Update on the noise performance of the FE chip for the Silicon Strip Detectors of the Super B SVT Inner Layers

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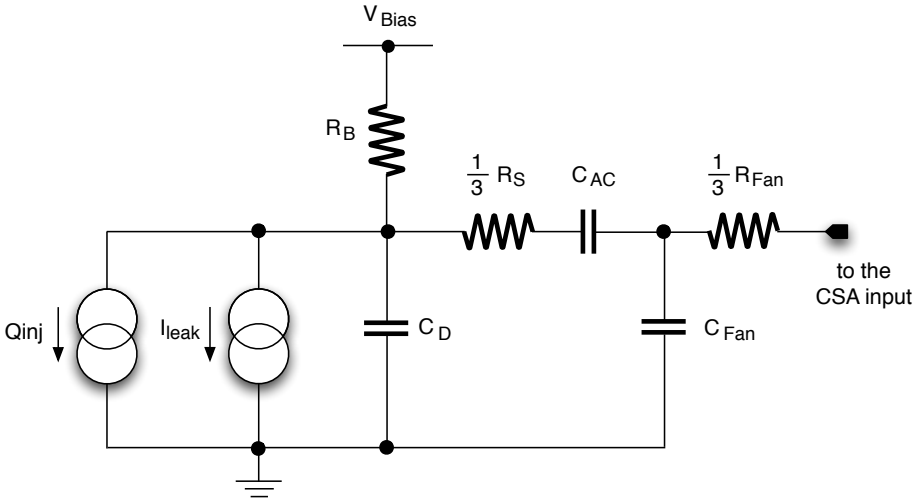
Detector Model and Parameters[1]



- Total Capacitance: $C_T = C_D + C_{Fan}$
- Total Resistance: $R_T = R_S + R_{Fan}$
- Decoupling Capacitance: $C_{AC} = 20 \cdot C_D$
- Leakage Current Shot Noise: $S_{leak}(f) = 2qI_{leak}$
- 1/3 coefficient for the distributed resistances
- Pairing $\times 2$ only in z side Layers 1, 2 and 3
- Option A only for Layer 3

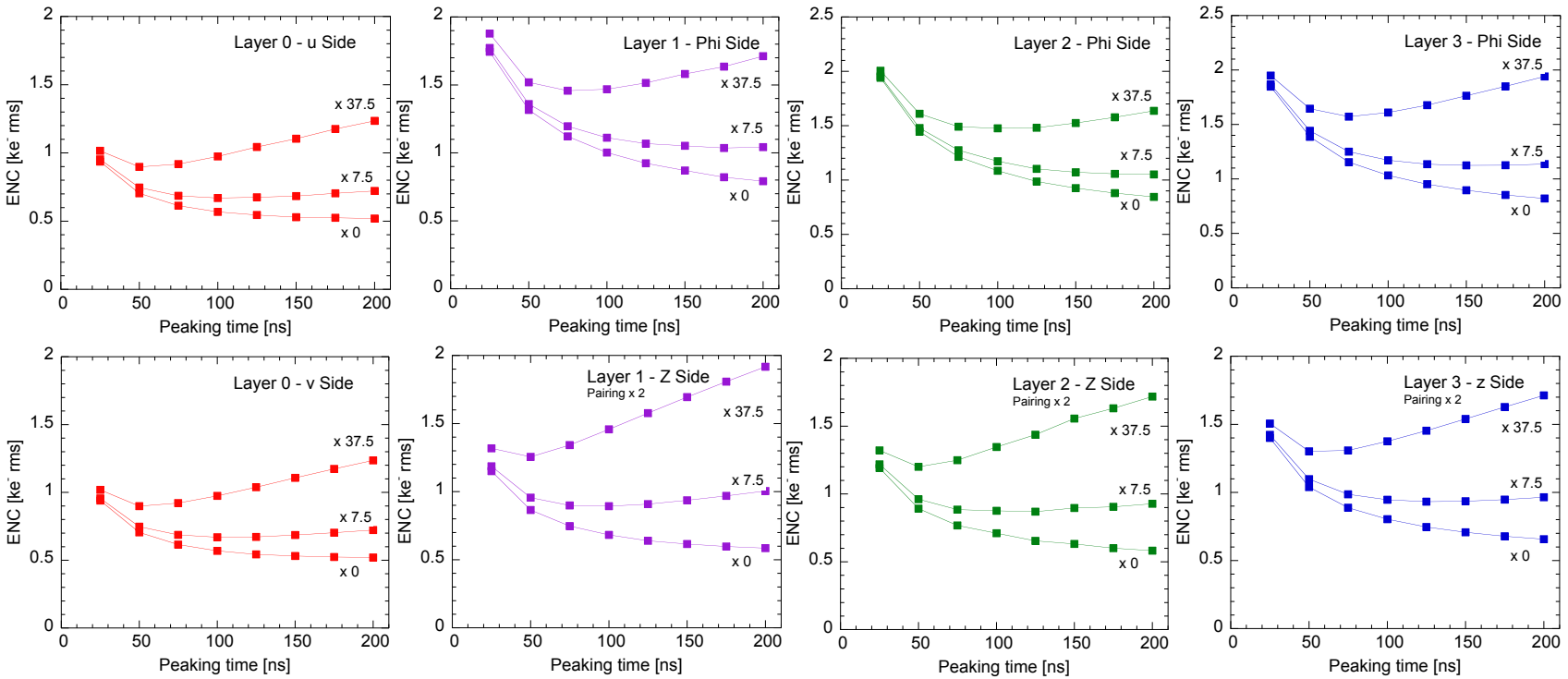
Layer	Sensor Side	Fanout Capacitance C_{Fan} [pF]	Fanout Resistance R_{Fan} [Ω]	Total Capacitance C_T [pF]	Total Resistance R_T [Ω]	Total R bias R_B [MΩ]	Total leakage I_{leak} [nA]
0-u	p	10	18	14.9	44	1	749
0-v	n	10	18	14.9	59	1	749
1 phi	n	5.8	12	33.4	107	1	1378
1 z	p	7	14	16.2	22	1	1992
2 phi	n	4.7	7	37.2	94	0.5	1158
2 z	p	7	14	18.0	24	1	1553
3 phi	p	3.4	7.5	35.7	84	1	1817
3 z	n	8.5	16	24.6	39	2	1475
4 phi	p	1.5	3.2	53.1	125	2.7	1917
4 z	n	21	53	47.2	99	3.3	2043
5 phi	p	1.5	3.2	66.2	155	3.6	2128
5 z	n	26	66	52.2	112	6.7	1809

[1] L. Bosisio - 03/09/2012

Equivalent Noise Charge for Inner Layers (L0-L3)

For each Layer the total ENC has been evaluated

- for fresh detectors with $\approx$ no leakage ($\times 0$)
- after 7.5 years of operation ($\times 7.5$)
- after 7.5 years of operation with a safety factor of 5 ($\times 37.5$)

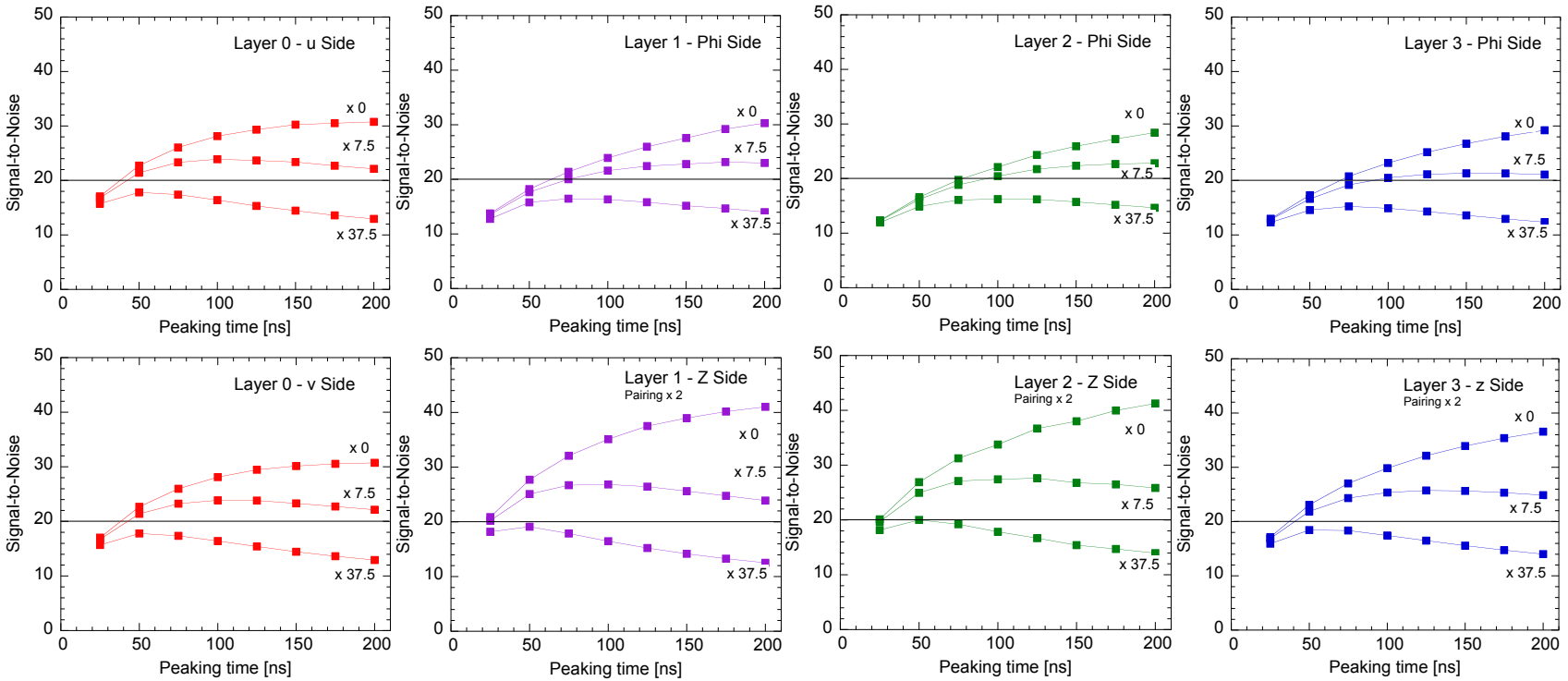


A detailed evaluation of ENC contributions can be found in backup slides:

▸ Layer 0 ▸ Layer 1 ▸ Layer 2 ▸ Layer 3

S/N ratio vs t_P at 1 MIP for Inner Layers (L0-L3)

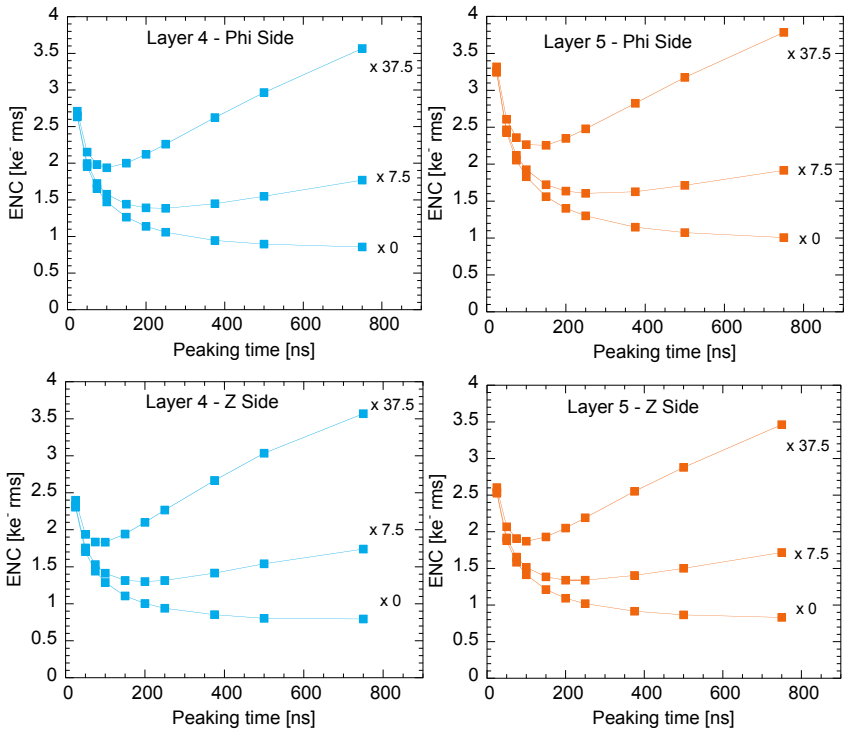
S/N evaluated at 1 MIP (16 ke- in L0 and 24 ke- in L1 to L3)



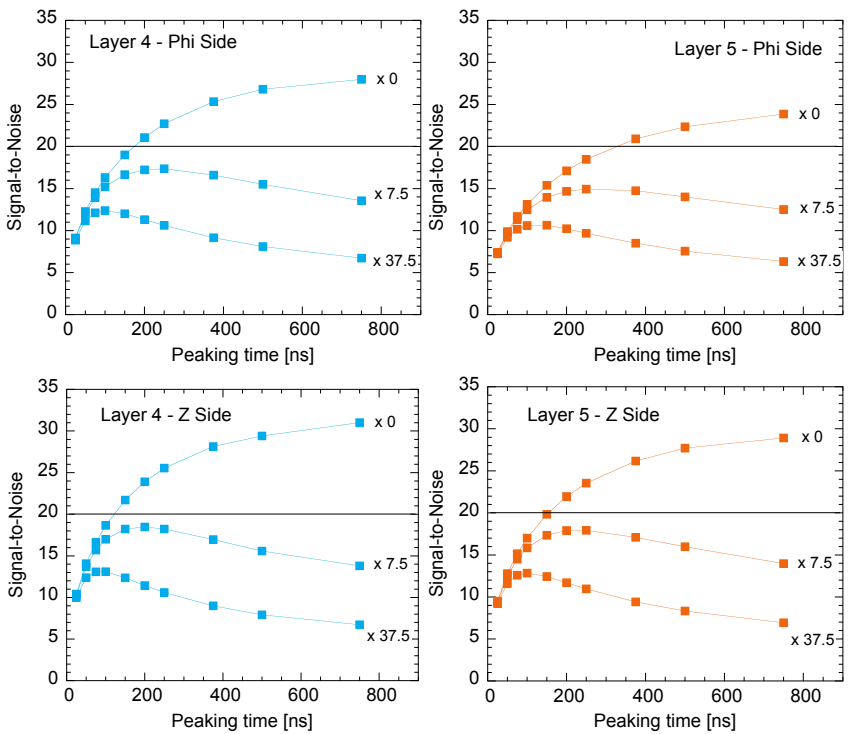
ENC and S/N ratio vs t_P at 1 MIP for Outer Layers (L4-L5)

The performance of the chip developed for the inner layers has been evaluated also for the outer layers with an extended range of peaking times

Equivalent Noise Charge



S/N ratio vs t_P at 1 MIP

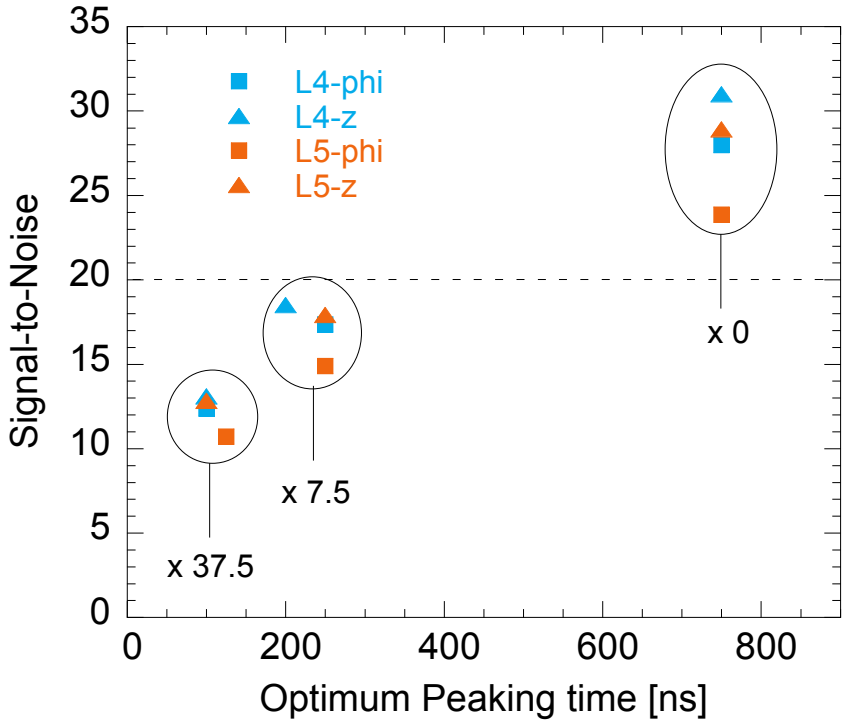


A detailed evaluation of ENC contributions can be found in backup slides:

▸ Layer 4 ▸ Layer 5

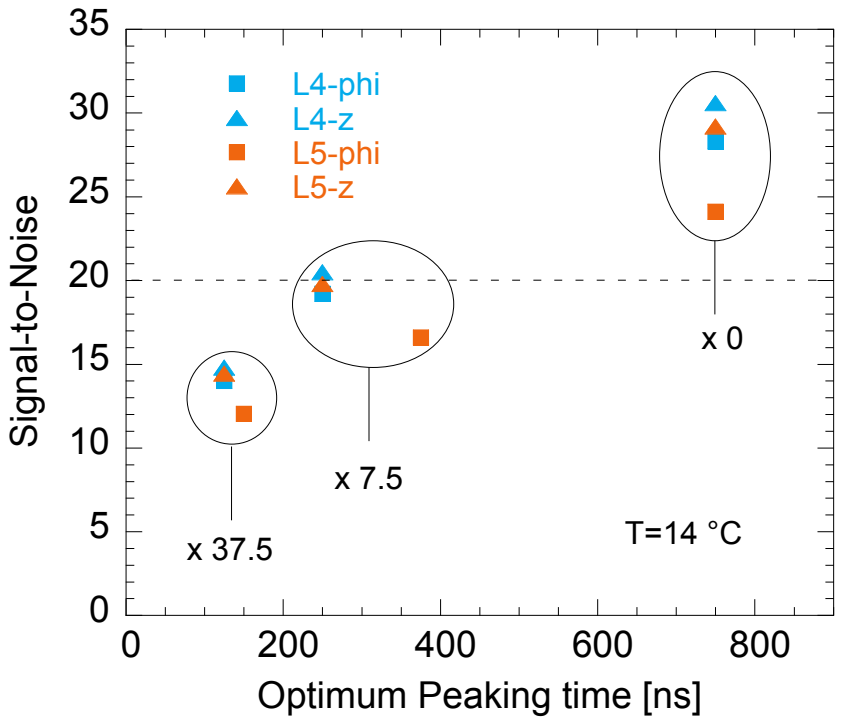
Optimum S/N vs t_P at 1 MIP for Outer Layers (L4-L5)

Simulation performed at T=20 °C



Layer	S/N	S/N 7.5 years	S/N 7.5 years with ×5
4 phi	28	17	12
4 z	31	18	13
5 phi	24	15	11
5 z	29	18	13

Simulation performed at T=14 °C



Layer	S/N	S/N 7.5 years	S/N 7.5 years with ×5
4 phi	28	19	14
4 z	31	21	15
5 phi	24	17	12
5 z	29	20	14

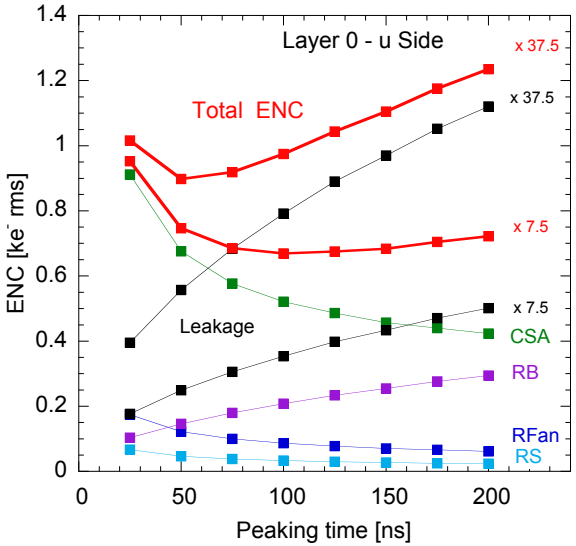
Equivalent Noise Charge and S/N

Layer	t_p [ns] Selected	Total ENC [e rms]	Total ENC [e rms] after 7.5 years	Total ENC [e rms] after 7.5 years with $\times 5$ safety factor	S/N	S/N after 7.5 years	S/N after 7.5 years with $\times 5$ safety factor
0 u	25	936	952	1016	17	17	16
0 v	25	939	956	1019	17	17	16
1 phi	75	1122	1197	1457	21	20	16
1 z	75	748	899	1342	32	27	18
2 phi	100	1085	1174	1476	22	20	16
2 z	100	711	876	1346	34	27	18
3 phi	150	897	1125	1763	27	21	14
3 z	150	707	935	1540	34	27	16
4 phi	500	895	1548	2964	27	15	8
4 z	500	802	1540	3034	29	16	8
5 phi	750	1005	1916	3785	24	12	6
5 z	750	829	1717	3463	29	14	7

Backup Slides

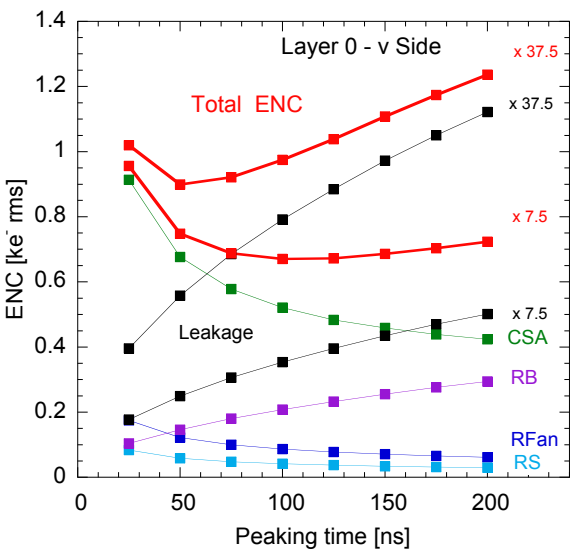
ENC in Layer 0

u Side



t_p [ns]	ENC [e rms]							
	CSA	R_{Fan}	R_S	R_B	I_{leak}		Total	
					$\times 7.5$	$\times 37.5$	$\times 7.5$	$\times 37.5$
25	911	174	67	104	177	395	**953**	**1015**
50	676	122	47	146	249	557	**747**	**898**
75	576	100	38	180	306	684	**686**	**919**
100	520	87	33	208	354	792	**670**	**974**
125	486	78	30	234	398	890	**675**	**1044**
150	457	71	27	255	434	970	**684**	**1104**
175	440	66	25	276	471	1052	**704**	**1175**
200	423	62	24	294	501	1120	**722**	**1235**

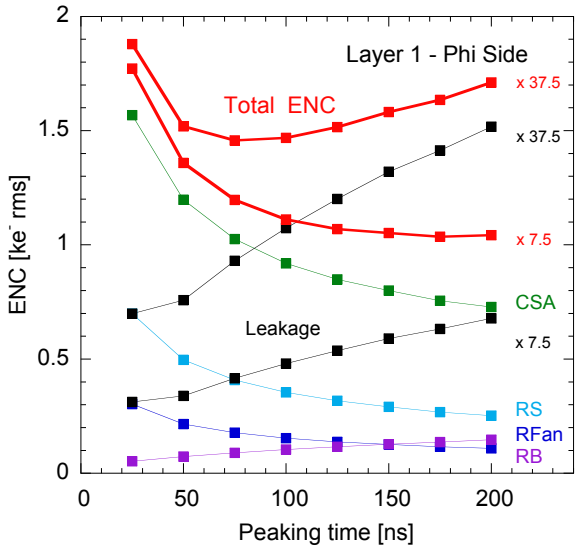
v Side



t_p [ns]	ENC [e rms]							
	CSA	R_{Fan}	R_S	R_B	I_{leak}		Total	
					$\times 7.5$	$\times 37.5$	$\times 7.5$	$\times 37.5$
25	913	175	84	103	177	396	**956**	**1019**
50	676	122	59	146	249	558	**748**	**899**
75	578	100	48	180	306	685	**688**	**921**
100	521	87	42	208	354	791	**670**	**975**
125	483	78	37	232	396	884	**672**	**1038**
150	458	71	34	255	435	972	**686**	**1108**
175	439	66	32	276	470	1050	**703**	**1174**
200	424	62	30	294	501	1121	**723**	**1236**

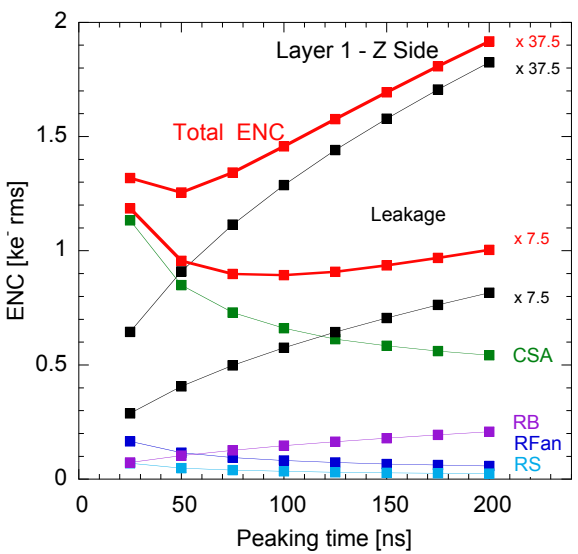
ENC in Layer 1

Phi Side



t_p [ns]	ENC [e rms]							
	CSA	R_{Fan}	R_S	R_B	I_{leak}		Total	
					$\times 7.5$	$\times 37.5$	$\times 7.5$	$\times 37.5$
25	1568	303	699	52	312	698	**1772**	**1878**
50	1197	216	497	73	339	758	**1359**	**1519**
75	1025	177	409	90	416	930	**1197**	**1457**
100	919	154	354	104	480	1073	**1111**	**1468**
125	849	138	318	116	537	1201	**1069**	**1515**
150	800	126	291	128	590	1320	**1052**	**1581**
175	755	116	268	137	632	1413	**1036**	**1635**
200	728	109	252	147	678	1517	**1043**	**1711**

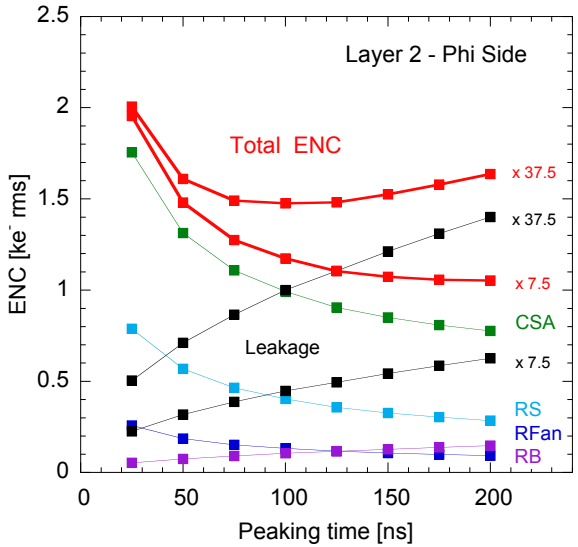
Z Side with Pairing $\times 2$ only



t_p [ns]	ENC [e rms]							
	CSA	R_{Fan}	R_S	R_B	I_{leak}		Total	
					$\times 7.5$	$\times 37.5$	$\times 7.5$	$\times 37.5$
25	1134	166	70	73	288	645	**1186**	**1318**
50	850	116	49	103	407	909	**956**	**1255**
75	730	95	40	127	498	1114	**899**	**1342**
100	661	82	34	146	576	1288	**893**	**1457**
125	613	73	31	164	644	1440	**908**	**1576**
150	584	67	28	179	706	1578	**936**	**1693**
175	561	62	26	194	763	1706	**969**	**1808**
200	543	58	24	208	816	1825	**1004**	**1916**

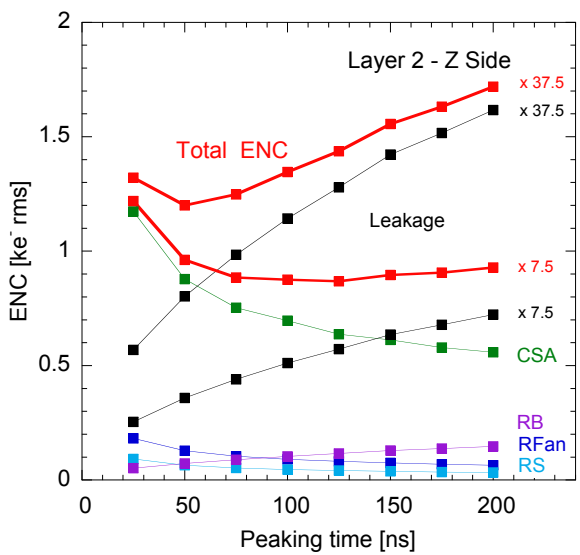
ENC in Layer 2

Phi Side



t_p [ns]	ENC [e rms]							
	CSA	R_{Fan}	R_S	R_B	I_{leak}		Total	
					$\times 7.5$	$\times 37.5$	$\times 7.5$	$\times 37.5$
25	1755	257	787	53	225	503	**1954**	**2006**
50	1313	186	568	75	318	710	**1479**	**1610**
75	1108	152	464	91	387	865	**1274**	**1491**
100	993	132	403	105	447	1000	**1174**	**1476**
125	905	117	357	116	494	1105	**1103**	**1481**
150	850	107	327	127	541	1211	**1073**	**1525**
175	809	99	303	137	586	1310	**1057**	**1578**
200	776	93	284	147	627	1401	**1052**	**1636**

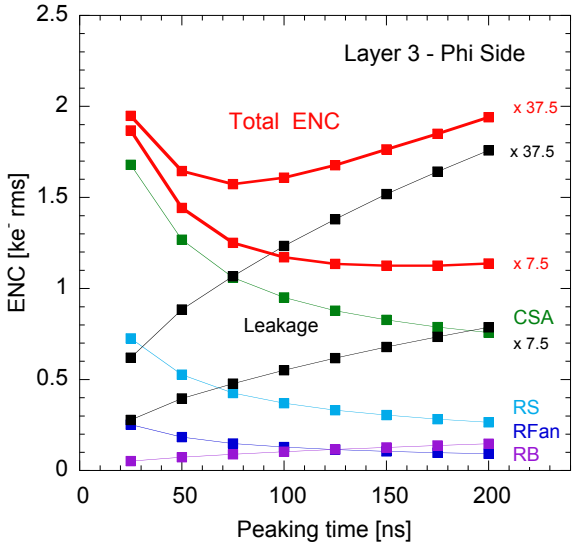
Z Side with Pairing $\times 2$ only



t_p [ns]	ENC [e rms]							
	CSA	R_{Fan}	R_S	R_B	I_{leak}		Total	
					$\times 7.5$	$\times 37.5$	$\times 7.5$	$\times 37.5$
25	1173	182	92	52	254	569	**1219**	**1320**
50	878	128	65	73	359	802	**962**	**1200**
75	753	104	53	89	440	984	**884**	**1248**
100	696	91	46	104	511	1142	**876**	**1345**
125	637	81	41	116	572	1279	**869**	**1437**
150	612	75	38	129	635	1422	**896**	**1556**
175	579	69	35	137	678	1517	**906**	**1631**
200	558	64	33	147	723	1617	**928**	**1718**

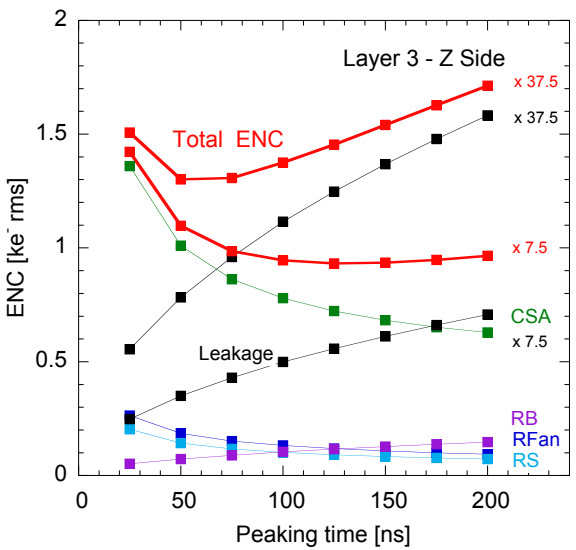
ENC in Layer 3

Phi Side



t_p [ns]	ENC [e rms]							
	CSA	R_{Fan}	R_S	R_B	I_{leak}		Total	
					×7.5	×37.5	×7.5	×37.5
25	1679	252	726	52	277	620	**1868**	**1948**
50	1268	183	527	74	395	884	**1442**	**1645**
75	1060	148	426	89	477	1067	**1250**	**1573**
100	950	129	370	103	552	1233	**1171**	**1609**
125	877	115	332	115	617	1381	**1134**	**1677**
150	827	106	305	127	679	1518	**1125**	**1764**
175	787	98	283	137	734	1641	**1126**	**1850**
200	758	92	265	147	787	1759	**1137**	**1941**

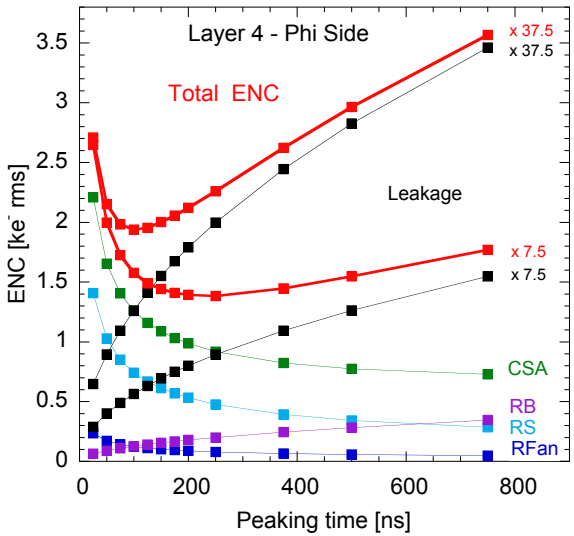
Z Side with Pairing ×2 only



t_p [ns]	ENC [e rms]							
	CSA	R_{Fan}	R_S	R_B	I_{leak}		Total	
					×7.5	×37.5	×7.5	×37.5
25	1360	263	203	52	248	555	**1422**	**1507**
50	1010	186	143	73	350	783	**1097**	**1302**
75	862	152	117	89	429	960	**986**	**1308**
100	780	132	102	104	499	1115	**946**	**1375**
125	722	118	91	116	558	1247	**932**	**1454**
150	682	108	83	127	612	1368	**935**	**1540**
175	652	100	77	137	661	1479	**947**	**1627**
200	628	94	73	147	708	1582	**965**	**1713**

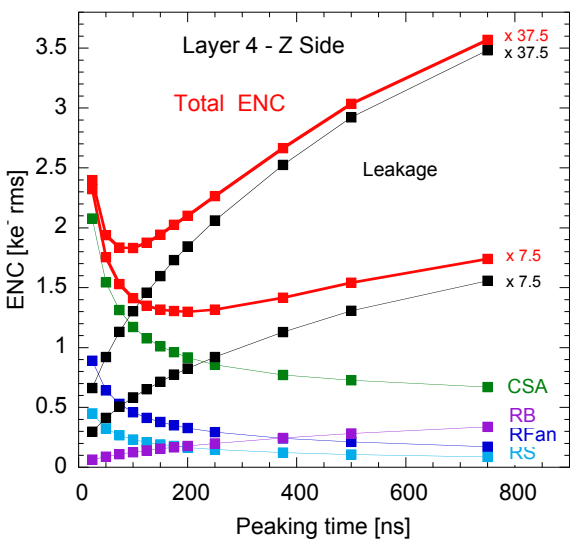
ENC in Layer 4

Phi Side



t_p [ns]	ENC [e rms]							
	CSA	R_{Fan}	R_S	R_B	I_{leak}		Total	
					$\times 7.5$	$\times 37.5$	$\times 7.5$	$\times 37.5$
25	2209	235	1408	65	290	647	**2647**	**2710**
100	1258	124	743	126	565	1262	**1576**	**1939**
150	1089	102	613	155	694	1552	**1441**	**2001**
200	987	89	533	179	801	1790	**1392**	**2122**
250	918	80	477	200	893	1997	**1384**	**2260**
375	823	66	393	245	1094	2446	**1447**	**2623**
500	775	57	343	283	1264	2826	**1549**	**2964**
750	729	48	285	346	1548	3461	**1770**	**3566**

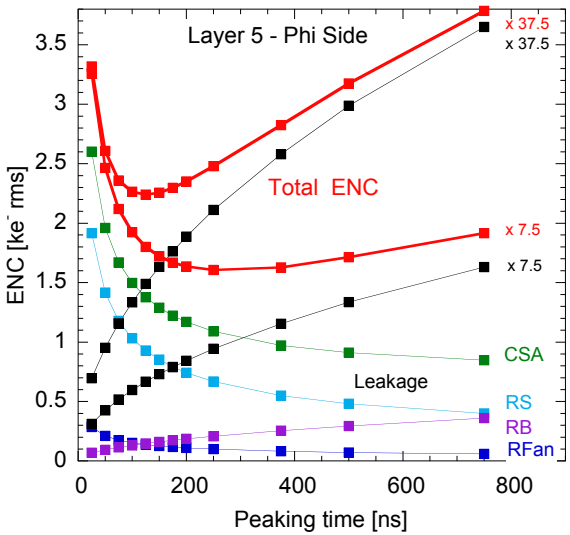
Z Side



t_p [ns]	ENC [e rms]							
	CSA	R_{Fan}	R_S	R_B	I_{leak}		Total	
					$\times 7.5$	$\times 37.5$	$\times 7.5$	$\times 37.5$
25	2077	889	450	64	296	662	**2324**	**2398**
100	1172	461	233	126	583	1304	**1412**	**1831**
150	1010	378	191	155	714	1596	**1316**	**1942**
200	917	328	166	179	825	1844	**1300**	**2100**
250	857	294	149	200	922	2062	**1316**	**2266**
375	770	242	123	245	1130	2526	**1415**	**2666**
500	728	212	107	283	1307	2922	**1541**	**3034**
750	669	172	87	337	1558	3483	**1739**	**3568**

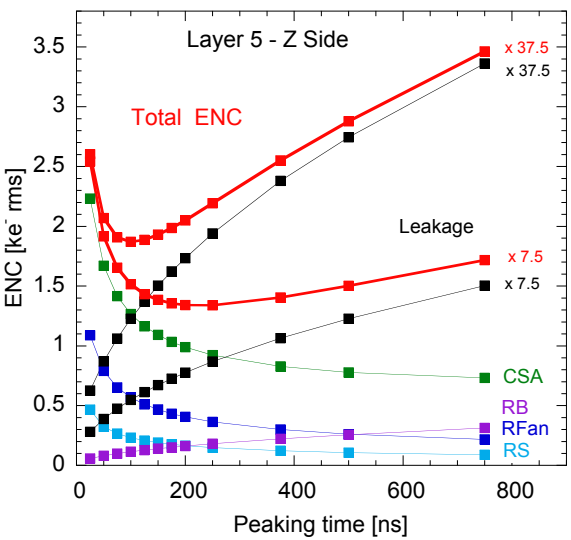
ENC in Layer 5

Phi Side



t_p [ns]	ENC [e rms]							
	CSA	R_{Fan}	R_S	R_B	I_{leak}		Total	
					$\times 7.5$	$\times 37.5$	$\times 7.5$	$\times 37.5$
25	2601	285	1917	69	312	697	**3259**	**3318**
100	1497	154	1032	132	597	1335	**1924**	**2264**
150	1289	127	852	161	730	1632	**1721**	**2257**
200	1169	111	743	186	843	1886	**1636**	**2350**
250	1090	99	668	208	944	2111	**1606**	**2479**
375	971	82	549	255	1154	2581	**1627**	**2824**
500	911	72	481	295	1336	2987	**1714**	**3174**
750	847	59	399	360	1632	3649	**1917**	**3785**

Z Side



t_p [ns]	ENC [e rms]							
	CSA	R_{Fan}	R_S	R_B	I_{leak}		Total	
					$\times 7.5$	$\times 37.5$	$\times 7.5$	$\times 37.5$
25	2232	1087	466	58	279	626	2542	2603
100	1266	568	232	114	548	226	1514	1870
150	1091	467	191	140	672	1504	1385	1930
200	988	405	165	161	775	1734	1340	2049
250	922	364	149	180	867	1940	1338	2191
375	828	300	122	221	1064	2380	1404	2550
500	777	261	107	255	1227	2745	1502	2878
750	731	217	89	313	1503	3362	1717	3463