X-ray gaseous emission in star forming galaxies

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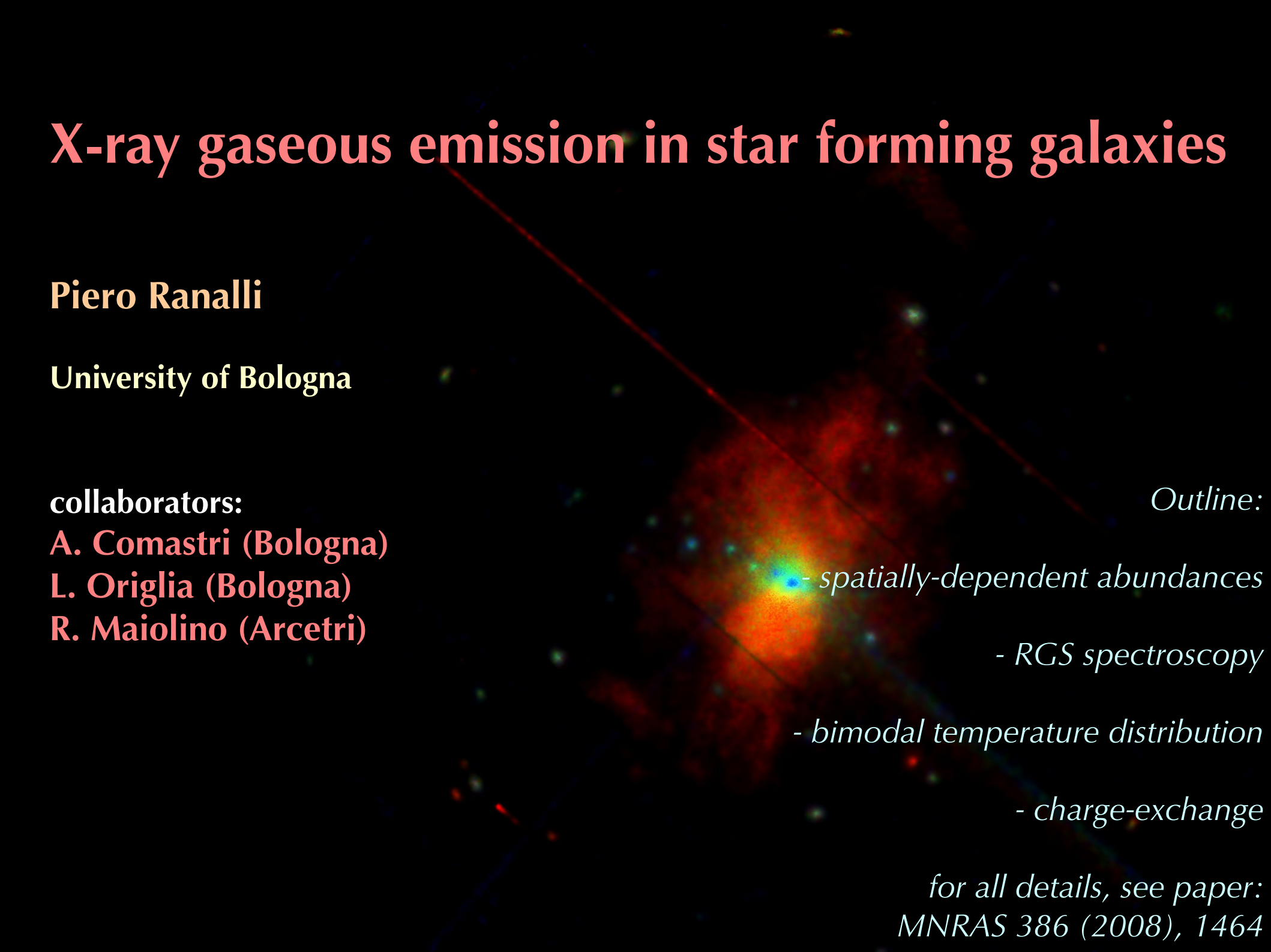


Outline:

- spatially-dependent abundances

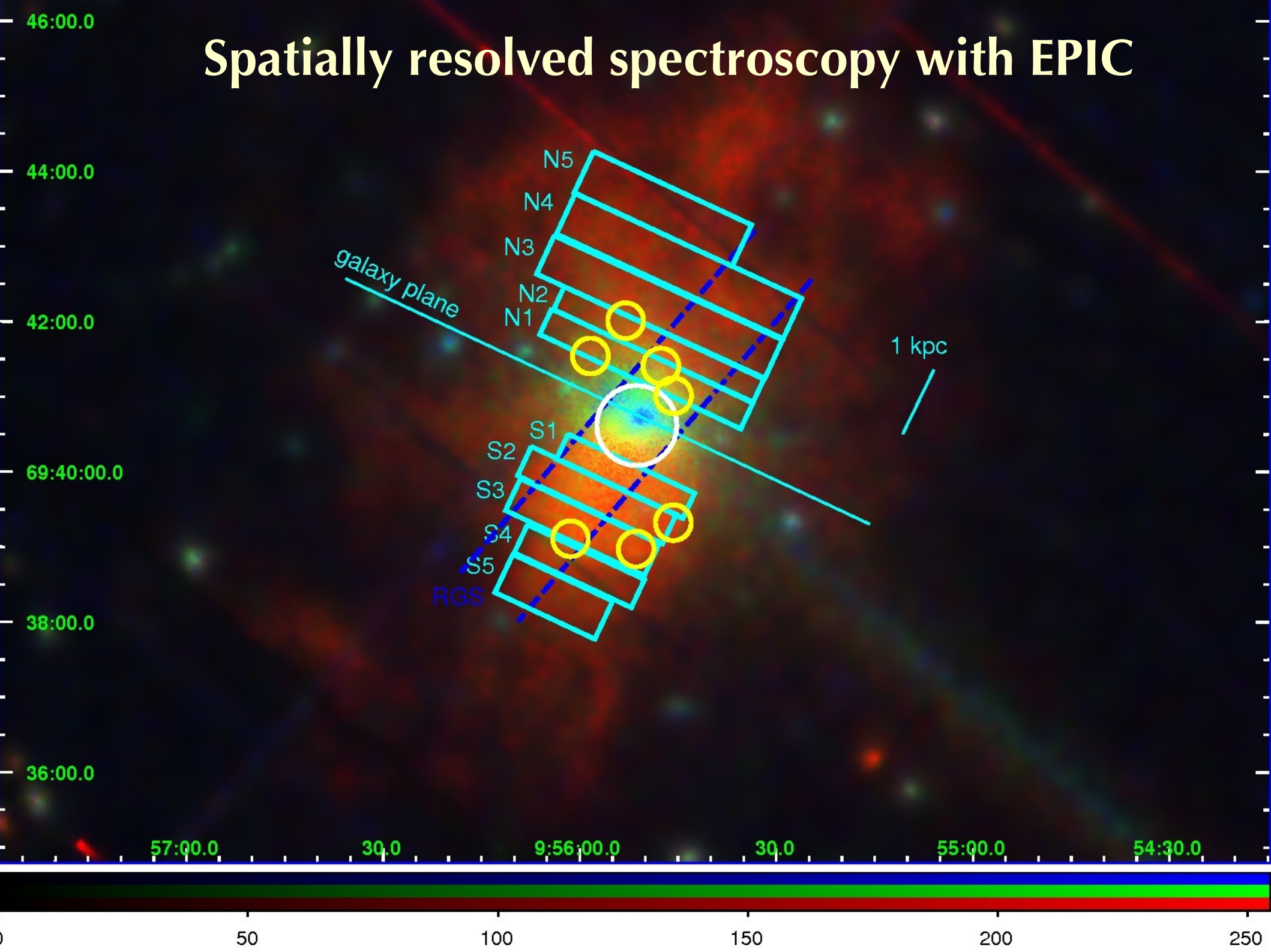
- RGS spectroscopy

- bimodal temperature distribution

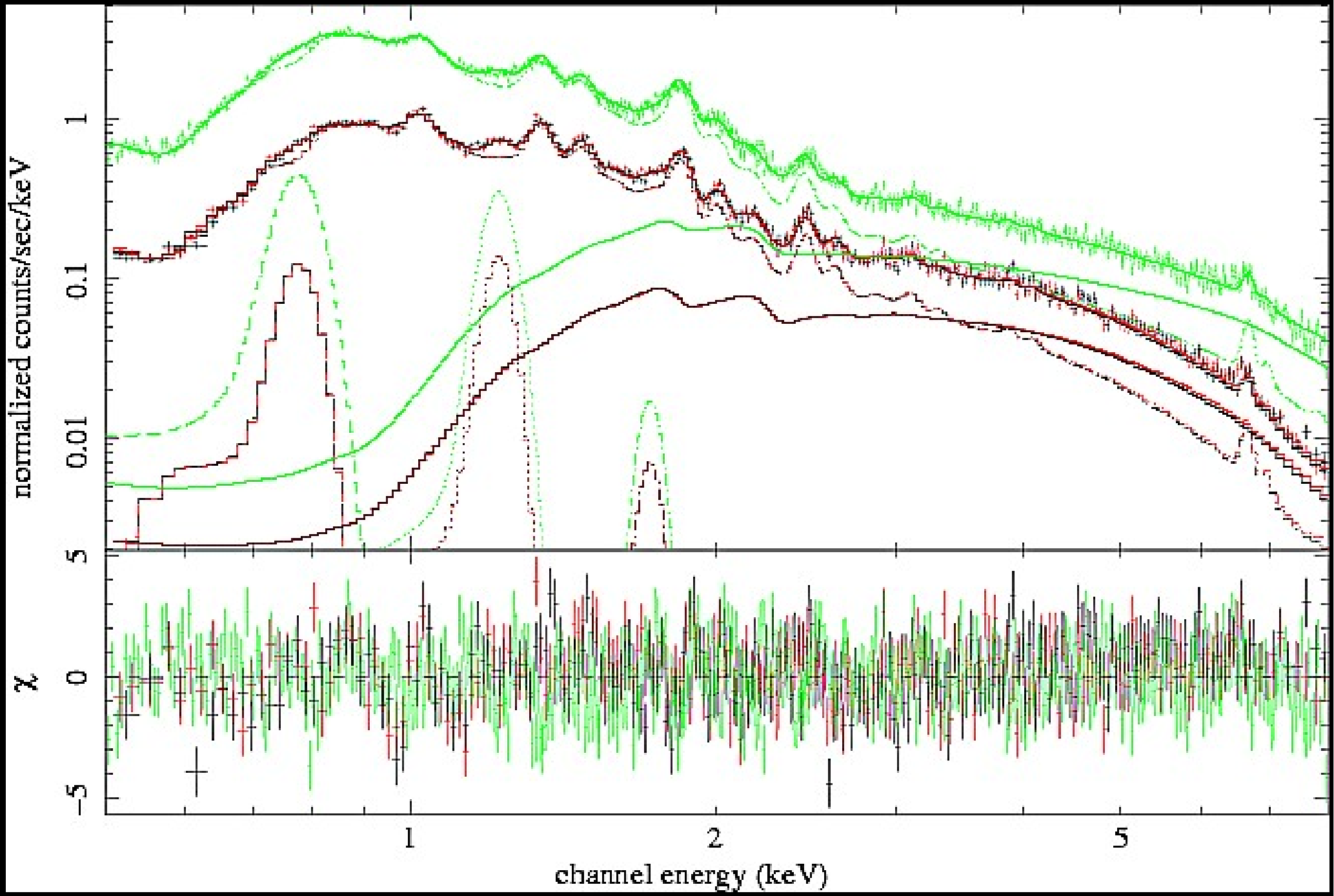
- charge-exchange

for all details, see paper:
MNRAS 386 (2008), 1464

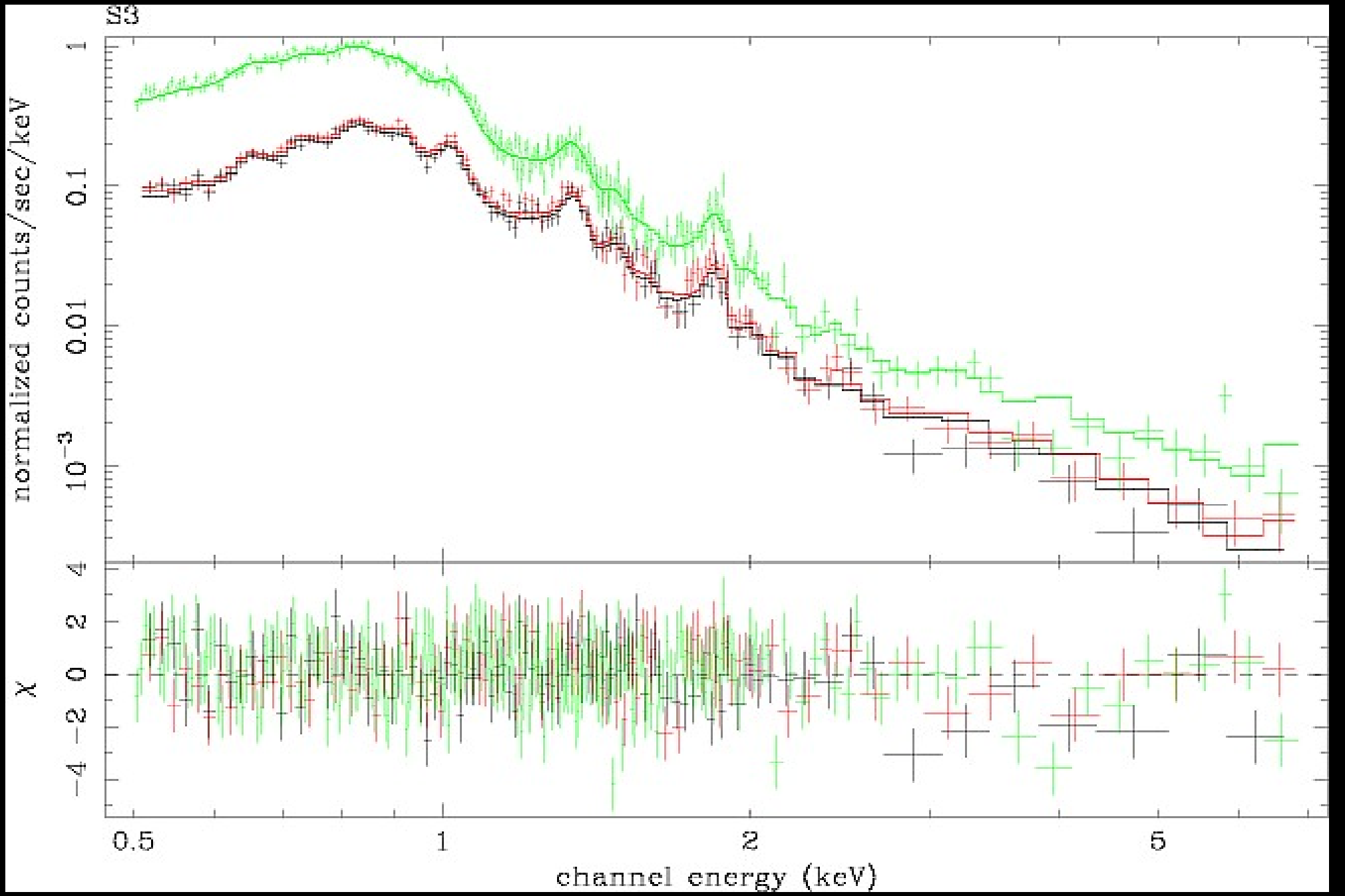
Spatially resolved spectroscopy with EPIC



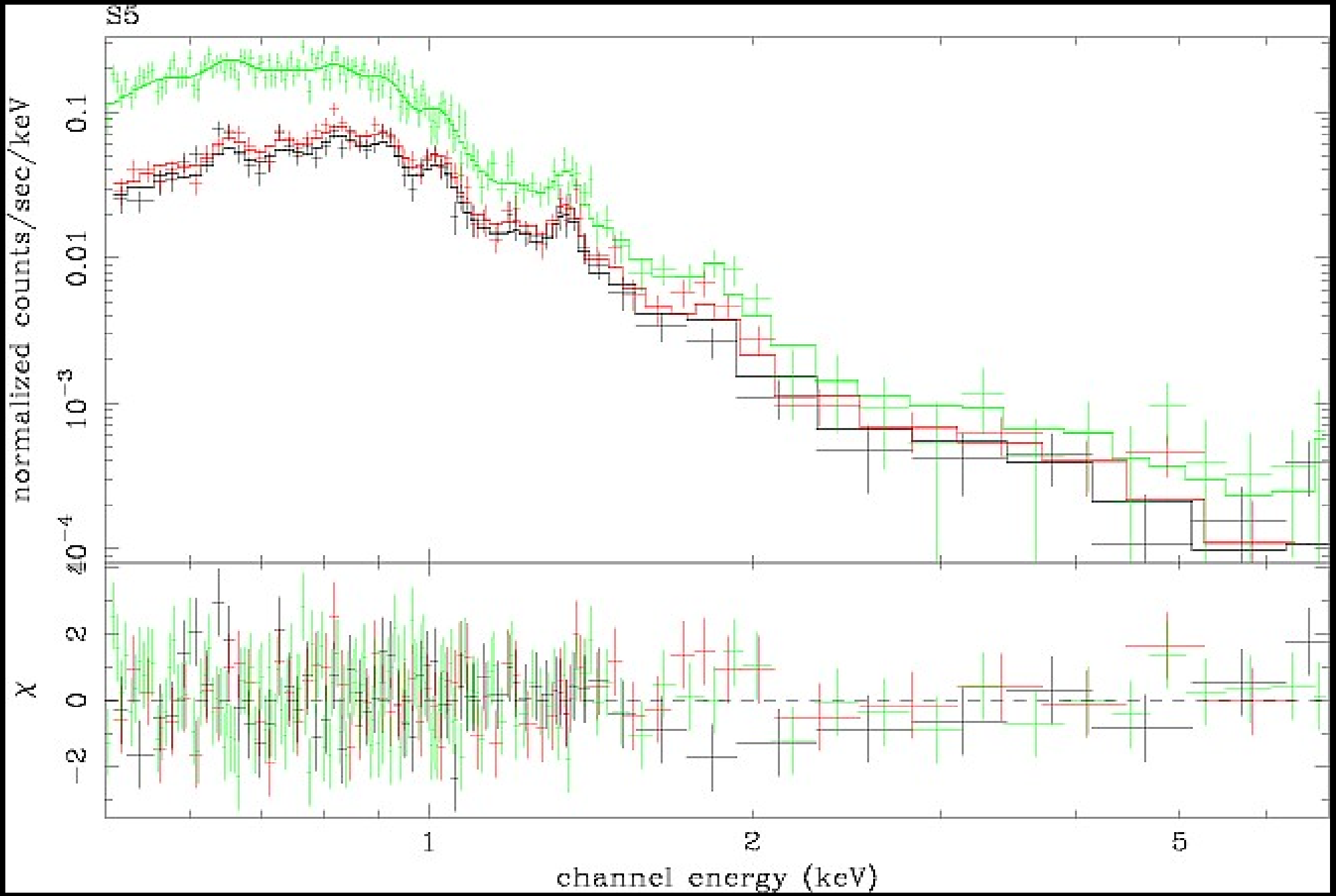
Gallery of spectra: centre ($4{\cdot}10^5$ counts)

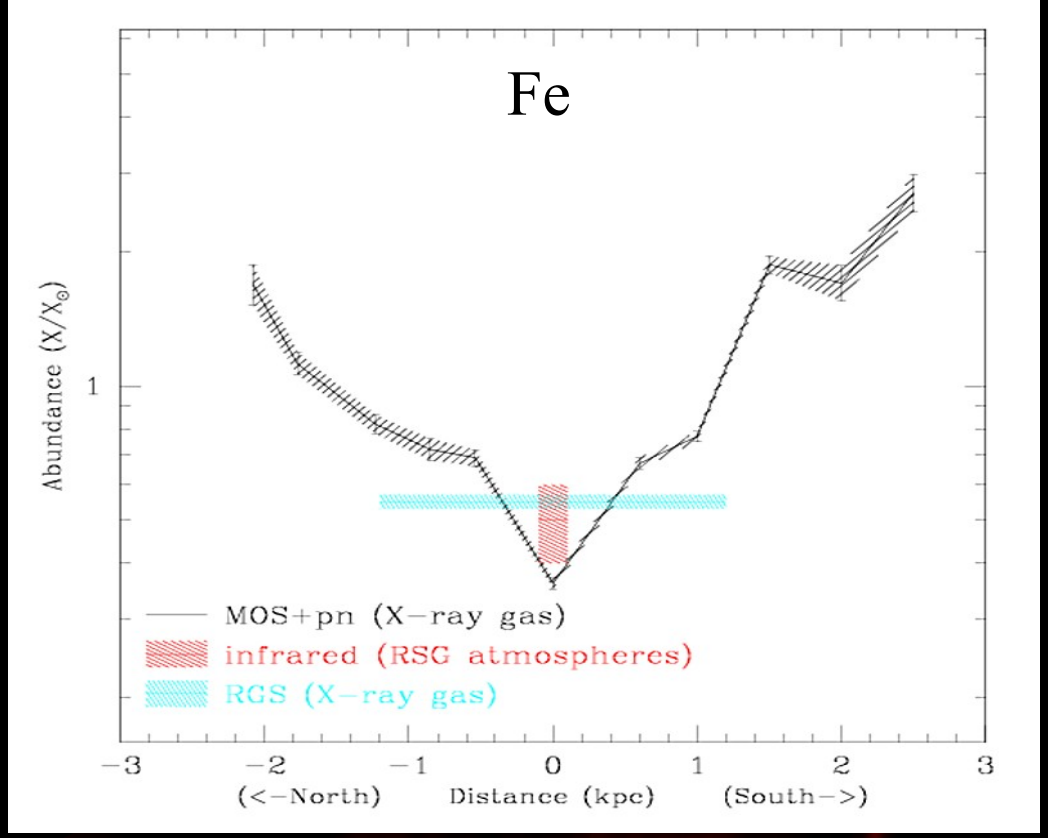


Gallery of spectra: S3 ($5 \cdot 10^4$ counts)



Gallery of spectra: S5 ($1.5 \cdot 10^4$ counts)

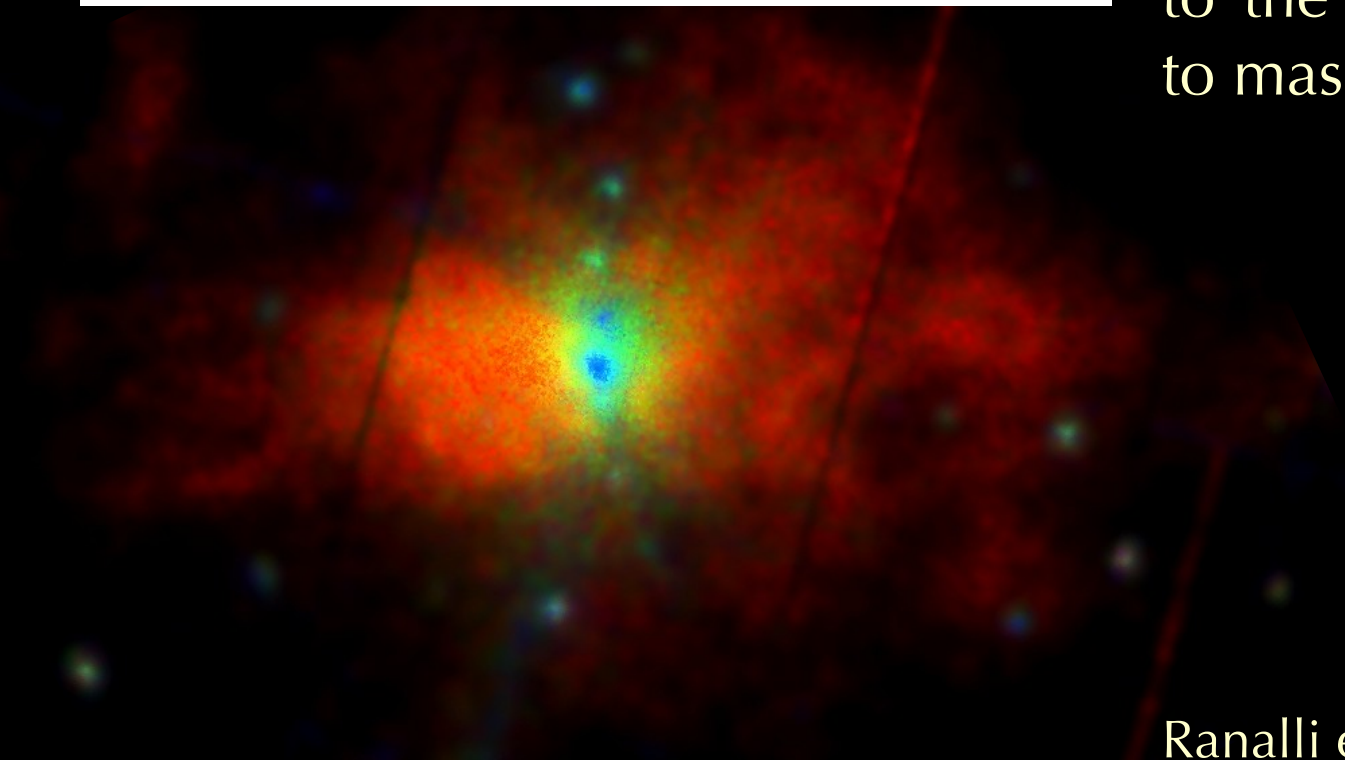




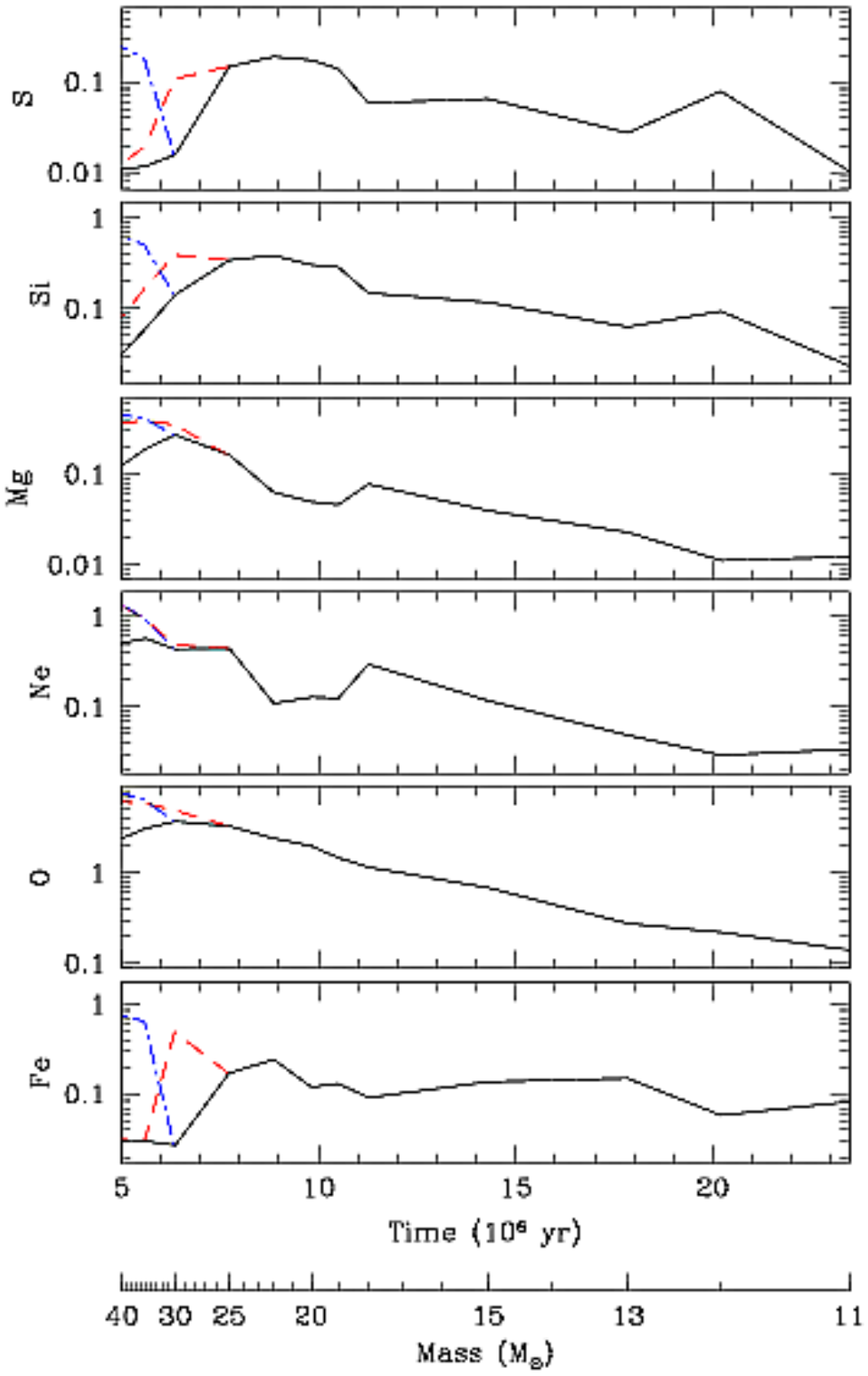
Understanding chemical evolution and enrichment

The spectral parameters of the outflow plasma in M82 are spatially dependent (Ranalli et al. 2008).

They are probably connected to the supernova yields and/or to mass loading, but how?



Ranalli et al. 2008 MNRAS 386, 1464



Interpretation framework:

SN yields as a function of progenitor's lifetime, from Woosley & Weaver 95.

most massive stars explode first

⬇

their ejecta can be found furthest in the outflow

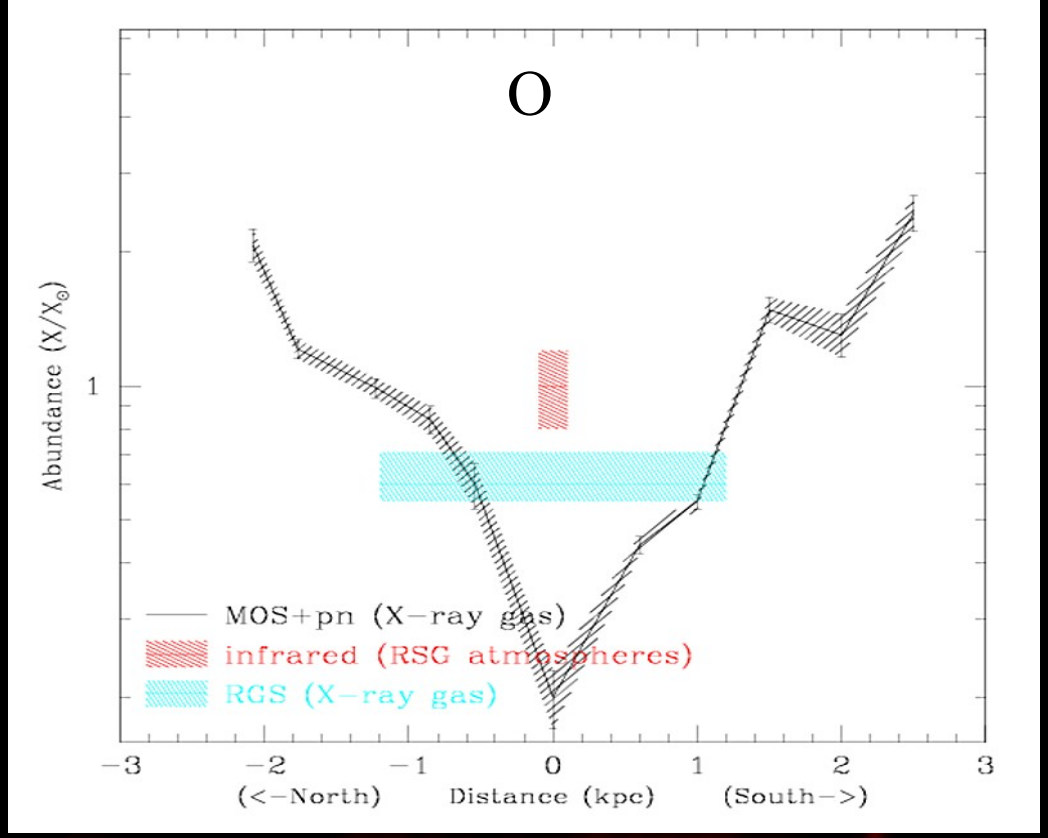
⬇

they have higher yields

⬇

abundances in the external outflow are higher

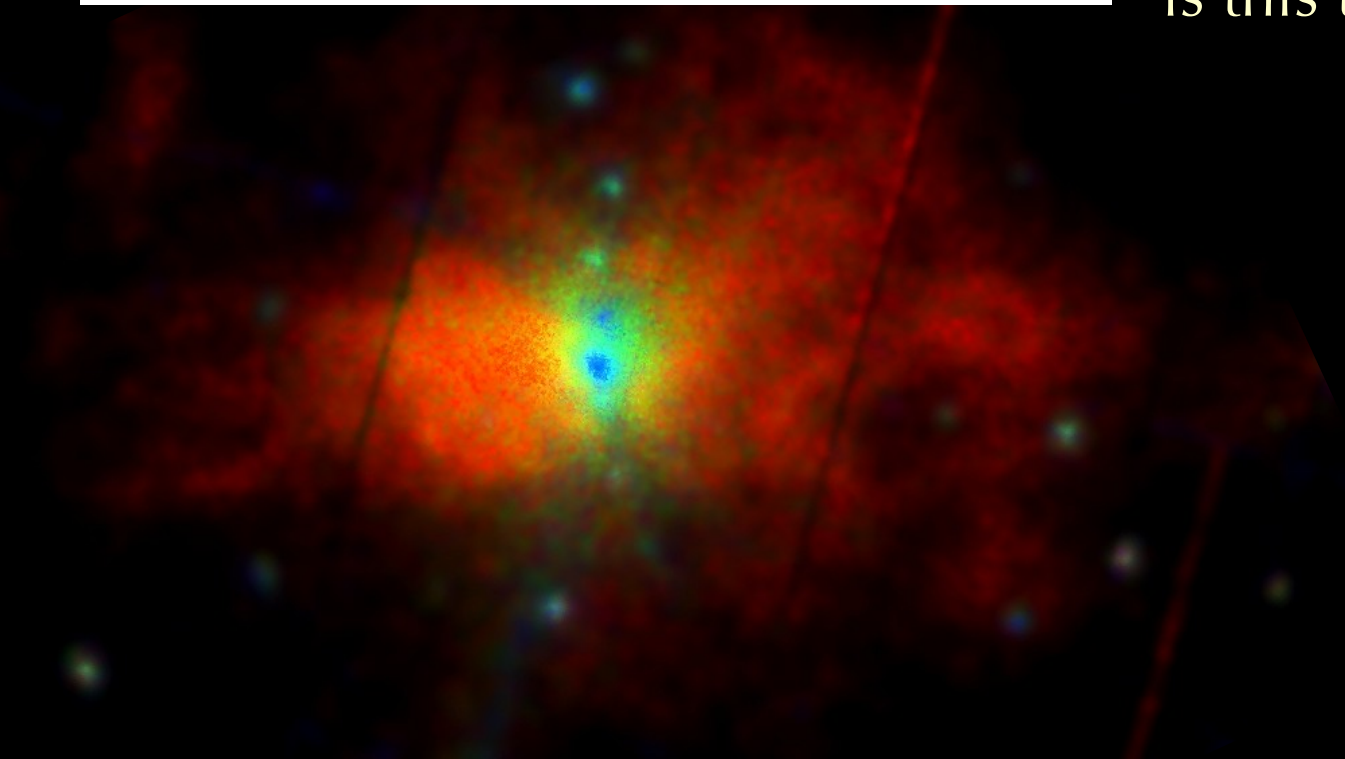
but this is probably too simple to be true



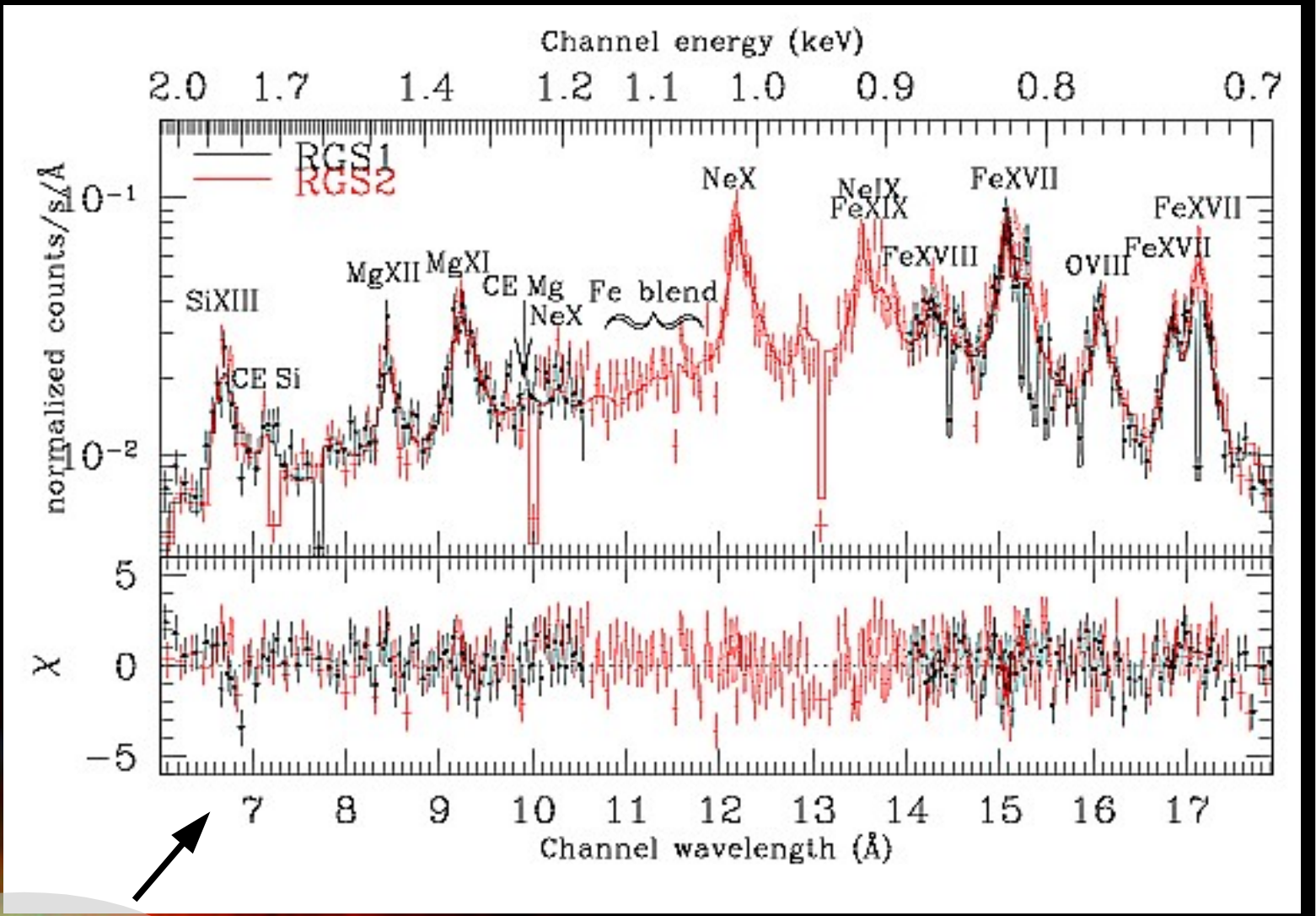
Understanding chemical evolution and enrichment

In the central areas, there is less oxygen in hot gas than in stars. Where did it go?

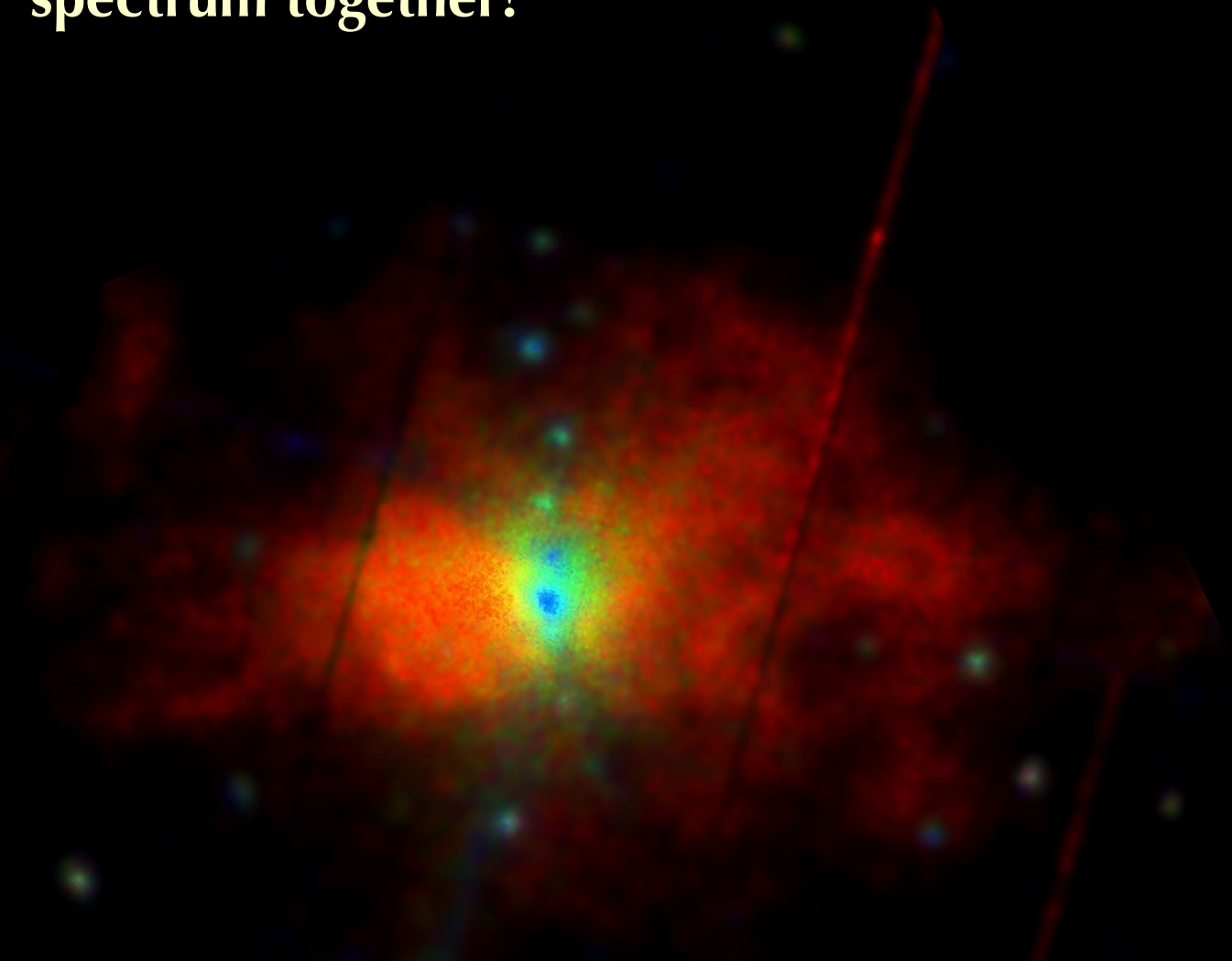
It has probably cooled. We detect charge-exchange lines, is this the cooling mechanism?



The XMM/RGS has produced a beatiful **average** spectrum which is extremely difficult to analyse

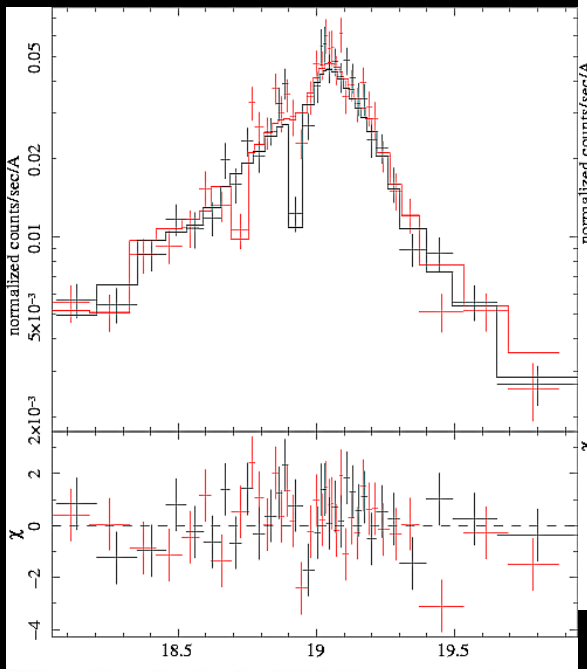


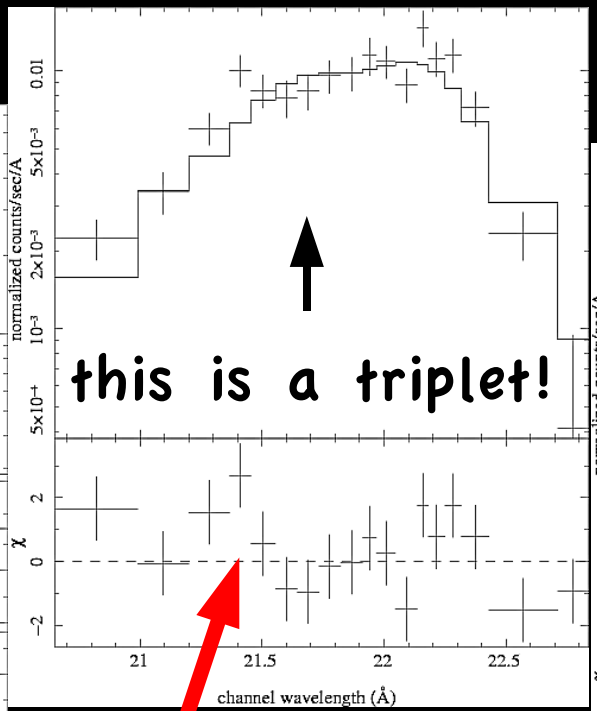
Need to consider the line broadening due to the source extent.
And this is **energy-dependent**!
Cannot fit all 0.4-2 keV spectrum together!



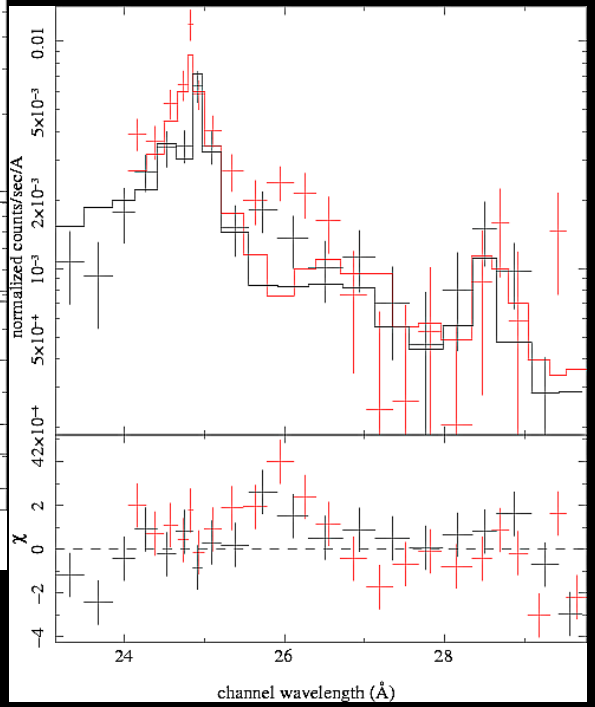
O VII

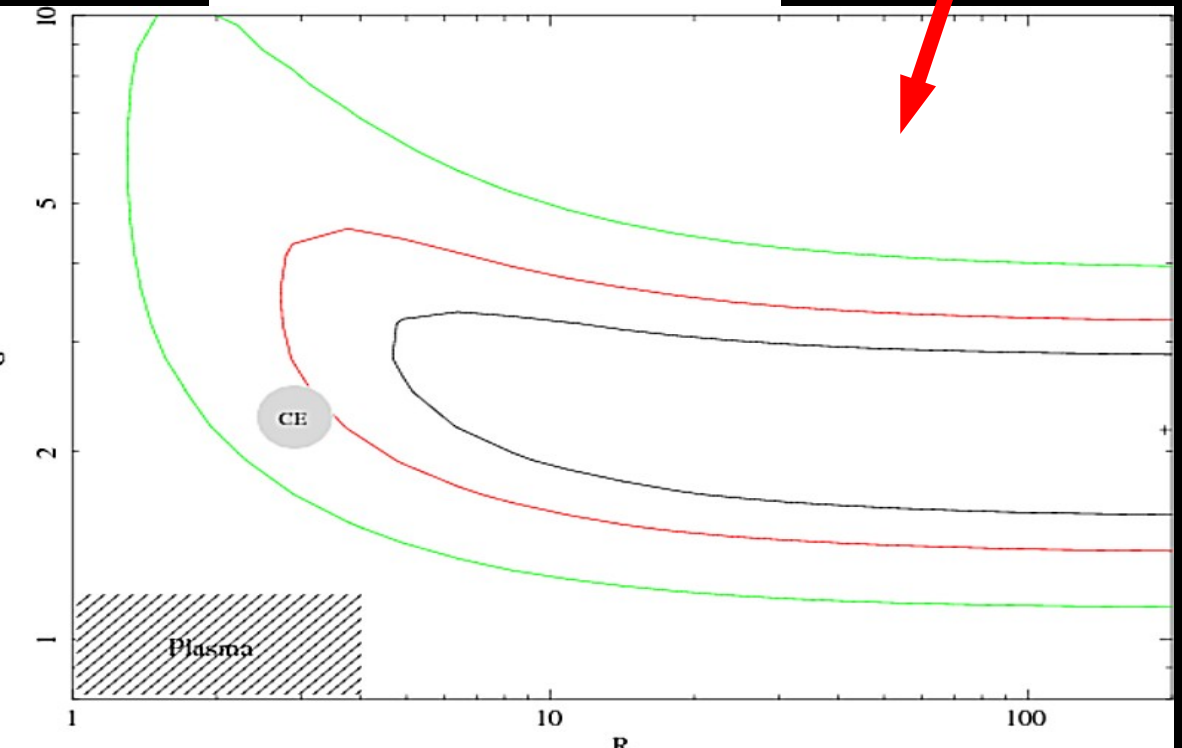
O VIII





N VII & C VI

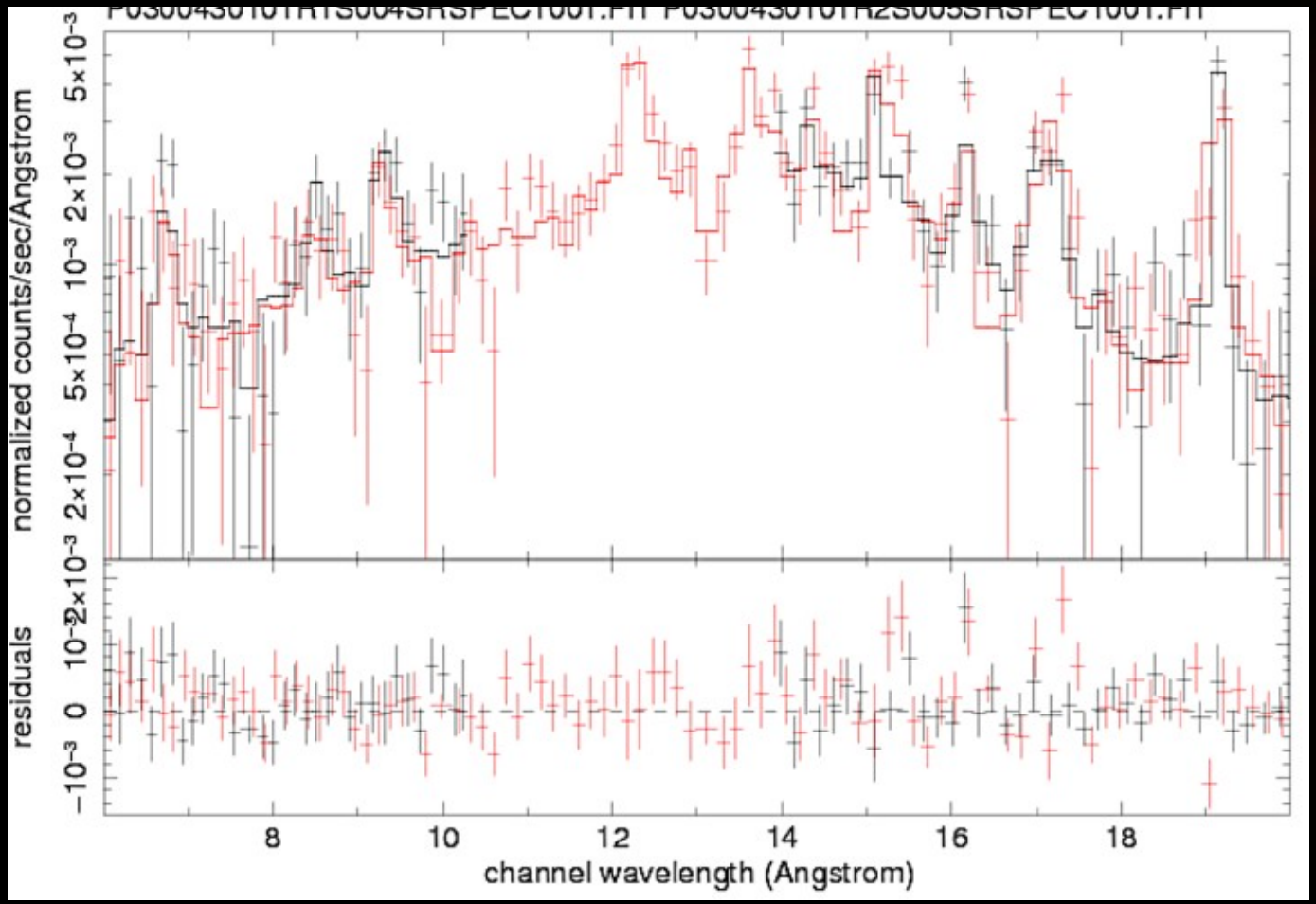


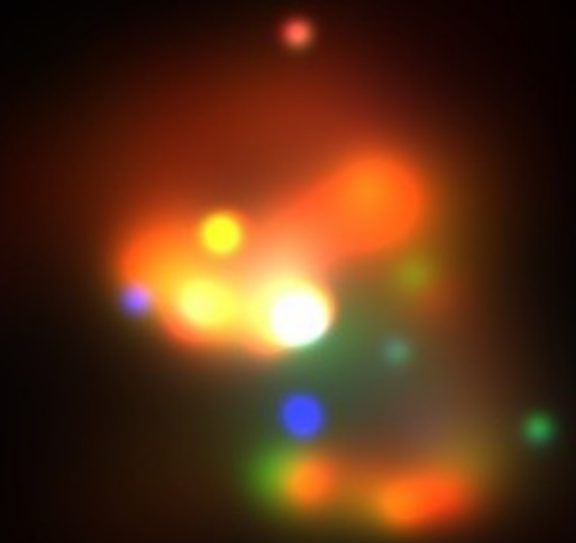


The low-energy regime is the most critical one (oxygen abundances, charge exchange emission) and also the most severely affected by line broadening.

Work in progress on NGC3256

$L_X \sim 10^{41}$ erg/s, observed face-on => cannot slice the outflow
(outflow is superimposed on the centre)
Observed 130ks with XMM



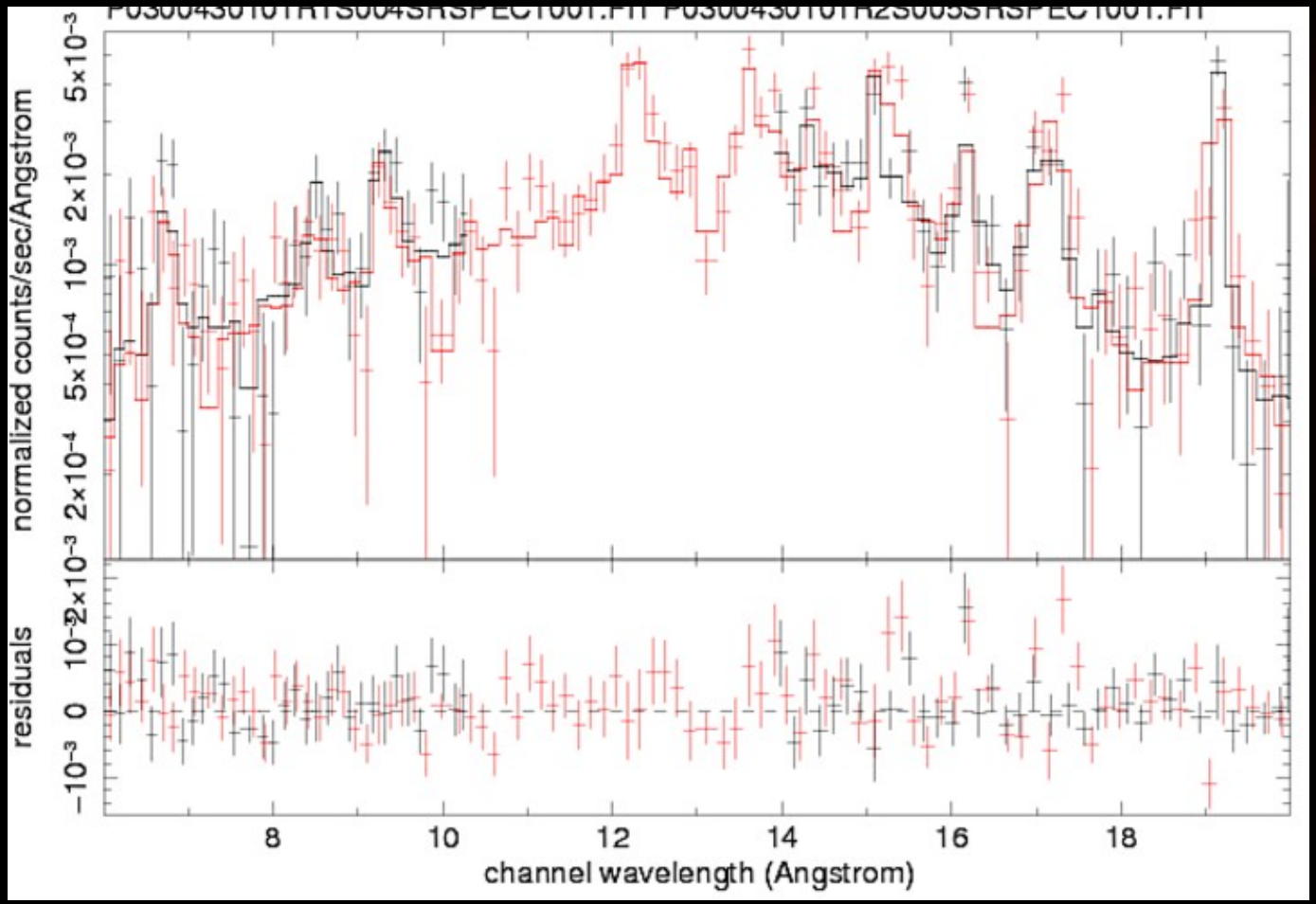


for point sources and Chandra data see Lira et al. 2002

Work in progress on NGC3256, results from RGS spectrum:

Highly (3-5 x) super-solar abundances

OVII triplet compatible with plasma emission

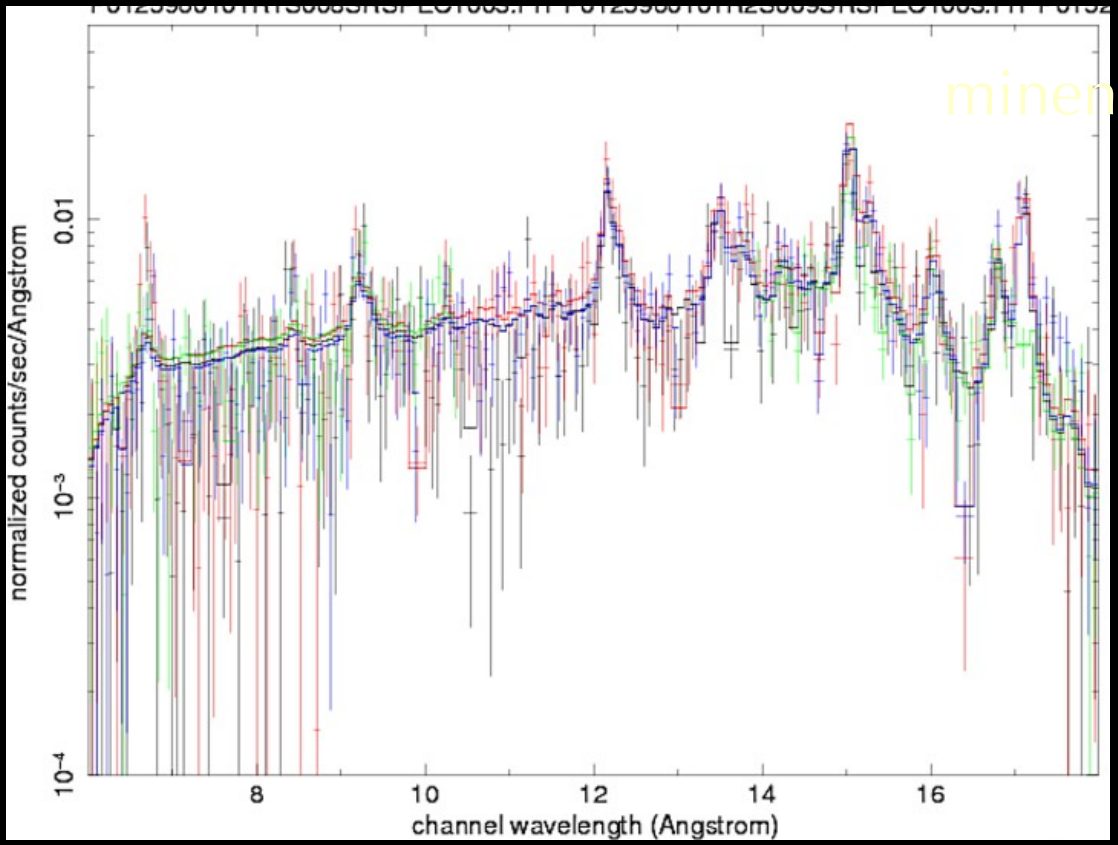


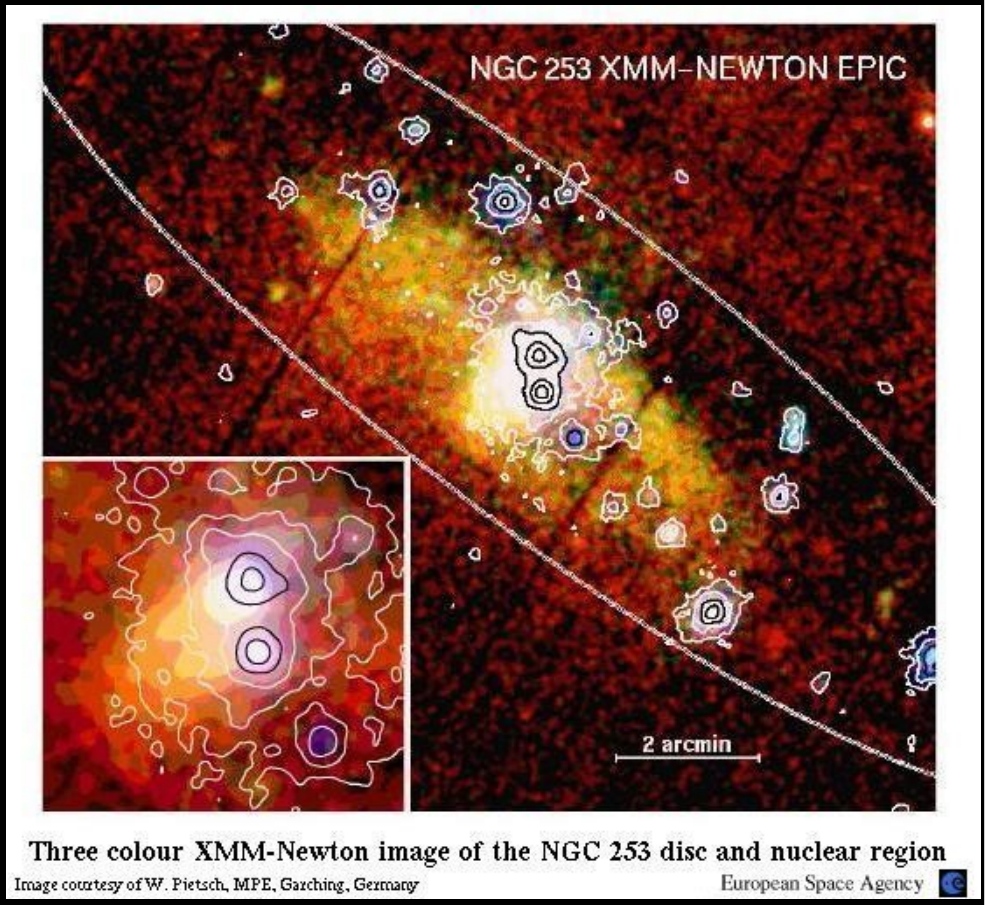
Work in progress on NGC253 (central region):

similar inclination to M82

less absorption in the centre (RGS can detect N line at 24Å)

outflow less prominent than M82 (slice not yet performed)





Three colour XMM-Newton image of the NGC 253 disc and nuclear region

Image courtesy of W. Pietsch, MPE, Garching, Germany

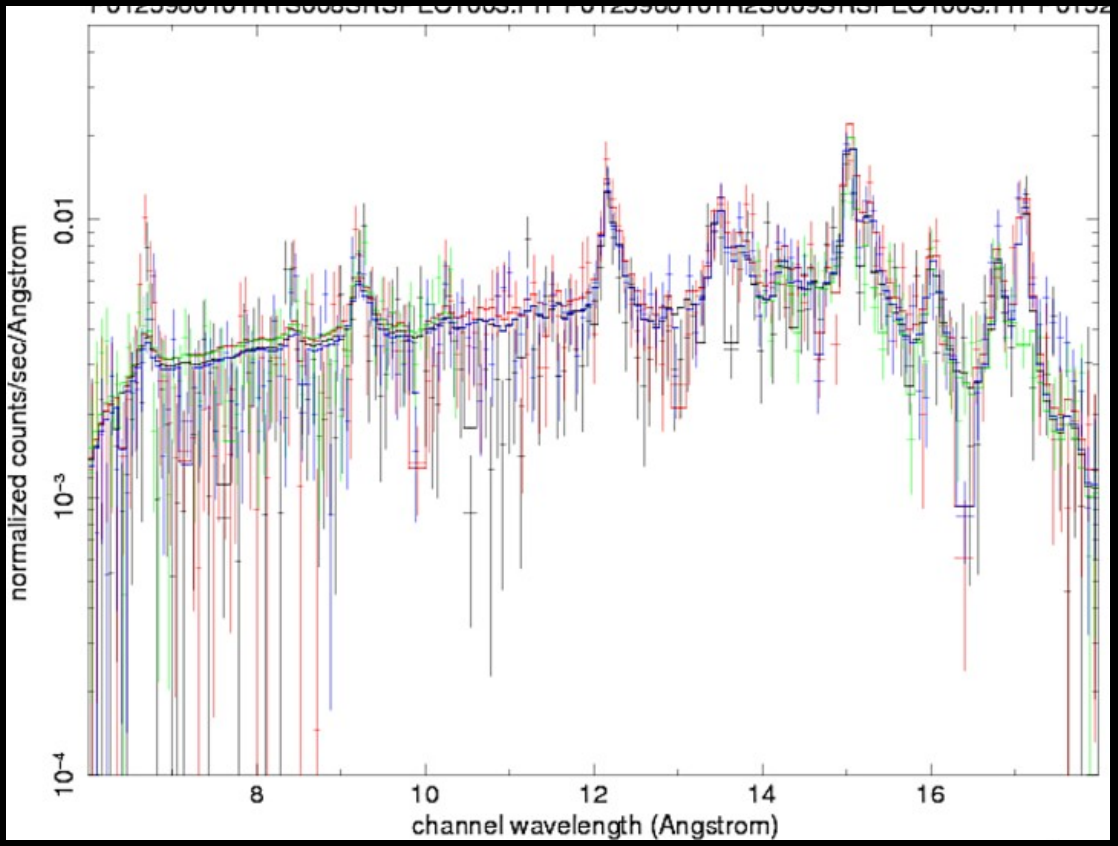
European Space Agency

main papers about NGC253:
Bauer et al. 2007,2008
Strickland et al. 2000,2002

Work in progress on NGC253

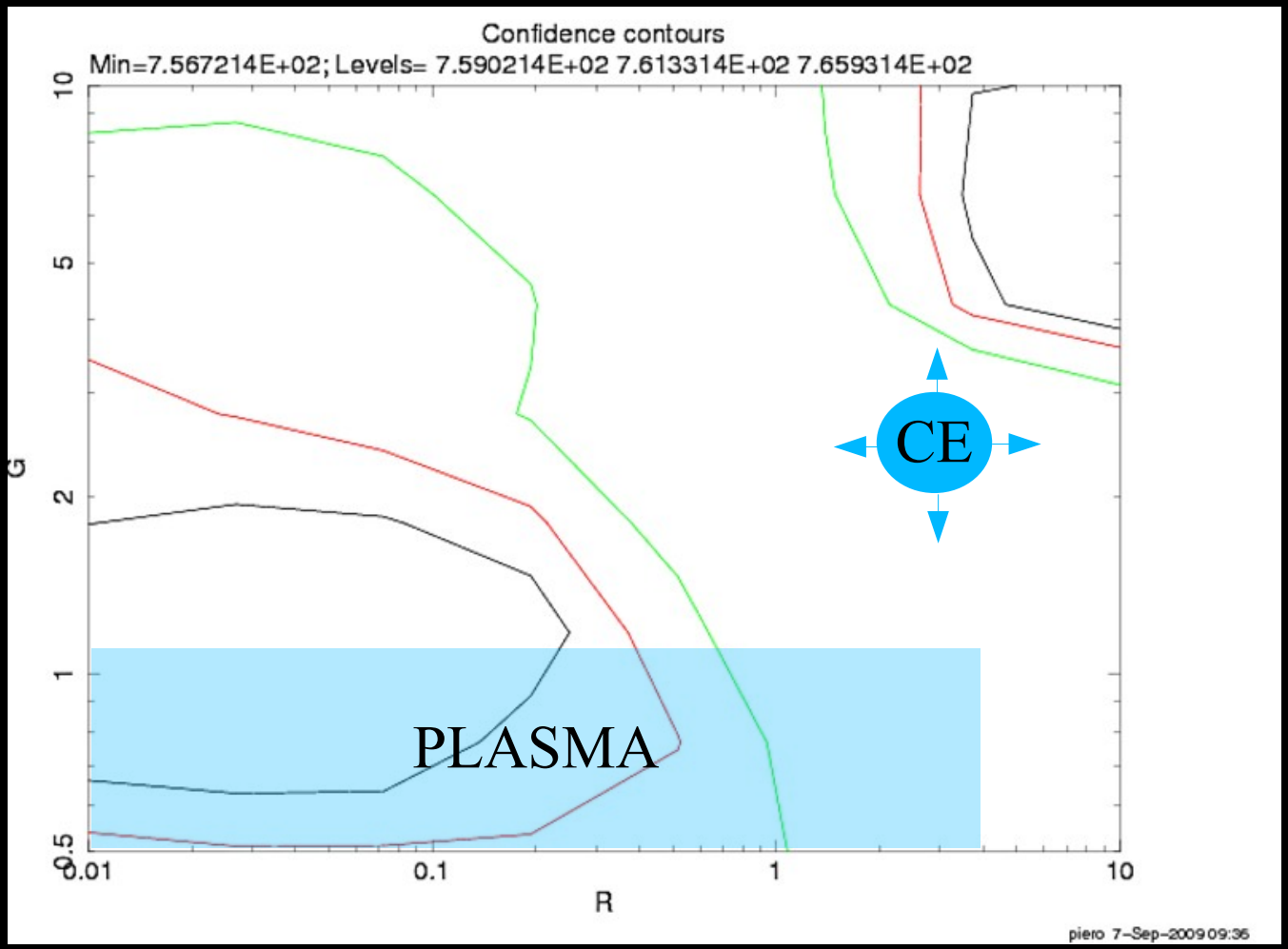
Abundances in the centre ~solar
except O/Fe <~ 0.5 solar
other elements: X/Fe ~ solar

abundances from RGS agree with
EPIC spectra



Work in progress on NGC253

O VII triplet (21.6/21.8/22.1 Å):
plasma or charge-exchange?

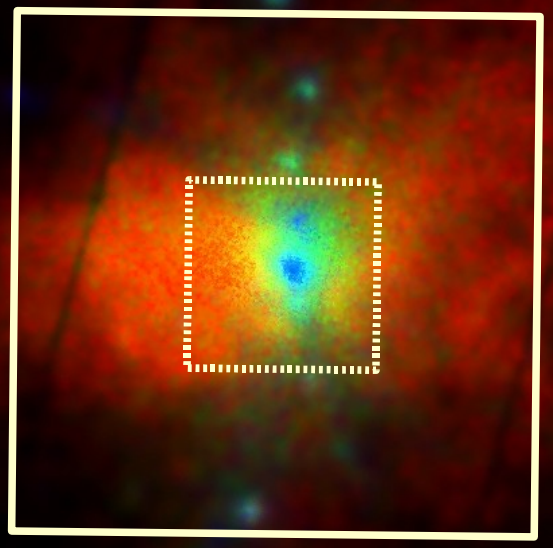


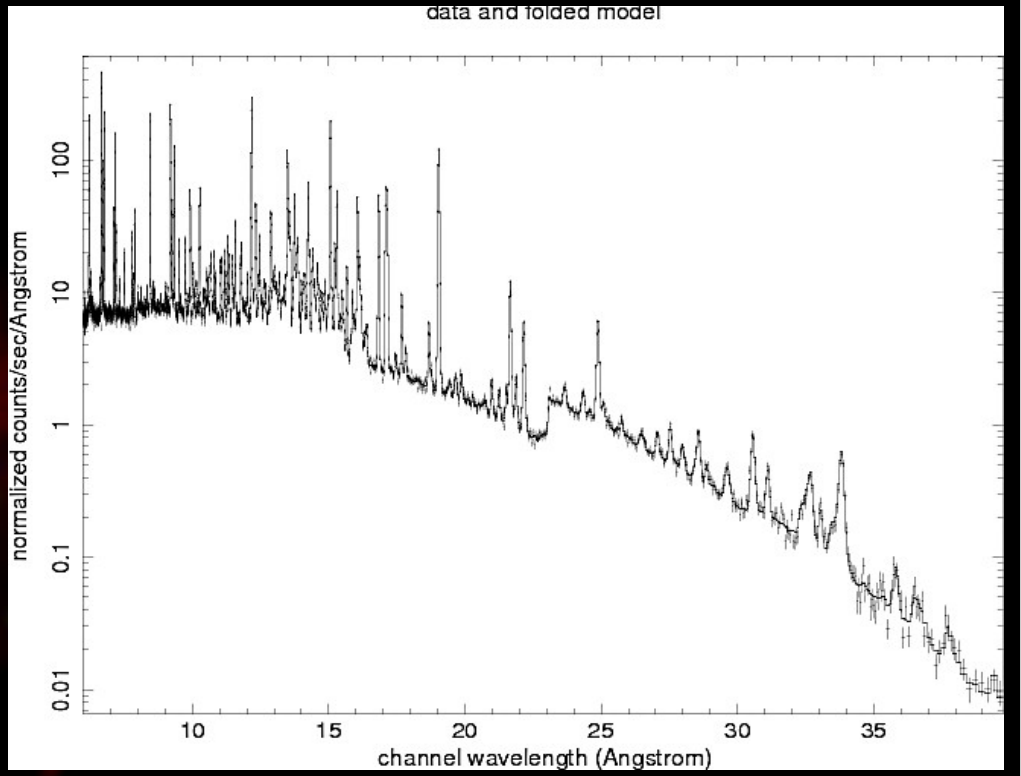
plasma-like line ratios
require z~1.7e-2
~ 5200 km/s

The future

A calorimeter as proposed for IXO (~5' FOV, ΔE~1.5--2.5 eV)
performs more or less like the XMM RGS does for point sources
and allows the separation of different patches of the sky
(and, hopefully, exclude point source)
E/ΔE @ 1 keV: EPIC/PN~7 RGS~300 (point sources) IXO~400--700

=> **the more resolution and coverage at low energies, the better**

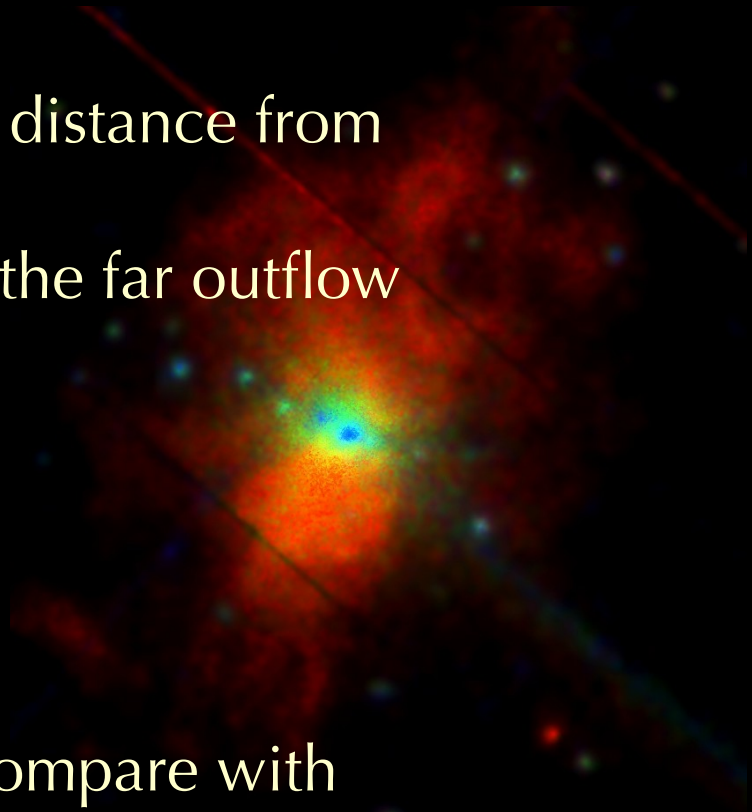




Conclusions:

M82

- chemical abundances depend on distance from the galaxy centre
- shows chemical enhancement in the far outflow
- bimodal temperature distribution
- detection of charge-exchange



NGC3256

- simple plasma spectrum (no CE)
- super-solar abundances => can compare with stellar (NIR data available)

NGC253

- abundances may be derived => comparison with stellar ones is feasible (NIR data already acquired)

Understanding chemical evolution and enrichment

The temperature structure (DEM) is bimodal!
What is the 7 kev peak?

Point sources not likely

Maybe there are nonthermal tails in the electron spectrum (Masai's plasma model), this means particle acceleration in the outflow