The state-of-the-art quantum technology

The Transformer & its Applications to High Energy Physics Problems

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Higgs to jets samples

☐ The $\nu\nu H \to b\bar{b}/c\bar{c}/gg$ samples from the arXiv: 2203.01469.

☐ The paper uses cut-based plus BDT for classifications.

☐ We could classify signal and background as done on the paper.

☐ Or we could do jet tagging ($b\bar{b}$, $c\bar{c}$, and gg) using Q/ParT.

☐ Make sure that the samples are correct:

   ○ Cut-flow cross-check

	$\nu\bar{\nu}Hq\bar{q}/gg$	2f	SW	SZ	WW	ZZ	Mixed	ZH	$\gamma\gamma$	$\frac{\sqrt{S+B}}{S}$ (%)
total	178890	8.01E8	1.95E7	9.07E6	5.08E7	6.39E6	2.18E7	961606	4.91E8	20.92
recoilMass (GeV) $\in (74, 131)$	157822	5.11E7	2.17E6	1.38E6	4.78E6	1.30E6	1.08E6	74991	2.69E7	5.98
visEn (GeV) $\in (109, 143)$	142918	2.37E7	1.35E6	8.81E5	3.60E6	1.03E6	6.29E5	50989	1.31E7	4.67
leadLepEn (GeV) $\in (0, 42)$	141926	2.08E7	3.65E5	7.24E5	2.81E6	9.72E5	1.34E5	46963	1.31E7	4.41
multiplicity $\in (40, 130)$	139545	1.66E7	2.36E5	5.24E5	2.62E6	9.07E5	4977	42751	1.24E7	4.15
leadNeuEn (GeV) $\in (0, 41)$	138653	1.46E7	2.24E5	4.72E5	2.49E6	8.69E5	4552	42303	1.10E7	3.94
Pt (GeV) $\in (20, 60)$	121212	248715	1.56E5	2.48E5	1.51E6	4.31E5	999	35453	1437	1.37
Pl (GeV) $\in (0, 50)$	118109	52784	1.05E5	74936	7.30E5	1.13E5	847	34279	1078	0.94
-log10(Y23) $\in (3.375, +\infty)$	96156	40861	26088	60349	2.25E5	82560	640	10691	1078	0.76
InvMass (GeV) $\in (110, 134)$	71758	22200	11059	6308	77912	13680	248	6915	359	0.64

☐ Cut-flow table from the original paper.

	$vvHqq/gg$	2f	SW	SZ	WW	ZZ	Mixed	ZH
Total	178889.77	801152067.77	19517400.70	10470039.73	50826215.02	6389432.00	20440839.31	80334.24
Recoil mass	157822.20	51183332.82	2175314.86	1760978.73	4776953.11	1303308.92	704595.62	43683.76
vis E	142918.00	23839267.87	1344895.23	1112718.63	3601425.26	1033507.56	396240.59	34533.09
Lead lepton E	141926.22	20869832.50	365035.93	746362.50	2813180.59	974044.25	109207.21	32244.82
Multiplicity	139182.69	16529204.40	231920.89	517324.71	2584821.43	899699.65	4368.30	29281.43
Lead v E	138297.26	14576550.43	220583.04	467276.66	2460346.26	863582.14	4068.15	28998.24
pt	120910.03	245084.20	151821.97	246718.86	1494007.36	427499.91	903.45	25259.34
pl	117814.00	52065.69	104070.62	74364.01	721367.19	112333.31	752.97	24462.33
-log10(Y23)	95968.53	40143.37	25738.27	59852.52	222980.62	81876.77	546.12	6502.74
Inv mass	1071.84	6045.30	749.27	479.69	5397.31	1179.03	29.97	62.14

Hybrid-Quantum Transformer

☐ Measuring Pauli bases for each qubit instead of the count.

☐ Total number of events: 50k.

☐ Training, validation, and testing: 160k, 6k, and 7.5k

☐ Number of variables: six

☐ L rate & batch: 0.0036 & 128

☐ **Architecture:**

   ○ $d_{FF} = 500$

   ○ Dropout = 0.0066

   ○ $iL = 6$

   ○ $h = 4$

   ○ Embedded dimension: 64

☐ Total time for the training and validation: 16h:8m:40s
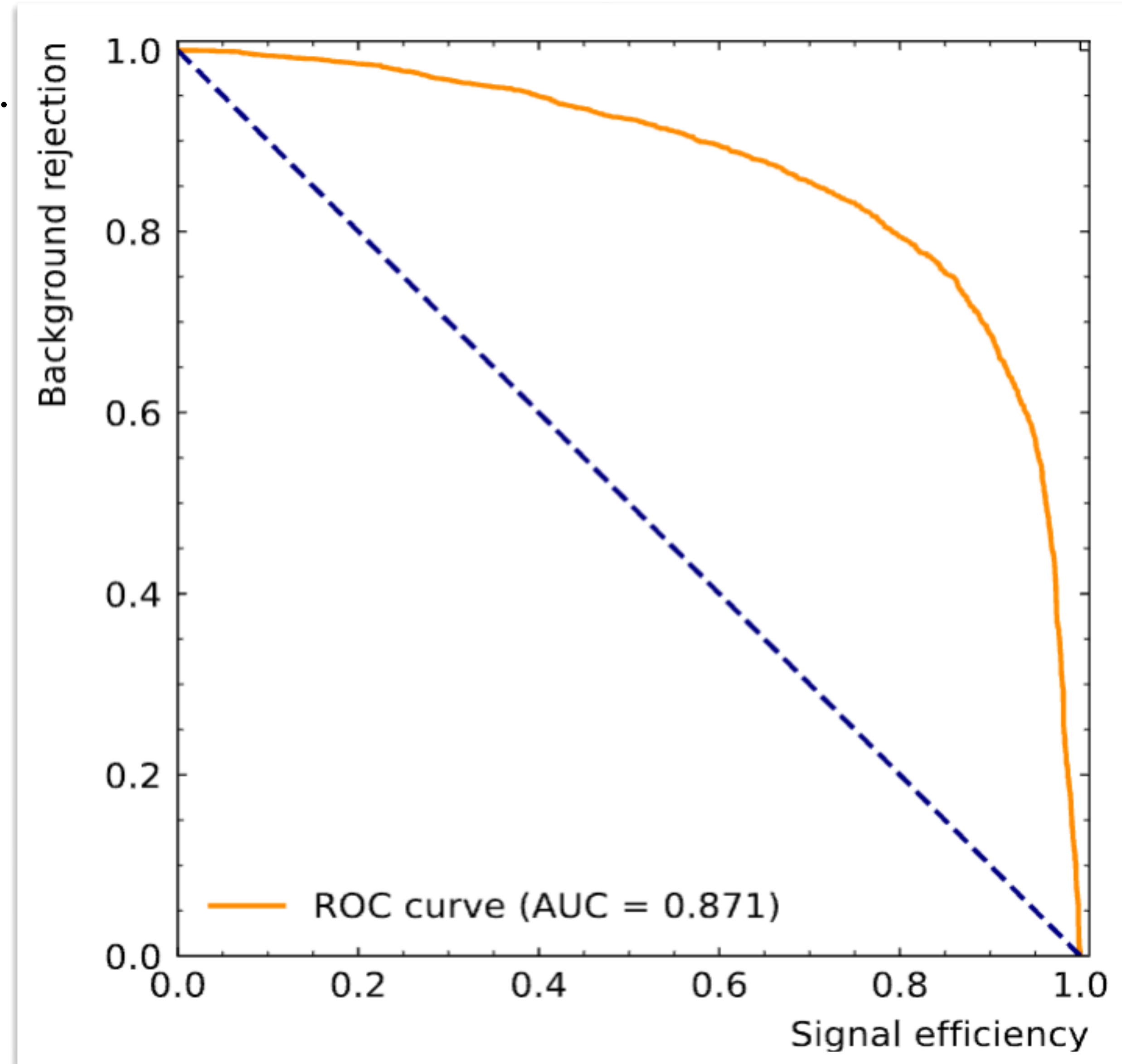
Summary

☐ I'm checking the Higgs to Jet samples and cross-checking them with the numbers on the paper.

☐ However, the numbers, especially the background ones, do not match up.

☐ The Hybrid-Quantum Transformer with Z Pauli bases was checked.

☐ The training time was improved at the cost of the performance.

☐ I'm trying to update the QParT with our new update so far and pass it to Mustapha.