The Summer Search for Galaxy Clusters

Victoria Sanzone
Dr. Xinyu Dai, Saloni Bhatiani
University of Oklahoma
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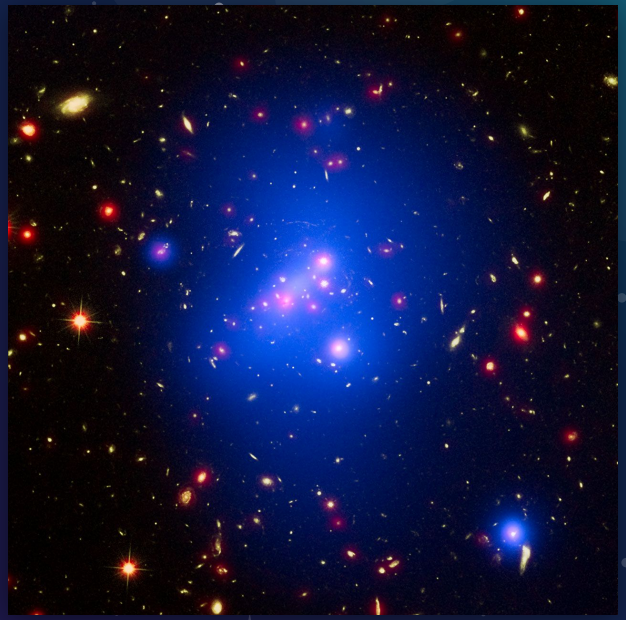
Galaxy Clusters

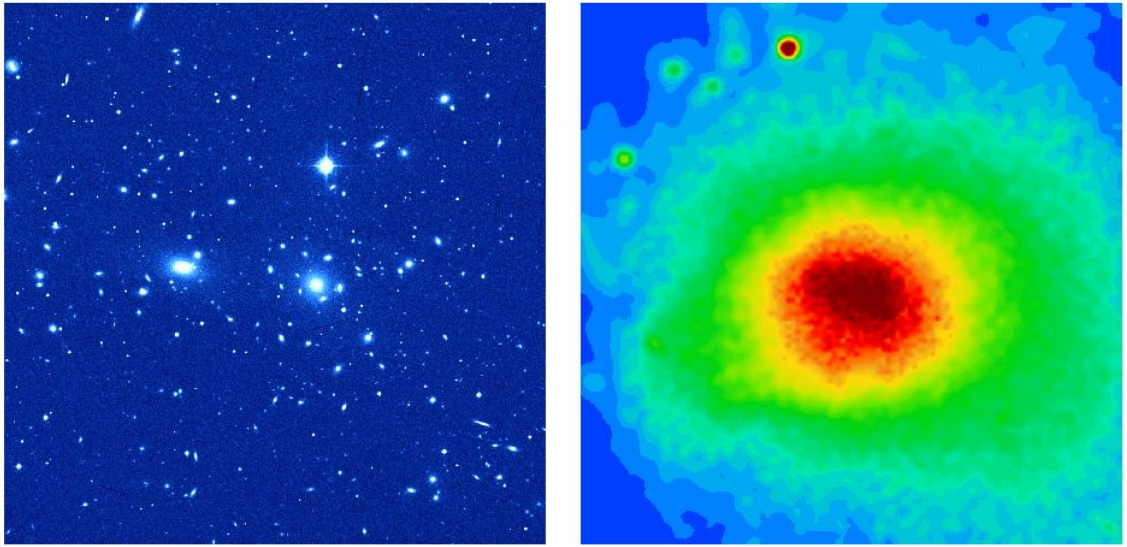
- ★ Galaxies not uniformly distributed in space
- ★ Intense source of X-ray radiation from Intracluster Medium (ICM)



IDCS J1426.5+3508 (IDCS 1426 for short), in X-rays from the NASA Chandra X-ray Observatory in blue, visible light from the NASA/ESA Hubble Space Telescope in green, and infrared light from the NASA Spitzer Space Telescope in red

Optical

X-ray



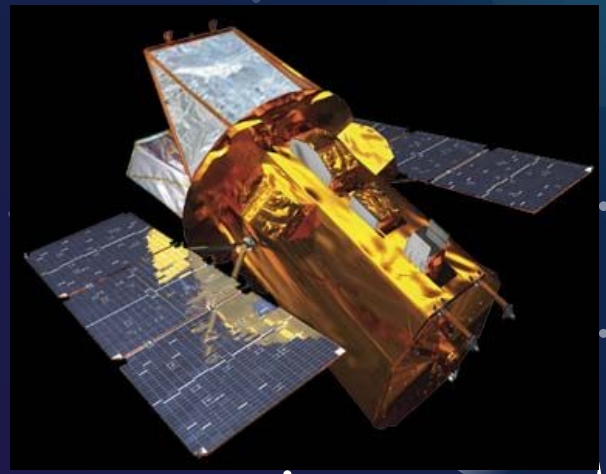
Coma Cluster of Galaxies

Why Galaxy Clusters?

- Most massive gravitationally bound and relaxed structures in the Universe
- Cosmological evolution is directly related to the growth of cosmic structures
- Study of galaxy formation, evolution, and dynamics

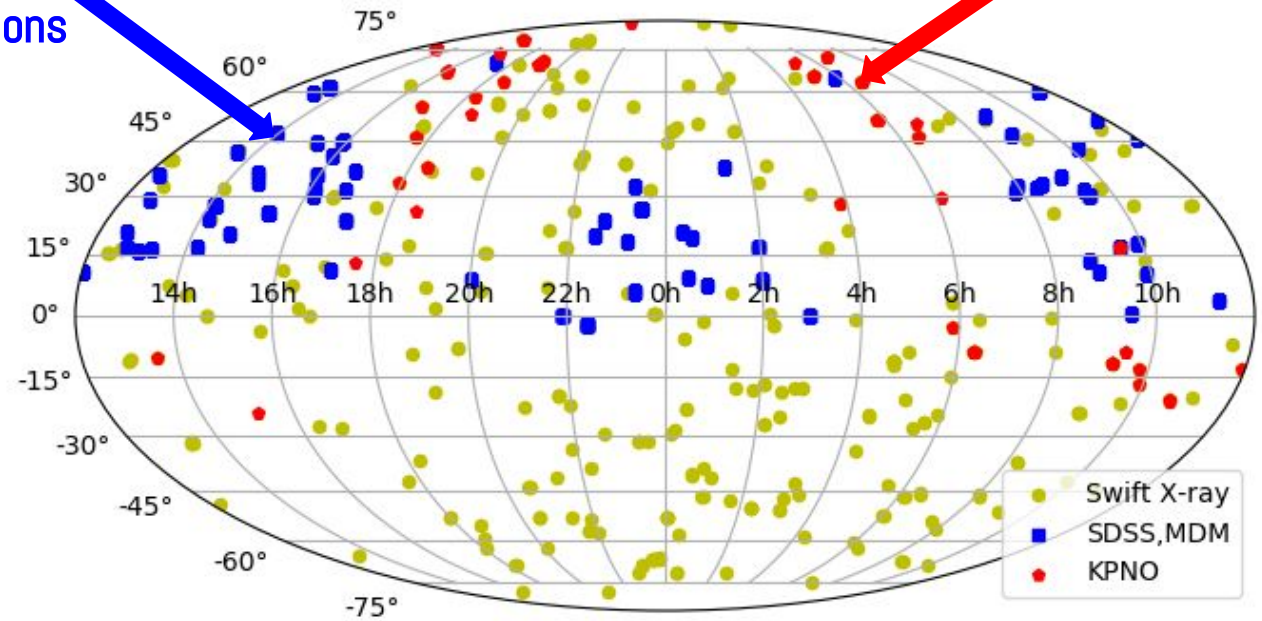
X-ray Data

- Swift AGN and Cluster Survey (Dai et al. 2015)
  - X-ray survey
  - Ideal for cluster detection
  - 442 total extended sources
    - Cluster candidates that require optical confirmation



SDSS
104 / 203 detections
MDM
31 / 77 detections

KPNO/Panstarrs
36/66 detections



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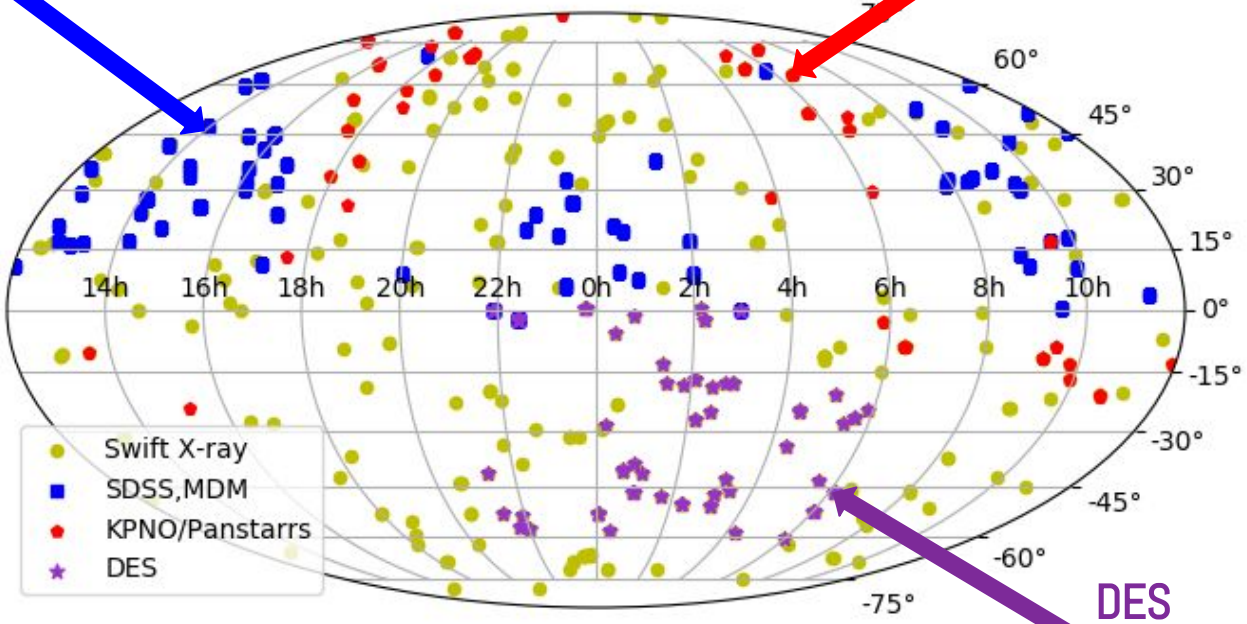
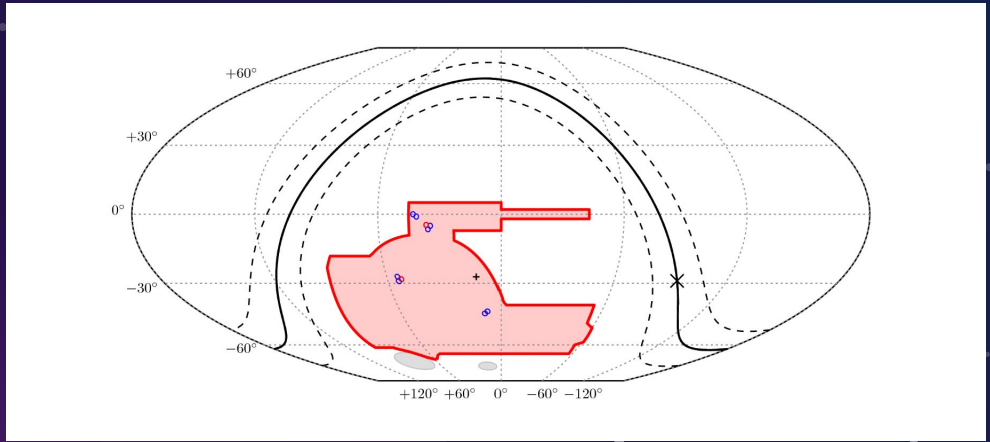


DES
45 / 75 detections

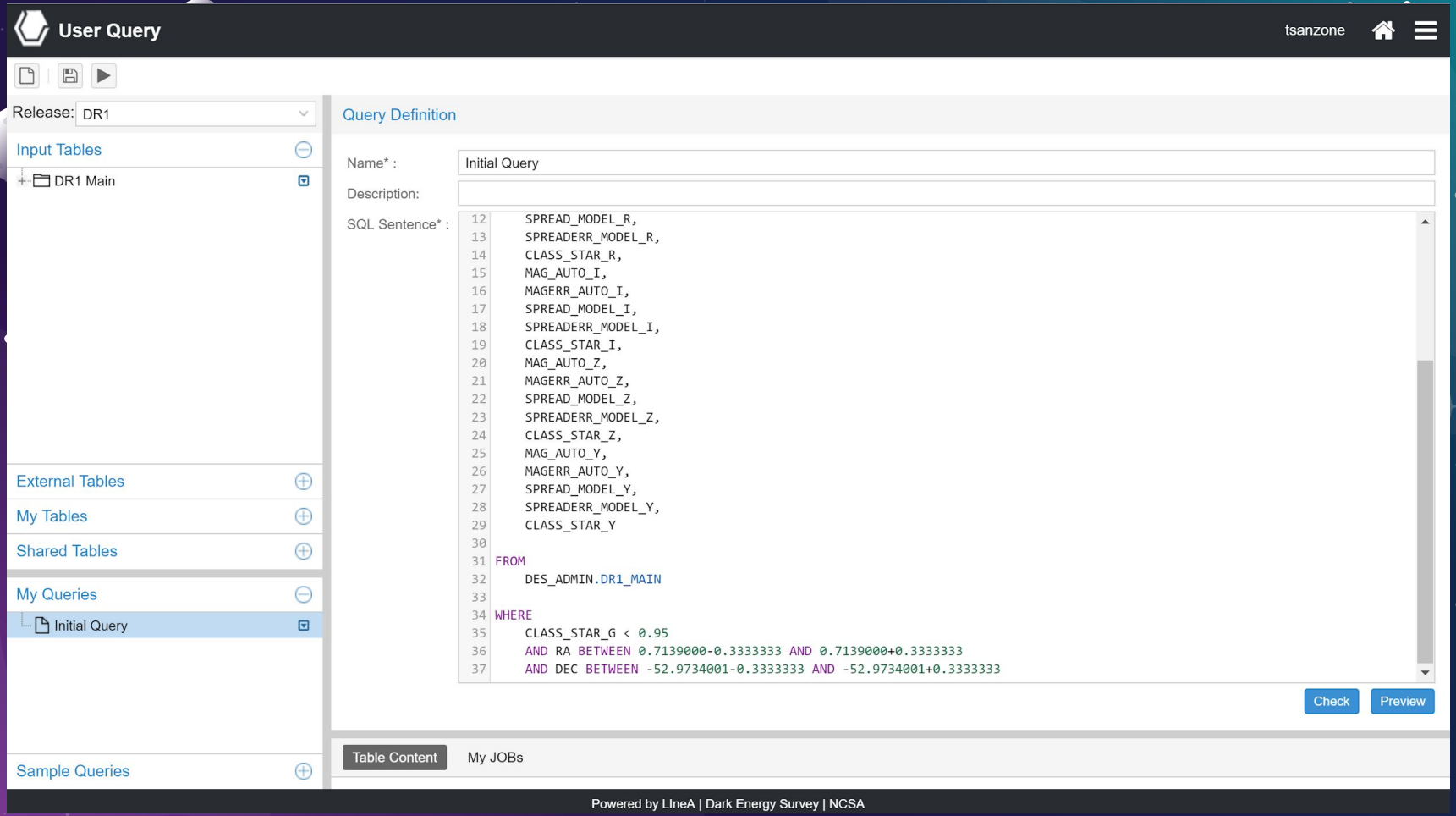
Project Process: Step 1

- Determine which Swift cluster candidates lie within the footprint of the DES



Project Process: Step 2

- Submit queries to DES for data around the cluster candidates
  - SQL queries
  - Each query individually submitted, processed, and downloaded


User Query
tsanzone
Release: DR1
Input Tables
DR1 Main
External Tables
My Tables
Shared Tables
My Queries
Initial Query
Sample Queries
Query Definition
Name* : Initial Query
Description:
SQL Sentence* :
SPREAD_MODEL_R,
SPREADERR_MODEL_R,
CLASS_STAR_R,
MAG_AUTO_I,
MAGERR_AUTO_I,
SPREAD_MODEL_I,
SPREADERR_MODEL_I,
CLASS_STAR_I,
MAG_AUTO_Z,
MAGERR_AUTO_Z,
SPREAD_MODEL_Z,
SPREADERR_MODEL_Z,
CLASS_STAR_Z,
MAG_AUTO_Y,
MAGERR_AUTO_Y,
SPREAD_MODEL_Y,
SPREADERR_MODEL_Y,
CLASS_STAR_Y
FROM
DES_ADMIN.DR1_MAIN
WHERE
CLASS_STAR_G < 0.95
AND RA BETWEEN 0.7139000-0.3333333 AND 0.7139000+0.3333333
AND DEC BETWEEN -52.9734001-0.3333333 AND -52.9734001+0.3333333
Check
Preview
Table Content
My JOBs
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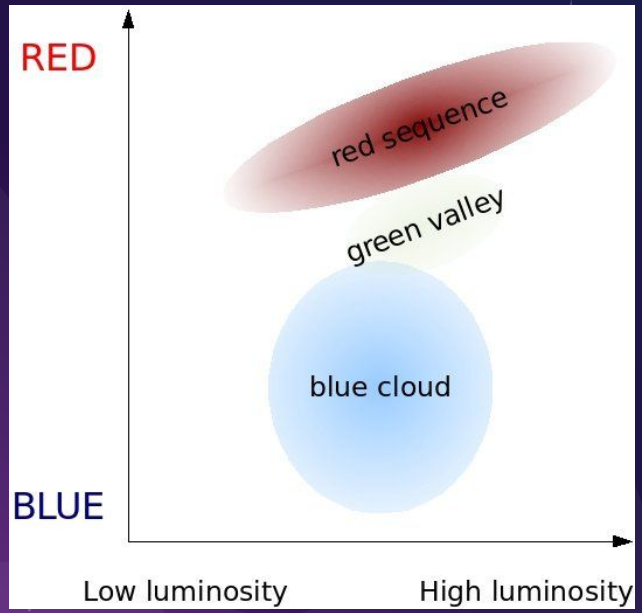
Project Process: Step 3

- ★ Analyze downloaded data
- ★ Lots and lots of Python
  - ☆ Source region and background region
  - ☆ Red Sequence Plots

Where are we Looking?

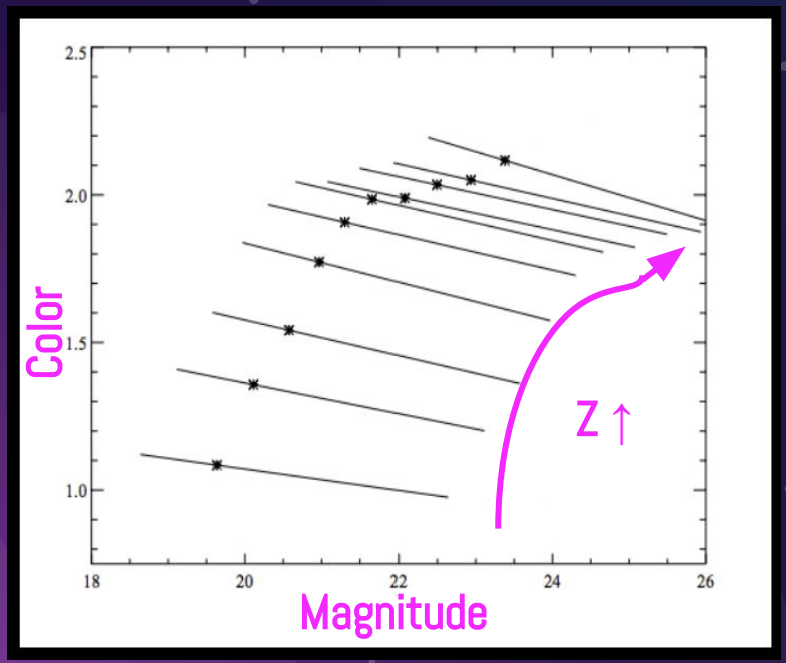
- Source Region
  - Radius 1 = 2 arcmin
- Background Region
  - Radius 2 = 10 arcmin
  - Radius 3 = 20 arcmin

Detection of Galaxy Clusters

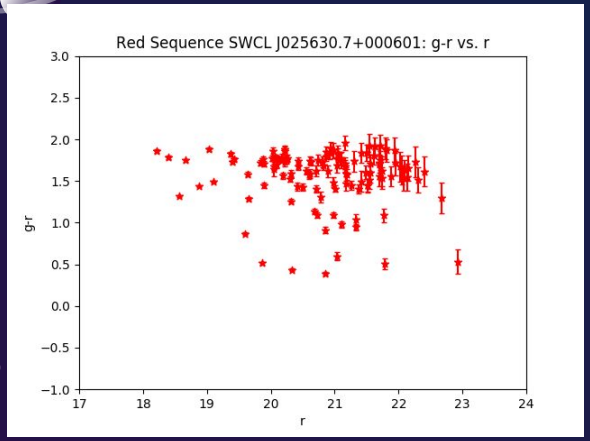


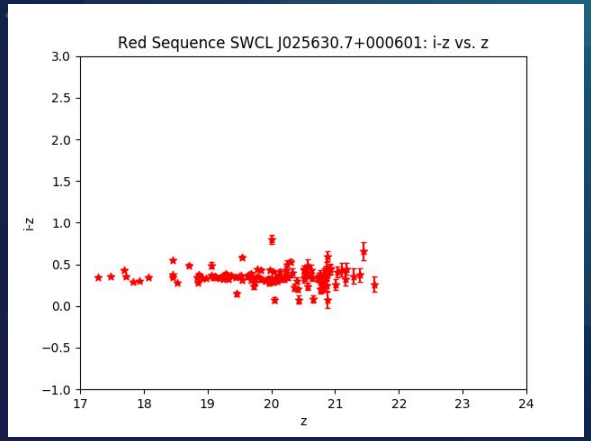
- ★ Red Sequence Method
  - ☆ Also known as Galaxy color–magnitude diagram

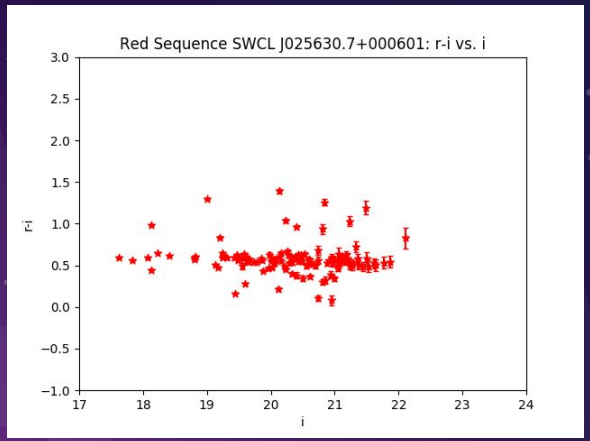
Redshift

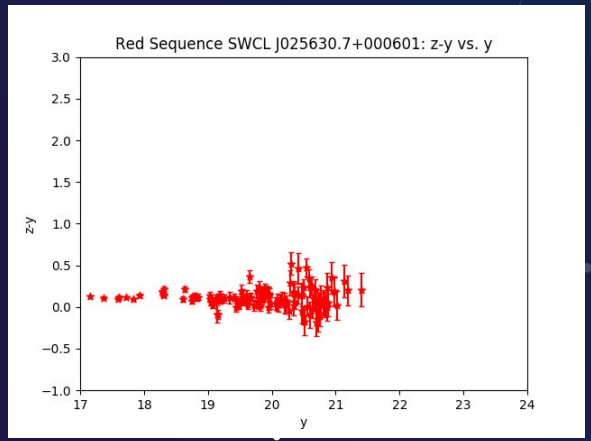


- ★ Red sequence acts as a good redshift (z) indicator
- ★ As z increases, galaxy moves color bands
  - ☆ (g-r) ➡️ (r-i) ➡️ (i-z) ➡️ (z-y)


Red Sequence SWCL J025630.7+000601: g-r vs. r
g-r
r

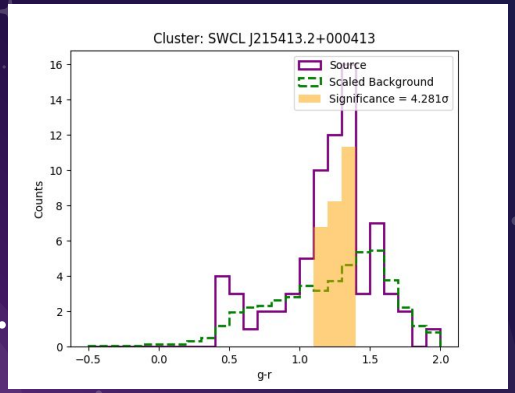

Red Sequence SWCL J025630.7+000601: i-z vs. z
i-z
z

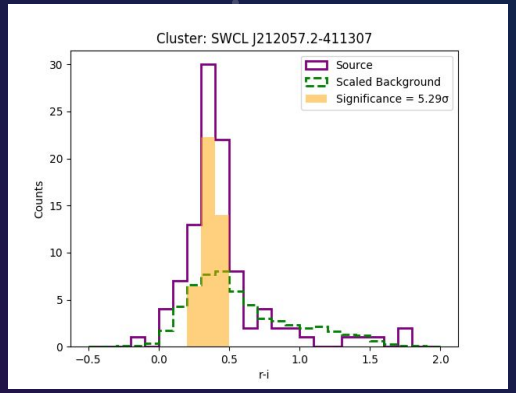

Red Sequence SWCL J025630.7+000601: r-i vs. i
r-i
i


Red Sequence SWCL J025630.7+000601: z-y vs. y
z-y
y

Project Process: Step 3

- ★ Create histograms and determine the significance of each candidate
- ★ Significances > 2σ considered to be detections



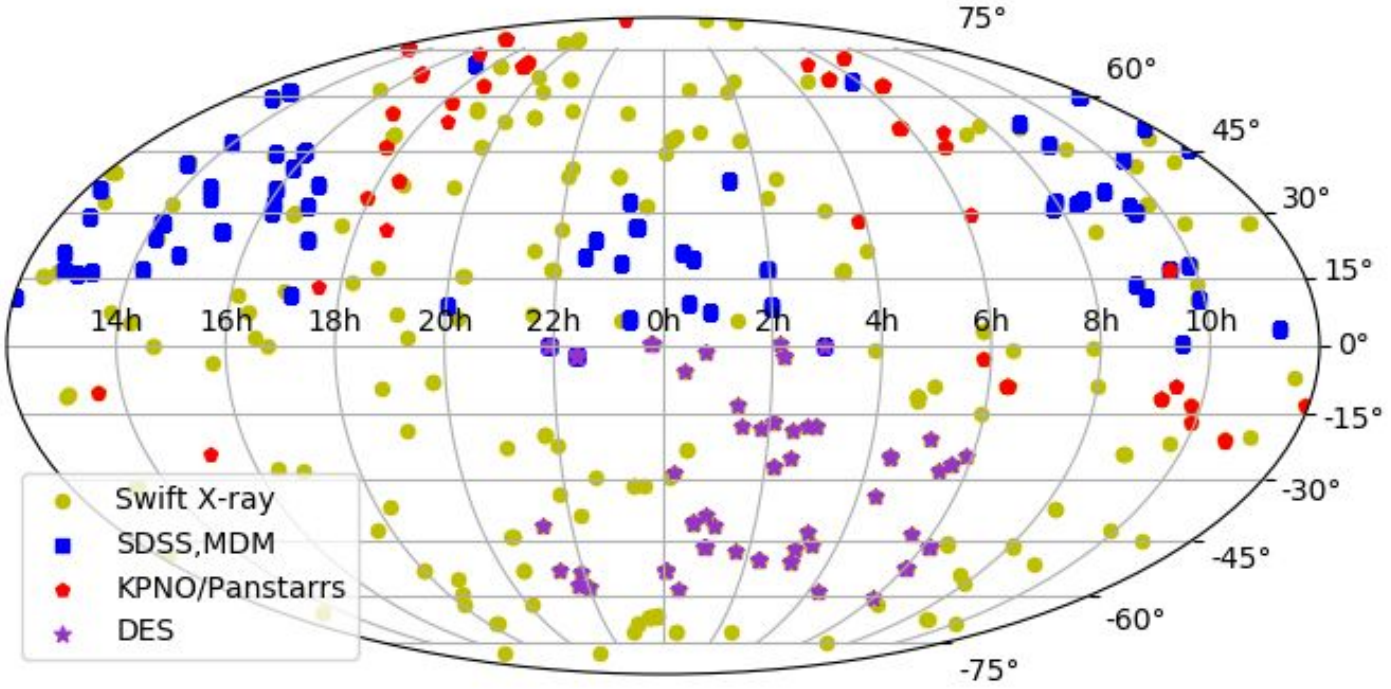


Results

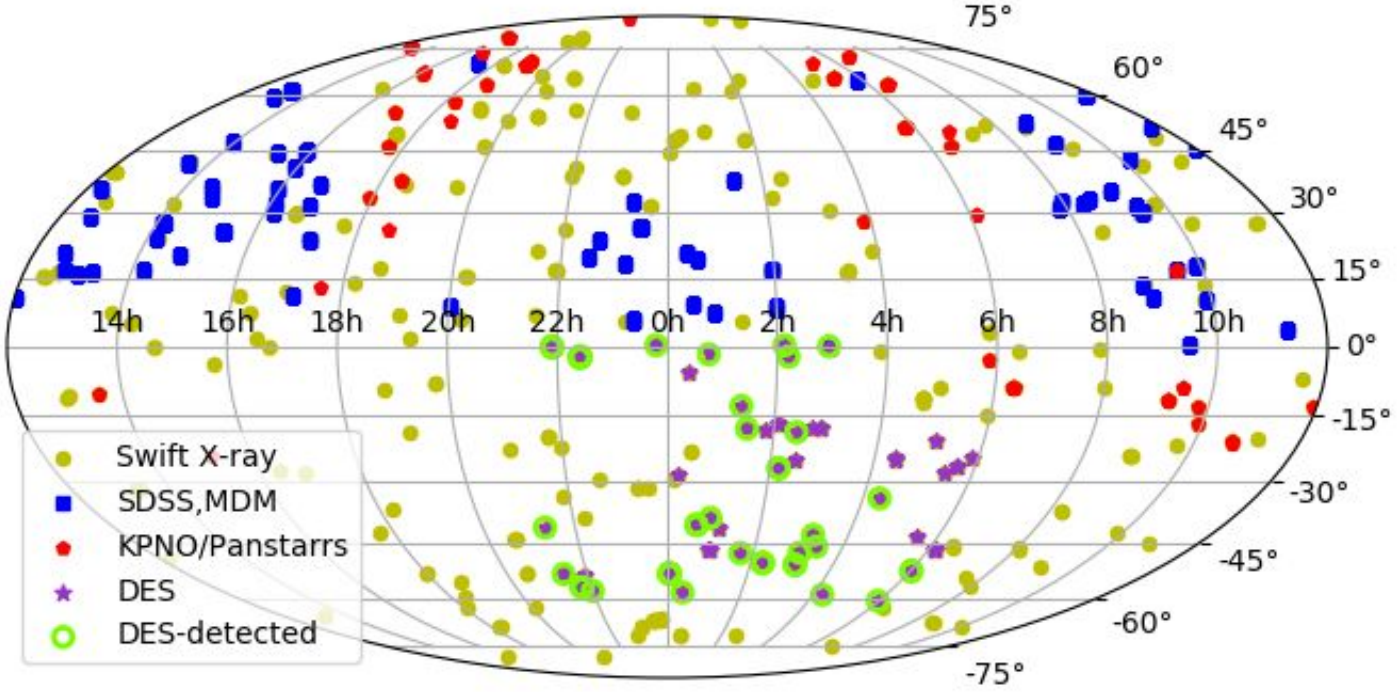
In all color bands, 45 > 2σ detections and 23 > 3σ detections.

Color	> 2σ detections	> 3σ detections
(g - r)	26	17
(r - i)	32	20
(i - z)	35	21
(z - y)	27	15

Results


75°
60°
45°
30°
15°
0°
-15°
-30°
-45°
-60°
-75°
14h
16h
18h
20h
22h
0h
2h
4h
6h
8h
10h
Swift X-ray
SDSS,MDM
KPNO/Panstarrs
DES

Results


75°
60°
45°
30°
15°
0°
-15°
-30°
-45°
-60°
-75°
14h
16h
18h
20h
22h
0h
2h
4h
6h
8h
10h
Swift X-ray
SDSS,MDM
KPNO/Panstarrs
DES
DES-detected

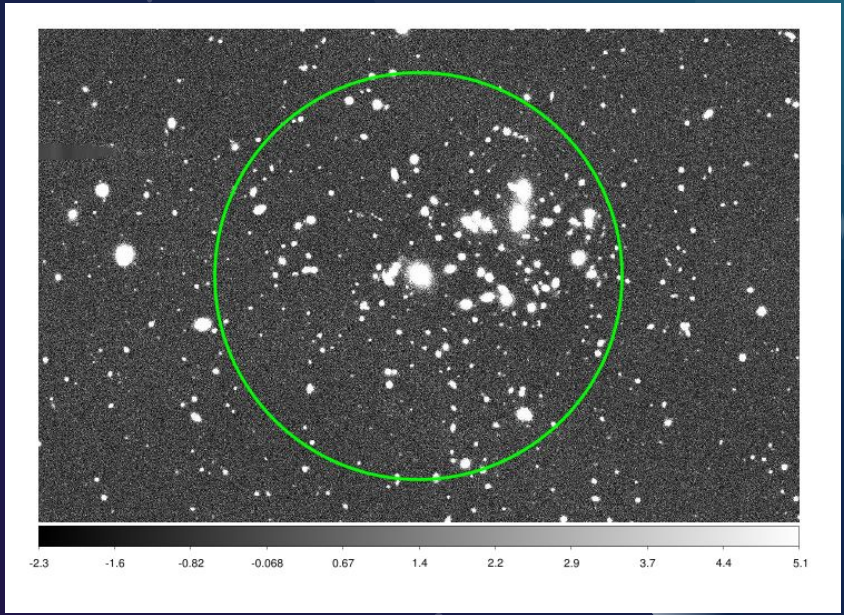
Significant Results

Time for some pictures!

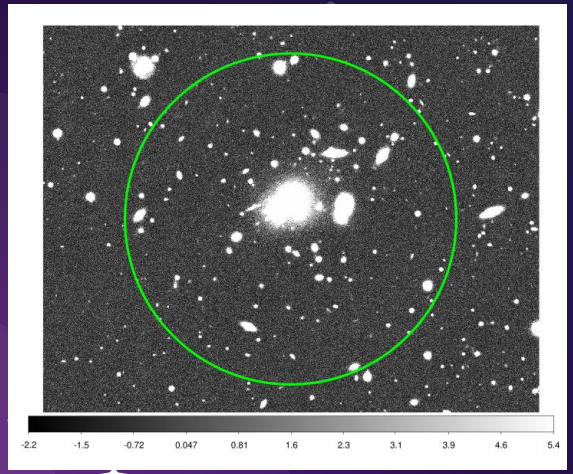
Q35_SWCL J025630.7+000601

By far the most significant detection!

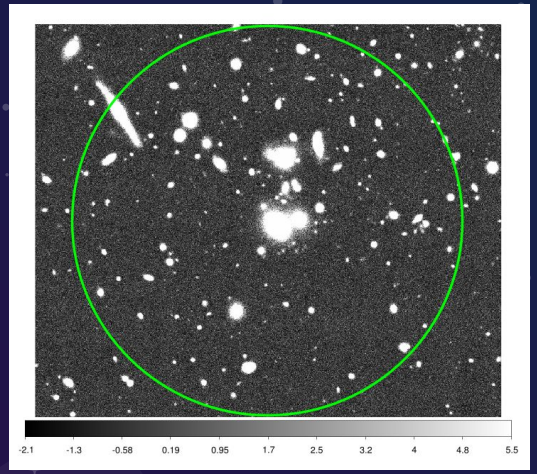
Significance = 8.791σ!



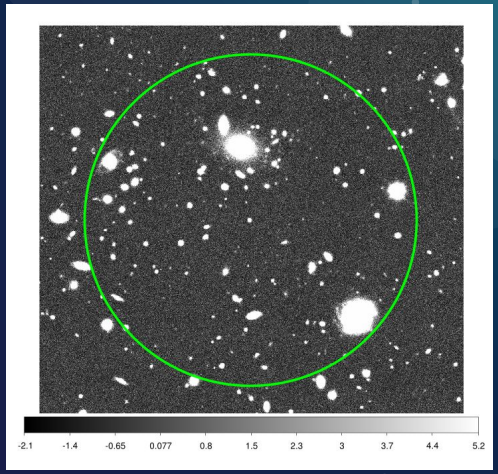
Significant Results



q56_SWCL J212057.2-411307
Significance = 6.246σ



q56_SWCL J212057.2-411307
Significance = 5.558σ



q56_SWCL J212057.2-411307
Significance = 5.591σ

Results Continued

- Non-detection does not indicate no cluster
  - Indicates higher redshift
  - Approximately 9 high redshift detections
  - We can see this redshift effect!

Redshift Visualized:

q75_SWCL J234757.5+002121

Image from g filter

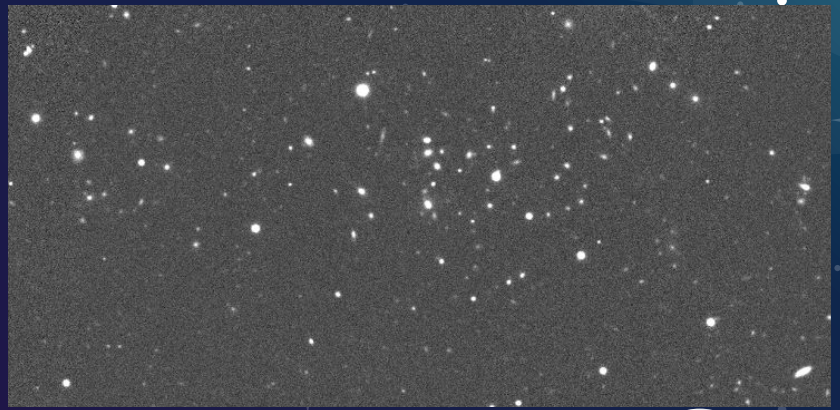


Image from i filter

What Comes Next?

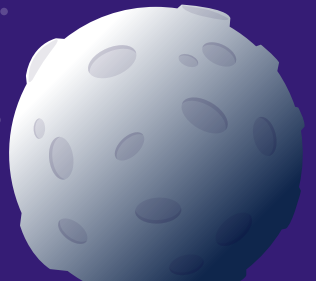
- Still Swift candidates require optical confirmation
  - More DES data- SVA1, Y1A1
  - CTIO data- Southern Hemisphere
- Once there is a more complete catalog of clusters, use data to study the universe

SO I LEARNED...

- How to write some IDL code
- How to submit SQL queries
- How to effectively use python and python packages to analyze massive amounts of data
- How to use ds9 to view images

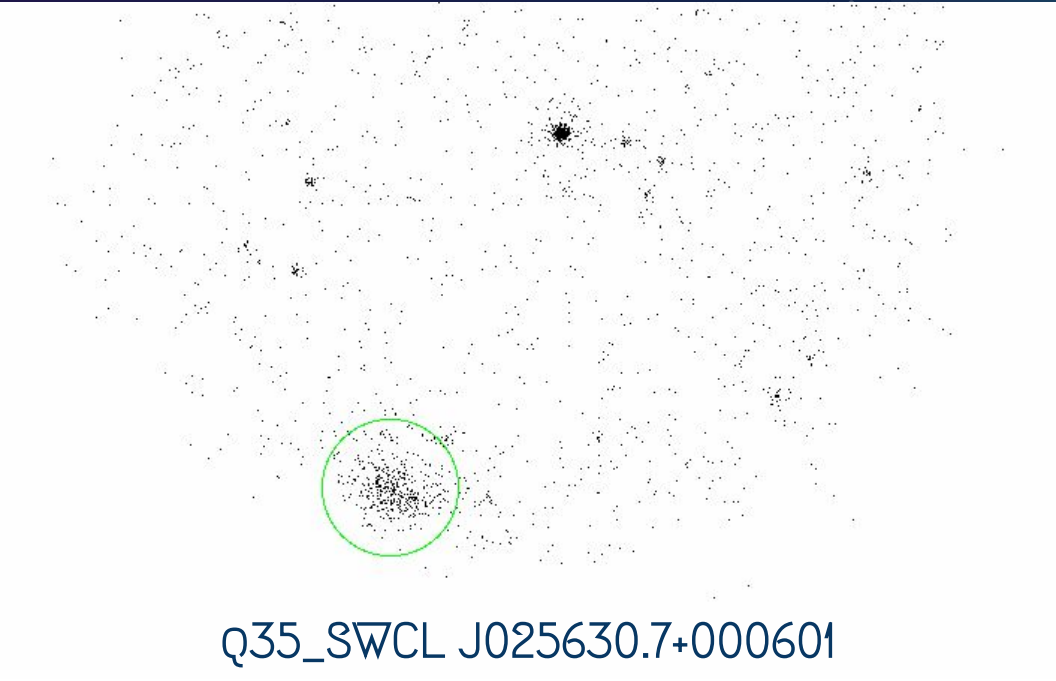
THANKS!

ANY QUESTIONS?



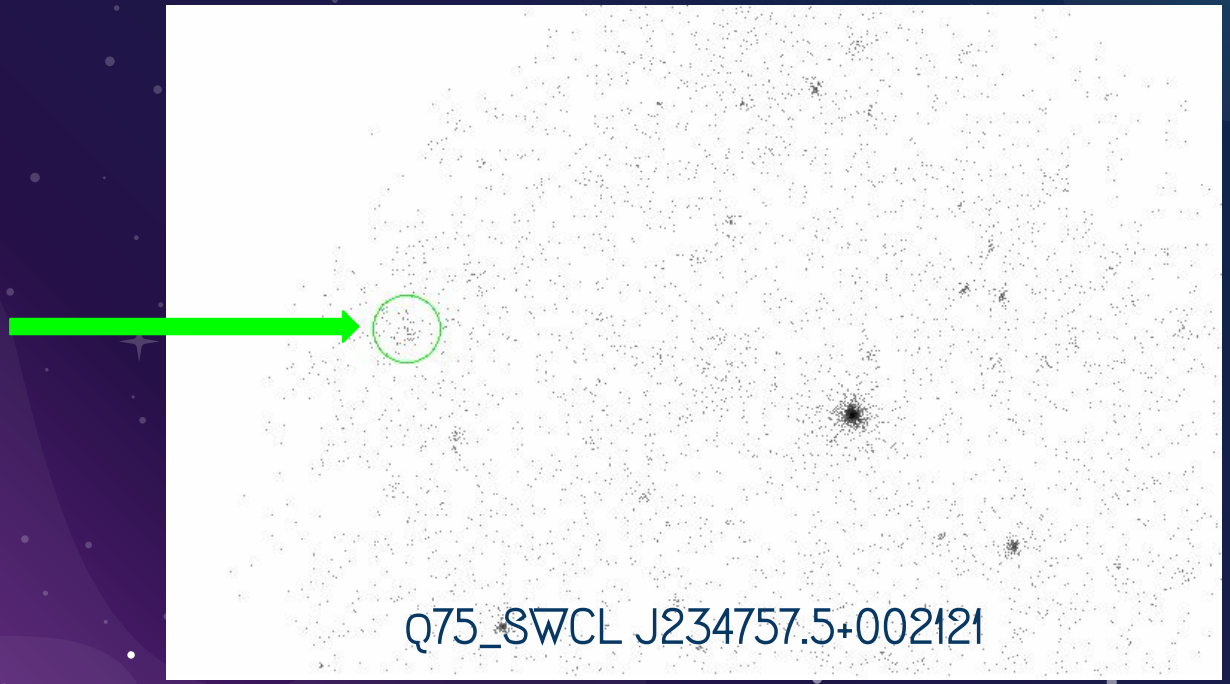
Extra Slides

X-Ray Images from Swift

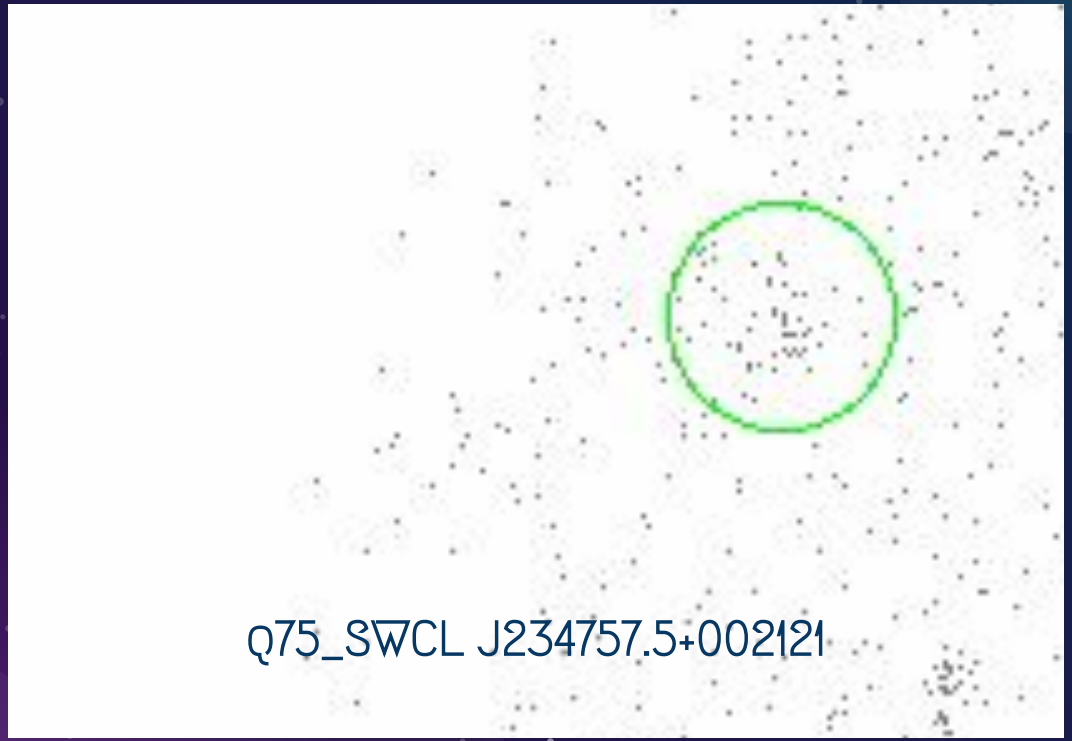


Q35_SWCL J025630.7+000601

X-Ray Images from Swift



X-Ray Images from Swift



References

- Bhatiani S., 2017
- Schneider P., 2006