#### デジタル画像検出システムの画像特性に関する研究班

#### 平成14年に技術学会の班活動の1つとして組織。 (2年間の班活動)

九州大学 医学部保健学科東田善治, 大喜雅文広島県立保健福祉大学 放射線学科吉田 彰大阪大学 大学院医学系研究科松本政雄岐阜大学 大学院・知能イメージ情報藤田広志大阪市立大学 医学部附属病院奥迫謙治九州大学 医学部附属病院氷室和彦国立病院機構九州医療センター井手口忠光

### 画像評価法

客観的評価(物理評価) 主観的評価(視覚評価) **1. ROC 1.H-D** Curve 2. C-D diagram 2. Presampling MTF **3**. Digital Wiener Spectrum 視覚評価(検出能)の 画質を物理的に評価 画質の定量化 定量化 医師は自分の好みで判断することができる 画像の良し悪しを 科学的に証明!

### 客観的評価(物理評価)

Digital H-D Curve (10%)
 Presampling MTF (80%)
 INNERVISION 2003年 11月

3. Digital Wiener Spectrum (10 %)

増感紙 - フィルム(アナログ)との比較をしながら・・・・



### デジタル特性曲線

相対照射線量に対するディジタル値の関係をディジ タル特性曲線(digital characteristic curve)

相対照射線量に対して、レーザーイメージャなどによっ てフィルム上に写真濃度として出力した特性曲線は、 オーバーオール特性曲線(overall characteristic curve) \*CRシステムの入出力特性にもよく用いられてきた。



# X線管 - カセッテの距離をLog E が 0.1 の間隔になるように変化。



#### **Digital H-D Curve**



FPD 固定 ・時間露光法 (相反則が成立)

CR 移動
・ 距離法
・ 時間露光法
(相反則が成立)

ダイナミックレンジが104と広いため1連の実験系ですべての 露光域を露光できない。距離法だと40cm~40m必要となる。 つなざ合わせ(フィルタが必要)

#### つなぎ合わせによる特性曲線の作成



#### サチュレーション









#### デジタル値の入力

| D          | E                |                | G  | H         |              | I                | J                  |          | K        |
|------------|------------------|----------------|--|-----------|--------------|------------------|--------------------|----------|----------|
|            |                  |                | 40kV   |           |              |                  |                    |          |          |
| Relative   | Digital Val      | 線重(mGy)        | Relativ <u>e</u>                               | Digital   | Val          | lue              |                    |          |          |
| 1          | 68.7             | 0.079          | 1 0.193  |           |              |                  |                    |          |          |
| 1.272      | 87.2             |                | <u>a n 244</u>                                 | 10000     |              |                  |                    |          |          |
| 1.616      | 111.3            | ── / / / / ● ● | <b>!≐+/</b> ⊂ ⊦                                | ストト       |              | 쌅릌ㅣ              |                    |          |          |
| 2.632      | 181.1            |                |  | ってし」      | 日ノ           | ′し里              |                    |          |          |
| 4.2        | 2914             | 0.328          | N: 11 X114<br>H:                               | 5기 스 /뷔 드 | <br>         | フォー ガニコの 通       | - 米百               |          |          |
| 5.928      | 18.2             | 0.51           | · · · · · ·                                    | JJ 919 T  | <u>`</u> - 1 | 74-0000          | EXR                | 00       | ·        |
| /.304      | <u> </u>         | 0.74           | │ 標準 │ユ-                                       | -ザー設定     |              |                  |                    |          |          |
| 10.6       | /51.1            | 1.03           | ・<br>グラフの種類(C)                                 | :         |              | 形式(T):           |                    |          |          |
| 16.904     | 1191.8           | 1.4/           |  |           | •            |                  |                    |          |          |
| 24.264     | 1709.2           | 1.86           | 黄棒   |           |              | 1 L / X   k      | ∕~_ I∖~            |          |          |
| 33.792     | 2383.2           | 2.2            | 🛃 折れ線  |           |              |                  | <u> </u>           |          | •        |
| 43.32      | 3007.0           |                |  |           |              |                  |                    |          |          |
| 04.224     | 3032.0           |                | ◎ 一般 市区  |           |              |                  | $\wedge$ $\wedge$  |          |          |
| 07.700     | 4730.0<br>5266 / |                | Mage 12 10 10 10 10 10 10 10 10 10 10 10 10 10 |           |              |                  | <u> </u>           | <u> </u> |          |
| 13.704     | 3150.4<br>2150.4 |                | 🍎 レーダー   |           |              |                  | -                  |          |          |
| 19 7288889 | 2572 9           |                | 🚡 等高線  |           |              |                  |                    |          |          |
| 55 2266667 | 3979             |                | 🍨 バブル  |           | -            |                  |                    |          |          |
| 62 1511111 | 4491 8           |                |  |           |              | データにフィーカーがの      | サートにわたにわれ          | 8577     |          |
| 70.1244444 | 5067.7           |                |  |           |              | リーダにマーバーが1<br>す。 | コロウ4 いとか14 いかお     | ///C     |          |
| 79.6622222 | 5758.5           |                |  |           |              |                  |                    |          |          |
| 90.0888889 | 6520.8           |                |  |           |              | サンプル             | を表示する(\/)          |          |          |
| 101.555556 | 7350.2           |                |  |           |              |                  | <u>escritte (j</u> |          | I        |
| 113.022222 | 8176.7           |                | 2  | キャンセル     |              | く戻る 次            | へ(N)> 完            | 7(E)     |          |
| 124.533333 | 9016.1           |                |  | 2000 }    |              |                  |                    |          | <u>.</u> |
| 141.822222 | 10269.5          |                | 12000  | •         | •            |                  |                    |          |          |
| 159.111111 | 11496.9          |                |  | . 🖍       |              |                  |                    |          |          |
| 182.177778 | 13131.6          |                | 1 0000   | 0         |              | 50 100           | ) 150              | :        | 200      |
| 205.244444 | 14730.9          |                |  |           |              |                  |                    |          |          |

#### 散布図を使って表示したHD 折れ線を使って表示したHD



**Relative Exposure** 

# Value Digital









#### 間接型FPD & CR 特性曲線

#### **GE FPD**

#### FCR 50 µ m



**Relative Exposure** 

## Presampling MTF

#### MTFの 測定 方法







#### なぜ露光量変換する必要があるか?

MTFは<u>入力波の振幅と出力波の振幅</u>の比によって求められる。

この定義が成立するには、入力と出力との間に、直線性が必要

#### <u>X線量と写真濃度の関係は直線ではない。</u>

露光量が変わる度にMTFは変わってしまう。

特性曲線を用いて露光量に変換する必要がある リニア階調に出力するデジタルでは必要?

#### 間接型FPD & CR 特性曲線

#### **GE FPD**

#### FCR 50 µ m



**Relative Exposure** 

## デジタルのMTFでは?

デジタル系では、サンプリング間隔に起因したエリアシング(aliasing)エラーや、

位置不変性が問題となる

#### エリアシング

## エリアシングとは標本化点を粗く(サンプリング間隔を広く) とれば、もとの信号にない波形が観測されること

ナイキスト周波数=1/(2\*サンプリング間隔)

 $5 \text{ Lp/mm} = 1 / (2 \times 0.1)$ 



#### スリットとピクセルの位置関係により スリット像の見え具合が変化する





ディジタル放射線画像より





ディジタル放射線画像より

サンプリング点の中心と信号の中心が 一致した配置のことをいう



医用画像工学より

サンプリング点の中心と信号の中心が 最大にずれた配置のことをいう

#### プリサンプリングMTF

- プリサンプリングMTFはエリアシングエラーを含んで おらず、アナログ系のMTFや他のデジタル系のMTF との比較をするのに有効である





#### FPDでスリットを撮影しましょう!



| File Edit<br>日 編集(E) 表示(G)<br>904x797 pixels, 16-bit grayscale, 140 | Image Process Type Adjust Show Info Properties Benchmarks Color Stacks Crop Dualised | Analyze Plugi<br>Ctrl+I | Ins Window Help                     |  |  |   |   |
|---|--|-------------------------|-------------------------------------|--|--|---|---|
|   | Duplicate<br>Rename<br>Scale<br>Rotate<br>Lookup Tables<br>Colors                    | Ctrl+Shiff+D<br>Ctrl+E  | pix<br>動す<br>lーマ<br>ieb<br>子メ<br>除す | File Edit Im<br>New<br>Open<br>Open Sampl<br>Import<br>Close<br>Save<br>Save<br>Save As<br>Revert<br>Page Setup<br>Print<br>Quit<br>に公開する<br>ールで送信 | nage Proce<br>Ctrl+N<br>Ctrl+O<br>es •<br>Ctrl+W<br>Ctrl+R<br>Ctrl+R<br>Ctrl+P | ImageJ<br>ess Analyze Plugins<br>・・・・・・・・・・・・・・・・・・・・・・・・・・・・・・・・・・・・ | Window Help<br>MTF slit Data<br>1632<br>7rfJk<br>1410<br>1662<br>7rfJk<br>1,410<br>1806<br>7rfJk<br>1,410<br>1836<br>7rfJk<br>1,410 |



#### 合成LSFを作りましょう!

|    |      |             |       |       |       |         |       |      |       |      |      |       |      |      |      | 8    | 0-300                     | -3.txt |       |       |       |      |      |      |      |      |      |      |      |        |                 |                      |                 |
|----|------|-------------|-------|-------|-------|---------|-------|------|-------|------|------|-------|------|------|------|------|---------------------------|--------|-------|-------|-------|------|------|------|------|------|------|------|------|--------|-----------------|----------------------|-----------------|
|    | AN   | AO          | AP    | AQ    | AR    | AS      | AT    | AU   | AV    | AW   | AX   | AY    | AZ   | BA   | BB   | BC   | BD                        | BE     | BF    | BG    | BH    | BI   | BJ   | BK   | BL   | BM   | BN   | BO   | BP   | BQ     | BR B            | S BT                 | В               |
| 40 | 1013 | 1056        | 1245  | 1013  | 1057  | 1192    | 1313  | 1291 | 1448  | 1501 | 1634 | 1738  | 1920 | 2226 | 2672 | 3259 | 3502                      | 2929   | 2411  | 2040  | 1814  | 1725 | 1579 | 1434 | 1314 | 1221 | 1193 | 1058 | 1164 | 1193   | 908 9           | 08 96                | 5 10            |
| 41 | 1097 | 965         | 841   | 966   | 1133  | 1059    | 1247  | 1293 | 1421  | 1503 | 1609 | 1783  | 1938 | 2203 | 2658 | 3245 | 3514                      | 2944   | 2429  | 2067  | 1777  | 1669 | 1549 | 1476 | 1405 | 1335 | 1222 | 1097 | 966  | 50Z    | 941 10          | 14 <mark>- 96</mark> | 7 9             |
| 42 | 759  | 1058        | 653   | 909   | 1059  | 1165    | 909   | 1293 | 1165  | 1436 | 1619 | 1740  | 1922 | 2214 | 2641 | 3226 | 3529                      | 2969   | 2439  | 2048  | 1800  | 1581 | 154  |      |      |      |      |      |      |        |                 | 91                   | 06              |
| 43 | 1015 | 965         |       |       |       |         |       | 105  | 1271  | 1464 | 1571 | 1753  | 1897 | 2199 | 2634 | 3206 | 3533                      | 2989   | 2456  | 2061  | 1847  | 1669 | 153  |      |      |      |      |      |      |        |                 | 09                   | 39              |
| 44 | 652  | . Mi        | •••   | ••••  | ••••  | •••     | •••   | 35   | 1420  | 1477 | 1626 | 1764  | 1913 | 2173 | 2609 | 3180 | 3536                      | 3005   | 2462  | 2082  | 1874  | 1652 | 147  | 100  | 1700 | 1000 | 102  | 1210 | 000  |        |                 | D1:<br>Alb. L C C C  | 5 10            |
| 45 | 1060 | 1165        | 044   | 1000  | 1015  | 4 4 7 7 | 11.05 | 616  | 1195  | 1451 | 1561 | 1728  | 1881 | 2169 | 2587 | 3161 | 3337                      | 2015   | 2468  | 2094  | 1876  | 1685 | 1572 | 1098 | 1390 | 1248 | 1060 | 1134 | 842  | 1016   | 67 5            |                      | J 6             |
| 46 | 966  | 884U        | 966   | 1222  | 1015  | 1133    | 1165  | 1222 | 1389  | 1436 | 1619 | 1740  | 1926 | 2153 | 2578 | 3144 | 3542                      | 3064   | 2490  | 2103  | 1870  | 1653 | 1478 | 1389 | 1335 | 1271 | 1097 | 1059 | 1015 | 1059 1 | 109 10          |                      | <u>5 2</u>      |
| 47 | 966  | 1008        | 1097  | 966   | 1247  | 1293    | 1315  | 1165 | 1.1   | 1538 | 1609 | 1747  | 1880 | 2145 | 2553 | 3122 | 3547                      | 3001   | 2504  | 2103  | 1901  | 1706 | 1636 | 134  | 1405 | 1247 | 966  | 1194 | 1059 | 966 1  | 105 9           |                      | 5 9             |
| 48 | 738  | 104         | 1058  | 1058  | 1058  | 1008    | 1164  | 1014 | 4     | 1420 | 1559 | 1591  | 1856 | 2121 | 2000 | 3101 | 3040                      | 7090   | 2517  | 2092  | 1850  | 1712 | 1580 | 1508 | 1314 | 1038 | 1246 | 1004 | 1050 | 109 1  | ыно 6<br>150 11 |                      | 2 9             |
| 50 | 070  | 117         | 1038  | 1057  | 1026  | 1272    | 1102  | 1201 | 1107  | 1420 | 1550 | 1711  | 1072 | 2101 | 2524 | 2065 | 3 <del>34</del> 1<br>7545 | 3090   | 2002  | 2132  | 1002  | 1770 | 1550 | 1778 | 1752 | 1270 | 1050 | 1172 | 1172 | 1050 1 | 172 0           |                      |                 |
| 51 | 967  |             | 1170  | 1056  | 1012  | 1244    | 1269  | 1290 | 11 90 | 1402 | 1512 | 1717  | 1977 | 2109 | 2502 | 3065 | 3543                      | 3107   | 2576  | 2119  | 1990  | 1697 | 1607 | 1490 | 1332 | 1171 | 1192 | 1269 | 1095 | 1057   | 94 7            | αμ <u>20</u>         | 2 0<br>7 9      |
| 52 | 1056 | 1065        | 1012  | 963   | 1130  | 1268    | 1056  | 1244 | 11 86 | 1475 | 1557 | 1703  | 1825 | 2091 | 2481 | 3027 | 3539                      | 3149   | 2586  | 2162  | 1885  | 1757 | 1625 | 1474 | 1387 | 1369 | 1013 | 1013 | 907  | 964    | 839 10          |                      | 7 5             |
| 53 | 1012 |             | 1012  | 963   | 756   | 1290    | 1191  | 1290 | 13 82 | 1368 | 1557 | 1737  | 1840 | 2070 | 2466 | 3010 | 3534                      | 3166   | 2606  | 2164  | 1910  | 1763 | 1634 | 1540 | 1476 | 1333 | 1313 | 1220 | 1013 | 757 1  | 45 10           |                      | a a             |
| 54 | 1163 | 166         | 907   | 964   | 1245  | 1291    | 1269  | 1333 | 12 91 | 1513 | 1501 | 1704  | 1855 | 2069 | 2463 | 2991 | 3531                      | 3185   | 2607  | 2179  | 1927  | 1775 | 1634 | 1518 | 1314 | 1370 | 1164 | 1221 | 1014 | 965 1  | 158 2           | 46 105               | 8 9 =           |
| 55 | 965  | 1013        | 1014  | 1058  | 1014  | 1096    | 1132  | 1435 | 13 88 | 1435 | 1570 | 1676  | 1842 | 2070 | 2446 | 2968 | 3517                      | 3202   | 2625  | 2201  | 1928  | 1739 | 1580 | 1435 | 1334 | 1164 | 1164 | 1058 | 1059 | 1015 1 | 65 10           | 5 109                | 7 2             |
| 56 | 1058 | 9464        | 1058  | 1193  | 1096  | 965     | 1246  | 1058 | 13 84 | 1420 | 1537 | 1691  | 1831 | 2047 | 2429 | 2947 | 3507                      | 3218   | 2646  | 2210  | 1887  | 1726 | 1590 | 1404 | 1370 | 1314 | 1058 | 1270 | 1165 | 966    | 966 10          | 97 109               | 7 10            |
| 57 | 1014 | 1067        | 1014  | 1132  | 1132  | 1058    | 1246  | 1164 | 1270  | 1370 | 1537 | 1652  | 1826 | 2038 | 2398 | 2932 | 3499                      | 3238   | 2659  | 2207  | 1924  | 1739 | 1608 | 1477 | 1352 | 1058 | 1058 | 1058 | 1133 | 1194   | 66 12           | 96                   | 6 10            |
| 58 | 908  | 1067        | 1058  | 1058  | 1058  | 1014    | 1132  | 1314 | 1221  | 1388 | 1537 | 1705  | 1841 | 2032 | 2399 | 2915 | 3488                      | 3256   | 2688  | 2241  | 1954  | 1746 | 1618 | 1404 | 1420 | 1334 | 1314 | 1221 | 966  | 841    | 66 5            | 03 84                | 1 6             |
| 59 | 1013 | 1056        | 1013  | 1013  | 1131  | 1131    | 1333  | 1333 | 1419  | 1403 | 1536 | 1682  | 1819 | 2019 | 2378 | 2898 | 3475                      | 3278   | 2699  | 2240  | 1950  | 1732 | 1569 | 1448 | 1334 | 1270 | 1132 | 965  | 1164 | 1014   | 65 10           | <b>\$8</b> 96        | 5 10            |
| 60 | 1056 | 155         | 1056  | 963   | 1012  | 1162    | 1056  | 1191 | 1:90  | 1402 | 1512 | 1642  | 1802 | 2006 | 2359 | 2879 | 3465                      | 3298   | 2713  | 2251  | 1941  | 1757 | 1579 | 146  | 1462 | 1245 | 1220 | 1057 | 1131 | 1131 1 | 92 9            | din 75               | 7 10            |
| 61 | 962  | 1010        | 1011  | 1055  | 1093  | 1055    | 1129  |      |       |      | 34   | 1596  | 1812 | 2011 | 2351 | 2863 | 3452                      | 3315   | 2736  | 2251  | 1963  | 1689 | 1624 | 1488 | 1332 | 1162 | 1350 | 1268 | 1056 | 1056   | 50 12           | 9 90                 | 6 9             |
| 62 | 962  | 154         | 837   | 755   | 1093  | 1055    | 1011  | 1    | 20    | Æ    | -60  | 1649  | 1796 | 2044 | 2353 | 2852 | 3441                      | 3340   | 2755  | 2277  | 1959  | 1737 | 1633 | 1438 | 1447 | 1332 | 1312 | 1056 | 906  | 1012   | 63 7            | <b>\$6</b> 75        | 6 10            |
| 63 | 962  | 856         | 962   | 962   | 962   | 1243    | 1129  | 1    | ) L'  |      | -60  | 1649  | 1785 | 2002 | 2319 | 2832 | 3429                      | 3356   | 2769  | 2286  | 1997  | 1762 | 1674 | 1512 | 1290 | 1368 | 1162 | 1056 | 1191 | 963 1  | 62 10           | 2 101:               | 2 10            |
| 64 | 906  | 756         | 1056  | 1012  | 1094  | 1056    | 1268  | 1    |       |      | 76   | 1617  | 1757 | 1984 | 2311 | 2806 | 3407                      | 3373   | 2785  | 2302  | 1981  | 1775 | 1589 | 1536 | 1388 | 1246 | 1014 | 1292 | 908  | 502 1  | 132 10          | <b>\$8</b> 109       | 6 11            |
| 65 | 1055 | 887         | 1011  | 1218  | 905   | 1011    | 1190  | 1095 | тарт  | 1207 | 1447 | 1557  | 1717 | 1959 | 2305 | 2789 | 3381                      | 3394   | 2804  | 2308  | 2000  | 1763 | 1625 | 1518 | 1369 | 1192 | 1245 | 1057 | 1013 | 964 1  | 95 7            | \$ <b>1</b> 7 83'    | 9 10            |
| 66 | 1055 | 1011        | 1093  | 755   | 962   | 1055    | 1093  | 1129 | 13 11 | 1511 | 1512 | 1597  | 1780 | 1959 | 2301 | 2772 | 3364                      | 3409   | 2820  | 2324  | 1993  | 1814 | 1718 | 1558 | 1419 | 1333 | 1333 | 1269 | 1220 | 1013 1 | <b>1</b> 57 10  | 18 75                | 7 8             |
| 67 | 1161 | 9462        | 1055  | 905   | 837   | 1331    | 1190  | 1267 | 1349  | 1417 | 1500 | 1666  | 1780 | 1983 | 2277 | 2751 | 3342                      | 3425   | 2834  | 2332  | 2018  | 1792 | 1659 | 1525 | 1403 | 1351 | 1269 | 1333 | 1245 | 1095 1 | 167 8           | <b>19</b> 24         | 5 2             |
| 68 | 1009 | 903         | 960   | 903   | 1009  | 1009    | 903   | 1053 | 12 55 | 1415 | 1498 | 1586  | 1766 | 1964 | 2265 | 2726 | 3322                      | 3443   | 2853  | 2338  | 1986  | 1749 | 1596 | 1545 | 1331 | 1385 | 1267 | 962  | 1055 | 1129   | 62 10           | \$5 101              | 1 8             |
| 69 | 1093 | 1093        | 905   | 1055  | 1093  | 1190    | 1011  | 1349 | 13 19 | 1460 | 1461 | 1650  | 1756 | 1926 | 2253 | 2715 | 3302                      | 3458   | 2877  | 2358  | 2039  | 1819 | 1643 | 1476 | 1313 | 1313 | 1163 | 1333 | 1245 | 1163   | 839 9           |                      | 5 11            |
| 70 | 904  | <b>90</b> 4 | 904   | 1054  | 1160  | 1310    | 1092  | 1330 | 12 +2 | 1473 | 1474 | 1632  | 1779 | 1955 | 2238 | 2696 | 3282                      | 3472   | 2892  | 2379  | 2006  | 1808 | 1696 | 1568 | 1433 | 1191 | 1130 | 1191 | 1130 | 1056 1 | 12 10           |                      | 5 9             |
| 1  | 1091 |             | 903   | 835   | 1053  | 1009    | 1159  | 1309 | 14 17 | 1458 | 1445 | 1604  | 1701 | 1943 | 2222 | 2679 | 3267                      | 3486   | 2914  | 2394  | 2029  | 1801 | 1665 | 151  | 1385 | 1349 | 1093 | 1055 | 1011 | 962 1  | 105 10          |                      | 5 9             |
| 72 | 903  | 1003        | 960   | 1053  | 1053  | 1009    | 1287  | 1241 | 12 +1 | 1585 | 1510 | 1566  | 1679 | 1900 | 2199 | 2655 | 3242                      | 3498   | 2955  | 2400  | 2052  | 1852 | 1709 | 1498 | 1385 | 1289 | 1093 | 1055 | 1011 | 962 1  |                 | WK 96.               | 2 10            |
| 74 | 903  | - (10-3<br> | 1009  | 960   | 1009  | 1159    | 1107  | 1150 | 1100  | 1744 | 1500 | 1574  | 1760 | 1937 | 2197 | 2643 | 3222                      | 3508   | 2931  | 2416  | 2076  | 1001 | 1665 | 1540 | 1705 | 1055 | 1747 | 1129 | 1011 | 905 1  | 00/0<br>055 7   |                      |                 |
| 79 | 1057 | 110         | 1009  | 1009  | 1009  | 1009    | 940   | 1241 | 1/07  | 1265 | 1510 | 1544  | 1704 | 1070 | 2170 | 2617 | 3204                      | 3512   | 2204  | 2420  | 2007  | 1012 | 1672 | 15/8 | 1407 | 1207 | 1067 | 1127 | 1011 | 962 1  | 111 7           |                      | 2 0             |
| 76 | 960  | 10057       | 1009  | 1009  | 1053  | 960     | 1091  | 1241 | 12 09 | 1765 | 1766 | 1622  | 1742 | 1912 | 2166 | 2594 | 3103                      | 3520   | 2997  | 2459  | 2054  | 1012 | 1652 | 1594 | 1705 | 1401 | 1011 | 1243 | 1055 | 977 1  | <b>1</b> 11 11  | 100 20.<br>100 105   | 5 10            |
| 77 | 961  | ₩4          | 498   | 1010  | 1092  | 1160    | 1242  | 1054 |       | 1310 | 1487 | 1556  | 1755 | 1897 | 2146 | 2576 | 317.4                     | 3535   | 018   | 2470  | 2087  | 1824 | 1642 | 147  | 1535 | 1312 | 1244 | 1290 | 1056 | 1056   | 963 9           | 1 24                 | 4 7             |
| 78 | 242  | 886         | 961   | 1160  | 1217  | 1054    | 1128  | 1092 | 13.66 | 1348 | 1499 | 1545  | 1730 | 1892 | 2142 | 2558 | 3 31                      | 3538   | 3136  | 2489  | 2077  | 1848 | 1696 | 1500 | 1447 | 1332 | 1191 | 1312 | 906  | 906 1  |                 | <b>1</b> 4           | 3 9             |
| 79 | 961  | ملله        | 1010  | 1010  | 1054  | 1054    | 1189  | 1010 | 1189  | 1366 | 1446 | 1577  | 1709 | 1871 | 2122 | 2546 | 3195                      | 3532   | 7 154 | 2506  | 2111  | 1857 | 1666 | 1534 | 1447 | 1268 | 1219 | 1244 | 967  | 1056 4 |                 | H 75                 | 6 6             |
| 80 | 836  | 4           | 904   | 836   | 1010  | 961     | 1189  | 1054 | 1128  | 1189 | 1331 | 1632  | 1688 | 1861 | 2108 | 2519 | 3085                      | 3032   | 3070  | 2514  | 2111  | 1844 | 1744 | 15   | 1402 | 1447 | 963  | 1268 | 906  | 1056   | 8 10            | 83                   |                 |
| 81 | 1011 | 962         | 962   | 962   | 1011  | 1093    | 1011  | 1055 | 1218  | 1289 | 1475 | 1616  | 1650 | 1839 | 2111 | 2504 | 5005                      | 0004   | 0010  | 2530  | 2139  | 1859 | 1711 | 1547 | 1448 | 1095 | 1057 | 1245 | 1131 | 1013 1 | 131 10          | 13 96                | 4 6             |
| 82 | 756  | 1012        | 963   | 963   | 1094  | 1012    | 1012  | 1350 | 1312  | 1418 | 1419 | 1569  | 1711 | 1830 | 2115 | 2496 | -                         |        |       | 2551  | 2135  | 1854 | 1643 | 1462 | 1477 | 1352 | 1221 | 1058 | 1014 | 1014 1 | 014             | 58 84                | 0 8             |
| 83 | 1056 | i.          | 10361 | 10361 | 10121 | 1036    | 1130  | 1219 | 1191  | 1330 | 1454 | 19291 | 1752 | 1894 | ZU88 | Z495 | 4                         |        |       | 20691 | Z1191 | 1881 | 1711 | 1008 | 1490 | 1334 | 1246 | 1246 | 1314 | 10581  | 9631            | 10 101               | 4 8             |
| 84 | 500  | 756         | 963   | 1056  | 1012  | 1290    | 1056  | 1332 | 1268  | 1418 | 1387 | 1589  | 1697 | 1854 | 2088 | 2465 |                           | - /    | J     | 2583  | 2161  | 1899 | 1718 | 1579 | 1435 | 1314 | 1246 | 1164 | 1193 | 1014 1 | 014 10          | 58 105               | 8 9             |
| 85 | 1055 | 649         | 1011  | 837   | 1161  | 1267    | 1161  | 1190 | 1331  | 1267 | 1331 | 1545  | 1658 | 1808 | 2082 | 2445 | 2770                      | 3322   | 5105  | 2592  | 2163  | 1876 | 1717 | 1597 | 1447 | 1332 | 1012 | 1130 | 1130 | 1130 1 | 094 10          | 12 90                | 6 9             |
| 86 | 1011 | 962         | 1011  | 837   | 1267  | 962     | 1218  | 1161 | 962   | 1367 | 1446 | 1534  | 1674 | 1834 | 2082 | 2445 | 2972                      | 3516   | 3186  | 2610  | 2179  | 1885 | 1717 | 1616 | 1368 | 1332 | 1268 | 1268 | 1219 | 1056 1 | 162 10          | 12 109               | 4 11            |
| 87 | 962  | , 905       | 1093  | 1161  | 1093  | 962     | 837   | 962  | 1289  | 1331 | 1523 | 1567  | 1666 | 1808 | 2033 | 2415 | 2955                      | 3510   | 3204  | 2627  | 2185  | 1898 | 1744 | 1606 | 1500 | 1290 | 1012 | 1056 | 1219 | 963 1  | 056 10          | 56 96                | <u>3 9 🎽</u>    |
|    |      |             |       |       | (     | _       |       |      | _     |      |      |       |      |      |      |      |                           | _      |       | _     |       |      |      |      |      |      |      |      |      |        |                 |                      | والمساعد المساح |

FPDスリット像のデジタル値

|     |             |       |             |              | 📃 🛄 FPD I   | HD&MTF(INNER)       |  |             |               |            | 민   |
|-----|-------------|-------|-------------|--------------|-------------|---------------------|--|-------------|---------------|------------|---|
|     | A I         | в     | С           | D            | E           | F                   | •  | θ           | н             | I          |   |
| _   |             |       |             |              |             |                     | -  |             |               |            |   |
| 2 🗙 | 、(距離1007)   | デジタル恒 | 有効露光量       | LSF(正規化)     | 外挿LSF       | 外挿LS                | GF FFT   | 外挿LSFFFT絶対值 | MTF           | 空間周波数      | 1.1   |
| 3   | d           | 967   | 0.19406759  | 0.001580522  | 0.00008     | 60.1286534329865    |  | 60.12865343 | 1             | 0          |   |
| - 4 | 0.00516129  | 653   | 0.088518051 | 0.000720907  | 8.11923E-05 | -56.6331497828061-1 | 10.7078146423872i  | 57.63654178 | 0.95855368    | 0.1953125  |   |
| 5   | 0.010322581 | 1165  | 0.31836754  | 0.002592844  | 8.24024E-05 | 48.8733946337643+1  | 9.0964606667677i   | 52.47174742 | 0.87265795    | 0.390625   |   |
| 6   | 0.015483871 | 965   | 0.193099674 | 0.001572639  | 8.36305E-05 | -40.01316515108-24. | 998443128805i  | 47.18026224 | 0.78465523    | 0.5859375  |   |
| 7   | 0.020645161 | 757   | 0.114801724 | 0.000934966  | 8.48769E-05 | 31.0281794149598+2  | 8.6041756301296i   | 42.20126516 | 0.7018495     | 0.78125    |   |
| 8   | 0.025806452 | 1057  | 0.243035252 | 0 001 070704 | 0 21/105-05 | -00 7004400440441-3 | ro oraeoraa 5546759i   | 37.49220008 | 0.62353301    | 0.9765625  |   |
| 9   | 0.030967742 | 1057  | 0.24303525  | ╇╋╲╷╼╬╷      |             |                     | 59962i   | 33.02080426 | 0.5491692     | 1.171875   |   |
| 10  | 0.036129032 | 246   | 0.03199905  | リノノリ         | ノノソ旧        |                     | <del>00</del> 0090i  | 28.8583674  | 0.47994368    | 1.3671875  |   |
| 11  | 0.041290323 | 1015  | 0.21001050  |              |             |                     | 04035i   | 25.06084307 | 0.41678703    | 1.5625     |   |
| 12  | 0.046451613 | 1097  | 0.26859549  | 16በ ±        | 1 = 0 00    | 1516120             | 545605i  | 21.68117279 | 0.36057972    | 1.7578125  |   |
| 13  | 0.051612903 | 1271  | 0.41497011  |              | 1 - 0.00    | 010123              | 635335i  | 18.71900832 | 0.31131594    | 1.953125   |   |
| 14  | 0.056774194 | 503   | 0.060837508 | 0.000493472  | 9.415776-00 | 7.37231365041864-14 | 4.3787567920502i   | 16.15879195 | 0.26873697    | 2.1484375  |   |
| 15  | 0.061935484 | 1058  | 0.2436436   | 0.001984278  | 9.55407E-05 | -0.54548872443188+1 | 11.03211301974 <del>0</del> 7i   | 13.95467288 | 0.23208025    | 2.34375    |   |
| 16  | 0.067096774 | 907   | 0.167035523 | 0.001360368  | 9.69646E-05 | 9.01358220637524-8. | .01773728992 <b>84</b> 5i  | 12.0635308  | 0.20062865    | 2.5390625  |   |
| 17  | 0.072258065 | 1219  | 0.36438336  | 0.002967605  | <b></b>     | · · · ·             |  | 4659        | 0.1735736     | 2.734375   |   |
| 10  | 0.077419355 | 756   | 14515070    | 0.000070670  | _ 全爪        | 「て」いト               | デジタ  | 6575        | 0.15028536    | 2.9296875  |   |
| 19  | 0.082580645 | 1012  | 0.217175656 | 0.001768719  |             | 6 <u>771</u>        | ////   | V LL 93523  | 0.13019739    | 3.125      |   |
| 20  | 0.087741935 | 1058  | 0.2436436   | 0.001984278  | 0.000102876 | 6.785831 4000 r     |  |             |               | 25         |   |
| -24 | 0.092907224 | 757   | 0.114901724 | 0.000974944  | 0.000104409 | -5 77173            |  |             |               | 25         | in the second |
| 170 |             |       |             |              |             | 3500                |  | Δ           |               | -1-1       |   |
| 330 | 1.667741755 | 1779  | 1.462744334 | 0.01191449   | 0.01009304  | 0.05500             |  |             |               | 25         |   |
| 331 | 1.692903226 | 1732  | 1.33703063  | 0.010540919  | 0.010243464 | -0.01301 3000       |  |             |               | 25         |   |
| 332 | 1.898064316 | 1720  | 1.274273666 | 0.010340819  | 0.010556151 | 0.04205             |  |             |               | 20         |   |
| 335 | 1.703223606 | 1732  | 1.33703063  | 0.010009024  | 0.010331072 | 2500                |  |             |               | 23         |   |
| 375 | 1 7125/0207 | 1770  | 1 212024150 | 0.011001239  | 0.010706525 | 0.03133             |  |             |               | 73         |   |
| 335 | 1 710700677 | 1757  | 1 79057174  | 0.010700125  | 0.010007917 | -0.01               |  |             |               | 75         | $\left  - \right $  |
| 330 | 1.710702077 | 1400  | 1.37037131  | 0.011370222  | 0.011194279 | 0.010451            |  |             |               | 23         |   |
| 376 | 1.720070968 | 1007  | 1.177723408 | 0.00760735   | 0.011761115 | -0.0071 1500        |  |             |               | 75         |   |
| 370 | 1.722032238 | 1762  | 1.000002102 | 0.010004714  | 0.011577407 | 0.000561            | A STATE OF THE STA |             |               |            |   |
| 307 | 1.734173348 | 1775  | 1.410103171 | 0.011000495  | 0.011000490 | -0.00022 1000       |  |             | 1.20          | 20         | $\left  - \right $  |
| 340 | 1.737334839 | 1773  | 1.462744334 | 0.01151449   | 0.0115(27/7 | -0.0072             |  |             | •             | 20         | $\left  - \right $  |
| 341 | 1.744316129 | 1014  | 1.412766015 | 0.011362363  | 0.01717447  | 500                 | • •  |             |               | - 20       | $\left  - \right $  |
| 342 | 1.747677419 | 1814  | 1.512/55815 | 0.01313467   | 0.01313467  | 0.00485             | •  |             |               | 75         | $\left  - \right $  |
| 345 | 1.73485871  | 1792  | 1.326439837 | 0.01245177   | 0.01245177  |                     | 11   | II          | I             | 25         |   |
| 344 | 1.76        | 1749  | 1.570877742 | 0.011164681  | 0.011164681 | 0.016211 0          | 1  | 2 3         | 4             | 5 25       |   |
| 345 | 1.76516129  | 1819  | 1.633052924 | 0.013299884  | 0.013299884 | -0.01862            |  |             | 0 000 3 300 4 | 75         | $\left  - \right $  |
| 346 | 1.770322581 | 1808  | 1.588755845 | 0.01293912   | 0.01293912  | 0.0215104352157304- | -0.019064602980990   | 0.028742963 | 0.00047802    | 66.9921875 |   |
| 347 | 1.775483871 | 1801  | 1.561194483 | 0.012714655  | 0.012714655 | -0.0282667857583252 | 2+0.02093463856856   | 0.035174853 | 0.00058499    | 67.1875    |   |

高速フーリエ変換によるMTF計算過程のワークシート

#### 露光量変換のために・・・



|   |  |  |   |   | FPD 🗐  | HD&MTF(INNER)  |   |   |   | 日日 |
|---|--|--|---|---|--|--|---|---|---|----|
|   | 6  | в  | с   | P   | E  | F  | 0   | н   |   |    |
| 1   |  |  |   | -   |  |  |   |   |   |    |
| 2 3   | x(距離mm)  | デジタル値  | 有効露光量   | LSF(正規化)  | 外挿 LSF   | 外挿LSF FFT  | 外挿LSF FFT絶対値  | MTE   | 空間周波数   |    |
| 3   | 0  | 967  | 0.19406759  | 0.001580522   | 80000.0  | 60.1286534329865   | 60.12865343   | 1   | 0   |    |
| 4   | 0.00516129   | 653  | 0.088518051   | 0.000720907   | 8.11923E-05  | -56.6331497626061-10.7076146423672i  | 57.63654178   | 0.95855368  | 0.1953125   |    |
| 5   | 0.010322581  | 1165   | 0.31836754  | 0.002592844   | 8.24024E-05  | 48.8733946337643+19.D964606667877i   | 52.47174742   | 0.87265795  | 0.390625  |    |
| 6   | 0.015483871  | 965  | 0.193099674   | 0.001572639   | 8.36305E-05  | -40.01316515108-24.998443128605i   | 47.18026224   | 0.78465523  | 0.5859375   |    |
| 7   | 0.020645161  | 757  | 0.114801724   | 0.000934966   | 8.48769E-05  | ₹·   | 10.0010/51/   | 0.2010405   | 0.78125   |    |
| Θ   | 0.025806452  | 1057   | 0.243035252   | 0.001979324   | 8.61419E-05  |  |   |   | 0.9765625   |    |
| 9   | 0.030967742  | 1057   | 0.243035252   | 0.001979324   | 8.74257E-05  | 兩方軍分換  |   |   | 1.171875  |    |
| 10  | 0.036129032  | 246  | 0.031999059   |   | 0.012012 00  |  |   |   | .3671875  |    |
| 11  | 0.041290323  | 1015   | 0.218810597   | 0.001782034   | 9.00511E-05  | O O172* EV   | D/N NN9   | 5*D2)   | 1.5625  |    |
| 12  | 0.046451613  | 1097   | 0.268595492   | 0.002187491   | 9.13932E-05  | $= \underline{0.0175} \mathbf{EA}$   | <u>「 (U.UU</u> ん  | <u>J DJ</u>   | .7578125  |    |
| 13  | 0.051612903  | 1271   | 0.414970113   | 0.003379593   | 9.27553E-05  |  |   |   | 1.953125  |    |
| 14  | 0.056774194  | 503  | 0.060837508   | 0.000495472   | 9.41377E-05  | 7.37231365041884-14.3789967920502i   | 16.15879195   | 0.26873697  | 2.1484375   |    |
| 15  | 0.061935484  | 1058   | 0.2436436   | 0.001984278   | 9.55407E-05  | -8.54548872443188+11.0321130197487i  | 13.95467288   | 0.23208025  | 2.34375   |    |
| 16  | 0.067096774  | 907  | 0.167035523   | 0.001360368   | 9.69646E-05  | 9.01358220637524-8.01773728992845i   | 12.0635308  | 0.20062865  | 2.5390625   |    |
| 17  | 0.072258065  | 1219   | 0.36438336  | 0.002967605   | 9.84098E-05  | -8.93668183790325+5.38721364721647i  | 10.43674659   | 0.1735736   | 2.734375  |    |
| 10  | 0.077419355  | 756  | 0.114515078   | 0.000932632   | 9.98764E-05  | 8.46315431812571-3.16742267673512i   | 9.036456575   | 0.15028536  | 2.9296875   |    |
| 19  | 0.082580645  | 1012   | 0.217175656   | 0.001768719   | 10.000101365   | <u>-7 711376</u> 74163993+1.34964635933689i  | 7.828593523   | 0.13019739  | 3.125   |    |
| 20  | 0.087741935  | 1058   | 0.2436436   | 0.001984278   | 0.000102876  | 6.78583024886539+0.0820787868859564i   | 6.786326627   | 0.11286344  | 3.3203125   |    |
| 1401  | 0.093907376  | - 353  | - 0.113891374   |   | <del></del>  |  | E 007770545   | A A0701055  | Z 515425  |    |
| 482   | 2.472258   |  |   |   |  |  |   |   |   |    |
| 407   |  | 3538   | 120.05515   | 0.97775124 0  | 97775124 -0.1  |  |   | +8/1/   |   |    |
| 403   | 2.477419   | 3538<br>3547   | 120.05515<br>122.787009   | 0.97775124 0<br>1   | 97775124 -0.1<br>1 0.1   | 第合成したスリ  | ットの正  | 規化  |   |    |
| 403   | 2.477419   | 3538<br>3547<br>3545   | 120.05515<br>122.787009<br>122.174607   | 0.97775124 0<br>1<br>0.99501248 0   | 97775124 -0.1<br>1 0.1<br>99501248 0.4   | 合成したスリ   | ットの正  | 規化  |   |    |
| 483<br>484<br>330   | 2.477419<br>2.482581<br>1.687741935  | 3538<br>3547<br>3545<br>1775   | 120.05515<br>122.787009<br>122.174607<br>1.462944554  | 0.97775124 0<br>1<br>0.99501248 0<br>0.01191449   | 97775124 -0.1<br>1 0.1<br>99501248 0.4<br>0.01009304   |  | ットの正<br>  | 規化  | 63.8671875  |    |
| 463<br>464<br>330<br>331  | 2.477419<br>2.482581<br>1.687741935<br>1.692903226   | 3538<br>3547<br>3545<br>1775<br>1739   | 120.05515<br>122.787009<br>122.174607<br>1.462944554<br>1.33703065  | 0.97775124 0<br>1<br>0.99501248 0<br>0.01191449<br>0.010889024  | 97775124 -0.1<br>1 0.1<br>99501248 0.4<br>0.01009304<br>0.010243464  | ☆ 合成したスリ ☆ (合成LSF) :   | ットの正<br>=C3/\$C   | <b>規化</b><br>\$483  | 63.8671875<br>64.0625   |    |
| 483<br>484<br>330<br>331<br>332   | 2.477419<br>2.482581<br>1.687741935<br>1.692903226<br>1.698064516  | 3538<br>3547<br>3545<br>1775<br>1739<br>1726   | 120.05515<br>122.787009<br>122.174607<br>1.462944554<br>1.33703065<br>1.294275686   | 0.97775124 0<br>1.99501248 0<br>0.01191449<br>0.010889024<br>0.010540819  | 97775124 -0.1<br>1 0.1<br>99501248 0.4<br>0.01009304<br>0.010243464<br>0.010396131   | ☆ 合成したスリ<br>(合成LSF)  | ットの正<br><u>=C3/\$C</u>  | 規化<br><u>\$483</u>  | 63.8671875<br>64.0625<br>64.2578125   |    |
| 483<br>484<br>330<br>331<br>332<br>333  | 2.477419<br>2.482581<br>1.687741935<br>1.692903226<br>1.698064516<br>1.703225806   | 3538<br>3547<br>3545<br>1775<br>1739<br>1726<br>1739   | 120.05515<br>122.787009<br>122.174607<br>1.462944554<br>1.33703065<br>1.294275686<br>1.33703065   | 0.97775124 0<br>1.99501248 0<br>0.01191449<br>0.010889024<br>0.010540819<br>0.010889024   | 97775124 -0.1<br>1 0.1<br>99501248 0.4<br>0.01009304<br>0.010243464<br>0.010396131<br>0.010551072  | 67<br>51<br>56<br>(合成したスリ<br>0.0<br>0.0<br>0.0<br>0.0<br>0.0<br>0.0<br>0.0<br>0.0<br>0.0<br>0.   | ットの正<br>=C3/\$C   | 規化<br><u>\$483</u>  | 63.8671875<br>64.0625<br>64.2578125<br>64.453125  |    |
| 403<br>404<br>330<br>331<br>332<br>333<br>333<br>334  | 2.477419<br>2.482581<br>1.687741935<br>1.692903226<br>1.698064516<br>1.703225806<br>1.708387097  | 3538<br>3547<br>3545<br>1775<br>1739<br>1726<br>1739<br>1746   | 120.05515<br>122.787009<br>122.174607<br>1.462944554<br>1.33703065<br>1.294275686<br>1.33703065<br>1.360634619  | 0.97775124 0<br>1.99501248 0<br>0.01191449<br>0.010889024<br>0.010540819<br>0.010889024<br>0.010889024<br>0.011081259   | 97775124 -0.1<br>1 0.1<br>99501248 0.4<br>0.01009304<br>0.010243464<br>0.010396131<br>0.010551072<br>0.010708323   | 67<br>51<br>56<br>•0<br>•0<br>•0<br>•0<br>•0<br>•0<br>•0<br>•0<br>•0<br>•0<br>•0<br>•0<br>•0   | ットの正<br>=C3/\$C   | 規化<br>\$483<br>0.00062258<br>0.00053731   | 63.8671875<br>64.0625<br>64.2578125<br>64.453125<br>64.6484375  |    |
| 463<br>464<br>330<br>331<br>332<br>332<br>333<br>334<br>335   | 2.477419<br>2.482581<br>1.687741935<br>1.692903226<br>1.698064516<br>1.703225806<br>1.708387097<br>1.713548387   | 3538<br>3547<br>3545<br>1775<br>1739<br>1726<br>1739<br>1746<br>1732   | 120.05515<br>122.787009<br>122.174607<br>1.462944554<br>1.33703065<br>1.294275686<br>1.33703065<br>1.360634619<br>1.313836158   | 0.97775124 0<br>0.99501248 0<br>0.01191449<br>0.010889024<br>0.010540819<br>0.010889024<br>0.010889024<br>0.011081259<br>0.010700123  | 97775124 -0.1<br>99501248 0.4<br>0.01009304<br>0.010243464<br>0.010396131<br>0.010551072<br>0.010708323<br>0.010867917   | 67<br>51<br>56<br>•0.0<br>•0.0<br>•0.0<br>•0.0<br>•0.0<br>•0.0<br>•0.0<br>•0.  | ットの正<br>=C3/\$C<br>0.037434775<br>0.032307728<br>0.028224686  | 規化<br>\$483<br>0.00062258<br>0.00053731<br>0.0004694  | 63.8671875<br>64.0625<br>64.2578125<br>64.453125<br>64.6484375<br>64.84375  |    |
| 463<br>464<br>330<br>331<br>332<br>333<br>334<br>335<br>336   | 2.477419<br>2.482581<br>1.687741935<br>1.692903226<br>1.698064516<br>1.703225806<br>1.708387097<br>1.713548387<br>1.718709677  | 3538<br>3547<br>3545<br>1775<br>1739<br>1726<br>1739<br>1746<br>1732<br>1757   | 120.05515<br>122.787009<br>122.174607<br>1.462944554<br>1.33703065<br>1.294275686<br>1.33703065<br>1.360634619<br>1.313836158<br>1.39857131   | 0.97775124 0<br>1.99501248 0<br>0.01191449<br>0.010889024<br>0.010540819<br>0.010889024<br>0.010889024<br>0.011081259<br>0.010700123<br>0.011390222   | 97775124 -0.1<br>99501248 0.4<br>0.01009304<br>0.010243464<br>0.010396131<br>0.010551072<br>0.010708323<br>0.010867917<br>0.01102989   | 67<br>51<br>56<br>• <b>合成したスリ</b><br>• <b>合成したスリ</b><br>• <b>(合成LSF)</b><br>• 0.0353140423950898-0.012418708047252<br>• 0.0315932667546264+0.00675683411909<br>0.0274331366692502+0.006657462851666<br>• 0.0198424249281888-0.02172333333550   | ットの正<br>=C3/\$C<br>0.037434775<br>0.032307728<br>0.028224686<br>0.029421506   | 規化<br>\$483<br>0.00062258<br>0.00053731<br>0.0004694<br>0.00048931  | 63.8671875<br>64.0625<br>64.2578125<br>64.453125<br>64.6484375<br>64.84375<br>65.0390625  |    |
| 463<br>464<br>330<br>331<br>332<br>333<br>334<br>335<br>336<br>337  | 2.477419<br>2.482581<br>1.687741935<br>1.692903226<br>1.698064516<br>1.703225806<br>1.708387097<br>1.713548387<br>1.718709677<br>1.723870968   | 3538<br>3547<br>3545<br>1775<br>1739<br>1726<br>1739<br>1746<br>1732<br>1757<br>1689   | 120.05515<br>122.787009<br>122.174607<br>1.462944554<br>1.33703065<br>1.294275686<br>1.33703065<br>1.360634619<br>1.313836158<br>1.39857131<br>1.179925408  | 0.97775124 0<br>0.99501248 0<br>0.01191449<br>0.010889024<br>0.010540819<br>0.010889024<br>0.010889024<br>0.011081259<br>0.010700123<br>0.011390222<br>0.00960953   | 97775124 -0.1<br>99501248 0.4<br>0.01009304<br>0.010243464<br>0.010396131<br>0.010551072<br>0.010708323<br>0.010867917<br>0.01102989<br>0.011194278  | 67<br>51<br>56<br>-0<br>0.0<br>0.0<br>0.0<br>0.0<br>0.0<br>0.0<br>0.0<br>0.0<br>0.0  | ットの正<br>=C3/\$C<br>0.037434775<br>0.032307728<br>0.028224686<br>0.029421506<br>0.032743856  | <b>規化</b><br><u>\$483</u><br>0.00062258<br>0.00053731<br>0.0004694<br>0.00048931<br>0.00054456  | 63.8671875<br>64.0625<br>64.2578125<br>64.453125<br>64.6484375<br>64.84375<br>65.0390625<br>65.234375   |    |
| 463<br>404<br>33D<br>331<br>332<br>333<br>334<br>335<br>336<br>337<br>338   | 2.477419<br>2.482581<br>1.687741935<br>1.692903226<br>1.698064516<br>1.703225806<br>1.708387097<br>1.713548387<br>1.718709677<br>1.723870968<br>1.729032258  | 3538<br>3547<br>3545<br>1775<br>1739<br>1726<br>1739<br>1746<br>1732<br>1757<br>1689<br>1737   | 120.05515<br>122.787009<br>122.174607<br>1.462944554<br>1.33703065<br>1.294275686<br>1.33703065<br>1.360634619<br>1.313836158<br>1.39857131<br>1.179925408<br>1.330362182   | 0.97775124 0<br>1.99501248 0<br>0.01191449<br>0.010889024<br>0.010540819<br>0.010889024<br>0.010889024<br>0.011081259<br>0.010700123<br>0.011390222<br>0.00960953<br>0.010834714  | 97775124 -0.1<br>99501248 0.4<br>0.01009304<br>0.010243464<br>0.010396131<br>0.010551072<br>0.010708323<br>0.010867917<br>0.01102989<br>0.011194278<br>0.011361115   | 67<br>51<br>56<br>0.0<br>0.0<br>0.0<br>0.0<br>0.0<br>0.0<br>0.0<br>0.0<br>0.0<br>0.  | <b>ットの正</b><br>   | <b>規化</b><br><u>\$483</u><br>0.00062258<br>0.00053731<br>0.0004694<br>0.00048931<br>0.00054456<br>0.00053332  | 63.8671875<br>64.0625<br>64.2578125<br>64.453125<br>64.6484375<br>64.84375<br>65.0390625<br>65.234375<br>65.4296875   |    |
| 463<br>464<br>330<br>331<br>332<br>333<br>334<br>335<br>336<br>337<br>338<br>339  | 2.477419<br>2.482581<br>1.687741935<br>1.692903226<br>1.698064516<br>1.703225806<br>1.708387097<br>1.713548387<br>1.718709677<br>1.723870968<br>1.729032258<br>1.734193548   | 3538<br>3547<br>3545<br>1775<br>1739<br>1726<br>1739<br>1746<br>1732<br>1757<br>1689<br>1737<br>1762   | 120.05515<br>122.787009<br>122.174607<br>1.462944554<br>1.33703065<br>1.294275686<br>1.33703065<br>1.360634619<br>1.313836158<br>1.39857131<br>1.179925408<br>1.330362182<br>1.416163171  | 0.97775124 0<br>1.99501248 0<br>0.01191449<br>0.010889024<br>0.010540819<br>0.010889024<br>0.010889024<br>0.011081259<br>0.010700123<br>0.011390222<br>0.00960953<br>0.010834714<br>0.011533493   | 97775124 -0.1<br>99501248 0.4<br>0.01009304<br>0.010243464<br>0.010396131<br>0.010551072<br>0.010708323<br>0.010867917<br>0.01102989<br>0.01102989<br>0.011194278<br>0.011361115<br>0.011533493  | 67<br>51<br>56<br>0.0<br>0.0<br>0.0<br>0.0<br>0.0<br>0.0<br>0.0<br>0.0<br>0.0<br>0.  | <b>ットの正</b><br>   | <b>規化</b><br><u>\$483</u><br>0.00062258<br>0.00053731<br>0.0004694<br>0.00048931<br>0.00054456<br>0.00053332<br>0.00045511  | 63.8671875<br>64.0625<br>64.2578125<br>64.453125<br>64.6484375<br>64.84375<br>65.0390625<br>65.234375<br>65.234375<br>65.4296875<br>65.625  |    |
| 405           404           330           331           332           333           334           335           336           337           338           339           340   | 2.477419<br>2.482581<br>1.687741935<br>1.692903226<br>1.698064516<br>1.703225806<br>1.708387097<br>1.713548387<br>1.718709677<br>1.723870968<br>1.729032258<br>1.73419354839   | 3538<br>3547<br>3545<br>1775<br>1739<br>1726<br>1739<br>1746<br>1732<br>1757<br>1689<br>1737<br>1762<br>1775   | 120.05515<br>122.787009<br>122.174607<br>1.462944554<br>1.33703065<br>1.294275686<br>1.33703065<br>1.360634619<br>1.313836158<br>1.39857131<br>1.179925408<br>1.330362182<br>1.416163171<br>1.462944554   | 0.97775124 0<br>0.99501248 0<br>0.01191449<br>0.010889024<br>0.010540819<br>0.010889024<br>0.010889024<br>0.011081259<br>0.010700123<br>0.011390222<br>0.00960953<br>0.010834714<br>0.011533493<br>0.01191449   | 97775124 -0.1<br>99501248 0.4<br>0.01009304<br>0.010243464<br>0.010396131<br>0.010551072<br>0.010708323<br>0.010867917<br>0.01102989<br>0.01102989<br>0.011194278<br>0.01133493<br>0.01191449  | 67         合成したスリ           51         合成したスリ           56         (合成しSE)           0.0         (合成しSE)           0.0         (合成しSE)           0.0         (合成しSE)           0.0         (合成しSE)           0.0         (合成しSE)           0.0         (Gのののののののののののののののののののののののののののののののののののの  | <b>ットの正</b><br>   | <b>規化</b><br><u>\$483</u><br>0.00062258<br>0.00053731<br>0.0004694<br>0.00048931<br>0.00054456<br>0.00053332<br>0.00045511<br>0.00037982                              | 63.8671875<br>64.0625<br>64.2578125<br>64.453125<br>64.6484375<br>64.84375<br>65.0390625<br>65.234375<br>65.234375<br>65.4296875<br>65.625<br>65.8203125  |    |
| 405           404           330           331           332           333           334           335           336           337           338           339           340           341   | 2.477419<br>2.482581<br>1.687741935<br>1.692903226<br>1.698064516<br>1.703225806<br>1.708387097<br>1.713548387<br>1.718709677<br>1.723870968<br>1.729032258<br>1.734193548<br>1.739354839<br>1.744516129   | 3538<br>3547<br>3545<br>1775<br>1739<br>1726<br>1739<br>1746<br>1732<br>1757<br>1689<br>1737<br>1762<br>1775<br>1763   | 120.05515<br>122.787009<br>122.174607<br>1.462944554<br>1.33703065<br>1.294275686<br>1.33703065<br>1.360634619<br>1.313836158<br>1.39857131<br>1.179925408<br>1.330362182<br>1.416163171<br>1.462944554<br>1.419708008  | 0.97775124 0<br>0.99501248 0<br>0.01191449<br>0.010889024<br>0.010540819<br>0.010540819<br>0.010889024<br>0.011081259<br>0.010700123<br>0.011390222<br>0.00960953<br>0.010834714<br>0.011533493<br>0.01191449<br>0.011562363  | 97775124 -0.1<br>99501248 0.4<br>0.01009304<br>0.010243464<br>0.010396131<br>0.010551072<br>0.010708323<br>0.010867917<br>0.01102989<br>0.01102989<br>0.01194278<br>0.011533493<br>0.01191449<br>0.011562363   | 67         合成したスリ           51         合成したスリ           56         (合成しSE)           0.0         (合成しSE)           0.0         (合成しSE)           0.0         (合成しSE)           0.0         (合成しSE)           0.0         (合成しSE)           0.0         (Gのののののののののののののののののののののののののののののののののののの  | <b>ットの正</b><br>   | <b>規化</b><br><b>\$483</b><br>0.00062258<br>0.00053731<br>0.0004694<br>0.00048931<br>0.00054456<br>0.00053332<br>0.00045511<br>0.00037982<br>0.00034811                | 63.8671875<br>64.0625<br>64.2578125<br>64.453125<br>64.6484375<br>65.0390625<br>65.234375<br>65.4296875<br>65.4296875<br>65.8203125<br>66.015625  |    |
| 403           404           330           331           332           333           334           335           336           337           338           339           340           341           342   | 2.477419<br>2.482581<br>1.687741935<br>1.692903226<br>1.698064516<br>1.703225806<br>1.708387097<br>1.713548387<br>1.718709677<br>1.723870968<br>1.729032258<br>1.734193548<br>1.739354839<br>1.744516129<br>1.749677419  | 3538<br>3547<br>3545<br>1775<br>1739<br>1726<br>1739<br>1746<br>1732<br>1757<br>1689<br>1737<br>1762<br>1775<br>1763<br>1814                                 | 120.05515<br>122.787009<br>122.174607<br>1.462944554<br>1.33703065<br>1.294275686<br>1.33703065<br>1.360634619<br>1.313836158<br>1.39857131<br>1.179925408<br>1.330362182<br>1.416163171<br>1.462944554<br>1.419708008<br>1.612766815   | 0.97775124 0<br>0.99501248 0<br>0.01191449<br>0.010889024<br>0.010540819<br>0.010540819<br>0.010889024<br>0.011081259<br>0.010700123<br>0.011390222<br>0.00960953<br>0.010834714<br>0.011533493<br>0.01191449<br>0.011562363<br>0.01313467  | 97775124 -0.1<br>99501248 0.4<br>0.01009304<br>0.010243464<br>0.010396131<br>0.010551072<br>0.010708323<br>0.010867917<br>0.01102989<br>0.01102989<br>0.01194278<br>0.011533493<br>0.011562363<br>0.01313467   | 67         合成したスリ           51         合成したスリ           56         (合成した)           0.0         (白成した)           0.0         (日本)           0.0         (日本) <t< th=""><th><b>ットの正</b><br/></th><th><b>規化</b><br/><b>\$483</b><br/>0.00062258<br/>0.00053731<br/>0.0004694<br/>0.00048931<br/>0.00054456<br/>0.00053332<br/>0.00045511<br/>0.00037982<br/>0.00034811<br/>0.00035294</th><th>63.8671875<br/>64.0625<br/>64.2578125<br/>64.453125<br/>64.6484375<br/>65.0390625<br/>65.234375<br/>65.4296875<br/>65.4296875<br/>65.625<br/>65.8203125<br/>66.015625<br/>66.2109375</th><th></th></t<>  | <b>ットの正</b><br>   | <b>規化</b><br><b>\$483</b><br>0.00062258<br>0.00053731<br>0.0004694<br>0.00048931<br>0.00054456<br>0.00053332<br>0.00045511<br>0.00037982<br>0.00034811<br>0.00035294  | 63.8671875<br>64.0625<br>64.2578125<br>64.453125<br>64.6484375<br>65.0390625<br>65.234375<br>65.4296875<br>65.4296875<br>65.625<br>65.8203125<br>66.015625<br>66.2109375  |    |
| 403           404           330           331           332           333           334           335           336           337           338           339           340           341           342           343   | 2.477419<br>2.482581<br>1.687741935<br>1.692903226<br>1.698064516<br>1.703225806<br>1.708387097<br>1.713548387<br>1.718709677<br>1.723870968<br>1.729032258<br>1.734193548<br>1.739354839<br>1.744516129<br>1.749677419<br>1.75483871                              | 3538<br>3547<br>3545<br>1775<br>1739<br>1726<br>1739<br>1746<br>1732<br>1757<br>1689<br>1737<br>1762<br>1775<br>1763<br>1763<br>1814<br>1792                 | 120.05515<br>122.787009<br>122.174607<br>1.462944554<br>1.33703065<br>1.294275686<br>1.33703065<br>1.360634619<br>1.313836158<br>1.39857131<br>1.179925408<br>1.330362182<br>1.416163171<br>1.462944554<br>1.419708008<br>1.612766815<br>1.526459837  | .97775124         0           1.99501248         0           0.01191449         0           0.010889024         0           0.010540819         0           0.010889024         0           0.010889024         0           0.010889024         0           0.010889024         0           0.010700123         0           0.011300222         0           0.010834714         0           0.011533493         0           0.01191445         0           0.011562363         0           0.01313467         0 | 97775124 -0.1<br>99501248 0.4<br>0.01009304<br>0.010243464<br>0.010396131<br>0.010551072<br>0.010708323<br>0.010867917<br>0.01102989<br>0.01102989<br>0.011361115<br>0.011533493<br>0.011562363<br>0.01313467<br>0.01243177                                | 67         合成したスリ           51         合成したスリ           56         (合成した)           0.0         (白成した)           0.0         (日本)           0.0         (日本) <t< th=""><th><b>vhot</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b><br/><b>constant</b></th><th><b>現代</b><br/><b>3</b><br/><b>3</b><br/><b>3</b><br/><b>4</b><br/><b>3</b><br/><b>5</b><br/><b>5</b><br/><b>5</b><br/><b>5</b><br/><b>5</b><br/><b>5</b><br/><b>5</b><br/><b>5</b></th><th>63.8671875<br/>64.0625<br/>64.2578125<br/>64.453125<br/>64.6484375<br/>65.0390625<br/>65.234375<br/>65.4296875<br/>65.4296875<br/>65.8203125<br/>65.8203125<br/>66.015625<br/>66.2109375<br/>66.40625</th><th></th></t<> | <b>vhot</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b><br><b>constant</b> | <b>現代</b><br><b>3</b><br><b>3</b><br><b>3</b><br><b>4</b><br><b>3</b><br><b>5</b><br><b>5</b><br><b>5</b><br><b>5</b><br><b>5</b><br><b>5</b><br><b>5</b><br><b>5</b> | 63.8671875<br>64.0625<br>64.2578125<br>64.453125<br>64.6484375<br>65.0390625<br>65.234375<br>65.4296875<br>65.4296875<br>65.8203125<br>65.8203125<br>66.015625<br>66.2109375<br>66.40625                            |    |
| 465           464           330           331           332           333           334           335           336           337           338           339           340           341           342           343           344                             | 2.477419<br>2.482581<br>1.687741935<br>1.692903226<br>1.698064516<br>1.703225806<br>1.708387097<br>1.713548387<br>1.718709677<br>1.723870968<br>1.729032258<br>1.734193548<br>1.739354839<br>1.744516129<br>1.749677419<br>1.75483871<br>1.76                      | 3538<br>3547<br>3545<br>1775<br>1739<br>1726<br>1739<br>1746<br>1732<br>1757<br>1689<br>1737<br>1762<br>1775<br>1763<br>1814<br>1792<br>1749                 | 120.05515<br>122.787009<br>122.174607<br>1.462944554<br>1.33703065<br>1.294275686<br>1.33703065<br>1.360634619<br>1.313836158<br>1.39857131<br>1.179925408<br>1.330362182<br>1.416163171<br>1.462944554<br>1.419708008<br>1.612766815<br>1.526459837<br>1.370877742                               | 0.97775124         0           1.99501248         0           0.01191449         0.010889024           0.010540819         0.010540819           0.010889024         0.010889024           0.010889024         0.011081259           0.010700123         0.0117300222           0.00960953         0.010834714           0.011533493         0.01191449           0.011562363         0.01313467           0.01243177         0.011164681   | 97775124 -0.1<br>99501248 0.4<br>0.01009304<br>0.010243464<br>0.010396131<br>0.010551072<br>0.010708323<br>0.010867917<br>0.01102989<br>0.01194278<br>0.011361115<br>0.011533493<br>0.011562363<br>0.01313467<br>0.01243177<br>0.011164681                 | 67         合成したスリ           51         合成したスリ           56         (合成したスリ           0.0         (合成した3)           0.0         (合成した3)           0.0         (合成した3)           0.0         (合成した3)           0.0         (合成した3)           0.0         (合成した3)           0.0         (白成した3)           0.0         (日本3)   | <b>9 FOE</b><br><b>C3/\$C</b><br>0.037434775<br>0.032307728<br>0.028224686<br>0.029421506<br>0.032067844<br>0.027365303<br>0.022838099<br>0.020931565<br>0.021221686<br>0.022576942<br>0.024040275  | <b>現代</b><br><b>3</b><br><b>3</b><br><b>3</b><br><b>4</b><br><b>3</b><br><b>5</b><br><b>5</b><br><b>5</b><br><b>5</b><br><b>5</b><br><b>5</b><br><b>5</b><br><b>5</b> | 63.8671875<br>64.0625<br>64.2578125<br>64.453125<br>64.6484375<br>65.0390625<br>65.234375<br>65.4296875<br>65.4296875<br>65.8203125<br>65.8203125<br>66.015625<br>66.2109375<br>66.40625<br>66.6015625              |    |
| 403           330           331           332           333           334           335           336           337           338           339           340           341           342           343           344           345                             | 2.477419<br>2.482581<br>1.687741935<br>1.692903226<br>1.698064516<br>1.703225806<br>1.708387097<br>1.713548387<br>1.718709677<br>1.723870968<br>1.729032258<br>1.734193548<br>1.739354839<br>1.744516129<br>1.749677419<br>1.75483871<br>1.76516129                | 3538<br>3547<br>3545<br>1775<br>1739<br>1726<br>1739<br>1746<br>1732<br>1757<br>1689<br>1737<br>1762<br>1775<br>1763<br>1814<br>1792<br>1749<br>1819         | 120.05515<br>122.787009<br>122.174607<br>1.462944554<br>1.33703065<br>1.294275686<br>1.33703065<br>1.360634619<br>1.313836158<br>1.39857131<br>1.179925408<br>1.330362182<br>1.416163171<br>1.462944554<br>1.419708008<br>1.612766815<br>1.526459837<br>1.370877742<br>1.633052924                | 0.97775124         0           1.99501248         0           0.01191449         0.010889024           0.010540819         0.010540819           0.010589024         0.010889024           0.010889024         0.011081259           0.010700123         0.0117300222           0.00960953         0.010834714           0.011533493         0.01191449           0.011562363         0.01313467           0.01243177         0.011164681           0.013299884         0.013299884                             | 97775124 -0.1<br>99501248 0.4<br>0.01009304<br>0.010243464<br>0.010396131<br>0.010551072<br>0.010708323<br>0.010867917<br>0.01102989<br>0.011194278<br>0.011361115<br>0.011533493<br>0.011562363<br>0.01313467<br>0.01243177<br>0.011164681<br>0.013299884 | 67         合成したスリ           51         合成したスリ           56         (合成したスリ           0.0         (合成した)           0.0         (合成した)           0.0         (合成した)           0.0         (合成した)           0.0         (白成した)           0.0353140423950090-0.012410700047252           -0.0315932667546264+0.00675663411909           0.0274331366692502+0.006657462051666           -0.0196424249201060-0.02172333333500           0.0104579494541465+0.031020679749347           -0.00314759694660664-0.0319129947039           0.000563790010395258+0.0273994945664           -0.000721666765569022-0.022626687760           -0.000256555754749515+0.02092992761           0.000465972237012629-0.02065776035236           -0.0112218493262047+0.01959051837743           0.0162136736606543-0.017749692872322           -0.0186237741724153+0.01713619465975   | <b>9 FOE</b><br><b>C3/\$C</b><br>0.037434775<br>0.032307728<br>0.028224686<br>0.029421506<br>0.032067844<br>0.027365303<br>0.022838099<br>0.020931565<br>0.021221686<br>0.022576942<br>0.022576942<br>0.025307986   | <b>現代</b><br><b>3</b><br><b>3</b><br><b>3</b><br><b>4</b><br><b>3</b><br><b>5</b><br><b>5</b><br><b>5</b><br><b>5</b><br><b>5</b><br><b>5</b><br><b>5</b><br><b>5</b> | 63.8671875<br>64.0625<br>64.2578125<br>64.453125<br>64.6484375<br>65.0390625<br>65.234375<br>65.4296875<br>65.4296875<br>65.8203125<br>66.015625<br>66.2109375<br>66.40625<br>66.6015625<br>66.796875               |    |
| 403           404           330           331           332           333           334           335           336           337           338           339           340           341           342           343           344           345           346 | 2.477419<br>2.482581<br>1.687741935<br>1.692903226<br>1.698064516<br>1.703225806<br>1.708387097<br>1.713548387<br>1.718709677<br>1.723870968<br>1.729032258<br>1.734193548<br>1.739354839<br>1.744516129<br>1.749677419<br>1.75483871<br>1.76516129<br>1.770322581 | 3538<br>3547<br>3545<br>1775<br>1739<br>1726<br>1739<br>1746<br>1732<br>1757<br>1689<br>1737<br>1762<br>1775<br>1763<br>1814<br>1792<br>1749<br>1819<br>1808 | 120.05515<br>122.787009<br>122.174607<br>1.462944554<br>1.33703065<br>1.294275686<br>1.33703065<br>1.360634619<br>1.313836158<br>1.39857131<br>1.179925408<br>1.330362182<br>1.416163171<br>1.462944554<br>1.419708008<br>1.612766815<br>1.526459837<br>1.370877742<br>1.633052924<br>1.588755845 | 0.97775124         0           1.99501248         0           0.01191449         0.010889024           0.010540819         0.010540819           0.010540819         0.010889024           0.010889024         0.011081259           0.010700123         0.0117300222           0.00960953         0.010834714           0.011533493         0.01191449           0.011562363         0.01313467           0.01243177         0.011164681           0.013299884         0.01293912                              | 97775124 -0.1<br>99501248 0.4<br>0.01009304<br>0.010243464<br>0.010396131<br>0.010551072<br>0.010708323<br>0.010867917<br>0.01102989<br>0.01194278<br>0.011361115<br>0.011562363<br>0.01313467<br>0.01243177<br>0.011164681<br>0.01293912                  | 67         合成したスリ           51         合成したスリ           56         (合成したスリ           0.0         (合成した)           0.0         (合成した)           0.0         (合成した)           0.0         (合成した)           0.0         (白成した)           0.0         (日本)  | <b>9 FOE</b><br><b>C3/\$C</b><br>0.037434775<br>0.032307728<br>0.028224686<br>0.029421506<br>0.032067844<br>0.027365303<br>0.022838099<br>0.020931565<br>0.022838099<br>0.020931565<br>0.022576942<br>0.022576942<br>0.025307986<br>0.028742963   | <b>現代</b><br><b>3</b><br><b>3</b><br><b>3</b><br><b>3</b><br><b>3</b><br><b>3</b><br><b>3</b><br><b>3</b>   | 63.8671875<br>64.0625<br>64.2578125<br>64.453125<br>64.6484375<br>65.0390625<br>65.234375<br>65.4296875<br>65.4296875<br>65.8203125<br>66.015625<br>66.2109375<br>66.40625<br>66.6015625<br>66.796875<br>66.9921875 |    |

高速フーリエ変換によるMTF計算過程のワークシート



# トランケーションエラー (裁断エラー)

## 外挿 & 倍数露光法

#### トランケーションエラー

線像強度分布(LSF)は<u>無限の広がりを持つ</u>と考えら れるが、実験上の制約で<u>有限の範囲までしか求まらず</u>、 LSFの裾野部分が<u>欠如している</u>。 <u>裾野が大きく欠如したLSF</u>をフーリエ変換すると、振 動したMTFが計算される。このような誤差をトランケー ションエラーという。 光学伝達関数OTF(u)は、線像強度分布(LSF)のフーリエ変換と定義され次式となる。

$$OTF(u) = \int_{-\infty}^{\infty} LSF(x) e^{-i2\pi ux} dx$$

また、上式は、オイラーの公式より

$$A_1 - iA_2 = \left| OTF(u) \right| e^{-i\delta u}$$

$$A_1 = \int_{-\infty}^{\infty} LSF(x) \cos 2\pi u x dx$$

$$A_2 = \int_{-\infty}^{\infty} LSF(x) \sin 2\pi u x dx$$

となり、MTFはOTF(LSFのフーリエ変換)の絶対値であるため

$$MTF(u) = |OTF(u)| = \sqrt{A_1^2 + A_2^2}$$

と定義される。

#### DFT (Discrete Fourier Transform:離散フーリエ変換)

OTF 
$$(u) = \frac{1}{N} \sum_{n=0}^{N-1} LSF(n) e^{-inu(2\pi/N)}$$

$$a_{n} = \frac{1}{N} \sum_{n=0}^{N-1} LSF \quad (n) \cos \left(2 \pi un / N\right)$$
$$b_{n} = \frac{1}{N} \sum_{n=0}^{N-1} LSF \quad (n) \sin \left(2 \pi un / N\right)$$

MTF (u) = 
$$|OTF(u)| = \sqrt{a_n^2 + b_n^2}$$

#### 離散フーリエ変換によるMTF計算過程のワークシート

|     | A         | B     | C          | D           | E           | ] FPD F      | ER <sup>4</sup> G | H                 | I I          | J           | ĐE   |
|-----|-----------|-------|------------|-------------|-------------|--------------|-------------------|-------------------|--------------|-------------|------|
| 1   |           |       |            |             |             |              |                   |                   |              |             |      |
| 2   | x (距離mm)  | デジタル値 | 有効露光量      | LSF(正規化)    | 外層LSF       | DFT(COS)     | DFT(SIN)          | 周波数               | Σ(COS)       | Σ (SIN)     |      |
| 3   | 0         | 967   | 0.19406759 | 0.00158052  | 0.00002     | 0.00002      | 0                 | 10                | -0.127299018 | 0.02938841  |      |
| 4   | 0.005161  | 653   | 0.08851805 | 0.00072091  | 2.0392E-05  | 1.93286E-05  | 6.49754E-06       | SQRT(cos2X+sin2X) | 0.130647306  |             |      |
| 5   | 0.010323  | 1165  | 0.31836754 | 0.00259284  | 2.0791E-05  | 1.65689E-05  | 1.25588E-05       |                   |              |             |      |
| 6   | 0.015484  | 965   | 0.19309967 | 0.00157264  | 2.1198E-05  | 1.19326E-05  | 1.75201E-05       | 周波数               | MTF          | MTF正規化      |      |
| 7   | 0.020645  | 757   | 0.11480172 | 0.00093497  | 2.1613E-05  | 5.8402E-06   | 2.08086E-05       | 0                 | 60.07040383  | 1           |      |
| θ   | 0.025806  | 1057  | 0.24303525 | 0.00197932  | 2.2036E-05  | -1.11609E-06 | 2.20075E-05       | 0.5               | 49.0141983   | 0.815945876 |      |
| 9   | 0.030968  | 1057  | 0.24303525 | 0.00197932  | 2.2467E-05  | -8.22835E-06 | 2.09061E-05       | 1                 | 36.21182926  | 0.602823137 |      |
| 10  | 0.036129  | 246   | 0.03199906 | 0.00026061  | 2.2907E-05  | -1.47441E-05 | 1.75311E-05       | 1.5               | 25.32313834  | 0.421557651 | _    |
| 11  | 0.04129   | 1015  | 0.2188106  | 0.00178203  | 2.3355E-05  | -1.99446E-05 | 1.21527E-05       | 2                 | 17.19098503  | 0.286180614 | _    |
| 12  | 0.046452  | 1097  | 0.26659549 | 0.00218749  | 2.3813E-05  | -2.32232E-05 | 5.26516E-V6       | 2.5               | 7 069770594  | 0.195194075 | - 11 |
| 13  | 0.051613  | 1271  | 0.41497011 | 0.00337959  | 2.4279EF05  | -2.41542E-05 | -2.43024E-06      | ن<br>۲۵           |              | 0.132037104 | - 11 |
| 14  | 0.056774  | 1059  | 0.00003731 | 0.00049547  | 2.4754E-05  | -2.20404E-00 | -1.720275-05      | 3.0               | 3.497040390  | 0.091525265 | - 11 |
| 15  | 0.067097  | 1058  | 0.2430430  | 0.00196428  | 2.52596-05  | -1.0400E-05  | -2.26247E-05      | 4                 | 2.613802657  | 0.003204993 | - 11 |
| 10  | 0.007097  | 1210  | 0.10703332 | 0.00130037  | 2.5755E-05  | -4.4977E-06  | -2.20247E-03      | 4.0               | 1.807581571  | 0.04001051  | - 11 |
| 10  | 0.077419  | 756   | 0.11451508 | 0.000298787 | 2.675E-05   | 4.05069E-06  | -2.64415E-05      | 55                | 1 135615265  | 0.018904738 |      |
| 19  | 0.082581  | 1012  | 0.21717566 | 0.00176872  | 2 7274E-05  | 1 2505E-05   | -2 4238E-05       | 6                 | 0.656122622  | 0.010922561 |      |
| 20  | 0.087742  | 1058  | 0.2436436  | 0.00198428  | 2 7808E-05  | 1 99595E-05  | -1.93618E-05      | 65                | 0.316398485  | 0.005267128 |      |
| 21  | 0.092903  | 757   | 0.11480172 | 0.00093497  | 2.8352E-05  | 2.55797E-05  | -1.22274E-05      | 7                 | 0.070246007  | 0.001169395 |      |
| 22  | 0.098065  | 1013  | 0.21771927 | 0.00177315  | 2.8907E-05  | 2.86935E-05  | -3.50672E-06      | 7.5               | 0.047117587  | 0.000784373 |      |
| 23  | 0.103226  | 839   | 0.14092199 | 0.00114769  | 2.9473E-05  | 2.88695E-05  | 5.93284E-06       | 8                 | 0.120475113  | 0.002005565 |      |
| 24  | 0.108387  | 1055  | 0.24182311 | 0.00196945  | 3.005E-05   | 2.5973E-05   | 1.51127E-05       | 8.5               | 0.123447767  | 0.002055051 |      |
| 25  | 0.113548  | 964   | 0.19261753 | 0.00156871  | 3.0638E-05  | 2.01913E-05  | 2.30434E-05       | 9                 | 0.118381823  | 0.001970718 |      |
| 26  | 0.11871   | 1056  | 0.24242842 | 0.00197438  | 3.1238E-05  | 1.20273E-05  | 2.88296E-05       | 9.5               | 0.152785231  | 0.002543436 |      |
| 27  | 0.123871  | 1055  | 0.24182311 | 0.00196945  | 3.1849E-05  | 2.25747E-06  | 3.17692E-05       | 10                | 0.130647306  | 0.002174903 |      |
| 28  | 0.129032  | 962   | 0.19165684 | 0.00156089  | 3.2473E-05  | -8.13939E-06 | 3.14362E-05       |                   |              |             |      |
| 29  | 0.134194  | 837   | 0.14021914 | 0.00114197  | 3.3109E-05  | -1.80791E-05 | 2.77366E-05       |                   |              |             |      |
| 30  | 0.139355  | 755   | 0.11422915 | 0.0009303   | 3.3757E-05  | -2.64832E-05 | 2.09321E-05       |                   |              |             |      |
| 31  | 0.144516  | 755   | 0.11422915 | 0.0009303   | 3.4417E-05  | -3.23945E-05 | 1.16257E-05       |                   |              |             |      |
| 32  | 0 149677  | 1129  | 0.29096602 | 0.00236968  | 3 509 1E-05 | -3 5084E-05  | 7 11192E-07       |                   |              |             |      |
|     |           | 1125  |            |             |             | 0.000 12 00  |                   |                   |              |             | - 11 |
| 4en | 2 46 1935 | 3529  | 117 384072 | 0 95599748  | 0 95599748  | -0.699539262 | -0.651594971      |                   |              |             |      |
| 491 | 2.467097  | 3535  | 119 158105 | 0.97044553  | 0.97044553  | -0.462336184 | -0.853234895      |                   |              |             |      |
| 492 | 2.472258  | 3538  | 120.05515  | 0.07775124  | 0.07775124  | -0.167615811 | -0.963276918      |                   |              |             |      |
| 402 | 2.477410  | 7547  | 122 787000 | 1           | 1           | 0.151/07779  | -0.088469704      |                   |              |             |      |
| 485 | 2.477419  | 3347  | 122.707009 | 0.00501249  | 0.00501249  | 0.101427770  | -0.900400324      |                   |              |             |      |
| 484 | 2.402301  | 3343  | 122.174007 | 0.99301240  | 0.99501240  | 0.400212002  | -0.004202304      |                   |              |             |      |
| 465 | 2.487742  | 3541  | 120.958949 | 0.98511194  | 0.98511194  | 0.707087324  | -0.00591038       |                   |              |             |      |
| 959 | 4.934194  | 1053  | 0.24061701 | 0.00195963  | 7.1189E-05  | -3.88733E-05 | 5.96388E-05       |                   |              |             |      |
| 96D | 4.939355  | 1009  | 0.21555293 | 0.0017555   | 7.009E-05   | -5.49882E-05 | 4.34623E-05       |                   |              |             |      |
| 961 | 4,944516  | 498   | 0.06008177 | 0.00048932  | 6.9008E-05  | -6.49524E-05 | 2.331E-05         |                   |              |             |      |
| 962 | 4 949677  | 961   | 0 1911783  | 0.00155600  | 6 7943E-05  | -6 79293E-05 | 1.377E-06         |                   |              |             |      |
| 902 | 7.545077  | 501   | 0.1911700  | 0.00100099  | 0.19402-00  | 0.192900 00  | 1.0772-00         |                   |              |             |      |
| 963 |           |       |            |             |             |              |                   |                   |              |             | _    |

#### フーリエ変換の式

#### どんな複雑な波でも(周期がなくても) 単純な波に分解できる。

## 見る時間(距離)によってそれがどのくらい確か、かという不確定さまで含み込んでいる

全部わからな〈ても一部分だけ見れば全体の形を 捉えることができる

人間の捉え方と非常によく似ている。



その中の一部だけ見て全体の特徴を知る。



#### アナログにおける倍数露光と外挿

- 増感紙 フィルム系においてスリットのMTFを求める場合は、トランケーションエラーを起こさないように、倍数露光法を用いて低露光部と、高露光部のLSFを結合し、また指数関数で外挿を行ってきた。
- この理由は増感紙 フィルム系のもつダイナミックレン
   ジが狭いこと、特性曲線の足の部分(ベース濃度 + カブリ)
   により<u>低濃度部の露光量変換に信頼性がない</u>ためである。

#### 高露光部は低露光部の5倍露光をおこなう









Extrapolation of line spread function



#### デジタルの外挿

デジタルの場合も低露光部は量子化の誤差やグレアの
 影響もあり、
 外挿を行う方が望ましい?



|  |   |  |  |   | FPD   | HD&MTF(INNER)  |   |   |  | 巴日       |
|--|---|--|--|---|---|--|---|---|--|----------|
|  | A I   | в  | С  | D   | E   | F  | 0   | н   | 1  |          |
| 1                                      |   |  |  |   |   |  |   |   |  |          |
| 2 X                                    | 、(距離mm) F   | デジタル値  | 有効露光量  | LSF(正規化)  | 外挿 LSF  | 外挿LSF FFT  | 外挿LSF FFT絶対値  | MTF   | 空間周波数  |          |
| 3                                      | 0   | 967  | 0.19406759   | 0.001580522   | 0.00008   | 60.1286534329865   | 60.12865343   | 1   | 0  |          |
| 4                                      | 0.00516129  | 653  | 0.088518051  | 0.000720907   | 8.11923E-05   | -56.6331497628061-10.7078146423872i  | 57.63654178   | 0.95855368  | 0.1953125  | ;        |
| 5                                      | 0.010322581   | 1165   | 0.31836754   | 0.002592844   | 8.24024E-05   | 48.8733946337643+19.D964806667877i   | 52.47174742   | 0.87265795  | 0.390625   | ;        |
| 6                                      | 0.015483871   | 965  | 0.193099674  | 0.001572639   | 8.36305E-05   | -40.01316515108-24.998443128605i   | 47.18026224   | 0.78465523  | 0.5859375  | ;        |
| 7                                      | 0.020645161   | 757  | 0.114801724  | 0.000934966   | 8.48769E-05   | 31.0281794149598+28.6041756301296i   | 42.20126516   | 0.7018499   | 0.78125  | 5        |
| θ                                      | 0.025806452   | 1057   | 0.243035252  | 0.001979324   | 8.61419E-05   | -22.3824609440111-30.0780735546759i  | 37.49220008   | 0.62353301  | 0.9765625  | ;        |
| 9                                      | 0.030967742   | 1057   | 0.243035252  | 0.001979324   | 8.74257E-05   | 14.4749272348702+29.679117159962i  | 33.02080426   | 0.5491692   | 1.171875   | ;        |
| 10                                     | 0.036129032   | 246  | 0.031999059  | 0.000260606   | 8.87287E-05   | -7.64554935170776-27.8271619880098i  | 28.8583674  | 0.47994368  | 3 1.3671875  | 5        |
| 11                                     | 0.041290323   | 1015   | 0.218810597  | 0.001782034   | 9.00511E-05   | 2.06775595705D12+24.9753927D4035i  | 25.06084307   | 0.41678703  | 3 1.5625   | 5        |
| 12                                     | 0.046451613   | 1097   | 0.268595492  | 0.002187491   | 9.13932E-05   | 2.22567343160345-21.5666323545605i   | 21.68117279   | 0.36057972  | 1.7578125  | 5        |
| 13                                     | 0.051612903   | 1271   | 0.414970113  | 0.003379593   | 9.27553E-05   |  |   |   | 1  |          |
| 14                                     | 0.056774194   | 503  | 0.060837508  | 0.000495472   | 9.41377E-05   | 7.37231 1日本1月本17   | 「们を田」   | いたの   | 、沽   |          |
| 15                                     | 0.061935484   | 1058   | 0.2436436  | 0.001984278   | 9.55407E-05   |  |   | v 1/2/1   | ·J#  |          |
| 16                                     | 0.067096774   | 907  | 0.167035523  | 0.001360368   | 9.69646E-05   | $9.01356$ 0 $\pm$ 1 0 $\wedge$ ( $r$   |   | $( \circ \circ$ |  | • •      |
| 17                                     | 0.072258065   | 1219   | 0.36438336   | 0.002967605   | 9.84098E-05   | $= \mathbf{A}^{\star} \mathbf{I} \mathbf{U}^{\prime} \mathbf{U}^{\prime} \mathbf{U}^{\prime}$  | ))^EXP(   | <b>Z.86</b> 6   | 53*A3  | 5)       |
| 18                                     | 0.077419355   | 756  | 0.114515078  | 0.000932632   | 9.98764E-05   | 8.46315  | <u> </u>  | <u></u>   | <u> </u>   |          |
| 19                                     | 0.082580645   | 1012   | 0.217175656  | 0.001768719   | 0.000101365   |  | 7VD( 2 (  | 1267*   | 1627   | `\       |
| 20                                     | 0.087741935   | 1058   | 0.2436436  | 0.001984278   | 0.000102876   | <u>6.78∎ =213.94 L</u>   | LAF (-J.(   | JJU/  | AUSI   | <u> </u> |
| 2401                                   | 0293903376  | - 353  | - 0.113801734  | 0.010000333944  |   | <del>152313</del>  |   |   |  | _        |
| 482                                    | 2.472258  | 3538   | 120.05515  | 0.97775124 (  | .97775124 -0.   | 67615811 -0.963276918  |   |   |  |          |
| 463                                    | 2.477419  | 3547   | 122.787009   | 1   | 1 0.  | 51427778 -0.988468324  |   |   |  |          |
| 484                                    | 2.482581  | 3545   | 122.174607   | 0.99501248  | .99501248 0.  | 156212682 -0.884262304   |   |   |  |          |
| 330                                    | 1.687741935   | 1775   | 1.462944554  | 0.01191449  | 0.01009304  | -0.0590086578883302+0.0060757560402  | 5 0.059320625   | 0.00098656  | 63.8671875   |          |
| 331                                    | 1.692903226   | 1739   | 1.33703065   | 0.010889024   | 0.010243464   | 0.0519370006127505-0.00606503042175  | 9 0.052289929   | 0.00086963  | 64.0625  |          |
| 332                                    | 1.698064516   | 1726   | 1.294275686  | 0.010540819   | 0.010396131   | -0.0420986208806332+0.0101979916676  | 1 0.043316197   | 0.00072039  | 64.2578125   |          |
| 333                                    | 1.703225806   | 1739   | 1.33703065   | 0.010889024   | 0.010551072   | 0.0353146423950696-0.01241670604725  | 2 0.037434775   | 0.00062258  | 64.453125  |          |
| 334                                    | 1.708387097   | 1746   | 1.360634619  | 0.011081259   | 0.010708323   | -0.0315932667546264+0.0067568341190  | 9 0.032307728   | 0.00053731  | 64.6484375   |          |
| 335                                    | 1.713548387   | 1732   | 1.313836158  | 0.010700123   | 0.010867917   | 0.0274331366692502+0.00663746285168  | e 0.028224686   | 0.0004694   | 64.84375   |          |
| 336                                    | 1.718709677   | 1757   | 1.39857131   | 0.011390222   | 0.01102989  | -0.0198424249281888-0.02172333333500   | 0.029421506   | 0.00048931  | 65.0390625   |          |
| 337                                    | 1.723870968   | 1689   | 1.179925408  | 0.00960953  | 0.011194278   | 0.0104579494541485+0.03102887974934  | 7 0.032743856   | 0.00054456  | 65.234375  |          |
| 338                                    | 1.729032258   | 1737   | 1.330362182  | 0.010834714   | 0.011361115   | -0.0031+759694660664-0.0319129947039   | 0.032067844   | 0.00053332  | 65.4296875   |          |
| 339                                    | 1.734193548   | 1762   | 1.416163171  | 0.011533493   | 0.011533493   | 0.000563790818395258+D.D27359494568  | + 0.027365303   | 0.00045511  | 65.625   |          |
| 34D                                    | 1.739354839   | 1775   | 1.462944554  | 0.01191449  | 0.01191449  | -0.000721868785569D22-0.022826687760   | 0.022838099   | 0.00037982  | 65.8203125   |          |
| 341                                    | 1.744516129   | 1763   | 1.419708008  | 0.011562363   | 0.011562363   | -0.0002565557547+9515+0.02092999276  | 0.020931565   | 0.00034811  | 66.015625  |          |
| 342                                    | 1.749677419   | 1814   | 1.612766815  | 0.01313467  | 0.01313467  | 0.00465972237012629-0.0206577603523  | 6 0.021221686   | 0.00035294  | 66.2109375   |          |
| 343                                    | 1.75483871  | 1792   | 1.526459837  | 0.01243177  | 0.01243177  | -0.0112218493262047+0.0195905183774  | 3 0.022576942   | 0.00037548  | 66.40625   |          |
| 344                                    | 1.76  | 1749   | 1.370877742  | 0.011164681   | 0.011164681   | 0.0162136736888543-0.01774969287232  | 2 0.024040275   | 0.00039981  | 66.6015625   |          |
| 345                                    | 1.76516129  | 1819   | 1.633052924  | 0.013299884   | 0.013299884   | -0.0166237741724153+0.0171361946597  | 5 0.025307986   | 0.0004209   | 66.796875  |          |
| 346                                    | 1.770322581   | 1808   | 1.588755845  | 0.01293912  | 0.01293912  | 0.0215104352157304-0.01906460296099  | 0.028742963   | 0.00047802  | 66.9921875   |          |
| 347                                    | 1.775483871   | 1801   | 1.561194483  | 0.012714655   | 0.012714633   | -0.0282667857583252+0.0209346385685  | 6 0.035174853   | 0.00058499  | 67.1875  |          |
| 34D<br>341<br>342<br>343<br>344<br>345 | 1.739354839<br>1.744516129<br>1.749677419<br>1.75483871<br>1.76<br>1.76516129 | 1775<br>1763<br>1814<br>1792<br>1749<br>1819 | 1.462944554<br>1.419708008<br>1.612766815<br>1.526459837<br>1.370877742<br>1.633052924 | 0.01191449<br>0.011562363<br>0.01313467<br>0.01243177<br>0.011164681<br>0.013299884 | 0.01191449<br>0.011562363<br>0.01313467<br>0.01243177<br>0.011164681<br>0.013299884 | -0.000721868785569022-0.022826687760<br>-0.0002565555754749515+0.02092999276<br>0.00465972237012829-0.0206577603523<br>-0.0112218493262047+0.0195905183774<br>0.0162136736886543-0.01774969287232<br>-0.0186237741724153+0.0171361946597 | 0.022838099<br>0.022838099<br>0.020931565<br>0.021221686<br>0.022576942<br>0.024040275<br>5 0.025307986 | 0.00037982<br>0.00034811<br>0.00035294<br>0.00037548<br>0.00039981<br>0.00039981                                      | 65.8203125<br>66.015625<br>66.2109375<br>66.40625<br>66.6015625<br>66.796875 |          |

高速フーリエ変換によるMTF計算過程のワークシート



距離(mm)

#### メニュー「ツール」「分析ツール」「フーリエ解析」

|    |   |            |               |             | 🗐 FPD I       | HD&MTF(INNER)                        |
|----|---|------------|---------------|-------------|---------------|--------------------------------------|
|    | ٨                                       | B          | С             | D           | Е             | F                                    |
| 1  |   |            |               |             |               |                                      |
| 2  | x(距離mm)                                 | デジタル値      | 有効露光量         | LSF(正規化)    | 外挿 LSF        | 外挿LSF FFT                            |
| 3  | 0                                       | 967        | 0.19406759    | 0.001580522 | 0.00008       | 60.1286534329865                     |
| 4  |   |            | フー            | リエ解析        |               | 8061-10.7078146423872i               |
| 5  |   |            |               |             |               | 643+19.D964806667877i                |
| 6  | 入力元                                     |            |               |             |               | 08-24.998443128805i                  |
| 7  | 1 - 5 - 5 - 5 - 5 - 5 - 5 - 5 - 5 - 5 - |            | \$F\$ Z.\$F   | \$1026      |               | OK 598+28.6041756301296i             |
| 8  |   |            |               | \$1020      |               | 0111-30.                             |
| 9  | - 日 先頭行                                 | うをラベルと(    | して使用          |             | ( <b>*</b> *) | ンセル 1702+29.6 77771 59962i           |
| 10 |   |            |               |             |               | 0776-27.8271619880098i               |
| 11 | <u>щ та т</u> а                         | s s.       |               |             |               | ルブ iD12+24.9758927D4635i             |
| 12 |   | / # /<br>F | \$F \$ Z. \$F | \$1026      | 150           | 345-21.5666323545605i                |
| 13 | ● ±719                                  | ъ          |               | \$1020      |               | 7394+17.9459277635335i               |
| 14 | 🔷 新規す                                   | または次のシー    | - ト           |             |               | 004-14.3709967920502i                |
| 15 | ○ 新祖-                                   | ブッ・ク       |               |             |               | 3186+11.0821180197487i               |
| 16 |   |            |               |             |               | 524-8.01773728 <del>9</del> 92845i   |
| 17 |   | 2          |               |             |               | 0325+5.38721364721847i               |
| 10 |   |            |               |             |               | :571-3.16742267673512i               |
| 19 |   | 1012       | 0.211110000   | 0.001100117 | 0.000101000   |                                      |
| 20 | 0.087741935                             | 1058       | 0.2436436     | 0.001984278 | 0.000102876   | 6.78583D24886539+0.0820787868859564i |

#### FFTは2のべき乗 ! 512, 1024, 2048, · · · · · ·

|     |                  |            |                 |                   | FPD 💼          | HD&MTF(INNER)                           |                            |              |              | DE |
|-----|------------------|------------|-----------------|-------------------|----------------|---|----------------------------|--------------|--------------|----|
|     | *                | В          | C               | D                 | E              | F                                       | θ                          | Н            | 1            | _  |
|     | x (95 \$\$ mana) | ディジカロノは    | 右孙露头星           | 19月(正相化)          | が増工CF          | 約 /編 I CE FET                           | ALE SE FETSAN              | мте          | <u>你問題选数</u> |    |
| 7   |                  | 947<br>947 | 19404759        | 0.001590522       | 0.00009        | 7M#L31111                               | 20 129457/Z                | 1            | 王间问(30,67    |    |
|     | 0.00516129       | 257        | 0.099519051     | 0.001380322       | 0.00000        | EL 177140700001-10 70701444070701       | 57 47454170                | 0.05855268   | 0 1957125    |    |
|     | 0.00310129       | 1145       | 0 21026754      | 0.000720907       | 9.240245-05    | 49 9777946777647419 0964905667977       | 52 47174740                | 0.87265795   | 0.1933123    |    |
|     | 0.015402071      | 945        | 0.31030734      | 0.002372844       | 0 747055-05    | 40.01710515106-34.099447139005          | 47 10026224                | 0.78465523   | 0.5959775    |    |
| 7   | 0.020645161      | 763        | 0.133033874     | 0.001372839       | 0.30303E-03    | 71 0301 704 140500 400 5041 751 70 1304 | 42 20126516                | 0.7018/05    | 0.3639373    |    |
|     | 0.025806452      | 1057       | 0.114801724     | 0.000934988       | 0.407092-03    | 1 4609440111-30 0780735544759;          | 42.20120318<br>37.49220008 | 0.62353301   | 0.76125      |    |
|     | 0.020067742      | 1057       |                 | $Z(z_{1}) = $     | <b>OTE</b> (   |   | 37.49220000                | 0.5491692    | 1 171975     |    |
| 10  | 0.036129032      | 246        | - <u>IVII</u>   | (u) =             |                |   | 29 9597474                 | 0.3431032    | 1 7671975    |    |
| 11  | 0.04129032       | 1015       |                 |                   |                | 595705012+24 975392704935               | 25.06084307                | 0.41678703   | 1.5625       |    |
| 12  | 0.046451613      | 10 -       |                 |                   |                | 7343160345-21 5666323545605             | 21.68117278                | 0.36057972   | 1 7578125    |    |
| 13  | 0.051612903      | 12         | - 夕  ( 夜見       | 玄羽)(              | つ約2寸化          |   | 18 7190087                 | 031131594    | 1 953125     |    |
| 14  | 0.056774194      | . 2        | <b>X</b> I / IX | ~~~ / ~~ / V      |                | 1365041884-14 3789967920502;            | 16 15879195                | 0.26873697   | 2,1484375    |    |
| 15  | 0.061935484      | 10:        |                 | C (E2)            | )              | 48872443188+11.0321130197487i           | 13 9546728                 | 0.23208025   | 2 34375      |    |
| 16  | 0.067096774      | 9(         |                 | <u>50 ( F3</u>    |                | 8220637524-8 01 773728992845i           | 12.0635308                 | 0.20062865   | 2 5390625    |    |
| 17  | 0.072258065      | 1219       | 0.36438336      | 0.002967605       | 9.84098E-05    | -8.93888183790325+5.38721364721847i     | 10.43674659                | 0.1735736    | 2,734375     |    |
| 18  | 0.077419355      | 756        | 0.114515078     | 0.000932632       | 9.98764E-05    | 8.46315431812571-3.16742267673512i      | 9.036456575                | 0.15028536   | 2.9296875    |    |
| 19  | 0.082580645      | 1012       | 0.217175656     | 0.001768719       | 0.000101365    | -7.71137674163593+1.34964635933689i     | 7.82859352                 | 0.13019739   | 3.125        |    |
| 20  | 0.087741935      | 1          | •               |                   |                | +0.0820787868859564                     | 6.786326627                | 0.11286344   | 3.3203125    |    |
| 24  | 0.092907226      | _ +        | ブロ国ミ            | 古教でコ              | <b>ニキヨイン</b> ( |   | 5 0077705/5                | 0.00701055   | Z 515625     |    |
| 330 | 1.687741935      | T L        | 느니/밋//          |                   | レベロし           | 302+0.0060757560+02                     | 0.059320625                | 0.00098656   | 63.8671875   |    |
| 331 | 1.692903226      | 1          |                 | ር ው ሲ             |                | 0                                       |                            | 0.00086963   | 64.0625      |    |
| 332 | 1.698064516      | 1'         | = (3/2)         | <b>G</b> 33       |                | 332+0.0101979916676                     | 0.043316197                | 0.00072039   | 64.2578125   |    |
| 333 | 1.703225806      | 1          |                 |                   |                | 98-0.01241870804725                     | 0.037434775                | 0.00062258   | 64.453125    |    |
| 334 | 1.708387097      | 1746       | 1.360634619     | 0.011081259       | 0.010708323    | -0.0315932667546264+0.0067568341190     | 0.032307728                | 0.00053731   | 64.6484375   | _  |
| 335 | 1.710348087      | 1752       | 1 70057171      | 0.010700128       | 0.010867917    | 0.027433136669290240.00665746269168     | 0.02822468                 | 0.0004694    | 64.84873     |    |
| 337 | 1.73             | 1131       | 1.37037131      | 0.011390222       | 0.01102989     | 0.01.00424249201000-0.02172000000       | 0.02742130                 | 0.00040351   | 65 234375    |    |
| 338 | 1.72             |            |                 |                   | h 📥 👘          |   |                            | 0.00053332   | 65,4296875   | -  |
| 339 | 1.73             | 司向)        | 反致に、            | ッナリカ              | や正             |   |                            | 0.00045511   | 65.625       |    |
| 34D | 1.73             |            |                 | 0                 |                |   |                            | 0.00037982   | 65.8203125   |    |
| 341 | 1.74             | 51日15      | 乳活教を            | ~ッチ =             |                |   |                            | 0.00034811   | 66.015625    |    |
| 342 | 1.74             |            | J WX XV r       | - / /             |                | _                                       |                            | 0.00035294   | 66.2109375   |    |
| 343 | 1.5              | 1          |                 | エに広っ              | 、たると           | ケッチキャノプロトノノ                             | ず門四口                       | 0.00037548   | 66.40625     |    |
| 344 |                  |            | <u>- (</u> [    | 「又」」              | ノに回奴           | ミス ワノ ノリノン                              | /旧リア田)                     | 0.0005990    | 66.6015625   |    |
| 345 | 1.7              |            |                 |                   | 004040         |   | -                          | 0.0004209    | 66.796875    |    |
| 346 | 1.77             | = 1        | / (1()2         | 24 <u>~ ().()</u> | 051612         | (9)                                     |                            | 0.00047802   | 66.9921875   |    |
| 347 | 1.75             |            |                 |                   |                |   |                            | 0.00058499   | 67.1875      |    |
|     |                  |            |                 |                   |                |   |                            | • <u>,</u> L |              |    |
|     |                  | 百述         | ノーリ-            | レダ探い              | 「トウマ           | 「「訂昇迴住の                                 | ハノークン                      |              |              |    |



空間周波数 (cycles/mm)

プリサンプリング MTF

# FFTにおける計算個数の違いによるMTFの比較 1024点 512点



空間周波数 (cycles/mm)

空間周波数 (cycles/mm)

#### 倍数露光法はデジタルに必要?

## シーメンス FPD (12bit) 距離 180cm

### 通常露光 120kV 10mAs 倍数露光 120kV 100mAs







#### MTFの 電 圧 依 存 性

## 水平方向、垂直方向のMTF

#### ST-V(100µ)の各管電圧におけるPre-sampling MTF



#### GE FPD のMTF 水平方向 & 垂直方向



Spatial Frequency(cycles/mm)



## **Digital Wiener Spectrum**

不規則現象の統計的な解析方法の一つに、パワースペクトル密度関数がある。画像の世界では、これをウイナースペクトルとよんでいる。



- FPDに一様露光(4.15 µ Gy)したデジタル画像データから 256 × 256の関心領域を抽出し、ピクセル値をデジタル 特性曲線により照射線量に変換した。
- 高さ3mmの仮想スリットを定義し、15ピクセル間隔で 走査を行い、合計300本の走査データを得た。
- 各走査データに対してトレンド処理を行い、照射線量のゆらぎに対して照射線量の平均値で除した後、高速フーリエ変換(FFT)し、デジタルWSを求めた。

|      |     |     |      |     |     |     |      |     |     |     |     |     |     |      |     |     |     |      |     |     |      |      | _    |      |     |     |     | -   |     |      |     |     |     |     |     |      |     |     |     |      |     | EB         |
|------|-----|-----|------|-----|-----|-----|------|-----|-----|-----|-----|-----|-----|------|-----|-----|-----|------|-----|-----|------|------|------|------|-----|-----|-----|-----|-----|------|-----|-----|-----|-----|-----|------|-----|-----|-----|------|-----|------------|
|      | A   | 8   | C    | Þ   | £   | F   | G    | н   | 1   | J   | K   | L   | M   | 14   | 0   | P   | 0   | R    | 5   | T   | 9.1  | ¥    | W    | ×    | Y   | Z   | 44  | AB  | AC  | 40   | 12  | NF  | AG  | AH  | AI. | AJ.  | łK. | NL  | AM. | AN I | 40  | AP         |
| 1    | 84  | 84  | 83   | 83  | 83  | 34  | 84   | 84  | 84  | 85  | 85  | 35  | 85  | 85   | 84  | 84  | 84  | 34   | 84  | B75 | 84   | 83   | 83   | 84   | 85  | 85  | 85  | 86  | 85  | 84   | 84  | 84  | 84  | 85  | 85  | 85   | Bő  | 84  | 84  | 86   | 86  | 85         |
| 2    | 84  | B4  | 84   | 84  | 83  | 84  | 85   | 83  | 83  | 84  | 25  | 86  | 86  | B4   | 84  | 84  | 84  | 85   | 84  | B4  | 84   | 84   | 84   | 84   | 84  | B4  | 85  | 85  | 85  | 85   | 84  | 84  | 85  | 86  | 85  | 83   | BS  | 84  | 83  | 85   | 85  | 84         |
| 3    | 85  | B4  | 83   | 83  | 83  | 84  | 85   | B4  | 85  | 85  | 5   | 84  | 85  | B4   | 83  | 84  | 84  | 84   | 84  | 85  | 85   | 84   | 84   | 84   | 83  | 83  | 85  | 86  | 85  | 85   | 84  | 84  | 85  | 84  | 84  | 84   | B4  | 84  | 84  | 84   | 83  | 84         |
| 4    | 84  | B4  | 83   | 84  | 85  | 84  | 84   | 85  | 84  | 85  | 5   | 82  | 83  | B4   | 83  | 83  | 84  | 84   | 85  | 84  | 83   | 84   | 85   | 84   | 84  | 85  | 84  | 85  | 84  | 84   | 84  | 85  | 84  | 83  | 84  | 85   | 85  | 85  | 84  | 85   | 85  | - 4        |
| 5    | 84  | 8.5 | 85   | 85  | 84  | 84  | 85   | 85  | 85  | 85  | 4   | 84  | 84  | 64   | 84  | 84  | 84  | 85   | 85  | 8.5 | 85   | 84   | 84   | 85   | 85  | 84  | 85  | 85  | 84  | 84   | 64  | 84  | 85  | 84  | 83  | 84   | 64  | 84  | 84  | 84   | 84  | - 4        |
| 6    | 84  | 84  | 85   | 85  | 84  | 85  | 85   | 84  | 84  | 84  | - 3 | 84  | 86  | 85   | 84  | 86  | 85  | 84   | 85  | 84  | 84   | 85   | 84   | 84   | 84  | 84  | 84  | 85  | 85  | 84   | 84  | 84  | 83  | 85  | 84  | 83   | 84  | 84  | 82  | 84   | 85  | -4         |
| 7    | 85  | 84  | 84   | 84  | 84  | 84  | 85   | 83  | 83  | 85  | 4   | 83  | 85  | 85   | 84  | 85  | 86  | 85   | 85  | 84  | 84   | 85   | 85   | 84   | 84  | 84  | 83  | 84  | 83  | 84   | 85  | 85  | 85  | 85  | 84  | 84   | 84  | 84  | 83  | 84   | 85  | -9         |
| 8    | 85  | B4  | 83   | 83  | 84  | 83  | 84   | B4  | 85  | 85  | 4   | 84  | 85  | B4   | 85  | 84  | 83  | 84   | 85  | 85  | 85   | 85   | 85   | 85   | 84  | 84  | 84  | 84  | 84  | 84   | 83  | 85  | 86  | 86  | 86  | 85   | 83  | 84  | 84  | 84   | 84  | 84         |
| 9    | 83  | B4  | 84   | 83  | 83  | 83  | 84   | BS  | 85  | 85  | 4   | 85  | 85  | B4   | 85  | 85  | 84  | 85   | 85  | 85  | 84   | 84   | 85   | 85   | 85  | B4  | 84  | 84  | 85  | 85   | 85  | 85  | 84  | 85  | 86  | 84   | B4  | 84  | 85  | 84   | 84  | 84         |
| 10   | 83  | B3  | 84   | 84  | 84  | 85  | 84   | B4  | 84  | 85  | 4   | 84  | 85  | B4   | 84  | 85  | 85  | 83   | 84  | B4  | 83   | 84   | 85   | 85   | 85  | 85  | 85  | 85  | 85  | 86   | 85  | 84  | 85  | 86  | 84  | 83   | B4  | 85  | 85  | 83   | 82  | 88         |
| 11   | 84  | 8-5 | 83   | 84  | 84  | 84  | 84   | 84  | 84  | 84  | 4   | 84  | 84  | 8.2  | 84  | 85  | 86  | 85   | 85  | 84  | 84   | 85   | 84   | 84   | 85  | 84  | 84  | 85  | 85  | 85   | 84  | 8.5 | 84  | 84  | 84  | 84   | 84  | 84  | 85  | 84   | 84  | 65         |
| 12   | 85  | 8-5 | 84   | 85  | 85  | 86  | 85   | 64  | 64  | 84  | 15  | 84  | 64  | 64   | 85  | 85  | 84  | 85   | 65  | 64  | 85   | 85   | 84   | 84   | 85  | 84  | 84  | 85  | 85  | 85   | 65  | 84  | 84  | 85  | 84  | 84   | 65  | 05  | 84  | 85   | 85  | 22         |
| 13   | 84  | 85  | 85   | 84  | 84  | 84  | 84   | 84  | 84  | 83  |     | 84  | 85  | 85   | 85  | 84  | 84  | 85   | 84  | 85  | 84   | 84   | 85   | 84   | 85  | 85  | 85  | 85  | 85  | 84   | 85  | 84  | 85  | 86  | 85  | 84   | 84  | 84  | 84  | 85   | 85  | -1         |
| 14   | 84  | 85  | 85   | 84  | 84  | 36  | 86   | 84  | 85  | 84  | 84  | 84  | 84  | 84   | 84  | 84  | 85  | 85   | 84  | 84  | 85   | 84   | 84   | 84   | 84  | 84  | 84  | 84  | 85  | 84   | 85  | 85  | 84  | 85  | 84  | 83   | 83  | 85  | 83  | 83   | 85  | 8 <b>9</b> |
| 15   | 85  | B6  | 85   | 84  | 87  | 86  | 85   | BS  | 83  | 84  | 84  | 84  | 84  | 83   | 83  | 84  | 85  | 85   | 84  | 84  | 85   | 85   | 84   | 84   | 83  | 83  | 84  | 85  | 85  | 84   | 84  | 84  | 86  | 85  | 84  | 84   | B4  | 84  | 84  | 84   | 85  | -1         |
| 16   | 85  | BS  | 83   | 83  | 86  | 86  | 83   | B4  | 85  | 84  | 83  | 84  | 84  | B4   | 84  | 85  | 85  | 84   | 85  | B4  | 85   | 84   | 83   | 83   | 84  | 85  | 85  | 85  | 86  | 85   | 84  | 84  | 84  | 84  | 85  | 84   | B4  | 85  | 84  | 84   | 85  | 84         |
| 17   | 84  | B/2 | 83   | 85  | 85  | 84  | 84   | B4  | 84  | 84  | 83  | 85  | 85  | 83   | 83  | 84  | 85  | 84   | 83  | B4  | 83   | 83   | 84   | 85   | 85  | B6  | 85  | 84  | 85  | 85   | B4  | B4  | 84  | 84  | 86  | 85   | BS  | 85  | 84  | 83   | 84  | -9         |
| 18   | 83  | 82  | 84   | 84  | 84  | 84  | 84   | 84  | 85  | 85  | 82  | 82  | 84  | 84   | 85  | 83  | 85  | 84   | 8.5 | 84  | 84   | 85   | 85   | 84   | 64  | 84  | 84  | 84  | 84  | 84   | 84  | 85  | 84  | 84  | 85  | 85   | 85  | 84  | 85  | 82   | 84  |            |
| 19   | 04  | 04  | 04   | 05  | 04  | 03  | 0.5  | 04  | 04  | 85  | 05  | 04  | 04  | 04   | 04  | 85  | 83  | 05   | 00  | 0.0 | 05   | 05   | 85   | 03   | 0.5 | 0.5 | 04  | 04  | 04  | 03   | 04  | 05  | 05  | 85  | 04  | 00   | 0.0 | 04  | 04  | 04   | 83  | -31        |
| 20   | 84  | 64  | 84   | 85  | 85  | 85  | 84   | 64  | 85  | 84  | 85  | 84  | 52  | 62   | 85  | 85  | 28  | 85   | 84  | 6.5 | 85   | 85   | 84   | 85   | 85  | 85  | 85  | 85  | 86  | - 84 | 85  | 64  | 84  | 84  | 86  | - 64 | 64  | 84  | 84  | 84   | 28  | 3 II       |
| 21   | 82  | 64  | 85   | 85  | 85  | 84  | 84   | 64  | 84  | 84  | 85  | 85  | 85  | 8.5  | 84  | 84  | 85  | 85   | 84  | 8.5 | 84   | 84   | 84   | 84   | 64  | 84  | 85  | 85  | 85  | 84   | 85  | 85  | 84  | 84  | 85  | 85   | 64  | 84  | 85  | 84   | 85  | -          |
| 22   | 85  | 8.5 | 85   | 85  | 85  | 85  | 82   | 83  | 84  | 84  | 85  | 84  | 85  | 84   | 85  | 85  | 84  | 84   | 84  | 84  | 84   | 85   | 84   | 84   | 85  | 84  | 84  | 85  | 85  | 84   | 85  | 85  | 84  | 84  | 85  | 85   | 84  | 84  | 84  | 84   | 85  |            |
| 23   | 85  | 8.5 | 85   | 85  | 84  | 84  | 89   | 84  | 84  | 84  | 84  | 85  | 89  | 85   | 84  | 84  | 85  | 85   | 84  | 85  | 84   | 85   | 85   | 85   | 56  | 85  | 84  | 84  | 34  | 84   | 89  | 84  | 84  | 84  | 85  | 86   | 64  | 82  | 85  | 85   | 85  | -          |
| 24   | 09  | 6.5 | 85   | 04  | 80  | 84  | 85   | 04  | 05  | 85  | 85  | 85  | 05  | 84   | 05  | 04  | 04  | 85   | 84  | 83  | 05   | 85   | 85   | 85   | 00  | 04  | 85  | 04  | 85  | 84   | 6.3 | 04  | 04  | 85  | 85  | 89   | 89  | 04  | 85  | 04   | 85  |            |
| 20   | 00  | 0.0 | 0.0  | 04  | 04  | 04  | 09   | 0.0 | 04  | 0.5 | 05  | 00  | 00  | 04   | 05  | 04  | 0.5 | 0.9  | 04  | 04  | 05   | 05   | 86   | 00   | 00  | 04  | 04  | 04  | 05  | 00   | 00  | 04  | 05  | 05  | 92  | 02   | 0.0 | 0.5 | 85  | 04   | 04  | -3         |
| 20   | 04  | 04  | 0.4  | 04  | 0.4 | 00  | 0.0  | 04  | 00  | 05  | 96  | 0.4 | 00  | 00   | 04  | 09  | 00  | 00   | 00  | 00  | 00   | 00   | 95   | 00   | 0.0 | 04  | 0.4 | 05  | 0.4 | 00   | 04  | 0.4 | 02  | 05  | 94  | 00   | 0.0 | 0.0 | 0.4 | 92   | 00  | 3 I I      |
| 27   | 00  | 0.4 | 04   | 04  | 09  | 03  | 04   | 0.4 | 04  | 04  | 00  | 0.4 | 00  | 0.0  | 00  | 00  | 95  | 00   | 00  | 0.1 | 04   | 00   | 00   |      | 04  | 04  | 04  | 05  | 95  | 0.0  | 0.4 | 0.3 | 00  | 00  | 00  | 00   | 04  | 04  | 04  | 0.5  | 0.6 | - C        |
| 20   | 00  | 04  | 04   | 04  | 04  | 04  | 04   | 04  | 05  | 04  | 94  | 00  | 0.4 | 04   | 0.1 | 05  | 95  | 04   | 0.4 | 0.4 | 0.5  | 95   | 95   | 04   | 04  | 03  | 00  | 05  | 00  | 04   | 04  | 0.4 | 04  | 96  | 95  | 00   | 00  | 04  | 04  | 95   | 95  | - C        |
| 30   | 00  | D:3 | 0.2  | 04  | 94  | 94  | 84   | D/G | 00  | 04  | 94  | 97  | 0.4 | 0.3  | 04  | 0.0 | 95  | 90   | 84  | D-4 | 04   | 03   | 94   | 0.4  | 84  | 0.3 | 00  | 95  | 96  | 04   | 8.4 | 0.4 | 00  | 96  | 96  | 00   | D.3 | 0.2 | 0.0 | 95   | 95  |            |
| 31   | 00  | 0.4 | 04   | 04  | 04  | 0.4 | 074  | 03  | 0.0 | 04  | 94  | 86  | 84  | 03   | 02  | 04  | 35  | 00   | 0.4 | 84  | 04   | 04   | 94   | 074  | 04  | 04  | 05  | 0.0 | 90  | 00   | 014 | 0.2 | 0.0 | 00  | 00  | 00   | 04  | 84  | 04  | 00   | 30  | 10         |
| 32   | 85  | 84  | 8.8  | 84  | 04  | 85  | 84   | 0.0 | 84  | 83  | 84  | 30  | 84  | 64   | 84  | 84  | 84  | 82   | 82  | 84  | 85   | 84   | 85   | 85   | 85  | 03  | 84  | 84  | 00  | 84   | 84  | 84  | 84  | 84  | 04  | 85   | 84  | 84  | 04  | 85   | 35  |            |
| 88   | 84  | 84  | 84   | 88  | 34  | 88  | 85   | 65  | 84  | 88  | 94  | 88  | 84  | 85   | 84  | 85  | 84  | 32   | 88  | 84  | 84   | 84   | 85   | 84   | 84  | 84  | 88  | 84  | 35  | 84   | 85  | 84  | 88  | 88  | 84  | 84   | 84  | 84  | 85  | 84   | 85  |            |
| 3.4  | 25  | 85  | 85   | 84  | 94  | 90  | 85   | 86  | 84  | 83  | 94  | 93  | 86  | 87   | 84  | 84  | 94  | 94   | 84  | 84  | 84   | 94   | 95   | 95   | 85  | 84  | 84  | 95  | 95  | 95   | 85  | 83  | 83  | 94  | 96  | 35   | 84  | 85  | 95  | 94   | 84  | 10         |
| 35   | 84  | 85  | 84   | 83  | 85  | 95  | 84   | 85  | 85  | 95  | 86  | 94  | 84  | 86   | 85  | 85  | 85  | 94   | 83  | Rd. | 85   | 94   | 35   | 26   | 85  | Rd. | 84  | 95  | 84  | 90   | Rd  | 87  | 83  | 95  | 94  | 84   | Rd. | 86  | 95  | 94   | 36  | 12         |
| 3.6  | 84  | Rd  | 83   | 83  | 83  | 85  | 85   | Bd  | 84  | 85  | 84  | 84  | 84  | Rd   | 85  | 85  | 84  | 93   | 83  | 85  | 86   | 85   | 84   | 25   | 86  | Bd  | 87  | 84  | 84  | 93   | Rd  | B.d | 82  | 84  | 85  | 84   | 85  | B6  | 85  | 85   | 85  | 20         |
| 37   | 9.5 | B.d | 85   | 85  | 95  | 95  | 83   | B.d | 85  | 84  | 93  | 93  | 84  | B.4  | 84  | 94  | 95  | 94   | 85  | 86  | 84   | 94   | 94   | 85   | 86  | 85  | 84  | 85  | 94  |      | 85  | 85  | 84  | 85  | 85  | 84   | Rd. | 85  | 86  | 85   | 95  |            |
| 3.0  | 83  | 84  | 85   | 84  | 84  | 84  | 83   | 8.5 | 85  | 84  | 84  | 85  | Rd. | 84   | 84  | 84  | 85  | 85   | 85  | 85  | 85   | 85   | 85   | 84   | 85  | 85  | 84  | 84  | 85  | 85   | 83  | Bd  | 86  | 85  | 85  | 105  | B.d | 85  | 85  | 84   | 85  | 10 F       |
| 14 4 | PP  | 心里  | DATA | 100 | 見入後 | +2  | / HI | 121 | 17  | トレン | F2  | THE | ンドス | 5/1- | 12  | 64/ | トレン | > F5 | 111 | 121 | 6/   | ML/3 | · F7 | ( HL | N   | 8/1 | NV2 | 169 | TH  | ンド   | 107 | 14  |     | 0.0 |     | -    | 201 |     |     | 24   | 11  |            |
| 37   | > F |     |      |     |     |     | -    | -   | 0   |     |     |     |     |      |     | - 0 |     |      |     |     | - 0- |      | -    |      | 1   |     |     | NUP | 1   |      | -   |     | -   | _   |     |      | _   |     | _   |      | -   | 198        |
| -    |     | _   | _    | _   | _   | _   | _    | _   | _   | _   | _   | _   | _   | _    | _   | _   | _   | _    | _   | -   | _    | _    | _    | _    | -   | _   | _   | -   | -   | -    | -   | -   | _   | _   | _   | _    | _   | _   | _   | _    | _   | _          |

高さ 3mm、幅1ピクセルの仮想スリット(太線枠)で、 均一照射より得られたデジタルデータを、矢印の方向にスキャンする。

|       |      |              |         |               |           |                  |          |          |           |             |                    |              |             |           |                                     |            | 2   | 日        |
|-------|------|--------------|---------|---------------|-----------|------------------|----------|----------|-----------|-------------|--------------------|--------------|-------------|-----------|-------------------------------------|------------|-----|----------|
|       | A    | В            | С       | D             | E         | F                | G        | Н        | 1         | J           | К                  | L            | M           | N         | 0                                   | P          | Q   |          |
| 1     | 22   | ピクセル値        | 線重値     |               |           |                  |          |          |           | 改変          |                    |              | 4           |           |                                     | 2          |     |          |
| 2     | 通し番号 | dD           | dD      | トレンド処理        | C-Dの差分:dE | dE/mean(dD)      | E列をFFT   | FFTの絶対値  | G列の2乗     | WS值         |                    |              | 1           |           |                                     |            |     | =        |
| 3     | 1    | 84.05        | 9.5959  | 9.605902      | -0.01     | -0.001034        | 0.085175 | 0.085175 | 0.0072549 | 2.8339E-06  |                    |              |             |           |                                     |            |     |          |
| 4     | 2    | 84.2         | 9.63759 | 9.606708      | 0.0308829 | 0.0031935        | 0.036578 | 0.119463 | 0.0142713 | 5.5747E-06  |                    | y = 0.845    | 6e0.0289x   |           |                                     | 2          |     |          |
| 5     | 3    | 84.15        | 9.62367 | 9.607517      | 0.014157  | 0.0014709        | 0.193724 | 0.204563 | 0.0418461 | 1.6346E-05  |                    |              |             |           |                                     |            |     |          |
| 6     | 4    | 84           | 9.58205 | 9.608         |           |                  | 0.249955 | 0.271579 | 0.073755  | 2.8811E-05  |                    |              |             |           |                                     |            |     |          |
| 7     | 5    | 84.3         | 9.66548 |               | え言い       | してする             | -0.01515 | 0.147247 | 0.0216816 | 8.4694E-06  | 10 r               | -            |             |           | ▲ 72 Tol                            | 1          | S   |          |
| 8     | 6    | 84.5         | 9.72151 | 9.609         |           |                  | 0.239521 | 0.244197 | 0.059632  | 2.3294E-05  |                    |              |             |           |                                     | 1          |     |          |
| 9     | 7    | 84.35        | 9.67946 | 9.610791      | 0.0686693 | 0.0071009        | -0.08634 | 0.134602 | 0.0181177 | 7.0772E-06  | 9.9                |              |             | #         | <br>——————————————————————————————— | 式(系列1)     | 2   |          |
| 10    | 8    | 84.15        | 9.62367 | 9.611618      | 0.0120567 | 0.0012468        | 0.186853 | 0.186884 | 0.0349256 | 1.3643E-05  | 9.8                |              |             |           | -                                   | 1 +        | 1   |          |
| 11    | 9    | 84.3         | 9.66548 | 9.612447      | 0.0530363 | 0.0054843        | 0.172000 | 0.208376 | 0.0434205 | 1.6961E-05  | 071                | ++ 12 2.     | AL. I HAN   | 的复数制      |                                     |            |     |          |
| 12    | 10   | 84.1         | 9.60978 | 9.61328       | -0.003502 | -0.000362        | 0.015116 | 0.145654 | 0.0212151 | 8.2872E-06  | 9.0                | 91 S S 10    | I STATE Y   |           | のないなどで                              | Constant I |     |          |
| 13    | 11   | 84.1         | 9.60978 | 9.614115      | -0.004    | -                |          | .083618  | 0.006992  | 2.7313E-06  | 9.6                |              |             |           |                                     |            |     |          |
| 14    | 12   | 84.4         | 9.69346 | 9.614953      | 0.1785    | <u>,   , ) ,</u> | ド石       | .062298  | 0.0038811 | 1.5161E-06  | 95                 | 2++4         | ****        |           |                                     | * + *      |     |          |
| 15    | 13   | 84.3         | 9.66548 | 9.615794      | 0.0496    | ・レノ              |          | .096318  | 0.0092772 | 3.6239E-06  | 9.0                |              |             |           |                                     | •          |     |          |
| 16    | 14   | 84.45        | 9.70747 | 9.616637      | 0.0908    |                  | _        | 059556   | 0.0035469 | 1.3855E-06  | 9.4 <mark>y</mark> | / = -2E-     | $08x^3 + 2$ | $E-06x^2$ | + 0.0008                            | 8× + —     |     |          |
| 17    | 15   | 84.5         | 9.72151 | 9.617483      | 0.1040294 | 0.0107574        | -0.12575 | 0.126515 | 0.0160061 | 6.2524E-06  | أمعا               |              | QF          | 051       |                                     |            |     |          |
| 18    | 16   | 84.2         | 9.63759 | 9.61833       | 0.0192607 | 0.0019917        | -0.11911 | 0.234192 | 0.054846  | 2.1424E-05  | 9.0                |              | - 2         |           |                                     |            |     |          |
| 19    | 17   | 83.9         | 9.55439 | 9.61918       | -0.064786 | -0.006699        | -0.10494 | 0.139942 | 0.0195839 | 7.65E-06    | 9.2                |              | R4 =        | 0.1396    |                                     |            |     |          |
| 20    | 18   | 83.75        | 9.51307 | 9.620031      | -0.106966 | -0.p++oc+        | 0.07//74 | 0.430350 | 0.0707177 | 1 0622E-05  | Q 1 1              |              |             |           |                                     |            |     |          |
| 21    | 19   | 83.95        | 9.56821 | 9.620885      | -0.052675 | -0.1             |          |          | しち 日      | 806E-06     | · · · ·            |              | 6F 07       | 100.10    |                                     | 005        |     |          |
| 22    | 20   | 83.35        | 9.40373 | 9.62174       | -0.218012 | <b>10.</b>       | ノン       | ト1IE -   | 一 杀光 百    | 655E-06     |                    | - 55         | 65 97       | 129 16    | 51 193                              | 225        |     |          |
| 23    | 21   | 83.7         | 9.49933 | 9.622597      | -0.123268 | -0.1             |          |          |           | 405E-06     |                    |              |             |           |                                     |            |     |          |
| 24    | 22   | 83.65        | 9.48561 | 9.623455      | -0.137843 | -0.014254        | 0.162249 | 0.220346 | 0.0485523 | 1.8966E-05  |                    |              |             |           |                                     |            |     |          |
| 25    | 23   | 83.85        | 9.5406  | 9.624315      | -0.083717 | -0.008657        | 0.130995 | 0.159876 | 0.0255602 | 9.9845E-06  |                    |              |             |           |                                     |            |     |          |
| 26    | 24   | 84.2         | 9.63759 | 9.625176      | 0.0124152 | 0.0012838        | -0.14657 | 0.14826  | 0.0219809 | 8.5863E-06  |                    |              | 1           |           |                                     |            | 1   |          |
| 27    | 25   | 84.25        | 9.65153 | 9.626038      | 0.0254896 | 0.0026358        | 0.056990 | 0.057476 | 0.0033035 | 1.2904E-06  |                    |              |             |           | -                                   |            |     |          |
| 28    | 26   | 84.35        | 9.67946 | 9.6269        | 0.0525599 | 0.0054351        | -0.18184 |          |           |             | <u> </u>           |              |             |           |                                     | 1          |     |          |
| 29    | 27   | 84.6         | 9.74965 | 9.627764      | 0.1218834 | 0.0126036        | 21190    | 幺딮 듣     | まうに       | ぎ / 幺       | 요들                 | <u>לער</u> י | <b>小</b>    |           |                                     |            |     |          |
| 30    | 28   | 84.3         | 9.66548 | 9.628629      | 0.0368547 | 0.003811         | -0.02781 | 亦大旦      | ミッ じ      |             | 水里                 | ╘╶┱╾┢        | シー          |           |                                     |            | )   |          |
| 31    | 29   | 84.5         | 9.72151 | 9.629494      | 0.0920177 | 0.0095153        | 0.014509 |          |           |             |                    |              |             |           |                                     |            |     |          |
| 32    | 30   | 84.05        | 9.5959  | 9.63036       | -0.034458 | -0.003563        | 0.04288  |          |           |             |                    |              | _           |           |                                     |            |     |          |
| 33    | 31   | 84.2         | 9.63759 | 9.631226      | 0.0063646 | 0.0006581        | -0.0361  | 民主       | ,伯旦       | · ビス こ ろ    | へん白                |              | ち ~ /       | $\tau $   |                                     |            |     |          |
| 34    | 32   | 83.8         | 9.52682 | 9.632093      | -0.105271 | -0.010886        | 0.01204  | 早11      | し泳里       | ヨリリ         | リ緑                 | 里泪           | 旦しし         |           | <b>` ` ` `</b>                      |            |     |          |
| 35    | 33   | 83.85        | 9.5406  | 9.632959      | -0.092361 | -0.009551        | -0.1129  |          |           |             | - 4170             |              |             |           | _                                   |            |     |          |
| 36    | 34   | 84.45        | 9.70747 | 9.633826      | 0.0736486 | 0.0076158        | 0.063657 | 0.063677 | 0.0040547 | 1.5839E-06  |                    | -            |             |           |                                     | -          |     |          |
| 37    | 35   | 84.55        | 9.73557 | 9.634693      | 0.1008772 | 0.0104314        | -0.03606 | 0.076456 | 0.0058455 | 2.2834E-06  |                    |              |             |           |                                     | .,         |     |          |
| 38    | 36   | 84.05        | 9.5959  | 9.635559      | -0.039657 | -0.004101        | 0.181536 | 0.250529 | 0.0627646 | 2.4517E-05  | LL.5. ("O          | 111.5.1911   | 0.711       |           |                                     |            |     | <b>–</b> |
|       | PP   | L There X 18 | の広人キャン  | <u>KEVZEL</u> | FUDF4/F   | UDEDXED.         | 244/40   | 249X FUS | TOKEDDE   | (A FUD FOXI | NU219/             |              | - 11 - A    |           |                                     |            | • • |          |
| 1 75: | 21   |              |         |               |           |                  |          |          |           |             | NUN                | 1            | 24.12       |           |                                     |            |     | 11       |

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|    |          |               |                         |                  |  | -           |                     |          |           |            |       |                 |                       |                      |                    |          | ĐE        |
|----|----------|---------------|-------------------------|------------------|--|-------------|---------------------|----------|-----------|------------|-------|-----------------|-----------------------|----------------------|--------------------|----------|-----------|
|    | A        | В             | С                       | D                | E  | F           | G                   | Н        | I         | J          | К     | L               | M                     | N                    | 0                  | Р        | Q         |
| 1  |          | ピクセル値         | 線重値                     |                  |  |             |                     |          |           | 改変         |       |                 |                       |                      |                    |          |           |
| 2  | 通し番号     | dD            | dD                      | トレンド処理           | C-Dの差分:dE  | dE/mean(dD) | E列をFFT              | FFTの絶対値  | G列の2乗     | WS值        |       |                 |                       |                      |                    |          | =         |
| 3  | 1        | 84.05         | 9.5959                  | 9.605902         | -0.01  | -0.00103    | 0.08517             | 0.085175 | 0.0072549 | 2.8339E-06 |       |                 |                       |                      |                    |          |           |
| 4  | 2        | 84.2          | 9.63759                 | 9.606708         | 0. <u>0308829</u>  | 0.003193    | 0.03657             | 0.119463 | 0.0142713 | 5.5747E-06 |       | y = 0.845       | 6e0.0289x             |                      |                    |          |           |
| 5  | - 3      | 84.15         | 9.62367                 | 9.607517         | Q  | 1670        | 0.19372             | 0.204563 | 0.0418461 | 1.6346E-05 | 08    |                 |                       |                      |                    |          |           |
| 6  | 4        | 84            | 9.58205                 | 9.608331         | - FF   | ~ ~         | 0.24995             | 0.271579 | 0.073755  | 2.8811E-05 |       |                 |                       |                      |                    |          |           |
| 7  | 5        | 84.3          | 9.66548                 | 9.609148         | 0. 📕 📕   | 5825        | -0.0151             | 0.147247 | 0.0216816 | 8.4694E-06 | 10    |                 |                       |                      | ∞.≣i               | 1        | · · · · · |
| 8  | 6        | 84.5          | 9.72151                 | 9.609968         | 0  | 1534        | 0.23952             | 0.244197 | 0.059632  | 2.3294E-05 | 00    |                 |                       |                      |                    |          |           |
| 9  | 7        | 84.35         | 9.67946                 | 9.610791         | 0.0686693  | 0.007100    | -0.0863             | 0.134602 | 0.0181177 | 7.0772E-06 | 9.9   |                 |                       | #                    |                    | 式(系列1)   |           |
| 10 | 8        | 84.15         | 9.62367                 | 9.611618         | 0.0120567  | 0.001246    | 0.18685             | 0.186884 | 0.0349256 | 1.3643E-05 | 9.8   |                 |                       |                      | + +                | <b>t</b> |           |
| 11 | 9        | 84.3          | 9.66548                 | 9.612447         | 0.0530363  | 0.005484    | 0.17200             | 0.208376 | 0.0434205 | 1.6961E-05 | 07    | ++ 12 3.        | a. I feet             | 1 4 M                |                    |          |           |
| 12 | 10       | 84.1          | 9.60978                 | 9.61328          | -0.003502  | -0.00036    | 0.015116            | 0.145654 | 0.0212151 | 8.2872E-06 | 9.1   |                 | PERSONAL PROPERTY.    |                      | 1. Star 1. Star 1. | Carlor   |           |
| 13 | 11       | 84.1          | 9.60978                 | 9.614115         | - 0  |             | 0.0835              | 0.083618 | 0.006992  | 2.7313E-06 | 9.6   |                 |                       |                      |                    |          |           |
| 14 | 12       | 84.4          | 9.69346                 | 9.614953         | 0. IN/   | ΊΩΡ         | 0.06                | 0.062298 | 0.0038811 | 1.5161E-06 | 05    | 1 + + +         |                       |                      |                    |          |           |
| 15 | 13       | 84.3          | 9.66548                 | 9.615794         | O. <b>IIVI</b>   |             | 0.02926             | 0.096318 | 0.0092772 | 3.6239E-06 | 9.0   |                 |                       |                      |                    |          |           |
| 16 | 14       | 84.45         | 9.70747                 | 9.616637         | 0  |             | D.0581              | 0.059556 | 0.0035469 | 1.3855E-06 | 9.4   | $y = -2E^{-1}$  | 08x <sup>3</sup> + 2l | E-06x <sup>2</sup> · | + 0.0008           | 3× + —   |           |
| 17 | 15       | 84.5          | 9.72151                 | 9.617483         | 0.1040294  | 0.010757    | -0.1257             | 0.126515 | 0.0160061 | 6.2524E-06 |       |                 | 0.6                   | 051                  |                    |          |           |
| 18 | 16       | 84.2          | 9.63759                 | 9.61833          | 0.0192607  | 0.001991    | -0.1191             | 0.234192 | 0.054846  | 2.1424E-05 | 9.0   |                 | 9.0                   | 1001                 |                    |          |           |
| 19 | 17       | 83.9          | 9.55439                 | 9.61918          | -0.064786  | -0.00669    | -0.1049             | 0.139942 | 0.0195839 | 7.65E-06   | 9.2   |                 | R4 =                  | 0.1396               |                    |          |           |
| 20 | 18       | 83.75         | 9.51307                 | 9.620031         | -0.106966  | - 9         | 0 0 <del>7</del> 63 | 0.179759 | 0.0323133 | 1.2622E-05 | a 1   |                 |                       |                      |                    |          |           |
| 21 | 19       | 83.95         | 9.56821                 | 9.620885         | -0.052675  | - ¶ TT/     | 168                 | 0.067996 | 0.0046234 | 1.806E-06  | 2.1   |                 |                       |                      |                    |          |           |
| 22 | 20       | 83.35         | 9.40373                 | 9.62174          | -0.218012  | -4 H′       | L +++               | 0.12 - 9 | 0.0147597 | 5.7655E-06 |       | 1 33            | 65 97                 | 129 16               | 1 193 2            | 225      |           |
| 23 | 21       | 83.7          | 9.49933                 | 9.622597         | -0.123268  | -0          | - 911               | 0.140768 | 0.0198158 | 7.7405E-06 |       |                 |                       |                      |                    |          | _         |
| 24 | 22       | 83.65         | 9.48561                 | 9.623455         | -0.137843  | -0.01425    | 0.16224             | 0.220346 | 0.0485523 | 1.8966E-05 |       |                 |                       |                      |                    |          |           |
| 25 | 23       | 83.85         | 9.5406                  | 9.624315         | -0.083717  | -0.00865    | 0.13099             | 0.159876 | 0.0255602 | 9.9845E-06 |       |                 |                       |                      |                    |          |           |
| 26 | 24       | 84.2          | 9.63759                 | 9.625176         | 0.0124152  | 0.001283    | -0.1465             | 0.14826  | 0.0219809 | 8.5863E-06 |       |                 |                       |                      |                    |          |           |
| 27 | 25       | 84.25         | 9.65153                 | 9.626038         | 0.0254896  | 0.002635    | 0.056990            | 0.057476 | 0.0033035 | 1.2904E-06 |       |                 |                       |                      |                    |          |           |
| 28 | 26       | 84.35         | 9.67946                 | 9.6269           | 0.0525599  | 0.005435    | -0.1818             | 0.220422 | 0.0485857 | 1.8979E-05 |       |                 |                       |                      |                    |          |           |
| 29 | 27       | 84.6          | 9.74965                 | 9.627764         | 0.1218834  | 0.012603    | -0.2119             | 0.221938 | 0.0492564 | 1.9241E-05 |       |                 |                       |                      |                    |          |           |
| 30 | 28       | 84.3          | 9.66548                 | 9.628629         | 0.0368547  | 0.00381     | -0.0278             | 0.029792 | 0.0008876 | 3.4671E-07 |       |                 |                       |                      |                    |          |           |
| 31 | 2        |               |                         |                  |  |             |                     |          | 0.0002125 | 8.299E-08  |       |                 |                       |                      |                    |          |           |
| 32 |          | _I2*          | < <i>(</i> 1 / <i>(</i> | つちんぉ             | <n 12<="" td=""><td>0))*/</td><td>ሰ 1 3</td><td>2012)</td><td>0.0982251</td><td>3.8369E-05</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></n> | 0))*/       | ሰ 1 3               | 2012)    | 0.0982251 | 3.8369E-05 |       |                 |                       |                      |                    |          |           |
| 33 |          | <b>-1</b> 0 ' | (1/(                    | $\Delta J 0$     | <b>0.13</b>  | フリニ         | 0.15                | リフニム)    | 0.0041822 | 1.6337E-06 |       |                 |                       |                      |                    |          |           |
| 34 | -        |               | ```                     | `                |  | · ·         | `<br>               | <u> </u> | D.0155869 | 6.0886E-06 |       |                 |                       |                      |                    |          |           |
| 35 | 33       | 83.85         | 9.5406                  | 9.632959         | -0.092361  | -0.00955    | -0.1129             | 0.119833 | 0.0143599 | 5.6093E-06 |       |                 |                       |                      |                    |          |           |
| 36 | 34       | 84.45         | 9.70747                 | 9.633826         | 0.0736486  | 0.007615    | 0.06365             | 0.063677 | 0.0040547 | 1.5839E-06 |       |                 |                       |                      |                    |          |           |
| 37 | 35       | 84.55         | 9.73557                 | 9.634693         | 0.1008772  | 0.010431    | -0.0360             | 0.076456 | 0.0058455 | 2.2834E-06 |       |                 |                       |                      |                    |          | <b>^</b>  |
| 38 | 36       | 84.05         | 9.5959                  | 9.635559         | -0.039657  | -0.00410    | 0.18153             | 0.250529 | 0.0627646 | 2.4517E-05 |       | 1               |                       |                      | _                  | -        |           |
|    | <b>F</b> | 生DATA 人仮      | 想スキャン                   | <u>א דראדו (</u> | トレンド2/ト  | レンド3/トレ     | /ンド4/FL             | シド5/トレン  | /ド6/トレンド  | 7/ 4/2 48/ | トレンドタ | <u> (トレンド10</u> | 14                    | Ш                    |                    |          |           |
| 17 | ンド       |               |                         |                  |  |             |                     |          |           |            | NU    | M               |                       |                      |                    |          | 111       |

大阪大学(松本先生より)

WSをデジタル計算するとき、試料の全長Xを、サンプリング間隔 Xで離散的に読み取ったデータをFFTにかける。

このときFFT演算には Xを省略してデジタル値を線量に変換した値のみで計算しFxを得る。

したがってWSは、サンプリング間隔と試料の全長を含めた計算



曲線で囲まれた図形の面積を求めるとき、棒グラフ上に区切っ たあと、それぞれの高さだけを演算(この場合積算)し最後に 横の長さを掛けて面積を求めることと同じ操作をしていること。

#### 16本の「1次元スキャンデータ」から 平均してWSを求める。

#### このときのスペクトル値の 理論的標準誤差(SE)は,25%。

100本で 10%

**400本で 5%** 

広島県立保健福祉大学(吉田先生より)



