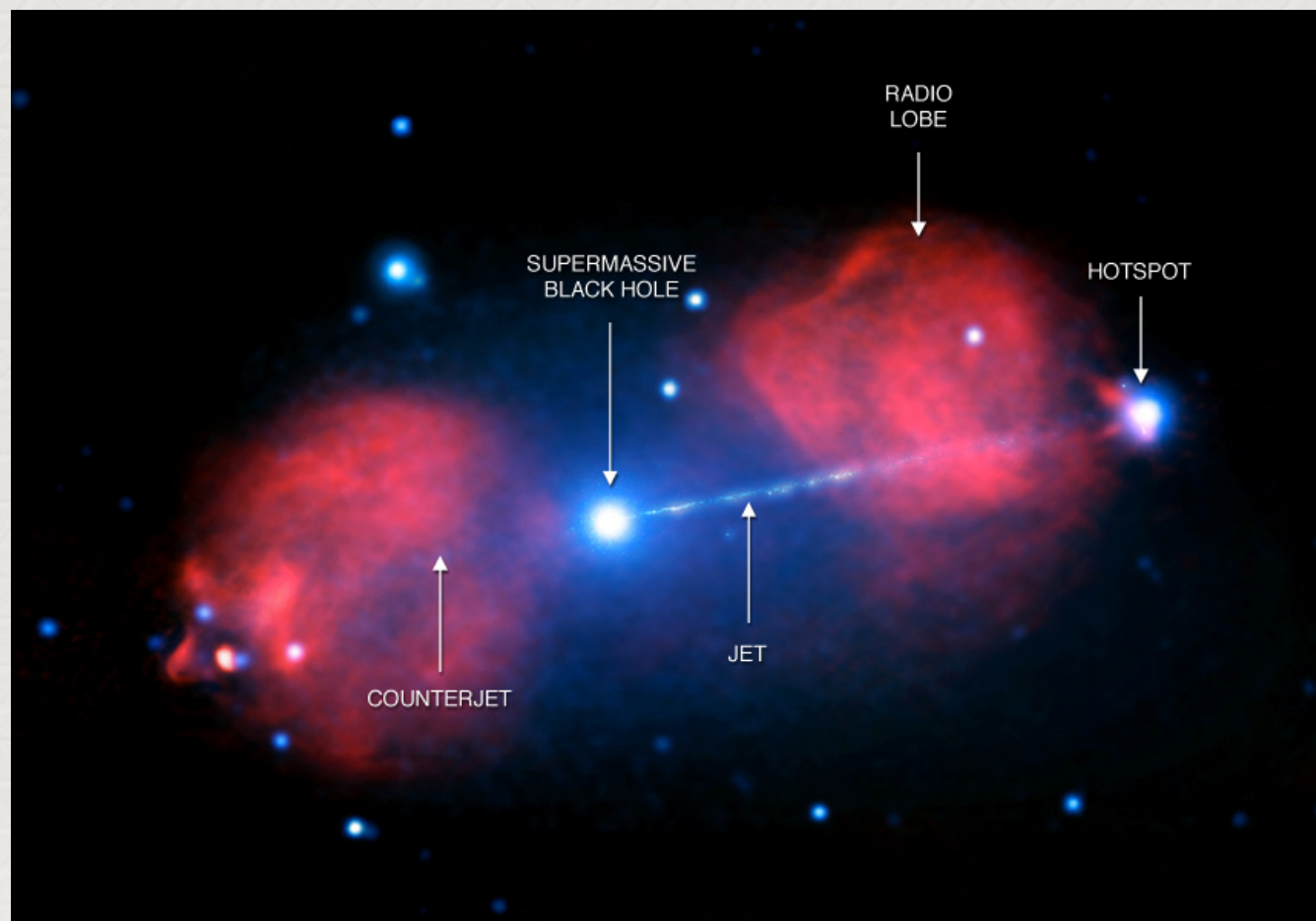


# The Radio Galaxy Pictor A with XMM-Newton

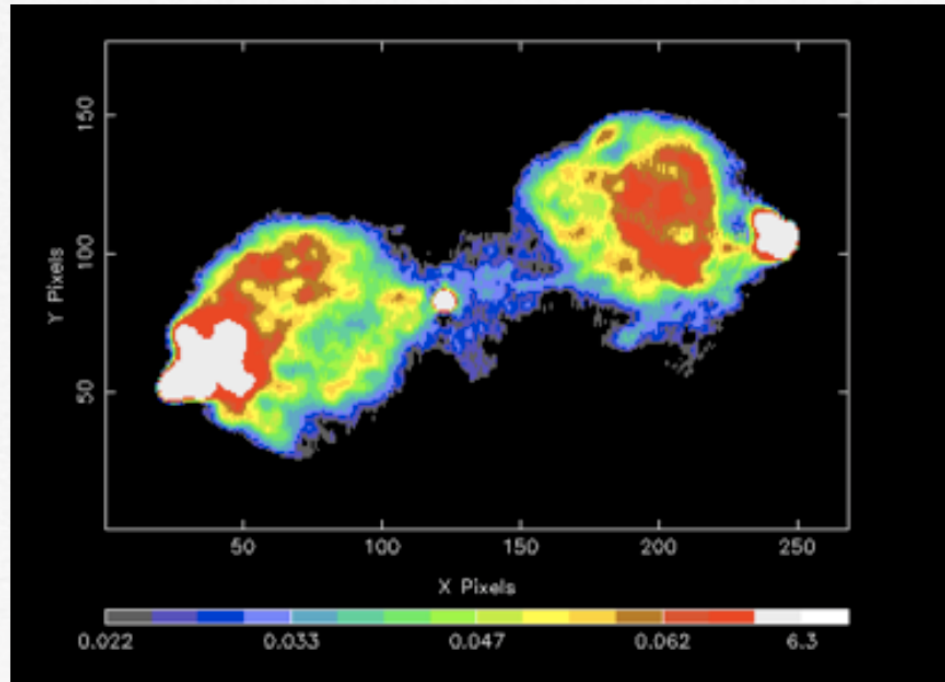
*Pictor A is a nearby ( $z=0.035$ ) radio galaxy optically classified as Broad Line Radio Galaxy. It is an isolated source.*





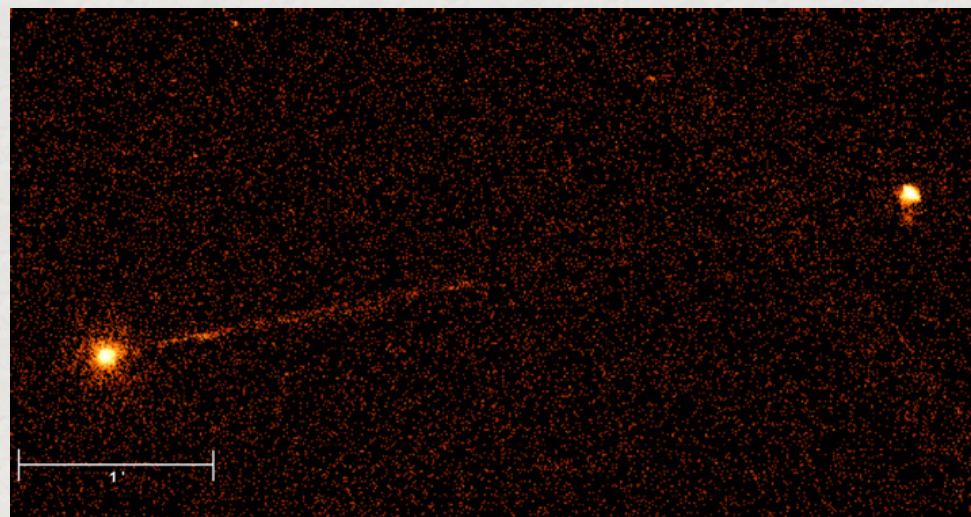
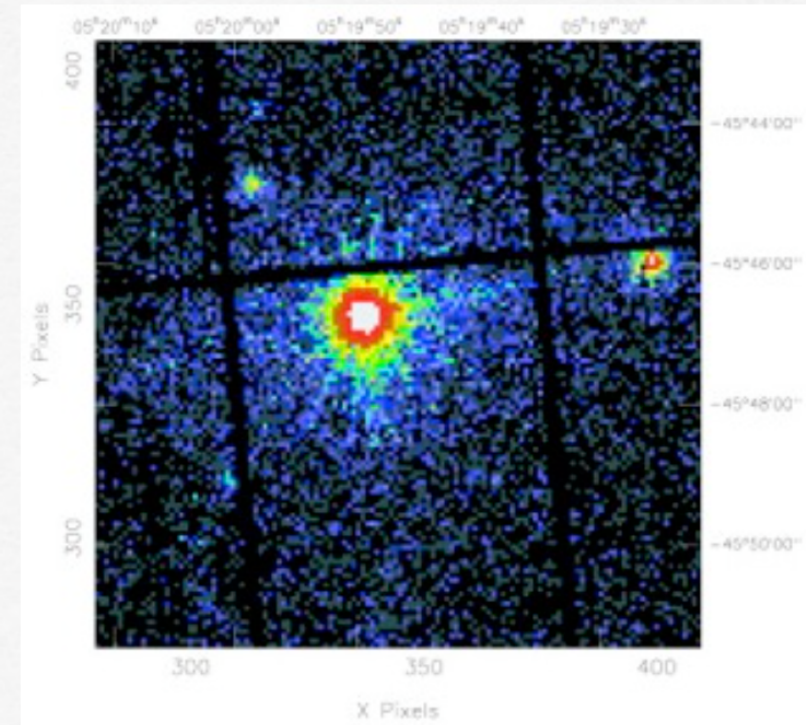
It is a double-lobed radio source with a FR II morphology

## VLA map 20cm



XMM/pn image.

## 0.2-12 keV



*Chandra*



# 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)



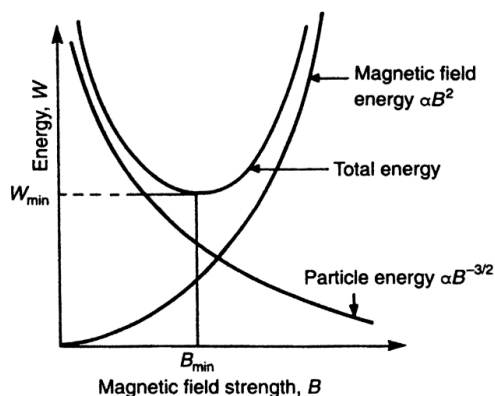
# Calcolo del Campo Magnetico

## Equipartition

$$W_{\text{total}} = G(\alpha)\eta L\nu B^{-3/2} + V \frac{B^2}{2\mu_0}$$

$$W_{\text{particles}} = G(\alpha)\eta L\nu B^{-3/2},$$

### Minimum Energy Requirements



The diagram shows the variation of the energies in particles and magnetic field as a function of  $B$ . There is a minimum total energy,

$$B_{\text{min}} = \left[ \frac{3\mu_0 G(\alpha)\eta L\nu}{2V} \right]^{2/7}$$

This magnetic field strength  $B_{\text{min}}$  corresponds to approximate equality of the energies in the relativistic particles and magnetic field. we find

$$W_{\text{mag}} = V \frac{B_{\text{min}}^2}{2\mu_0} = \frac{3}{4} W_{\text{partic}}$$

Thus, the condition for minimum energy requirements corresponds closely to the condition that there are equal energies in the relativistic particles and the magnetic field.

## X-ray - Radio Lobe Emission

Radio flux:

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

$$N(E) = kE^{-p} \quad \alpha = \frac{p-1}{2}$$

X-ray flux:

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



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

$$\alpha = \alpha_r = \alpha_x, \quad V = \text{volume}$$

*Magnetic Field calculation  
no a priori assumption*

$$B = [6.6 \times 10^{-40} (4800)^{-\alpha} (1+z)^{(3+\alpha)} F_R F_X^{-1} \nu_r^\alpha E_x^{-\alpha}]^{\frac{1}{1+\alpha}}$$

B [gauss]

$$F_R \propto \nu^{-\alpha}$$

$F_R$  is the flux density (in Jansky) at frequency  $\nu_R$  (GHz)

$F_X$  is the flux density in  $\text{erg cm}^{-2} \text{s}^{-1} \text{Hz}^{-1}$  at  $E_x$  (keV)



# References



- Grandi et al. 2003:* <http://adsabs.harvard.edu/abs/2003ApJ...586..123G>
- Perley et al 1997:* <http://articles.adsabs.harvard.edu/full/1997A%26A...328...12P>
- Migliori et al . 2007:* <http://adsabs.harvard.edu/abs/2007ApJ...668..203M>
- Miley 1980:* <http://articles.adsabs.harvard.edu/full/1980ARA%26A..18..165M>

**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**