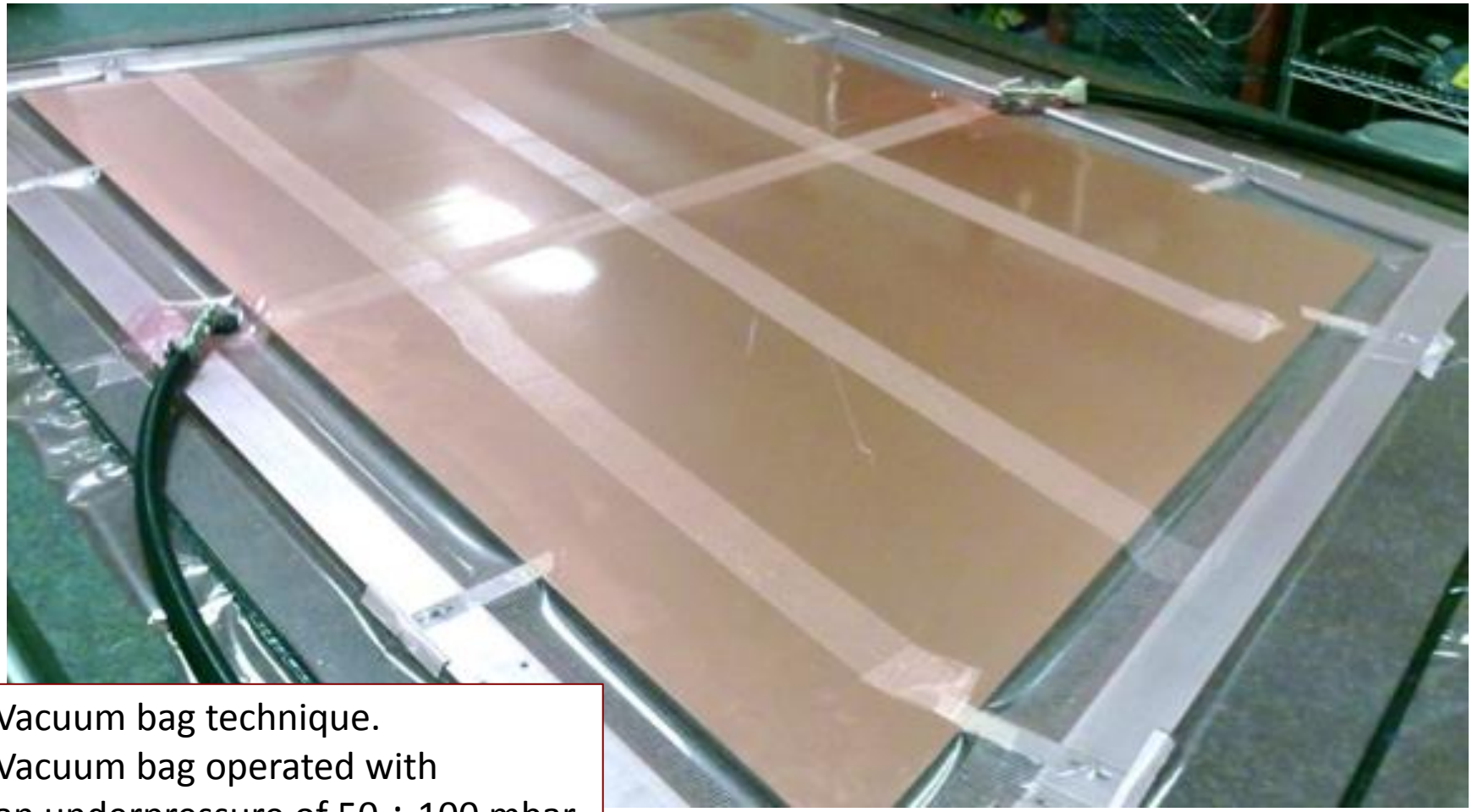
Status Update on Mechanical Prototype in Rome

November 6, 2013

Introduction

- We have built the mechanical ***M2 quadruplet*** prototype:
  - Assembly of the **5 panels** with the "*vacuum bag*" technique (with some variants);
  - Assembly of the **quadruplet**.
- Outline of the talk:
  - Description of the method used for the assembly of the last 2 panels (**two-steps gluing technique**);
  - M2 panels: structure and components
  - Results of **planarity measurements** of the last 2 panels;
  - Quadruplet assembly;
  - Conclusions.

Method of construction - I



Vacuum bag technique.
Vacuum bag operated with
an underpressure of 50 ÷ 100 mbar.

Method of construction - II

- First 3 panels (see july workshop presentation):
  - **Single-step** vacuum bag gluing:

    PCB-1 on the granite table, PCB-2 on the honeycomb "pushed" by the bag. Glue is put on both PCBs;

    ➔ asymmetric planarities obtained (*)

    ≈ 10 ÷ 20 μm (bottom side)

    ≈ 30 ÷ 50 μm (top side)
- Last 2 panels:
  - **Two-steps** vacuum bag gluing:

    PCB-1 glued as above. After a time Δt the panel is turned and glued to PCB-2 standing on the granite table.
  - Δt = 24 or 5 hrs (glue curing time ≈ 15 hrs @ 20°)

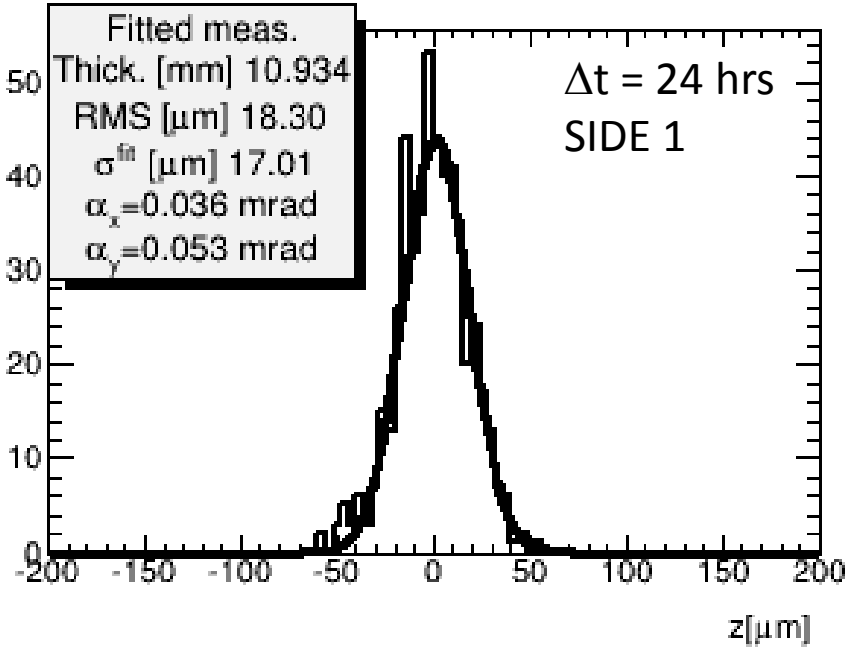
(*) Module 2 built with segmented honeycomb has larger RMSs

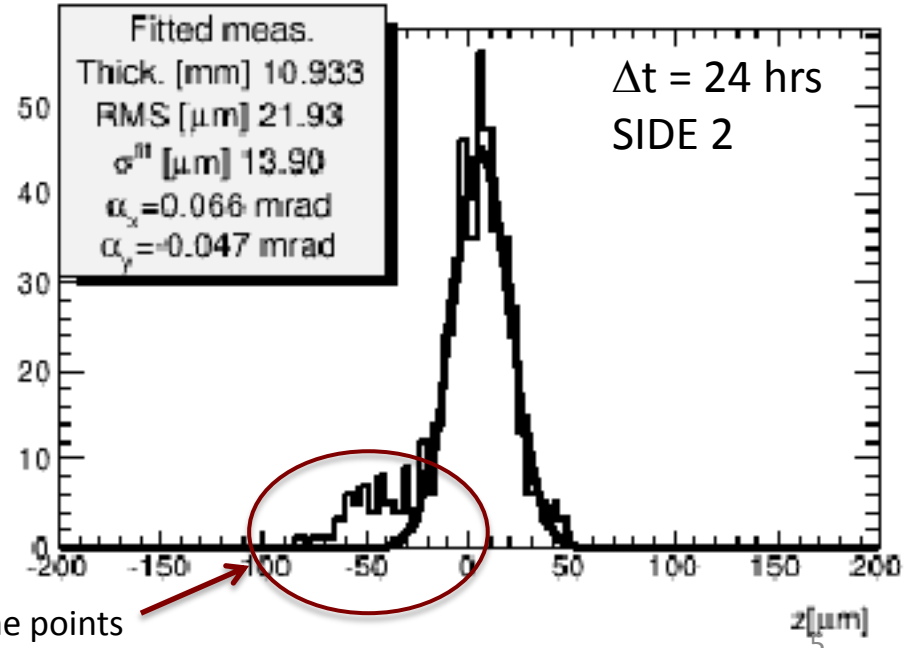
Test of two-step gluing method

Aim of the method: reach a good planarity on both sides of the panel. We have done several tests to validate the two-step method, both with **Δt=5** and **Δt=24 hrs** .

100x60 cm² panel ➔ planarity below 20 μm on both sides

➔ thickness value -26μm wrt nominal

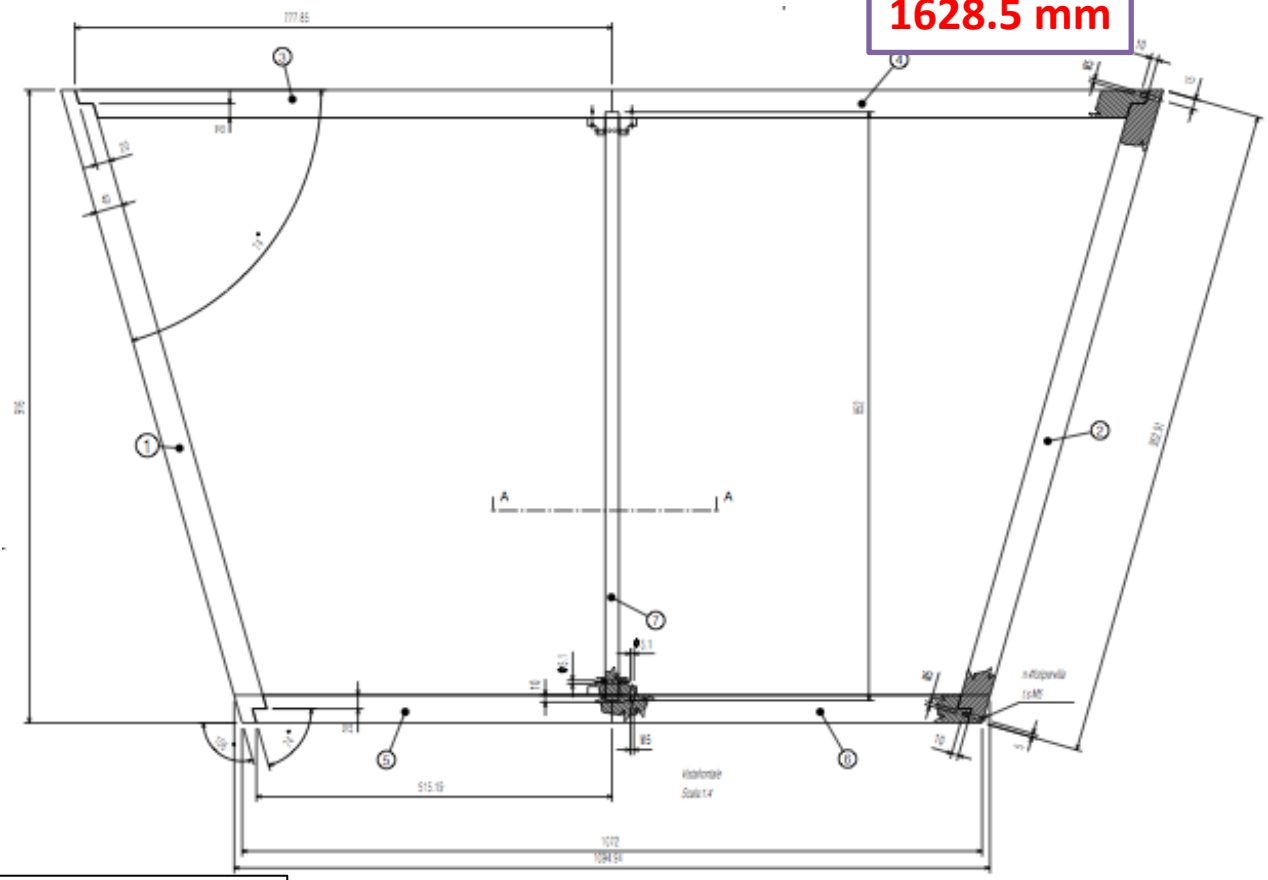




frame points

frames were not rectified in this test

M2 panels – general structure



Aluminium rectified frames:
40 mm the outer frame
20 mm the inner bar

M2 panels - components

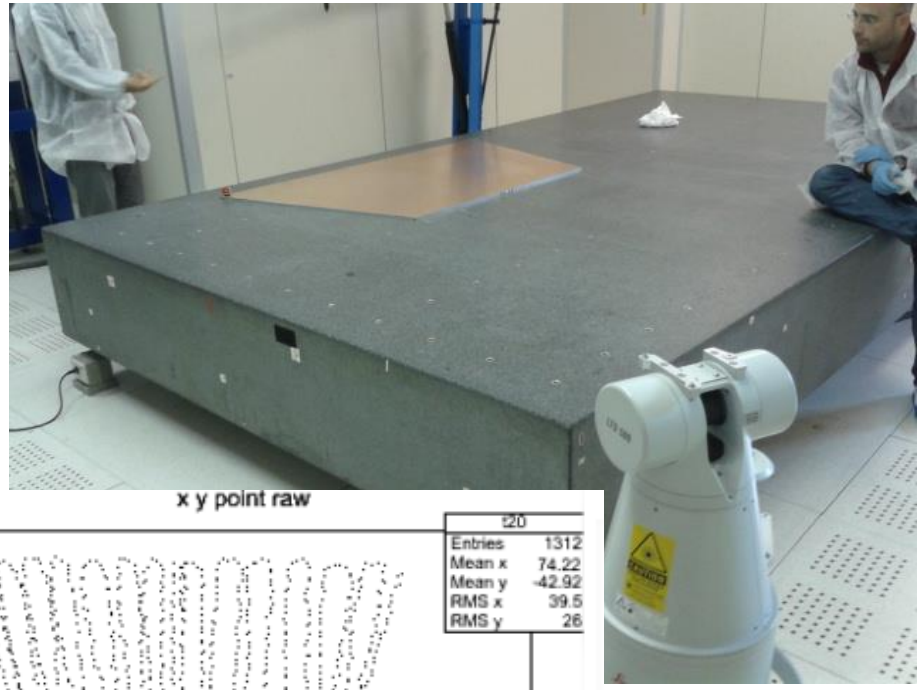
	PCB foils	**Honeycomb NOMEX**	**Aluminum frame**
nominal thickness (mm)	0.5	10	10
effective average thickness (mm)	0.40 0.56 (G10 foils)	10.040	10
planarity RMS (μm)	≈ 20 ÷ 30	≈ 25	≈ 25

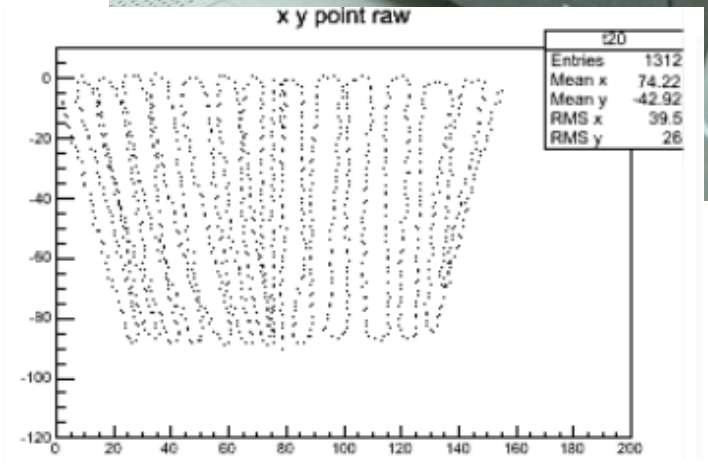
- **PCB** measurements done by PV group on sucking plane.
- **Honeycomb** measurements done using the LNF laser tracker with a gauge block above it.
- **Frame** thickness and planarity checked with Mitutoyo.
- **Glue** Araldite 2011: the glue is rolled to give a uniform layer of ≈ 60 μm thickness.
- **Nominal thickness**=2x0.40+2x0.06+10.040=**10.960** (**11.120** panel 2) mm

Methods of planarity measurement - I

Laser tracker @ LNF

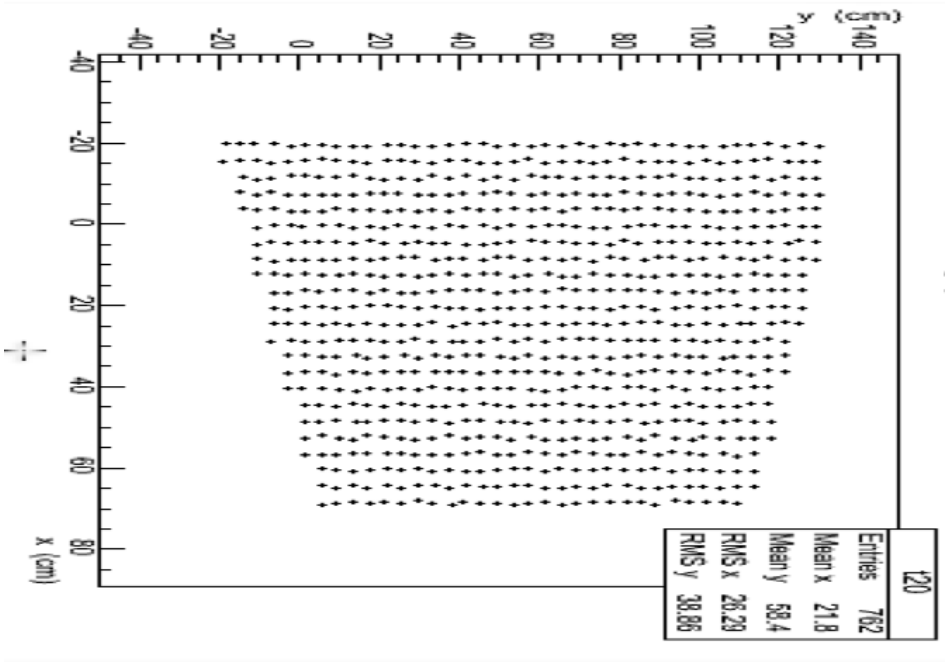
≈2500 points with few μm accuracy

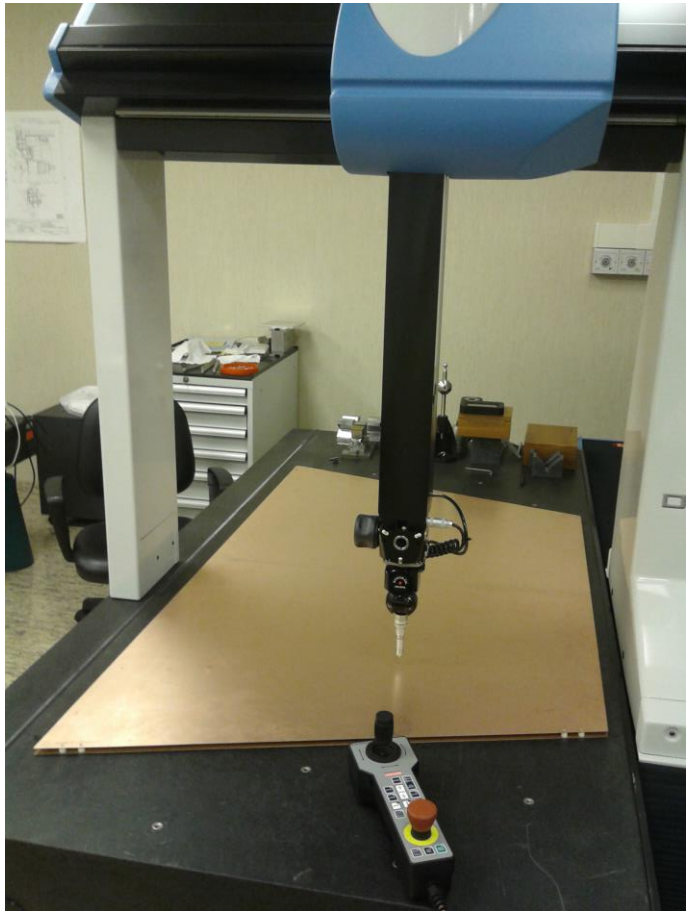




Methods of planarity measurement - II

CMM Machine @ INFN Pisa
(points are in a 4 cm spacing lattice)
≈700 points with 2 μm nominal precision

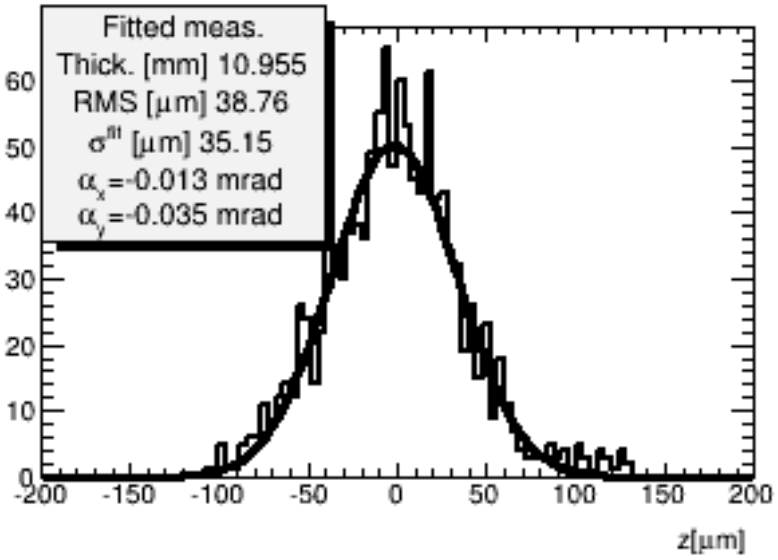


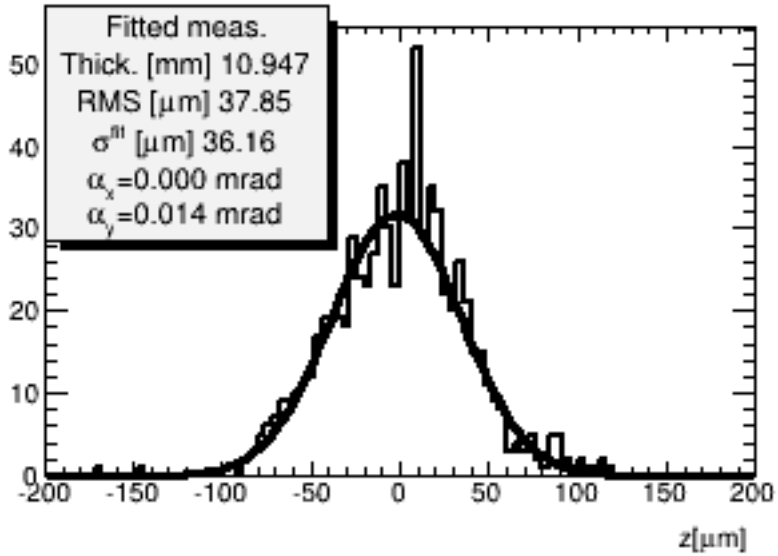


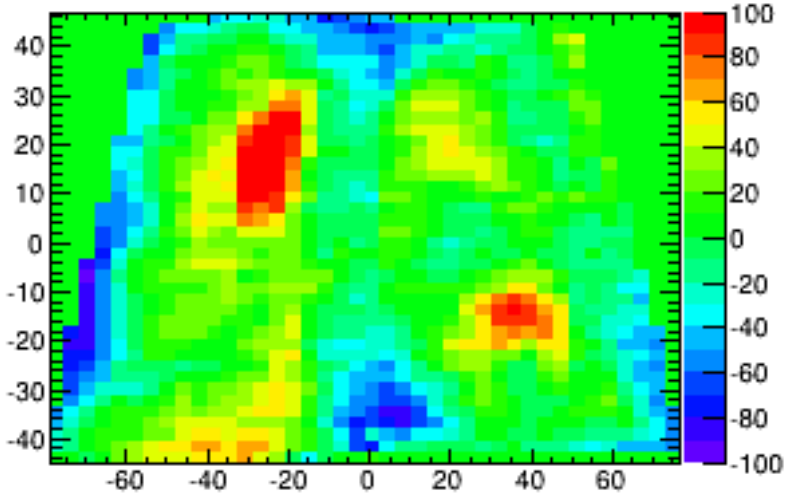
Analysis of planarity measurements

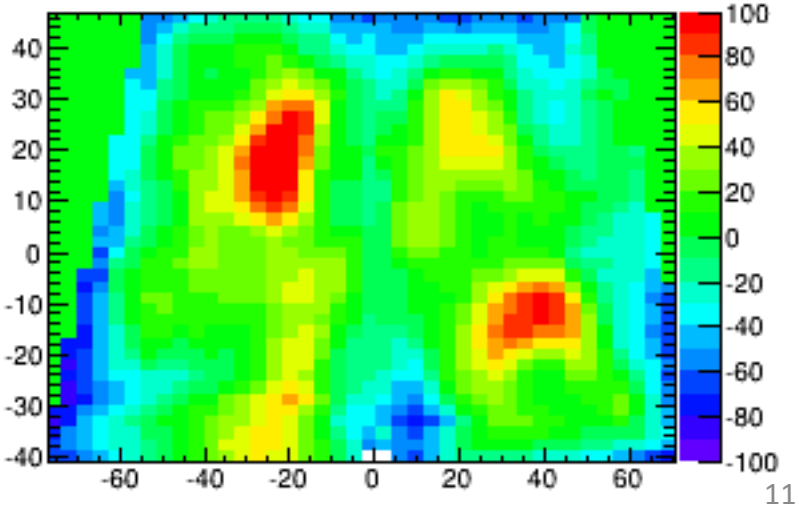
- ➔ A list of **3D points** wrt a plane defined by the machine itself (obtained by measuring the granite table).
- Our analysis:
  - **Raw distribution** of heights of the points ➔ σ_{RAW}
  - **Fit of the "best plane"** ➔ **<thickness>**, α_X, α_Y
  - Distribution of heights wrt fitted plane ➔ σ_{FIT}
- All these infos are given in the following.
- LNF laser tracker is our baseline measurement, comparison with CMM will be shown.

Comparison between planarity measurements: LNF (laser tracker) vs. Pisa (CMM machine) – panel 5 side 1

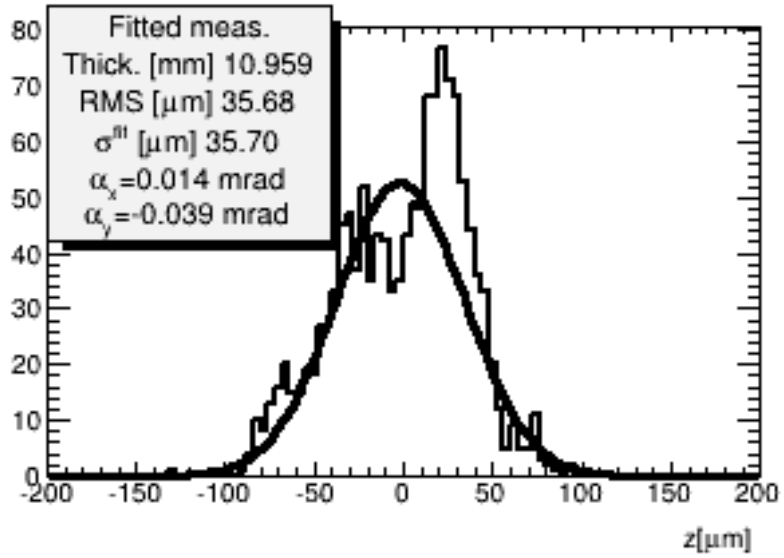


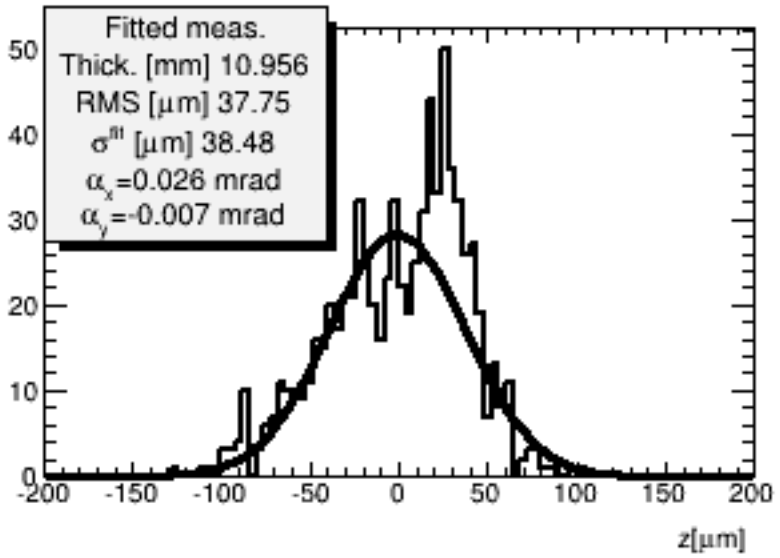


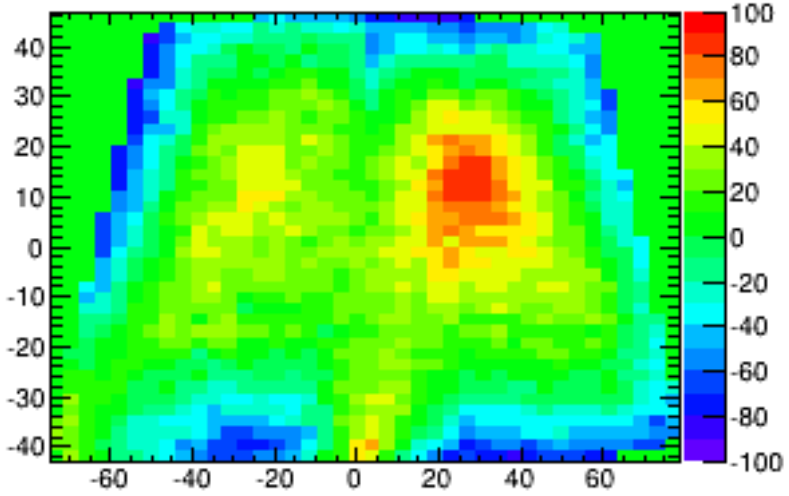


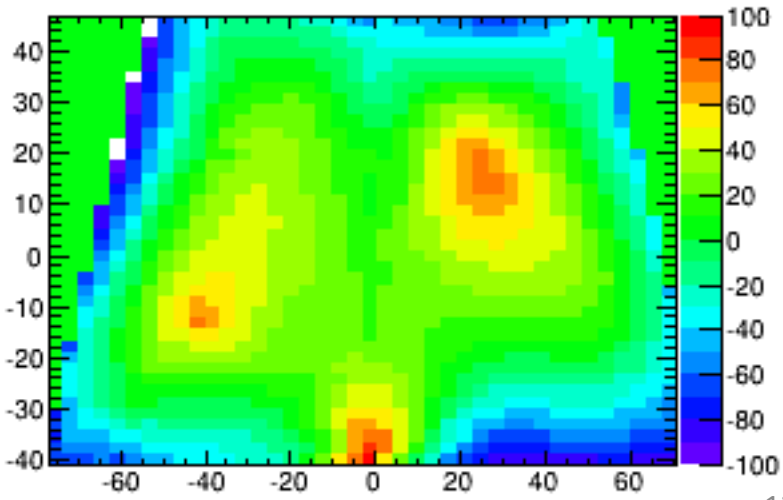


Comparison between planarity measurements: LNF (laser tracker) vs. Pisa (CMM machine) – panel 5 side 2







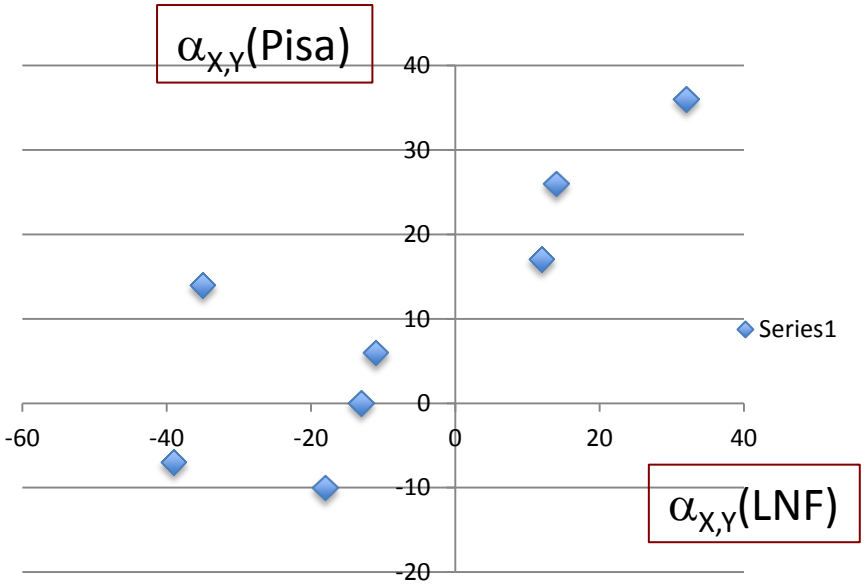


Angles of fitted planes

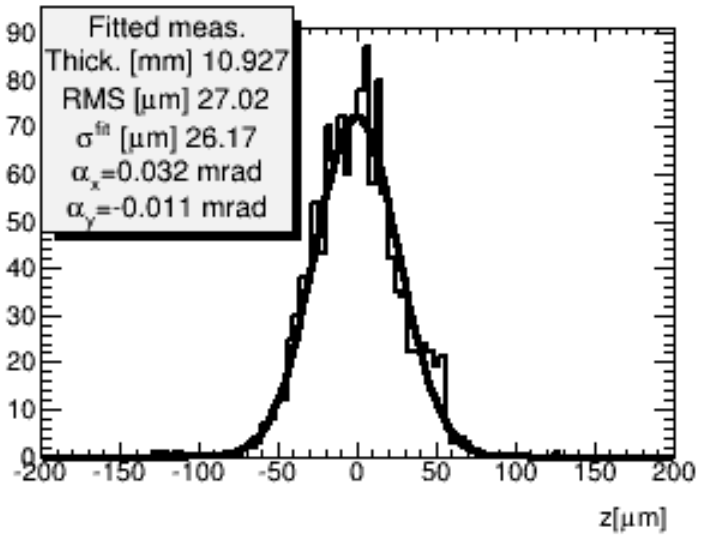
Panel	α_X(LNF)	α_X(Pisa)	α_Y(LNF)	α_Y(Pisa)
4_1	32	36	-11	6
4_2	12	17	-18	-10
5_1	14	26	-39	-7
5_2	-13	0	-35	14

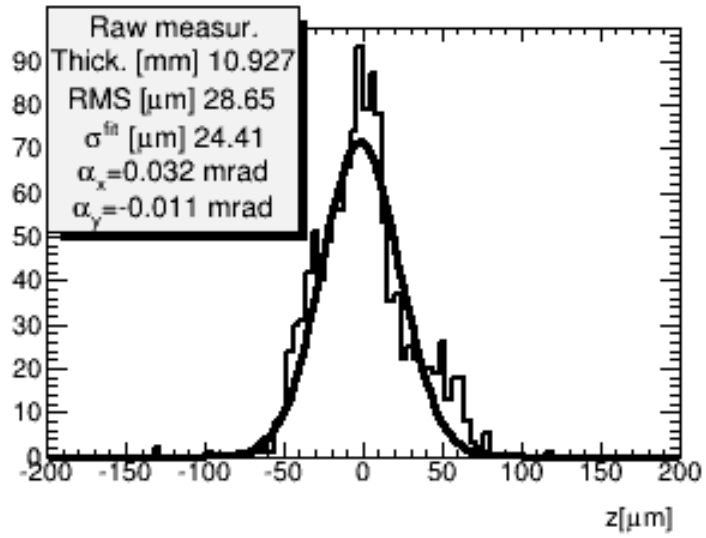
RMS(LNF) = 25 μrad
RMS(Pisa) = 16 μrad

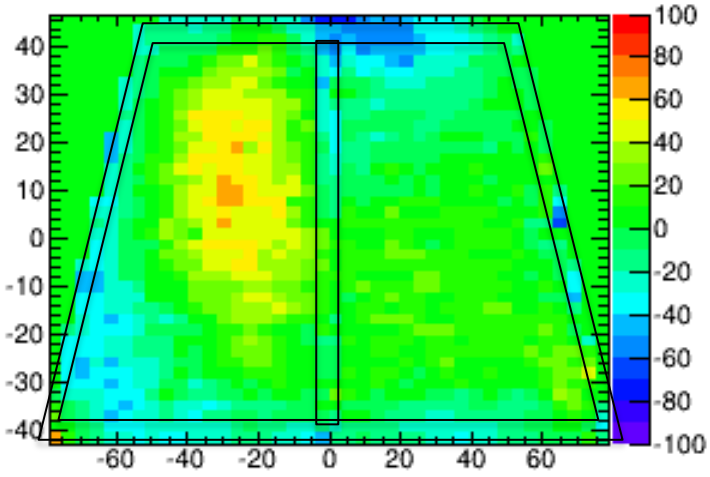
Correlation LNF-Pisa:
Some correlation is present.



Results: panel 4 (Δt = 24 hrs) side 1



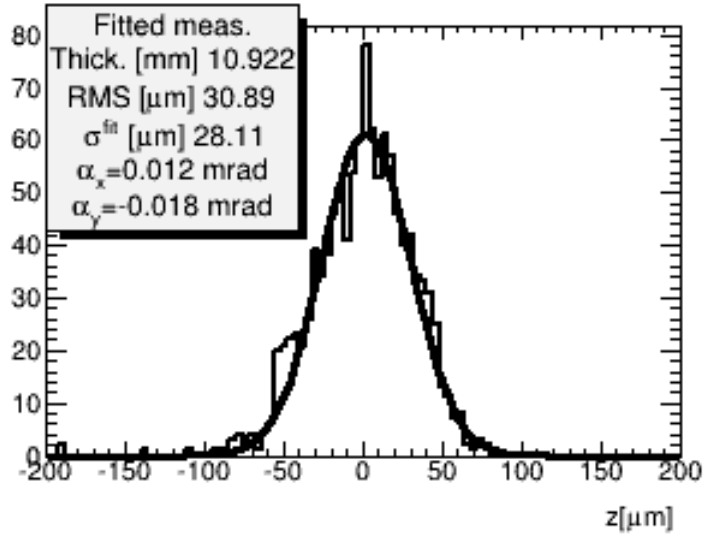


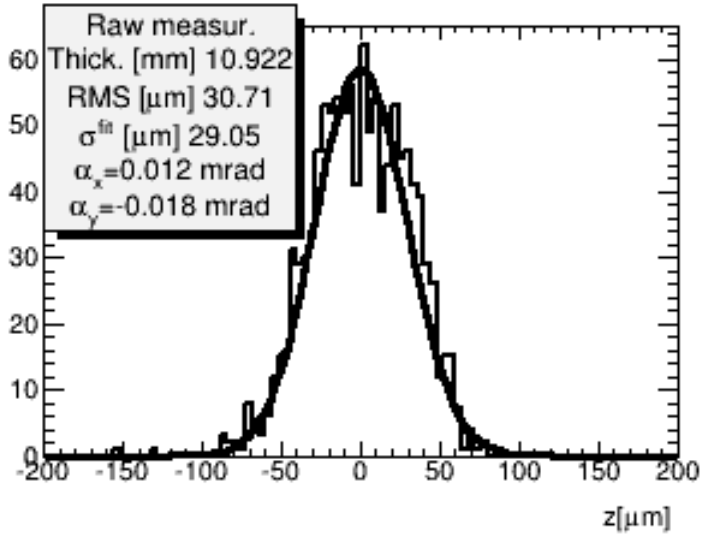


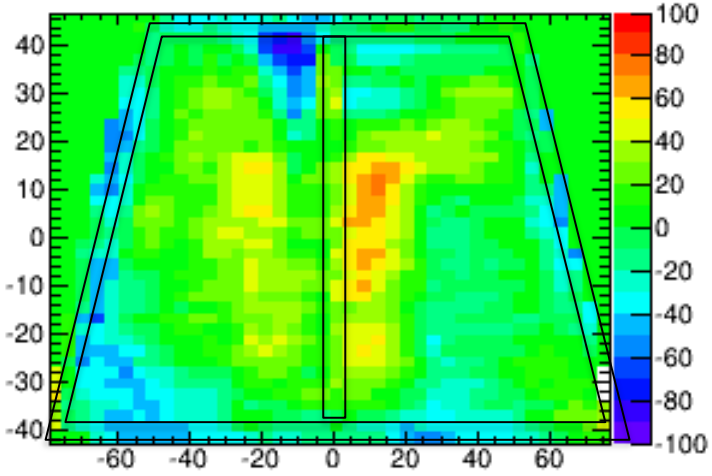
σ_{RAW} (RMS) = 24.4 (28.6) μm
σ_{FIT} (RMS) = 26.2 (27.0) μm

removing the frames:
σ_{FIT} = 21.7 μm

Results: panel 4 (Δt = 24 hrs) side 2



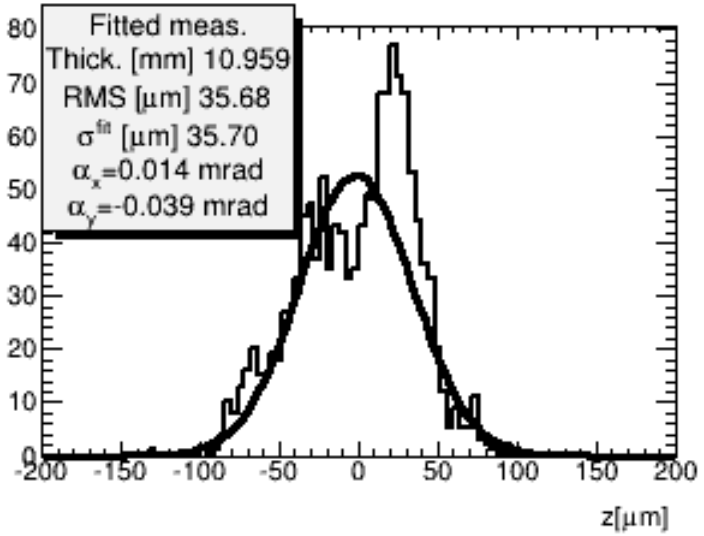


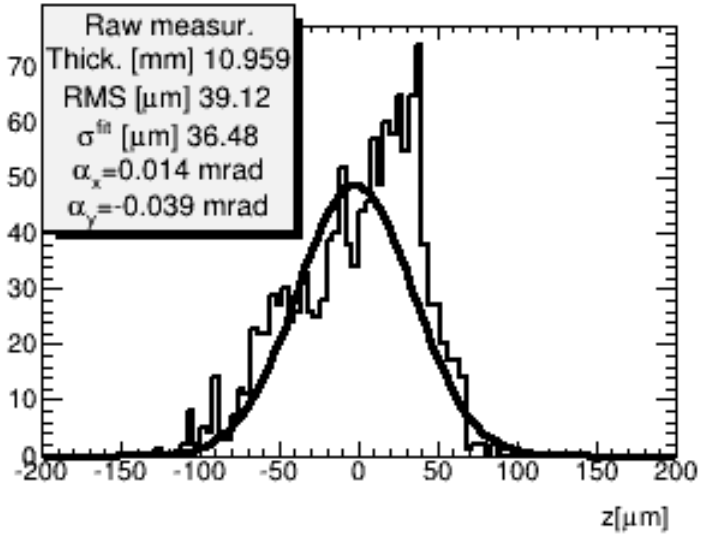


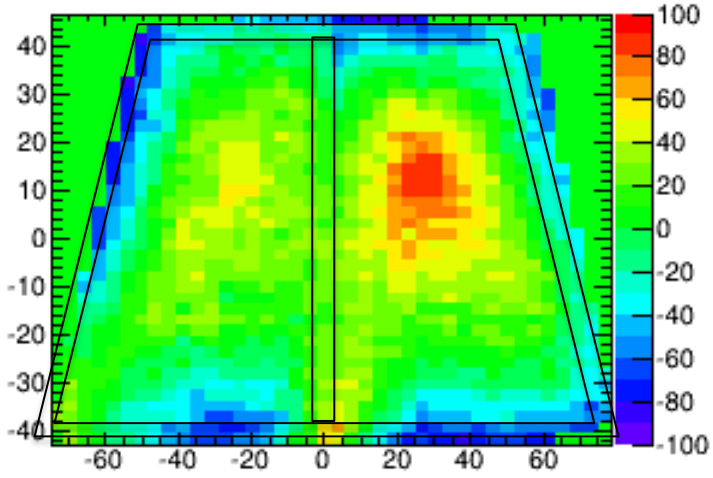
σ_{RAW} (RMS) = 29.0 (30.7) μm
σ_{FIT} (RMS) = 28.1 (27.9) μm

removing the frames:
σ_{FIT} = 22.9 μm

Results: panel 5 (Δt = 5 hrs) side 1



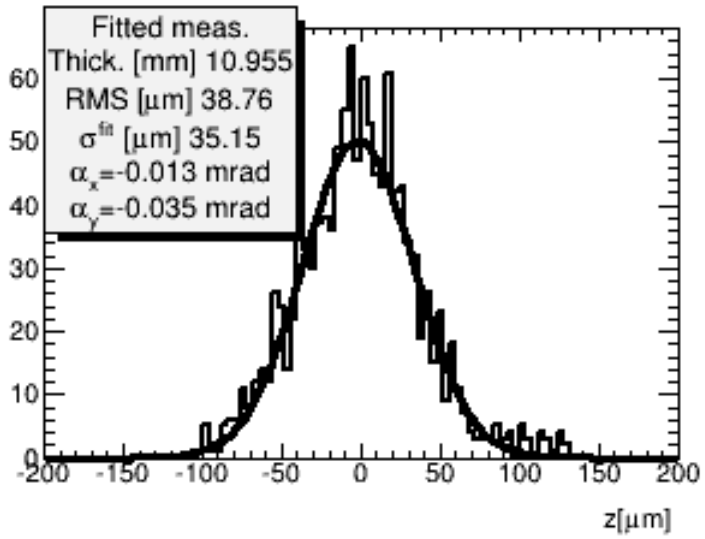


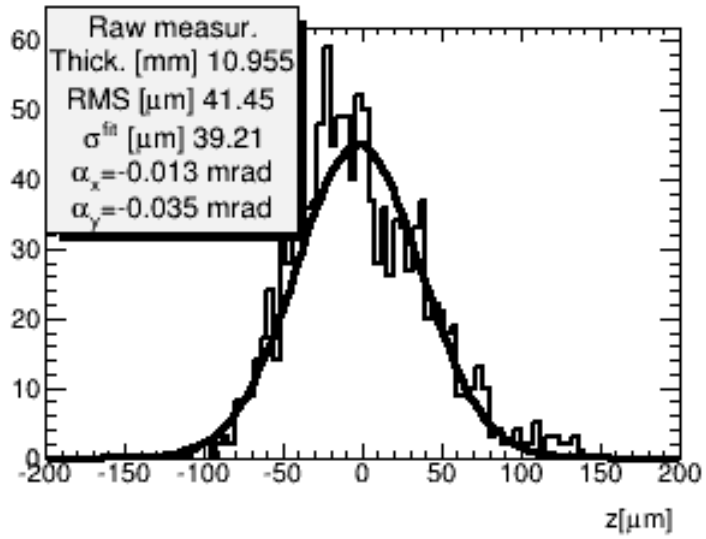


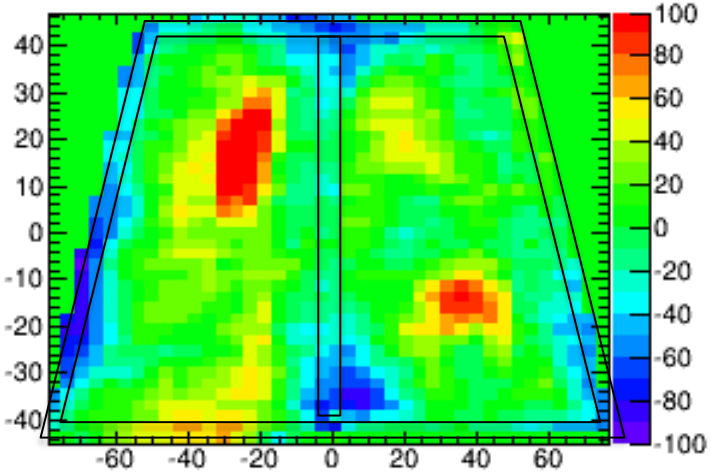
σ_{RAW} (RMS) = 36.5 (39.1) μm
σ_{FIT} (RMS) = 35.7 (35.7) μm
"depression" on external frame

removing the frames:
σ_{FIT} = 22.8 μm

Results: panel 5 (Δt = 5 hrs) side 2







σ_{RAW} (RMS) = 39.2 (41.2) μm
σ_{FIT} (RMS) = 35.2 (38.8) μm
"depression" on external frame

removing the frames:
σ_{FIT} = 21.5 μm

Summary - I

Panel #	construction	$\sigma(\mu m)^{(1)}$ overall	$\sigma(\mu m)^{(2)}$ no frame	Thickness$^{(3)}$ (mm)	
1	One-step gluing	16 47	11 34	10.948 (-12)	CMM machine
2	One-step gluing (segmented hc)	85 76	73 54	11.154 (-34)	CMM machine (not to be considered)
3	One-step gluing	15 41	12 38	10.963 (+3)	CMM machine
4	Two-step gluing (Δt = 24 hrs)	26 28	22 23	10.927 (-33)	Laser tracker
5	Two-step gluing (Δt = 5 hrs)	36 35	23 21	10.959 (-1)	Laser tracker

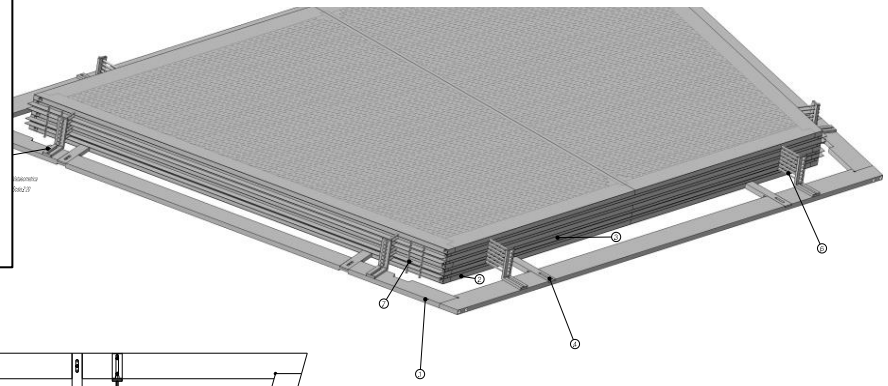
(1) Sigma obtained after plane fitting σ_{FIT}
(2) The measurement is performed removing all points within 10 cm from the frame
(3) Thickness measured with side 1 in the table. In () difference in μm wrt nominal.

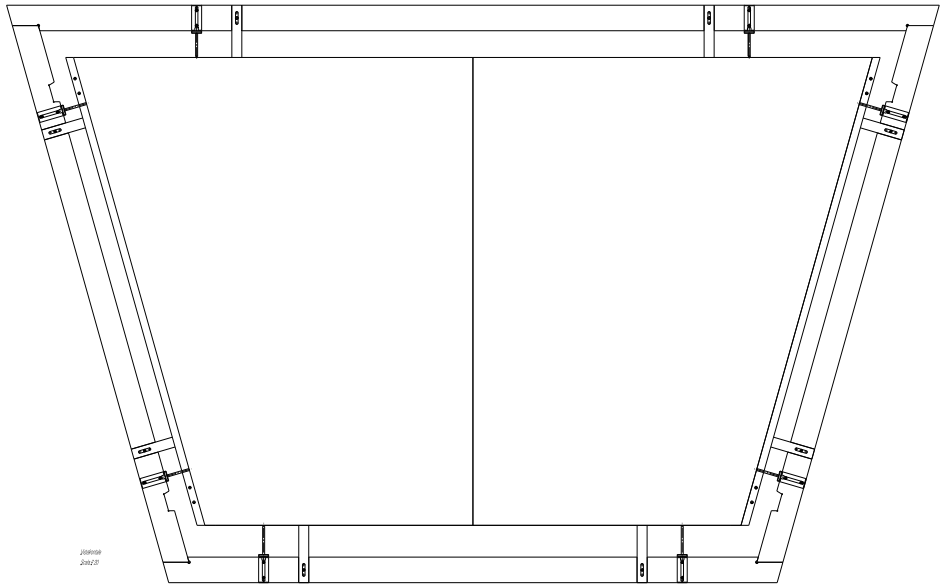
Summary - II

- **Planarities:**
  - Two-steps method with Δt = 24 hrs turns out to be the best option with overall planarities RMS well below 30 μm on both faces.
  - Improvements expected by a better "definition" of the frame ➔ 20 μm planarities can be reached.
- **Panel thickness** wrt nominal (assuming 2x60 μm glue thickness):
  - In average -15 μm with an RMS of 17 μm.
  - Improvements expected by a better control of the glue amount.
- **Methods of measurement**
  - CMM machine and Laser-tracker give results in good agreement.

Quadruplet assembly - I

Assembly scheme:
Panels are glued to drift gap frames
(5 mm thick Al not rectified, 20 mm wide)
No vacuum bag used, gluing by gravity
all panels in a single step.

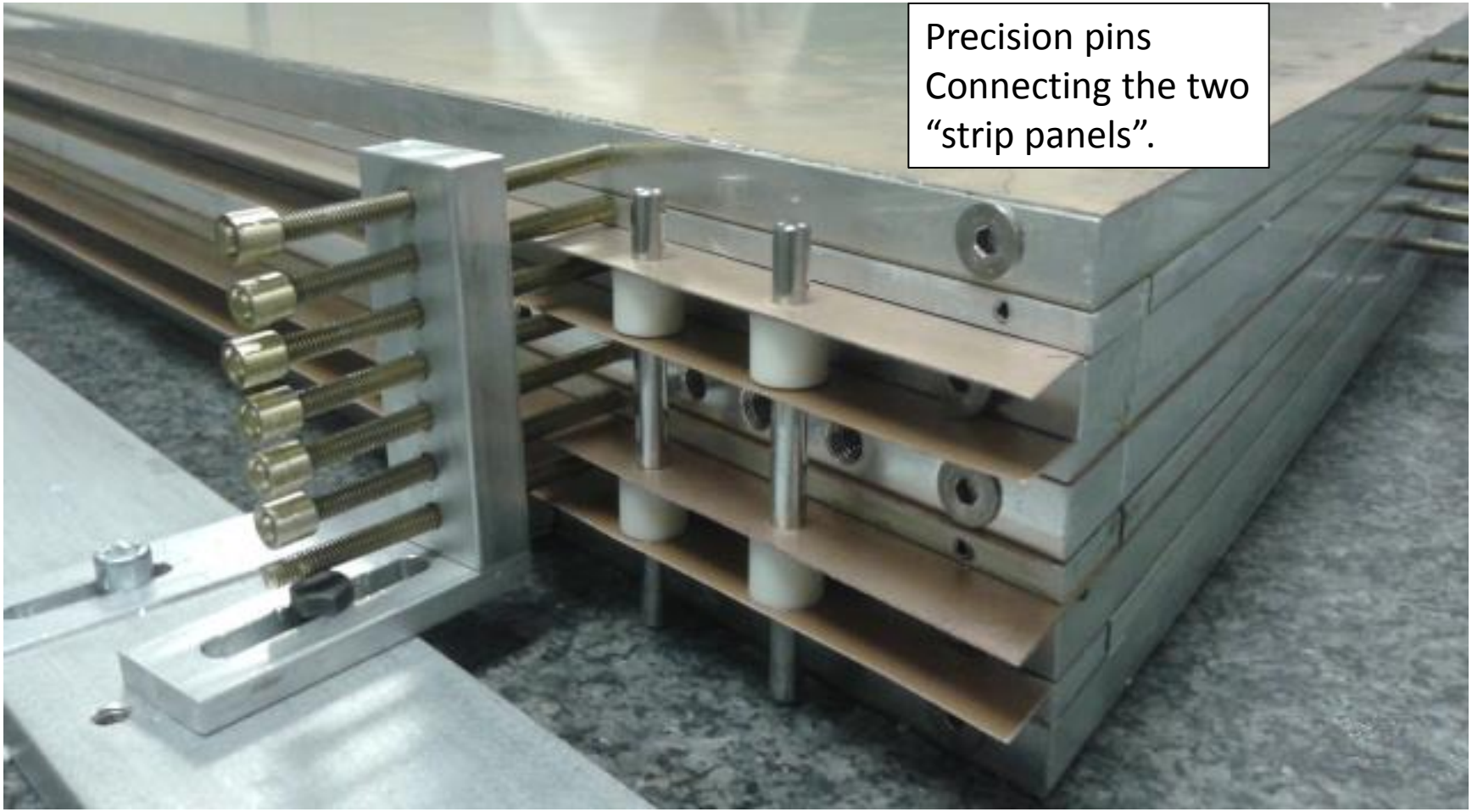




13		1		
12		2		
11		1		
10		1		
9		2		
8		1		
7	setpins pcb strips	1	steel	
6	setpins assmbl.	3	brass	
5	Assmbl. Block	2	Anticorodal	
4	block	2	Anticorodal	
3	Pannello di Strips	1	Anticorodal	

Quadruplet assembly - II

Quadruplet assembly - III



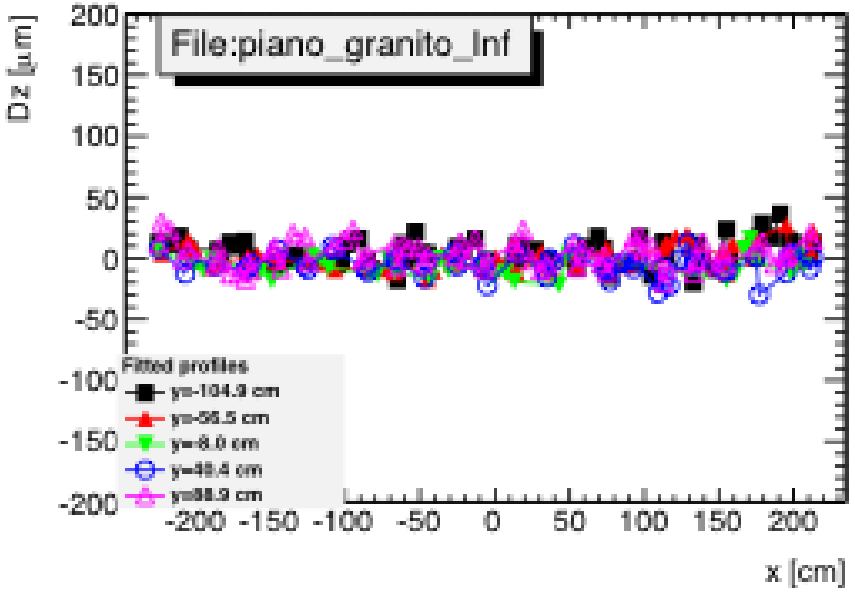
Status of quadruplet

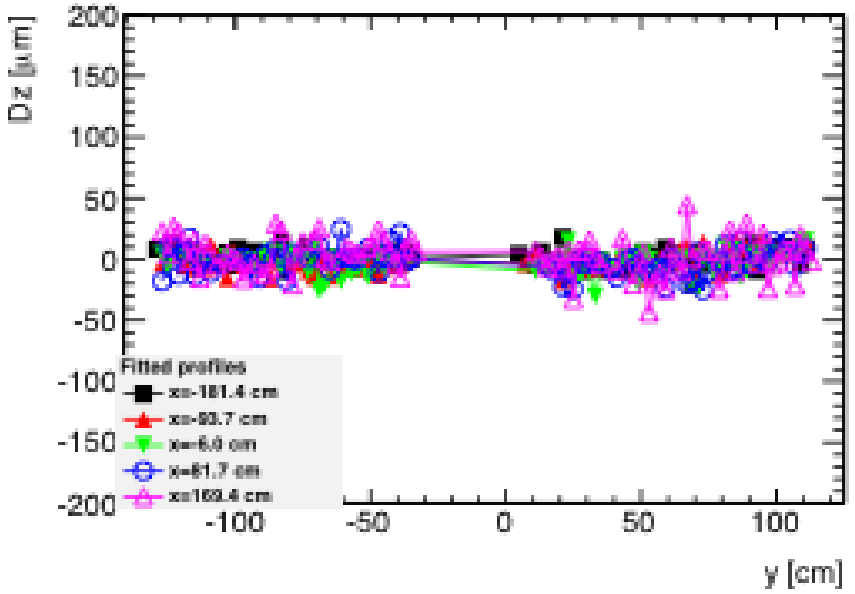
- Mechanical properties still to be measured. Probably a “sag” effect on the top side, to be quantified.
- We plan to make holes along the frame to allow mounting on the spacer.

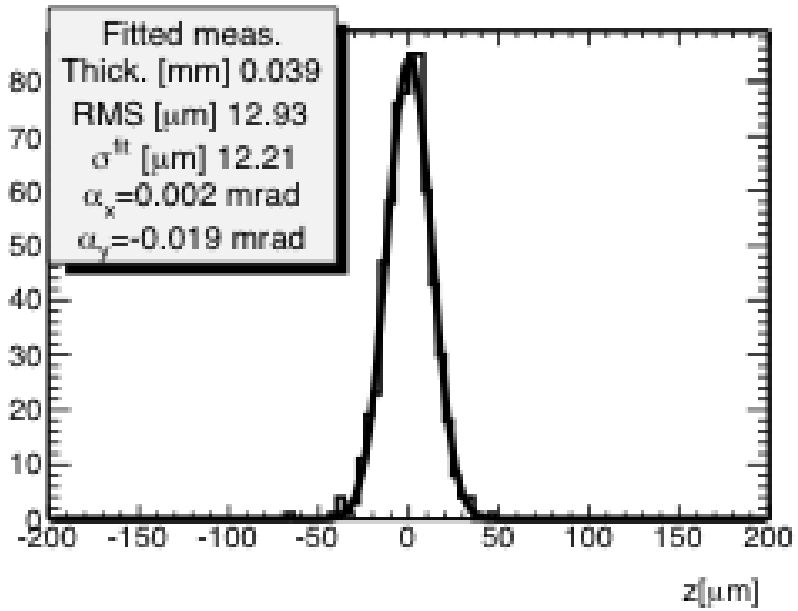
Conclusions

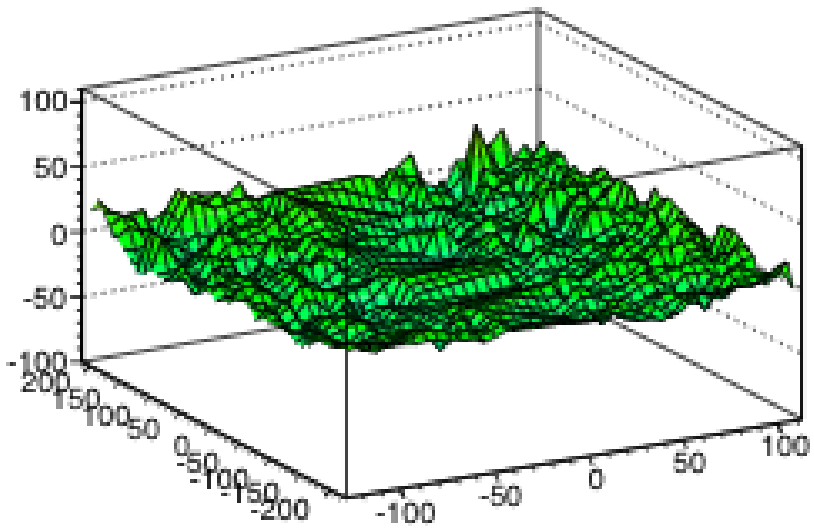
- **M2 dummy quadruplet ready to be mounted** (only holes are still missing).
- **Vacuum bag technique** (with two-steps gluing option) allows to get:
  - ***Overall planarities below 30 μm on both sides***;
  - ***Average thickness reproducibility better than 20 μm;***
  - Space for improvements from better frame structure and glue amount control.
- Plan to build a **full-size SM1 drift panel** using the two-step method with Δt = 24 hrs

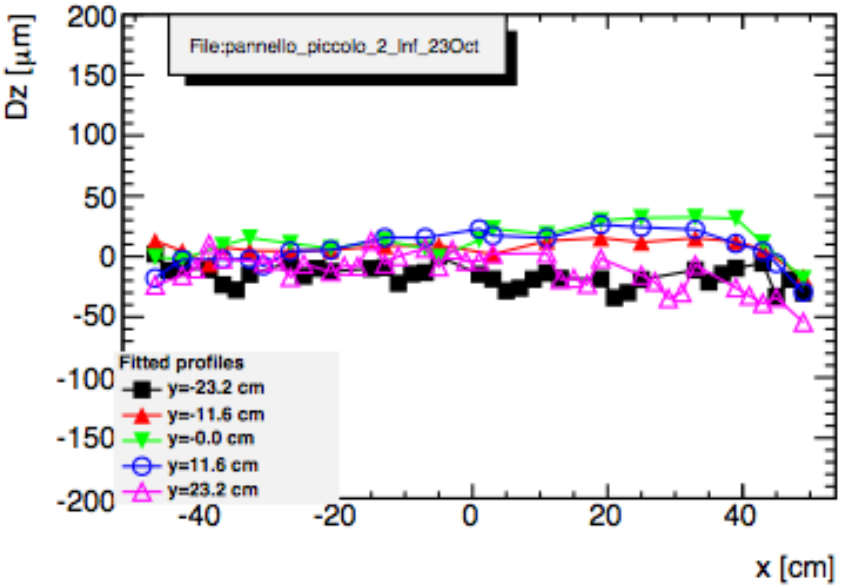
Backup

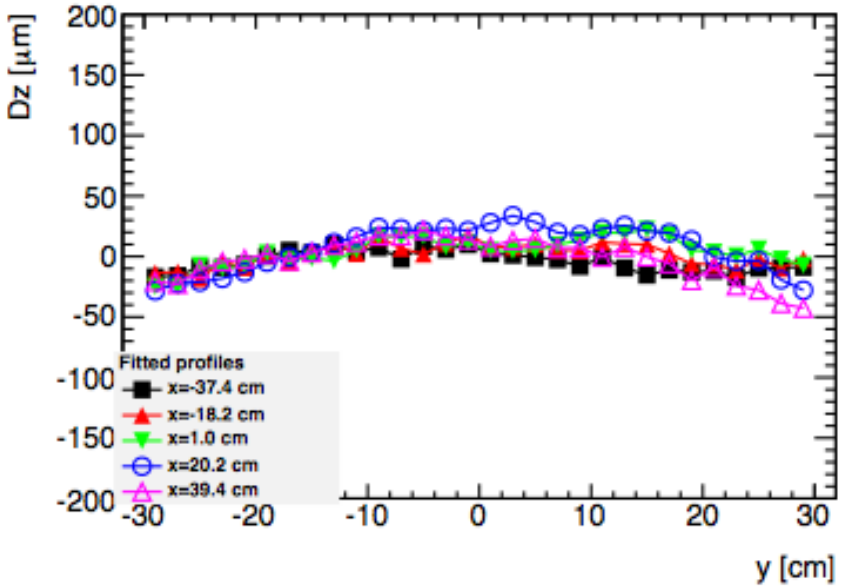

File:piano_granito_Inf
Dz [μm]
x [cm]
Fitted profiles
y=-104.9 cm
y=-56.5 cm
y=8.0 cm
y=48.4 cm
y=88.9 cm

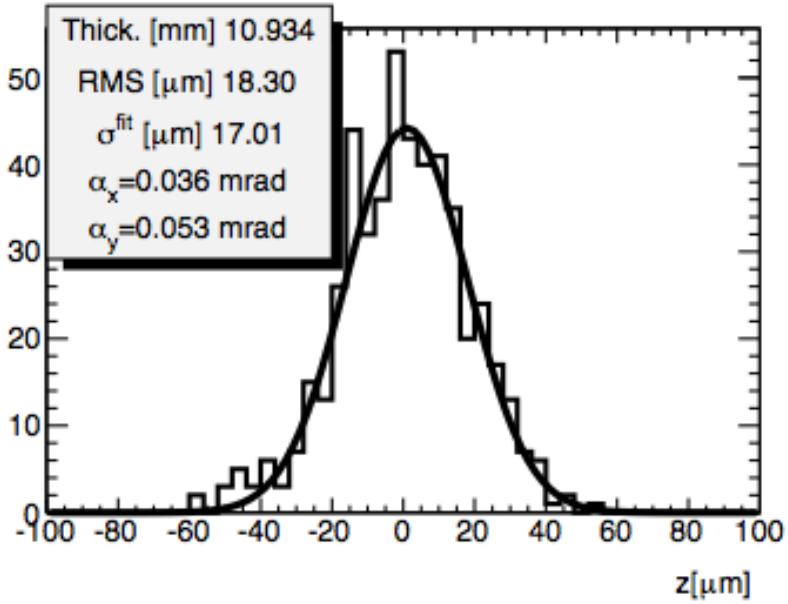

Dz [μm]
y [cm]
Fitted profiles
x=-181.4 cm
x=-93.7 cm
x=6.0 cm
x=81.7 cm
x=169.4 cm

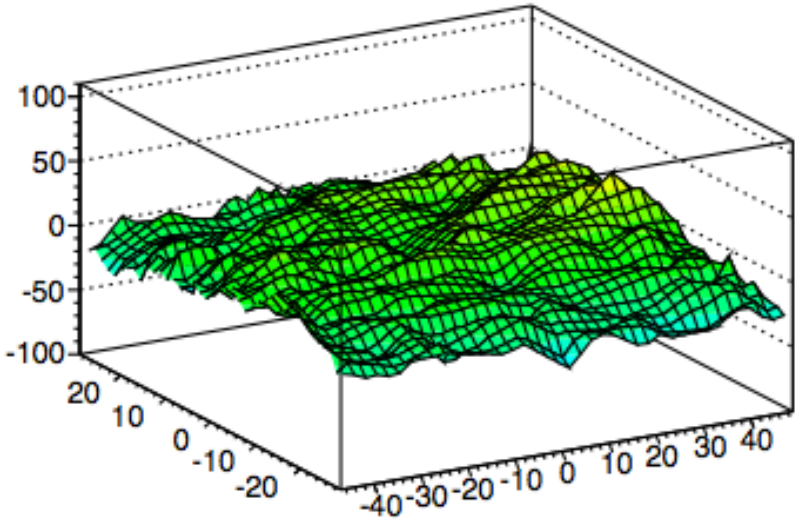

Fitted meas.
Thick. [mm] 0.039
RMS [μm] 12.93
σ^fit [μm] 12.21
α_x=0.002 mrad
α_y=-0.019 mrad
z[μm]

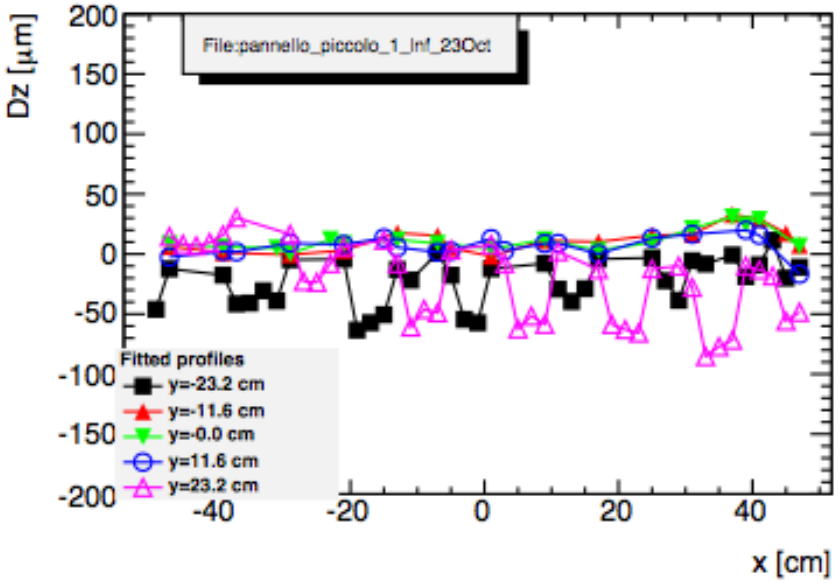


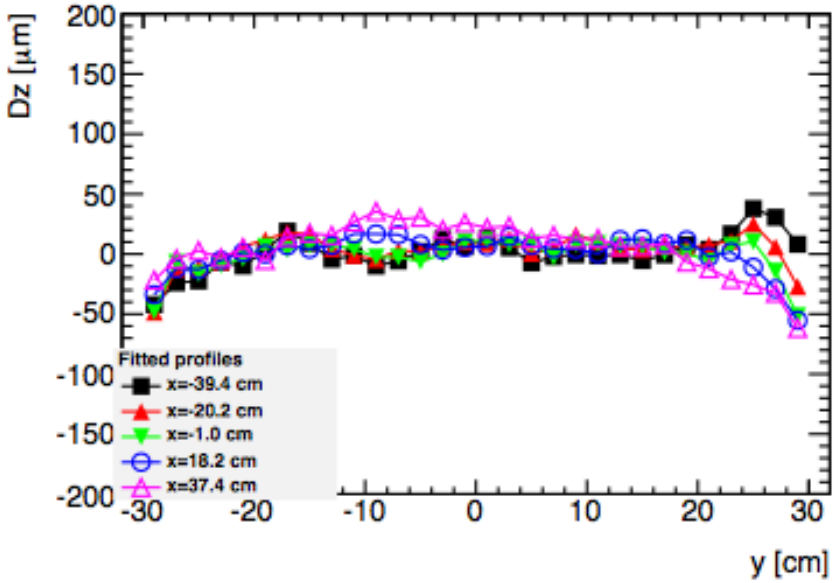

File:pannello_piccolo_2_Inf_23Oct
Dz [μm]
x [cm]
Fitted profiles
y=-23.2 cm
y=-11.6 cm
y=-0.0 cm
y=11.6 cm
y=23.2 cm

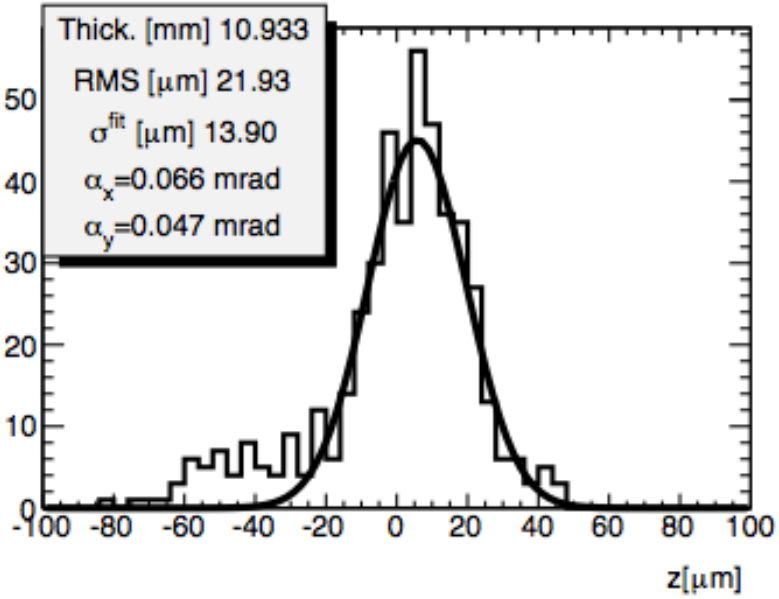

Dz [μm]
y [cm]
Fitted profiles
x=-37.4 cm
x=-18.2 cm
x=1.0 cm
x=20.2 cm
x=39.4 cm


Thick. [mm] 10.934
RMS [μm] 18.30
σ^fit [μm] 17.01
α_x=0.036 mrad
α_y=0.053 mrad
z[μm]




File:pannello_piccolo_1_Inf_23Oct
Dz [μm]
x [cm]
Fitted profiles
y=-23.2 cm
y=-11.6 cm
y=-0.0 cm
y=11.6 cm
y=23.2 cm


Dz [μm]
y [cm]
Fitted profiles
x=-39.4 cm
x=-20.2 cm
x=-1.0 cm
x=18.2 cm
x=37.4 cm


Thick. [mm] 10.933
RMS [μm] 21.93
σ^fit [μm] 13.90
α_x=0.066 mrad
α_y=0.047 mrad
z[μm]