Introduction to the *String* DAQ/Readout

part I

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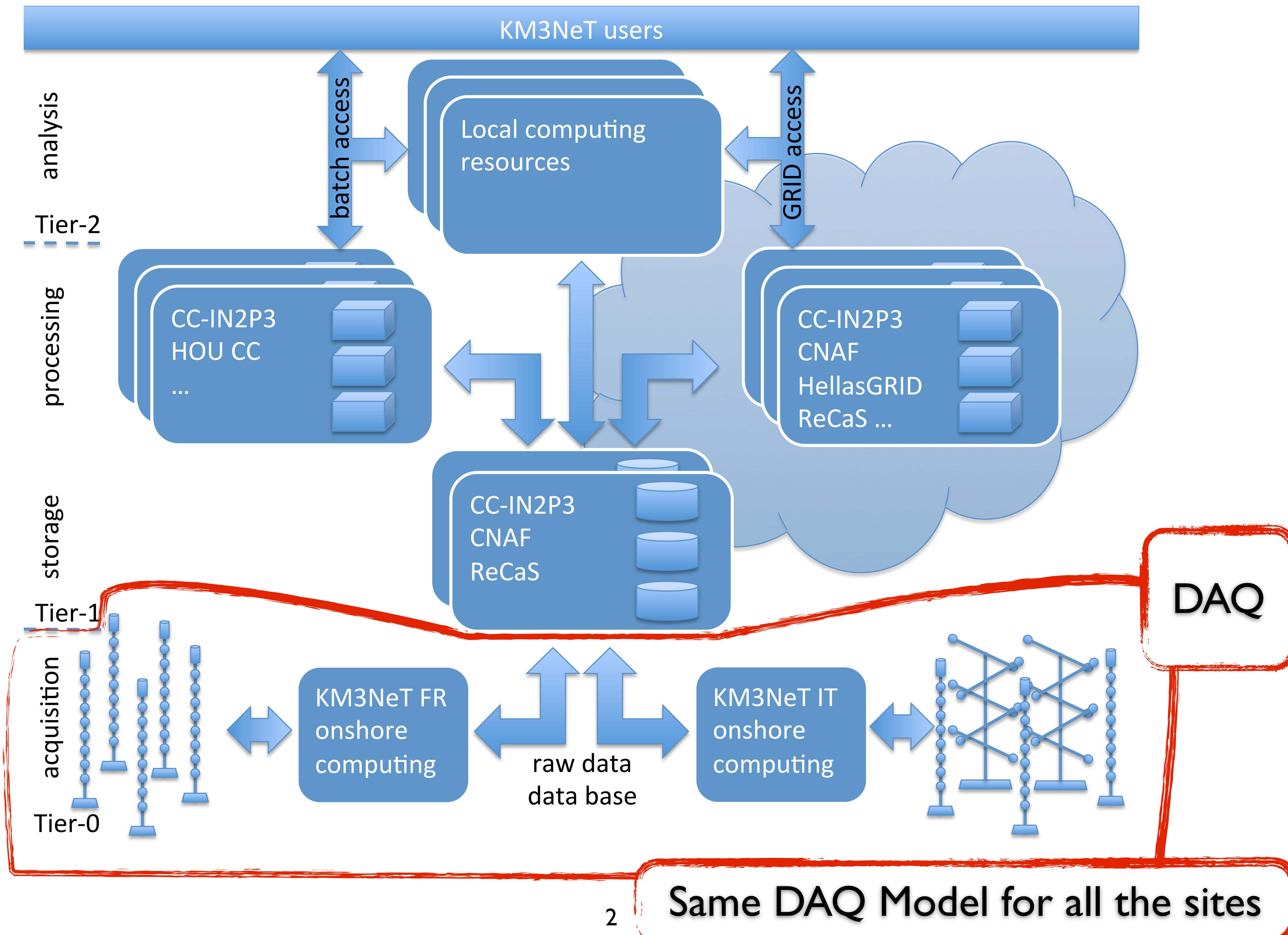
KM3NeT Data: from the sources to the comsumers…



Optical DAQ: *All data to shore*

KM3NeT-Eu

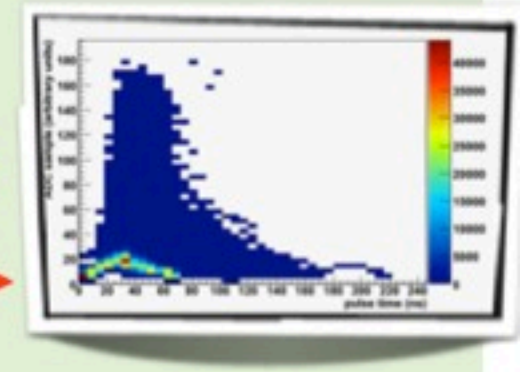
Hit PMT Info
Hit Abs Time
Hit ToT

6 Bytes

KM3NeT-Ita

Hit PMT Info
Hit Abs Time
Hit Charge
Hit Wave Form(samples) →

46 Bytes



Case (KM3NeT–Italia)		Expected (ν_{single} = 50 kHz)	Conservative (ν_{single} = 70 kHz)	Maximum (ν_{single} = 150 kHz)
10" PMT (0.25 p.e thresh.)	(Mbps)	18.0	25.0	53.0
Floor (6 PMT/Floor)	(Mbps)	110.0	150.0	320.0
Std Tower (14 Floors)	(Mbps)	1500.0	2100.0	4400.0
NEMO Phase 2 (8 Floors– 4 PMT/Floor)	(Gbps)	0.6	0.8	1.7
Full Detector (8 Std Towers)	(Gbps)	12.0	16.0	35.0

Case (KM3NeT–Europe)		Expected (ν_{single} = 6 kHz)	Conservative (ν_{single} = 10 kHz)	Maximum (ν_{single} = 15 kHz)
3" PMT (0.25 p.e. thresh.)	(Mbps)	0.3	0.5	0.8
DOM (31 PMT)	(Mbps)	9.3	16.0	23.0
String (18 DOM)	(Mbps)	170.0	280.0	420.0
Phase 1 (24 strings)	(Gbps)	4.0	6.7	10.0
Block (115 strings)	(Gbps)	19.0	32.0	48.0
Phase 1.5 (230 strings)	(Gbps)	39.0	64.0	96.0
Phase 2 (690 strings)	(Gbps)	120.0	190.0	290.0

Acoustic DAQ: for the positioning

KM3NeT-Eu

1 piezo sensor / DOM
1 Hydrophone / string base

total = 18 Piezo + 1 Hydrophone / String

KM3NeT-Ita

2 Hydrophone / floor
1 Hydrophone / tower base

total = 29 hydrophones / Tower

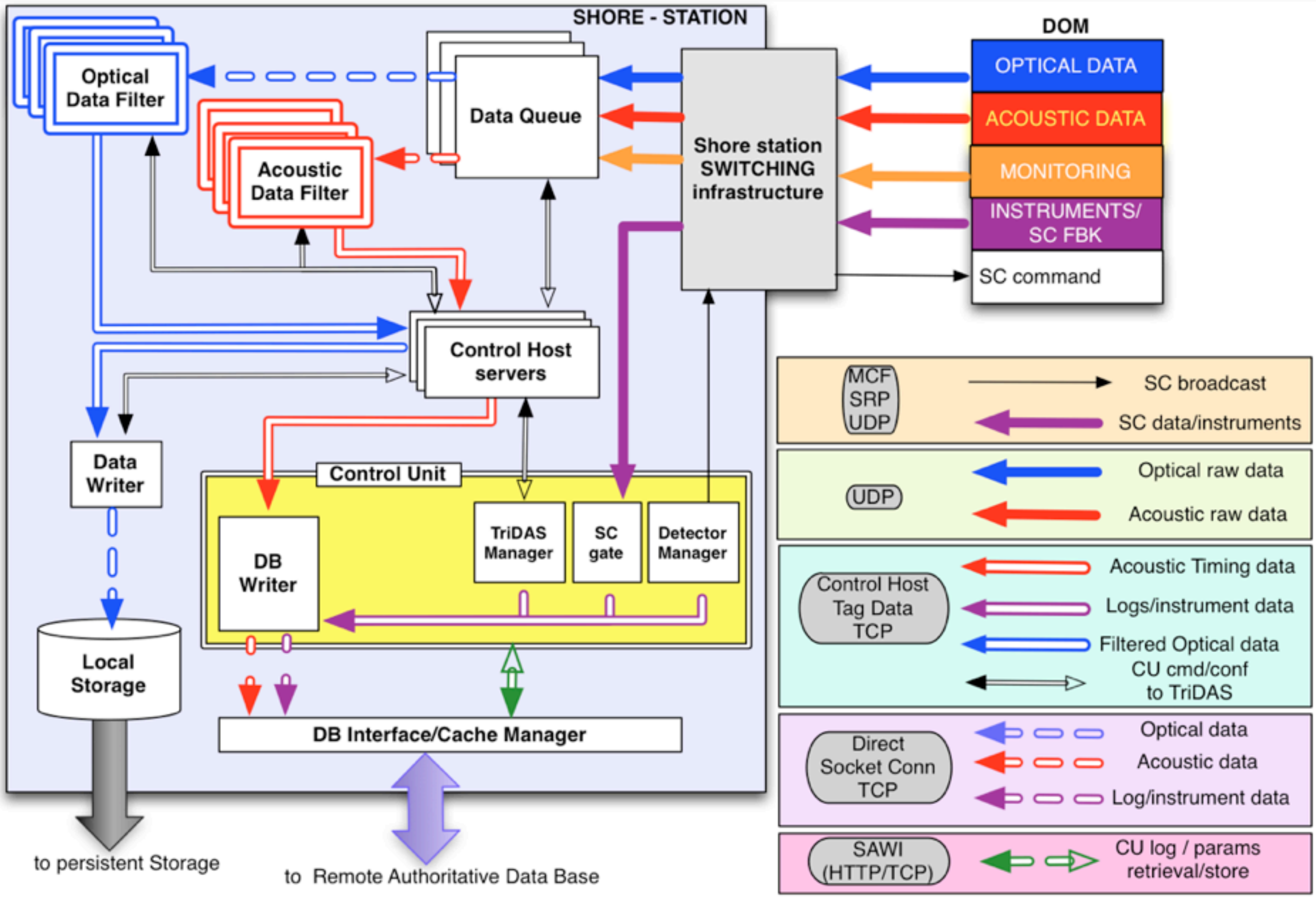
constant Sampling rate : 12 Mbps/sensor

Timings:
Rate per beacon: 0.1 Hz
N. Beacons: 10
Hyd ID : 2B
Beacon ID: 1 B
Timing (μs) : 16 B
Quality factor : 1 B
Total: 20 B = 160 bit

Positions:
Rate per info : 1 Hz
Timing (s): 8 B
Position: 3 × 4 B
Quality Factor : 1 B
Total: 22 B = 172 bit

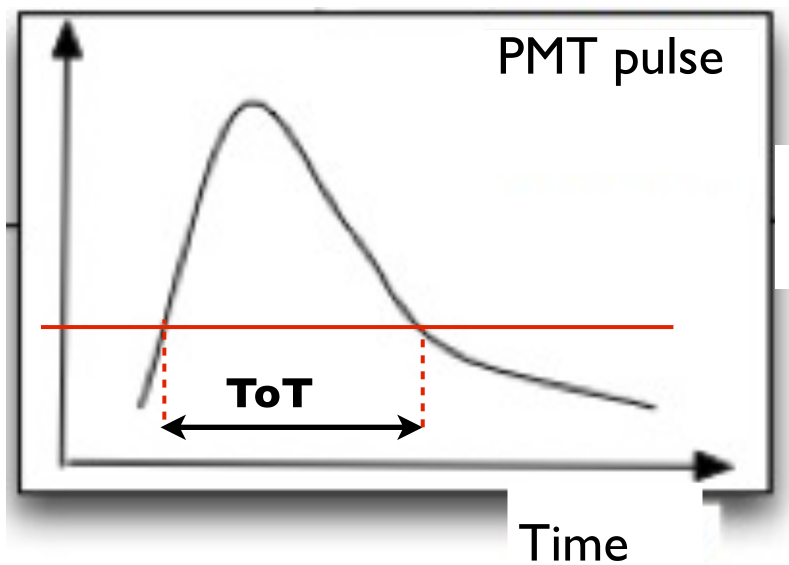
Case	Layer (Mb/s)	DU (Mb/s)	Det (Gb/s)	Timings (Mb/s)	Positions (Mb/s)
KM3Ita (8 Towers)	24.0	360.0	2.8	0.04	0.04
KM3NeT Ph1 (24 Strings)	12.0	240.0	5.6	0.07	0.08
KM3NeT Block (115 Strings)	12.0	240.0	27.0	0.35	0.38
KM3NeT Ph1.5 (230 Strings)	12.0	240.0	54.0	0.70	0.75
KM3NeT Ph2 (690 Strings)	12.0	240.0	160.0	2.10	2.30

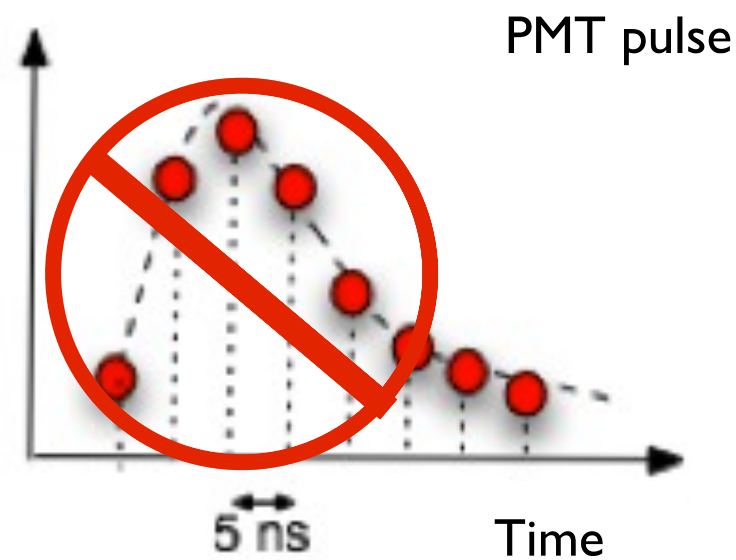
KM3NeT DAQ Model : *All data to shore*



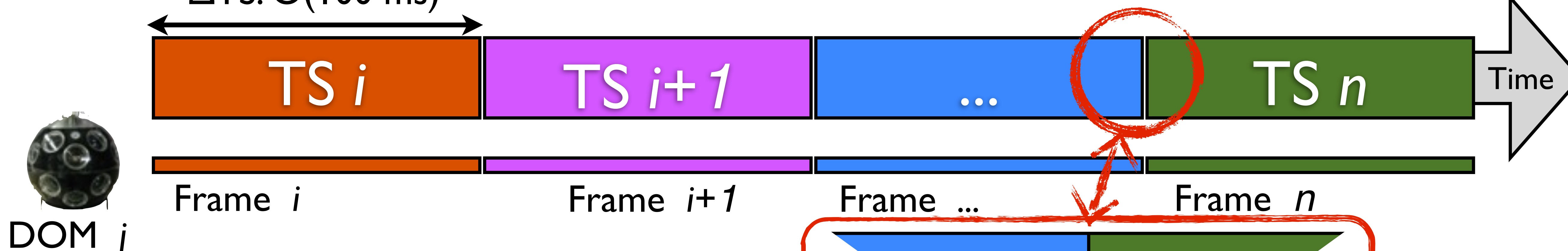
Principal peculiarities of the offshore detection

- Optical data: **timestamp + ToT** **... not sampled waveform!**

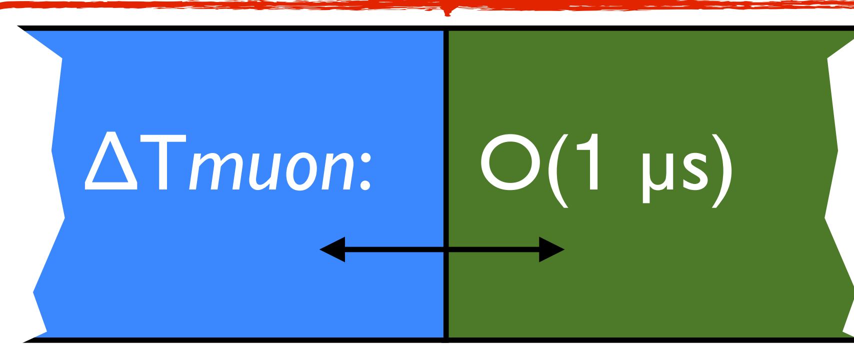




- Time-slicing performed off-shore by DOMs: **a DOM is a node of a LAN which extends both off- and on-shore**

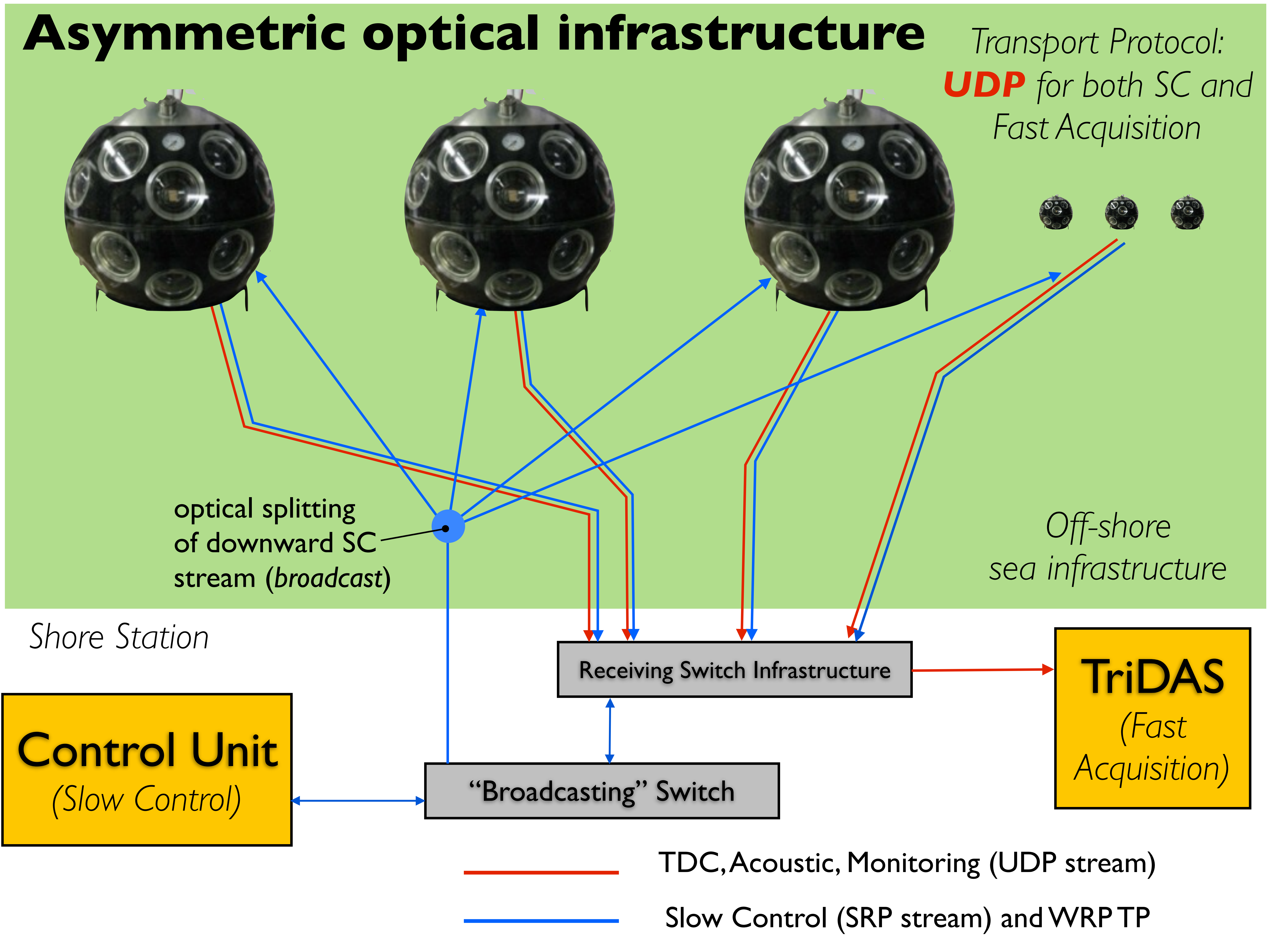


A DOM frame contains all data from its 31 PMTs occurring in a TS



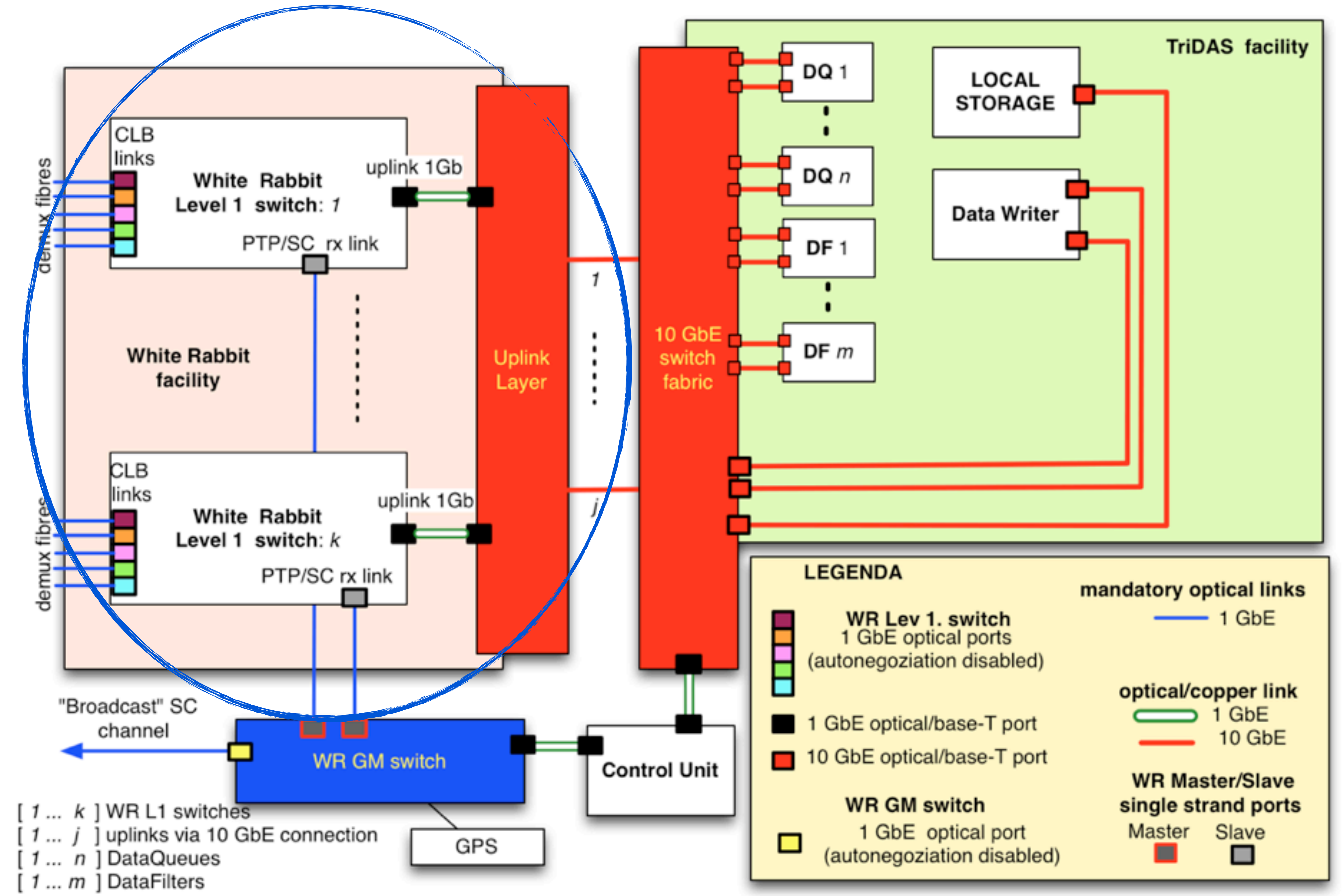
$\Delta TS >> \Delta T\mu$

Probability of a muon *crossing 2 TS* < 10^{-5}



Asymmetric optical infrastructure
Transport Protocol: UDP for both SC and Fast Acquisition
optical splitting of downward SC stream (broadcast)
Off-shore sea infrastructure
Shore Station
Receiving Switch Infrastructure
TriDAS (Fast Acquisition)
Control Unit (Slow Control)
"Broadcasting" Switch
TDC, Acoustic, Monitoring (UDP stream)
Slow Control (SRP stream) and WRP TP

Shore Station Layout



Shore station   Switching Front-End for the DOMs

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.

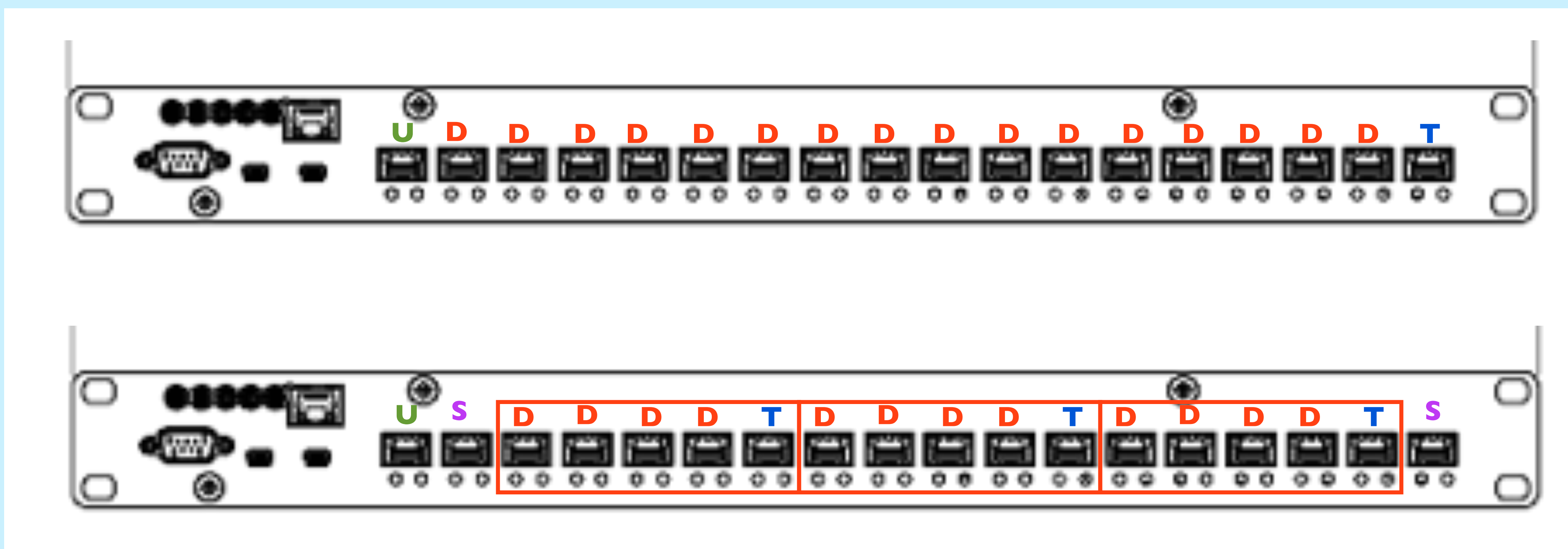
WR Switches

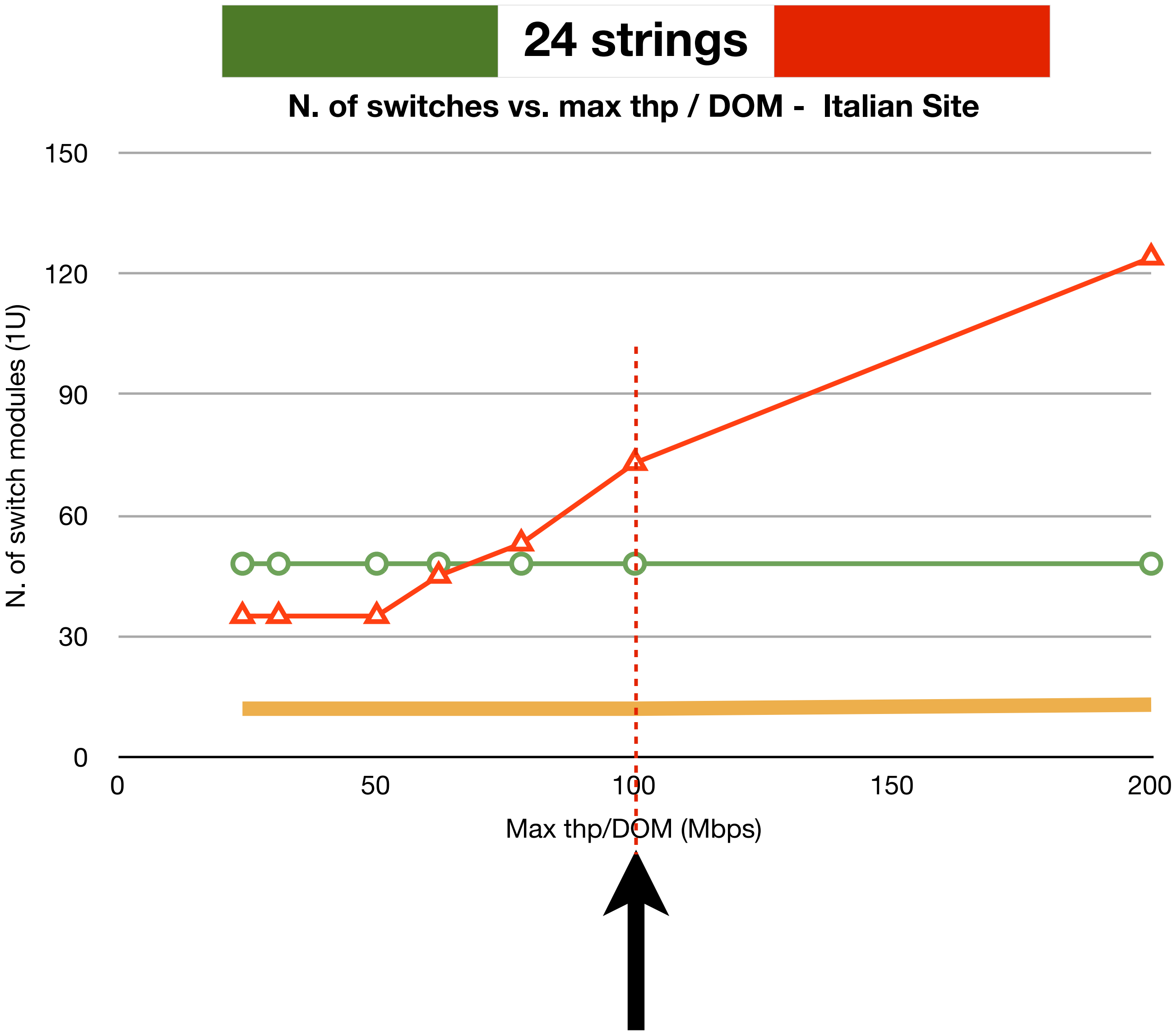
All 1 Gbps ports

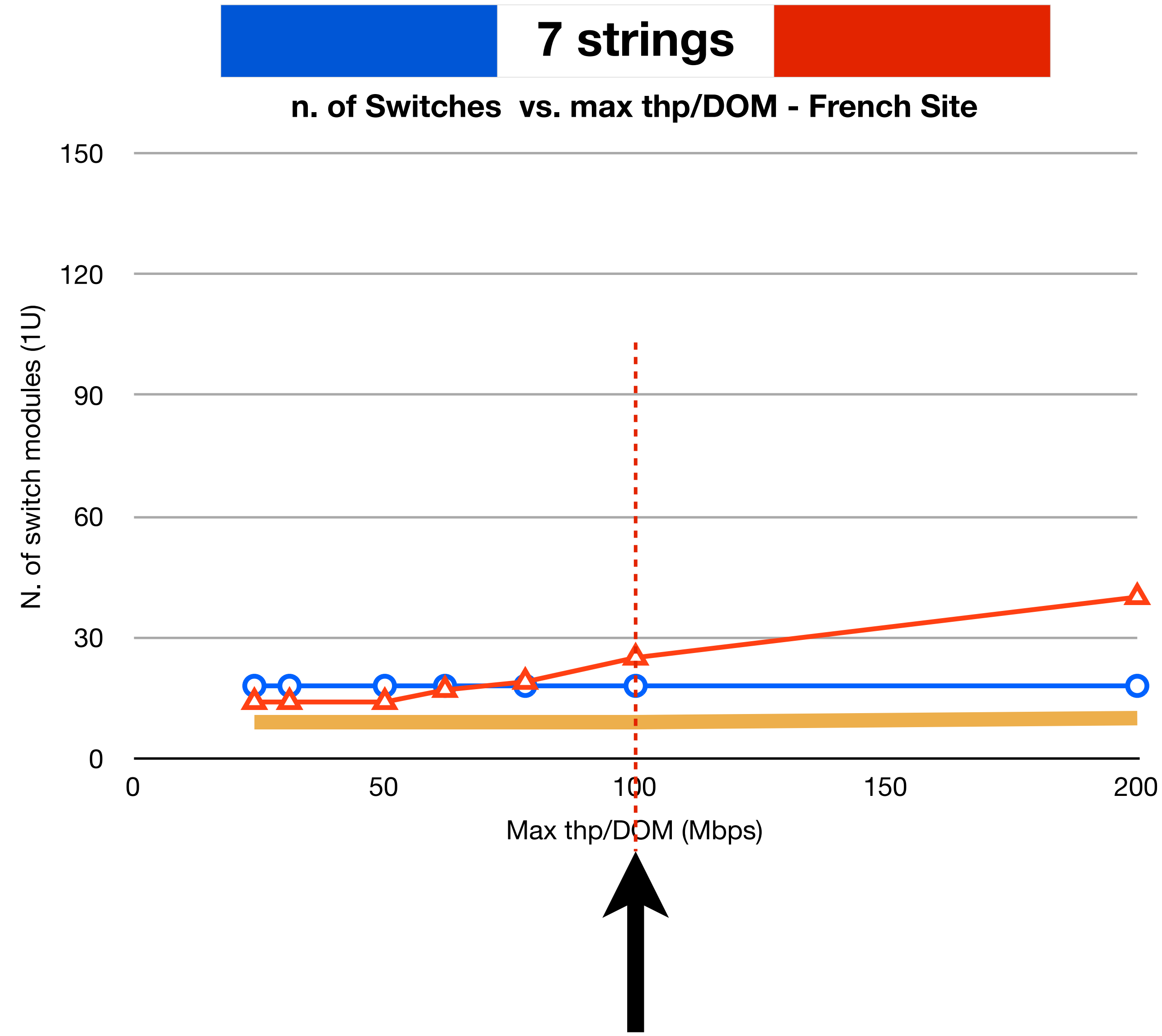
Legenda
U : PTP uplink
D : DOM port
T : TriDAS uplink
S : spare

No VLANs
current version 3.4

3 VLANs / WRS
possible with versions ≥ 4.0







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) and mainly suitable for the 24 strings shore-stations in KM3NeT-It... and for next phases

DAQ/Readout WG Coordinator

Tommaso Chiarusi

Resources

- **Networking**: **T. Chiarusi**, **Stefano Zani**, **L. Chiarelli**
- **WR switches**: Tassos Belias, K. Manolopoulos, **R. Travaglini**
- **Local Storage**: Juergen Brunner
- **Software managment**: Kay Graf, **F. Giacomini**
- **Hardware Procurement**: **T. Chiarusi**, R. Bruijn K. Graf

Control

- **Control Unit**: **Cristiano Bozza**
- **Slow Control**: Vincent Van Bevern, **C. Bozza**
- **Data Base Interface**: Albert Arnauld, **C. Bozza**
- **Data Base**: **C. Bozza**, Albert Arnauld, Kay Graf
- **RunSetup GUI**: **M. Favaro**

Data Processing

- **Data Queue**: **C. Pellegrino**, **T. Chiarusi**
- **Acoustic DataFilter**: **F. Simeone**, **S. Viola**
- **Optical DataFilter**: Ronald Bruijn
- **Trigger Algos**: Ronald Bruijn
- **Parallel Trigger**: Ronald Bruijn, Mieke Bouwhuis, **M. Manzali**
- **Dispatchers**: **T. Chiarusi**, Ronald Bruijn
- **Data Format**: Kay Graf, **T. Chiarusi**
- **Data Writer**: Ronald Bruijn
- **Post-processing API**: Kay Graf, Ronald Bruijn
- **PPM-DU**: **S. Biagi**, **C. Pellegrino**, Kay Graf

Monitoring

- **Online Monitoring**: Tamas Gal, **T. Chiarusi**
- **Quasi-Online Analysis**: Tamas Gal, Kay Graf

Test sites

- **Bologna Comp. Infrastr.**: **T. Chiarusi**, **A. Paolucci**
- **Bologna Test-Bench**: **G. Pellegrini**, **R. Travaglini**
- **DAQ Support to sites**: **C. Pellegrino**, **C. Bozza**
- **Integration Sites**: **LNS, Naples**, ECAP,Nikhef

Strong Italian contribution, in terms of FTE and resources

Bologna Common infrastructure
(BCI)

FARM (~ 150 cores)
10 Gbps network
4 CLBs (it will increase)

Mirror Data Base
(Authoritative: Lyon)

Server 8 cores
12 TB storage

Sez. Bologna: ½ S. Biagi , T. Chiarusi, I. D'AntoneA. Paolucci, G. Pellegrini, C. Pellegrino, R. Travaglini

CNAF: L. Chiarelli, M. Favaro, F. Giacomini, M. Manzali, S. Zani

Sez. Roma: F. Simeone

Univ. Salerno/INFN Napoli: C. Bozza

LNS: ½ S. Biagi, S.Viola

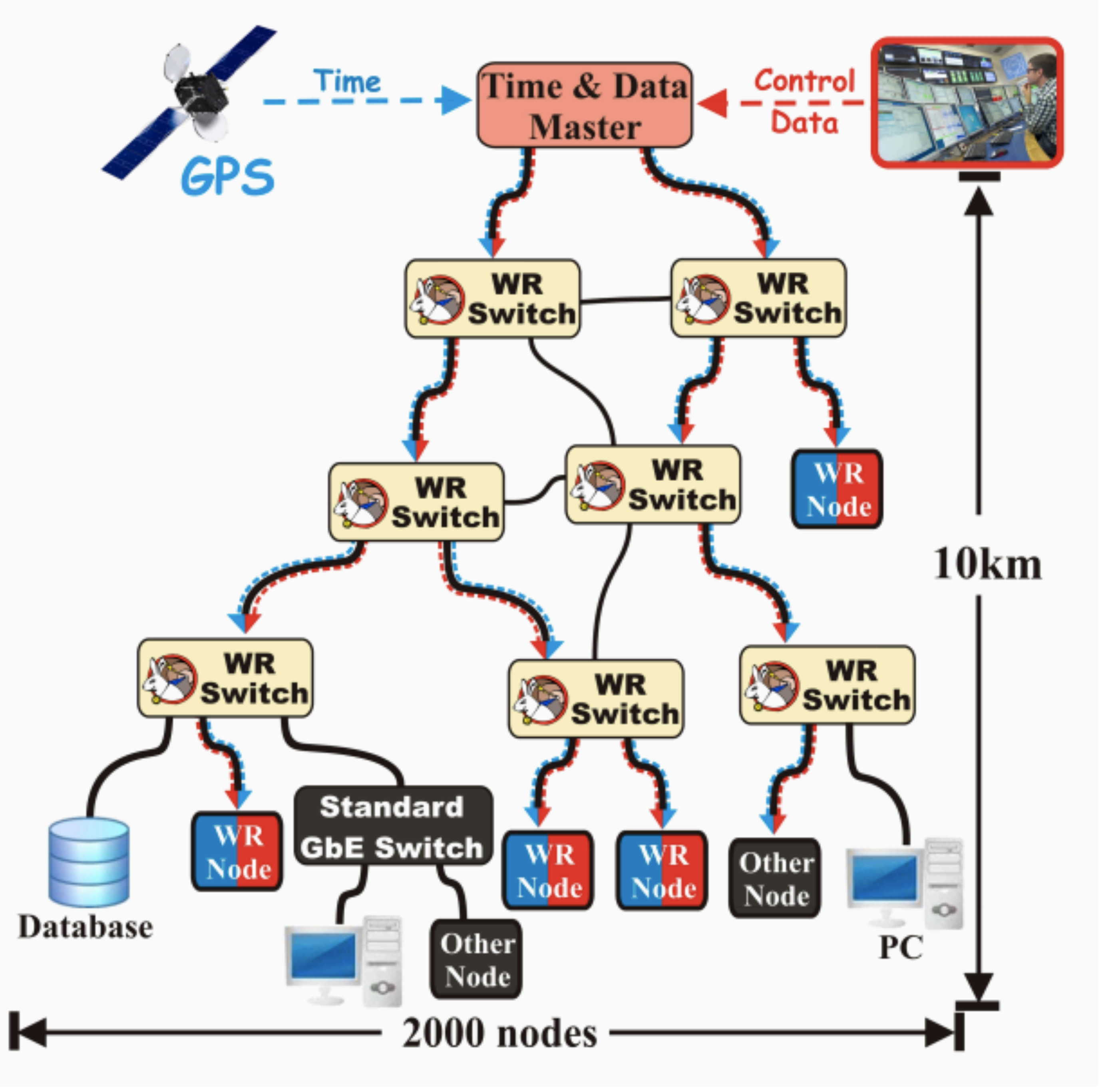
Moreover, it is worthy to mention all the "**beta-testers**" from the Integration Sites :V. Kulikovskiy (LNS), and the newcomers...

SPARE SLIDES

White Rabbit and the Network architecture

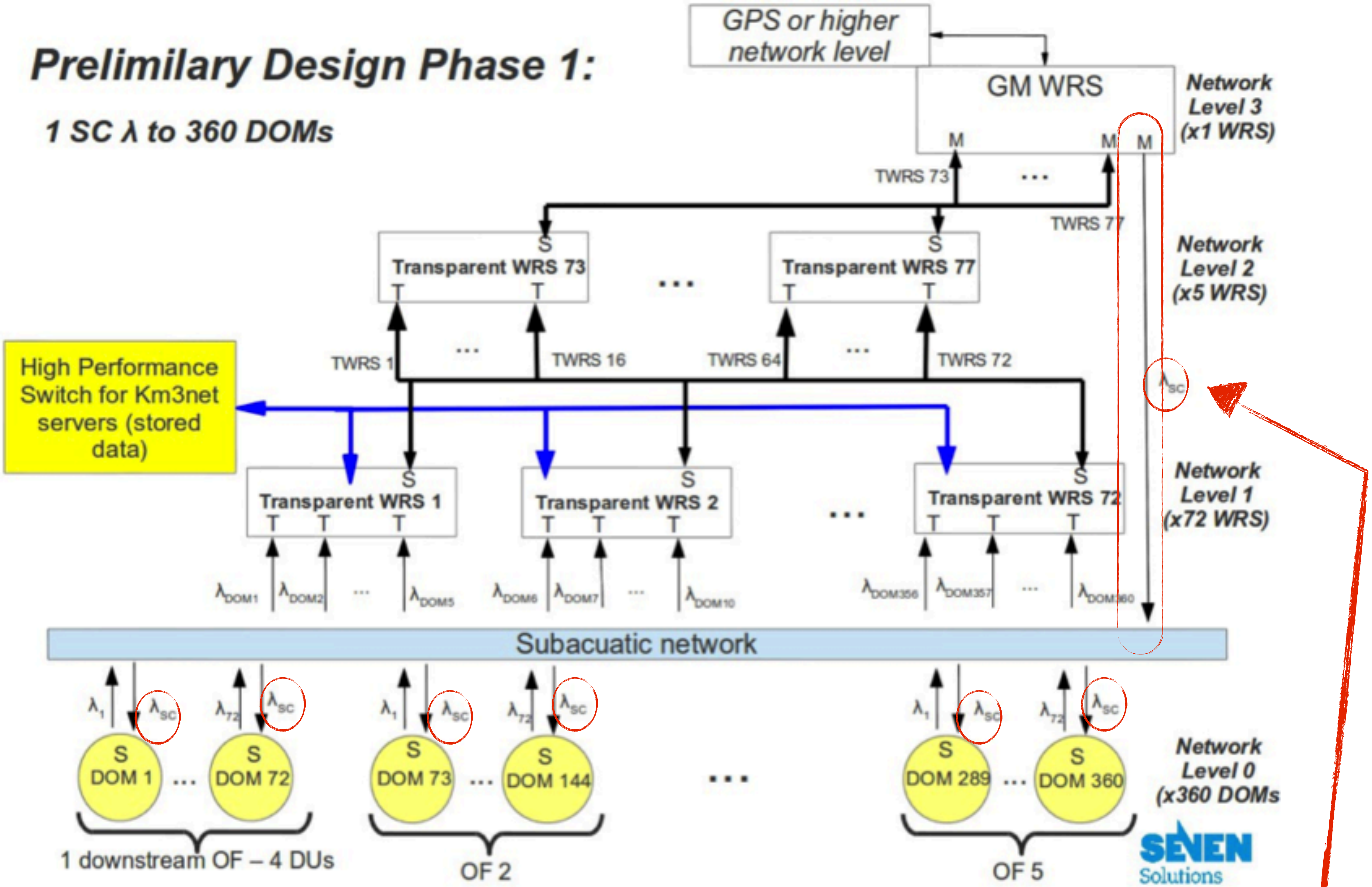
Two separate services (enhancements to Ethernet) provided by WR:

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

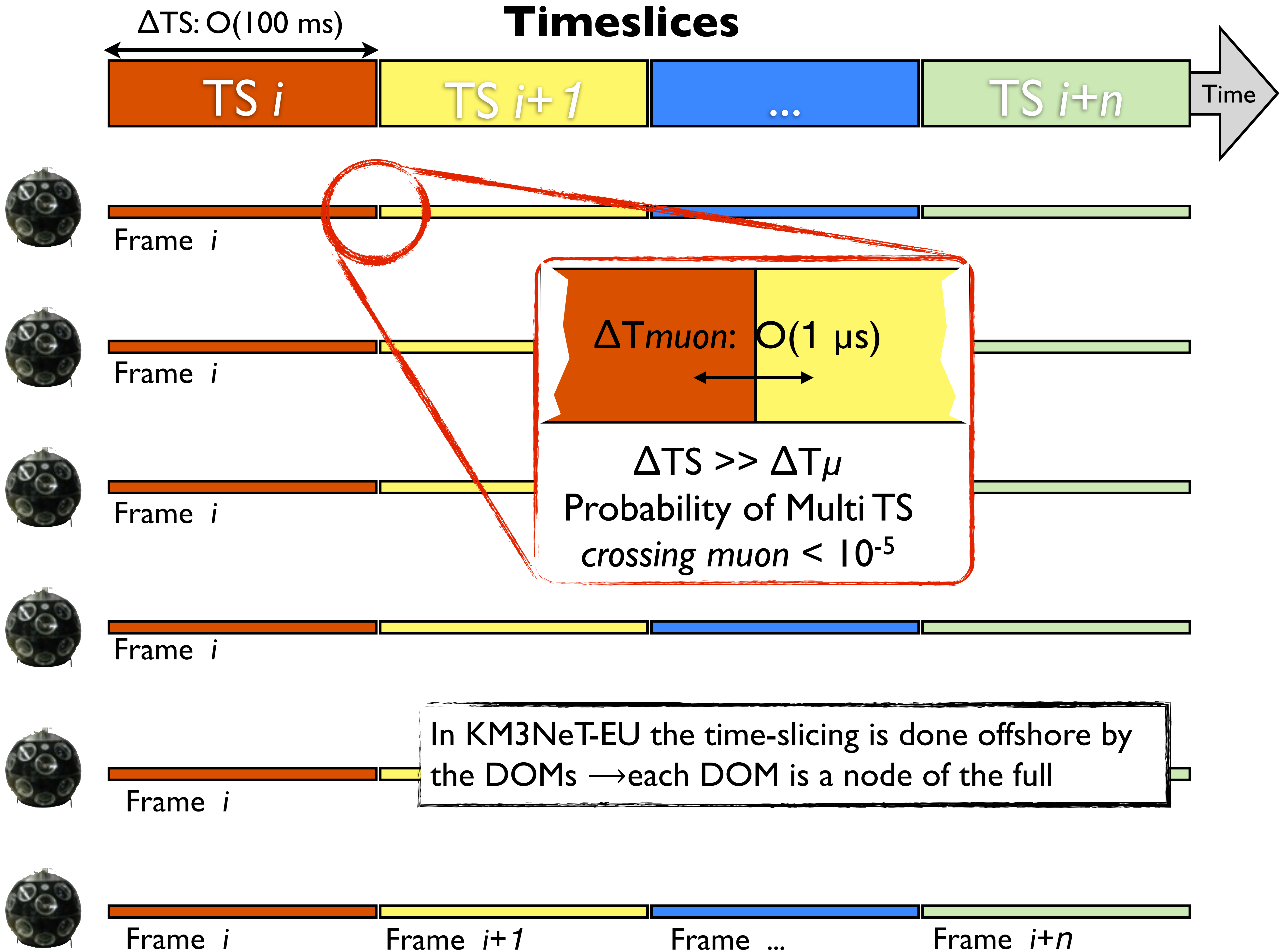


Credit: White Rabbit for Time Transfer, Erik van der Bij at TIPP'14

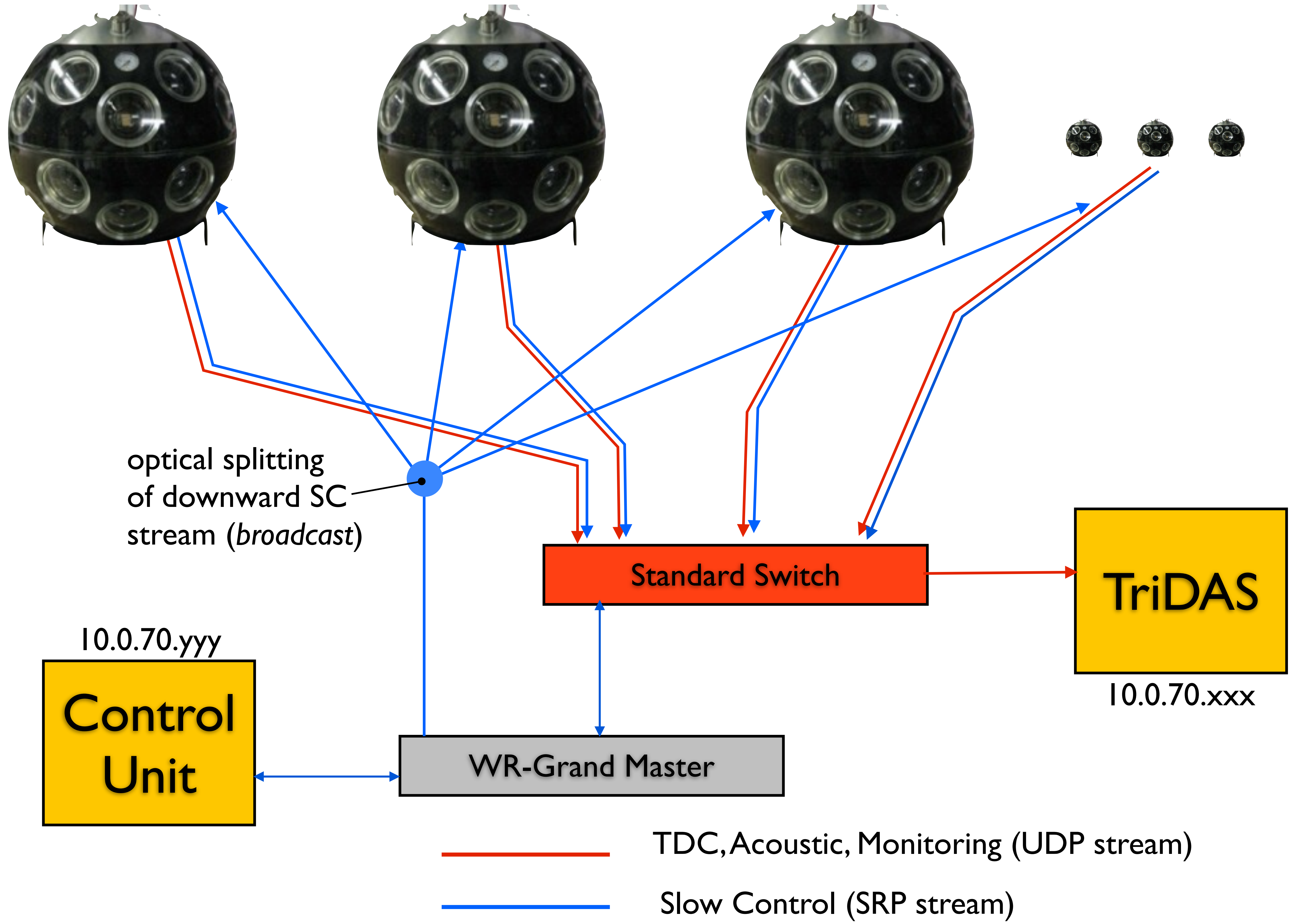
WR infrastructure in the Shore Station

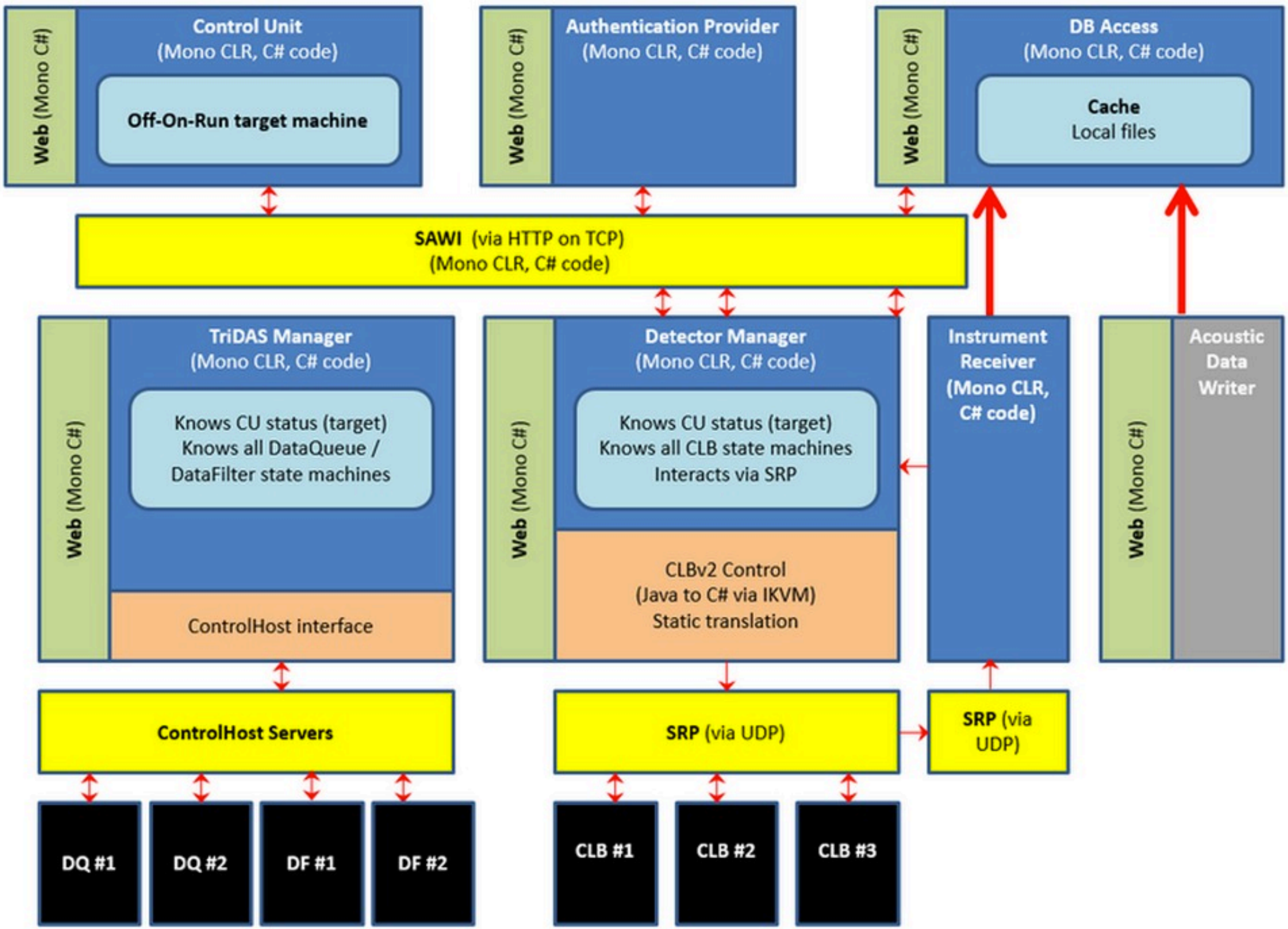


The "broadcast" channel (from on shore to offshore) implies an asymmetry for DOM send/return. Since WRPTP uses Ethernet, there has been a deep customization of WR swtich at software and gateware level


Timeslices
ΔTS: O(100 ms)
TS i
TS i+1
...
TS i+n
Time
Frame i
Frame i
Frame i
Frame i
Frame i
Frame i
Frame i+1
Frame ...
Frame i+n
ΔTmuon: O(1 μs)
ΔTS >> ΔTμ
Probability of Multi TS
crossing muon < 10-5
In KM3NeT-EU the time-slicing is done offshore by
the DOMs →each DOM is a node of the full

Data-stream scheme with hybrid scenario





Web (Mono C#)
Control Unit
(Mono CLR, C# code)
Off-On-Run target machine
Web (Mono C#)
Authentication Provider
(Mono CLR, C# code)
Web (Mono C#)
DB Access
(Mono CLR, C# code)
Cache
Local files
SAWI (via HTTP on TCP)
(Mono CLR, C# code)
Web (Mono C#)
TriDAS Manager
(Mono CLR, C# code)
Knows CU status (target)
Knows all DataQueue / DataFilter state machines
ControlHost interface
Web (Mono C#)
Detector Manager
(Mono CLR, C# code)
Knows CU status (target)
Knows all CLB state machines
Interacts via SRP
CLBv2 Control
(Java to C# via IKVM)
Static translation
Instrument Receiver (Mono CLR, C# code)
Web (Mono C#)
Acoustic Data Writer
ControlHost Servers
SRP (via UDP)
SRP (via UDP)
DQ #1
DQ #2
DF #1
DF #2
CLB #1
CLB #2
CLB #3