

Simulation for Light Collection Efficiency for SOLID Preshower, LASPD and FASPD

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1 Preshower with WLS-fiber-embedding read-out

Fiber#	5mm	10mm	15mm	20mm	25mm	30mm	35mm	40mm	45mm
1	0.09467	0.17270	0.23192	0.28284	0.32521	0.36226	0.39717	0.42594	0.44881
2	0.14717	0.25210	0.32680	0.38239	0.42995	0.46773	0.50023	0.52958	0.55377
3	0.18696	0.30754	0.38669	0.44344	0.49262	0.53131	0.56385	0.59153	0.61660
4	0.21872	0.34784	0.43090	0.48848	0.53438	0.57445	0.60740	0.63454	0.65791
5	0.24491	0.37994	0.46365	0.52149	0.56875	0.60939	0.63981	0.66746	0.68935
6	0.26637	0.40778	0.48926	0.54806	0.59593	0.63435	0.66629	0.69486	0.71523
7	0.28707	0.42951	0.51217	0.56980	0.62073	0.65530	0.68991	0.71558	0.73761

Table 1: Light collection efficiency of 10cm \times 10cm square-shape tiles. The reflectivity is 0.95 and 0.99 for total internal reflection. The fiber used is 1mm-diameter Kuraray Y11(200), embedding in a 9-cm diameter groove.

Fiber#	5mm	10mm	15mm	20mm	25mm	30mm	35mm	40mm	45mm
1	0.05196	0.09706	0.13620	0.16663	0.19639	0.22576	0.24664	0.26515	0.28519
2	0.10821	0.18986	0.25170	0.30229	0.34362	0.37883	0.40781	0.43030	0.45547
3	0.14897	0.25002	0.32150	0.37943	0.42030	0.45734	0.48839	0.51430	0.53266
4	0.18403	0.29782	0.37462	0.43380	0.47635	0.51346	0.54712	0.57007	0.58841
5	0.21532	0.33604	0.41762	0.47626	0.52219	0.55702	0.58924	0.61047	0.62922
6	0.24363	0.36969	0.45421	0.51218	0.55935	0.59367	0.62384	0.64437	0.66229
7	0.26996	0.39916	0.48438	0.54272	0.58968	0.62329	0.65439	0.67267	0.68906

Table 2: Light collection efficiency of 6.25-cm-side hexagon tiles. The reflectivity is 0.95 and 0.99 for total internal reflection. The fiber used is 1mm-diameter Kuraray Y11(200), embedding in a 9-cm diameter groove.

2 LASPD with direct light readout

Fiber#	1	2	3	4	5
circle	0.45040	0.53369	0.58160	0.61484	0.62890
racetrack	0.45335	0.54189	0.59613	0.63136	0.64817
twist	0.42374	0.50550	0.54788	0.57366	0.58550

Table 3: Light collection efficiency of 5mm-thick LASPD if using 6-deg radial segments. The reflectivity is 0.95 and 0.99 for total internal reflection. The fiber used is 1mm-diameter Kuraray Y11(200). The geometry of the tile and the three fiber-embedding scheme are shown in Fig.1,2,3

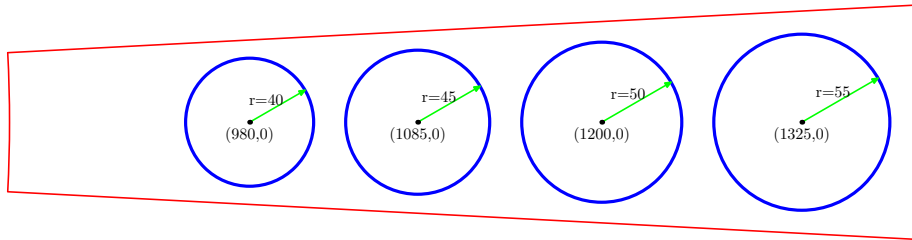


Figure 1: Geometry of "circle" fiber-embedding of LASPD

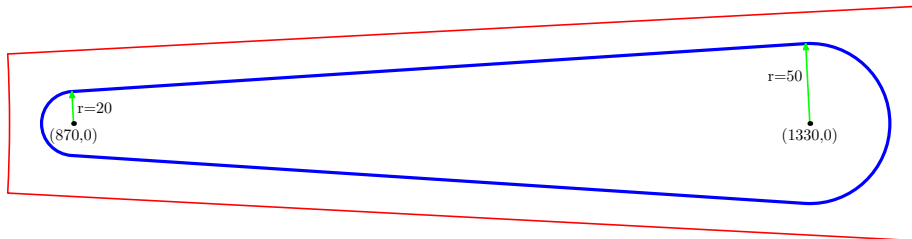


Figure 2: Geometry of "racetrack" fiber-embedding of LASPD

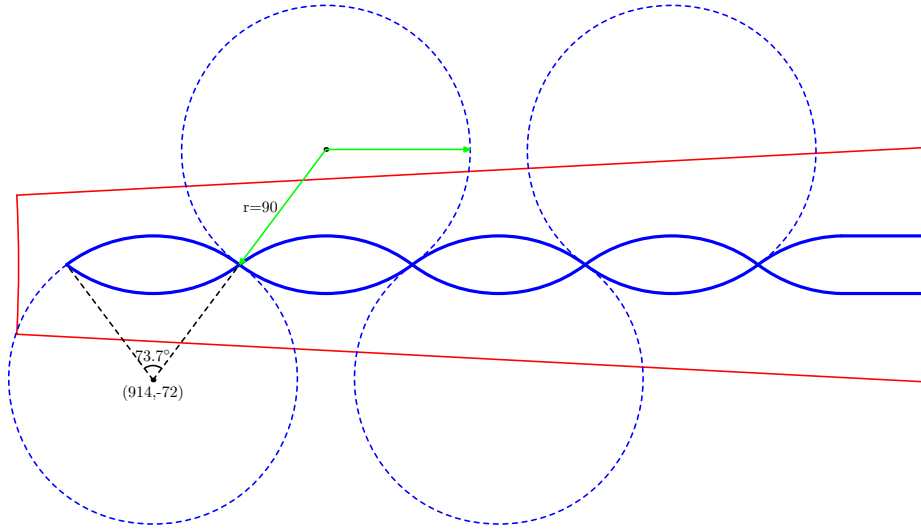


Figure 3: Geometry of "twist" fiber-embedding of LASPD

Fiber#	1	2	3	4	5	6	7	8
circle	0.40141	0.50009	0.55462	0.59624	0.62474	0.64865	0.66629	0.68555
racetrack	0.39377	0.49233	0.55119	0.59083	0.62394	0.65033	0.67264	0.69085
twist	0.37135	0.46632	0.52440	0.56260	0.59450	0.61837	0.63659	0.65299
Fiber#	9	10	11	12	13	14	15	16
circle	0.70006	0.71432	0.72479	0.73479	0.74383	0.75226	0.75999	0.76853
racetrack	0.70522	0.72186	0.73628	0.74692	0.75723	0.76742	0.77700	0.78439
twist	0.66743	0.67944	0.69051	0.70179	0.71024	0.71811	0.72480	0.72967
Fiber#	17	18	19	20				
circle	0.77469	0.78028	0.78346	0.78588				
racetrack	0.79101	0.79614	0.80070	0.80306				
twist	0.73509	0.73960	0.74168	0.74319				

Table 4: Light collection efficiency of 20mm-thick LASPD if using 6-deg radial segments. Other conditions are the same as Table 3.

radius range	830-860	860-890	890-920	920-950	950-980
efficiency	0.14625	0.14023	0.13523	0.12675	0.12059
radius range	980-1010	1010-1040	1040-1070	1070-1100	1100-1130
efficiency	0.11557	0.10881	0.10665	0.10190	0.10034
radius range	1130-1160	1160-1190	1190-1220	1220-1250	1250-1280
efficiency	0.09698	0.09377	0.09330	0.08953	0.08885
radius range	1280-1310	1310-1340	1340-1370	1370-1400	830-1400
efficiency	0.08628	0.08471	0.08582	0.08557	0.10657

Table 5: Light Collection Efficiency of LASPD tile with Direct Light Readout Configuration(5mm), PMT is coupled to the big arc surface of SPD

radius range	830-860	860-890	890-920	920-950	950-980
efficiency	0.23403	0.22409	0.21434	0.20190	0.18826
radius range	980-1010	1010-1040	1040-1070	1070-1100	1100-1130
efficiency	0.17970	0.17322	0.16627	0.15994	0.15538
radius range	1130-1160	1160-1190	1190-1220	1220-1250	1250-1280
efficiency	0.15007	0.14371	0.14023	0.13772	0.13440
radius range	1280-1310	1310-1340	1340-1370	1370-1400	830-1400
efficiency	0.13177	0.12889	0.12694	0.12353	0.16498

Table 6: Light Collection Efficiency of LASPD tile with Direct Light Readout Configuration(20mm)

3 FASPD with WLS-fiber-embedding readout

fibnum	tile 1	tile 2	tile 3	tile 4	average
1	0.46151	0.43025	0.39989	0.37001	0.39987
2	0.54694	0.51722	0.48410	0.45800	0.48633
3	0.59397	0.56177	0.52878	0.50096	0.53053
4	0.62241	0.59019	0.55891	0.52932	0.55940
5	0.63652	0.60460	0.57368	0.54120	0.57279

Table 7: Light Collection efficiency of 5-mm thick FASPD tile, using 4 (radial) by 60 (azimuthal) segmentation. The reflectivity is 0.95 and 0.99 for total internal reflection. The fiber used is 1mm-diameter Kuraray Y11(200). The geometry of the tile and the fiber-embedding scheme are shown in Fig.4.

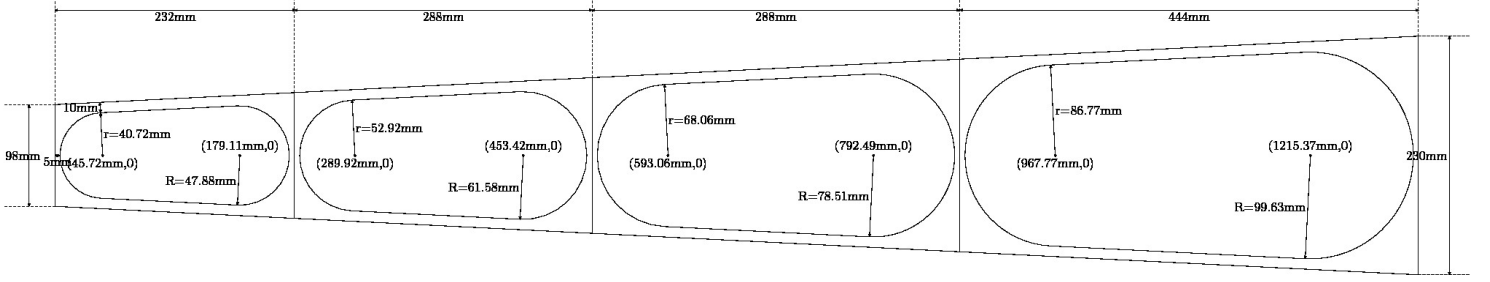


Figure 4: Geometry of FASPD and its fiber-embedding

fibnum	tile 1	tile 2	tile 3	tile 4	average
1	0.44458	0.41611	0.38705	0.35726	0.38635
2	0.53847	0.51083	0.47963	0.45052	0.47976
3	0.59278	0.56397	0.53249	0.50227	0.53237
4	0.63034	0.59960	0.56765	0.53945	0.56876
5	0.65846	0.62574	0.59694	0.56761	0.59686
6	0.68002	0.64795	0.61833	0.58876	0.61831
7	0.69882	0.66664	0.63648	0.60618	0.63633
8	0.71218	0.67952	0.64733	0.61924	0.64878
9	0.72165	0.68743	0.65552	0.62759	0.65714
10	0.73008	0.69347	0.66101	0.63200	0.66261

Table 8: Light Collection efficiency of 10-mm thick FASPD tile, using 4 (radial) by 60 (azimuthal) segmentation. The reflectivity is 0.95 and 0.99 for total internal reflection. The fiber used is 1mm-diameter Kuraray Y11(200). The geometry of the tile and the fiber-embedding scheme are shown in Fig.4.

fibnum	tile 1	tile 2	tile 3	tile 4	average
1	0.42918	0.40022	0.37358	0.34595	0.37314
2	0.52767	0.49771	0.47107	0.44245	0.47032
3	0.58473	0.54951	0.52549	0.50046	0.52611
4	0.62532	0.59051	0.56660	0.53807	0.56565
5	0.65362	0.62223	0.59613	0.56749	0.59538
6	0.67743	0.64726	0.61963	0.58882	0.61827
7	0.69892	0.66613	0.63914	0.60884	0.63811
8	0.71527	0.68352	0.65392	0.62429	0.65384
9	0.72860	0.69903	0.66734	0.63682	0.66724
10	0.74005	0.71106	0.68033	0.65030	0.68009

Table 9: Light Collection efficiency of 15-mm thick FASPD tile, using 4 (radial) by 60 (azimuthal) segmentation. The reflectivity is 0.95 and 0.99 for total internal reflection. The fiber used is 1mm-diameter Kuraray Y11(200). The geometry of the tile and the fiber-embedding scheme are shown in Fig.4.

fibnum	tile 1	tile 2	tile 3	tile 4	average
1	0.41083	0.38423	0.35837	0.33464	0.35908
2	0.51413	0.48552	0.45813	0.43323	0.45903
3	0.57088	0.54526	0.51676	0.48960	0.51668
4	0.61436	0.58678	0.55809	0.53077	0.55823
5	0.64397	0.61687	0.58803	0.56041	0.58803
6	0.66899	0.64079	0.61399	0.58592	0.61332
7	0.69051	0.66285	0.63414	0.60632	0.63408
8	0.70799	0.68364	0.65011	0.62524	0.65236
9	0.72414	0.69864	0.66466	0.63979	0.66717
10	0.73844	0.71093	0.67925	0.65114	0.67993

Table 10: Light Collection efficiency of 20-mm thick FASPD tile, using 4 (radial) by 60 (azimuthal) segmentation. The reflectivity is 0.95 and 0.99 for total internal reflection. The fiber used is 1mm-diameter Kuraray Y11(200). The geometry of the tile and the fiber-embedding scheme are shown in Fig.4.

fibnum	tile 1	tile 2	tile 3	tile 4	average
1	0.39601	0.37332	0.34619	0.32342	0.34723
2	0.49911	0.47517	0.44946	0.42123	0.44790
3	0.56006	0.53598	0.50747	0.47999	0.50708
4	0.60407	0.57909	0.55243	0.52166	0.55019
5	0.63626	0.61243	0.58398	0.55262	0.58188
6	0.66345	0.63792	0.60904	0.58012	0.60831
7	0.68522	0.65815	0.63125	0.60182	0.62990
8	0.70425	0.67624	0.64989	0.61844	0.64762
9	0.71798	0.69365	0.66645	0.63423	0.66368
10	0.73204	0.70793	0.68178	0.64764	0.67785

Table 11: Light Collection efficiency of 25-mm thick FASPD tile, using 4 (radial) by 60 (azimuthal) segmentation. The reflectivity is 0.95 and 0.99 for total internal reflection. The fiber used is 1mm-diameter Kuraray Y11(200). The geometry of the tile and the fiber-embedding scheme are shown in Fig.4.

fibnum	tile 1	tile 2	tile 3	tile 4	average
1	0.38518	0.36061	0.33323	0.31199	0.33522
2	0.49130	0.46697	0.43829	0.41152	0.43828
3	0.55405	0.52718	0.50239	0.47230	0.50010
4	0.59897	0.57003	0.54236	0.51455	0.54215
5	0.62923	0.60467	0.57573	0.54821	0.57550
6	0.65701	0.63199	0.60183	0.57525	0.60242
7	0.67917	0.65391	0.62483	0.59664	0.62444
8	0.69797	0.67326	0.64339	0.61640	0.64368
9	0.71407	0.68870	0.66141	0.63452	0.66106
10	0.72935	0.70364	0.67548	0.64992	0.67599

Table 12: Light Collection efficiency of 30-mm thick FASPD tile, using 4 (radial) by 60 (azimuthal) segmentation. The reflectivity is 0.95 and 0.99 for total internal reflection. The fiber used is 1mm-diameter Kuraray Y11(200). The geometry of the tile and the fiber-embedding scheme are shown in Fig.4.

fibnum	tile 1	tile 2	tile 3	tile 4	average
1	0.37101	0.34699	0.32370	0.29981	0.32327
2	0.48022	0.45285	0.42791	0.40214	0.42757
3	0.54393	0.51701	0.49128	0.46474	0.49079
4	0.58902	0.56138	0.53657	0.50906	0.53548
5	0.62296	0.59462	0.57007	0.54365	0.56945
6	0.64819	0.62260	0.59823	0.57168	0.59718
7	0.67186	0.64620	0.62017	0.59412	0.61983
8	0.69000	0.66556	0.64092	0.61251	0.63902
9	0.70783	0.68170	0.65810	0.63038	0.65638
10	0.72192	0.69603	0.67489	0.64566	0.67177

Table 13: Light Collection efficiency of 35-mm thick FASPD tile, using 4 (radial) by 60 (azimuthal) segmentation. The reflectivity is 0.95 and 0.99 for total internal reflection. The fiber used is 1mm-diameter Kuraray Y11(200). The geometry of the tile and the fiber-embedding scheme are shown in Fig.4.

fibnum	tile 1	tile 2	tile 3	tile 4	average
1	0.35965	0.33752	0.31433	0.29325	0.31485
2	0.46857	0.44284	0.42125	0.39466	0.41937
3	0.53479	0.50853	0.48540	0.45738	0.48343
4	0.57955	0.55272	0.52795	0.50161	0.52725
5	0.61147	0.58616	0.56419	0.53785	0.56248
6	0.64081	0.61452	0.59104	0.56525	0.59013
7	0.66369	0.64096	0.61444	0.58802	0.61375
8	0.68421	0.66005	0.63528	0.60684	0.63337
9	0.70069	0.67603	0.65106	0.62303	0.64945
10	0.71631	0.69228	0.66672	0.63920	0.66542

Table 14: Light Collection efficiency of 40-mm thick FASPD tile, using 4 (radial) by 60 (azimuthal) segmentation. The reflectivity is 0.95 and 0.99 for total internal reflection. The fiber used is 1mm-diameter Kuraray Y11(200). The geometry of the tile and the fiber-embedding scheme are shown in Fig.4.

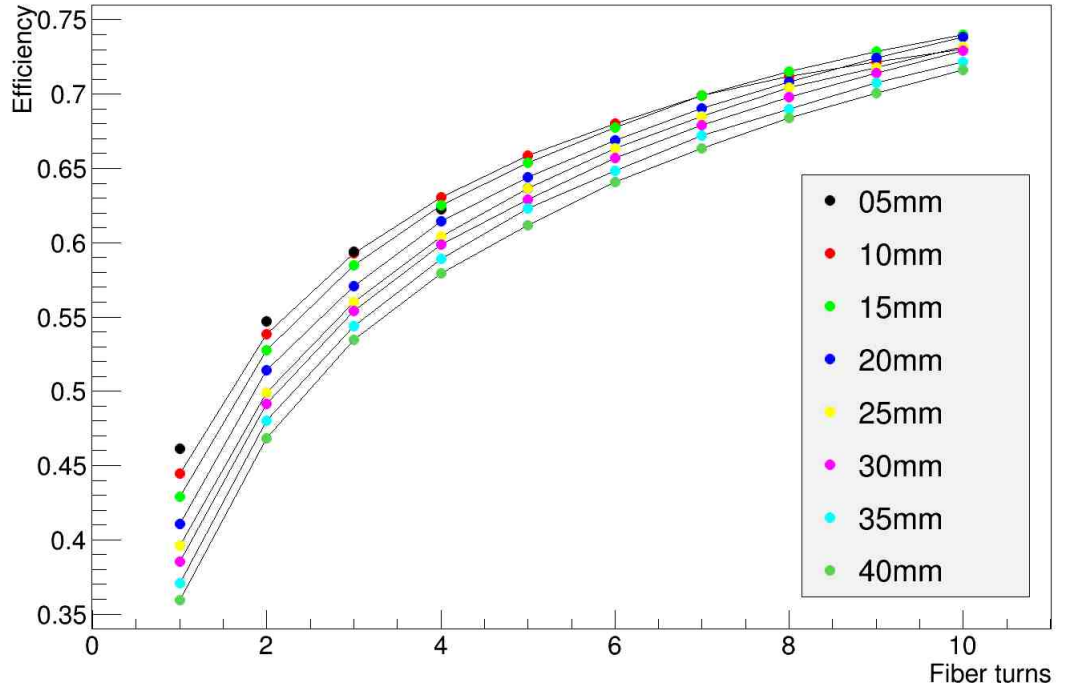


Figure 5: Light Collection efficiency of different thick(5 - 40 mm) FASPD tile 1, using 4 (radial) by 60 (azimuthal) segmentation. The reflectivity is 0.95 and 0.99 for total internal reflection. The fiber used is 1mm-diameter Kuraray Y11(200). The geometry of the tile and the fiber-embedding scheme are shown in Fig.4.

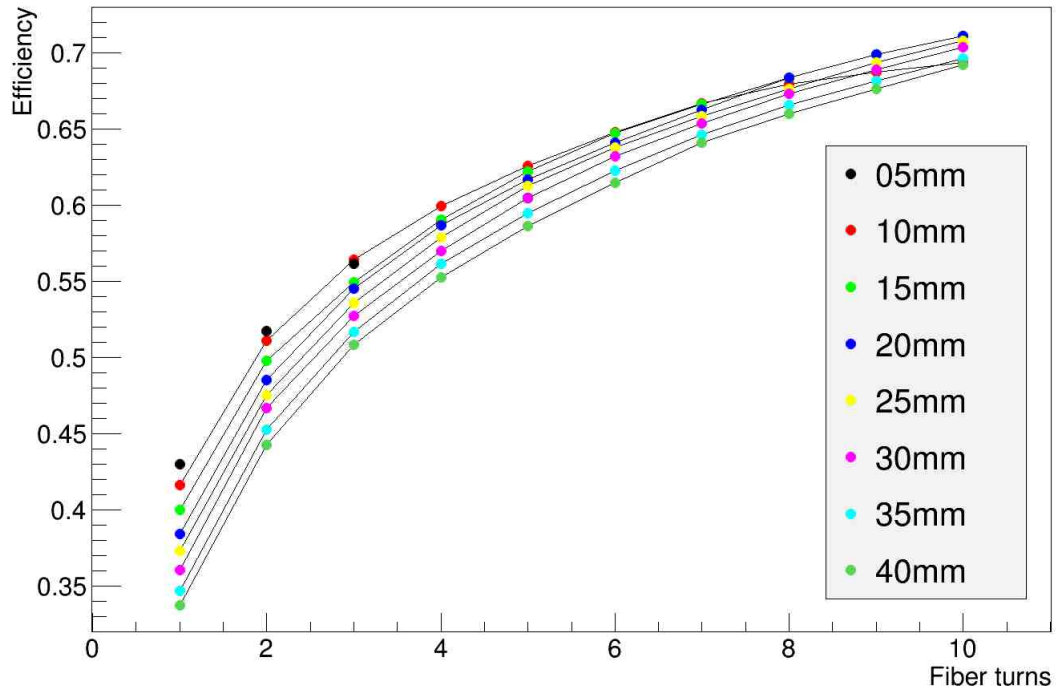


Figure 6: Light Collection efficiency of different thick(5 - 40 mm) FASPD tile 2, using 4 (radial) by 60 (azimuthal) segmentation. The reflectivity is 0.95 and 0.99 for total internal reflection. The fiber used is 1mm-diameter Kuraray Y11(200). The geometry of the tile and the fiber-embedding scheme are shown in Fig.4.

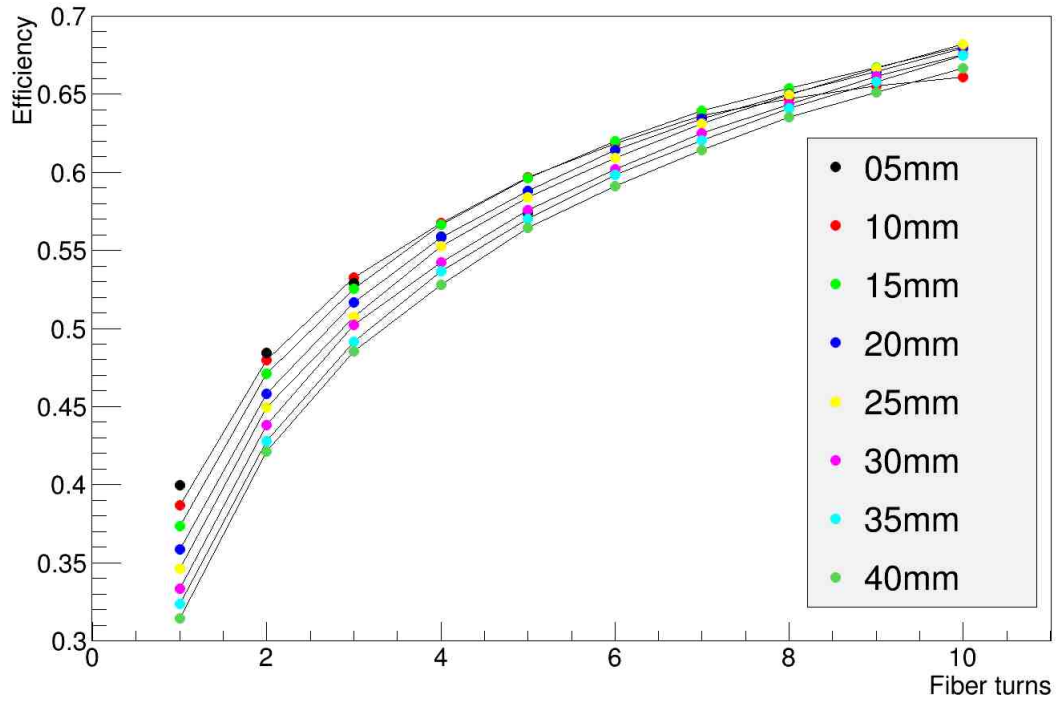


Figure 7: Light Collection efficiency of different thick(5 - 40 mm) FASPD tile 3, using 4 (radial) by 60 (azimuthal) segmentation. The reflectivity is 0.95 and 0.99 for total internal reflection. The fiber used is 1mm-diameter Kuraray Y11(200). The geometry of the tile and the fiber-embedding scheme are shown in Fig.4.

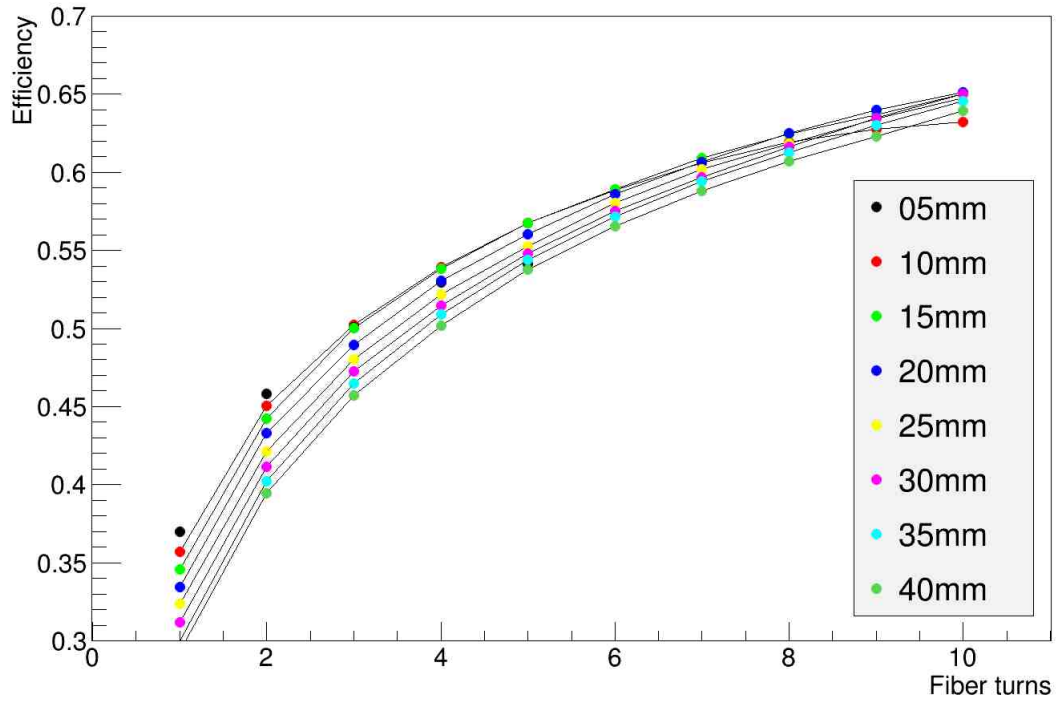


Figure 8: Light Collection efficiency of different thick(5 - 40 mm) FASPD tile 3, using 4 (radial) by 60 (azimuthal) segmentation. The reflectivity is 0.95 and 0.99 for total internal reflection. The fiber used is 1mm-diameter Kuraray Y11(200). The geometry of the tile and the fiber-embedding scheme are shown in Fig.4.

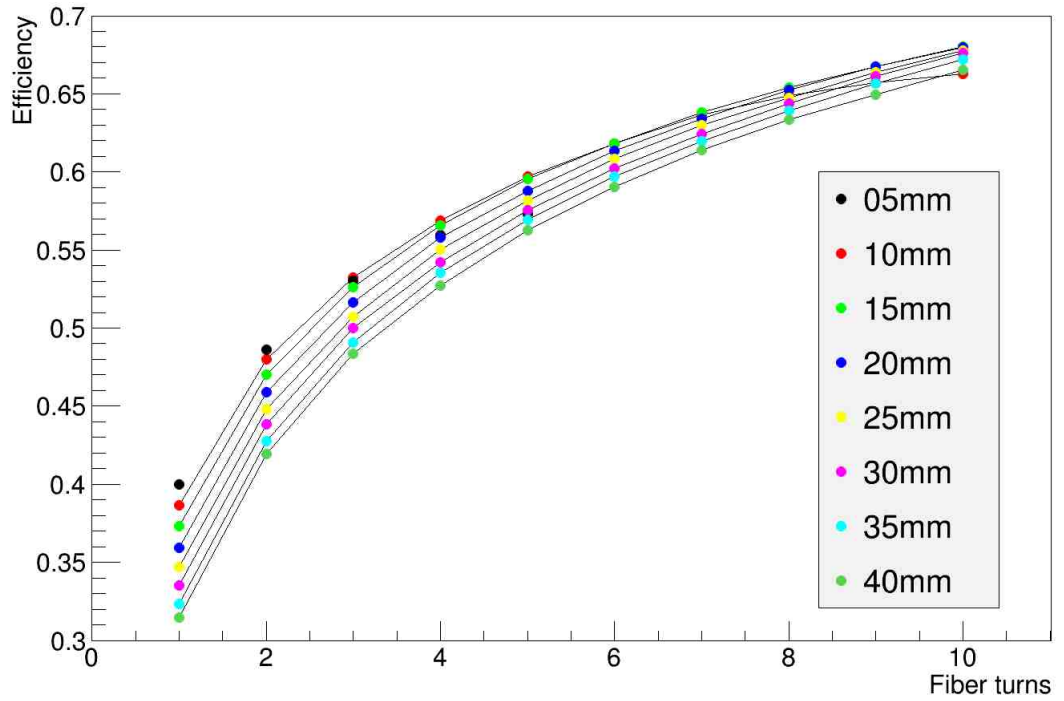


Figure 9: Light Collection efficiency of different thick(5 - 40 mm) FASPD(4 tiles as a whole), using 4 (radial) by 60 (azimuthal) segmentation. The reflectivity is 0.95 and 0.99 for total internal reflection. The fiber used is 1mm-diameter Kuraray Y11(200). The geometry of the tile and the fiber-embedding scheme are shown in Fig.4.

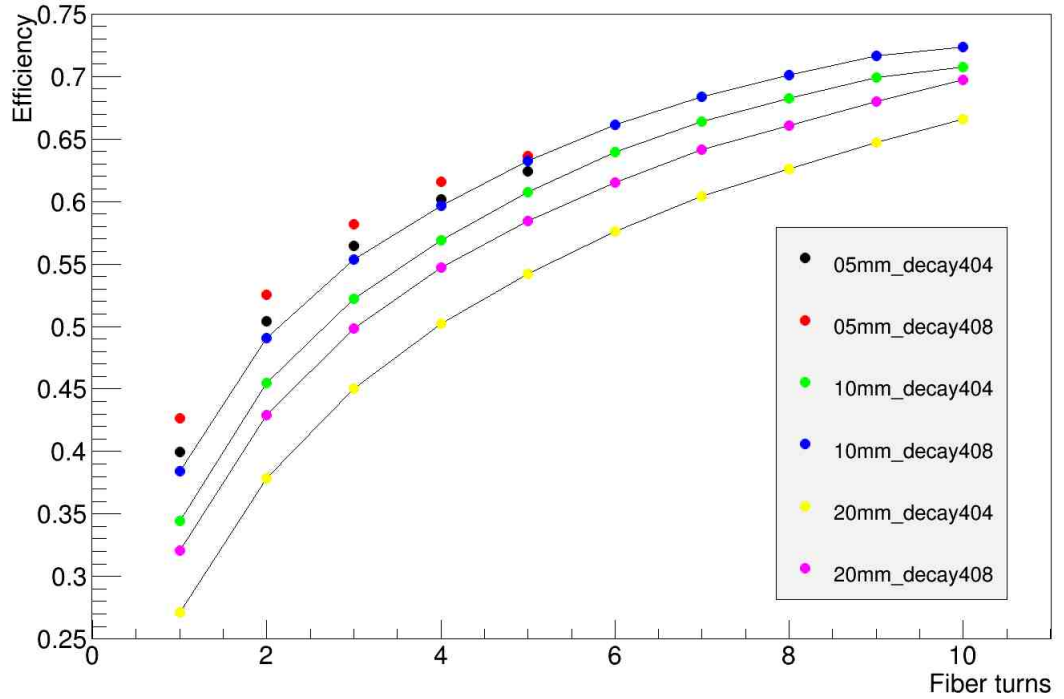


Figure 10: Light Collection efficiency of different thick(5,10,20 mm) FASPD tile1, using 4 (radial) by 60 (azimuthal) segmentation. The reflectivity is 0.95 and 0.99 for total internal reflection. The fiber used is 1mm-diameter Kuraray Y11(200). The geometry of the tile and the fiber-embedding scheme are shown in Fig.4. The efficiencies have include decay in two kinds of scintillator.

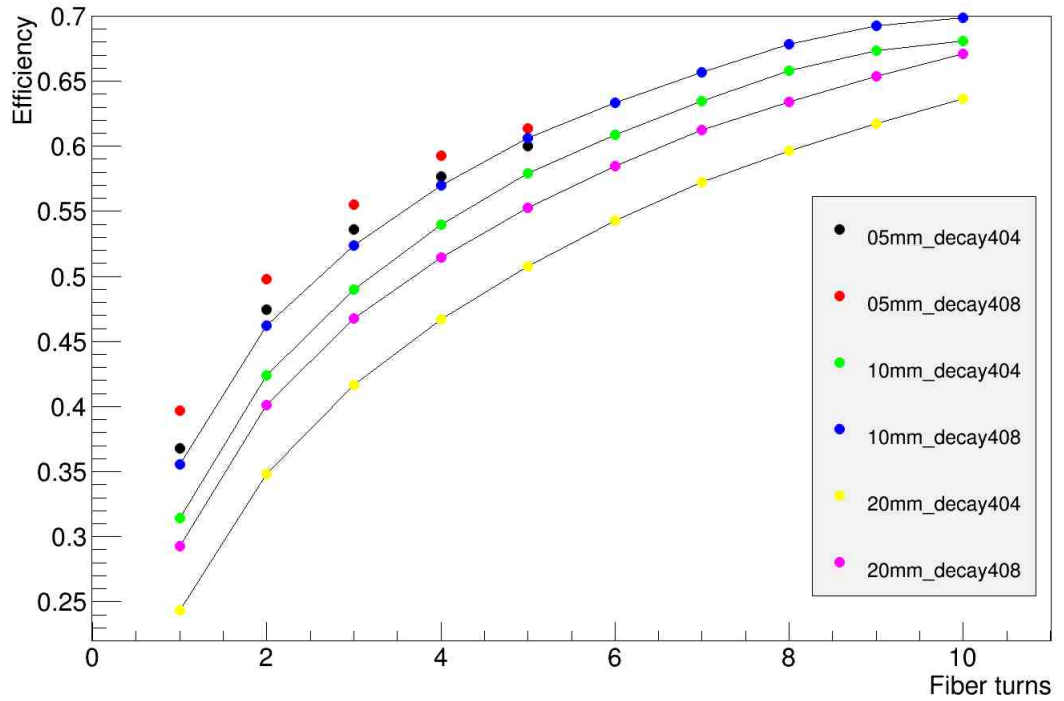


Figure 11: Light Collection efficiency of different thick(5,10,20 mm) FASPD tile2, using 4 (radial) by 60 (azimuthal) segmentation. The reflectivity is 0.95 and 0.99 for total internal reflection. The fiber used is 1mm-diameter Kuraray Y11(200). The geometry of the tile and the fiber-embedding scheme are shown in Fig.4. The efficiencies have include decay in two kinds of scintillator.

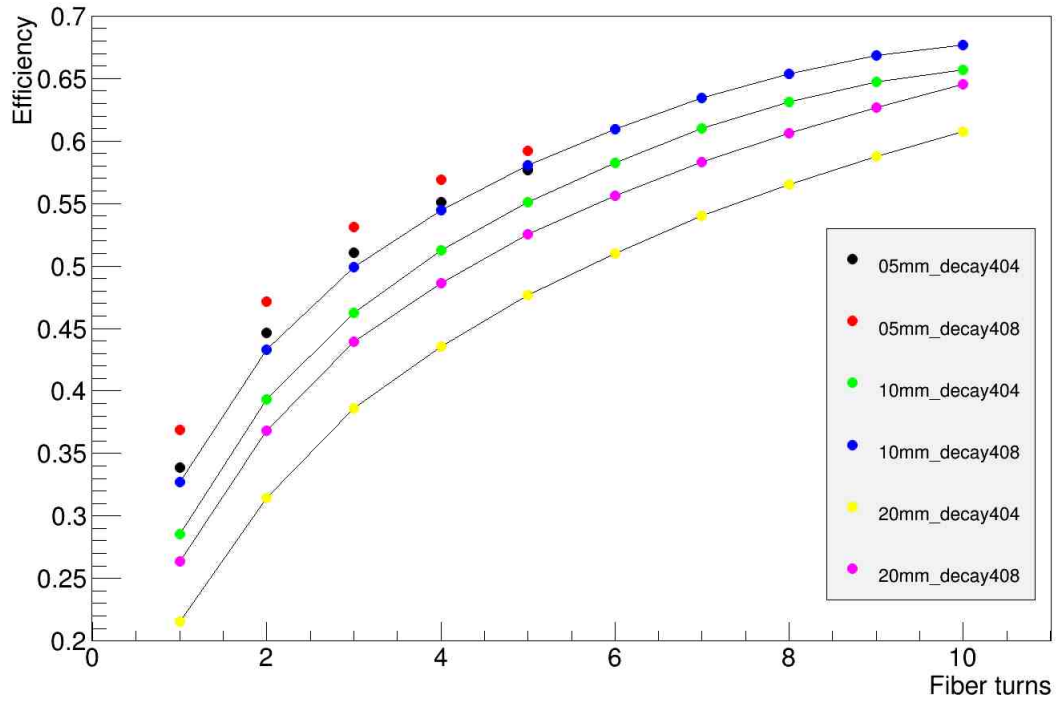


Figure 12: Light Collection efficiency of different thick(5,10,20 mm) FASPD tile3, using 4 (radial) by 60 (azimuthal) segmentation. The reflectivity is 0.95 and 0.99 for total internal reflection. The fiber used is 1mm-diameter Kuraray Y11(200). The geometry of the tile and the fiber-embedding scheme are shown in Fig.4. The efficiencies have include decay in two kinds of scintillator.

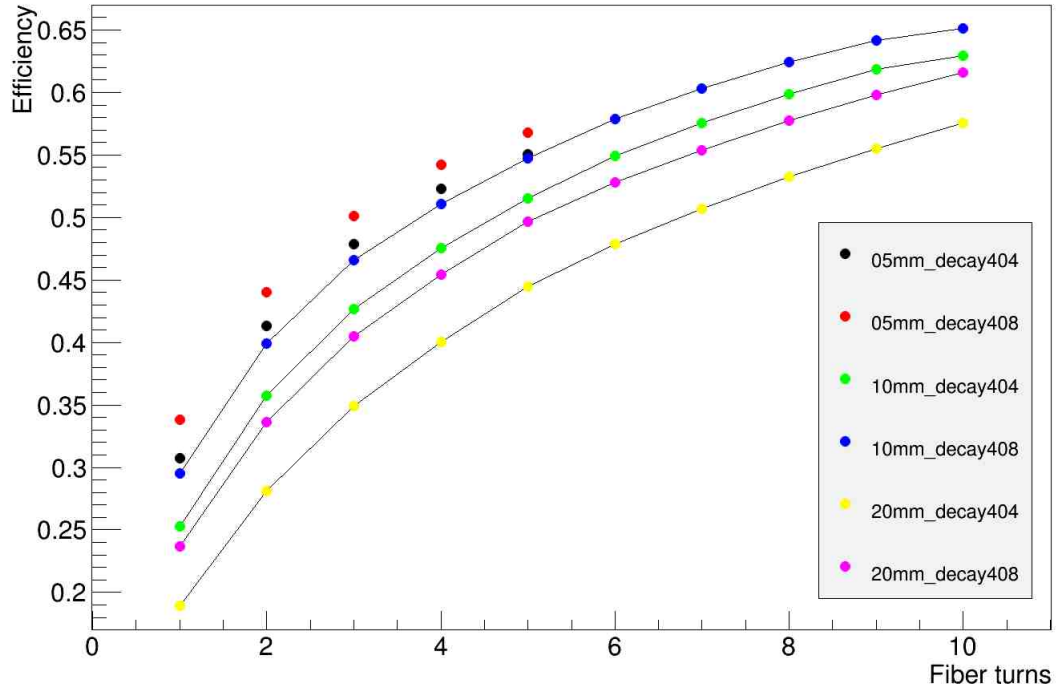


Figure 13: Light Collection efficiency of different thick(5,10,20 mm) FASPD tile4, using 4 (radial) by 60 (azimuthal) segmentation. The reflectivity is 0.95 and 0.99 for total internal reflection. The fiber used is 1mm-diameter Kuraray Y11(200). The geometry of the tile and the fiber-embedding scheme are shown in Fig.4. The efficiencies have include decay in two kinds of scintillator.