In [1]:
```
!pip install healpy
```

```
Defaulting to user installation because normal site-packages is not wri
teable
Requirement already satisfied: healpy in /global/homes/s/saaransh/.loca
l/perlmutter/python-3.11/lib/python3.11/site-packages (1.18.0)
Requirement already satisfied: numpy>=1.19 in /global/common/software/n
ersc/pe/conda-envs/24.1.0/python-3.11/nersc-python/lib/python3.11/site-
packages (from healpy) (1.26.3)
Requirement already satisfied: astropy in /global/common/software/ners
c/pe/conda-envs/24.1.0/python-3.11/nersc-python/lib/python3.11/site-pac
kages (from healpy) (6.0.0)
Requirement already satisfied: pyerfa>=2.0 in /global/common/software/n
ersc/pe/conda-envs/24.1.0/python-3.11/nersc-python/lib/python3.11/site-
packages (from astropy->healpy) (2.0.1.1)
Requirement already satisfied: astropy-iers-data>=0.2023.10.30.0.29.53
in /global/common/software/nersc/pe/conda-envs/24.1.0/python-3.11/nersc
-python/lib/python3.11/site-packages (from astropy->healpy) (0.2024.1.
8.0.30.55)
Requirement already satisfied: PyYAML>=3.13 in /global/common/software/
nersc/pe/conda-envs/24.1.0/python-3.11/nersc-python/lib/python3.11/site
-packages (from astropy->healpy) (6.0.1)
Requirement already satisfied: packaging>=19.0 in /global/common/softwa
re/nersc/pe/conda-envs/24.1.0/python-3.11/nersc-python/lib/python3.11/s
ite-packages (from astropy->healpy) (23.2)
```

In [2]:
```
!pip install astropy
```

```
Defaulting to user installation because normal site-packages is not wri
teable
Requirement already satisfied: astropy in /global/common/software/ners
c/pe/conda-envs/24.1.0/python-3.11/nersc-python/lib/python3.11/site-pac
kages (6.0.0)
Requirement already satisfied: numpy<2,>=1.22 in /global/common/softwar
e/nersc/pe/conda-envs/24.1.0/python-3.11/nersc-python/lib/python3.11/si
te-packages (from astropy) (1.26.3)
Requirement already satisfied: pyerfa>=2.0 in /global/common/software/n
ersc/pe/conda-envs/24.1.0/python-3.11/nersc-python/lib/python3.11/site-
packages (from astropy) (2.0.1.1)
Requirement already satisfied: astropy-iers-data>=0.2023.10.30.0.29.53
in /global/common/software/nersc/pe/conda-envs/24.1.0/python-3.11/nersc
-python/lib/python3.11/site-packages (from astropy) (0.2024.1.8.0.30.5
5)
Requirement already satisfied: PyYAML>=3.13 in /global/common/software/
nersc/pe/conda-envs/24.1.0/python-3.11/nersc-python/lib/python3.11/site
-packages (from astropy) (6.0.1)
Requirement already satisfied: packaging>=19.0 in /global/common/softwa
re/nersc/pe/conda-envs/24.1.0/python-3.11/nersc-python/lib/python3.11/s
ite-packages (from astropy) (23.2)
```

In [3]:
```
import numpy as np
import pandas as pd
```

```
import healpy as hp
import matplotlib
from matplotlib import pyplot as plt
from astropy.coordinates import SkyCoord
import astropy.units as u
from astropy.coordinates.matrix_utilities import rotation_matrix
from astropy.coordinates import SkyCoord, CartesianRepresentation
from astropy.wcs import WCS
from astropy.visualization import astropy_mpl_style
import utility as util
```

In [4]:

```
#Initializing all the variables.

NSIDE = 4096
NPIX  = hp.nside2npix(NSIDE)

og_df = pd.read_csv('simple_model_images_files_data.csv')
```

In [5]:

```
df = og_df[(og_df['POINTING'] == 330)]
```

Mosaic Wide (38) + Deep (7) Imaging Pattern

Wide Imaging Pattern

In [6]:

```
df_38 = util.translate_squares_custom_9x5_38(df)
```

```
/global/u2/s/saaransh/utility.py:987: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  single_pointing["remove"] = 0
/global/u2/s/saaransh/utility.py:987: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  single_pointing["remove"] = 0
/global/u2/s/saaransh/utility.py:987: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  single_pointing["remove"] = 0
```

```
/global/u2/s/saaransh/utility.py:987: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  single_pointing["remove"] = 0
/global/u2/s/saaransh/utility.py:987: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  single_pointing["remove"] = 0
/global/u2/s/saaransh/utility.py:987: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  single_pointing["remove"] = 0
/global/u2/s/saaransh/utility.py:985: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  single_pointing["remove"] = 1
/global/u2/s/saaransh/utility.py:996: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  single_pointing["remove"] = 0
/global/u2/s/saaransh/utility.py:1013: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  single_pointing["remove"] = 0
/global/u2/s/saaransh/utility.py:1025: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  single_pointing["remove"] = 0
/global/u2/s/saaransh/utility.py:1025: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead
```

```
See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  single_pointing["remove"] = 0
/global/u2/s/saaransh/utility.py:1023: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  single_pointing["remove"] = 1
/global/u2/s/saaransh/utility.py:1023: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  single_pointing["remove"] = 1
/global/u2/s/saaransh/utility.py:1023: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
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  single_pointing["remove"] = 1
/global/u2/s/saaransh/utility.py:1025: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  single_pointing["remove"] = 0
/global/u2/s/saaransh/utility.py:1025: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  single_pointing["remove"] = 0
/global/u2/s/saaransh/utility.py:1025: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  single_pointing["remove"] = 0
/global/u2/s/saaransh/utility.py:1034: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
```

```
  single_pointing["remove"] = 0
/global/u2/s/saaransh/utility.py:1051: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  single_pointing["remove"] = 1
/global/u2/s/saaransh/utility.py:1063: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  single_pointing["remove"] = 0
/global/u2/s/saaransh/utility.py:1063: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  single_pointing["remove"] = 0
/global/u2/s/saaransh/utility.py:1063: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  single_pointing["remove"] = 0
/global/u2/s/saaransh/utility.py:1063: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  single_pointing["remove"] = 0
/global/u2/s/saaransh/utility.py:1063: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  single_pointing["remove"] = 0
/global/u2/s/saaransh/utility.py:1063: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  single_pointing["remove"] = 0
/global/u2/s/saaransh/utility.py:1063: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
```

```
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  single_pointing["remove"] = 0
/global/u2/s/saaransh/utility.py:1061: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  single_pointing["remove"] = 1
```

In [7]:
```
ra_cen_38 = df_38[[f'RA{i}' for i in range(1, 5)]].mean().mean()
dec_cen_38 = df_38[[f'DEC{i}' for i in range(1, 5)]].mean().mean()

print(f"RA: {ra_cen_38}; DEC: {dec_cen_38}")
```

```
RA: 9.929758150728556; DEC: -43.989593039552204
```

Deep Imaging Pattern

In [8]:
```
df_7 = util.translate_squares_custom_7(df)
```

In [9]:
```
df_7_shifted = util.shift_centers(df_7, ra_cen_38, dec_cen_38)
```

In [10]:
```
ra_cen_7 = df_7_shifted[[f'RA{i}' for i in range(1, 5)]].mean().mean()
dec_cen_7 = df_7_shifted[[f'DEC{i}' for i in range(1, 5)]].mean().mean

print(f"RA: {ra_cen_7}; DEC: {dec_cen_7}")
```

```
RA: 9.929758150728556; DEC: -43.98959303955221
```

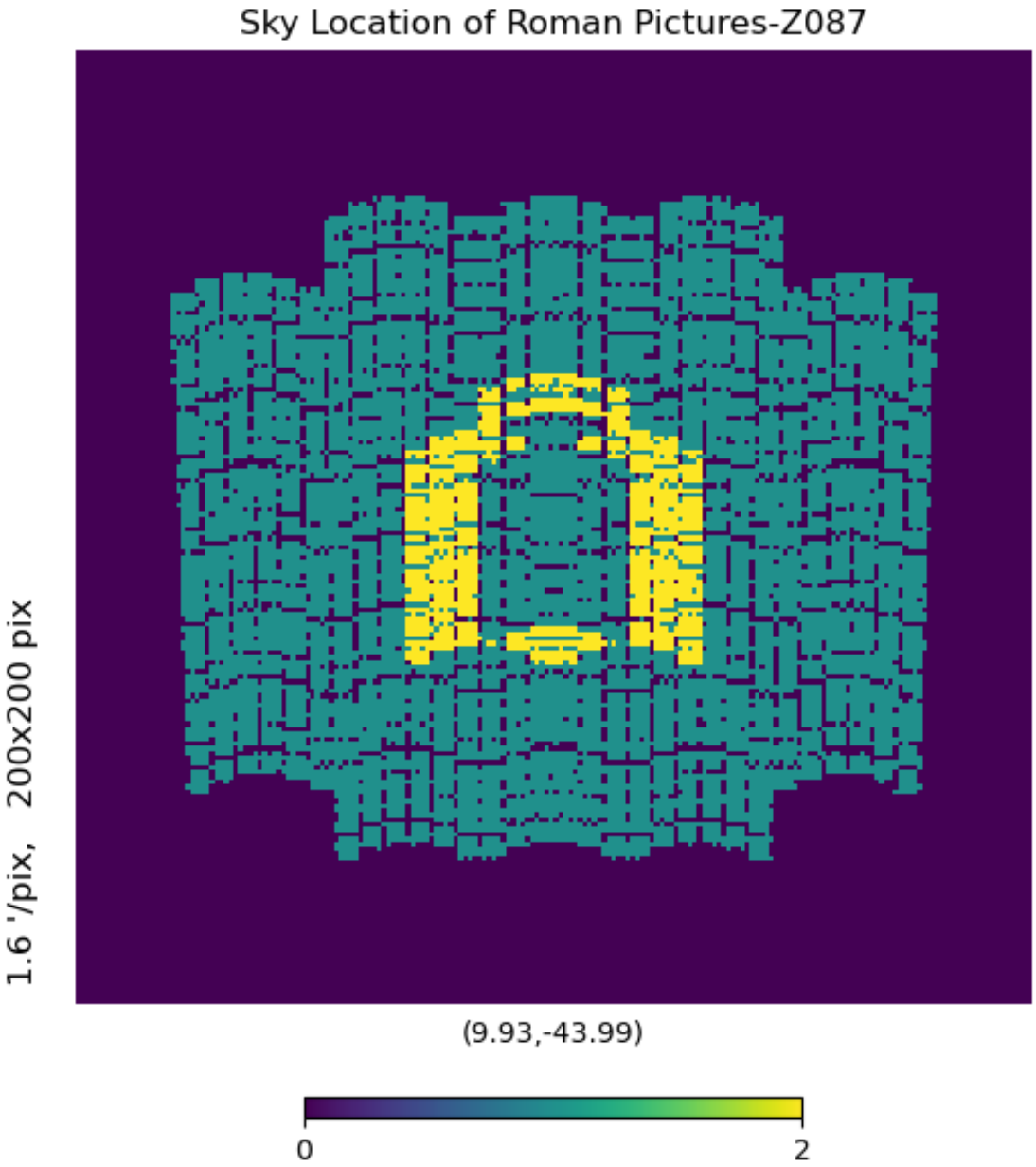
Final pattern

In [11]:
```
final_df = pd.concat([df_38, df_7_shifted], ignore_index=True)
```

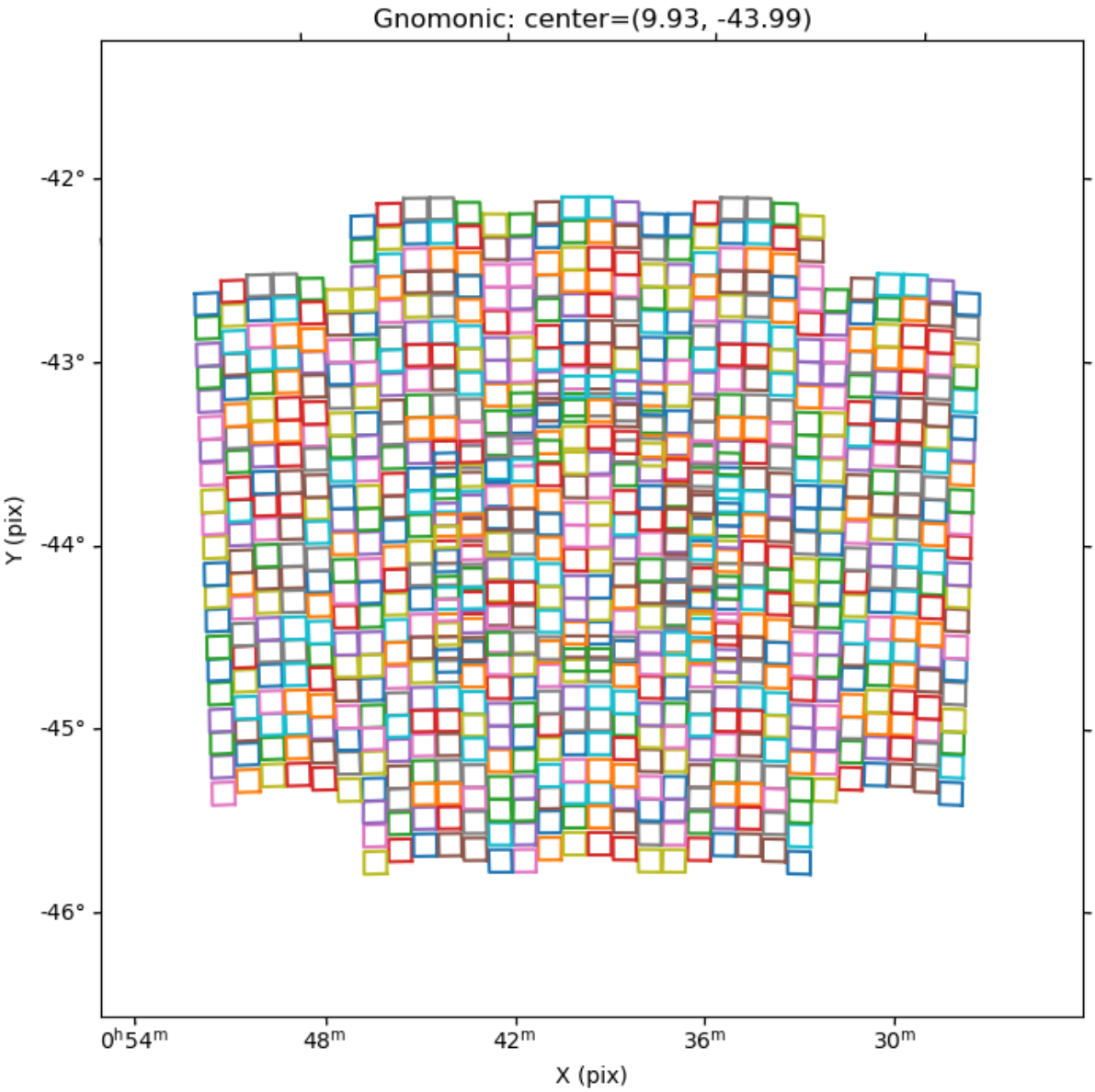
In [12]:
```
ra_cen = final_df[[f'RA{i}' for i in range(1, 5)]].mean().mean()
dec_cen = final_df[[f'DEC{i}' for i in range(1, 5)]].mean().mean()

print(f"RA: {ra_cen}; DEC: {dec_cen}")
```

```
RA: 9.929758150728556; DEC: -43.989593039552204
```

In [13]:
```
util.visualize_healpy(final_df, ra_cen, dec_cen)
```

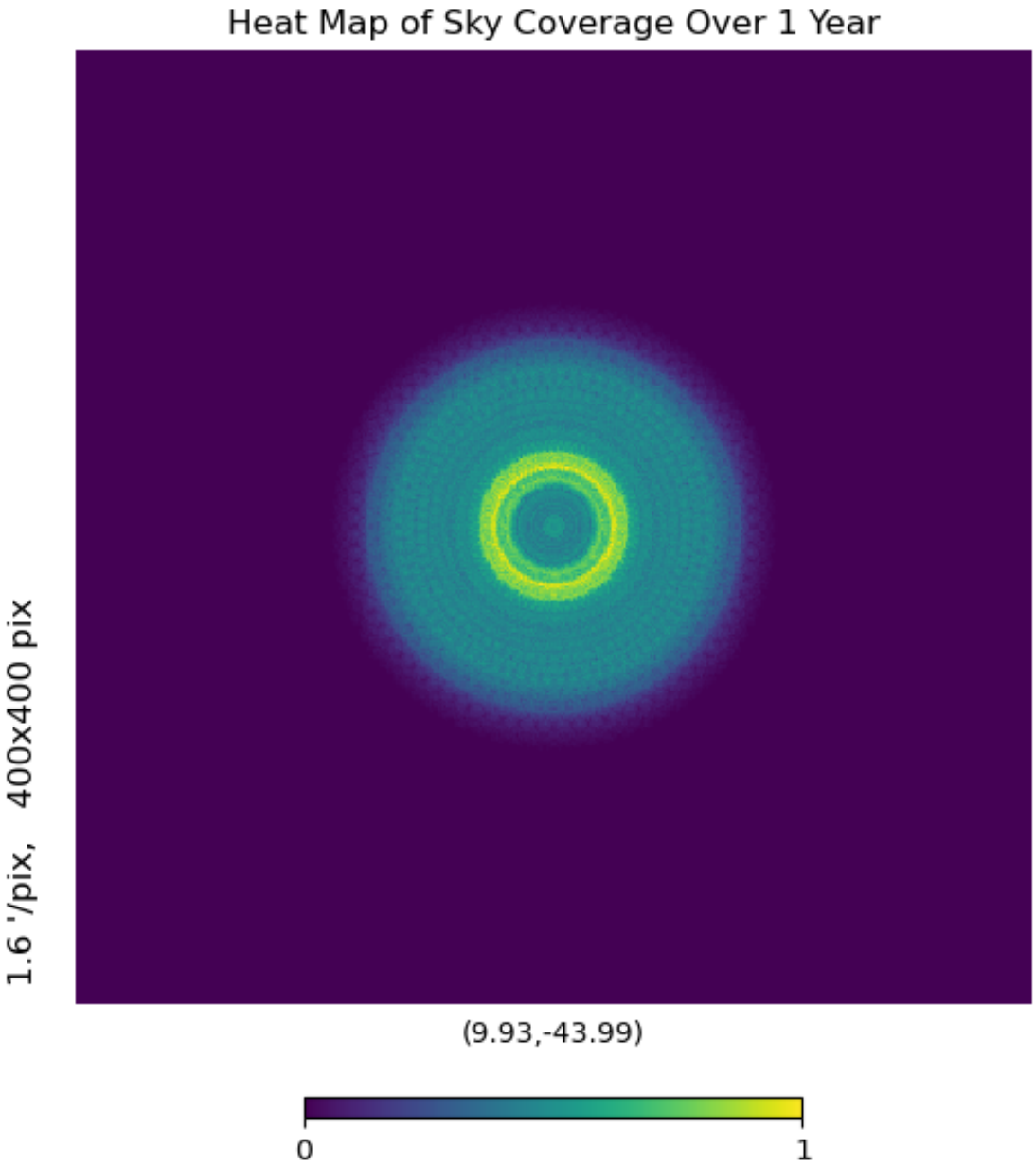


In [14]:
```
util.visualize_astropy_plotcoord(final_df, ra_cen, dec_cen)
```



Heat Map

In [15]:
```
heat_map = util.create_heat_map(final_df, ra_cen, dec_cen)
```

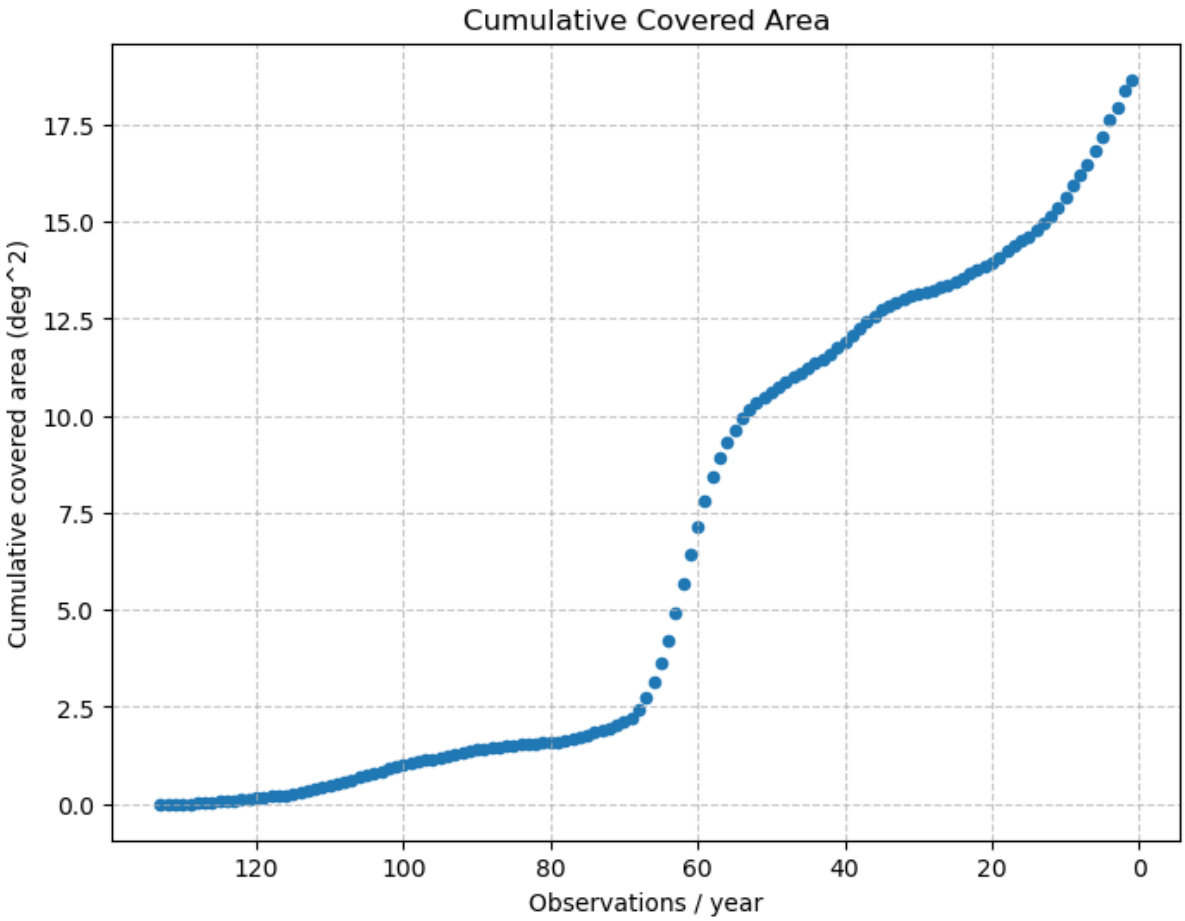


Pixel Efficiency Calculation

In [16]:
```
pixel_data, imaging_data = util.calculate_pixel_efficiency(final_df, r
```

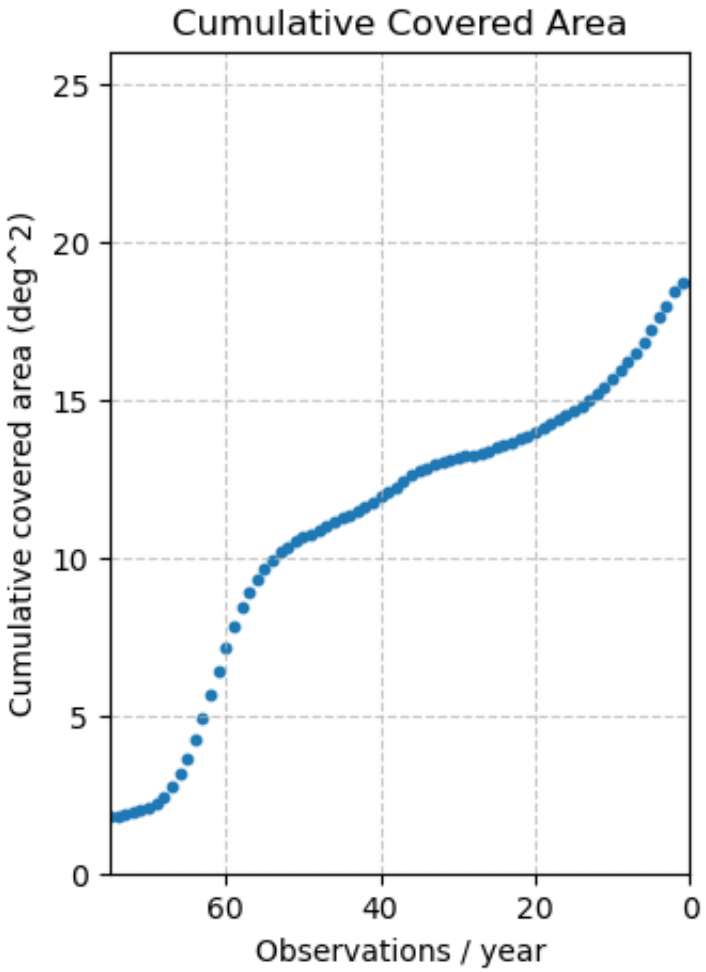
CDF Plot

In [17]:
```
util.cdf_calc(pixel_data)
```



In [34]:
```
from collections import Counter

pixel_freqs = []
for _, pix in pixel_data.items():
    pixel_freqs.append(pix['appearances'])

d = {}

d = Counter(pixel_freqs)
sorted_d = dict(sorted(d.items(), key=lambda x: -x[0]))
area_per_pixel = (0.014)**2
y = []
x = []
tot = 0
for k, v in sorted_d.items():
    tot += v*area_per_pixel
    y.append(tot)
    x.append(k)

plt.figure(figsize=(3.5, 5))
plt.scatter(x, y, marker='o', s=10)  # s controls dot size
plt.title("Cumulative Covered Area")
plt.xlabel("Observations / year")
plt.ylabel("Cumulative covered area (deg^2)")
plt.xlim(0,75)
```

```
plt.ylim(0,26)
plt.gca().invert_xaxis()  # Reverse X-axis to match earlier plot
plt.grid(True, linestyle='--', alpha=0.7)
plt.show()
```



In [38]:
```
imaging_data['wide'][0][-5:]
```

Out[38]:
```
[{'pixel': 169078645, 'cell': 43},
 {'pixel': 169078646, 'cell': 43},
 {'pixel': 169078647, 'cell': 43},
 {'pixel': 169078648, 'cell': 43},
 {'pixel': 169078649, 'cell': 43}]
```

In [ ]:
```

```