1. Producing helpy maps

https://gist.github.com/zonca/9c114608e0903a3b8ea0bfe41c96f255

https://healpy.readthedocs.io/en/latest/tutorial.html

https://healpix.sourceforge.io/documentation.php

also in IDL

https://sourceforge.net/projects/healpix/

https://github.com/healpy/healpy/issues/556

https://mhealpy.readthedocs.io/_/downloads/en/latest/pdf/

create a map with numpy https://python.hotexamples.com/examples/fermipy.skymap/HpxMap/create_from_fits/python-hpxmap-create_from_fits-method-examples.html?utm_content=cmp-true

with healpy https://stackoverflow.com/questions/31573572/healpy-from-data-to-healpix-map

1.1 Python environment

using opt/miniconda3/ installation jupyter notebook

opt/miniconda3/bin/python 2.9

In [121…

```
import matplotlib.pyplot as plt
import numpy as np
import healpy as hp
import pathlib
import pandas
from astropy.table import Table
```

NSIDE and ordering

Maps are simply numpy arrays, where each array element refers to a location in the sky as defined by the Healpix pixelization schemes (see the healpix website).

Note: Running the code below in a regular Python session will not display the maps; it's recommended to use an IPython shell or a Jupyter notebook.

The resolution of the map is defined by the NSIDE parameter, which is generally a power of 2.

In [122…

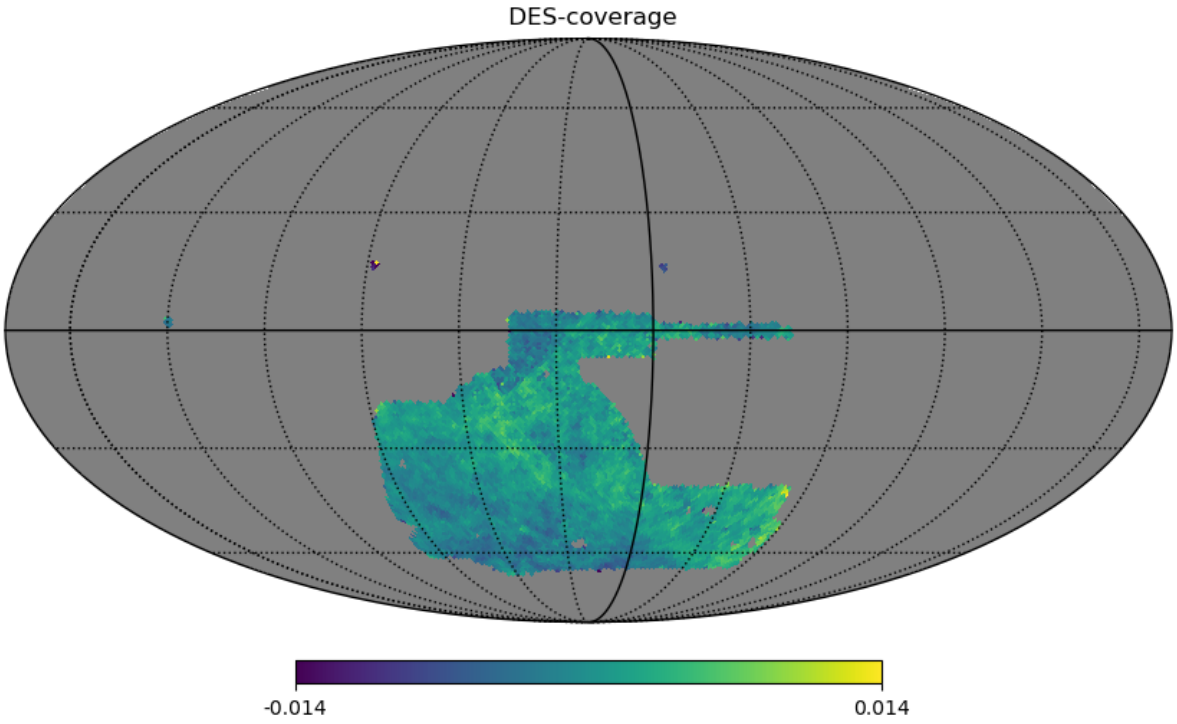
```
pdir = pathlib.Path('.').resolve()
ff1 = pdir / 'Y6A1_finsel_DR3_wXPSP_G17.65.fits'
df1 = Table.read(ff1).to_pandas()
#df2 = Table.read(ff2).to_pandas()
df1.columns
```

Out[122]:
```
Index(['FGCM_ID', 'RA', 'DEC', 'FLAG', 'MAG_STD_G', 'MAG_STD_R', 'MAG_STD_I',
       'MAG_STD_Z', 'MAG_STD_Y', 'MAGERR_STD_G', 'MAGERR_STD_R',
       'MAGERR_STD_I', 'MAGERR_STD_Z', 'MAGERR_STD_Y', 'NGOOD_G', 'NGOOD_R',
       'NGOOD_I', 'NGOOD_Z', 'NGOOD_Y', 'source_id_1', 'RAdeg', 'DEdeg', 'Plx',
       'e_Plx', 'pmRA', 'e_pmRA', 'pmDE', 'e_pmDE', 'RUWE', 'G', 'e_G', 'BP',
       'e_BP', 'RP', 'e_RP', 'bp_rp', 'NBPcont', 'NBPblend', 'NRPcont',
       'NRPblend', 'AG', 'E(BP-RP)', 'phot_bp_rp_excess_factor',
       'phot_variable_flag', 'in_qso_candidates', 'in_galaxy_candidates',
       'non_single_star', 'C_star', 'Decam_mag_g', 'Decam_mag_r',
       'Decam_mag_i', 'Decam_mag_i_corr', 'Decam_mag_z', 'Decam_mag_Y',
       'Decam_flux_g', 'Decam_flux_r', 'Decam_flux_i', 'Decam_flux_z',
       'Decam_flux_Y', 'Decam_flux_error_g', 'Decam_flux_error_r',
       'Decam_flux_error_i', 'Decam_flux_error_z', 'Decam_flux_error_Y',
       'Di_corr', 'Di_corr_2'],
      dtype='object')
```

In [246...

```
#https://stackoverflow.com/questions/31573572/healpy-from-data-to-healpix-map

ra_list=df1['RA'].tolist()
dec_list=df1['DEC'].tolist()
myfl=df1['Di_corr_2'].tolist()
phis = [np.deg2rad(ra) for ra in ra_list]
thetas = [np.pi / 2 - np.deg2rad(dec) for dec in dec_list]

nside = 70
# Go from HEALPix coordinates to indices
indices = hp.ang2pix(nside, thetas, phis)
# Initate the map and fill it with the values

nsources = len(myfl)
fs = myfl
npix = hp.nside2npix(nside)


hpxmap = np.zeros(npix, dtype=np.float) #;;;USING NUMPY
for i in range(nsources):
    hpxmap[indices[i]] += fs[i]

#hpxmap3 = np.zeros(npix, dtype=np.float) #;;;USING NUMPY
#for row in range(N):
#   for col in range(T):
#      dW[ x[row,col]  , :] += dout[row,col, :]

# Using numpy.add.at
# time: ~0.6 ms
hpxmap2 = np.zeros(npix, dtype=np.float) #different way still NUMPY
countmap= np.zeros(npix, dtype=np.float)
np.add.at(hpxmap2, indices, fs)
np.add.at(countmap, indices, 1)

hpxmap2=hpxmap2/(countmap)

#There is a function in NumPy called np.add.at which allows to add
#values to elements accessed by multi-index with repeated elements,
#such that for each repeated element all its corresponding values
#will be considered in the summation. E.g. see an example:
#A = np.zeros(5)
#np.add.at(A, [1, 1, 2], 1)
#A
#
#produces:
#
#array([0., 2., 1., 0., 0.])
#


# Inspect the map
hp.mollview(hpxmap2,title = ' DES-coverage', cbar = True, rot=(200, 180, 180), cmap
hp.graticule()
plt.show()
```

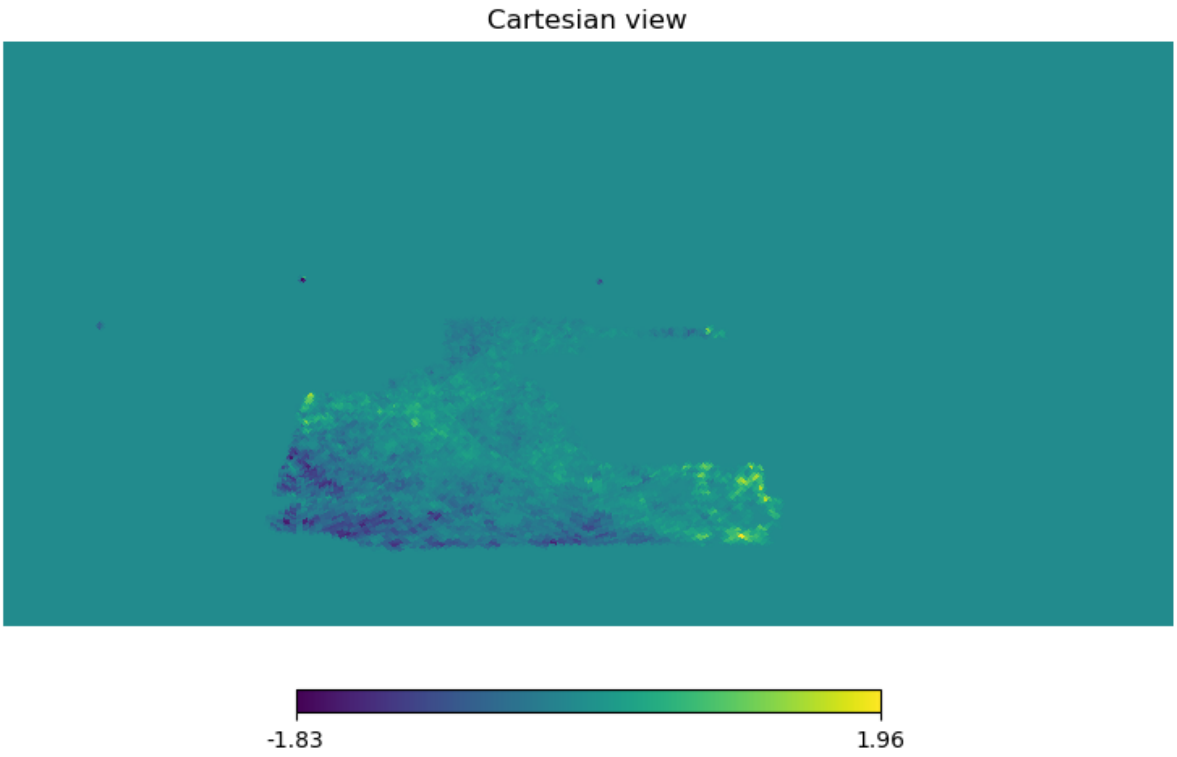
```
/var/folders/xj/dk8brxp96wd7smjjv42dznsm0000gp/T/ipykernel_71747/2912707839.py:19: D
eprecationWarning: `np.float` is a deprecated alias for the builtin `float`. To sile
nce this warning, use `float` by itself. Doing this will not modify any behavior and
is safe. If you specifically wanted the numpy scalar type, use `np.float64` here.
Deprecated in NumPy 1.20; for more details and guidance: https://numpy.org/devdocs/r
elease/1.20.0-notes.html#deprecations
  hpxmap = np.zeros(npix, dtype=np.float) #;;;USING NUMPY
/var/folders/xj/dk8brxp96wd7smjjv42dznsm0000gp/T/ipykernel_71747/2912707839.py:30: D
eprecationWarning: `np.float` is a deprecated alias for the builtin `float`. To sile
nce this warning, use `float` by itself. Doing this will not modify any behavior and
is safe. If you specifically wanted the numpy scalar type, use `np.float64` here.
Deprecated in NumPy 1.20; for more details and guidance: https://numpy.org/devdocs/r
elease/1.20.0-notes.html#deprecations
  hpxmap2 = np.zeros(npix, dtype=np.float) #different way still NUMPY
/var/folders/xj/dk8brxp96wd7smjjv42dznsm0000gp/T/ipykernel_71747/2912707839.py:31: D
eprecationWarning: `np.float` is a deprecated alias for the builtin `float`. To sile
nce this warning, use `float` by itself. Doing this will not modify any behavior and
is safe. If you specifically wanted the numpy scalar type, use `np.float64` here.
Deprecated in NumPy 1.20; for more details and guidance: https://numpy.org/devdocs/r
elease/1.20.0-notes.html#deprecations
  countmap= np.zeros(npix, dtype=np.float)
/var/folders/xj/dk8brxp96wd7smjjv42dznsm0000gp/T/ipykernel_71747/2912707839.py:35: R
untimeWarning: invalid value encountered in true_divide
  hpxmap2=hpxmap2/(countmap)
```



In [254…

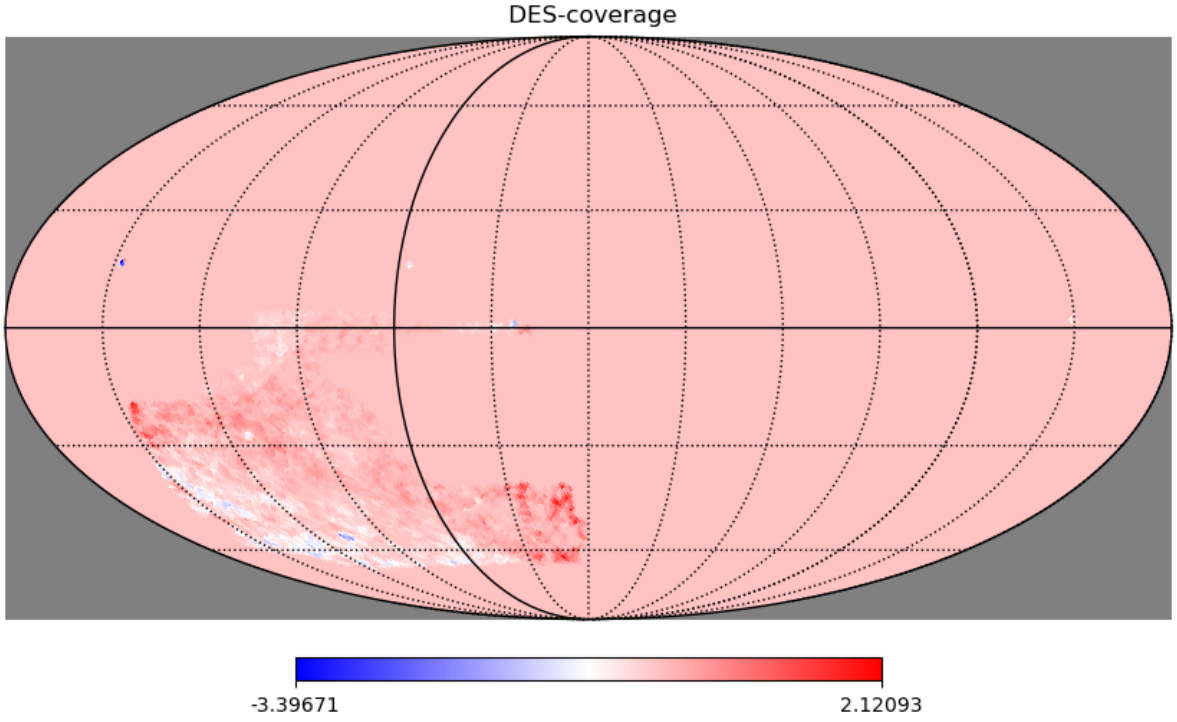
```
import healpy as hp
import pylab
from healpy.newvisufunc import projview, newprojplot
projview(hpxmap2, coord=["G"],
         graticule=True,
         graticule_labels=True,
    flip="astro",
    unit="delta_I",
    xlabel="longitude",
    ylabel="latitude",
    cb_orientation="vertical",
         norm='symlog2',
    projection_type="mollweide")
plt.savefig('map_moll.eps',dpi=1200,bbox_inches="tight",)
pylab.savefig('map_moll.png',bbox_inches="tight")
```

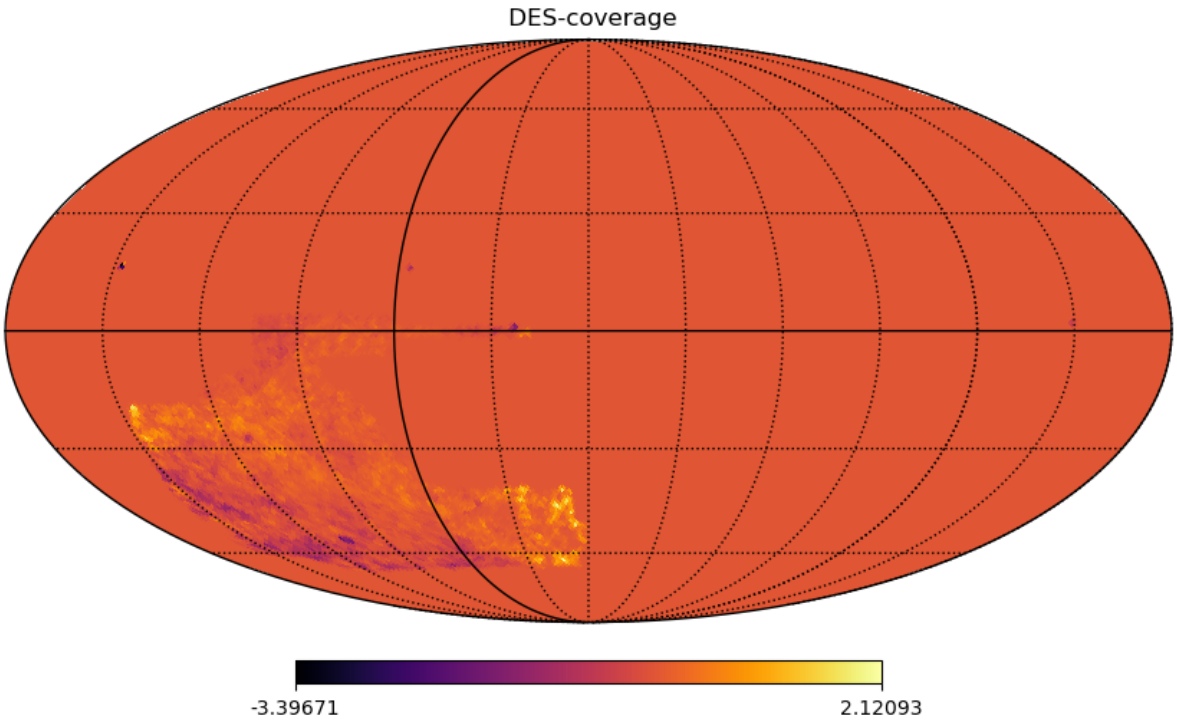
In [22]:
```
hp.cartview(hpxmap,fig=1,xsize=12000) #12000 pixels corresponds to ~2arcmin
plt.savefig('myFile.eps',dpi=1200)
```

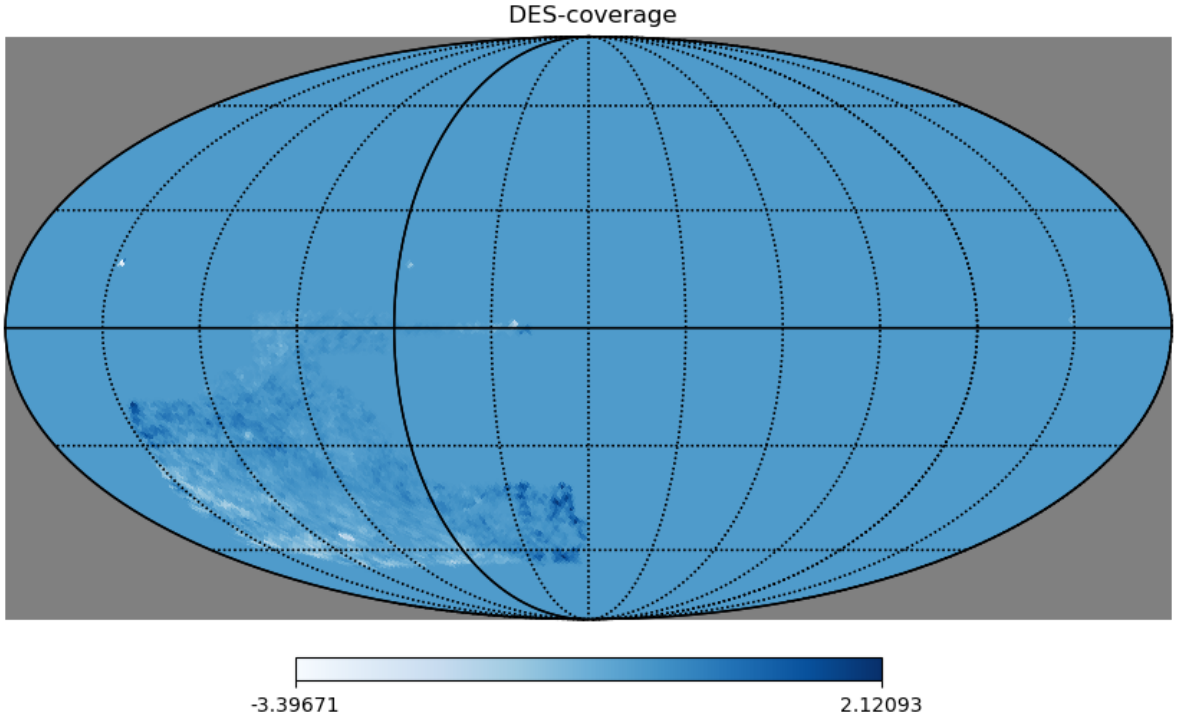


In [ ]:
```
from healpy import mollview
from pylab import arange, show, cm, Normalize
m = arange(768)
hp.mollview(hpxmap,title = ' DES-coverage', cbar = True, rot=(120, 180, 180), cmap
hp.graticule()

mollview(m, cmap=cm.bwr, norm=Normalize(vmin=0, vmax=768))
show()
```

In [257...
```
from healpy import mollview
from pylab import arange, show, cm, Normalize
m = arange(768)
m = arange(500)

hp.mollview(hpxmap,cmap=cm.bwr,norm=Normalize(vmin=0, vmax=768),title = ' DES-cover
hp.graticule()
plt.show()

# adjusting the colour map
cmap = cm.inferno
cmap.set_under('w')
cmap.set_bad('grey')

hp.mollview(hpxmap,cmap=cmap,title = ' DES-coverage', cbar = True, rot=(120, 180, 1
hp.graticule()
plt.show()


cmap = cm.Blues #cm.inferno
hp.mollview(hpxmap,norm='symlog2',cmap=cmap,title = ' DES-coverage', cbar = True, r
hp.graticule()

    # Plot mask
hp.visufunc.graticule()
plt.show()
```

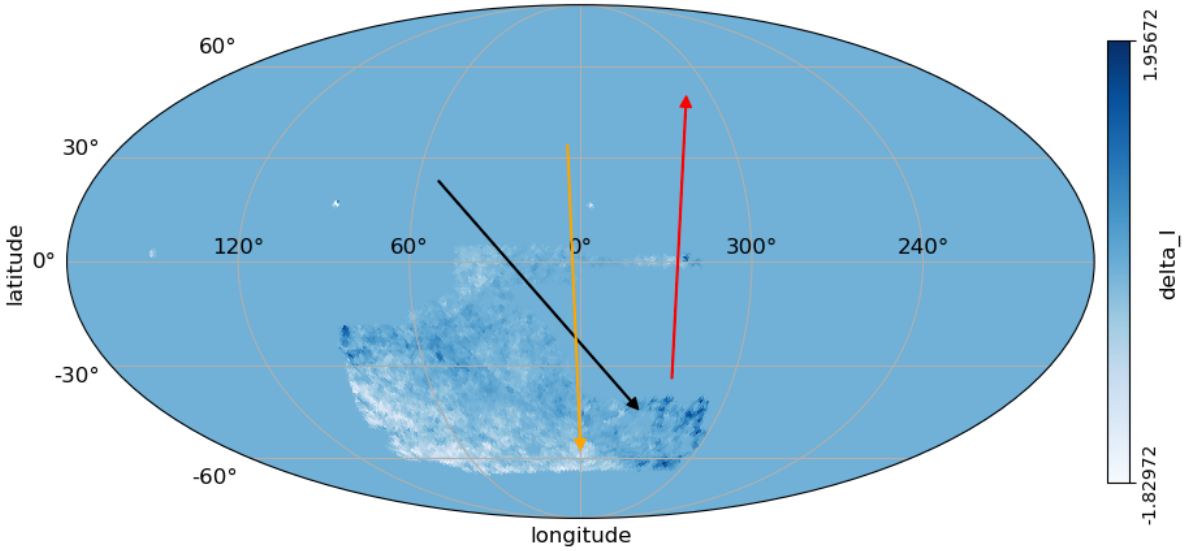

DES-coverage
-3.39671
2.12093


DES-coverage
-3.39671
2.12093



In [179…

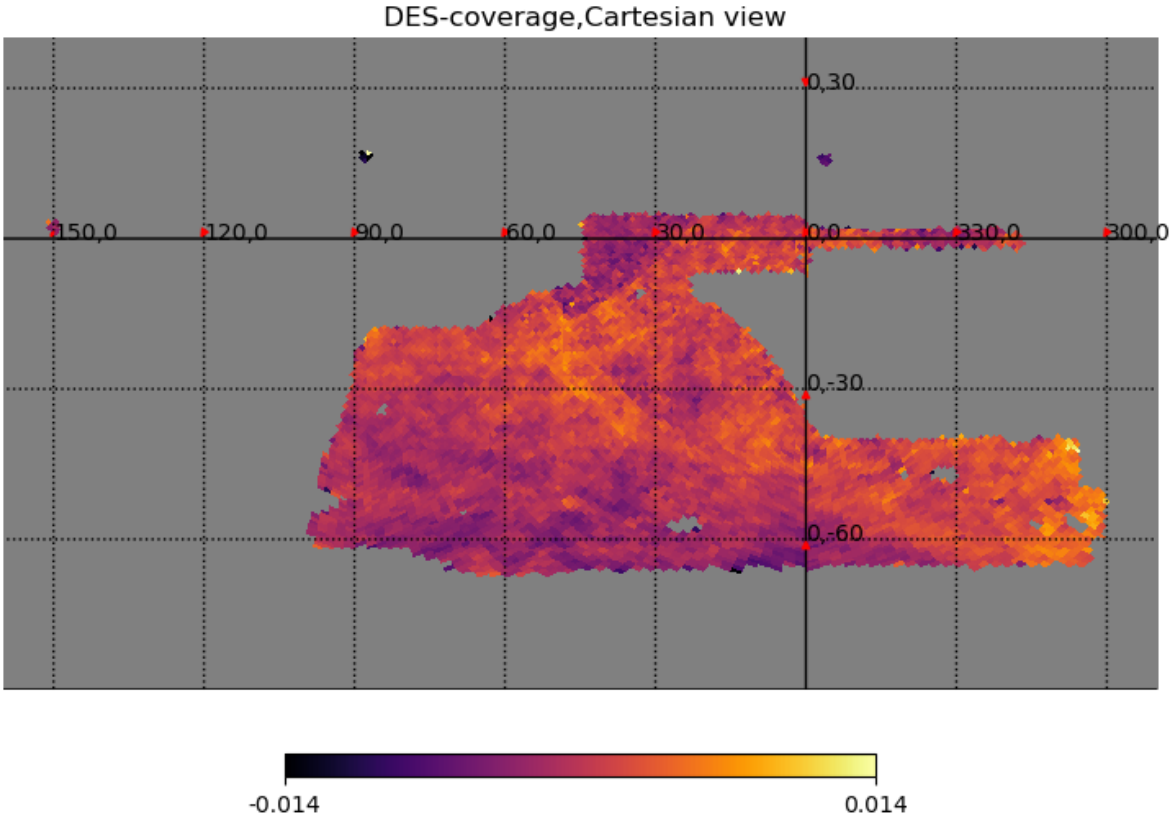
```
import healpy as hp
import pylab
from healpy.newvisufunc import projview, newprojplot
projview(hpxmap, coord=["G"],
         graticule=True,
         graticule_labels=True,
    flip="astro",
    unit="delta_I",
    xlabel="longitude",
    ylabel="latitude",
    cb_orientation="vertical",
         norm='symlog2',
    projection_type="mollweide",
        cmap=cmap)

def mollweid_vec(lat_start,long_start,lat_end,long_end,color,width,headwidth,headle
    proj = hp.projector.MollweideProj()
    plt.annotate('', xy=(proj.ang2xy(lat_end, long_end,lonlat=True)), xytext=(proj.

mollweid_vec(90,30,-60,-60,'black',0.5,6,6)
mollweid_vec(10,45,120,-90,'orange',0.5,6,6)
mollweid_vec(-70,-45,30,110,'red',0.5,6,6)

plt.show()
```


60°
30°
0°
-30°
-60°
latitude
120°
60°
0°
300°
240°
longitude
1.95672
delta_l
-1.82972

In [252...

```
cmap = cm.inferno
test=hp.cartview(hpxmap2,title = ' DES-coverage,Cartesian view',cmap=cmap,
            cbar = True,
            lonra=[-70,160],
           latra=[-90,40],
           return_projected_map=True,
           notext=True, min=-0.014,max=0.014)
#plt.imshow(test, origin='lower',extent=(-70,160,-90,40), interpolation = 'none')

hp.graticule()

def mollweid_vec(lat_start,long_start,lat_end,long_end,color,width,headwidth,headle
    proj = hp.projector.CartesianProj()
    plt.annotate('0,0', xy=(proj.ang2xy(lat_end, long_end,lonlat=True)), xytext=(pr
mollweid_vec(0,0,0.5,0.5,'red',0.2,3,3)

def mollweid_vec(lat_start,long_start,lat_end,long_end,color,width,headwidth,headle
    proj = hp.projector.CartesianProj()
    plt.annotate('0,30', xy=(proj.ang2xy(lat_end, long_end,lonlat=True)), xytext=(p
mollweid_vec(0,30,0,30.5,'red',0.2,3,3)

def mollweid_vec(lat_start,long_start,lat_end,long_end,color,width,headwidth,headle
    proj = hp.projector.CartesianProj()
    plt.annotate('0,-30', xy=(proj.ang2xy(lat_end, long_end,lonlat=True)), xytext=(
mollweid_vec(0,-30,0,-30.5,'red',0.2,3,3)

def mollweid_vec(lat_start,long_start,lat_end,long_end,color,width,headwidth,headle
    proj = hp.projector.CartesianProj()
    plt.annotate('0,-60', xy=(proj.ang2xy(lat_end, long_end,lonlat=True)), xytext=(
mollweid_vec(0,-60,0,-60.5,'red',0.2,3,3)

def mollweid_vec(lat_start,long_start,lat_end,long_end,color,width,headwidth,headle
    proj = hp.projector.CartesianProj()
    plt.annotate('0,-90', xy=(proj.ang2xy(lat_end, long_end,lonlat=True)), xytext=(
mollweid_vec(0,-90,0,-90.5,'red',0.2,3,3)

def mollweid_vec(lat_start,long_start,lat_end,long_end,color,width,headwidth,headle
    proj = hp.projector.CartesianProj()
    plt.annotate('30,0', xy=(proj.ang2xy(lat_end, long_end,lonlat=True)), xytext=(p
mollweid_vec(30,0,30.5,0.5,'red',0.2,3,3)

def mollweid_vec(lat_start,long_start,lat_end,long_end,color,width,headwidth,headle
    proj = hp.projector.CartesianProj()
    plt.annotate('60,0', xy=(proj.ang2xy(lat_end, long_end,lonlat=True)), xytext=(p
mollweid_vec(60,0,60.5,0.5,'red',0.2,3,3)

def mollweid_vec(lat_start,long_start,lat_end,long_end,color,width,headwidth,headle
    proj = hp.projector.CartesianProj()
    plt.annotate('90,0', xy=(proj.ang2xy(lat_end, long_end,lonlat=True)), xytext=(p
mollweid_vec(90,0,90.5,0.5,'red',0.2,3,3)

def mollweid_vec(lat_start,long_start,lat_end,long_end,color,width,headwidth,headle
    proj = hp.projector.CartesianProj()
    plt.annotate('120,0', xy=(proj.ang2xy(lat_end, long_end,lonlat=True)), xytext=(
mollweid_vec(120,0,120.5,0.5,'red',0.2,3,3)

def mollweid_vec(lat_start,long_start,lat_end,long_end,color,width,headwidth,headle
    proj = hp.projector.CartesianProj()
    plt.annotate('150,0', xy=(proj.ang2xy(lat_end, long_end,lonlat=True)), xytext=(
mollweid_vec(150,0,150.5,0.5,'red',0.2,1,1)

def mollweid_vec(lat_start,long_start,lat_end,long_end,color,width,headwidth,headle
    proj = hp.projector.CartesianProj()
    plt.annotate('300,0', xy=(proj.ang2xy(lat_end, long_end,lonlat=True)), xytext=(
mollweid_vec(300,0,300.5,0.5,'red',0.2,3,3)

def mollweid_vec(lat_start,long_start,lat_end,long_end,color,width,headwidth,headle
```

```
def mollweid_vec(lat_start,long_start,lat_end,long_end,color,width,headwidth,headle
    proj = hp.projector.CartesianProj()
    plt.annotate('330,0', xy=(proj.ang2xy(lat_end, long_end,lonlat=True)), xytext=(
mollweid_vec(330,0,330.5,0.5,'red',0.2,3,3)


plt.show()
#plt.savefig('map_cart.eps',dpi=1200,bbox_inches="tight",)
#pylab.savefig('map_cart.png',bbox_inches="tight")
```



In [ ]:

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