Interstellar Polarization and Be stars

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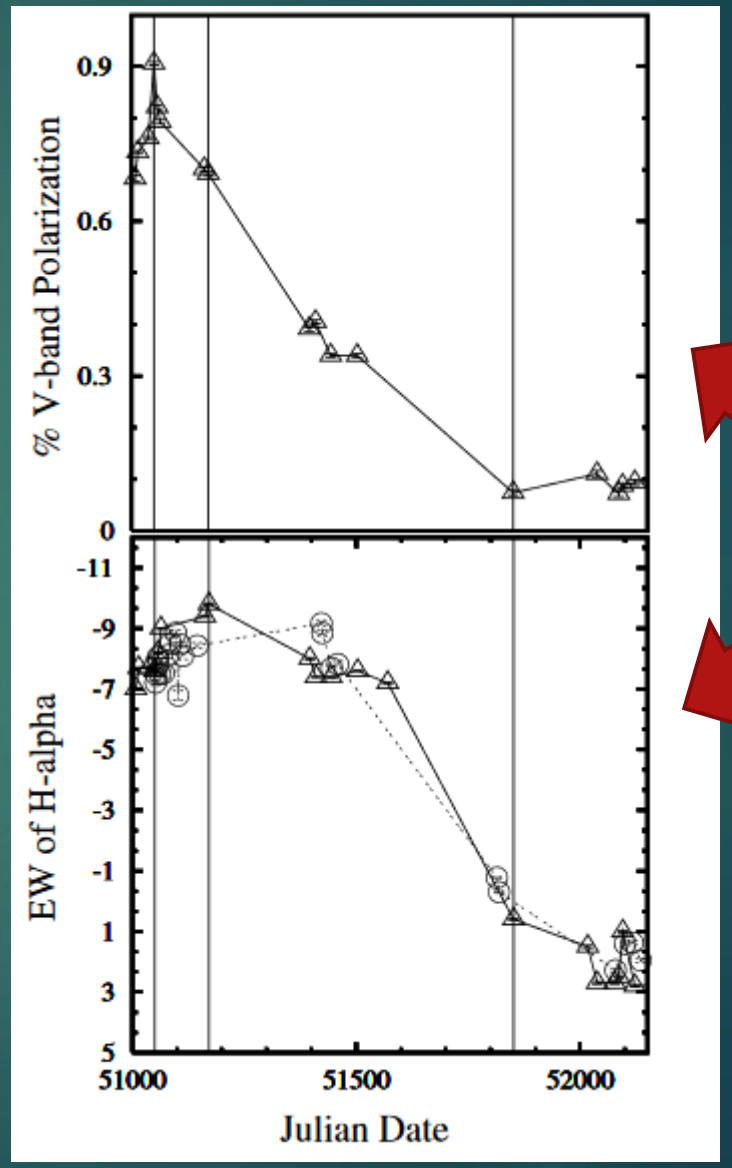
Be stars

- B stars are main sequence stars that are fairly large and hot.
- the e in Be means that at some point the star has shown Hα emission lines
- These stars have circumstellar disk of gas surrounding them that can evolve over time.
- Rapidly rotating
- The tools we can use to observe the stars are:
  - Photometric measurements - Hα
  - Polarization (This project)

Motivation

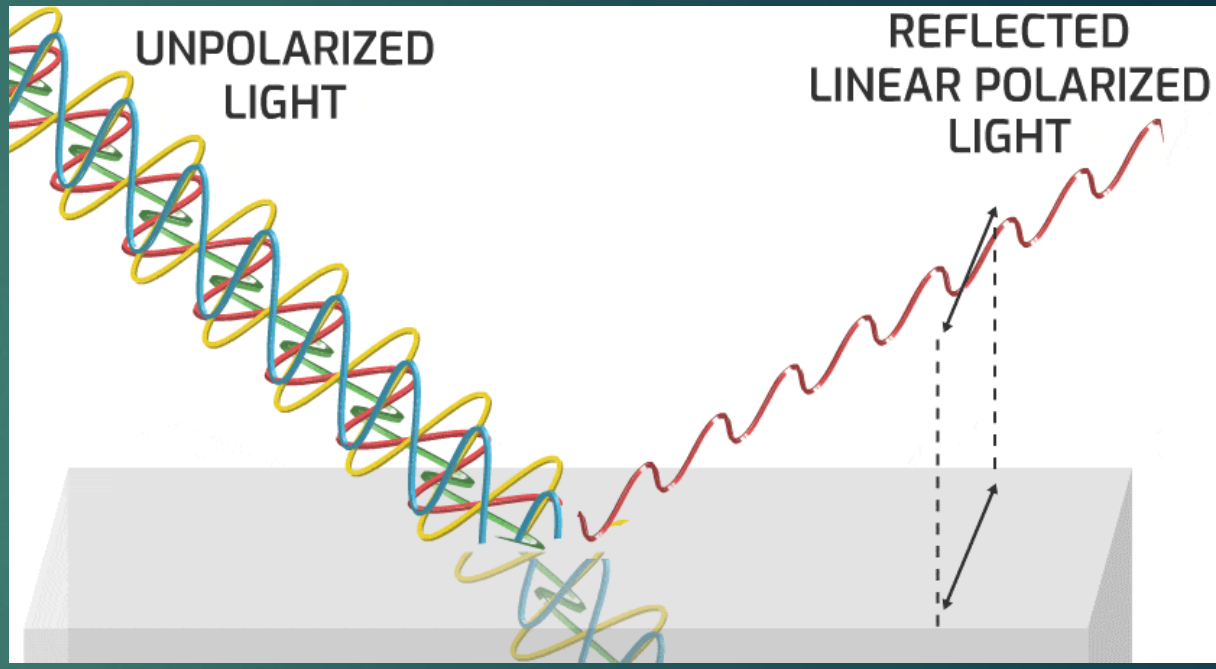
- Having cluster based Interstellar polarization allows us to follow the evolution of Be stars
  - Time series analysis of clusters with these stars will show how Be stars evolve.
- Other viscous disks include:
  - Protoplanetary disks
  - Quasar accretion disks.



X A Lot

Polarization

- The direction in which the electric field oscillates
- Unpolarized light occurs in all rotations
- Can be parametrized in four vectors ("Stokes Parameters")
  - I, Q, U, and V
  - Specify the phase and polarization of electric field waves
- Percent polarization
- Lets us probe the *outer* part of the disk
  - Materials in the disk
  - Disk angle

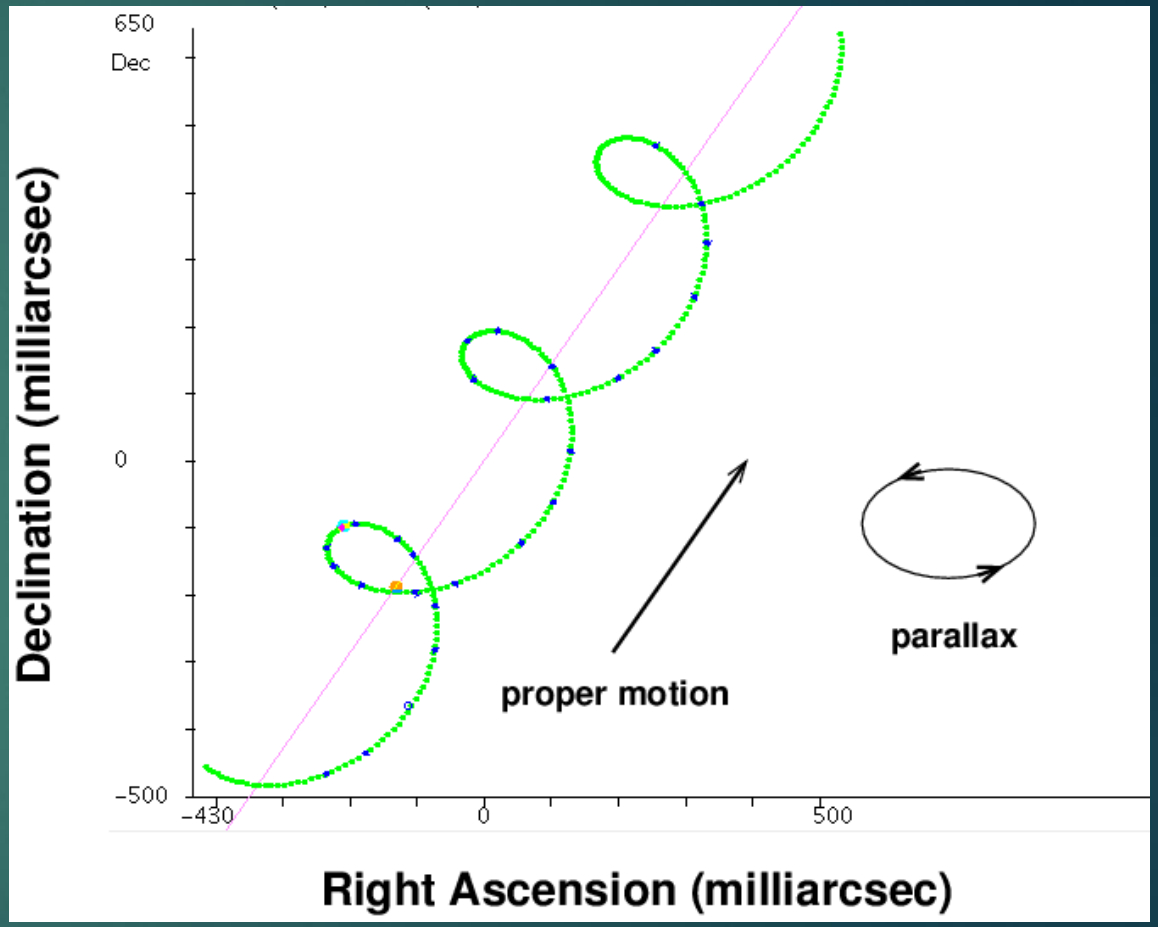


Interstellar Polarization

- Biggest obstacle is isolating disk polarization
- 3 components to polarization
  - Disk
  - Interstellar Polarization
  - Telescope
- An isolated polarization from the disk gives the most meaningful measurement
- Stars in the same cluster have similar space to travel through (same Interstellar polarization)

Parallax and Proper motion

- Measurement of how much a star is moving relative to the background
- Parallax can be used to determine the distance to the star
- Proper motion can be used to determine the relative movements of stars
- The two of these measurements can be used together to determine if stars are clustered together

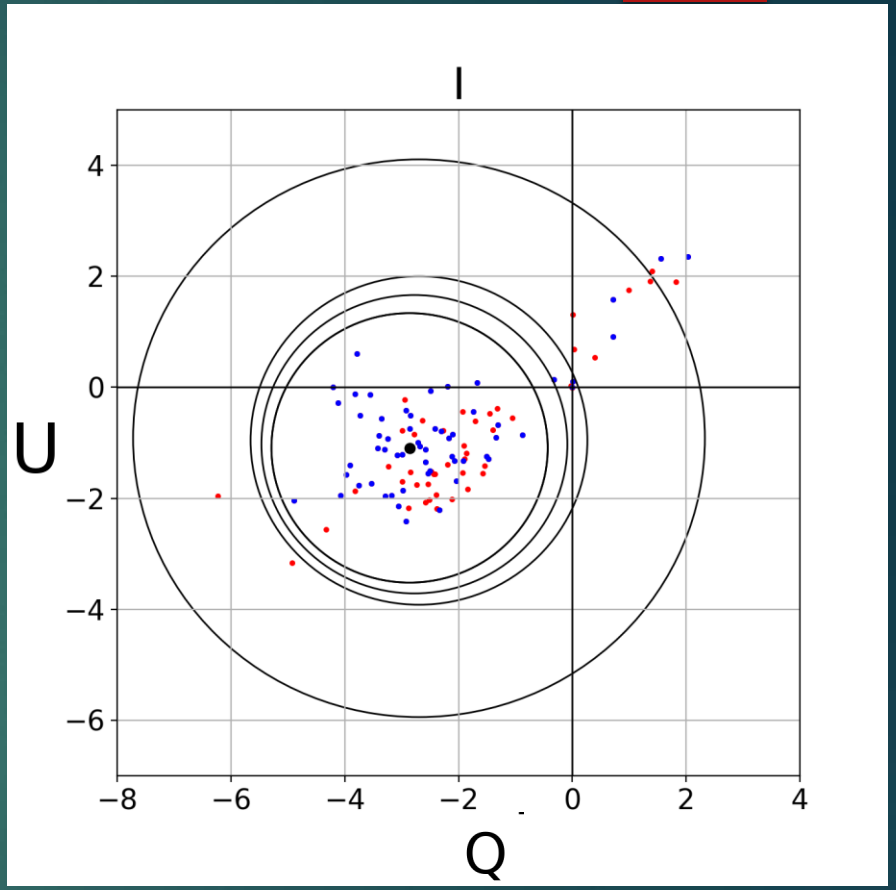


Cluster Membership

- We end up observing stars that are not actually at the same distance as the cluster (Background or Foreground stars)
- The distances to stars in an open cluster are normally distributed
- By fitting a gaussian to the distances of stars matched from a catalog we can find a reasonable estimate of distance bounds
- Combining this with a proper motion is how we do our final cut

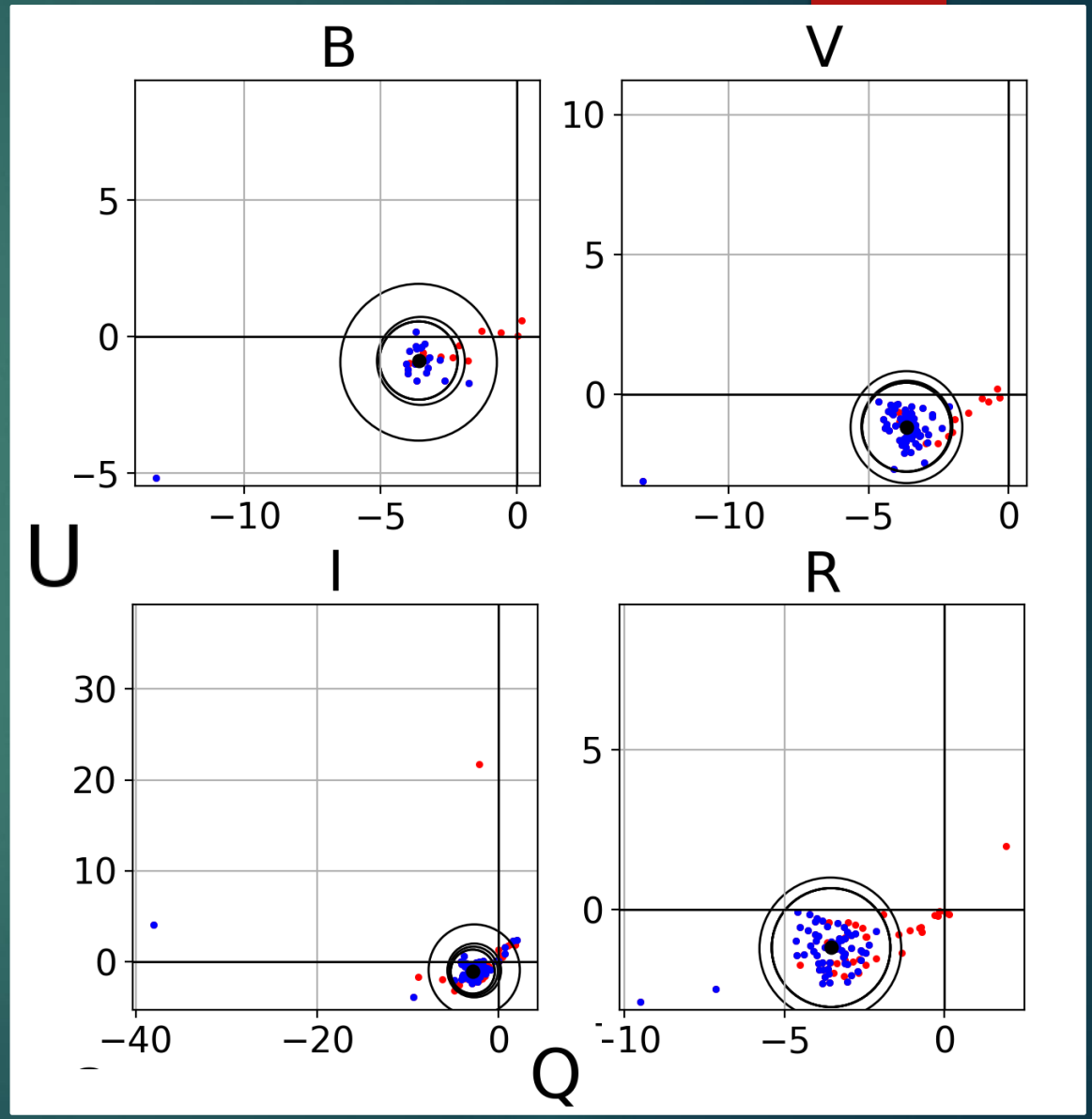
Clipping for the median

- Stars within the cluster can still have their own polarization
- Outliers influence the median less than the mean so the median polarization will characterize the ISP better.
- Removing the points farthest away and recalculating the median gave a better measure still.



NGC 663

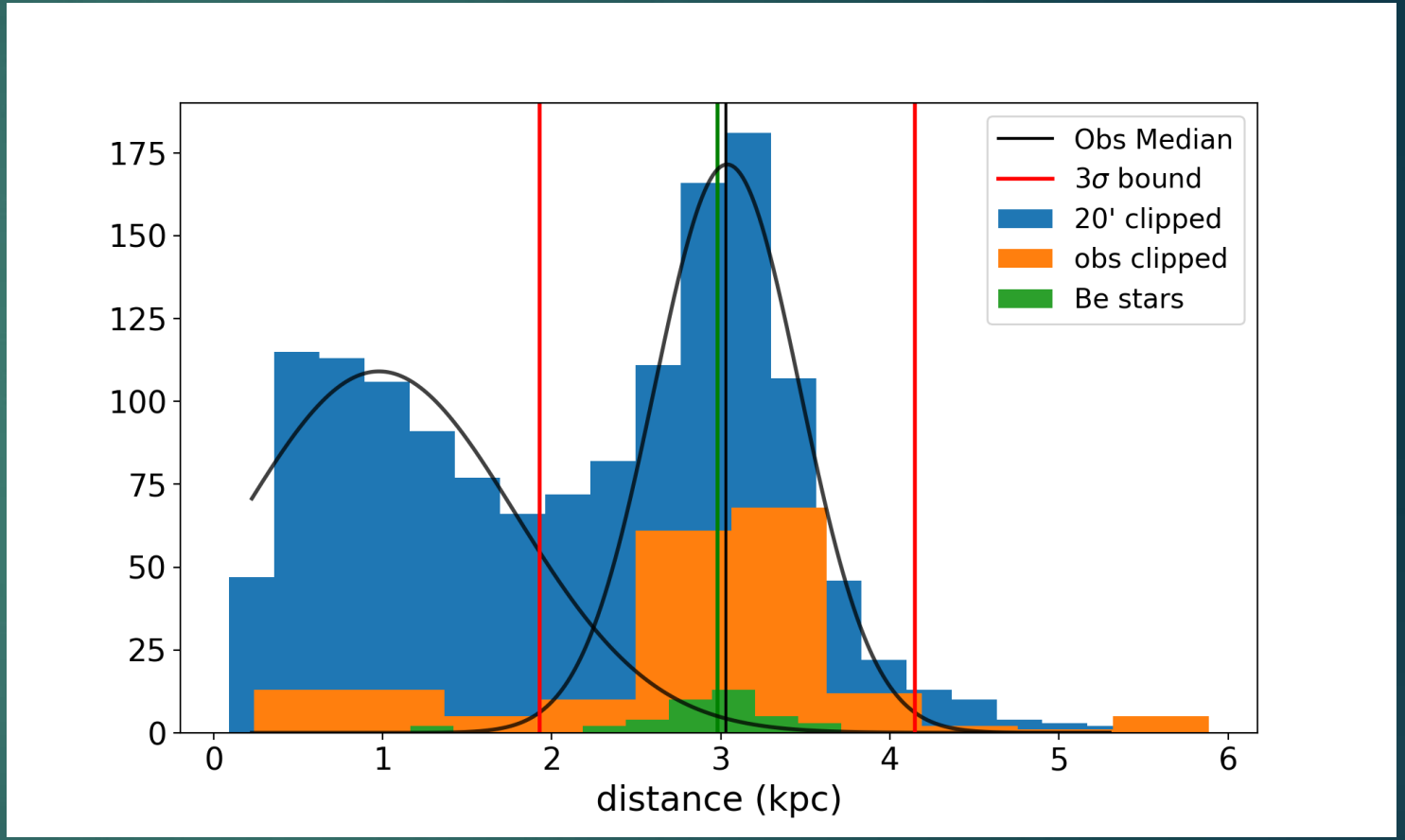
- The first cluster the group looked at because it has a large portion of Be stars
- Spent a lot of the time developing the frame work that we will be able to apply to the other 16 clusters
- This led us to the first two complications to the process



- Should over lap exactly
- Causes problems when we want to identify the stars we observe
- Solution is to go through each of the images and txt files and manually find the offsets to apply to each of the x ,y values

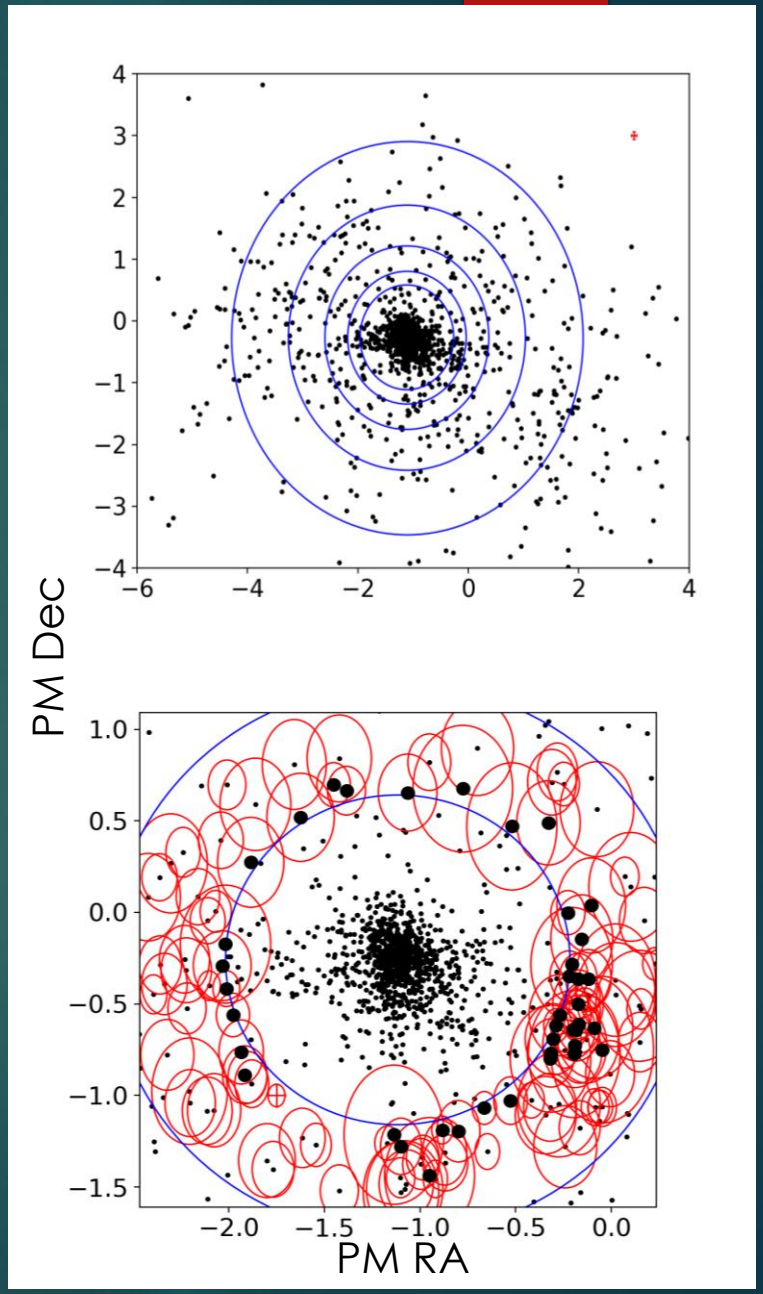
Membership complication

- Literature has suggested that the distance to the cluster is 2.4kpc (Pandley,2005)
- However when querying a 20’ radius around the cluster we find that there are two populations, a foreground population and what we believe is the cluster at 3kpc
- This difference would significantly change the median of the cluster



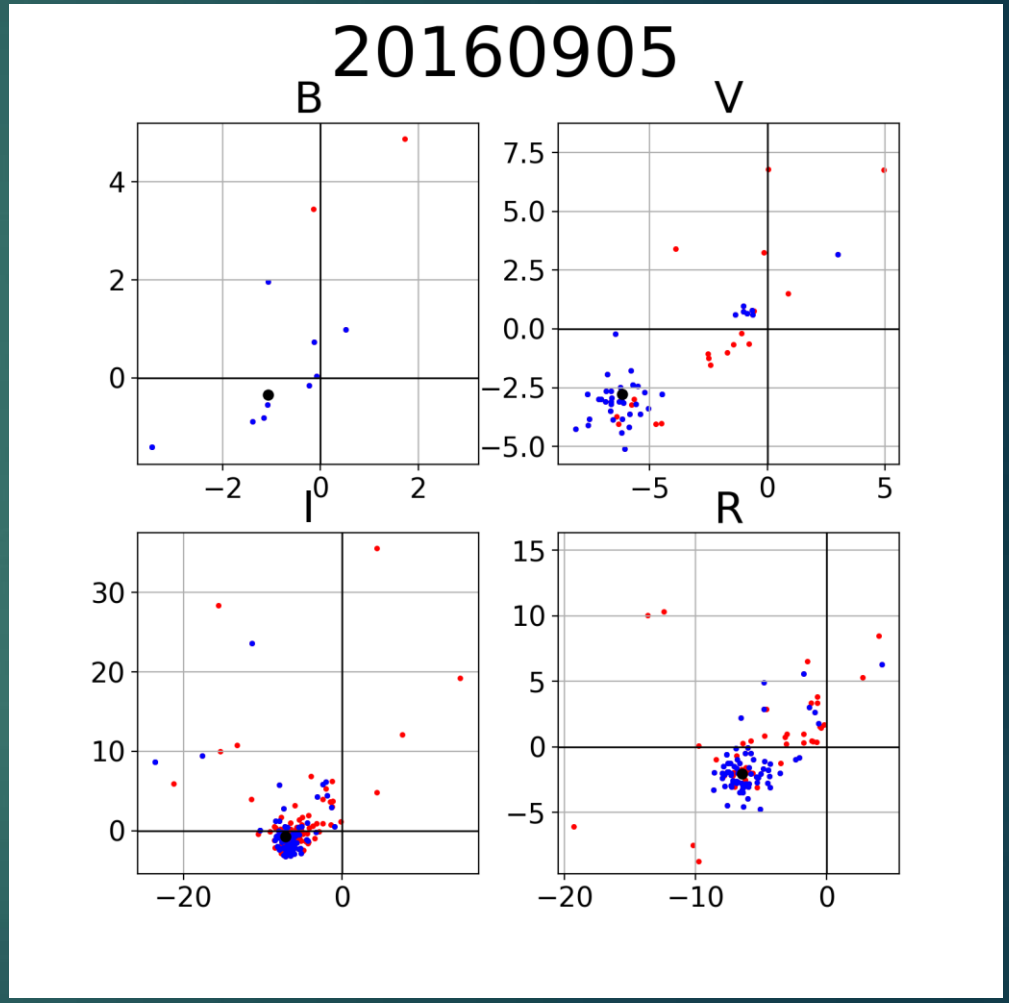
Proper Motion cuts

- To determine the final membership we need to make proper motion cuts
- To properly cut the proper motions we looked at the points in 2d space
- Similar to the cut we did with QU, the cut is based on the distance from the median value.
- After the final cut we had to consider if the error ellipse's fell into the final region



NGC 7419

- Our group did not have as much time with NGC 7419 so we still have a few problems to fix
- Our Cross Matching is still a problem that we deal with manually



Future Work

- NGC 663 has everything needed to look at polarization
- Individual star based
  - Find polarization of stars of a given cluster
  - Compare change in disk size of many stars
- The rest of the clusters
  - Find ISP to different clusters
  - Compare ISP of different clusters

Questions?