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ATLAS Pixel collaboration

# Test beam results on ATLAS Pixel sensors

Pixel2002

Carmel, 10/09/2002

# Overview

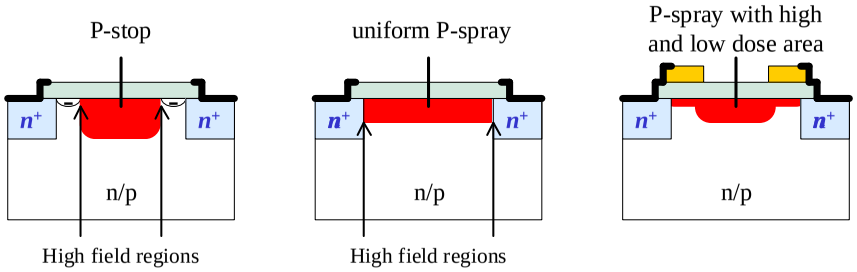
Pixel detectors with the ATLAS production design (oxygenated silicon sensors + DSM rad-hard electronics) have been irradiated to $1.1 \times 10^{15}$ $n_{eq}$ $cm^{-2}$and 600 kGray.

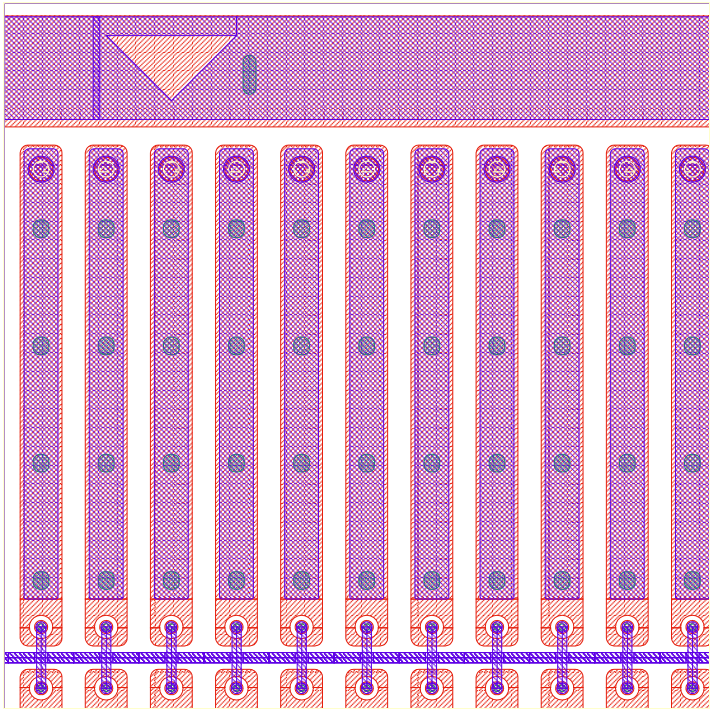
They have been tested at CERN with a 180 GeV pion beam.

The following measurements have been performed:

- Depletion depth
- Charge collection
- Detection efficiency
- Spatial resolution

# ATLAS Pixel sensors



Oxygenated silicon

$50 \times 400$ $\mu$m$^2$ pixels

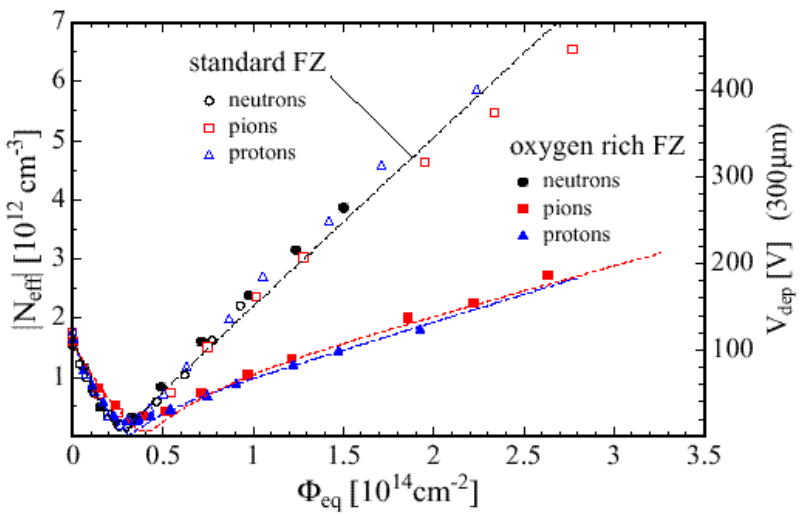
250 $\mu$m thickness

$8 \times 8$ mm$^2$ (single chip) or

$16 \times 64$ mm$^2$ (module) size

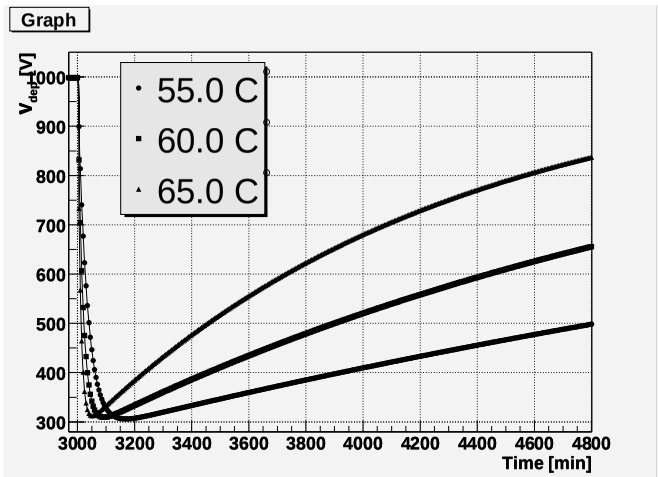
# Irradiation

Several single chip assemblies with oxygenated silicon have been irradiated to $1.1 \times 10^{15}$ $n_{eq}$ $cm^{-2}$and 600 kGray.




ROSE collaboration

NIM A466, 308

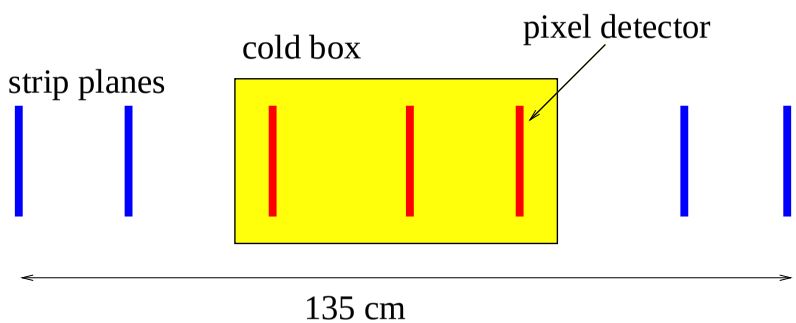



O. Krasel

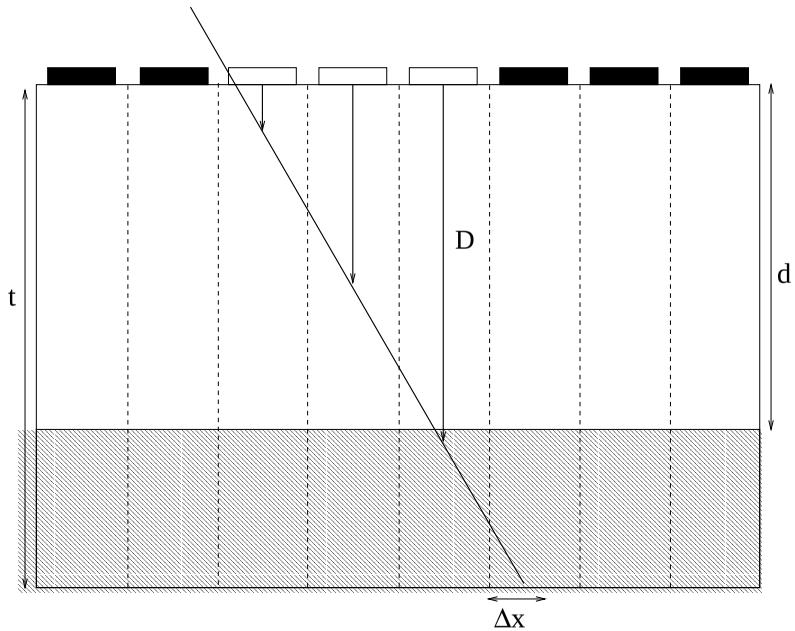
# Testbeam setup

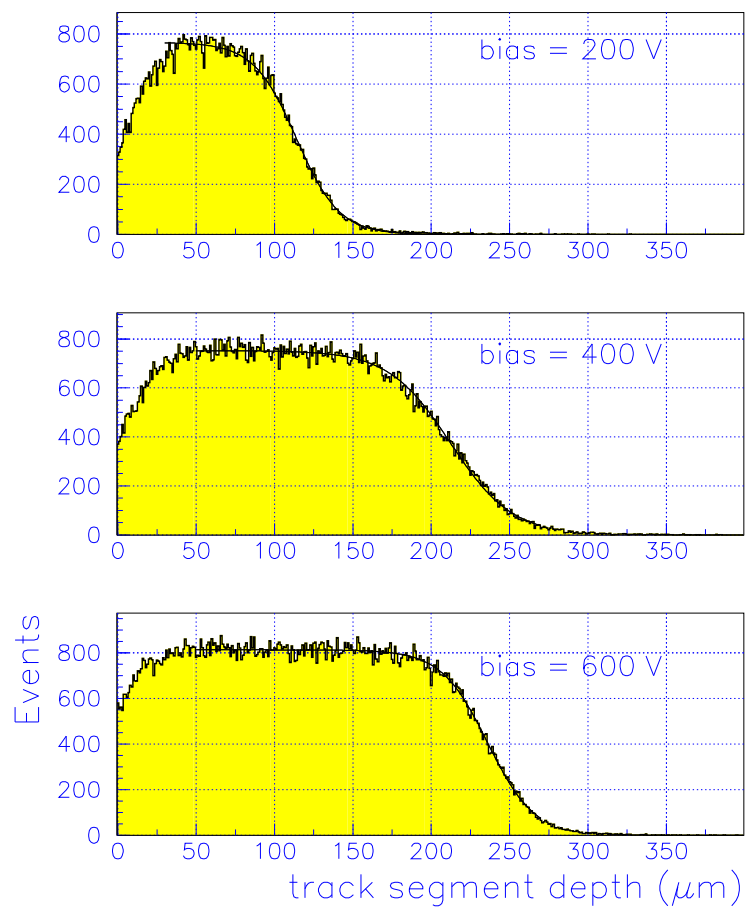
4 planes of double-sided microstrip planes track the particles with a resolution of $\sim 6\ \mu$m at the pixel detector planes.

Pixel detectors are inside a cold box.



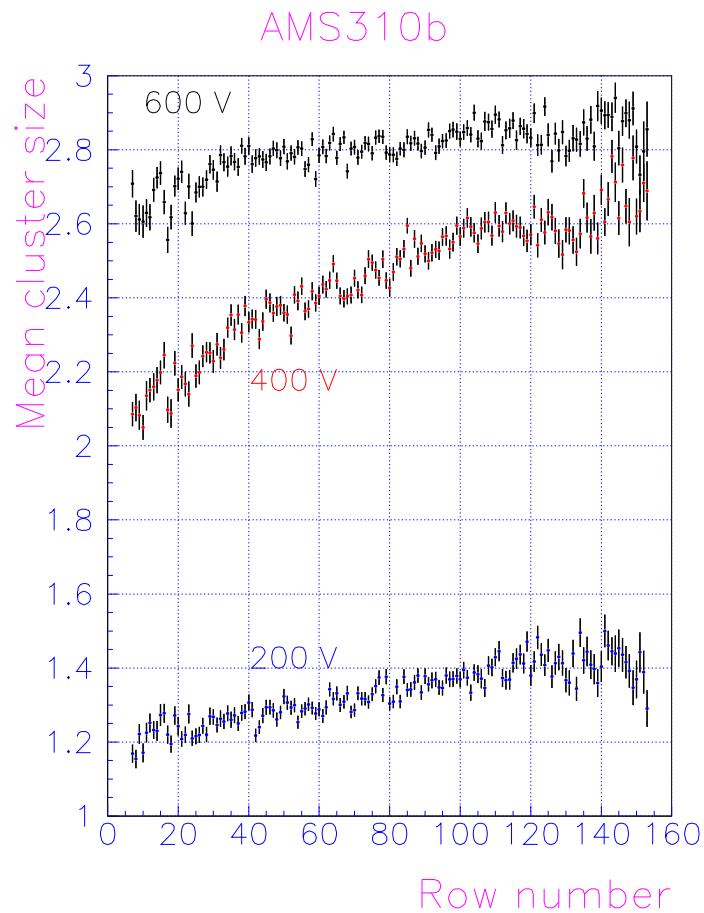
# Measurement of depletion depth



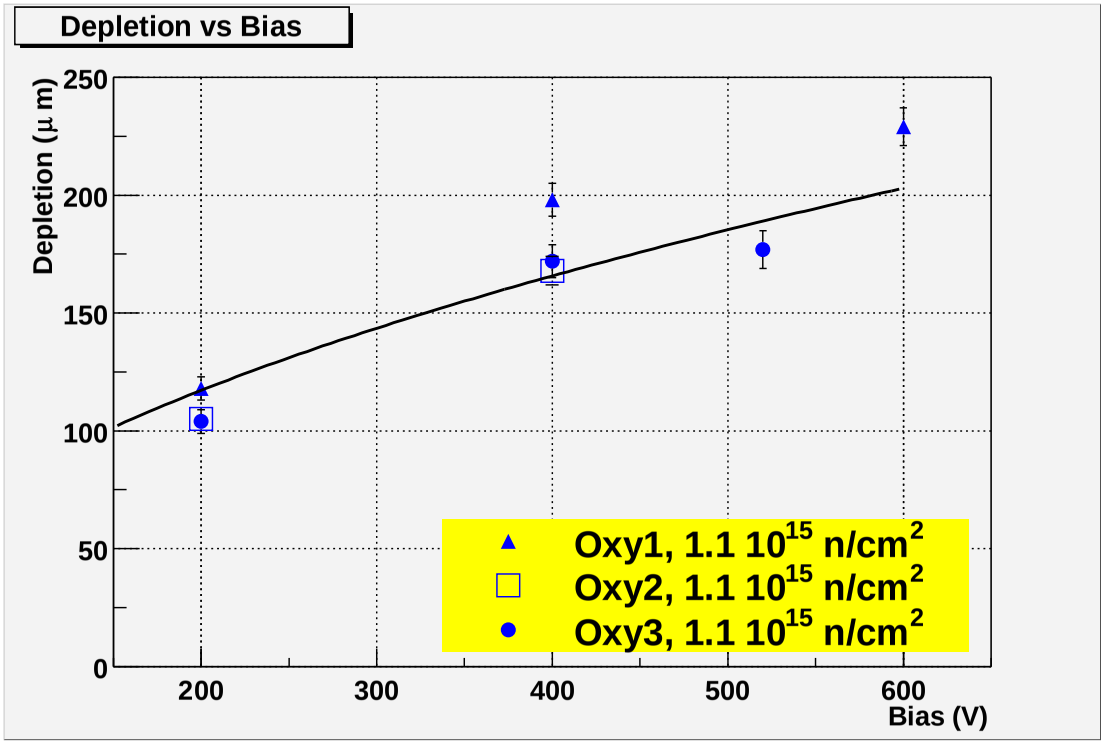
# Not uniform irradiation

| rows | depletion |
|---|---|
| 7-49 | $175 \pm 4 \pm 6$ |
| 50-79 | $189 \pm 4 \pm 6$ |
| 80-109 | $206 \pm 3 \pm 7$ |
| 110-151 | $220 \pm 6 \pm 7$ |




Leakage current decreases with row number. The same behaviour is observed for all the irradiated detectors.

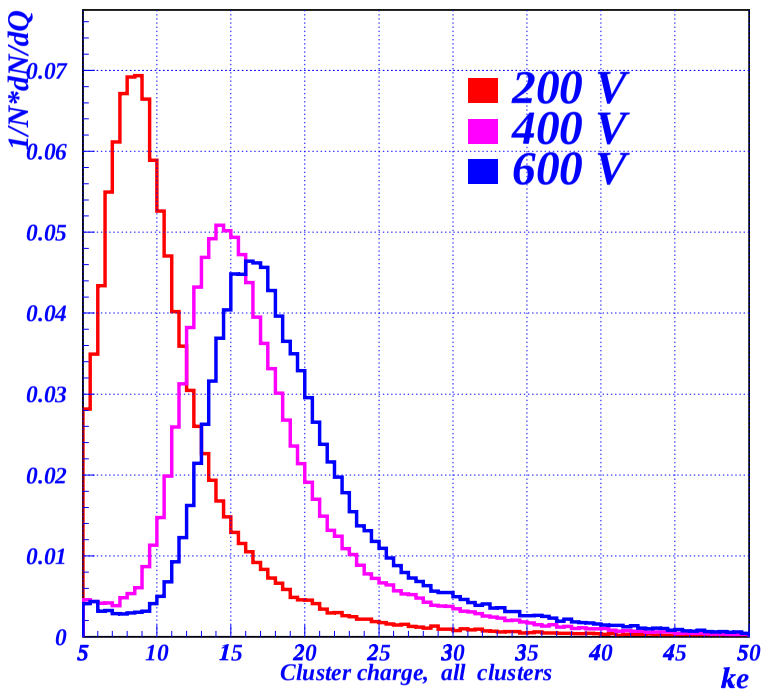
# Summary of depletion measurements



# Pulse height

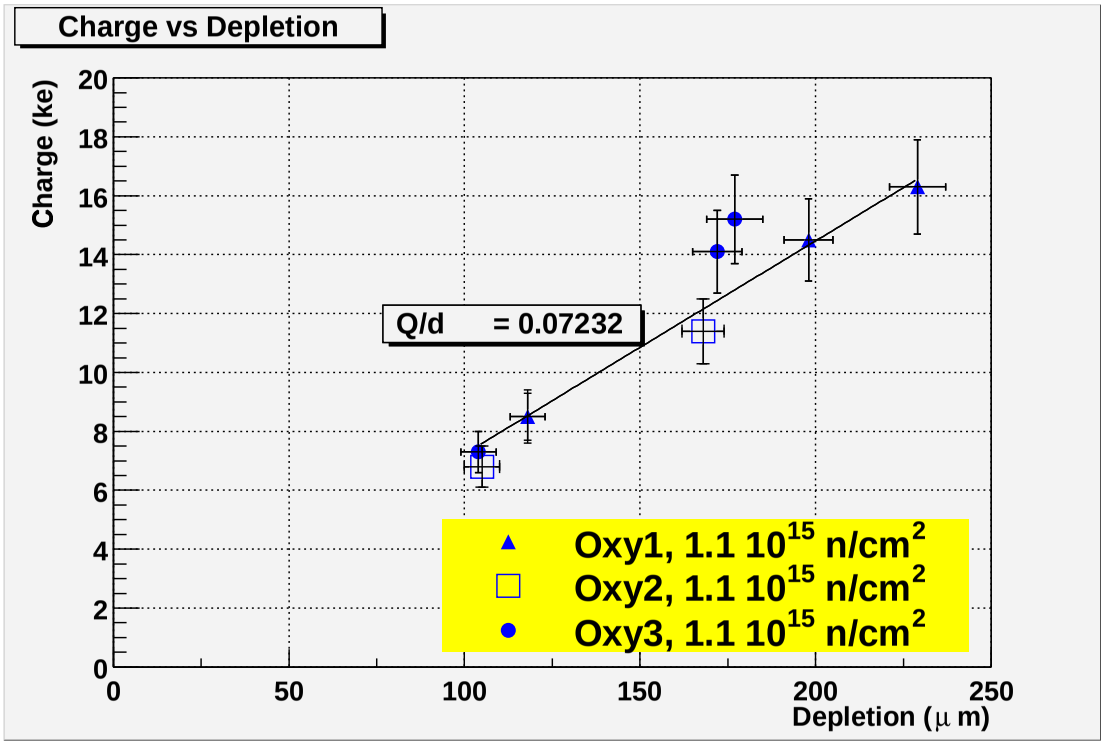
The charge is measured using the time over threshold of the signal.

The accuracy of the calibrations is about 10%

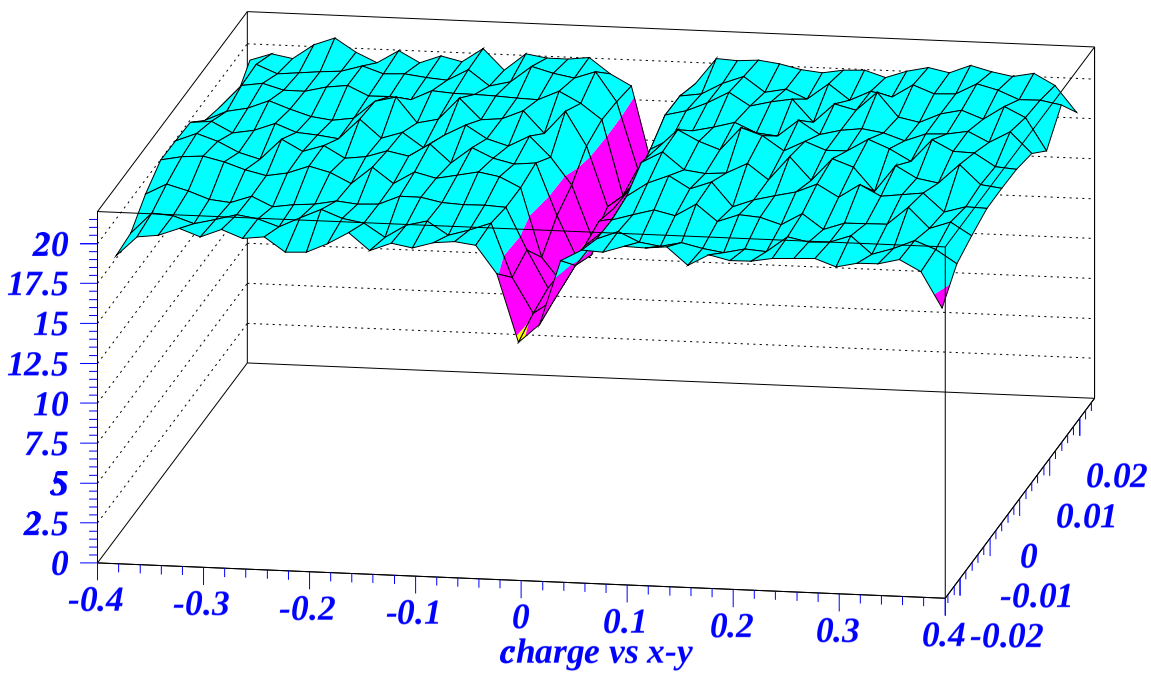


# Pulse height vs depletion

The most probable pulse height measured at 0 degree incidence angle scales as the depletion



# Charge collection uniformity




Charge collection as a function of track position inside a pair of pixel cells

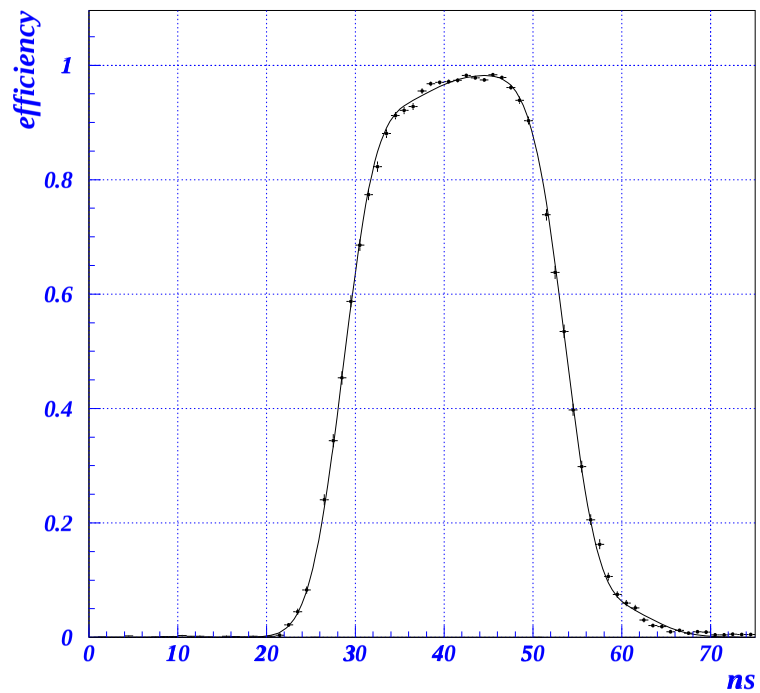
# Efficiency

Efficiency as a function of the difference between the arrival time of the particle (from a scintillator) and the clock edge

$\epsilon = 98.2\ \%$

$\tau = 1.75$ ns

$\sigma = 4.34$ ns




Fitting function:

$0 \qquad [0, t_0]$

$\epsilon - e^{-(t-t_0)/\tau} \qquad [t_0, t_0 + 25]$

$e^{-(t-t_0-25)/\tau} - e^{-(t-t_0)/\tau} [t_0 + 25, 75]$

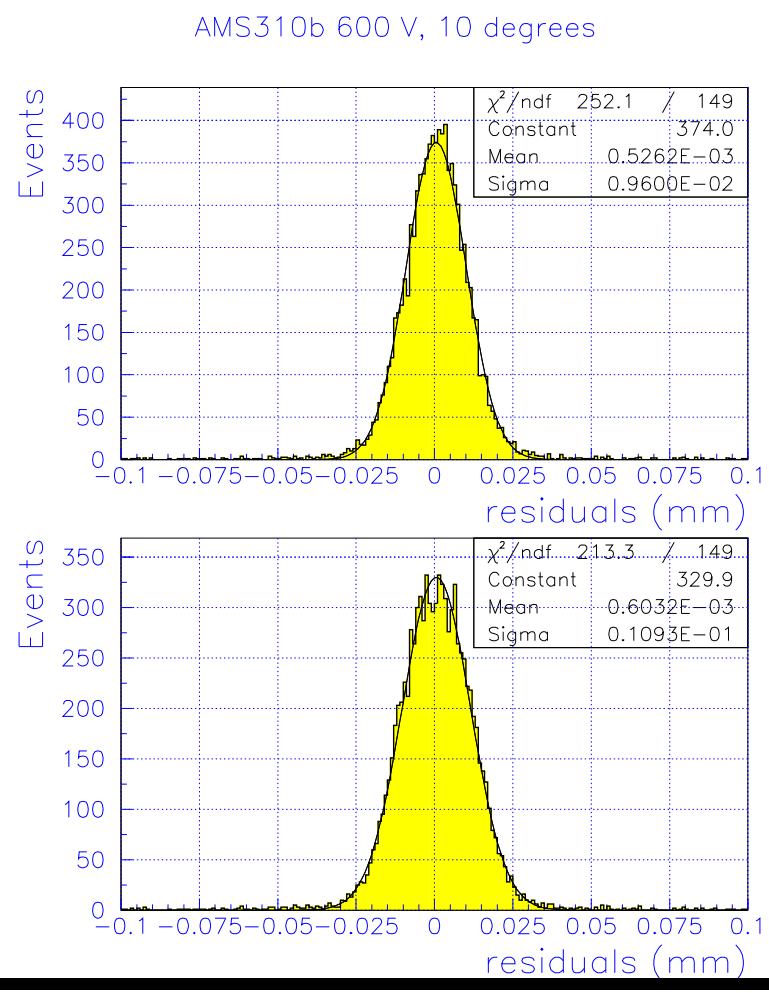
$+$ gaussian smearing

# Spatial residuals

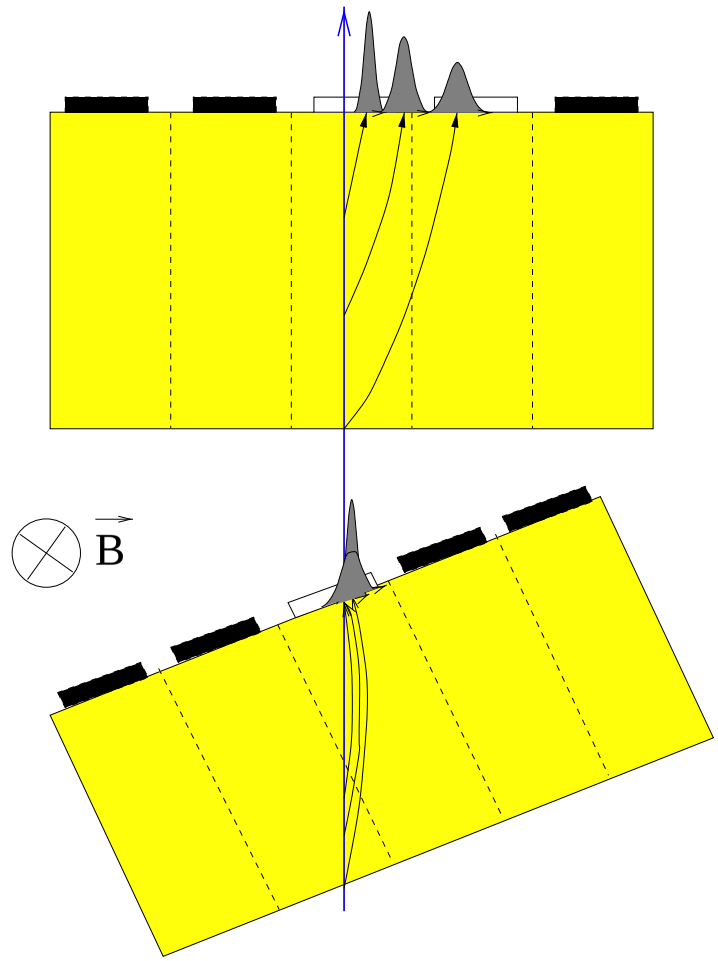
Irradiated detector at 10 degrees incidence angle

Residuals with charge interpolation for clusters with more than one pixel
$\sigma = 9.6 \ \mu\mathrm{m}$

Digital residuals
$\sigma = 10.9 \ \mu\mathrm{m}$



# Effective incidence angle in ATLAS




tilt angle = 20 degrees

Lorentz angle = 5 degrees
at 600 V, full depletion

# Conclusions

ATLAS Pixel detectors with oxygenated silicon sensors have been irradiated to the design fluence and operated at the test beam.

The depletion depth and charge collected were consistent with expectations and allowed to obtain the efficiency and spatial resolution required in ATLAS.

The depletion depth at 600 V is $229 \pm 8$ $\mu$m

The detection efficiency is 98.2 %

The spatial resolution at 10 degrees is 9.6 $\mu$m