RADOPT 2021

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Radiation test results of the aLFA-C: astronomy Large Format Array Controller

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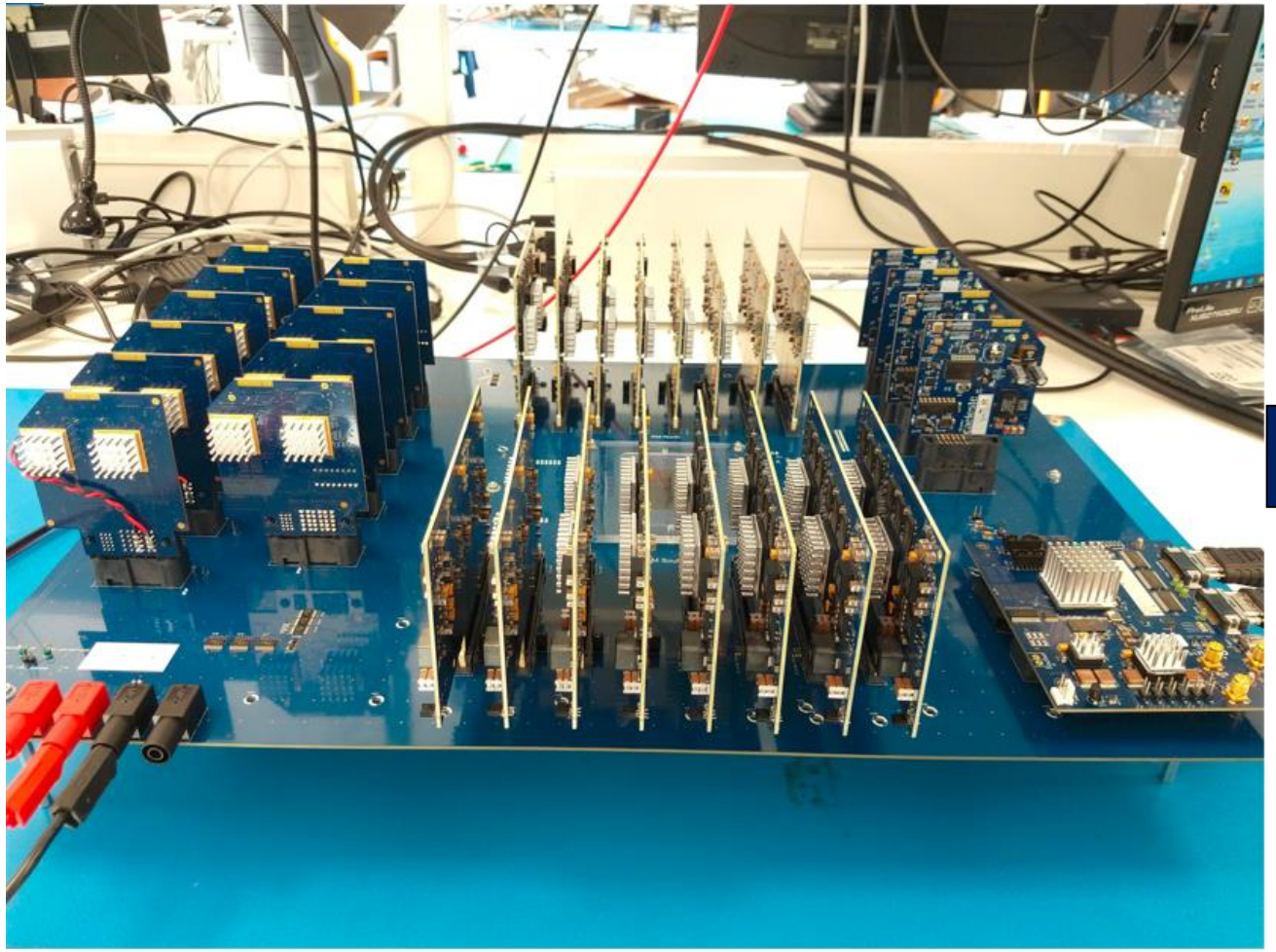
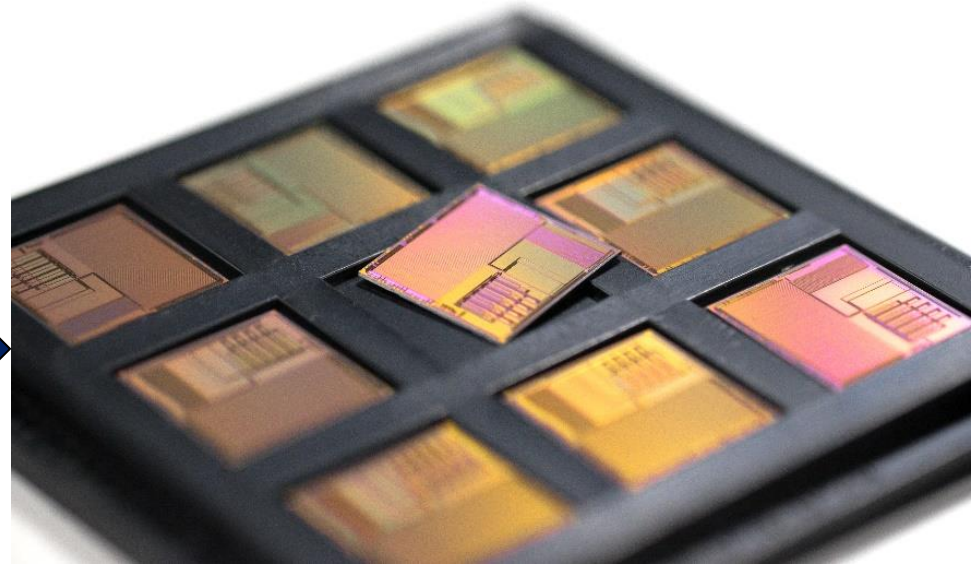
Outline

- **Motivation**
- **Architecture**
- Building blocks design
- Test results
- Conclusions

Motivation

Space applications need a compact, low power front-end electronics interfacing image sensors





Functionality and challenges

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aLFA-C ASIC: interfacing astronomical science missions sensors

- **Analog domain**
  - Signal conditioning
  - A/D converter
  - Regulated power supply
  - Bias voltage/current references
  - House keeping
- **Digital domain**
  - Sequencer
  - Memory
  - SpaceWire

Environmental constraints:

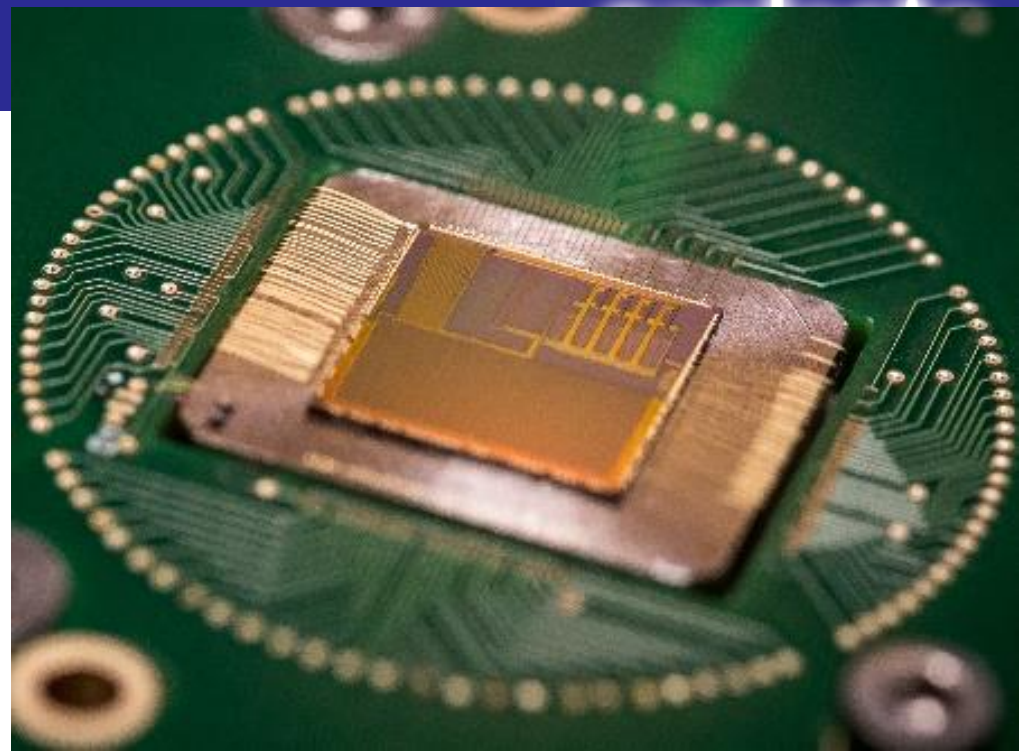
SPACE
•Radiation tolerance
•High reliability

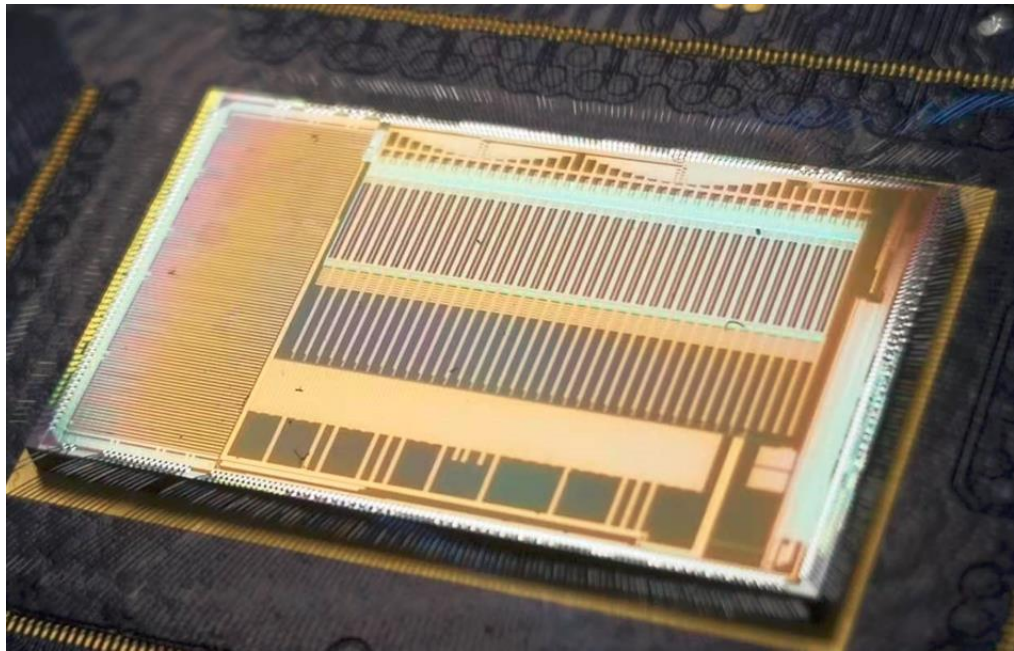
Infrared sensors
•Operating close to the focal plane temperature e.g. << 77K

Development status

- **aLFA-C: prototype (2014)**
  - 16-bit SAR ADCs
  - Programmable sequencer
  - Memory cells
  - All key building blocks perform well at RT and 77K

- **aLFA-C: full chip (this work)**
  - 38 16-bit ADCs
  - Digital core: DARE018 Analog core: Caeleste RH
  - Technology: UMC018
  - Successfully tested over temperature range
    - Operational down to 24.5K demonstrated
    - Characterized at RT, 77K and ~30K
  - Performed radiation test
    - TID: up to 290 krad
    - Heavy ion: up to LET 62,5 MeV.cm^2/g





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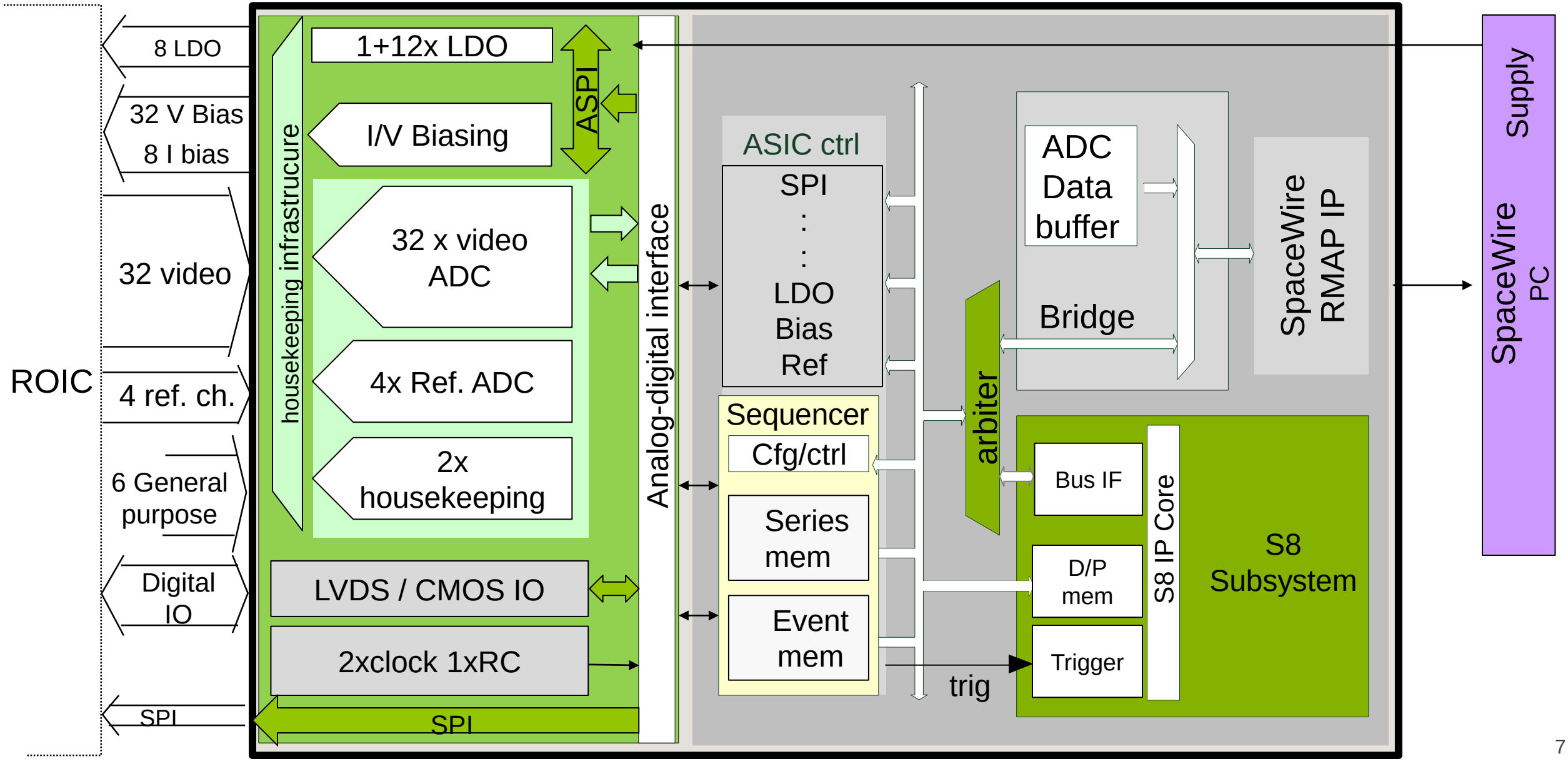
aLFA-C Architecture / block diagram



aLFA-C chip layout

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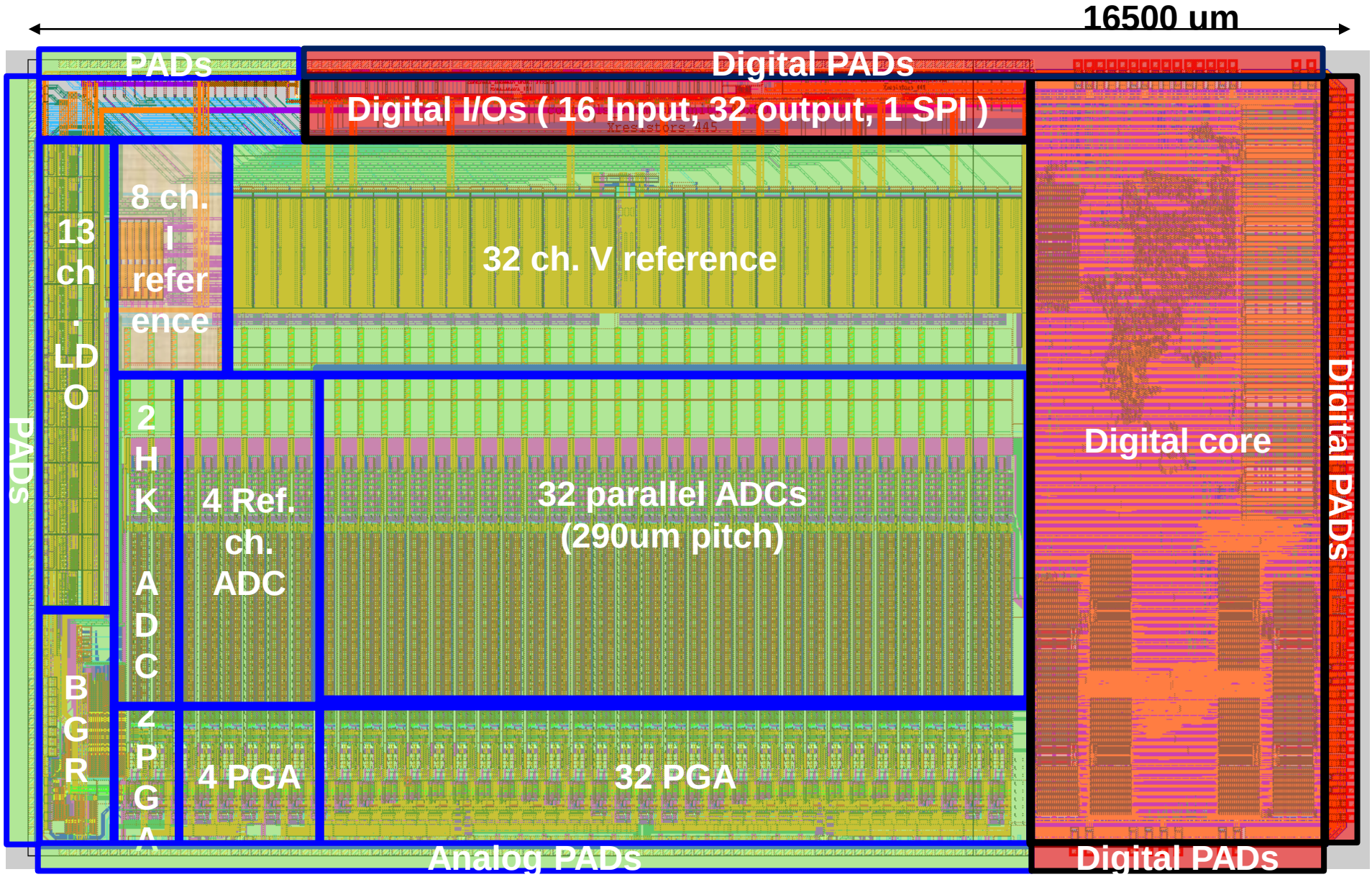
Analog core

Caeleste Library

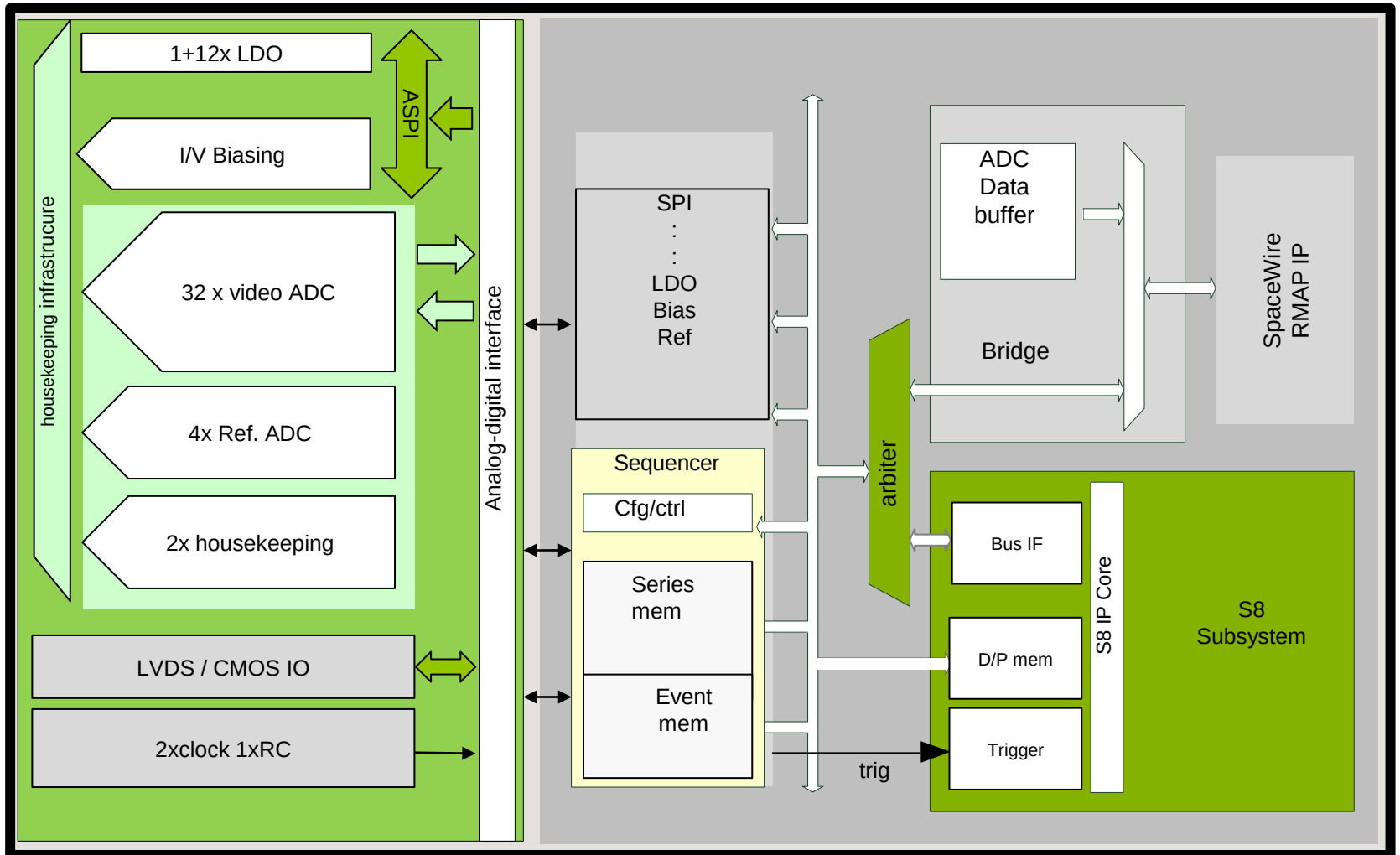


Digital core

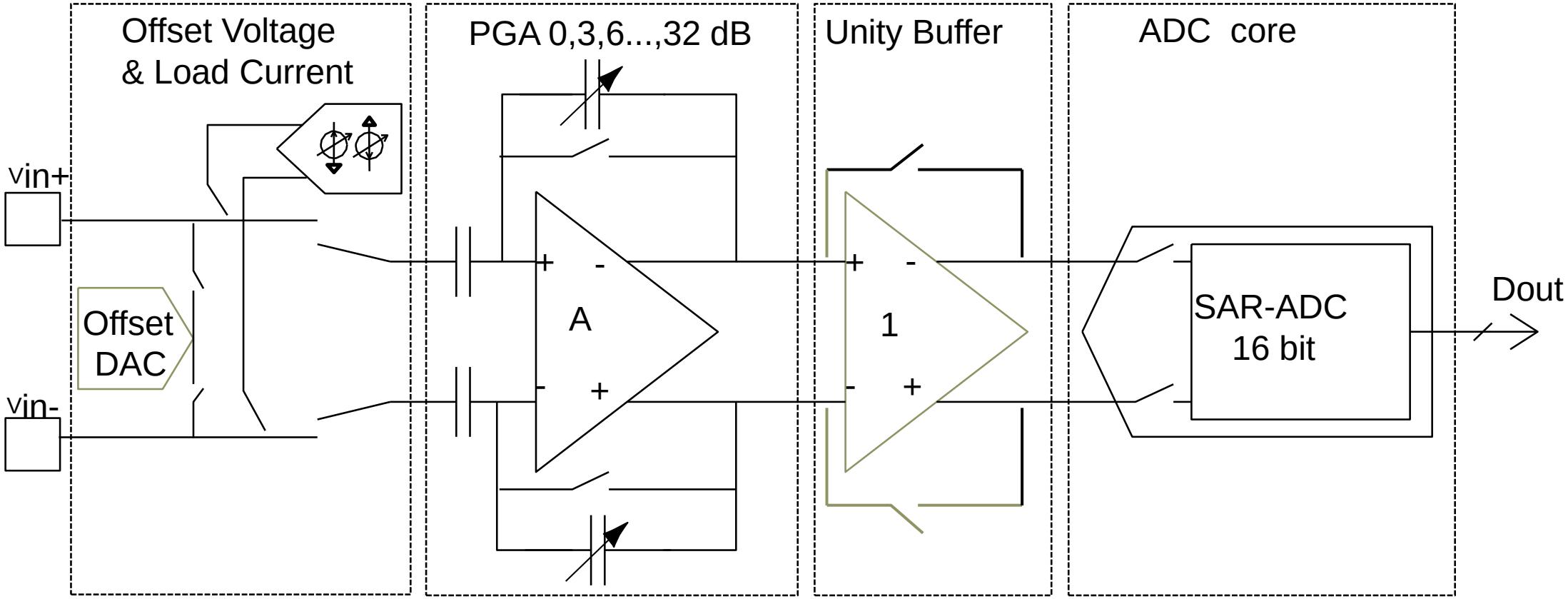
ESA / imec DARE Library

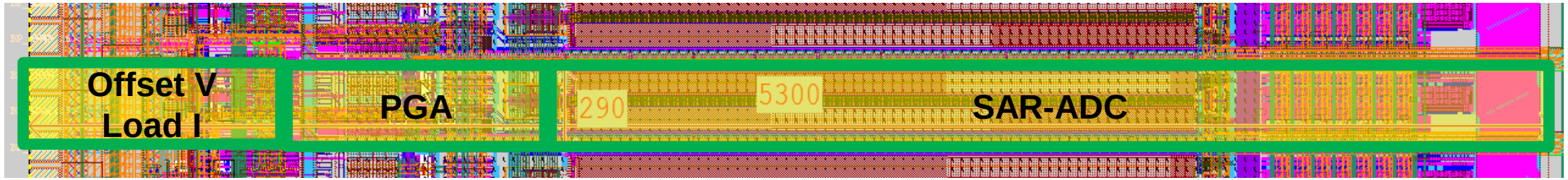
Video channels

- **32+4 channels**
- **100ksps**
- **Input method**
  - 32/64 Single ended
  - 32 Fully Differential
  - Parallel or interleaved sampling:
    1/2/4/8/16/32



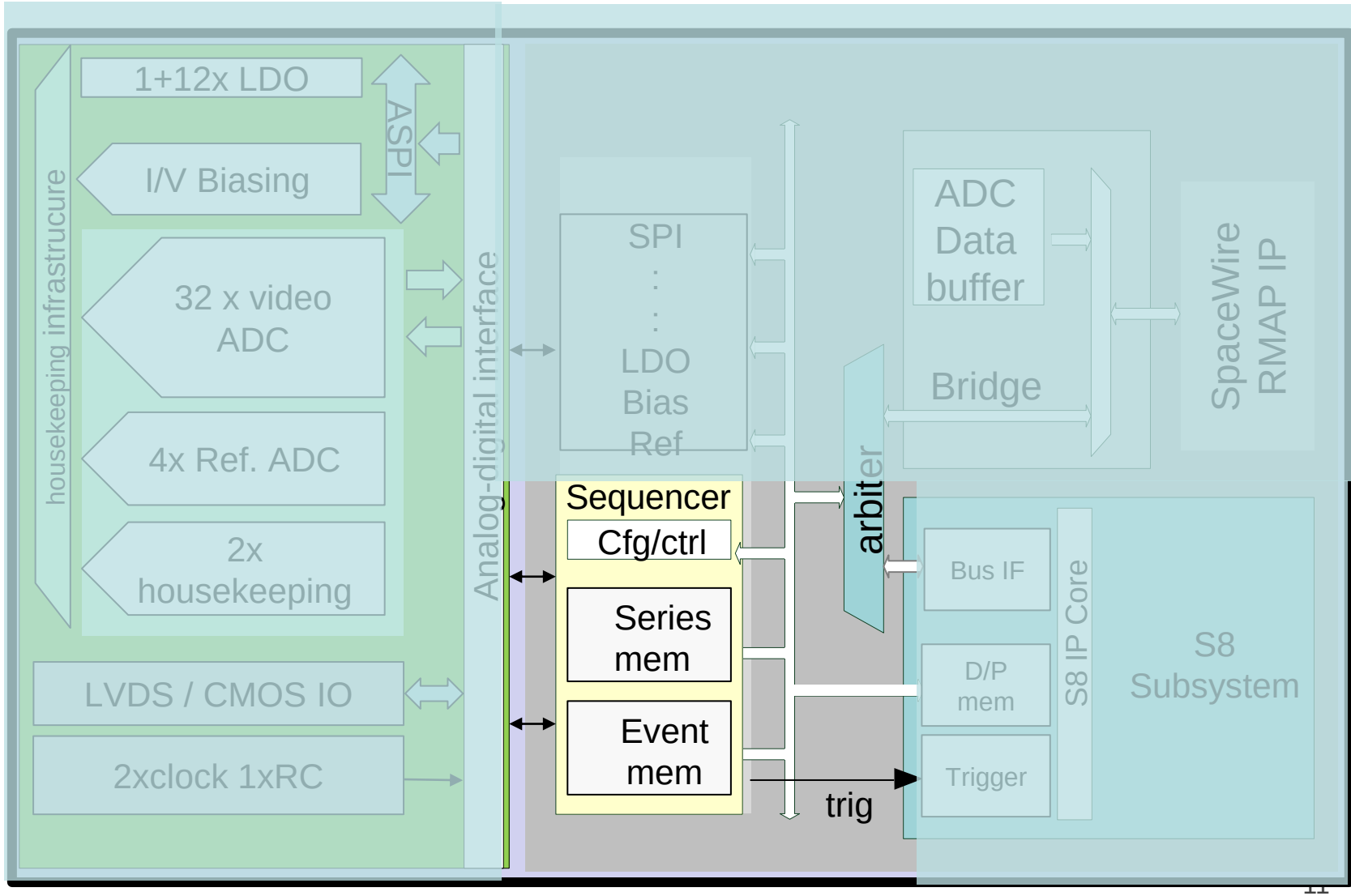
Single “video” channel



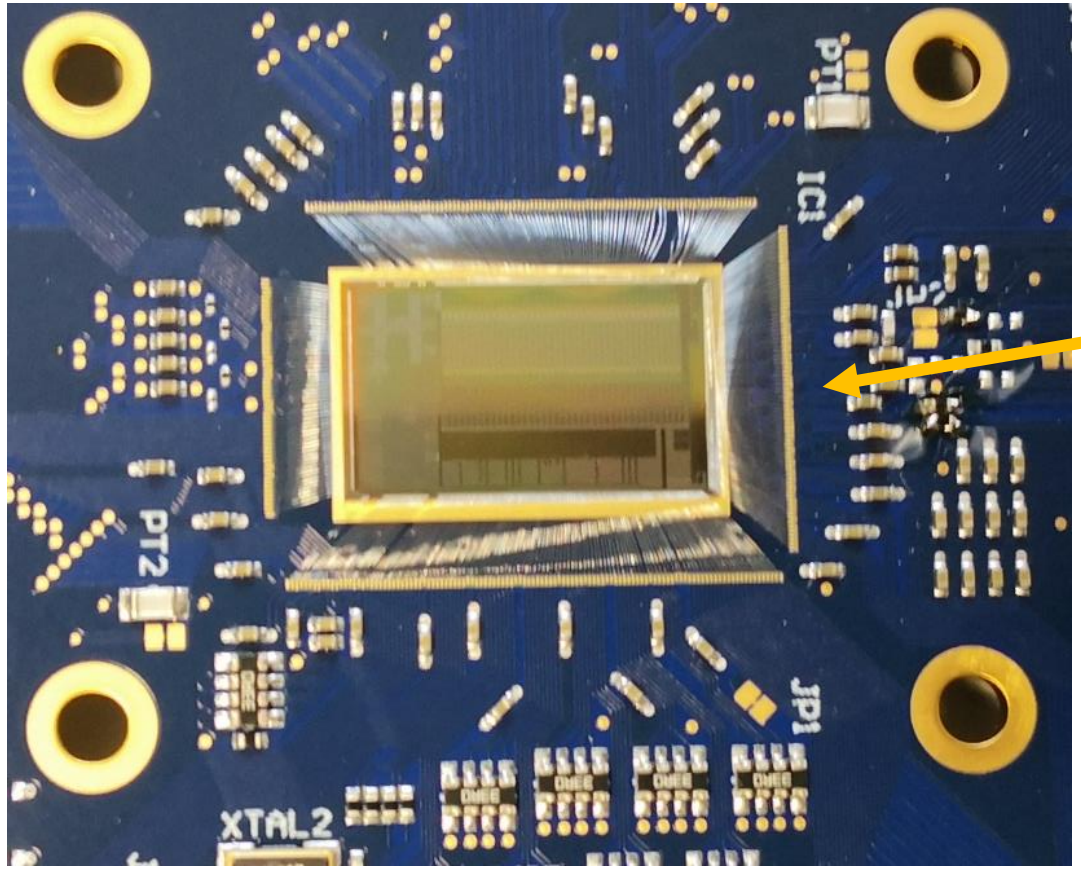


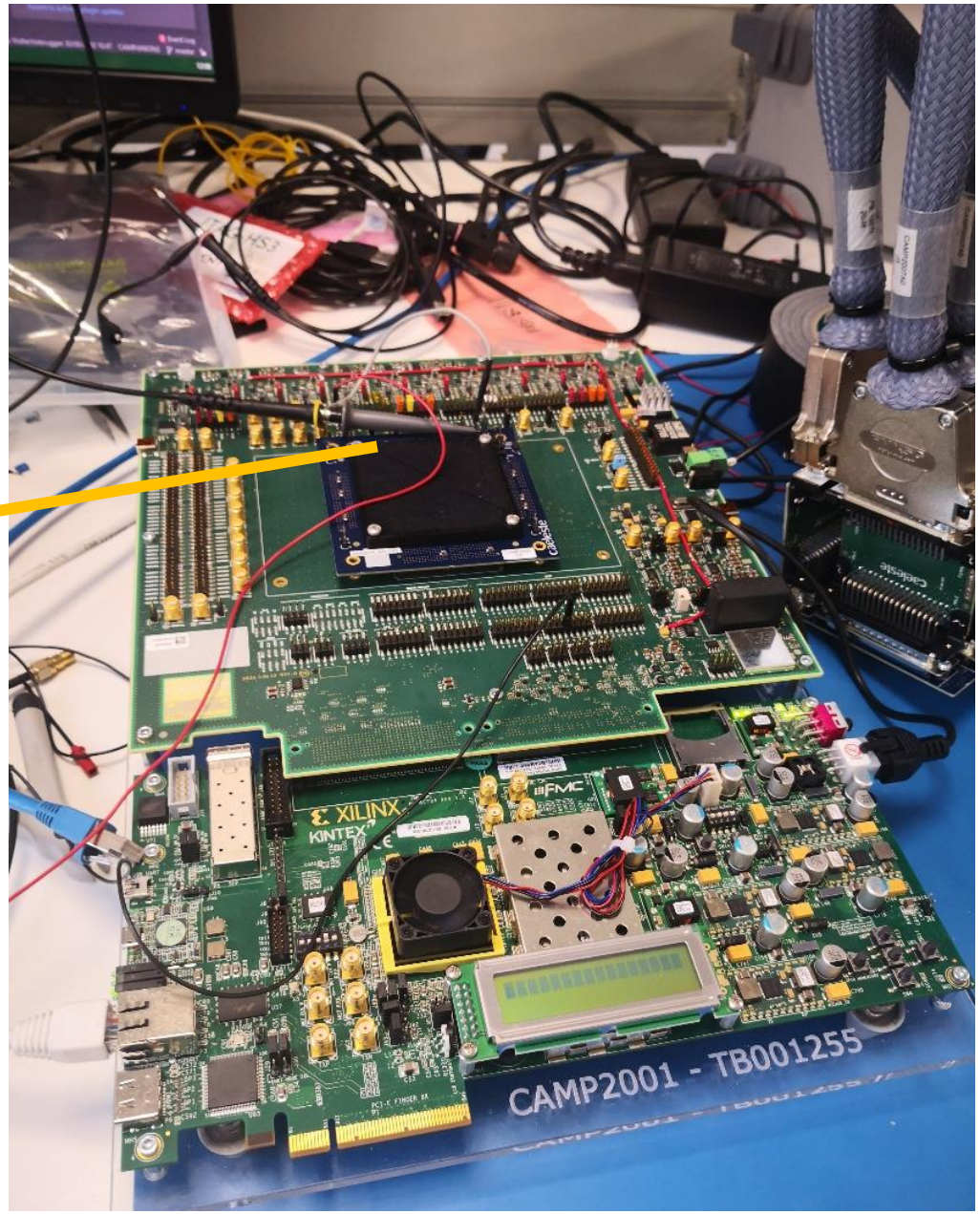
Programmable sequencer

- **Control**
  - All 38 ADCs
  - All 32 digital outputs
  - All 16 digital input
- **Trigger on-chip µ-processer**
  - Parameter Sweep
  - Other tasks

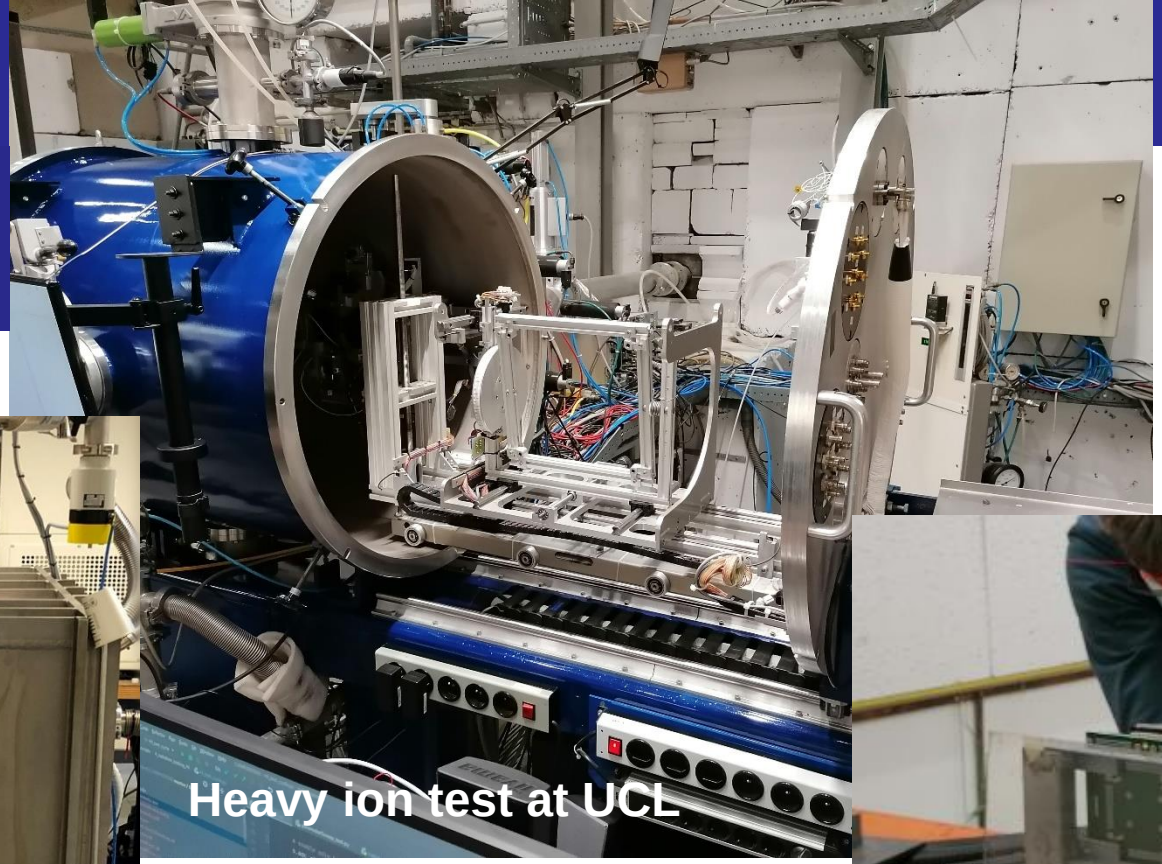


Room temperature test setup

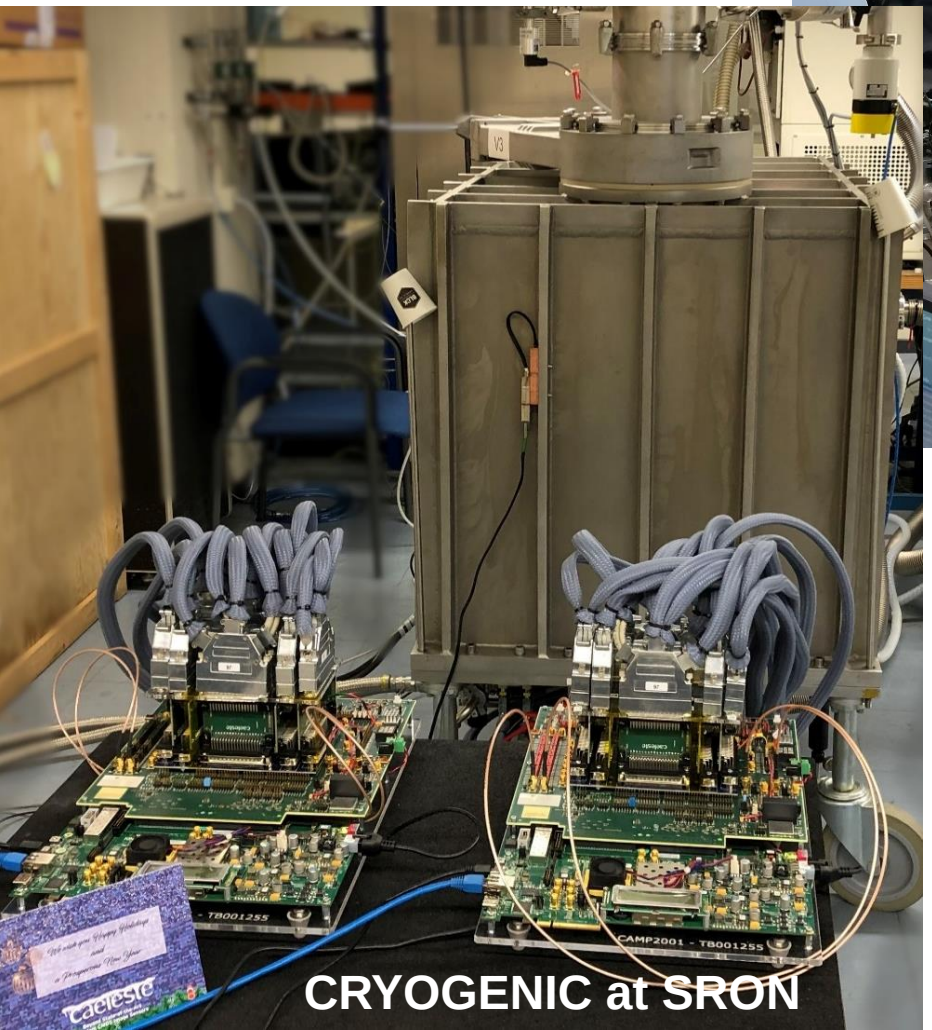




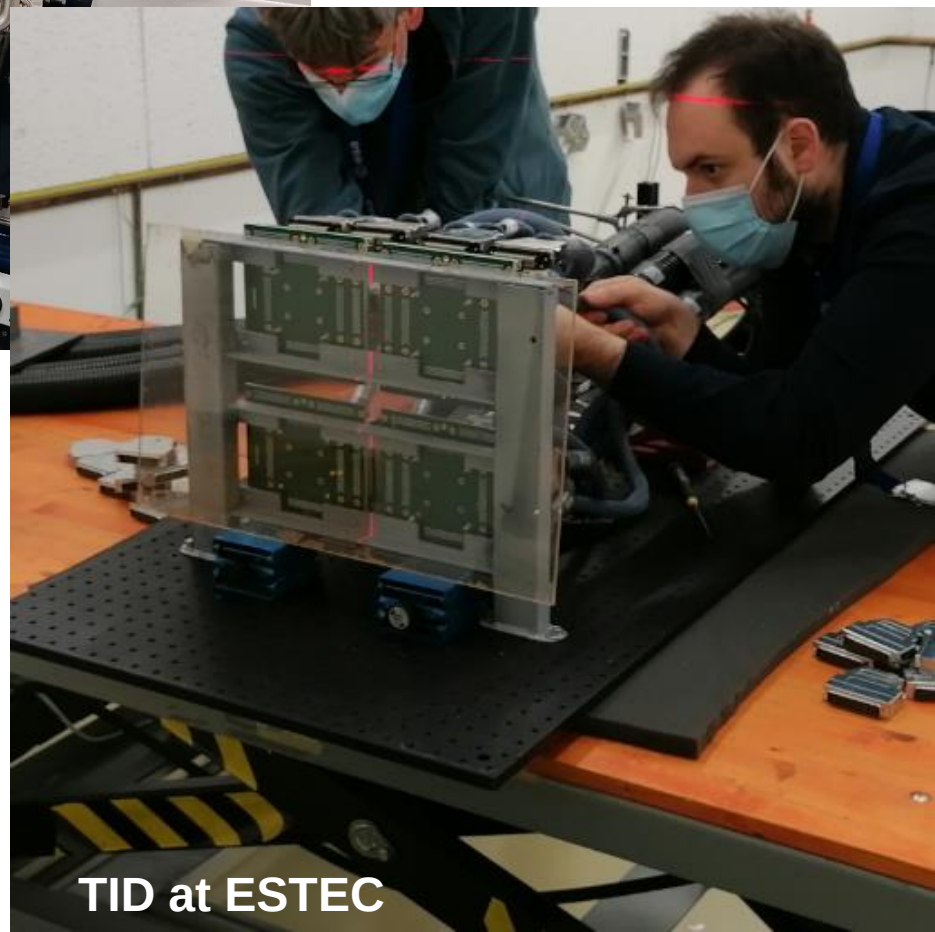
Cryo and radiation test setup



Heavy ion test at UCL



CRYOGENIC at SRON



TID at ESTEC

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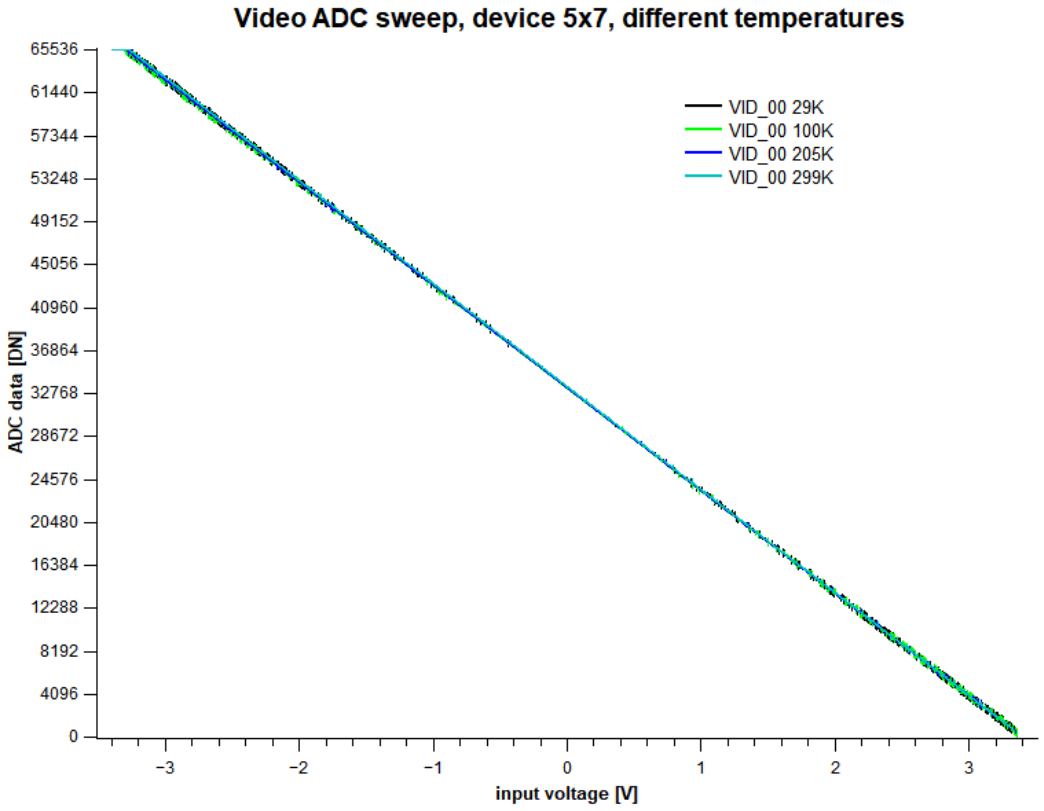
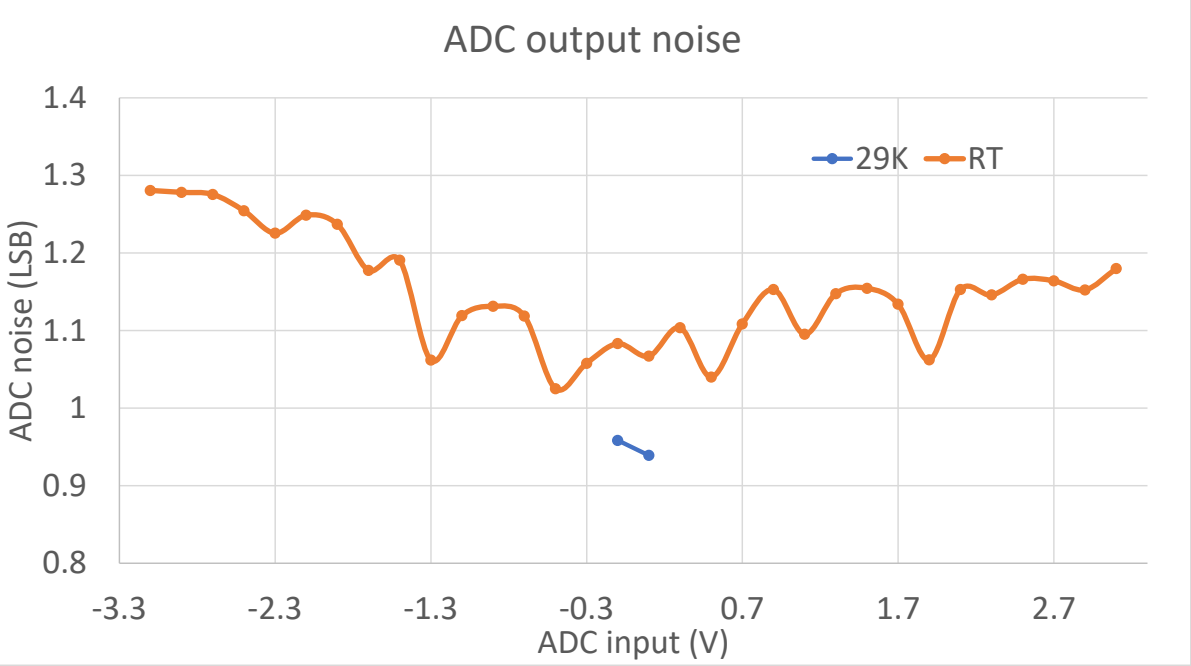
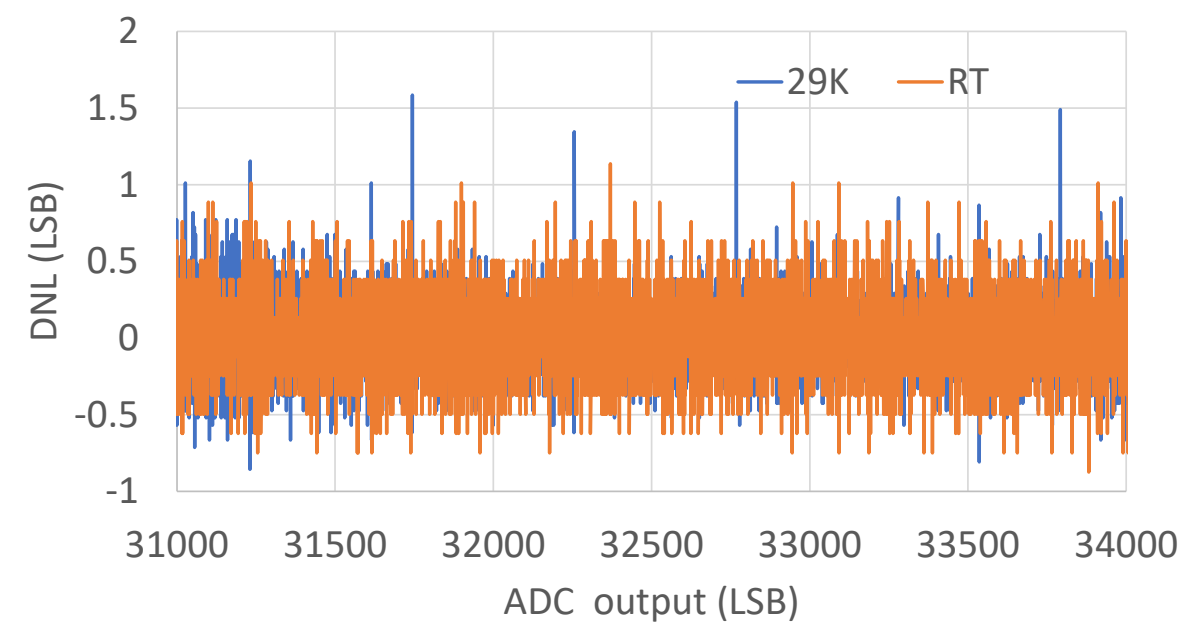
Cryogenic behavior, ADC as an example

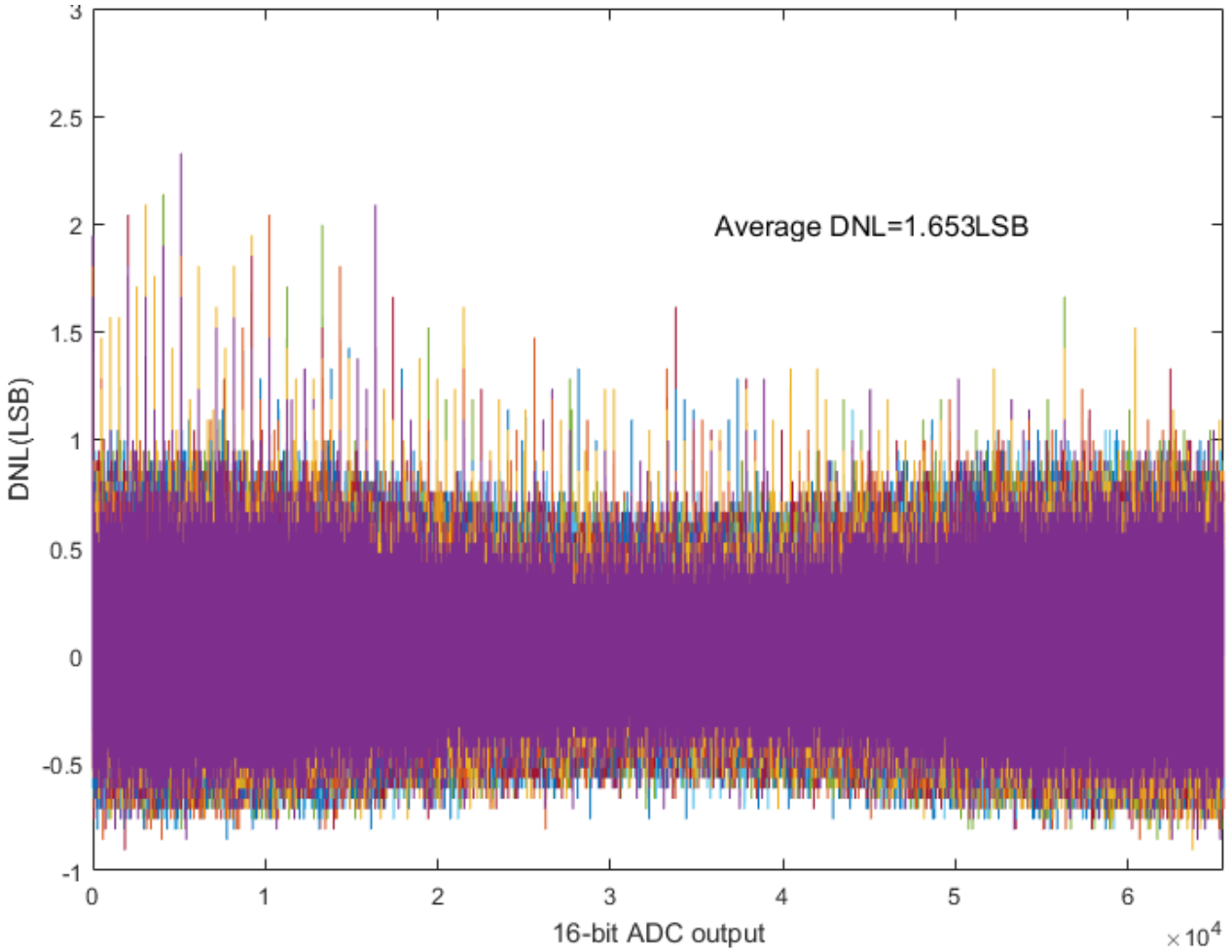


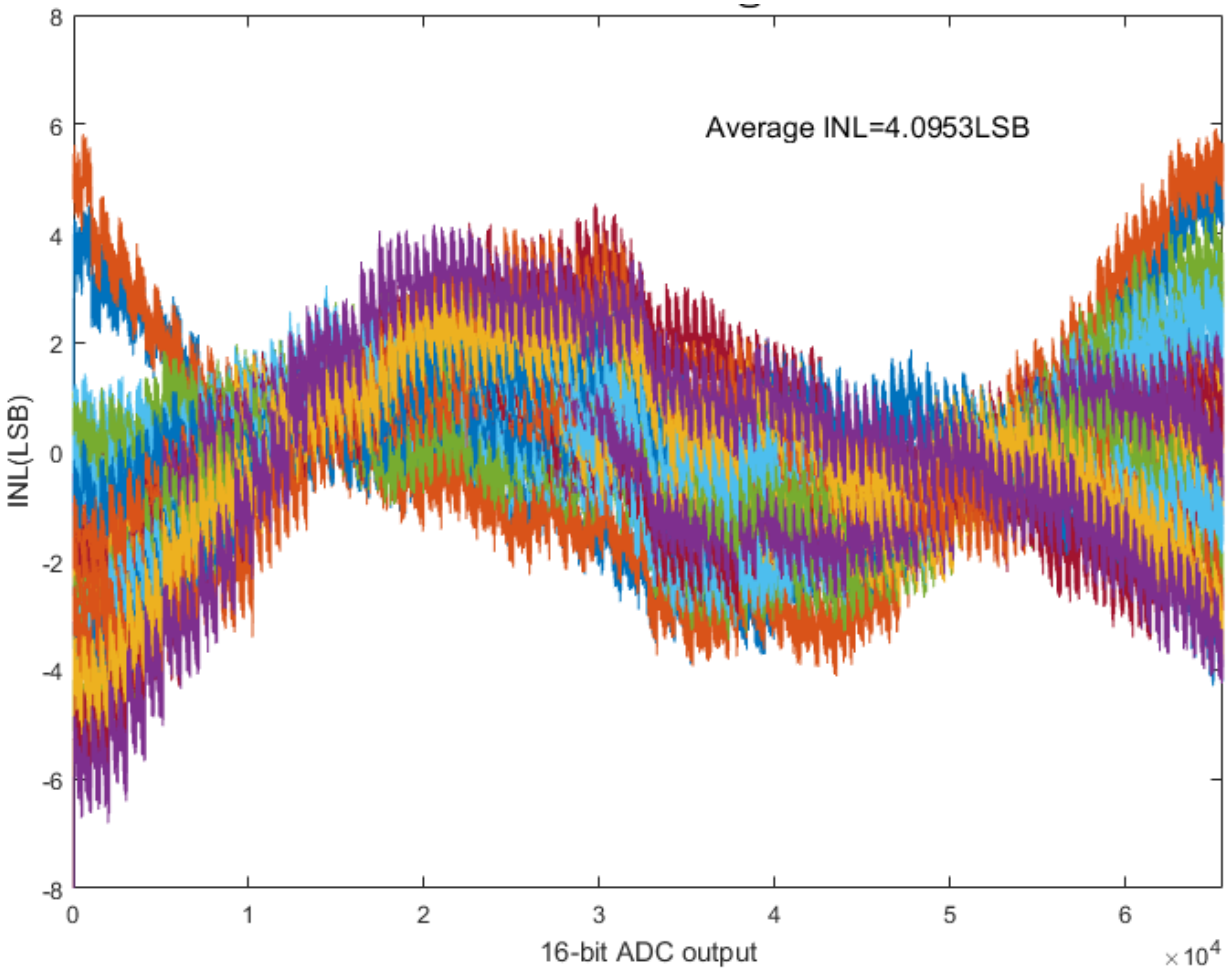




- 16 bit ADC: 92 µV/DN
- Slightly lower noise at 29 K

Measurement: ADC linearity @ RT





All 32 ADC's superimposed

Radiation: overall circuit behavior

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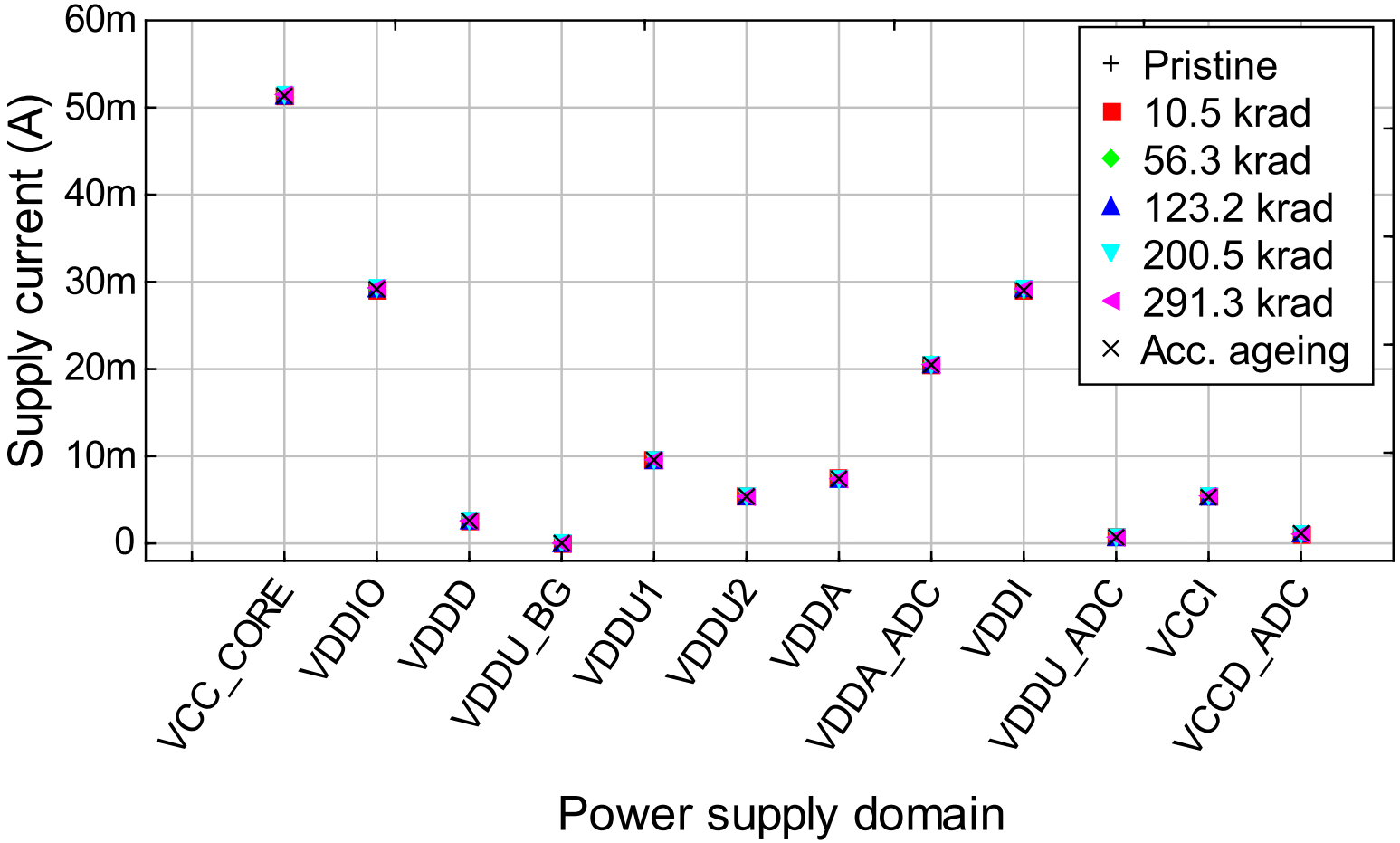
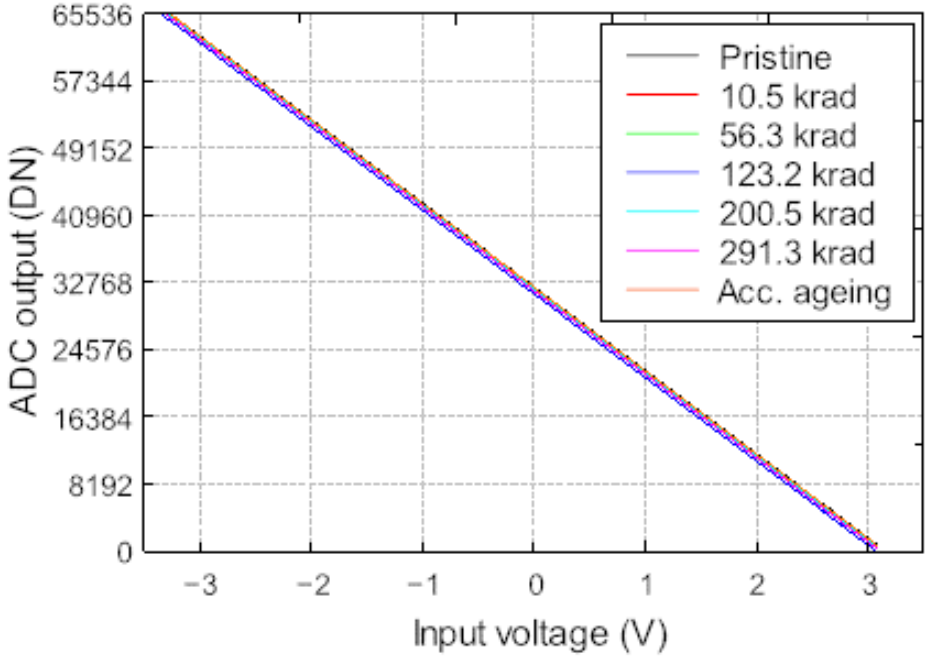
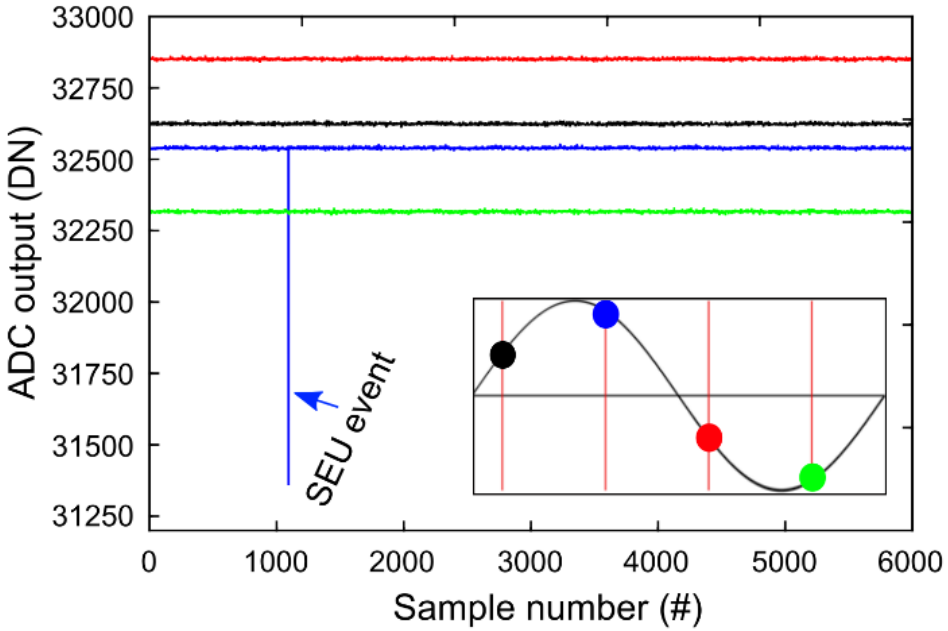
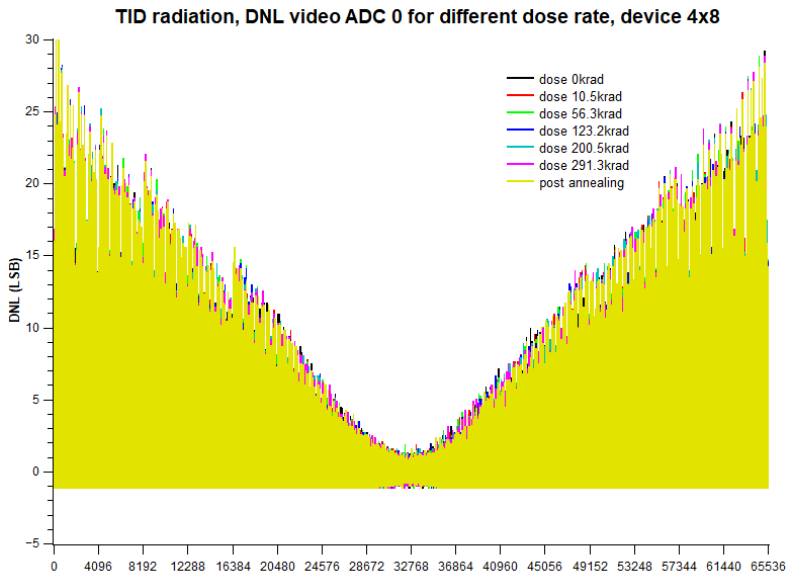
- Co-60 TID: measured at 6 times higher dose than spec
- No effect on power dissipation (graph)
- No Latch-up observed

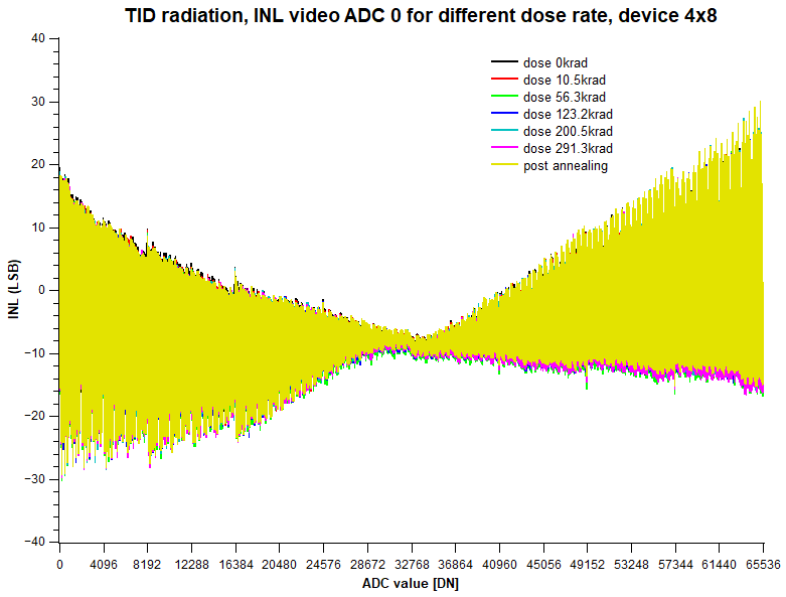


AD converter









SEE test digital core

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LET	Ion	Flux	Fluence reached	Scrubbing enabled?	SEU						SEFI
					RMAP	Ev.Mem.	Ser.Mem.	Prog.Mem.	Data.Mem.	CORR	ERR
10.2	Ar	300	9.16E+05	No							
20.4	Ni	1000	6.00E+05	No							
32.1	Kr	1000	5.20E+05	No							
62.5	Xe	500	7.00E+05	No							
62.5	Xe	500	8.00E+05	Yes							

Outline

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Conclusions

- **aLFA-C ASIC has all expected features to control IR FPAs**
  - High resolution ADC
  - Lower noise reference voltage
  - Highly programmable sequence

- **Proven operation**
  - Room T down to 24.5K
  - Radiation tolerance
    - TID: up to 290krad
    - Heavy ion: up to 62,5 MeV.cm^2/g LET

Acknowledgements

The work is performed under:
ESA Contract No. 4000124004/18/NL/HB

Our project partners