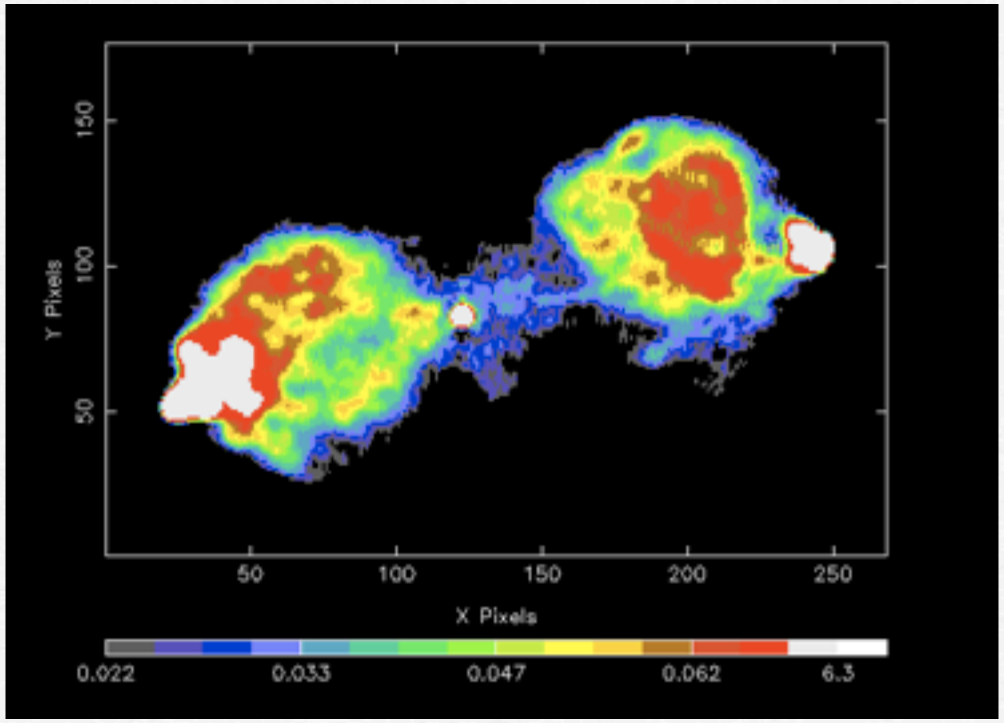
Pictor A with XMM

Pic A is a nearby (z =0.035) radio galaxy optically classified as broad-line radio galaxy. It is an isolated source.

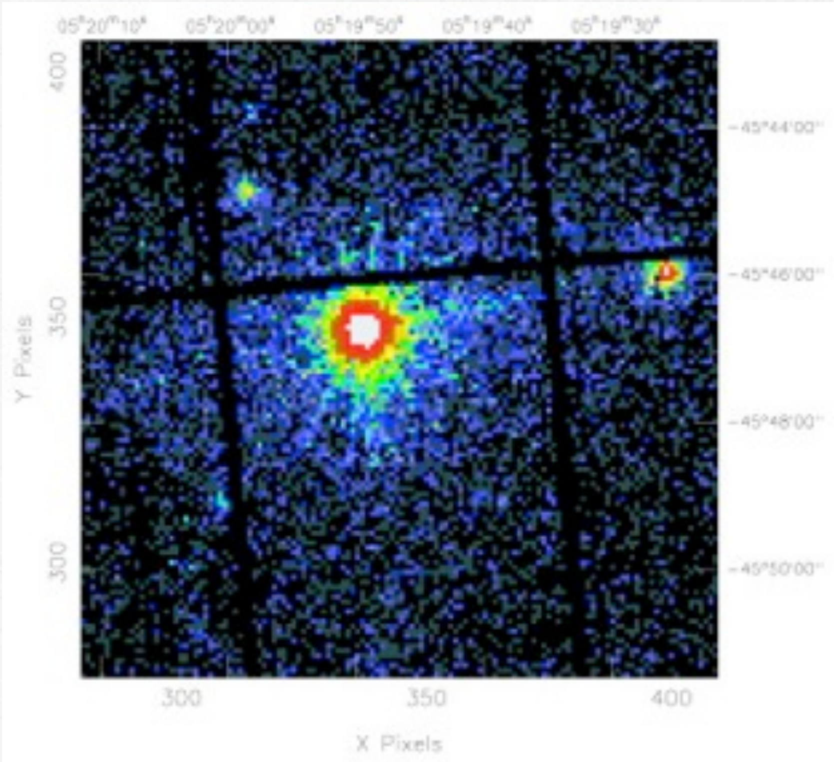
It is a double-lobed radio source with a FR II morphology

VLA map 20cm



XMM/pn image.

0.2-12 keV



Analysis of the XMM-Newton Observation: nucleus and lobe

Observation: 2005 January 14
Exposure time: ~50 ksec
The analysis has to be performed using:
MOS1 (for the lobe)
MOS2 (for the nucleus).

- Superposition of the X-ray and radio images (DS9) to individuate the region to be analyzed

- Nucleus: extraction of the spectrum and production of the .rmf and .arf files (SAS). Pile-up check. Light curve; Spectral analysis with XSPEC. Definition of the best data model: parameter uncertainties, confidence (68%, 90%, 99%) contour plots, flux and luminosity.

- Lobe (east): extraction of the spectrum/spectra and production of the .rmf and .arf files (SAS). Spectral analysis with XSPEC. Definition of the best data model: parameter uncertainties, confidence (68%, 90%, 99%) contour plots, flux and luminosity

- OPTIONAL: Determination of the magnetic field in the (eastern) lobe

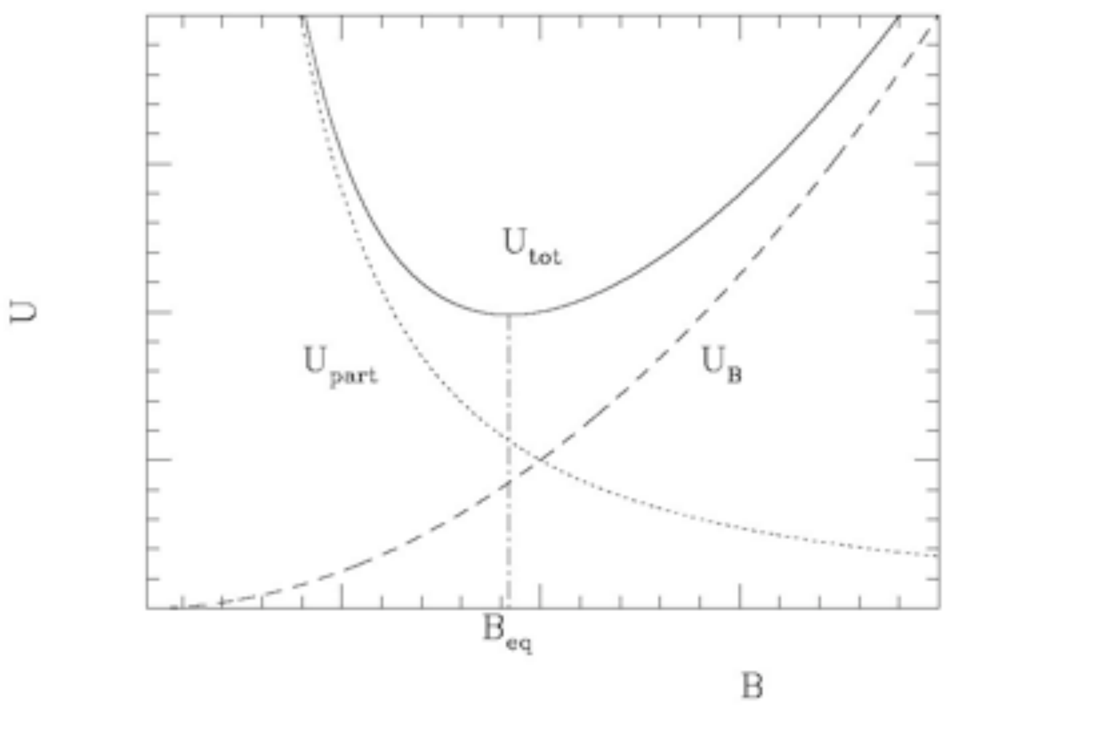
- Power point presentation of the results (+ lab experience)

Measures of Inverse Compton radiation provide the a formidable instrument to directly estimate the average magnetic field and the energy densities of the particles in the radio lobes (avoiding the equipartition assumption!).

Condition of Equipartition assumed a-priori

$U_{tot}=U_B+U_e+U_p$

$U_p=kU_e$, $U_B=B^2/8\pi$



Lobe+CMB allow to measure B and ke directly from radio and X-ray fluxes

Radio flux:

$$L_{\sin} = Vk_e C_{\sin} B^{\frac{p+1}{2}} \nu^{\frac{-(p-1)}{2}}$$

X-ray flux:

$$L_{IC} = Vk_e C_{IC} \nu^{\frac{-(p-1)}{2}}$$

$$B_{IC} = \left[\frac{F_{\sin}}{F_{IC}} \frac{C_{IC}(1+z)^{\alpha+3}}{C_{\sin}}\right]^{\frac{1}{\alpha+1}} \left(\frac{\nu_{\sin}}{\nu_{IC}}\right)^{\frac{\alpha}{\alpha+1}}$$

$\alpha=\alpha_r=\alpha_x$, V= volume

$N(\gamma)=Ke\ \gamma^{-(2\alpha+1)}$

3.1.3 MAGNETIC FIELD FROM COMPARISON WITH X RAYS An independent method of obtaining information about the distribution of magnetic field strengths in extended sources is based on the fact that the same relativistic electrons that produce the radio synchrotron emission will scatter photons of the microwave background to X rays. The ratio between radio and X-ray surface brightness depends on the magnetic field strength (Perola & Reinhardt 1972, Bridle & Feldman 1972, Costain et al. 1972, Harris & Romanishin 1974, Harris & Grindlay 1979). The process is reviewed by Gursky & Schwartz (1977).

The expression for the resultant magnetic field strength given by Harris & Grindlay (1979) can be approximated to within about $\pm 10\%$ between $-0.6 > \alpha > -1.4$ and rewritten as

$$B = \{6.6 \times 10^{-40}(4800)^{\alpha}(1+z)^{3-\alpha} F_{R} F_{x}^{-1} \nu_{R}^{-\alpha} E_{x}^{\alpha}\}^{1/1-\alpha} \text{ gauss} \quad (5)$$

where F_R is the radio flux density (in Jy) at frequency ν_R (GHz), F_x is the X-ray flux (erg cm^{-2} Hz^{-1}) at energy E_x (keV), α is the spectral index ($F_R \propto \nu_R^{\alpha}$), and z is the redshift.

References

Grandi et al. 2003 ApJ, 586, 123

Perley et al. 1997 A&A 328,12

Migliori et al. 2007, ApJ 668, 203

Miley G. 1980, ARAA, 18, 165