Review of possible **trigger algorithms** for the 8 Towers DAQ

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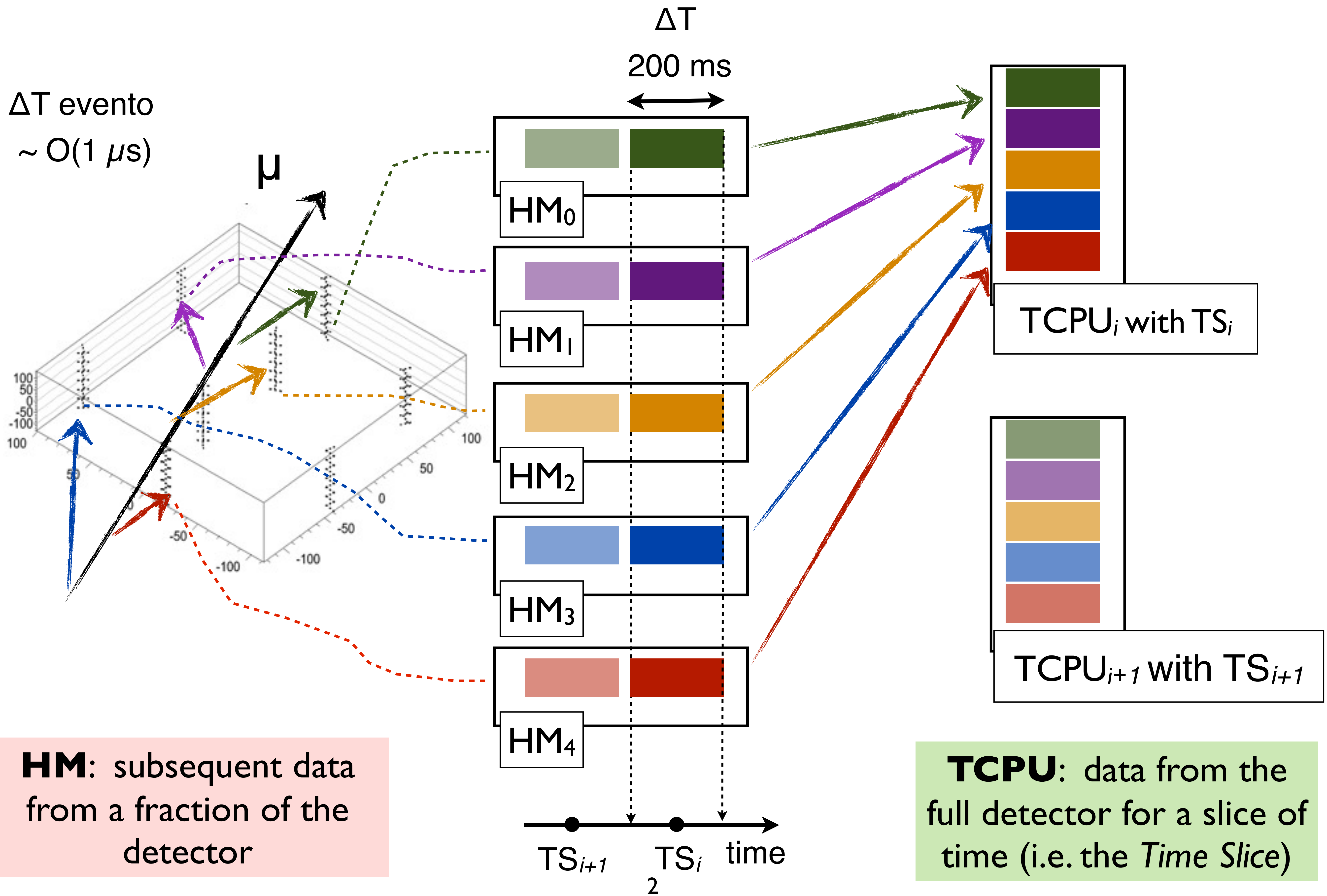
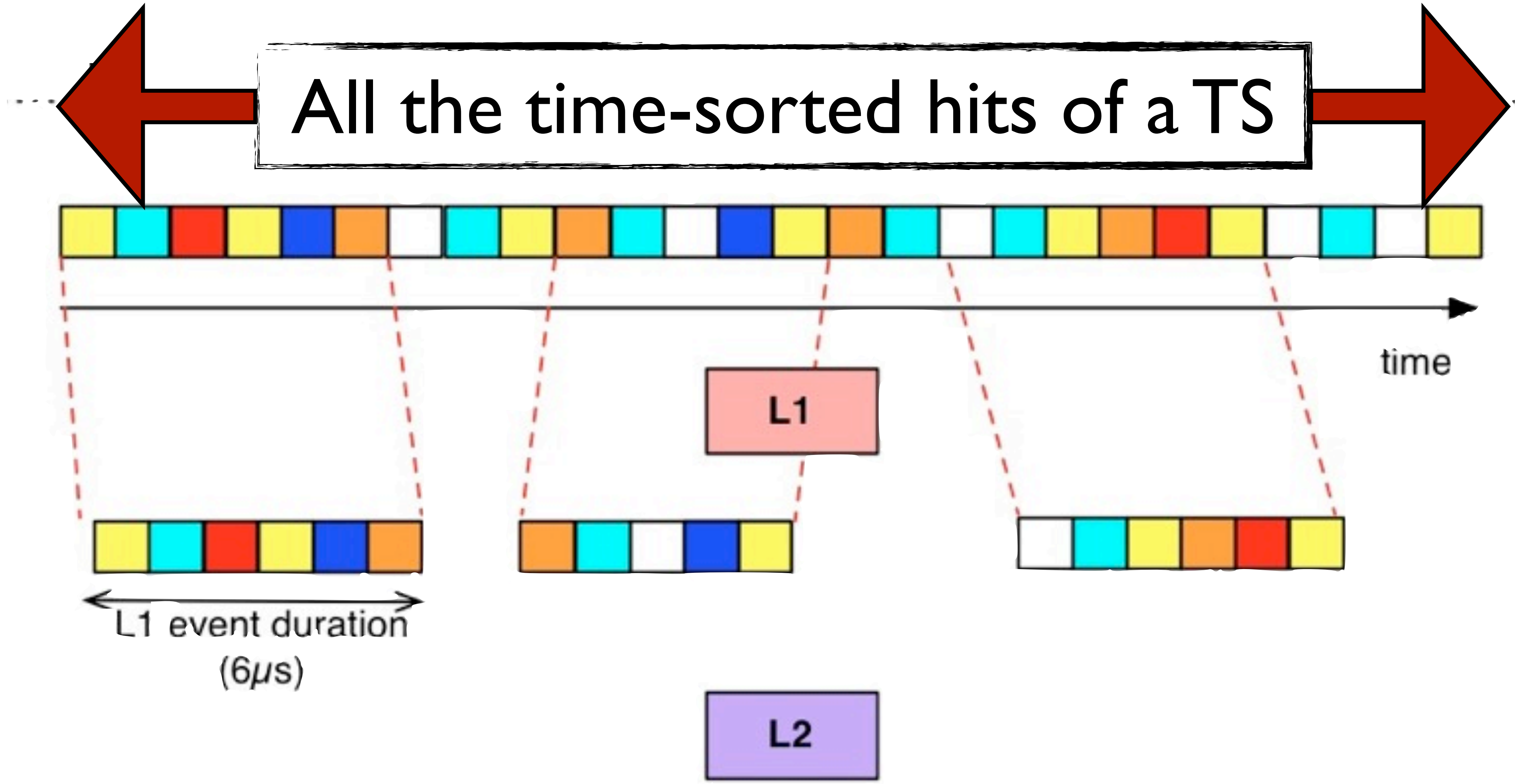
General context: the TriDAS framework



HM: subsequent data from a fraction of the detector

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

Trigger Levels

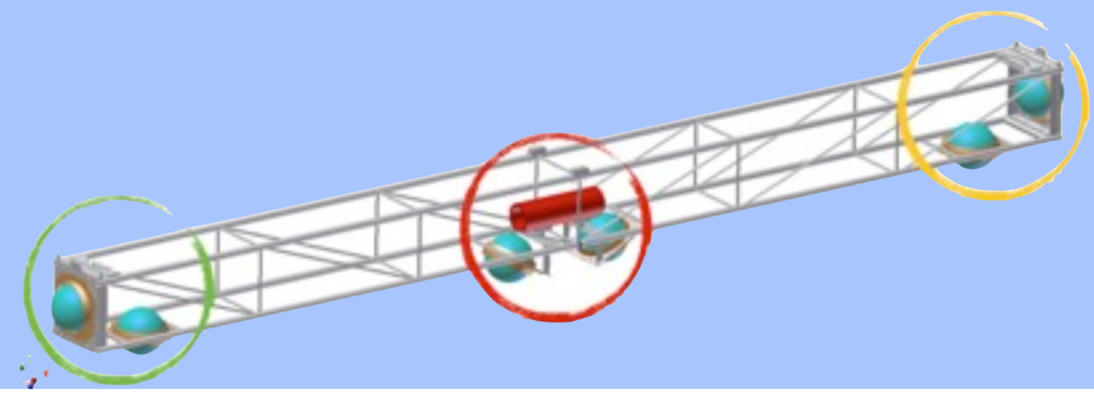


L1 = PRESELECTION

L2 = Dedicated Trigger Algorithm

L1 - PRESELECTION

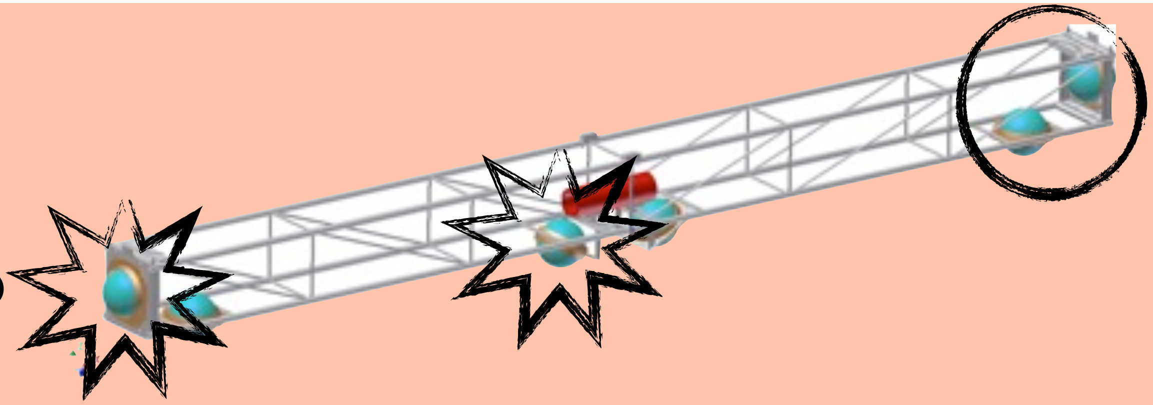
A



Simple Coincidences

$\Delta T \leq 20$ ns

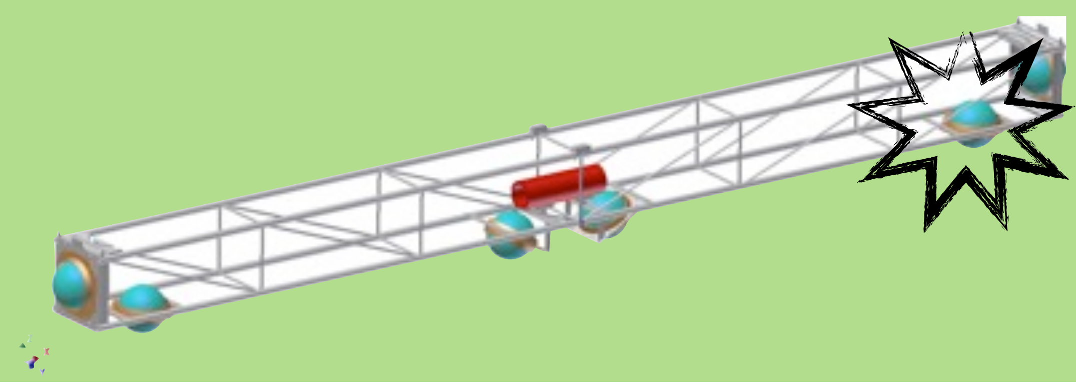
B



Simple Coincidences + shooting hits

$Q > Q_{th}$ && $\Delta T \leq 60$ ns(*)

C



Shooting hit

$Q > Q_{th}$

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

Sampling Window ΔT

n = n. involved PMTs

k = minimum searched hits within ΔT

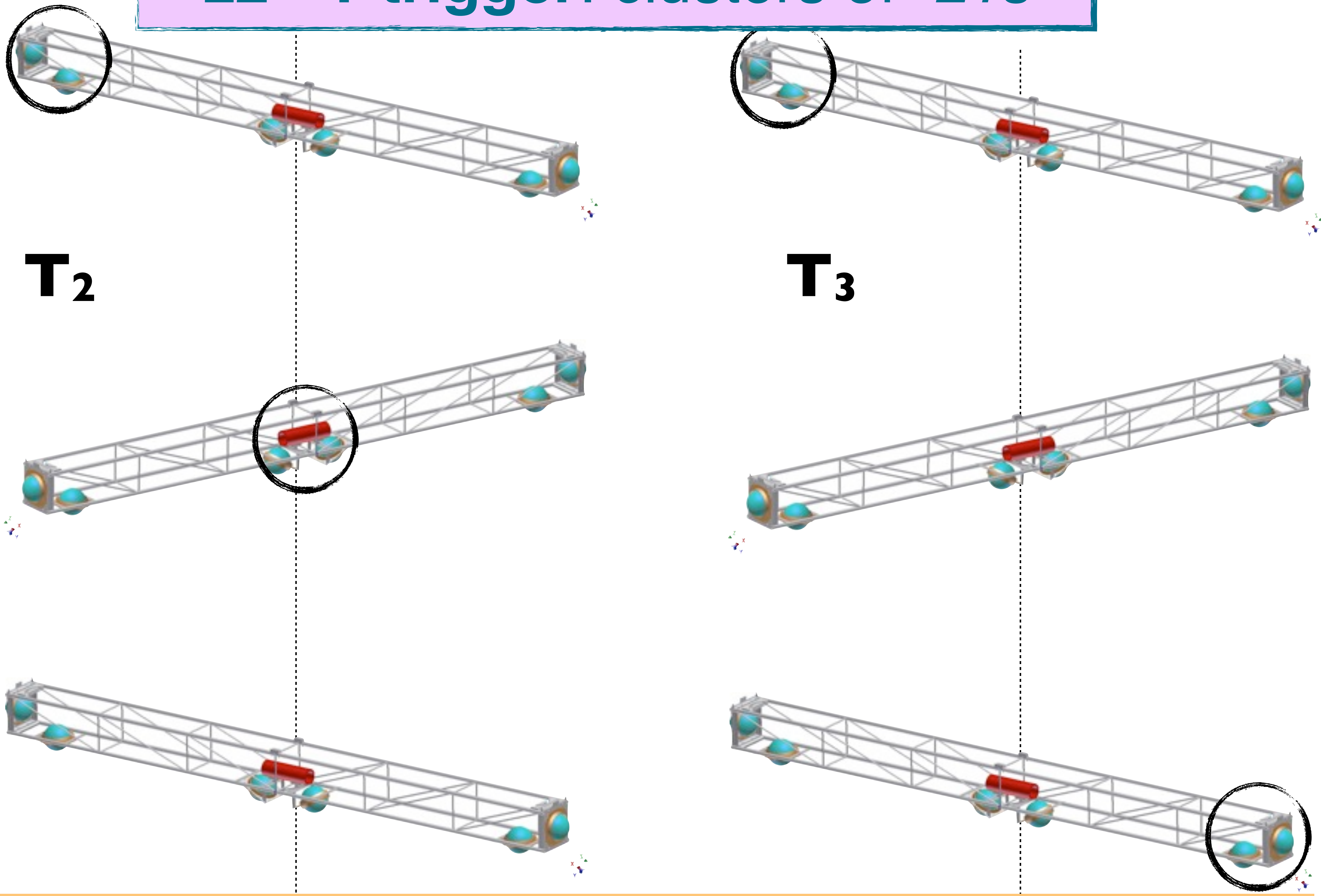
L2 - Generalities

Summary:

a) T- trigger
b) Simple Causality trigger
c) Sky scan trigger
d) Tracking source trigger
e) Vertex-splitting trigger
f) Follow-up trigger (GRB, supernovae, GW)

The dedicated L2 algorithms process only the hits yielding the **L1s** **but for the tracking source trigger** which combines all the hits of a **L1** event

L2 - **T-trigger**: clusters of *L1s*



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

L2 - Simple causality trigger

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

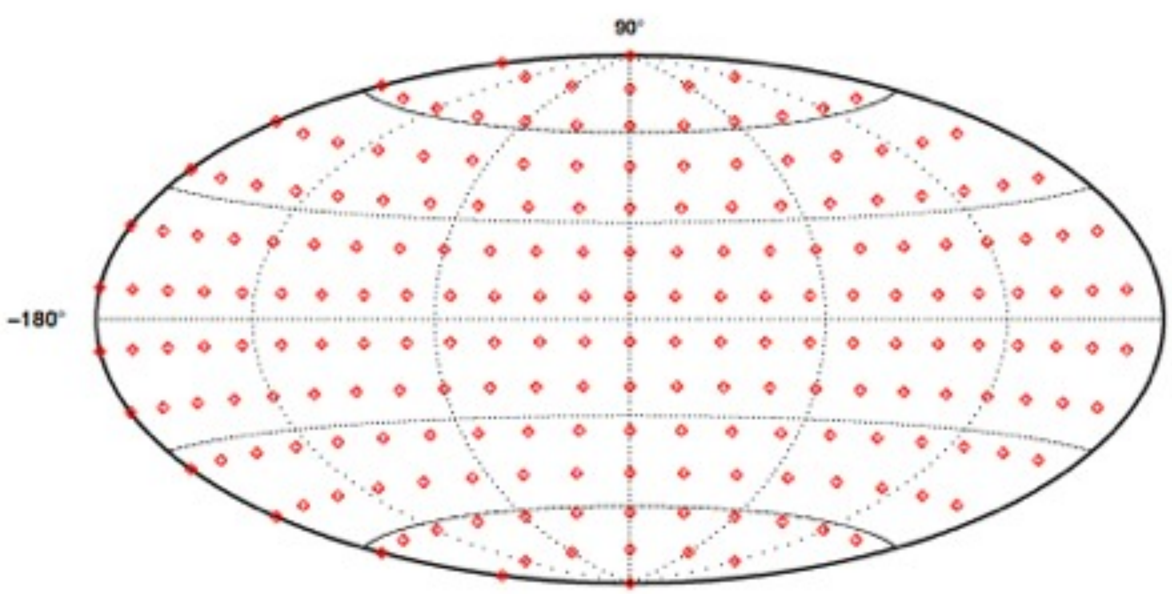
2. *3D*-causality filter : $\left| t_i - t_j \right| \leq \left| \vec{x}_i - \vec{x}_j \right| \frac{n}{c}$

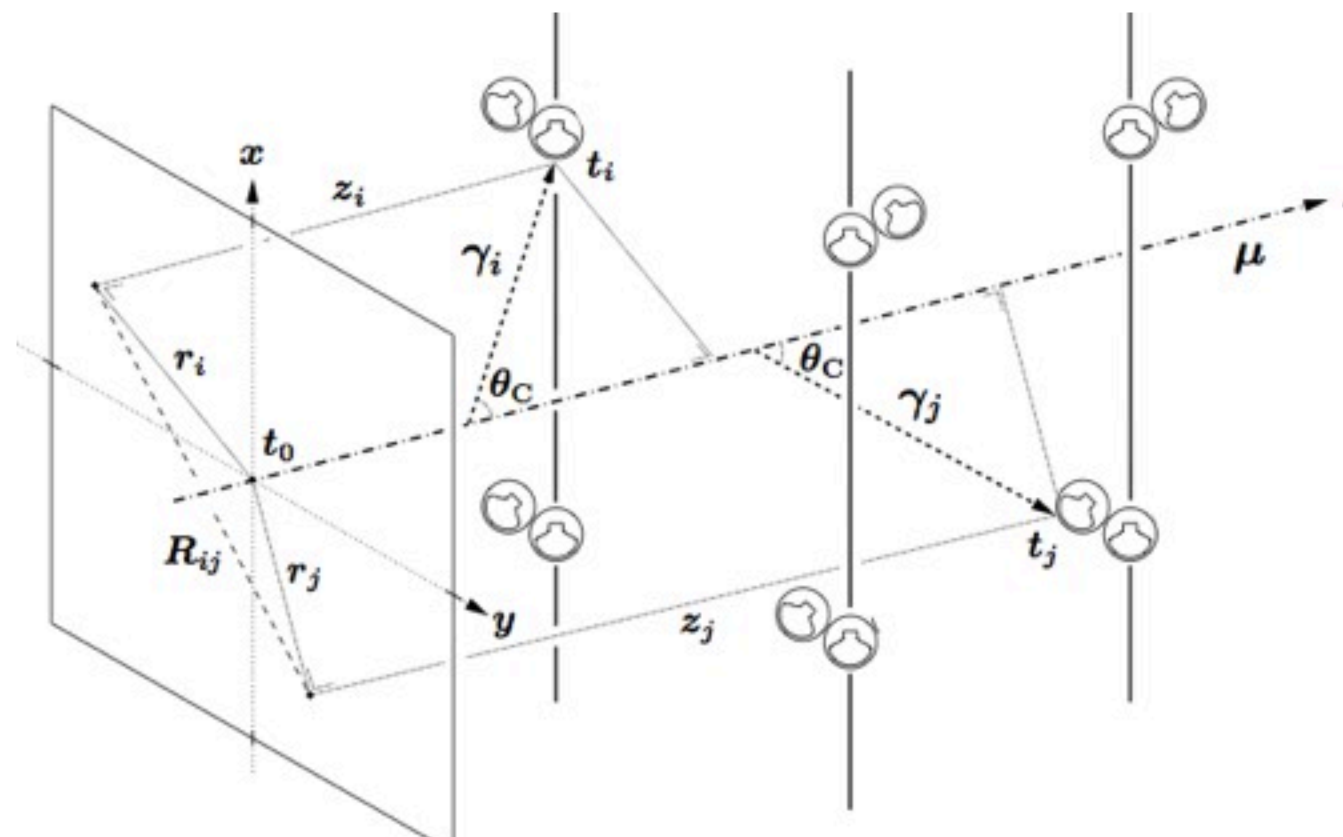
3. The trigger is set if the n. of satisfying hits is ≥ N'_{th}

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

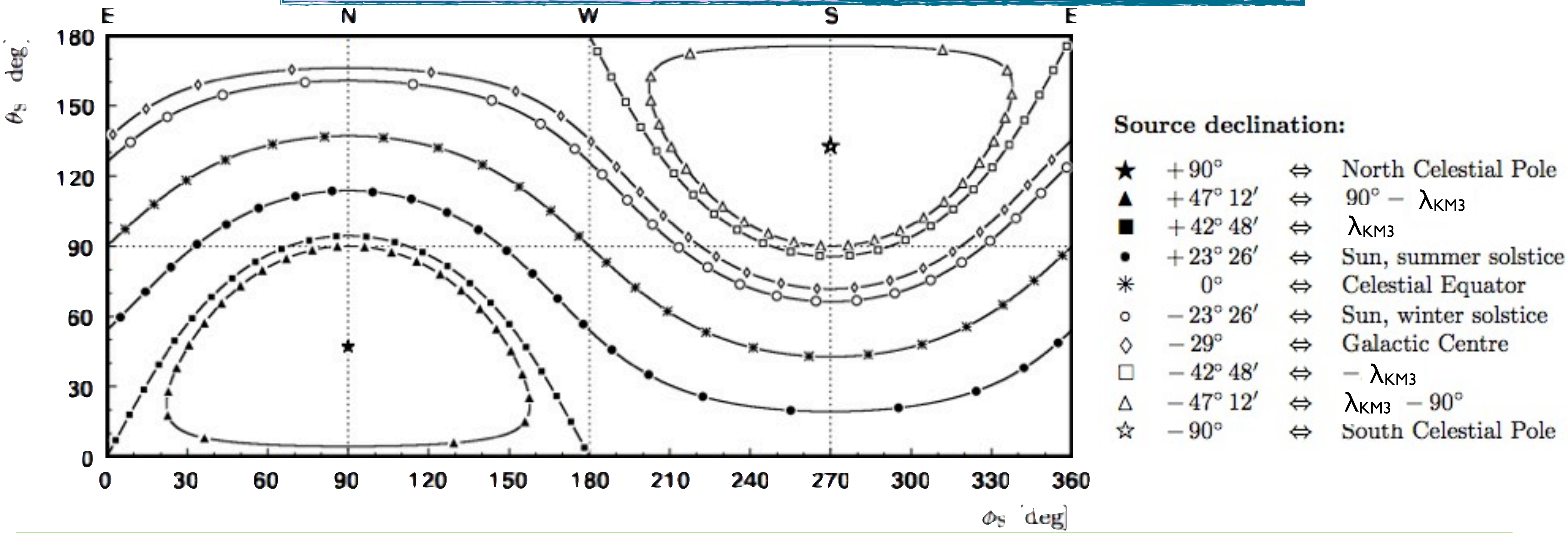




$$|(t_i - t_j)c - (z_i - z_j)| \leq \tan\theta_c \sqrt{[(x_i - x_j)^2 + (y_i - y_j)^2]} = \tan\theta_c \, |R_{ij}|$$

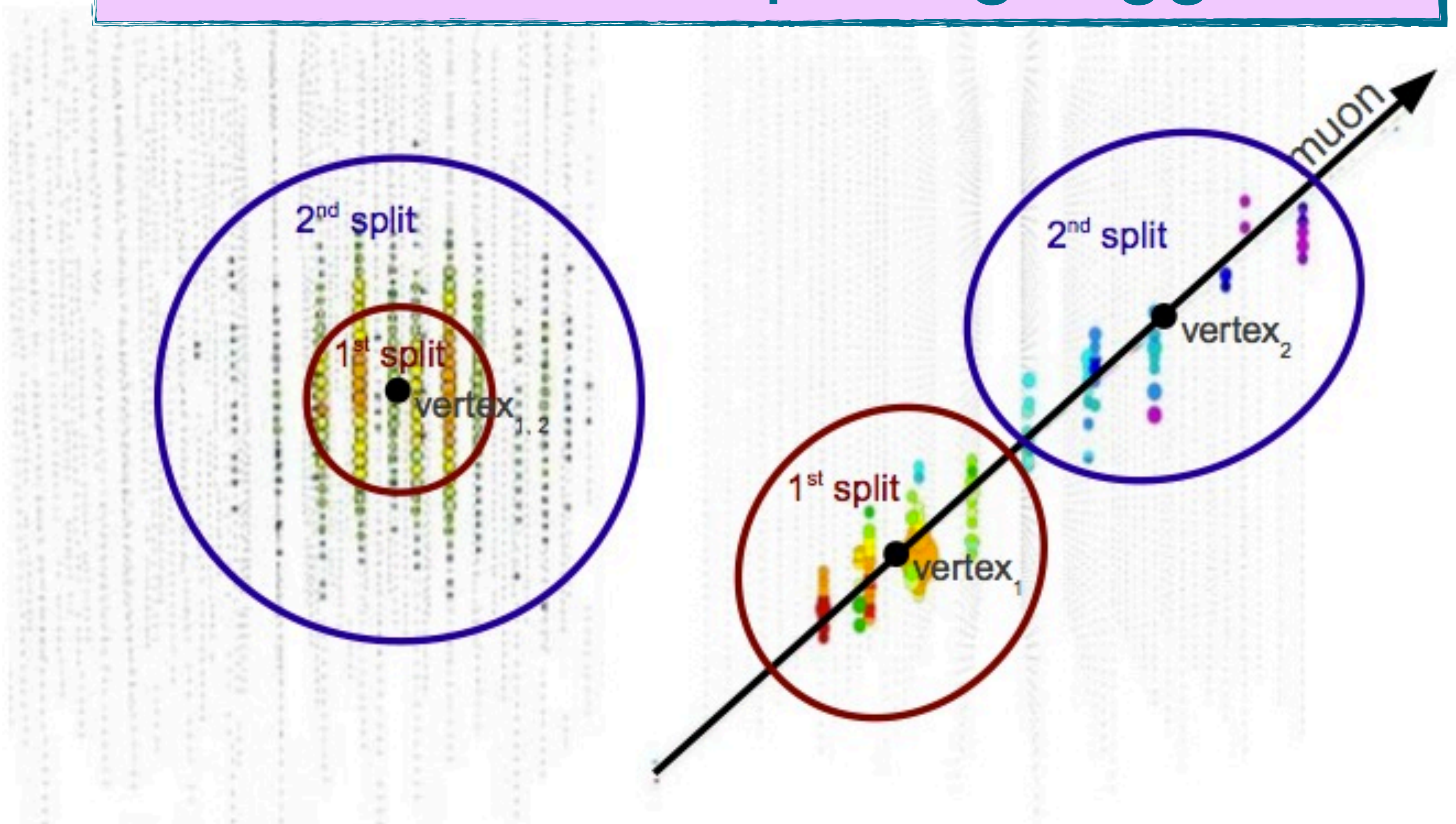
3. The trigger is set if the n. of satisfying hits is ≥ N'_{th}

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 $\mathbf{N_{min}}$ **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 + Simple Causality Filter + “Inertia” tensor eigenvalues

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

Algorithms serving Physics

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

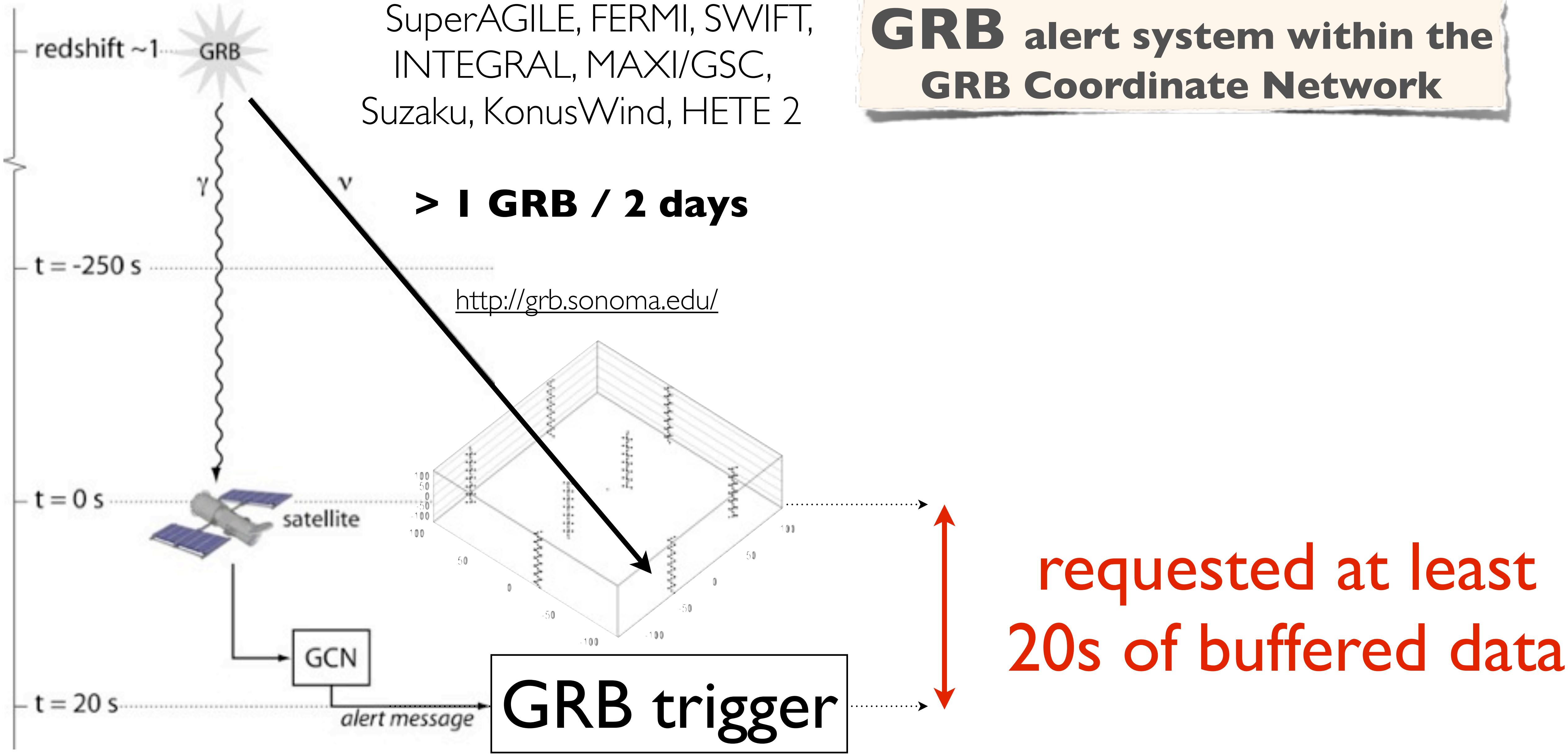
L2 - **Follow-up trigger**

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

> 1 GRB / 2 days

http://grb.sonoma.edu/

GRB alert system within the GRB Coordinate Network



... but who is supposed to be buffering ?

... and who is supposed to apply a stack-analysis through the expected duration of a burst?

First possible answer: BUFFERING **in TCPUs**

N. machines ? ← constraints from
CPU power + MEMORY (3-4 GB RAM/core; 10-16 HEPSPEC/Core).

- Note: 1 TS size: ranging within **180 (realistic 50 kHZ bkg) - 400 (hard 110 kHz bkg) MB/TS.**

- **Limit to 2 the number of processes / server**.
- each process will be **multithreading** → probable strong **parallelism among L2 triggers**

- the computing power scales if the n. processes (or threads) does not exceed the n. of physical cores.
- 32 GB RAM/server could allow us to buffer about 20 secs/process (in the *realistic* case).

If needed more buffer, necessary to do I/O to solid /state memory.

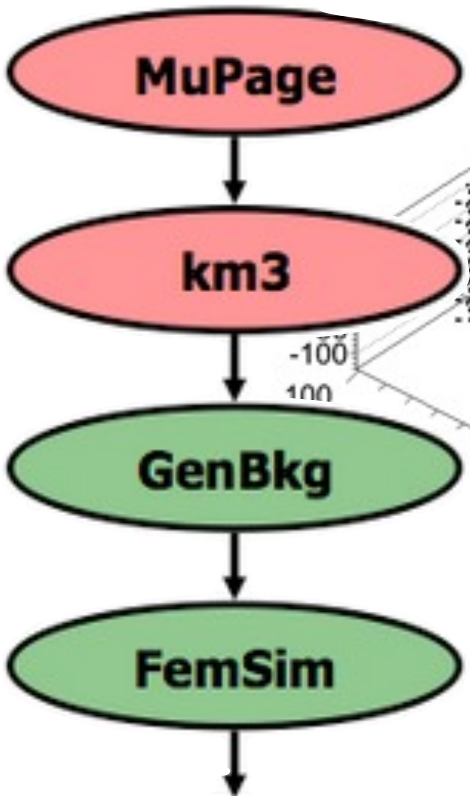
Second possible answer: BUFFERING **in HMs**

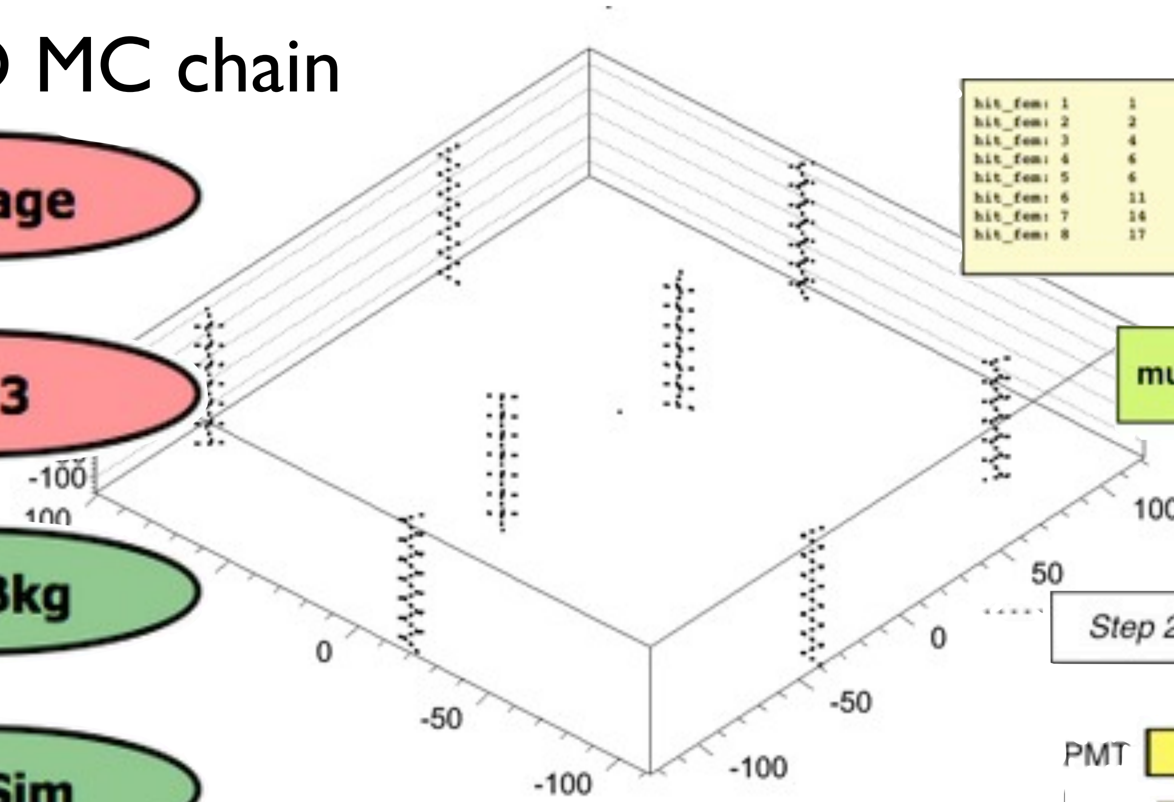
- With 32 GB/HM → buffer for 40 secs
- On one alert :
  a) each HM dumps proper ΔT data window (around the alert)
  b) the HMs transfer the data windows on an external machine (e.g. *fuCPU*)
  c) the external machine

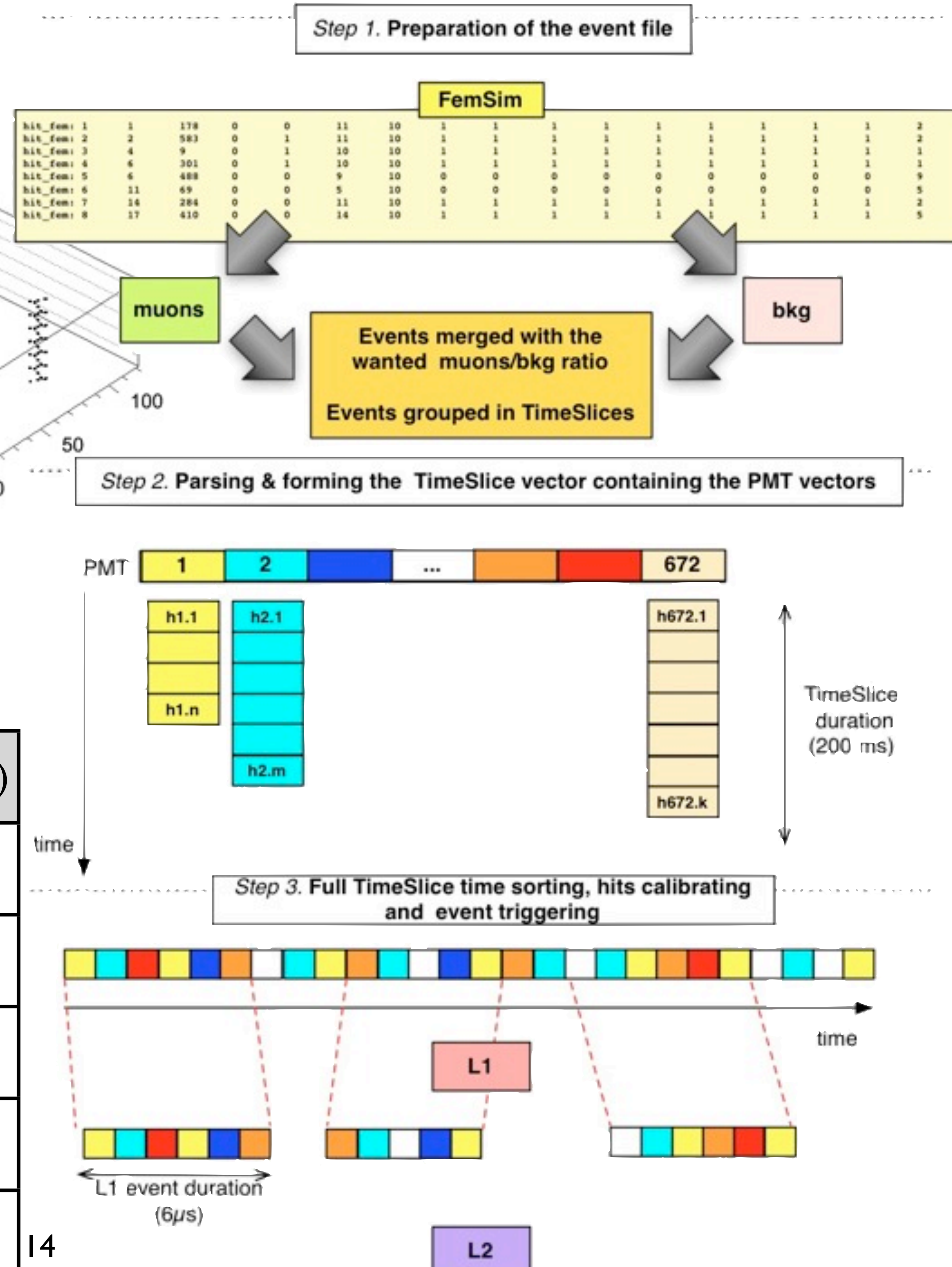
Dimensioning the TCPU procs with M. Manzali, F. Giacomini (CNAF), L. Fusco (Sez. BO)

(see Internal Note @ Indico)

Std. NEMO MC chain

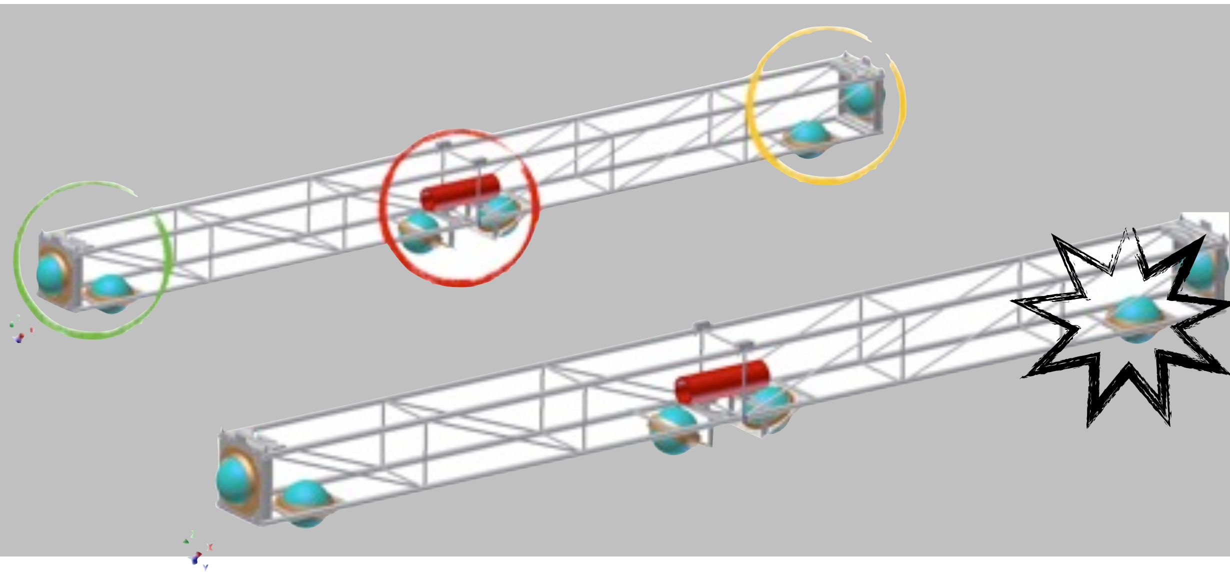






	APPROACH	rate μ (Hz)	rate BKG (kHz)
A	Realistic	27	50
B	Hardly realistic	270	50
C	Condensed	25×10^3	50
D	Heavy BKG	27	110
E	Heavy BKG Hardly Realistic	270	110

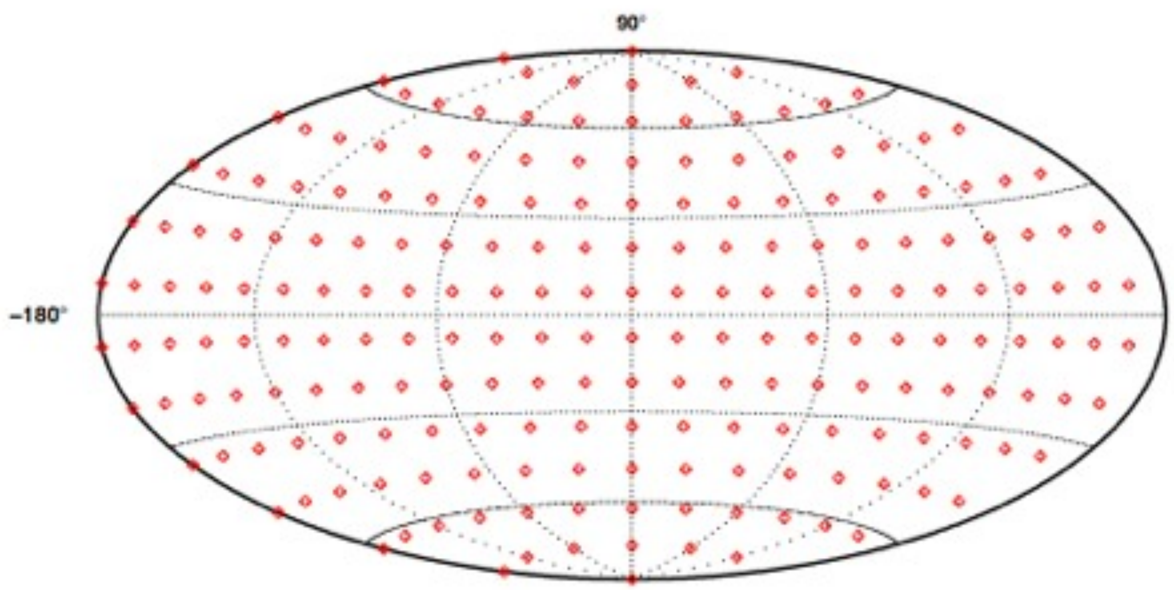
L_1 and L_2 Trigger algorithms

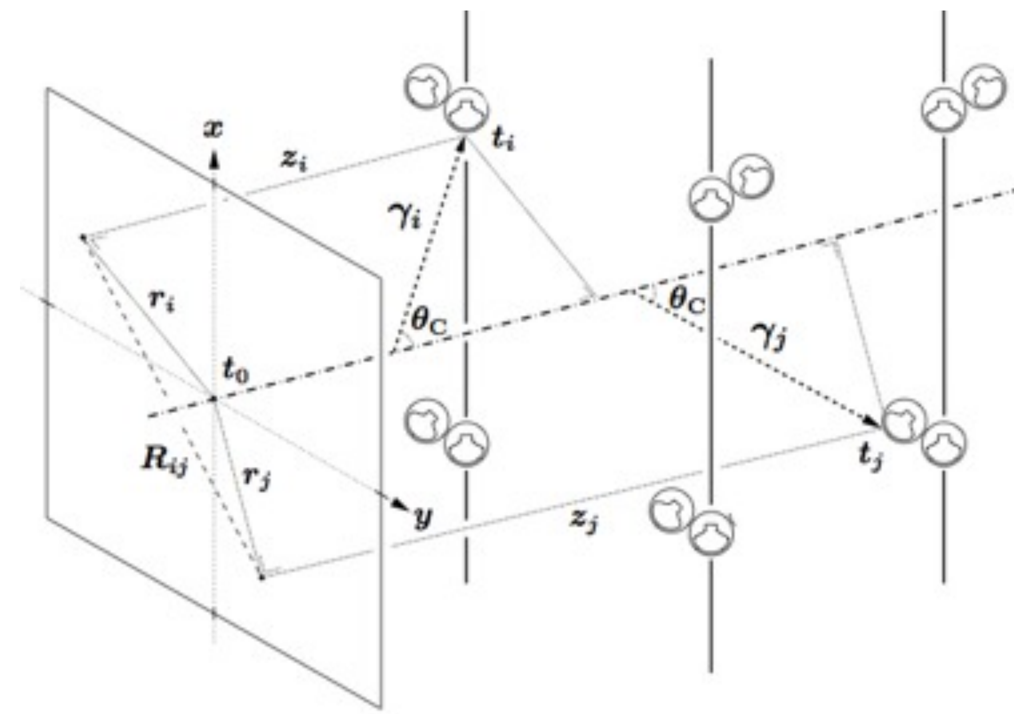


$\Delta t \leq 20$ ns

$Q \geq 2.5$ p.e.

→ L1





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If # L_1 hits satisfying ≥ 5 → L2

<μ_{atm} trigger efficiency> 3-5 % (similar to ANTARES)

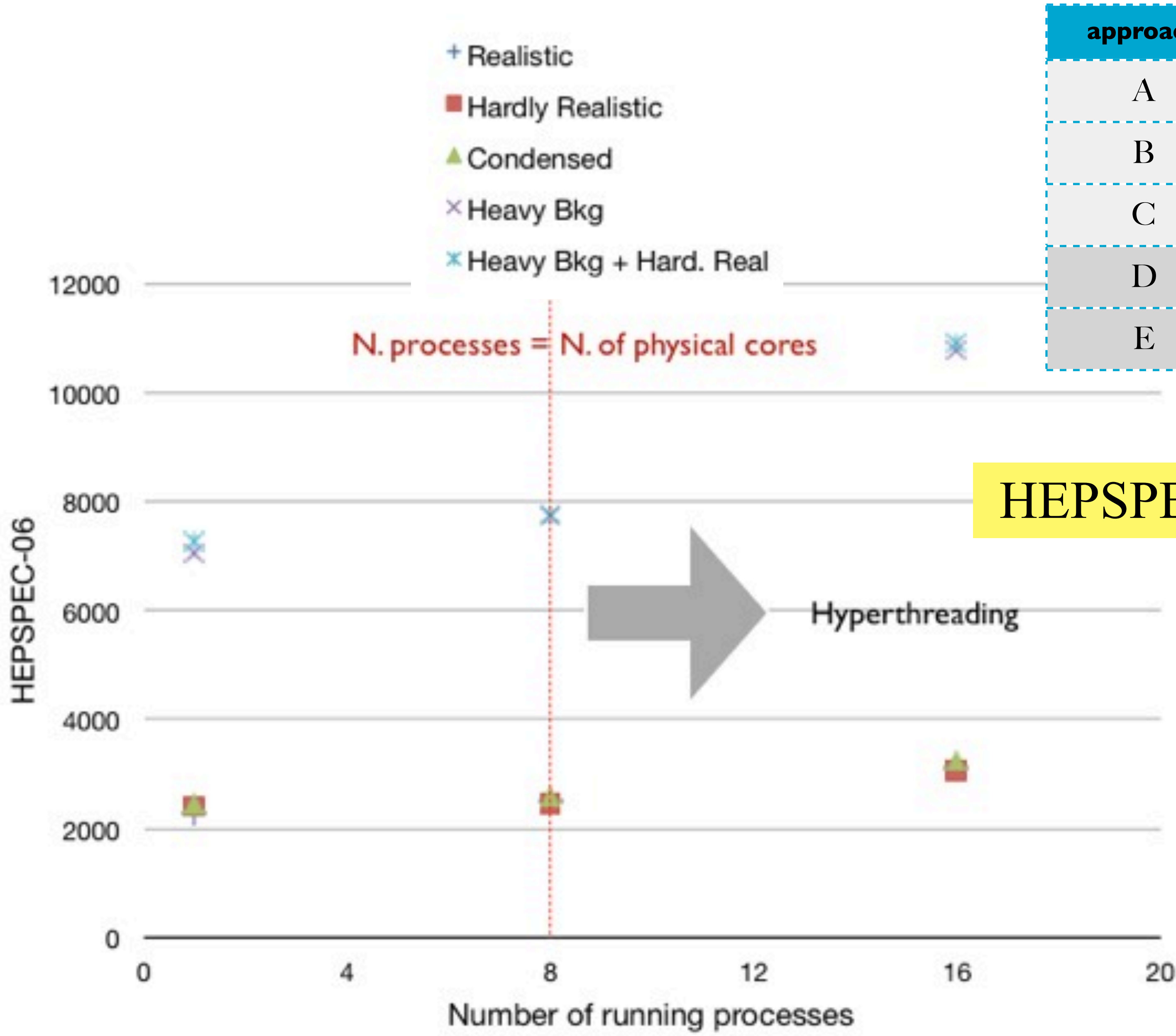
Hostname: wn-204-03-25-02-b.cr.cnaf.infn.it
OS: Scientific Linux release 6.4 (Carbon)
Kernel: 2.6.32-358.18.1.el6.x86_64
CPU type: Intel(R) Xeon(R) CPU E5520 @ 2.27GHz
Cores: 8 x 2 (2 CPU -> 4 Core/CPU)
CPU MHz: 2268.000
Cache size: 8192 KB
Memory: 24 GB
HEPSPEC version: hs06 sl6-32bit (**hyperthreading on**)
HEPSPEC score: 128.12

BENCHMARKED WORKER-NODE

- $T_p + T_{ma}$: **parsing data from the TimeSlice file** and **allocating the necessary memory** to host all the hits in a TimeSlice;
- T_{cal} : **calibrating** the hits ;
- T_{sort} : **time-sorting** all the the hits of each TimeSlice;
- T_{L1} and T_{L2} : **applying the L_1 and L_2** trigger level;
- T_{HM} = 175 ms

$$T_{tot} = T_{HM} + T_{ma} + T_{ca} + T_{sort} + T_{L1} + T_{L2}$$

approach	$T_p + T_{ma}$ (ms)	T_{ca} (ms)	T_{sort} (ms)	T_{L1} (ms)	T_{L2} (ms)
A	11280 ± 123	61 ± 1	1176 ± 12	596 ± 7	171 ± 2
B	11251 ± 118	57 ± 1	1167 ± 12	588 ± 7	174 ± 2
C	11318 ± 111	57 ± 1	1146 ±11	579 ± 6	400 ± 4
D	24792 ± 227	134 ± 2	2626 ± 24	1693 ± 18	5526 ± 49
E	24904 ± 212	139 ± 2	2624 ± 21	1685 ± 17	5529 ± 46



$$\text{HEPSPEC-06} = \text{HEPSPEC-06}_{\text{SCORE}} \times T_{tot} \times (\Delta T_{TS})^{-1}$$

approach	T_{tot} (ms)	HEPSPEC-06	N. TCPU processes
A	3880 ± 23	2483 ± 15	**20**
B	3862 ± 22	2472 ± 14	**20**
C	4058 ± 21	2597 ± 13	**21**
D	12064 ± 60	7721 ± 38	**61**
E	12062 ± 56	7720 ± 36	**61**

Conservative "extrapolation": serial *L2s* / process

$$T_{L2} = T_{T\text{-}trig} + T_{slow} + T_{Simp\ Caus} + T_{SkyScan} + T_{Tracking} + T_{showers} + T_{Follow\text{-}Up}$$

	T-trigger	Slow	Simple Causality	Tracking	showers	Follow-Up
$T_{algo} : T_{SkyScan}$	1:1	1:1	1:1	4:1	1:1	negligible

approach	T_{tot} (ms)	N. TCPU processes
A	5246	**27**
B	5250	**27**
C	7260	**37**
D	56276	**282**
E	56291	**282**

IF this scenario, mandatory to go parallel

TCPU

Template server: 128 HEPSPEC/server (8 core, 32 GB RAM)

TCPU input throughput (Gbps)	TCPU output throughput (Mbps)
≤ 10	< 2

conservative:
>30 TCPUs
(2 processes)

Conclusions

- Plenty of trigger to implement...
- ... ready to develope new ones (see Bachir's talk)
- Required a solid MonteCarlo study for determining the *Figures Of Merit* (~ efficiency, purity, effective areas/volumes)
- **MANPOWER**, please: Bo + Pi + CNAF + ***MORE...***

In some cases it is possible to refer to the ANTRES FOMs

(B. Bakker Ph.D. thesis, 2011

available on KM3NeT Portal)

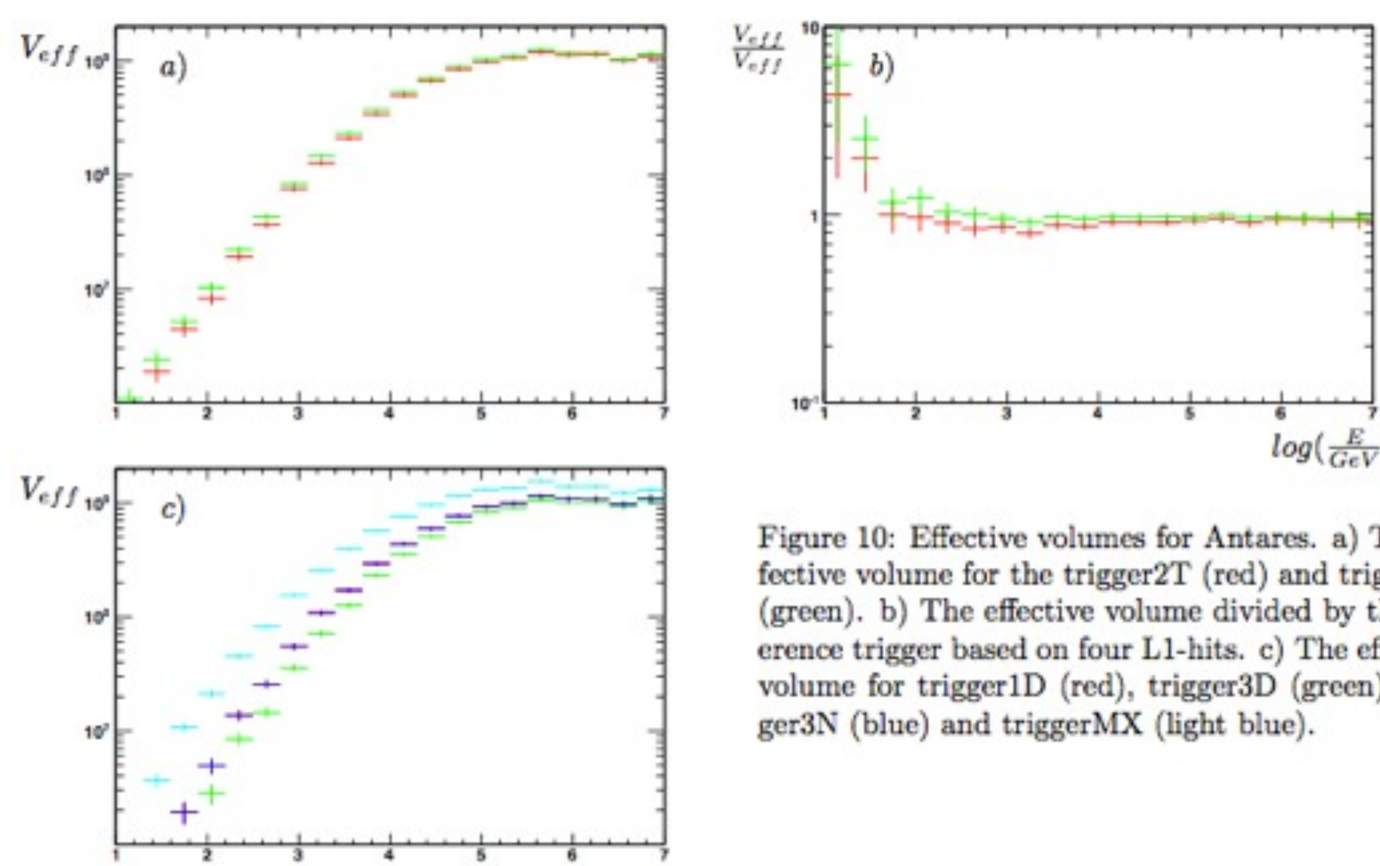


Figure 10: Effective volumes for Antares. a) The effective volume for the trigger2T (red) and trigger3T (green). b) The effective volume divided by the reference trigger based on four L1-hits. c) The effective volume for trigger1D (red), trigger3D (green), trigger3N (blue) and triggerMX (light blue).