ARCADIA at Fermilab

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Contributors:

Davide Chiappara, Piero Giubilato, Caterina Pantouvakis, Michele Rignanese

Updates:

S-curves – Fe55 measurement

GRIT Padova

INFN
PADOVA
Istituto Nazionale di Fisica Nucleare
Sezione di Padova

Università
degli Studi
di Padova

Dipartimento
di Fisica
e Astronomia
Galileo Galilei

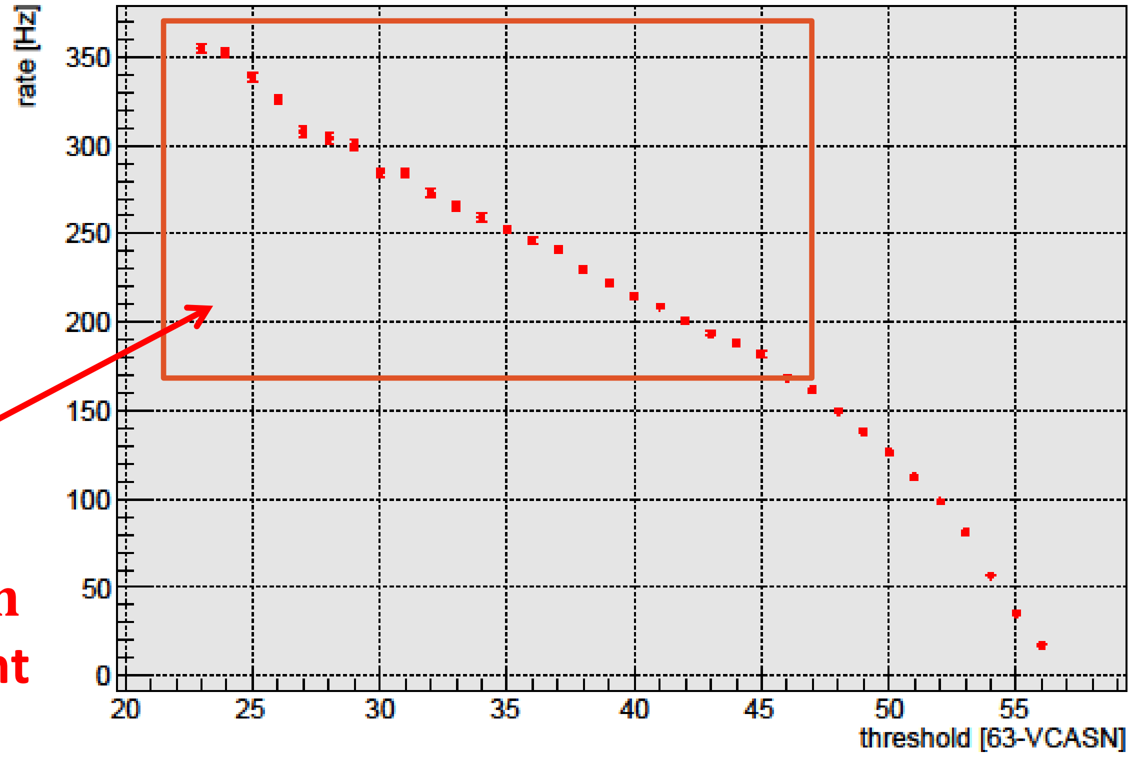
Fe55 measurement

Goal: S-curve measurement using an X-ray monochromatic source instead of performing TP injections

Measurement with Fe^{55} source scanning over different threshold values

Fe^{55}: kα_1 peak at 5.9 keV → ~ 1640 e$^-$

Example of a Fe^{55} measurement done on an array of 16x16 pixels in the central sector of the chip



With respect to a TP S-curve the rate does not saturate

~ 2 min per point

Fe55 measurement

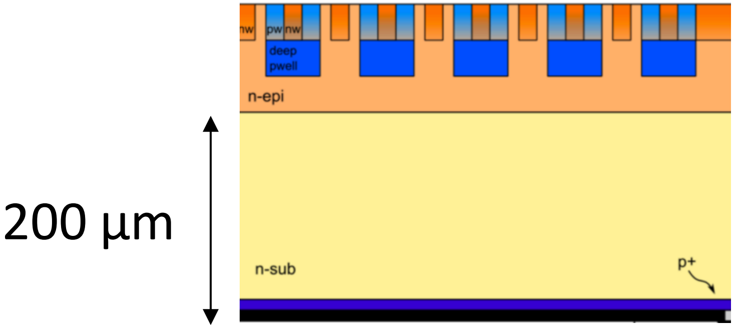
Why does the rate keep increasing decreasing the threshold?

Hypothesis:

- The electronic cloud generated by the X-ray interaction in Silicon widens by diffusion while drifting towards the electrodes and it can spread over more than one pixel (charge sharing).

To test:

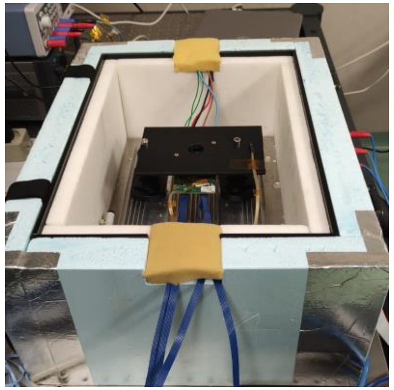
Comparison of measurements from frontside and backside of the chip + Monte Carlo simulations



- Fluctuations of gain, noise, and baseline pixel to pixel are relevant when performing measurements over an array of pixels. Measurable thermal fluctuations.

To comply:

Measurement on one single pixel in a temperature-controlled environment.



Single pixel simulation

Simple single pixel Monte Carlo simulation to study geometrical charge sharing effects

Simulation is performed using the following steps:

Set two different parameters:

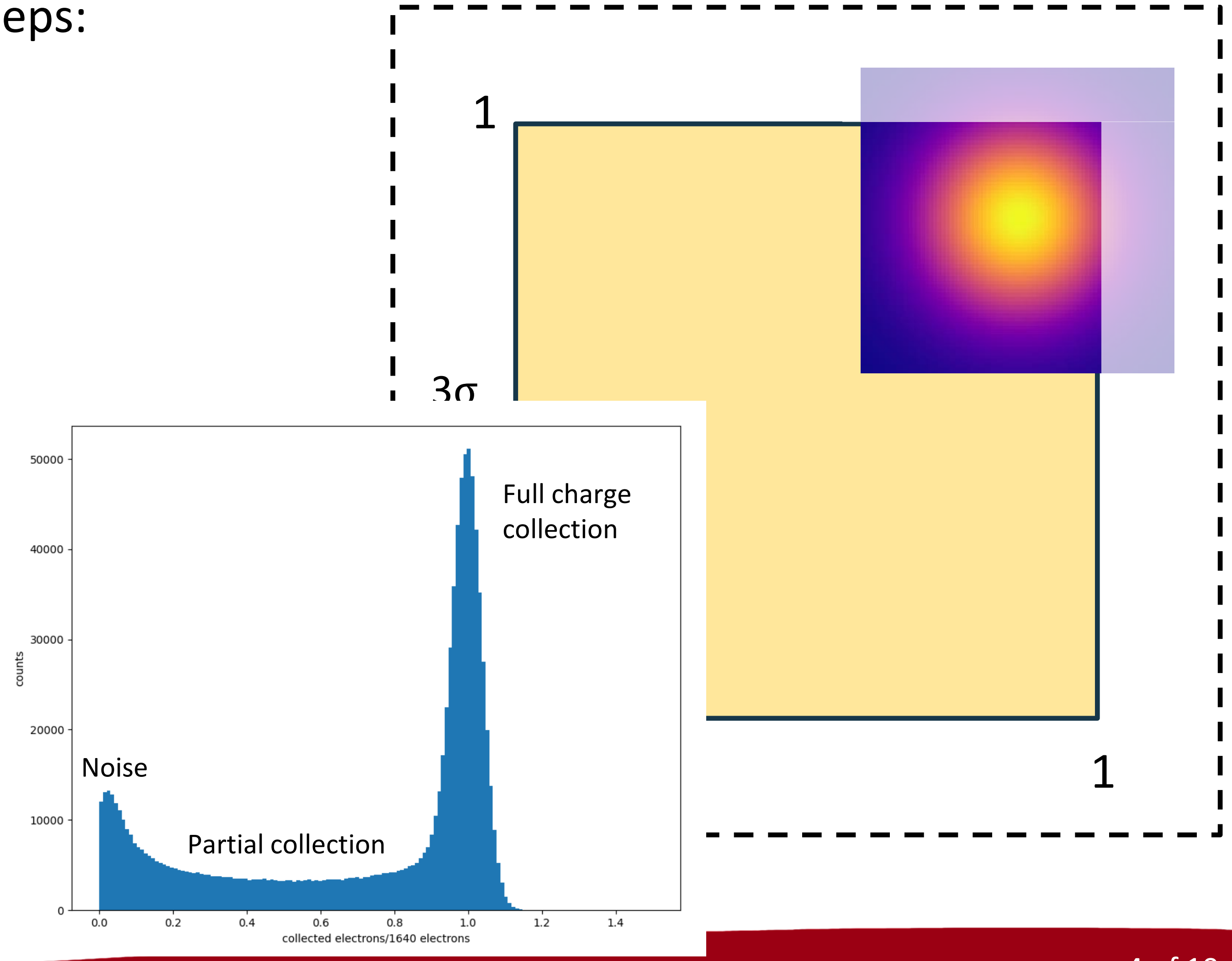
1. Width of the electrons cloud (***σ***)
2. Front-end electronic noise

Generate hit coordinates **(x, y)** in range [-3σ, 1 + 3σ]

Build a 2D gaussian with μ = **(x, y)** and ***σ***

Calculate numerical integral in pixel area

Fill analog histogram

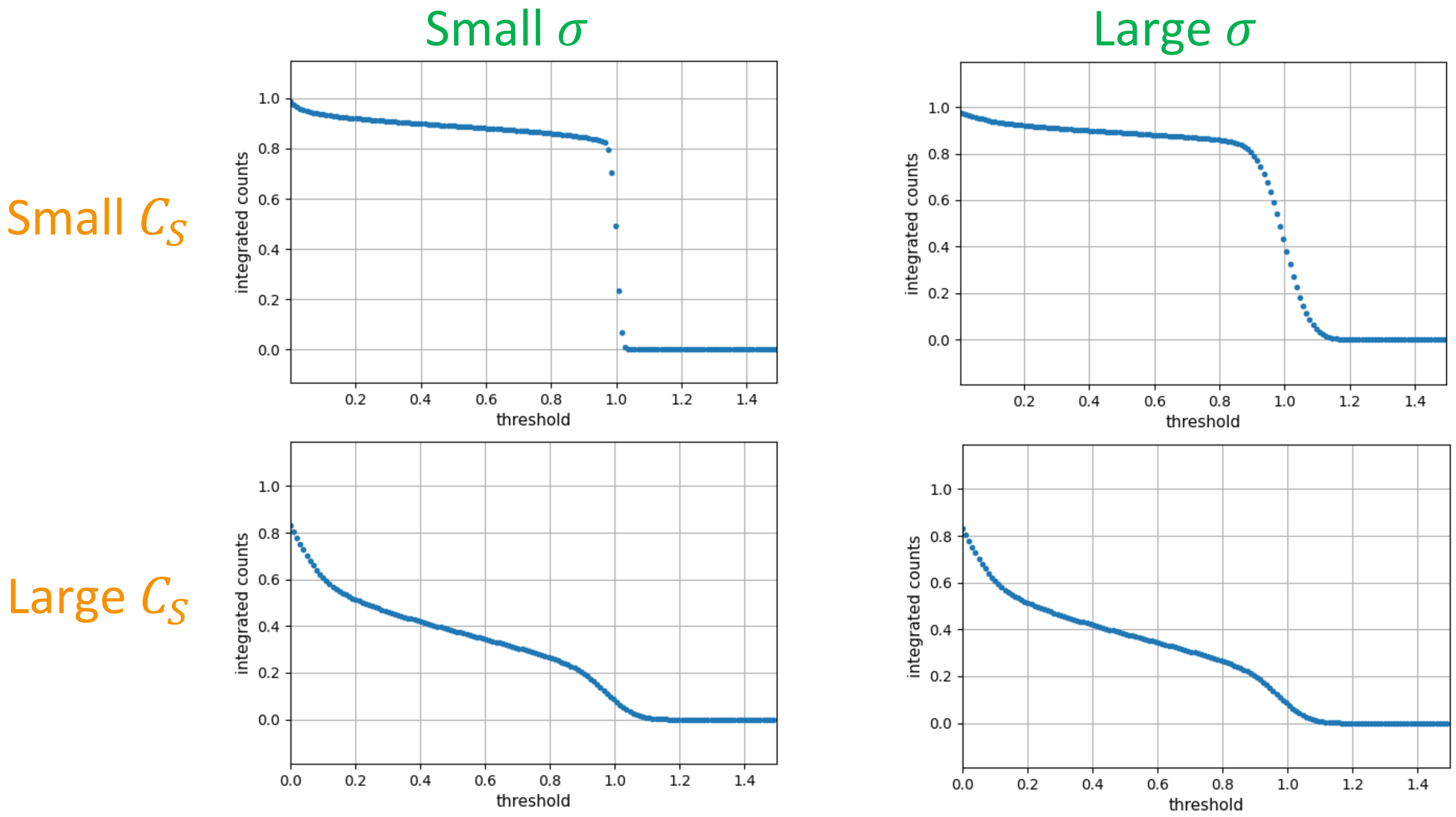


Fe55 simulations: rate vs threshold

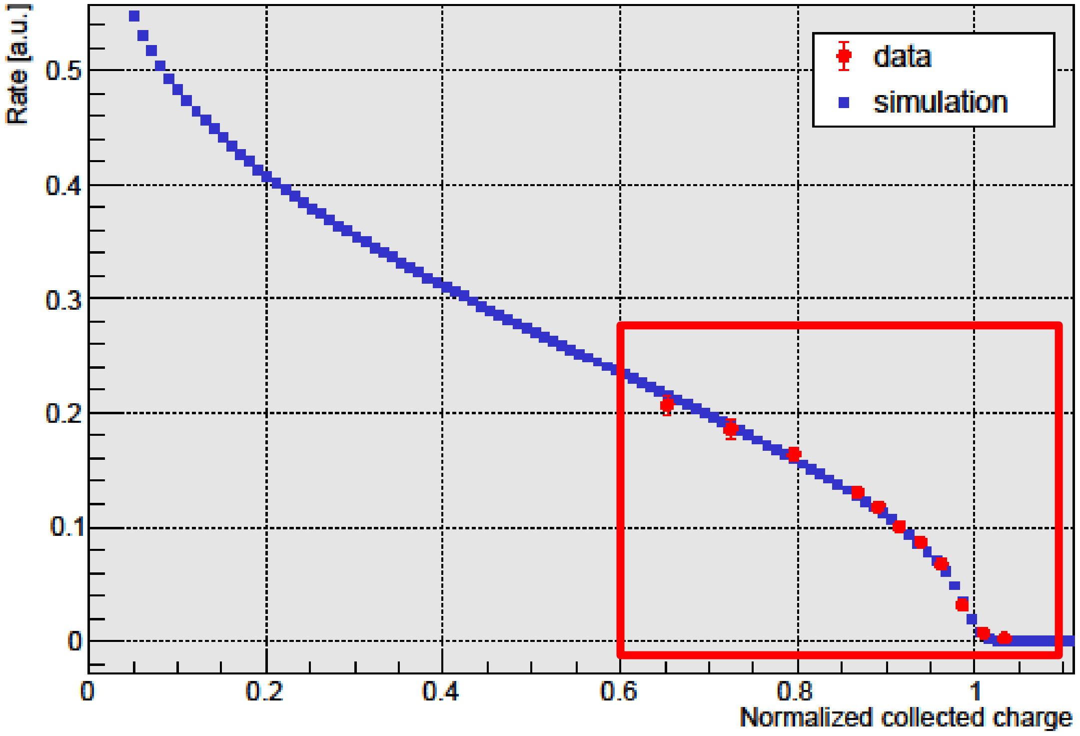
$$N(t) = \mathrm{N}_0\left(1 + \frac{\boxed{C_S}}{\boxed{\sigma}}(t_0 - t)\right)\left(1 + erf\left(\frac{(t_0 - t)}{\boxed{\sigma}}\right)\right)$$

C_S → Charge sharing contribution
σ → Electronic noise

t : threshold
t_0: threshold at which the s-curve inflection point is found



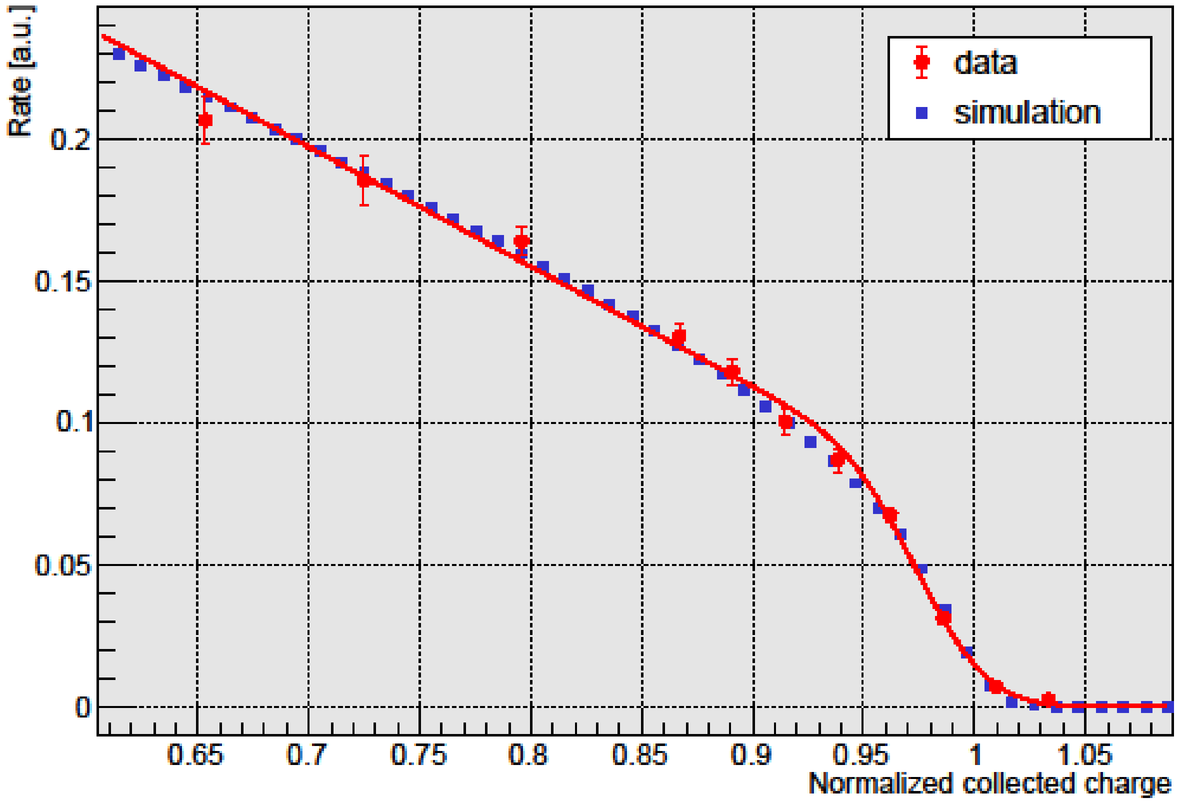
Fe55 frontside measurement vs simulation



Simulation parameters:

Cloud σ = 0.145

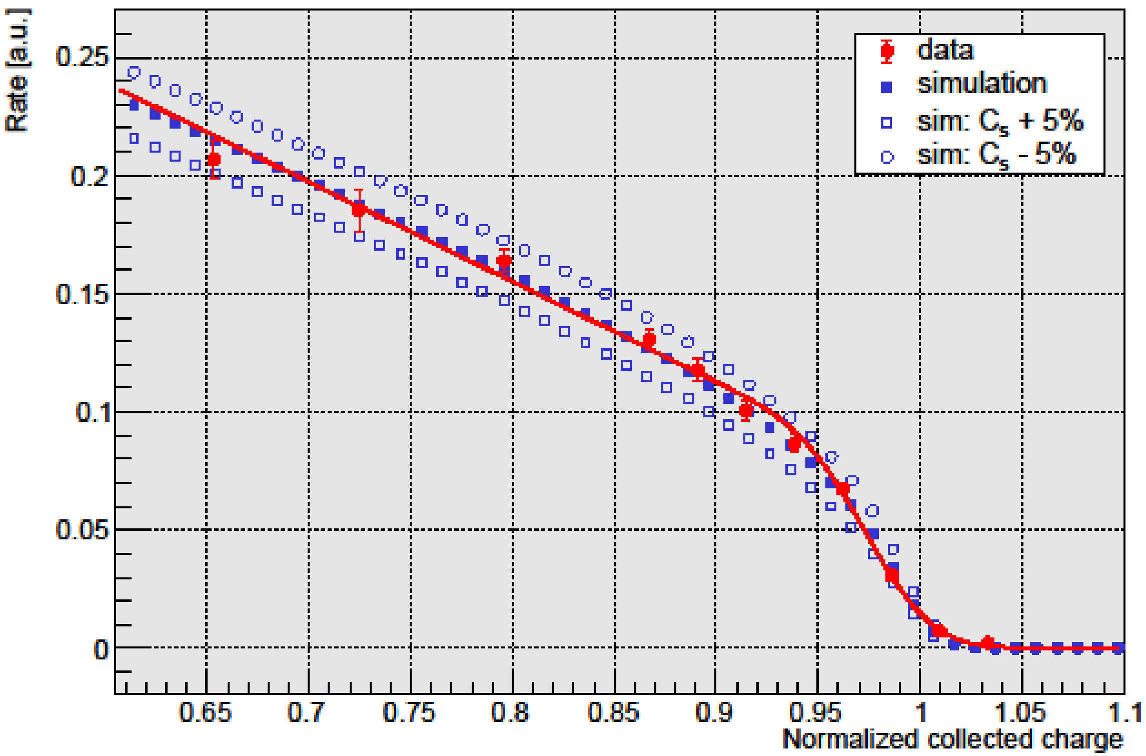
El. noise σ = 20 e$^-$



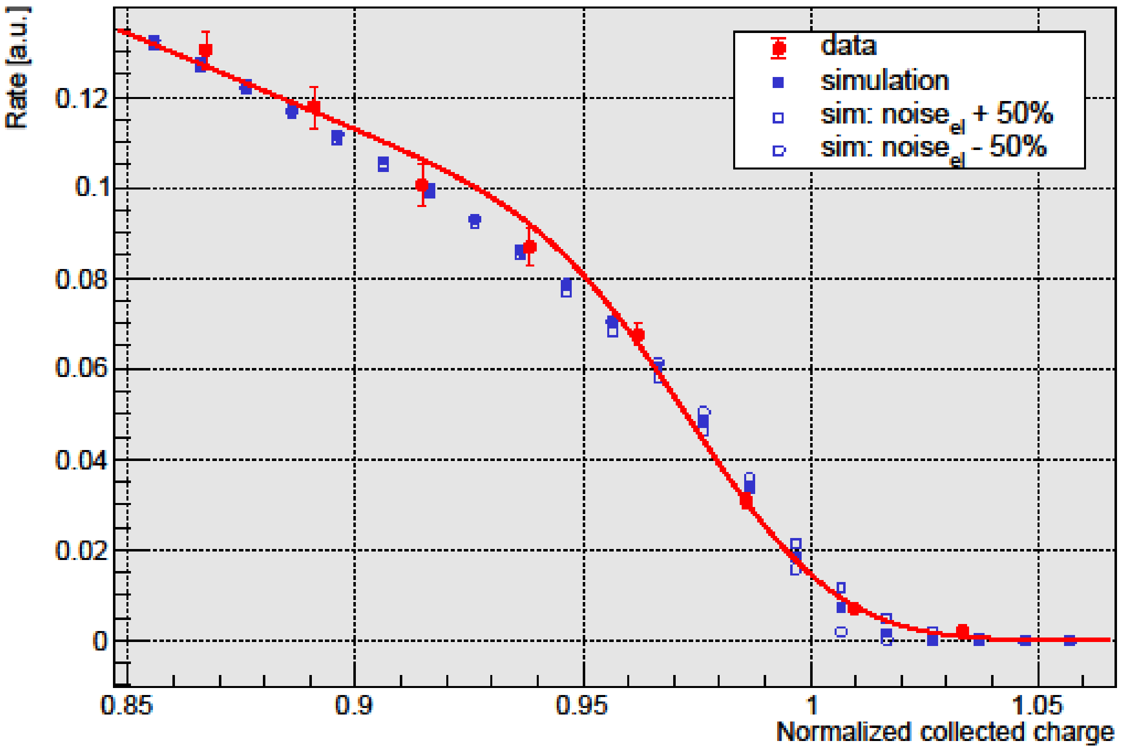
Fit Parameter	Data	Simulation
t_0	0.98	0.98
C_s	0.19	0.22
σ	0.025	0.030

Fe55 frontside measurement vs simulation

Fixed electronic noise, charge sharing **±5%**

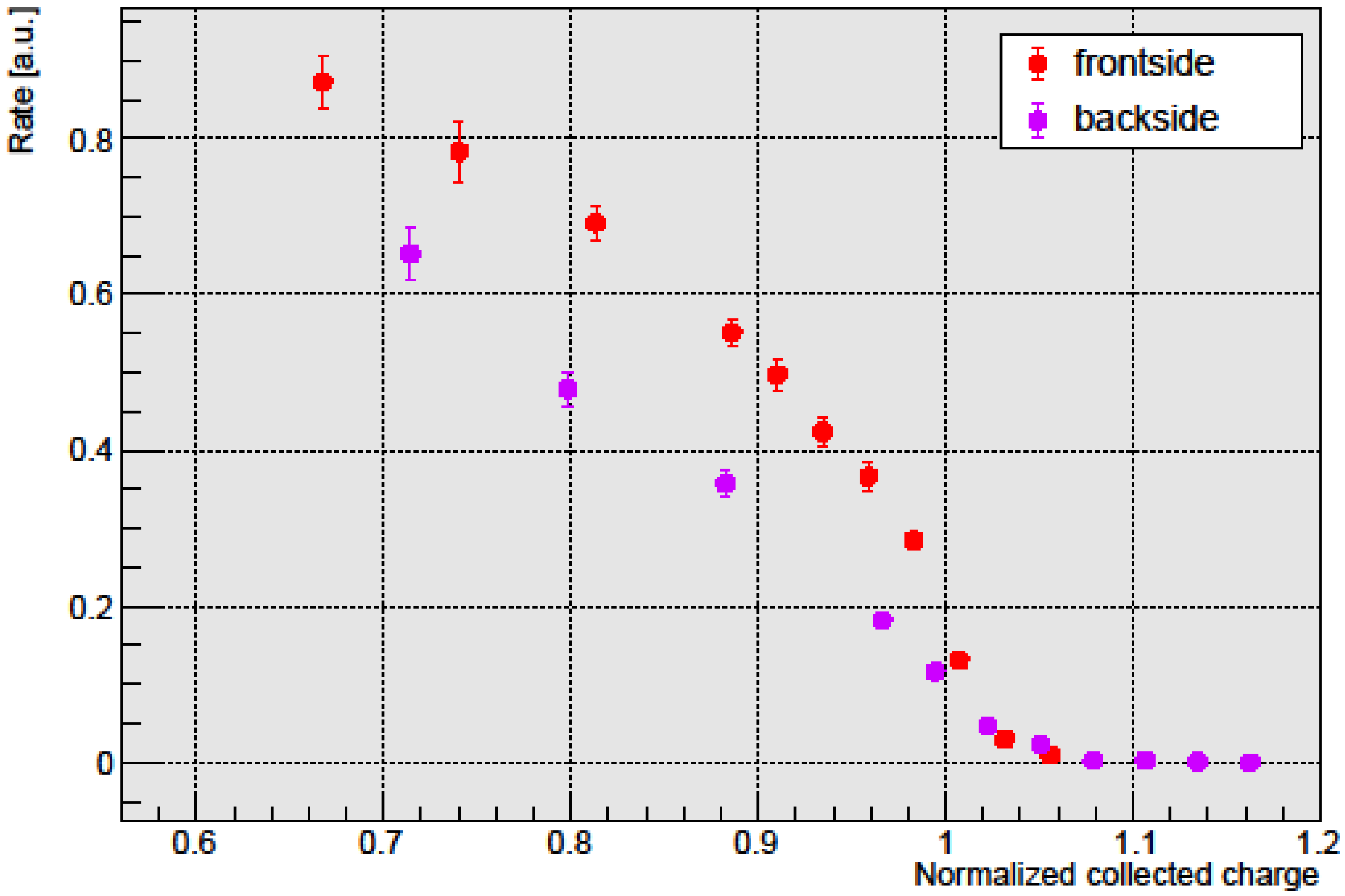


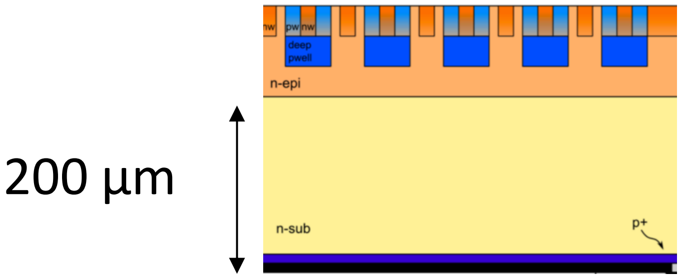
Fixed charge sharing, electronic noise σ **±50%**



The charge sharing contribution is dominant → Not sensitive on the electronic noise

Fe55 backside vs frontside





Fit Parameter	**Frontside**	**Backside**
t_0	0.98	0.98
C_s	0.19	0.54
σ	0.025	0.048

Ongoing work

- Improve statistics with ^{55}Fe source;
- Measurements with more pixels;
- More realistic simulation;
- Larger simulation domain;
- Measurements with monochromatic source at a different energy for calibration **?**

- Electronic cloud simulation with TCAD
- Replication on SPICE of the analog front end loading correctly the libraries;
    - Quantification of some features of the analog pixels around the array (baseline, noise, gain, …);
    - Understanding of the amount of charge injected in the pixel.