SW Test Workshop

Semiconductor Wafer Test Workshop

2-0-1-8

Test Cell Co-planarity Optimization

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Hoang Nguyen, Microsemi

Microsemi

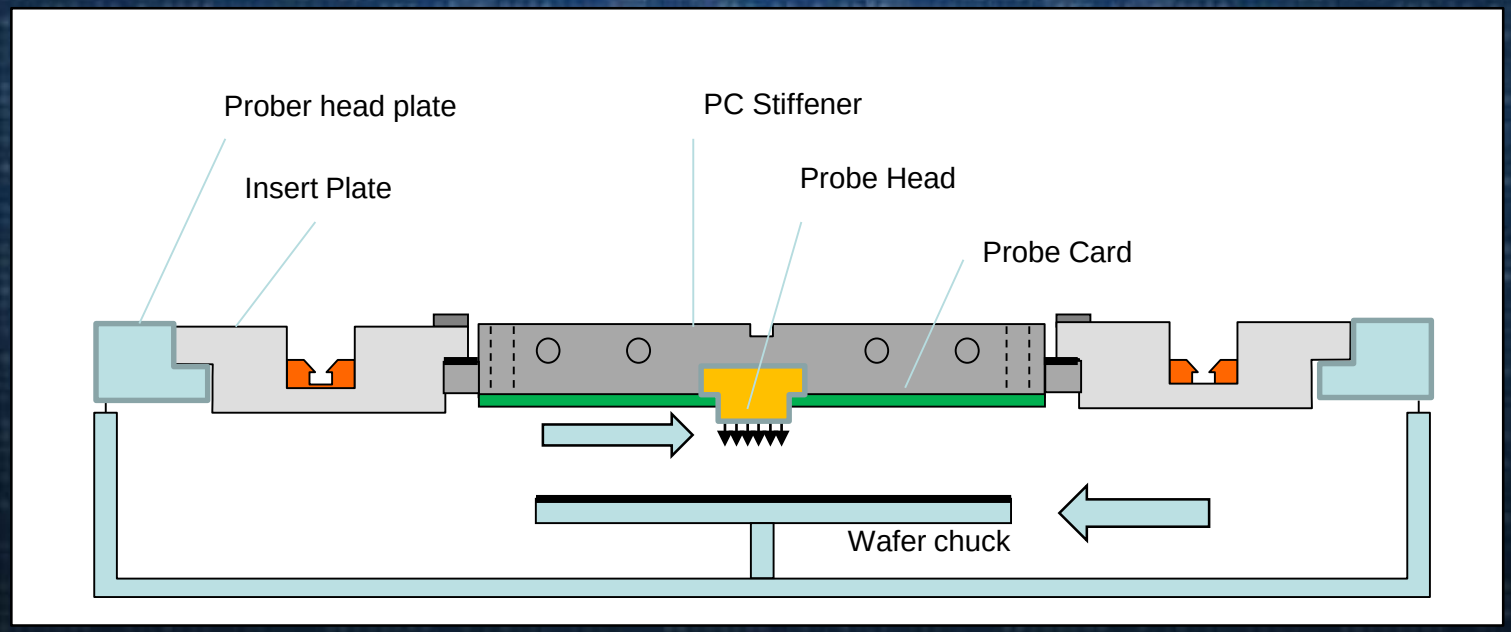
NXP SECURE CONNECTIONS FOR A SMARTER WORLD

TERADYNE TEST CELL SOLUTIONS

June 3-6, 2018

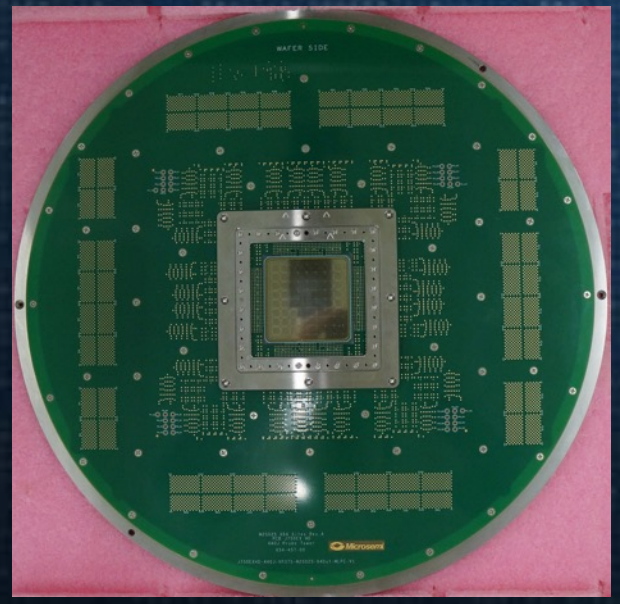
What is co-planarity of a test cell

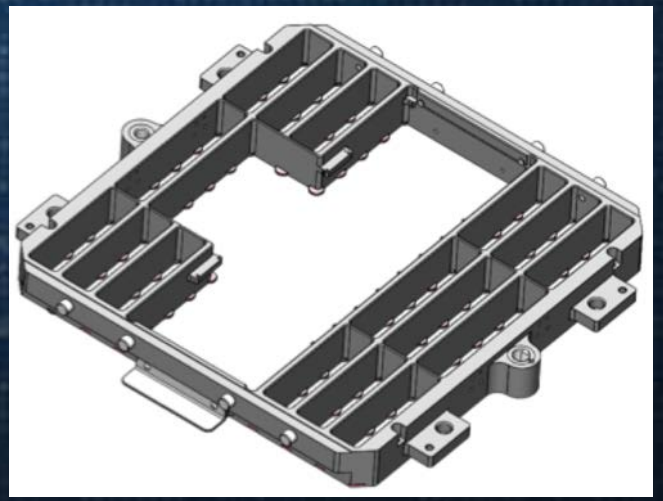
Parallel plane between wafer chuck and probe contacts



Why is test cell co-planarity important?

- Array sizes are increasing. Some exceed the applications space.
- Probe technologies are numerous & compliance restrictions
- Pad damage from multiple probe marks (re-probing)
- Active circuitry under pad regions are sensitive to probe forces





When is a co-planarity check recommended?

- Test cell installation / setup
- Changing instrumentation in TH
- Changing the insert plate
- Physical movement of any equipment
- Changing counter-balance weights
- Prober PM

Optional:

- Production maintenance checks

Goals

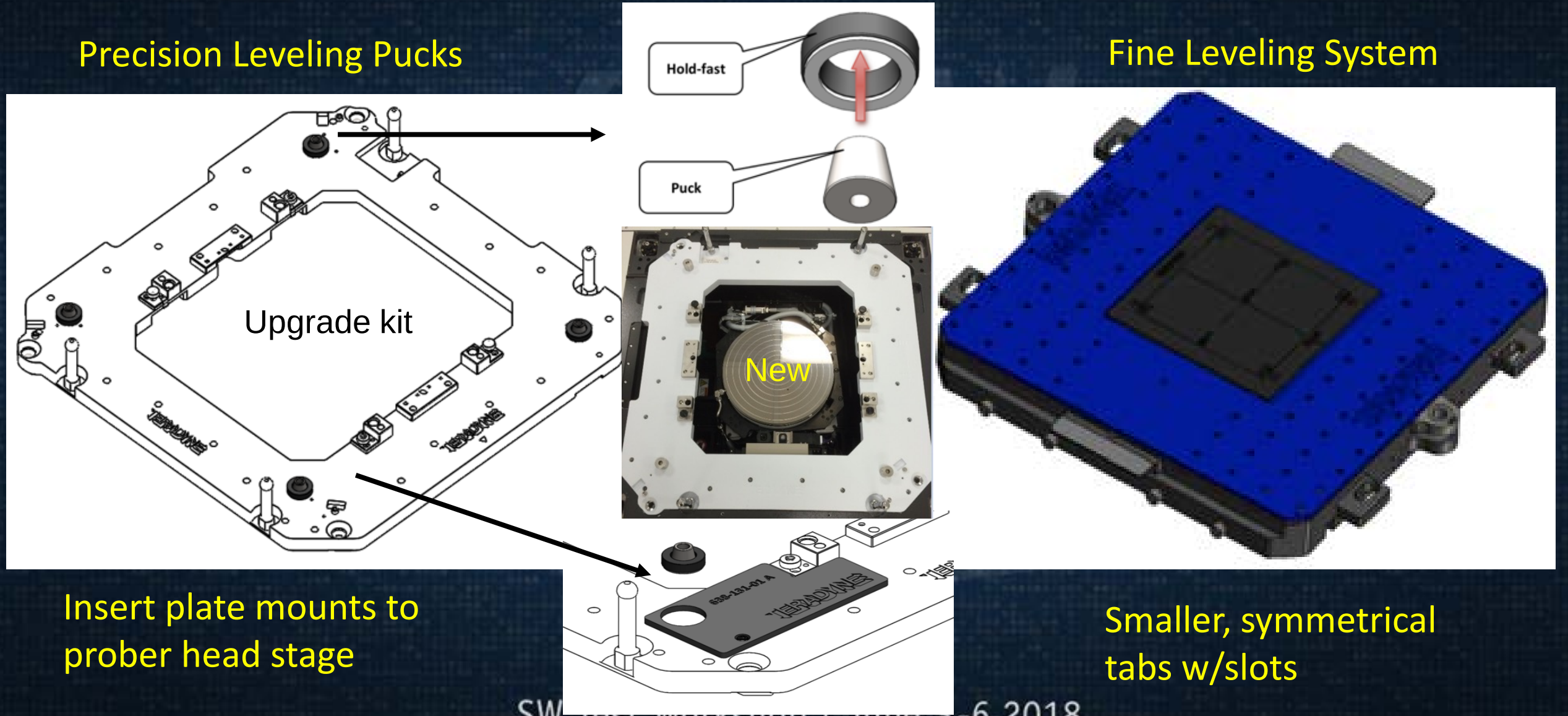
- Provide repeatable docking to prober interface
- Efficient conversion or transition capability
- Maintain experience with the “production proven” tools
- Closely emulate probecard architectures
- Compatible on multiple tester platforms (UltraProbe / J750-HD)
- Compatibility on probers
- Eliminate any tool calibrations
- Achieve a test cell co-planarity of <20 microns (5.5” x 5.5”)

Precision Leveling System

- **Precision Leveling Pucks (PLP)**
  - Provides repeatable docking interface – “UltraProbe only”
  - Solid engagement of TH with insert plate at corners
  - Utilizes the thickest area of insert plate
- **Fine Leveling System (FLS)**
  - Provides high-precision accuracy without tool calibration
  - Compatible on all UltraProbe or J750 tester and prober combinations
- **Software calculator tool as a guide for prober adjustments**

UltraProbe Components

Precision Leveling Pucks



Fine Leveling System

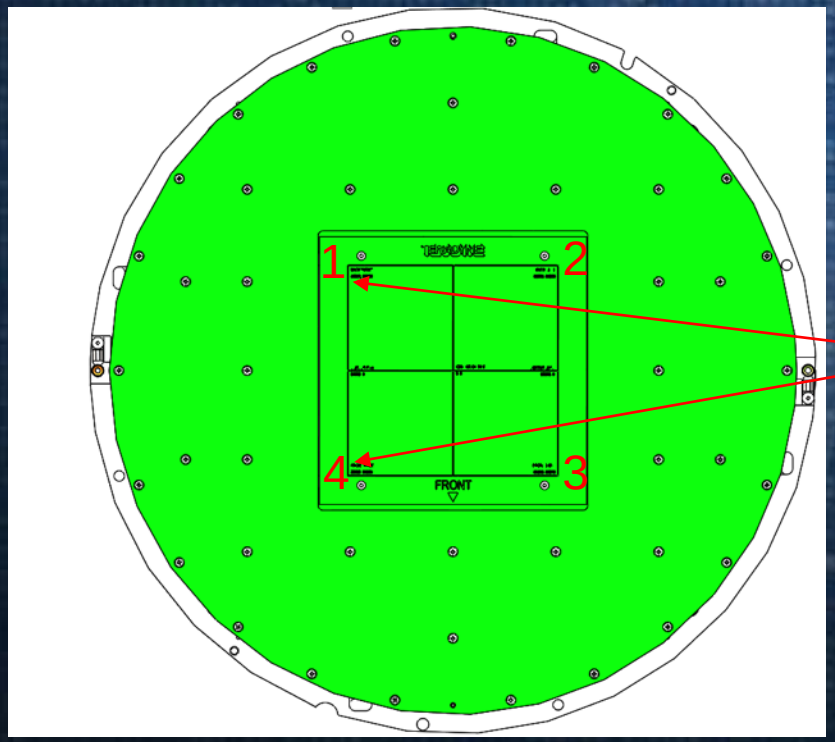
Insert plate mounts to prober head stage

Smaller, symmetrical tabs w/slots

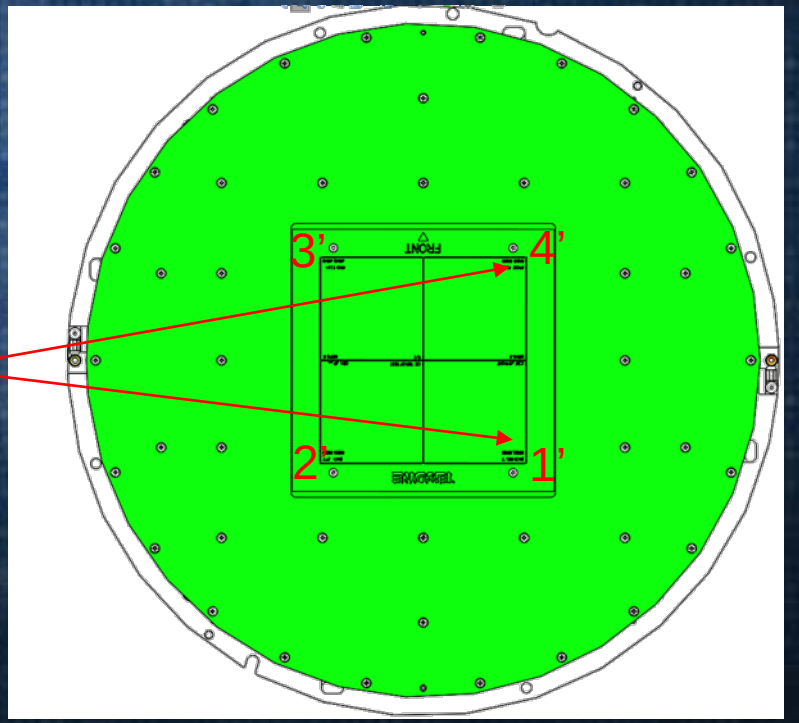
FLS Rotation – How it works

The calibration concept is easy to understand and uses the calibrated optics of the prober. There are 4 Z-height measurement points (one in each corner) taken in the 0 degree position. These Z-values are then compared to the Z-values after rotating the tool 180 degrees. If the co-planarity is perfect, each Z-value "pair" will equal the measurement in the opposing corner. Example: 1 = 1' 2 = 2' etc. If not equal, this provides the delta from perfect co-planarity and the height difference can be determined whether "+" or "–" from any given corner.

0° POSITION



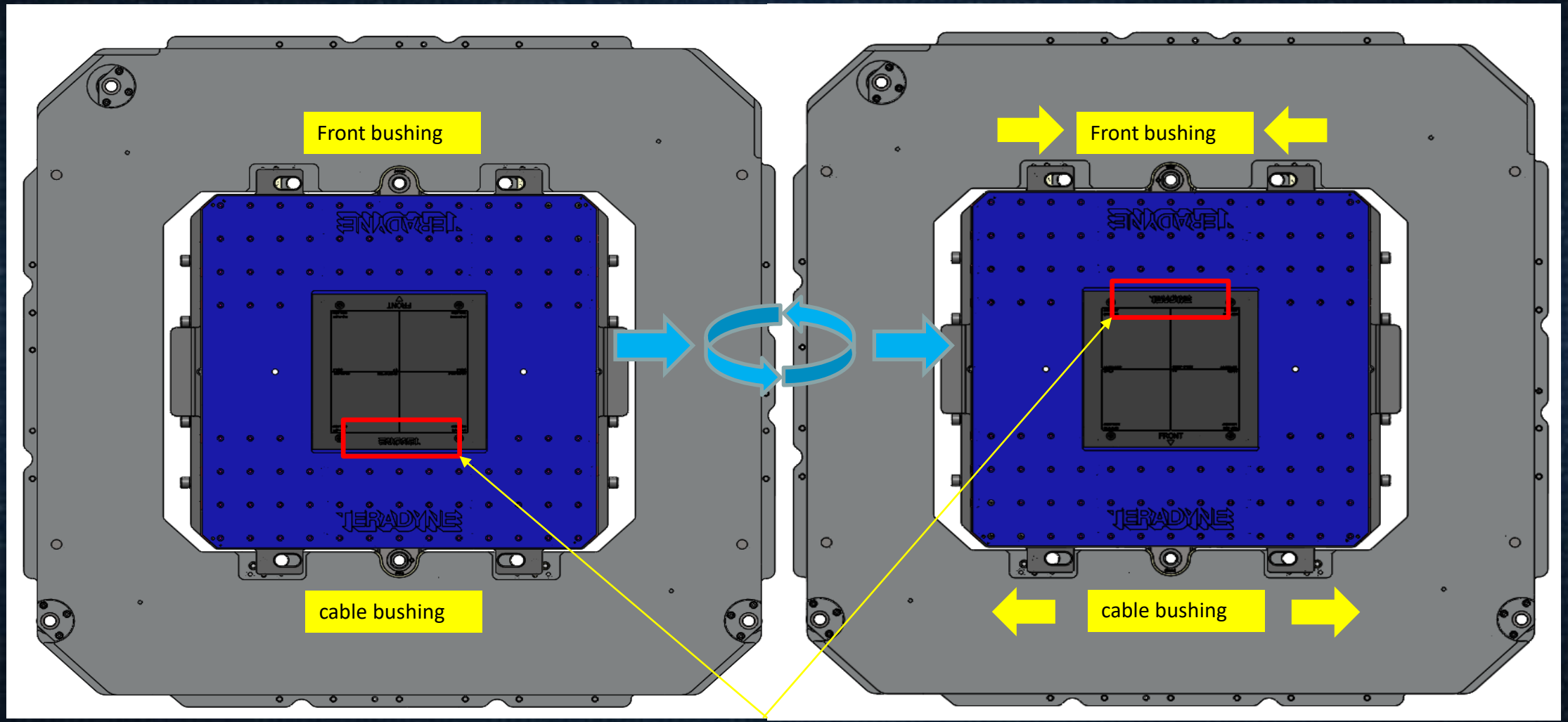
180° ROTATION



FLS Rotation Overview

0° POSITION

180° ROTATION

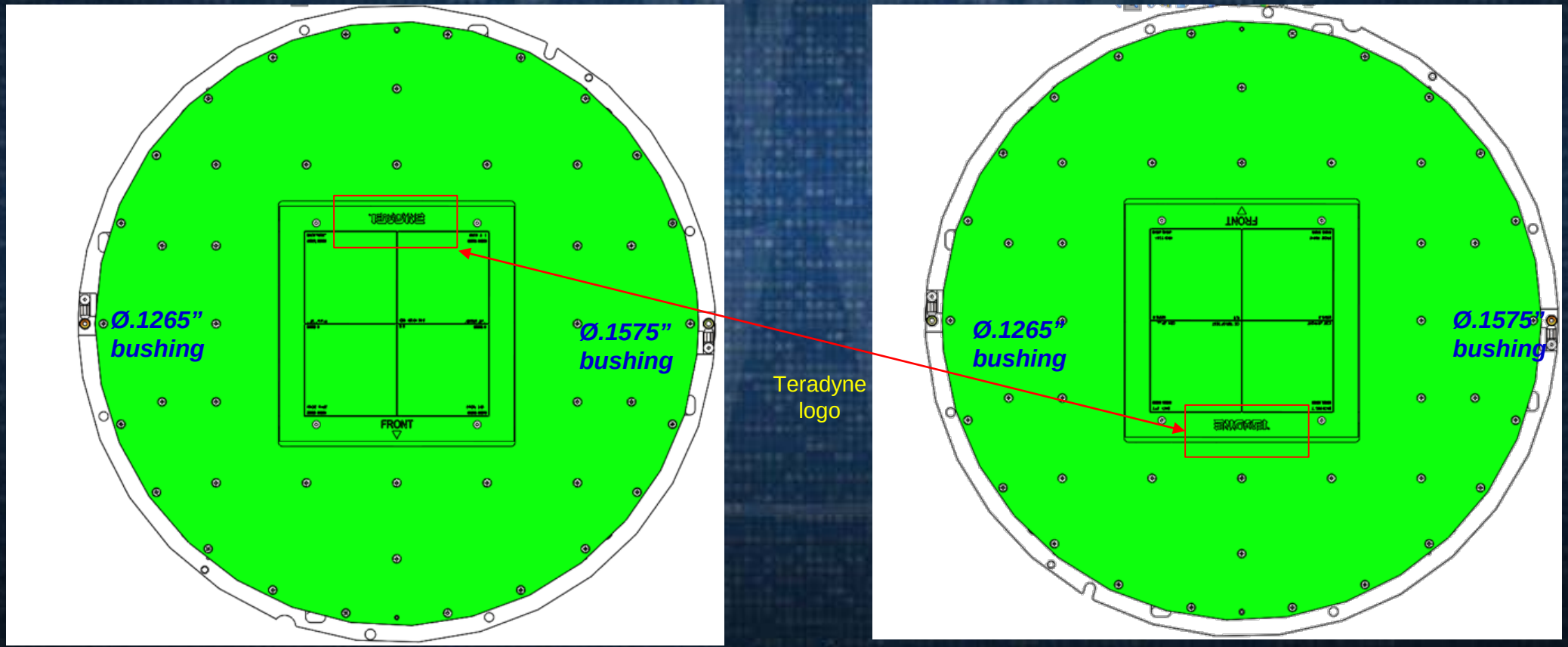


Teradyne Logo

J750-440J FLS Rotation Overview

0° POSITION

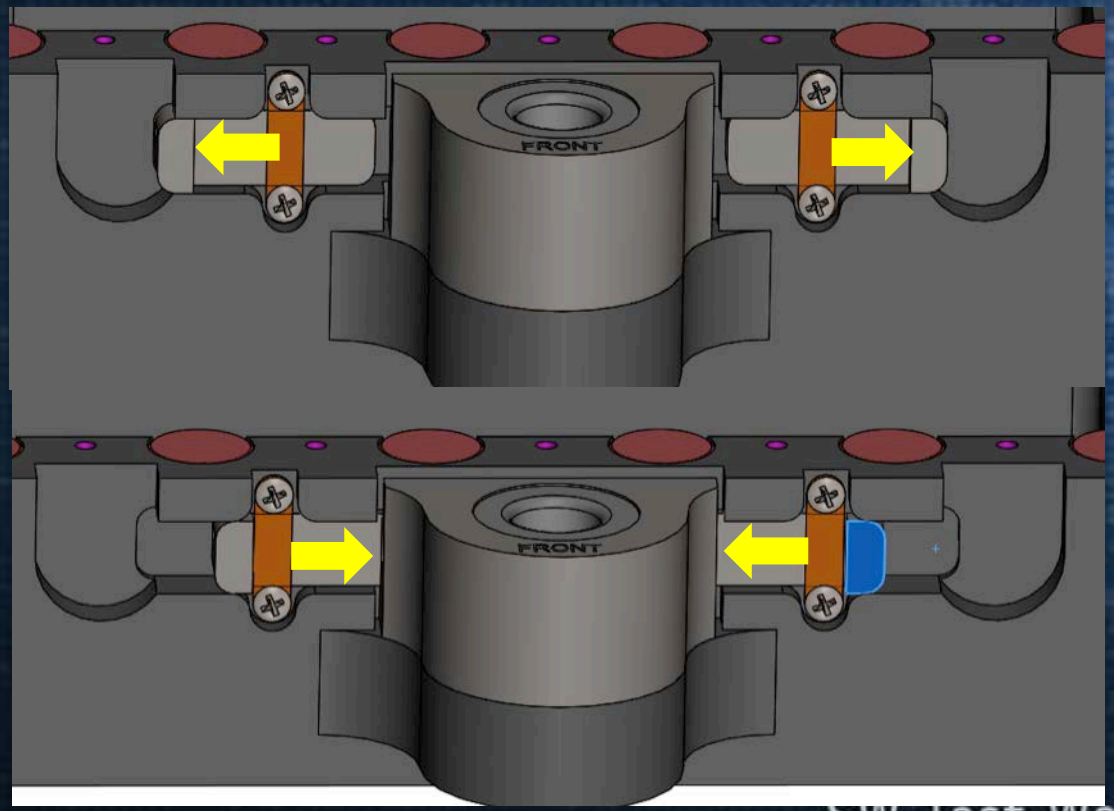
180° ROTATION



FLS Bushing Exchange Feature

Tool-less design has dual purpose:

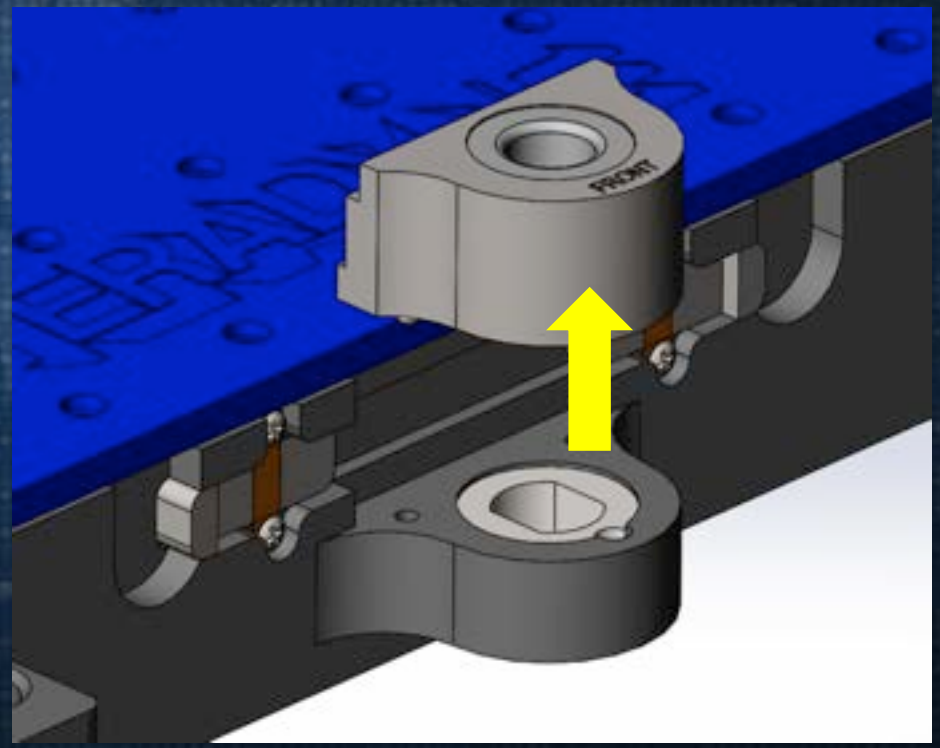
1. Enhance tool accuracy
2. Efficiency of rotation process



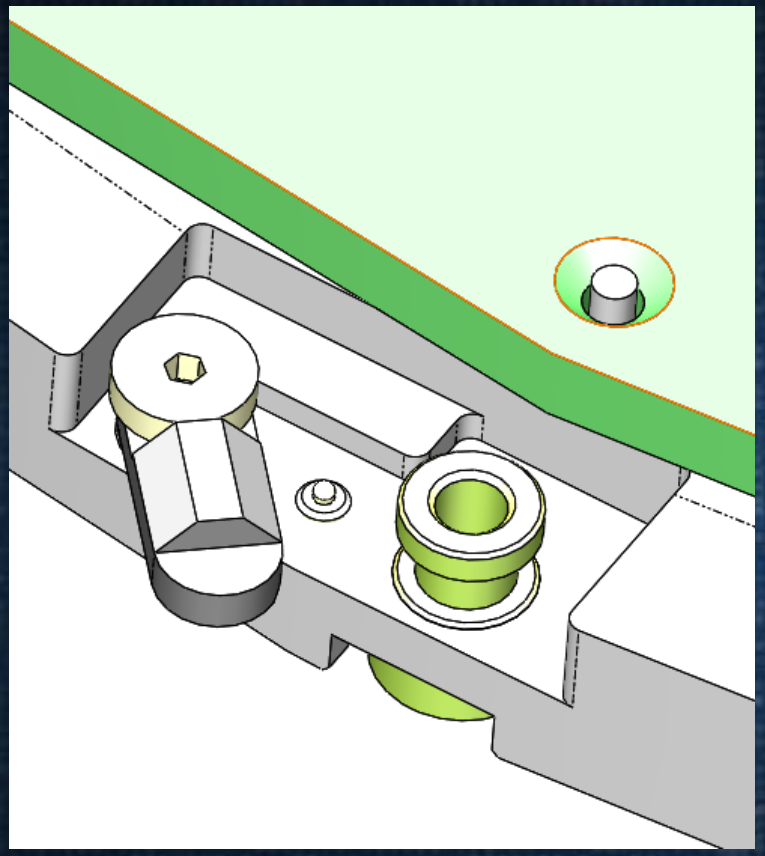
Open state

Latched state

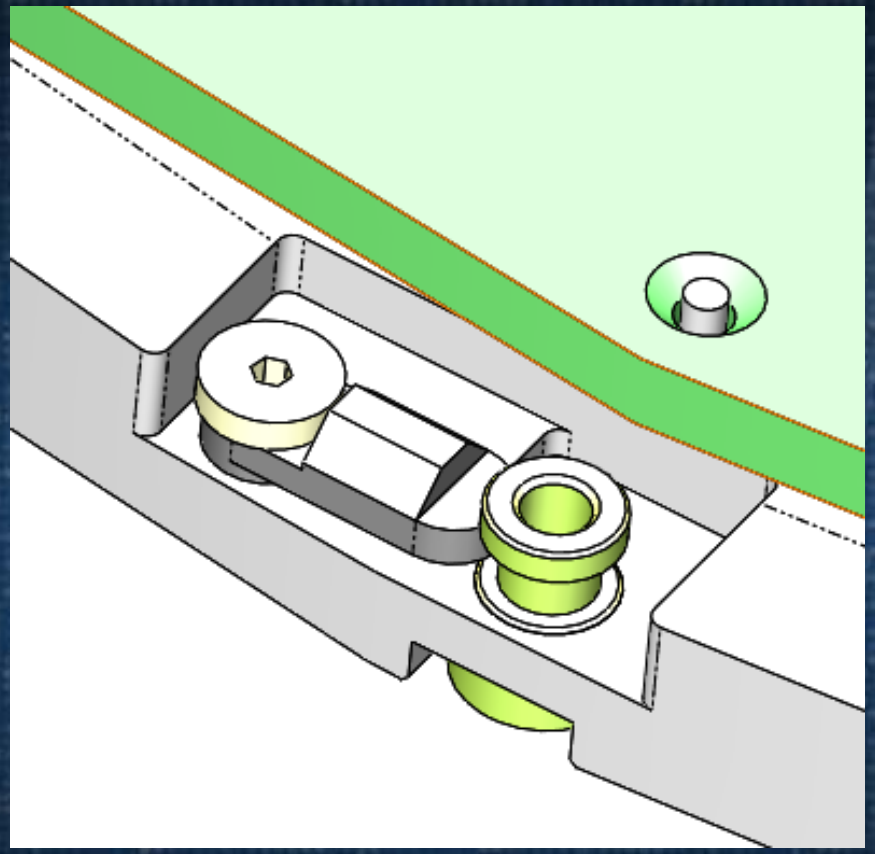
Bushing exchange allows for rotation on PC loader tray



J750 Bushing Exchange

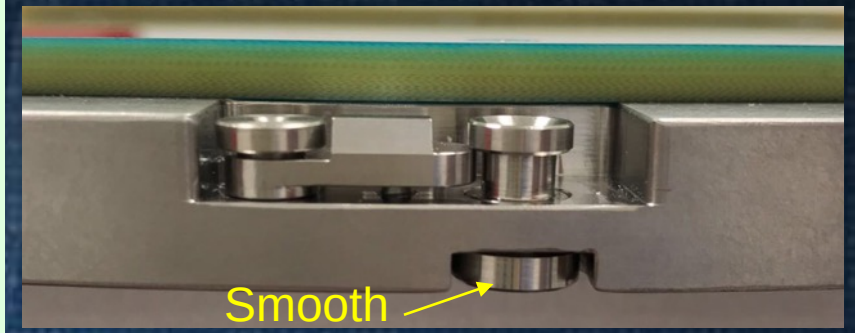


Open state

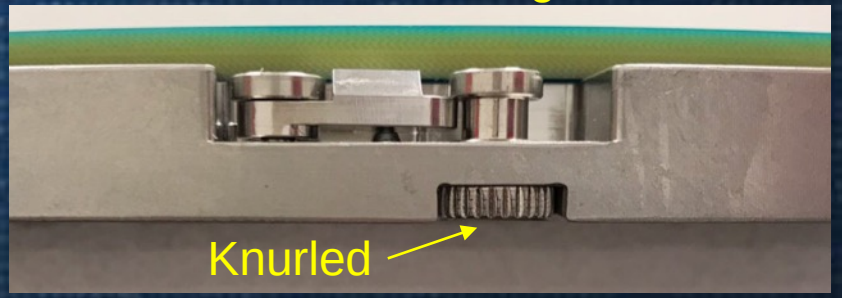


Latched state

0.1265” Bushing

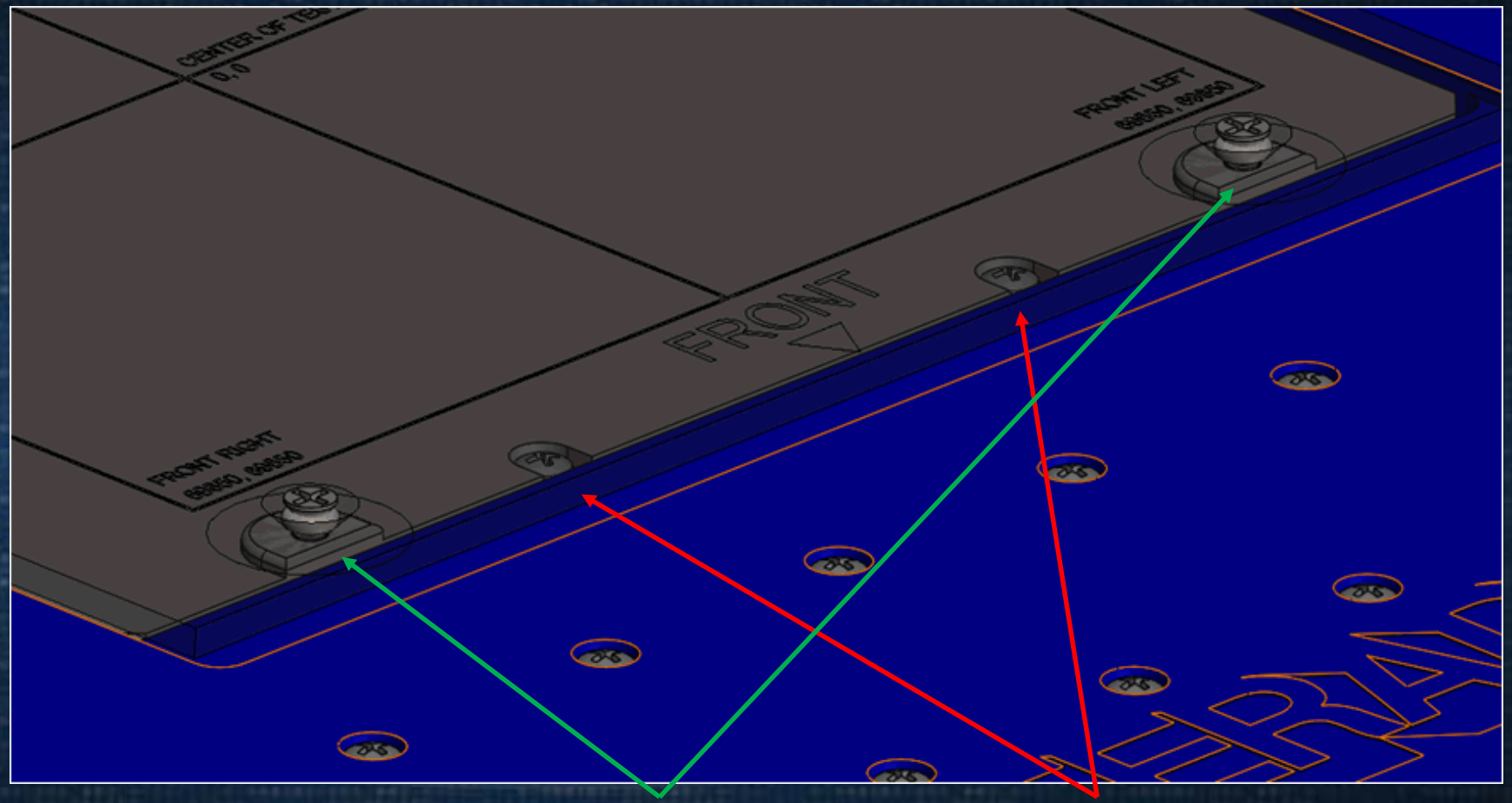


0.1575” Bushing



Emulates Probecard Architecture

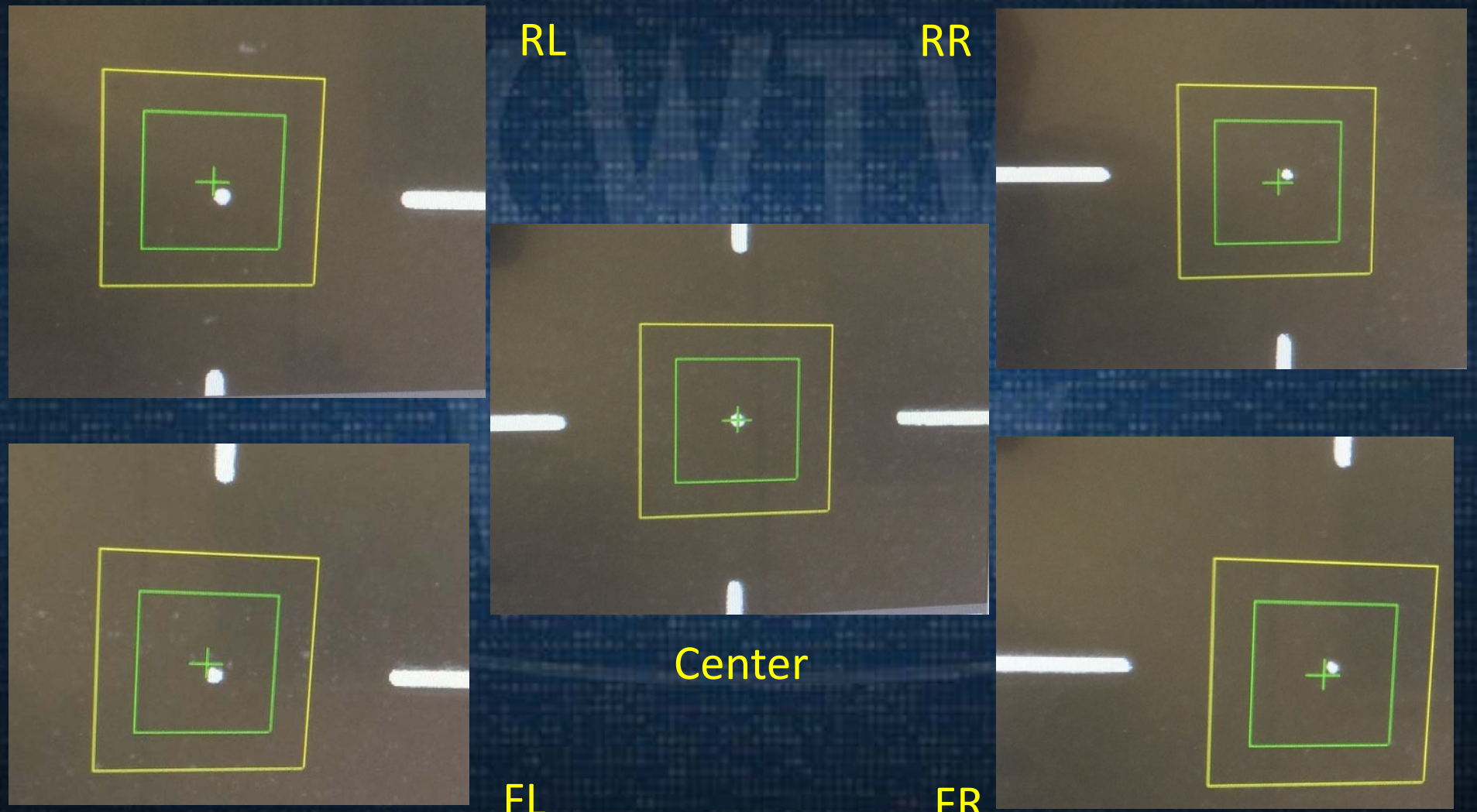
- Rigidly attached structures
- Provides optimal PC correlation



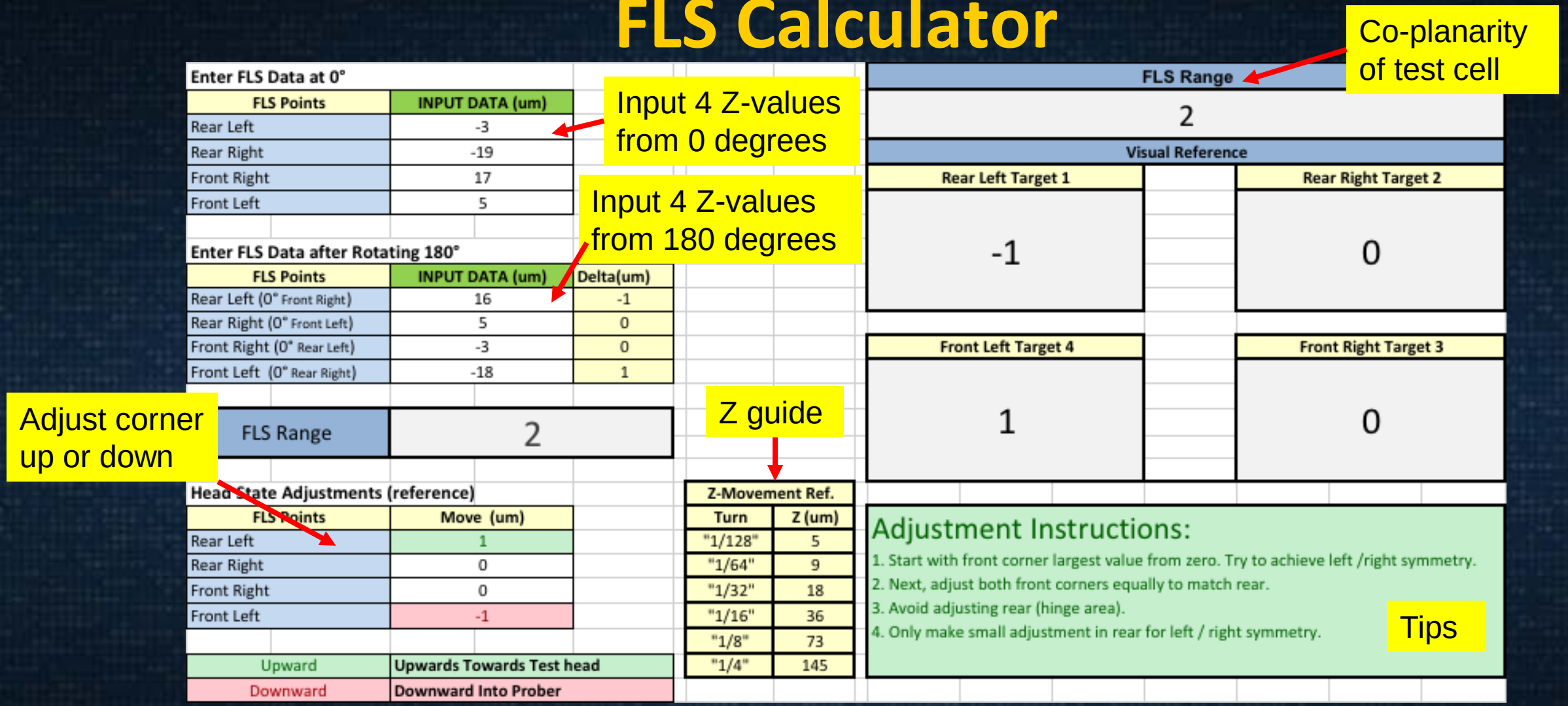
PCB targets mounted securely through Plate to PC stiffener

Plate mounted securely to PC stiffener under PCB

FLS Targets – Prober Macro View



FLS Calculator



Enter FLS Data at 0°

FLS Points	INPUT DATA (um)
Rear Left	-3
Rear Right	-19
Front Right	17
Front Left	5

Input 4 Z-values from 0 degrees

Input 4 Z-values from 180 degrees

Enter FLS Data after Rotating 180°

FLS Points	INPUT DATA (um)	Delta(um)
Rear Left (0° Front Right)	16	-1
Rear Right (0° Front Left)	5	0
Front Right (0° Rear Left)	-3	0
Front Left (0° Rear Right)	-18	1

FLS Range	2

Adjust corner up or down

Z guide

Head State Adjustments (reference)

FLS Points	Move (um)
Rear Left	1
Rear Right	0
Front Right	0
Front Left	-1

Upward	Upwards Towards Test head
Downward	Downward Into Prober

Z-Movement Ref.

Turn	Z (um)
"1/128"	5
"1/64"	9
"1/32"	18
"1/16"	36
"1/8"	73
"1/4"	145

Co-planarity of test cell

FLS Range
2

Visual Reference

Rear Left Target 1	Rear Right Target 2
-1	0

Front Left Target 4	Front Right Target 3
1	0

Adjustment Instructions:

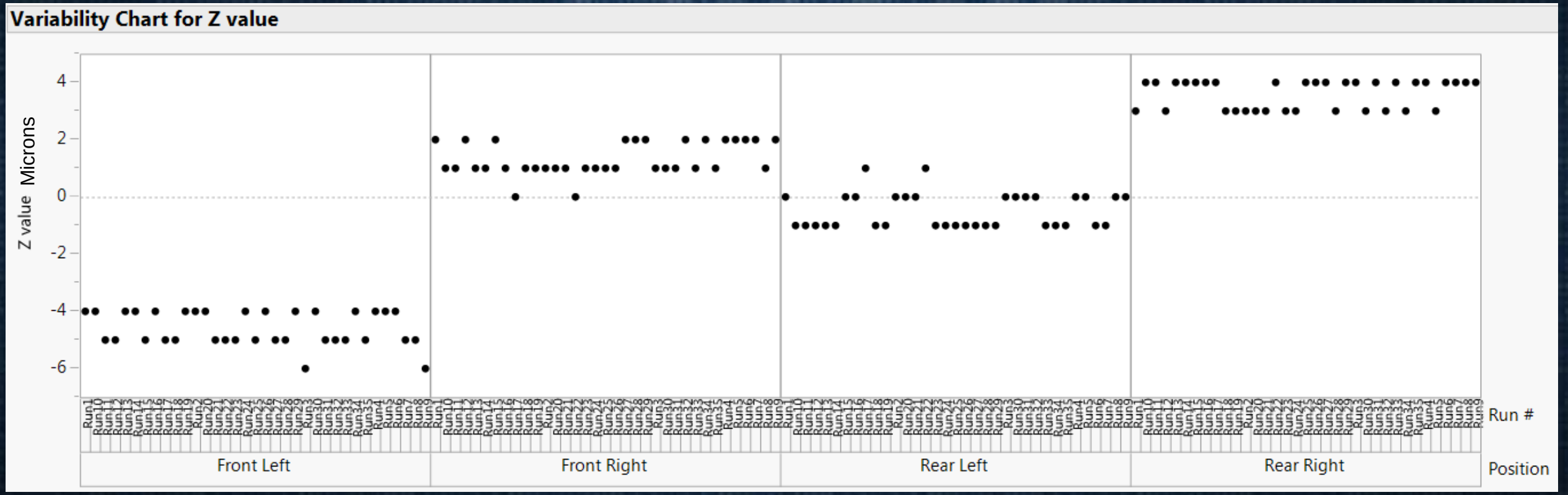
1. Start with front corner largest value from zero. Try to achieve left /right symmetry.
2. Next, adjust both front corners equally to match rear.
3. Avoid adjusting rear (hinge area).
4. Only make small adjustment in rear for left / right symmetry.

Tips

Setting up device file, training targets or manual measurements:
Always start in Rear Left location, continue clockwise.

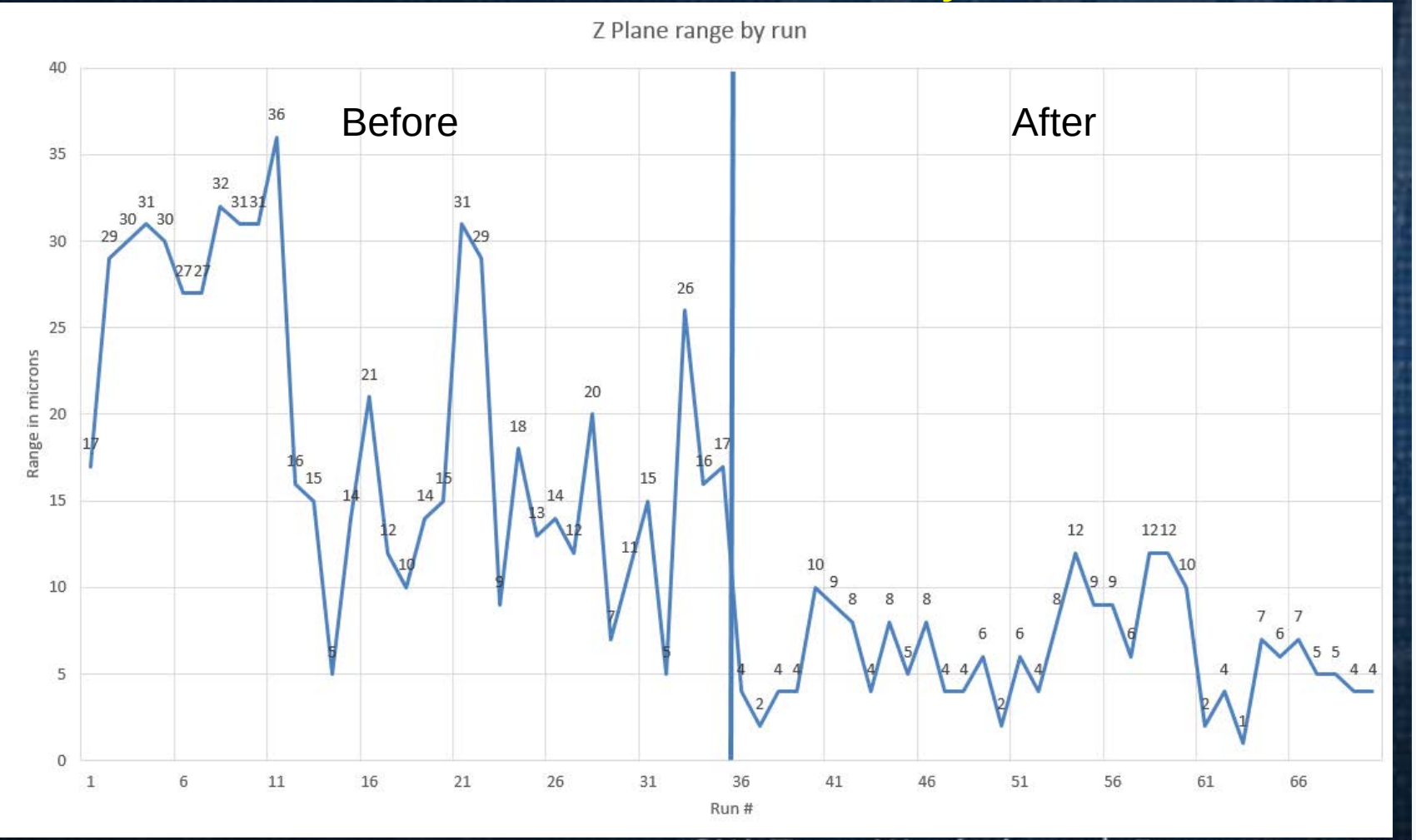
Prober Optics Results

FLS Target Acquisition Repeatability

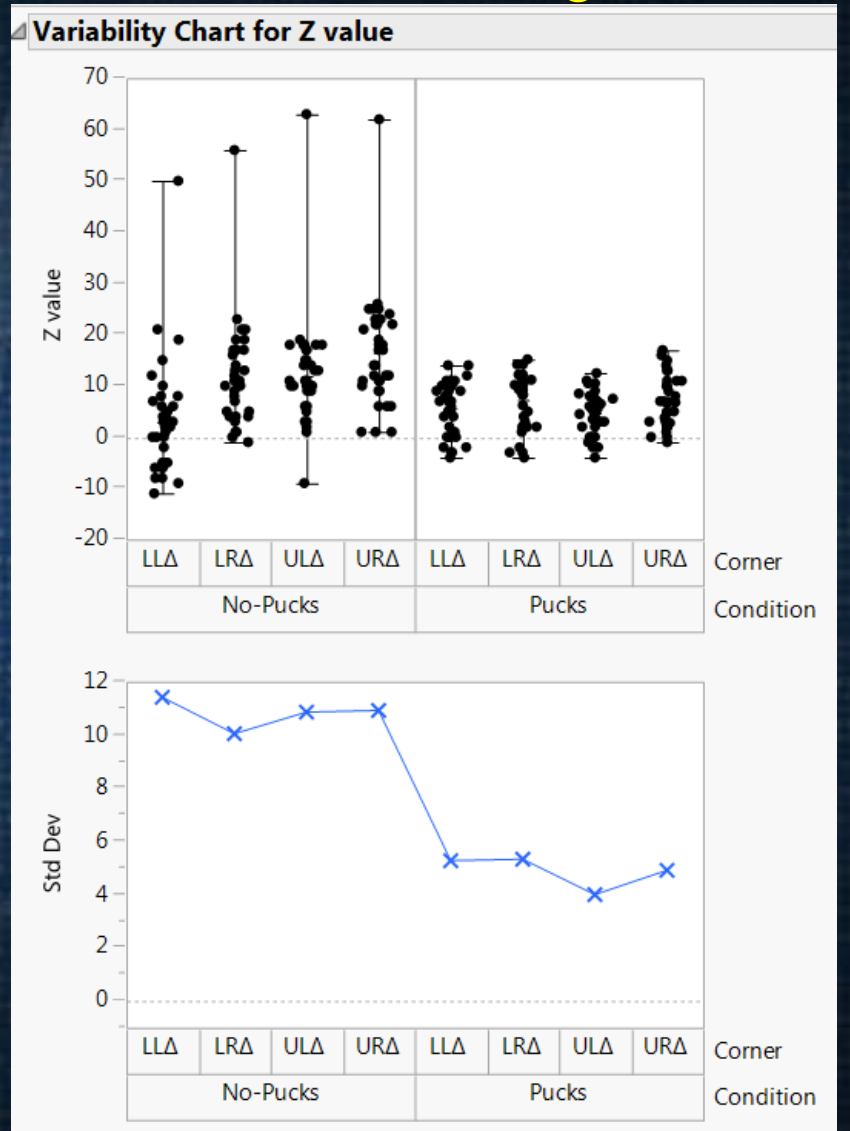


UltraProbe Results

Test Cell Co-Planarity



Test Cell Docking



J750 Results

Enter FLS Data at 0°

FLS Points	INPUT DATA (um)
Rear Left	50
Rear Right	-28
Front Right	-39
Front Left	17

Enter FLS Data after Rotating 180°

FLS Points	INPUT DATA (um)	Delta(um)
Rear Left (0° Front Right)	66	105
Rear Right (0° Front Left)	-24	-41
Front Right (0° Rear Left)	-57	-107
Front Left (0° Rear Right)	14	42

FLS Range	212

Head State Adjustments (reference)

FLS Points	Move (um)
Rear Left	-73
Rear Right	0
Front Right	33
Front Left	-42
Upward (CW)	Upwards Towards Test head
Downward (CCW)	Downward Into Prober

Z-Movement Ref.

Turn	Z (um)
"1/128"	5
"1/64"	9
"1/32"	18
"1/16"	36
"1/8"	73
"1/4"	145

FLS Range: 212

Visual Reference

Rear Left Target 1	Rear Right Target 2
105	-41

Front Left Target 4	Front Right Target 3
42	-107

Adjustment Instructions:

1. Start with front corner largest value from zero. Try to achieve left /right symmetry.
2. Next, adjust both front corners equally to match rear.
3. Avoid adjusting rear (hinge area).
4. Only make small adjustment in rear for left / right symmetry.

Enter FLS Data at 0°

FLS Points	INPUT DATA (um)
Rear Left	31
Rear Right	-16
Front Right	-20
Front Left	6

Enter FLS Data after Rotating 180°

FLS Points	INPUT DATA (um)	Delta(um)
Rear Left (0° Front Right)	47	67
Rear Right (0° Front Left)	-18	-24
Front Right (0° Rear Left)	-38	-69
Front Left (0° Rear Right)	9	25

FLS Range	136

Head State Adjustments (reference)

FLS Points	Move (um)
Rear Left	-46
Rear Right	0
Front Right	23
Front Left	-25
Upward (CW)	Upwards Towards Test head
Downward (CCW)	Downward Into Prober

Z-Movement Ref.

Turn	Z (um)
"1/128"	5
"1/64"	9
"1/32"	18
"1/16"	36
"1/8"	73
"1/4"	145

FLS Range: 136

Visual Reference

Rear Left Target 1	Rear Right Target 2
67	-24

Front Left Target 4	Front Right Target 3
25	-69

Adjustment Instructions:

1. Start with front corner largest value from zero. Try to achieve left /right symmetry.
2. Next, adjust both front corners equally to match rear.
3. Avoid adjusting rear (hinge area).
4. Only make small adjustment in rear for left / right symmetry.

Enter FLS Data at 0°

FLS Points	INPUT DATA (um)
Rear Left	3
Rear Right	-5
Front Right	5
Front Left	-3

Enter FLS Data after Rotating 180°

FLS Points	INPUT DATA (um)	Delta(um)
Rear Left (0° Front Right)	25	20
Rear Right (0° Front Left)	4	7
Front Right (0° Rear Left)	-15	-18
Front Left (0° Rear Right)	-13	-8

FLS Range	38

Head State Adjustments (reference)

FLS Points	Move (um)
Rear Left	-7
Rear Right	0
Front Right	13
Front Left	8
Upward (CW)	Upwards Towards Test head
Downward (CCW)	Downward Into Prober

Z-Movement Ref.

Turn	Z (um)
"1/128"	5
"1/64"	9
"1/32"	18
"1/16"	36
"1/8"	73
"1/4"	145

FLS Range: 38

Visual Reference

Rear Left Target 1	Rear Right Target 2
20	7

Front Left Target 4	Front Right Target 3
-8	-18

Adjustment Instructions:

1. Start with front corner largest value from zero. Try to achieve left /right symmetry.
2. Next, adjust both front corners equally to match rear.
3. Avoid adjusting rear (hinge area).
4. Only make small adjustment in rear for left / right symmetry.

Enter FLS Data at 0°

FLS Points	INPUT DATA (um)
Rear Left	0
Rear Right	-5
Front Right	9
Front Left	-4

Enter FLS Data after Rotating 180°

FLS Points	INPUT DATA (um)	Delta(um)
Rear Left (0° Front Right)	25	16
Rear Right (0° Front Left)	3	7
Front Right (0° Rear Left)	-13	-13
Front Left (0° Rear Right)	-15	-10

FLS Range	29

Head State Adjustments (reference)

FLS Points	Move (um)
Rear Left	-5
Rear Right	0
Front Right	10
Front Left	9
Upward (CW)	Upwards Towards Test head
Downward (CCW)	Downward Into Prober

Z-Movement Ref.

Turn	Z (um)
"1/128"	5
"1/64"	9
"1/32"	18
"1/16"	36
"1/8"	73
"1/4"	145

FLS Range: 29

Visual Reference

Rear Left Target 1	Rear Right Target 2
16	7

Front Left Target 4	Front Right Target 3
-10	-13

Adjustment Instructions:

1. Start with front corner largest value from zero. Try to achieve left /right symmetry.
2. Next, adjust both front corners equally to match rear.
3. Avoid adjusting rear (hinge area).
4. Only make small adjustment in rear for left / right symmetry.

Enter FLS Data at 0°

FLS Points	INPUT DATA (um)
Rear Left	-5
Rear Right	-4
Front Right	16
Front Left	-7

Enter FLS Data after Rotating 180°

FLS Points	INPUT DATA (um)	Delta(um)
Rear Left (0° Front Right)	16	0
Rear Right (0° Front Left)	4	11
Front Right (0° Rear Left)	-6	-1
Front Left (0° Rear Right)	-15	-11

FLS Range	22

Head State Adjustments (reference)

FLS Points	Move (um)
Rear Left	0
Rear Right	-6
Front Right	1
Front Left	6
Upward (CW)	Upwards Towards Test head
Downward (CCW)	Downward Into Prober

Z-Movement Ref.

Turn	Z (um)
"1/128"	5
"1/64"	9
"1/32"	18
"1/16"	36
"1/8"	73
"1/4"	145

FLS Range: 22

Visual Reference

Rear Left Target 1	Rear Right Target 2
0	11

Front Left Target 4	Front Right Target 3
-11	-1

Adjustment Instructions:

1. Start with front corner largest value from zero. Try to achieve left /right symmetry.
2. Next, adjust both front corners equally to match rear.
3. Avoid adjusting rear (hinge area).
4. Only make small adjustment in rear for left / right symmetry.

Enter FLS Data at 0°

FLS Points	INPUT DATA (um)
Rear Left	-3
Rear Right	-12
Front Right	14
Front Left	0

Enter FLS Data after Rotating 180°

FLS Points	INPUT DATA (um)	Delta(um)
Rear Left (0° Front Right)	15	1
Rear Right (0° Front Left)	-4	-4
Front Right (0° Rear Left)	-4	-1
Front Left (0° Rear Right)	-6	6

FLS Range	10

Head State Adjustments (reference)

FLS Points	Move (um)
Rear Left	0
Rear Right	3
Front Right	1
Front Left	-3
Upward (CW)	Upwards Towards Test head
Downward (CCW)	Downward Into Prober

Z-Movement Ref.

Turn	Z (um)
"1/128"	5
"1/64"	9
"1/32"	18
"1/16"	36
"1/8"	73
"1/4"	145

FLS Range: 10

Visual Reference

Rear Left Target 1	Rear Right Target 2
1	-4

Front Left Target 4	Front Right Target 3
6	-1

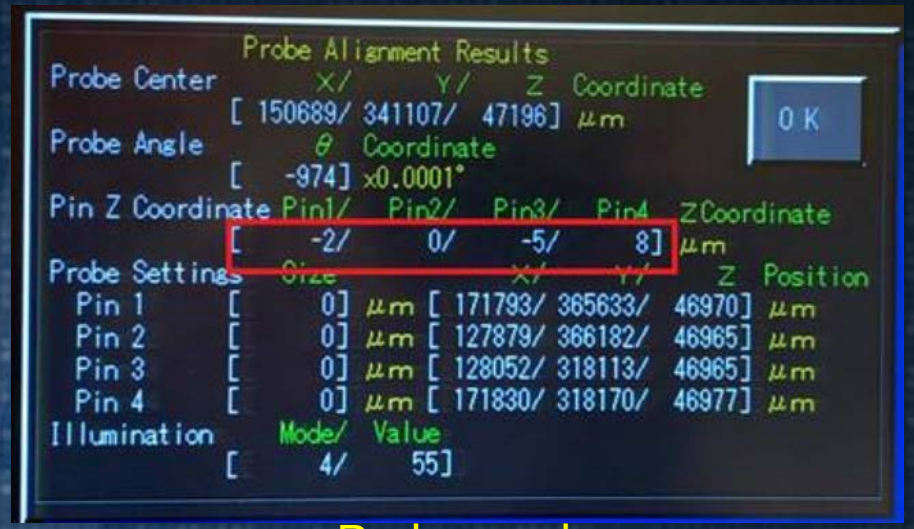
Adjustment Instructions:

1. Start with front corner largest value from zero. Try to achieve left /right symmetry.
2. Next, adjust both front corners equally to match rear.
3. Avoid adjusting rear (hinge area).
4. Only make small adjustment in rear for left / right symmetry.

J750 Probecard Correlation Results

- **New PC design – array (~4” x 4”)**
- **Four corner probes of array were within 13 microns**
  - (-2, 0, -5, 8).
- **PC metrology 50 microns planarity**
- **PC electrical continuity check on prober w/tester was 45 microns**
- **Uniform probe marks on all pads**

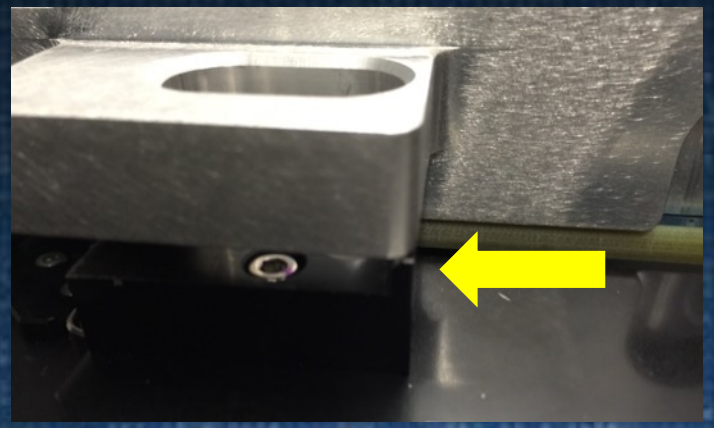
Prober optical results

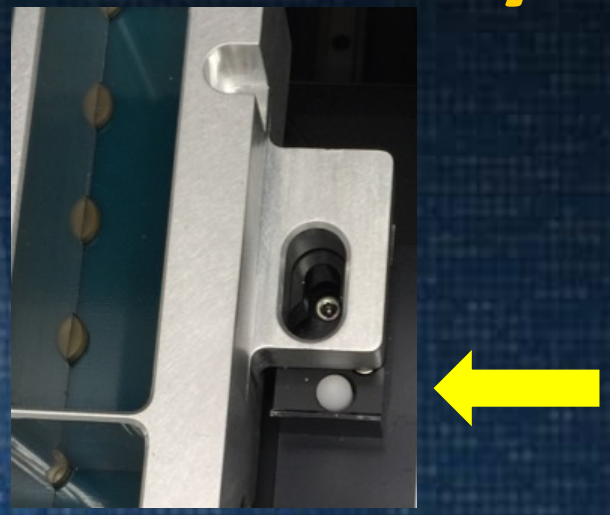


Probe marks

Accretech kit for UltraProbe – PC Tray

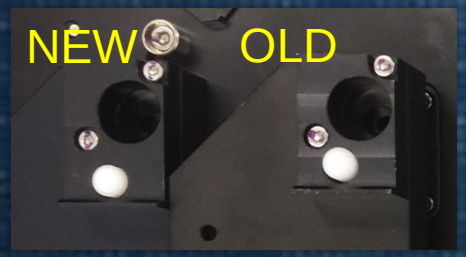
Before

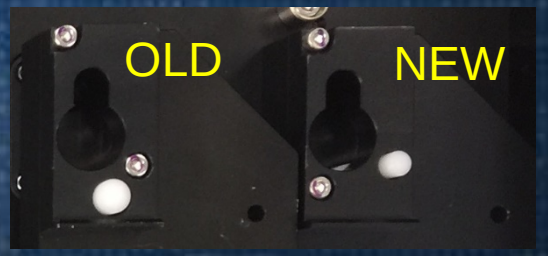


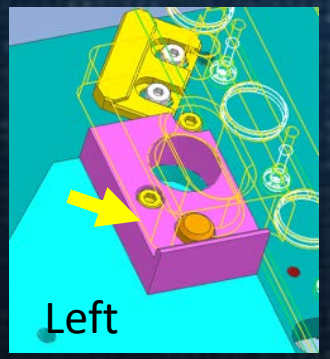


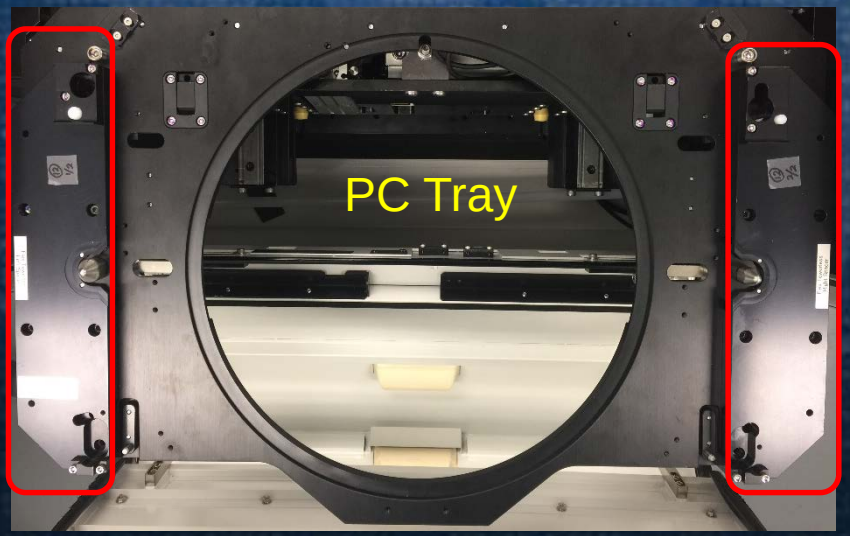
P/N: 1C0000231131-003
Kit supplied by Accretech

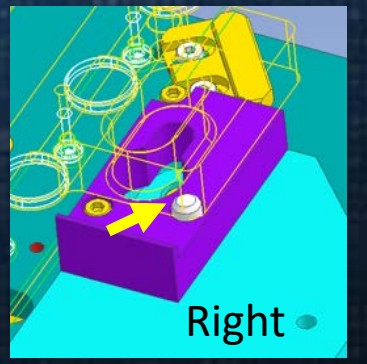
After











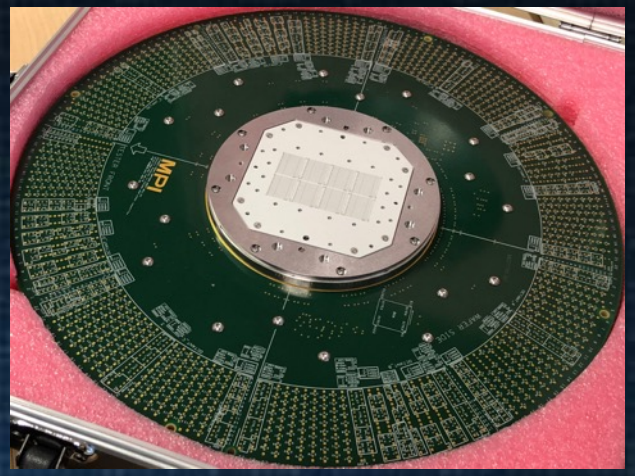
Tab block is elongated
Sensor Pin re-positioned

Sensor Pin is re-positioned

Conclusions

- ✓ • Repeatable docking for UltraProbe
- ✓ • Efficient PLP field conversion capability
- ✓ • Maintain knowledge & experience of proven tools
- ✓ • Emulate a probecard architectures for accuracy
- ✓ • Compatible on multiple tester platforms
- ✓ • Eliminated tool calibrations
- ✓ • Achieve a test cell co-planarity of <20 microns (5.5” x 5.5”)
- ☺ • Compatibility on probers – PC tray conversion

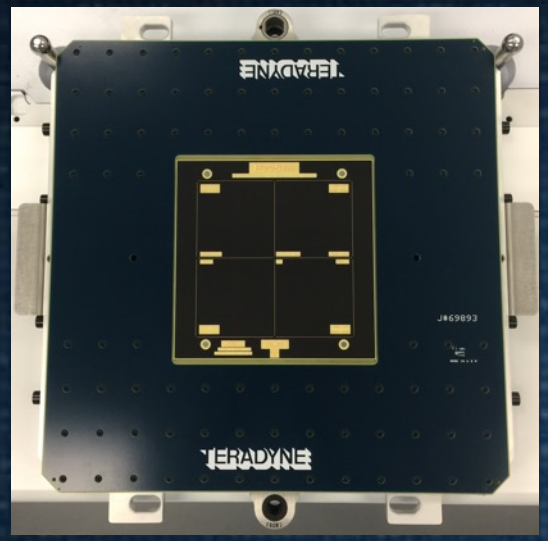
Future Work



~18,000 probes

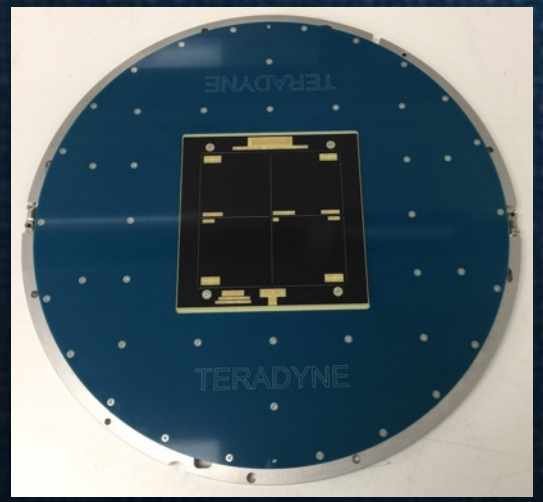
- **FLS for J750 with 300mm towers**
  - Probe array sizes are increasing
- **FLS for ETS-800 test cells**
- **Implement Auto-leveling / Auto-tilt feature of prober with FLS**
  - Automated head plate adjustment by stepper motors
    - Operator enables feature, only loads / unloads FLS both rotations
    - Prober does all calculations, adjusts, disables feature
  - A “one and done” process for setup or verification

Contributor Appreciation



Doug Garrett - NXP

NXP SECURE CONNECTIONS FOR A SMARTER WORLD



Hoang Nguyen - Microsemi

Microsemi