Status and first results of the UK active pixel collaboration

- APS1
  - Laser test
  - Simulation program
  - Radiation test
- APS2
  - Source measurements
  - FAPS
- Summary & Outlook

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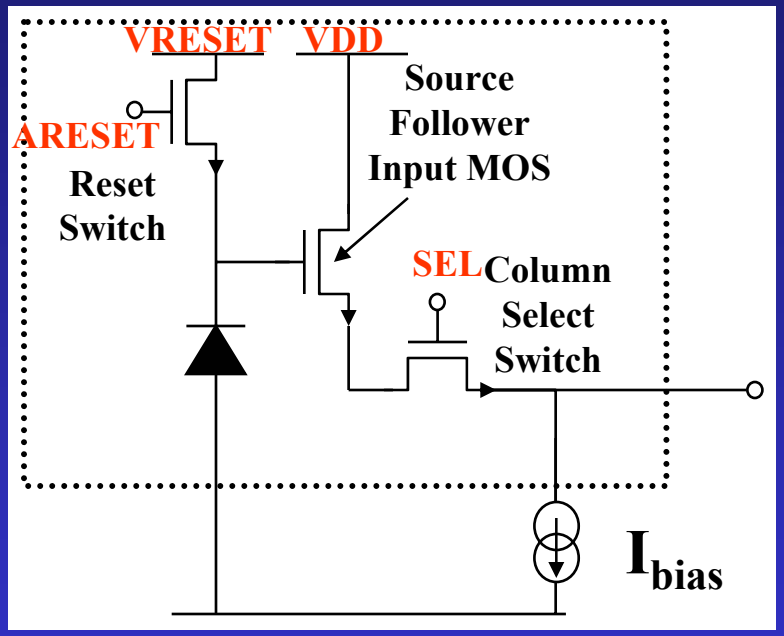
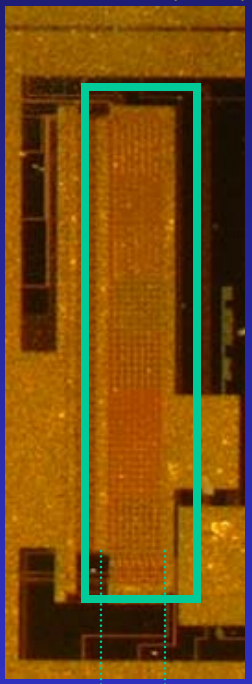
APS1

- Eight 8*8 arrays (15 μm pitch)
  - Baseline 3MOS pixel
  - 4 diode
  - TX (CDS)
  - Baseline with cal
  - (4 Photogate pixels)
- 2 μm epi-layer
- 0.25 CMOS IBM



Design: R. Turchetta (RAL)



120 μm

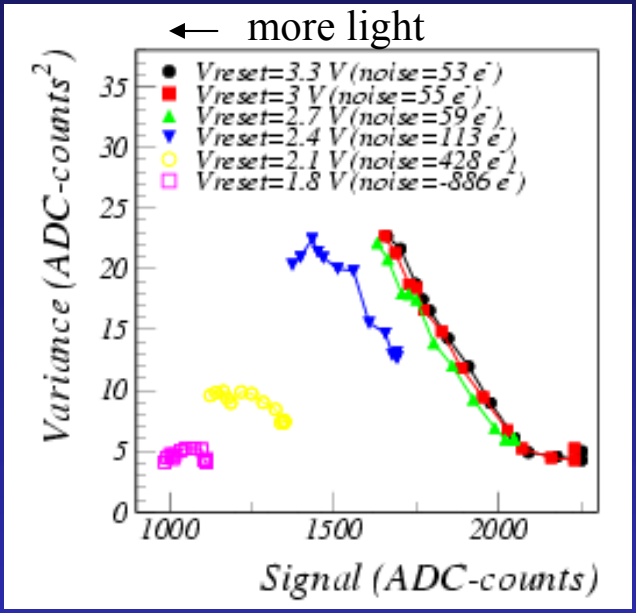
Noise: Photon-transfer curve

- Get noise using Photon-transfer curve
  - Assume: variation in signal dominated by variation in number of absorbed photons:

$$\sigma = G\sqrt{n_{photo-electrons}}$$

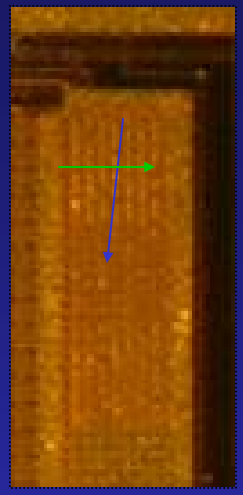
$$S = Gn_{photo-electrons}$$

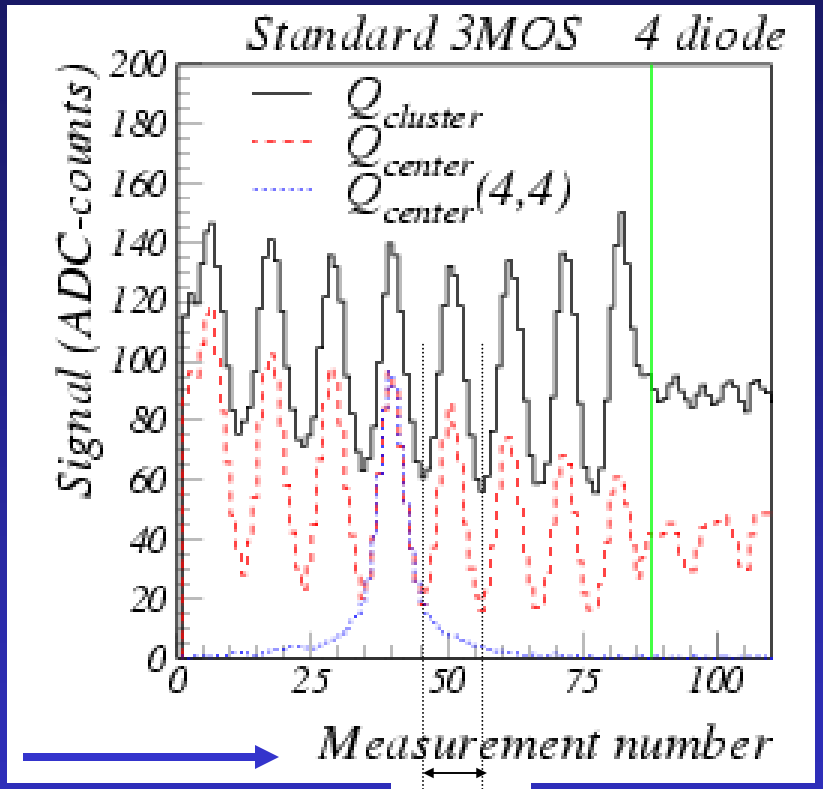
  - Plot Variance vs Signal
  - Fit straight line ⇒ gain in ADC/e^-
  - Convert dark noise in ADC to noise in e^-

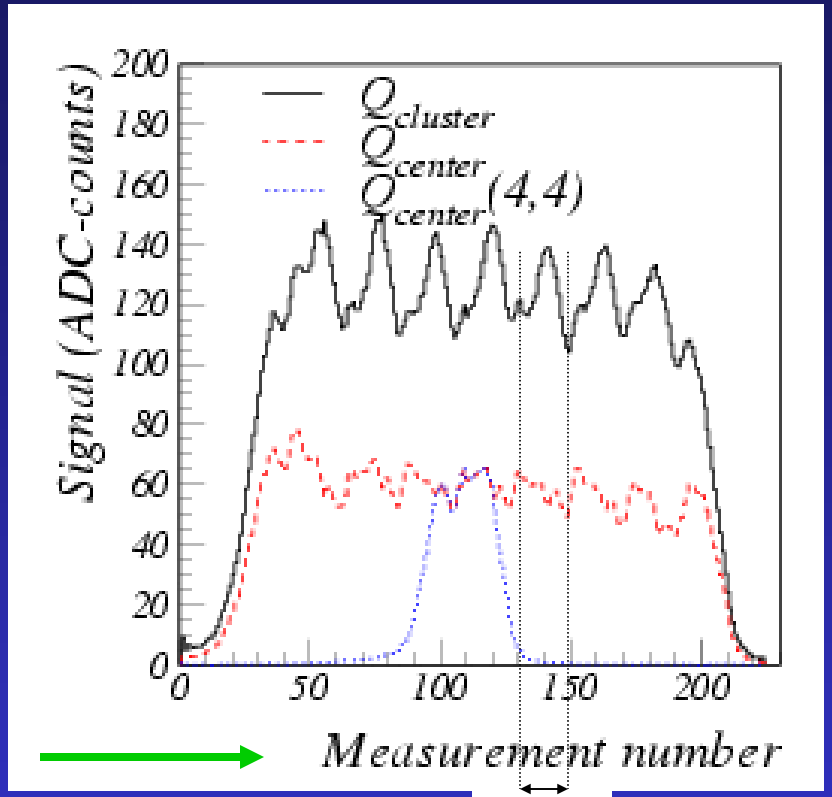


Pixel type	Noise (e^-)
Std 3MOS	52±1
4 diode	184±6
TX (diode conn)	52±2
3MOS+cal	54±1

APS1: Laser test



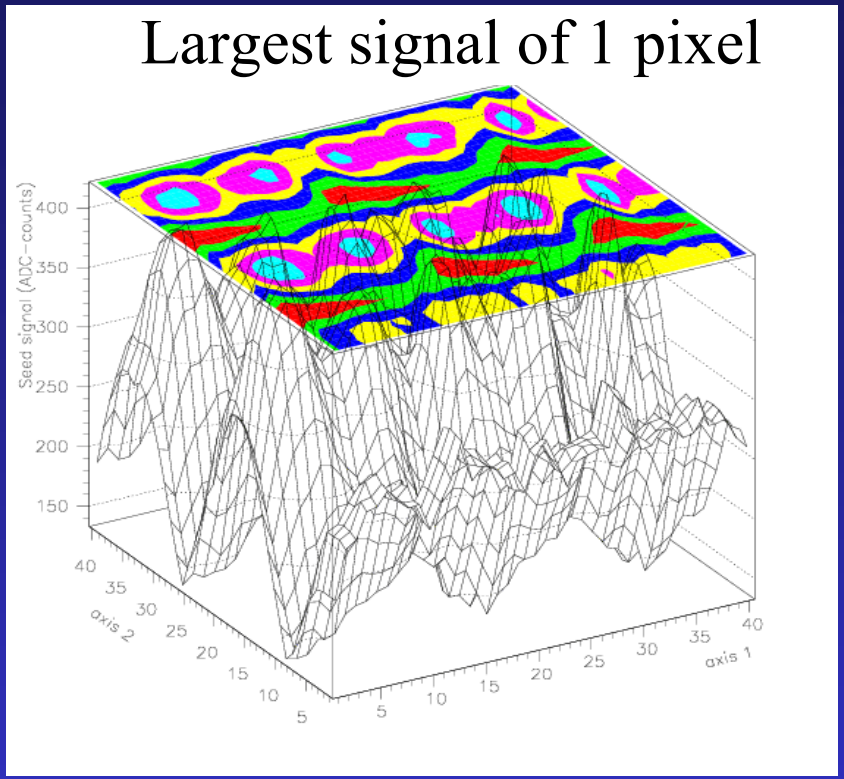




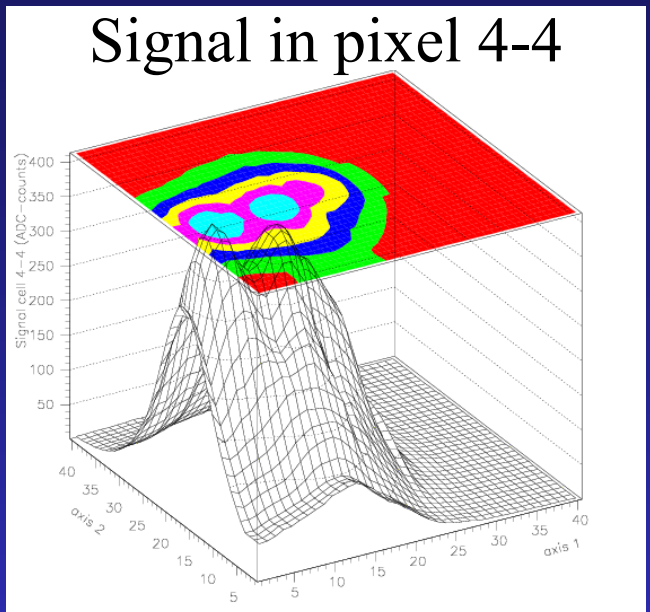
- Scan using laser along arrows
- Laser spot: σ=7μm
- Effects of metal structure clearly visible

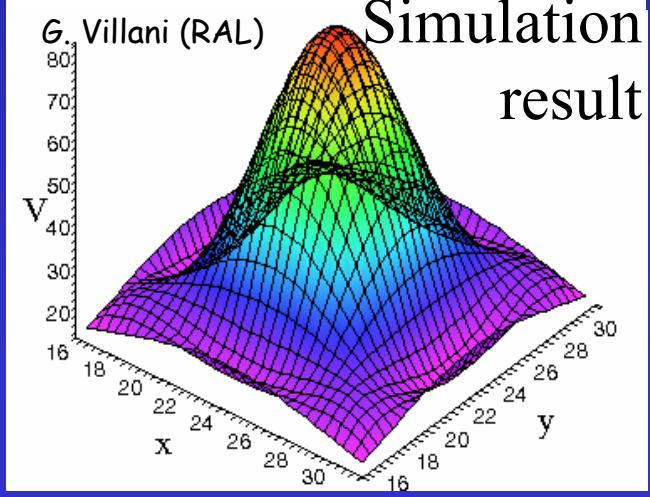
APS1: Laser test (II)

Largest signal of 1 pixel



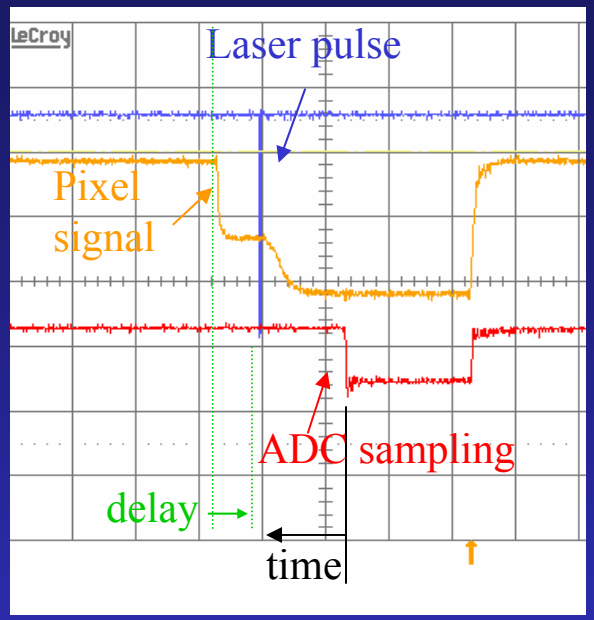
Signal in pixel 4-4

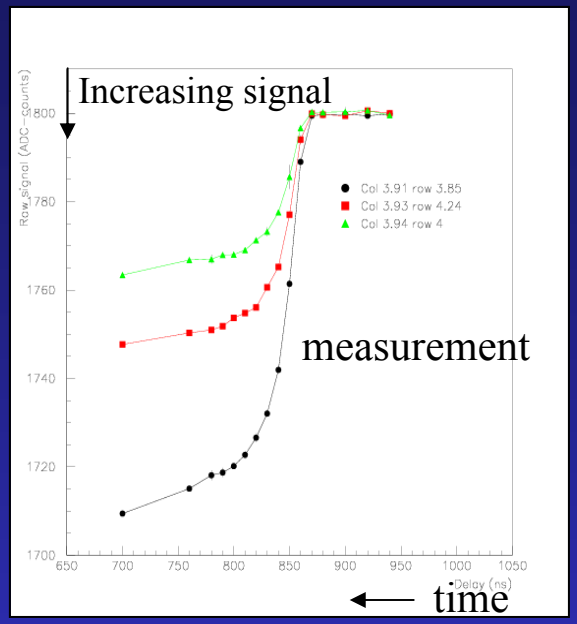


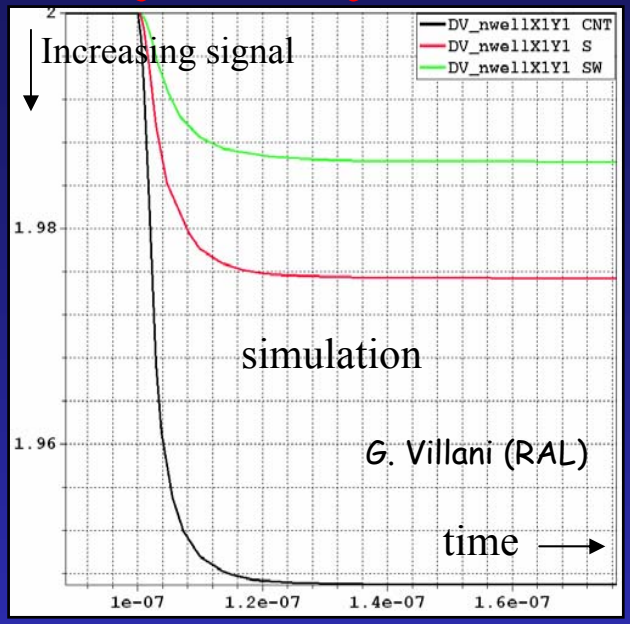


- Simulation agrees reasonably well (no metal in simulation)

APS1: Laser test (III)





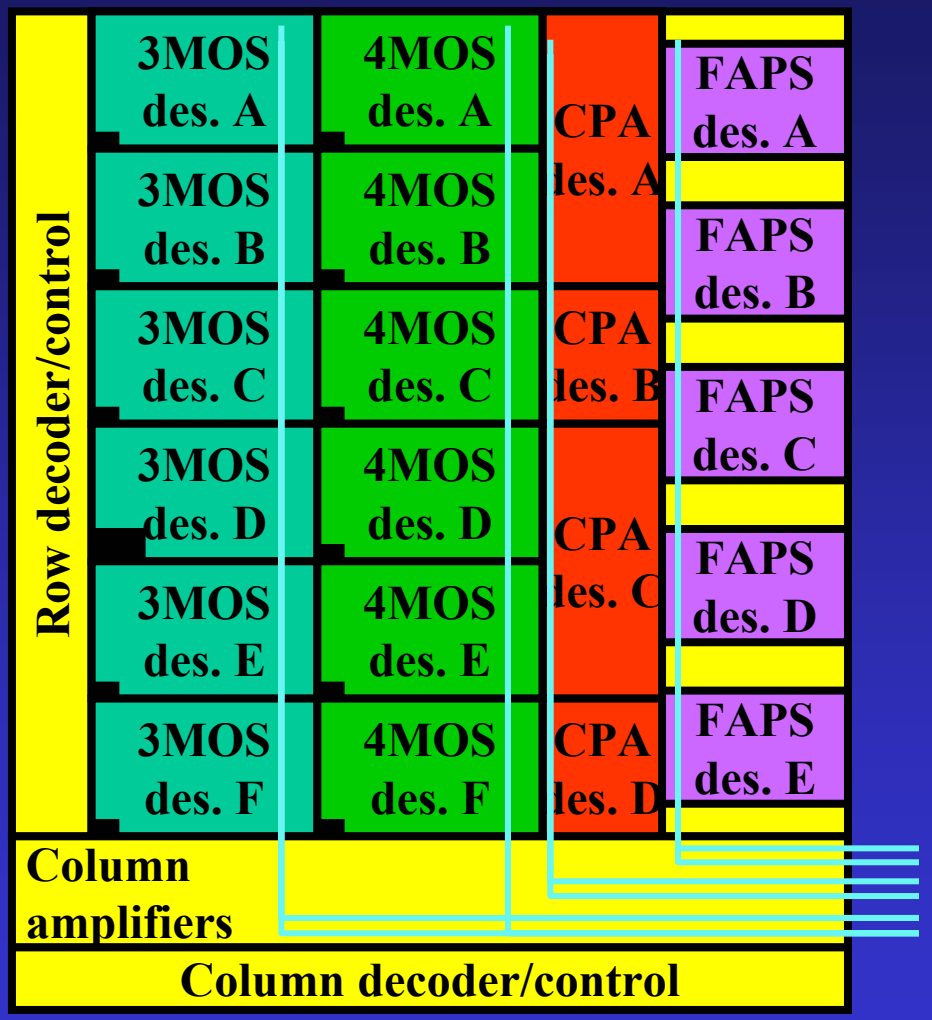


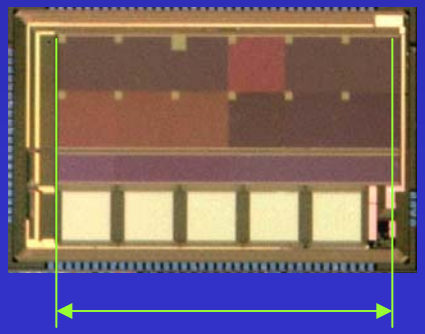
- Simulation reproduces unirradiated signal rise time.
- Measured APS1 at 10^{11} and 10^{12} p/cm^2. No noise increase measured. Agrees with simulation; expect deterioration around 10^{14} p/cm^2

APS2

- 4 pixel types, various flavours
  - Std 3MOS
  - 4MOS (CDS)
  - CPA (charge amp)
  - FAPS (10 deep pipeline)
- 3MOS & 4MOS: 64x64, 15μm pitch, 8μm epi-layer ⇒ MIP signal ~600 e-

Design: R. Turchetta (RAL)

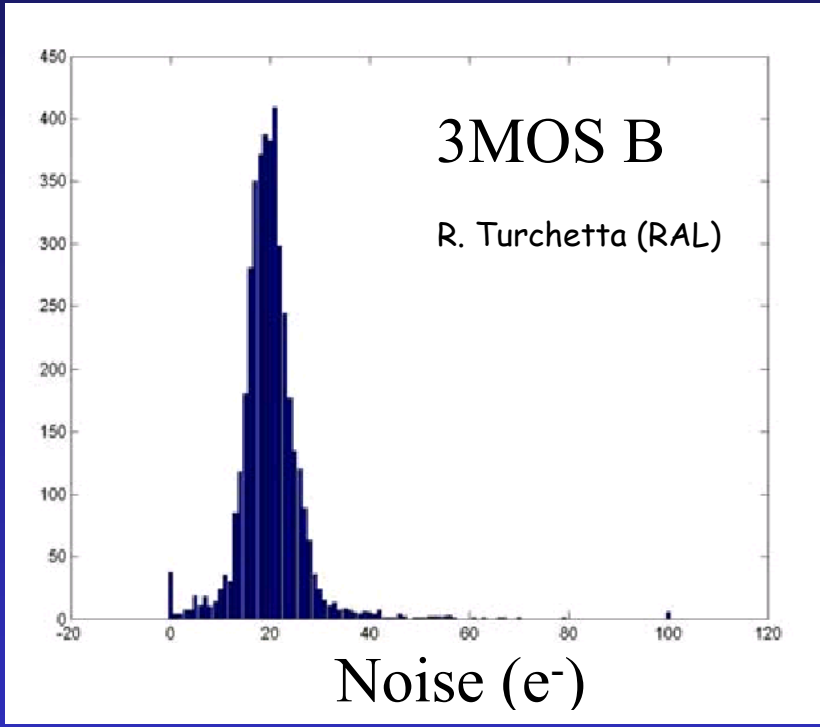




APS2: noise PTC

- Measured noise using PTC

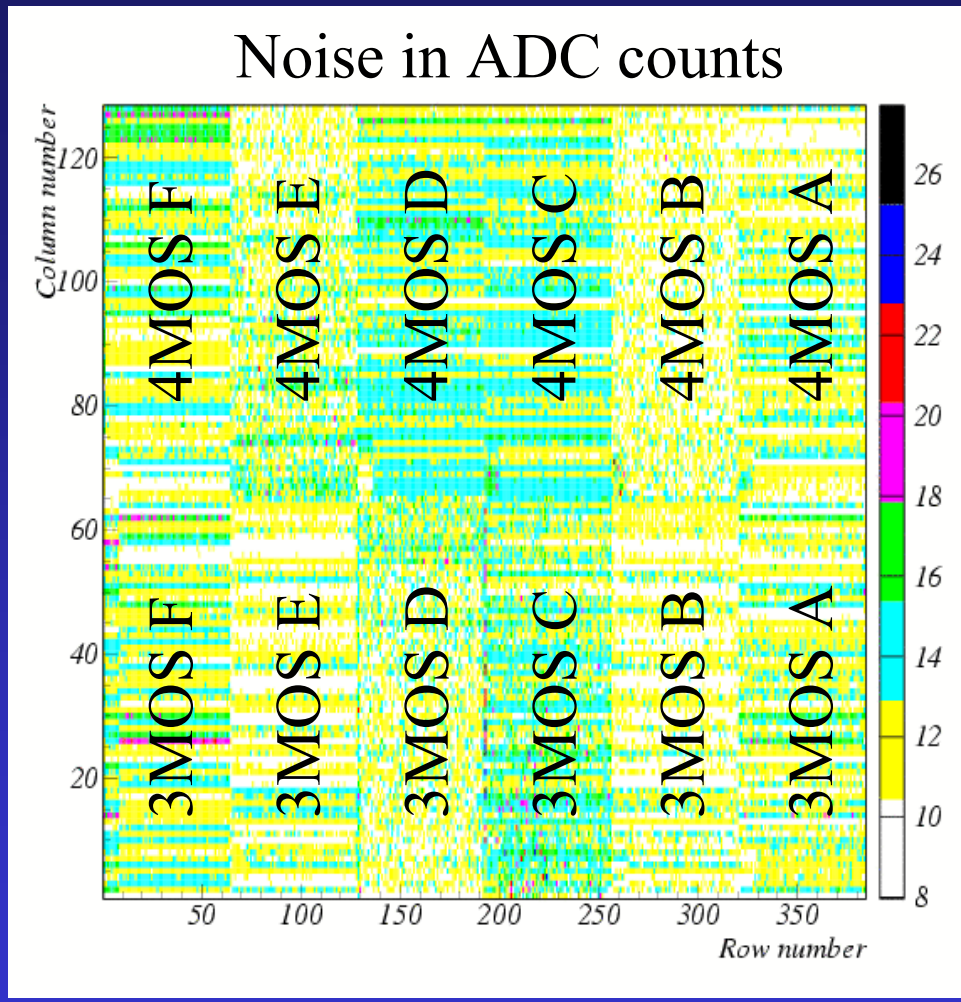
Type	Noise (e^-)
3MOS B	45.7±0.2
3MOS A	54.0±0.2
4MOS C	55.7±0.2
4MOS B	51.8±0.2
4MOS A	46.3±0.2



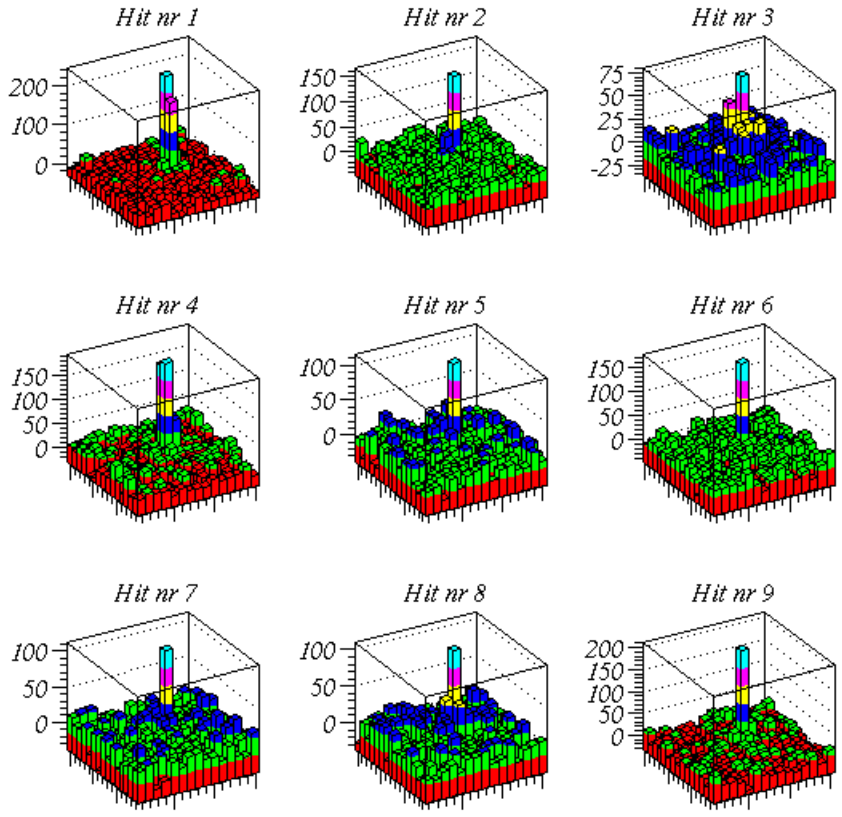
- Noise measured in Liverpool ~2x noise at RAL. Have identified problem in Liverpool. No results yet.

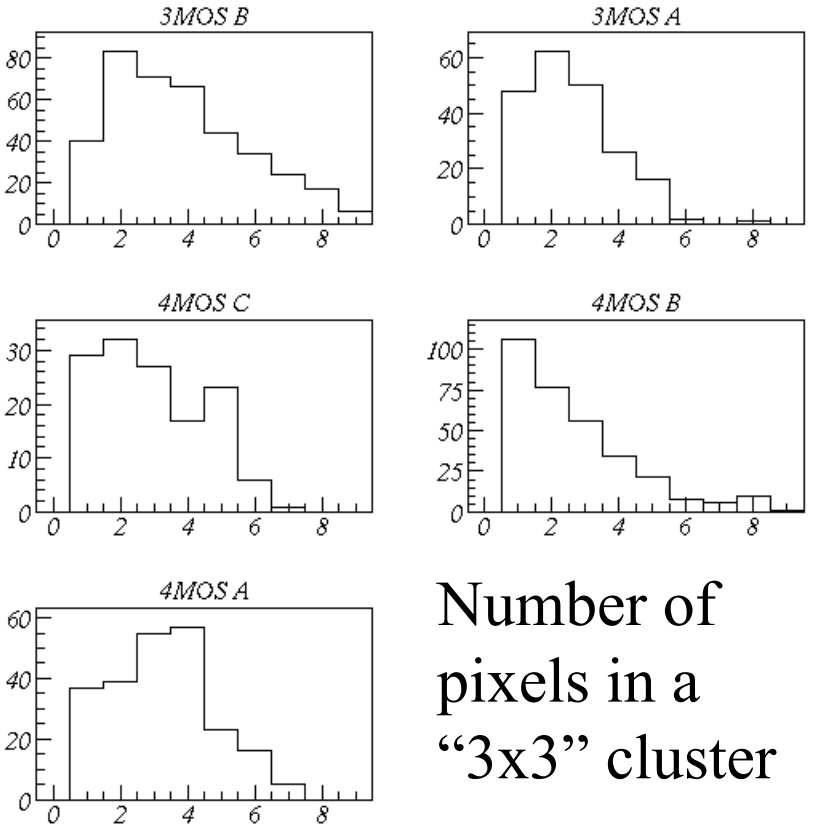
APS2: Source test

- Here only use 3MOS and 4MOS with TX high (no CDS)
- Calculate pedestals
  - Average output after removing hits
- Calculate common mode noise
  - Average pixel type output after pedestal subtraction
- Calculate random noise
  - Sigma of pedestal and common mode corrected output
- Cluster definition
  - Signal >6σ seed
  - Signal >2σ next



APS2: Some Clusters





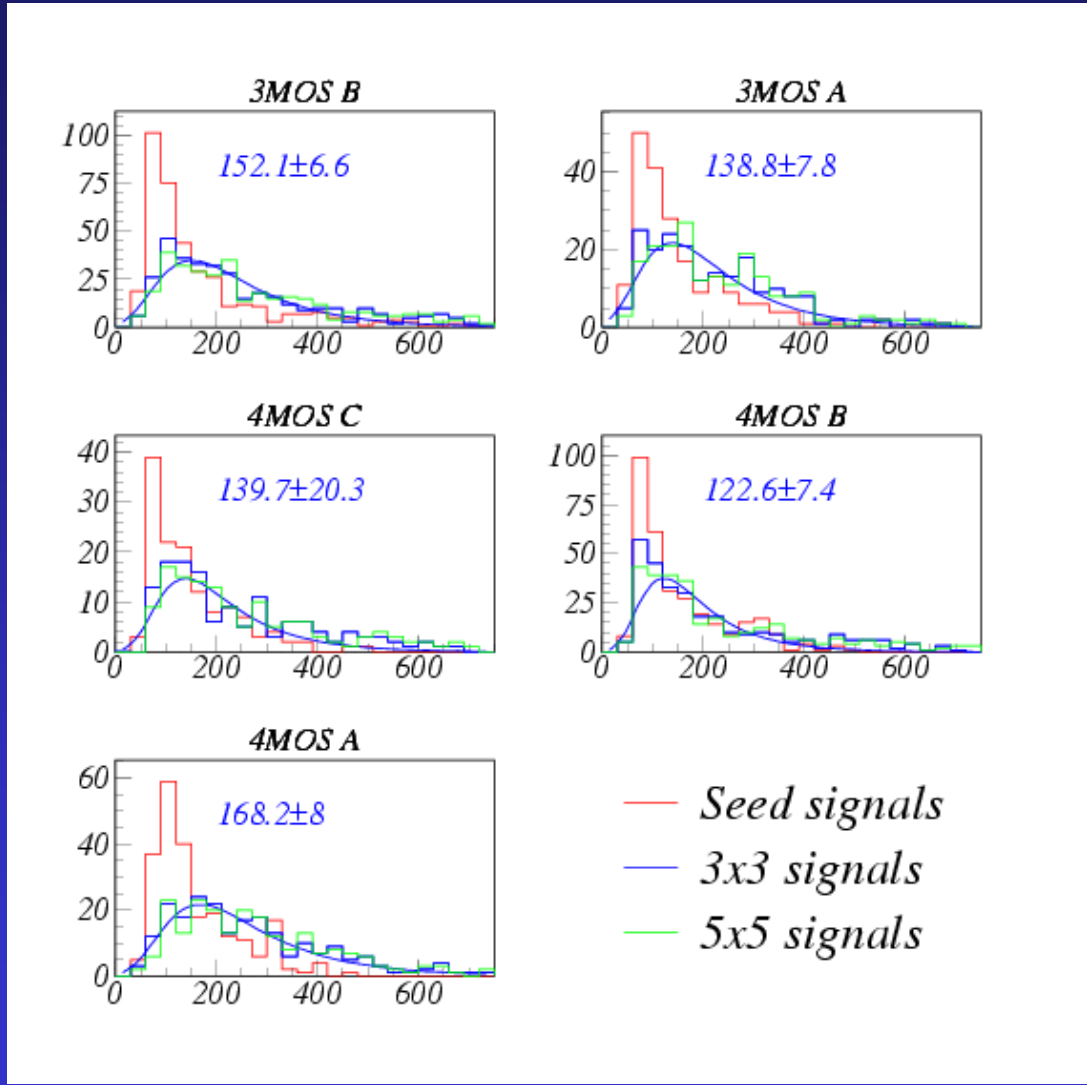
Number of pixels in a "3x3" cluster

APS2: Cluster signals

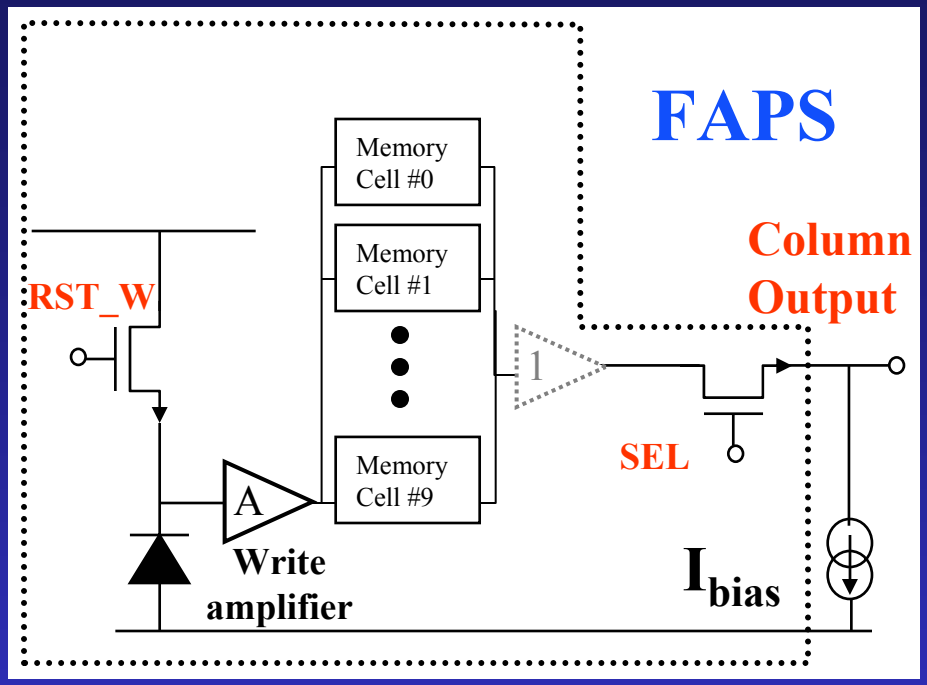
- From PTC hand waving S/N estimate

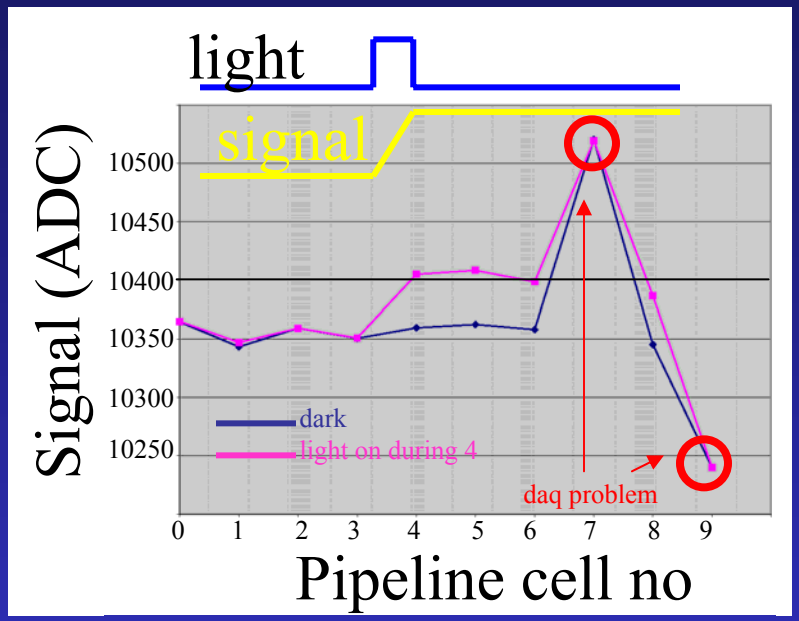
type	S/N exp	S/N
3MOS B	15	13.1±0.6
3MOS A	10	11.5 ±0.7
4MOS C	12	11.6 ±1.7
4MOS B	12	10.3 ±0.6
4MOS A	13	13.8 ±0.7

- Noise measured at RAL 2x smaller. Have identified problem in Liverpool. No results yet.



APS2: FAPS





- FAPS=Flexible APS
  - Every pixel has 10 deep pipeline

Data example using pulsed diode

Conclusions…

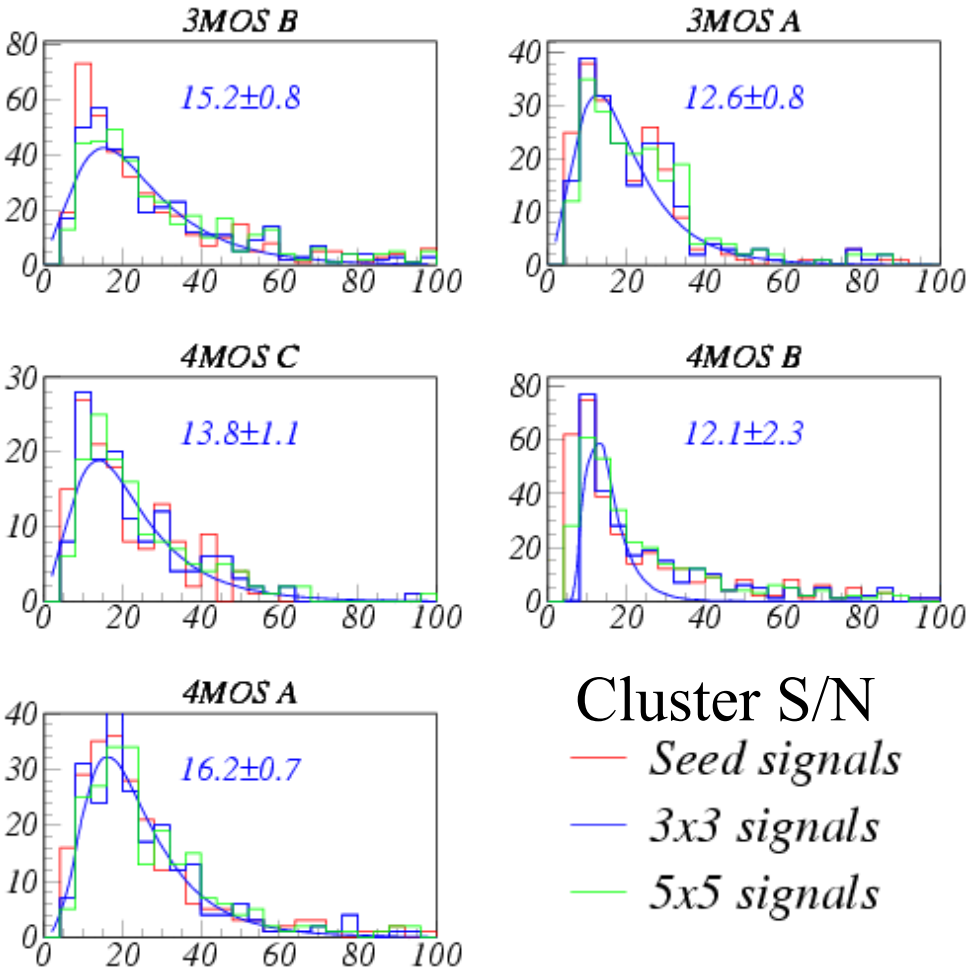
- Radiation study was performed using APS1:
  - Simulation reproduces unirradiated signal rise time.
  - No degradation of the noise was measured up to 10^{12} p/cm^2.
  - From simulation expect significant effects only after 10^{14} p/cm^2.
- Noise of 20 e^- measured in APS2 3MOS.
- MIPS have been detected in APS2 in 3MOS and 4MOS.
- FAPS work, characterisation in progress.

& Outlook

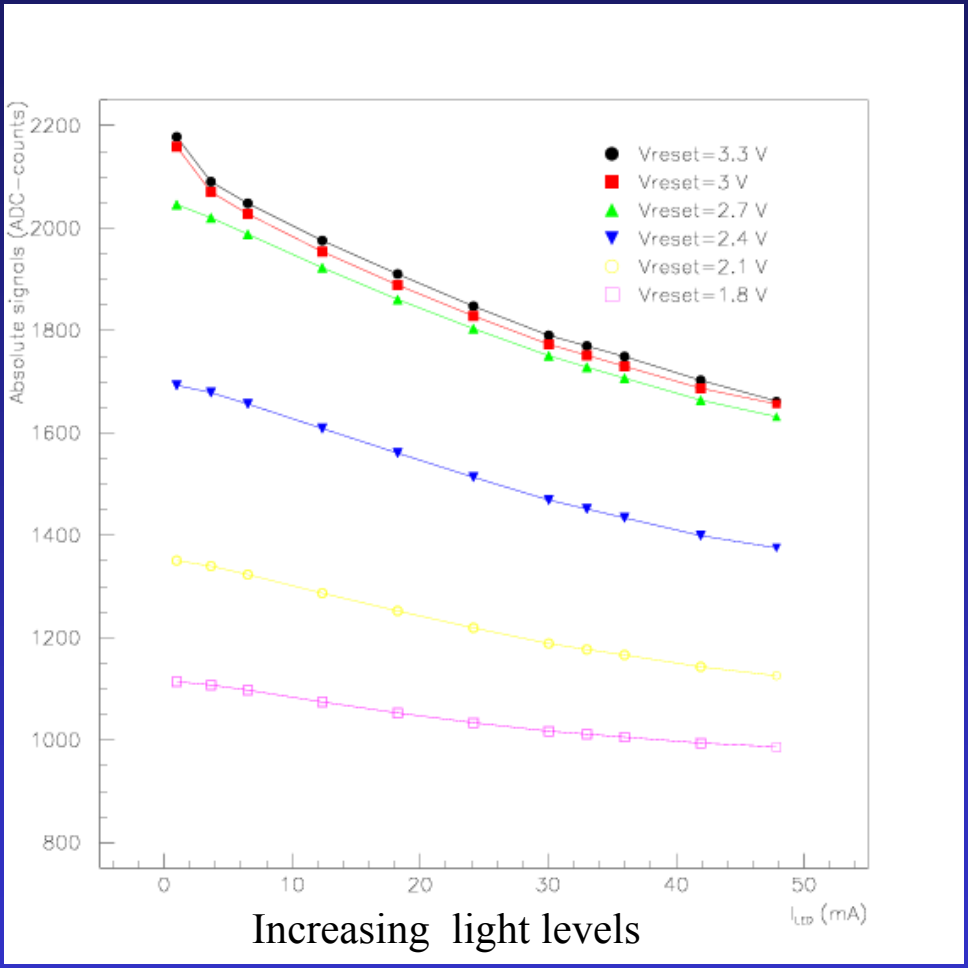
- Next we will focus on:
  - detecting particles using the FAPS.
  - Optimising settings and improve S/N.
  - Further irradiation of APS1 and also of APS2.

- APS3 will be operational by the end of May.

Cluster S/N


3MOS B
15.2±0.8
3MOS A
12.6±0.8
4MOS C
13.8±1.1
4MOS B
12.1±2.3
4MOS A
16.2±0.7
Cluster S/N
Seed signals
3x3 signals
5x5 signals

Signal vs Iled



- Output linear over large input range

APS2: Various flavours

3MOS

Like E but with p-well as small as possible

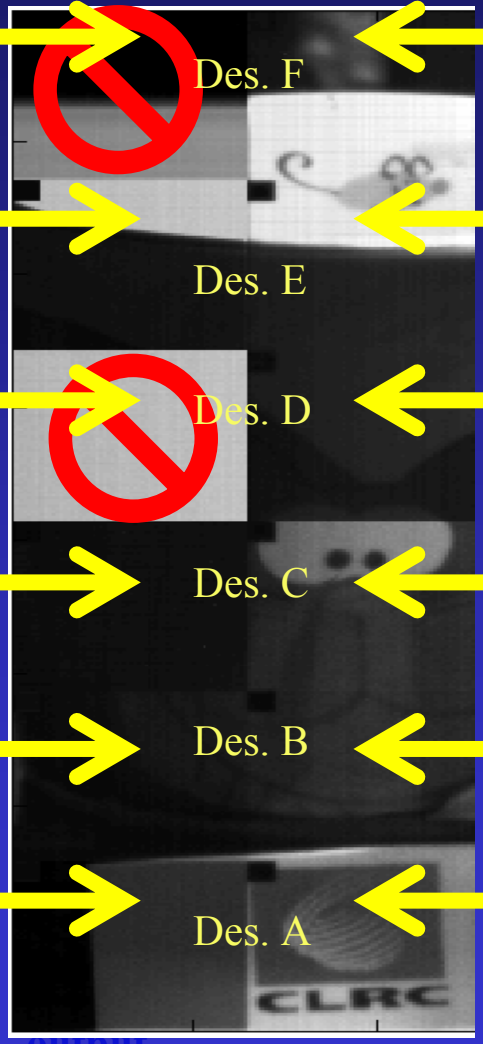
Like B but with four diodes in parallel

Like B but with p-well as small as possible

Like B but with gate-all-around transistors

Like A but with smallest diode (1.2*1.2 mm)

Reference pixel (diode ~ 3*3 mm)



4MOS

Like C but with gate-all-around transistors

Like B but with gate-all-around transistors

Like A but with gate-all-around transistors

Like A but the TX transistor has lower Vt

Like A but the TX transistor has higher Vt

Like 3MOS-A but with the TX transistor

output

APS1: Radiation test