FD1 TB meeting
08/11/2023

Temperature sensors on APAs

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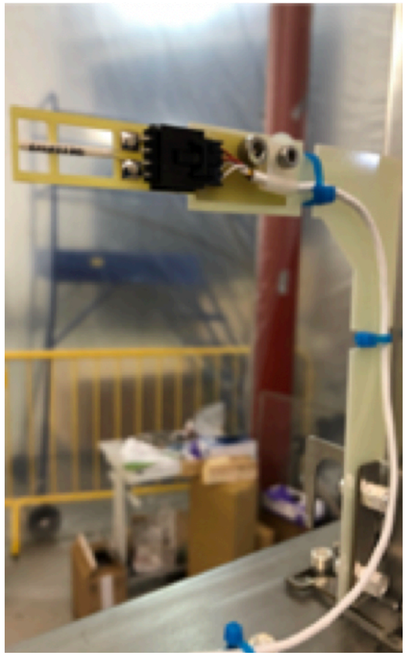
Introduction

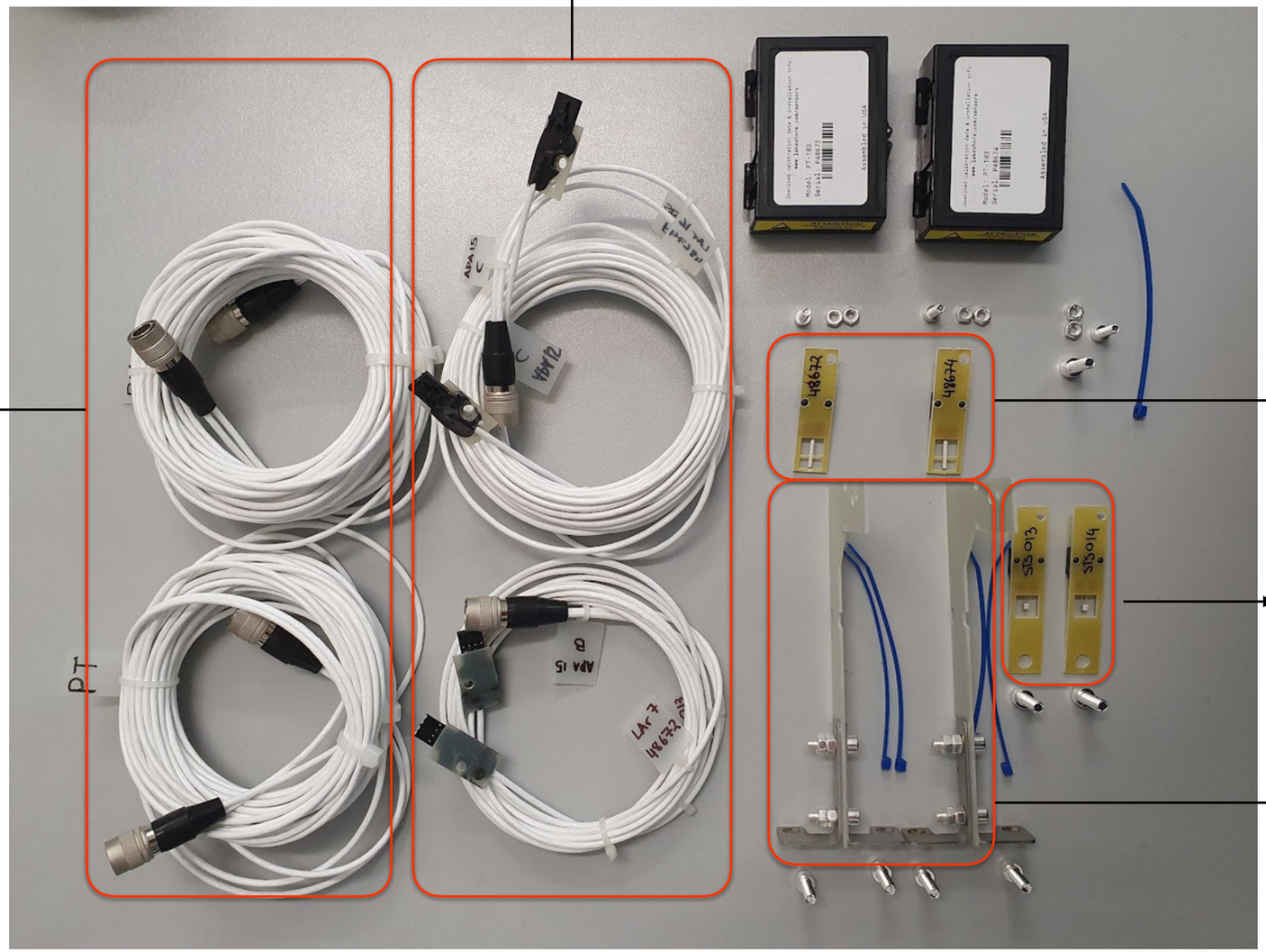
- Few problemas have been observed in RTD kits sent to Daresbury and Chicago. Many apologies to both for the inconveniences
- Kits not yet installed have been returned to IFIC and are being carefully inspected and repaired
- The path forward
  1. Characterise observed problems
  2. Repair existing kits
  3. Changes in production procedures for new kits
  4. Changes in QA/QC procedures for repaired/new kits
- These items will be covered in this talk



APA sensors hardware

RTD cables
One circular connector for 2 RTDs

passthrough cables
(Installed in upper APA
to readout lower APA in the
same doublet)

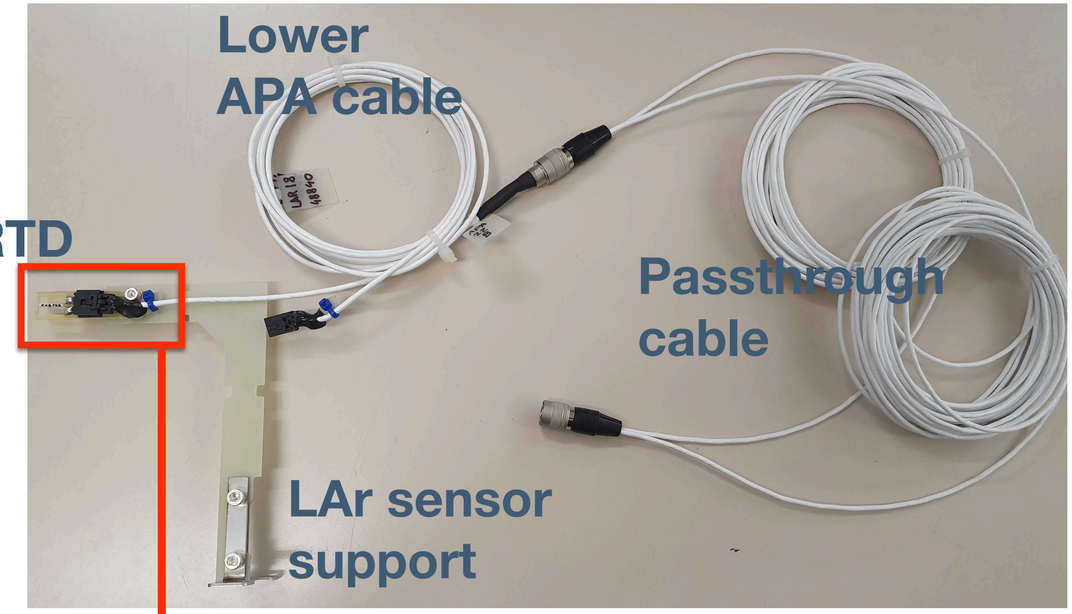


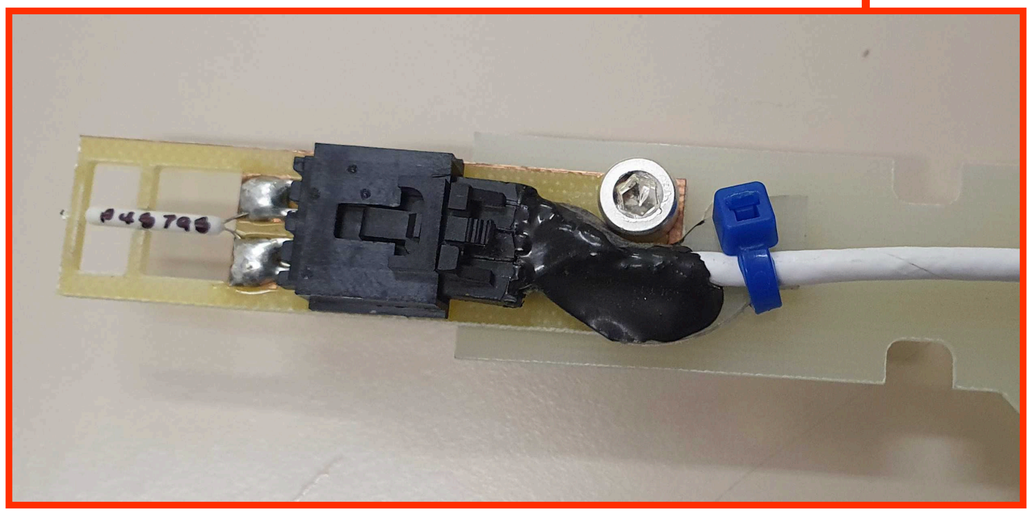
Precision RTDs (LAr)

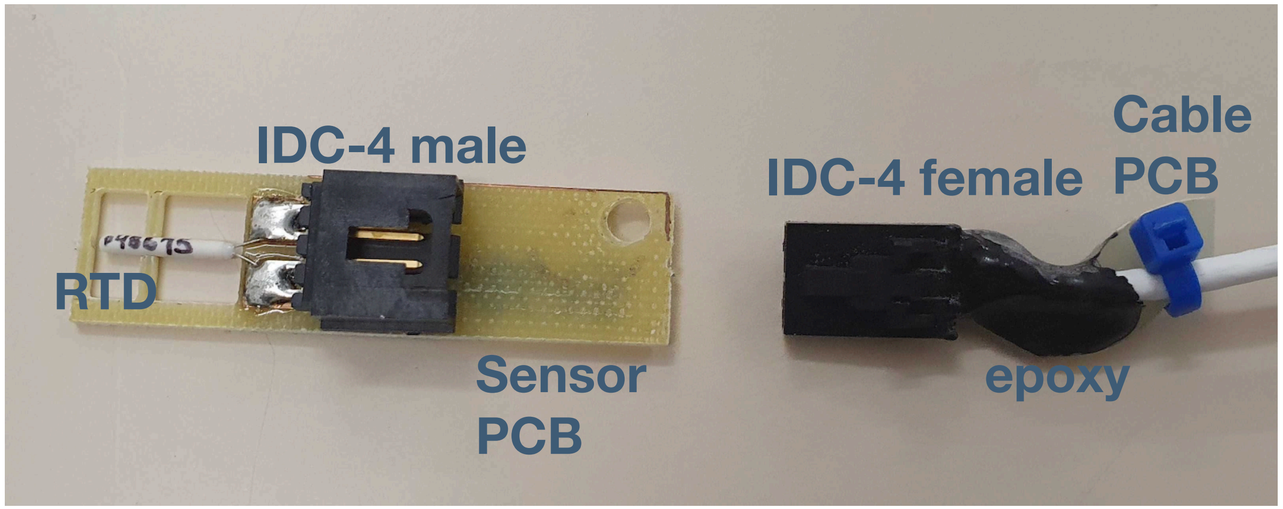
Standard RTDs (frame)

Support for LAr sensors

The elements







Diagnostic

- 15 kits with 4 cables each were sent back from Daresbury
  - Inspected carefully →

https://docs.google.com/spreadsheets/d/1YNHiGjV6-XVt4XpdNLR90WZ2ko7vvqBc/edit?usp=sharing&ouid=112967415463163046769&rtpof=true&sd=true

- 3 kits with 4 cables each were sent back from Chicago, not yet in Valencia

APA number	upper/ lower	APA factory	Sensor ID	Electrical Connection	Has Cable tie/clamp	Epoxy Quality				Connector gluing on board	
						Aesthetics	Covering small cables	Allowing M4 screw hole	Allowing adding cable ties	Aligned M4 holes	Connecting sensor
TOTAL	13/12	15	60	0	40	24	8	6	36	15	9
3	U	D	LAr1	1	1	1	1	1	1	1	1
			LAr6	1	1	1	1	1	1	0	1
			LAr11	1	1	0	1	1	1	1	1
			LAr16	1	1	0	0	1	1	1	1
6	L	D	LAr4	1	1	1	1	1	1	1	1
			LAr9	1	1	1	1	1	1	1	1
			LAr14	1	1	1	1	1	1	1	1
			LAr18	1	1	1	1	1	1	1	1
7	U	D	F1	1	1	1	1	0	1	1	1
			LAr1	1	1	1	1	0	1	0	1
			LAr10	1	1	1	1	0	1	0	1
			F2	1	1	1	1	0	1	0	1
8	L	D	F1	1	1	0	1	1	1	1	1
			LAr9	1	1	0	1	1	1	1	0
			LAr18	1	1	0	1	1	1	1	1
			F2	1	1	0	1	1	1	1	1
11	U	D	F1	1	1	1	1	1	1	0	1
			LAr5	1	1	1	1	1	1	0	0
			LAr14	1	1	1	1	1	1	1	1
			F2	1	1	1	1	1	1	0	1
14	L	D	LAr1	1	0	1	0	1	0	1	1
			LAr6	1	0	1	1	1	0	1	1
			LAr11	1	0	0	1	1	0	1	1
			LAr16	1	0	1	1	1	0	1	1
15	U	D	F1	1	0	1	1	1	0	0	1
			LAr7	1	0	1	1	1	0	0	1
			LAr16	1	0	1	1	1	0	1	0
			F2	1	0	1	1	1	0	1	1
16	L	D	F1	1	0	0	1	0	0	1	1
			LAr3	1	0	0	1	0	0	1	1
			LAr12	1	0	0	1	1	0	1	1
			F2	1	0	0	1	1	0	1	1
17	U	D	LAr4	1	0	1	0	1	0	1	0
			LAr9	1	0	1	1	1	0	1	1
			LAr14	1	0	1	1	1	0	1	0
			LAr18	1	0	1	0	1	0	1	0
18	L	D	LAr1	1	0	1	0	1	1	1	1
			LAr5	1	0	1	1	1	1	1	1
			LAr10	1	0	1	1	1	1	1	1
			LAr15	1	0	1	1	1	1	1	1
19	U	D	F1	1	0	0	1	1	0	1	1
			LAr9	1	0	0	1	1	0	0	0
			LAr18	1	0	0	1	1	0	0	1
			F2	1	0	0	1	1	0	1	1
20	L	D	F1	1	0	0	1	1	0	1	1
			LAr9	1	0	0	1	1	0	0	0
			LAr18	1	0	0	1	1	0	0	1
			F2	1	0	0	1	1	0	1	1
21	U	D	F1	1	0	1	1	1	0	1	1
			LAr9	1	0	1	1	1	0	0	1
			LAr18	1	0	1	1	1	0	1	1
			F2	1	0	1	0	1	0	1	1
22	L	D	F1	1	0	0	1	1	0	1	1
			LAr9	1	0	0	1	1	0	0	0
			LAr18	1	0	0	0	1	0	1	1
			F2	1	0	0	1	1	0	1	1
23	U	D	F1	1	0	1	1	1	0	1	1
			LAr9	1	0	0	1	1	0	1	1
			LAr18	1	0	1	1	1	0	1	1
			F2	1	0	1	0	1	0	1	1

Problems observed

Problem 1: electrical

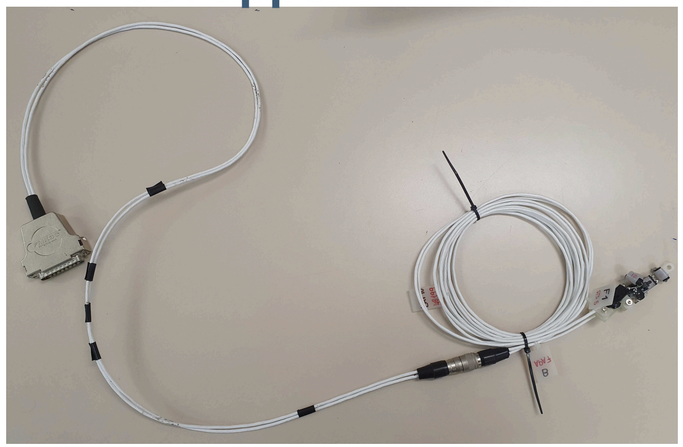
0/60

- Daresbury has reported electrical failures for many RTD cables
- We have retested all cables at IFIC and confirmed there is not a single failure
- Electrical tests were not foreseen at APA production factories and therefore there was not written procedure
  - All tests were done at IFIC before shipment, both in cold and in warm.
  - Probability of failure after shipment was estimated to be negligible
- We have now reconsidered this decision and will provide to APA production factories with the necessary hardware to quickly perform electrical tests in all cables

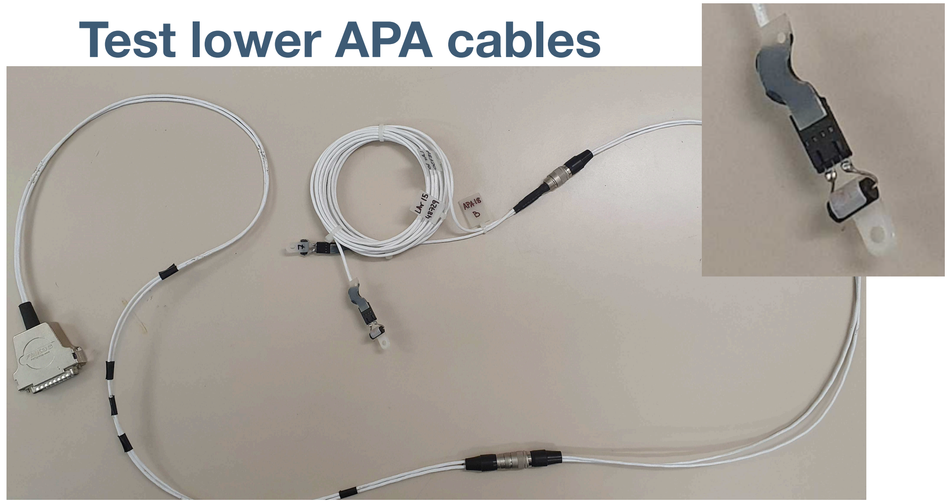
Problem 1: electrical

- **Repair:** none
- **Changes in production**: none
- **Changes in QA/QC**: electrical tests at APA production factories before and after installation

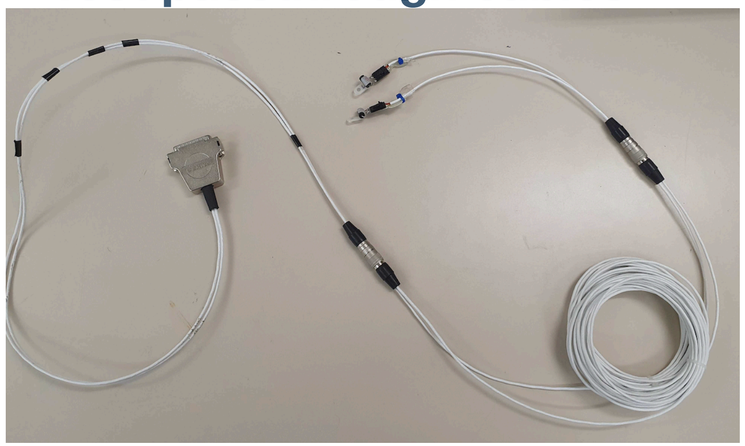
Test upper APA cables



Test lower APA cables



Test passthrough cables

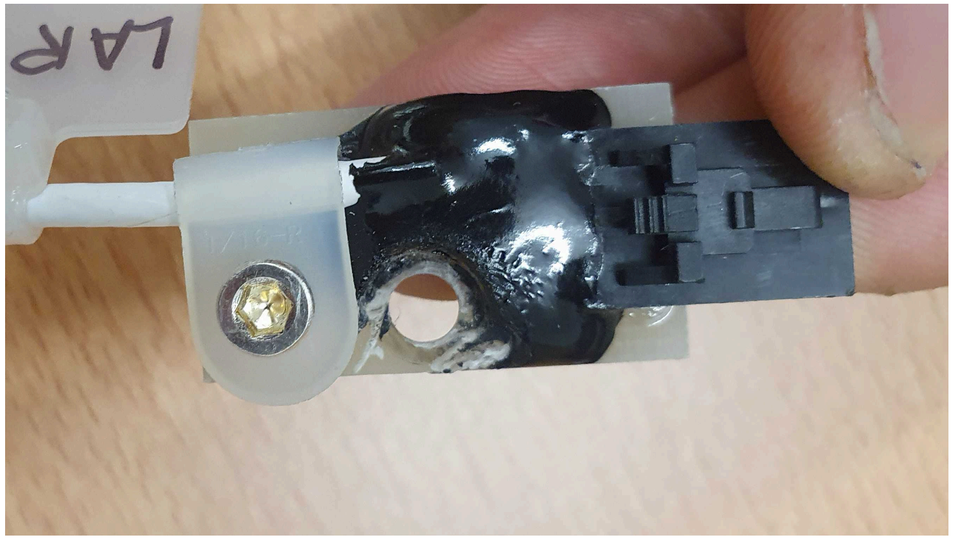


Substitute SUBD-25 connector by a PCB with 4 copper pads, two for each RTD

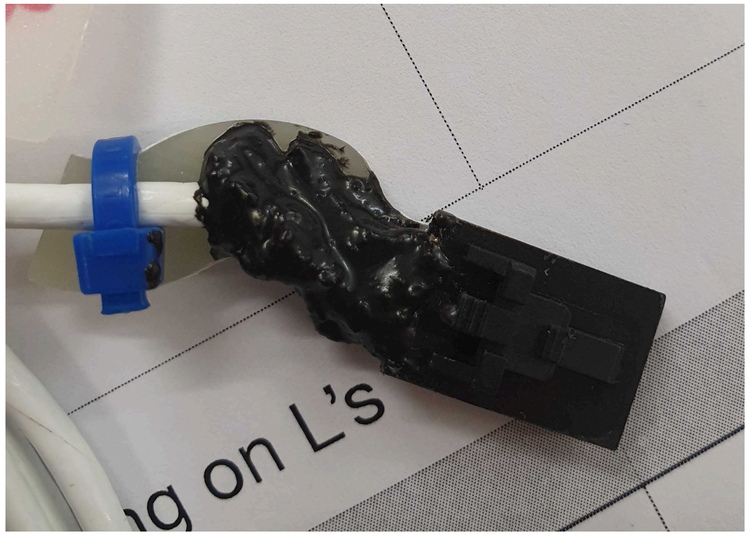
Problem 2: cable tie/clamp not present

- After APA 13 we decided to remove the cable tie/clamp in order to simplify the manufacturing process
- However we have noticed that the assembly is more robust with it
- In consequence, these elements will be restored

Cable clamp for upper APAs

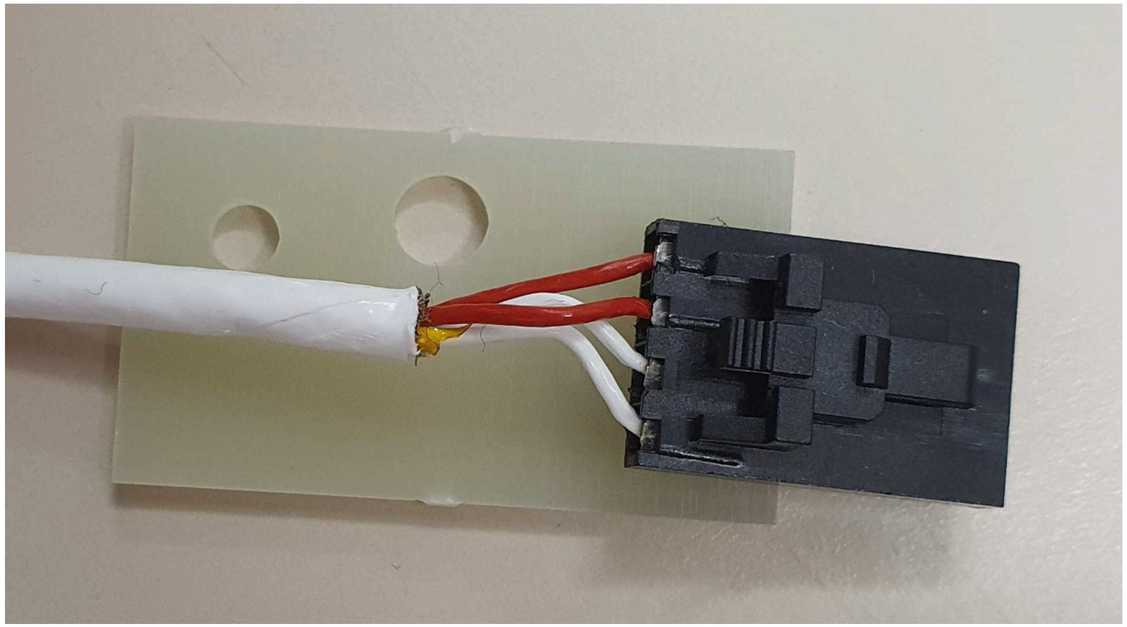


Cable tie for lower APAs



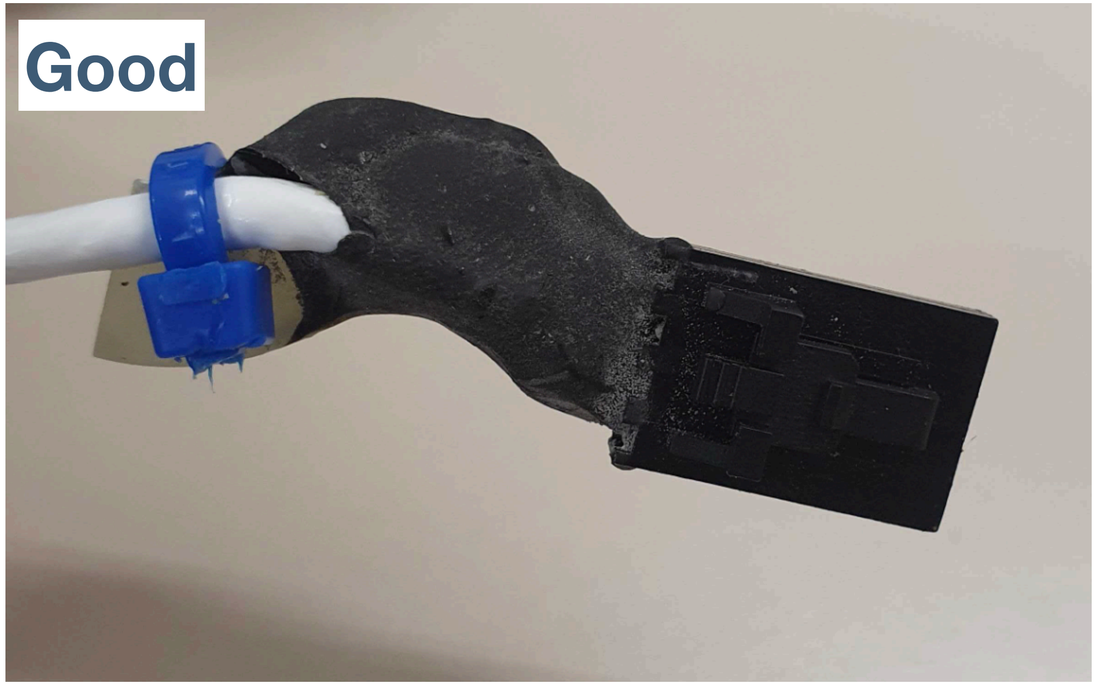
Problem 3: Epoxy quality

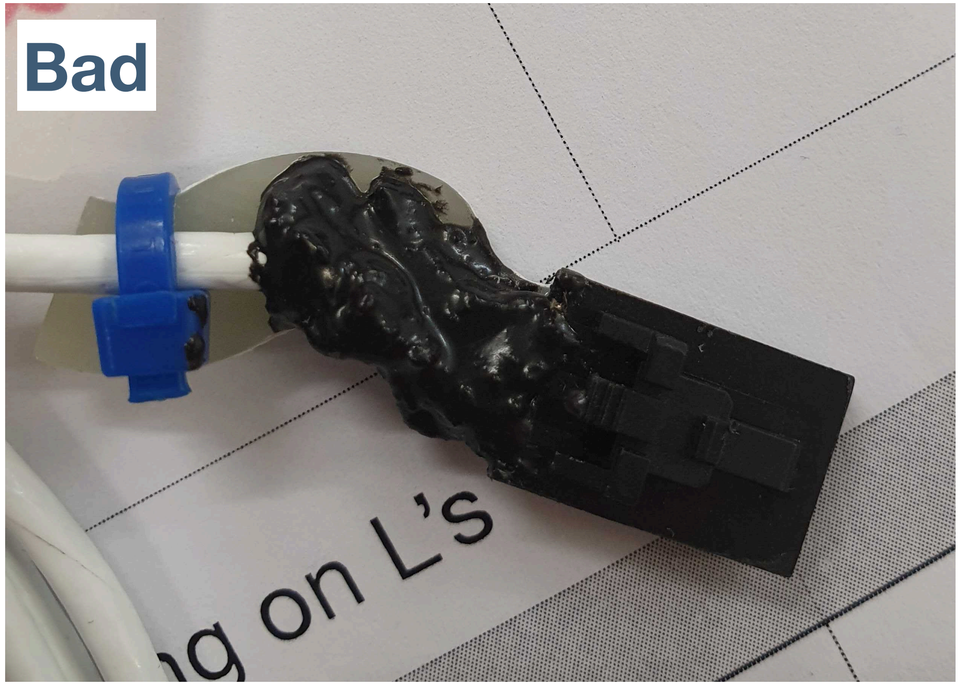
- Loctite Stycast 2850 FT epoxy is used to protect the four little cables in each sensor cable
- Several problems have been identified



Problem 3.a: Epoxy quality

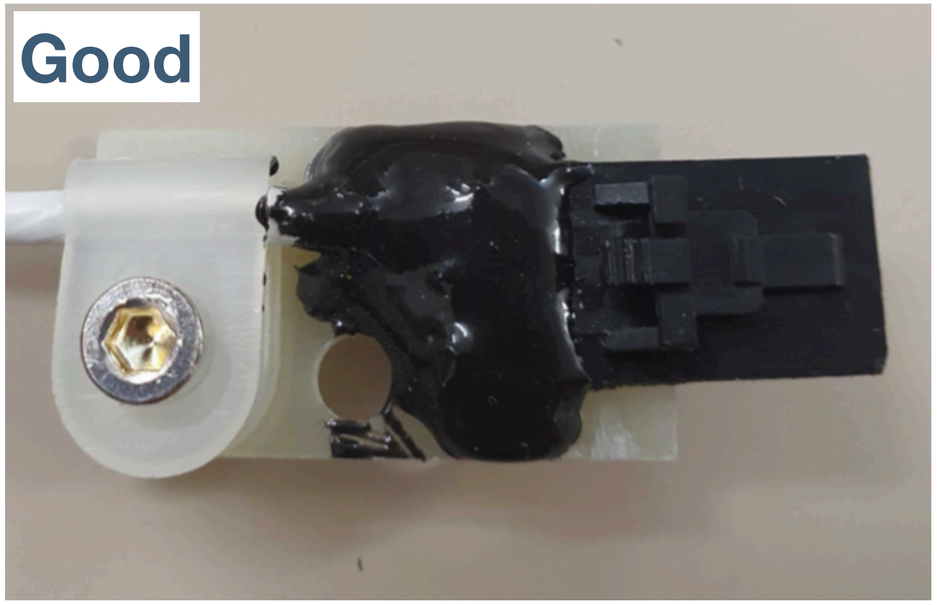
- Sometime it is only aesthetics
- **Repair:** add more epoxy with proper distribution
- **Changes in production**: remove bubbles before applying epoxy
- **Changes in QA/QC**: look at aesthetics

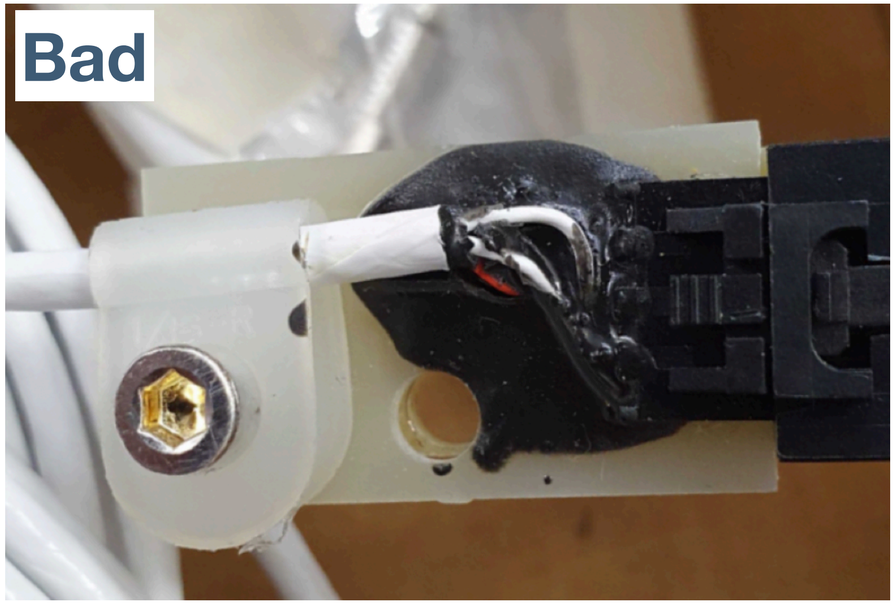




Problem 3.b: Epoxy quality

- The four little cables not completely covered by epoxy
- **Repair**: add more epoxy
- **Changes in production**: when applying epoxy make sure it covers cables
- **Changes in QA/QC**: make sure epoxy covers cables



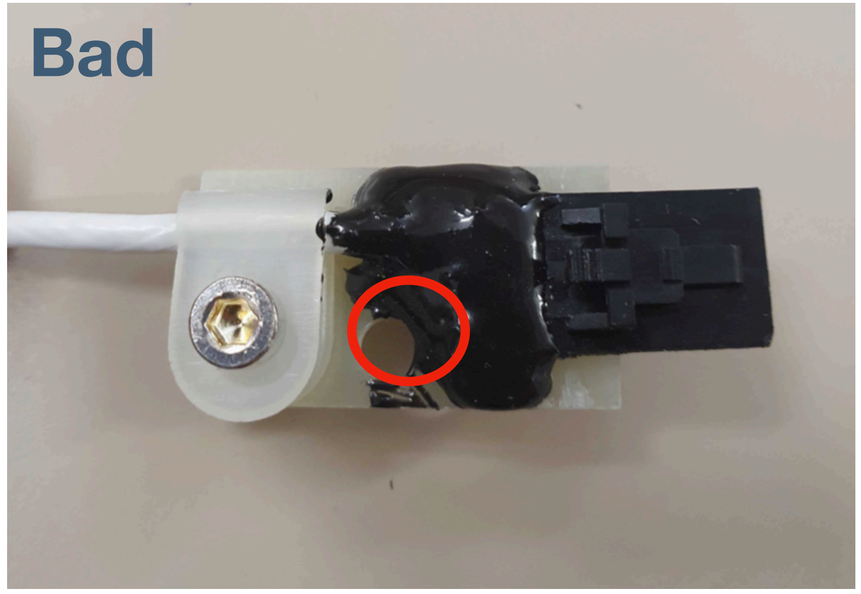


Problem 3.c: Epoxy quality

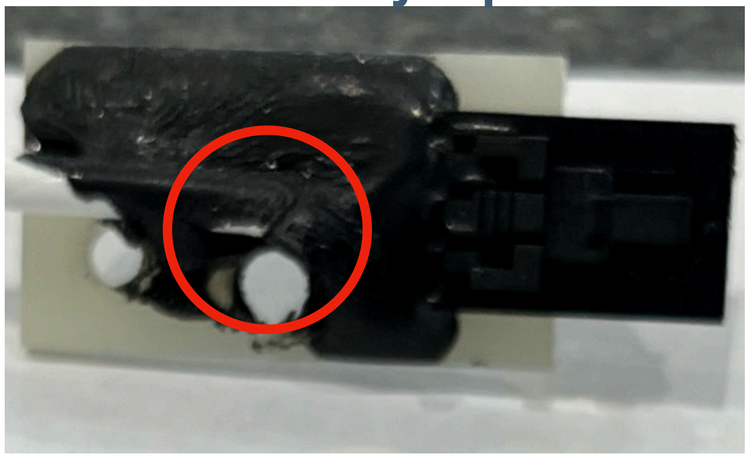
- Epoxy prevents housing the M4 screw head
- **Repair**: remove extra epoxy with a drilling machine
- **Changes in production**: none, a temporary bolt is used when adding epoxy
- **Changes in QA/QC:** mount entire kit

Good

Bad

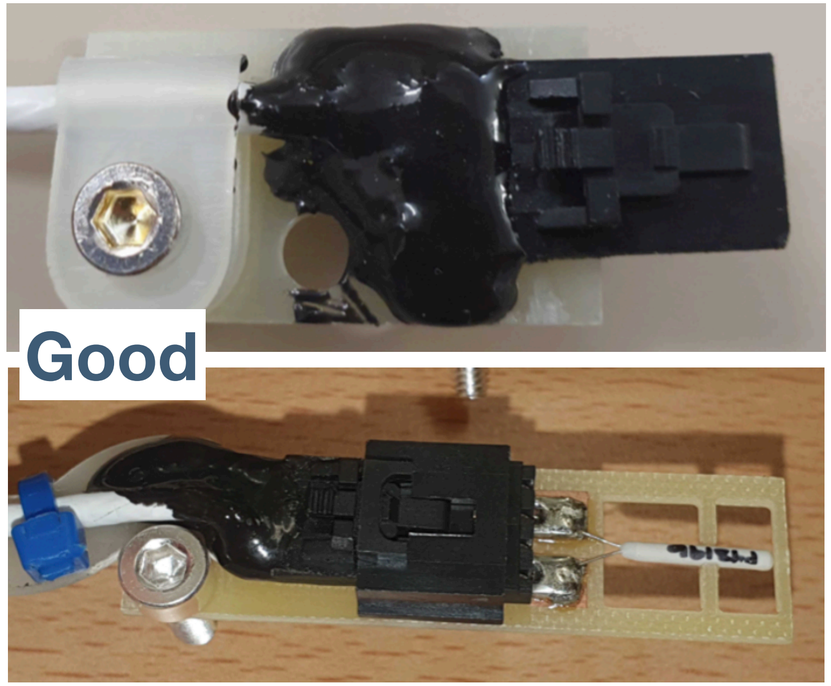


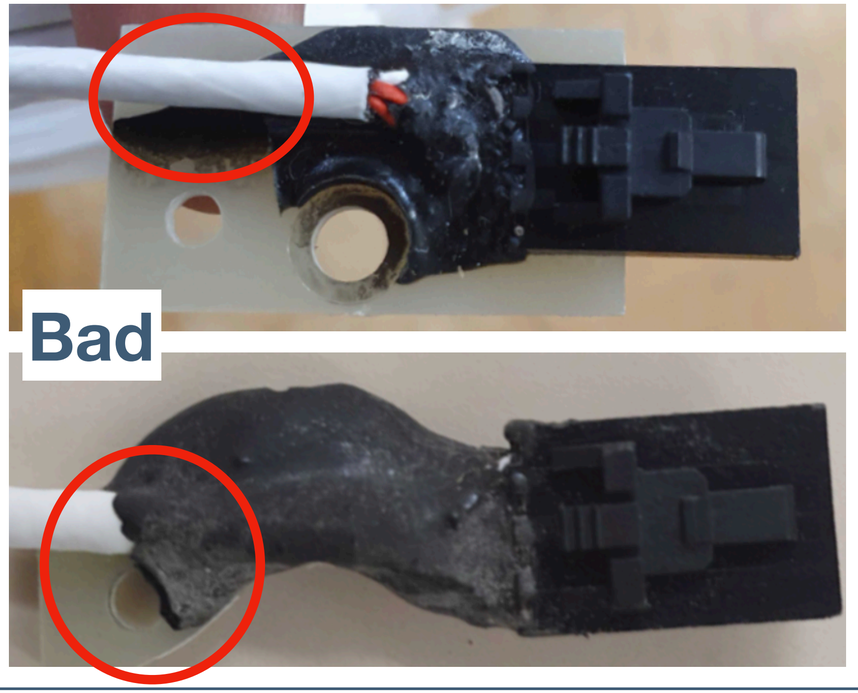
Cable is too close, cannot be easily repaired



Problem 3.d: Epoxy quality

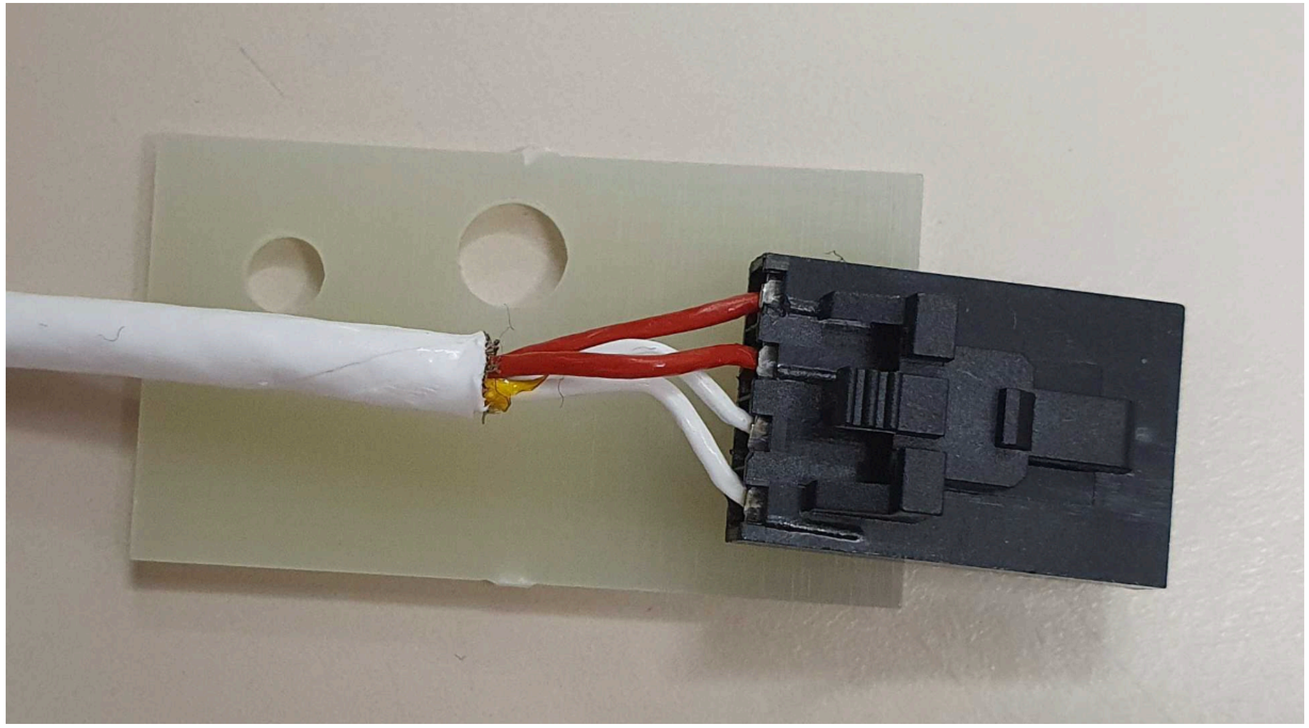
- Epoxy prevents adding the cable clamp/tie
- **Repair**: remove extra epoxy when possible
- **Changes in production**: add cable tie/clamp before epoxying
- **Changes in QA/QC**: make sure cable tie/clamp is present before





Problem 4: Misaligned holes in PCBs

- The IDC-4 female connector is glued with loctite super glue-3 on the cable PCB. This is done manually, and alignment is done by eye

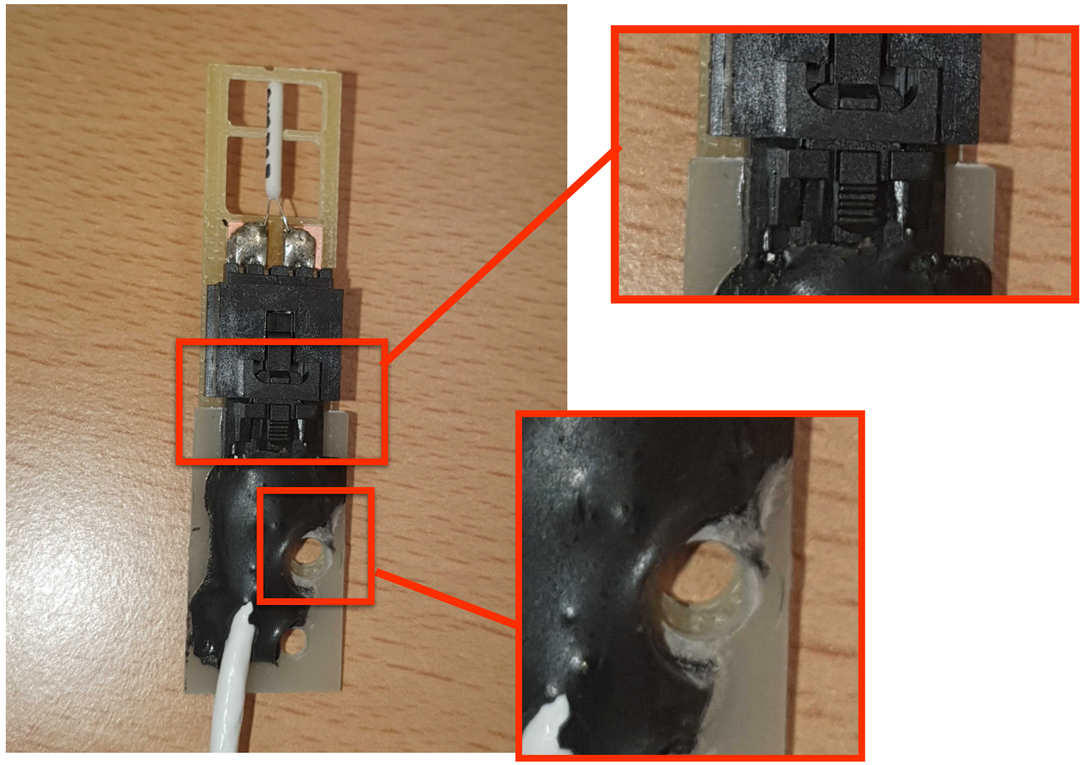


Problem 4: Misaligned holes in PCBs

- In some cases the alignment is not correct and once the sensor is plugged in the holes of the two PCBs doesn't match each other

Good

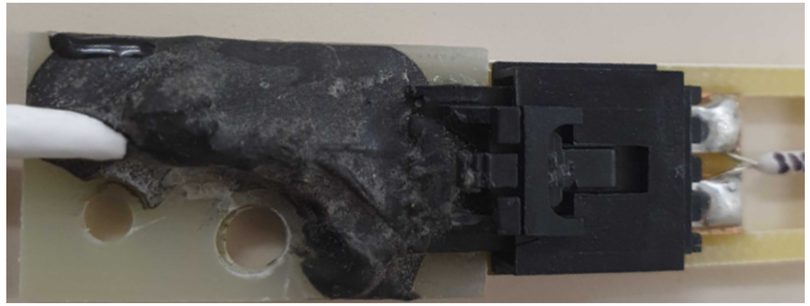
Bad

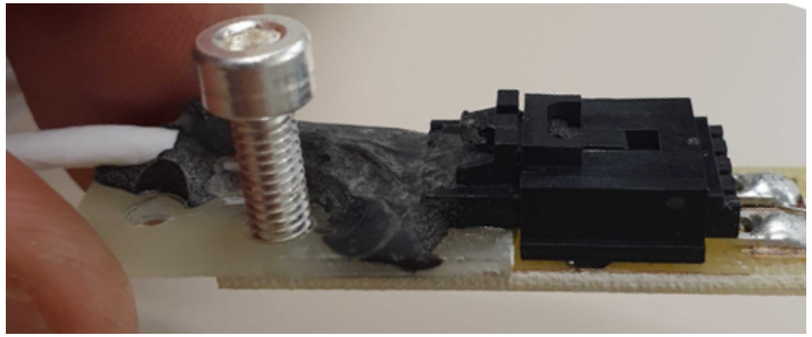


Problem 4: Misaligned holes in PCBs

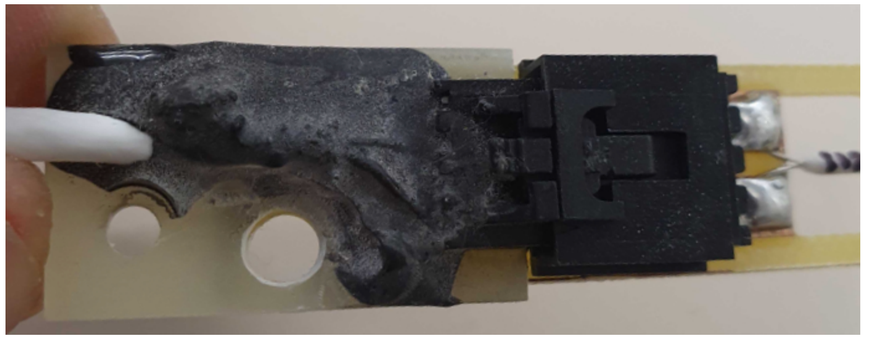
- **Repair**: Use a cylindrical lime to increase the size of hole in lower PCB
- **Changes in production**: A special tool where the cable PCB and the IDC-4 female connector are placed before gluing is been fabricated
- **Changes in QA/QC:** Mount the entire kit

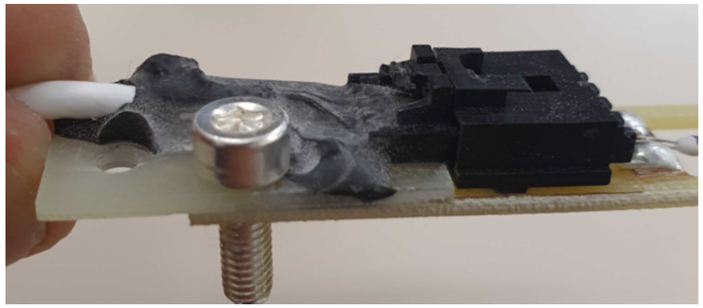
Before





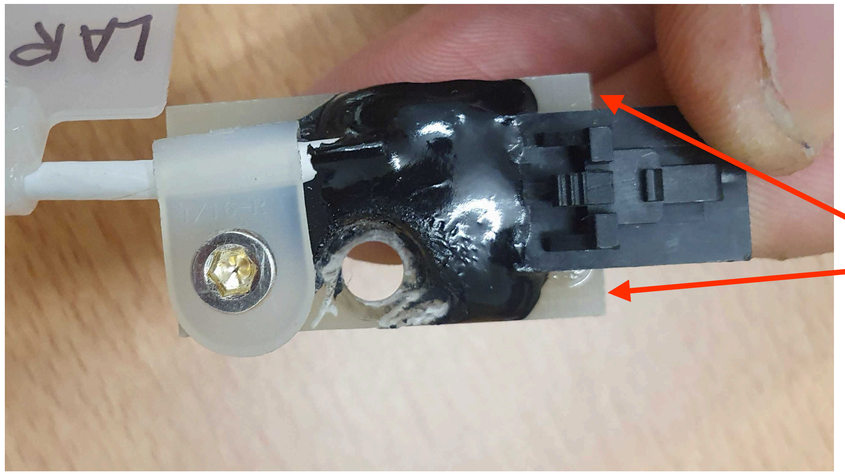
After





Problem 5: Sensor cannot be plugged in

- In some cases the IDC-4 female connector is not correctly placed on the cable PCB (too much inside the PCB) and the sensor cannot be plugged in
- **Repair**: remove FR4 material with flat lime
- **Changes in production**: use new tool to correctly place the IDC-4 connector
- **Changes in QA/QC**: make sure RTD can be plugged in

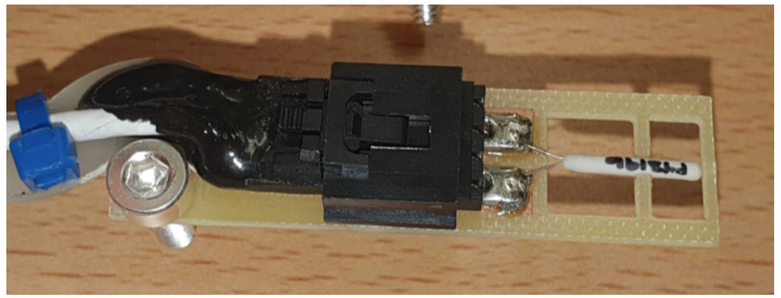


Remove a bit of material in these two points

Problem 6: Cable blocking M4 screw

- For lower APAs there is no hole in the PCB. Instead a narrower PCB with the appropriate curve is used. Sometimes the cable prevents adding the M4 bolt
- **Repair**: There is no quick solution for this. The cable must be cut as close as possible to the edge and a new PCB and connector should be installed
- **Changes in production**: Correctly position the cable before epoxying. Add a bit of loctite super glue to fix the cable
- **Changes in QA/QC:** Mount entire kit with M4 bolt

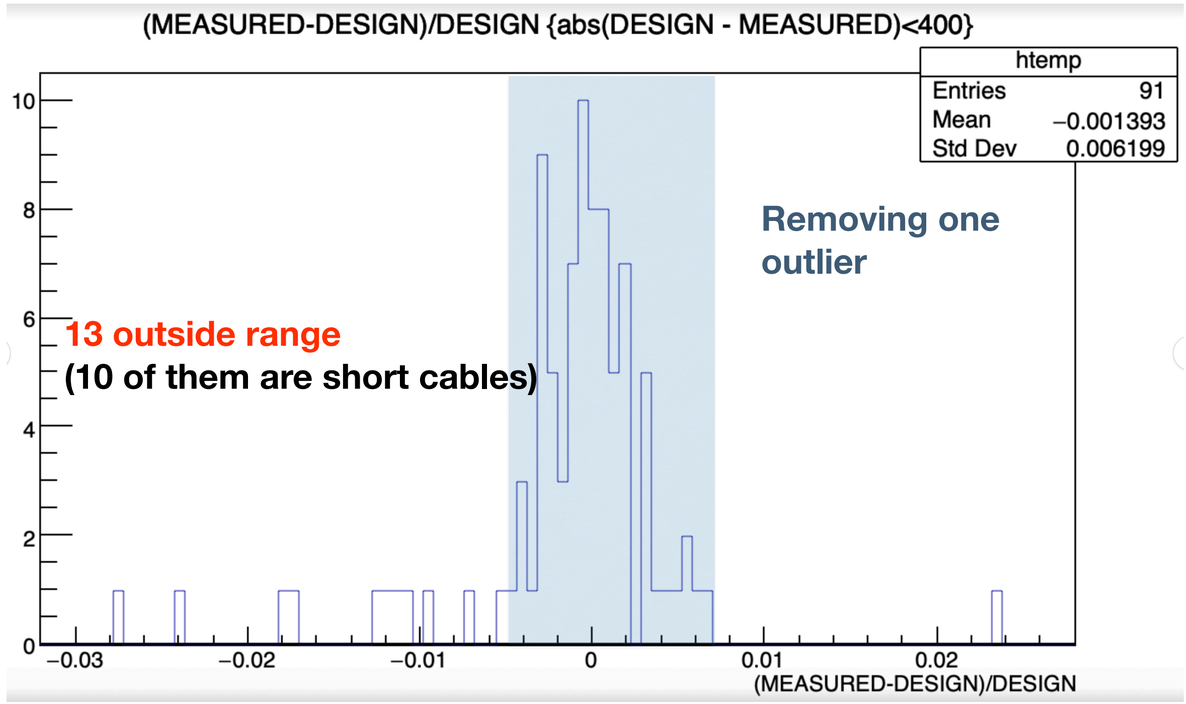
Good

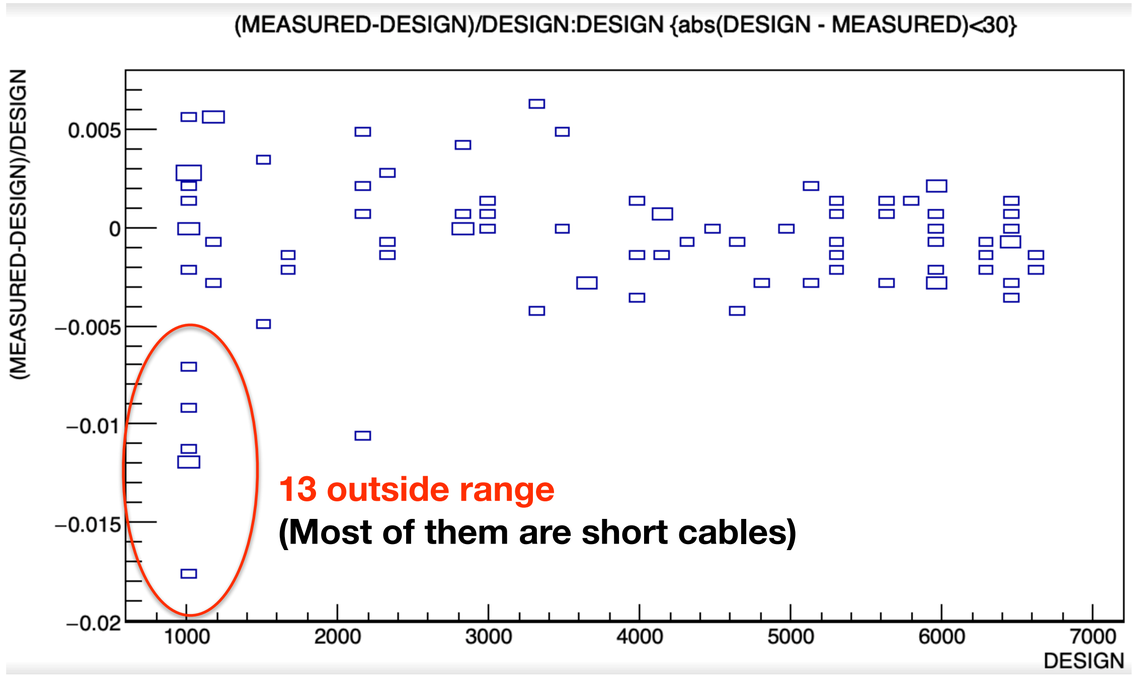


Bad

Problem 7: Cable length

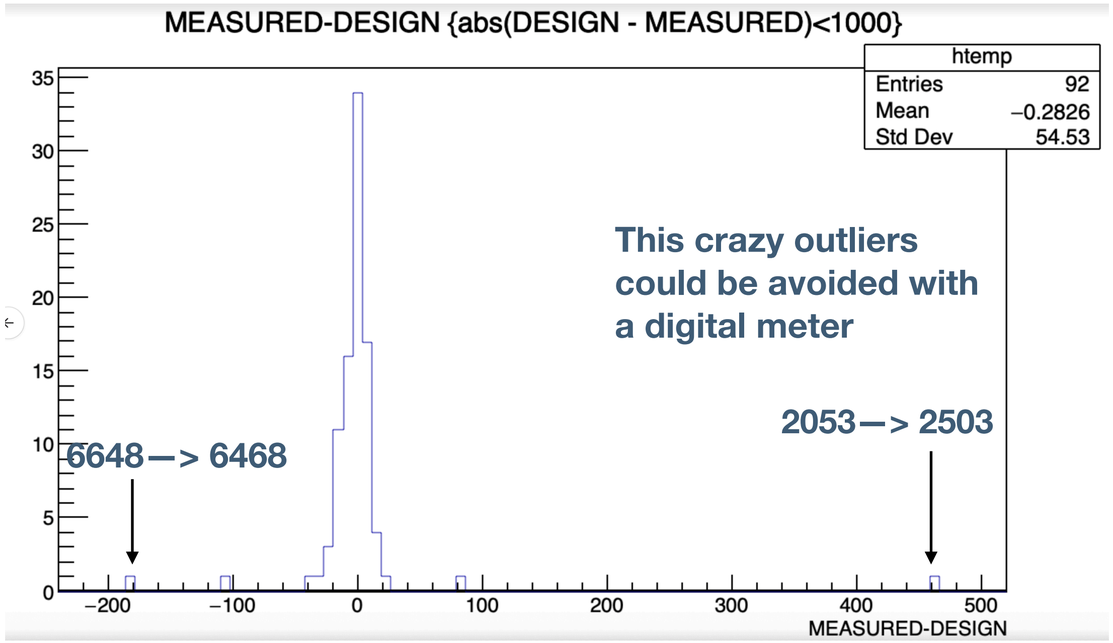
- Cables have 2% slack to account for contraction in cold
- When cutting, we used a 10m long tape measure on the floor
  - 0.5% tolerance is allowed
- We have cross-checked the lengths of 23 APA kits. Results available here

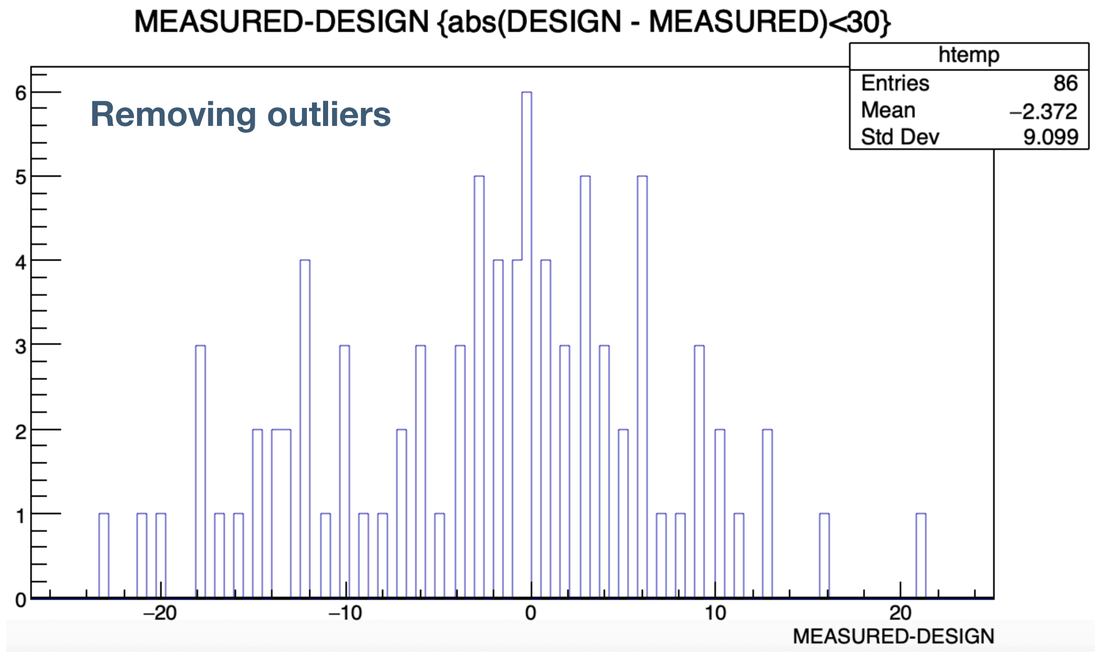




Problem 7: Cable length

- Absolute length





- 9 mm standard deviation on absolute length (removing outliers)
- This can be easily improved with a laser distance meter and better fixing tools

Problem 7: Cable length

- Insufficient QC for cable lengths
- **Repair**: redo cables with lengths outside allowed range
- **Changes in production**: use a laser distance meter and proper fixing tools
- **Changes in QA/QC**: measure cables at several stages during production
  - When cutting them
  - After connectorising
  - Before packaging for shipment

Summary

- All kits will be repaired and send back to production factories ASAP
- New production procedures are being put in place
  - This includes the fabrication of special hardware for aligning elements, epoxying and measuring cable lengths
- New QA/QC procedures are being put in place
  - QA/QC checks will be done several times by different people
  - Tools for electrical tests and appropriate instructions will be provided to production factories