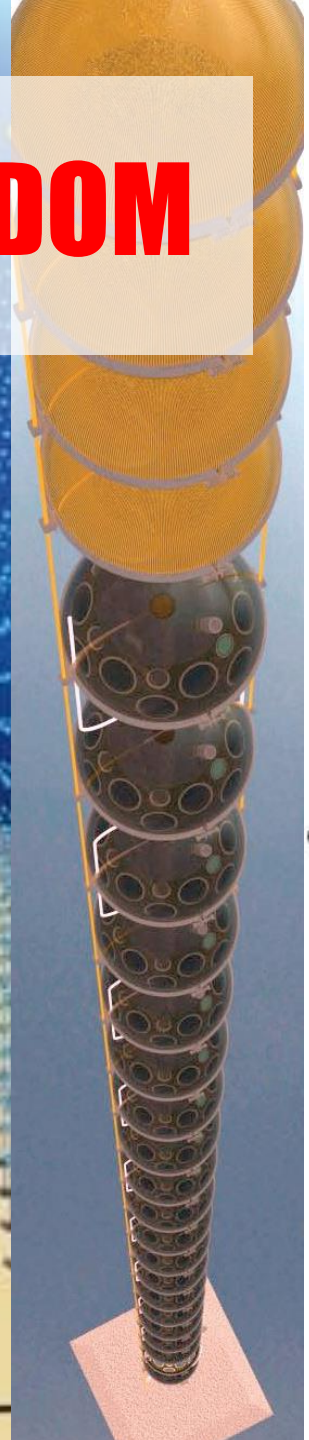
KM3NeT electronics acquisition:
the new version of the Central Logic Board and its related Power Board

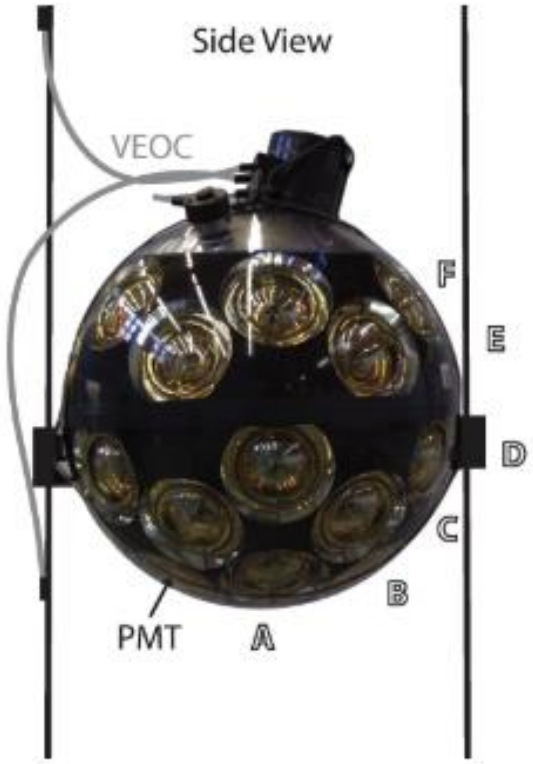
F. Versari, D. Real, C. Bozza, D.Calvo, P. Musico, P. Jansweijer, S. Colonges, V. Van Beveren, F. Carrio, G. Pellegrini, T. Chiarusi

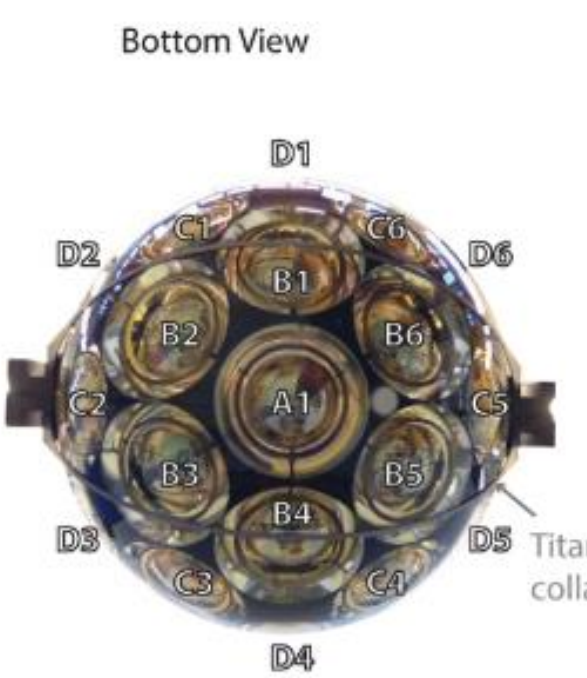
15/10/2019, IPRD19, Siena

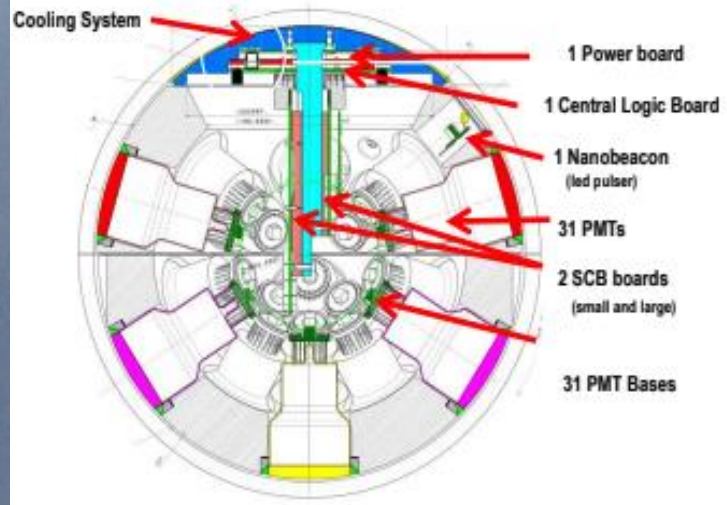
KM3NeT and the DOM

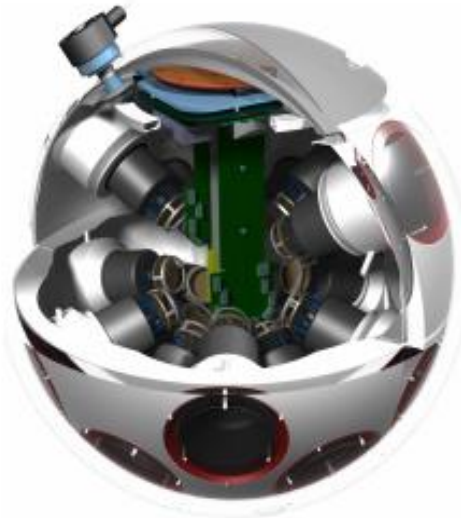
- 2 Detectors
- 345 Detection Unites (DUs)
- 18 Digital Optical Modules (DOMs) + 1 Detection Unite Base (DU base)
- 6.555 items to be controlled individually



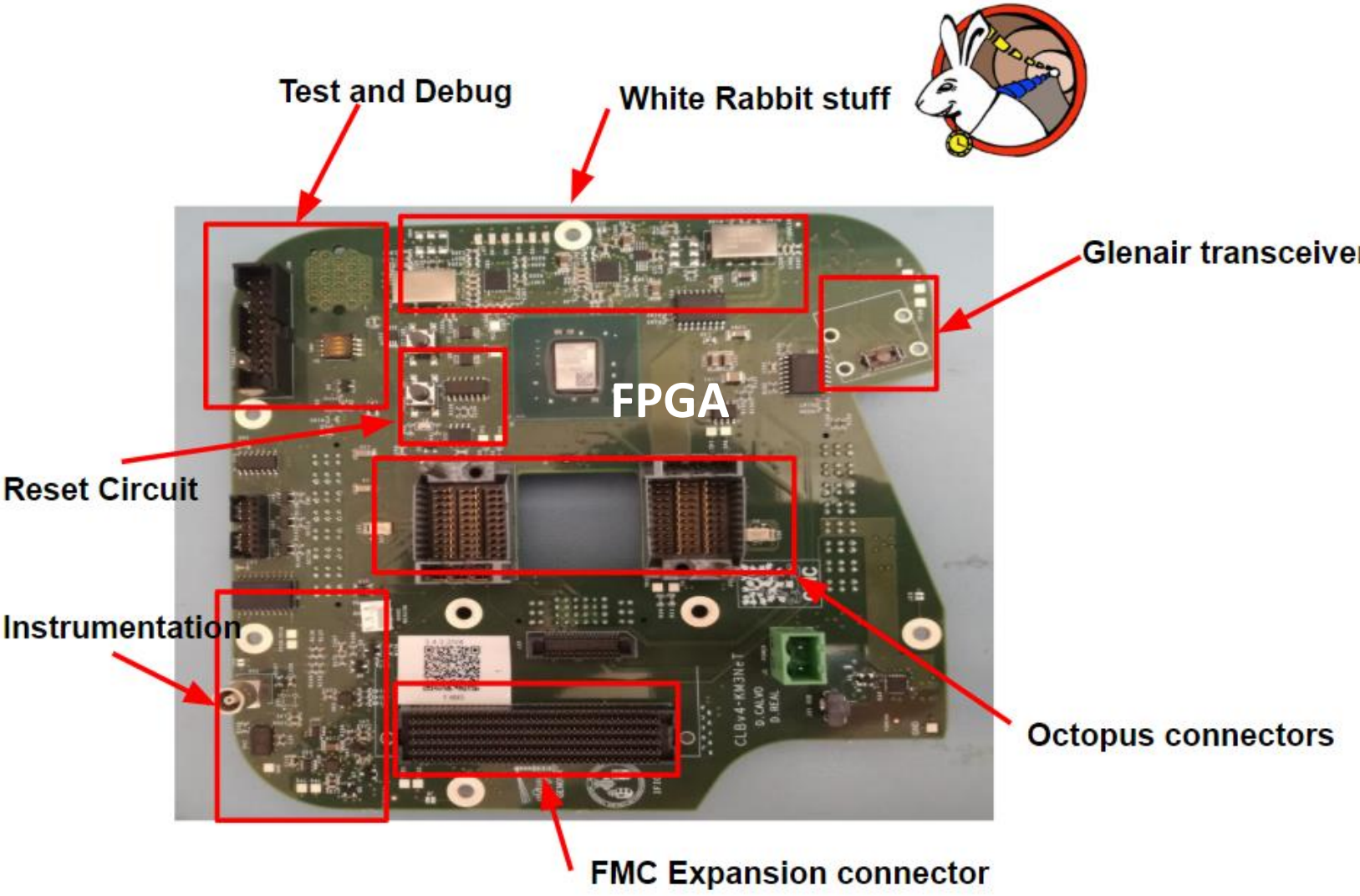








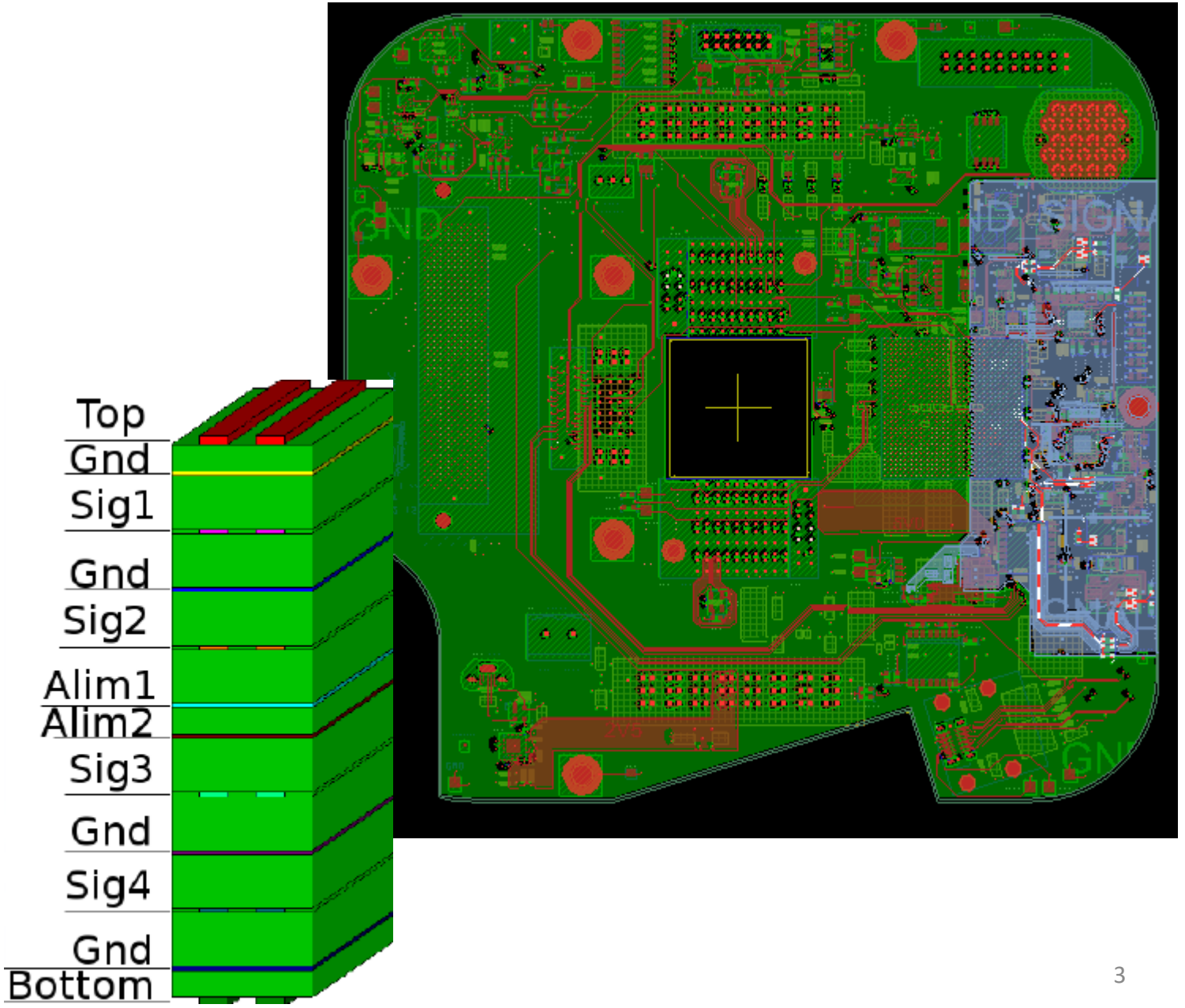
CLBv4



- **Two Flash memories** (Previous version only one. Now logout separated from FPGA image)
- **New** Glenair optical **transceiver with better reliability**
- **New sensors**: Gyroscope, accelerometer, compass and pressure
- **Hardware Watchdog and new reset scheme**
- **Several clock schemes** to evaluate the best solution for WR from the point of view of stability and phase noise:
  - Crystek (125 MHz and 124.99 MHz)
  - 25 MHz connected to clock generators
  - Possibility to evaluate other clocks like ABLNO

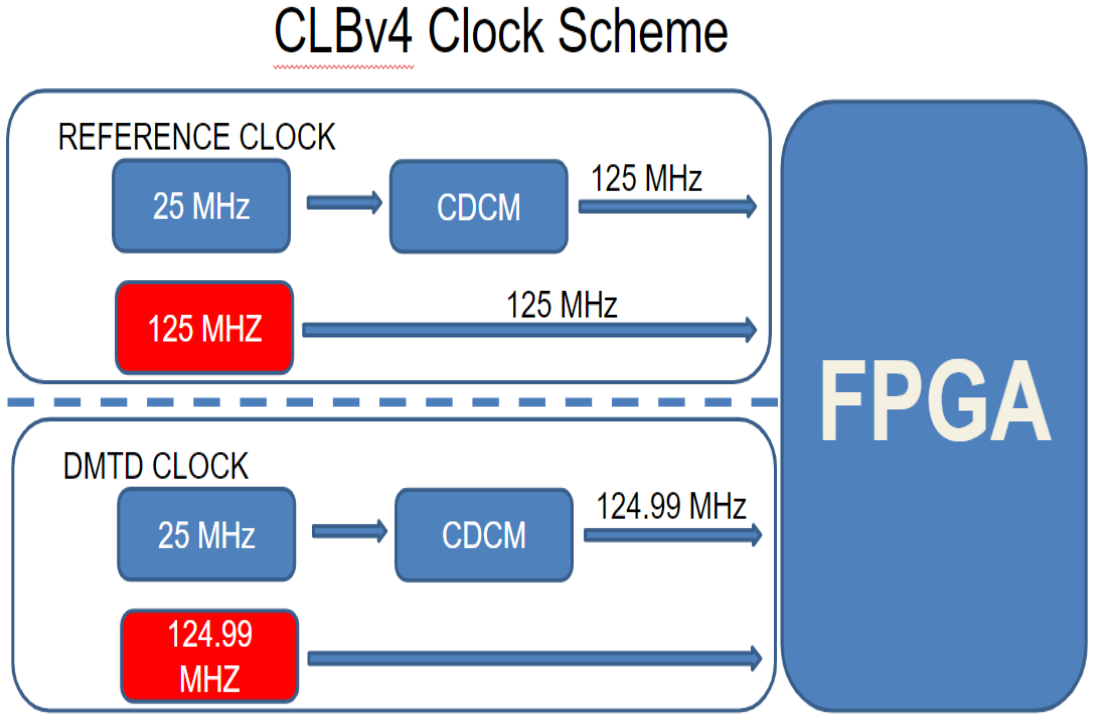
CLBv4: layout

- **12 layers**: 2 for power , 4 signals and 4 ground planes
- **More than 200 new components w.r.t. to previous version**
- Improved the placement of the synchronization components
- Improved the routing and grounds to avoid noise
- **Prototypes produced and under tests**

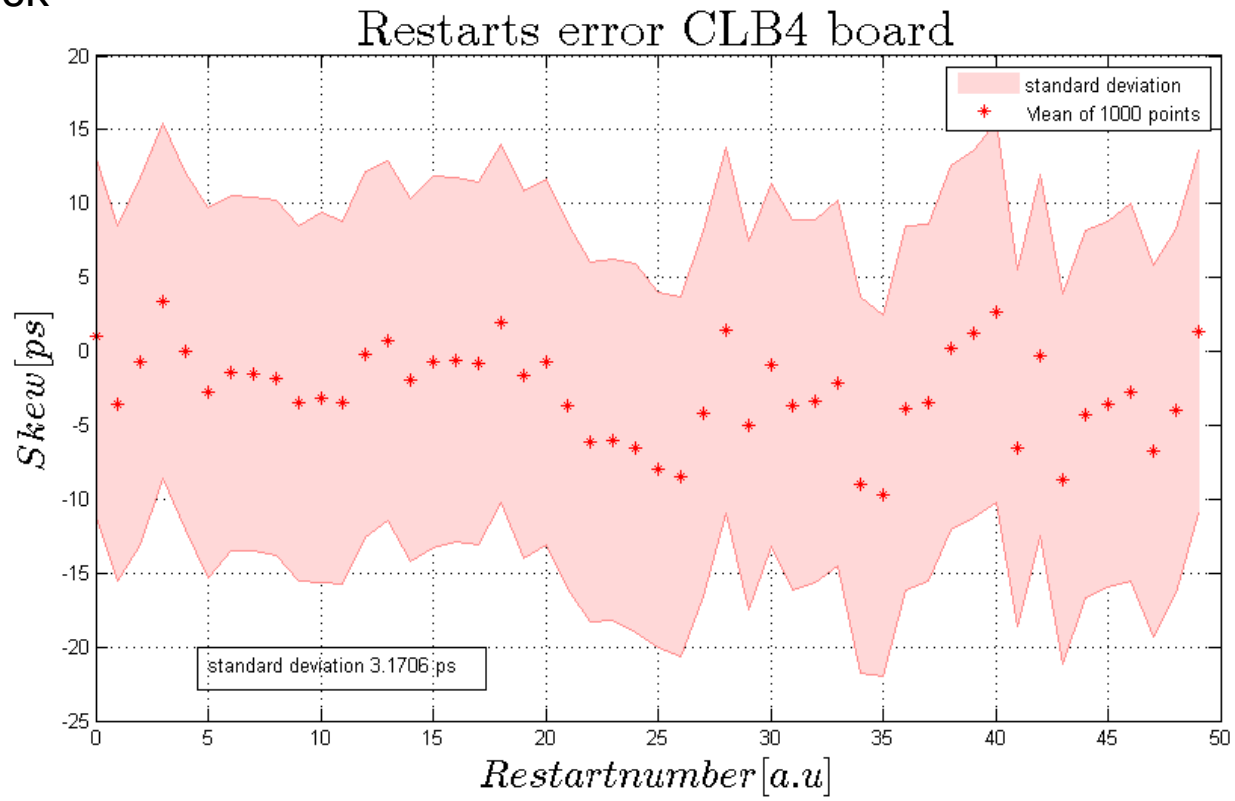


White Rabbit clock

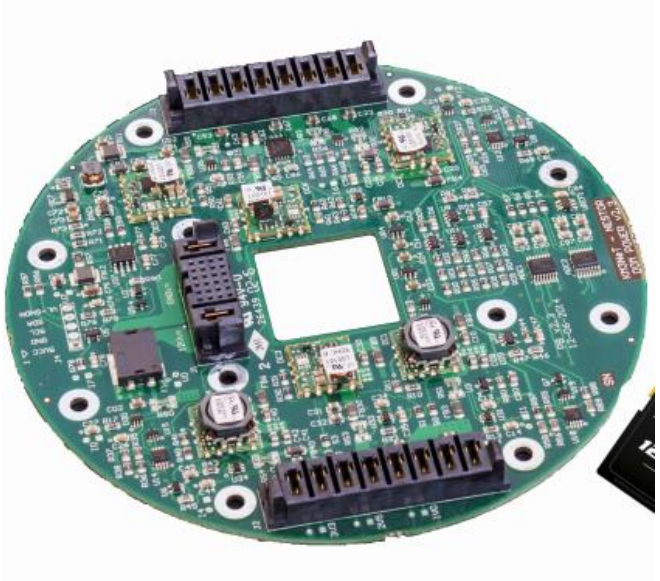
- White Rabbit → two clocks to provide the synchroniation
- CLBv4 → two different clock systems (red and blue)
- The output (FPGA input) are the same:
  - 125 MHZ (from 25 MHz to 125 with a Digital Clock Manager (CDCM))
  - 124.922 MHz



- **Jitter (skew) of one WR reference clock with respect the CLB clock**
- To do the measurement the PPS (pulse per second) signal of the CLB is compared with the PPS of a reference WR switch.
- The test includes the restart of the CLB (to see if after the restart the CLB synchornizes again)



Power board



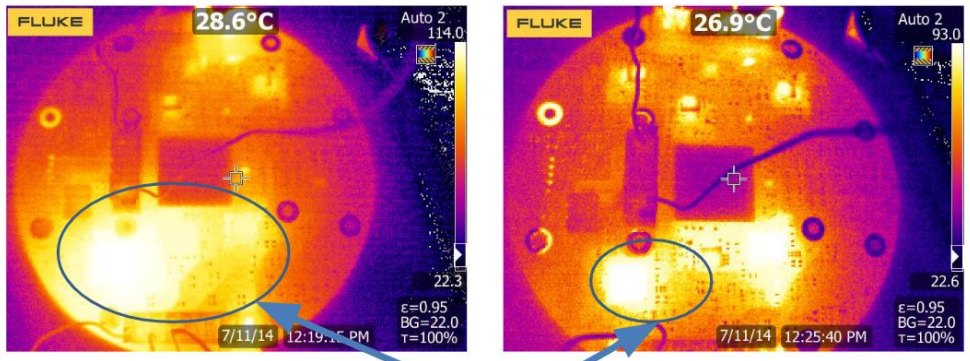
PBv2

PBv3 DC-DC efficiency

	Volt (V)	Current (A)	Efficiency PB_V2.3 (%)	Total DOM Power V_2.3 (W)	Efficiency PB_V3 (%)	Total DOM Power V_3 (W)
FPGA	1	0.13	80	~7 W	80	~6 W
	1.8	0.33	80		80	
	2.5	0.33	60		78	
	3.3	0.81	65		90	
	3.3 PMTS	0.46	90		90	
Piezo	5	0.10	60		90	

PBv3

Saving ~10-15%



KM3NeT

- FIT → faiure rate per billion hours
- FIDES

PB V2.3

Total FIT:	**947,47**
MTTF (hours)	1055436,89
MTTF (years)	120,48
Board quantity:	635

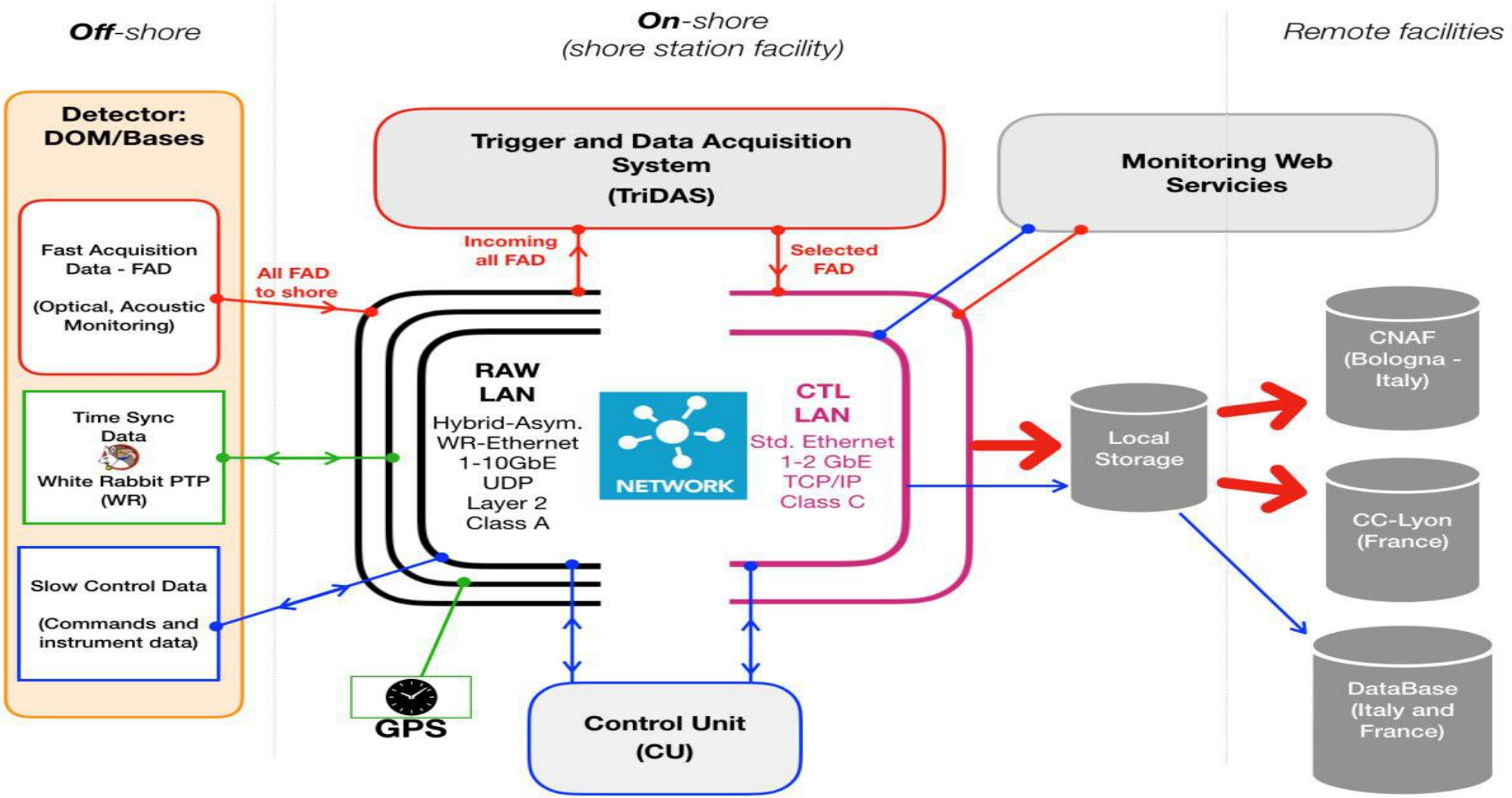
Mission (year)	Duration (hours)	Failure risk (%)	Board failures
1	8760	0,83	5,25
2	17520	1,65	10,45
5	43800	4,07	25,81
10	**87600**	**7,96**	**50,58**
15	131400	11,71	74,33
20	175200	15,30	97,12

PB V3

Total FIT:	**783,53**
MTTF (hours)	1277139,21
MTTF (years)	145,79
Board quantity:	635

Mission (year)	Duration (hours)	Failure risk (%)	Board failures
1	8760	0,68	4,34
2	17520	1,36	8,65
5	43800	3,37	21,41
10	**87600**	**6,63**	**42,09**
15	131400	9,78	62,08
20	175200	12,82	81,40

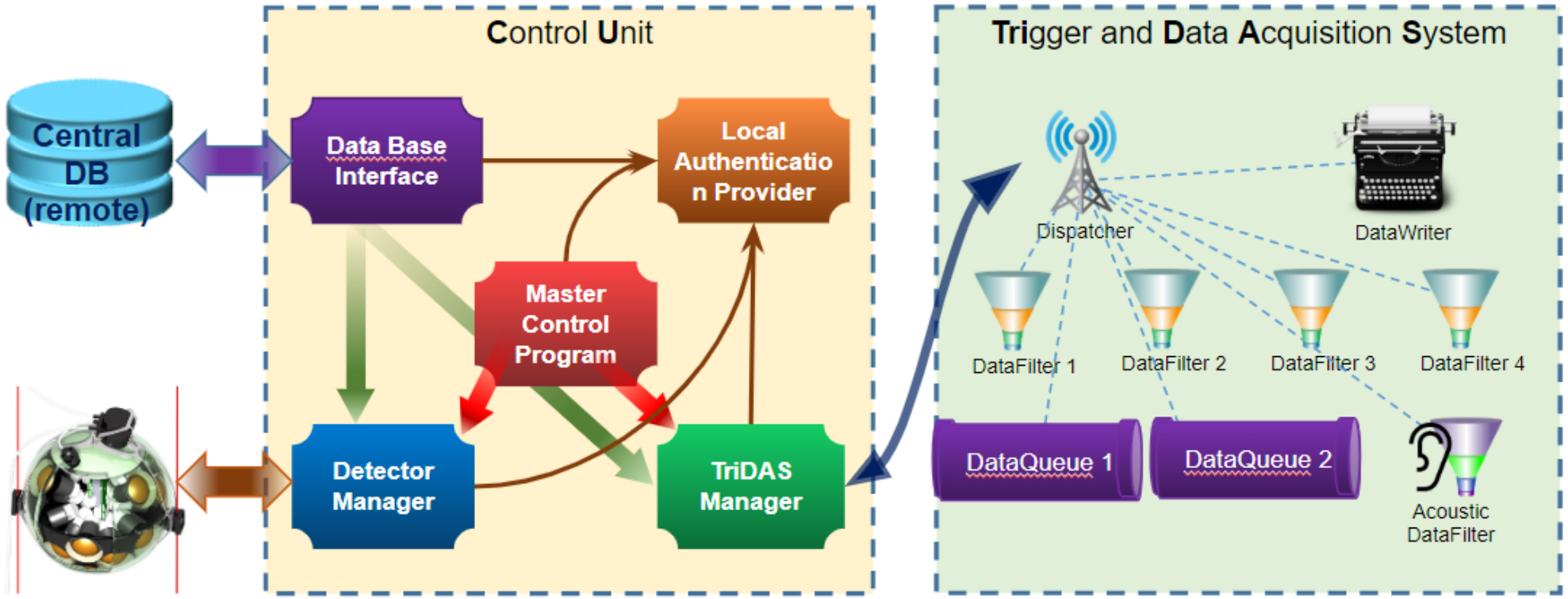
DAQ


Off-shore
On-shore
(shore station facility)
Remote facilities
Detector:
DOM/Bases
Fast Acquisition
Data - FAD
(Optical, Acoustic
Monitoring)
Time Sync
Data
White Rabbit PTP
(WR)
Slow Control Data
(Commands and
instrument data)
All FAD
to shore
Trigger and Data Acquisition
System
(TriDAS)
Incoming
all FAD
Selected
FAD
Monitoring Web
Servicies
RAW
LAN
Hybrid-Asym.
WR-Ethernet
1-10GbE
UDP
Layer 2
Class A
NETWORK
CTL
LAN
Std. Ethernet
1-2 GbE
TCP/IP
Class C
Local
Storage
CNAF
(Bologna -
Italy)
CC-Lyon
(France)
DataBase
(Italy and
France)
GPS
Control Unit
(CU)

CU - TriDAS

Control Unit and TriDAS

Only control-related connections shown



Modular system: Control Unit services can run/start/stop/upgrade independently of each other

Control tools

Control Unit: Detector Manager

Detector Manager

Monitors each CLB and linked PMTs individually and asynchronously

Applies operational parameters (HV, threshold, instrument setups)

Logs slow control data (power, temperature, humidity, compass, acceleration, etc.) to *Datalog* files for upload to the central DB and in a Virtual Directory structure accessible via HTTP

`/mon/clb/outparams/temp/3/12`

Recovering single DOMs does not require
acquisition stop/restart

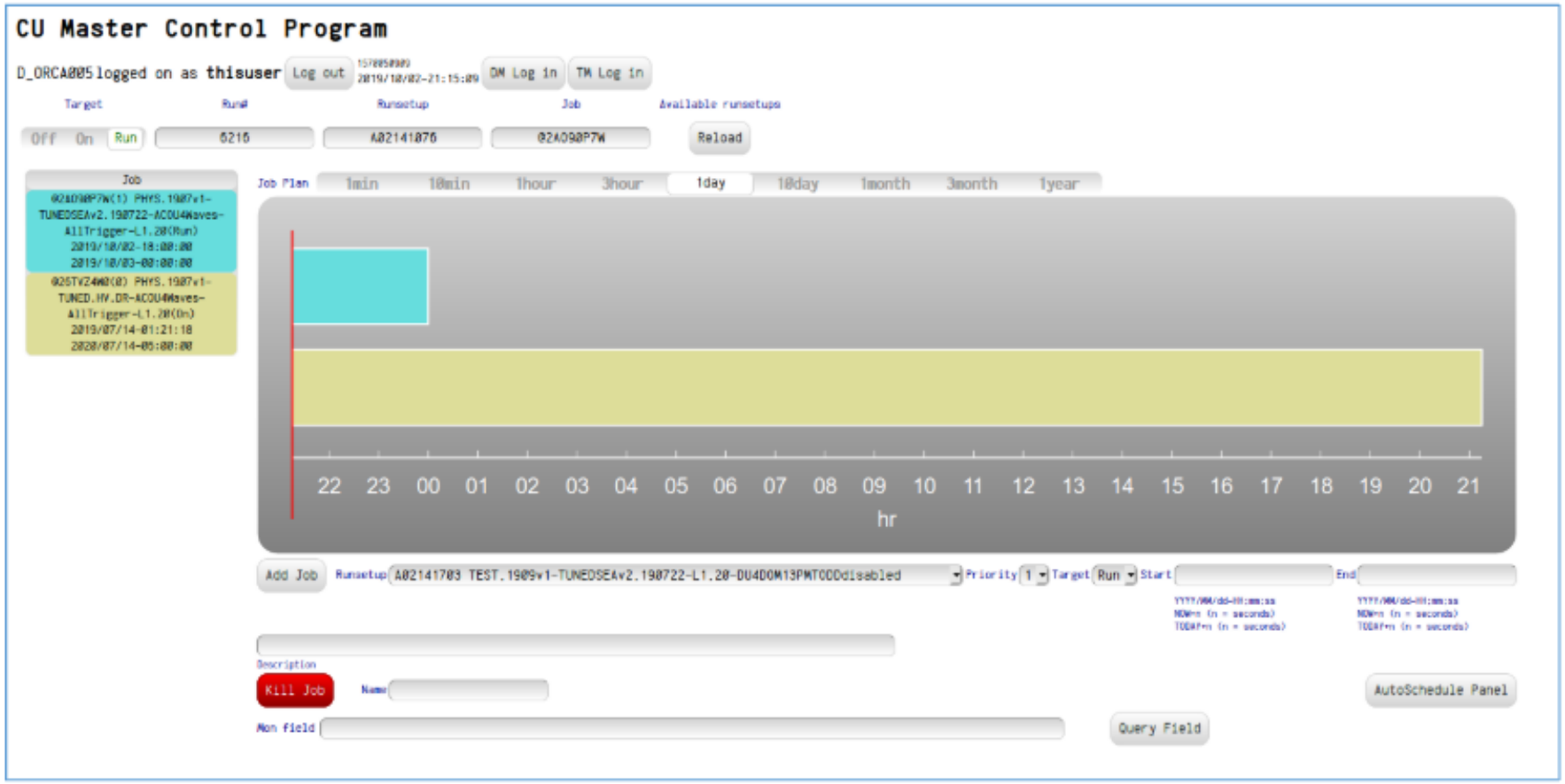
Control tools

Control Unit: Master Control Program

MCP GUI shows the current status

Jobs can be automatically scheduled

Manual addition and removal of jobs is allowed



Control tools

Control Unit: TriDAS Manager

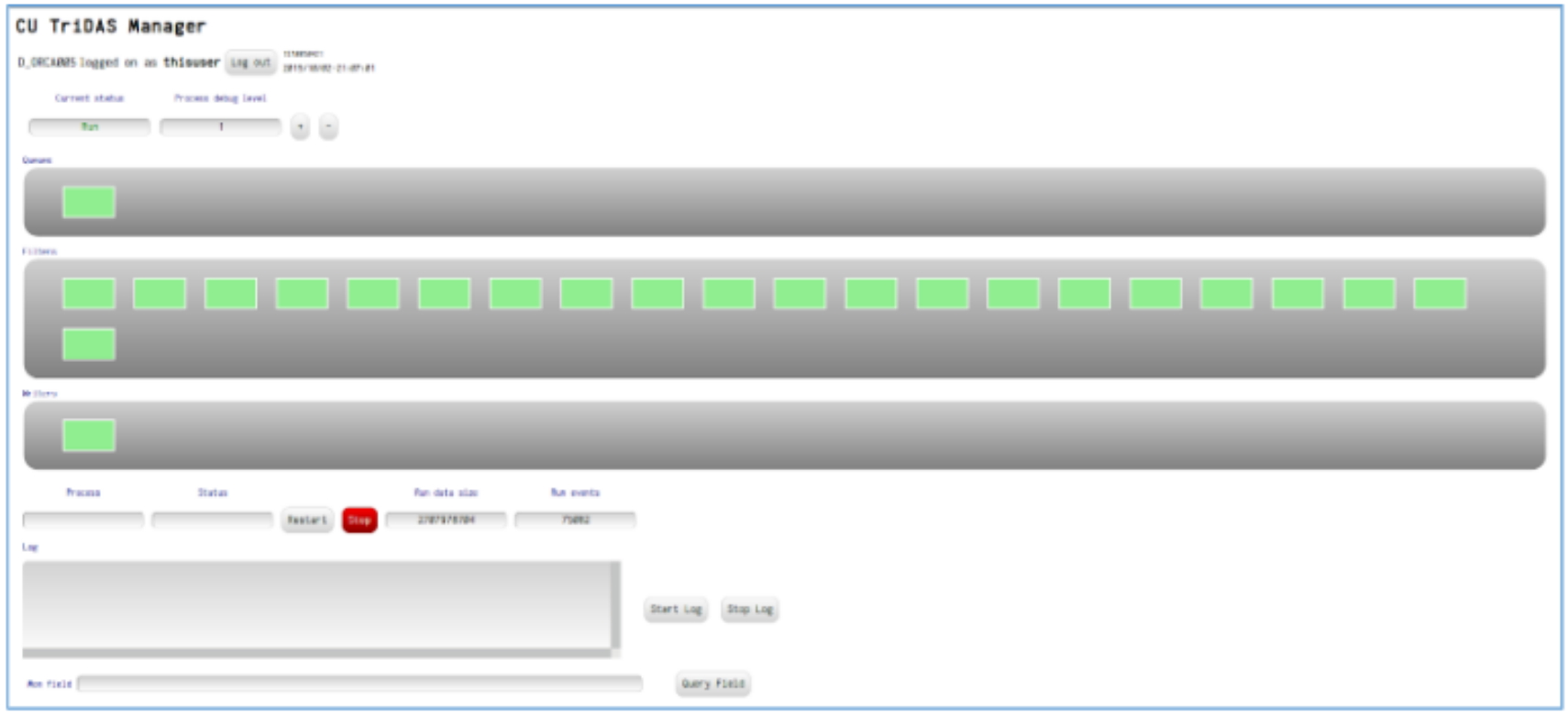
TriDAS Manager

Controls all processes via the ControlHost protocol and a Dispatcher

Logs control messages and action taken

Monitors data acquisition progress

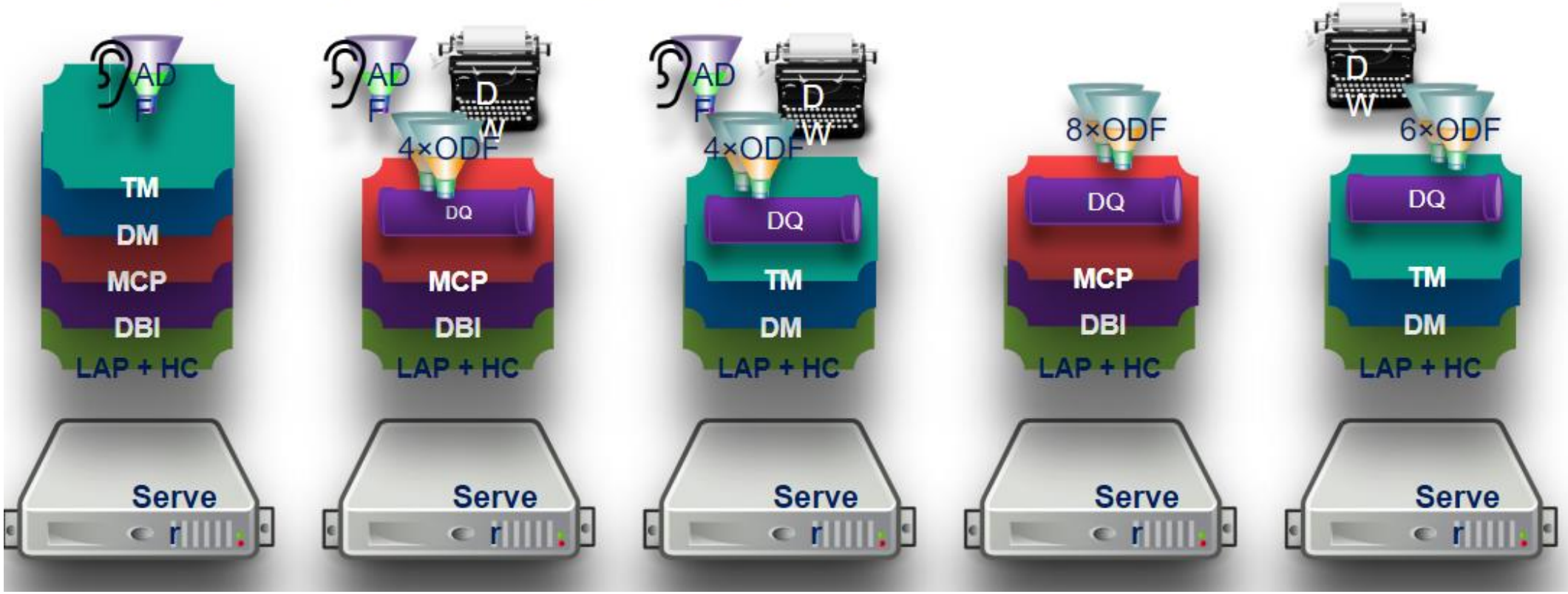
Provides Virtual Directory for monitoring



Control tools

Control Unit: LAP & Dynamic Resource Provisioning

Example of multiple-fault tolerant setup - removing any two servers will still leave all functions covered



Conclusions

- First DUs already working both in ARCA and ORCA
- Improved reliability for both the CLB and the PB
- Excellent synchronization with the WR system
- Hight reliability in the software to handle the infrastructure elements

Thank you

Control Unit: Data Base Interface

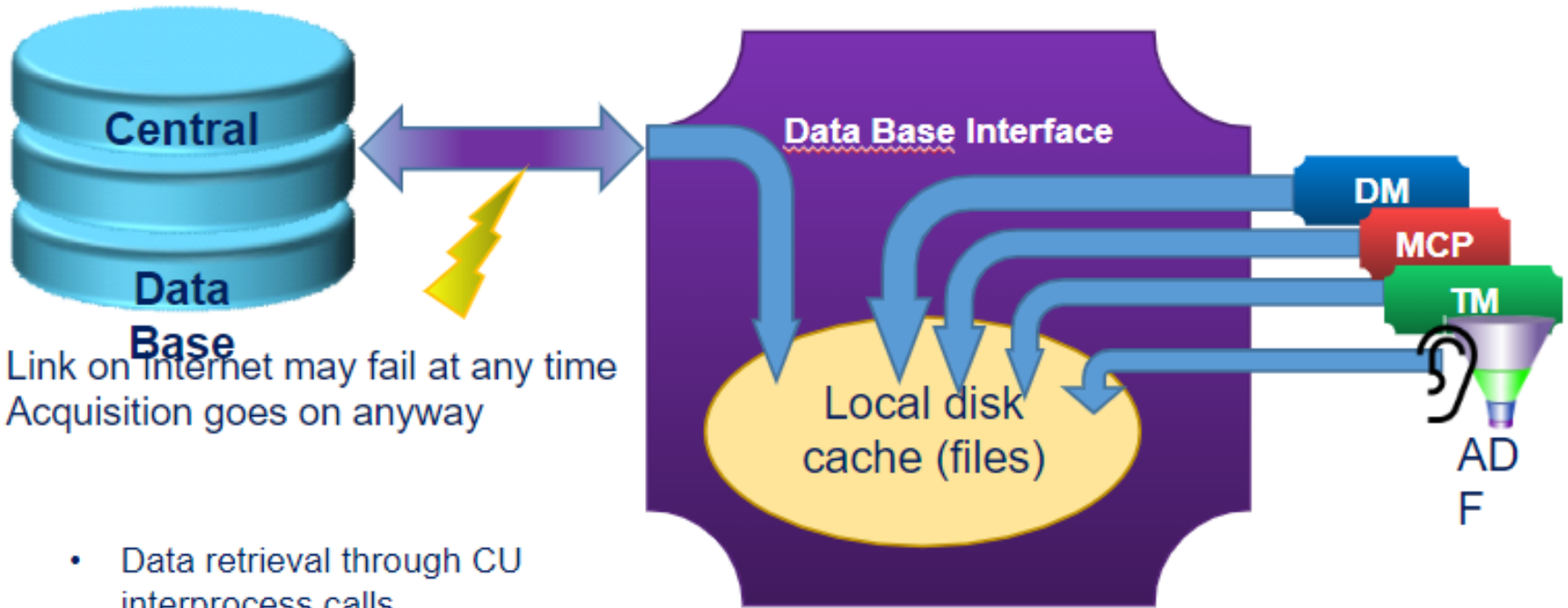
Data Base Interface

Data to be written to the DB are staged in the local cache
Writes are retried in case of link failure

- MCP jobs and runs
- DM detector monitoring and detector definition changes
- TM TriDAS monitoring and detector definition changes
- ADF Time of Arrival of acoustic signals for positioning
- LAP dynamic provisioning and failover actions (see next slides)

CU and TriDAS programs write directly to the stage directory

- Allows easy retrieval of data from the central Data Base
- All data relevant to detector operation are synchronized to a local cache that stores XML files



Link on Internet may fail at any time
Acquisition goes on anyway

- Data retrieval through CU interprocess calls
- DBI also notifies MCP of availability of new data

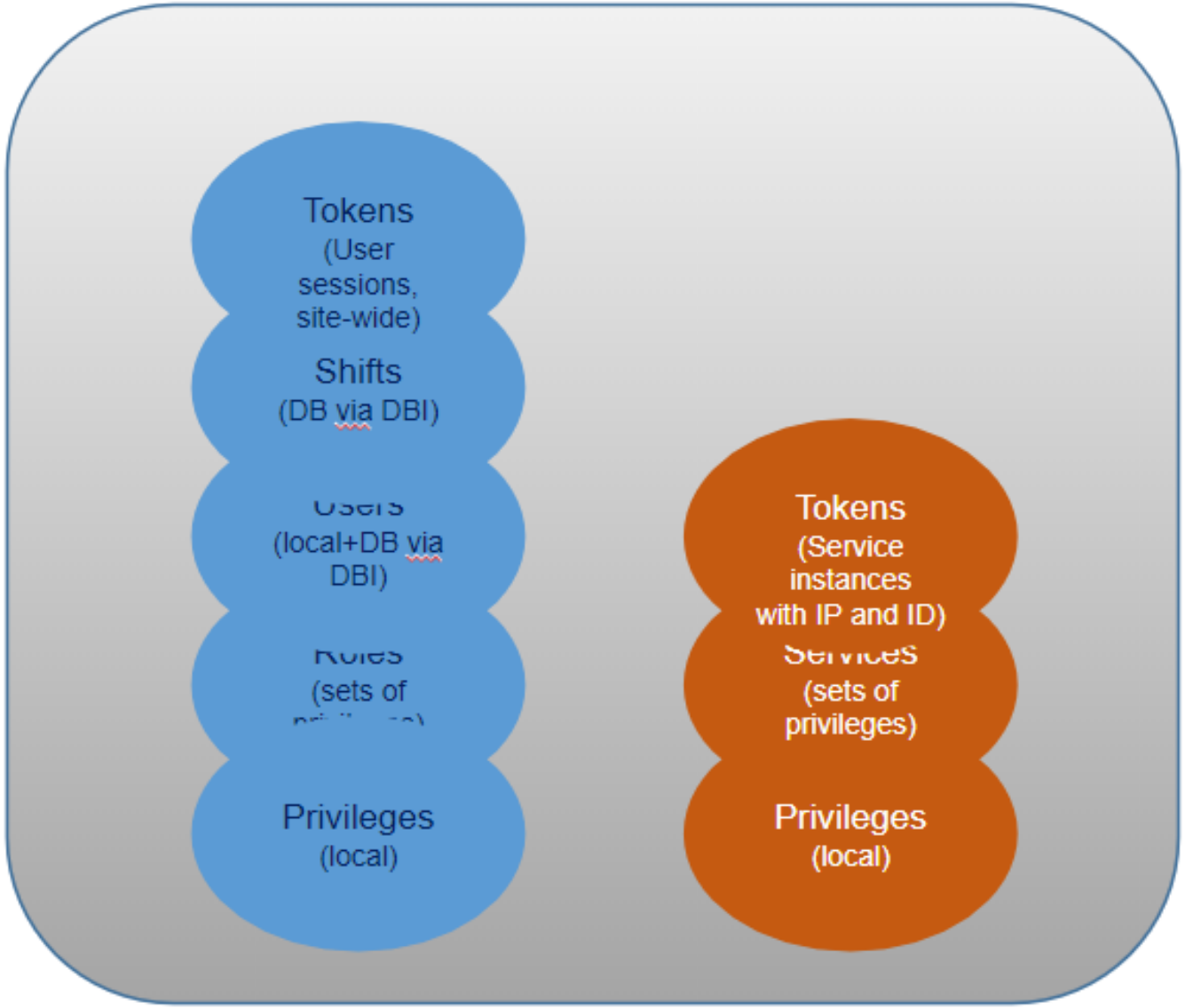
Control Unit: Local Authentication Provider

Local Authentication Provider

Cached and encrypted mirror of database user/password credentials

User privileges synchronized with data acquisition shifts

CU and TriDAS service allocation to the various servers is handled as login tokens



Moving a service to another machine is as simple as logging on

Token = set of privileges as a snapshot of the user account taken at a certain time

Control Unit: LAP & Dynamic Resource Provisioning

Full DAQ infrastructure for KM3NeT → many machines, hundreds of cores, tens of network interface cards - highly redundant

Machine replacement/insertion → system reconfiguration

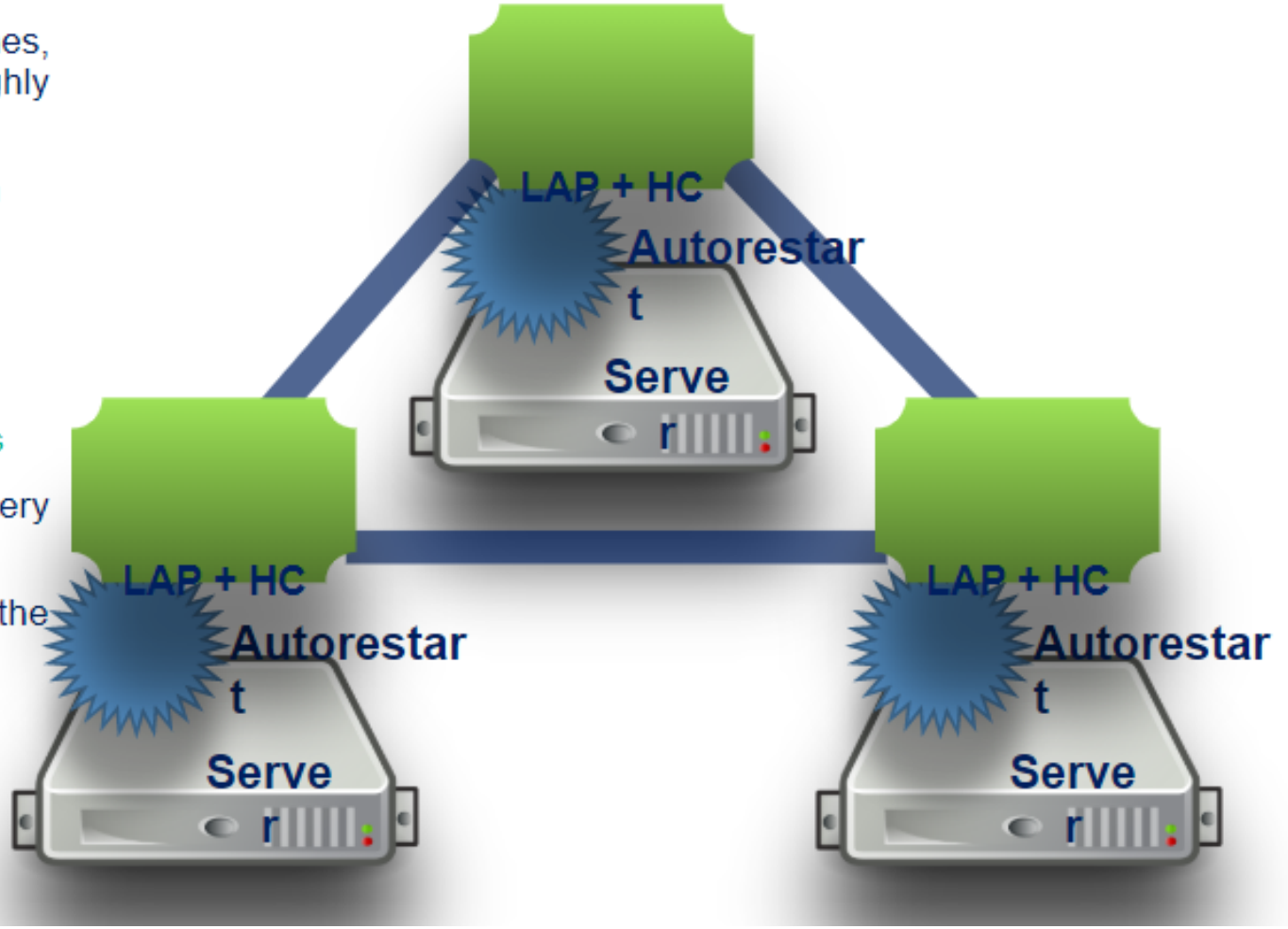
Impact of hardware failures

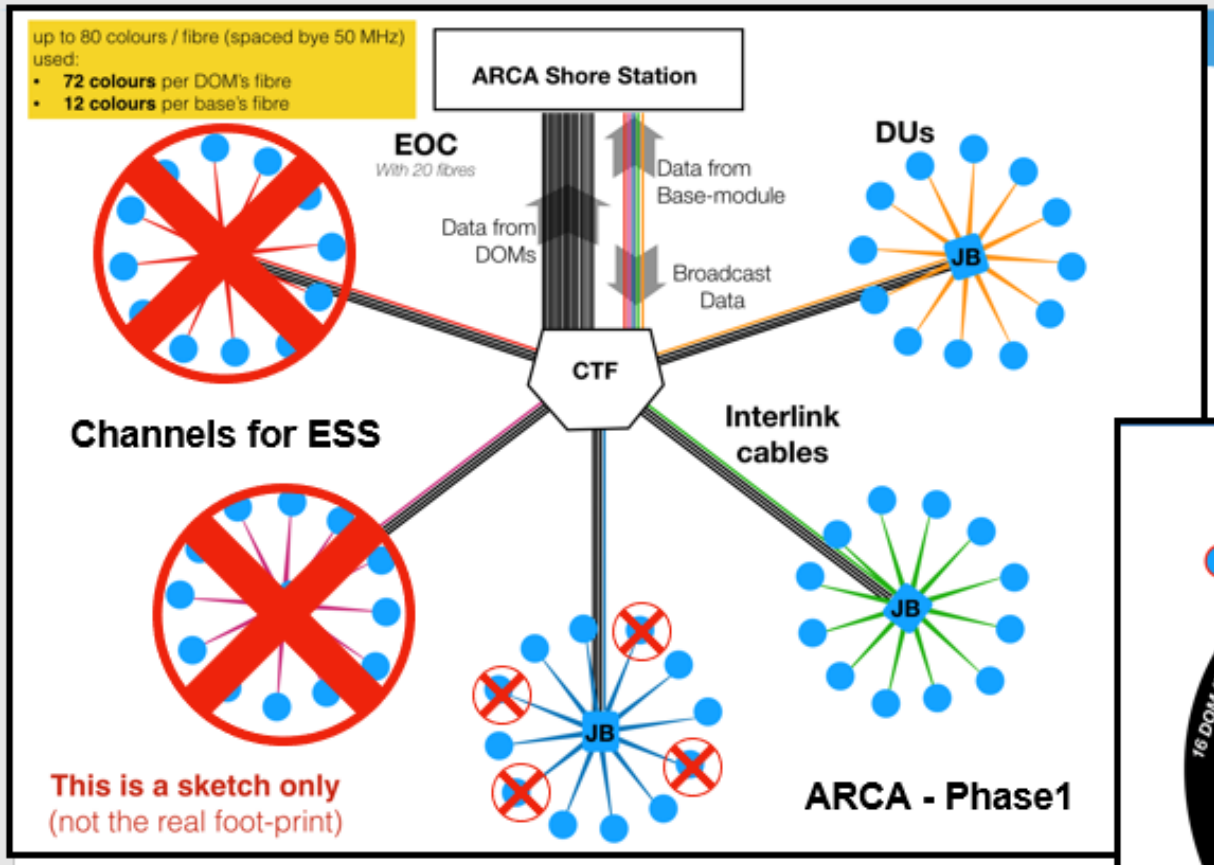
- Failure of processing machines → partial data loss
- Failure of control machines → operation stop (total data loss)
- The system has enough resources to work in sub-optimal configurations

A **H**ealth **C**hecker (HC) function is added to LAPs, polled every few seconds

Failure to answer or returning an exception would set the machine offline:

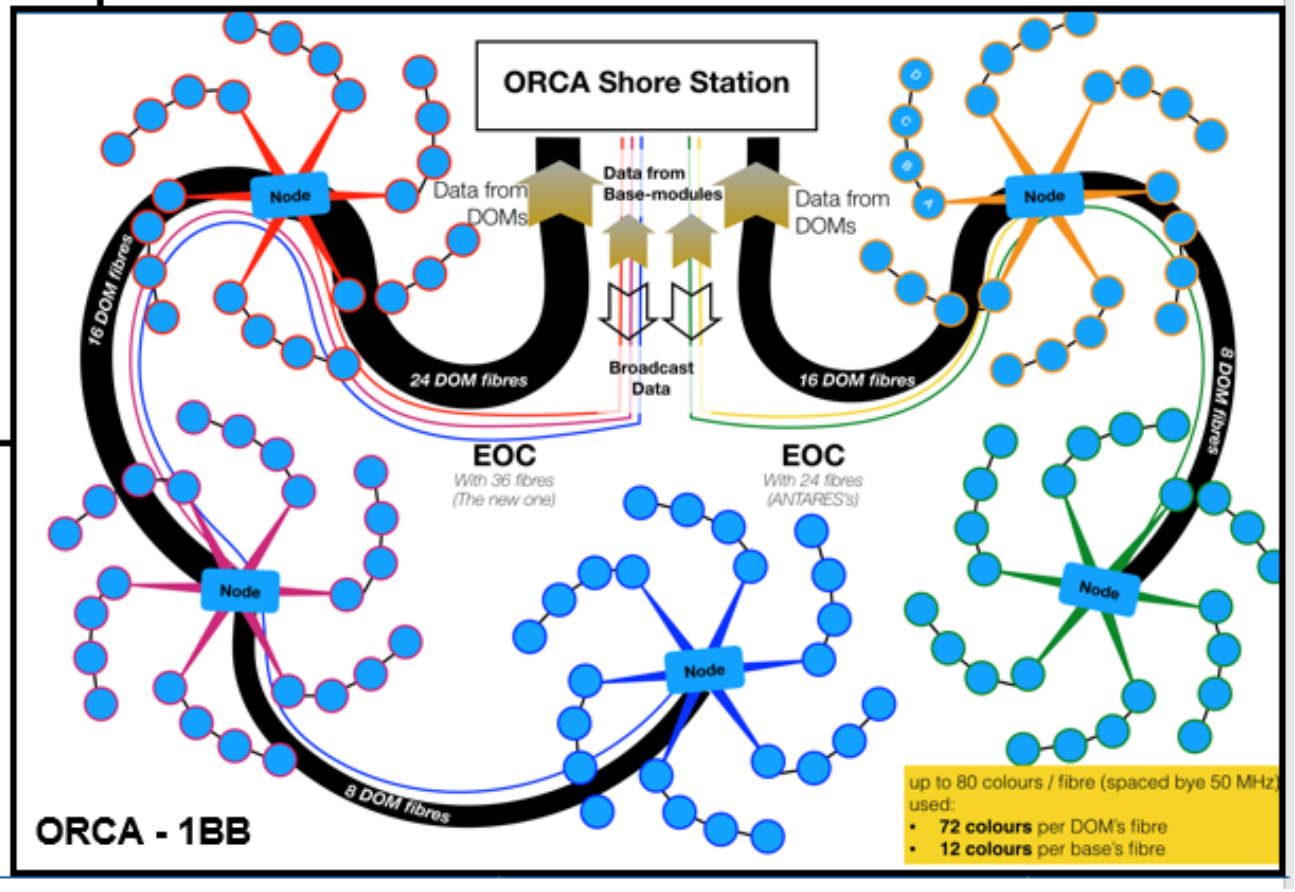
- peer servers know it failed
- failed machine, if still running, knows it's not operational
- the system reconfigures without the need for administrator intervention





ARCA Phase1 CTF: only 3 over 5 sockets are usable
⟹3x4 = 12 fibers ⟹ in principle max 36 DUs,
Only **32 are actually possible for power budget :**

- JB1: 8 DUs
- JB2: 12 DUs
- JB3: 12 DUs



NEUTRINO ASTRONOMY