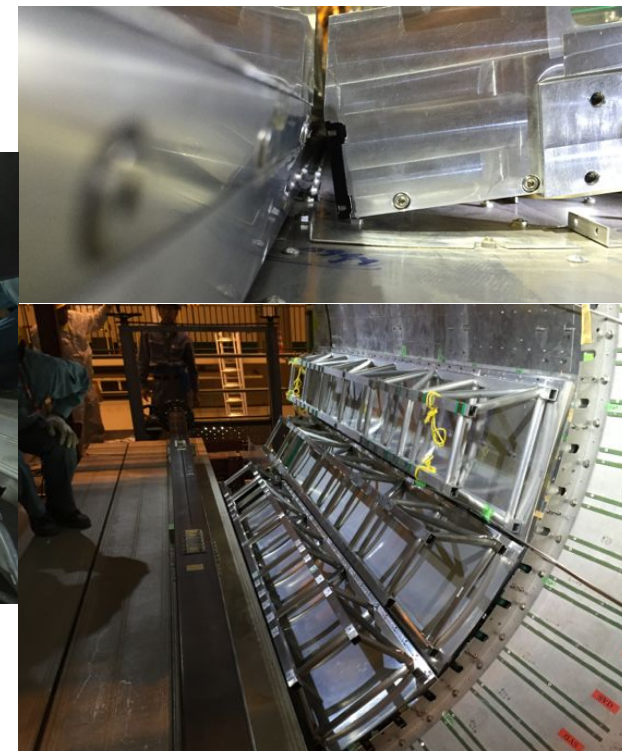
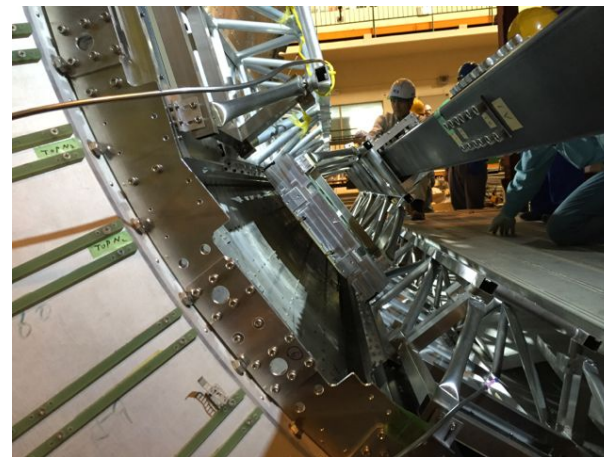
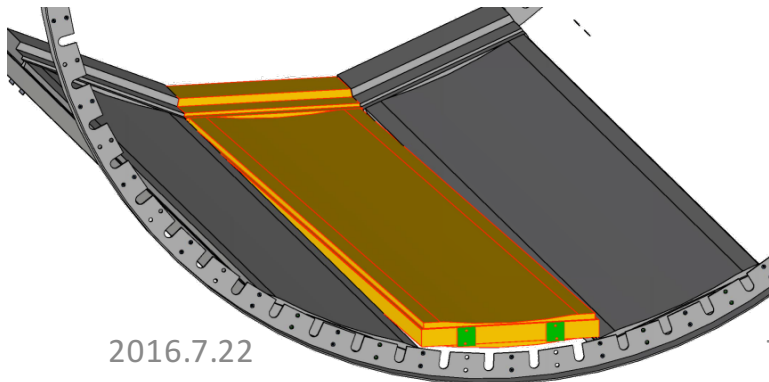
- Managing the guide pipe elasticity.



- Tight clearance

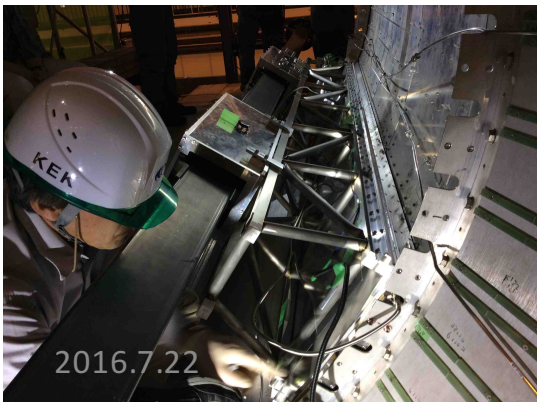
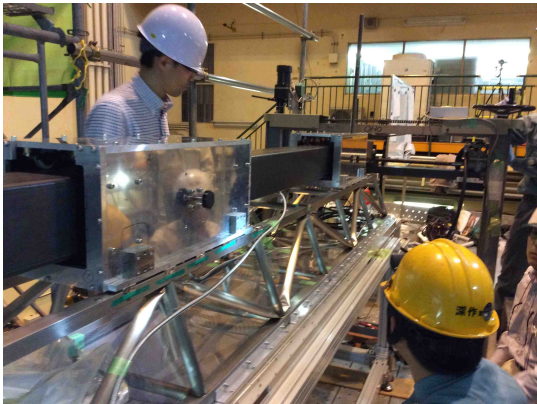
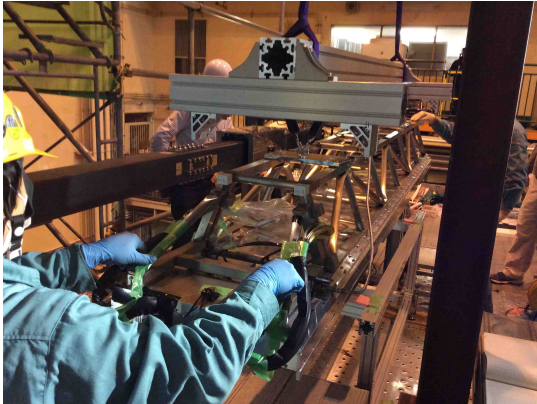


Need tilting to avoid the interference.

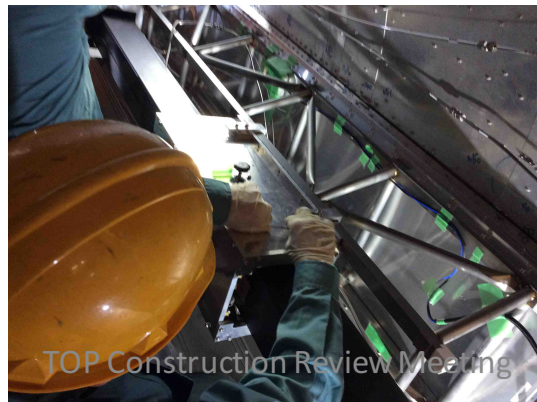


Module installation (1)

- Feb. 10, 2016: 1st module installation (M03).



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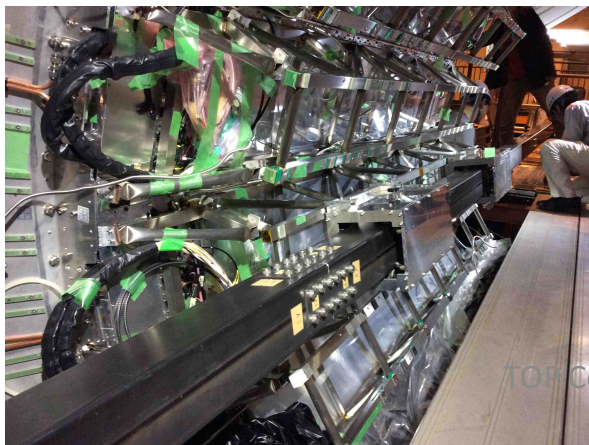
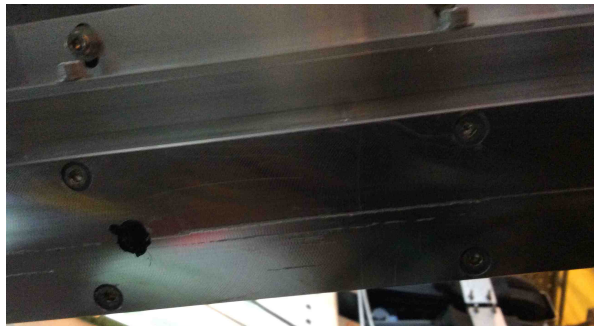
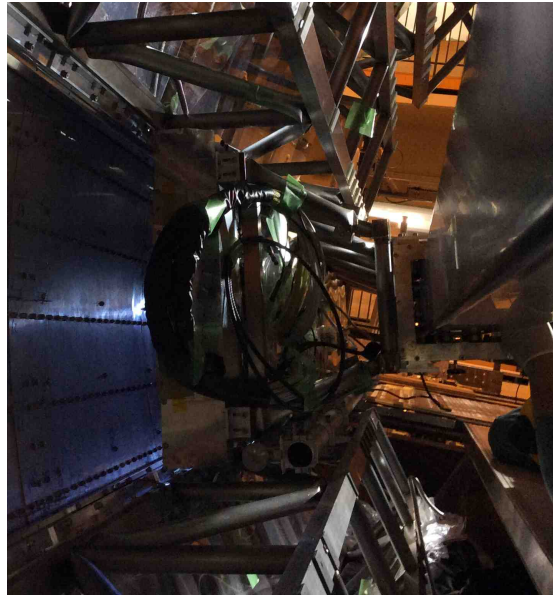
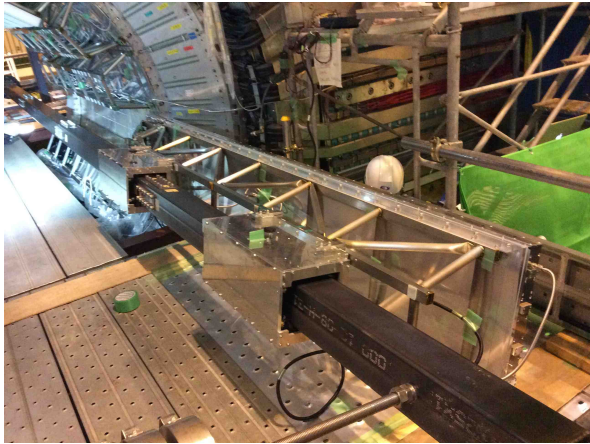


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Module installation (2)

- May 11, 2016: last module installation (M10).



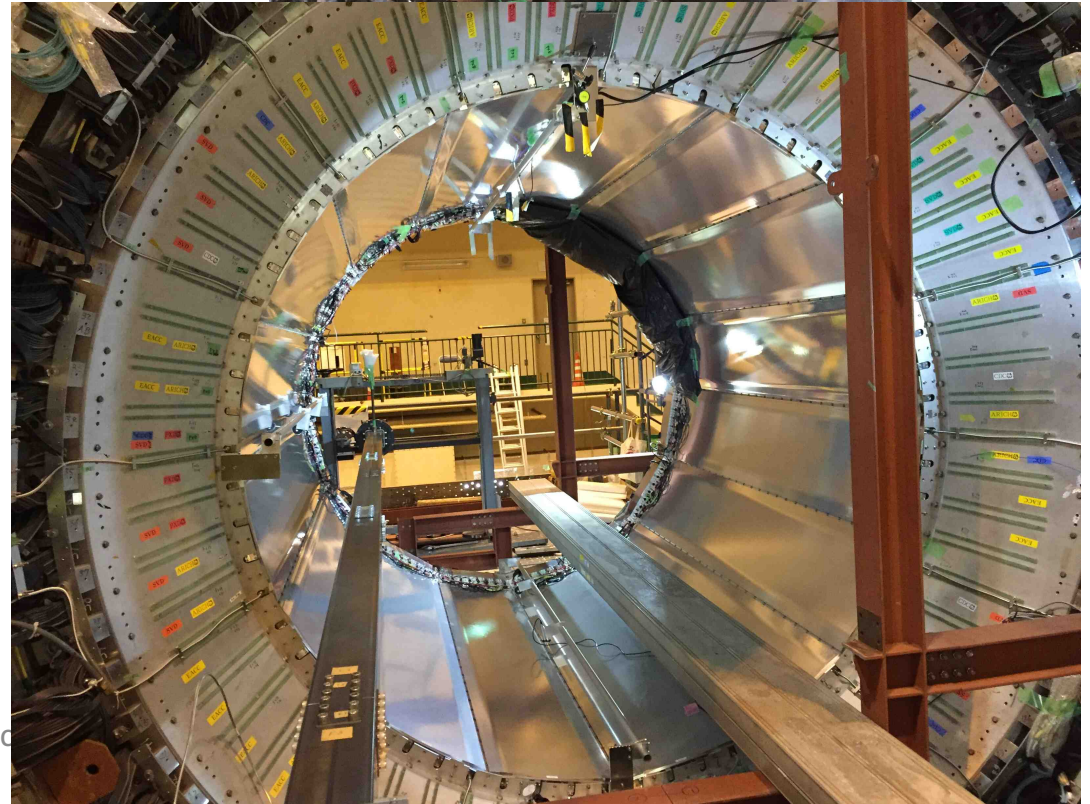
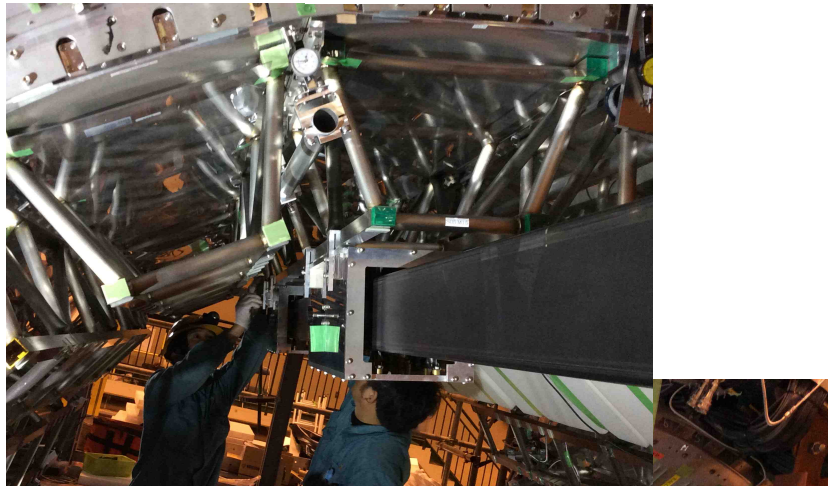
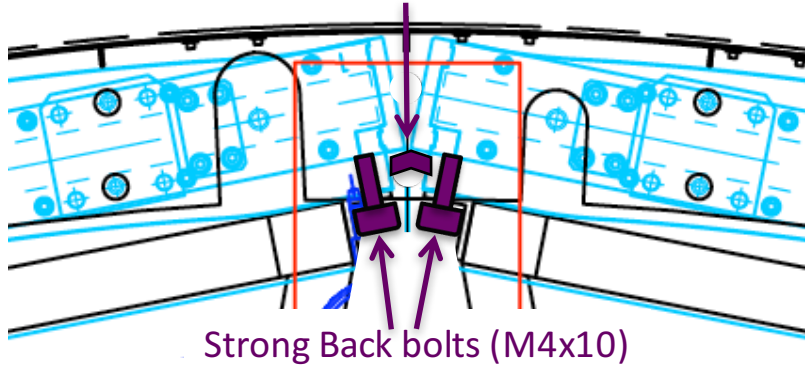
2016.7.22

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Module joining and SB removal

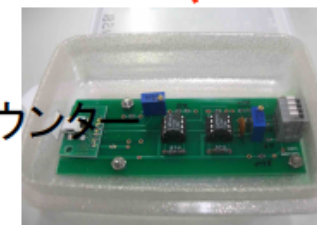
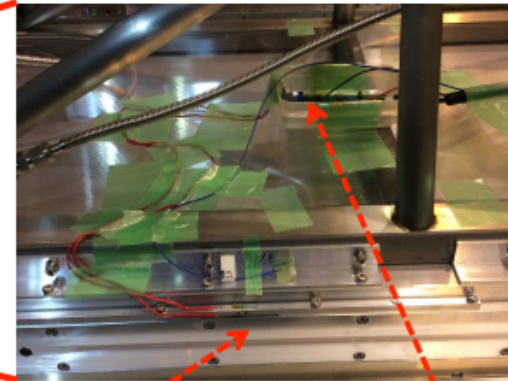
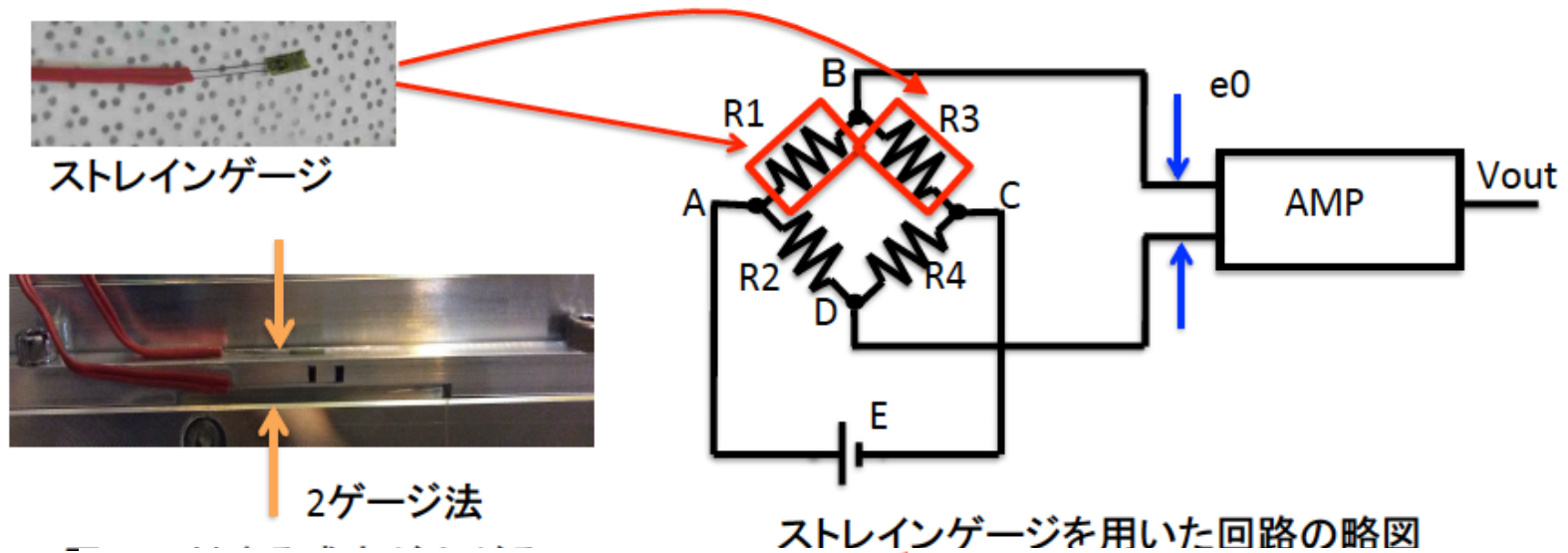
- May 20, 2016: SB removal completed.

z-beam (Al, 3 mm^t x 2650 mm)



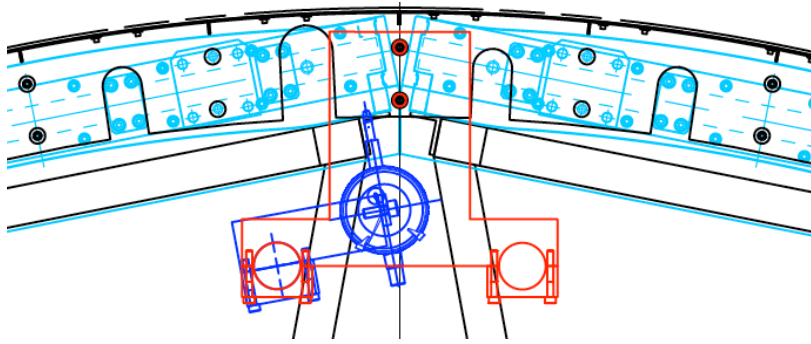
Module deflection monitors (1)

- Strain gauge (Omori, Inami)



Module deflection monitors (2)

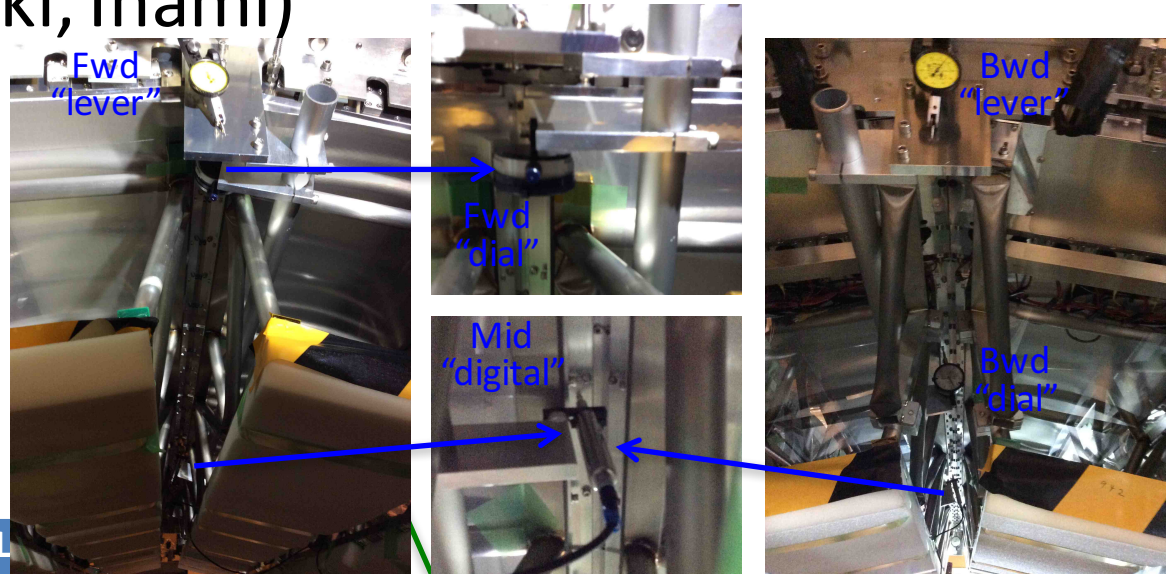
- Fixed pipe gauges (Kohriki, Inami)



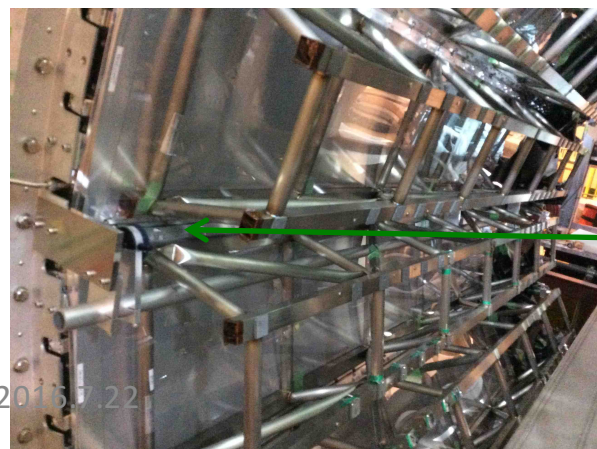
Used gauges

"fLever" "Fwd" "Mid" "Bwd" "bLever"

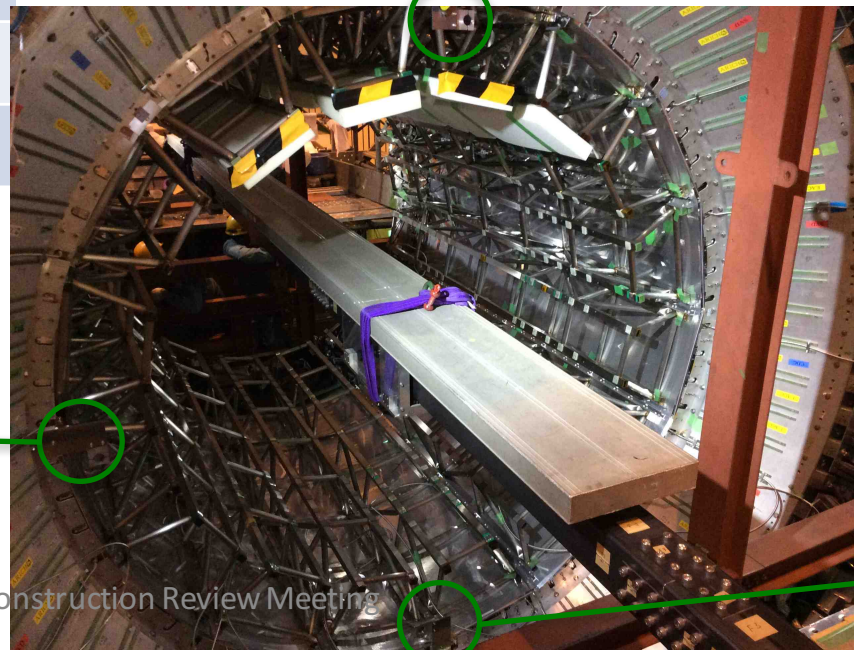
ϕ / z	Fwd ECL flange	60 mm	1450 mm	2340 mm	Bwd ECL flange
90°	lever	dial	digital	dial	lever
180°	---	dial	dial	dial	---
270°	---	dial	digital	dial	---



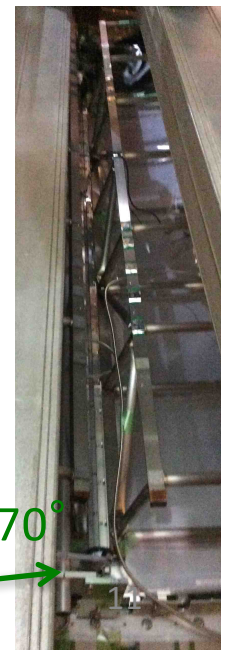
90°



180°

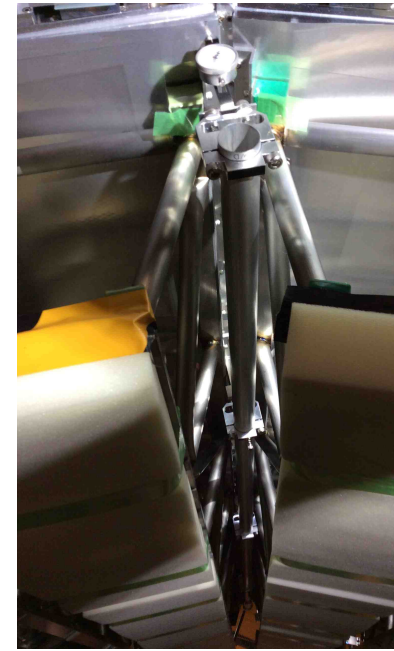
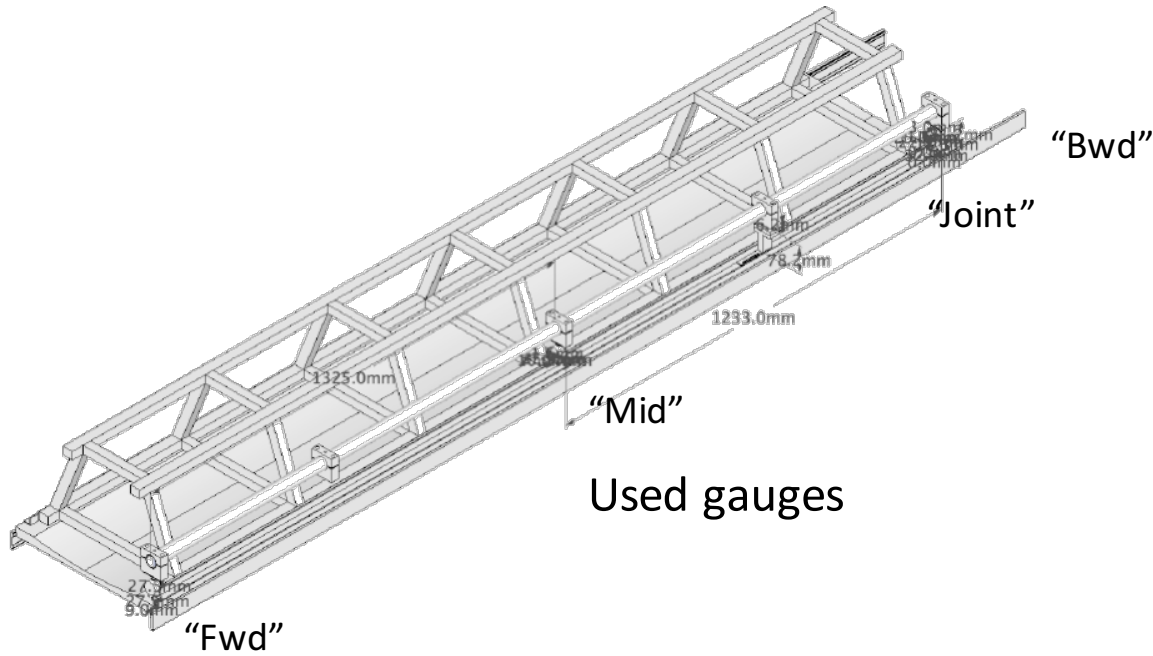


270°



Module deflection monitors (3)

- Portable pipe gauge (Suzuki)



“Fwd”



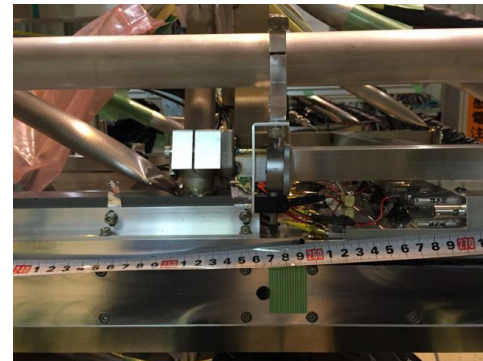
2016.7.22

“Mid”

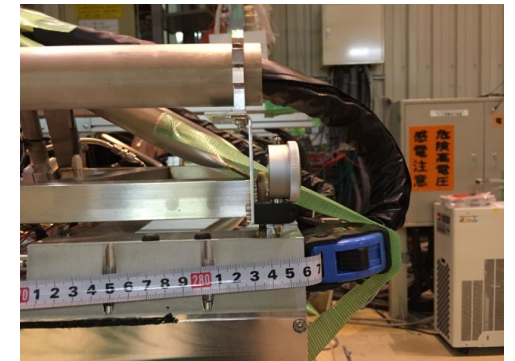


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“Joint”



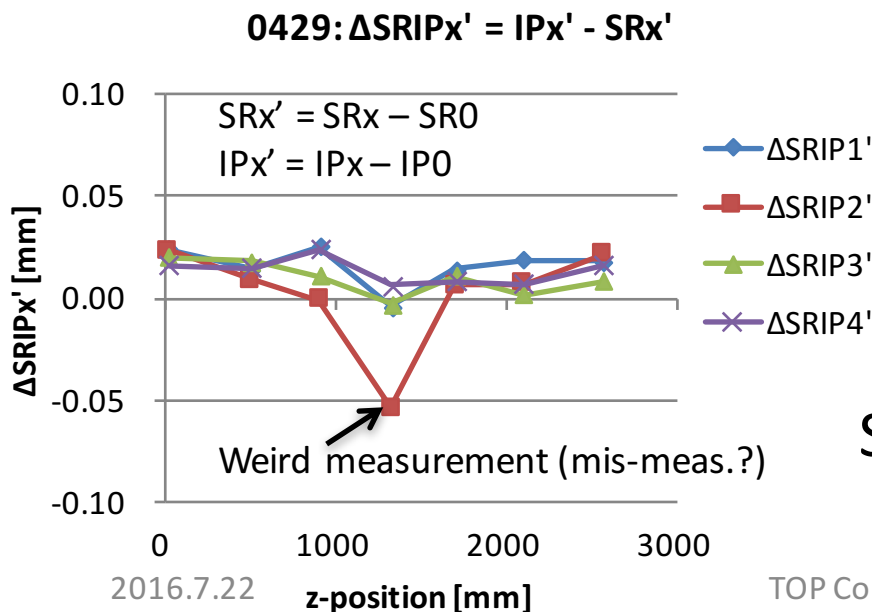
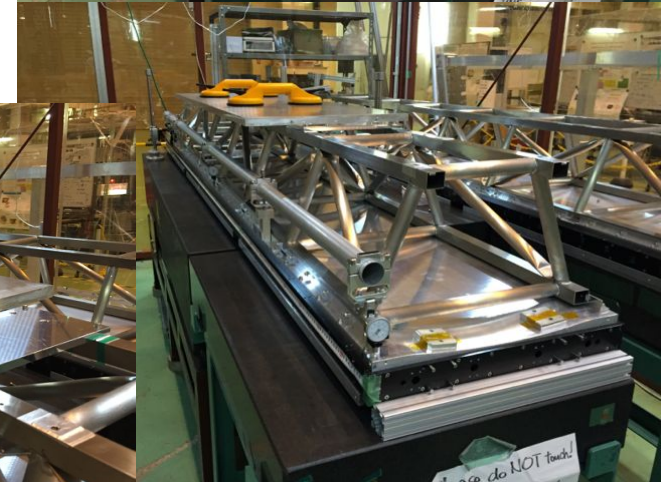
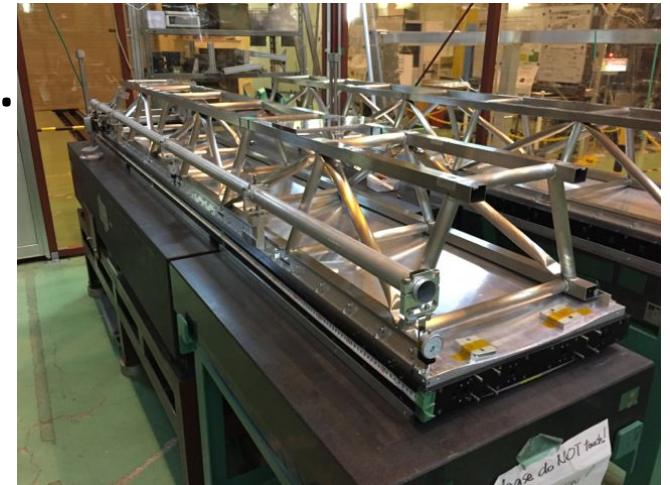
“Bwd”



Bench test for the lower slots (1)

- Compared the measurements of the PPG with that of the height gauge (HG).
 - To see if the PPG works in the expected sag

x	Load	Support
0	Self-load	None (Sit on the granite table.)
1	Self-load	Two-end supports
2	x=1 + 33.4 kg	Two-end supports
3	x=2 + 31.2 kg	Two-end supports
4	x=3 + 35.5 kg	Two-end supports



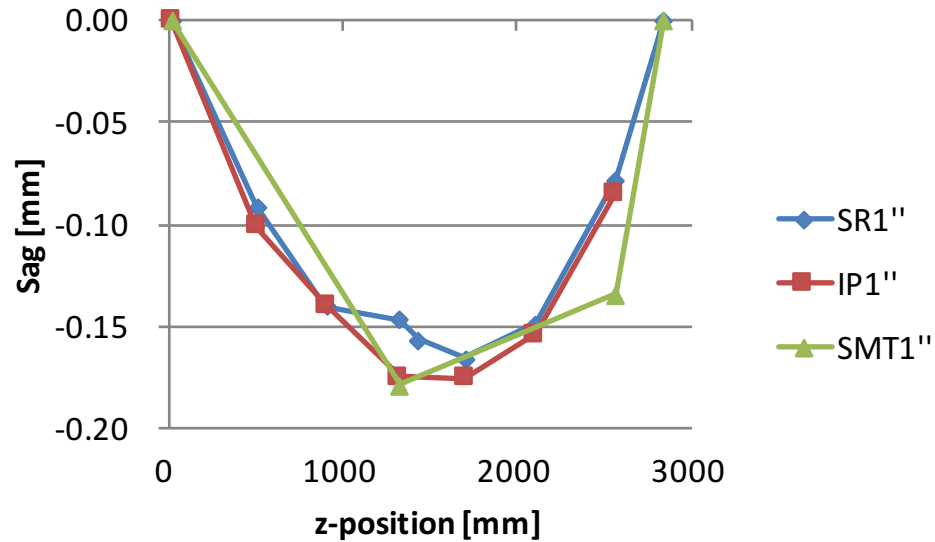
SR and IP seem to agree within 0.02 mm.

➤ Would be the meas. error of ± 0.01 mm.

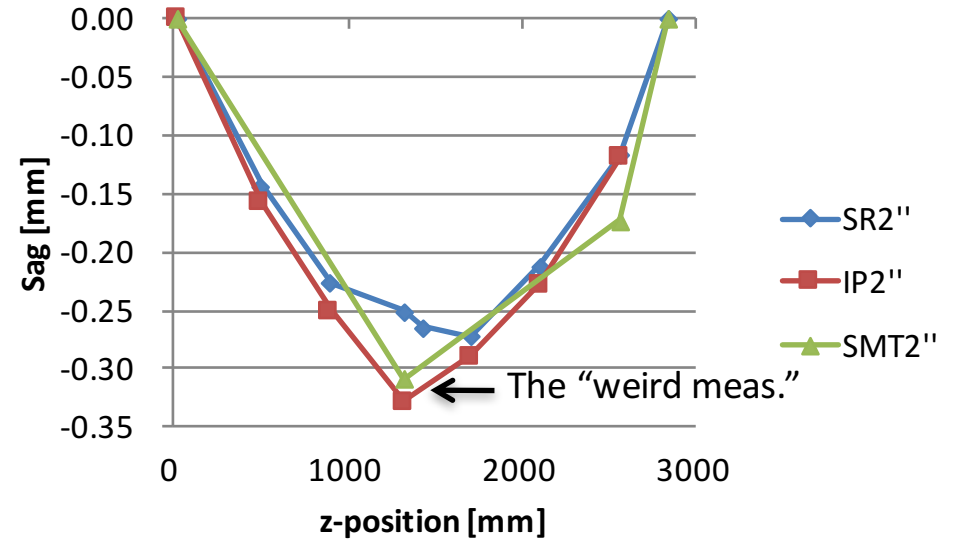
Bench test for the lower slots (2)

- PPG vs HG: integral measurements

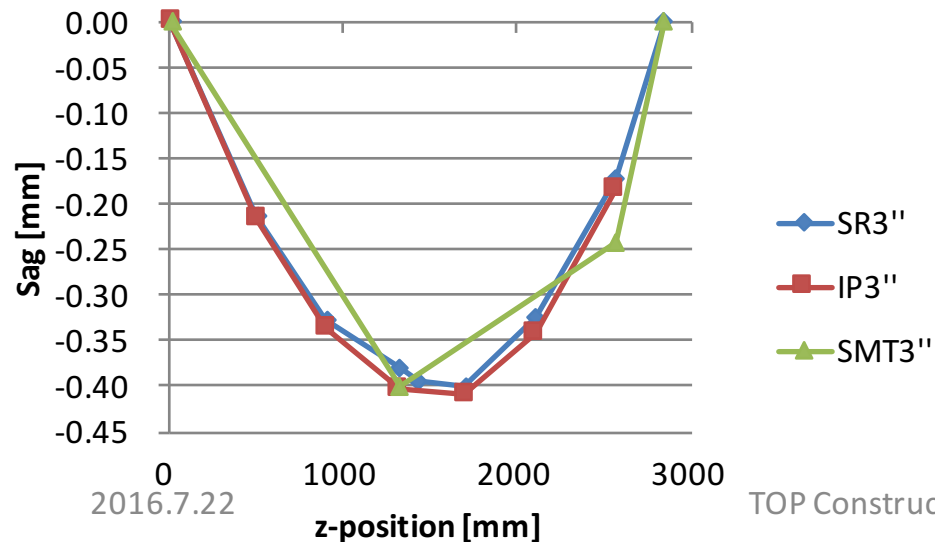
0429: Levelled shape (w= ~45 kg)



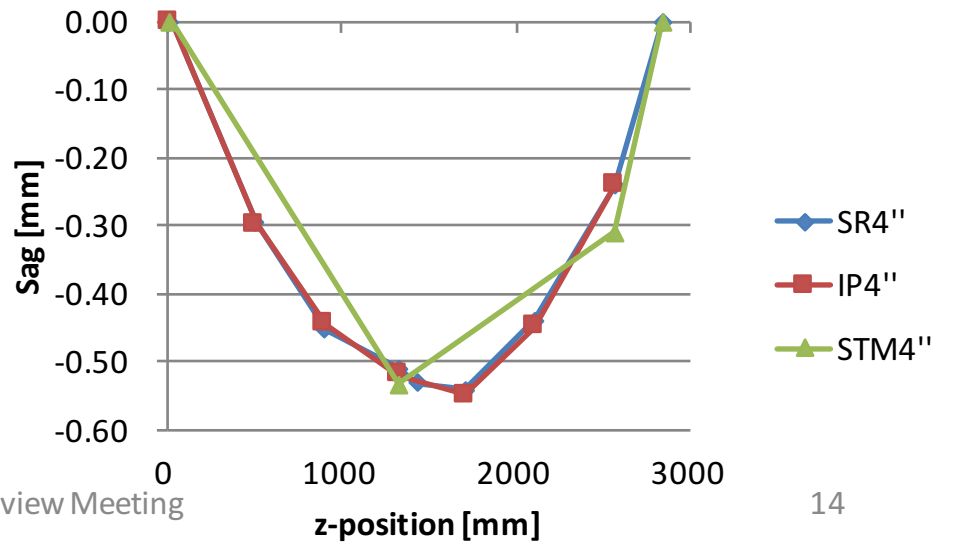
0429: Levelled shape (w= ~78.4 kg)



0429: Levelled shape (w= ~109.6 kg)



0429: Levelled shape (w= ~145.1 kg)

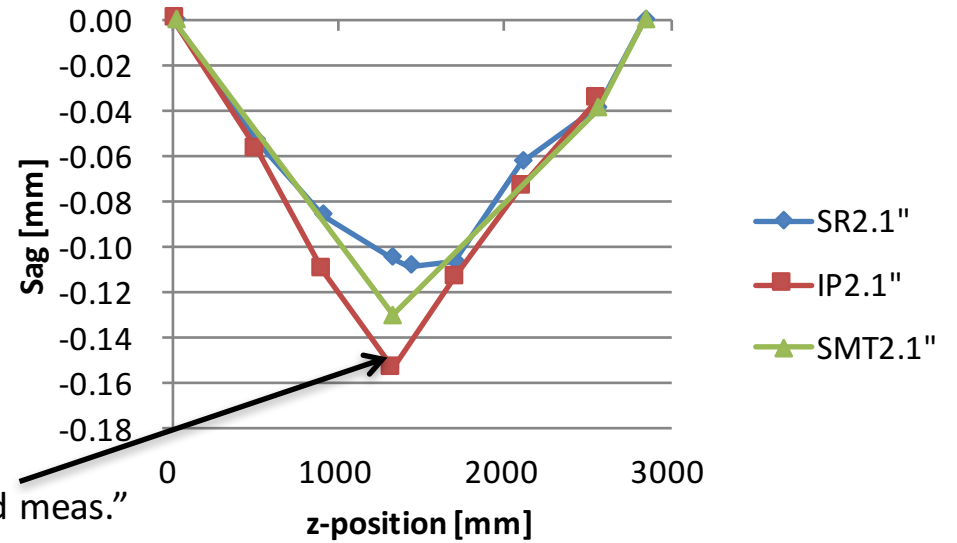


Bench test for the lower slots (3)

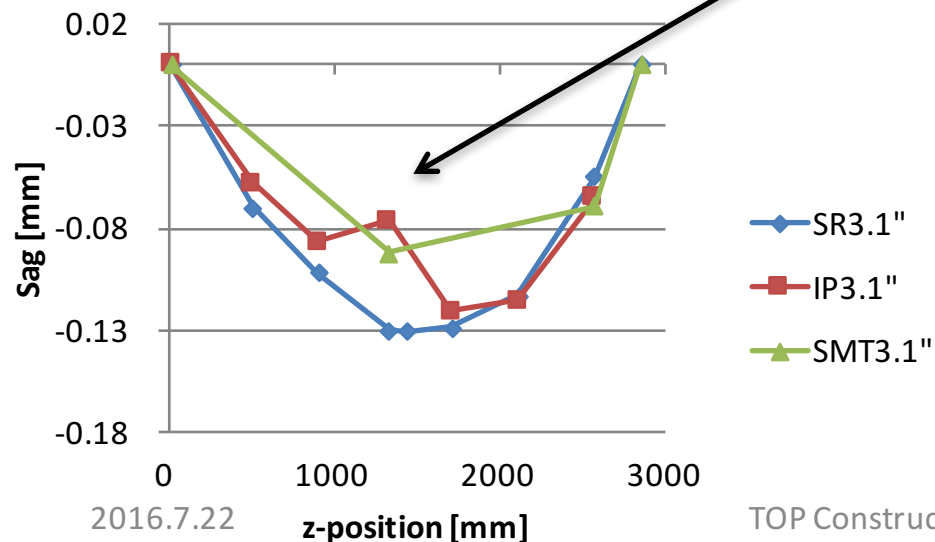
- PPG vs HG: differential measurements

x	Differential
2.1	= 2 - 1
3.1	= 3 - 2
4.1	= 4 - 3

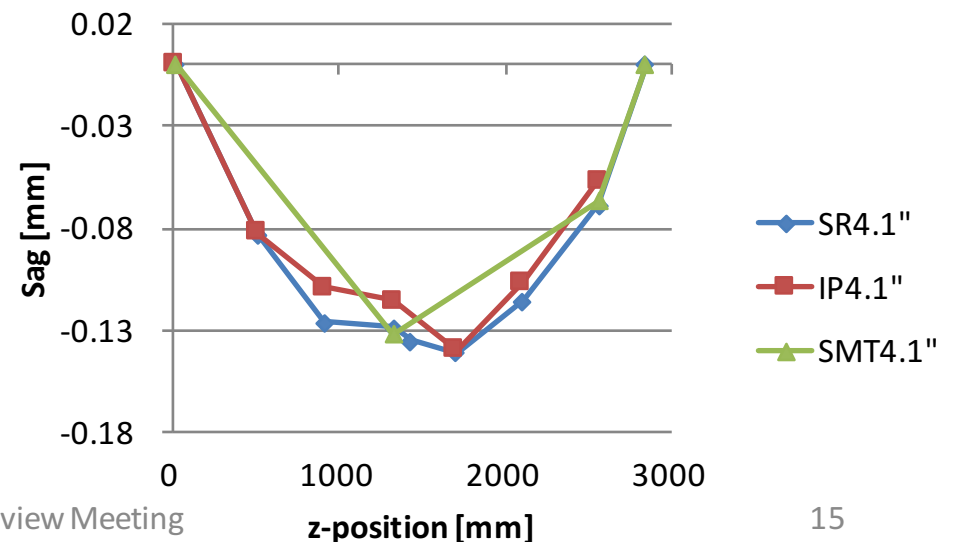
0429: Levelled shape (w= 33.4 kg)



0419: Levelled shape (w= 31.2 kg)

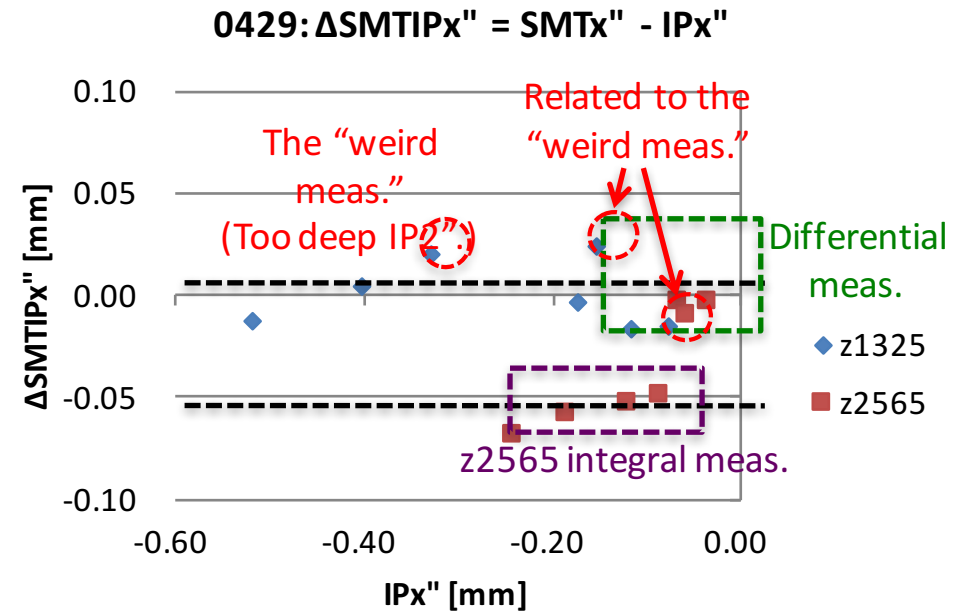
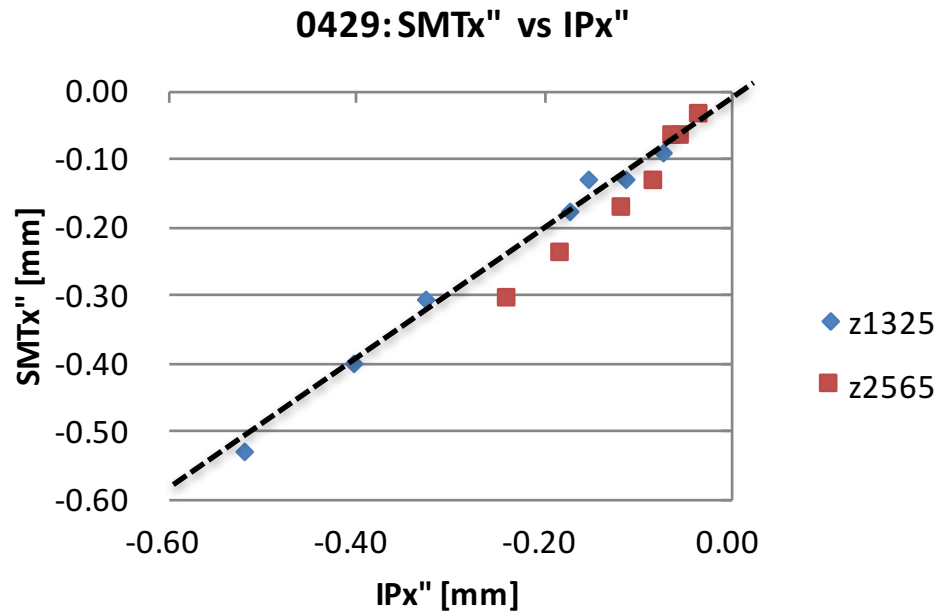


0429: Levelled shape (w= 35.5 kg)

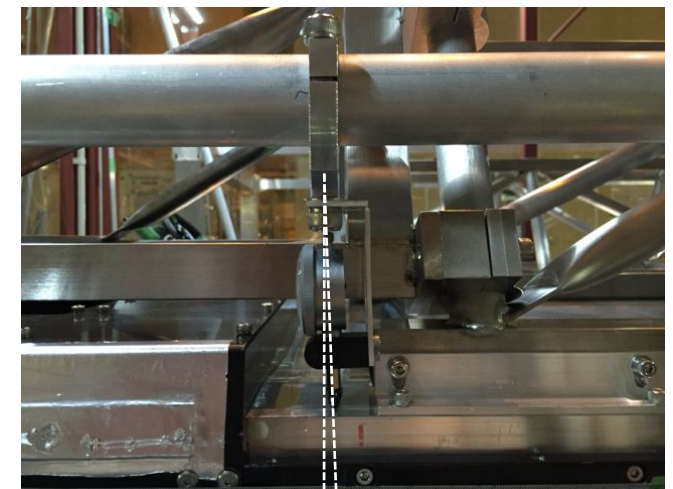


Bench test for the lower slots (4)

- Agreement between PPG and HG.



- They seem to agree within ± 0.02 mm.
- $\Delta\text{SMTIPx}'' = -0.06 \pm 0.01 \neq 0$ on the integral meas. of z2565.
 - ✓ Some shift would've happened on the dial gauge when transferring from "no supports" to "two-end supports".
 - ✓ Otherwise, consistent with IPx'' within 0.01 mm.
 - ✓ May have small sag-dependence due to the misaligned dial gauge.

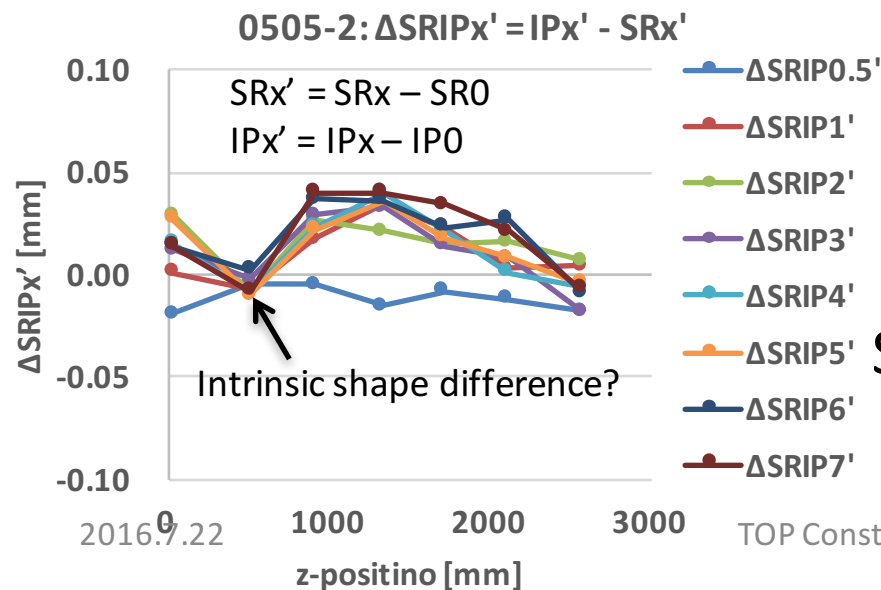
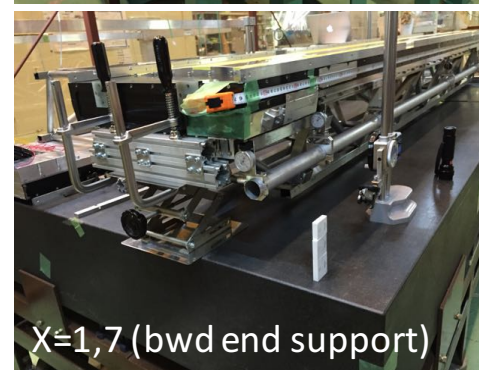


d $d' = d/\cos\theta$

Bench test for the upper slots (1)

- Repeated flipping the module upside down.

x	Load	Support
0	Self-load	None (Sit on the granite table.)
0.5	Self-load	Bessel-point supports
1	Self-load	Two-end supports
2	x=1 + 33.4 kg	Two-end supports
3	x=2 + 31.2 kg	Two-end supports
4	x=3 + 35.5 kg	Two-end supports
5	x=2 + 31.2 kg	Two-end supports
6	x=1 + 33.4 kg	Two-end supports
7	Self-load	Two-end supports

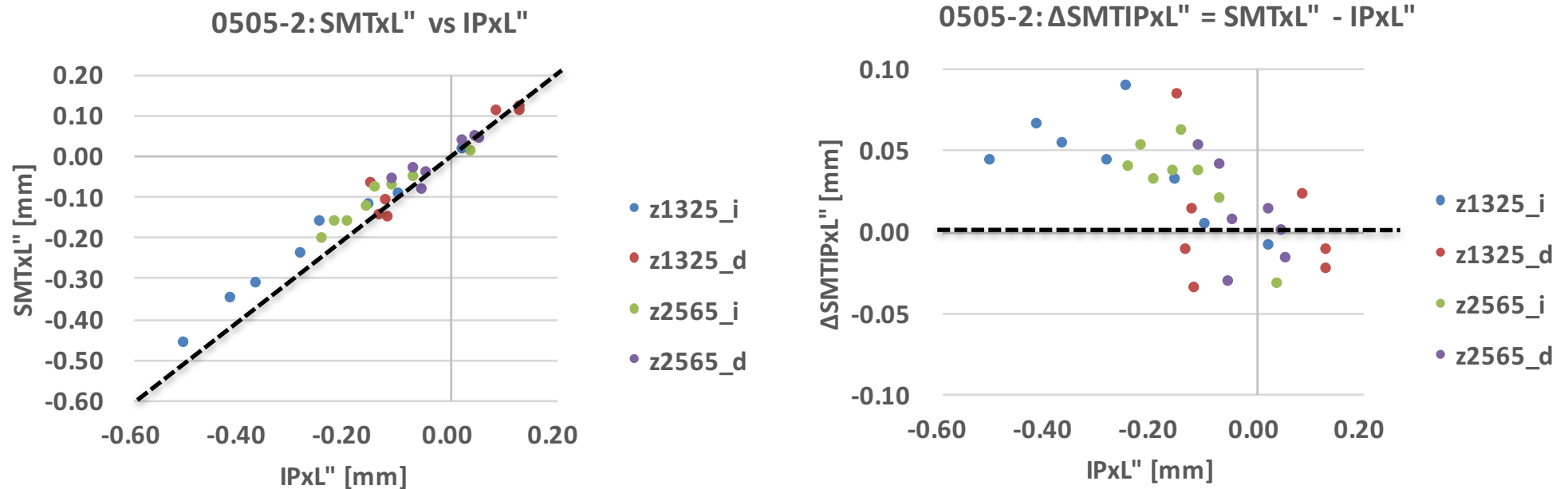


SR and IP seem to agree within

- +0.04/-0.01 mm for the two-end supports,
- -0.02 mm for the Bessel-point supports.

Bench test for the upper slots (2)

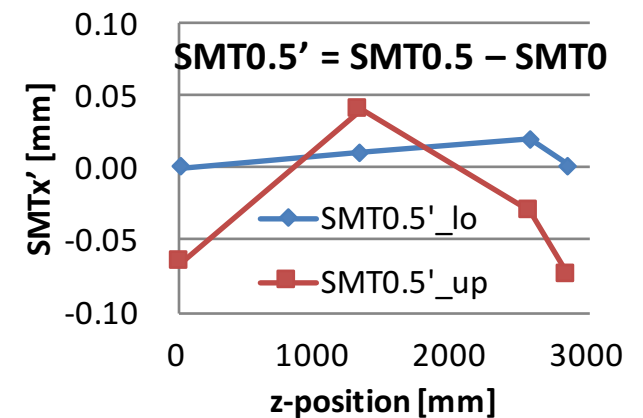
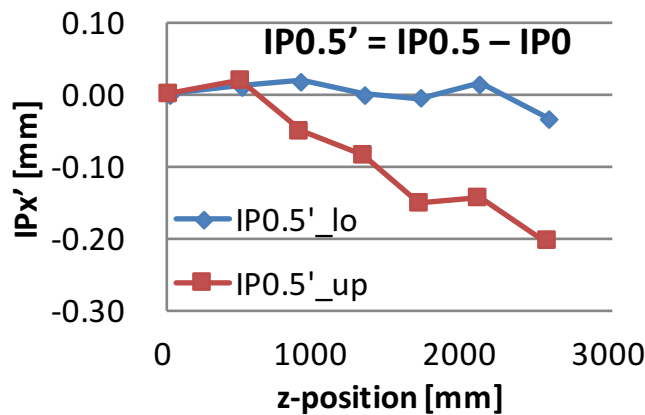
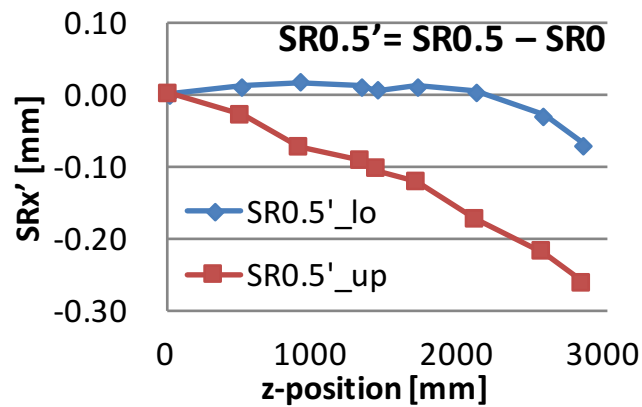
- Agreement between PPG and HG.



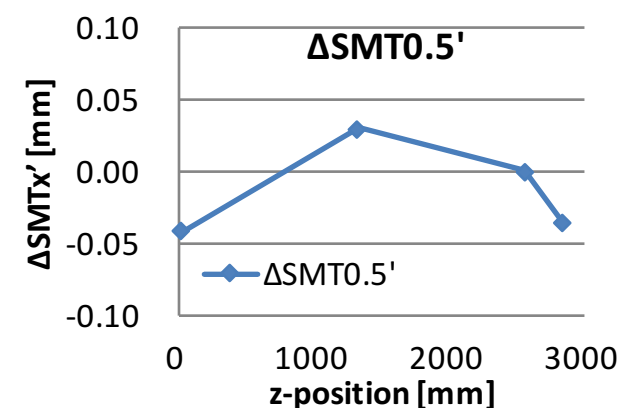
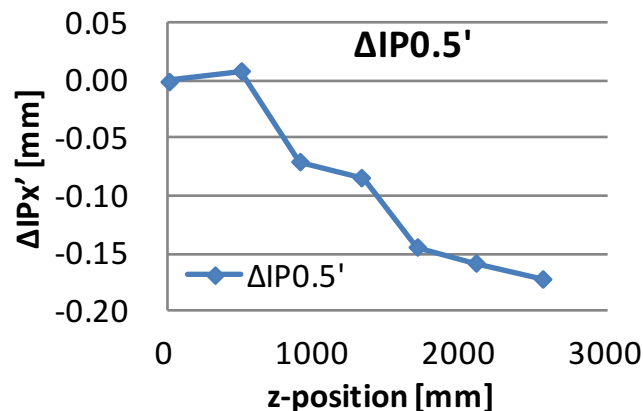
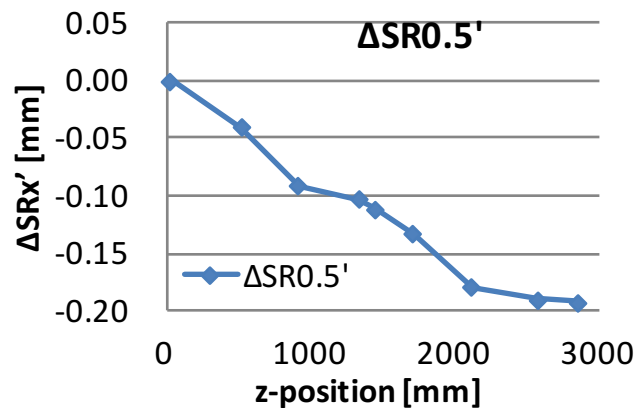
- They seem to agree within +0.08/-0.03 mm.
 - For both z1325 and z2565.
 - Worse than the lower-slot config.
- Some correlation may exist.
 - PPG may overestimate the sag in the upper-slot config.

“Lower” vs “upper” configs. (1)

- Effect of the configuration difference.
 - Relative shapes to the x=0 measurements.
 - HG: Effect of the enclosure weight even with the SBExt?
 - SMT: SMT attitude was not preserved between the configurations.

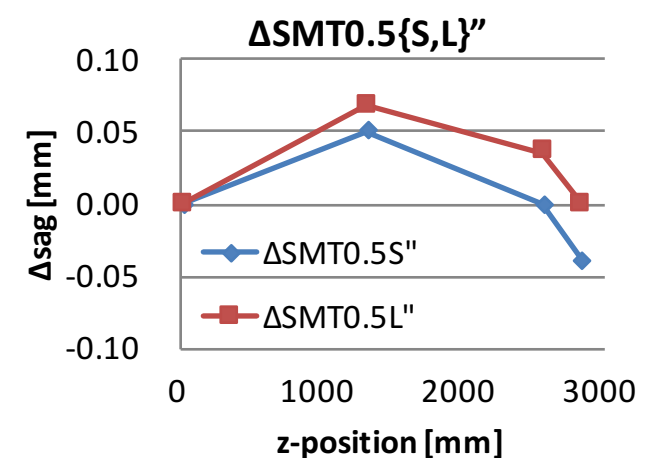
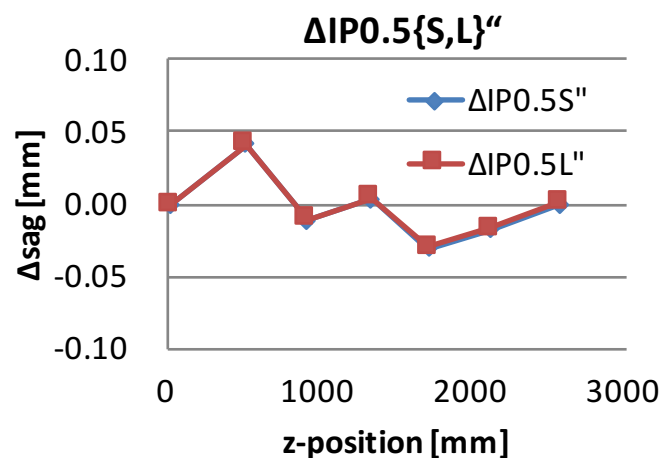
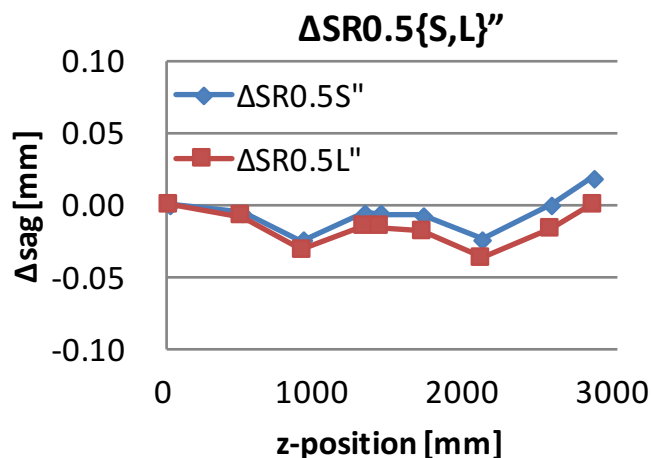


– Relative height differences: $\Delta = \text{“Upper”} - \text{“Lower”}$



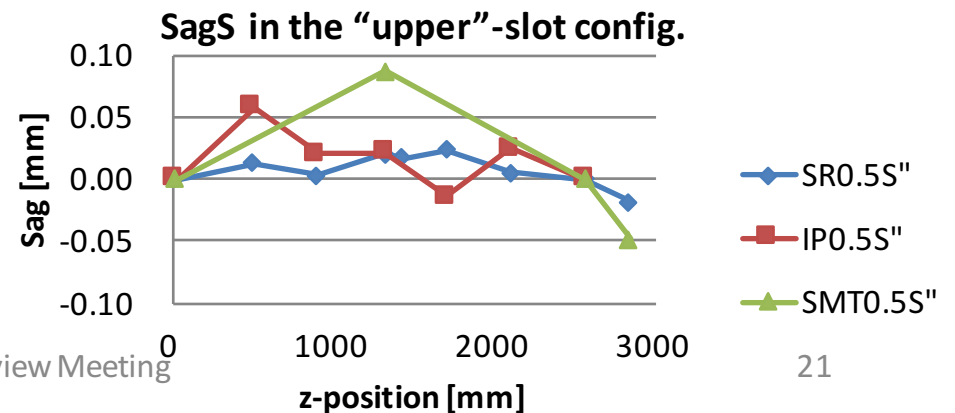
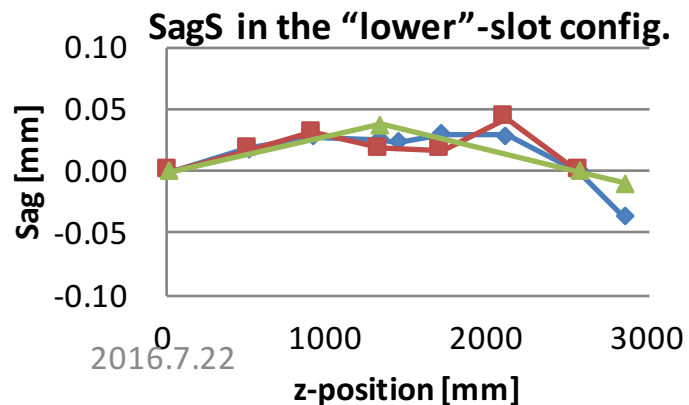
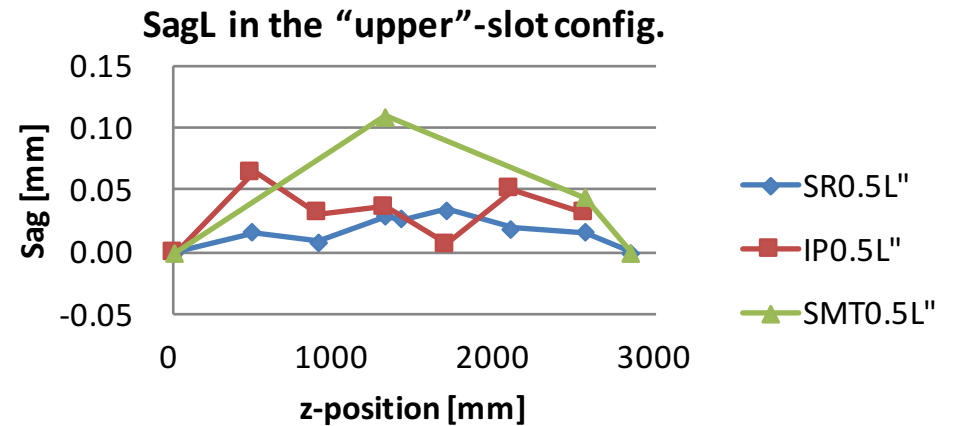
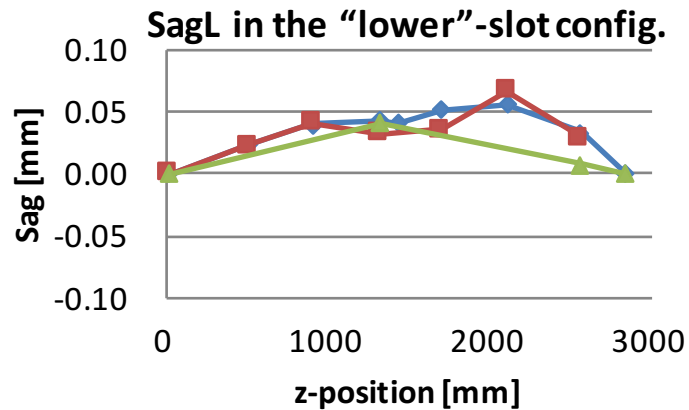
“Lower” vs “upper” configs. (2)

- Effect of the configuration difference. (cont'd)
 - ΔSag_L : Measurements in the two configurations agree within
 - -0.04 mm in SR0.5L”,
 - +0.04/-0.03 mm in IP0.5L”,
 - +0.07 mm in SMT0.5L”.
 - ΔSag_S : The agreements get slightly better when focusing on the inner panel region.
 - Since the “lowering” enclosure part is not included in the tilt-correction.



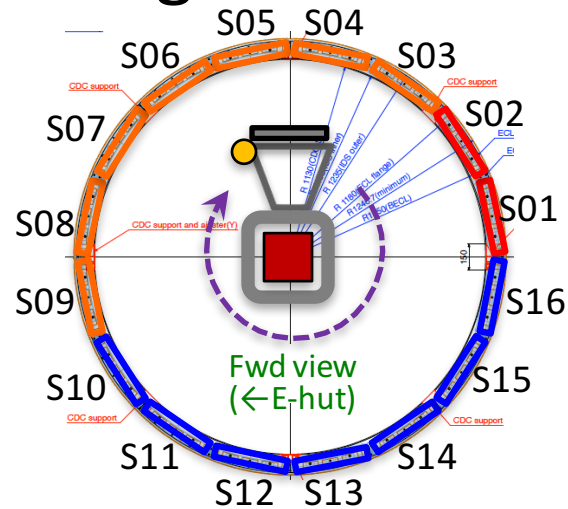
“Lower” vs “upper” configs. (3)

- Agreement among the SR, IP, SMT sag measurements.
 - “lower”: The meas. agree well.
 - Δ SMTIP0.5" in SagL: +0.01 mm @z1325, -0.02 mm @z2565.
 - Δ SMTIP0.5" in SagS: +0.02 mm@z1325.
 - “upper”: The agreement gets worse.
 - Δ SMTIP0.5" in SagL: +0.07 mm @z1325, +0.01 mm @z2565.
 - Δ SMTIP0.5" in SagS: +0.07 mm@z1325.

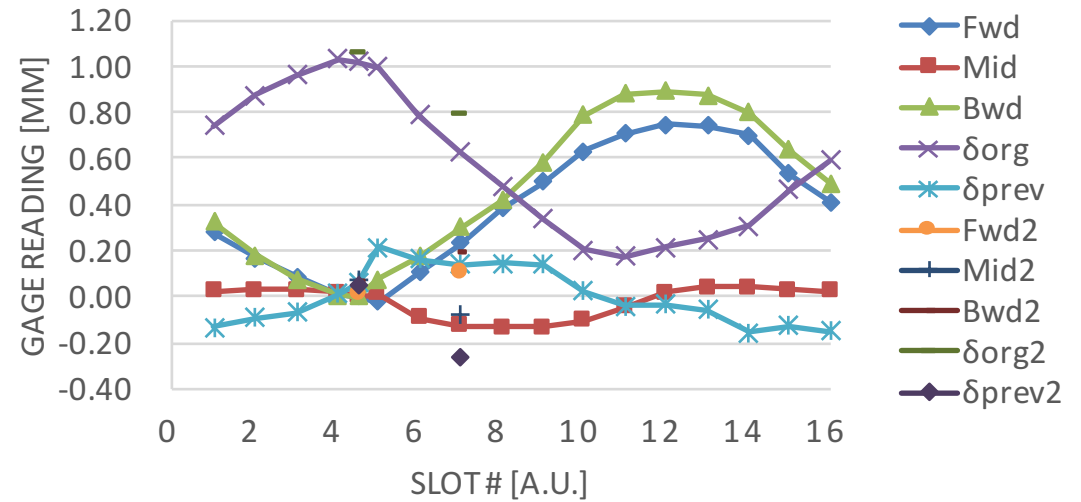


Variation of the gage readings

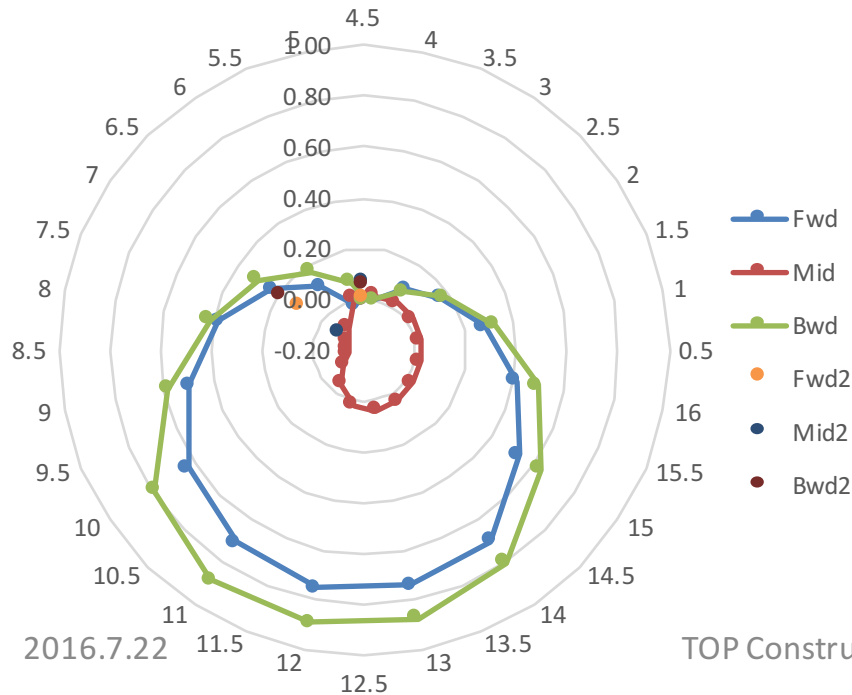
- Rotating a module with PPG.



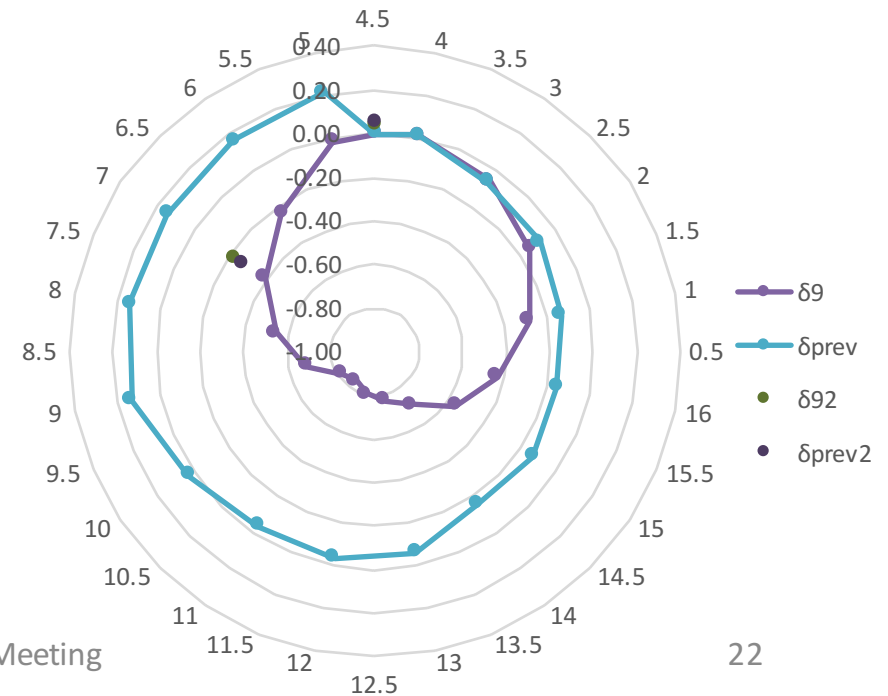
VARIATION OF GAGE READINGS AND SAG



Relative gage variations



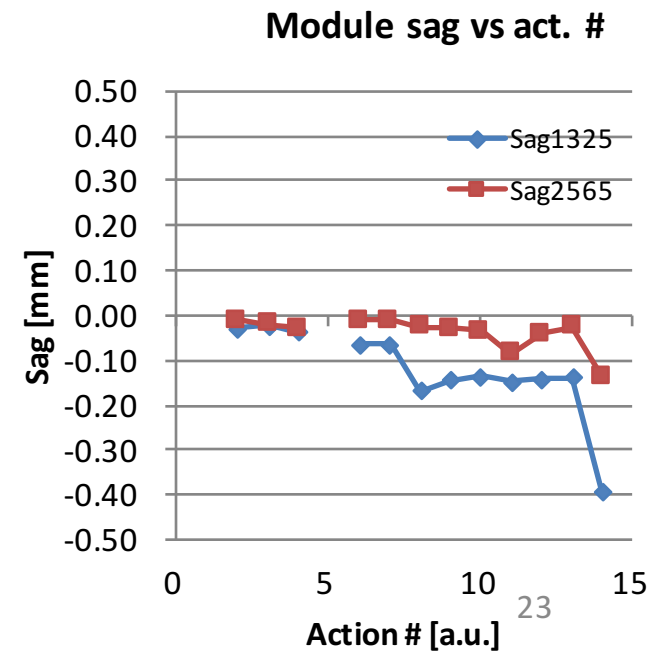
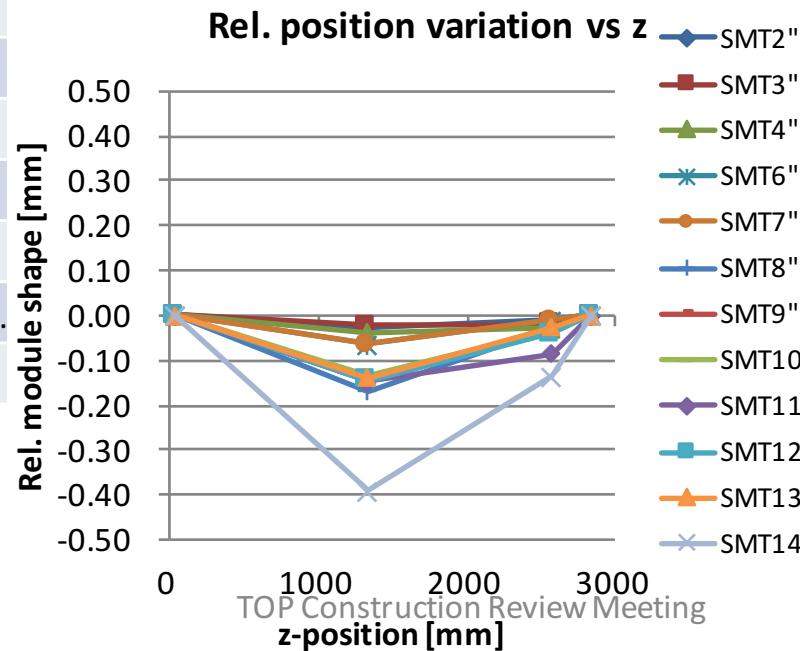
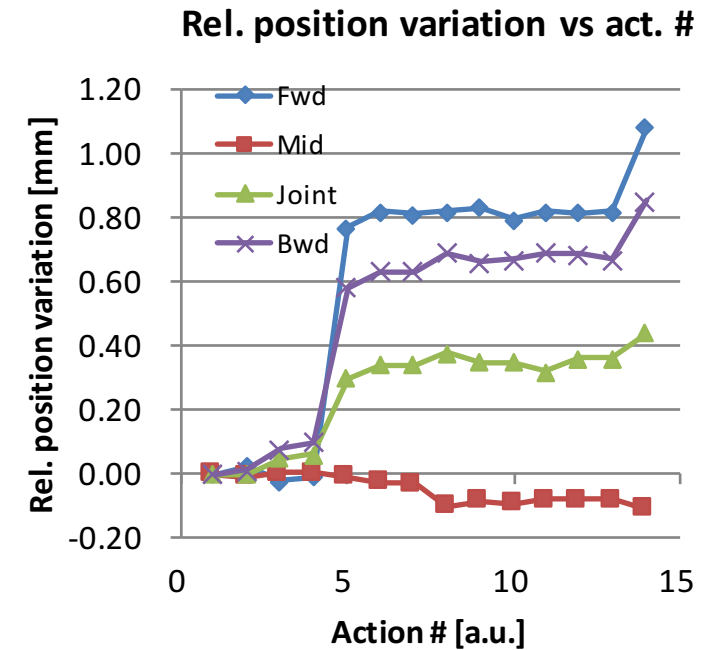
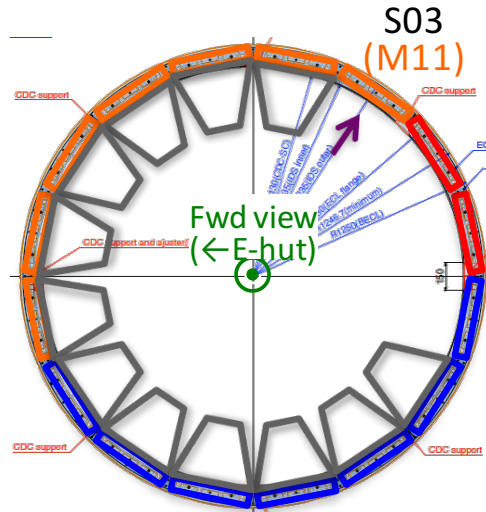
Relative sag variations



Deflection during the installation (1)

- S03 (M11) installation

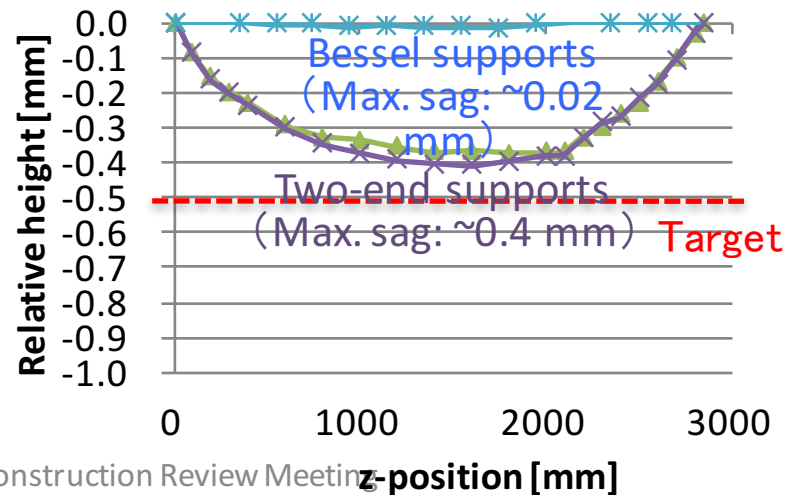
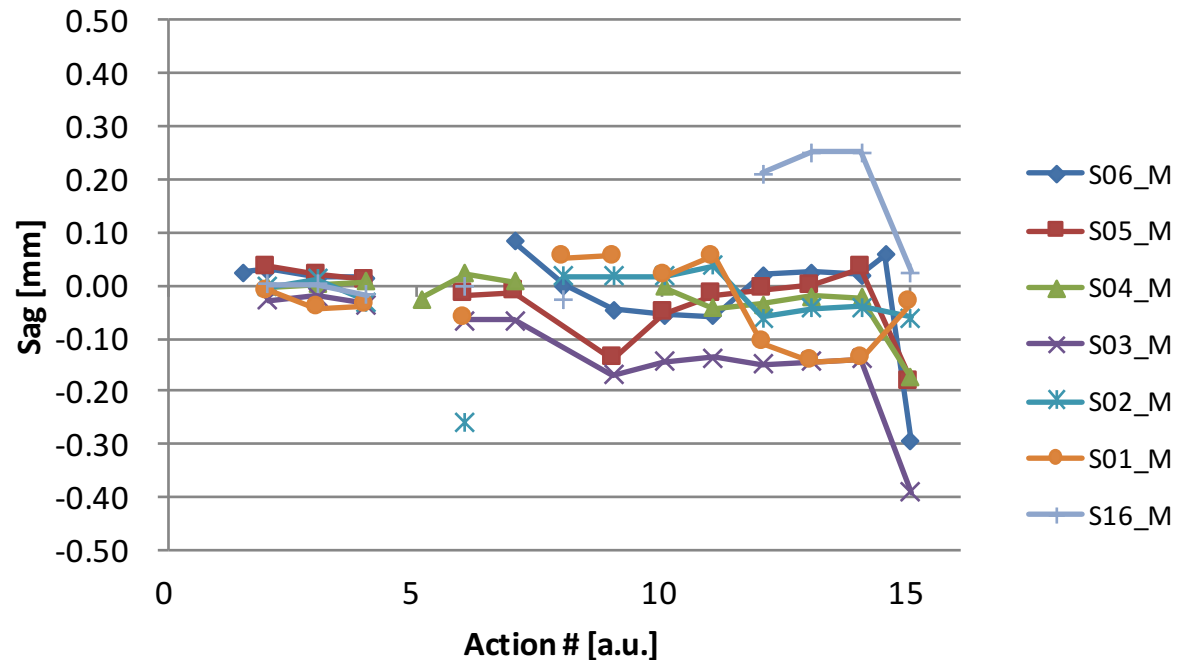
Act. #	Action
1	Before the slider approach.
2	Sliders joined.
3	Lifted up.
4	Set the weights.
5	Rotated to the top position.
6	Removed OP spacers.
7	Rotated to the S03 position.
8	Slided in the barrel.
9	Tightened the shoulder bolts.
10	Tightened the flange bolts.
11	Removed the weights.
12	Removed the slider bolts.
13	Removed the upper L-fixtures.
14	Removed the lower L-fixtures.



Deflection during the installation (2)

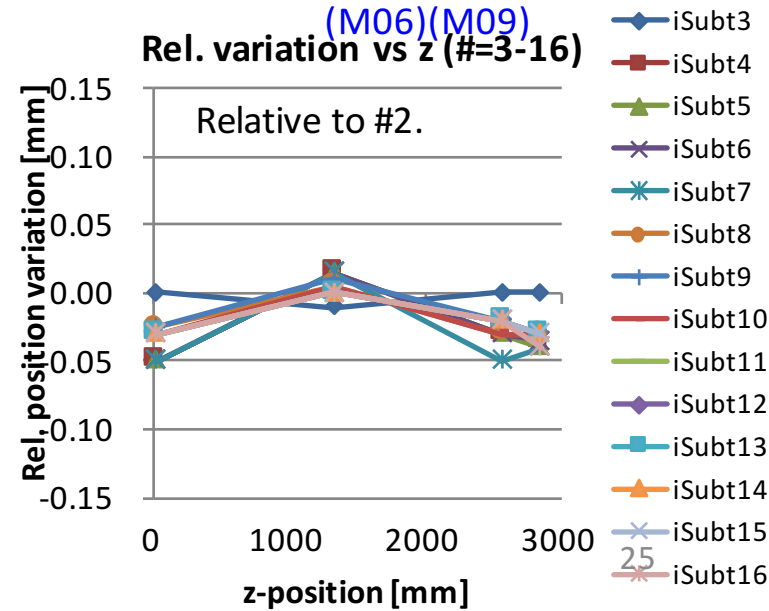
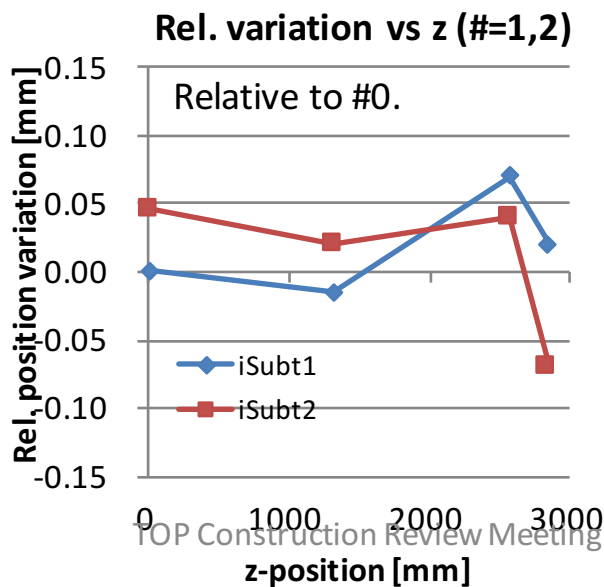
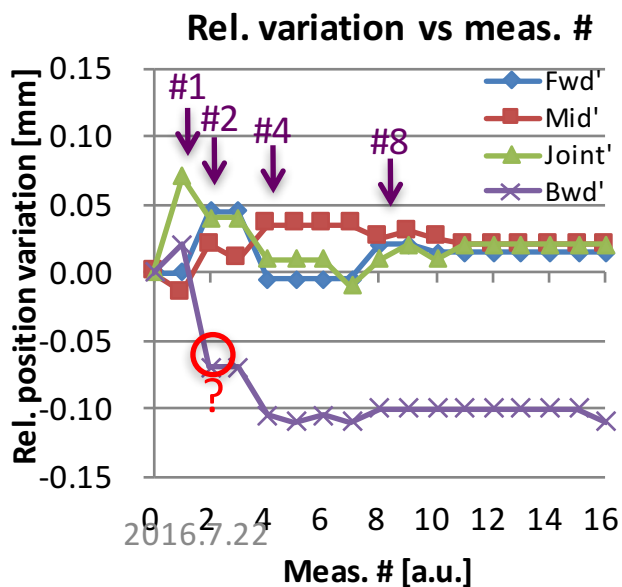
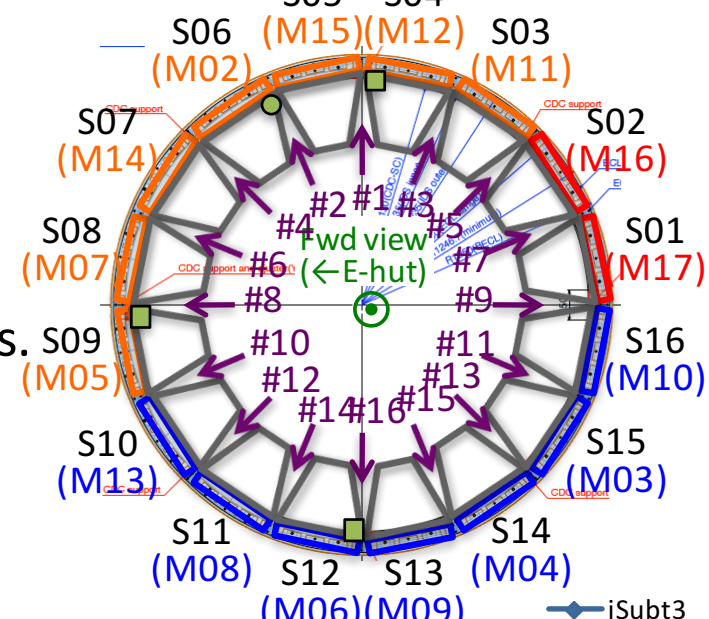
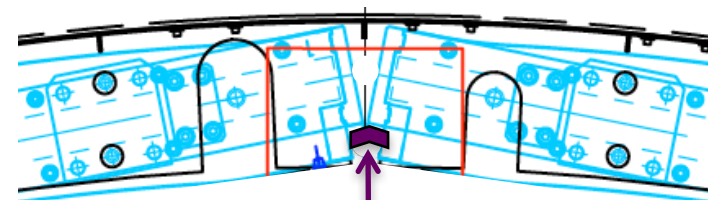
- Summary of S06-S01, S16 (preliminary)

Act. #	Action
1	Before the slider approach.
2	Sliders joined.
3	Lifted up.
4	Set the weights.
5	Rotated to the top position.
6	Removed OP spacers.
7	Rotated to the slot position.
8	Moved to a lower position.
9	Slid in the barrel.
10	Tightened the shoulder bolts.
11	Tightened the flange bolts.
12	Removed the weights.
13	Removed the slider bolts.
14	Removed the upper L-fixtures.
15	Removed the lower L-fixtures.



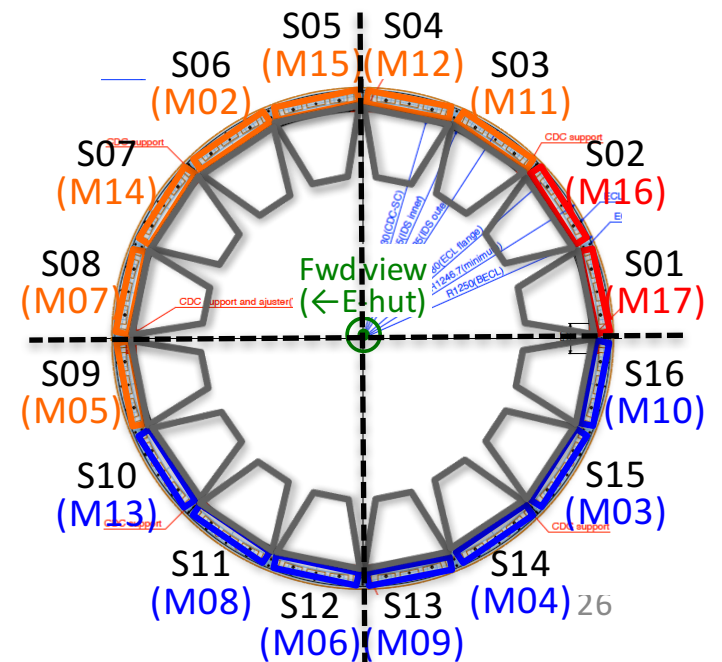
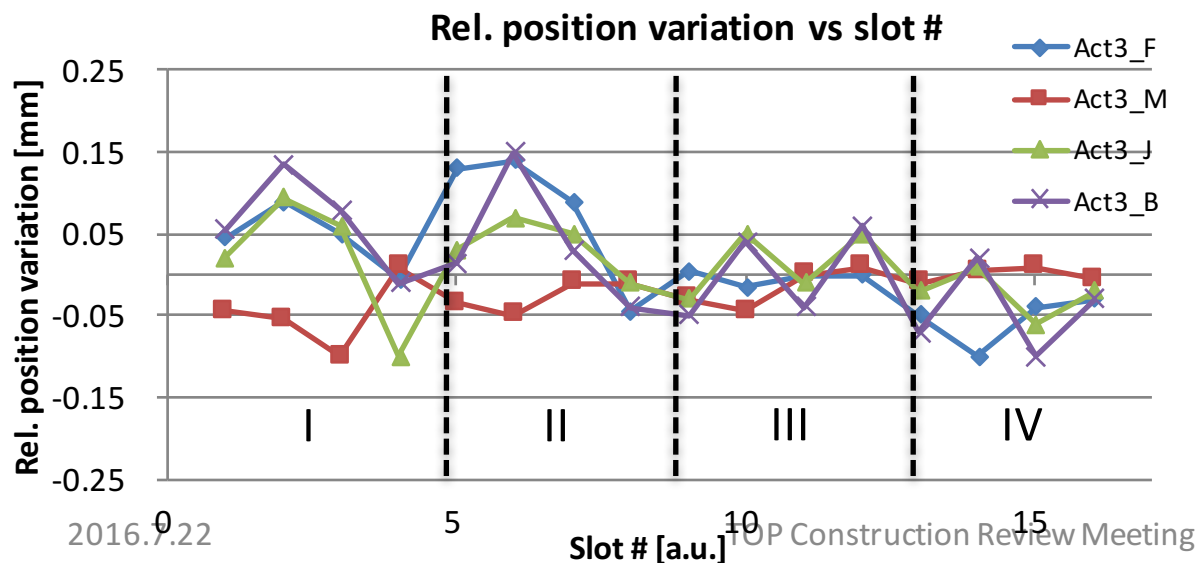
Module joining

- Module position variation in S06
 - PPG meas. at the S05 side of M02 (S06).
 - Variations can be seen in #1, #2 and #4.
 - Due to the proximity to the PPG.
 - PPG was touched accidentally in #2 and #8.
 - Due to the interference with the bolt-tightening work and the access check to the Strong Back bolts.
 - The variations were typically < 0.05 mm.
 - 0.07 mm at largest (or 0.12 mm including the questionable meas. of #2).



Strong Back removal

- Position variations in the SB removal.
 - Largest variation is +0.15 mm at the fwd and bwd ends of the upper slots.
 - They could be the overestimation in the upper slots (c.f. bench test results) since the fwd and bwd ends are fixed to the ECL flanges.
 - Mid. gauge variation is smaller and opposite (due to the PPG supports?).
 - Expected order of the variations would be $S05 \sim S06 > S07 > S08$, for instance in the quadrant-II.
 - Module rigidity was minimal at S05 and maximal at S08.
 - Seems to be consistent with the observation.



Summary

- Installation has been completed without a significant incident.
 - No significant problem has been reported so far.
 - Based on the sag meas. and post-installation data taking.
- Results of the deflection meas. will be finalized combining the other measurements.
 - To be documented in the Belle II Note.

