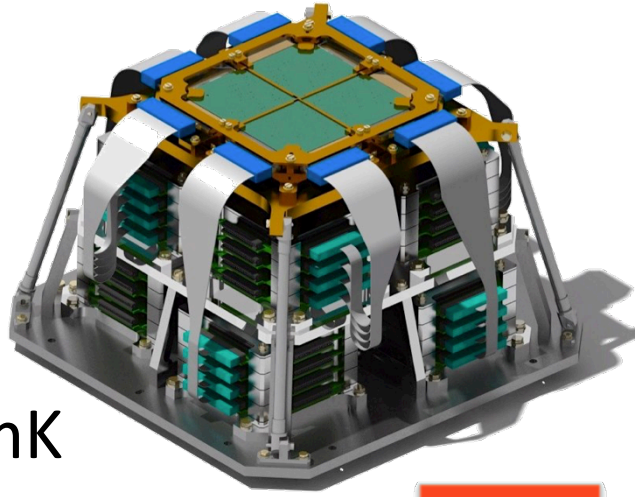
Readout chain sub-system for QUBIC

For Technological Demonstrator (T.D.)

And

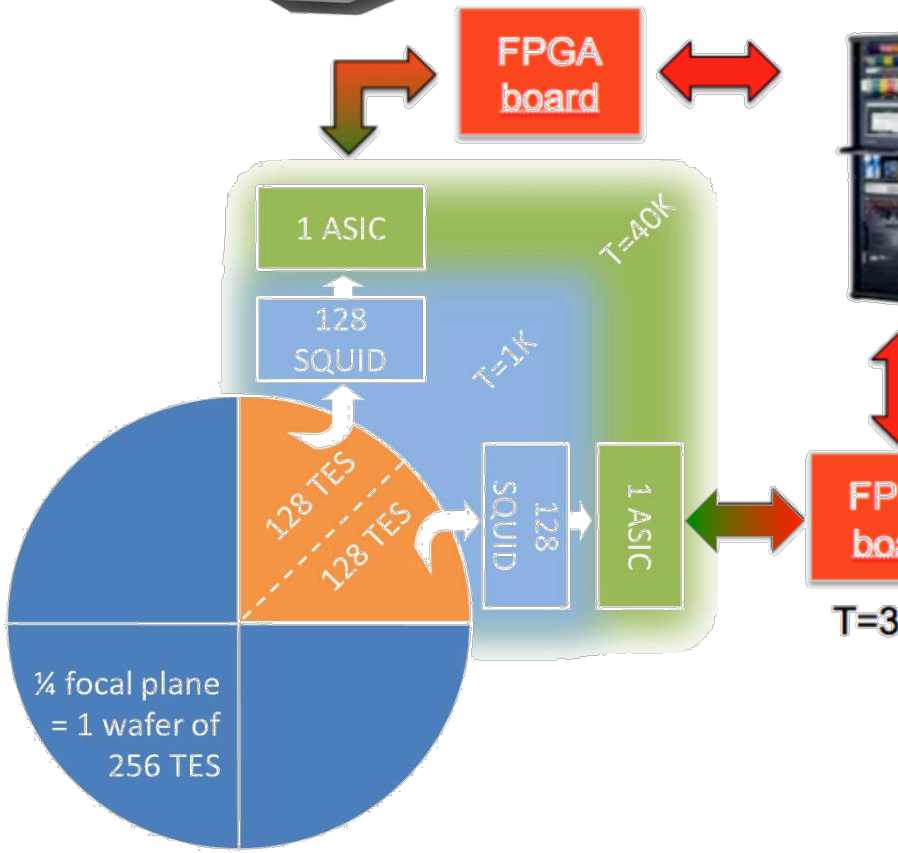
For Final Instrument (F.I.)

QUBIC detection chain

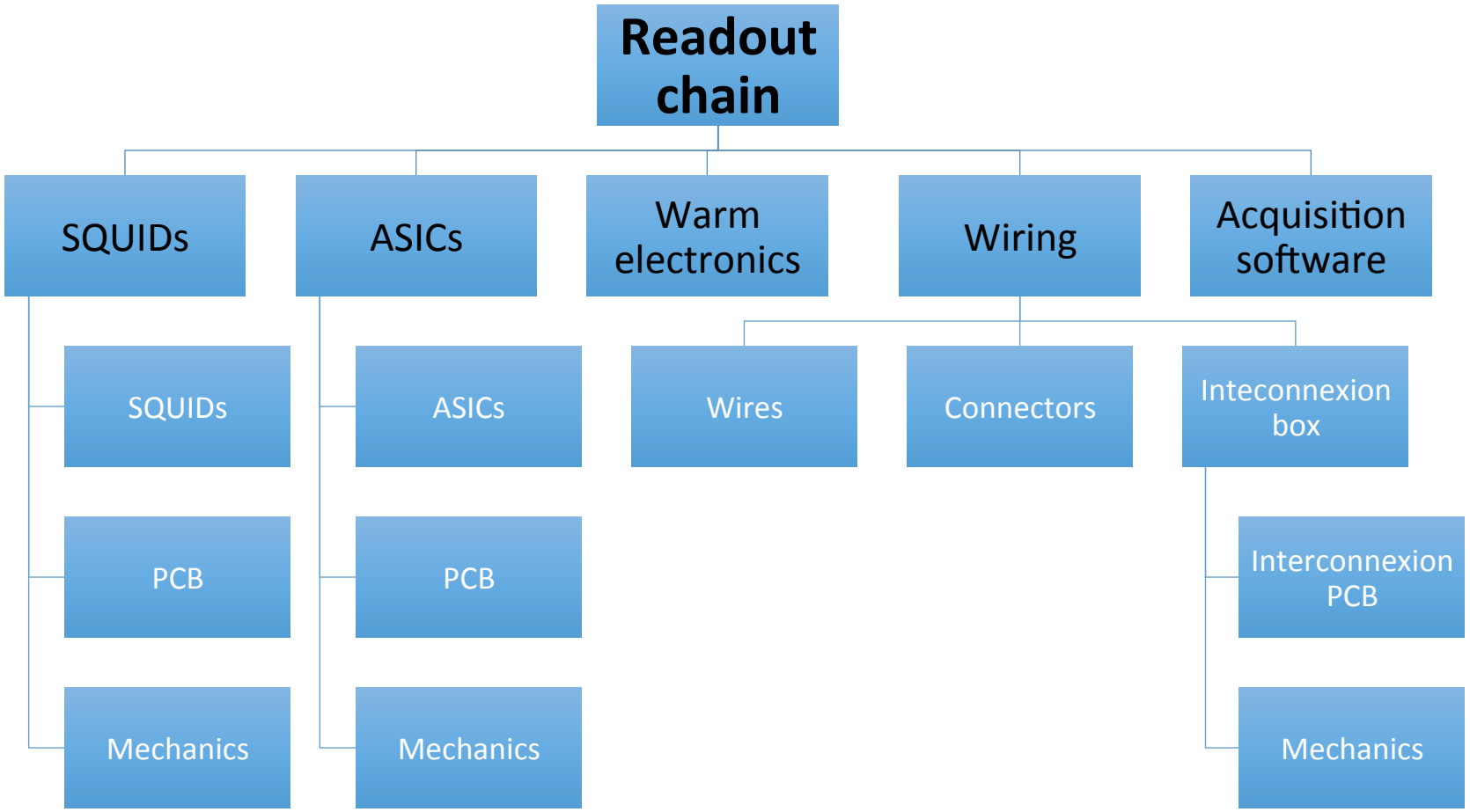


- 1 focal plane = 4 wafers of 256 TESs @300mK
  - Readout: Time Domain Multiplexing 128:1
  - 128 SQUIDs @ 1K + 1 ASIC @ 40 K

    for ⅛ focal plane
  - Specifications:
    - NEP < 5.10^{-17}W.Hz$^{-0.5}$
    - τ < 10ms
- 2 focal planes: 150GHz and 220GHz

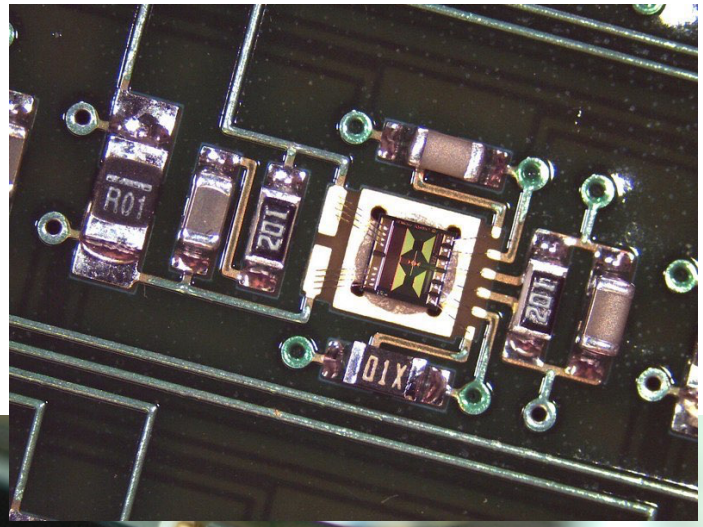


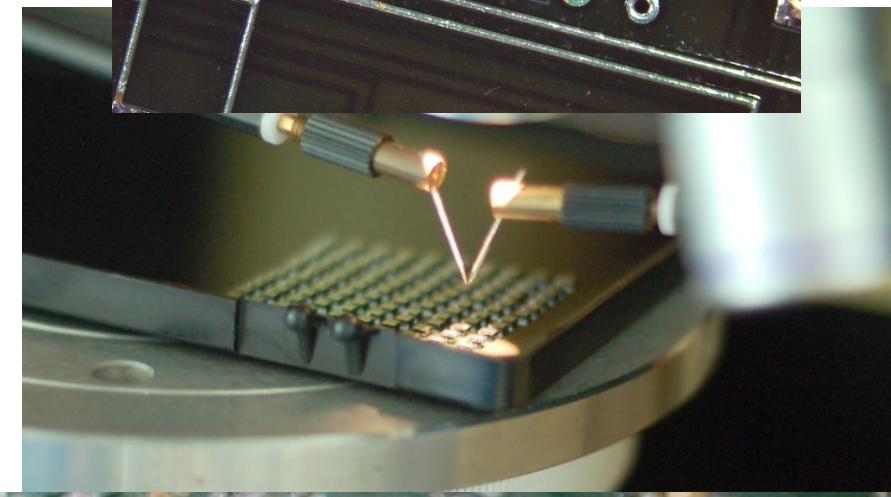
Sub-systems

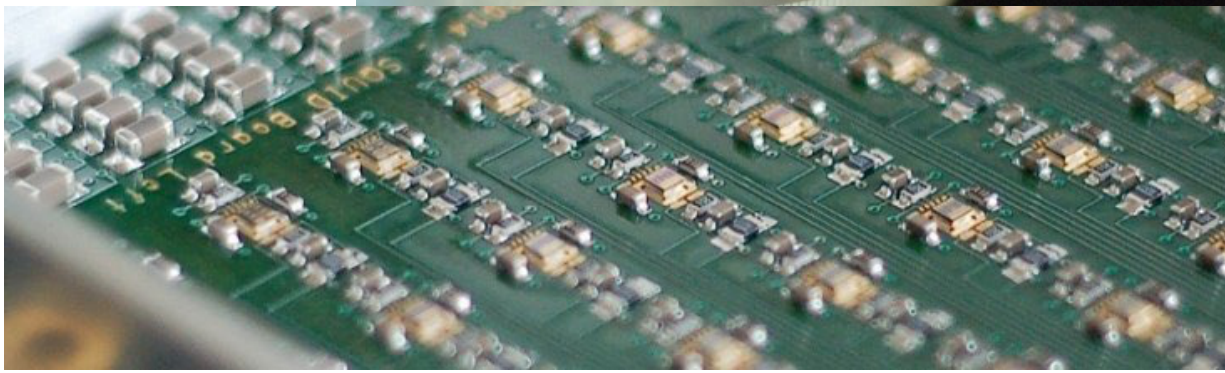

Readout chain
SQUIDs
ASICs
Warm electronics
Wiring
Acquisition software
SQUIDs
PCB
Mechanics
ASICs
PCB
Mechanics
Wires
Connectors
Inteconnexion box
Interconnexion PCB
Mechanics

SQUIDs

- SQUIDs custom design made by STAR Cryoelectronics
  - SQ600
- Status:
  - SQUIDS in hand: 2 wafers of 2000 SQUIDs each + 1 new wafer received with improved performances
  - Warm tests and selection done
  - PCBs production: received
    - Defect to be studied

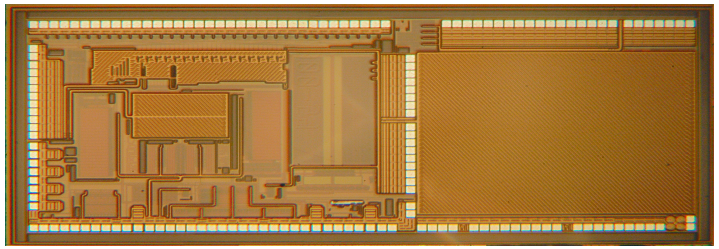


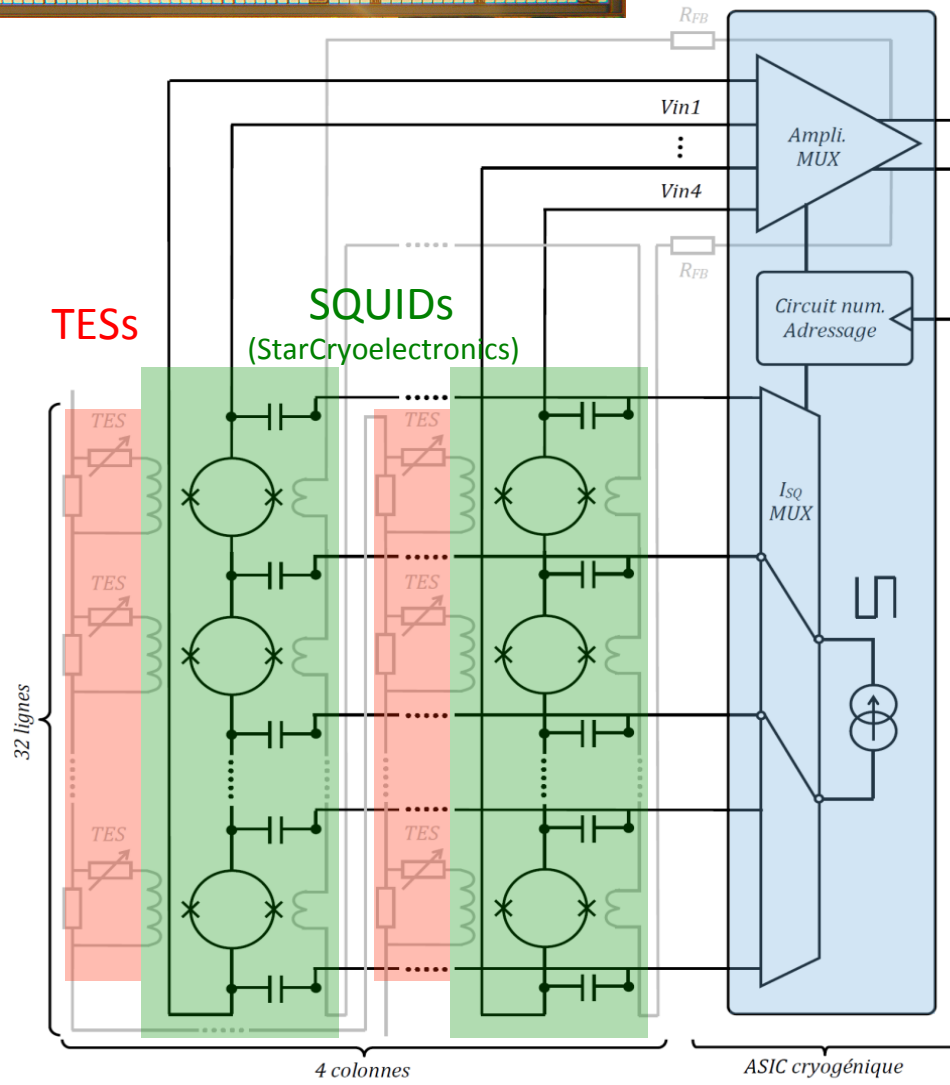




Detection chain: ASIC

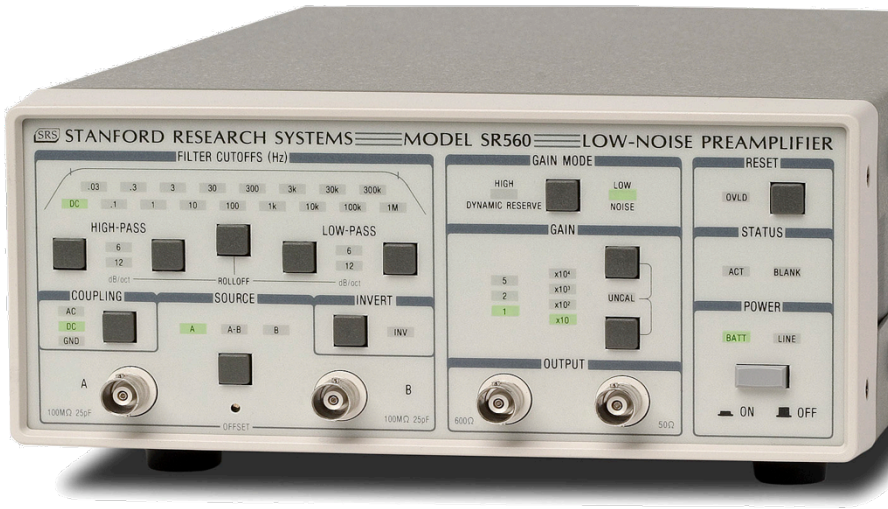
- First version: fully functionnal
  - Current source at warm T
- Second version: received and tested
  - Improved performances
  - Current source in the ASIC
  - Baseline for TD
  - PCB being integrated

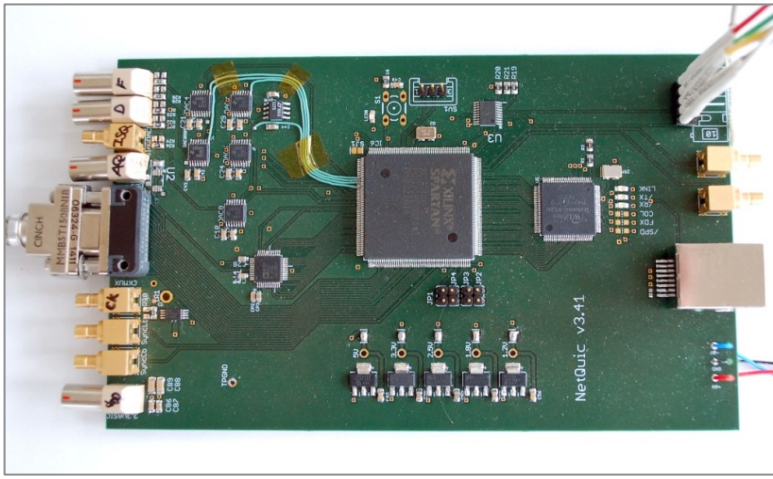




Warm electronics

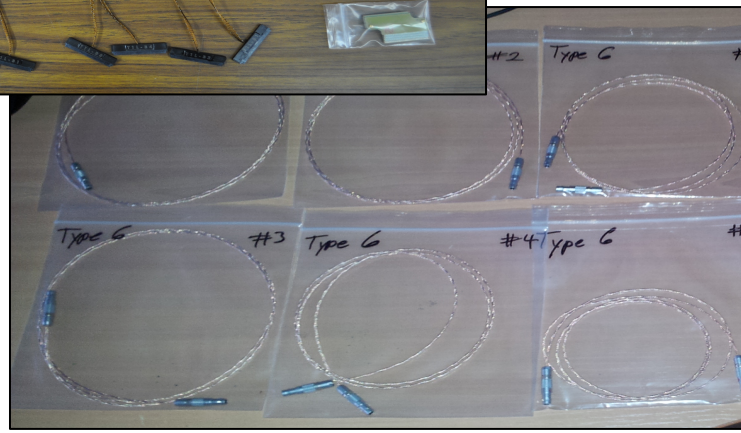
- Amplifier (APC): SR560
  - Home made amplifier also possible
- FPGA board (IRAP)
- Status:
  - 2x SR 560 available for TD
  - Home made amplifier being realised
  - FPGA board available and functional
    - With full acquisition speed and FLL in FPGA
    - Check with IRAP availability of 2nd FPGA board

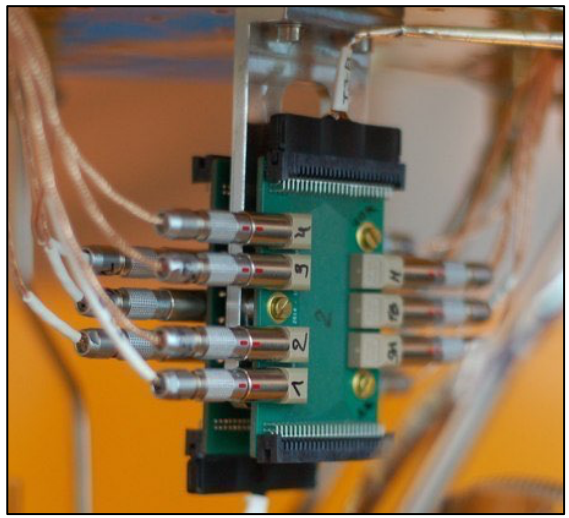




Wiring

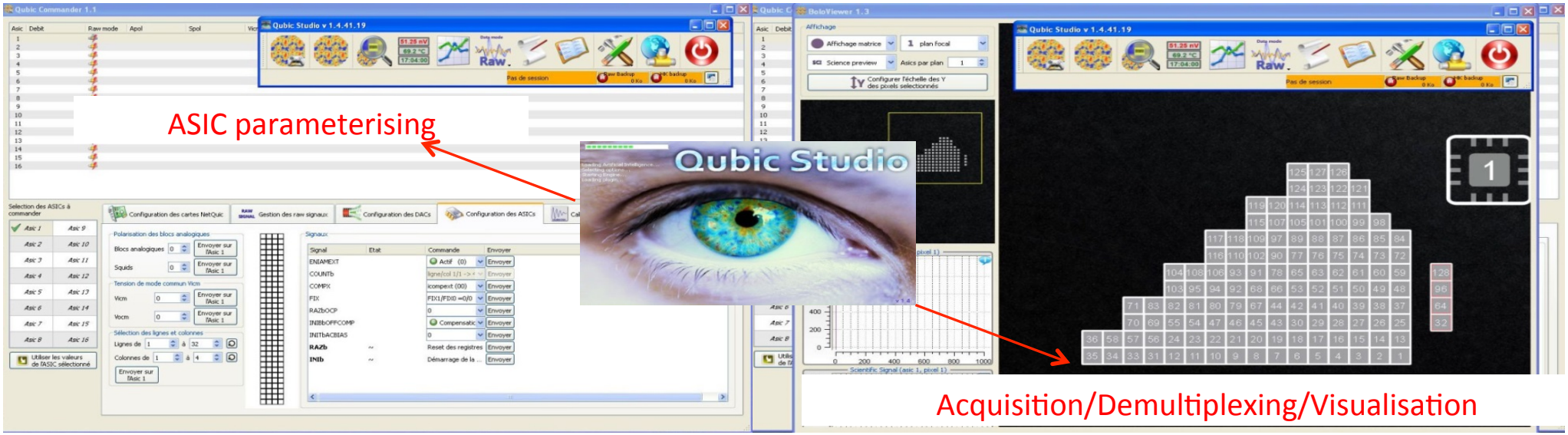
- Content:
  - Superconducting NbTi below 4K, Cu or Ph-Br wires above 4K
  - Inteconnexion PCB
  - Connectors
- Status:
  - Path defined in the cryostat, length known
  - Cold interfaces fixed
  - Interconnexion PCB under integration
  - Warm interface to be designed (connectors flange)
  - Detection chain wires: to be ordered to Universal Cryogenics
  - Connectors to be ordered



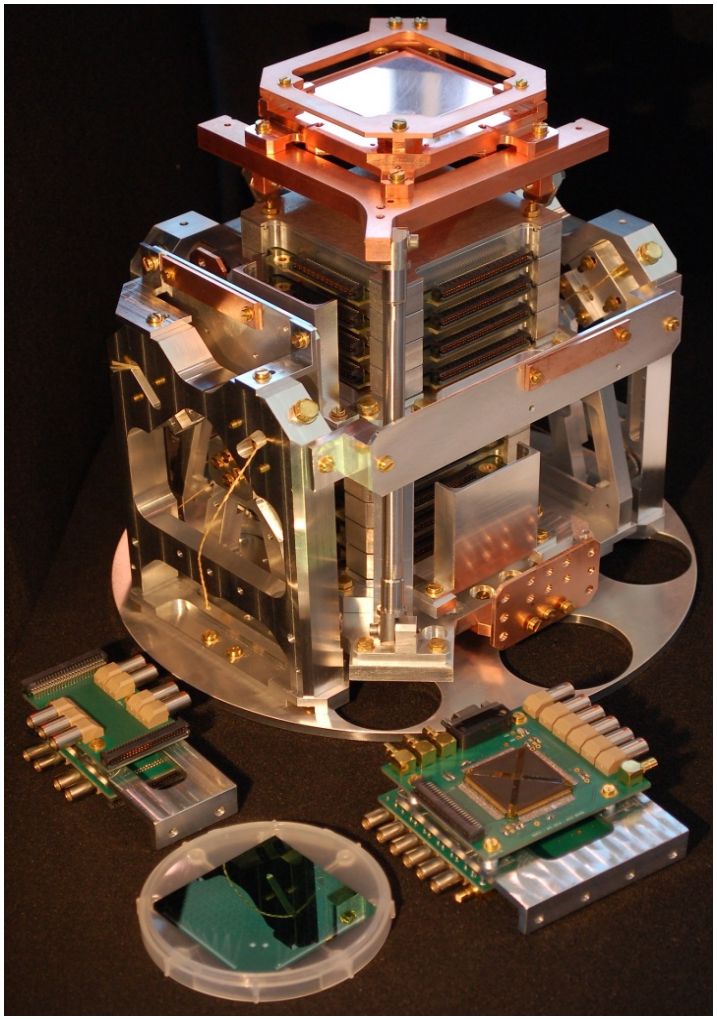


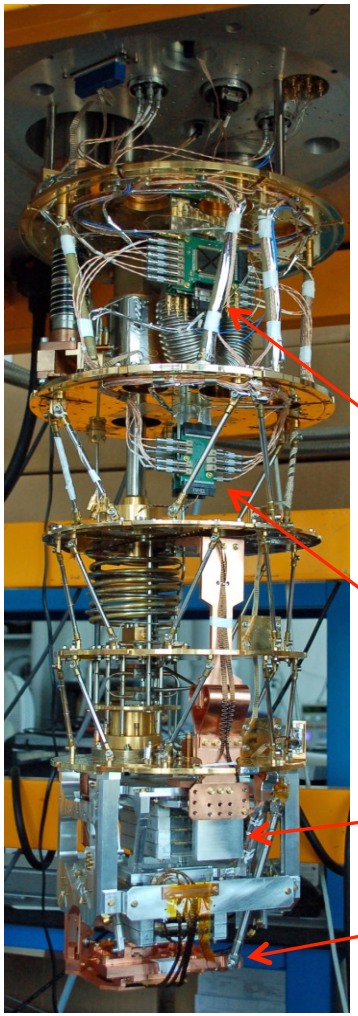
Acquisition software

- QUBIC Studio (IRAP):
  - Overall control of the experiment: TESs, RF switches, PT, thermometers, heaters
  - Status:
    - In use for detector characterisation
    - Connection with other subsystem to be done

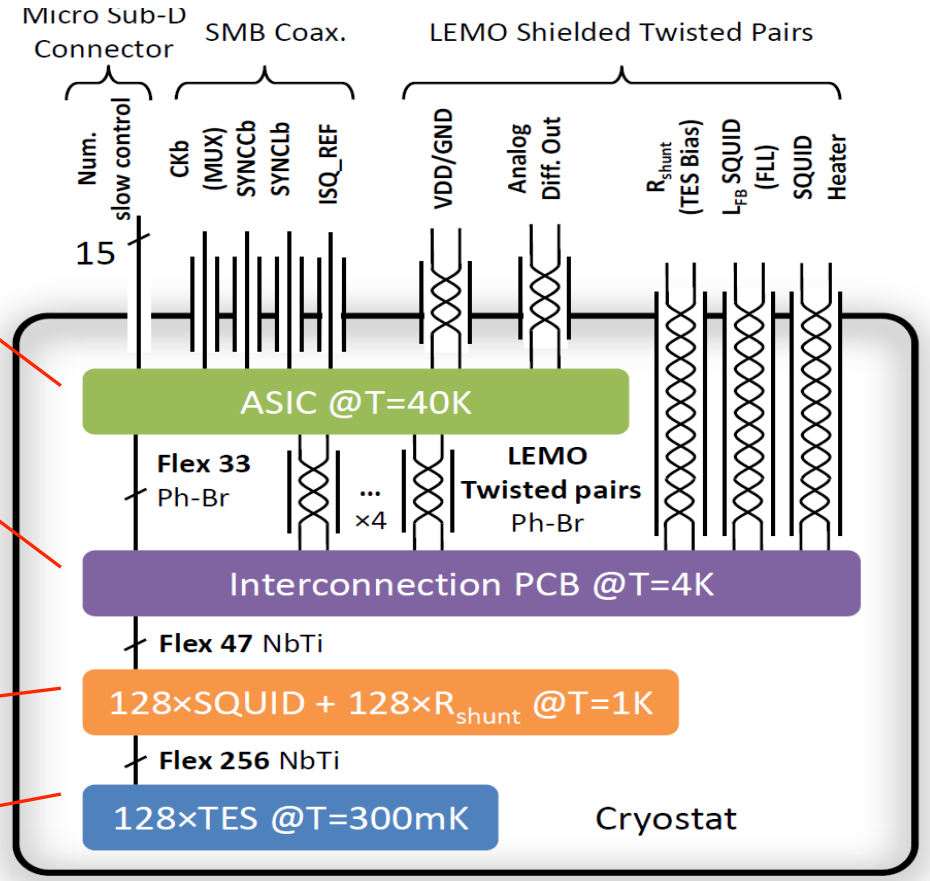


Detection chain: ¼ focal plane integration

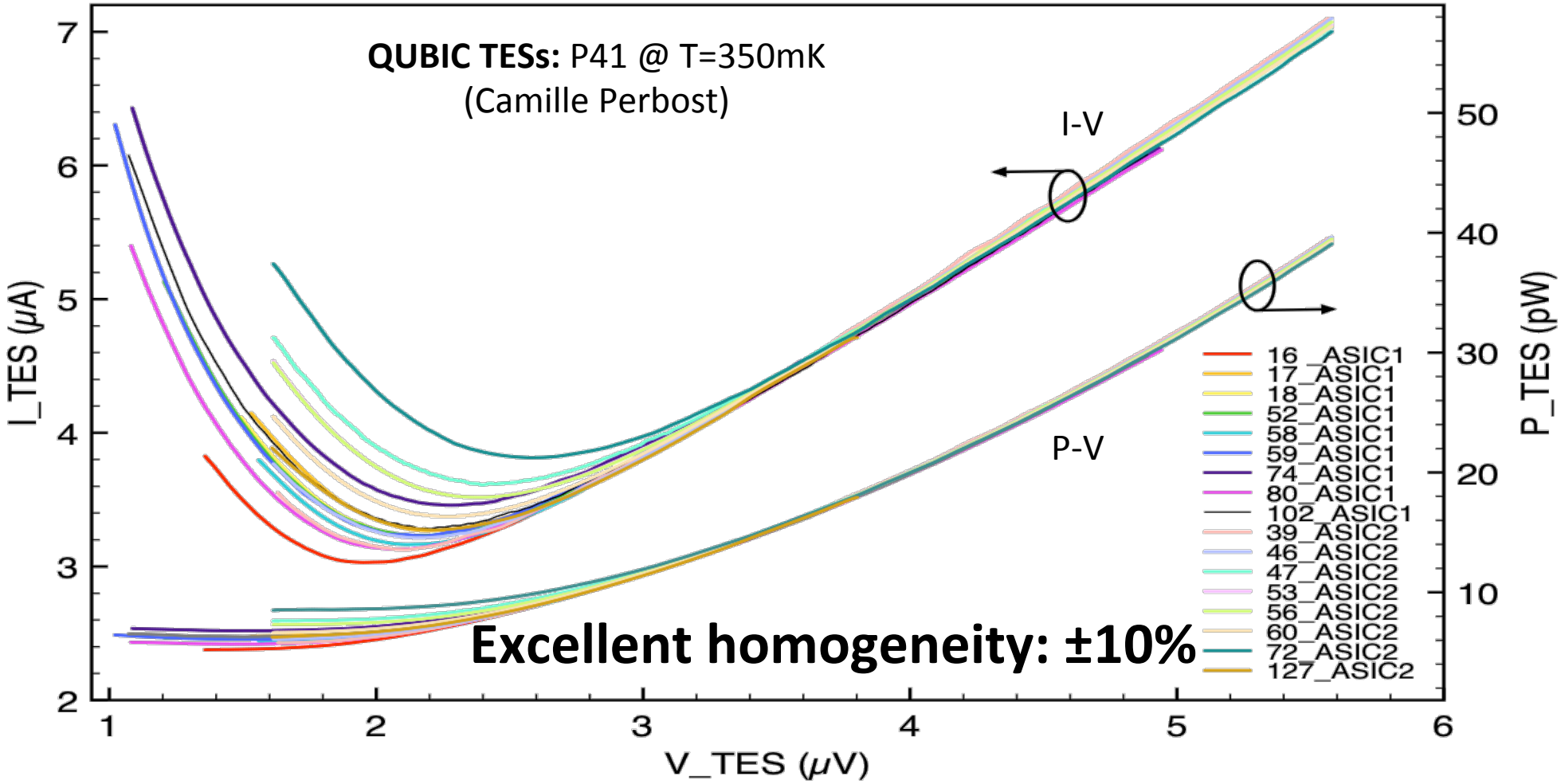




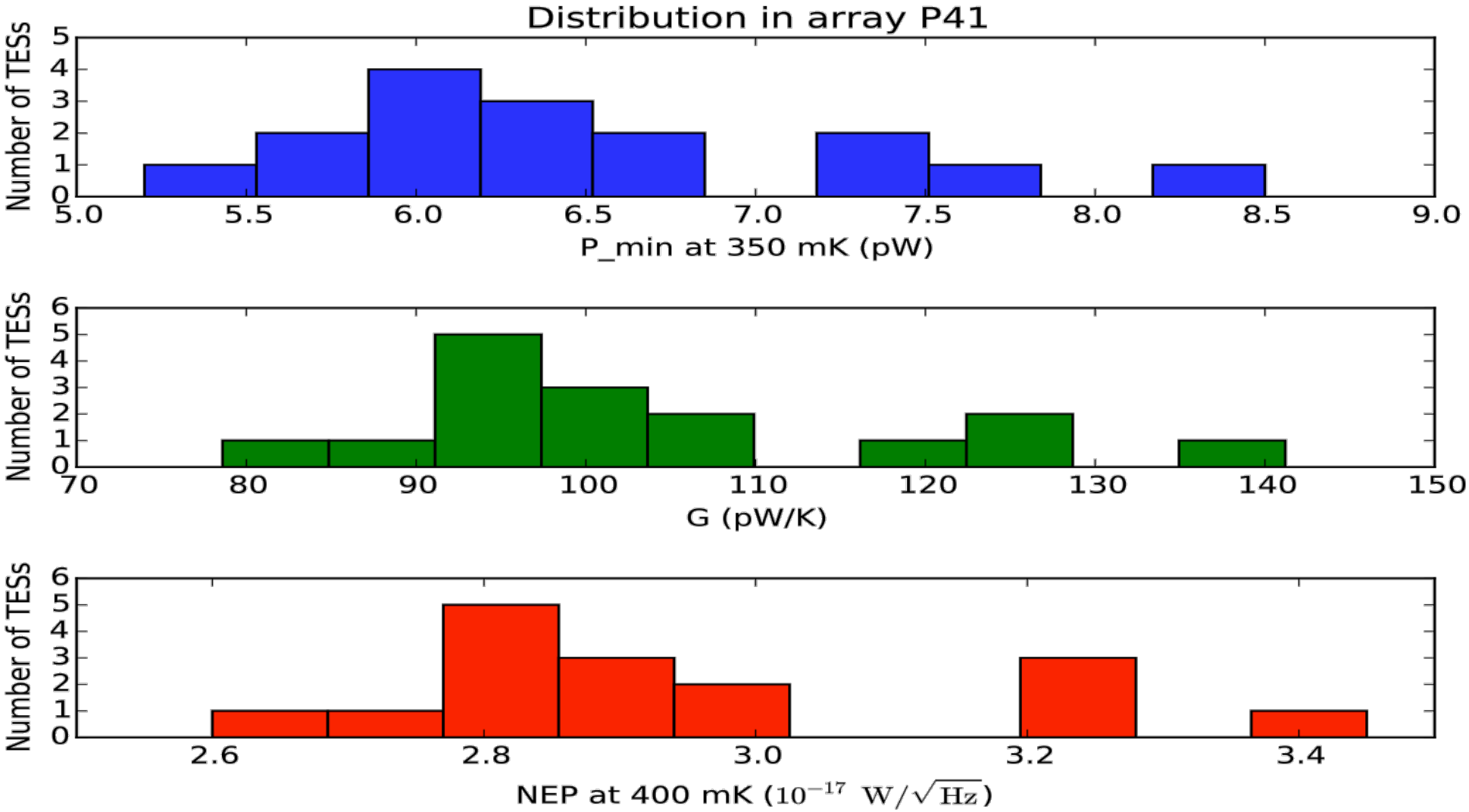
Cryostat wiring for 128 TESs readout



P41 characterisation

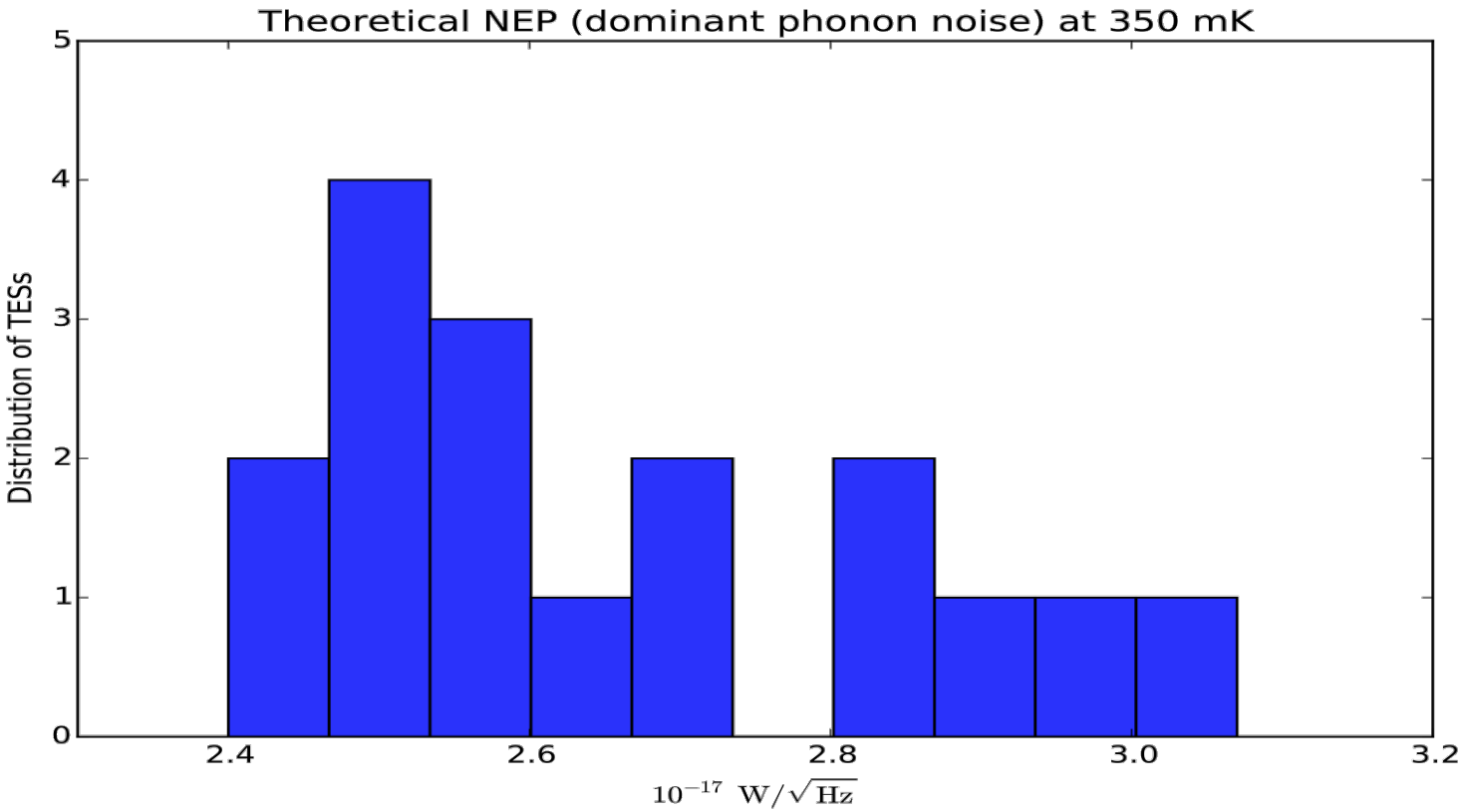


P41 characterisation



P41 characterisation

- Preliminary NEP distribution at 350mK:
  - Requirement: NEP < 5.10^{-17} $W.Hz^{-0.5}$

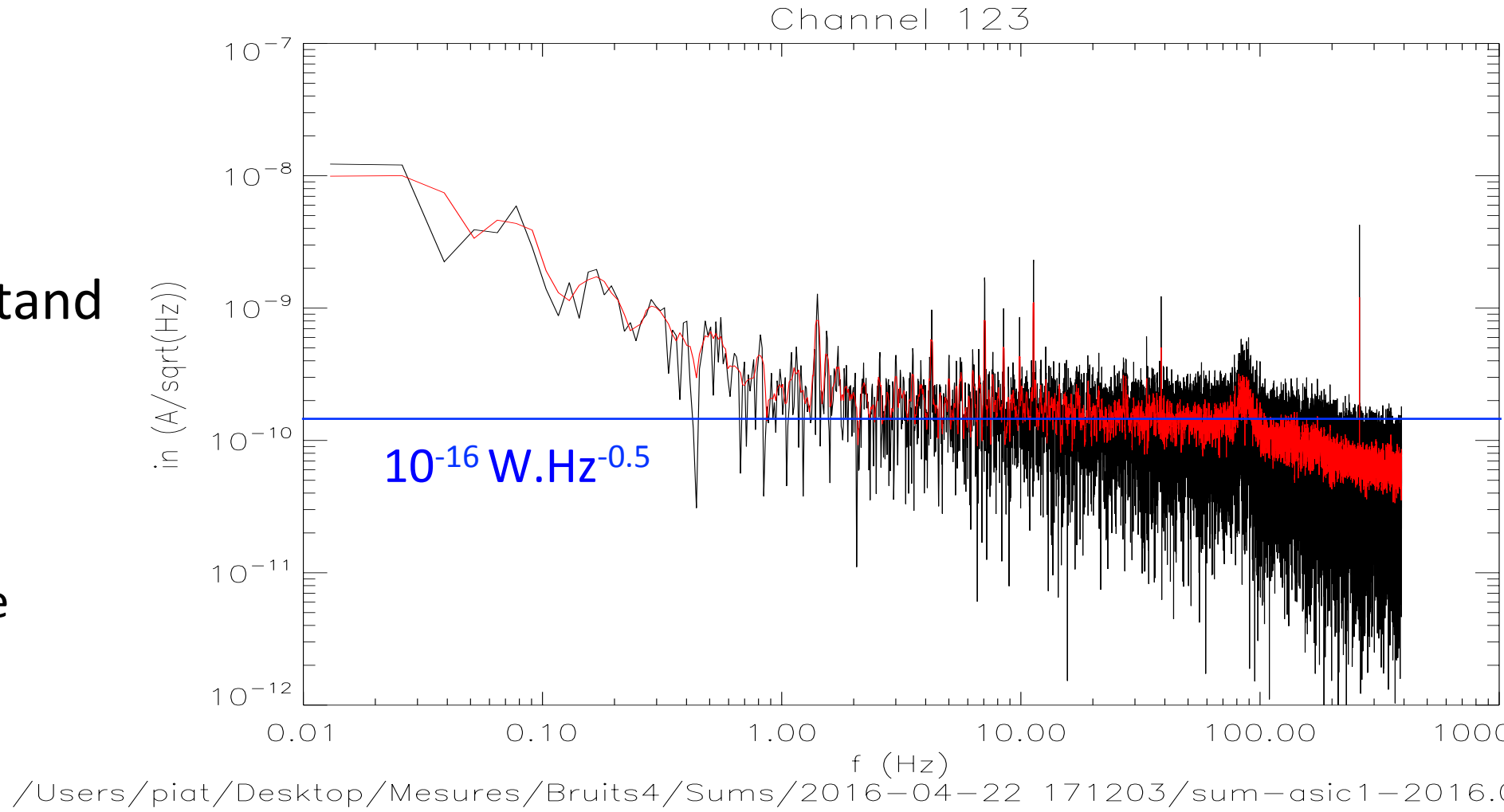


First noise measurements

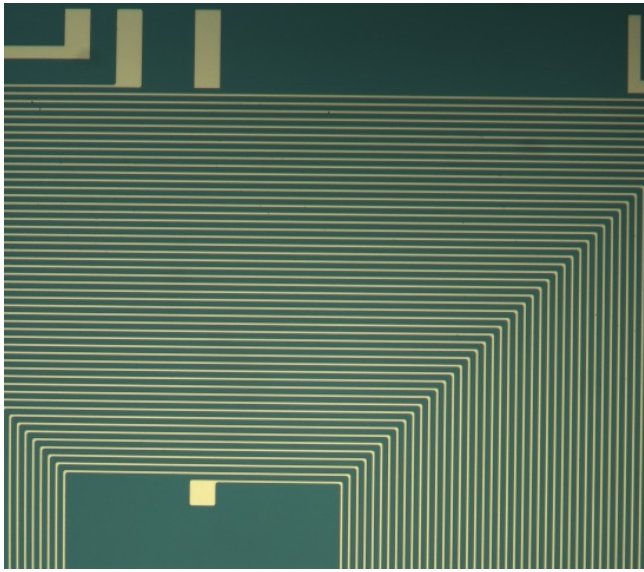
T=350mK,
V_{bias}=1µV

Noise level fully understand

- Aliasing
- Nyquist inductors to be reduce the aliasing



Nyquist inductors



- 32 Nb inductors (10µH) available from INFN Pisa
  - Integration on a single SQUID PCB under study
  - Tests to be done
- Quotation available from STAR Cryoelectronics: ~20k€ for 2 wafers, 350 inductors per wafer
  - Gradiometer version
- **For TD: no Nyquist inductors will be used at the beginning in order to save money**

Interfaces with other sub-systems

- Mechanical interfaces:
  - Wiring inside the cryostat, ASIC and interconnexion boxes frozen
  - Warm connector part to be designed asap
  - Localisation of warm electronics and FPGAs to be defined
- Other interfaces:
  - Acquisition software to be interfaced with switches, HWP rotating mechanism, mount

Test, Delivery, Assembly, Calibration Operations

- SQUID boards tests before delivery:
  - In the dilution fridge
  - Criterion: number of working SQUIDs, ΔV
- ASIC boards tests before delivery:
  - Warm functional test
  - Criterion: noise level,
- Wires tests before delivery:
  - Tests by Universal Cryogenics
- Assembly Operations in APC:
  - SQUIDs tests: needs T<8K so no tests possible during integration
  - ASIC functional test could be done after integration at room T

Manpower

Name and responsibility	% FTE 2016	% FTE 2017	% FTE 2018
Fabrice Voisin	60	60	60
Damien Prêle	30	30	30
Tanguy Decourcelle	30	0	0
Michel Piat	20	20	20
TOTAL FTE	1.4	1.1	1.1

Risks analysis

- Late delivery of wires or connectors
  - Possibility to use wires from APC dilution cryostat **but in this case we will have no test bed for SQUIDs and TESs**
- Degraded noise performances
  - 10^{-16} W.sqrt(Hz) demonstrated, OK for TD