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TAKING THE PULSE OF OUR PLANET FROM SPACE

Advanced Receiver for Future L-Band Radiometer development results

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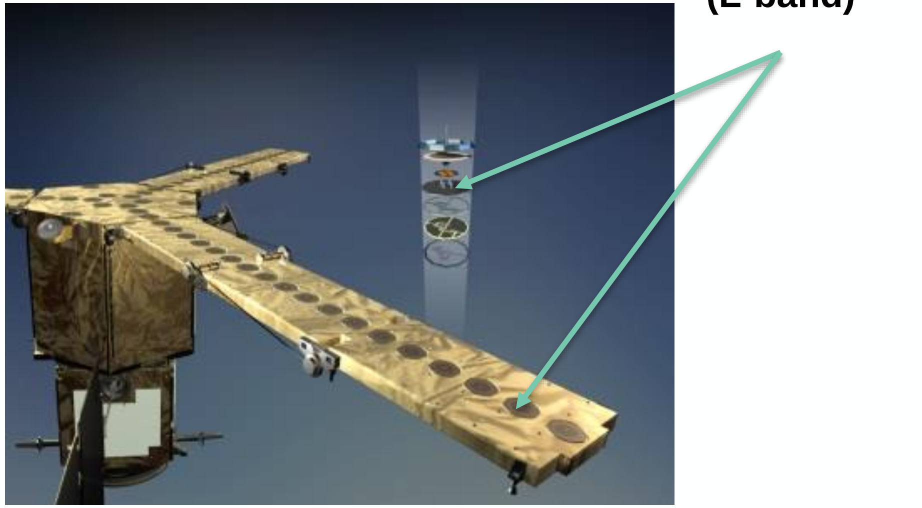
I – SMOS follow-on: targeted performance improvements

- SMOS was launched in 2009
- Provides L-band valuable scientific global measurements:
  - **Soil Moisture + Ocean Salinity**
  - **Secondary products:** thin sea ice, frost/thaw soils, high winds, ocean surface wind and Sun brightness temperature
- SMOS L-band receivers (LICEF) provided by SENER Aeroespacial



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I – SMOS follow-on: targeted performance improvements

- **ALR (Advanced L-band Receiver)** is a development under **ESA contract** of a new receiver to improve system level performance from SMOS:

  - **Increase spatial resolution** => Larger instrument (envelope, power, mass)
  - **Increase Alias free FOV** => Reduce antennas spacing (smaller receiver)
  - **Full-polarimetric mode** => Two RF chains (H and V polarisations) instead of 1 RF chain + input switch
  - **Improve instrument sensitivity** => Improve NF

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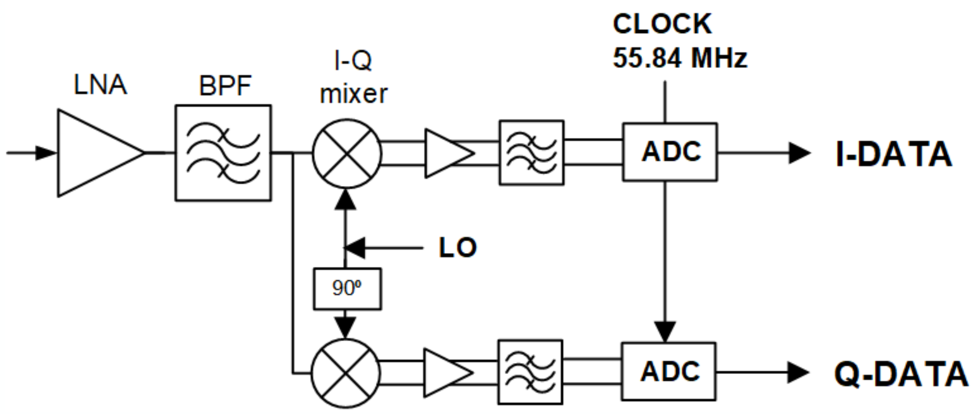
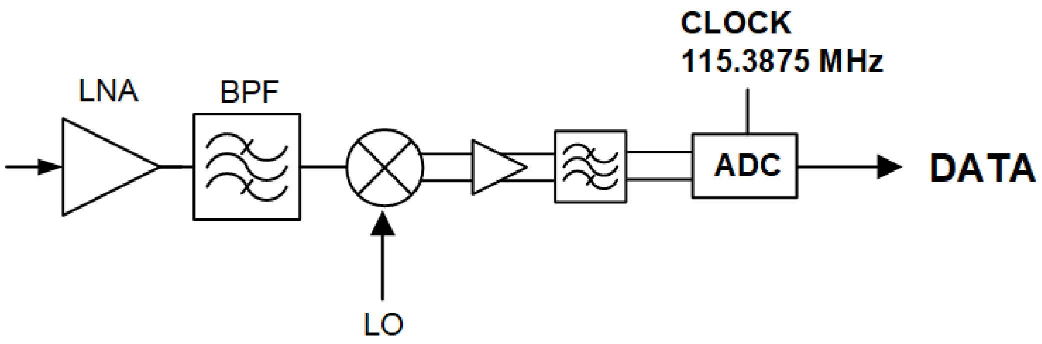
II – ALR trade-off's: Digital vs Analog I-Q

Analog I-Q (SMOS)



- ! Two mixers and IF chains
- ! Higher mass, power and envelope
- I-Q quadrature unbalance phase error
- I and Q IF chains frequency response must be matched

Digital I-Q (ALR)



- Only one IF chain
- Lower mass, power and envelope
- IF centre frequency (CLK / 4) error becomes relevant, but it can be corrected by data post-processing

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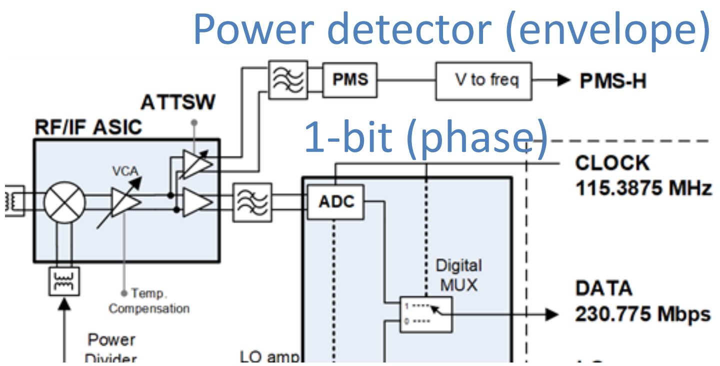
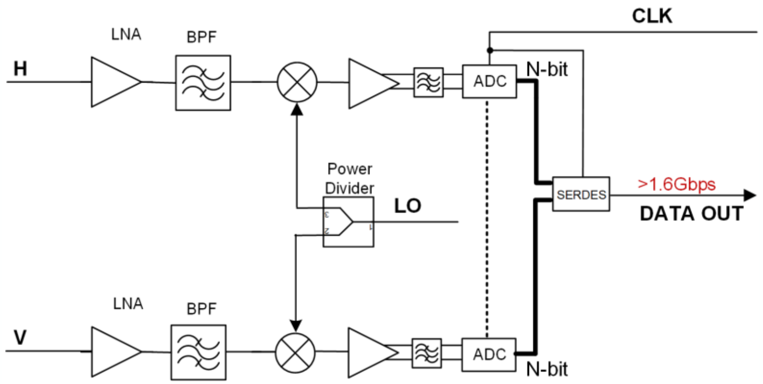
II – ALR trade-off’s: 1-bit ADC vs fully digital

PMS + 1-bit ADC (SMOS, ALR)



N-bit ADC + Digital processing

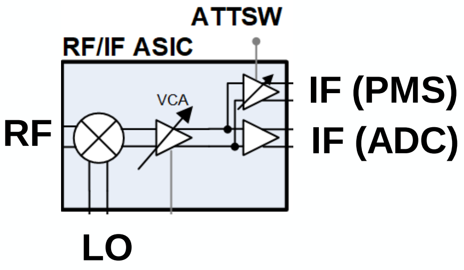


- **RFI mitigation** at **correlator level**
- **Instrument performance** and equations are **known from SMOS**
- **Digital correlations are simple**, require minimum FPGA/ASIC resources (XOR+Add/Accumulator)
- **230Mbps** of digital data / unit
- **Lower consumption** (<1.5W per unit)

- **Additional techniques** could be applied for **RFI mitigation** (sub-bands, etc)
- **Complex digital processing** (correlation requires Multiplier + Add/Accumulator)
- ! **>1600Mbps** of digital data / unit
- ! **Higher consumption** (>2W per unit) (plus digital processor)

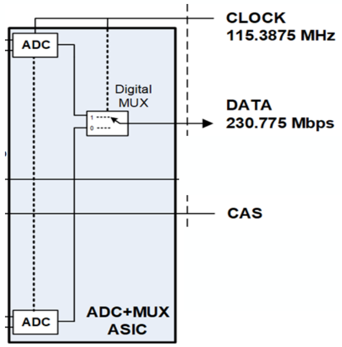
III – ALR improvements: ASIC

- SiGe mixed signal ASIC's developed to minituarize RF section and reduce power consumption:



RF/IF ASIC

- Mixer
- IF amplifiers
- Variable attenuator
- Slope corrector
- PMS switchable attenuator



ADC+MUX ASIC

- Dual 1-bit ADC's
- 2:1 Digital Multiplexer
- Transmission over single fiber

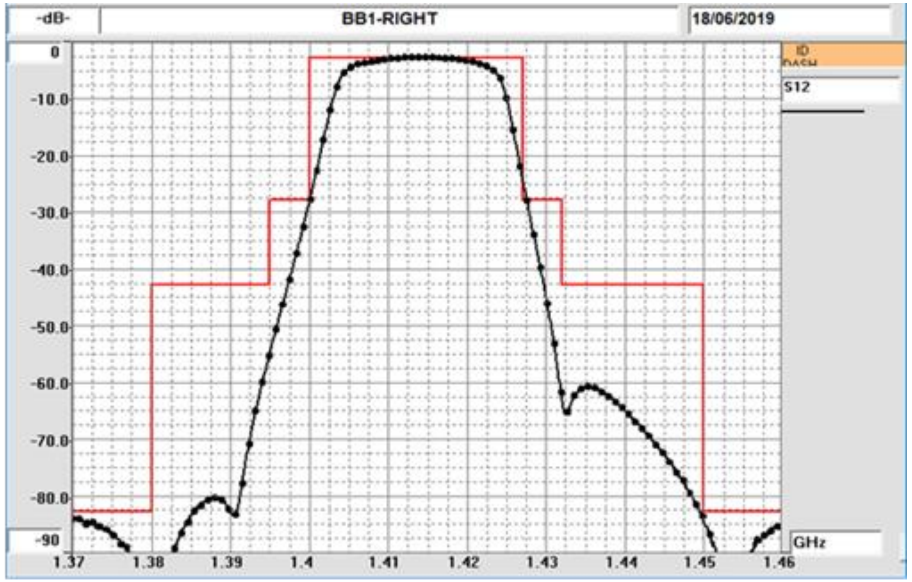
III – ALR improvements: BPF mass reduction

- Two BPF required => Mass, envelope driver!
- Added **transfer zeros** to reduce **order from 8 to 6 (mass reduction of 25%)**
- **Direct interface with RF substrates** instead of SMA cables
- Meet **same mask as SMOS** with 25% mass reduction

SMOS BPF

ALR BPF

ALR BPF test result



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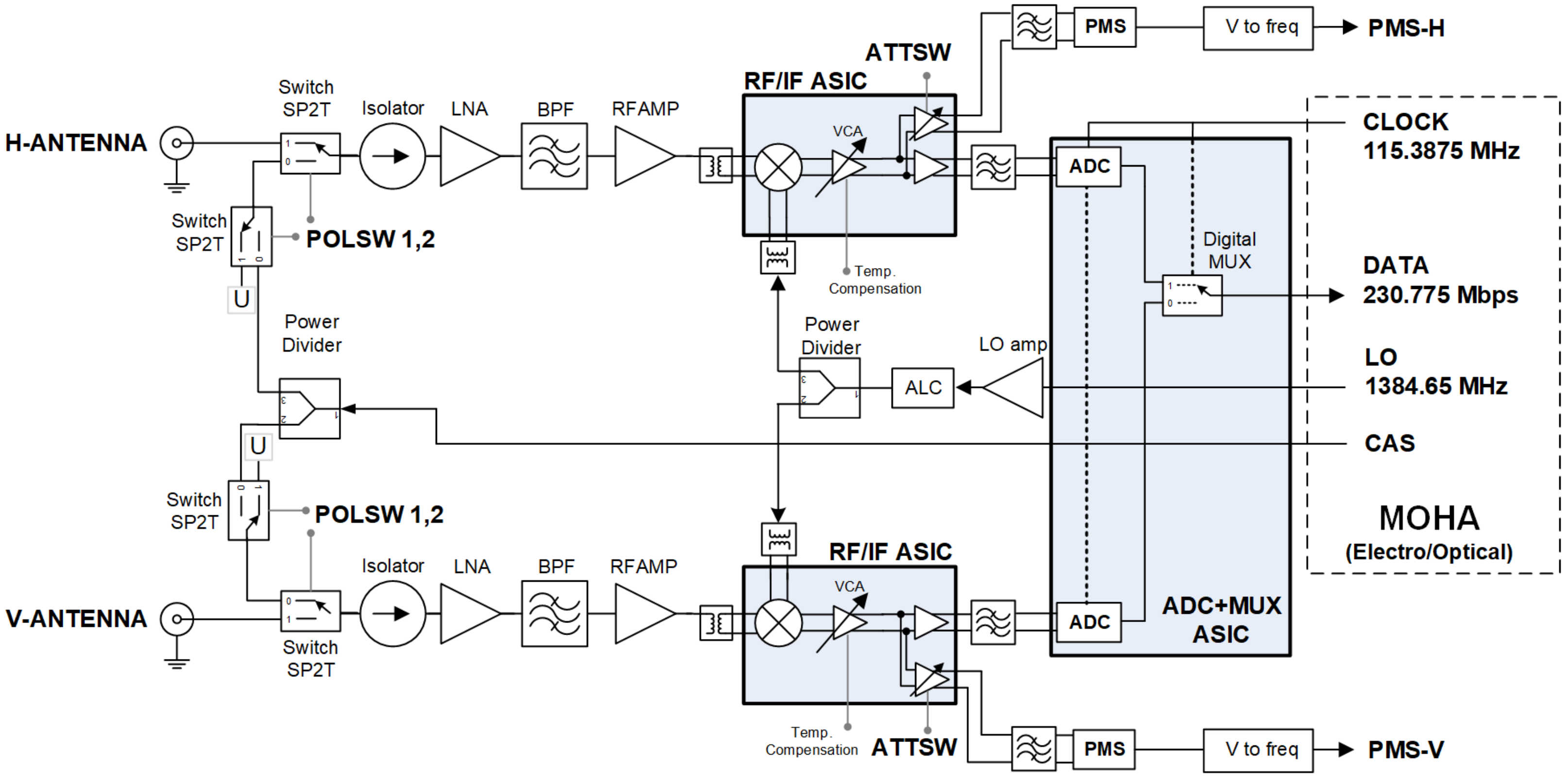
IV – ALR Design Description

- Radiometer **calibration switch** (U and CAS)
- **H & V** parallel receiver chains
- **LNA** with minimum NF
- **BPF**
- **PMS** (power monitor) with V to freq converter
- RF/IF and ADC based on **ASIC's**
- **Optical** signal distribution



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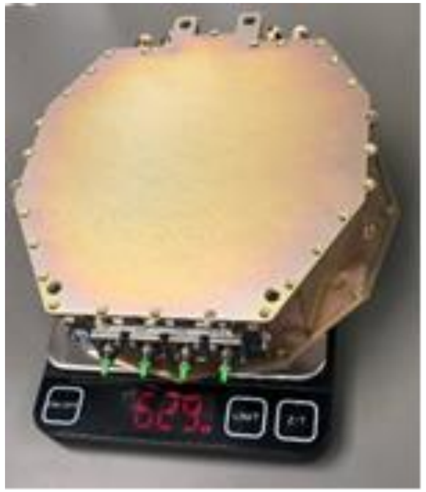
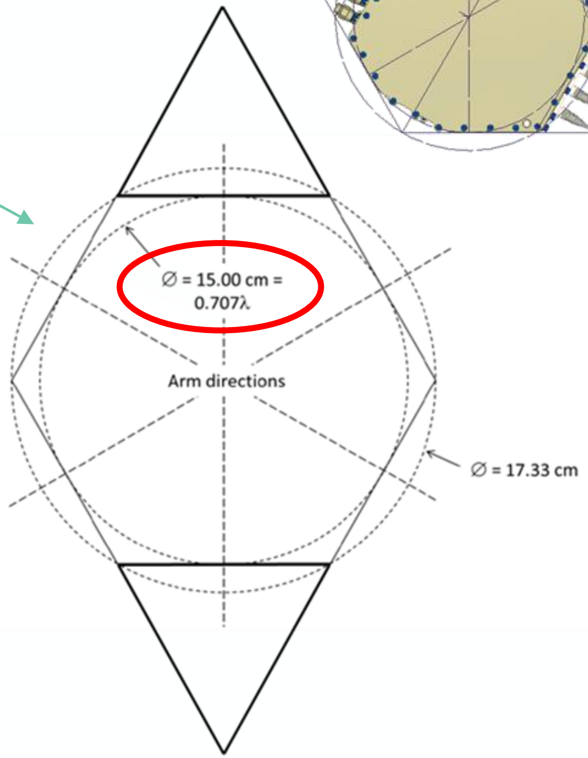
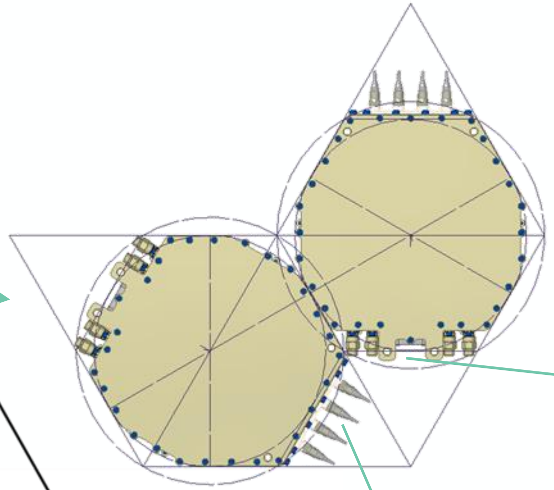
IV – ALR Design Description

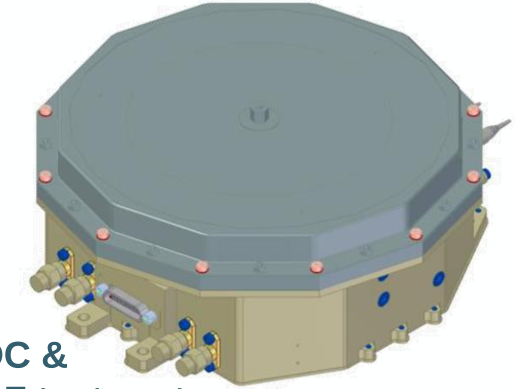
- **Connectors** location to **avoid mechanical interference**
- Envelope: Fit into **smaller hexagon**
- **Mass reduction**



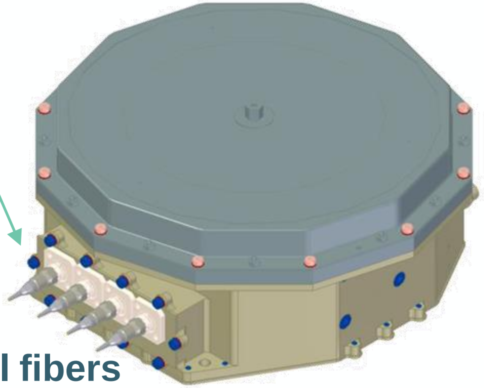
Mass without antenna







DC & RF test ports



Optical fibers

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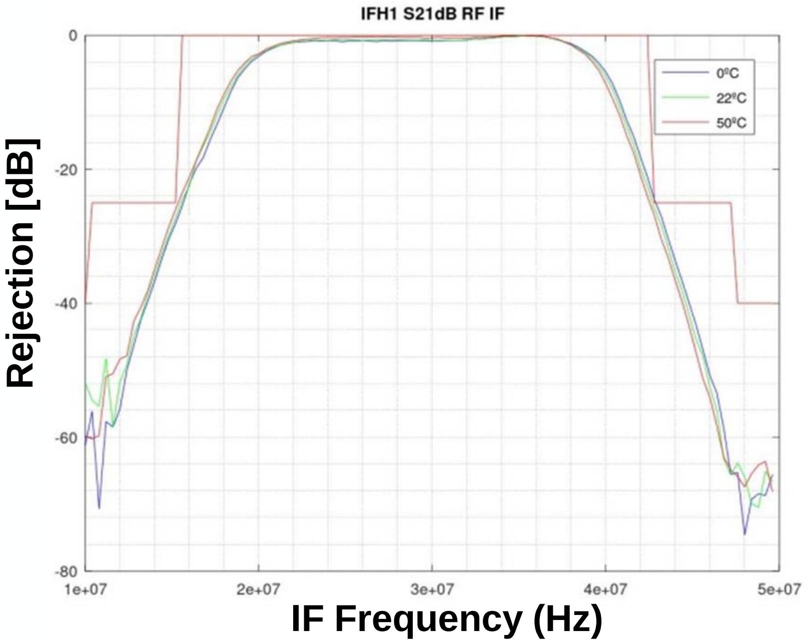
V – ALR test results

- NF @T=22°C reduced from 1.86dB (SMOS) to 1.35dB (ALR)

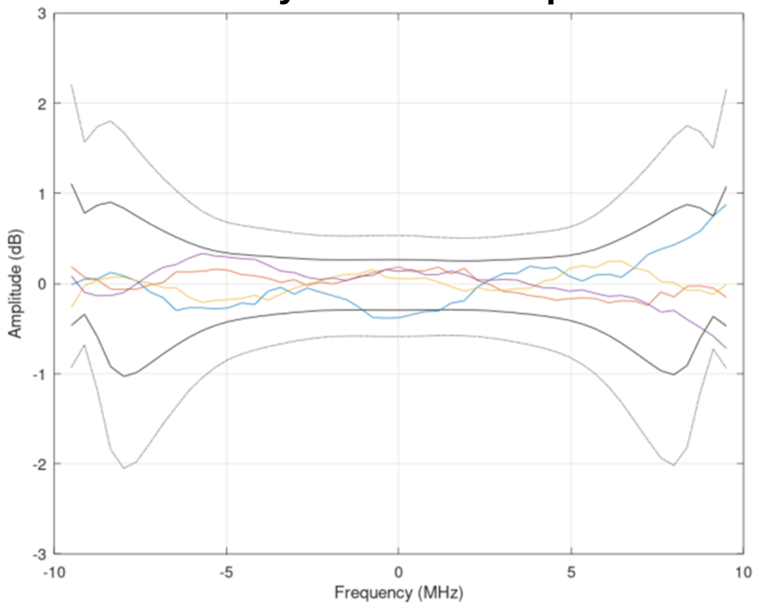
	0ºC	16ºC	22ºC	28ºC	50ºC
EM01-V	1.126	1.241	**1.296**	1.335	1.487
EM01-H	1.157	1.252	**1.352**	1.394	1.548

- RF/IF performance

(Rejection + similarity mask):



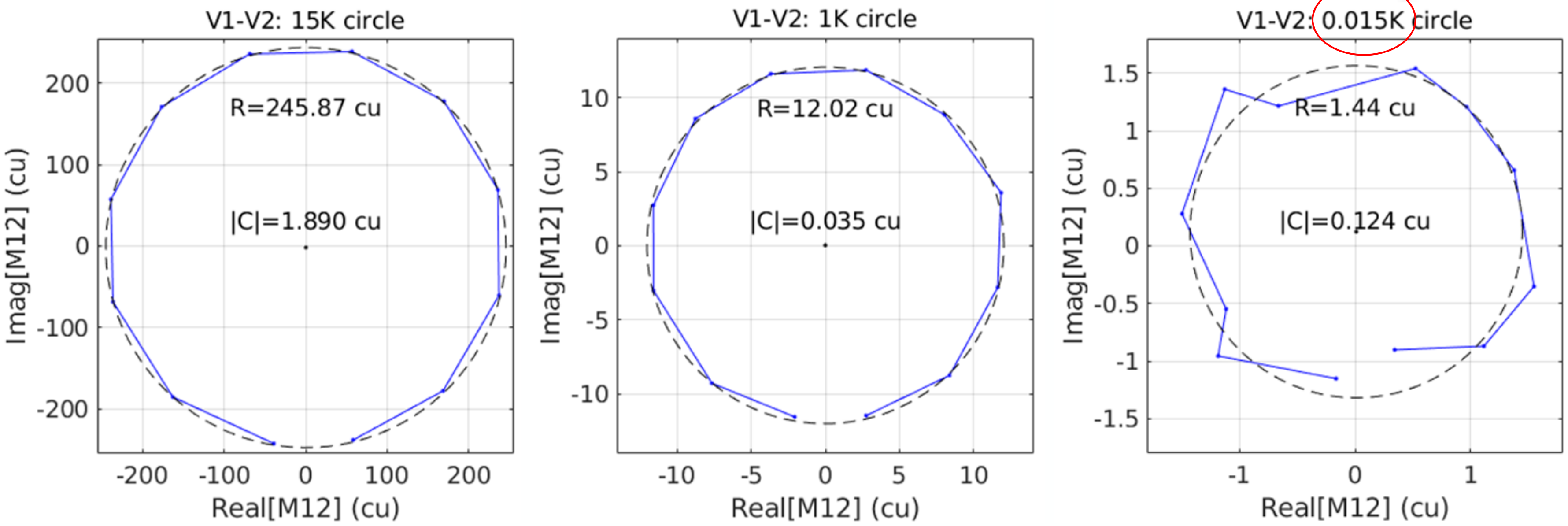
Similarity of 2 units x 2 polarisations



V – ALR test results

- Correlation measured with our **custom EGSE correlator**
- **>100 cross-correlation products** calculated in real time
- Results processed by **UPC**

0.015K of correlated noise measured



VI – Conclusions

Two ALR receivers have been **built and tested** achieving (compared with SMOS):

- Lower **NF** (higher instrument sensitivity)
- **Full polarimetric** (simultaneous measurement of H and V polarisations)
- **Smaller envelope** (reduced distance between receiver antennas to increase instrument alias-free field of view)
- **Lower mass** (more receivers can be included for higher spatial resolution)

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