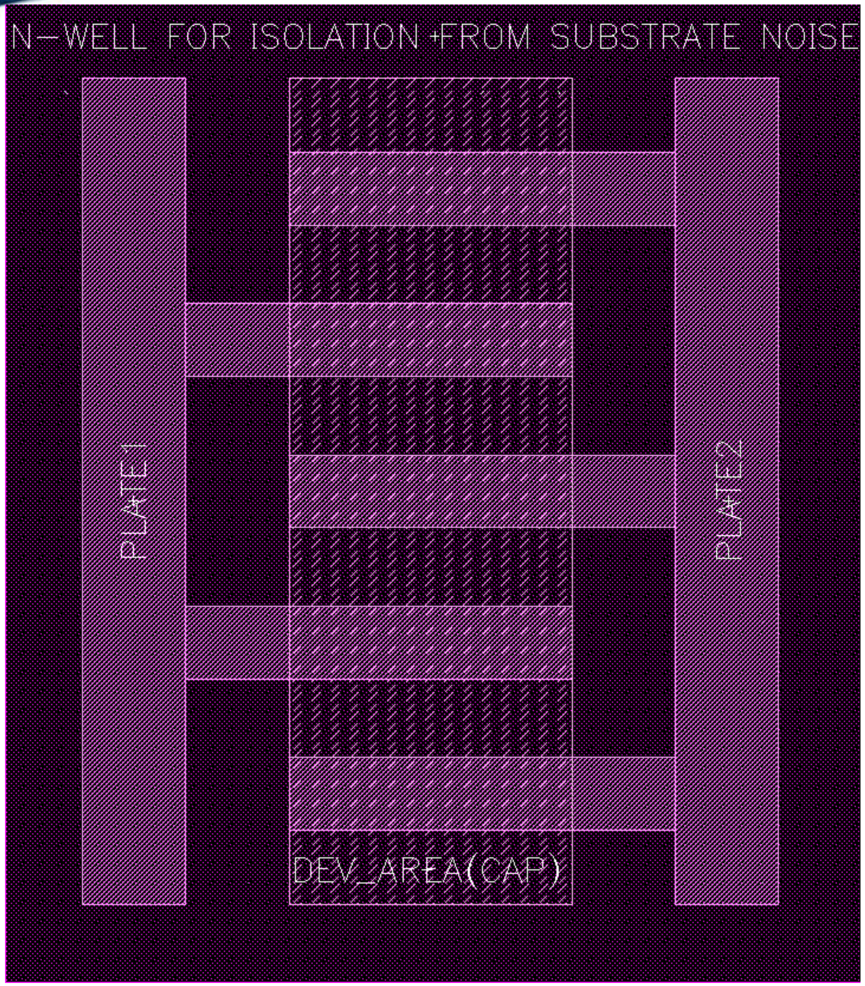
Backup Slides

D. Das
STFC-RAL, UK
29/10/15

Science & Technology Facilities Council
Technology

Pre-amplifier feedback capacitance implmentation



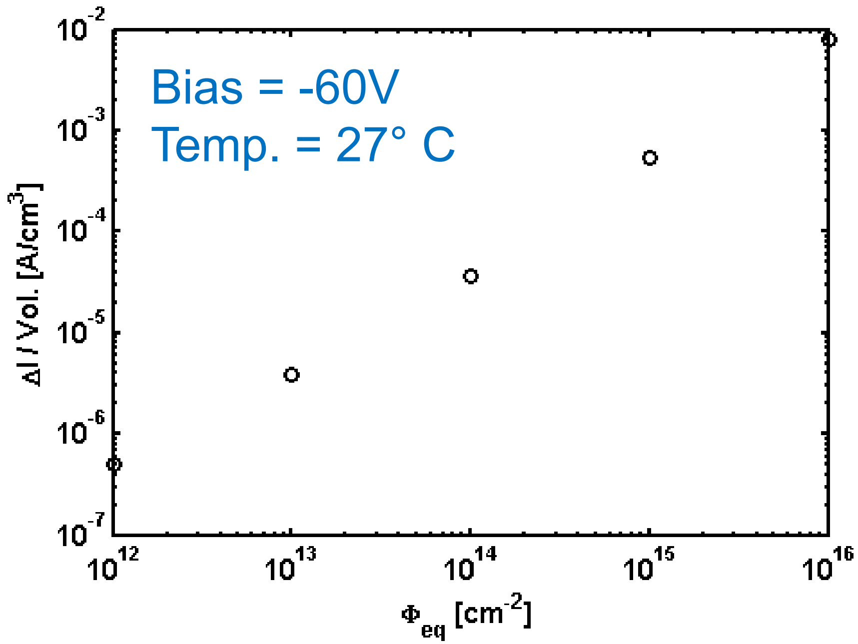
- Used M3, avoided M1 and M2 as they are close to substrate! Didn't stack more metal layers as we want small capacitance ≈ 1fF
- TJ allows metal fringe caps not designed according to it's design rules.
- Recognised by LVS, and we can extract it's capacitance using QRC ☺
- Used QRC **field solver**[1] to extract it's cap to be **1.2fF**
- QRC without field solver extracts 0.44fF, doesn't include fringe capacitance!
- Hand calculations give 0.42fF, close to QRC w/o field solver!

[1]*Field solvers provide physically accurate solutions. They calculate electromagnetic parameters by directly solving Maxwell's equations. Due to high calculation burden they are applicable only for very small designs or to parts of the designs.*

Science & Technology Facilities Council
Technology

Leakage current vs geometry from TCAD simulation

During simulated irradiation dark current increases linearly with fluence:



$$\frac{\Delta I}{V} = \alpha \, \Phi_{eq}$$

V = volume of sensor
ΔI = increase of total leakage current
Φ_{eq} = equivalent fluence
α = Current related damage rate

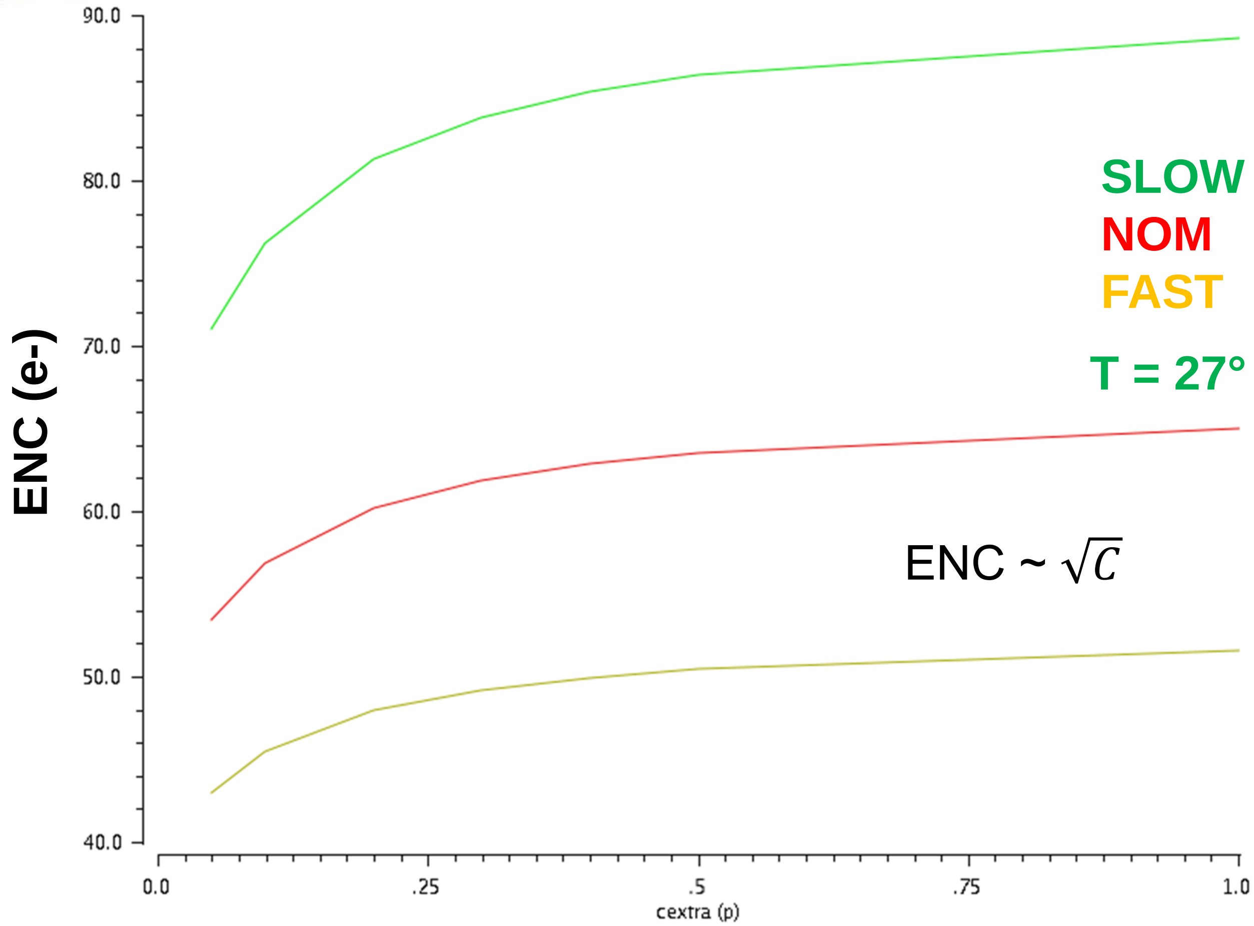
Current related damage rate is temperature dependent → α(T)

Geometry	Leakage Current @ 1 x 10^{16} n_{eq} [cm^{-2}] Bias = -60V
40µm x 25µm x 40µm	3.2pA
40µm x 25µm x 80µm	6.4pA
40µm x 25µm x 120µm	9.6pA
40µm x 25µm x 200µm	1.6nA
40µm x 25µm x 400µm	3.2nA
40µm x 25µm x 800µm	6.4nA

From simulation results at 27°C:
α ≈ 80 x 10^{-18} A/m

Science & Technology Facilities Council
Technology

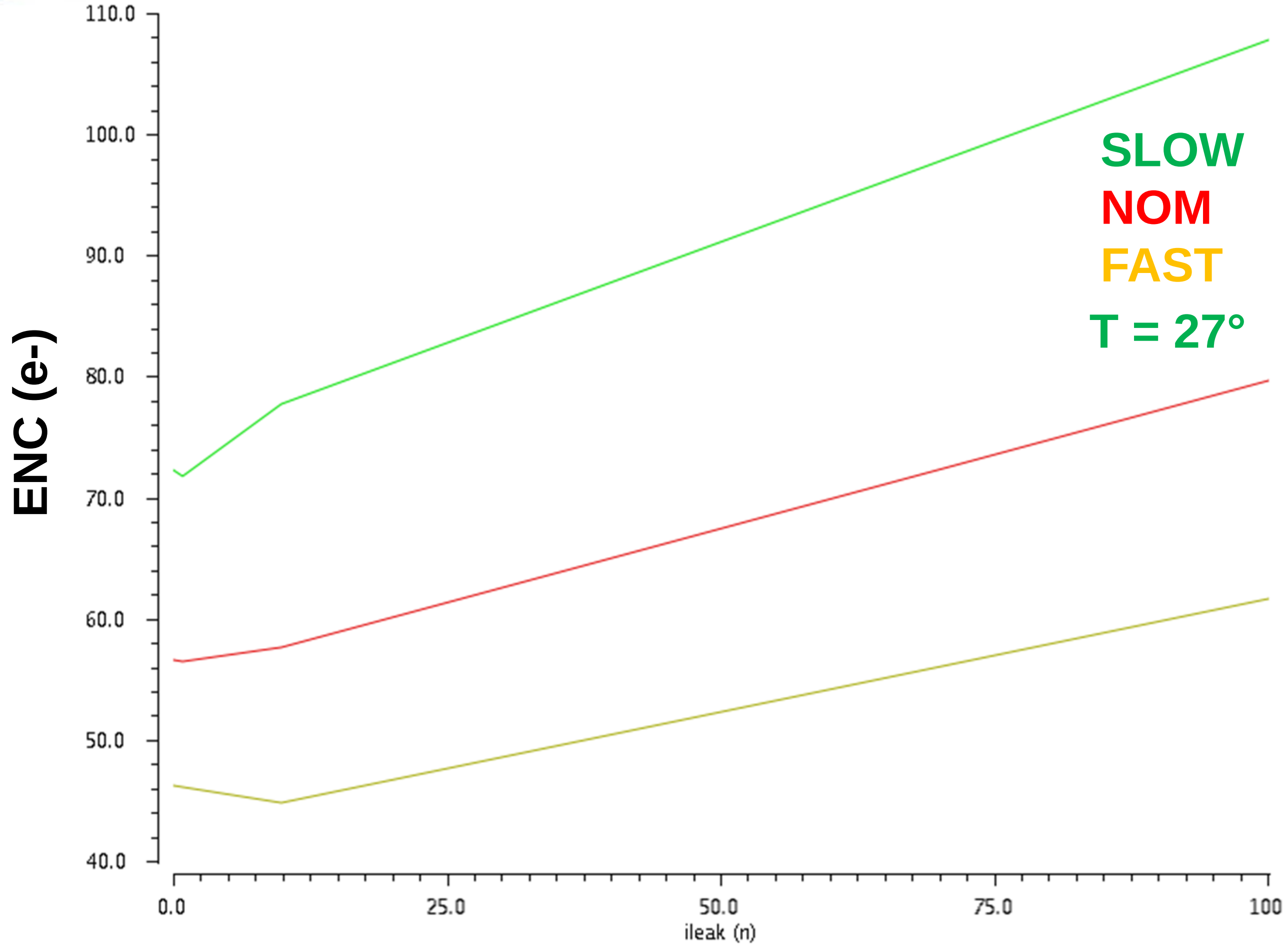
Noise as a function of input capacitance from AC simulation



- Noise at input of comparator as a function of input capacitance
- Process corners: NOM, FAST, SLOW
- Ileakage = 0A

Science & Technology Facilities Council
Technology

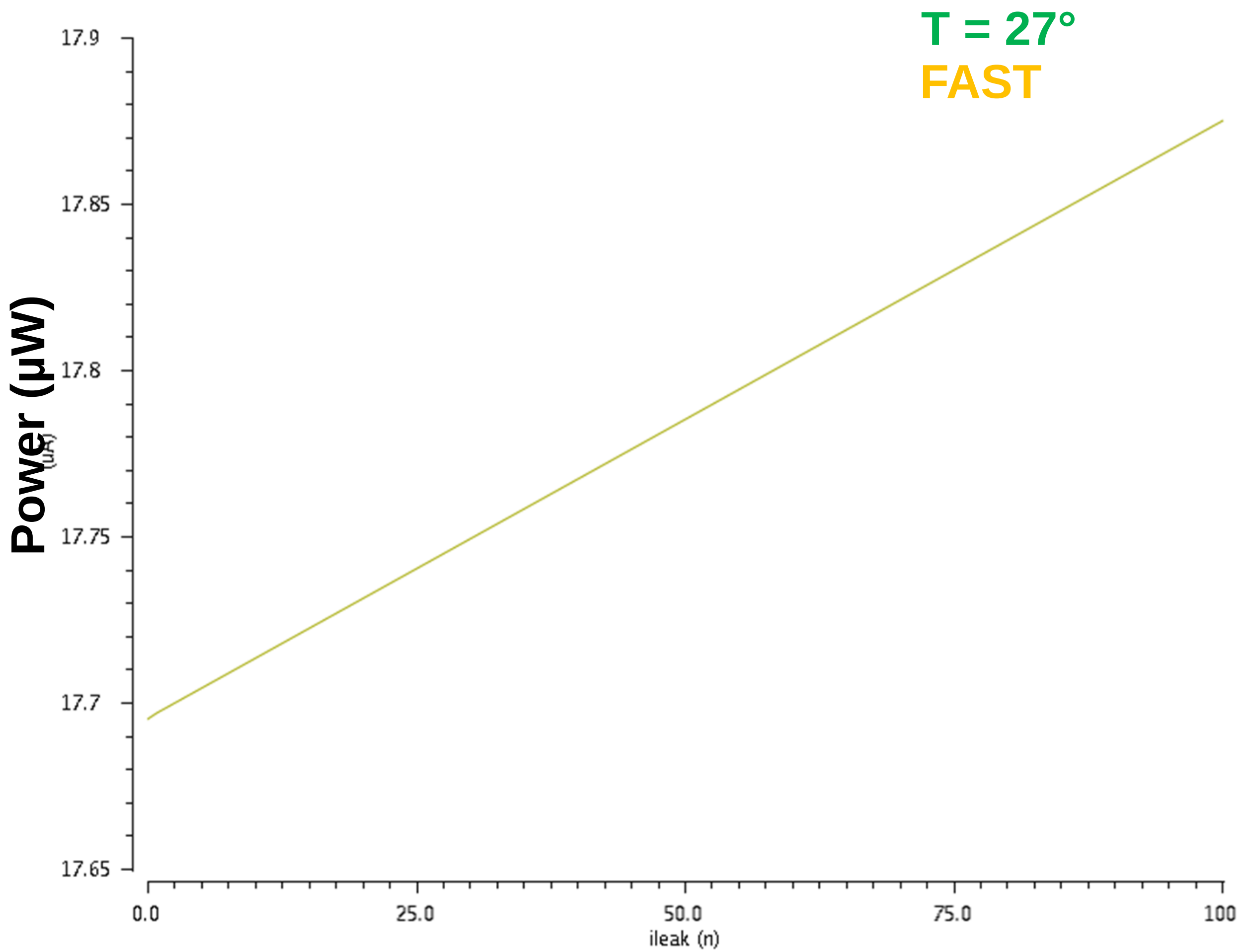
Noise as a function of detector ileakage from AC simulation



- Noise at input of comparator as a function of leakage current
- Process corners: NOM, FAST, SLOW

Science & Technology Facilities Council
Technology

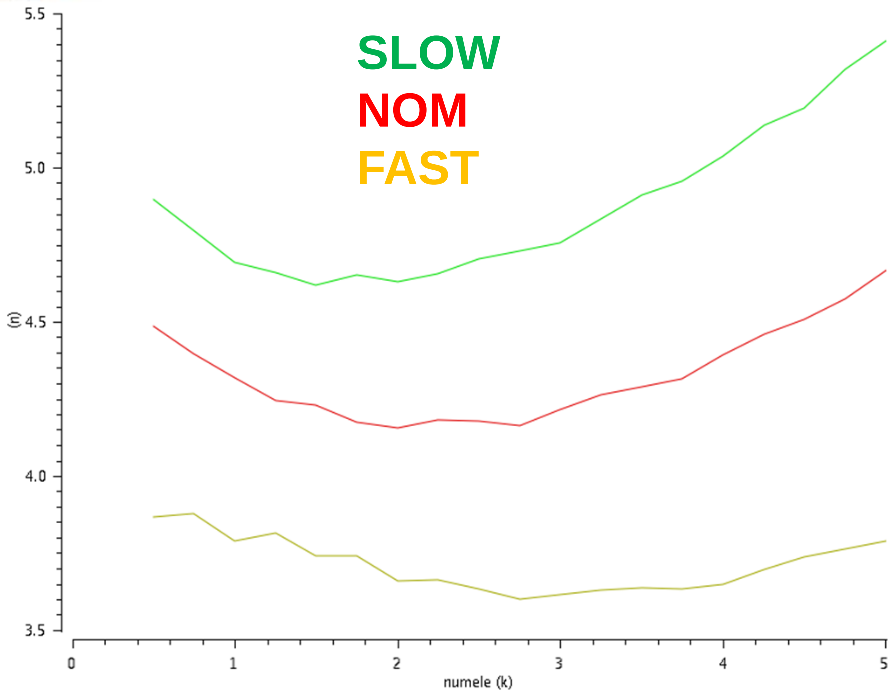
Noise as a function of detector ileakage from AC simulation



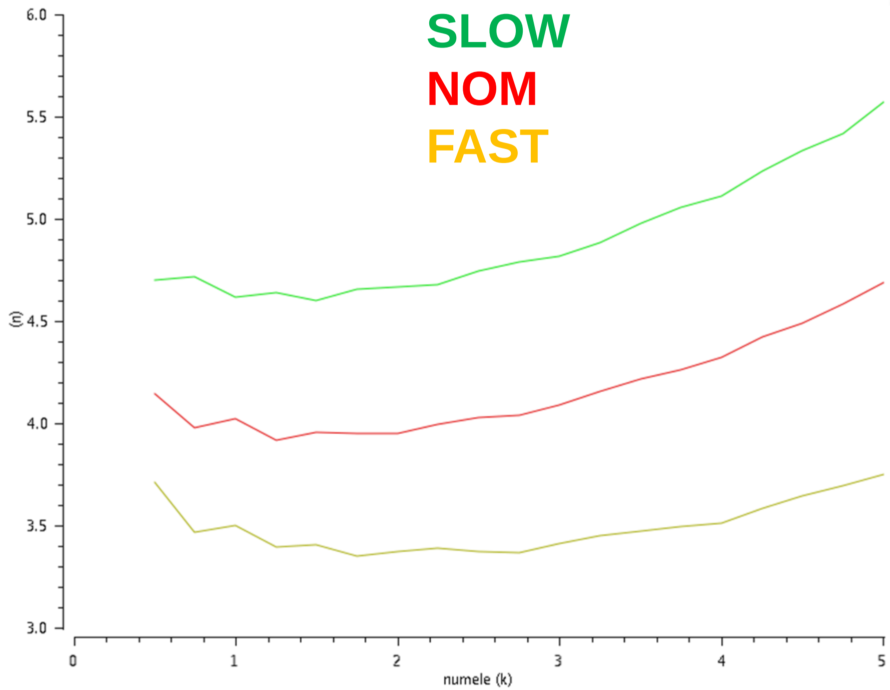
- Power consumption of pre-amplifier as a function of leakage current
- Process corner: FAST (worst case)

Science & Technology Facilities Council
Technology

Trise at comparator input vs signal



T = +40°

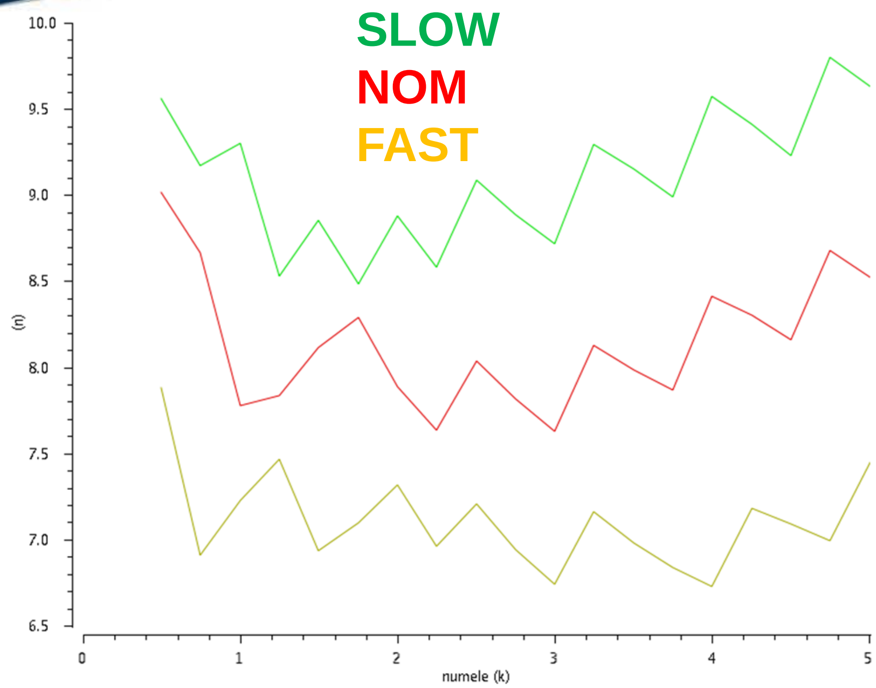


T = -40°

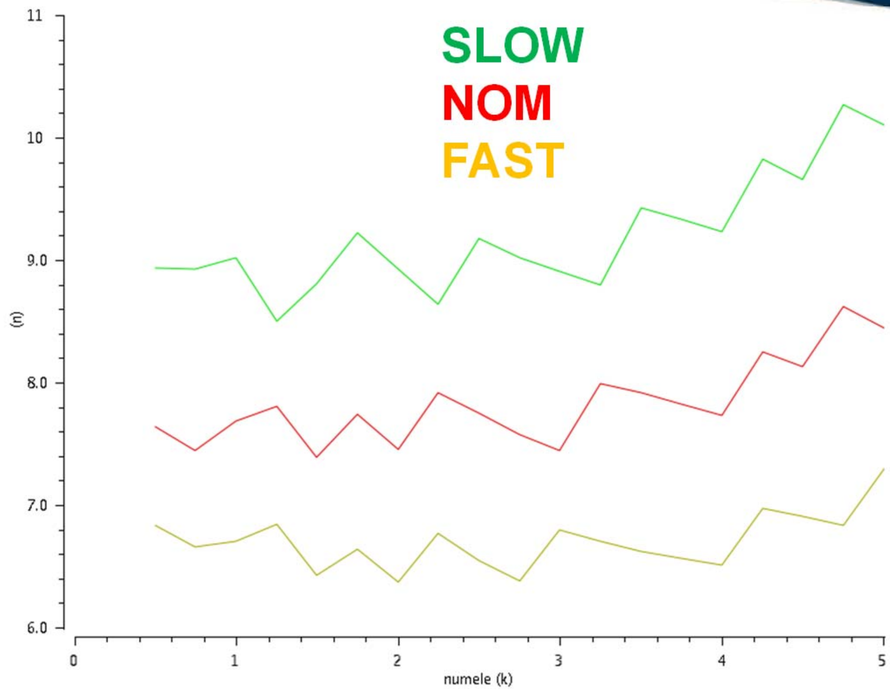
- Trise at input of comparator for signal values from 500e- to 5Ke- in 250e- steps
- Process corners: NOM, FAST, SLOW
- Ileakage = 0A

Science & Technology Facilities Council
Technology

Tpeaking at comparator input vs signal



T = +40°

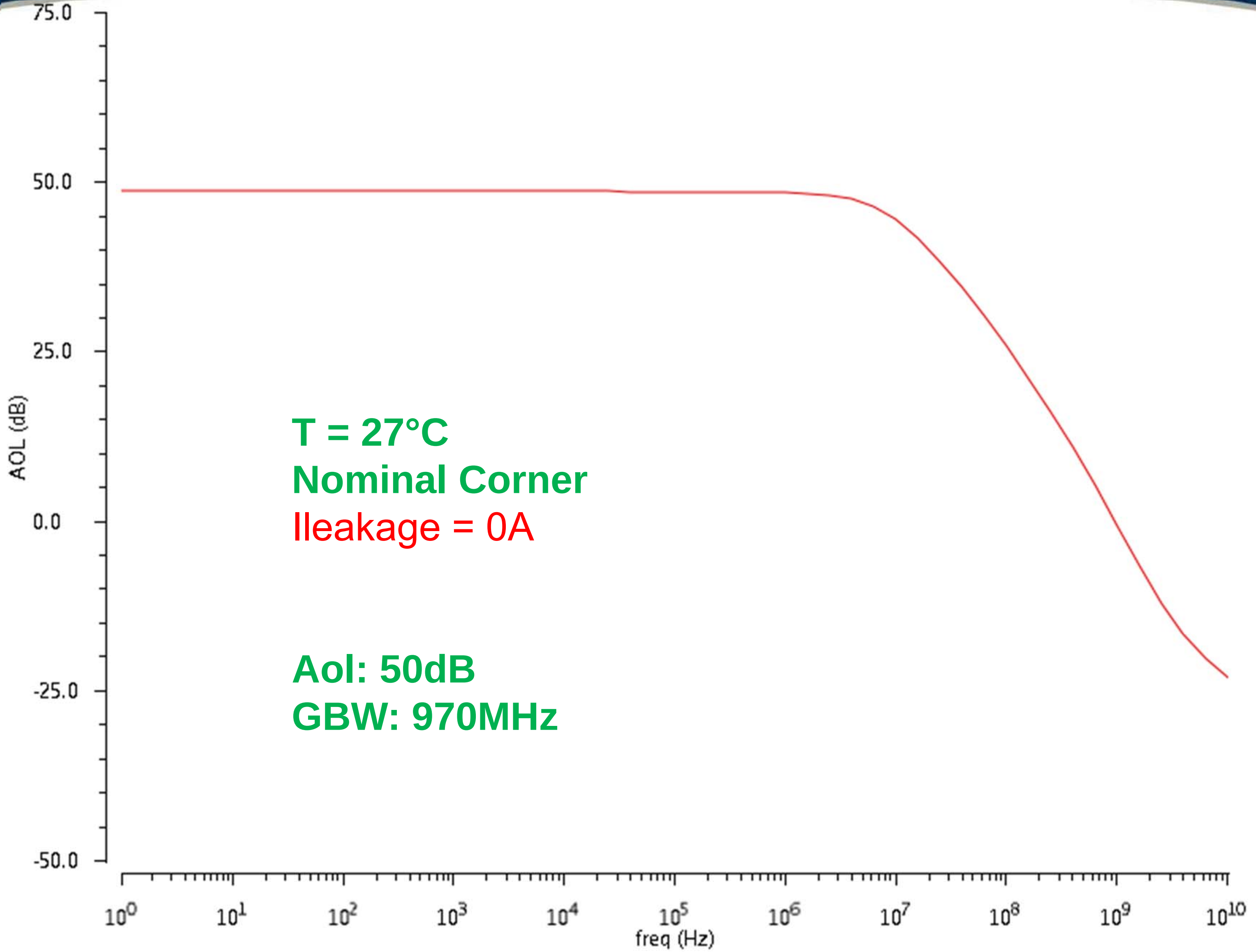


T = -40°

- Tpeaking at input of comparator for signal values from 500e- to 5Ke- in 250e- steps
- Process corners: NOM, FAST, SLOW
- Ileakage = 0A

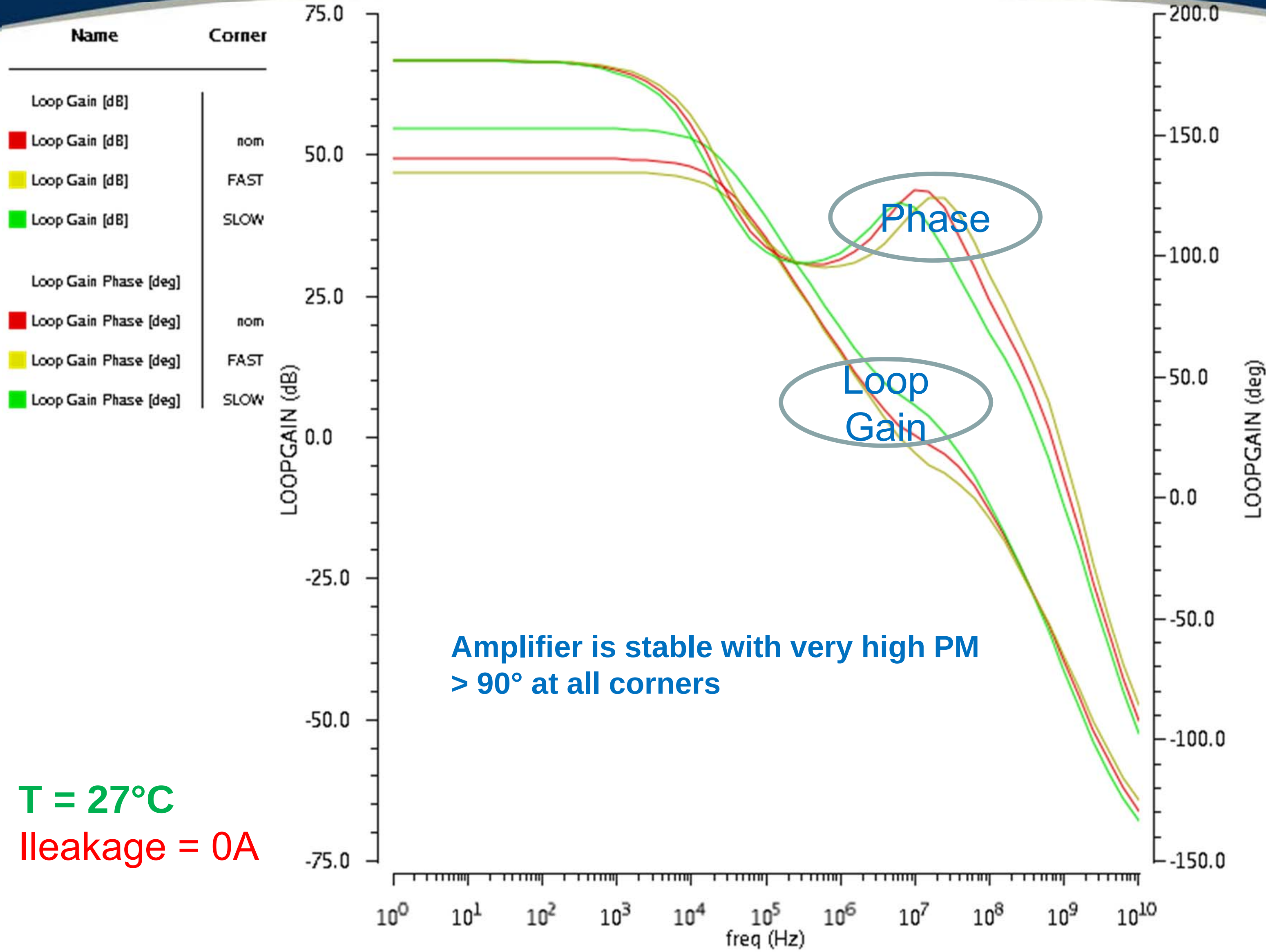
Science & Technology Facilities Council
Technology

Pre-amplifier open-loop gain



Science & Technology Facilities Council Technology

Pre-amplifier stability analysis at all corners



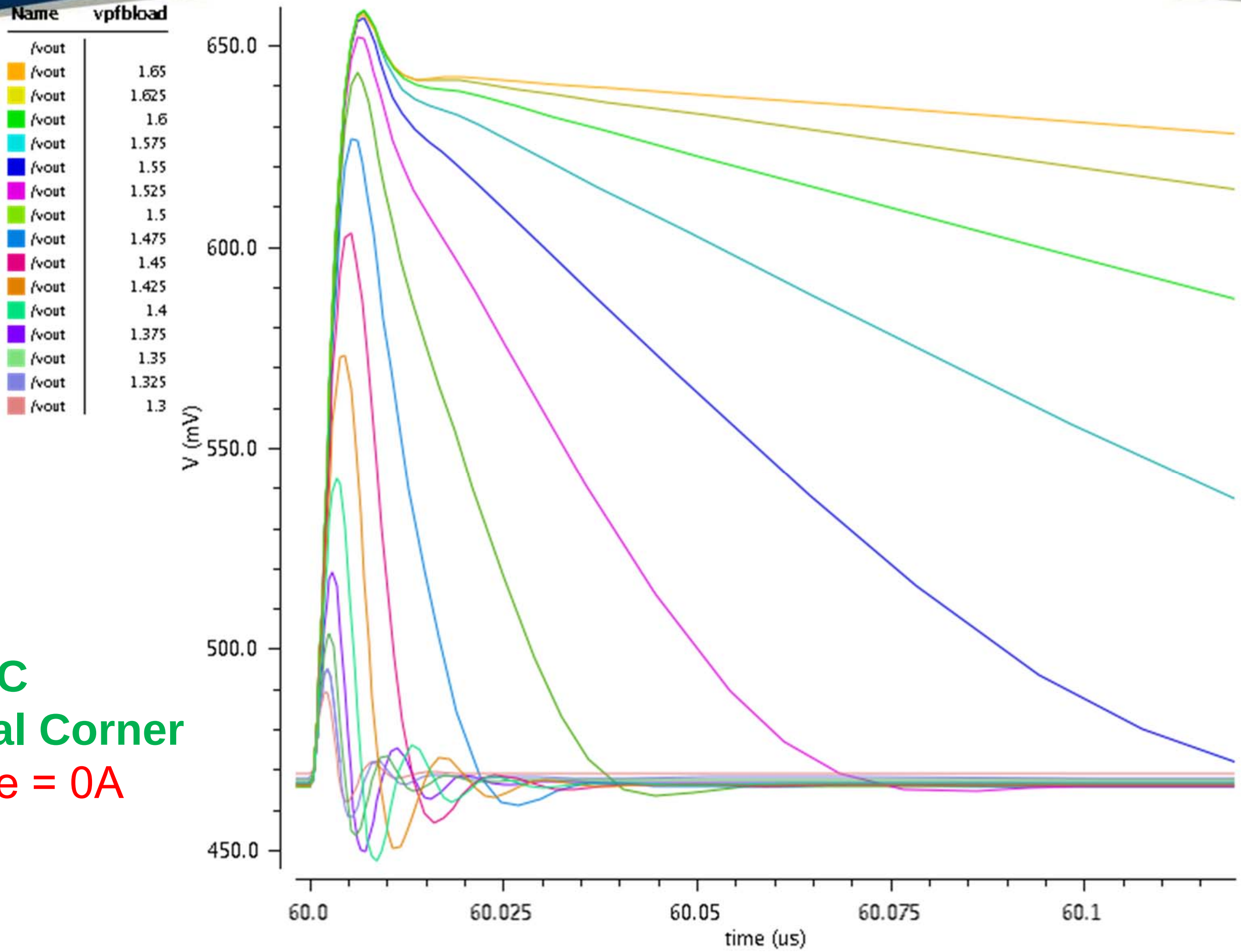
Amplifier is stable with very high PM > 90° at all corners

T = 27°C

Ileakage = 0A

Science & Technology Facilities Council
Technology

Pre-amp discharge control of pre-amplifier (2Ke-)



T = 27°C
Nominal Corner
Ileakage = 0A

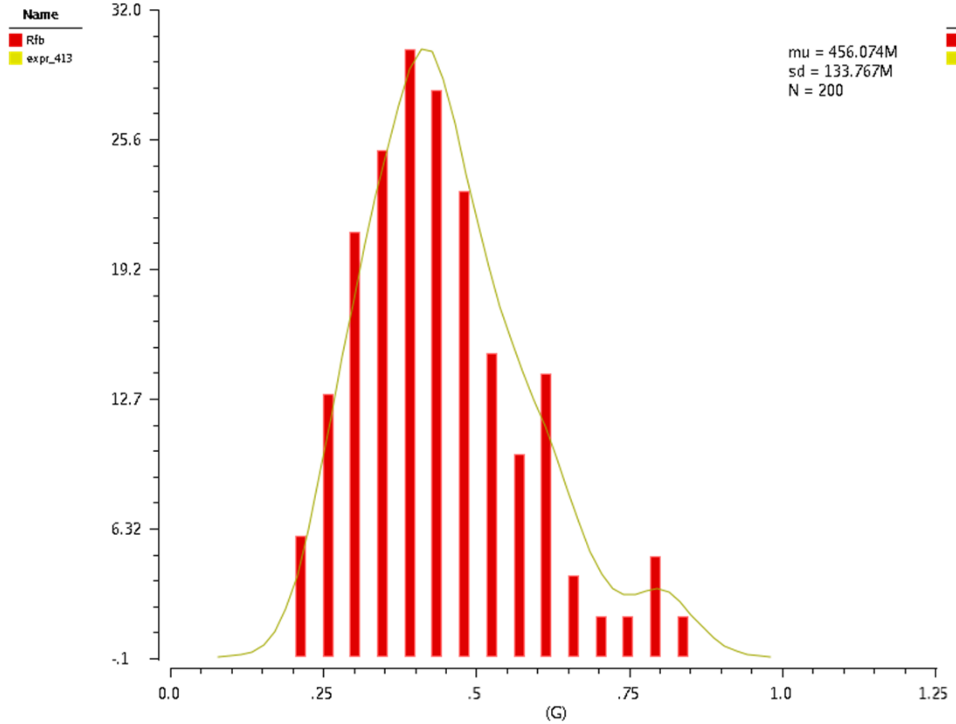
- Changing vPLoadFBPreAmp from1.3V to 1.65V in steps of 25mV
- Oscillations at high feedback current i.e. for vPLoadFBPreAmp < 1.45V (expected)

Science & Technology Facilities Council Technology

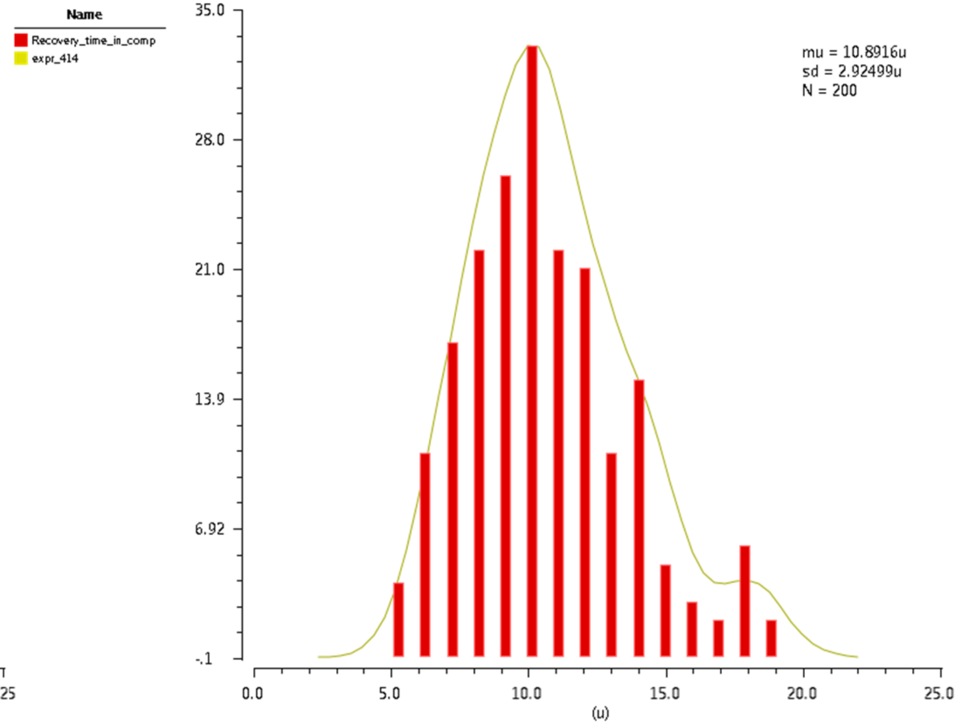
Pre-amp feedback resistance & recovery time variation (5Ke-)

T = - 40°C

Ileakage = 0A



Variation of feedback resistance

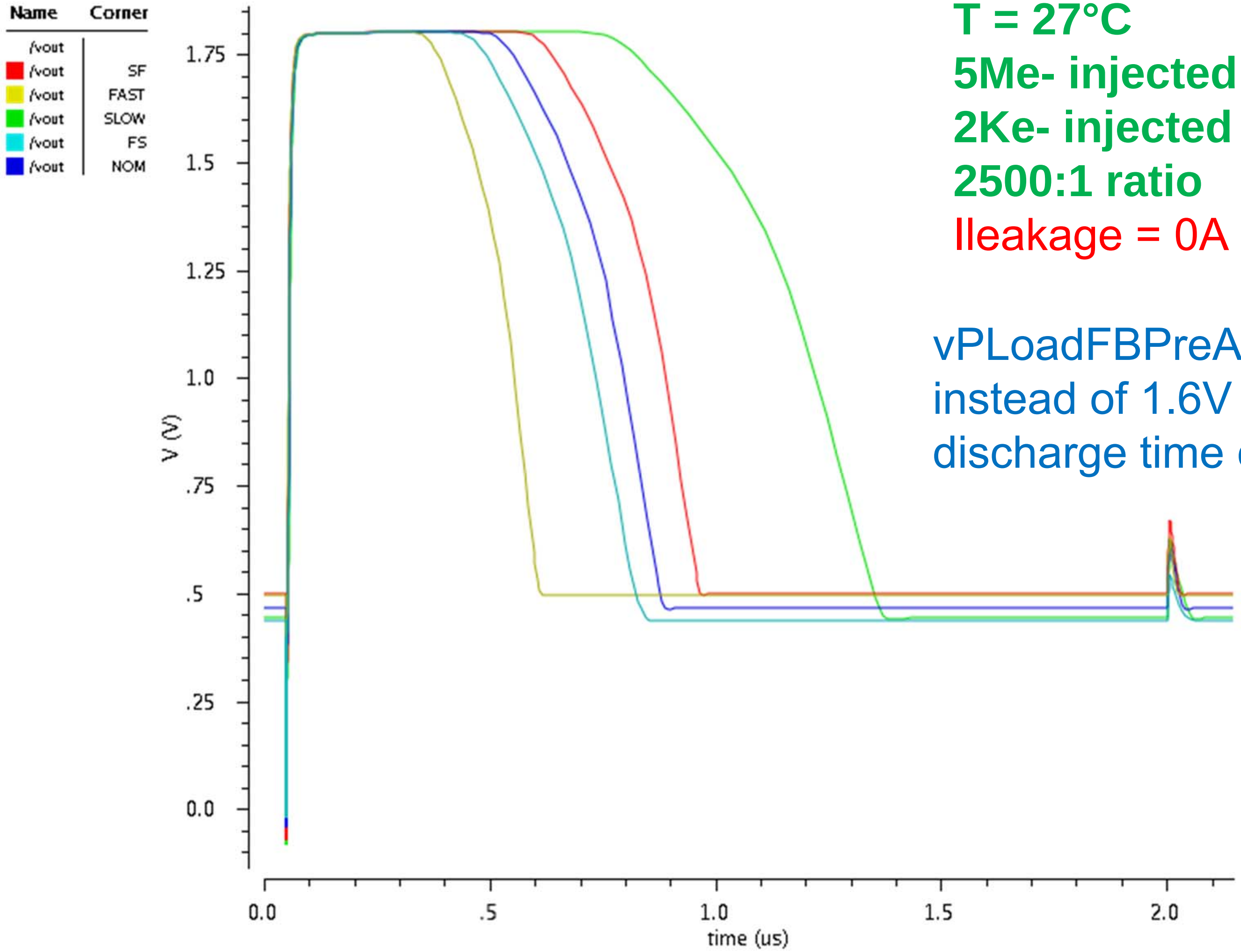


Variation of recovery time

200 MC iterations with vPLoadFBPreAmp set to 1.6V. The results show the variation of the pre-amplifier feedback resistance which affects the discharge time constant and as a result the recovery/discharge time

Science & Technology Facilities Council Technology

Overload Recovery of pre-amplifier @5Million e-



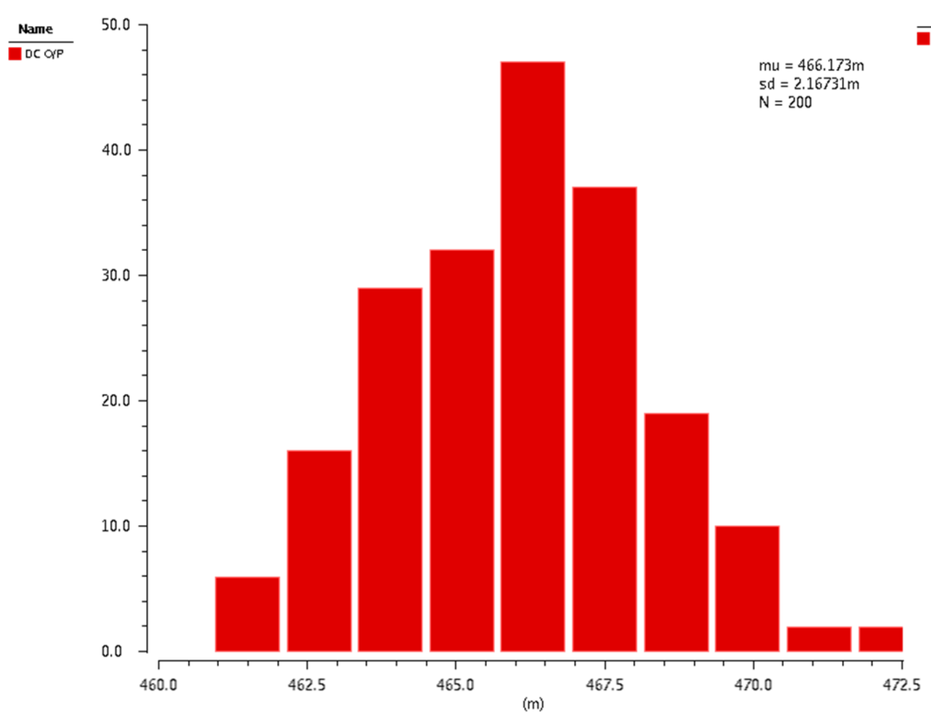
T = 27°C
5Me- injected at 50ns
2Ke- injected at 2µs
2500:1 ratio
Ileakage = 0A

vPLoadFBPreAmp = 1.5V instead of 1.6V to reduce discharge time constant

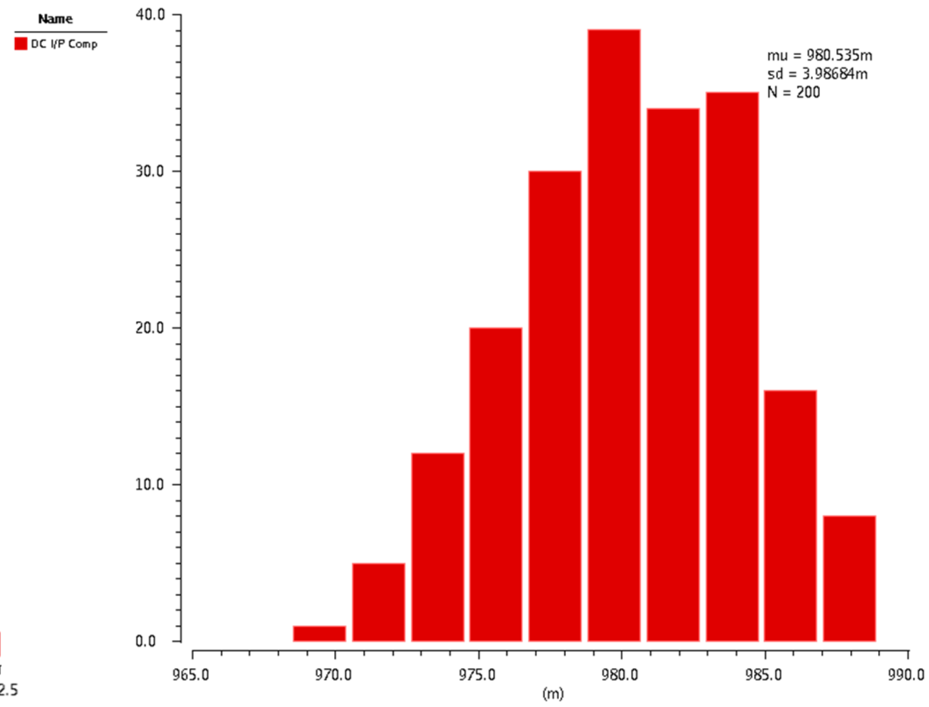
Return to base line within 2µs across all corners

Science & Technology Facilities Council
Technology

Distribution of output DC level of pre-amplifier (Output DC level as Noise)



Before SF



After SF at comparator input

T = 27°C

Ileakage = 0A