Chandra - XMM-Newton
Synergies

Now and in the Future

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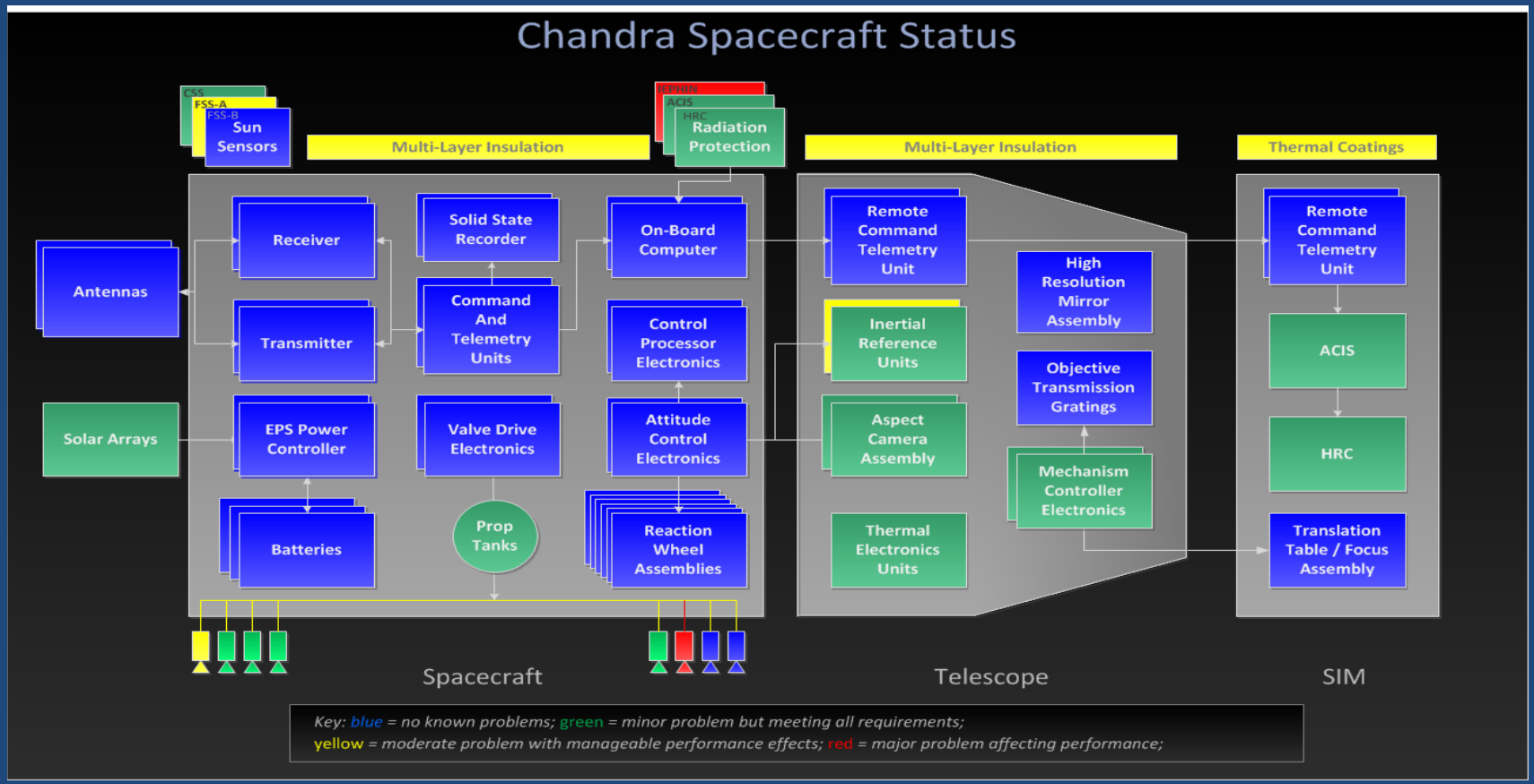
Chandra:16.5 years and counting!

*Detailed engineering review showed no show-stoppers to **10(+) more years** of observing*



Little red or yellow!

Chandra Challenges

- Thermal degradation:
  - Limits dwell time over most solar pitch angles
  - Long exposures generally split
  - Complex scheduling limits constrained time to maintain an efficient schedule

- Contaminant build-up on ACIS OBF
  - Reduced A_{eff} < 2 keV by ~80% since launch
  - Longer exposures for science requiring soft data

Joint *Chandra* & *XMM-Newton* Observing Time

- Proposals whose science question(s) require data from both observatories
- Up to 400ks time allocated by each observatory on the other
- 217 programs since Chandra Cycle 4 including all science categories
- **PLUS**: many projects which combine and/or compare results across both observatories

Capabilities of *XMM-Newton* and *Chandra*

	XMM-Newton	***Chandra***
Field-of-View	~30'*30'	16'*16'
Effective Area	4500 cm^2	800 cm^2
Spatial Resolution	6"	0.5"
Grating Spectroscopy	0.35-2.5 keV Simultaneous	0.08-10 keV
Spectral Resolution	200-800	200-1000
Timing Resolution	30µs (+imaging and spectra)	16µs (HRC) (+imaging or spectra)
Background	10 ct s^{-1} keV^{-1} $srad^{-1}$	0.25 ct s^{-1} $srad^{-1}$

Synergies

- Large Area Surveys: *XMM-Newton*
- Imaging Large Objects: *XMM-Newton*
- Imaging Crowded Regions: *Chandra*
- Source Identification: *Chandra*
- Detecting Complex Structure: *Chandra*
- High S/N Imaging Spectroscopy: *XMM-Newton*
- Grating Spectroscopy: ?? Science
- Rapid Timing: ?? Science

Overlap – common in most other wavebands:

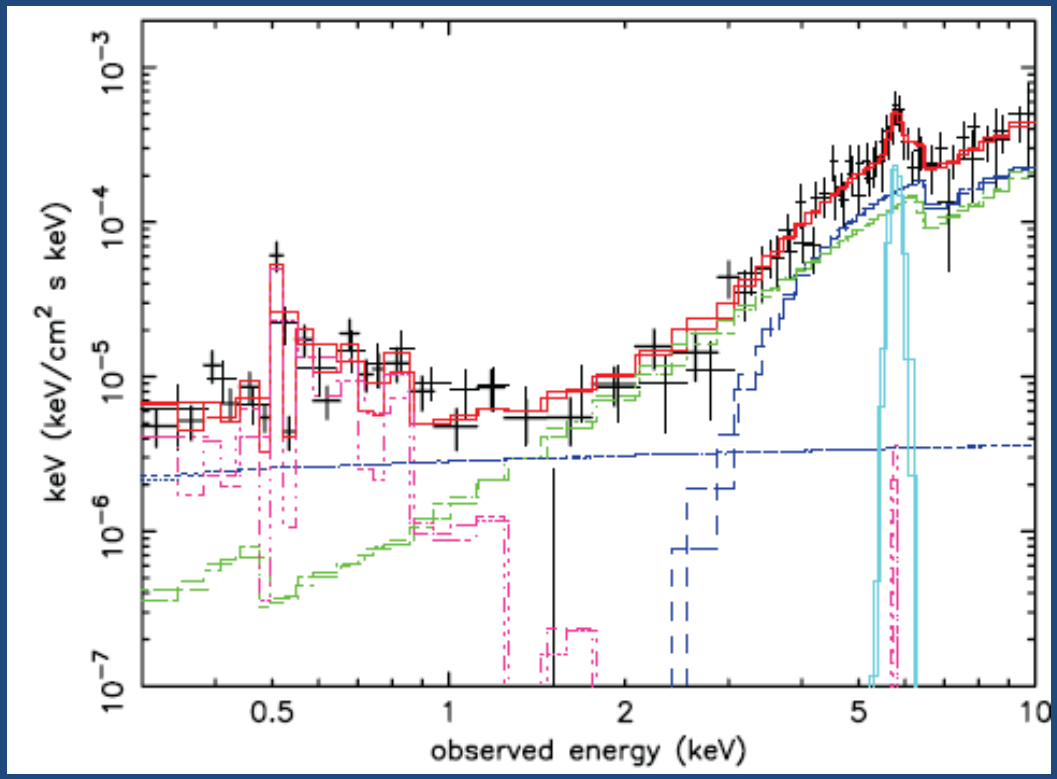
- Independent confirmation/not of results
- Complementary monitoring of variables and transients
- Coordinate on DDTs to avoid duplication

XMM-Newton Spectra of Red Quasars

2MASS1049+5837 (z=0.115)

- *Chandra* (5ks):
  - HR~0.6 → Γ~0.4, N_H~4x10^{22} cm^{-2}
- *XMM-Newton* (26 ks)
  - Power Law (PL), Γ=1.8, N_H~4x10^{23} cm^{-2}
  - ~2% Scattered PL
  - Line emission from extended photoionized plasma
  - Reflection component (R~2) and Fe Kα

Wilkes, Pounds & Schmidt 2008



M87: BCG of Virgo Cluster

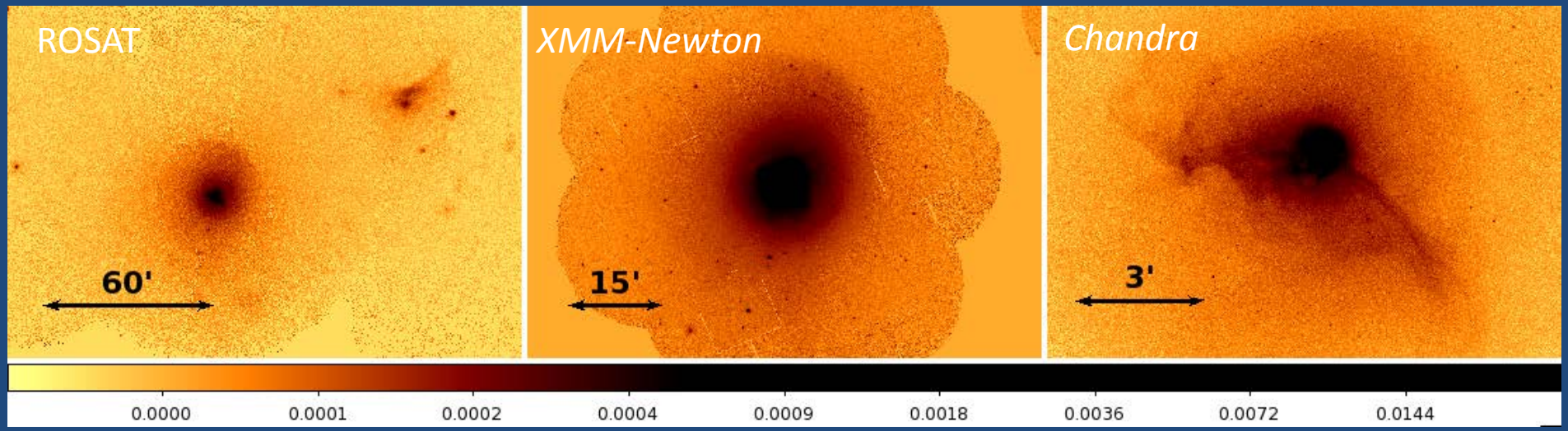


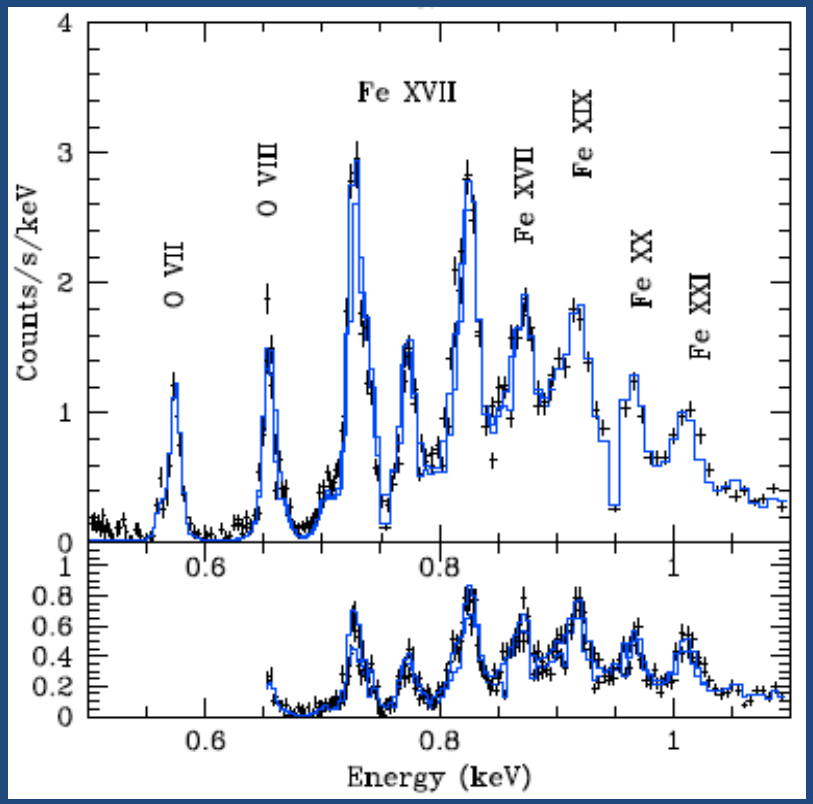
Image: courtesy Bill Forman

- ROSAT: whole galaxy+, some structure
- *XMM-Newton*: whole galaxy, sloshing structures
- *Chandra*: central regions, detailed structure, resolves edges, filaments, voids etc.
- e.g. *XMM-Newton* selects bright outer regions for detailed *Chandra* study of filaments

SNR Physics

Courtesy Fred Seward

Kosenko et al. 2010



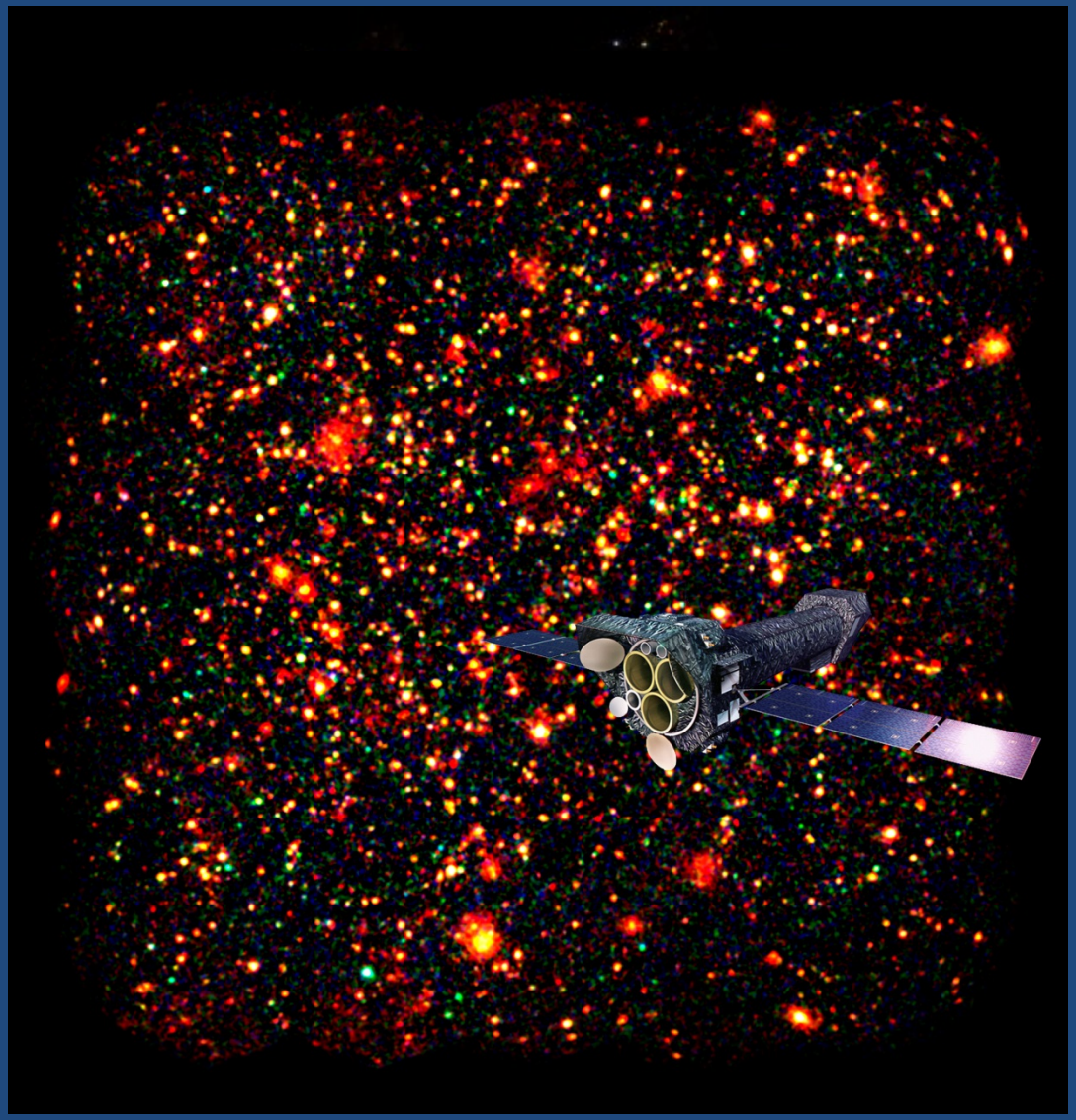
RGS spectrum + 3*NEI model

LMC SNR 0519-69.0: *Chandra*

- RGS & EPIC, ACIS spectra: multiple NEI emission line model
- Forward shock velocity ~2770 kms^{-1}
- Location: radial stratification O, IME, Fe
- Derive fractional masses in various regions

Large Area Surveys: e.g. COSMOS

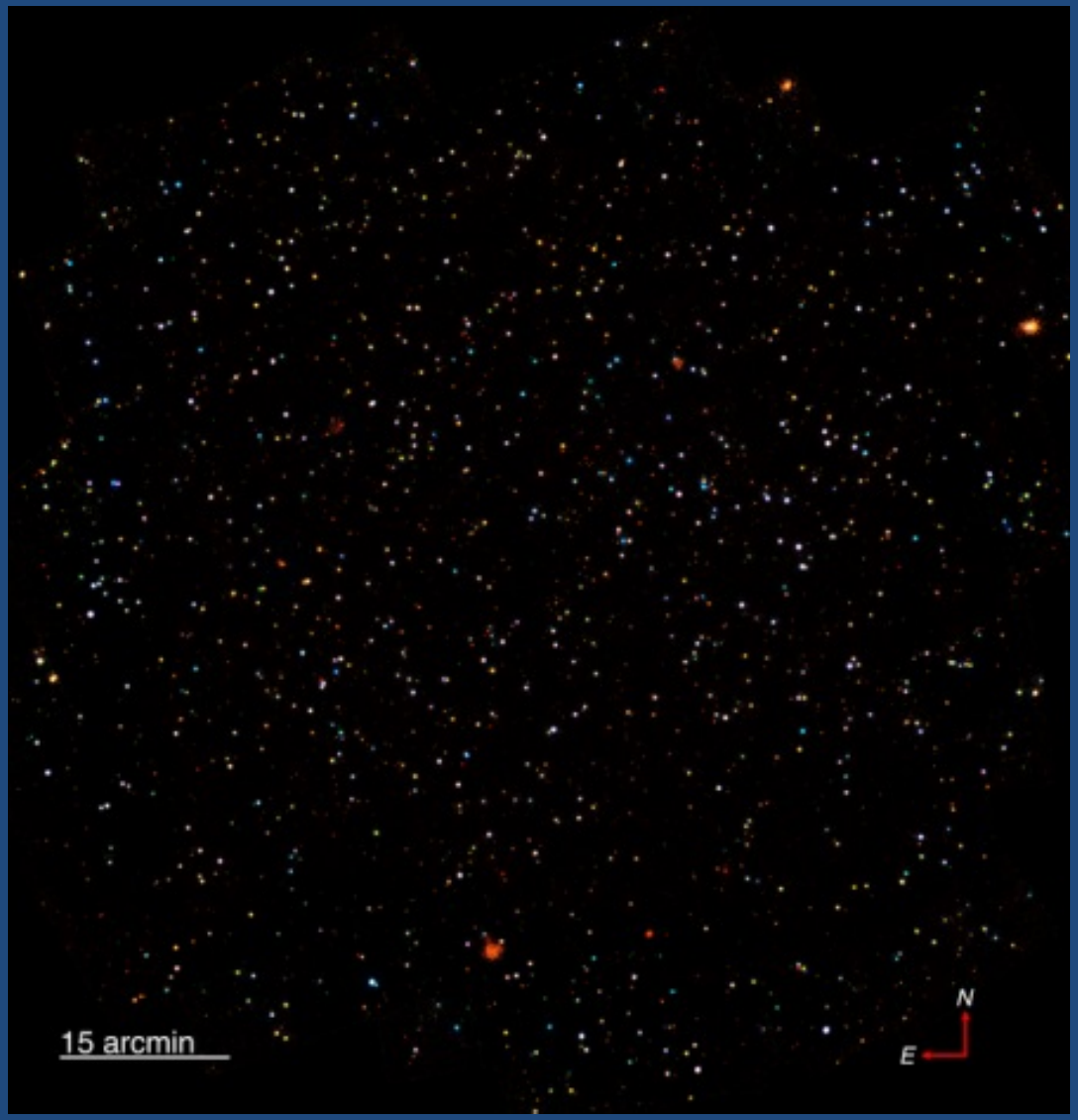
Courtesy: Francesca Civano



- *XMM-Newton* (July 2006):
  - 2°, 1.4 Ms (total)
  - 50 ks depth
- *Chandra* (Jan 2014):
  - 2.2° , 4.6 Ms (total)
  - 180 ks depth
  - 4000 sources
  - Resolves 10% of *XMM* sources into multiples
  - Reaches 5* depth

Large Area Surveys: e.g. COSMOS

Courtesy: Francesca Civano



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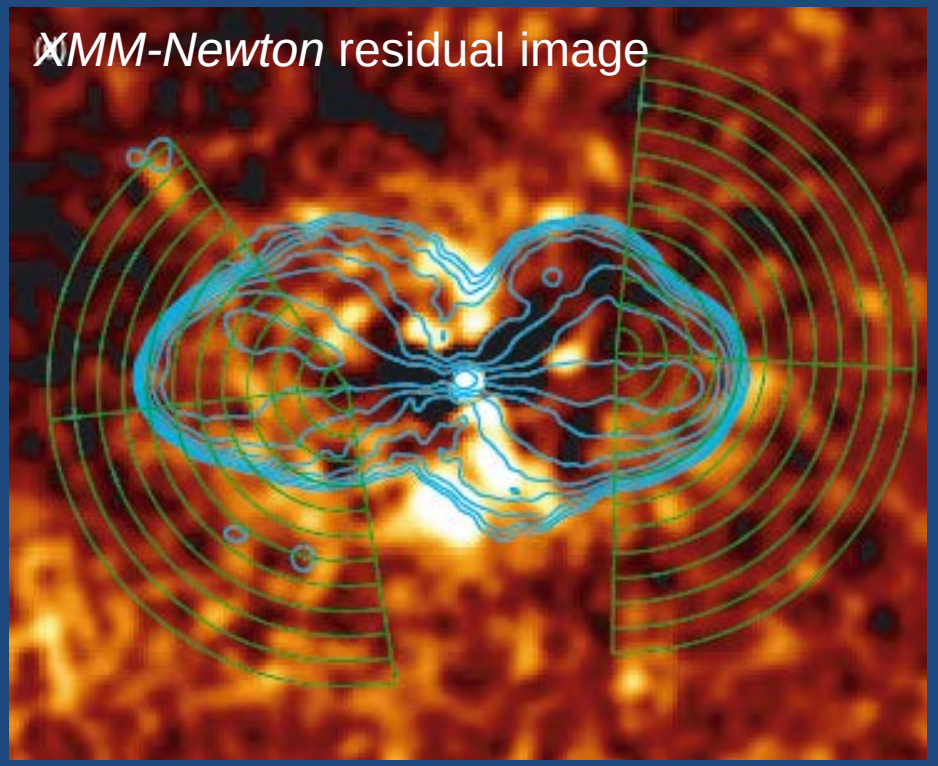
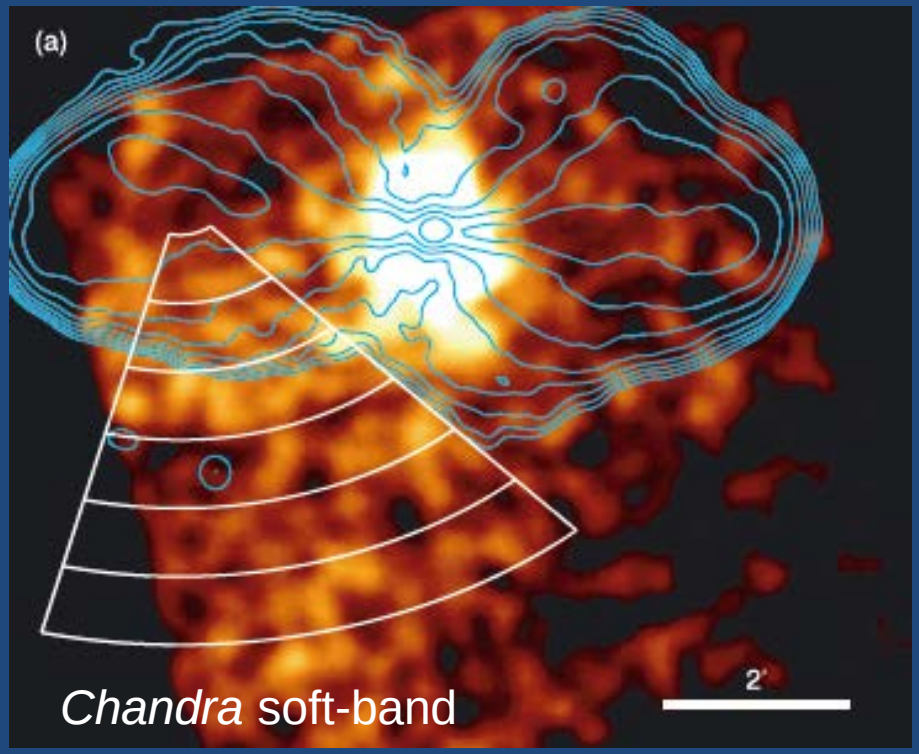
Galaxy Groups: FRI NGC 4261

O'Sullivan et al. (2011)





- Radio jets inflate large cavities
- Rims of compressed hot gas surround cavities
- Cool core, r~10 kpc, T~0.6 keV
- Spectra do not confirm shocks

Future: X-ray Legacy

- Assess *XMM-Newton* and *Chandra* archives for Legacy (using source catalogs, by science area):
  - Missing “Rosetta Stone” sources (in any waveband)
  - Incomplete samples of sources, e.g. 3CR, PG (AGN)
  - Multi-wavelength Survey fields
  - Confused *XMM-Newton* fields needing *Chandra* data
  - Athena (& X-ray Surveyor) preparatory science
- Expand joint program(s) to include Large Projects
- HST, Spitzer, ALMA, NuSTAR etc. “Legacy” science, e.g. Frontier Fields

Future: Multi-λ Opportunities

- ALMA: AGN outflows, star forming regions
- LOFAR and/or VLASS: observe one/more survey fields to study related X-ray emission

- E-ROSITA (2017): follow-up, e.g. clusters
- JWST (2018): CT AGN, galaxy structure, high-redshift galaxies etc.
- LSST: strategies to follow-up transients/variables

Chandra Workshop 2016

"Chandra Science for the Next Decade"

16-19 Aug, Cambridge MA

cxc.cfa.harvard.edu/cdo/next_decade2016/

Please join us to continue the conversation we are starting this week!