Karlsruhe Institute of Technology

Baseplate Production Overview

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Centralized conventions and requirements

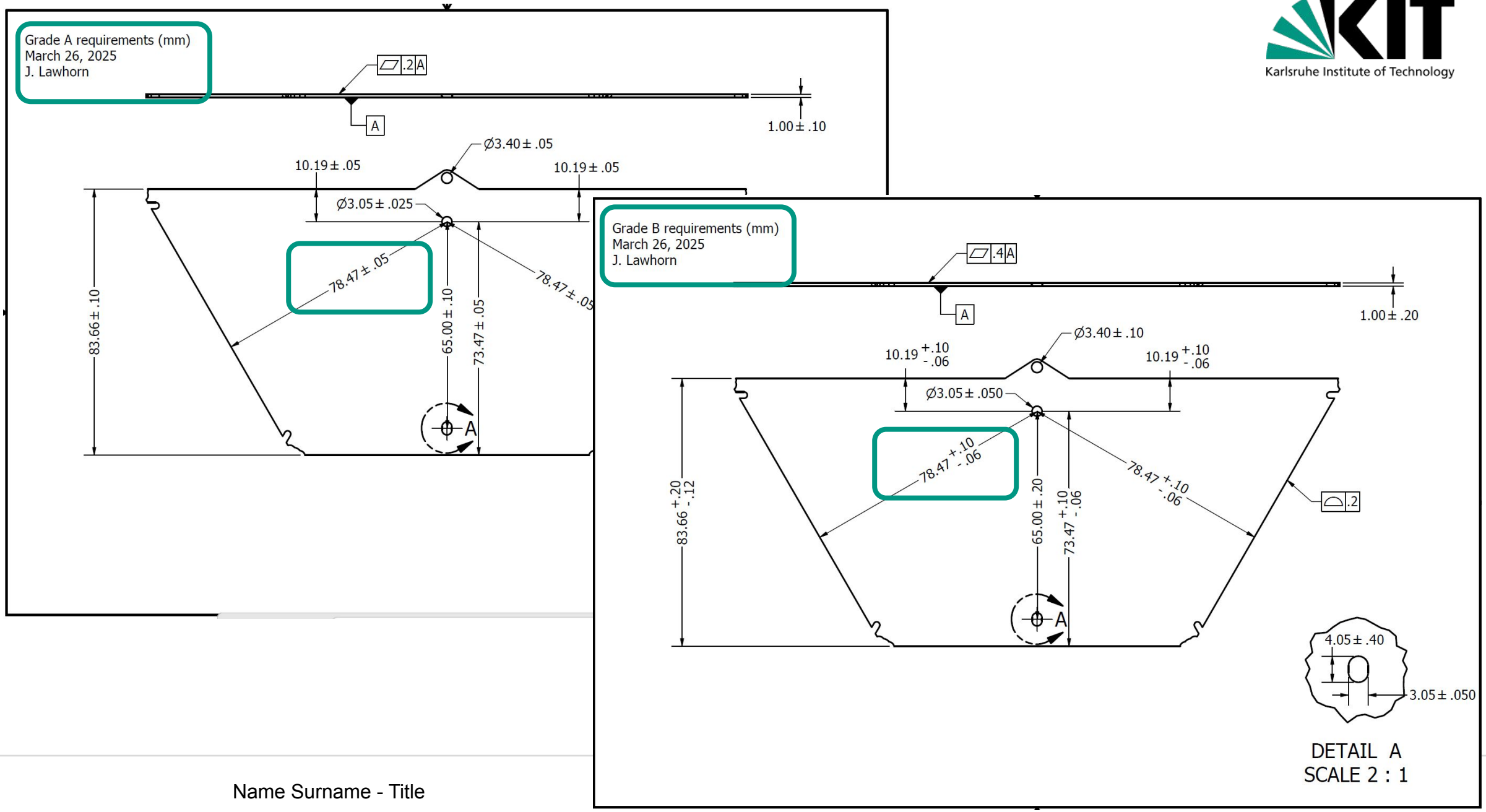
Naming conventions

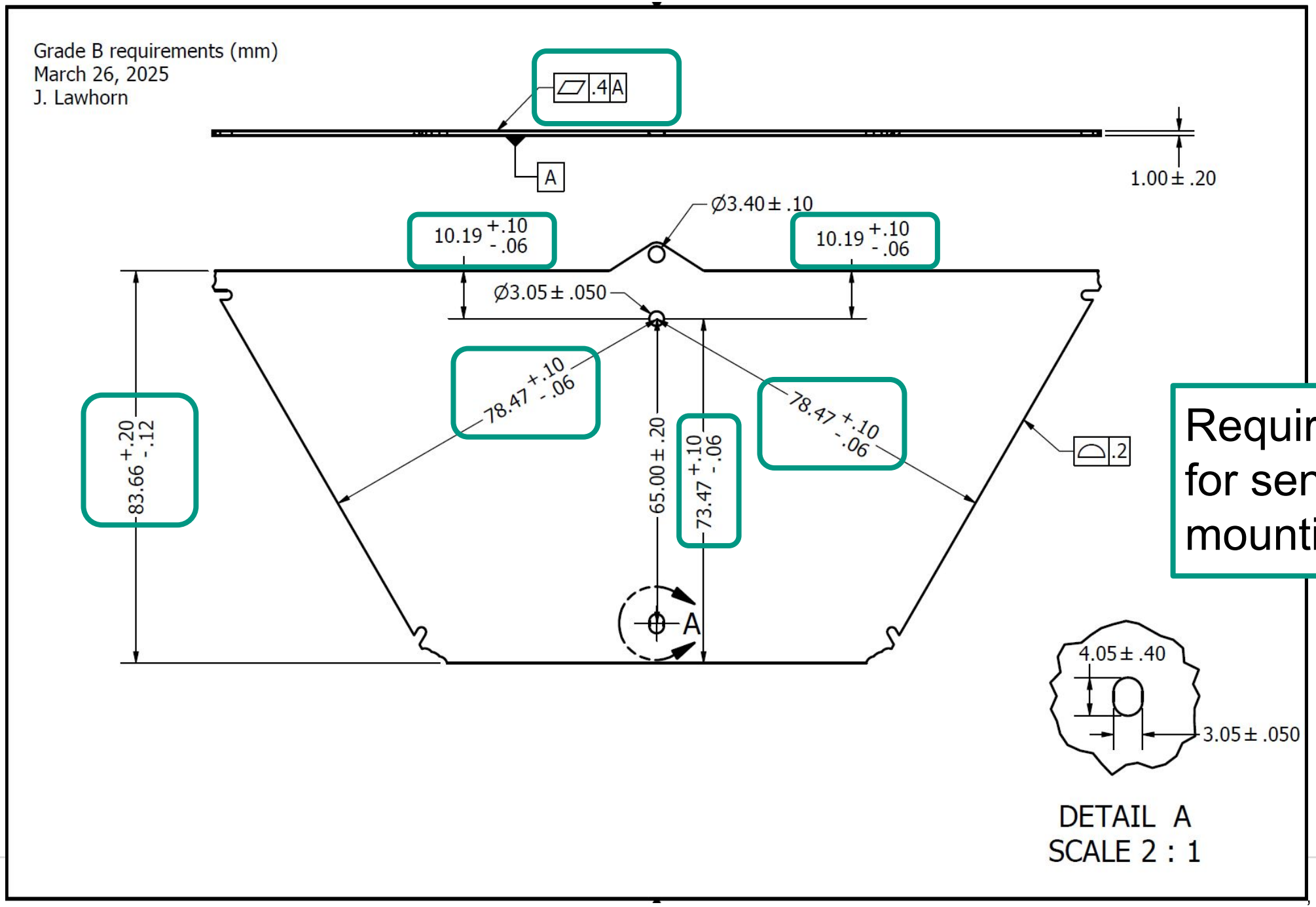
- 320BAXYZMMxxxxx
  - BA = baseplate
  - X is for cut type
    - B (Bottom), F (Full), L (Left), R (Right), T (Top), 5 (Five)
  - Y is for density
    - H (HD) or L (LD)
  - Z is for material
    - T (Titanium), W (CuW)
  - MM gives the production site
    - II = IIT Madras (KA = KIT, IH = IHEP, CI = CIEMAT)
  - xxxxx is the serial number
- Full definition in EDMS

- *Each piece must have a unique serial number*
  - *QR code included in the bag, but not attached to the baseplate or bag itself (per MAC request)*

Specifications and Tolerances

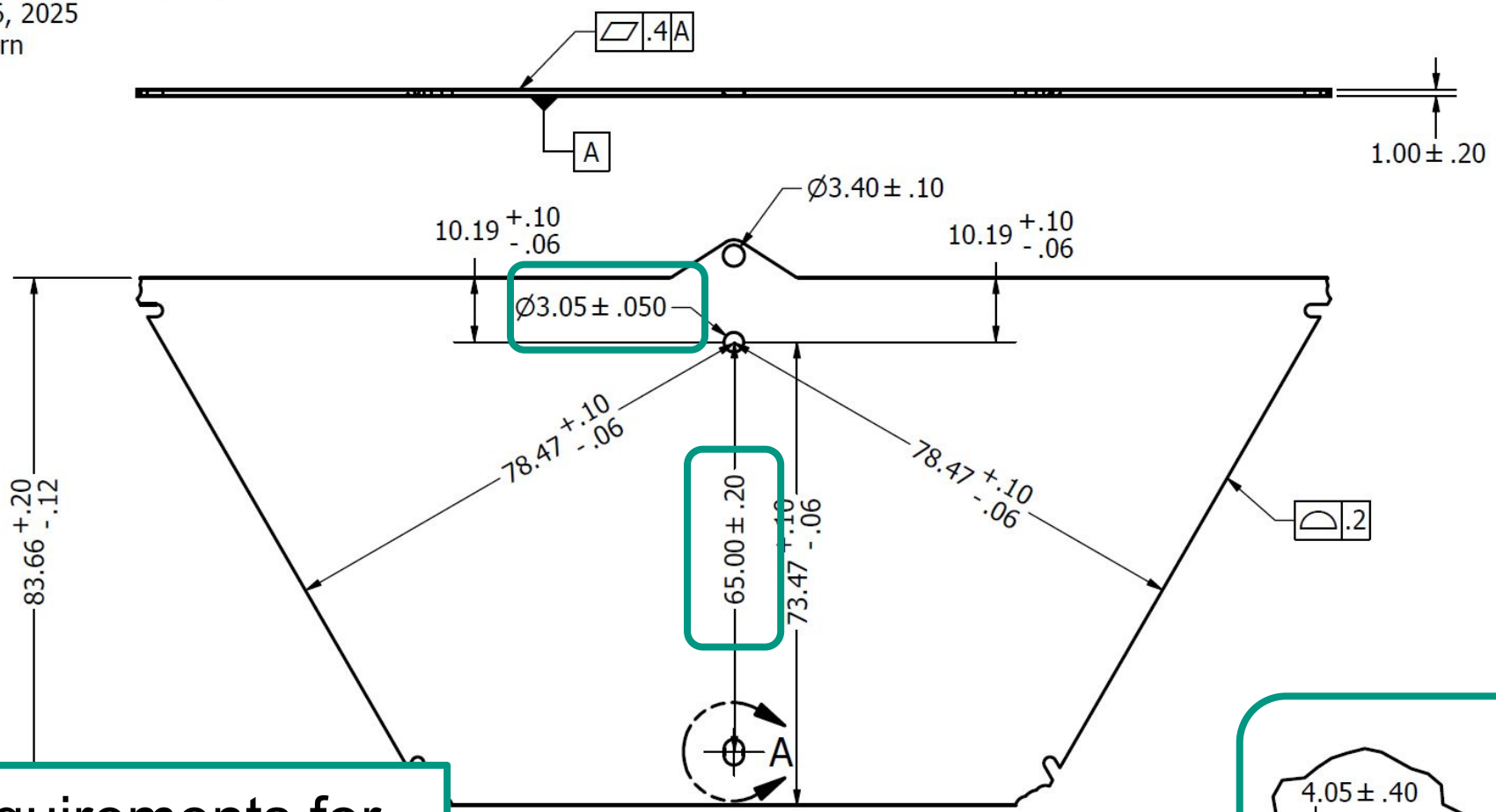
- Newest titanium baseplate drawings in EDMS (revision D)
- QC tolerances are not reflected entirely by EDMS drawings, find them in CERNBox
  - Defined with help from Susanne Kyre (UCSB) and Zoltan Gecse (FNAL)
- Three grades: A, B, C
  - A, B are acceptable for module assembly
  - C is not
- The overall grade is defined by the worst measurement grade


Grade A requirements (mm)
March 26, 2025
J. Lawhorn
.2 A
A
1.00 ± .10
Ø3.40 ± .05
10.19 ± .05
10.19 ± .05
Ø3.05 ± .025
78.47 ± .05
78.47 ± .05
83.66 ± .10
65.00 ± .10
73.47 ± .05
A
Grade B requirements (mm)
March 26, 2025
J. Lawhorn
.4 A
A
1.00 ± .20
Ø3.40 ± .10
10.19 +.10 -.06
10.19 +.10 -.06
Ø3.05 ± .050
78.47 +.10 -.06
78.47 +.10 -.06
83.66 +.20 -.12
65.00 ± .20
73.47 +.10 -.06
.2
A
4.05 ± .40
3.05 ± .050
DETAIL A
SCALE 2 : 1

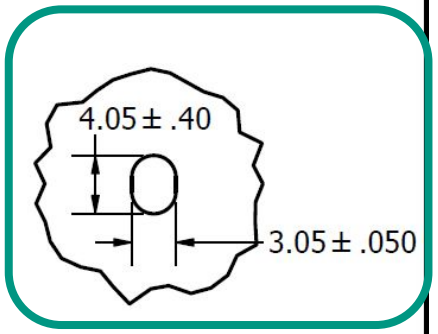


Requirements to for sensor mounting

Grade B requirements (mm)
March 26, 2025
J. Lawhorn

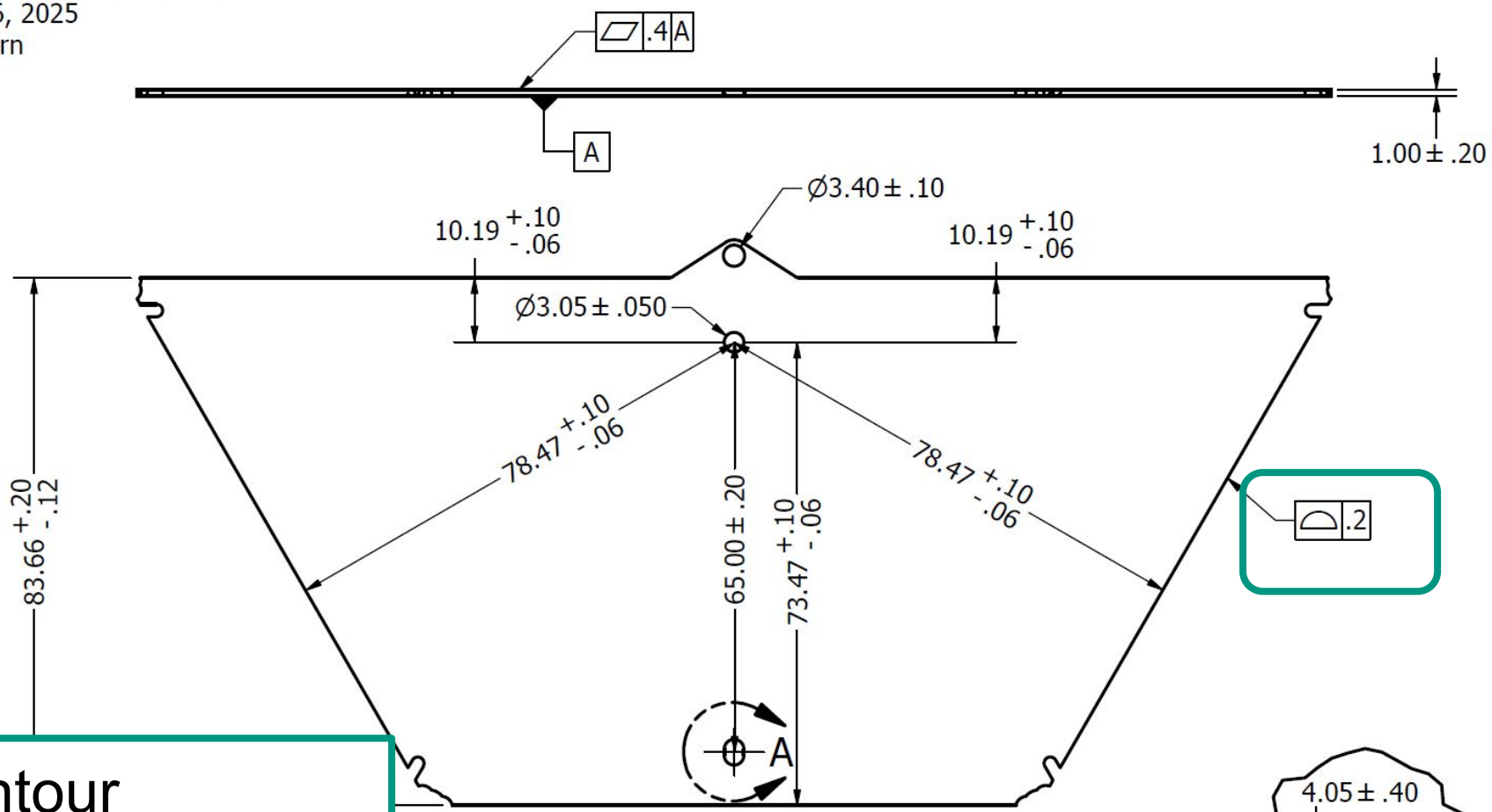


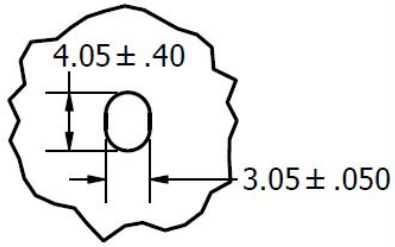
Requirements for alignment during module assembly



DETAIL A
SCALE 2 : 1

Grade B requirements (mm)
March 26, 2025
J. Lawhorn





DETAIL A
SCALE 2 : 1

Contour tolerance for cassette assembly (NEW)

Specifications and Tolerances

- Radius and edge-to-edge widths are important for Silicon mounting — too small and the Si is unsupported on the edges; too big and the kapton will not fully cover metal surface
- Hole and slot are used for MAC assembly alignment; size and relative position in the baseplate are important
- Contour for cassette assembly — fixing the modules to the cooling plate

CMS Database and tracking

- Each site needs one or more database operators
  - Instructions for getting started
- Jay is the baseplate part DB contact; definition of QC table contents
- Two places things need to be uploaded: parts list, and QC tables
- Any shipments need to be recorded in the shipment tracking tool
  - Parts uploaded to the database will appear for inclusion in a shipment
  - Each site need a shipment contact

New Parts Table

xml field	definition	example
KIND_OF_PART	full list here	CuW/Kapton Baseplate LD Full
SERIAL_NUMBER	same as BARCODE	320BAFLWKA00026
BARCODE	as explained previously	320BAFLWKA00026
LOCATION	place it is physically located now	KIT Baseplate
INSTITUTION	institution the location is in	KIT
MANUFACTURER	place the baseplate was cut	KIT, IIT, CIEMAT, or IHEP
PRODUCTION_DATE	date and time of lamination	2024-03-12 12:03:00

- Baseplate must exist as a part before QC data can be uploaded, or included in a shipment
- Copied from confluence page

QC Table

DB name	Description
WEIGHT_BARE	weight of bare baseplate in g
~~WEIGHT_LAM~~	~~weight of laminated baseplates in g~~
THICKNESS	average thickness in mm
HEIGHT_BARE0 ... HEIGHT_BARE9	heights used for bare flatness calculation in mm
FLATNESS_BARE	bare baseplate flatness in mm
~~HEIGHT_LAM0 ... HEIGHT_LAM9~~	~~heights used for laminated flatness calculation in mm~~
~~FLATNESS_LAM~~	~~laminated baseplate flatness in mm~~
~~FLATNESS_GRADE~~	~~laminated flatness grade (A, B, C)~~
WIDTH_EDGE0 ... WIDTH_EDGE2	edge-to-edge widths (166.94 nom for Full) in mm
~~WIDTH_CORNER0 ... WIDTH_CORNER2~~	~~not used for Ti~~
RADIUS0 ... RADIUS5	hole-to-edge radii (83.47 nom for Full) in mm
DIST_HOLE_SLOT	hole-to-slot distance (75 nom for Full) in mm
DIAMETER_HOLE_PASSED	does the hole diameter pass grade B?
LENGTH_SLOT	slot length (4.05 nom) in mm
WIDTH_SLOT_PASSED	does the slot width pass grade B?
~~NOTCH_SIZE_PASSED~~	~~not used for Ti~~
NOTCH_ALIGN_PASSED	does the baseplate meet the contour tolerance?
~~TAB_WIDTH0 ... TAB_WIDTH2~~	~~not used for Ti~~
~~TAB_HEIGHT0 ... TAB_HEIGHT2~~	~~not used for Ti~~
~~KAPTON_ALIGN_PASSED~~	~~laminated plate check~~
TEST_LOCATION	test location (must match CMS DB naming)
TEST_DATE	test date, ex: 2024-12-10 12:00:00.00000
TOLERANCE_GRADE	worst grade of all yellow measurements
COMMENT	

[Full implementation here]

Implementation at KIT

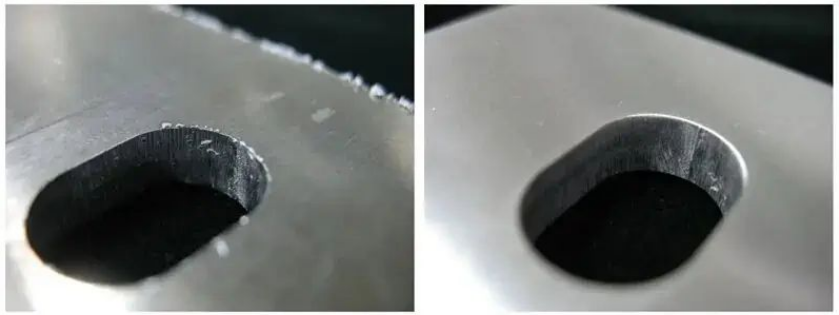
Water-jet cutting

- After cutting, each piece is cleaned, labelled, and put into a bag with an internal serial number
- Machinist takes Keyence measurements to adjust machine
- Often he has to adjust the pattern by hand to account for the fact less material is taken off the edges than the details on the corners

Cleaning & inspection

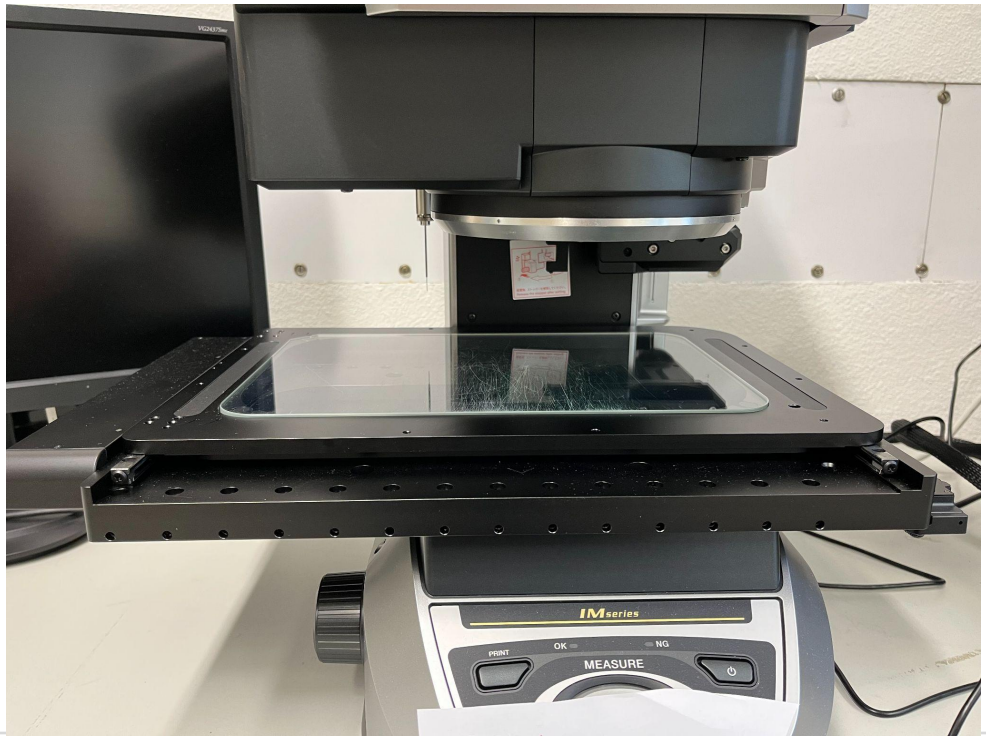
- Need to sand down ridges on each cut edge left by water-jet
  - Use sand paper and countersink for holes
- Check diameter of holes, drill out holes that are too small
- Check for defects in the metal or cut edges (burrs, chipped edges, depressions in the metal face, huge warping, etc)
- Send recoverable pieces back to the machinist
- Clean with isopropyl alcohol to remove sanded dust, residue from the water-jet, possible finger prints, etc
- Hand measurement of baseplate weight and thickness
  - No tolerance on weight, but keeping a record for future calibration

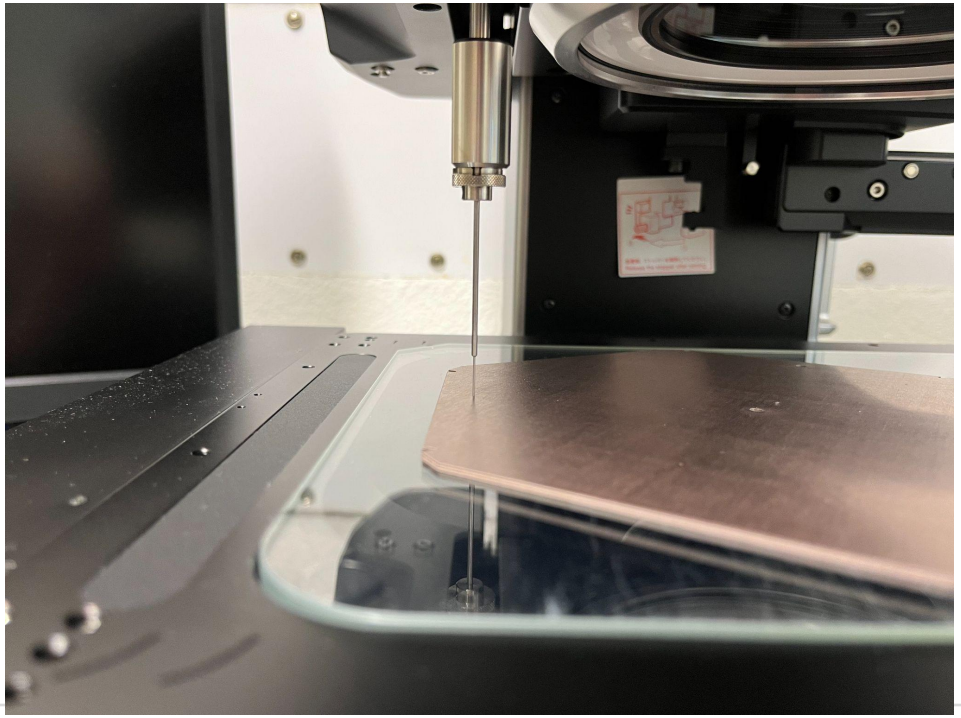
Deburring



Automatic measurements

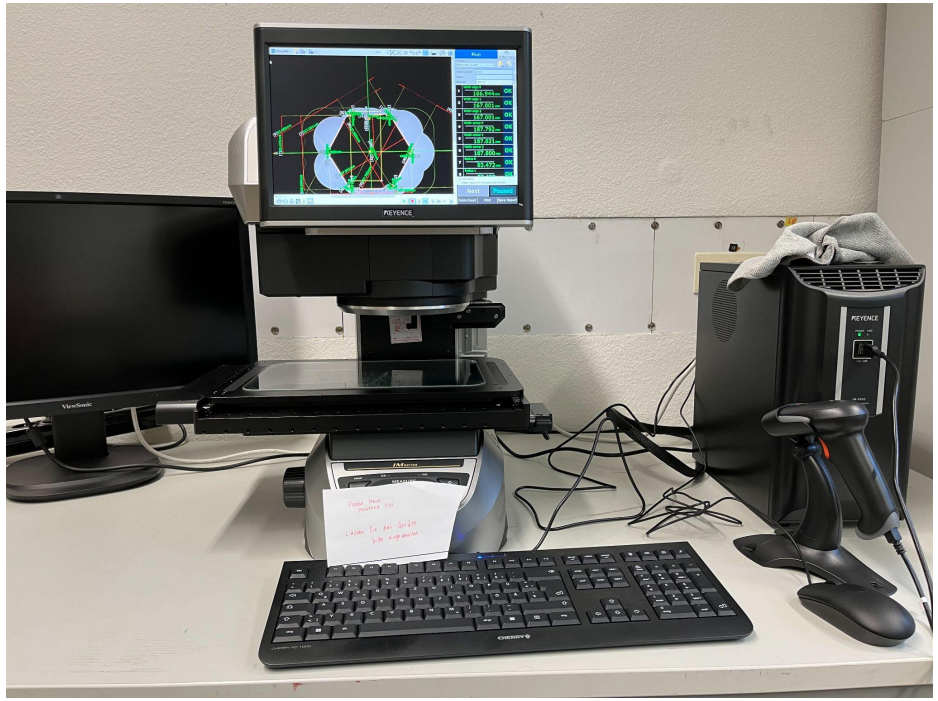
- We have a Keyence IM-8030T machine which can do optical measurements and height above the stage with a physical probe
- Takes about 30 seconds per measurement view, 4-5 views per baseplate



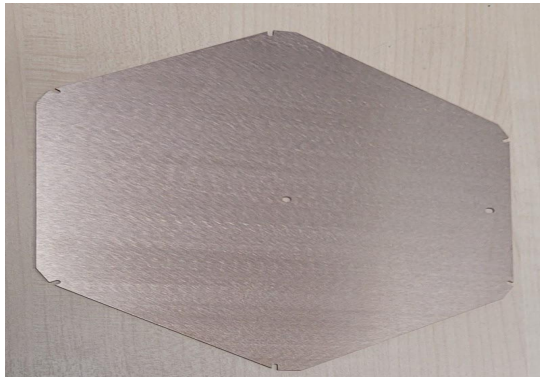


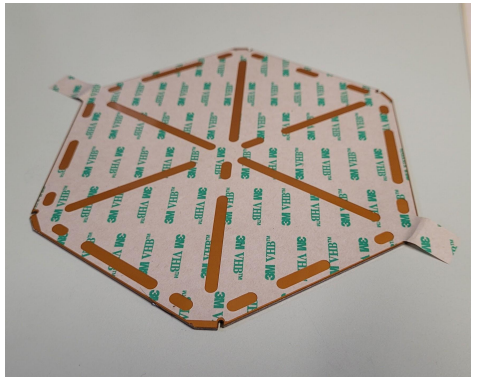
Keyence measurements

- Flatness (and planarity) — we use only 10 points on each face; UCSB & CIEMAT are using up to 25 points
- We are measuring only one side of each baseplate
  - For Ti LD Five, Ti LD Left, and Ti LD Right, only one usable side
  - For HD Top / LD Top / Bottom / Full, we are choosing a side (the one we don't write the number on) to measure

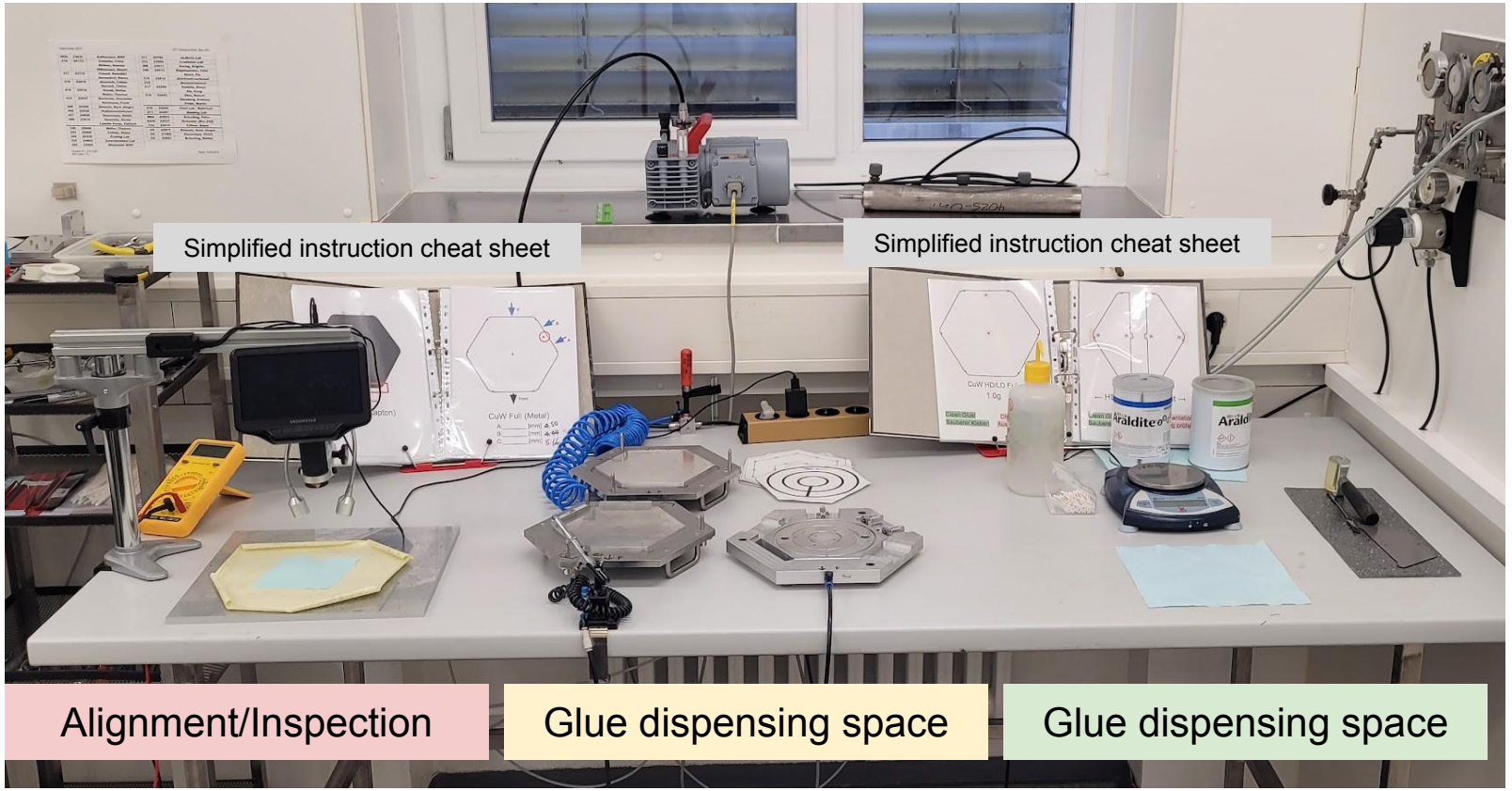


Baseplate lamination processes



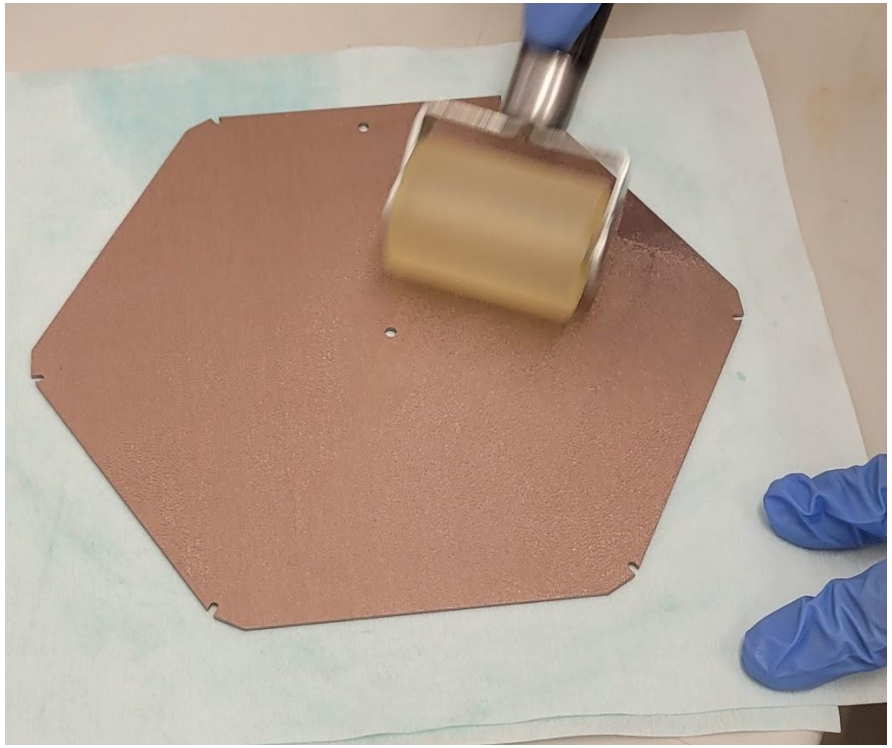


Lamination - workspace overview



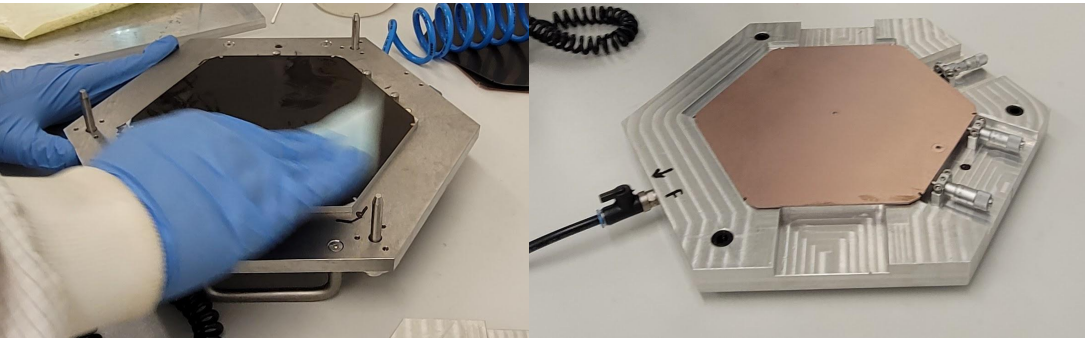
Space prepared to duplicate workspace for double throughput!

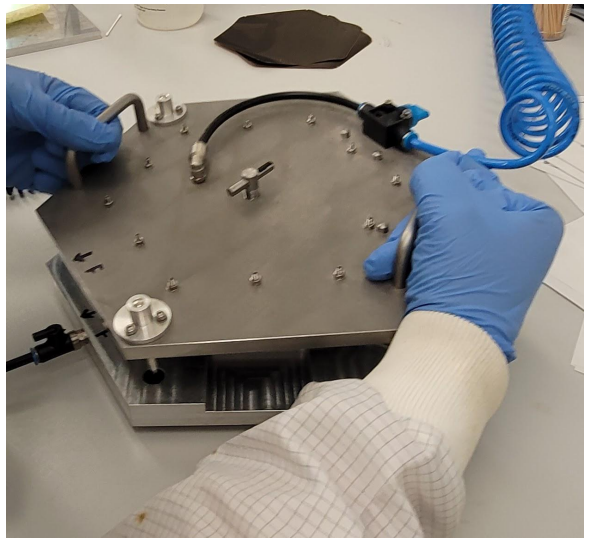
Baseplate-Kapton Lamination - step 1



- Mass-based method to determine thickness of Araldite layer
  - Full plates require 1.0±0.1g for target 35um thickness
- Uniformness achieved by roll dispensing
- Operation time: ~2-5min/plate.
  - Largely depends on plate surface area

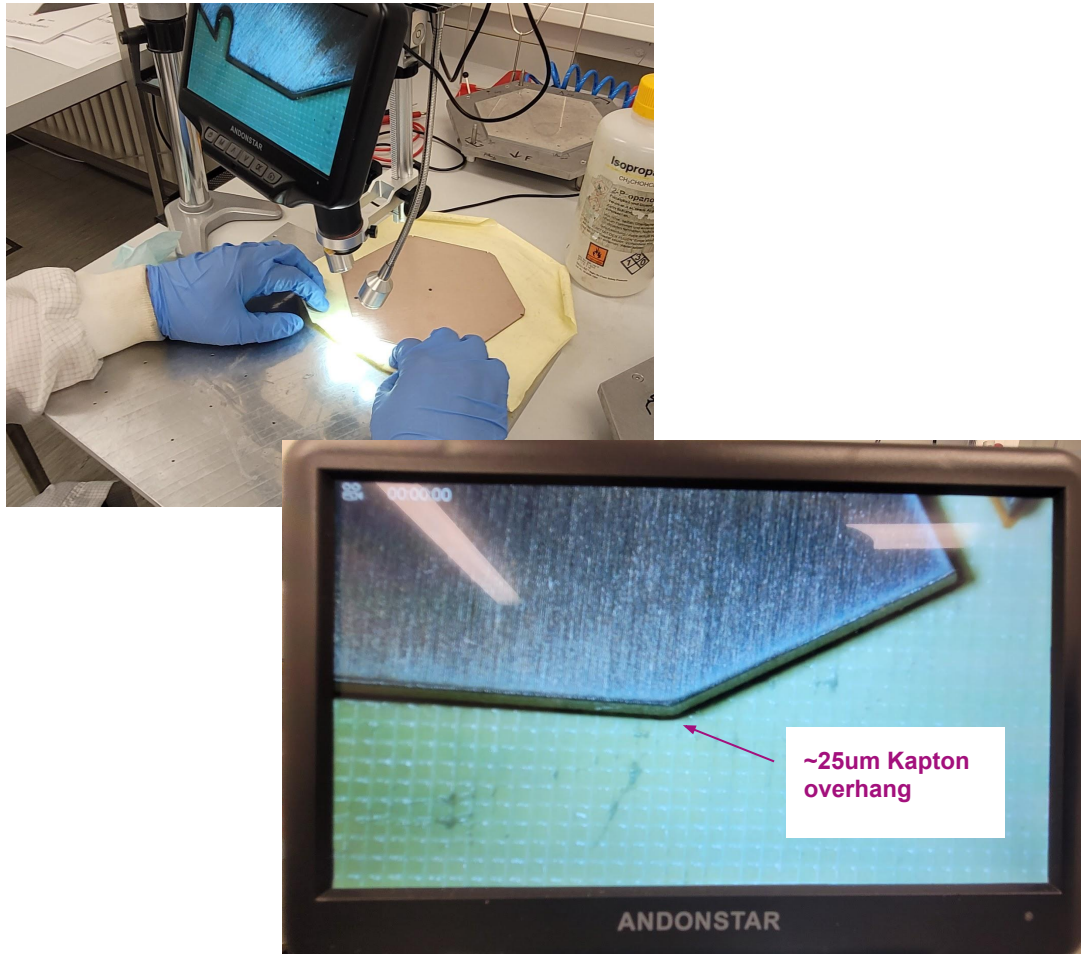
Baseplate-Kapton Lamination - step 2





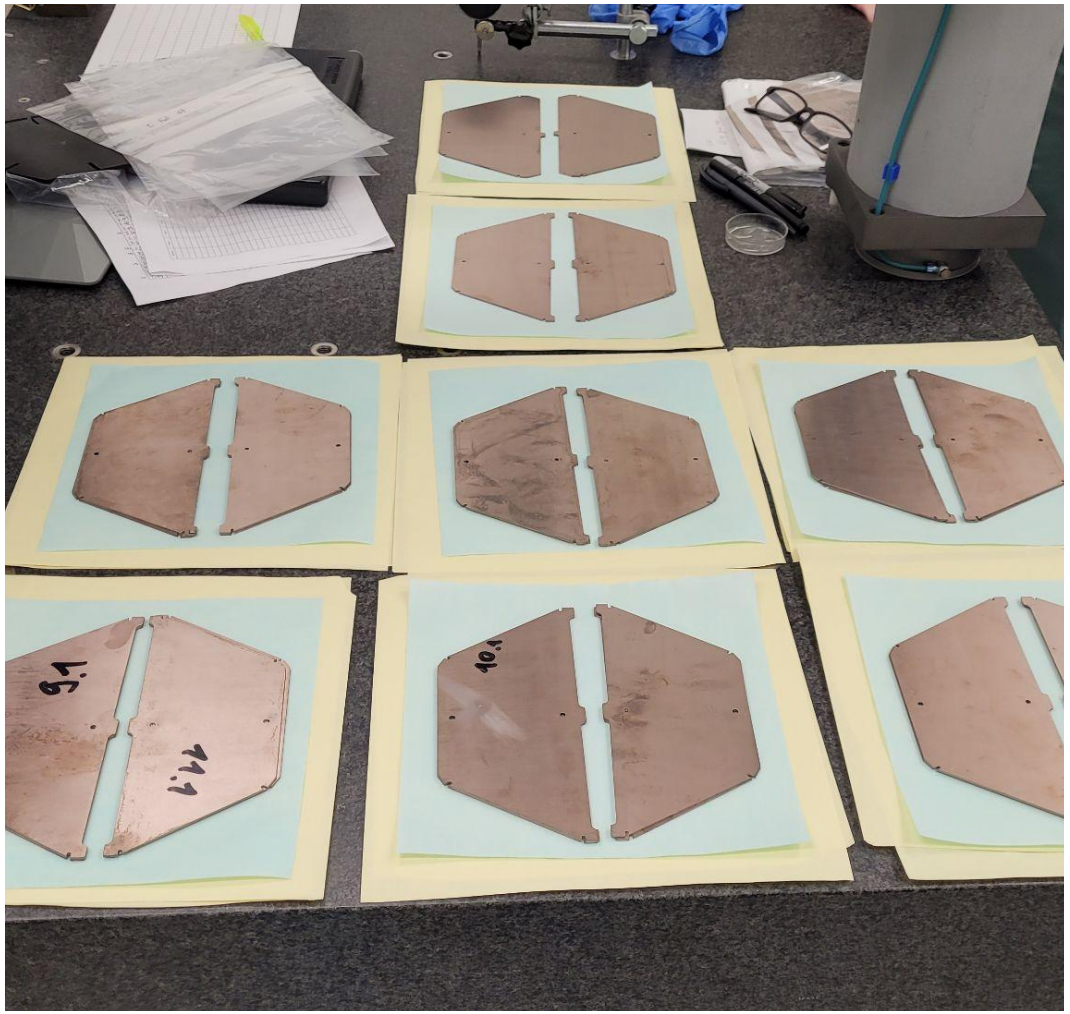
- Mechanical jig of Kapton-baseplate alignment
- ~50-100um precision
- Operation time (<30 sec/plate)

Baseplate-Kapton Lamination - step 3



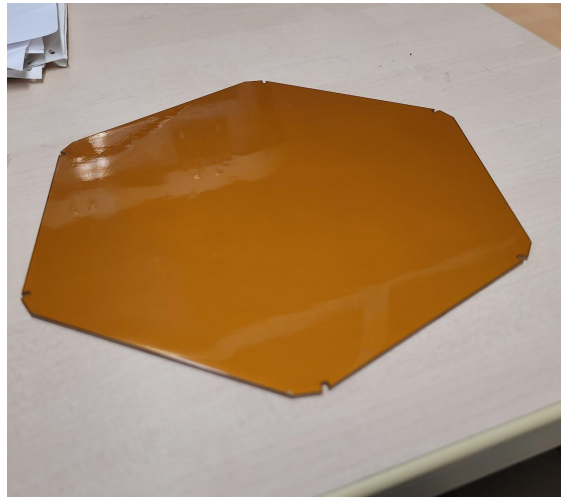
- Manual alignment under microscope
- ~10 um precision
- Operation time: 2-5 min, depending on Kapton-baseplate compatibility

Baseplate-Kapton Lamination - Curing

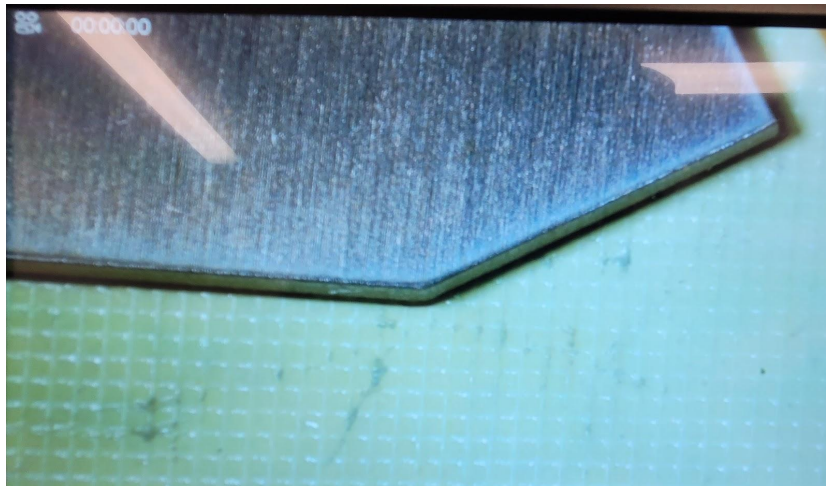


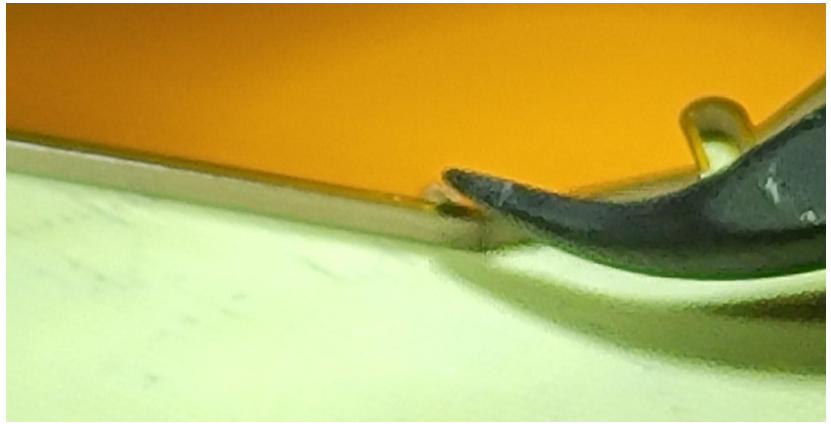
- 20hr (0% duty cycle)
- Currently limiting step due to space availability
- Dedicated equipment to increase capacity is coming in the next weeks!

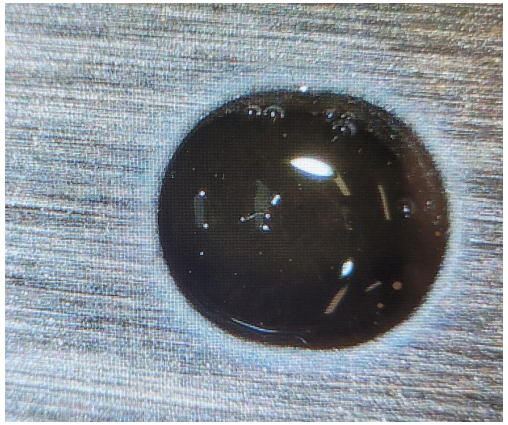
Output of Baseplate-Kapton lamination



Baseplate-Kapton Lamination QC

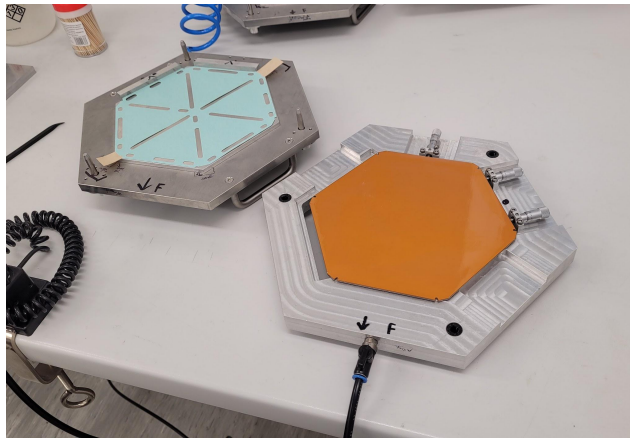




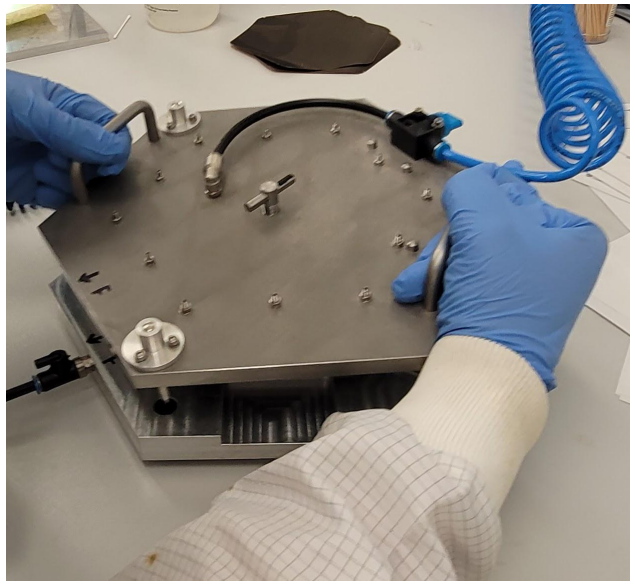


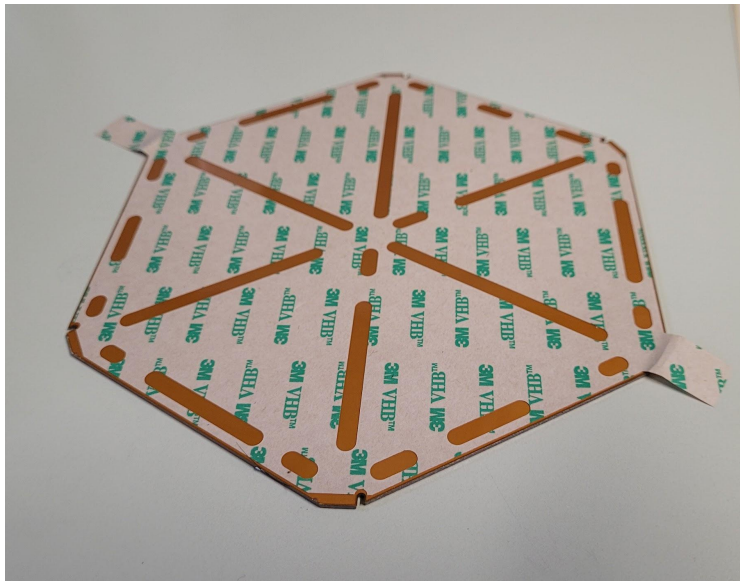
- Kapton overhangs metal everywhere
- Copper pads are fully supported by cured Araldite
- Copper pads are free of any obstruction
- Alignment holes and slot are free of interference

Baseplate-Transfer Tape Lamination



- Mechanical jig for Kapton-Tape alignment
- ~200-500 um precision, less precision with softer material.
- Looser tolerance requirement:
  - Tape cannot overhang Kapton or obstruct pads
- Operation time: 1 min/plate
- One-shot process! Operator needs to be keenly aware of all details!





Final product ready
for shipping-indexing

Packing and Shipment

- Aim for one shipment a month to each site
- Use wooden boxes with custom-cut foam inserts
  - Have asked these to be returned to us for re-use
- We are shipping all boxes through CERN
  - Each one needs to go in shipping tool with parts selected from database

Projected Schedule

	# plates	# plates / month	# IHEP / month	# ITT / month	# CIEMAT	# lam. at KIT	# cut at KIT
02/2025	0	0	0	0	0	0	0
03/2025	7	7	0	4	0	7	3
04/2025	271	264	60	118	13	204	73
05/2025	847	576	179	167	29	397	201
06/2025	1713	866	232	271	71	634	292
07/2025	2634	921	195	480	48	726	198
08/2025	4334	1700	496	782	85	1204	337
09/2025	5800	1466	441	614	95	1025	316
10/2025	7432	1632	588	625	72	1044	347
11/2025	9856	2424	881	1023	56	1543	464
12/2025	11879	2023	744	857	23	1279	399
01/2026	13988	2109	704	995	51	1405	359
02/2026	15834	1846	802	632	84	1044	328
03/2026	18554	2720	1059	1151	101	1661	409
04/2026	20688	2134	822	900	96	1312	316
05/2026	23262	2574	985	1071	85	1589	433
06/2026	25249	1987	743	833	42	1244	369
07/2026	26974	1725	688	691	24	1037	322
08/2026	27727	753	525	0	6	228	222
09/2026	27827	100	90	0	0	10	10
10/2026	27827	0	0	0	0	0	0
11/2026	27827	0	0	0	0	0	0

- Given dates are when the laminated plates will be **used at a MAC**
  - shipping and lamination time must be considered
- Maximum throughput@KIT: **~100 plates/day**
- Currently lamination procedure can achieve this rate assuming 4 people x 8 hr shift for 1 day.
- Material availability is key in ensuring everything is kept in schedule!

Personnel at KIT

- One shift = half-day

- Post-docs (Yi-Mu and Jay): 4 shifts / week
- Graduate students: potentially up to 8 shifts / week
- Research assistants: currently 5 shifts / week, potentially more
- Technicians: currently 5 shifts / week, but dependent on Tracker staffing needs

- To meet production expectations, we need up to 37 shifts / week