A Large Scale Jet in PKS 1127-145

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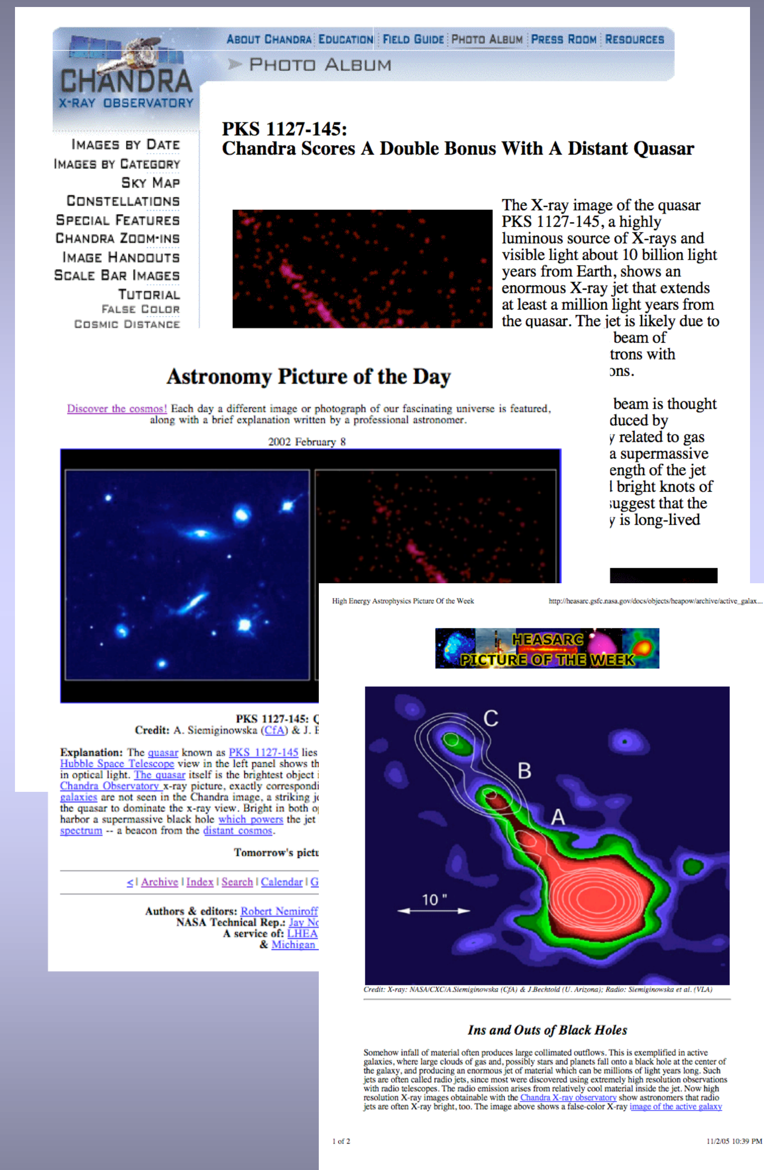
PKS 1127-145 Jet

- **PKS1127-145** z=1.18 is a radio-loud Quasar
- AO1 Chandra Observation **revealed** a large scale jet

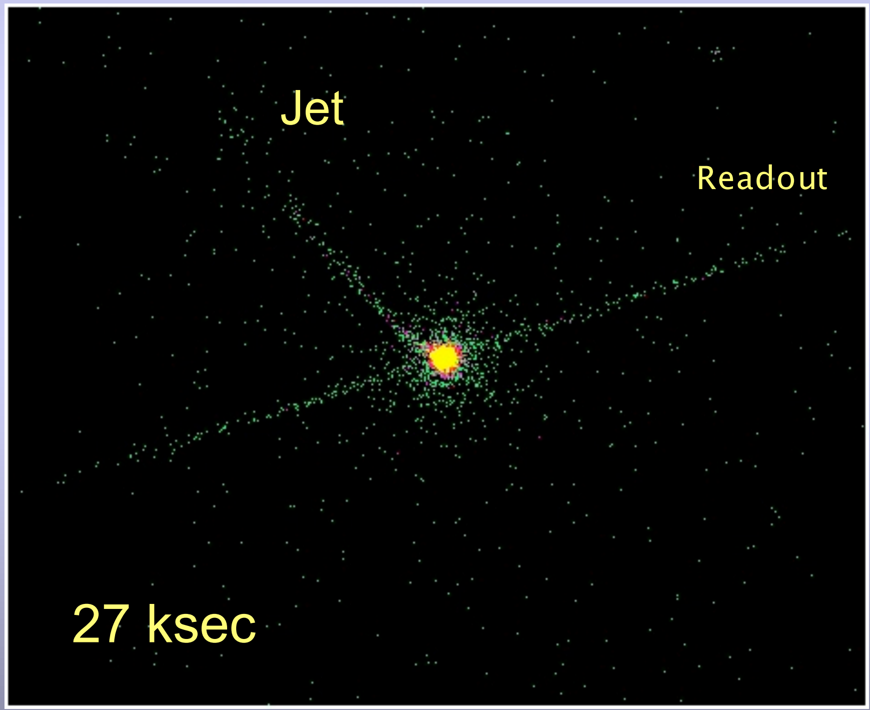
  $\sim 300(\sin\theta)^{-1}$ kpc
- $L_{jet}/L_{core} < 1\ \%$
- $U_{CMB}(z) = U_0(1+z)^4$

  z=1.18 => 9.75e-12 erg cm^{-3}



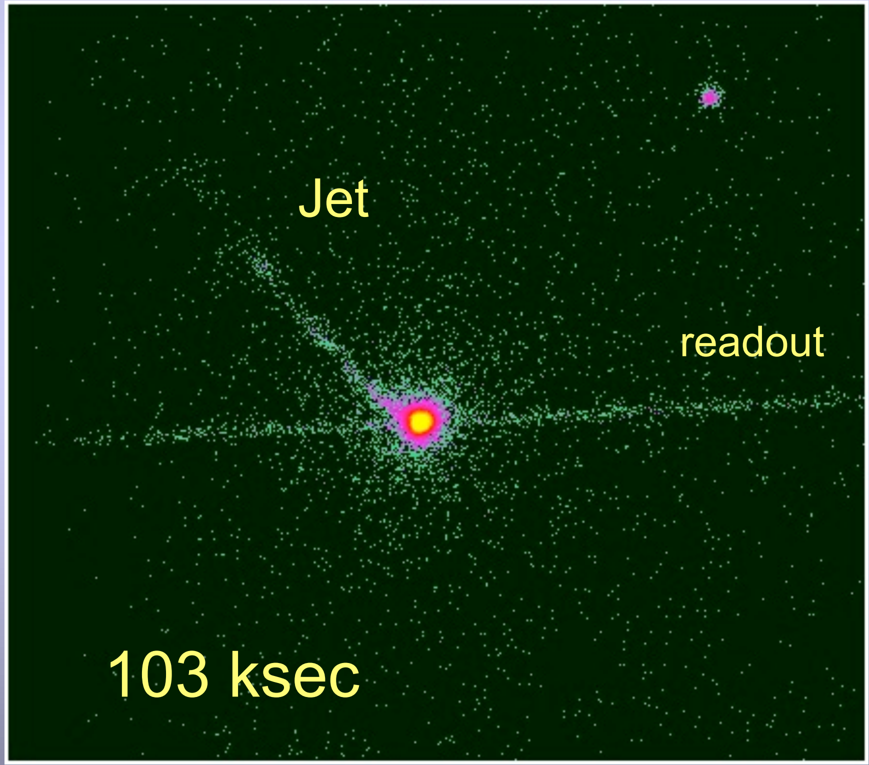
Chandra Observations of PKS 1127-145

AO1 May 2001

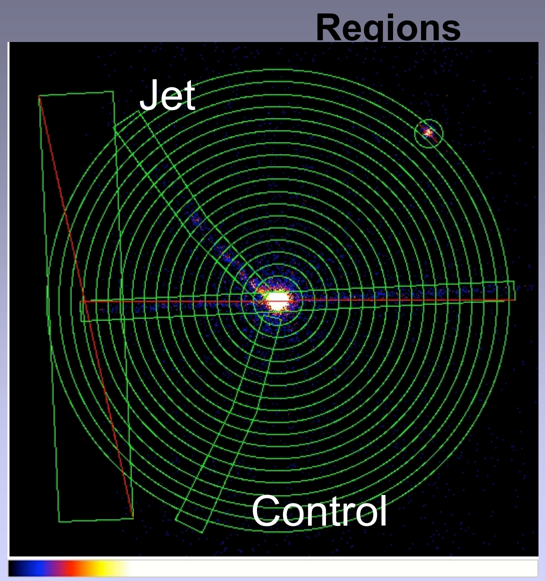


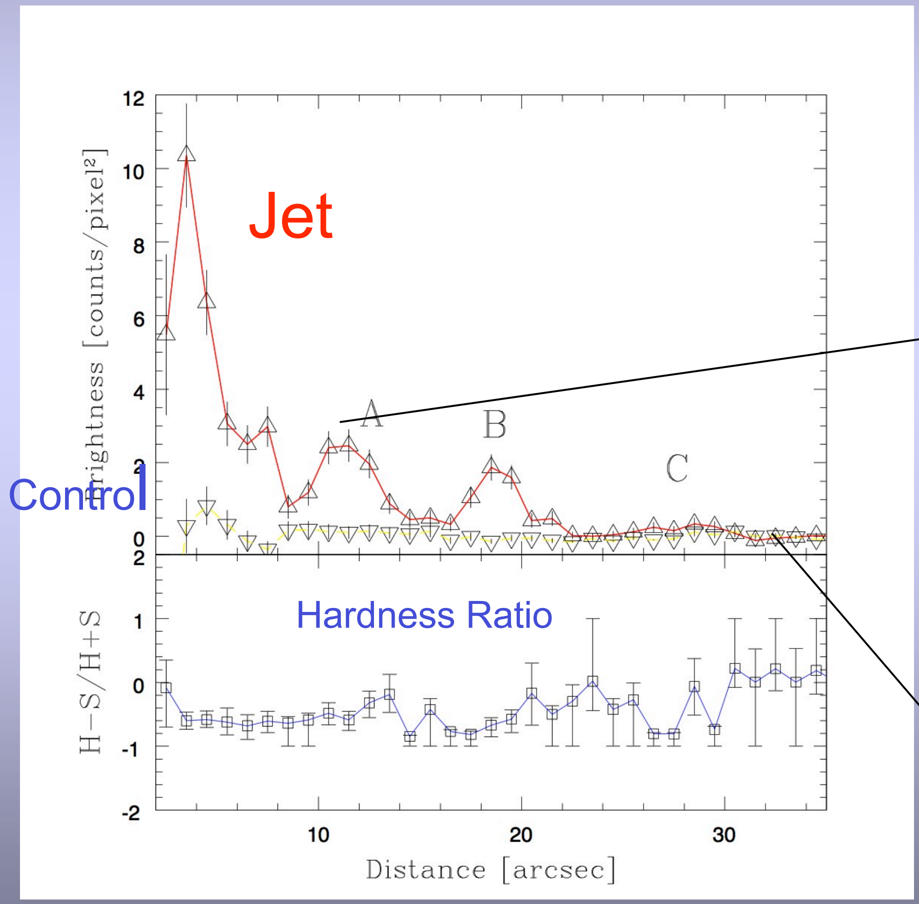
0.3-7 keV

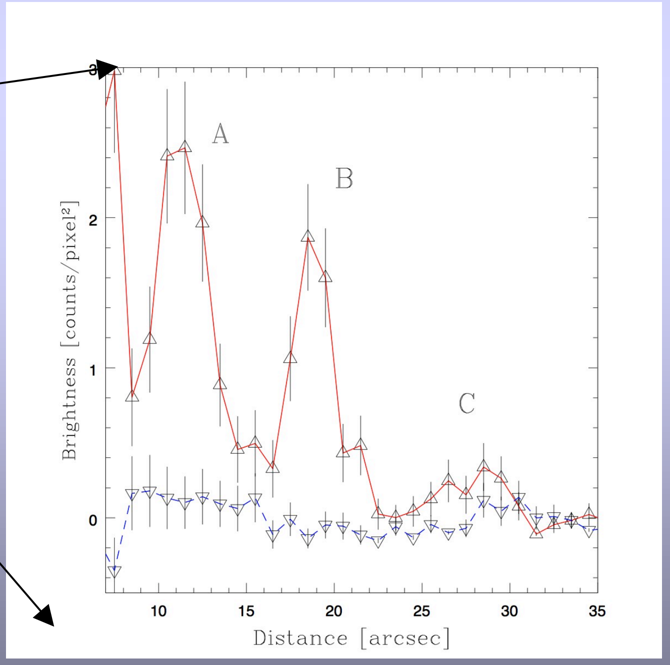
AO6 April 2005



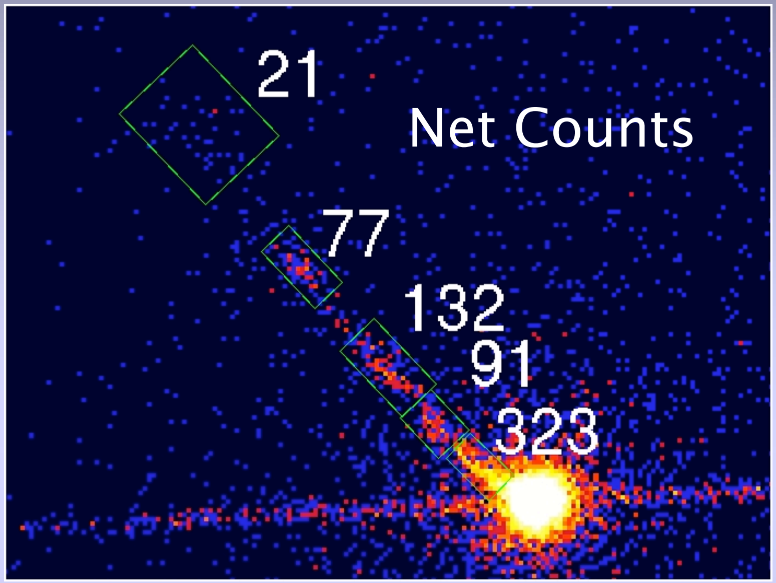
X-ray Jet Profile







X-ray Jet Parameters



Fitting Power Law Model:

Box	Γ	
I	$1.67^{+/-0.11}$	Flat
o	$1.69^{+/-0.19}$	
A	$1.66^{+/-0.15}$	
B	$2.0^{+/-0.2}$	Steep
C	$2.2^{+/-0.6}$	

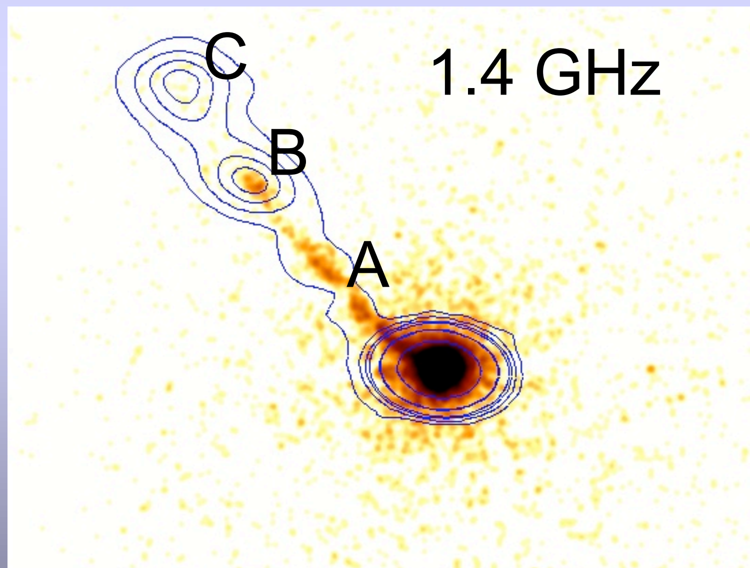
Radio Jet

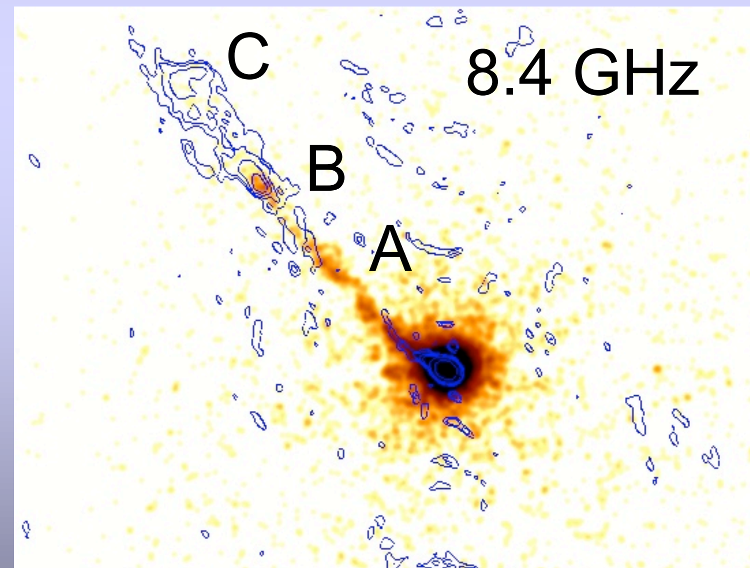
* Very weak radio jet with the radio intensity increasing outwards.

* Spectral index flattens at the outer knots (α_r~ 0.8)

* Knot A < 2.5mJy at 8.4GHz (α_r>1.5)

* ~10% polarization at knot C

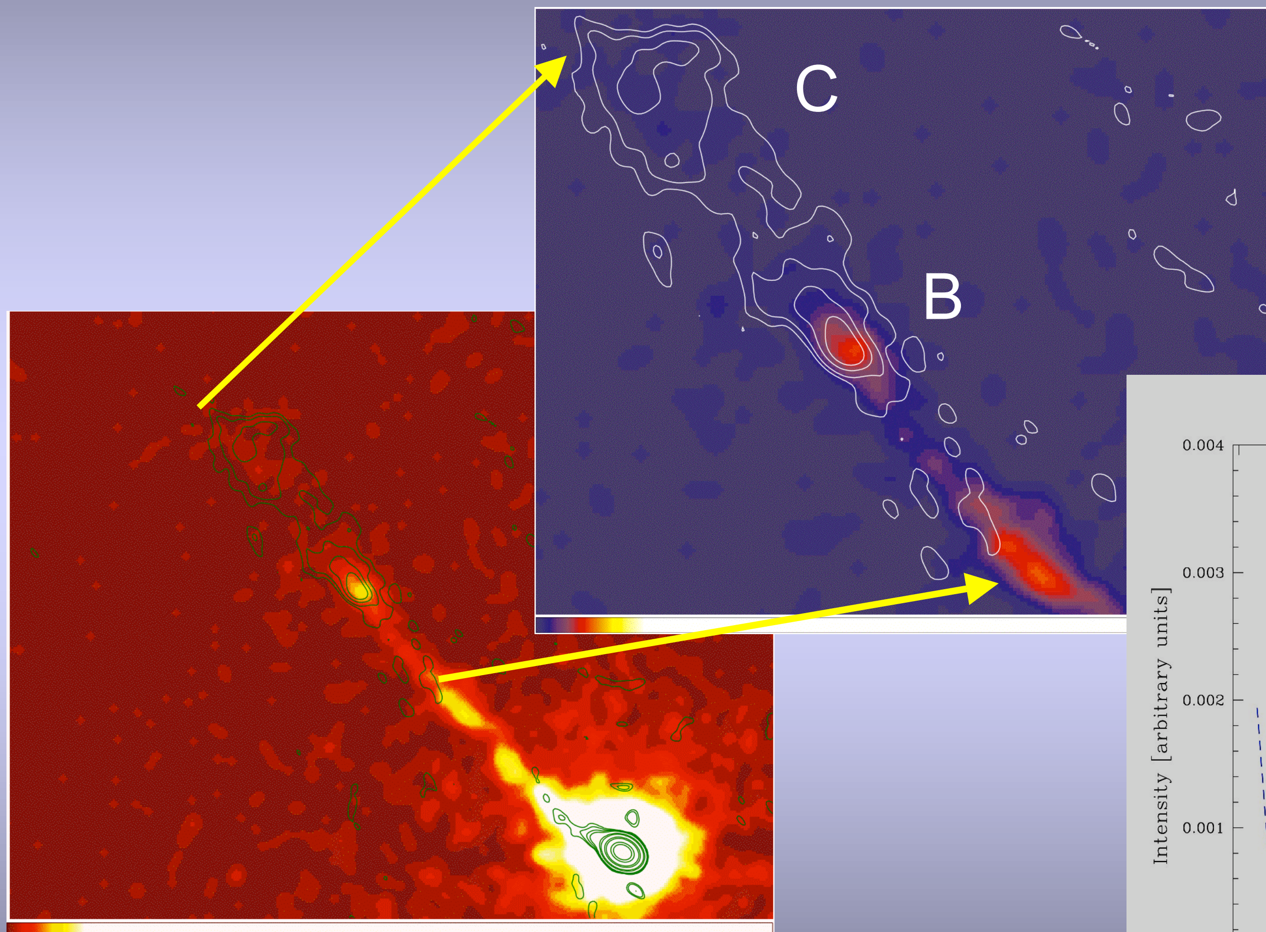




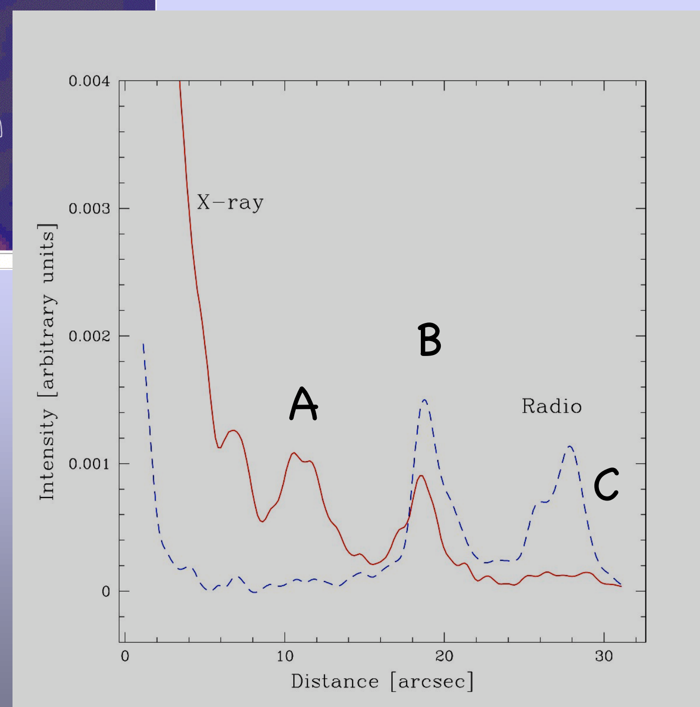
ACIS-S Images overlayed with Contours of radio emission

X-ray & Radio Emission

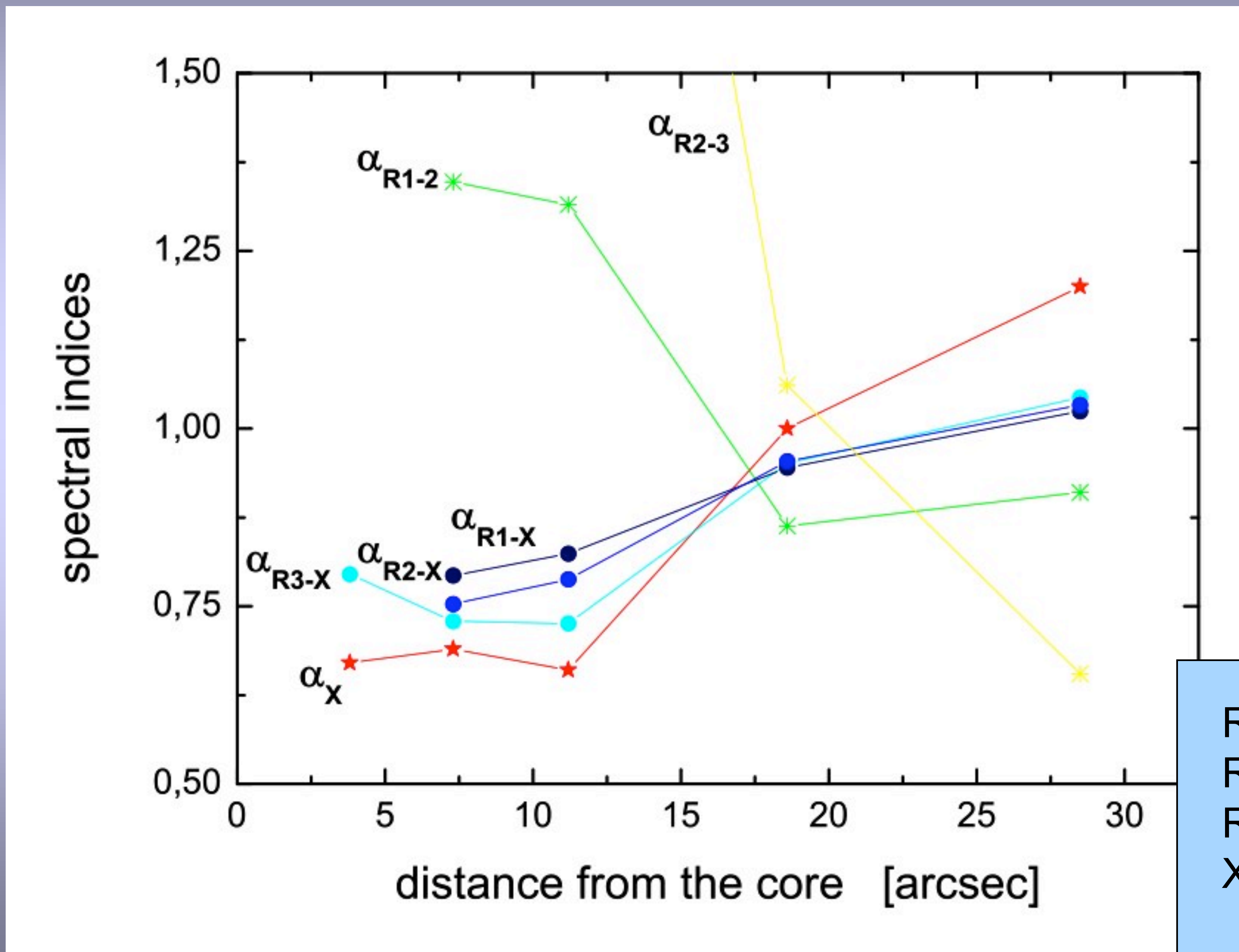
Knot B:
X-ray preceeds
Radio by 0.2arcsec



8.4GHz Radio - contours

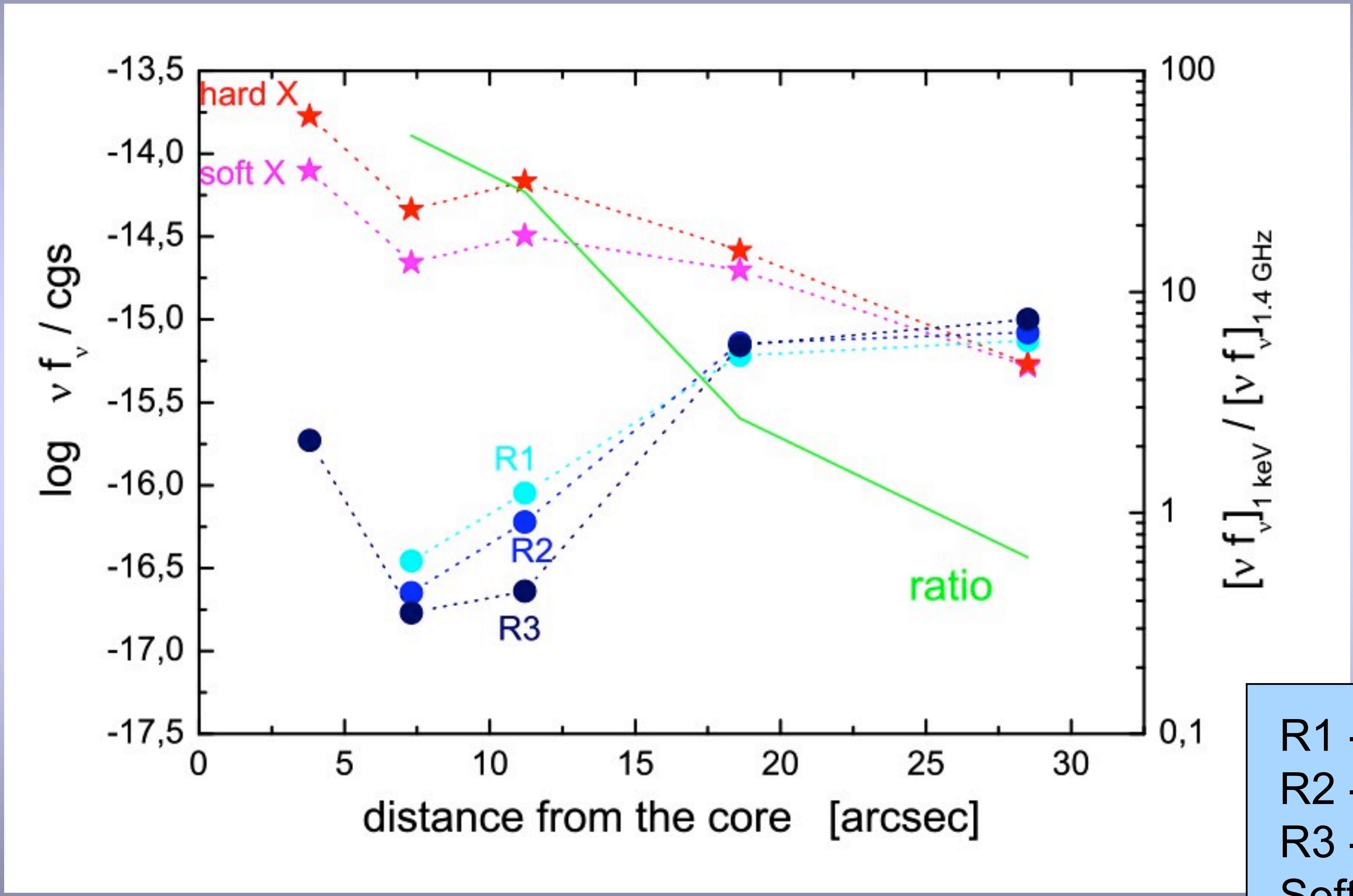


X-ray & Radio Emission: Spectral Index



R1 - 1.4GHz
R2 - 4.9GHz
R3 - 8.5GHz
X - 2keV

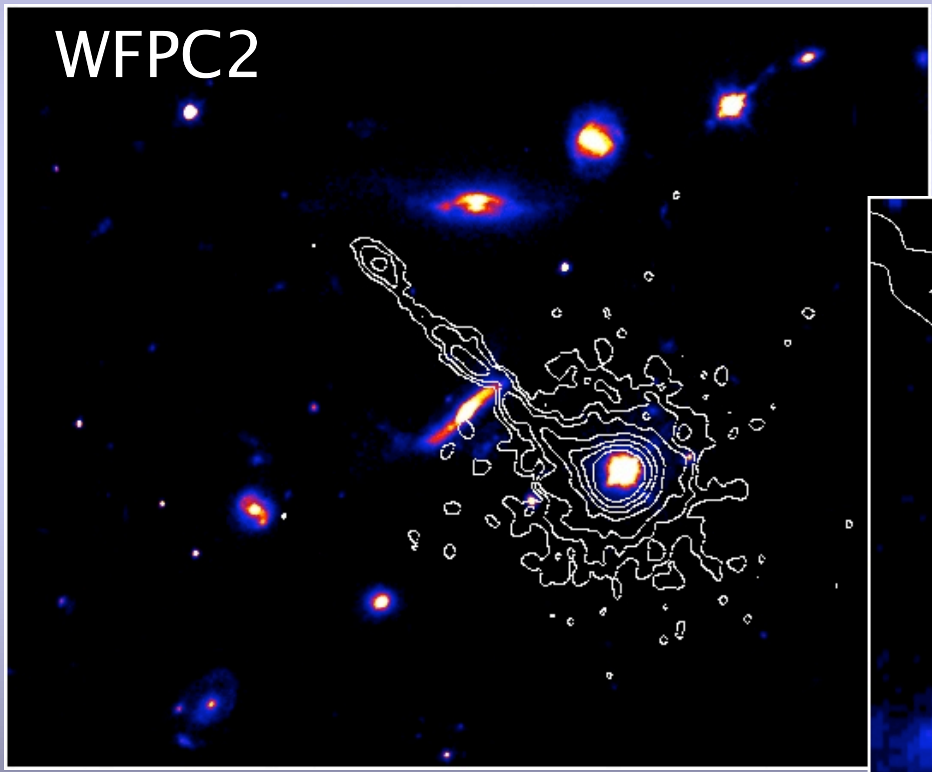
X-ray & Radio Emission: Flux



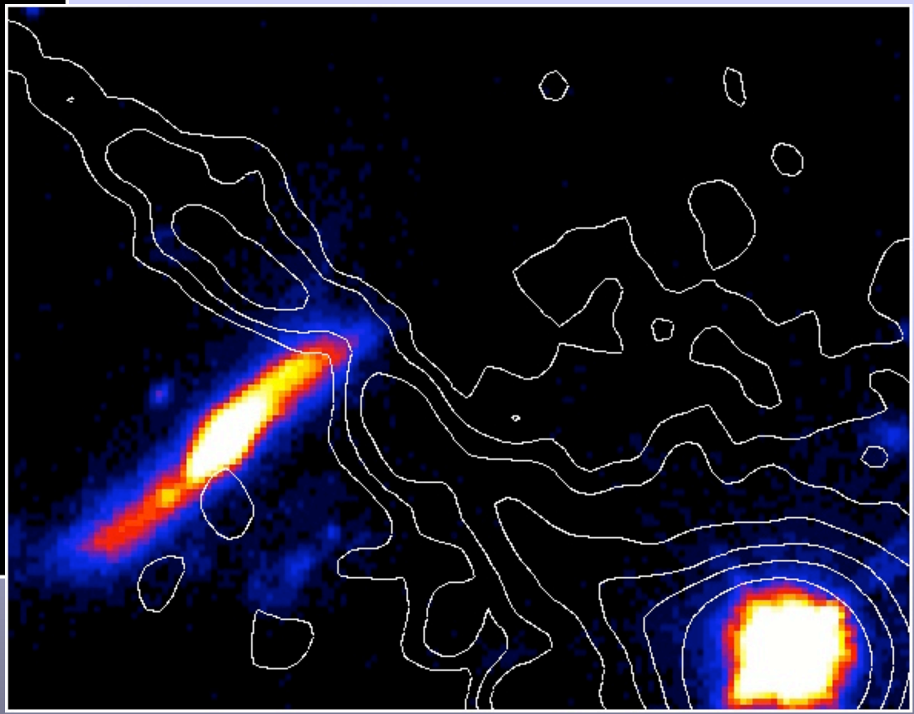
R1 - 1.4GHz
R2 - 4.9GHz
R3 - 8.5GHz
Soft - 0.3-2 keV
Hard - 2-7 keV

Optical/X-ray Images

Absorption of the X-ray Jet by a large Spiral Galaxy at z=0.312?
⇒ NO! Bent internal to the Jet
⇒ Observed in Radio and X-ray!



Contours show ACIS-S data



Issues for Modeling the Jet X-ray Emission

- Decrease in X-ray Flux
- Increase in Radio Flux
- Steepening of X-ray continuum along the jet:

  Inner Jet: $\alpha_x = 0.6$

  Outer Jet: $\alpha_x > 1.0$
- Flattening of Radio Continuum along the jet:

  Inner Jet: $\alpha_R > 1.5$

  Outer Jet: $\alpha_R = 0.8\text{-}0.9$
- L_x/L_R ratio varies along the jet in a non-uniform way.

One-Zone Inverse Compton Model:

- **IC/CMB Model:**
  - **Compton scattering of CMB photons on cold (γ~100) electrons .**

    At the equipartition condition high $\Gamma \geq 10$ (jet bulk Lorentz factors) are required at low redshifts. At z=1.18 for PKS1127-145 U_{CMB} is high, so $1 < \Gamma < 3$.

BUT .....

PKS 1127-145 Jet Morphology and Spectral properties give problems:

- **Knotty morphology**

  => long cooling times (>10^9yr for γ~100), so knots are hard to explain if the jet kinetic power has to be constant

- **Difference between X-ray and Radio Spectral Indices**

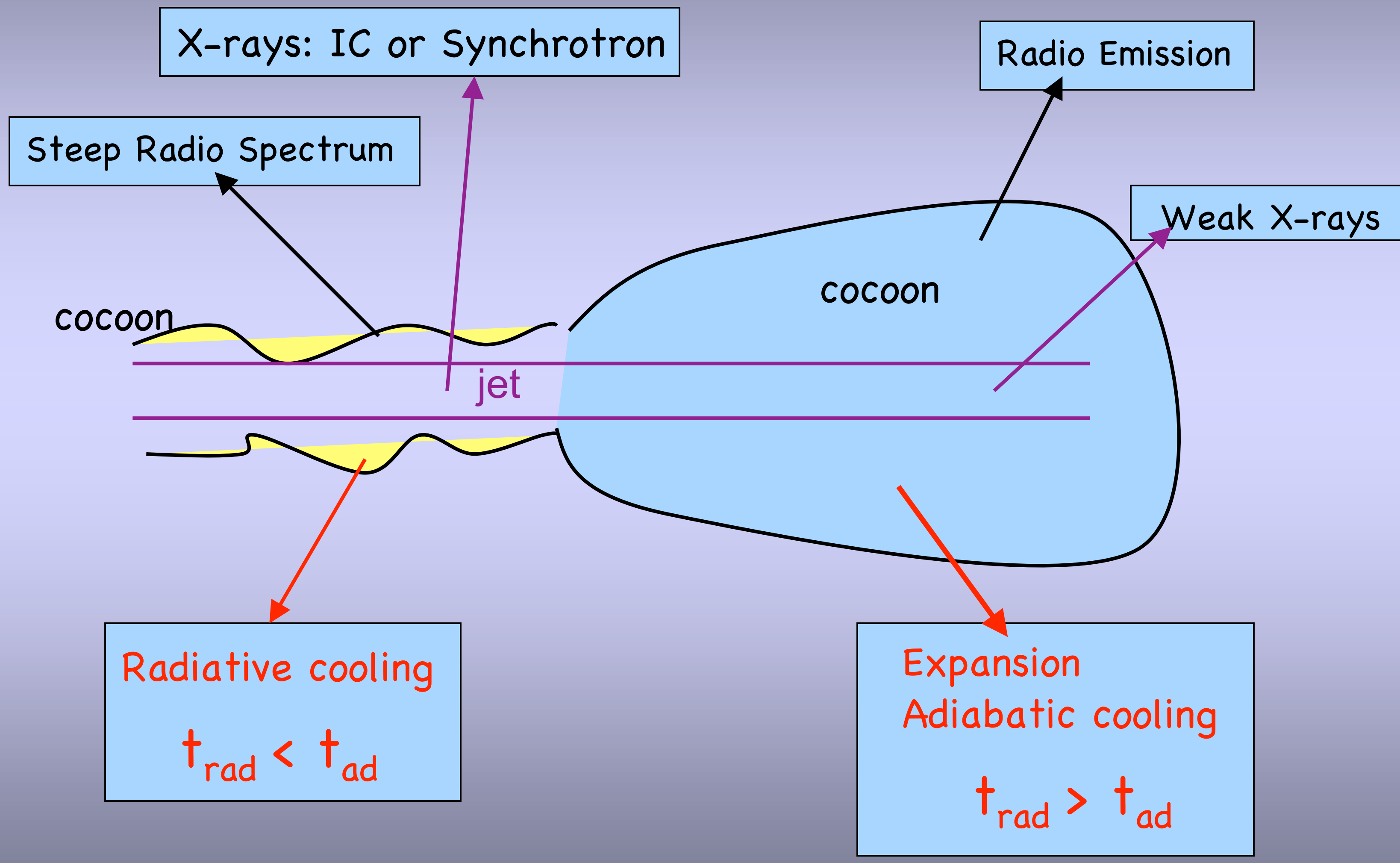
  => electron energy of X-ray emitting electrons lower than the radio electrons, so the X-ray spectra should follow radio spectra or be constant along the jet.

- **Adiabatic Expansion -> B-field conserved**
  - Both IC/CMB X-ray emission and Synchrotron Radio emission should decrease
  - But in PKS 1127-145 the luminosity ratio L_X/L_R varies along the jet!
  - => No adiabatic expansion
- **Amplification of B-field with no expansion:**
- **Radiative Cooling**

One-Zone Synchrotron Model

- Non homogenous models
  => different electron populations
- Require **effective** and **continuous acceleration** to high energies (E_e~100 TeV) along the entire jet.
- Acceleration process is not clear:
  => turbulent acceleration?
  => magnetic reconnection?
  ⇒ multiple shocks?
- No adiabatic expansion (as seen for the IC/CMB model)
- Requires **very high amplifications** of the B field!
  X-ray/Radio (0→r) => $\delta^{5/2} B^{1/2}$
  => $B_r/B_0 > 100$

Two-Component Model: Jet+Cocoon

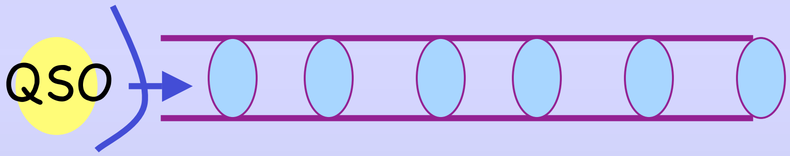


Modulated Jet Activity

QSO Intermittent Activity

=> Modulated Jet Ejections

=> Different spectral and spatial evolution of Radio and X-ray Emission



Jet duration Time linked to the QSO activity timescale to Create a jet => 10^5 years for PKS1127-145

Total Power in one episode: 2.5e58 erg

L_{Edd} = 9e46 erg/sec => $Mdot_{Edd}$ ~ 1.5 M_{sun}/yr

Summary

- Chandra Deep Image of the PKS 1127-145 Jet provides data for detailed analysis of the knots: **Inner jet regions** show **flatter** X-ray spectra than the **outermost regions** of the Jet.
- Jet **Radio emission is very weak** and the jet becomes weaker (non-detectable at 8.4GHz) at the strong X-ray emission of knot A.

  => X-rays are more efficient for jets studies
- The **offsets** between X-ray and radio brightness, which were detected in the AO1 data are not present.
- **Constraints on the jet X-ray emission models**: one zone model cannot explain the morphology and spectral properties of the jet in PKS1127-145.
- **Two-zone** models are promising, although the constraints on model parameters are not easily obtained from the current observations.