The KLOE Trigger System

M. Adinolfi [m] A. Aloisio [g] F. Ambrosino [g] A. Andryakov [f] A. Antonelli [c]
M. Antonelli [c] F. Anulli [c] C. Bacci [n] A. Bankamp [d] G. Barbiellini [o]
G. Bencivenni [c] S. Bertolucci [c] C. Bini [k] C. Bloise [c] V. Bocci [k] F. Bossi [c]
P. Branchini [n] S.A. Bulychjov [f] G. Cabibbo [k] A. Calcaterra [c] R. Caloi [k]
P. Campana [c] G. Capon [c] G. Carboni [m] A. Cardini [k] M. Casarsa [o] G. Cataldi [d]
F. Ceradini [n] F. Cervelli [j] F. Cevenini [g] G. Chiefari [g] P. Ciambrone [c] S. Conetti [q]
S. Conticelli [c] E. De Lucia [k] G. De Robertis [a] R. De Sangro [c] P. De Simone [c]
G. De Zorzi [k] S. Dell'Agnello [c] E. Denig [d] A. Di Domenico [k] C. Di Donato [g]
S. Di Falco [j] A. Doria [g] E. Drago [g] V. Elia [e] O. Erriquez [a] A. Farilla [n] G. Felici [c]
A. Ferrari [k] M.L. Ferrer [c] G. Finocchiaro [c] C. Forti [c] A. Franceschi [c]
P. Franzini [k,c] M.L. Gao [b] C. Gatti [c] P. Gauzzi [k] S. Giovannella [c]
V. Golovatyuk [e] E. Gorini [e] F. Grancagnolo [e] W. Grandegger [c] E. Graziani [n]
P. Guarnaccia [a] U.v. Hagel [d] H.G. Han [b] S.W. Han [b] X. Huang [b,c] M. Incagli [j]
L. Ingrosso [c] Y.Y. Jang [b,c] W. Kim [c] W. Kluge [d] V. Kulikov [f] F. Lacava [k]
G. Lanfranchi [k] J. Lee-Franzini [c,p] F. Lomtadze [j] C. Luisi [k] C.S. Mao [c,b]
M. Martemianov [f] M. Matsyuk [f] W. Mei [c] L. Merola [g] R. Messi [m] S. Miscetti [c]
A. Moalem [h] S. Moccia [c] M. Moulson [c] S. Mueller [d] F. Murtas [c] M. Napolitano [g]
A. Nedosekin [c,f] M. Panareo [e] L. Pacciani [m] P. Pagès [c] M. Palutan [m]
L. Paoluzi [m] E. Pasqualucci [k] L. Passalacqua [c] M. Passaseo [k] A. Passeri [n]
V. Patera [ℓ,c] E. Petrolo [k] G. Petrucci [c] D. Picca [k] G. Pirozzi [g] C. Pistillo [g]
M. Pollack [p] L. Pontecorvo [k] M. Primavera [e] F. Ruggieri [a] P. Santangelo [c]
E. Santovetti [m] G. Saracino [g] R.D. Schamberger [p] C. Schwick [j] B. Sciascia [k,1]
A. Sciubba [ℓ,c] F. Scuri [o] I. Sfiligoi [c] J. Shan [c] P. Silano [k] T. Spadaro [k]
S. Spagnolo [e] E. Spiriti [n] C. Stanescu [n] G.L. Tong [c] L. Tortora [n] E. Valente [k]
P. Valente [c] B. Valeriani [j] G. Venanzoni [j] S. Veneziano [k] Y. Wu [c,b] Y.G. Xie [b]
P.P. Zhao [b] Y. Zhou [c]

[a] *Dipartimento di Fisica dell'Università e Sezione INFN, Bari, Italy*
[b] *Institute of High Energy Physics of Academica Sinica, Beijng, China*
[c] *Laboratori Nazionali di Frascati dell'INFN, Frascati, Italy*
[d] *Institut für Kernphysik, Universität, Karlsruhe, Germany*
[e] *Dipartimento di Fisica dell'Università e Sezione INFN, Lecce, Italy*

Preprint submitted to Elsevier Preprint *19 May 2000*

[f] *Institute for Theoretical and Experimental Physics, Moscow, Russia*

[g] *Dipartimento di Scienze Fisiche dell'Università e Sezione INFN, Napoli, Italy*

[h] *Physics Department, Ben-Gurion University of the Negev, Israel*

[i] *Physics Department, Columbia University, New York, USA*

[j] *Dipartimento di Fisica dell'Università e Sezione INFN, Pisa, Italy*

[k] *Dipartimento di Fisica dell'Università e Sezione INFN, Roma, Italy*

[ℓ] *Dipartimento di Energetica dell'Università, Roma, Italy*

[m] *Dipartimento di Fisica dell'Università e Sezione INFN, Roma II, Italy*

[n] *Dipartimento di Fisica dell'Università e Sezione INFN, Roma III, Italy*

[o] *Dipartimento di Fisica dell'Università e Sezione INFN, Trieste, Italy*

[p] *Physics Department, State University of New York at Stony Brook, USA*

[q] *Physics Department, University of Virginia, USA*

Abstract

A double level trigger system has been developed for the KLOE experiment. Custom electronics asserts a trigger in a 2μs decision time. The decision is based on the combined information of the electromagnetic calorimeter and the drift chamber. The entire trigger system is continuosly monitored, and data flowing from the trigger system have allowed both an efficient online monitoring of the detector and an online luminosity measurement.

1 Introduction

The KLOE experiment [1] has been designed and built with the primary goal of measuring ϵ'/ϵ with a sensitivity of one part in ten thousands. It consists of three main parts; a large cylindrical tracking chamber (DC) [2]; a hermetic lead-scintillating fibres electromagnetic calorimeter (EmC) [3]; a large magnet surrounding the whole detector, consisting of a superconducting coil and a iron yoke.

Given the very high event rates at DAΦNE , and the uncommon accuracy aimed in the measurement of ϵ'/ϵ, the requirements that the trigger system has to satisfy are very stringent and somewhat unprecedented in e$^+$-e$^-$ collider experiments.

[1] Corresponding author

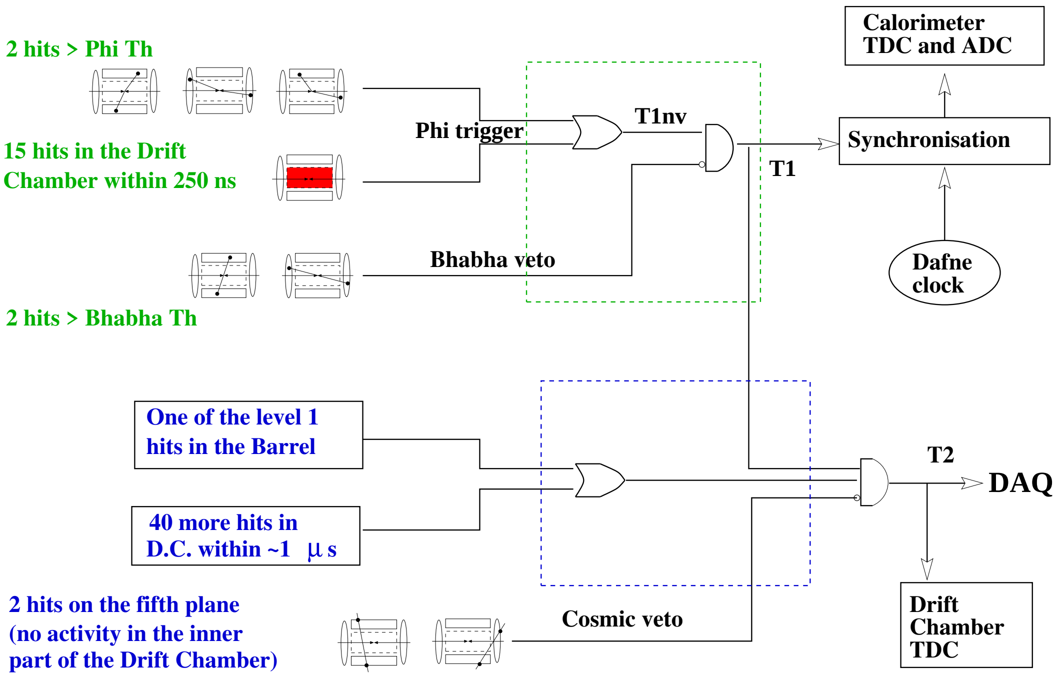

Fig. 1. KLOE Trigger Logic

Firstly its efficiency on the charged and neutral two pions decays of K^0_S and K^0_L has to be kept as close as possible to 100%. Secondly it has to produce a valid signal for starting the EmC FEE as fastly as possible, and anyway after not more than ∼350 ns from the interaction. Furthermore it has to efficiently reject the very high background rates , while maintaining the aimed efficiencies for neutral kaon's ϕ decays. Finally it has to take in account that the DAQ has been designed for an average troughput of 50 Mbytes/s and that the FEE cannot accept triggers less than 2 μs apart in time owing to the drift time in the chamber cells.

2 Overview of the Trigger system

The KLOE trigger system [4] is based on local energy deposits in the EmC and hit multiplicty information from the drift chamber. A two level scheme has been adopted in order to both produce early triggers with good timing to start the FEE operation and to use as much information as possible from the drift chamber. Specifically (see fig. 1), after the arrival of a first level trigger, additional information is collected from the drift chamber, which is used, together with the calorimetric information, to confirm the former and to start the DAQ system. The trigger hardware (see fig. 2) consists of 13 different types of custom-designed electronics modules, needed either to generate the elementary trigger signals from the various subdetectors or to produce the final trigger signals and to distribute them to the FEE modules.

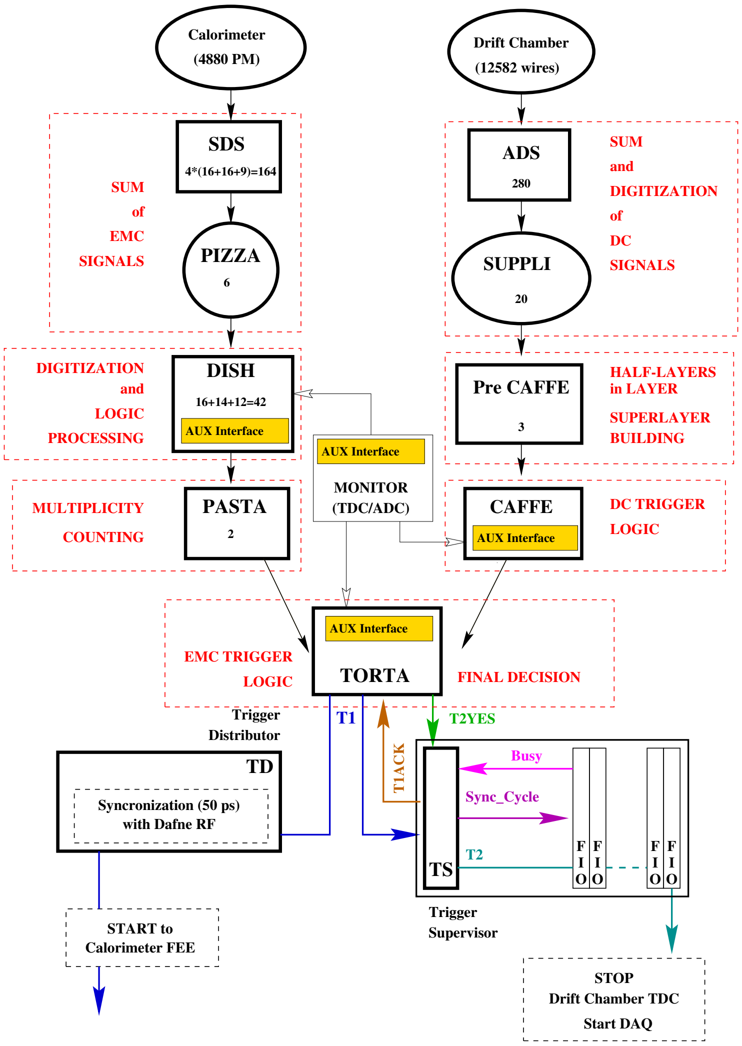

Fig. 2. Implementation of the Trigger Hardware

Signals from the EmC and the DC are properly treated to generate two *separate* trigger decisions, that are then OR-ed to form the final T1 and T2 signals of the experiment.

Since in DAΦNE the time between bunch crossings can be as short as ~ 2.7 ns, the trigger must operate in a continuous mode. However, before being distributed to the FEE, the first level trigger is synchronized with a resolution of 50 ps with the machine radiofrequency demultiplied by a factor 4 (T=10.8 ns). This technique allows to preserve the resolution on time measurement at the level of tens of picoseconds, which would be otherwise spoiled by the intrinsic jitter of the trigger signal formation. However the actual bunch crossing which originated the event has to be determined by the offline analysis.

3 Overview of the trigger hardware

3.1 The modules of the calorimeter trigger

The signals from the calorimeter PM's are collected on 164 boards (SDS/Splitter boards) and are divided into three different paths to the ADCs, the TDCs and the trigger. For trigger purposes, five adjacent PM signals corresponding to one calorimeter column are summed, for each side of the calorimeter separately. In addition, groups of 6 adjacent PM signals in the outmost layer of the calorimeter are summed in order to form the signals for the cosmic trigger. The trigger sector signals are formed in the so called PIZZA board by grouping together the output signals of the Splitter. The analog signals corresponding to each trigger sector are compared to a system of different thresholds and processed in a simple logic stage. This task is performed by the "DIgitiser-SHaper (DISH)" module. It provides output signals which indicate a local energy deposit above a certain threshold in the calorimeter. The number of hits in the calorimeter is determined in the "Precise Analogue STAge (PASTA)" which finally sends the informations to the "Trigger ORganiser and Timing Analyser (TORTA)" board, for the final decision.

3.2 The modules of the Drift Chamber trigger

The FEE stage of the drift chamber is made by 280 "Amplificator Discriminator Shaper (ADS)" boards, which provide digital signals for the TDCs and the signal for the trigger. At this purpose, the DC signals, shaped to a width of 250 ns, are summed by the ADS boards in groups of 12 contiguous wires, and then sent to 20 "Sum Unit Providing Plane Information (SUPPLI)" boards, housed in the same FEE crates, where the counting of the fired wires on half drift chamber planes is performed. The output signals from the SUPPLI boards are sent to 3 PreCaffe boards, which join the half-plane multiplicity information and pack the drift chamber layers in groups of 4-6, producing at the output the multiplicity signals from 10 superlayers. At the end of the chain the "Chamber Activity Fast FEtch (CAFFE)" board sums the signals of the superlayers to produce a current signal proportional to the number of fired wires in the chamber within 250 ns. A level one drift chamber trigger (T1D) is delivered whenever this current exceeds a given, programmable, threshold. A second level signal (T2D) is also generated on the basis of the number of DC hits integrated in the following 1 μs.

3.3 The trigger box and the Trigger DAQ interface

The multiplicity signals from the calorimeter and the first and second level chamber triggers, T1D and T2D, are sent to the TORTA (fig. 2), that merges all the informations to deliver the final trigger decision. The TORTA distributes T1 to the Trigger Supervisor (TS, in fig. 2) which sends back the T1ACK signal to disable trigger generation for a fixed time ($\sim 2\mu$s). At the same time, the TORTA sends the T1 signal also to a Distributor module (TD), which performs the 50 ps synchronization with the machine RF and distributes it to the calorimeter FEE. Whenever the TORTA generates a second level trigger (within 1.5μs from the T1) the Trigger Supervisor asserts a T2 exactly 2.6μs after the T1. This signal is sent by the TS to the "Fan in-out (FIO)" modules, that distribute it to the corresponding readout chain with a precision of 1 ns.

References

[1] The KLOE collaboration, LNF-93/002 (1993).
The KLOE collaboration, LNF-94/028 (1994).

[2] P. Valente for the KLOE collaboration, *The KLOE drift chamber* and references therein, these proceedings.

[3] S. Miscetti for the KLOE collaboration, *First performances of the KLOE electromagnetic calorimeter at DAΦNE* and references therein, these proceedings.

[4] The KLOE collaboration, *The KLOE Trigger System: Addendum to the technical proposal*, and references therein, LNF-96/043 (1996).