In [1]:
```
import astropy.units as u
import numpy as np
from astroquery.gaia import Gaia
from joblib import Memory
import matplotlib.pyplot as plt
from matplotlib import colors
```

```
Created TAP+ (v1.2.1) - Connection:
        Host: gea.esac.esa.int
        Use HTTPS: True
        Port: 443
        SSL Port: 443
Created TAP+ (v1.2.1) - Connection:
        Host: geadata.esac.esa.int
        Use HTTPS: True
        Port: 443
        SSL Port: 443
```

In [2]:
```
def get_gaia_query_results(ra=66.75, dec=15.86, radius=2, conds="", lim
it=50000):
    add = ""
    if conds != "":
        add = f"AND {conds}"
    query = f"""
    SELECT TOP {limit} *
    FROM gaiaedr3.gaia_source
    WHERE
        CONTAINS(
            POINT('ICRS',gaiaedr3.gaia_source.ra,gaiaedr3.gaia_source.d
ec),
            CIRCLE('ICRS',{ra},{dec},{radius})
        )=1
    """ + add
    job = Gaia.launch_job_async(query)
    return job.get_results()
```

In [3]:
```
location = "./cachedir"
memory = Memory(location, verbose=0)
get_gaia_query_results_cached = memory.cache(get_gaia_query_results)
```

In [33]:
```
stringent_conds = '''
    parallax_over_error > 10
    AND ABS(parallax - 21.052) < 5
    AND ABS(pmra-4.614) < 300
    AND ABS(pmdec+7.705) < 400
    AND phot_g_mean_flux_over_error>25
    AND phot_rp_mean_flux_over_error>10
    AND phot_bp_mean_flux_over_error>10
    AND pmra_error < 0.1
    AND pmdec_error < 0.1
    AND phot_bp_rp_excess_factor < 1.3+0.06*power(phot_bp_mean_mag-phot
_rp_mean_mag,2)
    AND phot_bp_rp_excess_factor > 1.0+0.015*power(phot_bp_mean_mag-pho
t_rp_mean_mag,2)
    AND astrometric_excess_noise < 1
'''
print("Starting stringent query...")
hyades_stringent = get_gaia_query_results_cached(radius = 5, conds = st
ringent_conds)
```

```
Starting stringent query...
```

In [34]:
```
less_conds = '''
    parallax_over_error > 10
    AND phot_g_mean_flux_over_error>50
    AND phot_rp_mean_flux_over_error>20
    AND phot_bp_mean_flux_over_error>20
    AND pmra_error < 0.1
    AND pmdec_error < 0.1
    AND phot_bp_rp_excess_factor < 1.3+0.06*power(phot_bp_mean_mag-phot
_rp_mean_mag,2)
    AND phot_bp_rp_excess_factor > 1.0+0.015*power(phot_bp_mean_mag-pho
t_rp_mean_mag,2)
    AND astrometric_excess_noise < 1
'''
print("Starting condless query...")
hyades_condless = get_gaia_query_results_cached(radius = 5, conds=less_
conds)
```

```
Starting condless query...
```

Stringent Conditions

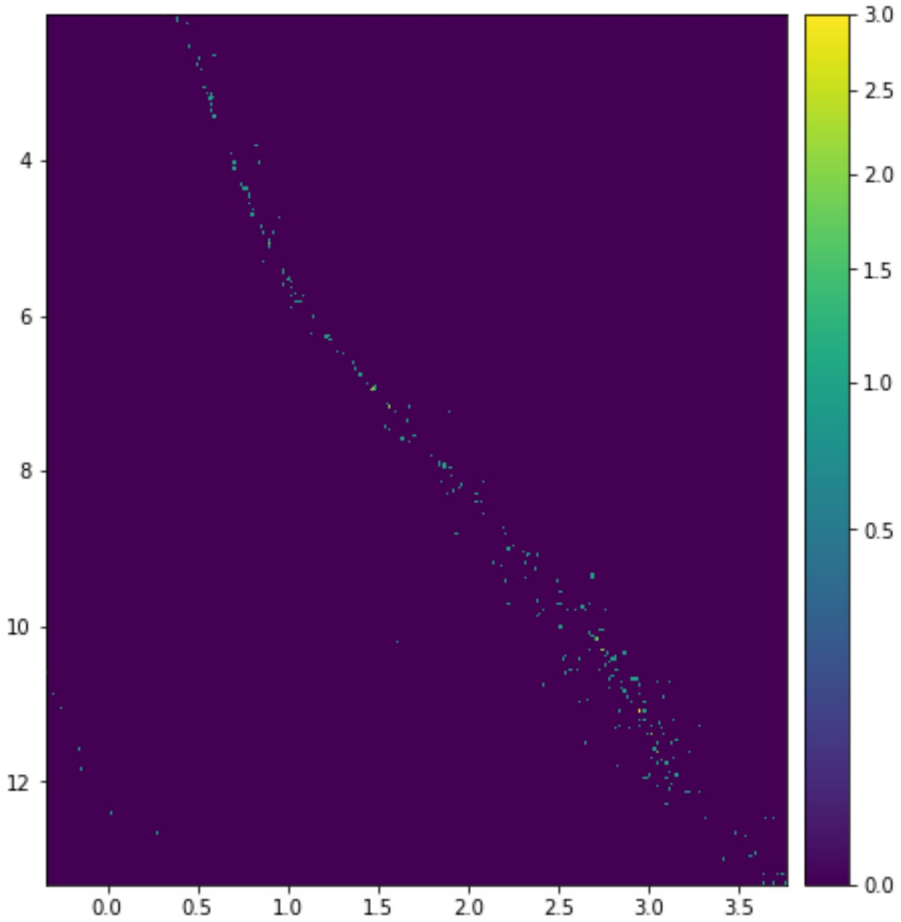
In [35]:
```
hyades_stringent
```

Out[35]: *Table length=247*

solution_id	designation	source_id	random_index	ref_epoch	
				yr	
int64	object	int64	int64	float64	
1636042515805110273	Gaia EDR3 45142206521351552	45142206521351552	36940397	2016.0	(
1636042515805110273	Gaia EDR3 45159901786885632	45159901786885632	945169460	2016.0	6
1636042515805110273	Gaia EDR3 45181651500848512	45181651500848512	1774298952	2016.0	(
1636042515805110273	Gaia EDR3 45198178534988672	45198178534988672	135362061	2016.0	(
1636042515805110273	Gaia EDR3 45968901826385024	45968901826385024	1207707882	2016.0	6
1636042515805110273	Gaia EDR3 45980377978968064	45980377978968064	1408778786	2016.0	6
1636042515805110273	Gaia EDR3 45293526808851200	45293526808851200	1536127738	2016.0	6
1636042515805110273	Gaia EDR3 46056862756712320	46056862756712320	1095147488	2016.0	(
1636042515805110273	Gaia EDR3 45367056650753280	45367056650753280	1589094382	2016.0	6
...	...	...	...	...	
1636042515805110273	Gaia EDR3 3308216770405335296	3308216770405335296	1661212099	2016.0	(
1636042515805110273	Gaia EDR3 3308269757418376576	3308269757418376576	1264895589	2016.0	
1636042515805110273	Gaia EDR3 3308356378319035136	3308356378319035136	720407392	2016.0	
1636042515805110273	Gaia EDR3 3308403897837092992	3308403897837092992	1329231947	2016.0	
1636042515805110273	Gaia EDR3 3308433069254919424	3308433069254919424	139838635	2016.0	
1636042515805110273	Gaia EDR3 3308851433430549632	3308851433430549632	830108508	2016.0	
1636042515805110273	Gaia EDR3 144121239687649536	144121239687649536	605770928	2016.0	(
1636042515805110273	Gaia EDR3 144171233106399104	144171233106399104	668710816	2016.0	(
1636042515805110273	Gaia EDR3 144252253369327360	144252253369327360	1203648749	2016.0	(
1636042515805110273	Gaia EDR3 144290220880929664	144290220880929664	1556290670	2016.0	

In [37]:
```
bp_rp_hyades = hyades_stringent['bp_rp'].data
phot_g_mean_mag_hyades = hyades_stringent['phot_g_mean_mag'].data
parallax_hyades = hyades_stringent['parallax'].data
pmra_hyades = hyades_stringent['pmra'].data
pmdec_hyades = hyades_stringent['pmdec'].data
mg_hyades = phot_g_mean_mag_hyades+5*np.log10(parallax_hyades)-10
```

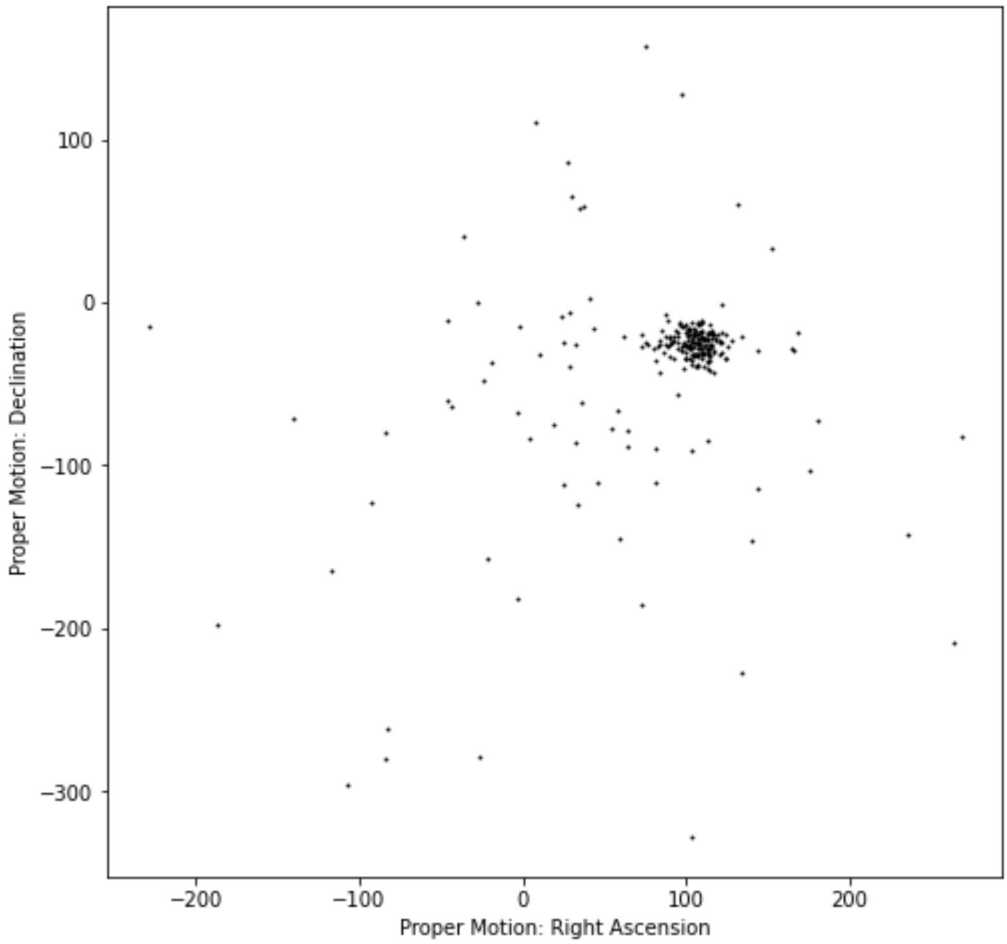
In [38]:
```
fig, ax = plt.subplots(figsize=(8,8))
h = ax.hist2d(bp_rp_hyades,mg_hyades,bins=300, norm=colors.PowerNorm(0.
5), zorder=0.5)
ax.scatter(bp_rp_hyades, mg_hyades, alpha=0.05, s=1, color='k', zorder=
0)
ax.invert_yaxis()
cb = plt.colorbar(h[3], ax=ax, pad=0.02)
plt.show()
```



In [40]:
```
print(f"RA mean: {np.mean(pmra_hyades)}, DEC mean:{np.mean(pmdec_hyade
s)}")
print(f"RA max: {np.max(pmra_hyades)}, DEC max: {np.max(pmdec_hyade
s)}")
print(f"RA min: {np.min(pmra_hyades)}, DEC min: {np.min(pmdec_hyade
s)}")
```

```
RA mean: 86.74581812332562, DEC mean:-38.3022036078993
RA max: 268.45112859881044, DEC max: 157.6947104412314
RA min: -229.02440169940525, DEC min: -327.9489428466409
```

In [41]:
```
fig, ax = plt.subplots(figsize=(8,8))
ax.scatter(pmra_hyades, pmdec_hyades, s=1, color='k')
plt.xlabel("Proper Motion: Right Ascension")
plt.ylabel("Proper Motion: Declination")
plt.show()
```



Conditionless (Limit 50,000)

In [42]:
```
hyades_condless
```

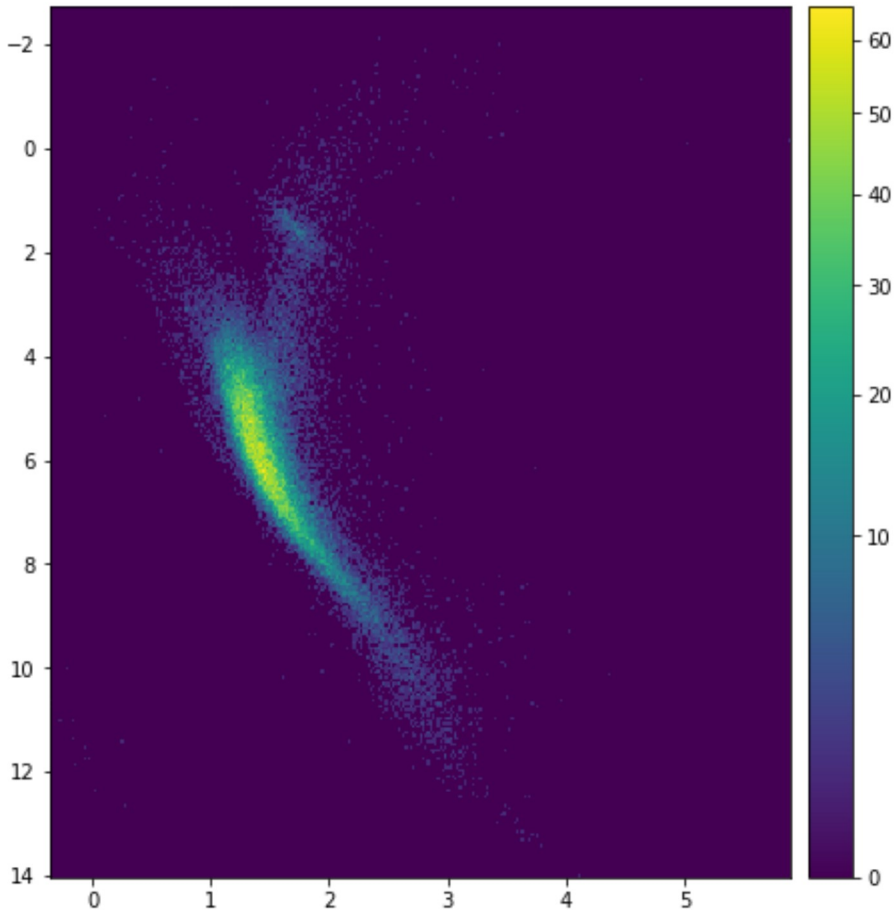
Out[42]: *Table length=50000*

solution_id	designation	source_id	random_index	ref_epoch	
				yr	
int64	object	int64	int64	float64	
1636042515805110273	Gaia EDR3 45903549604109184	45903549604109184	225872416	2016.0	
1636042515805110273	Gaia EDR3 45903583963848320	45903583963848320	1616775635	2016.0	
1636042515805110273	Gaia EDR3 45036103649325696	45036103649325696	874724449	2016.0	
1636042515805110273	Gaia EDR3 45036305511396480	45036305511396480	1606856282	2016.0	
1636042515805110273	Gaia EDR3 45036309807755776	45036309807755776	1195513971	2016.0	
1636042515805110273	Gaia EDR3 45036619045396480	45036619045396480	966912282	2016.0	
1636042515805110273	Gaia EDR3 45036619045397120	45036619045397120	1138617018	2016.0	6
1636042515805110273	Gaia EDR3 45036619045397376	45036619045397376	140782634	2016.0	
1636042515805110273	Gaia EDR3 45036683468516352	45036683468516352	1645325102	2016.0	
...	...	...	...	...	
1636042515805110273	Gaia EDR3 3304122811874937344	3304122811874937344	829823214	2016.0	
1636042515805110273	Gaia EDR3 3304123018033368320	3304123018033368320	378357629	2016.0	
1636042515805110273	Gaia EDR3 3306618050435084416	3306618050435084416	1252700344	2016.0	
1636042515805110273	Gaia EDR3 3306618119154560768	3306618119154560768	314580416	2016.0	
1636042515805110273	Gaia EDR3 3306618153514125312	3306618153514125312	967027812	2016.0	
1636042515805110273	Gaia EDR3 3306618394032291200	3306618394032291200	703725814	2016.0	
1636042515805110273	Gaia EDR3 3306618394032292608	3306618394032292608	742184858	2016.0	
1636042515805110273	Gaia EDR3 3304123224191795584	3304123224191795584	102504923	2016.0	
1636042515805110273	Gaia EDR3 3304123258551533440	3304123258551533440	421538884	2016.0	
1636042515805110273	Gaia EDR3 3306618634550457216	3306618634550457216	1361421491	2016.0	

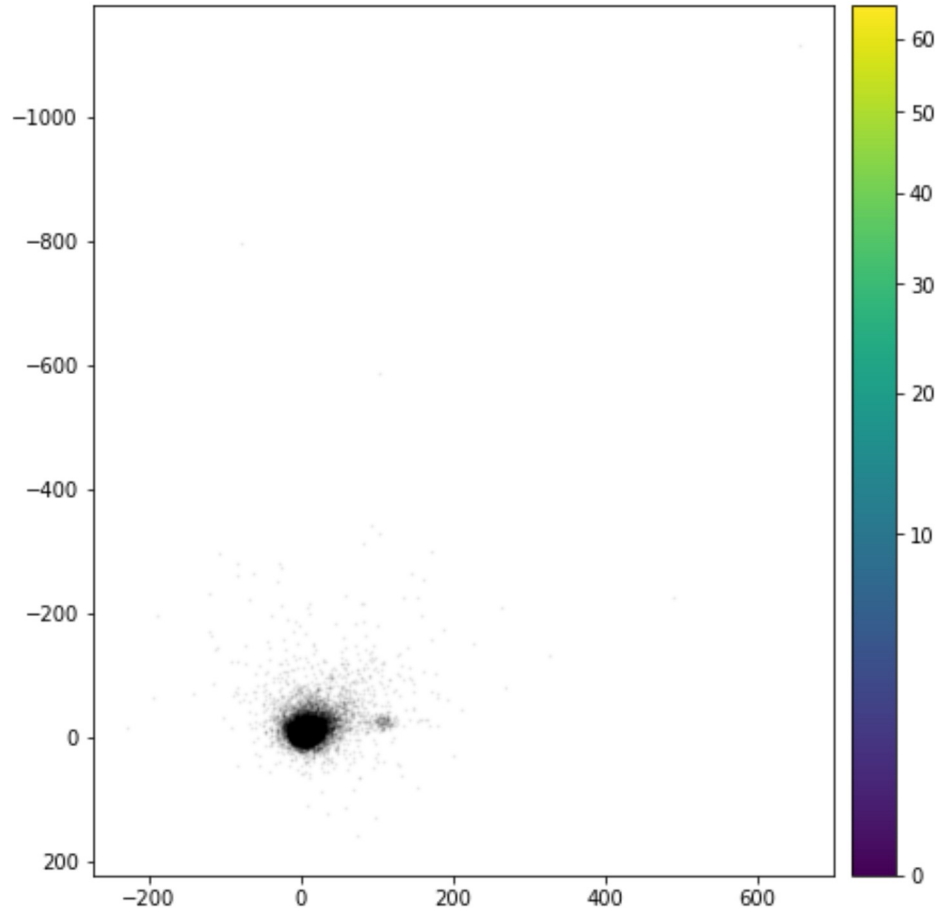
In [43]:
```
hyades_condless_pd = hyades_condless.to_pandas()
hyades_condless_pd = hyades_condless_pd[hyades_condless_pd['parallax'].
notna()]
hyades_condless_pd = hyades_condless_pd[hyades_condless_pd['parallax']
> 0.5]
hyades_condless_pd = hyades_condless_pd[hyades_condless_pd['bp_rp'].not
na()]
```

In [44]:
```
bp_rp_hyades_condless = hyades_condless_pd['bp_rp']
phot_g_mean_mag_hyades_condless = hyades_condless_pd['phot_g_mean_mag']
parallax_hyades_condless = hyades_condless_pd['parallax']
pmra_hyades_condless = hyades_condless_pd['pmra']
pmdec_hyades_condless = hyades_condless_pd['pmdec']
mg_hyades_condless = phot_g_mean_mag_hyades_condless+5*np.log10(paralla
x_hyades_condless)-10
```

In [45]:
```
fig, ax = plt.subplots(figsize=(8,8))
h = ax.hist2d(bp_rp_hyades_condless,mg_hyades_condless,bins=300, norm=c
olors.PowerNorm(0.5), zorder=0.5)
ax.scatter(bp_rp_hyades_condless, mg_hyades_condless, alpha=0.05, s=1,
color='k', zorder=0)
ax.invert_yaxis()
cb = plt.colorbar(h[3], ax=ax, pad=0.02)
plt.show()
```



In [46]:
```
fig, ax = plt.subplots(figsize=(8,8))
ax.scatter(pmra_hyades_condless, pmdec_hyades_condless, alpha=0.05, s=
1, color='k', zorder=0)
ax.invert_yaxis()
cb = plt.colorbar(h[3], ax=ax, pad=0.02)
plt.show()
```



Isochrones, MIST Models

In [47]:
```
import sys
sys.path.append(".")
from glob import glob
from read_mist_models import ISOCMD
```

In [48]:
```
glob("*")
```

Out[48]:
```
['cachedir',
 'lab0.ipynb',
 'lab0.pdf',
 'Lab_0_Astr128_2021.pdf',
 'MIST_iso_60173edbd8484.iso.cmd',
 'MIST_iso_601751b1dcb3c.iso.cmd',
 'MIST_iso_6017590e63448.iso.cmd',
 'read_mist_models.py',
 '__pycache__']
```

In [63]:
```
mist_fnames = glob("MIST*.iso.cmd")
isocmd_02 = ISOCMD(mist_fnames[2])
isocmd_13 = ISOCMD(mist_fnames[0])
```

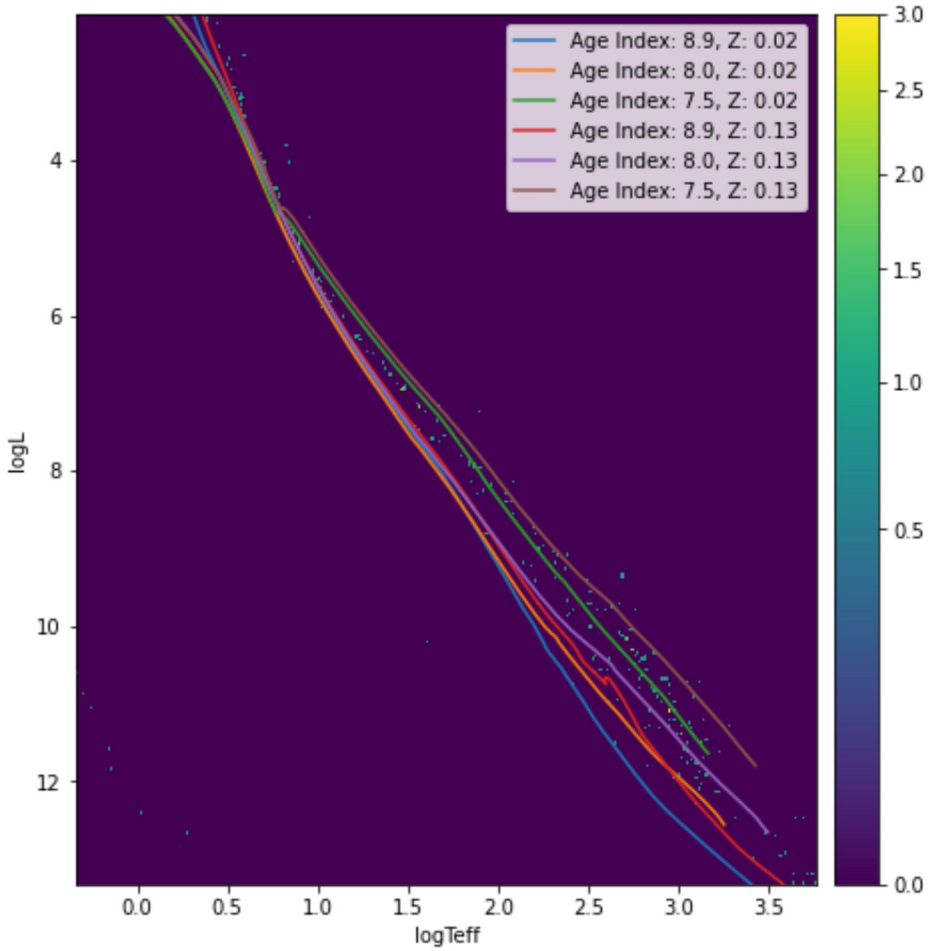
```
Reading in: MIST_iso_6017590e63448.iso.cmd
Reading in: MIST_iso_60173edbd8484.iso.cmd
```

In [64]:
```
print('version: ', isocmd.version)
print('photometric system: ', isocmd.photo_sys)
print('abundances: ', isocmd.abun)
print('rotation: ', isocmd.rot)
print('ages: ', [round(x,2) for x in isocmd.ages])
print('number of ages: ', isocmd.num_ages)
print('available columns: ', isocmd.hdr_list)
print('Av extinction: ', isocmd.Av_extinction)
```

```
version:  {'MIST': '1.2', 'MESA': '7503'}
photometric system:  UBV(RI)c, 2MASS, Kepler, Hipparcos, Gaia (Vega)
abundances:  {'Yinit': 0.2773, 'Zinit': 0.0188444, '[Fe/H]': 0.13,
'[a/Fe]': 0.0}
rotation:  0.4
ages:  [5.0, 5.05, 5.1, 5.15, 5.2, 5.25, 5.3, 5.35, 5.4, 5.45, 5.5,
5.55, 5.6, 5.65, 5.7, 5.75, 5.8, 5.85, 5.9, 5.95, 6.0, 6.05, 6.1, 6.1
5, 6.2, 6.25, 6.3, 6.35, 6.4, 6.45, 6.5, 6.55, 6.6, 6.65, 6.7, 6.75,
6.8, 6.85, 6.9, 6.95, 7.0, 7.05, 7.1, 7.15, 7.2, 7.25, 7.3, 7.35, 7.
4, 7.45, 7.5, 7.55, 7.6, 7.65, 7.7, 7.75, 7.8, 7.85, 7.9, 7.95, 8.0,
8.05, 8.1, 8.15, 8.2, 8.25, 8.3, 8.35, 8.4, 8.45, 8.5, 8.55, 8.6, 8.6
5, 8.7, 8.75, 8.8, 8.85, 8.9, 8.95, 9.0, 9.05, 9.1, 9.15, 9.2, 9.25,
9.3, 9.35, 9.4, 9.45, 9.5, 9.55, 9.6, 9.65, 9.7, 9.75, 9.8, 9.85, 9.
9, 9.95, 10.0, 10.05, 10.1, 10.15, 10.2, 10.25, 10.3]
number of ages:  107
available columns:  ['EEP', 'log10_isochrone_age_yr', 'initial_mass',
'star_mass', 'log_Teff', 'log_g', 'log_L', '[Fe/H]_init', '[Fe/H]', '
Bessell_U', 'Bessell_B', 'Bessell_V', 'Bessell_R', 'Bessell_I', '2MAS
S_J', '2MASS_H', '2MASS_Ks', 'Kepler_Kp', 'Kepler_D51', 'Hipparcos_Hp
', 'Tycho_B', 'Tycho_V', 'Gaia_G_DR2Rev', 'Gaia_BP_DR2Rev', 'Gaia_RP_
DR2Rev', 'Gaia_G_MAW', 'Gaia_BP_MAWb', 'Gaia_BP_MAWf', 'Gaia_RP_MAW',
'TESS', 'Gaia_G_EDR3', 'Gaia_BP_EDR3', 'Gaia_RP_EDR3', 'phase']
Av extinction:  0.0
```

In [65]:
```
def plot_temp_lum(isocmd = isocmd, age_index=5.0):
    age_ind = isocmd.age_index(age_index)
#     logTeff = isocmd.isocmds[age_ind]['log_Teff']
    logTeff = isocmd.isocmds[age_ind]['Gaia_BP_DR2Rev'] - isocmd.isocmd
s[age_ind]['Gaia_RP_DR2Rev']
    logL = isocmd.isocmds[age_ind]['Gaia_G_DR2Rev']
    fe_h = isocmd.abun['[Fe/H]']
#     print(isocmd.isocmds[age_ind]['[Fe/H]'])
    plt.plot(logTeff, logL, label=f"Age Index: {age_index}, Z: {fe_h}")
    plt.xlabel("logTeff")
    plt.ylabel("logL")
    plt.legend()
```

In [66]:
```
fig, ax = plt.subplots(figsize=(8,8))
h = ax.hist2d(bp_rp_hyades,mg_hyades,bins=300, norm=colors.PowerNorm(0.
5), zorder=0.5)
ax.scatter(bp_rp_hyades, mg_hyades, alpha=0.05, s=1, color='k', zorder=
0)
plot_temp_lum(isocmd_02, 8.9)
plot_temp_lum(isocmd_02, 8.0)
plot_temp_lum(isocmd_02, 7.5)
plot_temp_lum(isocmd_13, 8.9)
plot_temp_lum(isocmd_13, 8.0)
plot_temp_lum(isocmd_13, 7.5)
ax.invert_yaxis()
cb = plt.colorbar(h[3], ax=ax, pad=0.02)
plt.show()
```



In [ ]:
```
```