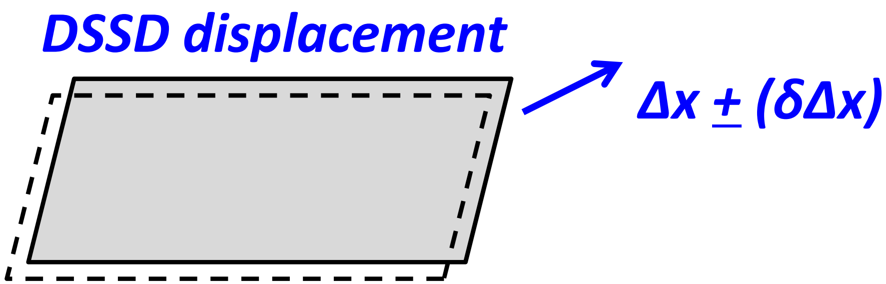
Discussion about the Target Precision of the Ladder Assembly

T. Higuchi (Kavli IPMU (WPI))

Requirement from Software Alignment

- **Precise determination of the sensor displacement converges the alignment constants with less errors.**



Δx … CMM measurement, laser scan
δΔ*x* … CMM error, laser system

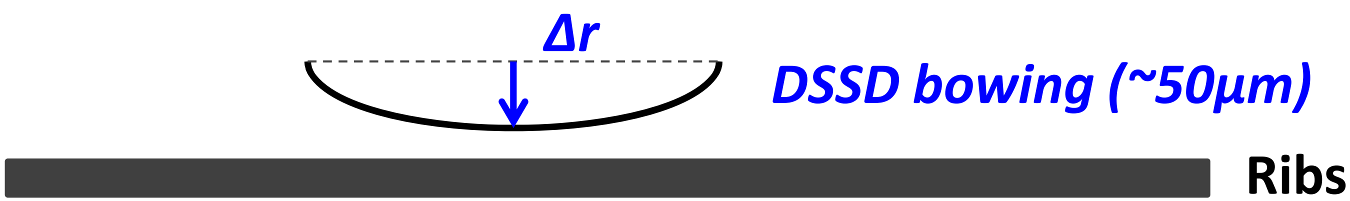
  – The δΔ*x* contributes more to the alignment constant error.

- **Action item** **(a large help from the software subgroup is needed)**
  – Work out the maximum allowed (Δ*x*,(δΔ*x*)) from the parameter convergence and impact to track positioning.

Quick communication with A.Bozek-san implies |Δ*x*|<*O*(10cm).

Requirement from Software Alignment

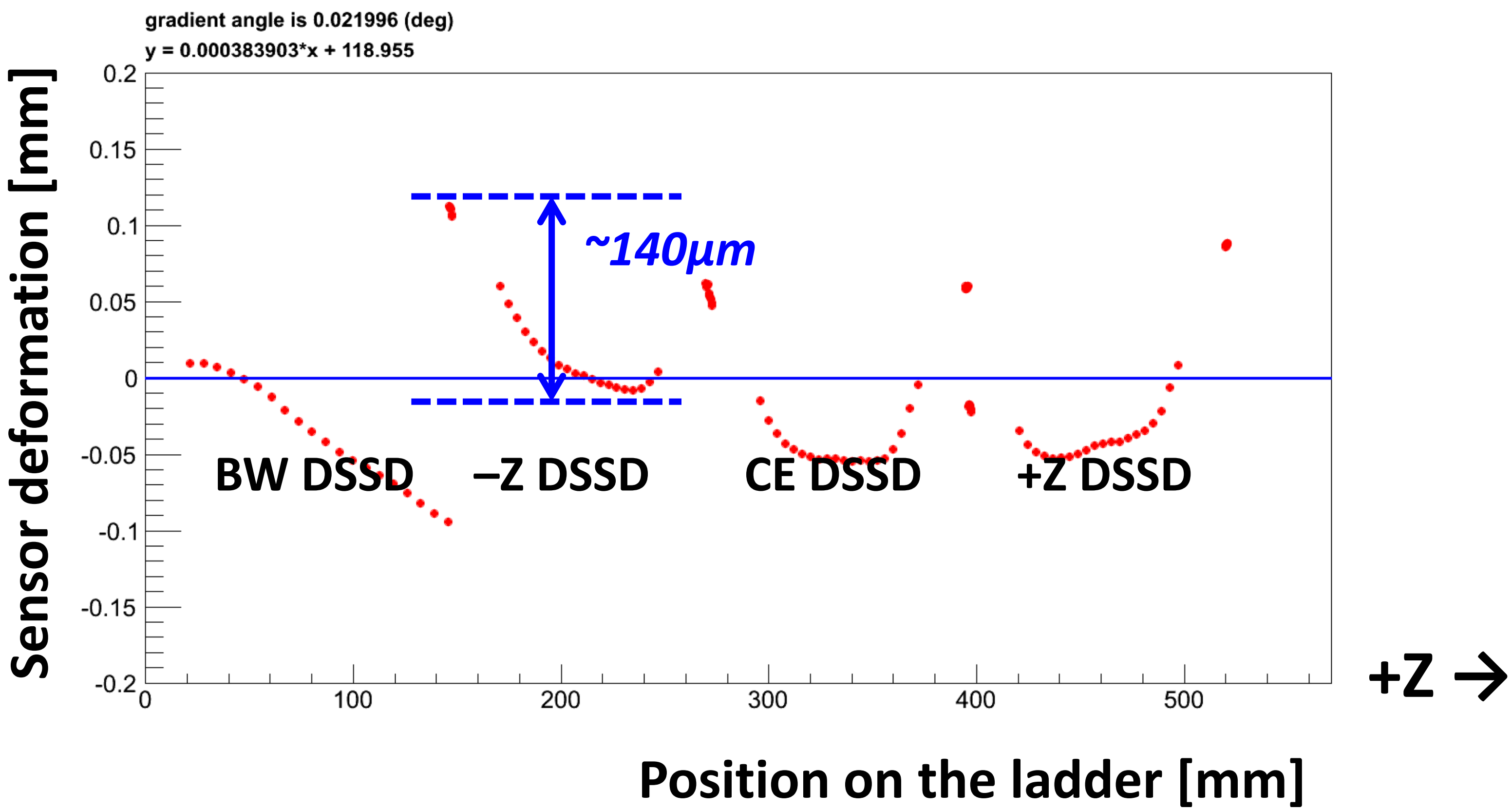
- **Sensor displacement in the *r*-direction is hard to calibrate with the cosmic ray runs,**
- **While the present software assumes the planar DSSD and no sensor bowing is taken into account.**



- **Action item**
  - List of sensor displacement/deformation modes needs informed to the software subgroup.

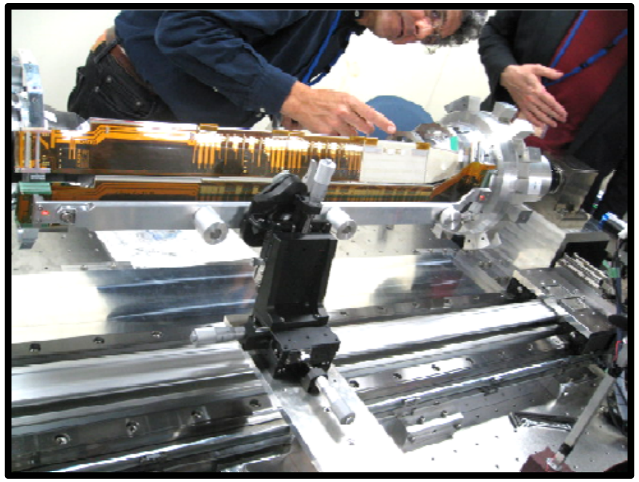
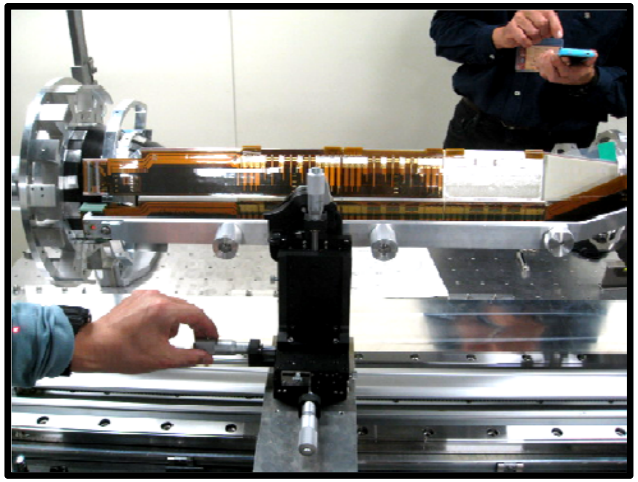
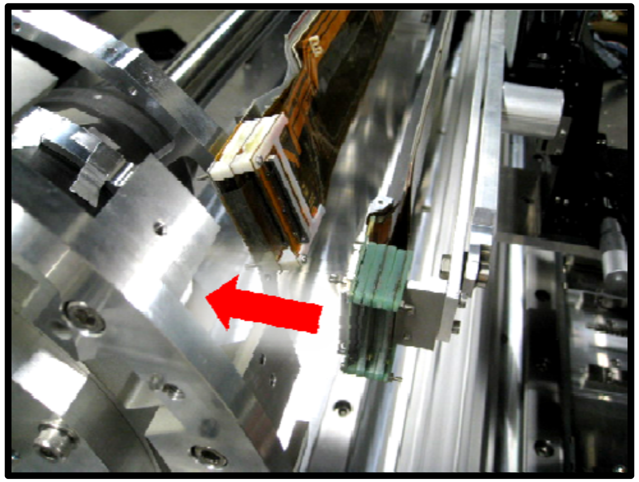
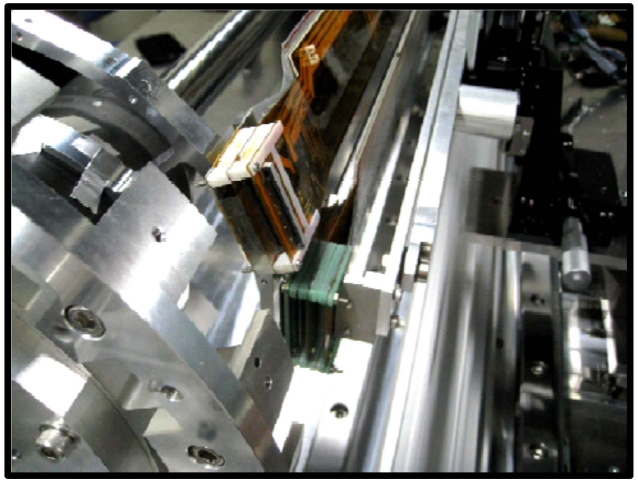
Revisit of the Sensor Bowing

- **Sensor bowing measured in the D-2 ladder of the L6**
  - Measurement was made by the CMM.



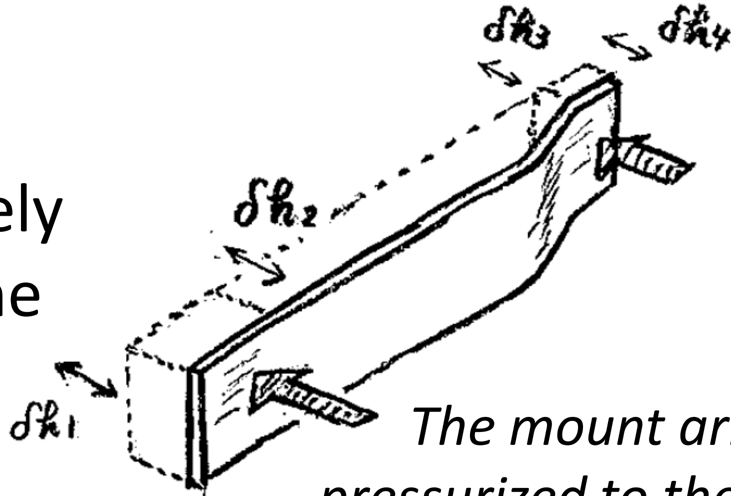
Requirement from Ladder Mount

- **Snapshots on Nov.4th,2014**

Requirement from Ladder Mount

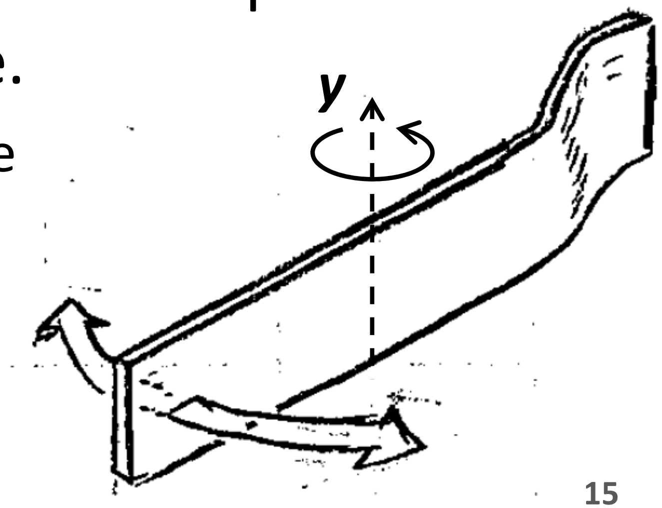
- **Key precision in the ladder**
  - The mount arm prefers precisely controlled total thickness of the stacked H/C-shapes.



The mount arm is pressurized to the ladder.

$\delta h_1 \ll 1, \delta h_2 \ll 1, \delta h_3 \ll 1, \delta h_4 \ll 1$

  - Quantitative requirement for the tolerance depends on the looseness of the Kokeshi-pin/hole.
    - Tight fitting of the Kokeshi-pin to the hole may kill the rotation shown in the right figure.



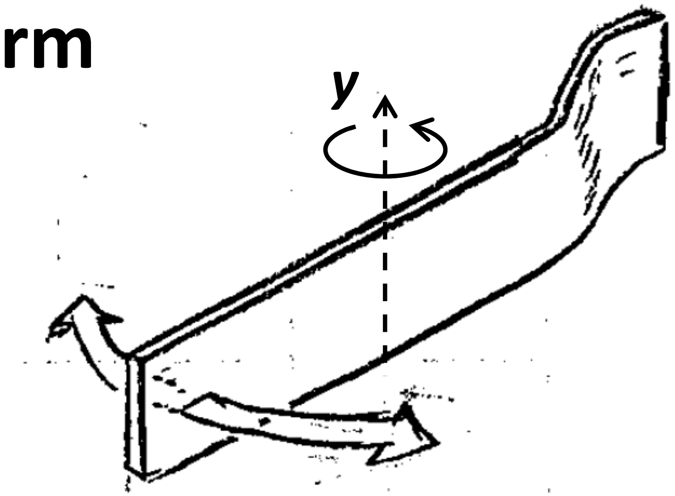
Requirement from Ladder Mount

- **Total tolerance at the critical area in the ladder**
  - (Predefined) parts tolerance
    - End-mount (aluminum) … *O*(±0.01mm).
    - H/C-shape … (–0mm, +0.1mm)
      → x6 H-shapes at the BW end → **(–0mm, +0.6mm)**.
    - Glue thickness … **?**
  - The total tolerance above ***may*** tell the precision at that part cannot be controlled well.

Other items (sensor-sensor gap, ORIGAMI tolerance, rib deformation, …) makes negligibly small contribution to the precision of this area.

Requirement from Ladder Mount

- **Tuning mechanism in the mount arm**
  - The mount arm should be equipped with the tuning mechanism around the rotational axis *y* to absorb the rather large tolerance.
    - Implementation by tuning screws.
  - Once the mechanism is implemented, tolerance up to **1mm** ***may be*** OK according to KEK engineer (N.Sato-san).
    - N.Sato-san absolutely said that before the conclusion, the jig design should be practically checked with a number of ladders.



Discussion about Stress Tests

T. Higuchi (Kavli IPMU (WPI))

Vibration Test

Ladder Vibrational Test

- Support Interface to be designed and fabricated for ladder
- FEA needed to verify the natural frequencies of the support

Vibrational Test:

Sine test cycle up to 2000 Hz on three axes

For each axis sine sweep 20/2000 Hz at 2oct/min to measure the modals / resonance frequency of the ladder;

Random test according to a random vibration environment of shipping to be defined (car and flight transportation)

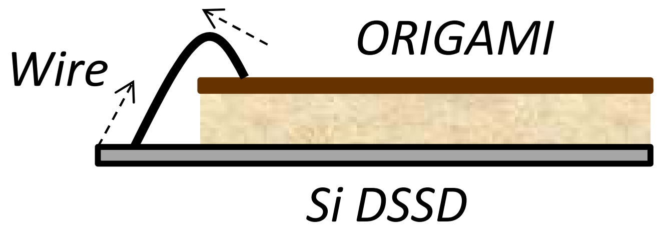
Shock test : also to be defined

Open issue: vibration frequency

Thermal Cycling Test

Possible wire break due to the different CETs

- **Permanent damage**
  - Ladder deformation and wire break.
  - Does APV fail?
  - Thermal program suggested by F.Bosi-san



Perform 100 cycles between -30 to 60 ° C

•Heating and cooling speed about 2 deg/min (total time for one cicle about 90 min)

Thermal Cycling Test

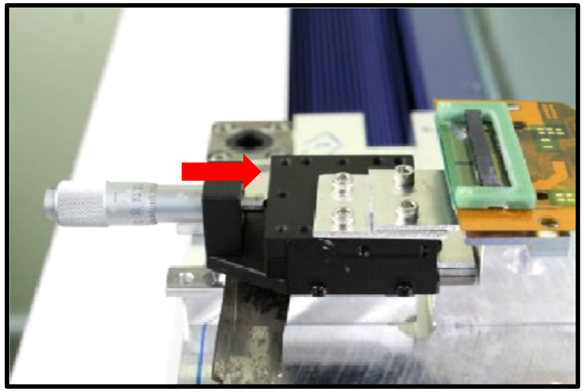
- **Accelerated aging test and thermal fatigue test**
  - Open issues:
    - **Do we need them?**
    - Which item to be concerned?
      - Glue lifetime at the PA wrapping … aging.
      - Rib … thermal fatigue.
    - Thermal programs

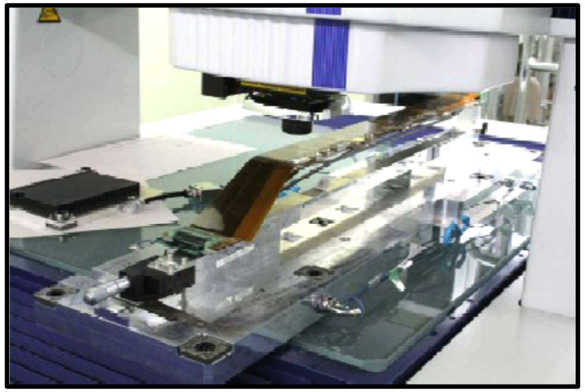
Equations have some empirical parameters.

Accelerated aging test: Arrhenius model	$\tau_2 \equiv \tau_1 / C \quad \ldots \quad C \equiv \text{acceleration factor}$ $\ln \tau_1/\tau_2 = \ln C = \frac{E_a}{k_B}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$	**τ … item lifetime** **E_a … activation energy** **k_B … Boltzmann constant** **T … absolute temperature**
Thermal fatigue test: Eyring model	$\tau_2 \equiv \tau_1 / C \quad \ldots \quad C \equiv \text{acceleration factor}$ $\ln \tau_1/\tau_2 = \ln C = -\alpha\left(\Delta T_1 - \Delta T_2\right)$	**ΔT … $T_{HI} - T_{LO}$ in the cycle** ***α … empirical parameter*** ***(hard to estimate…)***

Stress from the End-Rings

- **End-mount displacement → sensor displacement**
  - Shrink and stretch of end-ring distance.
    - An L6 student is seeing the correlation between the end-mount distance shrink and the sensor displacement; the original intention was to see the thermal stretch/shrink effect.
    - Quick analysis shows linear correlation; detailed result will be published in his thesis.
  - Twist around the beam axis.
- **Open issue:**
  - What is the end-ring tolerance?





Stress from the Cooling Pipe

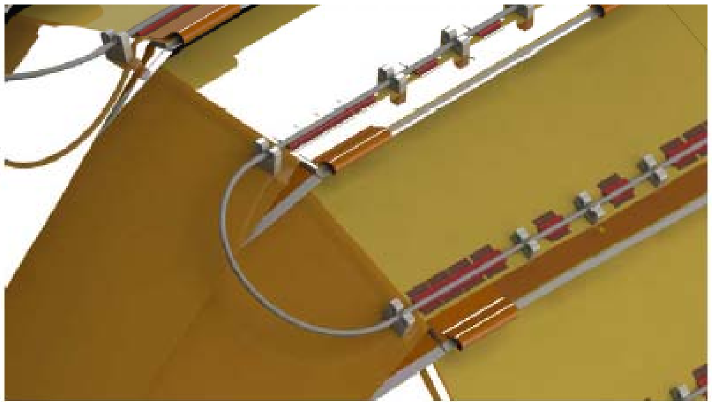
Deformation test

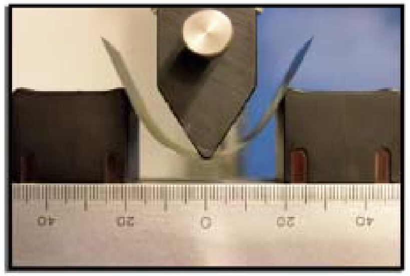
In order to simulate the insertion of the cooling pipes on the clamps :

Apply a known force on the ladder and measure relative deformation using the material testing machine

What is the maximum force we can apply?

Mechanichal test machine sensitivity order of fraction of gramms.





Open issue:
Force from the pipe

Gravity Sag

- **Open issues:**
  - Rotation angle variations: $(0^{o}, 45^{o}, 90^{o}, 135^{o}, 180^{o})$.
  - Holding jig that fits to the CMM scope.
    - N.Sato-san and an L6 student is considering.
  - Deformation measurement at $\theta = 90^{o}$.
    - Difficult to see with the optical CMM.

Point to Measure the Deformation

- **Origin of the coordinate**
  - The plane parallel to the BW DSSD: center of the BW Kokeshi-pin hole.
  - The axis normal to the BW DSSD: flat surface in the BW end-ring on which the BW end-mount is placed.

- **Open issue**
  - **Points to measure the deformation**