Joint ICTP-IAEA Workshop on Advanced Solutions for Field Measurements

8 - 19 August 2022, ICTP Trieste Italy

Organizers: Roman PADILLA ALVAREZ (IAEA), Petr SLADEK (IAEA), Maria Liz CRESPO (ICTP)

Support e-mail: smr3729@ictp.it

About ICTP

- ➢ Founded in 1964 by the late Nobel Laureate Abdus Salam

- ➢ Promote advanced scientific research in the developing world

- ➢ An institute run by scientists for scientists

- ➢ Cutting edge research, education and training

- ➢ Funded by the Italian Government, UNESCO, and the IAEA

ICTP Mission

➢ Foster the growth of advanced studies and research in physical, mathematical and related sciences, especially in support of excellence in developing countries.

➢ Develop high-level scientific programmes keeping in mind the needs of developing countries, and provide an international forum of scientific contact for scientists from all countries.

➢ Conduct research at the highest international standards and maintain a propitious environment of scientific inquiry for the entire ICTP community.

Research

- ➢ High Energy, Cosmology and Astroparticle Physics

- ➢ Condensed Matter and Statistical Physics

- ➢ Mathematics

- ➢ Earth System Physics

- ➢ Quantitative Life Sciences

- ➢ Science, Technology and Innovation

- ➢ Energy and Sustainability & Computing Sciences

Education and Programmes

Conferences, Workshops and Schools
- ➢ ICTP organizes more than 60 international workshops, schools, and conferences every year.
  Please check ICTP's Scientific Calendar frequently for updates.

Career Development
- ➢ Junior, Regular and Senior Associates
- ➢ Affiliated Centres
- ➢ Training and Research in Italian Laboratories (TRIL)
- ➢ External Activities Unit

Education and Programmes

Pre-PhD Programmes
- ➢ ICTP Postgraduate Diploma Programme
- ➢ ICTP/IAEA Sandwich Training Education Programme

Degree Programmes
- ➢ Joint ICTP/SISSA PhD Programme in Physics and Mathematics
- ➢ Joint PhD Programme, Earth Science and Fluid Mechanics
- ➢ Physics PhD Programme
- ➢ International Master, Physics of Complex Systems
- ➢ Master of Advanced Studies in Medical Physics
- ➢ Master in High Performance Computing

ICTP Laboratories

Scientific Fabrication Lab (SciFabLab)
- ➢ Open-source digital fabrication (3D printers)
- ➢ Science Dissemination

Marconi Lab
- ➢ Wireless ICT and IoT
- ➢ Ionospheric Physics and Modelling

Multidisciplinary Lab (MLab)
- ➢ Advanced Scientific Instrumentation
- ➢ X-Ray Analytical Techniques and Methods
- ➢ Optics and Lasers

Multidisciplinary Laboratory (MLab)

Science, Technology and Innovation Unit

Advanced Scientific Instrumentation

➢ Particle Physics Experiments

➢ Nuclear Applications

➢ Multidisciplinary Experimental Projects

X-Ray Imaging and Applied Science

➢ Cultural Heritage

➢ Paleontology

➢ Archaeology

Applied Optics and Lasers

Advanced Scientific Instrumentation

Main current collaborations and projects

➤ UniTS

➤ INFN Trieste

➤ CERN (COMPASS/AMBER Experiments)

➤ IAEA NSIL

➤ Associates and Researchers
(Argentina, Malaysia, Sri Lanka, Cameroon, Guatemala, India, …)
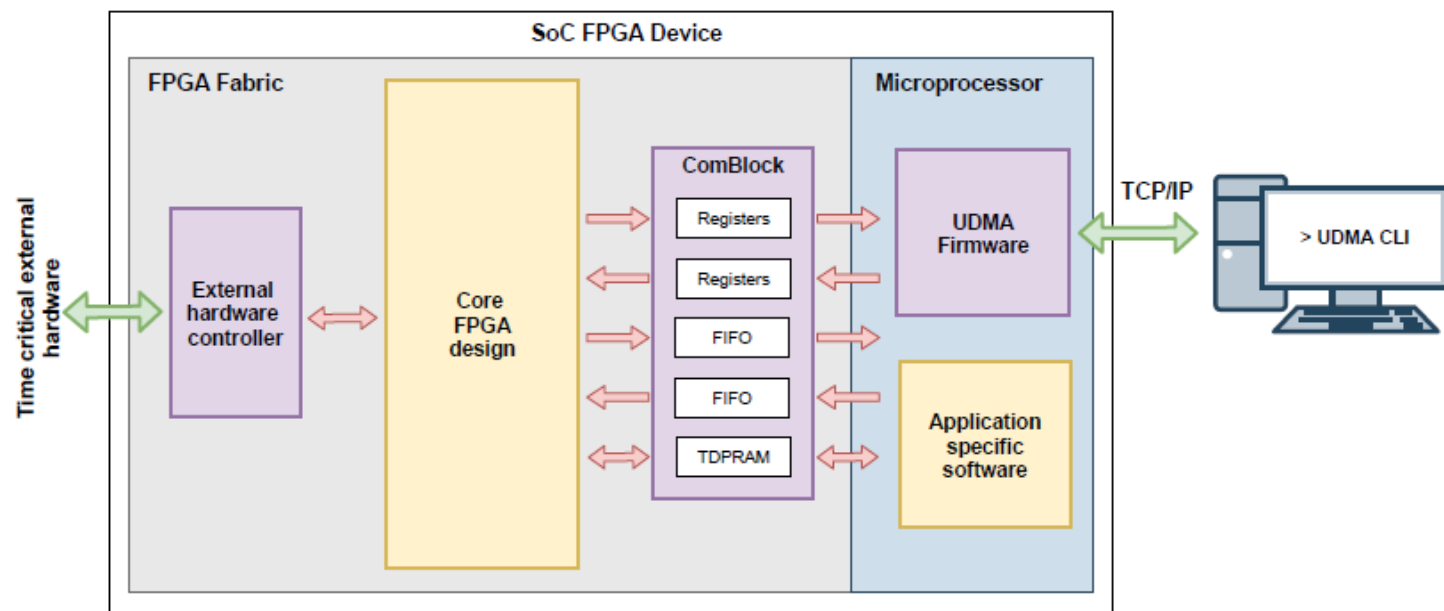
2022 School on SoC-FPGA

Joint ICTP-IAEA School on FPGA-based SoC and its Applications to Nuclear and Scientific Instrumentation
14 November - 2 December 2022 at ICTP (Deadline for applications: <u>18 September 2022</u>)

A scalable High Voltage Power Supply System with SoC control for Micropattern Gaseous Detectors

Luis Guillermo García Ordóñez (Guatemala), Joint ICTP-UniTS PhD student
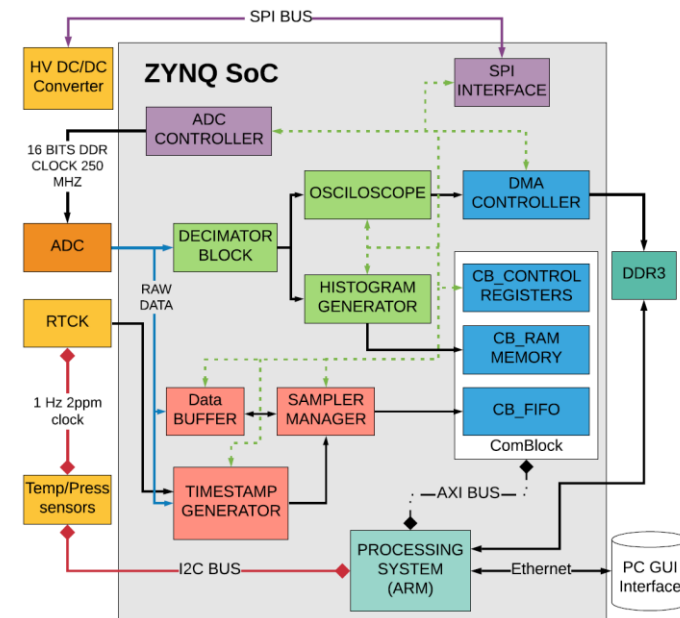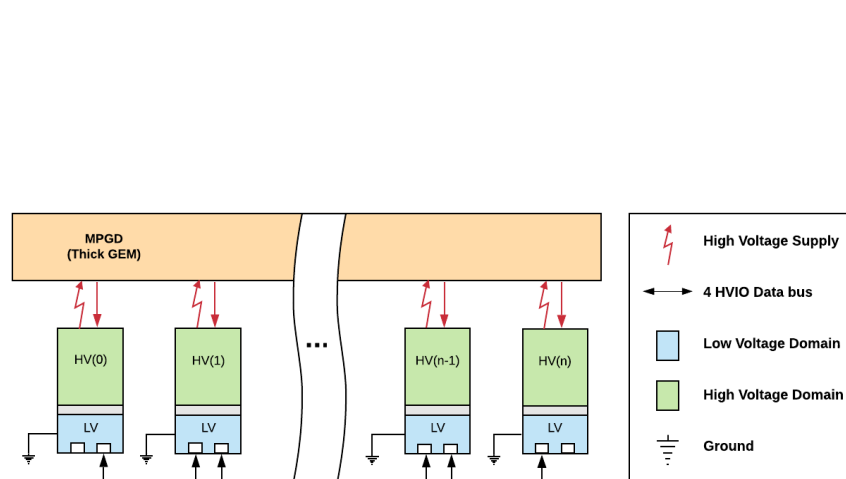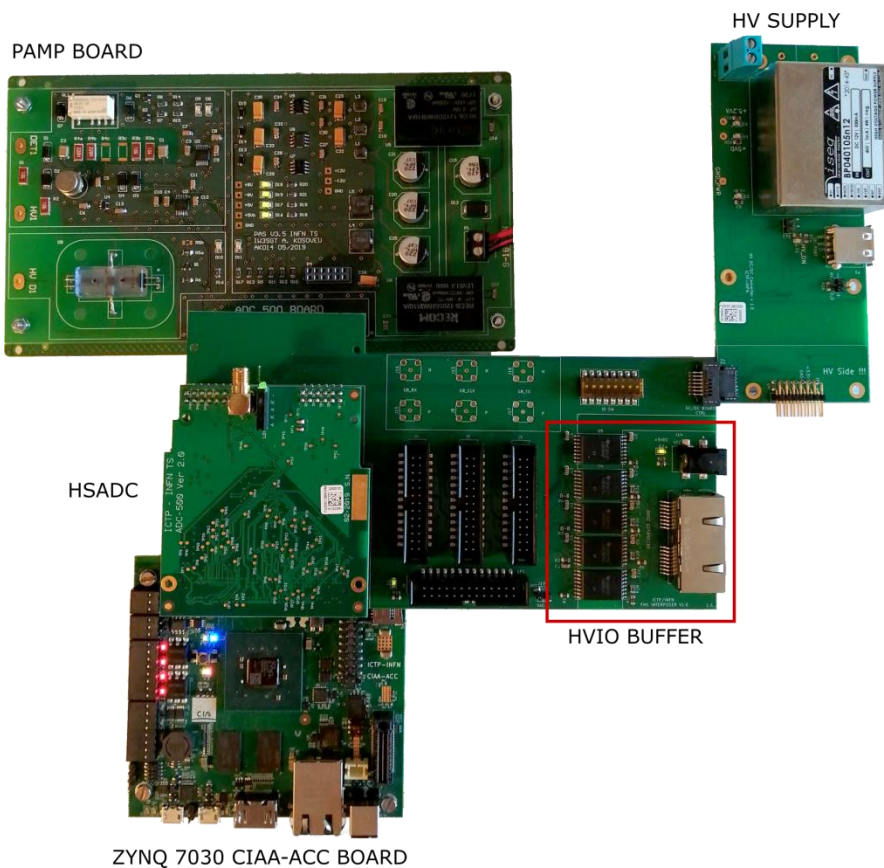

- **A scalable high voltage power supply system with system on chip control for micro pattern gaseous detectors**. *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment*, Volume 963

- **MPGD-based photon detectors for the upgrade of COMPASS RICH-1 and beyond.** *Journal of Instrumentation,* Volume *15*

- **High Voltage Isolated Bidirectional Network Interface for SoC-FPGA Based Devices**, In S. Saponara & A. De Gloria (Eds.) *Applications in Electronics Pervading Industry, Environment and Society*. Springer International Publishing

Real-Time Data Features Extraction for Trigger-less DAQ

Bruno Valinoti (Argentina), Joint ICTP-UniTS PhD student

- Data acquisition system for particle physics detectors

- CERN, COMPASS ECAL2 (3072 Ch), 2022 Proton Radius Measurement

- Hardware/Firmware/Software development for FPGA based Systems on Chip
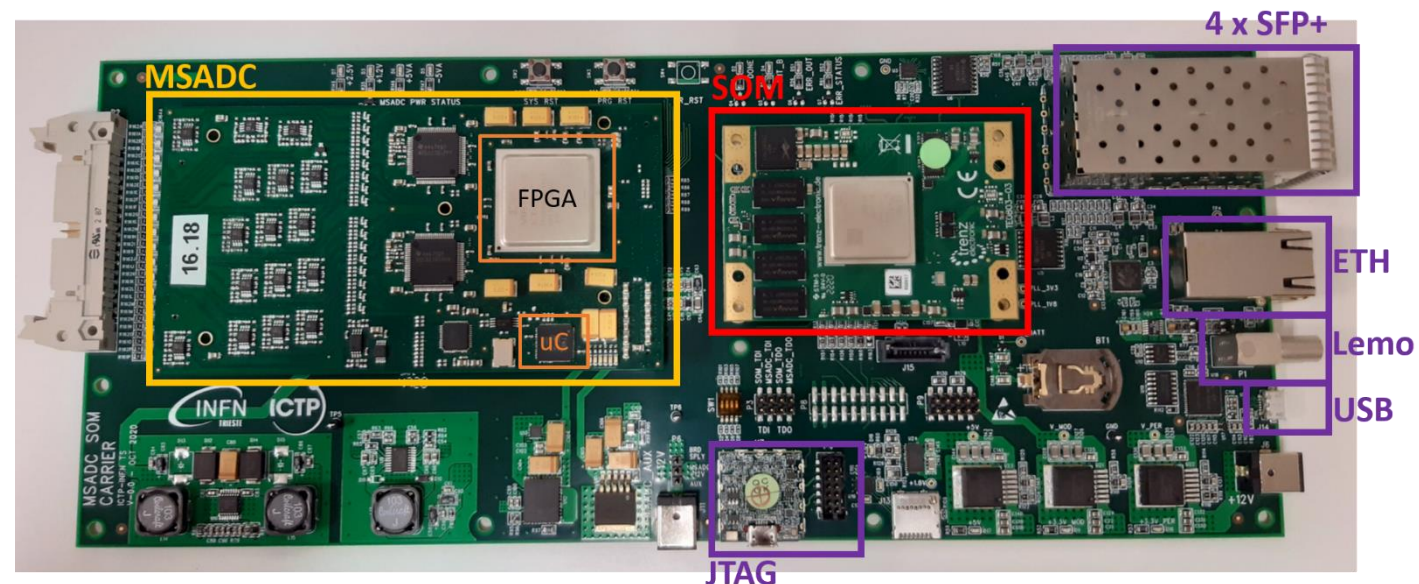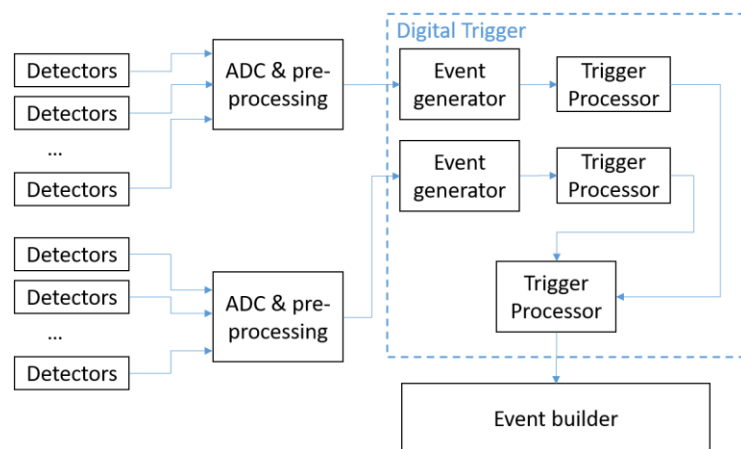
Hardware Acceleration of ML Algorithms

Romina Soledad Molina (Argentina), Joint ICTP-UniTS PhD student

- SoC-based FPGA implementation

- Compression techniques
- Re-ranking algorithm based on decision trees
- Pulse shape discrimination based on DNNs
- DNNs applied to image processing

Data

Training

Model compression

ML Inference model

SoC-based FPGA

Accurate

Fast

HW resources
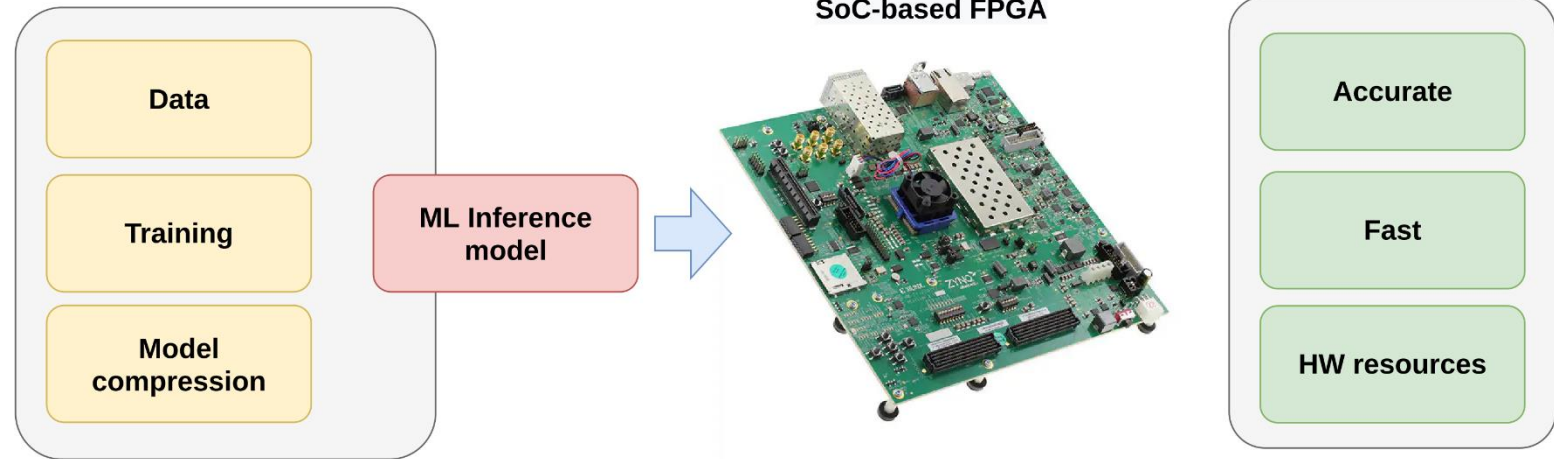
- Publications:

- **Efficient traversal of decision tree ensembles with FPGAs** (Journal of Parallel and Distributed Computing)
- **Muon–Electron Pulse Shape Discrimination for Water Cherenkov Detectors Based on FPGA/SoC** (MDPI – Electronics - 2021)
- **A Non-Linear Convolution Network for Image Processing** (MDPI – Electronics - 2021)

SoC-FPGA Cluster Architecture for Scientific Applications

Werner Florian (Guatemala), Joint ICTP-UniTS PhD student

- ➢ Abstract computing model
- ➢ Packet based protocol for Universal Direct Memory Access (UDMA)
- ➢ Foreseen applications
  - ✓ Cellular Automata Machines experiments
 - ✓ N-body simulations
  - ✓ …
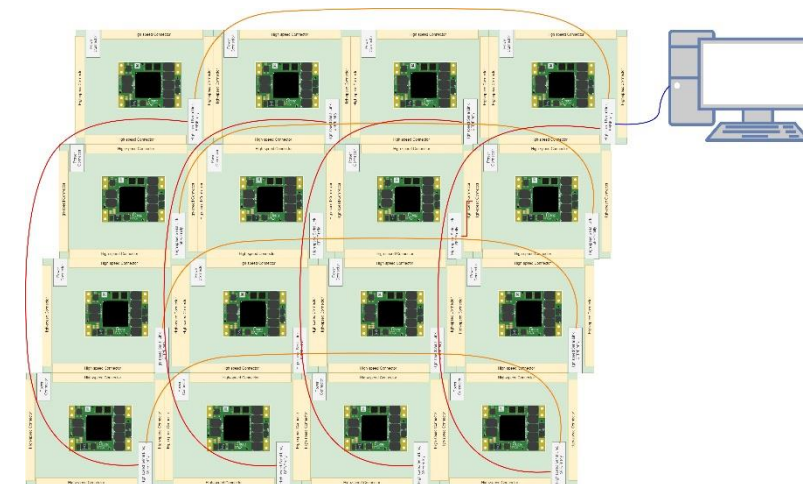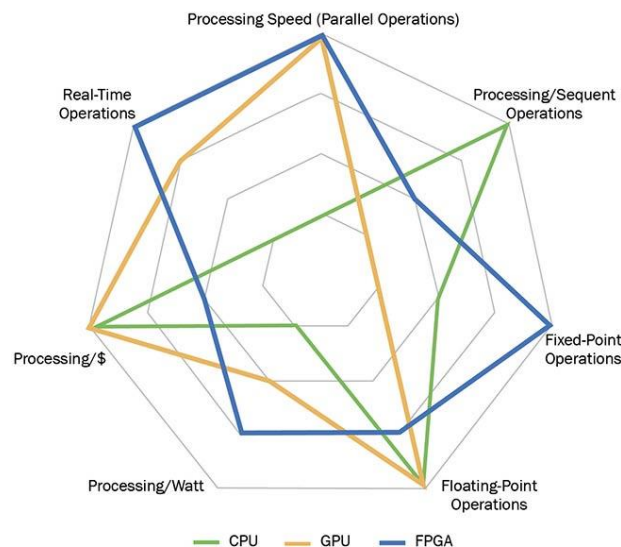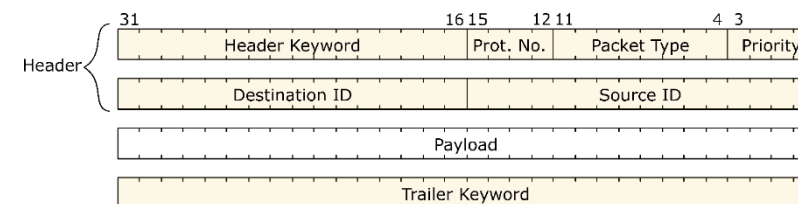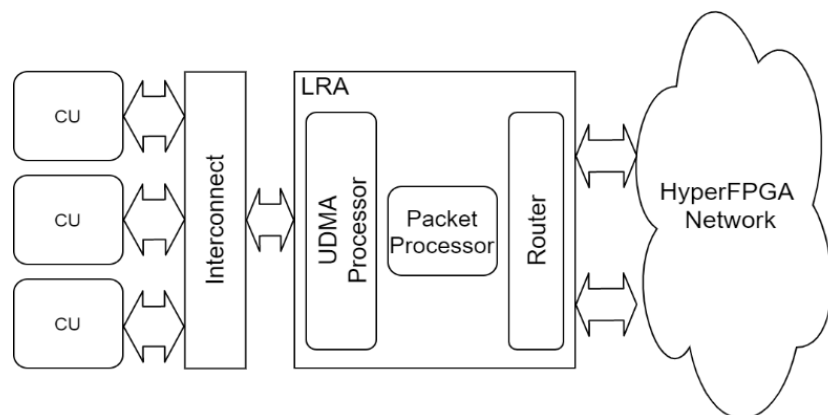
Embedded Nuclear Instrumentation Platform

Iván Morales (Guatemala), Joint ICTP-UniTS PhD student

➢ Reconfigurable and high speed

  ➢ Based on SoC-FPGA

➢ Real time detection and classification

➢ Traditional DSP and ML algorithms

➢ Compatible with multiple sensor technologies

➢ Embedded fast acquisition and slow control

➢ Two development projects

  ➢ IAEA (Portable Environmental Monitor)

  ➢ LAGO (Water Cherenkov Detection)

➢ Main Partner Institution

 ➢ NSIL IAEA

UAV Radiation Monitoring System
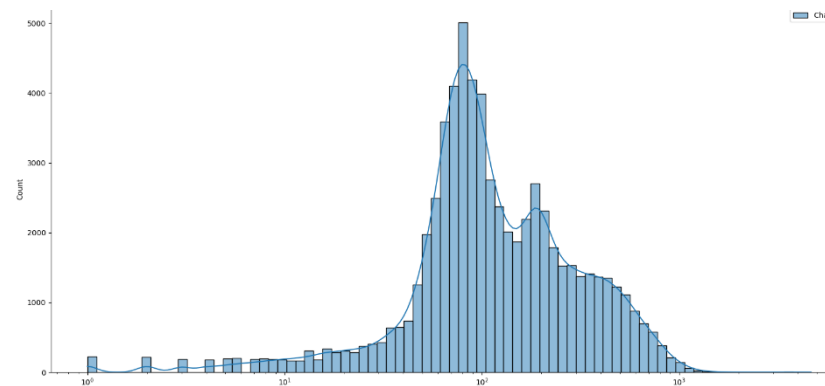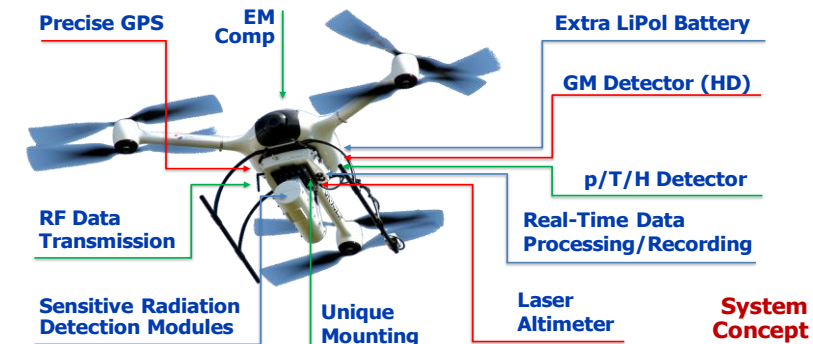
- **Publications:**
  Muon–Electron Pulse Shape Discrimination for Water Cherenkov Detectors Based on FPGA/SoC (2021)
  Garcia L., Molina R., Crespo M.L., Carrato S., Ramponi G., Cicuttin A., Morales I., Perez H.
  Electronics, 10(3), 224.

High-Channel Count Electrophysiology (HiCCE)

Kasun S. Mannatunga (Sri Lanka), Joint ICTP-UoM PhD student / former OFID-STEP fellow
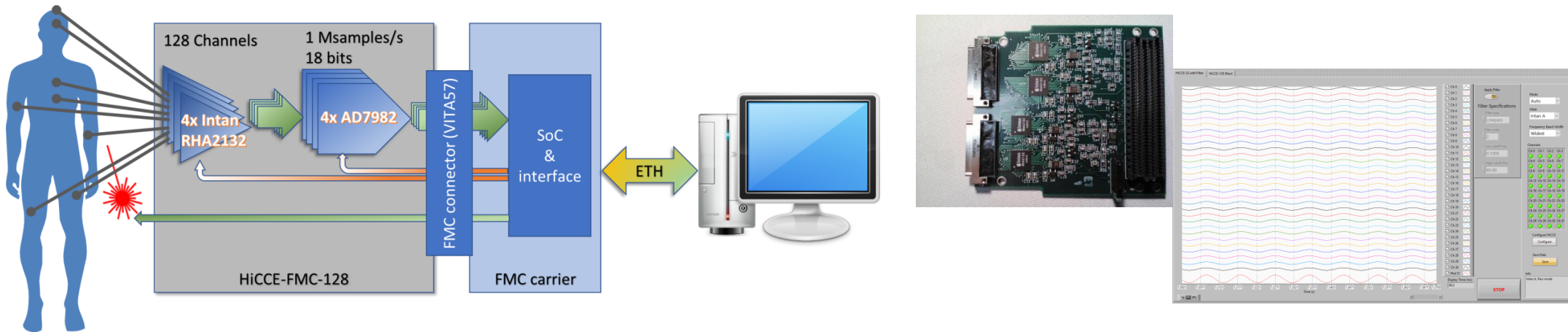
➢ Main goal of this project is to design a modular and scalable real-time data acquisition and processing system based on the SoC devices targeting Electrophysiology applications.

➢ HiCCE-128 acquisition system is well suitable for neurological rehabilitation.

➢ Currently use in vehicle driver's emotion recognition application.
- Understand the human behavior while driving a vehicle.
- Reduce the emotional behavior of the driver that led to road accidents.

- **Publications:**

K. S. Mannatunga, S. H. M. Ali, M. L. Crespo, A. Cicuttin, J. G. Samarawikrama, **High Performance 128-Channel Acquisition System for Electrophysiological Signals** in *IEEE Access*, vol. 8, pp. 122366-122383, 2020, doi:10.1109/ACCESS.2020.3007082.
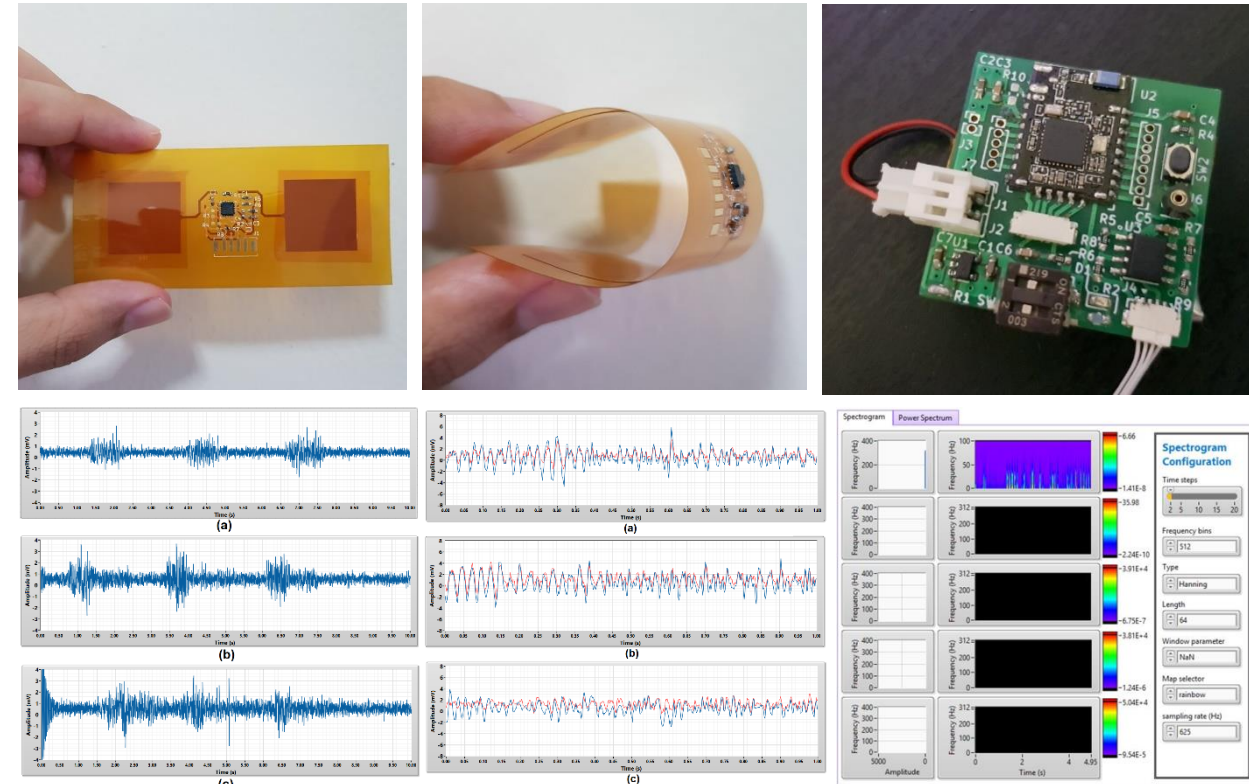
Wireless Capacitive Electromyography Sensor

Charn Loong Ng (Malaysia), STEP fellow

Project Main Goals:

1. Develop a flexible capacitive sensor that capable to measure EMG signals from human body.

2. Digitize the analog EMG signals at the sensor edge.

3. Wirelessly transfer the EMG signals from the sensor to the host computer.

4. Develop a complete GUI to monitor and analyze the EMG signals.

5. Characterize and validate the performance of the Capacitive EMG sensor.

EMG results measured using a) Micropore, b) Gauze, c) Crepe bandage insulated cEMG biomedical sensor.

- Publications:

Ng, C.L.; Reaz, M.B.I.; Crespo, M.L.; Cicuttin, A.; Chowdhury, M.E.H. **Characterization of capacitive electromyography biomedical sensor insulated with porous medical bandages**. *Sci. Rep.* 2020, doi:10.1038/s41598-020-71709-0.

Cellular Automata Networks

In collaboration with L. De Micco (ICTP-Associate) and A. Silva (STEP fellow), Argentina

UNIVERSIDAD NACIONAL
de MAR DEL PLATA

➢ Physical implementation of asynchronous cellular automata networks
➢ Modeling and experimental studies
➢ Applications to
   ✓ True random number generation
   ✓ Quantum computing simulation
   ✓ Cryptography
   ✓ Poissonian triggering
   ✓ . . .
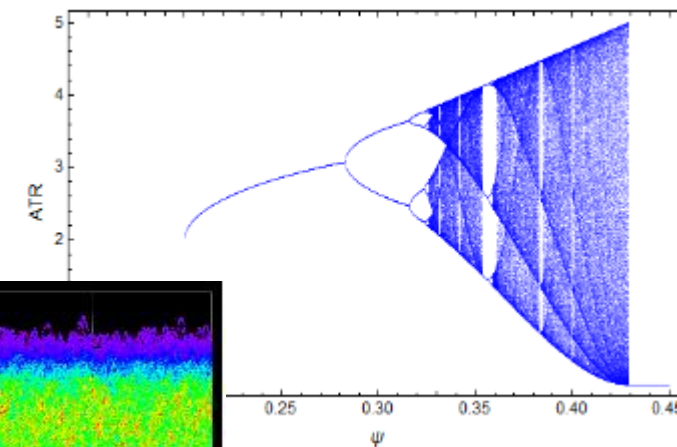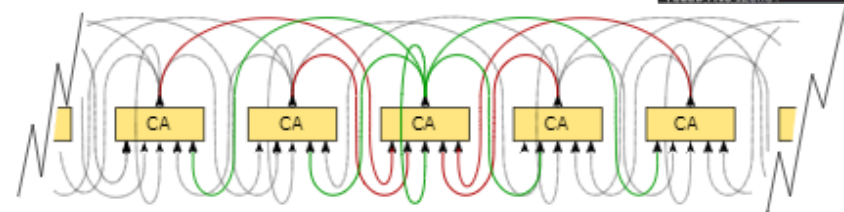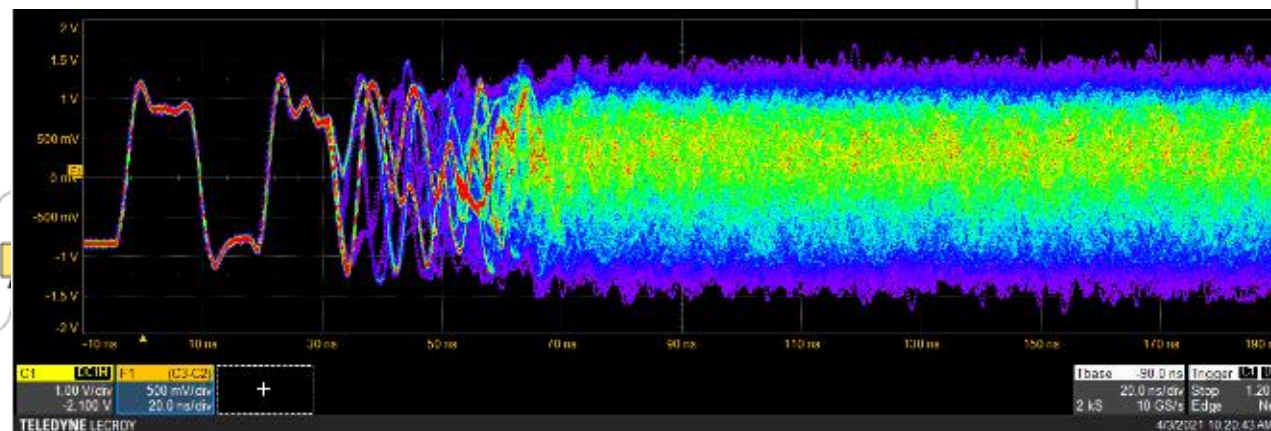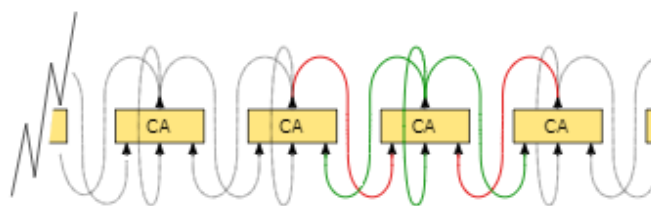
- Publications:
Physical implementation of asynchronous cellular automata networks: Mathematical models and preliminary experimental results.
A. Cicuttin, L. De Micco, M. L. Crespo, M. Antonelli, L. Garcia, W. Florian.
Nonlinear Dynamics J.