PMT Signal Simulation

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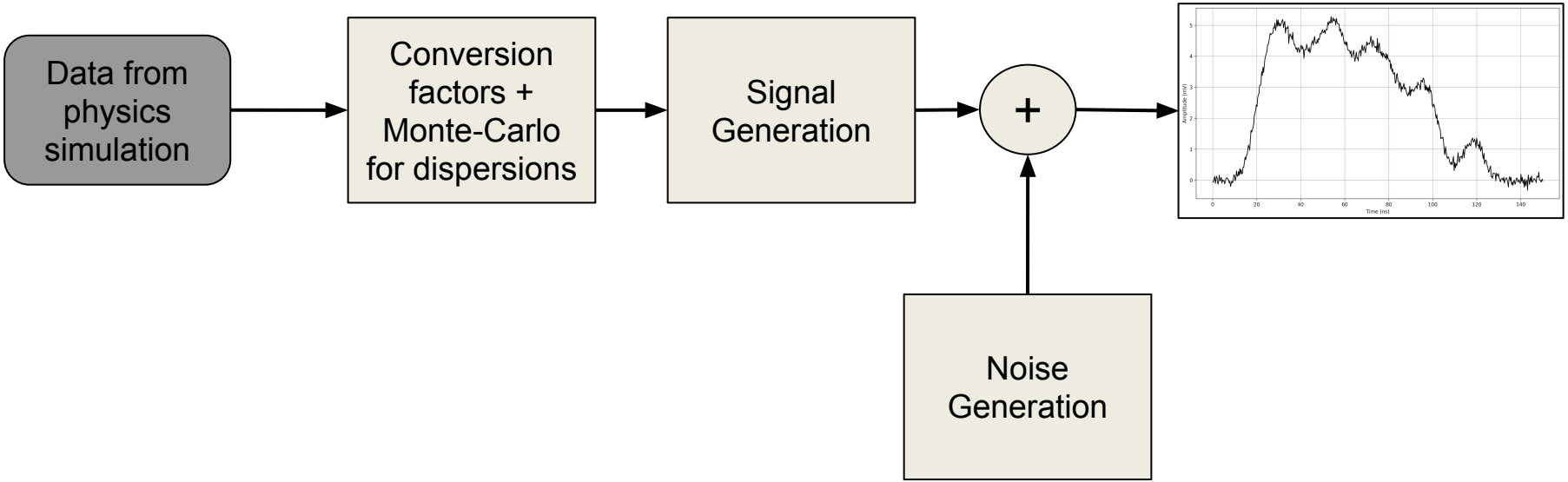
Summary

- PMT signal simulation - description *(development on going)*
- Examples using physics dataset
- Conclusions and next steps

PMT signal simulation

on going

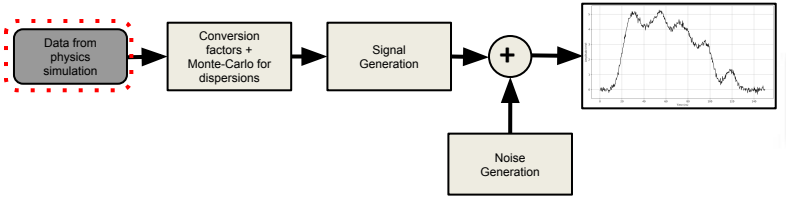
Simulation block diagram



Data from physics simulation

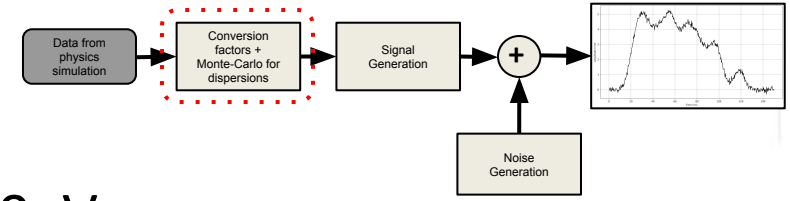
- SRIM simulation files from SRIM team

	Recoil	Cluster	X (mm)	Y (mm)	Z (mm)	Energy Loss (keV)
0	1	1	0.005507	-0.001011	0.000843	0.15760
1	1	2	0.007609	-0.004502	-0.000353	0.14330
2	1	3	0.014405	-0.007826	-0.001484	0.17150
3	1	4	0.018021	-0.010590	0.000364	0.12150
4	1	5	0.019184	-0.012940	-0.006842	0.19540
5	1	6	0.013007	-0.010070	-0.009480	0.16984
6	2	1	0.003862	-0.000198	0.000070	0.06820
7	2	1	0.008488	-0.000825	-0.000575	0.10180
8	2	2	0.011447	-0.001160	-0.007736	0.33780
9	2	3	0.012044	-0.001120	-0.019790	0.18040
10	2	4	0.007692	-0.001706	-0.019310	0.23073



- Input parameters:
  - Recoil and clusters indexes;
  - Distance in Z-axis;
  - Energy Loss.

Conversion factor and Monte-Carlo for dispersions



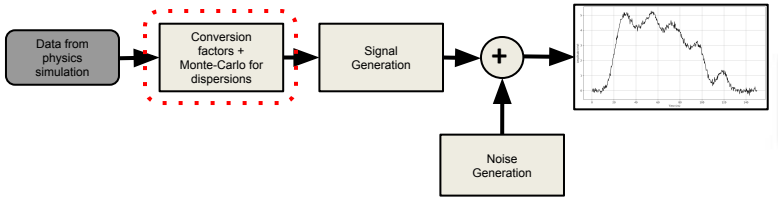
- Number of produced electrons: 1e-/40eV;
- Time of arrival on the GEM with drift velocity of 5 cm/us;
- Longitudinal dispersion:

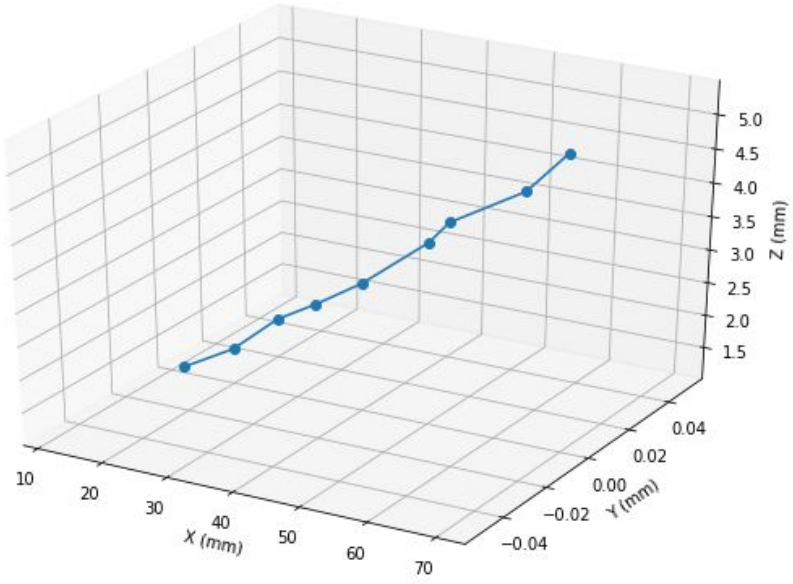
$$\sigma_T = \frac{1}{v_d}\sqrt{110\mu m \times Z}$$

- Signal amplitude using calibration factor of 0.66 mV/e-;

Generated particle for testing

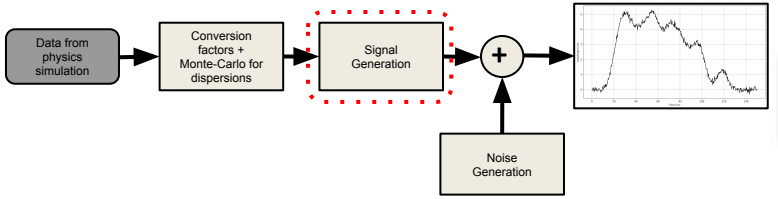
	Recoil	Cluster	X	Y	Z	Energy Loss	Electrons Created	Time of Arrival	Dispersion
0	1.0	1	12	0.0	1.10	0.16	4	22	6.957011
1	1.0	2	20	0.0	1.55	0.32	8	31	8.258329
2	1.0	3	27	0.0	2.15	0.08	2	43	9.726253
3	1.0	4	33	0.0	2.50	0.24	6	50	10.488088
4	1.0	5	40	0.0	2.95	0.32	8	59	11.392980
5	1.0	6	50	0.0	3.75	0.32	8	75	12.845233
6	1.0	7	53	0.0	4.10	0.20	5	82	13.431307
7	1.0	8	64	0.0	4.75	0.12	3	95	14.456832
8	1.0	9	70	0.0	5.40	0.12	3	108	15.414279





- X, Y and Z in mm;
- Energy Loss in keV;
- Time of arrival and dispersion in ns;

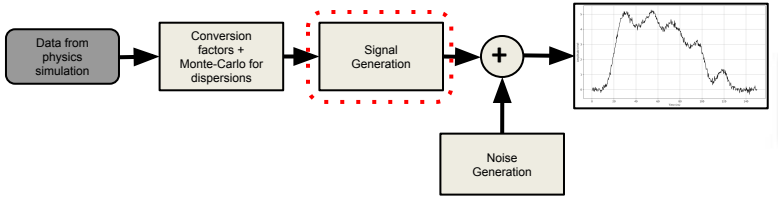
Signal Generation

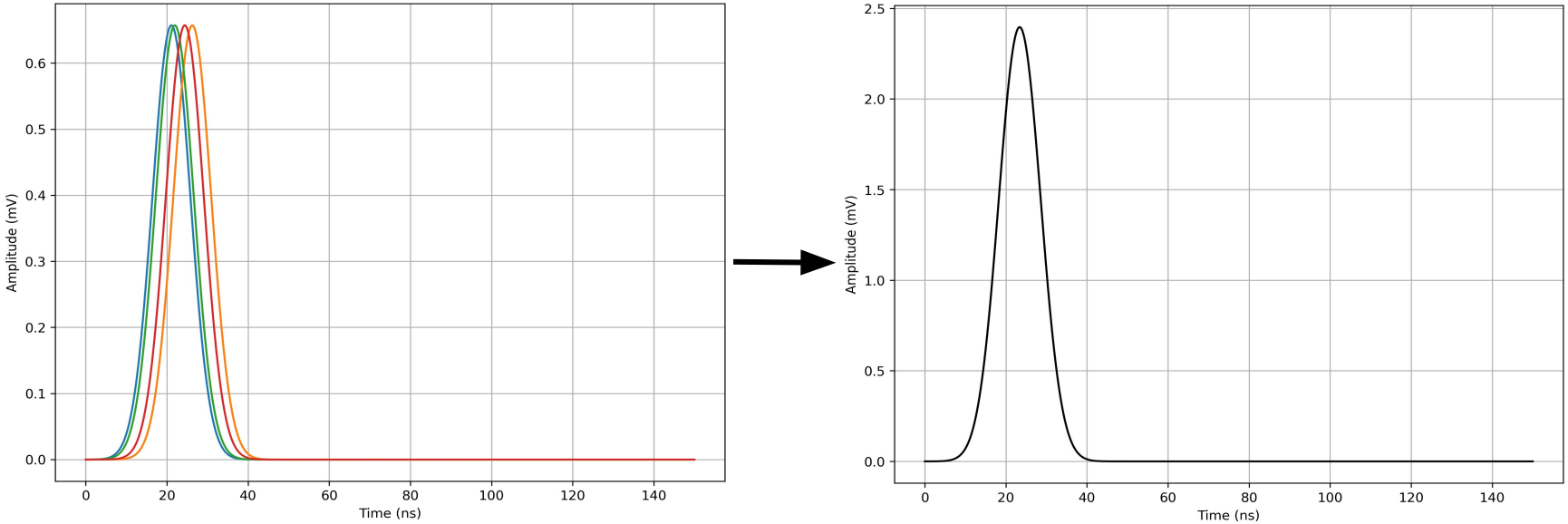


- Signal modeling:
  - Gaussian signal with FDHM of 11 ns;
  - Mean centered according to the time of arrival of the respective cluster + time of dispersion calculated for each electron;
  - Peak amplitude of 0.66 mV/e- and dispersion of 10% were considered.

Signal Generation

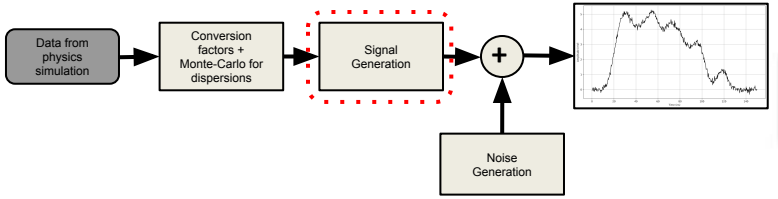
- For a single cluster:

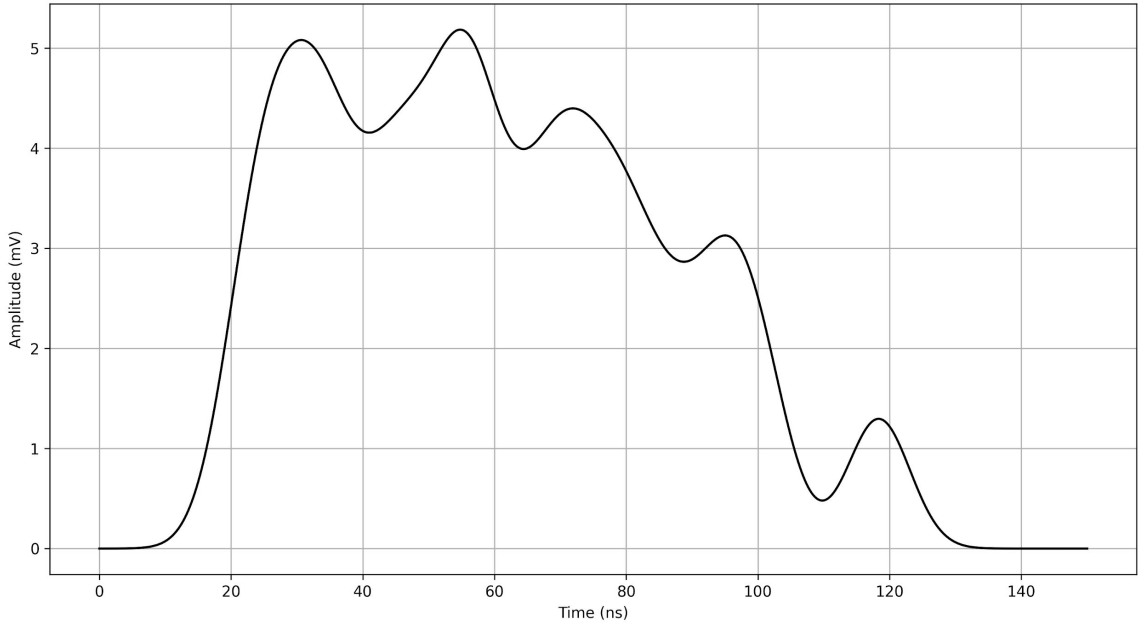




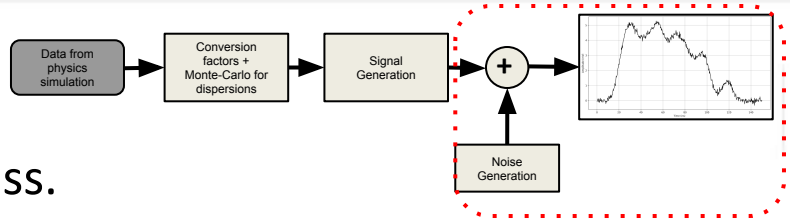
Signal Generation

- Sum of the electron signals:

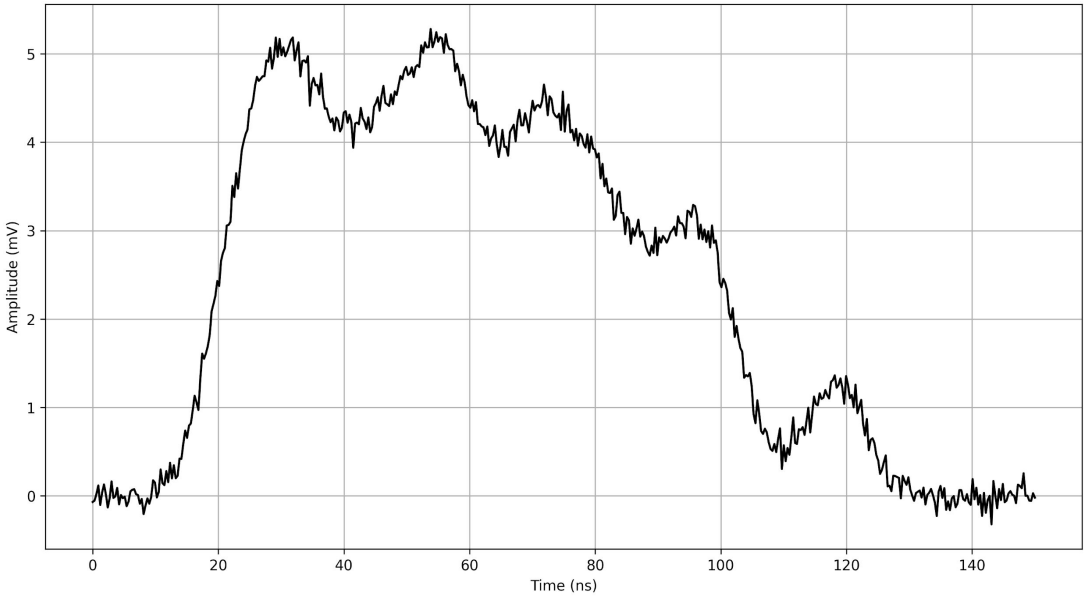




Signal Generation (noise addition)



- Adding noise signal
  - By now using White Gaussian Noise process.

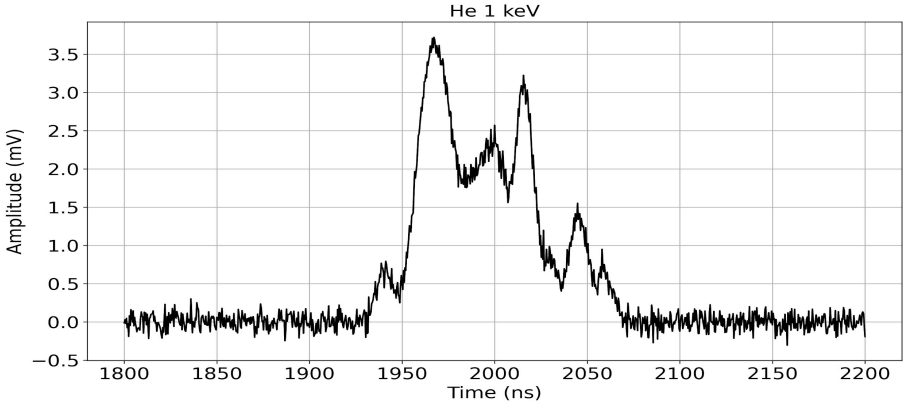


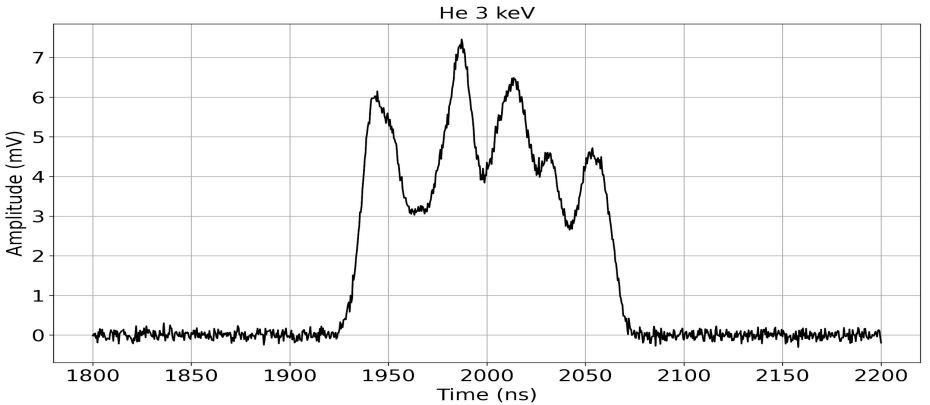
Examples using physics dataset

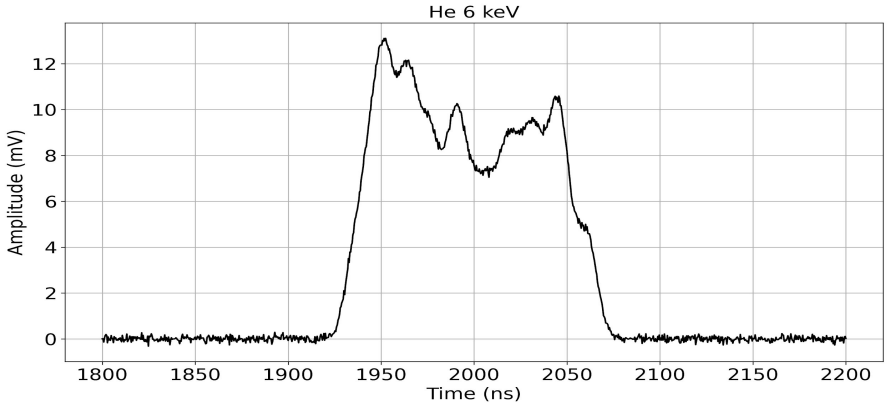
Steps using physics dataset

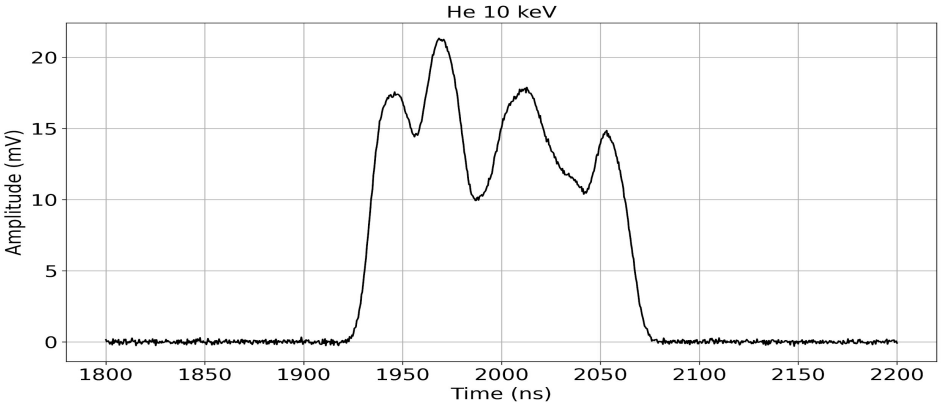
- For each simulated dataset:
  - The first recoil was selected;
  - Adopted distance from the GEM was around 10 cm;
  - Conversion factors and dispersions were calculated;
- Same noise process for all examples;
- Sample rate: 0.4 ns/sample.

Produced signals for 1 keV to 10 keV

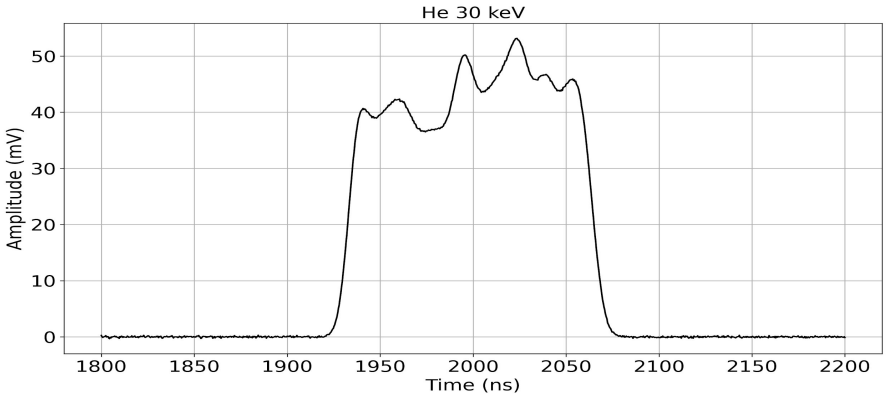


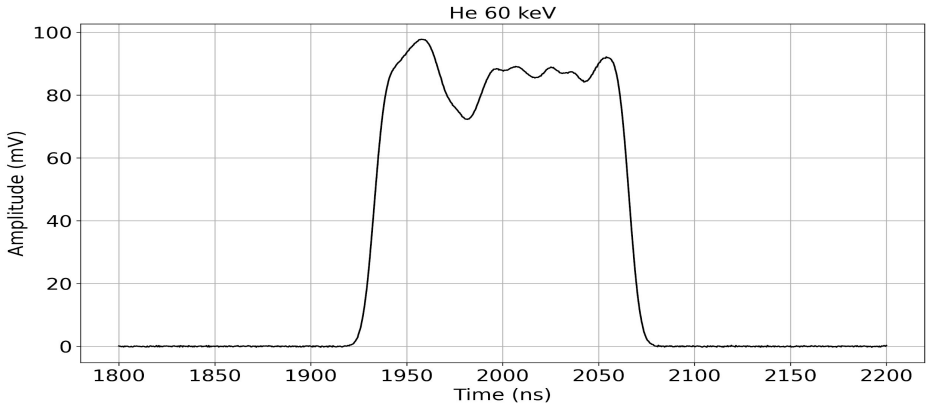


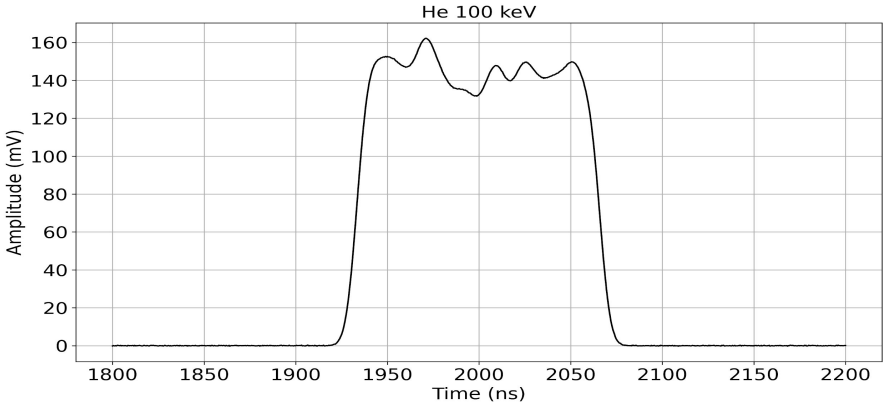




Produced signals for 30 keV to 100 keV







Conclusions and next steps

- **Parameters currently being used by the algorithm:**
  - Z axis
  - Energy loss converted to a number of electrons (1e-/40eV)
  - Time of arrival (5 cm/us) + dispersion (σ_T)
  - PMT signal shape (Gaussian with peak = 0.66 mV/e- and 10% of dispersion)
  - Noise (WGN)

- **To be improved or included:**
  - Input parameters
    - PMT signal shape (should be characterized? shape, peak and dispersion)
    - Check conversion factors: 1e-/40eV, 0.66 mV/e-, etc
  - Include DAQ parameters as:
    - Sampling rate and amplitude resolution

- **Suggestions??**