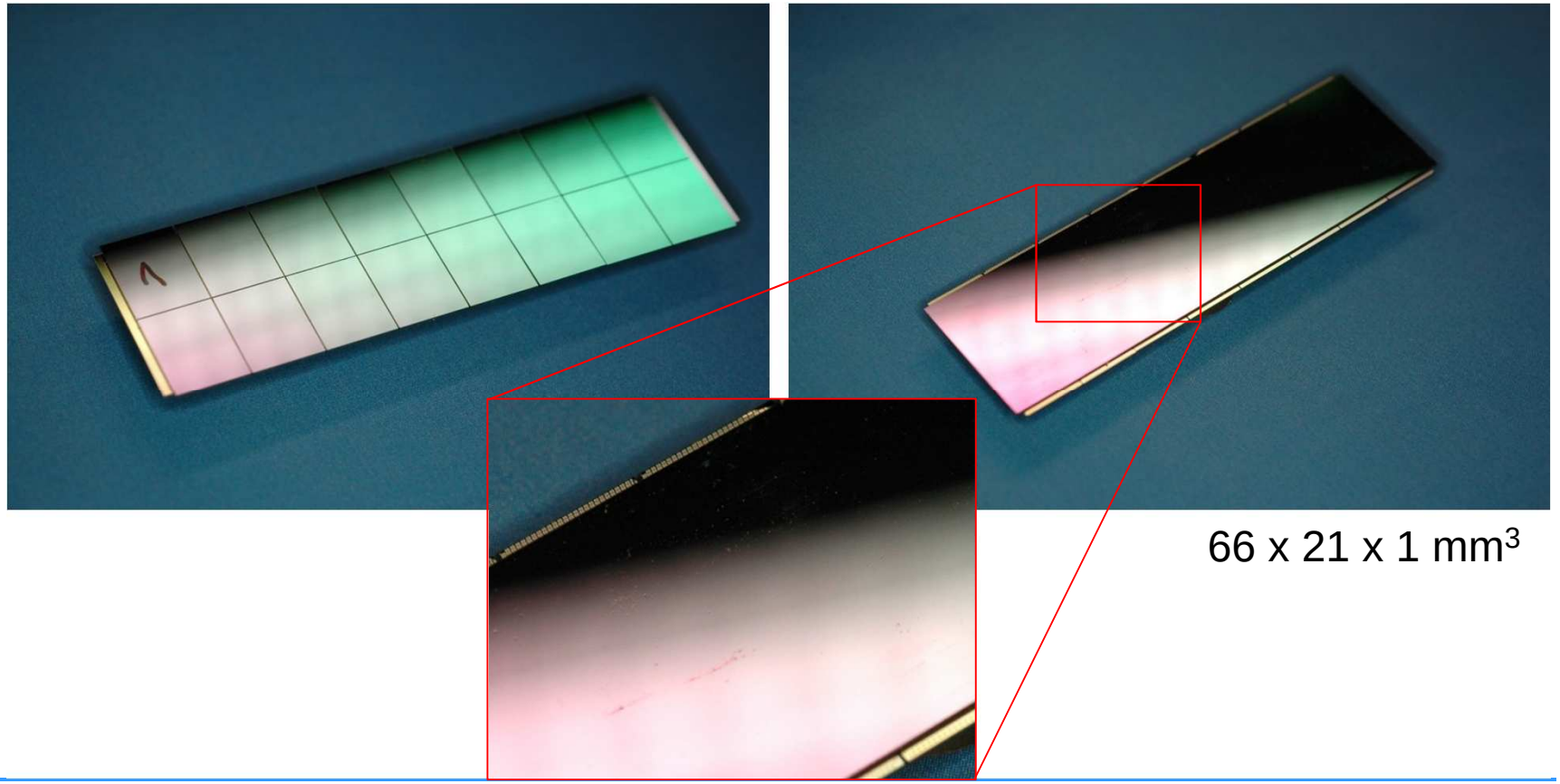
CMS BPIX dummy modules for in-house Flip-Chip technology tests

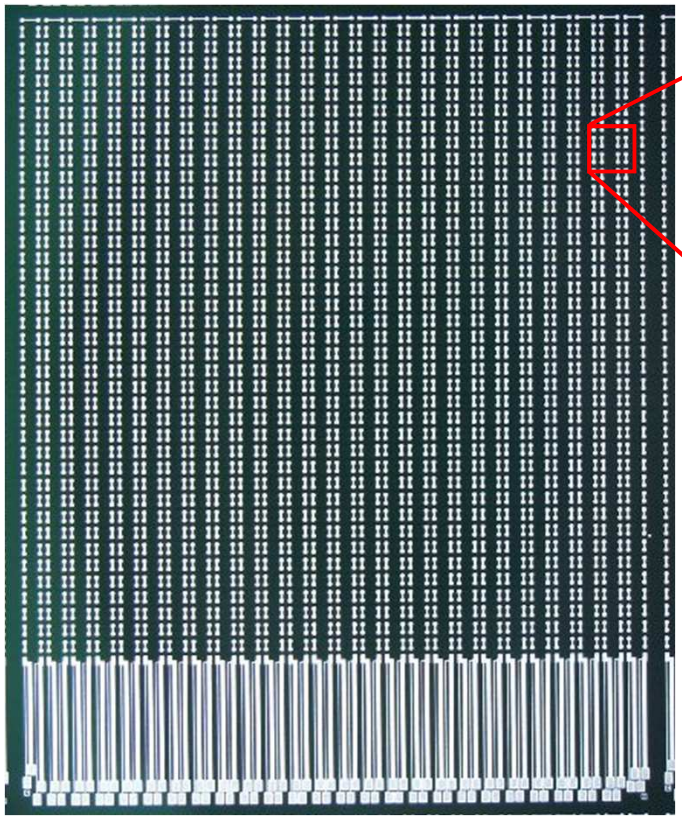
PICTURES OF A FABRICATED DUMMY MODULE

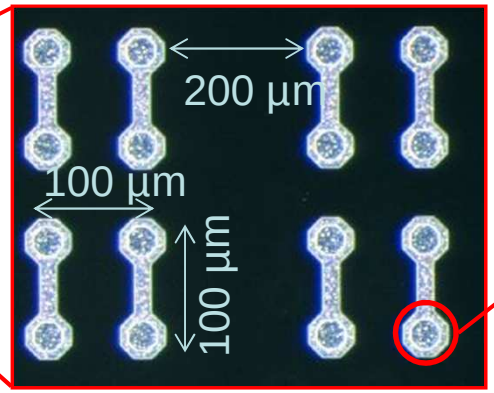


66 x 21 x 1 mm^3

Dummies mimic the crucial parts for bump bonding of the CMS pixel sensors and ROCs

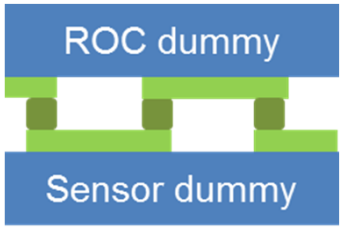
MICROGRAPH OF ONE CHIP AND ZOOM TO DAISY CHAIN PADS





Copy of the CMS contact pad and its pitch

Pad pitch = 100 µm / 200 µm
Pad metal = 50 µm
Passivation opening = 30 µm

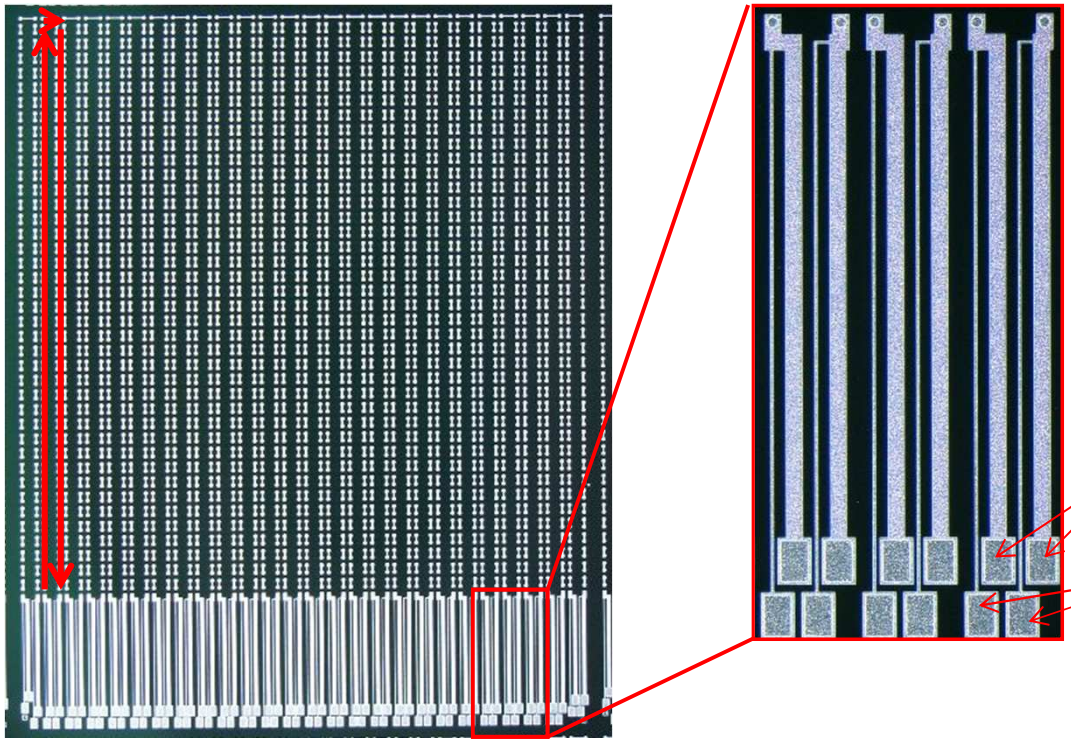


4160 contacts per chip
26 double columns per chip
66560 per substrate

- daisy chain pad structure for tests
- sensor provides the missing pieces of the electrical path to the ROC

26 daisy chains (comparable to double columns) per chip are resistance measured

MICROGRAPH OF ONE CHIP AND ZOOM TO CONNECTOR PADS



Four point resistance measurement

Current input

Voltage read out

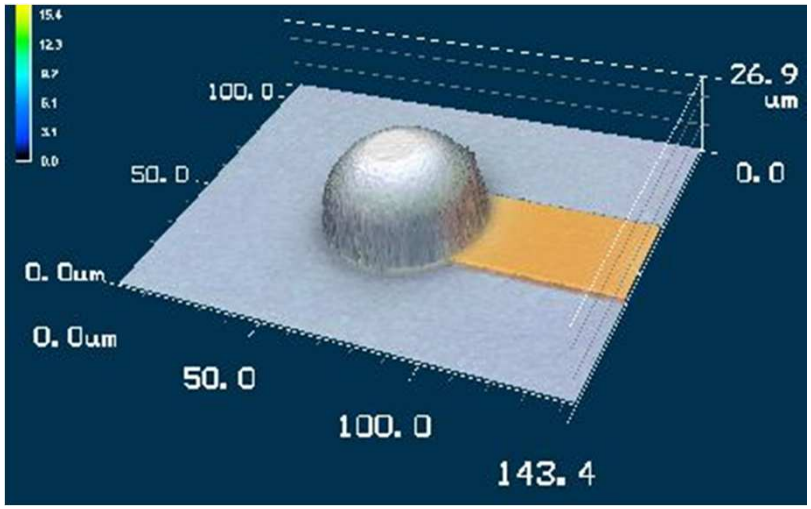
Chain resistance comprises

- metal path between the pads
- 160 bumps per chain

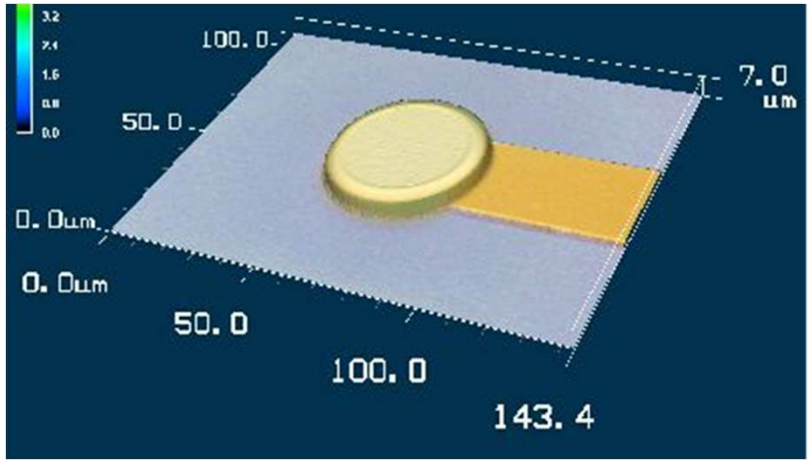
One „dead pixel“ → open circuit

UBM and solder is deposited on each pad

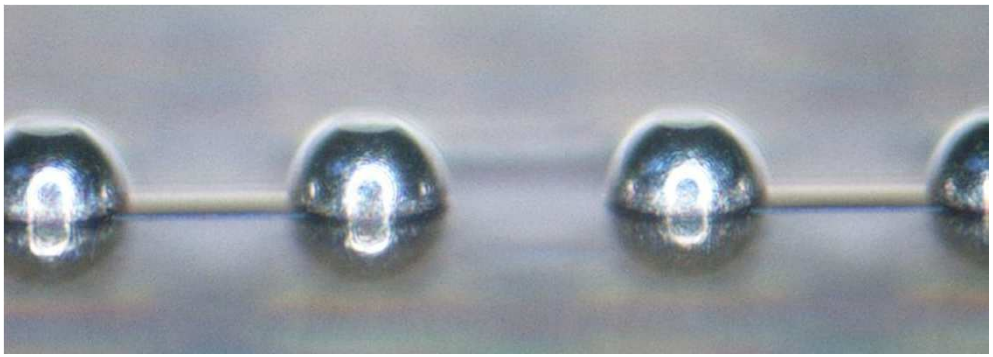
LASER SCAN AND OPTICAL MICROSCOPE PICTURES



Pad bumped with 40 µm solder ball



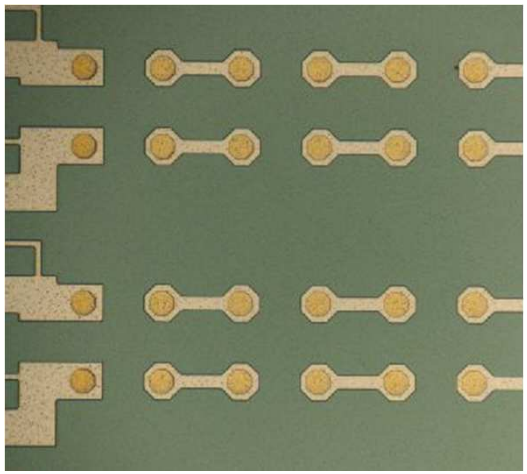
Pad with processed UBM



Side view of bumbed daisy chain structure on chip

First soldering tests with the Pac Tech SB² solderball jet have been successful

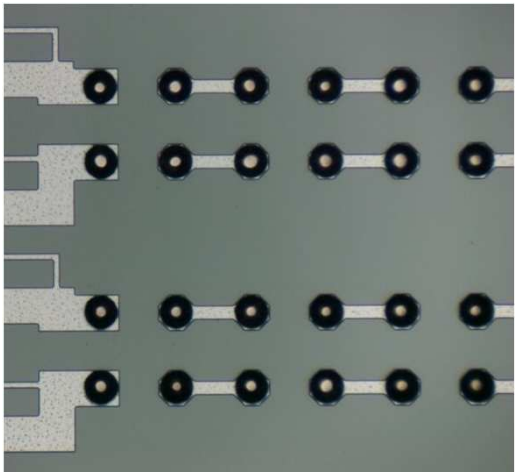
MICROGRAPHS OF DUMMY-ROC



Dummy-ROC with UBM

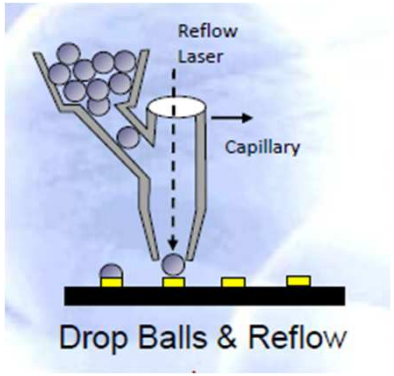
ENEPIG UBM:
40 µm diameter
5 µm Ni (layer)
200 nm Pd (layer)
50 nm Au (layer)

SAC solder:
Sn 96.5%$_{wt}$
Ag 3%$_{wt}$
Cu 0.5%$_{wt}$

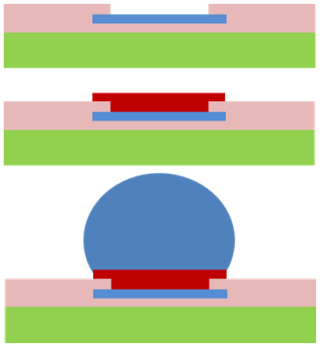


Dummy-ROC after solder placement

UBM at Pac Tech



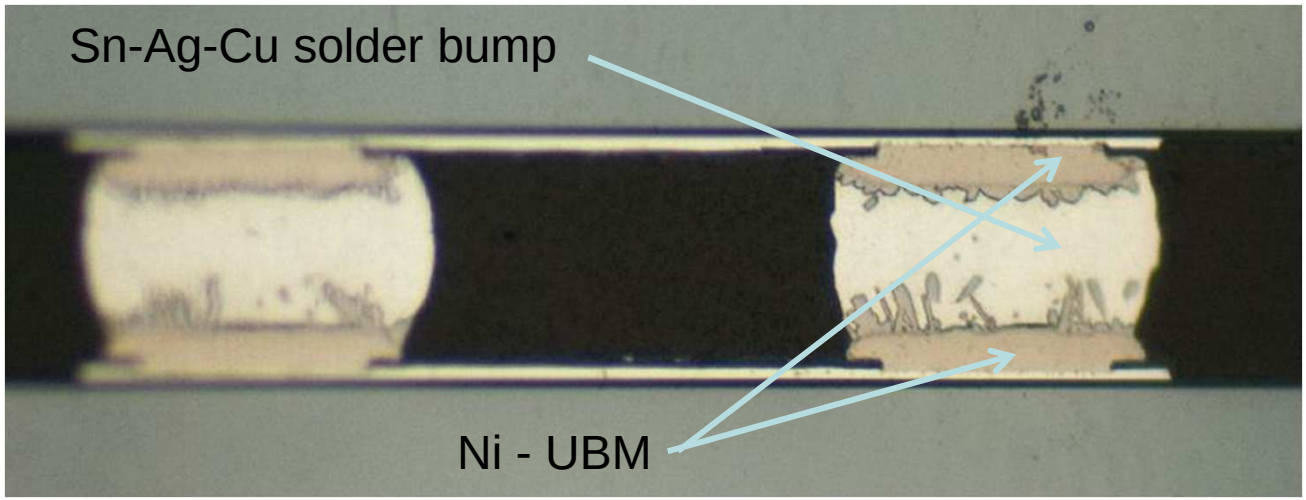
SB² Jet
(to be purchased)



Older tests already showed fine bump bond connections

CROSS SECTIONAL VIEWS TO BONDED DUMMY ROCS

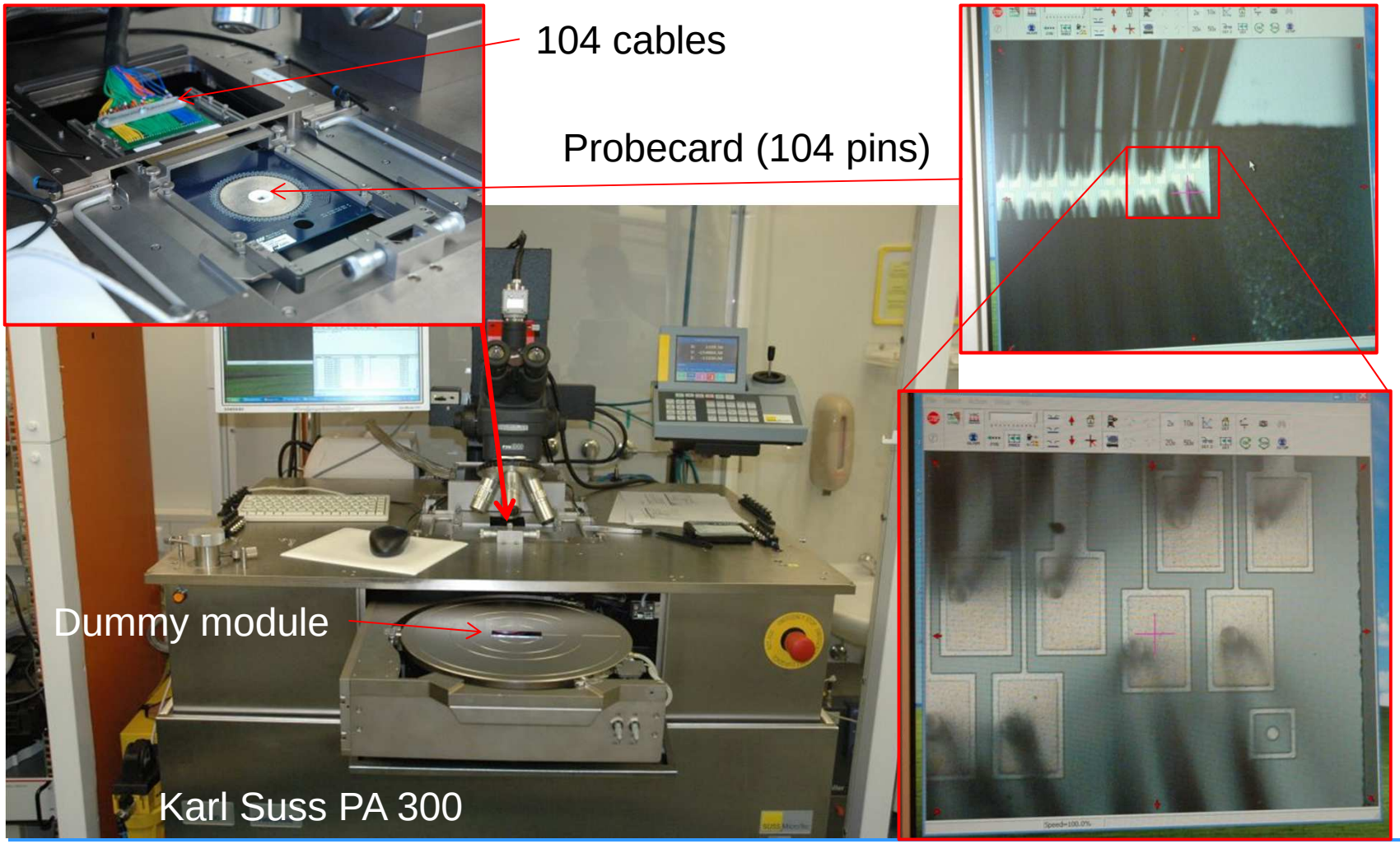
First ROC to ROC bond test cross sections



40 µm diameter
25 - 30 µm height
4160 per chip
80 per column

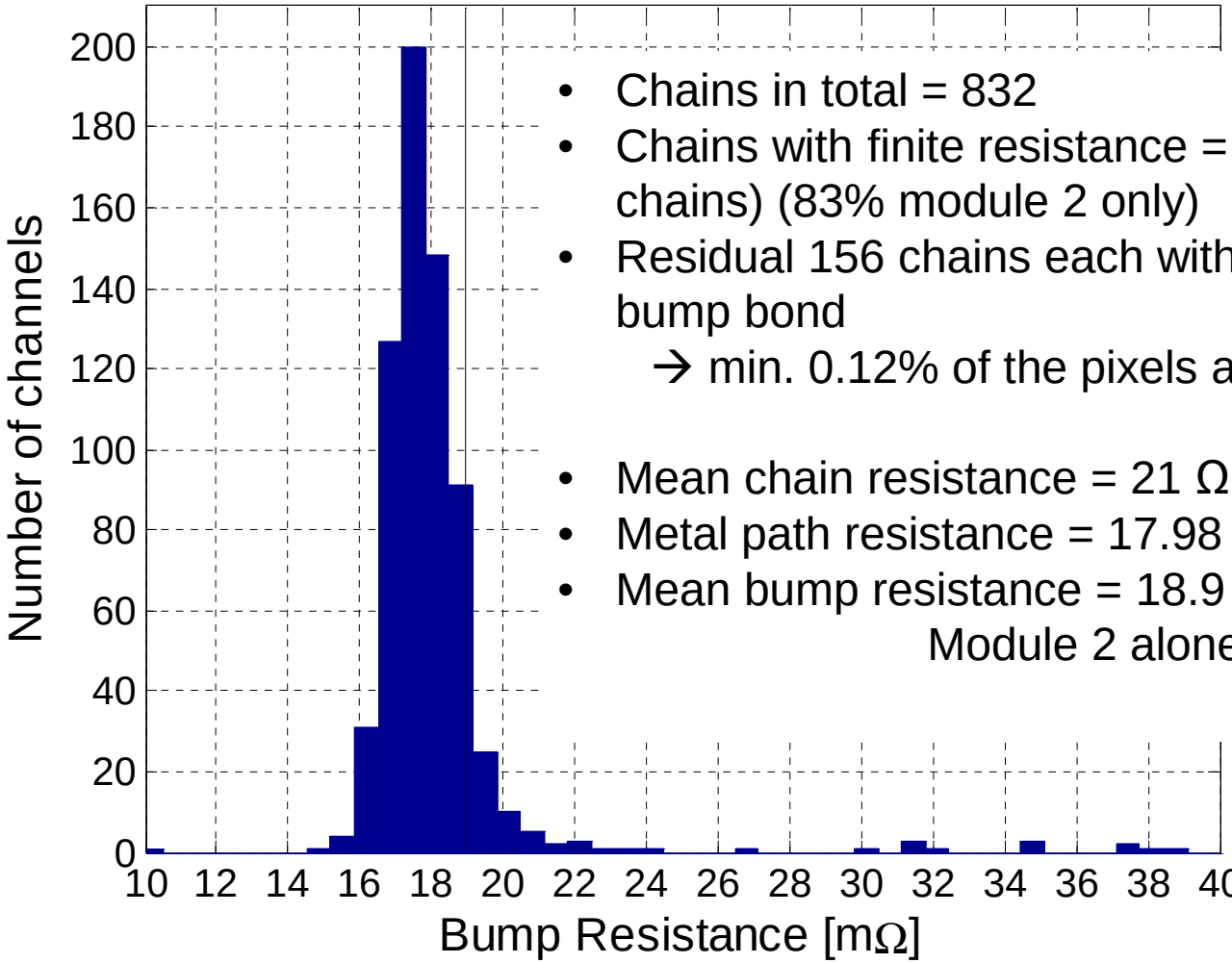
Dummy ROCs are contacted with a probecard according to their 104 pads each

PICTURES FROM THE PROBING STEPS



Bump resistance is around 18.9 mΩ

FEMTO TEST-JUNE2012-MODULE 1 + 2, HISTOGRAM

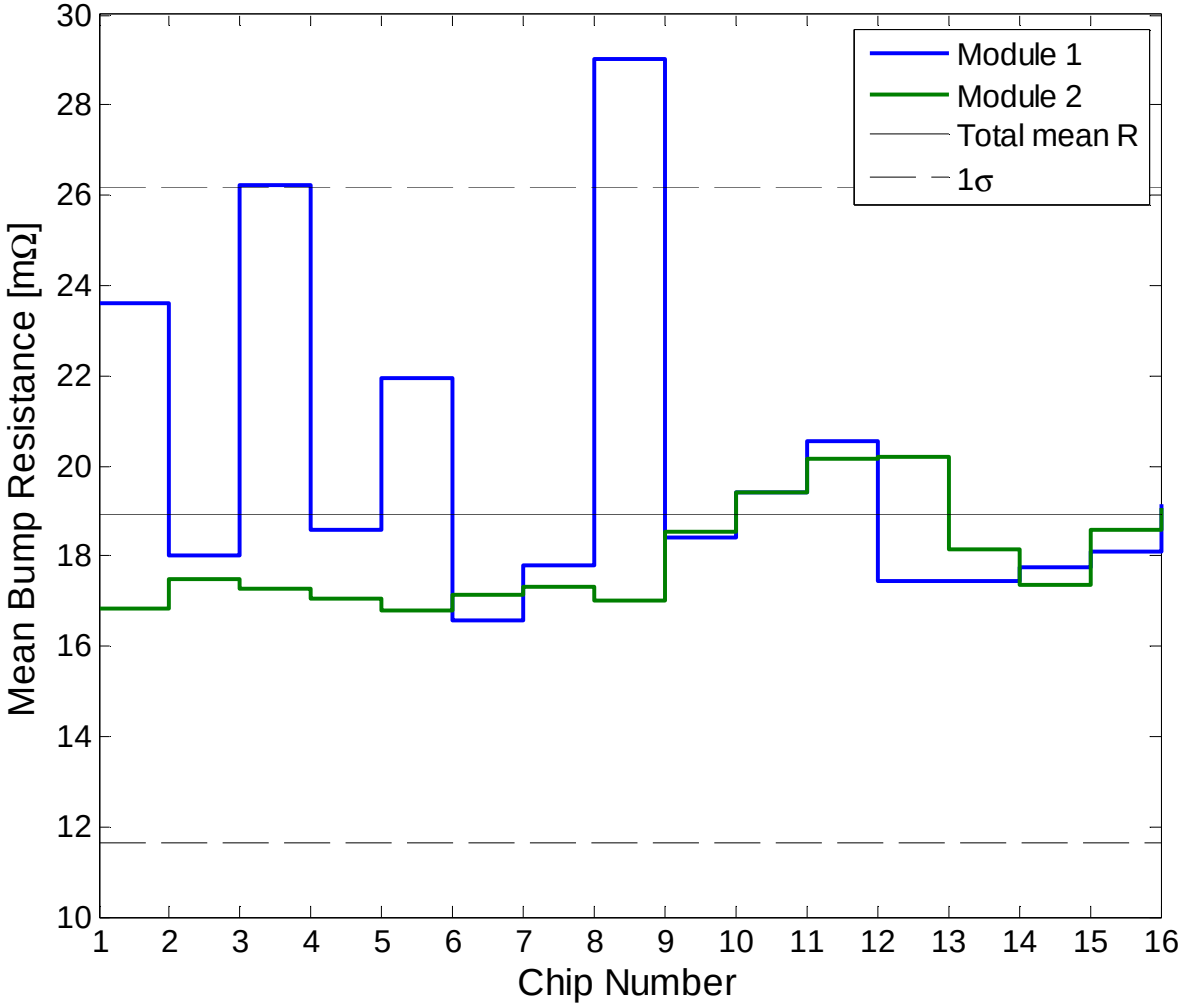


- Chains in total = 832
- Chains with finite resistance = 676 (81% of the chains) (83% module 2 only)
- Residual 156 chains each with at least 1 defective bump bond
  → min. 0.12% of the pixels are dead

- Mean chain resistance = 21 Ω
- Metal path resistance = 17.98 Ω
- Mean bump resistance = 18.9 mΩ
  Module 2 alone: 18 mΩ

Low variance of mean bump resistance per chip

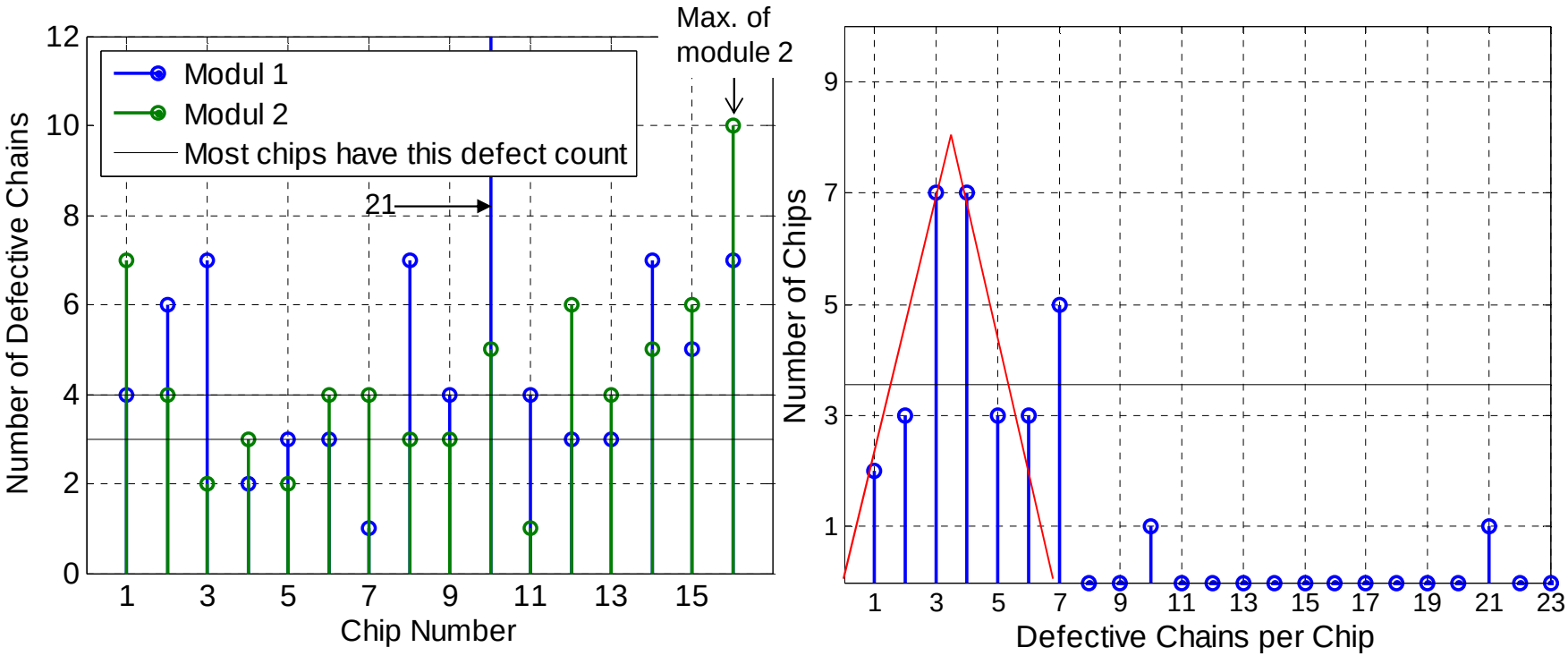
FEMTO TEST-JUNE2012-MODULE 1 + 2, BUMP RESISTANCE PER CHIP



First 8 chip areas of module 1 have been used in several attempts to find correct bonding parameter

The defect rate of 4 chains per chip (min. 0.1% dead pixels) is found for most of the chips

FEMTO TEST-JUNE2012-MODULE 1 + 2, DEFECT STATISTICS

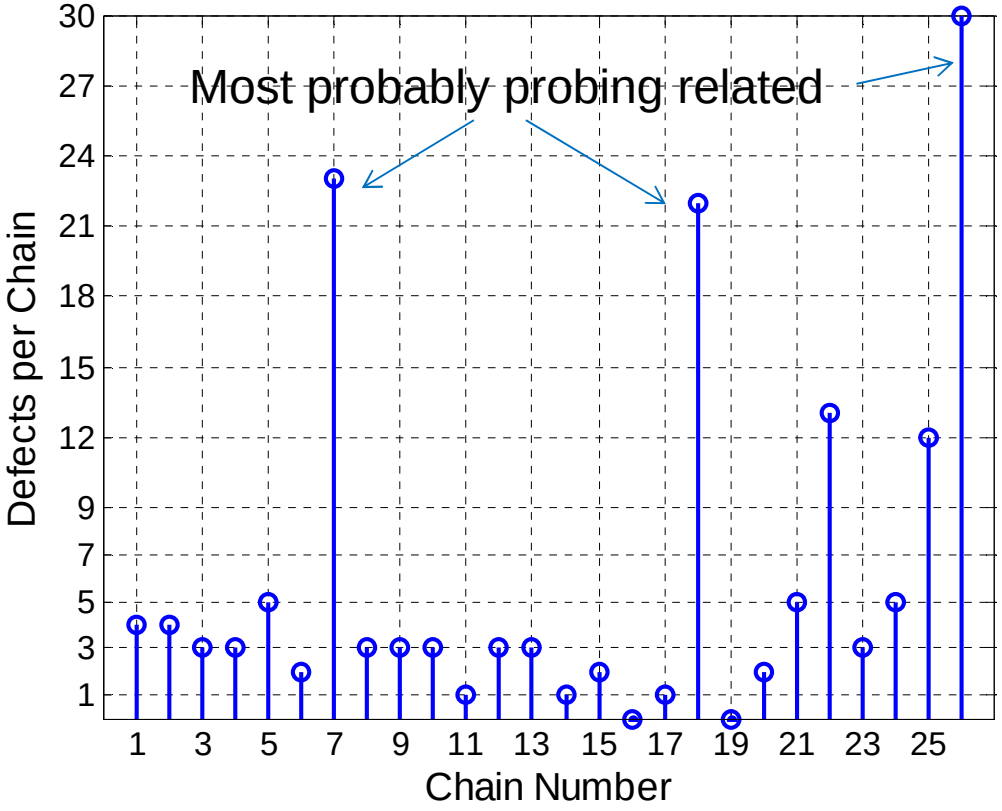


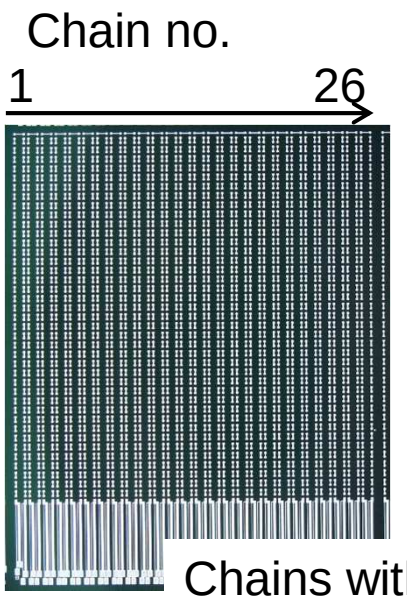
- Max. number of defects = 21 (1 Chip)
- Min. number of defects = 1 (2 Chip)
- Most chips (7 each) have 4 or 3 defects
- 13 chips with more defects
- 5 chips with less defects

Distribution around 4 defects per chip → 0.1%

Spatial defect distribution may indicate small misleveled bonding

FEMTO TEST-JUNE2012-MODULE 1 + 2, NUMBER OF DEFECTS PER CHAIN



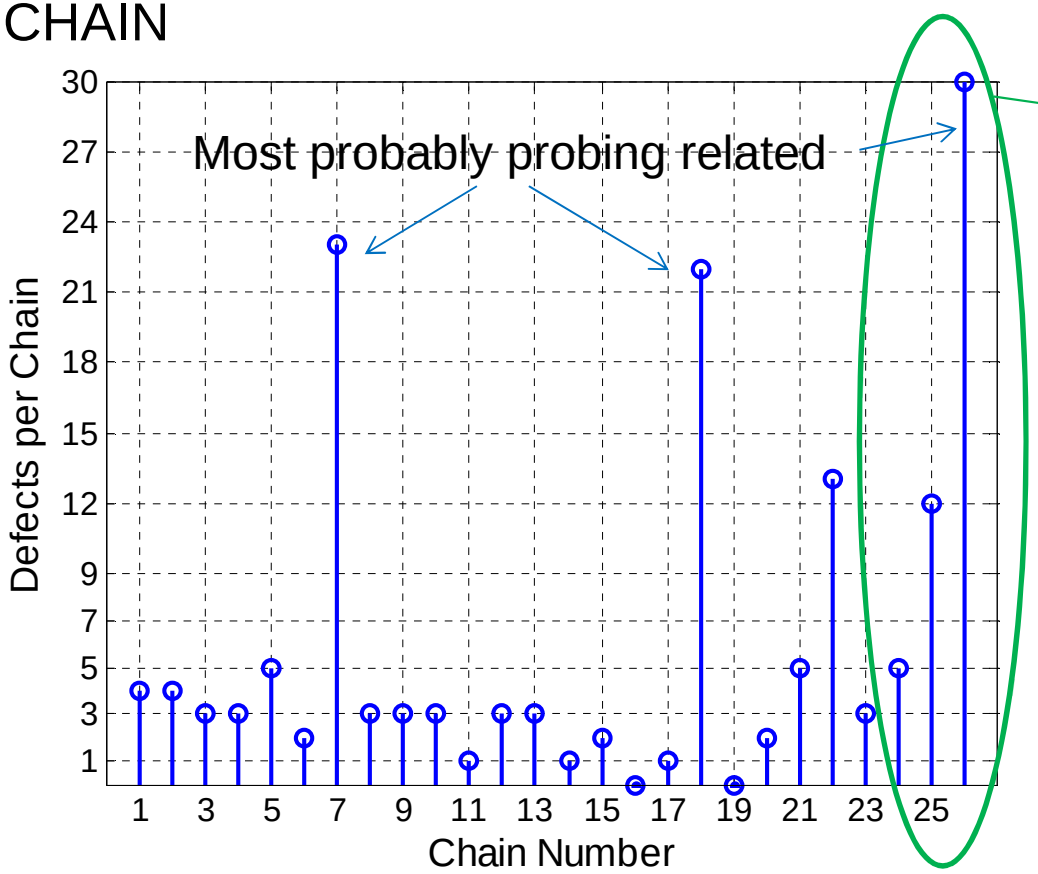


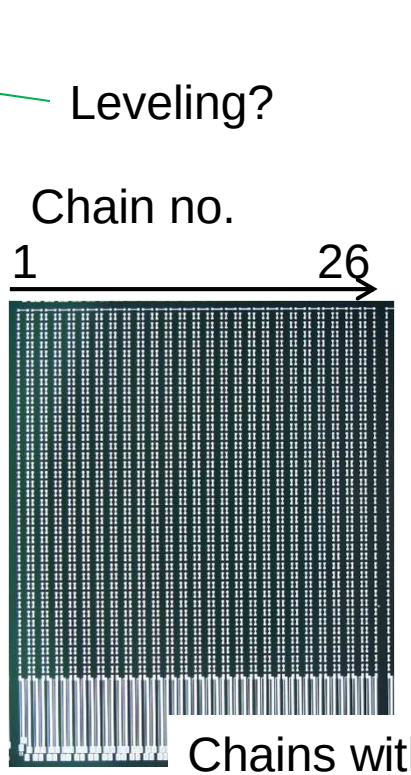
Chains with

- max. 2 errors = 8
- max. 1 error = 5
- no errors = 2

Spatial defect distribution may indicate small misleveled bonding

FEMTO TEST-JUNE2012-MODULE 1 + 2, NUMBER OF DEFECTS PER CHAIN





Chains with
- max. 2 errors = 8
- max. 1 error = 5
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3D X-ray investigation (CT) of the latest module tests within the next 4 weeks