Measurement Results on AGIPD02

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Outline

- Measurements on AGIPD02
- Summary

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Measurements on AGIPD02

Measurements done (up to now):

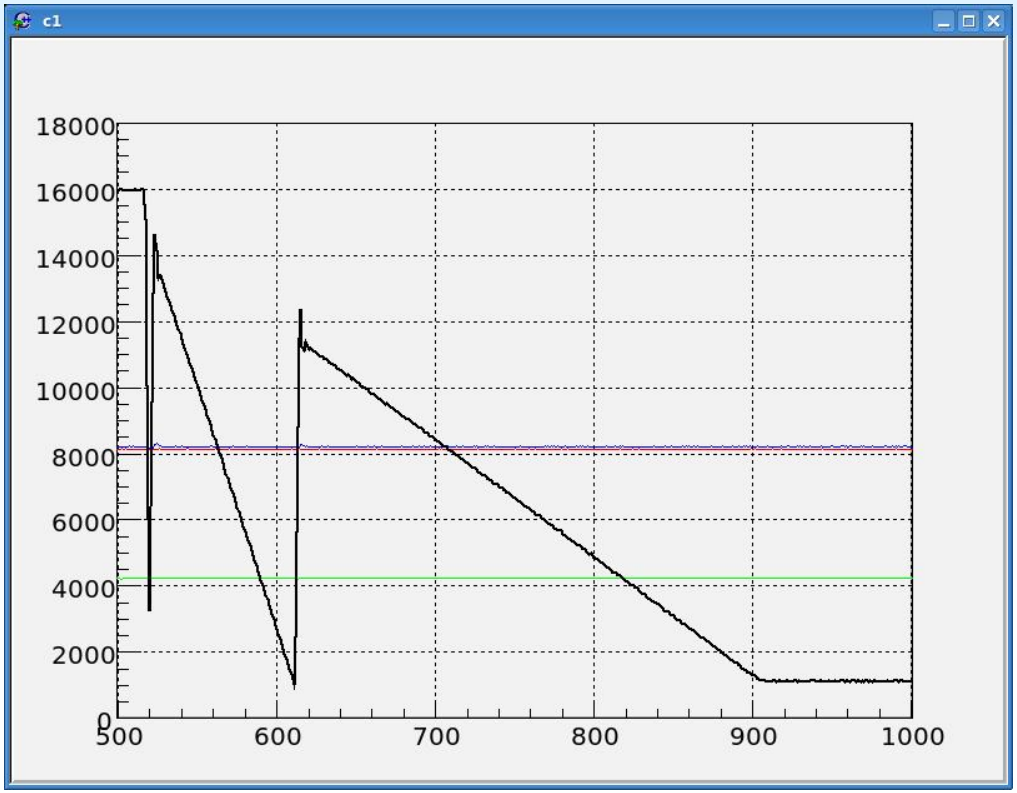
- Linearity and dynamic range of preamplifier
- Charge injection @ gain switches
- Functionality of addressing circuits
- Differences between SP and FP circuits
- Noise level (signal after preamp)
- Radiation hardness

Linearity & Dynamic Range of Preamplifier

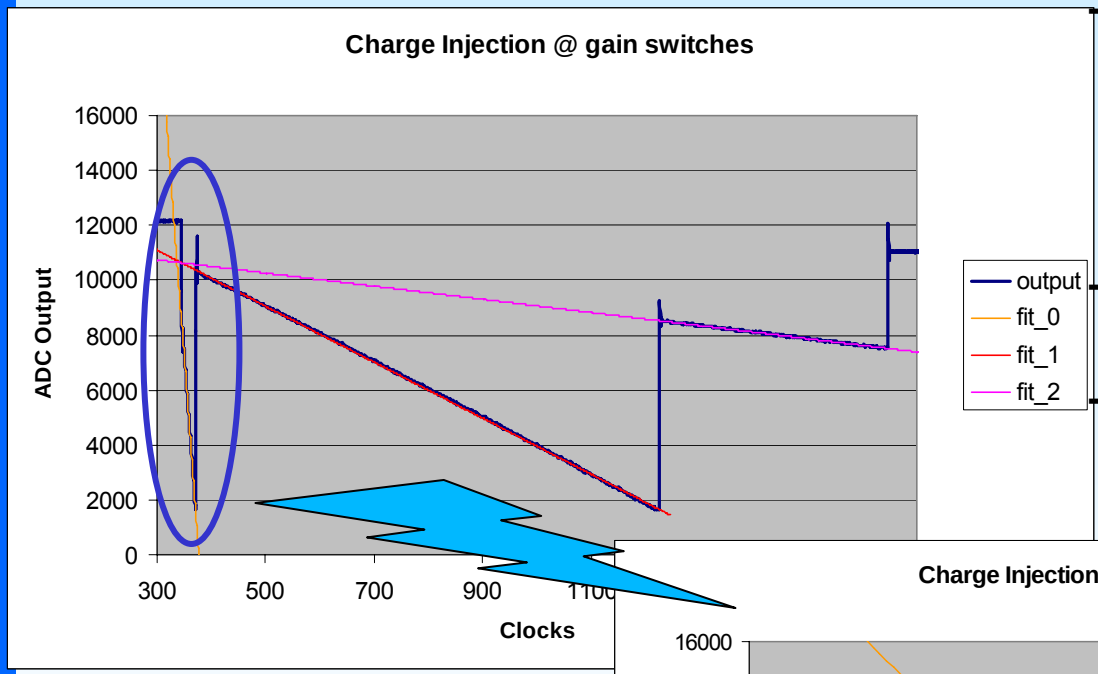
Linearity of preamp is good

(under f= 5MHz & with T- int. >10uS)

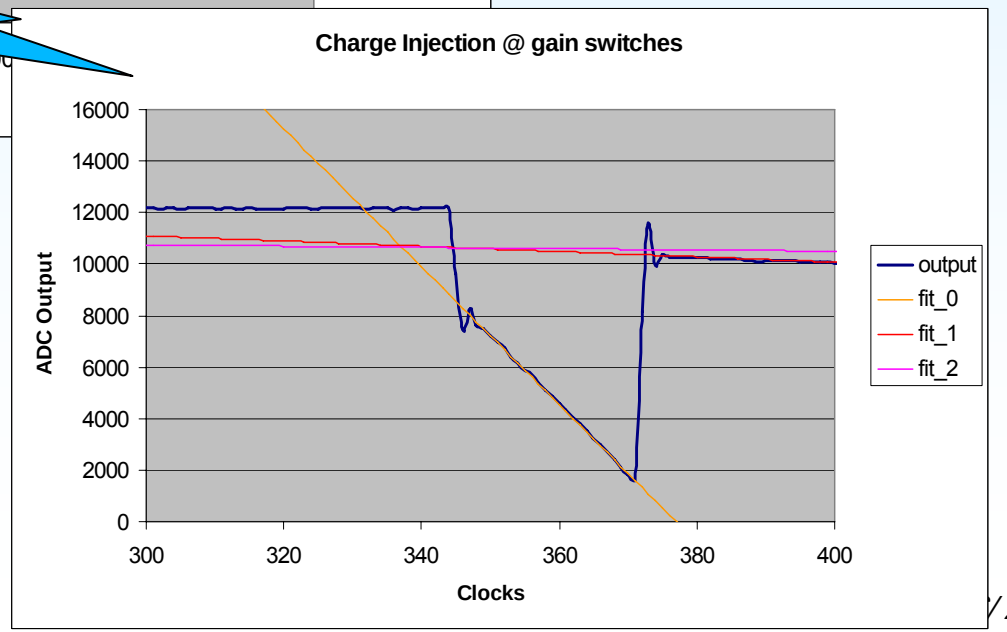
Dynamic range > 0.8 V (~ 19500 photons @ 12KeV)



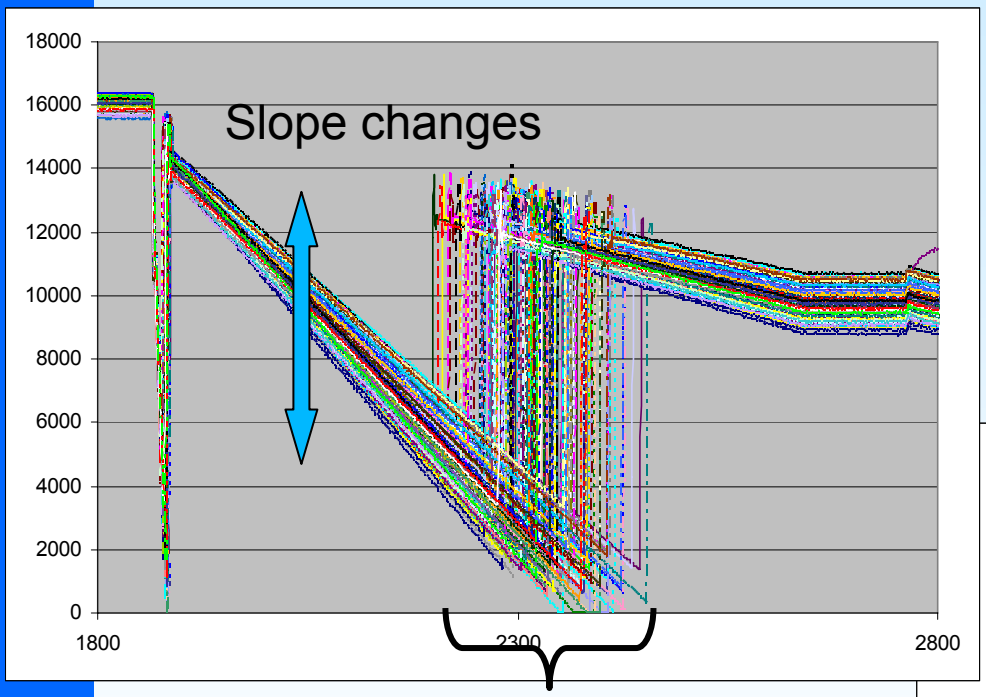
Charge Injection @ Gain Switch



- **Charge Injection @ first switch is significant and have to be calibrated**
  - **Worst case: offset 190mV → could be calibrated**
- **Charge Injection @ 2nd switch is Ok, ~ 50 photons**
- **Polarity diff. from AGIPD01**
  - **Reason: internal reset signal switches**



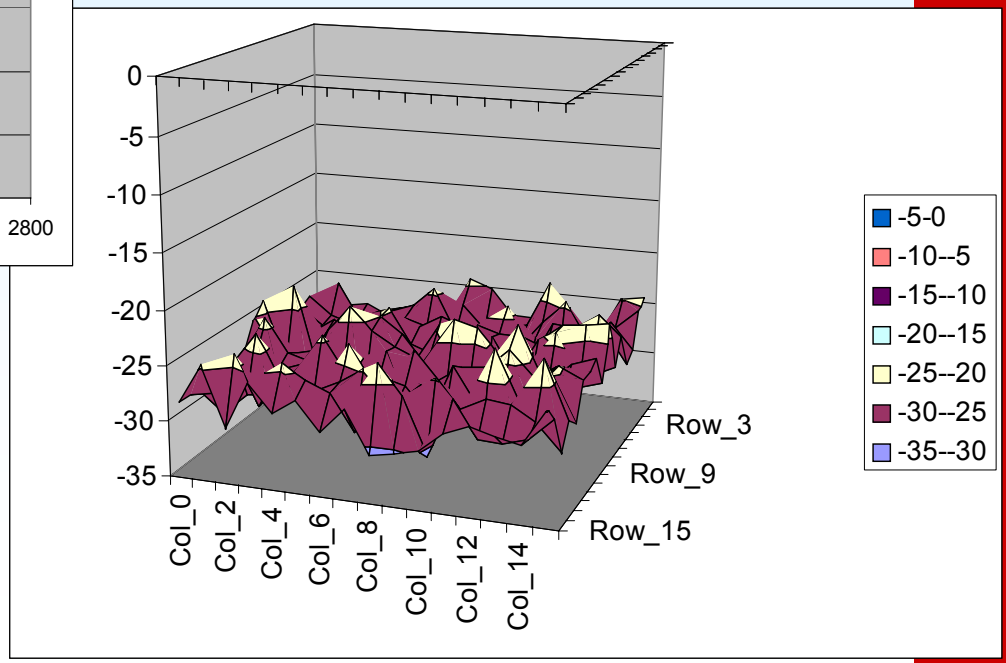
Pixel Sweep: Slope of 2nd Gain



- Reason:

  1) Discrepancy of test current source from pixel to pixel

  2) Discrepancy of discriminator from pixel to pixel

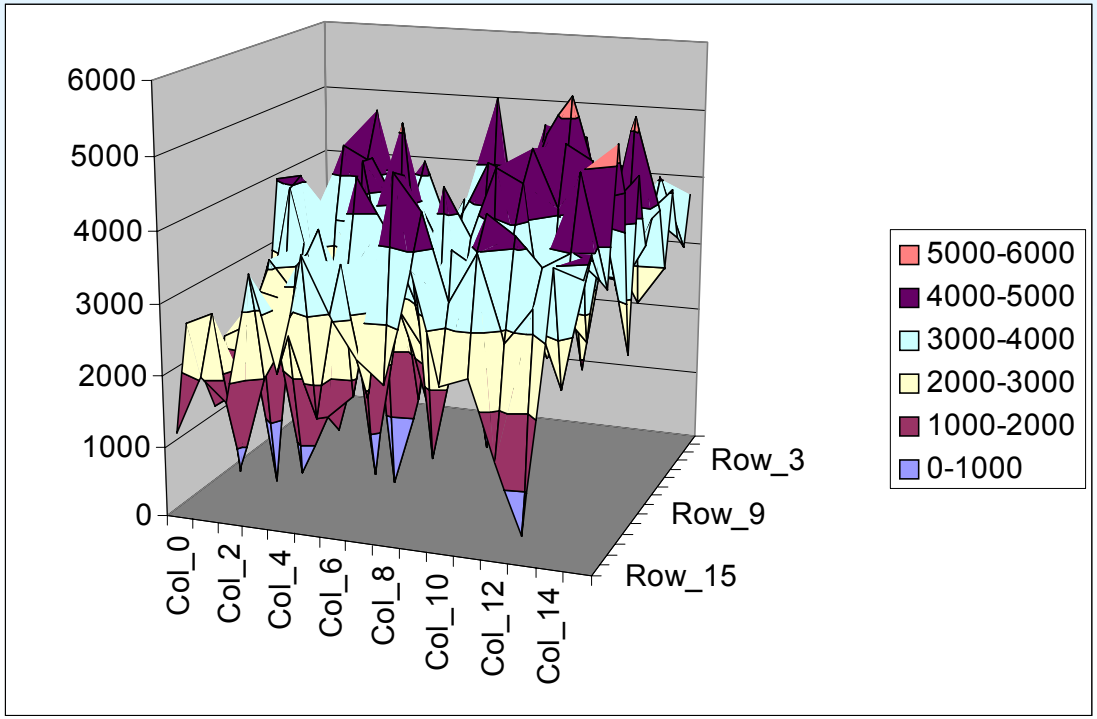


Pixel Sweep: Switch Points 1

- First gain switch points SW1 are very different (up to ~ 250mV)

  Reasons:

  - mismatch of transistors of the discriminator
  - drift of switch point due to strength of input signals
  - discrepancy of ADC sampling time

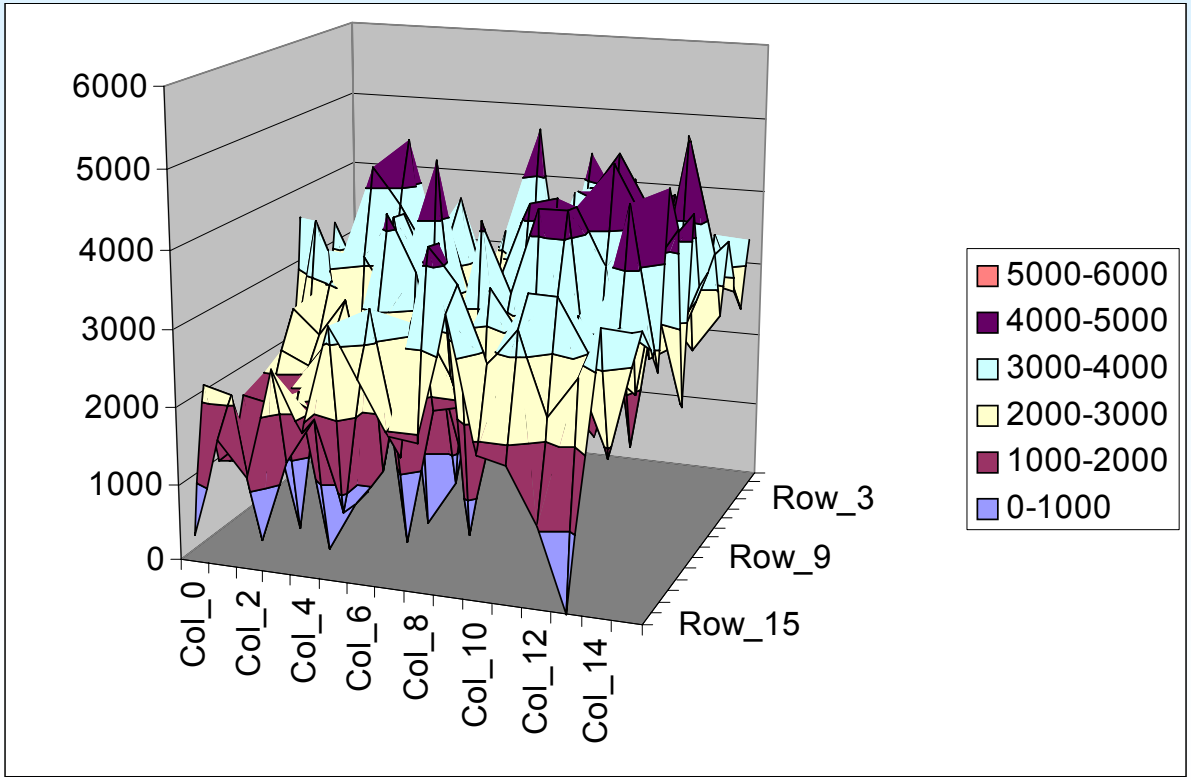


Pixel Sweep: Switch Points 2

- Second gain switch points SW2 are also very different (~190mV)

  Reasons:

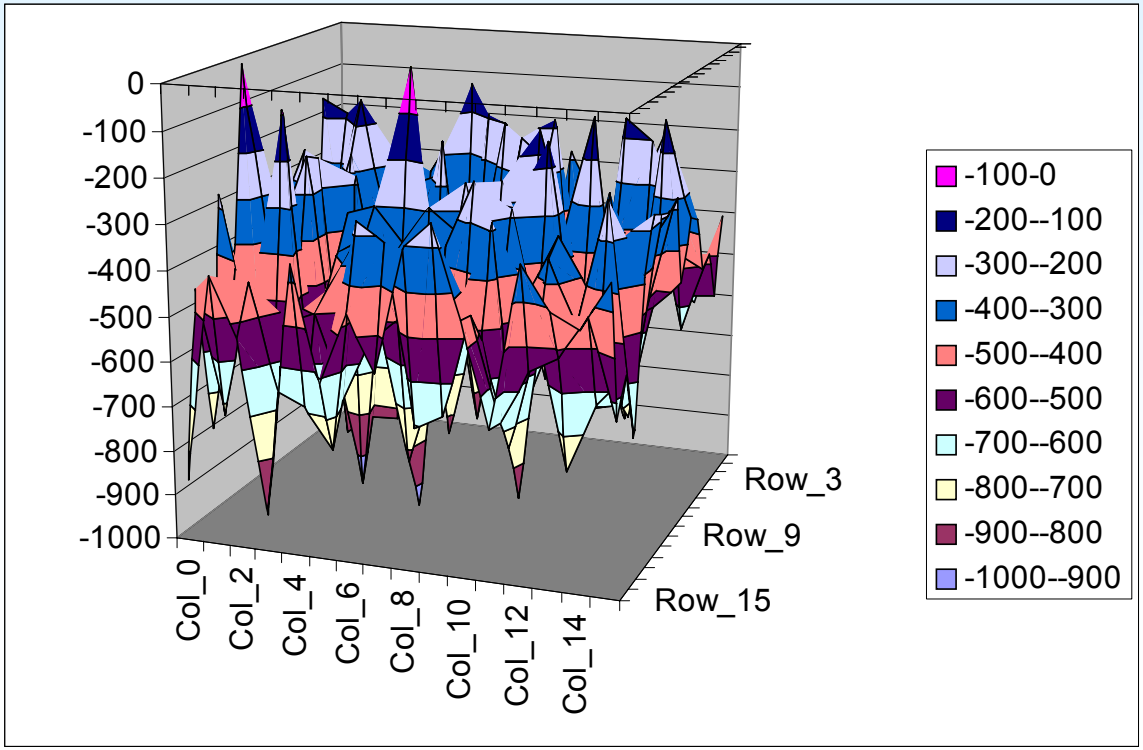
  - same as of SW1



Difference Between SW1 & SW2

- Difference between SW1 & SW2 of the same pre amplifier varies between 0 and 50mV
  - Discrepancy of discriminator due to mismatch of transistors
  - drift of switch point due to strength of input signals

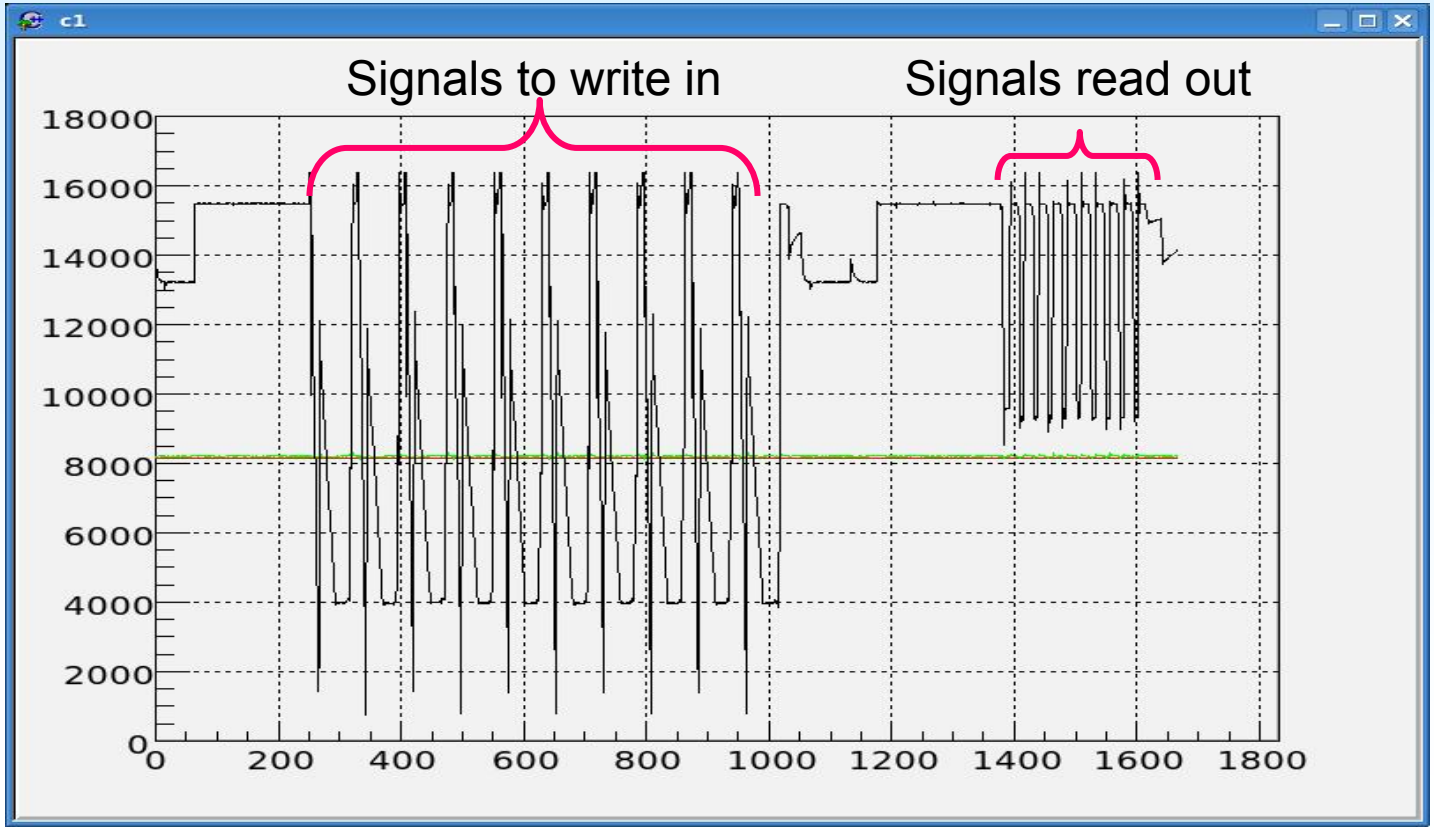
→ Discriminator to be improved (done √)



Cell Sweep: Cell for Charges

- Addressing circuit (SR) works: write & read well controlled
- Difference between the signals to write in (after the preamp) and the ones being read out is significant

  - loss of signal → output buffer needed (design in progress)



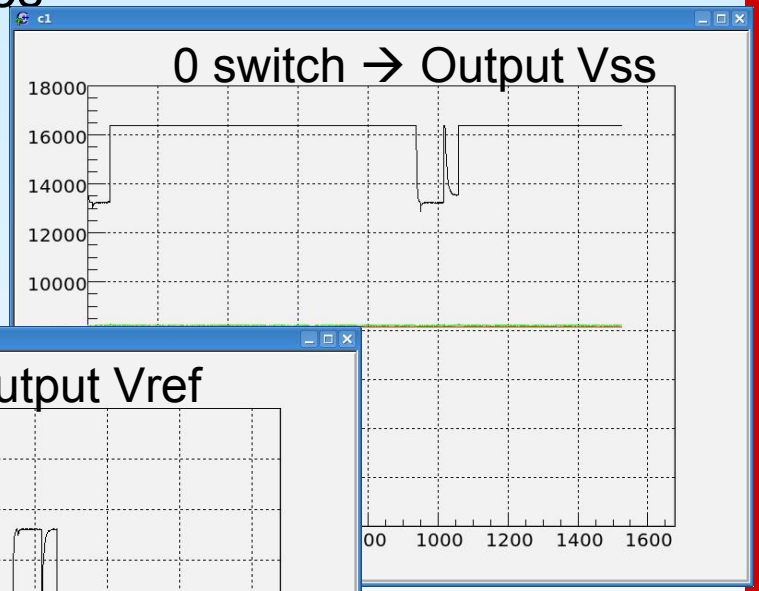
Cell Sweep: Readout problem?

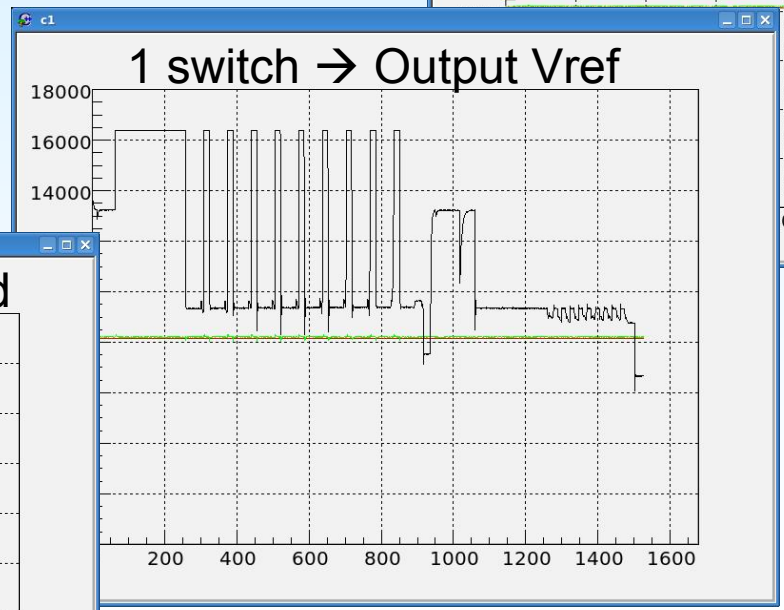
- First cell always with less output voltage, even with pre charging or twice writing process
- More loss of signal at read out for the first cell

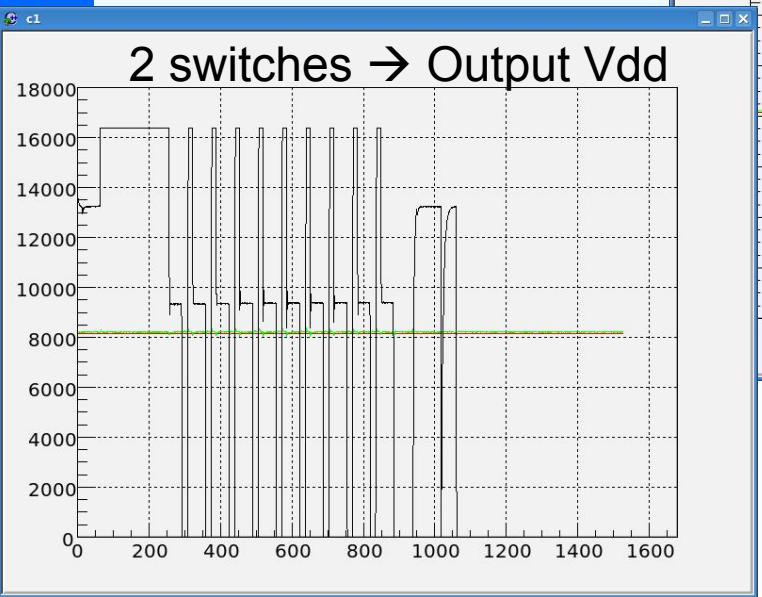
  → solved by calibration (?)

Cell Sweep: Cell for SW Numbers

- Ana. cells recording the gain switches
  - 0 switch → Vss
  - 1 switch → Vref-middle
  - 2 switches → Vdd







Difference Between SP & FP

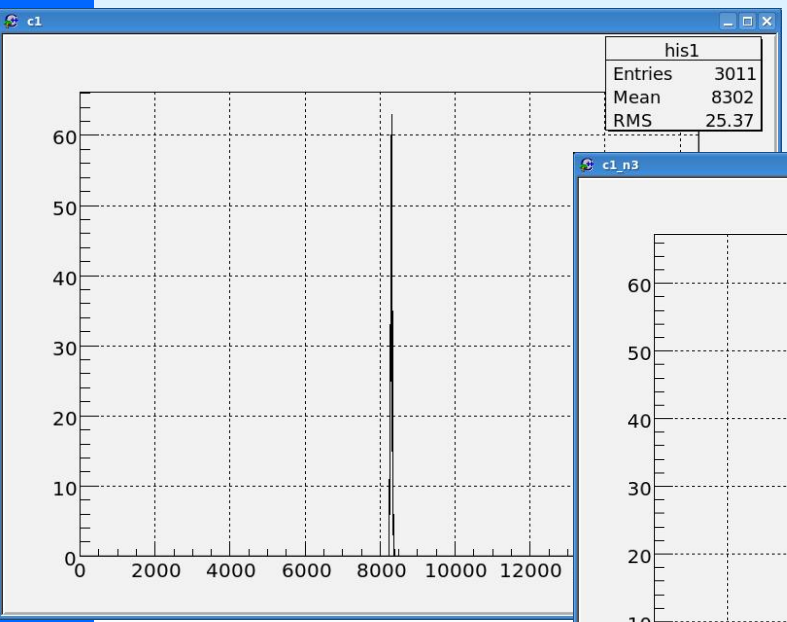
- Difference between standard preamp and fast preamp were not significant / available during the pixel sweep

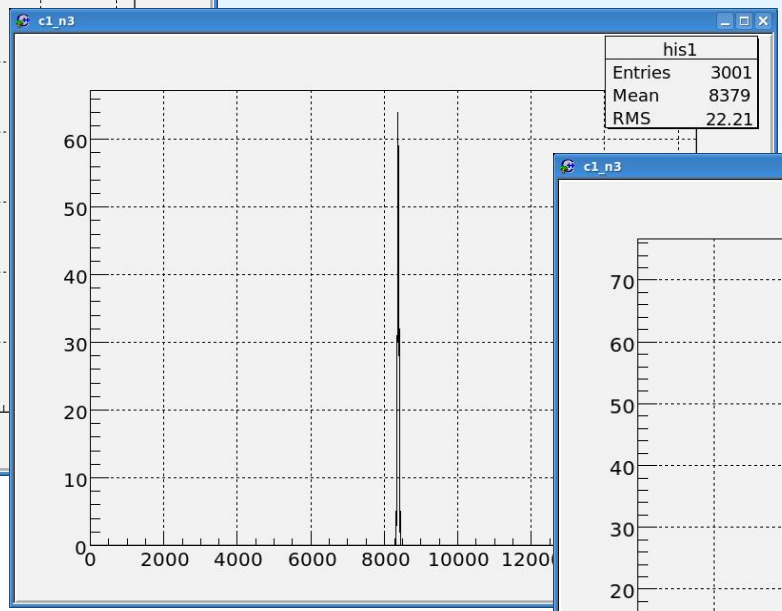
  - difference might be covered by difference from pixel to pixel

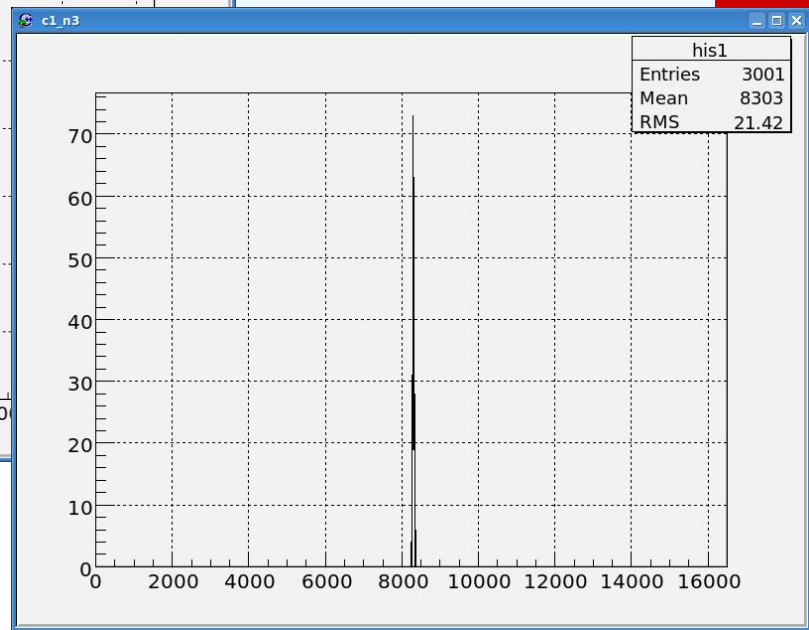
  (s. pictures on page 7-9: no significant differences available between col. 0-7 & col. 8-11)

Noise level (before radiation)

- Noise measured after preamp is low enough:
  At gain 1: 0.3 photons, gain2: 10 photons & gain3 ~30 photons



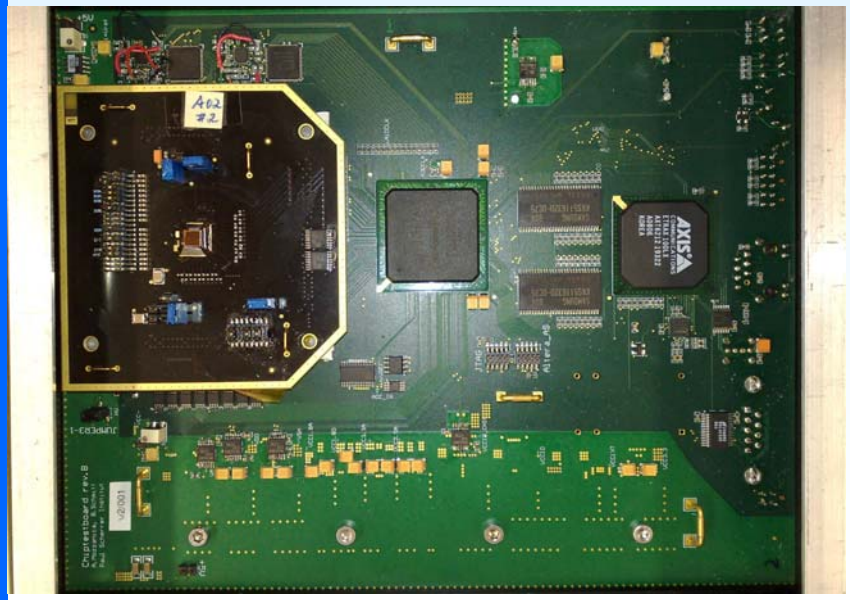


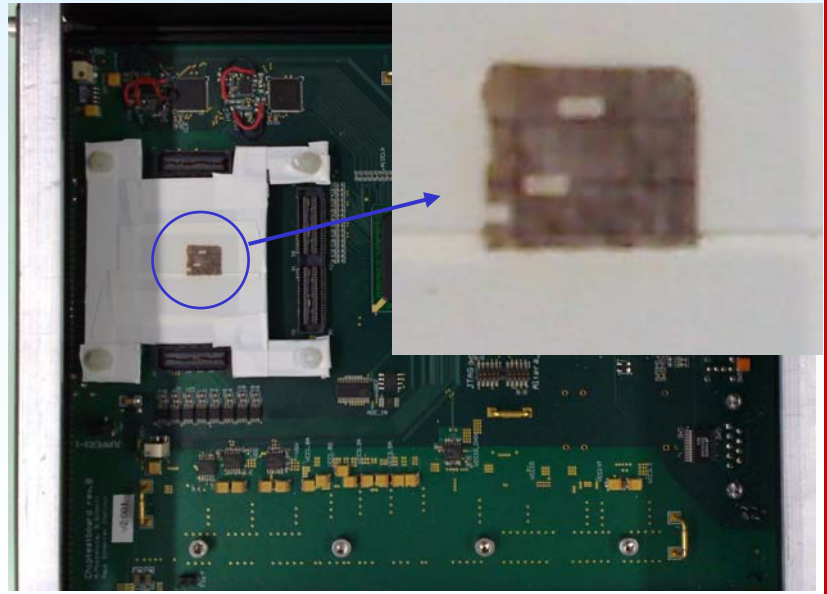


Radiation Hardness of AGIPD02

Construction of protection covers for FPGA:

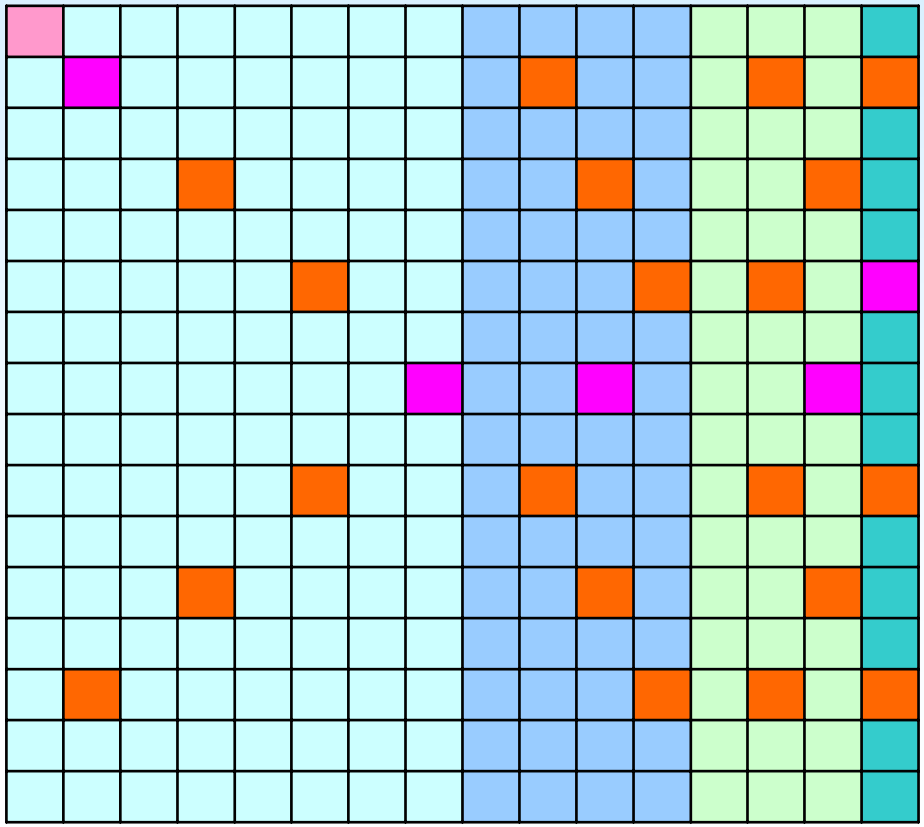
- 5mm Pb-Al-Pb sandwich cover with 1cmx1cm hole for beam line
- 1mm Pb shelf & Insulation film betw. adapter / main board





Radiation Hardness of AGIPD02

Test Map on AGIPD02 (16x16 Pixels):



Categories of Test Structures:

- standard preamplifier (SP) (W=8u)
- fast preamplifier (FP) (W=16u)
- SP with protection diode
- SP with buffered cells (10 x 8)

Categories of Measurements:

- cell measured
- PA performance measured
- PA performance & noise measured

Radiation Hardness of AGIPD02

Measurement conditions:

- At room temperature
- Under same bias conditions, before & after radiation
- Changing the bias conditions after radiation to get (roughly) the same performance as before

Measurements repetition:

- Cell performance: 50 times / pixel
- Preamp performance: 100 times / pixel
- Noise level: 1000 times / pixel

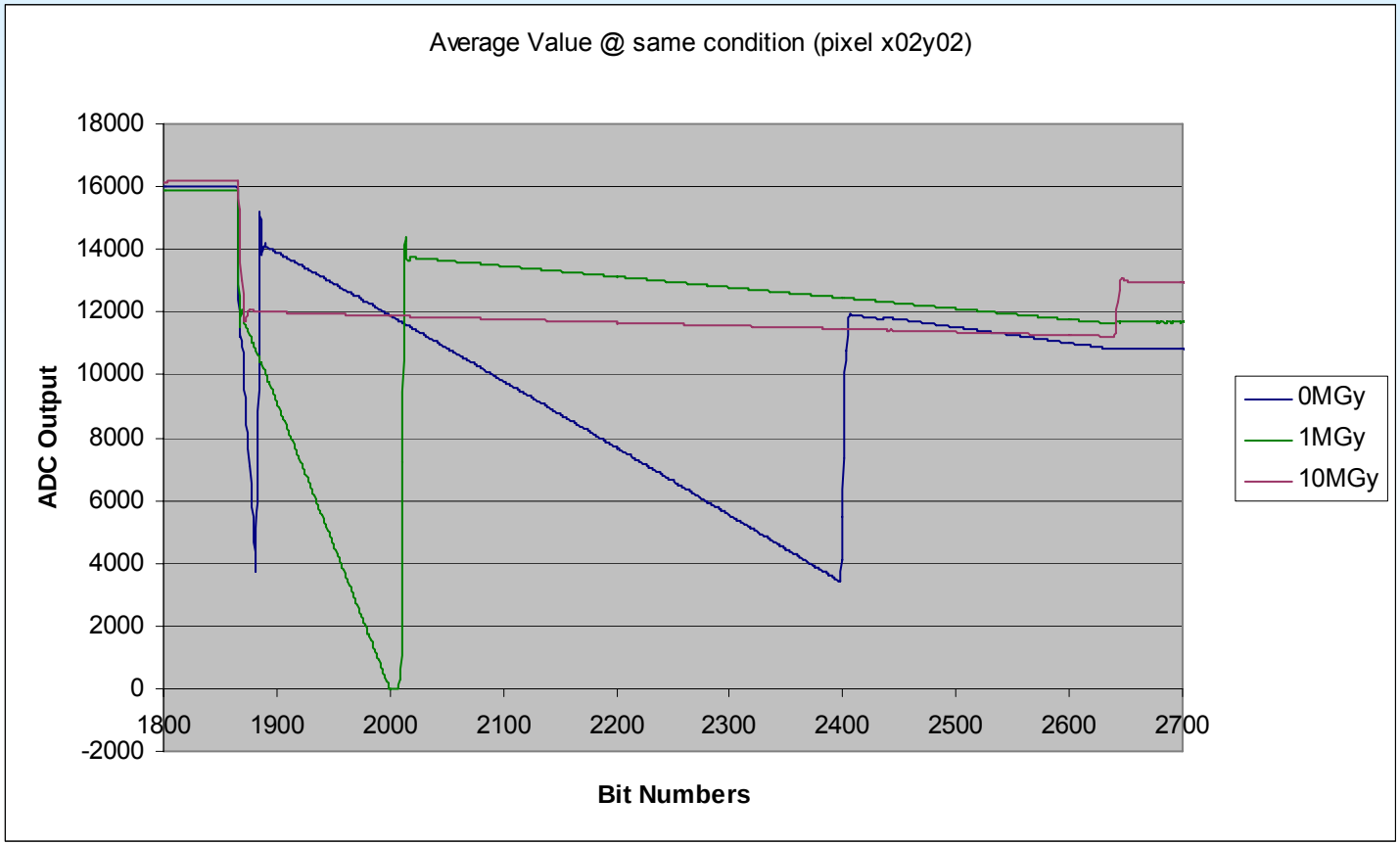
Radiation Dose:

- 1MGy & (10+1)MGy

PA Performance Comparison

- Under the same bias condition as before radiation:

  Va= 1560mV, Vsh=1544mV, Vdd=1565mV, … …

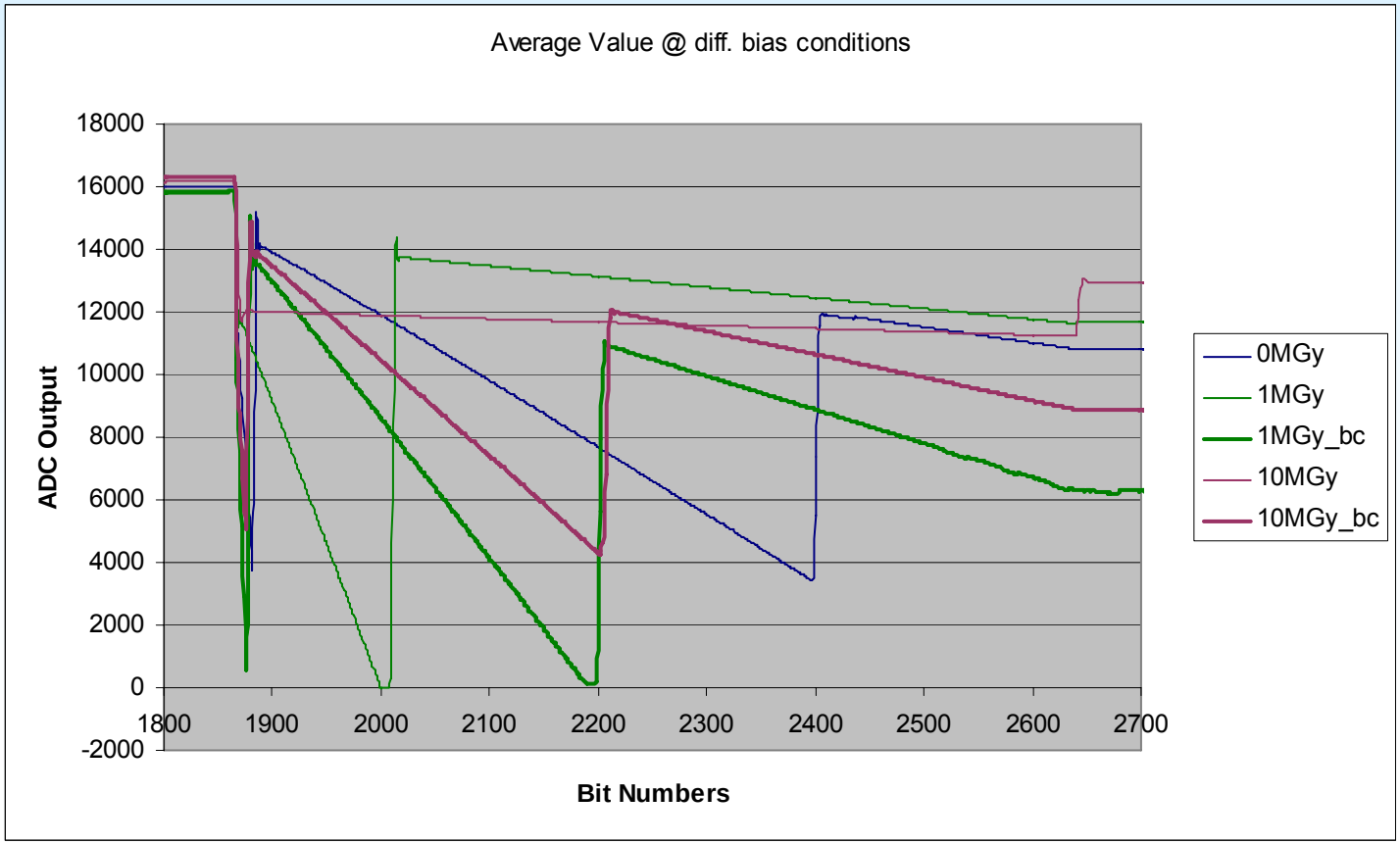


PA Performance Comparison

- Under diff. bias conditions:

  1MGy_bc: Va= 1669mV, Vsh=1606mV, Vdd= 1565mV, … → Vth Shift: ~ 100mV

  10MGy_bc: Va=1842mV, Vsh=1827mV, Vdd=1639mV, … → Vth Shift: ~ 300mV

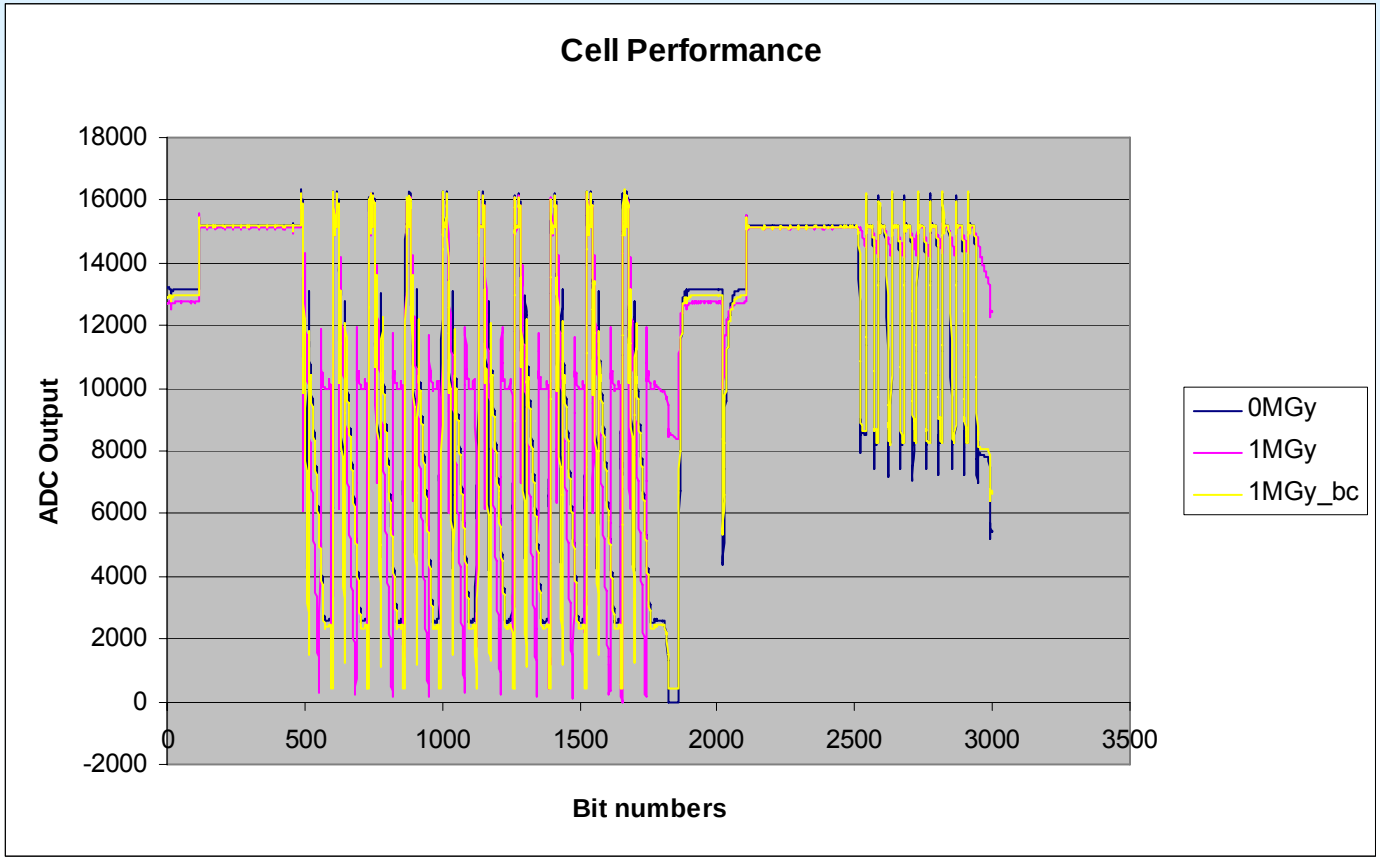


Cell Performance Comparison

- Under diff. bias conditions:

  0MGy & 1MGy: Va= 1560mV, Vsh=1544mV, Vdd=1565mV, … …

  1MGy_bc: Va= 1669mV, Vsh=1606mV, Vdd= 1565mV, …

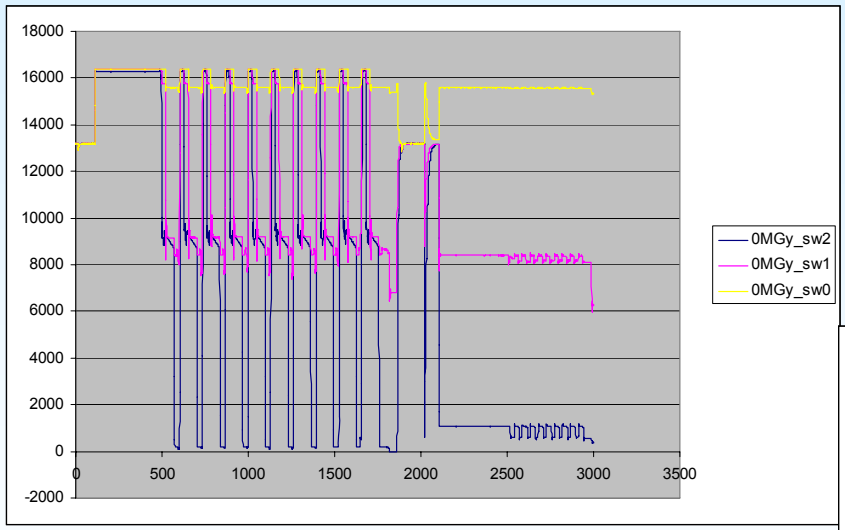


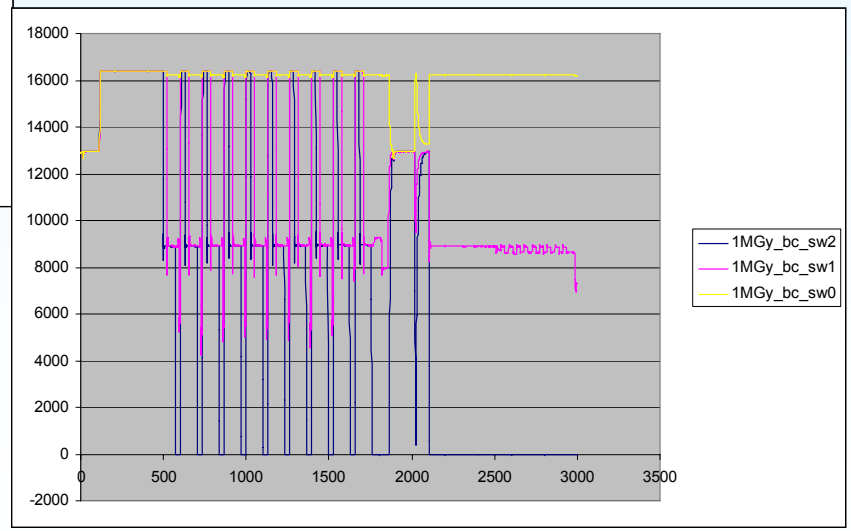
Cell Performance Comparison

- Under diff. bias conditions:

  0MGy: Va= 1560mV, Vsh=1544mV, Vdd=1565mV, … …

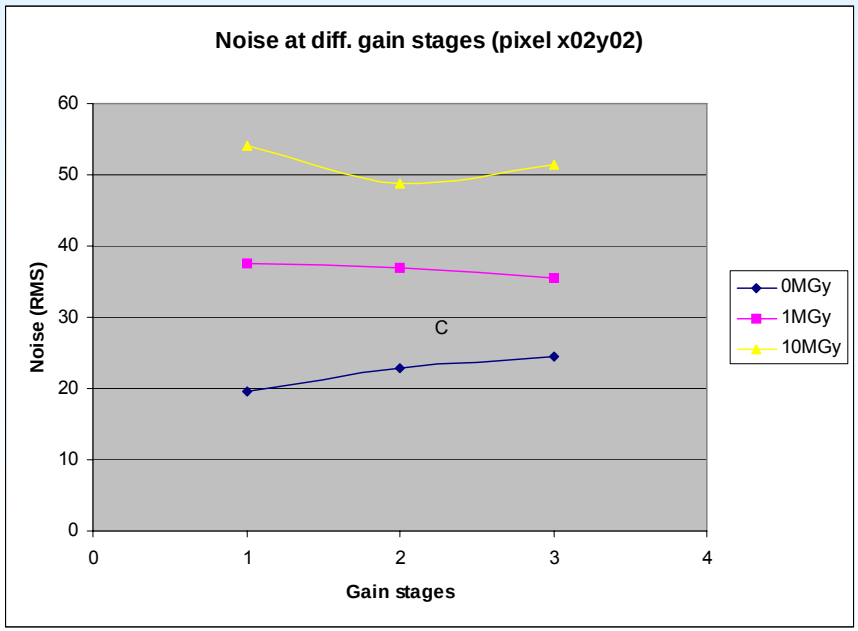
  1MGy_bc: Va= 1669mV, Vsh=1606mV, Vdd= 1565mV, …

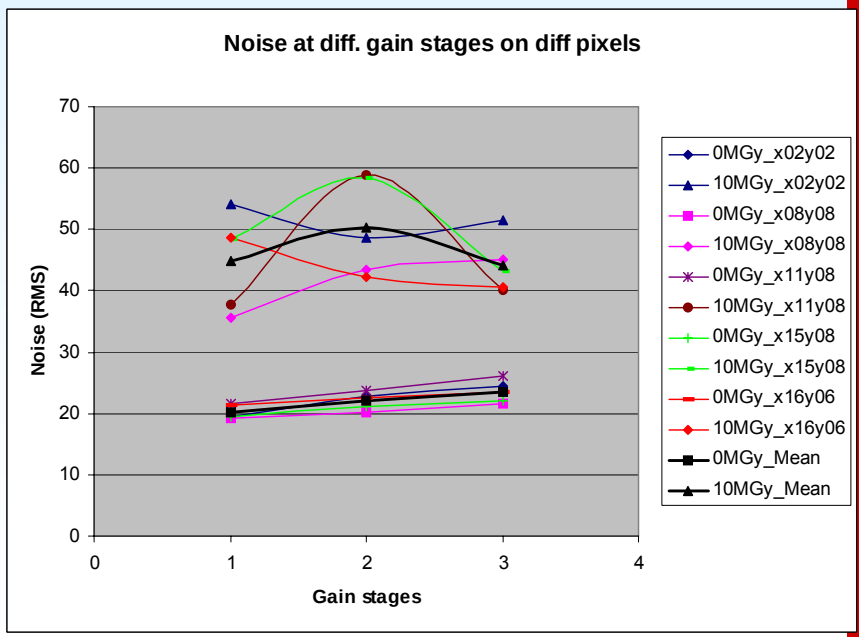




Noise Level Comparison

- Noise measured before radiation (signal after preamp):
  At gain 1: 0.3 photons, gain2: 10 photons & gain3 ~30 photons
- Noise measured after radiation of 11MGy:
  At gain 1: ~ 0.5/0.7 ph., gain2: ~ 17/21 ph. & gain3 ~ 64/78 ph.





Outline

- Measurement on AGIPD02
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Summary

- Linearity & dynamic range of preamp are very good
- Charge injection at gain switches is available but could be calibrated (to be discussed)
- Addressing circuit works well
- Difference betw. pixels / discriminator being improved
- Memory cells work well
- Significant signal loss → Output buffer in progress
- Noise level before radiation is low
- Radiation hardness up to 10MGy tested:
  noise, Vth shift, linearity and dynamic range … OK

Back Up

Tox & Vth Shift of PFETs

- Measurements von Volkan Kilic

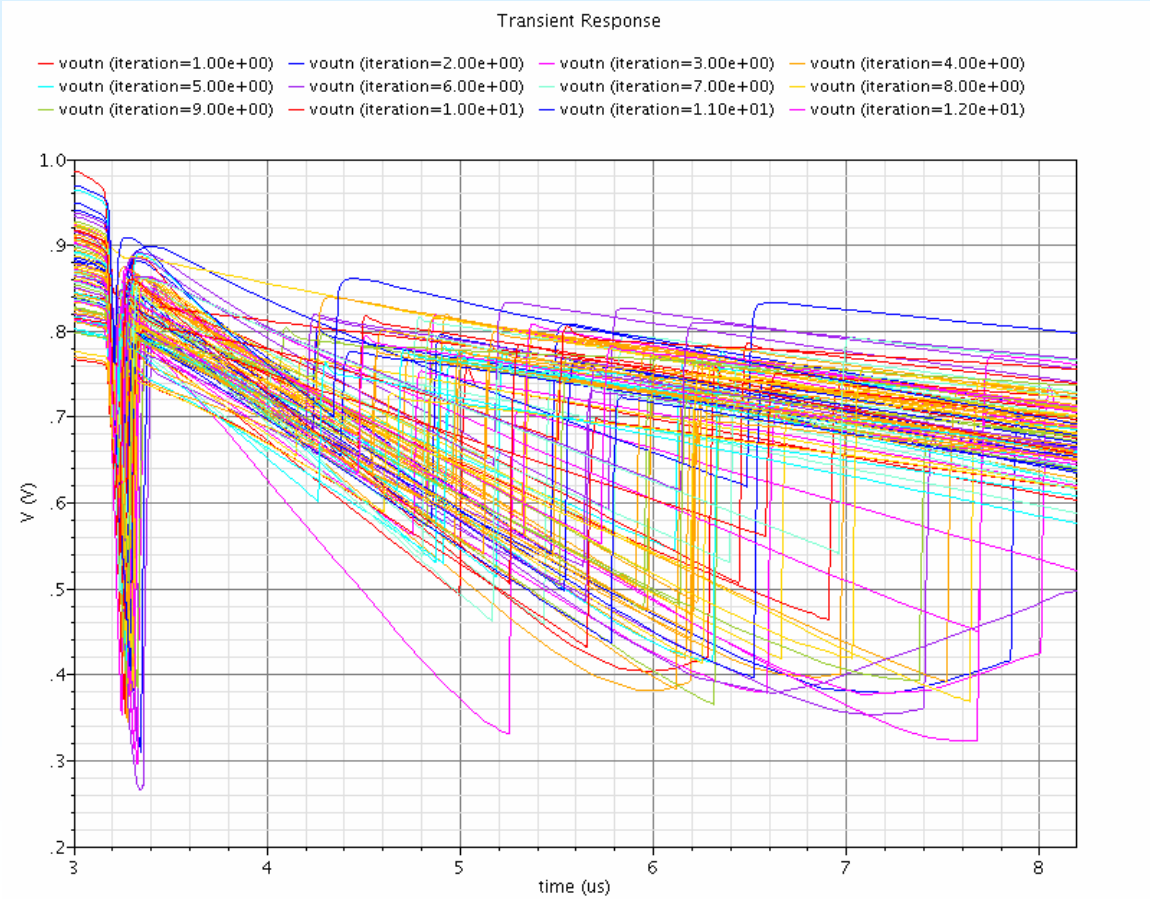
Chip6	Vt 0MGy(mV)	Vt 0MGy(mV)	Vt 0MGy(mV)	Diff. 1MGy	Diff. 10MGy
DGPMOS	-316	-698	-1226	-382	-910
DGNMOS	319	447	489	128	170
DGZVTNMOS	49	101	94	52	45
Chip5	**Vt 0MGy(mV)**	**Vt 0MGy(mV)**	**Vt 0MGy(mV)**	**Diff. 1MGy**	**Diff. 10MGy**
DGPMOS	-298	-628	-1178	-330	-880
DGNMOS	475	490	494	15	19
DGZVTNMOS	48	106	188	58	140

- Thickness of Oxide Sheets (IBM CMOS 8RF)

Standard NFET / PFET		
	L_{min}	0.12 µm
	L_p	0.092 µm
	V_t	0.33 V / -0.30 V
	I_{Dsat}	530 mA / 210 mA
	I_{off}	250 pA/µm / 200 pA/µm
	T_{ox}	2.2 nm
Thick-oxide NFET / PFET		
	L_{min}	0.4 µm
	L_p	0.24 µm
	V_t	0.41 V / -0.44 V
	I_{Dsat}	660 mA / 260 mA
	I_{off}	10 pA/µm / 2 pA/µm
	T_{ox}	5.2 nm

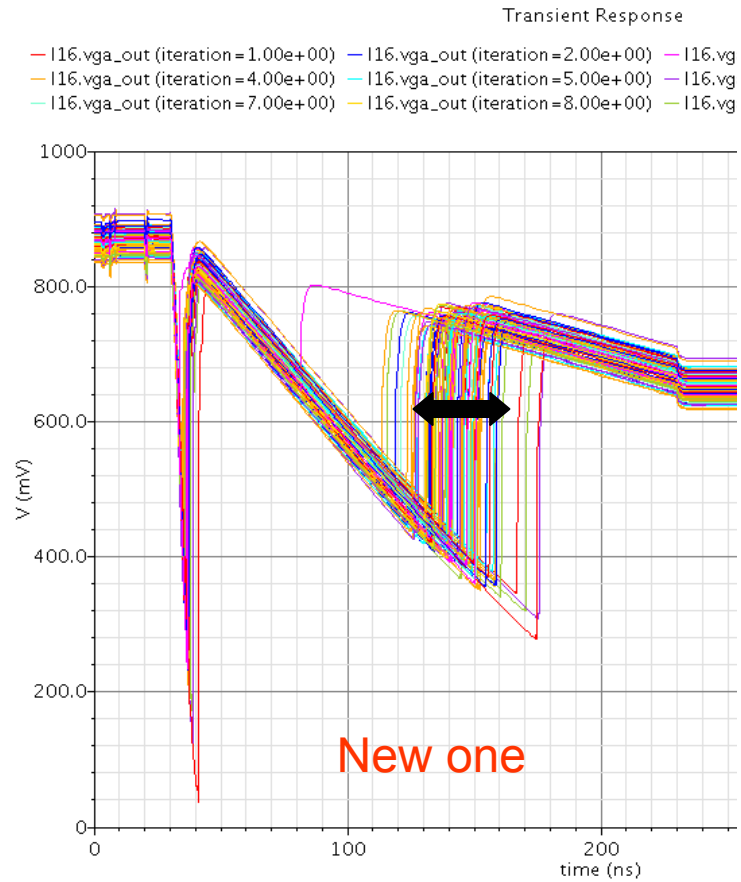
Mismatch Influence

- Both measurement (p.7) and simulation show strong influence of mismatch ← caused by discriminator



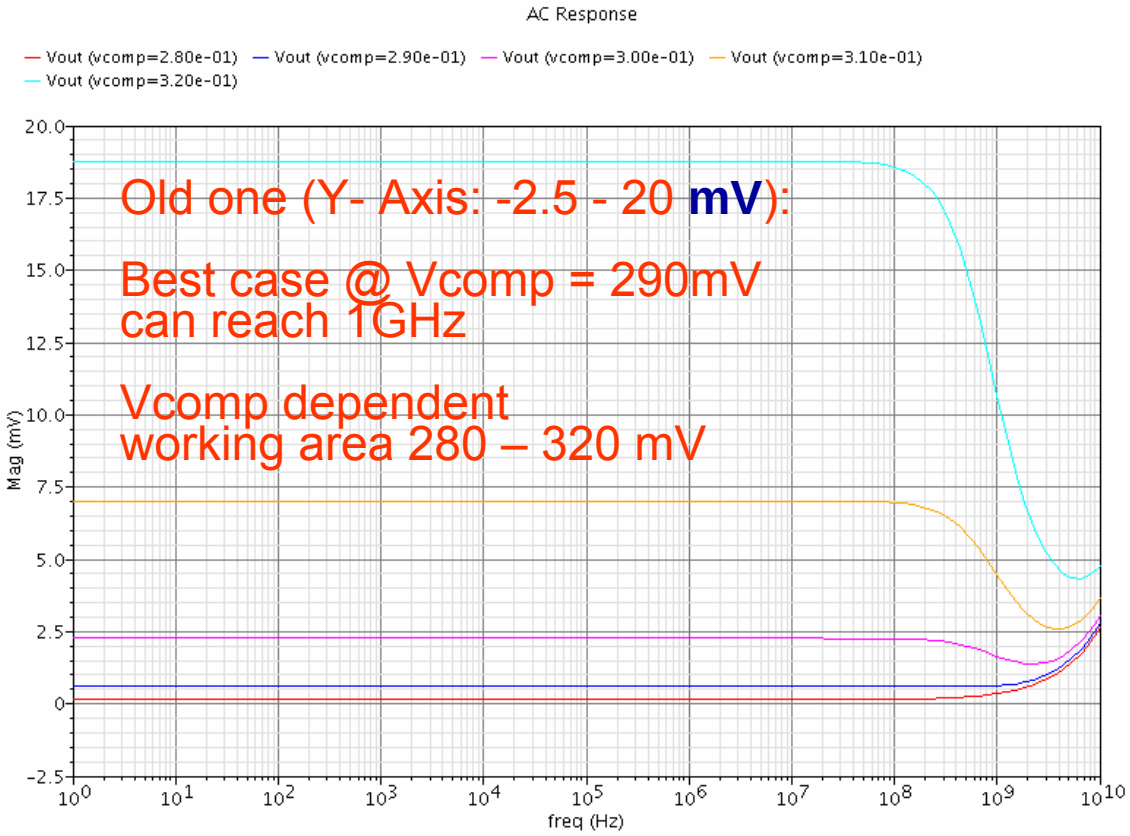
Comparison new & old discrim.

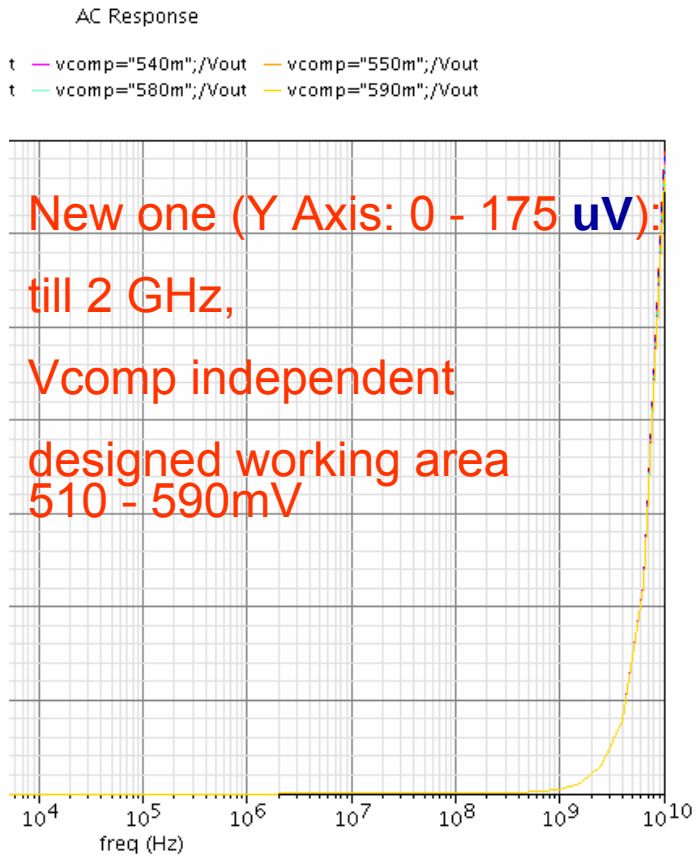
- Simulation shows that the new one has significant better concentration in MC simulation:



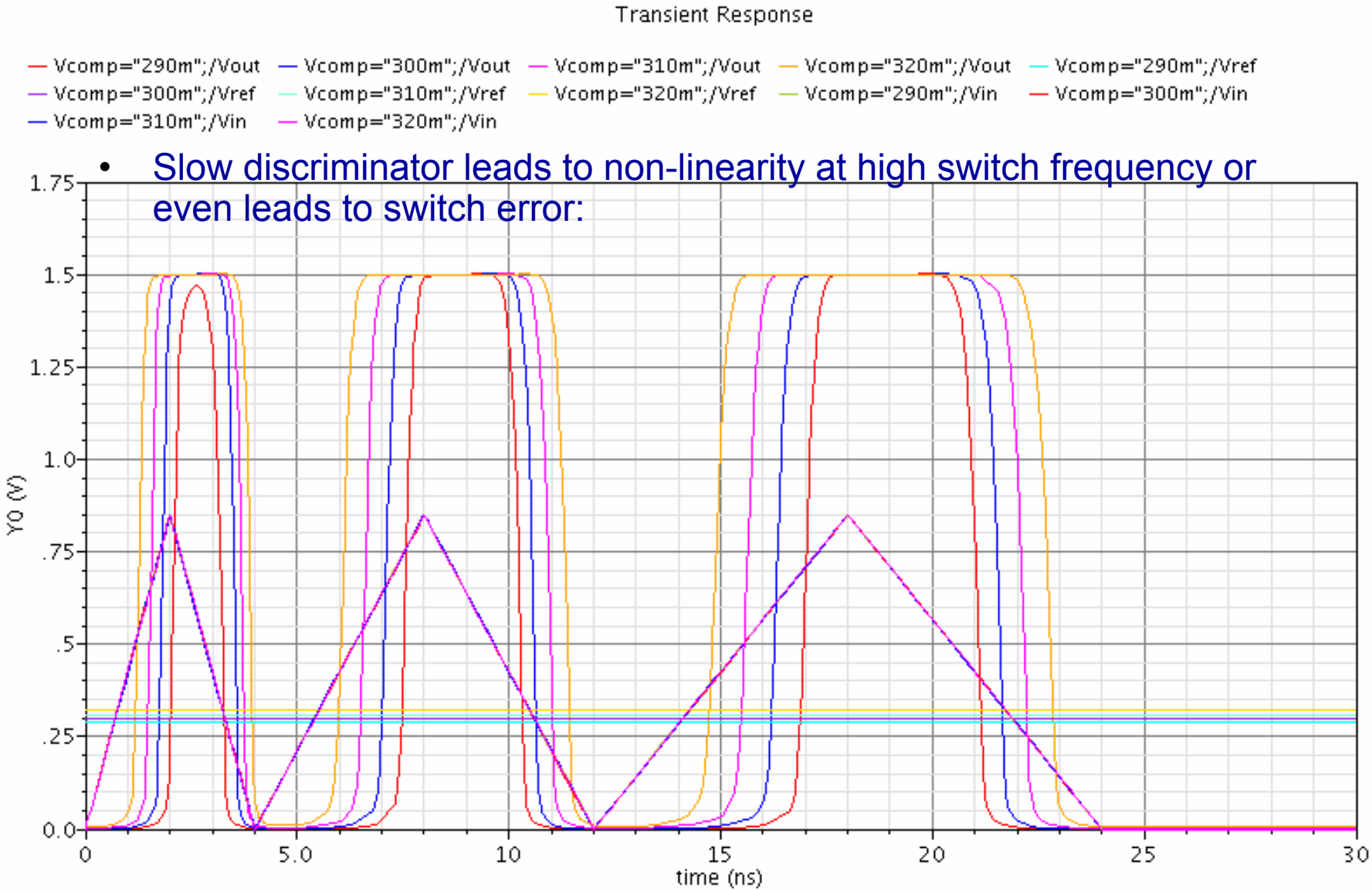
Comparison new & old discrim.

- Simulation shows that the new one has significant wider bandwidth & better stability:



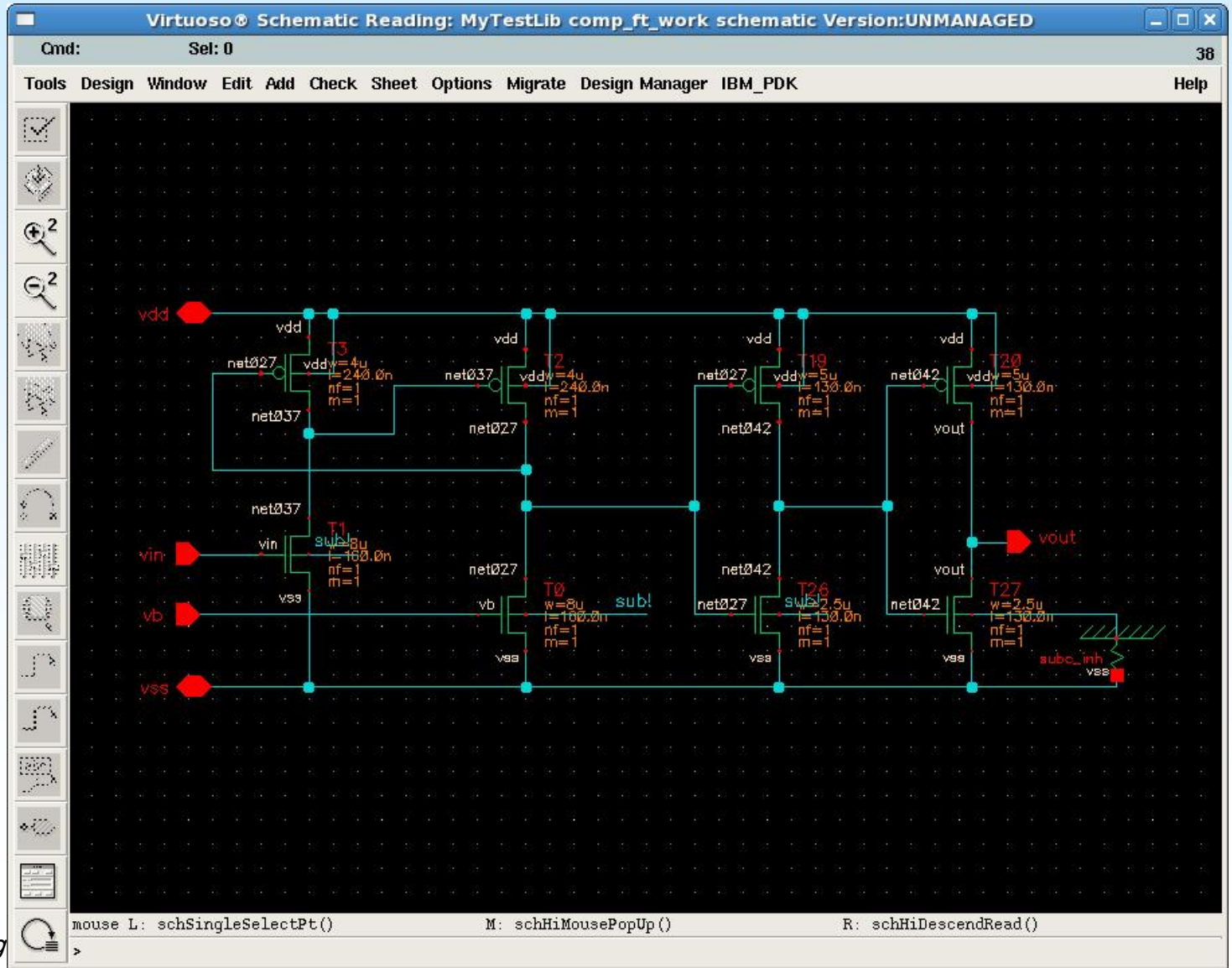


Transient Simulation old discrim.



- Slow discriminator leads to non-linearity at high switch frequency or even leads to switch error:

New Discriminator



Old Discriminator