

Electronic Supplementary Information

Detecting Impurity-Specific Effects on Structure and Radiolytic Hydrogen Production in Aluminum Hydroxide

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S1. Synthesis conditions for Cl-gibbsite and NO₃-gibbsite

Euhedral hexagonal gibbsite nanoplates were prepared through mild hydrothermal treatment of an amorphous aluminum hydroxide precursor obtained by neutralizing aqueous aluminum nitrate.¹ A 0.25 M solution of aluminum nitrate nonahydrate was titrated with 1.0 M sodium hydroxide to pH 5, yielding a dispersion. The dispersion was stirred for 1 h, collected by centrifugation, and washed three times by redispersion in water to remove residual Na⁺ and NO₃⁻ ions. Following the final wash, the pelleted solid was resuspended (0.3 g per mL water) and transferred to a 22 mL Teflon-lined Parr vessel. Hydrothermal treatment was carried out in a rotary oven at 80 °C and 10 rpm for 72 h. The resulting solid was isolated by centrifugation, washed three additional times, and dried overnight at 80 °C. NO₃-Gibbsite was obtained from aluminum nitrate nonahydrate precursor, while Cl-gibbsite was synthesized analogously using aluminum chloride under otherwise identical conditions.

S2. Experimental methods for ²⁷Al MQMAS NMR and TF-μSR

MQMAS: Proton decoupled ²⁷Al multi-quantum magic-angle spinning (MQMAS) NMR spectra were acquired at 14.1 T on a 3.2 mm MAS probe using zirconia rotors fitted with cavern-style Vespel drive caps, spun at 20.0 kHz. A z-filtered 3QMAS sequence was employed with hard pulse widths of 4.4 μs (p1) and 1.7 μs (p2), followed by a soft third pulse of 17 μs. A 2 s recycle delay was used with up to 256 evolution (t1_11) increments and 108–720 transients per increment. Spectral widths were 37.5 kHz (F1) and 20.0 kHz (F2). Data were processed with 100 Hz exponential line broadening in F2 prior to shearing and Fourier transformation. ²⁷Al chemical shifts were externally referenced to 0 ppm using a 1.0 M [Al(H₂O)₆]³⁺ standard prepared by dissolving aluminum nitrate nonahydrate in deionized water.

TF-μSR: The aluminum hydroxide samples were implanted with positive muons (μ⁺) at the M20 muon channel of the TRIUMF facility in Vancouver, Canada, where muoniated products were studied in real-time. For experiments, the samples were transferred into an aluminized Mylar cell, which was securely sealed using silver-foil tape. The sealed cell was then placed into a Horizontal Gas Flow (HGF) Cryostat compatible with the LAMPF spectrometer at TRIUMF. This cryostat was used to regulate temperature at 20 °C.

S3. TF-μSR analysis incorporating Monte Carlo uncertainty quantification

In this study, a Monte Carlo simulation approach was employed to determine and analyze the fit parameters and their associated uncertainties within a two-component model applied to transverse field muon spin rotation (TF-μSR) experiments on NO₃-gibbsite and Cl-gibbsite. Specifically, simulated heteroscedastic noise was added to the time-domain data, with the variance of the simulated noise matching the reported uncertainties of the binned experimental data. The noise was assumed to follow a Gaussian distribution,

which was generated using the Mersenne Twister algorithm. A total of >1000 simulations were performed for NO₃-gibbsite and simulations for Cl-gibbsite.

After introducing simulated noise, gradient-based optimization was employed to fit the data through minimization of the squared residual of the transverse field measurements of NO₃-gibbsite and Cl-gibbsite, utilizing Equation 1,

$$A(t) = \sum_i A_i \exp(-\lambda_i t) \cos(v_i t + \psi_i) + c \quad \text{Equation S1.}$$

where i is component, A_i is the amplitude, λ_i is the decay constant, v_i is the frequency, ψ_i is the phase angle of, t is time and c is the constant offset applied to the entire function. The boundary conditions for the fit parameters were specified to range from 60% to 140% of initial fit values, which were derived without accounting for bin uncertainties, in order to constrain the solution space and enhance convergence during gradient optimization.

For two component solutions $i = 1$ and the second component is the background c . For three component solutions $i = 1, 2$ and the third component is the background c .

S4. Overview of TF-μSR

The following provides a concise explanation of the TF-μSR technique as applied in this study. Readers seeking additional methodological detail are referred to Hillier *et al.* (2022).²

Step 1. Generation of muons

In a particle accelerator, a proton beam strikes a target, producing pions. These pions decay at rest, yielding positive muons (μ⁺). The μ⁺ are emitted with nearly 100 % spin polarization due to parity violation in the decay process. Depending on the accelerator, the emitted μ⁺ beam is either pulsed or continuous. The present work used a continuous source at TRIUMF.

Step 2. Transport of muons to the sample

The polarized μ⁺ beam is purified and guided to the sample through magnetic and electrostatic beamline elements. For example, these can include quadrupoles for focusing and kickers for rejecting other particles, which preserve the muon polarization and select the desired energy.

Step 3. Implantation of muons in the sample

In a continuous source, individual μ⁺ particles implant one at a time into the sample. They enter with kinetic energies of a few keV and lose energy by ionization and Coulomb interactions until stopping at interstitial sites within the solid. These processes do not appreciably reduce the spin polarization of the muon.

Step 4. Interactions between muons and the sample

The positive muon is a spin- $\frac{1}{2}$ particle with a high gyromagnetic ratio, making it sensitive to the local magnetic field of the sample and any applied external field. In TF- μ SR, an external magnetic field is applied perpendicular to the initial muon-spin direction. The muon spin precesses about this field, with its frequency reflecting the combined local and applied magnetic fields at the muon site.

Step 5. Detection of spin polarization of the muons

The muon is metastable with a mean lifetime of 2.2 μ s. It decays and one of the decay products is a positron emitted preferentially along its spin direction. The emitted positron is detected by scintillators. After appropriate normalization, the time-dependent asymmetry of positron counts represents the muon-spin polarization versus time and constitutes the primary signal analyzed.

Interpretation for this work

Upon implantation, the μ^+ creates an ionization track that generates excess electrons within the sample. These electrons may be scavenged by nitrate or trapped in structural disorder in gibbsite. If an electron binds to the μ^+ , a paramagnetic μ^+ -electron bound state (muonium or related radical) forms. If not, the μ^+ remains diamagnetic. Analogous to NMR, the local electronic environment alters the effective magnetic field and therefore the muon precession frequency. Some implanted μ^+ depolarize too rapidly to yield a measurable precession, forming a “lost” fraction. In this study, the relative amplitude of the diamagnetic signal serves as an inverse measure of sub-nanosecond electron availability following implantation with the remainder assigned to muonium or related radical forms, in addition to the lost fraction.

S5. Tables of diamagnetic fraction parameters and data used in Figure 2.

Table S1. Parameters for NO₃-gibbsite

	2 comp - MC UQ		3 comp - MC UQ		2 comp - NLLS	3 comp - NLLS
	Mean	St.Dev.	Mean	St.Dev.	Mean	Mean
A_{dia}	0.214	0.004	0.22	0.005	0.215	0.214
λ_{dia} (1/μs)	0.181	0.009	0.186	0.008	0.172	0.170
ν_{dia} (rad/μs)	4.963	0.01	4.957	0.01	4.967	4.967
w_{dia} (MHz)	0.790	0.001	0.789	0.001	0.791	0.791
ψ_{dia} (rad)	0.036	0.018	0.061	0.025	0.029	0.029
C	0.009	0.001	0.010	0.001	0.010	0.009
A_p	--	--	[0,0.04] ^A	--	--	0.03 ^B
λ_p (1/μs)	--	--	[0, 80] ^A	--	--	40 ^B
ν_p (rad/μs)	--	--	[400, 550] ^A	--	--	500 ^B
w_p (MHz)	--	--	[60-90] ^A	--	--	80
ψ_p (rad)	--	--	[0, 2] ^A	--	--	0.4 ^B

^A Parameter is not uniquely identifiable. However, MC-UQ constrains its value to the range.

^B Reported parameters assume a fixed λ_p of 40 μs⁻¹. This constraint was required because λ_p could not be independently resolved from the available data, and fixing it improved the fit convergence of the remaining parameters.

Table S2. Parameters for Cl-gibbsite

	2 comp - MC UQ		3 comp - MC UQ		2 comp - NLLS	3 comp - NLLS
	Mean	St.Dev.	Mean	St.Dev.	Mean	Mean
A_{dia}	0.187	0.005	0.194	0.006	0.189	0.188
λ_{dia} (1/ μs)	0.203	0.014	0.212	0.013	0.190	0.187
ν_{dia} (rad/ μs)	4.771	0.014	4.769	0.014	4.767	4.767
w_{dia} (MHz)	0.760	0.002	0.760	0.002	0.759	0.759
ψ_{dia} (rad)	0.018	0.027	0.025	0.026	0.024	0.025
C	0.014	0.002	0.014	0.002	0.016	0.016
A_{p}	--	--	[0,0.07] ^A	--	--	0.03 ^B
λ_{p} (1/ μs)	--	--	[0, 80] ^A	--	--	40 ^B
ν_{p} (rad/ μs)	--	--	[400, 550] ^A	--	--	500 ^B
w_{p} (MHz)	--	--	[60-90] ^A	--	--	80 ^B
ψ_{p} (rad)	--	--	[0, 2] ^A	--	--	0.4 ^B

^A Parameter is not uniquely identifiable. However, MC-UQ constrains its value to the range.

^B Reported parameters assume a fixed λ_{p} of 40 μs^{-1} . This constraint was required because λ_{p} could not be independently resolved from the available data, and fixing it improved the fit convergence of the remaining parameters.

Table S3. Binned data for Figure 2A.

time NO ₃ (us)	Asymmetry NO ₃	StDev Asymmetry NO ₃	time Cl (us)	Asymmetry Cl	StDev Asymmetry Cl
0.01875	0.236488	0.00278515	0.01875	0.220162	0.00350016
0.03867	0.21172	0.00287186	0.03867	0.186778	0.00361286
0.05859	0.201588	0.00288407	0.05859	0.19454	0.00361563
0.07852	0.201975	0.00289348	0.07852	0.178614	0.00363584
0.09844	0.186779	0.0029068	0.09844	0.168014	0.00365074
0.11836	0.175053	0.00293176	0.11836	0.167521	0.00367855
0.13828	0.1611	0.00294237	0.13828	0.150994	0.00371559
0.1582	0.149685	0.00296522	0.1582	0.135078	0.00372374
0.17812	0.135946	0.00298491	0.17812	0.120179	0.00374117
0.19805	0.118088	0.00300032	0.19805	0.113145	0.00377113
0.21797	0.0981142	0.00302806	0.21797	0.0985572	0.00379116
0.23789	0.0832899	0.00304377	0.23789	0.087005	0.00382843
0.25781	0.0579071	0.00306368	0.25781	0.0669584	0.00383442
0.27773	0.0362517	0.00308498	0.27773	0.0536558	0.00385258
0.29766	0.0228707	0.00310003	0.29766	0.0398134	0.00387034
0.31758	0.000650562	0.00311783	0.31758	0.0237508	0.00391075
0.3375	-0.0136853	0.00312803	0.3375	0.0041846	0.00392079
0.35742	-0.0296636	0.00313621	0.35742	-0.00171377	0.00393713
0.37734	-0.0493655	0.00314561	0.37734	-0.0339903	0.00393032
0.39727	-0.0746994	0.00315709	0.39727	-0.0336044	0.00396889
0.41719	-0.0823838	0.00316795	0.41719	-0.055275	0.00397566
0.43711	-0.103085	0.00318572	0.43711	-0.068996	0.00399078
0.45703	-0.113634	0.00318633	0.45703	-0.0759308	0.00400773
0.47695	-0.125797	0.00319308	0.47695	-0.0906154	0.00401933
0.49687	-0.135297	0.00321078	0.49687	-0.105594	0.00403859
0.5168	-0.152129	0.00321493	0.5168	-0.109059	0.00404959
0.53672	-0.159961	0.00323029	0.53672	-0.120247	0.00406245
0.55664	-0.168222	0.00323005	0.55664	-0.127716	0.00408486
0.57656	-0.160881	0.00325057	0.57656	-0.130237	0.00410878
0.59648	-0.175901	0.00327499	0.59648	-0.1424	0.00410432
0.61641	-0.178397	0.00327191	0.61641	-0.1429	0.00411994
0.63633	-0.179031	0.00329352	0.63633	-0.140738	0.00415689
0.65625	-0.170599	0.00331552	0.65625	-0.138563	0.00416645
0.67617	-0.164353	0.00333291	0.67617	-0.141948	0.00417721
0.69609	-0.160714	0.00335249	0.69609	-0.134351	0.00423355
0.71602	-0.156758	0.0033753	0.71602	-0.129017	0.00422689
0.73594	-0.150413	0.00338863	0.73594	-0.12704	0.00424984
0.75586	-0.139095	0.00341393	0.75586	-0.112529	0.00425994
0.77578	-0.121466	0.00343435	0.77578	-0.106579	0.00428907

0.7957	-0.112674	0.00345092	0.7957	-0.102187	0.00431631
0.81563	-0.09695	0.00348391	0.81563	-0.0959949	0.00436932
0.83555	-0.0791681	0.00349157	0.83555	-0.085331	0.00435461
0.85547	-0.0648991	0.00350489	0.85547	-0.0659815	0.00438906
0.87539	-0.0465165	0.00354053	0.87539	-0.0690583	0.00442277
0.89531	-0.0350671	0.00355553	0.89531	-0.046881	0.00442853
0.91523	-0.0214474	0.00356593	0.91523	-0.0410122	0.00447296
0.93516	0.00683619	0.00358495	0.93516	-0.0182133	0.00451004
0.95508	0.0227501	0.00358964	0.95508	-0.000605775	0.0045094
0.975	0.0362264	0.00361913	0.975	0.00406798	0.00453001
0.99492	0.055877	0.00362564	0.99492	0.0276841	0.00454145
1.01484	0.0646736	0.00364425	1.01484	0.0395492	0.0045496
1.03477	0.0934349	0.00364734	1.03477	0.0550211	0.00458852
1.05469	0.107758	0.00367386	1.05469	0.0626425	0.00461105
1.07461	0.116057	0.00367926	1.07461	0.0877776	0.00463119
1.09453	0.13016	0.00368351	1.09453	0.0916656	0.00462944
1.11445	0.136947	0.00370075	1.11445	0.108835	0.0046331
1.13438	0.152148	0.00371142	1.13438	0.117315	0.00467972
1.1543	0.163071	0.00372198	1.1543	0.109752	0.00468409
1.17422	0.164157	0.00373115	1.17422	0.140404	0.0047137
1.19414	0.173822	0.00374897	1.19414	0.129708	0.00471137
1.21406	0.174266	0.00376826	1.21406	0.151092	0.00471336
1.23399	0.18487	0.00377867	1.23399	0.158136	0.00474983
1.25391	0.181857	0.00380017	1.25391	0.15209	0.0047657
1.27383	0.173644	0.00380813	1.27383	0.158528	0.00477327
1.29375	0.166232	0.00383996	1.29375	0.157815	0.00480032
1.31367	0.17224	0.00383979	1.31367	0.155201	0.00483249
1.33359	0.16078	0.00388777	1.33359	0.150859	0.0048325
1.35352	0.158554	0.00388096	1.35352	0.160325	0.00487508
1.37344	0.150135	0.00391722	1.37344	0.163646	0.00488405
1.39336	0.139797	0.00393348	1.39336	0.148316	0.0049265
1.41328	0.120458	0.00396151	1.41328	0.127133	0.00496946
1.4332	0.114069	0.00399968	1.4332	0.117064	0.00497963
1.45313	0.0999494	0.00400764	1.45313	0.121091	0.00500647
1.47305	0.0849426	0.00403705	1.47305	0.115504	0.0050461
1.49297	0.0759959	0.00405747	1.49297	0.106571	0.00504614
1.51289	0.0582522	0.0040846	1.51289	0.0958277	0.00511487
1.53281	0.0466647	0.00409213	1.53281	0.0758017	0.00511574
1.55274	0.0336112	0.00411984	1.55274	0.0732323	0.00514811
1.57266	0.0161603	0.00413733	1.57266	0.0586287	0.00520263
1.59258	-0.00883373	0.00417404	1.59258	0.0504572	0.00519707

1.6125	-0.015141	0.00418104	1.6125	0.0332415	0.00524703
1.63242	-0.0406516	0.0041918	1.63242	0.0194077	0.00525321
1.65234	-0.0465218	0.00422639	1.65234	0.0146607	0.00526876
1.67227	-0.0718826	0.00421891	1.67227	0.00938698	0.00531614
1.69219	-0.0731625	0.00422833	1.69219	-0.012486	0.00532469
1.71211	-0.0881839	0.00426713	1.71211	-0.0365122	0.00535547
1.73203	-0.0991229	0.00428364	1.73203	-0.0369324	0.00537363
1.75195	-0.123048	0.00427984	1.75195	-0.0491969	0.00540534
1.77188	-0.124095	0.00429919	1.77188	-0.0703718	0.00543062
1.7918	-0.125557	0.00432183	1.7918	-0.0687452	0.00543567
1.81172	-0.137258	0.00433324	1.81172	-0.0746635	0.00546779
1.83164	-0.138913	0.00434573	1.83164	-0.0983335	0.00546092
1.85156	-0.150547	0.0043788	1.85156	-0.0914749	0.00553118
1.87149	-0.148455	0.00438764	1.87149	-0.108906	0.00550638
1.89141	-0.14299	0.0043944	1.89141	-0.0988332	0.00557715
1.91133	-0.144941	0.00445217	1.91133	-0.104032	0.00557805
1.93125	-0.134919	0.00446175	1.93125	-0.11525	0.00557264
1.95117	-0.142024	0.00447997	1.95117	-0.113849	0.00561263
1.9711	-0.125527	0.00451111	1.9711	-0.120712	0.00562705
1.99102	-0.122243	0.00452759	1.99102	-0.12569	0.00568342
2.01094	-0.116618	0.00455055	2.01094	-0.104565	0.00572068
2.03086	-0.102476	0.00459774	2.03086	-0.102967	0.00572382
2.05078	-0.0926706	0.00460847	2.05078	-0.095281	0.0057586
2.0707	-0.0863662	0.00464267	2.0707	-0.0946823	0.00578658
2.09063	-0.0778137	0.00466514	2.09063	-0.0956198	0.00585786
2.11055	-0.0572639	0.00468589	2.11055	-0.0882042	0.00583595
2.13047	-0.048067	0.004692	2.13047	-0.0732231	0.00587264
2.15039	-0.0381944	0.00473718	2.15039	-0.06289	0.00592078
2.17031	-0.0120146	0.0047791	2.17031	-0.0494277	0.00590577
2.19024	-0.00689441	0.00479681	2.19024	-0.0529184	0.00595521
2.21016	0.00859139	0.00482944	2.21016	-0.0303239	0.00601044
2.23008	0.032484	0.00482746	2.23008	-0.0162206	0.00601944
2.25	0.0495864	0.00483987	2.25	-0.011481	0.00608989
2.26992	0.0577365	0.00485541	2.26992	-0.003783	0.00608611
2.28984	0.0598054	0.00489189	2.28984	0.0126585	0.00612434
2.30977	0.0711944	0.00490244	2.30977	0.0197579	0.00614551
2.32969	0.103043	0.00490362	2.32969	0.0271563	0.00615895
2.34961	0.101845	0.00491967	2.34961	0.0423835	0.00622401
2.36953	0.110456	0.00494214	2.36953	0.0550908	0.00623154
2.38945	0.133698	0.00497684	2.38945	0.0689926	0.00623313
2.40937	0.129661	0.00500706	2.40937	0.0777669	0.00627767

2.4293	0.137696	0.00501377	2.4293	0.0831273	0.00631636
2.44922	0.136412	0.00502573	2.44922	0.0828302	0.00628541
2.46914	0.139419	0.00504225	2.46914	0.0958225	0.00631429
2.48906	0.145201	0.0050842	2.48906	0.0986607	0.00635569
2.50898	0.13279	0.00508414	2.50898	0.117623	0.00646274
2.52891	0.153204	0.00510724	2.52891	0.127309	0.00642302
2.54883	0.144707	0.00515712	2.54883	0.126919	0.00645714
2.56875	0.138985	0.00515741	2.56875	0.126678	0.00644791
2.58867	0.134889	0.00518459	2.58867	0.127354	0.00647119
2.60859	0.145675	0.00521407	2.60859	0.11535	0.00654645
2.62851	0.123965	0.00525082	2.62851	0.13151	0.00656357
2.64844	0.122542	0.00527206	2.64844	0.118769	0.0065673
2.66836	0.113466	0.00530955	2.66836	0.127117	0.00659668
2.68828	0.108499	0.00532109	2.68828	0.119358	0.00666225
2.7082	0.0882172	0.005356	2.7082	0.114097	0.00668874
2.72812	0.0775917	0.00537451	2.72812	0.101975	0.0066765
2.74804	0.0749011	0.00540979	2.74804	0.10421	0.00676643
2.76797	0.0428404	0.00546842	2.76797	0.105401	0.00679698
2.78789	0.0439311	0.00546588	2.78789	0.0936079	0.00683213
2.80781	0.0314156	0.005486	2.80781	0.100906	0.00685716
2.82773	0.00853511	0.00554715	2.82773	0.0748781	0.00689971
2.84765	-0.000211327	0.00557713	2.84765	0.0721068	0.00692298
2.86758	-0.00238289	0.00555975	2.86758	0.0643461	0.00699028
2.8875	-0.0236165	0.00559415	2.8875	0.0555375	0.00706154
2.90742	-0.0510019	0.00560113	2.90742	0.0299951	0.00706853
2.92734	-0.0592252	0.0056423	2.92734	0.0263782	0.00705528
2.94726	-0.0492392	0.00567346	2.94726	0.0215552	0.00710683
2.96718	-0.0689472	0.00569638	2.96718	0.0153523	0.00722686
2.98711	-0.0826027	0.00571557	2.98711	-0.00206223	0.00713676
3.00703	-0.0891775	0.00574206	3.00703	-0.015615	0.00721749
3.02695	-0.0929149	0.0057583	3.02695	-0.0128885	0.00723401
3.04687	-0.10067	0.00577739	3.04687	-0.0311841	0.00723306
3.06679	-0.112518	0.005806	3.06679	-0.0368275	0.00726233
3.08672	-0.116543	0.00584557	3.08672	-0.0486323	0.00737964
3.10664	-0.115378	0.00587821	3.10664	-0.0603087	0.00735268
3.12656	-0.123431	0.00585308	3.12656	-0.0500789	0.00737428
3.14648	-0.120821	0.0058703	3.14648	-0.0790659	0.00744741
3.1664	-0.120044	0.00593564	3.1664	-0.0767569	0.00744917
3.18632	-0.110037	0.00597055	3.18632	-0.0725856	0.00746129
3.20625	-0.115504	0.00598675	3.20625	-0.0922879	0.00752042
3.22617	-0.113802	0.00602225	3.22617	-0.081852	0.00769222

3.24609	-0.106986	0.00604896	3.24609	-0.102721	0.00761285
3.26601	-0.103687	0.0060879	3.26601	-0.0848223	0.00768621
3.28593	-0.0912972	0.00611076	3.28593	-0.0945129	0.00765271
3.30585	-0.0702425	0.00616783	3.30585	-0.0932246	0.00768274
3.32578	-0.0797207	0.00619763	3.32578	-0.0956916	0.0077486
3.3457	-0.0587826	0.0062347	3.3457	-0.100796	0.00780187
3.36562	-0.0508229	0.00625762	3.36562	-0.0751644	0.00781278
3.38554	-0.0422167	0.00628364	3.38554	-0.0812488	0.00787286
3.40546	-0.02677	0.00632232	3.40546	-0.0737953	0.00787079
3.42539	-0.0261508	0.00633855	3.42539	-0.052854	0.00802189
3.44531	-0.00892533	0.00635507	3.44531	-0.06457	0.00800422
3.46523	0.00327183	0.00639207	3.46523	-0.057711	0.00795885
3.48515	0.0176621	0.00645021	3.48515	-0.0495929	0.00802738
3.50507	0.0244508	0.00647885	3.50507	-0.0225363	0.00810052
3.52499	0.0337888	0.00653179	3.52499	-0.0124969	0.00818878
3.54492	0.0551443	0.00651588	3.54492	-0.0121784	0.00814821
3.56484	0.0653677	0.00654295	3.56484	-0.0177444	0.00817766
3.58476	0.0645324	0.00657687	3.58476	-0.0202959	0.00824087
3.60468	0.068747	0.00658644	3.60468	0.0162393	0.00828174
3.6246	0.093104	0.00661121	3.6246	0.0272104	0.00833476
3.64453	0.10218	0.00662695	3.64453	0.0131709	0.00838389
3.66445	0.10269	0.00667973	3.66445	0.0357274	0.00841739
3.68437	0.110174	0.00670005	3.68437	0.0414797	0.00849067
3.70429	0.118233	0.00667246	3.70429	0.0478124	0.00844404
3.72421	0.117668	0.00676608	3.72421	0.0380259	0.00852784
3.74413	0.133464	0.0067823	3.74413	0.0636777	0.00849119
3.76406	0.127016	0.00678416	3.76406	0.0729627	0.00858992
3.78398	0.123703	0.00687589	3.78398	0.0751409	0.00864782
3.8039	0.134403	0.00680685	3.8039	0.0913155	0.00860316
3.82382	0.119955	0.00690332	3.82382	0.100021	0.00872586
3.84374	0.124755	0.00694931	3.84374	0.102494	0.00872276
3.86366	0.11126	0.00700371	3.86366	0.100625	0.00871865
3.88359	0.114024	0.00702397	3.88359	0.0968493	0.00878471
3.90351	0.104367	0.00706754	3.90351	0.102566	0.00883584
3.92343	0.0930005	0.0070108	3.92343	0.105656	0.00887239
3.94335	0.0816293	0.00717786	3.94335	0.11456	0.00893183
3.96327	0.0717637	0.00713796	3.96327	0.0965704	0.00906081
3.9832	0.0848707	0.00720599	3.9832	0.10785	0.00901469
4.00312	0.0756148	0.00726633	4.00312	0.105197	0.00901416
4.02304	0.0453622	0.007301	4.02304	0.112528	0.009043
4.04296	0.0480864	0.00733648	4.04296	0.0983913	0.00911457

4.06288	0.0310577	0.00736502	4.06288	0.080807	0.00920298
4.0828	0.0213704	0.00736125	4.0828	0.0823676	0.00928212
4.10273	0.0147592	0.00744309	4.10273	0.0853642	0.00923398
4.12265	0.00402735	0.00738534	4.12265	0.0704582	0.00930825
4.14257	-0.0188126	0.00750563	4.14257	0.0760881	0.00937924
4.16249	-0.0186852	0.0075943	4.16249	0.0609804	0.00944362
4.18241	-0.0426657	0.00760049	4.18241	0.0644313	0.00950314
4.20233	-0.0350078	0.00759799	4.20233	0.0614247	0.00952036
4.22226	-0.0494607	0.00760509	4.22226	0.0418168	0.00946109
4.24218	-0.0515488	0.00761576	4.24218	0.0184002	0.00953608
4.2621	-0.0763393	0.00770457	4.2621	0.0183252	0.00963606
4.28202	-0.0663415	0.00768378	4.28202	0.0072272	0.00971364
4.30194	-0.0790284	0.0077764	4.30194	0.00877145	0.00974949
4.32187	-0.0818629	0.00783152	4.32187	0.00303758	0.00982654
4.34179	-0.0898965	0.00784137	4.34179	0.00219817	0.00985556
4.36171	-0.100294	0.00779053	4.36171	-0.0179858	0.00987906
4.38163	-0.10003	0.00787222	4.38163	-0.0211711	0.00986204
4.40155	-0.0850927	0.00791113	4.40155	-0.0363712	0.00991507
4.42147	-0.102478	0.00791848	4.42147	-0.0330124	0.00997882
4.4414	-0.0920111	0.00801952	4.4414	-0.0382125	0.0100589
4.46132	-0.0800361	0.0080558	4.46132	-0.0537742	0.0101065
4.48124	-0.0982261	0.00805959	4.48124	-0.0437685	0.0101506
4.50116	-0.0814826	0.00809912	4.50116	-0.0561082	0.010249
4.52108	-0.0725264	0.00816259	4.52108	-0.0618552	0.010278
4.54101	-0.0715377	0.00815526	4.54101	-0.0669636	0.0103008
4.56093	-0.0631633	0.00829285	4.56093	-0.0753532	0.0102543
4.58085	-0.0712086	0.00828062	4.58085	-0.0657702	0.0104514
4.60077	-0.0552471	0.00829594	4.60077	-0.0540734	0.0103542
4.62069	-0.0495073	0.00831024	4.62069	-0.0842451	0.0104381
4.64061	-0.0385612	0.00837781	4.64061	-0.0714421	0.0104381
4.66054	-0.0346704	0.00842535	4.66054	-0.056561	0.0105935
4.68046	-0.0340266	0.00848544	4.68046	-0.0651688	0.0106638
4.70038	-0.0140328	0.00853989	4.70038	-0.0621868	0.0107278
4.7203	-0.012654	0.00863149	4.7203	-0.0461787	0.0106996
4.74022	0.00540606	0.00864094	4.74022	-0.0516311	0.0108253
4.76014	0.0360336	0.00865472	4.76014	-0.0366395	0.0107871
4.78007	0.0192977	0.00876815	4.78007	-0.0335289	0.0108009
4.79999	0.0438328	0.00873128	4.79999	-0.0394375	0.0109419
4.81991	0.0529601	0.00877524	4.81991	-0.0143452	0.0110253
4.83983	0.0447445	0.00879295	4.83983	-0.0254479	0.0110381
4.85975	0.0748181	0.00880613	4.85975	-0.0143781	0.0112797

4.87968	0.0777624	0.00891551	4.87968	0.00135044	0.0111787
4.8996	0.0644501	0.00893492	4.8996	-0.00593761	0.0112752
4.91952	0.0860273	0.00894368	4.91952	0.020828	0.011274
4.93944	0.0707886	0.00892718	4.93944	0.0167108	0.0113955
4.95936	0.0755875	0.00906213	4.95936	0.00313106	0.0113181
4.97928	0.0813142	0.00903202	4.97928	0.027147	0.0114067
4.99921	0.081609	0.0091179	4.99921	0.0258493	0.0114873
5.01913	0.0834627	0.0091523	5.01913	0.045735	0.0115084
5.03905	0.0944037	0.00923257	5.03905	0.0617639	0.0114639
5.05897	0.0866355	0.00923888	5.05897	0.0444904	0.0116552
5.07889	0.0873758	0.00930657	5.07889	0.0452409	0.0117019
5.09882	0.0993485	0.00938887	5.09882	0.061584	0.0116993
5.11874	0.0942597	0.00935406	5.11874	0.0581298	0.0118156
5.13866	0.0633337	0.00950365	5.13866	0.0614707	0.0117276
5.15858	0.086906	0.00944761	5.15858	0.0560664	0.011919
5.1785	0.062724	0.00953208	5.1785	0.0905406	0.0119208
5.19842	0.0763789	0.00951928	5.19842	0.0710214	0.0121053
5.21835	0.0566859	0.00964291	5.21835	0.0725461	0.0118505
5.23827	0.0660338	0.00959922	5.23827	0.0579242	0.0121349
5.25819	0.0542789	0.00971445	5.25819	0.0704377	0.0120544
5.27811	0.0294956	0.00973998	5.27811	0.0772638	0.0120967
5.29803	0.0411963	0.00978179	5.29803	0.0763038	0.0122553
5.31795	0.039069	0.00978389	5.31795	0.0604932	0.0122829
5.33788	0.00717867	0.00992667	5.33788	0.0685833	0.0124305
5.3578	0.0299034	0.00995418	5.3578	0.0651532	0.0125256
5.37772	0.0006832	0.00993641	5.37772	0.0513763	0.0125285
5.39764	-0.010562	0.00995751	5.39764	0.0638814	0.0125991
5.41756	-0.00892322	0.0100675	5.41756	0.0712267	0.0127457
5.43749	-0.0049934	0.0101699	5.43749	0.0653471	0.0127784
5.45741	-0.0149931	0.0101986	5.45741	0.056895	0.0127239
5.47733	-0.038905	0.0103219	5.47733	0.0480338	0.0126991
5.49725	-0.036114	0.0103225	5.49725	0.0357388	0.0128923
5.51717	-0.0371151	0.0102882	5.51717	0.0550334	0.0129792
5.53709	-0.0373739	0.0102957	5.53709	0.0255964	0.0128945
5.55702	-0.0384482	0.0104175	5.55702	0.0211636	0.0130738
5.57694	-0.0515659	0.0104201	5.57694	0.00621658	0.0129936
5.59686	-0.078795	0.0105605	5.59686	0.00916033	0.0132438
5.61678	-0.0642368	0.010514	5.61678	0.00893195	0.0131988
5.6367	-0.0596996	0.0106331	5.6367	-0.00802126	0.0133072
5.65662	-0.0851433	0.0106863	5.65662	-0.0101144	0.0133352
5.67655	-0.0752508	0.0107599	5.67655	0.0025858	0.013327

5.69647	-0.0880552	0.0107132	5.69647	-0.0140595	0.0135927
5.71639	-0.0681915	0.0108038	5.71639	-0.0143763	0.0134873
5.73631	-0.0812237	0.0109056	5.73631	-0.00666723	0.0136905
5.75623	-0.0603085	0.0109957	5.75623	-0.0301127	0.0136759
5.77616	-0.0687644	0.0109256	5.77616	-0.0345438	0.0138843
5.79608	-0.0376906	0.0109476	5.79608	-0.0479559	0.0138537
5.816	-0.0394742	0.0109704	5.816	-0.0650051	0.0138005
5.83592	-0.0506941	0.0111598	5.83592	-0.0494964	0.0138076
5.85584	-0.0420057	0.011143	5.85584	-0.0277137	0.0140969
5.87576	-0.0249539	0.0112219	5.87576	-0.0399063	0.0141527
5.89569	-0.0397326	0.0112146	5.89569	-0.0223014	0.0142715
5.91561	-0.0479797	0.0113154	5.91561	-0.0359111	0.0144098
5.93553	-0.000108055	0.0114187	5.93553	-0.0420067	0.0142156
5.95545	-0.000110689	0.0115626	5.95545	-0.0561195	0.0141684
5.97537	-0.0226874	0.0115238	5.97537	-0.0297735	0.0144761
5.99529	0.00155571	0.0115573	5.99529	-0.0327233	0.0145051
6.01522	0.0116386	0.0116691	6.01522	-0.0372425	0.014436
6.03514	0.00369462	0.0117035	6.03514	-0.0333773	0.014608
6.05506	0.0391123	0.0116517	6.05506	-0.0259463	0.0145358
6.07498	0.0238954	0.0117983	6.07498	-0.0479123	0.0145648
6.0949	0.0507184	0.0120068	6.0949	-0.00744962	0.0149292
6.11483	0.0443418	0.0118534	6.11483	0.0108294	0.0148806
6.13475	0.0450211	0.0119475	6.13475	0.00723624	0.0148923
6.15467	0.0615688	0.0121375	6.15467	-0.0135129	0.0151053
6.17459	0.0627366	0.0119864	6.17459	-0.021341	0.0150124
6.19451	0.0707669	0.0122101	6.19451	-0.0350959	0.0150911
6.21443	0.0654428	0.0122522	6.21443	-0.00635946	0.0151674
6.23436	0.061187	0.0124147	6.23436	0.00789616	0.0153529
6.25428	0.06682	0.0121234	6.25428	-0.00605525	0.0156549
6.2742	0.0747006	0.0122136	6.2742	0.0303356	0.0155121
6.29412	0.0702116	0.012453	6.29412	0.0206137	0.015485
6.31404	0.0853771	0.0125349	6.31404	0.0202469	0.0156146
6.33397	0.0720533	0.0126499	6.33397	0.0129819	0.015727
6.35389	0.055062	0.0126406	6.35389	0.0178421	0.0161358
6.37381	0.0736467	0.0127101	6.37381	0.0487297	0.0158224
6.39373	0.0717293	0.0127342	6.39373	0.0531504	0.0161865
6.41365	0.0569394	0.0127897	6.41365	0.0507845	0.0159637
6.43357	0.0689409	0.0129203	6.43357	0.049486	0.0159503
6.4535	0.0352145	0.0130973	6.4535	0.0357876	0.01616
6.47342	0.065392	0.0128361	6.47342	0.0546566	0.0162259
6.49334	0.0697995	0.0128949	6.49334	0.0725481	0.0161347

6.51326	0.0447712	0.0131354	6.51326	0.0322459	0.0163436
6.53318	0.03129	0.0132782	6.53318	0.0478344	0.0164018
6.5531	0.0431699	0.0132485	6.5531	0.0432702	0.0166733
6.57303	0.0407788	0.013443	6.57303	0.0557225	0.0166331
6.59295	0.036651	0.0133106	6.59295	0.0676781	0.0167092
6.61287	0.000700304	0.013367	6.61287	0.0872332	0.0167615
6.63279	-0.0020307	0.013446	6.63279	0.0588448	0.0167848
6.65271	0.00260415	0.0134818	6.65271	0.0732187	0.016928
6.67264	-0.00718563	0.013637	6.67264	0.0561831	0.0169598
6.69256	-0.00139122	0.0136824	6.69256	0.0511771	0.0170419
6.71248	-0.00411443	0.013805	6.71248	0.0380463	0.0171315
6.7324	-0.00799871	0.013901	6.7324	0.0925522	0.0171212
6.75232	-0.0222226	0.0138967	6.75232	0.0579269	0.0175058
6.77224	-0.0401522	0.0138984	6.77224	0.0180366	0.0175566
6.79217	-0.0305879	0.0141572	6.79217	0.0167249	0.0176355
6.81209	-0.0232401	0.0140472	6.81209	0.0451099	0.0174983
6.83201	-0.0485058	0.0140829	6.83201	0.0512158	0.0175537
6.85193	-0.0439552	0.0142711	6.85193	0.0197024	0.0177986
6.87185	-0.0480752	0.0143427	6.87185	0.0100585	0.0179851
6.89178	-0.0573852	0.0143354	6.89178	0.0339228	0.0179367
6.9117	-0.0413682	0.0143268	6.9117	0.0235364	0.0180241
6.93162	-0.0369505	0.0147511	6.93162	-0.00245099	0.0181576
6.95154	-0.0493902	0.0147713	6.95154	0.0113785	0.0180727
6.97146	-0.0555199	0.0145925	6.97146	0.0155471	0.01838
6.99138	-0.0415481	0.0146908	6.99138	-0.0178699	0.0182886
7.01131	-0.0487347	0.0148317	7.01131	-0.0229615	0.0184499
7.03123	-0.0458838	0.0149127	7.03123	0.00710512	0.0185337
7.05115	-0.0391005	0.0151115	7.05115	0.0242233	0.0188274
7.07107	-0.034529	0.0150955	7.07107	0.00266238	0.018766
7.09099	-0.016332	0.0148679	7.09099	-0.0108742	0.0187927
7.11091	-0.0256019	0.0151781	7.11091	-0.0318966	0.0191703
7.13084	-0.018562	0.0152109	7.13084	0.000695761	0.0189055
7.15076	-0.0380127	0.0151537	7.15076	-0.0271279	0.0191875
7.17068	-0.0267567	0.0154696	7.17068	0.0140837	0.0194244
7.1906	-0.000649051	0.0156074	7.1906	-0.0379015	0.0192116
7.21052	-0.0236992	0.0155735	7.21052	-0.019141	0.0193342
7.23045	0.0197032	0.0156823	7.23045	-0.00466807	0.0197174
7.25037	0.00211768	0.0157926	7.25037	-0.0231098	0.0195517
7.27029	0.0262333	0.0157959	7.27029	-0.0102182	0.0198505
7.29021	0.0106954	0.0157952	7.29021	-0.04212	0.0197534
7.31013	0.00937029	0.0160708	7.31013	-0.0311359	0.0201133

7.33005	-0.00210381	0.0159956	7.33005	-0.0132609	0.0202461
7.34998	0.0406508	0.0160986	7.34998	-0.0233124	0.0203241
7.3699	0.0255514	0.0161993	7.3699	-0.0128984	0.0199475
7.38982	0.0362217	0.0162497	7.38982	-0.0277371	0.0196842
7.40974	0.0287806	0.0159324	7.40974	-0.00866257	0.0206869
7.42966	0.0246392	0.0162206	7.42966	0.0148643	0.0205507
7.44958	0.024555	0.0168284	7.44958	-0.0115711	0.0208235
7.46951	0.0534117	0.0165002	7.46951	-0.0190899	0.0207708
7.48943	0.0323437	0.0165314	7.48943	0.0151542	0.0210656
7.50935	0.0764028	0.0167942	7.50935	-0.0368769	0.0213431
7.52927	0.0430048	0.0166459	7.52927	0.000856538	0.0211347
7.54919	0.0415626	0.0169507	7.54919	-0.0517691	0.0217613
7.56912	0.0477815	0.0167738	7.56912	0.00436488	0.0217317
7.58904	0.0928217	0.017119	7.58904	0.0286538	0.0214009
7.60896	0.0605563	0.0173474	7.60896	0.00635063	0.021408
7.62888	0.0923478	0.0172363	7.62888	0.0386664	0.0210037
7.6488	0.051746	0.0170167	7.6488	0.0492295	0.0217866
7.66872	0.0623342	0.0174063	7.66872	0.0425421	0.0216278
7.68865	0.00681124	0.0175604	7.68865	0.0336234	0.0221316
7.70857	0.0613847	0.0176511	7.70857	0.00219949	0.0217262
7.72849	0.0718651	0.0177482	7.72849	0.0399269	0.0224143
7.74841	0.0637261	0.017833	7.74841	0.051637	0.0220415
7.76833	0.0288322	0.0179485	7.76833	0.0334499	0.0227371
7.78826	-0.00325357	0.0181365	7.78826	0.0556138	0.0216595
7.80818	-0.00865153	0.0178093	7.80818	0.0497855	0.0223528
7.8281	0.019355	0.0182136	7.8281	0.0619175	0.0227658
7.84802	-0.0021021	0.0183598	7.84802	0.0660034	0.0229102
7.86794	0.0190891	0.0185557	7.86794	0.050954	0.0233472
7.88786	0.00969785	0.0185301	7.88786	0.056015	0.0228239
7.90779	0.0233283	0.0183651	7.90779	0.0304299	0.0230477
7.92771	0.0213998	0.0184675	7.92771	0.0394553	0.0231543
7.94763	-0.000267721	0.0184905	7.94763	0.0689878	0.0235626
7.96755	-0.00940544	0.0189896	7.96755	0.0684916	0.0229257
7.98747	0.00257203	0.0186789	7.98747	0.0679321	0.023748
8.00739	-0.0212196	0.0190244	8.00739	0.0317314	0.0231821
8.02732	-0.00958451	0.018832	8.02732	0.0375812	0.0240479
8.04724	0.00169169	0.0191027	8.04724	0.0329297	0.0238589
8.06716	-0.00605984	0.0194151	8.06716	0.0376124	0.0238773
8.08708	-0.0151176	0.0191068	8.08708	0.0666375	0.0244228
8.10701	-0.0160736	0.0193027	8.10701	0.0347099	0.024351
8.12693	-0.0122898	0.0198272	8.12693	-0.0051919	0.0241039

8.14685	-0.0457223	0.0194605	8.14685	0.0121332	0.0247573
8.16677	-0.0308045	0.0196329	8.16677	0.000592838	0.0247028
8.1867	-0.0183019	0.0198355	8.1867	0.0121465	0.0247724
8.20662	-0.0304507	0.0198814	8.20662	0.0112444	0.0250165
8.22654	-0.0543238	0.0197388	8.22654	0.0117167	0.025593
8.24646	-0.0164273	0.0197636	8.24646	-0.00321907	0.0246198
8.26638	-0.0478956	0.0205648	8.26638	-0.0134814	0.0251012
8.28631	-0.060786	0.0203499	8.28631	0.0027372	0.0244826
8.30623	-0.0161458	0.0205659	8.30623	0.0431704	0.0255701
8.32615	-0.0762296	0.0207011	8.32615	-0.00615706	0.0251128
8.34607	-0.0250365	0.0208406	8.34607	-0.017193	0.0253689
8.366	-0.038094	0.0210472	8.366	0.0190737	0.0258625
8.38592	-0.0208883	0.0211171	8.38592	-0.0107282	0.0259575
8.40584	-0.0116913	0.0214172	8.40584	0.0112714	0.0257687
8.42576	-0.0167201	0.0212465	8.42576	0.0231888	0.0270102
8.44568	-0.0213594	0.0211588	8.44568	0.00452002	0.0269019
8.46561	-0.0245391	0.0217557	8.46561	-0.0343003	0.0265546
8.48553	0.0102738	0.021533	8.48553	-0.0176208	0.026207
8.50545	0.0320039	0.0214066	8.50545	-0.012087	0.0269133
8.52537	-0.0052787	0.0215772	8.52537	-0.0372566	0.0262423
8.5453	0.0185694	0.0216134	8.5453	0.00467516	0.0274152
8.56522	0.000474086	0.0217703	8.56522	-0.0153504	0.0269786
8.58514	0.0394408	0.0222346	8.58514	0.0150219	0.0278858
8.60506	0.0346654	0.0222302	8.60506	-0.0197646	0.0279439
8.62498	0.0371335	0.0223332	8.62498	0.0343491	0.0280133
8.64491	0.0122697	0.0218967	8.64491	-0.0136598	0.0280026
8.66483	0.0456972	0.022287	8.66483	0.0508315	0.0291426
8.68475	0.0284835	0.0225628	8.68475	-0.0394319	0.0284188
8.70467	0.0731536	0.0225888	8.70467	-0.0159865	0.0275989
8.7246	0.0871381	0.0221548	8.7246	0.0443915	0.0284187
8.74452	0.0385477	0.0231182	8.74452	-0.00953168	0.0279838
8.76444	0.0419619	0.0228839	8.76444	0.0096266	0.0291492
8.78436	0.0309854	0.0230587	8.78436	0.0226861	0.0295609
8.80429	0.0255377	0.023595	8.80429	0.0216416	0.0287809
8.82421	0.0747472	0.0237853	8.82421	0.0385481	0.0289316
8.84413	0.0819324	0.0239195	8.84413	0.0140002	0.0291017
8.86405	0.0462134	0.0241739	8.86405	-0.0488279	0.0302657
8.88397	0.016696	0.0242378	8.88397	0.0459496	0.0303742
8.9039	0.043157	0.0243216	8.9039	0.0136162	0.0295346
8.92382	0.0508382	0.0239332	8.92382	-0.0399955	0.0305551
8.94374	0.0477798	0.0233625	8.94374	0.0265715	0.0306435

8.96366	0.0351533	0.0243654	8.96366	-0.0133973	0.0314614
8.98359	0.0747794	0.0240617	8.98359	0.0248608	0.0311487
9.00351	0.0813933	0.0248774	9.00351	0.0795071	0.0309557
9.02343	0.0406018	0.0243151	9.02343	-0.0119424	0.0305723
9.04335	0.0248677	0.0245882	9.04335	0.000072682	0.0321633
9.06327	-0.0179193	0.0249093	9.06327	0.0692577	0.0310692
9.0832	0.00623145	0.0244967	9.0832	0.0606214	0.0309595
9.10312	0.0122372	0.0249196	9.10312	0.100982	0.0312514
9.12304	0.0376921	0.0255753	9.12304	0.0262291	0.031525
9.14296	0.00752101	0.0260825	9.14296	0.0366646	0.0316782
9.16289	0.011311	0.0250874	9.16289	0.0562102	0.0322283
9.18281	0.0316492	0.0258579	9.18281	0.0187063	0.0324507
9.20273	-0.00935401	0.0256009	9.20273	0.0698353	0.0318791
9.22265	0.0134775	0.0263484	9.22265	0.0617331	0.0325738
9.24257	-0.0238163	0.0259645	9.24257	0.0537201	0.032279
9.2625	-0.0121952	0.0263863	9.2625	0.0214251	0.0325013
9.28242	0.00409541	0.0261155	9.28242	-0.0161404	0.0327162
9.30234	0.0121288	0.0261192	9.30234	0.0285937	0.0331394
9.32226	-0.0364724	0.0267439	9.32226	0.015487	0.0328572
9.34219	-0.00343711	0.0264379	9.34219	-0.00782249	0.034534
9.36211	-0.0274435	0.0270777	9.36211	0.00587142	0.0340739
9.38203	-0.0185976	0.0273718	9.38203	-0.0257997	0.0331936
9.40195	-0.0483799	0.027504	9.40195	-0.0171279	0.0338642
9.42188	-0.0135312	0.0272776	9.42188	-0.0252726	0.0335013
9.4418	-0.0424059	0.0276355	9.4418	0.0423604	0.0344516
9.46172	-0.016158	0.0280667	9.46172	0.0302021	0.0348772
9.48164	-0.0392869	0.0282001	9.48164	0.00112237	0.0355201
9.50156	-0.0544171	0.0281869	9.50156	0.0398416	0.0346727
9.52149	0.0231664	0.0283319	9.52149	0.00110181	0.0351358
9.54141	-0.0833118	0.028665	9.54141	0.0311747	0.0348567
9.56133	-0.0734725	0.0278615	9.56133	0.0307738	0.035975
9.58125	-0.0168136	0.0287313	9.58125	0.0558146	0.035836
9.60118	-0.0209277	0.0287727	9.60118	-0.0636018	0.0359302
9.6211	0.0109632	0.0299488	9.6211	0.0115804	0.0357017
9.64102	-0.0158909	0.0292022	9.64102	-0.043665	0.0360843
9.66094	0.0168118	0.0292642	9.66094	-0.000978427	0.0361413
9.68086	0.0554627	0.0303019	9.68086	-0.0110919	0.0371524
9.70079	-0.0419376	0.0299019	9.70079	-0.0196017	0.0354994
9.72071	-0.000663312	0.0310287	9.72071	-0.0179516	0.0348066
9.74063	0.0193184	0.0296475	9.74063	-0.00680049	0.0377645
9.76055	-0.0468413	0.0298294	9.76055	-0.0337638	0.0373197

9.78048	-0.00526799	0.0309956	9.78048	0.0208062	0.0391224
9.8004	0.0730674	0.030833	9.8004	-0.0218172	0.0378238
9.82032	-0.0130479	0.0323063	9.82032	-0.0214814	0.0387132
9.84024	-0.020126	0.0305313	9.84024	-0.0665627	0.0384577
9.86016	-0.0293598	0.0302089	9.86016	-0.0408117	0.0374587
9.88009	0.0294989	0.0306813	9.88009	-0.0375632	0.0389962
9.90001	0.0323204	0.0310063	9.90001	-0.0324747	0.0397369

Table S4. Binned data for histogram in Figure 2B.

	2-comp	2-comp	2-comp	3-comp	3-comp	3-comp
bin range (Asymmetry)	Histogram Count	Normalized Count	Model Fit	Histogram Count	Normalized Count	Model Fit
0.0162	0	0	8.59E-05	0	0	0.009124
0.0163	0	0	0.000101	0	0	0.009979
0.0164	0	0	0.000118	0	0	0.010903
0.0165	0	0	0.000139	2	0.071429	0.011901
0.0166	0	0	0.000162	0	0	0.012979
0.0167	0	0	0.000189	0	0	0.01414
0.0168	0	0	0.000221	0	0	0.015391
0.0169	0	0	0.000257	0	0	0.016736
0.017	0	0	0.0003	0	0	0.018181
0.0171	0	0	0.000348	0	0	0.019732
0.0172	0	0	0.000404	1	0.035714	0.021394
0.0173	0	0	0.000467	0	0	0.023175
0.0174	0	0	0.000541	0	0	0.02508
0.0175	0	0	0.000625	0	0	0.027115
0.0176	0	0	0.00072	1	0.035714	0.029287
0.0177	0	0	0.00083	0	0	0.031604
0.0178	0	0	0.000954	0	0	0.03407
0.0179	0	0	0.001096	0	0	0.036694
0.018	0	0	0.001257	1	0.035714	0.039482
0.0181	0	0	0.00144	0	0	0.042441
0.0182	0	0	0.001646	0	0	0.045578
0.0183	0	0	0.00188	1	0.035714	0.0489
0.0184	0	0	0.002144	3	0.107143	0.052414
0.0185	0	0	0.002442	0	0	0.056126
0.0186	0	0	0.002777	0	0	0.060044
0.0187	0	0	0.003153	1	0.035714	0.064173
0.0188	0	0	0.003576	2	0.071429	0.068521
0.0189	0	0	0.004049	2	0.071429	0.073093
0.019	0	0	0.004579	2	0.071429	0.077896
0.0191	1	0.009259	0.00517	1	0.035714	0.082935
0.0192	0	0	0.00583	1	0.035714	0.088214
0.0193	1	0.009259	0.006565	8	0.285714	0.09374
0.0194	0	0	0.007381	2	0.071429	0.099517
0.0195	1	0.009259	0.008288	0	0	0.105548
0.0196	0	0	0.009292	4	0.142857	0.111838
0.0197	1	0.009259	0.010404	0	0	0.118388
0.0198	2	0.018519	0.011632	5	0.178571	0.125202

0.0199	3	0.027778	0.012987	7	0.25	0.132281
0.02	0	0	0.014479	5	0.178571	0.139627
0.0201	0	0	0.01612	4	0.142857	0.147239
0.0202	1	0.009259	0.017921	7	0.25	0.155117
0.0203	2	0.018519	0.019895	4	0.142857	0.16326
0.0204	1	0.009259	0.022056	3	0.107143	0.171666
0.0205	3	0.027778	0.024416	8	0.285714	0.180331
0.0206	5	0.046296	0.026991	4	0.142857	0.189252
0.0207	1	0.009259	0.029796	8	0.285714	0.198425
0.0208	4	0.037037	0.032845	11	0.392857	0.207842
0.0209	0	0	0.036155	5	0.178571	0.217497
0.021	9	0.083333	0.039743	9	0.321429	0.227382
0.0211	4	0.037037	0.043625	9	0.321429	0.237489
0.0212	4	0.037037	0.047818	10	0.357143	0.247807
0.0213	11	0.101852	0.05234	2	0.071429	0.258326
0.0214	14	0.12963	0.057209	12	0.428571	0.269033
0.0215	6	0.055556	0.062442	7	0.25	0.279915
0.0216	11	0.101852	0.068057	9	0.321429	0.290958
0.0217	10	0.092593	0.074073	4	0.142857	0.302146
0.0218	2	0.018519	0.080506	8	0.285714	0.313464
0.0219	13	0.12037	0.087375	8	0.285714	0.324894
0.022	10	0.092593	0.094695	5	0.178571	0.336417
0.0221	11	0.101852	0.102484	12	0.428571	0.348016
0.0222	15	0.138889	0.110756	18	0.642857	0.359669
0.0223	11	0.101852	0.119527	4	0.142857	0.371356
0.0224	19	0.175926	0.128809	9	0.321429	0.383055
0.0225	23	0.212963	0.138617	11	0.392857	0.394743
0.0226	18	0.166667	0.14896	15	0.535714	0.406398
0.0227	24	0.222222	0.159849	15	0.535714	0.417996
0.0228	15	0.138889	0.171291	9	0.321429	0.429513
0.0229	18	0.166667	0.183293	14	0.5	0.440924
0.023	18	0.166667	0.195858	21	0.75	0.452204
0.0231	21	0.194444	0.208988	9	0.321429	0.463328
0.0232	15	0.138889	0.222684	12	0.428571	0.47427
0.0233	26	0.240741	0.236941	8	0.285714	0.485005
0.0234	34	0.314815	0.251755	9	0.321429	0.495508
0.0235	28	0.259259	0.267117	10	0.357143	0.505752
0.0236	28	0.259259	0.283015	14	0.5	0.515713
0.0237	24	0.222222	0.299436	18	0.642857	0.525367
0.0238	24	0.222222	0.316361	16	0.571429	0.534687
0.0239	27	0.25	0.33377	18	0.642857	0.543651

0.024	41	0.37963	0.35164	11	0.392857	0.552236
0.0241	50	0.462963	0.369942	19	0.678571	0.560418
0.0242	38	0.351852	0.388646	15	0.535714	0.568176
0.0243	56	0.518519	0.407719	10	0.357143	0.575489
0.0244	45	0.416667	0.427123	23	0.821429	0.582337
0.0245	54	0.5	0.446818	12	0.428571	0.588701
0.0246	45	0.416667	0.46676	16	0.571429	0.594564
0.0247	37	0.342593	0.486902	10	0.357143	0.59991
0.0248	53	0.490741	0.507196	23	0.821429	0.604724
0.0249	65	0.601852	0.527588	16	0.571429	0.608991
0.025	65	0.601852	0.548024	23	0.821429	0.612701
0.0251	58	0.537037	0.568447	22	0.785714	0.615842
0.0252	73	0.675926	0.588797	20	0.714286	0.618406
0.0253	73	0.675926	0.609013	14	0.5	0.620385
0.0254	72	0.666667	0.629032	11	0.392857	0.621773
0.0255	68	0.62963	0.648791	17	0.607143	0.622567
0.0256	62	0.574074	0.668224	17	0.607143	0.622764
0.0257	85	0.787037	0.687266	28	1	0.622364
0.0258	65	0.601852	0.705851	13	0.464286	0.621367
0.0259	73	0.675926	0.723914	20	0.714286	0.619778
0.026	90	0.833333	0.741389	19	0.678571	0.617599
0.0261	82	0.759259	0.758212	15	0.535714	0.614839
0.0262	61	0.564815	0.77432	13	0.464286	0.611503
0.0263	99	0.916667	0.789653	10	0.357143	0.607602
0.0264	87	0.805556	0.80415	18	0.642857	0.603148
0.0265	74	0.685185	0.817755	15	0.535714	0.598152
0.0266	99	0.916667	0.830415	12	0.428571	0.592628
0.0267	86	0.796296	0.842078	18	0.642857	0.586592
0.0268	96	0.888889	0.852698	19	0.678571	0.580061
0.0269	93	0.861111	0.862231	15	0.535714	0.573053
0.027	95	0.87963	0.870637	15	0.535714	0.565587
0.0271	104	0.962963	0.877882	25	0.892857	0.557682
0.0272	99	0.916667	0.883936	12	0.428571	0.549361
0.0273	97	0.898148	0.888772	14	0.5	0.540645
0.0274	104	0.962963	0.892372	15	0.535714	0.531557
0.0275	77	0.712963	0.894719	20	0.714286	0.52212
0.0276	88	0.814815	0.895804	13	0.464286	0.51236
0.0277	108	1	0.895622	13	0.464286	0.502299
0.0278	103	0.953704	0.894174	16	0.571429	0.491964
0.0279	83	0.768519	0.891466	13	0.464286	0.48138
0.028	103	0.953704	0.887509	19	0.678571	0.470572

0.0281	98	0.907407	0.88232	8	0.285714	0.459565
0.0282	102	0.944444	0.875922	16	0.571429	0.448385
0.0283	95	0.87963	0.86834	13	0.464286	0.437058
0.0284	108	1	0.859606	12	0.428571	0.425608
0.0285	87	0.805556	0.849757	12	0.428571	0.414061
0.0286	93	0.861111	0.838833	7	0.25	0.402441
0.0287	73	0.675926	0.826879	12	0.428571	0.390772
0.0288	89	0.824074	0.813942	10	0.357143	0.379077
0.0289	78	0.722222	0.800075	11	0.392857	0.36738
0.029	71	0.657407	0.785332	7	0.25	0.355702
0.0291	79	0.731481	0.76977	11	0.392857	0.344065
0.0292	98	0.907407	0.75345	8	0.285714	0.33249
0.0293	81	0.75	0.736433	10	0.357143	0.320996
0.0294	75	0.694444	0.718783	9	0.321429	0.309602
0.0295	74	0.685185	0.700563	14	0.5	0.298327
0.0296	65	0.601852	0.68184	13	0.464286	0.287186
0.0297	76	0.703704	0.662679	7	0.25	0.276196
0.0298	71	0.657407	0.643146	14	0.5	0.265372
0.0299	68	0.62963	0.623306	5	0.178571	0.254728
0.03	71	0.657407	0.603223	2	0.071429	0.244276
0.0301	64	0.592593	0.582962	5	0.178571	0.234029
0.0302	70	0.648148	0.562585	2	0.071429	0.223996
0.0303	67	0.62037	0.542153	8	0.285714	0.214188
0.0304	59	0.546296	0.521724	5	0.178571	0.204613
0.0305	52	0.481481	0.501354	4	0.142857	0.195278
0.0306	48	0.444444	0.481099	2	0.071429	0.186191
0.0307	45	0.416667	0.461009	3	0.107143	0.177356
0.0308	52	0.481481	0.441134	8	0.285714	0.168779
0.0309	44	0.407407	0.421518	3	0.107143	0.160462
0.031	37	0.342593	0.402205	2	0.071429	0.152409
0.0311	46	0.425926	0.383234	2	0.071429	0.144621
0.0312	31	0.287037	0.364642	2	0.071429	0.137099
0.0313	38	0.351852	0.346461	6	0.214286	0.129844
0.0314	30	0.277778	0.328721	1	0.035714	0.122856
0.0315	32	0.296296	0.311449	1	0.035714	0.116131
0.0316	28	0.259259	0.294667	3	0.107143	0.10967
0.0317	28	0.259259	0.278394	8	0.285714	0.103469
0.0318	25	0.231481	0.262649	2	0.071429	0.097524
0.0319	20	0.185185	0.247443	4	0.142857	0.091834
0.032	29	0.268519	0.232789	5	0.178571	0.086392
0.0321	37	0.342593	0.218692	3	0.107143	0.081195

0.0322	21	0.194444	0.205159	1	0.035714	0.076237
0.0323	20	0.185185	0.192191	0	0	0.071513
0.0324	26	0.240741	0.179788	0	0	0.067018
0.0325	20	0.185185	0.167947	2	0.071429	0.062745
0.0326	11	0.101852	0.156665	2	0.071429	0.058688
0.0327	15	0.138889	0.145934	1	0.035714	0.054841
0.0328	14	0.12963	0.135745	1	0.035714	0.051197
0.0329	13	0.12037	0.12609	1	0.035714	0.047749
0.033	12	0.111111	0.116956	0	0	0.044491
0.0331	14	0.12963	0.108329	1	0.035714	0.041415
0.0332	14	0.12963	0.100198	2	0.071429	0.038515
0.0333	12	0.111111	0.092545	1	0.035714	0.035784
0.0334	15	0.138889	0.085357	1	0.035714	0.033214
0.0335	7	0.064815	0.078615	1	0.035714	0.030799
0.0336	7	0.064815	0.072303	0	0	0.028533
0.0337	6	0.055556	0.066404	0	0	0.026408
0.0338	6	0.055556	0.0609	0	0	0.024418
0.0339	4	0.037037	0.055774	0	0	0.022556
0.034	5	0.046296	0.051006	0	0	0.020816
0.0341	4	0.037037	0.046581	0	0	0.019192
0.0342	7	0.064815	0.042479	1	0.035714	0.017678
0.0343	5	0.046296	0.038683	3	0.107143	0.016267
0.0344	5	0.046296	0.035177	0	0	0.014955
0.0345	2	0.018519	0.031943	0	0	0.013735
0.0346	5	0.046296	0.028966	0	0	0.012603
0.0347	3	0.027778	0.026229	0	0	0.011553
0.0348	3	0.027778	0.023717	0	0	0.010581
0.0349	1	0.009259	0.021415	0	0	0.00968
0.035	2	0.018519	0.01931	0	0	0.008848
0.0351	5	0.046296	0.017386	0	0	0.00808
0.0352	2	0.018519	0.015632	0	0	0.007372
0.0353	3	0.027778	0.014036	0	0	0.006719
0.0354	1	0.009259	0.012584	0	0	0.006118
0.0355	1	0.009259	0.011267	0	0	0.005565
0.0356	2	0.018519	0.010073	0	0	0.005058
0.0357	0	0	0.008993	1	0.035714	0.004592
0.0358	0	0	0.008018	0	0	0.004165
0.0359	1	0.009259	0.007138	0	0	0.003775
0.036	1	0.009259	0.006345	0	0	0.003417
0.0361	0	0	0.005633	0	0	0.003091
0.0362	0	0	0.004994	0	0	0.002793

0.0363	0	0	0.004421	0	0	0.002521
0.0364	2	0.018519	0.003908	1	0.035714	0.002274
0.0365	0	0	0.00345	0	0	0.002049
0.0366	0	0	0.003041	0	0	0.001844
0.0367	0	0	0.002677	0	0	0.001658
0.0368	1	0.009259	0.002353	0	0	0.00149
0.0369	0	0	0.002065	0	0	0.001337
0.037	0	0	0.00181	0	0	0.001199

Table S5. Binned data for Figure 3A.

time NO ₃ (us)	Asymmetry NO ₃	StDev Asymmetry NO ₃	time Cl (us)	Asymmetry Cl	StDev Asymmetry Cl
0.00937	0.238122	0.011545	0.00937	0.221545	0.014541
0.01055	0.256366	0.011432	0.01055	0.229749	0.0146123
0.01172	0.241471	0.011438	0.01172	0.247267	0.0142771
0.01289	0.252463	0.011365	0.01289	0.206862	0.0147218
0.01406	0.253111	0.011292	0.01406	0.23985	0.014232
0.01523	0.240852	0.011226	0.01523	0.239253	0.0142036
0.01641	0.224803	0.011371	0.01641	0.209747	0.0145087
0.01758	0.225164	0.011516	0.01758	0.230919	0.0143189
0.01875	0.222775	0.011625	0.01875	0.196198	0.0142746
0.01992	0.24177	0.01147	0.01992	0.202869	0.014457
0.02109	0.212014	0.011576	0.02109	0.212115	0.0144472
0.02227	0.220444	0.011581	0.02227	0.221506	0.0144387
0.02344	0.256718	0.011404	0.02344	0.231023	0.0144443
0.02461	0.24013	0.011643	0.02461	0.217457	0.0143689
0.02578	0.218193	0.011568	0.02578	0.220313	0.0144538
0.02695	0.252392	0.011442	0.02695	0.199568	0.0144418
0.02813	0.221935	0.011737	0.02813	0.21622	0.014596
0.0293	0.234804	0.011807	0.0293	0.183279	0.0149639
0.03047	0.19415	0.011926	0.03047	0.182035	0.0147953
0.03164	0.214344	0.011867	0.03164	0.206122	0.0148116
0.03281	0.218277	0.011892	0.03281	0.168716	0.0148206
0.03398	0.212604	0.011856	0.03398	0.192487	0.0147856
0.03516	0.206851	0.01187	0.03516	0.188548	0.0149471
0.03633	0.214093	0.011837	0.03633	0.208444	0.0148382
0.0375	0.213485	0.011702	0.0375	0.18459	0.0150423
0.03867	0.220344	0.011902	0.03867	0.209627	0.0150436
0.03984	0.222932	0.011753	0.03984	0.191359	0.0149044

S6. References

1. X. Zhang, X. Zhang, T. R. Graham, C. I. Pearce, B. L. Mehdi, A. T. N'Diaye, S. Kerisit, N. D. Browning, S. B. Clark and K. M. Rosso, *Crystal Growth & Design*, 2017, **17**, 6801-6808.
2. A. D. Hillier, S. J. Blundell, I. McKenzie, I. Umegaki, L. Shu, J. A. Wright, T. Prokscha, F. Bert, K. Shimomura, A. Berlie, H. Alberto and I. Watanabe, *Nature Reviews Methods Primers*, 2022, **2**, 4.