



CYGNO
Experiment

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

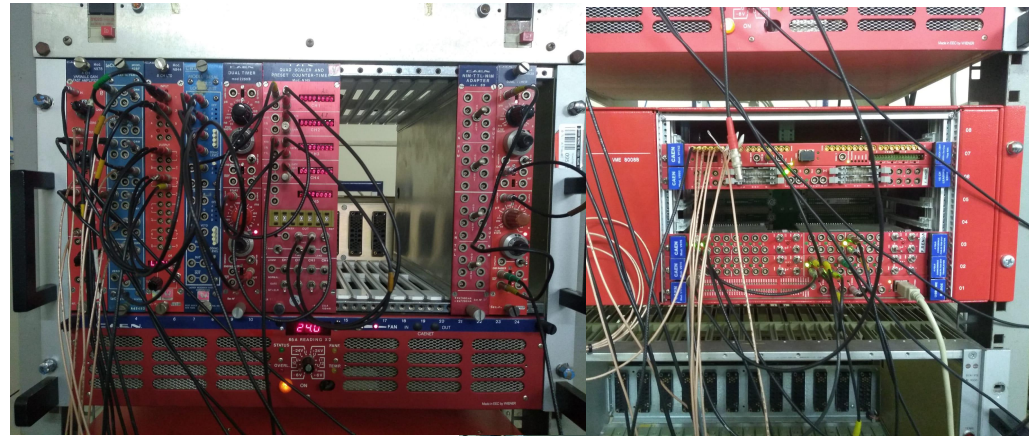
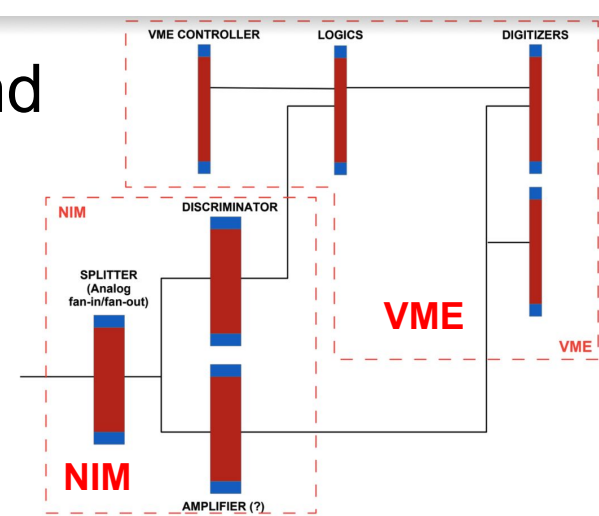
- Develop and maintain the trigger, data acquisition, and slow control system
- Meeting Wednesday 16:30 CET time:
 - DAQ mailing list cygno-daq@lists.infn.it
 - <https://agenda.infn.it/category/1149/>
 - Google Meet link room: <https://meet.google.com/rri-ivwo-heg>
 - Share folders for material, ideas, reports:
https://drive.google.com/drive/folders/1PF1bnkz3uSkQ_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**



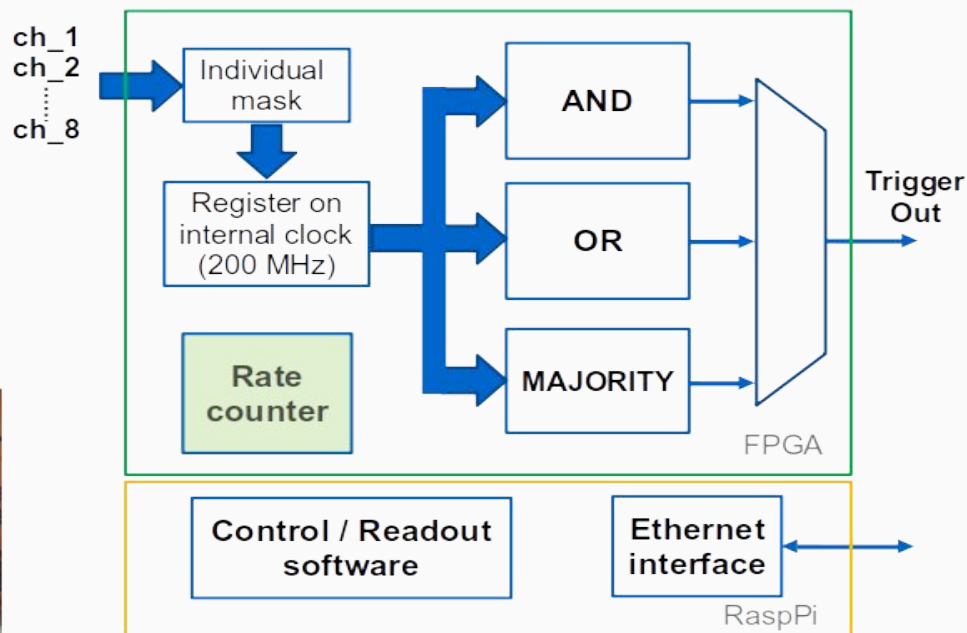
Trigger module for LIME/CYGN0

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).

Run Status

Run 8124	Start: Wed Nov 7 20:57:42 2018	Stop: Wed Nov 7 20:58:10 2018
Stopped	Alarms: Off	Restart: Off
<input type="button" value="Start"/>	Data dir: /data2/dragon/S1565/data	

1552340687 14:44:47.821 2019/03/11 [thresh,INFO] Program thresh on host smaug stopped

Equipment

Equipment +	Status	Events	Events[/s]	Data[MB/s]
HeadVME	Idle	0	0.0	0.000
HeadScaler	Idle	2.754M	1.0	0.000
TailVME	Idle	0	0.0	0.000
TailScaler	Idle	0	0.0	0.000
Epics	Frontend stopped	0	0.0	0.000
Wiener	Ok	0	0.0	0.000

Logging Channels

Channel	Events	MB written	Compr.	Disk Level
#0: run8119.mid	0	0.000	0.0%	77.8%

Logging Channels (Detailed)

Lazy Label	Progress	File Name	# Files	Total
g-drive	0%	run6895.mid	34	0.0%

Clients

fe_head [lxdragon01.triumf.ca]	mhttpd [smaug.triumf.ca]	mserver [smaug.triumf.ca]
Logger [smaug.triumf.ca]	fewiener [smaug.triumf.ca]	fevScaler [smaug.triumf.ca]
fe_tail [lxdragon02.triumf.ca]		

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)

High Voltage Control Page

Electric Fields		
	Input	Set
Drift field [kV/cm]	0	-0.063
Transfer field 1 [kV/cm]	0	0.100
Transfer field 2 [kV/cm]		0.100
VGEM 1 [V]	50	50
VGEM 2 [V]		50
VGEM 3 [V]		50
Offset [V]	2800	2800

SET ALL SET ZERO

Readings					
	Demand [V]	Read [V]	Current [μA]	⏻	▲
HV0	2800.000	0.000	0.000	●	●
HV1	50.000	0.000	0.000	●	●
HV2	20.000	0.000	0.000	●	●
HV3	50.000	0.000	0.000	●	●
HV4	20.000	0.000	0.000	●	●
HV5	50.000	0.000	0.000	●	●
HV6	0.000	0.000	0.000	●	●
HV7	ODB key */Equipment /CATHODE /Variables /Demand[0]: not found	ODB key */Equipment /CATHODE /Variables /Measured[0]: not found	ODB key */Equipment /CATHODE /Variables /Current[0]: not found	●	●

Settings

● HV0 ● HV1 ● HV2 ● HV3 ● HV4
● HV5 ● HV6 ● ALL CAEN
● ISEG HV

Ramp Up Speed [V/s] 100

Ramp Down Speed [V/s] 100

Trip Current [μA] 10

Trip Time [s] 1

Hot Spot Current [μA] 10 ●

ON ALL OFF ALL

DRIFT ON OFF

TRANSFER ON OFF

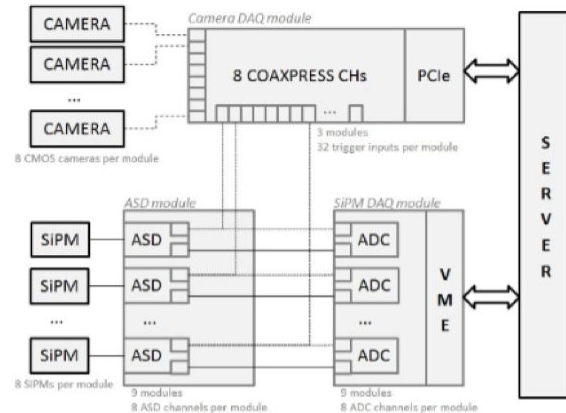
GAIN ON OFF

Trigger and DAQ for CYGNO



Two readout path:

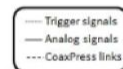
- camera (one per module):**
 - exposure 0.2-1 sec. 10MB of data;
 - run in continuum mode, 50 Mb/s
 - CameraLink PCIe frame grabber @ 2.5 GB/s (or USB3)
- photodetector (up to 8 channels per module):**
 - 12-bit digitisation @ 250 MS/s, $\lesssim 1\mu\text{s}$, 1 Mb/s



Two possible trigger levels:

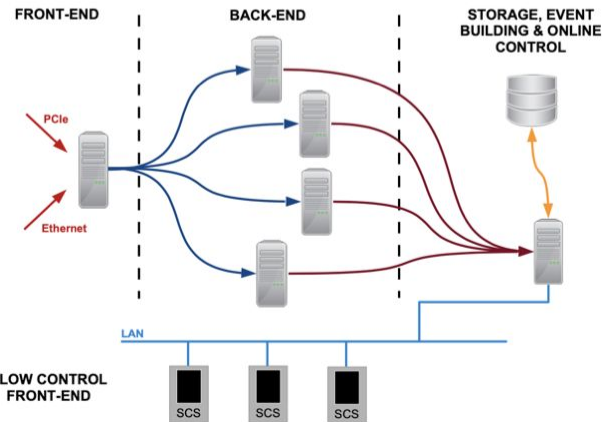
- HW trigger:** photodetectors with minimal logic (e.g. majority)
- Software trigger:** reconstruction of images and waveforms on a farm of CPUs/GPUs based and trigger on interesting features (e.g. clusters), typically 1 evt/s

MIDAS used for Readout, Trigger and slow control



MIDAS run control and slow control

Run Status					
Run	Start: Wed Nov 7 20:57:42 2018	Stop: Wed Nov 7 20:58:10 2018			
Stop	Reason: OK	Restart: Off	Data dir: /data/trigger/1555/data		
155230687: 14 44:47:02.1 2018/10/11 (Stream:DMC) Program: threshold on both among stopped					
Equipment					
Equipment	Status	Events	Events(1/2)	DataRate(1/2)	
FrontEnd	Idle	0	0.0	0.000	
ReadoutUnit	Idle	2,754K	0.0	0.000	
TriggerUnit	Idle	0	0.0	0.000	
TriggerUnit	Idle	0	0.0	0.000	
Event	Predefined threshold	0	0.0	0.000	
Monitor	On	0	0.0	0.000	
Equipment 1: FrontEnd					
Channel	Events	MB written	Comp.	Disk Level	
FR: readB10.mtd	0	0.000	0.0%	72.8%	
Program	0%				
File Name	File Name	# Files	Total		
data	data	14	0.0%		
Channels					
%Read (DataRate:0.000) [mtd:10]	trigger (DataRate:0.000) [ca]	trigger (DataRate:0.000) [ca]	trigger (DataRate:0.000) [ca]	trigger (DataRate:0.000) [ca]	
Trigger (DataRate:0.000) [ca]	Trigger (DataRate:0.000) [ca]	Trigger (DataRate:0.000) [ca]	Trigger (DataRate:0.000) [ca]	Trigger (DataRate:0.000) [ca]	
%Data (DataRate:0.000) [mtd:10]	trigger (DataRate:0.000) [ca]	trigger (DataRate:0.000) [ca]	trigger (DataRate:0.000) [ca]	trigger (DataRate:0.000) [ca]	

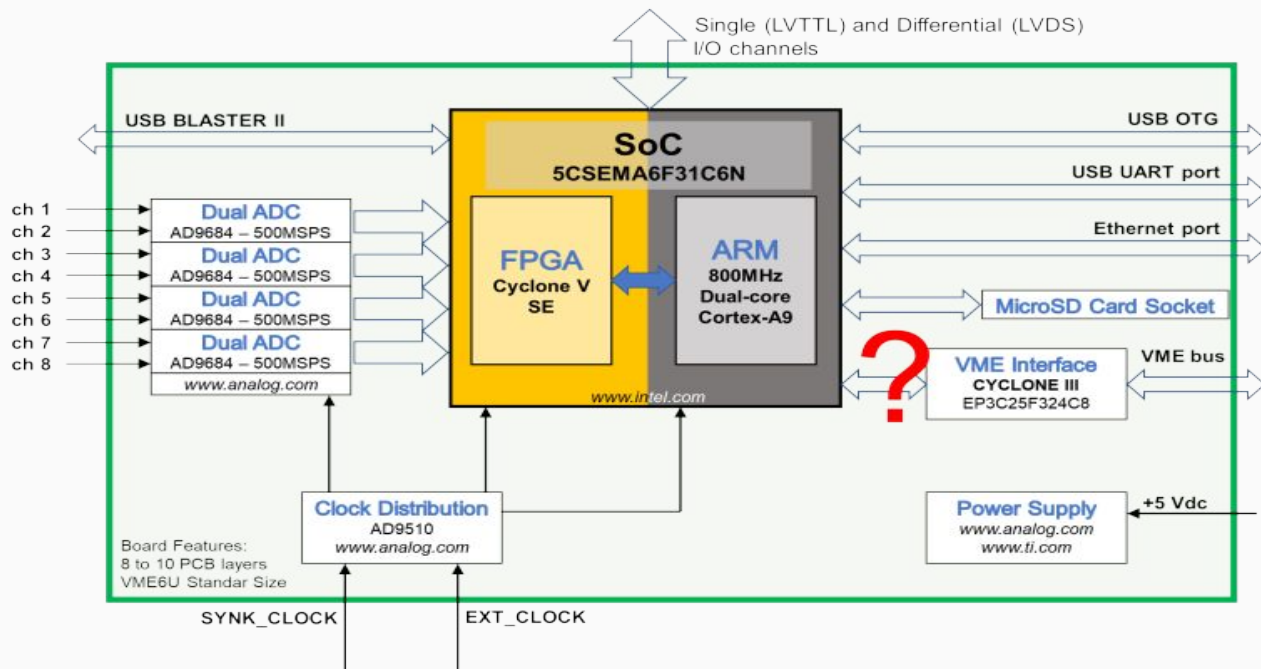


Custom digitizer for Photomultipliers

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

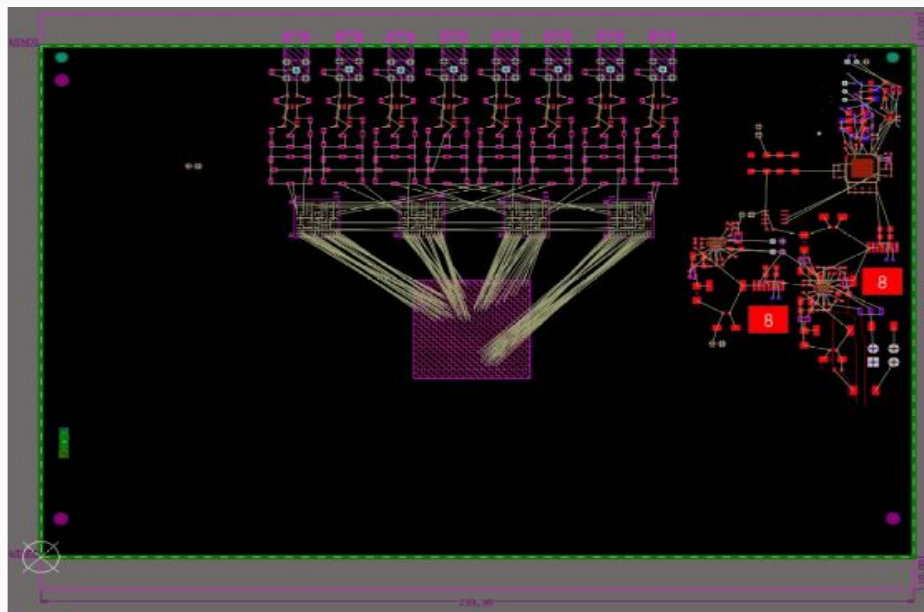


Custom digitizer for Photomultipliers

IN PROGRESS

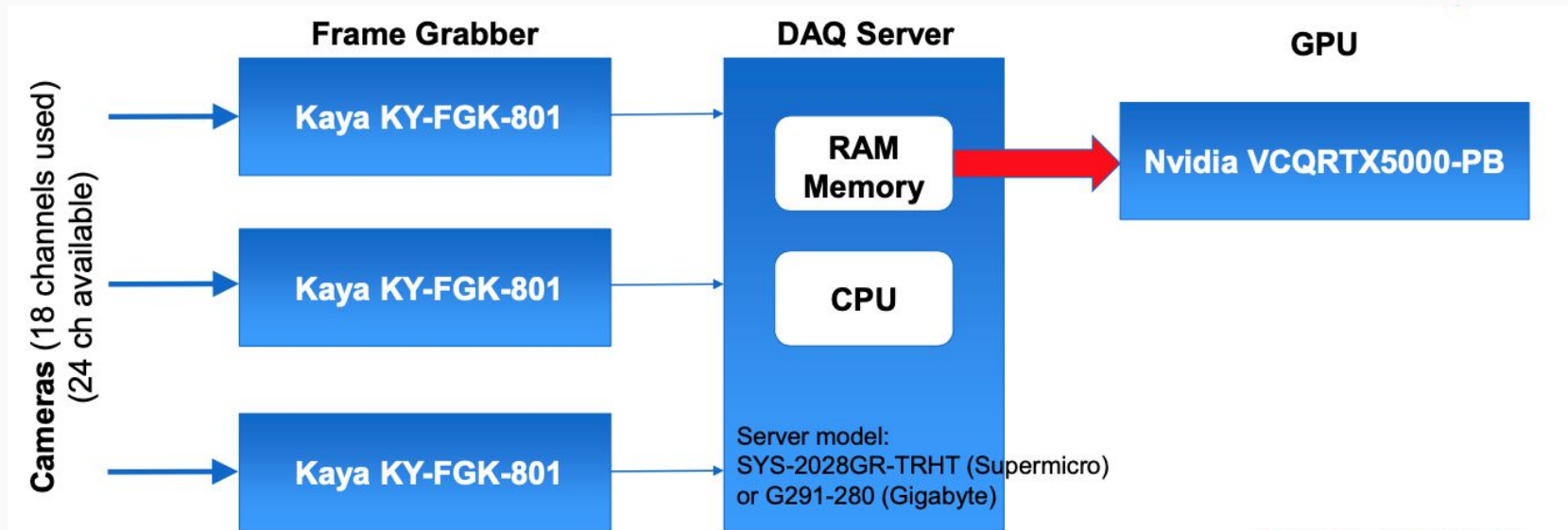
STATUS:

- Survey and selection of technologies/devices: ADC, FPGA, μ C, 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)

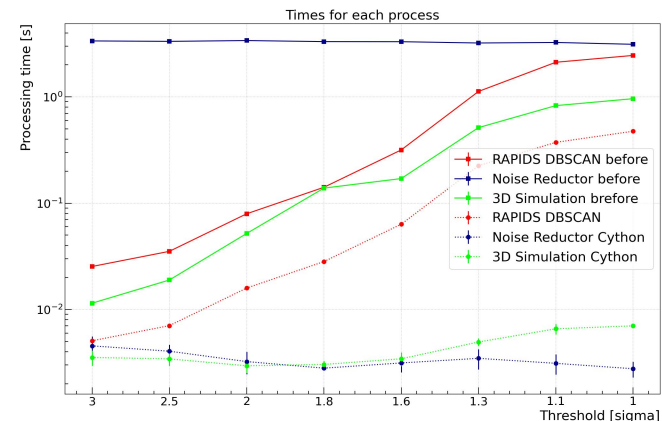
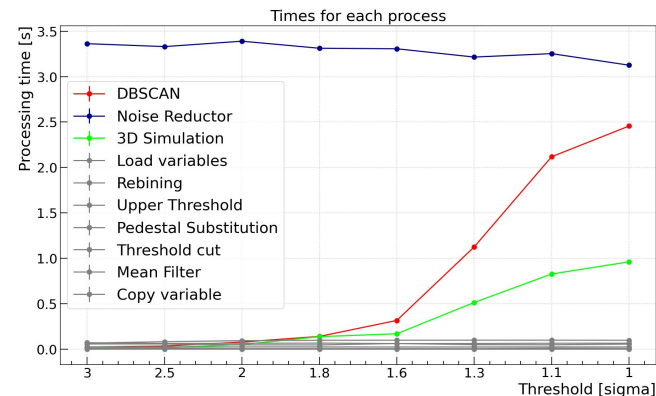
CAMERA readout system



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