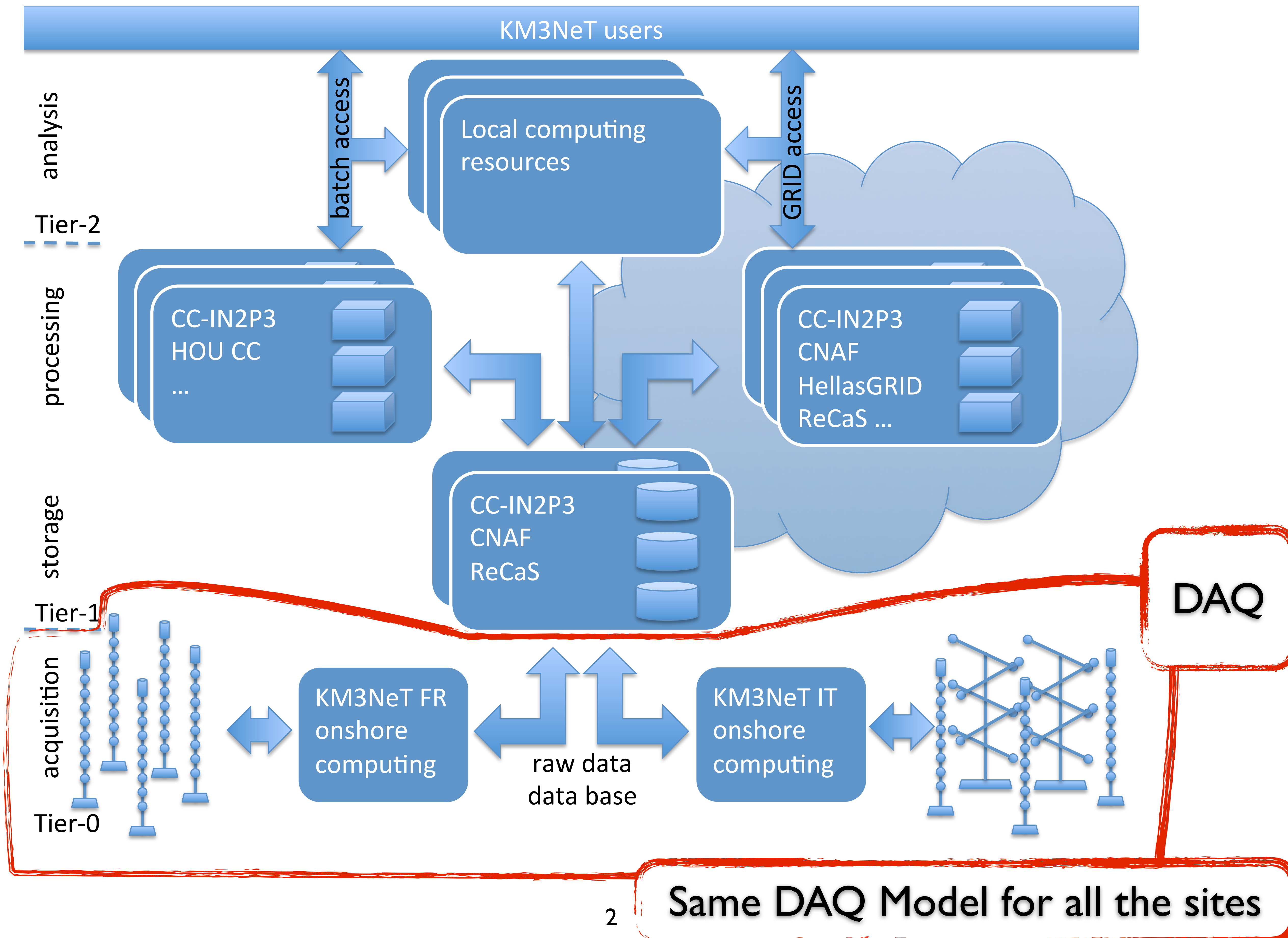
The KM3Net Data Acquisition System

Tommaso Chiarusi
INFN - Sezione di Bologna

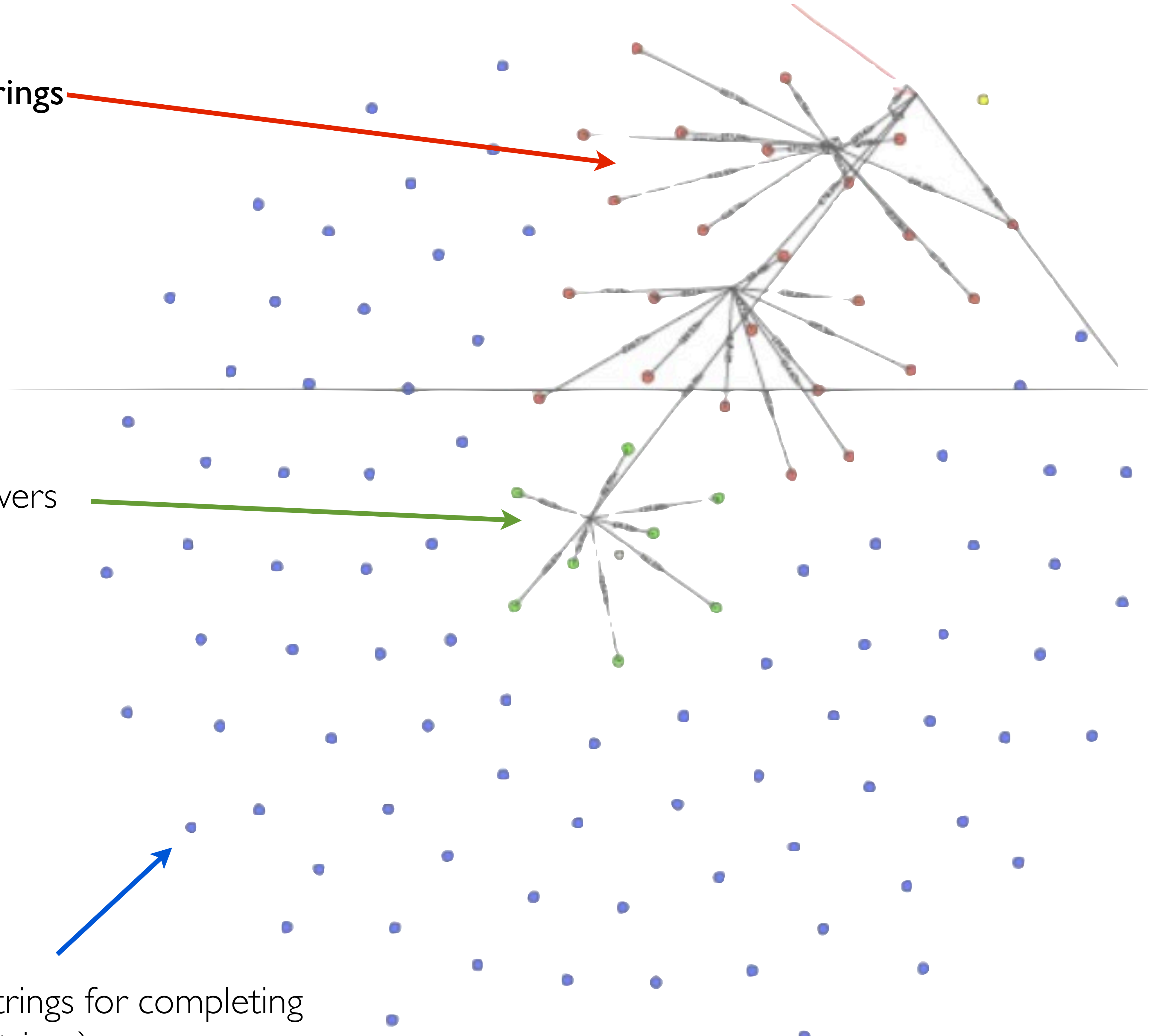
KM3NeT Data: from the sources to the comsumers…



The detector in the *Italian site* (1 building block)

KM3NeT-It Phase 1: **24** strings

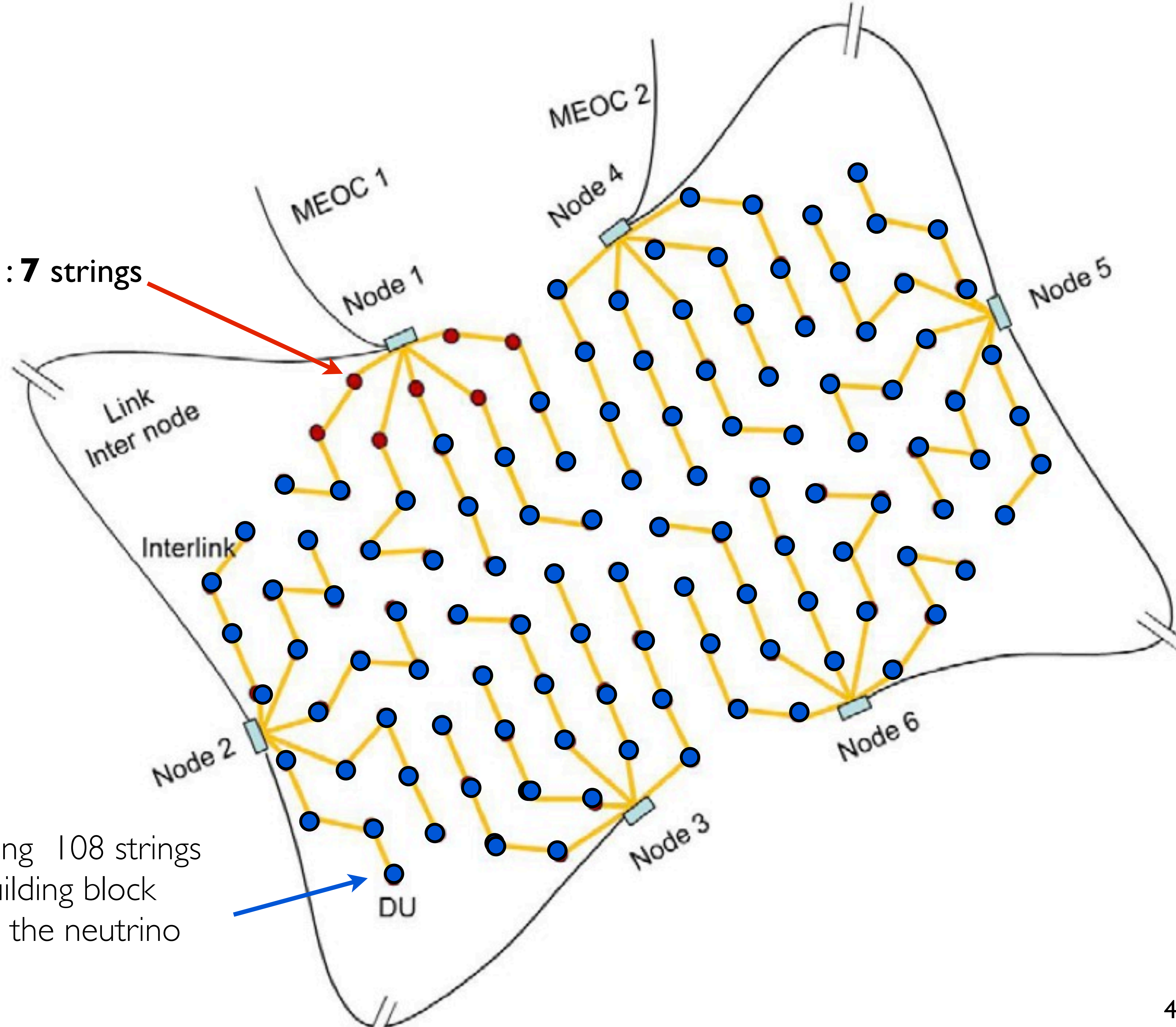
KM3Italy : 8 NEMO-like Towers



KM3Net-It : remaining 91 strings for completing
1 Building block (total 115 strings)

The detector in the *French site* (1 building block)

KM3NeT-Fr Phase 1: **7** strings



KM3Net-Fr : remaining 108 strings
for completing 1 Building block
(total 115 strings, in the neutrino
astronomy option)

Constraints to the DAQ design

- ⊙ big volumes
- ⊙ water optical properties (absorption & scattering of blue-green photons ~ 50-100 m)
- ⊙ good angular resolution **(.2 °)** for sky pointing (that's neutrino ASTRONOMY)

➠ **Many detection elements** (N. OMs > O(1000)/km^3) **deployed in bunches**

➠ SCALABLE DAQ design

- ⊙ No "beam crossing" reference such as for experiments at Colliders
- ⊙ complex DAQ structures in extreme conditions (mandatory: minimal underwater complexity)

➠ ALL DATA TO SHORE approach

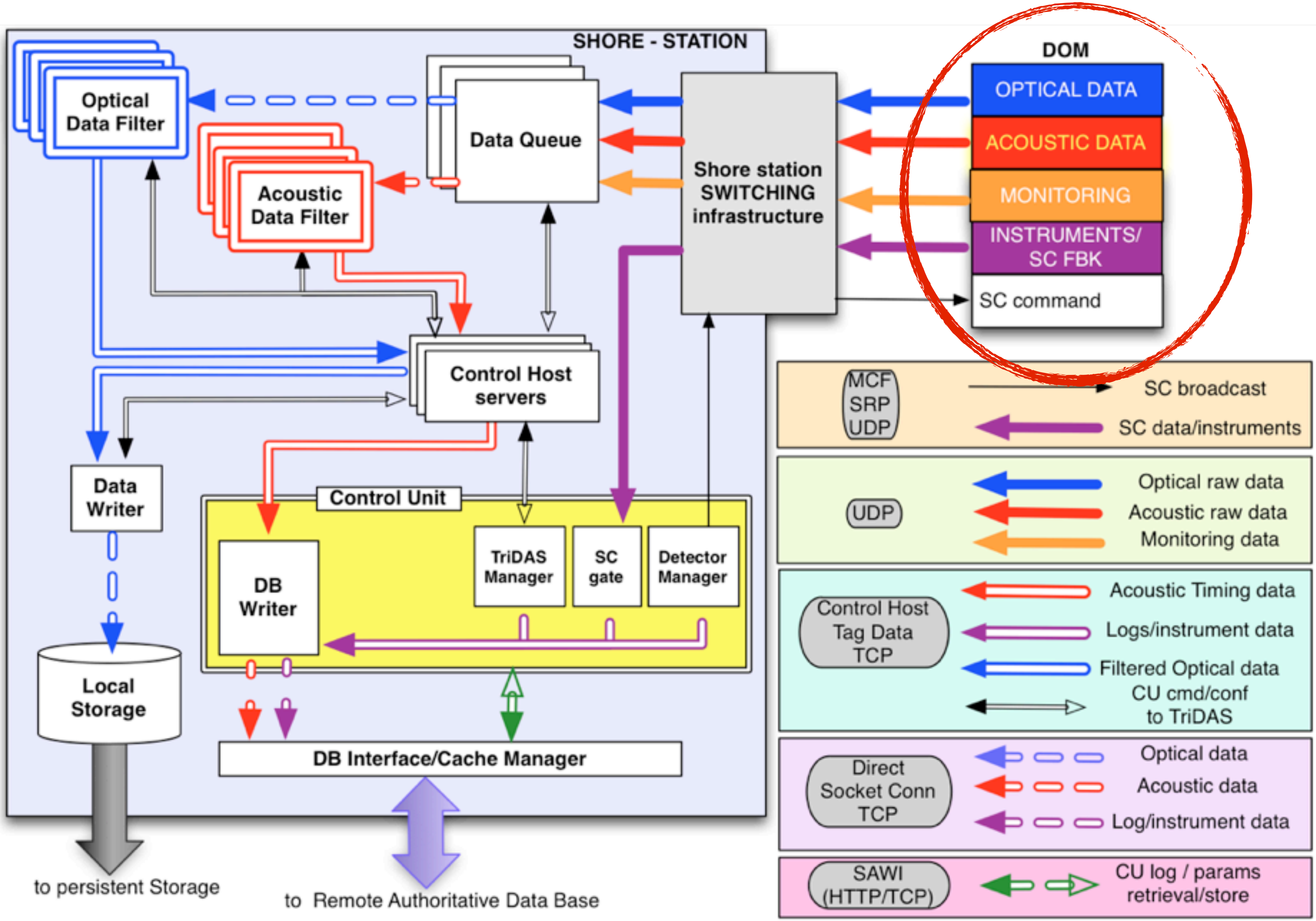
DRAWBACKS

signal-to-noise ratio extremely disfavored :

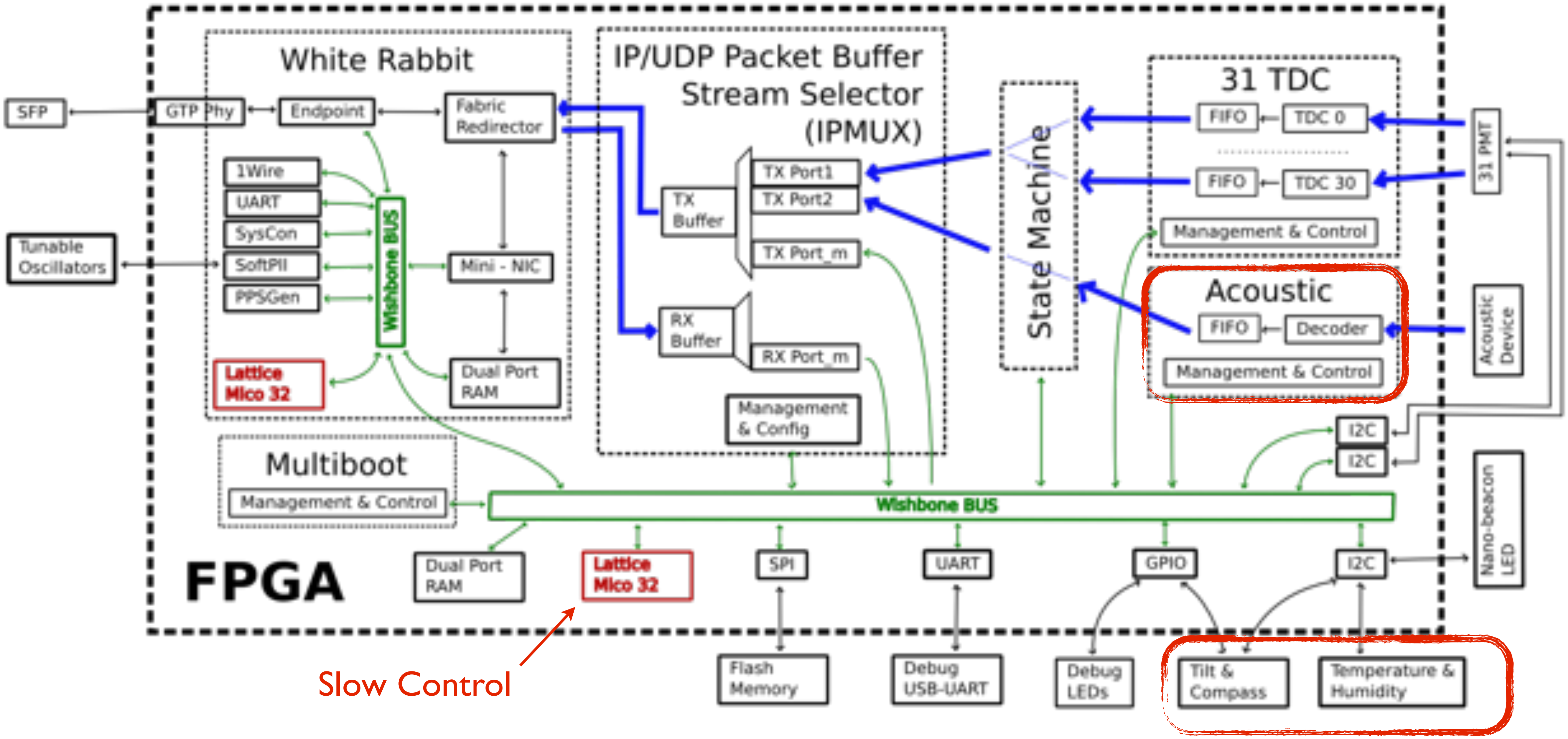
muon rate (atmospheric's dominate)	:	O(100) Hz/km^3
^{40}K decays (constant)	:	O(10) kHz/PMT(3", 0.5 p.e. thld)
Bioluminescence (occasional)	:	O(100) kHz/PMT(3", 0.5 p.e. thld)

➠ **High continuous throughput to shore, needed large bandwitdh switching infrastructure and a strong data reduction**

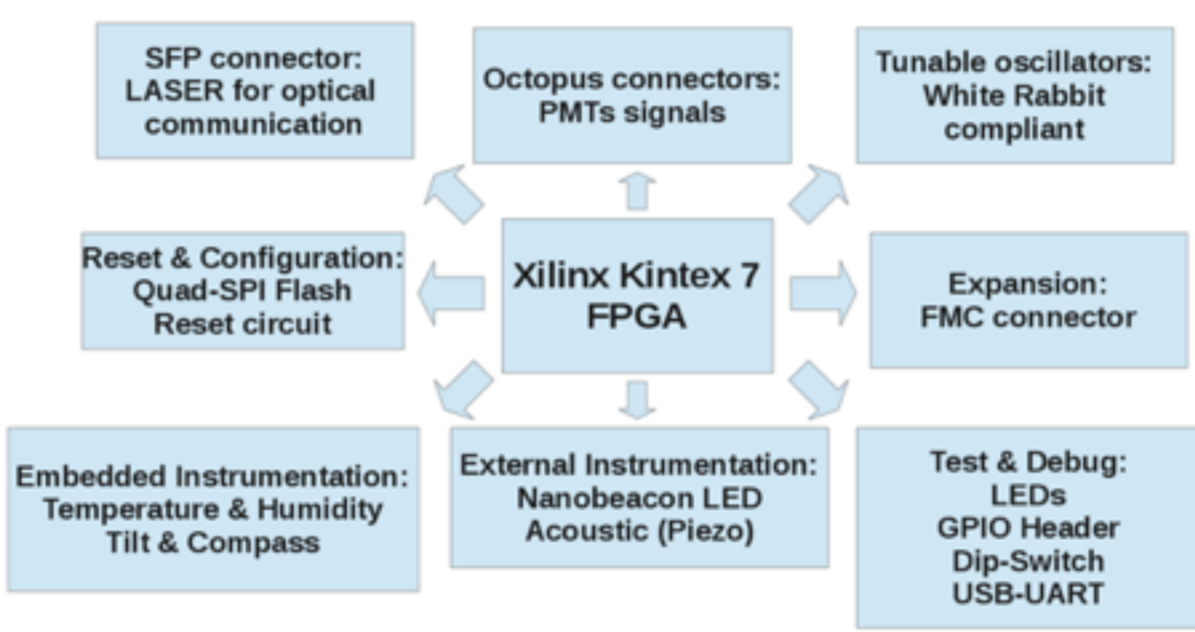
KM3NeT DAQ Model : *All data to shore*



The CLB ...the core of a DOM



Data sources:



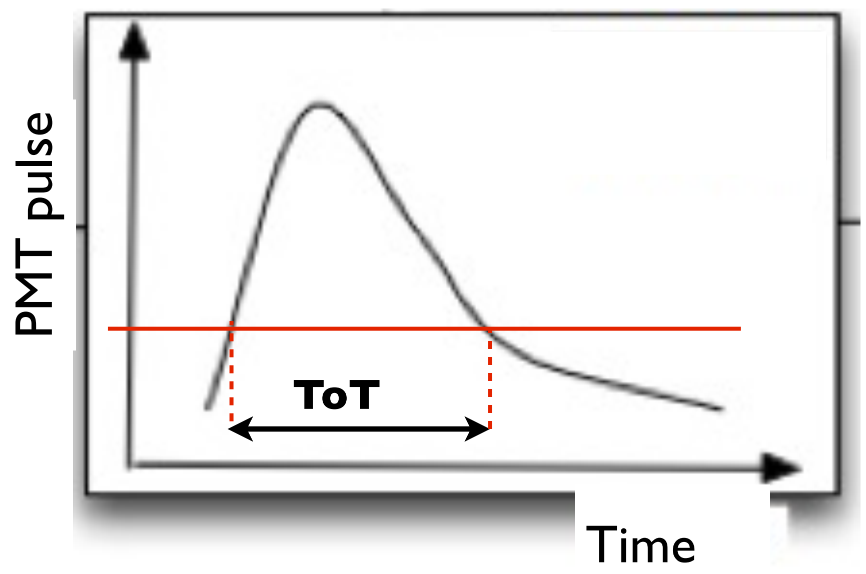
- **Slow Control** cmd & fbk (negligible)
- **I2C Instruments** (< 2 MBps from all the detector)
- **Acoustic data** (positioning)... **can** be *large* ...
- **Optical data** (Physics)... **are** the *largest*

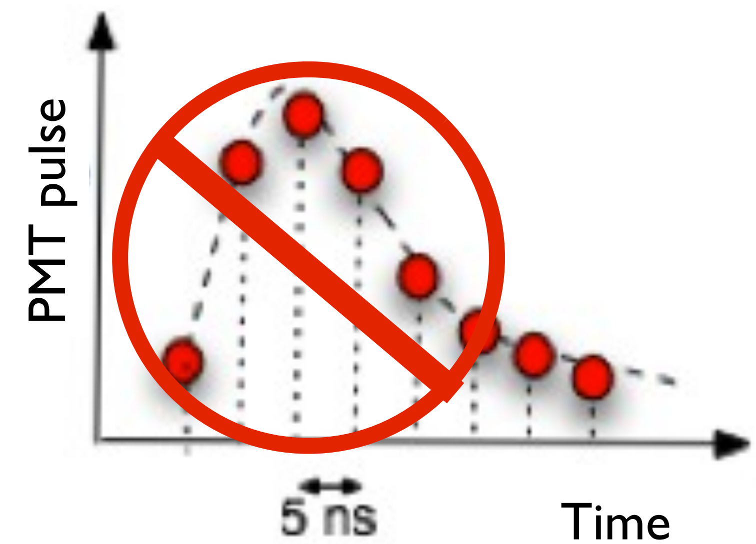
Optical Throughputs

- Timestamp + ToT + PMT id

SIZE ➠ **6 Bytes** / hit

… not sampled waveform!





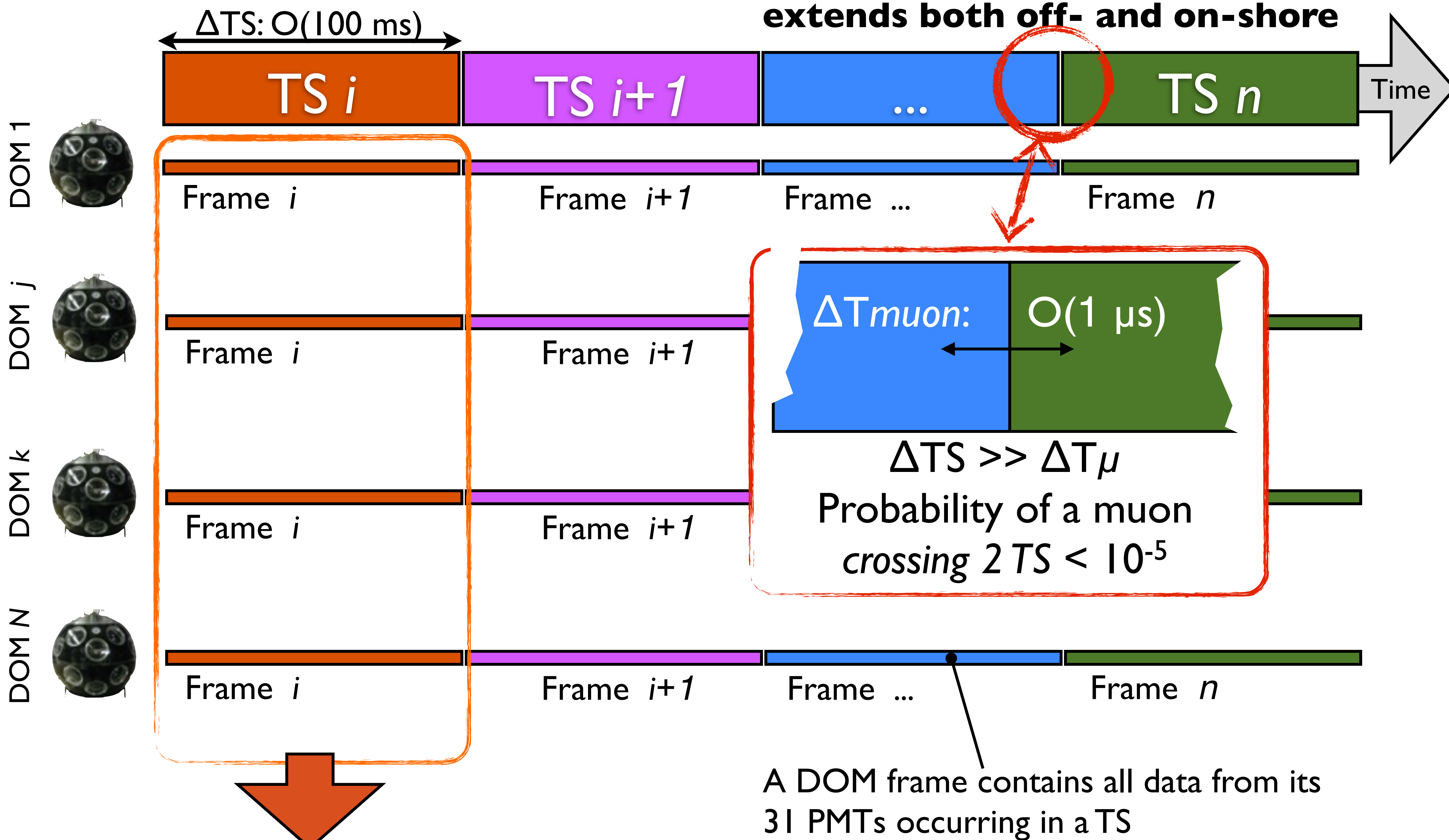
Case		Expected (ν_{single} = 6 kHz)	Conservative (ν_{single} = 15 kHz)	Maximum **HRV** (ν_{single} = 65 kHz)
3" PMT (0.25 p.e. thresh.)	(Mbps)	0.3	0.8	3.3
DOM (31 PMT)	(Mbps)	9.3	23.0	100.0
String (18 DOM)	(Mbps)	170.0	420.0	1800.0
Phase 1,It (24 strings)	(Gbps)	4.0	10.0	44.0
Phase 1,Fr (7 strings)	(Gbps)	1.2	2.9	13.0
Block (115 strings)	(Gbps)	19.0	48.0	210.0
Phase 1.5 (230 strings)	(Gbps)	39.0	96.0	420.0
Phase 2 (690 strings)	(Gbps)	120.0	290.0	1300.0

Used for dimensioning the computing resources (… timeslicing)

Used for dimensioning the switching infrastructures

TIMESLICING

- Time-slicing performed off-shore by DOMs: **a DOM is a node of a LAN which extends both off- and on-shore**



One full optical TS (data from all the detector) is sent to a specific filtering process (see ahead...)

Acoustic data-rate: *worst* case

In the case of the acoustic positioning system, the data rate is fixed because it depends basically on elements which are deterministically known:

- the sampling rates of the piezos or hydrophones onboard the DOMs (for a maximum of ~ 12 Mb/s);
- the number of acoustic beacons surrounding the Detection Units (here assumed to be 10) ;
- the beacon emission rate (which is assumed to be of 0.1 Hz) .

- *Data Format for TOA information:*
  KM3NeT Header: 38 B
  Emitter (Beacon) ID : 4 B;
  ToA = 8 B;
  Quality Factor = 4 B;
  Total: 54 B = 432 bit

- *Data Format for Pos information*
  Timing (s): 8 B
  Position: 3 4 B
  Quality Factor : 1 B
  Total: 22 B = 172 bit

- frequency beacon = 0.1 Hz
- frequency pos = 1 Hz

R_{sensor} = data – rate from a piezo or hydrophone (bit / s)
R_{DU} = data-rate from all the sensors in a DU (bit/s)
R_{det} = data-rate from all the sensors in the detector (bit/s)
$n_{sensor/layer}$ = number of sensors per layer
$n_{layer/DU}$ = number of layer per Detection Unit
n_{DU} = number of Detection Unit
n_{beacon} = number of acoustic emitters
ν_{beacon} = frequency of each emitter (Hz)
S_{timing} = size of each reconstructed Time Of Arrival (TOA) information
R_{timing} = TOA data-rate (after computations made by all the Acoustic DataFilters)
ν_{pos} = requested frequency for reconstructed positions (Hz)
S_{pos} = size of the reconstructed position information
R_{pos} = position data-rate (after computations made offline using the TOA data stored in the DataBase)

$$R_{layer} = R_{sensor} * n_{sensor/layer}$$
$$R_{DU} = R_{layer} * n_{layer/DU}$$
$$R_{det} = R_{DU} * n_{DU}$$
$$n_{sensors} = n_{sensor/layer} * n_{layer/DU} * n_{DU}$$
$$R_{timings} = n_{sensors} * n_{beacons} * \nu_{beacon} * S_{timings}$$
$$R_{pos} = n_{sensos} * n_{layer/DU} * \nu_{pos} * S_{pos}$$

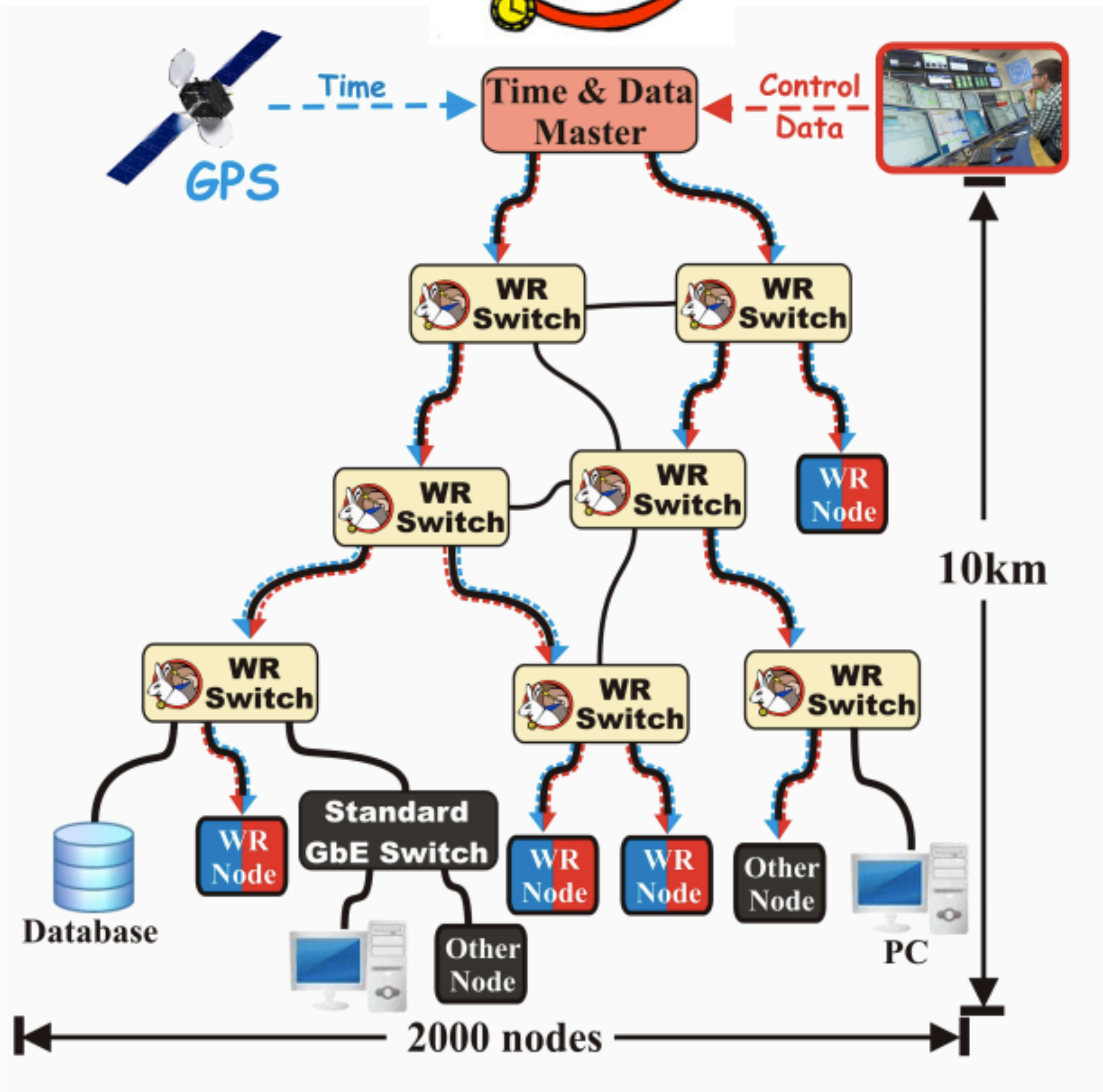
Case	Layer (Mb/s)	DU (Mb/s)	Det (Gb/s)	Timings (Mb/s)	Positions (Mb/s)
KM3NeT Ph1, *It* (24 Strings)	13.0	250.0	6.1	0.21	0.08
KM3NeT Ph1, *Fr* (7 Strings)	13.0	250.0	1.8	0.06	0.02
KM3NeT Block (115 Strings)	13.0	250.0	29.0	0.99	0.40
KM3NeT Ph1.5 (230 Strings)	13.0	250.0	58.0	2.00	0.79
KM3NeT Ph2 (690 Strings)	13.0	250.0	170.0	6.00	2.40

limiting actions:
- 1 channels
- duty-cycle

White Rabbit and the Network architecture

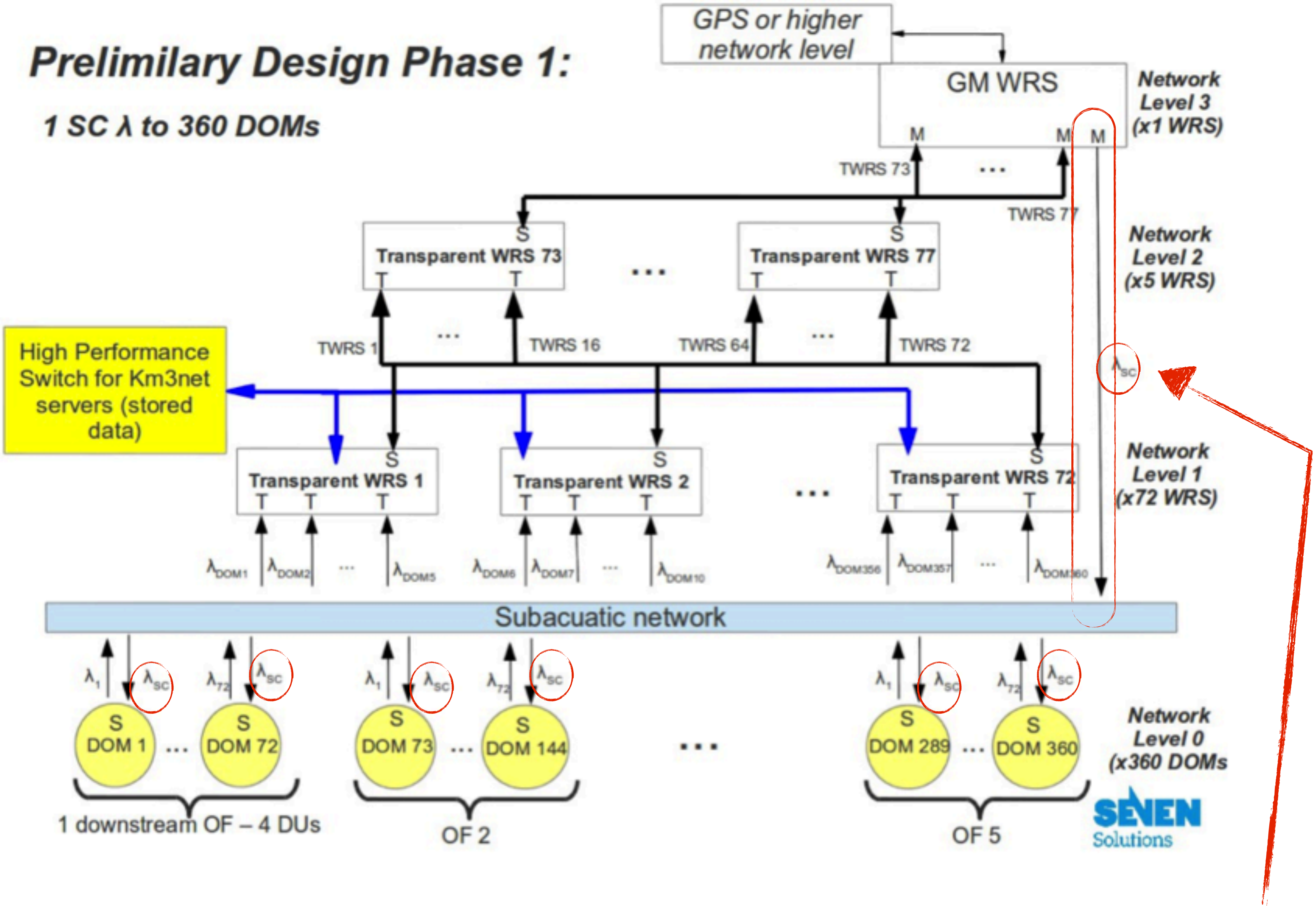
Two separate services (enhancements to Ethernet) provided by WR:

- Synchronization: accuracy better than 1 ns precision (tens of ps sdev skew max)
- Deterministic, reliable and low-latency Control Data delivery



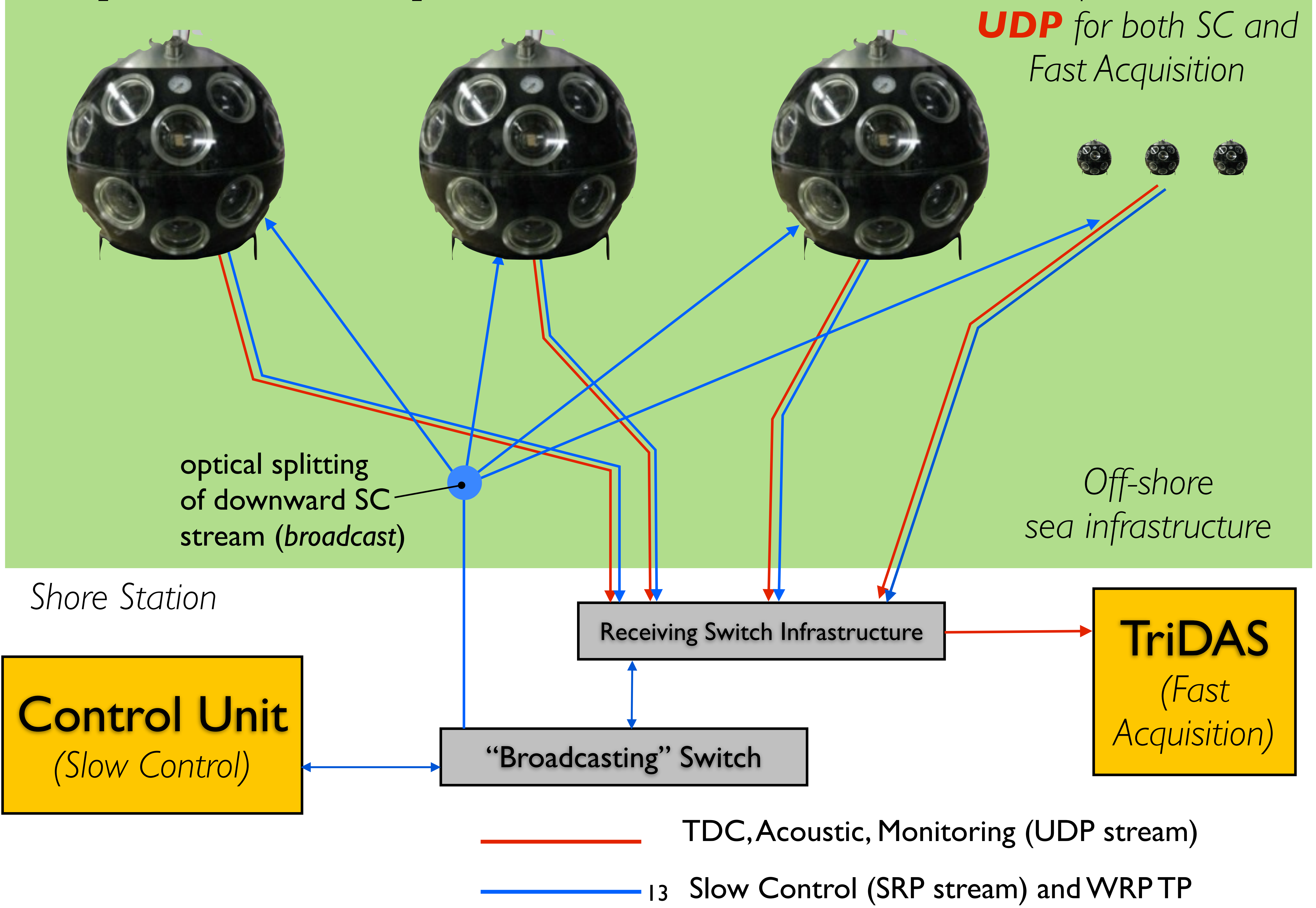
Credit: White Rabbit for Time Transfer, Erik van der Bij at TIPP'14

WR infrastructure in the Shore Station

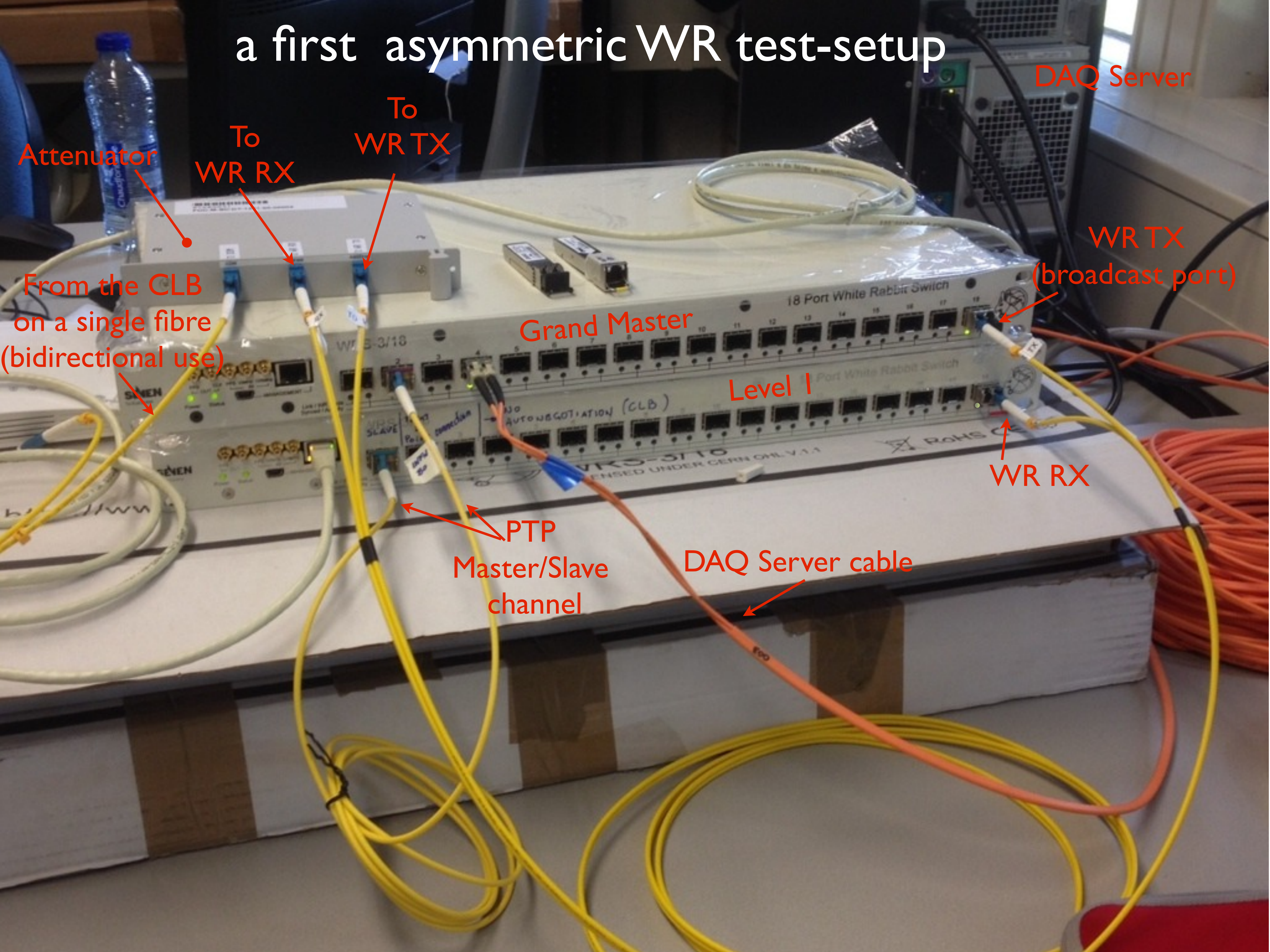


The "broadcast" channel (from on shore to offshore) implies an asymmetry for DOM send/return. Since WRPTP uses Ethernet, there has been a deep customization of WR swtich at software and gateware level

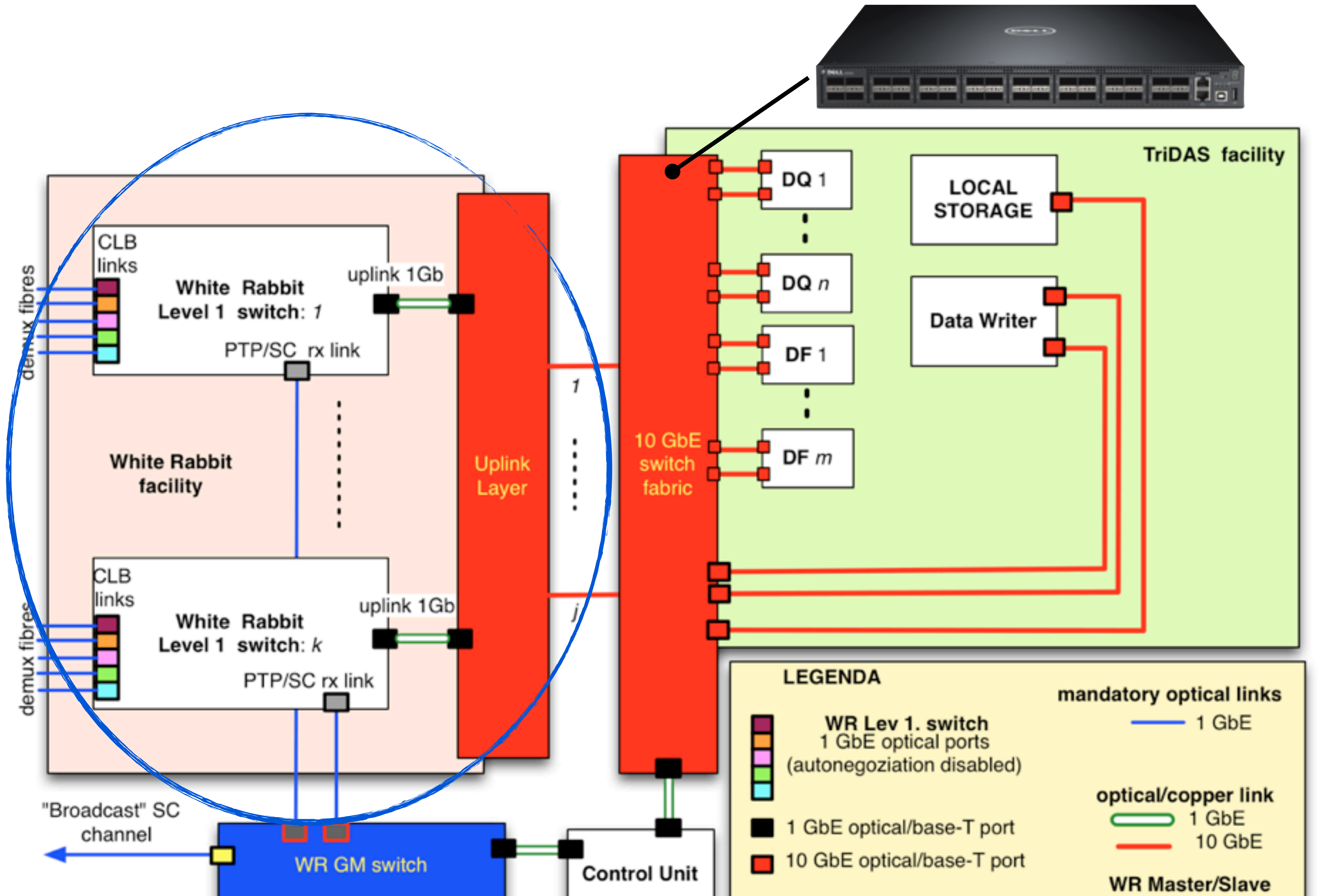
Asymmetric optical infrastructure



a first asymmetric WR test-setup



Shore Station Layout



[1 ... k] WR L1 switches
[1 ... j] uplinks via 10 GbE connection
[1 ... n] DataQueues
[1 ... m] DataFilters

FLAT Level 2 LAN

Definition of a number of ***Class B*** subnetworks

$$\texttt{AAA.BBB.x.y}$$

e.g, for *Phase 1:*

$\mathbf{x} \in$ *[1-4]* *for* ***CLBs*** (456)-***DataQueue*** (24)

$\mathbf{x}$ *= 5* *for* ***DataQueue***-***DataFilter*** (25)

$\mathbf{x}$ *= 7* *for* ***DataFilter***-***DataWriter*** (1) -***Storage*** (1)

$\mathbf{x}$ *= 8* *for* ***ControlUnit*** (1-2)

$\mathbf{x}$ *= 9* *for* ***Monitoring*** (<10)

$\mathbf{y} \in$ *[1-250]*

Shore station   Switching Front-End for the DOMs

WR Switches

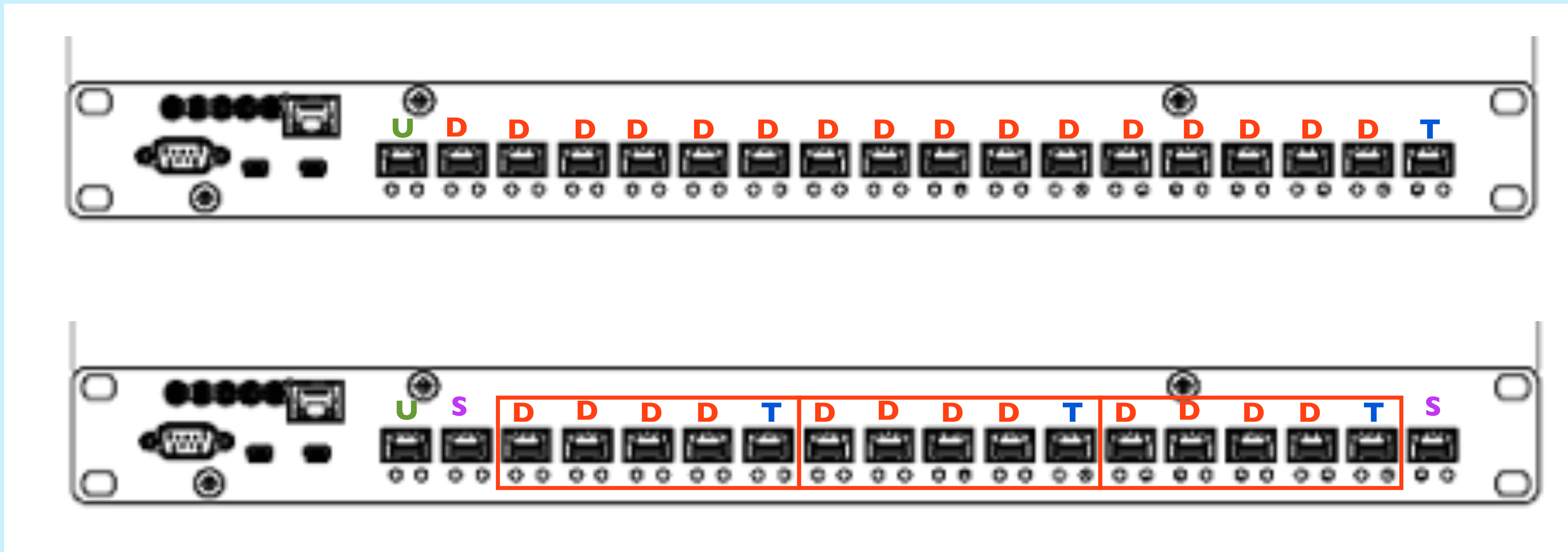
All   1 Gbps ports

Legenda

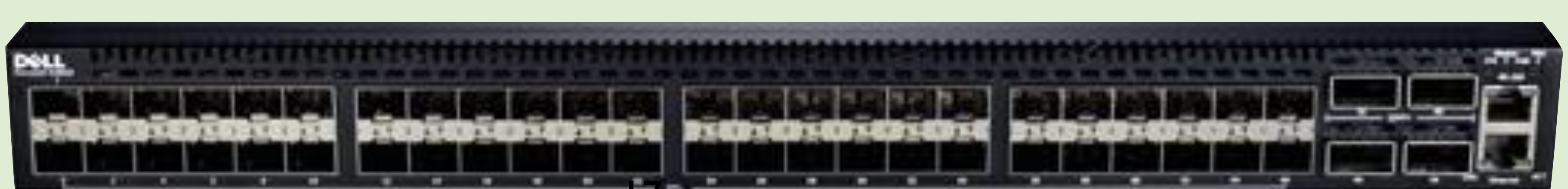
U : PTP uplink
D : DOM port
T : TriDAS uplink
S : spare

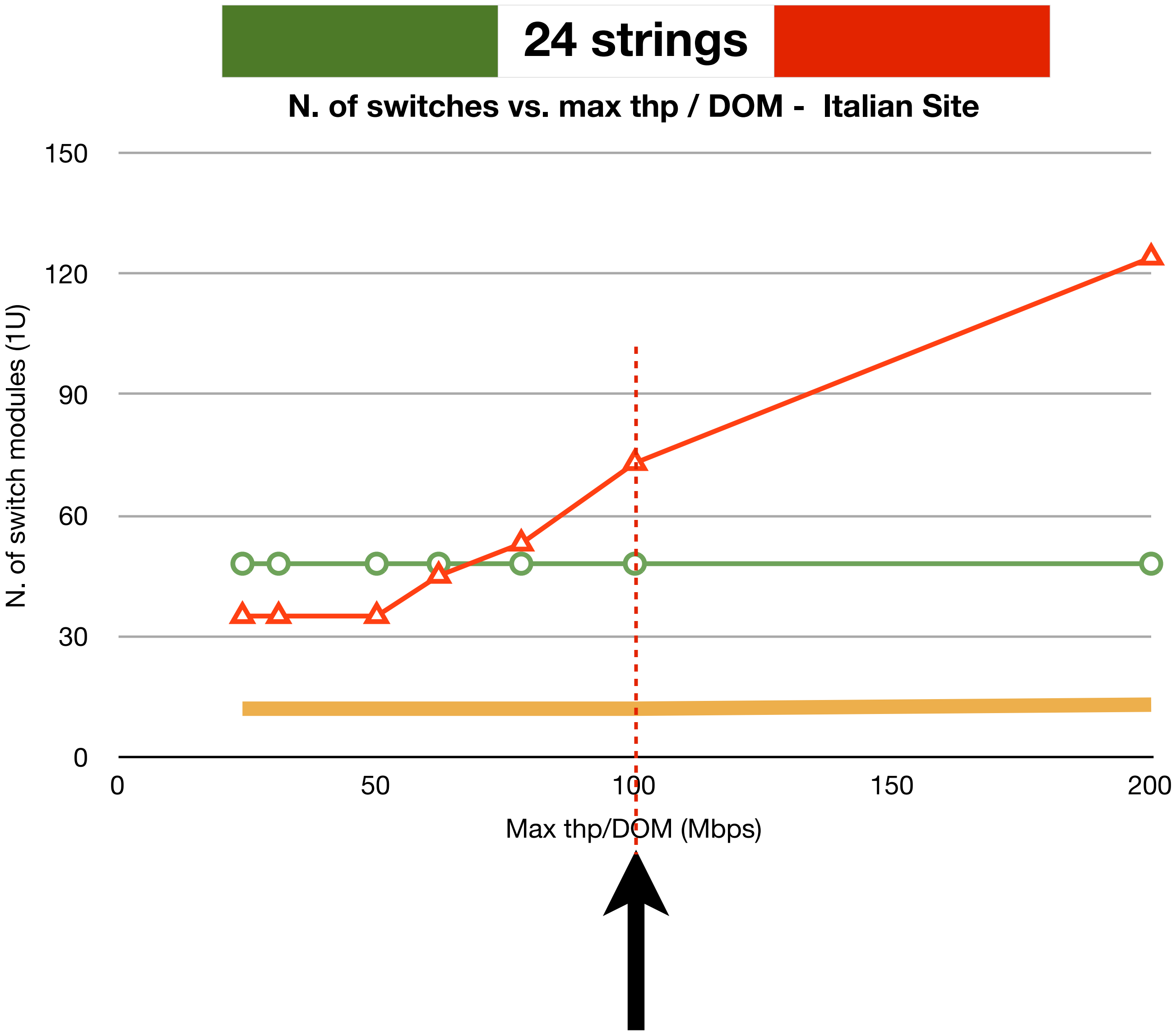
No VLANs
current version 3.4

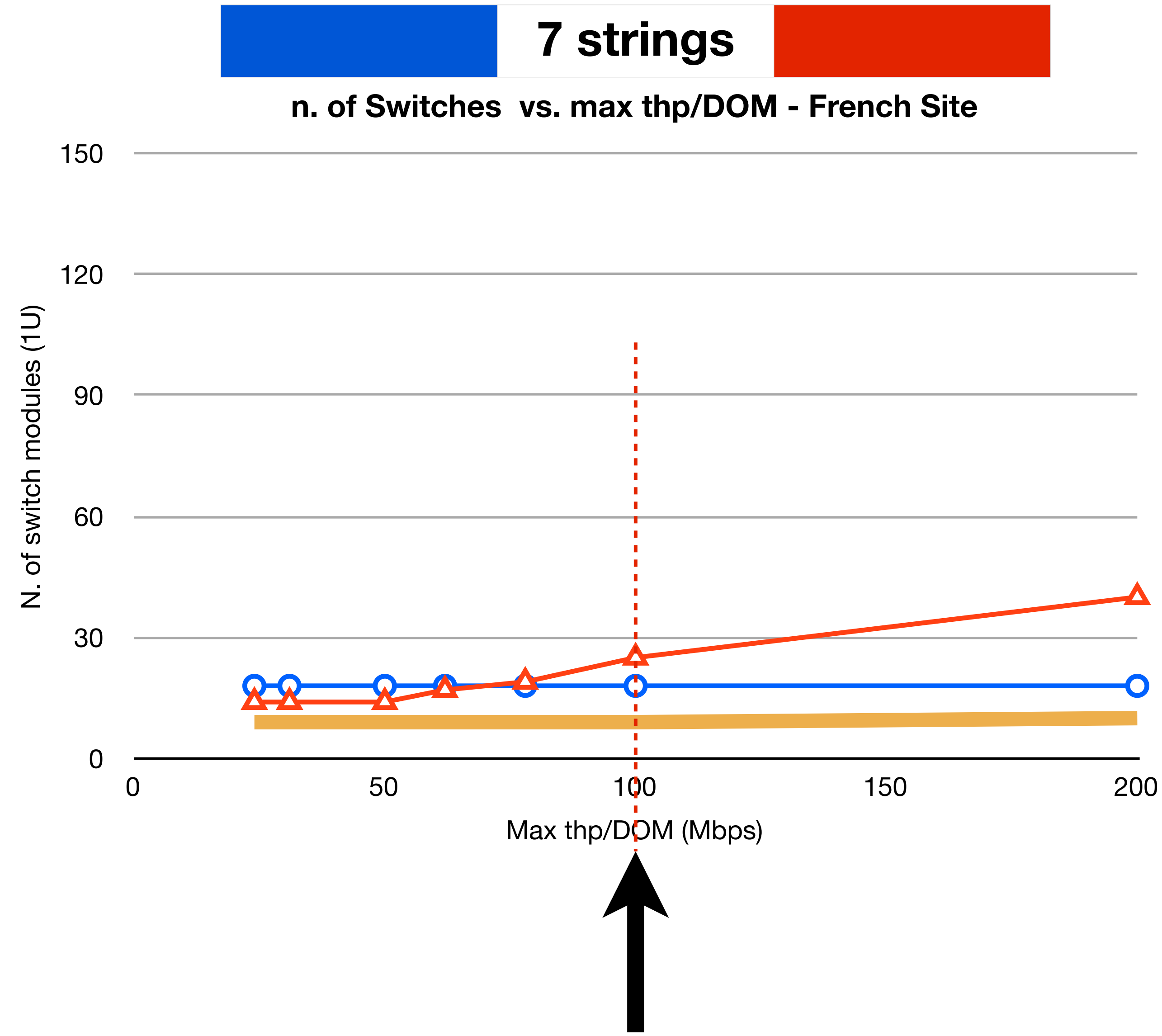
3 VLANs / WRS
possible with versions ≥ 4.0



Hybrid case: we consider switches similar to DELL s4810 or Juniper QFX5100 (*48x* 10 GbE) with uplinks at *4x* or *6x* 40 GbE. All (or almost all) the ports are used. No VLANs are necessary.





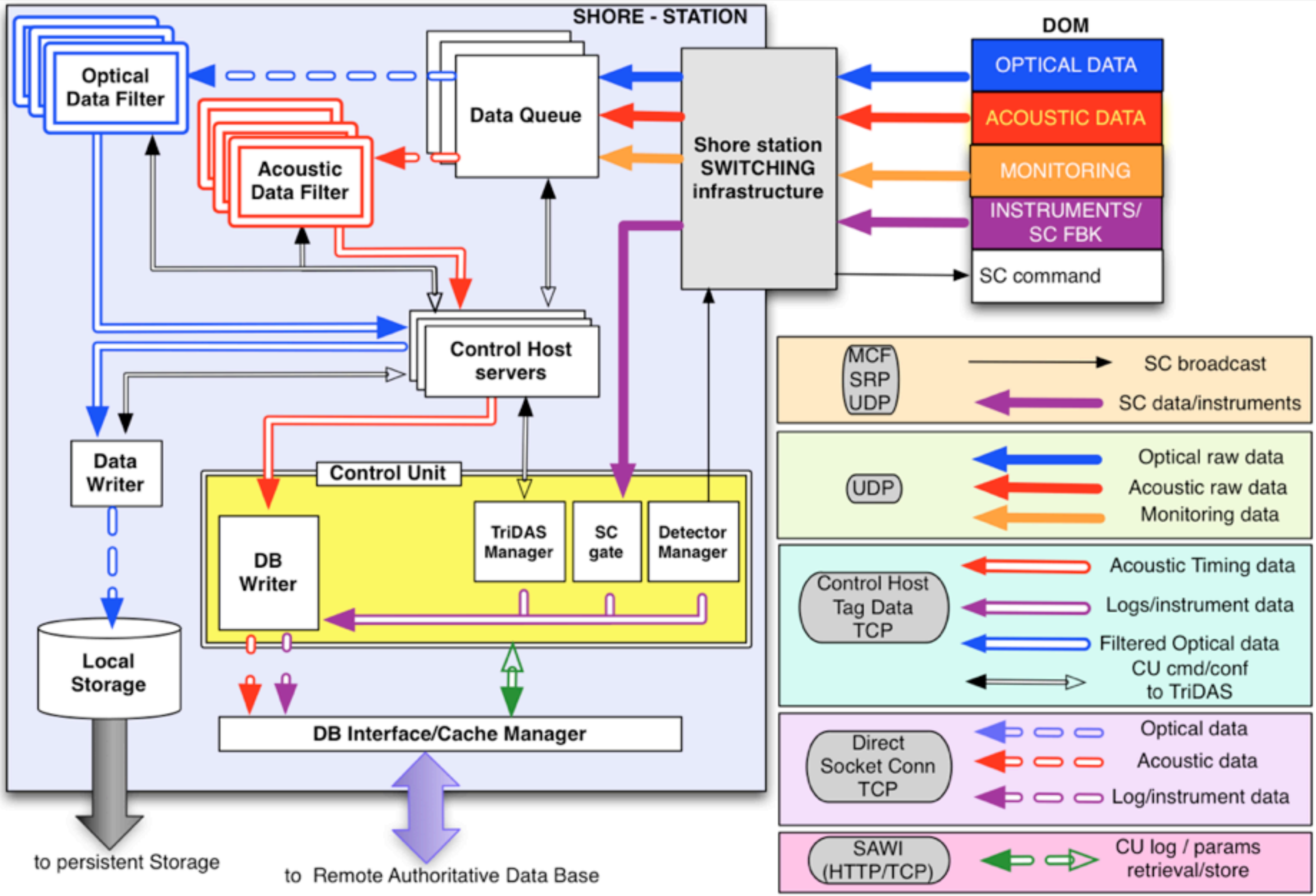


Decision: **full WR shore station** for both

- 1st string in KM3NeT-Fr site
- 1st 4 strings in KM3NeT-It site

Hybrid solution is currently under synchronization tests (h/w + f/w + emb. s/w). It may be suitable for the 24 strings shore-stations in KM3NeT-It... and for next phases

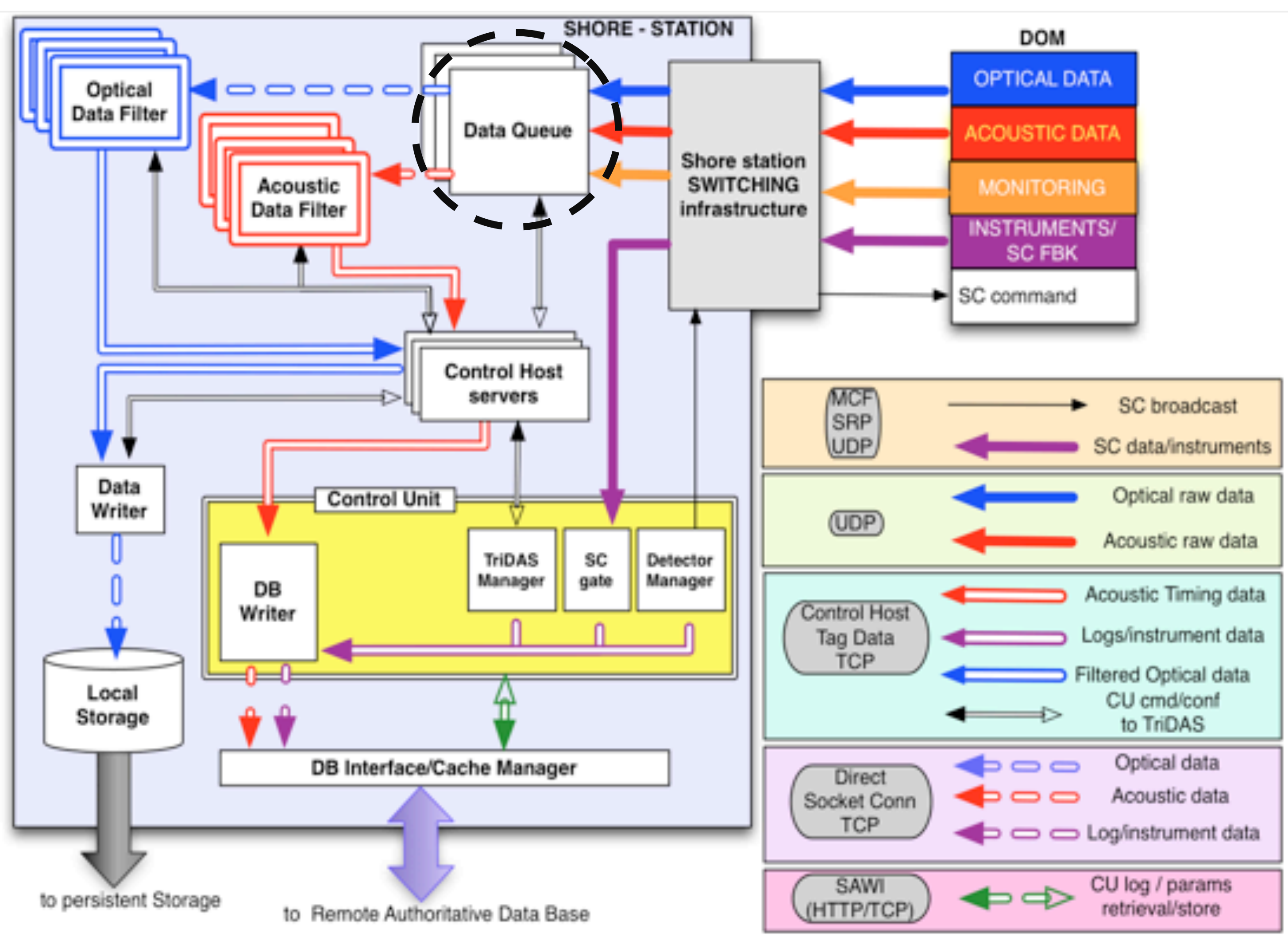
KM3NeT DAQ Model : *All data to shore*



DataQueue

The DataQueue (DQ) is the software component of the KM3NeT-EU TriDAS which provides the data aggregation and distribution layer for both acoustic and optical data.

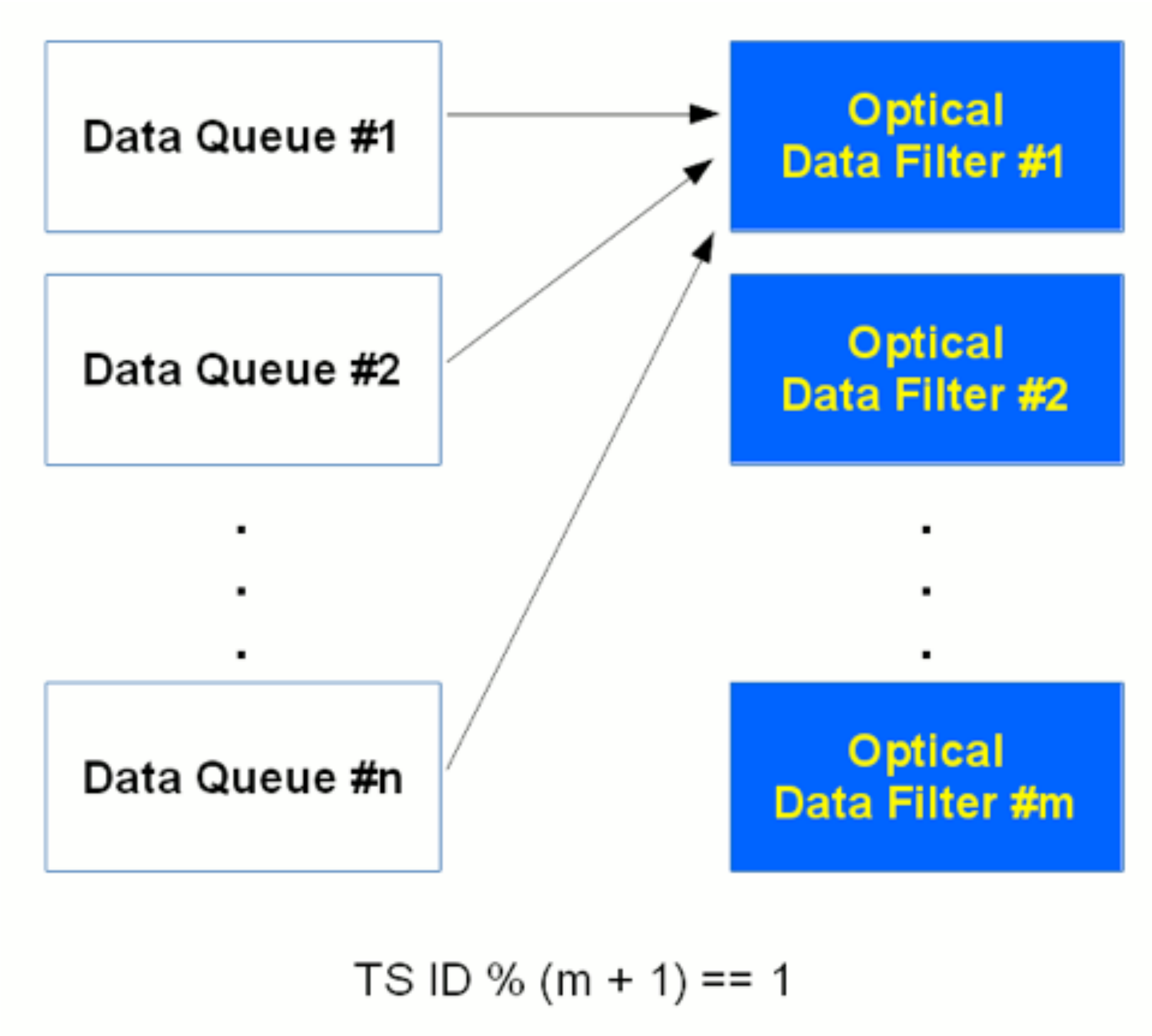
- Read-out of the KM3NeT-EU data frames (UDP) from a predefined number of CLBs
- Reassembling of the Time Slice (TS, which is compiled by the off-shore electronics)
- Distribution of the TSs to the proper DataFilter



DataQueue: Two flavours

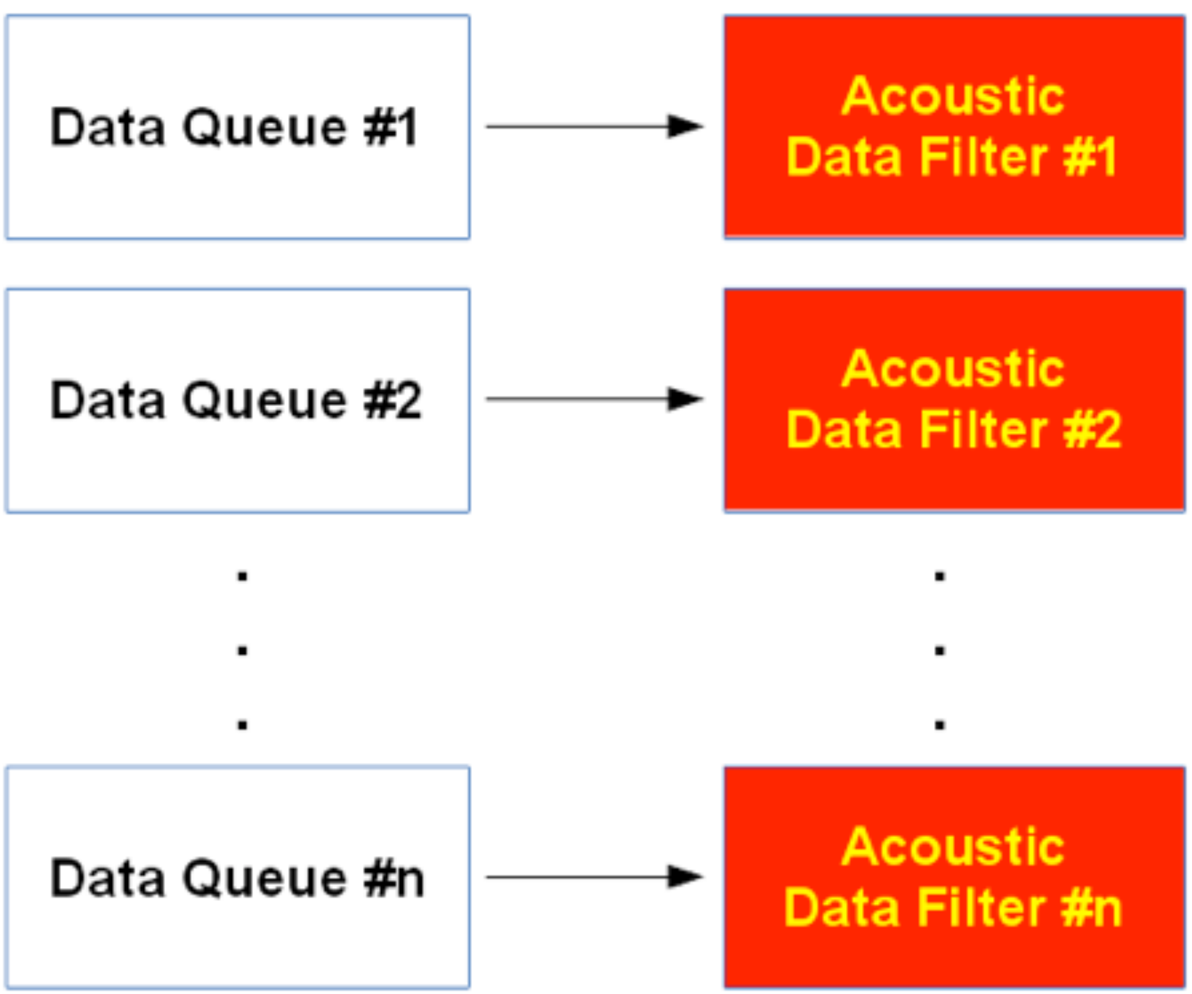
Optical World

Route the data collected from all DQs referring to a precise Time Slice to the very same oDF.



Acoustic World

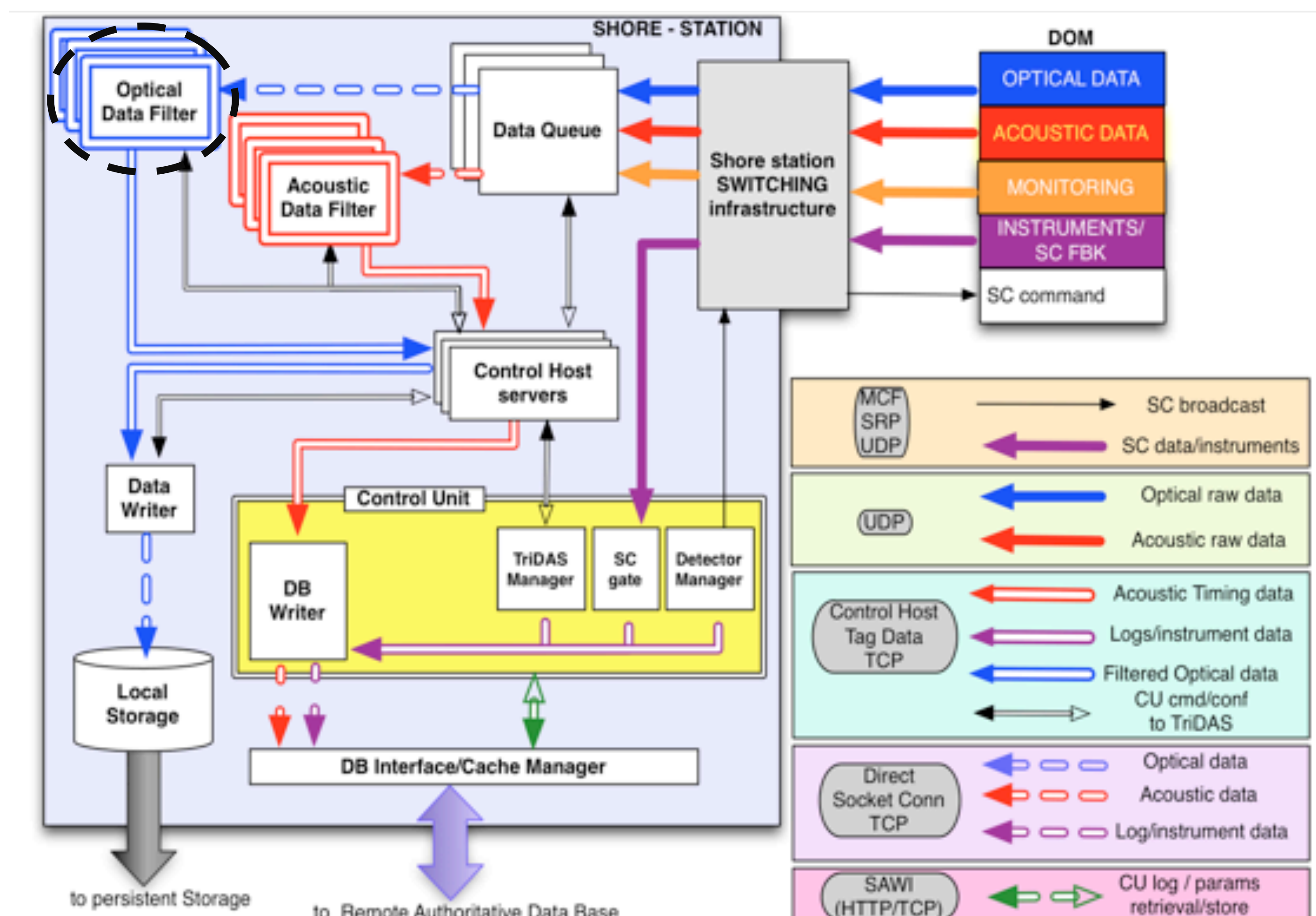
Acoustic data must be sent in a continuous stream, addressing all data from one DQ to a single aDF.



Optical DataFilter

The main task of the optical DataFilter (oDF) is to reduce the data-stream coming from the DOMs' PMTs by selecting events that are interesting for physics analyses.

- Apply **trigger algorithms** that find space-time correlations between hits.
- Keep a **buffer** of raw data for dumping in case of an external alert (follow-up trigger, e.g.: GRB...)
- Send data to the Data Writer



Filtering algorithms

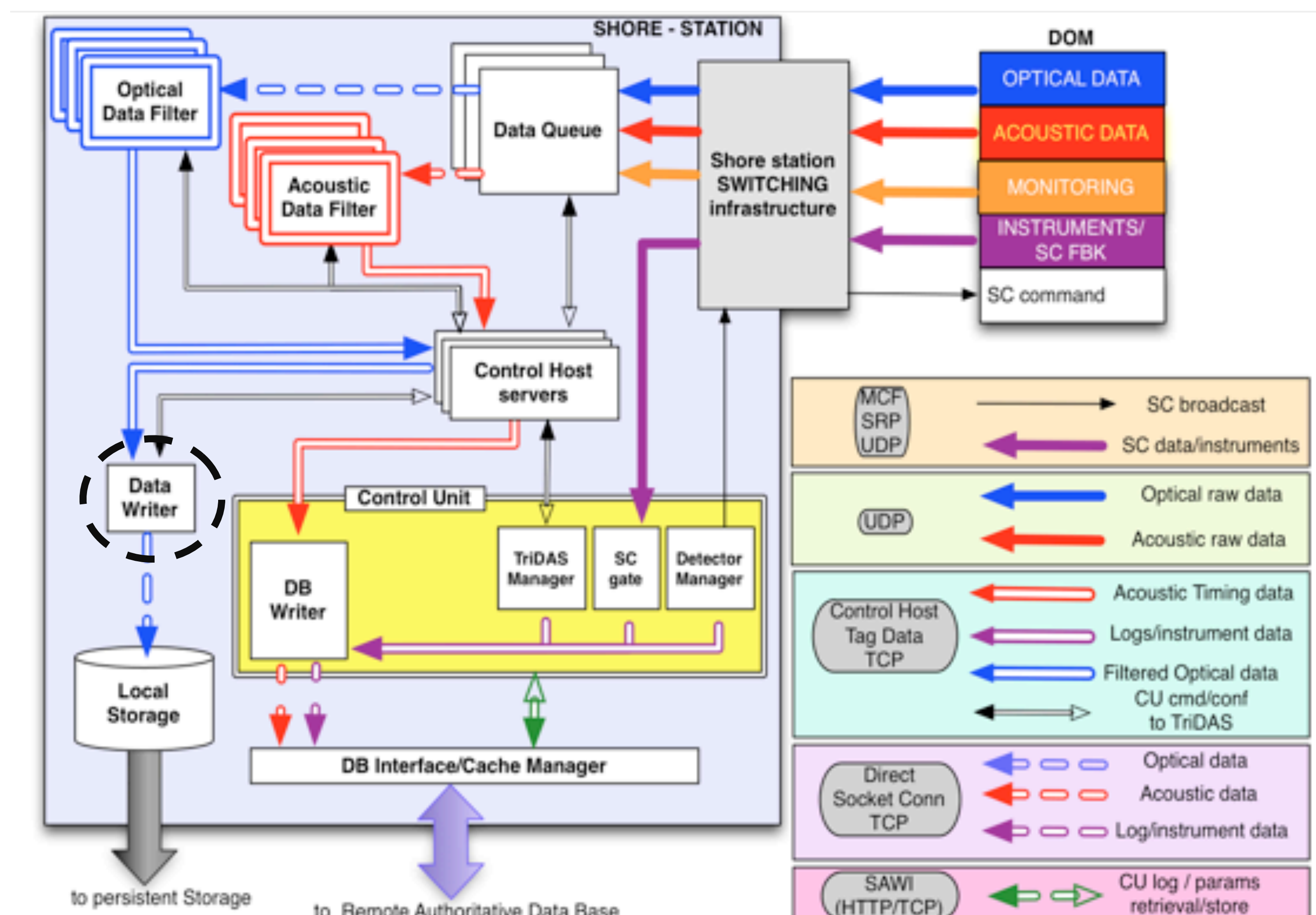
Motivation	Topological Trigger	Simple Causality Trigger	Sky Scan Trigger	Tracking	Stack-Analysis	Vertex / Inertia
muon	✔	✔	✔	✔	✔	✔
showers	✔	✔	✔	✔		✔
slowly moving particles	✔	✔	✔	✔		✔
sources	✔			✔	✔	✔

B. Bakker Thesis, *Trigger studies for the Antares and KM3NeT neutrino telescopes, Nikhef 2011*

But other algorithms are under development...

DataWriter

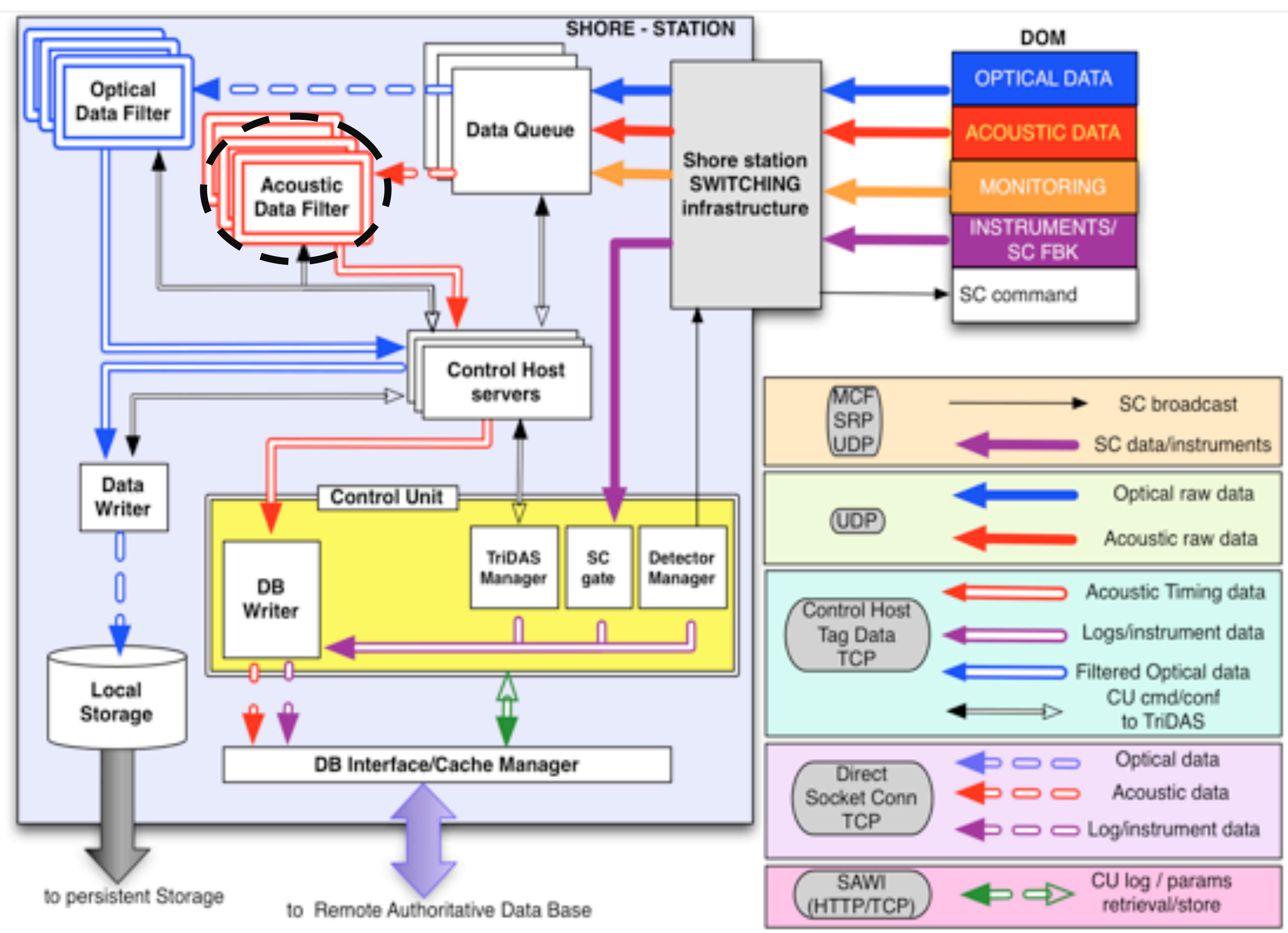
The DataWriter collects the filtered data coming from the various oDFs and performs write operation on permanent storage media in a ROOT compatible data format.



Acoustic DataFilter

The acoustic DataFilter (aDF) performs online calculation of the Time-Of-Arrival (TOA) of the acoustic signals emitted by the ground-based acoustic beacon array.

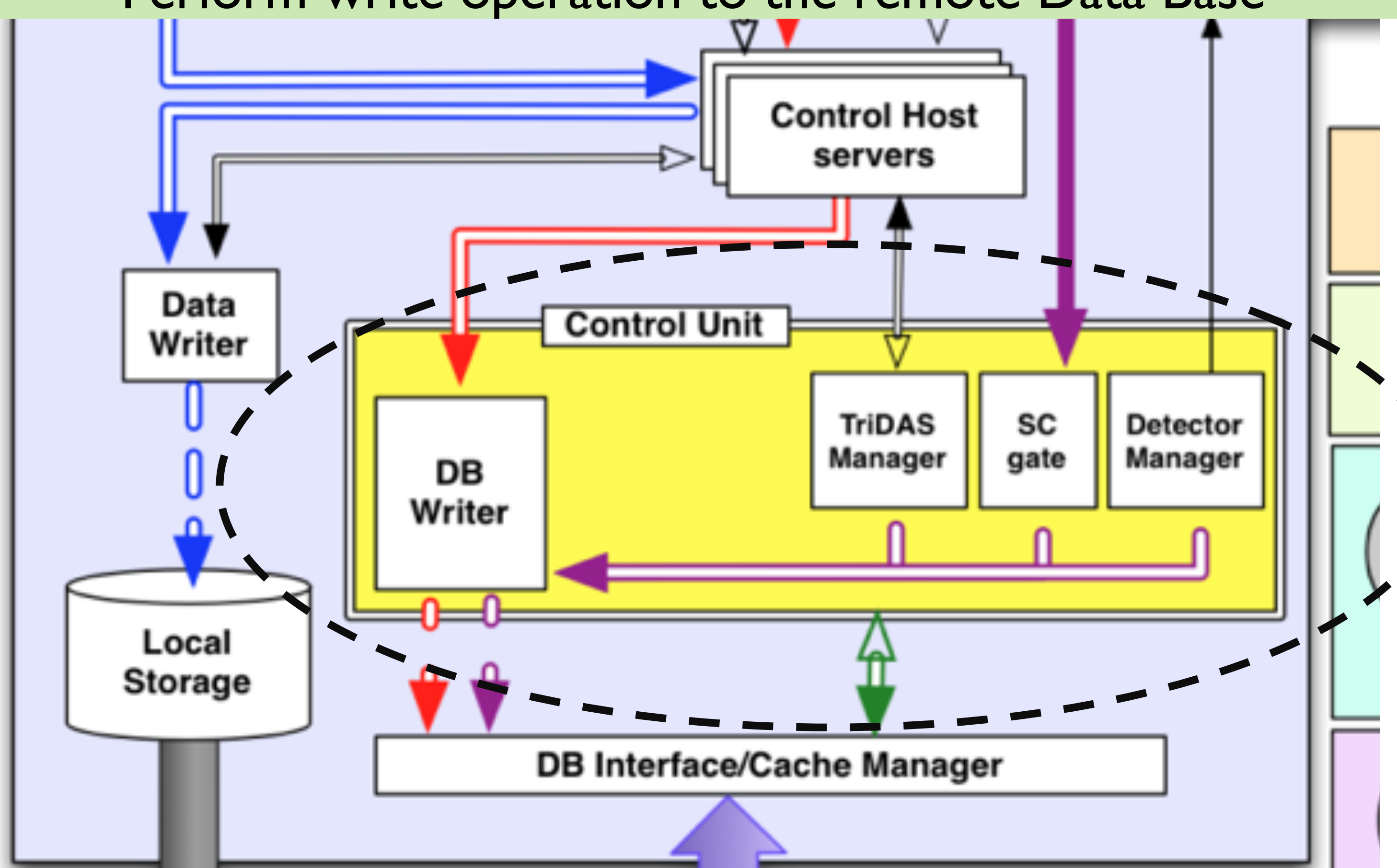
- Calculate the TOA using the data from all the sensors (piezo + hydrophone) collected on-shore by a DQ
- Send data directly to the DB Writer



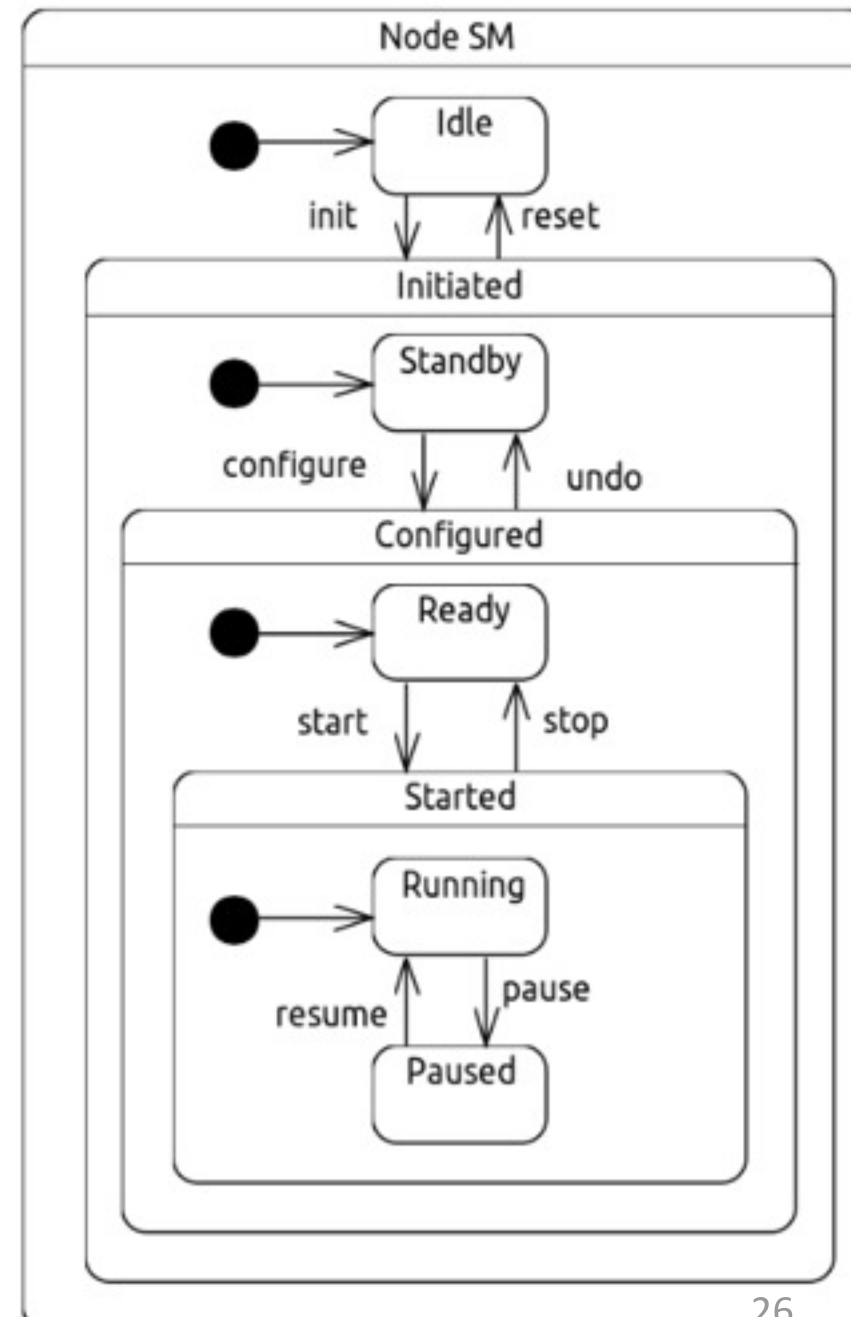
Control Unit

The Control Unit (CU) is composed of 4 elements:

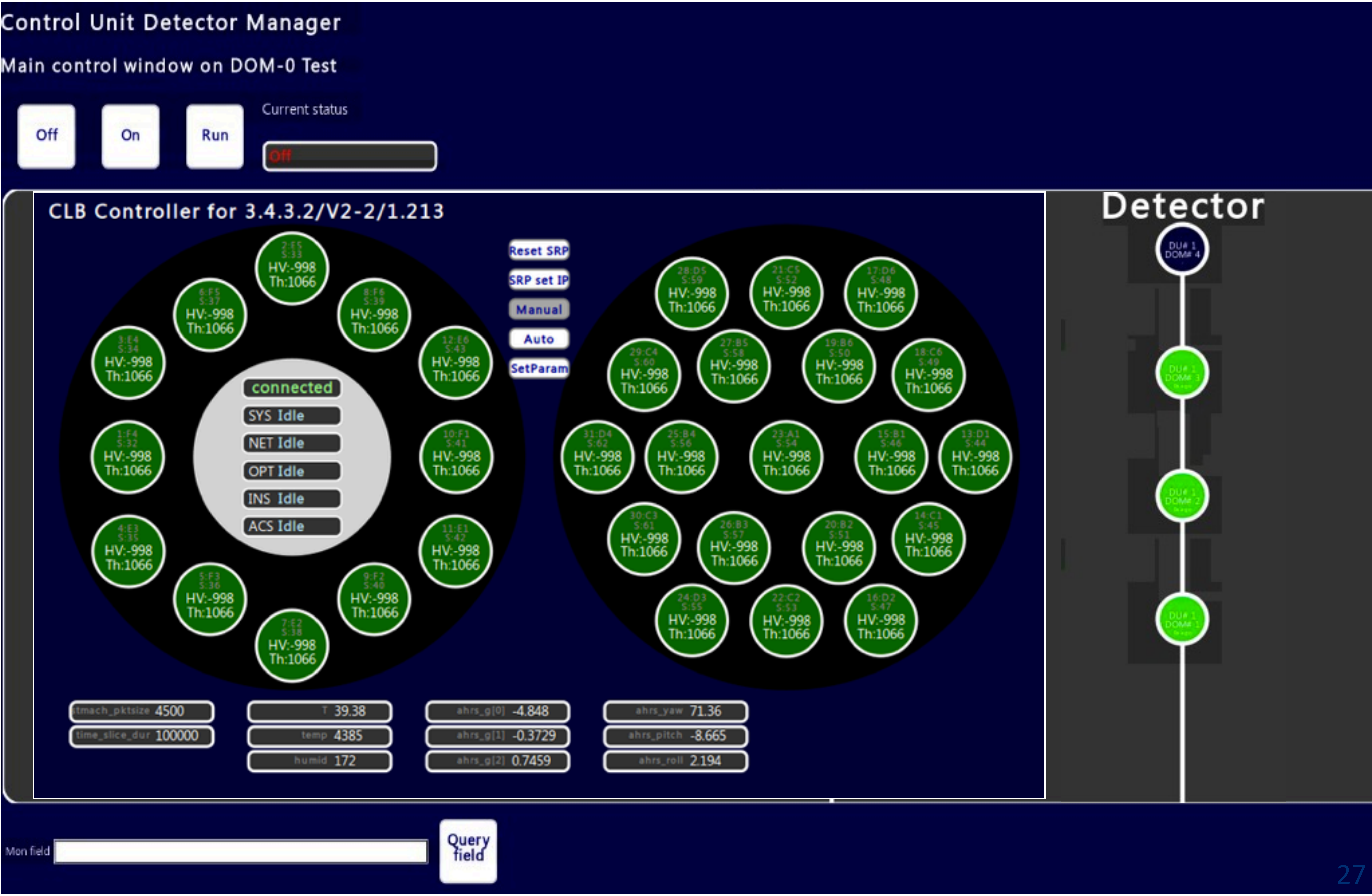
- **Detector Manager (DM):**
  - Perform complete configuration of the CLBs (PMT HV, instruments, etc…)
  - Record all parameters and the occurring events
  - Provide online monitoring of sensible parameters/ measurements
- **Tridas Manager (TM):**
  - Operate the TriDAS computing farm
- **SC Gate:**
  - Read-out of the SlowControl data
- **DB Writer**
  - Perform write operation to the remote Data Base



The **CU** controls the offshore detector and the onshore processes via a Finite State Machine



Detector Manager - Web GUI

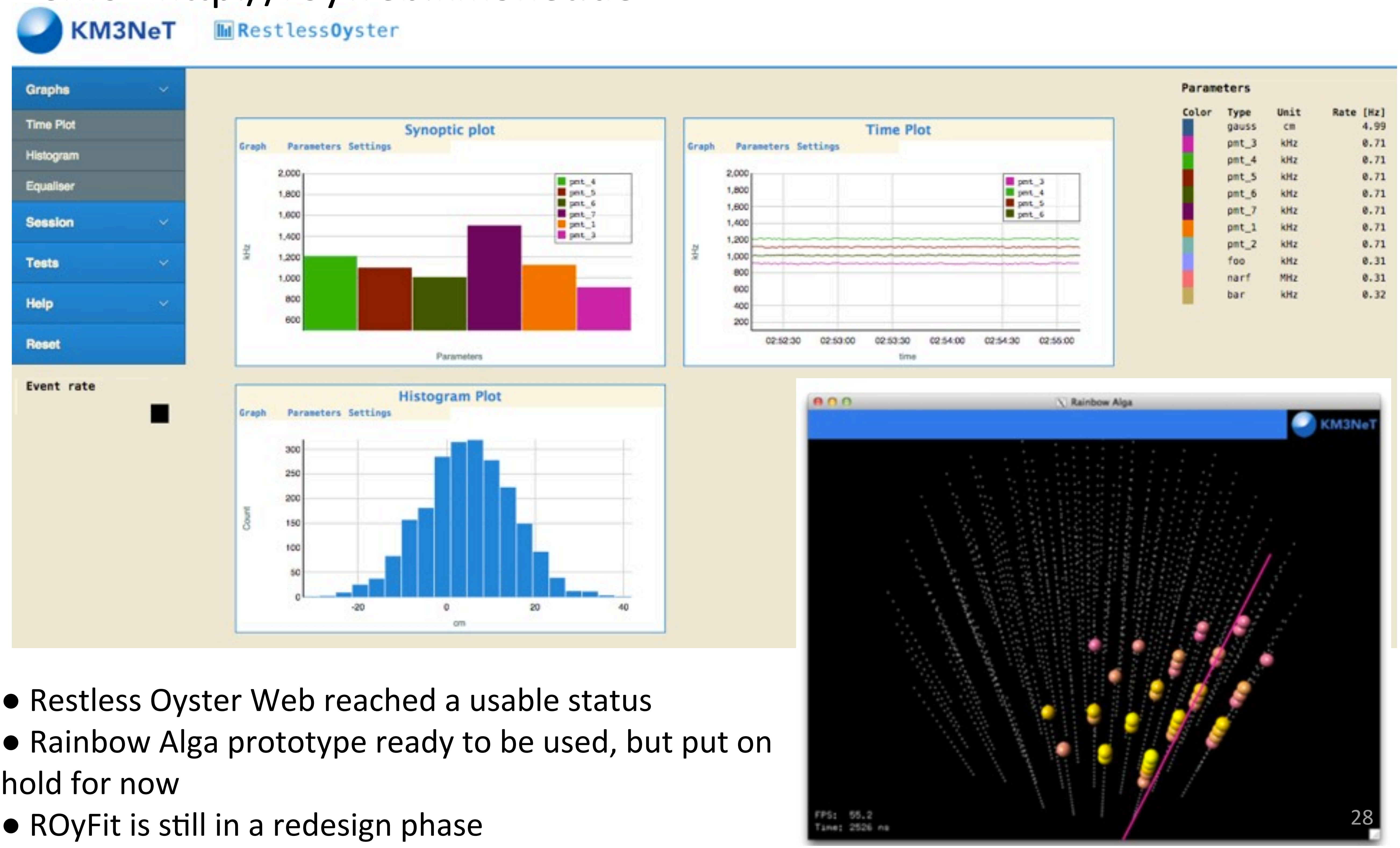


Monitoring Tools: ROyWeb, Rainbow Alga, ROyFit

Python-based web server - UDP-JSON

Python and C++ API classes

Demo - http://royweb.km3net.de



- Restless Oyster Web reached a usable status
- Rainbow Alga prototype ready to be used, but put on hold for now
- ROyFit is still in a redesign phase

Policies for test procedures and releases

Current Phase (development):
- single developer tests on private resources
- software deployment on the *Bologna Common Infrastructure*
- integration tests (API) within the DAQ chain
- long duration tests/test stress probing/checking requirements
- validation and release

Regime Phase (maintaining/upgrading):
- well identified reasons for migration/upgrade (proposal by main developers)
- release candidate
- validation period (e.g. test in parallel running mode)
- release/deployment
- official announcement (documentation: internal note + Wiki)

Software managing

Repository and software version: SUBVERSION

http://svn.km3net.de/

Software Configuration Manager: trac
Integrated SCM & Project Management

http://trac.km3net.de

Continuous Integration: Jenkins

http://jenkins.km3net.de

Software distribution: Open Source Puppet

Open source Puppet is a flexible, customizable framework available under the Apache 2.0 license designed to help system administrators automate the many repetitive tasks they regularly perform.

Conclusions

- Complex DAQ System
- Challenging techniques (Multi-PMT, WR)
- Currently Support to DOM Integration sites is giving us *REX*

We are looking further for the first DUs deployment next year.

Thanks for your attention!

SPARES

3. Monitoring and slow control: *monitoring datarate*

In the spreadsheet below, 4 storaging methods in the DB are presented.
All are based on the **Index-Organized-Tables (IOT)** together with a **flat "raw"** encoding.

For real numbers Oracle can allocate up to 22 bytes, but we don't t need such extreme precision. We can rescale real number to integers and coding them with 4 bytes.
The flat "raw" enconding implies that, in the DB , the data are not promptly ready to the user, but need to be decoded. If the user accesses the information through the DB Interface, the encoding/decoding is automatic.

A - Detector Customization Parameters

	Phase 1	Reference Det.	Phase 1.5	Phase 2
N. PMT / DOM	31	31	31	31
N. DOM/DU	18	18	18	18
N. DU/Detector	31	115	230	690
sampling frequency (Hz)	0.1	0.1	0.1	0.1

B - Summary of the data size per DOM

Data Size	112
Time Index Size	424
Parameter Long Index Size	477
Parameter Short Index Size	53
Flat storage Size	1013

C - Summary of the record entry per DOM

	Bare storage size(local keys + data)	Key Overhead (16 + 10% of data+key)	Safe Total/record
IOT (parameter, timestamp)	545	71	616
IOT (Timestamp, long parameter key)	597	76	673
IOT (Timestamp, short parameter key)	173	34	207
Flat Table	1445	161	1606

D - Summary of the Total GB/year

IOT (parameter, timestamp)	1010	3746	7491	22471
IOT (Timestamp, long parameter key)	1103	4092	8184	24550
IOT (Timestamp, short parameter key)	*340*	*1259*	*2517*	*7551*
Flat Table	*2633*	*9764*	*19528*	*58584*

More on data-rates

Input parameters

Case	n_{DU}	n_{layers}	$n_{pmt/layer}$	ν_{single} (kHz)	$\nu_{trigger}$ (Hz)	hit size (bit)
KM3NeT−Ph1,It	24	18	31	10	40	50
KM3NeT−Ph1,Fr	7	18	31	10	13	50
KM3NeT−Block	115	18	31	10	220	50
KM3NeT−Ph1.5	230	18	31	10	440	50
KM3NeT−Ph2	690	18	31	10	1320	50

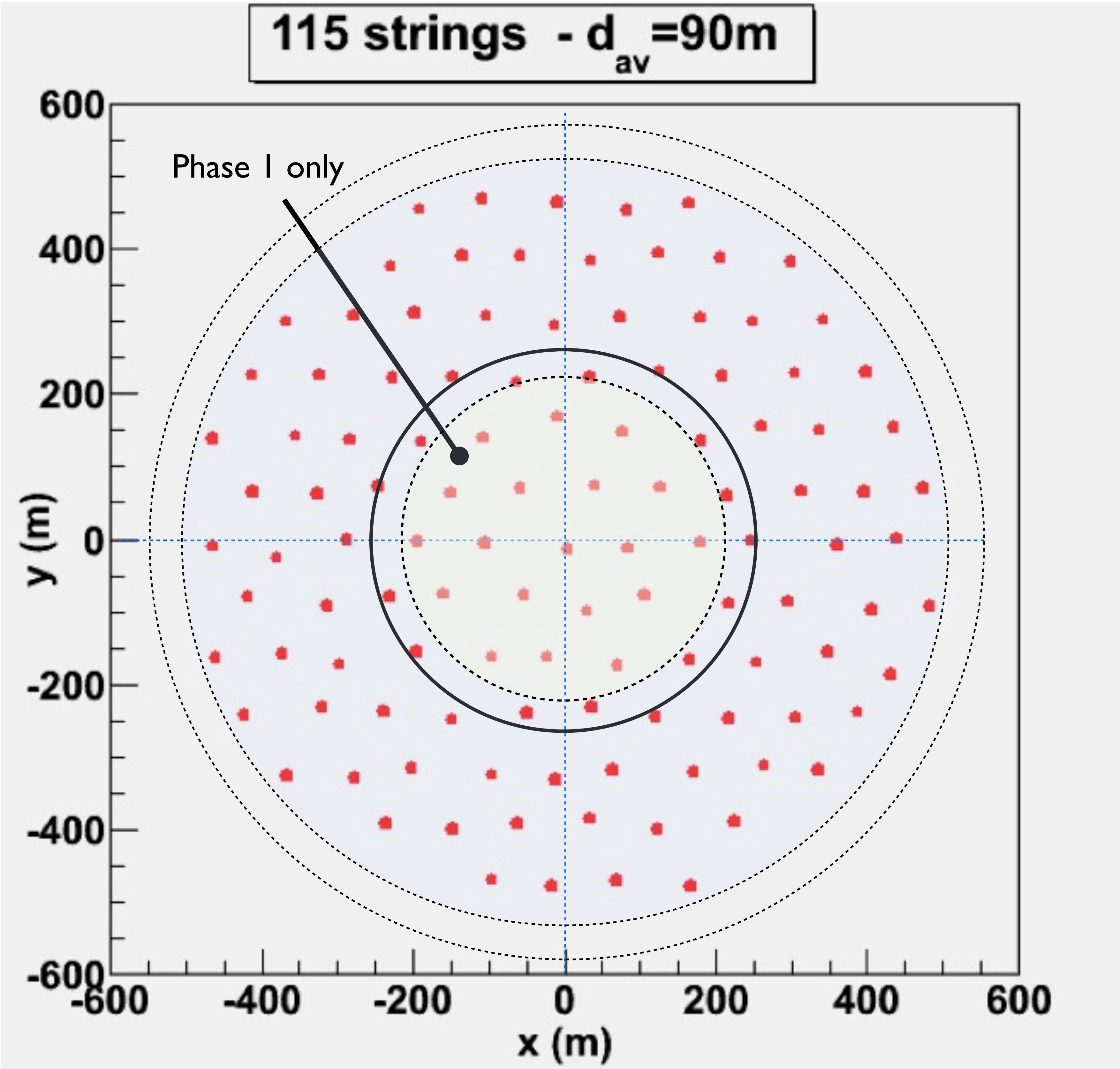
See next slide

Simply

1 Block ×2 (Ph. 1.5)

1 Block ×6 (Ph. 2)

1. Data transfers methods: Reference VS Phase 1 detectors



	Ph.I	ref det
R Can (m)	~240	~550
H Can (m)	700	700
depth (m usl)	3500	3500

From MC draft estimation:
ref det muon rate ~ 220 ev/s

=> Ph.I muon rate ~
ref det muon rate $(240/550)^2$
~ 40 ev/s

1. Data transfers methods: optical data-rate expectations

$$\textbf{Det thp} = (n_{DU}\, n_{layers}\, n_{pmt/layer})\, \nu_{single}\, S_{hit}$$

$$\textbf{Sel thp} = \text{Det thp} * (\nu_{trigger}\, \Delta T_{ev}) + \text{Min Bias}$$

with

$$\text{Min Bias} = \text{Det thp} * f$$

$\Rightarrow$

$$\textbf{Sel thp} = \text{Det thp} * (\nu_{trigger}\, \Delta T_{ev} + f)$$

generally :

$\Delta T_{ev} = 6\,\mu s$; $f = 10^{-3}$;

This is a draft value, good for a first running phase. Later on it can be decreased.
Anyway, with $f = 10^{-3}$ the Min Bias component strongly *bias* the selected data!

with Min Bias

Case	Layer thp (Mb/s)	DU thp (Gb/s)	Det thp (Gb/s)	Sel thp (MB/s)	Sel thp (TB/day)	Stored (TB/y)	event size(kB)
KM3NeT−Ph1,It	16.0	0.3	6.7	1.0	0.09	33.0	5.0
KM3NeT−Ph1,Fr	16.0	0.3	2.0	0.3	0.02	8.3	1.5
KM3NeT−Block	16.0	0.3	32.0	9.3	0.80	290.0	24.0
KM3NeT−Ph1.5	16.0	0.3	64.0	29.0	2.50	920.0	48.0
KM3NeT−Ph2	16.0	0.3	190.0	210.0	19.00	6800.0	140.0

without Min Bias

Case	Layer thp (Mb/s)	DU thp (Gb/s)	Det thp (Gb/s)	Sel thp (MB/s)	Sel thp (TB/day)	Stored (TB/y)	event size(kB)
KM3NeT−Ph1,It	16.0	0.3	6.7	0.2	0.02	6.3	5.0
KM3NeT−Ph1,Fr	16.0	0.3	2.0	0.0	0.00	0.6	1.5
KM3NeT−Block	16.0	0.3	32.0	5.3	0.46	170.0	24.0
KM3NeT−Ph1.5	16.0	0.3	64.0	21.0	1.80	670.0	48.0
KM3NeT−Ph2	16.0	0.3	190.0	190.0	16.00	6000.0	140.0

note 1: in the above tables, 1 TB = 10^3 GB = 10^6 MB = 10^9 kB

note 2: Sel thp ~ const $n_{DU}\ \nu_{trigger} \sim n_{DU}^2$, if assuming $\nu_{trigger} \sim n_{DU}$

4. - part 2: OS, software platform etc...

ITEM	TYPE	VERSION/RELEASE	INFO
Operating system	Scientific Linux (SL)	6.4/x86_64	
	kernel	2.6.32-358.2.1	
	X11	1.5.0-4	libX11 libX11-devel libXpm libXpm-devel libXft libXft-devel libX11-common libXext libXext-devel
Compiler/Interpreter/ libraries	gcc	4.4.7-3	gcc-c++, compat-gcc-34-g77
	Python	2.7.2	
	java-openjdk	1:1.7.0.45-2.4.3.2	
	make	1:3.81-20	
	cmake	2.8.12.2	
	bison	2.4.1-5	
	mono	3.2.8	
	boost	1.41.0-15.el6_4.x86_64	
Scientific computing	ROOT	5-34-09	
Versioning	subversion	1.6.11-9	
	cvs	1.11.23	
Shells	bash	4.1.2(1)	GNU bash
	tcsh	6.17.00	Astron
	zsh	4.3.10	

The Bologna Computing Infrastructure (BCI)

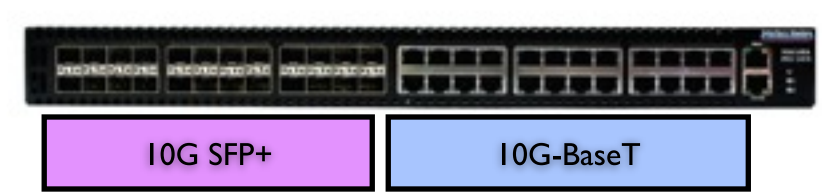
17 physical servers + 2 VMs (see next slide for details)

1 GbE Network: for connecting the public ifces and a private VLAN

48-port L2 Managed Gigabit Ethernet Standalone Switch with 4 combo ports

10 GbE Network: for special tests

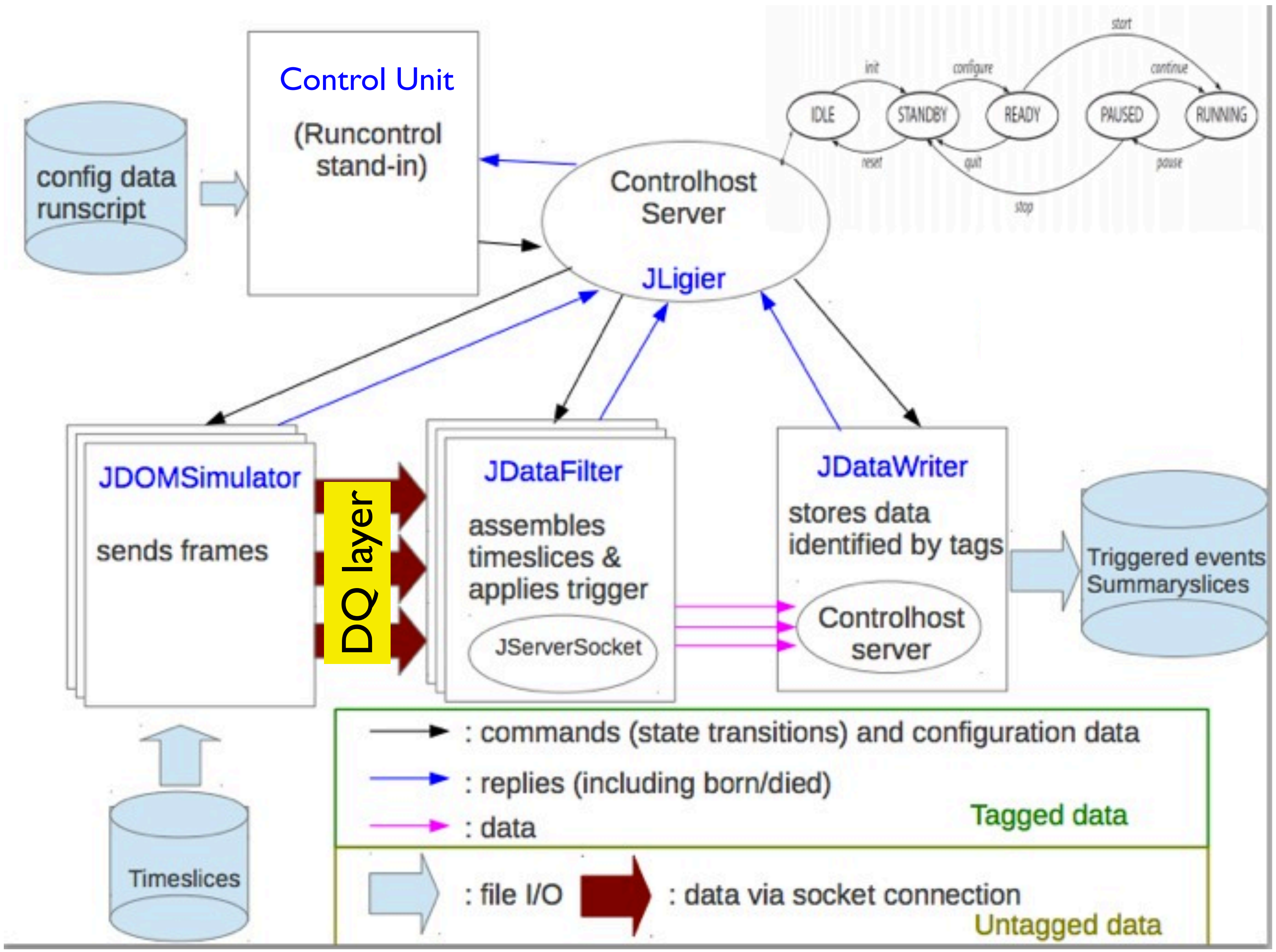
NIAGARA 2924-24TX



BCI - computing resources

name	physical(p)/ virtual(v)	n. cores	mem (GB)	disc (GB)	n. nics (1 GbE)	n. nics (10 GbE-T)	n. nics (SFP+)	single	twin	twin^2
km3tridas1	p	4	8	1x250	2			x		
km3tridas2	p	8	8	1x250	2			x		
km3tridas3	p	8	8	1x250	2			x		
km3tridas4	p	8	8	1x250	2			x		
km3tridas5	p	16	10	1x320	2				x(1a)	
km3tridas6	p	16	12	1x320	2				x(1b)	
km3tridas7	p	24	50	1x1024	4				x(2a)	
km3tridas8	v		10	1x50						
km3tridas9	p	24	50	1x1024	4				x(2b)	
km3tridas10	v		10	1x50						
km3tridas11	p	4	32	2x1024	2	2		x		
km3tridas12	p							x		
km3tridas13	p							x		
km3tridas14	p	16	128	1x1024	2	1	1			x(a)
km3tridas15	p	16	128	1x1024	2	1	1			x(b)
km3tridas16	p	16	128	1x1024	2	1	1			x(c)
km3tridas17	p	16	128	1x1024	2	1	1			x(d)
km3tridas18	p	24	64	1x1024		2				
km3tridas19	p	24	64	1x1024						
lxstorage1	p	16	16	15368	2					
lxstorage2	p	4	2		2					

Current Test-Bed in the BCI



NEXT also other tests listed in previous SC slides (soon also in TDR WiKi)

Control Unit features

High flexibility

- Customizable GUI via HTML files
- Easy read-out of the parameters via HTTP/JSON

  http://<mysrv>:1302/mon/clb/outparams/pmt_threshold@/1/1/2

- Manual mode (authorization required)

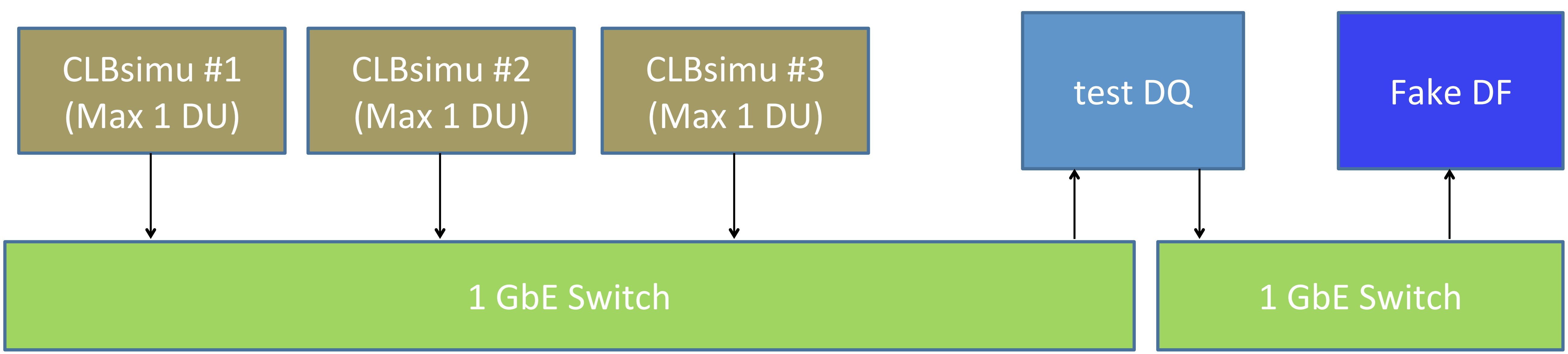
  http://<mysrv>:1302/override?inp=pmt_highvolt&inv=-1500&du=1&dom=2&pos=3&scope=0

Security

- Authentication required
  - Local Authentication Provider + DBInterface
- «Jolly token» to be used in test benches
  - To be configured at Detector Manager start-up

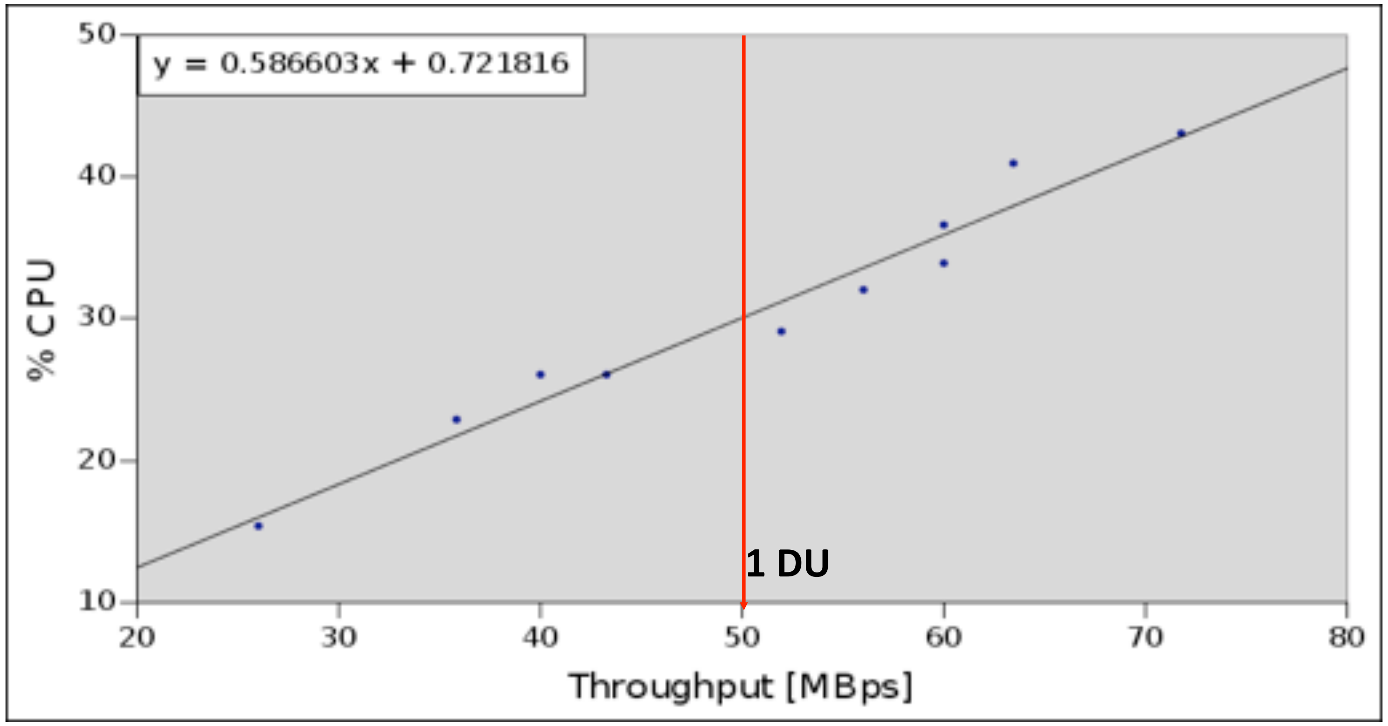
Performance tests

DQ tests performed on the Bologna Common Infrastructure (BCI) using a 81 HEP-SPEC06 (http://w3.hepix.org/benchmarks/doku.php/) computer (km3tridas5). All processes running on different server.



Performance tests results

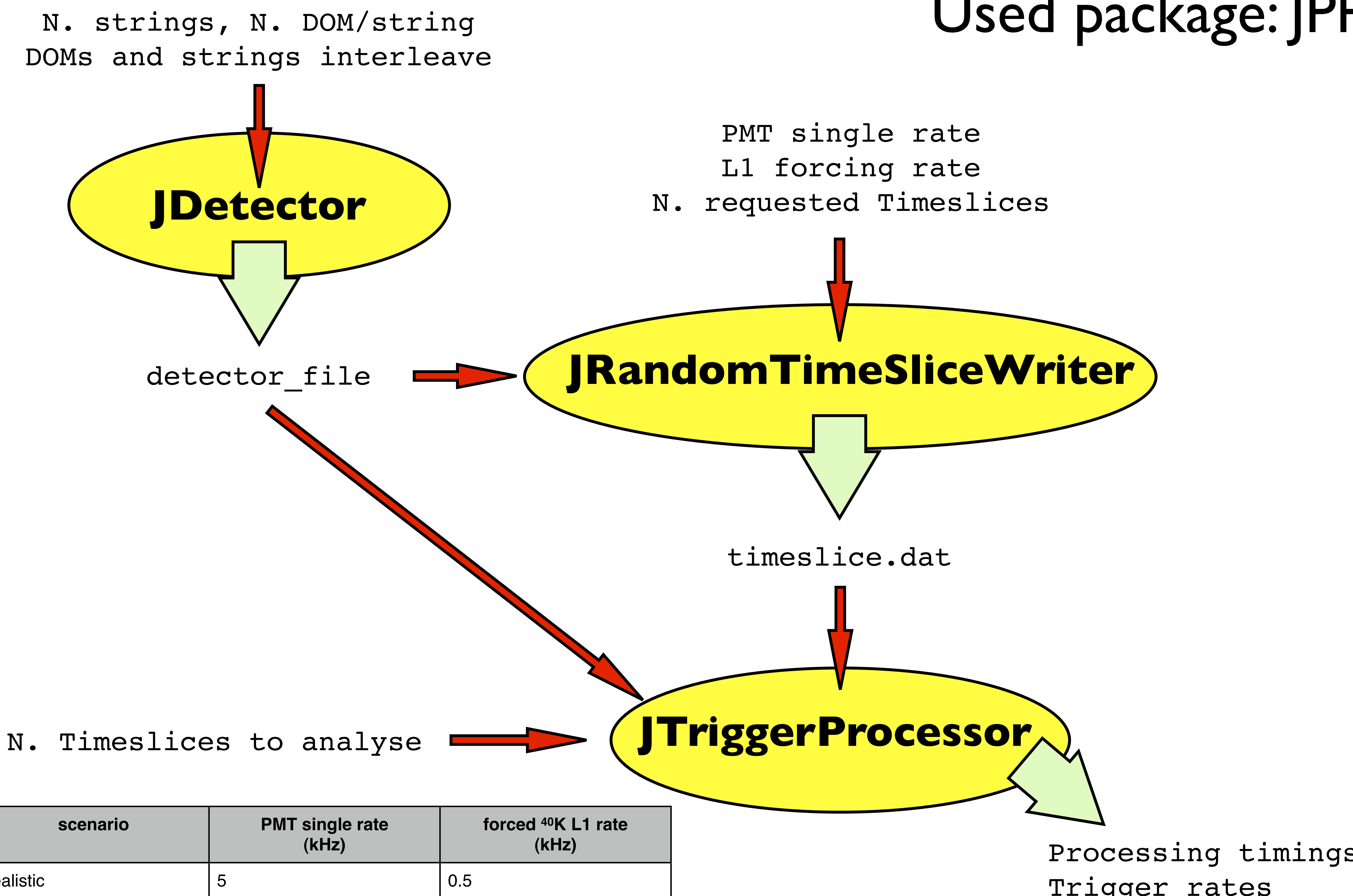
Unexpectedly, the DQ is CPU-bound!!! The most resource hungry task is receiving data from UDP sockets.



MTU	DUs allowed for a single DQ process
1500 Bytes	≈3.4
9000 Bytes	≈13.4

Estimating the computing resources: Data Filter processes

Used package: JPP

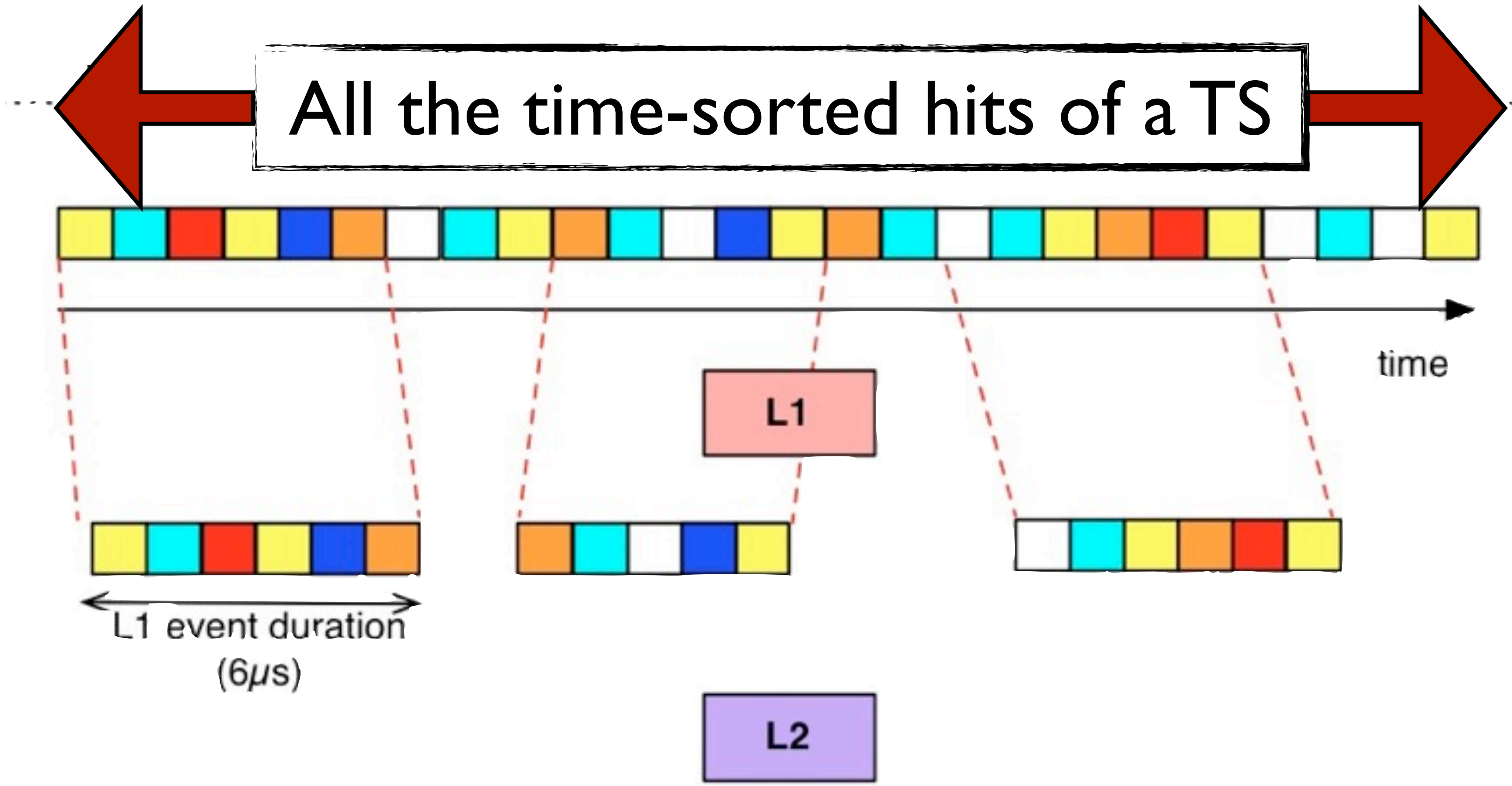


scenario	PMT single rate (kHz)	forced ^{40}K L1 rate (kHz)
realistic	5	0.5
conservative	15	1.5

Phase 1 (26 strings)	REALISTIC settings (5 kHz/PMT) (ms) average on 400 TS	CONSERVATIVE settings (15 kHz/PMT) (ms) average on 50 TS
I/O	293	1100
Calibration	43	126
L1 Search	201	600
TimeSlice routing	20	35
Trigger search	5	60
Trigger routing	0	3
Total (no I/O)	269	824
global queueing time overhead	41	122
Grand Total	310	946
Time Ratio	**4:1**	**10:1**

Reference detector (120 strings)	REALISTIC settings (5 kHz/PMT) (ms) average on 200 TS	CONSERVATIVE settings (15 kHz/PMT) (ms) average on 50 TS
I/O	1080	4859
Calibration	200	600
L1 Search	900	2700
TimeSlice routing	61	114
Trigger search	64	3500
Trigger routing	0.3	340
Total (no I/O)	1225.3	7254
global queueing time overhead	187	561
Grand Total	1412.3	7815
Time Ratio	**15:1**	**79:1**

Trigger Levels



L1 = PRESELECTION

L2 = Dedicated Trigger Algorithm

✔ Most of the algorithms reported here are currently working in ANTARES

L1 - PRESELECTION

A

Simple Coincidences

$\Delta T \leq 10$ ns

B

large ToT hit

$\sim Q > Q_{th}$

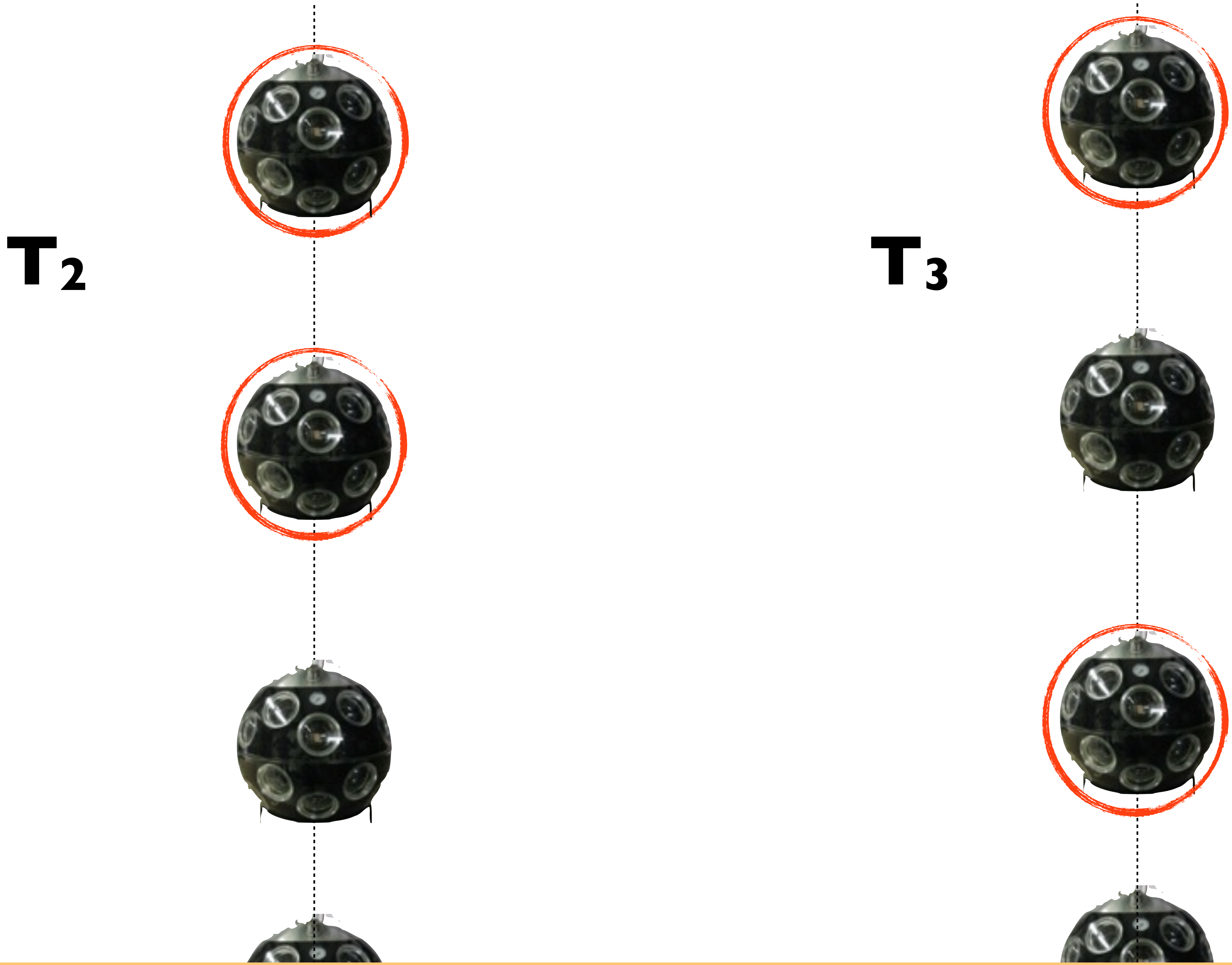
$$\nu_{out} = \frac{1}{\Delta T}\binom{n}{k}p^k(1-p)^{n-k}, \qquad p = 1 - e^{-\Delta T\,\nu_{bkg}}$$

Sampling Window ΔT

n = n. involved PMTs

k = minimum searched hits within ΔT

✔ L2 - **T-trigger**: clusters of *L1*s



The trigger is set when the n. of consecutive T_2 or T_3 pairs is $\geq N_{th}$ within a certain time-window **ΔT**

✔ L2 - **Simple causality trigger**

1. A minimum n. of ***consecutive*** L1s ≥ N_{th} within a ΔT (at least $n_{PMTs} \geq 5$)

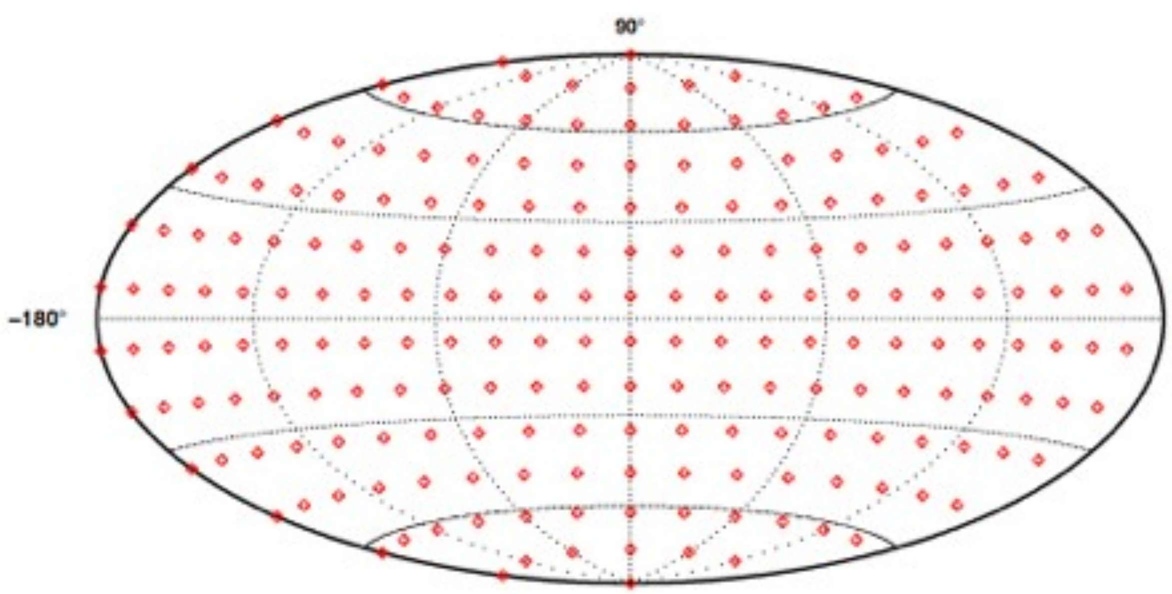
2. *3D*-causality filter : $$\left| t_i - t_j \right| \leq \left| \vec{x}_i - \vec{x}_j \right| \frac{n}{c}$$

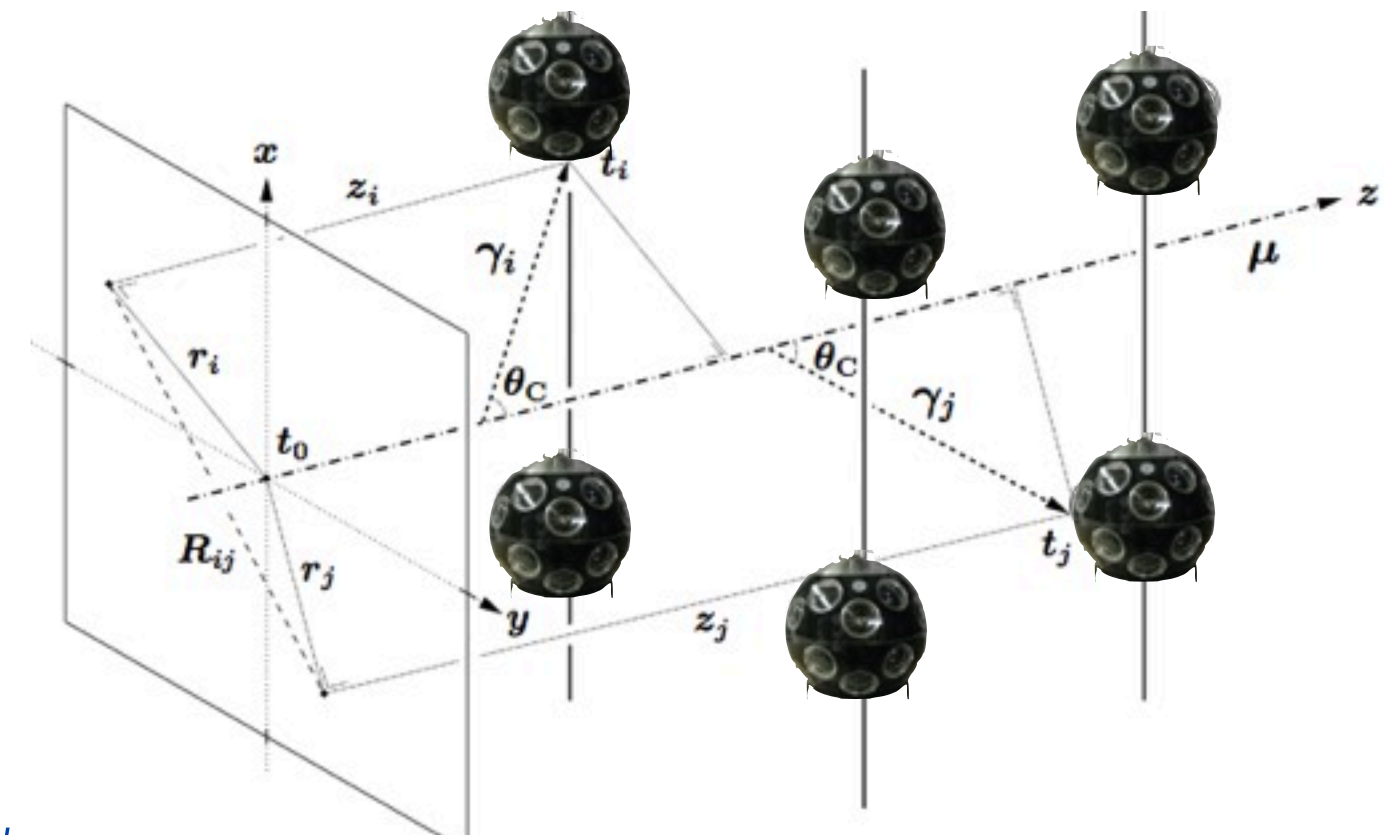
3. The trigger is set if the n. of satisfying hits is ≥ N'_{th}

✔ L2 - Sky scan trigger

1. A minimum n. of ***consecutive*** L1s ≥ N_{th} within a ΔT (at least $n_{PMTs} \geq 5$)

2. A homogeneous sky survey is done → "***rotation***" *procedure:* μ // z

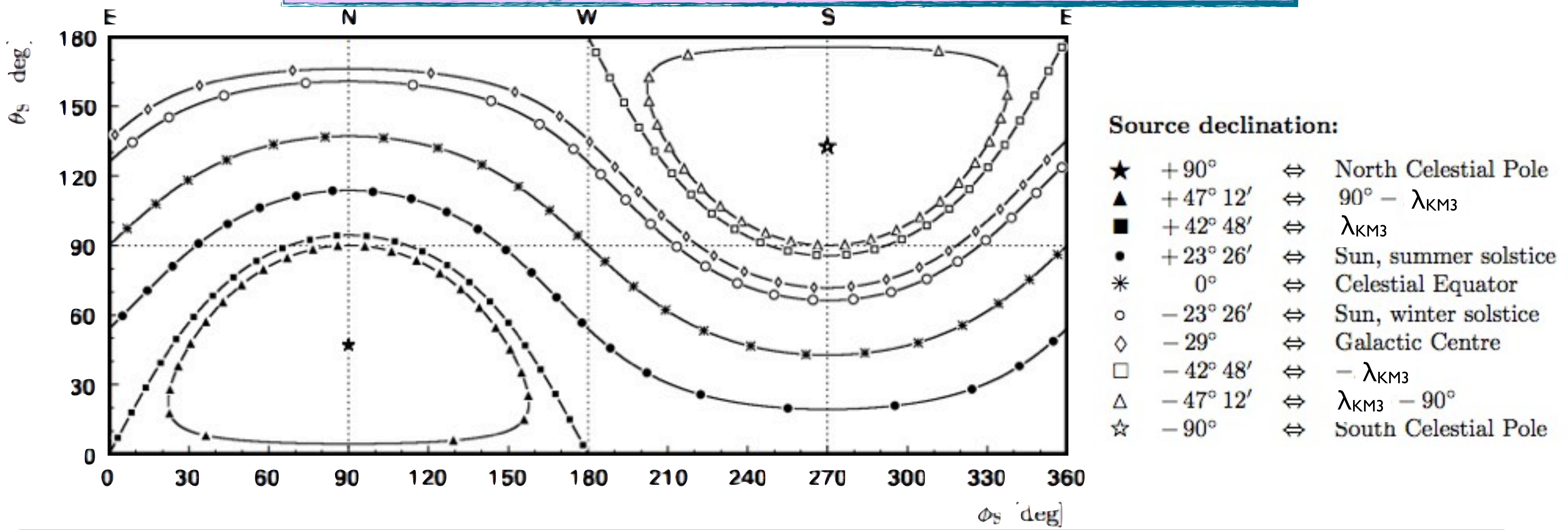




$$|(t_i - t_j)c - (z_i - z_j)| \leq \tan\theta_c \sqrt{[(x_i - x_j)^2 + (y_i - y_j)^2]} = \tan\theta_c |R_{ij}|$$

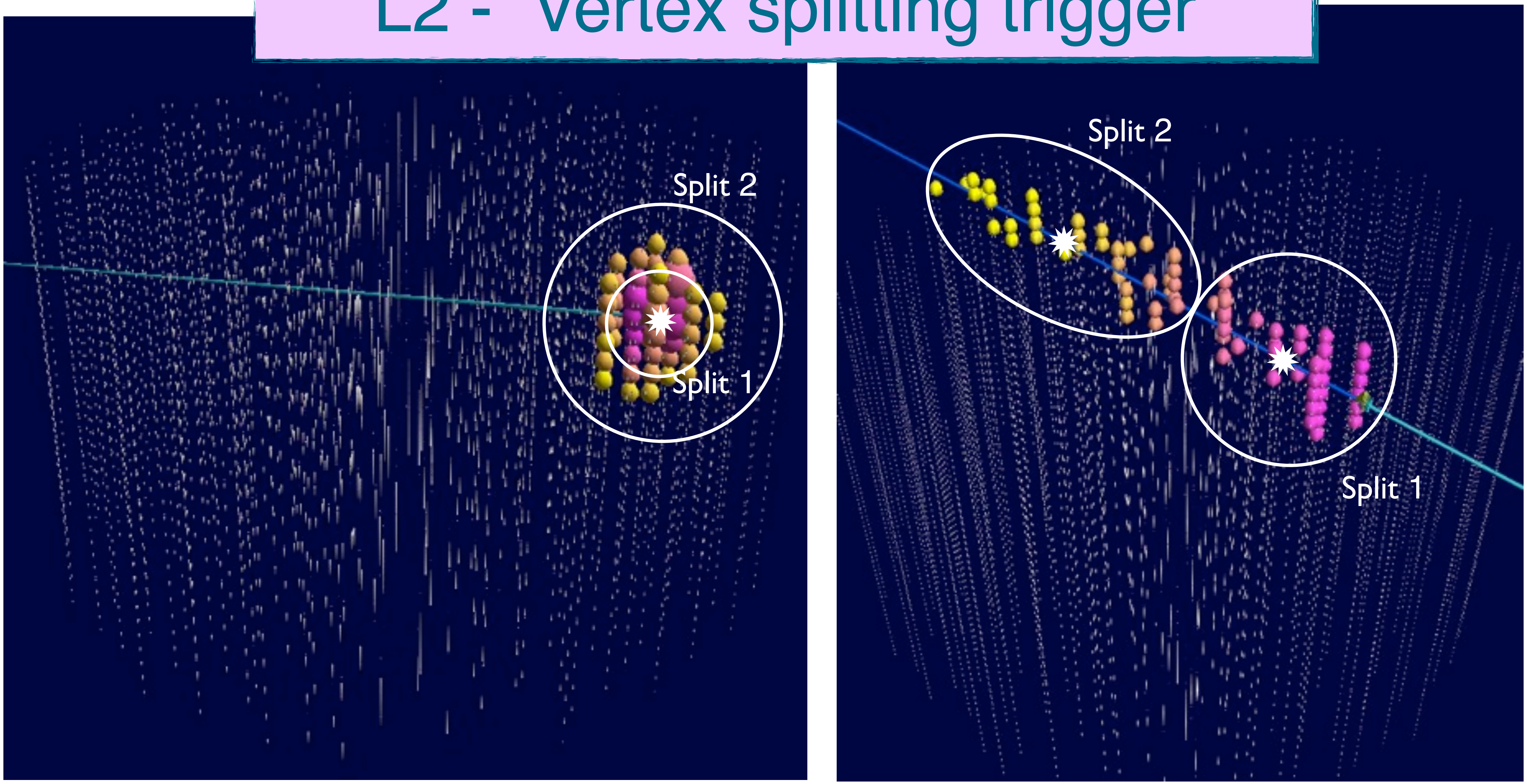
3. The trigger is set if the n. of satisfying hits is ≥ N'_{th}

✔ L2 - Source tracking trigger



1. From **GPS** time of timeslice → **source direction**
2. L1 preselected events with **even one seed** are accepted.
3. **All hits** of each event are tested with the "**rotation**" procedure (**road-width** R_{max} restriction w.r.t. direction)
4. A *cluster* is formed when found **N_{min} consecutive hits**, **L1 seed included**.
5. If **time-overlap** among clusters → **clusters are merged** into one only bigger cluster.
6. **Small clusters** are treated with a **quick reconstruction** (to avoid accidental clustering of bkg)
7. The trigger is set if PMT ***surface density*** (w.r.t. the convex hull ⊥ direction) ≥ σ_{th}

L2 - Vertex splitting trigger



1. Subdividing all the event hits in 2 time splitted groups
2. Vertexes reconstruction and vertex position discrimination
3. “Inertia” tensor eigenvalues ratio

$$I^{k,l} = \sum_{i=1}^{N} A_i(\delta^{k,l}\mathbf{r_i^2} - r_i^k r_i^l), \qquad \mathcal{T} = \frac{I_1}{I_1 + I_2 + I_3}.$$

inspired by IceCube

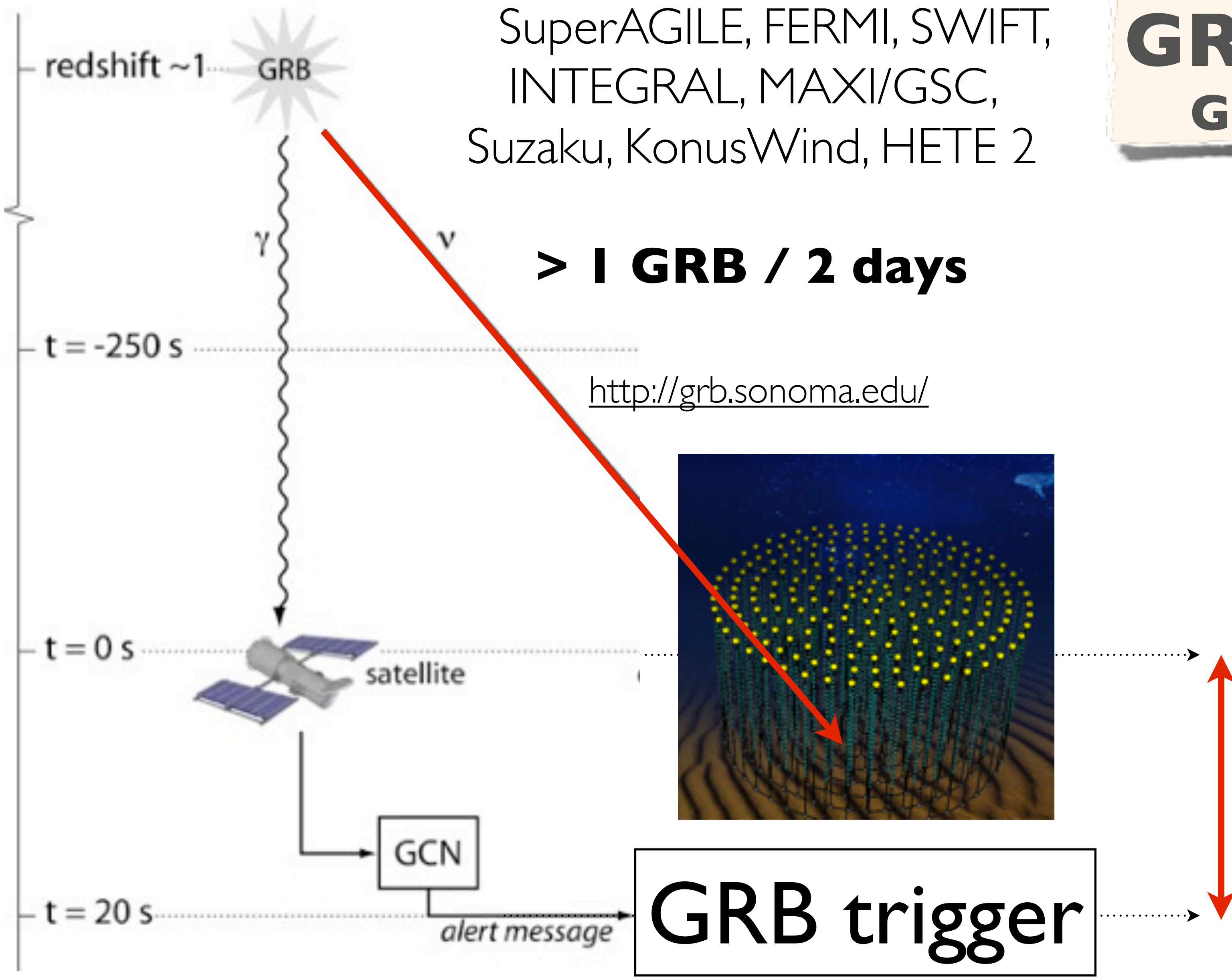
✔ L2 - Follow-up trigger

GRB alert system within the GRB Coordinate Network

SuperAGILE, FERMI, SWIFT, INTEGRAL, MAXI/GSC, Suzaku, KonusWind, HETE 2

> 1 GRB / 2 days

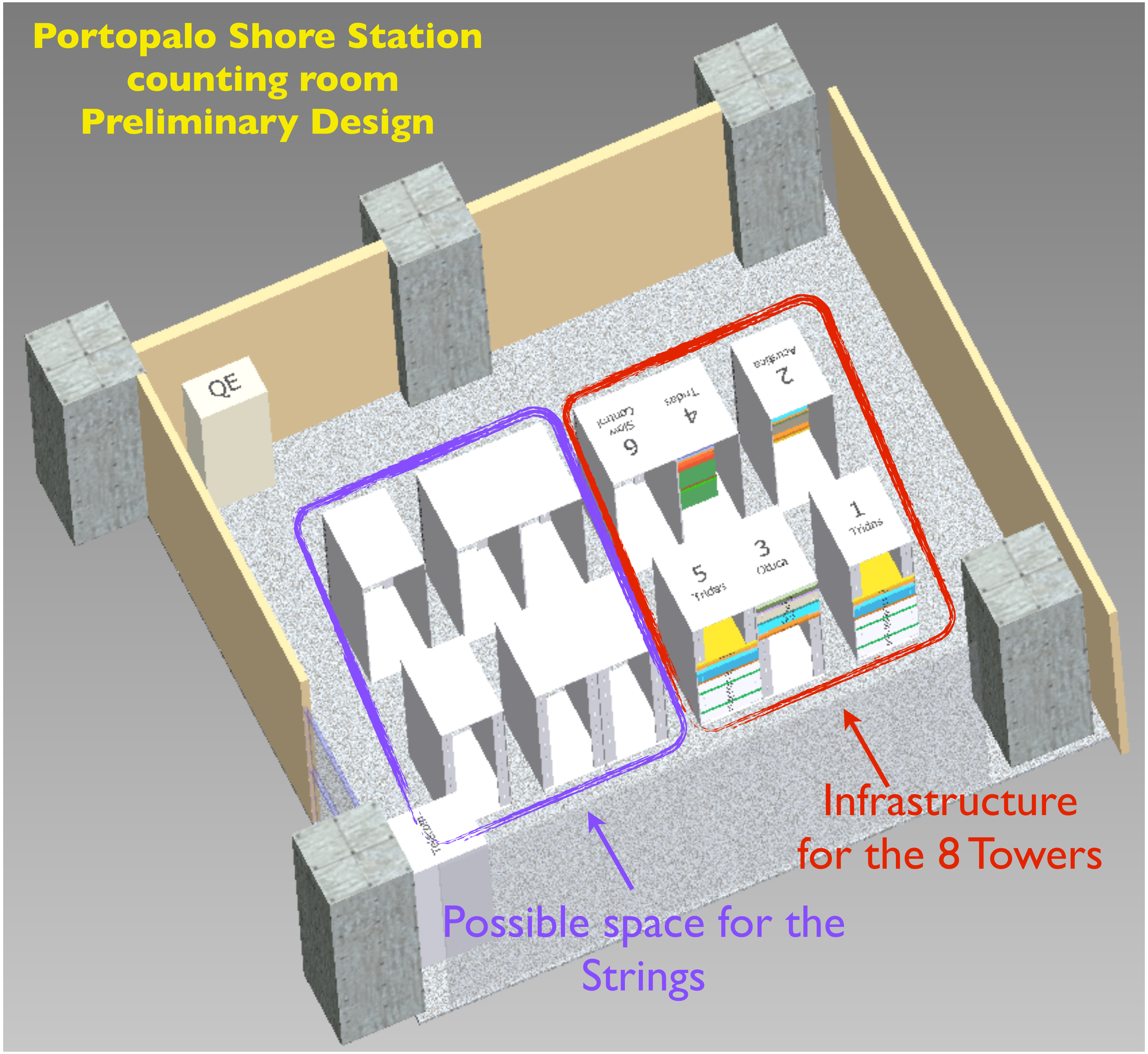
http://grb.sonoma.edu/



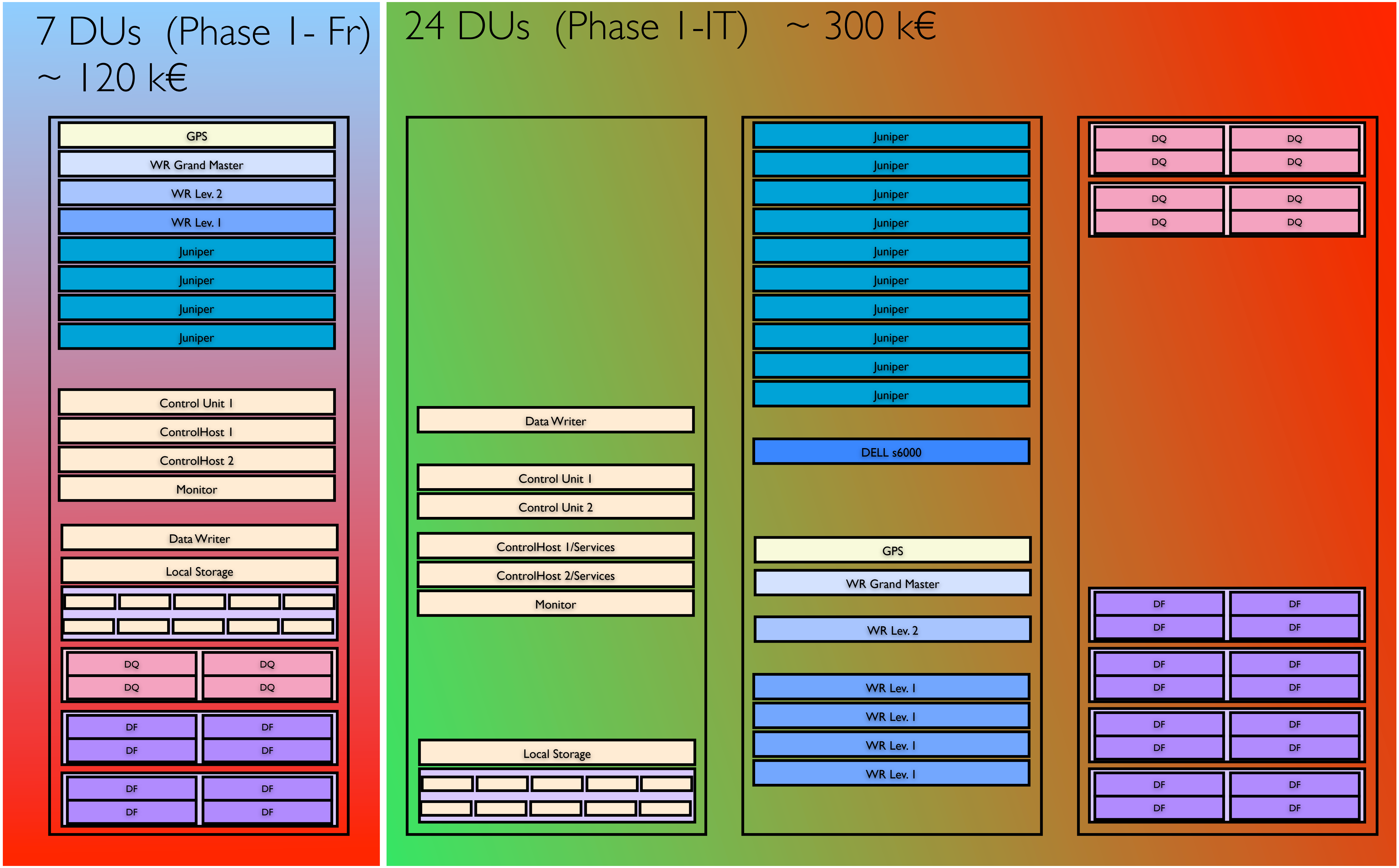
requested at least 20s of buffered data

... Buffering in the DataFilter .

... offline stack-analysis


Portopalo Shore Station
counting room
Preliminary Design
QE
Infrastructure
for the 8 Towers
Possible space for the
Strings

On the way for defining the ShoreStations - Hybrid Case



Strategy	Building stage	Purposes	Context	operations on DAQ data	Impact on DAQ	requirements of infrastructure implementatio	problems by DAQ design	Feasibility
Correlated events	offline	bundles, VHE/UHE events diffuse flux	correlation of absolute time	none	none	none	none	for free
Correlated DAQ	offline	sgmented events, (any events)	external trigger (follow-up);	none	rate of follow-up, managing of dedicated buffers	shared TriDAS switch fabric	none	medium
Integrated DAQ	online	any	standard triggers	Tower 2 String conversion on HMs	computing power at aggregation stages (HMs)	shared TriDAS switching and computing resources	none	complex