ICARUS General Trigger Design

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Physics considerations

- Events:
  - Cosmic rays muons
  - Atmospheric neutrinos
  - Solar neutrinos + neutrons $\rightarrow$ E ~ MeV
  - Neutrinos from Supernova (burst) $\rightarrow$ E ~ MeV
  - Proton decay
  - CNGS neutrinos $\rightarrow$ external timing
  - Beam muons

Supernova burst

(See A.Rubbia presentation Sept. 02)

- Specific time structure
  - Ex.: ~ 100 SN triggers in T300 in 1 sec
- Global trigger: bandwidth + storage problem
  - 1 event = 27648 ch × 2500 samples × 2 bytes
  - ~ 130 MB → 13 GB total
- Local trigger: SN events are localized and limited to 1 crate per view
  - 5 events per crate in COLL + IND2 views ~ 40 MB/crate
  - 13 events per crate in IND1 view ~ 60 MB/crate
- ⇒ Each crate can be read-out as a separate event

Preliminary considerations

- Trigger rate is dominated by physics background
  - Neutron capture rates expected in T600 (ICARUS/TM-2002/13):
    - 2×10^{-4} s^{-1} from natural radioactivity of the rock
    - $0.03\div0.1$ s^{-1} from Al container
- Segmented trigger potentially solves bandwidth and storage problems
- Event pre-classification → data streams
  - extraction of solar neutrino data from low energy stream
- Test bench for T1200 low energy trigger

Trigger Input

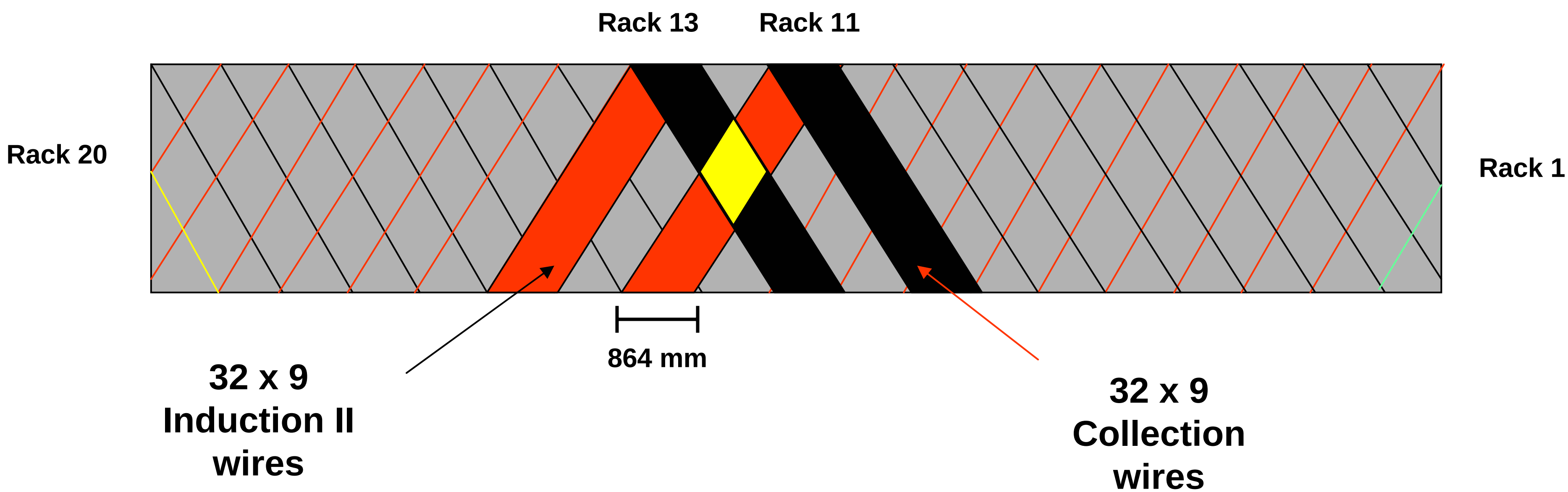
- PMTs
- DAEDALUS
- AWS (Analog wire sum)
- External (beam profile chambers, cern-spill, …)

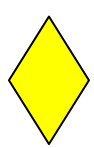
Basic design requirements

- Redundancy important to measure efficiency
- Global trigger:
  - Generated by PMTs or external
  - drift deadtime GLOBAL_DRIFT (1ms)
  - Read-out deadtime GLOBAL_BUSY (1s) vetoes new global triggers
  - Local triggers vetoed during GLOBAL_DRIFT
- Local trigger:
  - Generated by AWS + PMT
  - LOCAL_DRIFT (1ms) vetoes new local triggers

T600 pixel definition

T600 Half Module – 1 chamber viewed from cathode

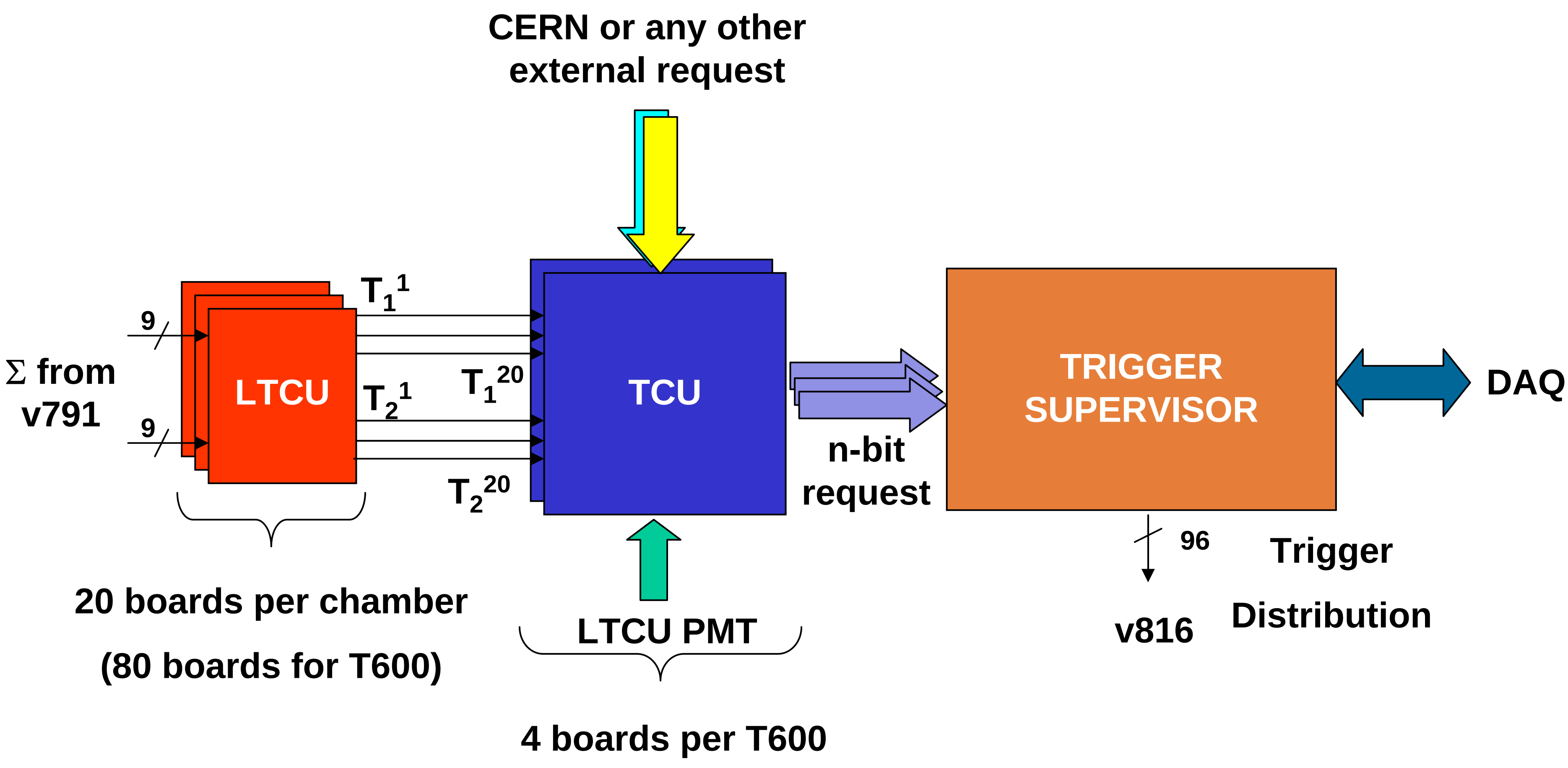




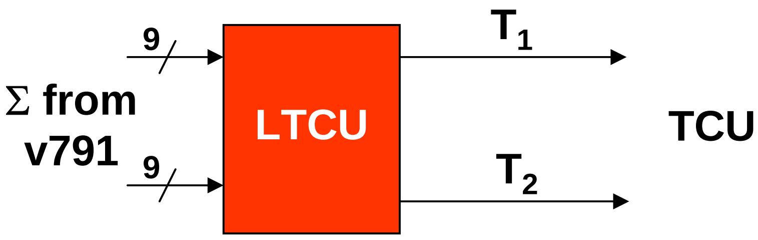
1 pixel area: ~ 0.6 m^2

Total Number of Pixels ~ 80

Trigger System Architecture



LTCU overview



• 1 board per crate - 20 boards per chamber

• each board receives as input 9 + 9 Σ coming from the v791 analog boards (generally 9 of 2nd induction and 9 of collection)

• LTCU discriminates the 18 inputs comparing them with remotely controlled thresholds. Noisy inputs can be masked

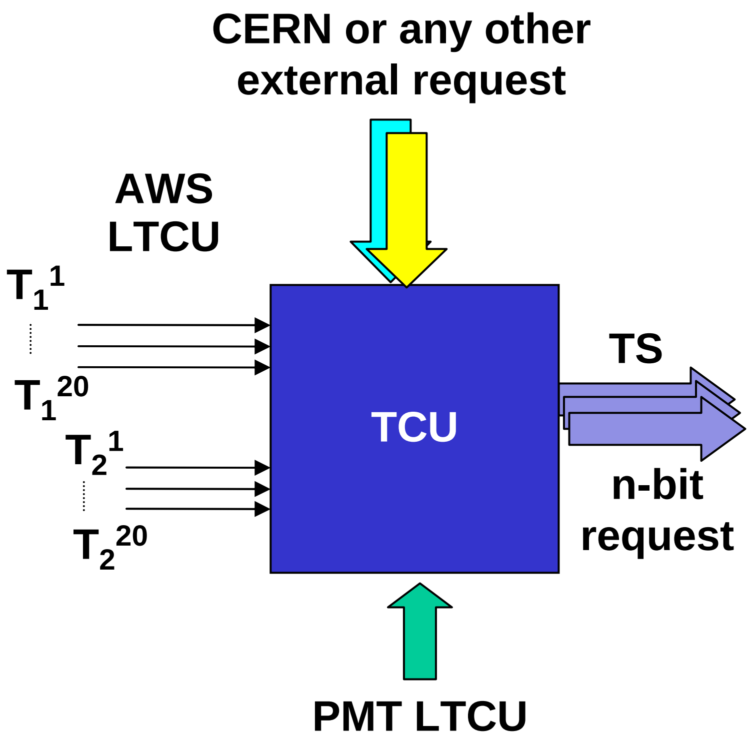
• Gives as output two separate trigger proposals (T_1 and T_2), corresponding to the OR of INDII or COLL boards respectively

• Test mode to check the working status

• Counting capabilities to check rates of trigger proposals for each input

• Board functionalities are driven by a remote controller

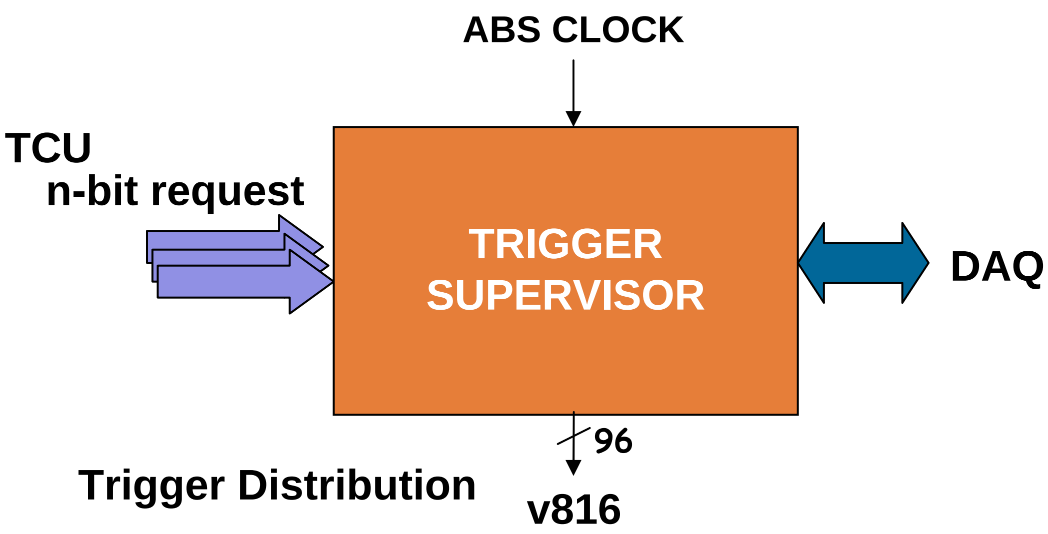
TCU overview



- 1 board per chamber
- VME standard
- each board receives as input 40 signals from the AWS LTCUs (2 T signals x 20 boards) and N signals from PMT LTCU
- TCU performs coincidences between:
  - the wire planes (in a ~3 μs time window),
  - the PMT signals,
  - the external requests
- checks Majority, Minority, 2D Pattern logic conditions
- event is labelled according to topology

- An n-bit-word trigger request is sent to the Trigger Supervisor, defining the fired crates

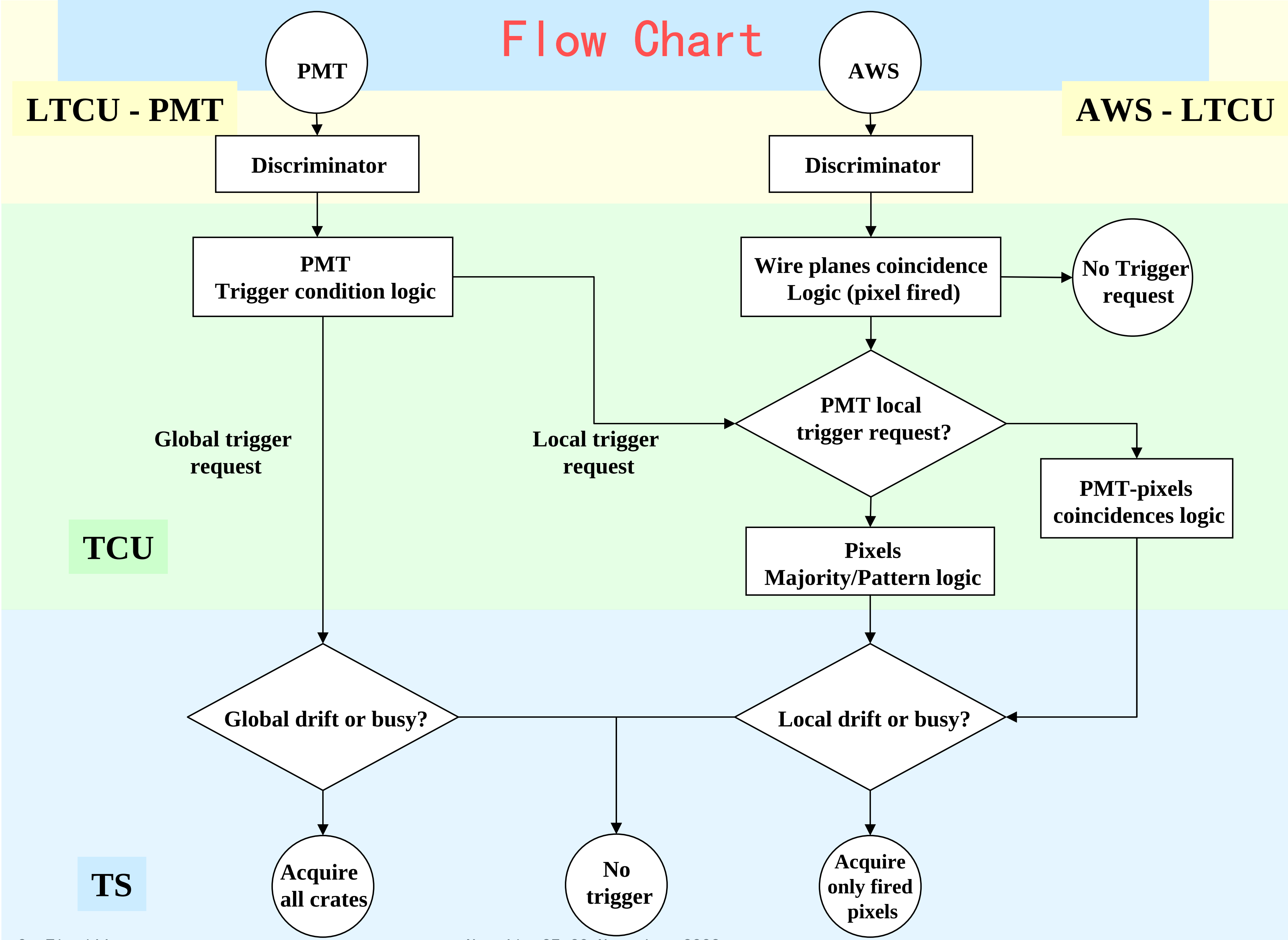
Trigger Supervisor overview



- 1 or more boards
- VME standard
- TS receives 4 input n-bit-words from the TCU and the ABS CLOCK
- TS evaluates if the trigger request from TCU corresponds to a Local Trigger or a Global Trigger

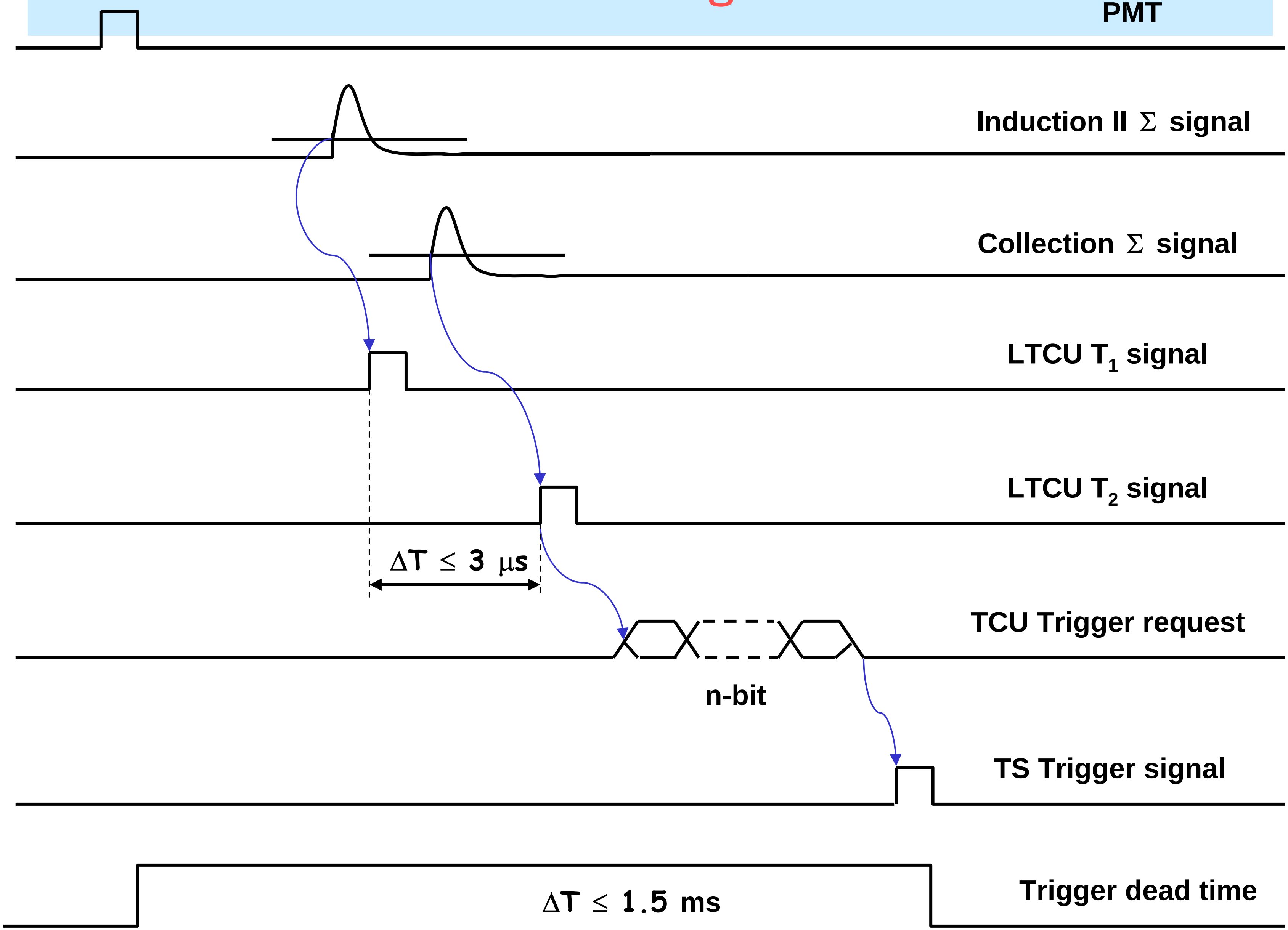
- Monitoring of the system and validation of Trigger requests.
- GLOBAL/LOCAL DRIFT/BUSY Logic
- Trigger signal distribution to the v816
- Event trigger tag (trigger number, time, type, acquisition dead time…)
- Statistics for the trigger system

Flow Chart



LTCU - PMT
AWS - LTCU
PMT
AWS
Discriminator
Discriminator
PMT
Trigger condition logic
Wire planes coincidence
Logic (pixel fired)
No Trigger
request
PMT local
trigger request?
Global trigger
request
Local trigger
request
PMT-pixels
coincidences logic
TCU
Pixels
Majority/Pattern logic
Global drift or busy?
Local drift or busy?
TS
Acquire
all crates
No
trigger
Acquire
only fired
pixels

Time Diagram



TS GLOBAL/LOCAL Logic

- Trigger classification depends on:
  - Energy deposition/number of PMT fired.
  - Detector occupancy
  - 2D/3D Pattern of fired pixels
- TS gives GLOBAL trigger when a MAJORITY condition is met in PMT logic
- Otherwise the trigger is LOCAL

On-going activities

- Trigger simulation to test trigger logic (Battistoni, Fiorillo, Santorelli, ...)
  - optimal segmentation
  - logic conditions
  - efficiency
  - fake trigger rate
- Design of PMT-LTCU (Antonello, Raselli, Rossella, Segreti, Vignoli, …)
  - studies of input signals
  - trigger logic
- Prototyping of AWS-LTCU (Della Pietra, Di Cicco, Napoli INFN electronic workshop)
  - studies of input signals with laboratory tests
  - tests on commercial elements
  - design of FPGA
- Design of TCU, TS (Di Cicco, Parascandolo)
- Optimization studies (Gibin, Guglielmi, ...)
  - analysis of AWS in Pavia run events
  - electronic noise evaluation