Gate-controlled shutter mechanism for DEPFETs

for Belle II to circumvent the ‘dirty bunch problem‘

First considerations

First experimental results (PXD5)

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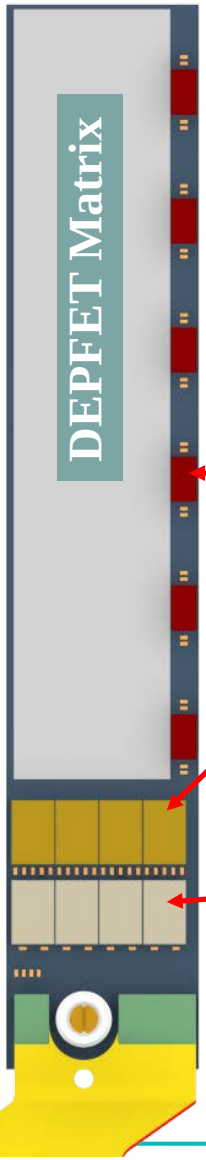
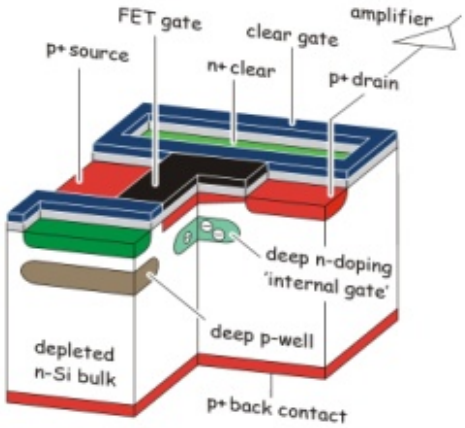
DEPFET and auxiliary ASICs

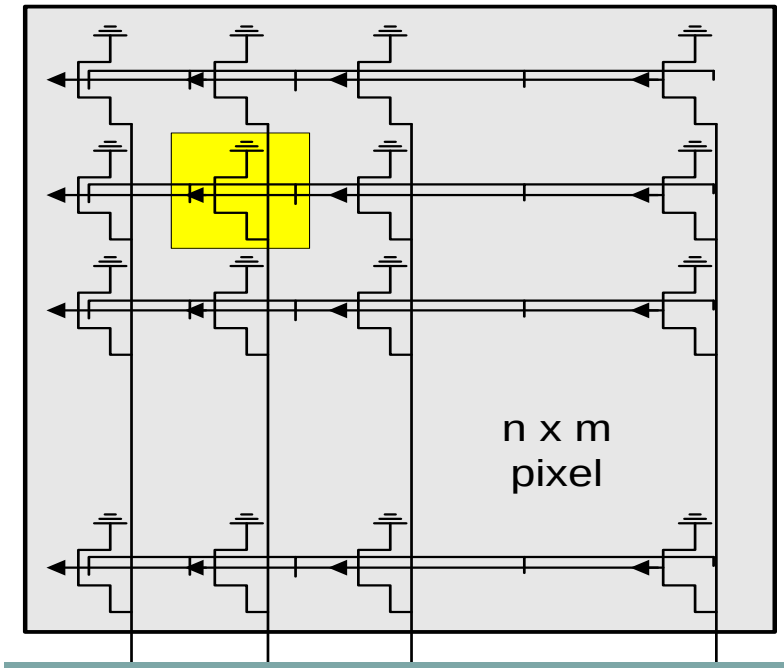




Switcher:
Gate and Clear Signal

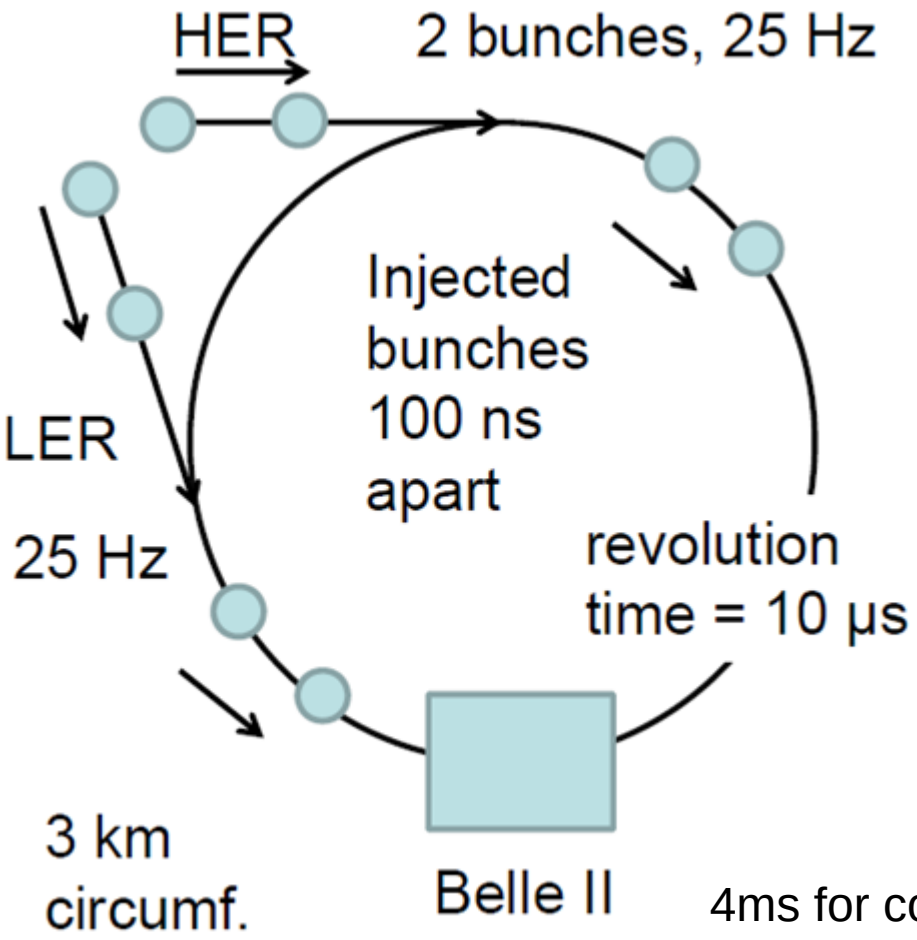
DCD:
"Drain Current Digitizer"

DHP:
"Data Handling Processor"



- DEPFET = depleted p-channel field effect transistor
- Fully depleted sensitive volume
- Charge collection in the "off" state, read out on demand
- Modulation of the FET current by the charge in the internal gate
- Clear contact to empty the internal gate
- Low power dissipation
  - DEPFETs ~ 1 W
  - Switcher ~ 1 W
  - DCD/DHP ~ 8 W on each ladder end

Injection Scheme & Injection Noise



Problem:

‚Noisy' bunches cannot be gated away

4ms for cooling mechanism

=> Loss of particles (‚noisy' bunches)

Within the sensor - what is needed?

Ideal situation:

Electron-hole pairs are generated when the ‘noisy’ bunches hit the detector

⇒ These electrons should not drift to the internal gate, but should be diverted to the clear contact by applying the clear potential

Consequently, no additional charge is stored in the internal gate

Meanwhile, the previous stored charge (the real signal) should remain in the internal gate

Real situation:

Three aspects (detector related) have to be considered:

1) To which degree can we protect charge in the internal gate from being cleared?

2) How much of the chunk charge will arrive in the internal gate?

3) Which dump voltage do we need at the clear?
(power consumption)

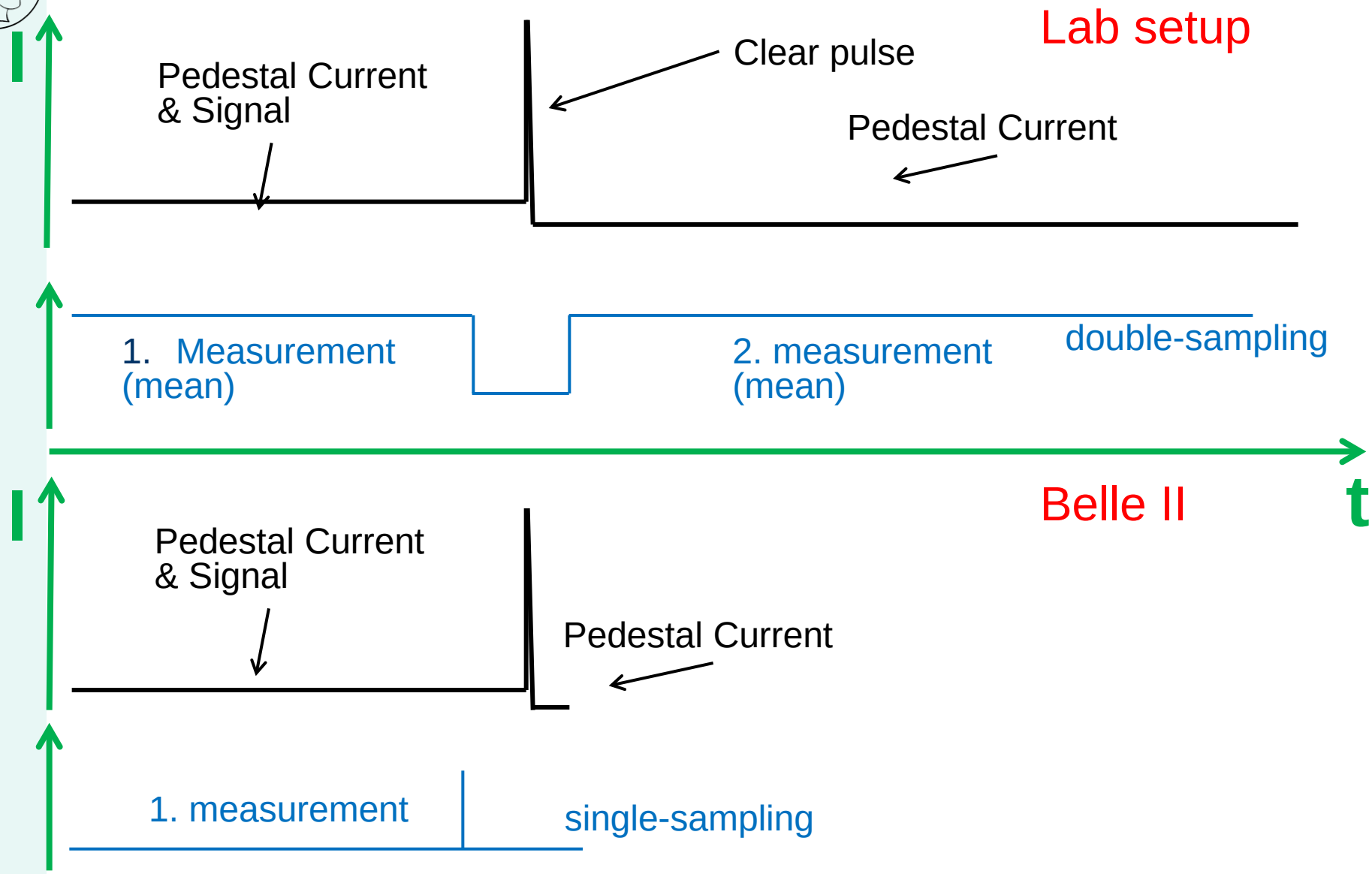
Some Numbers

Pixel in off state: Vgate = 5V

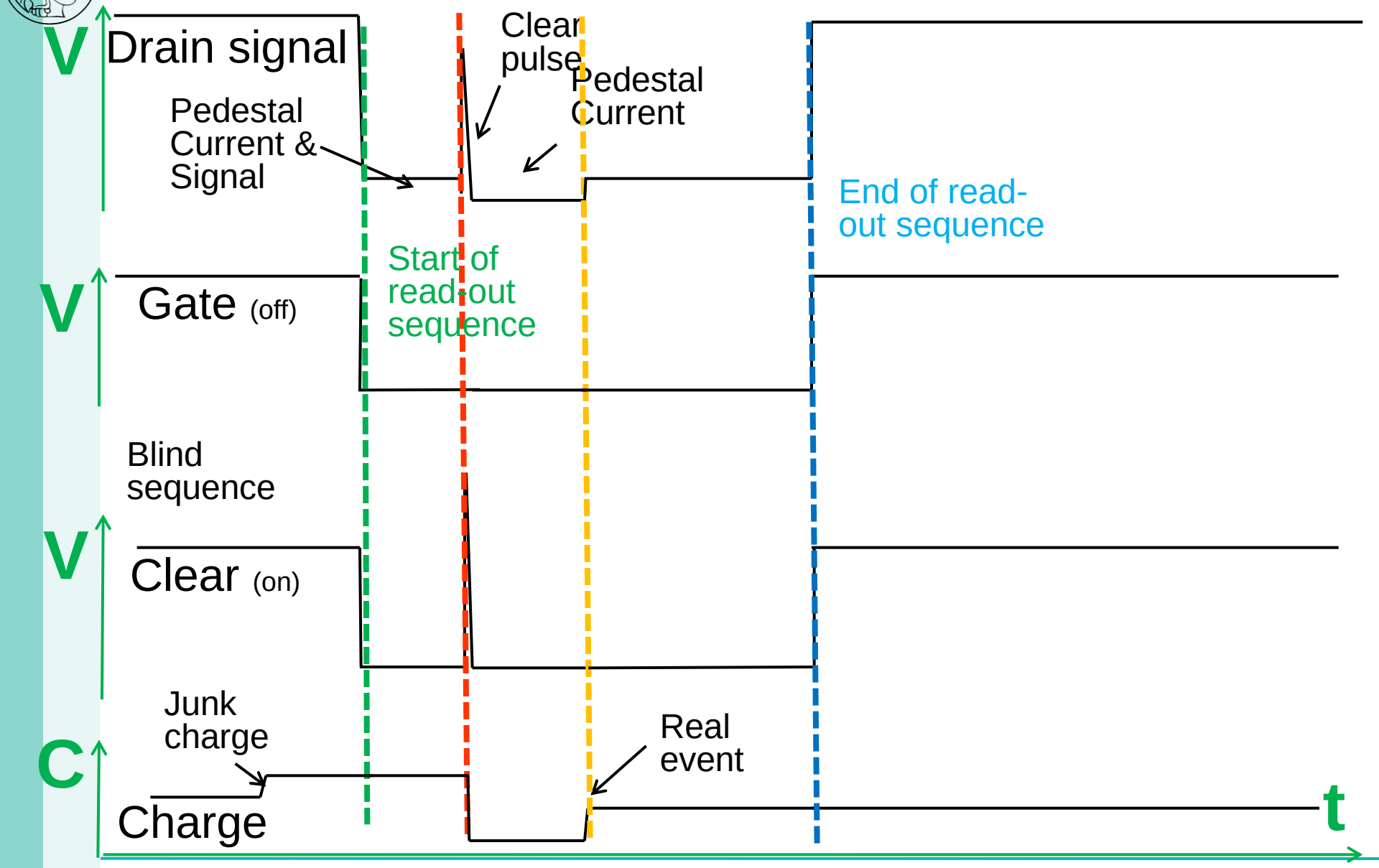
	Internal Gate protection during dump phase Number of electrons in the internal Gate if 10000 electrons are generated:			Signal Charge Protection 10000 electrons stored
Vclear	Beneath internal gate	Globally	Beneath clear	Number of signal electrons removed from the int. Gate
13V	4080	1300	120	3
16V	625	130	0	17
19V	450	90	0	64

Numbers from simultion done by Rainer Richter

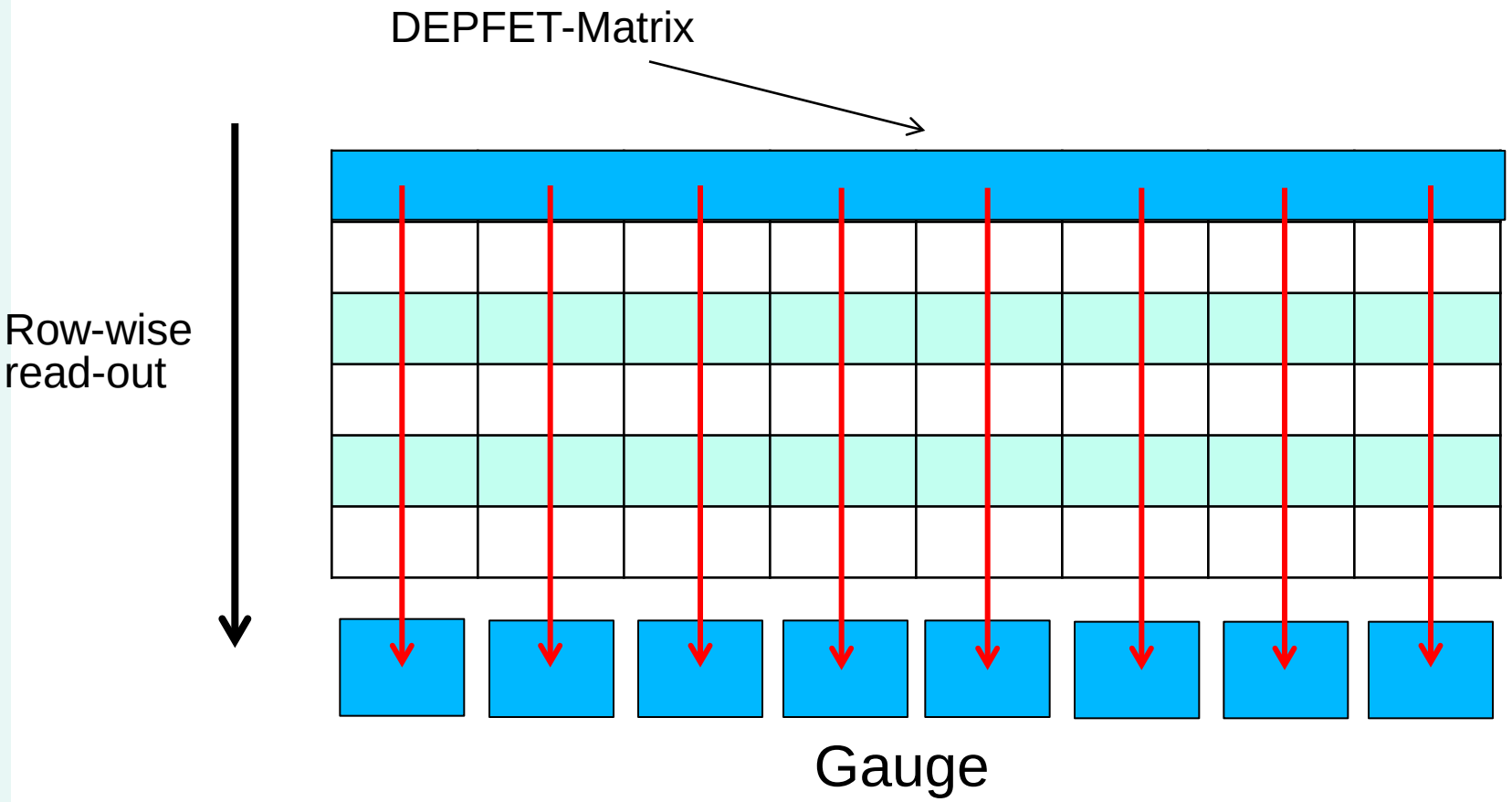
Signal of one pixel



Signal of one pixel

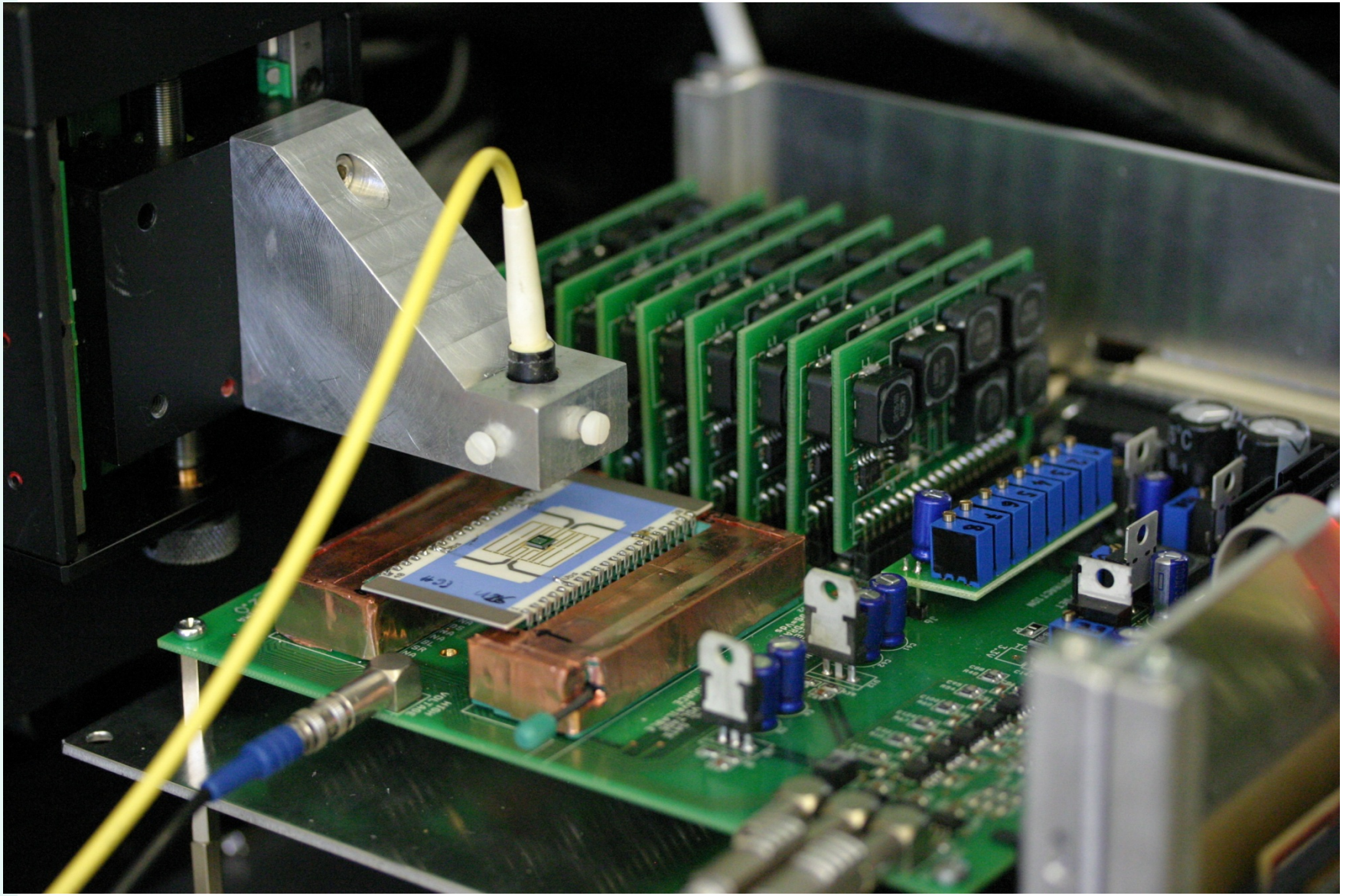


Read-out mechanism

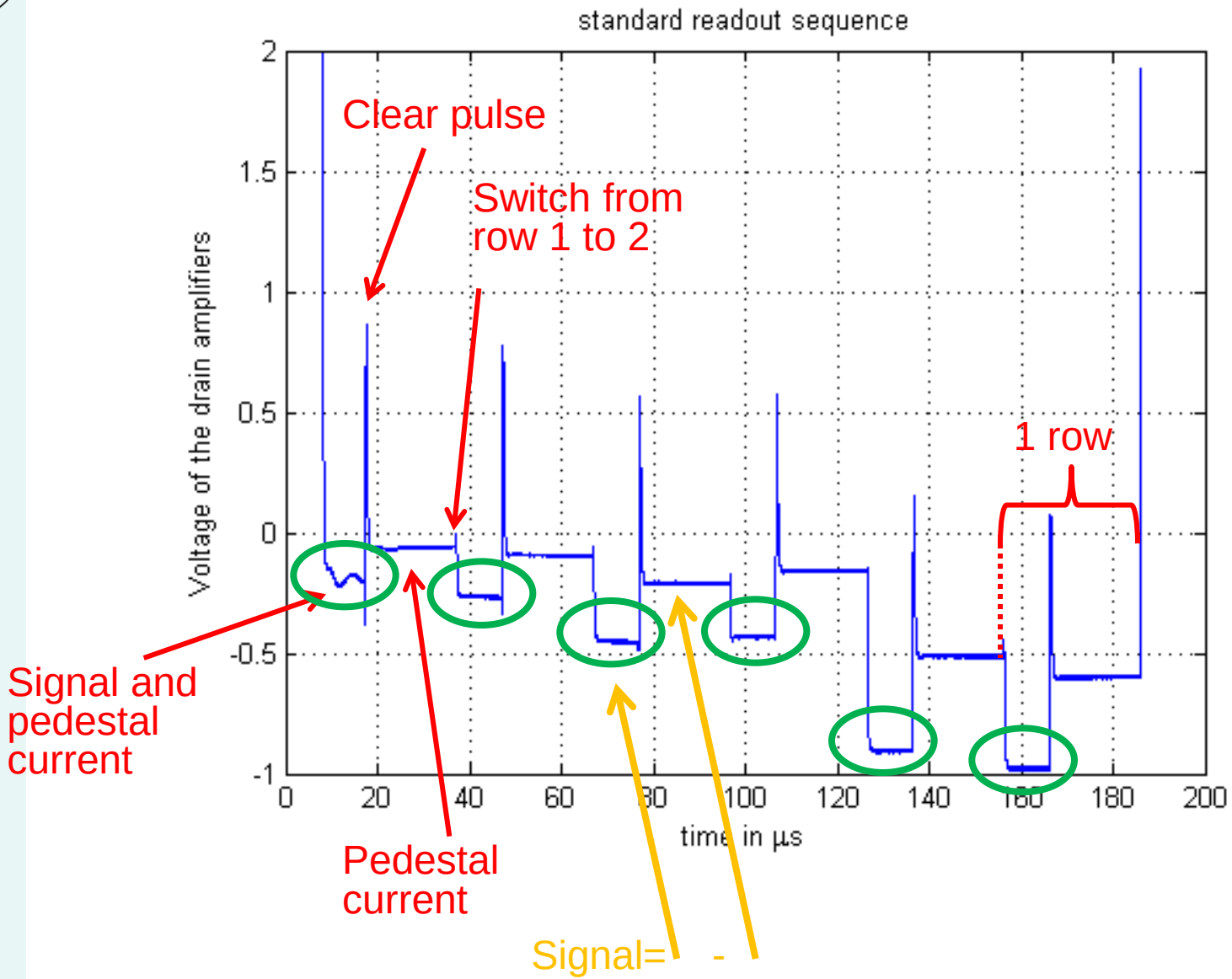


⇒ Receive the signal

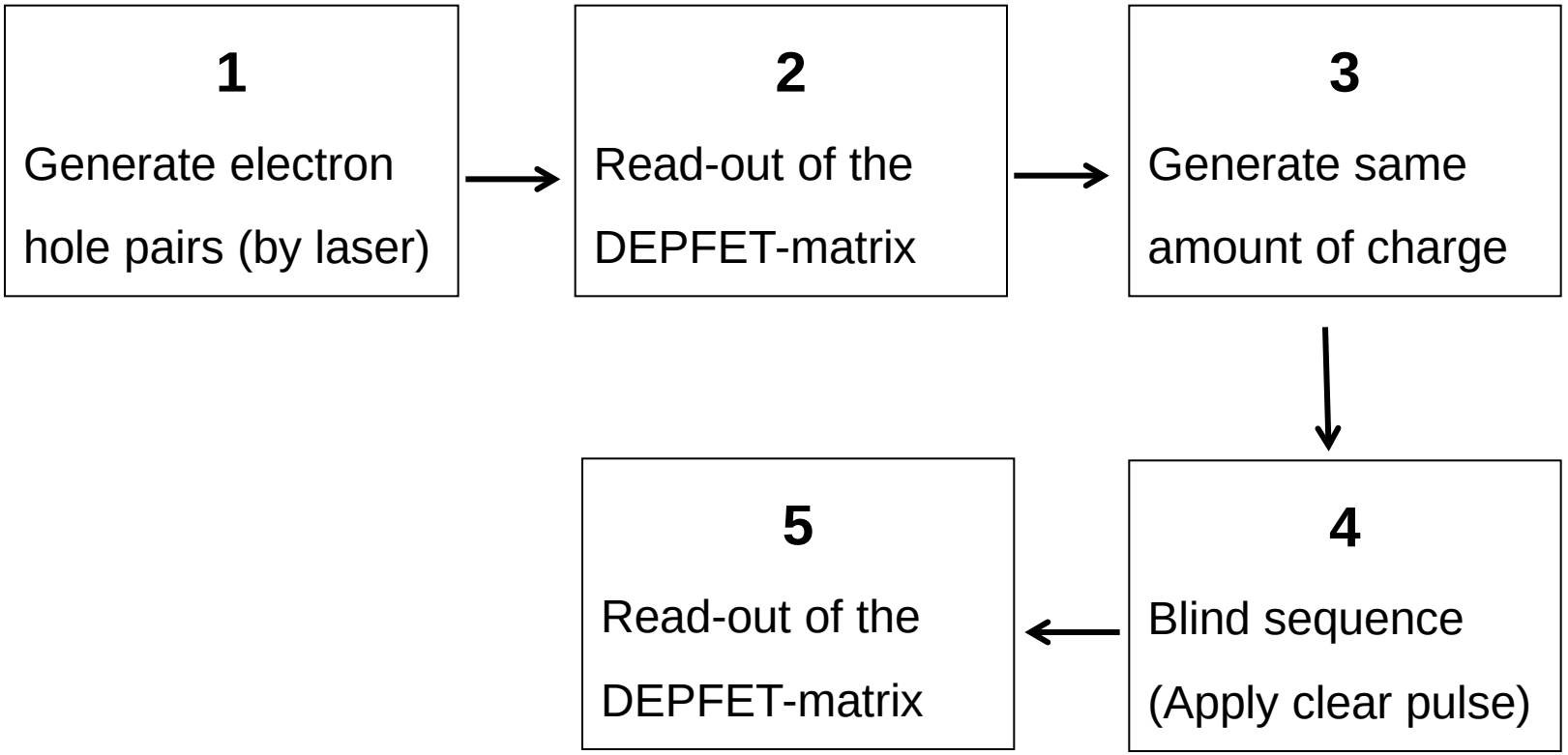
Experimental Setup



Read-out signal of one column



Test-sequence



4a) No charge is created during the blind sequence (i.e. laser off)

4b) Additional charge is generated in the blind sequence (i.e. laser on)

Read-out mechanism for the test-sequence

1
Generate electron hole pairs (by laser)

↓

2
Read-out of the DEPFET-matrix

↓

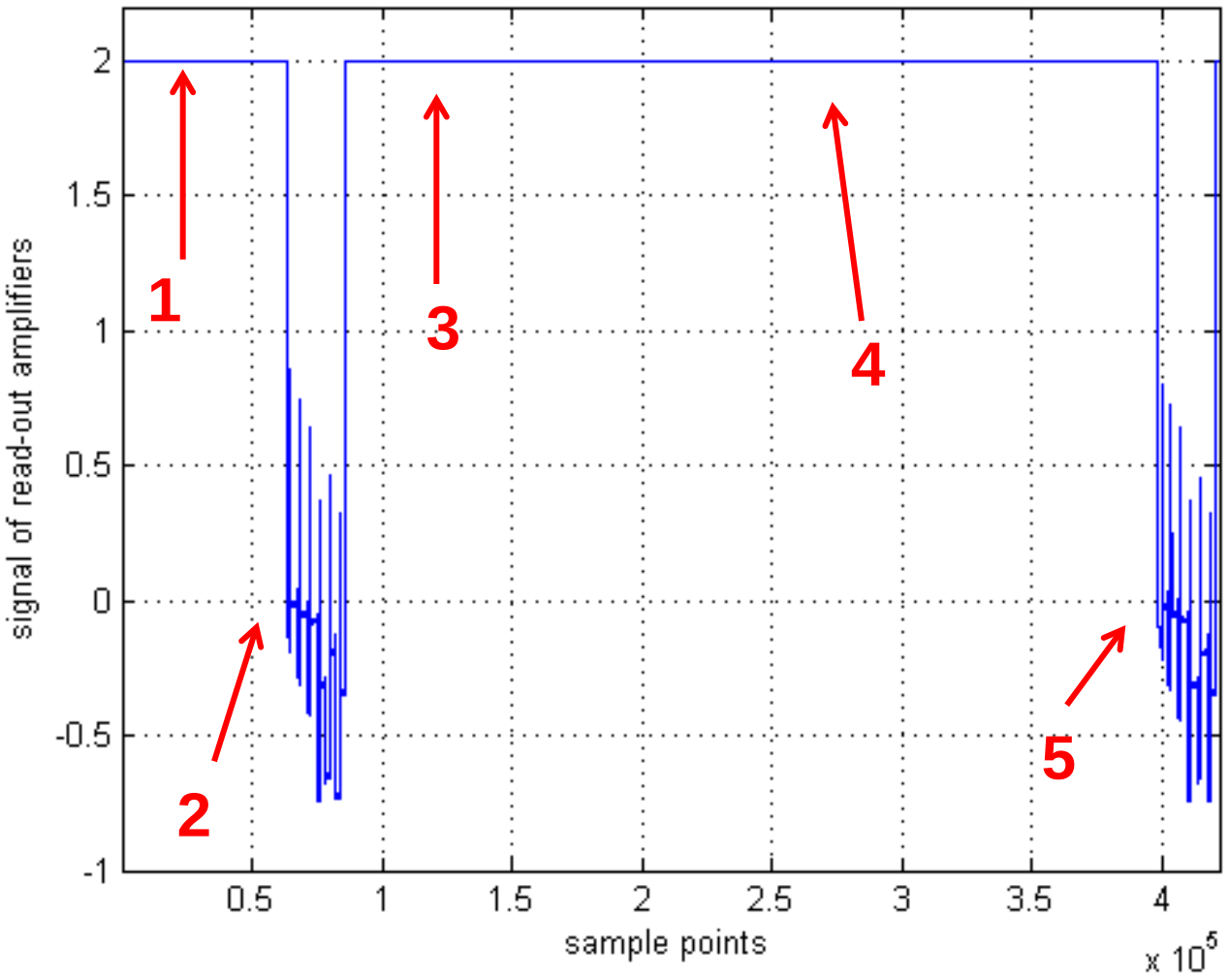
3
Generate same amount of charge

↓

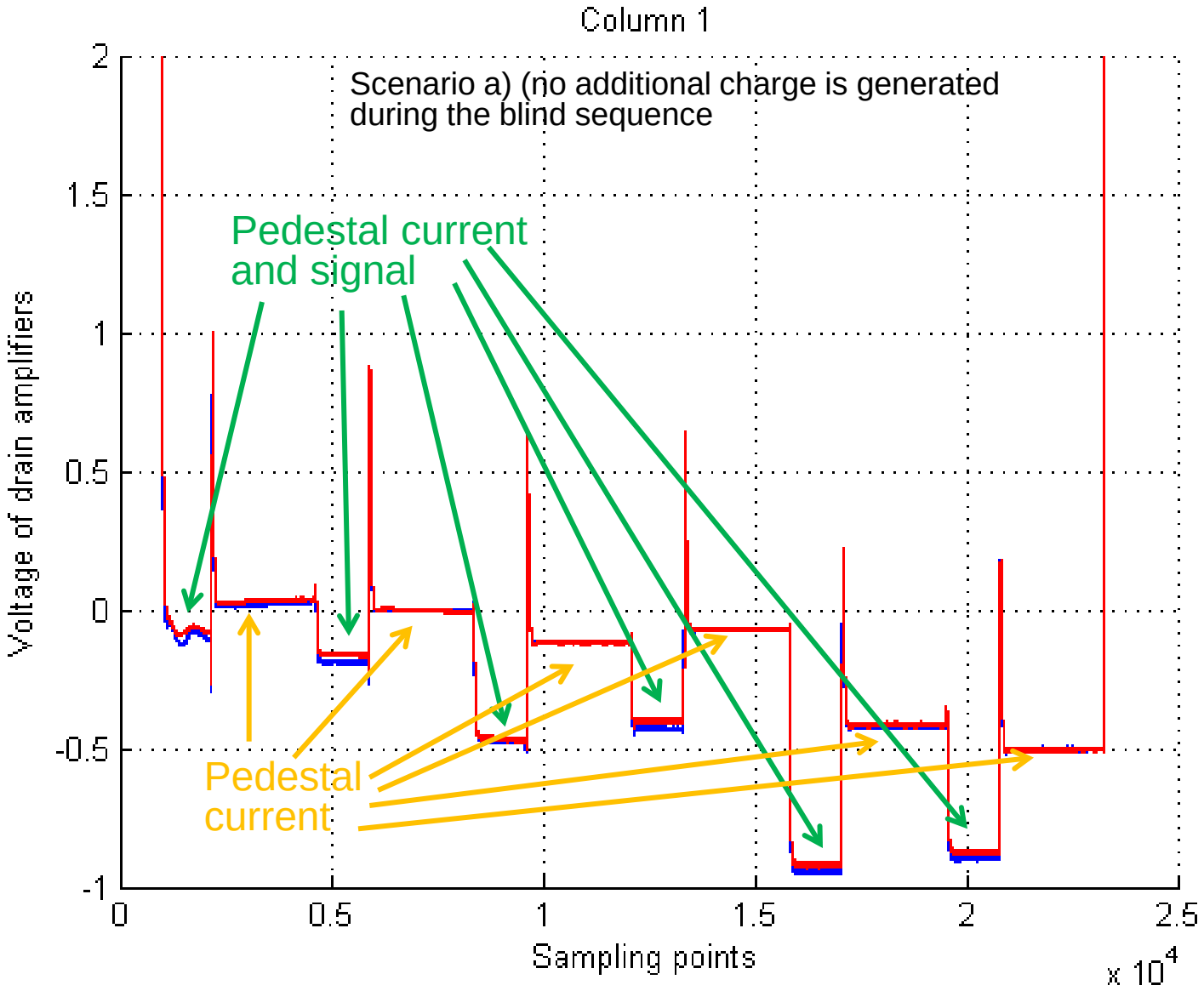
4
Blind sequence (Apply clear pulse)

↓

5
Read-out of the DEPFET-matrix

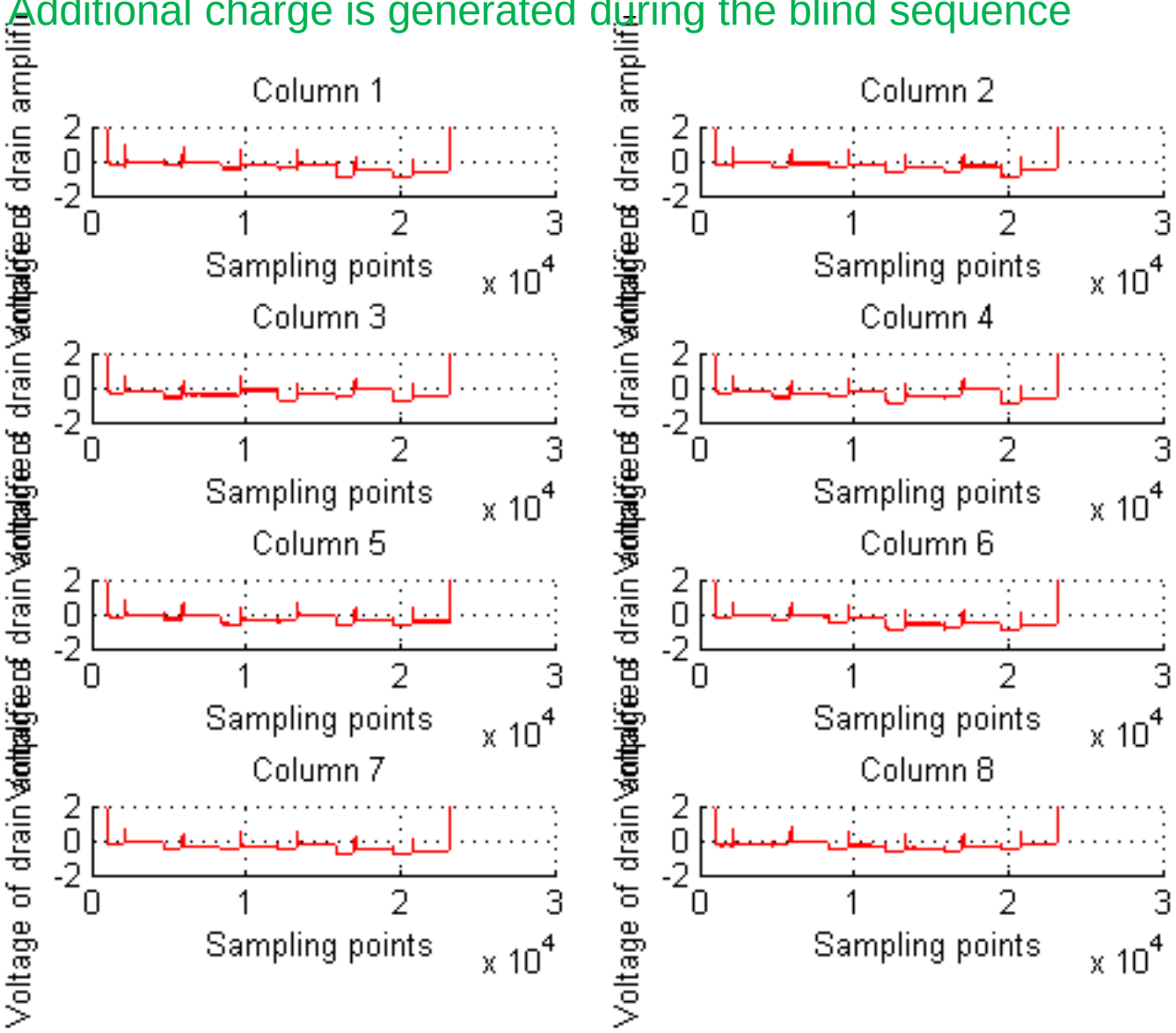


Comparision between 1st & 2nd measurement



Comparision between 1st & 2nd measurement

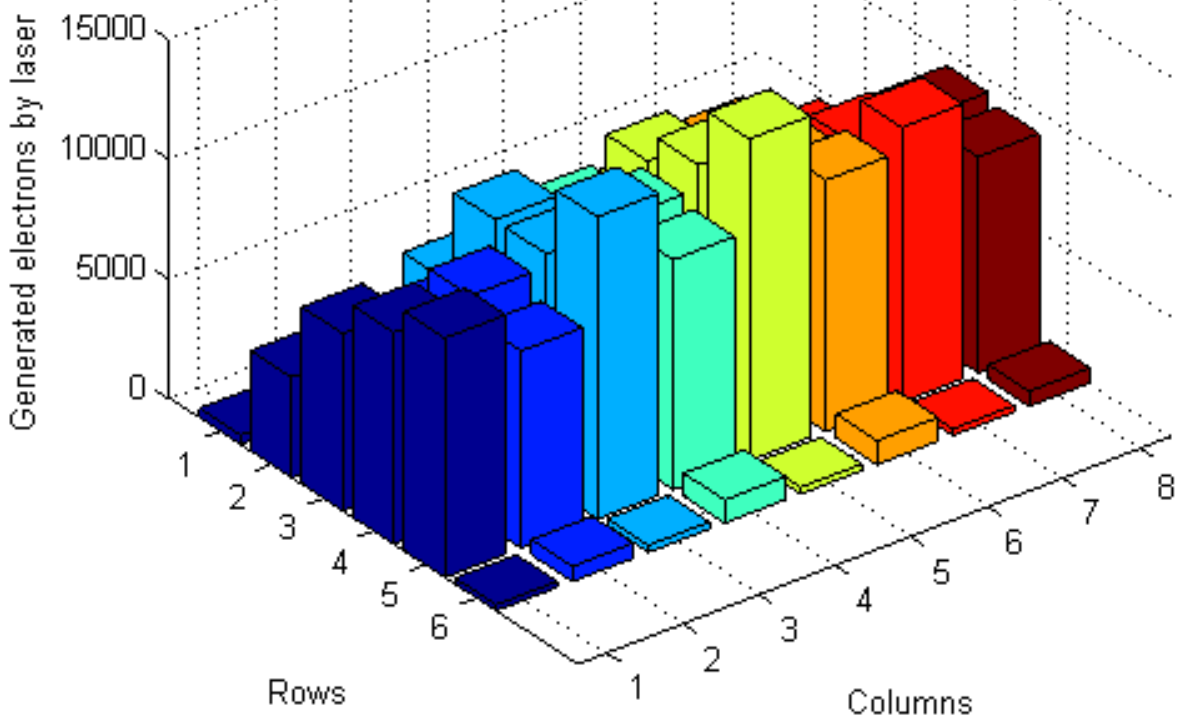
Additional charge is generated during the blind sequence



Comparision between 1st & 2nd measurement

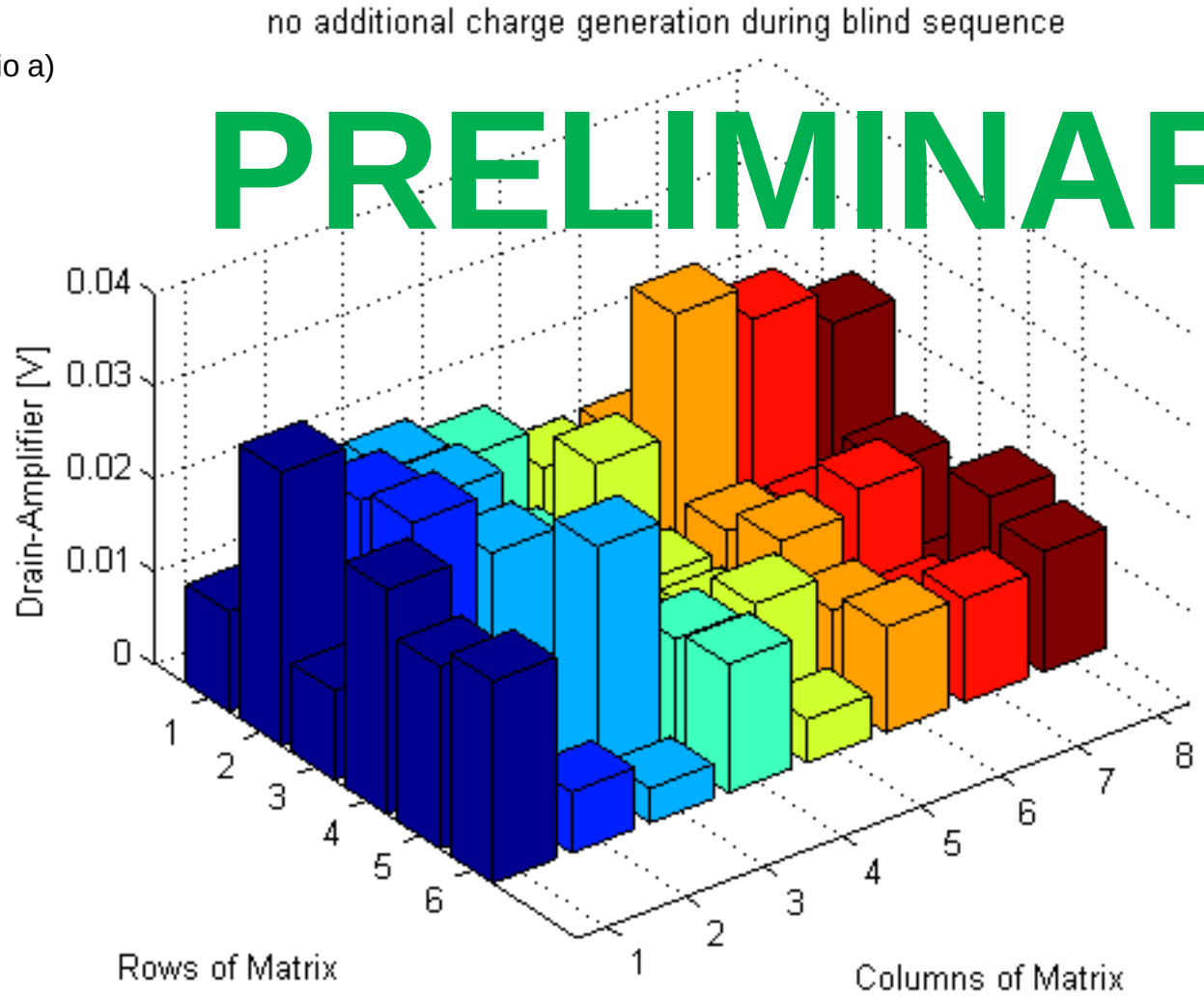
Electrons accumulated in the internal gate after one laser shot

PRELIMINARY



Comparision between 1st & 2nd measurement

Scenario a)



2.05nA ≙ 250µV

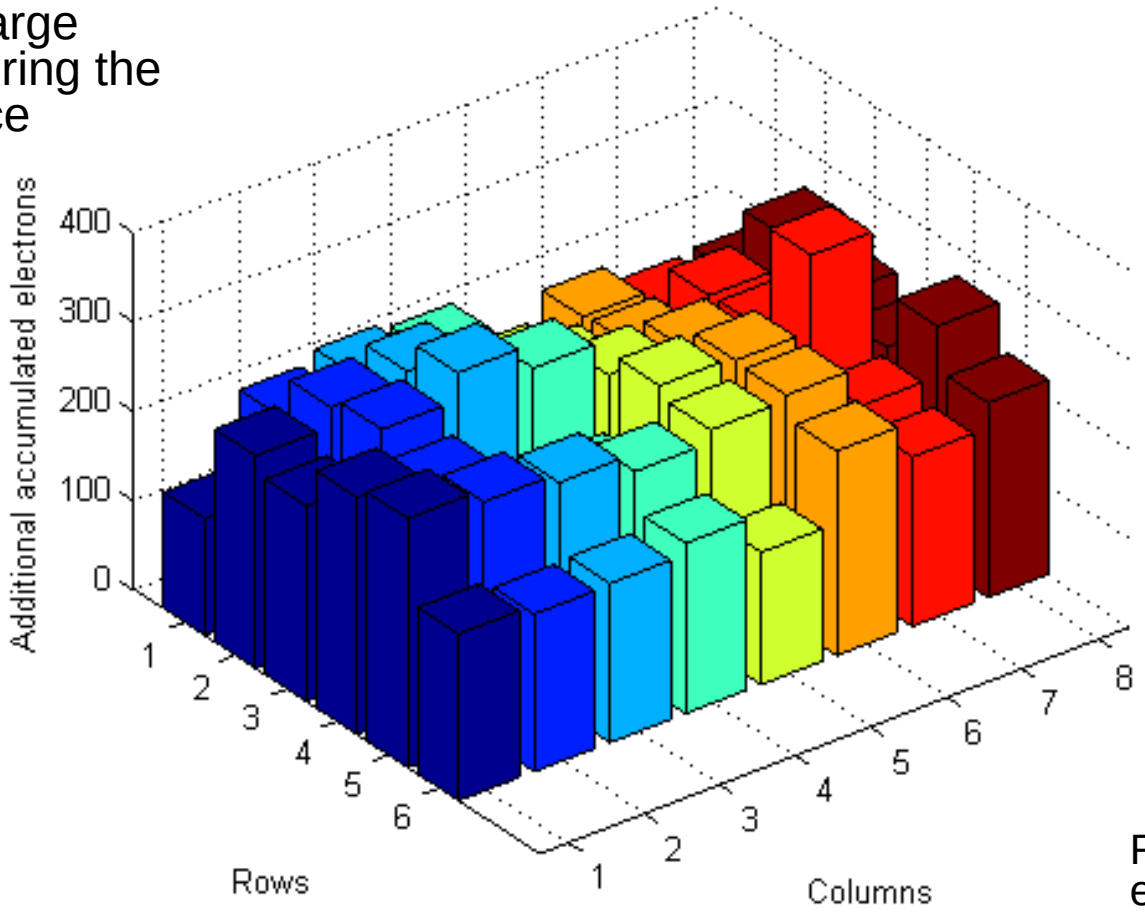
Comparision between 1st & 2nd measurement

Scenario b)

PRELIMINARY

Averaged additional accumulated electrons in the internal gate

Additional charge generation during the blind sequence



Rough estimation

Outlook

- Take **PXD6** matrices
- Scan of clear voltages
- Other radiation sources (Fe55) for laser calibration
- Laser matrix scans (xy-position)
- Apply ‚common mode correction' & consider pedestal currents
- Test in electron-beam (DESY, March 12)

Thank you!

Backup slide

PRELIMINARY

Pedestal current