# LHC-ALICE 実験における電磁カロリメータを用いたトリガーシステムの開発

Development of EMCALs' Trigger System in LHC-ALICE

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Heavy Ion Physics in LHC

* LHC (Large Hadron Collider)
  * Run1 (2009-2013)
    * $\sqrt{s}$ = 7, 8TeV p+p
    * $\sqrt{s_{NN}}$ = 0.9, 2.76TeV Pb+Pb
  * LS1 (2013-2015)
  * Run2 (2015-)
* ALICE Experiment
  * heavy ion physics @high T_c, ε_c
  * Quark-Gluon Plasma (QGP)
    * deconfined state of quarks and gluons
* detector upgrade
  * EMCALs for precise analysis
  * EMCAL, PHOS and DCAL(NEW!)

Vue d'ensemble des expériences LHC.

EMCAL

DCAL

PHOS
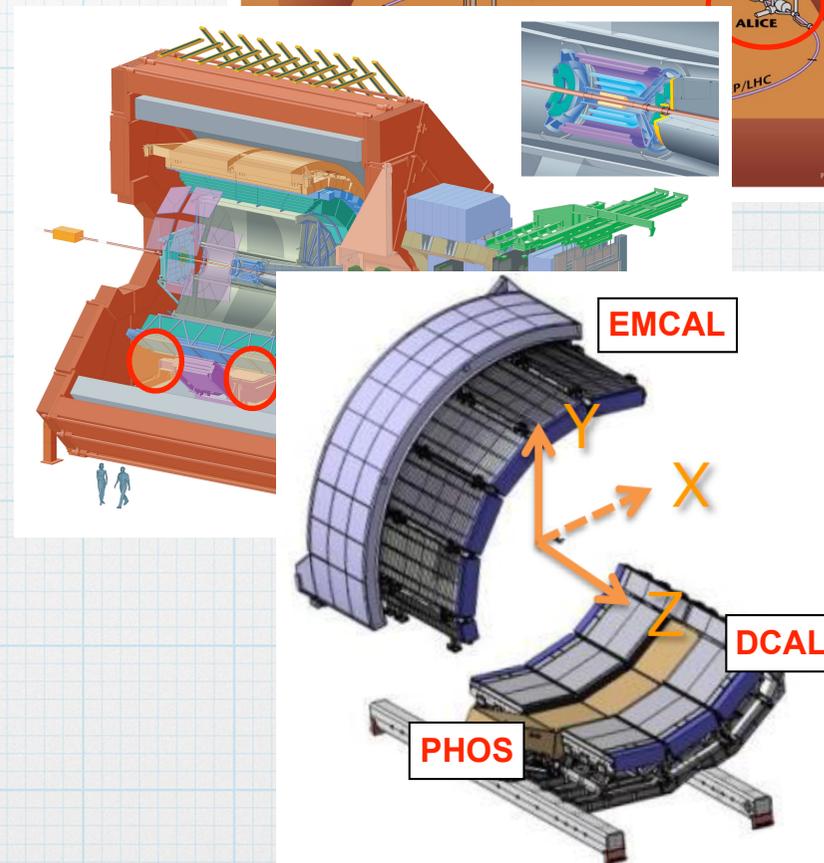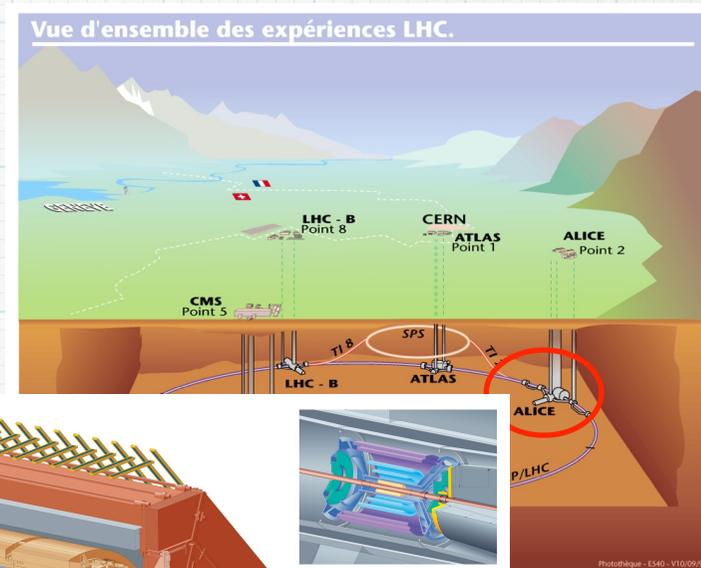
Jet Quenching
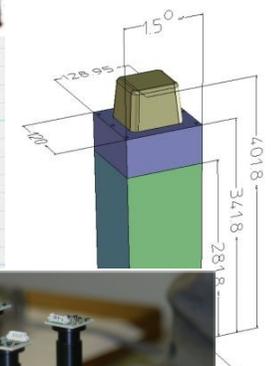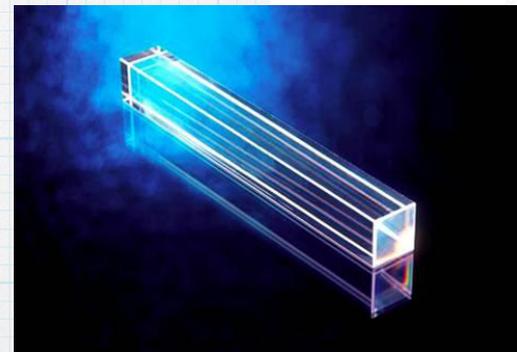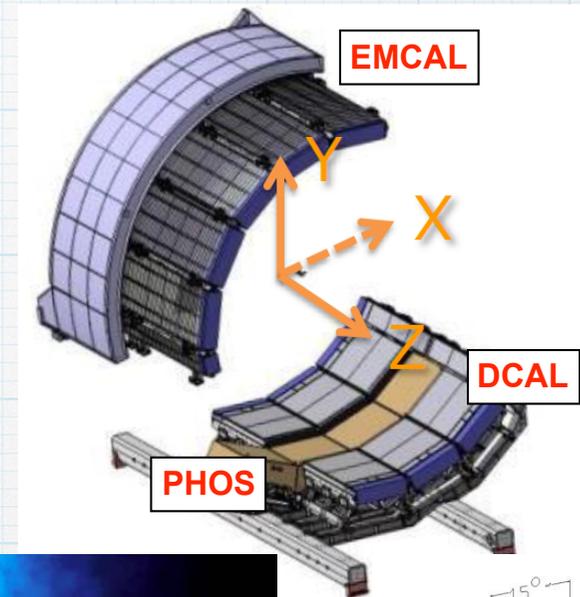
* Jet Quenching

  * energy loss of hard-scattered parton in QGP

  * Info of parton's behaviour

* Di-Jet and gamma-Jet

  * Calos have back-to-back geometry

    are very helpful

  * => EMCAL and DCAL
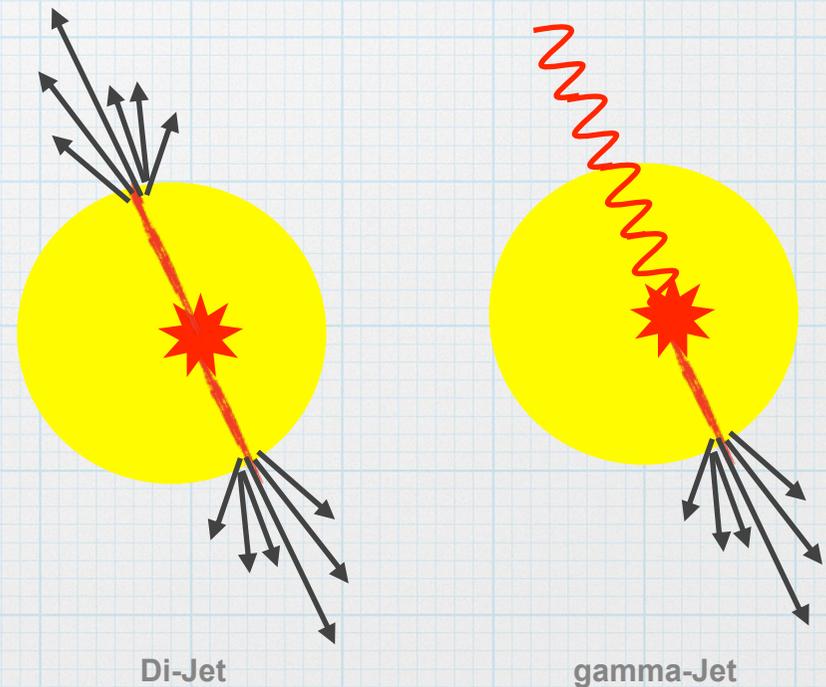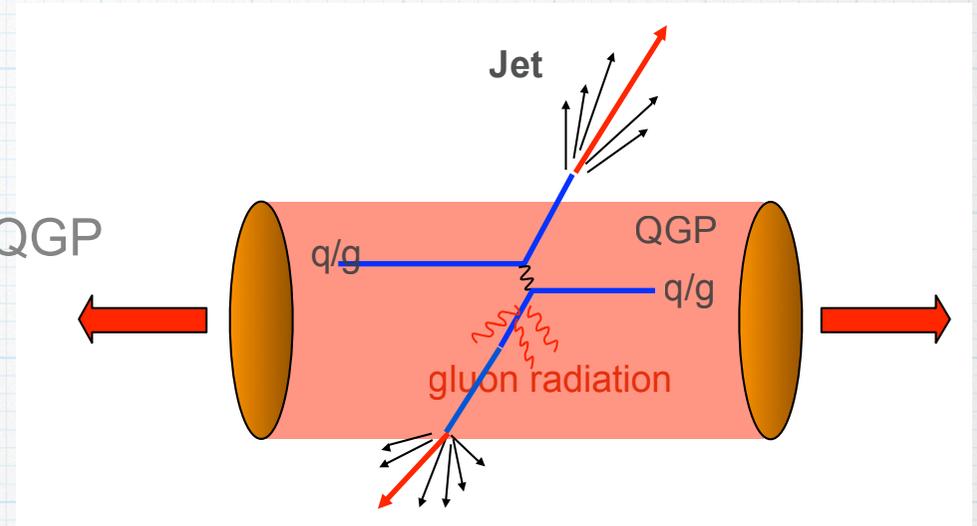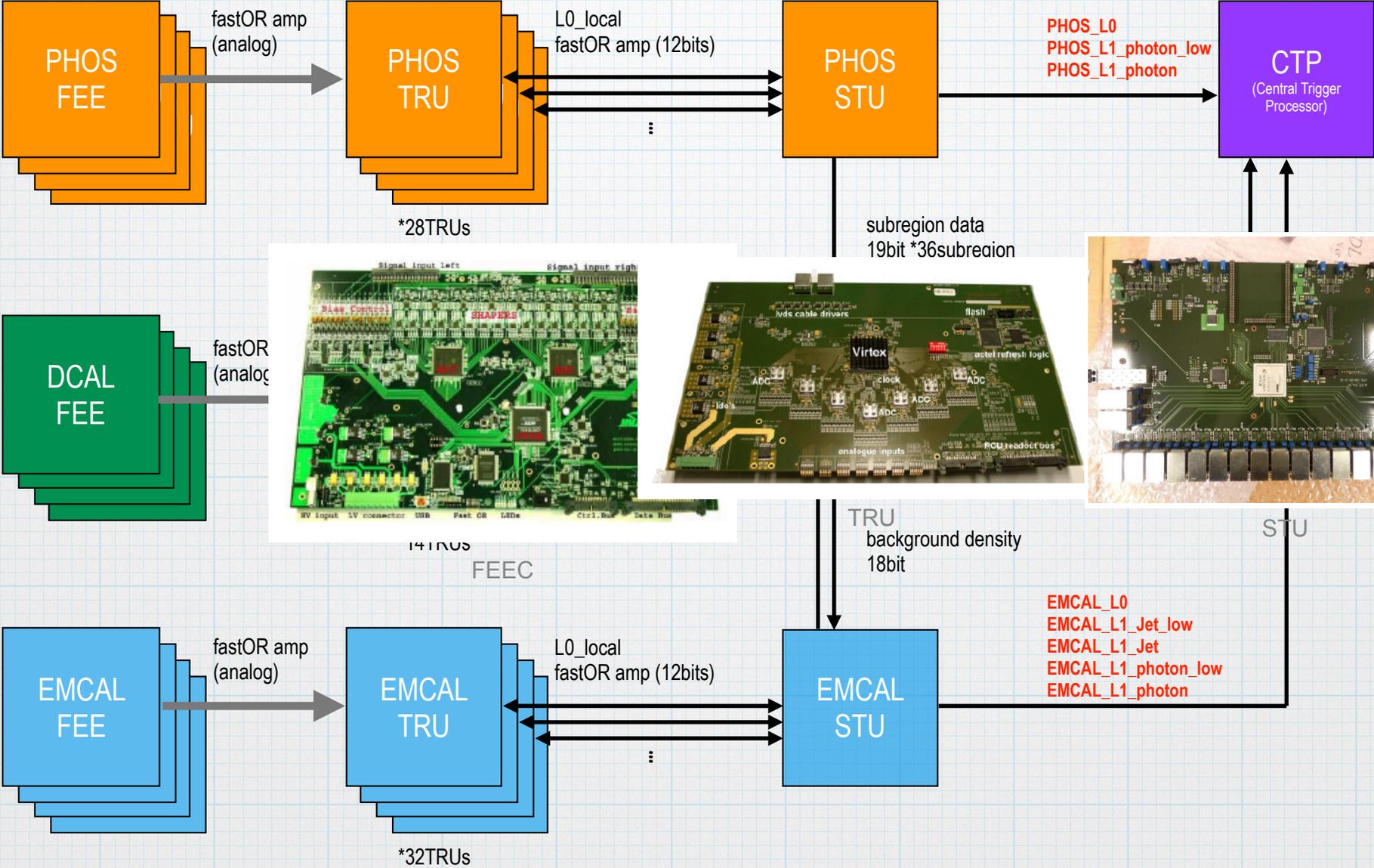
Development of appropriate trigger system is needed to trigger such rare events as Jet event.

Jet

QGP

q/g

q/g

gluon radiation

Di-Jet

gamma-Jet

Calorimeter structure

* EMCAL
  * Pb-Scintillator sandwich type calorimeter
  * total 12288 towers (1tower = ~6.0x6.0x24.6 cm)
* DCAL
  * opposite side of EMCAL in phi
  * same tower structure
  * total 5376 towers
* PHOS
  * opposite side of EMCAL in phi (central in eta)
  * lead-tungsten crystal(PWO) based calorimeter
  * total 12544 crystals (1 crystal = ~2.2x2.2x18cm)

* 2x2 towers(DCAL/EMCAL) = 1FastOR
* 2x2 crystals(PHOS) = 1FastOR

Calo triggers system

PHOS FEE →[fastOR amp (analog)]→ PHOS TRU →[L0_local, fastOR amp (12bits)]→ PHOS STU →[PHOS_L0, PHOS_L1_photon_low, PHOS_L1_photon]→ CTP (Central Trigger Processor)

*28TRUs

subregion data
19bit *36subregion

DCAL FEE →[fastOR (analog)]→ 14TRUs

FEEC

TRU
background density
18bit

STU

EMCAL FEE →[fastOR amp (analog)]→ EMCAL TRU →[L0_local, fastOR amp (12bits)]→ EMCAL STU →[EMCAL_L0, EMCAL_L1_Jet_low, EMCAL_L1_Jet, EMCAL_L1_photon_low, EMCAL_L1_photon]

*32TRUs
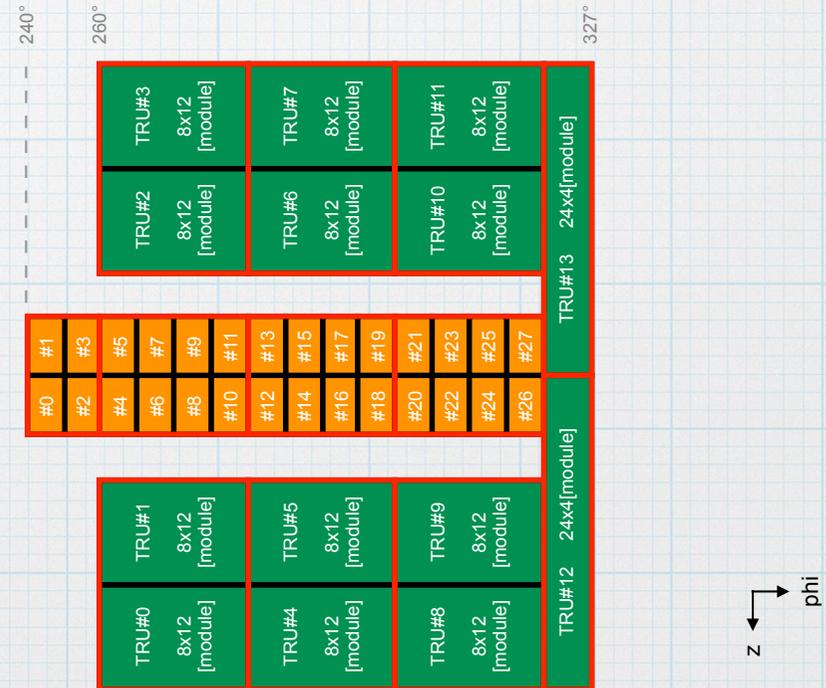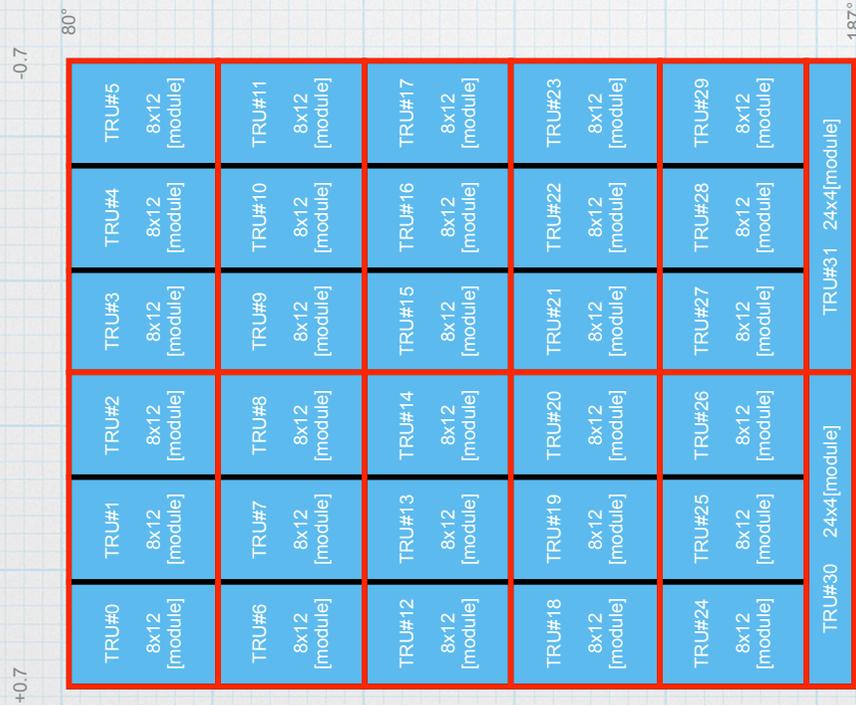
Geometry

EMCAL
* ten SM + two 1/3SM
* 32 TRUs
* 30 TRUs : 8x12 modules
* 2 TRUs : 24x4 modules

DCAL
* six 2/3SM + two 1/3SM
* 14 TRUs
* 12 TRUs : 8x12 modules
* 2 TRUs : 24x4 modules

PHOS
* three SM + one 1/2SM
* 28 TRUs : 14x8 [2x2crystals]

* spacial gap b/w DCAL and PHOS : ~336mm

* inner -> outer view

L1-photon patch

* L1 photon patch
    * 2x2 fastOR (= 4x4 towers for DCAL,EMCAL / 4x4 crystals for PHOS)
    * sliding window algorithm
    * over boundaries between each TRU region
* L1-photon threshold
    * threshold = A*V0^2 + B*V0 + C
    * calculated by Multiplier module in STU-FPGA

☐ photon-patch

xx fastOR

☐ TRU

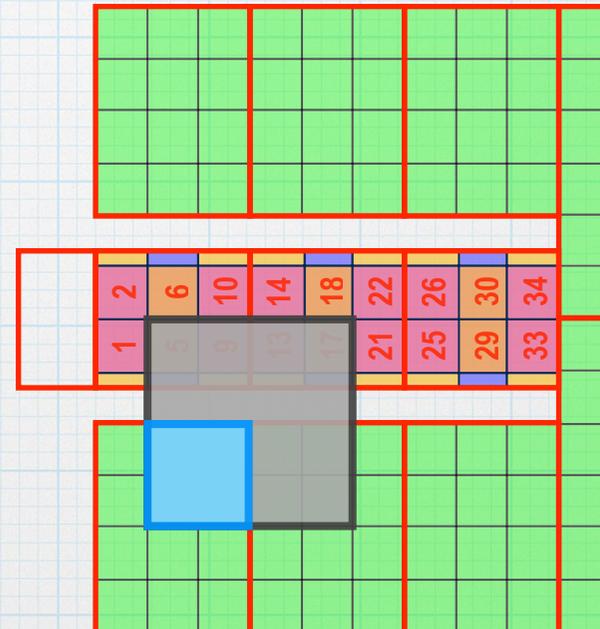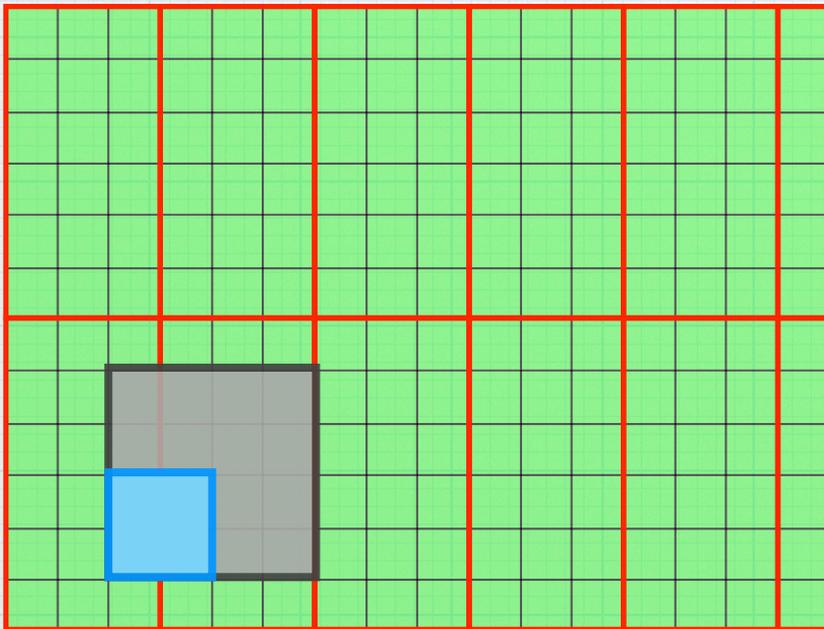number : the received data order from TRU

L1-Jet patch
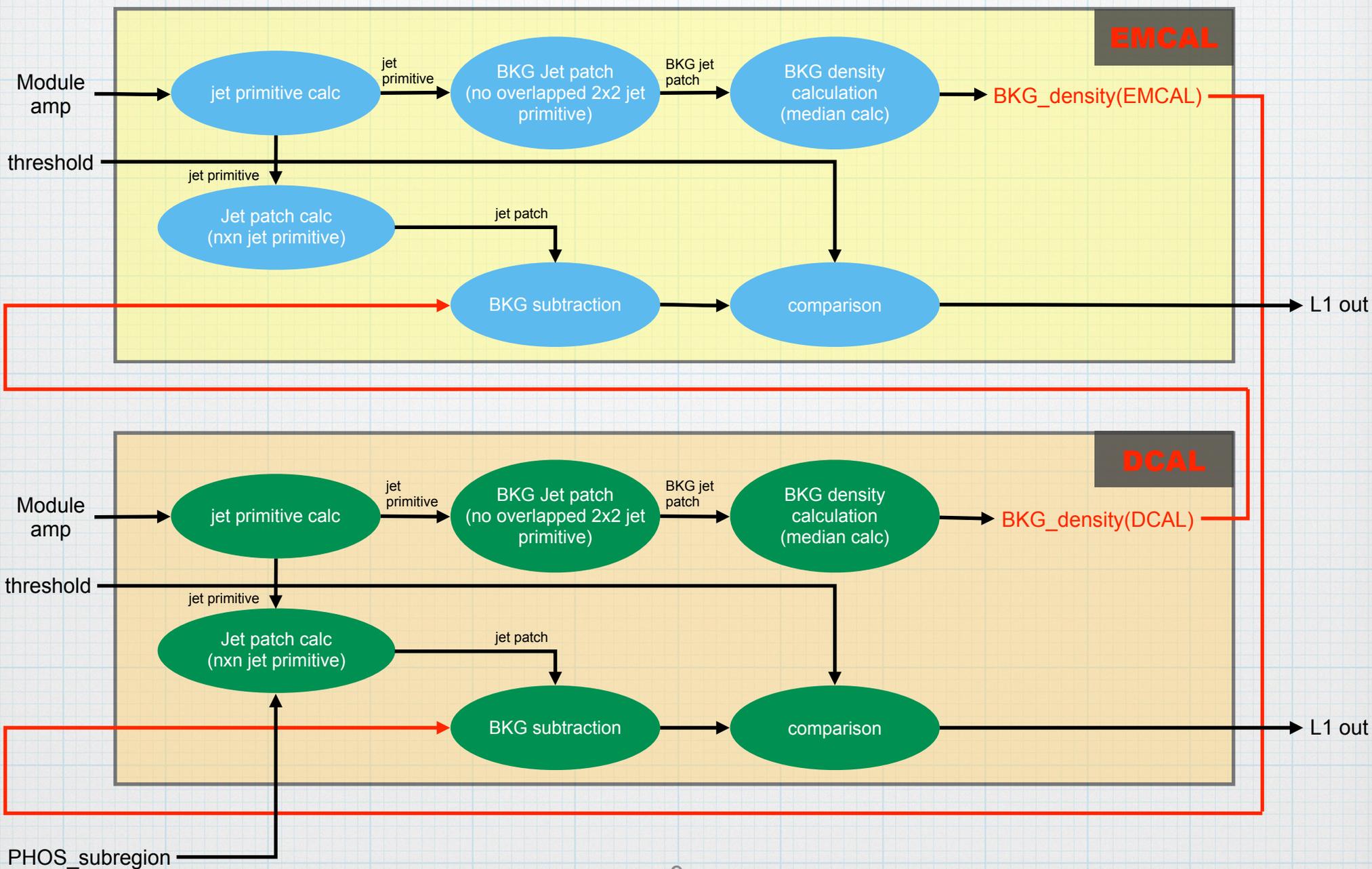
* L1 Jet patch
  * 2x2 or 4x4 jet primitives
  * sliding window algorithm based on jet primitive

* In DCAL side, before the L1-Jet calculation, amplitude of PHOS jet primitive are scaled to match with DCAL's amplitude
* this scaling factors are set by DCS

jet primitive = 4x4 fastOR   L1-jet patch 2x2 jet primitives   L1-jet patch 4x4 jet primitives

L1-Jet BKG subtraction

EMCAL

Module amp → jet primitive calc

jet primitive → BKG Jet patch (no overlapped 2x2 jet primitive)

BKG jet patch → BKG density calculation (median calc) → BKG_density(EMCAL)

threshold

jet primitive → Jet patch calc (nxn jet primitive)

jet patch → BKG subtraction → comparison → L1 out

DCAL

Module amp → jet primitive calc

jet primitive → BKG Jet patch (no overlapped 2x2 jet primitive)

BKG jet patch → BKG density calculation (median calc) → BKG_density(DCAL)

threshold

jet primitive → Jet patch calc (nxn jet primitive)

jet patch → BKG subtraction → comparison → L1 out

PHOS_subregion

summary

* Calorimeters in ALICE upgraded during LS1.

    * DCAL installed

* Trigger system upgrade

    * DCAL L1-photon trigger

    * DCAL+PHOS L1-Jet trigger

        * background subtraction method for L1-Jet