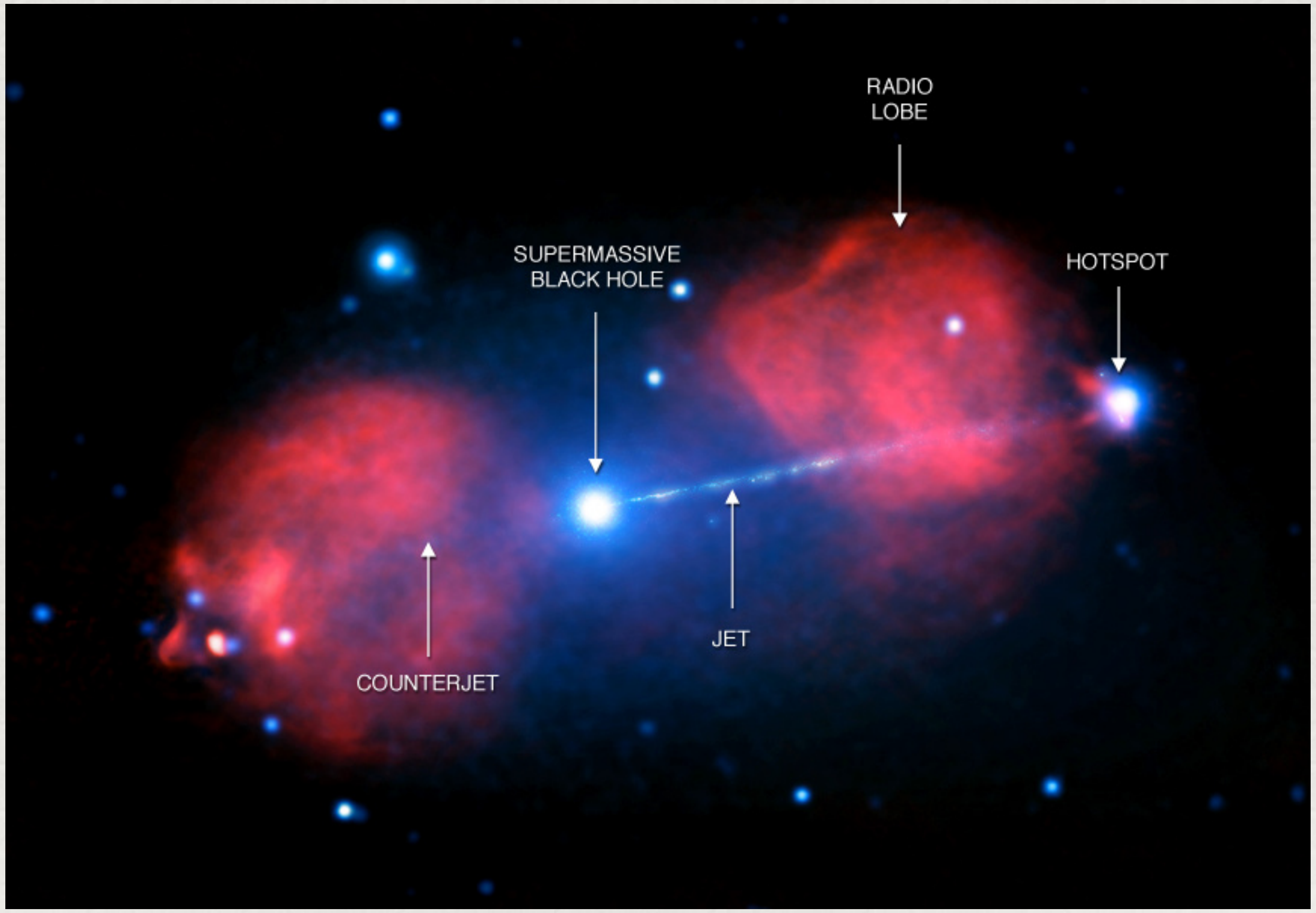
The Radio Galaxy Pictor A with XMM-Newton

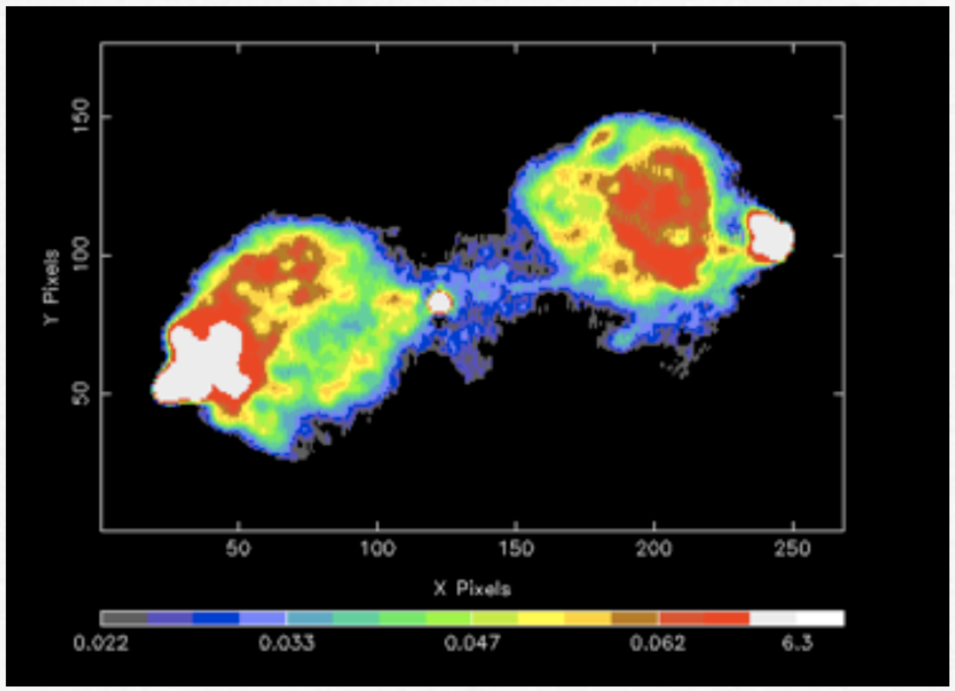
Pictor A is a nearby (z=0.035) radio galaxy optically classified as Broad Line Radio Galaxy. It is an isolated source.



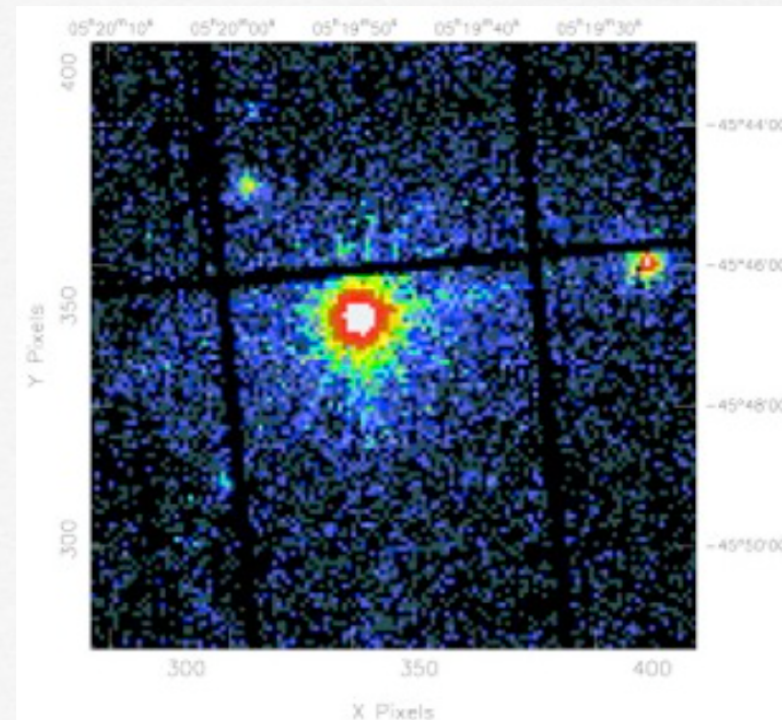
It is a double-lobed radio source with a FR II morphology

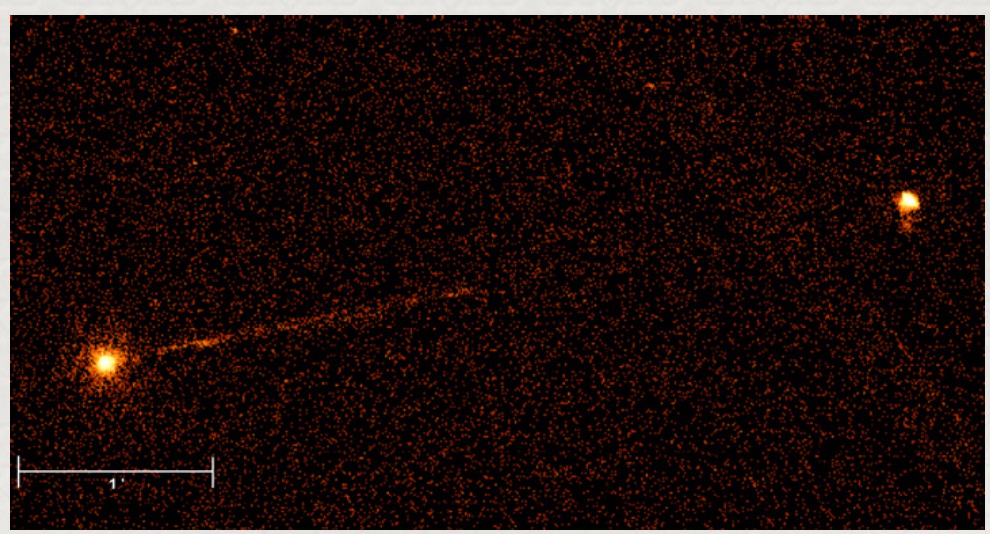
XMM/pn image.

VLA map 20cm



0.2-12 keV





Chandra

Analysis of the Pictor A nucleus

Observation:2005 January 14
Exposure time ~ 50 ksec
Use MOS2 camera to analyse the nucleus

1. Superposition of the X-ray and radio images (DS9) to individuate the region emitting in both X-ray and radio bands

2. Nucleus Analysis:

- filtering event list for flaring particle background;
- production of the light curve and check of time variability;
- spectrum extraction;
- production of the ARF and RMF files (response matrices);
- pile-up check;
- spectral analysis with XSPEC: definition of the best model;
- estimation of the parameter uncertainties;
- production of (68%, 90%,))% contour plots;
- calculation of the (unabsorbed) flux and luminosity.

Optional

1. Study of the eastern lobe with MOS1

- spectrum extraction (extraction region + radio flux provided);
- production of the ARF and RMF files (response matrices);
- spectral analysis with XSPEC: definition of the best model;
- estimation of the parameter uncertainties;
- production of (68%, 90%) contour plots;
- calculation of the (unabsorbed) flux and luminosity.

2. Determination of the magnetic field in the eastern lobe.

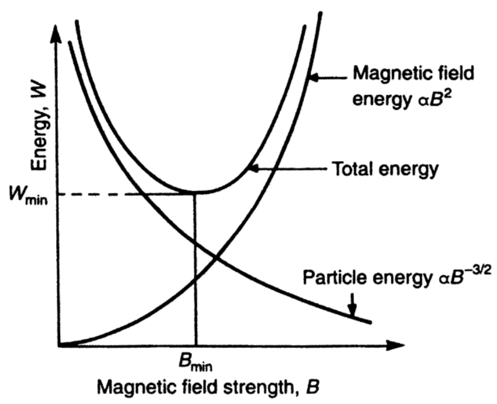
Calcolo del Campo Magnetico

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,

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

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

we find

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

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:

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

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

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

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 ν_R (GHz)

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

References

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