



Proton Computed Tomography

Data analysis with neural networks

Author: Dudás Bence

Eötvös Loránd University

Cancer Treatments in general



Treating cancer

- Locate cancer
 - Destroy cancerous cells
 - Minimize the harm in healthy cells
-

Treating cancer

- Locate cancer
- Destroy cancerous cells
- Minimize the harm in healthy cells



Treating cancer

- Locate cancer
- Destroy cancerous cells
- Minimize the harm in healthy cells



Treating cancer

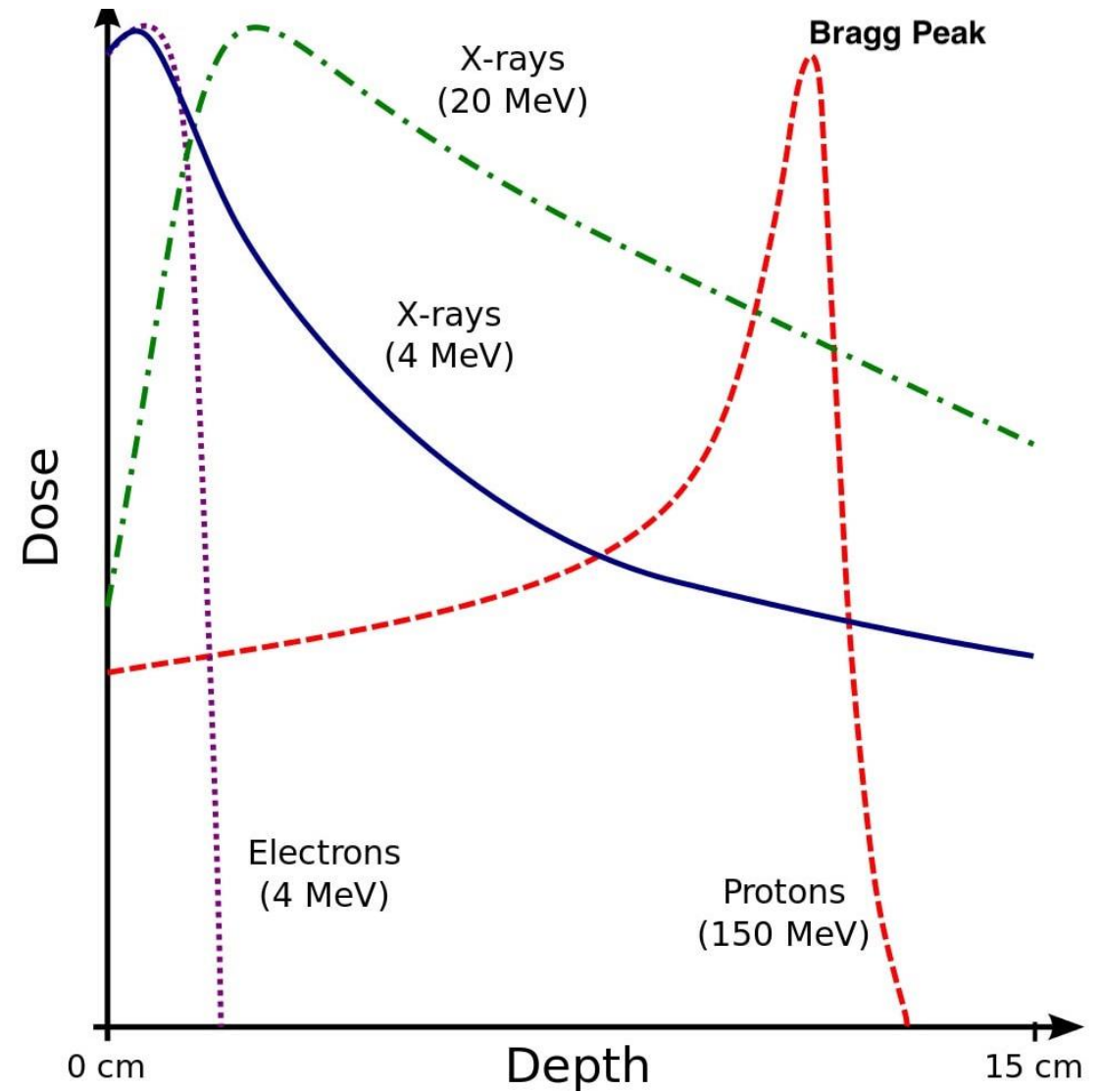
- Locate cancer
- Destroy cancerous cells
- Minimize the harm in healthy cells



What is Hadron Therapy

What is Hadron Therapy

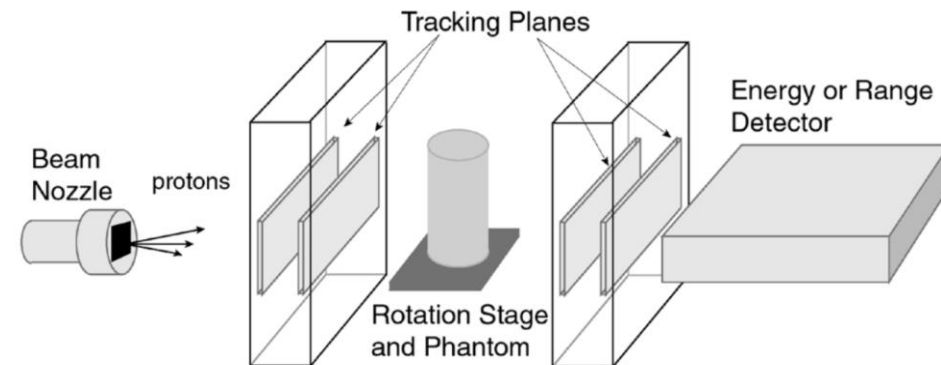
- Type of cancer therapy
- Radiation
- Using the Bragg-peak of protons
- Ambulant treatment
- Minimized harm
- Require tomography in respect of the proton



What is Proton Computed Tomography

Proton Computed Tomography

- Photons are absorbed
- Protons are scattered
- Uses high energy protons



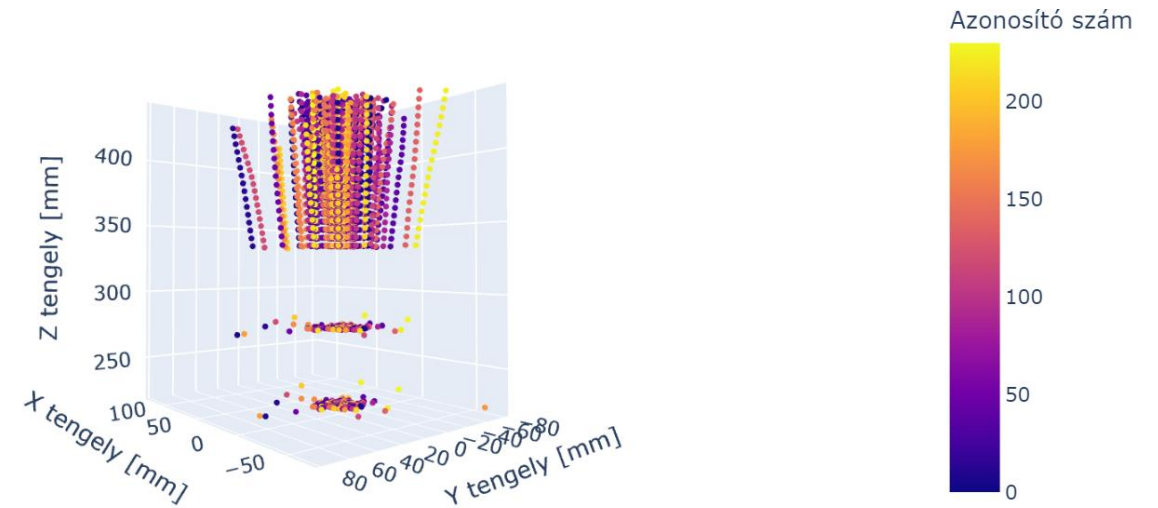


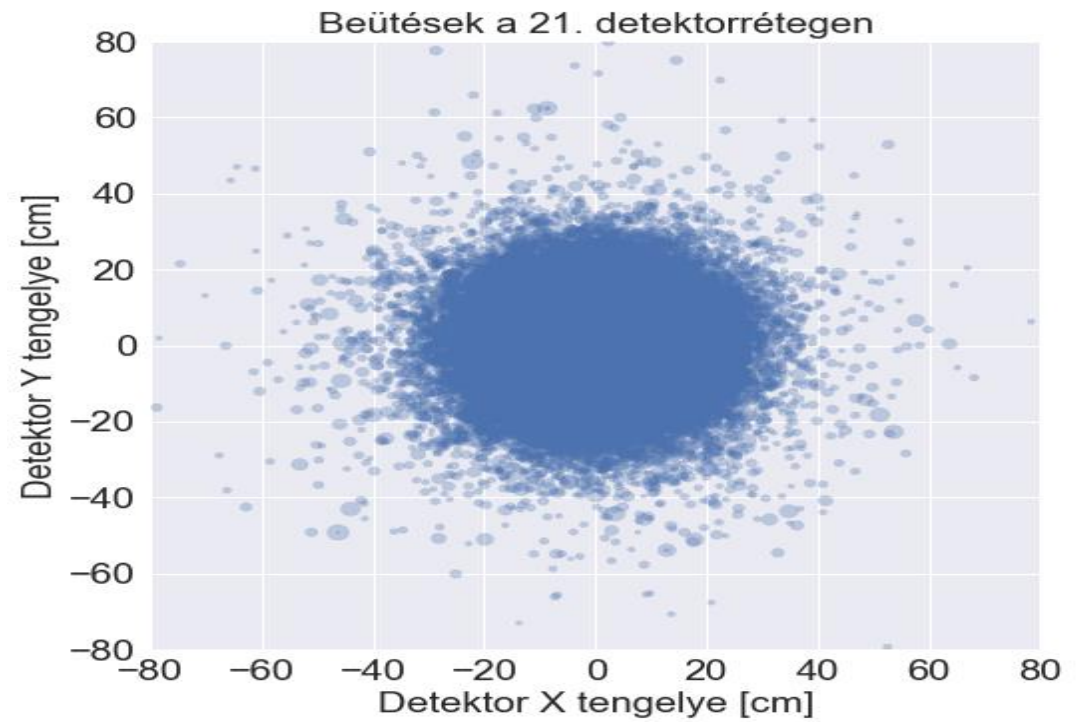
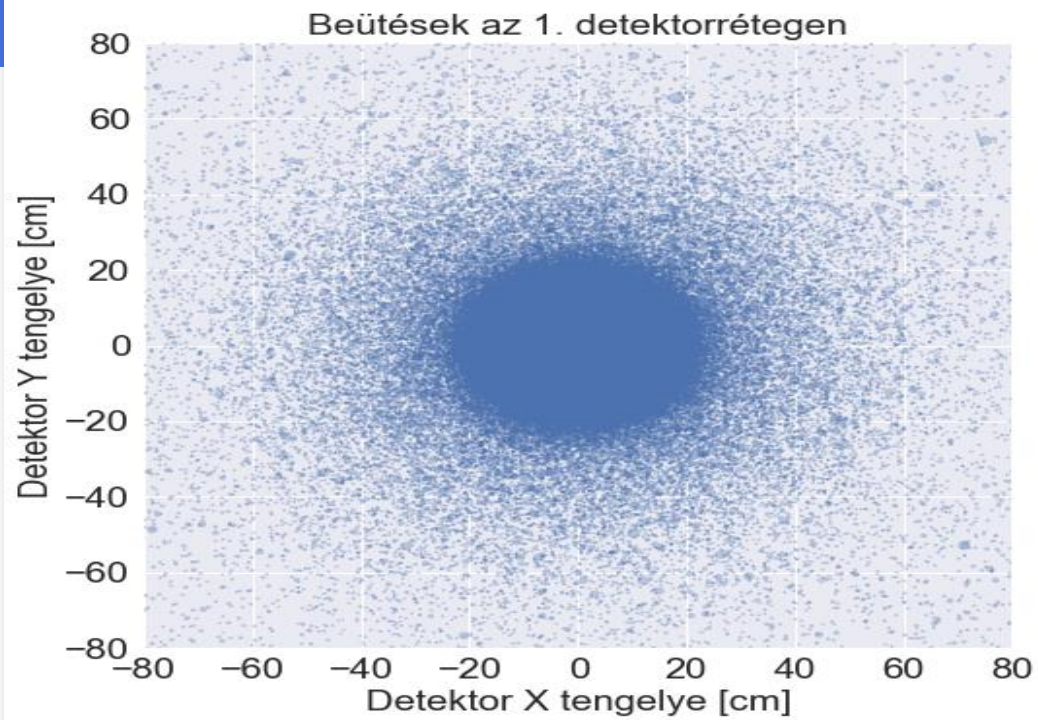
Problem to Machine Learning

- Reconstruct the trajectories
 - For image reconstruct we need:
 - Get the scattering angle
 - Get the energy deposition
-

Data Structure

- Unknown number of finite data points
- Every point consists of X,Y,Z position and energy deposit



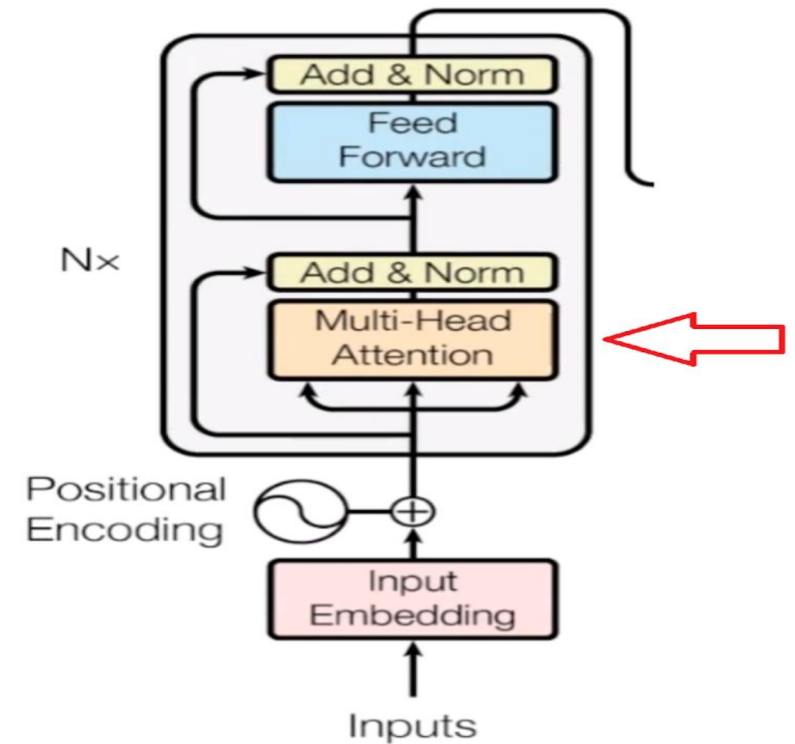


Data Structure

- Unknown number of finite data points
- Every point consists of X,Y,Z position and energy deposit

Transformers

- One of the most promising DL architecture
- Attention to time series
- Inputs(Key/Query): X,Y,DE,
- Targets(Value): ϕ , θ Kinetic Energy





Techniques

- From the last go through every detector layer
 - Connect their position with respect to the previous ones
 - Random permutation of data after every step
-

Techniques

Simplified input:

particleID	posX Layer 1	posY Layer 1	edep Layer 1	posX Layer 2	posY Layer 2	edep Layer 2	Layer 2 phi	Layer 2 theta	Layer 2 Kinetic Energy
201.0	-5.270845	-3.595398	0.017549	-4.385777	-2.706028	0.047970	0.558944	0.015338	1.010996
211.0	10.546306	-6.913294	0.014950	7.517128	-6.153238	0.013059	-0.189815	0.039254	0.984106
323.0	-6.645960	9.060479	0.020807	-6.385914	9.027344	0.017258	0.631320	0.001503	0.977893
426.0	9.977738	-4.597143	0.019536	4.087589	-1.368756	0.021477	-0.245477	0.007361	1.006767
610.0	-24.864347	5.516530	0.022252	-20.606434	4.643063	0.011719	-0.142552	0.050522	0.988553
638.0	4.233015	6.192639	0.018278	2.743159	5.259545	0.025586	0.380910	0.017769	0.984155
704.0	27.766716	17.202879	0.015921	22.179344	12.701468	0.020413	0.444017	0.084300	0.970685
717.0	14.715588	-0.694850	0.021307	12.158639	-0.234766	0.023950	-0.097056	0.029246	0.987204
801.0	12.039177	-6.085821	0.028384	11.070741	-3.372214	0.013725	-0.821730	0.030957	0.997857
807.0	7.407540	-4.109287	0.023920	5.940067	-3.212990	0.028634	-0.427719	0.021717	1.006031

Techniques

Simplified input:

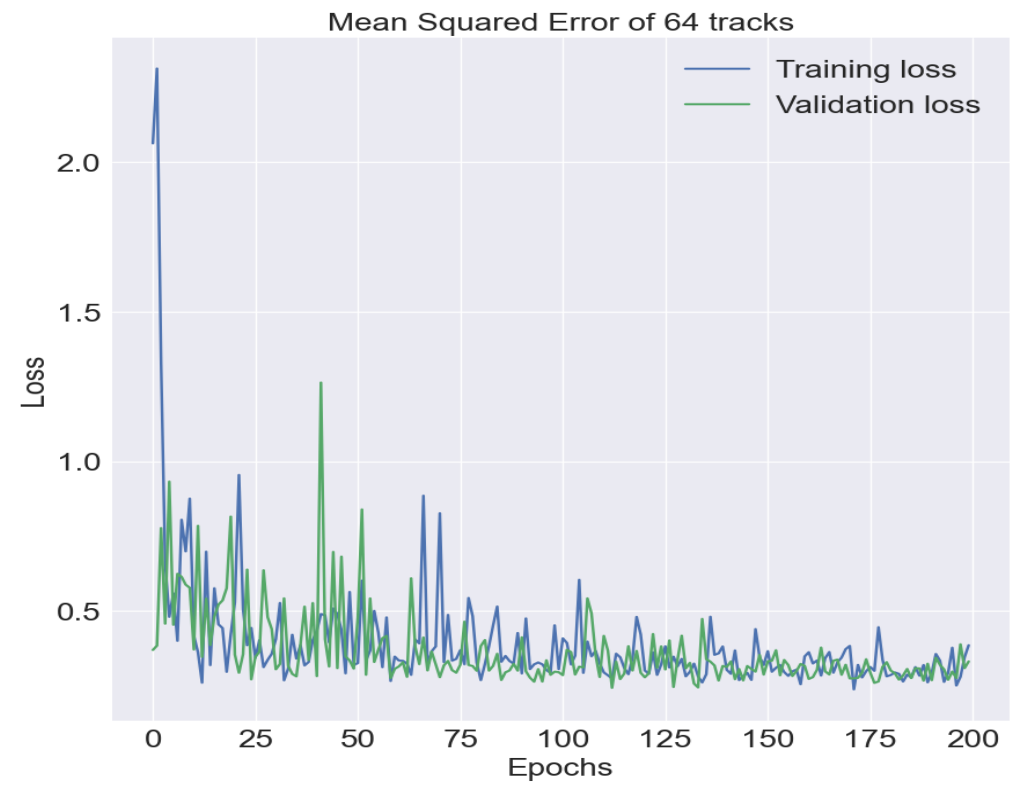
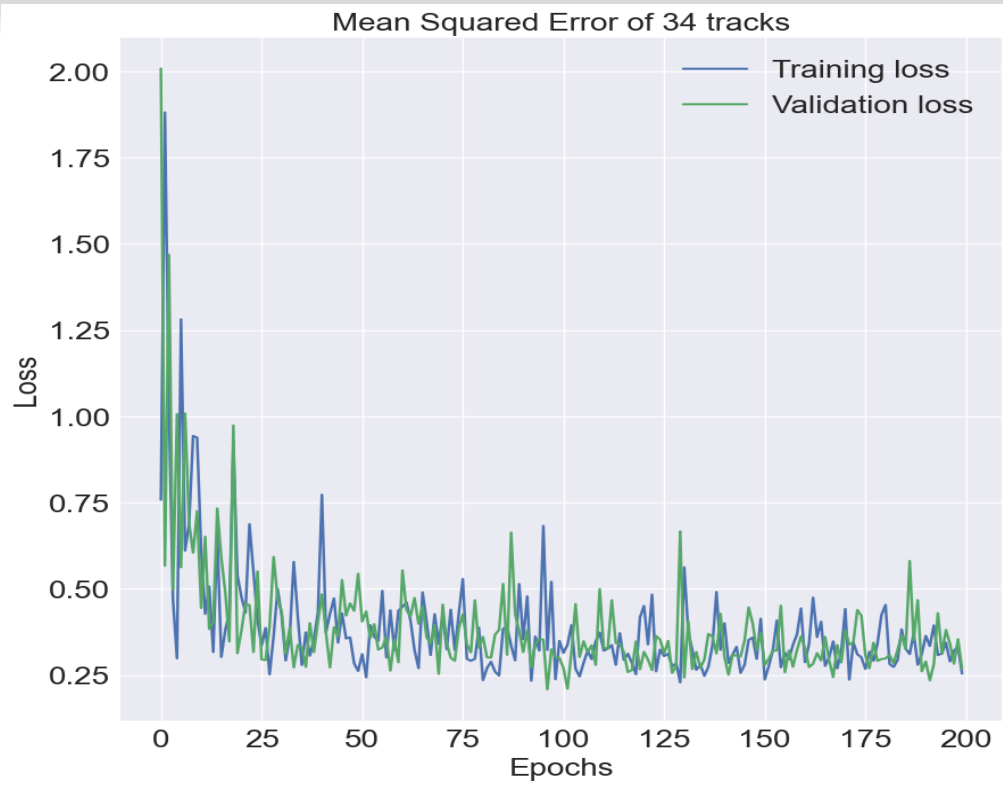
particleID	posX Layer 1	posY Layer 1	edep Layer 1	posX Layer 2	posY Layer 2	edep Layer 2	Layer 2 phi	Layer 2 theta	Layer 2 Kinetic Energy
201.0	-5.270845	-3.595398	0.017549	-4.385777	-2.706028	0.047970	0.558944	0.015338	1.010996
211.0	10.546306	-6.913294	0.014950	7.517128	-6.153238	0.013059	-0.189815	0.039254	0.984106
323.0	-6.645960	9.060479	0.020807	-6.385914	9.027344	0.017258	0.631320	0.001503	0.977893
426.0	9.977738	-4.597143	0.019536	4.087589	-1.368756	0.021477	-0.245477	0.007361	1.006767
610.0	-24.864347	5.516530	0.022252	-20.606434	4.643063	0.011719	-0.142552	0.050522	0.988553
638.0	4.233015	6.192639	0.018278	2.743159	5.259545	0.025586	0.380910	0.017769	0.984155
704.0	27.766716	17.202879	0.015921	22.179344	12.701468	0.020413	0.444017	0.084300	0.970685
717.0	14.715588	-0.694850	0.021307	12.158639	-0.234766	0.023950	-0.097056	0.029246	0.987204
801.0	12.039177	-6.085821	0.028384	11.070741	-3.372214	0.013725	-0.821730	0.030957	0.997857
807.0	7.407540	-4.109287	0.023920	5.940067	-3.212990	0.028634	-0.427719	0.021717	1.006031

The targets:

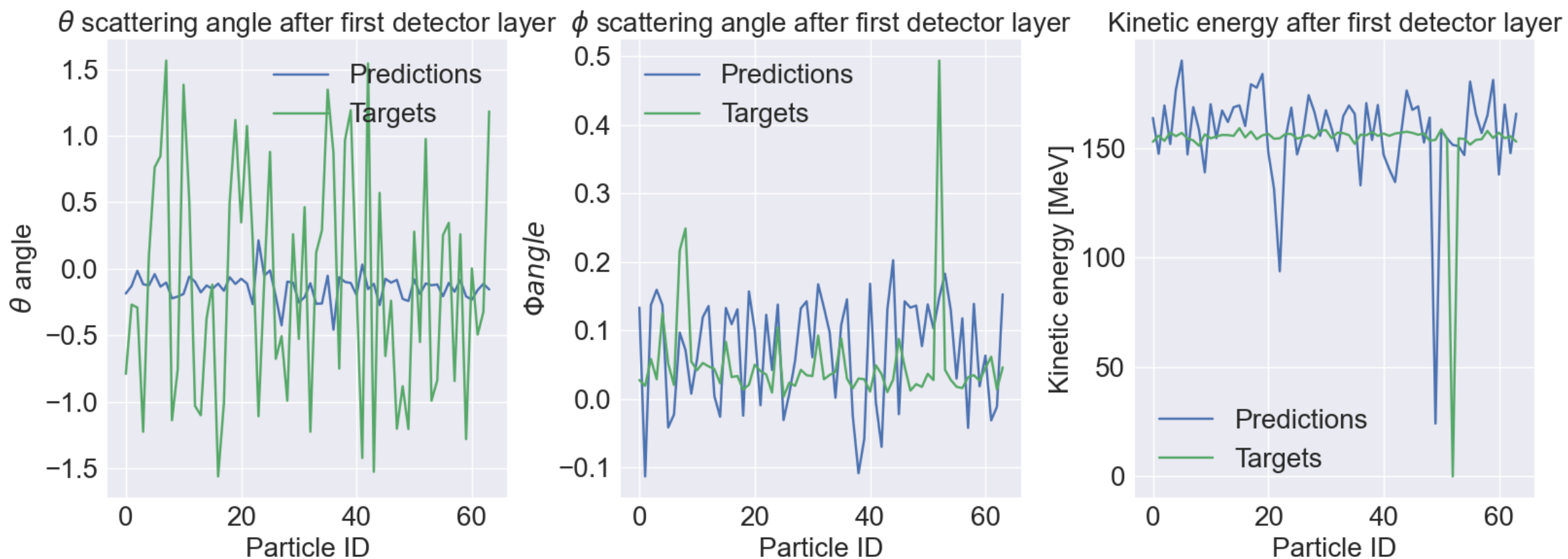
particleID	phi Layer 1	theta Layer 1	Kinetic Energy Layer 1
201.0	0.514713	0.014221	1.004261
211.0	-0.171526	0.036071	0.979061
323.0	-0.126409	0.002932	0.972875
426.0	-0.333796	0.077350	0.999797
610.0	-0.129275	0.049894	0.982761
638.0	0.371393	0.020308	0.978153
704.0	0.452268	0.082123	0.966255
717.0	-0.113383	0.029899	0.981227
801.0	-0.822665	0.033471	0.993475
807.0	-0.368660	0.019950	1.000267

Results

Results



Results





Thank you!



Thank you for my supporters!

- Dr. Papp Gábor & Dr. Bíró Gábor
- A kutatás az Európai Unió támogatásával valósult meg, az RRF-2.3.1-21-2022-00004 azonosítójú, Mesterséges Intelligencia Nemzeti Laboratórium projekt keretében.
- MassivPara@HEP (2020-2.1.1-ED-2021-00179)

Resources

- <https://www.uwa.edu.au/study/courses/master-of-surgery>
- <https://www.timesofisrael.com/major-israeli-hospital-admits-giving-cancer-patients-expired-chemotherapy-drugs/>
- <https://www.saferradiationtherapy.com/radiation-therapy-2/>
- <https://builtin.com/artificial-intelligence/transformer-neural-network>