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INFN

DAQ activities for CAOS

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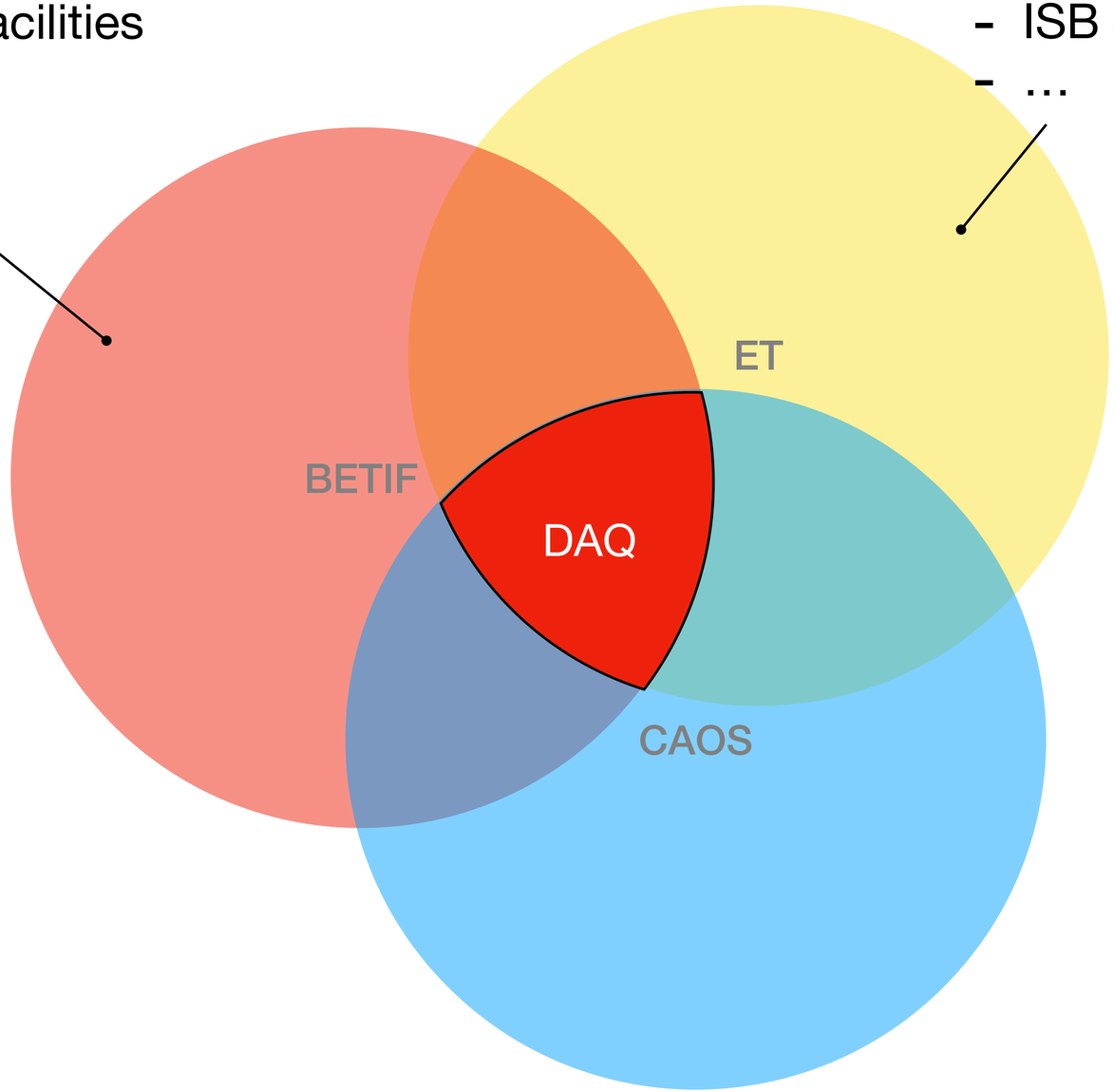
Planned R&D activities

- Electronics
- Time synchronisation
- Networking
- Computing

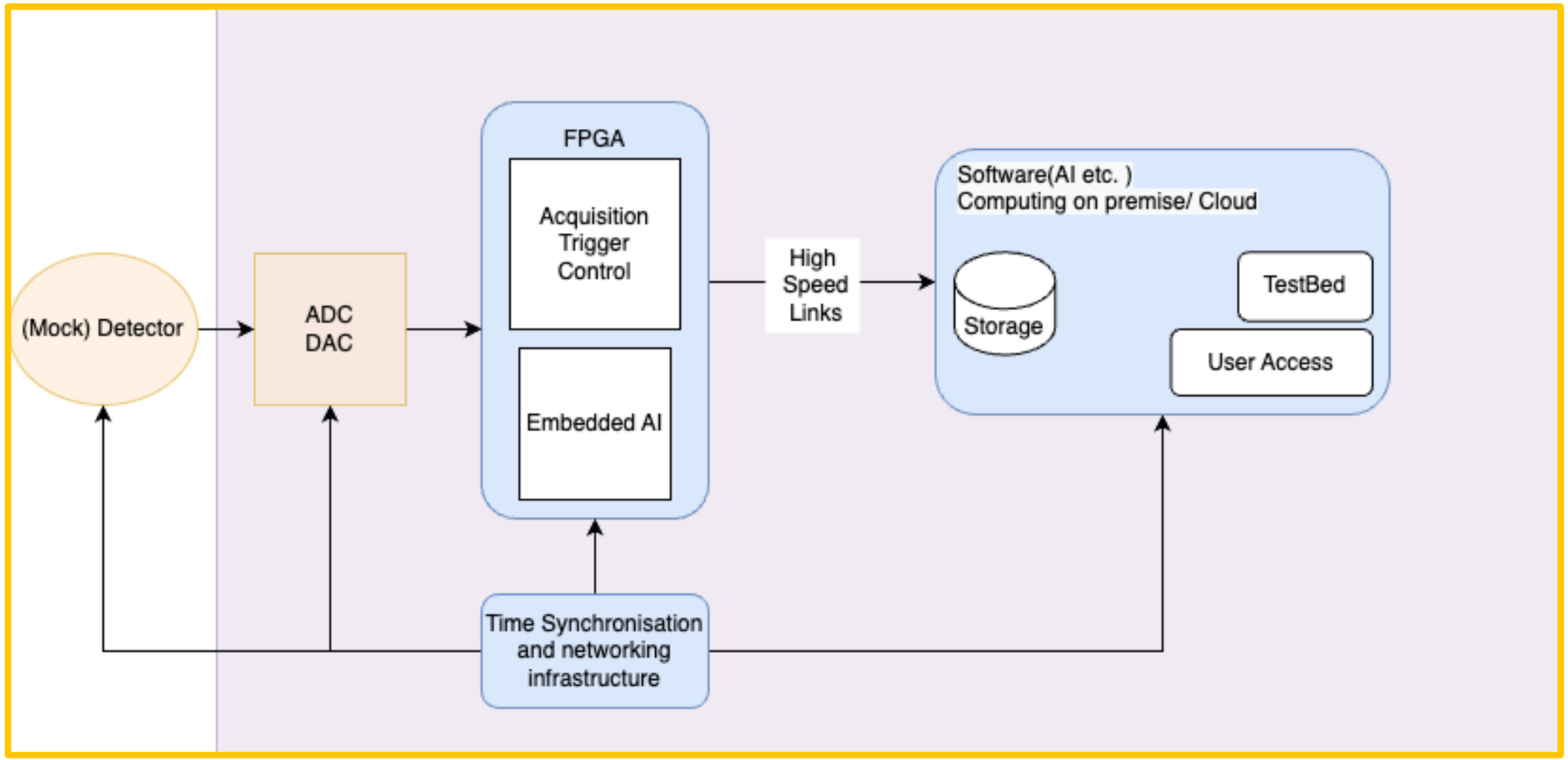
Bologna ET Integrated Facility
One of the PNRR-ETIC facilities

Einstein Telescope ecosystem
- PNRR ETIC project
- ISB (DAQ and realtime control WG)
- …



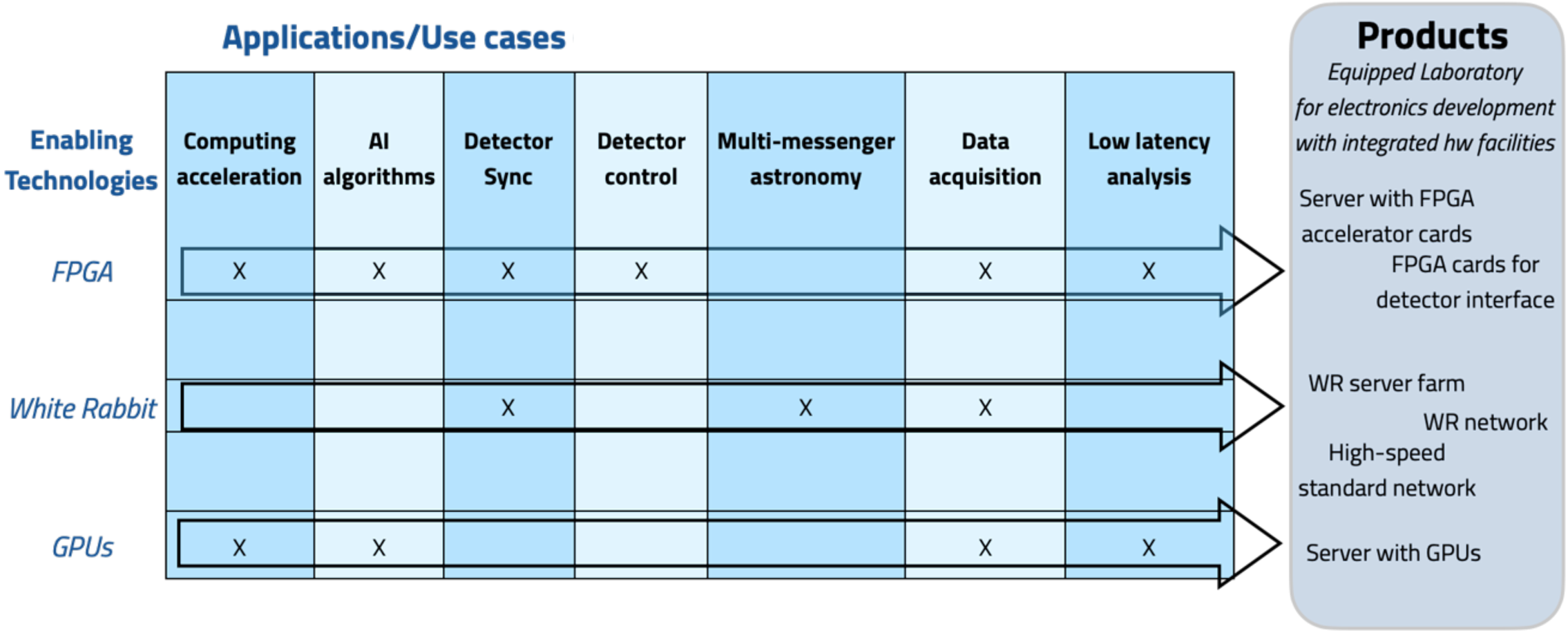
CAOS is a large-scale test-bench for DAQ developments

BETIF in a sketch



It can be seen as a “naked” test-bench preliminary to CAOS applications

BETIF - fields of research

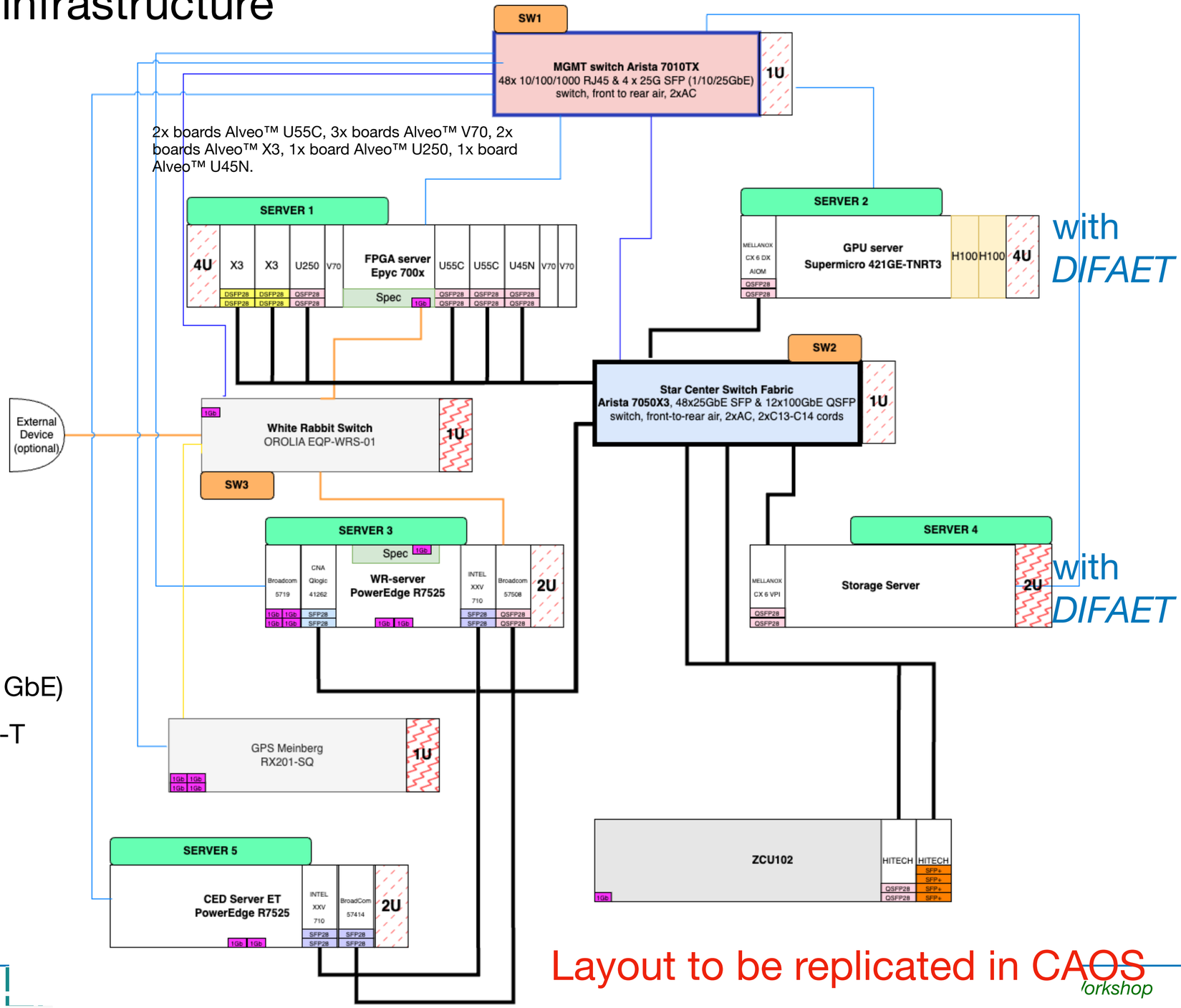


BETIF Networking/computing infrastructure

LB (10-100 GbE)

1GbE Base-T

1GbE fibre



Layout to be replicated in CAOS

BETIF Main R&D targets (spendable for CAOS):

Electronics

- setting up a **heterogeneous FPGA facility** (strong connection with WP4)
- implement and test “**matched filter “on FPGA**;
- implement a **FPGA based pipelines**, also exploiting AI-based approaches, for data pre-processing (raw data reduction, data managing);
- Performance **benchmarks of PTP distribution with FPGA-based accelerators** (with/without WR).
- developing **control systems** including the WR protocol for timing;
- developing f**irmware and hardware for WR-based instrumented node** (sensors / actuators)

Timing

- Implementing a local network which harmonises a **White Rabbit part together with a standard network infrastructure**
- Implementing the **WR PTP Core block** of the White Rabbit firmware and embedded software (OHWR project), **on FPGA** that are used for DAQ boards
- **Calibrating** the WR devices,
- Updating the driver and the firmware for the **SPEC board**, to get a WR carrier board pluggable via PCIe on standard devices

Procurement for CAOS to equip a DAQ infrastructure and a “first-aid” **laboratory**

Type	Quantity
GPS	1
White rabbit switch (18 port 1 GbE)	4
Optical Fibre	20
SFP, SPF+	40
Time tagger - SWABIAN multi-channels comparator O(10) ps accuracy	1
Spec board	1
Star center switch	1
Mgmt switch	1
Server	3
Cooled Rack + PDU	1
UPS	1
DAC cables 25 GbE 3 m	5
Network cables 1 GbE RJ45	50
KVM	1
Desktop	2
Oscilloscope	1
Sismometer Trillium Horizon T120 + Centaur DAQ + data cable + wifi module 2 channel + GPS antenna	1
AimTTi QL355TP power-supply 2 x 35/3A or 15V/5A plus 1-6V/3A with USB, RS232, GPIB and LAN	2
AimTTi QL564TP power-supply 2 x 56V/2A or 25V/4A plus 1-6V/3A with USB, RS232, GPIB and LAN	2
AimTTi CPX400DP power-supply DC double output 420W 60V 20A with USB, RS232 and LAN (GPIB optional)	2
KEYSIGHT 33622A arbitrary waveform generator	1
KEYSIGHT 34461A multimeter	2
KEYSIGHT 53230A - frequencimeter / timer, 350 MHz, 12 cifre / s, 20ps, LAN, USB, GPIB	1
Extech SDL900 magnetic meter and datarecorder AC/DC	1
Data Logger Pico + temperature probes	2
FLIR E54 Infra-red Thermocamera 320 x 240px - 24° wide field	1
LEMO connectorised cables (2,4,8,16,24,64) ns	40

Timing

Networking
Computing

Ancillary
Equipment

Perspective on needed channels for data acquisition/device control (*very draft numbers - also affordability constraints - **to be improved***)

subsystem	Frequency range	n. Channels
Laser	10 kHz	~20 ADC + 20 DAC
	100 kHz	1 Fast DAQ
Vacuum	10 kHz	50
Suspensions	2.5Gbps/crate	2 crates/tower x 2 towers

Milestones (to be achieved as soon as possible):
- data format(s)
- data aggregation stages (hardware and software) and data processing flows

Some of possible future applications…

Use-case: suspension electronics for **Advanced VIRGO +**

Suspension electronics to be renewed

Lead by *Alberto Gennai*, INFN-Pisa

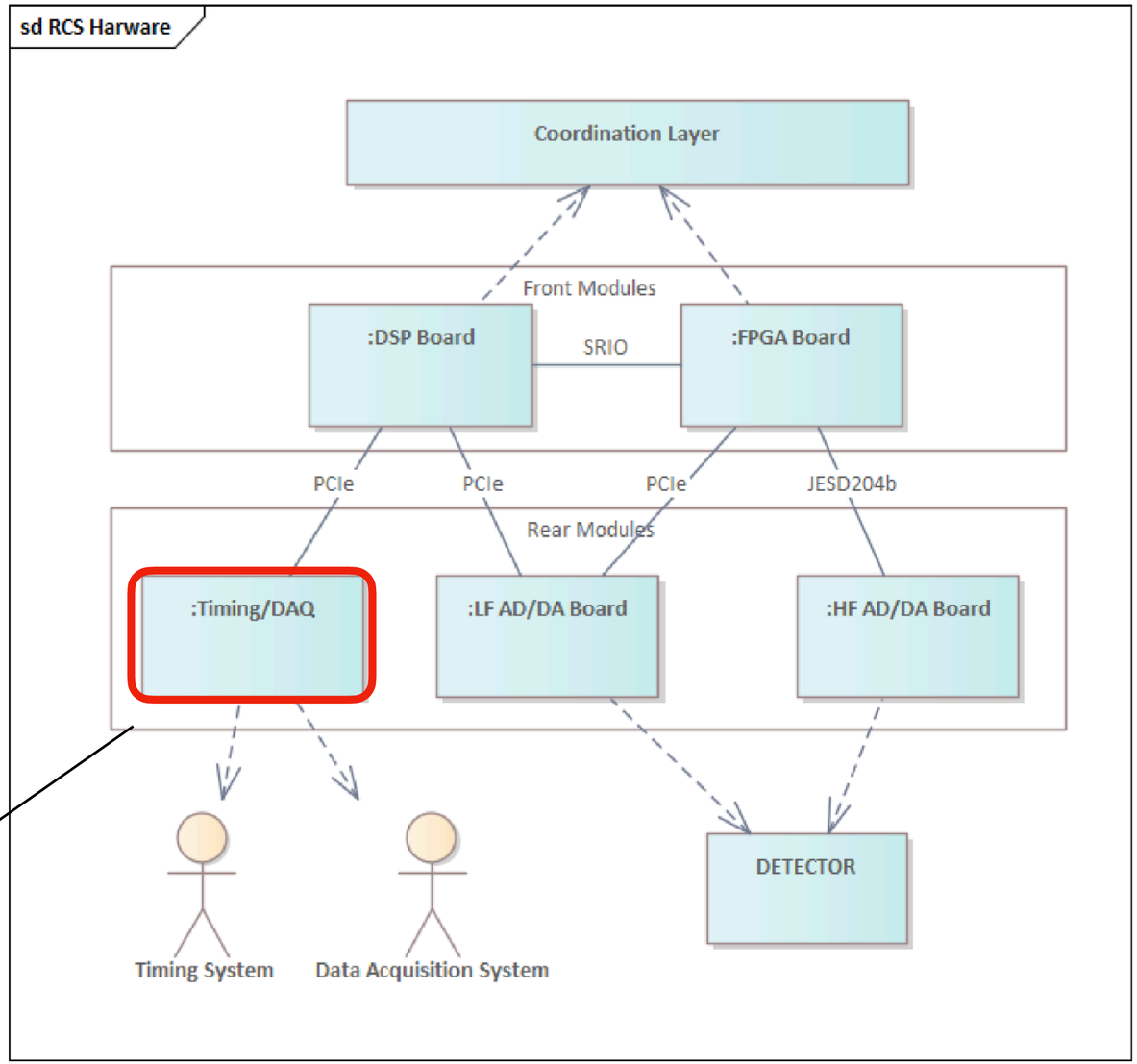
Change-Request issued to the Management and Steering Committee of Advanced-Virgo+

Joint activities: **INFN Pisa-Perugia-Bologna**

Presented planning, impact and budget (Internal review passed)

New boards: can be prototypes for ET R&D
→Test-bench in BETIF and CAOS

Proposal: Timing/DAQ board compatible with VIRGO-wise && WR-wise timing distribution



M2TECH: EU HORIZON-INFRA-2024-TECH-01-01 (lead by CNRS) — target: 10 M€ fundings

Technologies for Multi-Messenger research infrastructures. 10 INFN Units and associated Universities

WP5 “Synchronisation and Control” (WP Coordination: TC)

Currently in the “Reserve List”. Waiting for a final decision from EU

Tasks:
- WRS v4 with 10 GbE links + seamless redundancy + adaptive calibrations to external bias.
- Intelligent control / predictive maintenance / hybrid virtual-hardware in the loop

Active compensation of the variable delays δ_{ms}

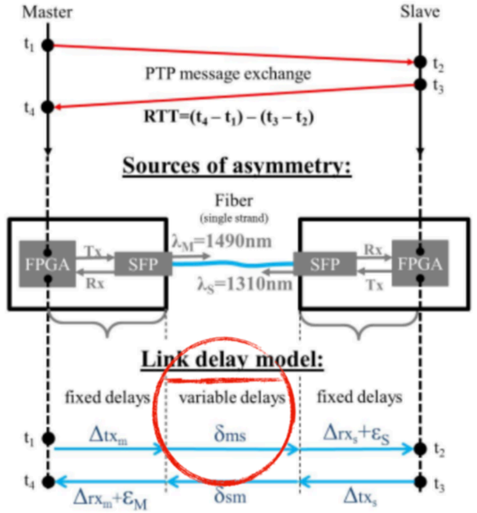
- Correction of Round Trip Time (RTT) for asymmetries
- Asymmetry sources: FPGA, PCB, electrical/optical conversion, chromatic dispersion
- Link delay model:
  - **Fixed delays** – calibrated/measured
  - **Variable delays** – evaluated online with:

$$\alpha = \frac{\nu_g(\lambda_s)}{\nu_g(\lambda_m)} - 1 = \frac{\delta_{ms} - \delta_{sm}}{\delta_{sm}}$$

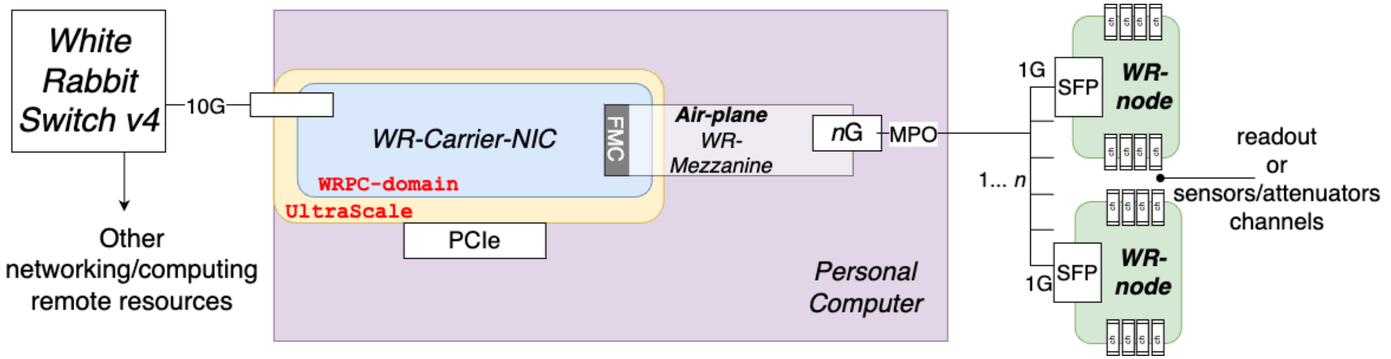
- Accurate offset from master (OFM):

$$\delta_{ms} = \frac{1+\alpha}{2+\alpha}\,(RTT - \sum\Delta - \sum\epsilon)$$

$$OFM = t_2 - (t_1 + \delta_{ms} + \Delta_{txm} + \Delta_{rxs} + \epsilon_S)$$



- PCIe WR-capable FMC carrier board
- Air-Plane FMC mezzanine board and WR-nodes



Bologna and Perugia ET groups synergies

White Rabbit is a central technology

Tight coordination with the WR CERN Group

INFN is joining the **WR Collaboration**

About the software part

Under evaluation:
- slow control system(s) (discussion open in ISB)
- Dispatching systems / middleware
- Storage system

Ready to manage the developments in synergy with other dedicated WGs
Sharing technologies and reflecting a common roadmap.