Imaging the Narrow Line Region with *Chandra*
Going deeper to resolve AGN environments with today's premier X-ray IFU

**CHEERS:**
Nearby AGN with extended evidence for radiative and kinematic feedback

**Voorwerpjes:**
Galaxy-Zoo selected extended NLRs with evidence for AGN shutdown

with Pepi Fabbiano, Martin Elvis, Margarita Karovska, Alessandro Paggi, John Raymond, Junfeng Wang, Thaisa Storchi-Bergmann, Bill Keel, Kevin Schawinski, Lia Sartori, Chris Lintott, Vardha Bennert
CHEERS: Nearby AGN with extended evidence for radiative and kinematic feedback
CHEERS and NGC 3393: Getting the Most out of Chandra
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See poster #8, “Long-term Dynamic Evolution of Wind Accreting Interacting Binaries” by Margarita Karovska!

3 arcsec

750 pc
NGC 3393: Distinctive Ionization Regimes

0.3-8 keV (Chandra-EMC2)

[O III]/Hα (HST/WFC3)

[S II]/Hα (HST/WFC3)

8.46 GHz (VLA)

750 pc
Photoionization vs. Shocks with Chandra

![Ionization Cones](image1)

![Ionization Cones: Ratios](image2)

![CXO: O VII](image3)

![CXO: O VIII](image4)

![CXO: Ne IX](image5)
The Necessity of Resolution

Left: Koss et al, 2015
Right: WPM et al, in prep

Extended up to ~4 keV!
Voorwerpjes: Galaxy-Zoo selected extended NLRs with evidence for AGN shutdown
Hanny's Voorwerp: Our Nearest (ex-)Quasar

Left: Garrett et al, 2011
Right: Keel et al, 2012
Sudden Radiative-Kinematic Mode Switching?

Sartori et al (incl. WPM), 2016
Bubbles, Filaments & Tidal Streams

Extended Gas in Active Galaxies • Hubble Space Telescope • WFPC2 • ACS/WFC • WFC3/UVIS

SDSS 1430+13
NGC 5972
SDSS 1510+07
UGC 7342

NGC 5252
Mkn 1498
UGC 11185
SDSS 2201+11

NASA and ESA

Keel, WPM et al, 2015

Chandra Science for the Next Decade
Peter Maksym – 2016 August 16th
Bubbles, Filaments & Tidal Streams

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SDSS 1430+13
Dadina et al. 2010
NASA and ESA

NGC 5972
In hand

SDSS 1510+07
In hand

UGC 7342

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Keel, WPM et al, 2015

STScl–PRC15–13a
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Harrison et al, Cycle 17
SDSS 1430+13

Cycle 18
NGC 5972
SDSS 1510+07

Cycle 18
UGC 7342

Dadina et al, 2010
NGC 5252

In hand
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Harrison et al, Cycle 17

Cycle 18

Cycle 19?

Cycle 18

Dadina et al, 2010

In hand

In hand

Cycle 19?

NASA and ESA

Keel, WPM et al, 2015

StScI-PRC15-13a

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The NLR and ACIS Contaminant

--NLR emission: some as hard as ~4 keV, and Fe Kα but most photons are below 1 keV...
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--A cue from Hubble's UV initiative?
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A cue from Hubble's UV initiative?

--HRC becoming competitive?
Summary

Voorwerpjes and CHEERS point to AGN feedback Chandra can resolve!

- Substantial complexity on sub-arcsecond scales!
  (LINER regions bicone edge, outflow-ISM structure, jet-ISM hotspots, etc)

- Resolved evidence for large AGN variation and mode switching on <<Myr scales

- Sites of jet-ISM or wind-ISM interaction may be physically small relative to the integrated system (~10s of pc vs ~kpc)

- Hard emission may be extended on ~kpc scales, up to a few keV!

- The correlation between X-rays and optical line emission is not simple in AGN
...but

Contaminant is a particularly bad problem for the NLR, and will only get worse.

Creative approaches are needed to mitigate it!