Supporting Information

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Chinese Remainder Sieve Construction

Eppstein et al. (1) recently proposed the "Chinese remainder sieve," a number-theoretic method for the deterministic construction of d-disjunct matrices. To generate a d-disjunct matrix with at least n columns, first choose a sequence $\{p_1^{e_1}, p_2^{e_2}, \ldots, p_k^{e_k}\}$ of powers of distinct primes such that $\prod_{i=1}^{k} p_i^{e_i} \geq n^d$. A $t \times n$ matrix A with $t = \sum_{i=1}^{k} p_i^{e_i}$ is then created by vertical concatenation of $p_\ell^{e_\ell} \times n$ matrices A_ℓ as follows:

$$A = \begin{bmatrix} A_1 \\ A_2 \\ \vdots \\ A_k \end{bmatrix}, \quad A_\ell(i,j) = \begin{cases} 1 & i \equiv j \mod p_\ell^{e_\ell} \\ 0 & \text{otherwise} \end{cases}.$$

As an example, consider the construction of a 1-disjunct 5×6 matrix generated based on $p_1 = 2$ and $p_2 = 3$. Applying the above definition we obtain:

$$A = \begin{bmatrix} A_1 \\ \hline \\ A_2 \end{bmatrix} = \left[\begin{array}{cccccc} 1 & 0 & 1 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 & 0 & 1 \\ \hline 1 & 0 & 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 0 & 1 & 0 \\ 0 & 0 & 1 & 0 & 0 & 1 \end{array}\right].$$

The above construction requires $t = \mathcal{O}(d^2 \log^2 n / (\log d + \log \log n))$ rows for a d-disjunct matrix of size n (1). This is only slightly worse than the best-known $\mathcal{O}(d^2 \log n)$ construction by Porat and Rothschild (2). Using a near-exhaustive search over prime-power combinations, we construct d-disjunct matrices with size at least 3,600. The parameters giving designs with the smallest number of rows are given in Table S1.

Additional Simulation Results

In this section we provide some additional data obtained from the numerical simulations of scintillation events. For details on the setup, please refer to the main article. Tables S2–S4 provide the decoding statistics for time-to-digital converter intervals of 10 ps and 40 ps, respectively. Table S5 summarizes the simulation results on a 120×120 pixel array for various parameter choices.

1. Eppstein D, Goodrich MT, Hirschberg DS (2007) Improved combinatorial group testing algorithms for real-world problem sizes. *SIAM J Comput* 36: 1360–1375.

2. Porat E, Rothschild A (2008) Explicitnon-adaptive combinatorial group testing schemes. *Automata, Languages and Programming*, eds Aceto L, et al. (Springer, Berlin), Vol 5125 of *Lecture Notes Comp Sci*, pp 748–759.

Table S1. Prime powers used for the construction of d-disjunct $t \times n$

d	t	n	Prime powers
2	82	4,077	$\{2^3, 3^2, 5, 7, 11, 13, 17, 23\}$
3	155	3,855	$\{2^2, 3, 5, 7, 11, 13, 17, 19, 23, 29, 37\}$
4	237	3,631	$\{2^3, 3, 5, 7, 11, 13, 17, 19, 23, 29, 31, 37, 43\}$
5	333	4,023	$\{2^3, 3^2, 5, 7, 11, 13, 17, 19, 23, 29, 31, 37, 41, 43, 53\}$
6	445	4,077	$\{2^3, 3^2, 5, 7, 11, 13, 17, 19, 23, 29, 31, 37, 41, 43, 53, 61\}$

Table S2. Decoding statistics for a 60 × 60 pixel grid using the default parameters with a pixel dead time of 20 ns and a time-to-digital converter (TDC) interval length of 10 ps

		Decoded events, %				
No. simultaneous	No. of events	$d = 2$ (51)	$d = 3$ (85)	$d = 4$ (142)	$d = 5$ (174)	$d = 6$ (206)
1	2,215,860	100.000	100.000	100.000	100.000	100.000
2	358,800	100.000	100.000	100.000	100.000	100.000
3	57,314	44.199	100.000	100.000	100.000	100.000
4	8,566	2.603	89.412	100.000	100.000	100.000
5	1,066	0.000	43.621	99.906	100.000	100.000
6	147	0.000	10.204	99.320	100.000	100.000
7	16	0.000	0.000	100.000	100.000	100.000
		Pixel firings missed: groupwise, individual, %				
		4.312	0.240	0.000	0.000	0.000
		1.128	0.010	0.000	0.000	0.000

Results shown correspond to the decoding of 1,000 sequential scintillation events. d, disjunctness; number of TDCs is given in parentheses in column headings. Total number of pixel firings, 3,145,990.

Table S3. Decoding statistics for a 120 × 120 pixel grid using the default parameters with a pixel dead time of 20 ns and a time-to-digital converter (TDC) interval length of 10 ps

		Decoded events, %				
No. simultaneous	No. of events	*d* = 2 (63)	*d* = 3 (110)	*d* = 4 (161)	*d* = 5 (233)	*d* = 6 (323)
1	2,392,049	100.000	100.000	100.000	100.000	100.000
2	450,460	100.000	100.000	100.000	100.000	100.000
3	81,201	16.558	100.000	100.000	100.000	100.000
4	13,109	0.099	95.217	100.000	100.000	100.000
5	1,760	0.000	64.205	99.830	100.000	100.000
6	228	0.000	11.842	96.930	100.000	100.000
7	25	0.000	0.000	80.000	100.000	100.000
8	1	0.000	0.000	0.000	100.000	100.000
		Pixel firings missed: groupwise, individual, %				
		7.390	0.196	0.003	0.000	0.000
		4.341	0.003	0.000	0.000	0.000

Results shown correspond to the decoding of 1,000 sequential scintillation events. *d*, disjunctness; number of TDCs is given in parentheses in column headings. Total no. of pixel firings, 3,599,359.

Table S4. Decoding statistics for a 120 × 120 pixel array using a pixel dead time of 20 ns and TDC interval length of 40 ps

		Decoded events, %				
No. simultaneous	No. of events	*d* = 2 (63)	*d* = 3 (110)	*d* = 4 (161)	*d* = 5 (233)	*d* = 6 (323)
1	992,945	100.000	100.000	100.000	100.000	100.000
2	444,448	100.000	100.000	100.000	100.000	100.000
3	230,712	16.390	100.000	100.000	100.000	100.000
4	118,381	0.091	95.275	100.000	100.000	100.000
5	56,684	0.000	62.900	99.737	100.000	100.000
6	25,215	0.000	15.435	96.764	99.996	100.000
7	10,061	0.000	1.312	80.698	99.901	100.000
8	3,711	0.000	0.054	43.897	99.111	100.000
9	1,224	0.000	0.000	12.582	95.997	99.918
10	421	0.000	0.000	1.663	83.610	99.525
11	115	0.000	0.000	0.000	56.522	99.130
12	33	0.000	0.000	0.000	27.273	100.000
13	8	0.000	0.000	0.000	12.500	100.000
14	3	0.000	0.000	0.000	0.000	100.000
		Pixel firings missed: groupwise, individual, %				
		44.554	10.326	1.430	0.068	0.001
		35.707	1.999	0.061	0.000	0.000

Results shown correspond to the decoding of 1,000 sequential scintillation events. *d*, disjunctness; number of TDCs is given in parentheses in column headings. Total number of pixel firings, 3,599,359.

Table S5. Percentage of pixel firings missed for various combinations of pixel dead time, TDC interval length, and disjunctness

Dead time (no. of firings)	TDC interval, ps	No. simultaneous	Pixel firings missed, %				
			$d=2$	$d=3$	$d=4$	$d=5$	$d=6$
10 ns (3.7 m)	5	6	1.20	0.00	0.00	0.00	0.00
	10	8	4.45	0.00	0.00	0.00	0.00
	20	12	14.47	0.10	0.00	0.00	0.00
	40	14	36.58	2.05	0.06	0.00	0.00
20 ns (3.6 m)	5	6	1.17	0.00	0.00	0.00	0.00
	10	8	4.34	0.00	0.00	0.00	0.00
	20	12	14.10	0.10	0.00	0.00	0.00
	40	14	35.71	2.00	0.06	0.00	0.00
40 ns (3.5 m)	5	6	1.17	0.00	0.00	0.00	0.00
	10	8	4.33	0.00	0.00	0.00	0.00
	20	12	14.02	0.10	0.00	0.00	0.00
	40	14	35.29	2.03	0.06	0.00	0.00
80 ns (3.4 m)	5	6	1.19	0.00	0.00	0.00	0.00
	10	8	4.42	0.00	0.00	0.00	0.00
	20	12	14.29	0.11	0.00	0.00	0.00
	40	14	35.84	2.10	0.07	0.00	0.00

Results shown correspond to the decoding of 1,000 sequential scintillation events on a 120×120 pixel array. The first three columns show the dead time (and total number of pixel firings), TDC time interval, and maximum number of simultaneous hits, respectively. M, millions.