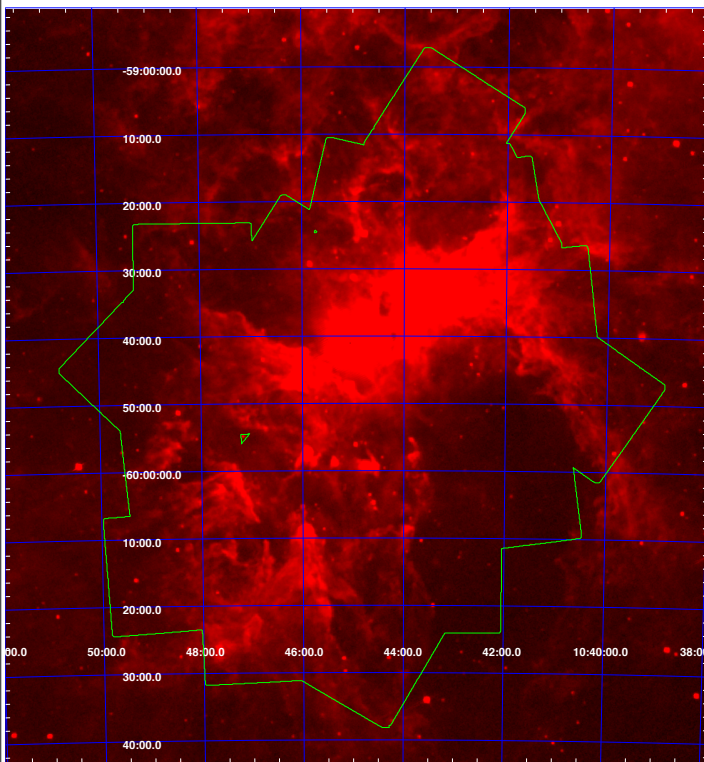


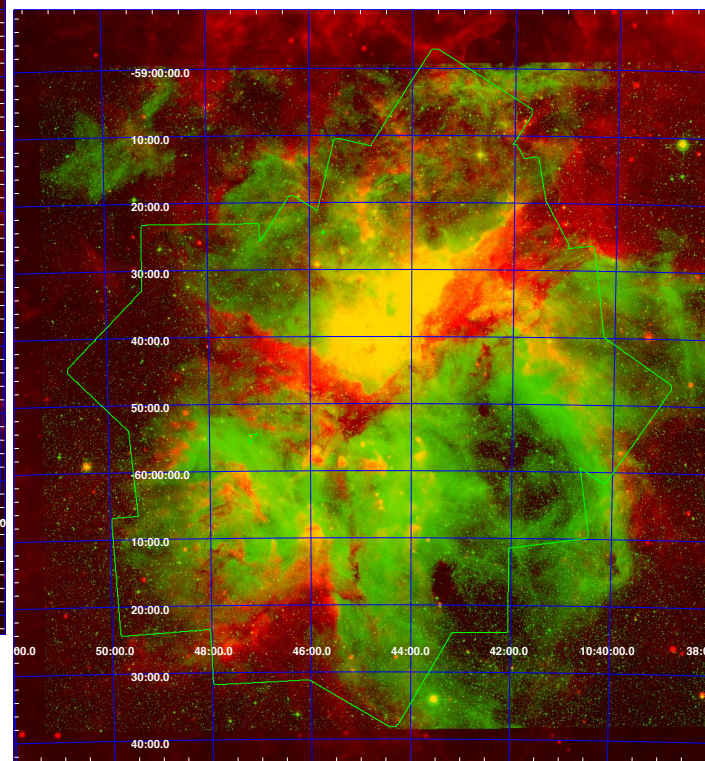
The Great Nebula in Carina: Protoplanetary Disks to Starburst Galaxies

~The Chandra Carina Complex Project (CCCP), a 1.2 Ms Cycle 9 VLP~

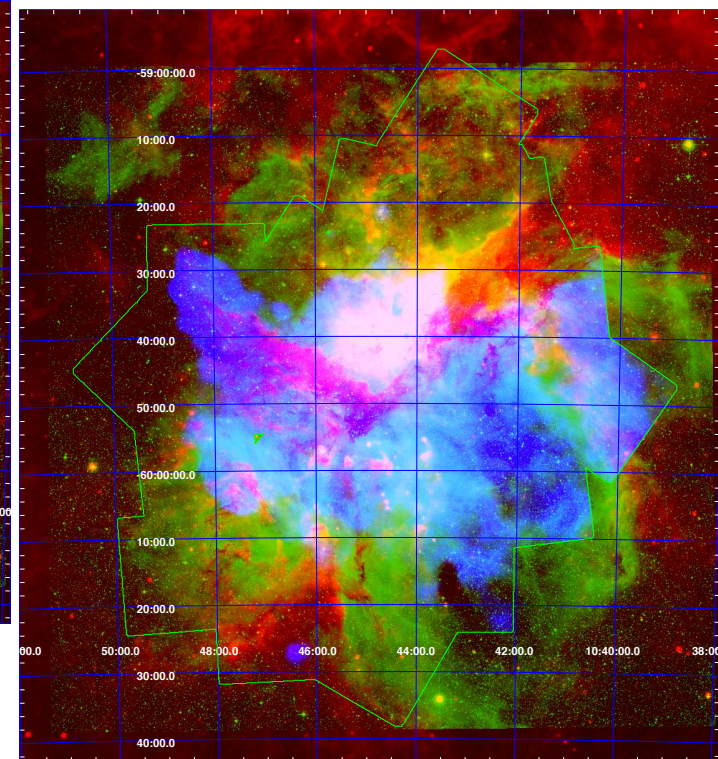
Leisa Townsley
Patrick Broos



MSX 8 um



MSX 8 um + DSS



MSX 8 um + DSS + ACIS 0.5-2 keV

See Pat's poster for details!

The CCCP Team

~53 co-investigators

7 science groups

2-5 papers per group planned or in progress

Data Products

Patrick Broos (Lead), Eric Feigelson, Marc Gagne,
Konstantin Getman, Mike Muno, Andy Pollock,
Leisa Townsley, Junfeng Wang, Scott Wolk

Massive Stars

Mike Corcoran & Marc Gagne (Leads), David Cohen,
Nancy Evans, Maurice Leutenegger, Tony Moffat, Yael Naze,
Joy Nichols, Lida Oskinova, Stan Owocki, Ross Parkin, Julian
Pittard, Andy Pollock, Gregor Rauw, Norbert Schulz, Rich
Townsend, Asif ud-Doula, Nolan Walborn, Wayne Waldron

Diffuse Emission

Leisa Townsley (Lead), You-Hua Chu, Gordon
Garmire, Robert Gruendl, Kenji Hamaguchi,
Mordecai-Mark Mac Low, Thierry Montmerle, Yael
Naze, Rob Petre, Julian Pittard, Norbert Schulz

Revealed Stellar Populations

Eric Feigelson (Lead), Marc Audard, Cathie Clarke, Gordon
Garmire, Konstantin Getman, Manuel Guedel, Mark
McCaughrean, Gus Muench, Mike Muno, Thomas Preibisch,
Gregor Rauw, Keivan Stassun, Junfeng Wang, Hans Zinnecker

Multiwavelength Studies

Nathan Smith (Lead), Richard Alexander, Marc Audard, Kate
Brooks, You-Hua Chu, Ed Churchwell, Robert Gruendl,
Manuel Guedel, Warrick Lawson, Mordecai-Mark Mac Low,
Mark McCaughrean, Gus Muench, Matt Povich, Keivan
Stassun, Nolan Walborn, Barbara Whitney

Obscured Stellar Populations

Thierry Montmerle (Lead), Marc Audard, John Bally,
Nicolas Grosso, Manuel Guedel, Kenji Hamaguchi,
Mordecai-Mark Mac Low, Gus Muench, Rob Petre, Thomas
Preibisch, Steve Skinner, Barbara Whitney, Scott Wolk

Global Synthesis

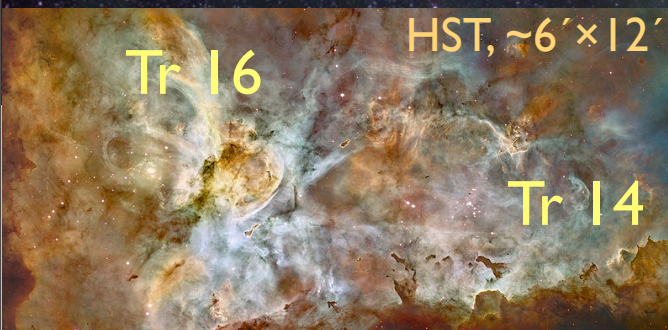
Sally Oey (Lead), You-Hua Chu, Cathie Clarke, Mordecai-Mark
Mac Low, Eric Pellegrini, Julian Pittard, Nathan Smith, Keivan
Stassun, David Strickland, Nolan Walborn, Hans Zinnecker

Narrow-band visual images
by John Gleason,
<http://jpgleason.zenfolio.com/>

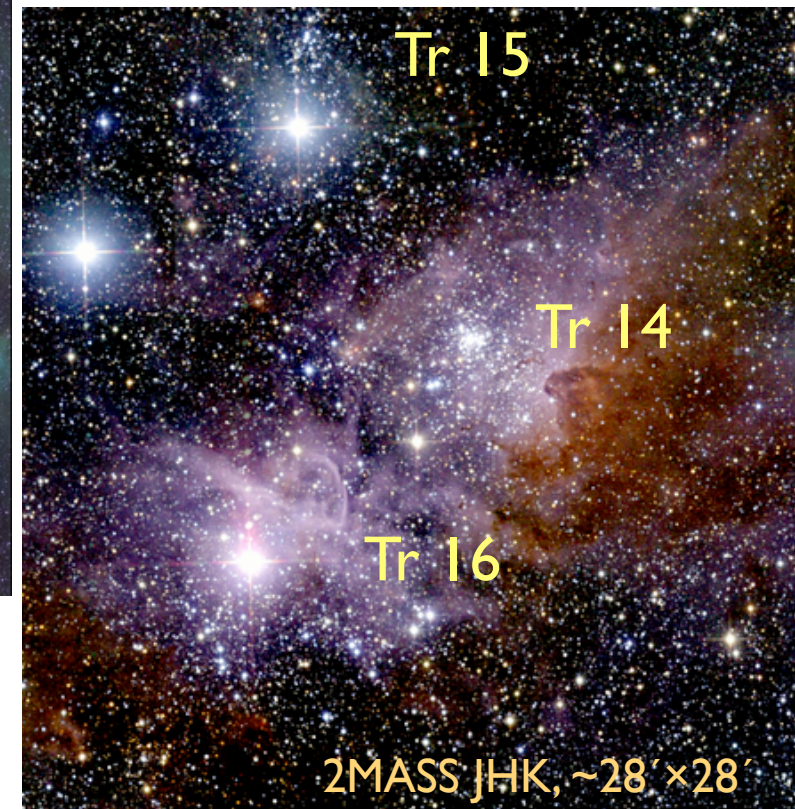
$D \sim 2.3 \text{ kpc},$
 $10' \sim 6.7 \text{ pc}.$

Note proto-
bipolar
superbubble.

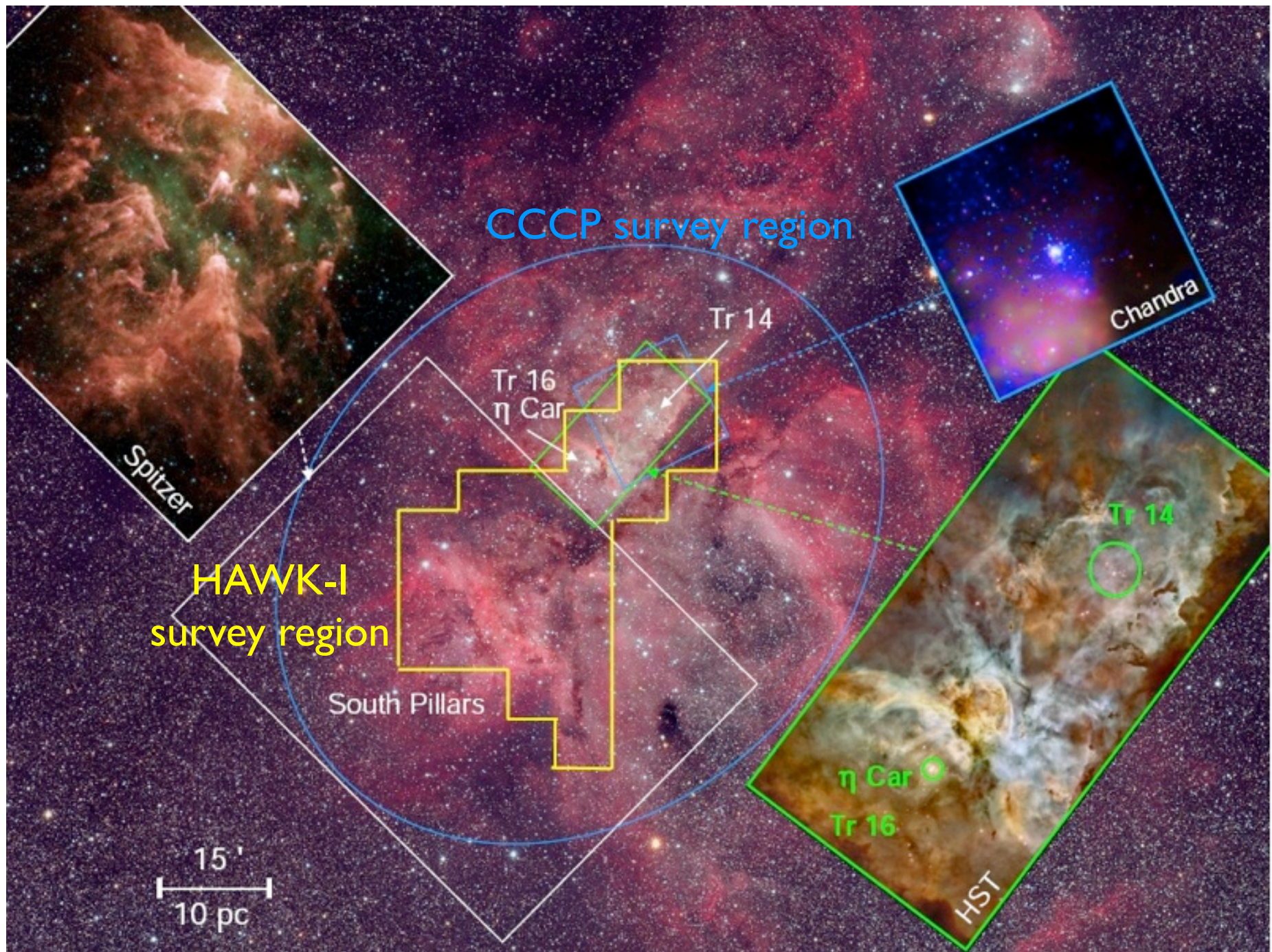
- Carina is a “**starburst cluster**,” an example of the large-scale star formation seen in starburst galaxies.
- The Carina complex is a “**cluster of clusters**,” with at least **10 YSCs** covering a range of ages, $\sim 0.1\text{-}3 \text{ Myr}$.
- Carina contains at least **60 O and early-B stars**, including an O2 star.
- LBV $\eta \text{ Car}$ & bright diffuse X-rays hint that the Carina complex **might** have seen **cavity supernovae**.



*The Carina Massive
Star-forming Complex*



The Great Observatories Focus on Carina



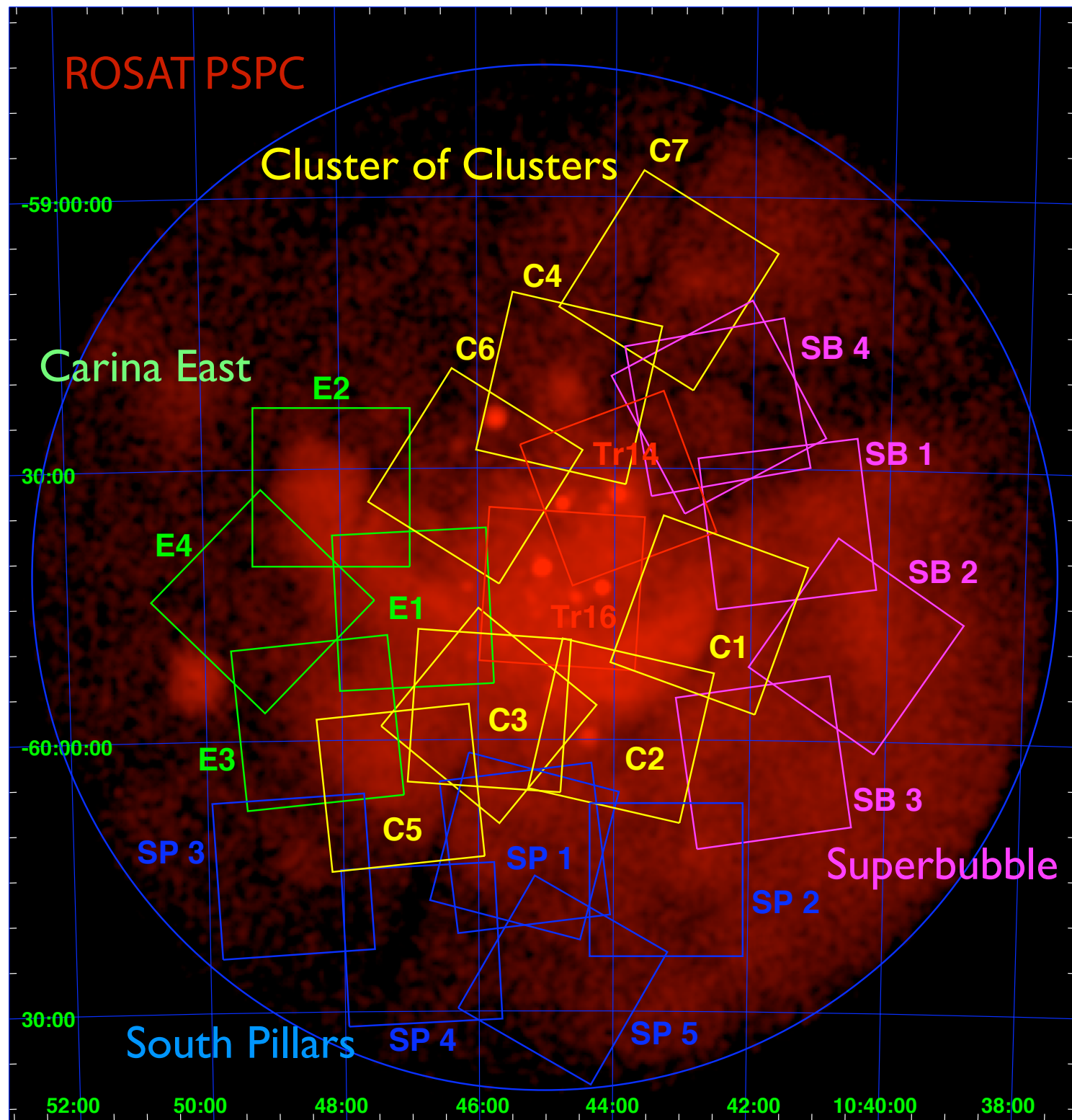
Composite image by Thomas Preibisch

CCCP survey details:

- 60 ks per pointing
- 20 new pointings
- 2 archival pointings

Final results:

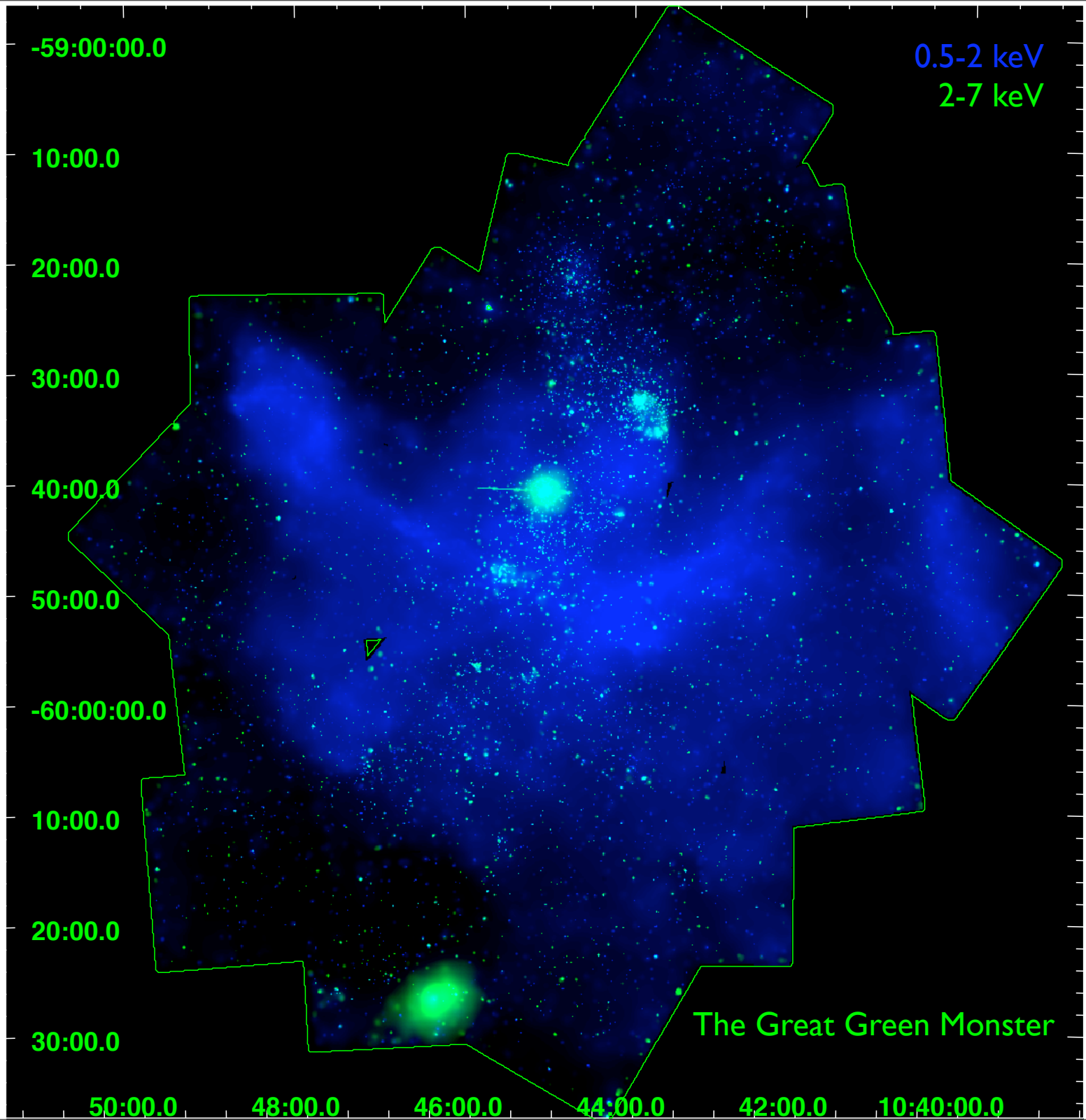
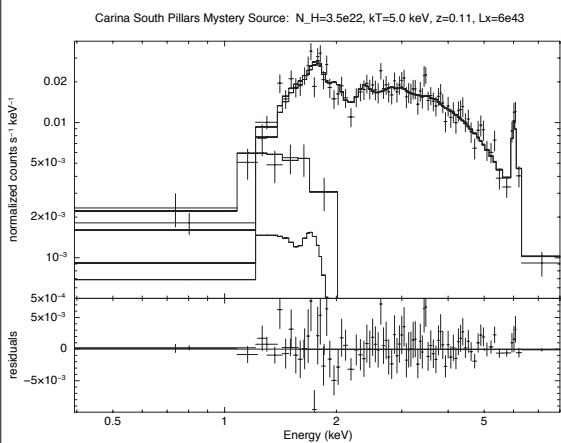
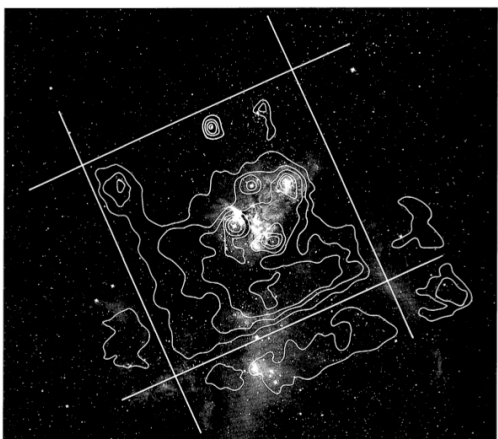
- Data obtained
12 Feb - 15 Oct 2008
- 38 ObsID's
- 1.42 sq deg (5112 sq
arcmin) sky coverage



The CCCP

Chandra resolves out
14,369 point sources.

Diffuse emission
from Einstein
(Seward et al. 1979)
remains diffuse.

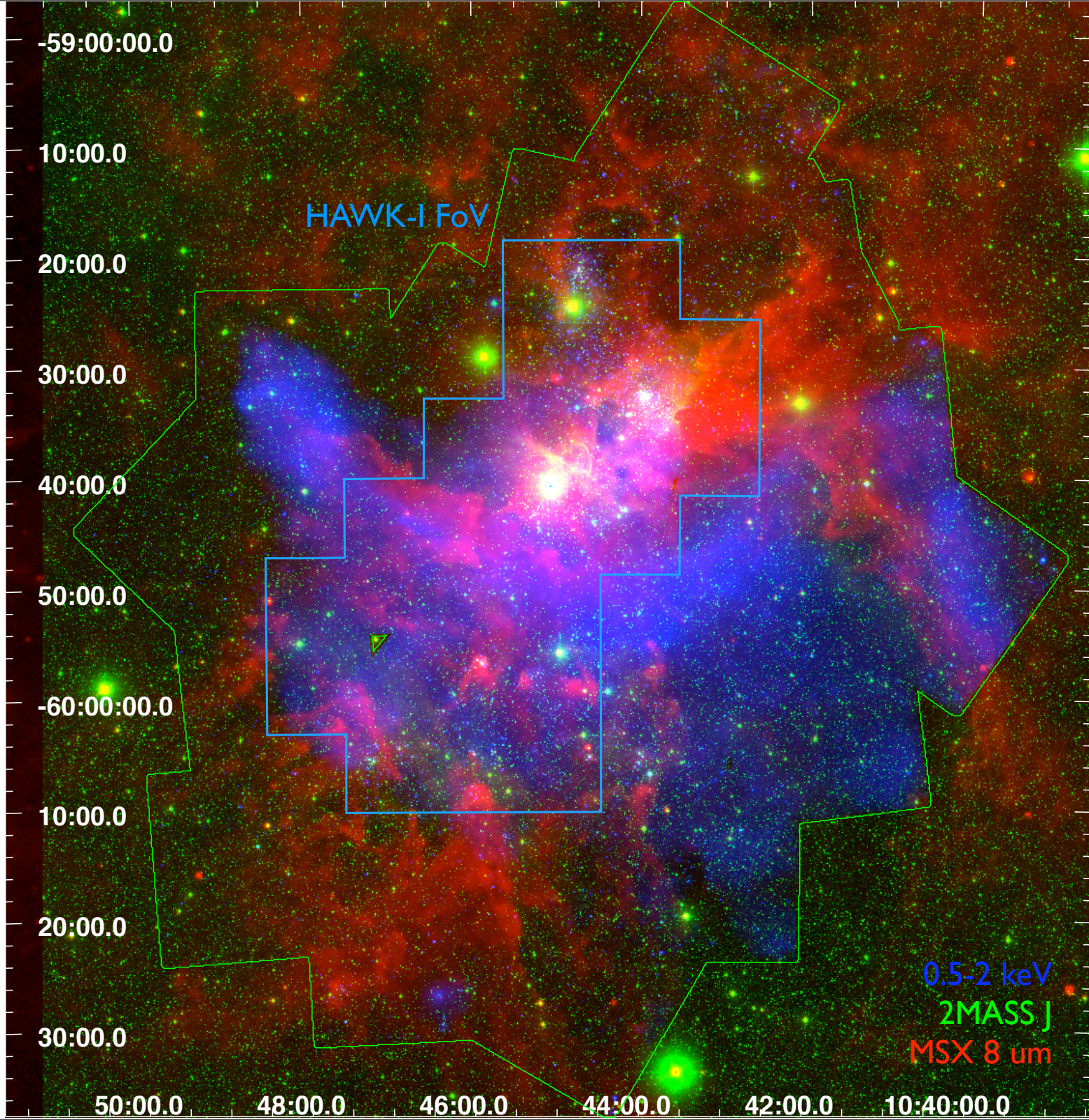


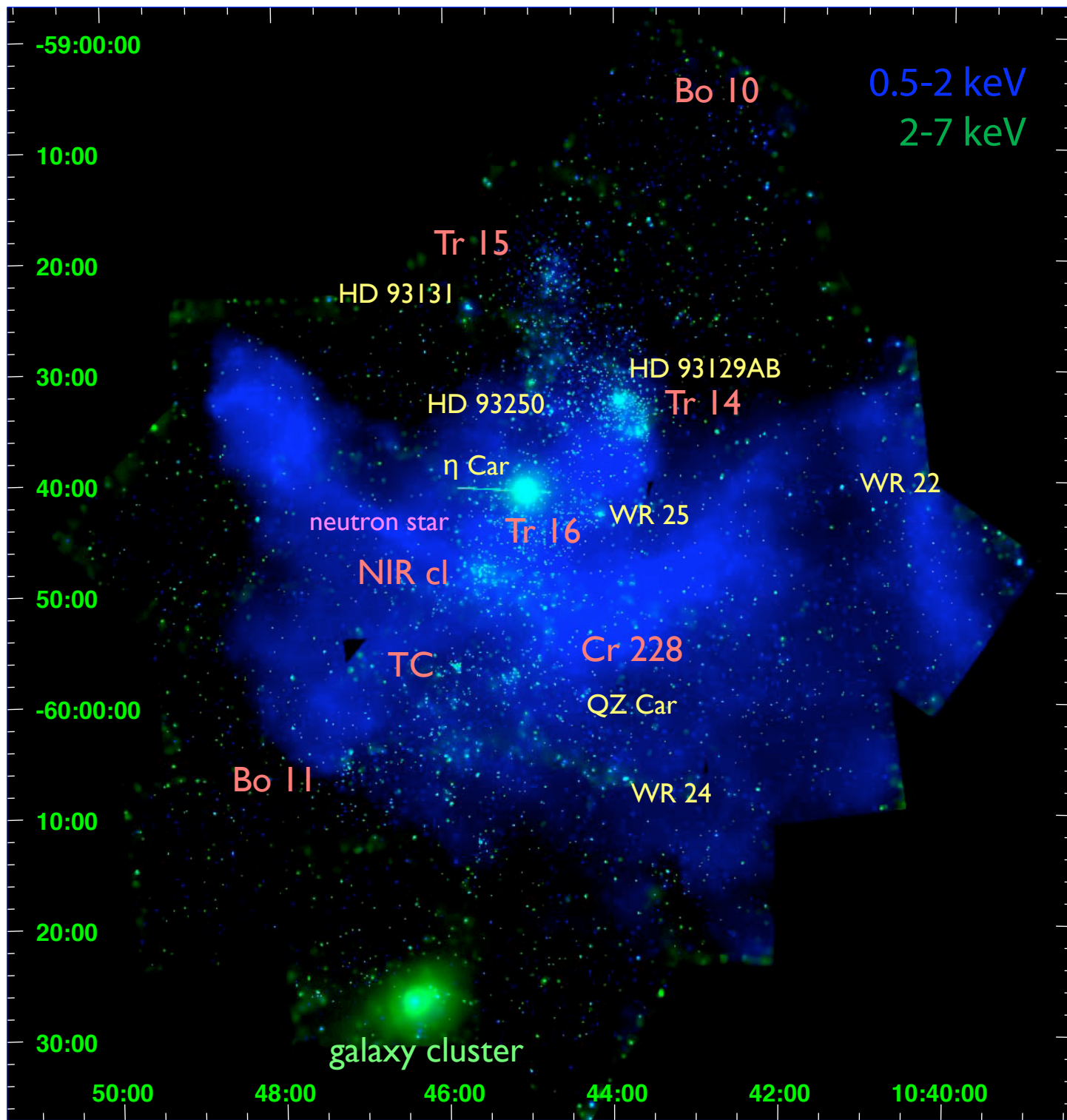
Counterparts

X-ray sources
matched to 18
visual & IR catalogs:
9465 counterparts
(so far).

VLT/HAWK-I gives
deep JHK imaging --
there **87%** of
Chandra sources
have counterparts.

Outside that, only
44% have
counterparts --
Carina's pre-MS
stellar population
peaks in JHK past
2MASS limit.





Field covers 8 of the 10 catalogued stellar clusters in Carina.

We detect 117 massive stars (OB, WR, LBV).

First CCCP paper: Hamaguchi et al. 2009, ApJ 695, L4, on the new neutron star. Chandra position rules out OIR counterparts. See Kenji's poster!

Trumpler 14 -- the confusion limit

30'' x 30'' ACIS
image, binned to
0.5 sky pixels

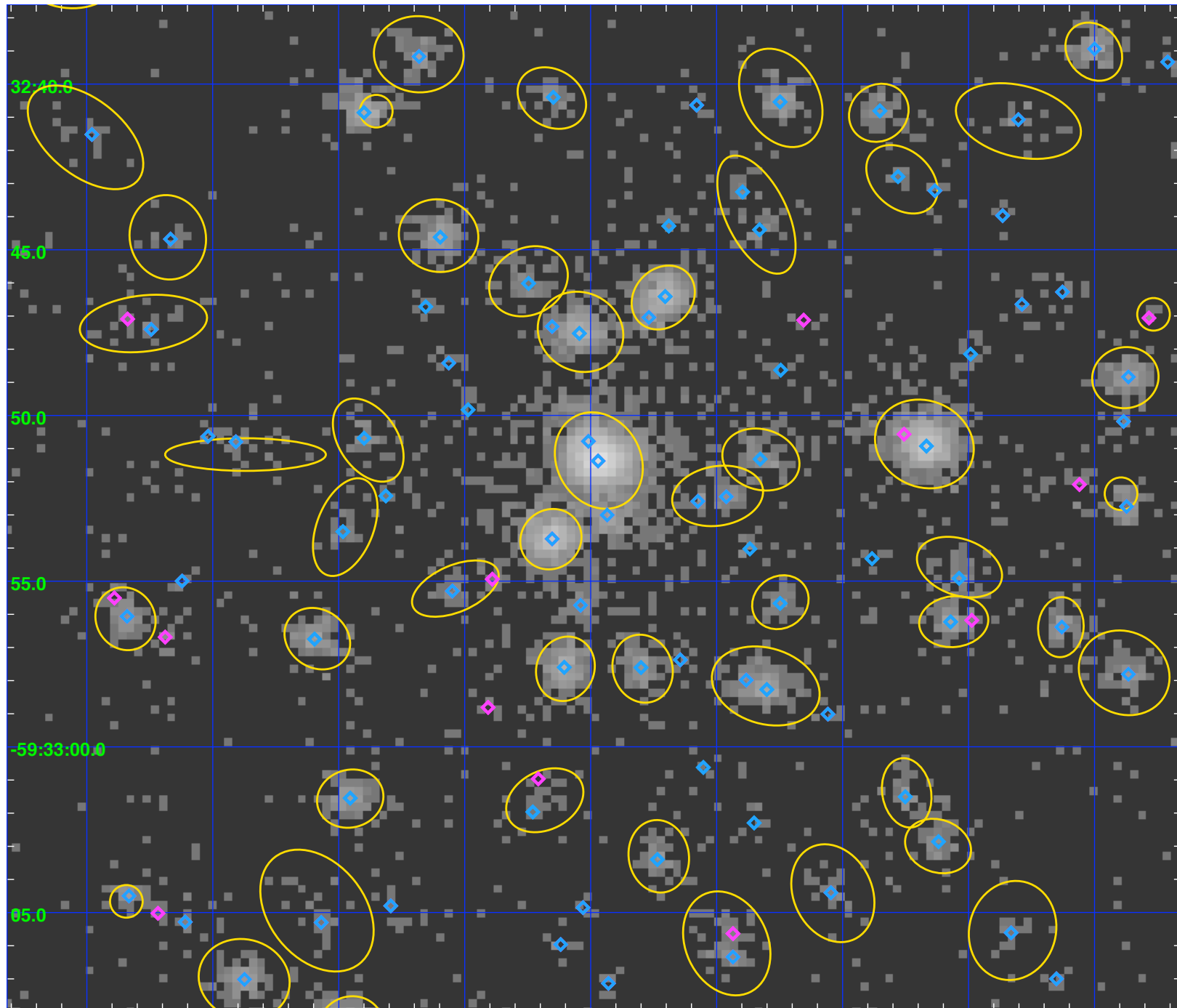
49 wavdetect
sources

97 sources from
image
reconstruction:

13 unmatched
84 matched

Matching: NIR

sources from
Ascenso et al. 2007,
NTT/SOFI &
VLT/NACO
(VLT/HAWK-I
matches 3 more)



The Treasure Chest, Bochum II, & the Giant Pillar -- a whiff of what's to come

Image: $\sim 30' \times 30'$ MSX
8 μm , DSS, smoothed
diffuse X-rays, 0.5-2 keV
(pt srcs removed)

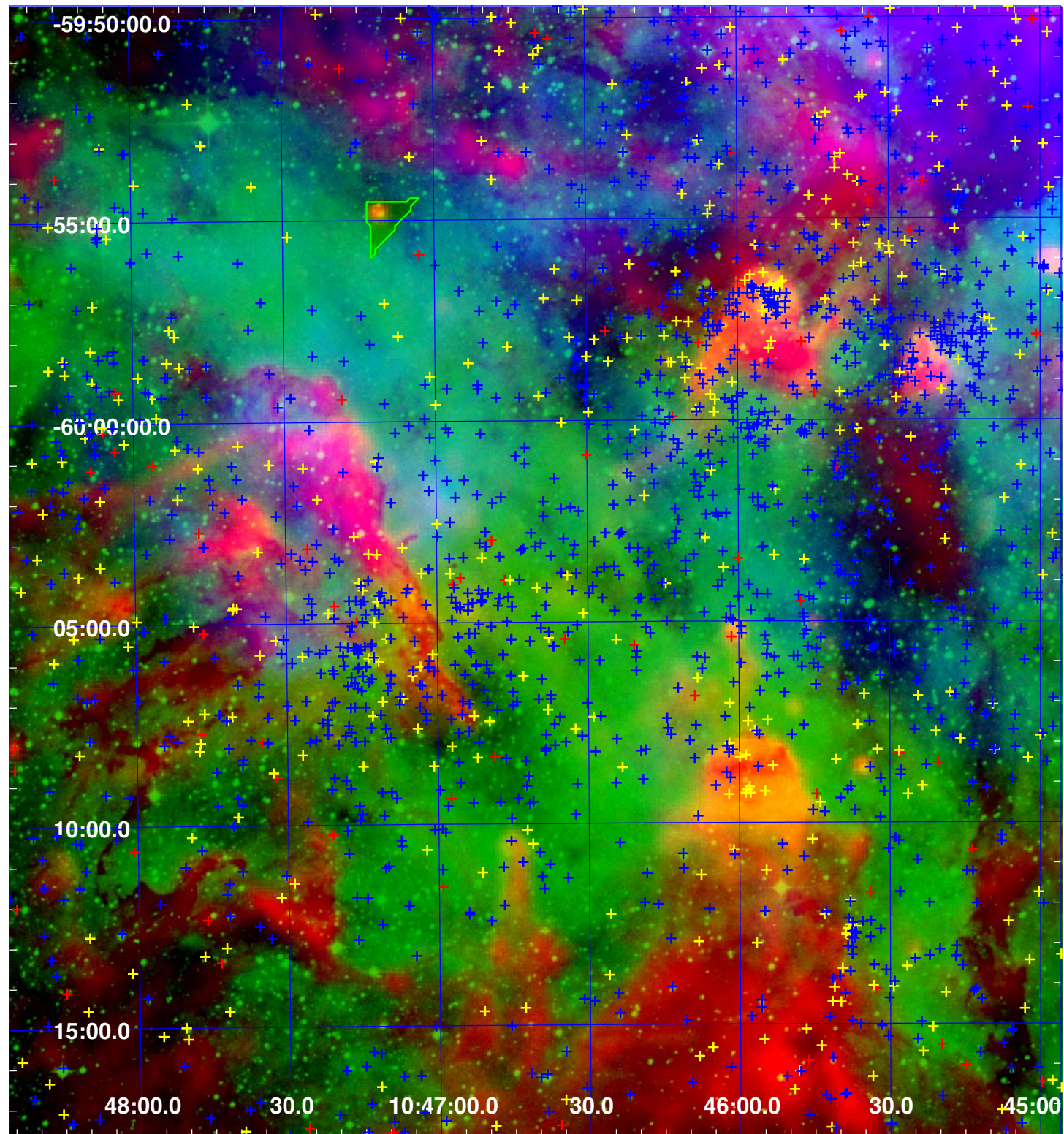
Crosses: ACIS point
sources, coded by
median energy:

$0 < E_{\text{med}} < 2 \text{ keV}$

$2 < E_{\text{med}} < 4 \text{ keV}$

$4 < E_{\text{med}} < 8 \text{ keV}$

weak sources omitted



Source Classification

Patrick Broos is working on a **Bayesian source classifier**:

-- requires custom simulations of Carina's contaminating source properties
(Konstantin Getman)

-- uses available measurements (X-ray, IR, etc.)

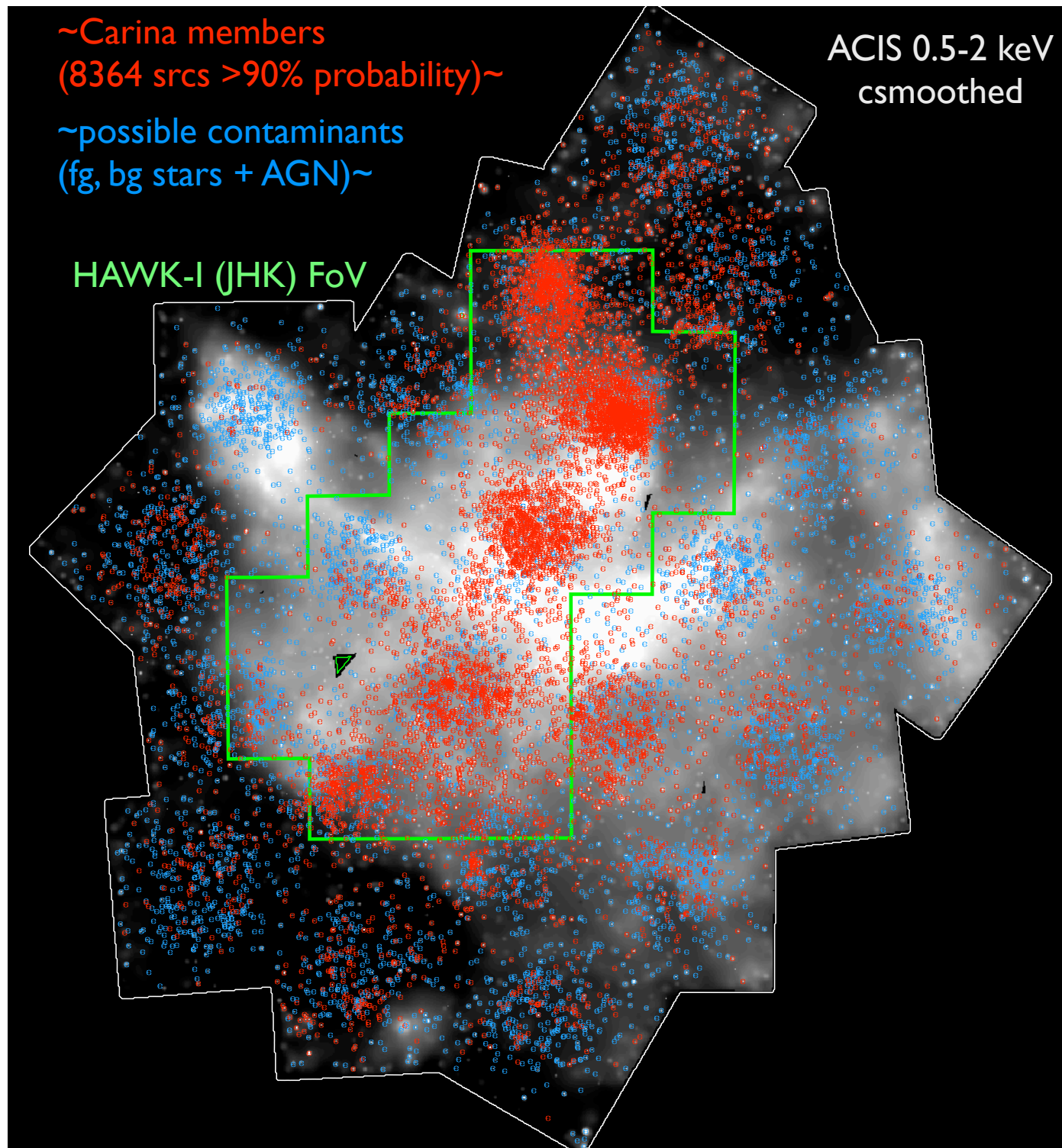
-- incorporates prior knowledge (source clustering)

Results

-- Known clusters *do not merge* in X-ray sample

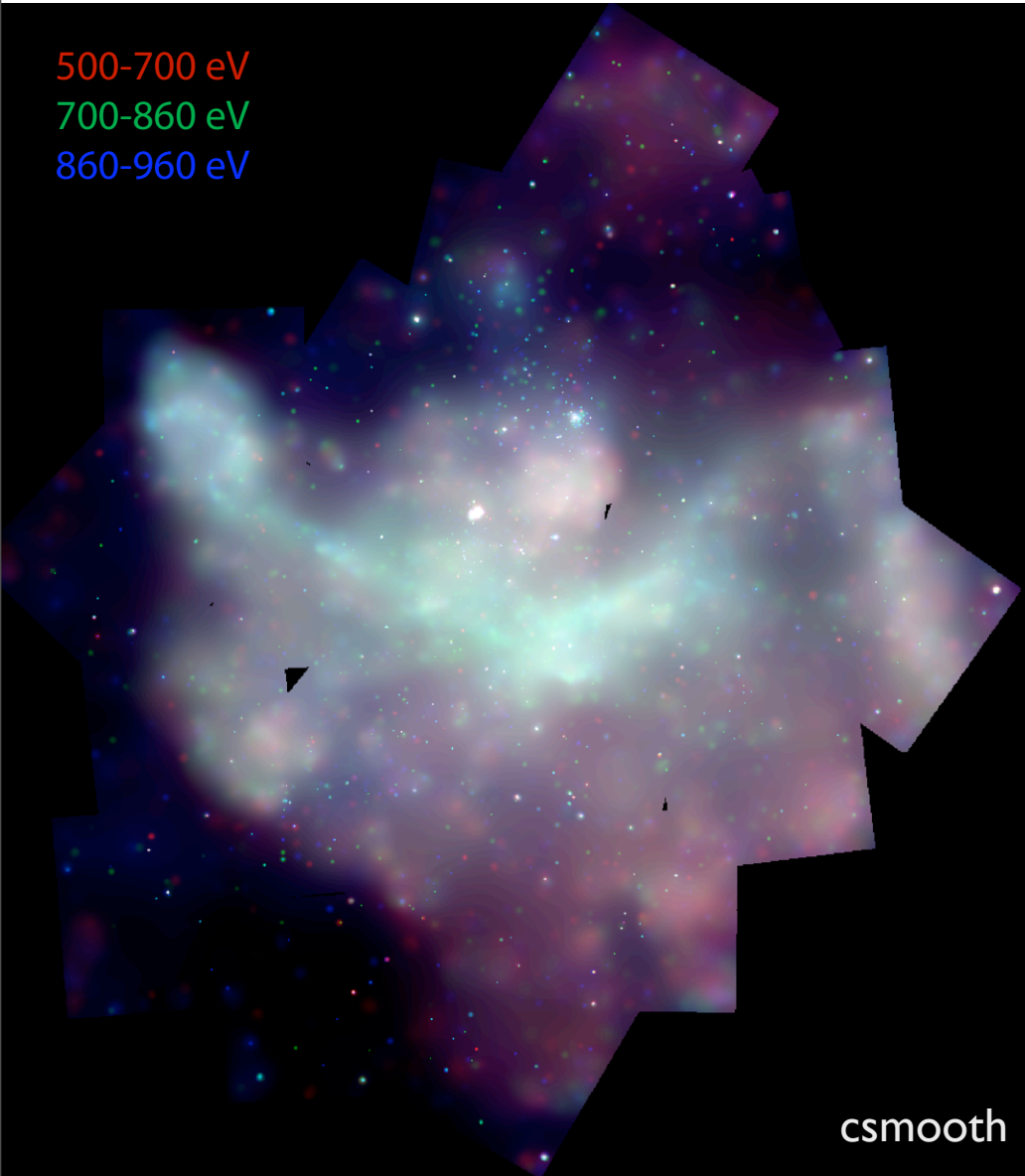
-- small clumps abound

-- evidence for a *distributed population* of pre-MS stars!



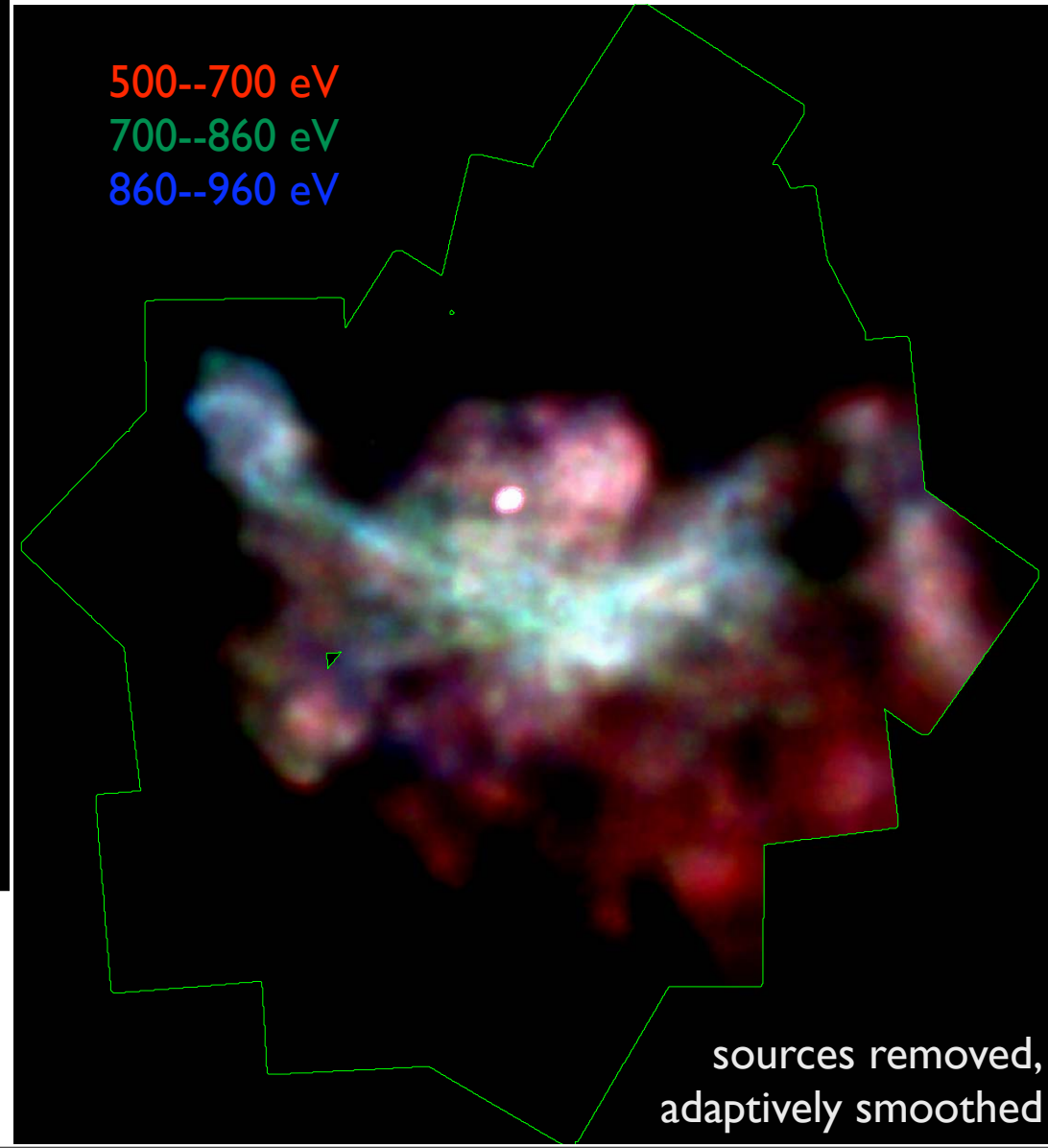
CCCP Soft Diffuse Emission

500-700 eV
700-860 eV
860-960 eV



Note 3 soft bands!

500--700 eV
700--860 eV
860--960 eV



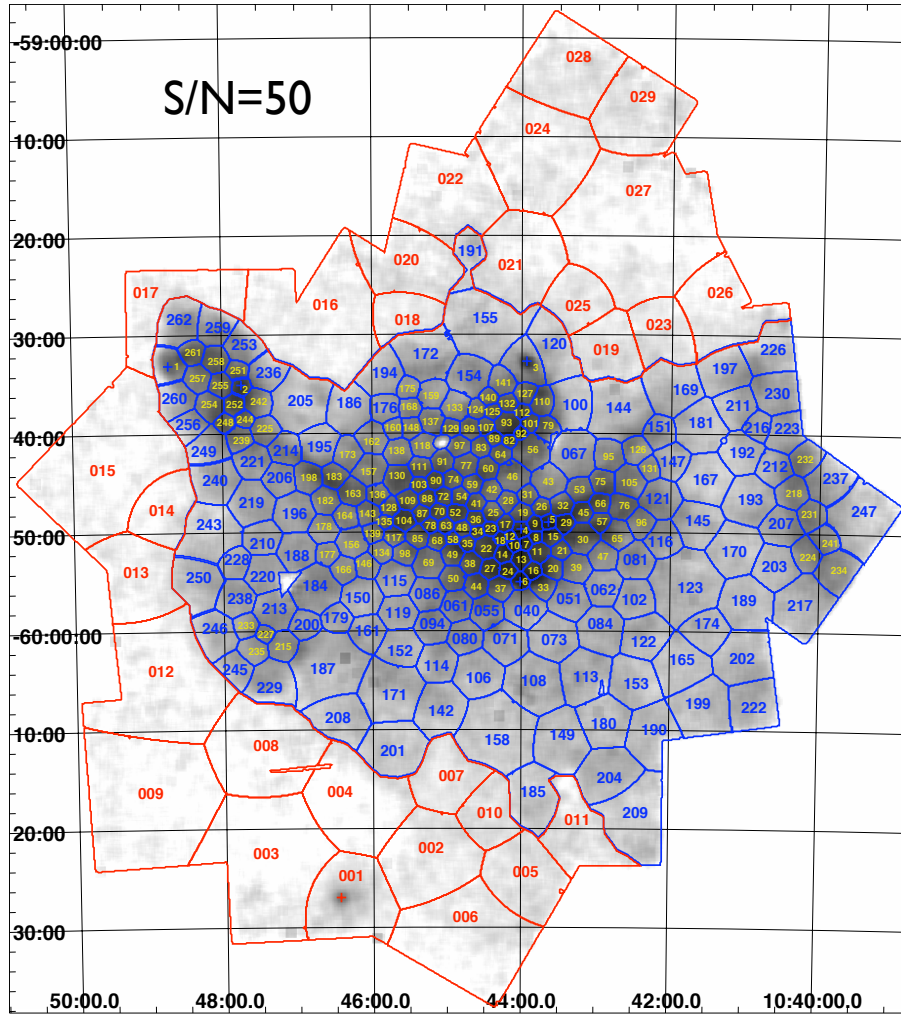
Diffuse Emission Analysis

Tile flux image, give regions to ACIS Extract for multi-ObsID extraction, XSPEC fitting.

WVT Binning

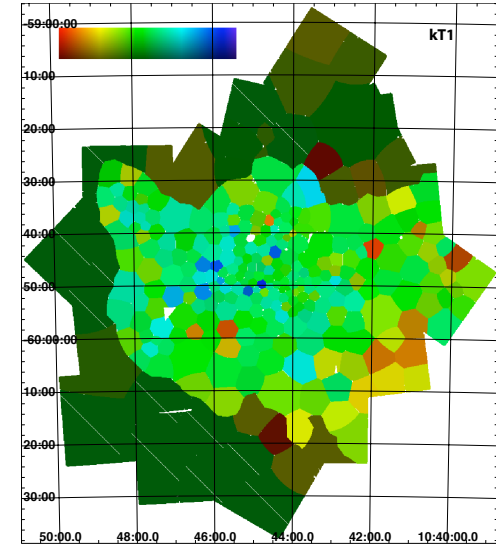
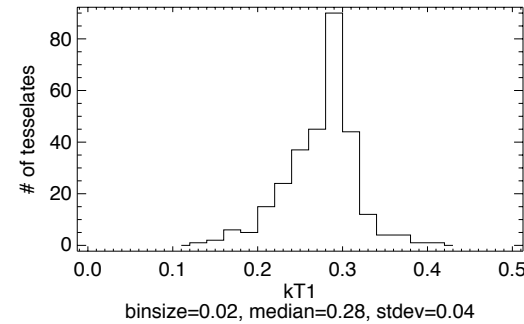
Diehl & Statler 2006

<http://www.phy.ohiou.edu/~diehl/WVT/index.html>

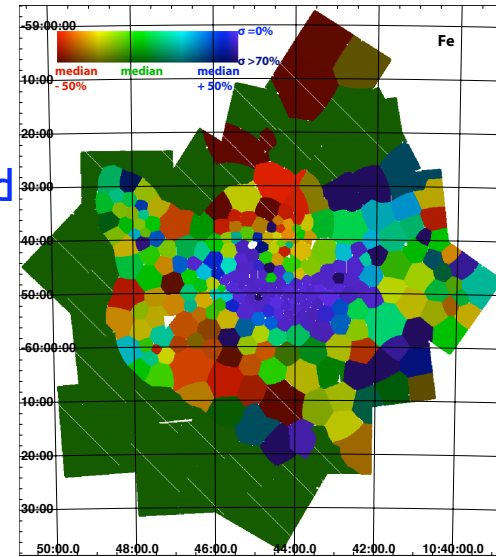
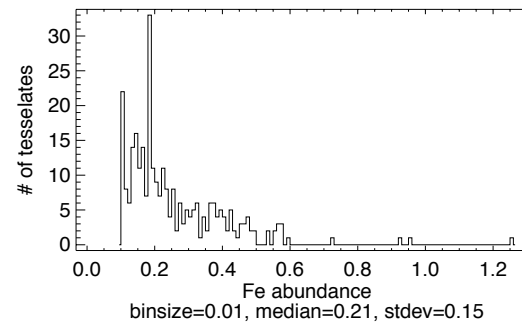


Global diffuse fit:
 $L_x \sim 1.5 \times 10^{35}$ ergs/s

One dominant thermal plasma temp:
 $kT \sim 0.3$ keV

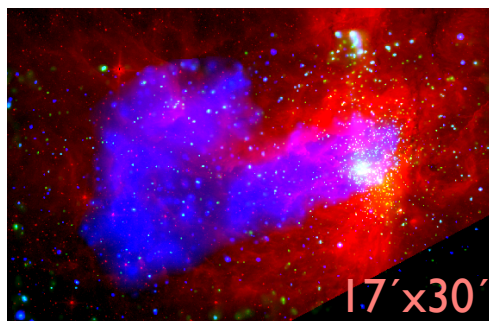


Tessellate spectra fit independently, yet high Fe spatially concentrated



So are Carina's diffuse X-rays from winds or supernovae?

My guess is YES.



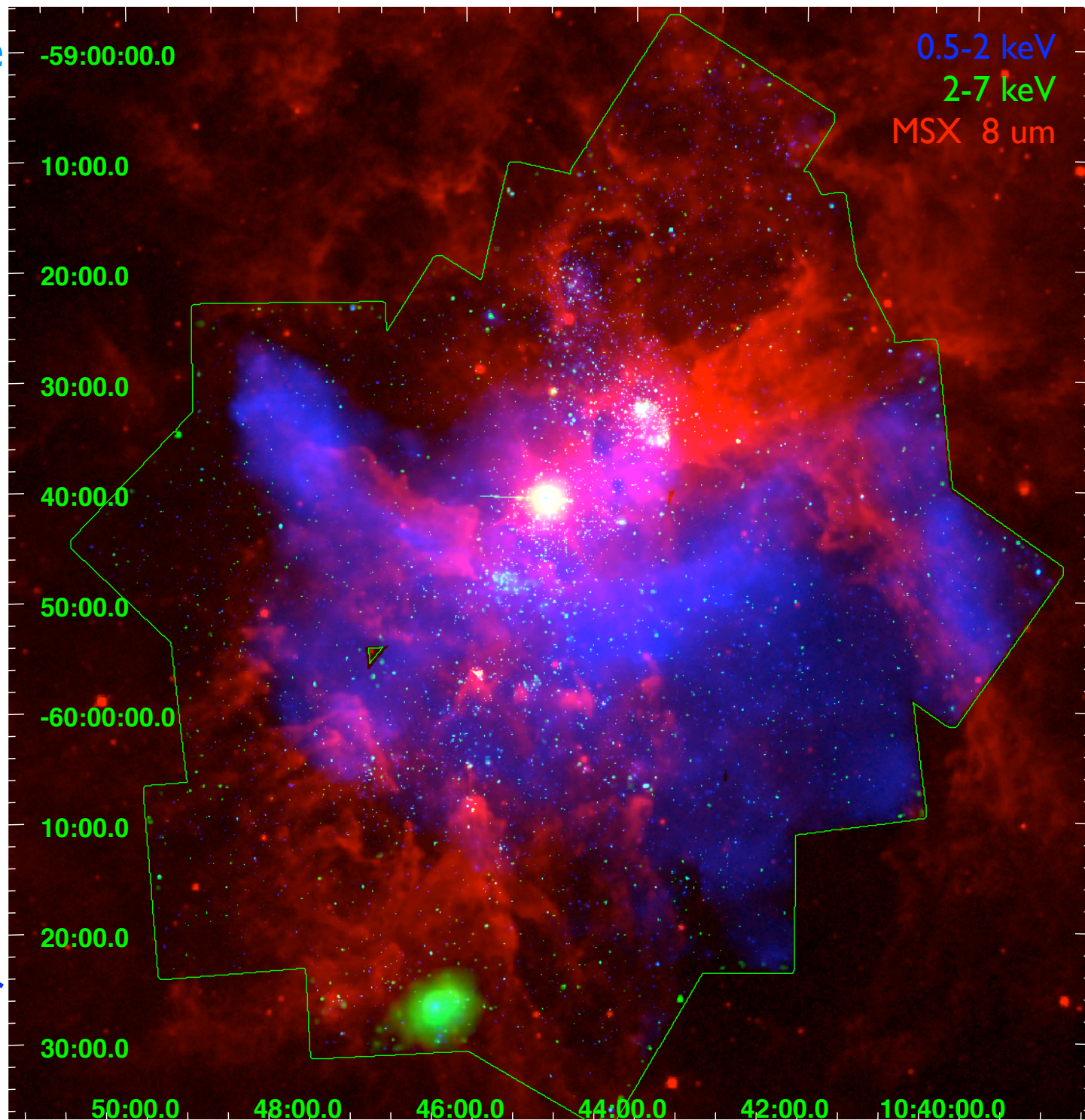
17'x30'

M17, age = 0.5-1 Myr,
likely wind-dominated
soft diffuse X-rays,
7 stars O6 or earlier.

$L_x \sim 8 \times 10^{33}$ ergs/s.

Carina has 21 stars O6 or
earlier, + 3 WR + η Car.

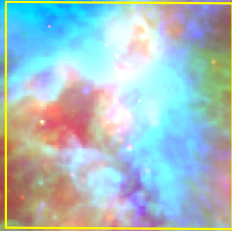
$L_x \sim 150 \times 10^{33}$ ergs/s.



30 Doradus

0.5-2 keV ACIS-I
MCELS H-alpha
(You-Hua Chu)
Spitzer 8 μ m
(Bernhard Brandl)

CCCP



Bright, soft diffuse emission dominates the field: 20-pc patches show $kT = 0.3\text{--}0.8$ keV, $L_x = 0.2\text{--}16 \times 10^{35}$ ergs/s. These are supernova-filled superbubbles.

Carina as a microcosm of starburst astrophysics:

the Chandra Carina mosaic in context.

The 1.42 square degree Carina survey just hints at the complexity waiting for us in GEHRs!

Chandra's 30 Doradus

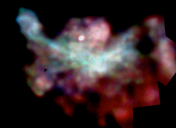
$\sim 250 \times 250$ pc

110 ksec ACIS-I

0.5--0.7 keV

0.7--1.1 keV

1.1--2.3 keV



Carina

Image processing by
Kim Kowal & Eli
Bressert, CXC EPO