The complex circumnuclear environment of radio galaxies revealed by Chandra HETG

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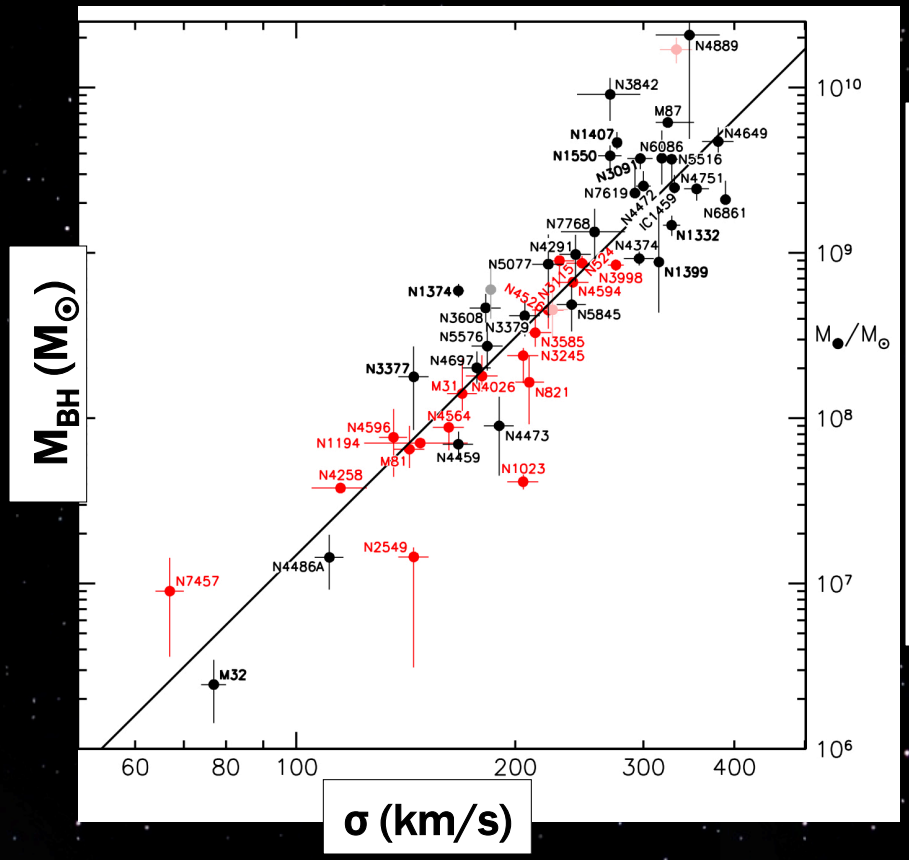
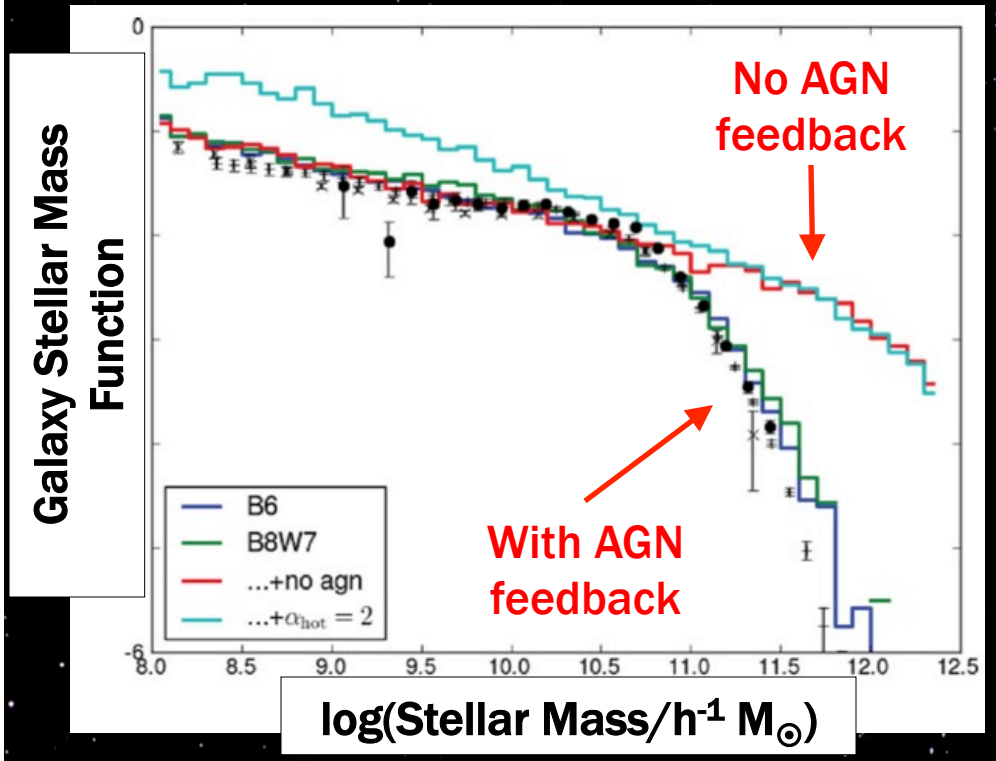
Relations between SMBHs and host galaxies



(Kormendy & Ho 2013)



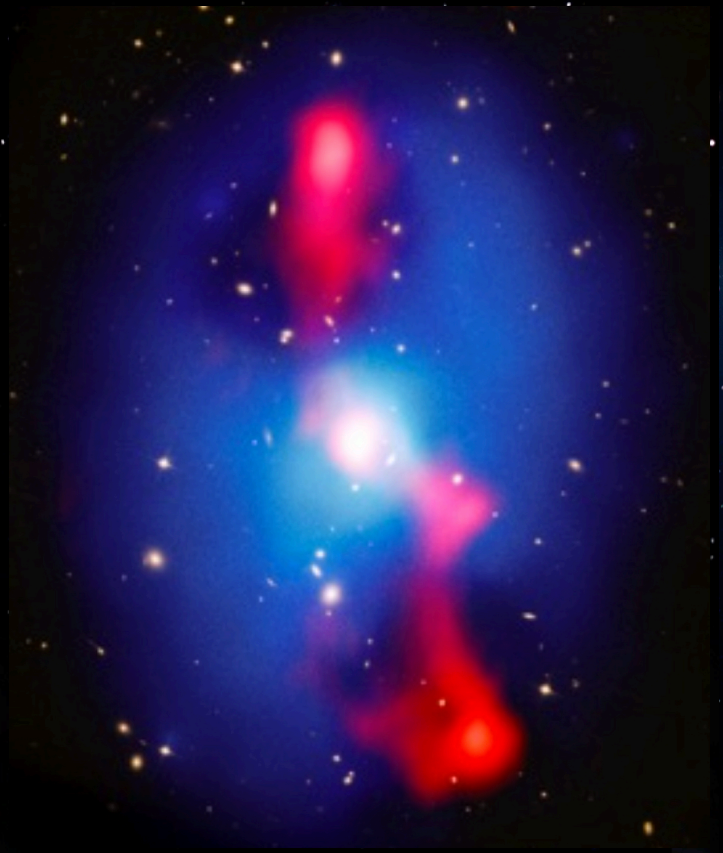
(Bower et al. 2012)

- SMBH size ~10^9 smaller typical galaxy (~ 10^{27} in volume!)
- SMBH mass is ~1% stellar bulge mass
- SMBH gravitational energy ~ binding energy galaxy bulge!

Tombesi et al. (2015)

Flavors of AGN feedback

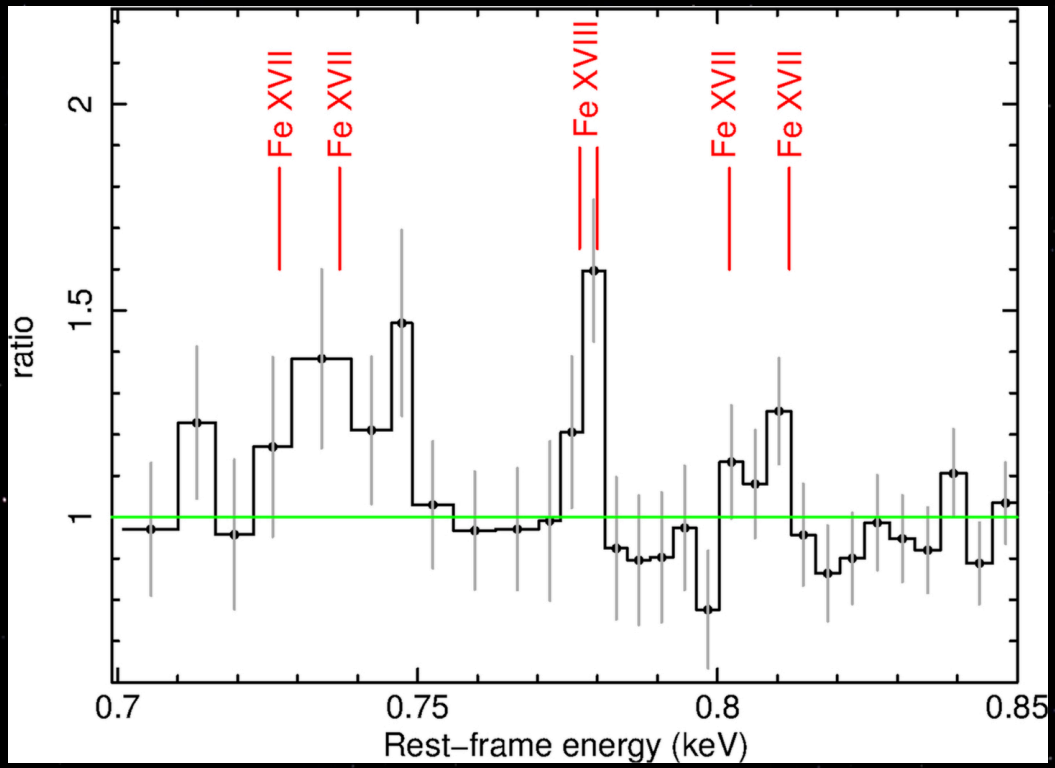
Relativistic jets



Disk winds

- Chandra HETG large program in AO-15
- 3C 390.3 (150ks), 3C 111 (150ks), 3C 120 (200ks)

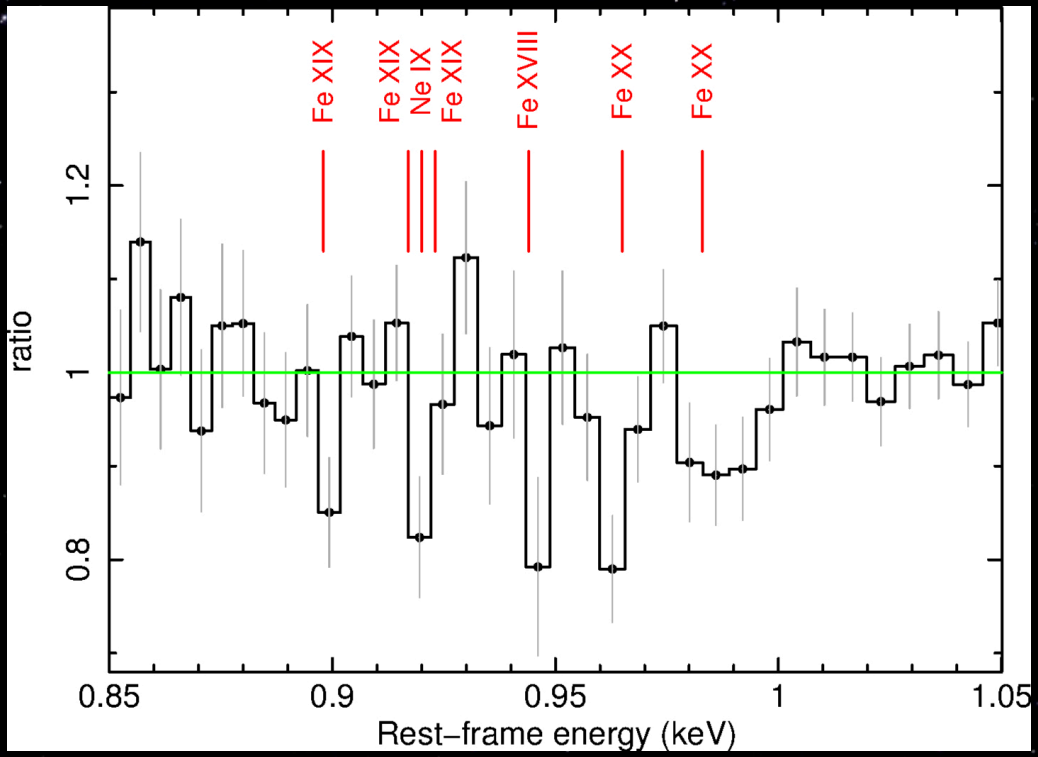
3C 390.3: soft X-ray emission lines



(Tombesi et al. 2016)

- Series of narrow emission lines due to Fe L transitions (Fe XVII-XVIII)
- Hot ISM/halo emission elliptical galaxy, kT=0.5±0.1 keV, EM=5.4x10^{64} cm^{-2}
- Luminosity L_{ISM}~3x10^{42} erg/s, cooling time ~10^{7-8} yrs. What is heating source?
- Mechanical energy from AGN jet/disk wind is L_K ~10^{44-45} erg/s

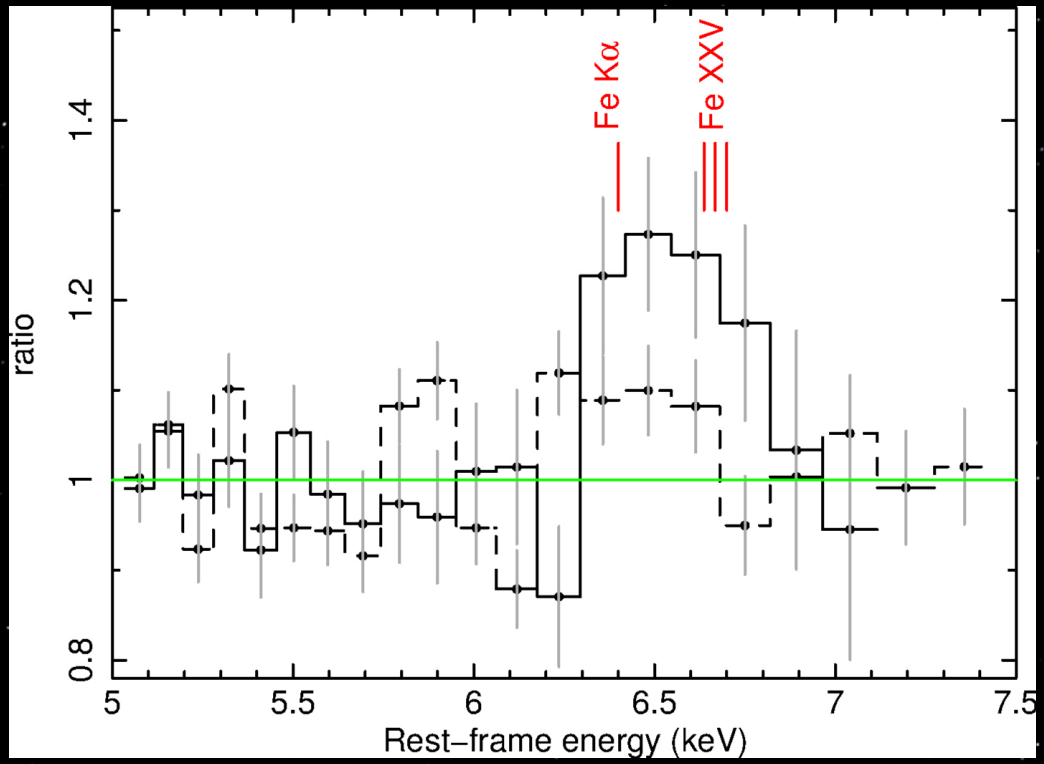
3C 390.3: soft X-ray absorption lines



(Tombesi et al. 2016)

- Series of absorption lines from higher Fe L transitions (Fe XVIII, Fe XIX, Fe XX)
- Warm absorber: $\log N_H = 20.7 \pm 0.1$ cm^{-2}, $\log\xi = 2.3 \pm 0.5$, $v_{out} < 150$ km s^{-1}
- Parameters consistent with 2004 XMM/RGS observation (Torresi et al. 2012)
- R~3.5pc–3.5kpc, P_{wa}~0.001% L_{bol} ~0.01% P_{jet} ~0.1% disk wind P_{wind}

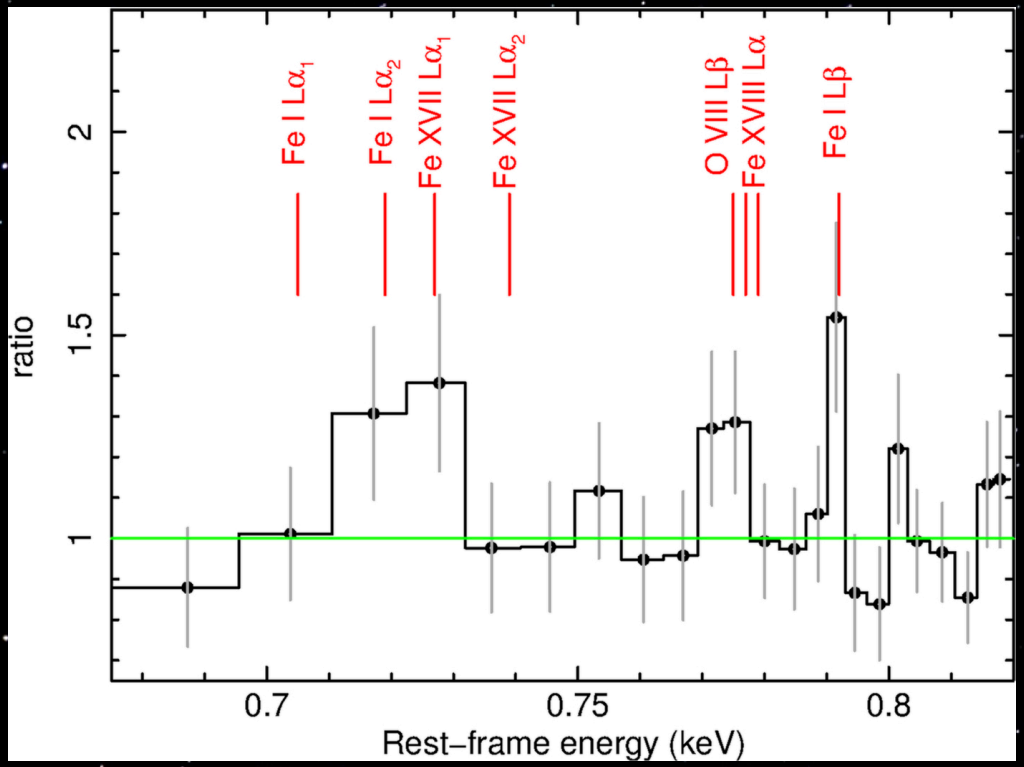
3C 390.3: Fe K emission lines



(Tombesi et al. 2016)

- Fe Kα E=6.40±0.4 keV, FWHM=8,300±3,300 km/s
- Lowly ionized *xillver* reflection logξ=1.3±0.3 erg s^{-1} cm
- Line width consistent with optical Hα, origin in BLR or outer accretion disk

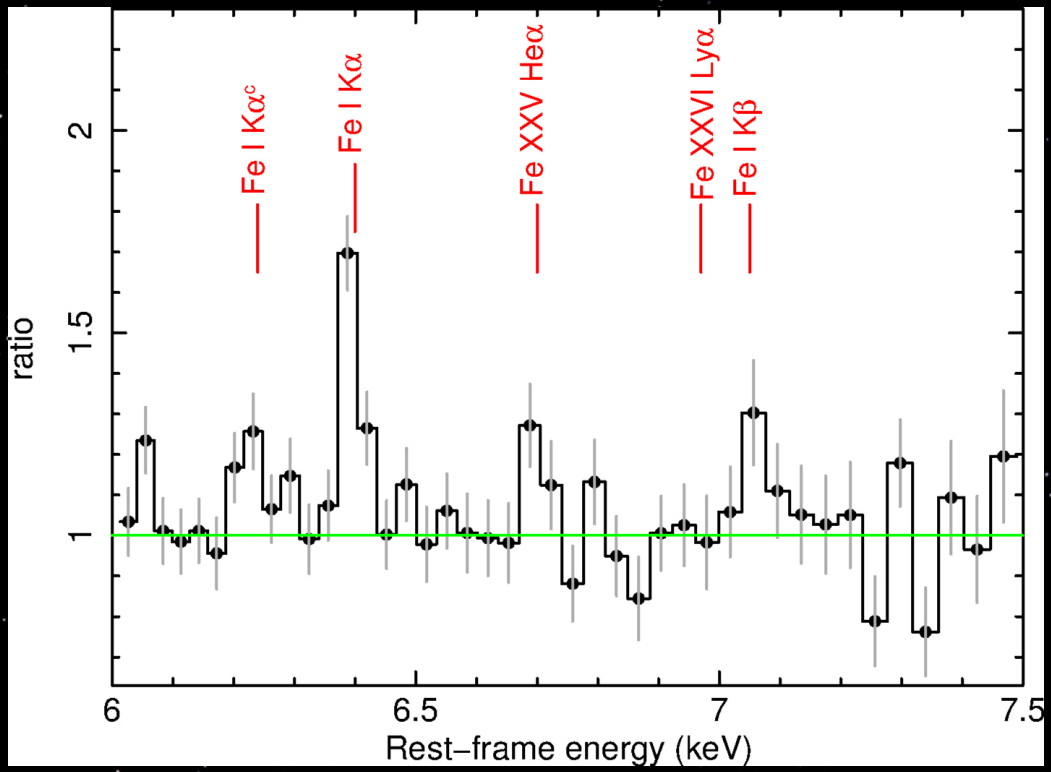
3C 120: soft X-ray emission lines



(Tombesi et al. in prep.)

- Series of emission lines, possibly associated with Fe I, Fe XVIII, and O VIII
- Hot gas model kT~0.1 keV requires redshift of ~3,000 km/s
- Best-fit neutral/lowly ionized Fe L fluorescence lines? (related to Fe K?)

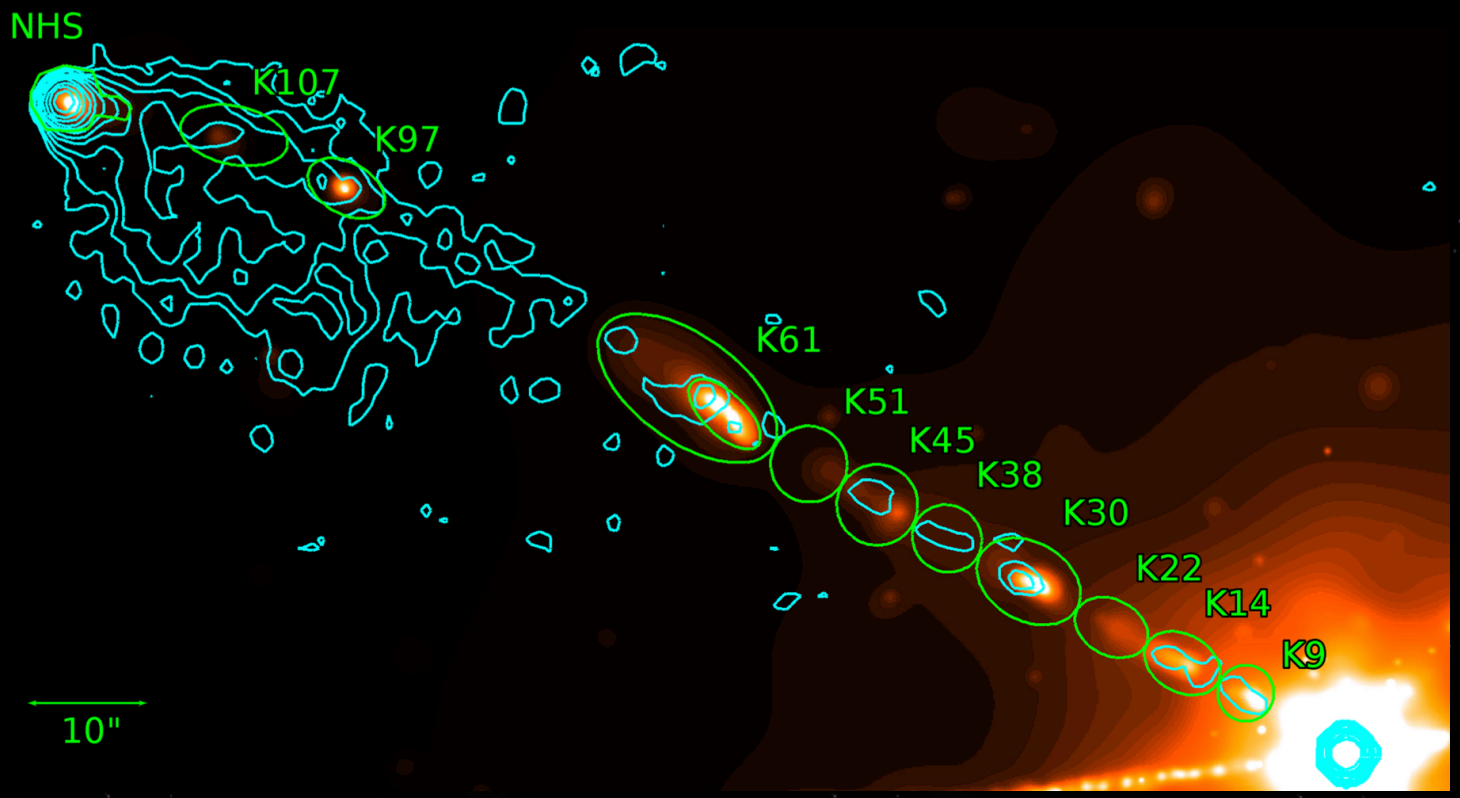
3C 120: Fe K emission lines



(Tombesi et al. in prep.)

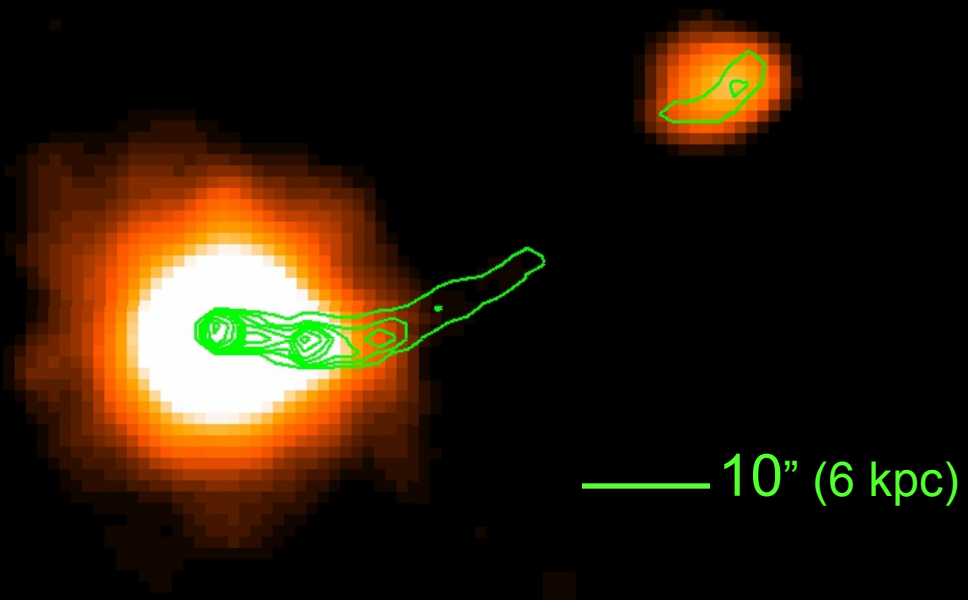
- Series of narrow neutral/ionized Fe K lines (including Fe K Compton shoulder)
- FWHM Fe Kα line is <2,300 km/s, comparable to BLR in optical Hα/β (i~20°)
- Best-fit reflection *pexmon* R=0.22±0.04; *MYTorus* i=20°, N_H>6x10^{24} cm^{-2}
- Possible wind (99%) v_{out}~20,000 km/s, logξ~3.5 erg s^{-1} cm, N_H~3x10^{21} cm^{-2}

3C 111: HETG analysis and zeroth order jet image

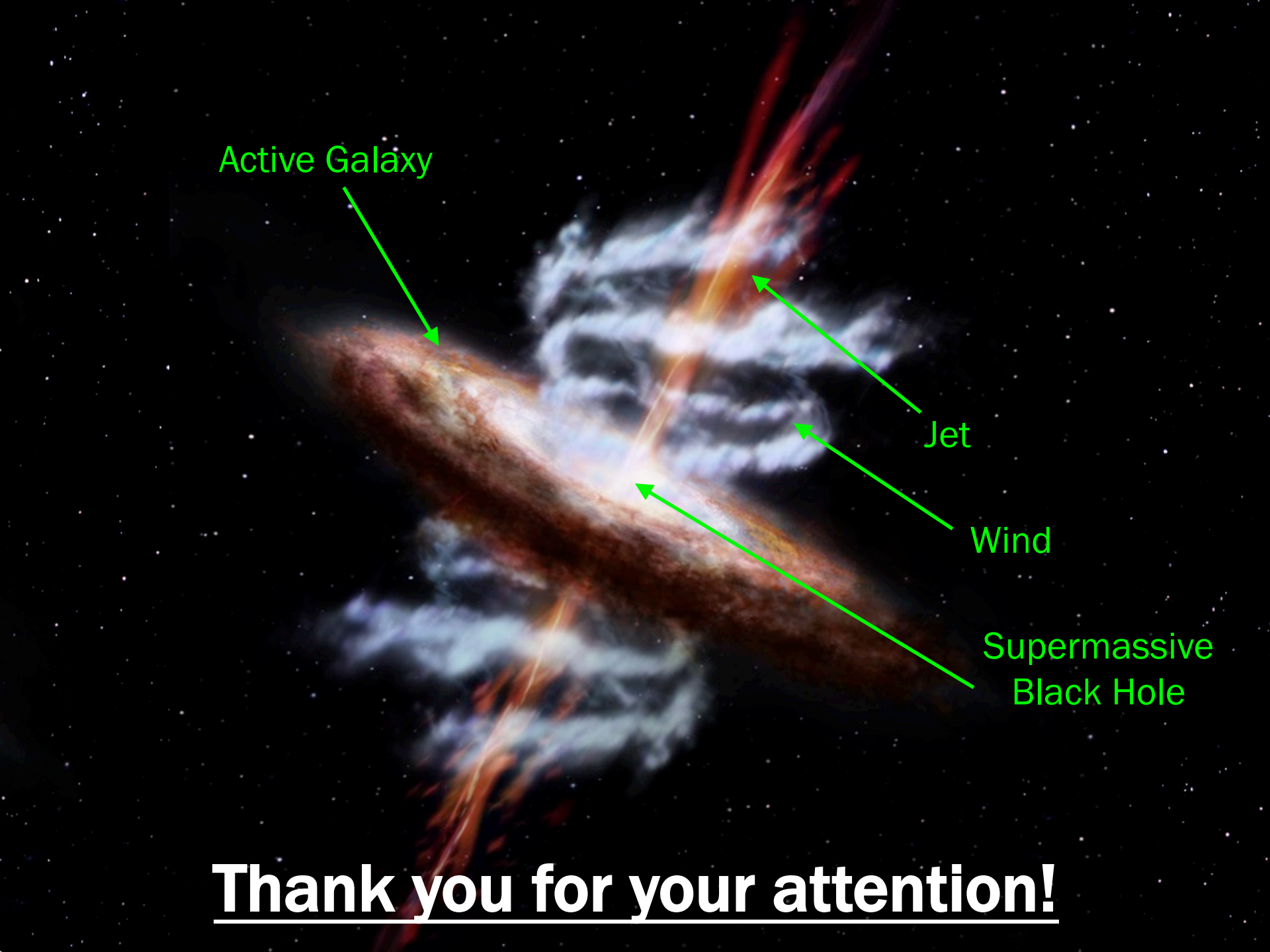


- Combined 100ks ACIS-S + 150ks ACIS/HETG, 100 kpc jet, 10 knots+hot spots, favoring a two-component synchrotron X-ray emission model (Clautice et al. 2016)
- 3x excess Galactic absorption compared to tabulated values. N_H=(8.60+/-0.02) x 10^{21} cm^{-2} (Tombesi et al. in prep.)

3C 120: Zeroth order image Chandra HETG



- Zeroth order Chandra HETG image Dec 2014/Jan 2015 (Tombesi et al. in prep.)
- Combined VLA radio contours (Thanks CIAO Workshop organizers!)
- Compare to short 2001 snapshot observations: variability? X-ray emission? SED?



Thank you for your attention!