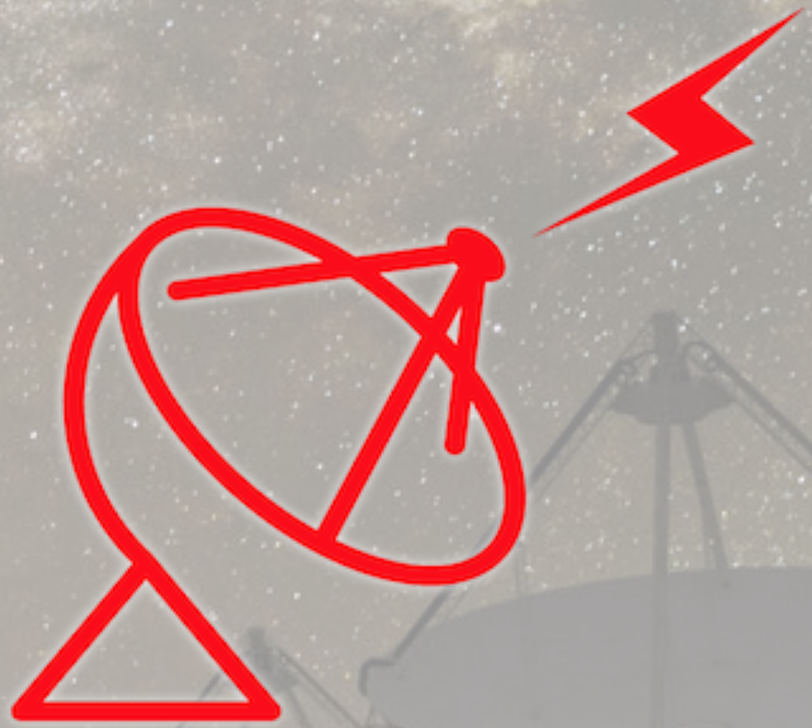
SEAFOG

Studies of eROSITA And FLASH Obscured Galaxies

Vanessa Moss

ASTRON/University of Sydney



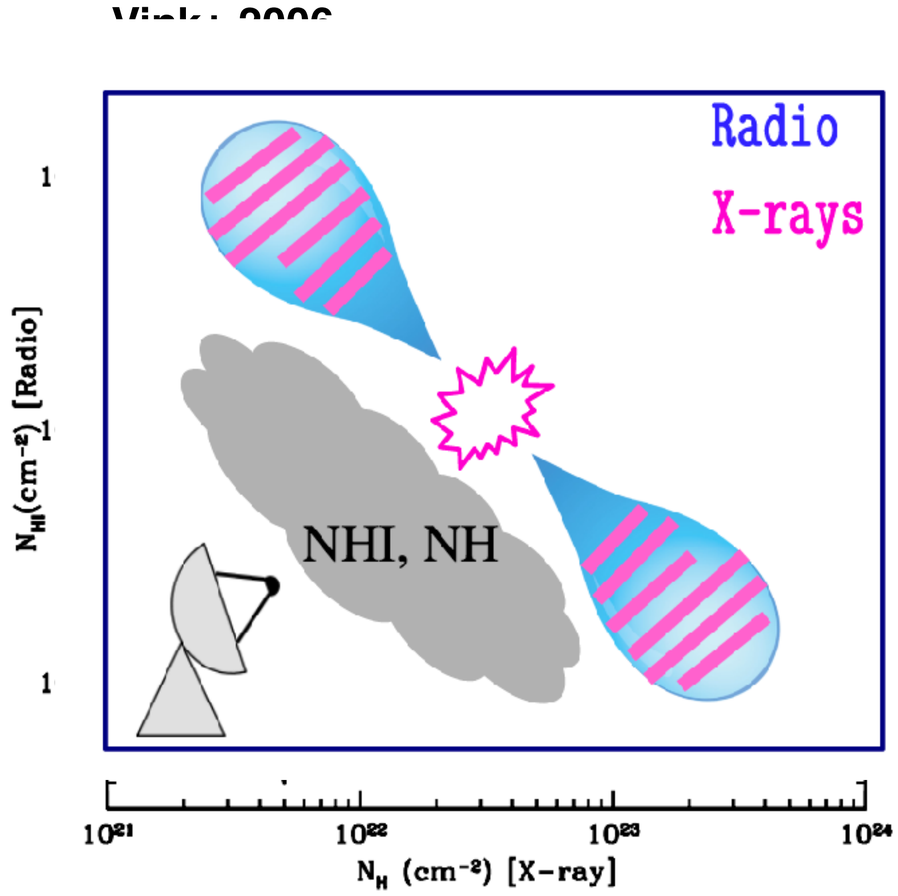
ASKAP-FLASH

First Large Absorption Survey in HI

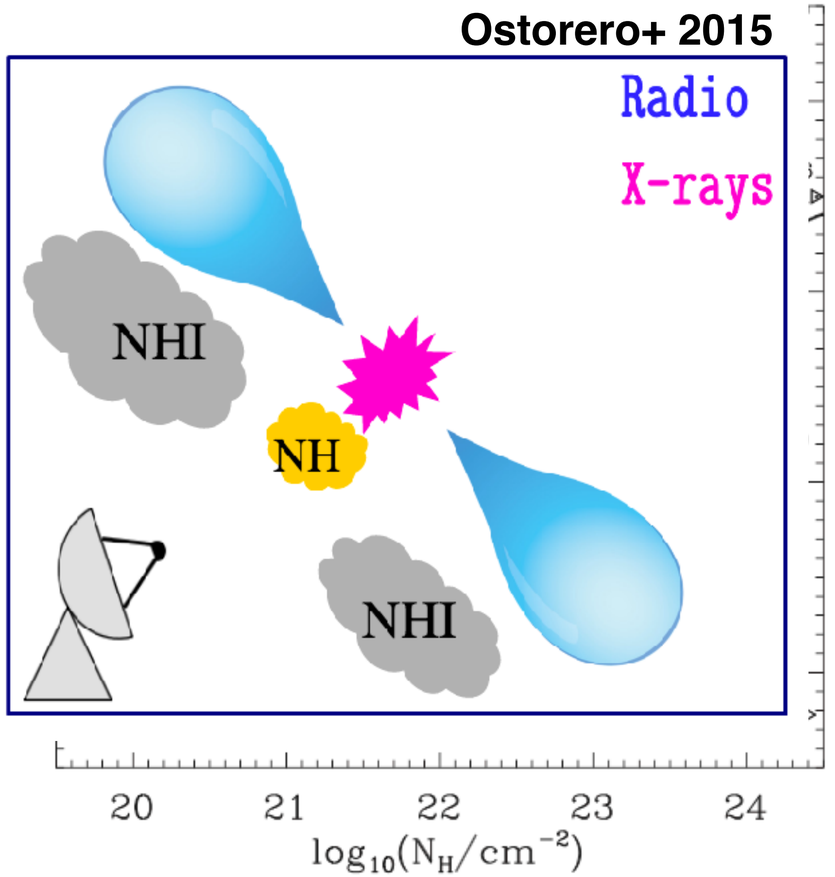
http://www.physics.usyd.edu.au/sifa/Main/FLASH

https://www.astron.nl/astronomy-group/apertif/science-projects/sharp-search-hi-absorption-apertif/sharp

X-rays/HI in GPS sources

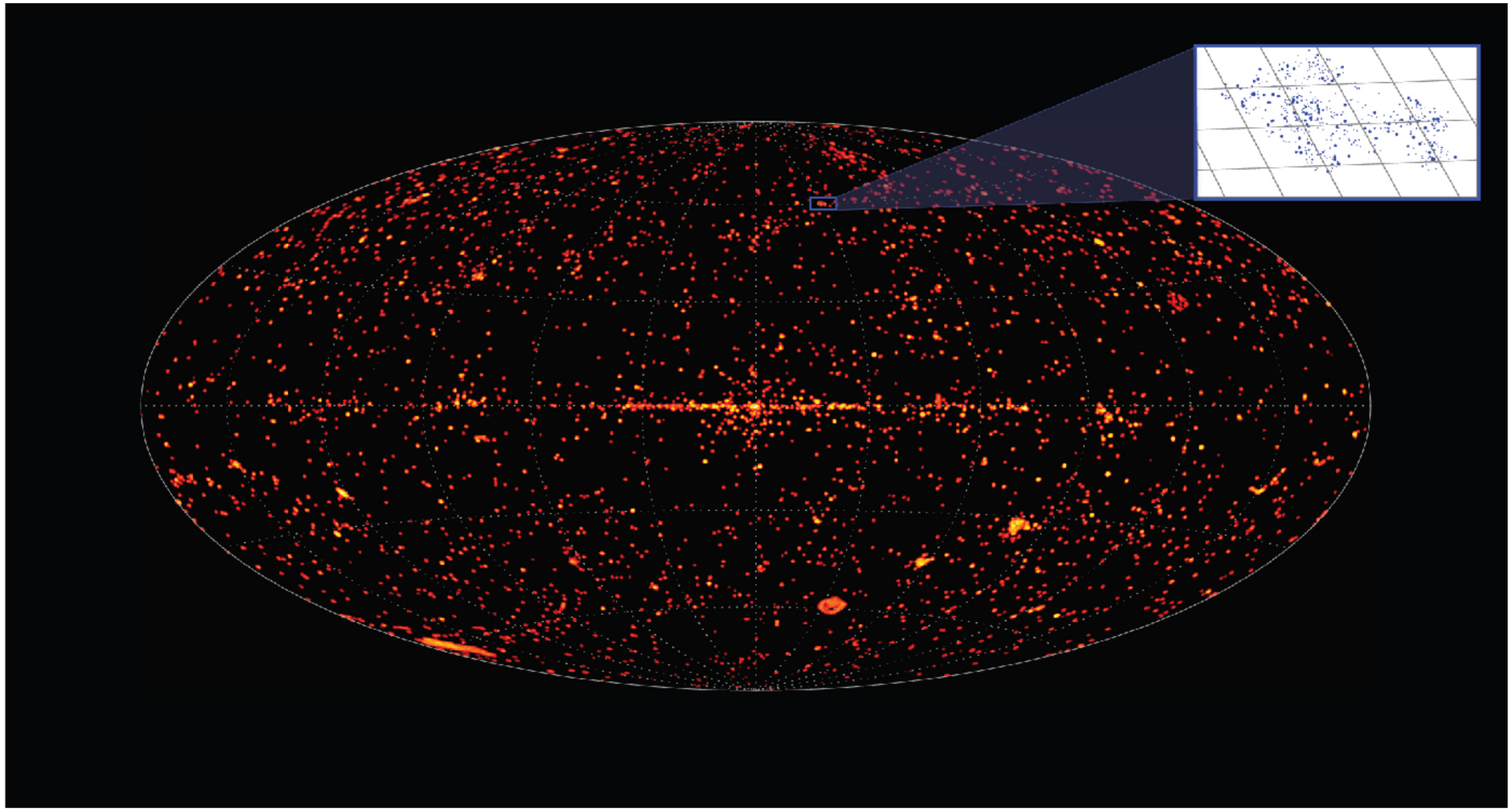


Ostorero+ 2015



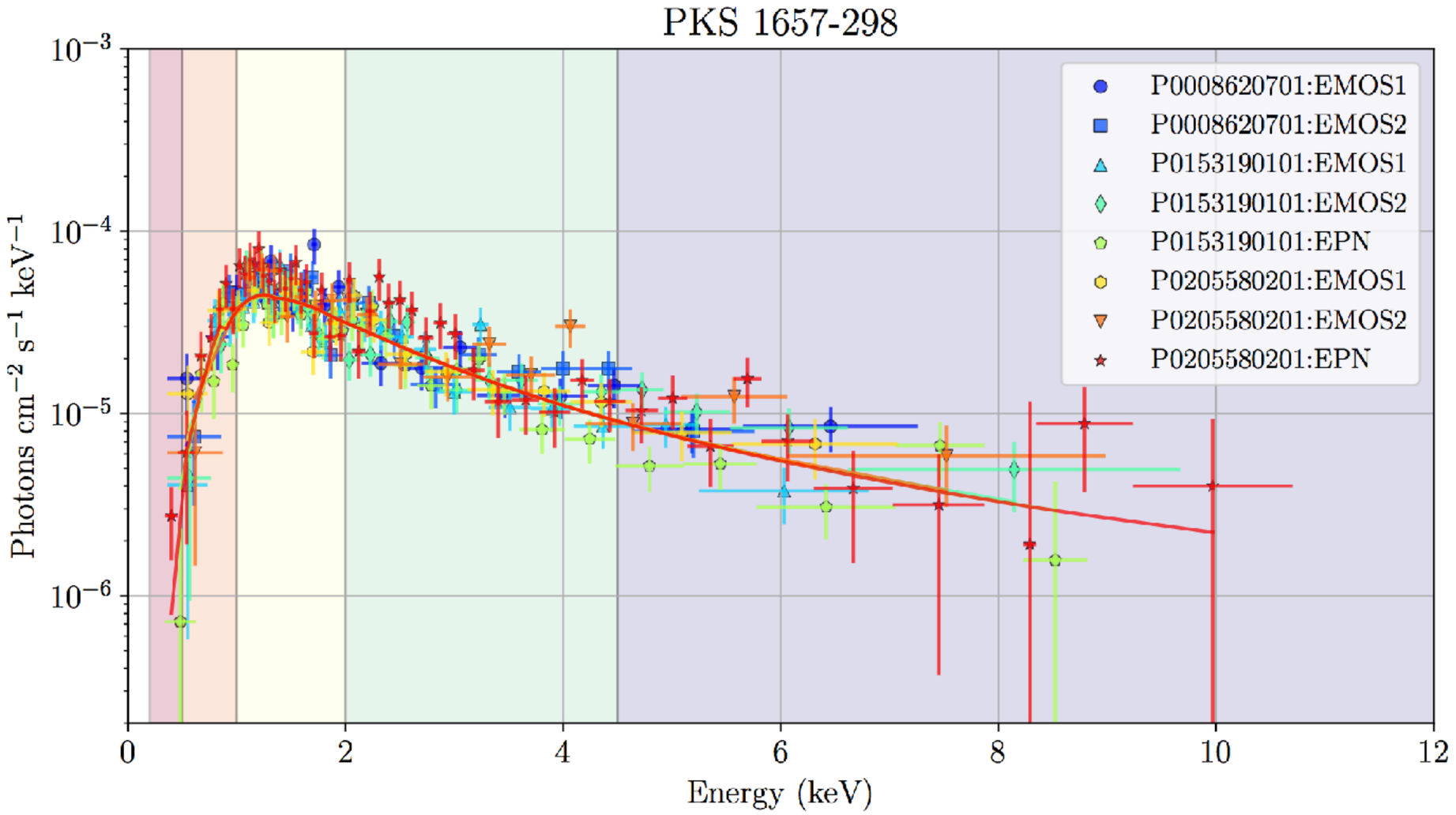
IMAGES: VINK+ (2006), OSTORERO+ (2015, 2017)

3XMM DR4 catalogue

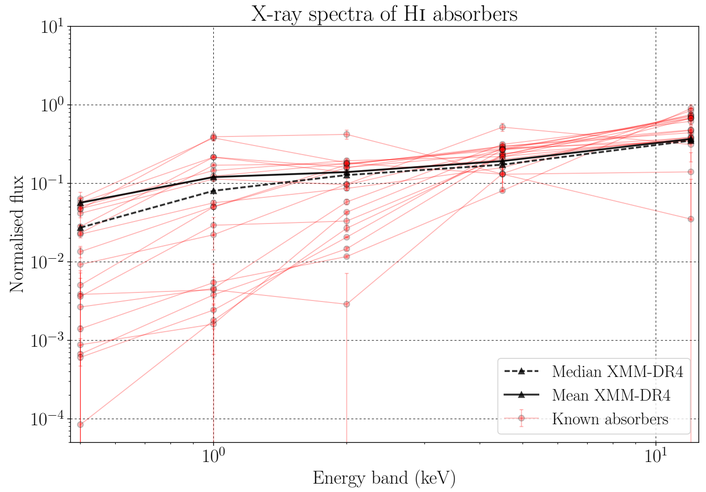


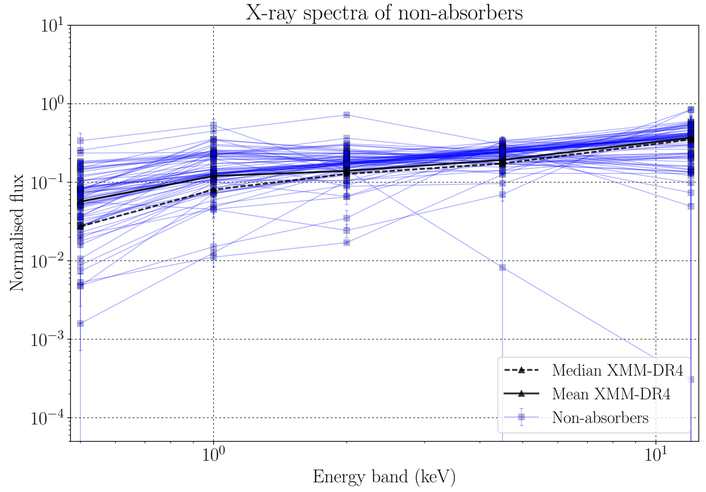
ALL-SKY 3XMM DR4: ESA/XMM-NEWTON/EPIC/M. WATSON

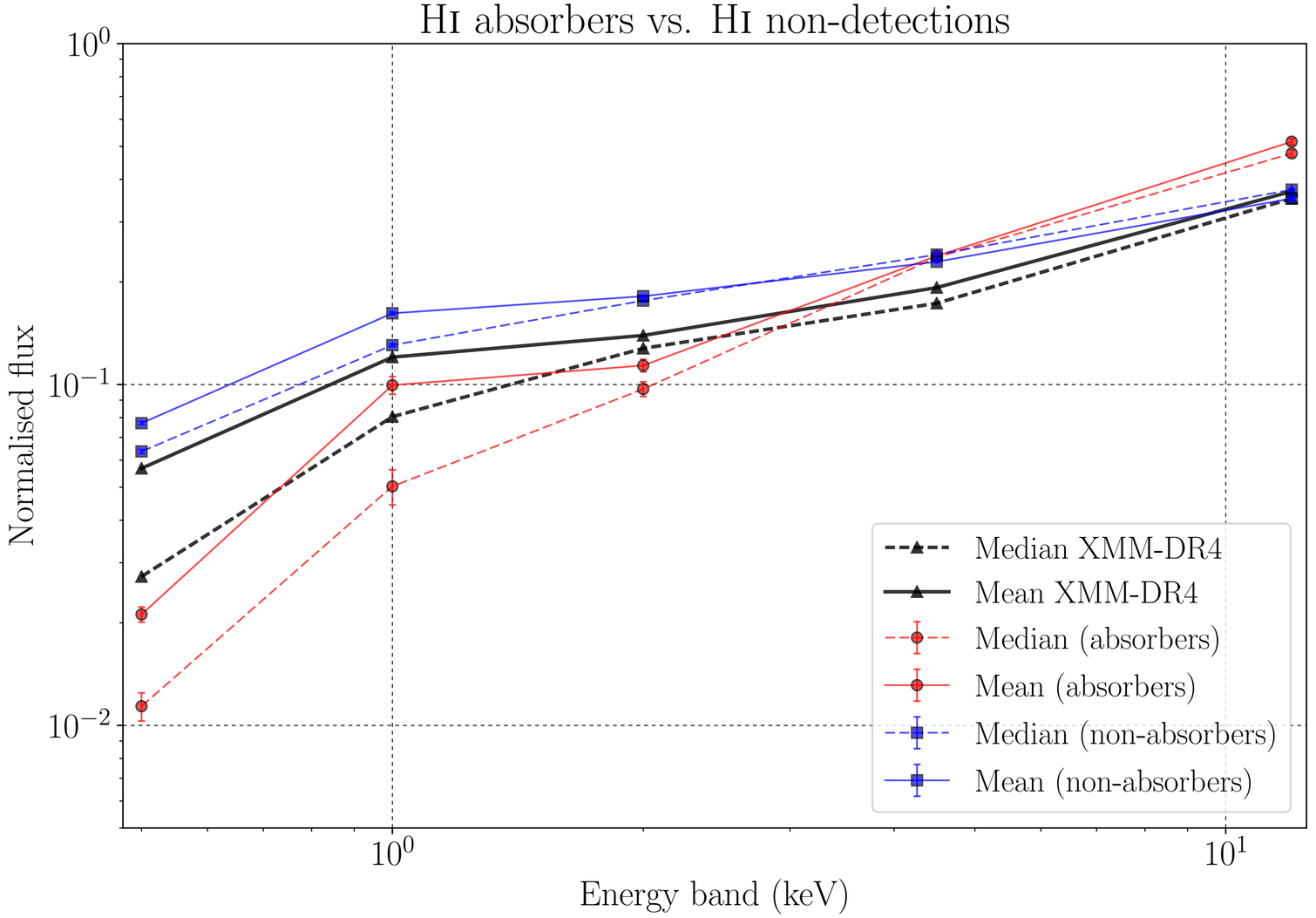
Catalogued flux values



HI absorbers vs. non-absorbers

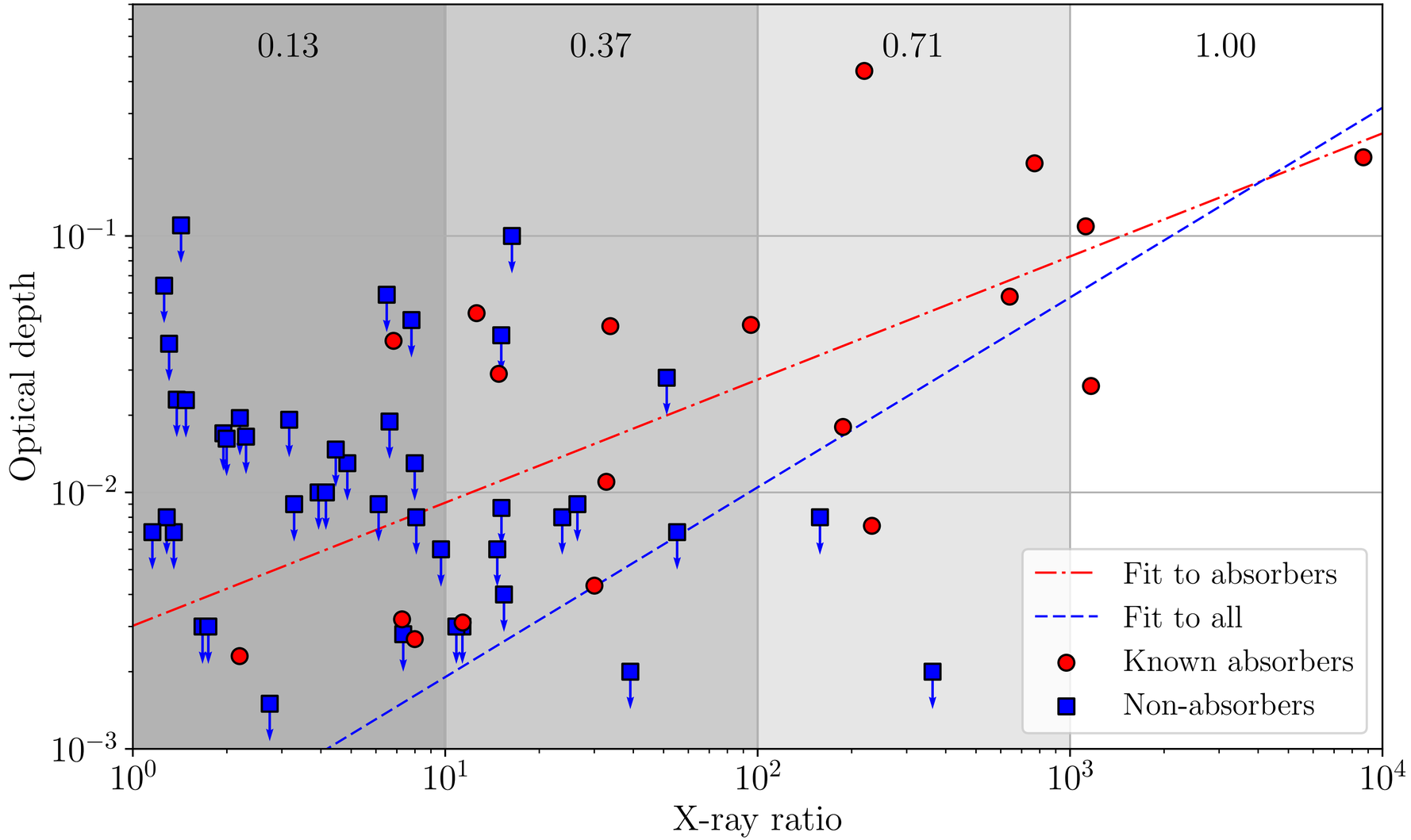






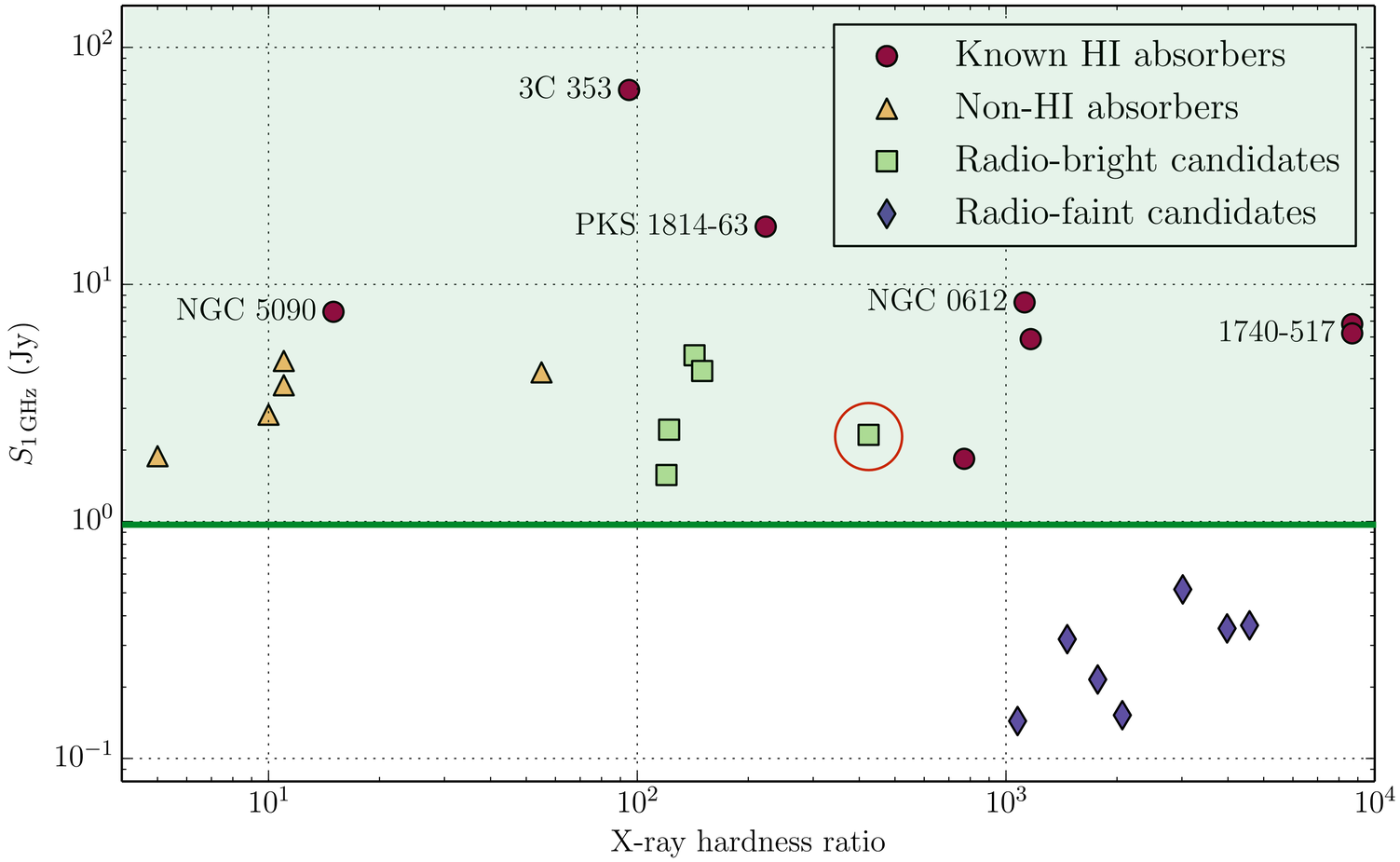
MOSS+2017

Optical depth vs. X-ray hardness



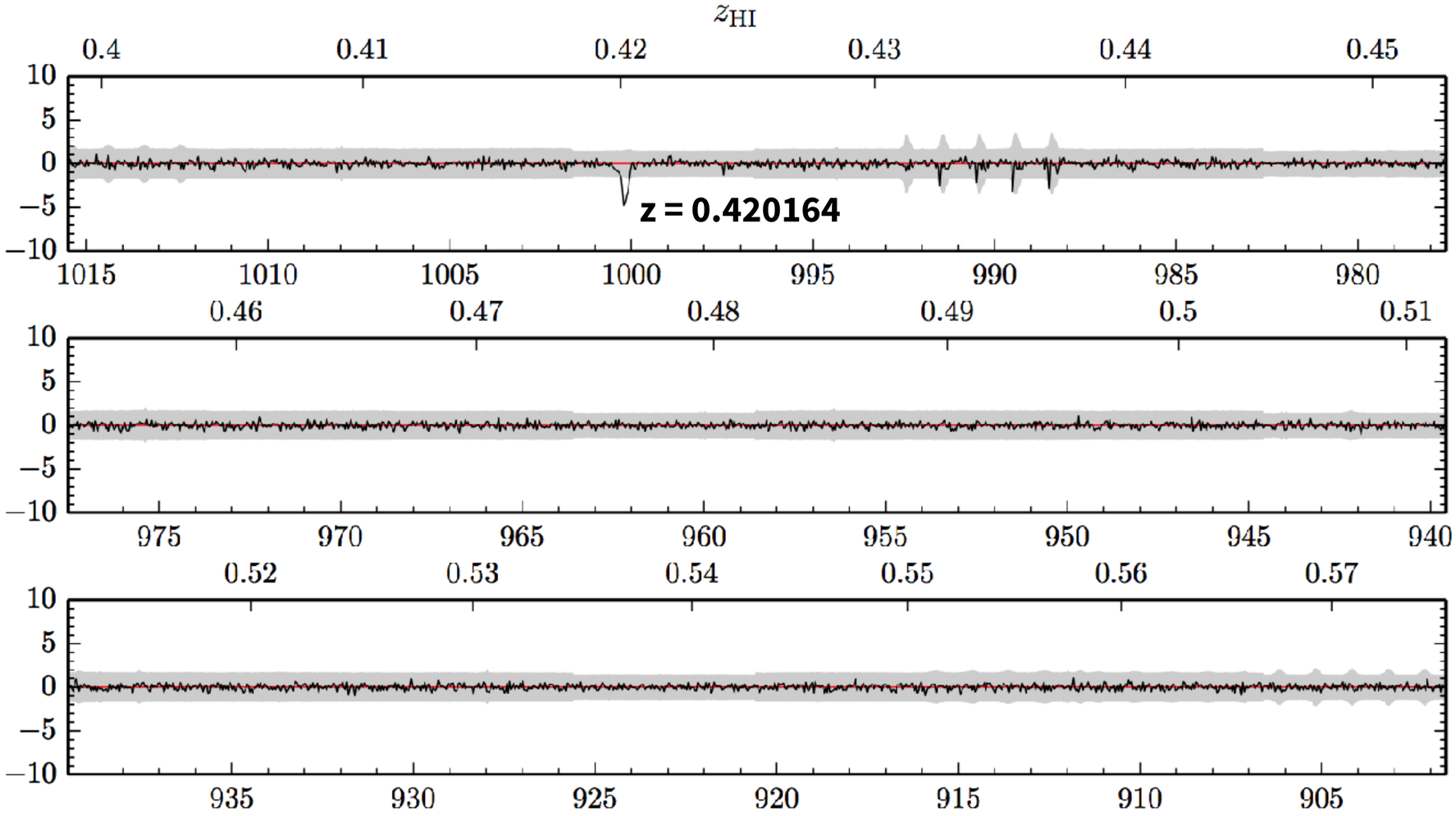
MOSS+2017

The ASKAP-BETA X-ray sample



MOSS+2017

HI detection: PKS 1657-298

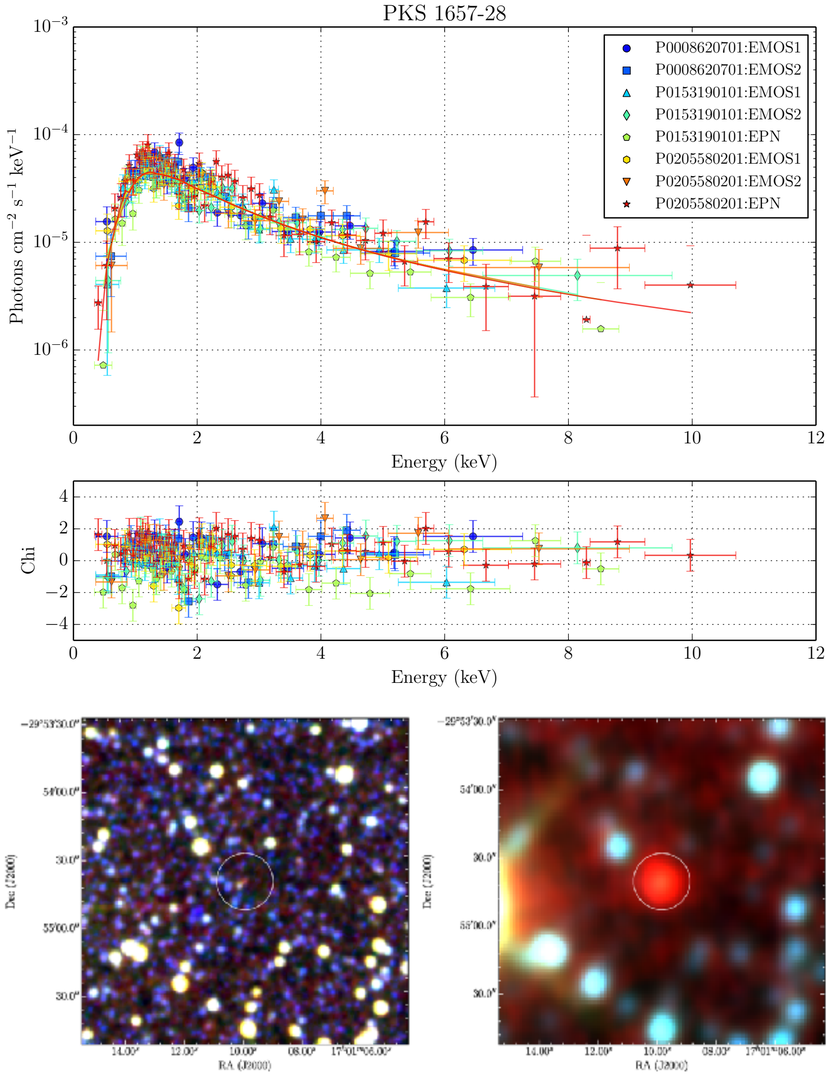


Line-width = **63 km s^{-1}** Peak optical depth = **0.046** N_{HI} = **5.3 x 10^{20} cm^{-2}**

MOSS+2017

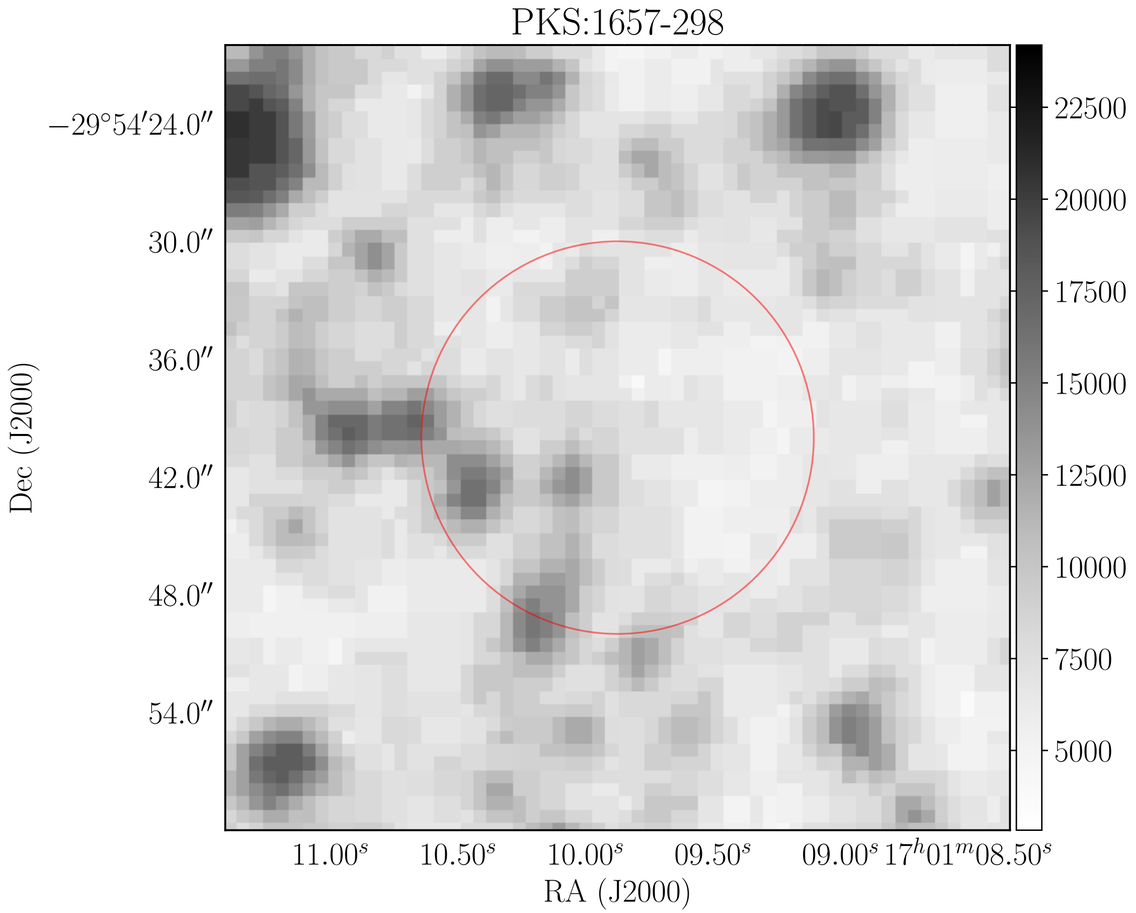
PKS 1657-298 in X-rays/IR

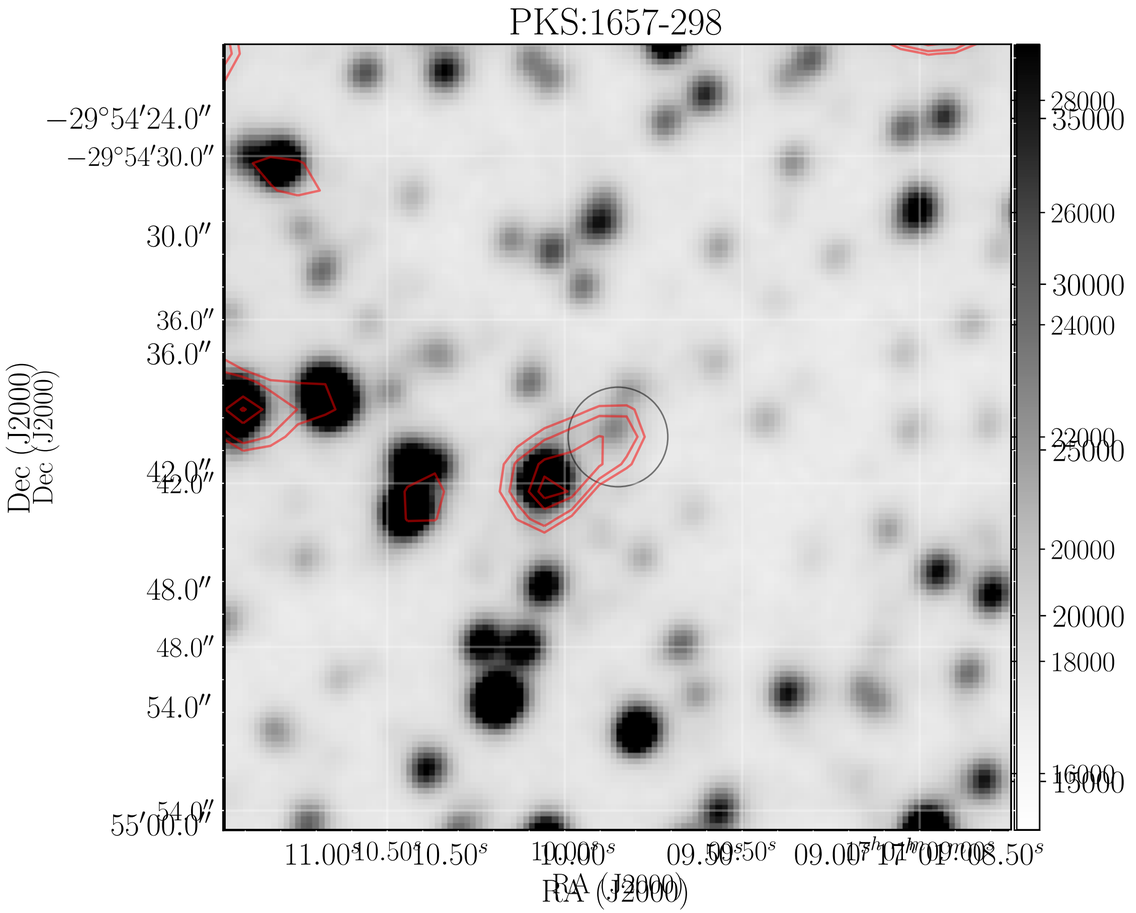
- Observed **serendipitously** with XMM towards X-ray binary V* V2134 Oph (globular cluster)
- Well-fit by an **absorbed power-law** model
- $N_H \sim 6 \times 10^{21}$ cm^{-2}
- Photon index **Γ ~ 1.9** (consistent with ~1.6 Tengstrand+ 2009)
- **$N_{HI} = 0.1\ N_H$** (T_s effect or ionised gas fraction?)
- Bright **reddened** WISE source and evidence for a faint source at **2 micron** in *K*-band
- Galactic position: ***l* = 353, *b* = +7** (challenging!)



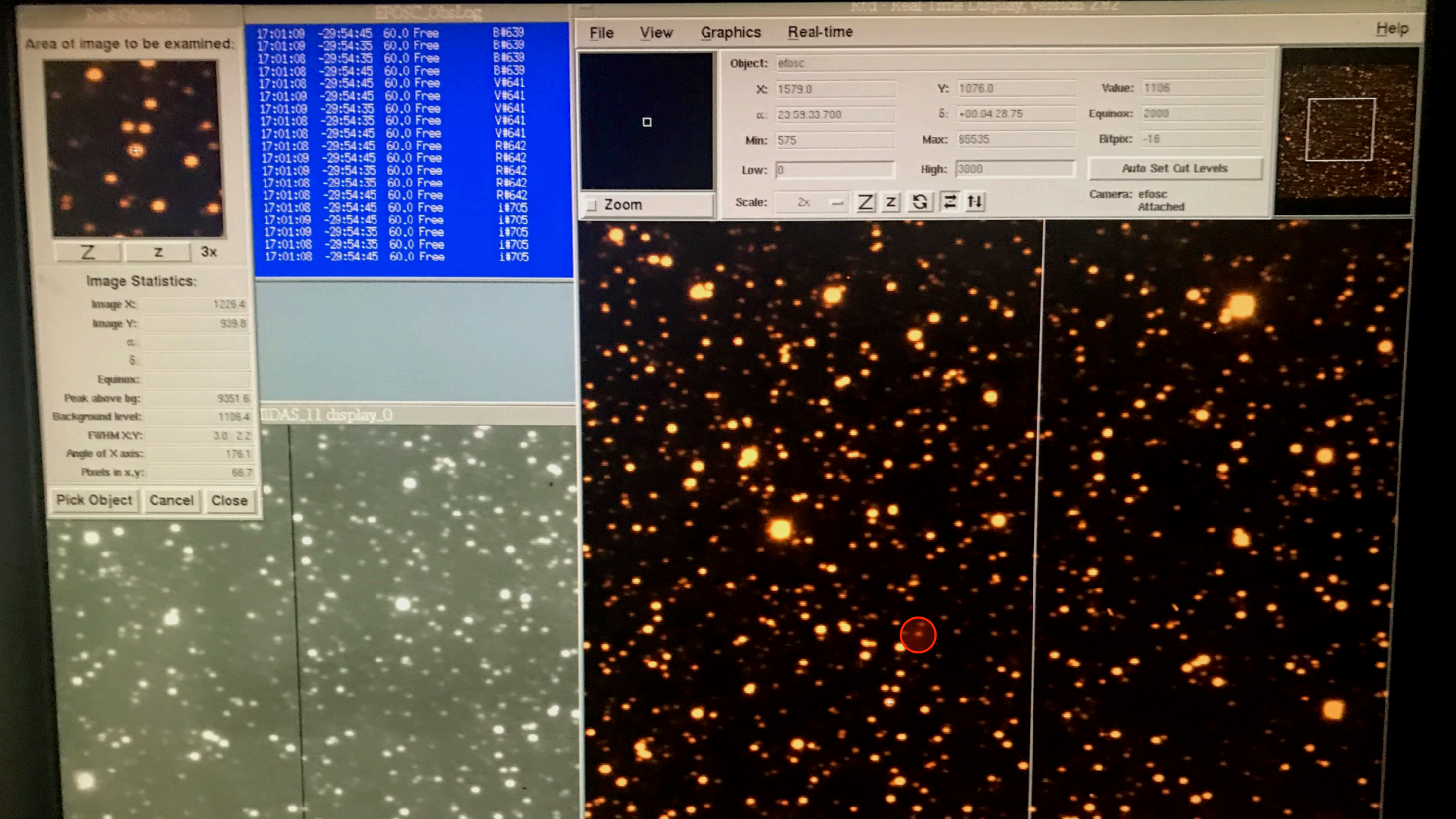
MOSS+2017

Follow-up in optical





SUPERCOSMOS VS. NOT IMAGE: T. PURSINO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Area of image to be examined:
Z
z
3x
Image Statistics:
Image X: 1226.4
Image Y: 939.8
α:
δ:
Equinox:
Peak above bg: 9351.6
Background level: 1106.4
FWHM X,Y: 3.0 2.2
Angle of X axis: 176.1
Pixels in x,y: 66 7
Pick Object
Cancel
Close
17:01:09 -29:54:45 60.0 Free B#639
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17:01:09 -29:54:45 60.0 Free V#641
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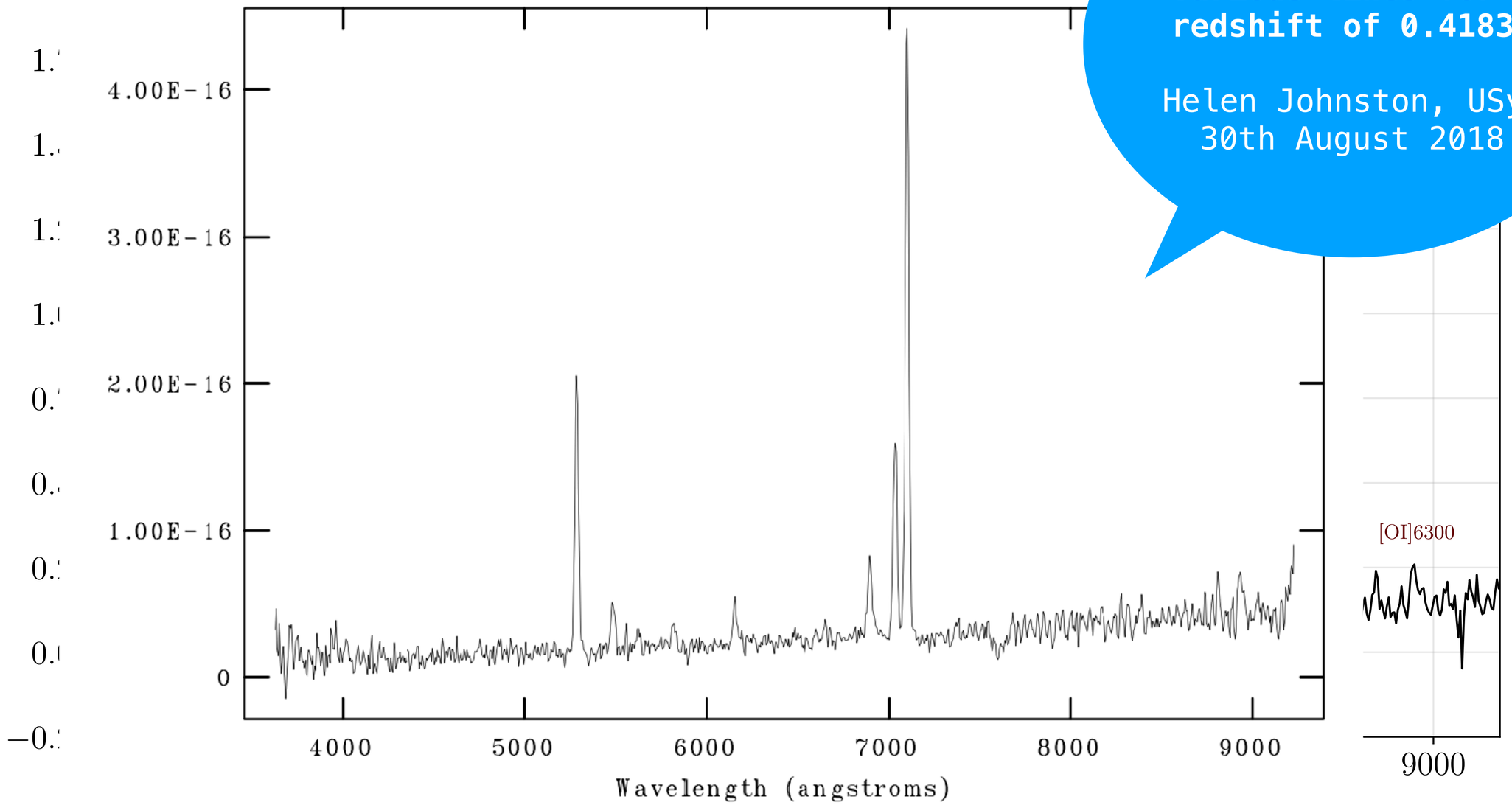
MIDAS_11 display_0
File
View
Graphics
Real-time
Help
Object: efosc
X: 1579.0
Y: 1076.0
Value: 1106
α: 23:59:33.700
δ: +00:04:28.75
Equinox: 2000
Min: 575
Max: 65535
Bitpix: -16
Low: 0
High: 3000
Auto Set Cut Levels
Zoom
Scale: 2x
Camera: efosc
Attached

Follow-up in optical



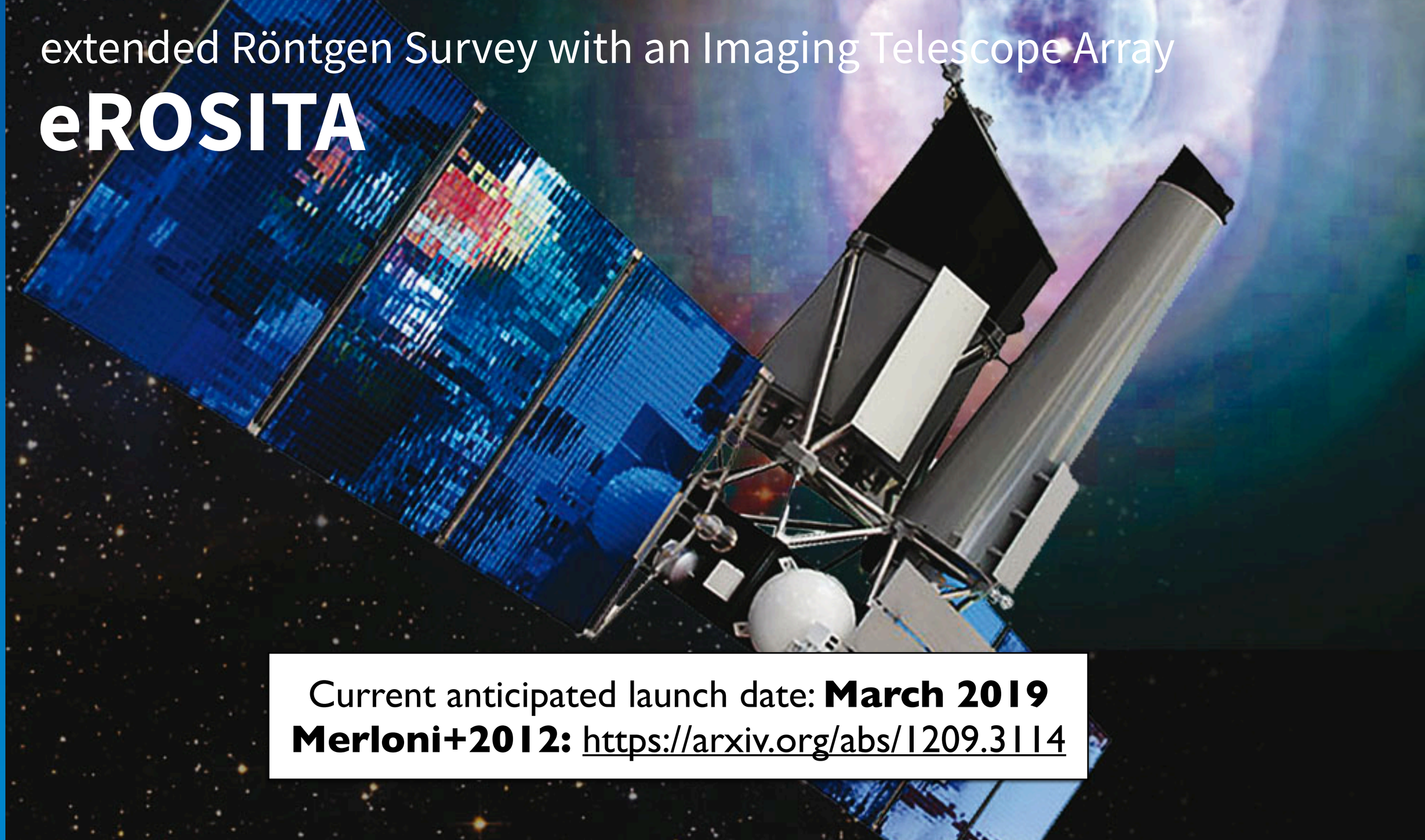
“We can clearly see various lines for a redshift of 0.4183”

Helen Johnston, USyd
30th August 2018

NEW REDUCED SPECTRUM: H. JOHNSTON

extended Röntgen Survey with an Imaging Telescope Array

eROSITA



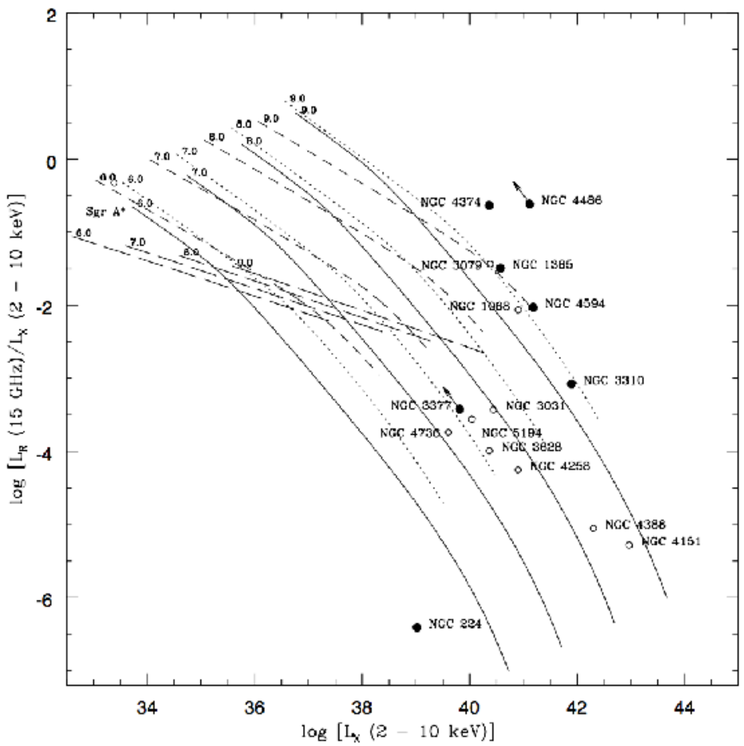
Current anticipated launch date: **March 2019**

Merloni+2012: https://arxiv.org/abs/1209.3114

FLASH + eROSITA

- FLASH: 150,000 sources > 50 mJy
  (~1000 associated, ~1000 intervening)
- eROSITA: all-sky mapping, 15”-30”, five bands covering 0-10 keV
- X-ray luminosity typically **~10^4 brighter** than radio luminosity (see e.g. Chang+ 2012, Panessa+ 2015)
- This translates to an X-ray sensitivity requirement of **~4 x 10^{-12} erg cm^{-2} s^{-1}** for complete coverage in eROSITA

Chang+ 2012



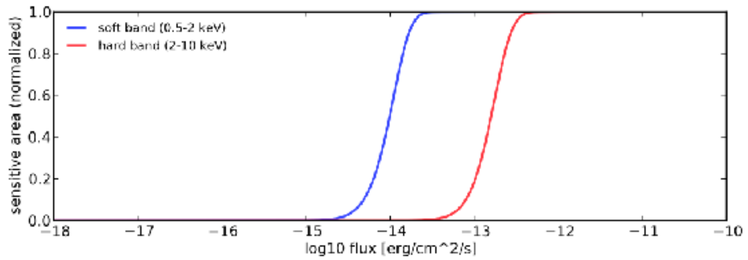


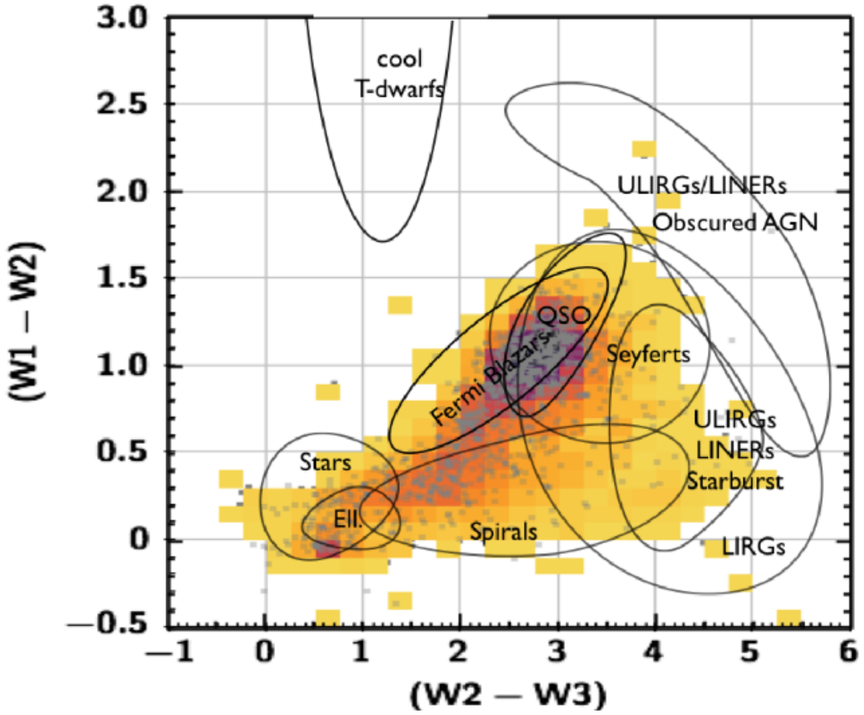
Figure 4.3.2: Sensitivity curves for the full 4-years eROSTTA survey: the normalized sensitive area is plotted as a function of the limiting flux for point source detection for both soft (blue) and hard (red) band. The computations are based on the exposure map and background model of Fig. 3.1.2

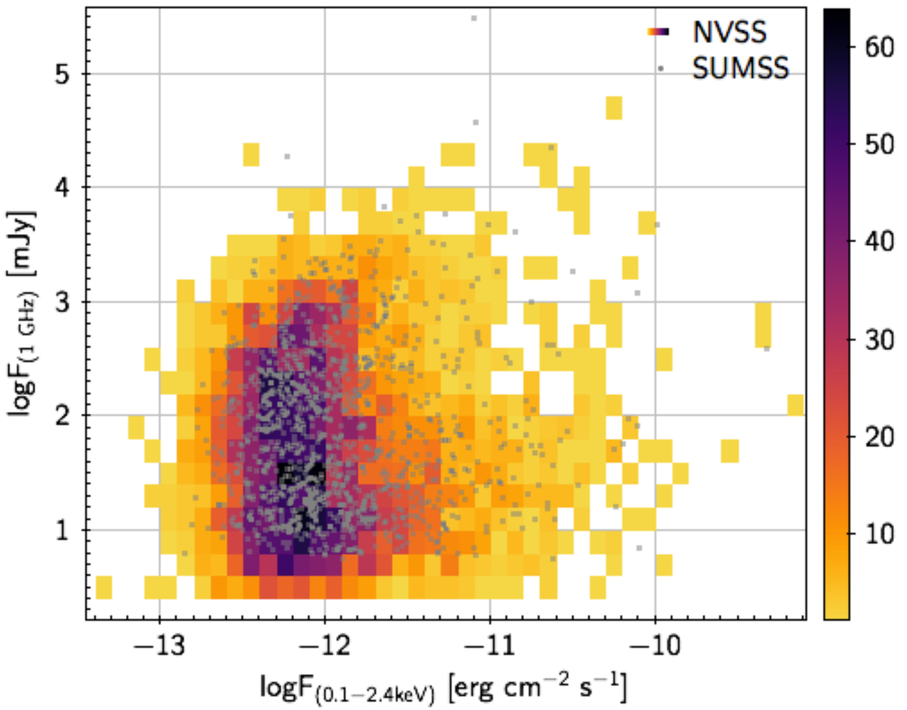
SEAFOG

***eROSITA**: M. Salvato, A. Merloni, A. Georgakakis, A. Del Moro, J. Buchner, T. Dwelly*
***CAASTRO**: V. Moss (PI), E. Sadler, J. Allison, E. Mahony*

- MoU collaboration between **CAASTRO (AAL)** and **eROSITA_DE**
- Approved as of **5th June 2017** by the Management Committee
- Current timescale planned: **June 2017 - December 2019+**
- Will serve as useful preparation for **SKA/Athena** synergy beyond this time

FLASH + eROSITA

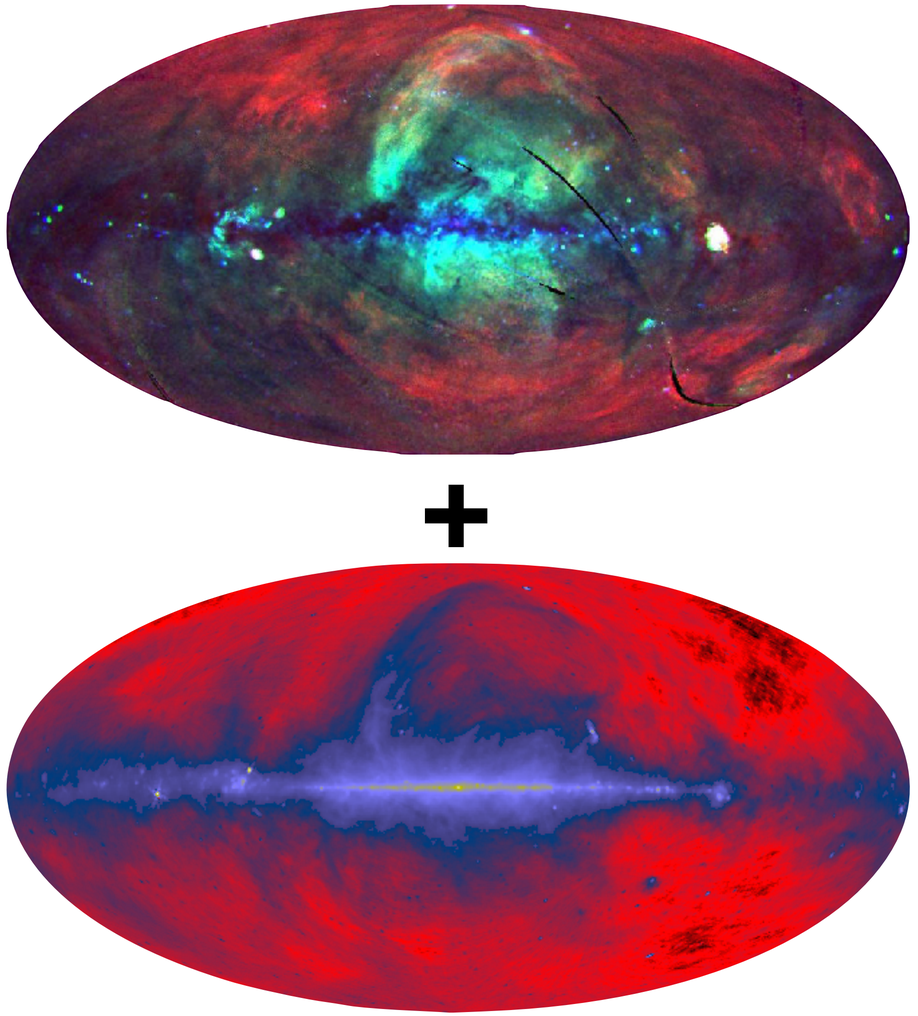




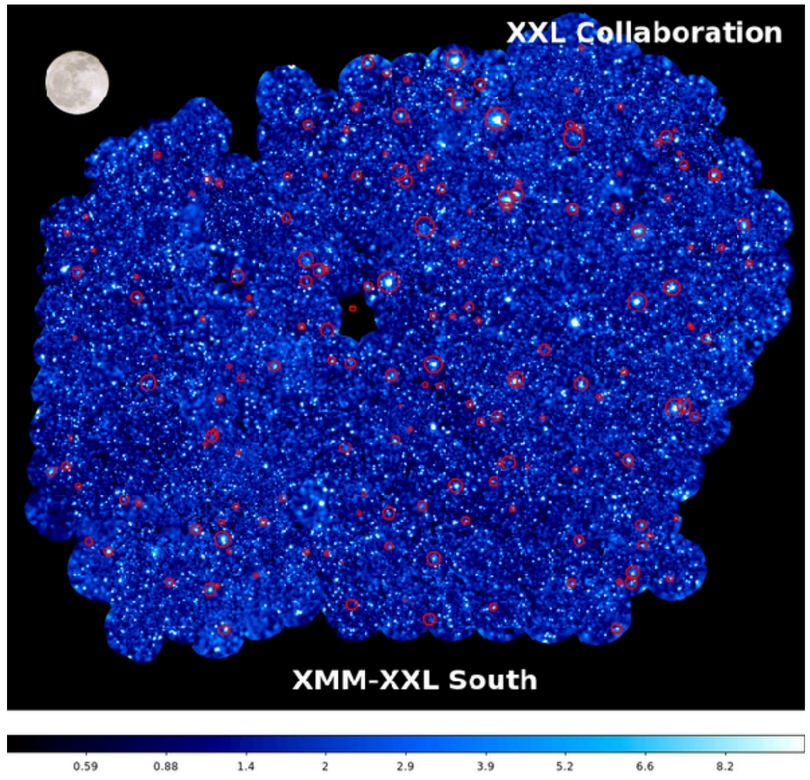
- **Expected radio/X-ray population** based on NVSS/SUMSS and 2RXS
- We predict **complete sensitivity** in X-rays to all radio AGN detected in FLASH
- eROSITA will allow study of a **much deeper** population than previously accessible

FLASH + eROSITA

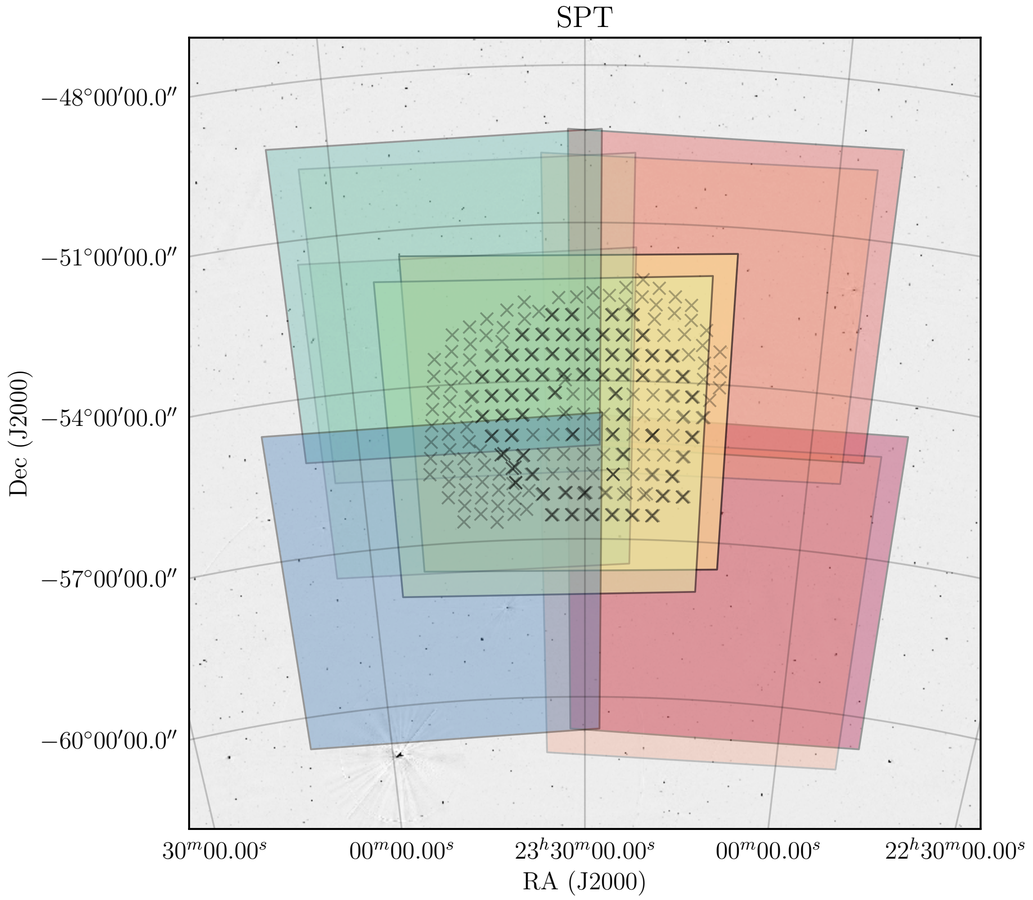
- What do we learn from a **FLASH/eROSITA** survey?
- Connection between radio AGN **with/without** X-rays: emission mechanism
- What kinds of galaxies have: 1) radio AGN, 2) X-ray AGN, 3) HI absorption?
  - Trace **multi-wavelength** properties
- Comparable angular resolution studies (20” FLASH, 20-30” eROSITA)
- **N_H vs. N_{HI}** for a large sample (~100s of galaxies)
- Studies of **variability** in radio/X-rays



SEAFOG: pilot fields

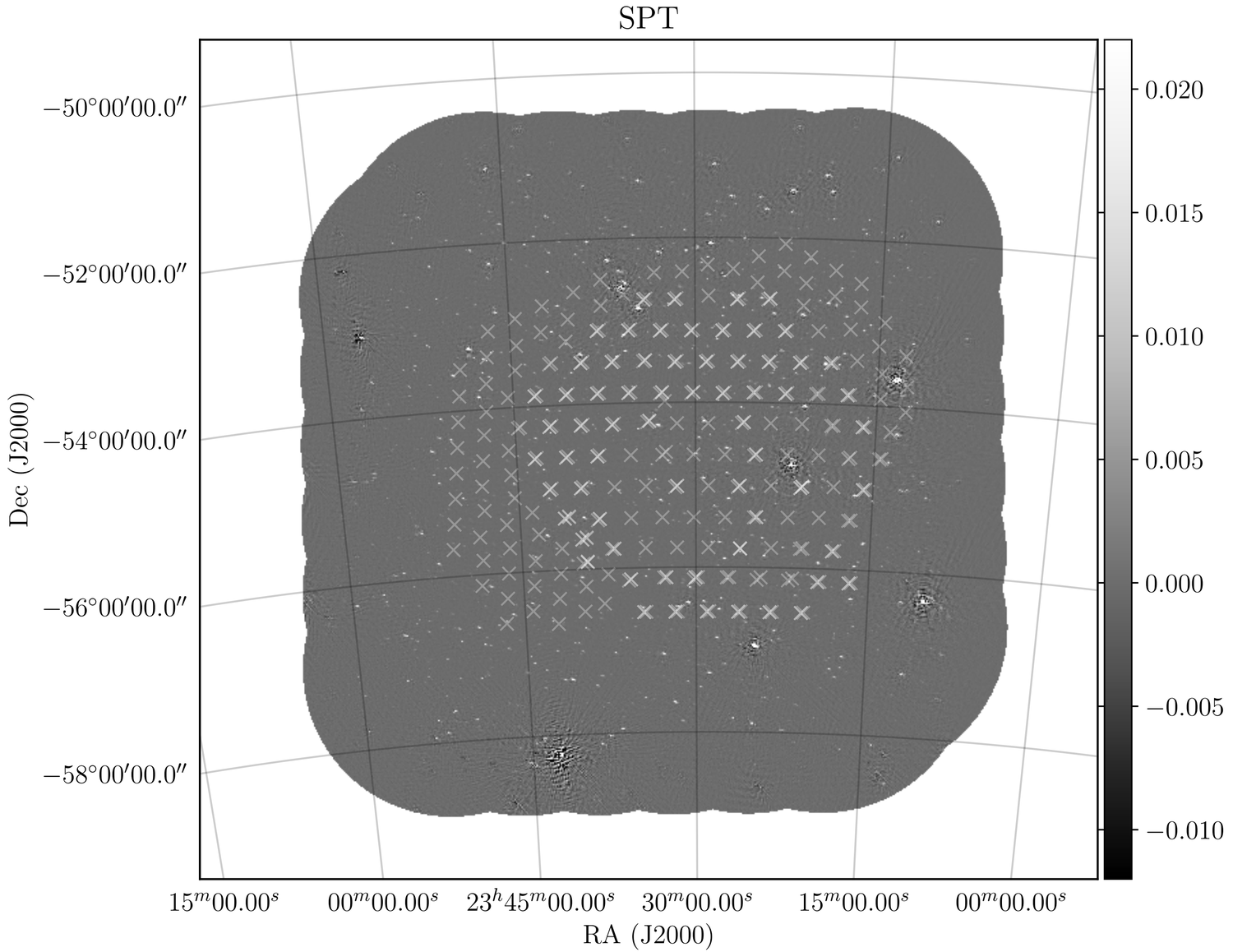


XMM-XXL South
Deep XMM-Newton field
~220 pointings, ~12,000 AGN



ASKAP Early Science
Deep fields at 864/1272/1320 MHz

SEAFOG: pilot fields



Field: SPT

Frequency: 864 MHz

 # X-ray: ~9300 sources

 # radio: ~300 sources

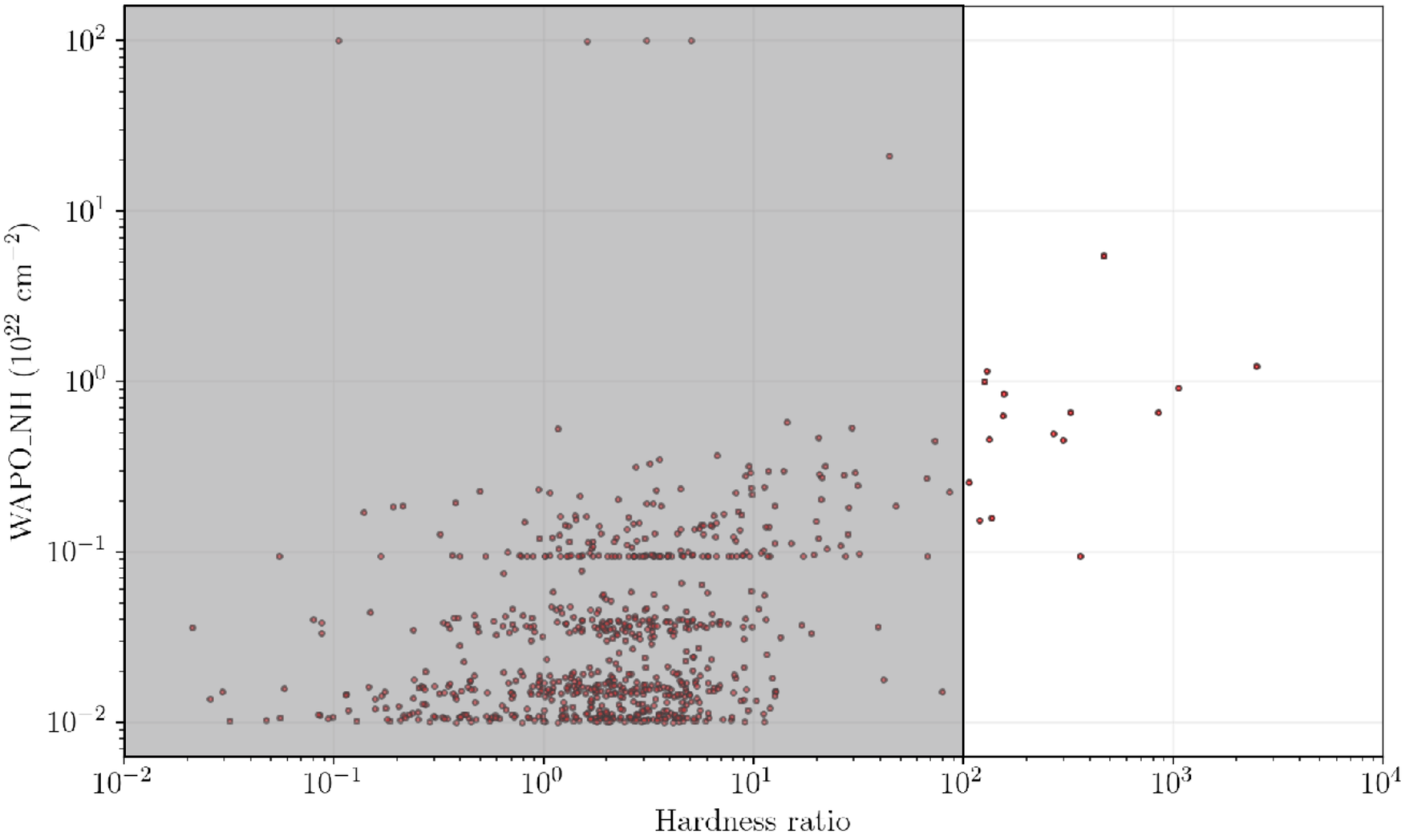
(flux > 100 mJy)

 # HI absorbers: ???

ASKAP-FLASH

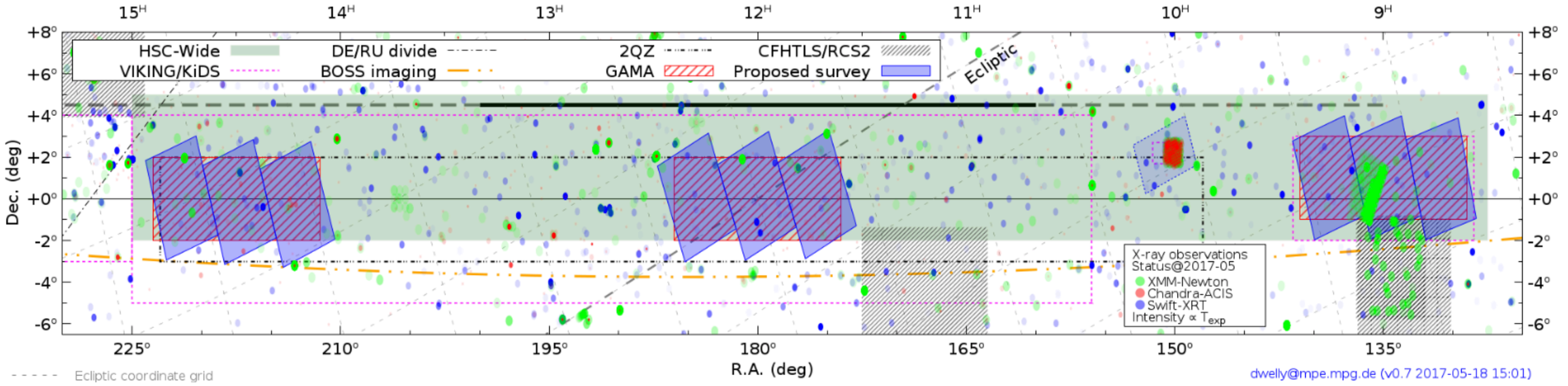
First Large Absorption Survey in HI

SEAFOG: XMM-DR7



HARDNESS RATIO VS. MEASURED NH IN XMM-XXL SOUTH

SEAFOG: pilot fields



eROSITA eFEDS

Part of performance verification

2 GAMA equatorial fields

ASKAP-18

Deep fields possible at 700-1800 MHz

Pilot fields to be determined

EFEDS TARGET FIELDS: T. DWELLY

SEAFOG future directions:

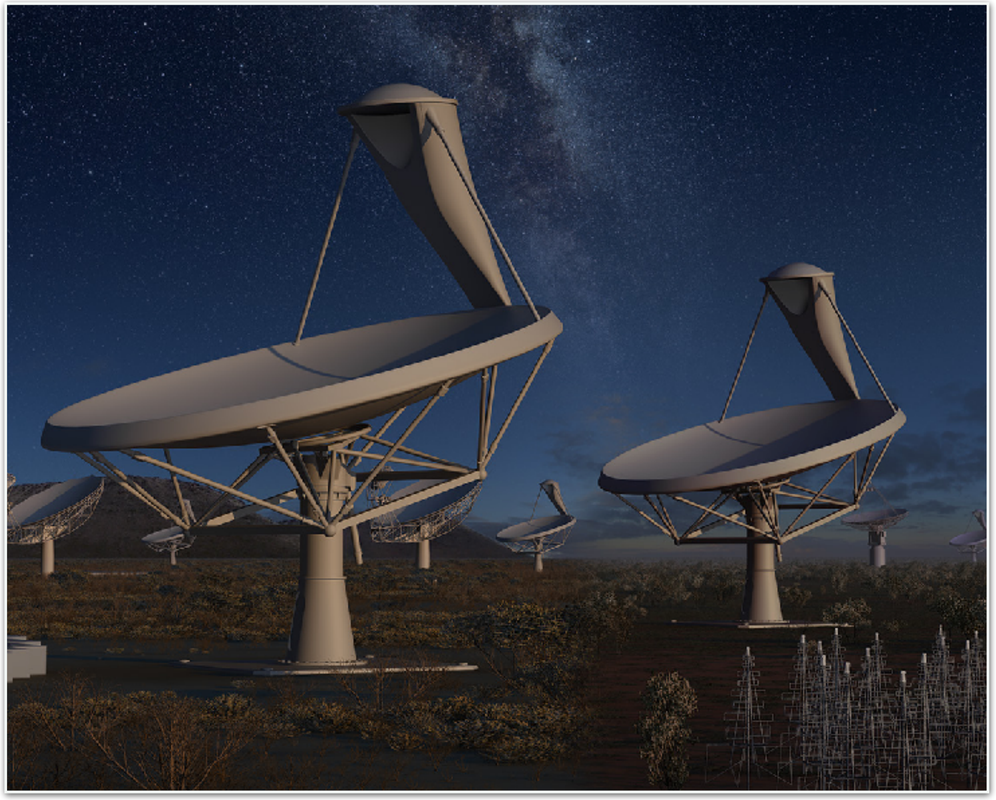
Extension of BETA X-ray sample to wider Universe:

1) northern + *southern* hemisphere
2) lower redshifts (0 < z < 0.4) — APERTIF
3) middle redshifts (0.4 < z < 1) — *ASKAP*
4) higher redshifts (1 < z < 3+) — *SKA*
5) effect of environment: clusters/groups
6) high angular resolution studies in HI and X-ray — *LBA*/EVN
7) lower radio/X-ray luminosities/column densities
8) variability studies in HI and X-ray — *ATCA*/XMM-Newton
9) *FLASH* + eRosita (2018+) - **SEAFOG**
10) *SKA* + Athena (2028+)

The future future

SQUARE KILOMETRE ARRAY MID-FREQUENCY
(SKA MID)

***Redshift coverage (HI line)**: 0 < z < 3*
***Channel sensitivity (SKA1-SCI-5):** 0.25 mJy at 2" (2 years)*



ADVANCED TELESCOPE FOR HIGH ENERGY ASTROPHYSICS
(ATHENA)

***Spectral coverage (WFI):** 0.2-15 keV at ~80 keV resolution*
***Sensitivity:** 10x XMM-Newton*

Future challenges

CHAD: as seen on Wednesday

CHAD

CONSOLIDATED HI ABSORPTION DATABASE

V. Moss, J. Allison, S. Curran, A. Edge, M. Glowacki, F. Maccagni, E. Mahony, R. Morganti, T. Oosterloo, E. Sadler, M. Zwaan…

CHADonline: chadonline.pbworks.com
HI Absorption: hiabsorption.pbworks.com

Your input needed!
tinyurl.com/chadfields
tinyurl.com/chadsurveys

Processing capability

- Impact of **processing and storage** is already seen across the various telescopes
- Dataset sizes, even in commissioning, are already **orders of magnitude** higher
  e.g. a 12-hr APERTIF 135 MHz dataset ~ **3 TB**, a 12-hr ASKAP 240 MHz dataset ~ **8.2 TB**
- "**Experimental**" data reduction with varying parameters does not scale for large FOV
- Requires **massive changes** to the way we think about data reduction and processing!

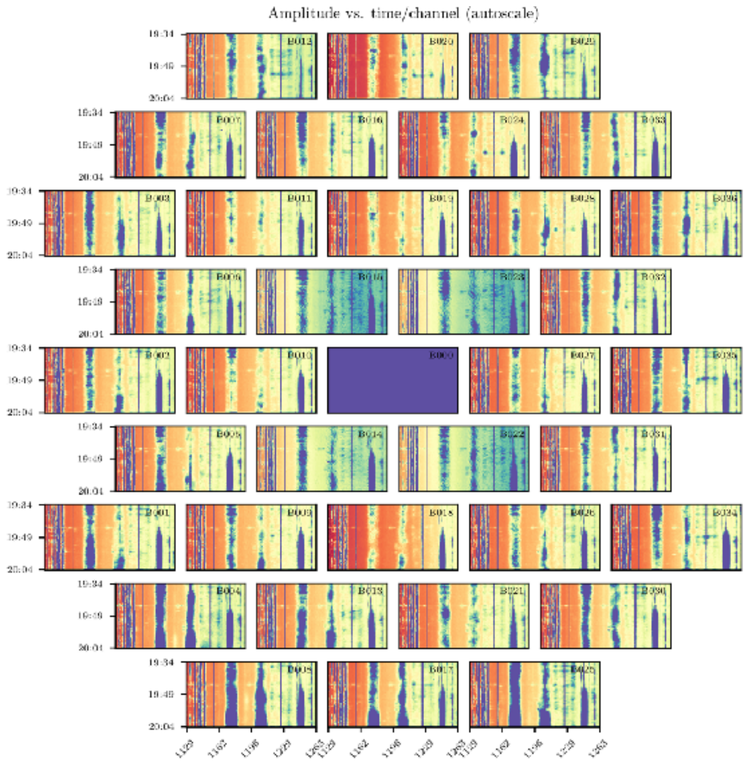
The growing impact of RFI

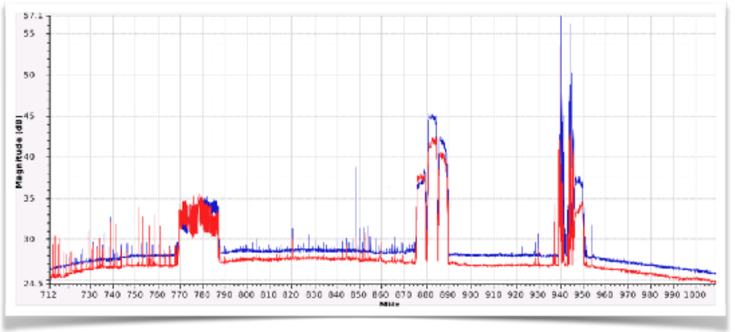
- Growth in **technology** + more **occupancy** of the frequency spectrum combined with our **wider bandwidths** (e.g. 300 MHz, 4 GHz) + higher **time resolution** (pulsars, FRBs, other transients) + more **sensitive** telescopes

- Even an RFI-quiet zone is susceptible to **satellite** emission (and sky is getting crowded)

- **CyberSKA PHISCC RFI working group: https://tinyurl.com/rfi-wg**

- **Topics**: current experience, mitigation ideas, visualisation, future plans, collaboration…





Summary

ASKAP-FLASH
First Large Absorption Survey in HI

- We are searching **new parameter space** for distant HI in galaxies between **0.4 < z < 1.0**
- We find **evidence supporting the connection** between HI absorption and X-ray absorption
- Our BETA pilot sample revealed a **new HI absorber** at z = 0.42 (Moss+2017)
- FLASH/eRosita are **ideally matched** to extend this study of dense gas near AGN cores
- Supplementary **multi-wavelength** info is vital
- The SEAFOG project will allow us to conduct **detailed population studies** for the first time!