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https://indico.bnl.gov/event/10381/

Test of a double layer detector prototype at HJET

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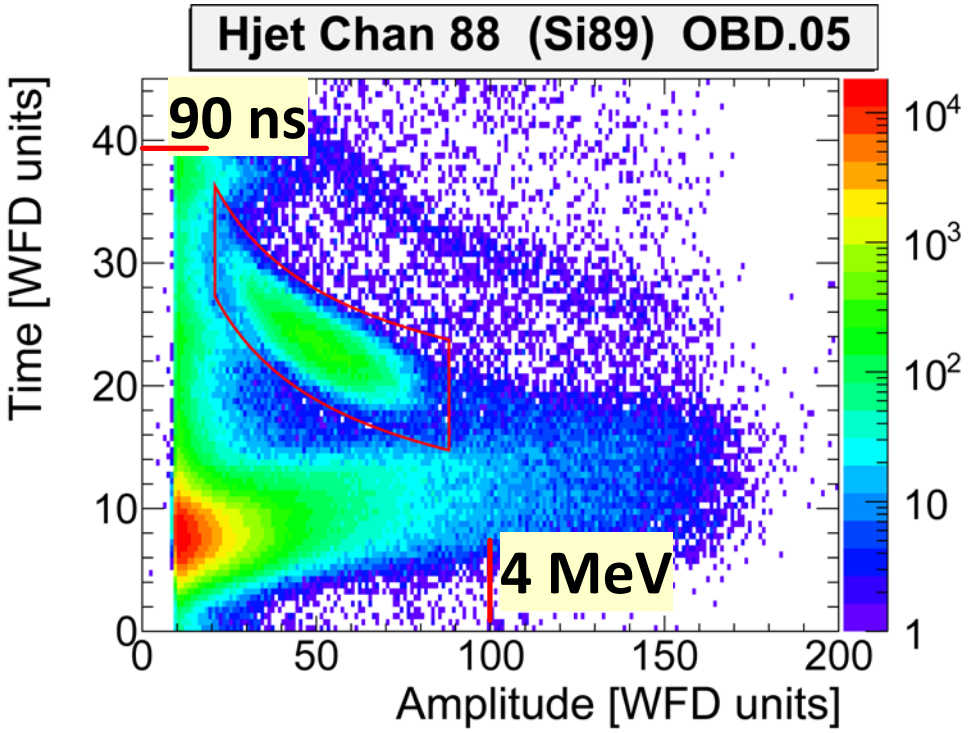
The prompts at HJET



Possible contributions to the prompts:

- For the pp scattering
  - pions, $p_{\text{jet}} \rightarrow \pi + X \quad (T_R < 3\ \text{MeV})$
  - photons, $\pi^0 \rightarrow \gamma\gamma$
- For the pA scattering
  - "target ion" dissociation
    $A \rightarrow (p, d, \alpha, \dots) + X$
- Beam halo
- Induced pulses (must not be seen at HJET)
- Optical photons (???)

The prompts rate is reduced by factor 3-4 if the jet is OFF

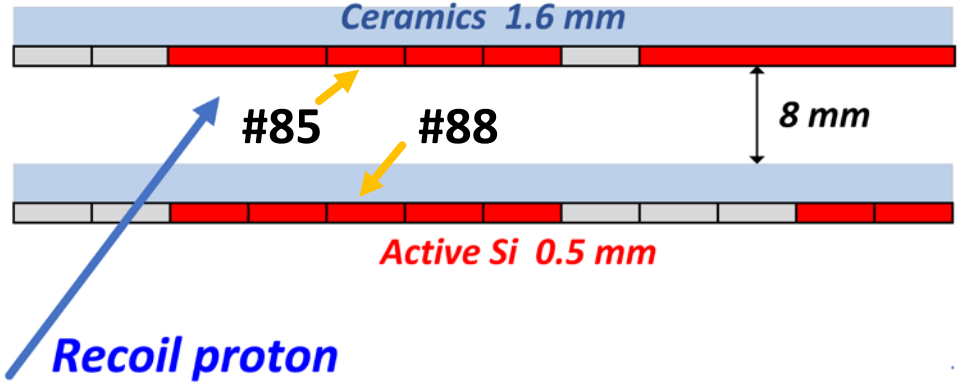
- For 107 ns bunch spacing at RHIC, prompts are not real problem. However, it may be an issue at EIC with 10 ns bunch spacing
- Due to relatively low rate, $< 100\ \text{Hz/strip} \quad (T_R > 0.5\ \text{MeV})$, of the prompts, the problem can be solved by *hardware* and/or *software* elimination of prompts.

Prototype of a double-layer detector for HJET

The prototype was assembled using available components:

- **1.6 mm of ceramics between layers**
- **~10 mm gap between layers**

One of 8 HJET detectors was replaced by the prototype.

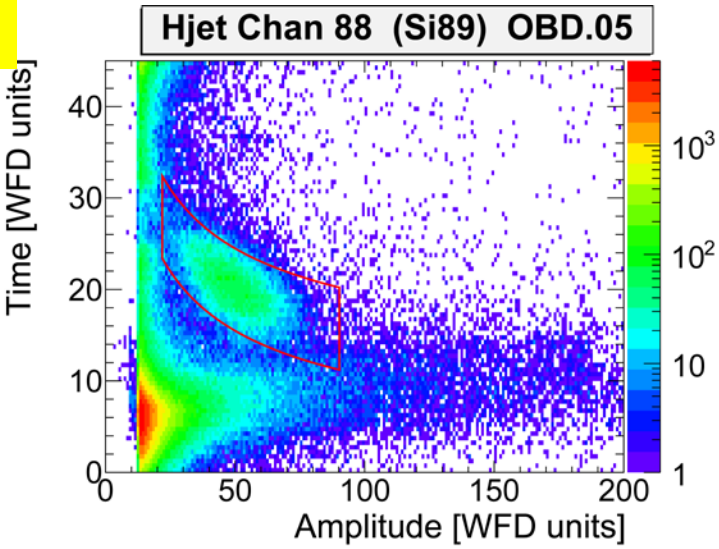


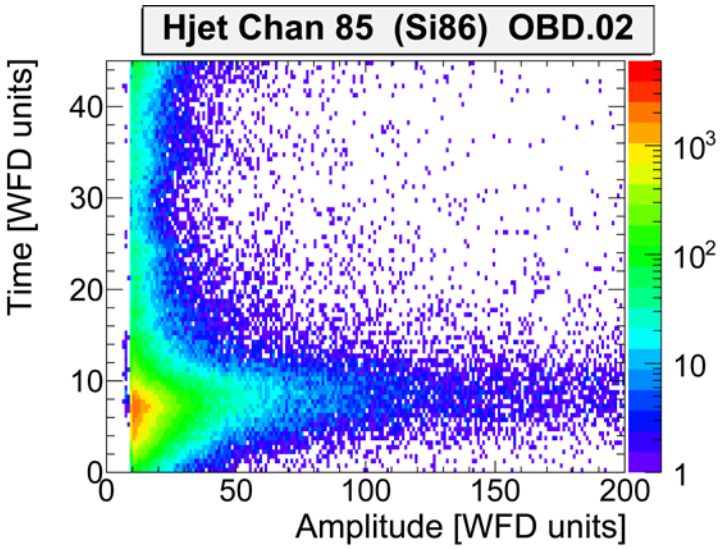
- **The goal was to veto punch-through $\pi, p, d, \alpha, \ldots$, which are expected to have momentums 100-500 GeV/c. The ceramics between layers must not be the problem for that.**
- **The detector was tested in 5.76 GeV/n Au beam (Run 2020)**
- **The prompts rate in the second layer was 30-40% compared to the first one.**
- **The prompts veto efficiency can be evaluated as $\lesssim$10-20%.**

The test was unsuccessful. No good understanding of how to improve.

Time-amplitude distributions

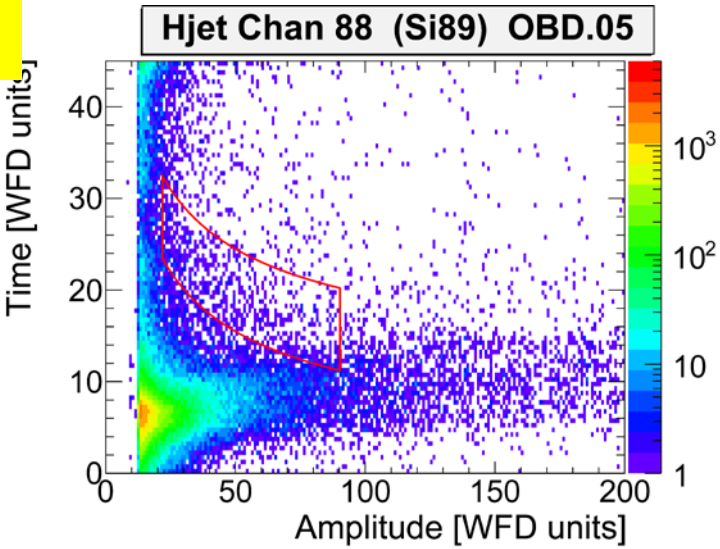
Fills 25150-25153

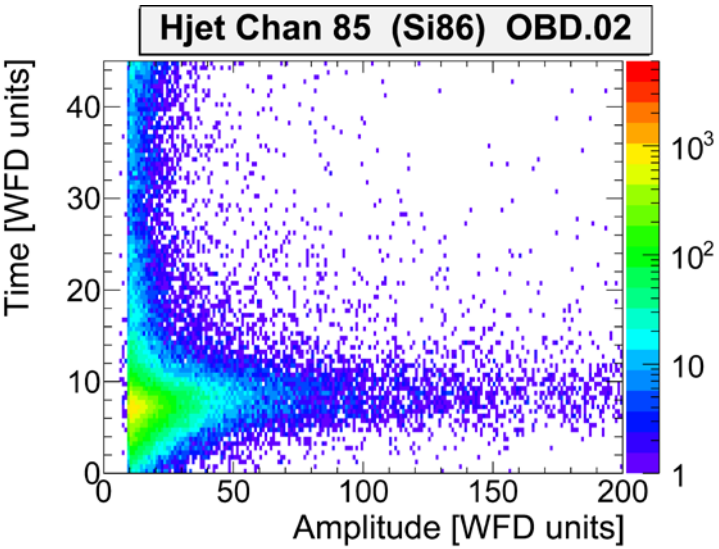




First layer **Second layer**

Fills 25156-25159
(empty target)





Fills 25150-25153 (Au, 5.76 GeV/n)

All Events

		362229		228936	222019	221149		628868		
		373521	585727	402643	327413	400952			294688	1964667

Correlated events:

		0		52853	10039	1965		2814		
		4356	10135	11415	5782	3500			1426	1421

		2120		1039	56358	9687		3338		
		2343	5518	9359	10779	0			1656	1519

		1663		1965	9687	45756		0		
		1621	2849	4665	8572	11475			1734	1525

Prompts only

		138175		94311	90983	91961		199968		
		238662	412914	289865	226425	291725			207248	201337

Correlated events:

		0		18526	1758	355		433		
		1847	4399	4897	2447	1431			517	442

		358		1758	17308	1733		458		
		871	2190	4213	4708	0			565	454314

		314		355	1733	16268		0		
		549	1000	2054	3903	5154			678	528

Fills 25156-25159 (Au, 5.76 GeV/n) Empty Target

All data (Empty target)

		130280		80732	80470	77968		235618		
		94355	140344	107326	91237	115158			90616	1072799

Correlated events:

		0		21674	4130	856		1263		
		1965	4551	4289	2023	1339			621	637

		894		4130	23827	4250		1485		
		951	2501	4169	4092	0			739	616

		664		856	4250	18921		0		
		697	1171	2048	3641	4347			651	596

Prompts only (Empty target)

		50920		34058	33336	33047		77207		
		66682	101250	79361	65164	83049			63233	1102820

Correlated events:

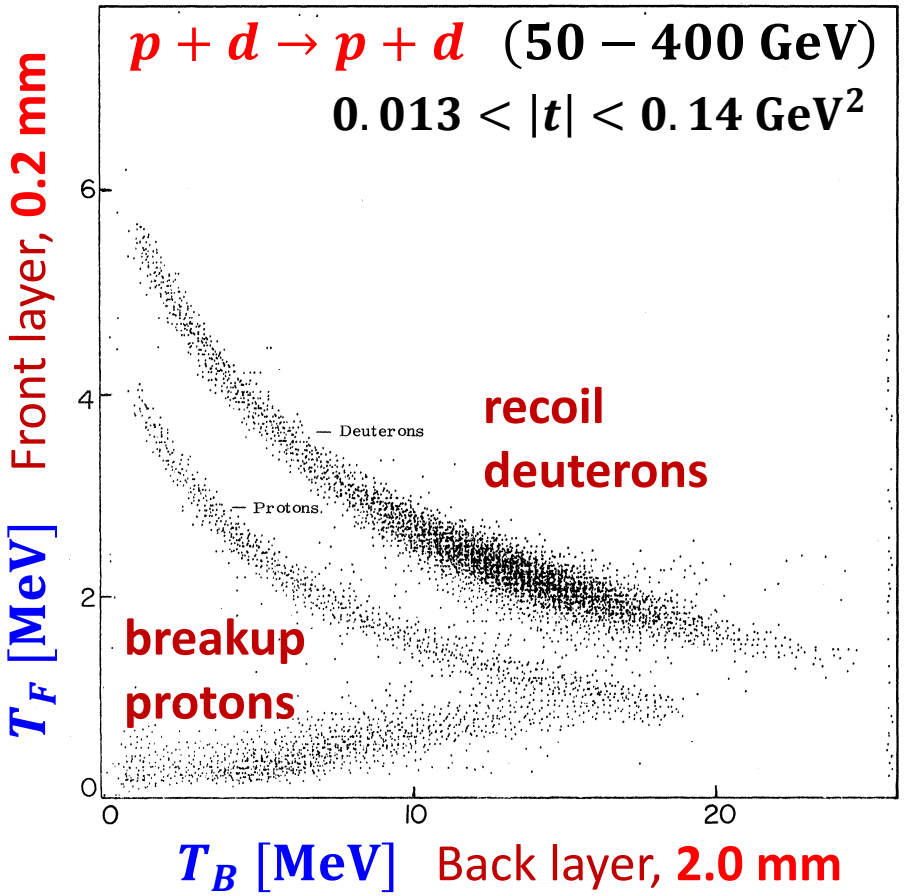
		0		7732	725	180		200		
		844	2073	1887	828	560			226	209

		146		725	7401	755		203		
		336	970	1949	1819	0			277	221

		134		180	755	6694		0		
		256	399	906	1684	1928			248	204

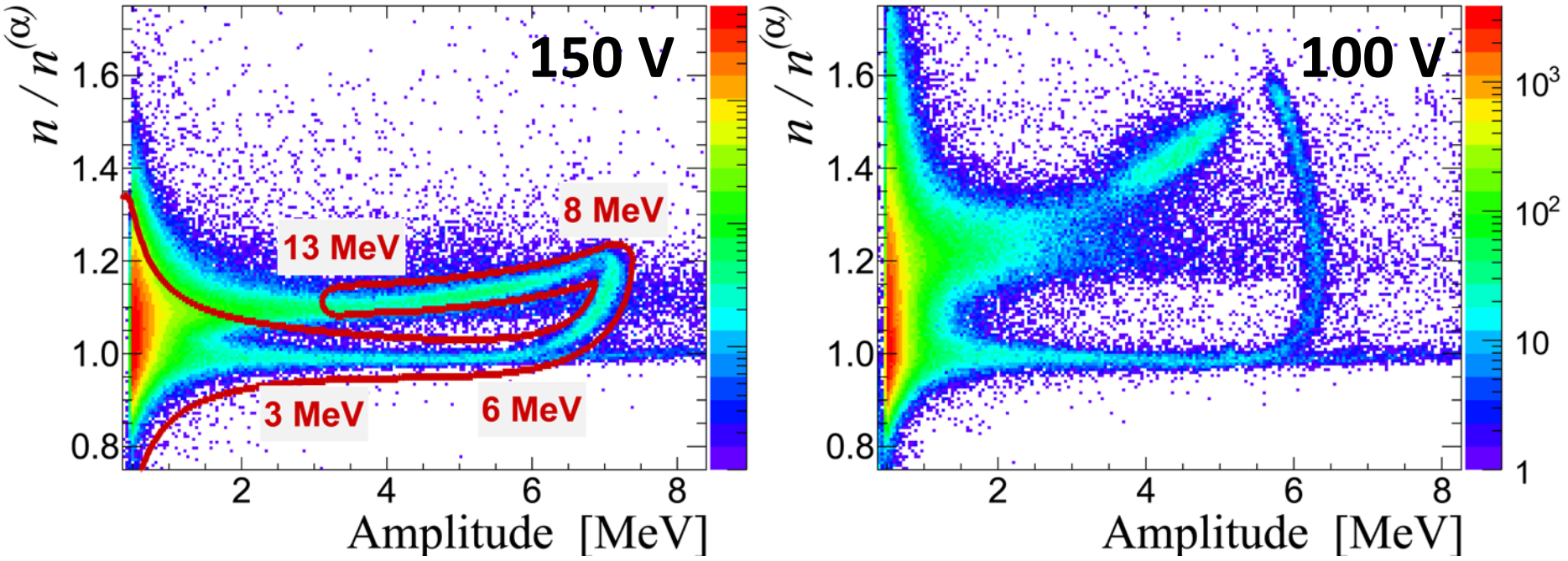
Y. Akimov *et al.*, Phys. Rev. D 12, 3399 (1975)

- **Amplitudes in front and back detectors are well correlated**
- **No evidence of prompts !?**
- **Large fraction of the deuteron breakup events.**



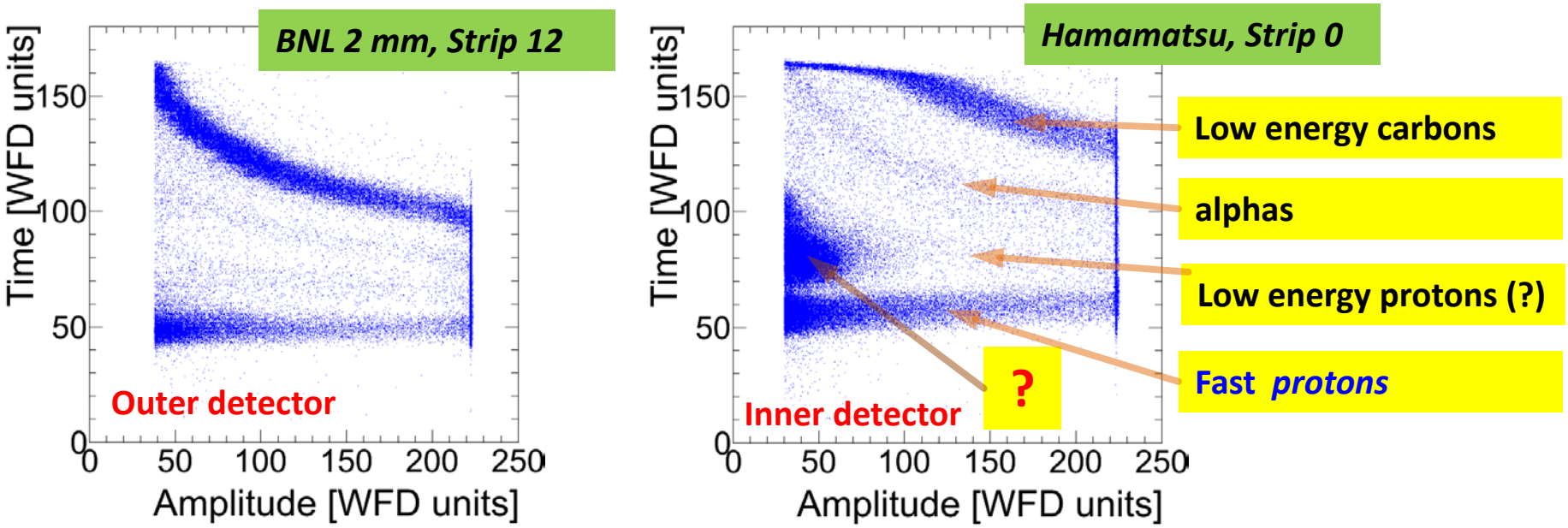
Waveform dependence on the particle kinetic energy

- $A(t) \propto At^n e^{-t/\tau}, \quad t > 0$
- **All data including prompts is displayed**



- **For the deposited energies > 2 MeV, the waveform shape analysis allows us to reliable separate punch through and stopped particles, i.e. to suppress prompts.**
- **For HJET, the method can be used instead (in addition to) the double layer detectors.**
- **Optimization of the bias voltage, to reduce the threshold energy can be considered.**

AGS pCarbon. Run 51969 (2012). Low Intensity ≈0.3.

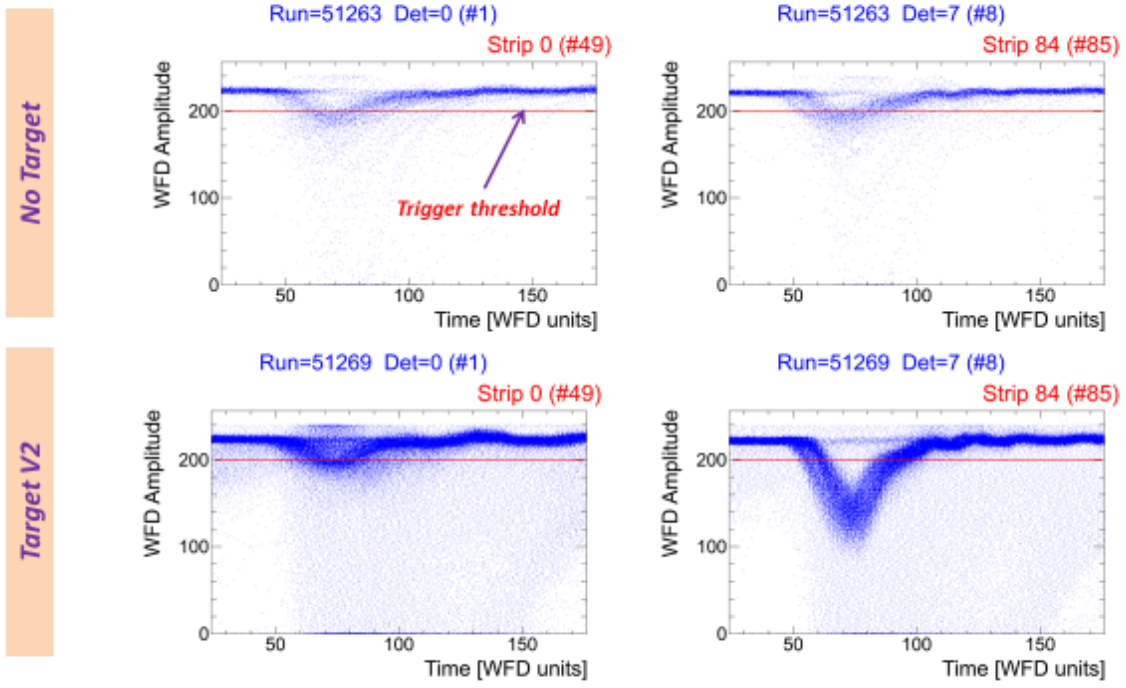


In a pCarbon polarimeter, the prompt rate is very high. Typically, multiple pileup events per bunch.

- In AGS/RHIC polarimeters, the prompts are eliminated by setting time cutoff windows in WFD firmware.
- This method can not be used at EIC (10 ns bunch spacing).
  - Very high event rate
  - For low recoil energy threshold, all elastic events will be vetoed by prompts
  - For high threshold, the time and energy resolution will be degraded by overlapping elastic signal in one bunch with prompt signal in other.

AGS pCarbon. Run 12

Superimposed waveforms. Beam Intensity ≈0.5



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- **The distributions shown can be interpreted as WFD baseline in the measurements**
- **In AGS/RHIC pCarbon the prompts related perturbations were cut off at the firmware level.**
- **At EIC the perturbations will be repeated with 10 ns step.**

Summary

- **A prototype of the double layer Si detector for HJET was tested using 5.76 GeV/n Au beam**
- **The result obtained appeared to be inconsistent with the expectations. Most likely, punch through $\pi, p, \ldots$ are not the dominant contribution to the prompts.**
- **No proofs were found that such a detector can solve the prompts problem at EIC.**
- **For HJET, alternative methods should be considered:**
  - **The prompts suppression by the waveform shape analysis**
  - **Coincidence between recoil and scattering protons (changes in the accelerator optics may be required)**
- **Currently, I am skeptical that RHIC pCarbon can be used at EIC (10 ns bunch spacing). However, I did not consider a high energy threshold, $T_R \gtrsim 1\ \mathrm{MeV}$, option for the recoil Carbons.**