

Comments to the presentation

“Test of a double layer detector prototype at HJET”
(BNL EIC Polarimetry Monthly Meeting, Jan. 13, 2021)
<https://indico.bnl.gov/event/10381/>

For preliminary tests, a prototype of double layer detector was assembled from two available HJET detectors (see slide 3 of the presentation). The 12 readout channels used are shown in Table 1.

Table 1. The readout channels numeration in the double layer detector. Active Si strips in first (front) layer are shown green and in second (back) layer are marked light yellow.

		84	85	91	92		93				
		86	87	88	89	90				94	95

The prototype was tested in the 5.76 GeV/n Gold beam in Run 2020. Two sets of data, Fills 25121-25153 (regular jet run) and 25156-25188 (empty target run, i.e. the jet OFF) were used in the data analysis. The gas pressure in HJET during these measurements is depicted in Fig. 1.

In this study, the prompts (in the front layer) was identified by the following signal amplitude and time ranges

Amplitude: 13 - 28 WFD units (0.52 – 1.12 MeV)
Time: 1 – 11 WFD units (2.4 - 27 ns)

The prompt identification cuts (for Si strip 88) are illustrated in Fig. 3. For such a defined prompt and for strip 88, fraction of prompt events is 70% (the jet ON) and 73% (the jet OFF). It should be noted that total fraction of punch through events, which can affect the polarization measurements at EIC, is larger.

For prompts deposited energy range used, 1.6 mm ceramics between front and back silicon layers (slide 3) must not critically affect the results of the test measurements. A simple evaluation of the energy deposited in two layers, including the losses in ceramics, for incident pions, protons, and deuterons is given in Table 2.

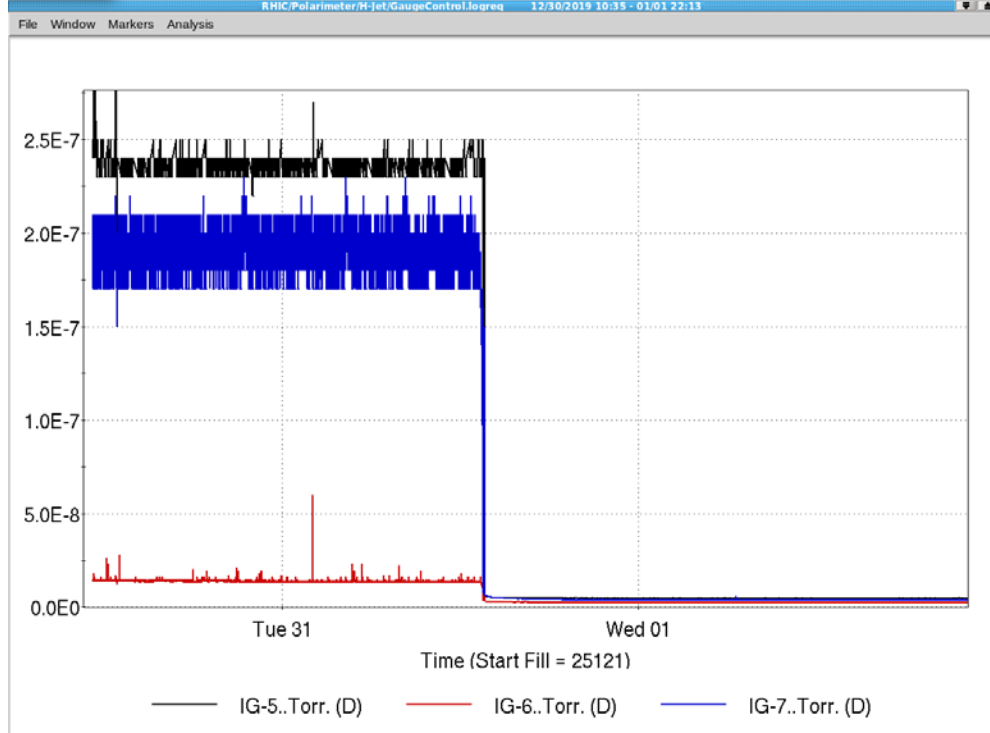


Figure 1 Gas pressure (Torr) in HJET chambers 5 (black), 6 (red), and 7 (blue) during Fills 25121-25188 (December 30, 2019 – January 1, 2020)

Table 2 dE/dx based evaluation of the entry kinetic energy T_R and momentum p_R in the front and back layers and energy, E_{dep} , detected in the back layer depending on the energy deposited in the first layer by a punch through pion, proton, or deuteron.

	Front Layer			Back Layer		
	E_{dep} [MeV]	T_R [MeV]	p_R [MeV/c]	E_{dep} [MeV]	T_R [MeV]	p_R [MeV/c]
π	0.6	18	71	0.65	15	65
	1.0	9	50	3.20	3	30
p	0.6	120	475	0.61	117	469
	1.0	60	336	1.06	56	323
d	0.6	170	800	0.61	167	793
	1.0	84	561	1.05	80	545

Explanation of the tables in slides 5-6 of the presentation.

There are four groups of four tables discriminated by RHIC Fills (25150-25153 or 25156-25159) and by an event selection (all events or prompts only). The first sub-table in each group gives the statistics in each readout channel. In a “Correlated events” sub-table, red colored number shows total number of the correlated events detected in the corresponding Si strip (85, 91, or 92). For each the strip, number of the related coincidences in all other strips are shown blue. The sum of blue numbers is equal to the red one.

Self-trigger in a FADC channel generates the board common trigger. In Run 2020, pre-selecting signal in one channel (e.g. shown red) resulted in vetoing simultaneous signals in other channels of the same board. In the “Correlated signals” sub-table, the vetoed channels were marked by gray color.

More accurate analysis (not included to the presentation)

For a prompt signal in front layer strip 88, the coincidence signals in other 11 readout channels were searched. The analysis was done for Fills 25121-25153 (Table 3) and 25156-25188 (Table 4). The integral beam intensity was about the same in both cases.

Time-amplitude distributions for some front layer strips are shown in Fig. 3 (25121-25153). For the back layer, the distributions are depicted in Fig. 4 (25121-25153) and Fig. 5 (25156-25188).

Table 3. For **209718** prompt events detected in the front layer strip 88 detected in Fills 25121-25153, the **coincident** (all) signal statistics in other 11 strips is displayed.

		49770	56374	44206	22420		27956		
		5534	30984	2095718	0	8194		5270	5175

Table 4. Same as in Table 3, but for the **empty target** Fills 25156-25188.

		13280	15679	14266	7215		9253		
		2720	11361	431647	0	4146		2338	2311

Key results.

- For the front layer, the prompt rate in the empty target run was about 20% of the regular run rate. For the back layer, the ratio was 27%.
Is there a correlation with beam line gas pressure in chamber 6?
- The prompt rate ratio in back and front layers is about 28% (40%), where the second number includes corrections to the energy losses in front layer and in ceramics. In empty target run the ratio is 38% (54%).
- Efficiency of the vetoing of a prompt signal in the front layer strip 88 by a single back layer strip behind is about 2.7% (3.6% in empty target run). Using 5 strips in the back layer, the efficiency can be increased to 8% (12%).

- Efficiency of the prompt vetoing by a coincidence in the same front layer strip is about 5% (10%). For such events, the vetoing efficiency can, *potentially*, be improved by reducing the gap between the layers.
- It was found that the waveform shapes (see page 8 of the presentation) are essentially different for events with coincidence in the same and in the different layers. However, no detail study was done yet.
- The estimates above have been done assuming negligible fraction of the triple coincidences. However, this assumption was not verified.

Conclusion.

Neither process listed in slide 2 of the presentation can adequately explain the observed results. *Currently, my best guess is that we should consider multiple inelastic scattering.*

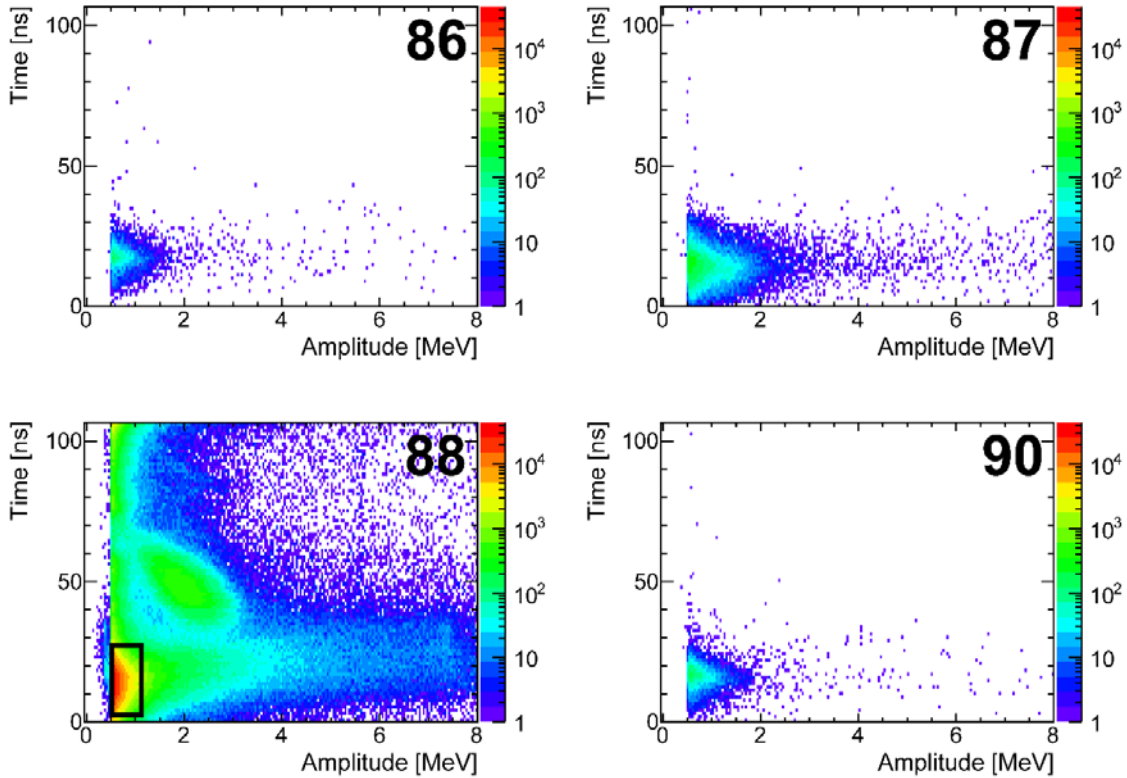


Figure 2 Time-amplitude distribution in a front layer strip **88** in Fills 25121-25153. For prompt events, defined by the rectangular, the coincident signal distributions in the front layer strips **86**, **87**, and **90** are also shown. The events per bin color indexes are the same in all histograms.

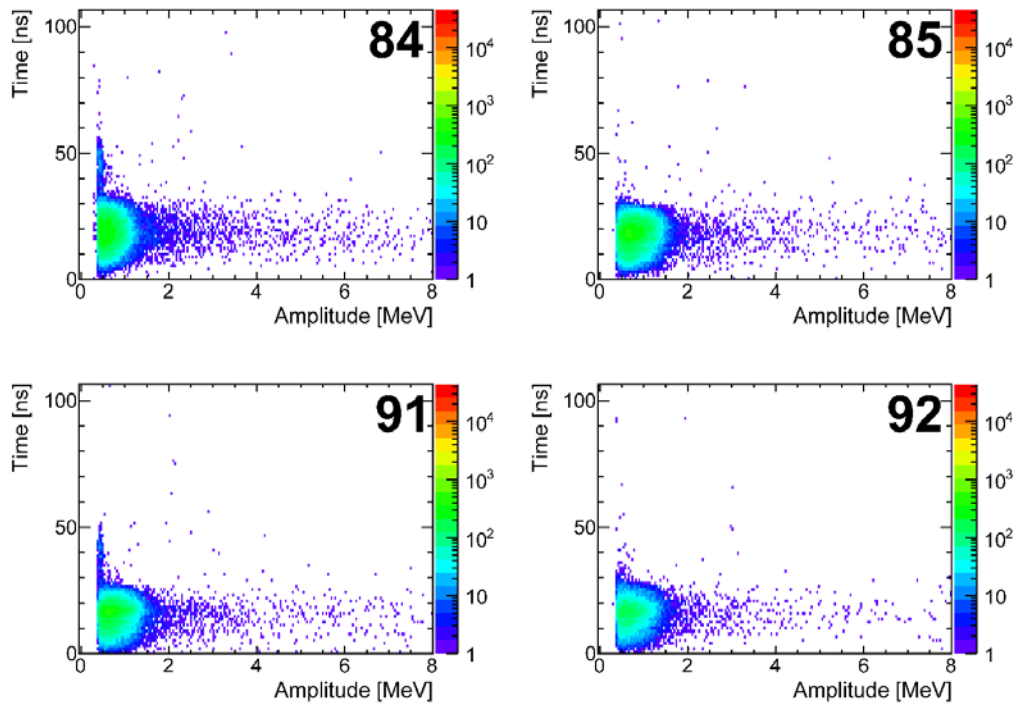


Figure 3 The second layer strip distributions for coincidences with a prompt in strip 88 (Fills 25121-25153).

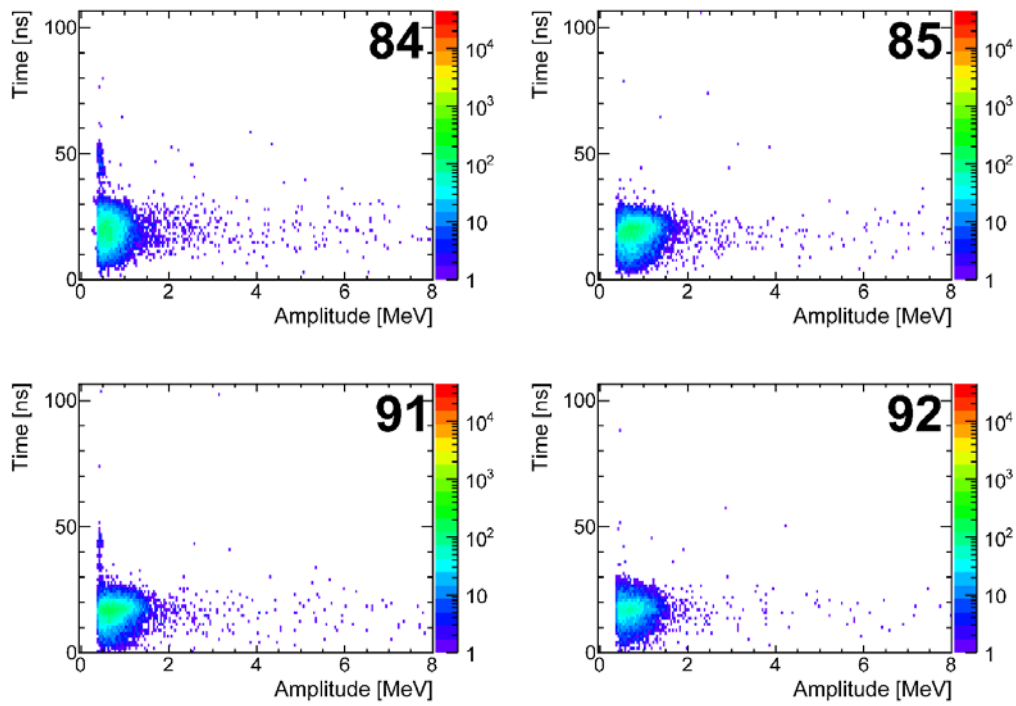


Figure 4 The second layer strip distributions for coincidences with a prompt in strip 88 (Empty target Fills 25121-25153).