How to glue that!

Lessons learned LHCb VELO upgrade module construction

09-06-2022

Krista de Roo on behalf of LHCb VELO

Krista de Roo on behalf of LHCb VELO

Contents

- Introduction
- VELO detector
- VELO module layout
- Microchannel substrate
- Module construction
- Glue, glue and more glue
- Glue recipe

https://www.youtube.com/watch?v=llC5inFwGUU

VELO detector

- Nominal position within
  5 mm interaction point

- Within beam vacuum, inside
  RF-box

- Total 52 modules;
  26 modules both sides beam

- Power 30 Watt per module

- 2-phase CO_2 cooling at -30°C
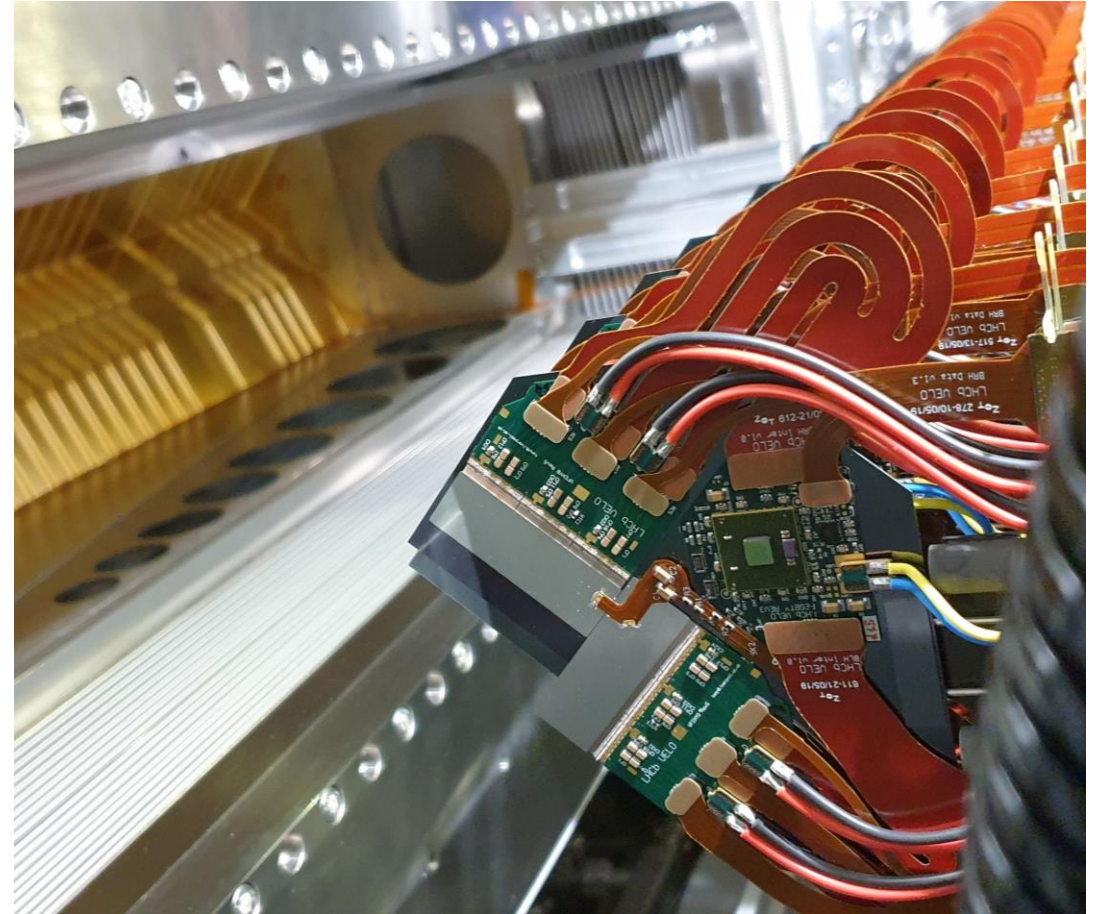
VELO at the moment

**Installation C-side detector
March 2022**

**Installation A-side detector
May 2022**

VELO module layout

C-side

N-side
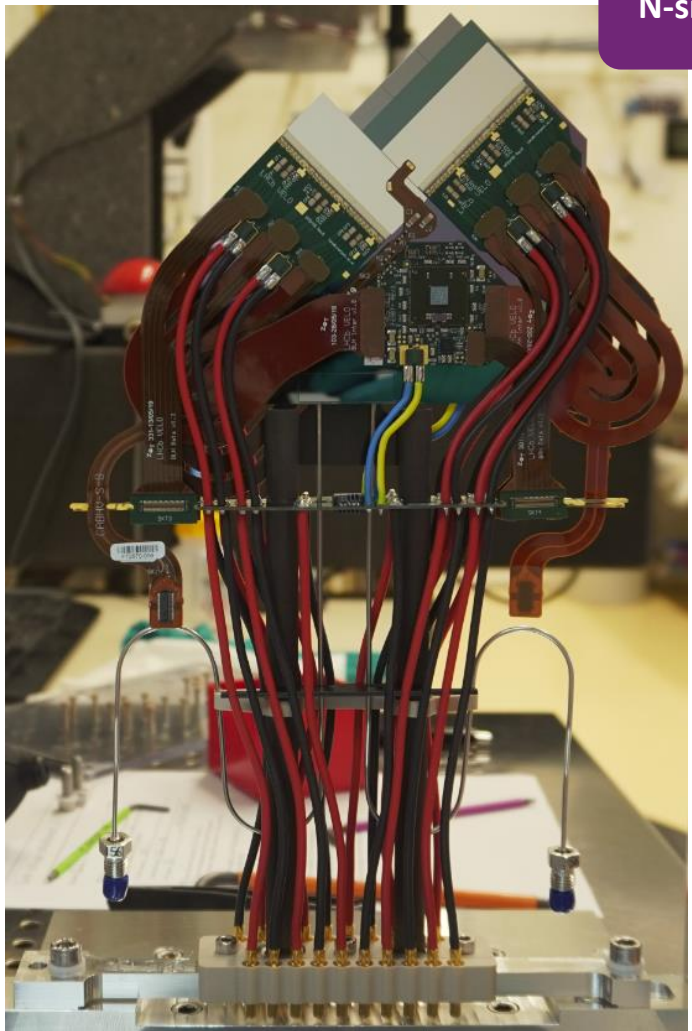
Tile alignment:
30 μm
Temperature gradient:
$\Delta T_{max} = 7\ °C$
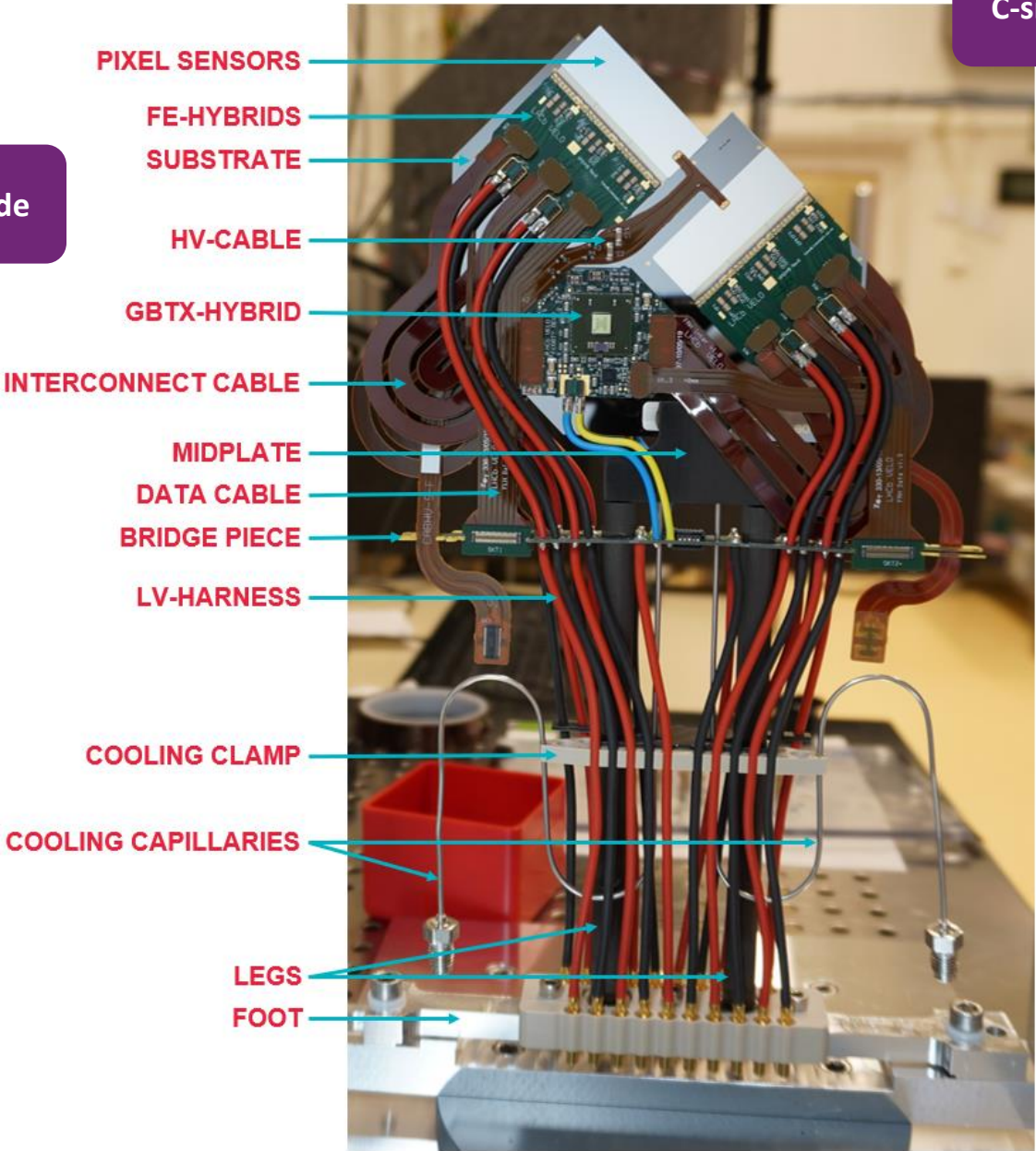Displacement operation:
< 100 μm
Low voltage drop:
LV supply 1.2 to 2.5 V
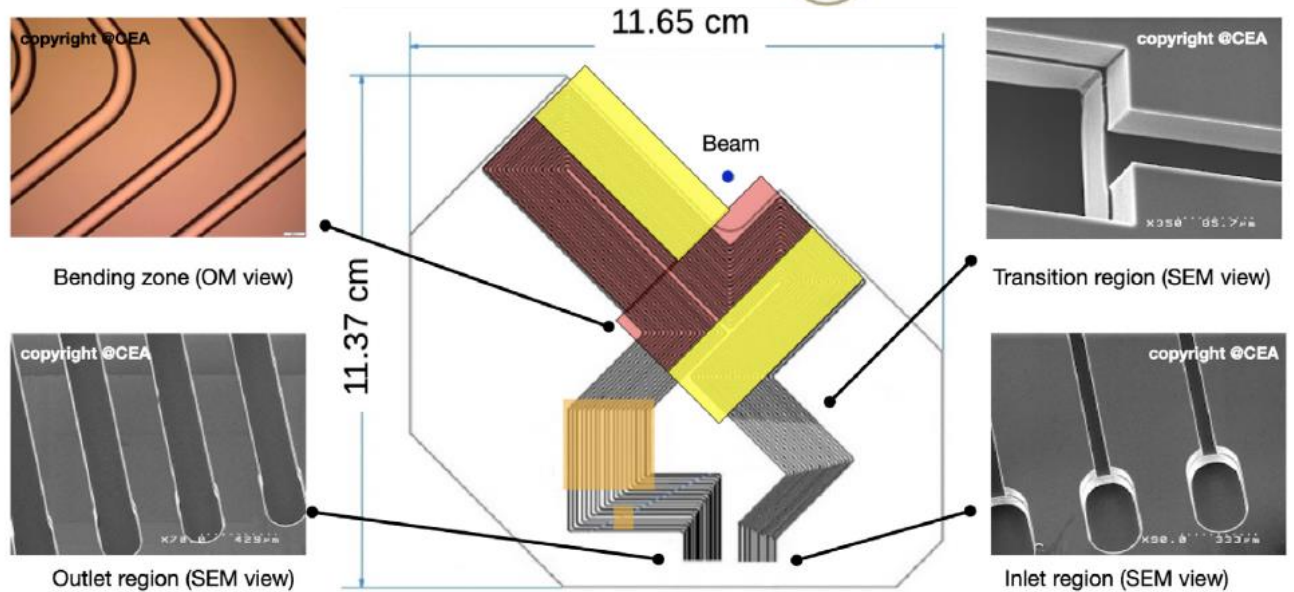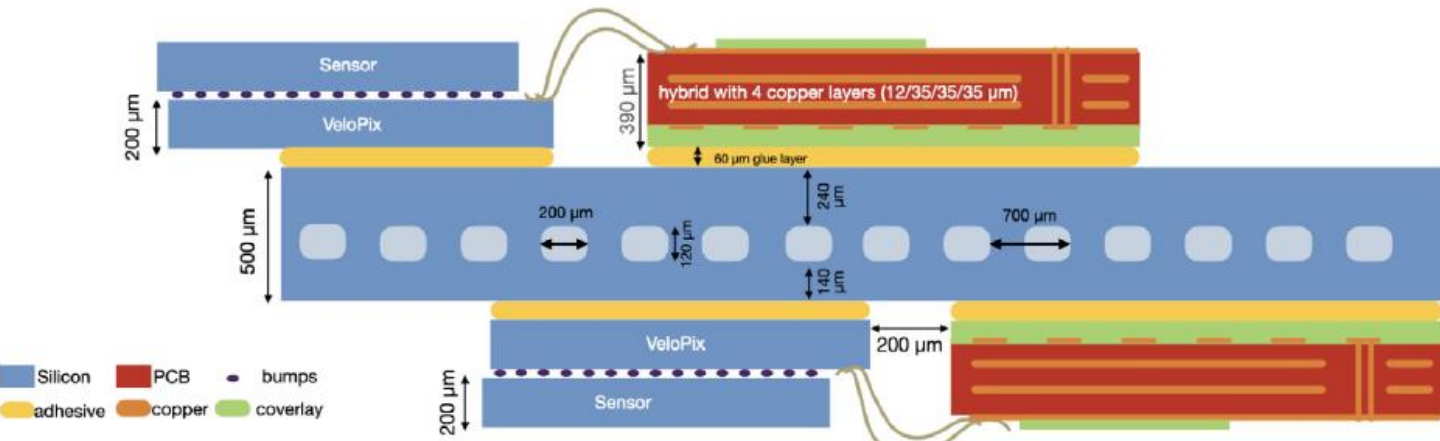High voltage for depletion:
Nominal 140 V

PIXEL SENSORS
FE-HYBRIDS
SUBSTRATE
HV-CABLE
GBTX-HYBRID
INTERCONNECT CABLE
MIDPLATE
DATA CABLE
BRIDGE PIECE
LV-HARNESS
COOLING CLAMP
COOLING CAPILLARIES
LEGS
FOOT

Microchannel substrate

Bending zone (OM view)
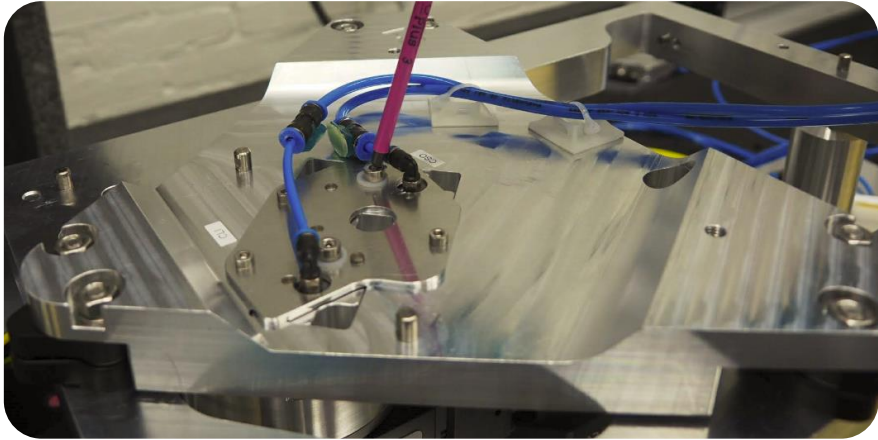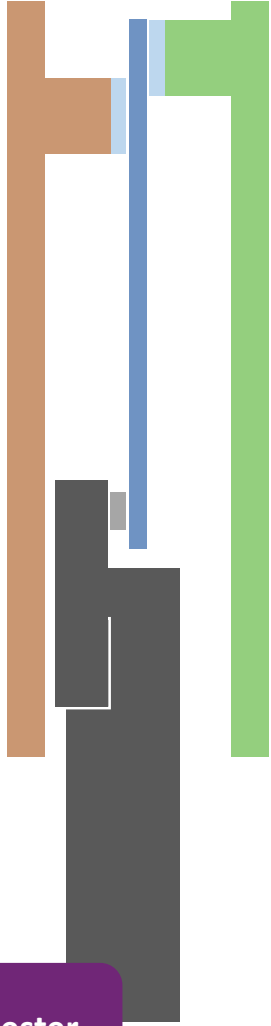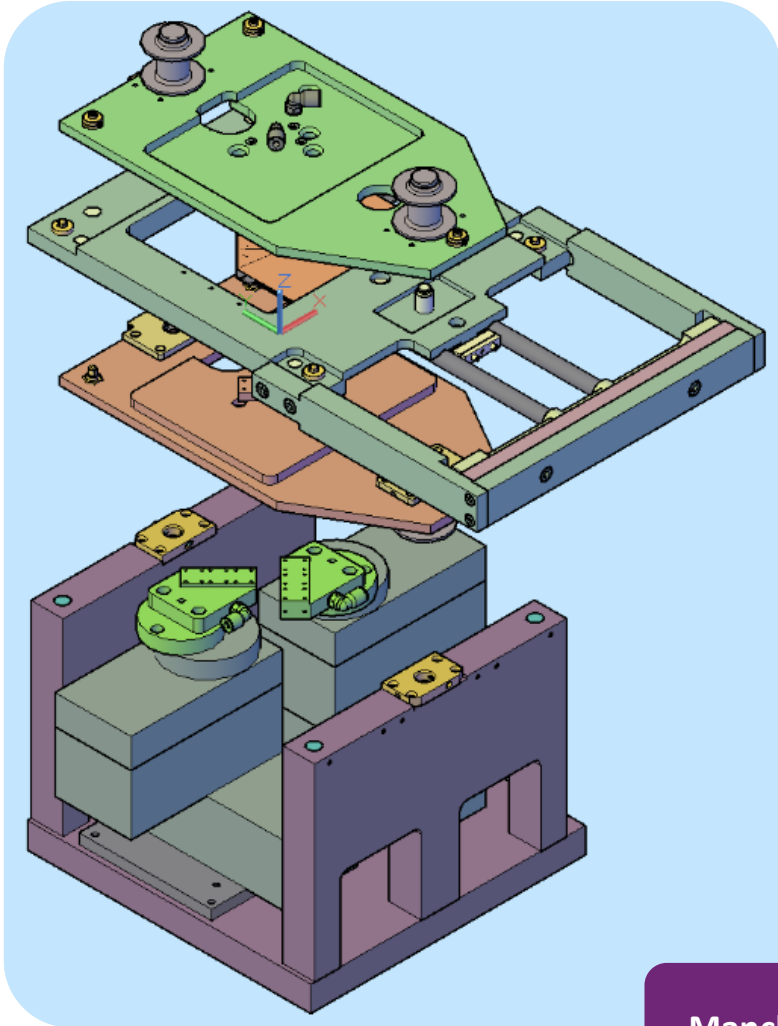
Transition region (SEM view)

Outlet region (SEM view)

Inlet region (SEM view)

Building a module

Bare module

Metrology

Tiles attachment

Metrology

Hybrids attachment

Installation in vacuum tank for testing

Cables attachment

Wires pull-test

Wire-bonding

Metrology

Tile glueing jigs

Manchester

Nikhef

Forum on Tracking Detector Mechanics 2022

Glue requirements

- Glue selected for sensor tiles:
  - Stycast 2850FT catalyst 9
   - ➢ Thermal conductive filler in Stycast
- Glue selected in a later stage for better viscosity properties
  - Stycast 2850FT catalyst 23LV
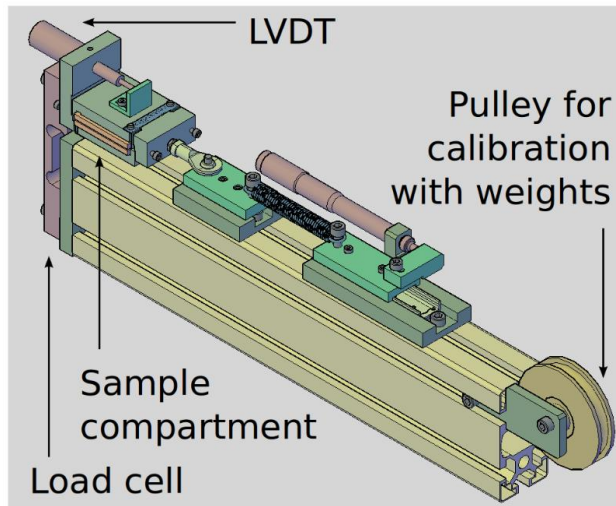
- Adhesive strength
  Tested with Double Cantilever Beam (DCB) tests

- Radiation hardness
  Tested

- Thermal conduction
  Manufacturer specifications and tested with dummy heaters

- Electrical conduction
  Manufacturer specifications

- Outgassing in vacuum
  Manufacturer specifications

LVDT

Pulley for calibration with weights

Sample compartment

Load cell

Glue patterns sensor tiles

- Star pattern with indentations along edges

- Viscosity
  - Needle tip dimensions
  - Needle tip alignment
  - Purge pressure
  - Line speed glue robot
  - Glue thickness
  - Surface coverage

Glue patterns hybrids

- Flexible
CTE mismatch
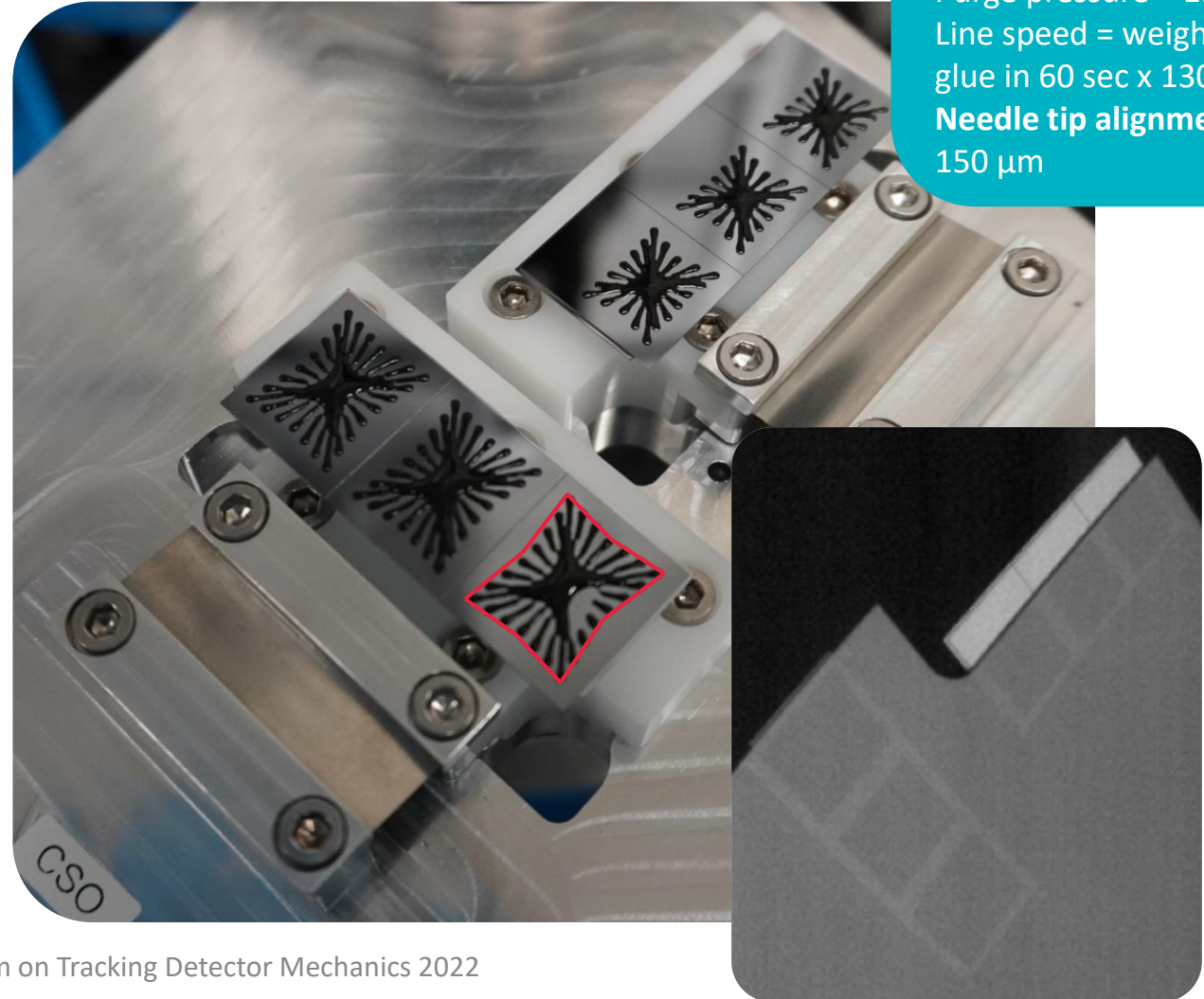
- Glue for hybrids:
  - Loctite 5145
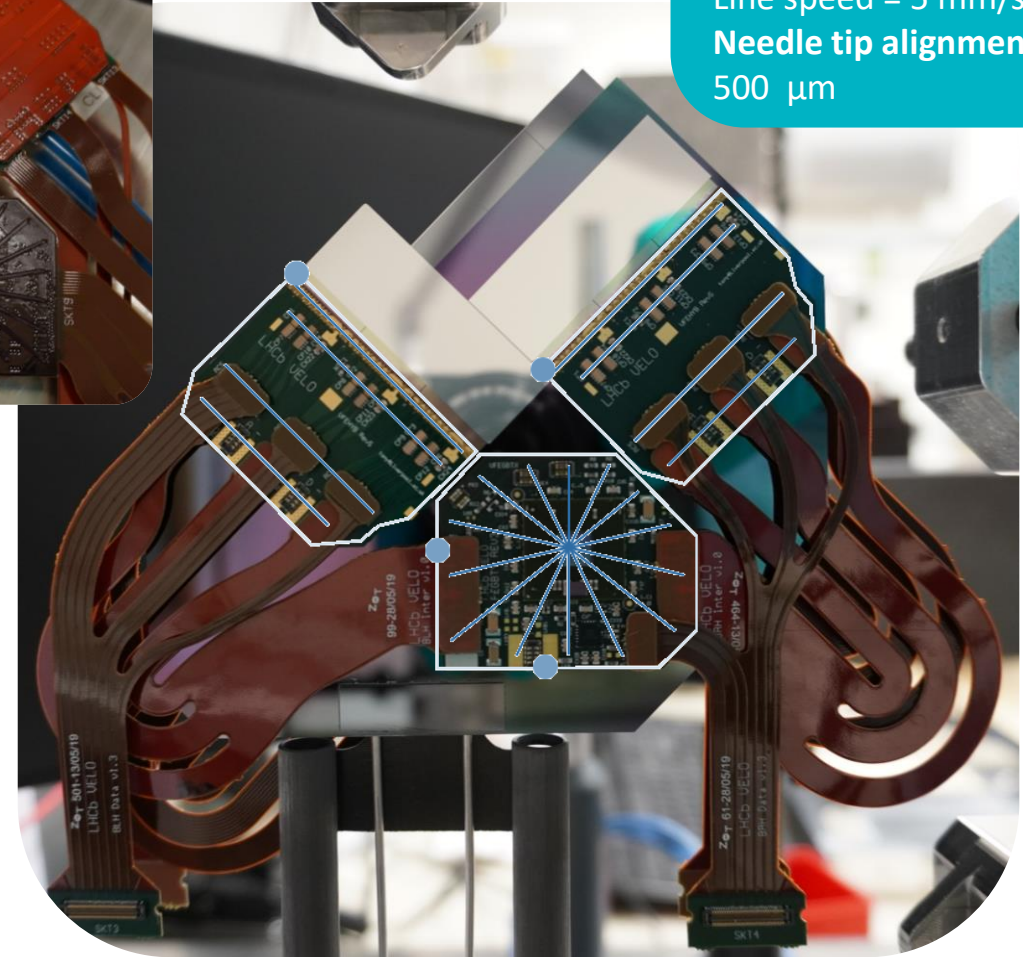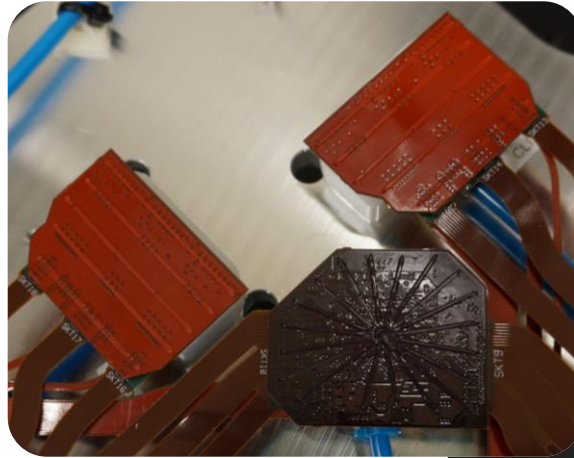
Glue thickness:
100 μm
Needle tip:
18 ga, length 0.5 inch
Glue robot settings:
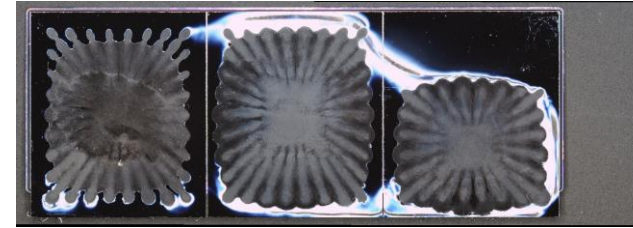Purge pressure = 3.5 bar
Line speed = 5 mm/s
Needle tip alignment:
500 μm

Sticky situation

- Problems NSI tile M76

- Lost adhesion to substrate

- Water layer on thin glue layer causes problems
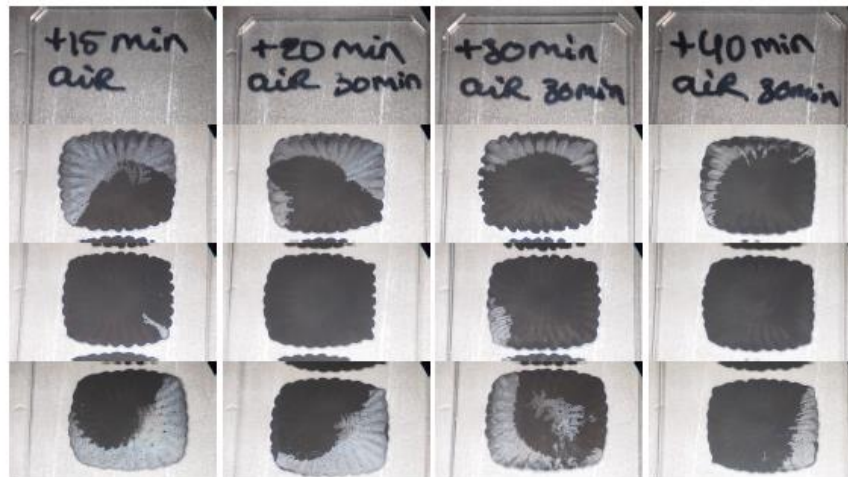
NSI tile from M76

Figure 31: Samples produced at different working points and pressed after 30 minutes in the clean room. Photographed after curing

Figure 32: Samples produced at different working points and pressed after 30 minutes in the clean room. Photographed after curing and ageing for 284 hours at 70°

Heat treatment
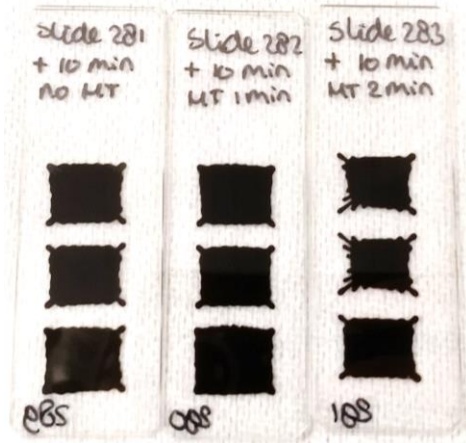
Heat gun settings
Heat gun fan: 10
Temperature: 100 °C
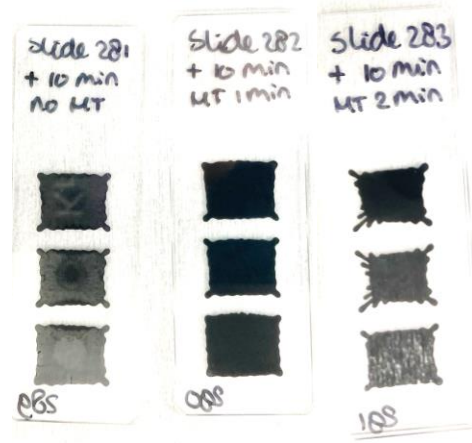Distance nozzle to surface: 55 mm
Surface temperature: 60 °C

- Heat gun with special designed 3D-printed nozzle

- Removes water layer just before glueing
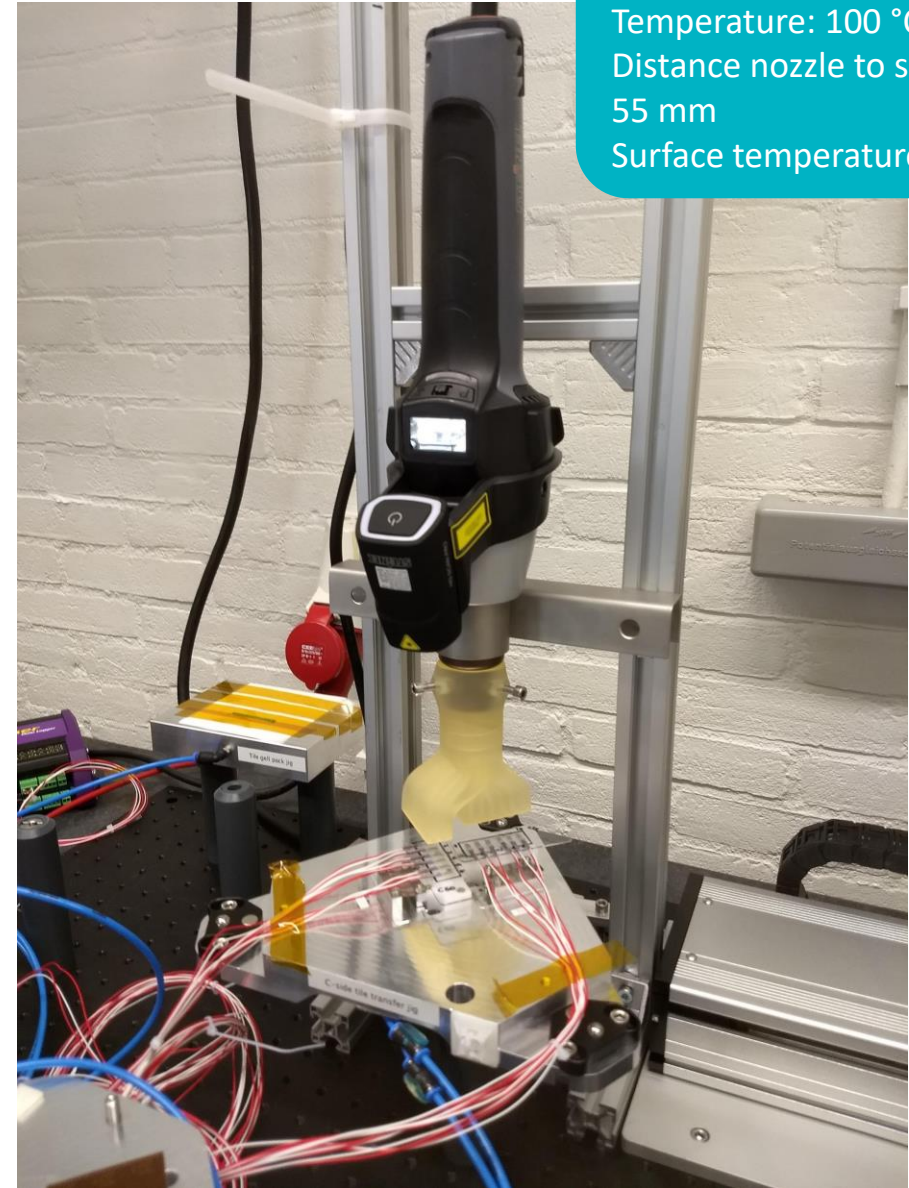
- 1 minute heating has minimal effect on curing time

Samples pressed after 10 minutes in air, with and without heat treatment

Photographed after curing

Photographed after ageing

Glueing recipe

Step 1: Always use quality ingredients

- Contact manufacturer
- Contact safety department

Step 2: Clean the ingredients before starting

- Investigate possible cleaning methods
- Test cleaning methods

Step 3: Always try the recipe before the big day

- Adhesion strength
- Radiation hardness
- Ageing
- Thermal conduction
- Outgassing
- Electrical conduction

Surface cleaning
- Traces from cleaning solvents
- Coolant/grease traces from machining
- Compatibility materials with cleaning solvents
- Time between cleaning and glueing

Questions?

Back-up slides

- Glue robot: Fisnar 5200N

- Glue mixer: Thinky mixer ARE-250

- Heat gun: STEINEL HL-BD75

- https://www.nil.nl/wp-content/uploads/2017/07/VM89-Keuren-van-lijmen-en-lijmverbindingen.pdf

- https://cds.cern.ch/record/2229009/files/LHCb-PUB-2016-026.pdf

- https://www.research.manchester.ac.uk/portal/files/174357740/IEEE_Svihra_Design_and_Construction_of_LHCb_VELO_modules_v1.pdf

- https://cds.cern.ch/record/2806219/files/CERN-THESIS-2021-309.pdf?version=1

- https://indico.cern.ch/event/724616/contributions/3034494/attachments/1686973/2713085/ManchesterAssembly.pdf

- https://indico.cern.ch/event/849967/.

- https://cds.cern.ch/record/1624070/files/LHCB-TDR-013.pdf

- https://indico.cern.ch/event/825588/contributions/3457049/attachments/1860525/3057530/Site_PRR_Nikhef_-_Bare_Module.pdf

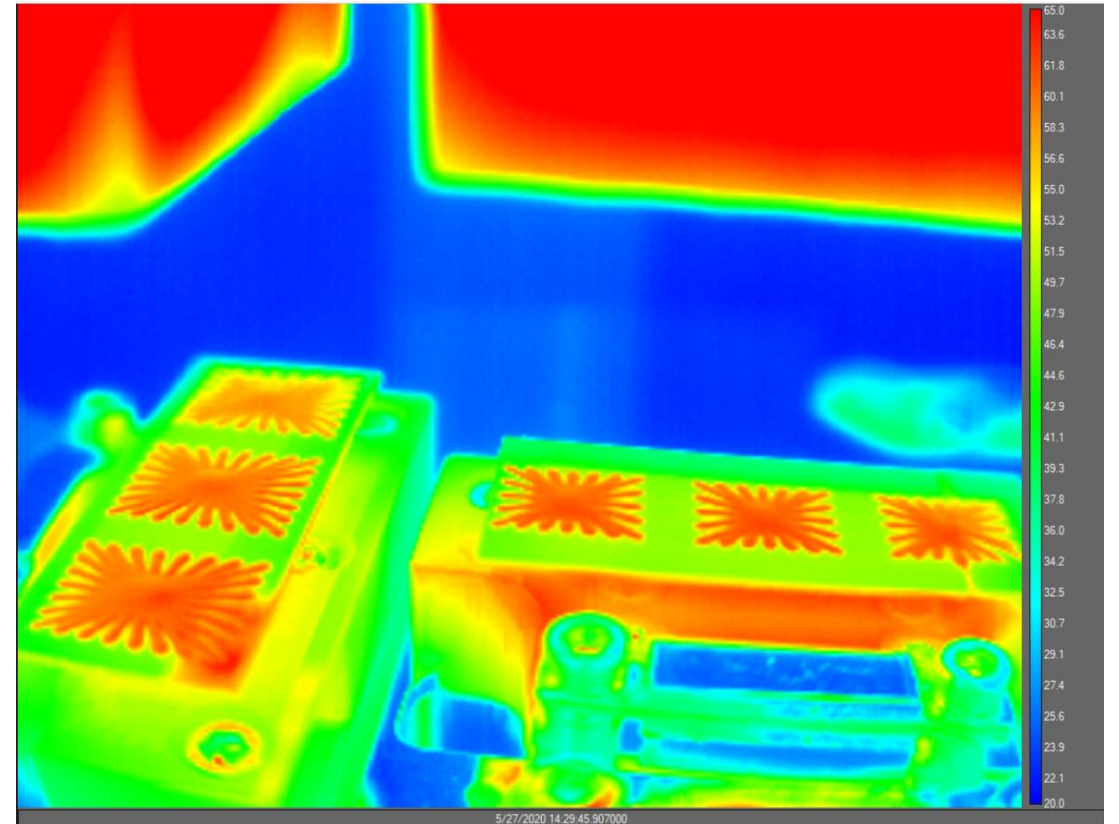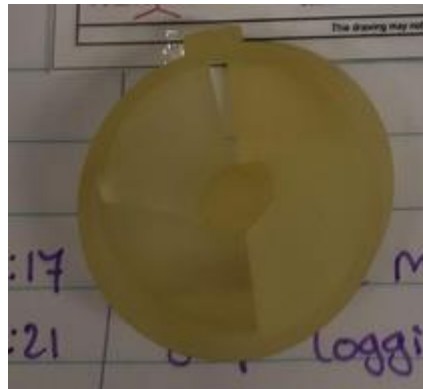- https://doi.org/10.1016/j.nima.2022.166874

Back-up slides: Heat gun nozzle

- Diffuser for forced partial flow to outer channels of heat gun nozzle

- Restrictor compensates resistance differences due to channel lengths

Restrictor

Diffuser

Back-up slides:
# Needle tip alignment & Water accumulation

- Due to the viscosity of the glue, threads are created when the distance between the surface and the needle tip is too large. In order to create the desired glue pattern, the needle tip is aligned close to the surface. Experience taught that half the diameter of the needle tip is a good working distance between surface and the needle tip. Unfortunately the average needle tip length nor angle is manufactured with this precision and thus the alignment of the glue robot, and thereby each needle tip, relative to the sensor tiles surfaces is an important part of the glue procedure.

- Because the glue lines are originating from the centre of the ASIC, the glue thickness isn't perfectly even. For this the line speed of the glue robot should be a function of the distance to the centre, which is too difficult to program for this purpose.
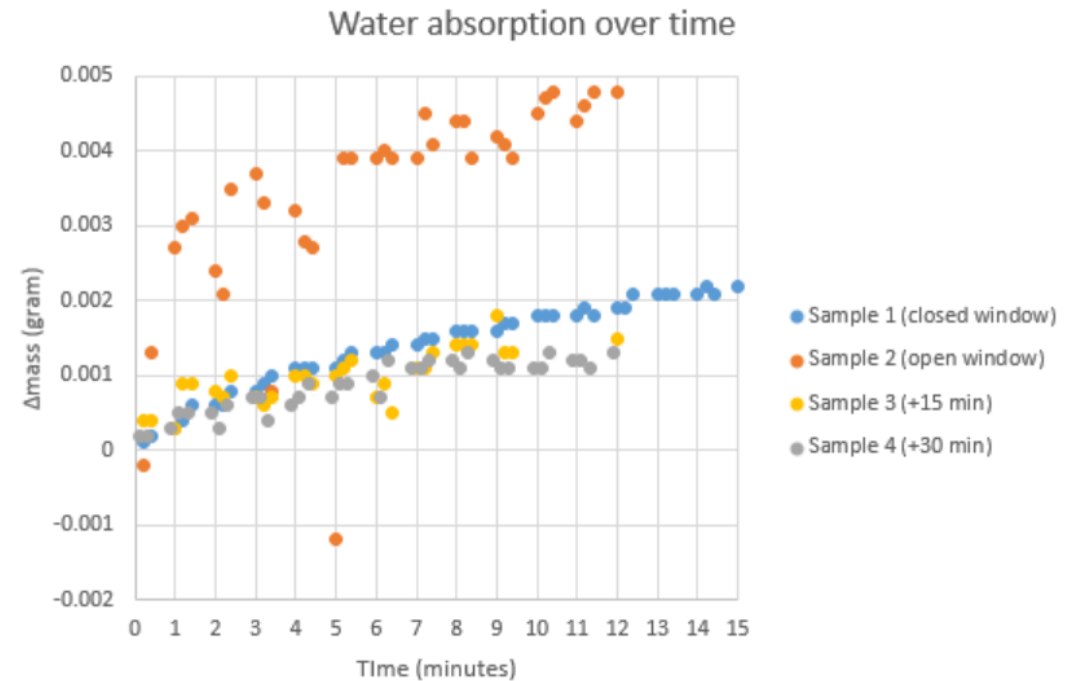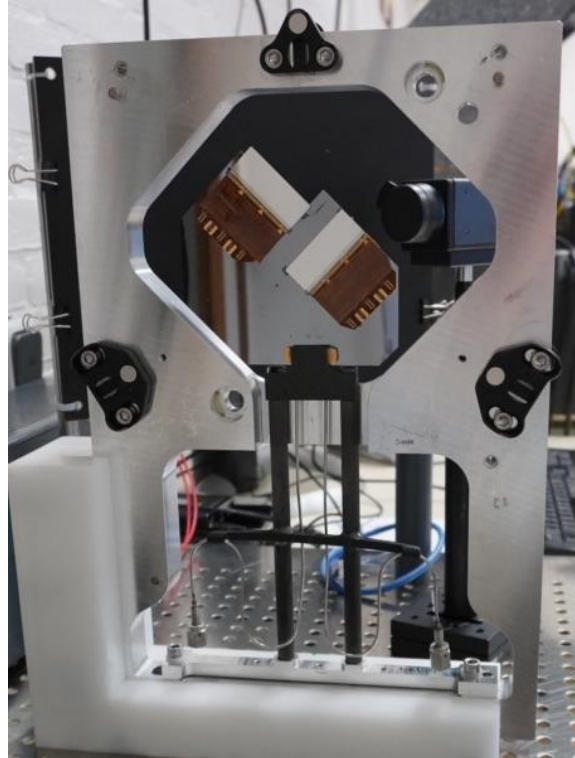

The graph shows that for a glue pattern sample, the weight of the sample increases over time. The increase is caused by accumulation of water on the glue layer applied.
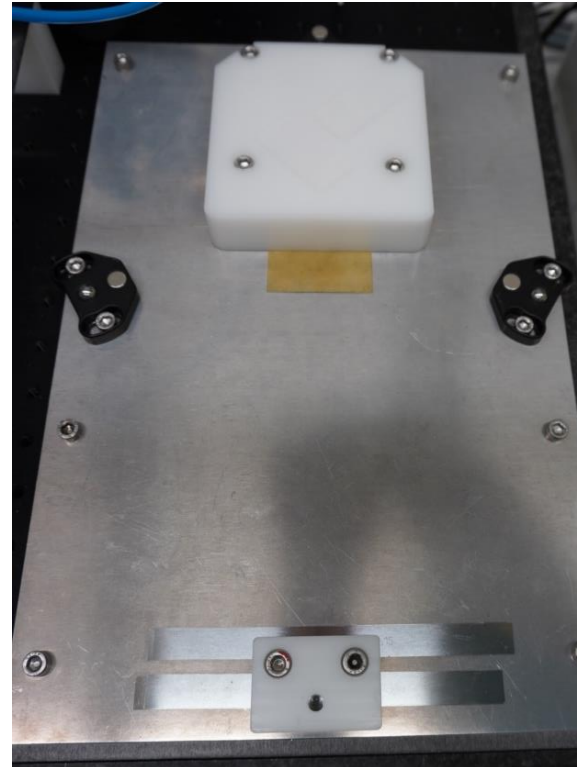
Back-up slides:
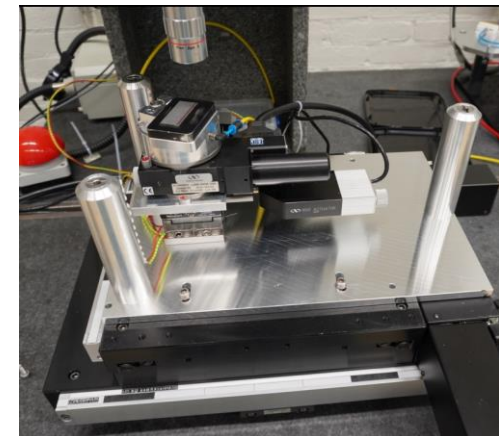# Bare module and tile glueing jigs

Bare module jig
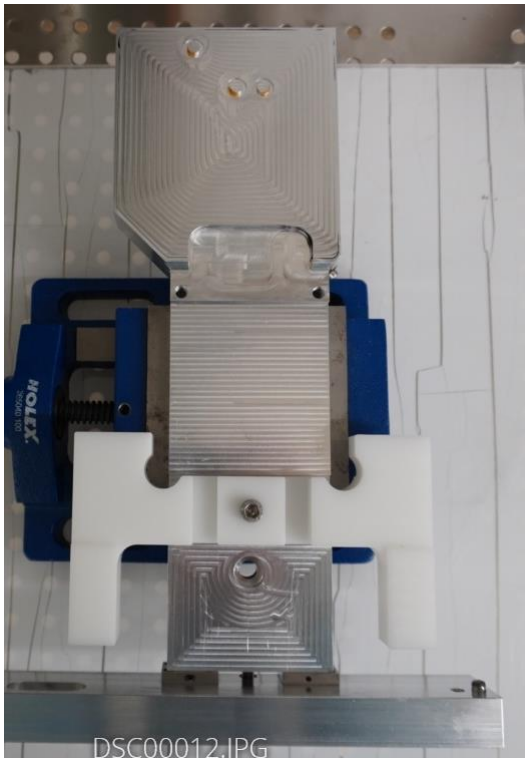
Tile turn jig
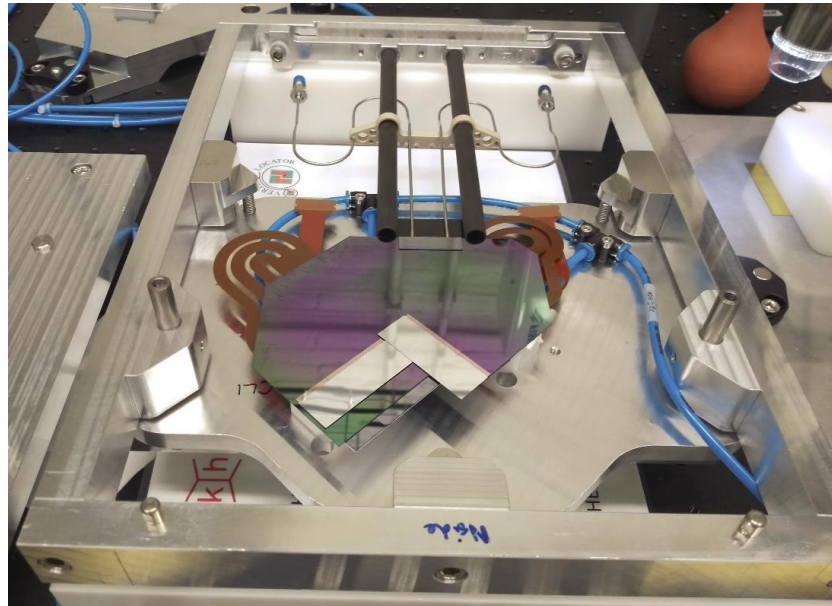
Tile glueing support jig

Tile transfer jig

Pick & Place Machine

Back-up slides:
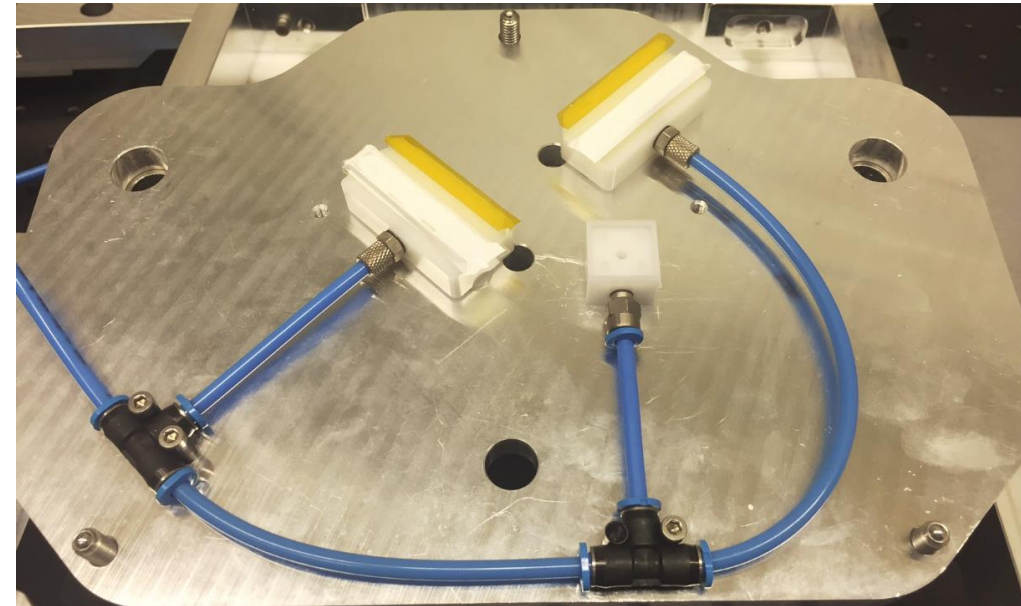# Module hybrid glueing jigs

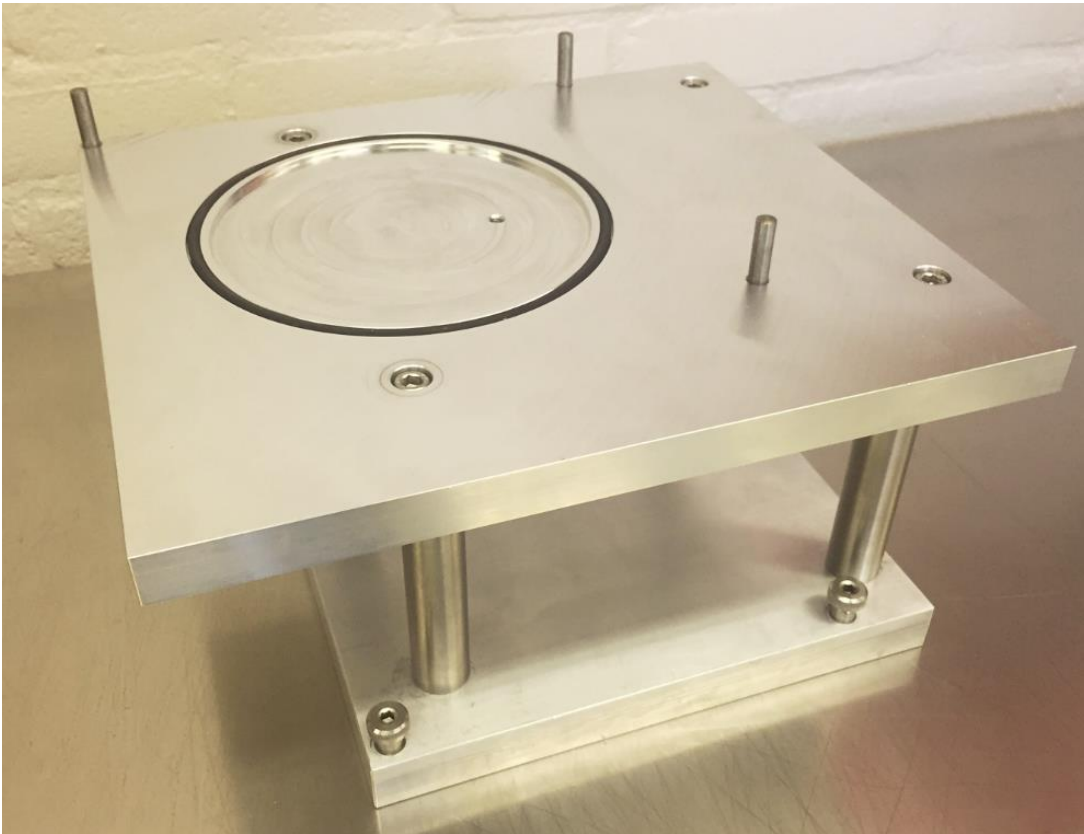Hybrid alignment jig

Hybrid turn jig

Hybrid transfer jig

Back-up slides:
Wire bond and vertical jigs

Wire bond jig support for wire bond machine

Wire bond jig

Vertical jig