
# Status of the data acquisition and the trigger system

## DAQ working group

## CYGNO Collaboration Meeting - GSSI 20-21 Dec 2021

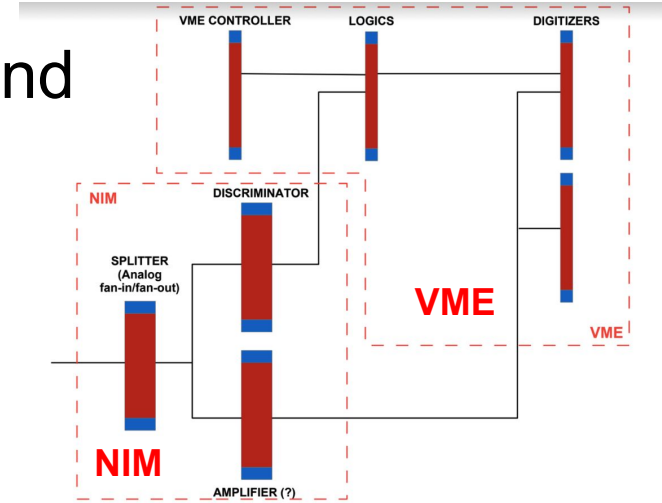
# Outline

- Group overview and activities
- Status of DAQ for LIME at LNGS
- Plans and development of the system for CYGNO

# Group overview and activities

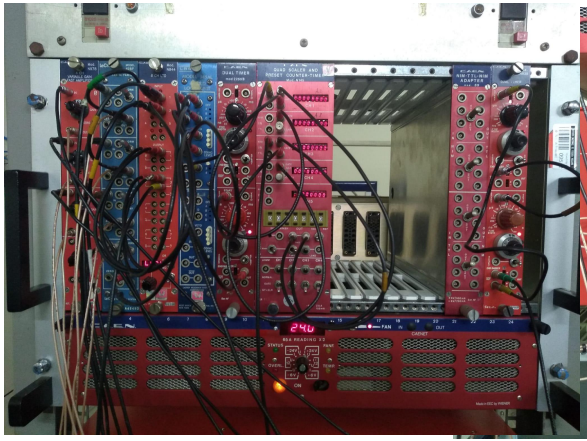
- Develop and maintain  the trigger, data acquisition, and slow control system
- Meeting Wednesday 16:30 CET time:
  - DAQ mailing list cygno-daq@lists.infn.it
  - https://agenda.infn.it/category/1149/
  - Google Meet link room: https://meet.google.com/rri-ivwo-heg
  - Share folders for material, ideas, reports: https://drive.google.com/drive/folders/1PFlbnkz3uSkQ_3XQ-Eya-OP4MKO2ckuj
- Group members: Rafael Antunes Nóbrega, Amaro Lopes (UFJF), Herman Pessoa Lima Jr., Danilo Cardoso (CBPF), Giorgio Dho (GSSI), Francesco Renga, Francesco Iacoangeli, Davide Pinci (Roma1), Stefano Piacentini, Andrea Messina (Sapienza)

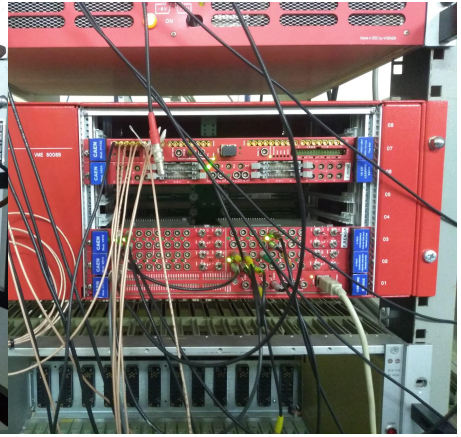
# Hardware status for LIME underground




**DAQ system based on USB for the camera + NIM and VME modules for analog signals:**

- **NIM**: Splitting (N625), discriminating (N840) and amplification if needed
- **VME**: Fast digitization (V1742) for PMT, slow digitization (V1720) for the GEM, controller (V1718, V3718), and logic (V976 or custom trigger module)
- **Two servers Xeon** 16 core 4216 32 GB RAM+ 2x8 TB HD + NVIDIA RTX5000 24 GB





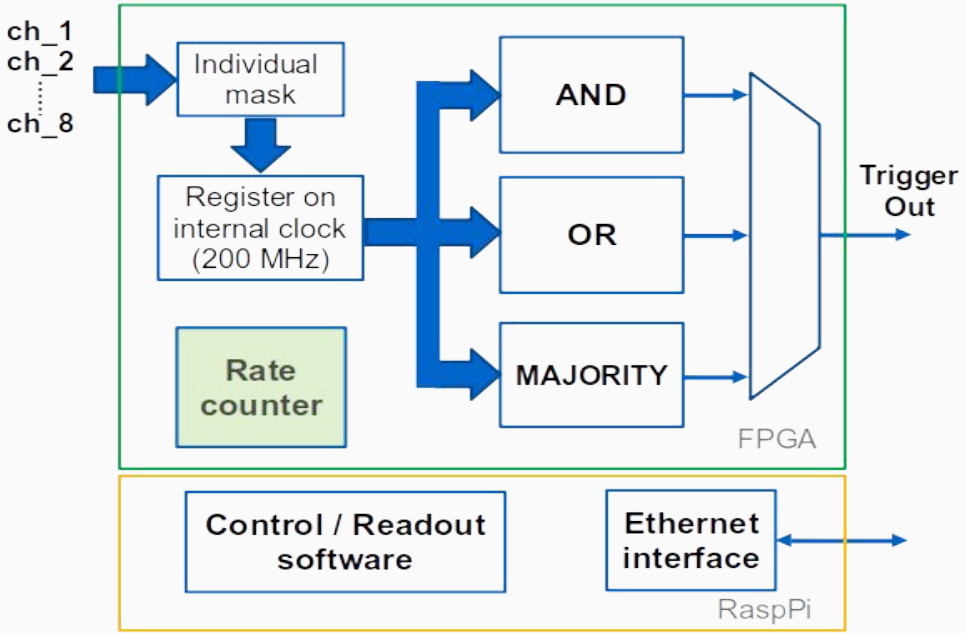
# Trigger module for LIME/CYGNO

DONE

**Custom firmware/software design:**

- 8 digital input channels
- Trigger logic remotely configurable through Ethernet connection
- Trigger logic based on the CAEN V976 module (AND, OR, Majority)
- More functionalities under development (ex: rate counter)

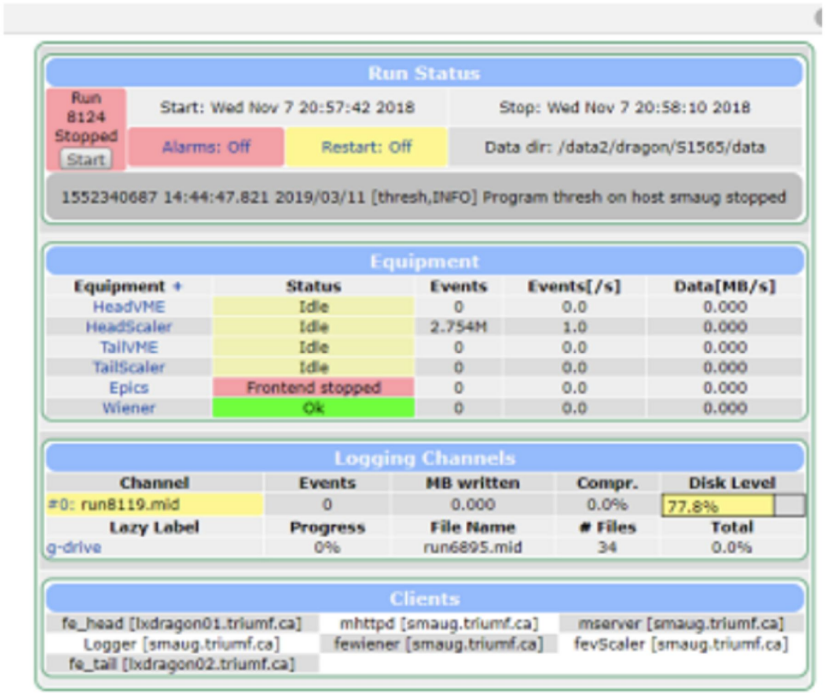
**STATUS: first prototype delivered to Rome in Oct/21:**



# Software status for LIME underground

- DAQ for 2 digitizers + camera has been implemented, debugged, and smoothly working.

- Dumping of run information (run log) into MySQL DB has been implemented and tested (DB structure and variables to be defined).



# Slow Control status for LIME underground

## Also implemented in MIDAS

- Hardware:
  - SCS3000 (PSI microcontroller for DAQ of external sensors)
  - CAEN HV mainframe
  - GAS system
- Software:
  - Managed by a single SC frontend application
  - Instantaneous readout and setpoint values stored in the online DB
  - Stream of values saved in history files (visualised in MIDAS)

# Trigger and DAQ for CYGNO

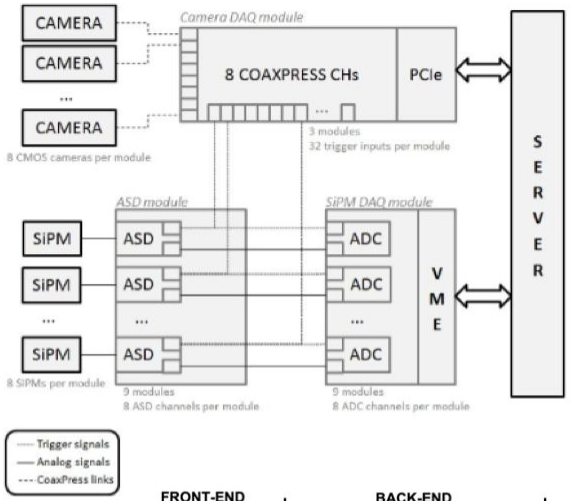
**Two readout path:**

- **camera (one per module):**
  - exposure 0.2-1 sec. 10MB of data;
  - run in continuum mode, 50 Mb/s
  - CameraLink PCIe frame grabber @ 2.5 GB/s (or USB3)
- **photodetector (up to 8 channels per module):**
  - 12-bit digitisation @ 250 MS/s, $\lesssim 1\mu$s, 1 Mb/s

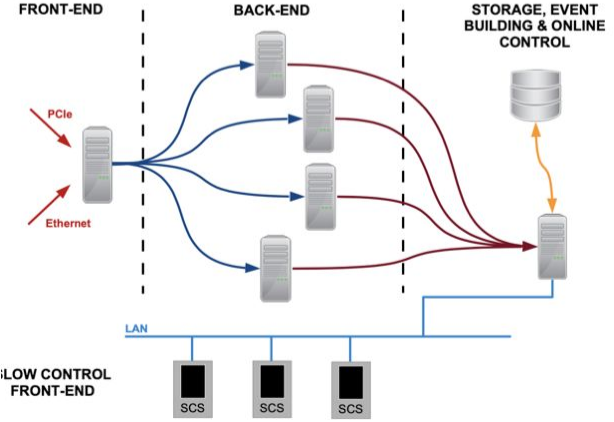
**Two possible trigger levels:**

- **HW trigger:** photodetectors with minimal logic (e.g. majority)
- **Software trigger:** reconstruction of images and waveforms on a farm of CPUs/GPUs based and trigger on interesting features (e.g. clusters), typically 1 evt/s

**MIDAS** used for Readout, Trigger and slow control




**MIDAS run control and slow control**

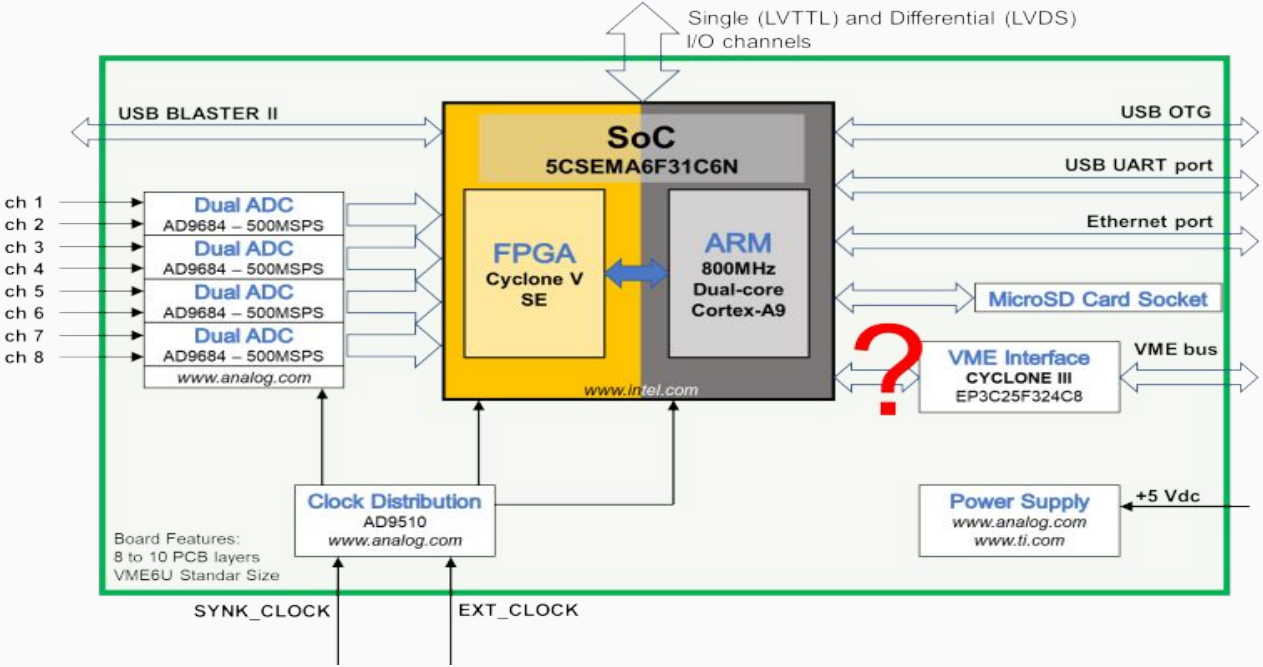


# Custom digitizer for Photomultipliers

IN PROGRESS

**Custom hardware design:**

- 8 analog input channels
- 500 MSPS sampling rate
- Single-ended and Differential GPIO (General Purpose IO)
- Flexible and programmable processing capabilities using SoC FPGA with embedded ARM processor
- Ethernet and USB communication interface

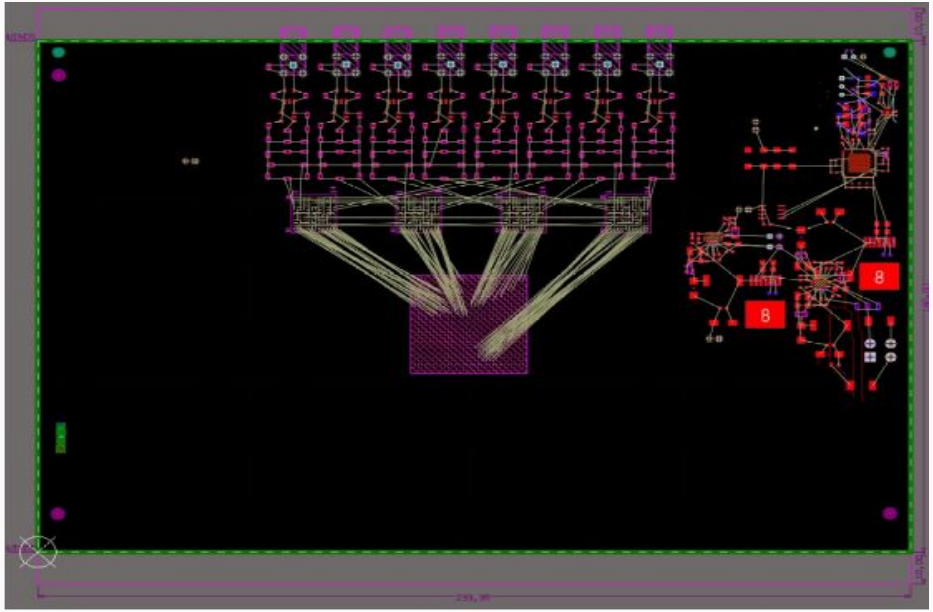


# Custom digitizer for Photomultipliers

IN PROGRESS

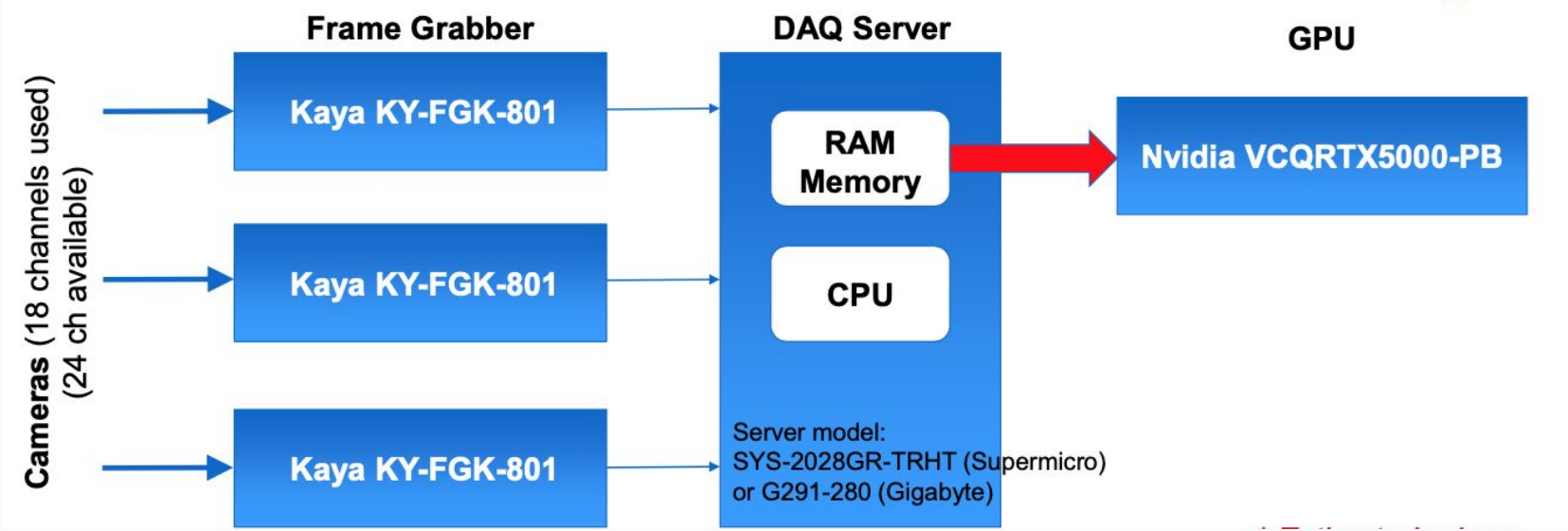
**STATUS:**

- Survey and selection of technologies/devices: ADC, FPGA, µC, clock, power. **DONE**
- Drawing of electrical schematics: analog/digital conversion circuit, ADC connections. **DONE**
- Defining and drawing ADC to FPGA data buses (16 x 4 LVDS channels). **DONE**
- Drawing of electrical schematics: FPGA circuit. **DOING**
- Learning and programming the FPGA ARM processor to implement the Ethernet and USB communication. **DOING**



First layout view (component placement and connections)

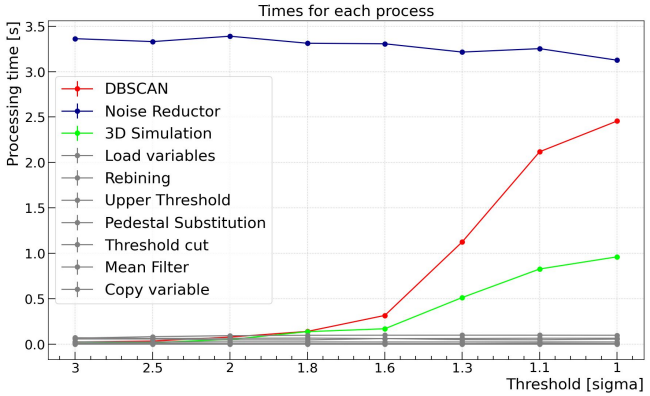
# CAMERA readout system

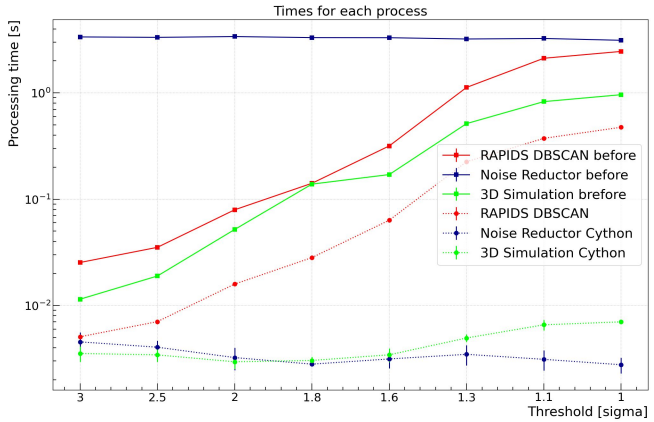


# DAQ related studies

IN PROGRESS

- **Timing the preprocessing steps in the reconstruction searching for optimization candidates;**
- **Searched for a better way of optimizing the slowest processes:**
  - *DDBSCAN* using GPU accelerated Rapids
  - *Noise reductor* and *3dsimulator** using Cython
- **Tested with $^{55}$Fe data achieving 15% decrease in total time with same results (only Cython tested)**
- **Test some simple algorithm to select candidates based on acquire images**




** today, noise 3dsimulator is not used anymore*

# Conclusions

LIME:

- The software and hardware trigger and DAQ systems for LIME has been working for the runs at LNF, we are currently finalised the system at LNGS:
  - Hardware based on NIM/VME commercial modules (+ a remote trigger board)
  - DAQ, trigger, and slow control software based on MIDAS

CYGNO:

- Development of a custom board for the acquisition of the photodetectors
- Use a frame grabber to acquire the camera
- Development of a software preprocessing of the images on GPUs and possible use the output for a software trigger