A (very) Chandra-centric path to HiPS

Raffaele D'Abrusco

on behalf of

Michael Tibbetts, Zografou Panagoula
and the CXC Data System team

CENTER FOR ASTROPHYSICS
HARVARD & SMITHSONIAN

Chandra HiPS

- An intuitive, easy-to-use visualization of Chandra data that makes justice to its unique observational properties
  - **need to look nice**
  - ensure a satisfactory level of scientific fidelity

- Support for exploration and discovery of Chandra data
  - single observations
  - Chandra Source Catalog (CSC) sources
  - aggregate datasets (future)

- Everybody else is doing it…

Vela PWN

The “raw” data

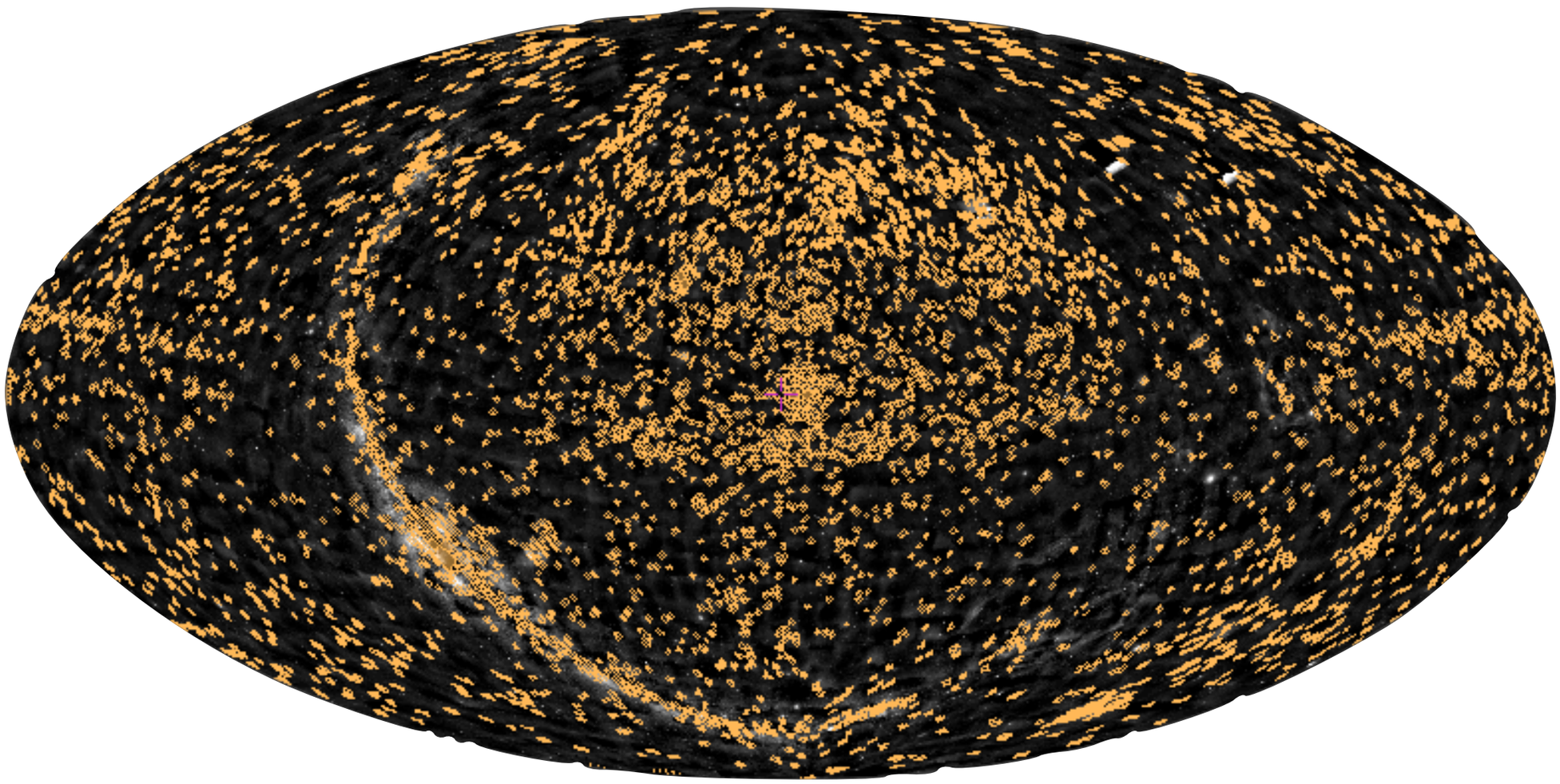
- Chandra has observed a variety of different astrophysical environments with observational configurations meant to optimize the scientific goals of the PIs
  - different instruments
  - variable exposures and observing strategies
  - ad hoc spatial/time arrangements of observations

- Very **heterogeneous archive**
  - large dynamical range intra- and inter-observations, cross- and intra-field
  - variety of different spectral behaviors
  - point-like sources to complex, extended emission regions with complex morphologies, brightness and spectral structures

Centaurus A

Archival geometry

- Global footprint of Chandra archival observations is geometrically complex
  - Small total footprint area (~1.9 square degrees)
  - 12766 (ACIS) observations



Kepler SNR

Requirements

- HiPS max spatial resolution comparable to ACIS pixel max resolution
  - HiPS order 11 -> 0.2” tile pixel angular size
- Standard data processing
  - CIAO tools
  - Red-Green-Blue images obtained filtering the event files according to the events’ energy
  - avoid custom processing methods for **replicability and simplicity**
- Same approach for all the sky
  - good solution for most fields
  - still **works well enough** for fields with extreme properties


GW170817

Divide et impera

- Divide the sky into distinct fields and produce field-based HiPS
  - 2.1° radius
  - each observation associated to only 1 field
  - 12766 (ACIS) observations split in 1370 fields
  - good for **management of computational resources**, **gradual scientific QA** of fields

- Generate per-field monochromatic HiPS in three energy bands and combine them to create the per-field RGB HiPS
  - Used the CSC energy bands definitions
    - R -> “soft” band (0.5-1.2 keV)
    - G -> “medium” band (1.2-2.0 keV)
    - B -> “hard” band (2.0-7.0 keV)
  - No smoothing

- Merge the per-field RGB HiPS's into the all-sky RGB HiPS

NGC 6231

Training and Testing

- "Fine-tuning" of the HiPS production method
  - ~30 reference "**rich**" **fields**
  - ~20 **problematic fields**: low signal, high background, high-exposure/low-exposure high-background/low-background combinations

- Validation of the final, global HiPS
  - ~200 "famous" fields compared with the "press release" images and images from scientific publications
  - reference+problematic fields
  - metadata validation


M87

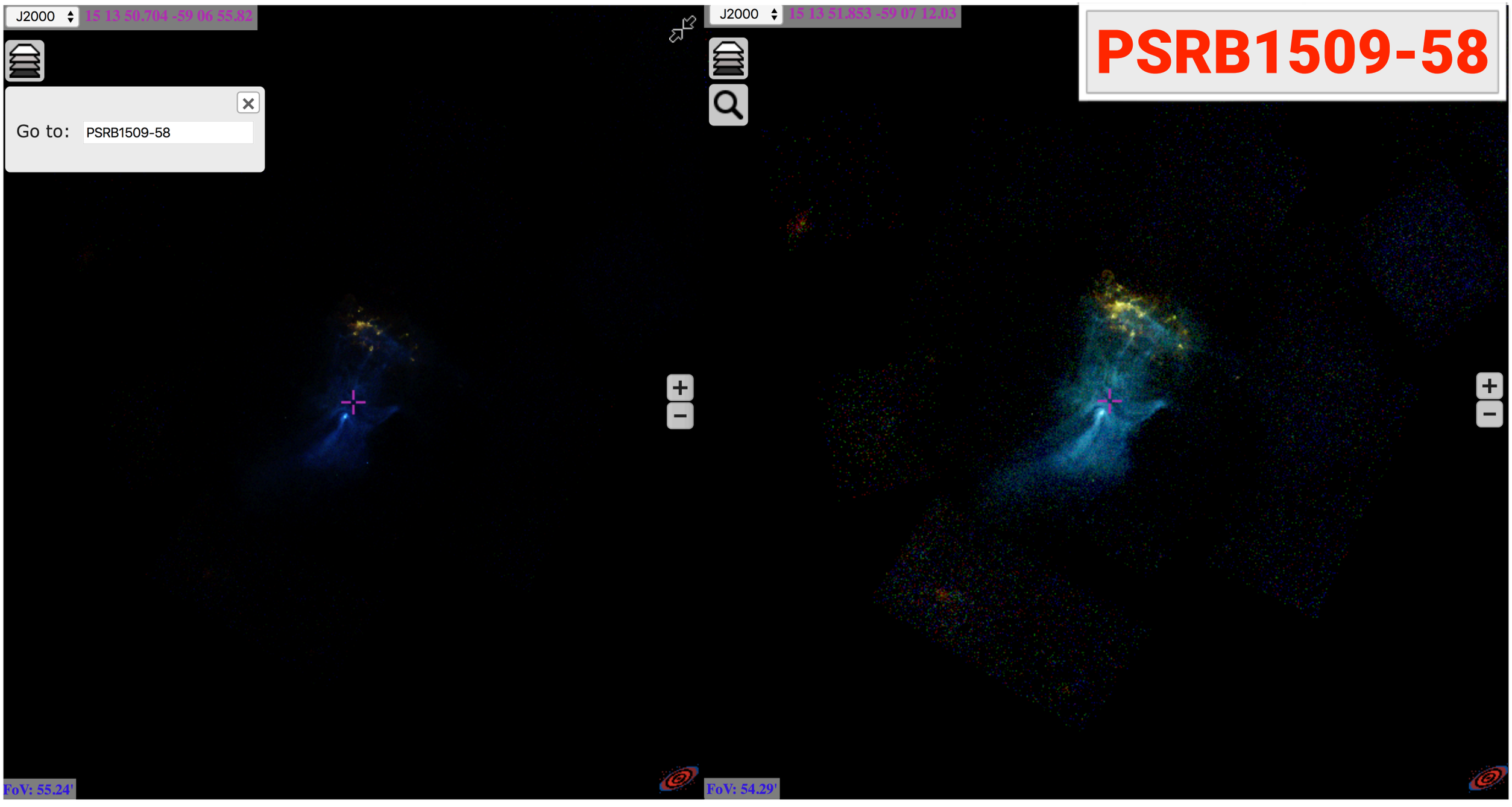
Labor limae

- Processing of input images:
  - **binned event files**
  - exposure corrected images

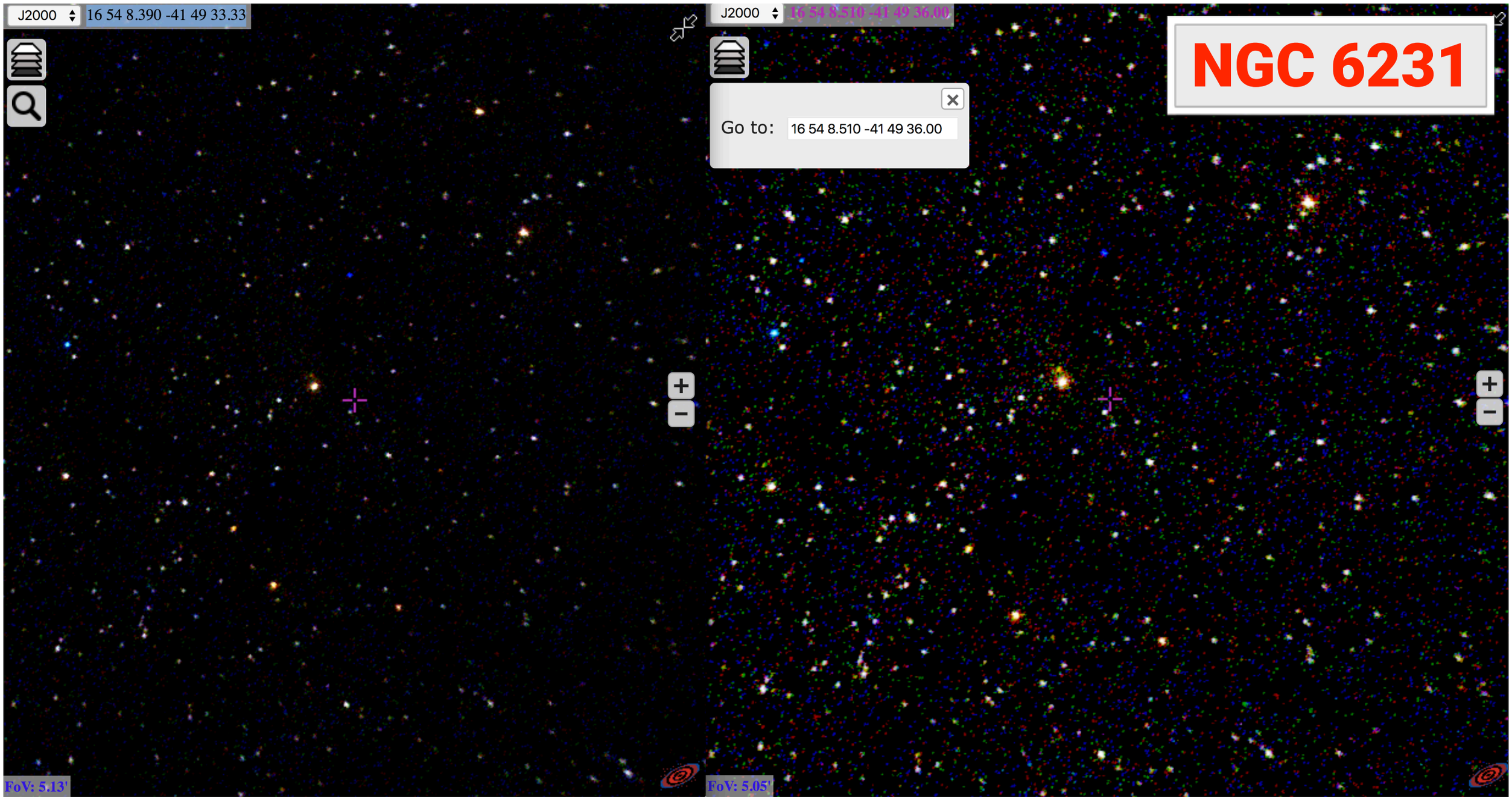
- Optimal “normalization” of the pixel distribution of input images
  - cutoffs on pixel distribution max and min to reduce noise and impact of brightest pixels
  - several options tested, **.05 and .99 quantiles** of distributions in each image were adopted

- Mapping from pixel values to RGB space
  - ***asinh* function**
  - logarithm

Example 1


J2000
15 13 50.704 -59 06 55.82
Go to:
PSRB1509-58
FoV: 55.24'
J2000
15 13 51.853 -59 07 12.03
FoV: 54.29'
PSRB1509-58

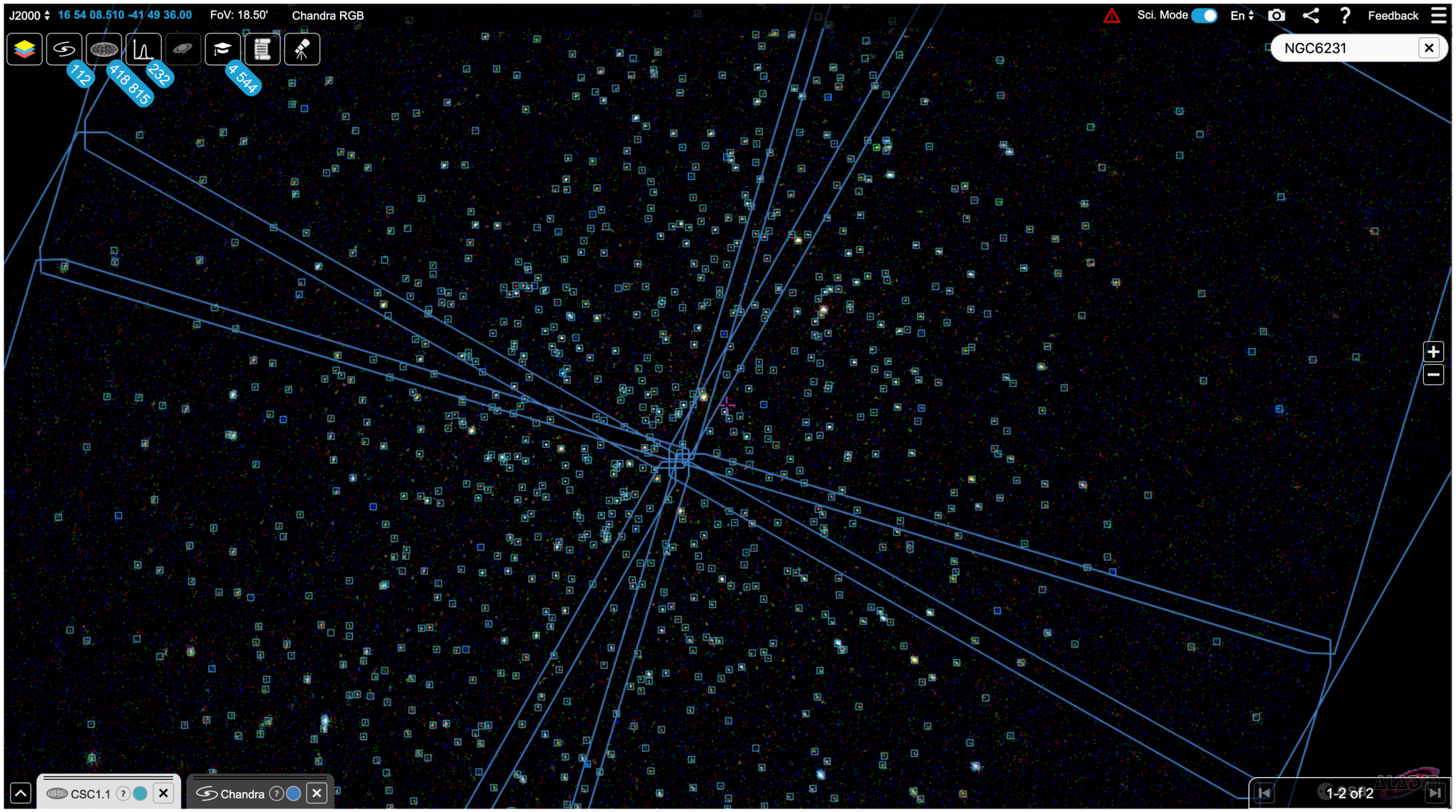
Example 2

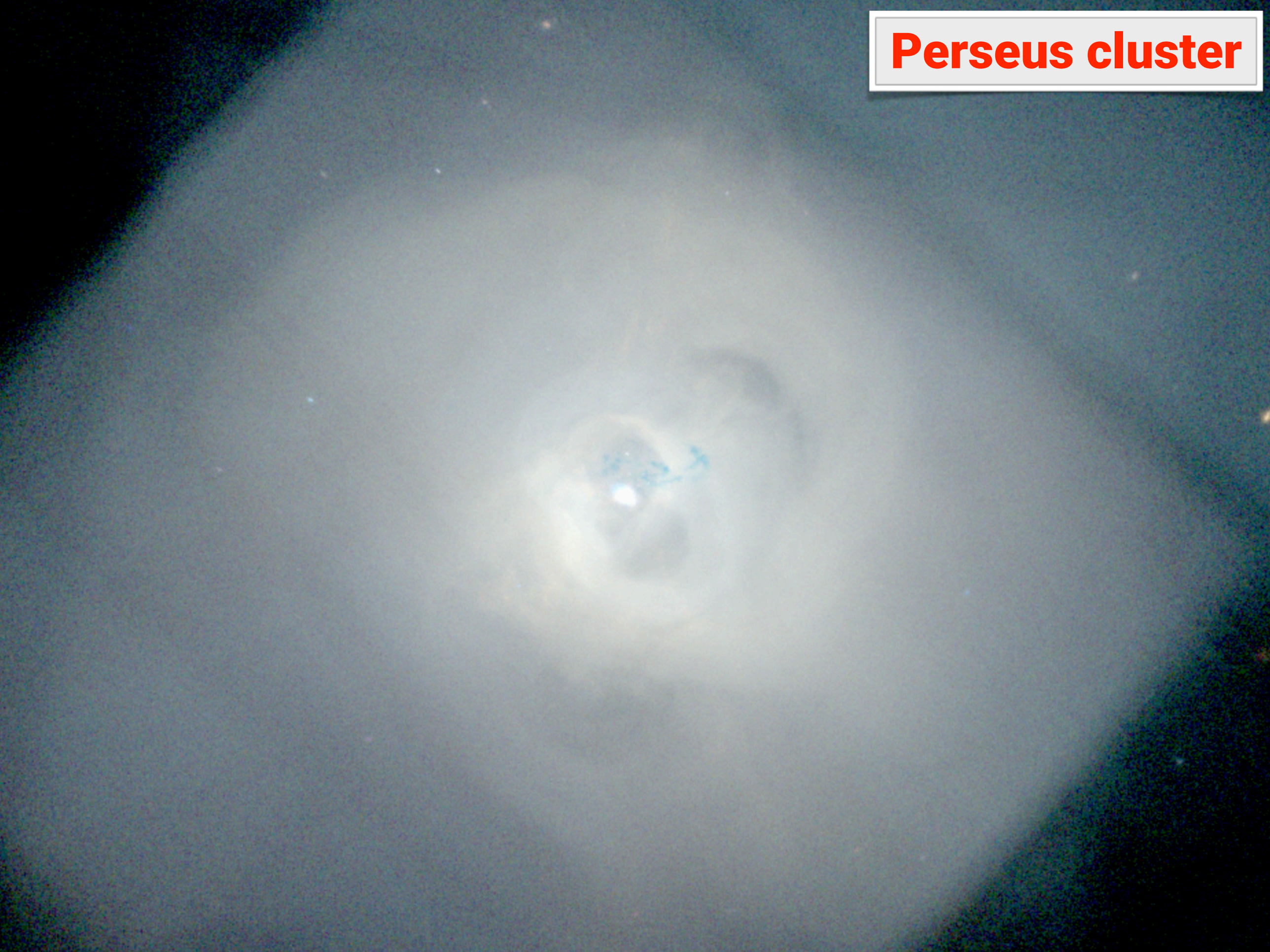

J2000
16 54 8.390 -41 49 33.33
J2000
16 54 8.510 -41 49 36.00
Go to:
16 54 8.510 -41 49 36.00
NGC 6231
FoV: 5.13'
FoV: 5.05'

Crab nebula

Final tests

- Our friends at ESA kindly agreed to ingest the total Chandra HiPS in the integration ESASky server
  - checks on **astrometric registration** of HiPS relative to the fov's of single observations and CSC1.1 sources




Perseus cluster

Future developments

- Short term
  - Approve final RGB Chandra HiPS for public distribution and distribute it as widely as possible

- Short-medium term
  - Develop and test **update mechanism** to regularly add new public observations to the total RGB Chandra HiPS

- Medium-long term
  - create the **Chandra catalog HiPS**
    - matched release with CSC versions
    - based on stacked CSC data products (deeper)
  - create grayscale archival HiPS (including HRC observations)