Measurements of position resolution of ATLAS Pixel Sensors

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Spatial resolution as a function of incident particle angle has been measured for

- nonirradiated and irradiated sensors
- different sensor designs
- analog and digital readout

The ATLAS Pixel Collaboration

- **Canada**

  University of Toronto

- **Czech Republic**

  Academy of Science - Institute of Physics, Charles University and Czech Technical University, Prague

- **France**

  CPPM, Marseille

- **Germany**

  University of Bonn

  University of Dortmund

  University of Siegen

  Bergische University, Wuppertal

- **Italy**

  INFN and University of Genova

  INFN and University of Milano

  INFN and University of Udine

- **Neatherlands**

  NIKHEF, Amsterdam

- **USA**

  University of New York, Albany

  University of New Mexico, Albuquerque

  LBL and University of California, Berkeley

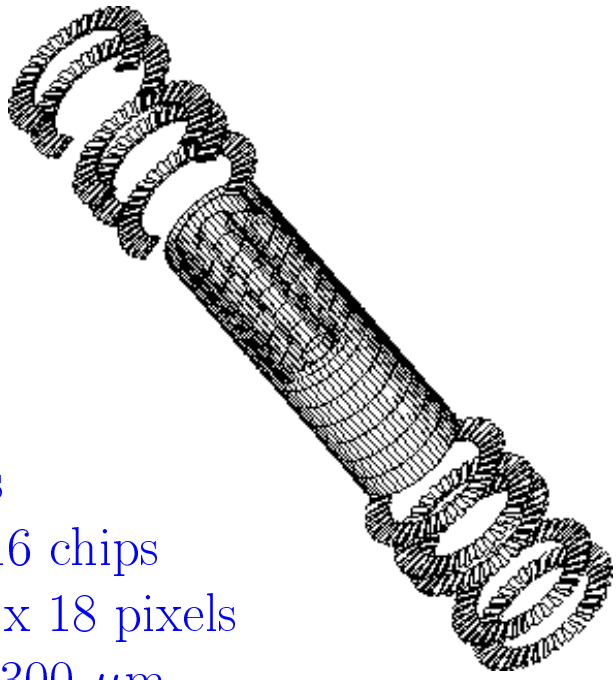
  Ohio State University, Columbus

  University of Wisconsin, Madison

  University of Oklahoma, Norman

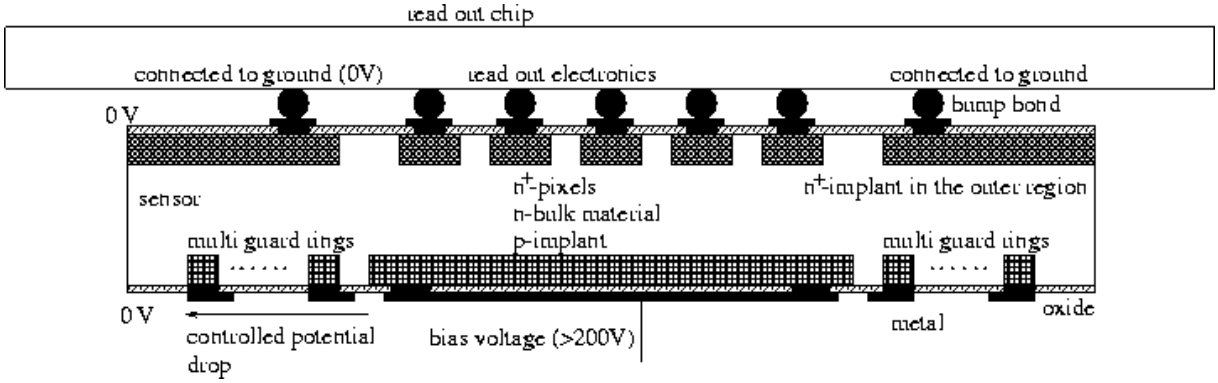
  University of California, Santa Cruz

The ATLAS Pixel Detector

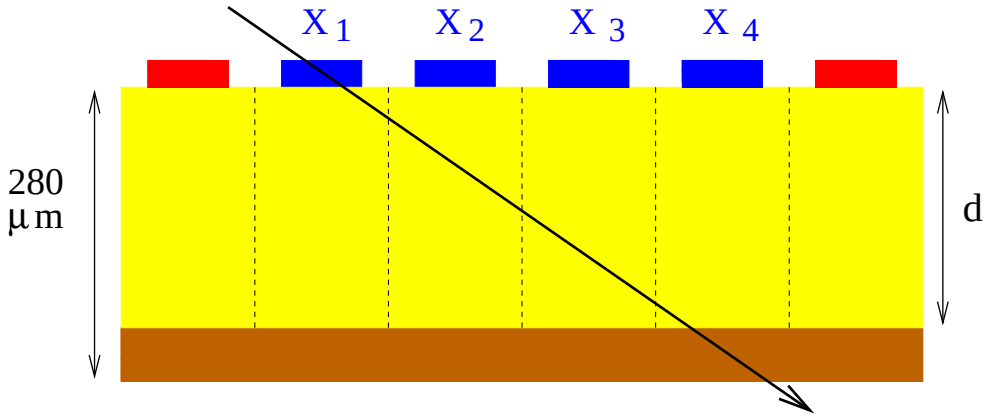


2228 modules
1 module = 16 chips
1 chip = 160 x 18 pixels
1 pixel: 50 x 300 μm

Fluence of $10^{15} n_{eq}/cm^2$ for the innermost layer after 5 years



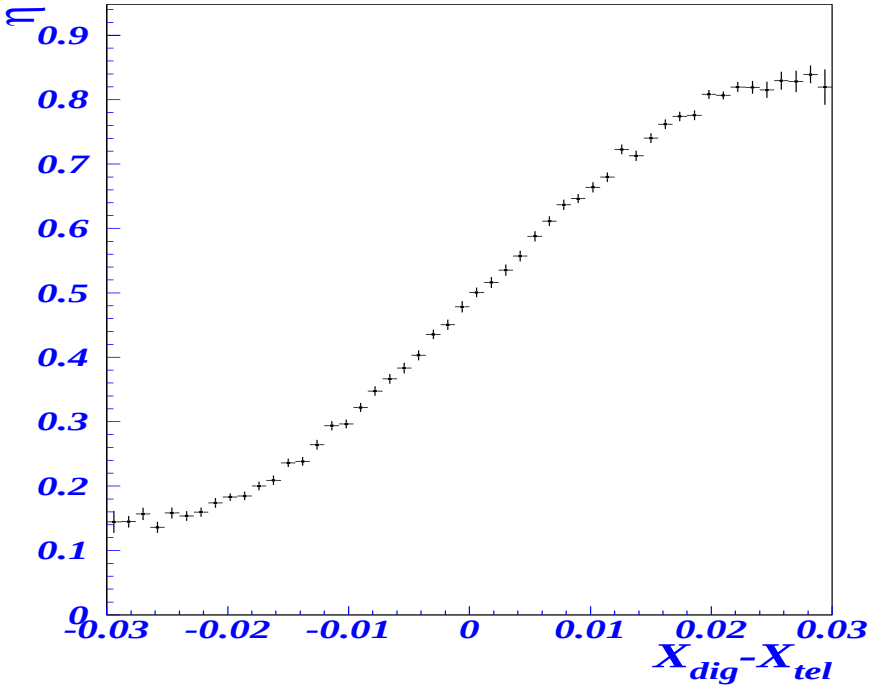
Analog and Digital resolution



Digital algorithm: $x = \Sigma x_i / N$

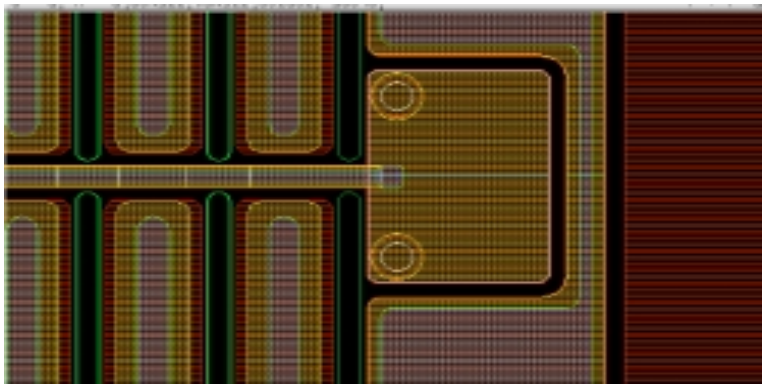
Analog algorithm: use of $\eta = Q_f/(Q_f + Q_l)$

(if $Q_i > Q_{\text{cut}}$ then $Q_i = Q_{\text{cut}}$)



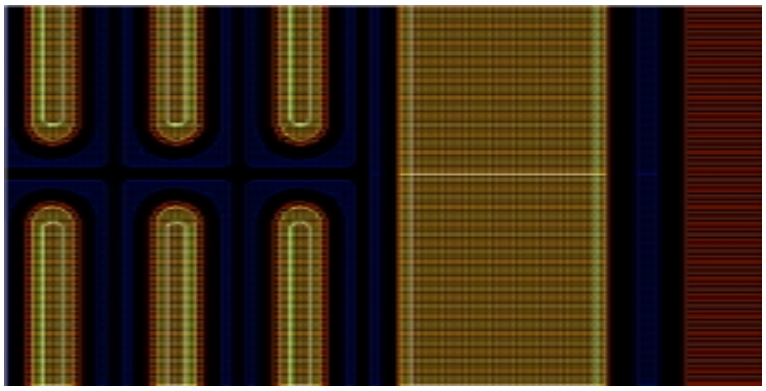
Designs of tested detectors

SSG



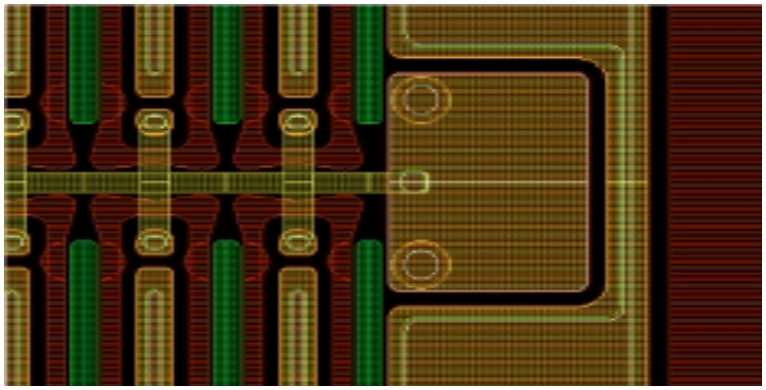
p-spray

ST1



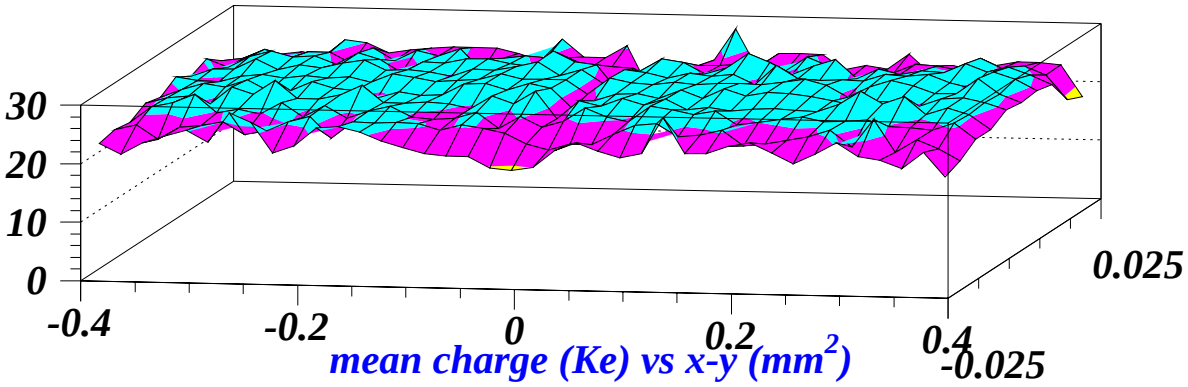
p-stop

ST2

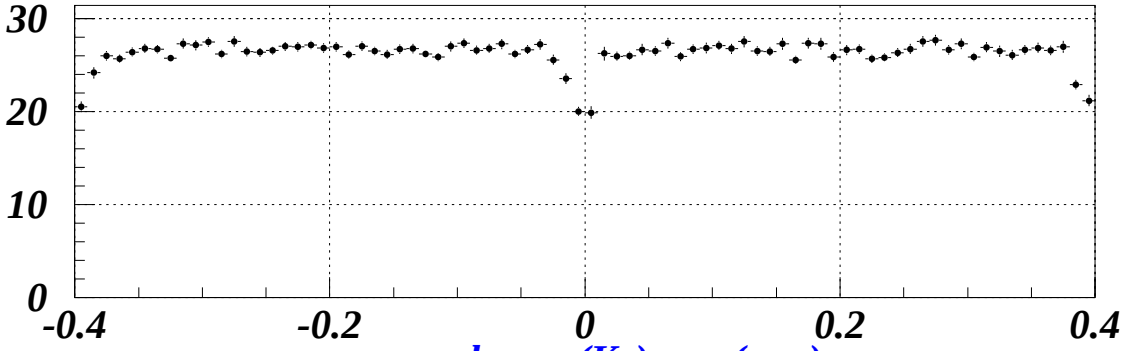


p-spray

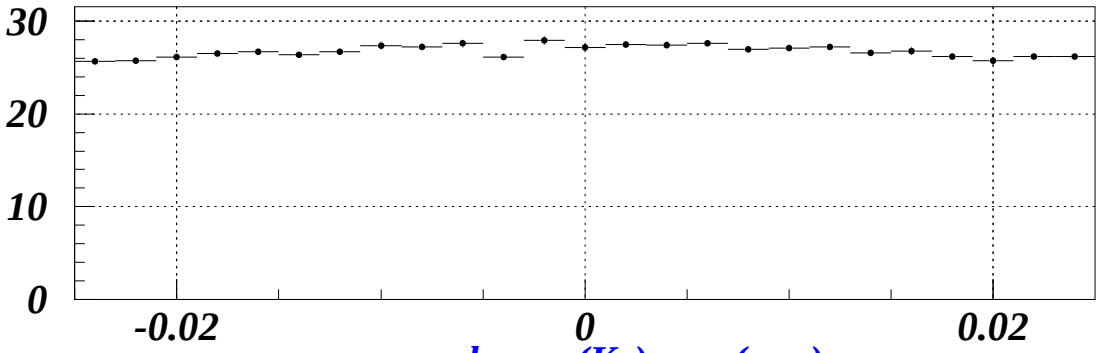
p-stop charge collection



mean charge (Ke) vs x-y (mm^2)

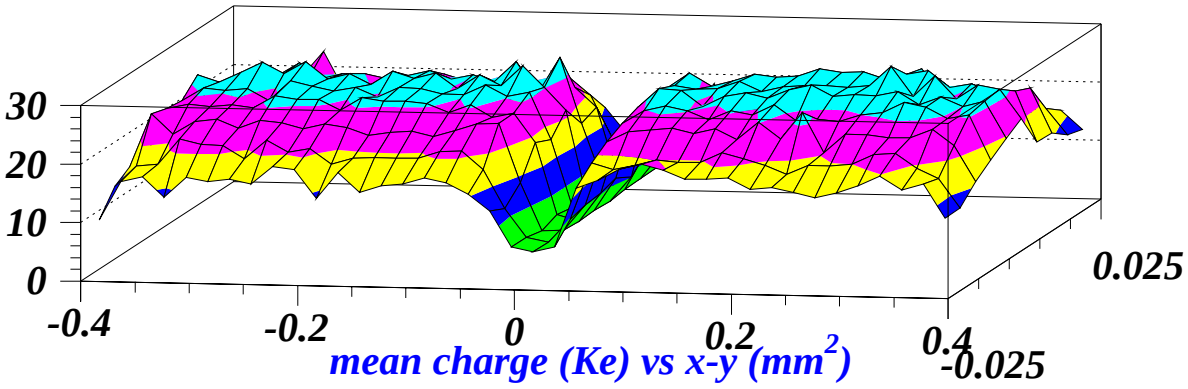


mean charge (Ke) vs y (mm)

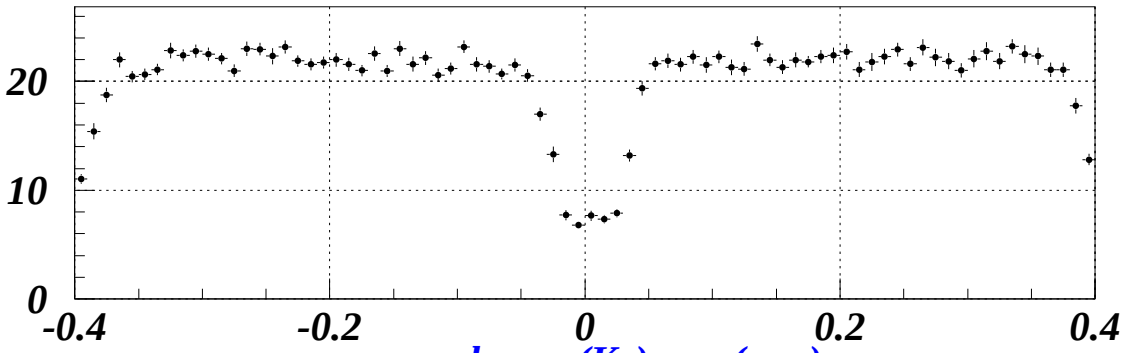


mean charge (Ke) vs x (mm)

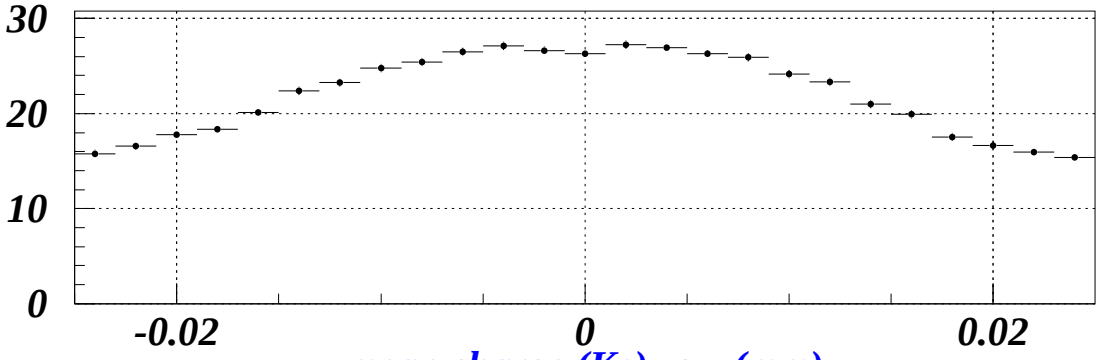
p-spray (ST2) charge collection



mean charge (Ke) vs x-y (mm^2)

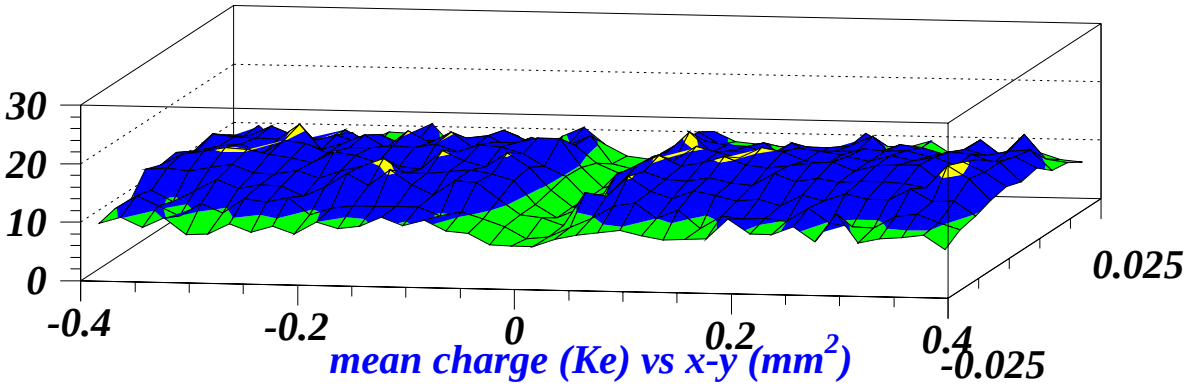


mean charge (Ke) vs y (mm)

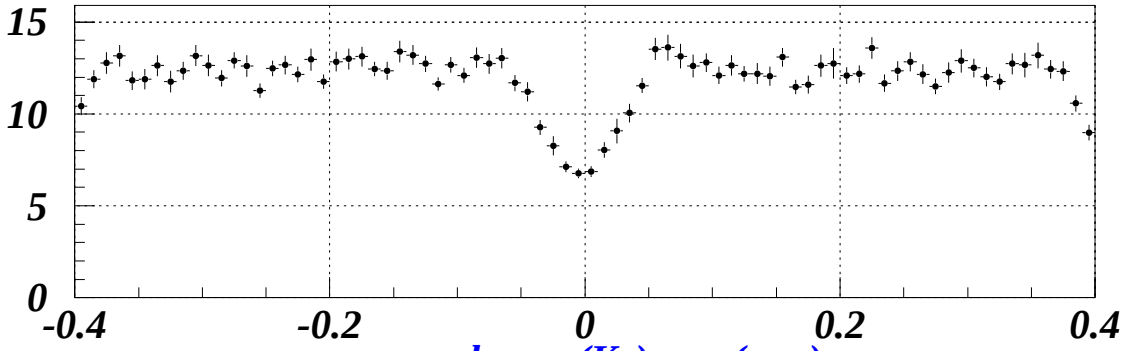


mean charge (Ke) vs x (mm)

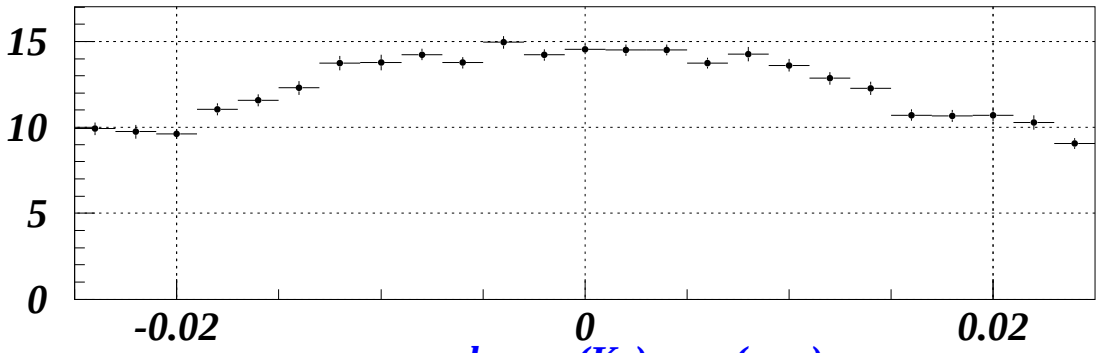
Irradiated p-spray charge collection



mean charge (Ke) vs x-y (mm^2)

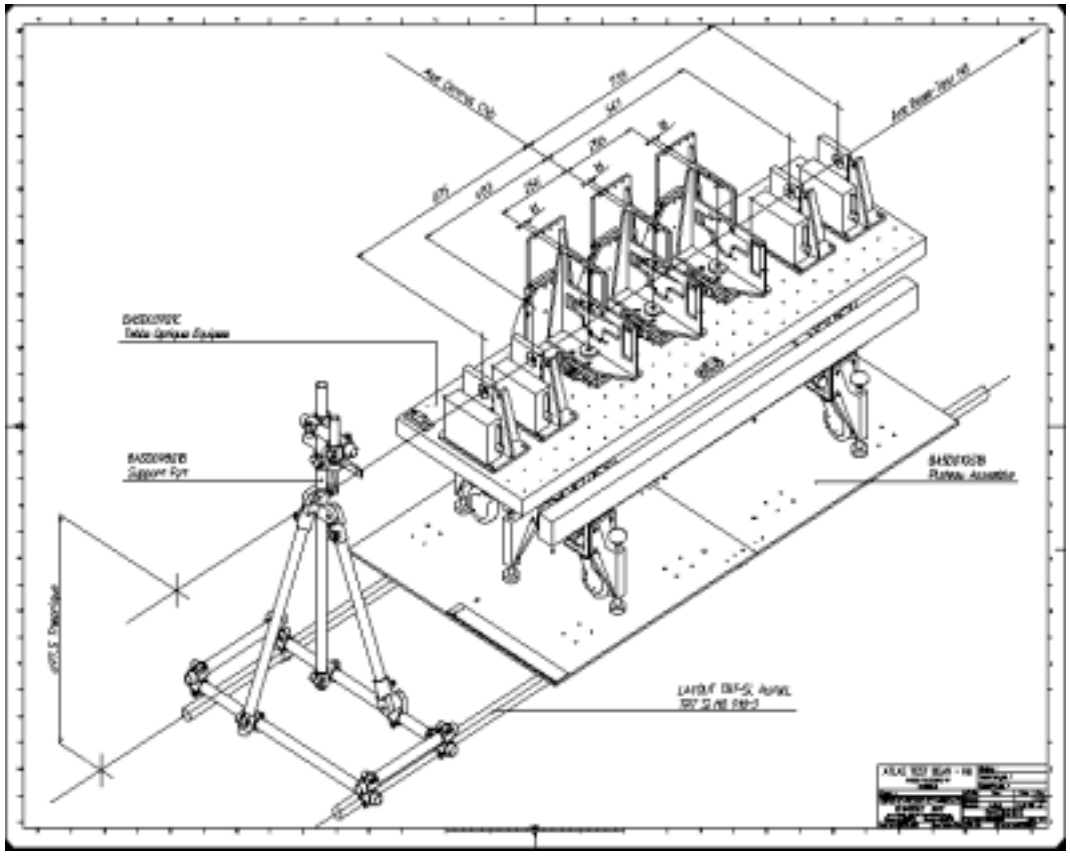


mean charge (Ke) vs y (mm)



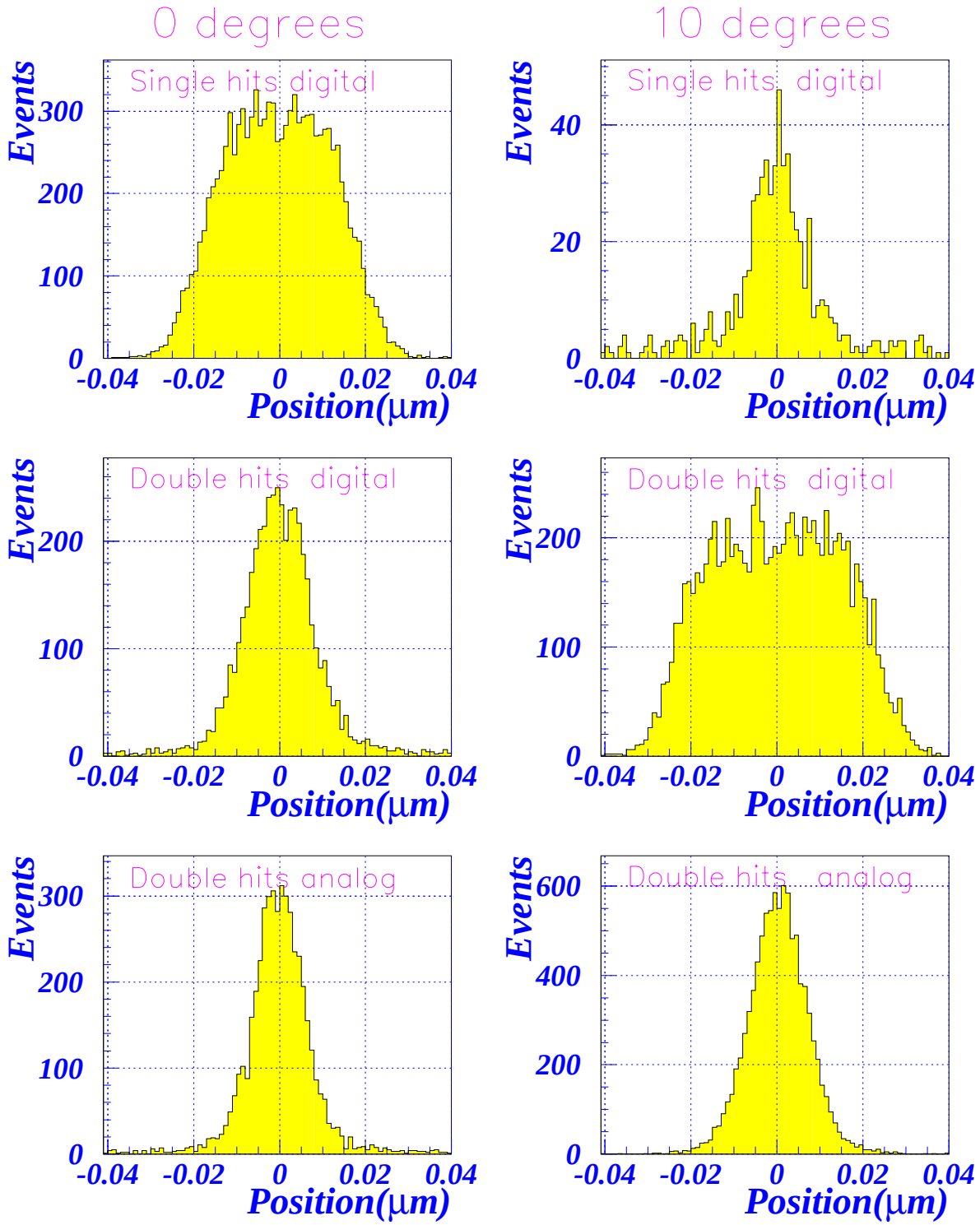
mean charge (Ke) vs x (mm)

Test beam setup

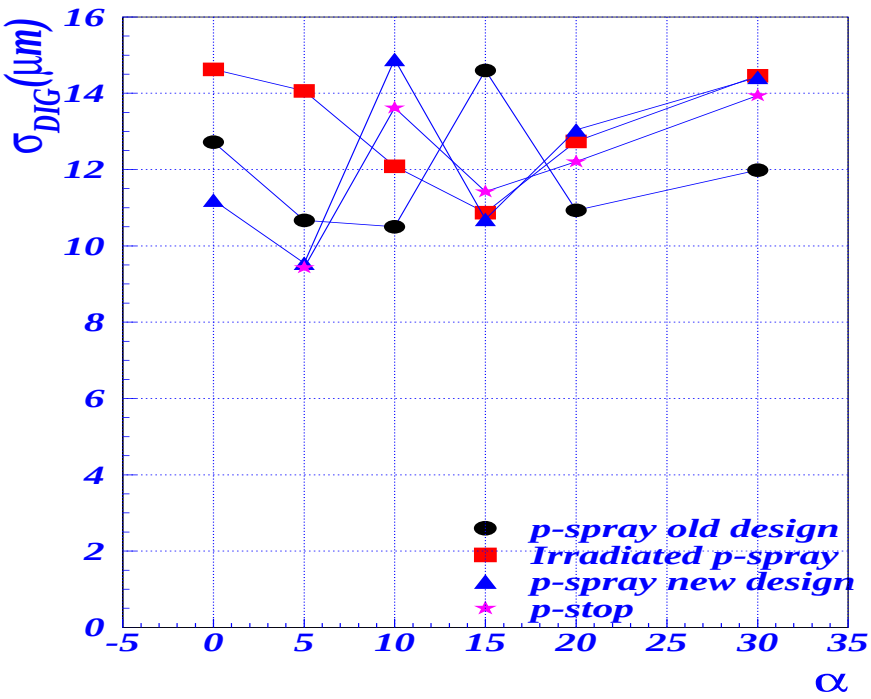


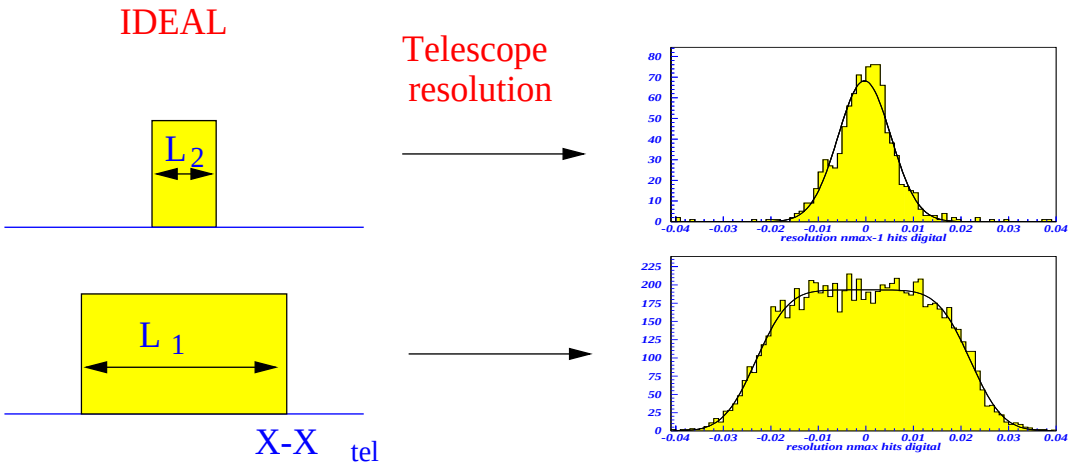
π beam of 180 GeV/c at CERN SPS
Material along the beam: $\sim$ 0.1 radiation lengths

Residuals distributions



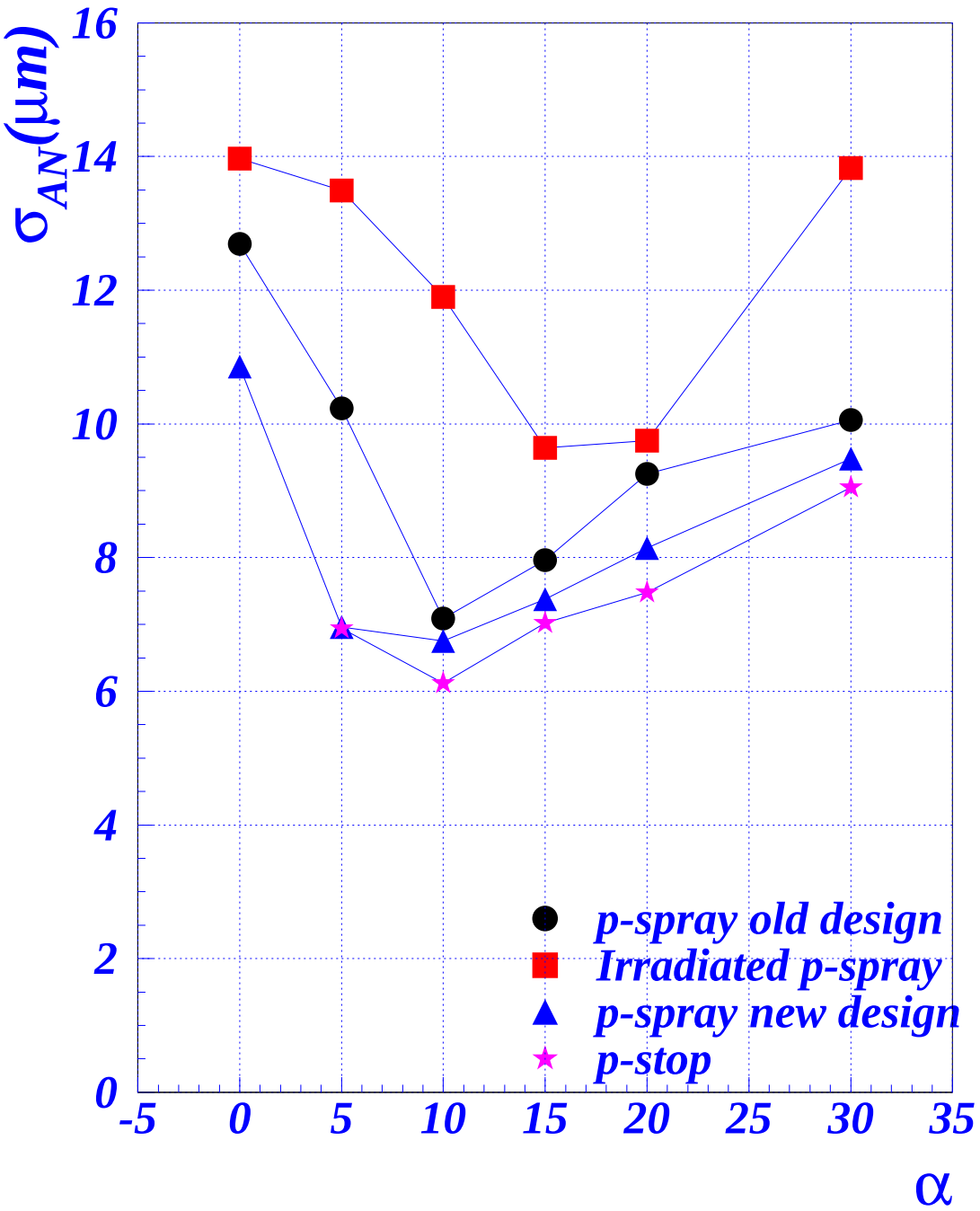
Digital resolution (detector+telescope)



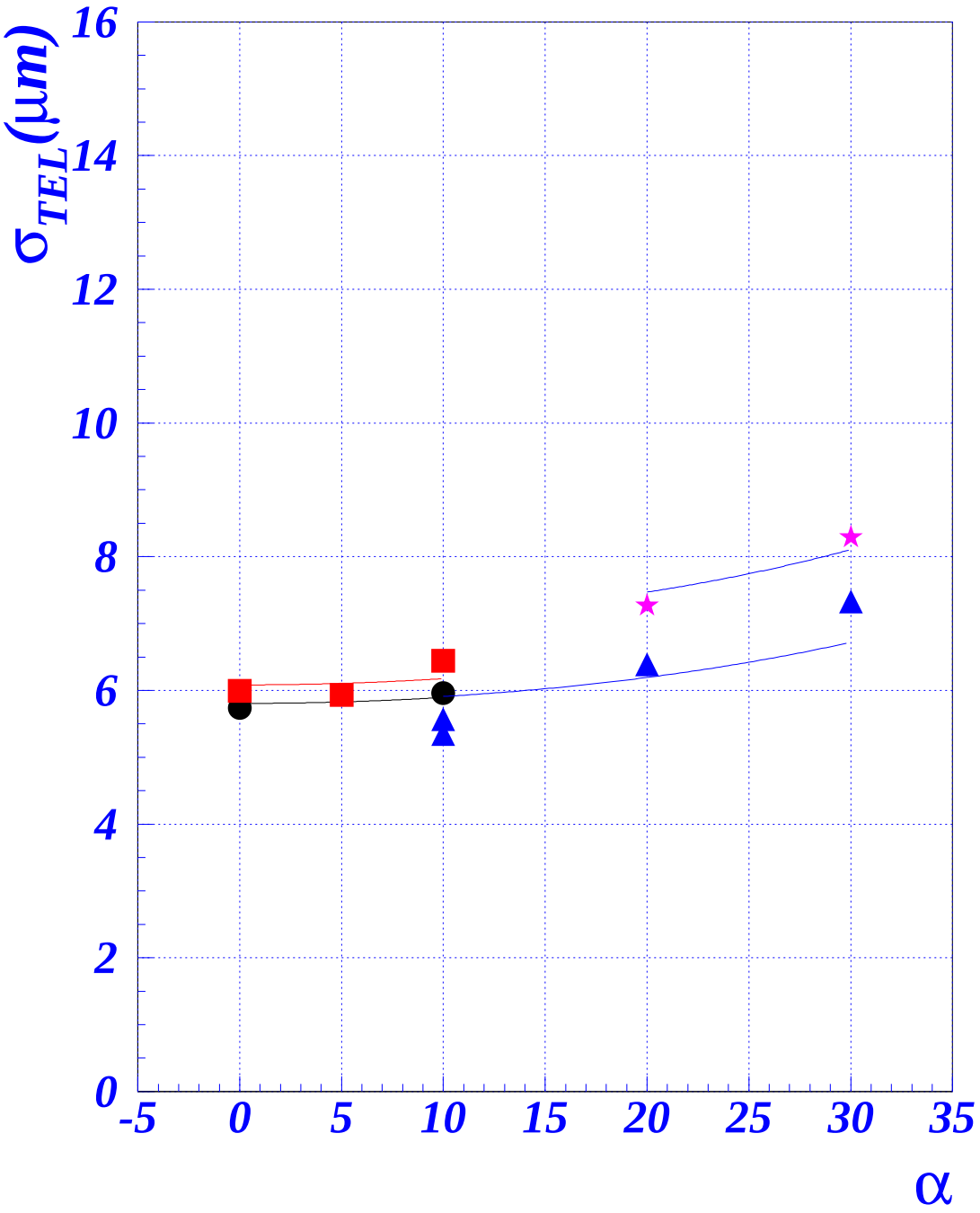


$$\sigma_{\mathrm{dig}} = \sqrt{\frac{L_1^2}{12} + \frac{L_2^2}{12} + \sigma_{\mathrm{tel}}^2}$$

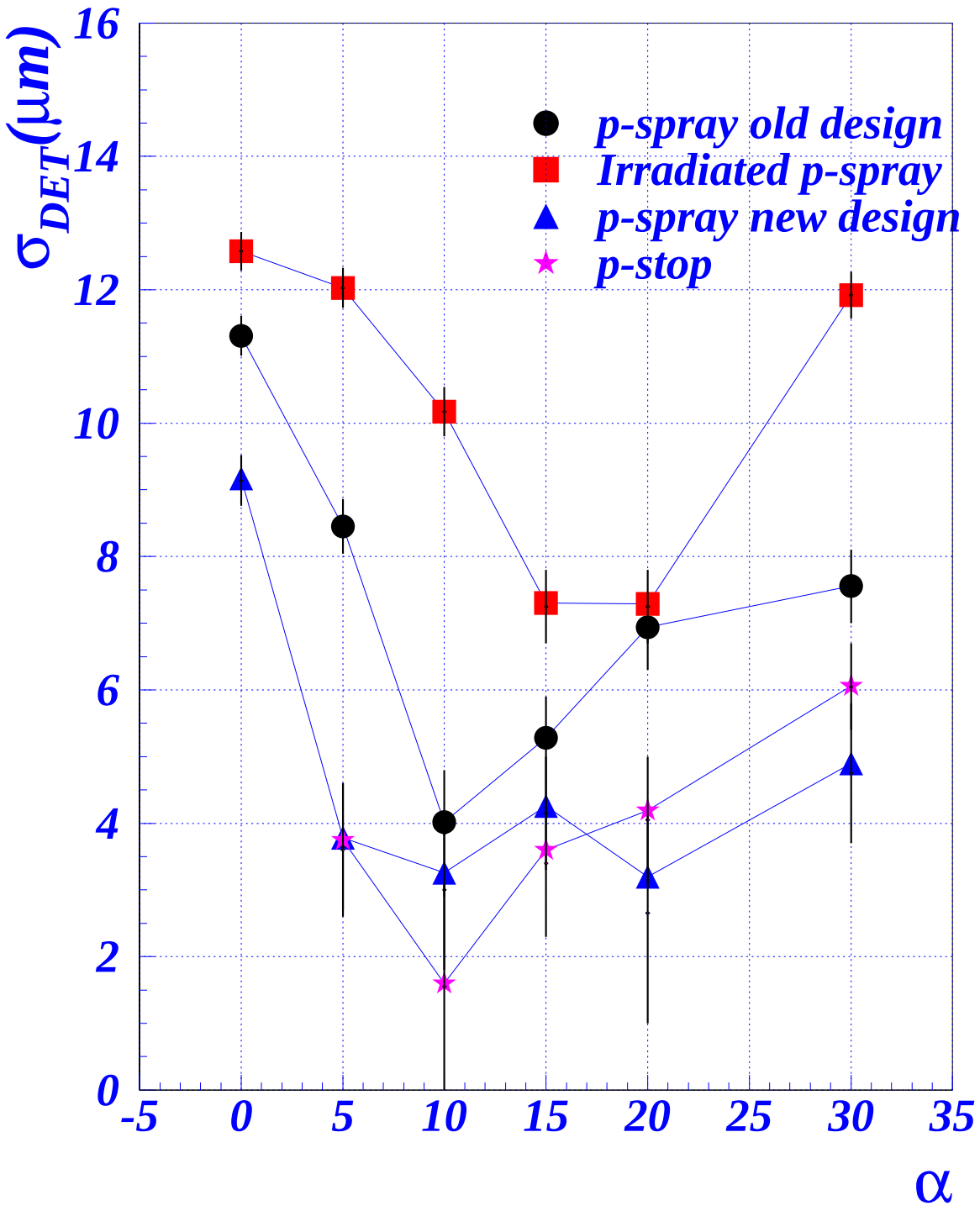
Analog resolution (detector+telescope)



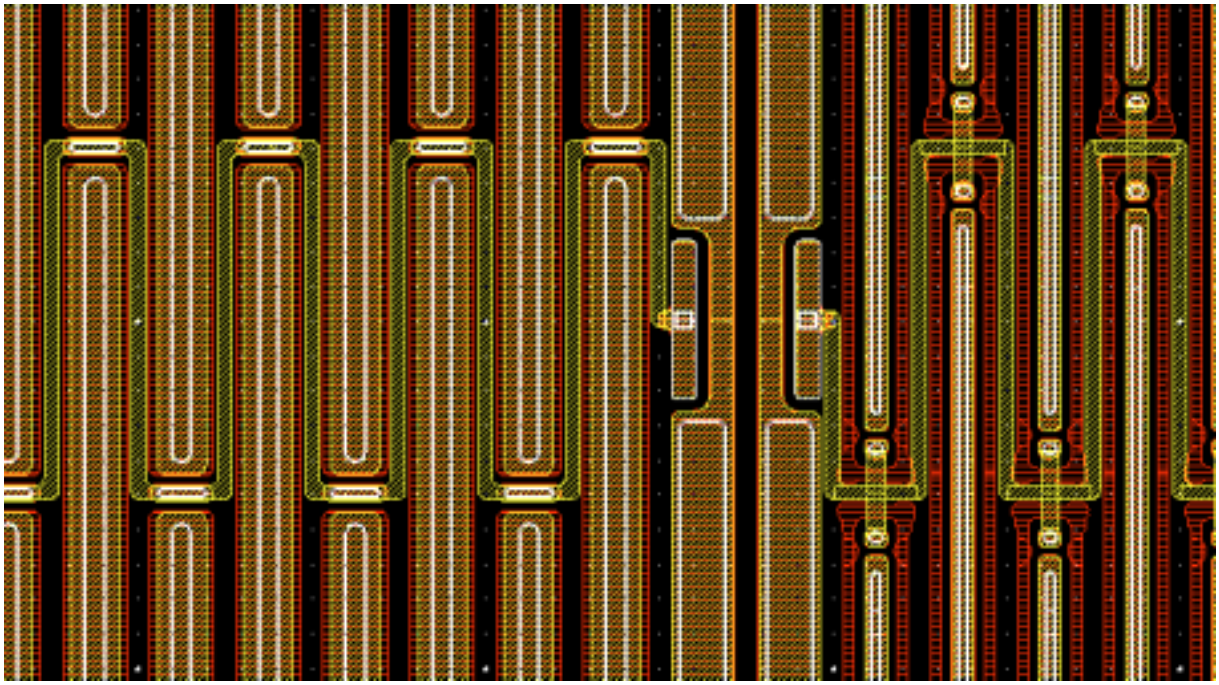
Telescope resolution



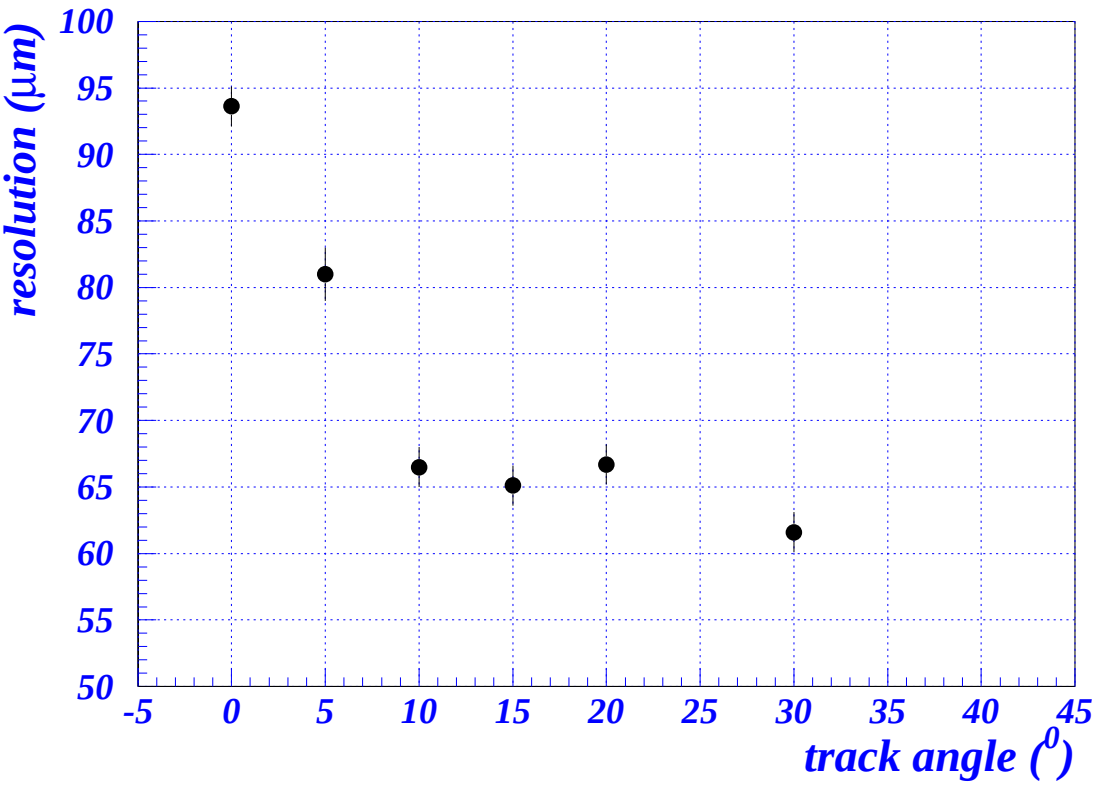
Analog resolution (detector only)



The bricked design



y-resolution of bricked design



Conclusions

Measurements of the resolution of ATLAS pixel detector prototypes with analog readout and no magnetic field has yielded:

det.	Φ(n/cm^2)	α_{best}	σ_{best} (μm)	$\overline{\sigma}$(μm)
p-spray (new)	0	10	6.8 (< 4)	8.3 (5)
p-stop	0	10	6.1 (< 4)	7.9 (5)
p-spray (old)	0	10	7.1 (~ 4)	9.6 (7.3)
irradiated	10^{15}	20	9.6 (7.2)	12.1 (10.2)

New data with better telescope resolution are being analysed.
Analysis of data with magnetic field will follow.