TRIDAS: a **TRI**ggerless **D**ata **A**cquisition **S**ystem

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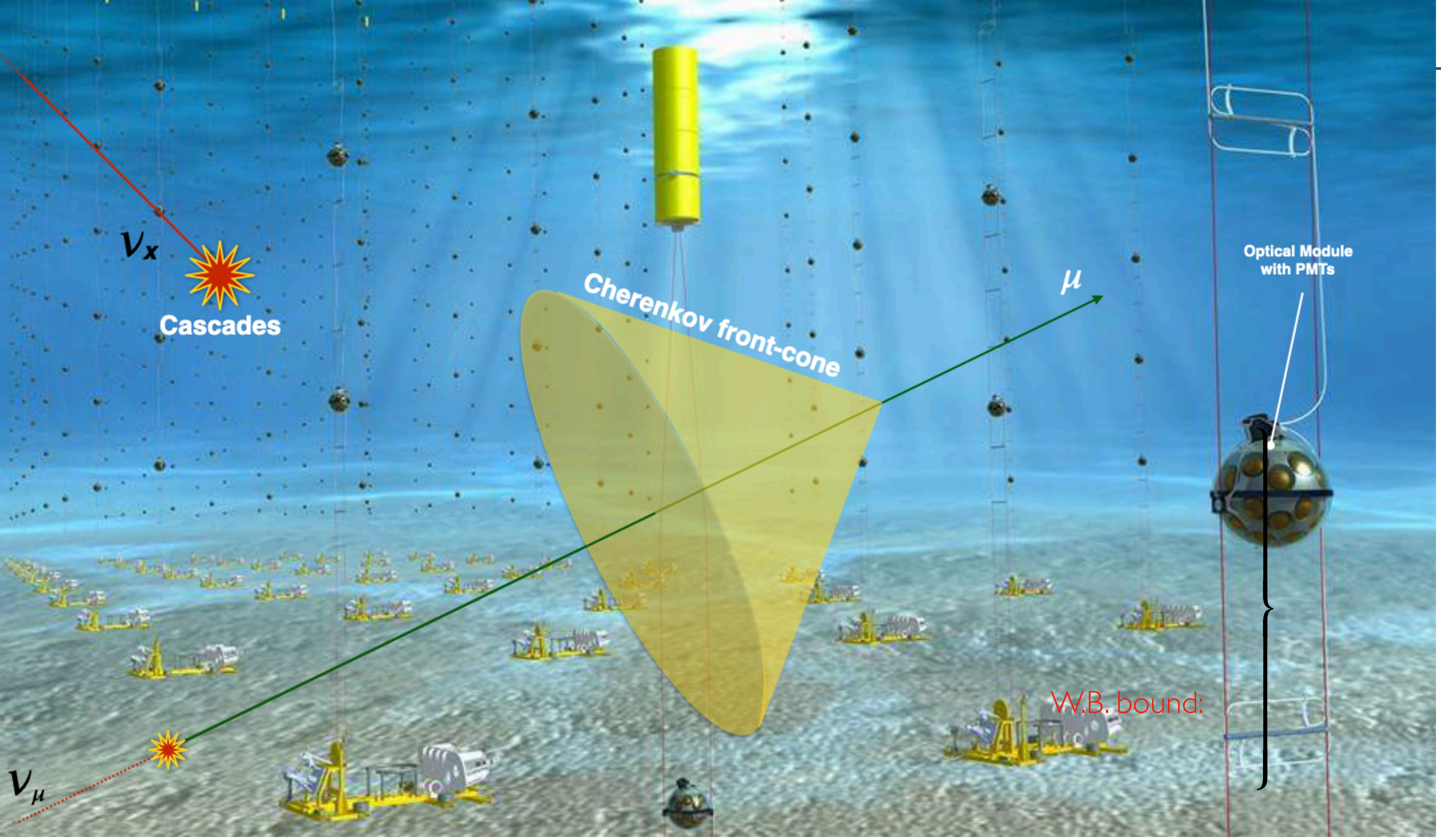
TriDAS original constraints



Very small neutrino cross-sections

$$\sigma_{\nu N} \sim 7.8 \times 10^{-36} \left(\frac{E}{GeV}\right)^{0.36} [cm^2] \quad \text{for } E_\nu > 1 \text{ TeV}$$

Very small expected fluxes

W.B. bound:

$$\frac{dN_\nu}{dE} \sim 9 \times 10^{-9} \left(\frac{E}{GeV}\right)^{-2} \quad [GeV^{-1}\, cm^{-2}\, sr^{-1}\, s^{-1}]$$

$\Downarrow$

- **O(km³) volume size detector**
- **many detector elements**
- **many years uptime**

Astrophysical source searches
with angular resolution < 1 deg over a km³ scale

$\Rightarrow$ **-Time resolution of O(1ns)**
- Positioning resolution O(10 cm)

No bunch-crossing time info

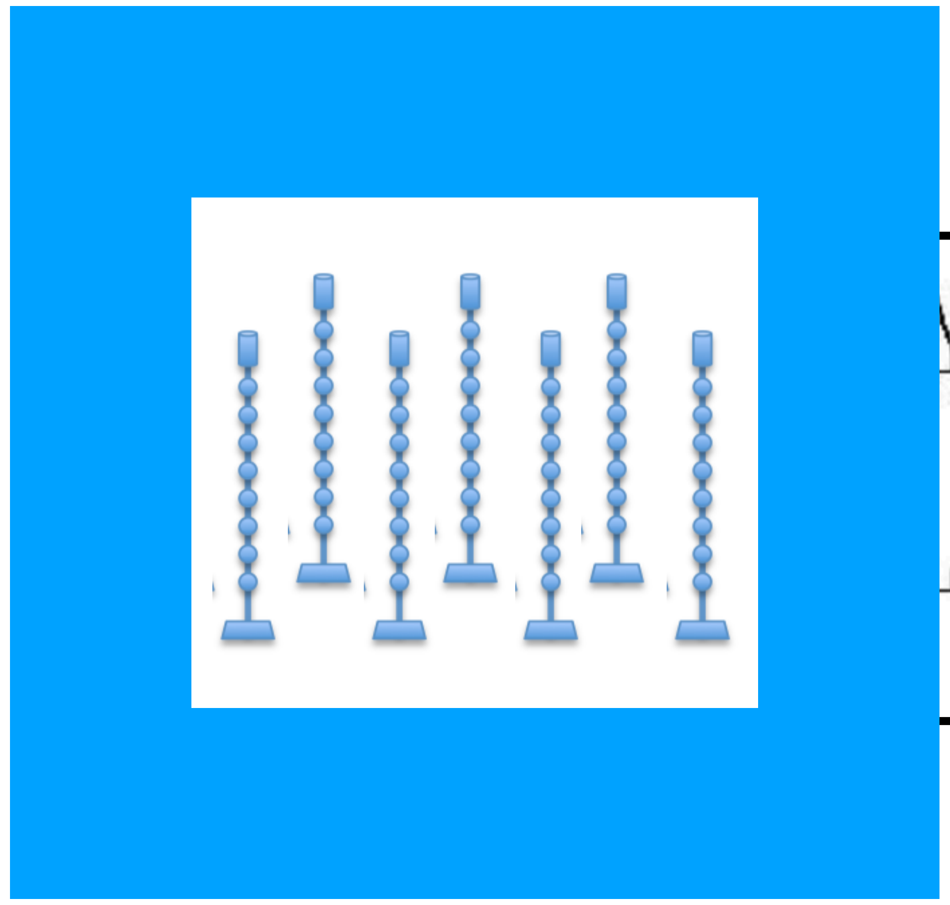
Abyssal sites

Undersea only: ^{40}K and bioluminescence
e.g.: > 50 kHz @ 10" PMT (0.3 p.e. threshold)
Signal (atm. μ) to noise ratio $< 10^{-4}$

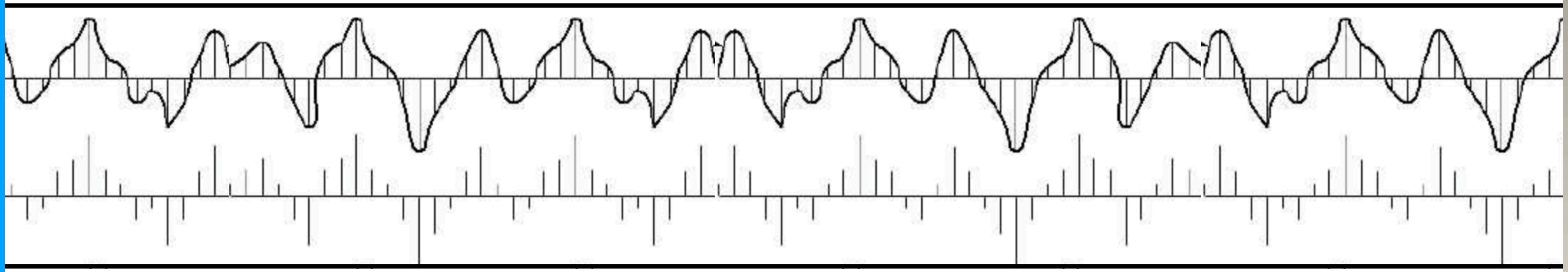
$\Rightarrow$
- Simple detector off-shore
- On-line Trigger on-shore
- Continuous data taking

Note: in nu-Tel, the S/N is < 1E-6 !!!

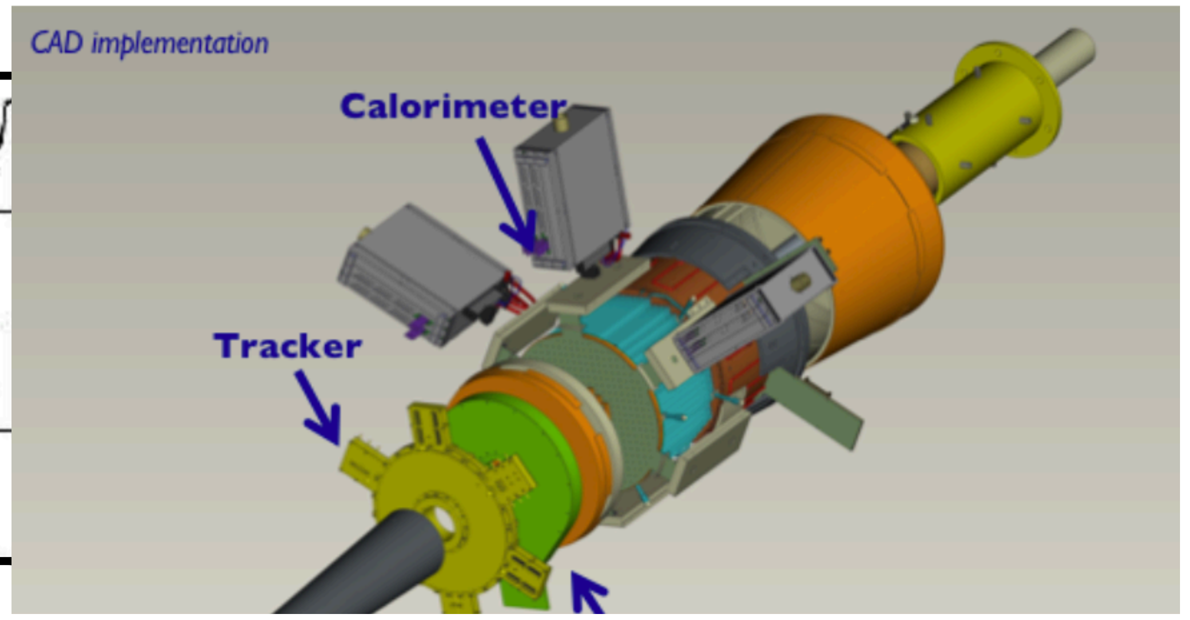
Neutrino Telescopes
PMTs inside the "*scintillator*"



Continuous signal sampling (e.g. one PMT channel)

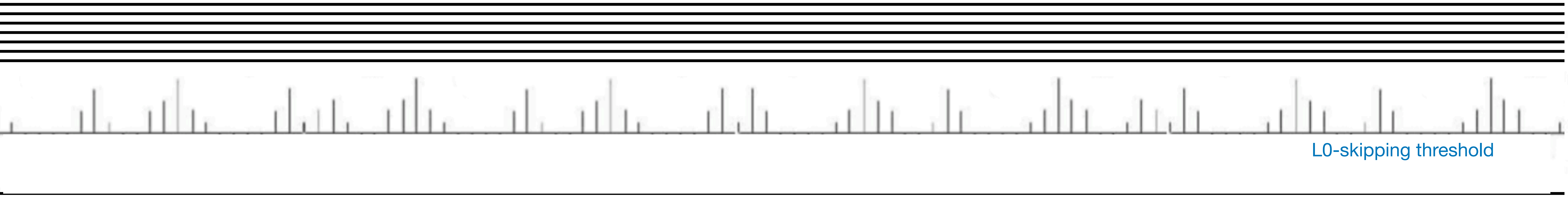


CLAS 12 FTCAL



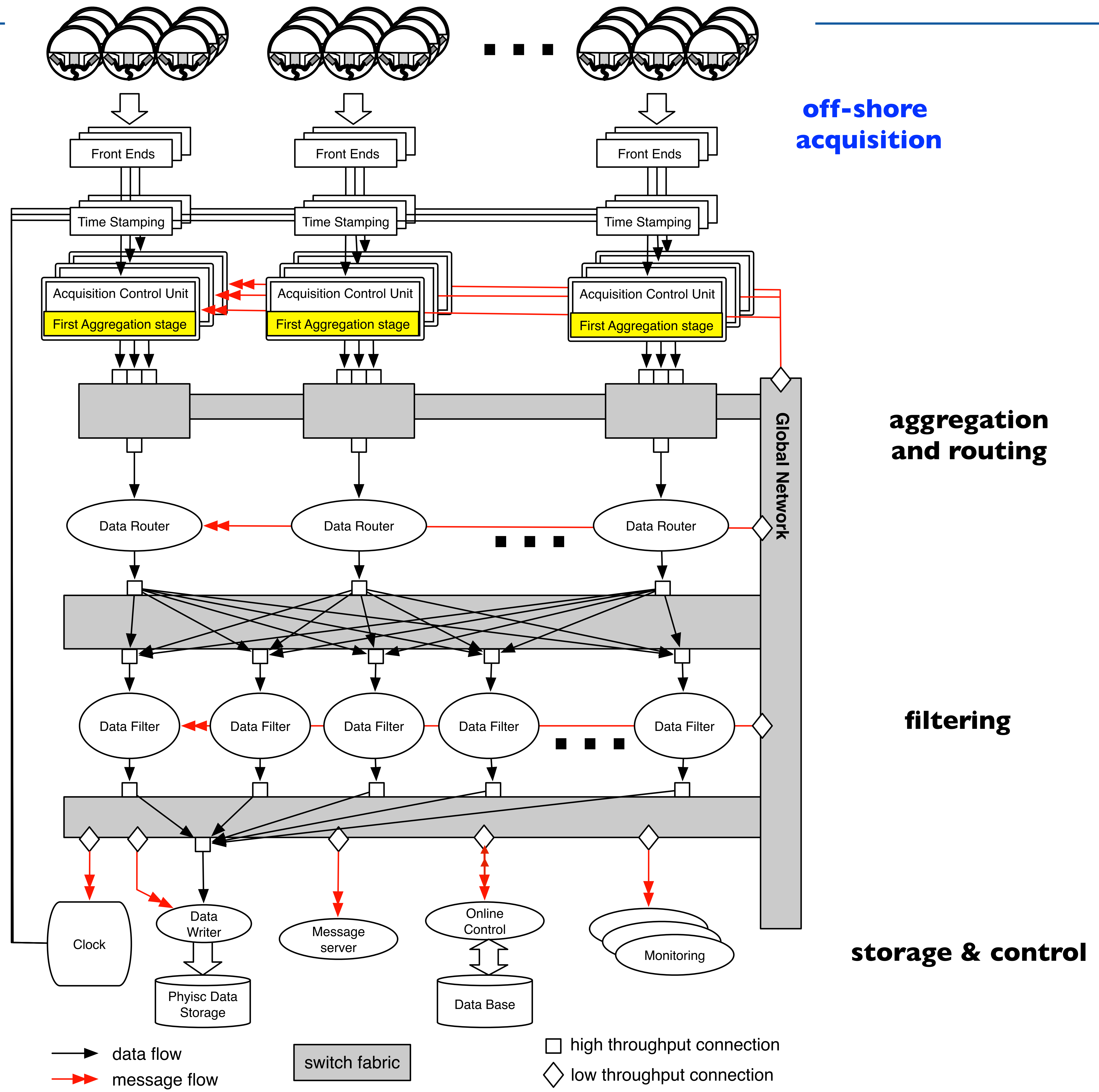
Refer also to Marco Battaglieri talk on Wednesday

- **continuous,**
- **asynchronous**
- **channels streaming out** of over-threshold (L0-skipping) samplings



The data are streamed out to the *Trigger-less Data Acquisition System* - ***TriDAS***, implemented on the computing resources


time
Time-slice *i-1*
Time-slice *i*
Time-slice *i+1*
all channels
Scan full TS - all channels
for **Level 1 triggers** events
Event 1
Event 2
Event n-k
Event n
Event by event check for **Level 2 triggers**
at least
one L2 ?
No
Drop
Yes
Storage

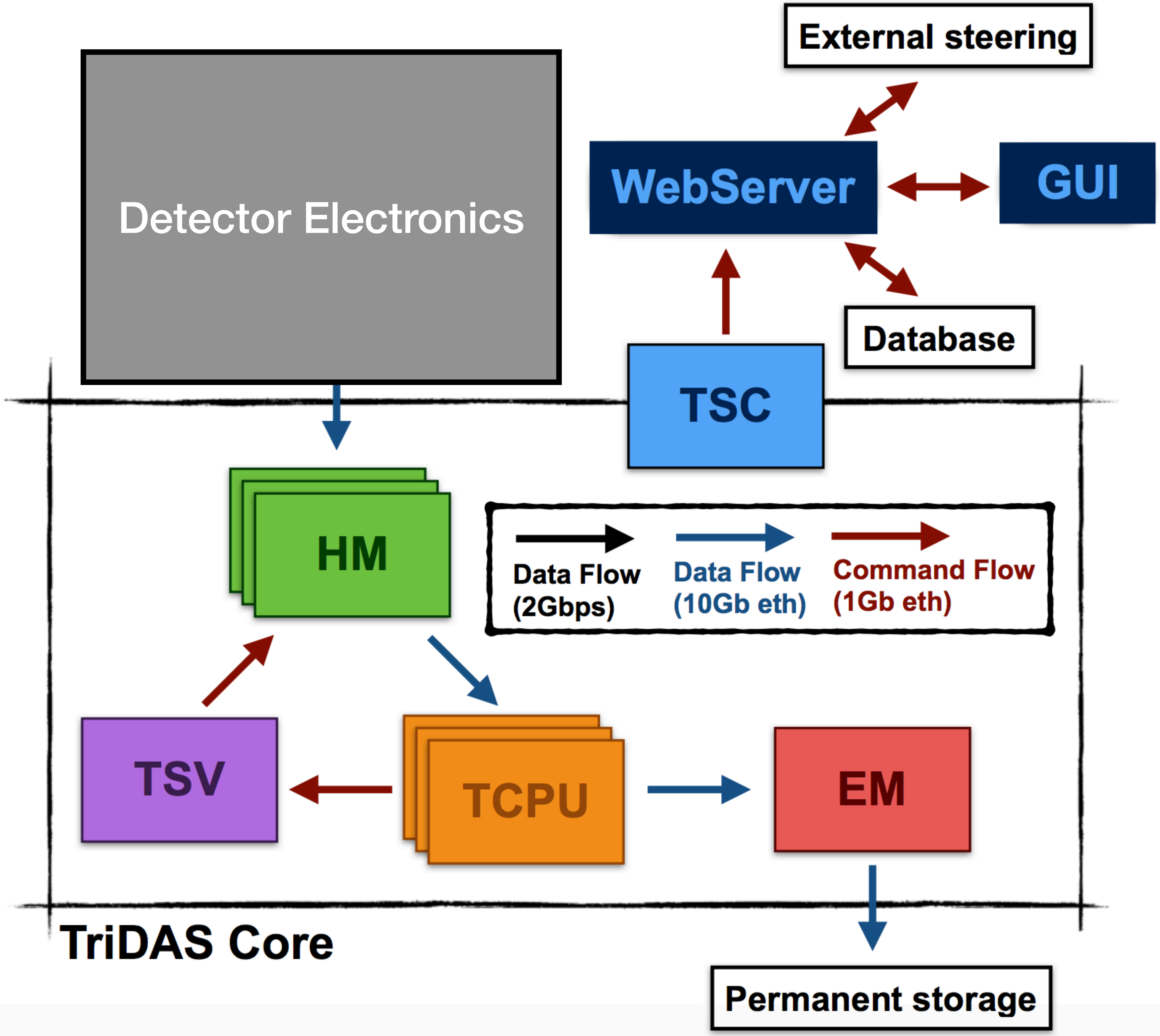


A similar DAQ model is applied to both ANTARES and KM3NeT.

a) It ***exploits fixed latency electronics*** for clock distribution (different implementations)

b) The recorded type and number of information per each hit may be different.

c) It can be generalised for other applications, with the due dimensioning of resources.



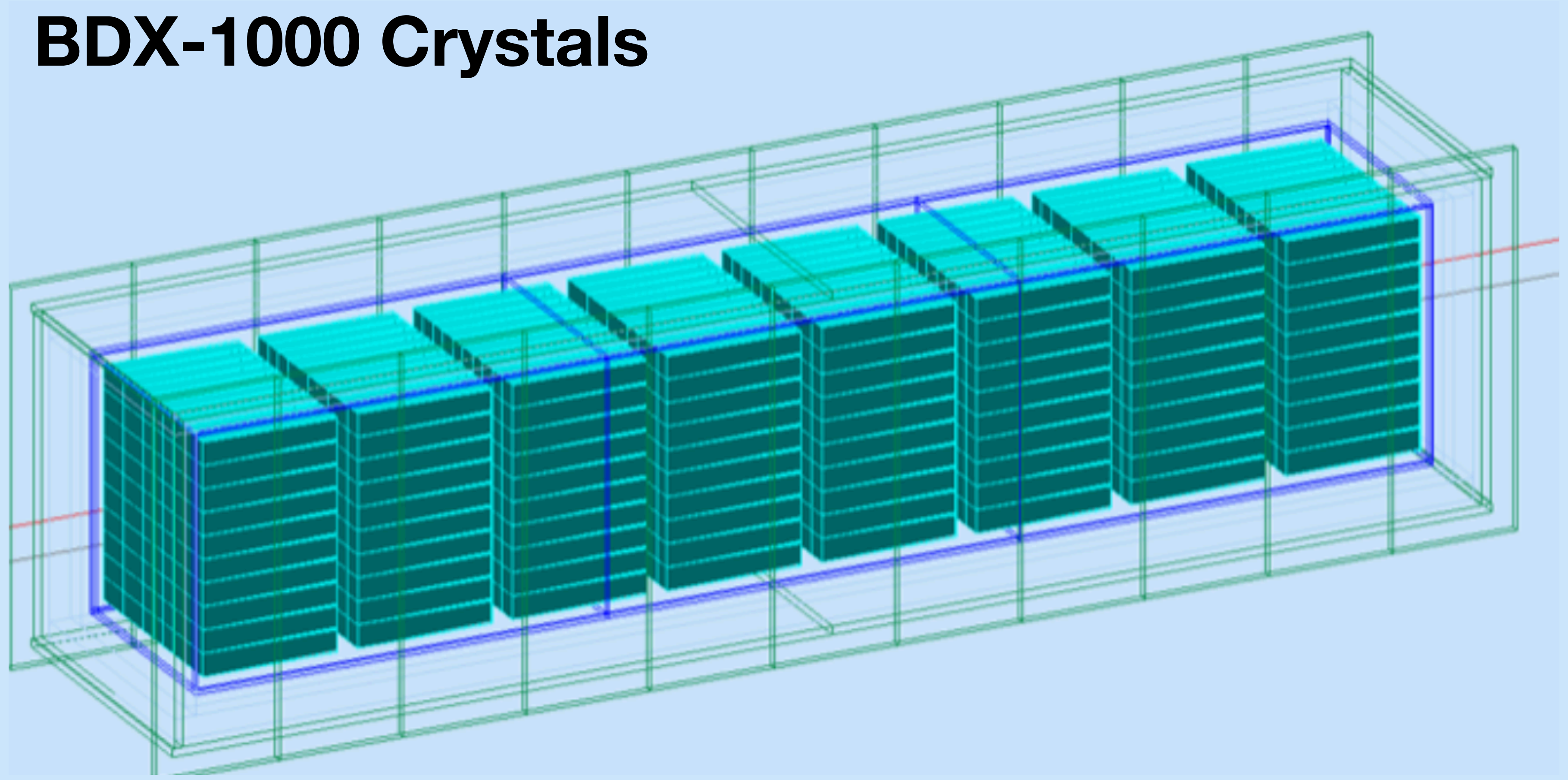
TriDAS core written in C++ 11

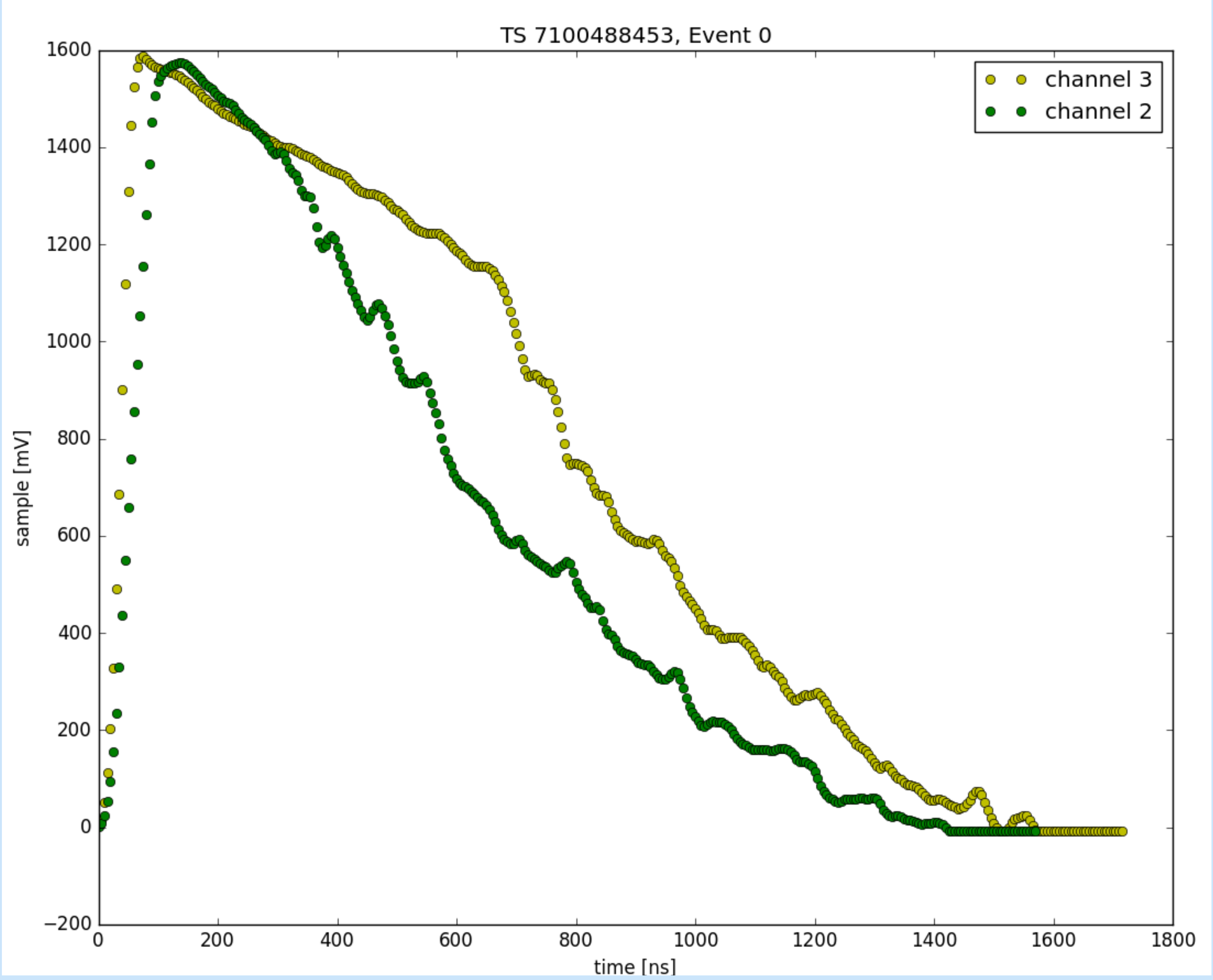
Auxiliary technologies

boost C++ LIBRARIES, Jenkins, git, ANGULARJS, Crossbar.io

Atlassian Bitbucket, CMake, ØMQ

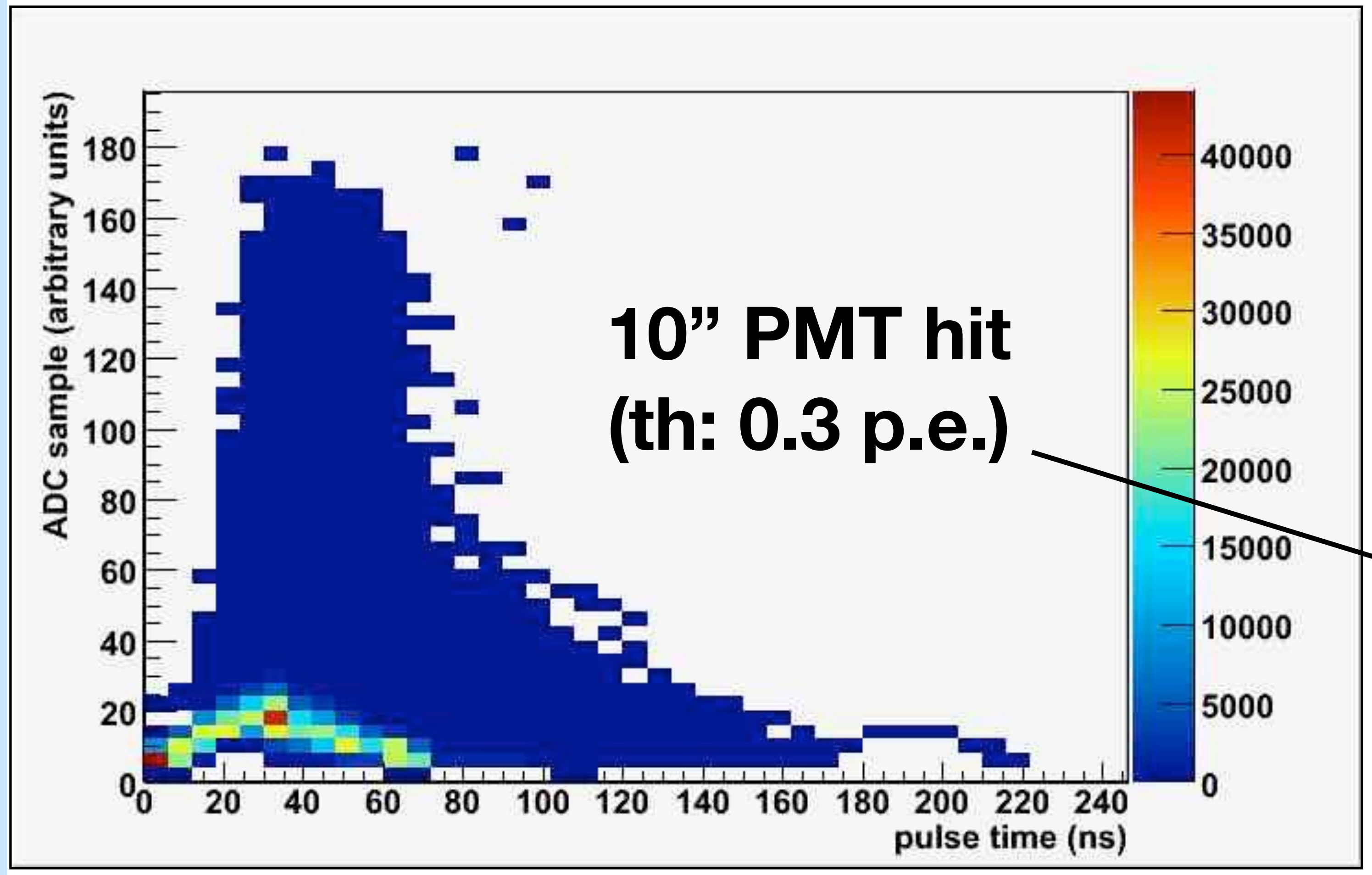
BDX-1000 Crystals





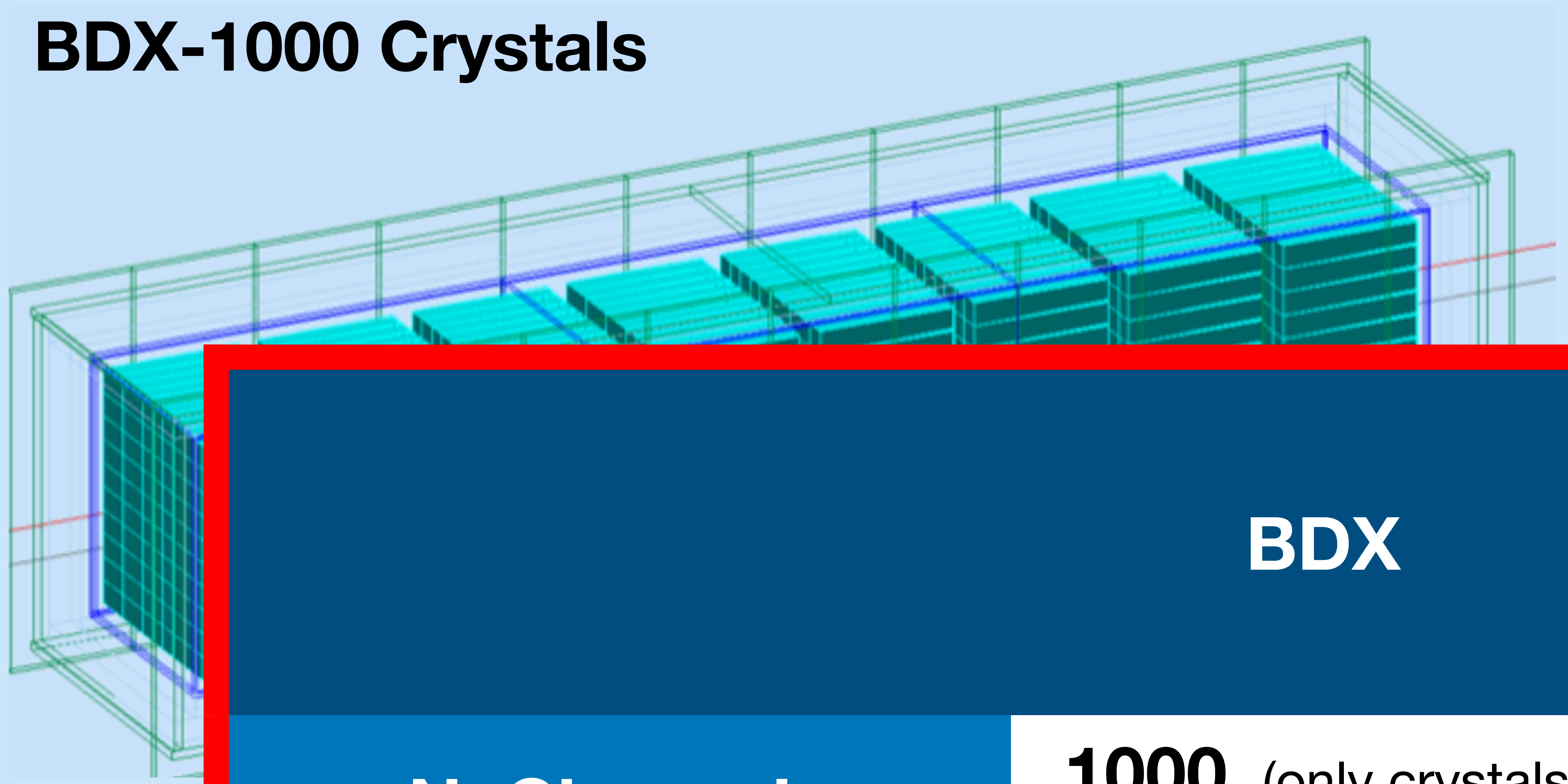
SiPM-CsI(Tl) chrystals hit (th: 0.5 p.e.)

10” PMT hit (th: 0.3 p.e.)



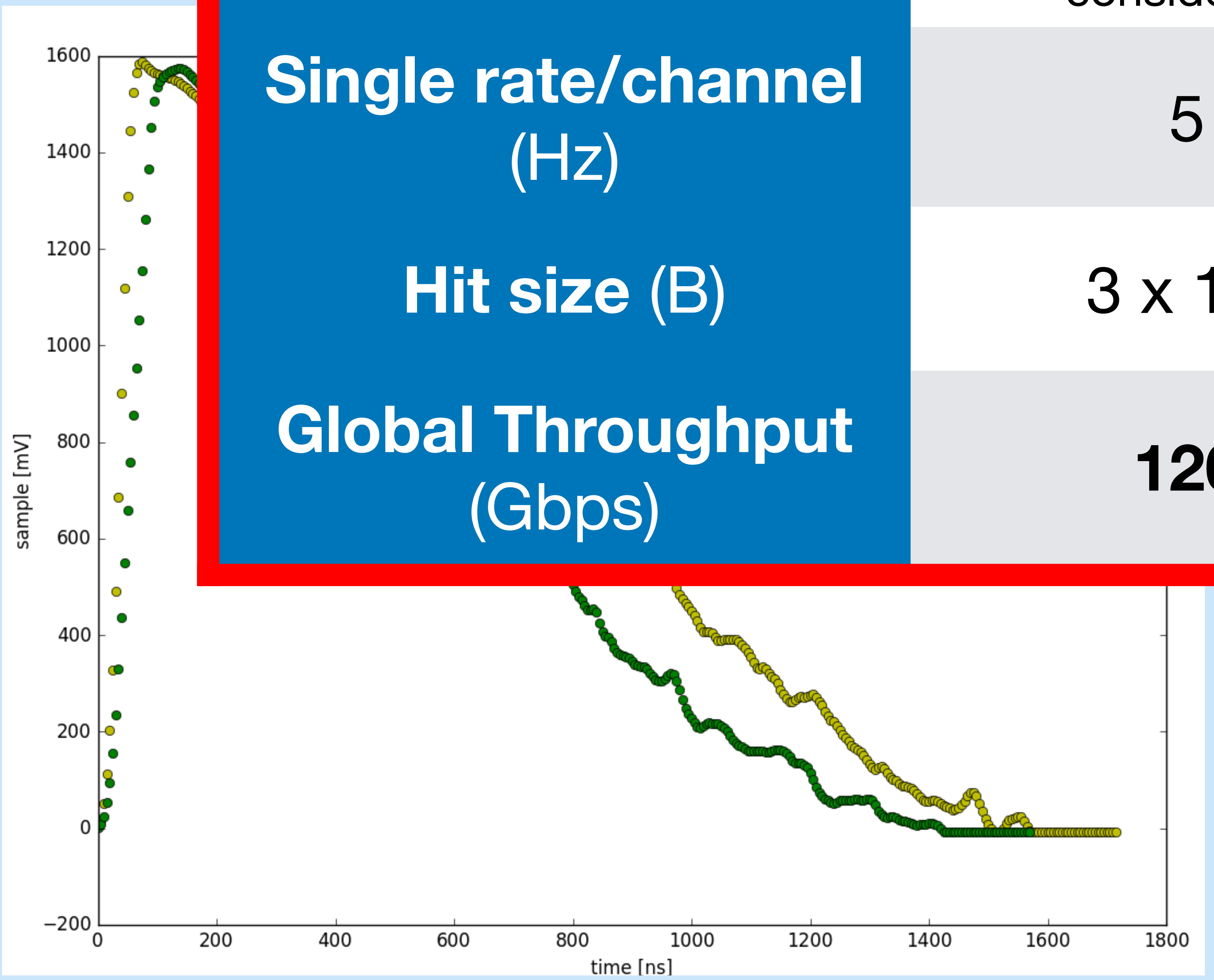
A sketch of a KM3NeT-Italy tower

BDX-1000 Crystals



approximative(conservative) estimations

	BDX	KM3NeT (Towers)	Clas12 FT-ECAL beam on/ high thresholds	Clas12 TF-ECAL no beam/low thresholds
N. Channels	**1000** (only crystals) considered)	**672** (6 PMTs x 14 floors x 8towers)	**384** (crystals + flashADC w/o wavefornm)	**384** (crystals + flashADC w/o wavefornm)
Single rate/channel (Hz)	5	50 x 10^3	<1 x 10^5	<5 x 10^6
Hit size (B)	3 x 10^3	46	12 B	12B
Global Throughput (Gbps)	**120**	**12**	**2**	**150**



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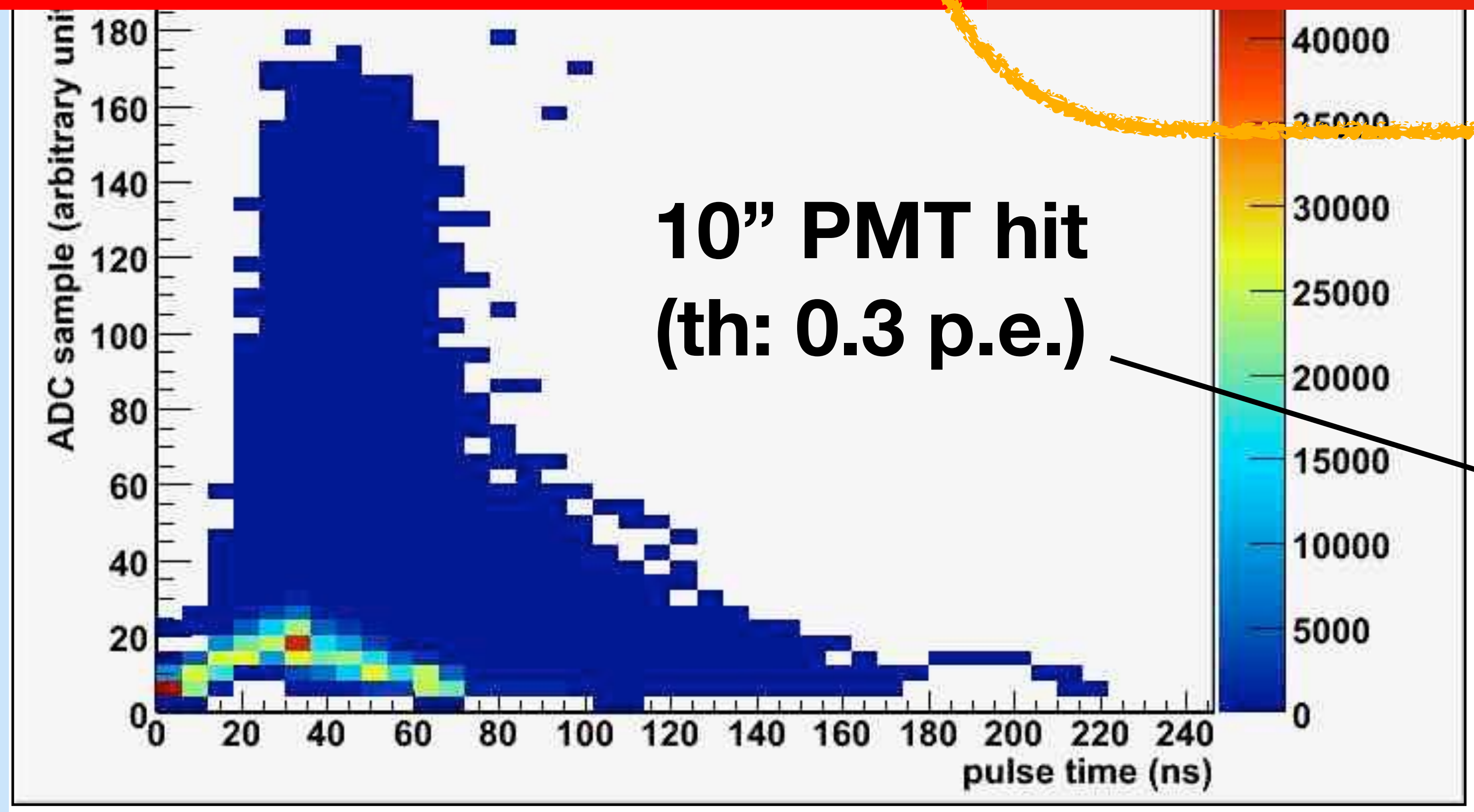
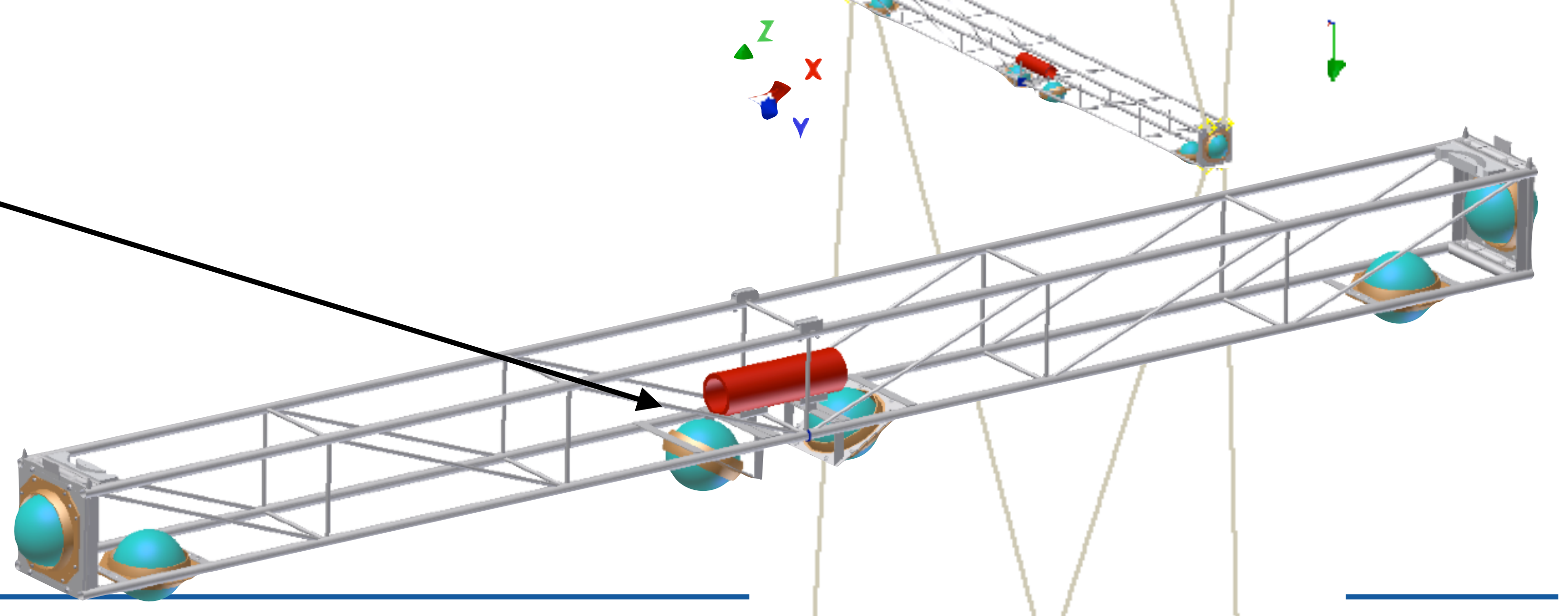
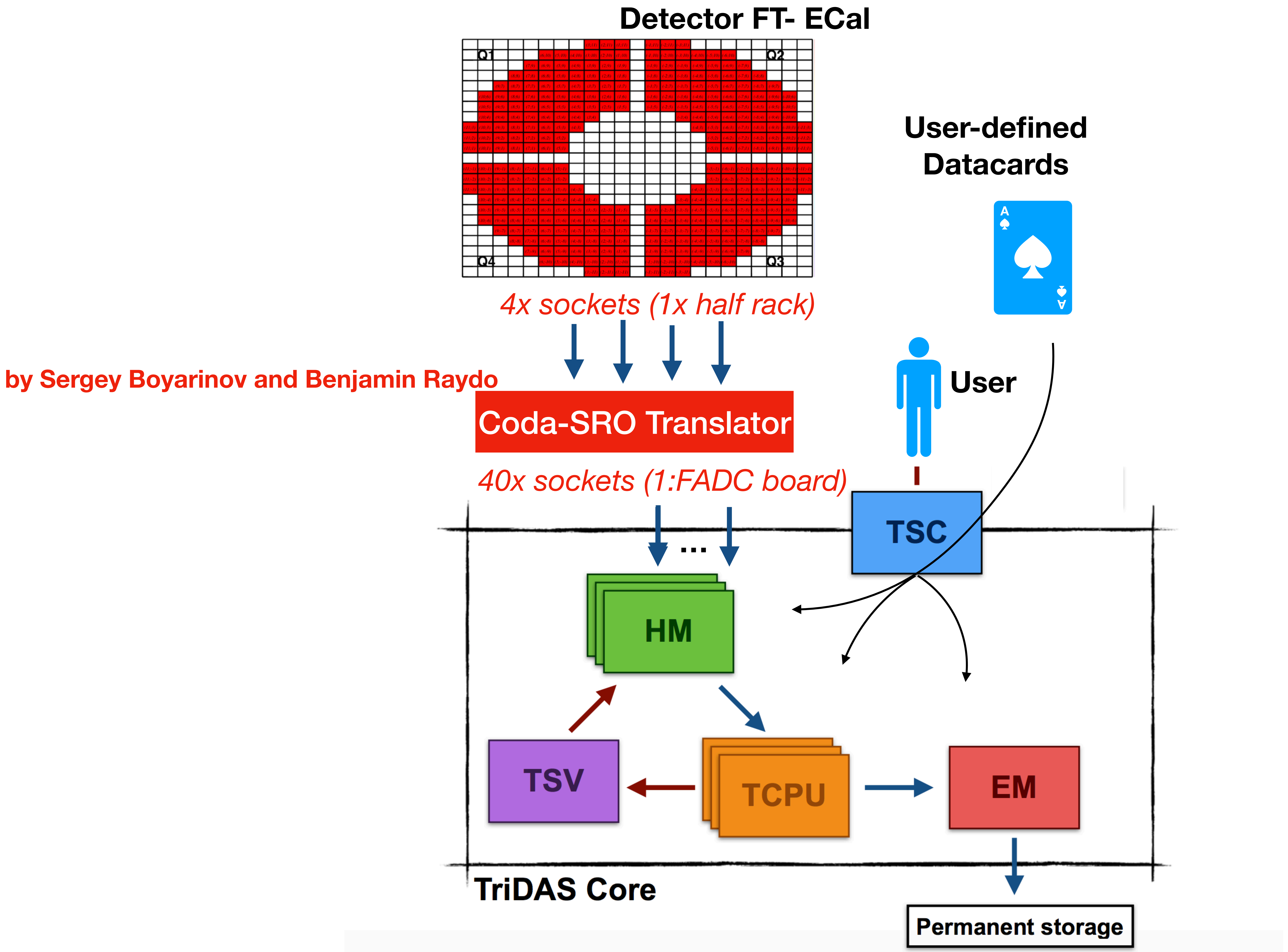


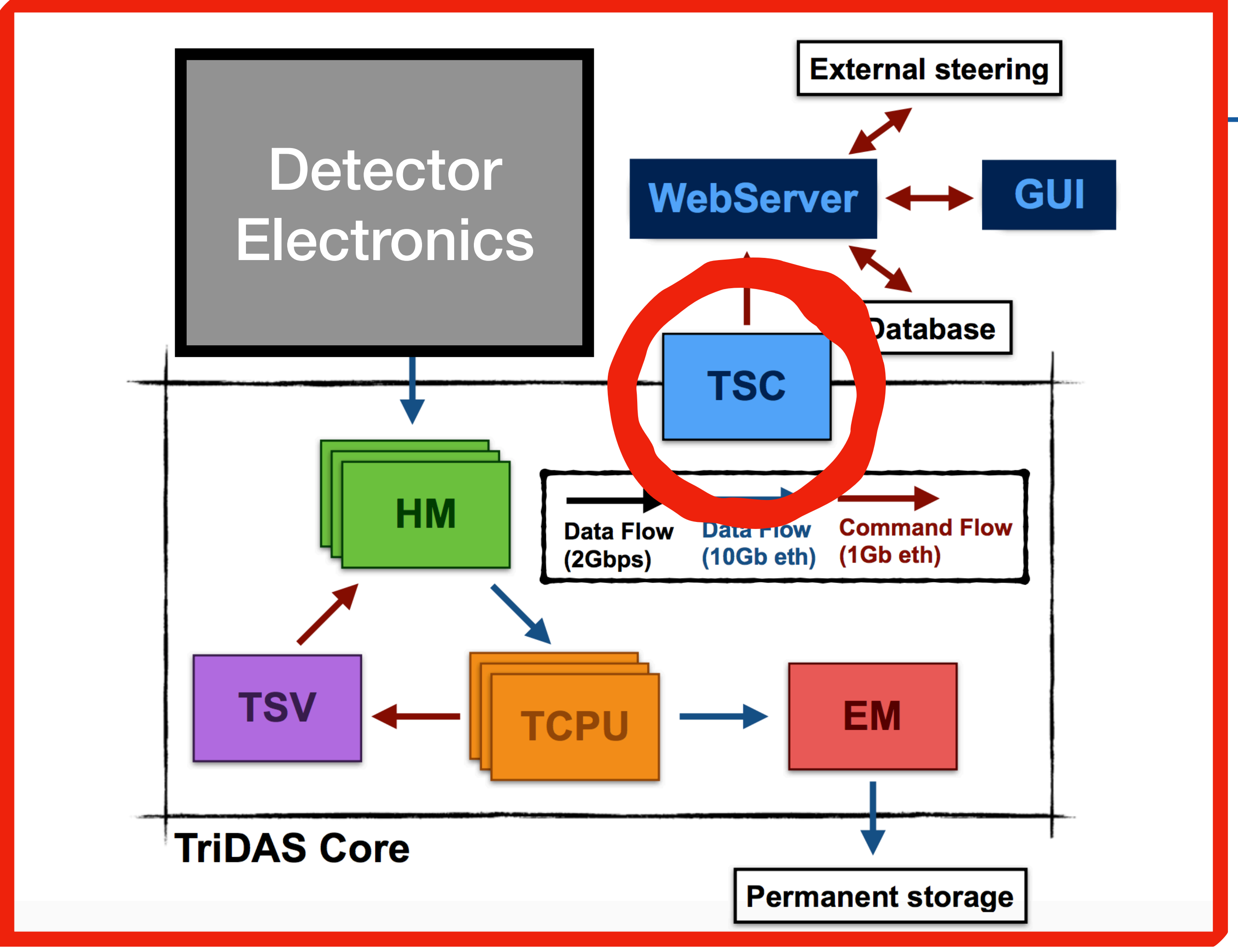
10” PMT hit
(th: 0.3 p.e.)

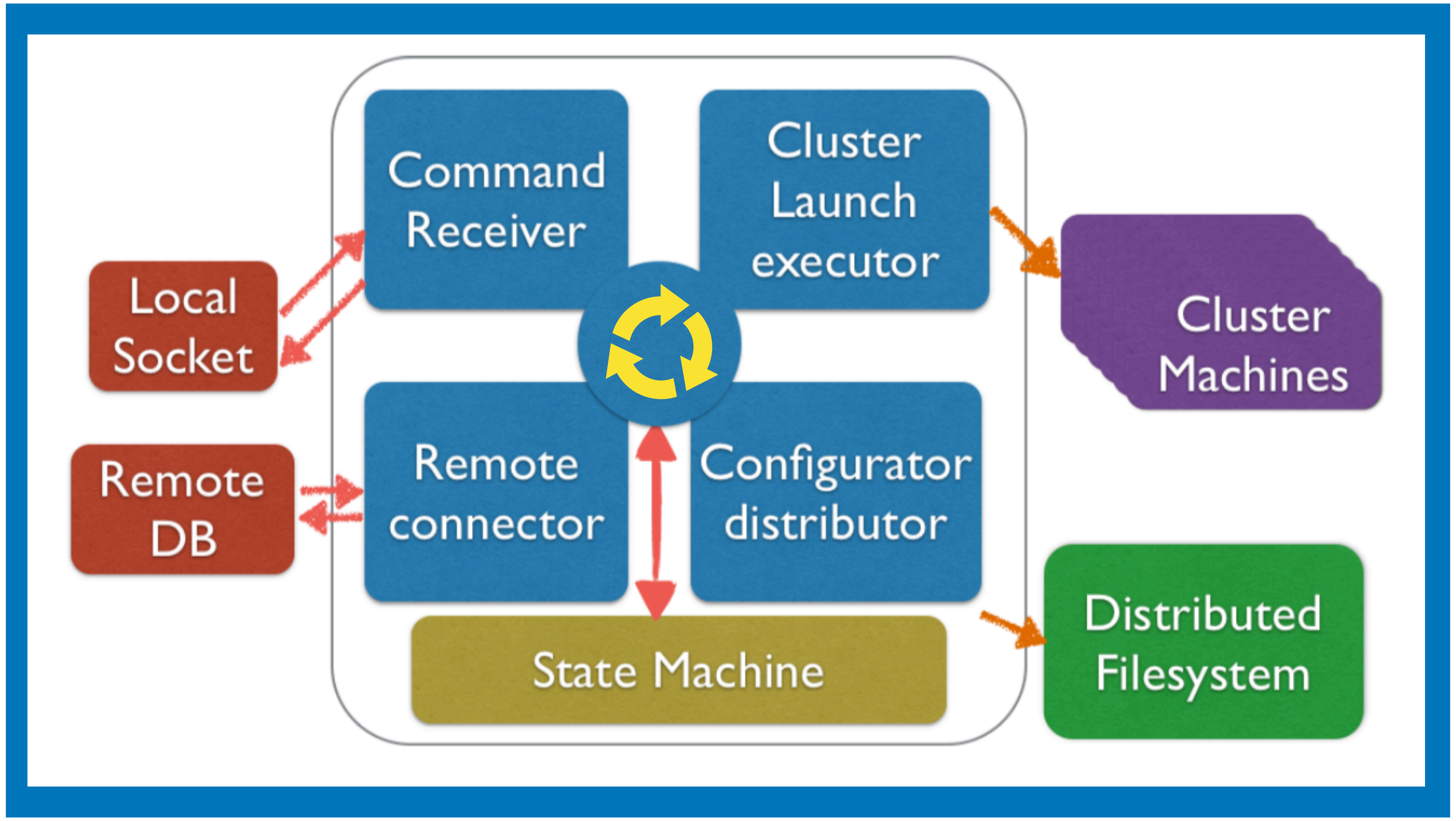
A sketch of a KM3NeT-Italy tower



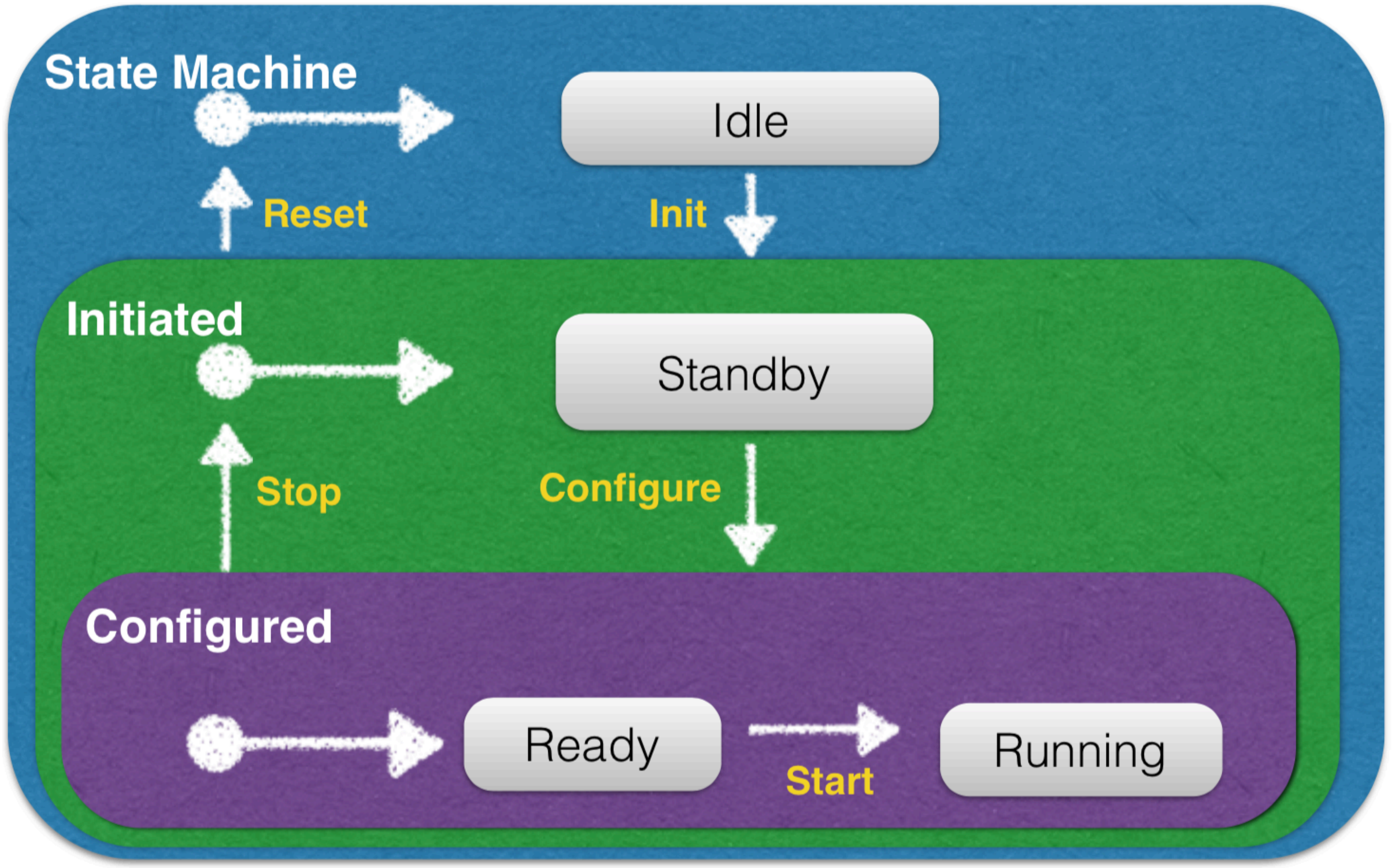


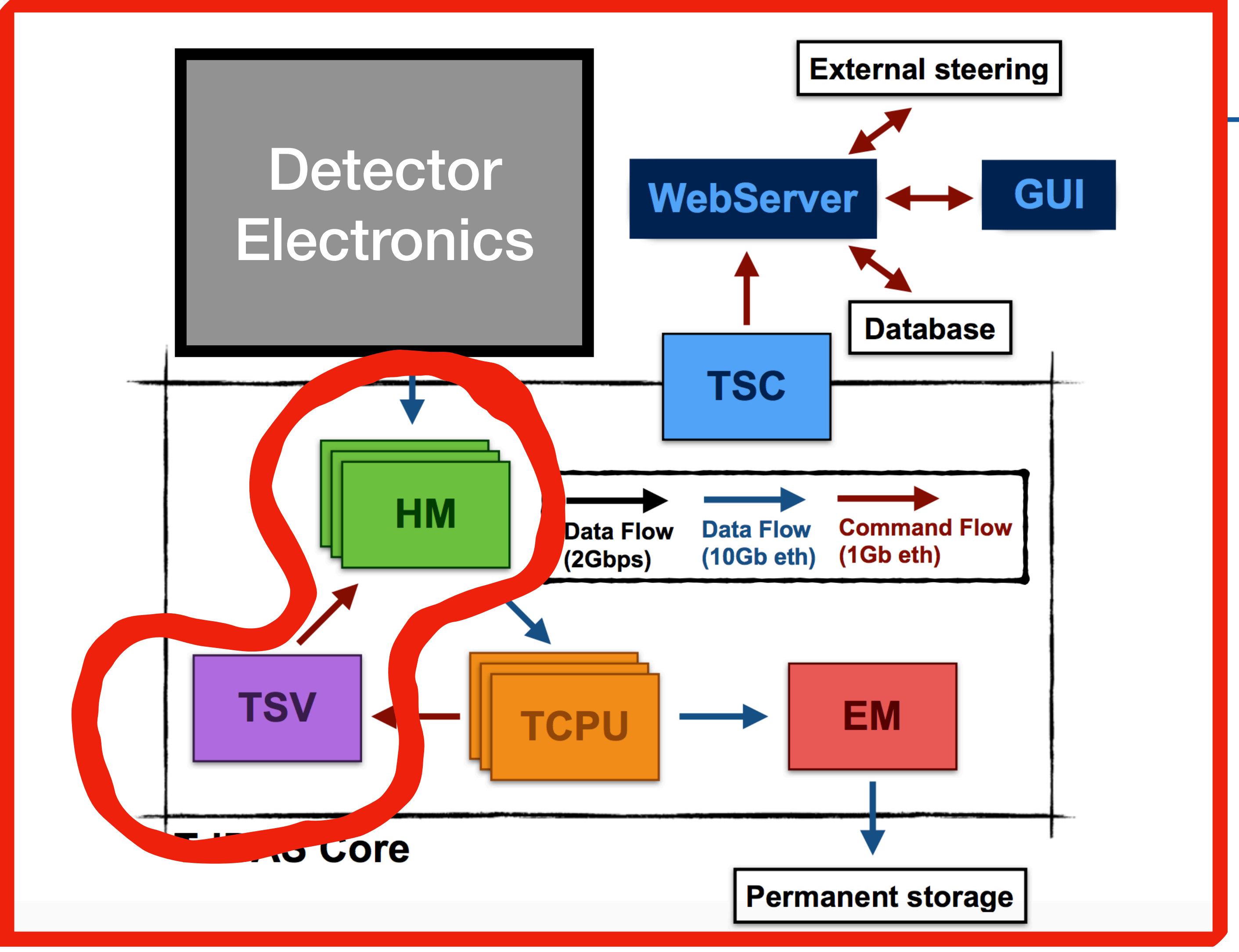
Detector FT- ECal
Q1
Q2
Q4
Q3
4x sockets (1x half rack)
by Sergey Boyarinov and Benjamin Raydo
Coda-SRO Translator
40x sockets (1:FADC board)
User-defined
Datacards
User
TSC
...
HM
TSV
TCPU
EM
TriDAS Core
Permanent storage

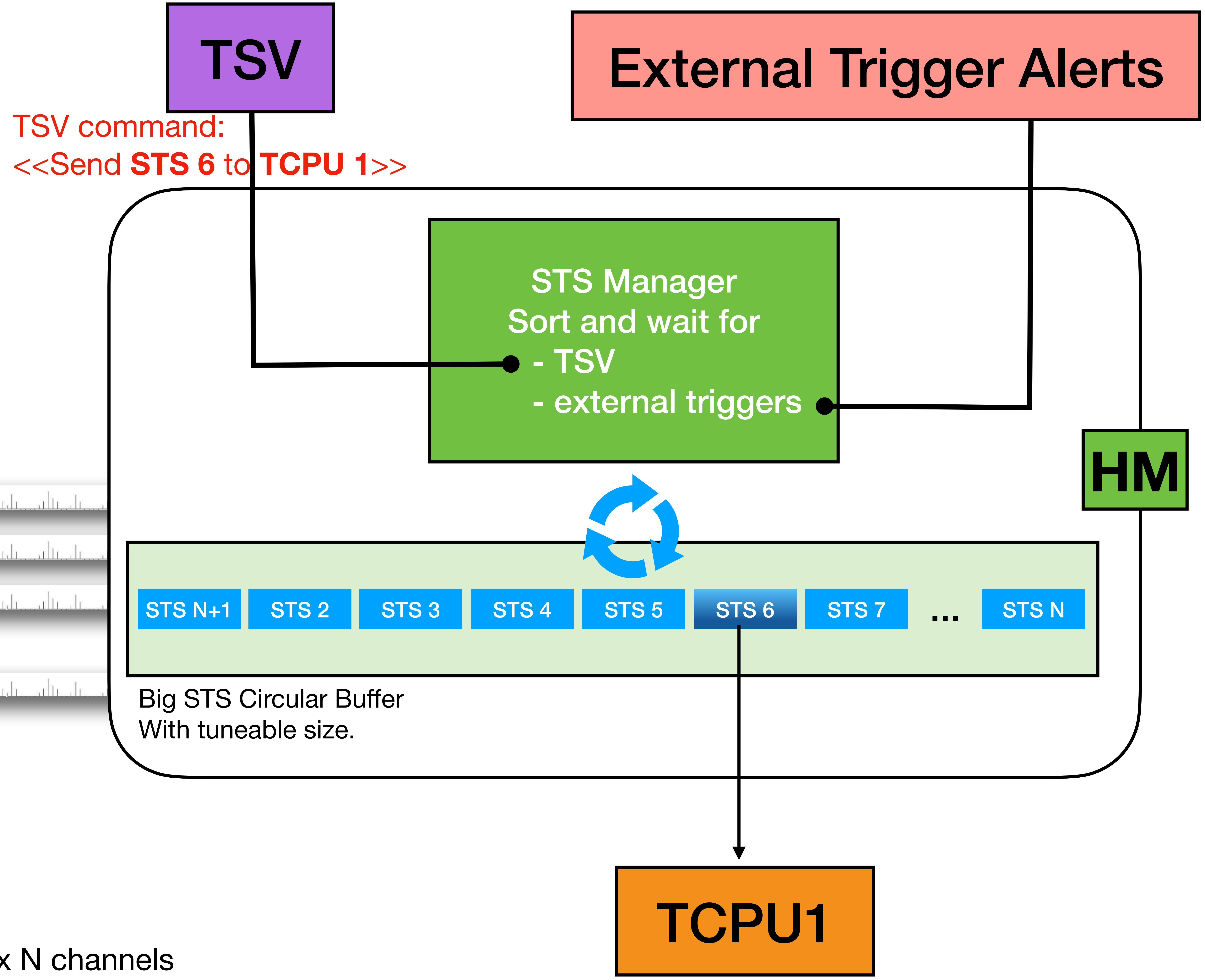


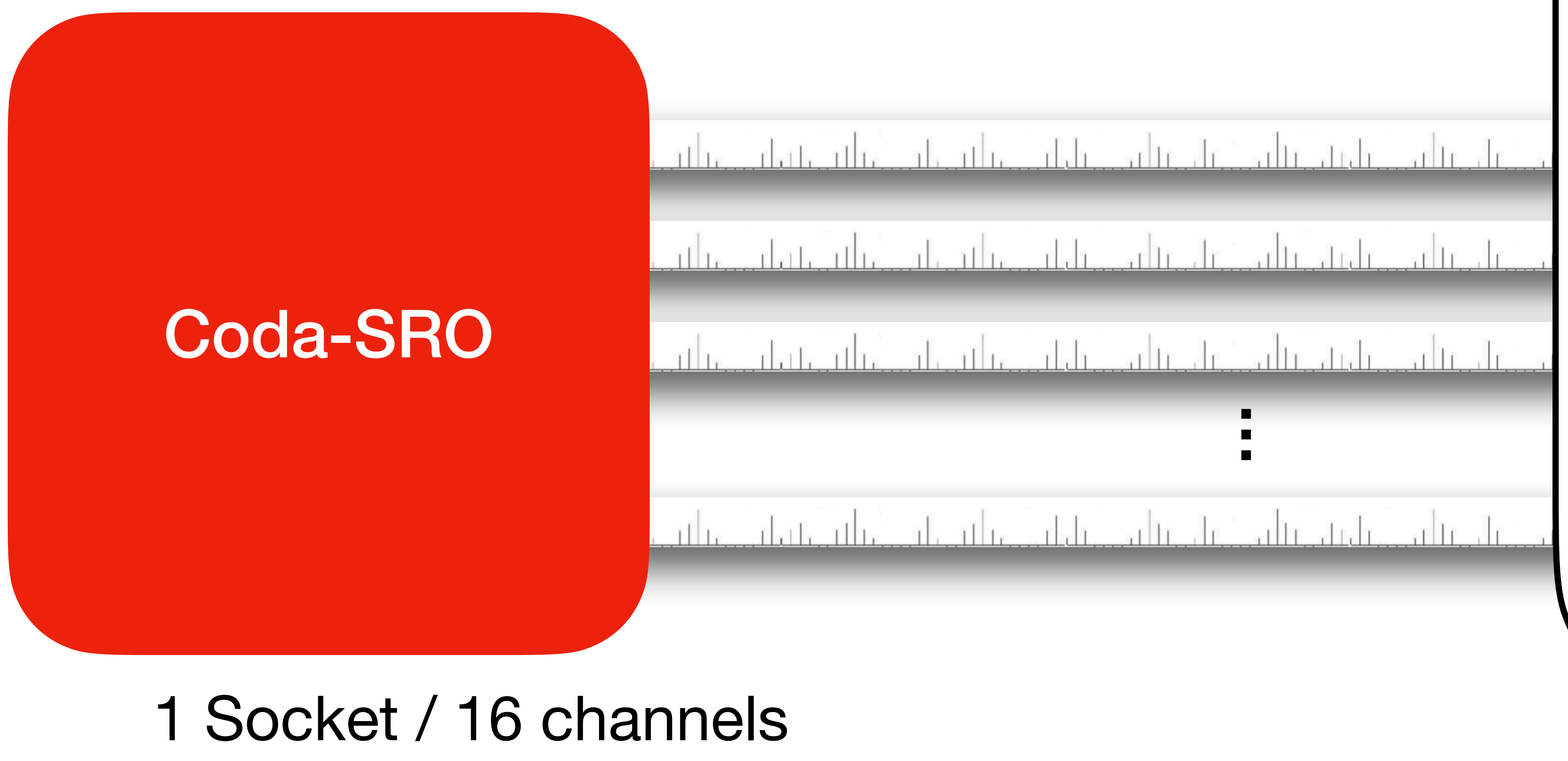


TriDAS
Hierarchical State Machine



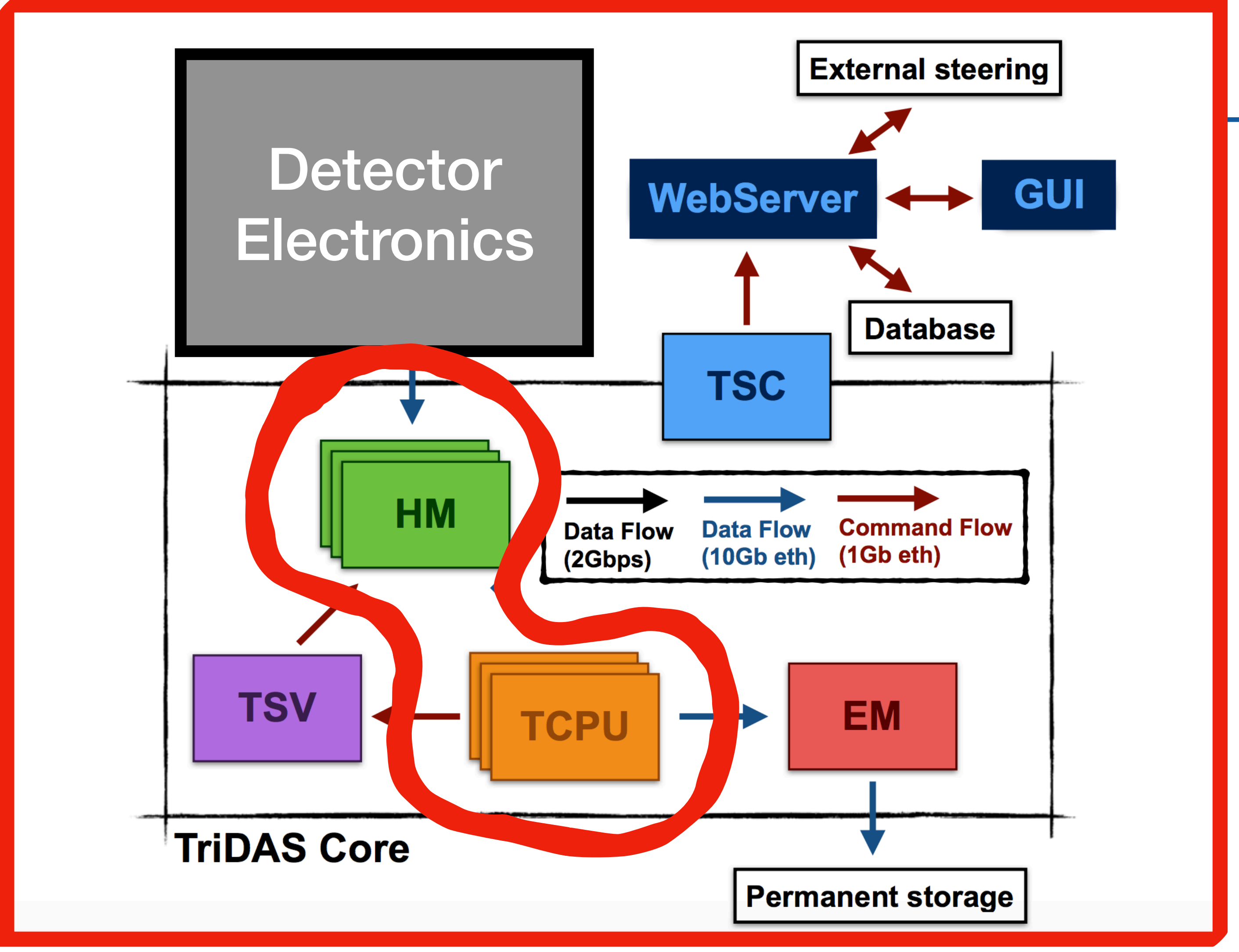






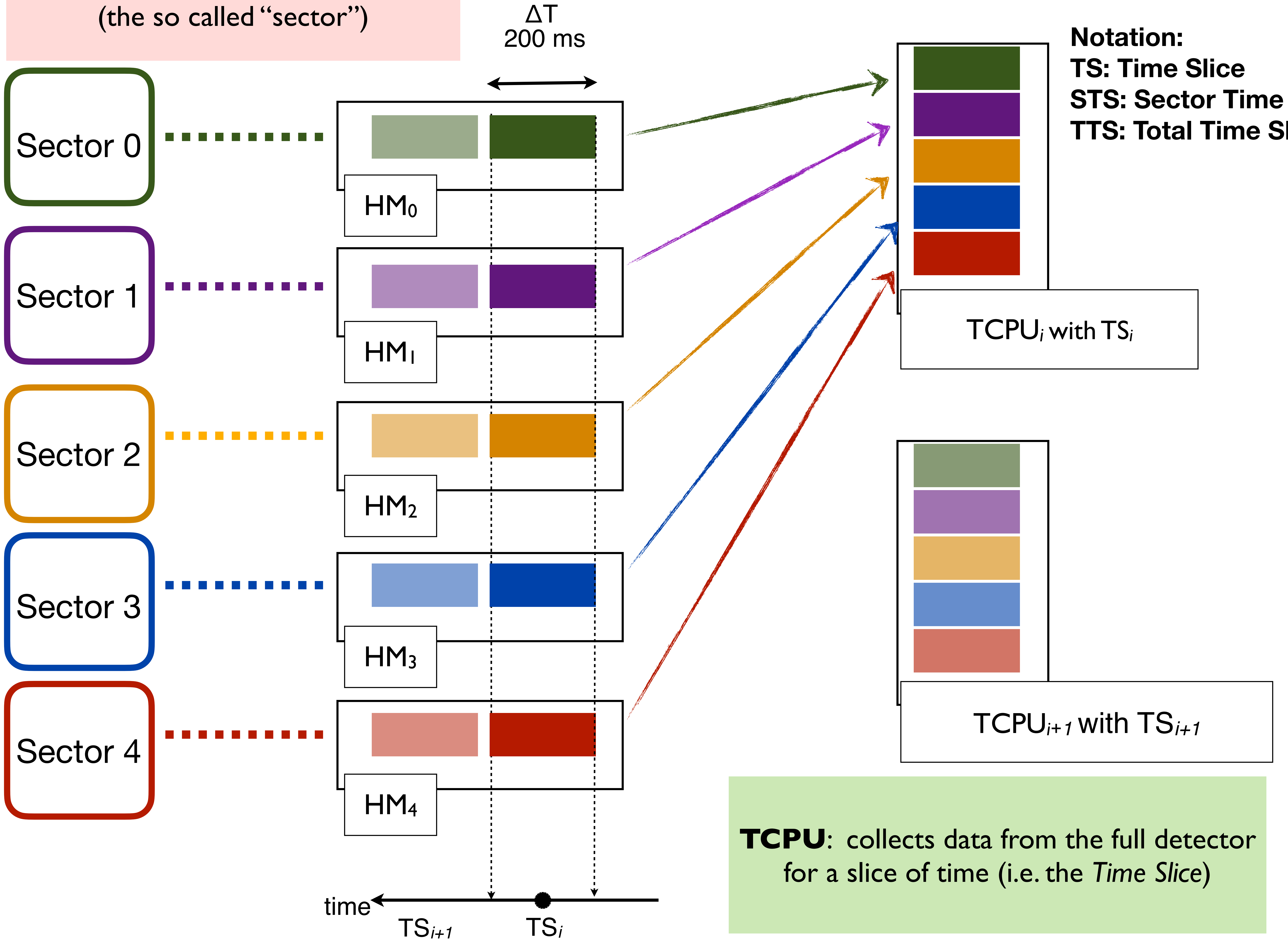
Notation:
TS: Time Slice
STS: Sector Time Slice, containing data from 12 x N channels

From Hit Manager to TriggerCPUs



HM: receives subsequent data from a fraction of the detector (the so called "sector")

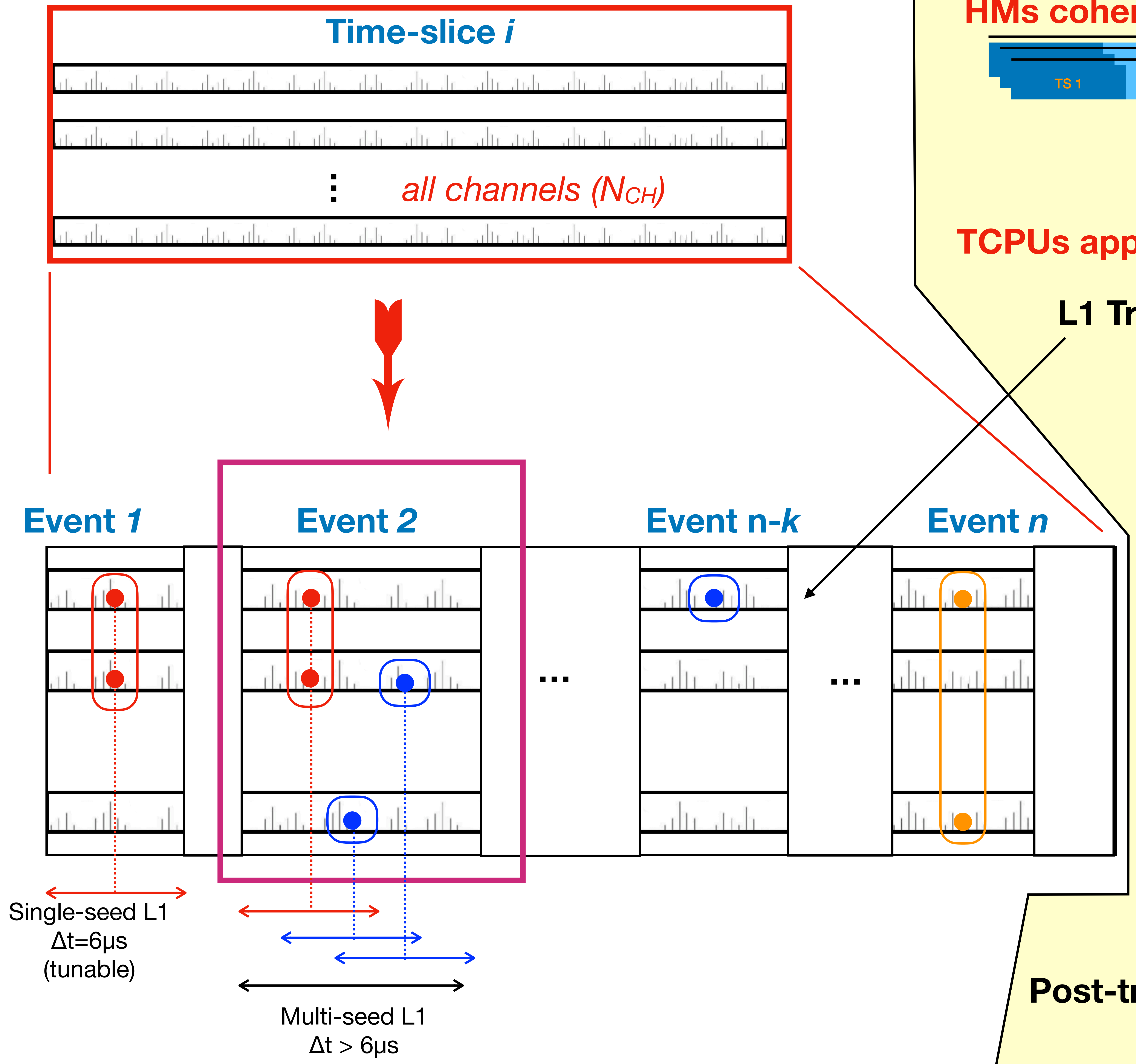
Sector
N FADC-Boards = *N x 16* channels



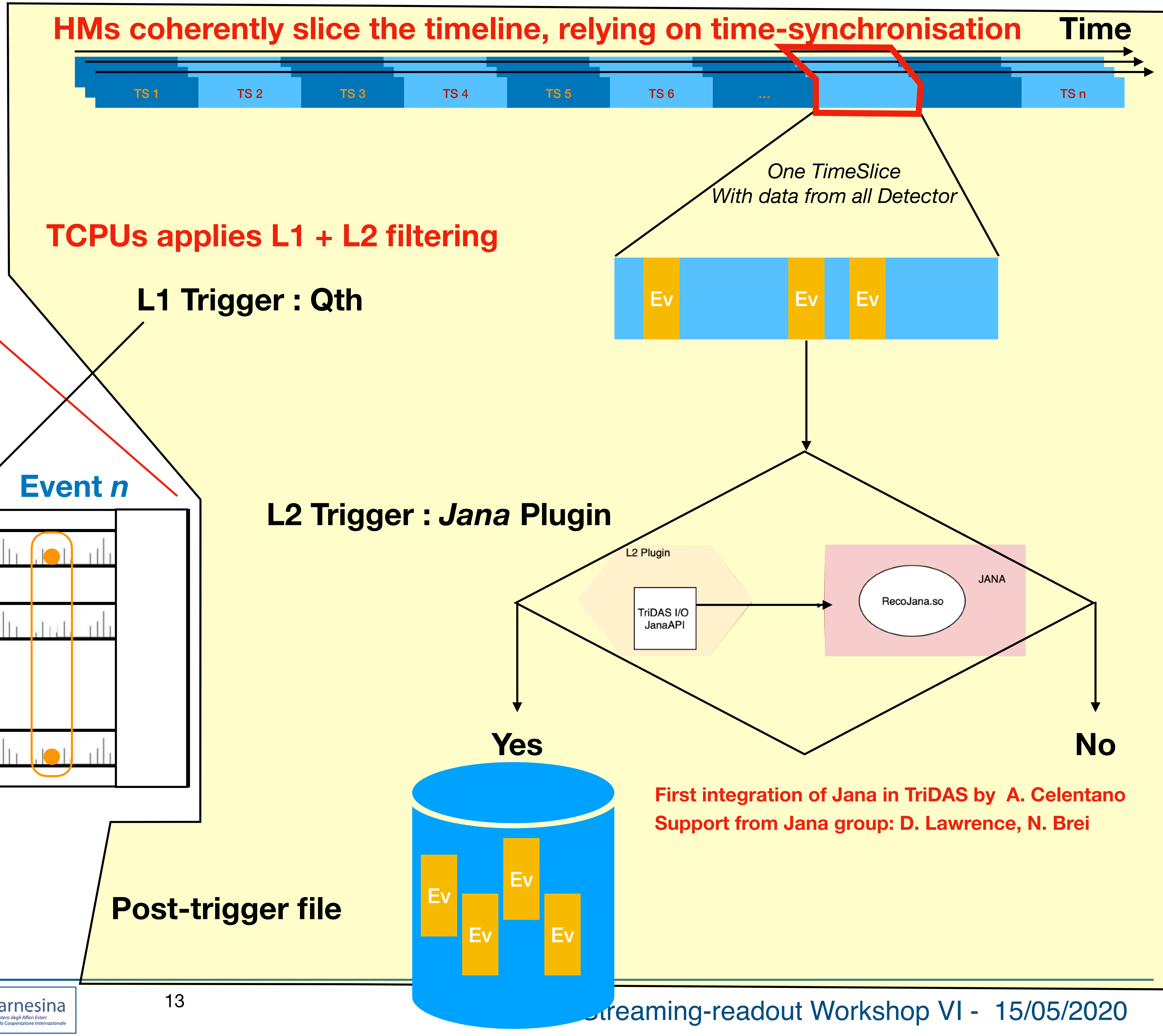
Notation:
TS: Time Slice
STS: Sector Time Slice
TTS: Total Time Slice

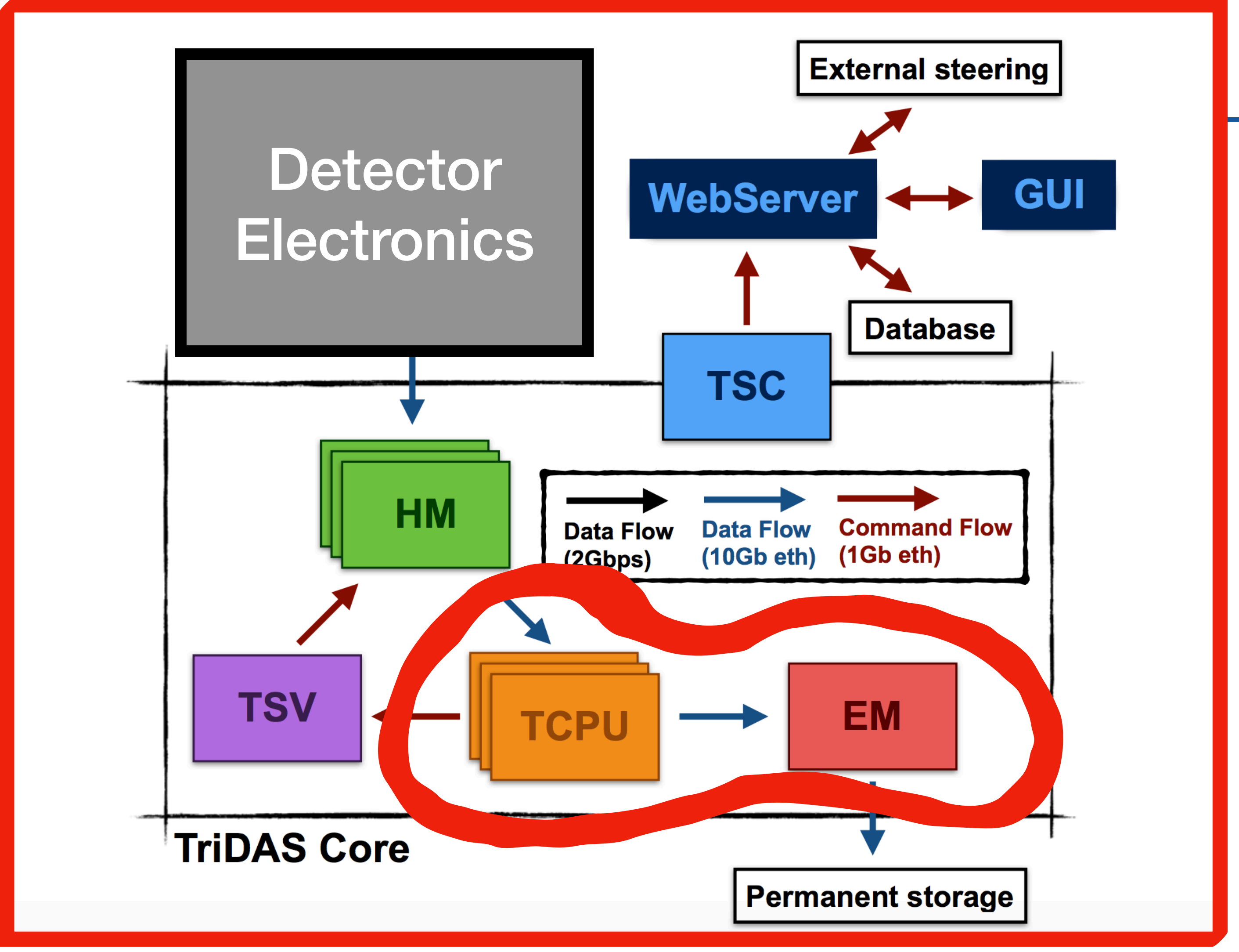
TCPU: collects data from the full detector for a slice of time (i.e. the *Time Slice*)

What TriDAS can Do



What done with Clas12

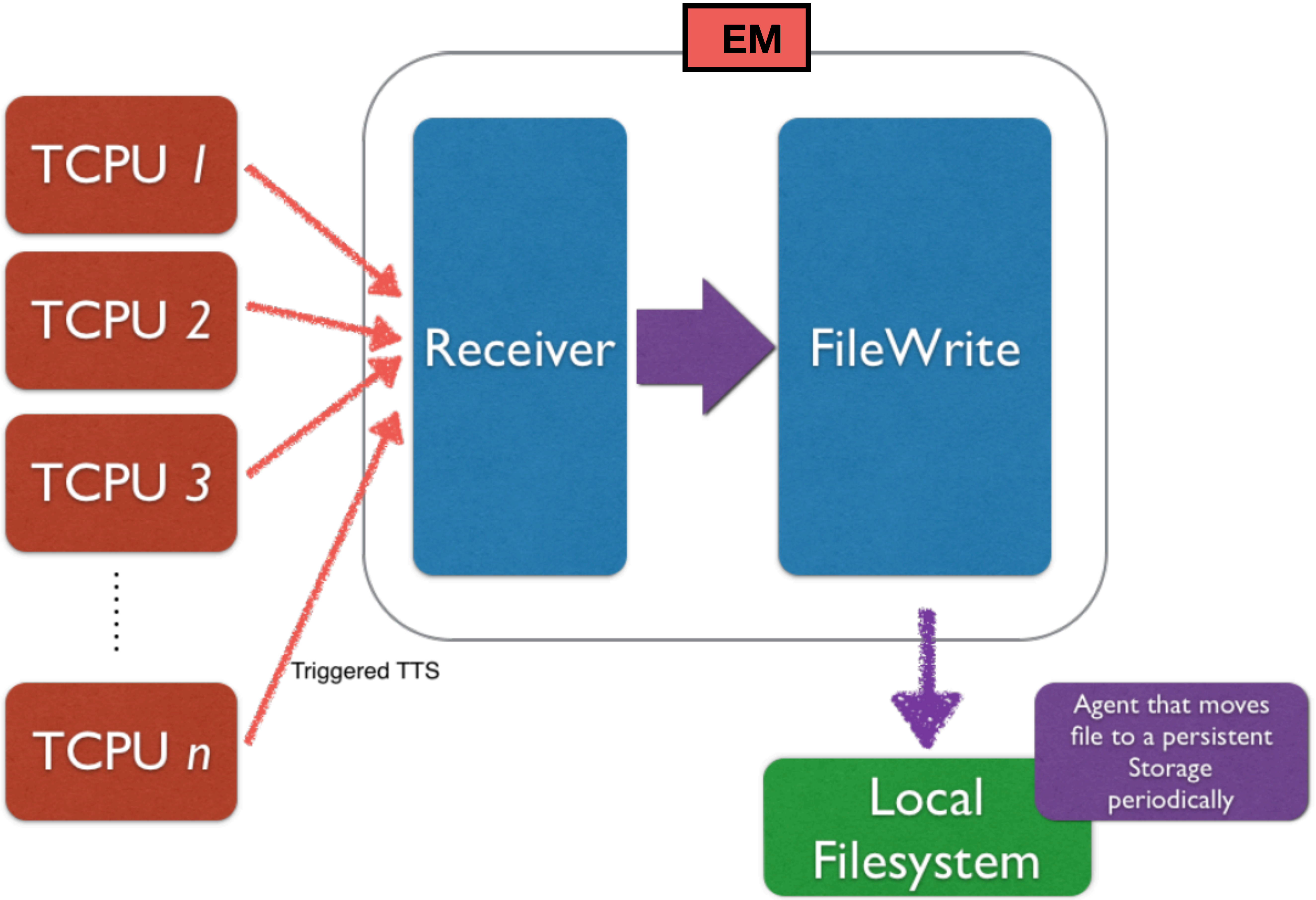




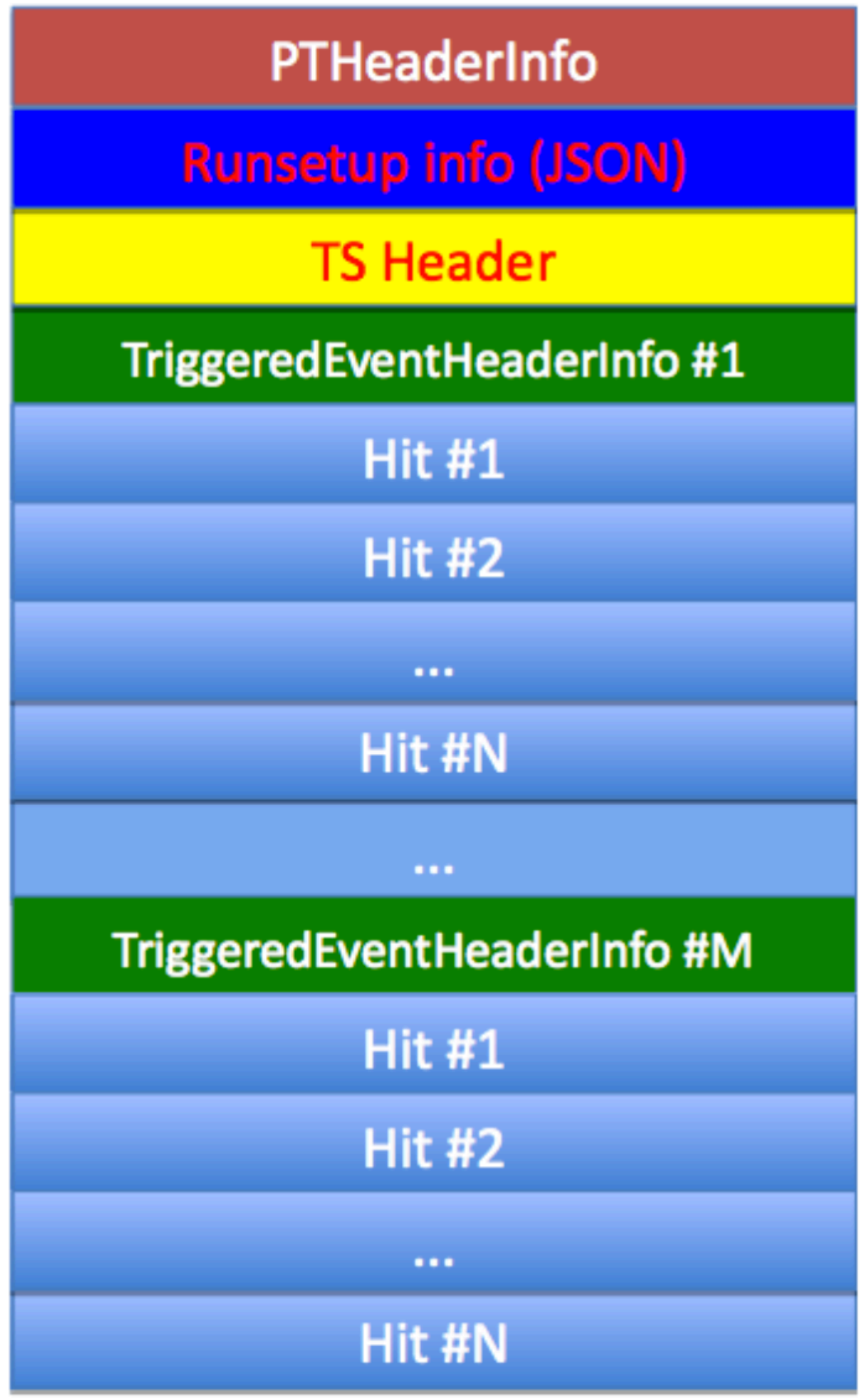
One **event is the collection of hits** which is supposed to describe the passage of neutrino induced muon or shower.

TCPUs **asynchronously process** independent Time Slices. The events are collected, but not time ordered, by the EM into a file.

High-level readout classes are prepared to parse the recorded file.

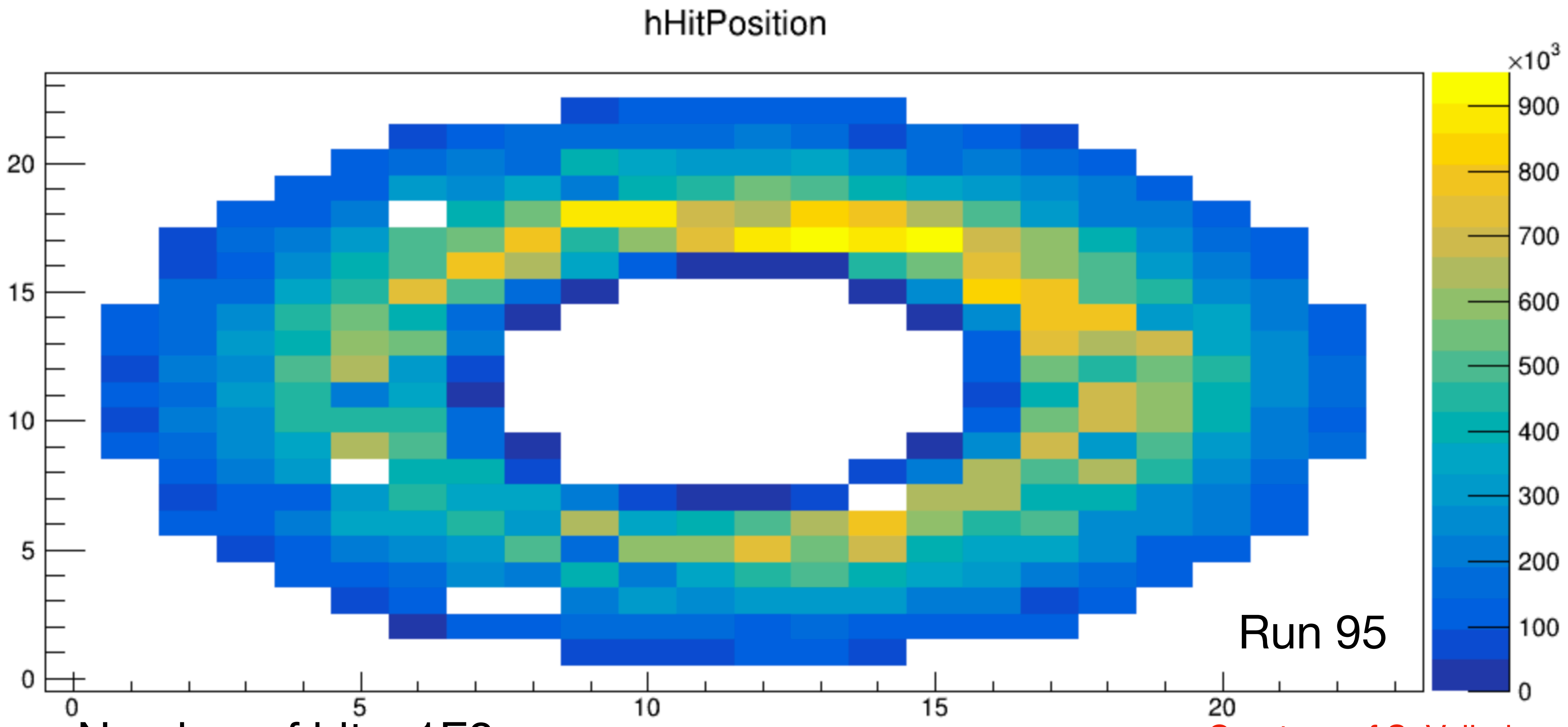


Binary post-trigger file



Aim of the tests:

- optimising the performance of data receptions (*HM* level)
- optimising the performance of data filtering (*TCPU* level)
- Studying memory + cpu consumption
- Studying online monitoring and coherence with recorded data



Number of hits: 1E8

Number of events (searched within 400 ns): 16E6

Courtesy of S. Vallarino and M. Bondì

Data analysis ongoing:

S. Vallarino - Clustering

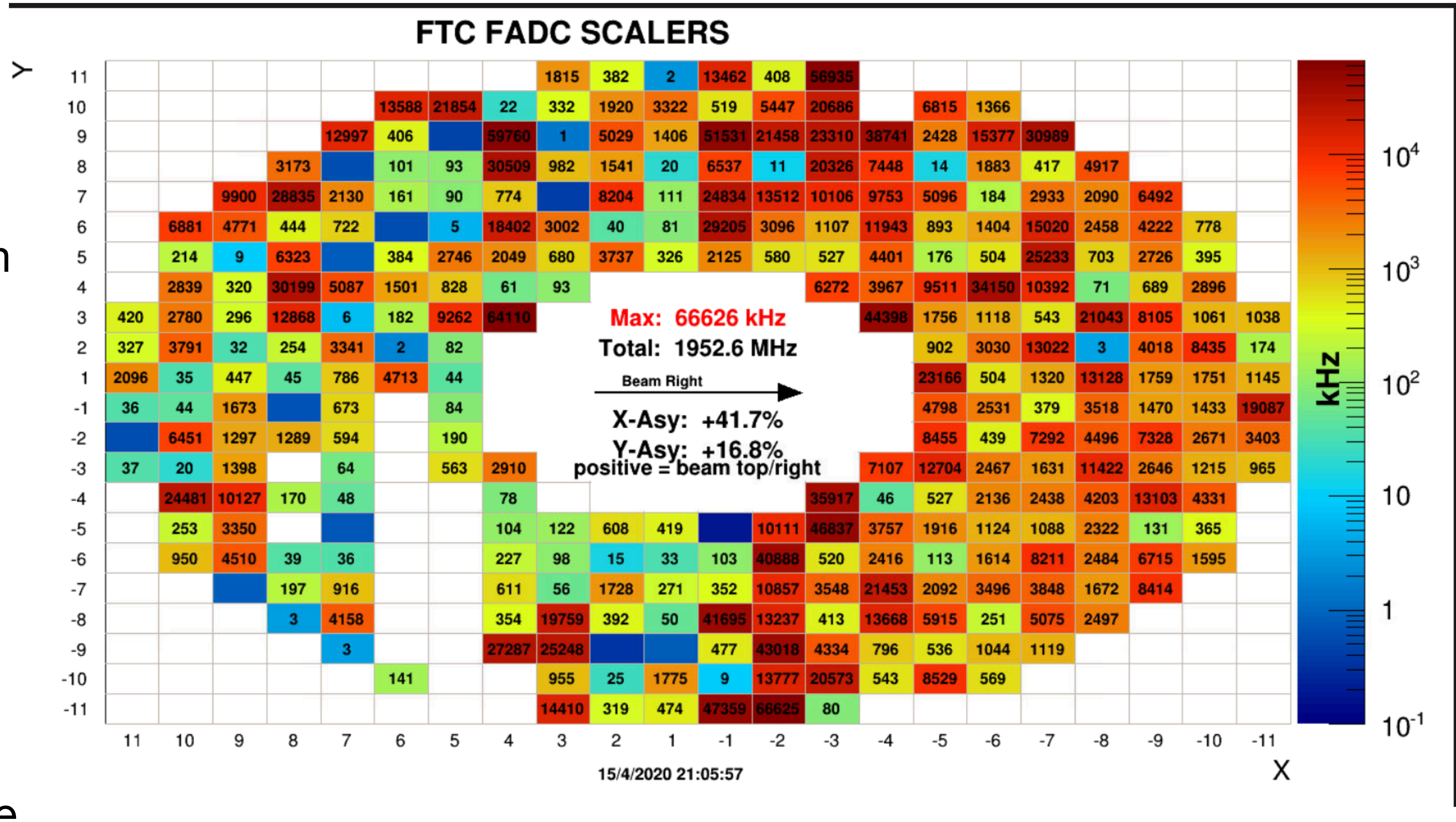
C. Fanelli - AI (see Cristiano's talk, yesterday)

Recent (ongoing) tests of TriDAS with Clas12

(no beam) - low thresholds

- **Situation:**

- inhomogeneous distribution of many channels with large rates ⟹ **stress test.**



- **Inputs for revision:**

Need of a revision of part of the TriDAS design for:

- enhancing the flexibility and resilience;
- focus to the used detector;
- In particular, aiming to combine multiple sub-detectors, also the trigger-layering design must be expanded (possible evolution from HTC → HPC).

Consider that with **nu-Tel**, **most of data are to be rejected**. In **Clas12**-like experiment, **most of data are good events.**

An implication is to invest in on-line reconstruction, and focus on computing resources.

Conclusions and Outlook

- Trigger-less approach derived from DAQ system of large scale neutrino telescopes in the Mediterranean Sea
- TriDAS design is modular and scalable with incoming throughput;
- Some constraints derived by nu-Tel assumptions imply to review TriDAS for JLab detectors (e.g. Clas12)
- Early 2020 tests @ JLab with Clas12 produced data for analysis (search for π0)
- Stress tests are ongoing with Clas12 FTCAL (although without beam)
- Improve the integration with auxiliary software developed @ JLab (JANA)
- Review (rethink) the trigger-layers model
- Interaction between TriDAS developers with JLab's SRO team

Thank you!

Further readings

T. Chiarusi, M. Spurio, High-energy astrophysics with neutrino telescopes, DOI: 10.1140/epjc/s10052-009- 1230-9, The European Physical Journal C (2010).

C. Pellegrino, et al., The trigger and data acquisition for the NEMO-Phase 2 tower, DOI 10.1063/1.4902796, AIP Conference Proceedings (2014).

M. Pellegriti et al., Long-term optical background measurements in the Capo Passero deep-sea site, DOI: 10.1063/1.4902780, AIP Conference Proceedings (2014).

TriDAS web site: https://bitbucket.org/chiarusi/tridas.

C. Pellegrino, T. Chiarusi , The TriDAS for KM3NeT neutrino telescope, DOI 10.1051/epjconf/201611605005, VLVNT 2015 Conference Proceedings (2015).

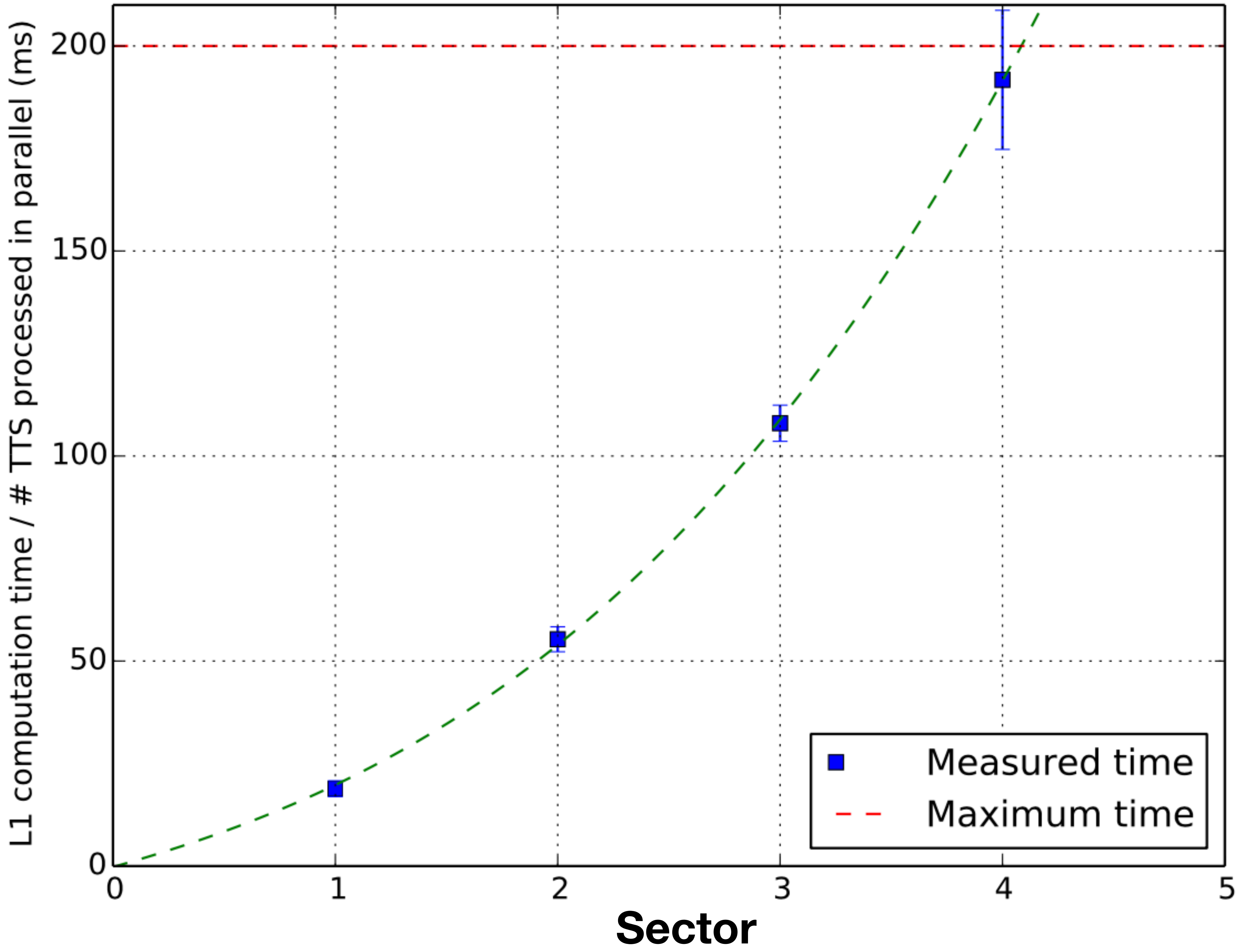
R. Ammendola et al., NaNet3: The on-shore readout and slow-control board for the KM3NeT-Italia underwater neutrino telescope, EPJ Web of Conferences 116, 05008 (2016).

M. Favaro, et al., The Trigger and Data Acquisition System for the KM3NeT-Italia towers EPJ Web of Conferences 116, 05009 (2016)

M. Manzali, et al., The Trigger and Data Acquisition System for the KM3NeT-Italy neutrino telescope , Proceedings of CHEP 2016

BDX proposal: https://arxiv.org/abs/1607.01390

- Simulated Poissonian single rate per cahnnel: ***100 kHz***
- N. of TCPUs: 4 nodes (**32 cores** Intel(R) Xeon(R) CPU E5-2640 v2 @ 2.00GHz)
- Concurrent TimeSlice processing: **20 TS in parallel/node**
- Time Slice duration : **200 ms**
- L1 event length: **6 μs**
- 1 Sector = **7 WaveBoards** (84 channels)



It means that for N>4 Sectors (336 channels at 100 kHz single rate!) additional TCPU nodes are needed (or more trigger threads, if allowed by the computing resources).

Granny's recipe:

add TCPU as much as it suffices !!

…without affecting the DAQ design.

Scalability is granted!