DAQ with CAEN TDC and QDC

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CHEP/KNU

- **CAEN VME Bridge (V1718 and V4718)**
- **CAEN DAQ with V1290N TDC**
  - How to use CAEN V1290N TDC with DAQ software (**V1190Readout)**
  - TDC Linearity Test of CAEN V1290N TDC
  - 2 Coincidence Test with with CAEN V1290N TDC
- **CAEN DAQ with V792N QDC**
  - How to use CAEN V792N QDC with DAQ software (**QTPD_DAQ)**
  - TDC Linearity Test with of CAEN V792N QDC
  - Gamma Spectrum Measurement by LYSO detector with Co-60 with CAEN V792N QDC

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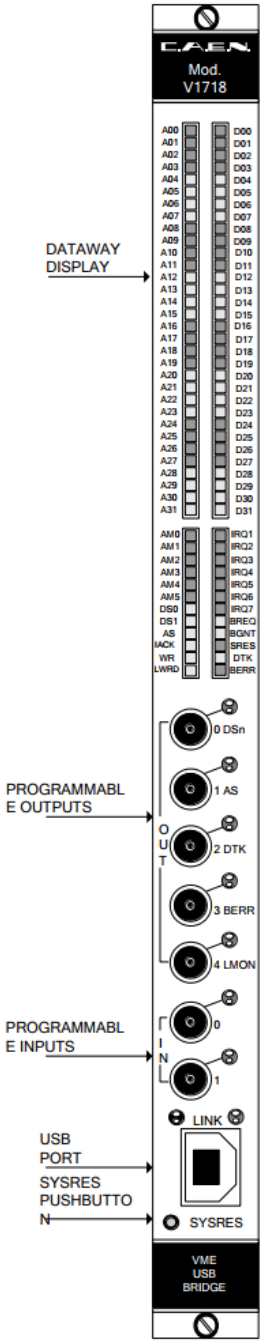
V1718 Bridge

V1718 Bridge



Overview

The Mod. V1718 is a 1-unit wide VME master module which can be operated from the USB port of a standard PC, which represents the "intelligent" section of the system. The module is capable of performing all the cycles foreseen by the VME64X specifications[1].

The Mod. VX1718 is the VME64X mechanics version of the module; in the present manual the "generic" term "V1718" refers to all versions, except as otherwise specified.

It can work in a "multimaster" system with the possibility of operating as a system controller, in this case (which is the default option as the board is inserted in the slot 1), it works as Bus Arbiter, Sysclock Driver, IACK Daisy Chain Driver, etc.

Operation as a Slave module is available for reading the Dataway display and the Internal Test RAM.

The module features a LED display[2] which allows to monitor the VME bus activity in detail. The front panel features 5 TTL/NIM programmable outputs[3] on LEMO 00 connectors (default assignment is: DS, AS, DTACK, BERR signals and the output of a programmable Location Monitor) and two programmable TTL/NIM inputs[4] (on LEMO 00 connectors).

The V1718 – PC interface is USB 2.0 compliant; previous issues are also supported. USB data transfer takes place through the High Speed Bulk Transaction protocol. The VME Bus data transfer does not require to be strictly synchronised to the USB transfer thanks to a 128 kbyte local buffer.

The Module is supported by the most common PC platforms (Windows 7/8/8.1/10, Linux), thanks tho the drivers available for free download on the product web page (§ **4.1.1**).
Useful example programs are provided as well. Firmware upgrades are possible via USB; only tools developed by CAEN must be used for the firmware upgrade.

Environment setup for CAEN DAQ system

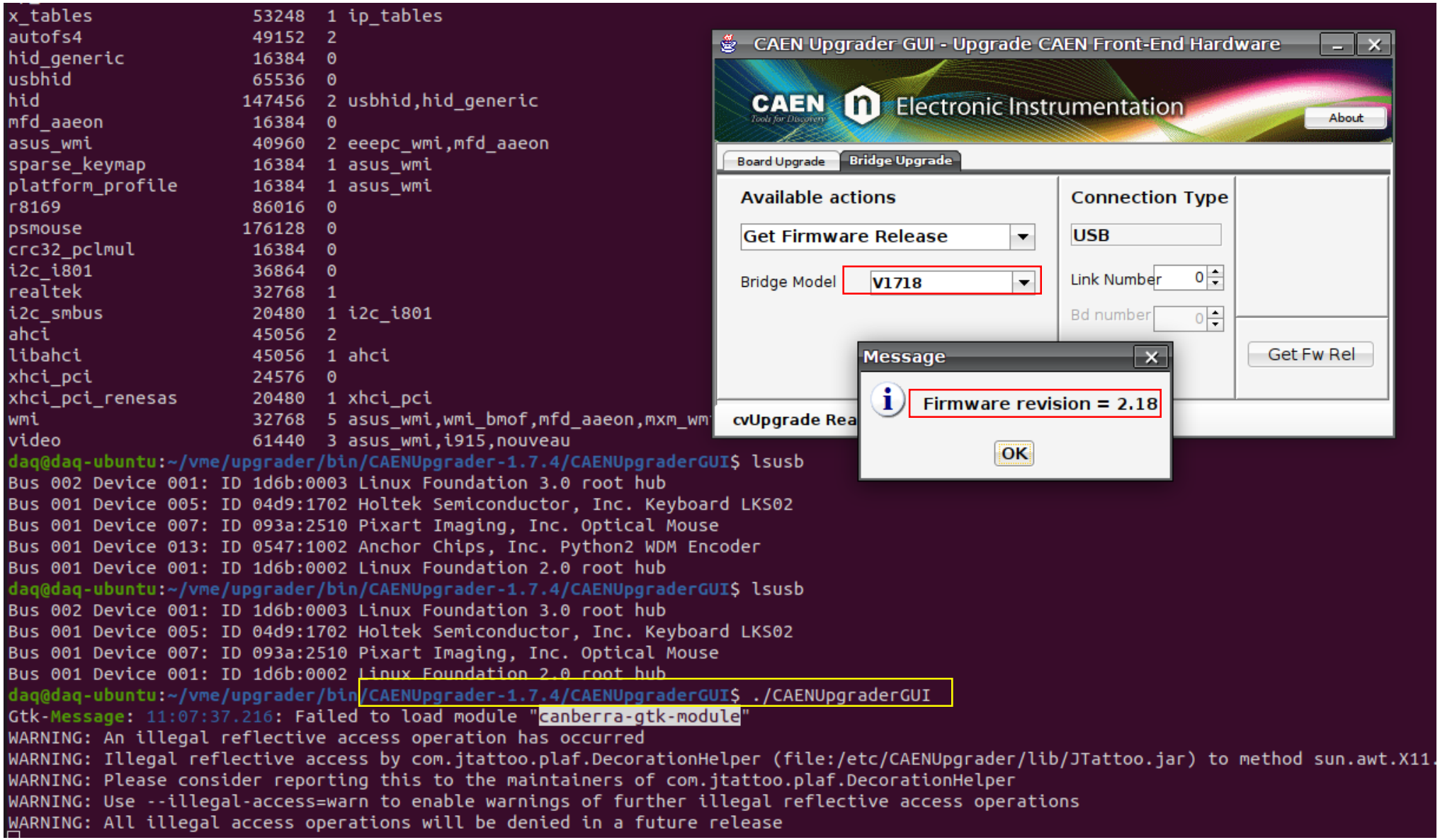
OS: Ubuntu 20.04
source path: ~/newVMEDAQ/

CAEN USB driver 1.5.4 ➔ cd ~/newVMEDAQ/CAENUSBdrvB-1.5.4
make
sudo make install
sudo reboot (or sudo shutdown –r now)
➔ Once the DAQPC reboots, CAENUSBdrvB will be loaded automatically.

```
daq@daq-ubuntu:~/vme/v1718/bin/CAENUSBdrvB-1.5.4$ lsmod
Module                  Size  Used by
CAENUSBdrvB            16384  0
btrfs                1540096  0
blake2b_generic        20480  0
```

```
daq@daq-ubuntu:~/vme/upgrader/bin/CAENUpgrader-1.7.4/CAENUpgraderGUI$ lsusb
Bus 002 Device 001: ID 1d6b:0003 Linux Foundation 3.0 root hub
Bus 001 Device 005: ID 04d9:1702 Holtek Semiconductor, Inc. Keyboard LKS02
Bus 001 Device 007: ID 093a:2510 Pixart Imaging, Inc. Optical Mouse
Bus 001 Device 013: ID 0547:1002 Anchor Chips, Inc. Python2 WDM Encoder
Bus 001 Device 001: ID 1d6b:0002 Linux Foundation 2.0 root hub
daq@daq-ubuntu:~/vme/upgrader/bin/CAENUpgrader-1.7.4/CAENUpgraderGUI$ lsusb
Bus 002 Device 001: ID 1d6b:0003 Linux Foundation 3.0 root hub
Bus 001 Device 005: ID 04d9:1702 Holtek Semiconductor, Inc. Keyboard LKS02
Bus 001 Device 007: ID 093a:2510 Pixart Imaging, Inc. Optical Mouse
Bus 001 Device 001: ID 1d6b:0002 Linux Foundation 2.0 root hub
daq@daq-ubuntu:~/vme/upgrader/bin/CAENUpgrader-1.7.4/CAENUpgraderGUI$
```

Get Firmware version of CAEN VME Bridge



Environment setup for CAEN DAQ system

CAEN VME Library

CAEN VME Lib 3.4.0 ➔ cd ~/newVMEDAQ/CAENVMELib-v3.4.0/lib
sudo install_x64
cd ../sample
make
./CAENVMEDemo V1718 0

```
daq@daq-ubuntu:~/vme/lib/bin/CAENVMELib-v3.4.0/sample$ ll
total 188K
drwxr-xr-x 2 daq daq 4.0K 11월 14 14:53 ./
drwxrwxr-x 6 daq daq 4.0K  2월 14  2023 ../
-rwxrwxr-x 1 daq daq  39K 11월 14 14:53 CAENVMEDemo*
-rw-r--r-- 1 daq daq 3.2K  1월 24  2023 CAENVMEDemoMain.c
-rw-rw-r-- 1 daq daq 3.8K 11월 14 14:53 CAENVMEDemoMain.o
-rw-r--r-- 1 daq daq  22K  1월 24  2023 CAENVMEDemoVme.c
-rw-rw-r-- 1 daq daq  24K 11월 14 14:53 CAENVMEDemoVme.o
-rw-r--r-- 1 daq daq  21K  1월 24  2023 CaenVmeVSL.c
-rw-rw-r-- 1 daq daq  18K 11월 14 14:53 CaenVmeVSL.o
-rw-r--r-- 1 daq daq  16K  1월 24  2023 console.c
-rw-r--r-- 1 daq daq 9.2K  1월 24  2023 console.h
-rw-rw-r-- 1 daq daq 6.0K 11월 14 14:53 console.o
-rw-r--r-- 1 daq daq 1.5K  1월 24  2023 Makefile
daq@daq-ubuntu:~/vme/lib/bin/CAENVMELib-v3.4.0/sample$ ./CAENVMEDemo V1718 0
daq@daq-ubuntu:~/vme/lib/bin/CAENVMELib-v3.4.0/sample$
```

```
    CAEN VME Manual Controller

R - READ
W - WRITE
B - BLOCK TRANSFER READ
T - BLOCK TRANSFER WRITE
I - CHECK INTERRUPT
1 - ADDRESS                    [EE000000]
2 - BASE ADDRESS               [EE000000]
3 - DATA FORMAT                [D16]
4 - ADDRESSING MODE            [A32]
5 - BLOCK TRANSFER SIZE        [256]
6 - AUTO INCREMENT ADDRESS     [OFF]
7 - NUMBER OF CYCLES           [1]
8 - VIEW BLT DATA
F - FRONT PANEL I/O
X - EXECUTE SCRIPT FILE
Q - QUIT MANUAL CONTROLLER
```

V4718 Bridge

V4718 Bridge

Introduction

The V4718 is CAEN VME-to-USB 3.0/Ethernet/Optical Link Bridge implementing a VME master controlled by a PC via USB 3.0, Gigabit Ethernet and CONET Link (CAEN proprietary optical link protocol), including all the functions in a 1-unit wide VME 6U form factor. The V4718 is characterized by an enhanced data rate and extended interfacing capabilities, thanks to the on-board Zynq Ultrascale+ SoC module (including an ARM-based processor running Linux OS).

The Bridge is also available in the VX4718 version with VME64X mechanics (VME64X cycles not implemented). In the present document, the "V4718" term will be used to generally refer to both versions, unless otherwise specified.

The optical link connection between the V4718 and the host PC requires a CAEN optical controller (A3818 PCI Express or the A2818 PCI card) or the A4818 USB 3.0-to-CONET compact adapter, and an optical fiber cable (see **Tab. 1.1**). Multi-crate sessions can be easily performed thanks to the CONET Daisy chain capability: up to eight V4718 units can be controlled by a single link of an A2818/A3818/A4818 building a CONET Optical Network.

The V4718 is compliant with the USB 3.1 Gen1 speed protocol and can be connected to the USB port of the PC running Windows or Linux OS. The V4718 also have a 1 Gigabit Ethernet port allowing high data transfer rate.

The V4718 can perform all the cycles foreseen by the VME64 standard except those intended for 3U boards. The Bridge can operate as VME System Controller (normally when plugged in the slot 1) acting as a Bus Arbiter in Multi-Master systems. The activity on the VME bus can be monitored in detail both locally (through an 88-LED DataWay Display) and remotely.

The front panel of the V4718 hosts 6 TTL/NIM programmable I/Os on LEMO connectors: four outputs (default assignment is: DSn, AS, DTK, BERR) and two inputs. The I/Os can be programmed via USB, Ethernet and Optical Link to implement functions like Timer, Counter, Pulse generator, I/O register, and others (see Chap. **8**).

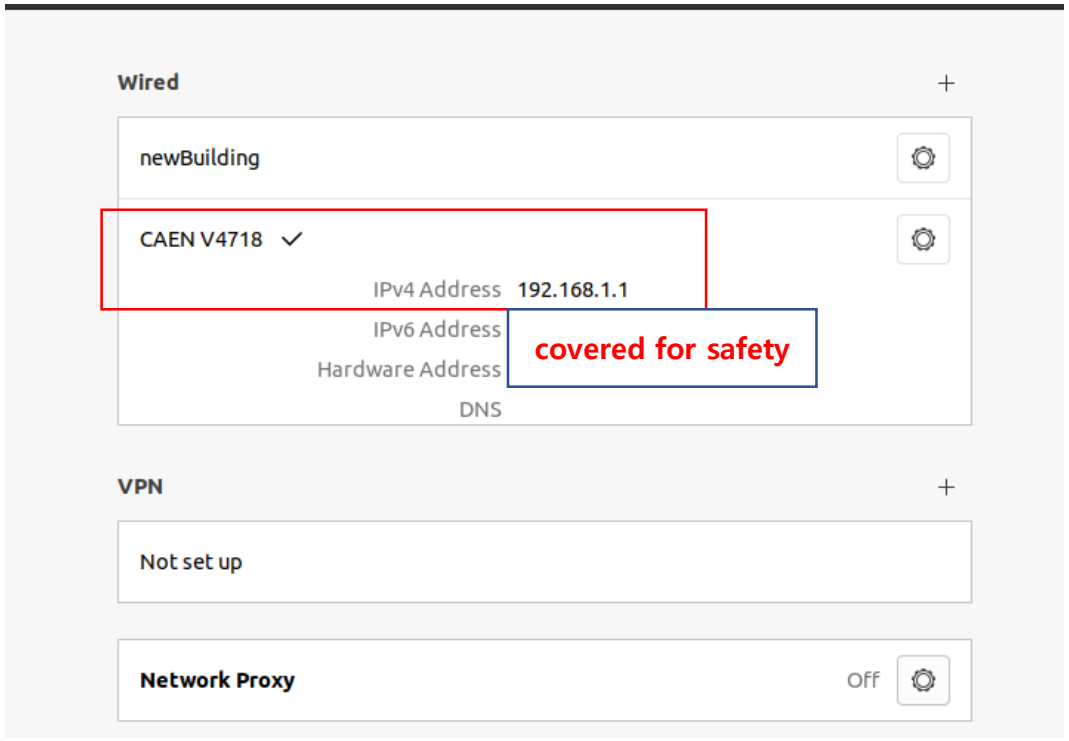
The supported data transfer rate, with a CAEN slave readout in MBLT64 data transfer mode, is up to 60 MB/s by USB 3.0 and Ethernet and up to 80 MB/s by CONET2. Thanks to the 128KB memory buffer, the activity on the VME bus is not slowed down by the transfer rate on the USB port, on the Ethernet or on the CONET one, especially when several V4718 units share the same network.

The V4718 can be integrated into the most common Windows® and Linux® computers and middleware libraries are also provided. Moreover, the presence of an embedded Linux-based CPU gives to the user the chance of running custom software directly on-board.

The user can completely control and monitor the V4718 by Web Interface, including the firmware upgrade.

Connection to V4718 Bridge via IP

V4718 USB driver ➔ cd ~/newVMEDAQ/V4718-USB-Drv
sudo install.sh



Connection status of DAQ PC to V4718 Bridge (1.1)

```
mryu194@TPCsim:~$ ping 192.168.1.1
PING 192.168.1.1 (192.168.1.1) 56(84) bytes of data.
64 bytes from 192.168.1.1: icmp_seq=1 ttl=64 time=0.015 ms
64 bytes from 192.168.1.1: icmp_seq=2 ttl=64 time=0.017 ms
64 bytes from 192.168.1.1: icmp_seq=3 ttl=64 time=0.017 ms
^C
--- 192.168.1.1 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2042ms
rtt min/avg/max/mdev = 0.015/0.016/0.017/0.000 ms
```

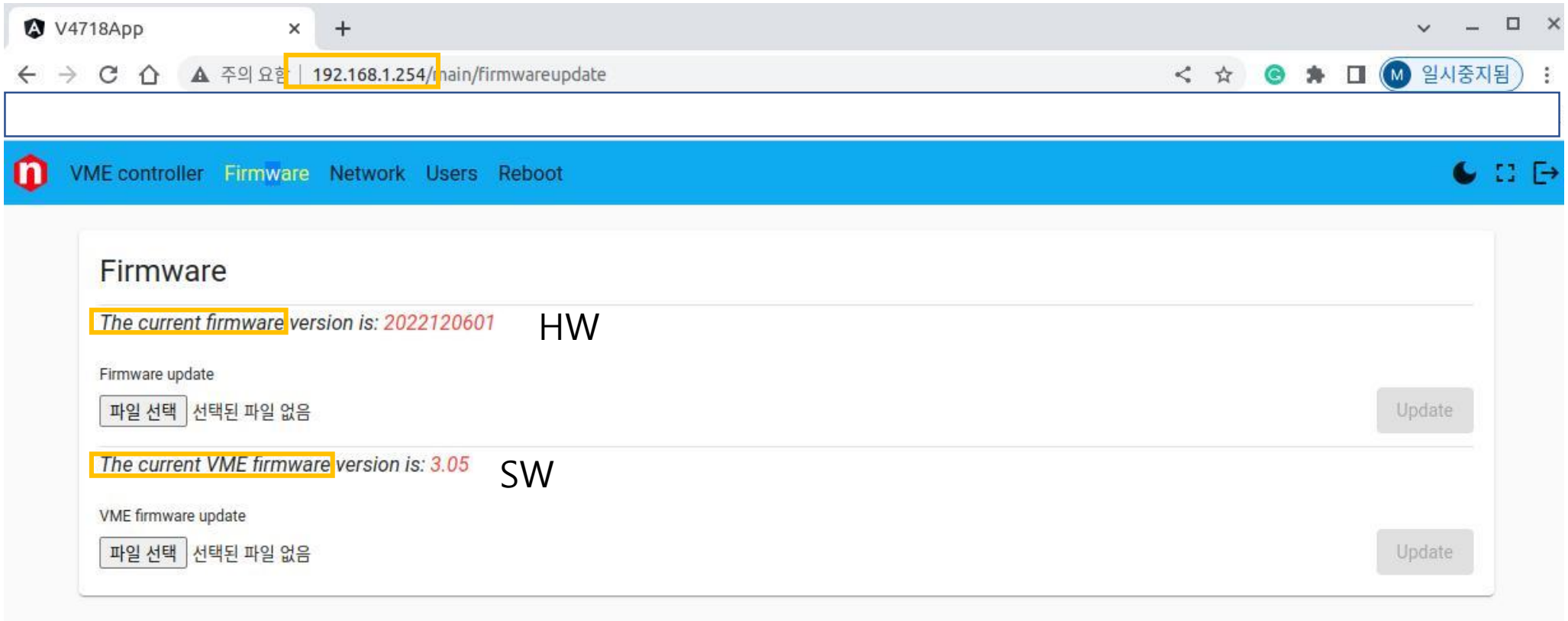
IP of V4718 Bridge: 192.168.1.1~253 available in local network

Connection IP(192.168.1.254) into V4718 Bridge controller

Update of V4718 and VME firmwares

Connection IP(192.168.1.254) into V4718 Bridge controller

```
mryu194@TPCsim:~$ ping 192.168.1.254
PING 192.168.1.254 (192.168.1.254) 56(84) bytes of data.
64 bytes from 192.168.1.254: icmp_seq=1 ttl=64 time=0.501 ms
64 bytes from 192.168.1.254: icmp_seq=2 ttl=64 time=0.104 ms
^C
--- 192.168.1.254 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1031ms
rtt min/avg/max/mdev = 0.104/0.302/0.501/0.198 ms
```



RUN Demo program in V4718 SoC

```
mryu194@TPCsim:~$ ssh root@192.168.1.254
The authenticity of host '192.168.1.254 (192.168.1.254)' can't be established.
ECDSA key fingerprint is SHA256:9kSQuh3+pkHCQ5kLbGB8LEXiEhE0jwCkX68UvWD3Nqs.
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added '192.168.1.254' (ECDSA) to the list of known hosts.
root@192.168.1.254's password:  root
Linux fd163d6c79a9 5.4.0-xilinx-v2020.2 #1 SMP Tue Jul 27 07:54:29 UTC 2021 aarch64

The programs included with the Debian GNU/Linux system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/copyright.

Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
Last login: Thu Mar  4 11:42:57 2021 from 172.17.0.1
root@fd163d6c79a9:~# ll
total 8
drwxr-xr-x 2 root root 4096 Mar  4 11:30 CAENVMEDemo
-rw-r--r-- 1 root root  981 Jul 15  2021 README
```

1) Enter the directory "cd CAENVMEDemo"

2) type "make"

3) run "./ CAENVMEDemo"

➔ if nothing is displayed on the screen, all is good.

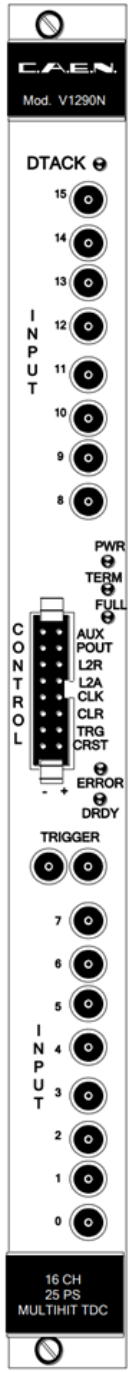
gnuplot for real-time monitoring

Install “gnuplot” package by using apt-get

1) sudo apt-get update
2) sudo apt-get install gnuplot
3) sudo apt-get install gnuplot-data
4) sudo apt-get install gnuplot-doc
5) sudo apt-get install gnuplot-mode
6) sudo apt-get install gnuplot-nox
7) sudo apt-get install gnuplot-x11
8) sudo apt-get install gnuplot-qt

V1290N TDC

V1290N TDC



Overview

The Model V1290 A is a 1-unit wide VME 6U module that houses 32 independent Multi-Hit/Multi-Event Time to Digital Conversion channels. The unit houses 4 High Performance TDC chips, developed by CERN/ECP-MIC Division. Resolution is 25 ps (21 bit dynamics). The module accepts both ECL and LVDS inputs.

The Model V1290 N is a 1-unit wide VME 6U module that houses 16 independent Multi-Hit/Multi-Event Time to Digital Conversion channels. The unit houses 2 High Performance TDC chips and shares most of its features with the V1290 A. The module accepts NIM inputs.

The VX1290 A and the VX1290 N are the VME64X mechanics versions of the Mod. V1290 A and of the Mod. V1290 N respectively. They provide all the features of the std. VME versions, moreover they support the GEOgraphical Address.

The CERN/ECP-MIC HPTDC is a General Purpose time-to-digital converter, with 32 channels per chip. The chips can be enabled to the detection of the rising and/or falling edges.

The data acquisition can be programmed in "EVENTS" ("TRIGGER MATCHING MODE" with a programmable time window: the so called *match window*) or in "CONTINUOUS STORAGE MODE".

The board houses a 32 kwords deep Output Buffer, that can be readout via VME (as single data, Block Transfer and Chained Block Transfer) in a completely independent way from the acquisition itself.

The TDCs' programming is performed via a microcontroller that implements a high-level interface towards the User in order to mask the TDCs' hardware.

Both the Mod. V1290 A and the Mod. V1290 N fit into standard, V430 and VME64x VMEbus crates.
The Mod. VX1290 A and the Mod. VX1290 N require VME64x VMEbus crates.

ReadMe.txt: Compile and Run command

```
                  --- CAEN SpA - Computing Division ---

                               www.caen.it

------------------------------------------------------------------------------

Program: V1190Readout


------------------------------------------------------------------------------


Content
------------------------------------------------------------------------------

README.txt        :  This file.

ReleaseNotes.txt  :  Revision History and notes.

 src          :  Source files
 inc          :  Include files
 build    :  Windows Project files
 bin          :  Executable files, precompiled and custom-developed
             template specific files (config.txt)


System Requirements
------------------------------------------------------------------------------
- Linux 32/64-bit
- CAENVMELib library
- V1190 | V1290 Digital TDC

Installation
------------------------------------------------------------------------------
Execute "make"


Syntax
------------------------------------------------------------------------------
./V1190Readout [config_file]


How to get support
------------------

CAEN makes available the technical support of its specialists for requests
concerning CAEN products. Use the support form available at the following link:
https://www.caen.it/support-services/support-form
-UU-(DOS)----F1  ReadMe.txt     Top L1     (Text) ------------------------------------
Beginning of buffer
```

Compile DAQ code

Run DAQ code with **V1190Config.txt**

ReadMe.txt: Makefile

```
#################################################################
#
#               --- CAEN SpA - Front End Division ---
#
#   Created  :  November 2007      (Rel. 1.0)
#
#   Author: L. Colombini
#
#################################################################

EXE     =       V1190Readout

CC      =       gcc

COPTS   =       -fPIC -DLINUX -Wall
#COPTS  =       -g -fPIC -DLINUX -Wall

FLAGS   =       -Wall -s
#FLAGS  =       -Wall

DEPLIBS =       -l CAENVME -lncurses -lm

LIBS    =

INCLUDEDIR =    -I.

OBJS    =       src/$(EXE).o src/keyb.o

INCLUDES =      src/keyb.h src/V1190.h

#################################################################

all     :       $(EXE)

clean   :
                /bin/rm -f $(OBJS) $(EXE)

$(EXE)  :       $(OBJS)
                /bin/rm -f $(EXE)
                $(CC) $(FLAGS) -o $(EXE) $(OBJS) $(DEPLIBS)

$(OBJS) :       $(INCLUDES) Makefile

%.o     :       %.c
                $(CC) $(COPTS) $(INCLUDEDIR) -c -o $@ $<
```

Output

V1190Config.txt: Connection VME Master

```
# ****************************************************************
# Readout Configuration File
# ****************************************************************

# LINK (VME Master)
#LINK V1718
LINK ethV4718 192.168.1.254

# methode for wavedump with V4718
# OPEN ETH_V4718 192.168.1.254 0 32100000
#LINK ethV4718 192.168.1.254 0 32100000

# Base Address of the VME board
# V1290N TDC
#BASE_ADDRESS    EE000000

### YUSH
BASE_ADDRESS    EE000000
#BASE_ADDRESS    CC110000


# ----------------------------------------------------------------
# RAW DATA
# ----------------------------------------------------------------
RAW_DATA  1


# ----------------------------------------------------------------
# Channel for the time reference
# ----------------------------------------------------------------
TIME_REF  0


# ----------------------------------------------------------------
# Enable/Disable Output File with event list
# ----------------------------------------------------------------
WRITE_EVENT_FILE 1
```

connection VME Master (V4718)
LINK V4718 192.168.1.254

BASE_ADDRESS of VME module (TDC)
check the address of the side panel of TDC
BASE_ADDRESS EE000000

RAW DATA (save data in "Raw_Data.txt")
RAW_DATA 1

Time reference among input channels (ChTref = 0 ch)
TIME_REF 0

Enable Output File "V1190EventList.txt
WRITE_EVENT_FILE 1

V1190Config.txt: Trigger Matching Window

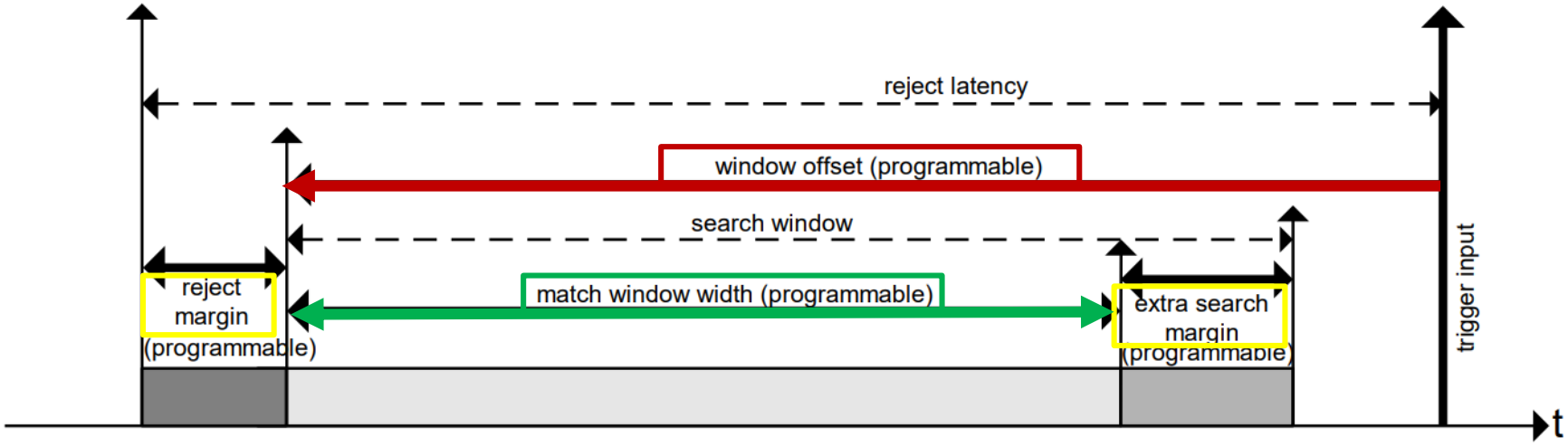


Fig. 2.5: Mod. V1290A/N Trigger Matching Mode timing diagram

```
# ------------------------------------------------------------------
# Trigger Matching Window (width,         offset in steps of 25 ns)
#                    set width: 500 ns (20 clocks), offset: -700 ns (28 clocks)
# set value have to be divided by 25 ns (1 clock).
# reject margin: 100 ns
# extra search margin: 200 ns
# ------------------------------------------------------------------
# TRIGGER_WINDOW 350 -350
TRIGGER_WINDOW 20 -28
```

Trigger Matching Window (1 clock = 25 ns)
offset -700 ns (-28 clocks)
width 500 ns (20 clocks)
reject margin 100 ns (default)
extra search margin: 200 ns (default)
TRIGGER_WINDOW 20 -28

V1190Config.txt: Channel Mask and Histogram

```
# ------------------------------------------------------------
# Channel Mask
# ------------------------------------------------------------
CHANNEL_MASK  F

# ch 0 and 1
#CHANNEL_MASK  3


# ------------------------------------------------------------
# Histogram Channels (number of bin = 2^Nbit) and bin size (1=25ps)
# ------------------------------------------------------------
#HISTO_CHANNELS 12000 1
HISTO_CHANNELS 1200 10
#HISTO_CHANNELS 4000 1
#HISTO_CHANNELS 400 10
```

Channel selection

gnuplot

Enable All Channel
CHANNEL_MASK FFFF
ch0~7
CHANNEL_MASK FF
ch0~3
CHANNEL_MASK F
ch0~1
CHANNEL_MASK 3

2^N bit and bin size (1 bin = 25 ps = 0.1 clock)
HISTO_CHANNELS 12000 1

V1190Readout.c: main – read config.txt

```
    // ********************************************************************
    // Read configuration file
    // ********************************************************************

    if (argc > 1){
      strcpy(tmpConfigFileName, argv[1]);
      printf("copy name of config file \n");
    }

#ifdef  WIN32
    sprintf(path, "%s\\VME\\", getenv("USERPROFILE"));
    _mkdir(path);
    sprintf(ConfigFileName, "%s\\%s", path, tmpConfigFileName);
#else
    sprintf(path, ".");
    sprintf(ConfigFileName, "%s/%s", path, tmpConfigFileName);
#endif

    sprintf(path, ".");
    //    sprintf(ConfigFileName, "%s/%s", path, tmpConfigFileName);
    sprintf(ConfigFileName, "./%s", tmpConfigFileName);
    printf("read config file: %s \n",ConfigFileName);

    if ( (f_ini = fopen(ConfigFileName, "r")) == NULL ) {
      printf("Can't open Configuration File %s\n", ConfigFileName);
      goto exit_prog;
    }

    fgets(str, 1000, f_ini);
    printf("%s \n", str);
    //    sleep(3);

    printf("Reading Configuration File: %s \n", ConfigFileName);
    printf("start while \n");
```

It is not working properly.

Read file “config.txt “

Code running check point

V1190Readout.c: main – LINK V4718

```
// ###################################################################
// Global Variables
// ###################################################################
int handle=-1;
unsigned int BaseAddress = 0xEE000000;
int VMEerror = 0;
FILE *gnuplot=NULL;
int PlotError=0;
int RawData=0;
char path[128];
```

BaseAddress is updated by config.txt

CAENVMELib-v3.4.0/include/CAENVMEtypes.h:
cvSuccess = 0, /* Operation completed successfully */

V1190Readout.c
Int handle=-1;

```
printf("Reading Configuration File: %s \n", ConfigFileName);
printf("start while \n");

while(!feof(f_ini)) {
  int data, addr;
  int nwopc, val;
  unsigned short opcd[10];
  int app;
  //      printf("t0 \n");

  str[0] = '#';
  fscanf(f_ini, "%s", str);
  //      printf("t01 \n");
  if (str[0] == '#'){
    fgets(str, 1000, f_ini);
    //      printf("t02 \n");
  }
  else {
    // LINK: Open VME master
    if (strstr(str, "LINK")!=NULL) {
      CVBoardTypes BType;
      int link=0, bdnum=0;

      fscanf(f_ini, "%s", tmp);
      if (strstr(tmp, "V1718")!=NULL)
        BType = cvV1718;
      else if (strstr(tmp, "V2718")!=NULL)
        BType = cvV2718;
      else if (strstr(tmp, "ethV4718")!=NULL) {
        BType = cvETH_V4718;
        fscanf(f_ini, "%s", ip);
        printf("%s \n", ip);

      }
      else {
        printf("Invalid VME Bridge Type\n");
        goto exit_prog;
      } // end if Btype
```

Board type = cvETH_V4718
IP = 192.168.1.254

```
if (BType == cvETH_V4718) {
  if (CAENVME_Init2(BType, ip, bdnum, &handle) != cvSuccess) {
    printf("Can't open VME controller\n");
    Sleep(1000);
    goto exit_prog;
  } else {
    printf("Open V4718 by CAENVME_Init2 \n");
  }
}
```

 # Initialization of CAEN VME
 # CAENVME_Init2 for V4718 Bridge

CAENVME_Init2(BType, ip, bdnum, &handle) != cvSuccess

```
mryu194@TPCsim:~/newVMEDAQ/V1190Readout$ ./V1190Readout V1190Config.txt

************************************************************
                    V1190Readout 1.1
************************************************************
copy name of config file
read config file: ./V1190Config.txt
# ************************************************************

Reading Configuration File: ./V1190Config.txt
start while
192.168.1.254
Open V4718 by CAENVME_Init2
(int *)&BaseAddress: dbe30014
(int *)&RawData: -605880260
&ChTref: 620023984
&Write2File: 620023964
(int *)&ChMask: 24f4d0ac
&HistoNbin: 620023968
&HistoBinSize: 620023972
&addr and &data: 24f4d0b8 and 24f4d0b4
&addr and &data: 24f4d0b8 and 24f4d0b4
Configuration Complation

Open Raw_Data.txt
```

V1190Config.txt: Write Register (Default)

```
# ****************************************************************
# VME Write to board registers
# ****************************************************************

# ----------------------------------------------------------------
# Reset the board
# ----------------------------------------------------------------
WRITE_REGISTER 1014 0


# ----------------------------
# BLT Event Number
# ----------------------------
WRITE_REGISTER 1024 FF


# ----------------------------
# Trigger Matching
# ----------------------------
WRITE_OPCODE 1 0000
```

Reset VME Board
WRITE_REGISTER 1014 0

BLT Event Number
WRITE_REGISTER 1024 FF

Trigger Matching Mode
or CONTINUOUS STORAGE MODE
WRITE_OPCODE 1 0000

```
      // Write File
      if (strstr(str, "WRITE_EVENT_FILE")!=NULL){
        fscanf(f_ini, "%d", &Write2File);
        printf("&Write2File: %ls \n", &Write2File);
      }

      // Generic VME Write
      if (strstr(str, "WRITE_REGISTER")!=NULL) {
        fscanf(f_ini, "%x", &addr);
        fscanf(f_ini, "%x", &data);

        printf("&addr and &data: %ls and %ls \n", &addr, &data);
        V1190WriteRegister((unsigned short)addr, (unsigned short)data);

        if (VMEerror) {
          printf("VME Write failure at address %08X\n", BaseAddress + addr);
          goto exit_prog;
        }
      } // end if strstr WRITE_REGISTER

      // Write Opcode
      if (strstr(str, "WRITE_OPCODE")!=NULL) {
        fscanf(f_ini, "%d", &nwopc);
        printf("&nwopc: %ls \n", &nwopc);

        for(i=0; i<nwopc; i++) {
          //fscanf(f_ini, "%x", (int *)&opcd[i]);
          fscanf(f_ini, "%x", &app);
          printf("&app: %ls \n", &app);
          opcd[i] = (unsigned short) app;
        }
        if(V1190WriteOpcode(nwopc, opcd)) {
          printf("Opcode Write failure (nwopc=%d, opcd=%x)\n", nwopc, opcd[0]);
          goto exit_prog;
        }
      } // end if WRITE_OPCODE
    }  // end if (str[0] == '#')
  } // end while(!feof(f_ini))
  fclose (f_ini);
```

Reset & BLT Event Number

V1190WriteRegister is failed, it returns VMEerror = 1.

Trigger Matching

V1190Readout.c: main – Initialization of TDC

```
// ****************************************************************************
// Initialize the board and the variables for the acquisition
// ****************************************************************************
// Read Board Type, Firmware Revisions and Serial Number
fwrev = V1190ReadRegister(FW_REVISION);
printf("SerNum = %d, Fw Revision = %d.%d\n", sn, (fwrev >> 8) & 0xFF, fwrev & 0xFF);
sn = (int)V1190ReadRegister(CR_SERNUM0);
printf("SerNum = %d, Fw Revision = %d.%d\n", sn, (fwrev >> 8) & 0xFF, fwrev & 0xFF);
sn |= (int)V1190ReadRegister(CR_SERNUM1) << 8;
printf("SerNum = %d, Fw Revision = %d.%d\n", sn, (fwrev >> 8) & 0xFF, fwrev & 0xFF);

BoardType = (int)V1190ReadRegister(CR_BOARDID0);
printf("Board Type: V%d: SerNum = %d, Fw Revision = %d.%d\n", BoardType, sn, (fwrev >> 8) & 0xFF, fwrev & 0xFF);
BoardType |= (int)V1190ReadRegister(CR_BOARDID1) << 8;
printf("Board Type: V%d: SerNum = %d, Fw Revision = %d.%d\n", BoardType, sn, (fwrev >> 8) & 0xFF, fwrev & 0xFF);
BoardType |= (int)V1190ReadRegister(CR_BOARDID2) << 16;
printf("Board Type: V%d: SerNum = %d, Fw Revision = %d.%d\n", BoardType, sn, (fwrev >> 8) & 0xFF, fwrev & 0xFF);

if (VMEerror) {
  printf("Can't read the configuration ROM\n");
  goto exit_prog;
}
printf("Board Type: V%d: SerNum = %d, Fw Revision = %d.%d\n", BoardType, sn, (fwrev >> 8) & 0xFF, fwrev & 0xFF);
```

```
mryu194@TPCsim:~/newVMEDAQ/V1190Readout$ ./V1190Readout V1190Config.txt

************************************************************
                        V1190Readout 1.1
************************************************************
copy name of config file
read config file: ./V1190Config.txt
# ************************************************************

Reading Configuration File: ./V1190Config.txt
start while
192.168.1.254
Open V4718 by CAENVME_Init2
(int *)&BaseAddress: dbe30014
(int *)&RawData: -605880260
&ChTref: 620023984
&Write2File: 620023964
(int *)&ChMask: 24f4d0ac
&HistoNbin: 620023968
&HistoBinSize: 620023972
&addr and &data: 24f4d0b8 and 24f4d0b4
&addr and &data: 24f4d0b8 and 24f4d0b4
Configuration Complation

Open Raw_Data.txt

SerNum = 5590599, Fw Revision = 0.17
SerNum = 169, Fw Revision = 0.17
SerNum = 24489, Fw Revision = 0.17
Board Type: V10: SerNum = 24489, Fw Revision = 0.17
Board Type: V1290: SerNum = 24489, Fw Revision = 0.17
Board Type: V1290: SerNum = 24489, Fw Revision = 0.17
Board Type: V1290: SerNum = 24489, Fw Revision = 0.17
Board Ready. Press a key to start the acquisition (q' to quit)

Readout started.
No data
TDC_ErrorFlags = 0000; Ovf=0; TrgLost=0
No Trigger


No data
TDC_ErrorFlags = 0000; Ovf=0; TrgLost=0
No Trigger


No data
TDC_ErrorFlags = 0000; Ovf=0; TrgLost=0
No Trigger


No data
TDC_ErrorFlags = 0000; Ovf=0; TrgLost=0
No Trigger



mryu194@TPCsim:~/newVMEDAQ/V1190Readout$
```

V1190Readout.c: main – Set Opcode

```
    // Write Control Register1 (enable BERR and Align64)
    ctrl = V1190ReadRegister(CONTROL);
    V1190WriteRegister(CONTROL, ctrl | 0x11);

    V1190WriteRegister(BLT_EVNUM, 0xFF);

    opcd[0]=0x0000;
    V1190WriteOpcode(1, opcd);  // Enable Trigger Matching

//    opcd[0]=0x3100;
//    V1190WriteOpcode(1, opcd);  // Disable TDC Header/Trailer

    opcd[0]=0x1000; opcd[1]=TMWwidth;
    V1190WriteOpcode(2, opcd);  // Set Trigger Matching Window Width

    opcd[0]=0x1100; opcd[1]=TMWoffs;
    V1190WriteOpcode(2, opcd);  // Set Trigger Matching Window Offset

    opcd[0]=0x4400;
    opcd[1]=(unsigned short)(ChMask & 0xFFFF);
    opcd[2]=(unsigned short)((ChMask>>16) & 0xFFFF);
    opcd[3]=0x0000;
    opcd[4]=0x0000;
    opcd[5]=0x0000;
    opcd[6]=0x0000;
    opcd[7]=0x0000;
    opcd[8]=0x0000;
```

BLT Event Number

Enable Trigger Matching Mode

Width and offset of Trigger Matching Window

```
  if (BoardType == 1190)
    V1190WriteOpcode(9, opcd);  // Enable Channels
  else
    V1190WriteOpcode(3, opcd);  // Enable Channels

  V1190WriteRegister(SW_CLEAR, 0);

  printf("Board Ready. Press a key to start the acquisition ('q' to quit)\n");
  if (getch()=='q')
    goto exit_prog;

  // Set maximum buffer size for event readout
  BufferSize =  1024 * 1024;
  if ( (buff = (unsigned int *)malloc(BufferSize)) == NULL) {
    printf("Can't allocate memory buffer of %d KB\n", BufferSize/1024);
    goto exit_prog;
  }

  printf("NUM_CHANNELS = %d  \n", NUM_CHANNELS); // NUM_CHANNELS = 32

  for(i=0; i<NUM_CHANNELS; i++) {
    Histo[i] = (unsigned int *)malloc(4*HistoNbin);
    memset(Histo[i], 0, 4*HistoNbin);
    DiscardCnt[i] = 0;
    HitCnt[i] = 0;
    NegCnt[i] = 0;

    mean[i]=0;
    stddev[i]=0;
    nstat[i]=0;
  }
  TrgCnt = 0;

  if (Write2File)
    fout = fopen(OUTFILE_NAME, "w");
```

Enable channel for V1290N

Buffer size = 1024 x 1024

Initialization of all histogram variables

Open fout to write "V1190EventList.txt"

```
mryu194@TPCsim:~/newVMEDAQ/V1190Readout$ ./V1190Readout V1190Config.txt

************************************************************
                        V1190Readout 1.1
************************************************************
copy name of config file
read config file: ./V1190Config.txt
# ************************************************************

Reading Configuration File: ./V1190Config.txt
start while
192.168.1.254
Open V4718 by CAENVME_Init2
(int *)&BaseAddress: dbe30014
(int *)&RawData: -605880260
&ChTref: 620023984
&Write2File: 620023964
(int *)&ChMask: 24f4d0ac
&HistoNbin: 620023968
&HistoBinSize: 620023972
&addr and &data: 24f4d0b8 and 24f4d0b4
&addr and &data: 24f4d0b8 and 24f4d0b4
Configuration Complation

Open Raw_Data.txt

SerNum = 5590599, Fw Revision = 0.17
SerNum = 169, Fw Revision = 0.17
SerNum = 24489, Fw Revision = 0.17
Board Type: V10: SerNum = 24489, Fw Revision = 0.17
Board Type: V1290: SerNum = 24489, Fw Revision = 0.17
Board Type: V1290: SerNum = 24489, Fw Revision = 0.17
Board Type: V1290: SerNum = 24489, Fw Revision = 0.17
Board Ready. Press a key to start the acquisition ('q' to quit)

Readout started.
No data
TDC_ErrorFlags = 0000; Ovf=0; TrgLost=0
No Trigger


No data
TDC_ErrorFlags = 0000; Ovf=0; TrgLost=0
No Trigger


No data
TDC_ErrorFlags = 0000; Ovf=0; TrgLost=0
No Trigger


No data
TDC_ErrorFlags = 0000; Ovf=0; TrgLost=0
No Trigger


mryu194@TPCsim:~/newVMEDAQ/V1190Readout$
```

V1190Readout.c: main – Readout Loop and Write buff[]

Added by ryu

```
PreviousTime = get_time();
// Readout Loop
while(!Quit) {
  //      printf("\n Quit=%d \n", Quit);
  if (kbhit()) {

    // added by ryu
    printf("\n\n");
    printf("choose the command: \n");
    printf("Quit                    = 'q' \n");
    printf("Refresh (stat & Histo) = 'r' \n");
    printf("Save Histograms         = 'h' \n");
    printf("Plot Histograms         = 'p' \n");
    printf("Change Input Channel    = 'c' \n");
    printf("show menu (space bar)   = ' ' \n");
    printf("\n\n");

    char c;
    c = getch();
    if (c == 'q')
      Quit = 1;
    if (c == 'r') {
      printf("Statistics and Histograms have been cleared\n");
      TrgCnt=0; PrevTrgCnt=0;
      for(i=0; i<NUM_CHANNELS; i++) {
        memset(Histo[i], 0, 4*HistoNbin);
        DiscardCnt[i] = 0;
        HitCnt[i] = 0;
        NegCnt[i] = 0;
      }
    }
    if (c == 'h')
      SaveHistograms(Histo, HistoNbin, ChMask);
    if (c == 'p')
      if ((ChMask >> ChToPlot) & 0x1)
        PlotHistograms(Histo, HistoNbin, ChToPlot);
    if (c == 'c') {
      printf("Enter Channel to Plot: ");
      scanf("%d", &ChToPlot);
    }
    if (c == ' ') {
      printf("\n\n[q] Quit\n");
      printf("[r] Reset Statistics\n");
      printf("[h] Save Histograms\n");
      printf("[p] Plot Histogram\n\n");
    }

  }

  ret = CAENVME_FIFOBLTReadCycle(handle, BaseAddress, (unsigned char *)buff, BufferSize, cvA32_U_MBLT, cvD64, &nb);
  if ((ret != cvSuccess) && (ret != cvBusError)) {
    printf("Readout Error\n");
    goto exit_prog;
  }
```

```
choose the command:
Quit                    = 'q'
Refresh (stat & Histo) = 'r'
Save Histograms         = 'h'
Plot Histograms         = 'p'
Change Input Channel    = 'c'
show menu (space bar)   = ' '
```

Default
But it is shown when the “space bar” is pushed.

```
// ------------------------------------------------------------------------
// Save raw data to output files
// ------------------------------------------------------------------------
//                int r;
if (RawData == 1){
  for(r=0; r<nb/4; r++)
    fprintf(fr, "buff[%d]=%8x,  r=%d \n", r, buff[r], r);
  sleep(2);
}
```

Write **buff[]** to “**Raw_Data.txt**”

V1190Readout.c: main – Read rate & Trigger rate

```
// ---------------------------------------------------------------
// Calculate throughput rate (every second)
// ---------------------------------------------------------------
CurrentTime = get_time(); // Time in milliseconds
ElapsedTime = CurrentTime - PreviousTime;
if (ElapsedTime > 1000) {
  TPrate = ((float)(totnb) / ElapsedTime)*1000.0;     // Bytes/second
  TRGrate = ((float)(TrgCnt - PrevTrgCnt) / ElapsedTime)*1000.0;  // Triggers/second

  if (totnb==0)   printf("No data\n");
  else            printf("Readout Rate=%.2fMB/s. TrgRate=%.4f Hz\n", TPrate/1048576, TRGrate);

  printf("TDC_ErrorFlags = %04x; Ovf=%d; TrgLost=%d\n", TDCerrors, Ovf, TrgLost);

  if (TrgCnt==0) {
    printf("No Trigger\n");
  } else {
    printf("%lld triggers processed\n", TrgCnt);
    printf("CH\tFound\tDiscarded\tNegative\n");

    for(i=0; i<(NUM_CHANNELS); i++) {
      // printf("%d\t%.2f%%\t%.2f%%\n", i, (float)HitCnt[i]*100.0/TrgCnt, (float)DiscardCnt[i]*100.0/TrgCnt);
      if (nstat[i] > 0) {
        mean[i] = mean[i] / nstat[i];
        stddev[i] = sqrt(stddev[i]/nstat[i] - mean[i]*mean[i]);
        if (BoardType == 1190)
          printf("%d\t%.2f%%\t%.2f%%\t\t%.2f%%\t  nstat=%d m=%.3f (ps)  s=%.3f (ps)\n",
                 i, (float)HitCnt[i]*100.0/TrgCnt, (float)DiscardCnt[i]*100.0/TrgCnt,
                 (float)NegCnt[i]*100.0/TrgCnt, nstat[i], 100*mean[i], 100*stddev[i]);
        else
          printf("%d\t%.2f%%\t%.2f%%\t\t%.2f%%\t  nstat=%d m=%.3f (ps)  s=%.3f (ps)\n",
                 i, (float)HitCnt[i]*100.0/TrgCnt, (float)DiscardCnt[i]*100.0/TrgCnt,
                 (float)NegCnt[i]*100.0/TrgCnt, nstat[i], 25*mean[i], 25*stddev[i]);
      } else {
        printf("%d\t%.2f%%\t%.2f%%\t\t%.2f%%\t  ---\n",
               i, (float)HitCnt[i]*100.0/TrgCnt, (float)DiscardCnt[i]*100.0/TrgCnt,
               (float)NegCnt[i]*100.0/TrgCnt);

      }
      mean[i]=0;
      stddev[i]=0;
      nstat[i]=0;
    }
  }
  printf("\n\n");
  totnb=0; TDCerrors=0; Ovf=0; TrgLost=0;
  PrevTrgCnt = TrgCnt;
  PreviousTime = CurrentTime;
}

if (nb == 0)
  continue;
totnb += nb;
```

Readout rate (TPrate/1048576), Trigger rate (TRGrate)

Overflow (Ovf), Trigger Lost (TrgLost)

Number of trigger: TrgCnt

```
Readout Rate=0.00MB/s. TrgRate=4.9950 Hz
TDC_ErrorFlags = 0000; Ovf=0; TrgLost=0
517 triggers processed
CH      Found   Discarded       Negative
0       100.00%   0.00%           0.00%    ---
1       100.00%   0.00%           0.00%   nstat=5 m=61505.000 (ps)  s=3284.905 (ps)
2         0.00%   0.00%           0.00%    ---
3         0.00%   0.00%           0.00%    ---
4         0.00%   0.00%           0.00%    ---
5         0.00%   0.00%           0.00%    ---
6         0.00%   0.00%           0.00%    ---
7         0.00%   0.00%           0.00%    ---
8         0.00%   0.00%           0.00%    ---
9         0.00%   0.00%           0.00%    ---
10        0.00%   0.00%           0.00%    ---
11        0.00%   0.00%           0.00%    ---
12        0.00%   0.00%           0.00%    ---
13        0.00%   0.00%           0.00%    ---
14        0.00%   0.00%           0.00%    ---
15        0.00%   0.00%           0.00%    ---
16        0.00%   0.00%           0.00%    ---
17        0.00%   0.00%           0.00%    ---
18        0.00%   0.00%           0.00%    ---
19        0.00%   0.00%           0.00%    ---
20        0.00%   0.00%           0.00%    ---
21        0.00%   0.00%           0.00%    ---
22        0.00%   0.00%           0.00%    ---
23        0.00%   0.00%           0.00%    ---
24        0.00%   0.00%           0.00%    ---
25        0.00%   0.00%           0.00%    ---
26        0.00%   0.00%           0.00%    ---
27        0.00%   0.00%           0.00%    ---
28        0.00%   0.00%           0.00%    ---
29        0.00%   0.00%           0.00%    ---
30        0.00%   0.00%           0.00%    ---
31        0.00%   0.00%           0.00%    ---
```

V1190Readout.c: main – Data Analysis I

```
// ---------------------------------------------------------------------------
// Data Analysis
// ---------------------------------------------------------------------------
Rpnt = 0;
while (Rpnt < (nb/4)) {
  if(IS_GLOBAL_HEADER(buff[Rpnt])) {
    if (!Header)
      printf("Unexpected Header (word n. %d)\n", Rpnt);
    if (Write2File)
      fprintf(fout, "Event Counter = %d (Ev.n.%lld)\n", DATA_EVENT_COUNTER(buff[Rpnt]), TrgCnt);
    Header=0;
    WordPnt = 1;
    TrgCnt++;
    ErrorFlags=0;
    memset(ChFound, 0, NUM_CHANNELS*sizeof(ChFound[0]));
  } else if (IS_GLOBAL_TRAILER(buff[Rpnt])) {
    //nw = DATA_TDC_WORD_CNT(buff[Rpnt]);
    Ovf = buff[Rpnt]>>25&1;
    TrgLost = buff[Rpnt]>>26&1;
    /*if (nw != (WordPnt+1)) {
      printf("Wrong Event size: Word counter in trailer is %d, while actual is %d\n", nw, WordPnt);
      }*/
    if (Write2File) {
      fprintf(fout, "Status: ErrorFlags = %04x; Ovf=%d; TrgLost=%d\n\n", ErrorFlags, buff[Rpnt]>>25&1, buff[Rpnt]>>26&1);
    }
    if (ChFound[ChTref]) {
      fprintf(fout, "Tref(Ch %d) = %d\n", ChTref, TimeAbs[ChTref]);
      for (i=0; i<NUM_CHANNELS; i++) {
        if ((ChFound[i]) && (i != ChTref)) {
          timerel = TimeAbs[i] - TimeAbs[ChTref];
          if (timerel > 0) {
            nstat[i]++;
            mean[i] += (double)timerel;
            stddev[i] += (double)(timerel*timerel);
            if (Write2File)
              fprintf(fout, "Ch %d = %d\n", i, timerel);
            if ((timerel > 0) && ((timerel/HistoBinSize) < HistoNbin))
              Histo[i][(timerel/HistoBinSize)]++;
          }
          else
            NegCnt[i]++;
```

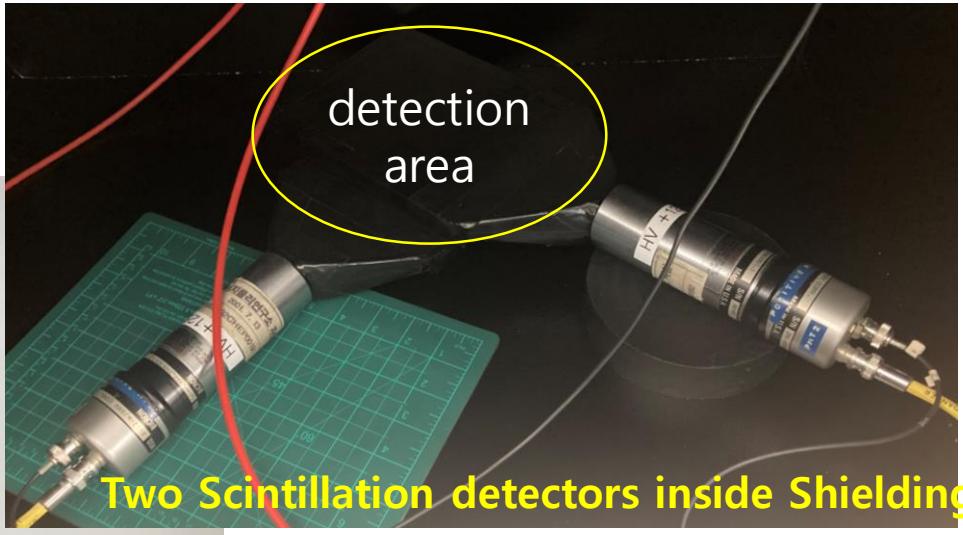
DAQ is working properly

V1190EventList.txt

```
Event Counter = 0 (Ev.n.0)
Status: ErrorFlags = 0000; Ovf=0; TrgLost=0

Tref(Ch 0) = 696971
Ch 1 = 1332
Event Counter = 1 (Ev.n.1)
Status: ErrorFlags = 0000; Ovf=0; TrgLost=0

Tref(Ch 0) = 531284
Ch 1 = 1411
Event Counter = 2 (Ev.n.2)
Status: ErrorFlags = 0000; Ovf=0; TrgLost=0

Tref(Ch 0) = 956736
Ch 1 = 1392
Event Counter = 3 (Ev.n.3)
Status: ErrorFlags = 0000; Ovf=0; TrgLost=0

Tref(Ch 0) = 923665
Ch 1 = 1482
Event Counter = 4 (Ev.n.4)
Status: ErrorFlags = 0000; Ovf=0; TrgLost=0

Tref(Ch 0) = 1386517
Ch 1 = 1418
Event Counter = 5 (Ev.n.5)
Status: ErrorFlags = 0000; Ovf=0; TrgLost=0

Tref(Ch 0) = 1992249
Ch 1 = 1435
Event Counter = 6 (Ev.n.6)
Status: ErrorFlags = 0000; Ovf=0; TrgLost=0

Tref(Ch 0) = 669618
Ch 1 = 1452
Event Counter = 7 (Ev.n.7)
Status: ErrorFlags = 0000; Ovf=0; TrgLost=0

Tref(Ch 0) = 1161309
Ch 1 = 1364
```

V1290N TDC

DAQ setup for V1290N TDC via V4718 Bridge

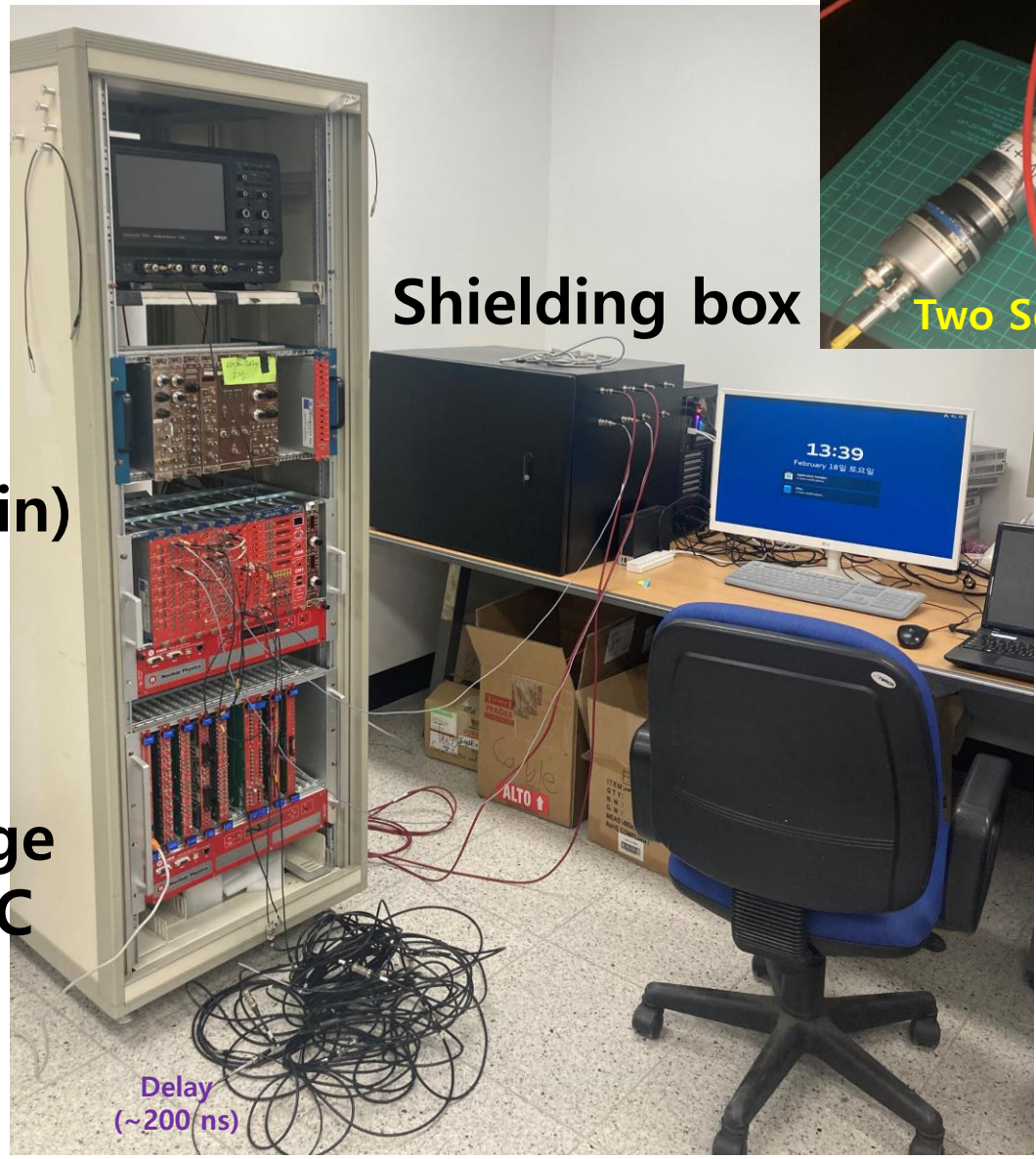


Oscilloscope

Shielding box

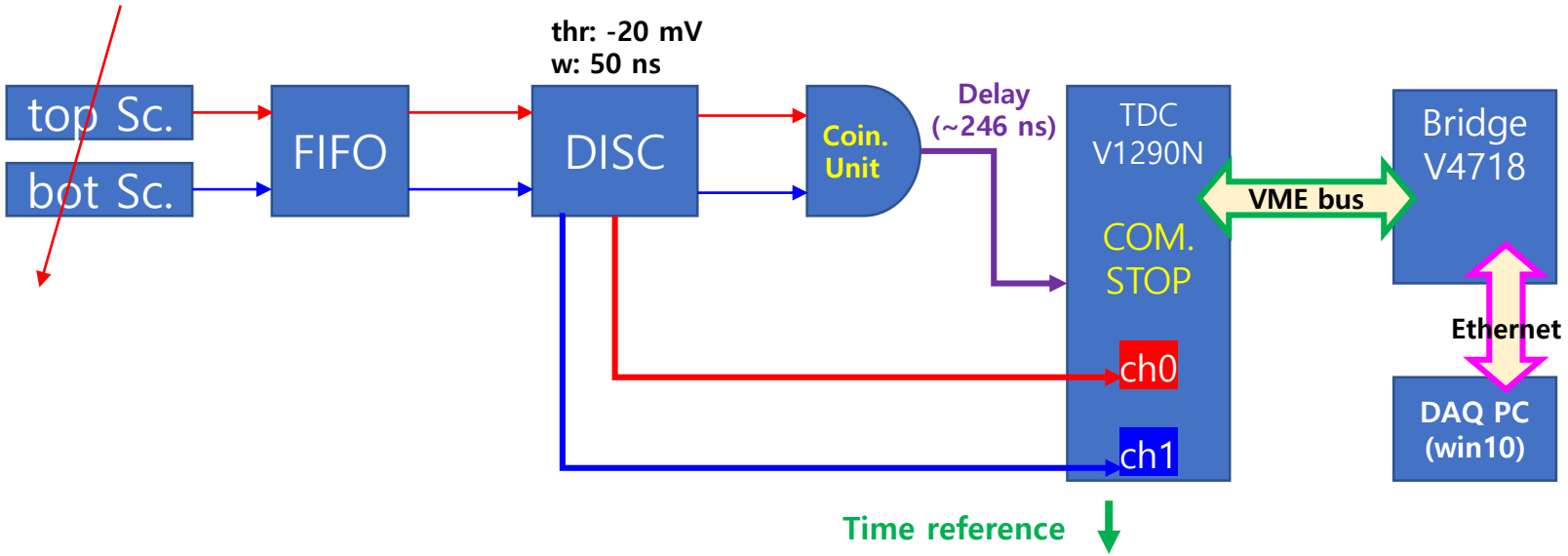
NIM system
(HV, FIFO, DISC, Coin)

VME system
- V4718 Bridge
- V1290N TDC



DAQ PC

DAQ setup with V1290N TDC



ch1 (raw signal)

ch2 (raw singal)

ch3 (top Sc, NIM)

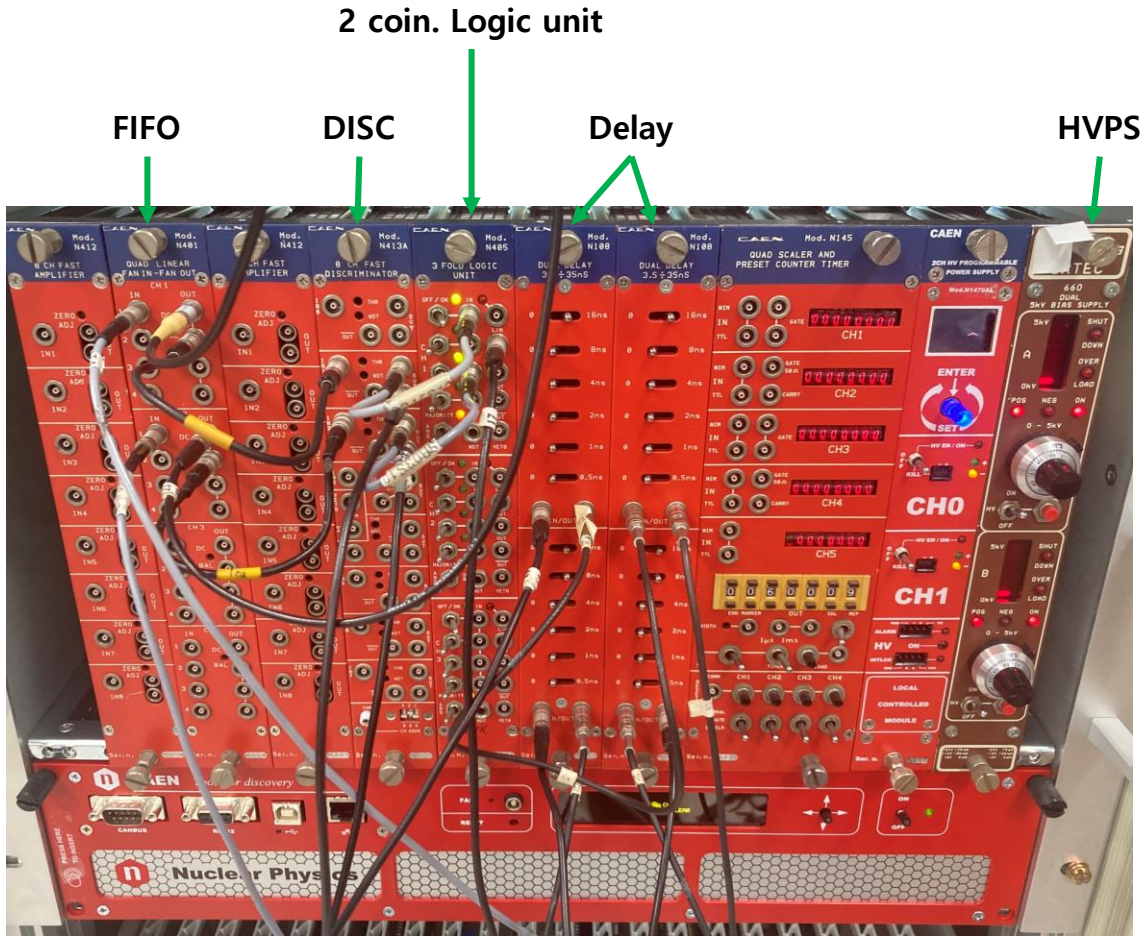
ch4 (2 Coin., **COM. STOP**)

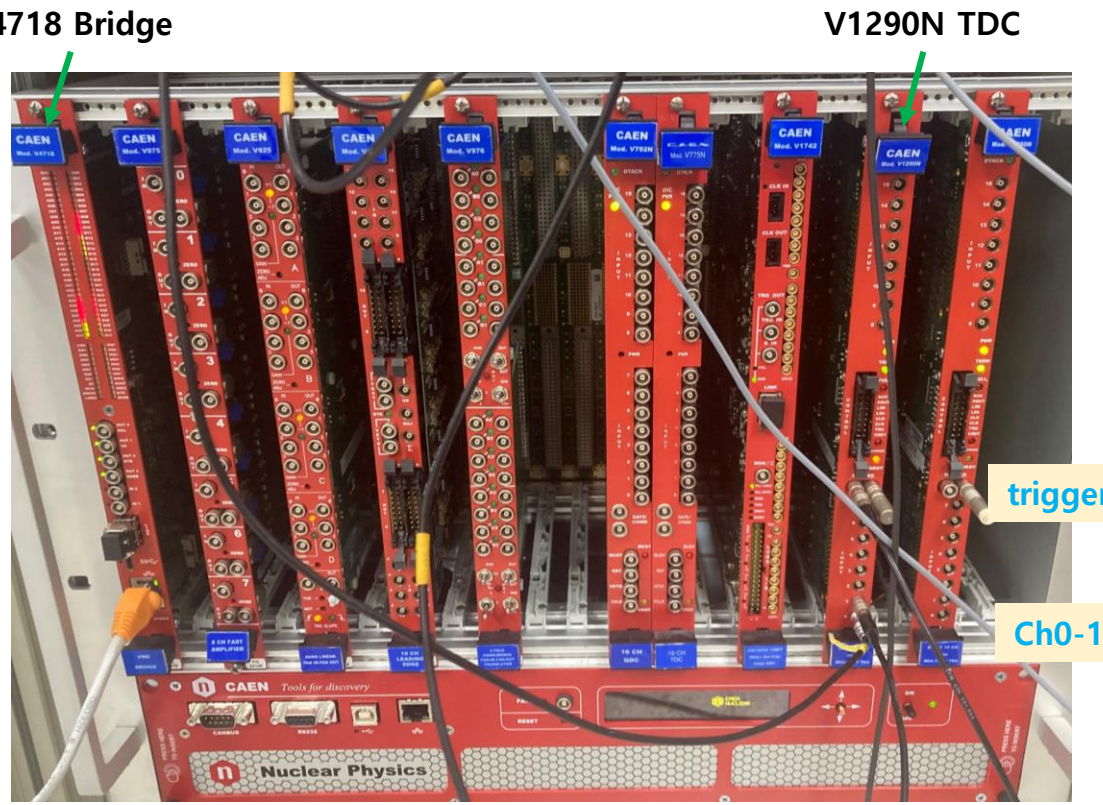
ch1 (20 mV/div)
ch2 (20 mV/div)
ch3 (500 mV/div)
ch4 (500 mV/div)

100 ns/div

Time difference between COM. STOP (ch4 leading edge) and input (ch3 trailing edge): at least 200 ns delay

DAQ setup for V1290N TDC





Running DAQ program without/with trigger

```
mryu194@TPCsim:~/newVMEDAQ/V1190Readout$ ./V1190Readout V1190Config.txt

************************************************************
                      V1190Readout 1.1
************************************************************
copy name of config file
read config file: ./V1190Config.txt
# ************************************************************

Reading Configuration File: ./V1190Config.txt
start while
192.168.1.254
Open V4718 by CAENVME_Init2
(int *)&BaseAddress: dbe30014
(int *)&RawData: -605880260
&ChTref: 620023984
&Write2File: 620023964
(int *)&ChMask: 24f4d0ac
&HistoNbin: 620023968
&HistoBinSize: 620023972
&addr and &data: 24f4d0b8 and 24f4d0b4
&addr and &data: 24f4d0b8 and 24f4d0b4
Configuration Complation

Open Raw_Data.txt

SerNum = 5590599, Fw Revision = 0.17
SerNum = 169, Fw Revision = 0.17
SerNum = 24489, Fw Revision = 0.17
Board Type: V10: SerNum = 24489, Fw Revision = 0.17
Board Type: V1290: SerNum = 24489, Fw Revision = 0.17
Board Type: V1290: SerNum = 24489, Fw Revision = 0.17
Board Type: V1290: SerNum = 24489, Fw Revision = 0.17
Board Ready. Press a key to start the acquisition ('q' to quit)

Readout started.
No data
TDC_ErrorFlags = 0000; Ovf=0; TrgLost=0
No Trigger


No data
TDC_ErrorFlags = 0000; Ovf=0; TrgLost=0
No Trigger


No data
TDC_ErrorFlags = 0000; Ovf=0; TrgLost=0
No Trigger


No data
TDC_ErrorFlags = 0000; Ovf=0; TrgLost=0
No Trigger


mryu194@TPCsim:~/newVMEDAQ/V1190Readout$
```

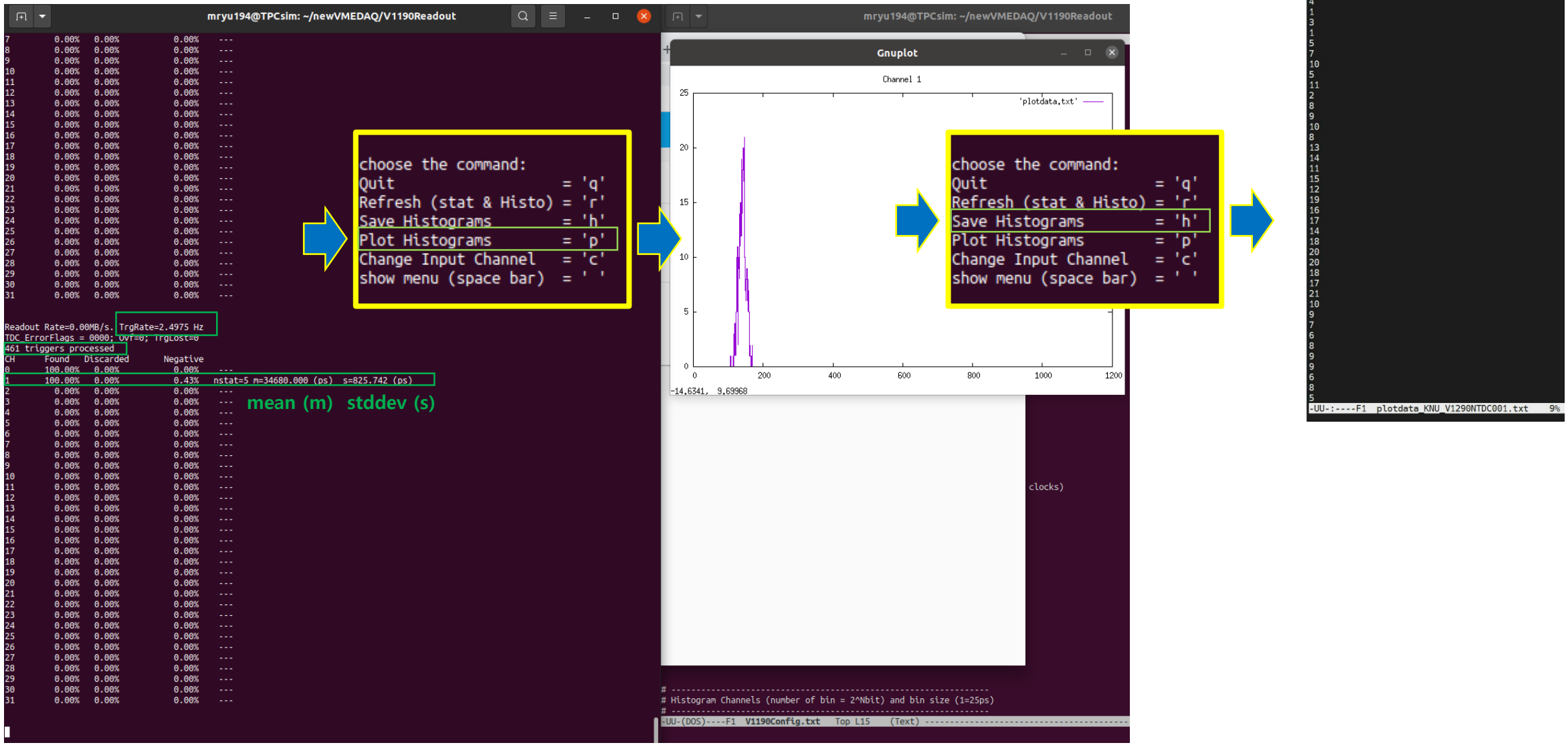
no trigger

```
Open Raw_Data.txt

SerNum = 5590599, Fw Revision = 0.17
SerNum = 169, Fw Revision = 0.17
SerNum = 24489, Fw Revision = 0.17
Board Type: V10: SerNum = 24489, Fw Revision = 0.17
Board Type: V1290: SerNum = 24489, Fw Revision = 0.17
Board Type: V1290: SerNum = 24489, Fw Revision = 0.17
Board Type: V1290: SerNum = 24489, Fw Revision = 0.17
Board Ready. Press a key to start the acquisition ('q' to quit)
NUM_CHANNELS = 32

Readout started.  Quit=0
No data
TDC_ErrorFlags = 0000; Ovf=0; TrgLost=0
No Trigger


Readout Rate=0.00MB/s. TrgRate=0.4998 Hz
TDC_ErrorFlags = 0000; Ovf=0; TrgLost=0
1 triggers processed
CH      Found   Discarded       Negative
0       100.00%   0.00%           0.00%    ---
1       100.00%   0.00%           0.00%    ---
2         0.00%   0.00%           0.00%    ---
3         0.00%   0.00%           0.00%    ---
4         0.00%   0.00%           0.00%    ---
5         0.00%   0.00%           0.00%    ---
6         0.00%   0.00%           0.00%    ---
7         0.00%   0.00%           0.00%    ---
8         0.00%   0.00%           0.00%    ---
9         0.00%   0.00%           0.00%    ---
10        0.00%   0.00%           0.00%    ---
11        0.00%   0.00%           0.00%    ---
12        0.00%   0.00%           0.00%    ---
13        0.00%   0.00%           0.00%    ---
14        0.00%   0.00%           0.00%    ---
15        0.00%   0.00%           0.00%    ---
16        0.00%   0.00%           0.00%    ---
17        0.00%   0.00%           0.00%    ---
18        0.00%   0.00%           0.00%    ---
19        0.00%   0.00%           0.00%    ---
20        0.00%   0.00%           0.00%    ---
21        0.00%   0.00%           0.00%    ---
22        0.00%   0.00%           0.00%    ---
23        0.00%   0.00%           0.00%    ---
24        0.00%   0.00%           0.00%    ---
25        0.00%   0.00%           0.00%    ---
26        0.00%   0.00%           0.00%    ---
27        0.00%   0.00%           0.00%    ---
28        0.00%   0.00%           0.00%    ---
29        0.00%   0.00%           0.00%    ---
30        0.00%   0.00%           0.00%    ---
31        0.00%   0.00%           0.00%    ---
```

with trigger

Running DAQ with trigger (plotdata.txt)

Gnuplot (“P”) and plotdata.txt (“h”)



V1190EventList.txt

```
Event Counter = 0 (Ev.n.0)
Status: ErrorFlags = 0000; Ovf=0; TrgLost=0

Tref(Ch 0) = 696971
Ch 1 = 1332
Event Counter = 1 (Ev.n.1)
Status: ErrorFlags = 0000; Ovf=0; TrgLost=0

Tref(Ch 0) = 531284
Ch 1 = 1411
Event Counter = 2 (Ev.n.2)
Status: ErrorFlags = 0000; Ovf=0; TrgLost=0

Tref(Ch 0) = 956736
Ch 1 = 1392
Event Counter = 3 (Ev.n.3)
Status: ErrorFlags = 0000; Ovf=0; TrgLost=0

Tref(Ch 0) = 923665
Ch 1 = 1482
Event Counter = 4 (Ev.n.4)
Status: ErrorFlags = 0000; Ovf=0; TrgLost=0

Tref(Ch 0) = 1386517
Ch 1 = 1418
Event Counter = 5 (Ev.n.5)
Status: ErrorFlags = 0000; Ovf=0; TrgLost=0

Tref(Ch 0) = 1992249
Ch 1 = 1435
Event Counter = 6 (Ev.n.6)
Status: ErrorFlags = 0000; Ovf=0; TrgLost=0

Tref(Ch 0) = 669618
Ch 1 = 1452
Event Counter = 7 (Ev.n.7)
Status: ErrorFlags = 0000; Ovf=0; TrgLost=0

Tref(Ch 0) = 1161309
Ch 1 = 1364
Event Counter = 8 (Ev.n.8)
Status: ErrorFlags = 0000; Ovf=0; TrgLost=0

Tref(Ch 0) = 353153
Ch 1 = 1346
Event Counter = 9 (Ev.n.9)
Status: ErrorFlags = 0000; Ovf=0; TrgLost=0
```

Time reference (Tref)
Tref(Ch 0) = measured time?

Ch 1 = time difference against Tref

Status: ErrorFlags = 0000;

# if overflow = 1
Ovf = 0

# if Trigger lost = 1
TrgLost = 0

New code for V1290N TDC

```
daq@daq-ubuntu:~/spdak2024/daq_V1290N_TDC$ l
total 596K
-rw-r--r-- 1 daq daq  13K 12월  27 10:31 CAEN License Agreement.txt
-rwxr-xr-x 1 daq daq 8.1K  1월  16 17:04 convert.sh*
-rwxr-xr-x 1 daq daq 2.0K  1월  10 18:09 convert.sh~*
-rw-r--r-- 1 daq daq 1.8K  1월   8 17:51 convert_V1290nDataIntoRoot.C
-rw-r--r-- 1 daq daq 1.8K 12월  27 11:25 convert_V1290nDataIntoRoot.C~
-rw-r--r-- 1 daq daq 5.5K  1월  16 15:22 convert_V1290nPlotFromRoot.C
-rw-r--r-- 1 daq daq 5.5K  1월  10 15:39 convert_V1290nPlotFromRoot.C~
drwxrwxr-x 2 daq daq  36K  1월  16 20:19 data/
-rw-rw-r-- 1 daq daq  12K 12월  27 10:31 LICENSE
-rwxr-xr-x 1 daq daq  834 12월  27 10:31 Makefile*
-rw-rw-r-- 1 daq daq 2.0K 12월  27 10:31 README_ryu.txt
-rw-r--r-- 1 daq daq 1.6K 12월  27 10:31 ReadMe.txt
-rw-r--r-- 1 daq daq 1.1K 12월  27 10:31 ReleaseNotes.txt
-rwxr-xr-x 1 daq daq  304  1월  15 17:50 runV1290.sh*
drwxr-xr-x 2 daq daq 4.0K  1월  15 19:11 src/
-rw-r--r-- 1 daq daq 3.8K  1월  16 16:53 V1290Config.txt
-rw-r--r-- 1 daq daq 3.6K 12월  27 10:31 V1290Config.txt~
-rw-rw-r-- 1 daq daq 120K  1월  16 16:54 V1290_EventList.txt
-rw-rw-r-- 1 daq daq 2.4K  1월  16 16:54 V1290_plotdata.txt
-rw-rw-r-- 1 daq daq 301K  1월  16 16:54 V1290_Raw_Data.txt
-rwxrwxr-x 1 daq daq  31K  1월  10 18:21 V1290Readout*
daq@daq-ubuntu:~/spdak2024/daq_V1290N_TDC$
```

4) Run ➔ $./conver.sh

```
root -b -q 'convert_V1290nDataIntoRoot.C(rn, evts)'
root -b -q 'convert_V1290nDataIntoRoot.C(52, 1024)'
```

Output: rn52_V1290_DataAll_evts1024.root
Input: rn52_V1290_DataAll_evts1024.txt

```
root -b -q 'convert_V1290nPlotFromRoot.C(rn, evts)'
root -b -q 'convert_V1290nPlotFromRoot.C(52, 1024)'
```

Output
- rn52_V1290_DataAll_evts1024.hst
- rn52_V1290_DataAll_evts1024.hst_c1_tdcCh0_7.png
- rn52_V1290_DataAll_evts1024.hst_c2_tdcCh8_15.png

3) Run ➔ $./V1290Readout V1290Config.txt

1) configuration

2) Compilation (make)

V1190Config.txt (original form)

```
# ************************************************************
# Readout Configuration File
# edited by Min Sang RYU with Heejeong BYEON, Sehwook LEE
# ************************************************************

# LINK (VME Master)
#LINK V1718
LINK ethV4718 192.168.1.254

# methode for wavedump with V4718
### OPEN ETH_V4718 192.168.1.254 0 32100000
#LINK ethV4718 192.168.1.254 0 32100000
```

```
# ------------------------------------------------------------
# Base Address of the VME board
# ------------------------------------------------------------
# V1290N TDC
BASE_ADDRESS    EE000000


# ------------------------------------------------------------
# RAW DATA
# ------------------------------------------------------------
RAW_DATA  1


# ------------------------------------------------------------
# Channel for the time reference
# ------------------------------------------------------------
TIME_REF  0


# ------------------------------------------------------------
# Enable/Disable Output File with event list
# ------------------------------------------------------------
WRITE_EVENT_FILE 1
```

```
# ------------------------------------------------------------
# Trigger Matching Window (width,         offset in steps of 25 ns)
#                     set width: 500 ns (20 clocks), offset: -700 ns (28 clocks)
# TRIGGER_WINDOW [set width in hexa] [offset in hexa]
# set value have to be divided by 25 ns (1 clock).
# extra search margin: 200 ns [default] TMW
# reject margin: 100 ns [default] -> it is not included in offset region.
# ------------------------------------------------------------
### TRIGGER_WINDOW 350 -350
### TRIGGER_WINDOW 20 -28
```

```
# ------------------------------------------------------------
# Channel Mask (Hexa number)
# For 8 ch (0~7) FF
# For 16 ch (0~15) FFFF
# ------------------------------------------------------------
#CHANNEL_MASK  FF
CHANNEL_MASK  FFFF

# only ch 0 and 1
#CHANNEL_MASK  3

# only ch0 and 3
#CHANNEL_MASK  9

# only ch0, ch1, ch7
#CHANNEL_MASK  83

# ch0 ~ 3
#CHANNEL_MASK  F

# ch0 ~ 7
#CHANNEL_MASK  FF


# ------------------------------------------------------------
# Histogram Channels (number of bin = 2^Nbit) and bin size (1bin=25ps)
# ------------------------------------------------------------
#HISTO_CHANNELS 12000 1
#HISTO_CHANNELS 1200 10
#HISTO_CHANNELS 4000 1
HISTO_CHANNELS 1200 10


# ************************************************************
# VME Write to board registers
# ************************************************************

# ------------------------------------------------------------
# Reset the board
# ------------------------------------------------------------
WRITE_REGISTER 1014 0
```

New code for V1290N TDC

```
# ------------------------------------------------------------------
# Run Number (unsigned int) - added by ryu
# ------------------------------------------------------------------
RUN_NUMBER 52

# ------------------------------------------------------------------
# Number of Trigger (unsigned int) - added by ryu
# Number of Trigger should be 2^n (n=integer) and mininum 2^7=128
# ------------------------------------------------------------------
#NUNBER_OF_TRIGGER 1000
NUNBER_OF_TRIGGER 1024
#NUNBER_OF_TRIGGER 2048
#NUNBER_OF_TRIGGER 16384
```

~/spdak2024/daq_V1290N_TDC/src/data

```
rn52_V1290_DataAll_evts1024.txt
rn52_V1290_EventListAll_evts1024.txt
rn52_V1290_SavedHisto_ch0_evts1024.txt
rn52_V1290_SavedHisto_ch10_evts1024.txt
rn52_V1290_SavedHisto_ch11_evts1024.txt
rn52_V1290_SavedHisto_ch12_evts1024.txt
rn52_V1290_SavedHisto_ch13_evts1024.txt
rn52_V1290_SavedHisto_ch14_evts1024.txt
rn52_V1290_SavedHisto_ch15_evts1024.txt
rn52_V1290_SavedHisto_ch1_evts1024.txt
rn52_V1290_SavedHisto_ch2_evts1024.txt
rn52_V1290_SavedHisto_ch3_evts1024.txt
rn52_V1290_SavedHisto_ch4_evts1024.txt
rn52_V1290_SavedHisto_ch5_evts1024.txt
rn52_V1290_SavedHisto_ch6_evts1024.txt
rn52_V1290_SavedHisto_ch7_evts1024.txt
rn52_V1290_SavedHisto_ch8_evts1024.txt
rn52_V1290_SavedHisto_ch9_evts1024.txt
```

DataAll: only data
EventListAll: data with comments

Spectrum of each channel

```
# ------------------------------------------------------------------
# Trigger Matching Window (width,         offset in steps of 25 ns)
#                      set width: 500 ns (20 clocks), offset: -700 ns (28 clocks)
# TRIGGER_WINDOW [set width in hexa] [offset in hexa]
# set value have to be divided by 25 ns (1 clock).
# extra search margin: 200 ns [default] TMW
# reject margin: 100 ns [default] -> it is not included in offset region.
# ------------------------------------------------------------------
### TRIGGER_WINDOW 350 -350
### TRIGGER_WINDOW 20 -28

### 2024.01.10
# width500ns, offset 600ns, exMargin 100ns, rejectmargin 100ns
TRIGGER_WINDOW 20 -24 4 4
```

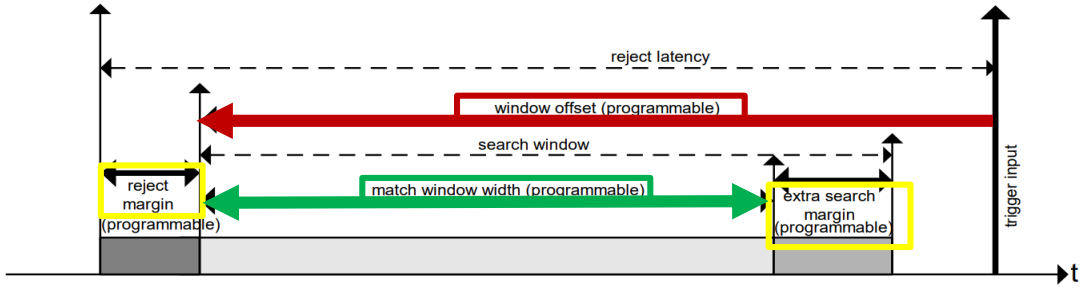
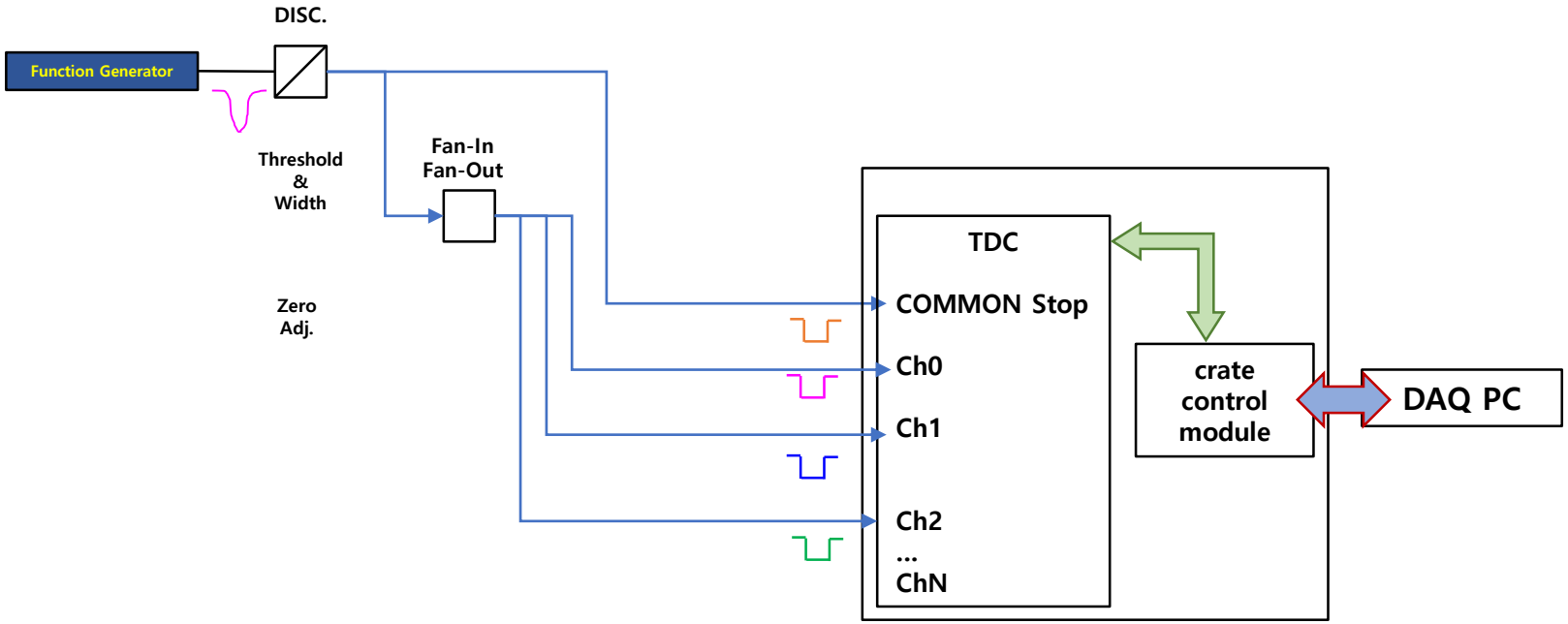
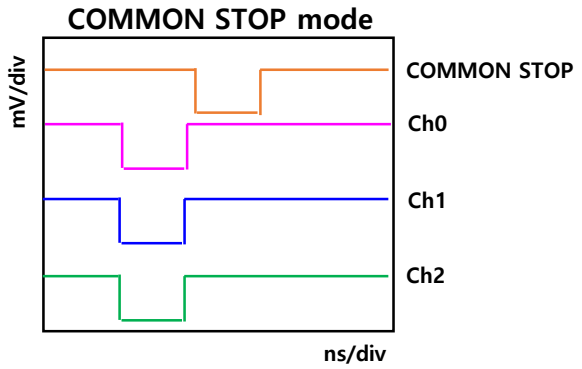


Fig. 2.5: Mod. V1290A/N Trigger Matching Mode timing diagram

TDC Linearity Test

DAQ logic of TDC Linearity Test



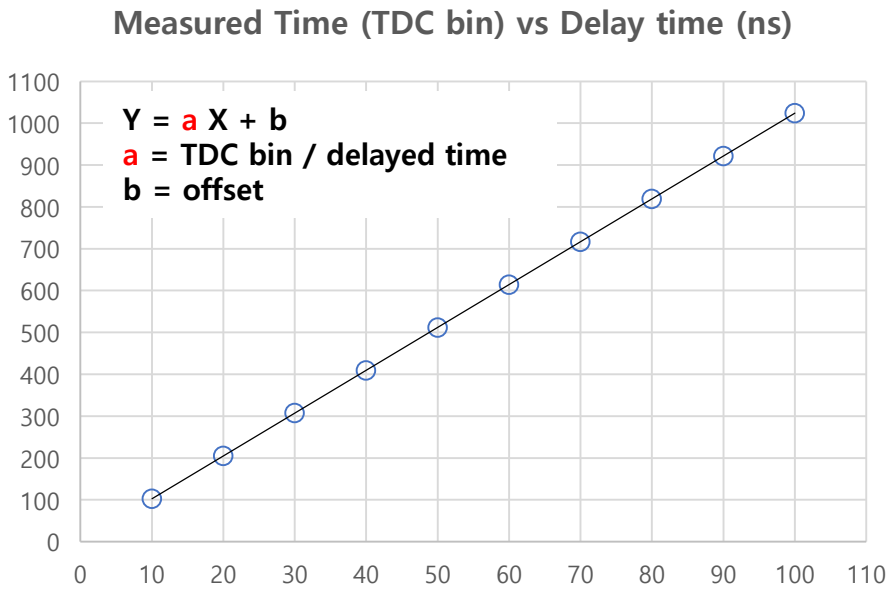


TDC Linearity Test for Calibration

T_full = 100 ns with 10 bit (1024) data set

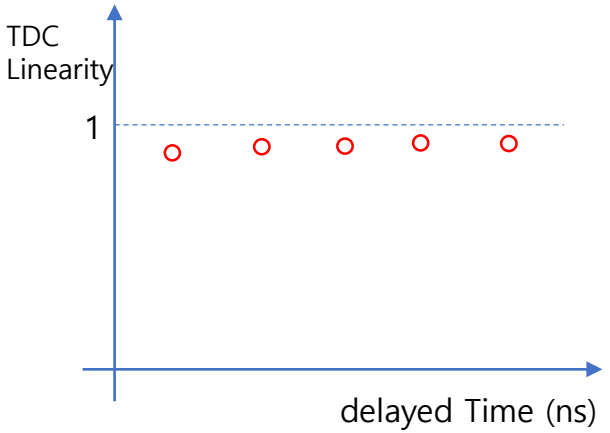
100	ns
1024	bin
0.09765625	ns/bin

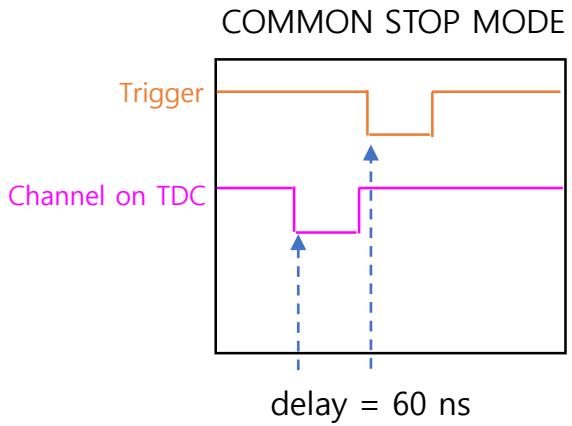
delay (ns)	unit time (ns/bin)	Measured Time (TDC bin)
10	0.09765625	102.4
20	0.09765625	204.8
30	0.09765625	307.2
40	0.09765625	409.6
50	0.09765625	512
60	0.09765625	614.4
70	0.09765625	716.8
80	0.09765625	819.2
90	0.09765625	921.6
100	0.09765625	1024



TDC Linearity

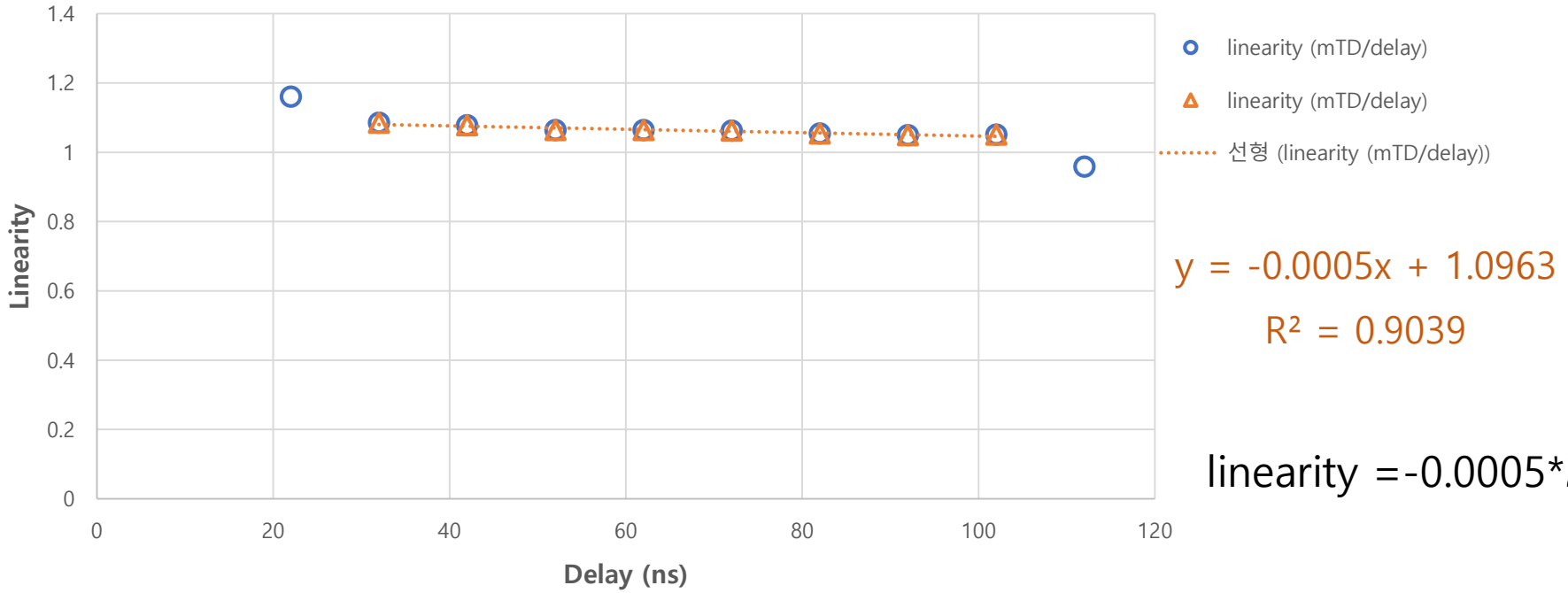
= measured Time (ns) / delayed Time (ns)





TDC Linearity Test

	tCh0: time ref	default delay 22 ns			
rn	delay (tCh1 – tCh0), ns	delay (tCh1 – tCh0), ns	measured time difference (tCh1 – tCh0), TDC ch	mTD = measured time difference (tCh1 – tCh0), ns	**Linearity (=mTD/delay)**
42	0	22	1021	25.525	1.160227273
43	10	32	1389	34.725	1.08515625
44	20	42	1810	45.25	1.077380952
45	30	52	2212	55.3	1.063461538
46	40	62	2639	65.975	1.064112903
47	50	72	3059	76.475	1.062152778
48	60	82	3456	86.4	1.053658537
49	70	92	3861	96.525	1.049184783
50	80	102	4286	107.15	1.050490196
51	90	112	4292	107.3	0.958035714
52	140	162	Out of Range	#VALUE!	



$y = -0.0005x + 1.0963$

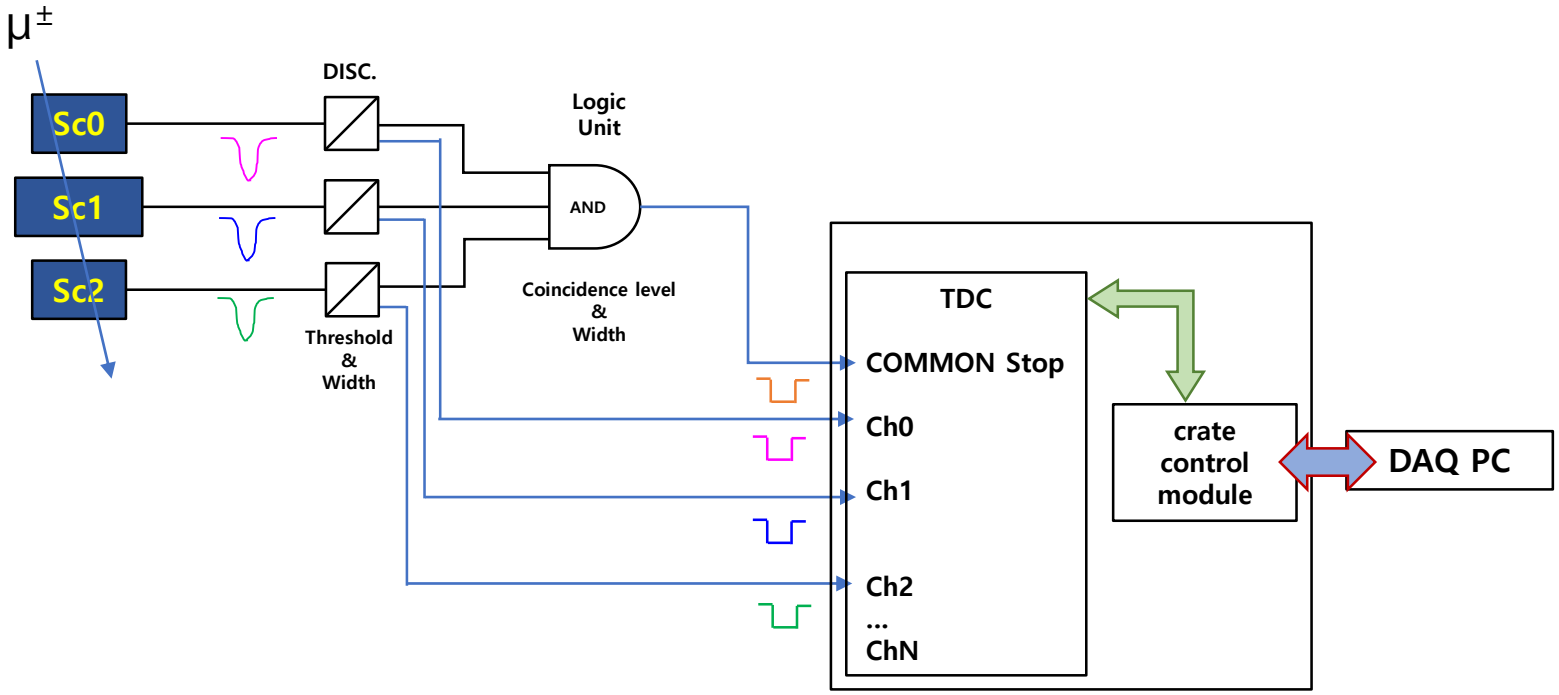
$R^2 = 0.9039$

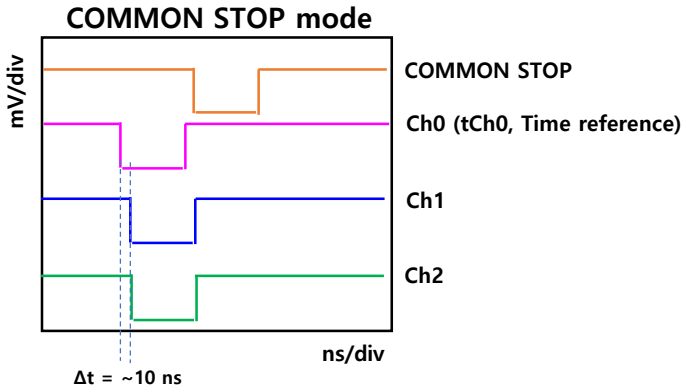
linearity =-0.0005*25 ps=-0.0125 ps/ns

2 Coin. Test

Time measurement of triple scintillation detectors

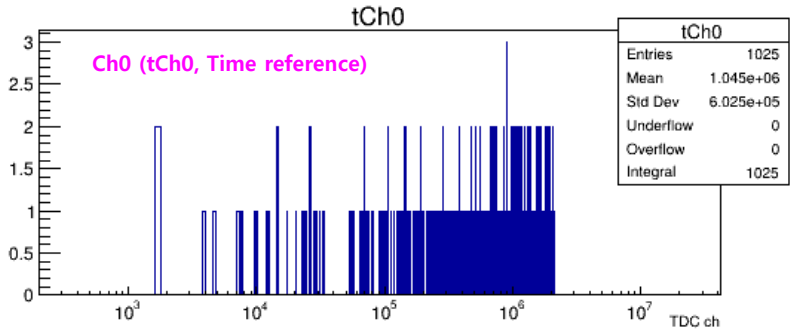
Scintillation counter/detector:
Scintillator + **P**hoto**M**ultiplier **T**ube (PMT)

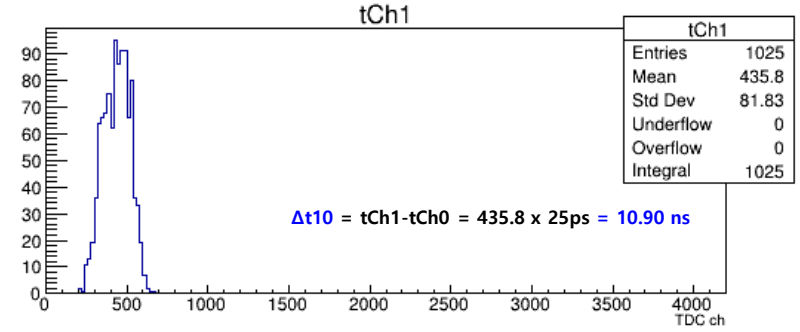


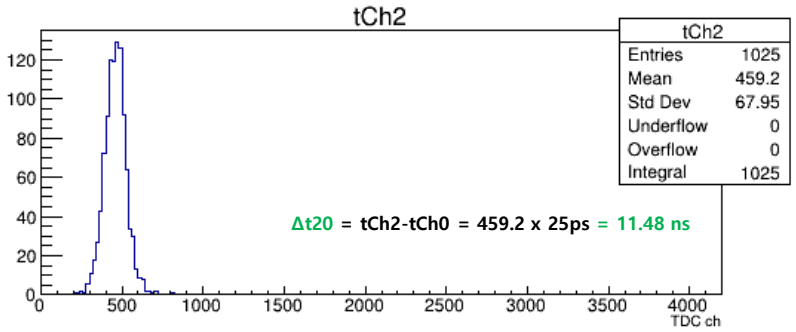


Detection efficiency

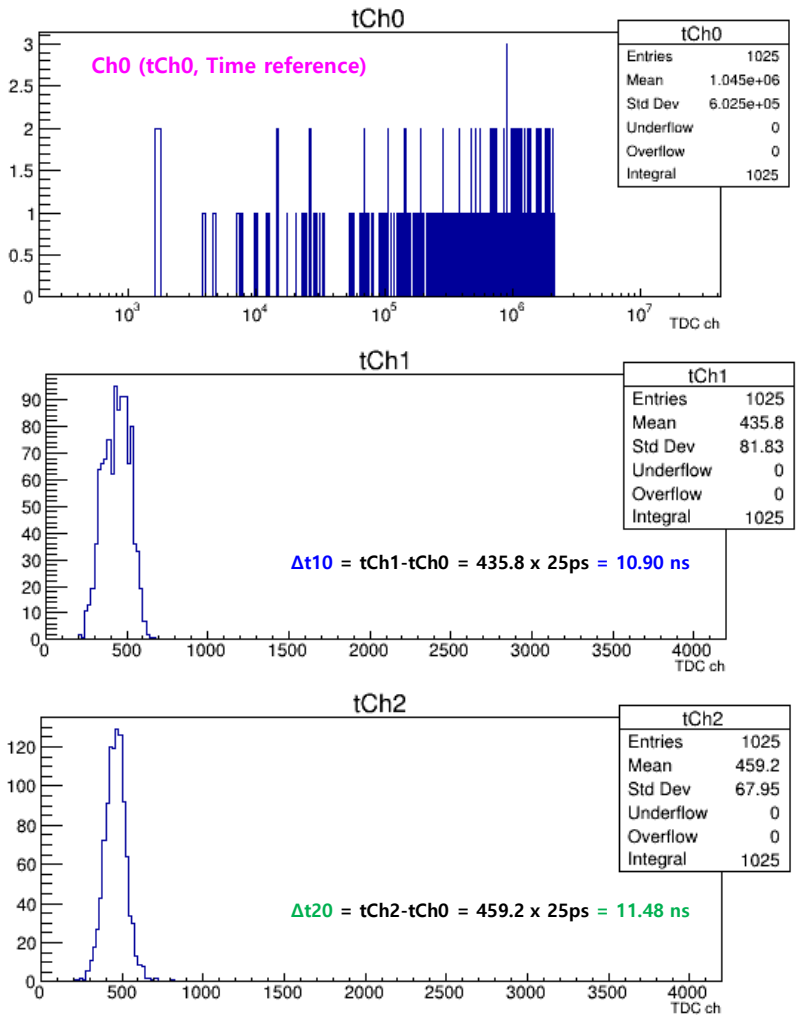
$$\varepsilon = \frac{\text{Number of Count (Sc1)}}{\text{Number of Coincidence (Sc0\&Sc2)}}$$







Time resolution between (Sc0 & Sc1) and (Sc0 & Sc2)



Fit the Δt10 and Δt20 with the Gauss formula

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2}$$

root[] hist.Fit("gaus");

```
f(x) = p0*exp(-0.5*((x-p1)/p2)^2)
p0: Constant
p1: mean of Gaussian distribution
p2: standard deviation of Gaussian distribution
```

Time resolution (σ_{t1} and σ_{t0})

$\sigma_{\Delta t10} = 81.83\ count \times 25ps/count = 2.046\ ns$

$\sigma^2_{\Delta t10} = \sigma^2_{t1} + \sigma^2_{t0}$

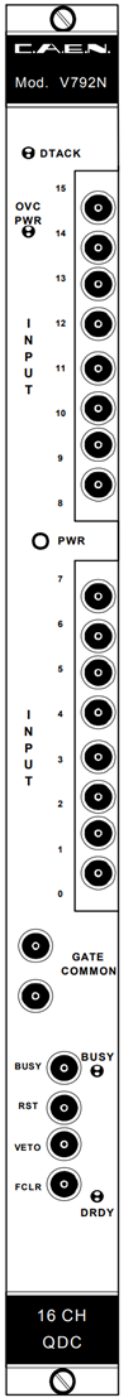
If $\sigma^2_{t1} \cong \sigma^2_{t0}$

$$\sigma_{t1} = \sigma_{t0} = \frac{\sqrt{\sigma^2_{\Delta t10}}}{2} = \frac{\sqrt{2.046ns}}{2} = 0.7152ns = 715.2\ ps$$

<<Recommendation paper>>
Characteristics of Multigap timing RPC
M. S. RYU et al, JKPS 52 (2008) 1748

V792N QDC

V792N QDC



Overview

The **Model V792** is a 1-unit wide VME 6U module housing 32 Charge-to-Digital Conversion channels with current integrating negative inputs (50 Ω impedance). For each channel, the input charge is converted to a voltage level by a QAC (Charge to Amplitude Conversion) section. Input range is 0 ÷ 400 pC. The **Model V792 N** houses 16 input channels on LEMO 00 connectors and shares most of the other features with the Mod. V792.

The outputs of the QAC sections are multiplexed and subsequently converted by two fast 12-bit ADCs. The ADCs use a sliding scale technique to improve the differential non-linearity.

The Mod. V792/V792 N offer a 32 event buffer memory, A24/A32 addressing mode, D16, D32, BLT32/MBLT64 and CBLT32/CBLT64 data transfer mode. Multicast commands also supported.

The boards are available both for standard and V430 VME crates; all versions support live insertion, allowing the User to insert (or remove) the board into (or from) the crate without switching it off.

A 16 ch. decoupling board (Mod. A992) is available for the Mod. V792 to avoid ground loops and signal reflections when long flat cable (110 Ω) connections to the 50 Ω inputs are used (one 32 ch. V792 requires two A992 boards).

A 16 ch. flat cable to LEMO input adapter (Mod. A392) is also available for the Mod. V792 (one 32 ch. V792 requires two A392 boards).

Environment setup for CAEN DAQ system

QTPD DAQ 1.1.0 ➔ cd ~/newVMEDAQ/QTPD_DAQ-1.1.0

./configure

make

sudo make install

→ if you face the error "aclocal-1.15: command not found" during **make**

➔ **restart 'autoreconf -f –i'**

cd src/

sudo chown -R mryu194 config.txt/

sudo chgrp -R mryu194 config.txt/

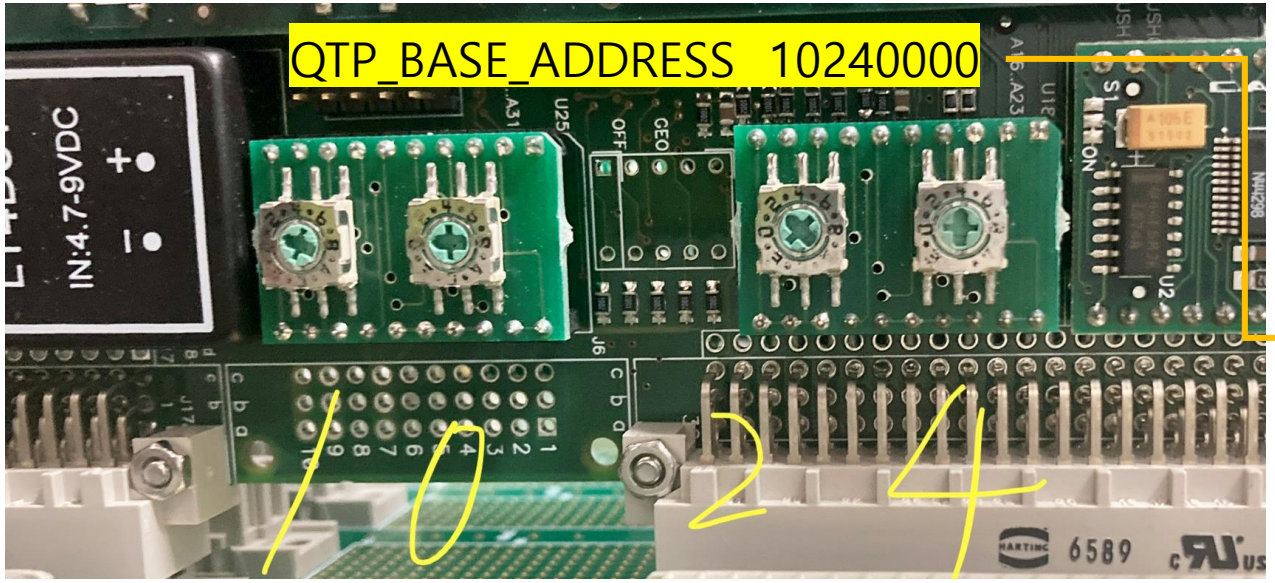
[Configuration] emacs -nw config/config.txt (CONNECTION, QTP_Base_Address, Iped, etc)

[RUN] ./QTPD_DAQ

Configuration of CAEN V792N QDC

config file path: ~/newVMEDAQ/QTPD_DAQ-1.1.0/src/config/

```
mryu194@TPCsim:~/newVMEDAQ/QTPD_DAQ-1.1.0/src/config$ l
total 24K
-rw-r--r-- 1 mryu194 mryu194 4.2K  2월   8 14:35 config.txt
-rw-r--r-- 1 mryu194 mryu194 4.2K  2월   8 14:35 config.txt_V775N
-rw-r--r-- 1 mryu194 mryu194 4.2K  2월   8 14:34 config.txt_V792N
mryu194@TPCsim:~/newVMEDAQ/QTPD_DAQ-1.1.0/src/config$
```



Backplane board

```
# ************************************************************************
# Configuration File for the QTPD_DAQ
# ************************************************************************

# ************************************************************************
# Settings for the QTP (Analog QDC, TDC and Peak sensing ADC)
# Supported Models
# Q = QDC       : V792, V792N, V862, V965, V965A
# T = TDC       : V775, V775N
# P = Peak ADC  : V785, V785N, V1785
# ************************************************************************

# ************************************************************************
# Connection type V1718 | V2718 | V3718 | V4718 | A4818
#
# Examples:
#                       V1718 => usbV1718
#                       V2718 => pciV2718
#                       V3718 => usbV3718 | pciV3718
#                       V4718 => usbV4718 PID
#                       V4718 => pciV4718
#                       V4718 => ethV4718 ipaddress
#                       A4818 => usbA4818 PID
#
# ************************************************************************
CONNECTION ethV4718 192.168.1.254
#CONNECTION usbV1718

# ------------------------------------------------------------------
# Base Address (32 hex number) of the QTP board (0 if not present)
# ------------------------------------------------------------------
# V1290N TDC
#QTP_BASE_ADDRESS    EE000000

# V1742 ADC (DRS)
#QTP_BASE_ADDRESS    32100000

# V792N QDC
QTP_BASE_ADDRESS    CC110000

# V775N TDC (PNF-0102, s/n 585)
#QTP_BASE_ADDRESS    22220000

# ------------------------------------------------------------------
# Iped (pedestal for the QDC or range for the TDC)
# ------------------------------------------------------------------
IPED 100
```

Unit: QDC count

Integration capacitance = 100 pF
QAC output = 1 mV/count
Q/count=CV = 100 pF * 1 mV/count = 100 fC/count

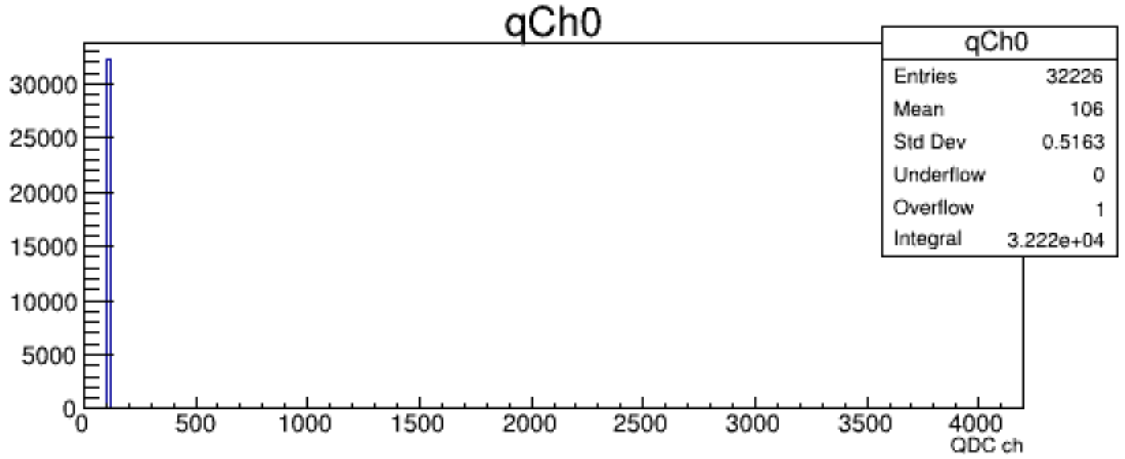
Configuration of pedestal current value (I_P)

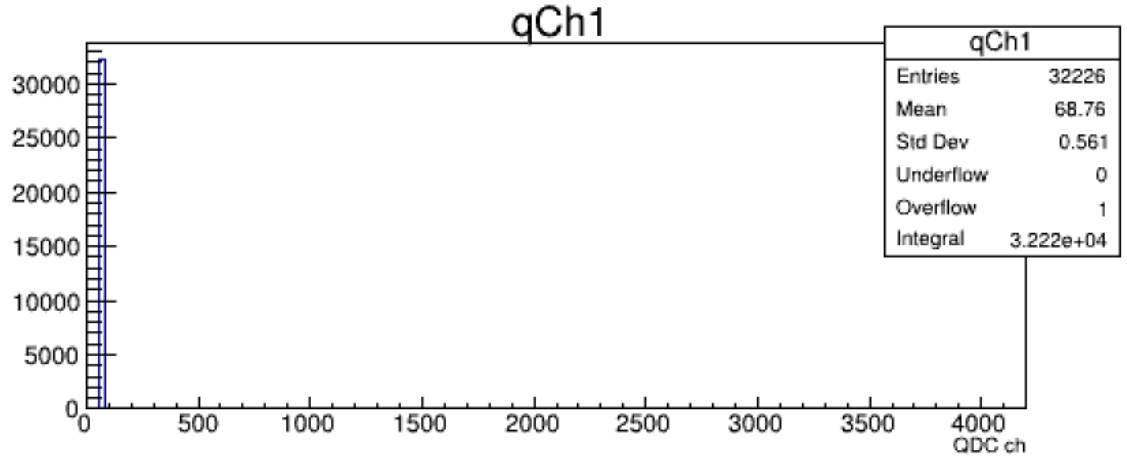
Integration capacitance = 100 pF
QAC output = 1 mV/count
Q/count=CV = 100 pF * 1 mV/count = 100 fC/count

In config.txt
Iped =100 QDC count
➔ **Qped = 100 count x 100 fC/count = 10^4 x fC= 10 pC**

Qped = 10 pC
➔ **I_P = Qped / T_{GATE} = 10 pC / 100 ns = 0.1 mA = 100 uA**

Pedestal run of New QDC (PID 22192)





qCh0 = 10.6 pC
➔ **I_{P_qCh0} = qCh0 / T_{GATE} = 10.6 pC / 160 ns = 66.25 uA**
➔ **I_{P_qCh0} /count = 66.25 uA/100 count = 6.625 nA/count**

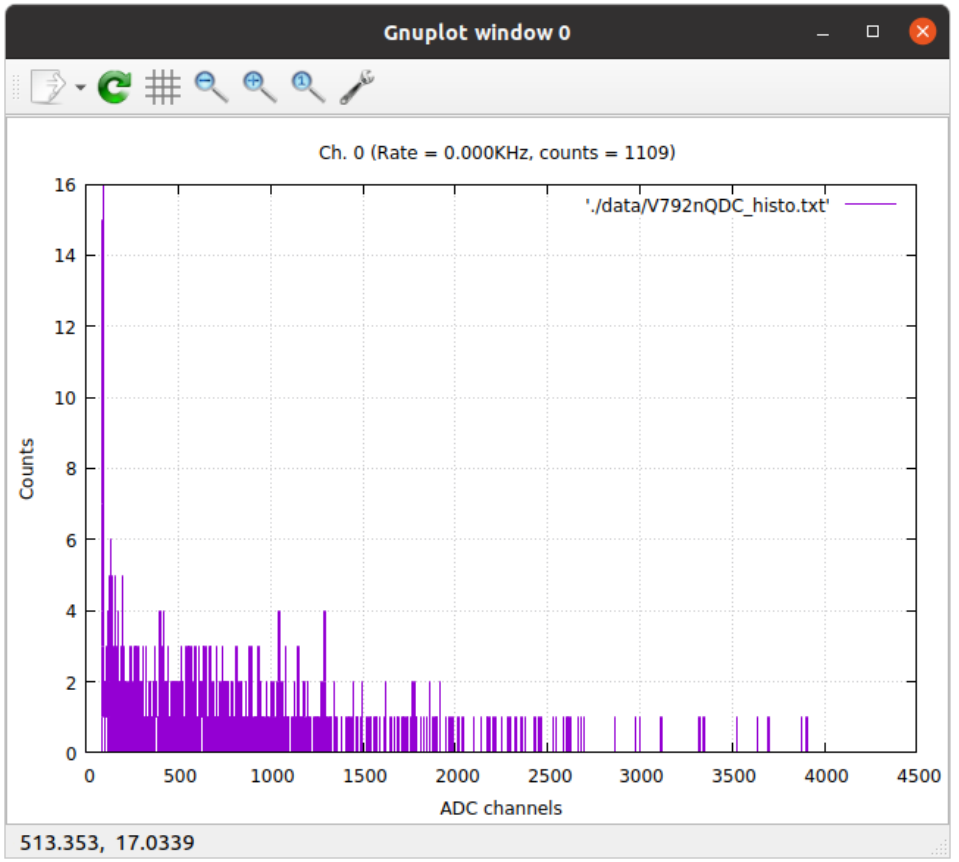
qCh1 = 6.876 pC
➔ **I_{P_qCh1} = qCh1 / T_{GATE} = 6.876 pC / 160 ns = 42.96 uA**
➔ **I_{P_qCh1} /count = 42.96 uA/100 count = 4.296 nA/count**

Run DAQ for CAEN V792N QDC

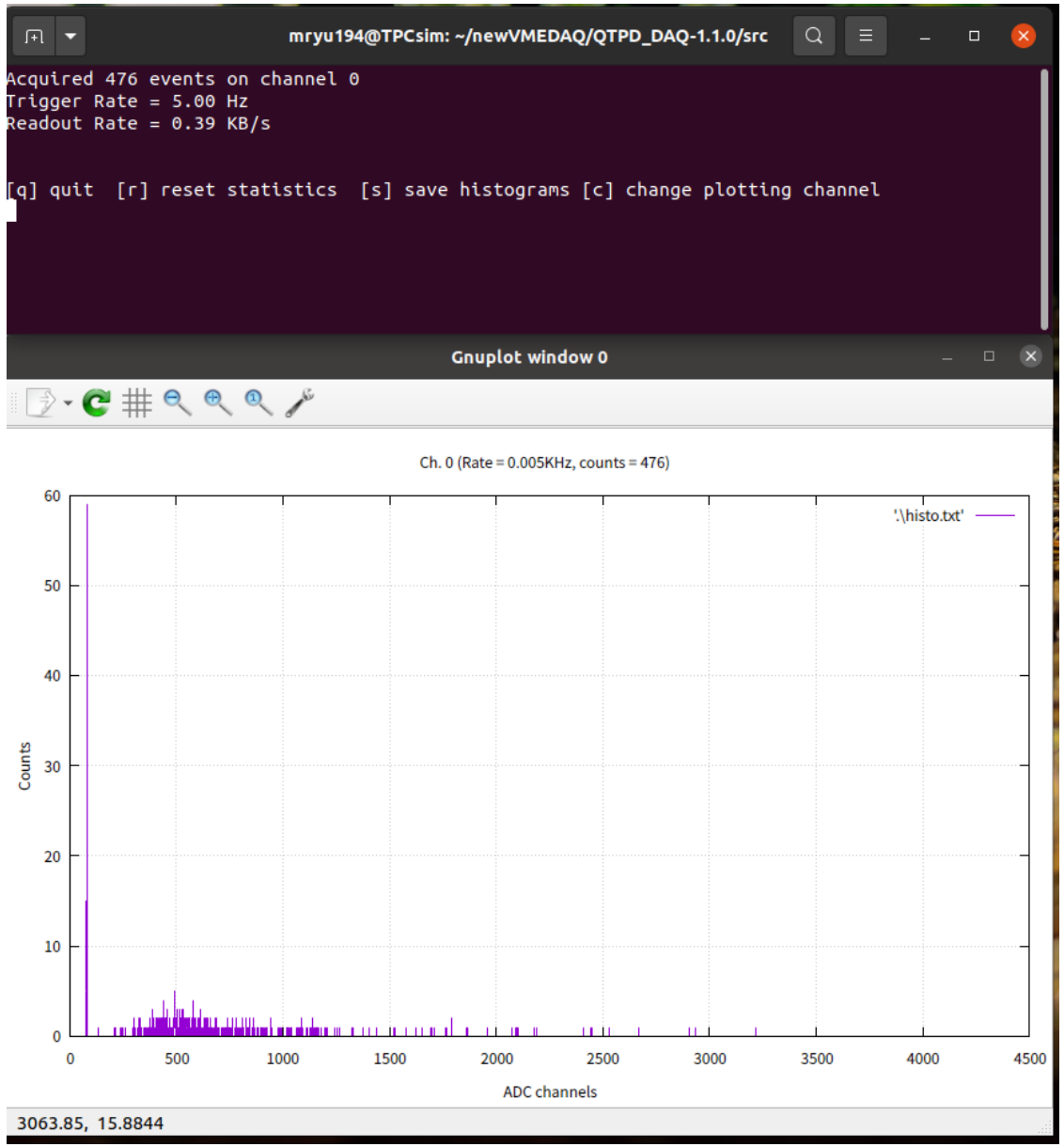
exe file path: ~/newVMEDAQ/QTPD_DAQ-1.1.0/src/QTPD_DAQ*

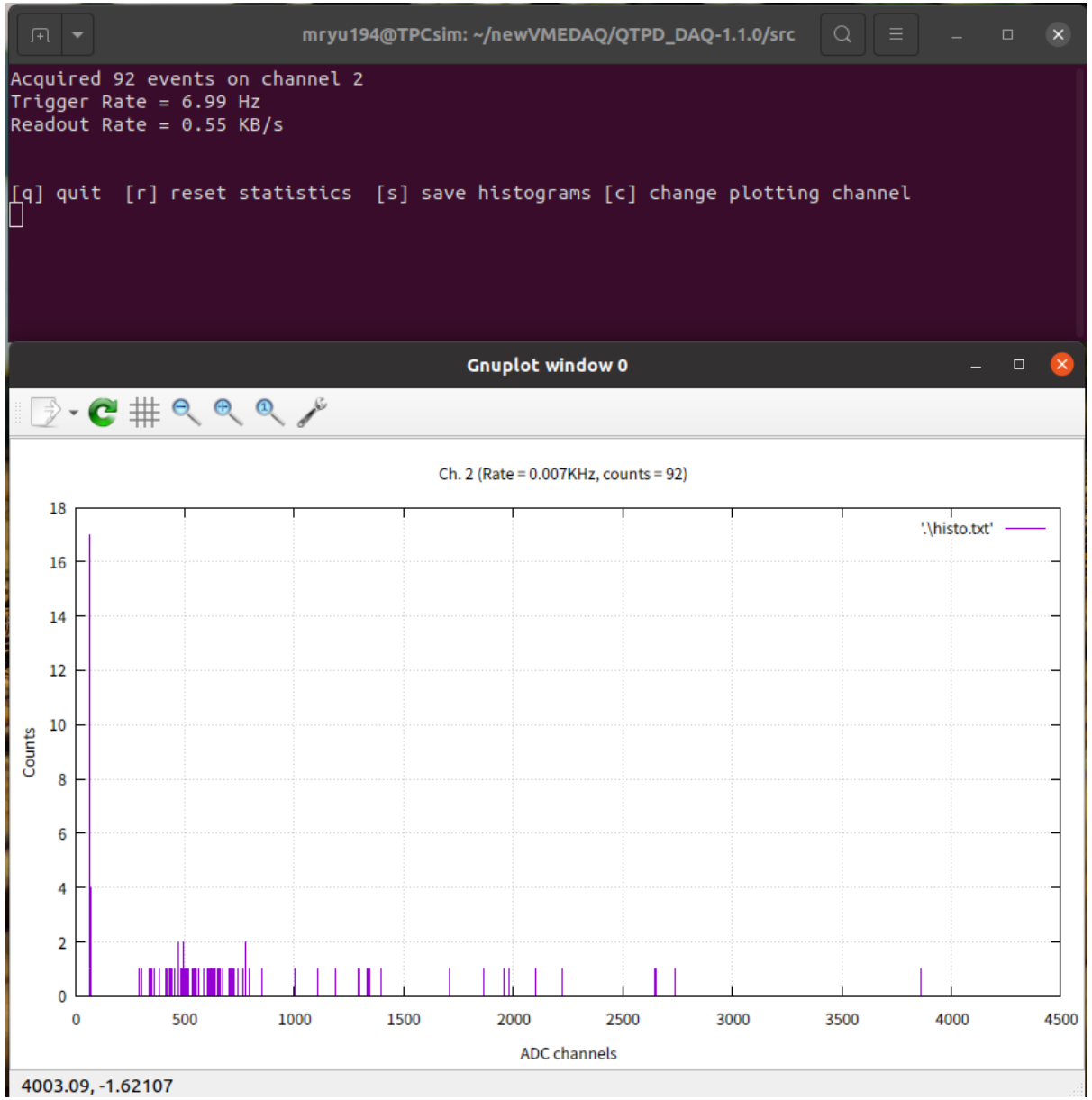
```
-rwxrwxr-x 1 mryu194 mryu194 4.4K  5월  26  2016  Console.c*
-rw-rw-r-- 1 mryu194 mryu194  15K  2월   5 15:31  Console.o
-rw-rw-r-- 1 mryu194 mryu194  21K  2월   5 15:31  Makefile
-rwxrwxr-x 1 mryu194 mryu194  186  2월   3  2020  Makefile.am*
-rw-rw-r-- 1 mryu194 mryu194  20K  2월   5 15:31  Makefile.in
-rwxrwxr-x 1 mryu194 mryu194  71K  2월   8 15:50  QTPD_DAQ*
-rwxrwxr-x 1 mryu194 mryu194  24K  2월   8 15:50  QTPD_DAQ.c*
-rwxrwxr-x 1 mryu194 mryu194  24K  2월   8 15:43  QTPD_DAQ.c~*
-rw-rw-r-- 1 mryu194 mryu194 114K  2월   8 15:50  QTPD_DAQ.o
-rwxr-xr-x 1 mryu194 mryu194 7.3K  2월   5 15:31  compile*
drwxr-xr-x 2 mryu194 mryu194 4.0K  2월   8 14:35  config/
-rwxr-xr-x 1 mryu194 mryu194  24K  2월   5 15:31  depcomp*
-rw-rw-r-- 1 mryu194 mryu194 8.1K  2월   8 15:51  histo.txt
-rwxr-xr-x 1 mryu194 mryu194  16K  2월   5 15:31  install-sh*
-rwxr-xr-x 1 mryu194 mryu194 6.8K  2월   5 15:31  missing*
mryu194@TPCsim:~/newVMEDAQ/QTPD_DAQ-1.1.0/src$
```

```
Acquired 1134 events on channel 2
Trigger Rate = 1.00 Hz
Readout Rate = 0.08 KB/s


[q] quit  [r] reset statistics  [s] save histograms [c] change plotting channel
end: 1700833419
Running Time: 79min 0sec
input: 1134
Trigger rate: 14.354430 #/m
Saved histograms to output files
daq@daq-ubuntu:~/vme/qtpd_msr/bin/QDC_rate_V792N/src$
```

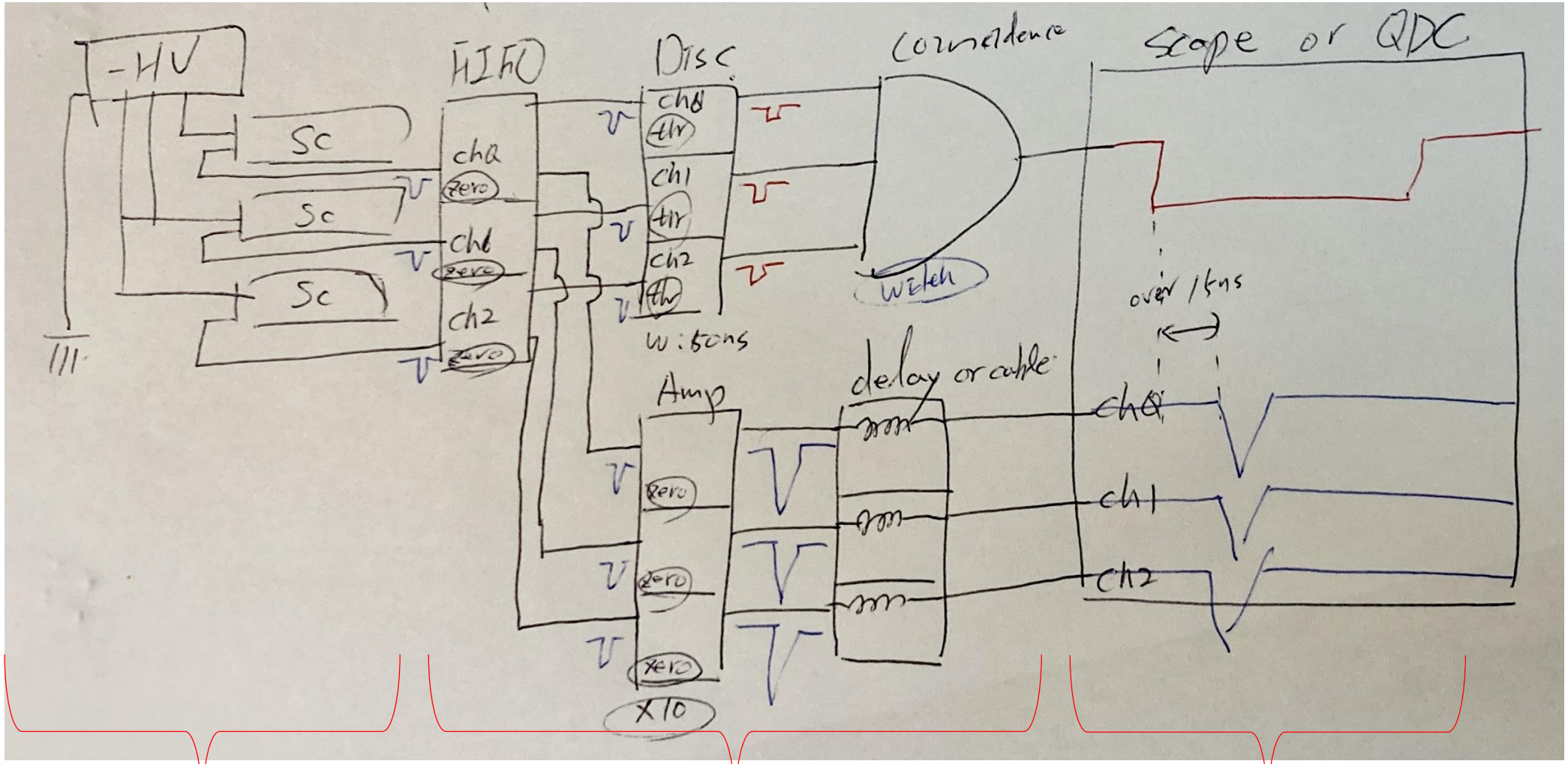


Histogram of V792N QDC





DAQ with two Scintillation detectors



1) FIFO
2) Discriminator
3) Coin. Logic Un
4) Amplifier
5) Delay (or Cabl
6) Scope

Detector with HVPS

Fast Electronics (NIM or VME)

VME system

New code for V792N QDC

New code for V792N QDC

```
daq@daq-ubuntu:~/spdak2024/daq_V792N_QDC/src$ l
total 780K
-rwxr-xr-x 1 daq daq 7.3K  1월  10 15:05 compile*
drwxr-xr-x 2 daq daq 4.0K  1월  16 20:44 config/
-rwxrwxr-x 1 daq daq 4.4K  1월  10 15:05 Console.c*
-rw-rw-r-- 1 daq daq  15K  1월  12 21:04 Console.o
-rw-r--r-- 1 daq daq 1.6K  1월  10 15:05 convert_DataIntoRoot.C
-rw-r--r-- 1 daq daq 1.6K  1월  10 15:05 convert_DataIntoRoot.C~
-rw-r--r-- 1 daq daq 1.6K  1월  16 17:47 convert_DataIntoRoot.C.ver0.org
-rw-r--r-- 1 daq daq 5.9K  1월  16 20:40 convert_PlotFromRoot.C
-rw-r--r-- 1 daq daq 5.9K  1월  16 20:36 convert_PlotFromRoot.C~
-rw-r--r-- 1 daq daq 5.5K  1월  12 21:19 convert_PlotFromRoot.C.ver0.3coin4000_250psPerBin
-rw-r--r-- 1 daq daq 5.5K  1월  12 21:19 convert_PlotFromRoot.C.ver1.QDCcal
-rw-r--r-- 1 daq daq 5.8K  1월  16 18:08 convert_PlotFromRoot.C.ver2.SetLogy
-rw-r--r-- 1 daq daq 5.8K  1월  16 18:09 convert_PlotFromRoot.C.ver3.SetLiny
-rwxr-xr-x 1 daq daq  24K  1월  16 20:46 convert.sh*
-rwxr-xr-x 1 daq daq  23K  1월  16 20:37 convert.sh~*
-rwxr-xr-x 1 daq daq 7.0K  1월  16 11:04 convert.sh.NewQDCLinearityTest*
-rwxr-xr-x 1 daq daq  18K  1월  16 12:17 convert.sh.OldQDCLinearityTest*
drwxrwxr-x 2 daq daq 104K  1월  16 20:52 data/
-rwxr-xr-x 1 daq daq  24K  1월  10 15:05 depcomp*
-rw-rw-r-- 1 daq daq 8.0K  1월  10 15:05 histo.txt
-rwxr-xr-x 1 daq daq  16K  1월  10 15:05 install-sh*
-rw-rw-r-- 1 daq daq  21K  1월  12 21:03 Makefile
-rwxrwxr-x 1 daq daq  186  1월  10 15:05 Makefile.am*
-rw-rw-r-- 1 daq daq  20K  1월  10 15:05 Makefile.in
-rwxr-xr-x 1 daq daq 6.8K  1월  10 15:05 missing*
-rwxrwxr-x 1 daq daq  73K  1월  16 17:38 QTPD_DAQ*
-rwxrwxr-x 1 daq daq  26K  1월  16 17:38 QTPD_DAQ.c~*
-rwxrwxr-x 1 daq daq  26K  1월  10 17:15 QTPD_DAQ.c~*
-rwxrwxr-x 1 daq daq  24K  1월  10 15:05 QTPD_DAQ.c.ver1.V4178*
-rwxrwxr-x 1 daq daq  25K  1월  10 15:05 QTPD_DAQ.c.ver2.DATAfileASCII*
-rwxrwxr-x 1 daq daq  25K  1월  10 15:05 QTPD_DAQ.c.ver3.outputFileLocation*
-rwxrwxr-x 1 daq daq  26K  1월  10 15:05 QTPD_DAQ.c.ver4.FailDueTo_Form*
-rwxrwxr-x 1 daq daq  26K  1월  16 17:39 QTPD_DAQ.c.ver5.EditCommentsKeep*
-rw-rw-r-- 1 daq daq 118K  1월  16 17:38 QTPD_DAQ.o
-rwxr-xr-x 1 daq daq   42  1월  10 15:05 runV792NC.sh*
-rwxr-xr-x 1 daq daq  244  1월  10 15:05 runV792NC.sh~*
daq@daq-ubuntu:~/spdak2024/daq_V792N_QDC/src$ l config/
total 40K
-rw-r--r-- 1 daq daq 5.0K  1월  16 20:44 config.txt
-rw-r--r-- 1 daq daq 4.9K  1월  16 12:12 config.txt~
```

root -b -q 'convert_V792nDataIntoRoot.C("filename")'
root -b -q 'convert_V792nDataIntoRoot.C("rn69_evts1000000_v792n_List")'

```
rn9_evts1024_v792n_List.root
rn9_evts1024_v792n_List.txt
```

root -b -q 'convert_V792nPlotFromRoot.C("filename")'
root -b -q 'convert_V792nPlotFromRoot.C("rn69_evts1000000_v792n_List")'

```
rn9_evts1024_v792n_List.hst
rn9_evts1024_v792n_List.hst_c1_qdcCh0_7.png
rn9_evts1024_v792n_List.hst_c2_qdcCh8_15.png
```

4) Run ➔ $./conver.sh

2) Compilation (make)

3) Run ➔ $./QTPD_DAQ config/config.txt

1) configuration

config/config.txt (original)

```
# ********************************************************************
# Settings for the QTP (Analog QDC, TDC and Peak sensing ADC)
# Supported Models
# Q = QDC       : V792, V792N, V862, V965, V965A
# T = TDC       : V775, V775N
# P = Peak ADC  : V785, V785N, V1785
# ********************************************************************

# ********************************************************************
# Connection type V1718 | V2718 | V3718 | V4718 | A4818
#
# Examples:
#                       V1718 => usbV1718
#                       V2718 => pciV2718
#                       V3718 => usbV3718 | pciV3718
#                       V4718 => usbV4718 PID
#                       V4718 => pciV4718
#                       V4718 => ethV4718 ipaddress
#                       A4818 => usbA4818 PID
#
# ********************************************************************
CONNECTION ethV4718 192.168.1.254
#CONNECTION usbV1718
```

```
# ---------------------------------------------------------------
# Base Address (32 hex number) of the QTP board (0 if not present)
# ---------------------------------------------------------------
# V1290N TDC
#QTP_BASE_ADDRESS    EE000000

# V1742 ADC (DRS)
#QTP_BASE_ADDRESS    32100000

# V792N QDC new (PID22192)
QTP_BASE_ADDRESS    CC110000

# V792N QDC (old SN 603)
#QTP_BASE_ADDRESS    10240000

# V775N TDC (PNF-0102, s/n 585)
#QTP_BASE_ADDRESS    22220000

# ---------------------------------------------------------------
# Iped (pedestal for the QDC or range for the TDC)
# ---------------------------------------------------------------
IPED 100

# ---------------------------------------------------------------
# Low Level Discriminator for the ADC (values below LLD will be discarded)
# Syntax: QTP_LLD ch lld
# ch = channel (0 to 31; -1 means all channels)
# lld = low level threshold in ADC channels (0 to 4095, granularity = 16)
# ---------------------------------------------------------------
QTP_LLD -1 0
```

```
# ---------------------------------------------------------------
# Enable Zero and Overflow suppression (zero suppression means ADC_VALUE < QTP_LLD)
# ---------------------------------------------------------------
###ENABLE_SUPPRESSION  1
ENABLE_SUPPRESSION  0

# ---------------------------------------------------------------
# Output Files
# ---------------------------------------------------------------
ENABLE_LIST_FILE        1   # List of events (event number + ADC values of the unsuppressed channels) in text format
ENABLE_RAW_DATA_FILE    1   # Raw data (board memory dump); 32 bit words in binary format.
ENABLE_HISTO_FILES      1   # If enabled, the channel histograms (spectra) are saved every second during the run.
                            # NOTE: histograms are also saved at the end of the run or when 's' is pressed during the run.
```

New configuration

```
# ---------------------------------------------------------------
# Run Number (unsigned int) - added by ryu
# ---------------------------------------------------------------
RUN_NUMBER 69

# ---------------------------------------------------------------
# Number of Trigger (unsigned int) - added by ryu
# Number of Trigger should be 2^n (n=integer) and mininum 2^7=128
# ---------------------------------------------------------------
#NUMBER_OF_TRIGGER 50
#NUNBER_OF_TRIGGER 64
#NUNBER_OF_TRIGGER 1024
#NUNBER_OF_TRIGGER 2048
#NUNBER_OF_TRIGGER 4096
#NUNBER_OF_TRIGGER 65536
#NUNBER_OF_TRIGGER 131072
#NUNBER_OF_TRIGGER 262144
#NUNBER_OF_TRIGGER 300000
#NUNBER_OF_TRIGGER 1048576
NUNBER_OF_TRIGGER 1000000
```

New code for V792N TDC

```
# ------------------------------------------------------------------
# Run Number (unsigned int) - added by ryu
# ------------------------------------------------------------------
RUN_NUMBER 69

# ------------------------------------------------------------------
# Number of Trigger (unsigned int) - added by ryu
# Number of Trigger should be 2^n (n=integer) and mininum 2^7=128
# ------------------------------------------------------------------
#NUMBER_OF_TRIGGER 50
#NUNBER_OF_TRIGGER 64
#NUNBER_OF_TRIGGER 1024
#NUNBER_OF_TRIGGER 2048
#NUNBER_OF_TRIGGER 4096
#NUNBER_OF_TRIGGER 65536
#NUNBER_OF_TRIGGER 131072
#NUNBER_OF_TRIGGER 262144
#NUNBER_OF_TRIGGER 300000
#NUNBER_OF_TRIGGER 1048576
NUNBER_OF_TRIGGER 1000000
```

~/spdak2024/daq_V792N_TDC/src/data

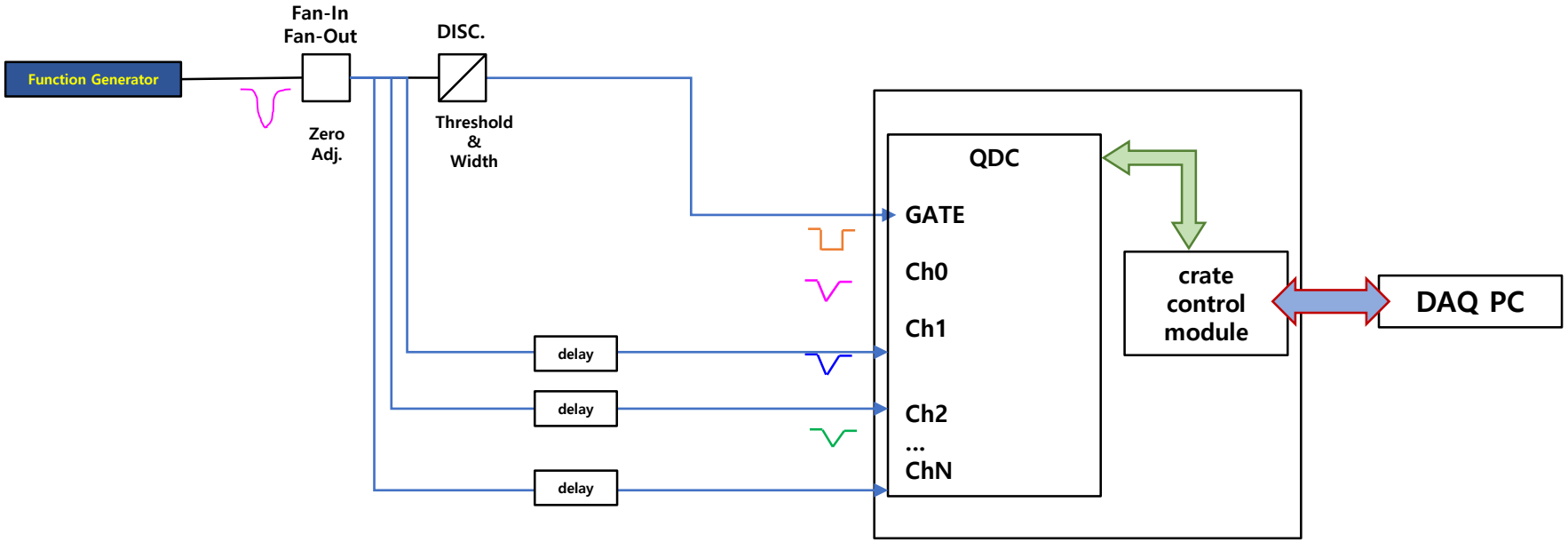
```
rn9_evts1024_v792n_Histo_ch0.txt
rn9_evts1024_v792n_Histo_ch10.txt
rn9_evts1024_v792n_Histo_ch11.txt
rn9_evts1024_v792n_Histo_ch12.txt
rn9_evts1024_v792n_Histo_ch13.txt
rn9_evts1024_v792n_Histo_ch14.txt
rn9_evts1024_v792n_Histo_ch15.txt
rn9_evts1024_v792n_Histo_ch1.txt
rn9_evts1024_v792n_Histo_ch2.txt
rn9_evts1024_v792n_Histo_ch3.txt
rn9_evts1024_v792n_Histo_ch4.txt
rn9_evts1024_v792n_Histo_ch5.txt
rn9_evts1024_v792n_Histo_ch6.txt
rn9_evts1024_v792n_Histo_ch7.txt
rn9_evts1024_v792n_Histo_ch8.txt
rn9_evts1024_v792n_Histo_ch9.txt
rn9_evts1024_v792n_histo.txt
rn9_evts1024_v792n_List.txt
rn9_evts1024_v792n_RawData.txt
```

Spectrum of each channel

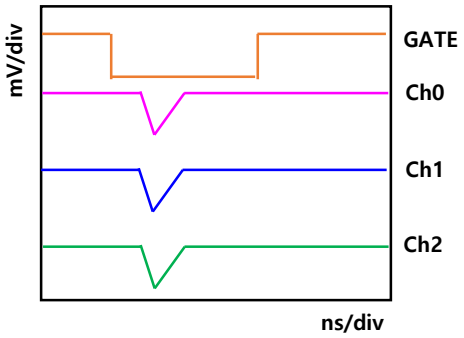
List.txt: data without any comments

QDC Linearity Test

DAQ logic of QDC Linearity Test



Time domain of signals for QDC



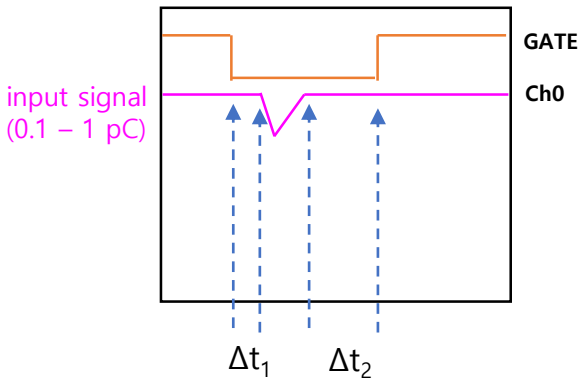
QDC Linearity Test

Full Dynamic Range (FDR) = 1 pC with 12 bit

1	pC
1024	bin
0.00097656	pC/bin

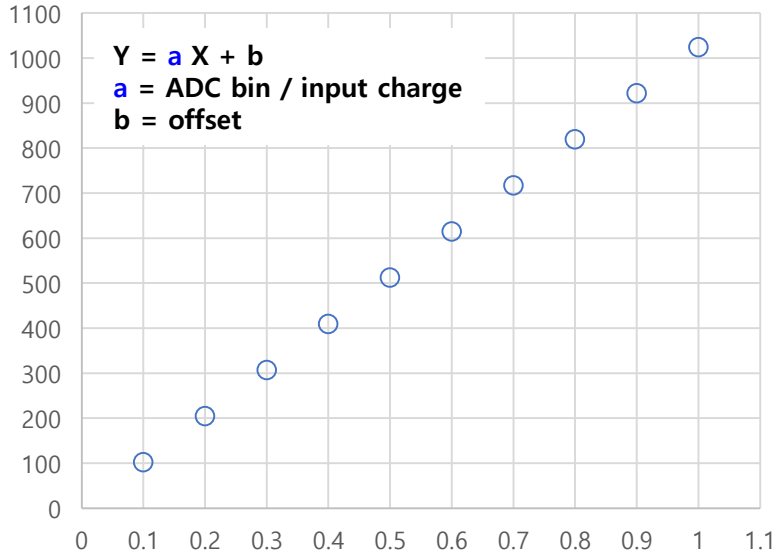
Input charge (pC)	unit charge (pC/count)	Measured Charge (QDC count)
0.1	0.000976563	102.4
0.2	0.000976563	204.8
0.3	0.000976563	307.2
0.4	0.000976563	409.6
0.5	0.000976563	512
0.6	0.000976563	614.4
0.7	0.000976563	716.8
0.8	0.000976563	819.2
0.9	0.000976563	921.6
1	0.000976563	1024

Time domain of signals for QDC calibration



Δt_1 and Δt_2 depends on charge and shape of signal (ex, 10 ns or more).

Measured Charge (QDC count) vs input charge (pC)



Co-60 Test

Gamma Spectrum Measurement by LYSO detector with Co-60

Co-60 Gamma spectra with NaI and HPGe

Plot from https://www.nuclear-power.com/nuclear-engineering/radiation-detection/gamma-spectroscopy/cobalt-60-spectrum/

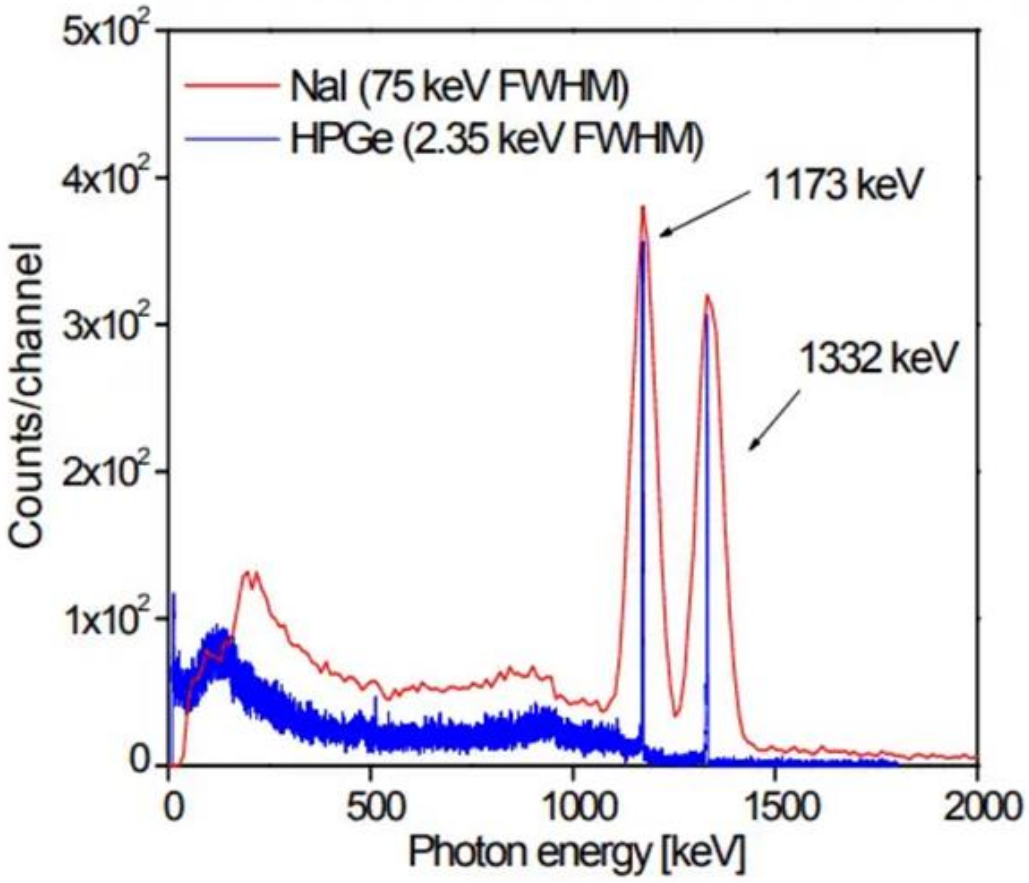
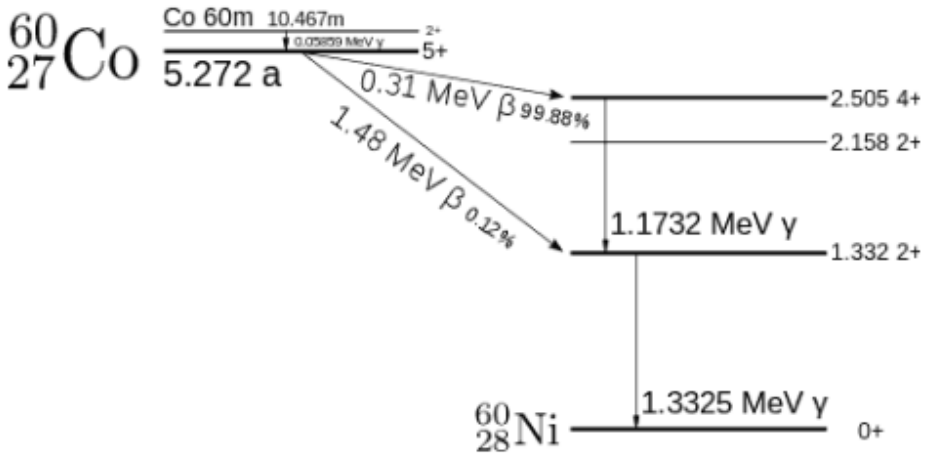


Figure: Caption: Comparison of NaI(Tl) and HPGe spectra for cobalt-60. Source: Radioisotopes and Radiation Methodology I, II. Soo Hyun Byun, Lecture Notes. McMaster University, Canada.



Energy resolution (σ_E)

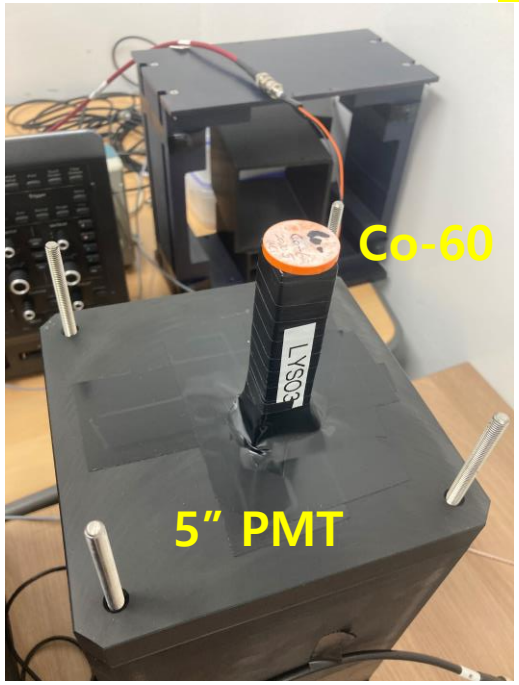
$$\sigma_{E\_NaI} = \frac{FWHM_{NaI}}{<\mu_{NaI}>} \times 100\% = \frac{FWHM_{NaI}}{1173\ keV} \times 100\% = 75\ keV$$

$$\sigma_{E\_HPGe} = \frac{FWHM_{HPGe}}{<\mu_{HPGe}>} \times 100\% = \frac{FWHM_{HPGe}}{1332\ keV} \times 100\% = 2.35\ keV$$

<<Recommendation paper>>

Characterisation of Cerium-Doped Lanthanum Bromide scintillation detector
Etim Iniobong Prosper, et al,
Lat. Am. J. Phys. Educ. Vol. 6, No. 1, March 2012

DAQ with LYSO detector



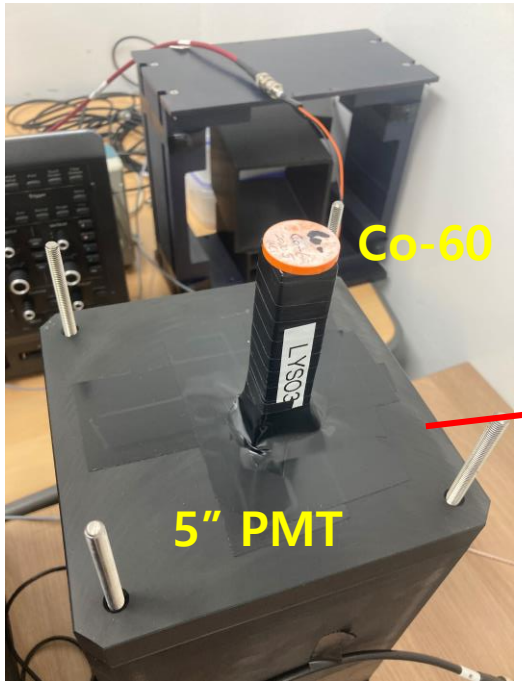
Delayed analog signal

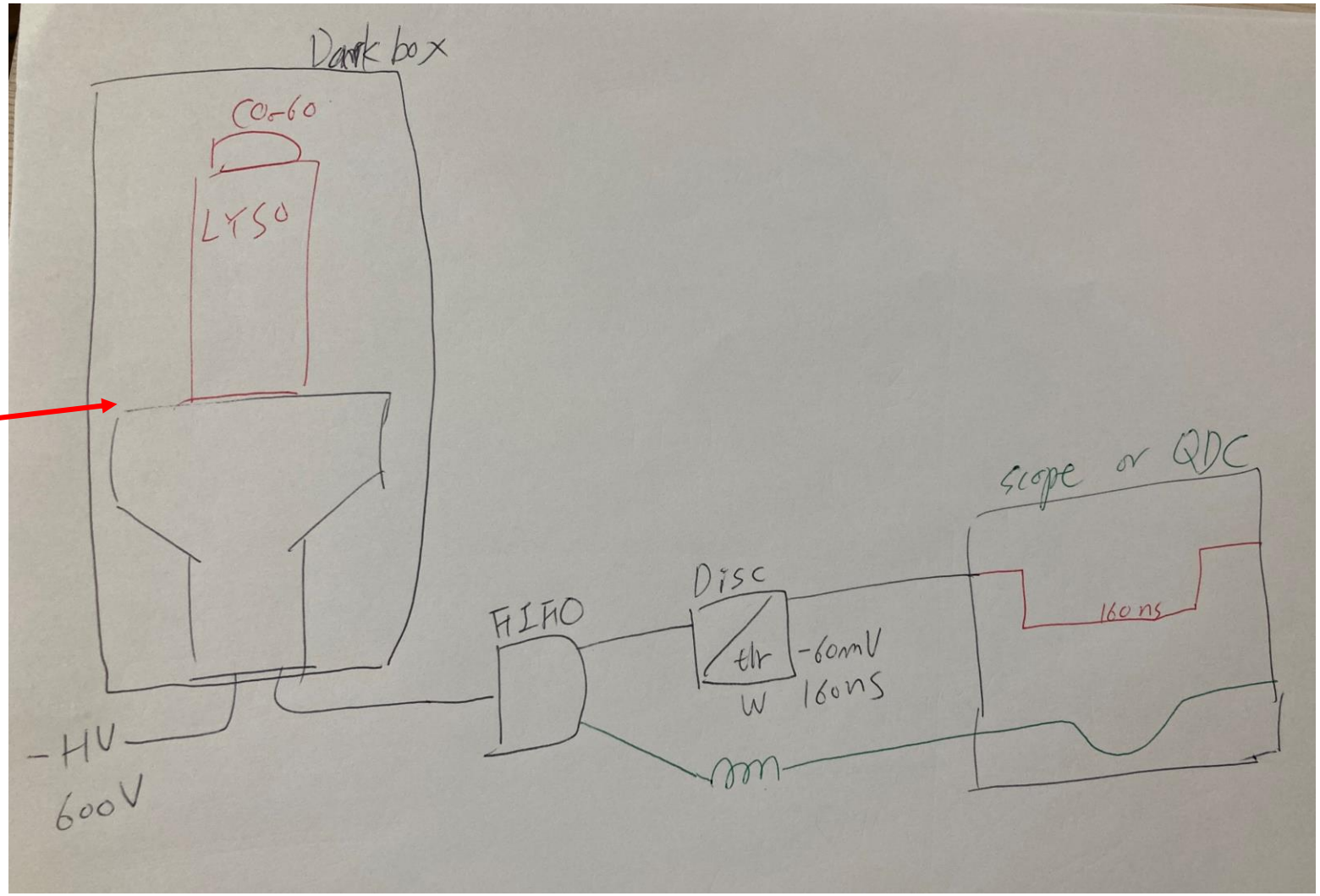
Self-trigger

Run DAQ

```
daq@daq-ubuntu: ~/spdak2024/daq_V792N_QDC/src
Acquired 850850 events on channel 0
Trigger Rate = 5.23 KHz
Readout Rate = 392.09 KB/s


[q] quit  [r] reset statistics  [s] save histograms [c] change plotting channel
Stop taking event (evt# = 1000000)Saved histograms to output files
daq@daq-ubuntu:~/spdak2024/daq_V792N_QDC/src$
```

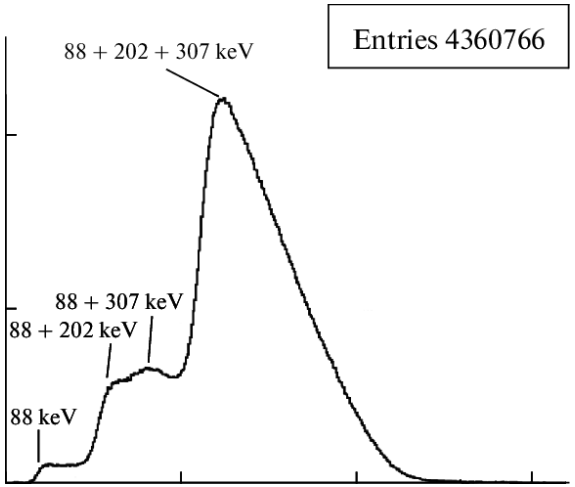
DAQ logic

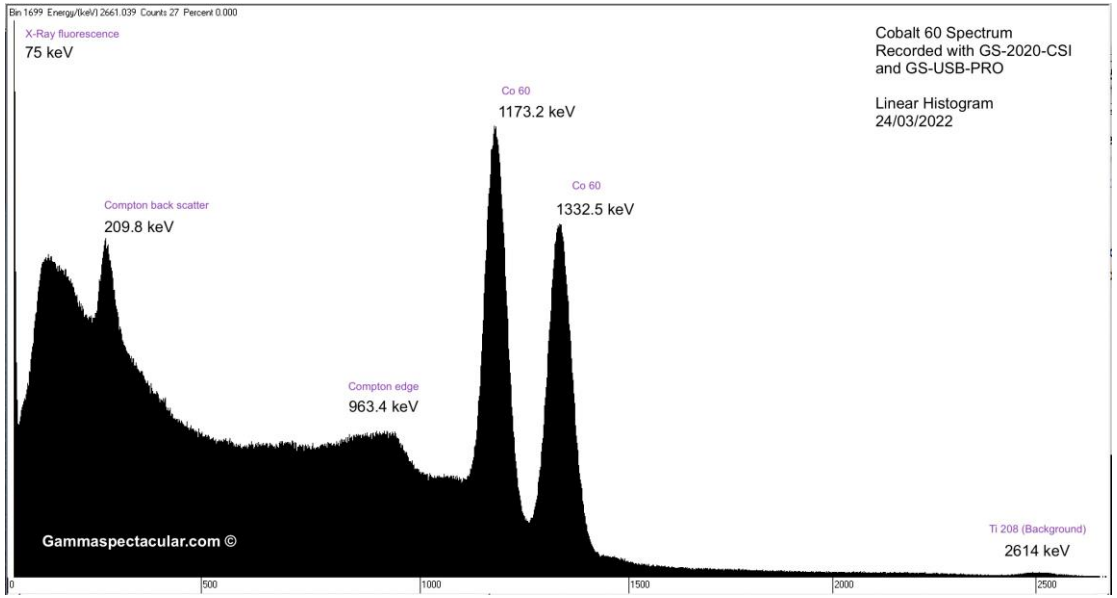

Co-60
LYSO3
5” PMT


Dark box
Co-60
LYSO
-HV
600V
FIFO
Disc
thr
W
-60mV
160ns
Scope or QDC
160ns

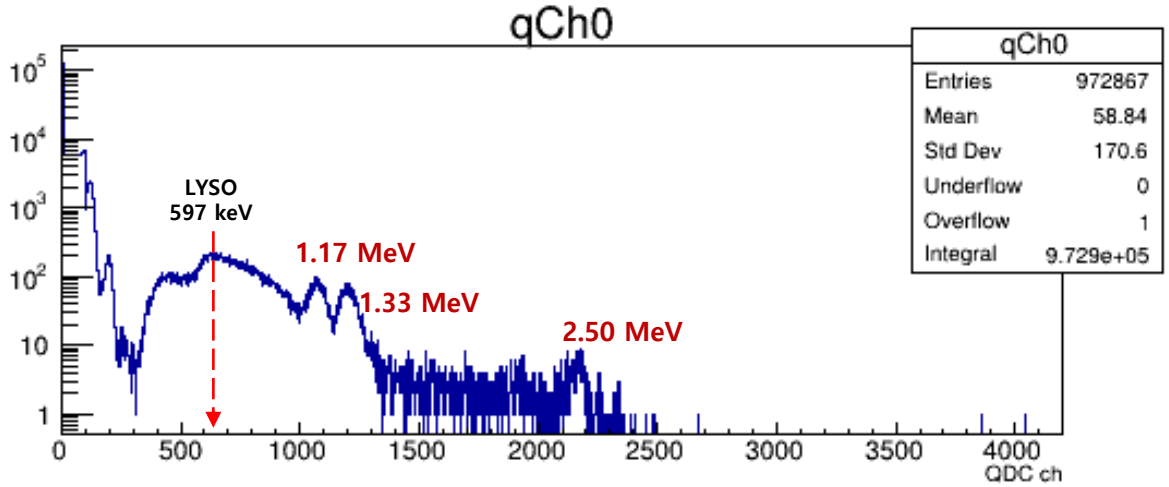
Gamma spectra of LYSO crystal and Co-60

LYSO crystal (Lu_2SiO_5:Ce): inorganic scintillator





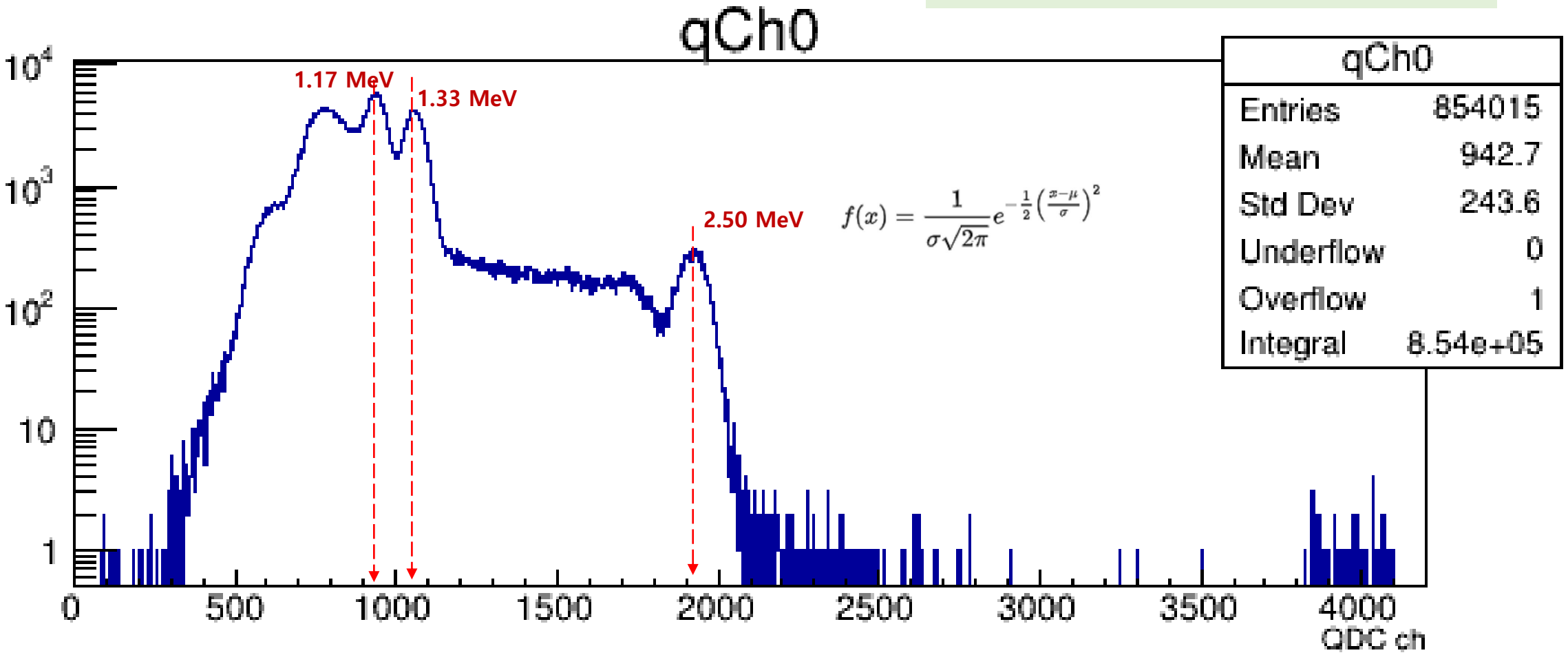
Self-trigger threshold: -20 mV (preamp gain 10)



Gamma spectra of LYSO crystal and Co-60

Self-trigger threshold: -60 mV (preamp gain 10)

```
root[] hist.Fit("gaus");

f(x) = p0*exp(-0.5*((x-p1)/p2)^2)
p0: Constant
p1: mean of Gaussian distribution
p2: standard deviation of Gaussian distribution
```



Summary

“Welcome to jumping into the DAQ world”