Short description of the modifications of the H1 Time-of-Flight System in the framework of the H1/HERA upgrade

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1 Introduction: The existing ToF System

The present Time of Flight System (ToF) in H1 consists of the following devices (listed according to the z-position of the counters)

1. FTOF:
   The Forward ToF is installed at $z \approx 7.0\,\mathrm{m}$, in between the forward muon system, since 1993
2. PTOF:
   A ToF installed in the region of the Plug calorimeter at $z \approx 5.3\,\mathrm{m}$, since 1995
3. FIT:
   The Forward Interaction Timing system is mounted on the Forward side of the Forward Tracker ($z \approx 2.7\,\mathrm{m}$). since 1997
4. BTOF:
   The backward ToF (mounted in the VLQ-Tagger region) is installed at $z \approx -3.3\,\mathrm{m}$ since 1995
5. VETOWALL:
   The Vetowall system consists out of 2 systems:
   The big vetowall, covering nearly the entire surface of H1, installed in a big frame a $z \approx -6.5\,\mathrm{m}$ since 1992
   The small veto counters, located very close to the beamline inbetween some HERA magnet components at $z \approx -8.1\,\mathrm{m}$ since 1992

The ToF system is shown in Fig. 1 and its performance is described in several internal H1 notes and the detector paper. See section 6 for references.

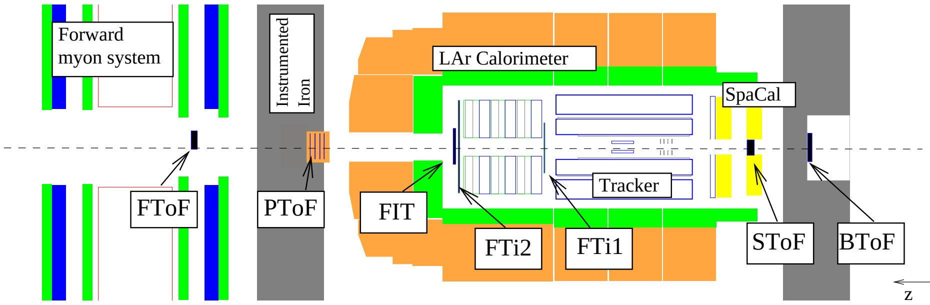


Figure 1: Sketch of ToF system after the year 2000.

2 Global requirements

The global requirements for all Time of Flight systems in H1 is to resolve substructure in the electron and proton bunches (so-called satellite bunches). The time resolution has to be in the order of 1 ns, allowing a detailed analysis of TDC data for satellite data suppression.

The operation of the system is clocked by the HERA clock with a frequency of 96 ns. These 96 ns are typically divided into three subranges:

- an interaction window,
- a background window and
- the global window.

For each of these windows a separate trigger output (so-called trigger element) has to be generated, which has to be transmitted properly to the central trigger.

For monitoring purposes a local system is and shall be operated, allowing a fast independent system check.

3 The future ToF System

In the framework of the upgrade of HERA in 2000 an installation of additional machine components is foreseen. In the region of the beamline between $+/-40$ m with respect to the interaction point the complete vacuum system and magnet system will be exchanged and additional components like superconducting magnets will be introduced to the H1 experiment (see Fig. 2).

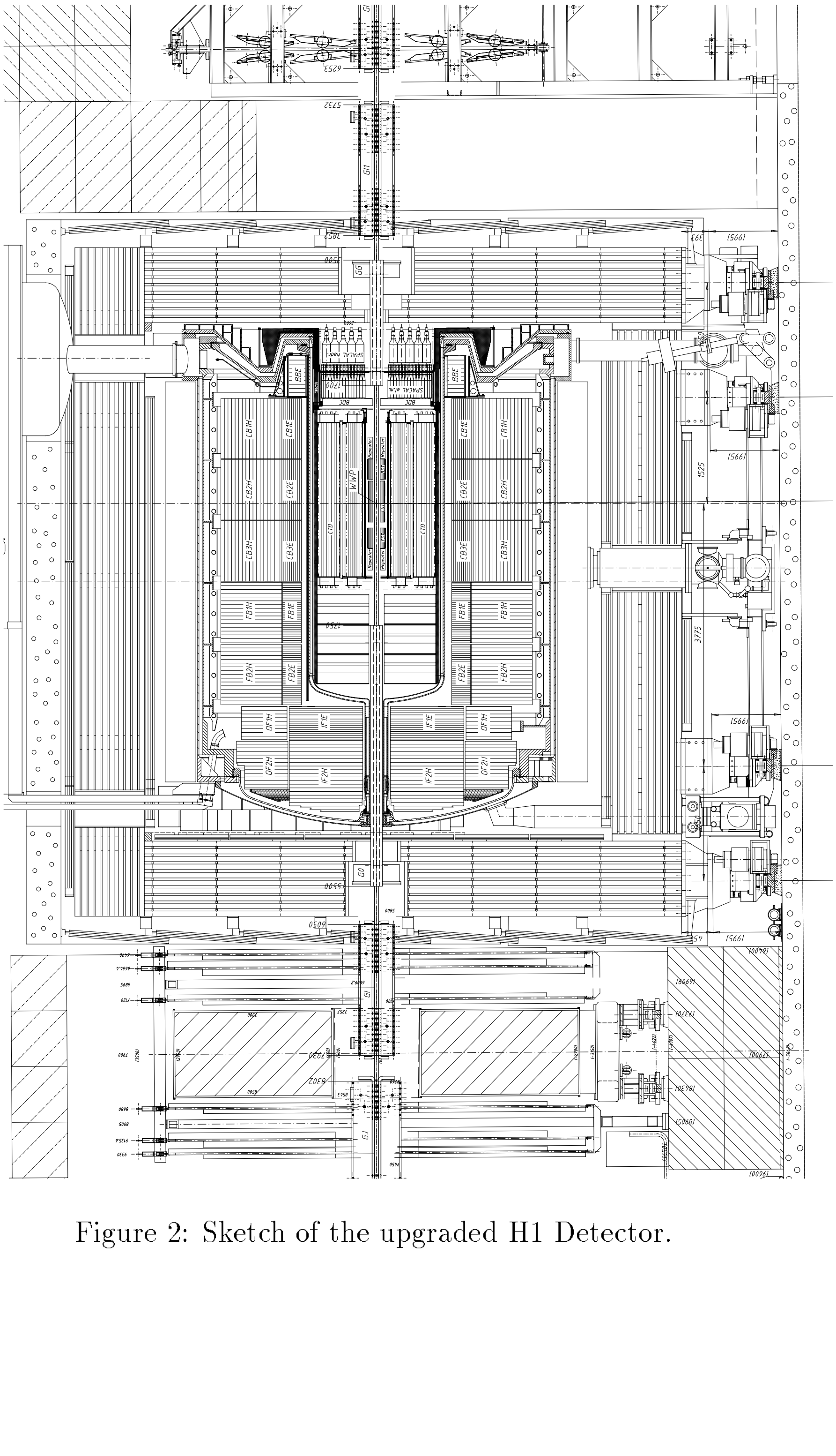


Figure 2: Sketch of the upgraded H1 Detector.

As consequence of this upgrade, those H1 subdetectors installed close to the beamline need to be modified. This has to be done for the ToF system, and reliable operation is crucial for H1 operation after the upgrade, because a completely different/worse background situation may be experienced due to the new beamline elements as well as to the higher beam currents.

In detail the following modifications of the hardware have to be done:

1. FToF:
   Due to the new magnets, the existing FToF scintillation counters have to be arranged in new position. The available space/volume has to be found in between the new magnets below the forward muon system. For this device an upgrade may be appropriate, such that the FToF covers the full azimuth of 2 π.
   H/W needed:
   - Scintillators
   - PMs (may be re-used. Caveat: there might be a stronger B-field from the new magnets)
   - Mechanical support of the counters
   - Electronics for 2 channels (+ addition channels??)

2. PToF:
   The plug region will be modified by the Dubna H1 group. They will provide all detector. Their responsibility extends just to the TDC output of the photomultipliers, such that in this case the implementation of these counters into the electronics system has to be done.
   H/W needed:
   - Electronics for 8 channels

3. FIT:
   The FIT system stays probably untouched, but this has to be verified w.r.t. to the inner radius of the scintillators. It consists of 8 channels which shall be incorporated into the electronics system.
   H/W needed:
   - Electronics for 8 channels

4. FTi1:
   This is a new scintillator system foreseen for the region between the central tracker and the forward tracker, to be installed in the region of the magnet support GOB at z=1.3 m. It is foreseen to arrange 1 plane of 16 counters subdivided into 8 segments in azimuth arranged radially in 2 rings. These counters shall be operated in combination with the:

5. FTi2:
   A new scintillator system to be installed between the forward tracker and the inner forward section LAr Calorimeter. Identical to the trigger granularity in the calorimeter this plane shall be divided into 16 segments in azimuth and arranged (like the FTi1) in 2 rings.
   For the FTi(1+2) system the scintillator material is available, but it has to be manufactured according to the available space/volume. The decision on the PMs/HPDs is not yet taken, and needs to be clarified. Perhaps some PM of the SPACAL become available due to modifications in that region. The support of the system FTi1 needs to be discussed in the framework of the magnet supports, the support of FTi2 is less problematic, since a fixation on the forward endwall of the forward tracker seems feasible.
   H/W needed:

   - Support structure
   - PMs/HPDs ???
   - Electronics for 16+32 channels.

6. SToF:
   Due to the modifications of the backward SPACAL the very inner region is to be supplied with a timing device, such that adequate timing performance in that region is ensured. The SToF counters might be built by an ITEP/LPI group. Signals must be handled in both the SPACAL and the ToF subsystems. So in this case only electronics is to be provided.
   H/W needed:

   - Electronics for 8 channels

7. BToF:
   The region between the instrumented iron and the endbox of the GG magnet is available for the new backward ToF ($-3.0 < z < -3.3\,\mathrm{m}$) The inner diameter of the BTOF is defined by the outer shape of the GG magnet (diameter: 200 mm, but 20 mm horizontally off axis). The outer diameter is defined by the iron endcap, which is 1000 mm. In case of the BToF no geometry is defined yet. If it fills up the entire volume as described above a 2 plane configuration is preferred, each with a 4 fold segmentation.
   H/W needed:
   - Scintillators
   - Supports (easily mounted on the endcaps)
   - Electronics for 8 (?) channels
   - Cables?

8. LARGE VETOWALL:
   The large veto wall shall stay as it is at present. Only during the installation of the HERA machine components all counters have to be dismounted, and afterwards mounted again. This is to be done together with the local staff. In the framework of the ToF upgrade, also these 20 channels should be arranged in new electronics.
   H/W needed:
   - Electronics for 20 channel

9. SMALL VETOWALL:
   similar to the FToF the small vetowall has to get a new position close to the beamline in the backward region.
   H/W needed:
   - Scintillators
   - PMs (old PMs might be re-used)
   - Supports
   - Electronics for 8 channels

An overview on the H/w needs is given in following two tables:

	Components:	FTOF	PTOF	FIT	FTI1+2	STOF	BTOF
Existing:	Scintillators	2	8	8	-	-	4
	PMs	2	8	8	-	-	4
	Electronics channels	2	8	8	-	-	4
Needed:	Scintillators	2(+2?)	-	-	-	-	8
	PMs	-(+2?)	-	-	??	-	4
	Electronics channels	2(+2?)	4	8	48	8	4

Table 1: Components of the upgraded ToF system

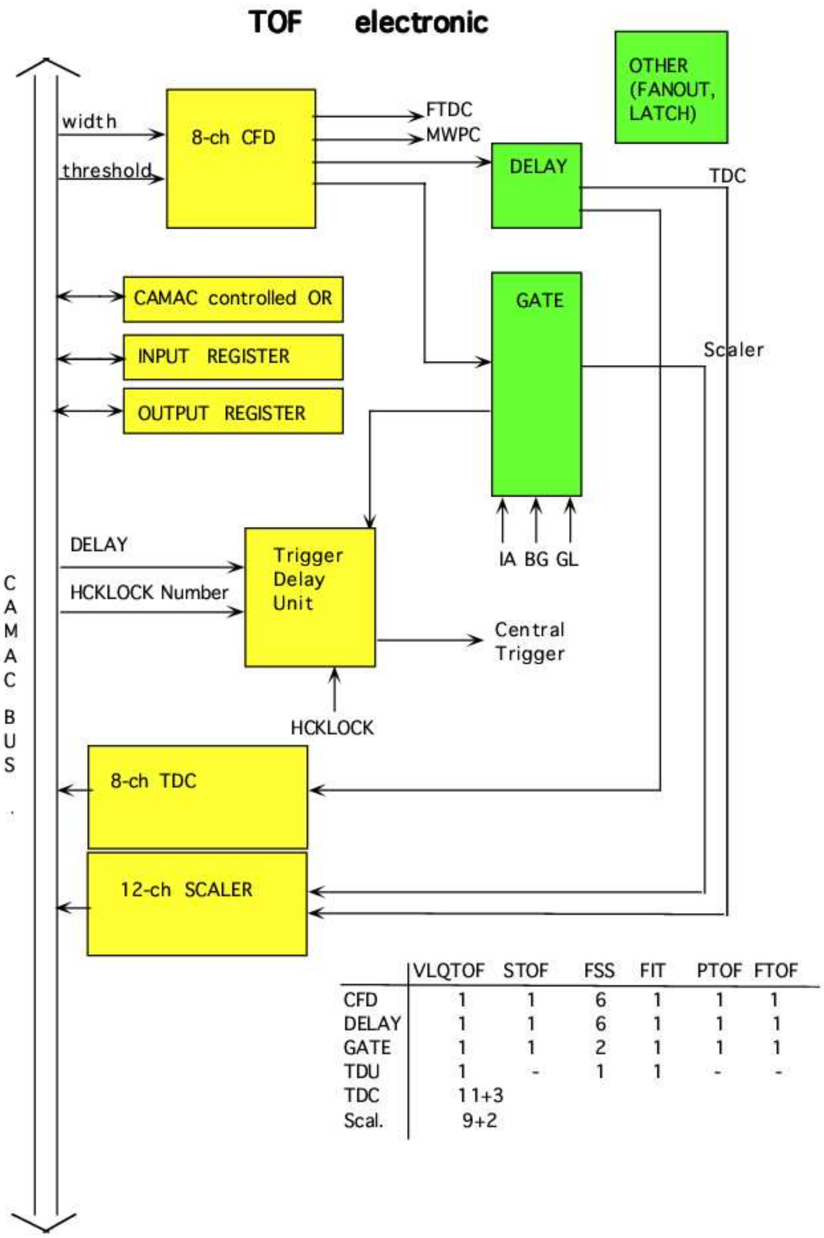
	Components:	LVETO	SVETO
Existing:	Scintillators	20	8
	PMs	20	8
	Electronic channels	20	8
Needed:	Scintillators	-	8
	PMs	-	8 (?)
	Electronic channels	20	8

Table 2: Components of the VETOWALLs

4 Electronics setup

The TOF electronics setup (see Fig. 3) will be based on CAMAC and NIM (see Tab. 3 for the components needed). The input signals after amplification (if needed) will be connected to the programmable (threshold and pulsewidth) CAMAC Constant Fraction Discriminator module and afterwards split into the following data streams:

- to the Flash TDC for offline data analys (CJC branch);
- to MWPC side (must be determined with MWPC experts);
- through NIM multichannel delay line to the CAMAC TDCs for online monitoring;
- GATE unit for generating background, interaction and global gated output for further passing to the CAMAC programmable Trigger Delay Unit and then to the Central Trigger pipeline.



	VLQTOF	STOF	FSS	FIT	PTOF	FTOF
CFD	1	1	6	1	1	1
DELAY	1	1	6	1	1	1
GATE	1	1	2	1	1	1
TDU	1	-	1	1	-	-
TDC	11+3					
Scal.	9+2					

Figure 3: Sketch of the ToF electronics setup.

Equipment to buy:			
	CAMAC	Crate	4 (+1)
	CAMAC	Crate-controller	
		+interface	
		+PC_card	4 (+1)
	PC		1 (+1)
Modules to design:			
	CAMAC	8-ch CFD	15 (+2)
	CAMAC	Trigger Delay Unit	4 (+1)
	NIM	Delay Unit	15 (+2)
From the old setup:			
	CAMAC	ADC	
	CAMAC-OR	Unit	
	CAMAC	I/O Register	
	CAMAC	TDC	
	CAMAC	Scaler	
	NIM	Discriminator	
	NIM	Latch	
	NIM	Fanout	

Table 3: List of necessary electronics in case of CAMAC/NIM environment

The VETO electronic setup (see Fig. 4) has a similar shape. The only difference to the ToF electronics is the parallel ADC readout for input channels by means of CAMAC fast gated ADCs.

Disposition of both systems will be same as before, which allows the current cabling to the detector to be kept. The data acquisition will be done by PC, connected to setup by a Wiener crate-controller and interface card, which provides long distance CAMAC monitoring.

Presently under investigation is also the option to change to a more homogeneous H1 environment, which is based on the VME standard. A replacement of CAMAC/NIM electronics by VME modules has to be considered where adequate.

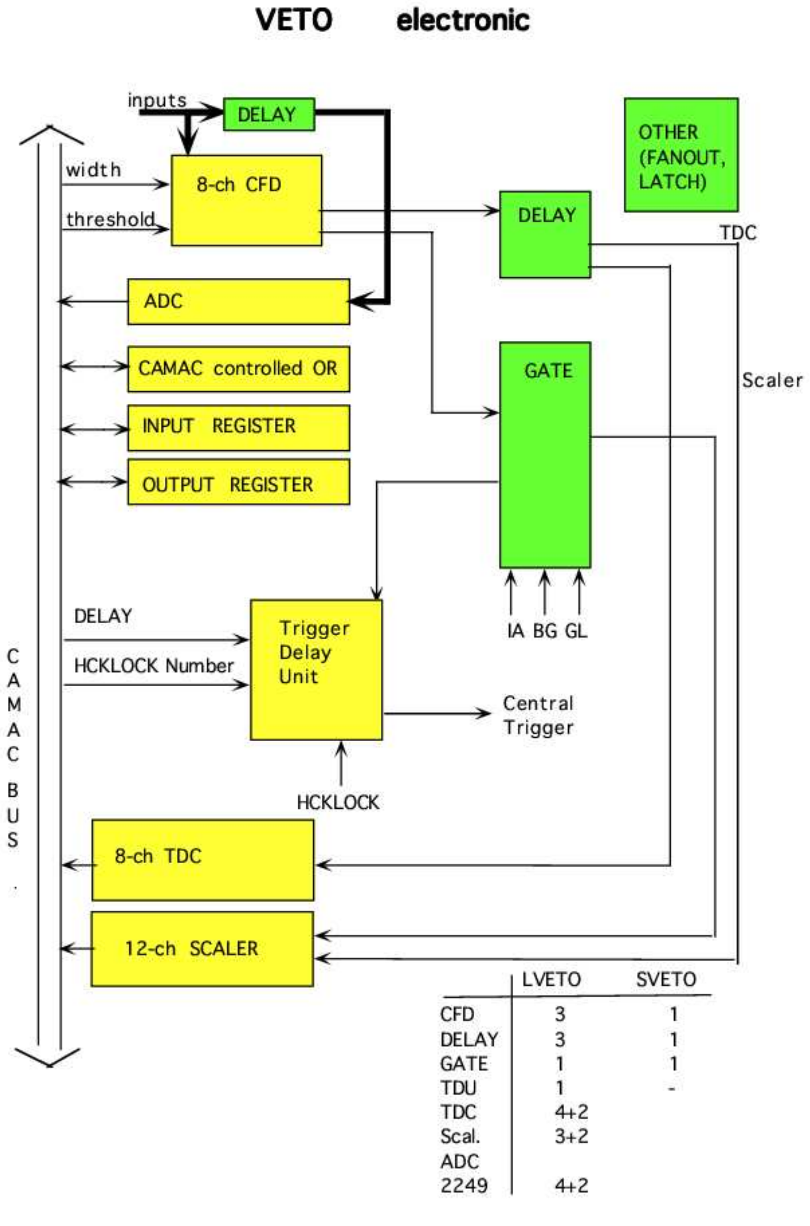


Figure 4: Sketch of the VETO electronics setup.

5 Instrumentation and Operation

The ToF system is a crucial part of the H1 Trigger system. The instrumentation requires great care to avoid any malfunction of any ToF device. This is a large task carrying a very important responsibility, since all H1 data rely on ToF timing. So proper monitoring and maintenance has to be ensured during Luminosity operation. As usual in H1 an on-call expert has to be available in the entire data taking period. Shut downs have to be used for detailed checks and maintenance of the hardware.

6 Appendix 1: References

H1 notes:

H1-07/93-306: *Studies of ToF efficiency during Autumn 1992 run*

H1-08/93-307: *Studies on ToF FTDC data*

H1-08/93-308: *ToF efficiency as function of the strobe positions*

H1-09/93-313: *Analysis of ToF offline monitor plots*

H1-10/93-318: *Measurement of ToF Average Counter Efficiency*

H1-02/94-340: *ToF timing correlation for upstream vertex events*

H1-03/94-349: *A log likelihood method of combining individual ToF counter FTDC data for trigger independent background rejection*

H1-06/94-362: *Analysis of FToF TDC data*

H1-01/98-533: *The H1 ToF system in 1996 and 1997*

H1 detector paper:

Chapter 2.7 "Scintillators" in
The tracking, calorimeter and muon detectors of the H1 detector a HERA
Nucl. Instr. and Meth. A 386, 1997, 348 - 396

PhD and Diploma theses:

Ch. Pichler (1989): (in GERMAN)
Pulshöhe und Zeitauflösung der Szintillatorplatten fuer die inneren Veto-Wände des HERA H1-Detektors

K. Flamm (1992): (in GERMAN)
Messung von Strahluntergrund bei HERA fuer den Betrieb von H1

J. Heatherington (1995):
ToF - The Time-of-Flight Device for H1
(the available ps file doesn't contain all figures;
a complete version is available from Hella Kleinebenne)

R. Wallny (1996): (in GERMAN)
Untersuchung des Strahlinduzierten Untergrundes bei der Datennahme von Ereignissen der tief-inelastischen Streuung durch den H1-Detektor bei HERA

Ch. Wissing (1998): (in GERMAN)
Bestimmung der Charakteristika des Flugzeitsystems des H1-Detektors zur Messung des Strahluntergrundes

Summerstudent reports:

Carol Chauvin (1996): (mostly in FRENCH)
The BToF

Andrea Vargas (1998):
Experience with FIT detector in H1