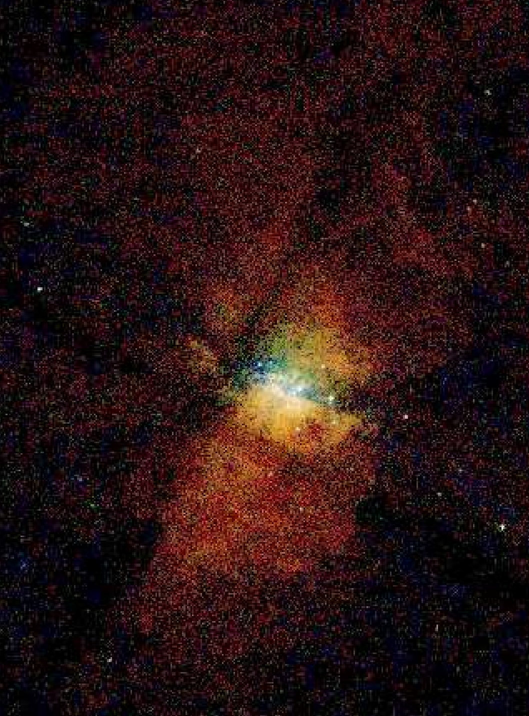
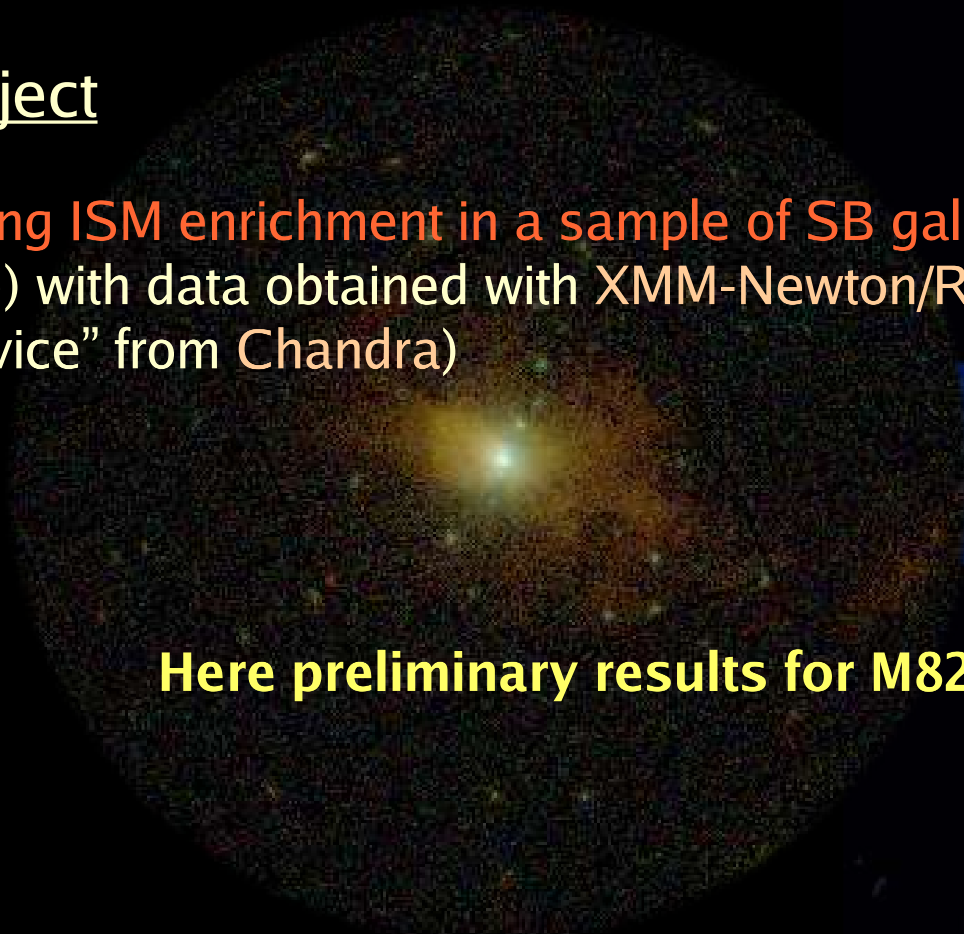
Enrichment of **a**-elements in star bursts: the case of M82



Piero Ranalli
Universita' di Bologna

in collaboration with Andrea Comastri, Livia Origlia, Roberto Maiolino



Our project

determining ISM enrichment in a sample of SB galaxies (M82, NGC253, NGC4449, Antennae) with data obtained with XMM-Newton/RGS and TNG/NICS (and some “good advice” from Chandra)

Here preliminary results for M82 will be presented

While abundance determinations have been attempted with data from previous missions, it is the high resolution and throughput of the RGS onboard XMM which makes reliable determinations possible.

ISM enrichment in star bursts / 1

Abundance patterns in galaxies are the result of the star formation history: can we measure how much the ISM in enriched in a star burst episode?

The NIR emission of SB galaxies is dominated by Massive Red Supergiants which formed in the last SF burst.

Absorption spectra: atomic and molecular lines => reliable abundance determinations for the stellar compontent

Most massive stars explode as SN => ISM enrichment and heating => X-ray emission

gaseous abundances can be determined from high resolution grating spectroscopy

⇩

ISM enrichment can be measured by comparing NIR- and X-ray derived abundances

ISM enrichment in star bursts / 2

Different elements have different timescales for their release in the ISM, depending on when/ where they are produced:

a-elements are mainly released in type II supernova explosions which begin ~10 Myr after the onset of the star burst

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a-elements should be enriched in the gaseous phase w.r.t. the stellar one

Fe and Ni are mainly released in type Ia supernova explosions

lower mass progenitors lead to a timescale of ~1 Gyr

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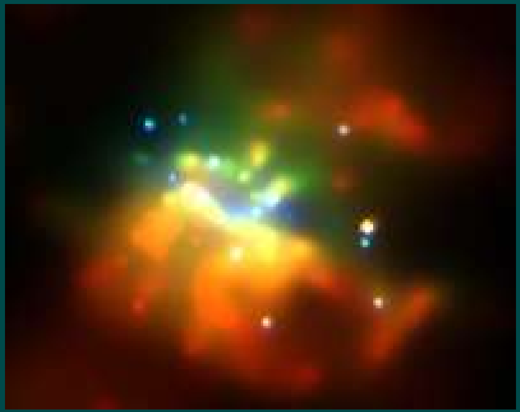
no enrichment is expected in the gaseous phase

The X-ray spectrum of a SB galaxy



Chandra closeup of the centre of M82

Two main components are present:
• diffuse emission (continuum + lines)
• point sources (continuum only)

Sensible absorption in the central regions (M82 is edge-on).

Constraining the emission from point sources is extremely important, since it helps to fix the normalization of the thermal continuum, and hence the equivalent widths of the emission lines.

The high resolution of Chandra allows a separation of diffuse and point source emission, so that indipendent constraints on both components can be made, and is a guide to the interpretation of RGS spectra.
RGS is also the only instrument available for this work, since Chandra gratings resolution is rapidly degraded for extended sources

Previous studies suffered of large, unknown systematics (see also Dahlem et al. 2000).

Read & Stevens (2002) also analyzed XMM data for M82 but did not account for point sources.

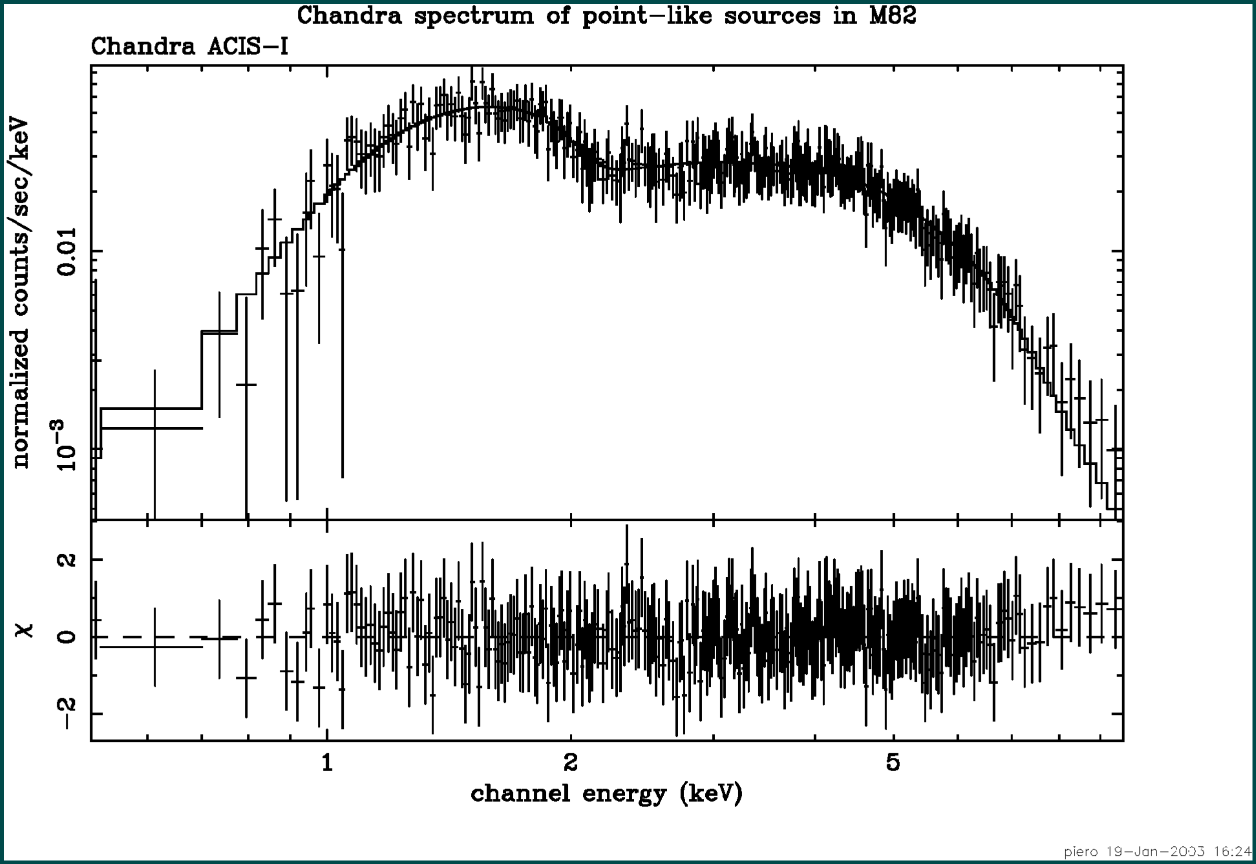
Constraining the point source contribution with Chandra observations

Chandra closeup of the centre of M82

From Chandra data:
we extracted a summed spectrum of the brightest point sources in the centre of M82

Best fit model is an absorbed power-law:
G=0.88±0.07, N_H=(7.6±0.07) x 10^{21}

These values will be used in subsequent fit of XMM spectra.



XMM-Newton spectra of M82

XMM view of M82

20 ks of data available

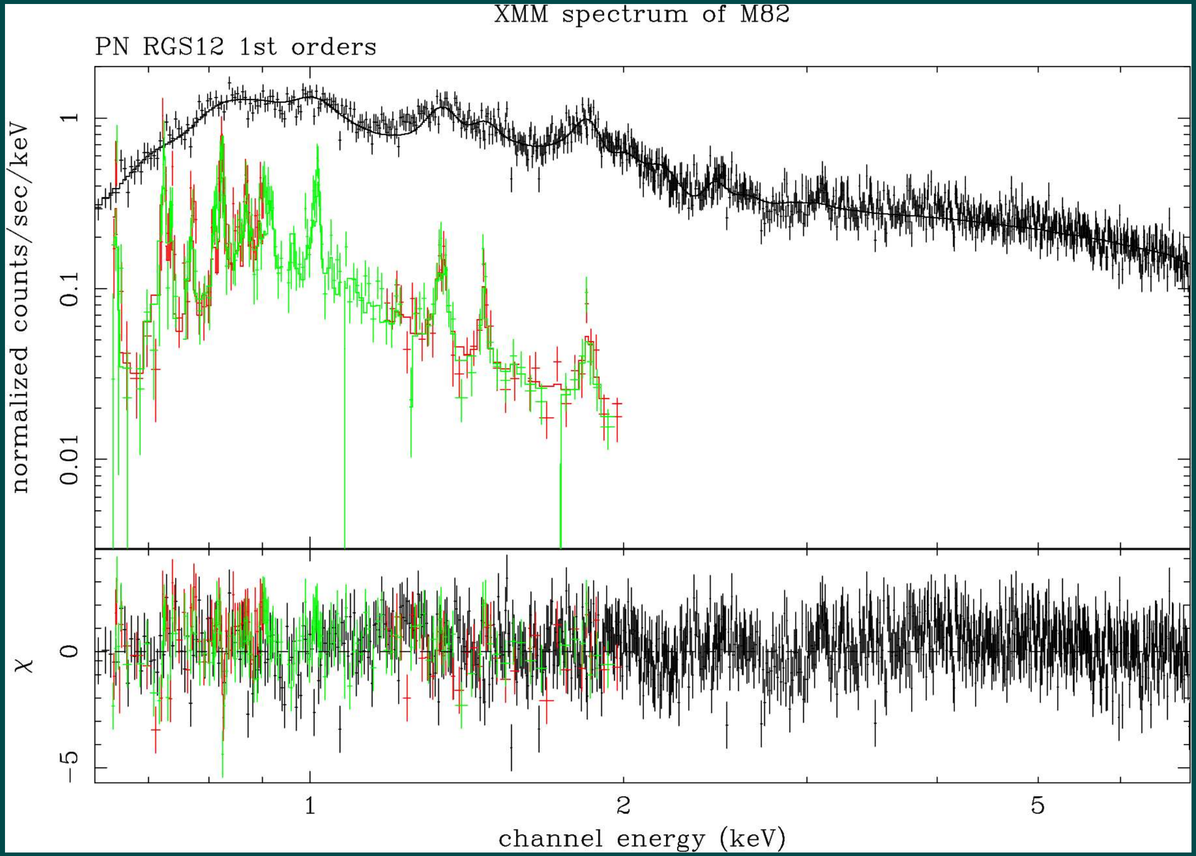
The PN spectrum of the inner 15" (matching the RGS PSF) is used to constrain the point source contribution:

the 2-7 keV spectrum is best fit by a power-law with the same slope of the Chandra spectrum, thus our model is:

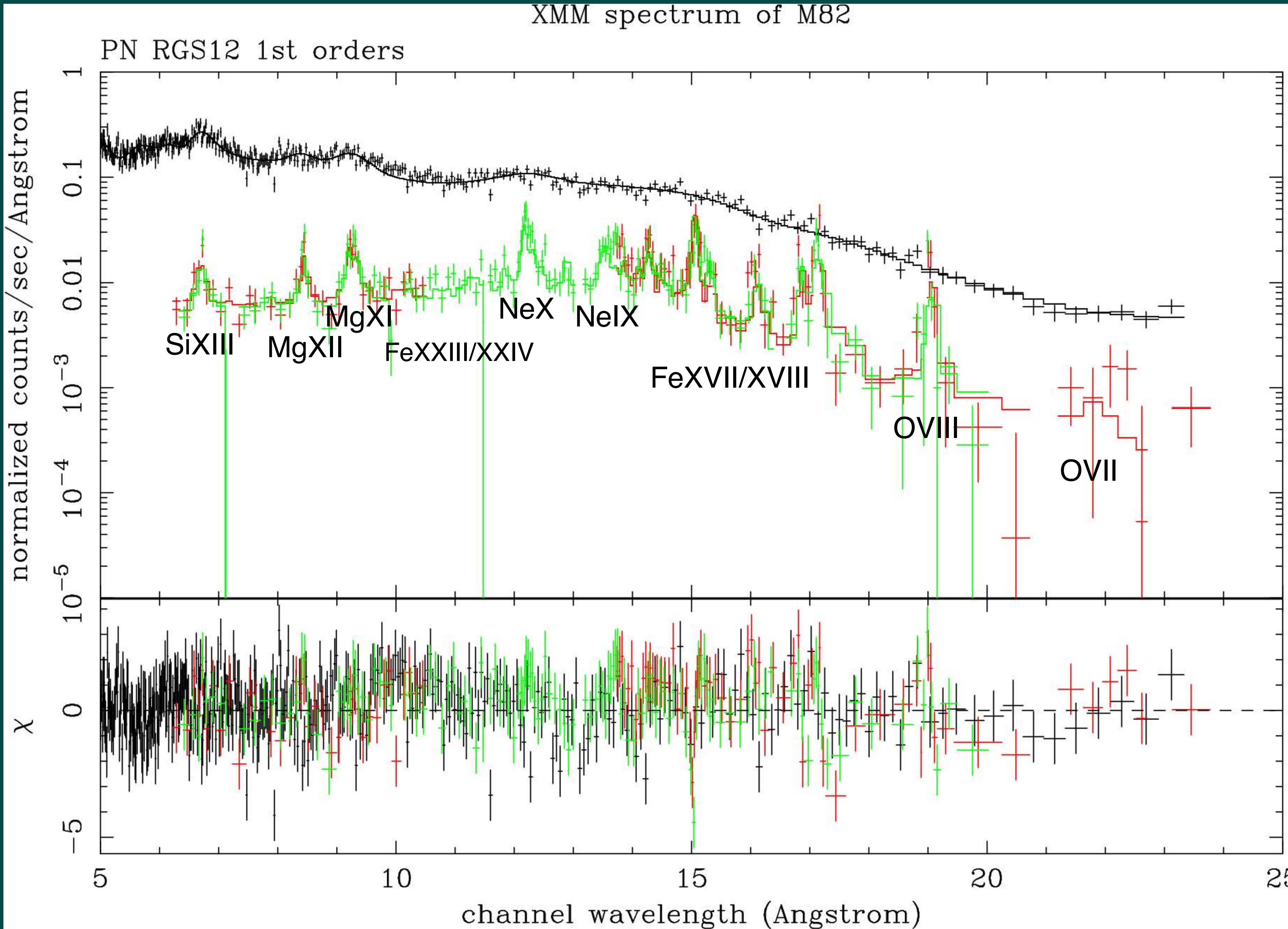
absorbed power-law
(**G**: fixed at Chandra/PN value;
N_H: fixed at Chandra value;
norm: free since point sources are variable)

+

thermal component
best fit model is an absorbed, multitemperature mekal (c6pvmkl)



XMM-Newton spectra of M82



XMM-Newton spectra of M82

The DEM distribution can be constrained quite well
(mean kT~0.7 keV, FWHM~0.65 keV)

Derived abundances:

Fe	0.52±0.03
O	0.33±0.07
Ne	0.52±0.10
Mg	1.5±0.1
Si	1.7±0.2
S	1.6±0.4

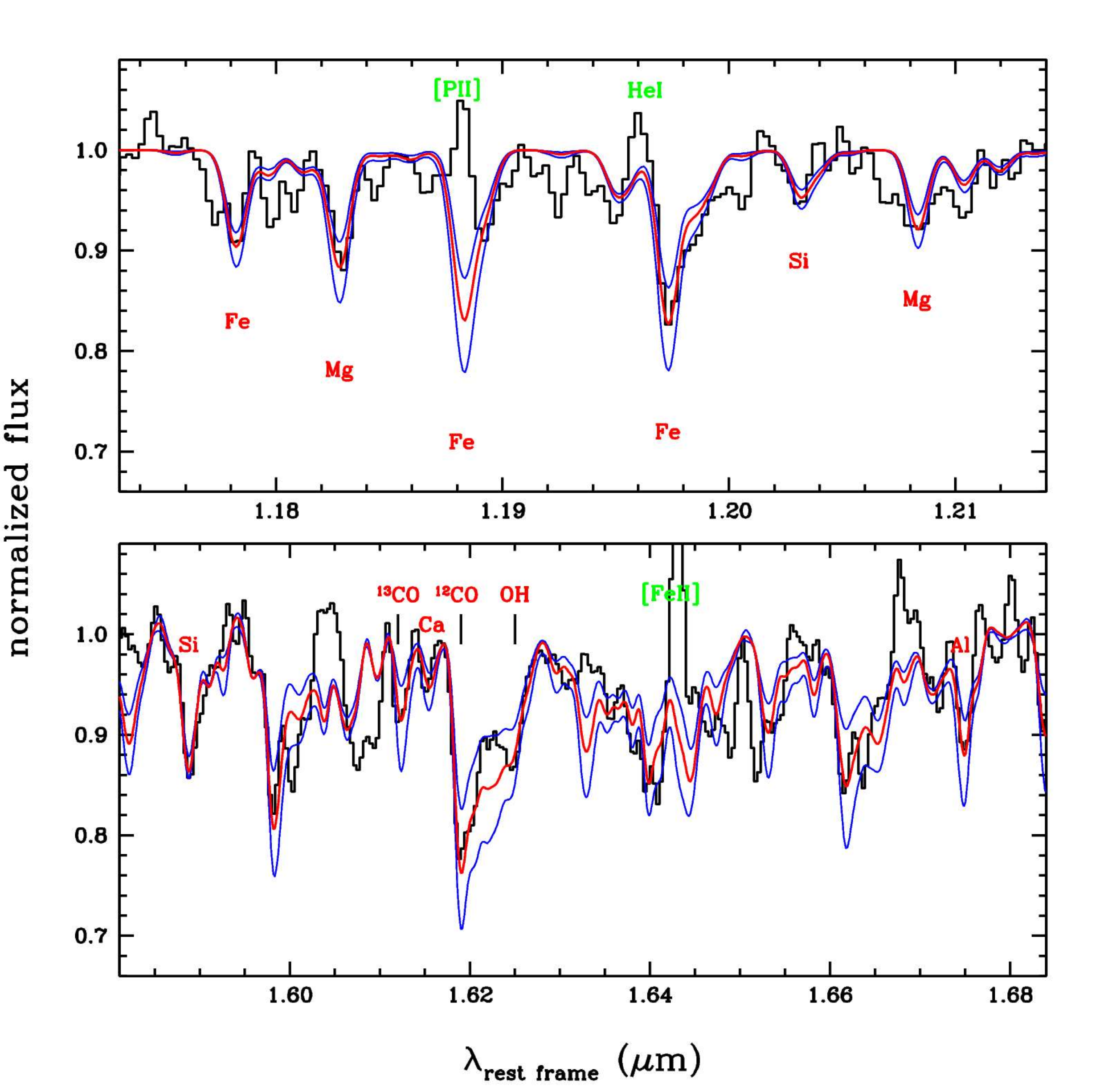
Abundance ratios are in agreement with previous studies (Read & Stevens 2002), absolute abundances are different, due to different modeling of the continuum.

O underabundance: extremely low statistics on the OVII 22Å complex, coupled with uncertainties in the RGS calibration make this uncertain.
However, it may also be possible that O (and some Ne) are lost by the SN progenitor,
so that it cools before the SN explosions begin.

Infrared spectrum of M82

Stellar abundances were derived from a H and J band spectrum taken at the 3.6 m Italian Telescopio Nazionale Galileo:

Fe	0.5±0.1
O,Si,Mg,Ca	1.0±0.2
Al	1.5±0.3
C	0.25±0.05



Preliminary results

a-elements abundances ARE enriched Si: +70%, Mg: +50%
Fe is unchanged

O is underabundant (0.3 in the hot gas, 1.0 in the stars)
this may be an instrumental issue (uncalibrated features at O wavelengths in the RGS response) but its magnitude, and a similar behaviour of Ne suggest that this may also be real.
Possible explanations (both problematic):

- O loss in stellar winds and cooling, dust depletion
- explosive nucleosynthesis in core-collapse hypernovae (>20-25 Mo)

Future work

Analysis of XMM and TNG spectra of NGC253, Antennae which should be less absorbed since they are face on; proposed deep XMM AO3 observations of M82 and NGC4449 (a WR galaxy with an ongoing SB) to achieve better statistics on the OVII, and detection of NVII and C VI in the 25-30 Å region