3D profiler for contactless probe-card inspection

BE PRECISION TECHNOLOGY

Rob Marcelis

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Introduction
BE precisions technology

- **Dutch based company**
- **Founded 2000**
- **20 employees**
- **WW sales network**
- **Main focus: probe-card analysis tools**
  - Optical, Electrical, 3D laser

Objectives

- Provide process and quality improvements
- Probe-card screening tool
- Create a quick way to check contactless the mechanical condition of MEMS probe-cards
- Present the outcome in a user friendly GUI
- Re-use as much as possible existing systems parts
- Avoid a tester-platform dedicated motherboard
- Good ROI

Challenges

- **Speed**
  - Inspect < 1 pin/sec
- **Accuracy**
  - Better then +/- 3 µm
- **Parallelism**
  - Better then +/- 3 µm

Basics

- **Why needle inspection?**
  - Ware
    - Tip diameter and shape
    - contamination (debris)
  - Mechanical damage
    - caused by handling
    - caused by process (fritting; needle stuck to bond-pad or cleaning)
    - Gram-force
  - Electrical characteristics verification
    - Cres
    - Leakage
    - Wire check
- **Probe-cards get more complex and more expensive**

Basics

- **What is normally tested by probe-card analyzer?**
  - Planarity (Z)
  - Alignment (X/Y)
    - Air image
    - Contact image @ normal overtravel
    - Scrub length , Scrub angle
    - Entire spider angle
  - Cres
  - Leakage (with and without contact pressure)
  - Gram-force
  - Probe-card electronics (relay's and other components)
  - Wire check

For the gray items a probe-card electrical test system is required incl. motherboard

Methods for 3D analysis

- **Optical**
  - 2 camera
    - Resolution
    - calibration
  - Interfero-metrology
    - Complex
    - expensive
- **Laser**
  - Spot laser
  - Line-scan laser

Critical parameters

- Stage-base flatness
- Parallelism between stage-base & probe-card
- Resolution (dot size of laser beam)
- Scan time
- Reference file, containing probe-card data

Design Of Experiment

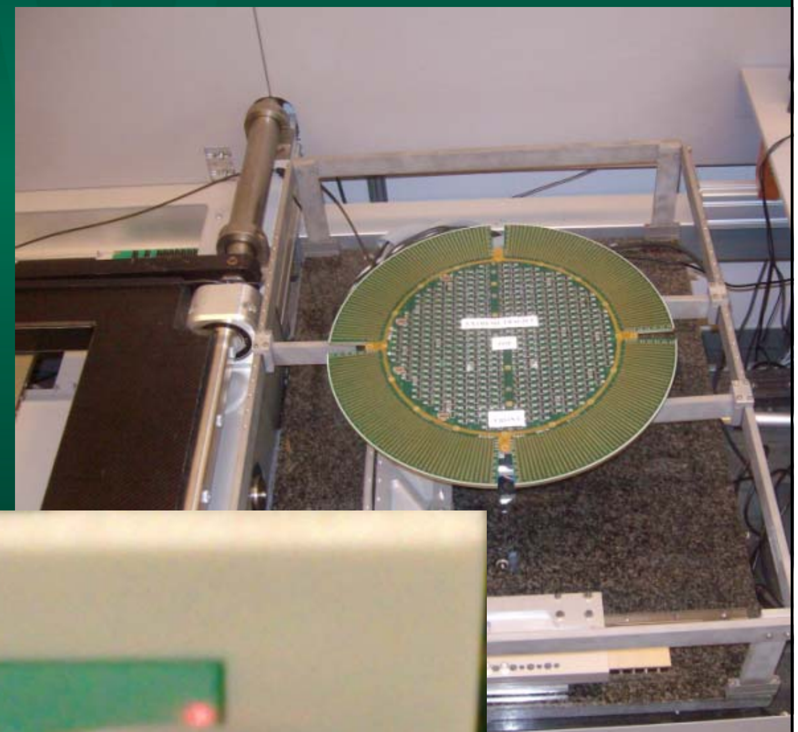
- X/Y/Z stage
- Laser head
- Ceramic substrate with dots

System buildup

- **Existing stage of M3 analyzer**
- **Additional probe-card holder rack**
  - Parallelism to stage < 3 µm
- **Mounting bracket for laser head**
- **Interpretation and representation SW**

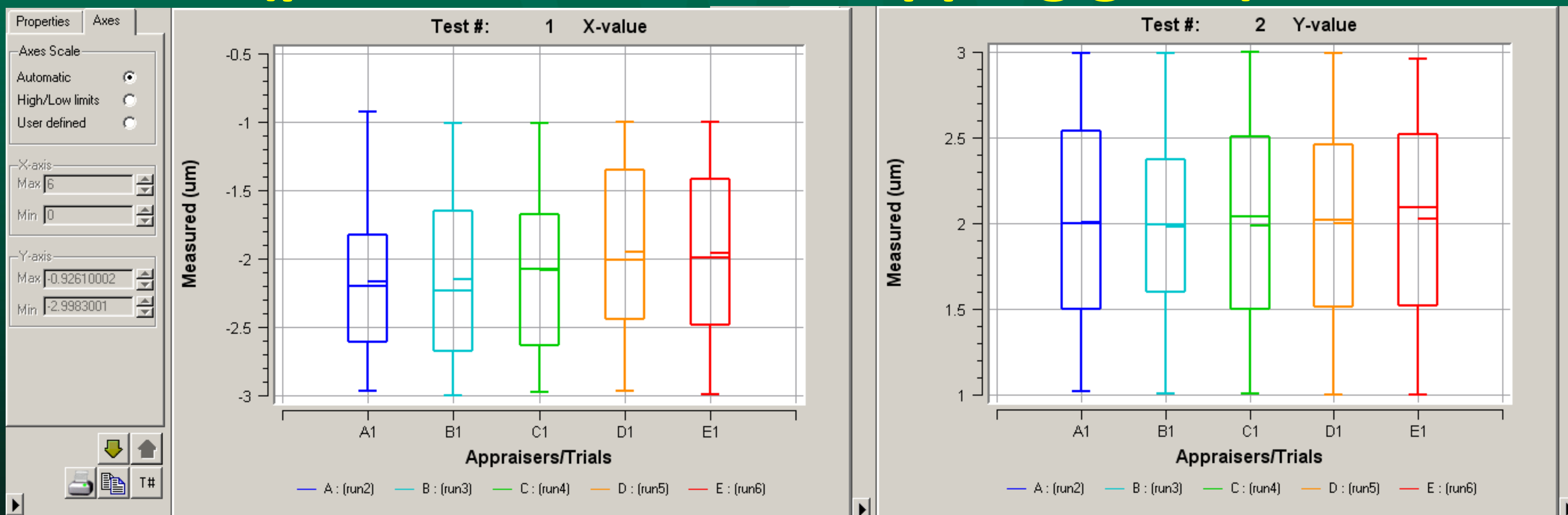
System build-up

System build-up



Stage performance

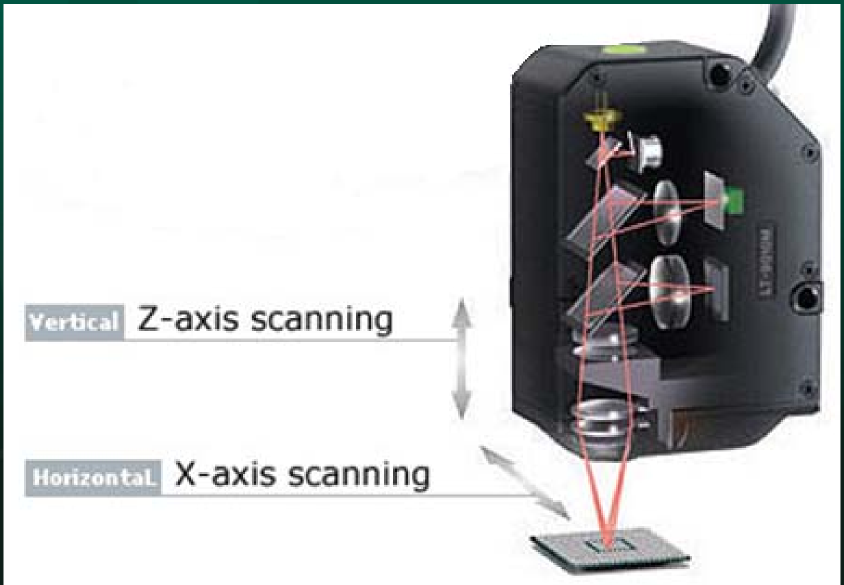
- Position accuracy within 2 µm over multiple runs. (position error to mapping glass)



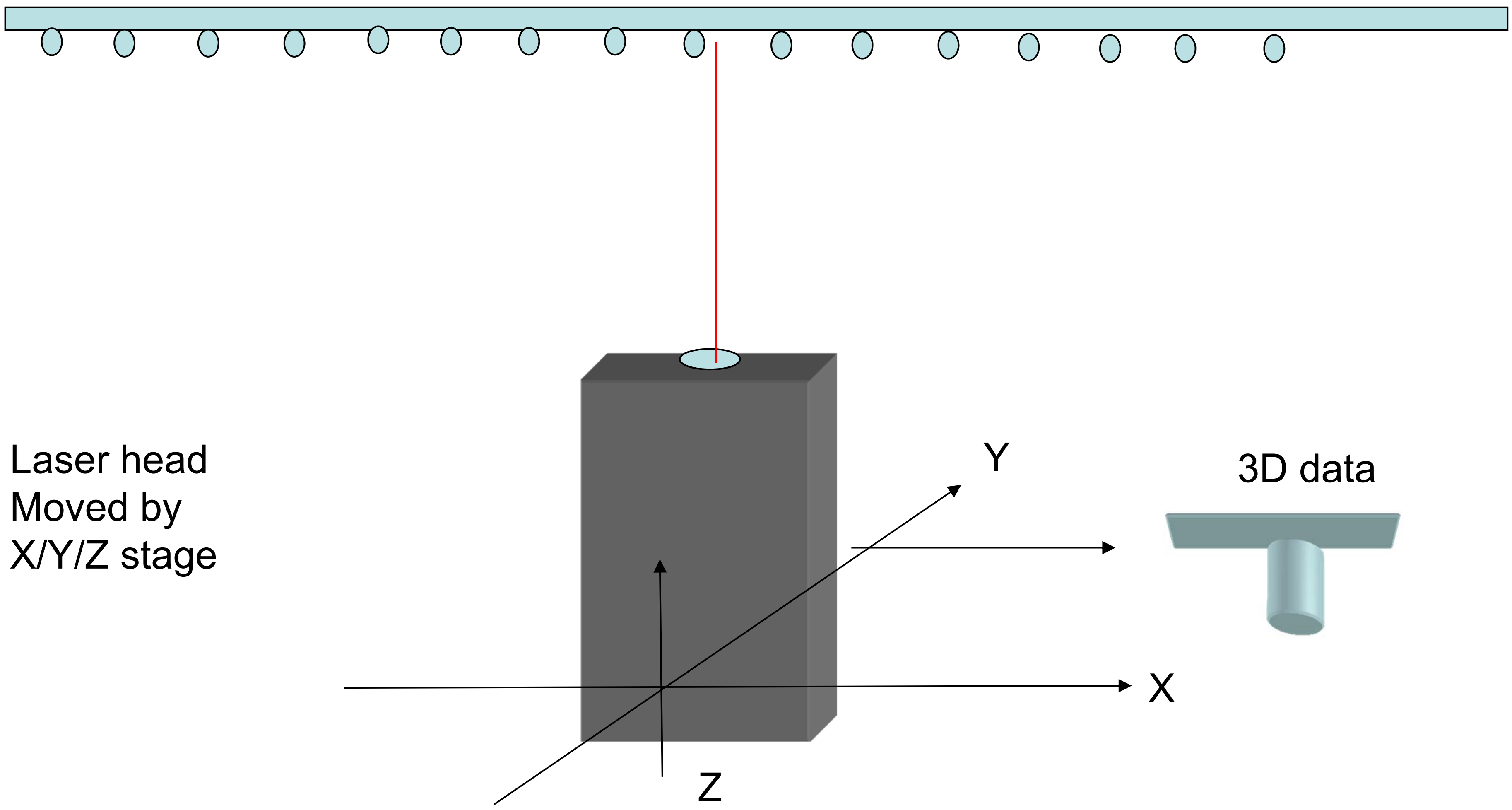
- Overall stage flatness <4 µm over used travel area

Laser specifications

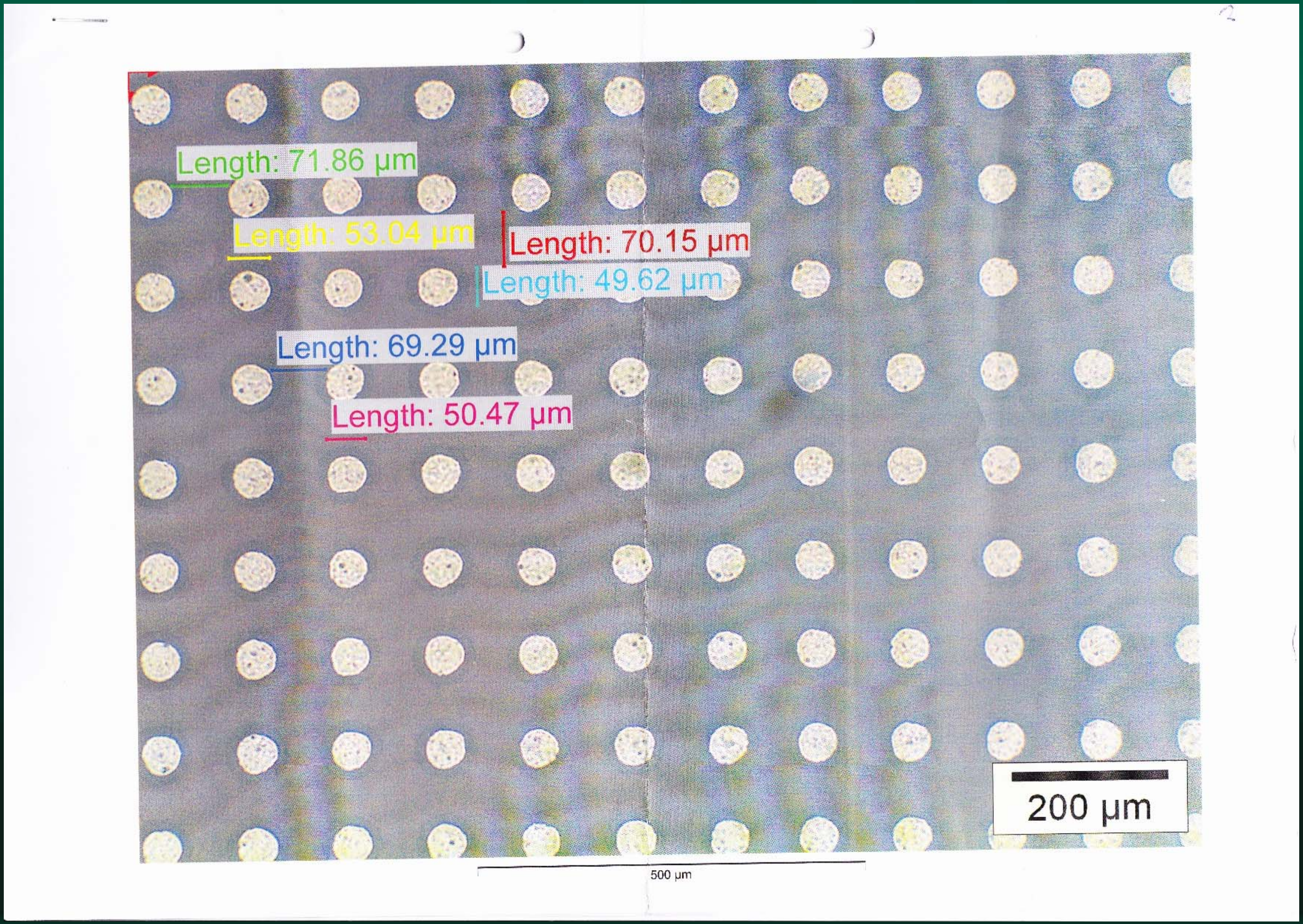
- 2 µm spot
- Confocal displacement measurement system
- Scan in Z and X direction
- Resolution of 0.01µm
- Max scan line 1.1 mm



Scan motion

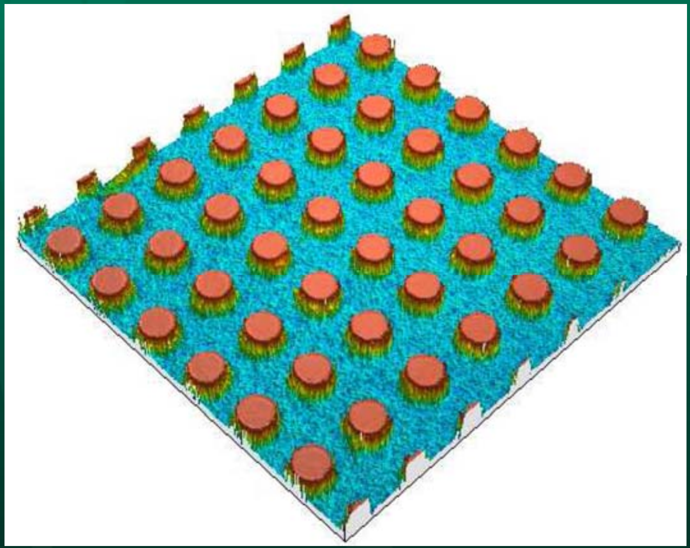


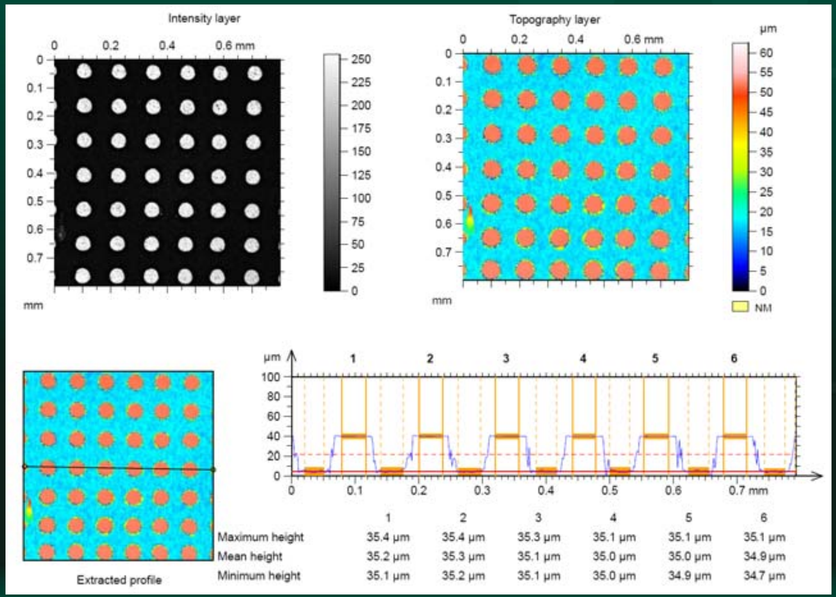
Reference substrate



Reference substrate

- 4” square ceramic substrate with ink Dots
- +/- 50 µm ø & +/-35 µm high
- 120 µm grid
- Better then 2 µm flatness





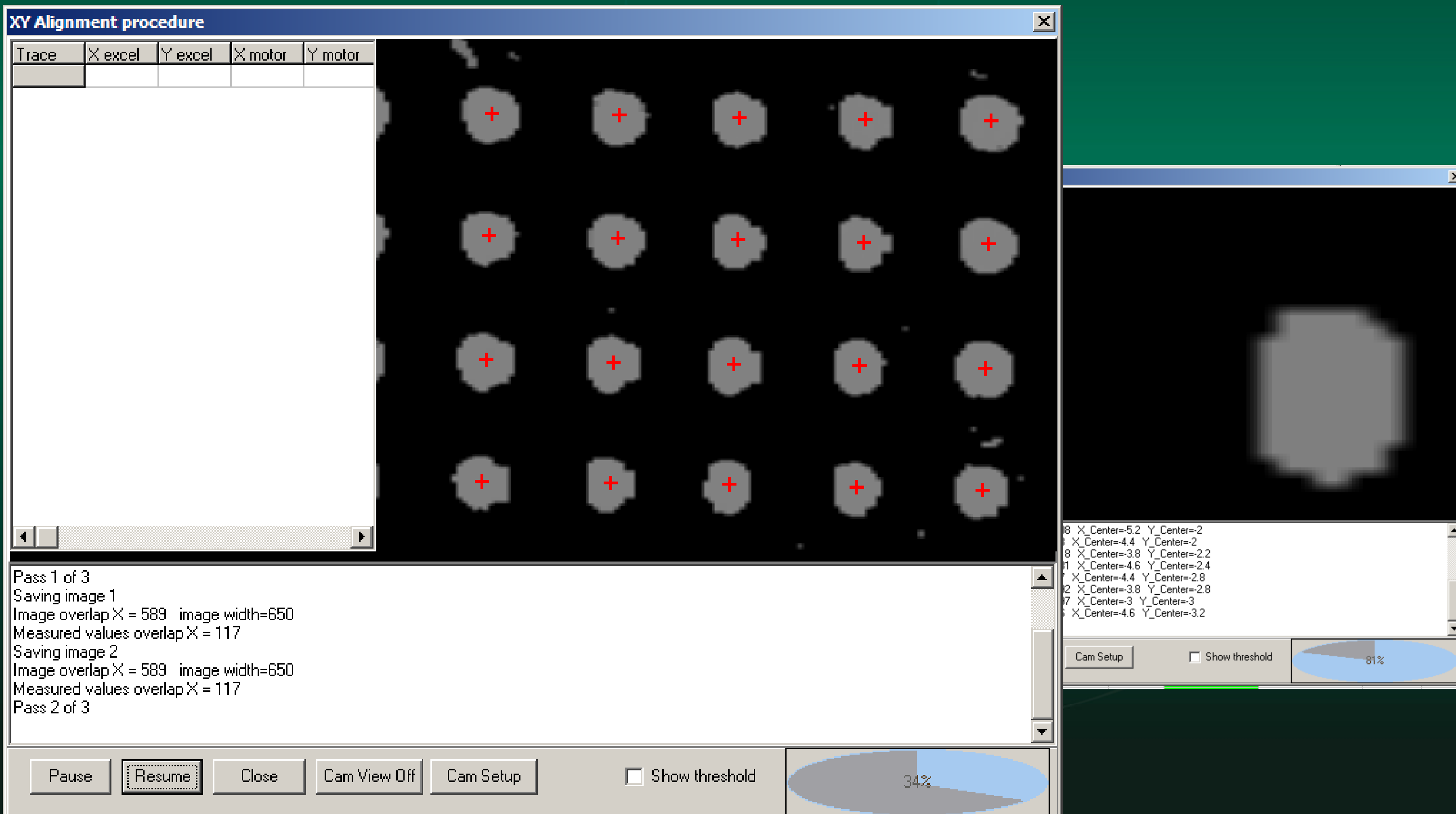
1st trials

- **Confocal Spot laser results**
  - 2 µm spot
  - Moved in X/Y in the area where pin suppose to be
  - 120 µm X 120 µm area with 5 µm grid
  - Time required little over 100 sec/pin (scan area)
- **Line-scan confocal laser**
  - 2 suppliers
  - Due to big price difference focused on 1 supplier
  - Stage movement in X direction
  - Laser head scanning in Y direction
  - Same 120 µm X 120 µm area with 5 µm grid scan area
  - Time required just under 16 sec/pin

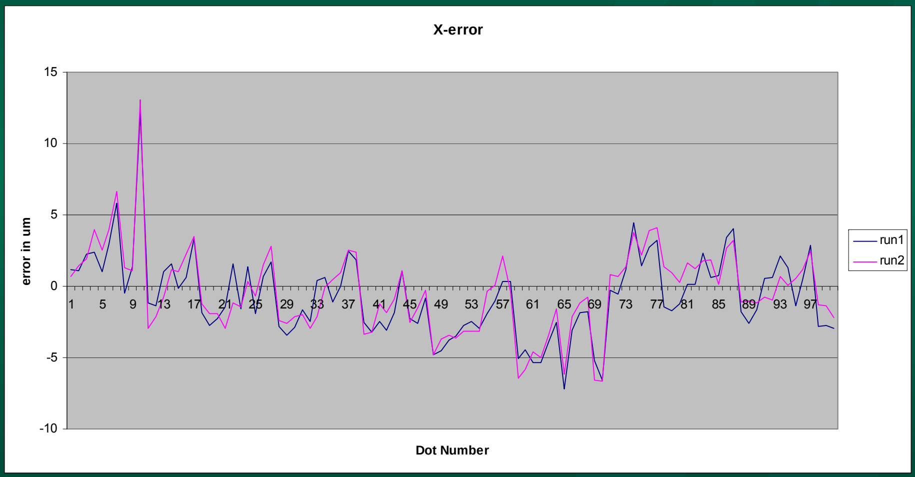
2th trial

- **Line-scan confocal laser**
  - Stage movement in X direction
  - Laser head scanning in Y direction
  - 550 µm scanline
  - 5 µm increments
  - Time required just under 4 sec/pin

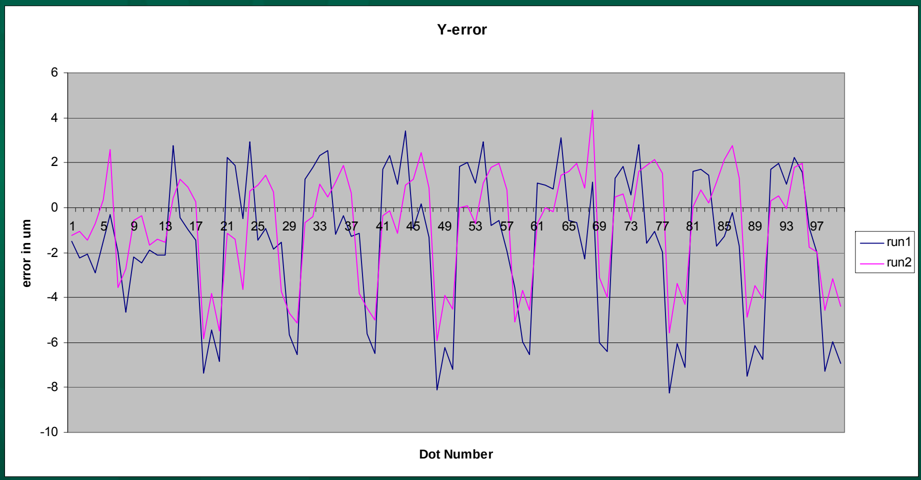
Results; digitized image



2^{st} trials results



Aver. 0.313



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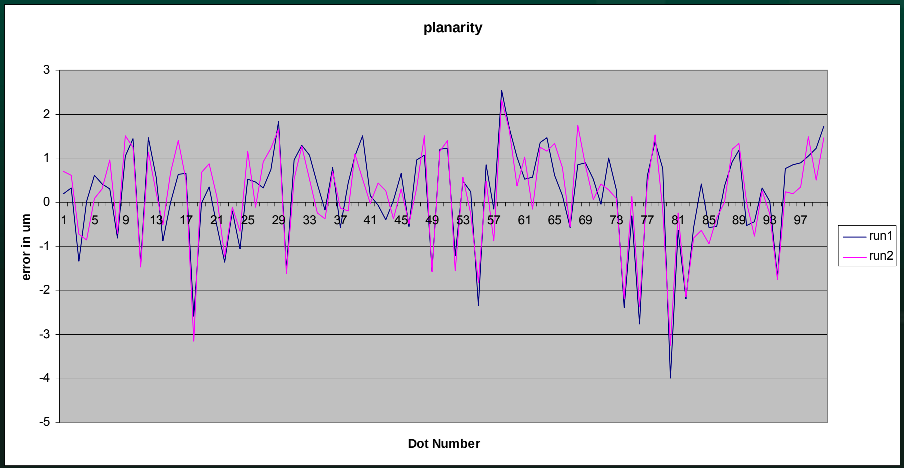
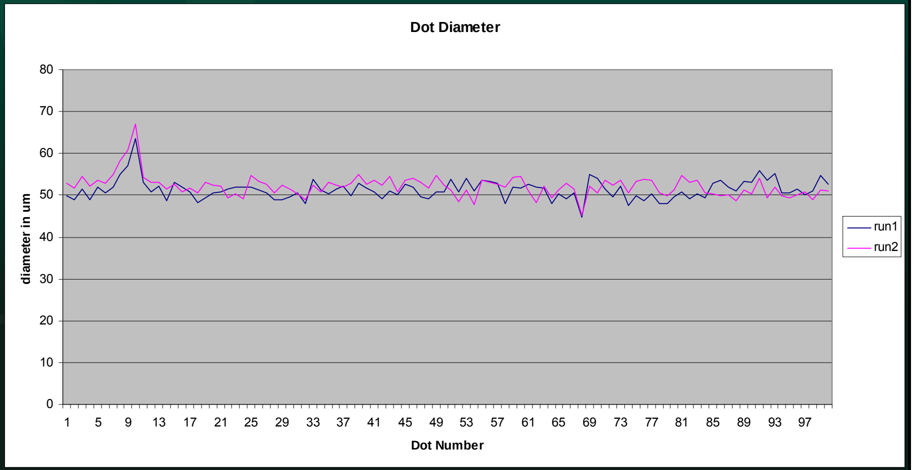
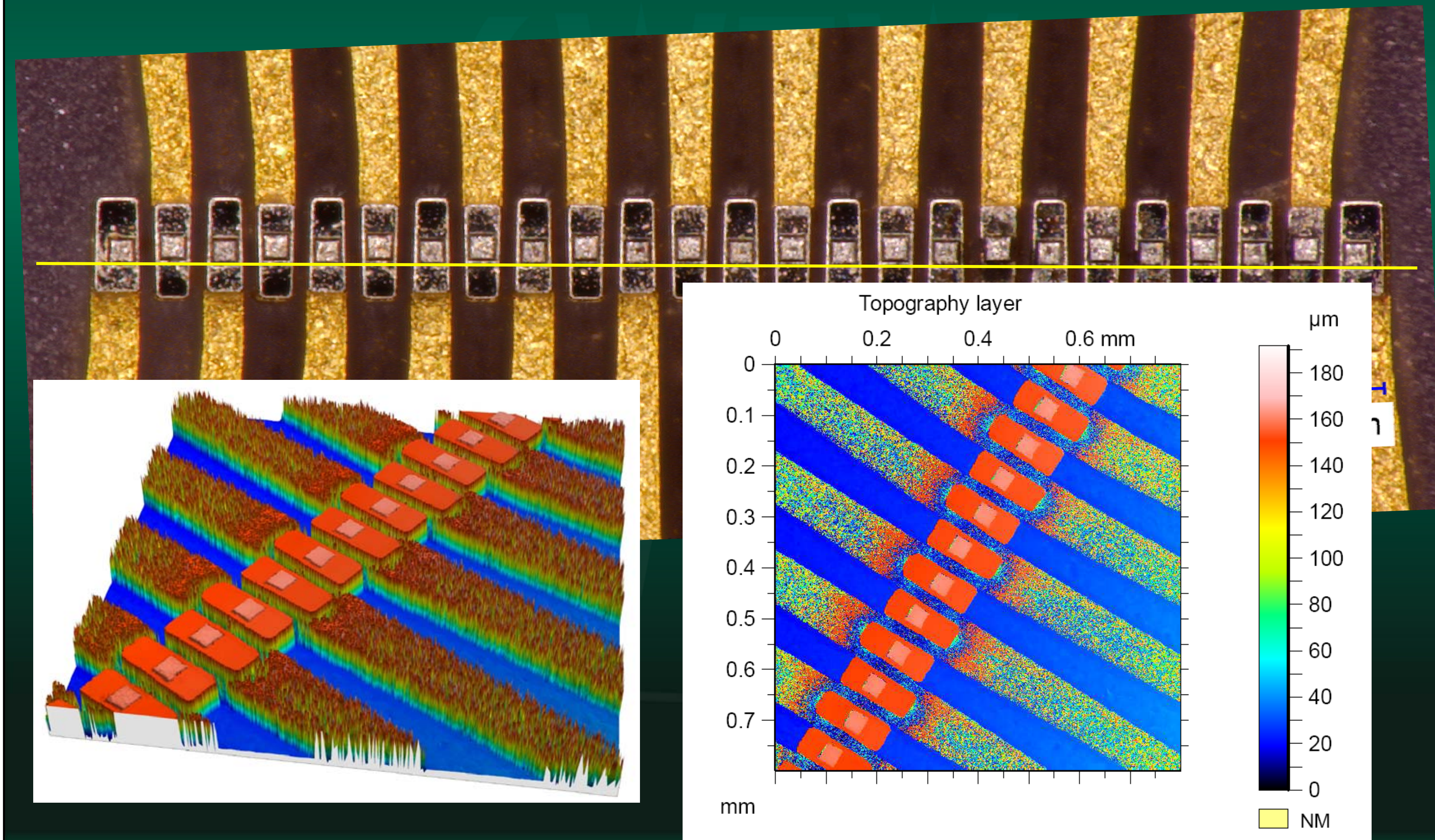


Aver. 0.024

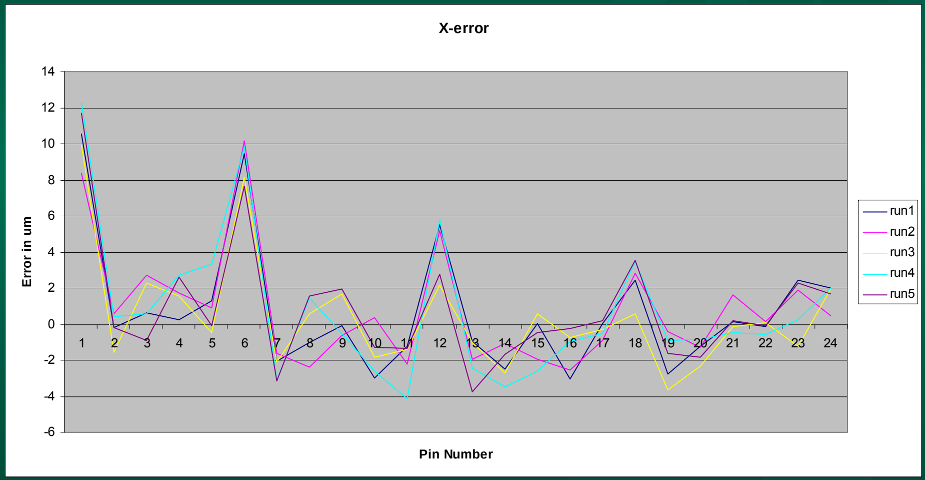


Aver.0.859

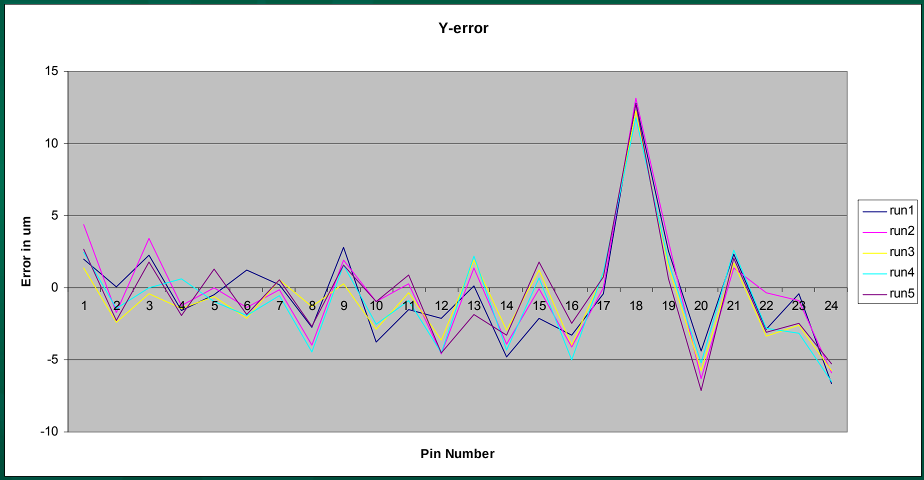
Results Small mems probe head



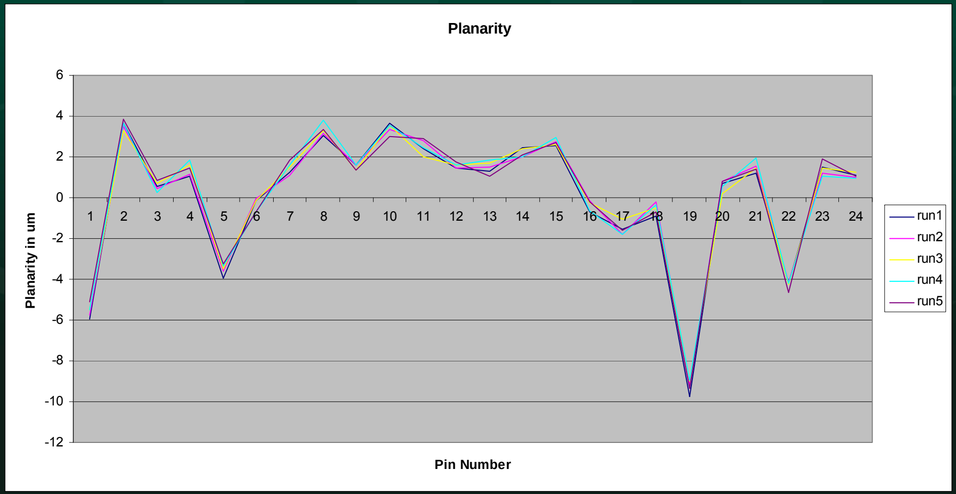
Results; 3D Repeatability data



Aver. 2.676

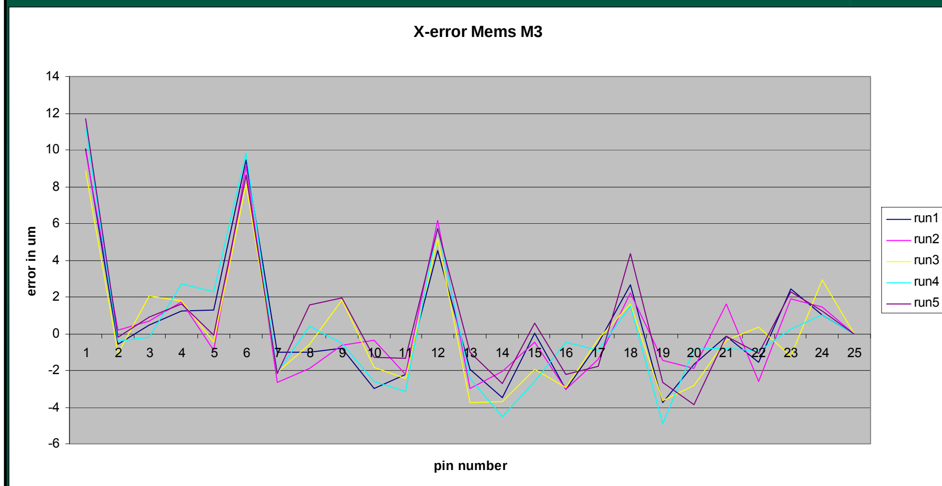


Aver. 2.534

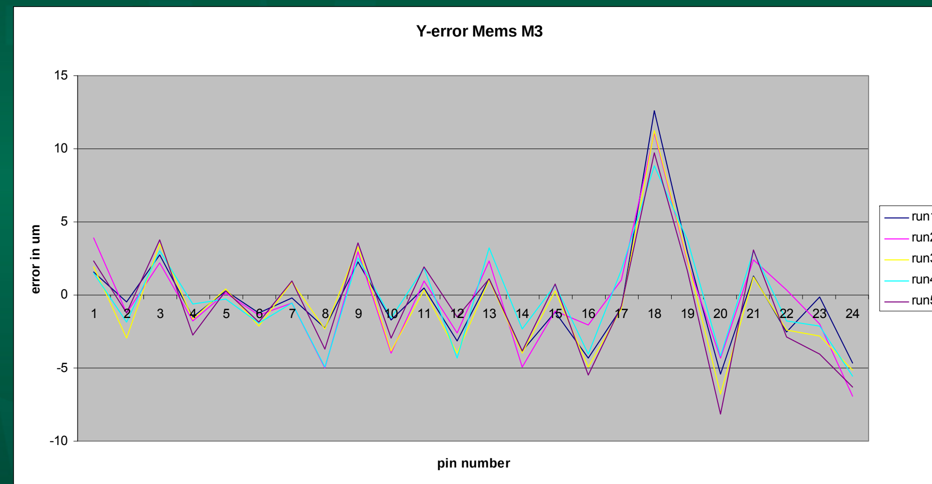


Aver. 0.632

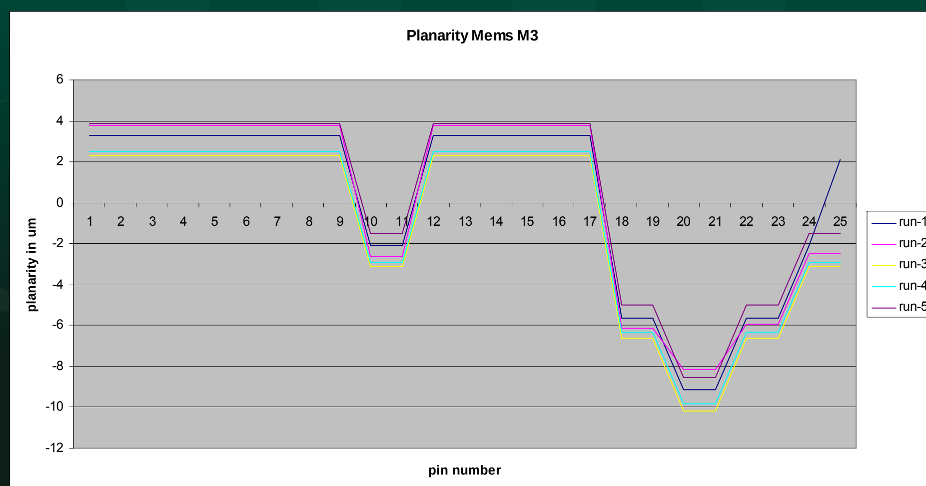
Results traditional analyzer



Aver. 2.271



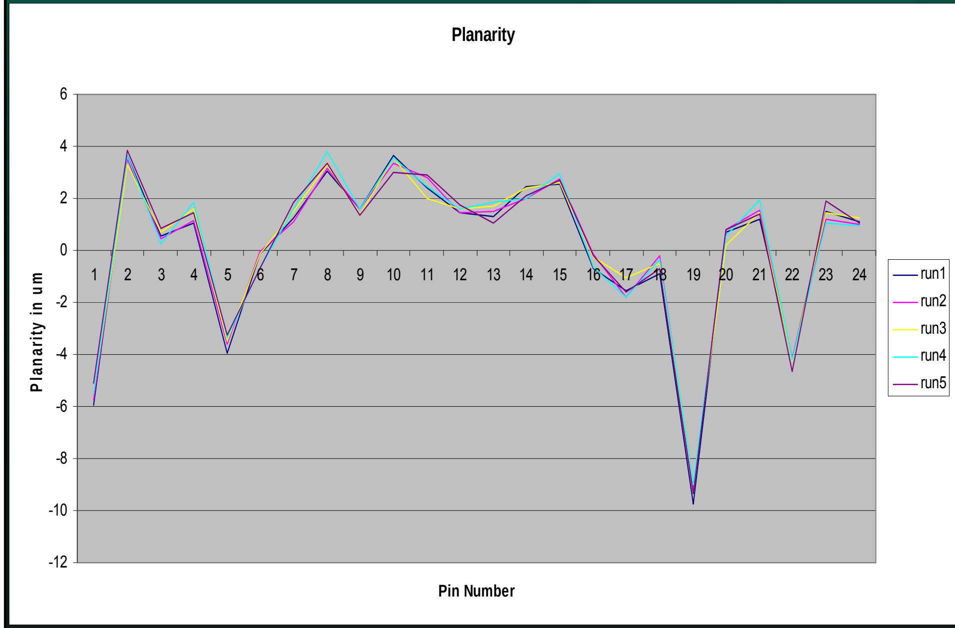
Aver. 2.358



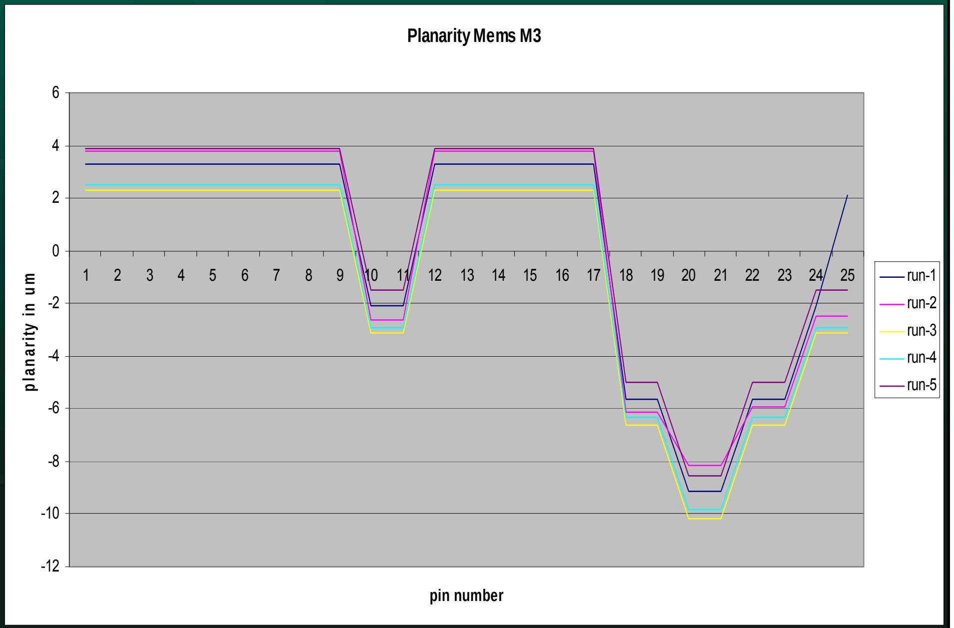
Aver. 1.632

Results

- **Comparison traditional & 3D data of mems card**
  - Most remarkable planarity differences
    - contact resistance, discrete motor steps
    - Same range 14 um!
  - X & Y look very similar

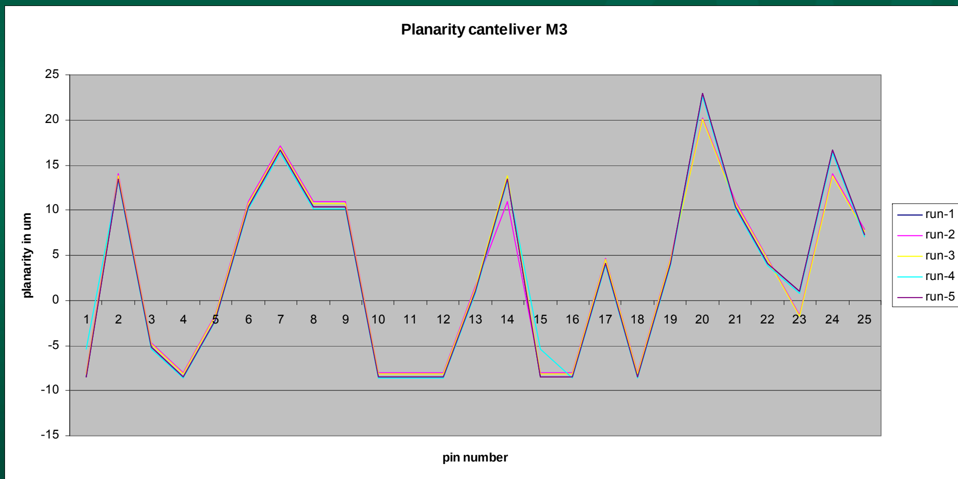


Aver. 0.632

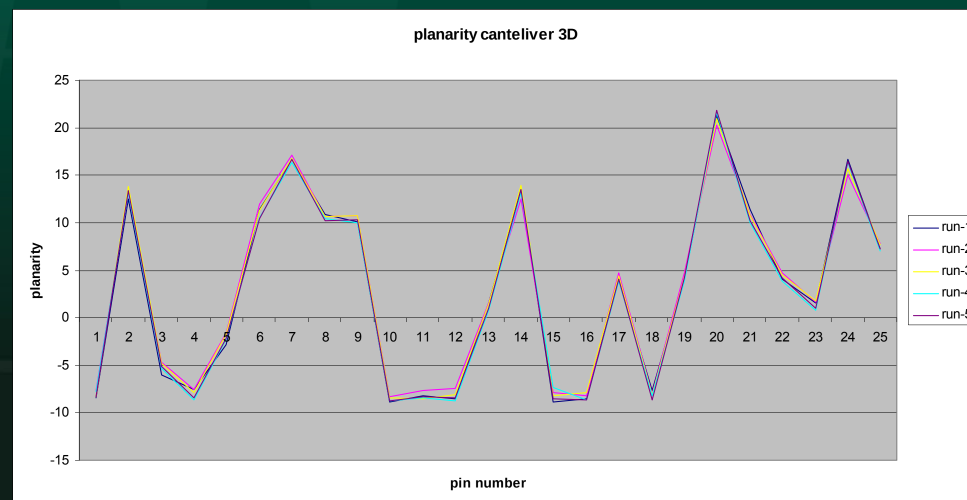


Aver. 1.632

Results planarity cantilever



Aver. 1.261

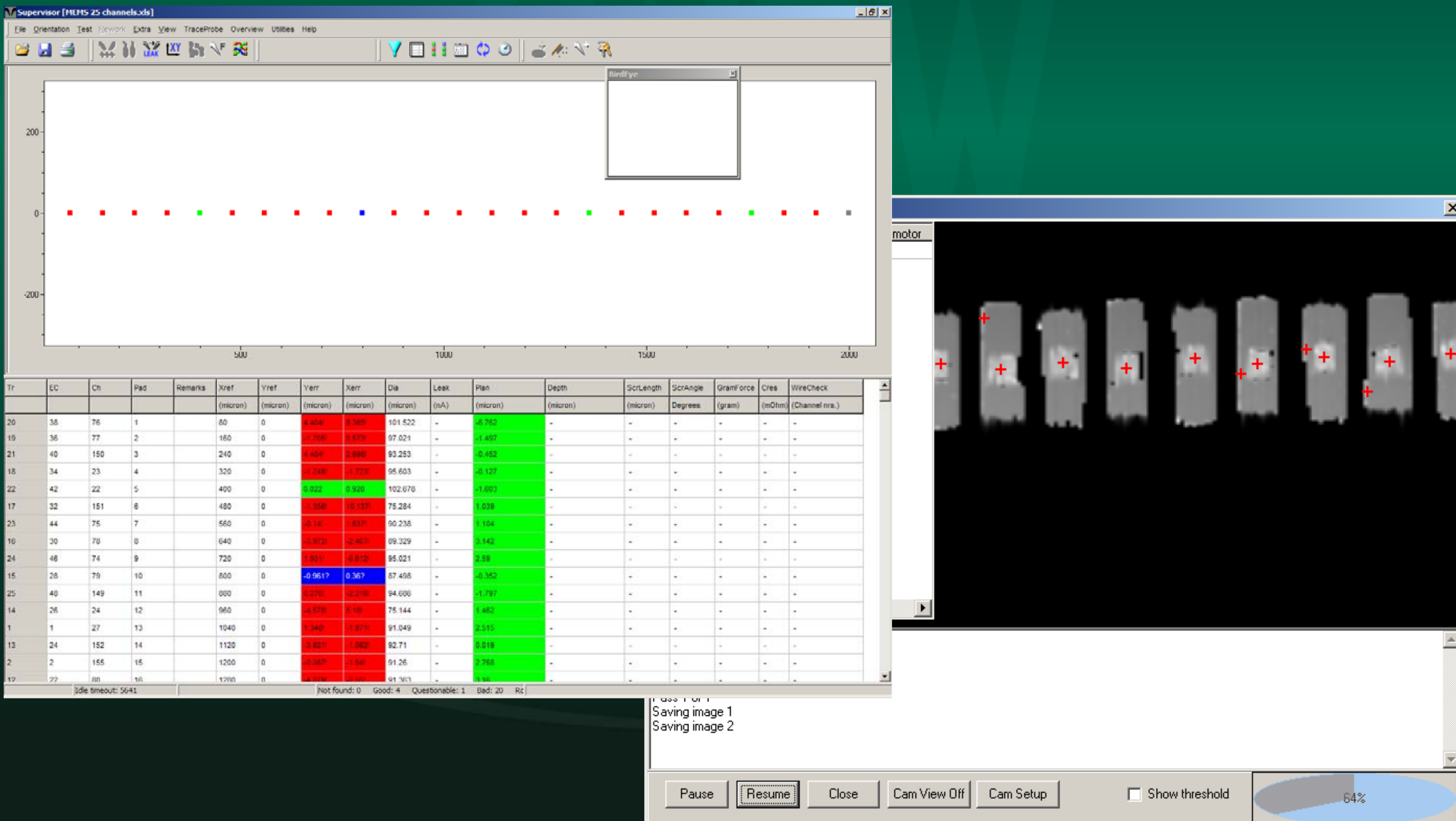


Aver. 1.046

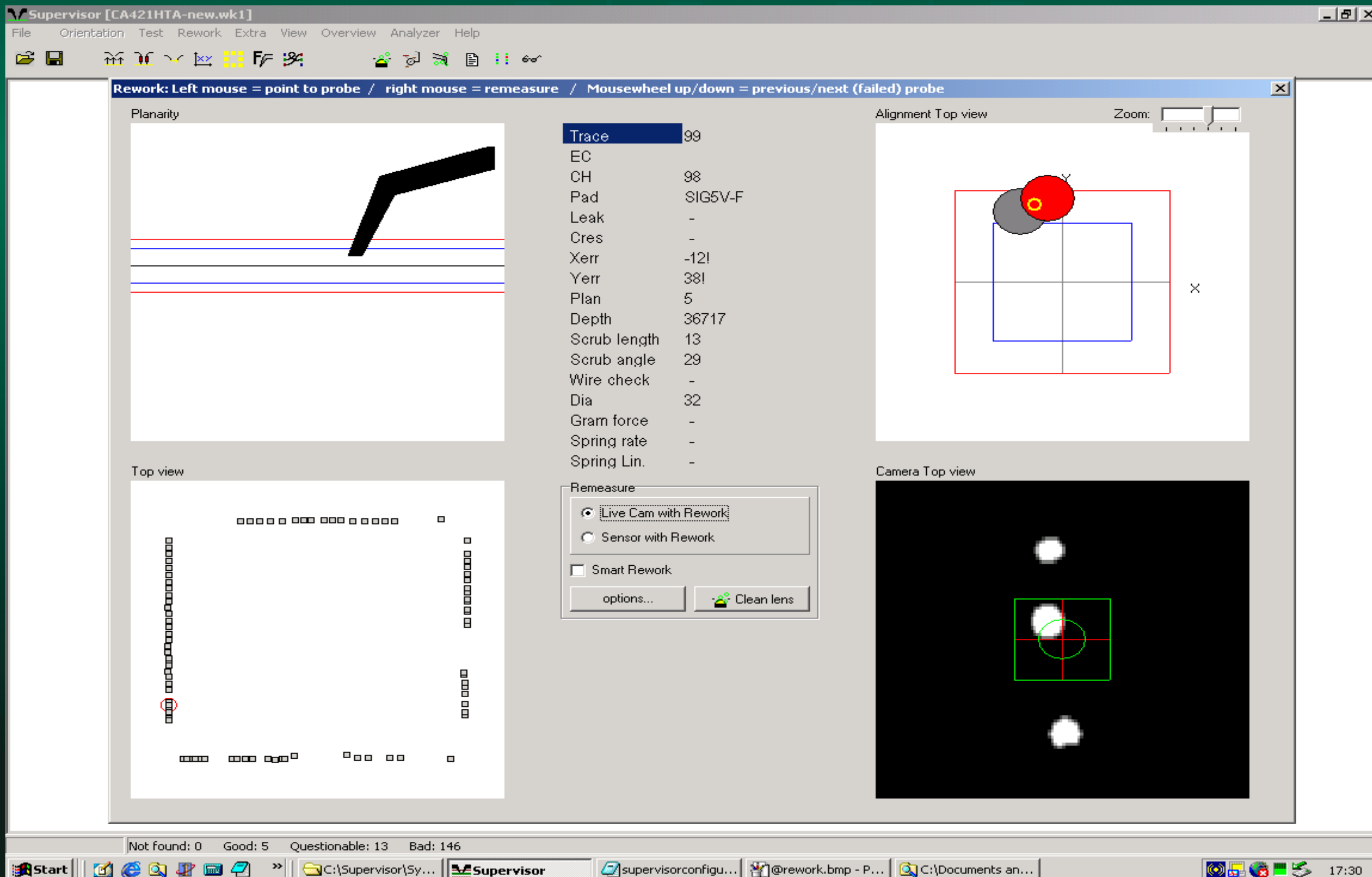
Data transformation

- **3D picture is nice to look at! but do we know if what we look at is all ok?**
- **Get the laser data linked to probe-card data.**
- **Use existing analyzer GUI**
  - Position error in X/Y
  - Z-height
- **Comparison to probe-card spec's**

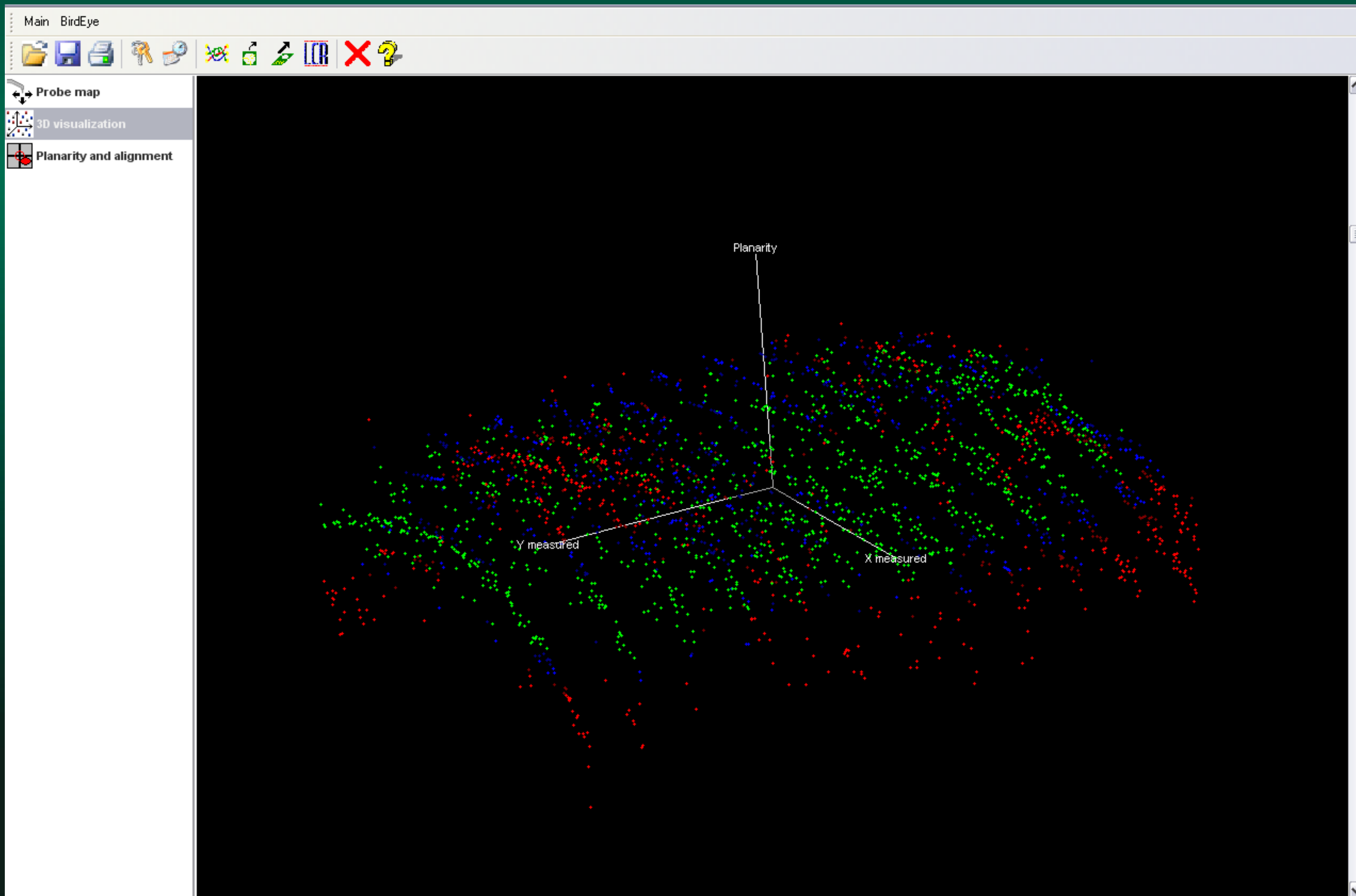
3D data in GUI



Probe-card data in GUI



3D data in GUI



Possible probe-card types

Probe-card type	3D screening	added value	remarks
Cantilever	+	+/-	Proven
vertical	+	+/-	"hanging" probes
MEMS	++	++	no vision upgrade needed
APT	+++	++	Bi-level probe heights

Advantages / disadvantages

- Contactless
- Accurate (debris visible)
- No expensive MB needed
- Quick set-up
- Measurement data of all pins in X/Y/Z
- Comparison with probe-card specifications (pass/fail-indication)
- Good ROI

- No electrical characteristics:
  - Cres
  - Leakage
  - Wire check
- No scrub analysis
- Dimensions of laser head
- No repair guidance

Summary/Conclusions

- **3D contactless profiling works for mechanical position verification of contact-pins**
- **Easy add-on for existing probe-card analyzer**
- **3D profiler with laser head is as accurate as basic system (higher res. in Z)**
- **3D results import in "normal" analyzer for repair and electrical verification**
  - Save time (not necessary to analyze entire card)
- **When inspection results are stored per card after each run, a probe-card behavior becomes visible**

Follow-up work

- Speed improvements
- Accuracy improvements
- Investigation to add laser-head to wafer prober
- 3D-OEM package for integration
- Investigate use for final test sockets inspection

Thanks for your attention

- **Any questions?**