Quad laser setup results

Kees Ligtenberg

Lepcol meeting

September 3, 2018

Contents

Data from setup

Registered data:

- Trigger time, stage position
- Hit time, ToT, row, col (for all 4 chips)
- Temperature, pressure, Oxygen concentration, relative humidity

$V_{\text{drift}} = 280\,\text{V/cm}$ and $V_{\text{Grid}} = 330\,\text{V}$

Selection

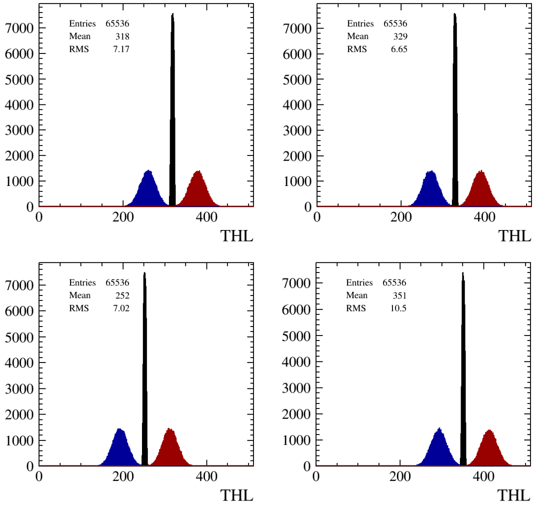
Selection
$-500\,\text{ns} < t_{\text{drift}} < 500\,\text{ns}$
Hit ToT $> 0.15\,\mu\text{s}$
Reject outliers ($> 2\sigma_x, > 2\sigma_y, > 3\sigma_z$)

Define $t_{\text{drift}} = t_{\text{hit}} - t_{\text{trigger}}$
Consider all hits with a drift time between $-500\,\text{ns}$ and $500\,\text{ns}$
Put z0 for outlier rejection at too low value of -1, until there is a preciser estimate

Data is mostly from

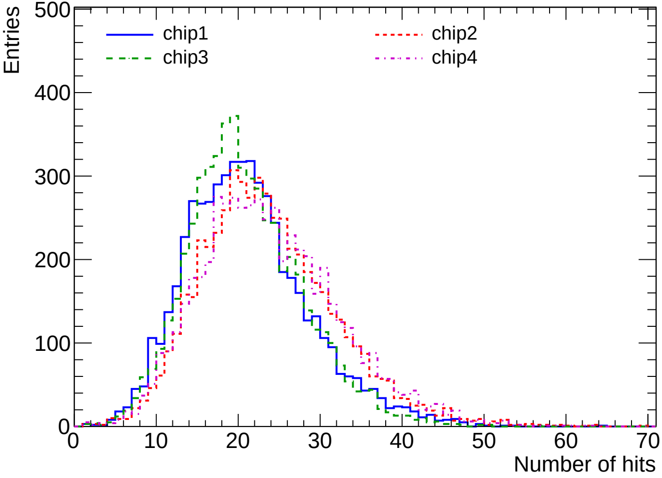
- run310: 1 mm x,y scan at a drift distance of $\sim$5 mm
- run316: 1 mm z scan at 2 points per chip

Equalisation



Number of hits per laser pulse

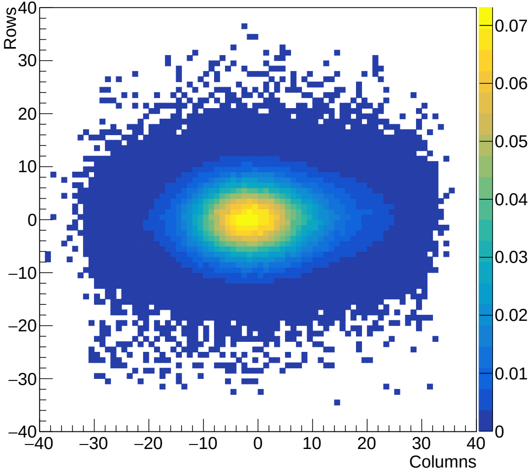
More than 2 mm away from the edges



3	2
guard	
4	1

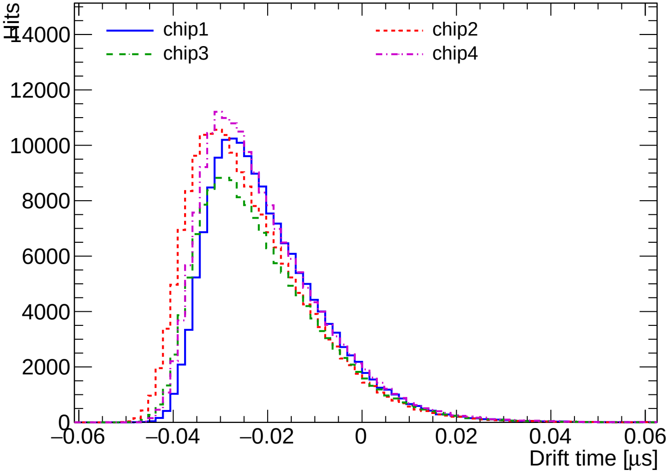
Average hits per pixel per trigger

and chance of double hits



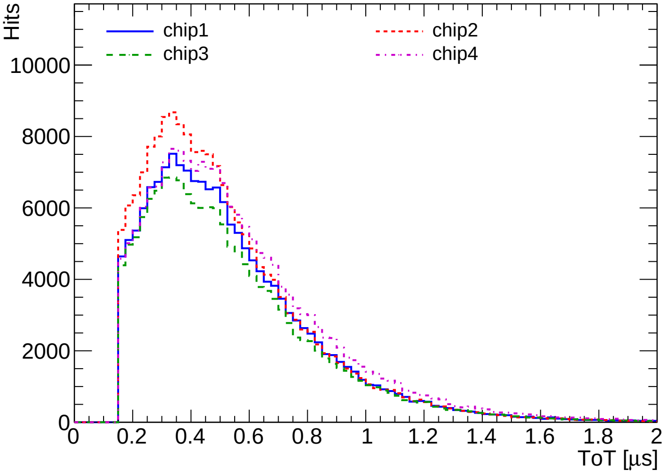
If Poisson-distributed, $< 4\%$ of the hits on any pixel are double hits

Drift time



Hits
14000
12000
10000
8000
6000
4000
2000
0
chip1
chip2
chip3
chip4
–0.06
–0.04
–0.02
0
0.02
0.04
0.06
Drift time [µs]

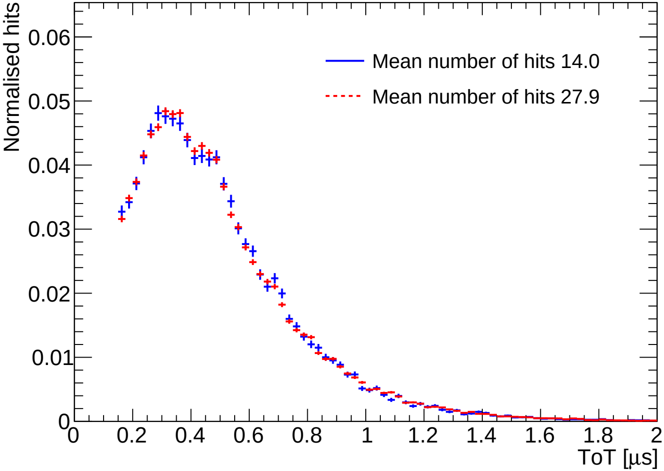
Time over Threshold



Is the second peak at 0.5 µs is caused by double hits?

Nikhef

Time over threshold distribution for different number of average hits



Is the second peak at 0.5 µs is caused by double hits?

Alignment

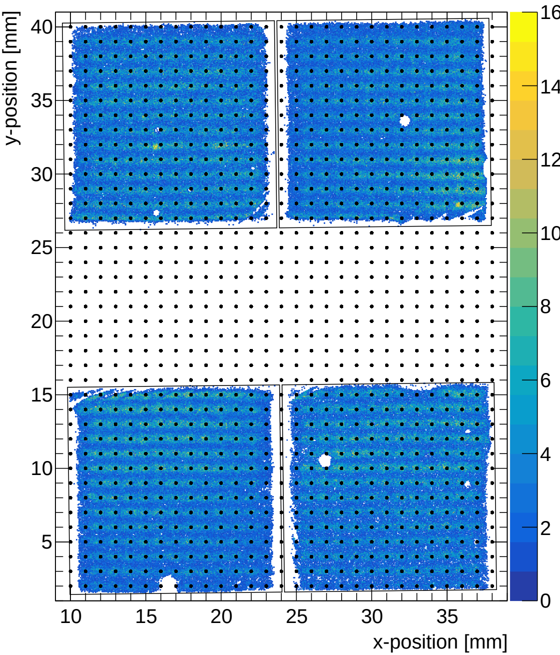
The chips positions on the quad are taken from drawings
Align the quad by shifting along 3 axes and rotating around 3 axes: $(3 + 3)$ parameters

Rotations around x-axis: 0.0054 (0.31°), y-axis: -0.00450 (-0.26°), z-axis: 0.0116 $(\ 0.66^{\circ})$ with respect to laser stage axis

Hitmap

Hitmap with laser positions

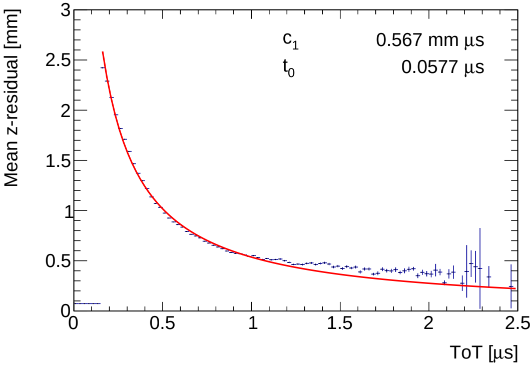
The boxes indicate the position of the sensitive part of the chip



Time walk

Correct z-residuals due to time walk by

$$\delta z_{\text{tw}} = \frac{c_1}{t_{\text{ToT}} + t_0} \tag{1}$$

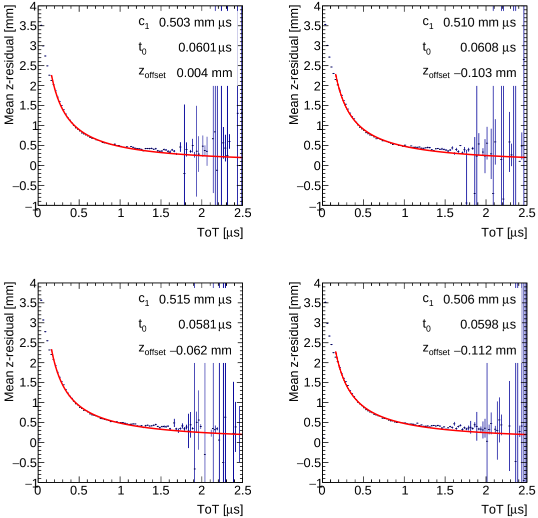


From Test beam paper

c_1	$0.525\,\text{mm}\,\mu\text{s}$
t_0	$-0.0102\,\mu\text{s}$

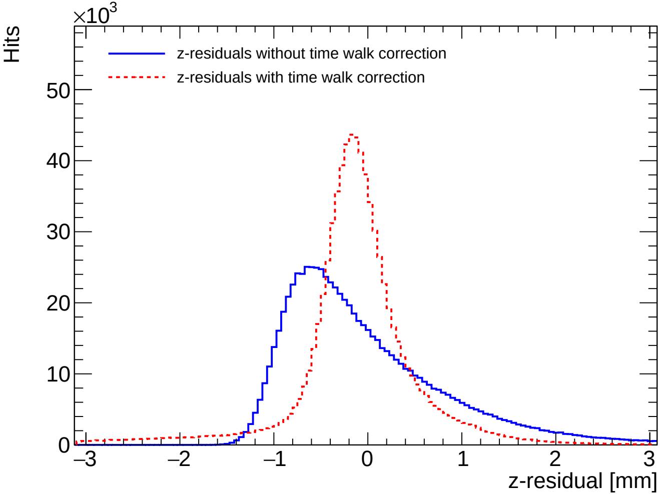
Fit can be improved by increasing the bin size or calculating the expected error, instead of taking the simplest statistical error

Time walk per chip

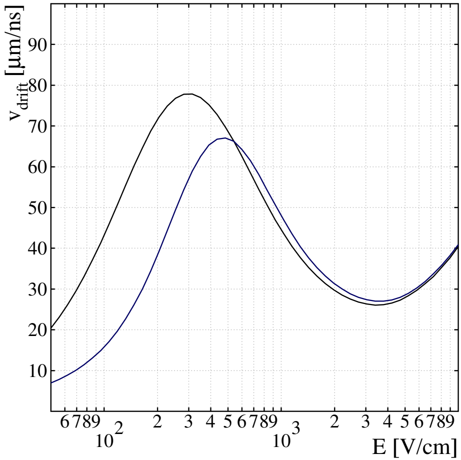


Fit can be improved by increasing the bin size or calculating the expected error, instead of taking the simplest statistical error

Time walk effect on z-residuals

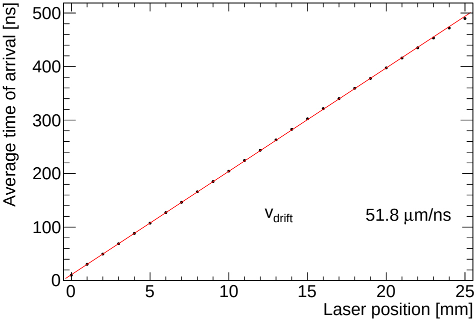


Drift velocity with and without water vapor



Blue line is 94.6% Ar, 3% CF4, 2% iC4H10, 0.1% O2, 0.4% H20,
Black line is 94.9% Ar, 3% CF4, 2% iC4H10, 0.1% O2, 0% H20

Drift velocity



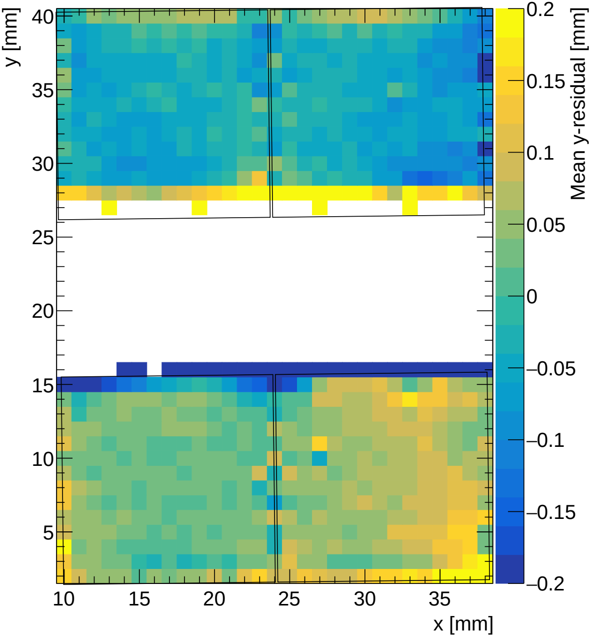
The drift velocity (51.8 μm/ns) is close to expected (54 μm/ns) and lower than without water vapor (78 μm/ns)
For the single chip laser test the drift velocity (66.5 μm/ns) was also lower than expected (73 μm/ns)

y-deformations

Tuned values for guard voltages

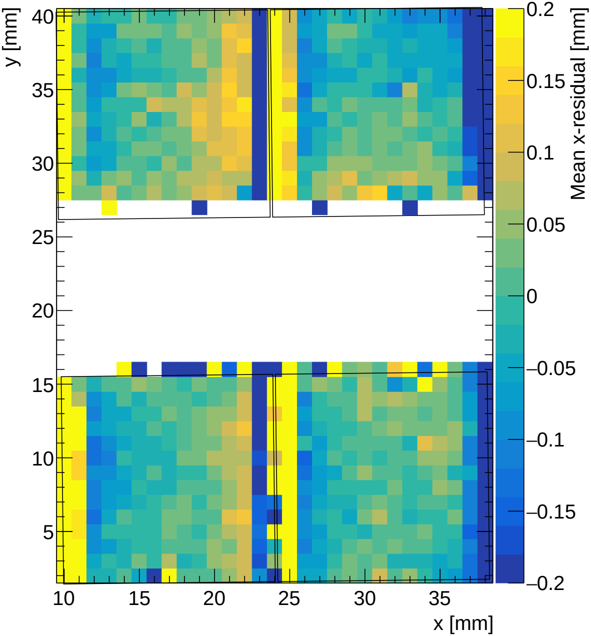
$V_{\text{central guard}}$	$-350\,\text{V}$
$V_{\text{guard cage}}$	$-340\,\text{V}$

The distance between the top and bottom row is not yet correct
The central guard seems to cover a greater part of the top row



x-deformations

Tuned values for guard voltages



$V_{\text{central guard}}$	$-350\,\text{V}$
$V_{\text{guard cage}}$	$-340\,\text{V}$

The hits are still pulled toward the cage guard?

z-deformations

Tuned values for guard voltages

$V_{\text{central guard}}$	$-350\,\text{V}$
$V_{\text{guard cage}}$	$-340\,\text{V}$

Every chip might have the same pattern, which is related to the charge-ToT response

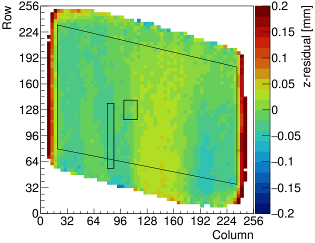
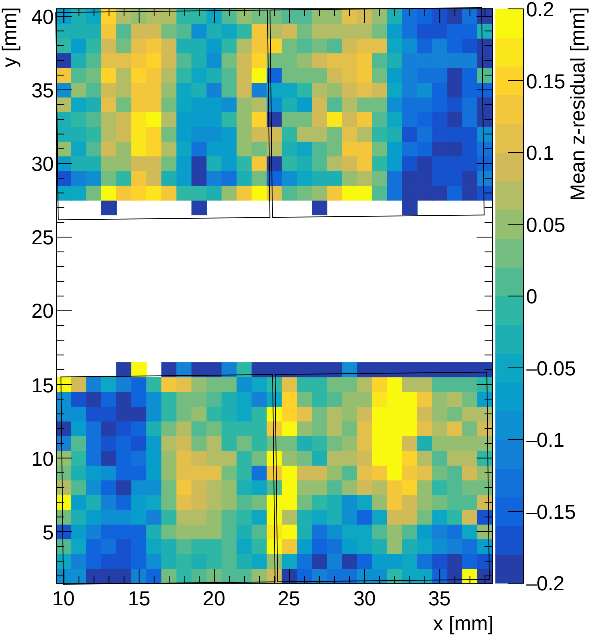
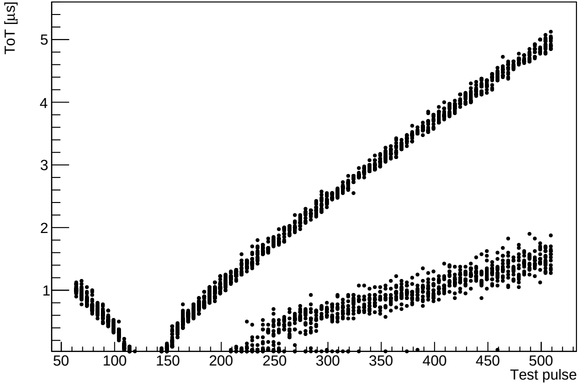


figure 11 from test beam paper



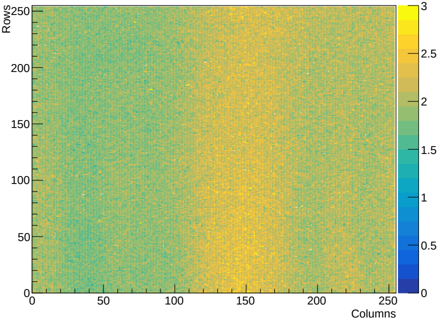
Charge-ToT calibration

The Charge-ToT relation can vary per pixel, and can be calibrated using a test pulse.



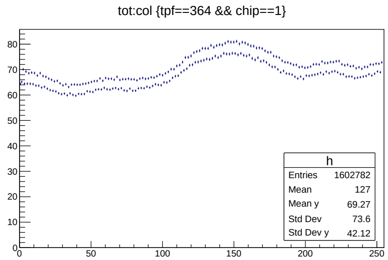
Top band is the charge-ToT curve
Why is there a second band in this diagram?

Mean ToT for a test pulse



Chip 1 for test pulse fine=404

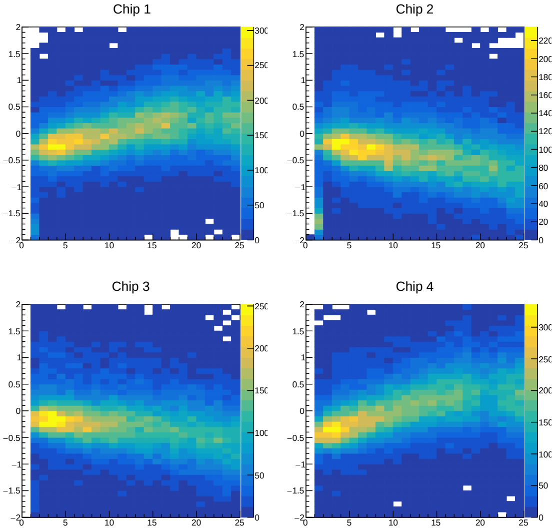
Mean ToT for a test pulse per column



A clear pattern per column

z-residuals by z

for new alignment, no cuts



Unexplained pattern in z-residual by drift distance

Tuning of guard voltages

Voltage of central guard and the guard around the quad (gaurd cage) can be tuned

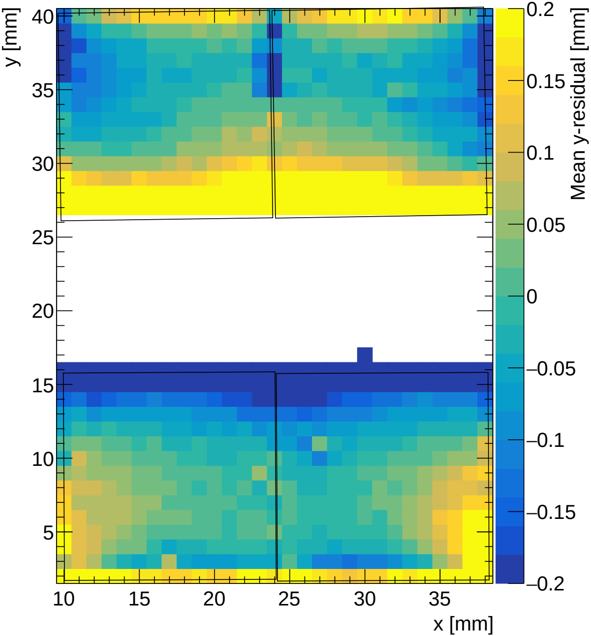
This tuning was done using old alignment method were each chip was shifted and rotated separately

y-deformations

Start values for guard voltages

$V_{\text{central guard}}$	$-360\,\text{V}$
$V_{\text{guard cage}}$	$-335\,\text{V}$

The hits are repelled from the central guard
The hits are pulled toward the cage guard

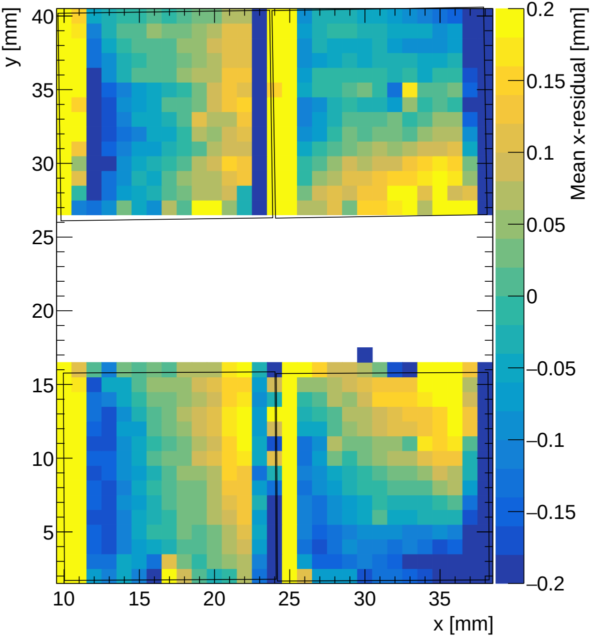


x-deformations

Start values for guard voltages

$V_{\text{central guard}}$	$-360\,\text{V}$
$V_{\text{guard cage}}$	$-335\,\text{V}$

The hits are pulled toward the cage guard



z-deformations

Start values for guard voltages

$V_{\text{central guard}}$ $-360\,\text{V}$
$V_{\text{guard cage}}$ $-335\,\text{V}$

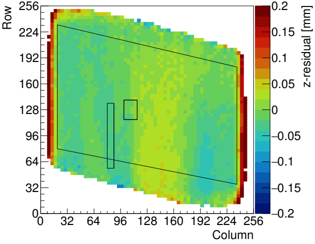
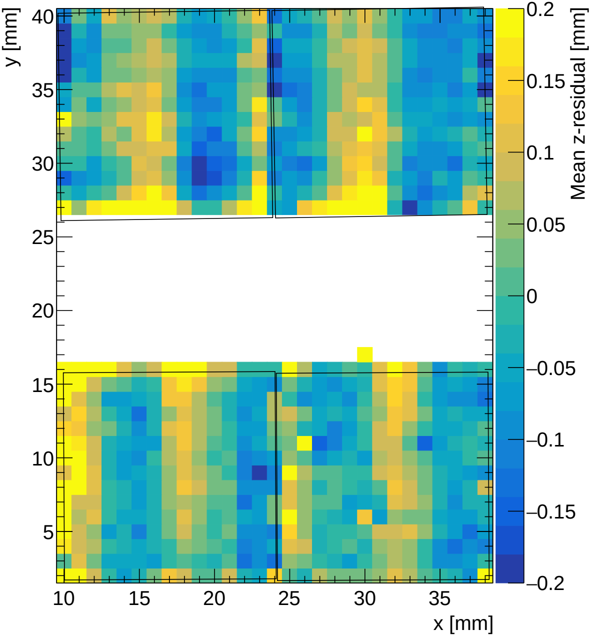


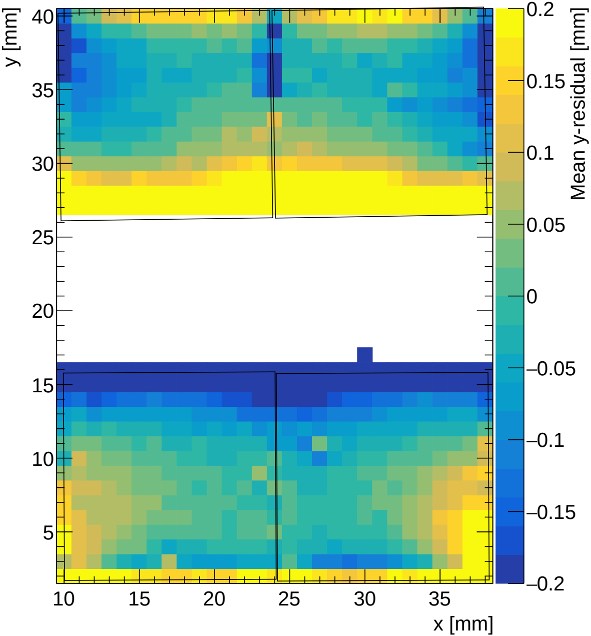
figure 11 from test beam paper



y-deformations

Start values for guard voltages

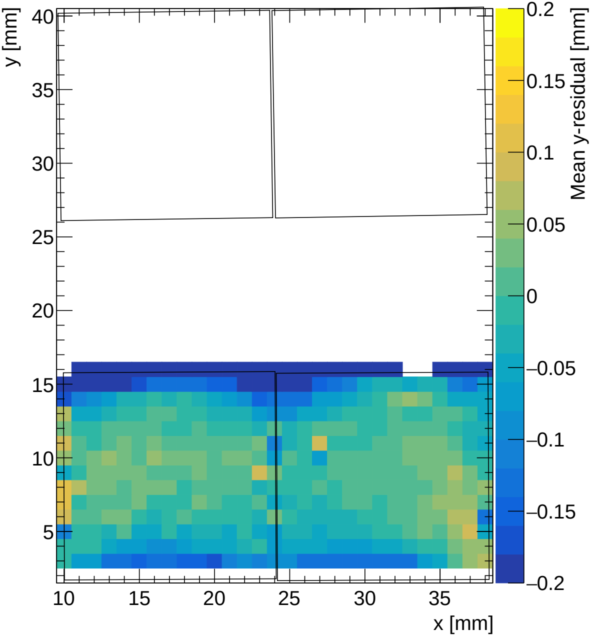
$V_{\text{central guard}}$	$-360\,\text{V}$
$V_{\text{guard cage}}$	$-335\,\text{V}$



y-deformations

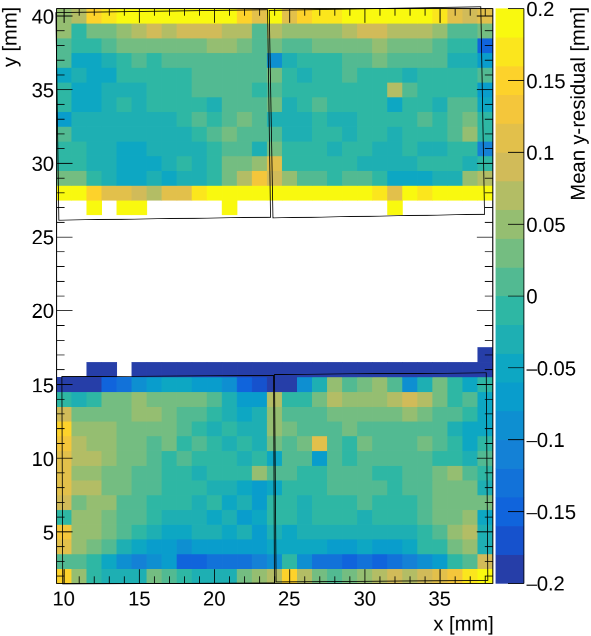
Central Guard voltage +5 V

$V_{\text{central guard}}$	$-355\,\text{V}$
$V_{\text{guard cage}}$	$-335\,\text{V}$



y-deformations

Central Guard voltage +10 V

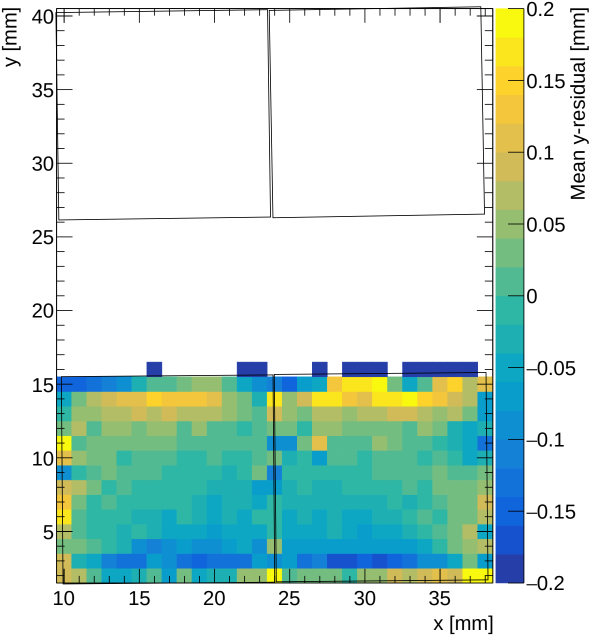


$V_{\text{central guard}}$	$-350\,\text{V}$
$V_{\text{guard cage}}$	$-335\,\text{V}$

y-deformations

Central Guard voltage +15 V

$V_{\text{central guard}}$	$-345\,\text{V}$
$V_{\text{guard cage}}$	$-335\,\text{V}$

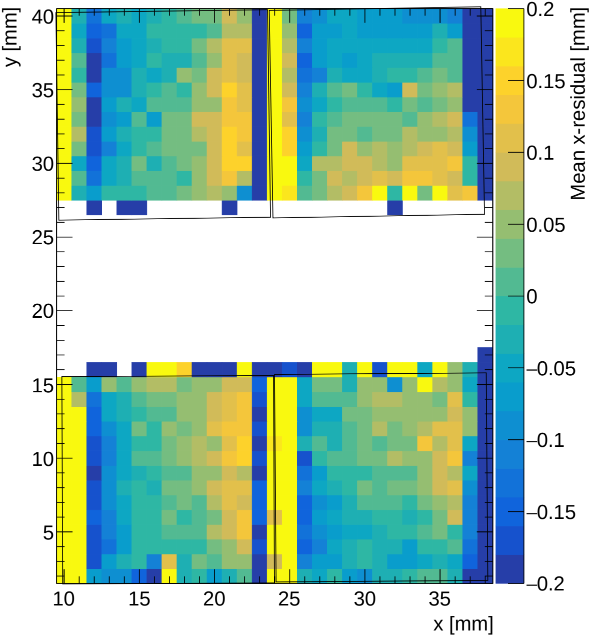


x-deformations

Cage guard voltage -0 V

Central Guard +10 V

$V_{\text{central guard}}$	$-345\,\text{V}$
$V_{\text{guard cage}}$	$-335\,\text{V}$

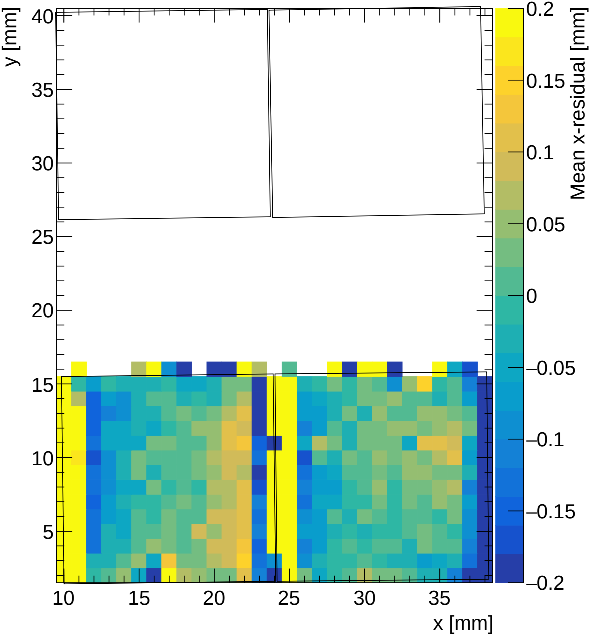


x-deformations

Cage guard voltage -5 V

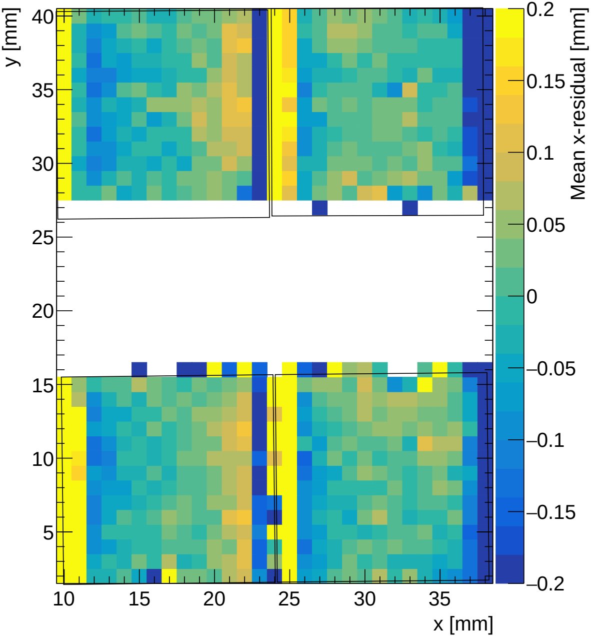
Central Guard +10 V

$V_{\text{central guard}}$	$-350\,\text{V}$
$V_{\text{guard cage}}$	$-340\,\text{V}$



y-deformations

Cage guard voltage -10 V



Central Guard +10 V

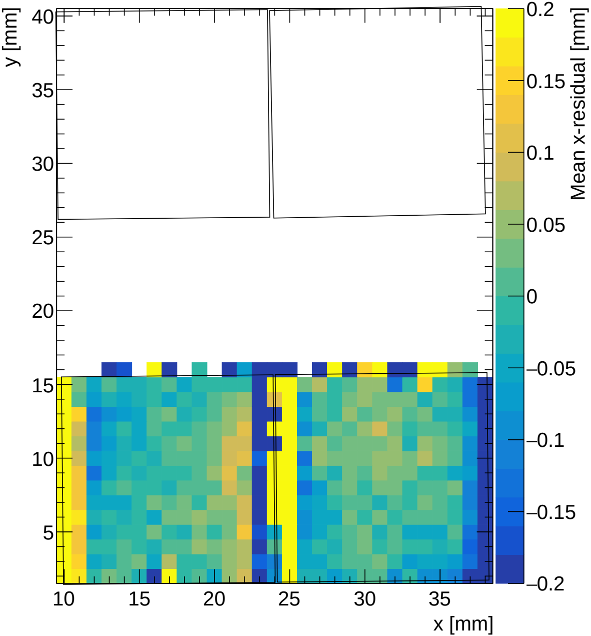
$V_{\text{central guard}}$	$-350\,\text{V}$
$V_{\text{guard cage}}$	$-345\,\text{V}$

x-deformations

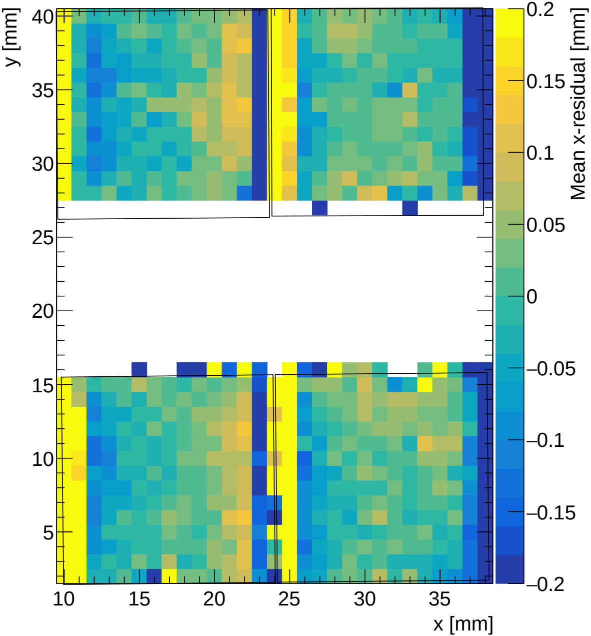
Cage guard voltage -15 V

Central Guard +10 V

$V_{\text{central guard}}$	$-350\,\text{V}$
$V_{\text{guard cage}}$	$-350\,\text{V}$



x-deformations



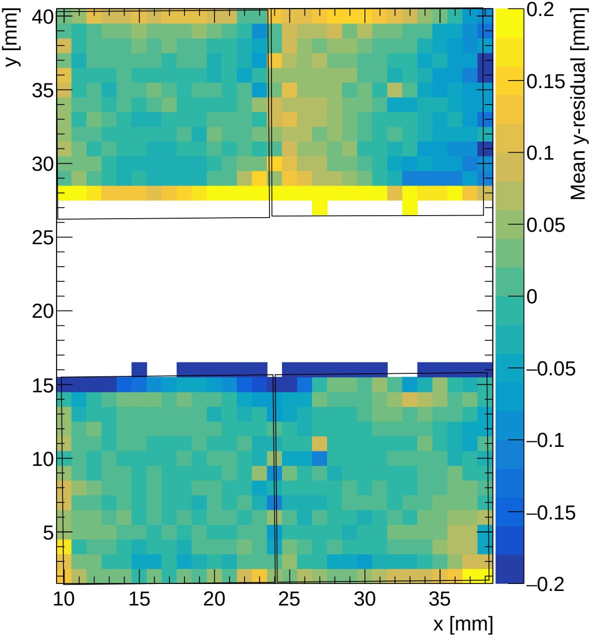
Central Guard +10 V
Cage guard -10 V

$V_{\text{central guard}}$	$-350\,\text{V}$
$V_{\text{guard cage}}$	$-345\,\text{V}$

y-deformations

Central Guard +10 V
Cage guard -10 V

$V_{\text{central guard}}$	$-350\,\text{V}$
$V_{\text{guard cage}}$	$-345\,\text{V}$

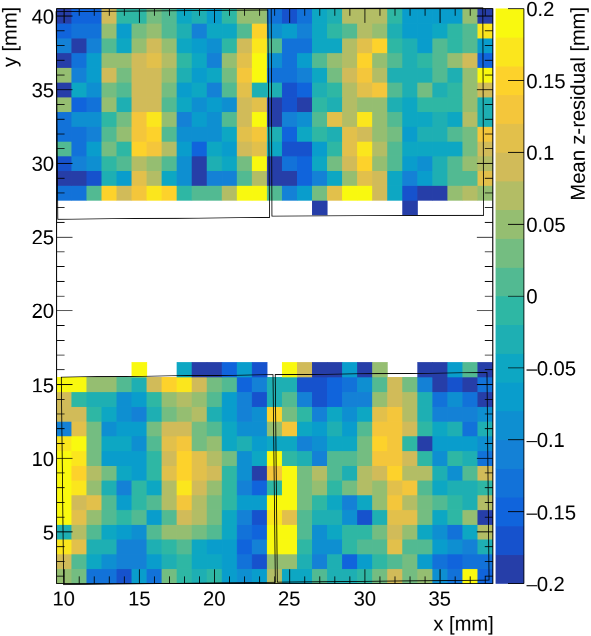


z-deformations

Central Guard +10 V

Cage guard -10 V

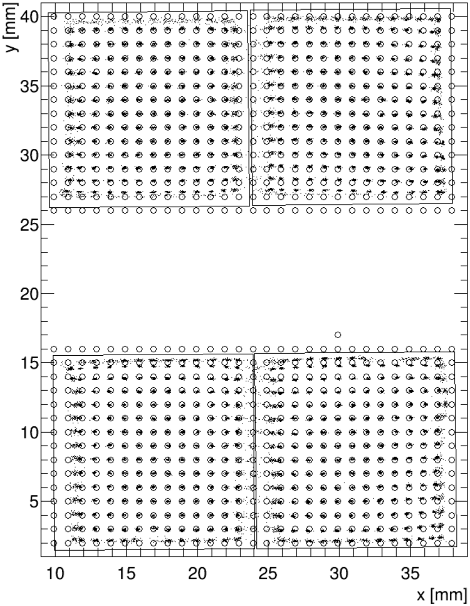
$V_{\text{central guard}}$	$-350\,\text{V}$
$V_{\text{guard cage}}$	$-345\,\text{V}$



Average hit position

Start values for guard voltages

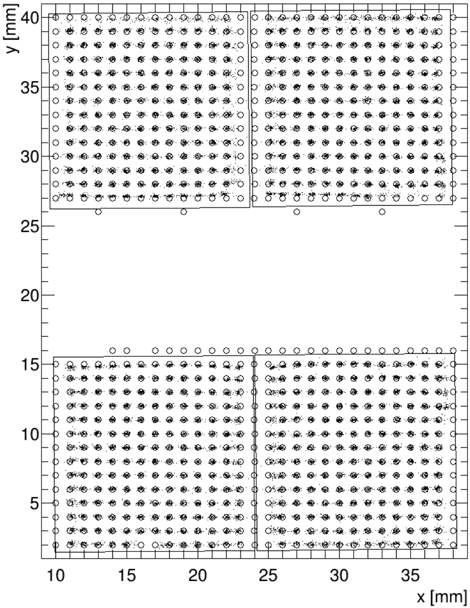
$V_{\text{central guard}}$	$-360\,\text{V}$
$V_{\text{guard cage}}$	$-335\,\text{V}$



Average hit position

At calibrated voltages

$V_{\text{central guard}}$	$-340\,\text{V}$
$V_{\text{guard cage}}$	$-345\,\text{V}$



Hit Resolution

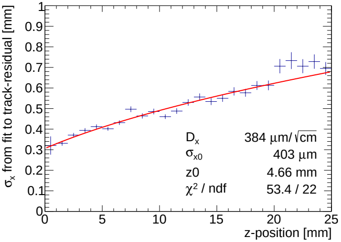
Use standard hit resolution equation for $i = \{x, y, z\}$

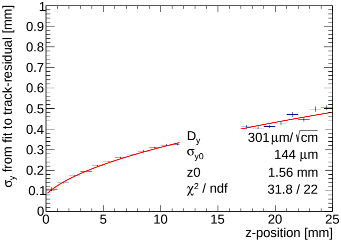
$$\sigma_i^2 = \sigma_{i0}^2 + D_i^2(z - z_0) \tag{2}$$

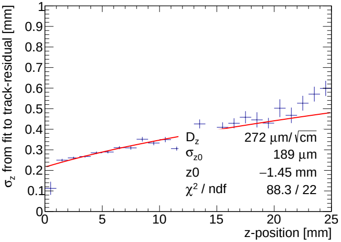
σ_{i0} also contains a contribution from the laser focus size, and therefore it is not known in advance. Because both σ_{i0} and $z0$ are free parameters and correlated, fitting is more difficult

Hit resolution of hits on a single chip

For chip 4 with D_i, σ_{i0} and $z0$ as free parameters



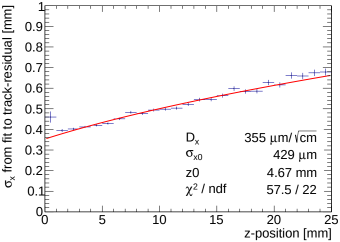


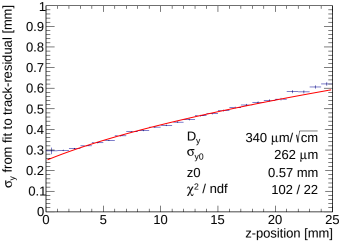


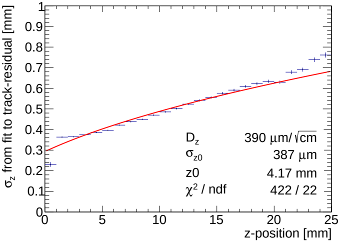
Note the different values for $z0$

Hit resolution of all chips summed

For all chips summed, with D_i, σ_{i0} and $z0$ as free parameters



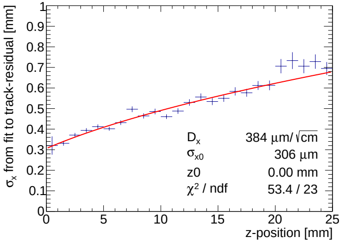


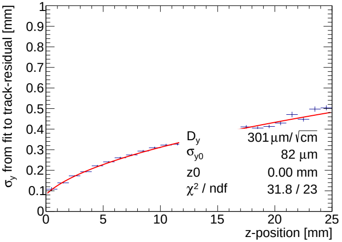


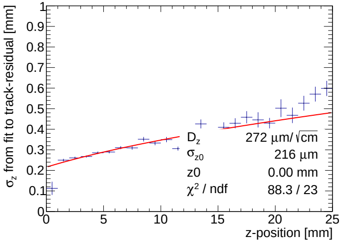
In the combination σ_{i0} is larger

Hit resolution of hits on chip 4

For chip 4, with $z_0 = 0$ and D_i, σ_{i0} as free parameters



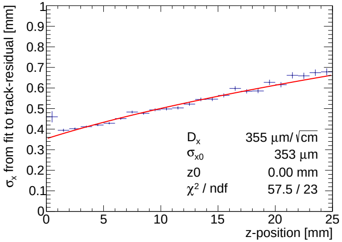


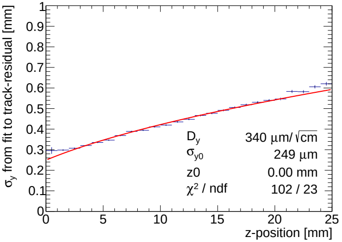


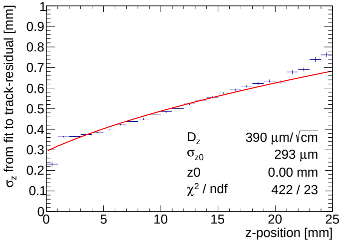
z_0 is fixed to the approximately correct value of 0
(this is the limit of the laser stage).

Hit resolution of all chips summed

For all chips summed, with $z_0 = 0$ and D_i, σ_{i0} as free parameters







z_0 is fixed to the value of 0.
In the combination σ_{i0} is larger