Hunting for γ-rays from Fast Radio Burst (FRBs) using *Swift*/BAT & GUANO

By: Maxwell A. Fine

Advised by: Dr. Ziggy Pleunis, Dr. Paul Scholz,
Prof. Bryan Gaensler

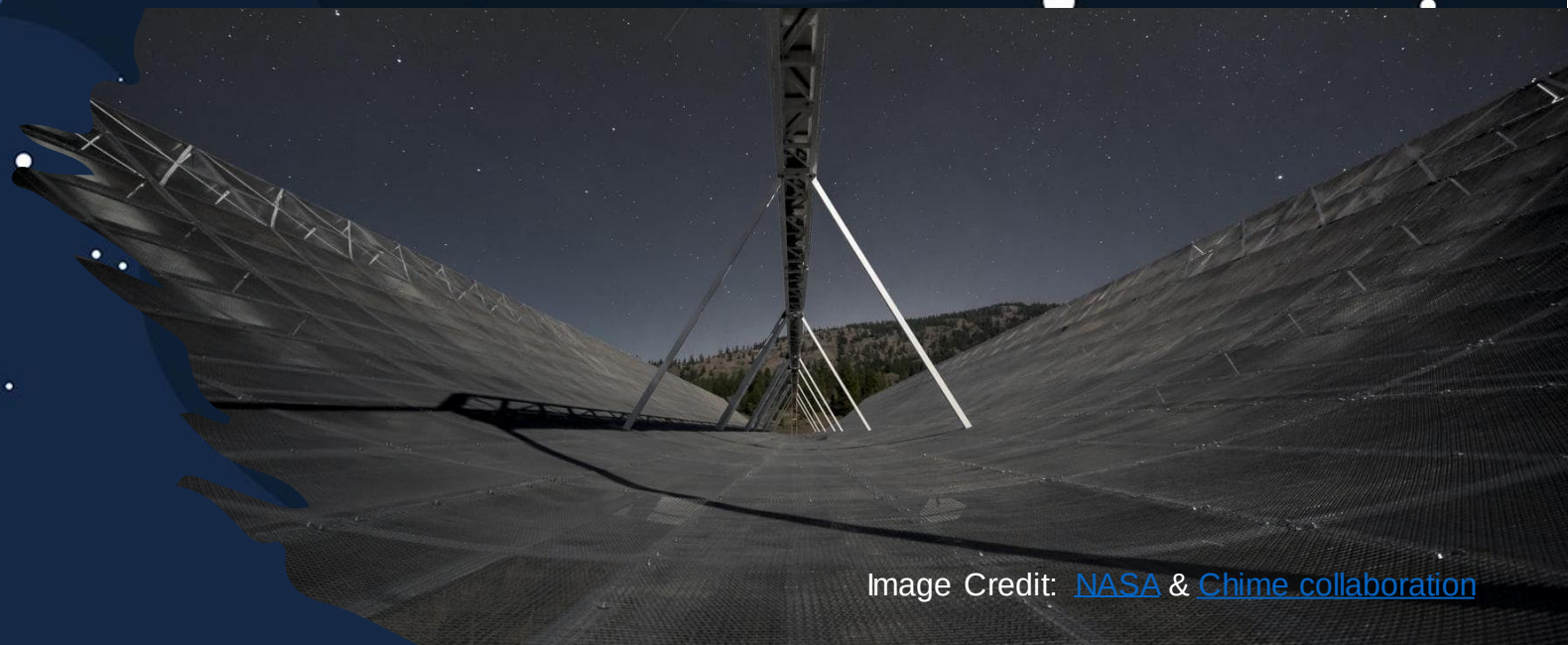
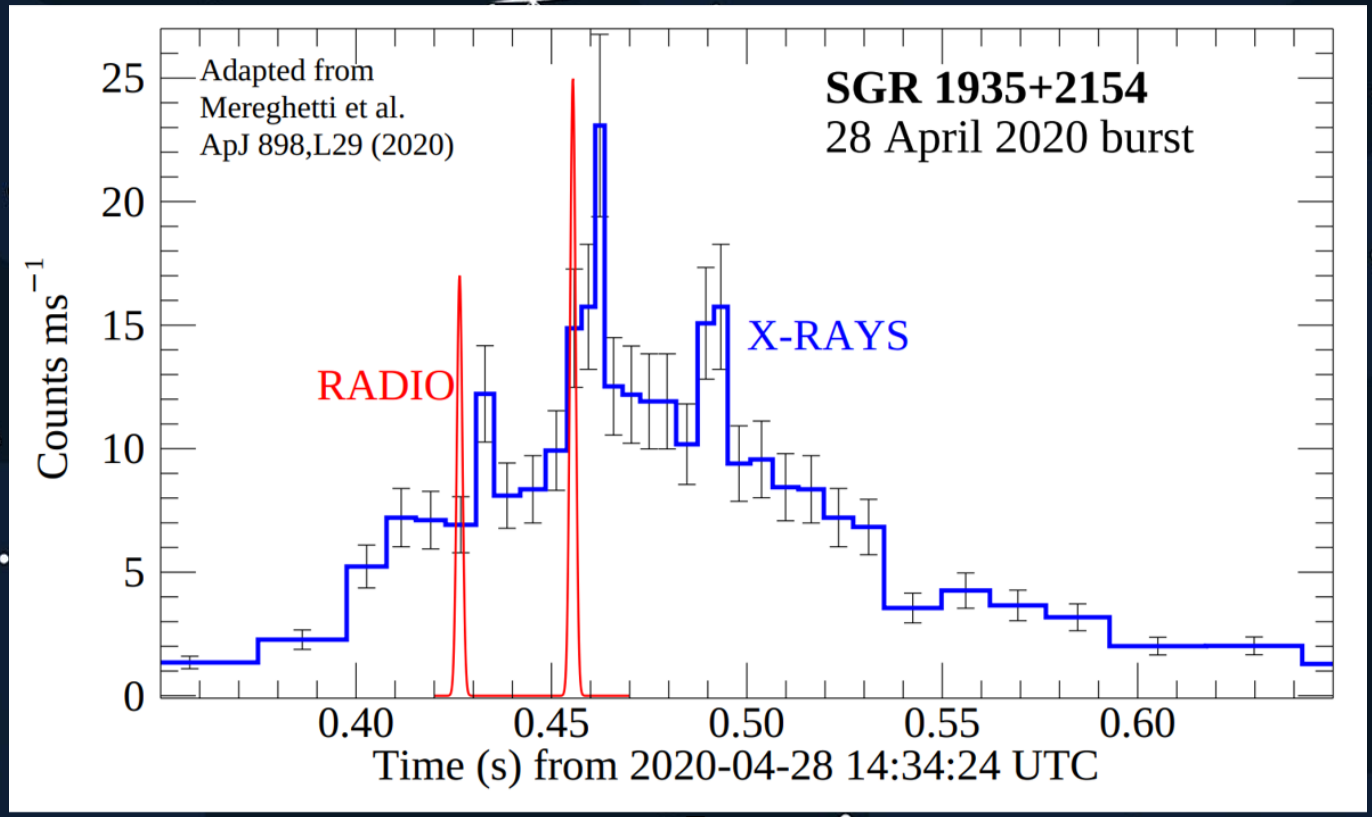


Image Credit: NASA & Chime collaboration

Fast Radio Bursts (FRBs):

- Transient radio emission of unknown extra-galactic origin, there are more than 600 CHIME/FRBs
- Timescale of burst in radio wavelengths is ~1ms to 1s
- Most FRB progenitor models involve magnetars, and predict associated γ-ray emission
- So far, FRBs have only been observed at radio wavelengths

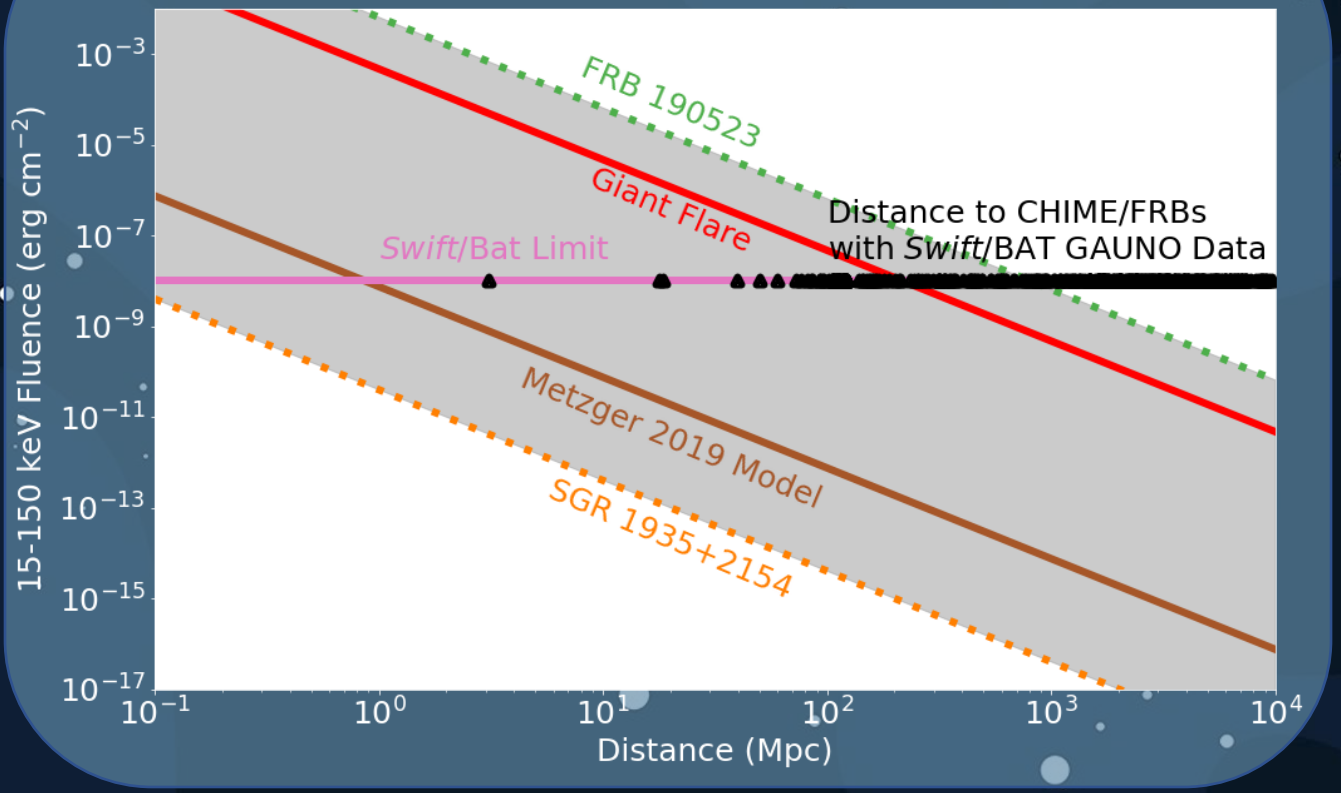


Source: Petroff E., Hessels J. W. T., Lorimer D. R., 2022, Astron. Astrophys. Rev., 30, 2

Project Motivation:

- Previous γ-ray searches looked at a single repeating FRB, and established fluence limits of ~ 10^{-7} erg/cm^2
- Thanks to GAUNO, there is corresponding *Swift*/BAT data for more than 500 CHIME/FRBs
- No one has yet searched these CHIME/FRBS with *Swift*/BAT data
- Project: systematic survey to look for γ-ray emission from more than 500 CHIME/FRBs

Swift/BAT Prospects



Source: Nicastro L., Guidorzi C., Palazzi E., Zampieri L., Turatto M., Gardini A., 2021, Universe, 7, 76

Goals & Timeline:

Mid October

- Decide on search parameters
  - Timescales in γ-rays ✓
  - Energy Bands
  - Model Spectrums ✓

January-February

In Progress

- Develop analysis pipeline to look for γ-ray counterparts to CHIME/FRB events

March

- Run pipeline on all CHIME/FRB events with GUANO data
  - Determine fluence limits on γ-ray counterparts

Read In catalogue of CHIME/FRBs & Download Corresponding *Swift*/BAT Data ✓

In Progress

Analysis of Light Curves of CHIME/FRB Targets

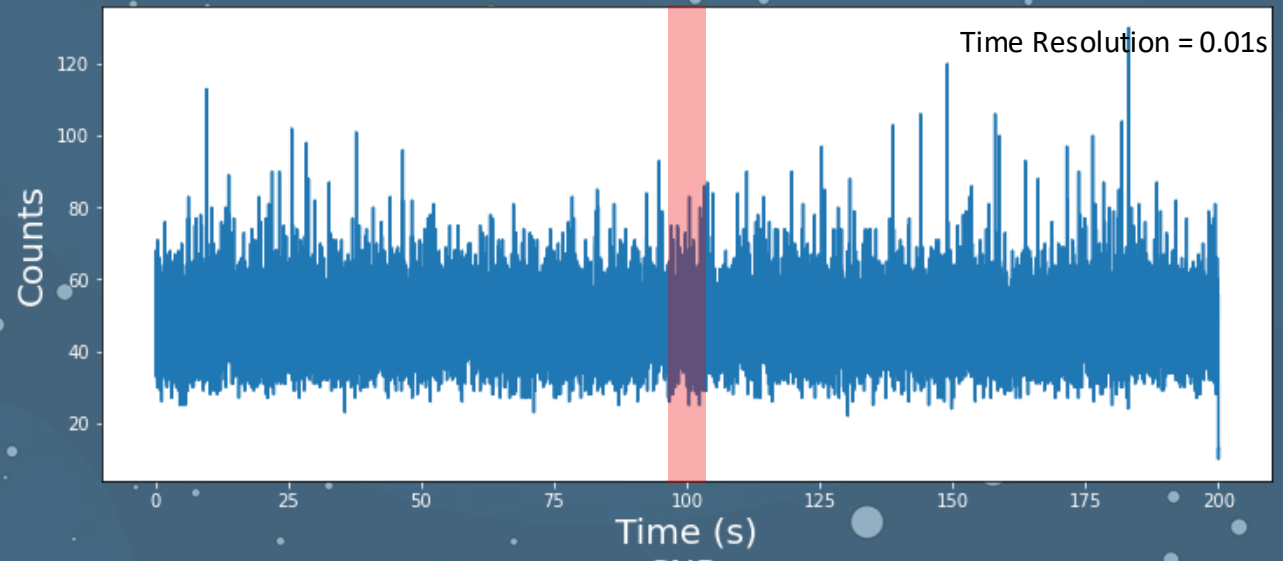
Analysis of Images of CHIME/FRB Targets

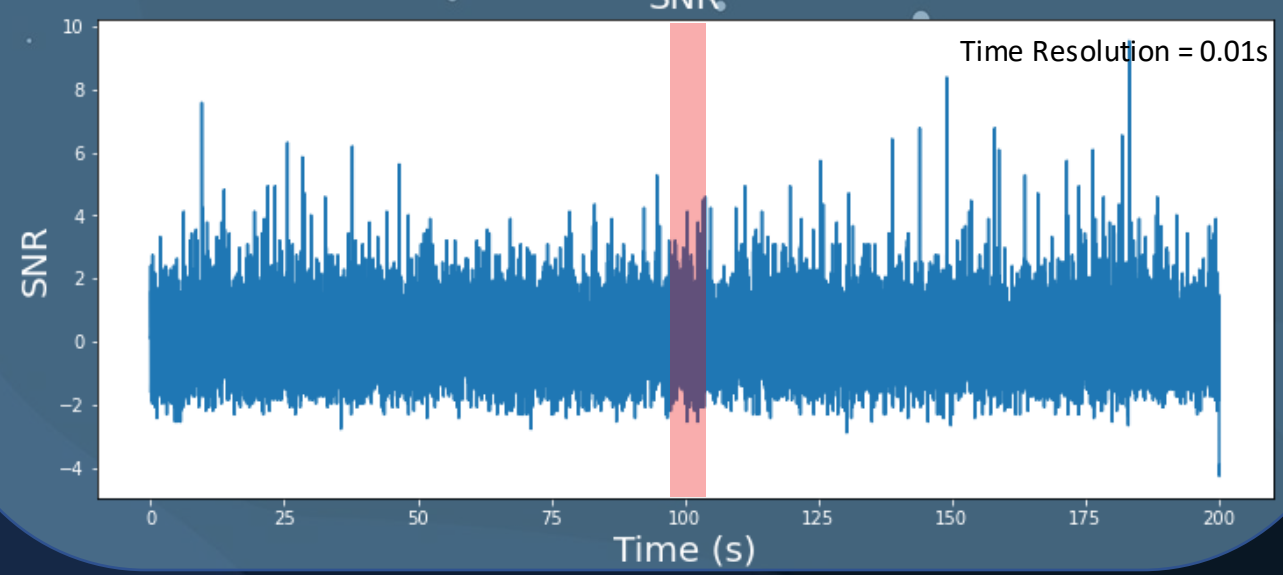
Pipeline

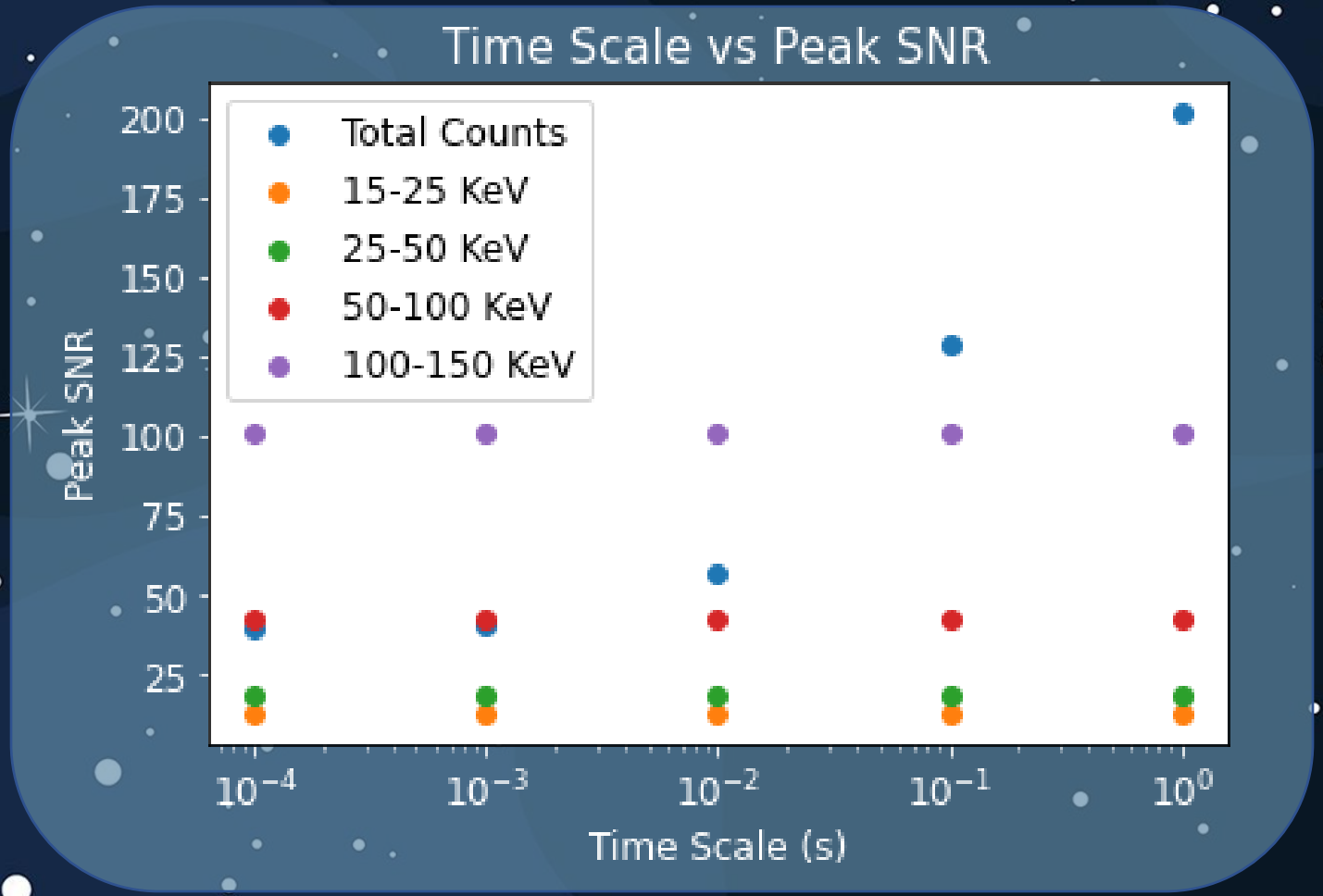
Background Image credit badrusblue

Light Curve Analysis:

- *Swift*/BAT light curves are more sensitive then corresponding images. If there is a corresponding γ-ray event we should see it
- Searches light curve in signal to noise (SNR) space for a peak using a boxcar search with different sized boxcars for different time scales
- Boxcar search is looking around a window ±3s centered on the CHIME/FRB detection time in the light curve

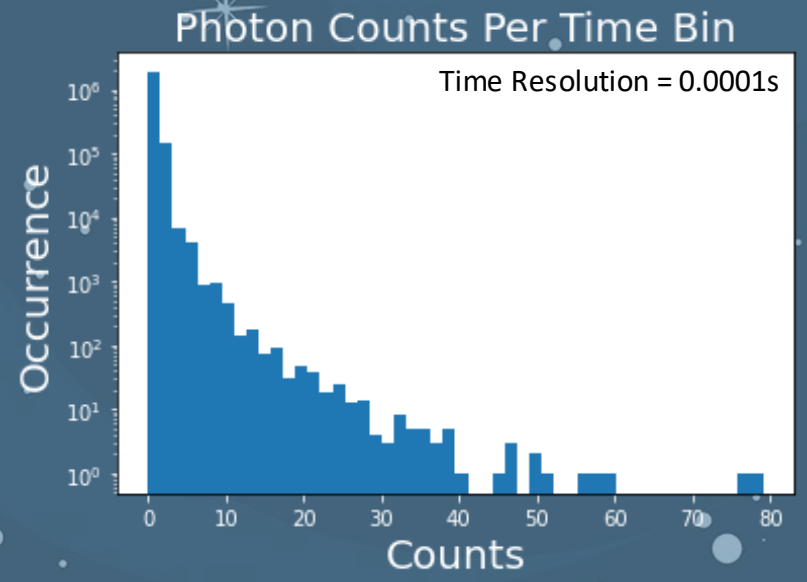


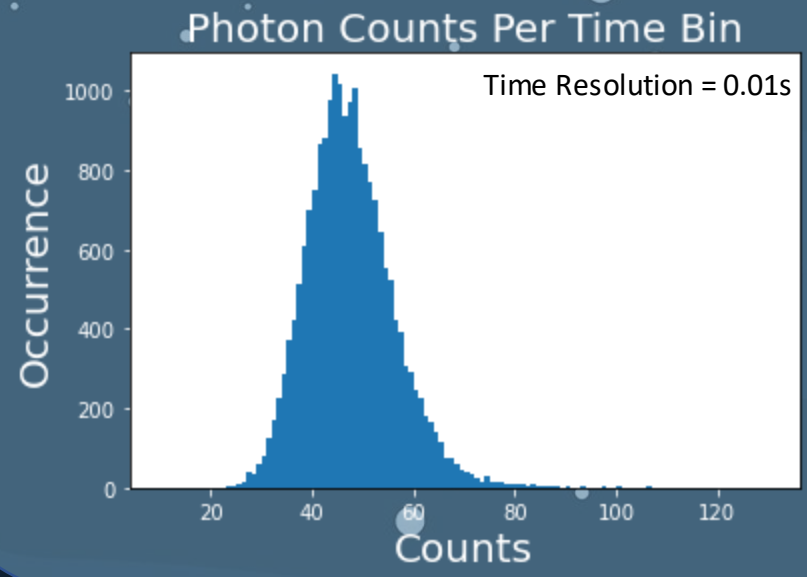


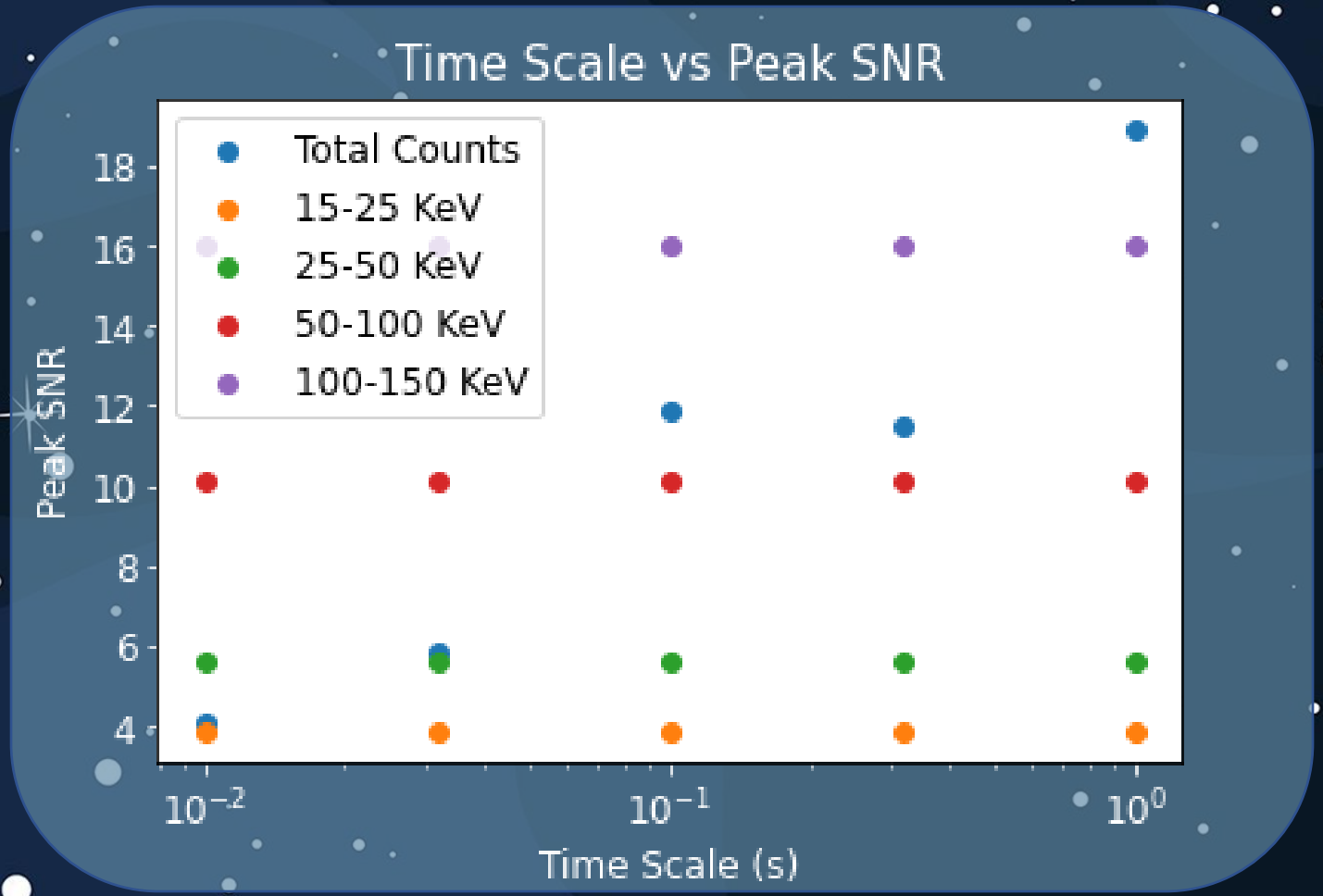

Time Scale vs Peak SNR
Total Counts
15-25 KeV
25-50 KeV
50-100 KeV
100-150 KeV
Peak SNR
200
175
150
125
100
75
50
25
10^{-4}
10^{-3}
10^{-2}
10^{-1}
10^{0}
Time Scale (s)

Issues:

- SNR Is way off for our test! WHY!
- Lead to an investigation of the statistical properties of the light curves
- Mean and STD are too low, when using the instrumental resolution of 0.0001s (1e-4s)
- Photon Counts do not follow a Gaussian distribution when light curve time resolution is small ≤ 0.001s (1e-3s)



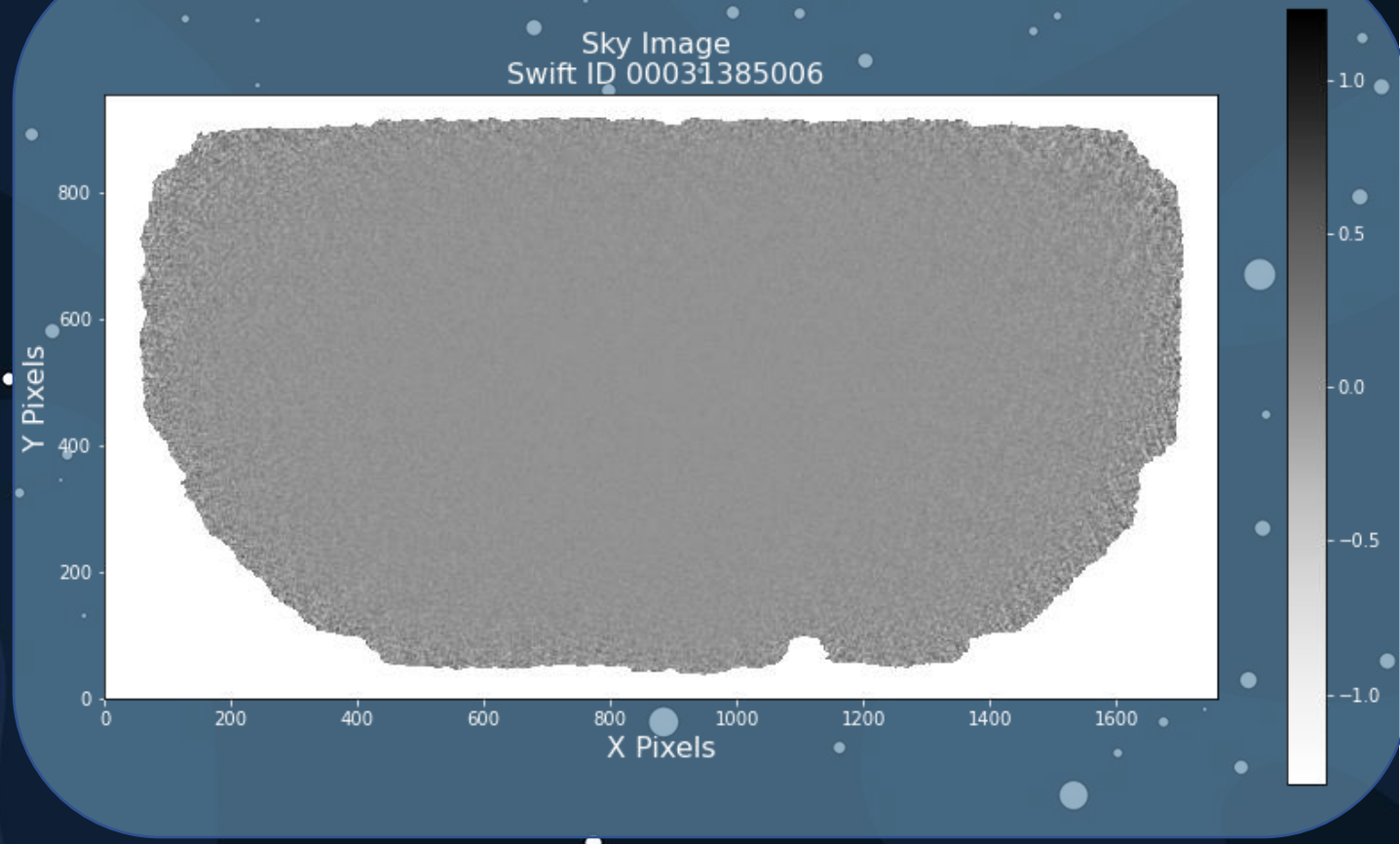



Time Scale vs Peak SNR
Total Counts
15-25 KeV
25-50 KeV
50-100 KeV
100-150 KeV
Peak SNR
18
16
14
12
10
8
6
4
10^{-2}
10^{-1}
10^{0}
Time Scale (s)

Outlook & Next Steps:

December:

- Further test the light curve analysis code with simulations or real GRBs
- Start the *Swift*/BAT sky image analysis code

January & Early February:

- Finish the *Swift*/BAT sky image analysis code
- Test sky image code
- Run pipeline