

Dithering of SPIRE scan maps

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By default, SPIRE scan maps provide excellent spatial sampling of the region being surveyed. However, for repeated observations of the same field, the user has the option of specifying multiple AORs (rather than a single multiple-repetition AOR), offset from each other by a small distance, to produce a more uniform coverage over the map ("dithering").

Whether this leads to a noticeable improvement in sensitivity has yet to be demonstrated, and there is a small time cost involved in dithering (an overhead of ##### seconds per AOR). So this note is neither a recommendation that dithering should be employed for repeat observations, nor does it claim to describe the optimal scheme for dithering; rather it is an example of one way in which dithering may be implemented, should the observer wish to do so.

This note describes the dithering pattern for SPIRE scan maps as implemented for many observations taken for HerMES (the Herschel Multi-tiered Extragalactic Survey). Scripts and example outputs for certain numbers of dithering offsets are included below.

As illustrated in Figure 2, the AOR centres are distributed around the edges of a rectangle in the telescope Y and Z axes, in order to give more uniform sampling with respect to the "A" and "B" scan directions, spread evenly across the separation between two adjacent scan legs (348 arcsec for SPIRE scan maps). (This spacing was chosen because the main source of non-uniformity in the sampling comes from the overlap between adjacent scan legs.)

The offsets in Y and Z may be entered into HSpot to plan the AORs (one AOR for each dither offset).

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1. PROCEDURE

The offsets are chosen as follows.

- (1) The distance between scan legs is set first. For SPIRE scan maps this is 348 arcsec.
- (2) The offsets along the "A" and "B" scan directions for N dither offsets are set. These are evenly distributed and centred on zero, spanning the distance between the scan legs.
- (3) These offsets in the "A" and "B" scan directions are converted to offsets in Y and Z (the scan directions are +/- 42.4 degrees from the Z axis).
- (4) The Y and Z offsets are combined to place the offsets around the edge of a rectangle.

Figure 1 shows the effect of dithering on the coverage map while Figure 2 shows the offsets for the 8-point dither pattern.

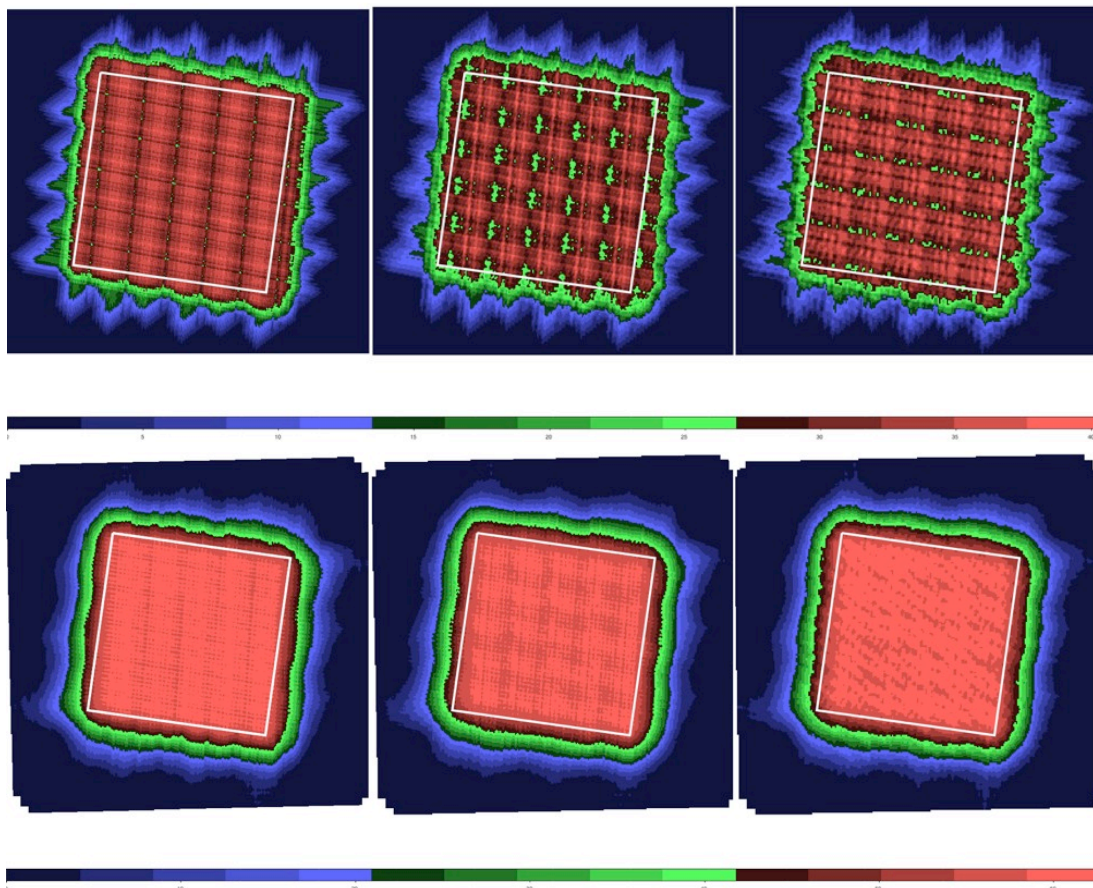


Figure 1 Coverage maps, convolved with the beam, for no dithering (top) and 8-point dithering (bottom), for PSW (left), PMW (middle) and PLW (right). The white square shows a 30' x 30' field. Note that the colour scales are different for the top and bottom panels.

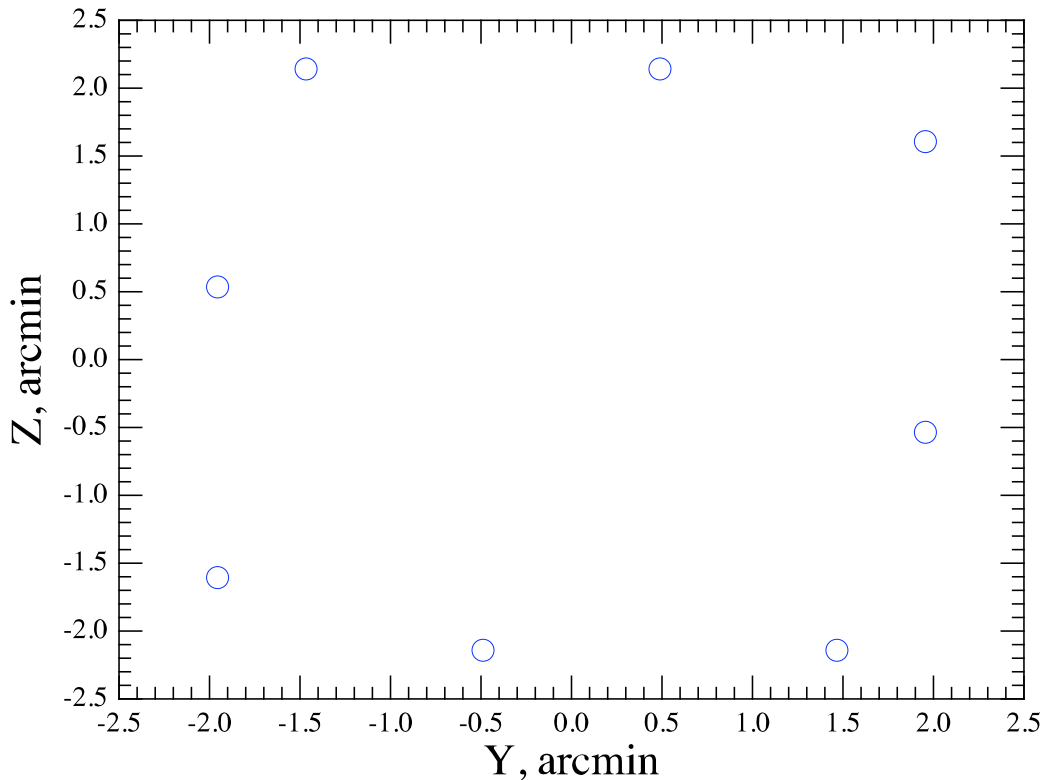


Figure 2 Offsets for the 8-point dithering pattern, with the target position at (0.0, 0.0).

2. IDL script

N = 6

```
;; Step (1), distance between scan legs
scan = 348.0 / 60.0
```

```
;; Step (2), steps in "A" and "B"
steps = dblarr(N)
for i = 0, N - 1 do $
  steps[i] = scan * (-0.5 + (i + 0.5) / N)
```

```
;; Step (3), steps in Y and Z for "A" and "B" directions
steps_y_a = sin(42.4 * !dtor) * steps
steps_z_a = cos(42.4 * !dtor) * steps
steps_y_b = steps_y_a
steps_z_b = -steps_z_a
```

```
;; Step (4), combined steps in Y and Z
b_order = intarr(N)
for i = 0, floor((N+1)/2) - 1 do $
  b_order[i] = floor((N-1)/2) - (-1)^i * floor((i+1)/2) * 2
for i = floor((N+1)/2), N - 1 do $
```

```

    b_order[i] = floor((N-1)/2) - (-1)^i * (floor((N-i-1)/2) * 2 + 1)
offsets_y = steps_y_a + steps_y_b[b_order]
offsets_z = steps_z_a + steps_z_b[b_order]

;; Output
for i = 0, N - 1 do begin
    print, i + 1, offsets_y[i], offsets_z[i]
endfor

end

```

3. Python/Jython/HIPE script

```

N = 6

# Step (1), distance between scan legs
scan = 348.0 / 60.0

# Steps (2), steps in "A" and "B"
# and Step (3), steps in Y and Z for "A" and "B" directions
steps = []
steps_y_a = []
steps_z_a = []
steps_y_b = []
steps_z_b = []
for i in range(N):
    steps.append(scan * (-0.5 + (i + 0.5) / N))
    steps_y_a.append(0.67430238758372329 * steps[i]) # sin(42.4 deg)
    steps_z_a.append(0.7384553406258838 * steps[i]) # cos(42.4 deg)
    steps_y_b.append(steps_y_a[i])
    steps_z_b.append(-steps_z_a[i])

# Step (4), combined steps in Y and Z
offsets_y = []
offsets_z = []
for i in range(int((N+1)/2)):
    try:
        offsets_y.append(steps_y_a[i]
            + steps_y_b[int((N-1)/2)
                - (-1)**i * int((i+1)/2) * 2])
        offsets_z.append(steps_z_a[i]
            + steps_z_b[int((N-1)/2)
                - (-1)**i * int((i+1)/2) * 2])
    except IndexError:
        offsets_y.append(steps_y_a[i] + steps_y_b[N - 1])
        offsets_z.append(steps_z_a[i] + steps_z_b[N - 1])

for i in range(int((N+1)/2), N):

```

```

offsets_y.append(steps_y_a[i]
                 + steps_y_b[int((N-1)/2)
                              - (-1)**i * (int((N-i-1)/2) * 2 + 1)])
offsets_z.append(steps_z_a[i]
                 + steps_z_b[int((N-1)/2)
                              - (-1)**i * (int((N-i-1)/2) * 2 + 1)])

# Output
for i in range(N):
    print "%2d %10.7f %10.7f" % (i + 1, offsets_y[i], offsets_z[i])

```

4. Examples

Offsets are shown below for a selection of dithering schemes, with 3, 6, 7, 9, 10, 12 or 19 separate AORs.

AOR | Map centre offset Y (arcmin) | Map centre offset Z (arcmin)

3-point dither

```

1 -1.304 -1.428
2  1.304 -1.428
3  0.000  2.855

```

6-point dither

```

1 -1.955 -1.428
2  0.000 -2.142
3 -1.955  1.428
4  1.955 -1.428
5  0.000  2.142
6  1.955  1.428

```

7-point dither

```

1 -1.676 -1.836
2  0.000 -2.447
3 -1.676  0.612
4  1.676 -1.836
5 -1.117  2.447
6  1.676  0.612
7  1.117  2.447

```

9-point dither

```

1 -1.955 -1.606
2 -0.489 -2.142
3 -1.955  0.535
4  1.467 -2.142
5 -1.467  2.142
6  1.955 -0.535
7  0.489  2.142

```

8 1.955 1.606

10-point dither

1 -1.955 -1.713
2 -0.782 -2.142
3 -1.955 0.000
4 0.782 -2.142
5 -1.955 1.713
6 1.955 -1.713
7 -0.782 2.142
8 1.955 0.000
9 0.782 2.142
10 1.955 1.713

12-point dither

1 -1.955 -1.785
2 -0.978 -2.142
3 -1.955 -0.357
4 0.326 -2.142
5 -1.955 1.071
6 1.630 -2.142
7 -1.630 2.142
8 1.955 -1.071
9 -0.326 2.142
10 1.955 0.357
11 0.978 2.142
12 1.955 1.785

19-point dither

1 -1.853 -2.029
2 -1.235 -2.254
3 -1.853 -1.127
4 -0.412 -2.254
5 -1.853 -0.225
6 0.412 -2.254
7 -1.853 0.676
8 1.235 -2.254
9 -1.853 1.578
10 1.853 -2.029
11 -1.647 2.254
12 1.853 -1.127
13 -0.823 2.254
14 1.853 -0.225
15 0.000 2.254
16 1.853 0.676
17 0.823 2.254
18 1.853 1.578
19 1.647 2.254