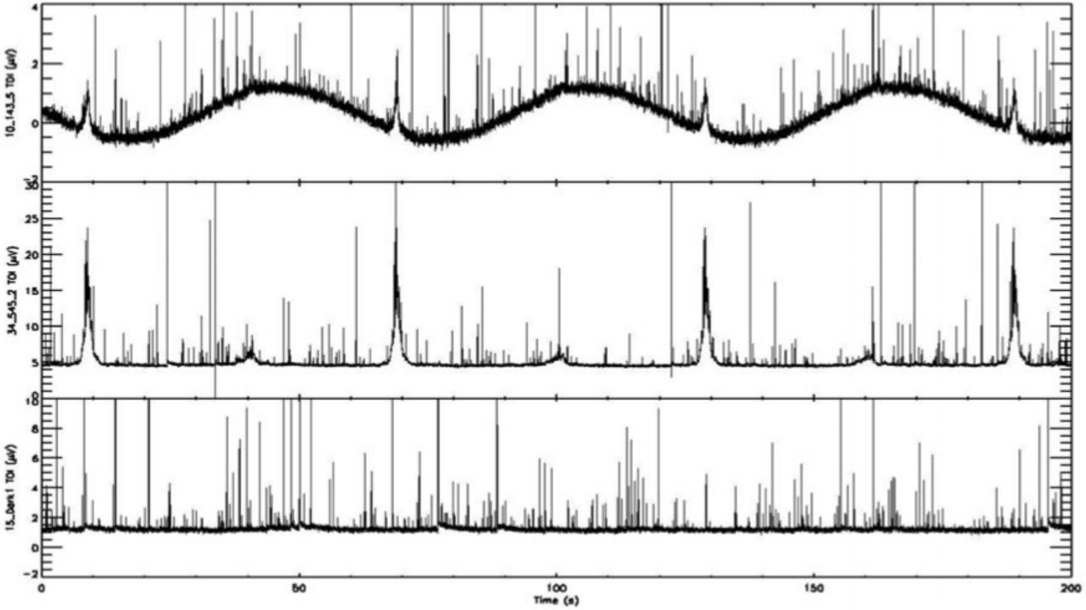
Real-Time Detection of Cosmic Ray Systematic Glitches for the LiteBIRD satellite

Emile Carinos (IRAP, emile.carinos@irap.omp.eu)

Cosmic rays at L2

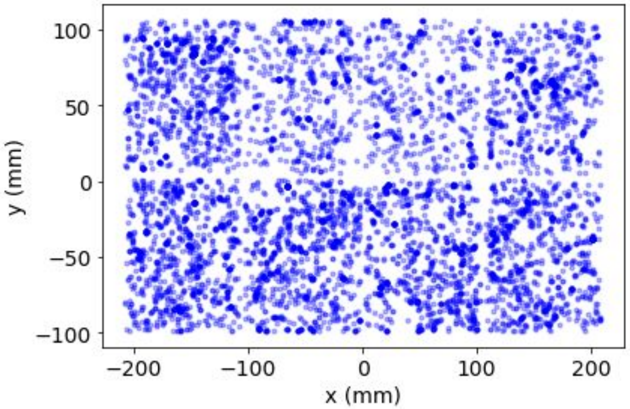


A Catalano et al., J Low Temp Phys (2014) 176:773–786

-Two contributions :

Direct hits : **glitches**

Heating of the focal plane : **common mode noise**

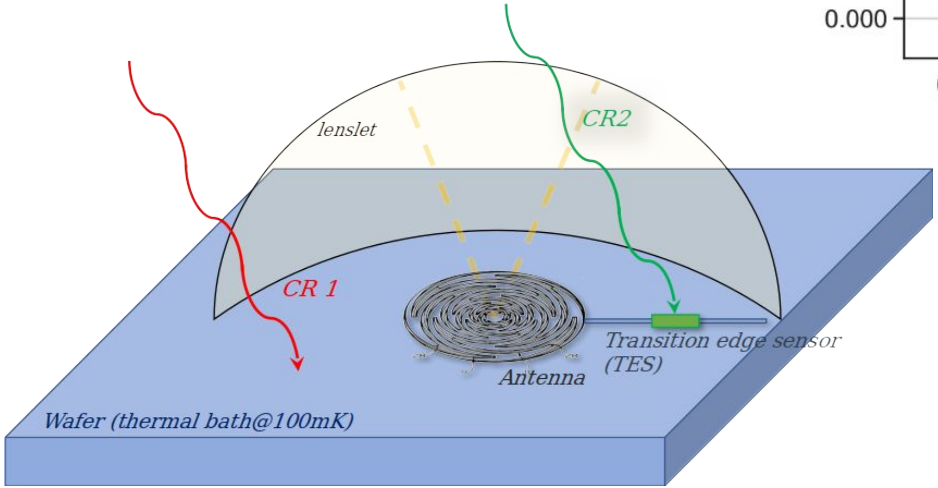


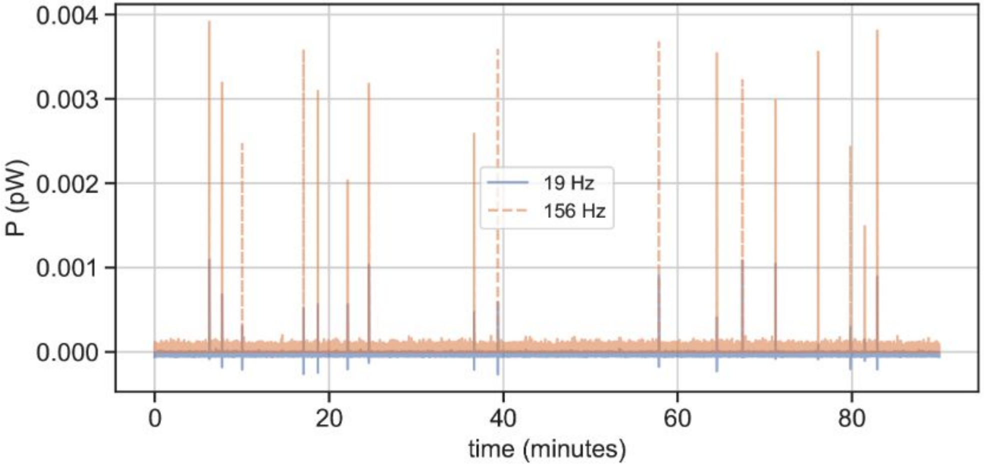
S. L. Stever et al. 2024 SPIE proceedings

Cosmic rays and LiteBIRD

Few glitches, mostly
common mode noise
from wafer impacts

Data decimation !



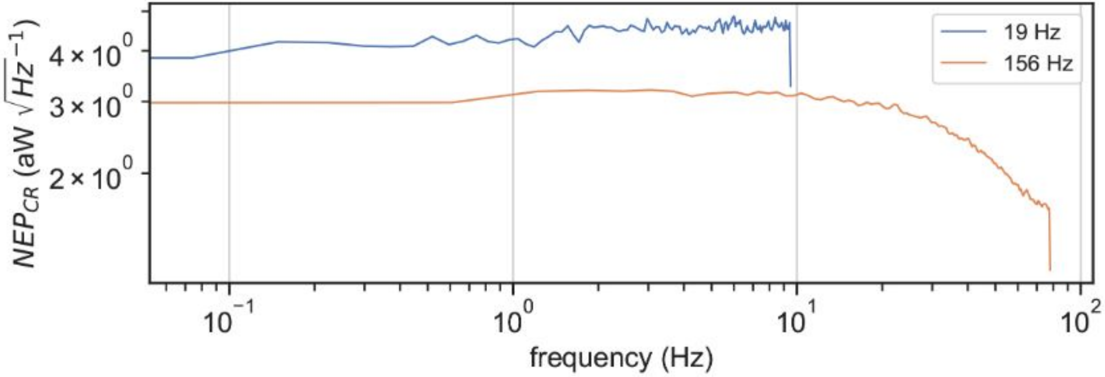


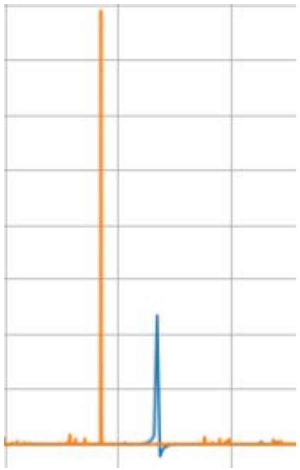
S. L. Stever et al. 2021, 2024 SPIE

Cosmic rays and LiteBIRD

Very large amount of detectors : the data has to be decimated for downlink

Data decimation : **ringing effects** in 19Hz data which contributes to the noise level





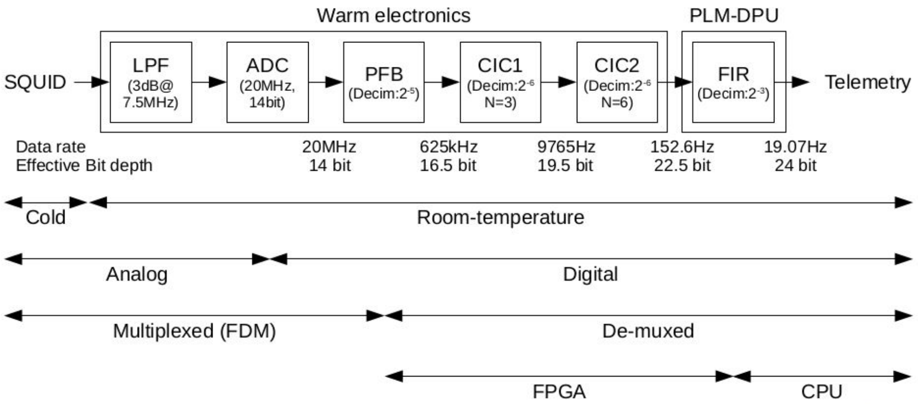
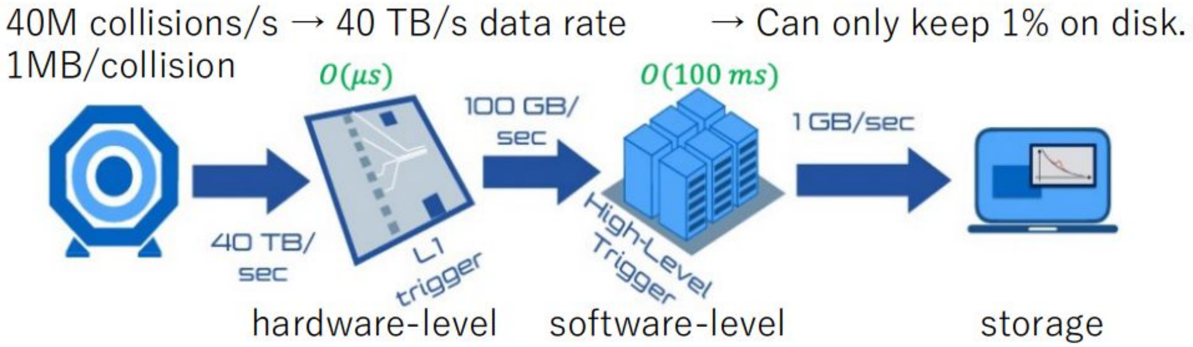


Figure 4. Decimation of the bolometer data in the orbit [4].

Real-time data processing : the LHC case

Yu Nakahama (KEK IPNS & QUP)



Use **Neural Networks** for fast and efficient real-time data processing

New software and hardware make it even possible to use on FPGAs and DPUs

→Process large amounts of data in real-time using pre-trained NNs

Fast and resource-efficient Deep Neural Network on FPGA for the Phase-II Level-0 muon barrel trigger of the ATLAS experiment

Stefano Giagu[1,*] *on behalf of the ATLAS Collaboration*

[1]Dipartimento di Fisica, Sapienza Università di Roma and INFN Sezione di Roma, Roma, IT

Abstract. The Level-0 muon trigger system of the ATLAS experiment will undergo a full upgrade for the High Luminosity LHC to stand the challenging requirements imposed by the increase in instantaneous luminosity. The upgraded trigger system will send raw hit data to off-detector processors, where trigger algorithms run on a new generation of FPGAs. To exploit the flexibility provided by the FPGA systems, ATLAS is developing novel precision deep neural network architectures based on trained ternary quantisation, optimised to run on FPGAs for efficient reconstruction and identification of muons in the ATLAS "Level-0" trigger. Physics performance in terms of efficiency and fake rates and FPGA logic resource occupancy and timing obtained with the developed algorithms are discussed.

Real-time data processing : ongoing work

→ Main focus on the 152 Hz -> 19 Hz decimation

→ Glitch detection :

- Goal : **flag direct hits**
- Compare the **performances** and **footprint** of traditional algorithms (**z-score**, wavelet based peak prominence) and ML-based algorithms (1d **CNN, LSTM**, ...)

→ Common mode noise :

- Goal : evaluate in real-time the **coupling correlation matrix** of the detectors

→ Other prospects :

- FPGA implementation at higher sampling frequencies
- Real-time **deglitching** and **noise reduction** using pre-trained neural networks

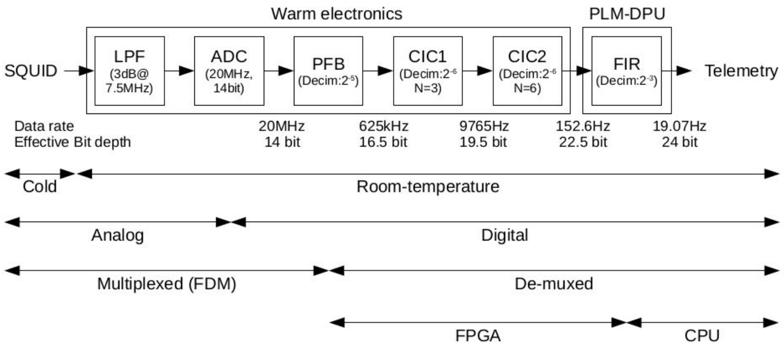
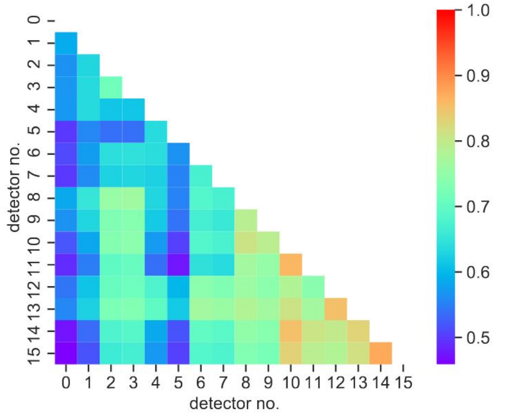


Figure 4. Decimation of the bolometer data in the orbit [4].



Cosmic rays at L2

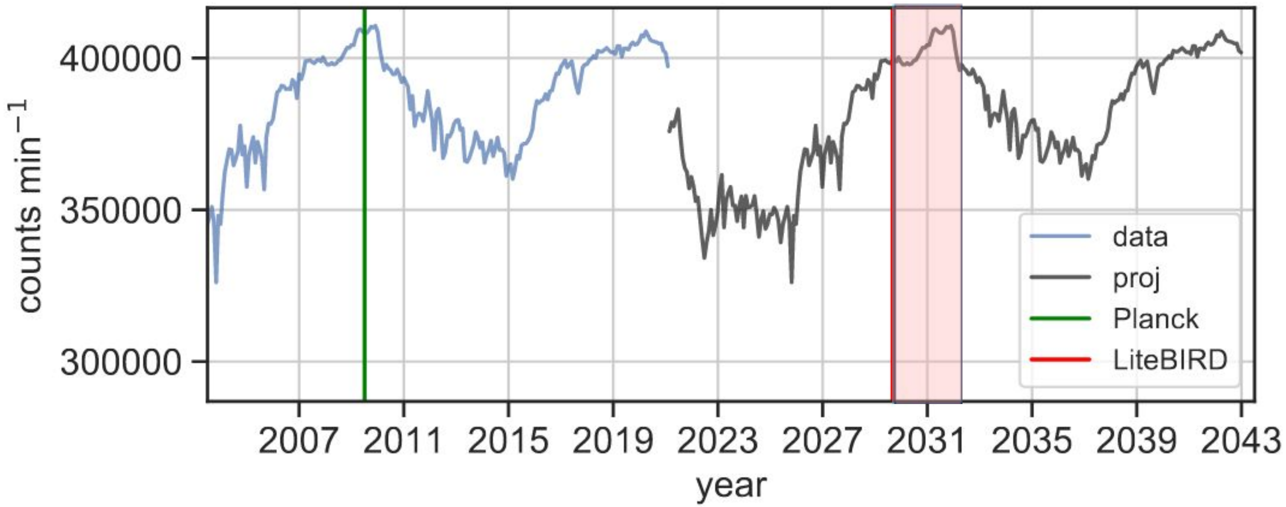


Figure 1. Oulu neutron observatory data up to the present day (blue), the projected data for the next 22 years (black), the observation time of Planck HFI (green line), and the observation time of LiteBIRD (red line).

S. L. Stever et al. 2021