Dedicated to innovation in aerospace

FFT at 100 Msamples/sec with the SkyFFT

OBDP-2019

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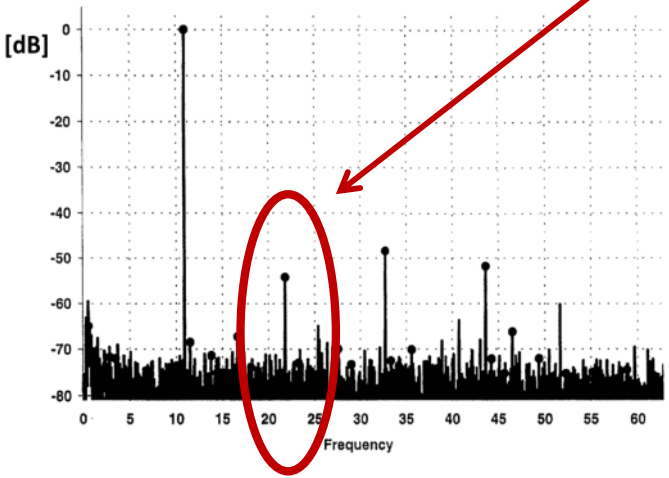
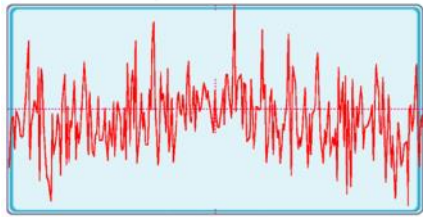
What is the ‘fun’ of Fast Fourier Transform

- Tracking of signals...
- Digital filtering
- Spectrum Analysis
- Synthetic Aperture Radar (SAR) imaging/compression
- Image pattern recognition
- Sonar
- Pulse Compression
- Doppler Processing

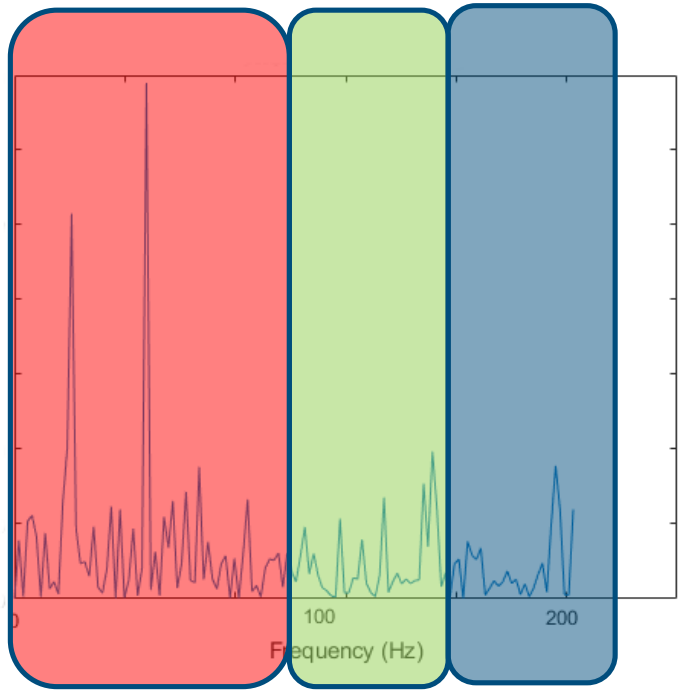
This is easier to track than this





What is the ‘fun’ of Fast Fourier Transform

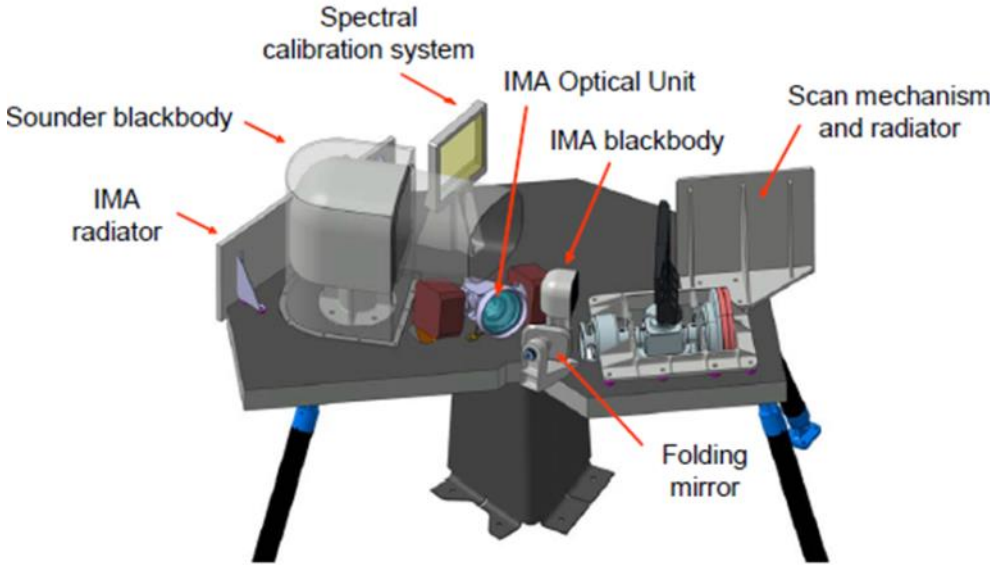
Better data compression

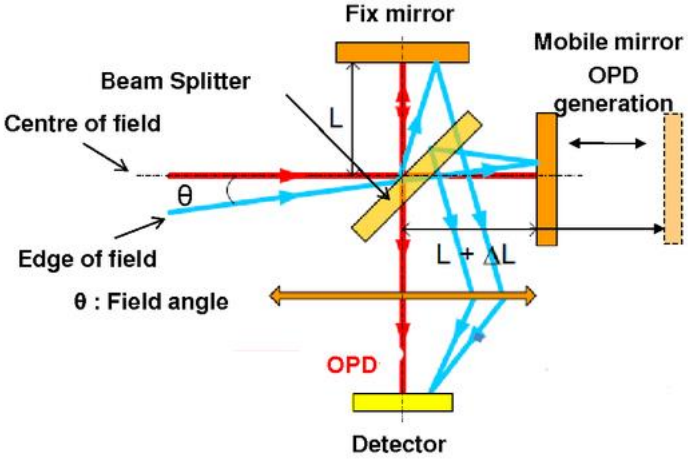


Low frequencies ➔ 4 bits (or more)
Mid frequencies ➔ 3 or 2 bits
High frequencies (oversampling) ➔ 1 bit

Interferometer

Some instruments even *require* FFT in order to be able to operate...





IASI-ng

(c) Airbus D&S
https://iasi-ng.cnes.fr

SkyFFT aka FFTC

Multi Wafer Project 180nm RHA process of Atmel

Functions:

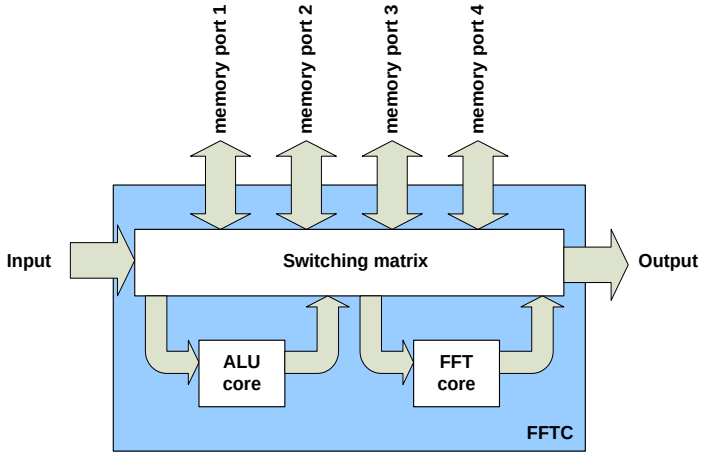
- Full floating point accuracy (32-bits I and 32-bits Q)
- Upto 1024-point **FFT** **FFT^{-1}**
- With twiddle upto 1 million point **FFT** (or **FFT^{-1}**)
- Addition, Subtraction, Multiply, Conjugate, Conjugate multiply

Data formats:

- Floating point I and floating point Q (or only I)
- 32-bit integer I and 32-bits integer Q (or only I)
- 16-bit integer I and 16-bit integer Q (or only I)

Performance:

- 1D FFT of 1024 points in 10 us
- Long 1D FFT of 1 million points in 20 ms
- 2D FFT of 1024 x 1024 points in 20 ms



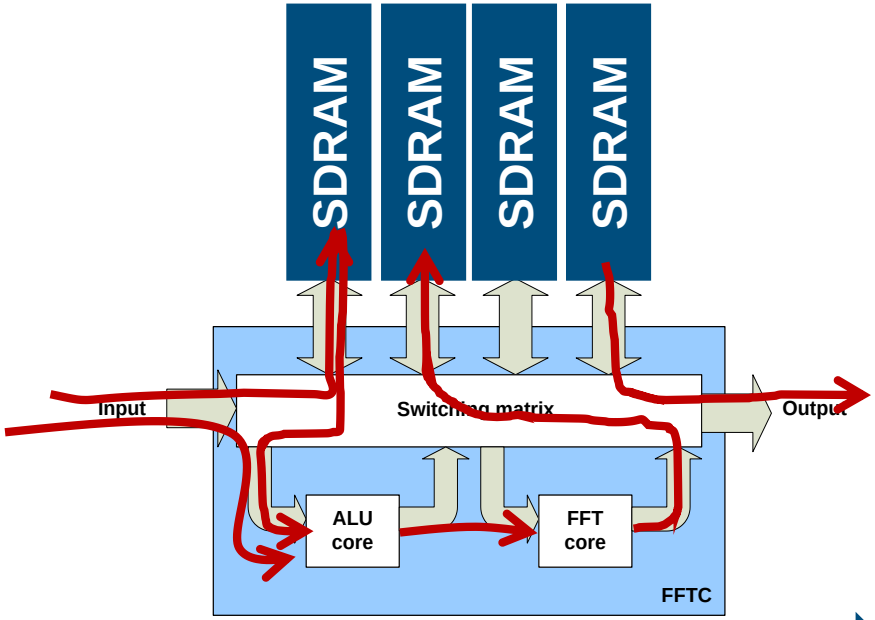
Comparison

- “Performances of LEON3 IP Core”
  64 byte (512 bit) FFT-operation in 194 us.

- DFT implemented by Spiral
  A 1024-points FFT, 16 bits fixed point
  in Xilinx Virtex-5 QV ➔ approximately 50 Mega-single-samples per sec
  ➔ approx 20 us

- WvFEv3 FFTcore, developed in 2011
  in space qualified RTAX2000 FPGA
  1024-point FFT in 10.4 ms

SkyFFT aka FFTC



* Load gain factors (or offset)
  Eg after every calibration cycle

* Combine
  - gain factor x data
  - fed to FFT core
  - store in SDRAM

* SDRAM to output

} At the same time!!

→ Or use twiddle factors for long FFTs

→ Or 2D-FFT operations
(write horizontal – read vertical)

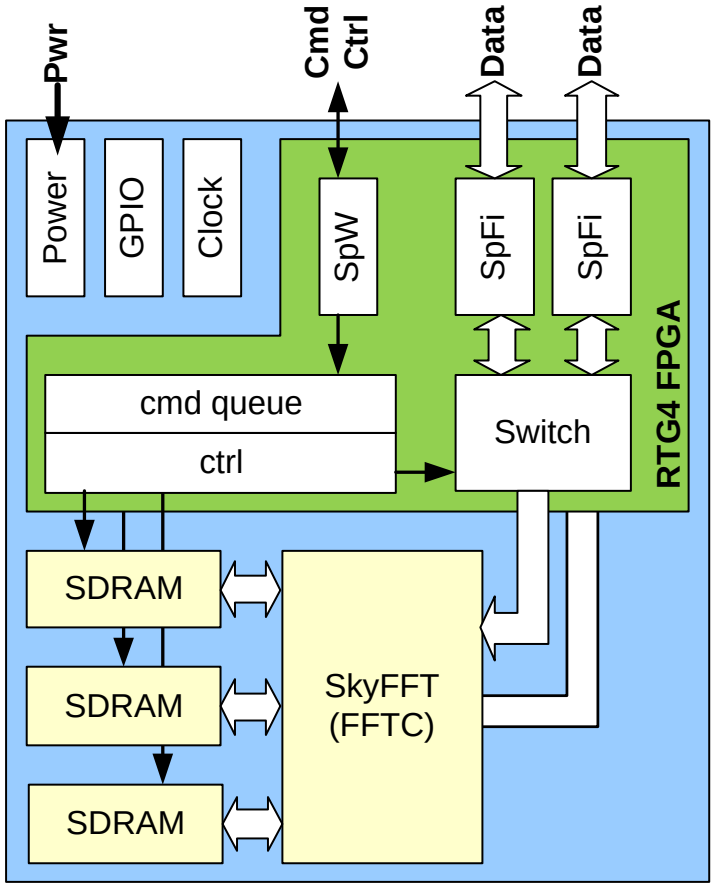
→ Or FFT → multiply → FFT^{-1}

Elegant Breadboard // EM-model now available

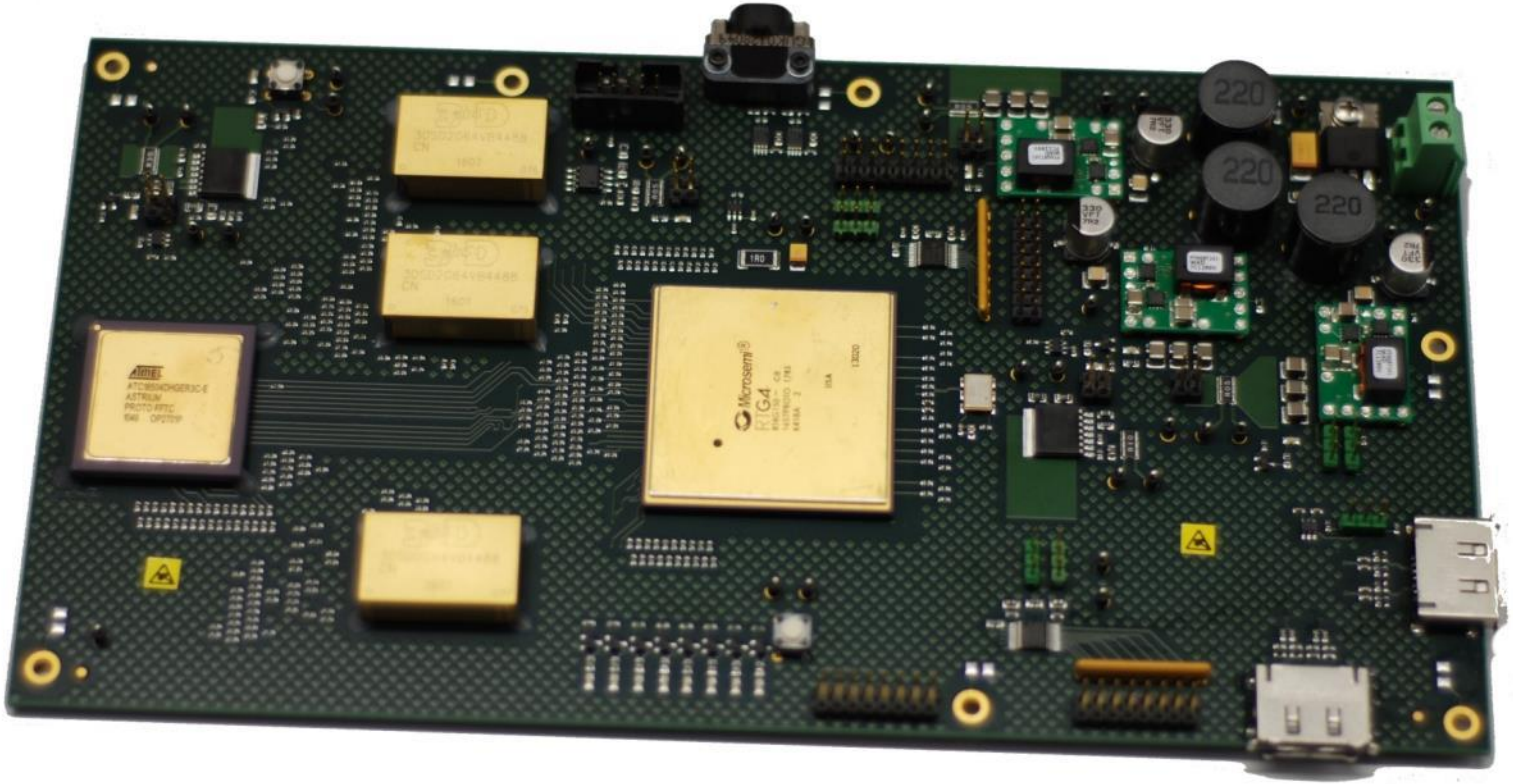
- SkyFFT / FFTC
- MicroSemi RTG4 FPGA
- SDRAM memory of 3Dplus
  2Gbit

- SpaceWire command and control
  200 Mbit/s
- SpaceFibre data interface
  net 2.0 Gbit/s

- RTG4 is approx 10-15% full
- Boards size 245 x 125mm
  (could be reduced to 125 x 125mm)
- Power consumption **8 – 10 Watt**



Picture of the board



Conclusion

FFT processing on-board the satellite

- **Now available in rad-hard / rad tolerant technology**

Dedicated to innovation in aerospace

Fully engaged

Netherlands Aerospace Centre

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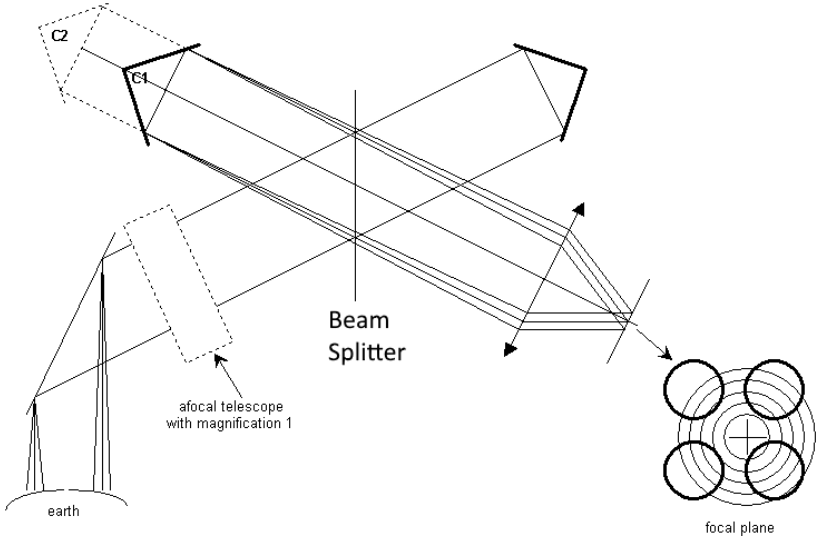
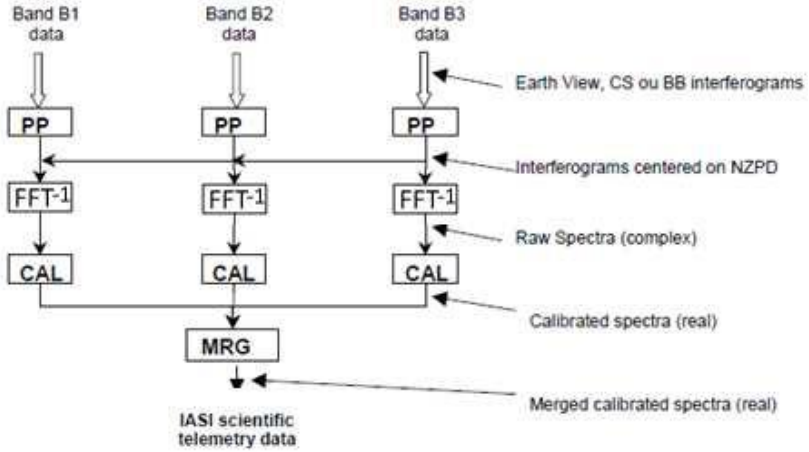
Michelson Interferometer

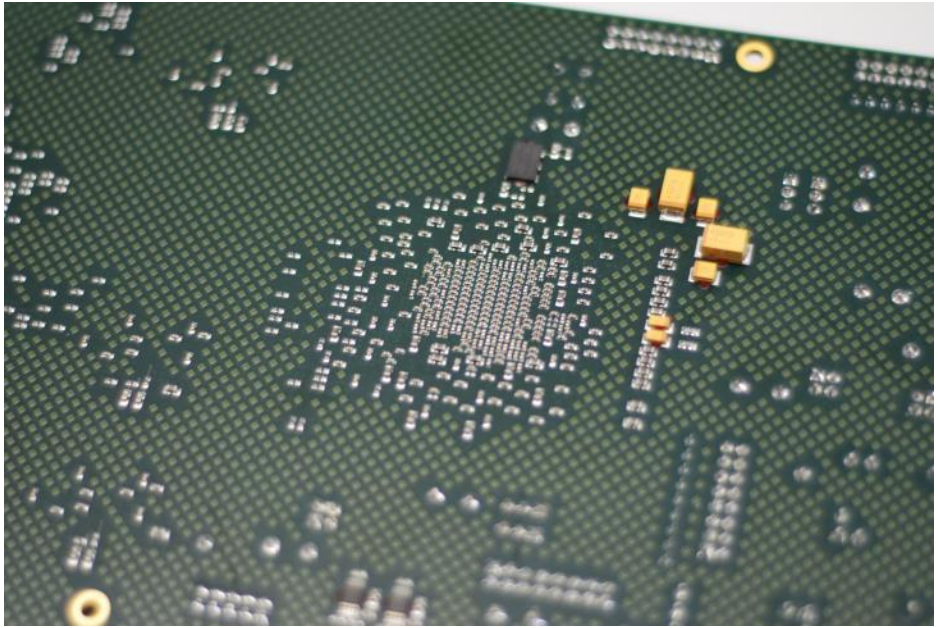
Some instruments require on-board FFT



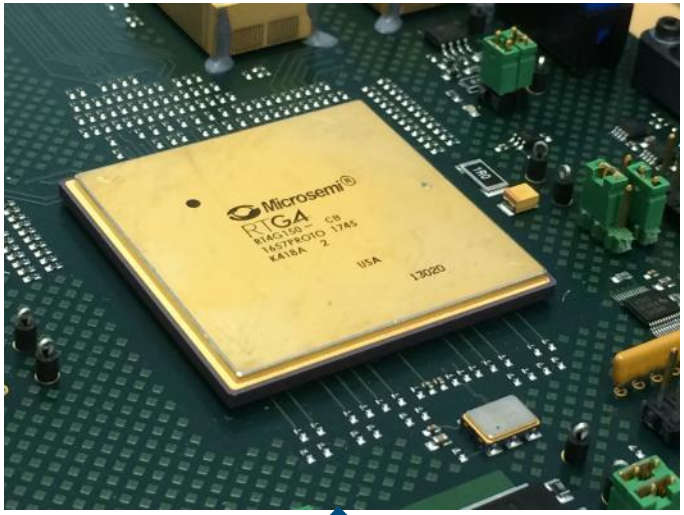


In order to align the fringes, one need on-board calibration that requires FFT

Pictures of the board



Termination resistors



RTG4 FPGA

SkyFFT