Cross-talk measurements of RD53A module with HLL sensors of 25x100 µm² pitch and 150µm thickness: Comparing different methods for linear and differential FEs

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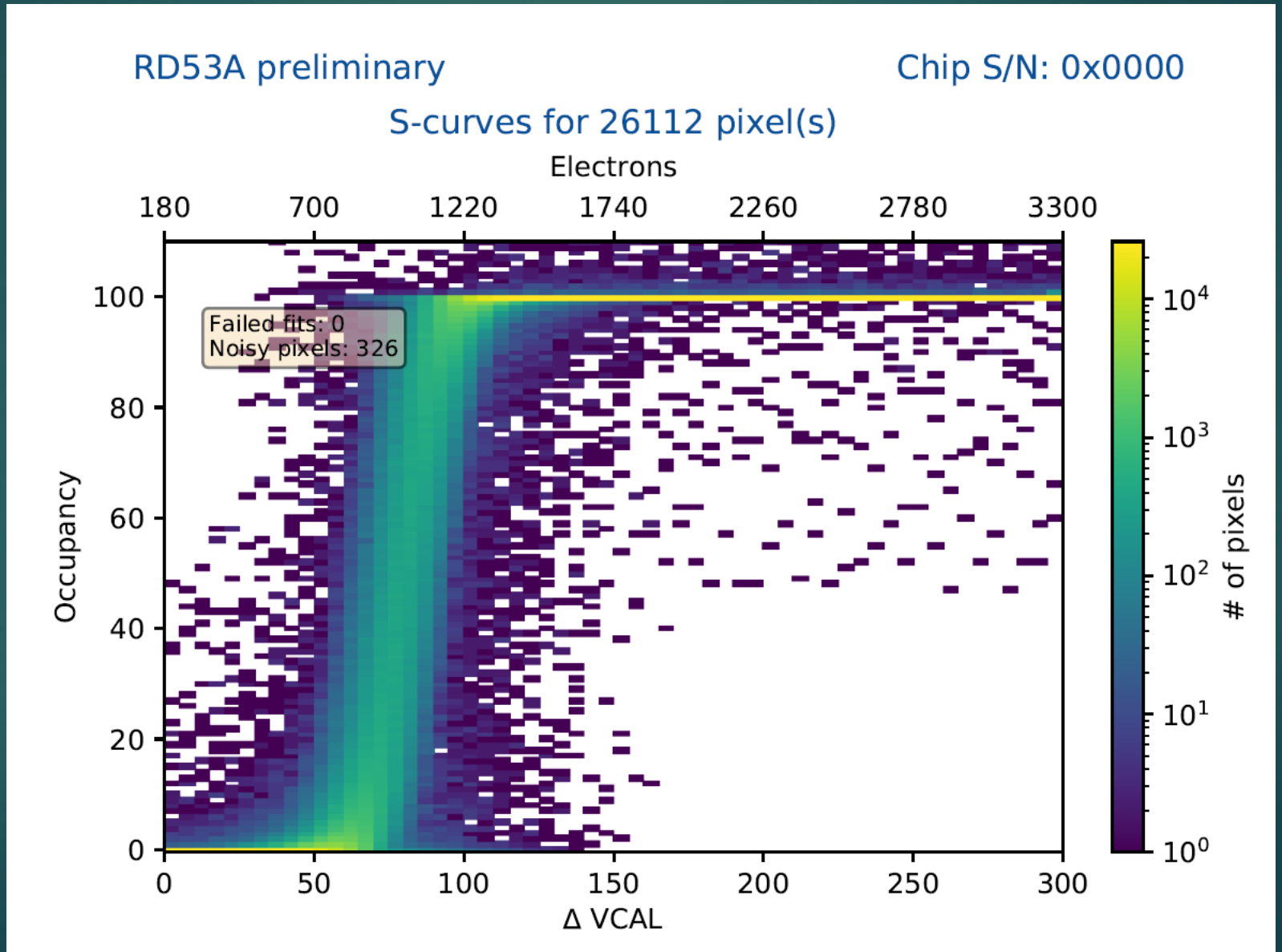
Introduction

- Here are the recent cross-talk measurements of 25x100µm^2 pitch modules with 150µm thick HLL sensors tuned at the threshold of 980 electrons for the linear FE and 1070 for the differential FE
- Apart from some details regarding the BDAQ version and different cross-talk scan codes, in general there are two ways of measuring cross-talk by charge injection into RD53A modules:
  - The legacy way in which the charge injection and readout was for all the channels.
  - Injecting charge in a set of pixels but reading another set of pixels.
- The new method was introduced since version 13 of BDAQ53 in which one can read a pixel when the charge is injected in the neighbor(s) in specific directions.
- I had already modified the threshold scan code in the previous versions to inject in completely arbitrary set of pixels and read another completely arbitrary set which gave me more handle to investigate different effects. I have used this method before for irradiated modules and the results are consistent with the BDAQ53 crosstalk scan code.

Comparing The Methods

- First, the main effective threshold of the channels is measured either by a normal threshold scan or by injecting and reading the same channels. The latter is cleaner as we can make sure we neither inject nor read the neighboring channels when doing so.
- Then we inject charge in some pixels and read one of their neighbors. The 50% point of the corresponding S-curve indicates the amount of charge x% of which will fire the neighboring channel while x is the cross-talk value. So to measure the cross-talk one should just divide these two thresholds.
- **But,** if we use the legacy method (i.e. reading the injected channels as well), the measured value of cross-talk is significantly less.
- This effect is seen in the linear FE but not the differential one.
- As Timon has proposed, the effect might be related to the power down feature of the linear FE

The main threshold of pixels – linear FE
987 electrons



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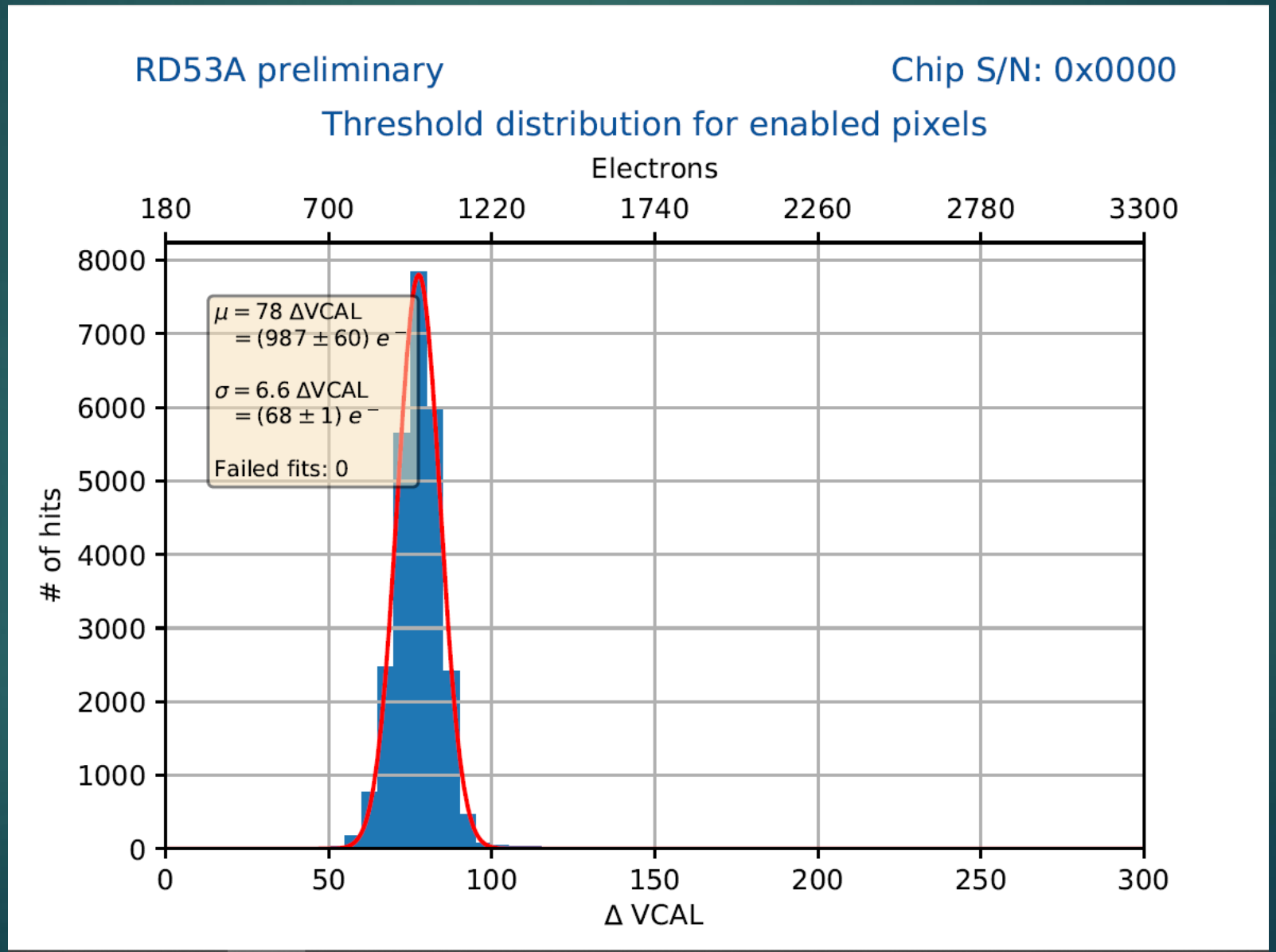
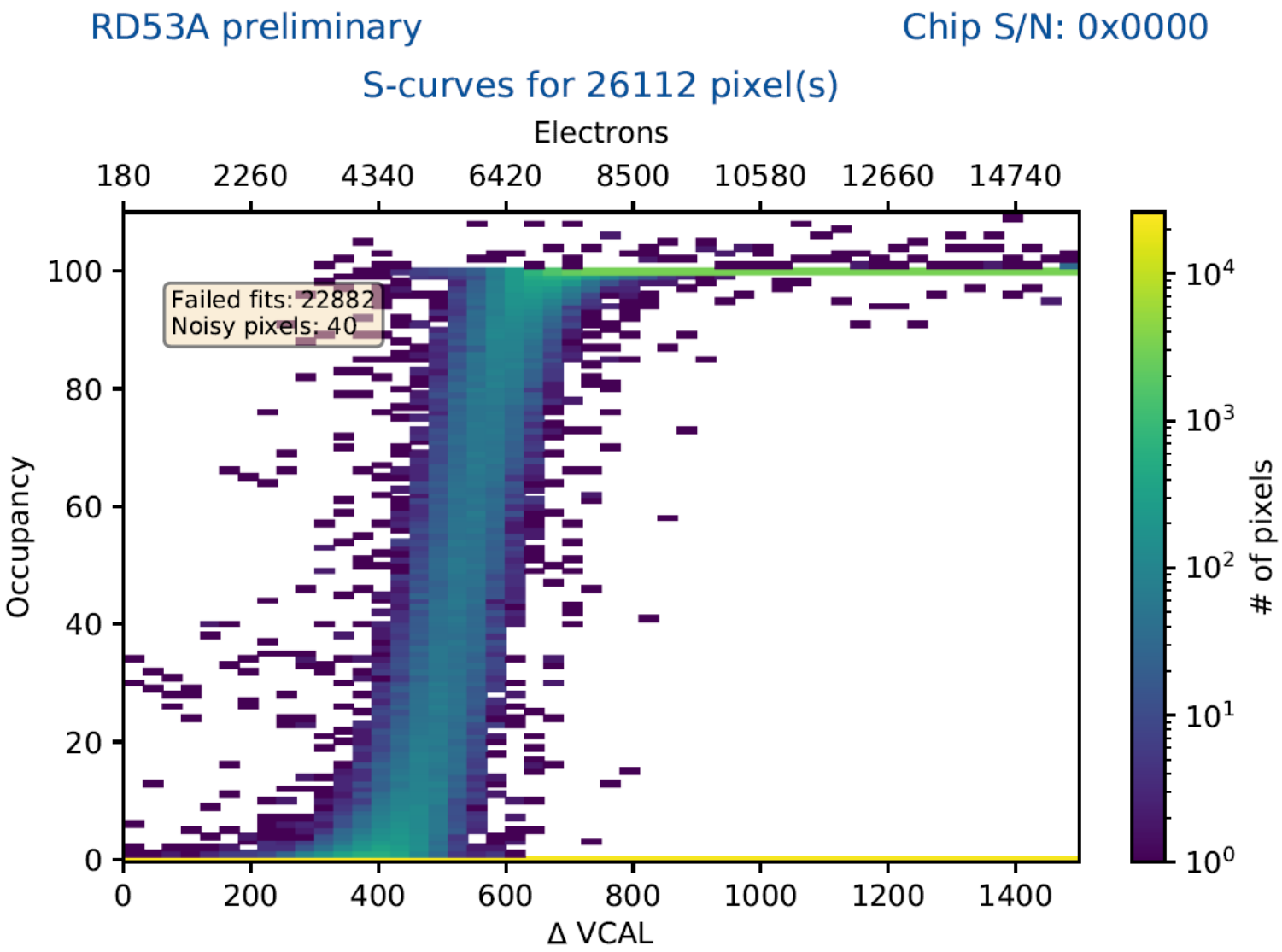
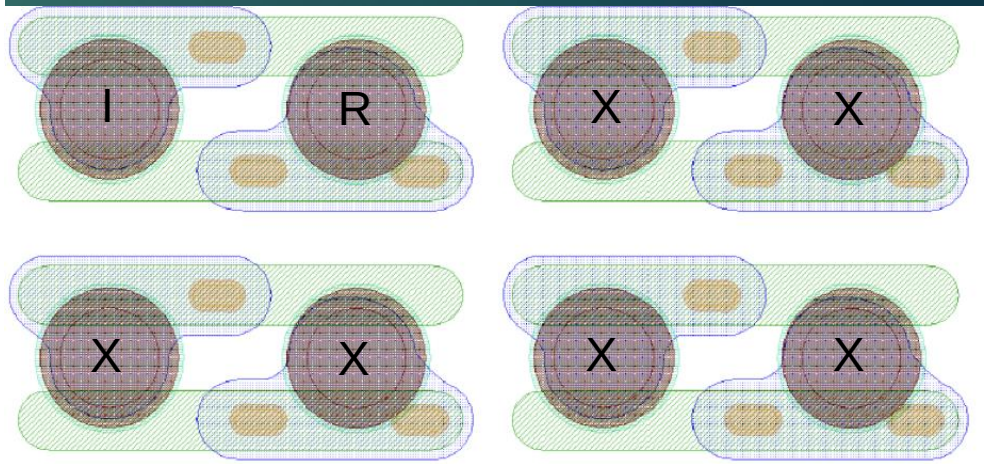


Reading only the paired channel of the injected pixel and not the injected channel – linear FE

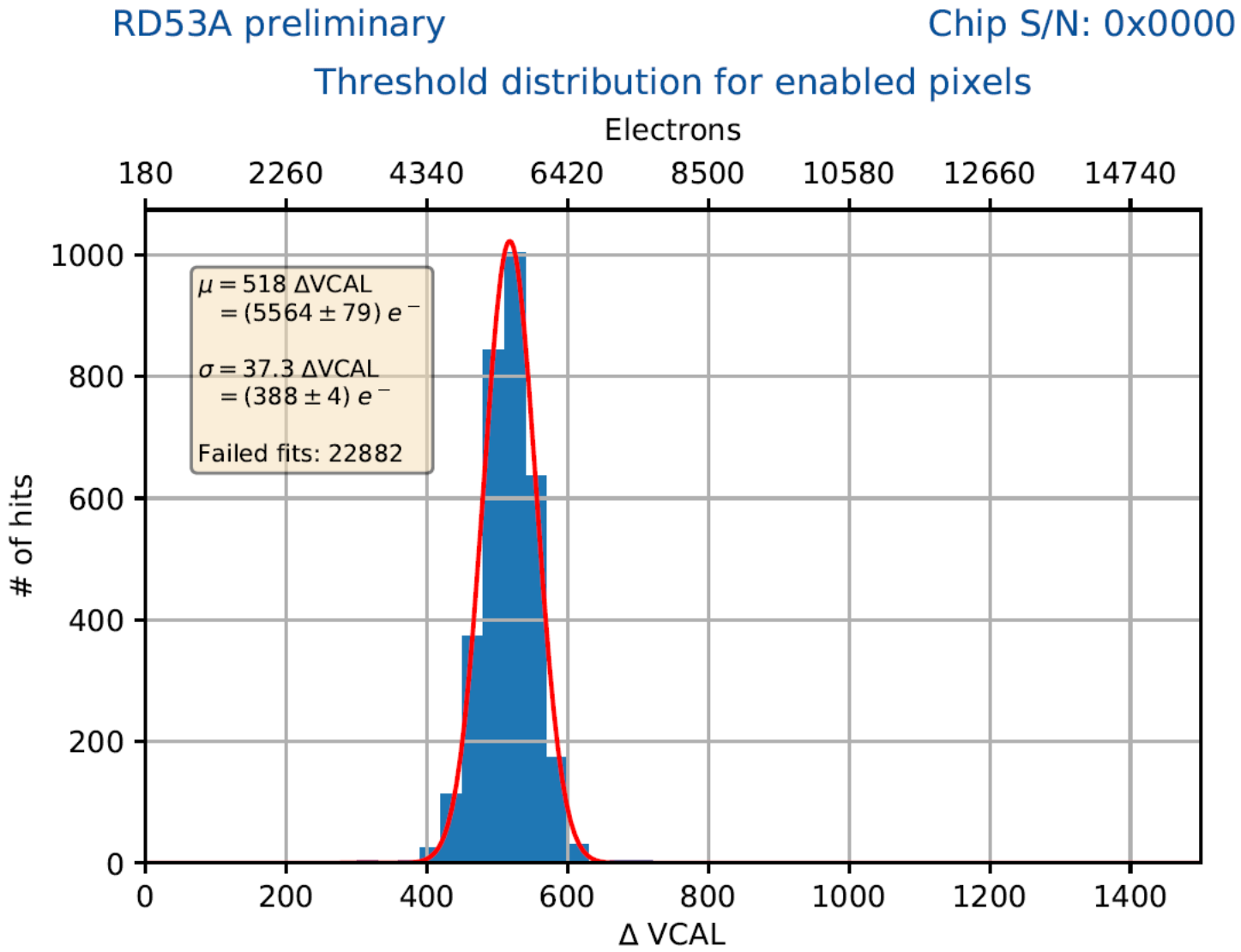


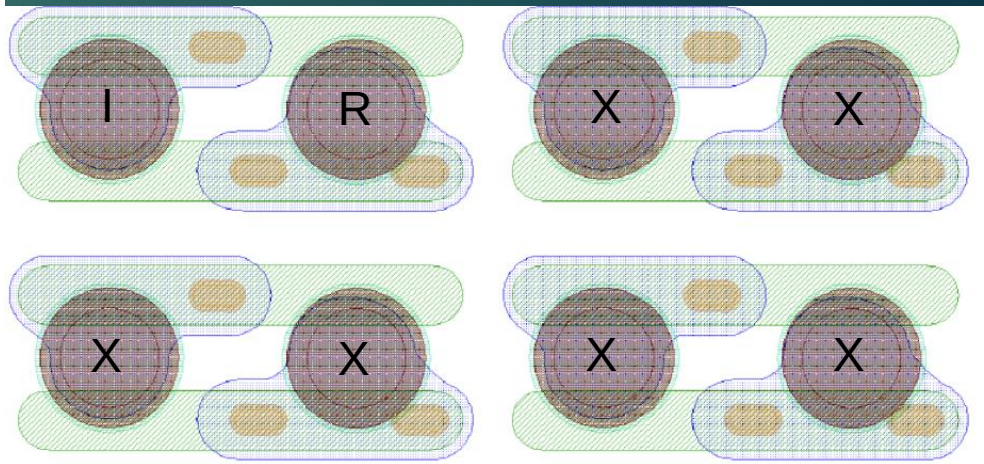


$$\text{xtalk} = \frac{main\ threshold}{second\ threshold}$$

~ 18%

Reading only the paired channel of the injected pixel and not the injected channel – linear FE

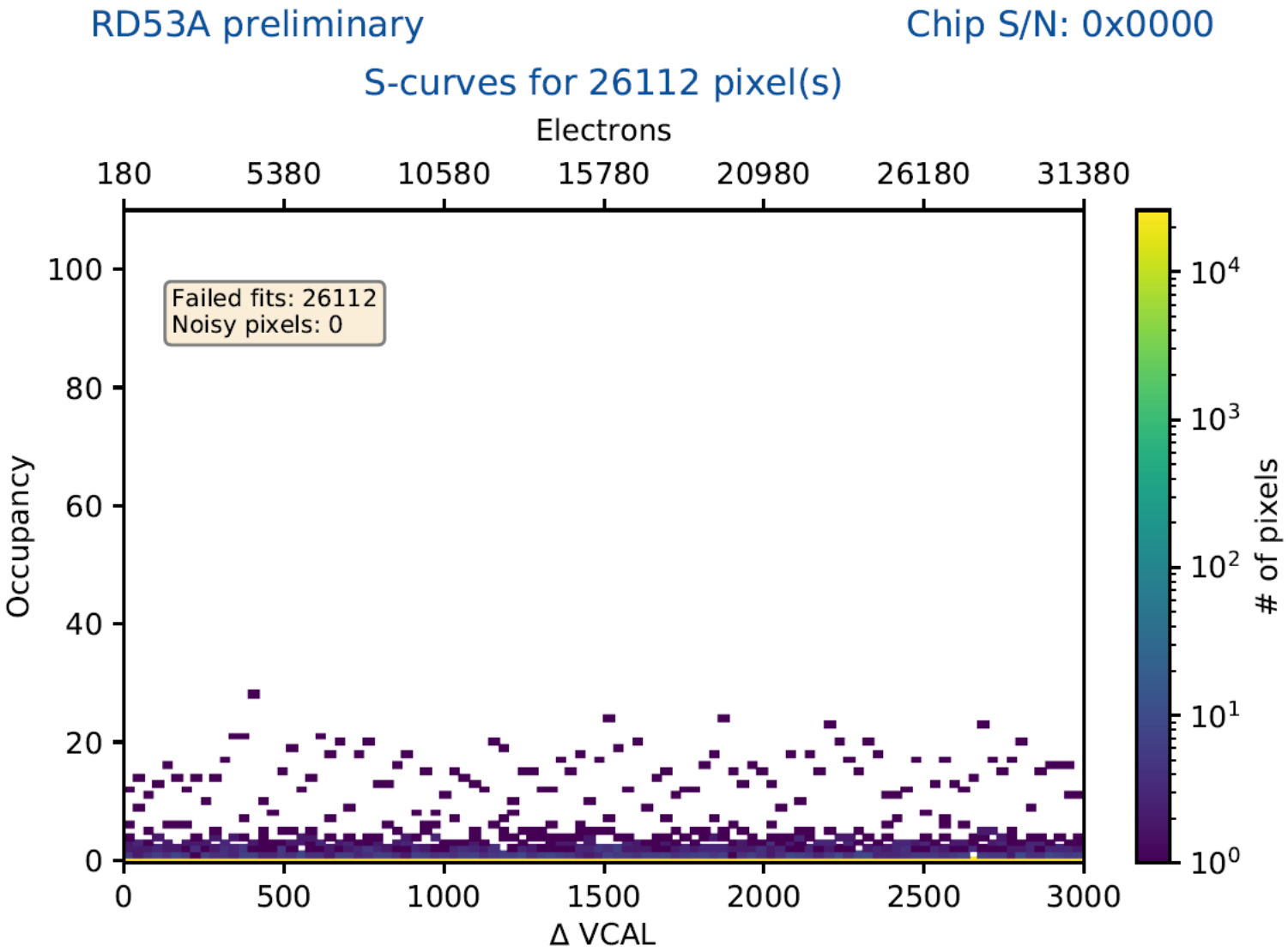


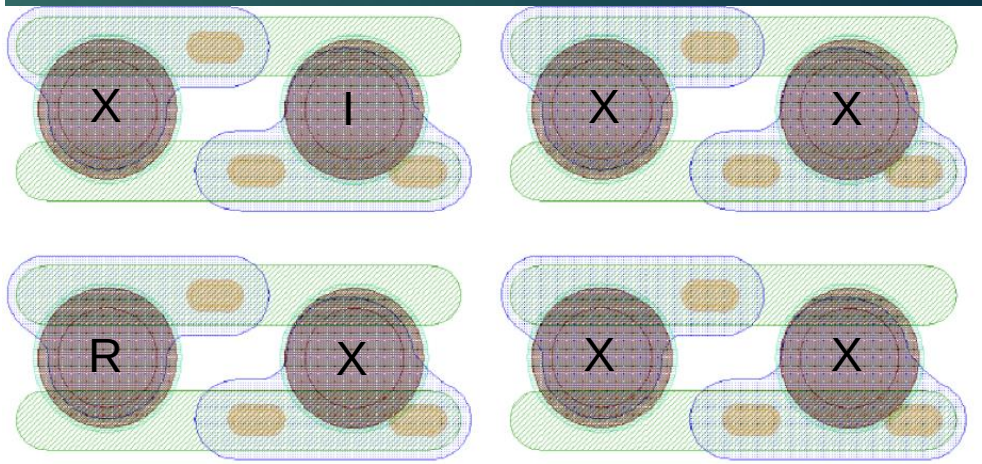


$$\text{xtalk} = \frac{main\ threshold}{second\ threshold}$$

~ 18%

Reading only the paired channel of the injected pixel And not the injected channel – linear FE

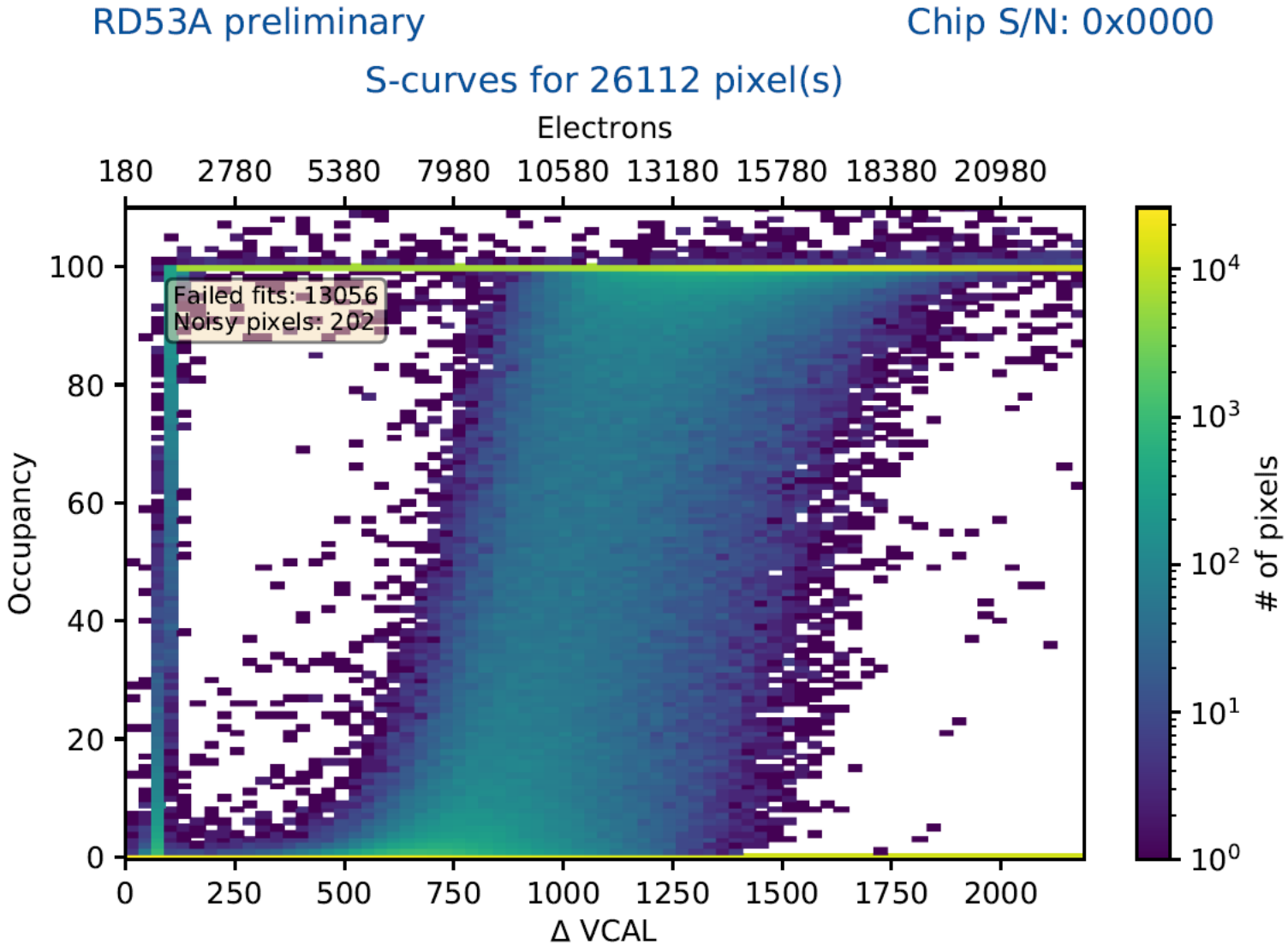


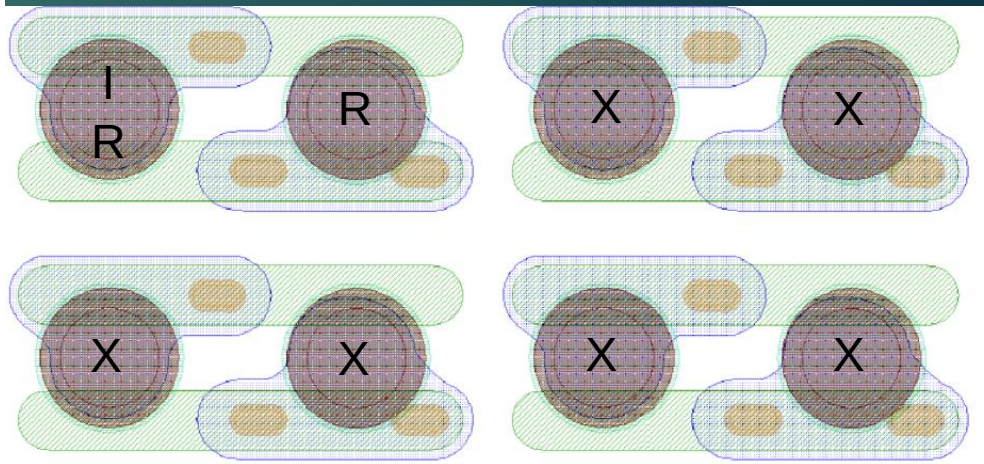


$$\text{xtalk} = \frac{main\ threshold}{second\ threshold}$$

~ 0%

Reading the paired channel of the injected pixel and the injected channel itself – linear FE

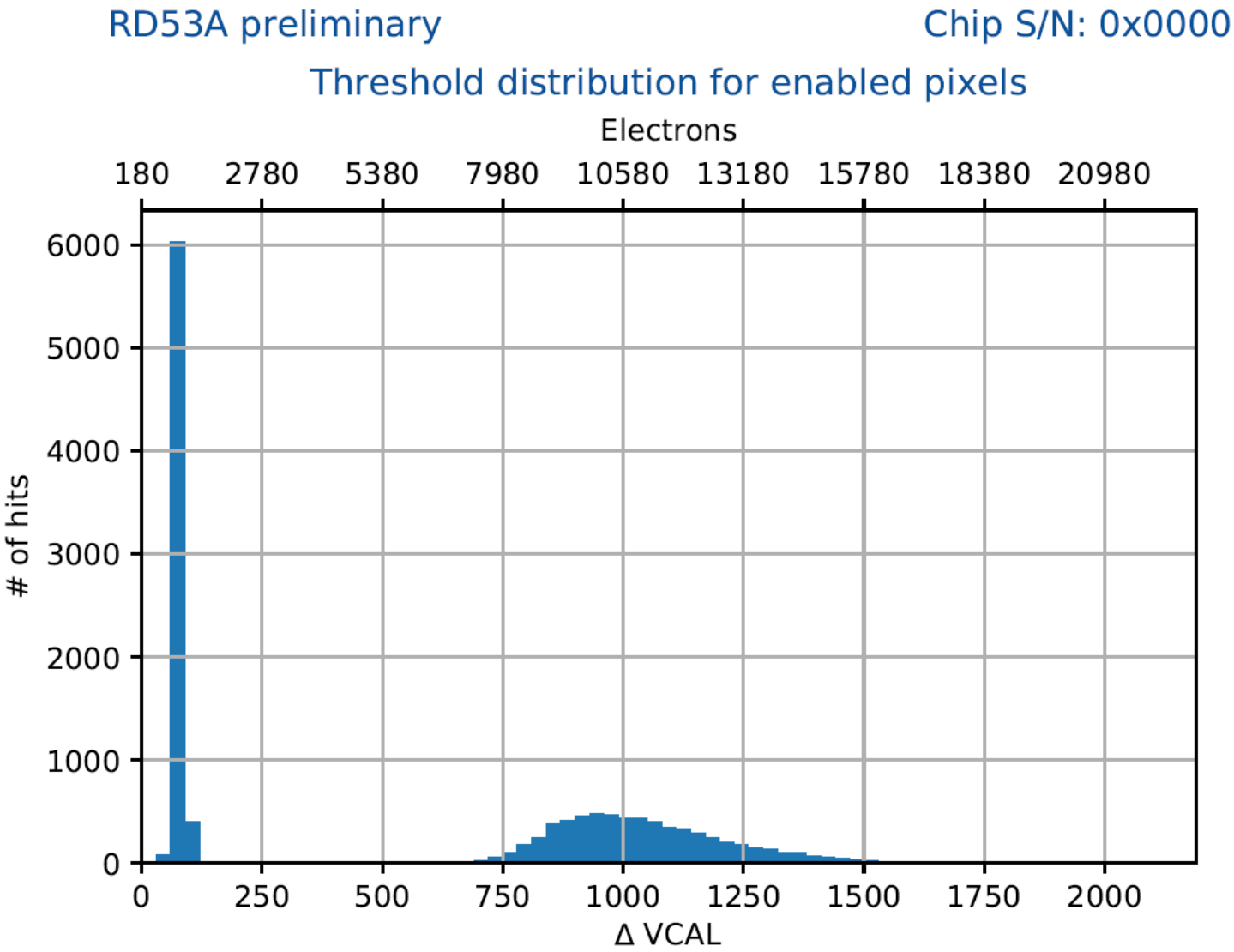


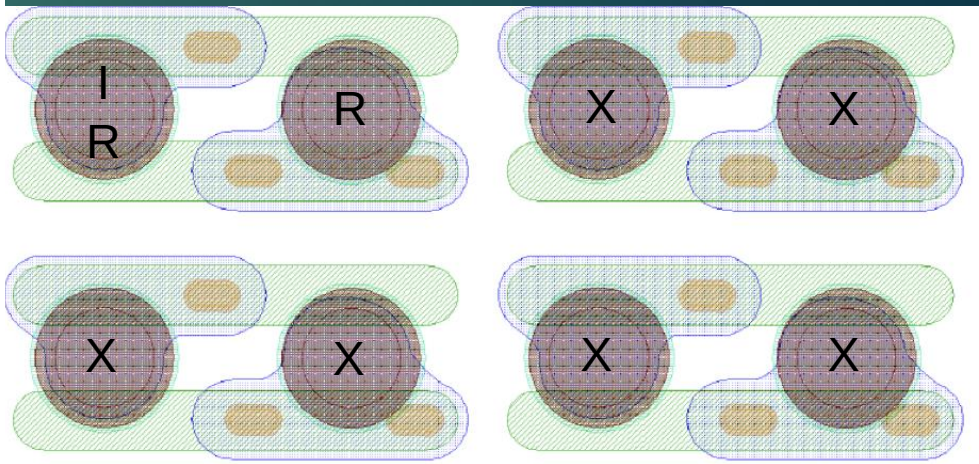


$$\text{xtalk} = \frac{main\ threshold}{second\ threshold}$$

~ 9.5%

Reading the paired channel of the injected pixel and the injected channel itself – linear FE

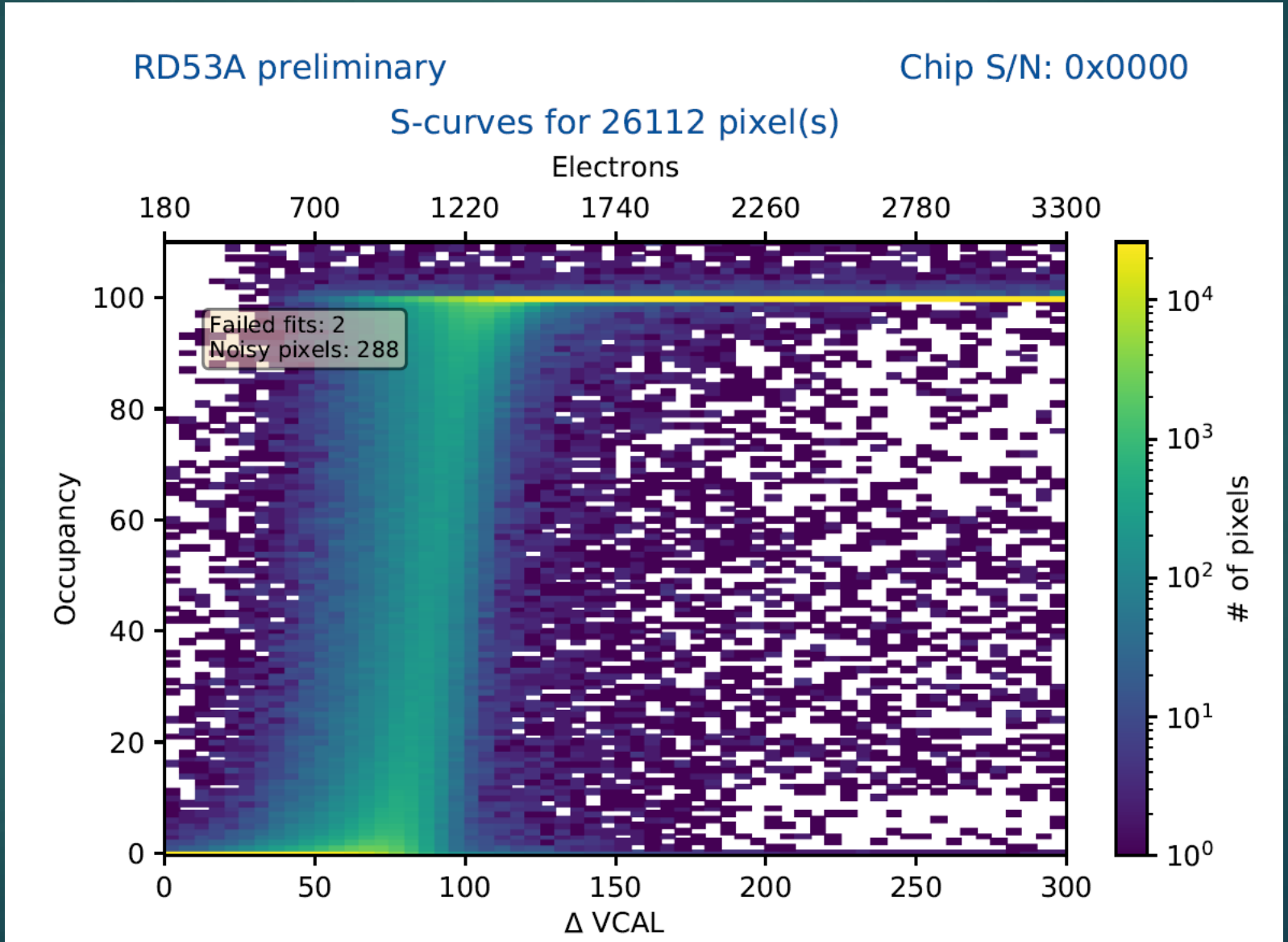




$$\text{xtalk} = \frac{main\ threshold}{second\ threshold}$$

~ 9.5%

The main threshold of pixels – differential FE 1070 electrons



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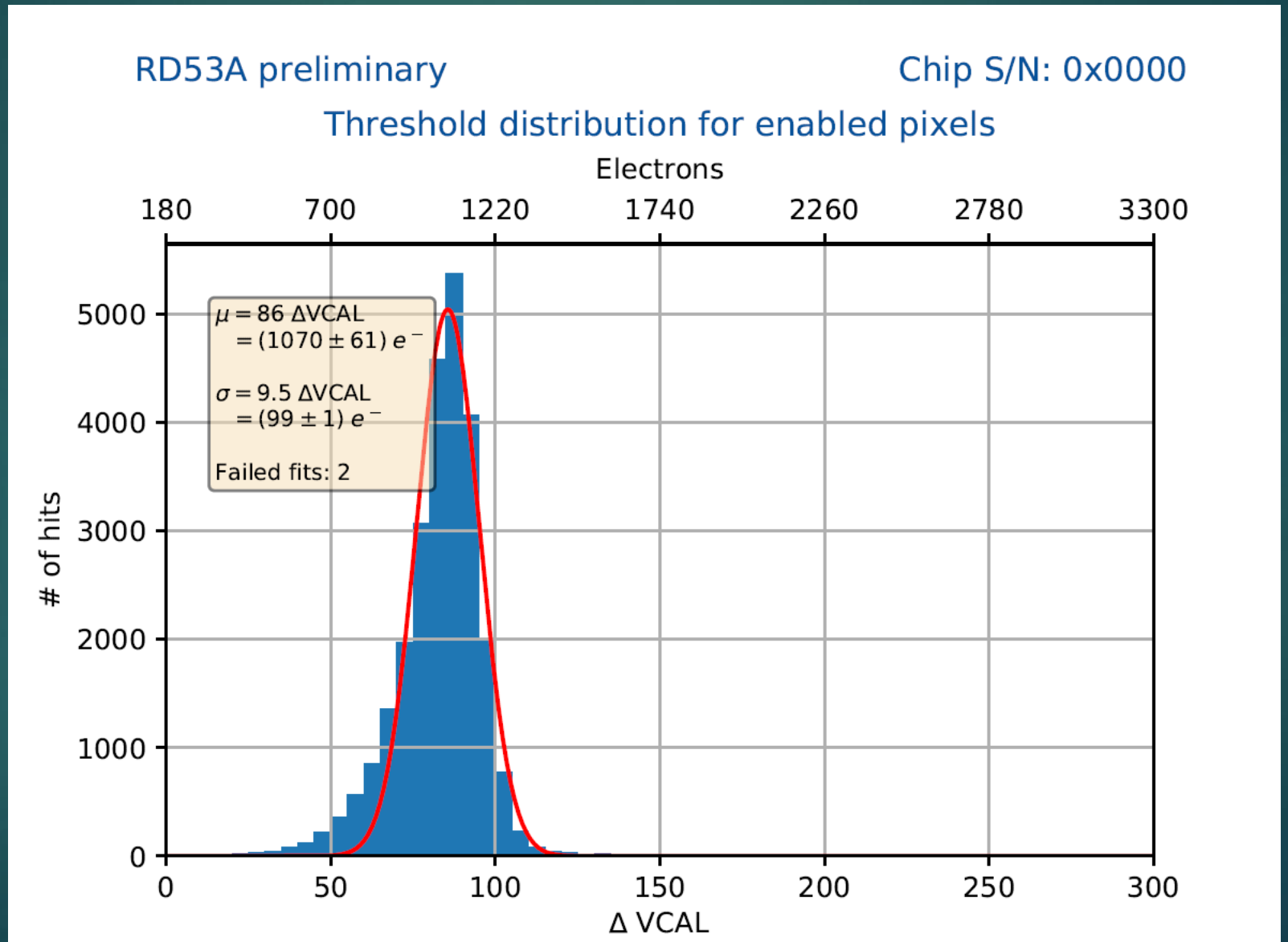
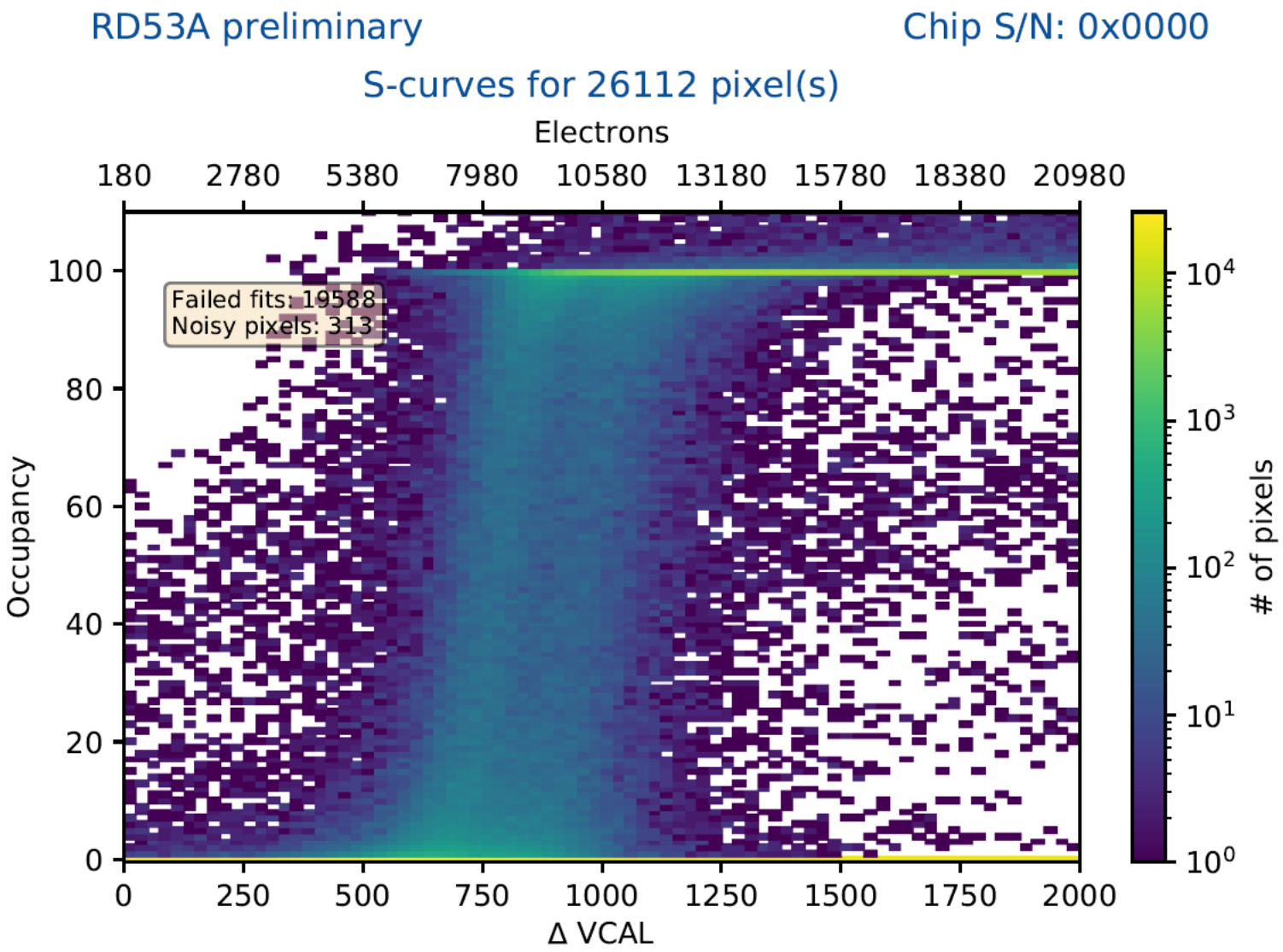
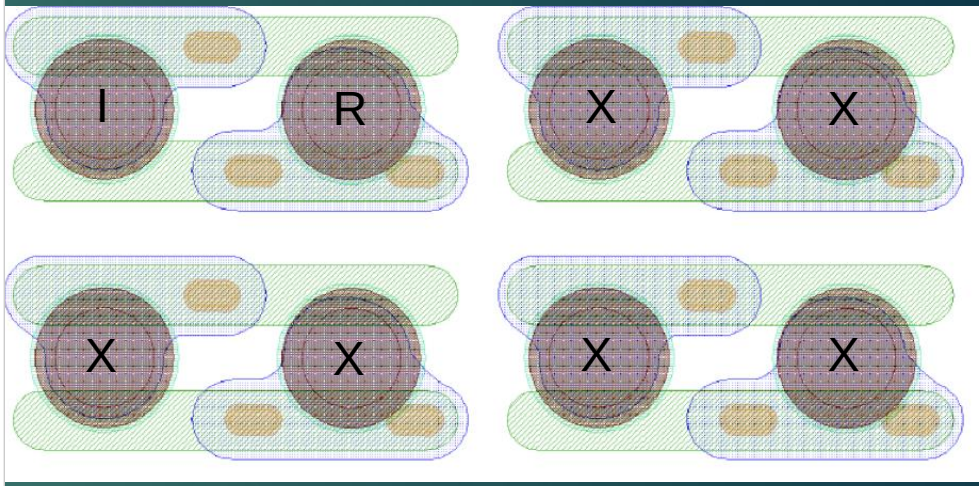


Reading only the paired channel of the injected pixel and not the injected channel – differential FE

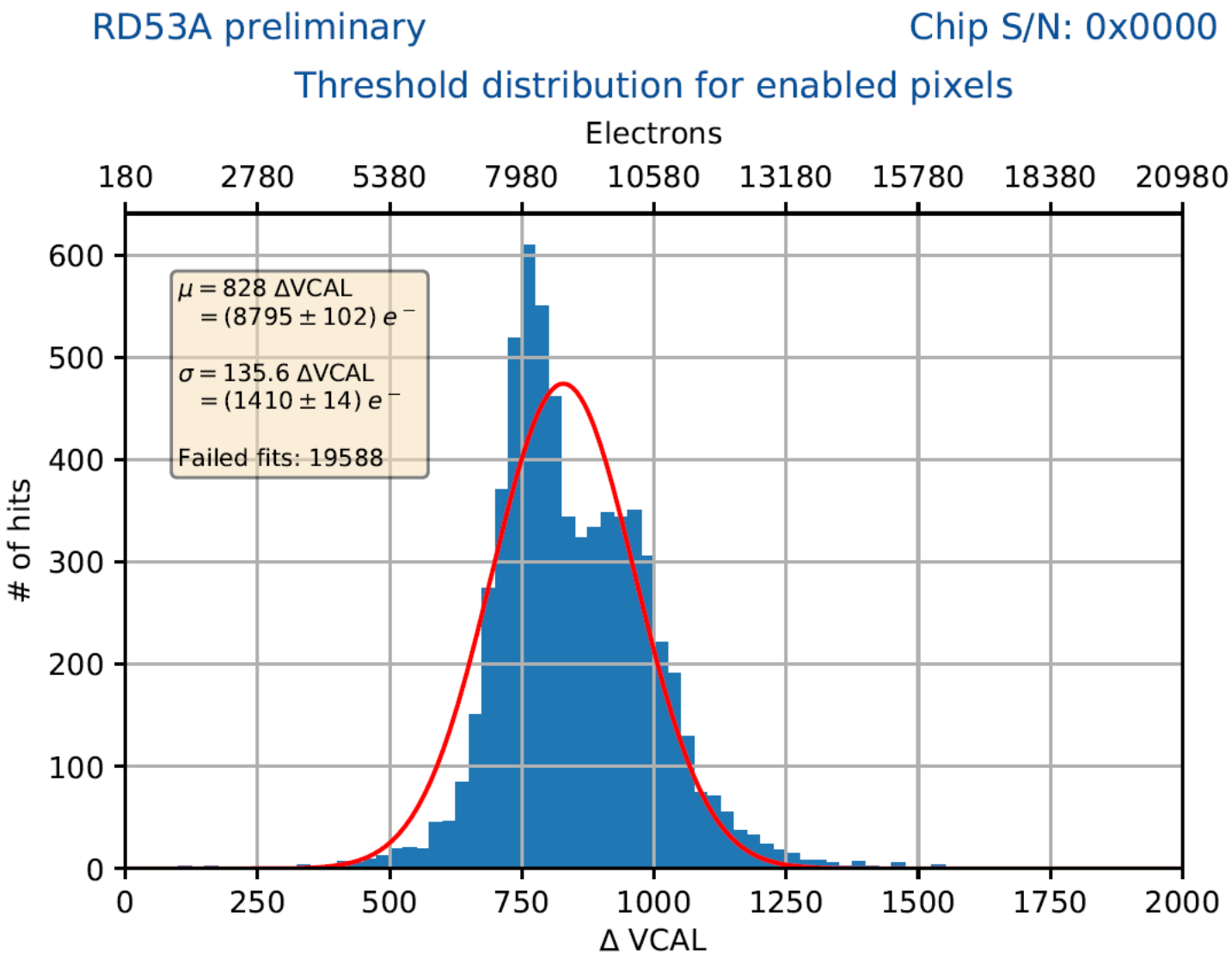


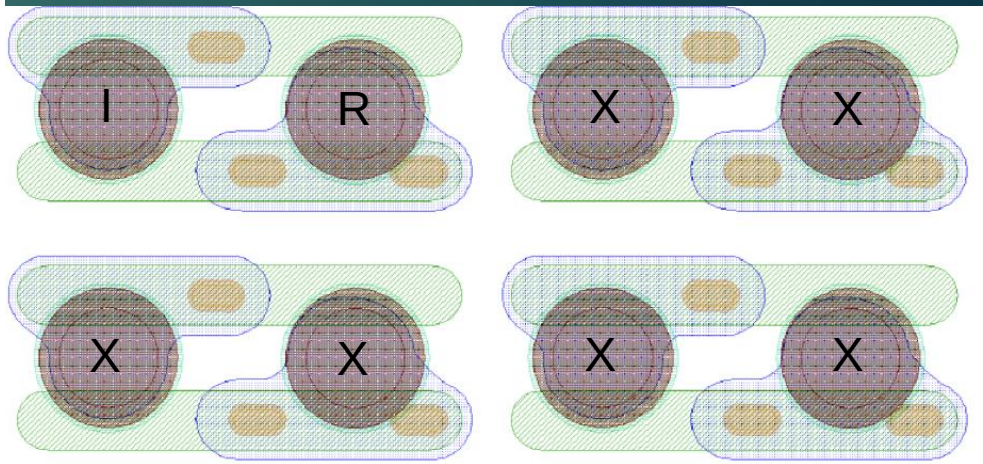


$$\text{xtalk} = \frac{main\ threshold}{second\ threshold}$$

~ 12%

Reading only the paired channel of the injected pixel and not the injected channel – differential FE

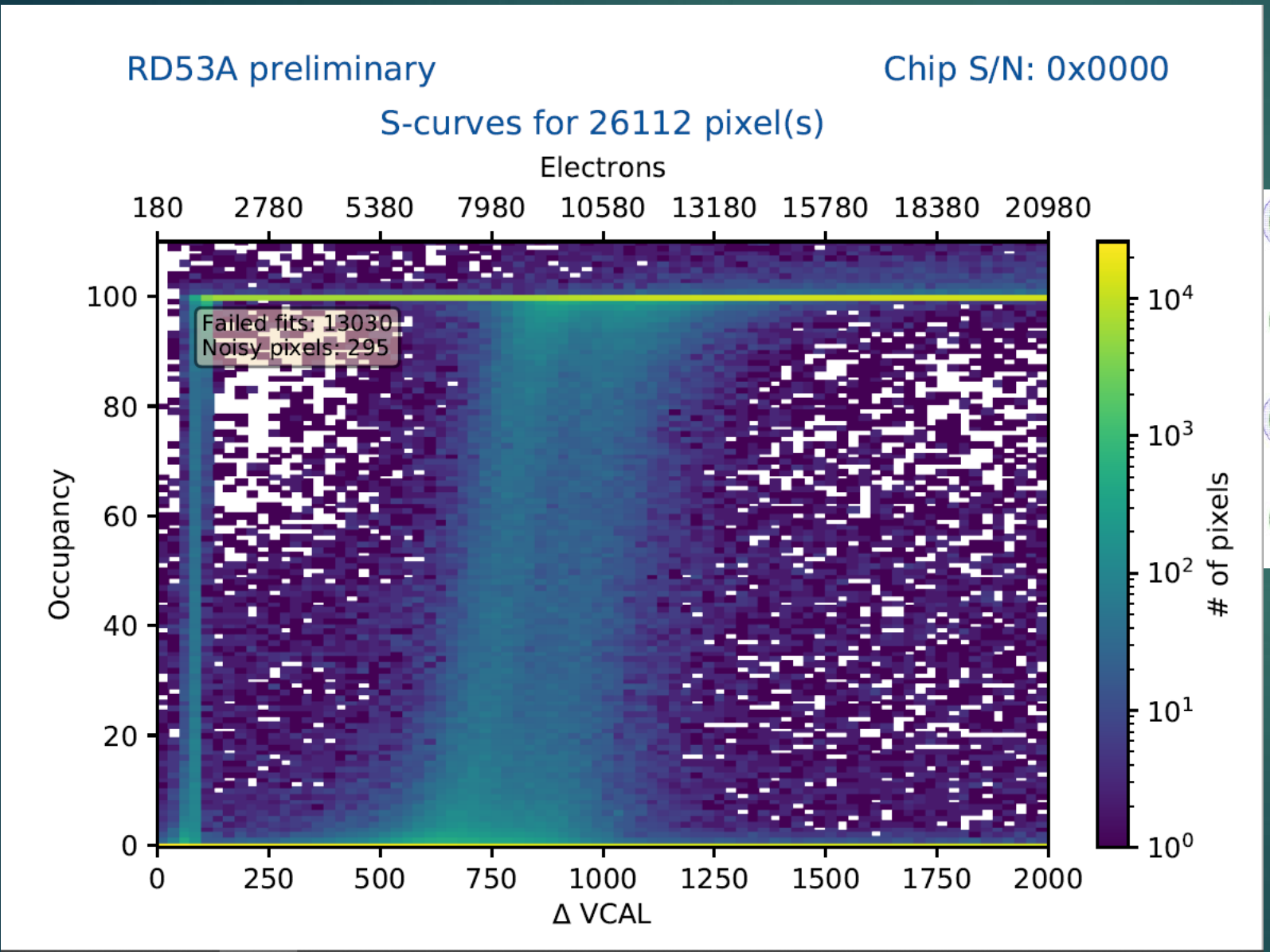


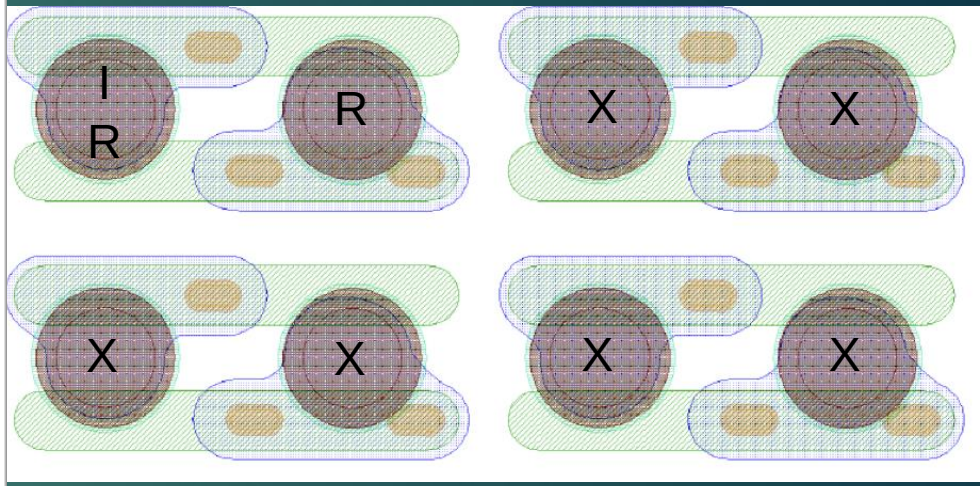


$$\text{xtalk} = \frac{main\ threshold}{second\ threshold}$$

~ 12%

Reading both the injected and the paired channel – differential FE

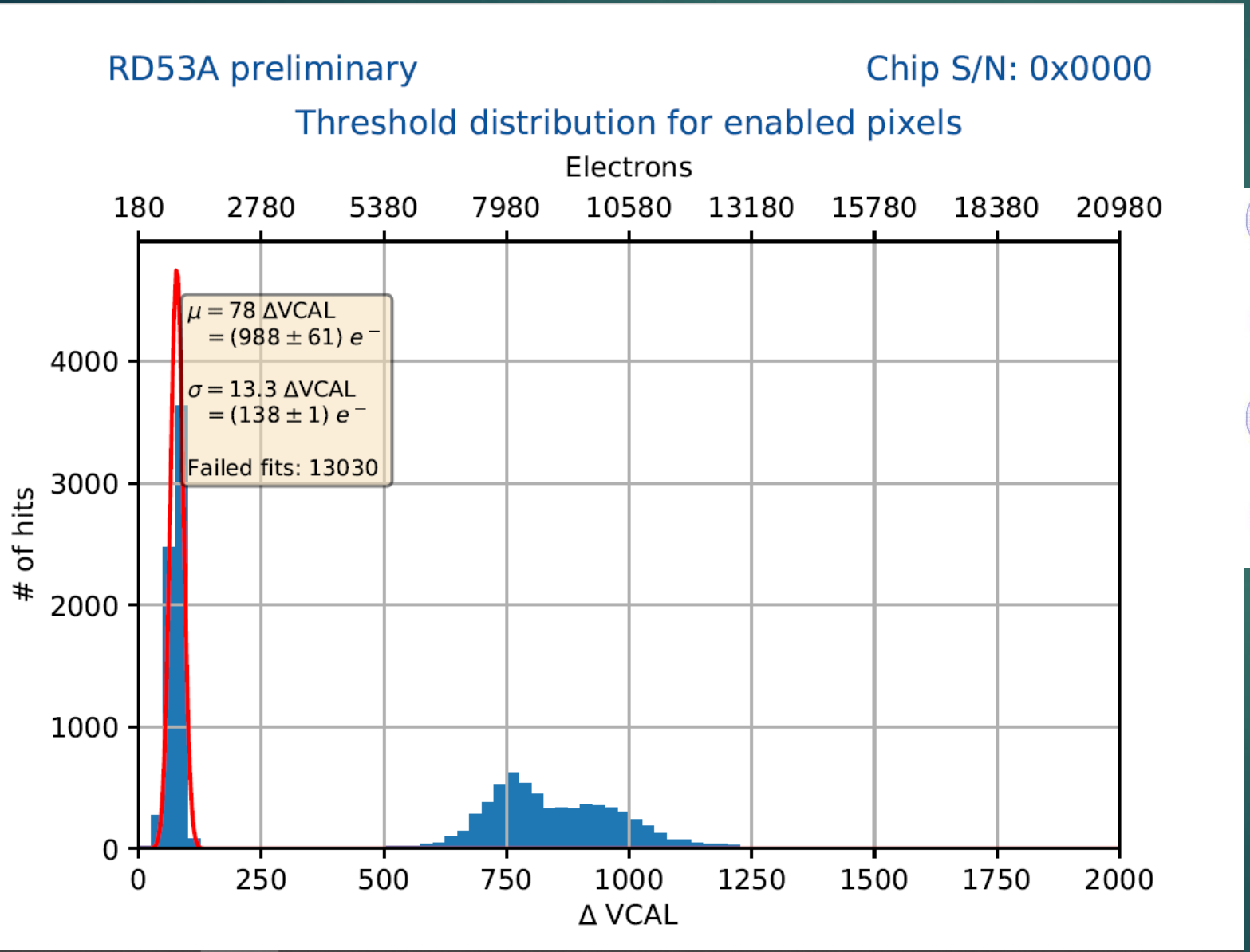


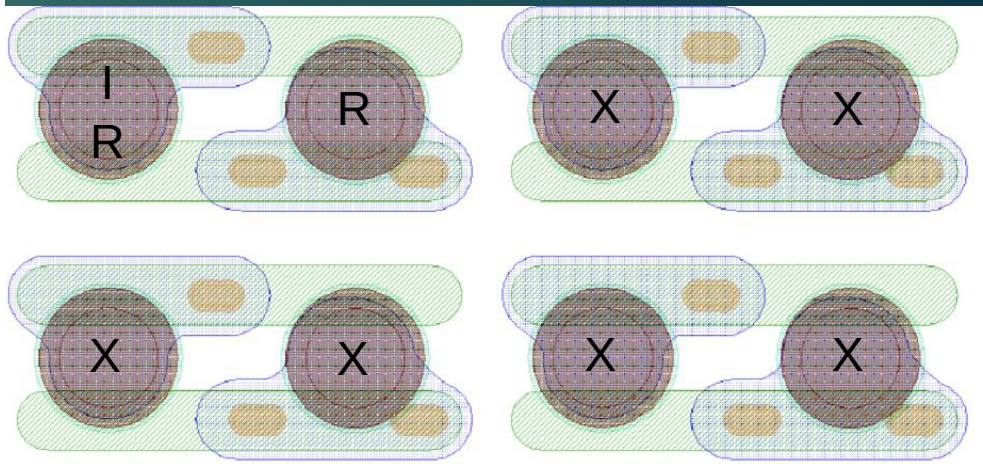


$$\text{xtalk} = \frac{main\ threshold}{second\ threshold}$$

~ 12%

Reading both the injected and the paired channel – differential FE





$$\text{xtalk} = \frac{main\ threshold}{second\ threshold}$$

~ 12%

Conclusions and remarks

- If the assumption that this inconsistency arises from reading the injected channel is right:
  - The lower values of cross-talk are closer to the operational conditions
  - The current BDAQ53 crosstalk measurement code gives wrong values for the linear FE
- Maybe it's worth to investigate more the real cause of this inconsistency in the linear FE
- In the test beam and the actual data taking all the channels can be fired and read. This can explain why for the linear FE we measure cross-talk values of typically 10% in the test beam and around 18% by injecting charge directly in the same module.
- Any comments and ideas will be much appreciated!