Hodoscope & NIM Handbook

NMSU Nuclear Physics Group

E1039/SpinQuest Experiment
November 30, 2022

SpinQuest Spectrometer Layout

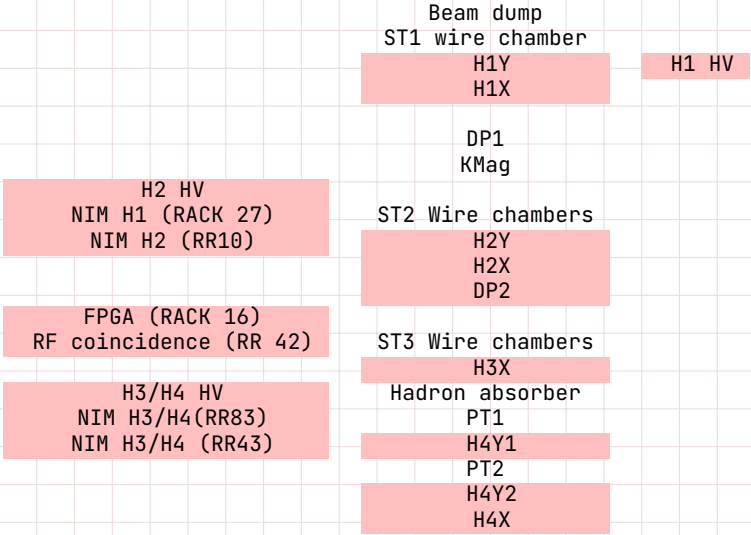


Table 1: Block diagram of the SpinQuest spectrometer. Pink shaded blocks are in the Hodoscope/NIM sub-system.

Debugging Hodoscope/NIM Sub-System

Some common steps of debugging Hodoscope/NIM sub-system includes;

- Check the hodocope hits in online monitor.
- Check the raw signal from the hodoscopes.
- Check the output signal from the discriminator.
- Check the raw NIM signal.
- Check the RF gated signal.

Order of these steps might change depending on the type of the issue.

Replacing Electronics

- When replacing 4413 discriminators make sure to;
  - keep the module threshold at the minimum. Typically this is $\sim$ -15 mV.
  - adjust the width to $\sim$ 15 - 20 ns.
- When replacing LEMO cables (or any cables) make sure that they are in the same length and they have correct labels in the both ends of the cable.

NIM Signal

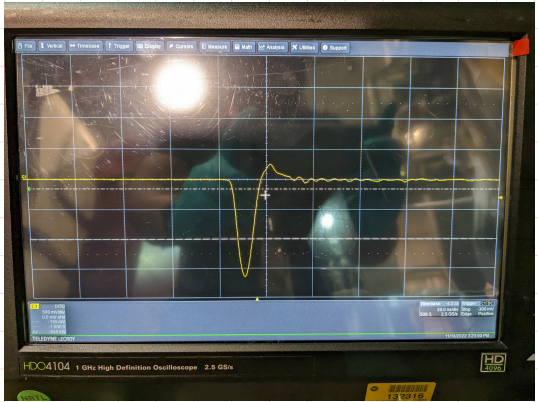


Figure 1: Typical raw signal from the hodoscope paddle. Time scale 20ns/div. and voltage scale 500mV/div.

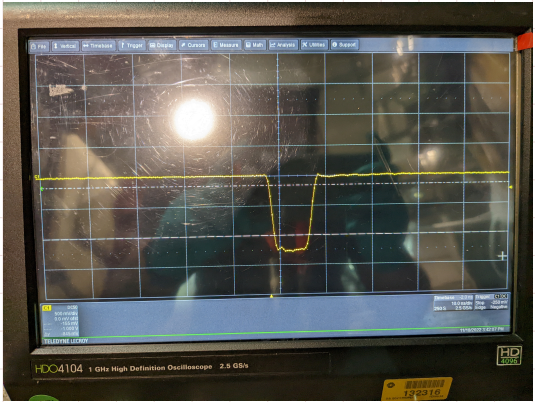


Figure 2: Typical NIM output signal from the LeCroy 4413 discriminator. The threshold of the discriminator set for the minimum value ($\sim$-15mV) and the width is set to $\sim$ 15ns. Time scale 10ns/div. and voltage scale 500mV/div.

Electronics

Mostly used electronics in the NIM sub-system include.

- LeCroy Model 4413: a 16-input discriminator in a single- width CAMAC module. Info.
- LeCroy Model 623B: a low cost eight channel discriminator featuring high-sensitivity, high-speed, updating performance. Info.
- LeCroy Model 4416 ECL/NIM/ECL: The Model 4416 is simultaneously an ECL-to-NIM and a NIM-to-ECL converter, specially designed to fill the gap between the new growing ECL circuitry and the old NIM electronics. Info.
- LeCroy Model 1440 system: This is the high voltage system for the hodoscopes. Info.
- For general infomations about NIM electronics link.

H1 Patch Panels

H1T23	H1T11	H1B23	H1B11			H1L20	H1R20	H1L10	H1R 10
H1T22	H1T10	H1B22	H1B10			H1L19	H1R19	H1L09	H1R 09
H1T21	H1T09	H1B21	H1B09			H1L18	H1R18	H1L08	H1R 08
H1T20	H1T08	H1B20	H1B08			H1L17	H1R17	H1L07	H1R 07
H1T19	H1T07	H1B19	H1B07			H1L16	H1R16	H1L06	H1R 06
H1T18	H1T06	H1B18	H1B06						

Table 2: Block diagram of the top patch panel.

H1T17	H1T05	H1B17	H1B05			H1L15	H1R15	H1L05	H1R 05
H1T16	H1T04	H1B16	H1B04			H1L14	H1R14	H1L04	H1R 04
H1T15	H1T03	H1B15	H1B03			H1L13	H1R13	H1L03	H1R 03
H1T14	H1T02	H1B14	H1B02			H1L12	H1R12	H1L02	H1R 02
H1T13	H1T01	H1B13	H1B01			H1L11	H1R11	H1L01	H1R 01
H1T12		H1B12							

Table 3: Block diagram of the bottom patch panel.

4413 LEMO Connections

7	8
5	6
3	4
1	2
9	10
11	12
13	14
15	16

Table 4: LEMO connections of the 4413 discriminator.

Figure 3: A 4413 discriminator.

H1 4413 Discriminator Channel Mapping

H1XT13	H1XT12	H1XB13	H1XB12	H1XT02	H1XT01
H1XT15	H1XT14	H1XB15	H1XB14	H1XT04	H1XT03
H1XT17	H1XT16	H1XB17	H1XB16	H1XT21	H11XT20
H1XT19	H1XT18	H1XB19	H1XB18	H1XT23	H1XT22
H1XT11	H1XT10	H1XB11	H1XB10	H1XB23	H1XB22
H1XT09	H1XT08	H1XB09	H1XB08	H1XB21	H1XB20
H1XT07	H1XT06	H1XB07	H1XB06	H1XB04	H1XB03
H1XT05		H1XB05		H1XB02	H1XB01

Table 5: H1X channel mapping to discriminators. This is the layout of the left most 3 4413 16 channel discriminators in the NIM bin. Each color represent one discriminator.

H1 4413 Discriminator Channel Mapping

H1YL17	H1YL16	H1YR17	H1YR16	H1YL07	H1YL06	H1YR07	H1YR06
H1YL19	H1YL18	H1YR19	H1YR18	H1YL09	H1YL08	H1YR09	H1YR08
H1YL20			H1YR20		H1YL10		H1YR10
H1YL15	H1YL14	H1YR15	H1YR14	H1YL05	H1YL04	H1YR05	H1YR04
H1YL13	H1YL12	H1YR13	H1YR12	H1YL03	H1YL02	H1YR03	H1YR02
H1YL11		H1YR11		H1YL01		H1YR02	

Table 6: H1Y channel mapping to discriminators. This is the layout of the right most 4 4413 16 channel discriminators in the NIM bin. Each color represent one discriminator.

H2 Patch Panel Layout

H2L19	H2R19	H2L09	H2T16	H2B16
H2L18	H2R18	H2L08	H2T15	H2B15
H2L17	H2R17	H2L07	H2T14	H2B14
H2L16	H2R16	H2L06	H2T13	H2B13
H2L15	H2R15	H2L05	H2T12	H2B12
	H2R09	H2R06	H2T11	H2B11
	H2R08	H2R05	H2T10	H2B10
	H2R07		H2T09	H2B09

Table 7: H2 top patch panel. This is located in rack RR10.

H2L14	H2L11	H2R13	H2L04	H2L02	H2R04	H2R02	H2T08	H2T06	H2T04	H2T02	H2B08	H2B06	H2B04	H2B02
H2L13	H2L10	H2R12	H2L03	H2L01	H2R03	H2R01	H2T07	H2T05	H2T03	H2T01	H2B07	H2B05	H2B03	H2B01
H2L12	H2R14	H2R11	H2R10											

Table 8: H2 bottom patch panel. This is located in rack RR10.

H2 429A Logic Fan Outs

H2L19	H2L18	H2L17	H2L09	H2L08	H2B16	H2B15	H2B15	H2B14
H2L16	H2L15	H2R19	H2L06	H2L05	H2B13	H2B12	H2B12	H2B11
H2R18	H2R17	H2R16	H2R08	H2R07	H2B10	H2B09	H2B09	H2T12
H2R15	H2T16	H2T15	H2R05	H2T14	H2T13	H2T11	H2T10	H2T09

Table 9: H2 top 429A Logic Fan Outs. This is located in rack RR10.

H2L14	H2L13	H2L12	H2L04	H2L03	BAD	H2T04	H2T03	H2T02
H2L11	H2L10	H2L02	H2L01	H2R04	H2R03	H2T01	H2B08	H2B07
BAD	H2R13	H2R12	H2R02	H2R01	H2T08	H2B06	H2B05	H2B04
H2R11	H2R10	H2R14	H2T07	H2T07	H2T05	H2B03	H2B02	H2B01

Table 10: H2 bottom 429A Logic Fan Outs. This is located in rack RR10.

H2 4413 Discriminator Mapping

H2L16	H2L15	H2R16	H2R15	H2L06	H2L05	H2T19	H2T09	H2B10	H2B09
H2L18	H2L17	H2R18	H2R17	H2L08	H2L07	H2T12	H2T11	H2B12	H2B11
	H2L19		H2R19		H2L09	H2T14	H2T13	H2B14	H2B13
						H2T16	H2T15	H2B16	H2B15
H2L14	H2L13	H2R14	H2R13	H2L04	H2R03	H2T08	H2T07	H2B08	H2B07
H2L12	H2L11	H2R12	H2R11	H2L02	H2R01	H2T06	H2T05	H2B06	H2B05
H2L10		H2R10				H2T04	H2T03	H2B04	H2B03
						H2T02	H2T01	H2B02	H2B01

Table 11: H1Y channel mapping to discriminators. Each color represent one discriminator. This is located at RR10 rack.

NIM Trigger Mapping in the Patch Panel

CHR01	H1XT	OUT
CHR02	H1XB	OUT
CHR03	H1YB	OUT
CHR04	H1YT	OUT
CHR05	H2XT	OUT
CHR06	H2XB	OUT
CHR07	H2YB	OUT
CHR08	H2YT	OUT
CHR09	H3XT	OUT
CHR10	H3XB	OUT
CHR11	H4XT	OUT
CHR12	H4XB	OUT
CHR13	H4Y1B	OUT
CHR14	H4Y1T	OUT
CHR15	H4Y2B	OUT
CHR16	H2Y2T	OUT

CHR17		
CHR18		
CHR19		
CHR20		
CHR21	NIM1	IN
CHR22	NIM2	IN
CHR23	NIM4	IN
CHR24	MATRIX	IN

Table 12: NIM trigger channel mapping in the patch panel. This is located at RR42 rack.

H3/4 4413 Discriminator Channel Mapping

CHANNEL	ELEMENT
8	UP PMT 1 LEFT/RIGHT
7	UP PMT 2 LEFT/RIGHT
6	UP PMT 3 LEFT/RIGHT
5	UP PMT 4 LEFT/RIGHT
4	UP PMT 5 LEFT/RIGHT
3	UP PMT 6 LEFT/RIGHT
2	UP PMT 7 LEFT/RIGHT
1	UP PMT 8 LEFT/RIGHT
16	DOWN PMT 1 LEFT/RIGHT
15	DOWN PMT 2 LEFT/RIGHT
14	DOWN PMT 3 LEFT/RIGHT
13	DOWN PMT 4 LEFT/RIGHT
12	DOWN PMT 5 LEFT/RIGHT
11	DOWN PMT 6 LEFT/RIGHT
10	DOWN PMT 7 LEFT/RIGHT
9	DOWN PMT 8 LEFT/RIGHT

CHANNEL	ELEMENT
8	UP PMT 9 LEFT/RIGHT
7	UP PMT 10 LEFT/RIGHT
6	UP PMT 11 LEFT/RIGHT
5	UP PMT 12 LEFT/RIGHT
4	UP PMT 13 LEFT/RIGHT
3	UP PMT 14 LEFT/RIGHT
2	UP PMT 15 LEFT/RIGHT
1	UP PMT 16 LEFT/RIGHT
16	DOWN PMT 9 LEFT/RIGHT
15	DOWN PMT 10 LEFT/RIGHT
14	DOWN PMT 11 LEFT/RIGHT
13	DOWN PMT 12 LEFT/RIGHT
12	DOWN PMT 13 LEFT/RIGHT
11	DOWN PMT 14 LEFT/RIGHT
10	DOWN PMT 15 LEFT/RIGHT
9	DOWN PMT 16 LEFT/RIGHT

Table 13: Channel mapping in the two near by 4413 discriminators.

NIM Triggers

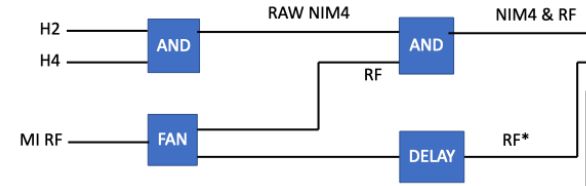
- Four NIM triggers were used with cosmic rays;

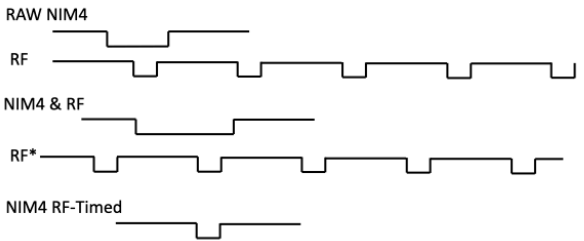
```
NIM1: (H1X||H1Y)&&(H2X||H2Y)&&(H3X||H4Y1)&&(H4X||H4Y2)
NIM2: (H1X||H1Y)&&(H2X||H2Y)
NIM3: Random
NIM4: (H2X||H2Y)&&(H4X||H4Y2)
FPGA5: ((H1X||H1Y)&&(H2X||H2Y)) || ((H2X||H2Y)&&(H4X||H4Y2)) // Made
with NIM modules. Time adjustment is reversed beamlike. RF timing is
not included.
```

- We will use `NIM1` trigger to optimize the hodoscope efficiencies.
- Four fold NIM trigger will use in the beam time for physics data;

```
TRIGGER: H1X && H2X && H3X && H4X
```

RF Timed Trigger





Notes:
Main Injector extraction frequency = 53.1 MHz
➔ MI RF period is 18.8 ns
Raw NIM4 width = 9 ns
RF width = 2-3 ns
NIM4&RF width = 18 ns
RF* delay with respect to RF is 9 ns
RF* width = 2-3 ns

The width of RAW NIM4 should be ½ of the RF period.
Width of RF and RF* should be as narrow as possible.
RAW NIM4 width + RF width must be less than a full RF period.
RF* delay is ½ of the RF period.
NIM4&RF width is a full RF period.

Figure 4: RF timed NIM trigger (Thanks to S. Pate).

Hodoscope Voltage Debugging

- Navigate to settings folder use the following commands;

```
kinit user@FNAL.GOV
ssh -X user@spinquestgat1.fnal.gov
cd /data2/e1039/daq/slowcontrols/lecroy/hv/
```

- Use the following commands for basic debugging;

```
./status plane # check status of plane
./on plane # turn on the hodoscope plane
./off plane # turn off the hodoscope plane
./monitor plane # check the status of the plane
./reset_netrs232.sh -y plane # reset the connection
```

Hodoscope Efficiency Software

- Efficiency of the each hodoscope paddle can be calculated using finding the straight line fit. Git repository.
- Using reconstructed elements use repository.
- Follow the instructions in README file to calculate the efficiencies.

Updating this Notebook

- You can update the notebook my making a pull request to the git repository.