Introduction to BESIII EMC sub-trigger system

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Introduction

Trigger system is the central event selection and hardware control system of the BESIII. All of the trigger primitives and conditions are transported to the Global Trigger system to generate the Level 1 pass signal L1, which is fanned out to the trigger systems and to all the electronics for data acquisition.

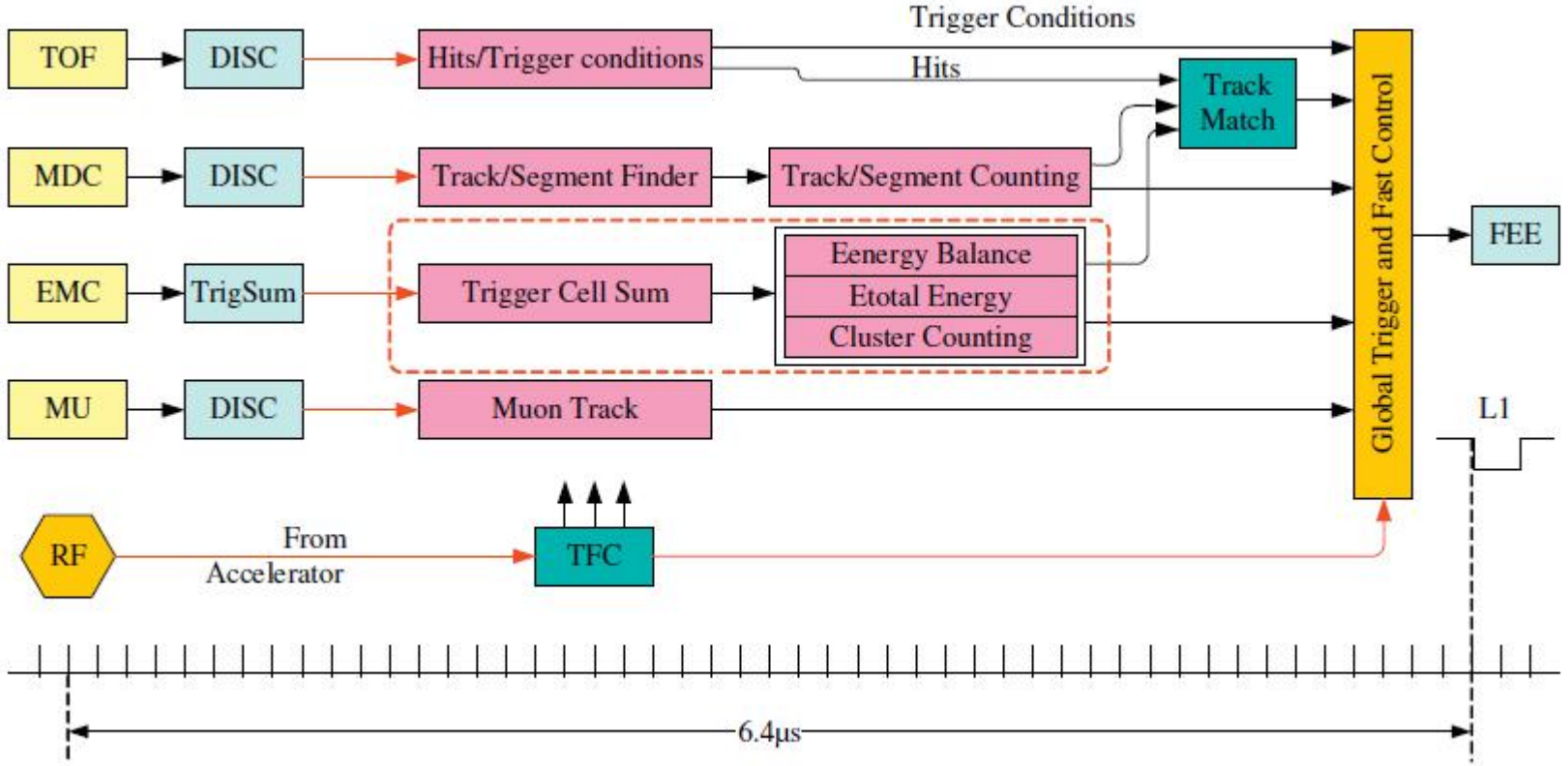


Fig. 1. Scheme of the trigger system.

Simulation of the EMC sub-trigger system

Simulation is the base o the hardware design of the trigger system.
Trigger Cell(TC) is taken as the fundamental element in the simulation.
A good TC should be large enough to contain most of the showered energy and not too large for accurate positioning of a shower.

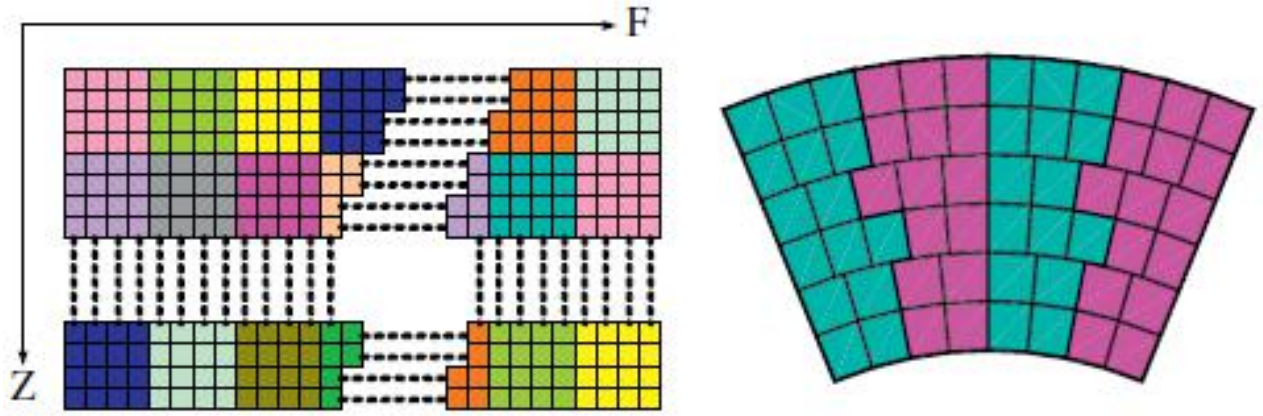


Fig. 3. TCs division (left: barrel; right: 1/8 endcap).

Determination of TC

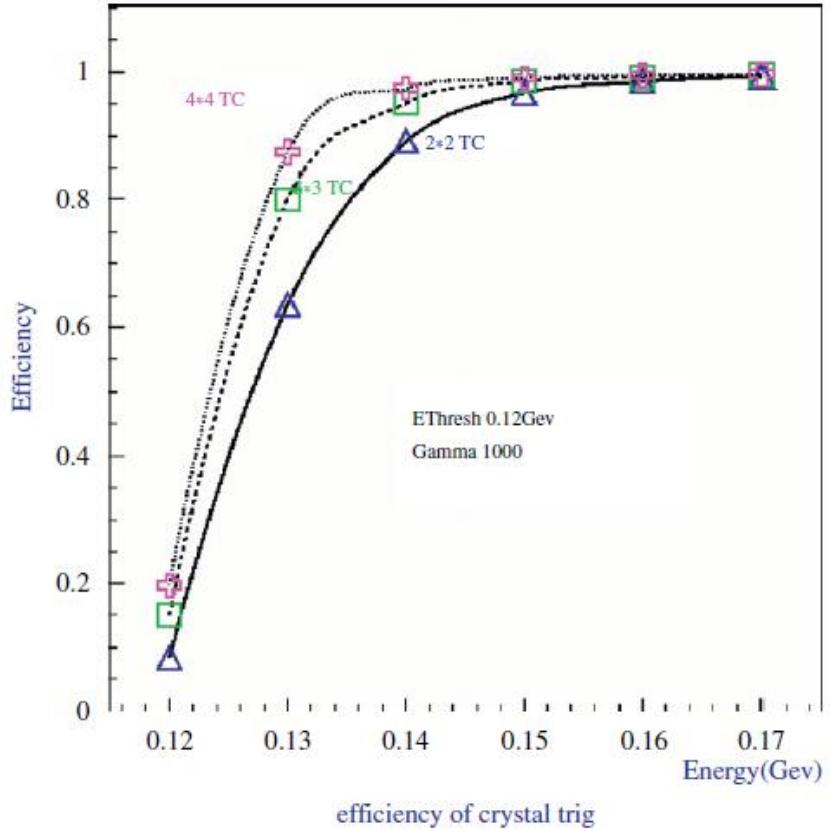


Fig. 2. Determination of the TC sizes.

Simulation of the EMC sub-trigger system

A good energy threshold should be low enough to have a good trigger efficiency for the minimum ionization particles and not too low for effective rejection of background hits.

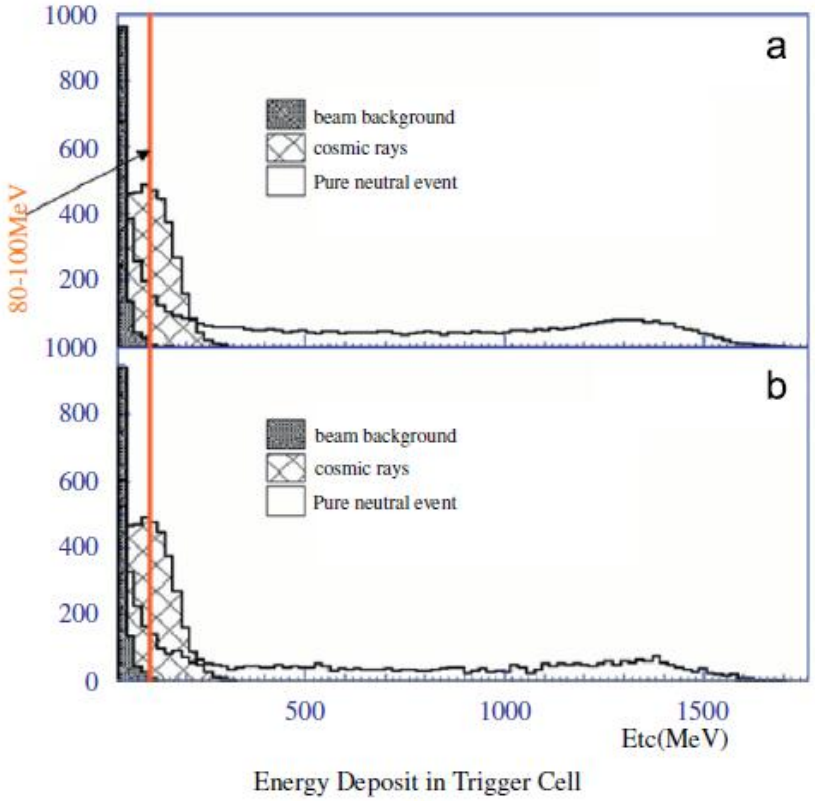


Fig. 4. Energy deposition in TCs.

Energy threshold of TC

Table 1
United trigger efficiency of EMC trigger subsystem

	Combined EMC triggers (%)
Bhabha at 3.097 GeV	100
Radiative BB (3097 MeV)	100
$(3\gamma)J/\psi \rightarrow \gamma+\eta$	100
$(5\gamma)J/\psi \rightarrow \omega+\eta$	100
$J/\psi \rightarrow P+\bar{P}$	92.93
$J/\psi \rightarrow K^{+}K^{-}+\pi^{0}$	94.51
$J/\psi \rightarrow \gamma+\eta(1440)$	96.20
$J/\psi \rightarrow \rho+\pi$	90.87
$J/\psi \rightarrow \pi^{0}+P+\bar{P}$	96.20
$J/\psi \rightarrow$ anything	94.75
$\psi(2S) \rightarrow$ anything	96.67
$\psi(3770) \rightarrow$ anything	98.39

Trigger efficiency of EMC trigger subsystem

Trigger conditions of EMC trigger subsystem

EMC trigger primitives and conditions are based on two kinds of information:

1. cluster information
2. energy block information

Several TCs may be fired by a showered particle.

A cluster finding logic should be established to find out the TC that stands for the shower.

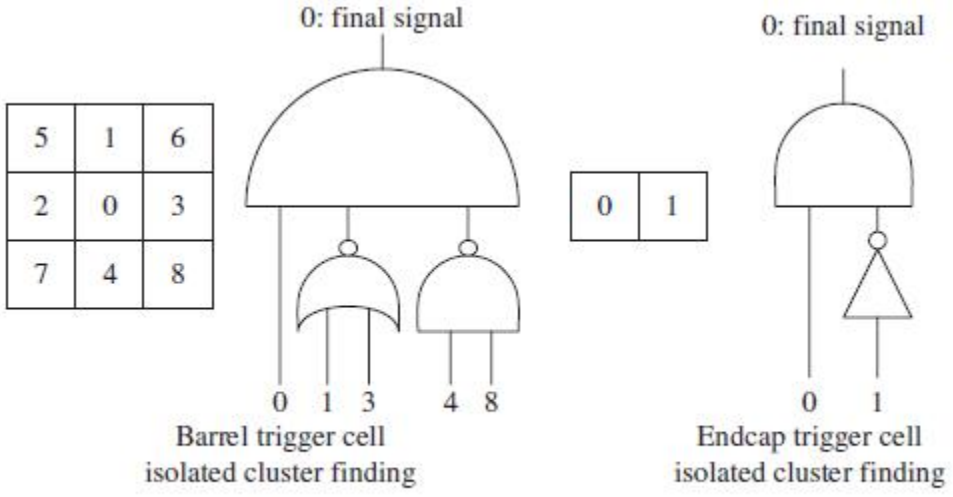


Fig. 5. Isolated cluster finding logic.

Isolated cluster finding

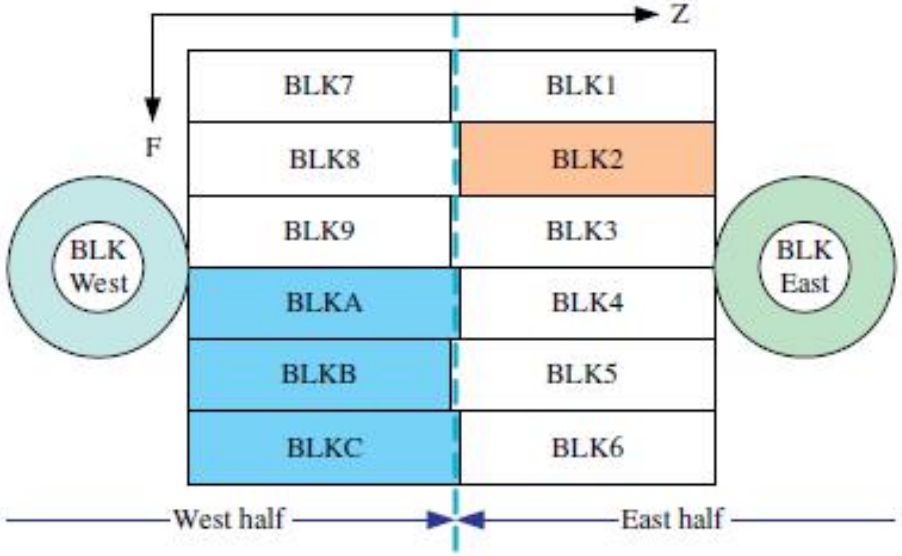


Fig. 6. Energy block definition.

Definition of the energy blocks

Trigger conditions of EMC trigger subsystem

Two types of trigger primitives are defined as shown in Tables 2 and 3.
One is the cluster-related ones for shower positioning and counting, another one is the energy-related ones for energy balance and total energy decision.
When a primitiveis satisfied, the relevant condition signal is set active.

Table 2
EMC cluster trigger conditions

Name	Comments
NClus $\geqslant 1$	Cluster counts are greater than or equal to 1
NClus $\geqslant 2$	Cluster counts are greater than or equal to 2
BclusBB	Back to back cluster in barrel
EblusBB	Back to back cluster in endcap
ClusPhiB	Barrel cluster balance at Φ direction
ClusPhiE	Endcap cluster balance at Φ direction
ClusZ	Each half at Z direction has at least 1 cluster

Table 3
EMC energy trigger conditions

Name	Comments
BEtotH	Total energy of barrel exceeds the high threshold
EEtotH	Total energy of endcap exceeds the high threshold
EtotL	Total energy of all EMC exceeds the low threshold
EtotM	Total energy of all EMC exceeds the middle threshold
BL_Z	Z direction energy balance (include barrel and endcap)
DiffB	Energy difference balance between each barrel half
DiffE	Energy difference balance between each endcap half
BL_BLK	Energy balance of barrel blocks
BL_EEMC	Energy balance between east and west endcap

Trigger conditions

Hardware scheme of EMC trigger subsystem

The hardware scheme of the EMC sub-trigger system is shown in Fig. 7.
Two types of PCB board(printed circuit board) are designed to fulfill the whole functions, which are 16 Trigger Cell and energy Block Adding(TCBAs) and 1 Energy Adding and Cluster Counting(EACC).
All the TC information and the energy information are assembled inFPGA.

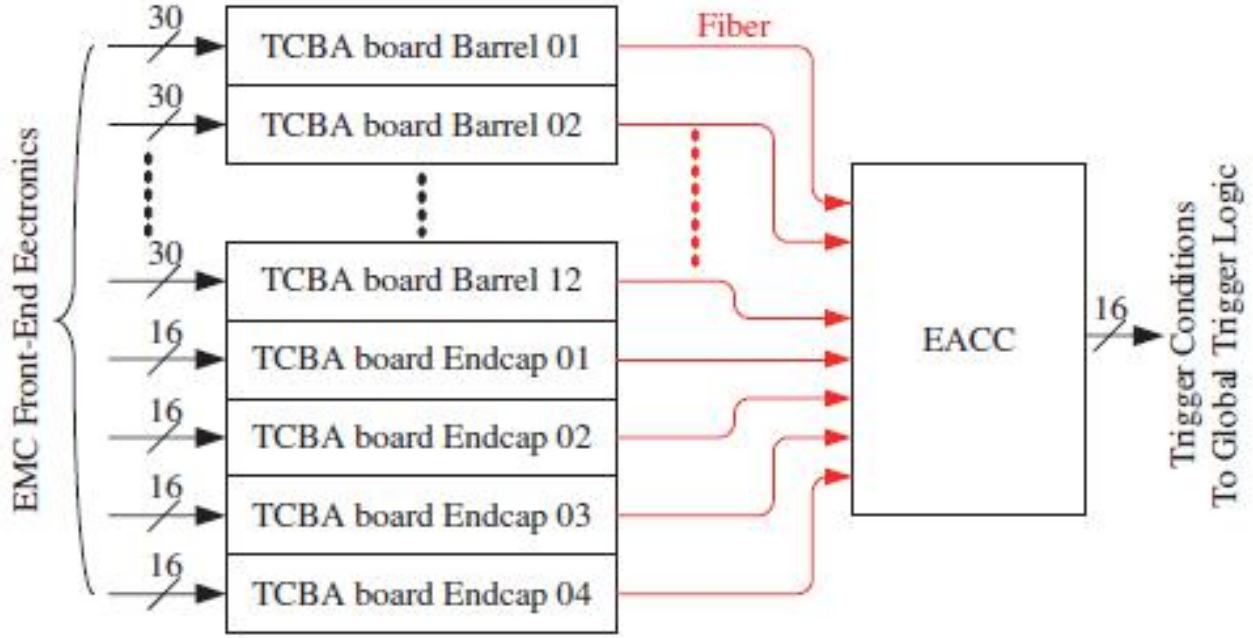


Fig. 7. Scheme of EMC sub-trigger system.

Hardware scheme of EMC trigger subsystem

When the analog TC signals from one energy block are fed to a TCBA board, they are processed in two parallel ways:

1. generating a 30 bit TC cluster information by discriminators;
2. and adding all the 30 analog signals to form a partial total energy signal, which is digitized(named 'energy information') with a 10 bit FADC thereafter.

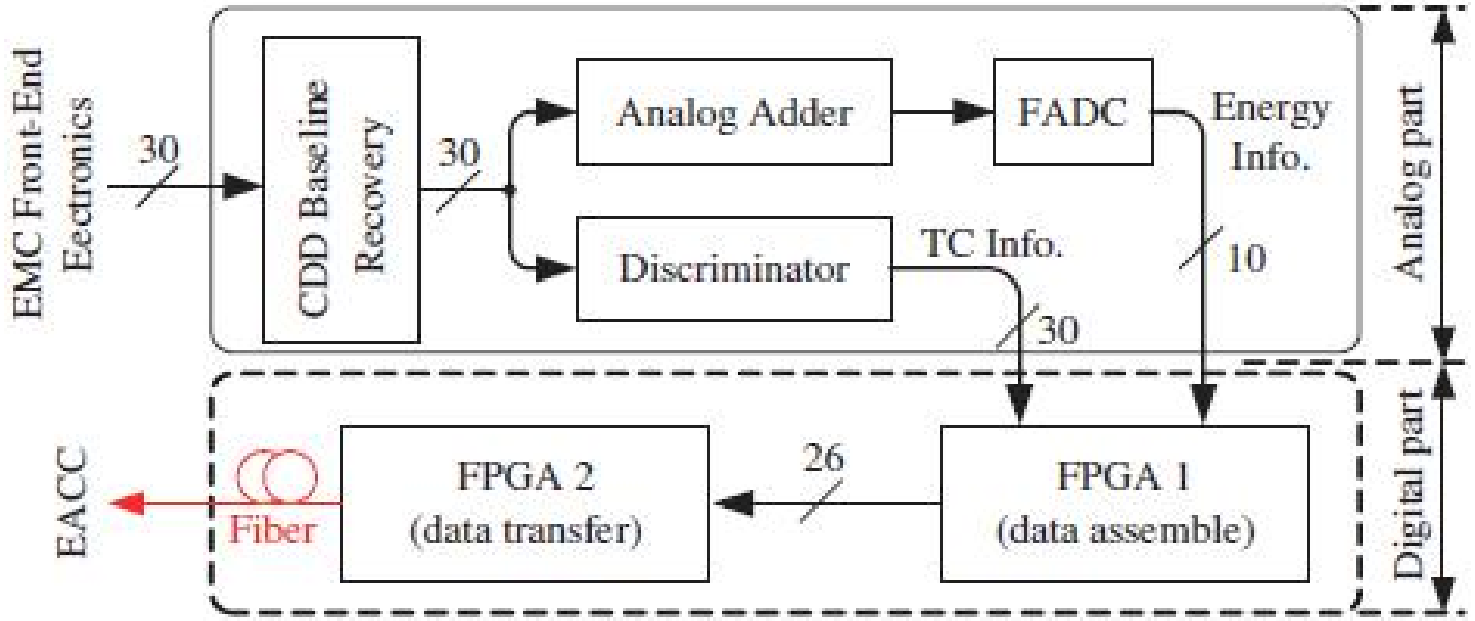


Fig. 8. Scheme of TCBA board.

Hardware scheme of EMC trigger subsystem

All the trigger primitives are generated in the EACC board. The cluster and energy parts are processed independently.

cluster finding
trigger condition generating
(Table 2)

selects the cluster and energy data from all block information, then send the cluster data to the module of CSUM Logic, at the same time, send the energy data to the module of ETOT Logic

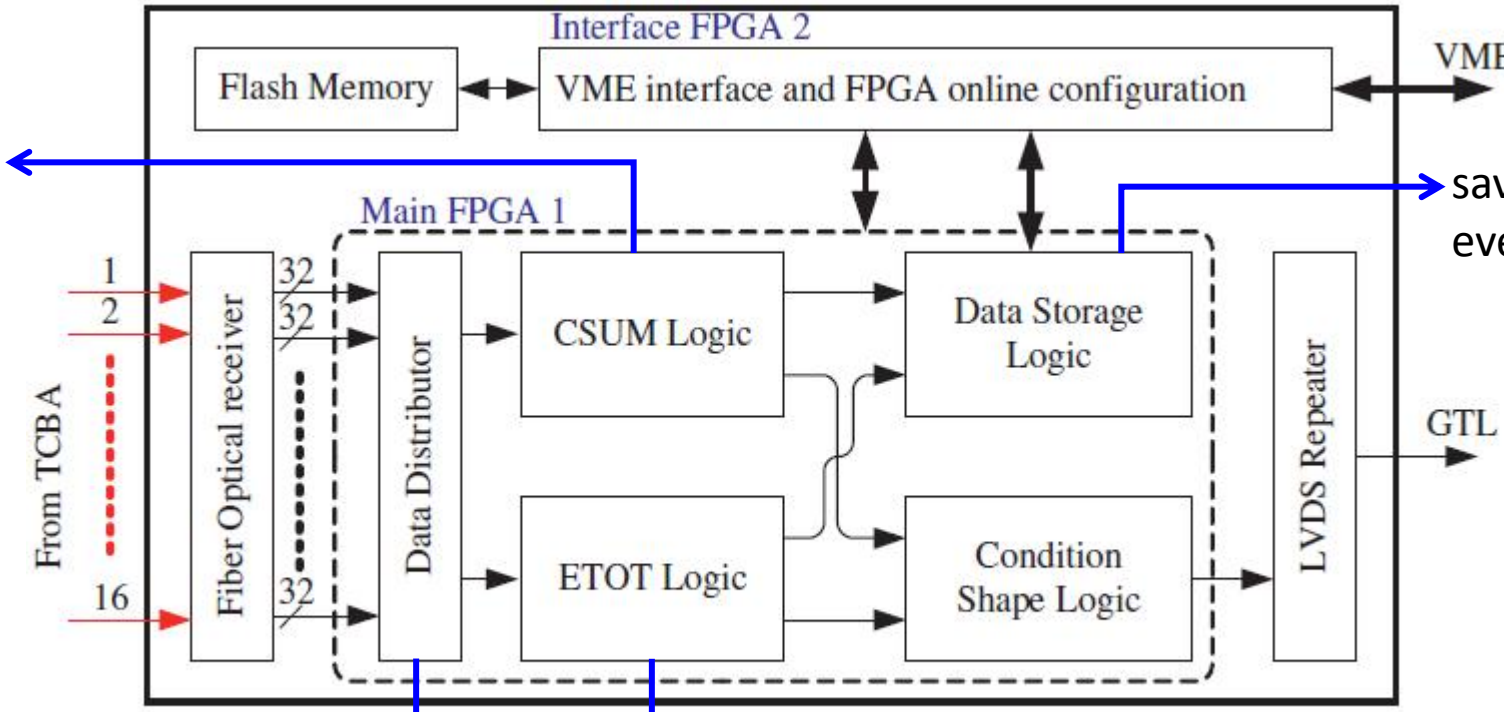


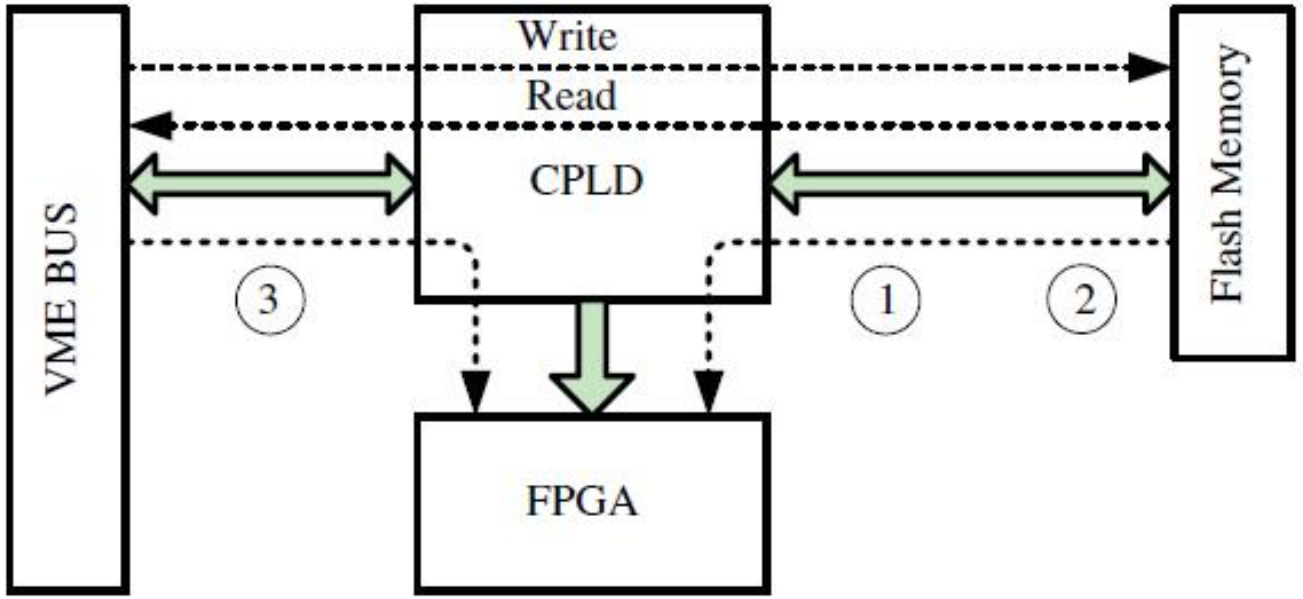
Fig. 9. Scheme of EACC board.

save and readout the event data of interest

energy trigger conditions
cluster trigger conditions (Table 3)

Hardware scheme of EMC trigger subsystem

As a part of hardware design in BESIII trigger system, online FPGA configuration technique based on VME BUS can provide a flexible and reliable FPGA configuration method for the system.



① Auto Configure FPGA from Flash Memory when Power on
② Configure FPGA from Flash Memory under the VME command
③ Configure FPGA from VME bus under the VME command

Fig. 10. Scheme of online FPGA configuration.

Hardware scheme of EMC trigger subsystem

The technique of optical fiber high-speed transmission is implemented based on RocketIO transceiver module embedded in VirtexII Pro series FPGA and optical transceiver module HFBR-5921L.

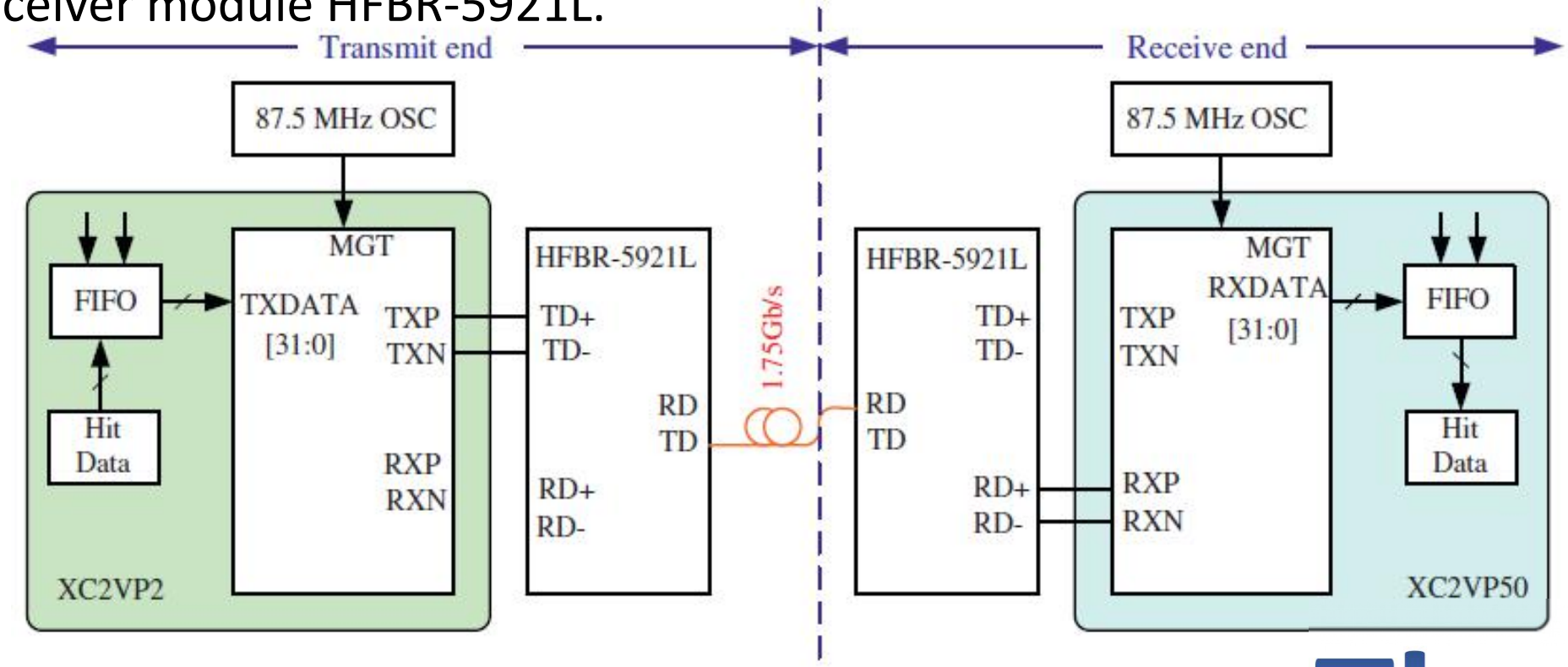


Fig. 11. Scheme of RocketIO and optical fiber technique.

Thanks!