SPHEREx spectral fiducial functions

Howard Hui hhui@caltech.edu

SPHEREx Calibration Product

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1. DELIVERY OVERVIEW

This document describes the SSDC R7 spectral-calibration delivery. It provides, for each of the six SPHEREx detectors (Bands 1–6), the geometric spectral-channel maps and the fiducial (per-channel) spectral response functions. The fiducial spectral responses are provided at four granularities — 17, 34, 51, and 68 sub-channels per detector — each delivered as two separate products, the middle-pixel and all-pixel cases (Section 3).

Additionally, we include band-center and band-width statistics for each of the nominal 17 sub-channels of every detector (Section 4).

Table 1. Contents of the spectral calibration delivery.

Product	**Format**	**Count**	**Location**
Spectral channel maps	FITS, 2040^2, values $0 \ldots N{+}1$	4	`ChannelMaps/`
Fiducial response — middle pixel (`Cent`)	CSV (`Wavelength_um`, `NormTransmission`)	1020	`MiddlePixel/`
Fiducial response — all pixel (`Allpix`)	CSV (`Wavelength_um`, `NormTransmission`)	1020	`MeanAllPixel/`
Band summary (from fiducial)	CSV (`SpecCh`,λ_c,$\Delta\lambda$, Allpix)	24	`FidSpecSummary/`
Band-center / band-width maps	FITS, 2040^2 (`20260604_SSDC_BC/BW`)	12	`ParameterFiles/`

The fiducial and summary products are organized in the tree `SubChannel`N`/Band`b`/` with $N \in \{17, 34, 51, 68\}$ and $b \in \{1, \ldots, 6\}$.

2. SPECTRAL CHANNEL DEFINITION

Each spectral channel map is a 2040×2040 integer array, in which every element corresponds to one detector pixel; the value identifies the pixel's spectral channel index. The channel map is defined geometrically rather than by the exact calibrated wavelength at each pixel. This convention is adopted because the survey strategy steps in units of spectral channel between exposures, and these steps are designed to have uniform geometric spacing across the focal plane. The curvature visible in the channel boundaries (Figure 1) arises from the fabrication of the linear variable filter. The detailed wavelength progression and the spectral calibration are described in H. Hui et al. (2026).

For N sub-channels, the nominal channels are indexed 1 through N, with the channel index increasing with wavelength. The non-rectangular excess regions of the detector footprint — the edge and corner extensions outside the nominal survey channels — are labelled 0 (beyond channel 1, short-wavelength side) and $N{+}1$ (beyond channel N, long-wavelength side). Although outside the nominal channel set used for survey stepping, spectral information is provided for these pixels so they may be used for calibration, validation, or consistency checks. The same geometric definition is applied to every detector; taken together across Bands 1–6, channels 1–17 span the nominal wavelength range 0.75–5.0 μm. The four granularities nest exactly: coarsening an N sub-channel map reproduces the 17-channel map. The 34, 51, and 68 sub-channel products are integer multiples of the nominal 17 channels, provided as a higher-resolution option for analyses that want a finer spectral sampling; the survey scan step itself remains one nominal channel (17 per detector).

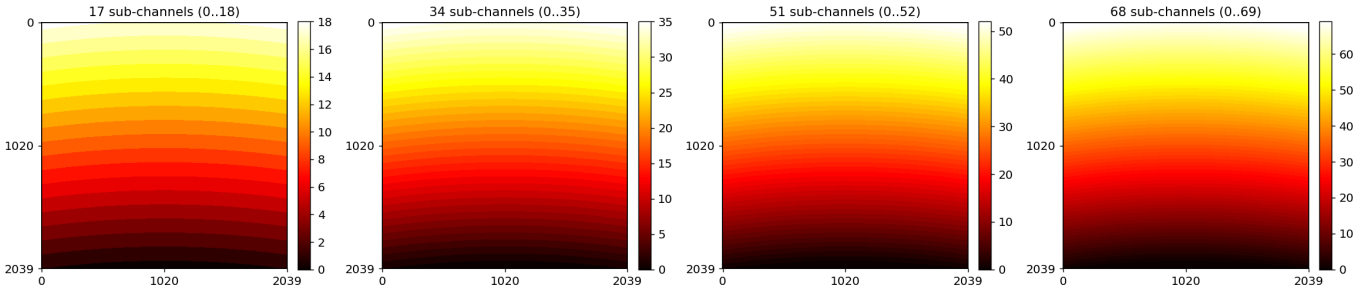

Figure 1. Spectral channel maps (2040^2) at the four delivered granularities. Nominal channels $1 \ldots N$ increase with wavelength (dark to light); the excess regions are labelled 0 and $N+1$. The smile curvature is from the linear variable filter fabrication.

3. FIDUCIAL SPECTRAL RESPONSE

For each band and spectral channel we provide a fiducial (representative) normalized spectral response as a function of wavelength. Two cases are delivered separately:

- **Middle pixel** (`Cent`): the response of the pixels along the central smile strip of the channel. This preserves the true channel bandwidth $\Delta\lambda$. Because the response varies approximately linearly in wavelength across the channel, the response of a pixel away from the central strip is well approximated by shifting this curve in wavelength.

- **All pixel** (`Allpix`): the mean response over all pixels assigned to the channel. This represents the channel-averaged response; because it averages over the intra-channel wavelength gradient, its band width $\Delta\lambda$ is slightly broader than the true (middle-pixel) value.

Figure 2 illustrates the two sampling choices on the detector: the middle-pixel case uses the central smile strip of the channel, whereas the all-pixel case averages the entire channel footprint.

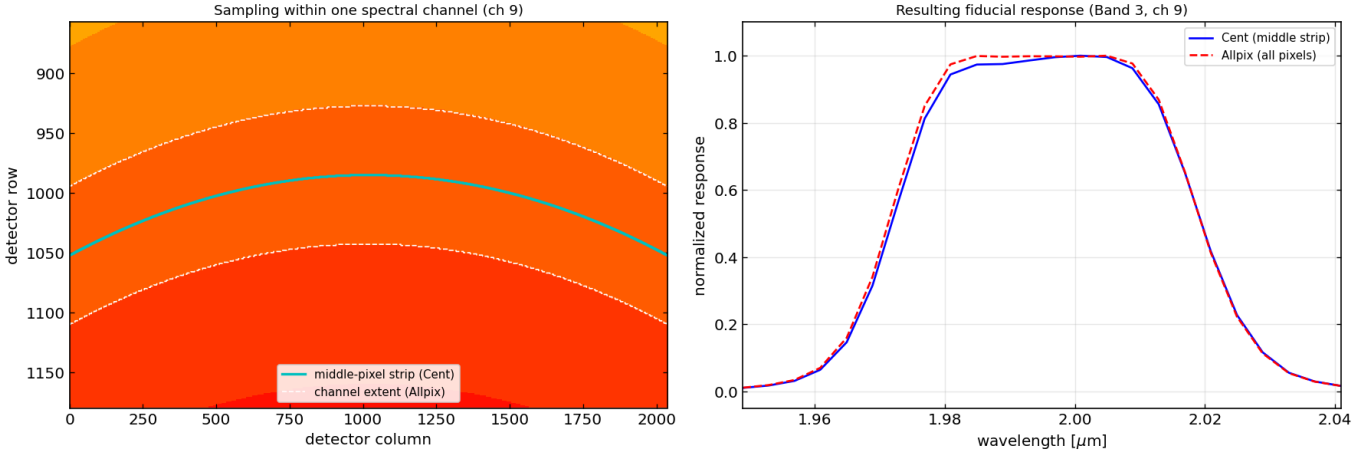

Figure 2. Left: pixel sampling within one spectral channel on the 2040×2040 detector. The middle-pixel (`Cent`) product samples the central smile strip (cyan); the all-pixel (`Allpix`) product averages the full channel footprint (between the dashed boundaries). Right: the resulting fiducial responses for the same channel, where the all-pixel curve is slightly broader.

Figure 3 compares the two for representative channels; the all-pixel curve is consistently broader than the middle-pixel curve. Users requiring the correct per-pixel bandwidth should use the middle-pixel product (with the linear shift for off-center pixels); users requiring the channel-integrated response may use the all-pixel product directly. The full set of 17 sub-channel response curves is shown in Figures 4 and 5; the 34, 51, and 68 sub-channel products follow the same format.

3.1. *Fiducial function band center and band width*

The band summary files (`FidSpecSummary_Band`b`_SpecCh`N`.csv`) give a band center and band width for each channel that are derived from the fiducial spectral response function. Both quantities are tabulated for the middle-pixel (`Cent`) case as the primary values, and additionally for the all-pixel (`Allpix`) case. These fiducial-derived values are distinct from the pixel-population statistics of the parameter maps tabulated in Section 4.

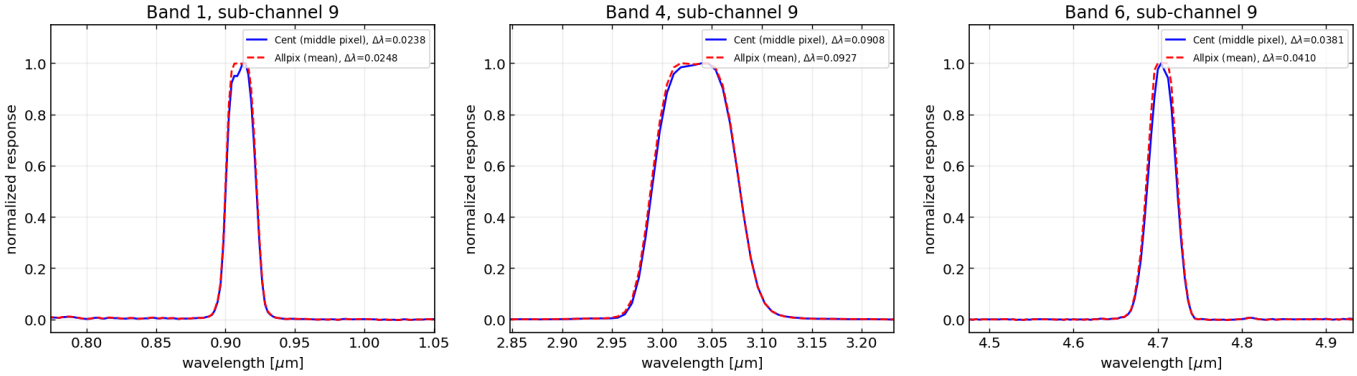

Figure 3. Middle-pixel (`Cent`, solid) versus all-pixel (`Allpix`, dashed) fiducial response for a representative sub-channel in three bands. The all-pixel mean is broader (larger $\Delta\lambda$) because it averages over the intra-channel wavelength gradient.

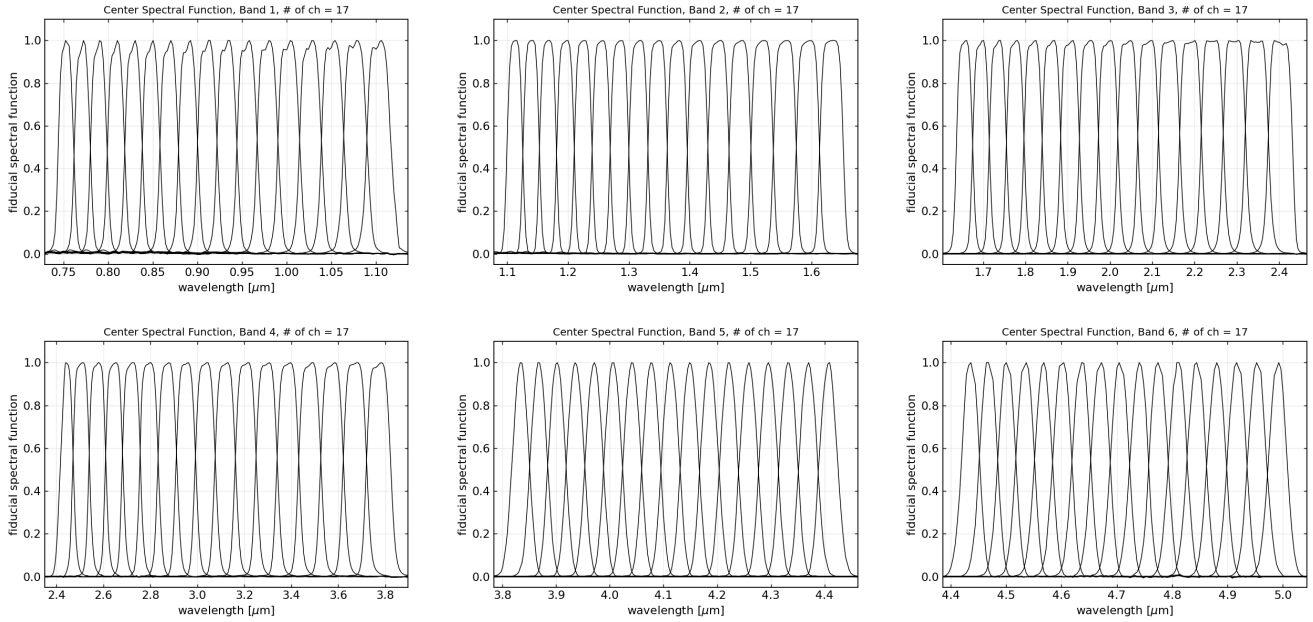

Figure 4. Middle-pixel (`Cent`) fiducial spectral response, 17 sub-channels, Bands 1–6.

4. SPECTRAL BAND DEFINITION FROM THE PARAMETER MAPS

This section characterizes the nominal 17 spectral channels of each of the six detectors (17+2 per detector including the excess channels 0 and N+1) using the delivered band-center (BC) and band-width (BW) parameter maps, `20260604_SSDC_BC_Band`b`.fits` and `20260604_SSDC_BW_Band`b`.fits` (2040 × 2040). Unlike the fiducial-derived quantities of Section 3.1, these are pixel-population statistics: for each channel we collect all detector pixels assigned to it in the 17-channel map and report

- λ_c: the median of the band-center map over the channel pixels;

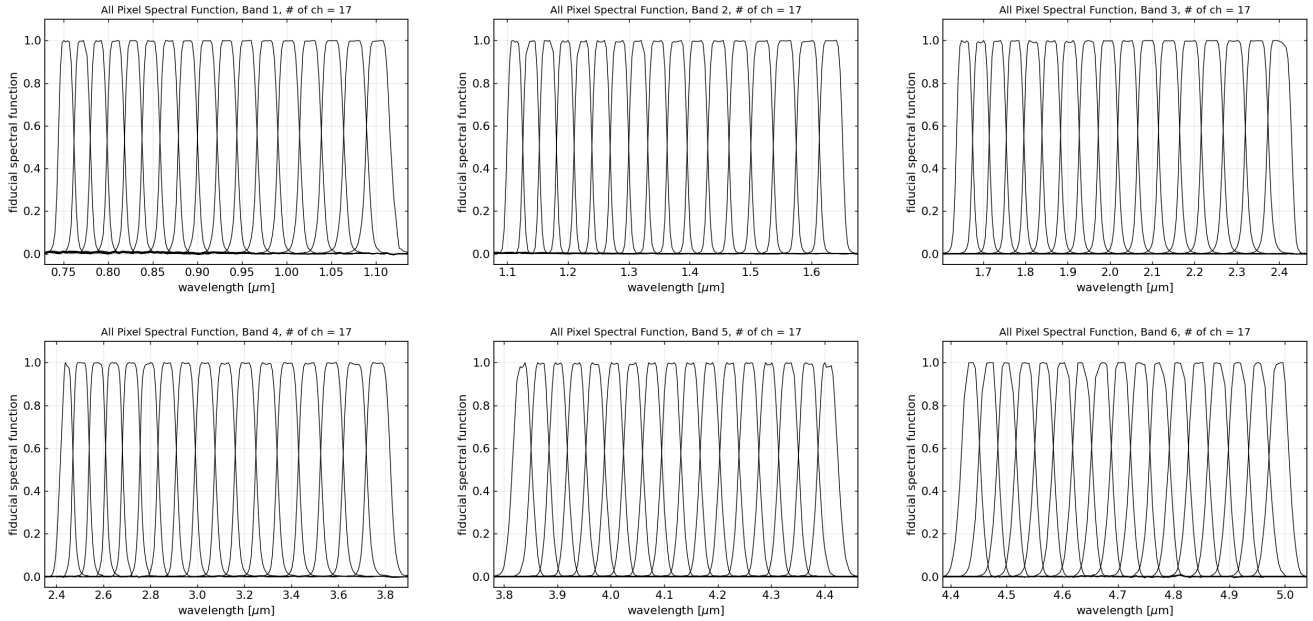

Figure 5. All-pixel (`Allpix`) fiducial spectral response, 17 sub-channels, Bands 1–6.

- $[\lambda_{\min}, \lambda_{\max}]$: the range of band center across the channel pixels;
- $R = \lambda_c/\Delta\lambda$: the median resolving power, with $\Delta\lambda$ the median of the band-width map, quoted with its pixel-to-pixel scatter (1σ).

Table 2 lists these for all six detectors. Channels are numbered continuously 1–102 across the detectors; within detector b the local channel is the global index minus $17(b-1)$. Bands 5 and 6 include the +6.4 nm (+0.0064 μm) MWIR band-center correction compared to previous calibration.

5. FILE ORGANIZATION AND CHANNEL NUMBERING

Products are delivered under `SSDC_R7/` as follows:

- `ChannelMaps/spectral_channels_`N`ch_2040.fits`
- `MiddlePixel/SubChannel`N`/Band`b`/FiducialSpec_Band`b`_SubCh`XX`_`N`_Cent.csv`
- `MeanAllPixel/SubChannel`N`/Band`b`/FiducialSpec_Band`b`_SubCh`XX`_`N`_Allpix.csv`
- `FidSpecSummary/SubChannel`N`/Band`b`/FidSpecSummary_Band`b`_SpecCh`N`.csv`
- `ParameterFiles/20260604_SSDC_BC_Band`b`.fits`, `..._BW_Band`b`.fits`

The spectral channel index increases with wavelength (channel 1 is the shortest-wavelength nominal channel in each band), consistent across the channel maps, the fiducial products, and the band table. This is the reverse of the sub-channel numbering used in the previous `FiducialFunction` release, where `SubCh01` was the longest-wavelength channel; the mapping is $XX_{\rm new} = (N{+}1) - XX_{\rm old}$.

REFERENCES

Hui, H., Bock, J. J., Condon, S., et al. 2026, The Astrophysical Journal Supplement Series, 284, 10, doi: 10.3847/1538-4365/ae522c

Table 2. Spectral band definition from the band-center (BC) and band-width (BW) parameter maps (2040 × 2040). For each detector (Band) and spectral channel, the columns list the median band center λ_c, the 3σ-clipped range of band center $[\lambda_{min}, \lambda_{max}]$ over the channel pixels, and the median resolving power $R = \lambda_c/\Delta\lambda$ with its pixel-to-pixel scatter. Channels are numbered continuously 1–102 across the six detectors (17 nominal channels each).

Band	Ch	λ_c	$[\lambda_{min}, \lambda_{max}]$	R	Band	Ch	λ_c	$[\lambda_{min}, \lambda_{max}]$	R
1	1	0.753	[0.743, 0.762]	42 ± 1.1	4	52	2.445	[2.422, 2.474]	42 ± 7.6
1	2	0.771	[0.761, 0.781]	42 ± 1.0	4	53	2.506	[2.470, 2.542]	34 ± 0.4
1	3	0.790	[0.780, 0.800]	41 ± 0.9	4	54	2.575	[2.538, 2.612]	35 ± 0.5
1	4	0.809	[0.798, 0.819]	40 ± 0.9	4	55	2.646	[2.607, 2.684]	35 ± 0.5
1	5	0.828	[0.817, 0.839]	40 ± 0.8	4	56	2.719	[2.678, 2.758]	35 ± 0.6
1	6	0.848	[0.837, 0.859]	40 ± 0.8	4	57	2.794	[2.752, 2.835]	35 ± 0.8
1	7	0.868	[0.857, 0.879]	40 ± 0.7	4	58	2.871	[2.828, 2.914]	34 ± 0.6
1	8	0.889	[0.877, 0.900]	39 ± 0.7	4	59	2.951	[2.906, 2.995]	34 ± 0.6
1	9	0.910	[0.898, 0.922]	39 ± 0.6	4	60	3.033	[2.985, 3.079]	34 ± 0.6
1	10	0.932	[0.920, 0.944]	39 ± 0.6	4	61	3.118	[3.069, 3.164]	34 ± 0.6
1	11	0.955	[0.942, 0.967]	39 ± 0.5	4	62	3.204	[3.155, 3.252]	35 ± 0.5
1	12	0.978	[0.964, 0.990]	38 ± 0.5	4	63	3.293	[3.242, 3.342]	35 ± 0.5
1	13	1.001	[0.988, 1.014]	38 ± 0.5	4	64	3.383	[3.330, 3.434]	35 ± 0.6
1	14	1.025	[1.012, 1.039]	38 ± 0.5	4	65	3.476	[3.422, 3.528]	36 ± 0.6
1	15	1.050	[1.036, 1.064]	38 ± 0.5	4	66	3.570	[3.514, 3.624]	36 ± 0.6
1	16	1.075	[1.061, 1.090]	37 ± 0.4	4	67	3.667	[3.610, 3.723]	36 ± 0.8
1	17	1.102	[1.086, 1.116]	37 ± 0.4	4	68	3.768	[3.707, 3.827]	36 ± 0.9
2	18	1.113	[1.099, 1.126]	43 ± 0.7	5	69	3.833	[3.8144, 3.8514]	109 ± 0.4
2	19	1.139	[1.125, 1.153]	42 ± 0.6	5	70	3.867	[3.8494, 3.8854]	109 ± 0.6
2	20	1.167	[1.152, 1.182]	42 ± 0.5	5	71	3.901	[3.8824, 3.9194]	109 ± 0.4
2	21	1.195	[1.180, 1.210]	41 ± 0.5	5	72	3.935	[3.9164, 3.9534]	108 ± 0.5
2	22	1.224	[1.209, 1.240]	41 ± 0.5	5	73	3.970	[3.9504, 3.9884]	109 ± 0.5
2	23	1.254	[1.238, 1.269]	41 ± 0.5	5	74	4.005	[3.9854, 4.0244]	110 ± 0.6
2	24	1.284	[1.267, 1.300]	42 ± 0.4	5	75	4.040	[4.0204, 4.0594]	110 ± 0.6
2	25	1.315	[1.298, 1.331]	42 ± 0.4	5	76	4.076	[4.0554, 4.0954]	111 ± 0.7
2	26	1.346	[1.329, 1.363]	42 ± 0.4	5	77	4.112	[4.0914, 4.1314]	112 ± 0.6
2	27	1.378	[1.360, 1.396]	42 ± 0.4	5	78	4.148	[4.1264, 4.1674]	113 ± 0.6
2	28	1.412	[1.393, 1.430]	41 ± 0.4	5	79	4.184	[4.1624, 4.2034]	113 ± 0.6
2	29	1.446	[1.426, 1.464]	41 ± 0.3	5	80	4.220	[4.1994, 4.2404]	115 ± 1.1
2	30	1.481	[1.461, 1.500]	41 ± 0.3	5	81	4.257	[4.2354, 4.2774]	114 ± 0.9
2	31	1.517	[1.496, 1.537]	41 ± 0.3	5	82	4.294	[4.2714, 4.3134]	115 ± 0.8
2	32	1.554	[1.533, 1.575]	41 ± 0.3	5	83	4.331	[4.3084, 4.3514]	116 ± 0.9
2	33	1.592	[1.570, 1.613]	41 ± 0.3	5	84	4.368	[4.3454, 4.3884]	116 ± 1.0
2	34	1.631	[1.608, 1.651]	41 ± 0.3	5	85	4.405	[4.3824, 4.4264]	117 ± 1.2
3	35	1.656	[1.636, 1.676]	42 ± 0.3	6	86	4.435	[4.4184, 4.4524]	128 ± 1.6
3	36	1.695	[1.675, 1.715]	42 ± 0.3	6	87	4.467	[4.4504, 4.4844]	125 ± 1.1
3	37	1.735	[1.714, 1.756]	41 ± 0.3	6	88	4.500	[4.4824, 4.5174]	127 ± 1.2
3	38	1.775	[1.754, 1.797]	41 ± 0.3	6	89	4.533	[4.5154, 4.5504]	126 ± 1.2
3	39	1.818	[1.795, 1.840]	41 ± 0.3	6	90	4.566	[4.5484, 4.5844]	127 ± 1.3
3	40	1.861	[1.838, 1.884]	41 ± 0.3	6	91	4.600	[4.5824, 4.6184]	125 ± 1.4
3	41	1.905	[1.881, 1.928]	41 ± 0.3	6	92	4.635	[4.6154, 4.6534]	127 ± 1.4
3	42	1.949	[1.925, 1.973]	41 ± 0.3	6	93	4.669	[4.6494, 4.6884]	126 ± 1.7
3	43	1.995	[1.970, 2.019]	41 ± 0.3	6	94	4.704	[4.6844, 4.7234]	128 ± 1.9
3	44	2.041	[2.015, 2.067]	40 ± 0.4	6	95	4.739	[4.7194, 4.7584]	130 ± 3.4
3	45	2.089	[2.062, 2.115]	40 ± 0.3	6	96	4.773	[4.7534, 4.7924]	131 ± 2.4
3	46	2.139	[2.111, 2.166]	40 ± 0.3	6	97	4.808	[4.7884, 4.8274]	132 ± 2.6
3	47	2.189	[2.160, 2.216]	40 ± 0.3	6	98	4.843	[4.8224, 4.8624]	131 ± 2.3
3	48	2.240	[2.211, 2.268]	40 ± 0.3	6	99	4.879	[4.8574, 4.8994]	130 ± 2.5
3	49	2.292	[2.262, 2.321]	40 ± 0.4	6	100	4.915	[4.8934, 4.9364]	130 ± 2.8
3	50	2.345	[2.314, 2.375]	40 ± 0.3	6	101	4.951	[4.9304, 4.9724]	132 ± 3.0
3	51	2.399	[2.367, 2.440]	41 ± 4.0	6	102	4.988	[4.9664, 5.0094]	135 ± 4.2