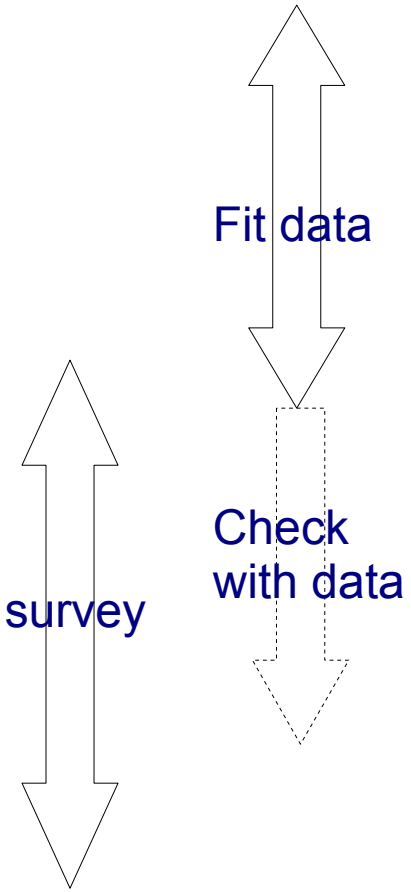
HFT Pixel Survey Plan

Qiu Hao (LBNL)

- Transformation frame
- Precision
- TPS fitting method

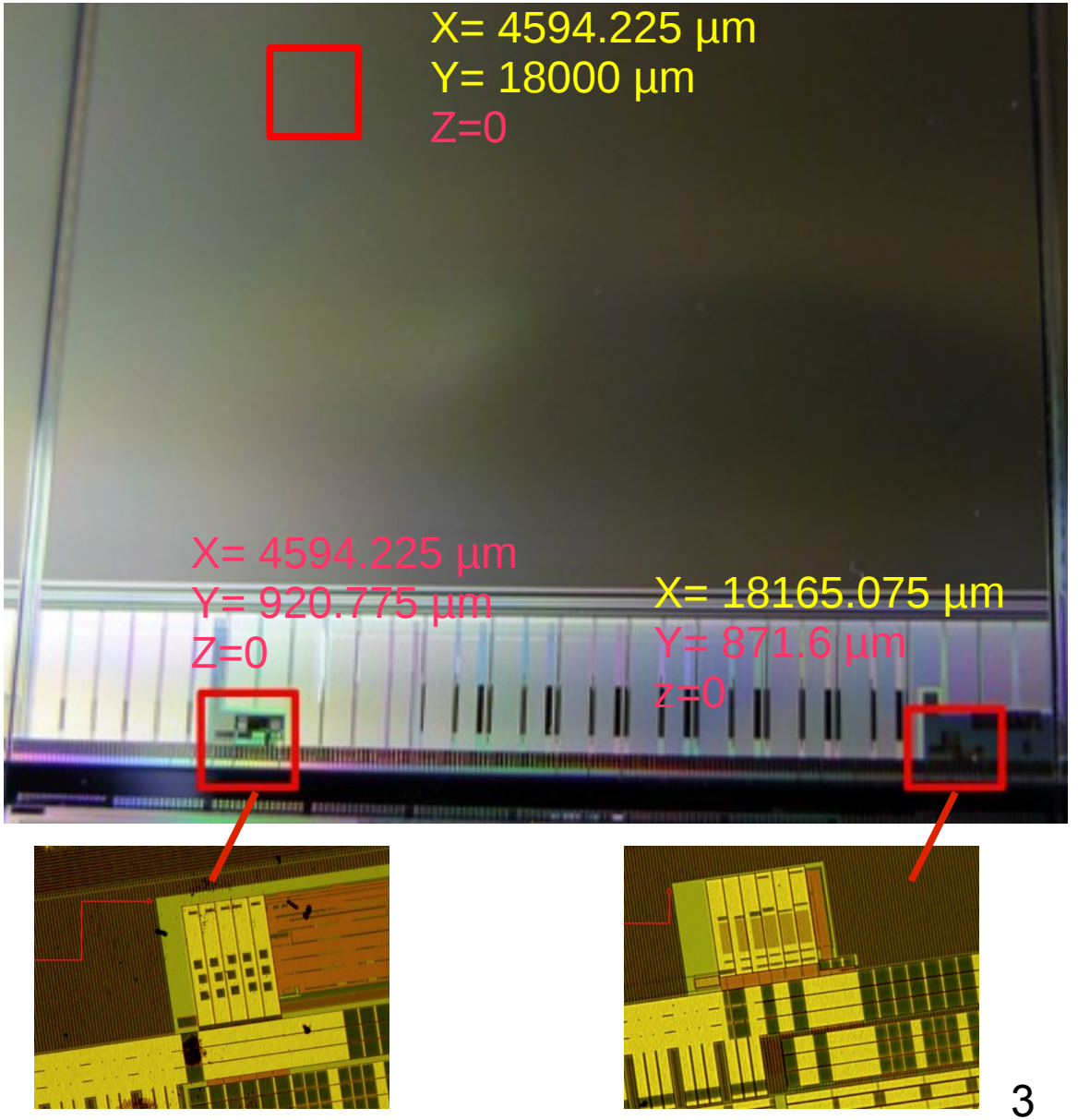
Transformation Frame

- STAR global
  - rotation + shift
- Whole pixel detector
  - rotation + shift
- Half (5 sectors)
  - rotation + shift
- Sector
  - rotation + shift
- Ladder
  - rotation + shift
- Chip
  - dx, dy, dz
- pixel



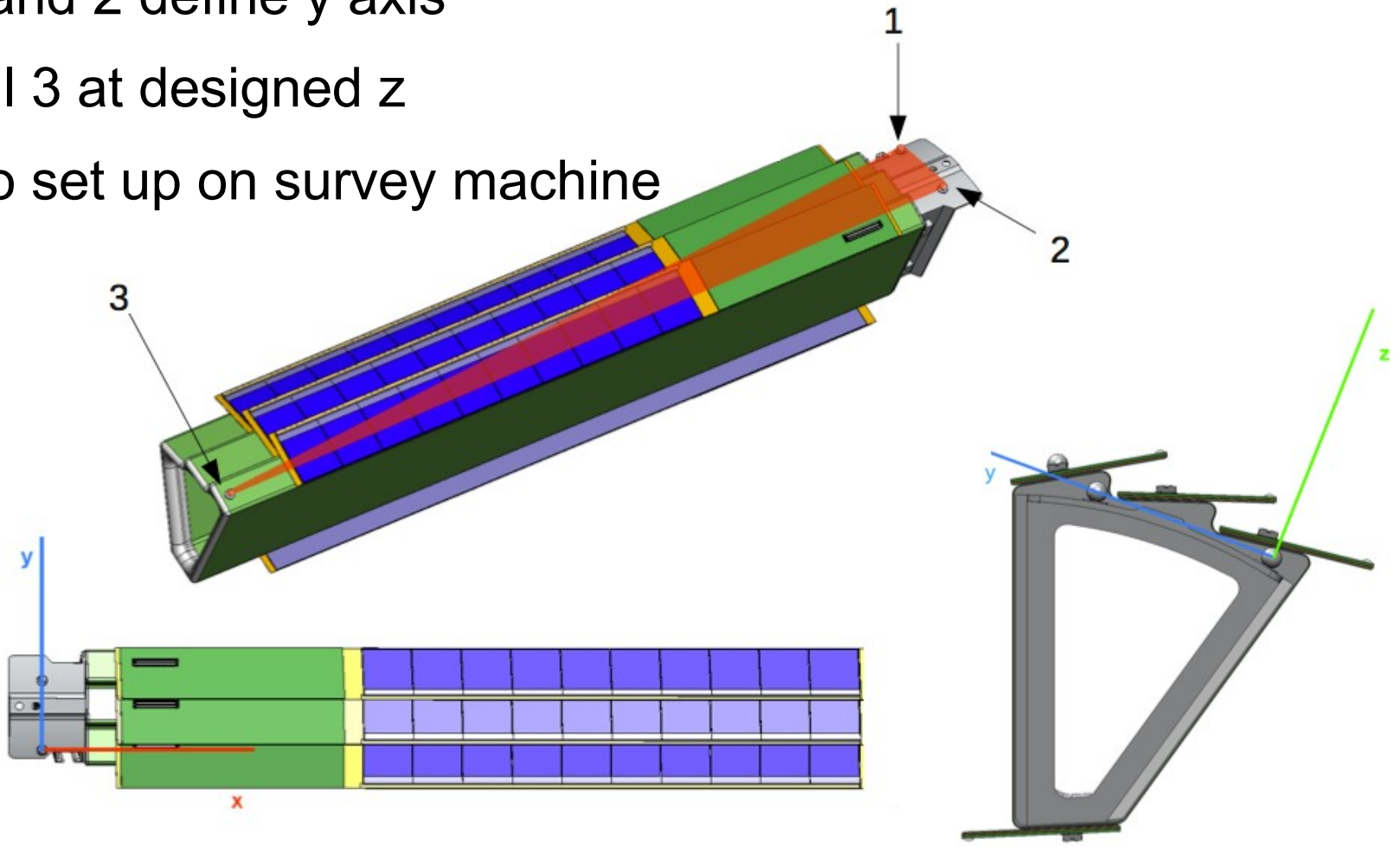
Determination of Chip Local Coordinate

- Chip local coordinate is determined by the feature ideal positions + 1 point on sensitive area
- Can be set up before survey of the whole chip
- Red: used to restrict the coordinate
- Yellow: ideal position



Determination of Sector Local Coordinate

- Ball 1 defines origin
- Ball 1 and 2 define y axis
- Put ball 3 at designed z
- Easy to set up on survey machine



Other Coordinates

- Ladder local coordinate
  - Not planed to have additional alignment from survey, use ideal transformation from sector

- Half pixel detector (5 sectors) coordinate
  - In ideal geometry, use STAR global coordinate for north half

- Whole pixel detector coordinate
  - In ideal geometry, use STAR global coordinate

Precision

- The aim is to get survey precision below hit error (< 20 μm)
- For one chip surveyed with vision, ~< 5 μm can be reached
- Not sure about the feather probe and rotation yet
- Mechanic changes (~ 20 μm [Howard, CD1 Review]) may come after survey
  - Thermal
  - Gravity
  - Humidity
  - Vibration
  - Force received during transportation and installation
- Whole pixel detector relative to STAR global ~< 200 μm from fitting data

TPS Method

Thin Plate Spline

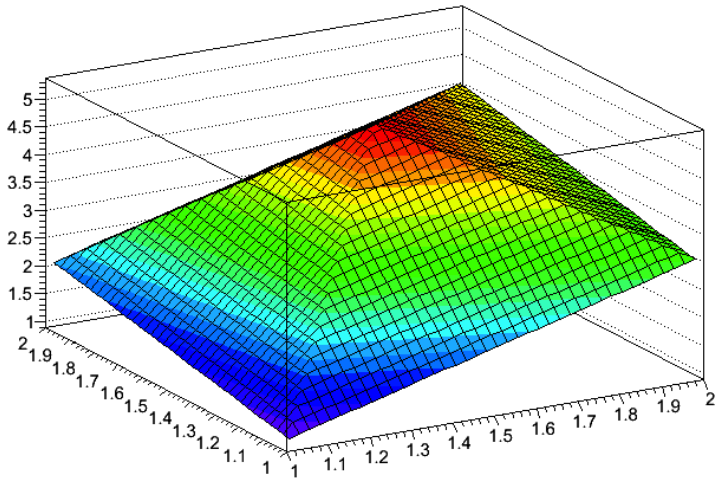
Principal Warps: Thin-Plate Splines and the Decomposition of Deformations
김진욱 (이동통신망연구실; rein@mobilenet.snu.ac.kr) etc.

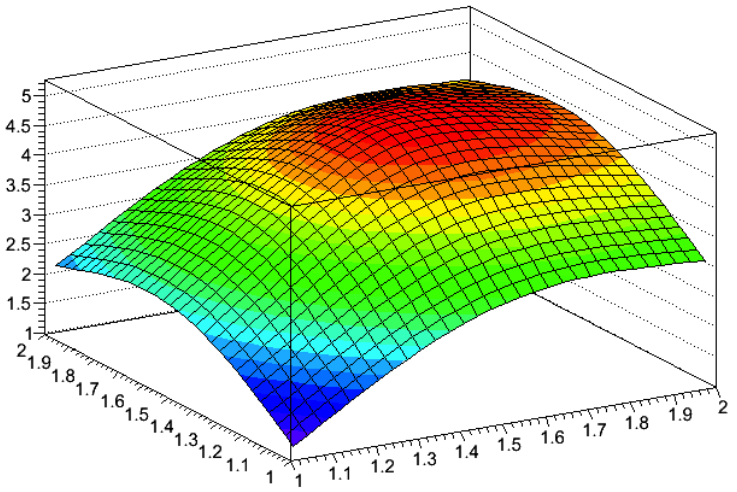
Used to fit survey measurements on a pixel chip, describing a plane used in the last chip ↔ pixel transformation

Found and realized in VC by Xiangming, rewriten in ROOT

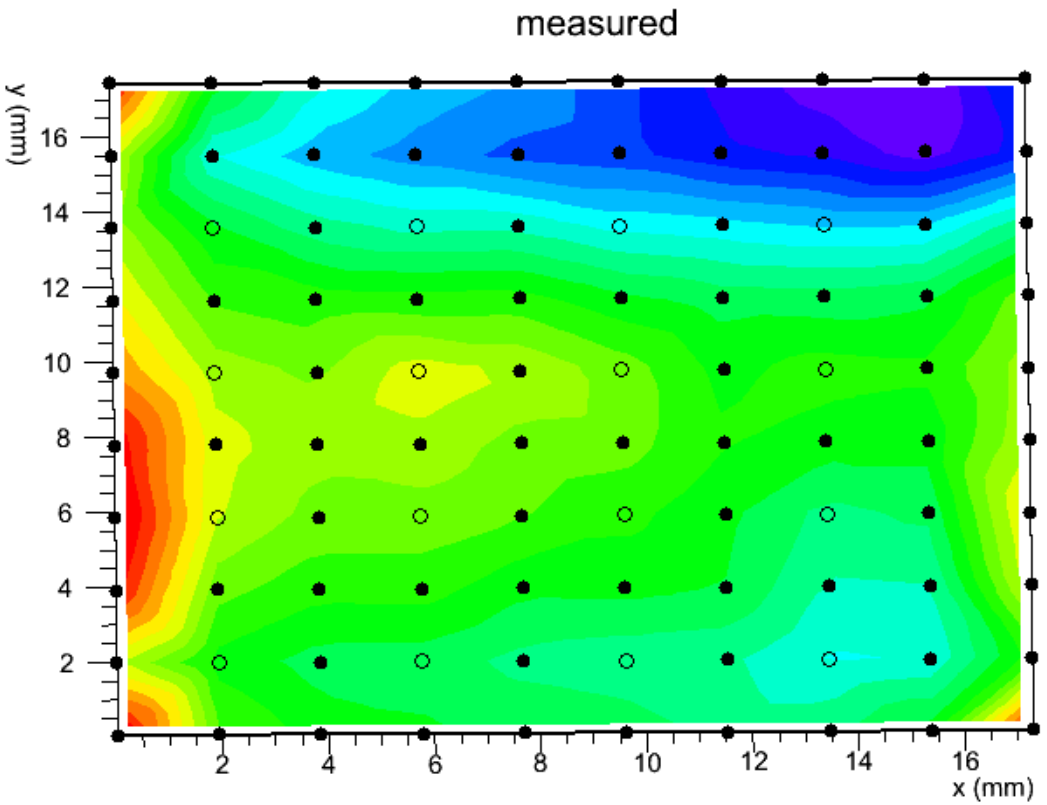
minimize the “bending energy”, defined by

$$I(f) = \iint_{R^2} (f_{xx}^2 + 2f_{xy}^2 + f_{yy}^2) dx dy$$



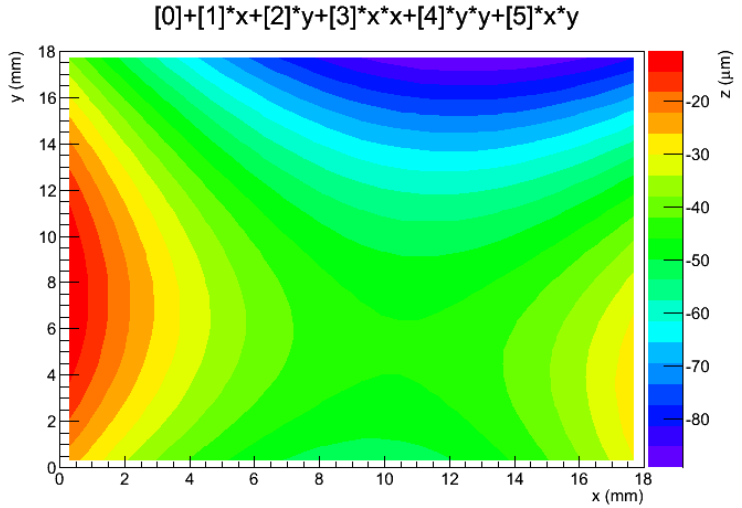


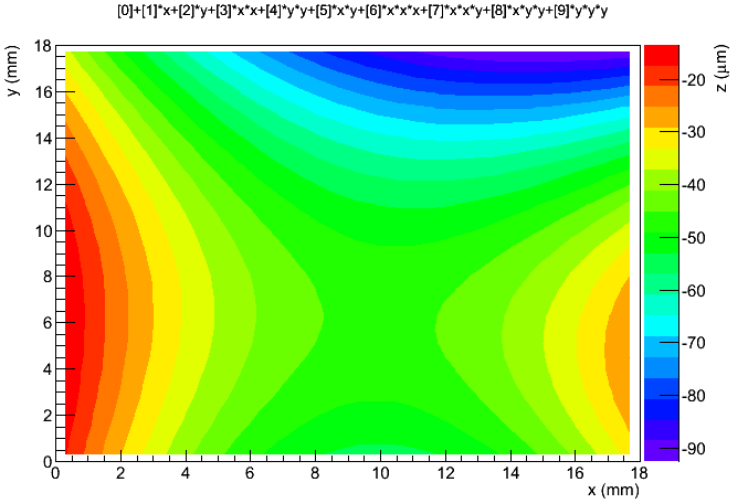
Measurements to Fit and to Test

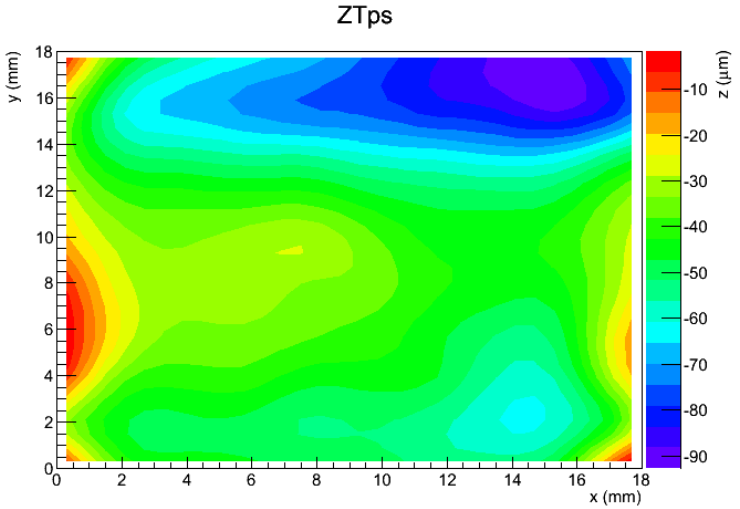


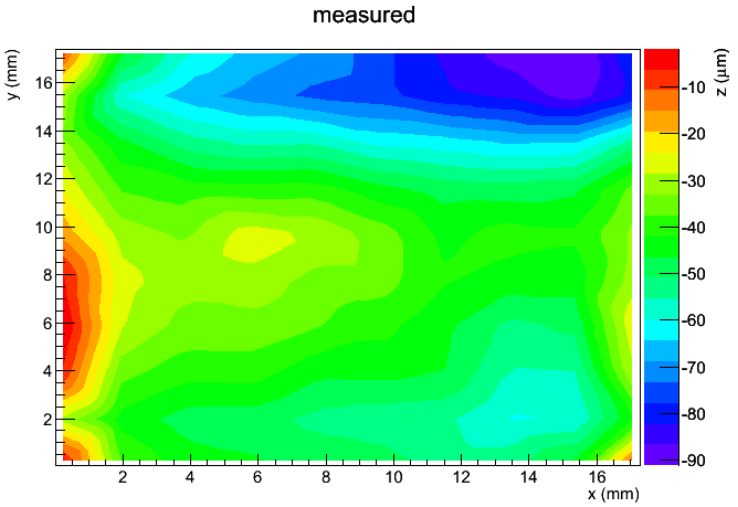
Black points – to fit
Circles – to test

Fit Result – Chip 1

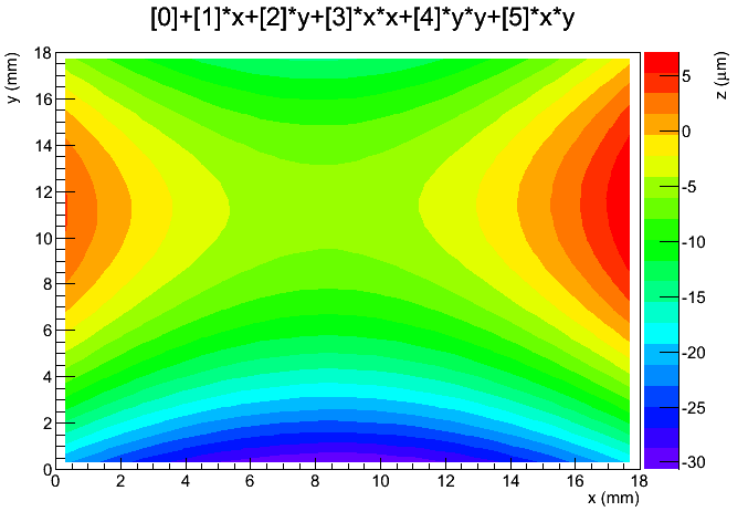


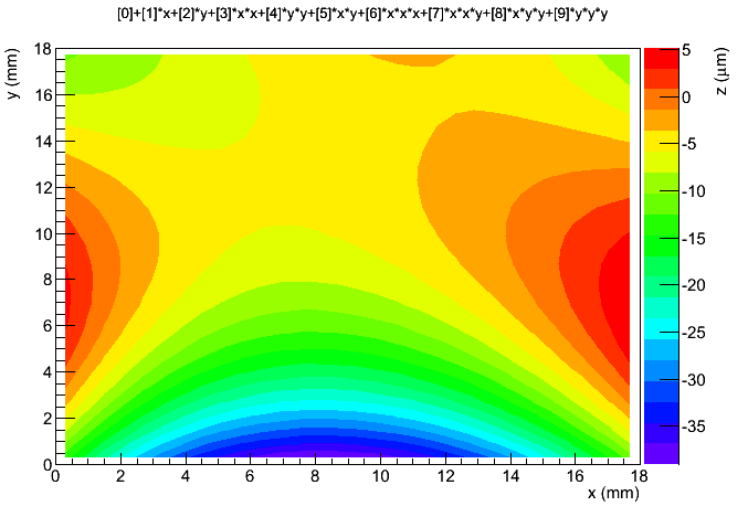


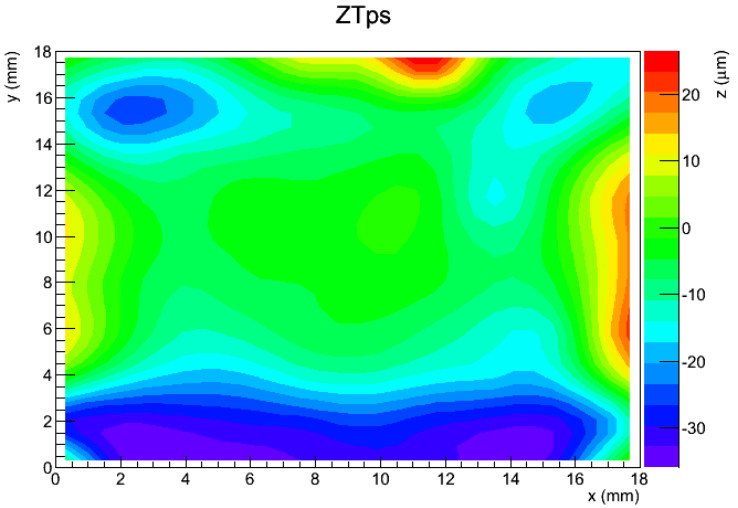


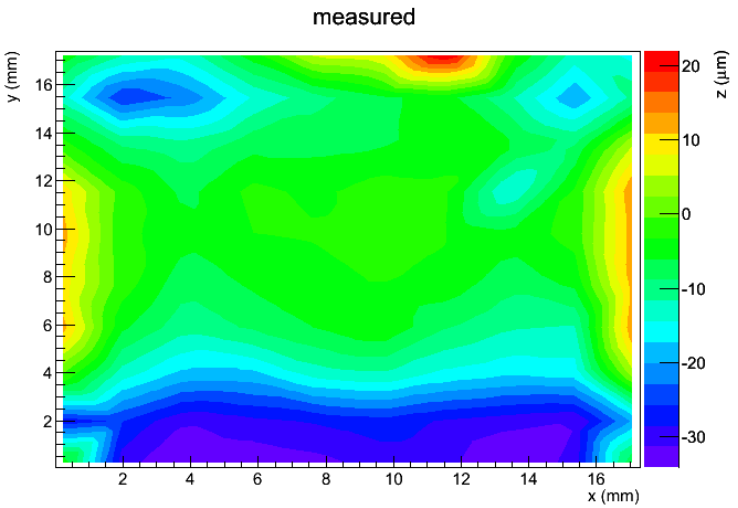


Fit Result – Chip 2

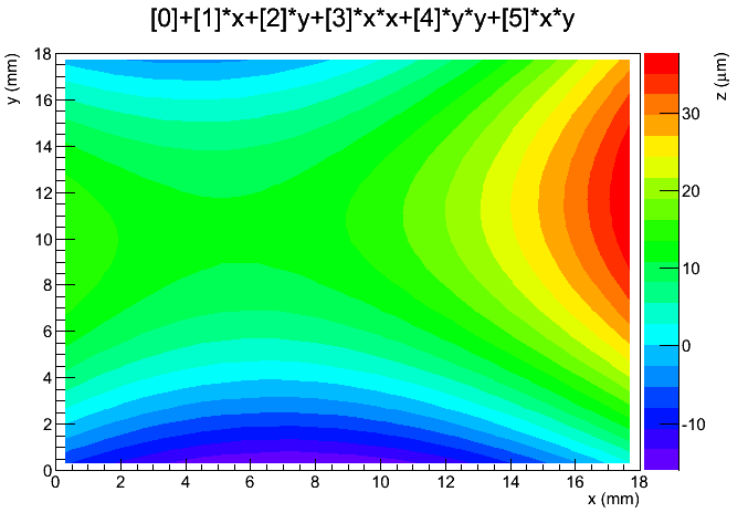


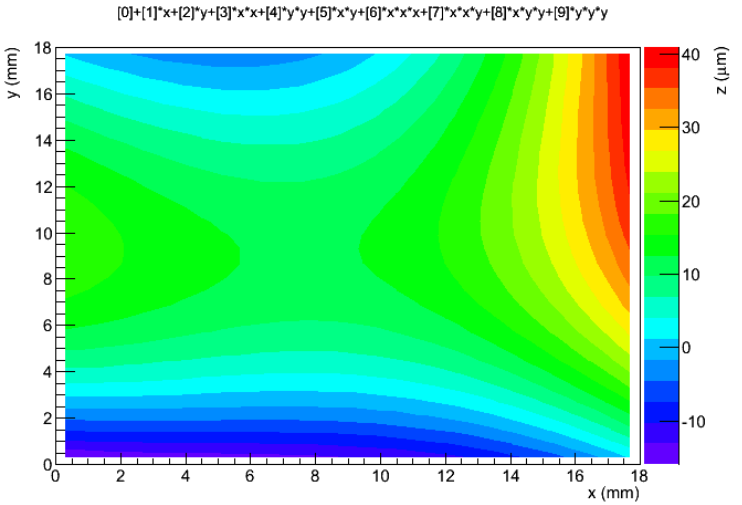


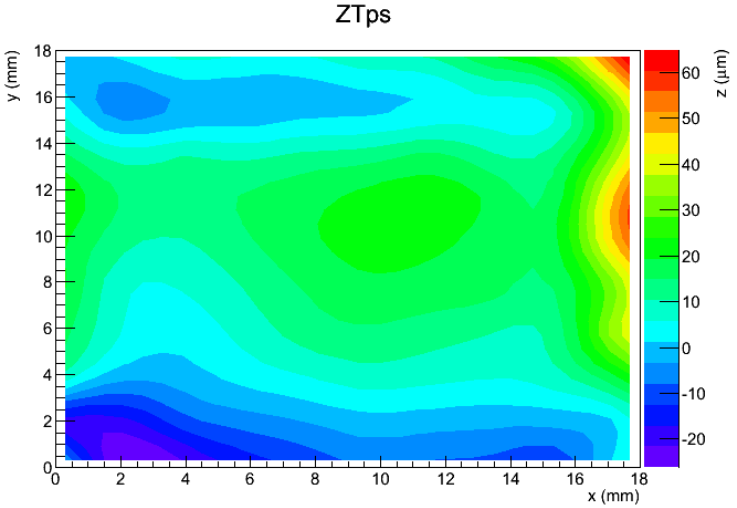


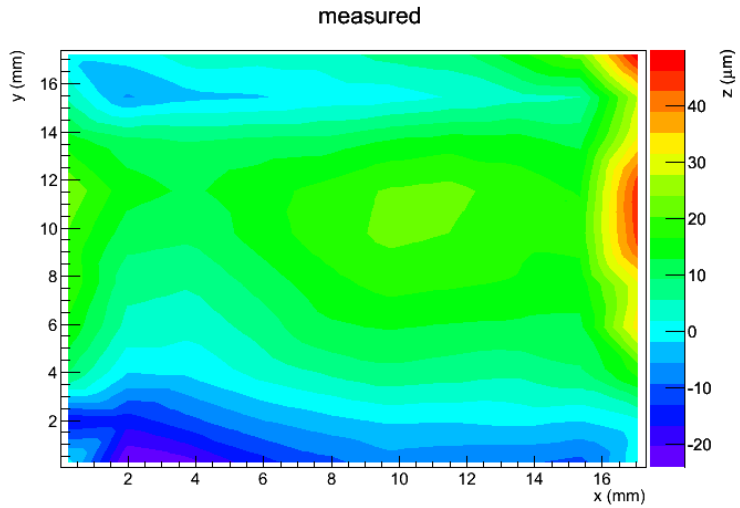


Fit Result – Chip 3

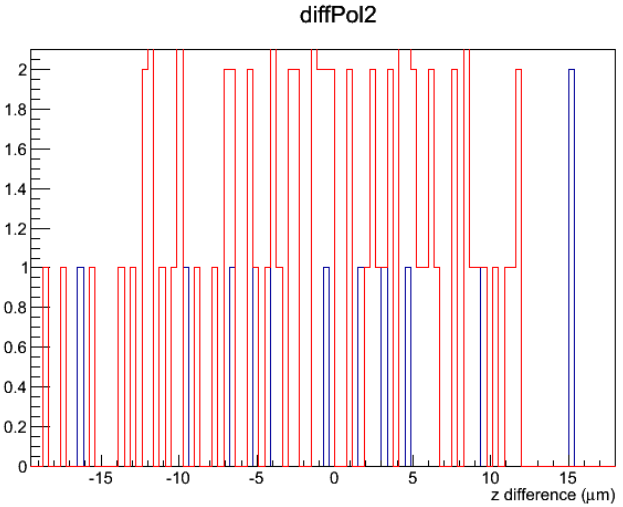


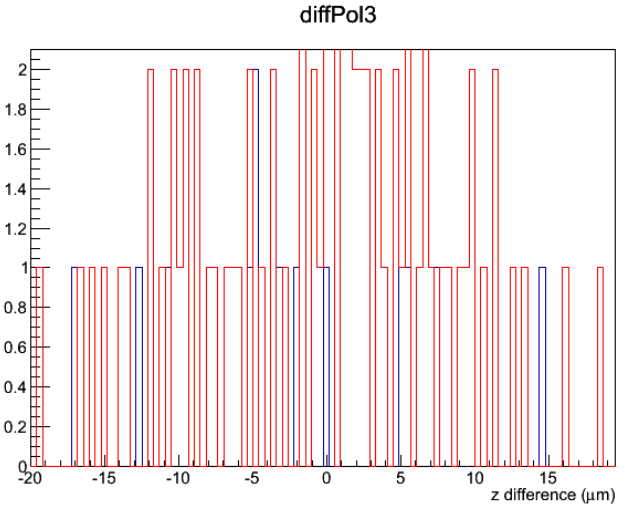


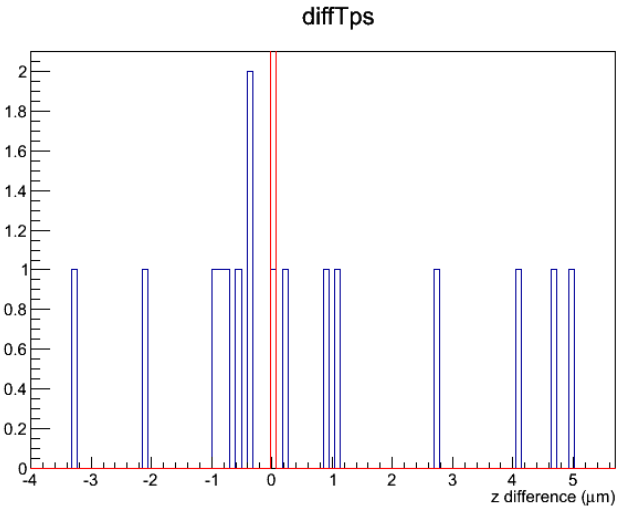




Difference between Measured and Fit

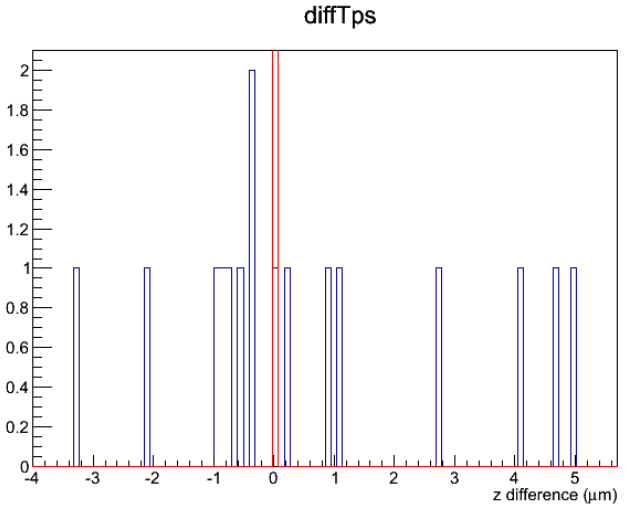


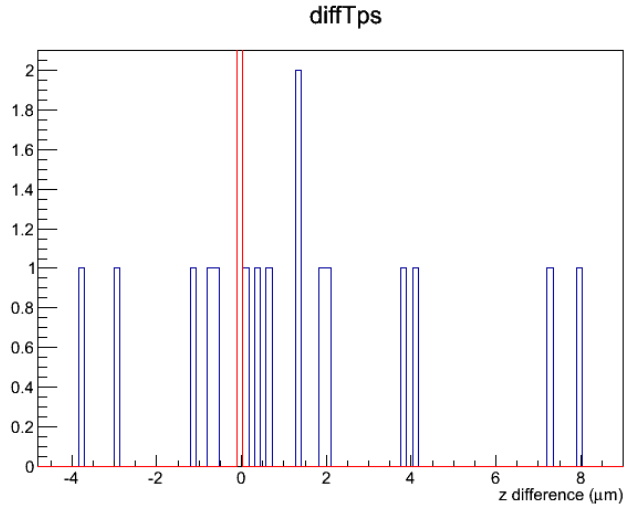


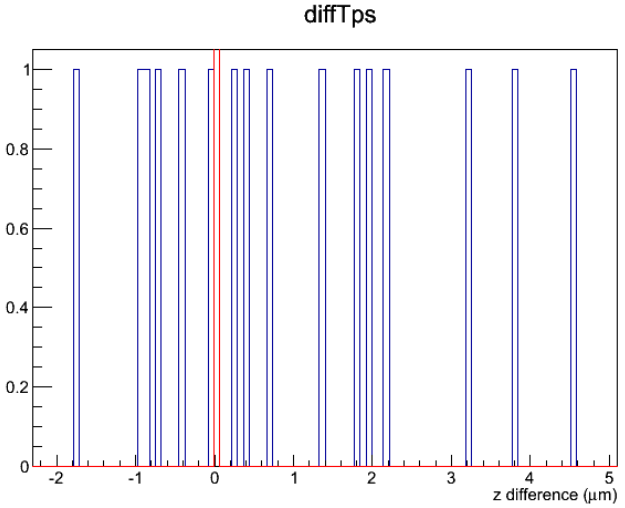


- Red: measurements to fit
- Blue: measurements to test
- TPS does better job than global pol2 and pol3 fit for a chip

Difference between Measured and Fit







- Z difference ~< 5 μm

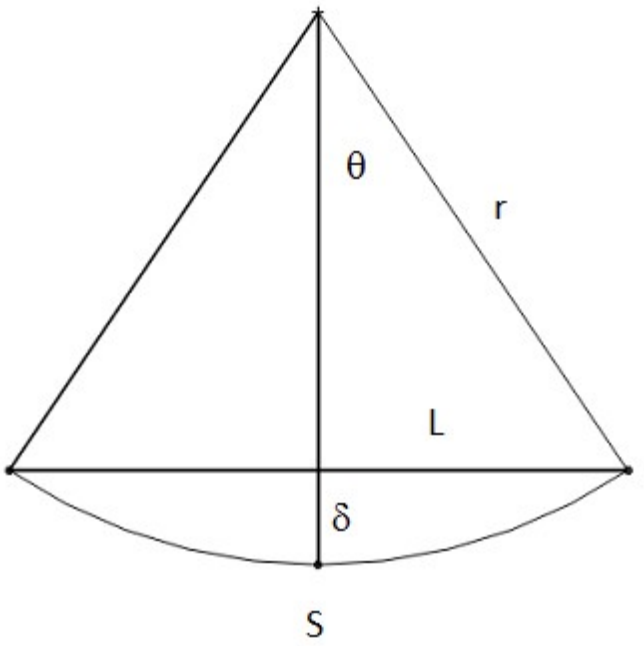
Utilization of TPS

With n measurements of (x, y, z)

Fitting results need to calculate z(x, y):
    a0, a1, a2, array x[n], y[n], w[n]
Size in DB and memory if n = 132:
    (3+132*3)*10*4*10 ~ 160 k --------not a big deal

CPU time if n = 132:
    0.18 s for 20 k hits (n hits for pile up in RHIC II luminosity)
----------acceptable

Δx, Δy



For circularly curved chip with length 2L = 20 mm, Δz = 100 μm
Δx = 4/3*Δz/L = 1.4 μm << 20 μm --Howard

Conclusion

- Transformation frame defined
- Precision which can be reached is not very clear yet, hopefully below hit error (<20 μm)
- TPS proposed to be applied for chip ↔ pixel transformation

Thank you!
:-)