X ray Observations:
XMM-Newton View of Starburst

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Thanks to

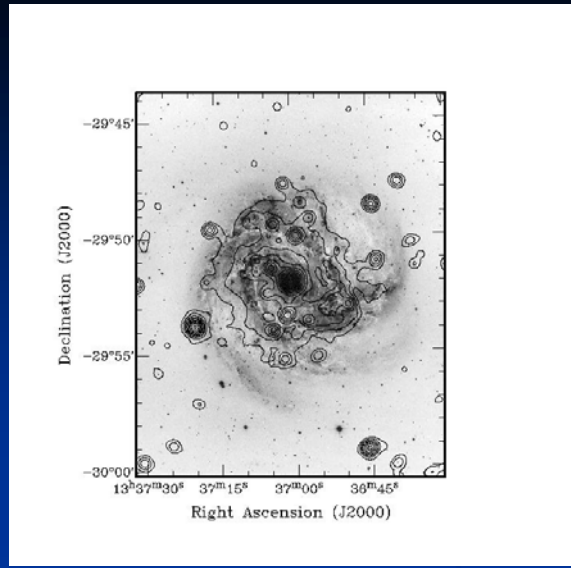
Matthias Ehle & Florencia Jimenez Lujan

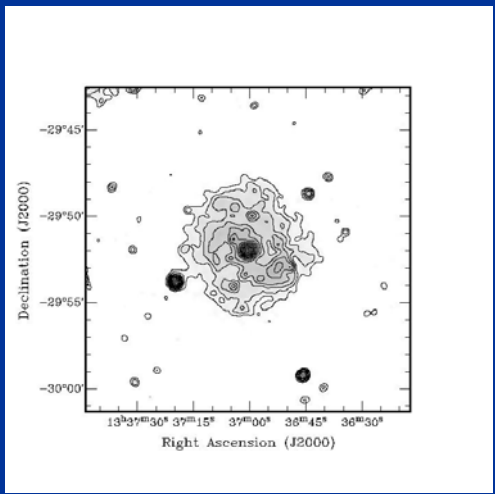
Outline

- SB: face-on: source detection
  extended, difuse emission
- SB: high resolution spectroscopy
- SB: edge-on: hot ionized gas
- Nucleus: Seyfert 2
- Nucleus: Seyfert 1
- Tools

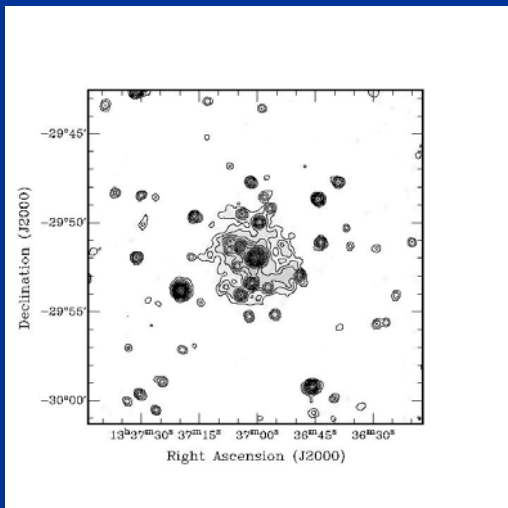
M83

- Barred, spiral, close to face on
- 4.5 Mpc (z=0.0017)
- D = 11’.5

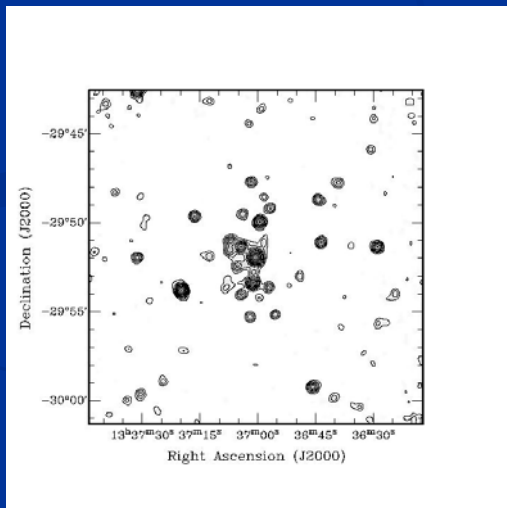




200-1000 eV



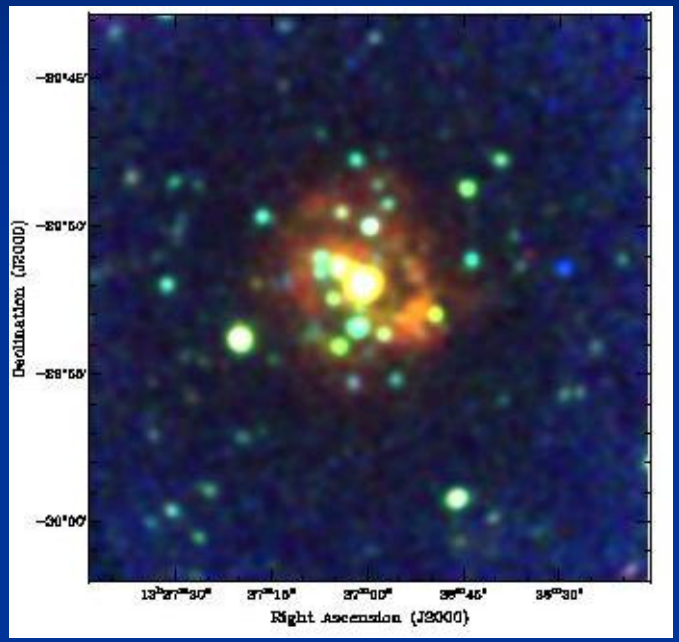
1000-2000 eV



2000-4500 eV

F.Jimenez Lujan, M.Ehle

M 83: sources and fluxes

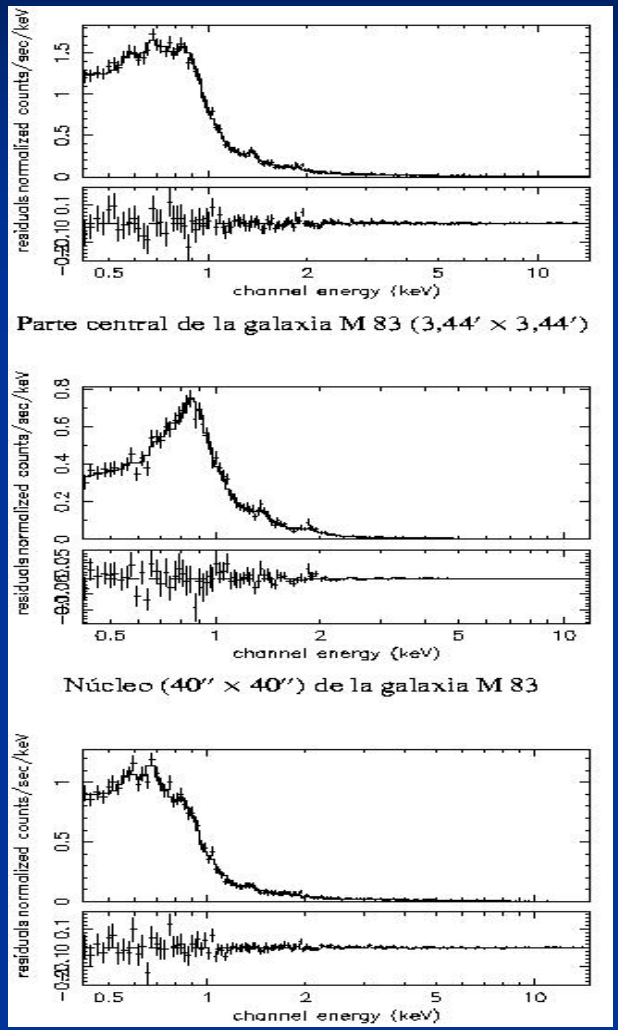


- 0.13 c/s $3.2\pm0.3\times10^{-13}$ erg/cm^2/s
- 0.045 $1.7\pm0.5\times10^{-13}$ erg/cm^2/s
- 0.026 $1.7\pm0.1\times10^{-13}$ erg/cm^2/s
- (…)
- 0.0019 $0.2\pm0.1\times10^{-13}$ erg/cm^2/s

Luminosities $\approx 10^{38\text{-}39}$ erg/s

Exposure time ≈ 30000 s

M83: nucleus+gas



- Center r=3'4
- Nuclear region r=40" (hotter)
- Difuse emission, r=3'4-sources-nucleus 70% of center (hard) 60% (soft)
- Fluxes≈0.5-2.5 10^{-12}erg/cm^2/s
- Lum≈ 10^{39-40} erg/s

M82: Spectroscopy !

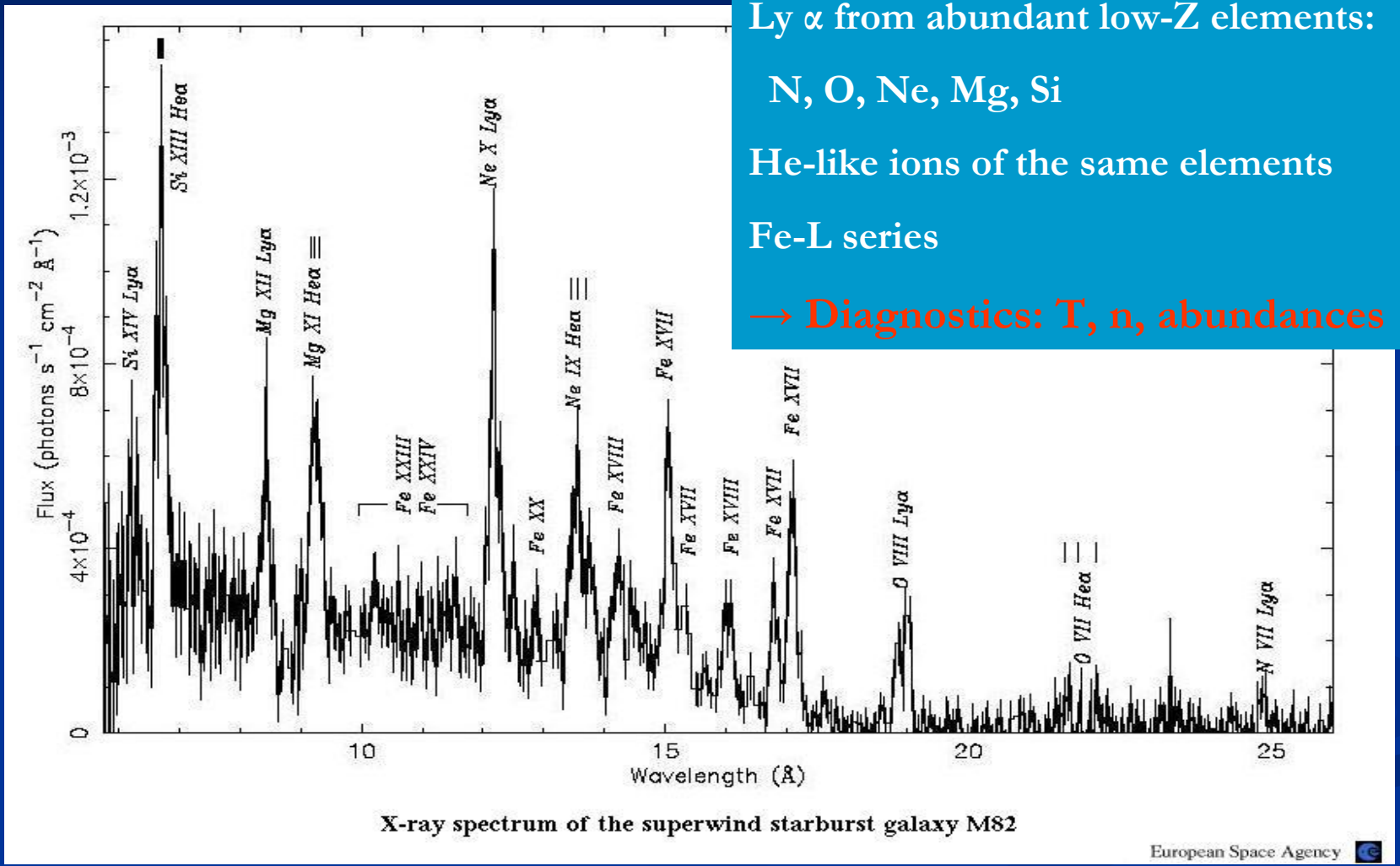
Ly α from abundant low-Z elements:

N, O, Ne, Mg, Si

He-like ions of the same elements

Fe-L series

→ Diagnostics: T, n, abundances …

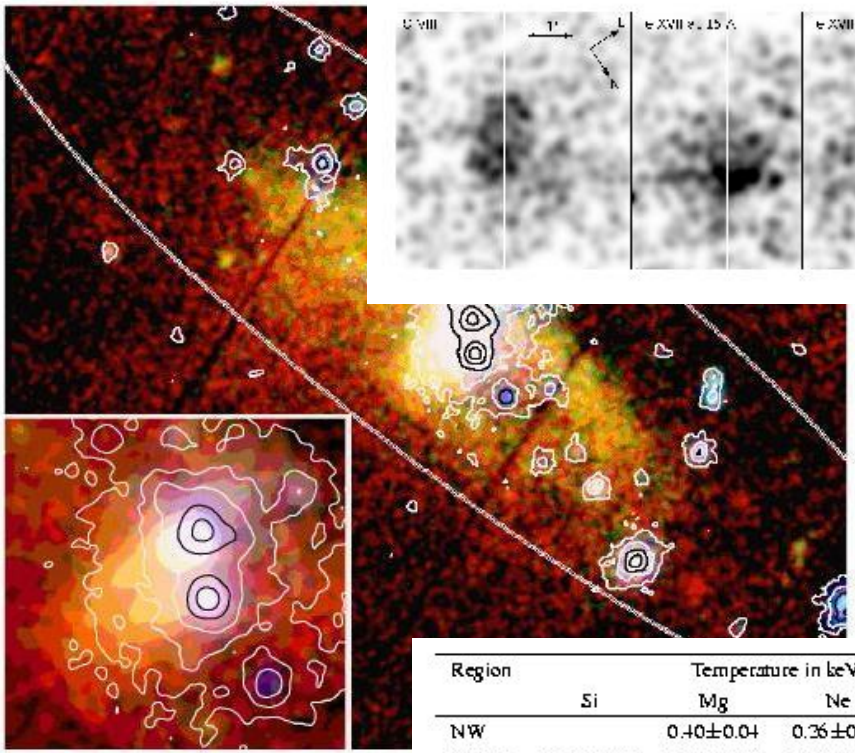


X-ray spectrum of the superwind starburst galaxy M82

European Space Agency

Soft Flux 2x10^{11} erg s^{-1}cm^{-2}; 30 ks ; **A. Read, Leicester**

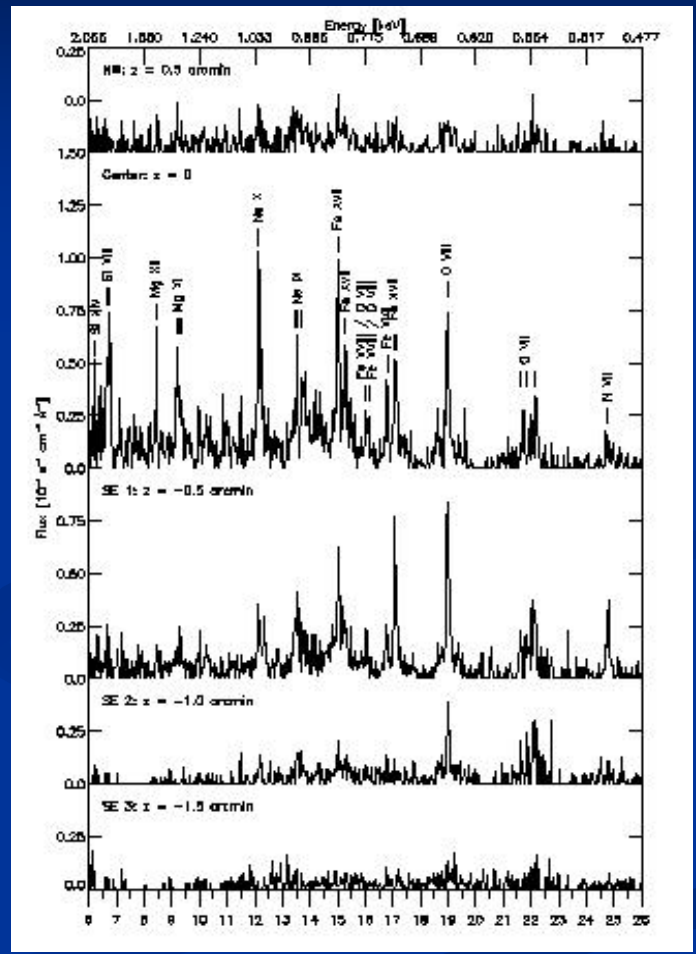
NGC 253: Spectroscopy !



Three colour XMM-Newton image o

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

Region	Temperature in keV			
	Si	Mg	Ne	O
NW		0.40±0.04	0.36±0.06	0.17±0.02
Center	0.77±0.10	0.48±0.04	0.31±0.05	0.23±0.03
SE 1		0.40±0.05	0.23±0.02	0.24±0.03
SE 2			0.22±0.05	0.21±0.02

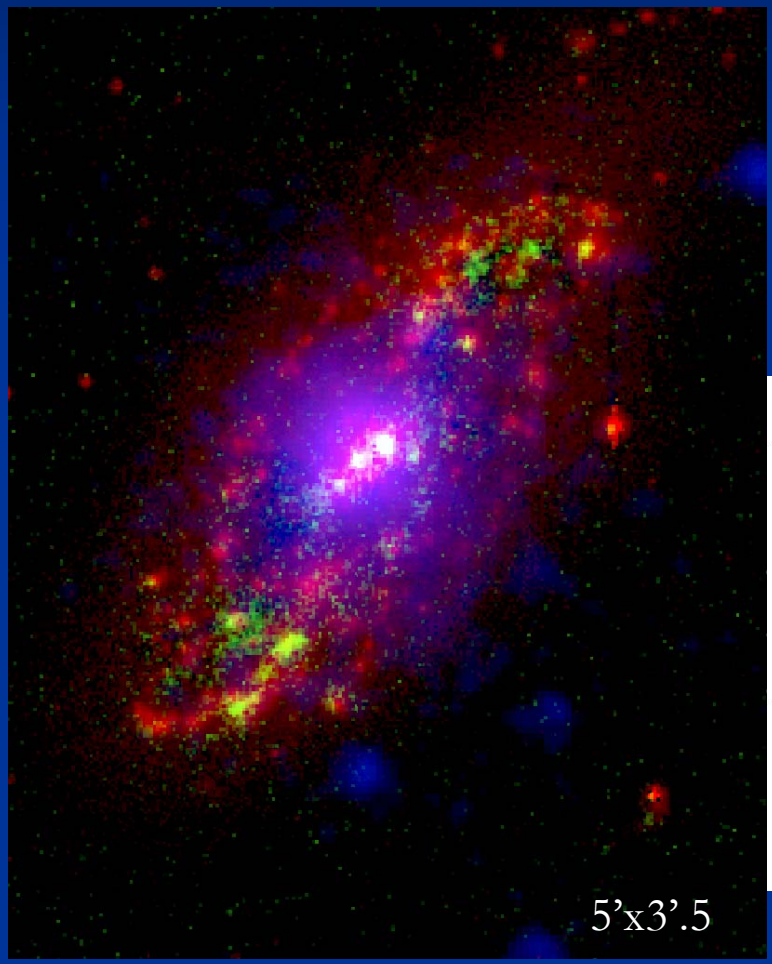


Soft Flux, 5×10^{-12} erg $s^{-1} cm^{-2}$; 30 ks

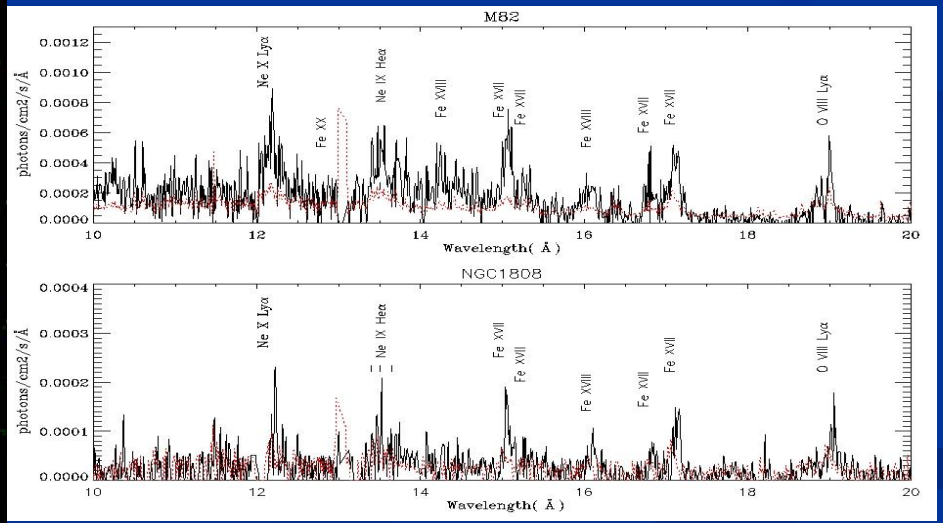
Temperatures from line ratios !

Bauer et al. 2006, Proceedings of X-ray Universe 2005 conference

NGC 1808: closer to 'real' life



- ≈ 10 times weaker than M82
- Similar exposure time ≈ 36ks
- 10.9 Mpc; 53pc/"

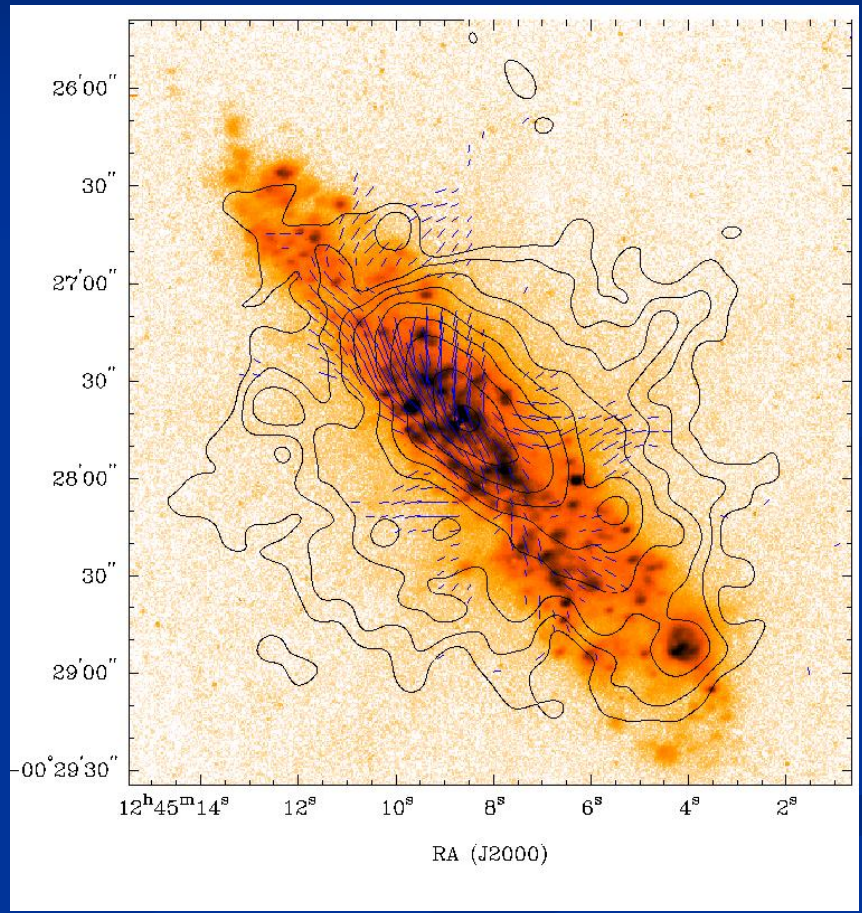


Jimenez-Bailon et al. 2005

NGC 4666: Hot ionized gas

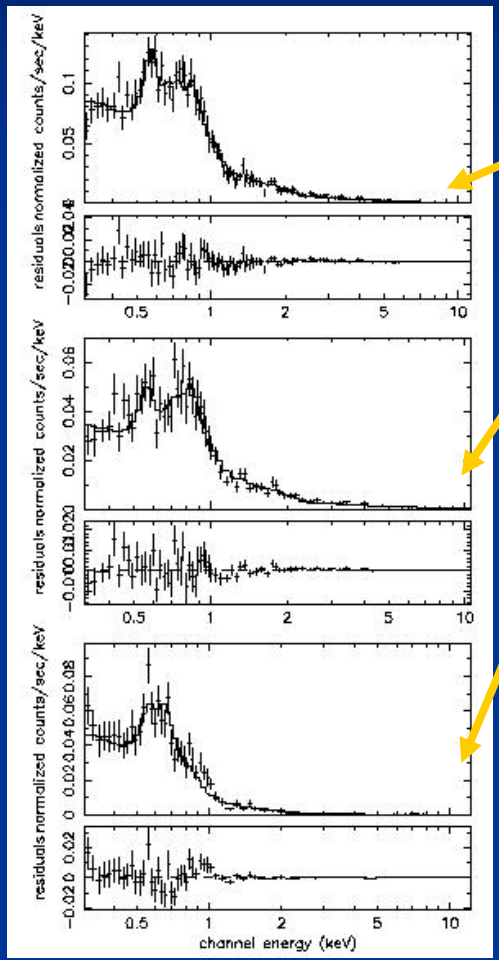
- Sc starburst Galaxy
- D = 26.3 Mpc
- Nuclear activity
  (Fe Kα line)
- 'Super wind' ≈ 7 kpc

≈ 50 ks



M.Ehle, 2005, ASP Series 331

NGC 4666: X-ray disk and halo



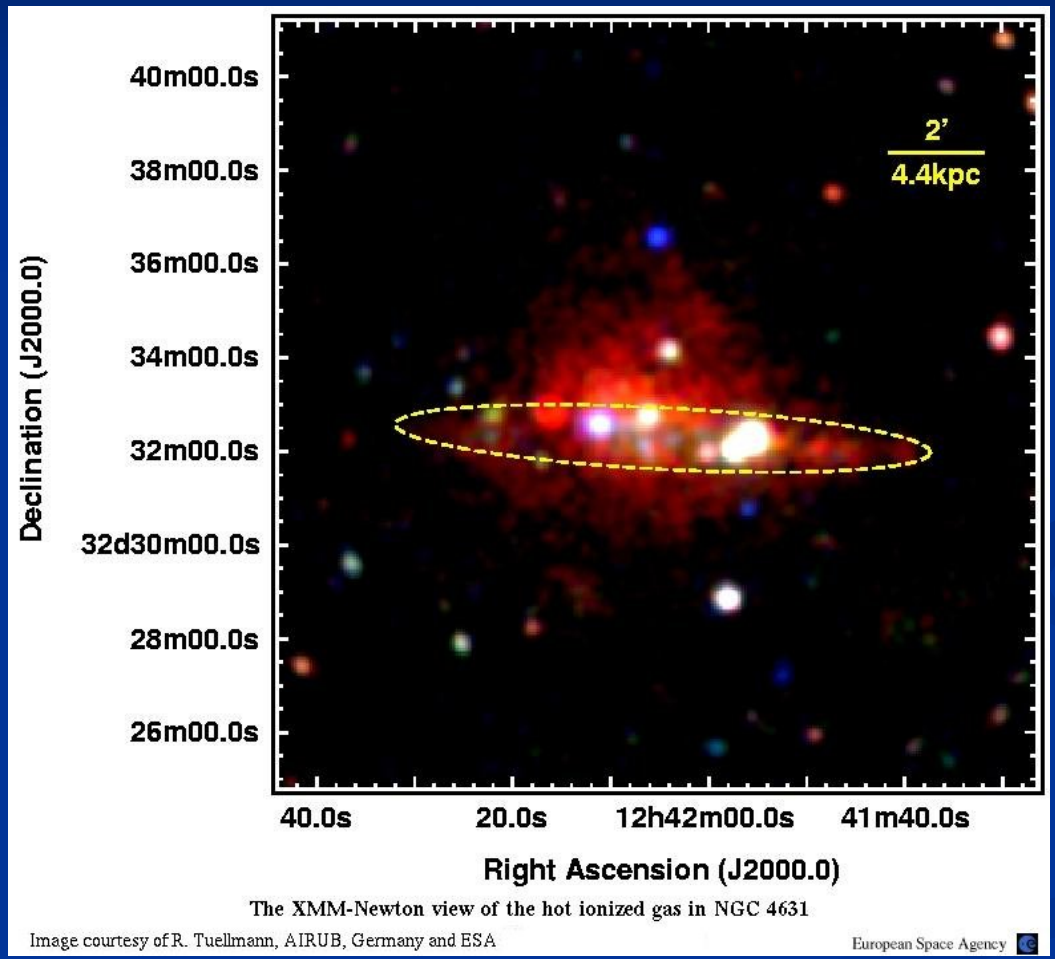
- Disk 6.4×10^{-14} erg s^{-1}cm^{-2}
- Lower halo 2.5×10^{-14} erg s^{-1}cm^{-2}
- Upper halo 3.8×10^{-14} erg s^{-1}cm^{-2}

Need low Galactic n_H !!!

Table 1. Parameters of the diffuse X-ray emission components of NGC 4666

	T [keV]	$f_{X,0.3-12}^{mekal,\,unabs}$ [10^{-14} erg/cm^2/s]	L_X [10^{39} erg/s]	n_e [10^{-3}cm^{-3}]	m_{Gas} [$10^7 M_{sun}$]	U_{th}/U_{mag}
disk	0.29 ± 0.01	7.21	5.97	1.0 - 2.9	2.5 - 7	0.1 - 0.2
lower halo	0.35 ± 0.03	2.77	2.29	2.5 - 7.1	0.5 - 1	0.7 - 2.0
upper halo	0.23 ± 0.01	4.40	3.64	1.2 - 3.3	1 - 4	0.2 - 0.6
total halo	0.27 ± 0.01	7.38	6.11	1.4 - 4.0	2 - 5	0.3 - 0.9

NGC 4631: Hot ionized gas in … non-starburst galaxy !



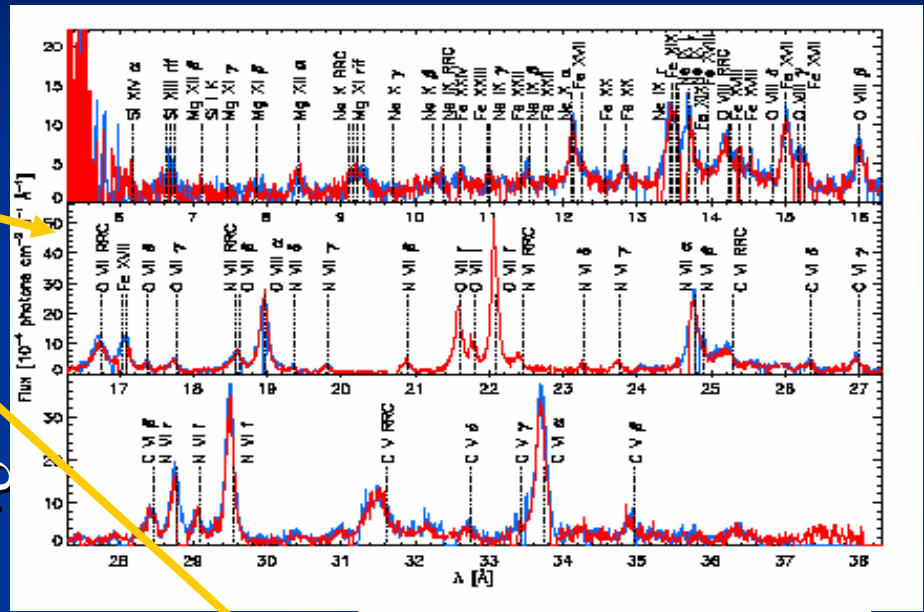
- Sc edge-on
- D=7.5 Mpc
- Disk star-formation
- Non-nuclear SB/act.
- Second non-SB (NGC 891) with diffuse X-ray halo

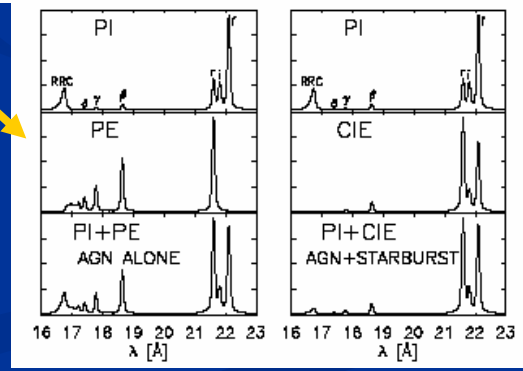
Soft flux ≈ 1×10^{-12} erg $s^{-1} cm^{-2}$

50 ks

When the nucleus is active: Seyfert 2

- NGC 1068 and …:
  spectral diagnostics
  RRC →photoinization
- `'Real life': signal ?
  - soft X-rays: extended ?
  - luminosity: SB ?
  - hard X-rays: iron lines ?
  - luminosity ?

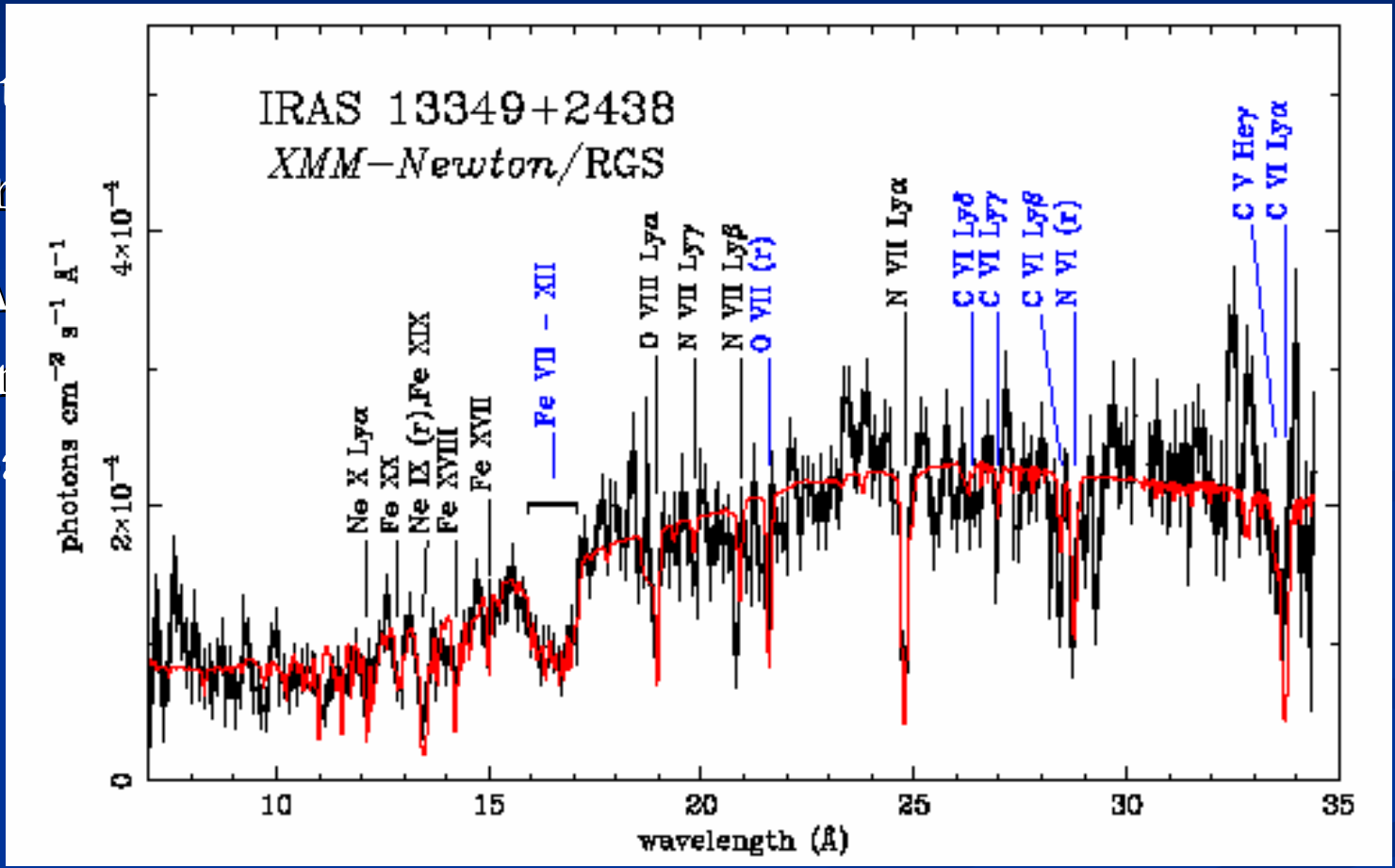




Kinkhabwala et al. 2002, ApJ 575

When the nucleus is active: Seyfert 1

- S
- I
- A
  e
  b



Sako et al. 2001, A&A 365 L168

Tools: an RGS Atlas

Rosario Gonzalez-Riestra & Pedro Rodriguez Pascual

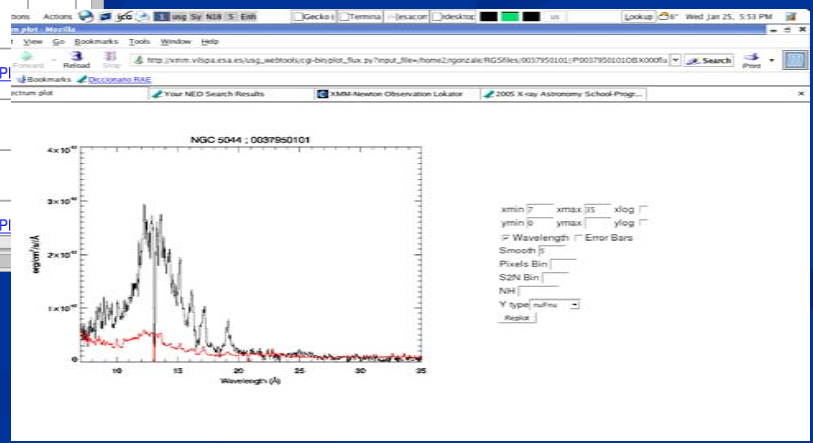
- **Select by: Simbad Object Type**
  S/N
  N_H
  redshift
- **Example: all Galaxy, Galaxy in Pair, Radio, HII, emission-line, starburst, Seyfert, Sy 1, Sy2, liner**
  751 observations

RGS Atlas: Example

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RGS Spectra database | Your NED Search Results | XMM-Newton Observation Lokator | 2005 X-ray Astronomy School-Progr...

Obsid	Object	Simbad Name	Coordinates	Obs Time	Exp. rights	Simbad Type	S2N	NH	Z	RGS	PN		B
0204250101	1610-608	ESO 137- 6	16:15:03.8 -60:54:26.0	2004-09-19 10:12:11	2005-10-07 00:00:00	Galaxy	34.4	2.64e+21	0.017909	Plot	Plot	Image	P
0158160201	GRB031203	GRB 031203	08:02:30.0 -39:50:48.0	2003-12-04 04:09:29	2003-12-04 00:00:00	Galaxy	44.6	7.46e+21	0.1055	Plot		Image	
0201901001	RXCJ0605.8-3518	LEDA 650626	06:05:52.8 -35:18:01.8	2004-10-29 01:53:12	2005-12-03 00:00:00	Galaxy	39.1	4.07e+20	0.0	Plot		Image	
0152150101	NGC1550	NGC 1550	04:19:37.9 +02:24:35.6	2003-02-22 09:31:28	2004-03-24 00:00:00	Galaxy	70.1	1.17e+21	0.012349	Plot	Plot	Image	P
0150651101	NGC 2403	NGC 2403	07:36:51.0 +65:36:10.0	2003-04-30 11:26:56	2004-10-08 00:00:00	Galaxy	53.7	4.19e+20	0.00043	Plot		Image	
0149160101	NGC 2613	NGC 2613	08:33:22.6 -22:58:19.1	2003-04-23 14:03:29	2004-06-14 00:00:00	Galaxy	35.1	6.76e+20	0.005551	Plot		Image	
0202730101	NGC3221	NGC 3221	10:22:20.2 +21:34:11.6	2004-05-30 10:44:47	2005-07-15 00:00:00	Galaxy	31.0	1.83e+20	0.013666	Plot		Image	
0038540401	NGC3332	NGC 3332	10:40:29.0 +09:10:59.0	2001-11-25 04:01:50	2002-12-13 00:00:00	Galaxy	32.7	3.07e+20	0.019427	Plot		Image	
0146510301	NGC3411 Group	NGC 3411	10:50:26.1 -12:50:41.8	2002-12-20 23:01:26	2004-01-31 00:00:00	Galaxy	66.7	3.76e+20	0.015167	Plot	Plot	Image	P
0204410201	UGC8831	NGC 5356	13:54:58.4 +05:20:03.3	2004-01-28 02:18:28	2005-02-20 00:00:00	Galaxy	33.0	1.99e+20	0.004613	Plot			
0102640101	M33_1	NGC 598	01:33:51.0 +30:39:37.0	2000-08-04 05:17:12	2002-12-15 00:00:00	Galaxy	53.7	5.71e+20	-0.000607	Plot	Pl		
0102641701	M33_12_CAL_CLOSED	NGC 598	01:33:38.0 +30:21:49.0	2000-08-02 00:23:43	2002-12-15 00:00:00	Galaxy	32.0	6.02e+20	-0.000607	Plot			
0102641801	M33_1_c.cal	NGC 598	01:33:51.0 +30:39:37.0	2000-08-04 00:15:36	2002-12-15 00:00:00	Galaxy	50.5	5.71e+20	-0.000607	Plot			
0141980801	M33_1	NGC 598	01:33:51.0	2003-02-12	2004-03-20	Galaxy	36.0	5.71e+20	-0.000607	Plot	Pl		



S/N>30, 223 objexts

NGC 5044: Galaxy in group

4.65e+20 cm^{-2}

Z=0.009

Tools: XSA

- Useful for first look and quick analysis tools
- http://xmm.vilspa.esa.es/xsa

How to learn more ?

- XMM-Newton Web
  http://xmm.vilspa.esa.es
- Science Analysis Software (developed for XMM-Newton data analysis)
  VI SAS Workshop, ESAC (vilspa) 30May-2June
- Science Conference at ESAC (vilspa)
  Broad Iron features from black holes
  26-30 June

XMM-Newton : overview

Table 1: **XMM-Newton** *characteristics – an overview*

Instrument	**EPIC MOS**	**EPIC pn**	**RGS**	**OM**
Bandpass	0.15–12 keV	0.15–15 keV	0.35–2.5 keV (1)	180–600 nm
Orbital target vis.(2)	5–135 ks	5–135 ks	5–135 ks	5–145 ks
Sensitivity(3)	$\sim 10^{-14}$ (4)	$\sim 10^{-14}$ (4)	$\sim 8\times 10^{-5}$ (5)	20.7 mag (6)
Field of view (FOV)	30' (7)	30' (7)	$\sim$5'	17'
PSF (*FWHM/HEW*)(8)	5"/14"	6"/15"	N/A	1.4"–2.0"
Pixel size	40 μm (1.1")	150 μm (4.1")	81 μm (9×10^{-3} Å)(9)	0.476513" (10)
Timing resolution(11)	1.5 ms	0.03 ms	16 ms	0.5 s
Spectral resolution(12)	$\sim$70 eV	$\sim$80 eV	0.04/0.025 Å(13)	350 (14)

Need help with XMM-Newton?

Can always ask us !

We are at ESAC (former Vilspa) near Madrid !

Check our web, send e-mail to us