

Ladder Bending Tests

BPAC Concerns & Recommendations

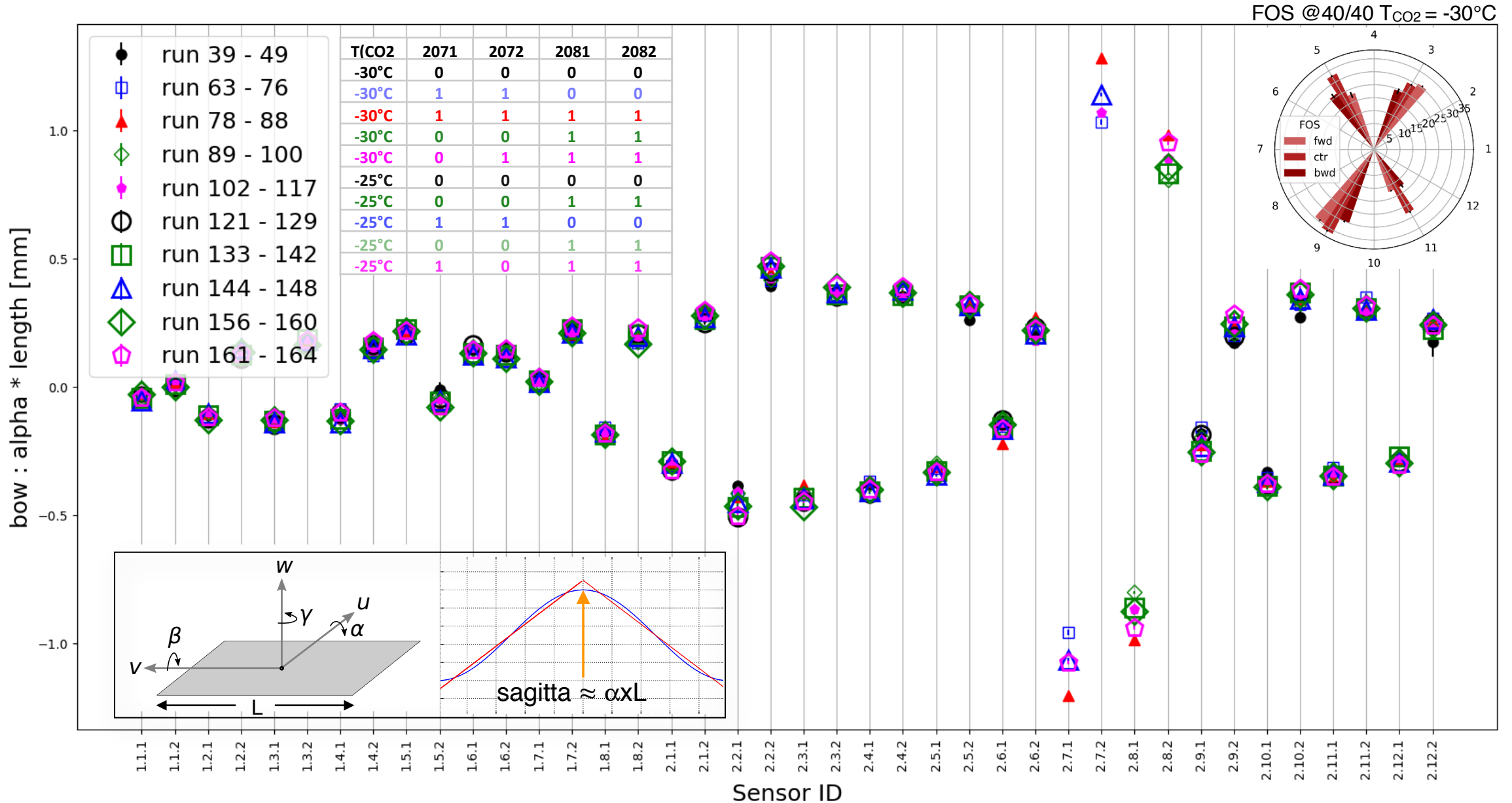
- Concerns

- The bowing of ladders and the open issue of how to power the ladders remain a concern. At our last review it was suggested that a small working group of experts of the affected systems be appointed to evaluate the full impact of this change. At this brief review no update was provided.
- The grounding of the PXD2 to the beam pipe seems to have no adverse effect, but further studies seem warranted.
- Preservation of the knowledge, which lead to the successful installation of the detector needs to be guaranteed.

- Recommendations

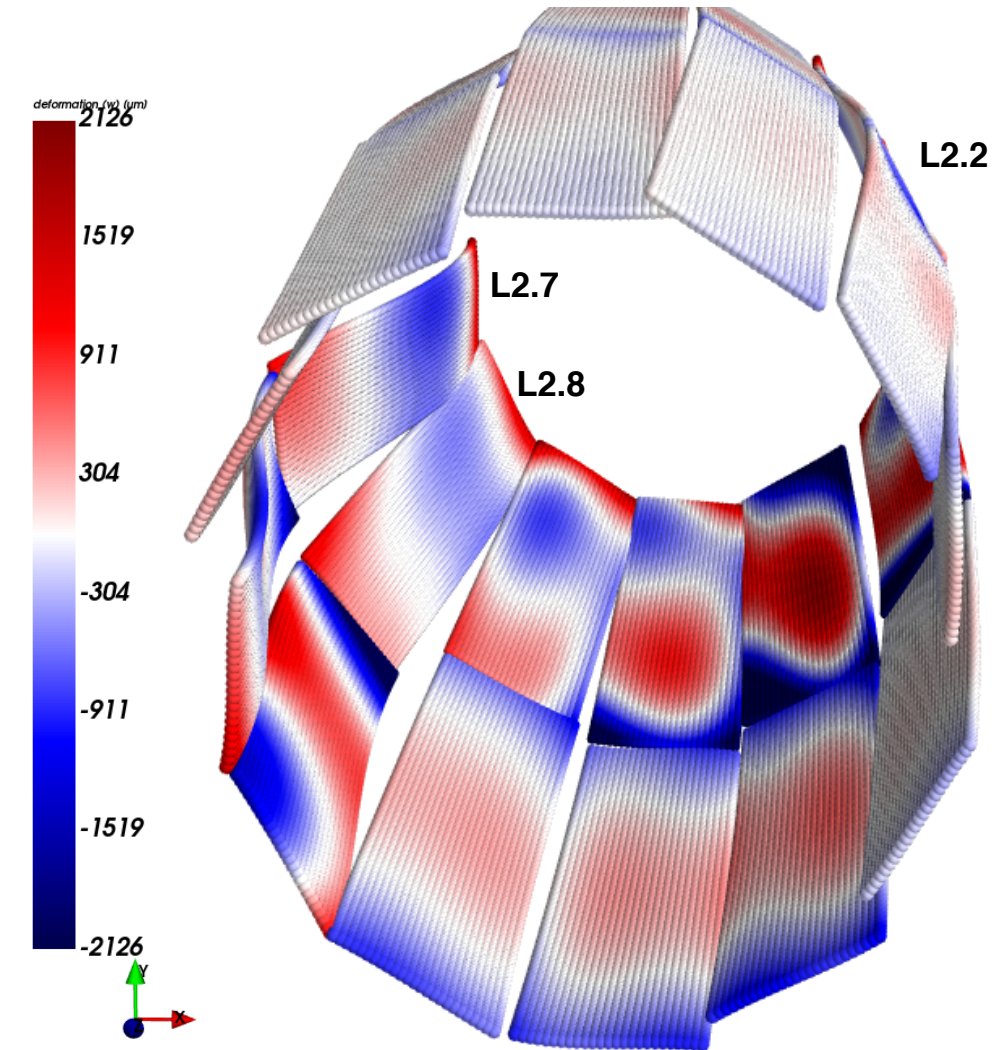
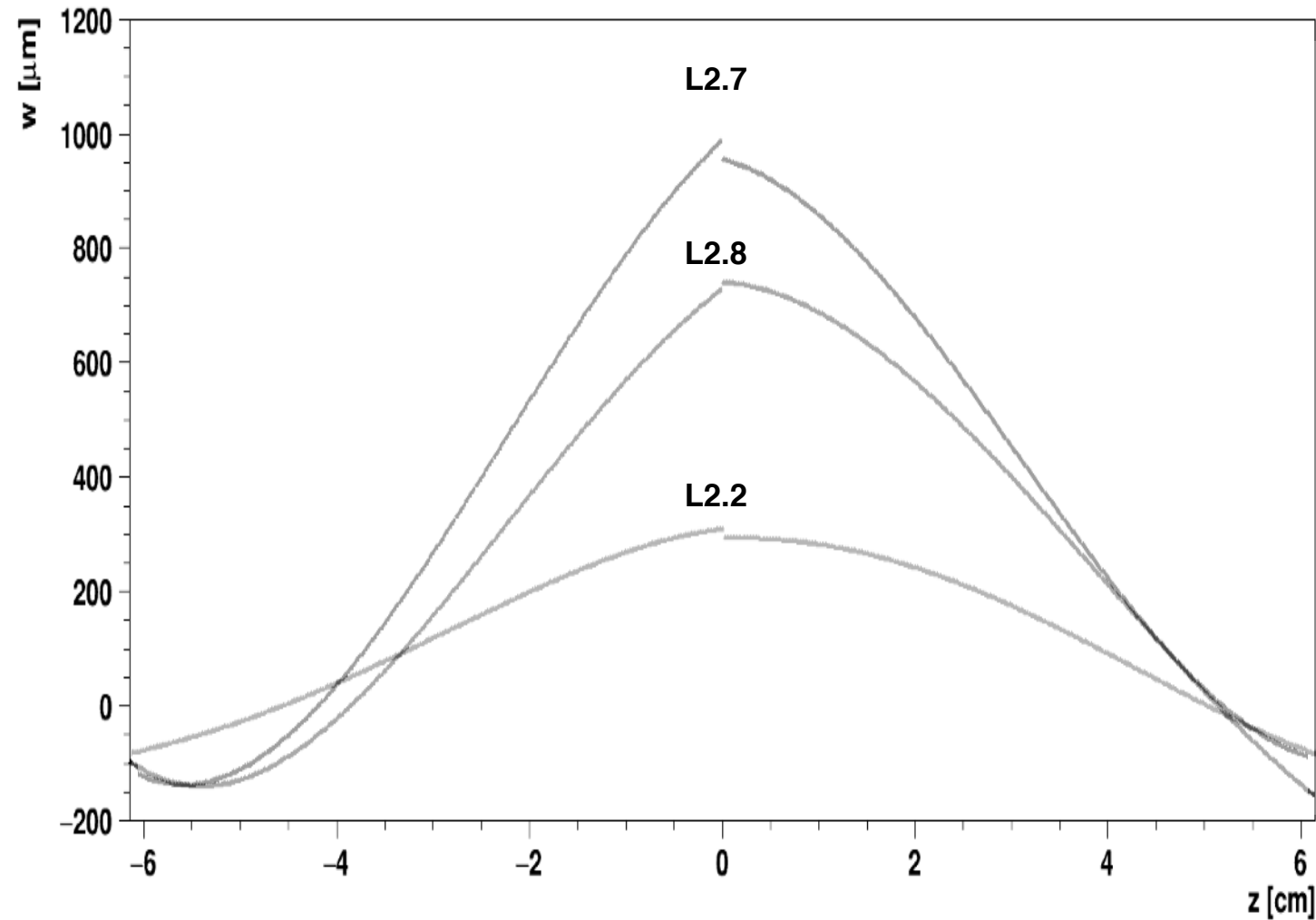
- Continue to study the ladder bowing as best as possible, understand its behaviour and develop mitigation strategies.
- Decide, after careful study, a safe operating temperature of the detector.
- Document in full detail the as-built PXD2 detector (repeat of the July recommendation)

Reminder: Cosmics 2023 Alignment Results

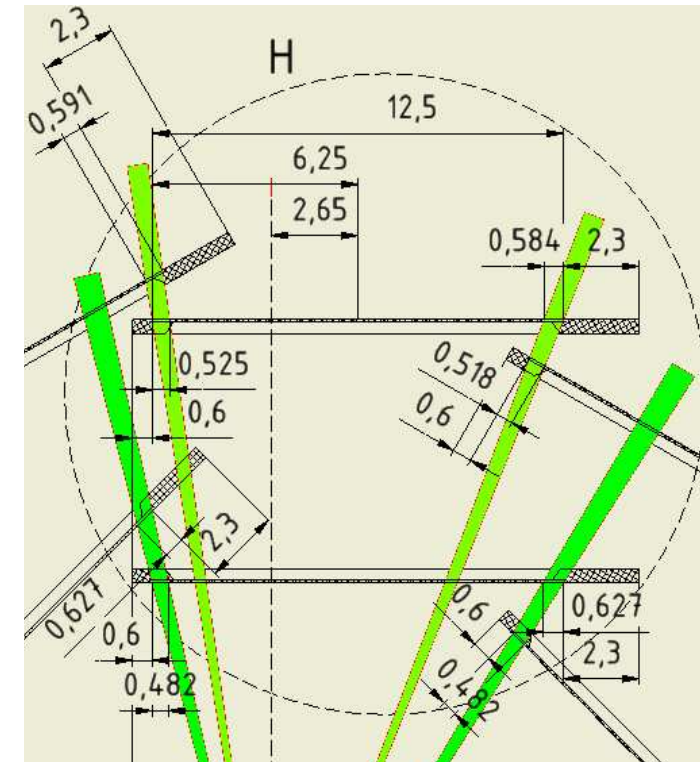
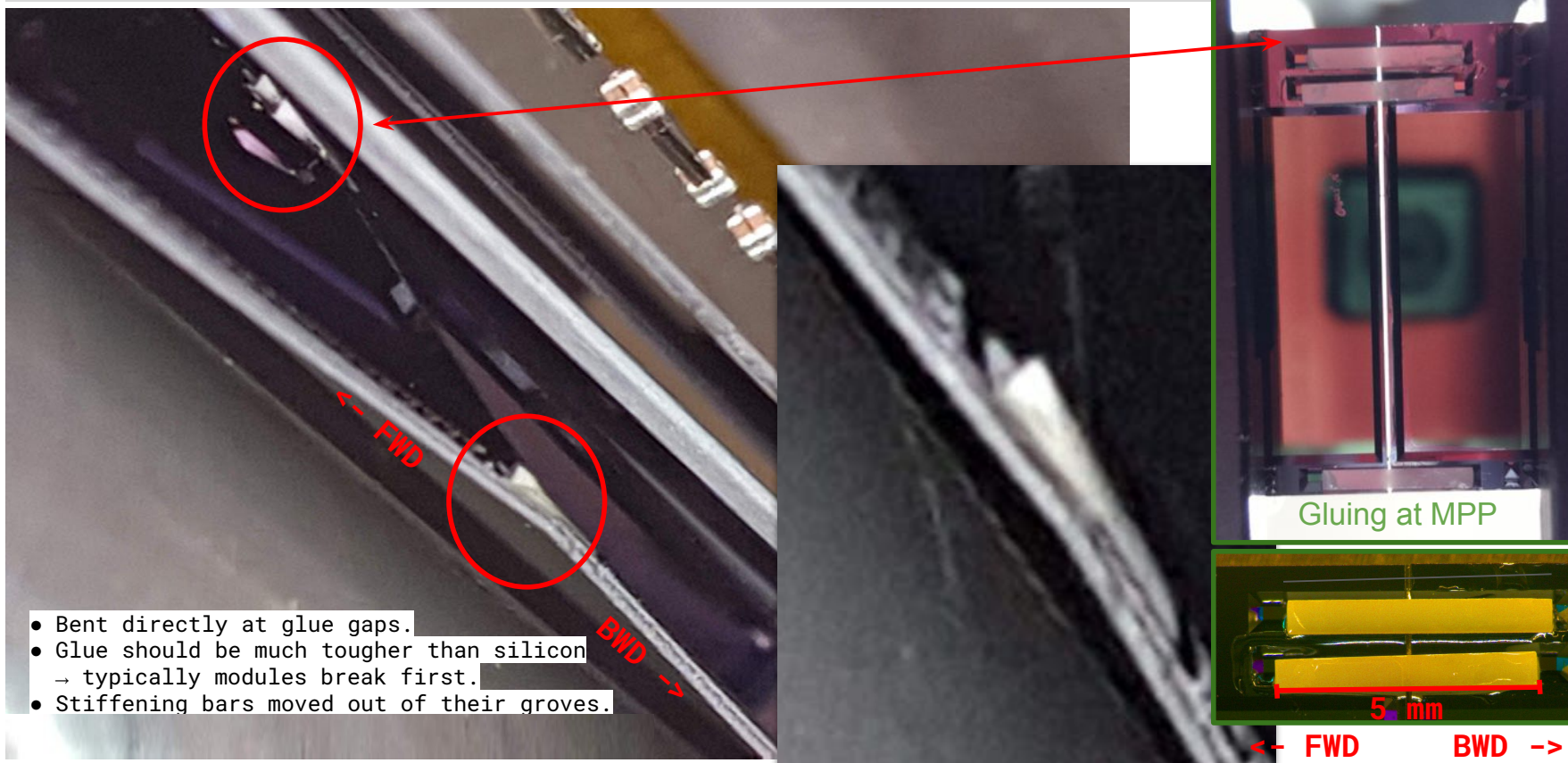


Visualisation of Sensor Deformations

Here: All misalignment parameters in payloads multiplied by 10. Sensor 3D surface plotted point by point (+ color for w-coordinate)



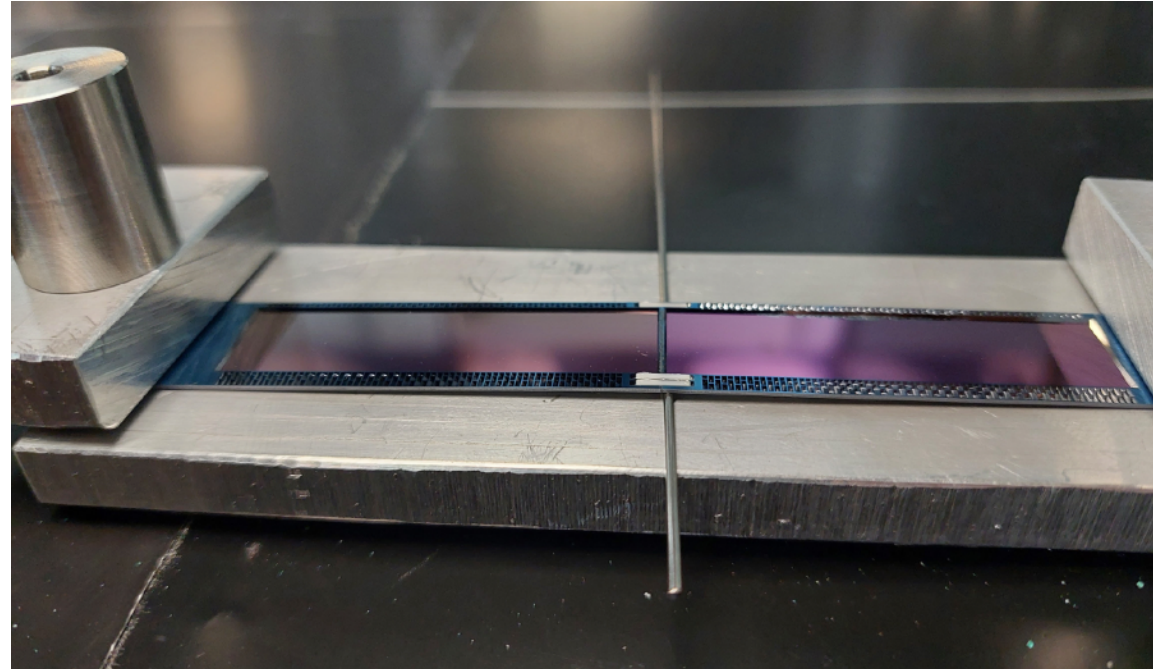
Reminder: Broken L1 Ladders in DESY Setup



- Fortunately, ladders 2.7 and 2.8 bend in the opposite direction to the sensor surface
- Even if glue joint opens, ceramic stiffeners do not push into neighbouring sensor

Stress Tests of Glue Joint at MPP in September 2022

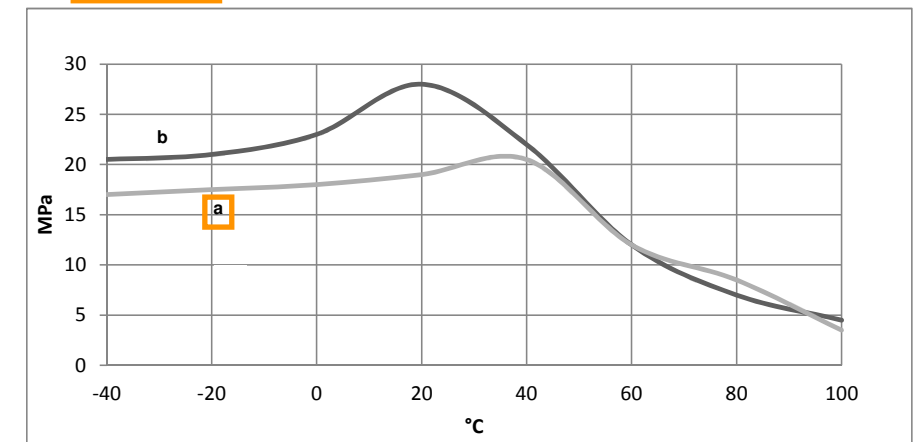
Ladder	Layer	Joint type	Thickness	Sagitta	Time	Temp	Result
LK38	L2	face-up	525	1,4 mm	48h	25°C	ok
					72h	25°C	bent
LK60	L1	face-up	450	1,0 mm	24h	25°C	ok
					3h	40°C	ok
					3h	60°C	bent
dummy #6	L2	face-up	525	2,0 mm	48h	25°C	ok
dummy #4	L2	face-down	525	2,0 mm	48h	25°C	ok
					3h	60°C	ok
					3h	85°C	bent



- Statistics very small, but
 - face-up adhesive joint possibly a bit weaker than face-down joint
 - ▶ may be due to the difference in the way how glue is dispensed
- Avoid temperatures above 40°C for longer periods of time
 - lap shear strength reduced by 50% at 60°C
- Conclusion
 - adhesive joint not as rigid as previously assumed
 - no reason to believe that affected adhesive joints were particularly problematic

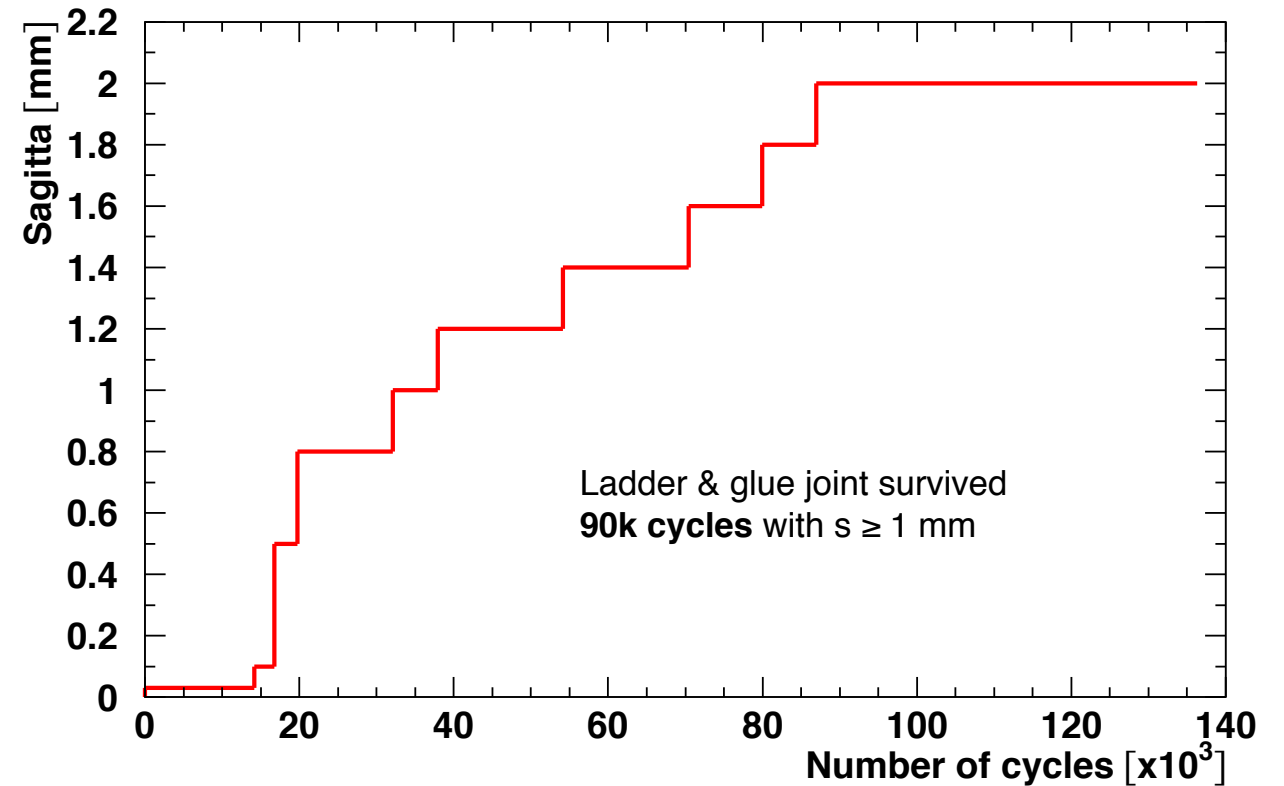
Lap shear strength versus temperature (ISO 4587) (typical average values)
Cure: (a) = 7 days /23°C (b) = 24 hours/23°C + 30 minutes/80°C

Araldite 2011



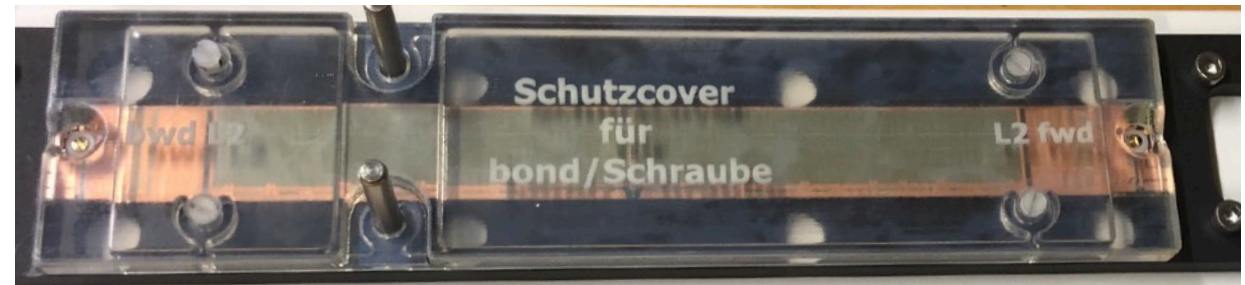
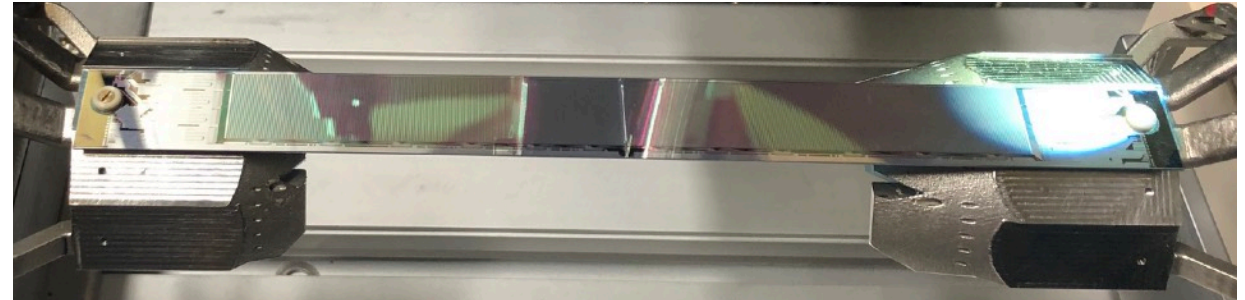
Mchanical Stress Tests of L2 Dummy Ladders at DESY

L2 glue joint endurance test with thick ladder



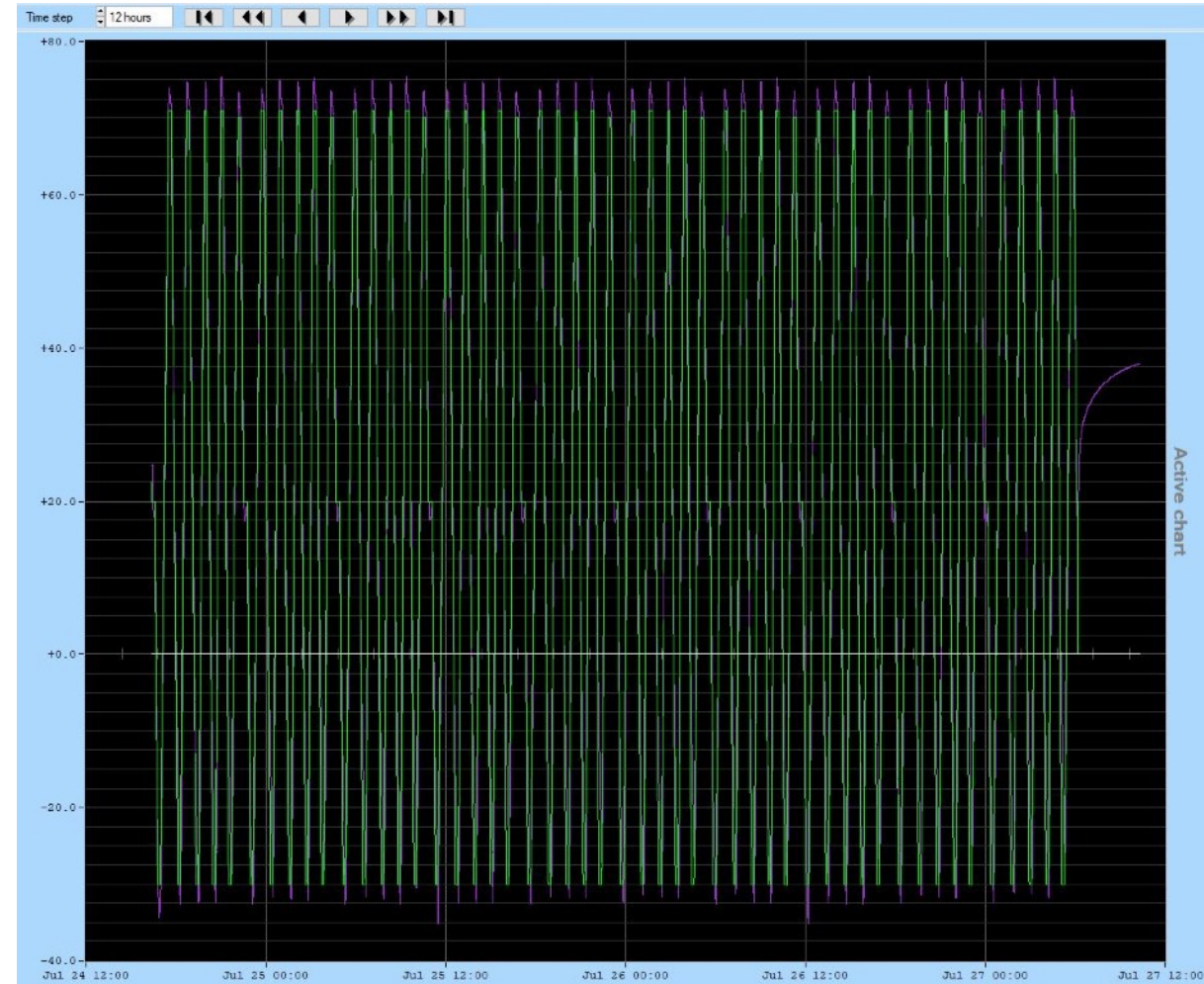
Mchanical Stress Tests of L2 Dummy Ladders at DESY

- Last year two new L2 ladders (LK79 & LK80) assembled using **thin** (450 μm) modules, originally meant for Kapton attachment tests
 - no ASICs
- LK79
 - **20k** cycles with $s \sim 1\text{-}2\text{ mm}$ ✓
 - **50** thermal cycles in 2.5 days temperature range -30°C to $+70^{\circ}\text{C}$
 - **4k** cycles with $s \sim 1\text{-}2\text{ mm}$ ✓
- LK80
 - **10k** cycles with $s \sim 1\text{-}2\text{ mm}$ ✓
- Next step
 - try to attach heating foil with NTC to glue joint and repeat bending tests at elevated temperatures



Mchanical Stress Tests of L2 Dummy Ladders at DESY

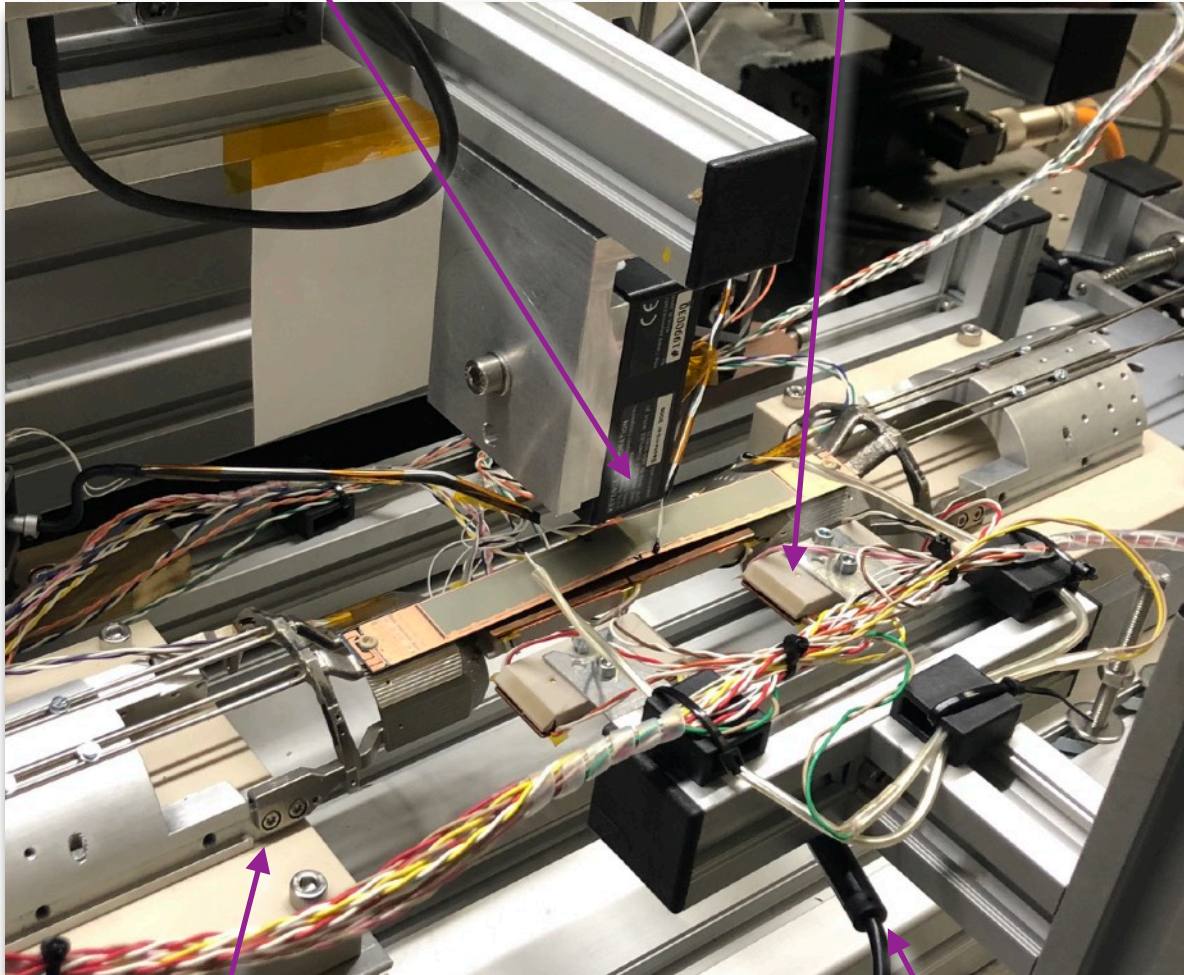
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Modified Stress Test Setup

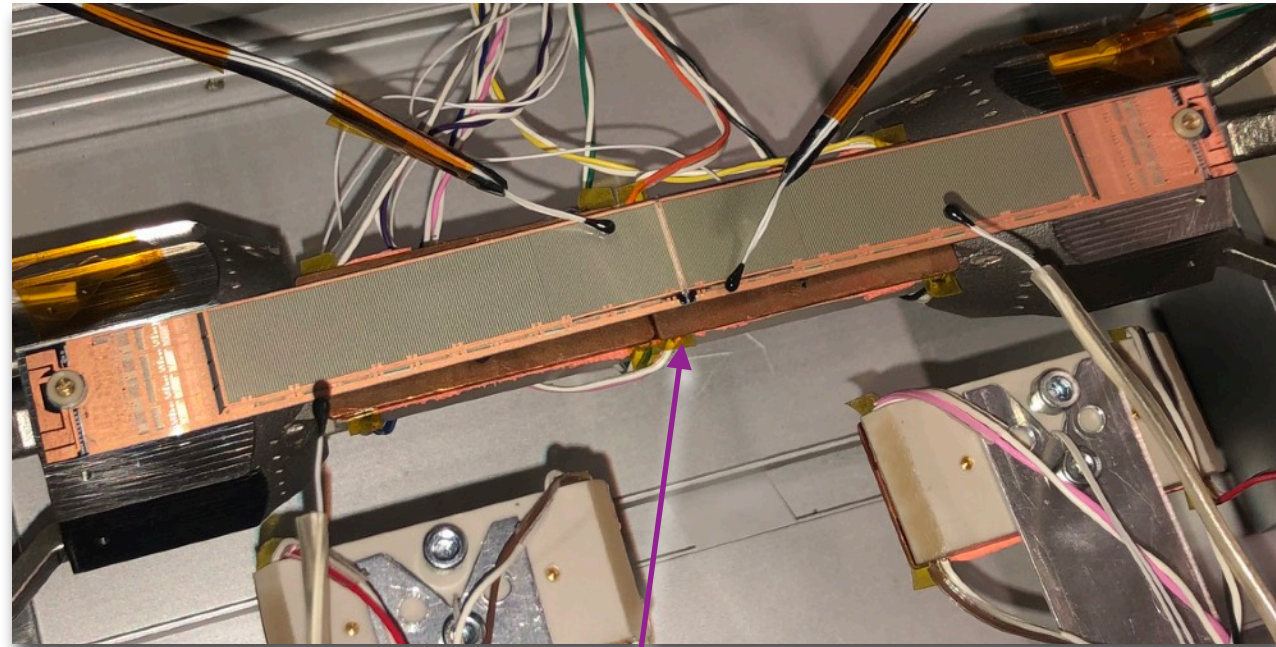
Laser

Top heater (not used)

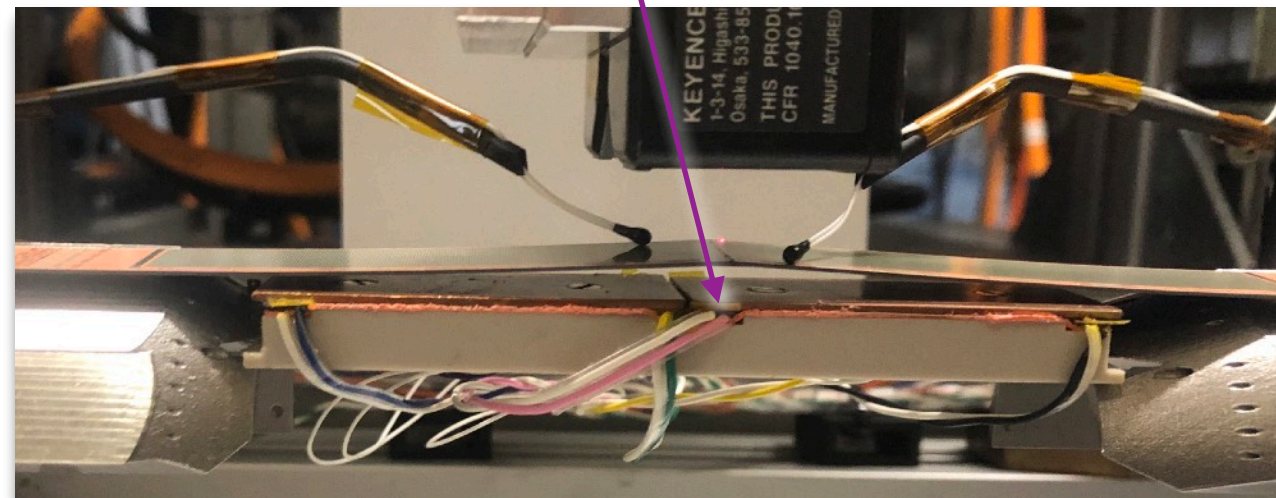


SCB support with 3D force sensor

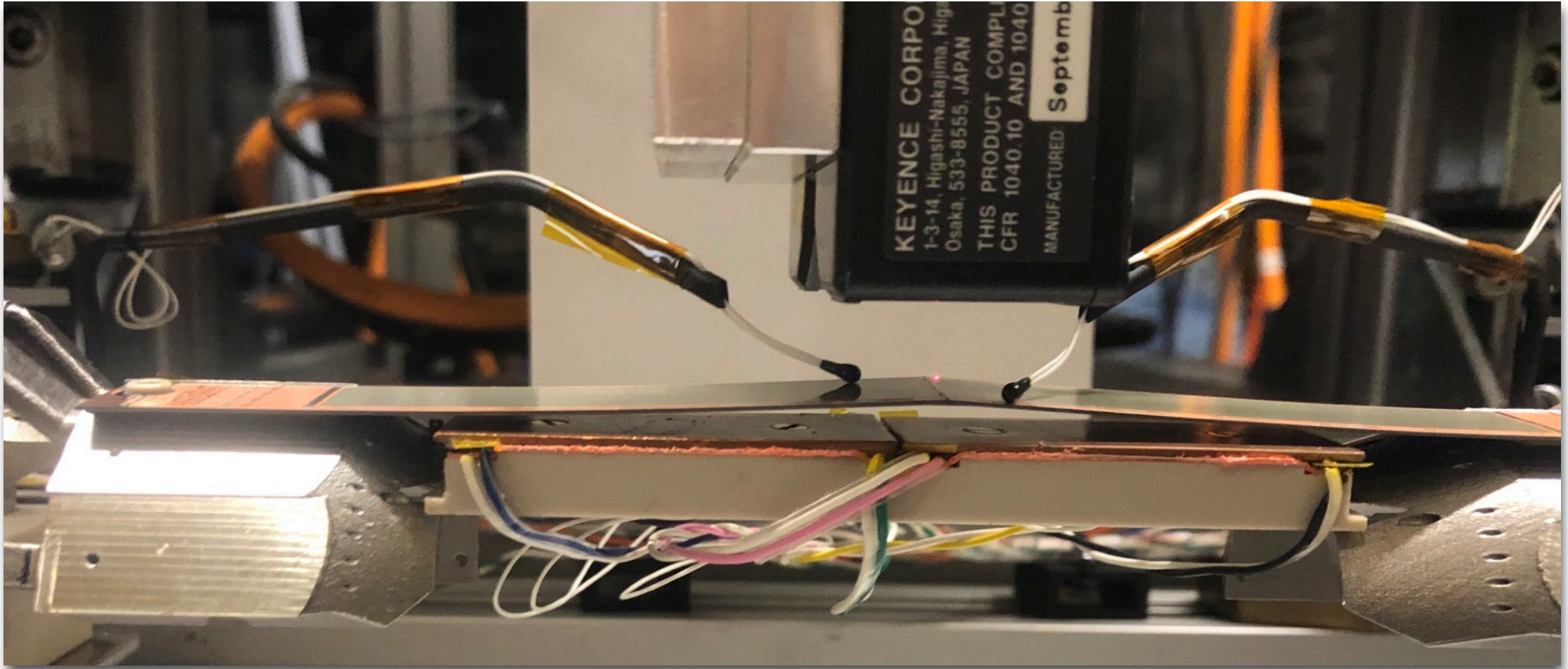
Camera



Bottom heater with Cu plate and NTC

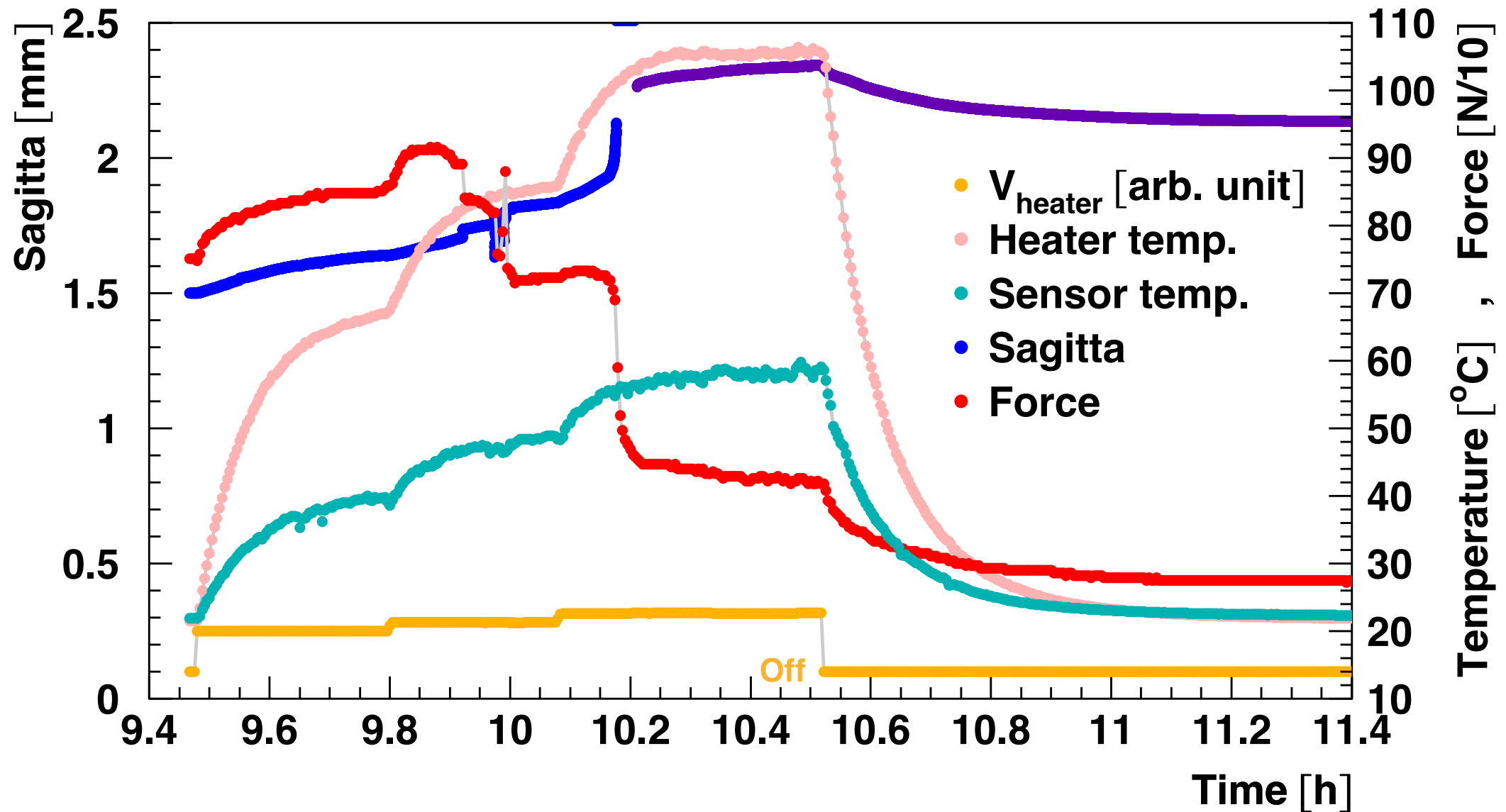


Modified Stress Test Setup

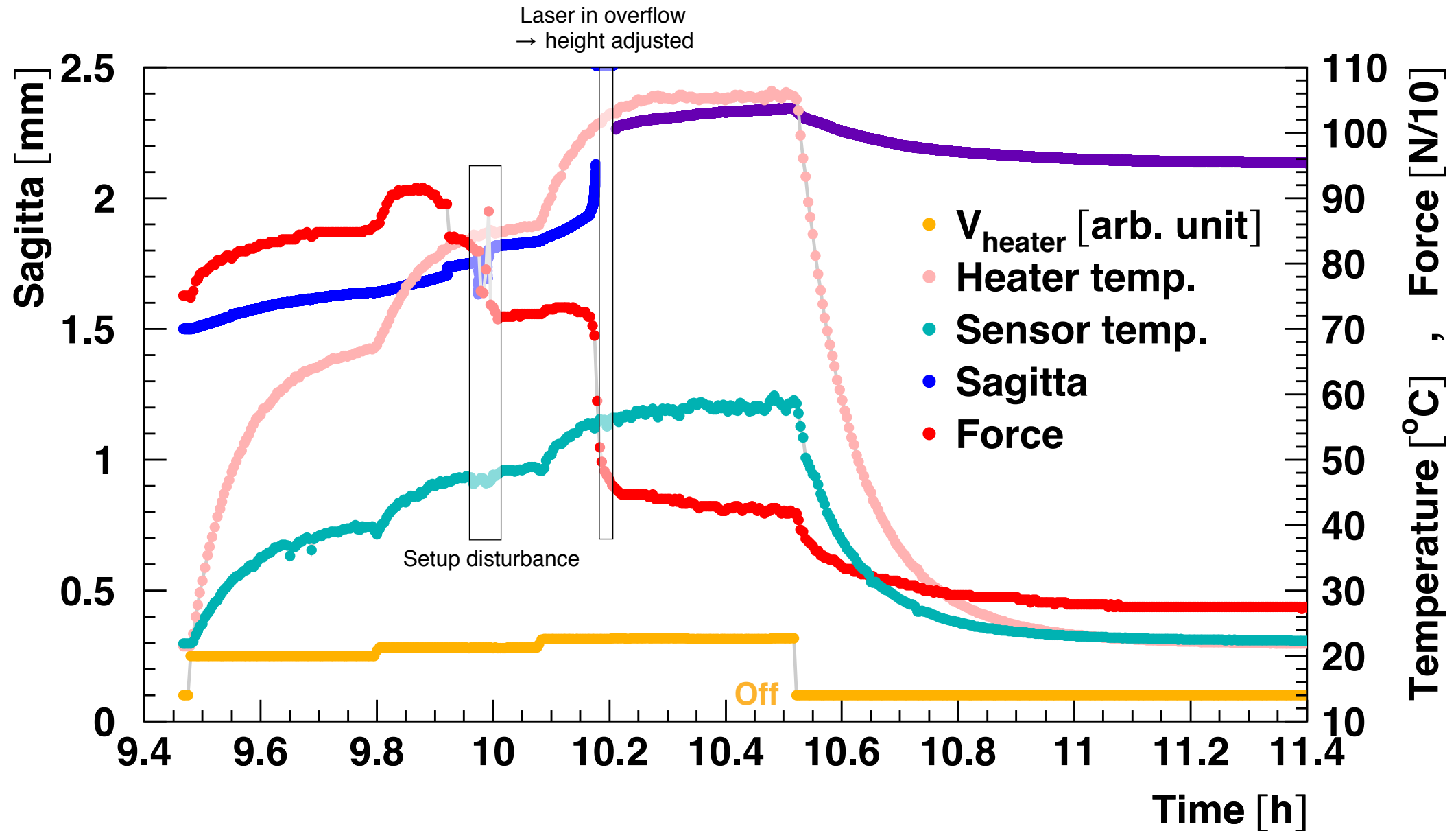


- L2 Ladder fixed at both ends and pre-bent
- Ladder heated in stages from below by radiant heater
- Simultaneous measurement of sensor temperature, bending and force

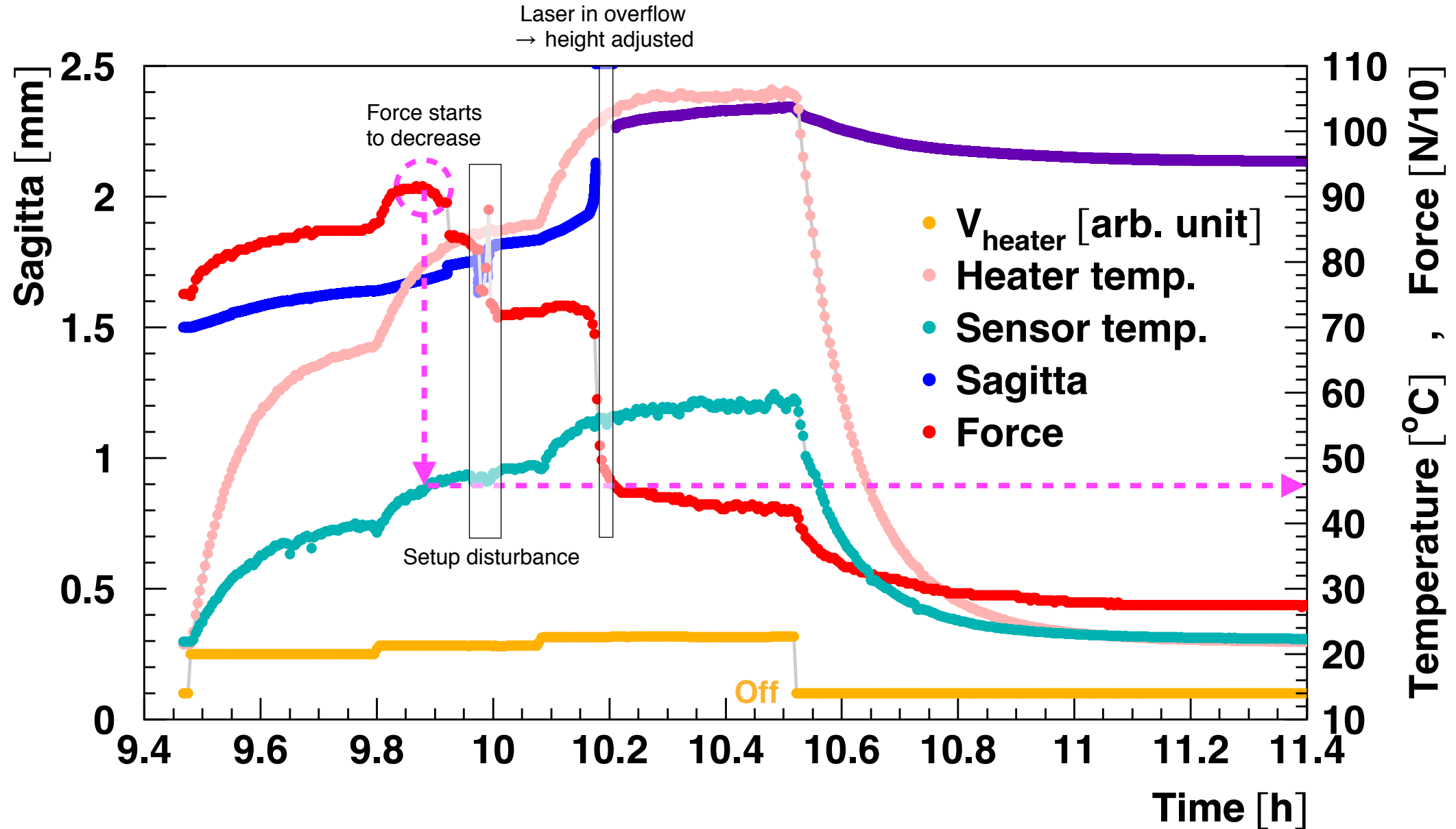
LK79 Heating Test: Pre-bent with 1.5 mm Sagitta



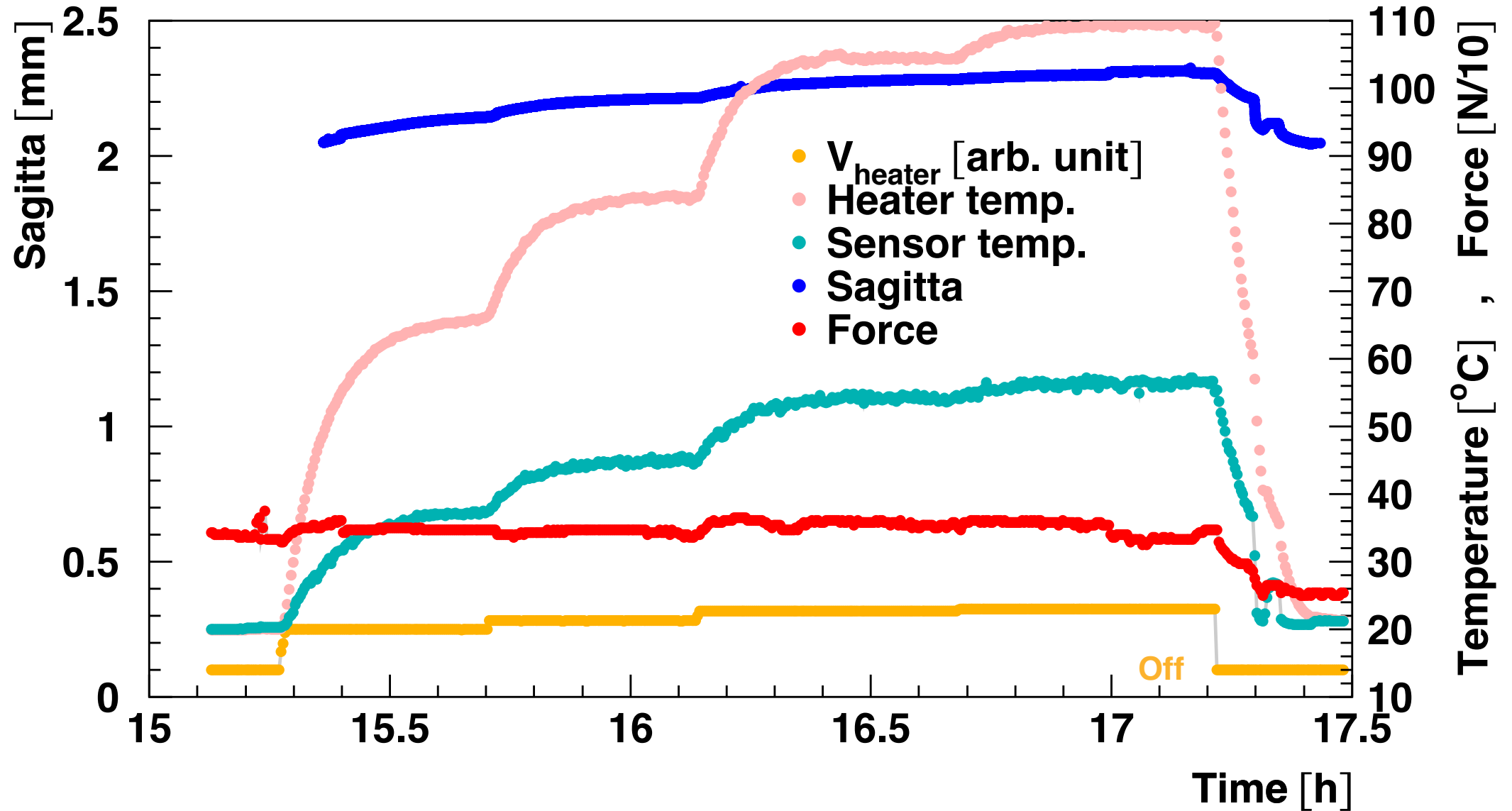
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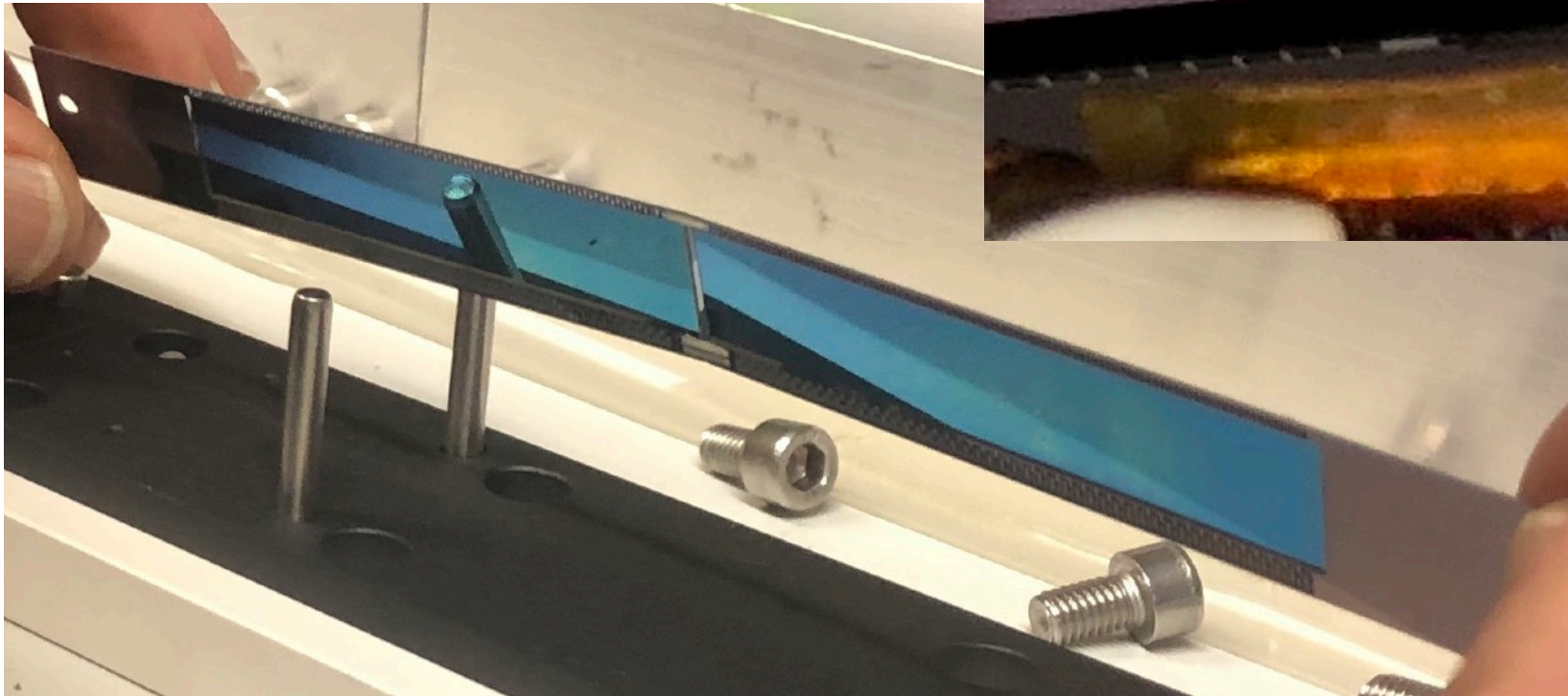
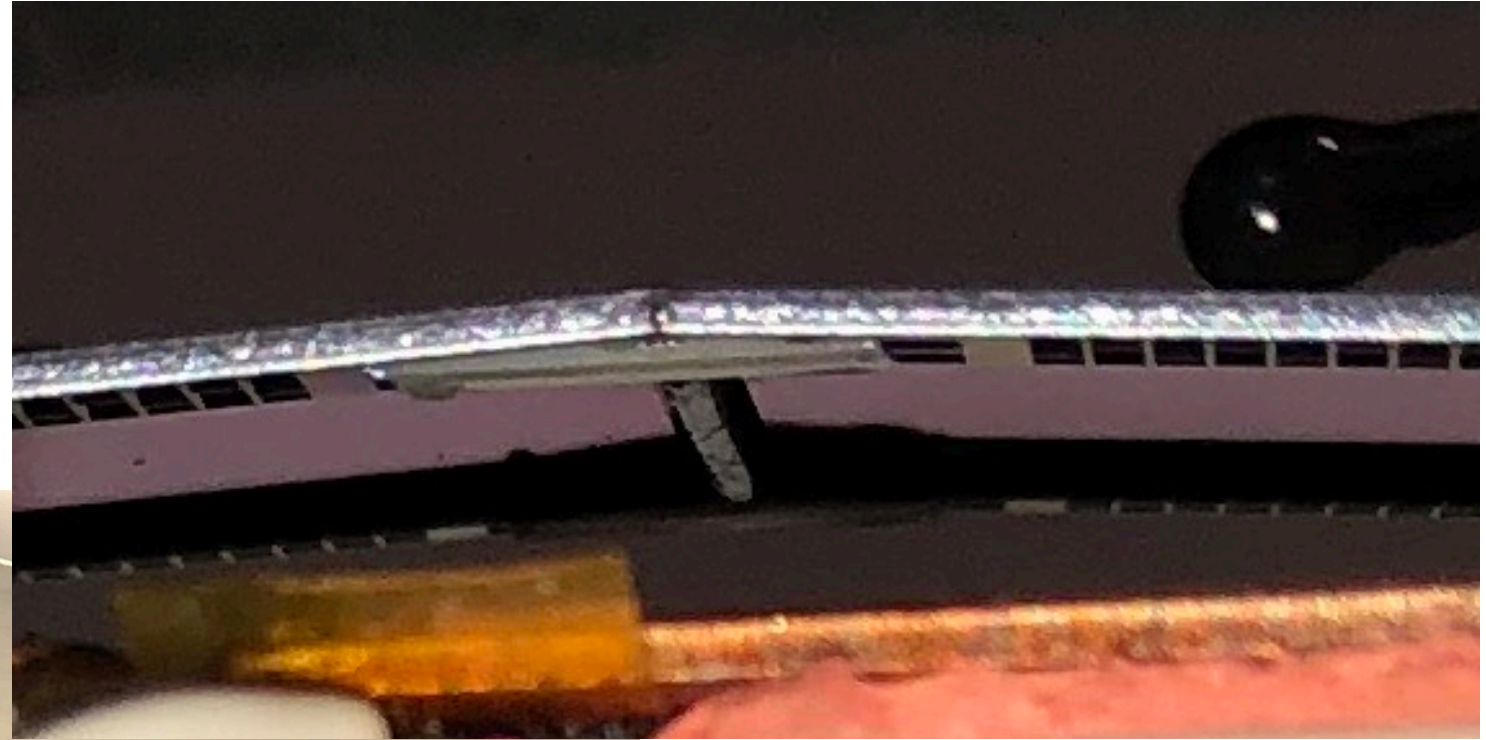


2nd LK79 Heating Test

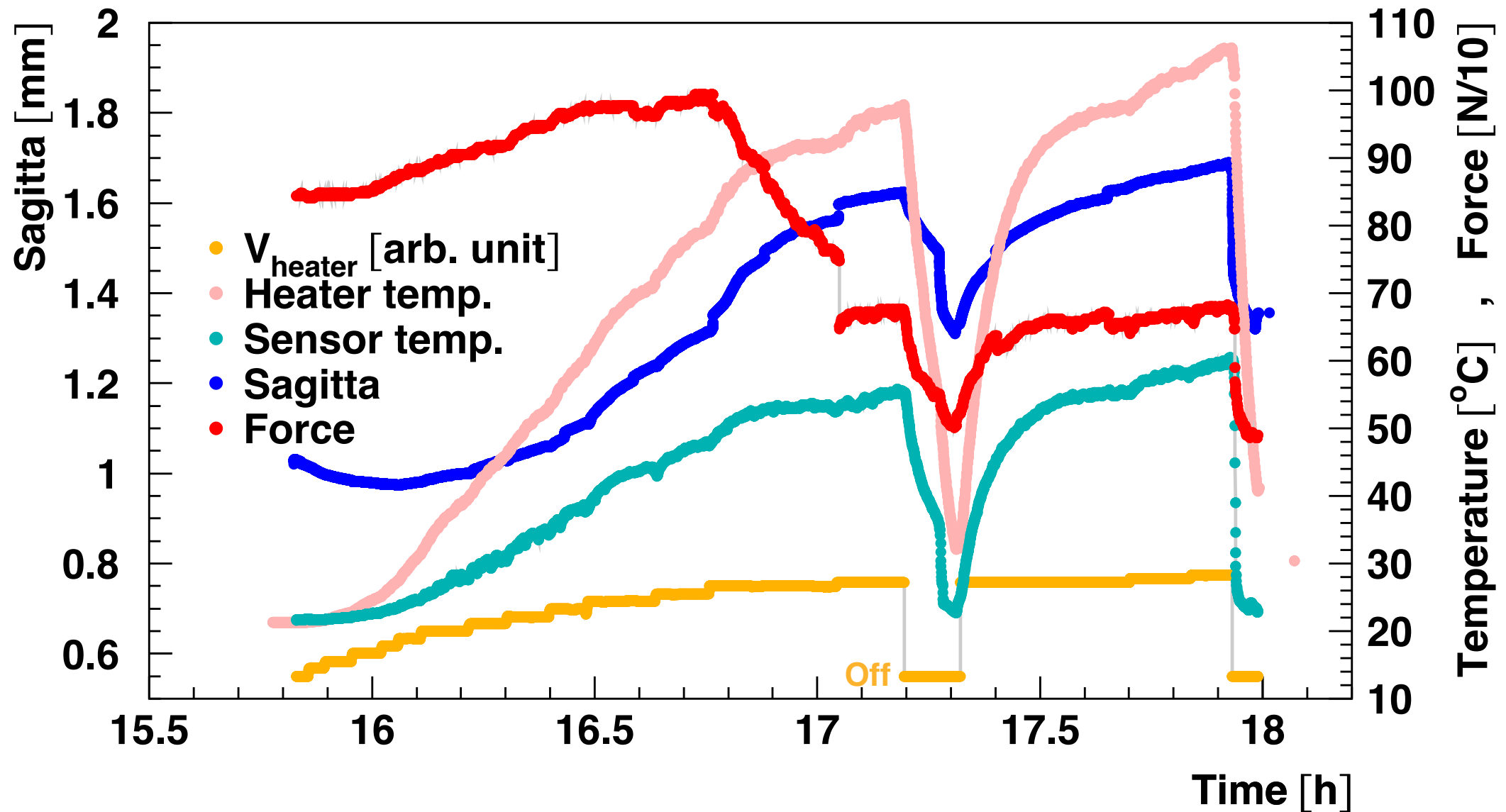


LK79 Glue Joint after 2nd Heating

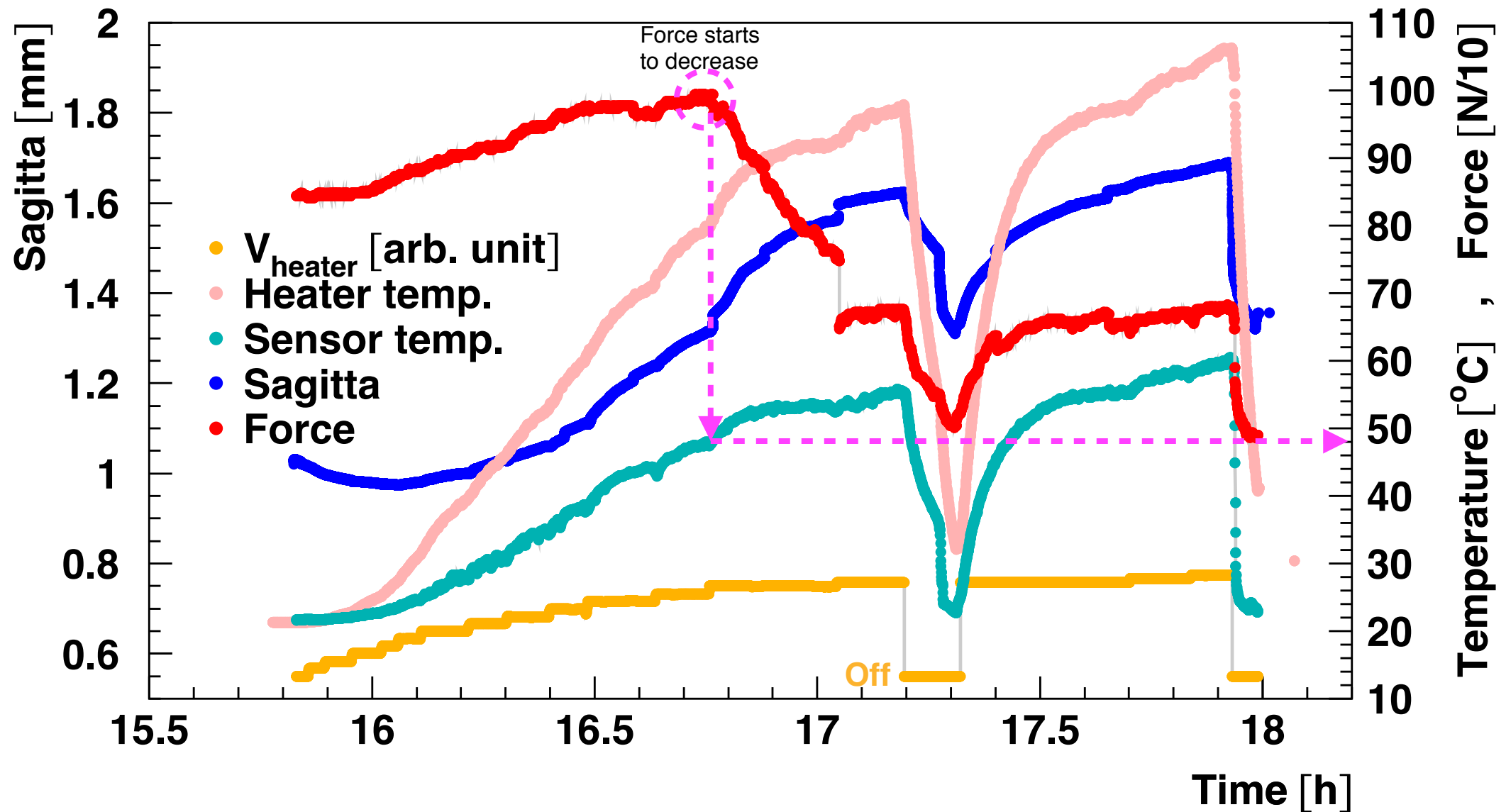
- Ceramic stiffeners remain in place after second heating cycle
- Bend remains but modules are mechanically intact and still firmly connected at room temperature



LK80 Heating Test: Pre-bent with 1.0 mm Sagitta



LK80 Heating Test: Pre-bent with 1.0 mm Sagitta



Handling of LK80 after 2nd Heating



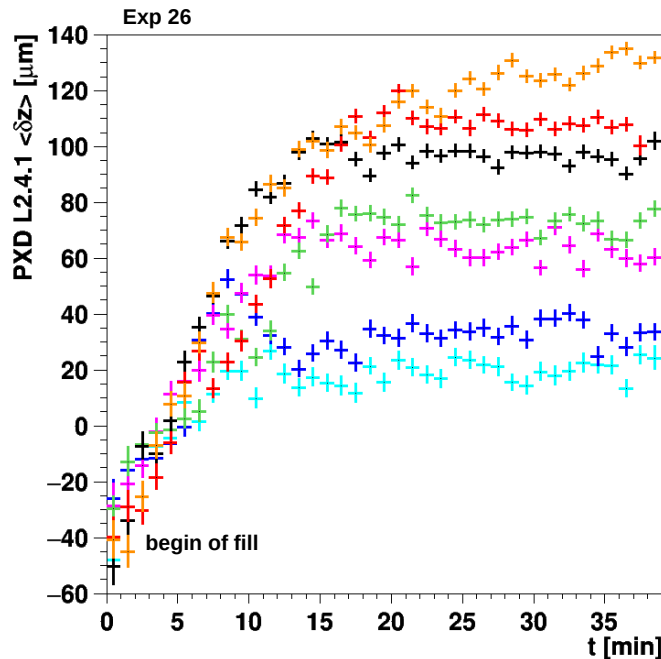
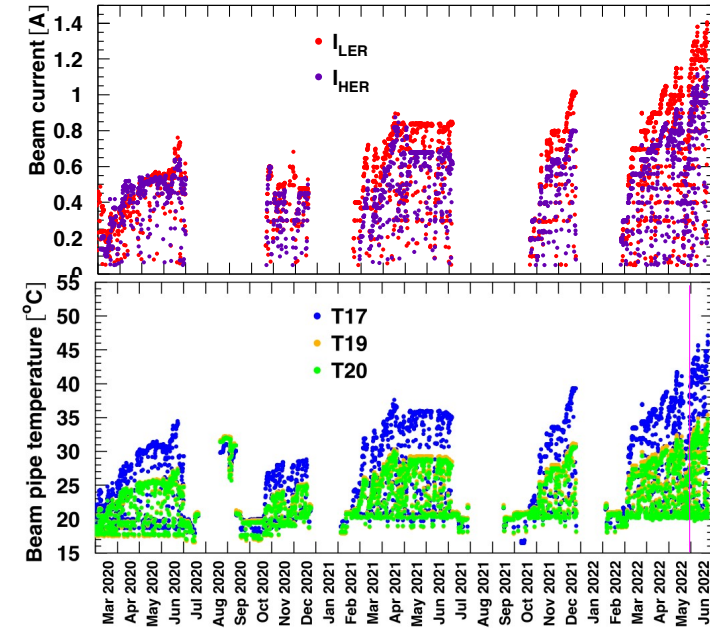
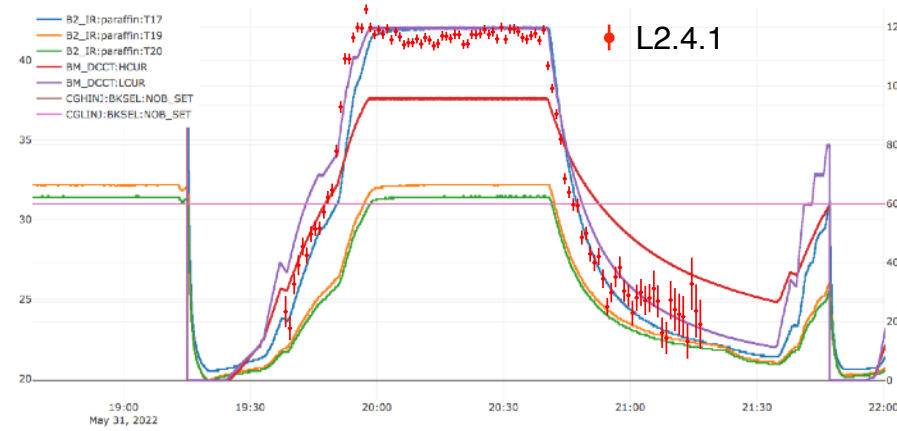
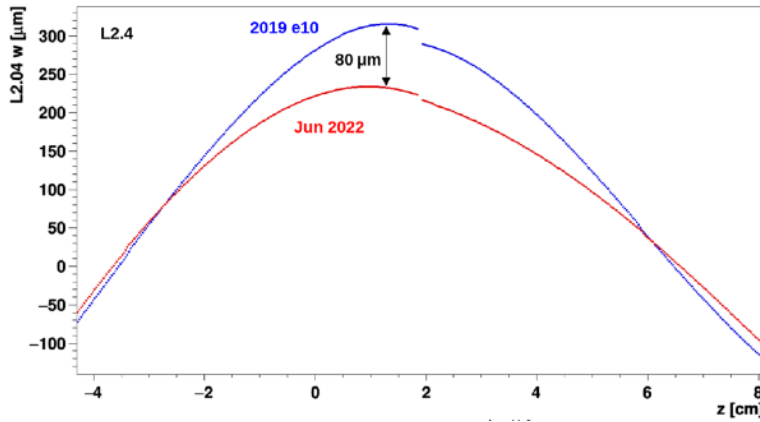
Results of Heating Test

- In the test setup, the Araldite softens at a sensor temperature of $\sim 46\text{--}48^\circ\text{C}$
 - after repeating the heat cycle ceramic stiffeners stay in place and modules stay connected
 - above temperature is only a lower limit as the NTC is only lightly touching the sensor surface
 - in general the result is in accordance with adhesive specifications
 - for PXD2 at $T_{\text{CO}_2} = -30^\circ\text{C}$ and after N_2 flow optimisation, maximum FOS temperature is around 38°C
 - ▶ however this is still without beam in the machine
 - ▶ no direct temperature measurement of the sensor surface at the ladder center available
- Under mechanical stress and high temperature, the adhesive joint gradually opens
- This is best monitored by the decrease in longitudinal force
 - bending moment moves away from the joint \rightarrow mechanical stress on the joint is reduced
- After cooling, some of the bend remains, but in all the studies we have done so far, the modules remain mechanically intact and firmly connected

Proposed Strategy for the First Weeks of Beam Operation

- For safety reasons, ladders 2.7 and 2.8 should not be used at first
- Observe behaviour of other ladders under beam heating and check effects
 - of improved cooling of new beam pipe at the „hot spot“ on +Z side
 - of fixing SCBs to PXD mounting block (to reduce tilting effect observed in 2022)
- In addition to standard alignment data for all other modules, determine off-state bending of ladders 2.7 and 2.8 using nuclear interactions
 - based on Run 1 experience, this will require several weeks of collision data, depending on the time required to ramp up machine performance
- Continue lab testing and, once all the above information is available, decide how to proceed at a future TB meeting
 - if it is decided to switch L2.7 and L2.8 partially or fully on, IBelle should be operated at **-30°C** temperature, as higher temperatures not only increase bowing but also reduce the lap shear strength of the glue

Ladder Bowing in PXD1 L2 due to Beam Pipe Heating



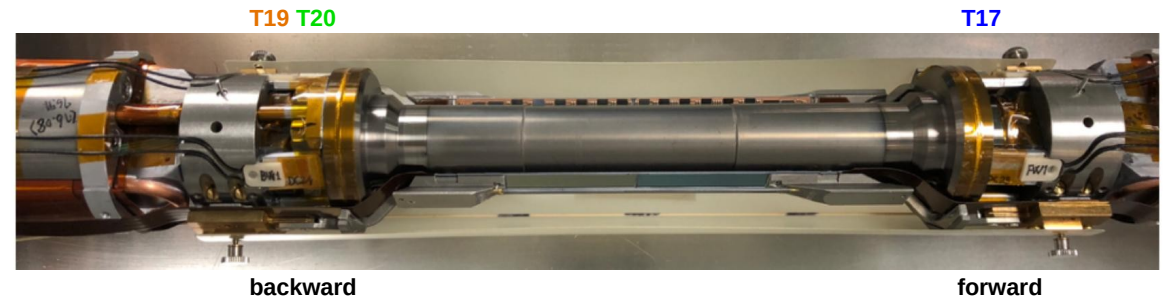
• PXD L2.4.1 vs SVD tracks: $-\delta z$

- 1080x1350 mA²
- 920x1150 mA²
- 840x1050 mA²
- 720x900 mA²
- 640x800 mA²
- 520x650 mA²
- 400x500 mA²

• alignment: e26 at 160x200 mA²

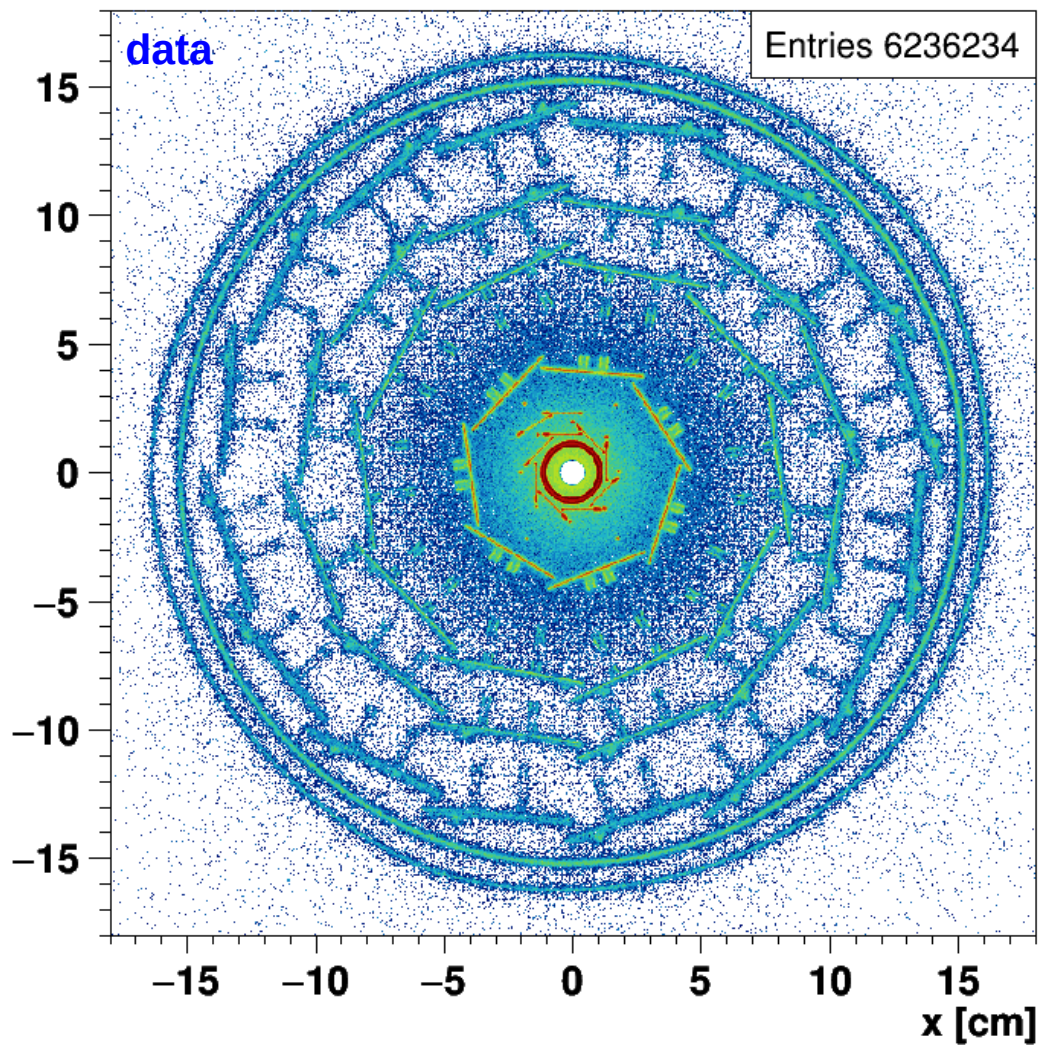
at run start: \approx constant

lumi state: depends on beams

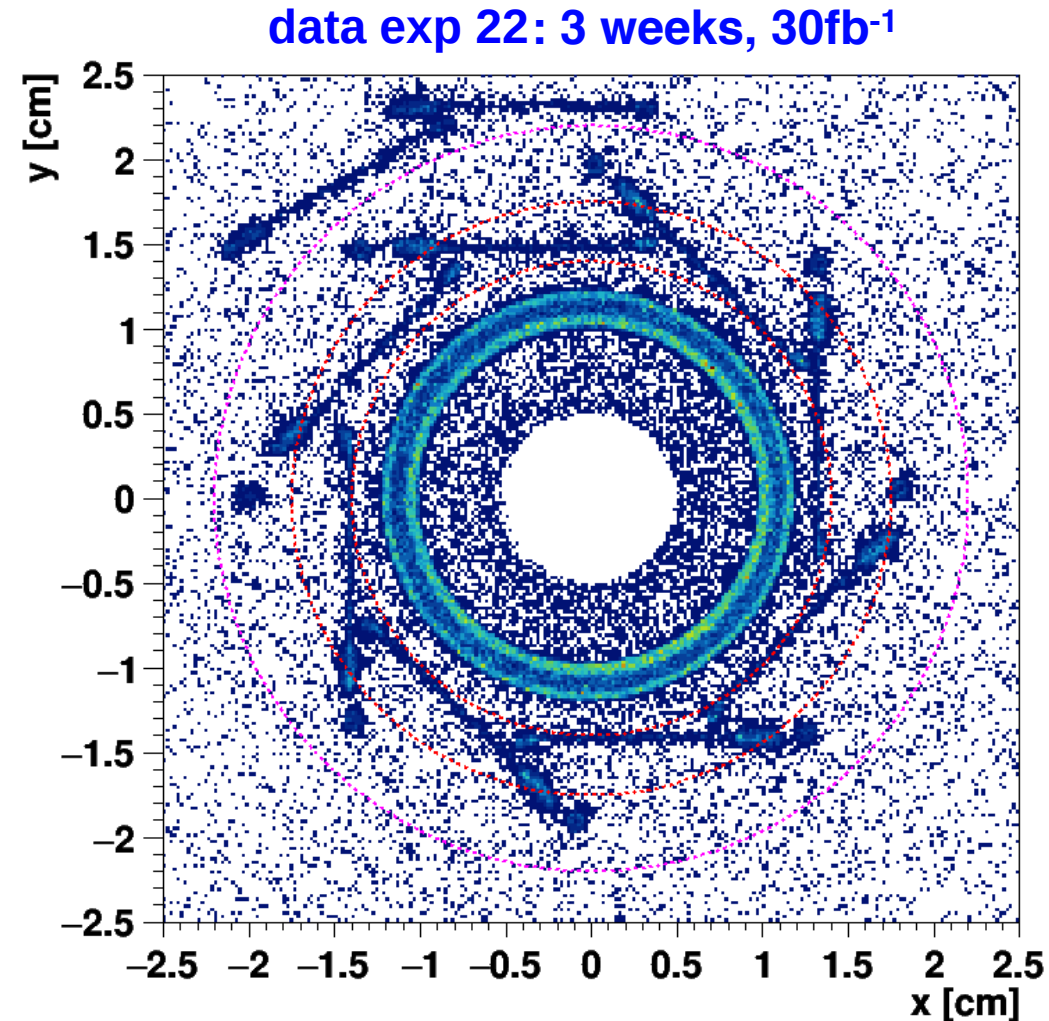


Improved beam pipe cooling implemented in LS1

Nuclear Interactions: 3-Track displaced Vertices



polar angle: 17° to 150°



upper PXD half-shell shifted upwards

PXD2 Documentation

Layer 1 - inner layer

Half shell	ladder position	ladder name (hephyDB)	FWD (module page link)	name (hephyDB)	BWD (module page link)	name (hephyDB)	module thickness
1 / top / HS-2p4	a	L1_076	1011	W68_IF	1012	W61_IB	450
1 / top / HS-2p4	b	L1_057	1021	W11_IF	1022	W46_IB	525
1 / top / HS-2p4	c	L1_058	1031	W10_IF	1032	W05_IB	525
1 / top / HS-2p4	d	L1_037	1041	W05_IF	1042	W42_IB	525
2 / bottom / HS-1p4	a	L1_067	1051	W67_IF	1052	W67_IB	450
2 / bottom / HS-1p4	b	L1_068	1061	W66_IF	1062	W58_IB	450
2 / bottom / HS-1p4	c	L1_069	1071	W69_IF	1072	W59_IB	450
2 / bottom / HS-1p4	d	L1_062	1081	W53_IF	1082	W53_IB	450

[Hyperlinks to database, confluence or elog entries](#)

Layer 2 - outer layer

Half shell	ladder position	ladder name (hephyDB)	FWD (module page link)	name (hephyDB)	BWD (module page link)	name (hephyDB)	module thickness
1 / top / HS-2p4	a	L2_051	2011	W45_OF1	2012	W42_OB2	525
1 / top / HS-2p4	b	L2_074	2021	W56_OF1	2022	W53_OB2	450
1 / top / HS-2p4	c	L2_049	2031	W08_OF2	2032	W08_OB1	525
1 / top / HS-2p4	d	L2_048	2041	W03_OF2	2042	W46_OB1	525
1 / top / HS-2p4	e	L2_050	2051	W46_OF2	2052	W08_OB2	525
1 / top / HS-2p4	f	L2_044	2061	W32_OF2	2062	W32_OB2	525
2 / bottom / HS-1p4	a	L2_073	2071	W57_OF2	2072	W59_OB2	450
2 / bottom / HS-1p4	b	L2_071	2081	W56_OF2	2082	W54_OB1	450
2 / bottom / HS-1p4	c	L2_070	2091	W60_OF1	2092	W56_OB1	450
2 / bottom / HS-1p4	d	L2_054	2101	W45_OF2	2102	W10_OB1	525
2 / bottom / HS-1p4	e	L2_053	2111	W05_OF1	2112	W04_OB1	525
2 / bottom / HS-1p4	f	L2_052	2121	W43_OF1	2122	W33_OB1	525

Ladder thickness and screw torque

Thickness of modules

The modules consist of two silicon wafers, which are connected with an oxide bond (~O(100) nm thick).

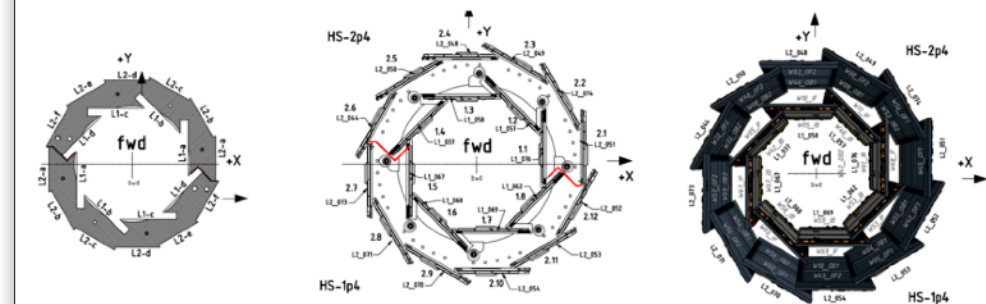
Total thickness is 525 um (450 um) for old (new) modules.

1. The 'DEPFET wafer' is 75 um thick and contains all the frontside- and backside processing for the sensor and module interconnections.
2. The 'handle wafer' is 450 um thick for 'old' PXD modules (wafers W01-W49) and 375 for newer modules (W50-74)

Ladder screw torque

- BWD: 15 mNm
- FWD: 10 mNm
 - exceptions: 2.02.1, 2.07.1, 2.08.1, lowered torques to 7.5 mNm during commissioning because of ladder bending

Module positions



106-012600-013c_20230306.pdf

Documentation of VXD reinstallation

Katsuro Nakamura posted on 30. Mär. 2022 16:31h - last edited by Kang Kookhyun on 04. Dez. 2023 06:53h

- Schedule and person-power availability
- Infrastructure preparation
- Beam Pipe assembly
- Beam Pipe new diamonds attachment
- PXD commissioning
- VXD cable/pipe disconnection
- VXD extraction
 - BWD bellows pipe removal
 - BWD cable cage removal
 - VXD extraction
- VXD disassembly
- SVD standalone commissioning
- SVD attachment
- VXD assembly work after the SVD attachment
 - SVD position alignment
 - Attachment of installation ring
 - FWD cable cage attachment
 - Optimization of FWD SVD cable packing
 - FWD cable space test
- VXD commissioning (in the B4 clean room)
- Bellows pipe and shield attachment
- VXD outer cable/pipe connection
- VXD installation
 - VXD insertion
 - BWD cable cage installation
- VXD inner cable/pipe connection
- VXD commissioning after the installation

Confluence Documentation

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PXD commissioning

responsible person: @Arthur Bolz deputy @Botho Paschen

Checklist google doc (to be completed)

- Mechanical setup on the granite table for the PXD mount
- Plan of commissioning?
 - timeline / checklist
 - Half Shell to beampipe mounting manual
- What information to be kept?
 - PSU rack setup and cabling
 - DHH setup and cabling
 - Dockbox setup and cabling
- PXD commissioning setup: (more details: [PXD2 Commissioning at KEK](#))
 - Setup is similar to what was used in 2018
 - Outside of B4 cleanroom
 - 2 PXD Power supply racks ([DESY pictures](#))
 - 1 ATCA Rack for DHH setup ([DESY pictures](#))
 - Optical switch B4 ↔ e-hut
 - PXD control desk/PC
 - Inside of B4 cleanroom
 - 2 PXD half shells (mounted on BP)
 - 8 Dockboxes with 20 - 40 PCBs and outer PXD cables (40 A + 40 D green power, 40 black CLC, 16 blue optical fibers) at [scaffolding](#)
 - 40 PXD patch panels, 20 loose and 20 connected to Dockbox PCBs ([DESY pictures](#))
 - E-Hut
 - Slow control and local DAQ PCs
- 3D measurement after attachment
 - Faro-arm CMM was used in 2018 (see pictures in <https://photos.app.goo.gl/jF2ceUbtqYtwkMEw6>)
 - preferred, accessible reference surfaces to be defined (L2 SCB surfaces used in 2018 not an option anymore)
 - likely scan brass mount block envelopes to ensure clearance to SVD
 - MPP's 3D scanner to be brought and used in addition by @David Kittlinger
 - 3D scan of PXD was tested at DESY. While scanning reflective surfaces of PXD is a challenge, can give a much more detailed picture than FARO-routing of pipes, Kaptons, etc.
- Open issues:
 - Humidity monitoring and cooling interlock in preparation. Work in progress by @Boqun Wang

responsible persons: @Michelle Klotz for transfer tubes in B4 VXD clean room

- CO2 distributor setup in the B4 clean room
 - All 12 tri-axial transfer tubes were installed.
 - Tightness of the tubes was confirmed.
- PXD standalone IBBelle operation considerations (CO2 flow configuration, base load via return flow heater for stable warmup, interlock test, ...)

Some of the end-game activities (e.g. grounding before closing) still need to be better documented

ELOG during PXD2 Commissioning at KEK

Home general Software/Computing DAQ Beast PXD VXD CDC SVD ECL TOP ARICH KLM TRG LABM UPGRADE PXD-SVD testbeam phase 2 marco xfel cooler VXD mock-up co2lean IBBelle VXD commissioning VXD Radiation Monitor										
VXD Commissioning, Page 1 of 1										Logged in as "Carsten Niebuhr"
List New Edit Delete Reply Duplicate Find Help Logout Config										
Start date:		2023/03/16 Thu 00:00 UTC								
End date:		2023/04/30 Sun 00:00 UTC								
Full Summary Threaded										
<input type="text" value="-- Author --"/> <input type="text" value="-- CO2 Temp [deg] --"/> <input type="text" value="-- DAQ Run# --"/> <input type="text" value="-- Run Type --"/> 55 Entries										
ID	Date	Subject	JSTTime	Author	CO2 Temp [deg]	DAQ Run#	Run Time [sec]	Run Type	Local Run Menu	Text
106	2023/03/24 Fri 06:35 UTC	PXD Commissioning Preparations	2023/03/24 15:35 JST	Arthur Bolz				Hardware work		Dry Volume - The PXD dry volume was set up. The heavy metal "Lego" pieces were installed into the
105	2023/03/23 Thu 22:25 UTC	PXD Commissioning Preparations	2023/03/24 07:25 JST	Arthur Bolz						23/03/23 Dewpoint Monitoring and Interlock
104	2023/03/23 Thu 06:03 UTC	Paraffin setup	2023/03/23 15:03 JST	Shuji.Tanaka				Hardware work		1, Paraffin piping setup change Connecting with IP pipe today. 2, Paraffin circulation test
103	2023/03/22 Wed 22:03 UTC	PXD Commissioning Preparations	2023/03/23 07:03 JST	Arthur Bolz				Hardware work		22/03/23 CO2 Connection:
102	2023/03/22 Wed 08:29 UTC	Paraffin setup	2023/03/22 17:28 JST	Shuji.Tanaka				Hardware work		1, Paraffin piping work in the VXD room (test circulation was done) 2, PT100 sensor connection (b2epics)
101	2023/03/22 Wed 01:19 UTC	PXD Commissioning Preparations	2023/03/22 10:18 JST	Arthur Bolz				Hardware work		Work from 23/03/21 - Services:
100	2023/03/20 Mon 05:44 UTC	PXD Commissioning Preparations	2023/03/20 14:44 JST	Arthur Bolz				Hardware work		- Services: - 20 Belle2 DB PCBs installed in B4 CR Dockboxes. Fibers connected.
99	2023/03/17 Fri 10:12 UTC	PXD Commissioning Preparations	2023/03/17 19:12 JST	Arthur Bolz				Hardware work		- PXD work areas in B4 and F2 were cleaned up in preparation for PXD commissioning - PXD standalone environmental monitoring
98	2023/03/17 Fri 08:58 UTC	Beampipe Inspection for Mount Block Isolation Scheme and DESY Camera Setup	2023/03/17 17:57 JST	Arthur Bolz				Hardware work		- KEK Mechanics Team (Tanaka-san, Kohriki-san) and DESY PXD Team (Anselm, Arthur, Carsten, Fabian) inspected beampipe.
97	2023/03/17 Fri 08:28 UTC	paraffin setup	2023/03/17 17:27 JST	Shuji.Tanaka				Hardware work		Paraffin cooling status: 1, cabling btw. VXD room and the paraffin
96	2023/03/17 Fri 08:26 UTC	PXD Transport to KEK	2023/03/17 17:26 JST	Arthur Bolz						- Bonn PXD Commissioning team (Botho, Georgios, Jannes, Munira) traveled to KEK March 14/15. They transported the PXD Half Shell Mockup

PXD2 Commissioning Picture Collection

PXD2_TransportToKEK

- public: <https://syncandshare.desy.de/index.php/s/64deQprzGYpsH52>
- upload: <https://syncandshare.desy.de/index.php/s/ftQcygr942DStcd>

PublicPXD2_Transport (for outside of VXD collaboration sharing)

- public: <https://syncandshare.desy.de/index.php/s/jt7R2GMCQK4EbMm>
- upload: <https://syncandshare.desy.de/index.php/s/x9D744nzGWpz866>

bp_preparation

- public: <https://syncandshare.desy.de/index.php/s/BPwa5Lp86DB7aa7>
- upload: <https://syncandshare.desy.de/index.php/s/znrW88dy3Qw2in>

230320_dummyHSMounting

- public: <https://syncandshare.desy.de/index.php/s/Am8yK8FJNR8R7gZ>
- upload: <https://syncandshare.desy.de/index.php/s/WdsNjeT7EKC3jNp>

230320_B4ServicesSetup

- public: <https://syncandshare.desy.de/index.php/s/CPntKeK8XYe82PR>
- upload: <https://syncandshare.desy.de/index.php/s/SGTgaGZD5nRYoeF>

20230320_B4_dockbox_transport

- public: <https://syncandshare.desy.de/index.php/s/f5jFyWSkB2FfEDj>
- upload: <https://syncandshare.desy.de/index.php/s/QJy8HTy3rSKHTGo>

230321_hs2p4_installation

- public: <https://syncandshare.desy.de/index.php/s/z9NBssPcS2NoJdo>
- upload: <https://syncandshare.desy.de/index.php/s/fis8DYiY8r3D5Bt>

230322_DESYServicesArrival

- public: <https://syncandshare.desy.de/index.php/s/GJHf5amPzQ2d7tH>
- upload: <https://syncandshare.desy.de/index.php/s/5pgGmz5sQZGNBot>

230322_CO2Connection_HS2p4

- public: <https://syncandshare.desy.de/index.php/s/W9F4jsGdmmsiDC5>
- upload: <https://syncandshare.desy.de/index.php/s/YrgcC6p4MPHYFED>

230323_N2_connection

- public: <https://syncandshare.desy.de/index.php/s/6gyGdkBKRxrZe6A>
- upload: <https://syncandshare.desy.de/index.php/s/t6RCfPEwCjdEoWC>

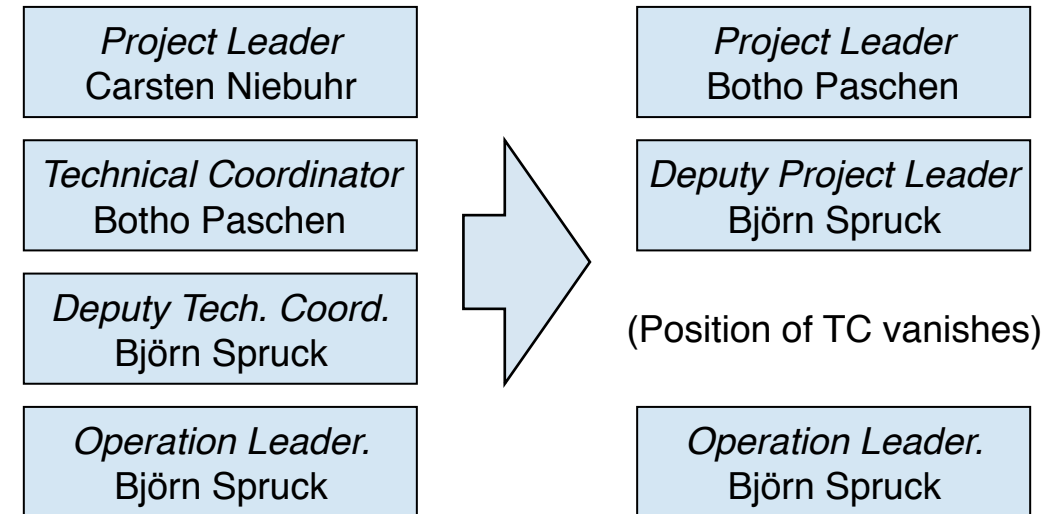
PXD2 Commissioning Issue Tracking

The image displays several overlapping panels from a project management tool, each representing a different task or category of work. The panels are:

- documentation** (18 items):
 - ONSEN inventory (#27)
 - Label DHH Components and Add to HephyDB (DHH) (#4)
 - Label PSU Components and Add to HephyDB (Power Supply System) (#5)
 - Phoebus documentation (#61, Mar 31, 2023)
 - Update pxdioc4 documentation (DHH, computing) (#152, Apr 5, 2023)
 - Document exchange procedure for genesys master or slave after failure (Power Supply System) (#273)
 - PXD documentation dump
- PXD2 Installation** (4 items):
 - HS_2p4 Source Scan (#181)
 - PXD2 Standalone Test (#180)
- Slow Control** (4 items):
 - Change DHE critical temperature limit in DHE ioc (#111)
 - Start PXD2 PV Archiving (computing) (#15, Mar 24, 2023)
- Cooling** (2 items):
 - Cooling Run Preparations For CW 17 (DHH, PXD Testing, Power Supply System) (#219)
 - N2 Monitoring and ITLK System for PXD2 (Critical) (#303)
- Power Supply System** (21 items):
 - Flash new OVP firmware and retest PS units (#358)
 - Label PSU Components and Add to HephyDB (documentation) (#5)
 - Add PXD2 Cables to HephyDB (#18)
 - Interlock Box Remote (#116)
 - Crate Controller IOC a (#141, Apr 4, 2023)
- DHH** (10 items):
 - Label DHH Components and Add to HephyDB (documentation) (#4)
 - Install remaining ONSSEN fibers (ONSEN) (#47, Mar 28, 2023)
 - Update pxdioc4 documentation
- PXD Testing** (1 item):
 - Cooling Run Preparations For CW 17 (Cooling, DHH, Power Supply System) (#219)
- Sudatory Labor** (1 item):
 - B4 Shelf Inventory (#33)

PXD Leadership Change

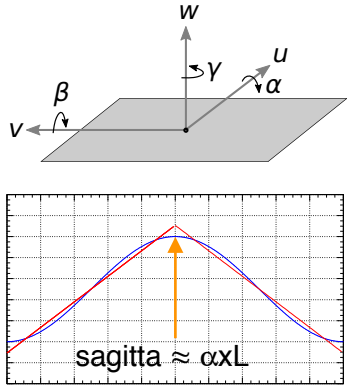
- At last week's PXD IB meeting **Botho Paschen** was elected as the new PXD Project Leader and **Björn Spruck** was elected as his deputy. Congratulations to both of them and best wishes for exciting years ahead!
- This also implements the intended change in the PXD management structure from PL + TC to PL + deputy PL, which we feel is more appropriate given the completion of PXD2.
- For all the support over the last few years, I would like to thank you all and especially all the members of the great PXD team!
- It all comes down to one thing:
„You have to have good people: Good people!"



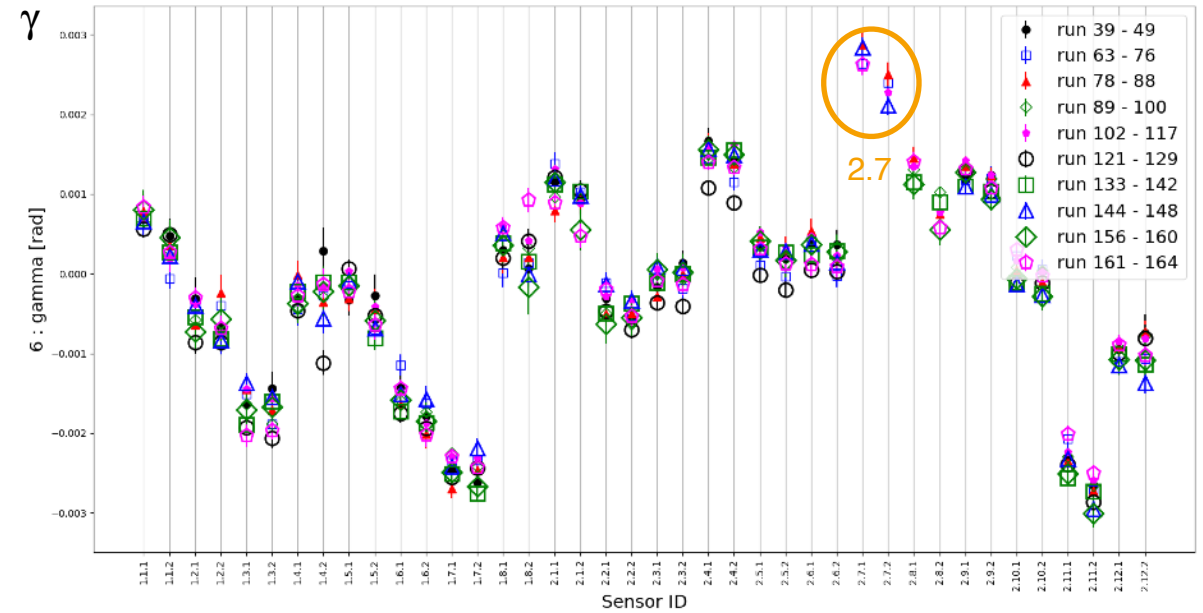
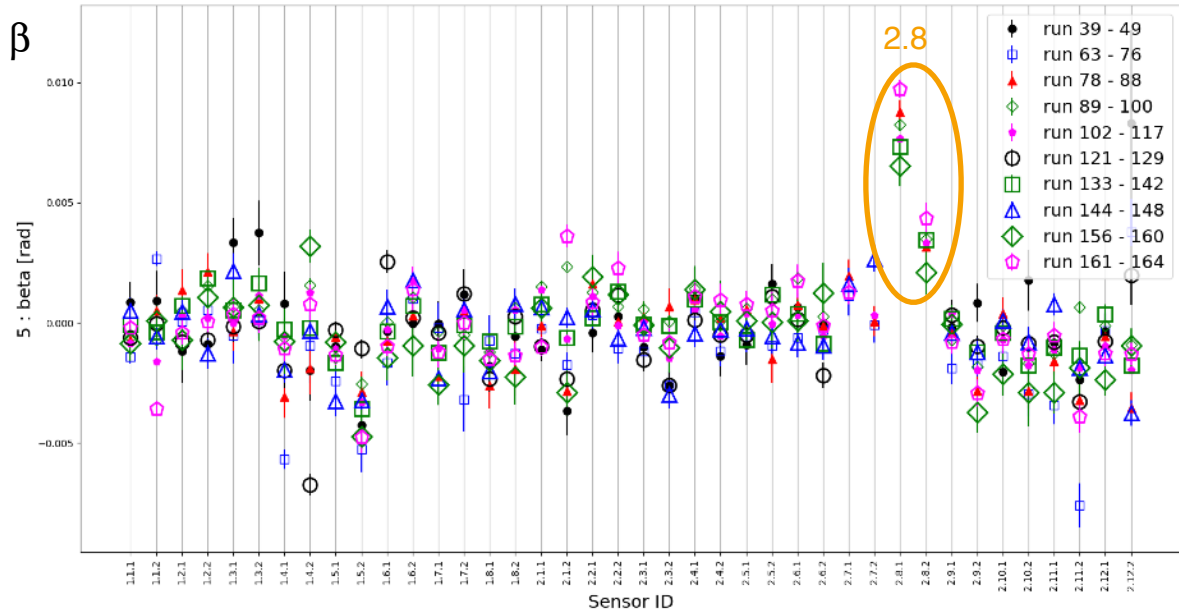
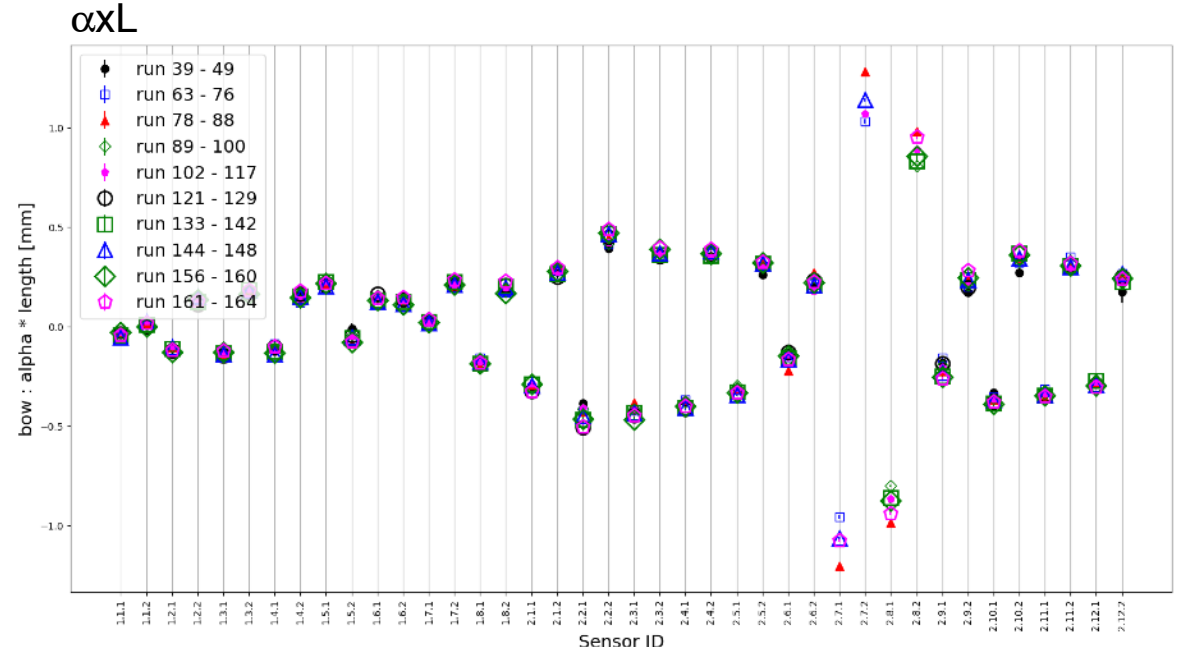
Additional Slides

Ladder Bending Studies with Field-off Cosmics

- Most bent ladders 2.7 and 2.8 also have large β and γ values
- Suspect that gliding impossible as these ladders are not optimally mounted on SCBs
- Reminder: Unlike other half-shell, this one not disassembled at DESY

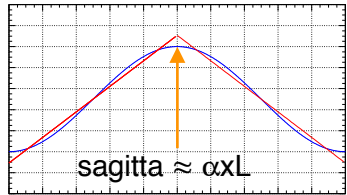
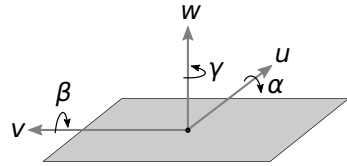


T(CO2)	2071	2072	2081	2082
-30°C	0	0	0	0
-30°C	1	1	0	0
-30°C	1	1	1	1
-30°C	0	0	1	1
-30°C	0	1	1	1
-25°C	0	0	0	0
-25°C	0	0	1	1
-25°C	1	1	0	0
-25°C	0	0	1	1
-25°C	1	0	1	1

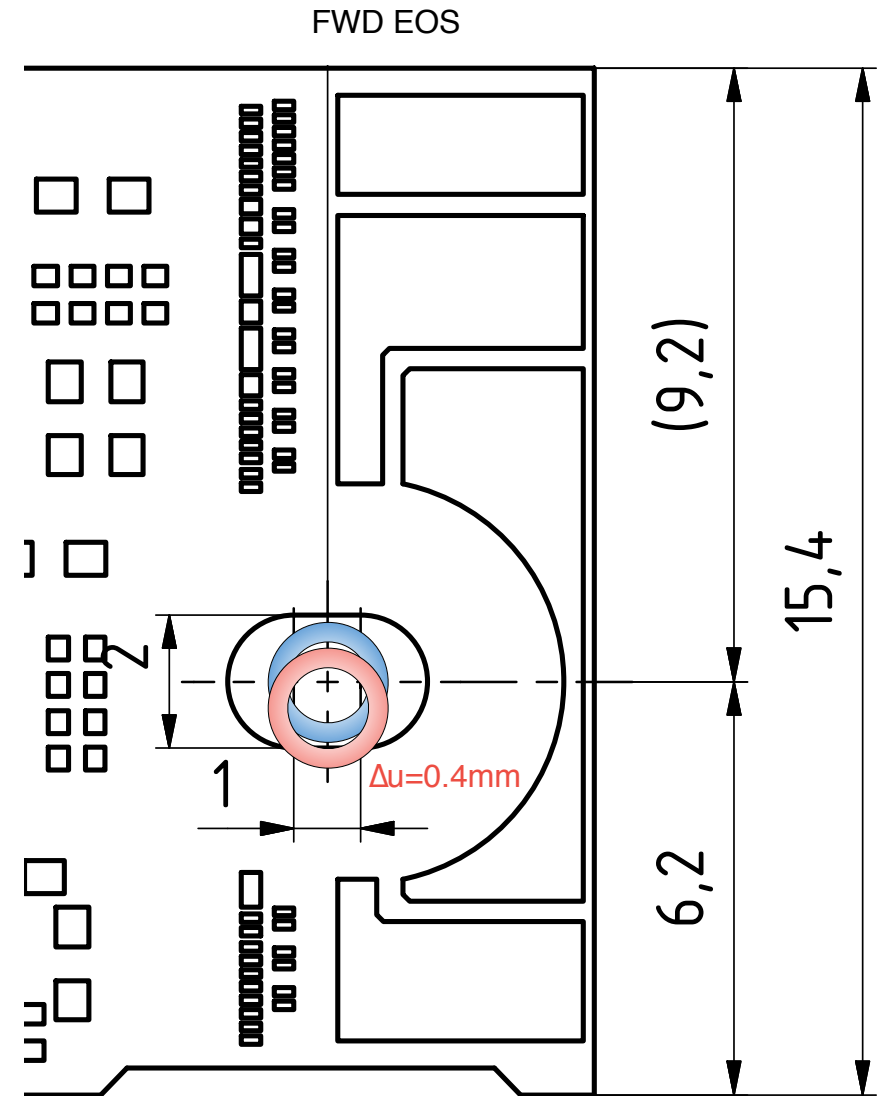
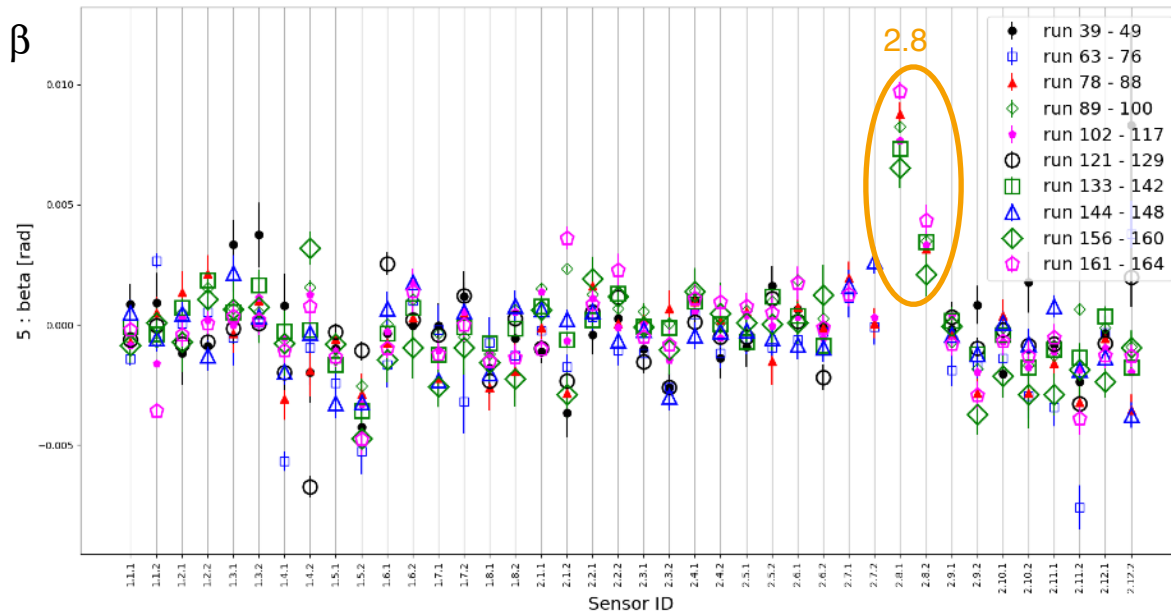


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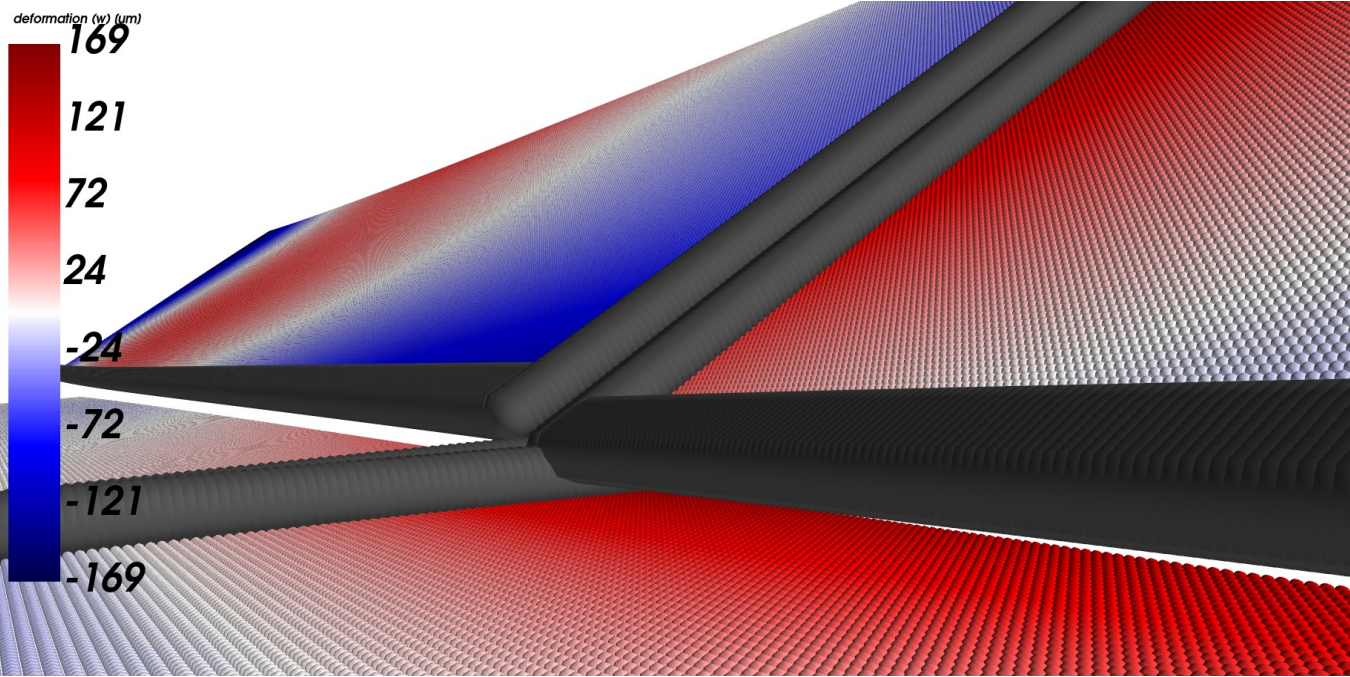
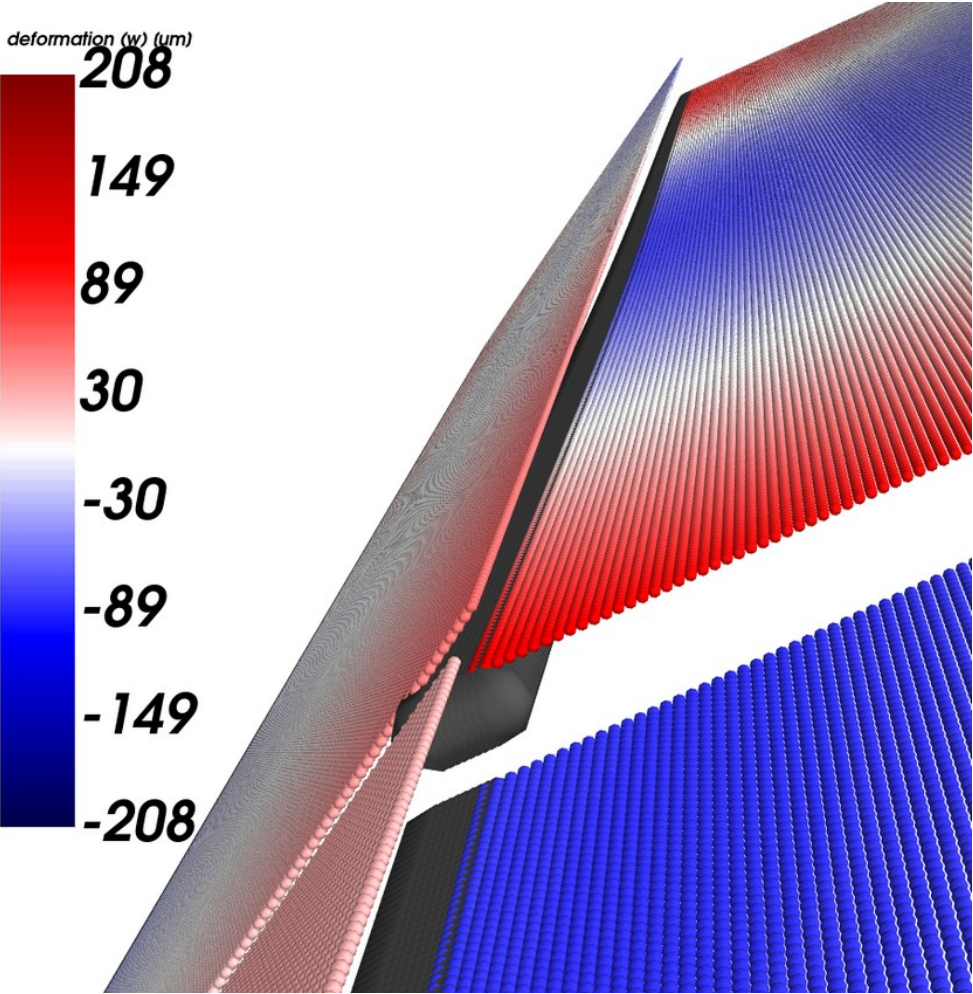


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-30°C	0	0	1	1
-30°C	0	1	1	1
-25°C	0	0	0	0
-25°C	0	0	1	1
-25°C	1	1	0	0
-25°C	0	0	1	1
-25°C	1	0	1	1

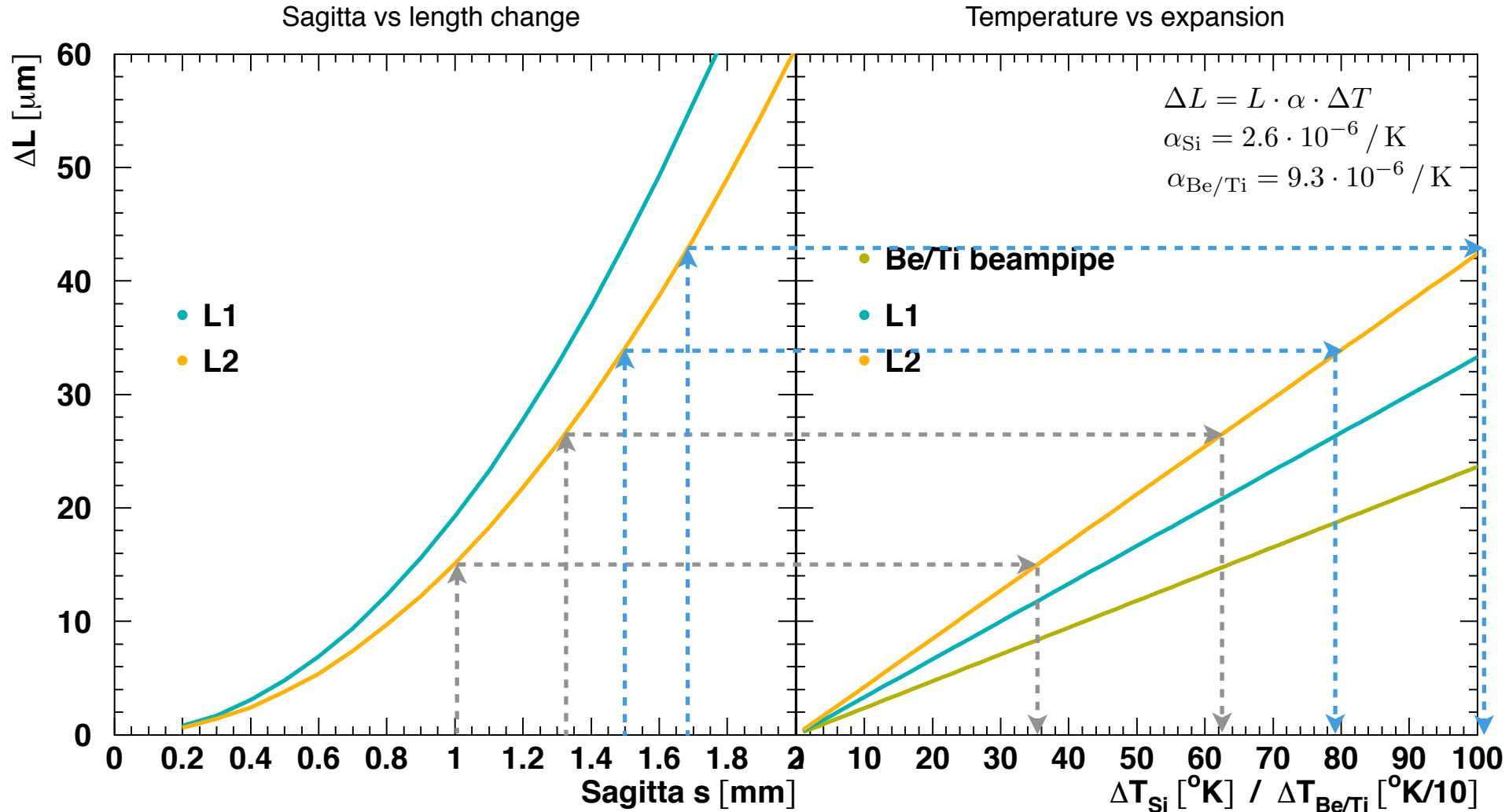


Possible Interference between L2.7 and L2.8

T.Bilka

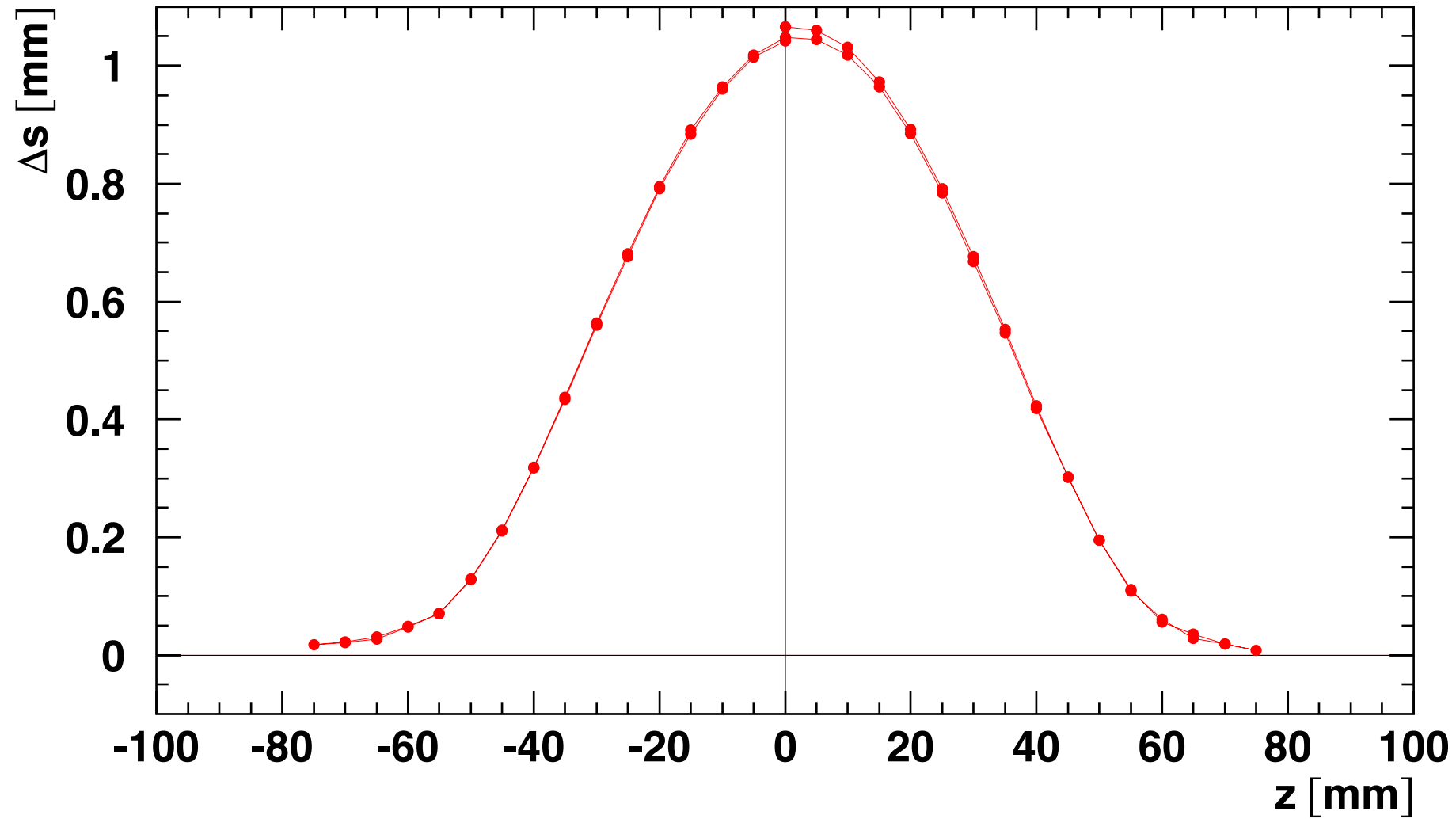


Expected Relation between Sagitta and Temperature

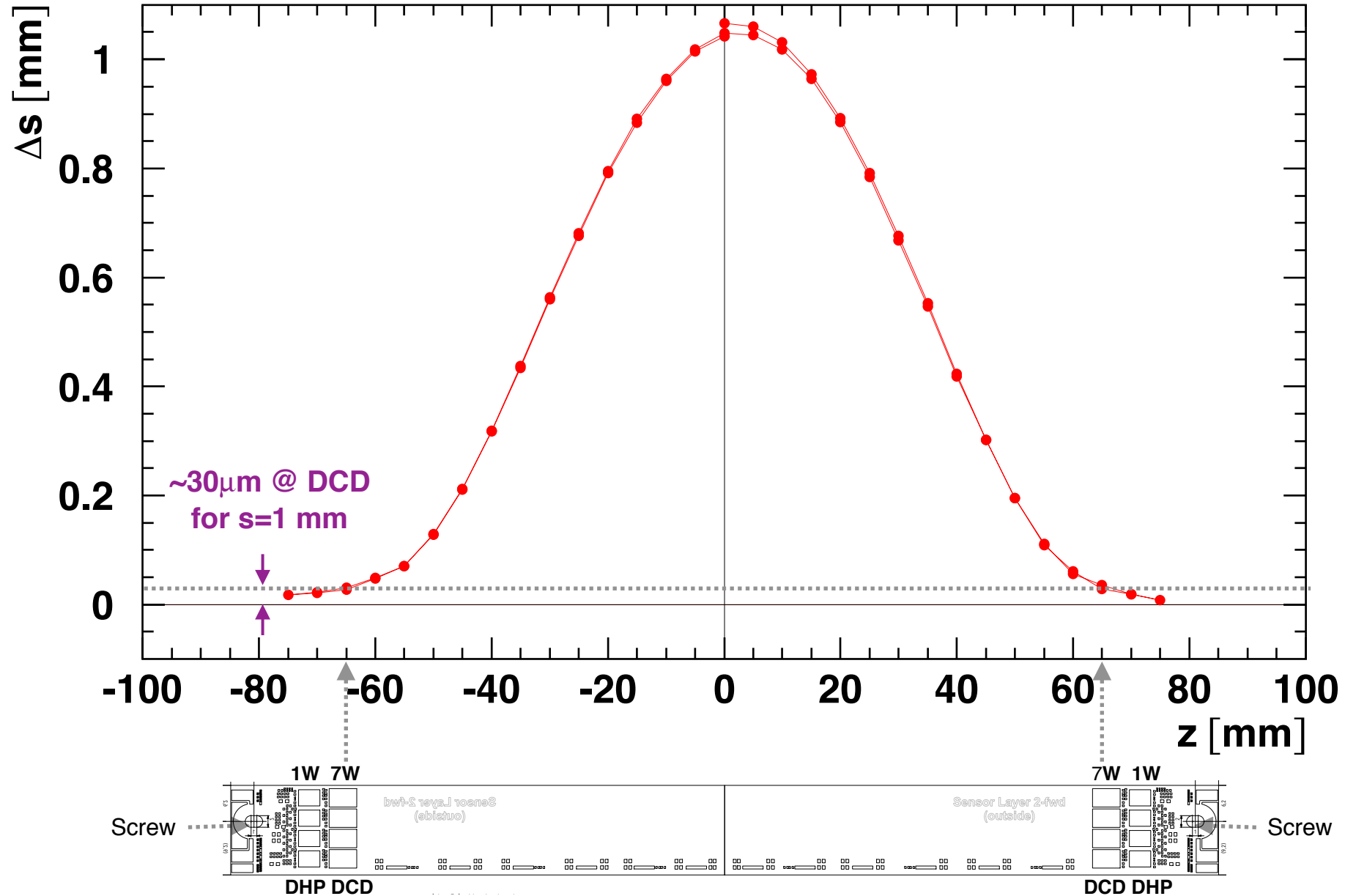


- Under the simplifying assumption of a constant temperature profile along the ladder
 - KEK: for bent ladder EOS probably hotter than sensor area
 - DESY test setup: radiant heating only in L1 area → EOS colder than sensor area

LK79 Longitudinal Profil - Offset corrected



LK79 Longitudinal Profil - Offset corrected



Ladder Dimensions

