The Chandra X-ray Observatory

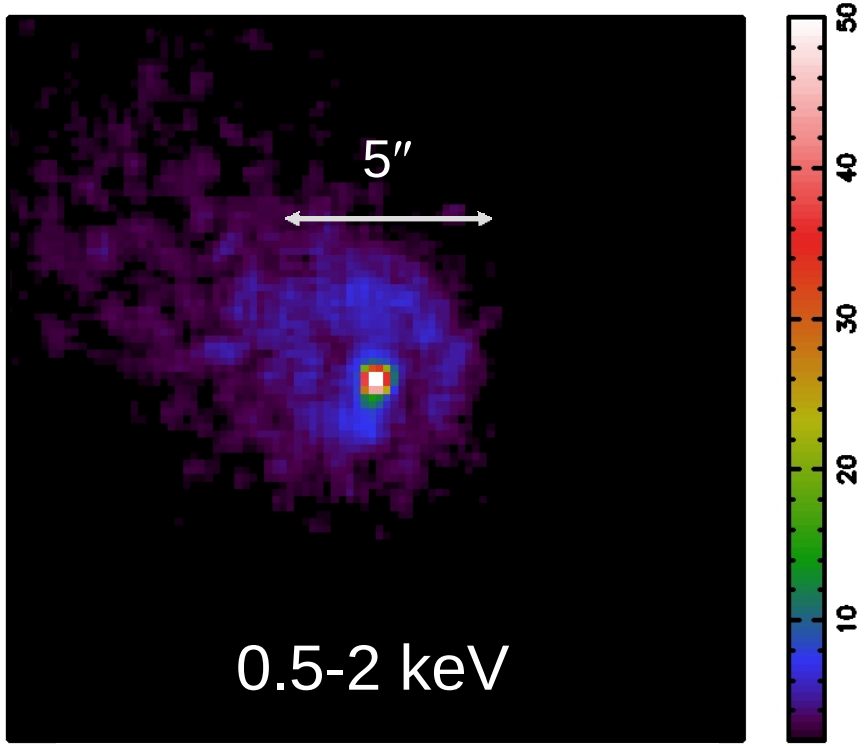
Martin C. Weisskopf

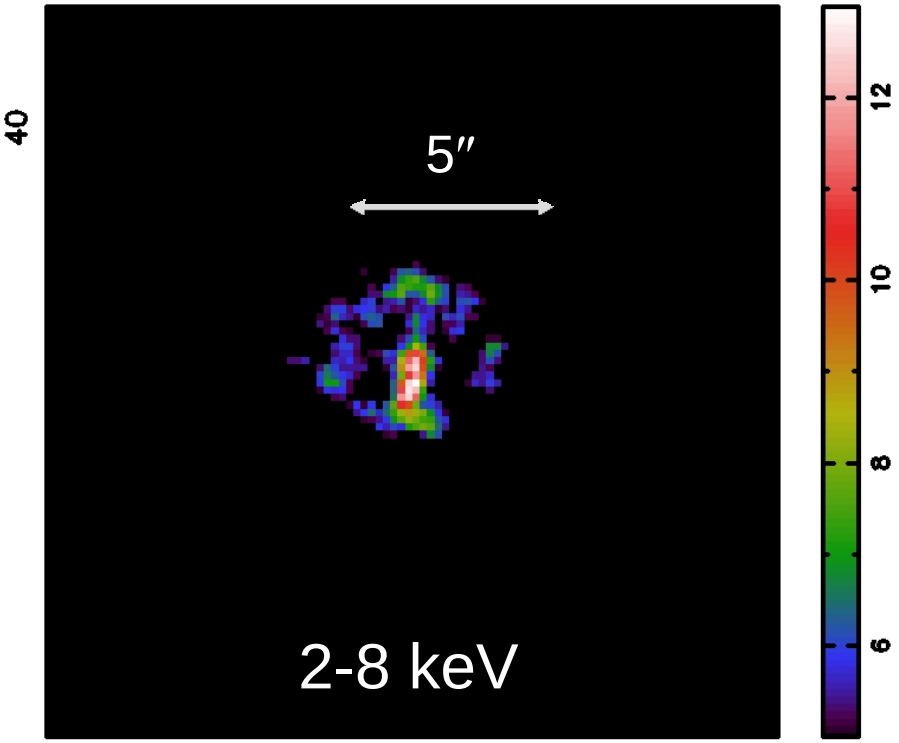
SPIE

3 July 2012

Chandra is unique

No other X-ray observatory, now or in the foreseeable future, approaches Chandra's angular resolution and sensitivity for X-ray source detection and mapping



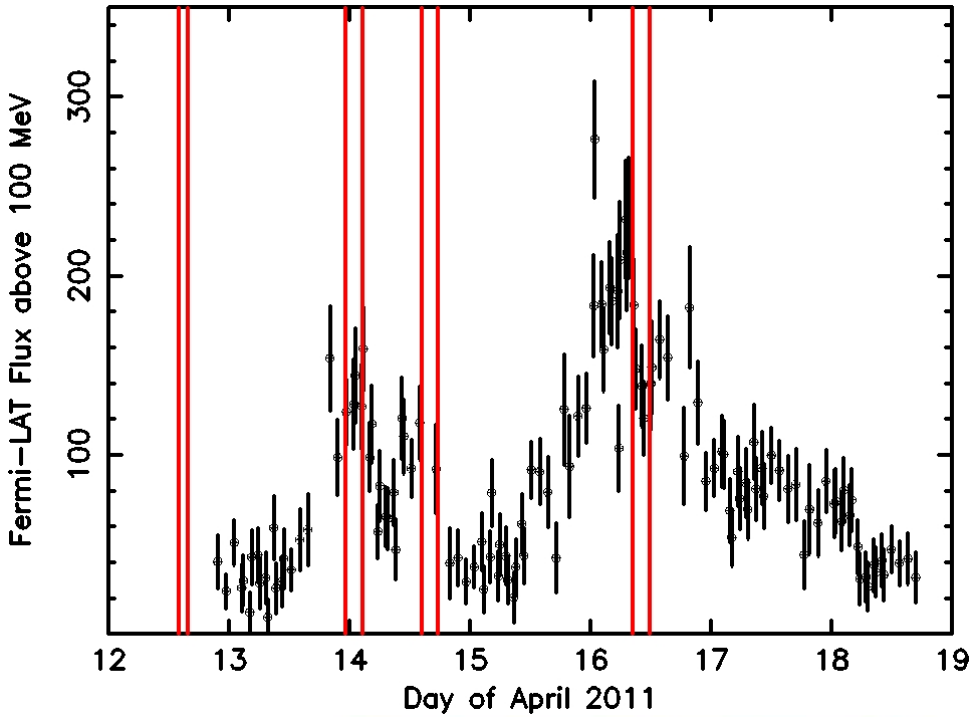


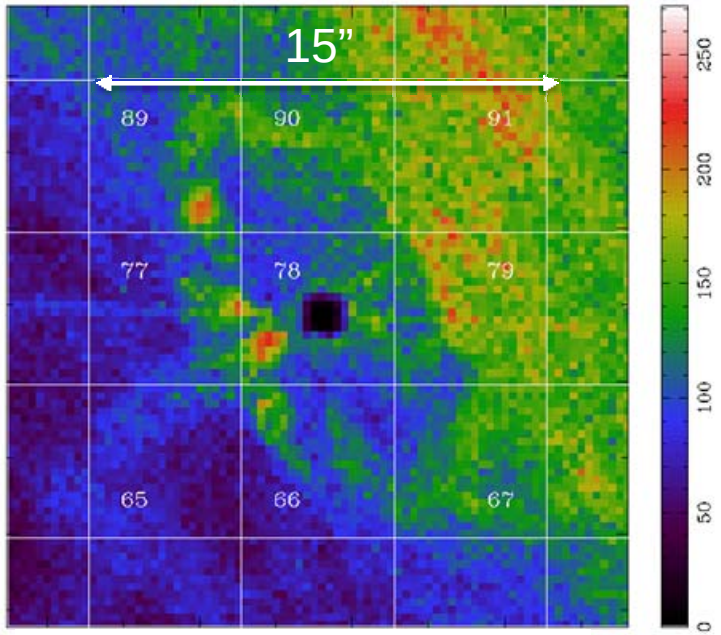
IC 443 Supernova Remnant

Chandra is essential

Chandra is well-matched to capabilities of major observatories at all wavelengths, making it critically important for providing a more complete view of many phenomena

- 2010 Sept - *AGILE*/Fermi-LAT discover γ-ray flaring from Crab Nebula
- 2010 Sept - Chandra initiates monitoring program and sets up target of opportunity
- 2011 April - Fermi-LAT/*AGILE* detect major flare
- Time scale implies sub-arcsecond source which only Chandra can hope to find



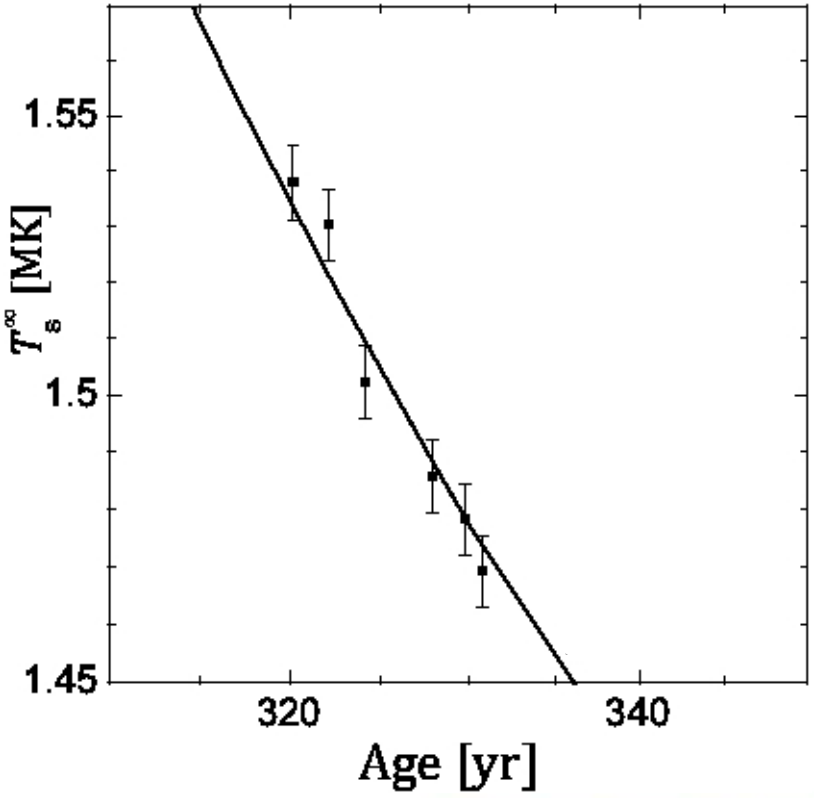


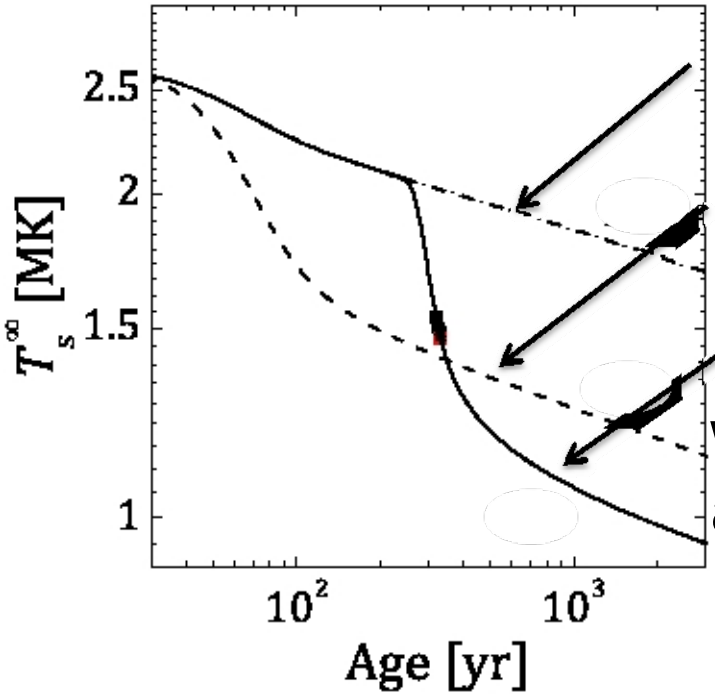
Buehler et al. (2012)

Chandra is long-lived & well calibrated

Together with reasonably stable performance, these provide another dimension to Chandra's uniqueness and usefulness to the community

Long term monitoring provided evidence for superfluidity (SF) in the core of the CAS A neutron star





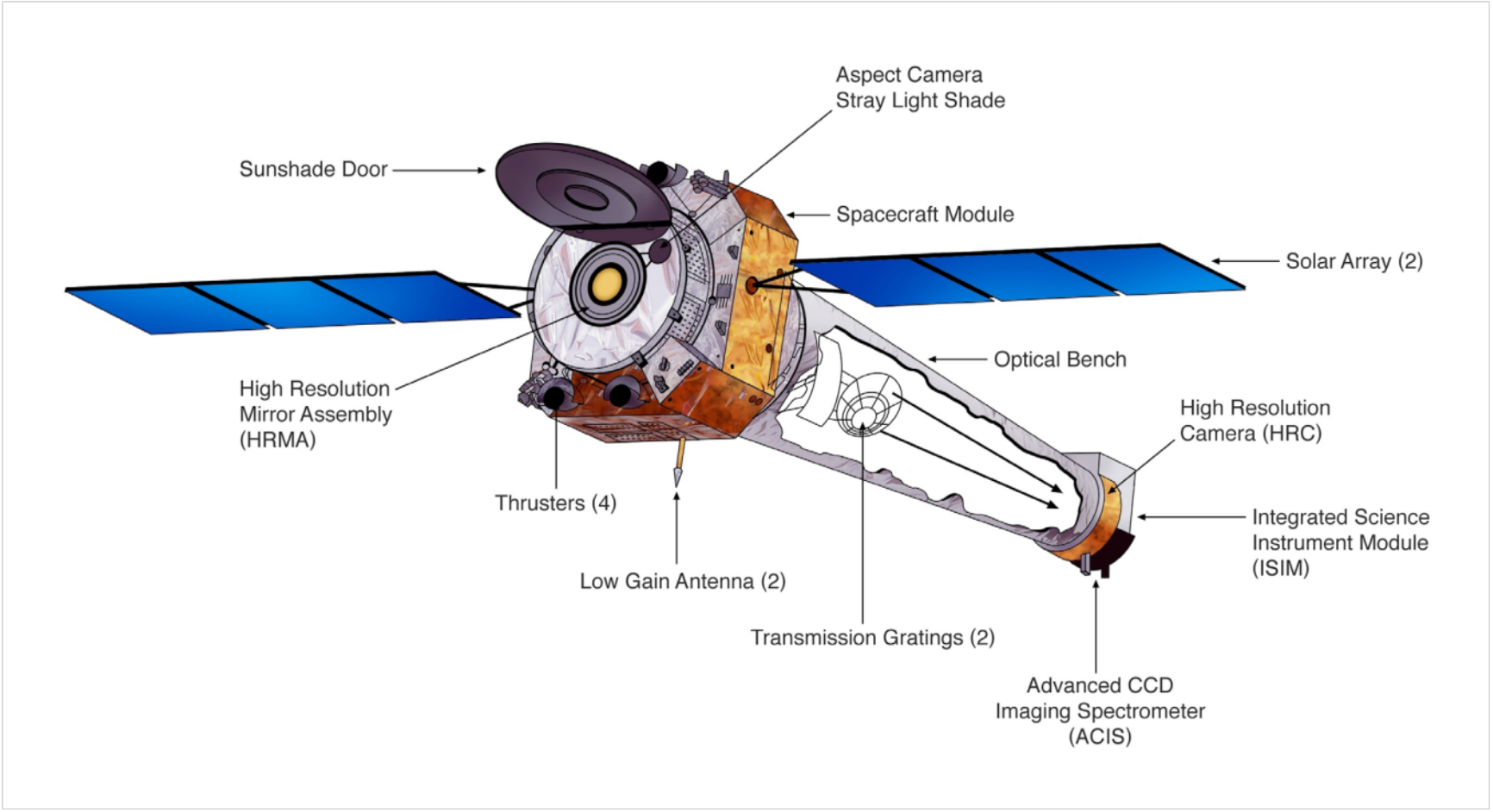
Proton SF

No SF

Best model with both n and p SF

Ho & Heinke (09), Heinke & Ho (10), Page et al. (11), Shternin et al. (11)

Observatory status



Chandra is alive and well in its 13-th year of operation

Observatory status

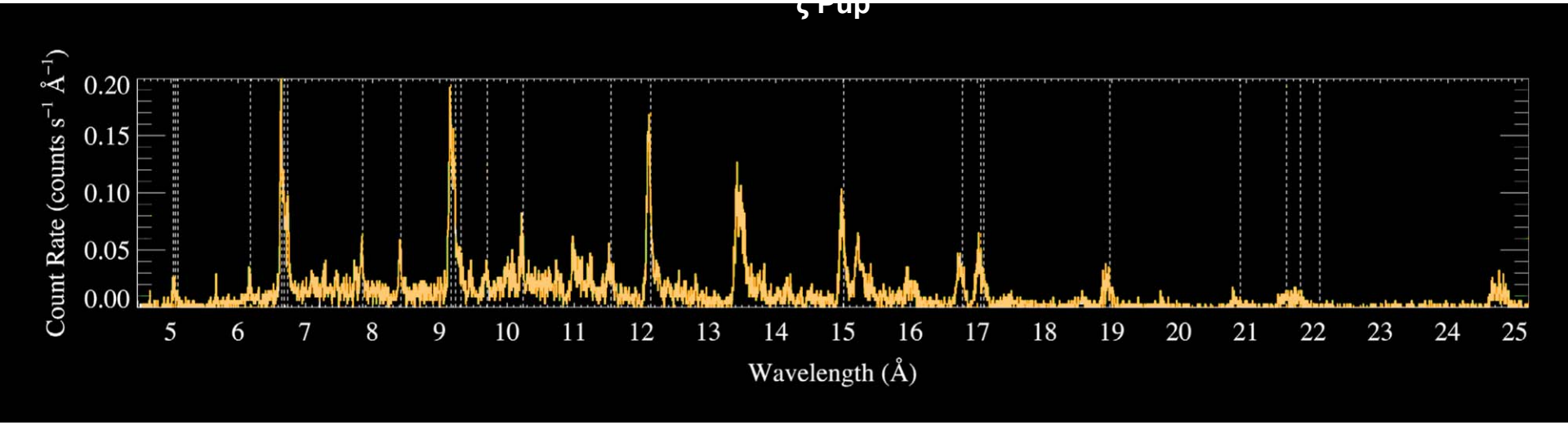
- The multilayer insulation is degrading
  - Increased complexity in mission planning
- Degradation of the Integrated Electron Proton Helium Instrument
  - Using HRC anticoincidence shield and ultimately ACIS
- Noisy gyroscope (but still within specification)
  - Switched to the backup
- Warm pixels in the aspect camera
  - Avoid them when placing guide stars on the CCD
- Contamination buildup on ACIS filters
  - Gradual decrease in the energy efficiency at and below 1.5 keV

Usage

- Total number of papers in refereed journals is 4934 (Jan 2012)
  - Citation rate is 32/year after five years
- ~ 3380 distinct PIs and Co-Is
  - Does not include use of the archive
- Demand is very high
  - ~ 700 proposals per cycle
  - ~ 200 proposals accepted per cycle
- 27% of the proposals from non-USA PIs
  - Involves 25 different countries

Please note the references

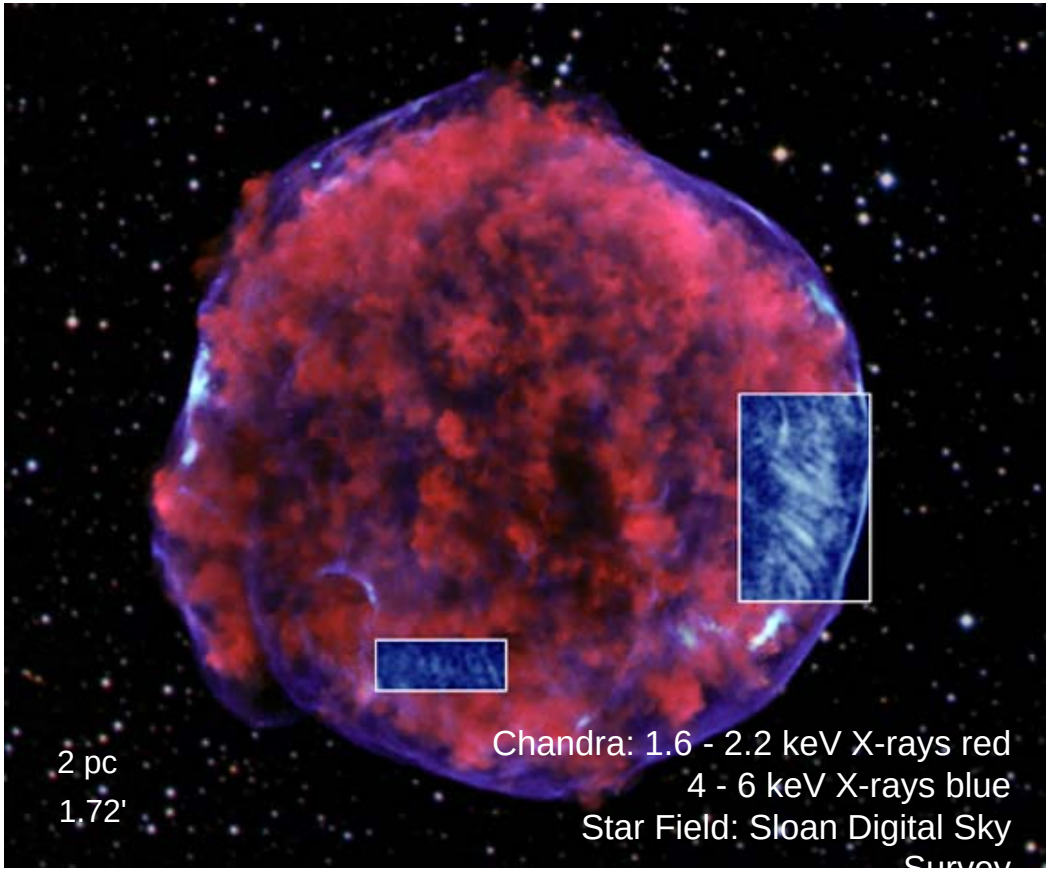
O-star emission line profiles indicate low mass-loss rate



- X-ray line widths and profiles used to determine wind properties
- For both stars:
  - mass-loss rates 3-4x lower than smooth-wind models

Cohen et all. (2010, 2011)

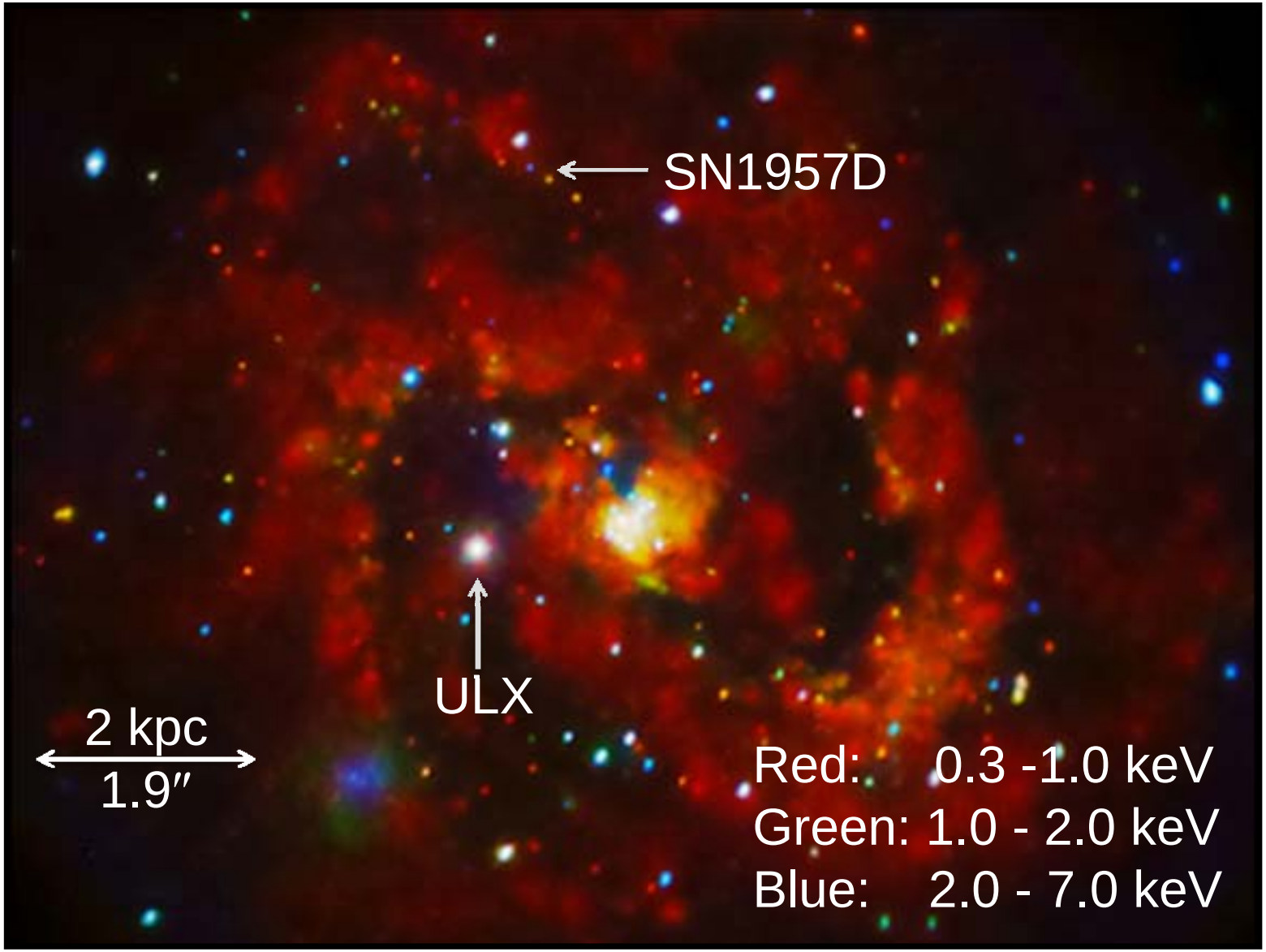
X-ray stripes show acceleration of cosmic rays to 10^{15} eV



- Spacing of stripes corresponds to gyroradii of 10^{14}-10^{15} eV protons for magnetic fields of few to few tens of μG
- However, synchrotron radiation from electrons trapped in regions of strong magnetic field can also produce observed pattern

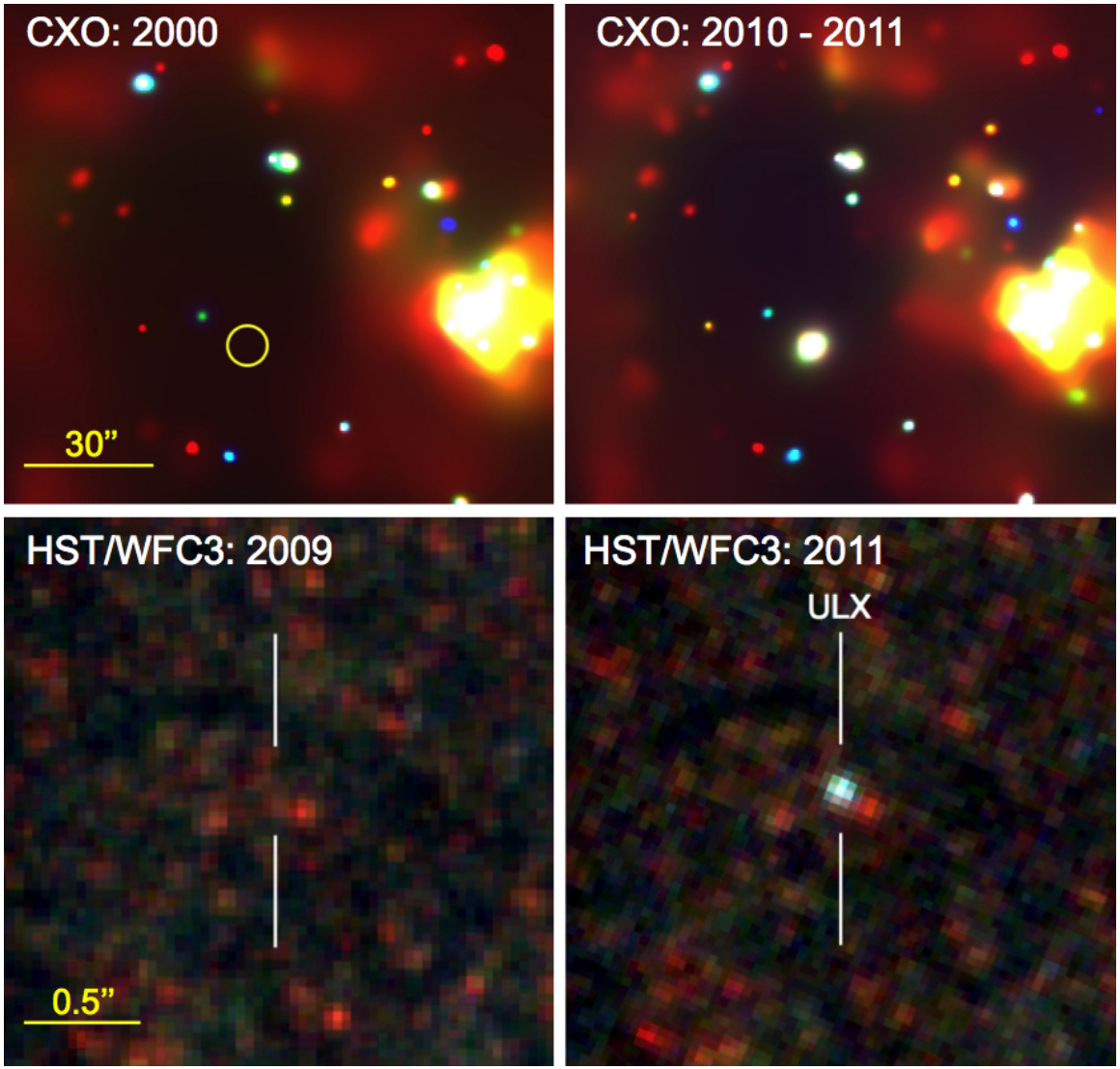
Eriksen et al.(2011)

Many new sources discovered in M83



Long et al (2012)

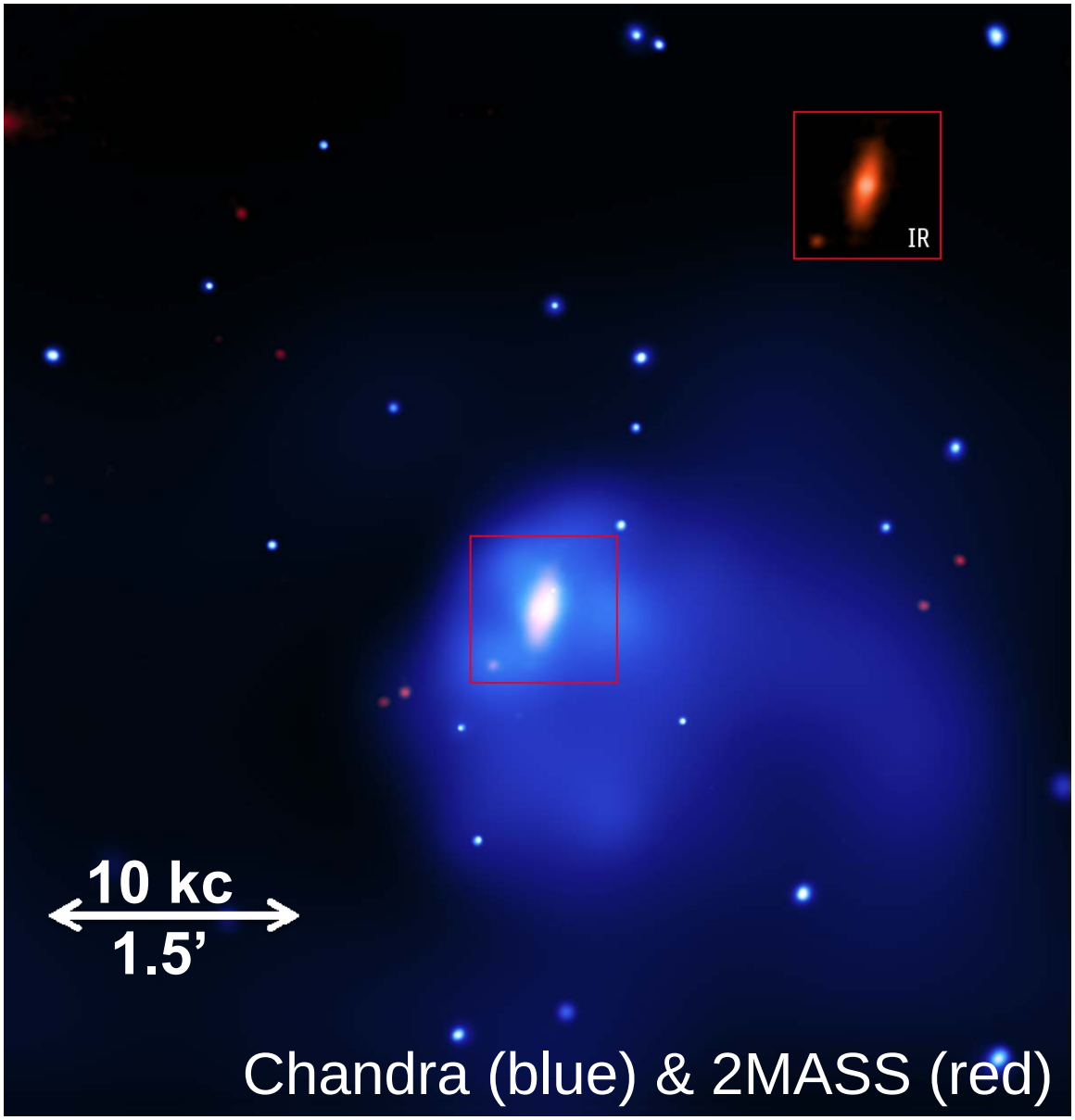
The Ultra Luminous X-ray source in M83



- M_{BH} ~ 40-100 $M_{\odot}$
- Optical observations from 2009 requires low mass donor star
- Some ULXs in star-forming galaxies have low mass
- Suggests multiple evolutionary paths.

Soria et al (2012)

Black hole growth coupled to dark matter halo

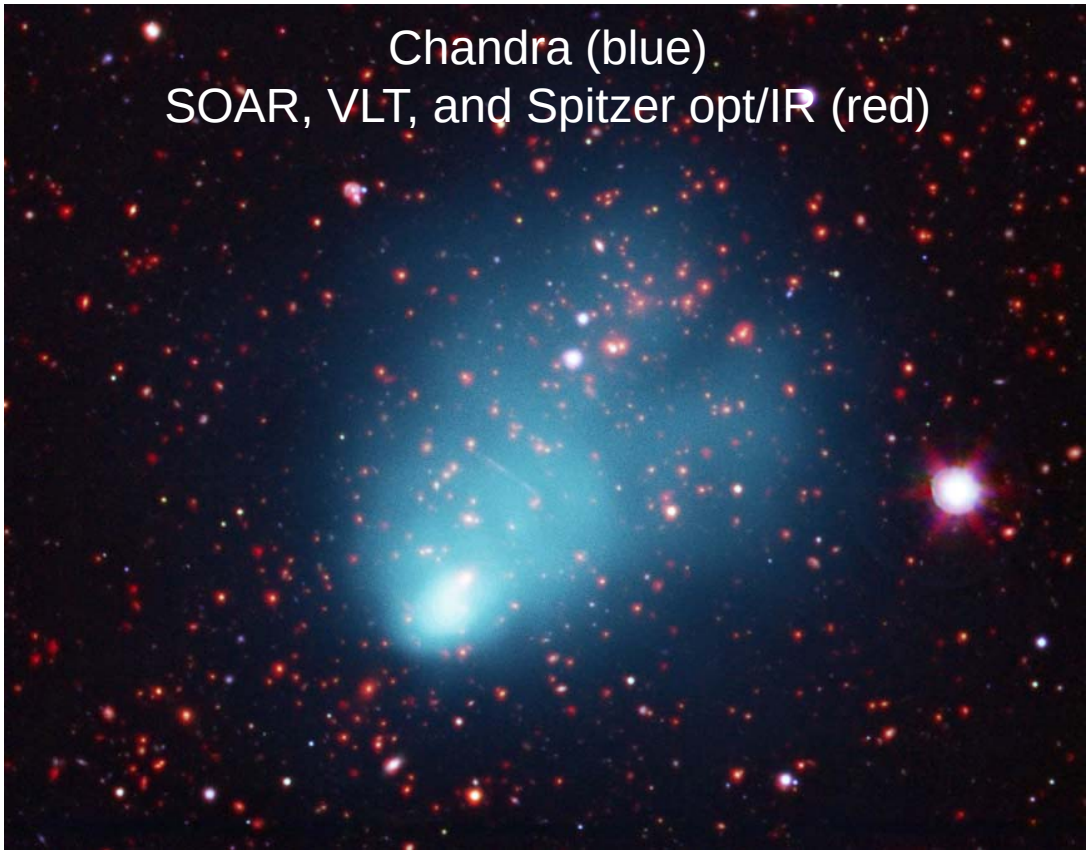


- Early-type galaxy at 23 Mpc
- BH/bulge mass ratio ~4%
- ~20x higher than typical
- Chandra detects extended gas halo and thus massive dark matter halo

.

Bogdan et al (2012)

Chandra observations reveal extraordinary galaxy cluster

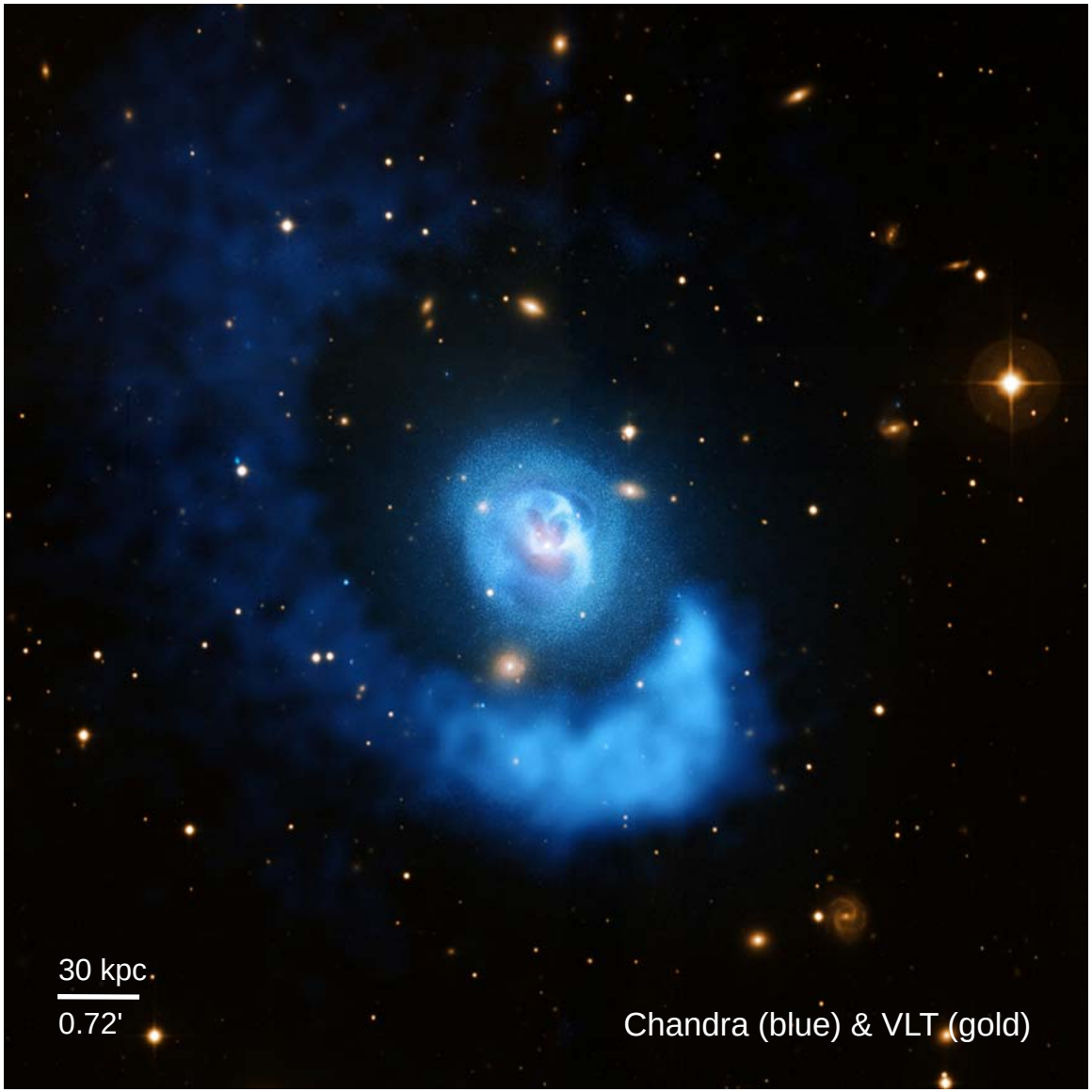


•"El Gordo" with M_{200} ~2.2 x 10^{15} $M_{\odot}$, T ~14.5 keV, L_x ~2.2 x 10^{45} erg/s — all highest known for cluster at z>0.6

• X-ray morphology indicate collision — a more distant analog of Bullet Cluster with separation of baryonic and dark matter

Menanteau et al (2011)

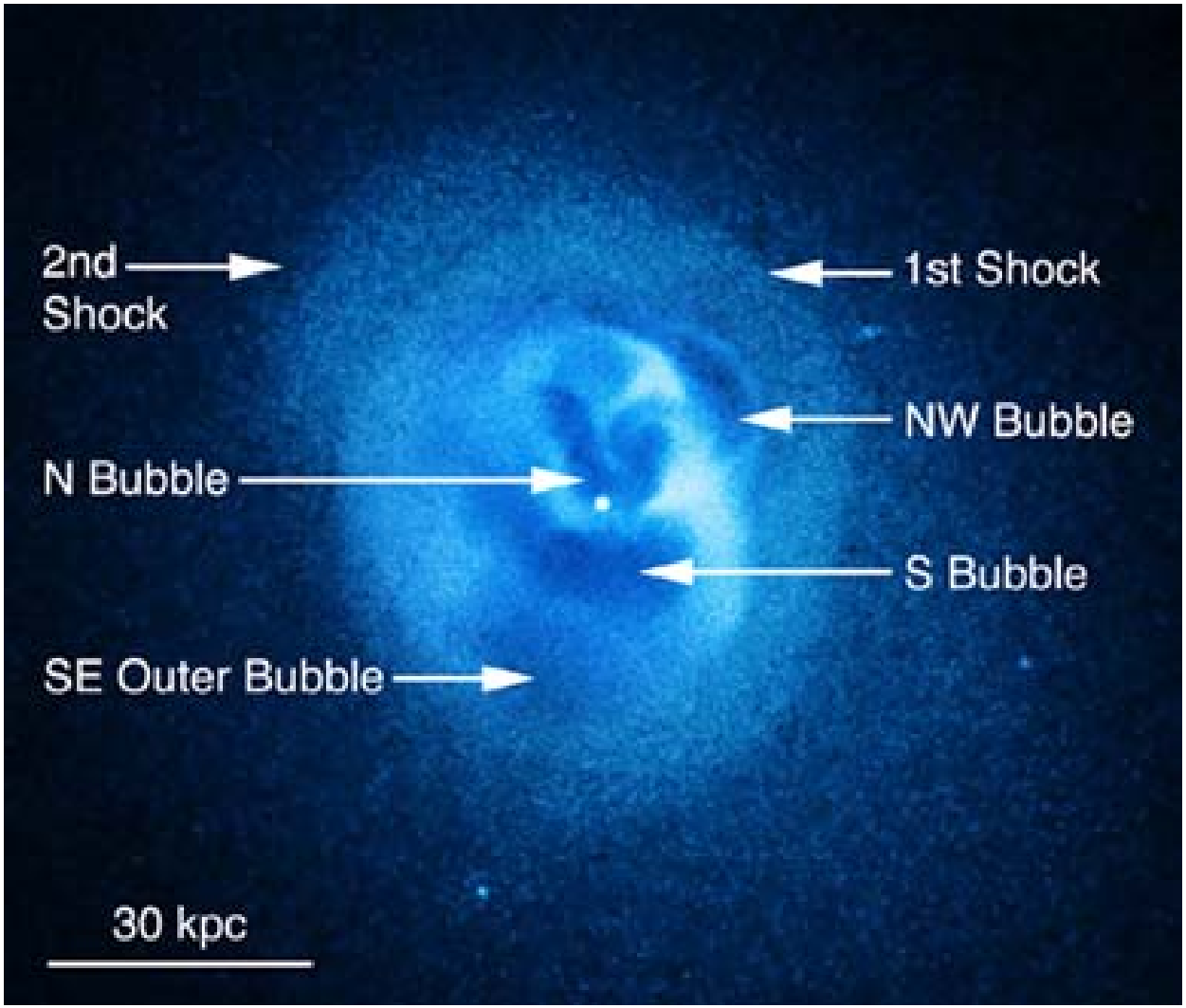
Tracing impacts of mergers and SMBH outbursts



- Off-center collision drives sloshing of gas
- Produces spiral-like ~300 kpc, edges, and shock fronts
- Sloshing transports gas away from core, slows cooling, star formation, and redistributes metals
- Bubbles result from interactions between SBMH outflows/jets and cluster gas,

Blanton et al (2011)

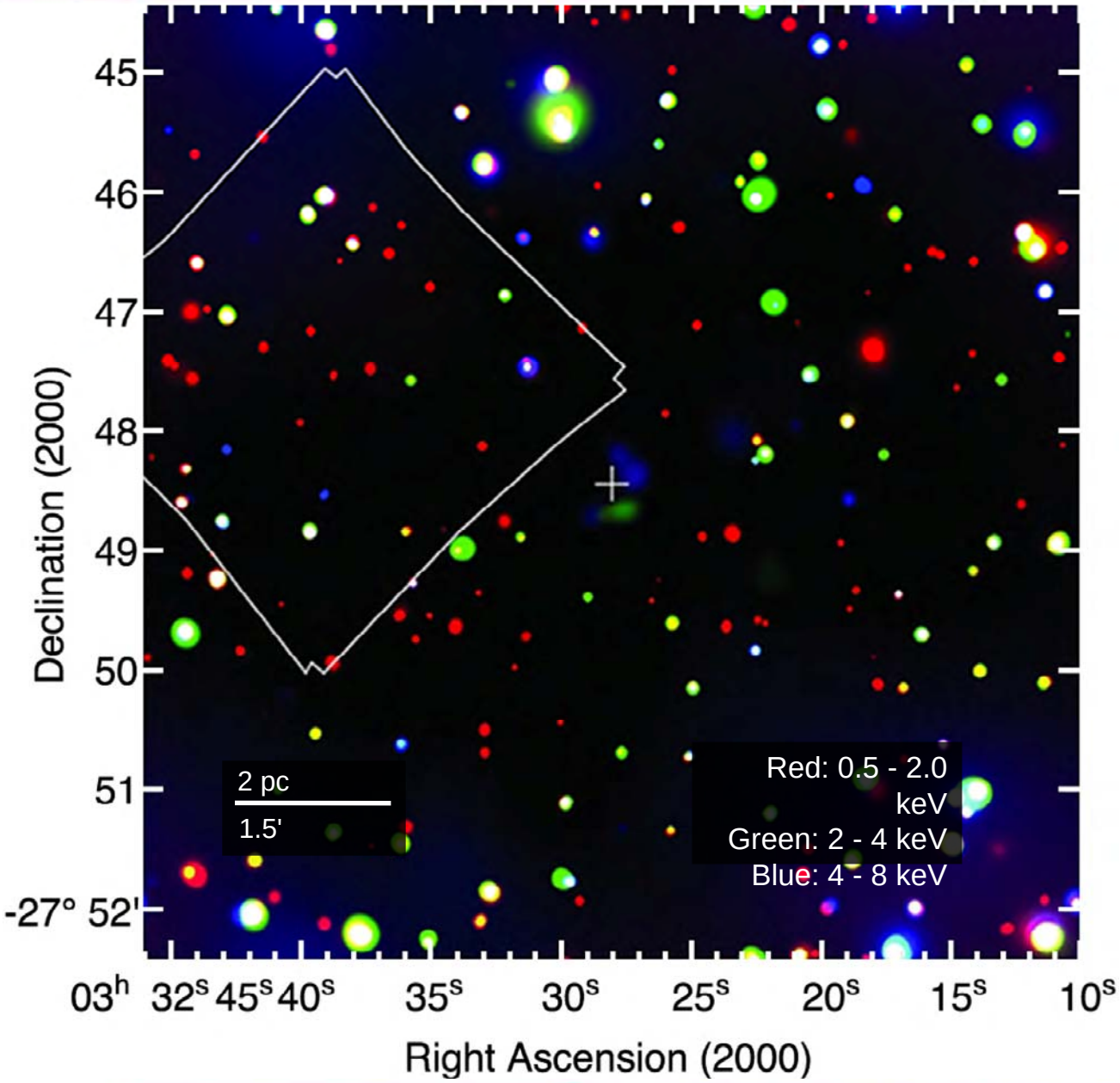
More AGN feedback --- a closeup



• Chandra image of the central region of the galaxy cluster Abell 2052

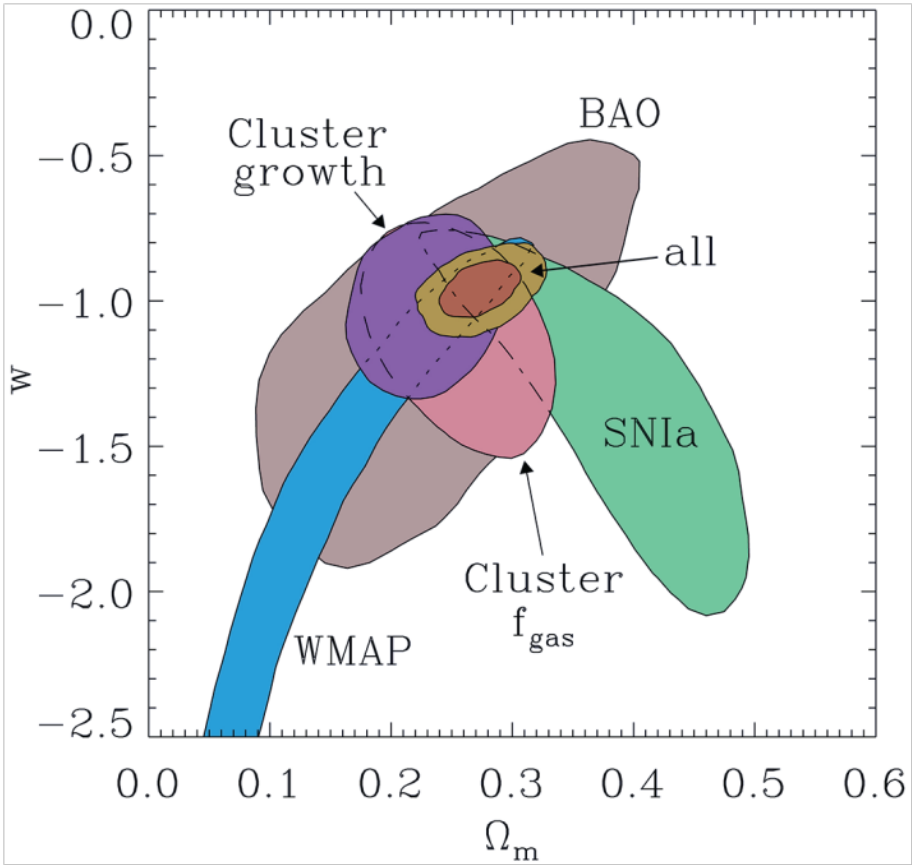
Blanton et al. (2011)

Four Ms image of Chandra Deep Field South



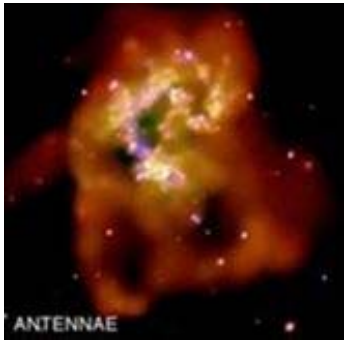
Xue et al. (2011)

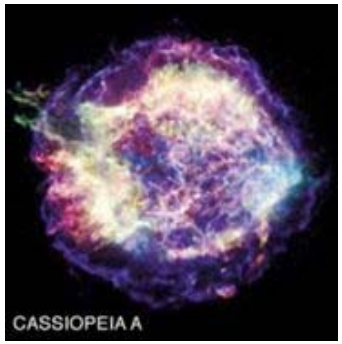
Constraining the universe

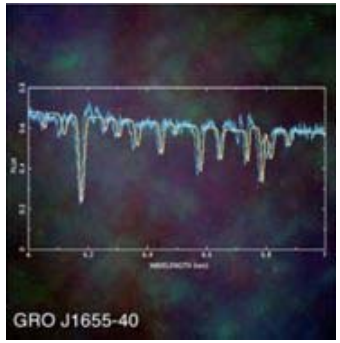


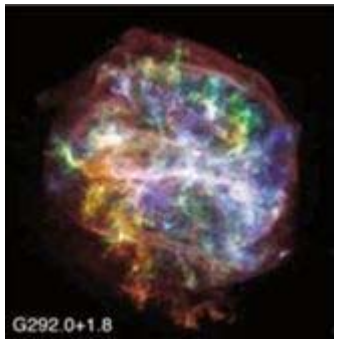
Allen et al. (08), Mantz et al. (10) Dunkley et al. (09), Kowalski et al. (08), Percival et al. (10)

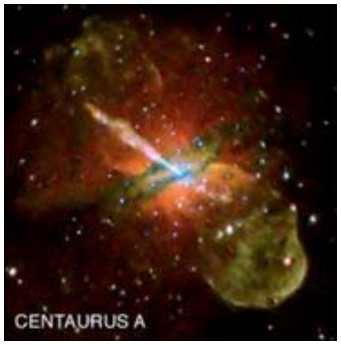
The future looks bright

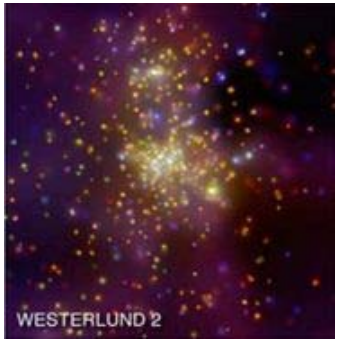












The opportunity for exploration and discovery with Chandra remains as high as it was at launch