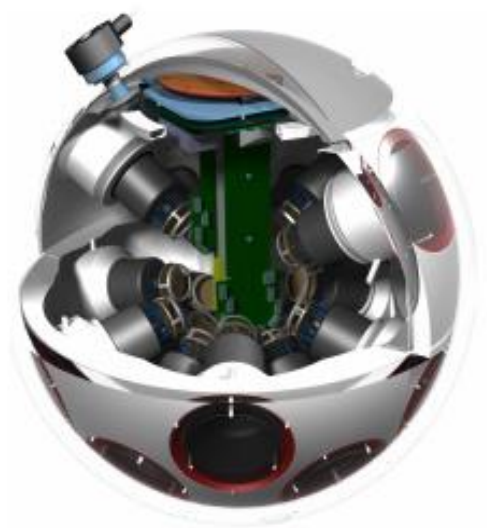
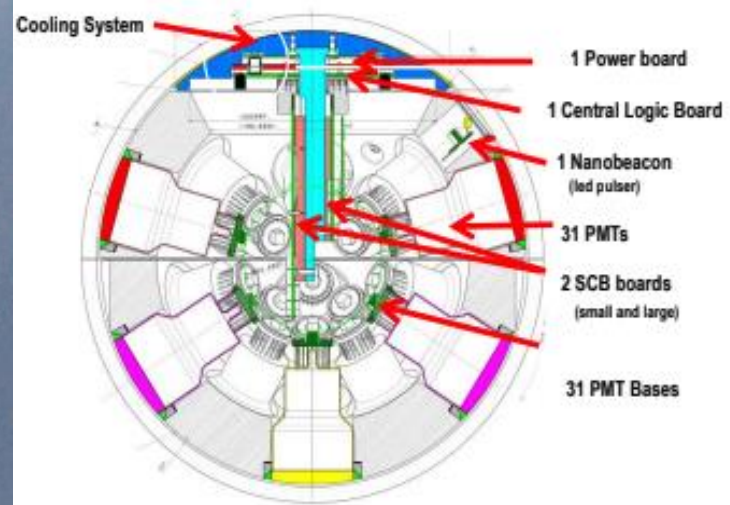
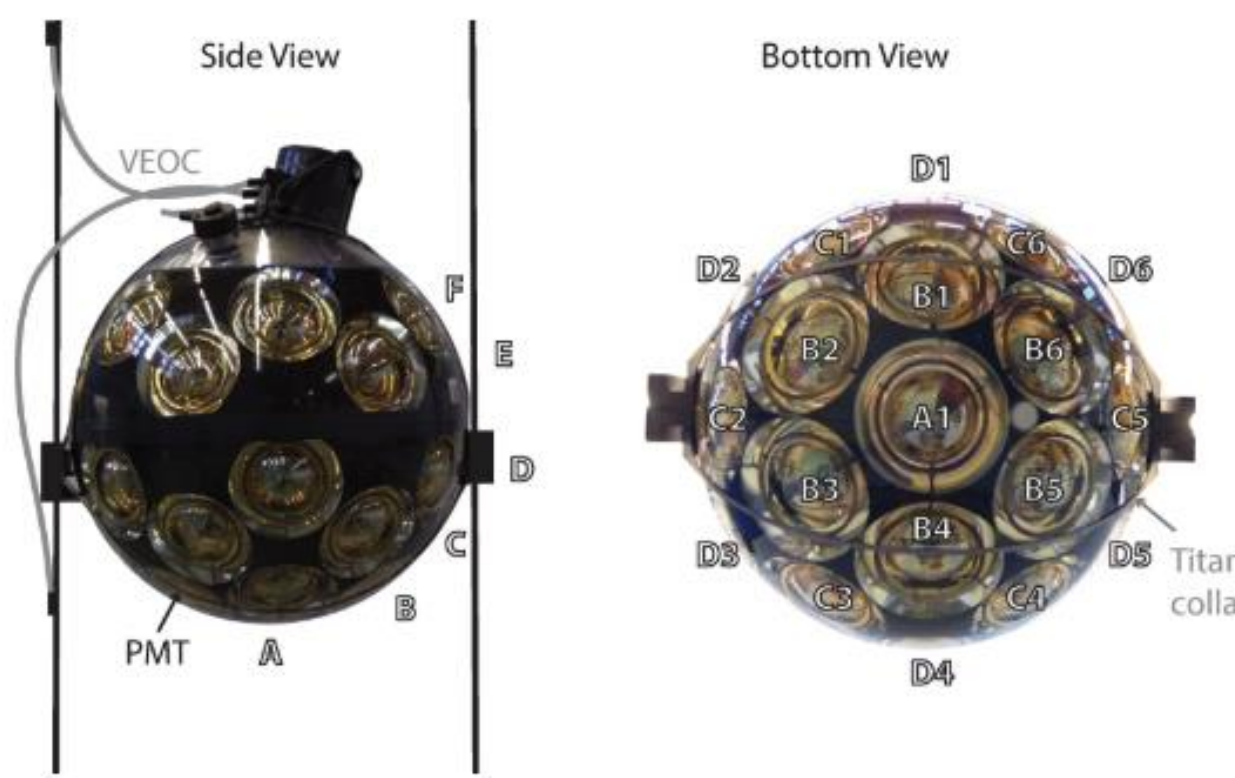


# **KM3NeT electronics acquisition:** **the new version of the Central Logic Board and** **its related Power Board**

**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**

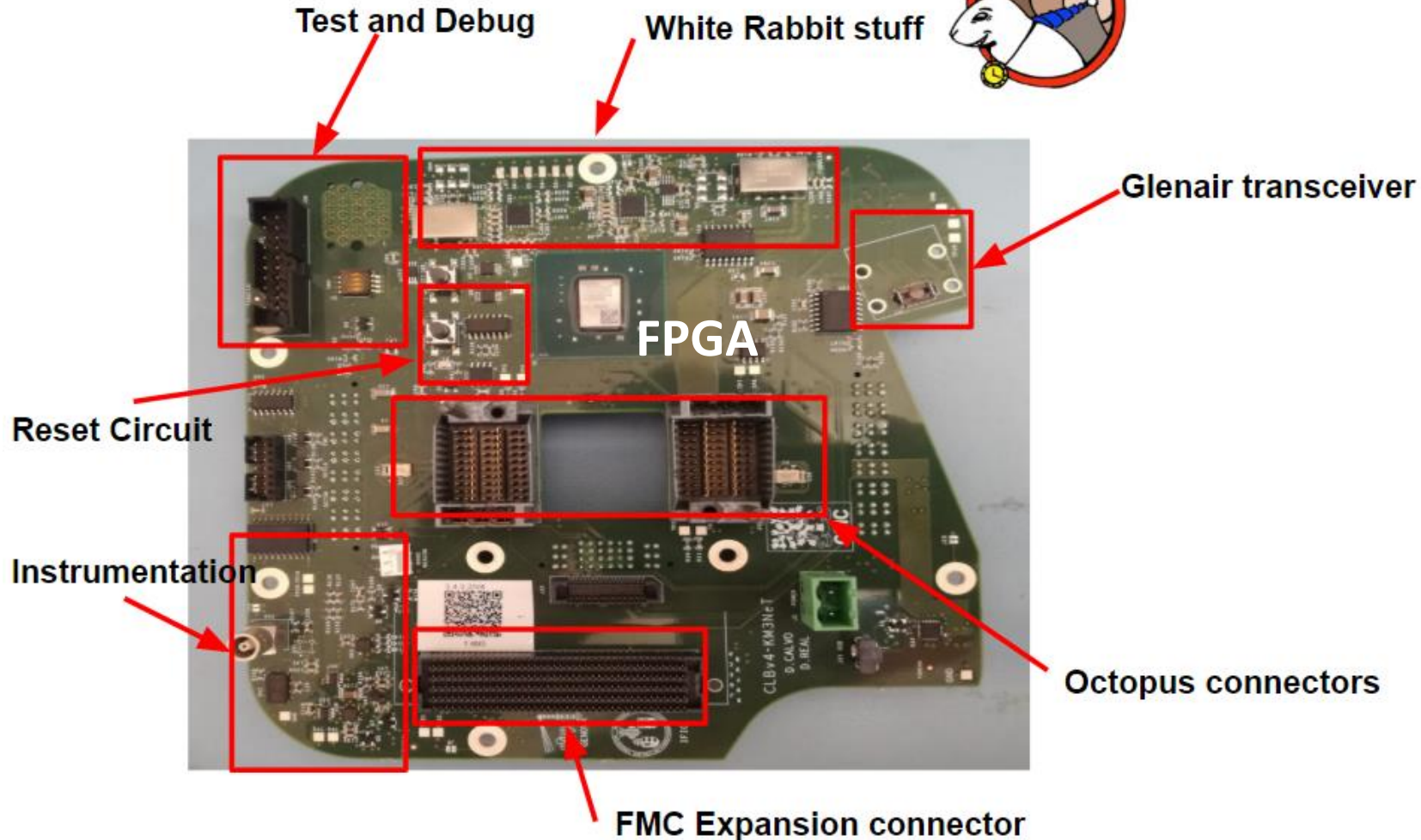
# KM3NeT and the DOM

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





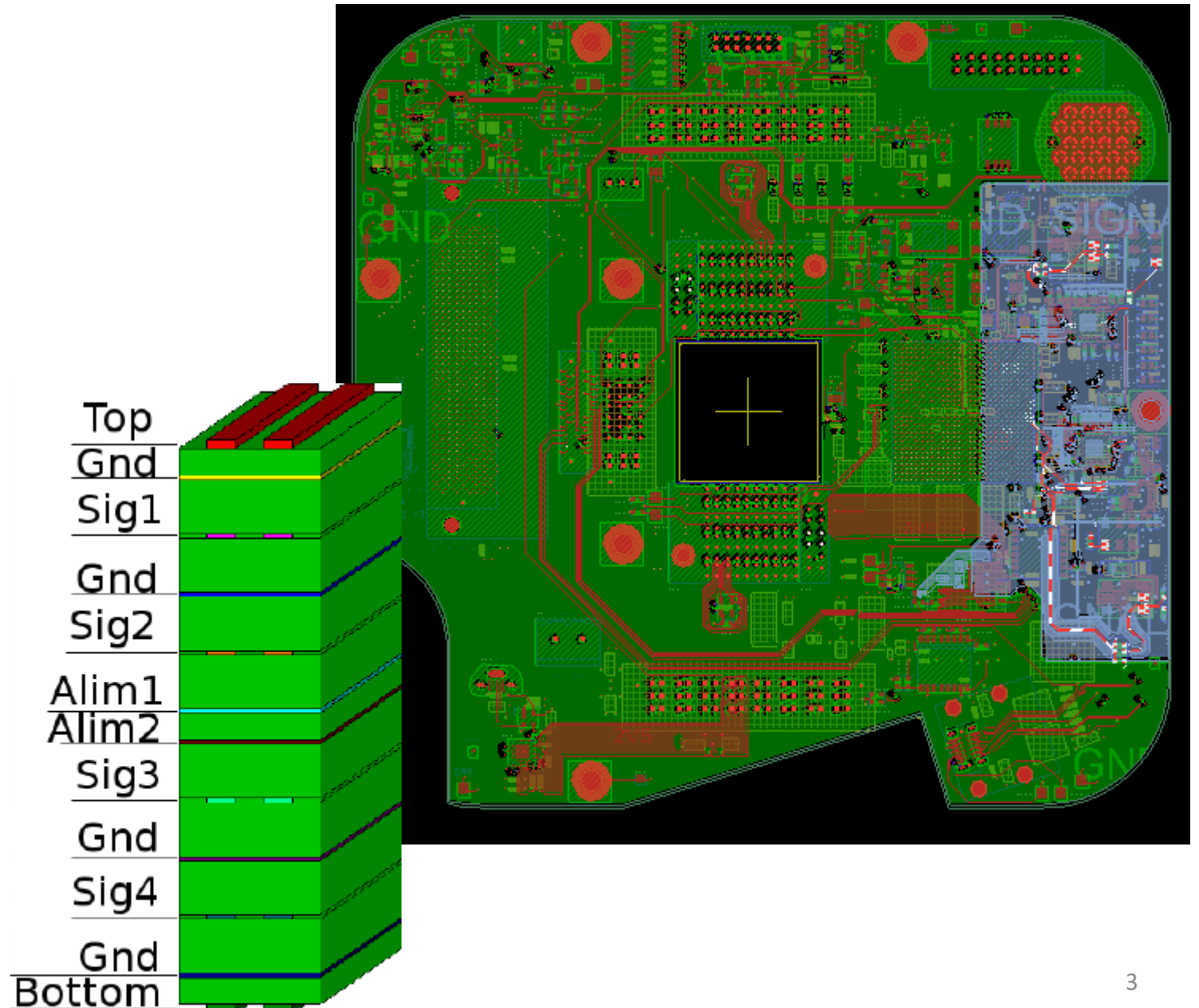
# CLBv4



- **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

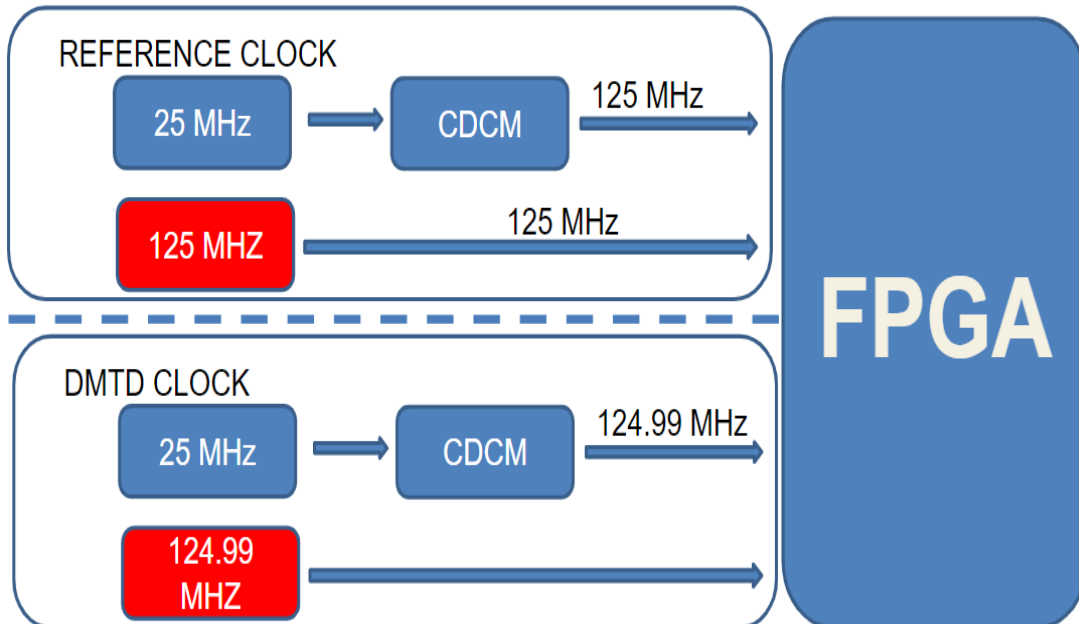
- **12 layers:** 2 for power , 4 signals and 4 ground planes
- **More than 200 new components w.r.t. to previous version**
- Improved the placement of the synchronization components
- Improved the routing and grounds to avoid noise
- **Prototypes produced and under tests**



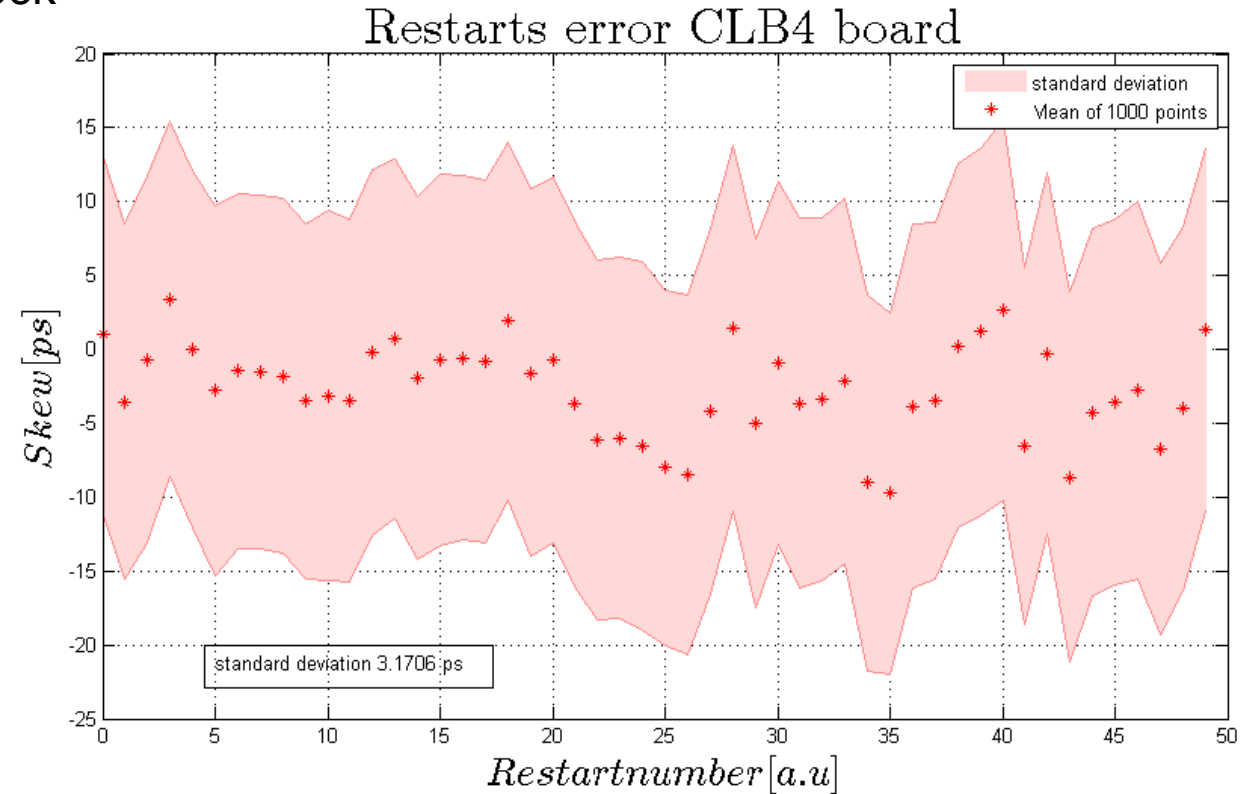
# White Rabbit clock

- White Rabbit → two clocks to provide the synchronisation
- 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

## CLBv4 Clock Scheme



- **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 synchronizes again)





# Power board

## PBv3 DC-DC efficiency



PBv2

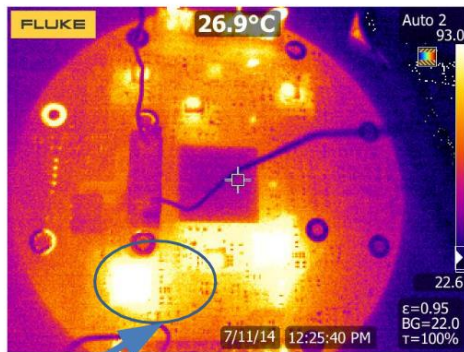
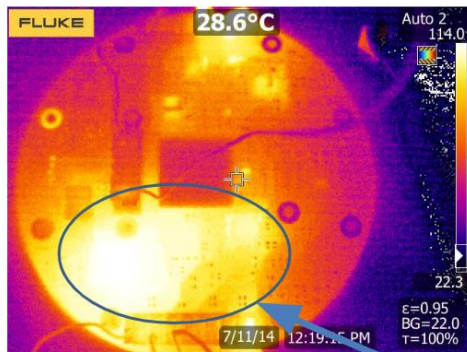
PBv3

FPGA

Piezo

Volt (V)	Current (A)	Efficiency PB_V2.3 (%)	Total DOM Power V_2.3 (W)	Efficiency PB_V3 (%)	Total DOM Power V_3 (W)
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	
5	0.10	60		90	

**Saving  
~10-15%**



3.3 V

# KM3Net

- FIT → failure rate per billion hours
- FIDES

## PB V2.3

<b>Total FIT:</b>	<b>947,47</b>
MTTF (hours)	1055436,89
MTTF (years)	120,48
Board quantity:	635

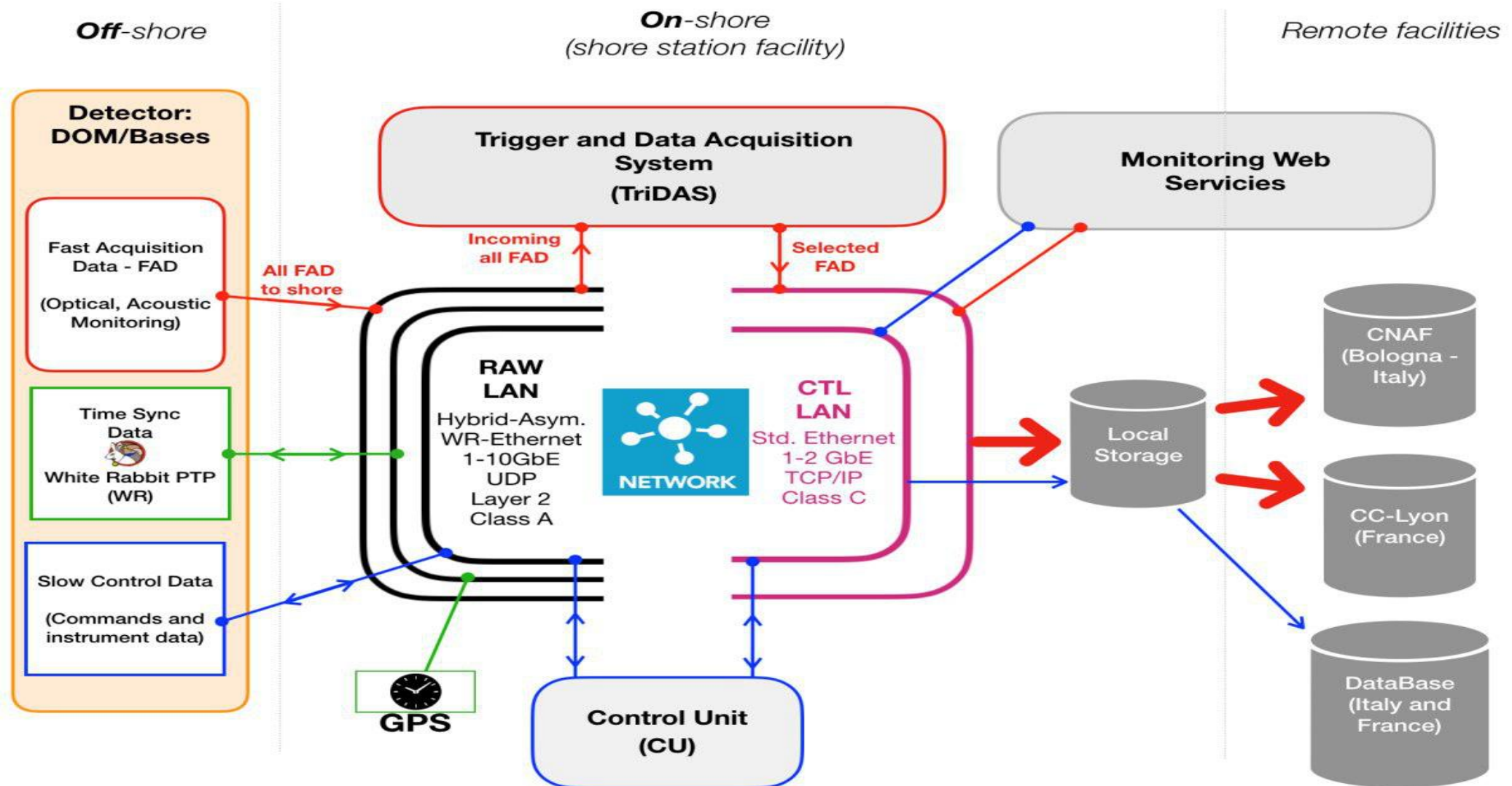
Mission (year)	Duration (hours)	Failure risk (%)	Board failures
1	8760	0,83	5,25
2	17520	1,65	10,45
5	43800	4,07	25,81
<b>10</b>	<b>87600</b>	<b>7,96</b>	<b>50,58</b>
15	131400	11,71	74,33
20	175200	15,30	97,12

## PB V3

<b>Total FIT:</b>	<b>783,53</b>
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
<b>10</b>	<b>87600</b>	<b>6,63</b>	<b>42,09</b>
15	131400	9,78	62,08
20	175200	12,82	81,40

# DAQ

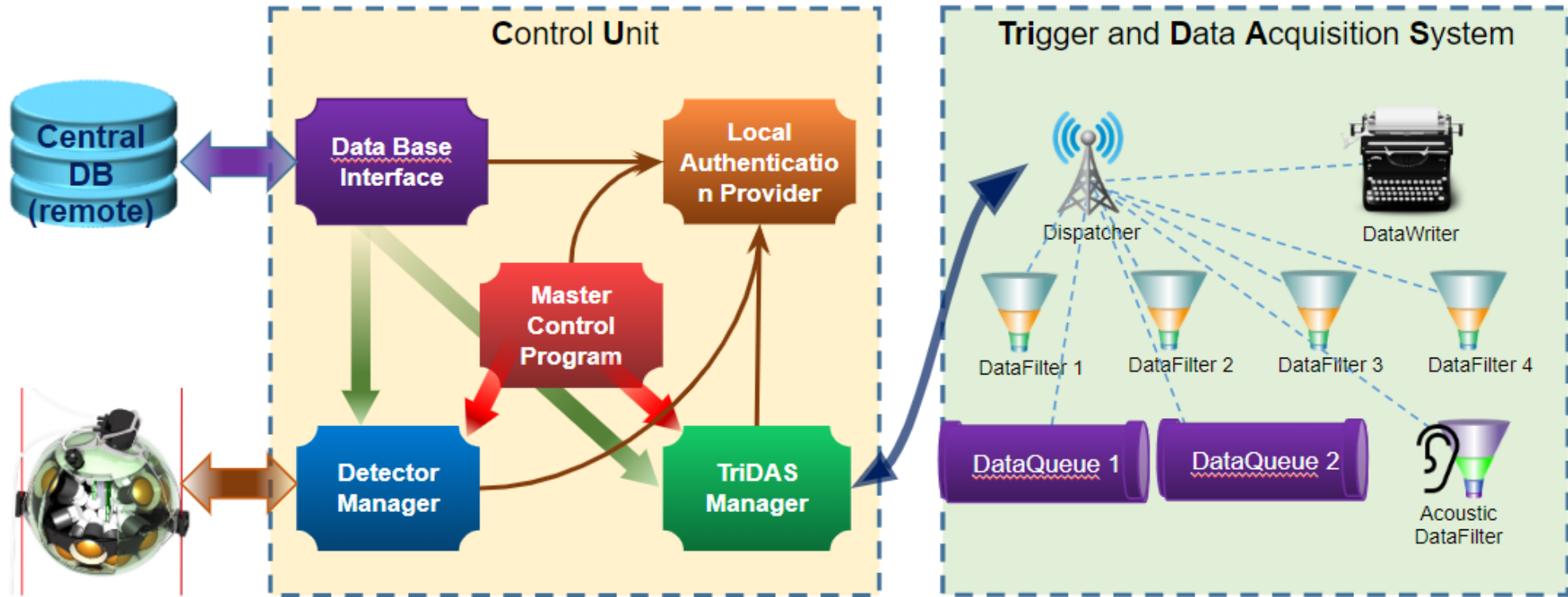




# CU - TriDAS

## 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

The image shows a screenshot of the 'CU Detector Manager' web interface. At the top, it displays the user 'D\_ORCARRIS logged on as cbozza' with a 'Log out' button and the date '2012/07/04-21:47:40'. Below this, the 'Current status' is 'Run' and the 'Current run number' is '5457'. There are buttons for 'Run' and 'Ping'. The main area shows five vertical columns of detector status indicators, numbered 1 to 5. Column 1 has two black indicators, column 2 has two green indicators, column 3 has a black indicator at the top and green ones below, column 4 has all green indicators, and column 5 has a black indicator at the bottom and green ones above. An inset window titled 'CLB Controller for 3.4.3.2/V2-2-1/2.571' shows two circular diagrams of detector clusters. The left cluster is labeled 'connected' and has a 'connected' status. The right cluster is also labeled 'connected'. Below these diagrams are control buttons: 'Reset SRP', 'SRP set 2P', 'Manual', 'Auto', 'Set param', 'Pause', 'Stop', 'Continue', 'Start', 'Power', 'Status', 'Stop', 'Reset', and 'Quit'. At the bottom of the inset is a table with columns for 'attach\_pathname', 'temp', 'humidity', 'voltage', and 'current' for various detector channels.

attach_pathname	temp	humidity	voltage	current
3072	1	8	4000.000000	247.38160004075
3073	1	8	4000.000000	247.38160004075
3074	1	8	4000.000000	247.38160004075
3075	1	8	4000.000000	247.38160004075
3076	1	8	4000.000000	247.38160004075
3077	1	8	4000.000000	247.38160004075
3078	1	8	4000.000000	247.38160004075
3079	1	8	4000.000000	247.38160004075
3080	1	8	4000.000000	247.38160004075
3081	1	8	4000.000000	247.38160004075
3082	1	8	4000.000000	247.38160004075
3083	1	8	4000.000000	247.38160004075
3084	1	8	4000.000000	247.38160004075
3085	1	8	4000.000000	247.38160004075
3086	1	8	4000.000000	247.38160004075
3087	1	8	4000.000000	247.38160004075
3088	1	8	4000.000000	247.38160004075
3089	1	8	4000.000000	247.38160004075
3090	1	8	4000.000000	247.38160004075
3091	1	8	4000.000000	247.38160004075
3092	1	8	4000.000000	247.38160004075
3093	1	8	4000.000000	247.38160004075
3094	1	8	4000.000000	247.38160004075
3095	1	8	4000.000000	247.38160004075
3096	1	8	4000.000000	247.38160004075
3097	1	8	4000.000000	247.38160004075
3098	1	8	4000.000000	247.38160004075
3099	1	8	4000.000000	247.38160004075
3100	1	8	4000.000000	247.38160004075

Recovering single DOMs does not require acquisition stop/restart

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

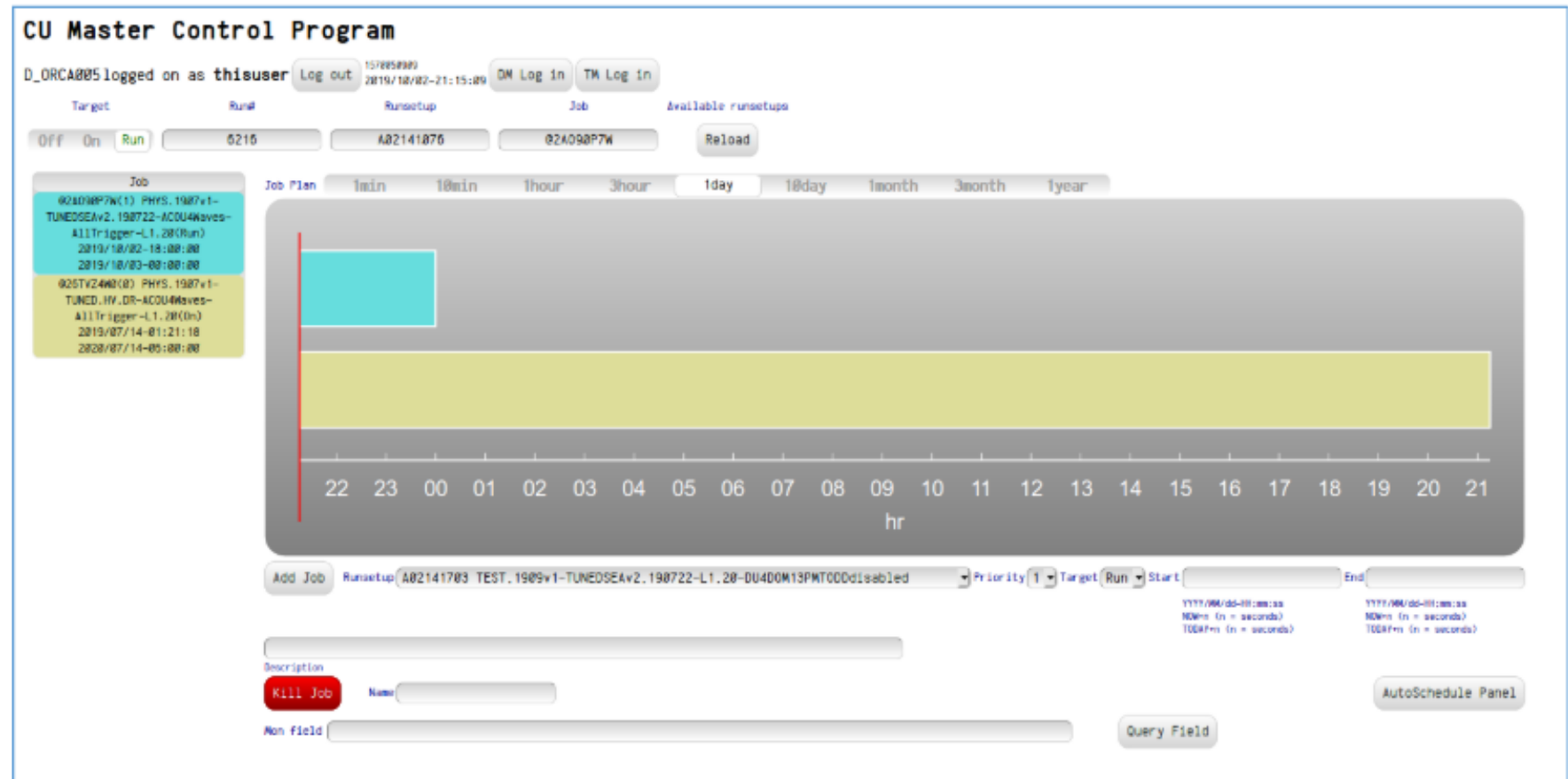
# Control tools

## 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

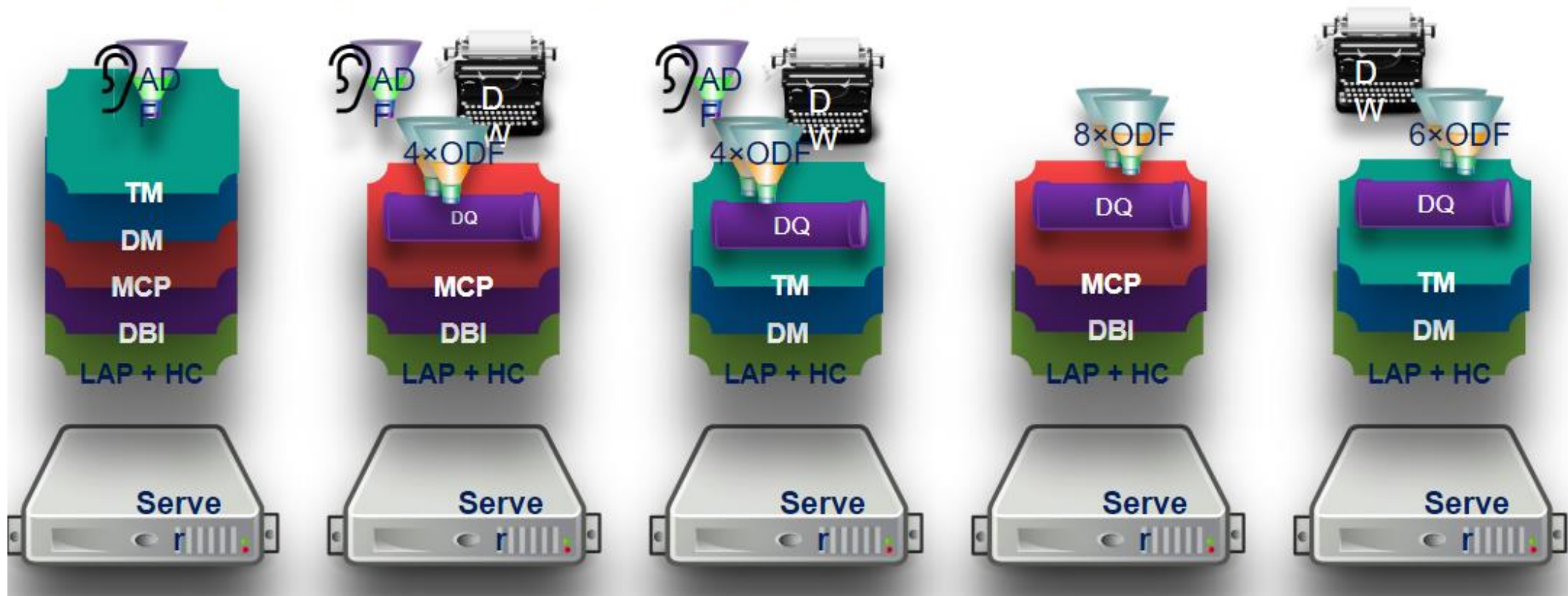
Provides Virtual Directory for monitoring

The screenshot displays the 'CU TriDAS Manager' web interface. At the top, it shows the user 'D\_ORCAMS' logged in as 'thouser' with a 'LOG OUT' button and a timestamp '11:28:21 2015/08/02 21:48:21'. Below this, there are controls for 'Current status' (set to 'Run') and 'Process debug level' (set to '1'). The interface is divided into three main sections: 'Genets' with one green progress bar, 'Filters' with 17 green progress bars, and 'Modules' with one green progress bar. At the bottom, there are controls for 'Process' (with 'Restart' and 'Stop' buttons), 'Status', 'Run data size' (2787978704), and 'Run events' (7082). A 'Log' section includes a text area, 'Start Log', and 'Stop Log' buttons. At the very bottom, there is a 'Run field' and a 'Query Field' button.

# 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**
- **High reliability in the software to handle the infrastructure elements**





Thank you

# Control Unit: Data Base Interface

## Data Base Interface

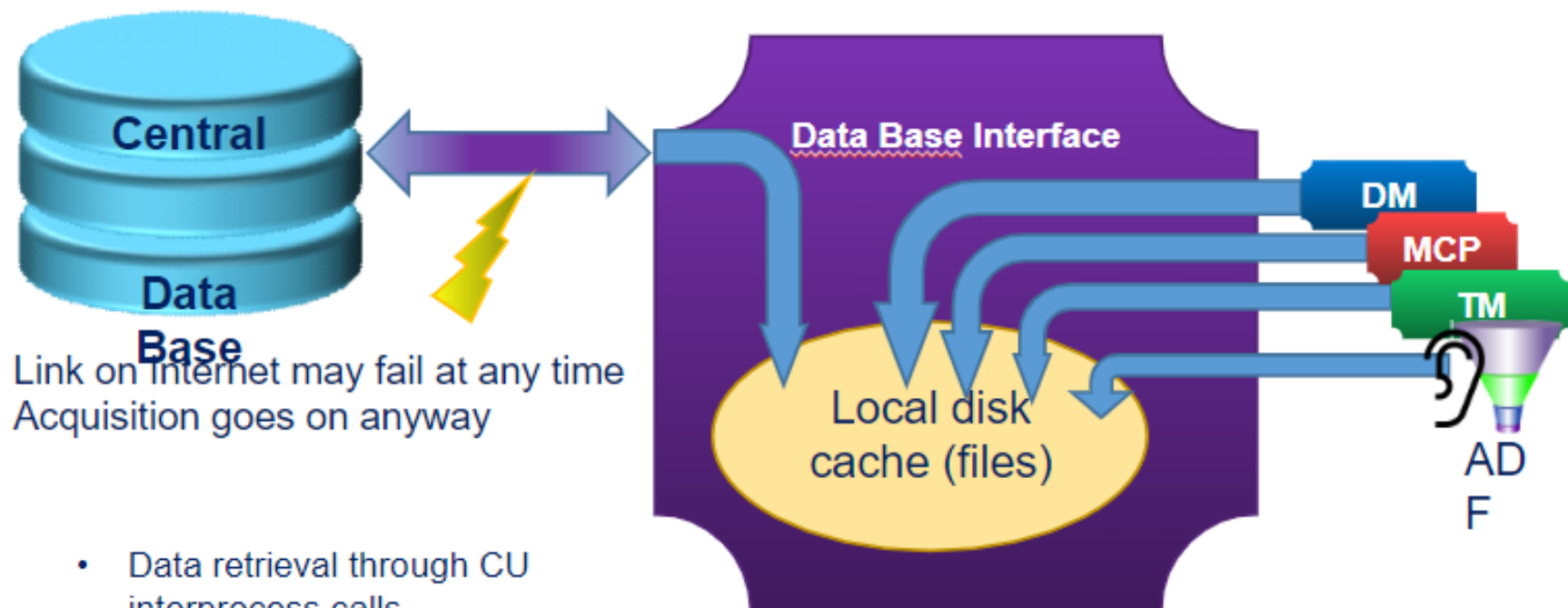
Data to be written to the DB are staged in the local cache

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



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

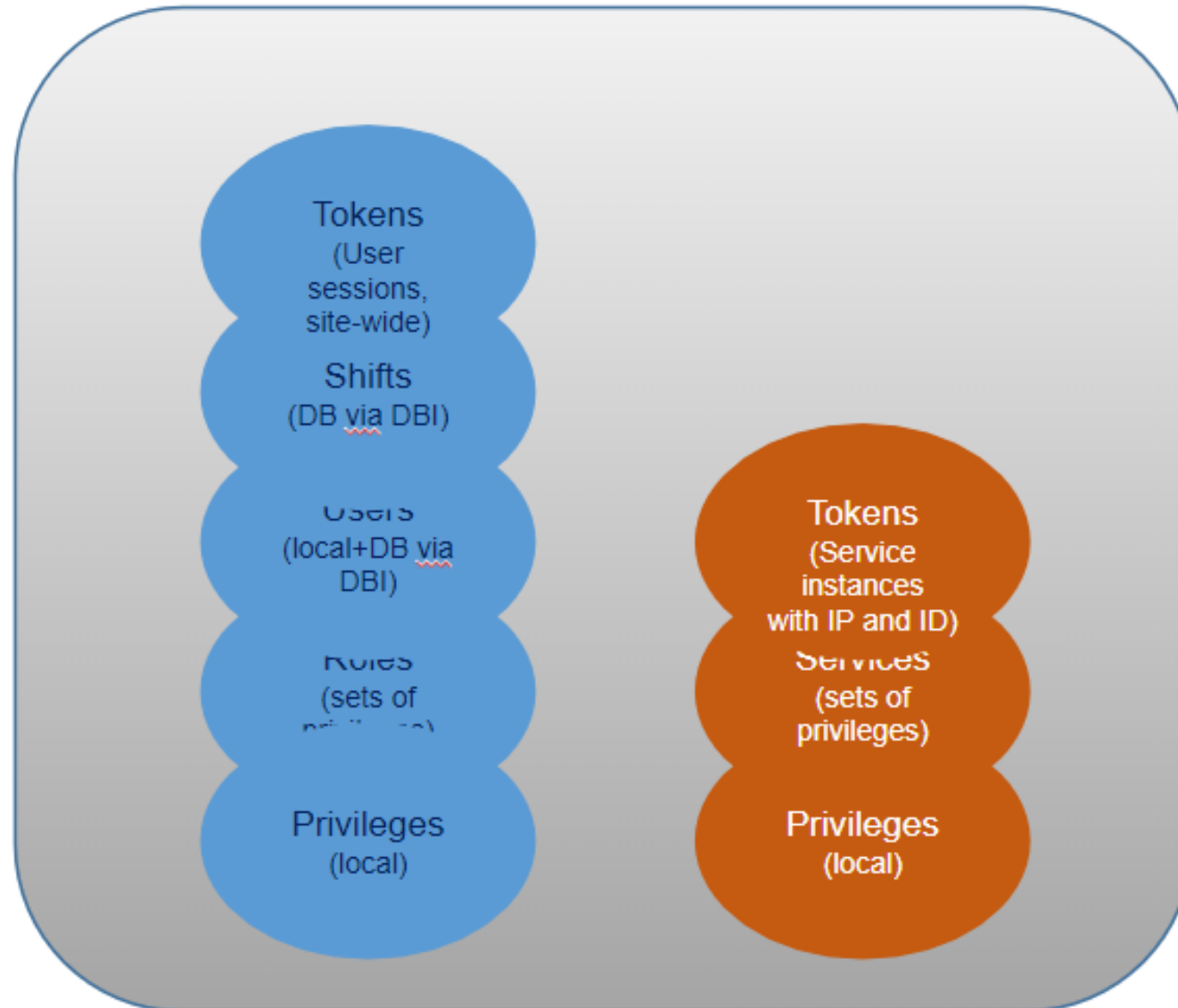
# Control Unit: Local Authentication Provider

## 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

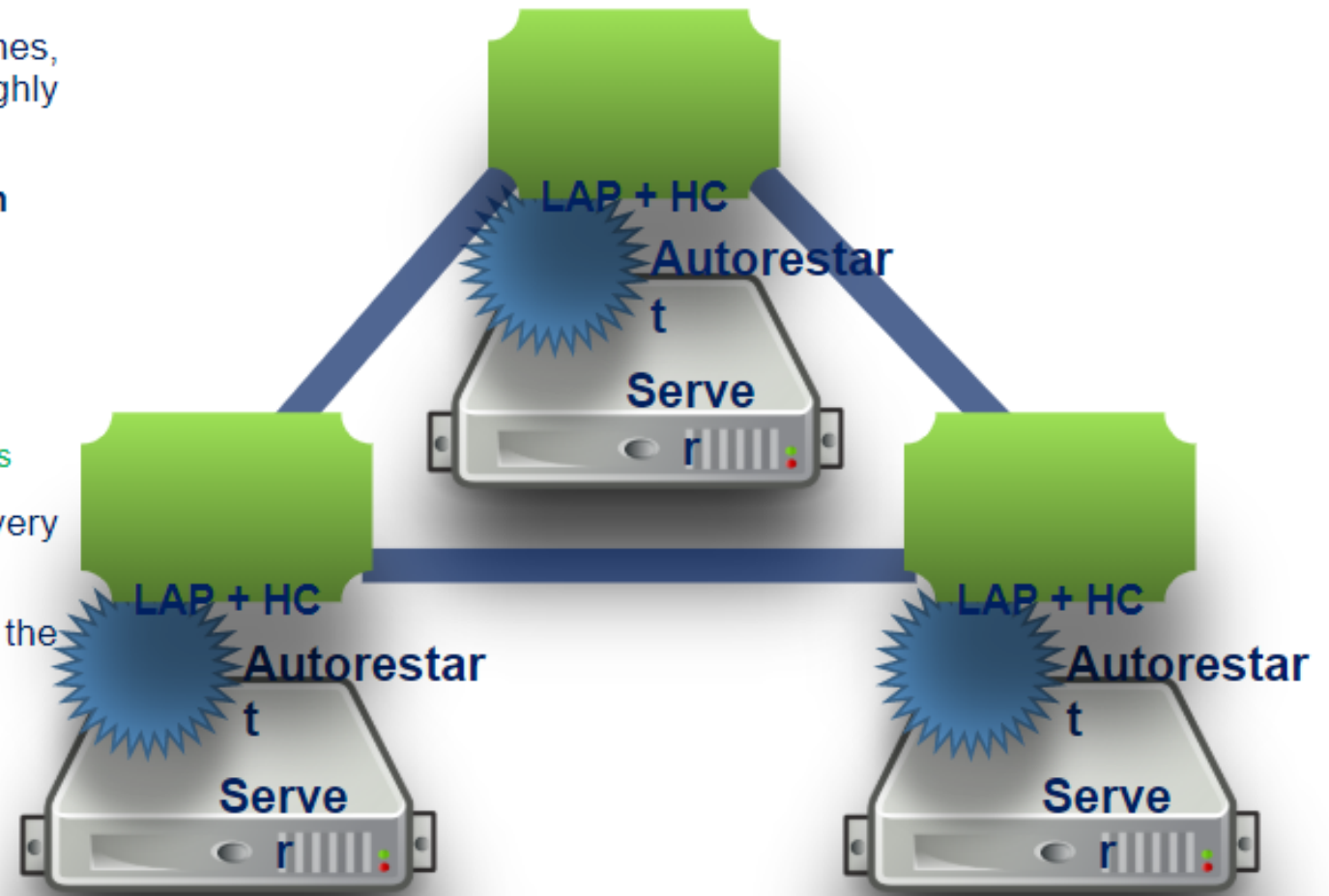
Impact of hardware failures

- 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**

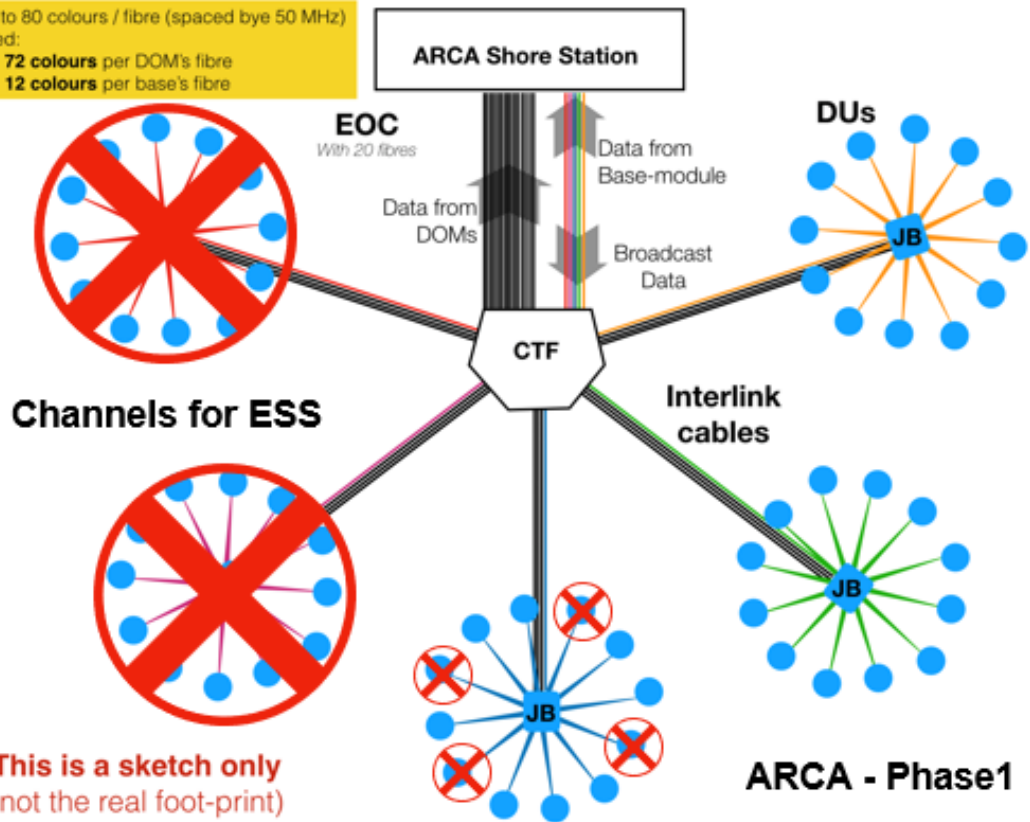
A **Health Checker (HC)** function is added to LAPs, polled every few seconds

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**



up to 80 colours / fibre (spaced by 50 MHz) used:  
 • 72 colours per DOM's fibre  
 • 12 colours per base's fibre



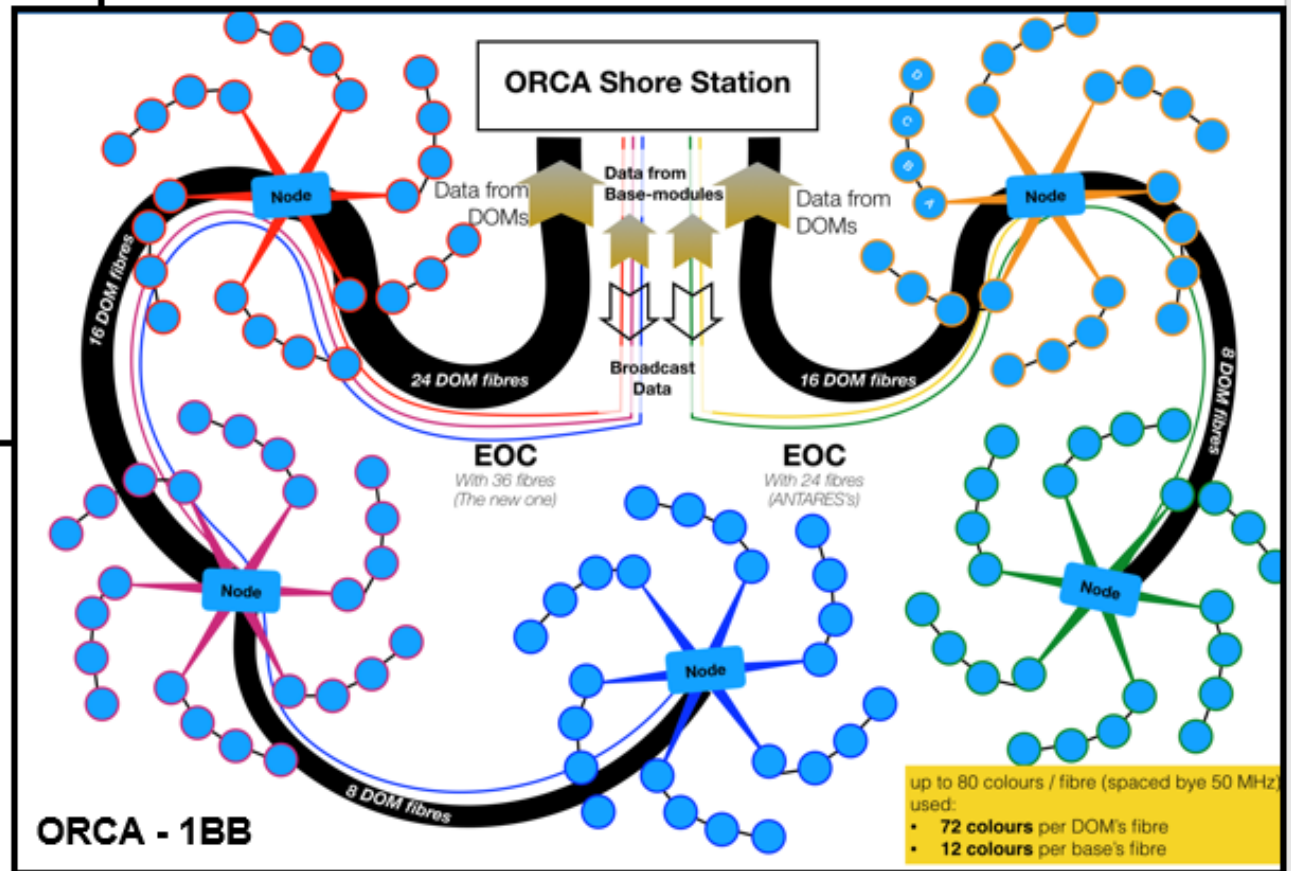
This is a sketch only  
 (not the real foot-print)

ARCA - Phase1

ARCA Phase1 CTF: only 3 over 5 sockets are usable  
 $\Rightarrow 3 \times 4 = 12$  fibers  $\Rightarrow$  in principle max 36 DUs,  
 Only 32 are actually possible for power budget :

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

Phase1 asymmetry in ARCA and ORCA .



ORCA - 1BB

up to 80 colours / fibre (spaced by 50 MHz) used:  
 • 72 colours per DOM's fibre  
 • 12 colours per base's fibre

# NEUTRINO ASTRONOMY

