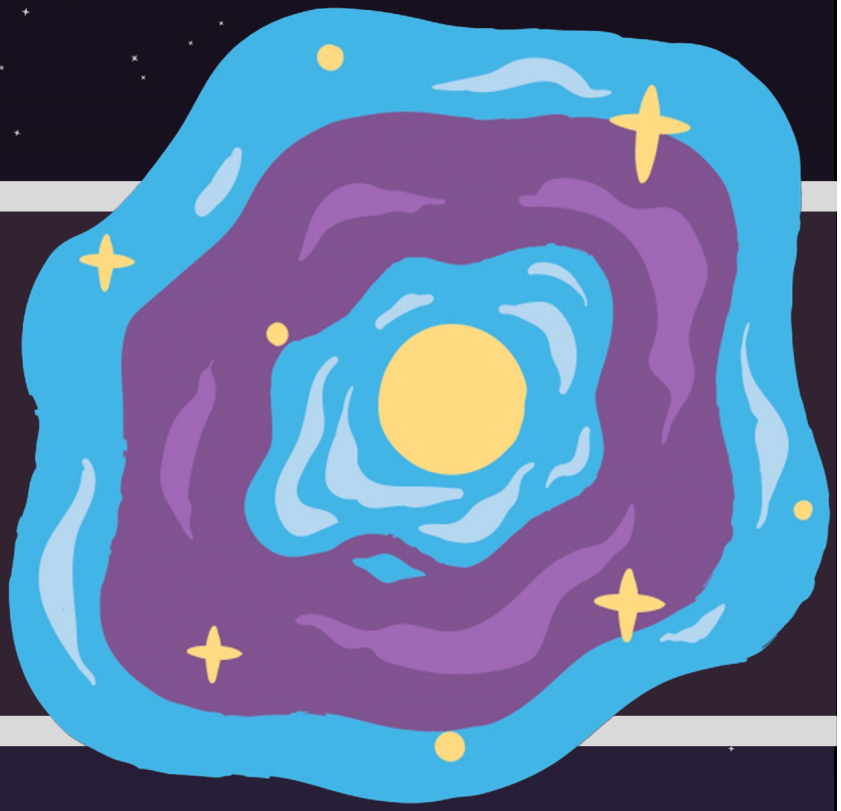
Applying Clustering Algorithms to X-ray Emission from Planetary Nebulae



Lizette Rodriguez

CENTER FOR ASTROPHYSICS
HARVARD & SMITHSONIAN

UTSA
Physics and Astronomy

CENTER FOR

ASTROPHYSICS

HARVARD & SMITHSONIAN

SMITHSONIAN ASTROPHYSICAL OBSERVATORY

About Me!

Rising physics junior at the University of Texas at San Antonio

My advisor is Rodolfo Montez

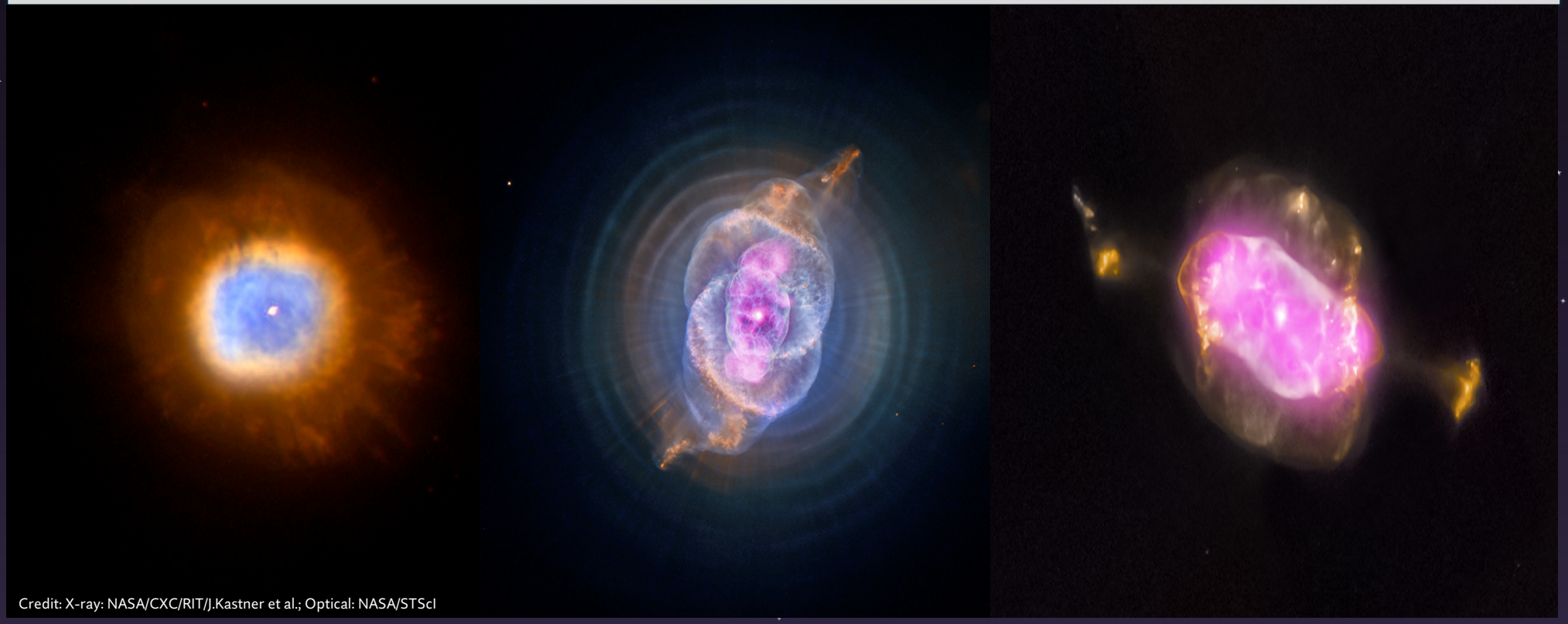
My favorite memory is watching The Hunger Games with friends

What are planetary nebulae, and how do they form?

Planetary nebulae are shells of ionized gas with white dwarfs at the center

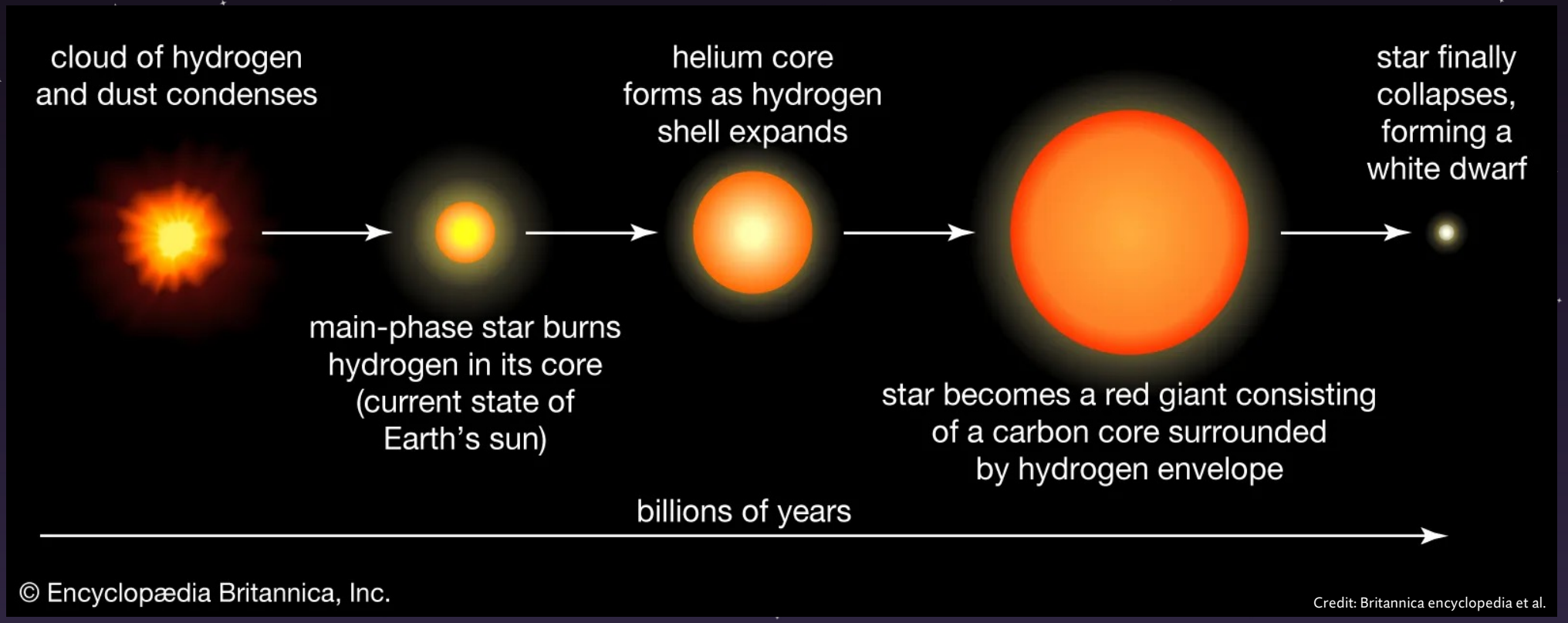
Planetary Nebulae are made from the following:

- Ionized gas
- Hot bubbles
- White dwarf(s)



Credit: X-ray: NASA/CXC/RIT/J.Kastner et al.; Optical: NASA/STScI

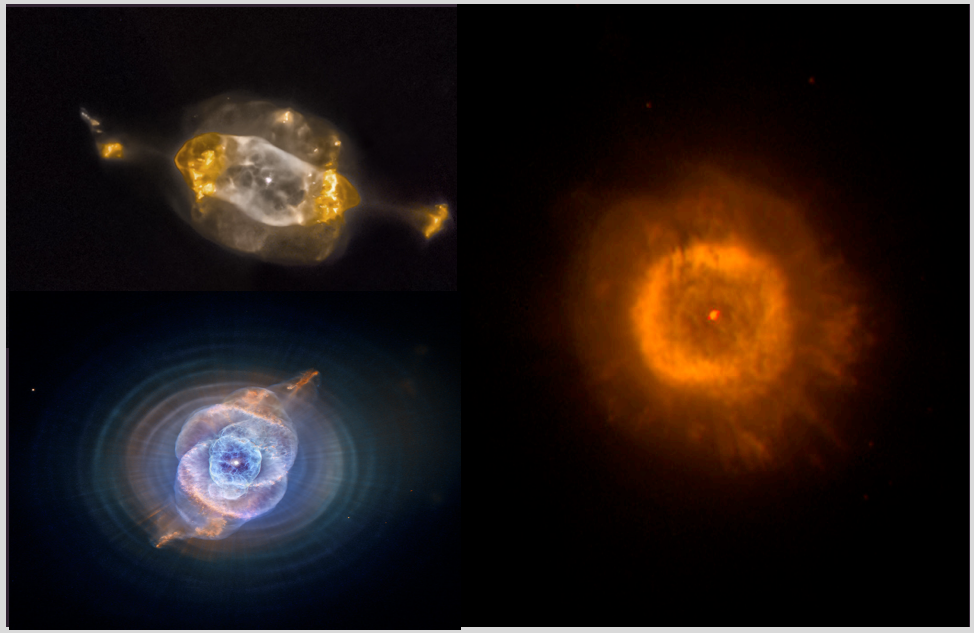
- Planetary nebulae form from intermediate-mass stars
- After a star expands into the red giant phase it will enter the AGB phase
- From the AGB phase, the star loses material that ends up in space
- After the star's core collapses the star dies and leaves ionized gas in space



Credit: Britannica encyclopedia et al.

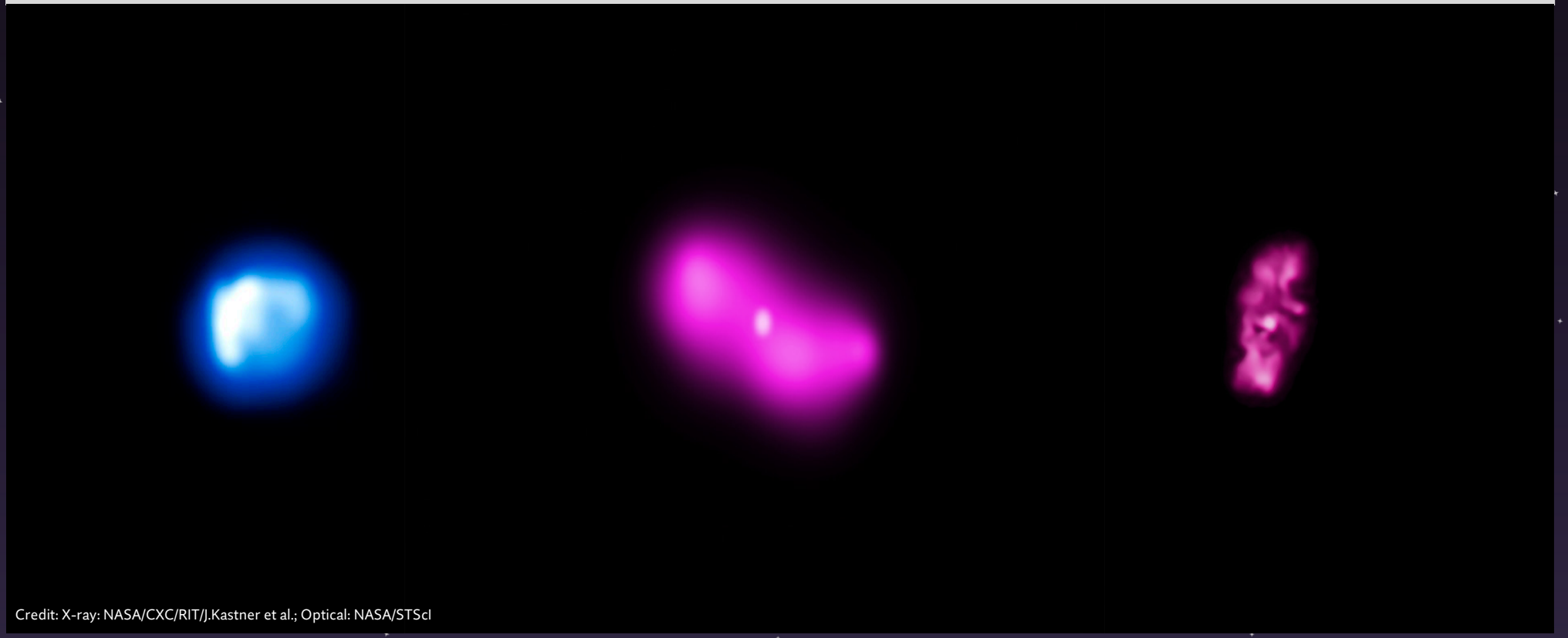
Chandra Observations

- Nebulas are observed by Chandra in the x-ray range (≥0.5 keV)
- The process we can observe in the nebula:
  - Diffuse X-Rays
  - Point like X-Rays



Credit: X-ray: NASA/CXC/RIT/J.Kastner et al.; Optical: NASA/STScI

X-ray Observations



Credit: X-ray: NASA/CXC/RIT/J.Kastner et al.; Optical: NASA/STScI

Hot Bubbles and Point-Like Sources

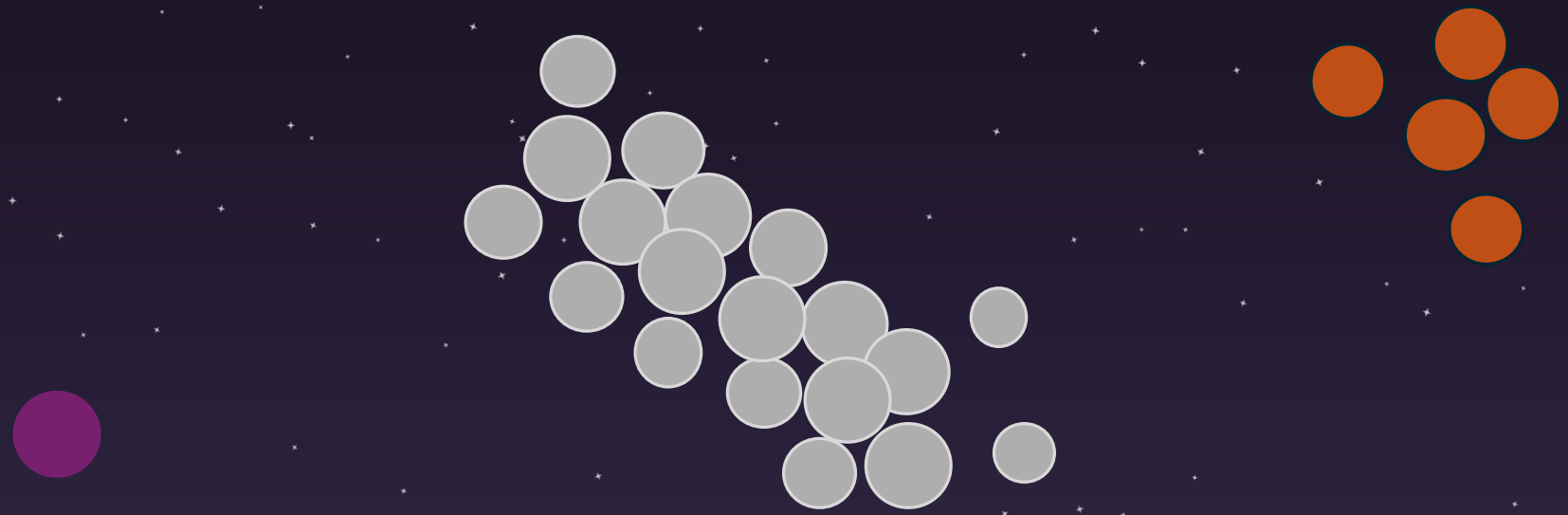
- Hot bubbles are formed through shocked winds and gas that collide with each other due to magnetic pull
- Hot bubbles emit soft X-rays from 0.3 to 1 keV

- Point-like sources refer to the X-ray emission of the white dwarf at the center of the nebula
- Point-like sources emit harder X-rays than hot bubbles
- Point-like sources are references for symmetry in the morphology of planetary nebula

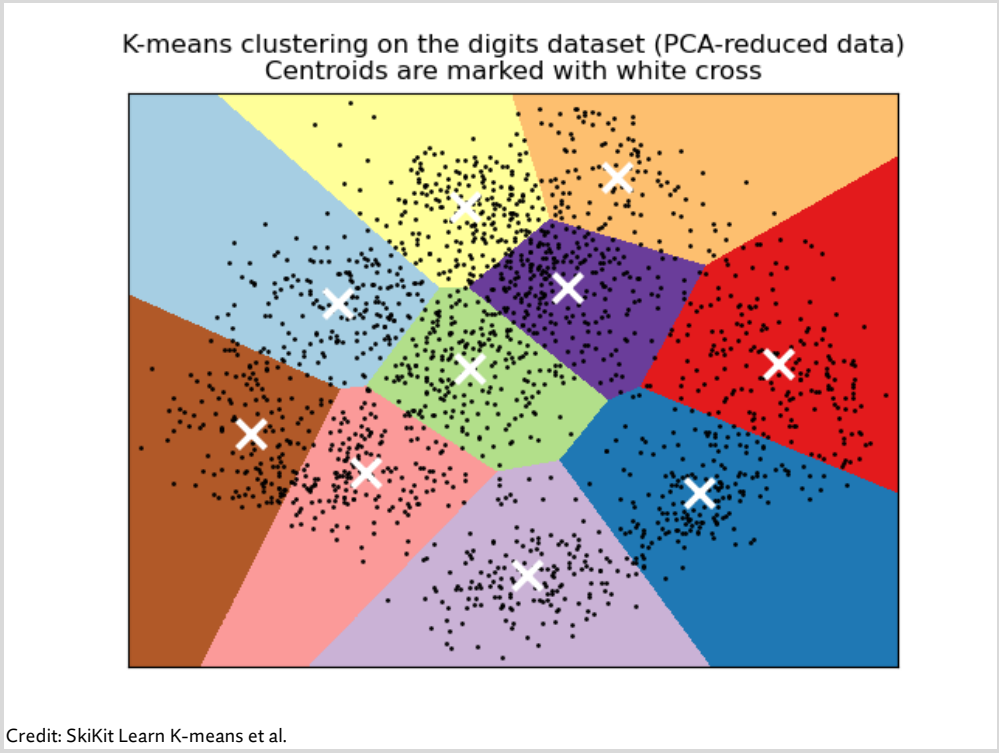
Can we use clustering algorithms to identify types of x-ray emission from PNe?

What Are Clusters?

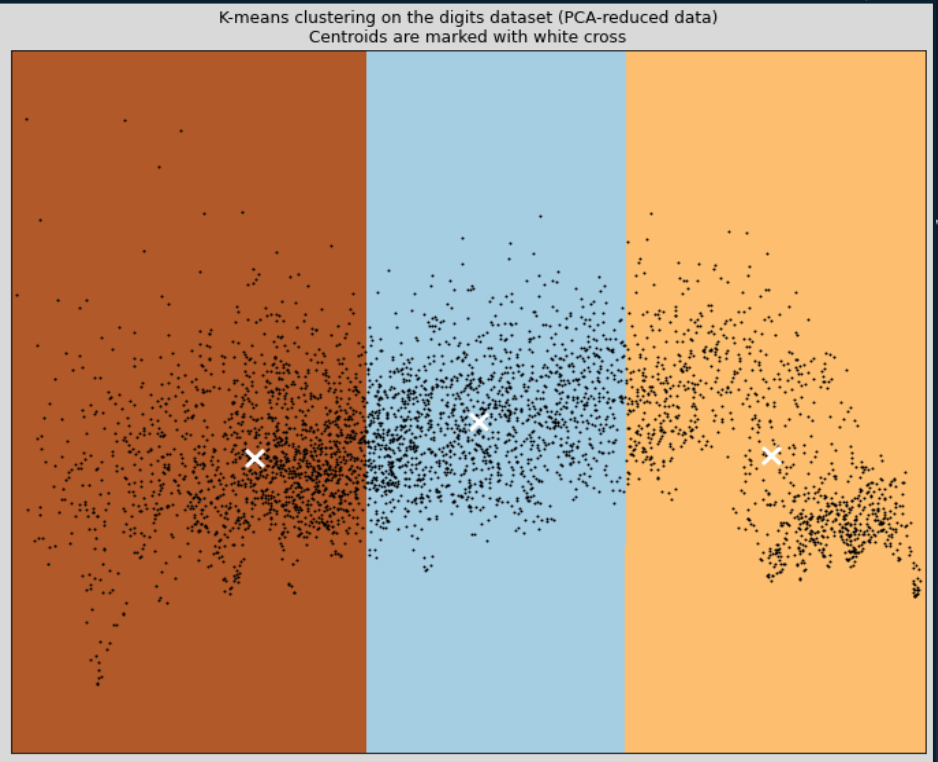
- Clusters are groups of points with different population sizes
- In our case our clusters consist of photons



K-means Doesn't Work!

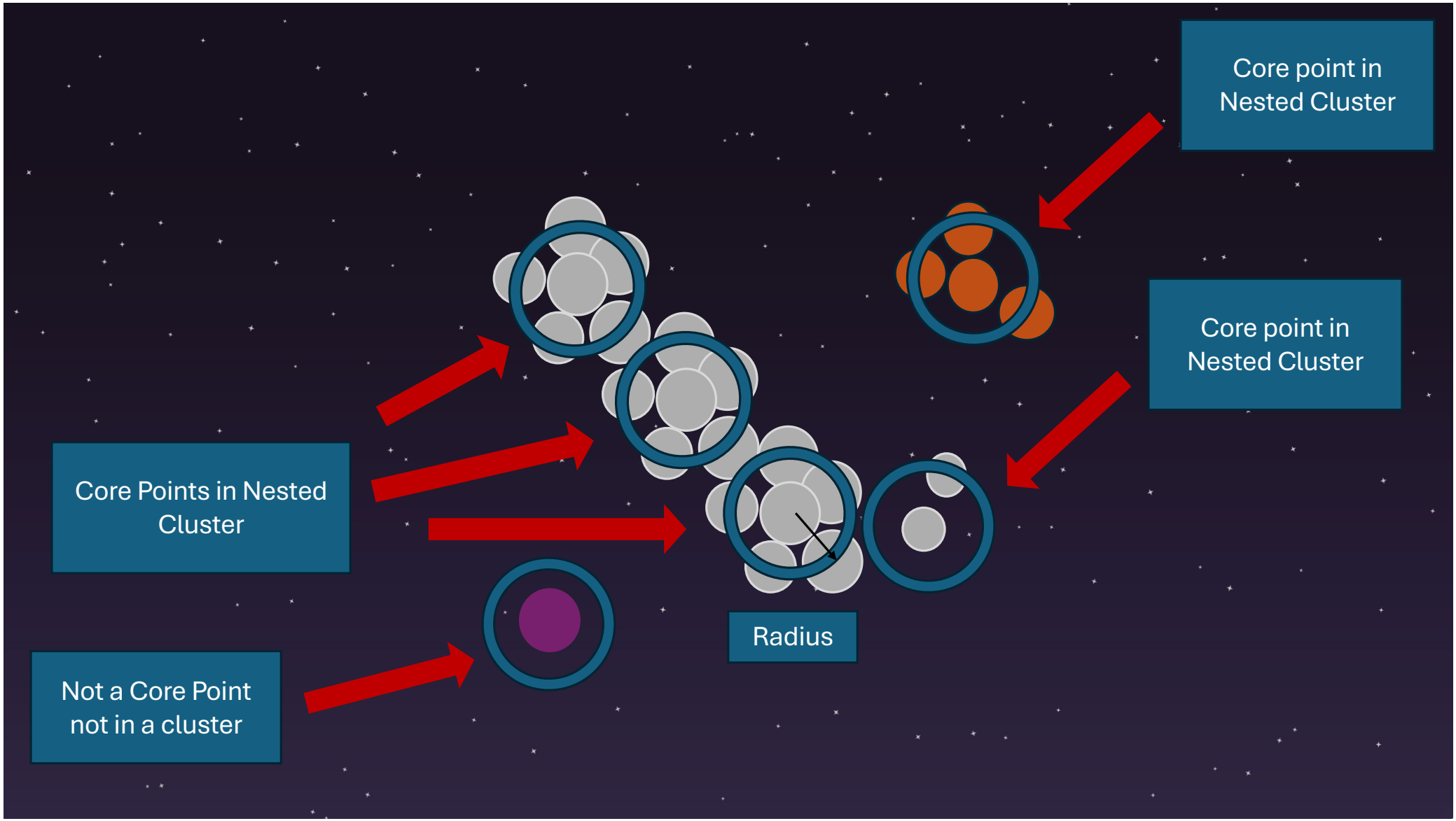


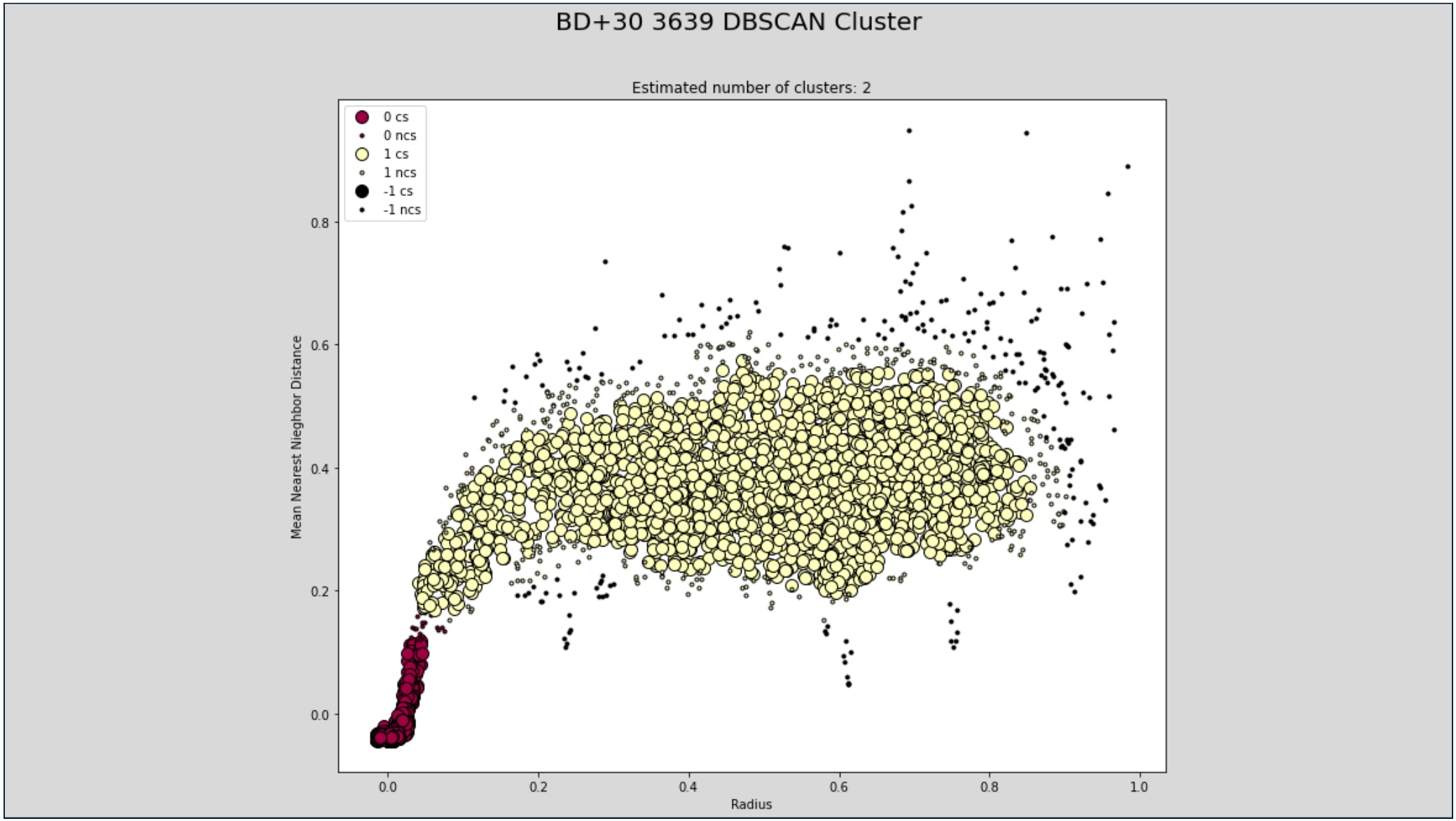
Credit: SkiKit Learn K-means et al.

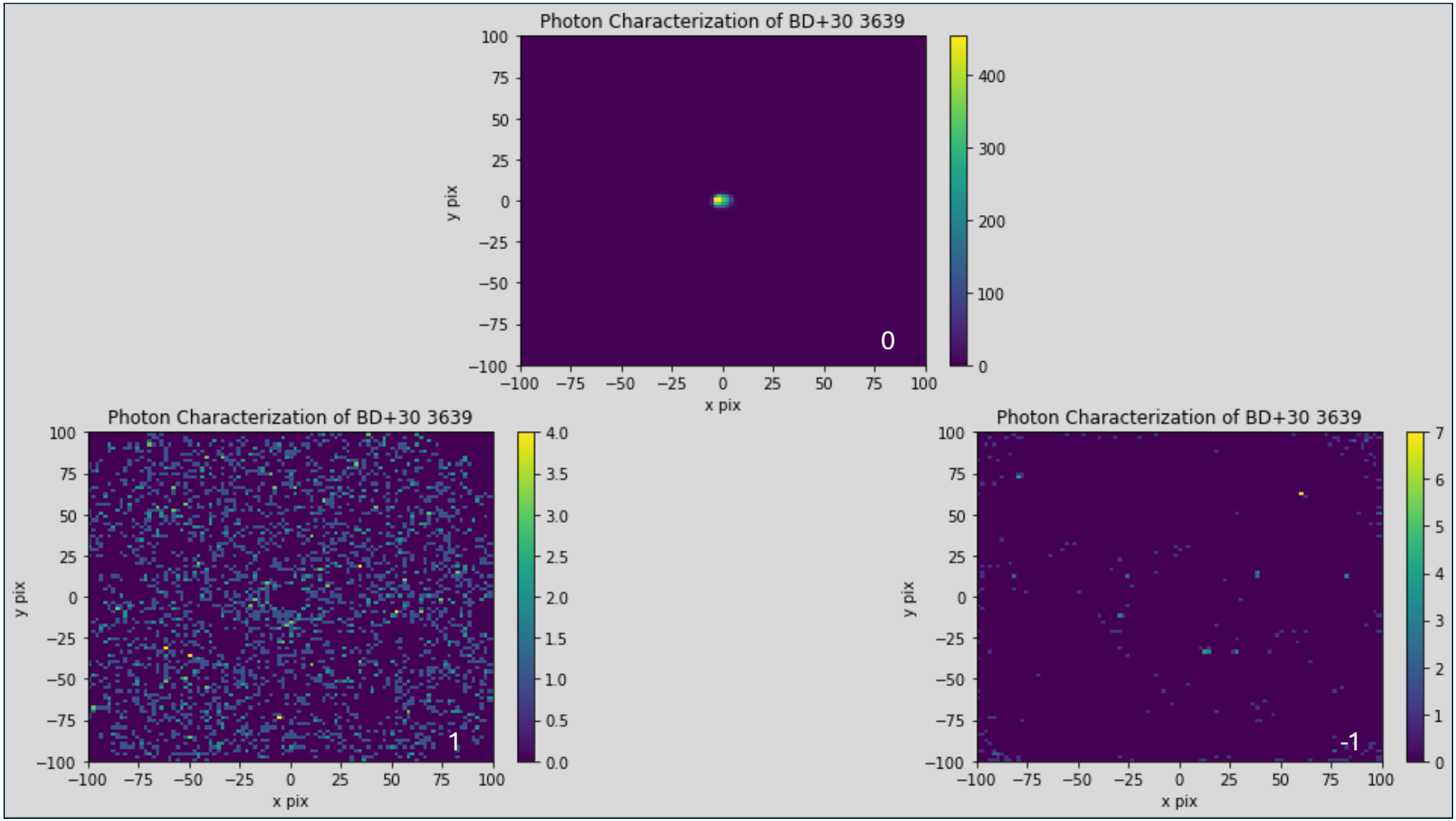


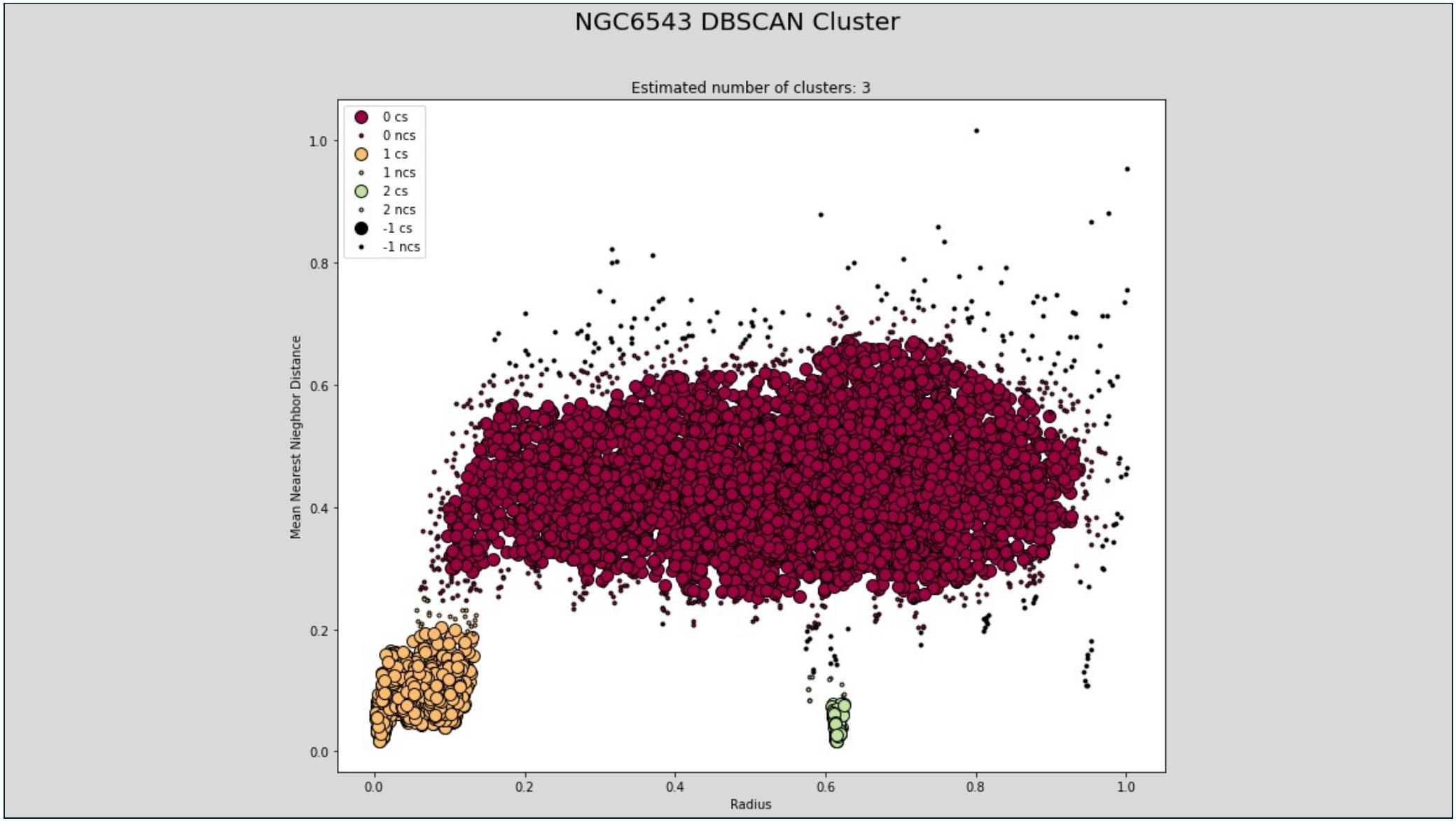
DBSCAN Works!

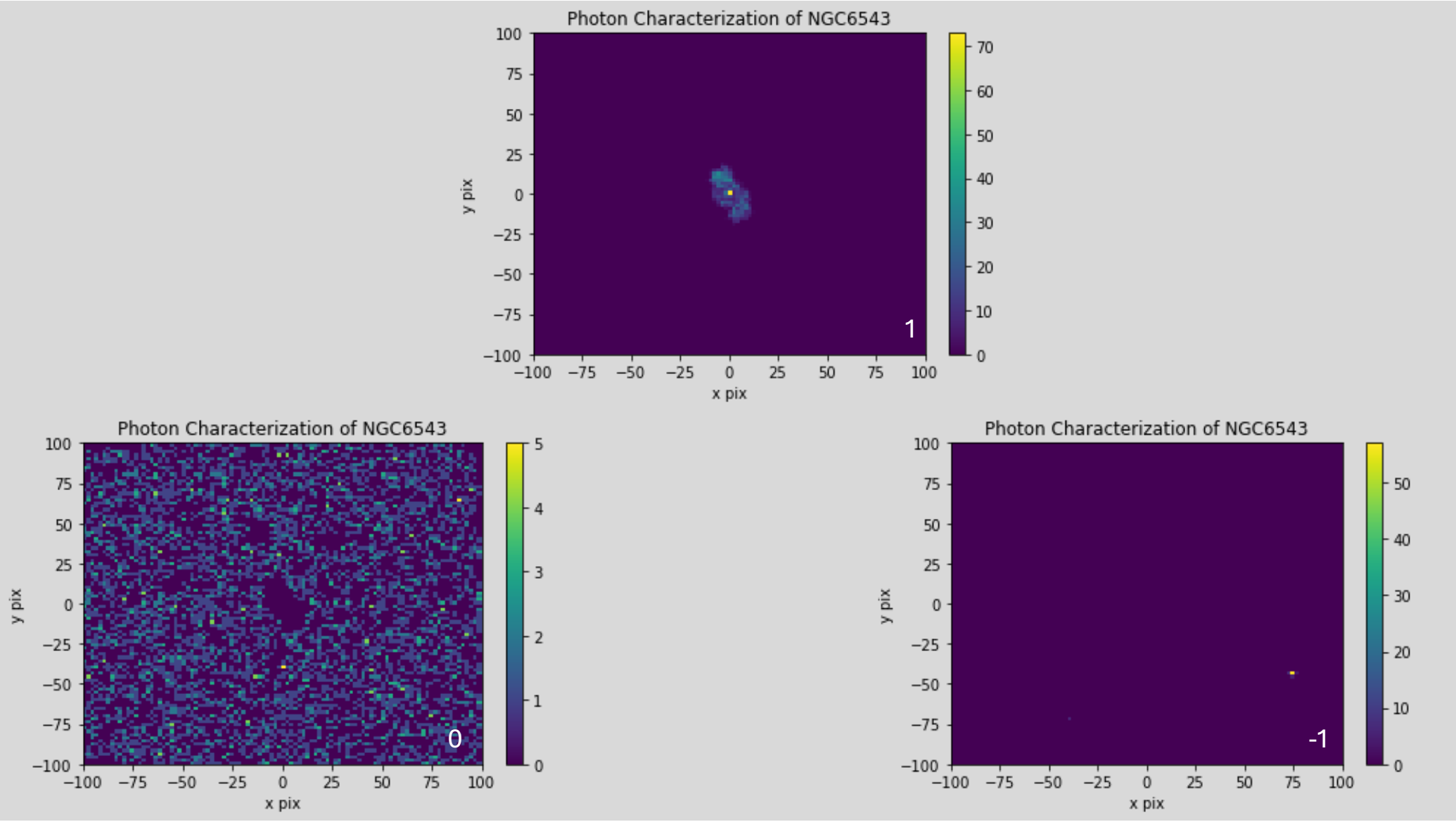
- DBSCAN is a clustering algorithm that separates areas of high density from populations of low density
- Eps or epsilon is a radius distance value
- Min_samples or minimum samples is the number of points to be added in a cluster

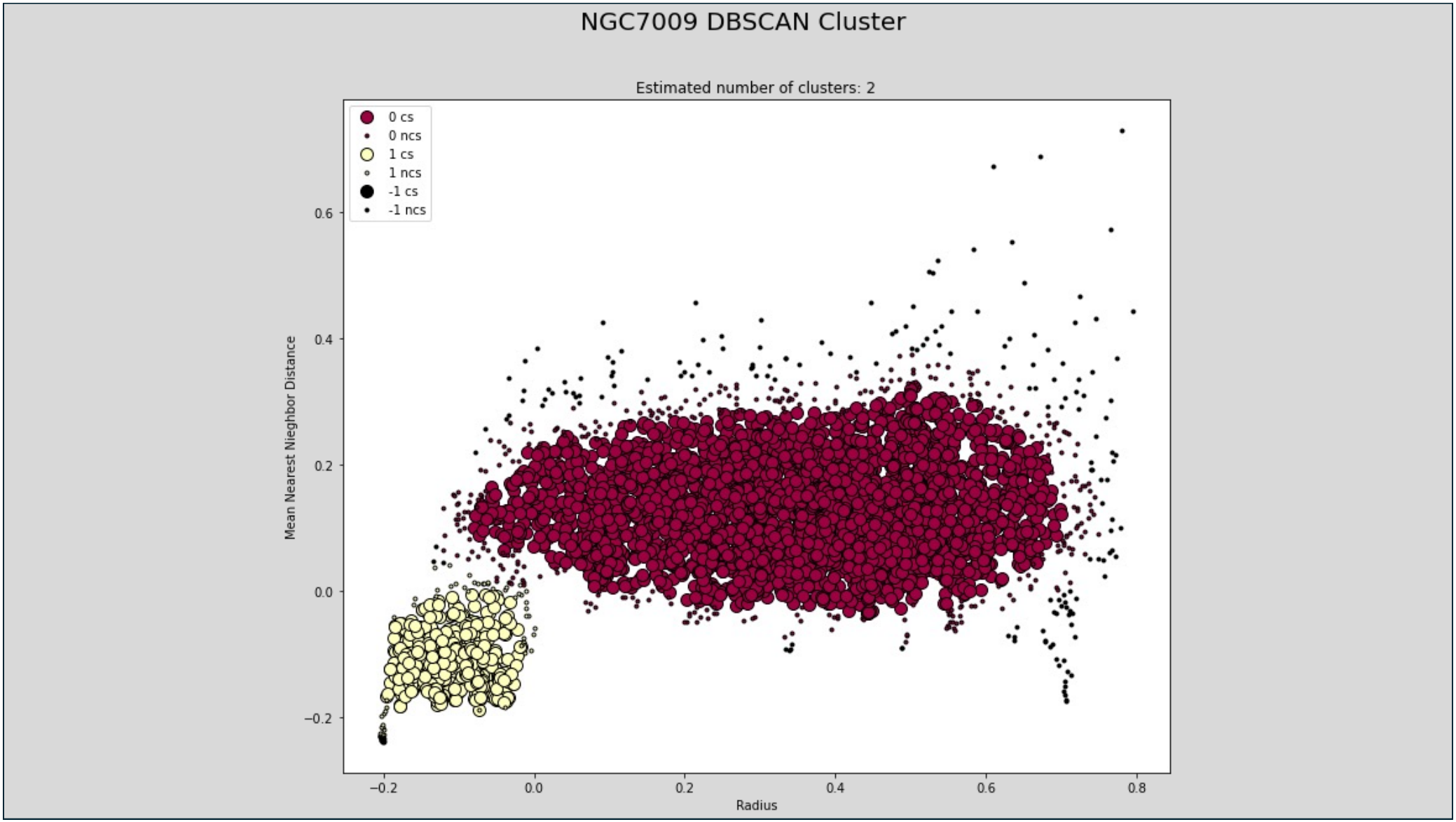

Core point in Nested Cluster
Core point in Nested Cluster
Core Points in Nested Cluster
Radius
Not a Core Point not in a cluster

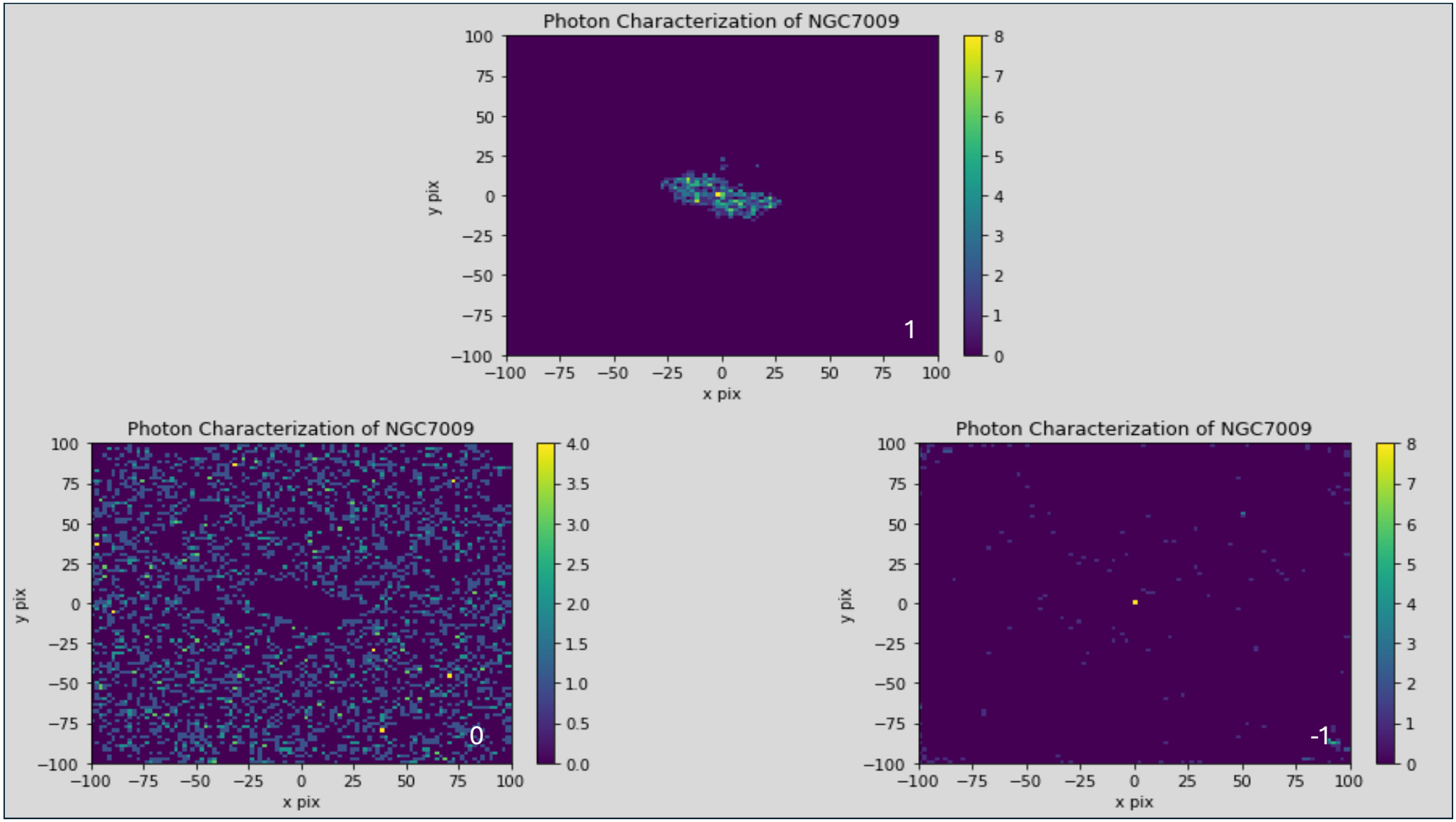

BD+30 3639 DBSCAN Cluster
Estimated number of clusters: 2
0 cs
0 ncs
1 cs
1 ncs
-1 cs
-1 ncs
Mean Nearest Nieghbor Distance
Radius
0.0
0.2
0.4
0.6
0.8
1.0


Photon Characterization of BD+30 3639
y pix
x pix
0
Photon Characterization of BD+30 3639
y pix
x pix
1
Photon Characterization of BD+30 3639
y pix
x pix
-1


NGC6543 DBSCAN Cluster
Estimated number of clusters: 3
0 cs
0 ncs
1 cs
1 ncs
2 cs
2 ncs
-1 cs
-1 ncs
Mean Nearest Nieghbor Distance
Radius
0.0
0.2
0.4
0.6
0.8
1.0


Photon Characterization of NGC6543
y pix
x pix
1
Photon Characterization of NGC6543
y pix
x pix
0
Photon Characterization of NGC6543
y pix
x pix
-1


NGC7009 DBSCAN Cluster
Estimated number of clusters: 2
0 cs
0 ncs
1 cs
1 ncs
-1 cs
-1 ncs
Mean Nearest Nieghbor Distance
Radius
0.6
0.4
0.2
0.0
−0.2
−0.2
0.0
0.2
0.4
0.6
0.8


Photon Characterization of NGC7009
y pix
x pix
1
Photon Characterization of NGC7009
y pix
x pix
0
Photon Characterization of NGC7009
y pix
x pix
-1

Things I've Learned

- I've learned how to code!
- More time would allow for a robust algorithm for non-scaled data
- Further research must be done into algorithms such as HDBSCAN

Thank you everyone!!