Modeling X-ray emission of a straight jet: PKS0920-397

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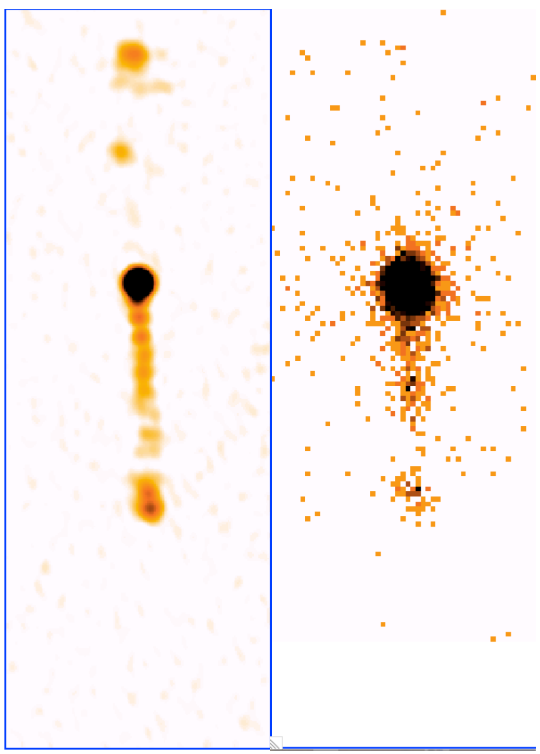
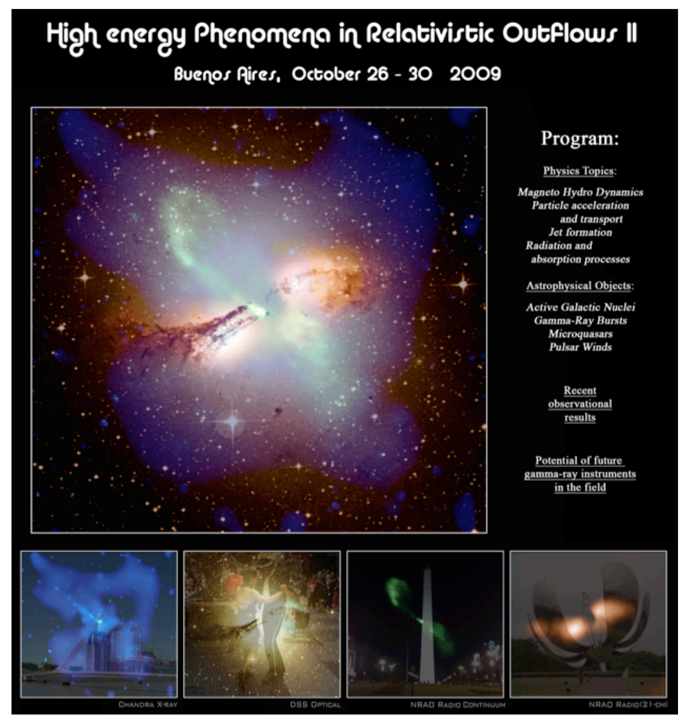


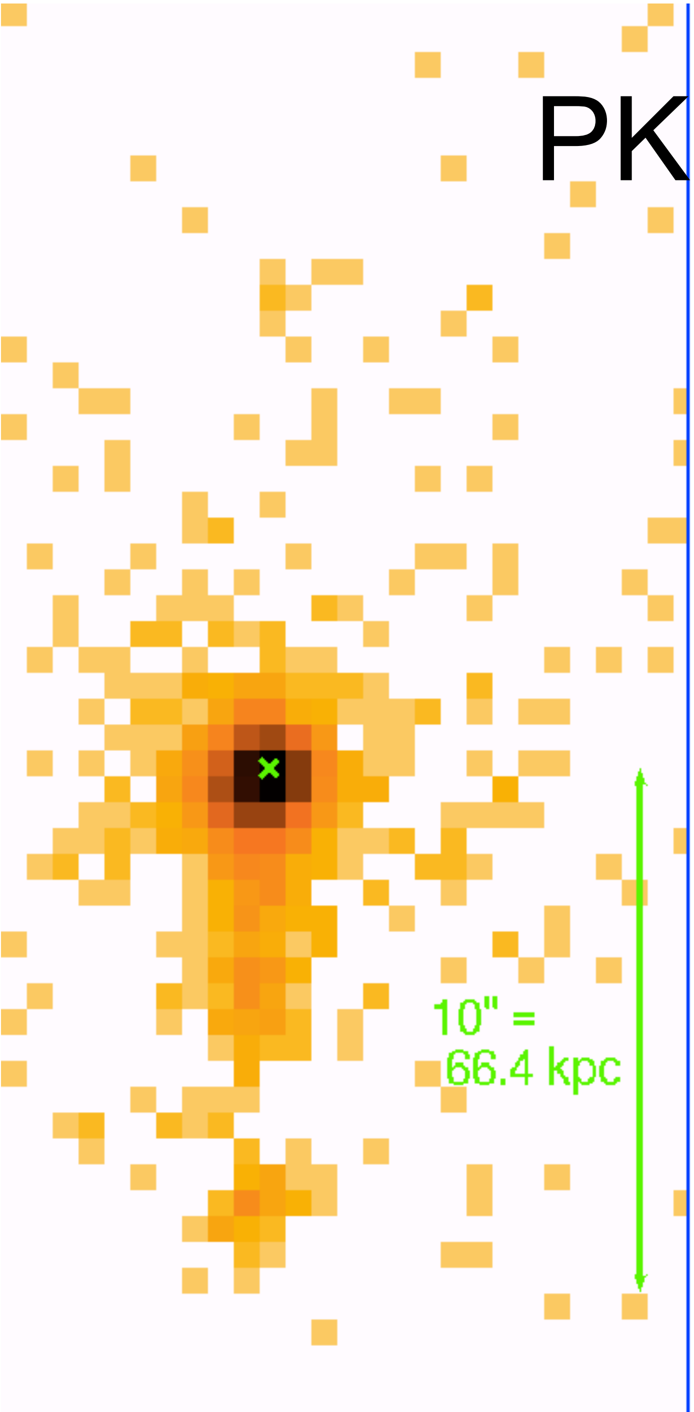


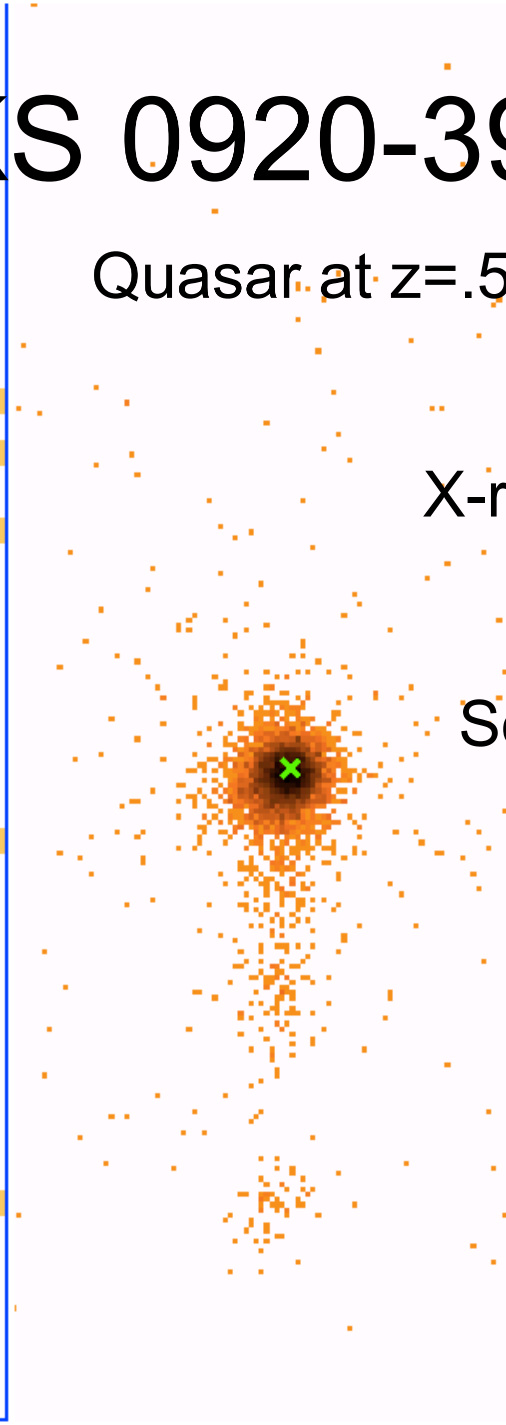
Chandra observations of relativistic quasar Jets: PKS 0920-397

- Assume X-rays from inverse Compton scattering of the CMB by the same relativistic electron population emitting synchrotron radio.
  - Energy in the electron spectrum: fix γ_{min} instead of ν_{min}
  - Relativistic transformations for "supersnapshot"(Jester`08)

- Physical properties depend on resolving the δ, Γ, θ uncertainty
  - Bulk Lorentz factor Γ
  - Rest frame Magnetic field H
  - Kinetic Flux $\propto H^2\Gamma^2$

PKS 0920-397





Quasar at z=.591

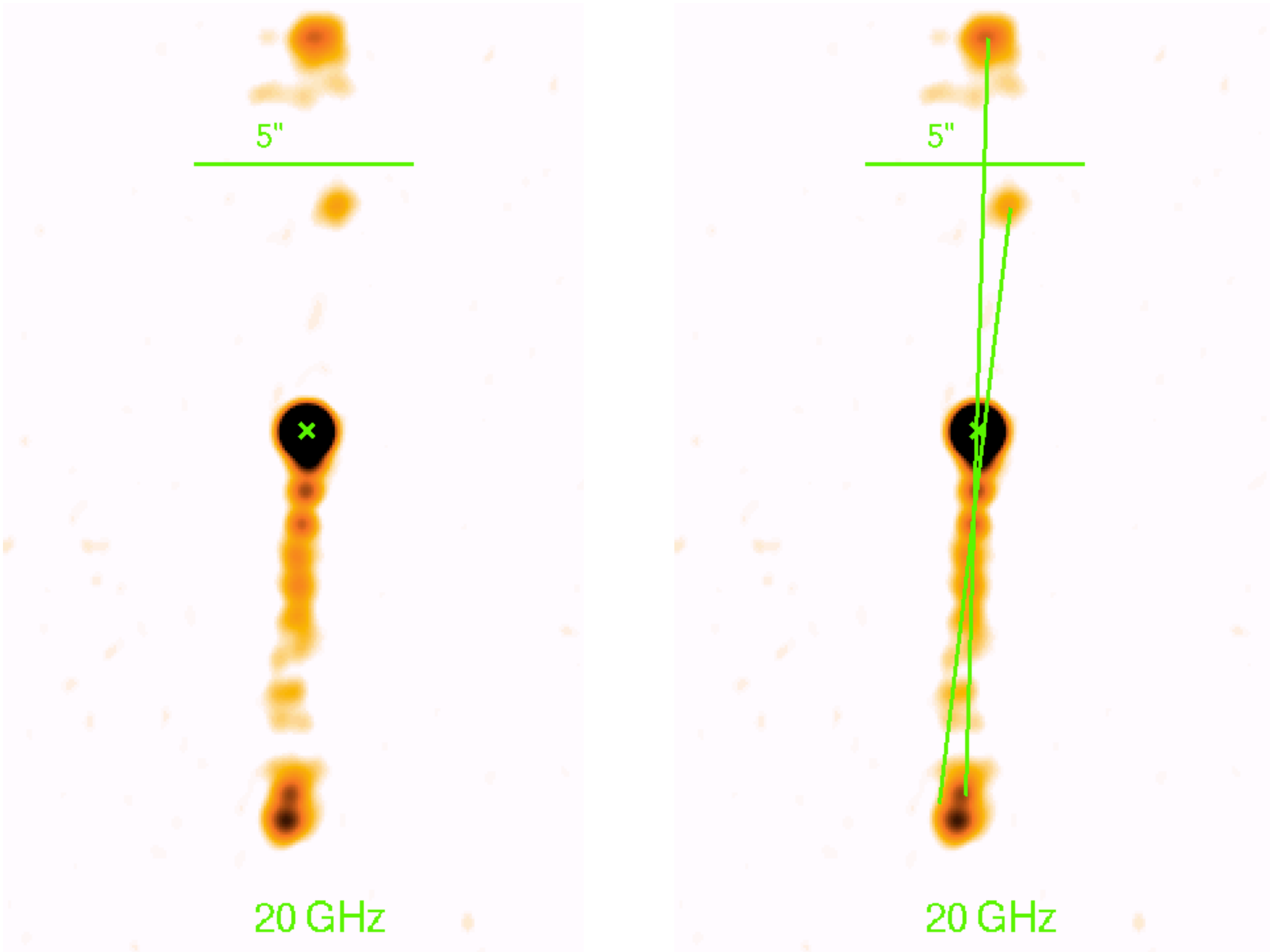
X-ray Luminosity:

Quasar = 2.2×10^{45}

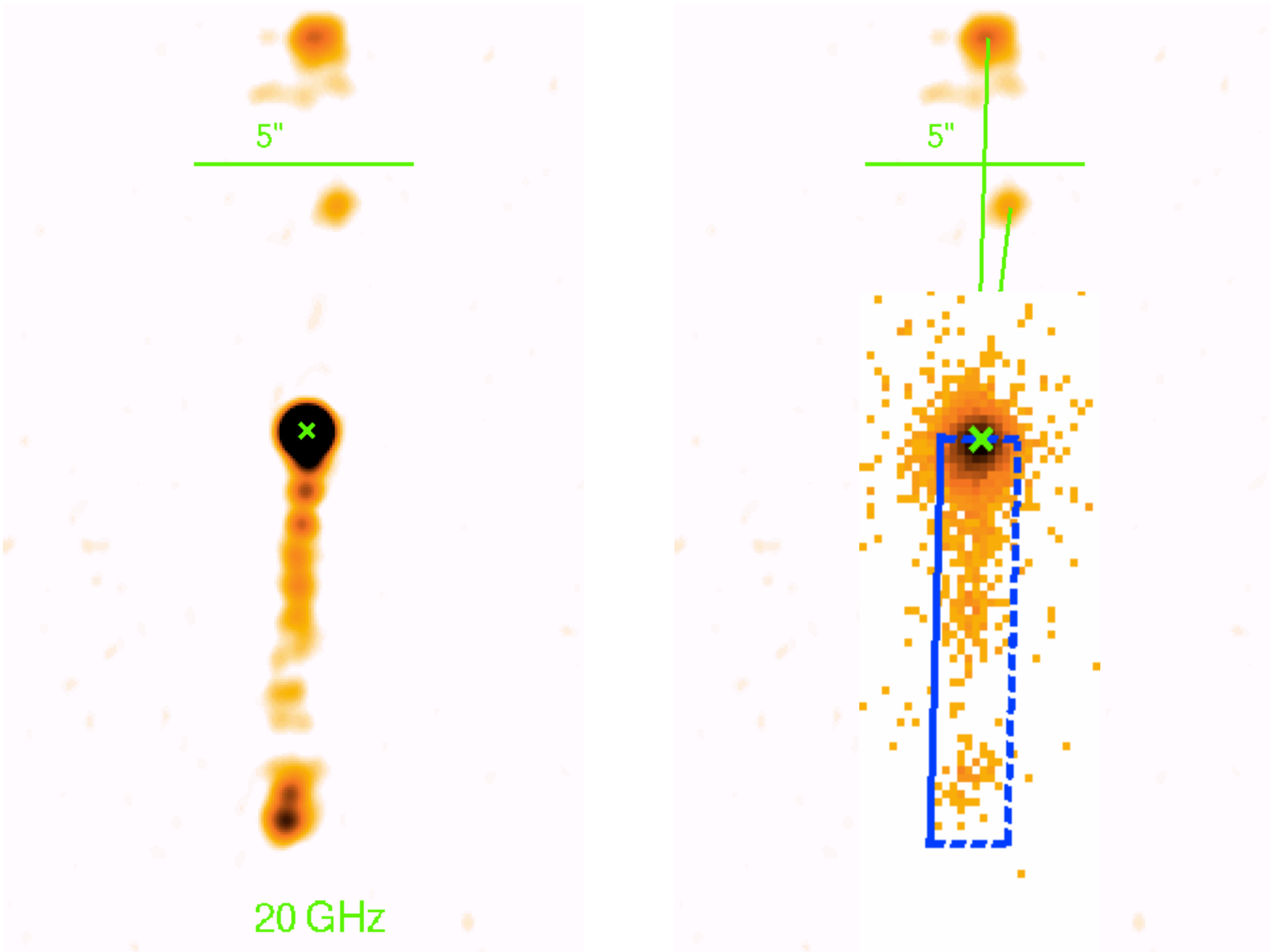
Jet = 8.1×10^{43}

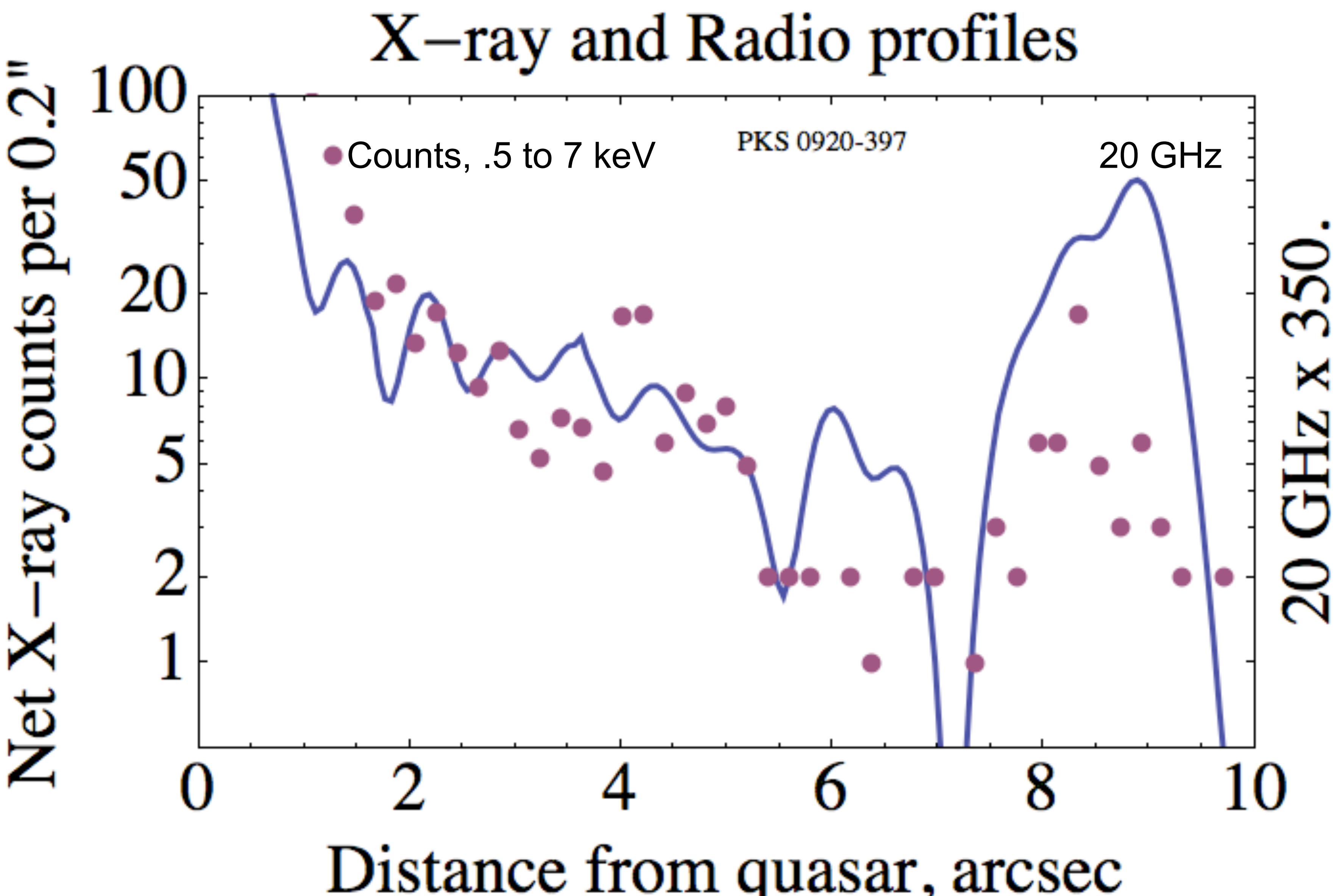
South lobe = 2×10^{43}

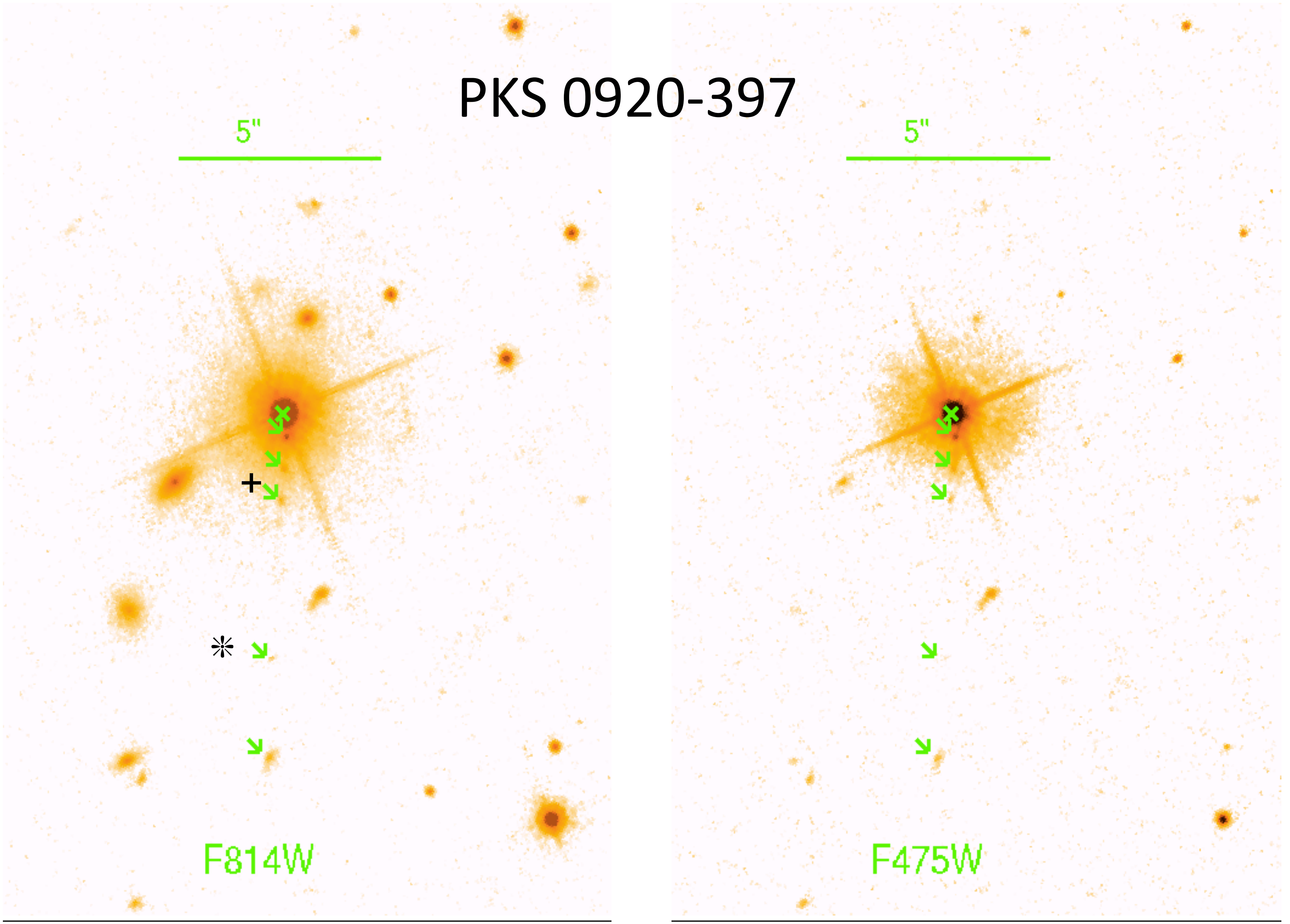
0.5 to 7 keV

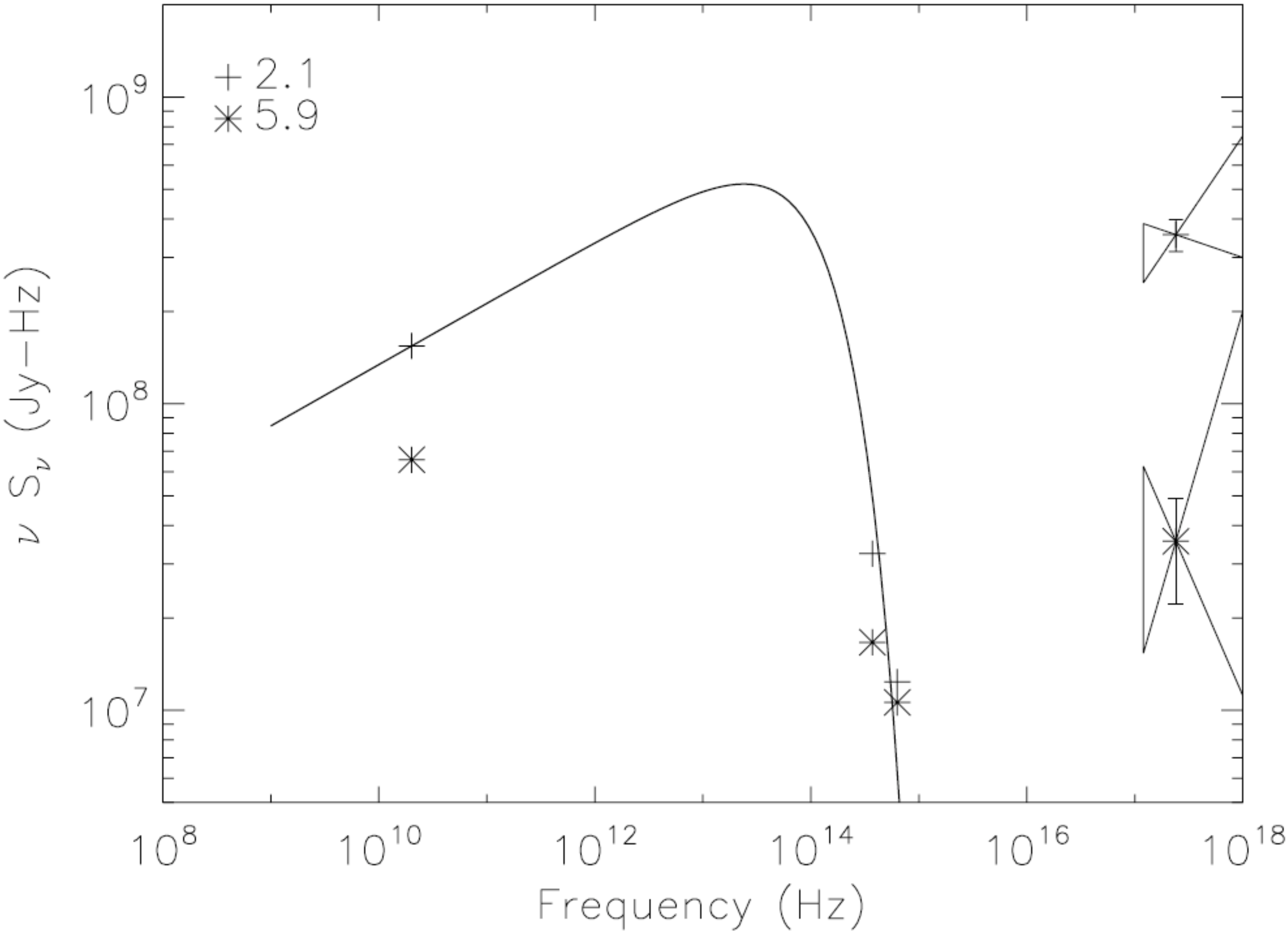


5"
20 GHz
5"
20 GHz

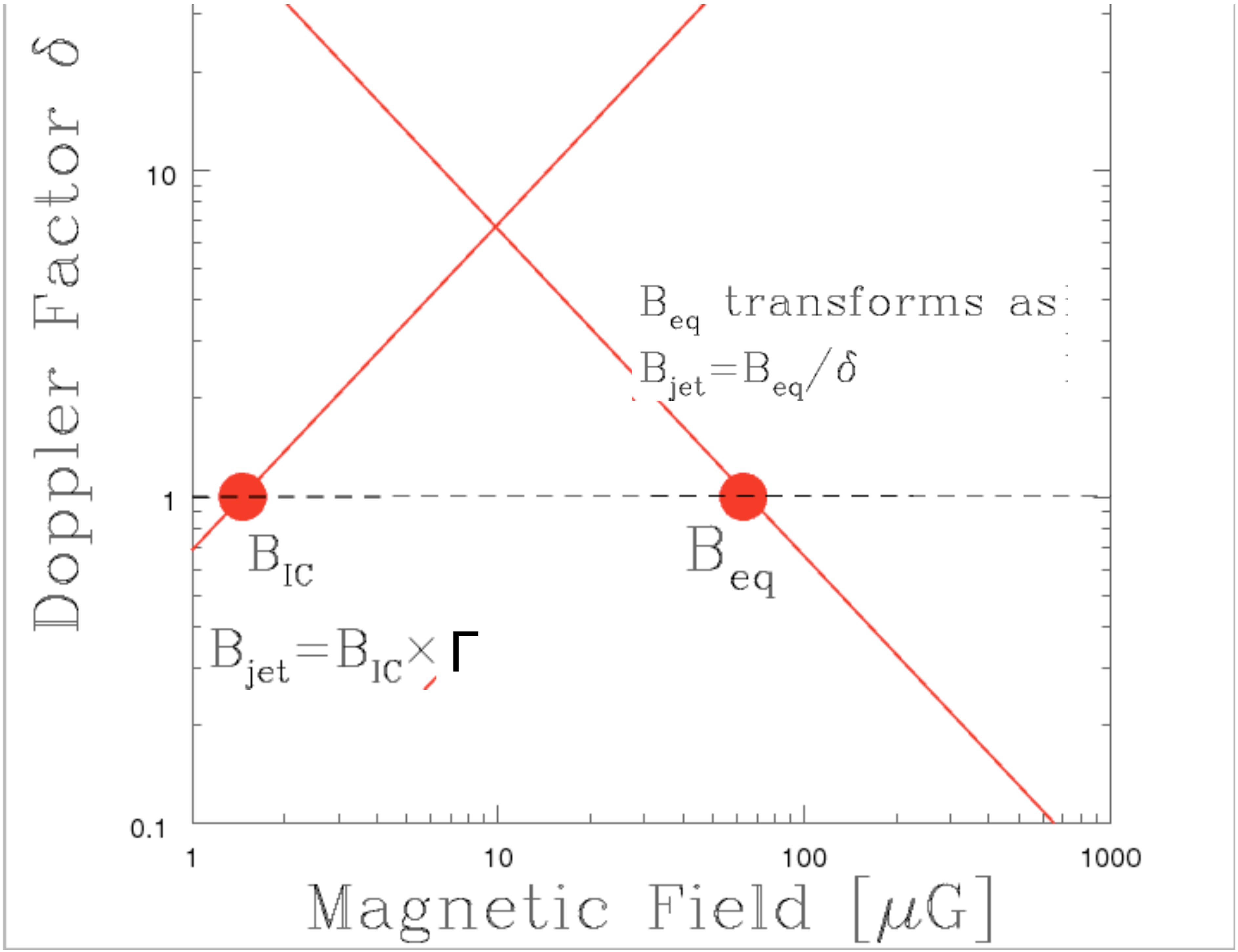

5"
20 GHz
5"


X–ray and Radio profiles
Counts, .5 to 7 keV
PKS 0920-397
20 GHz
Net X–ray counts per 0.2"
100
50
20
10
5
2
1
20 GHz x 350.
0
2
4
6
8
10
Distance from quasar, arcsec


PKS 0920-397
5"
5"
F814W
F475W



+ 2.1
✳ 5.9
$\nu\ S_\nu$ (Jy−Hz)
10^9
10^8
10^7
10^8
10^{10}
10^{12}
10^{14}
10^{16}
10^{18}
Frequency (Hz)



Doppler Factor δ
Magnetic Field [μG]
10
1
0.1
1
10
100
1000
B_eq transforms as
B_jet=B_eq/δ
B_IC
B_eq
B_jet=B_IC× Γ

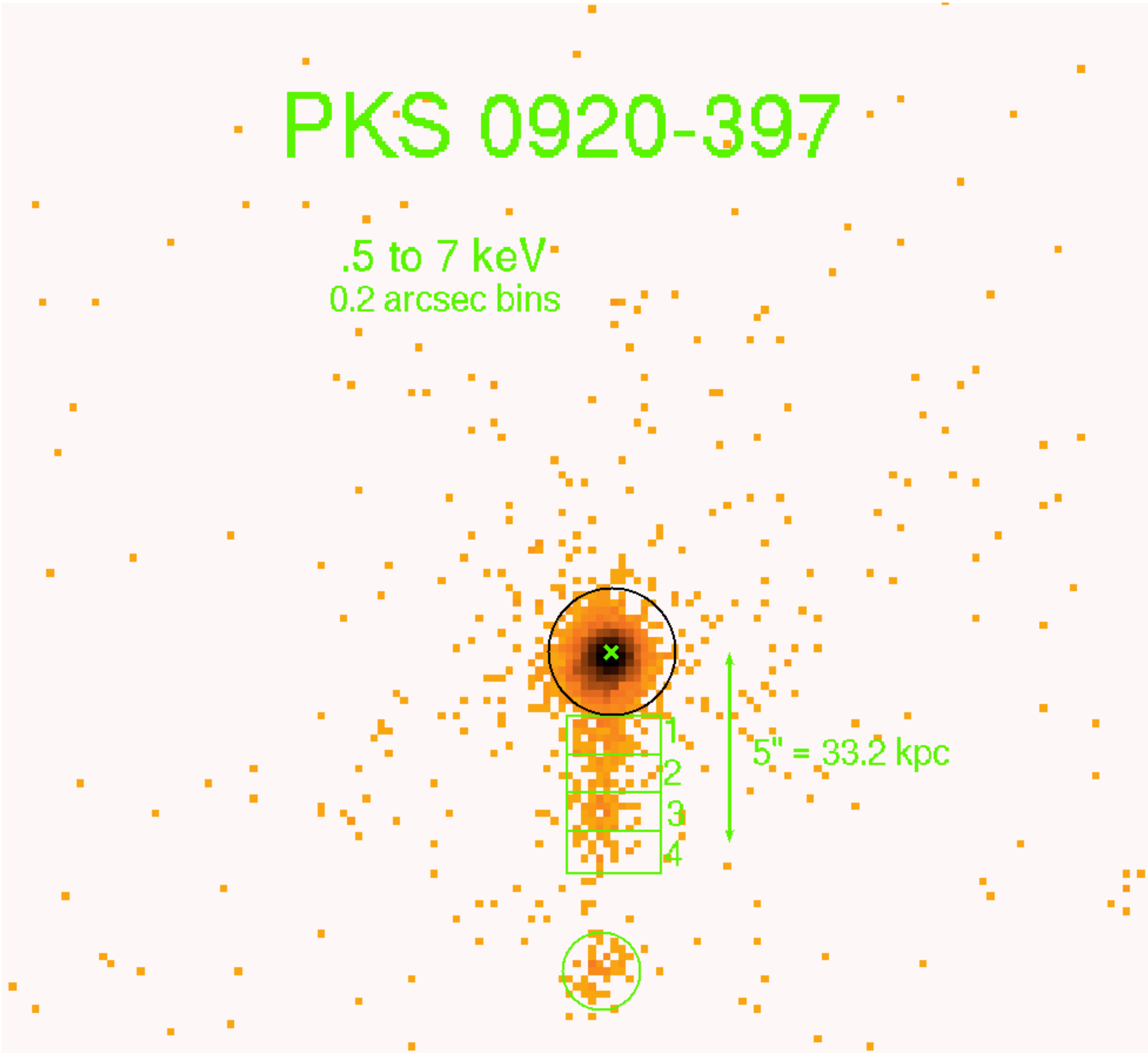
Calculation of H and δ

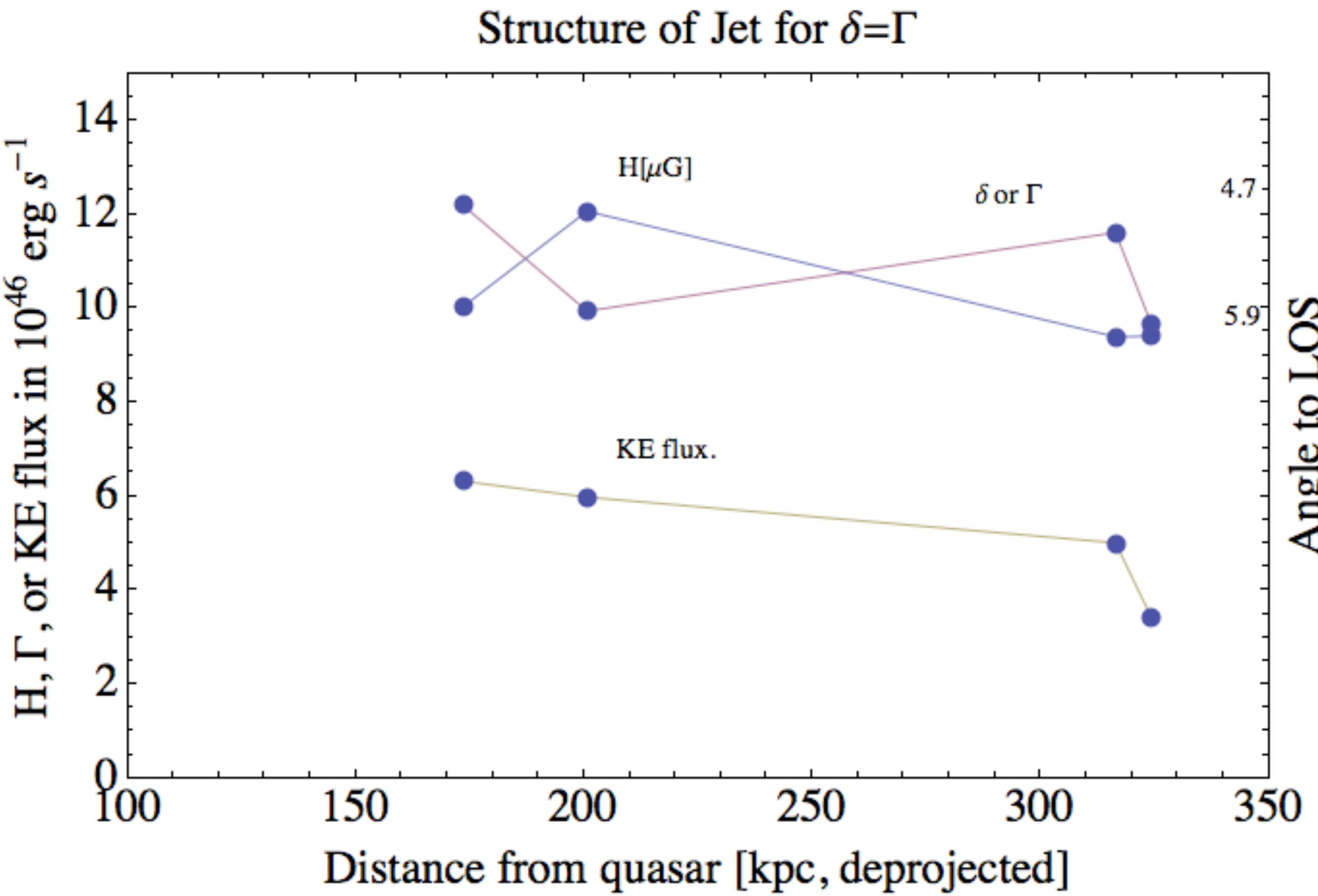
- Assume Minimum Energy
  - Fixed observed frequencies: $H \propto \left(\frac{L_S\, \nu_1^{0.5-\alpha}\, \nu_2^{-1+\alpha}}{Vol}\right)^{2/7}$
  - Fixed electron spectrum: $H \propto \left(\frac{\nu\, L_\nu\, \left(\gamma_{max}^{1-2\alpha} - \gamma_{min}^{1-2\alpha}\right)}{Vol}\right)^{\frac{1}{3+\alpha}}$
- Require Relativistic beaming to produce IC/CMB X-rays
- Jester Formulas:

$$Vol = Vol_{obs} / (\delta \sin(\theta))$$

$$L_S = L_{obs}\, \delta^{-4}$$

$$L_\nu \propto \frac{S_{\nu,obs}}{\delta^3}$$


PKS 0920-397
.5 to 7 keV
0.2 arcsec bins
1
2
3
4
5" = 33.2 kpc


Structure of Jet for δ=Γ
H[μG]
δ or Γ
4.7
5.9
KE flux.
H, Γ, or KE flux in 10^46 erg s^-1
Angle to LOS
Distance from quasar [kpc, deprojected]
0
2
4
6
8
10
12
14
100
150
200
250
300
350

In general, $\Gamma \neq \delta$

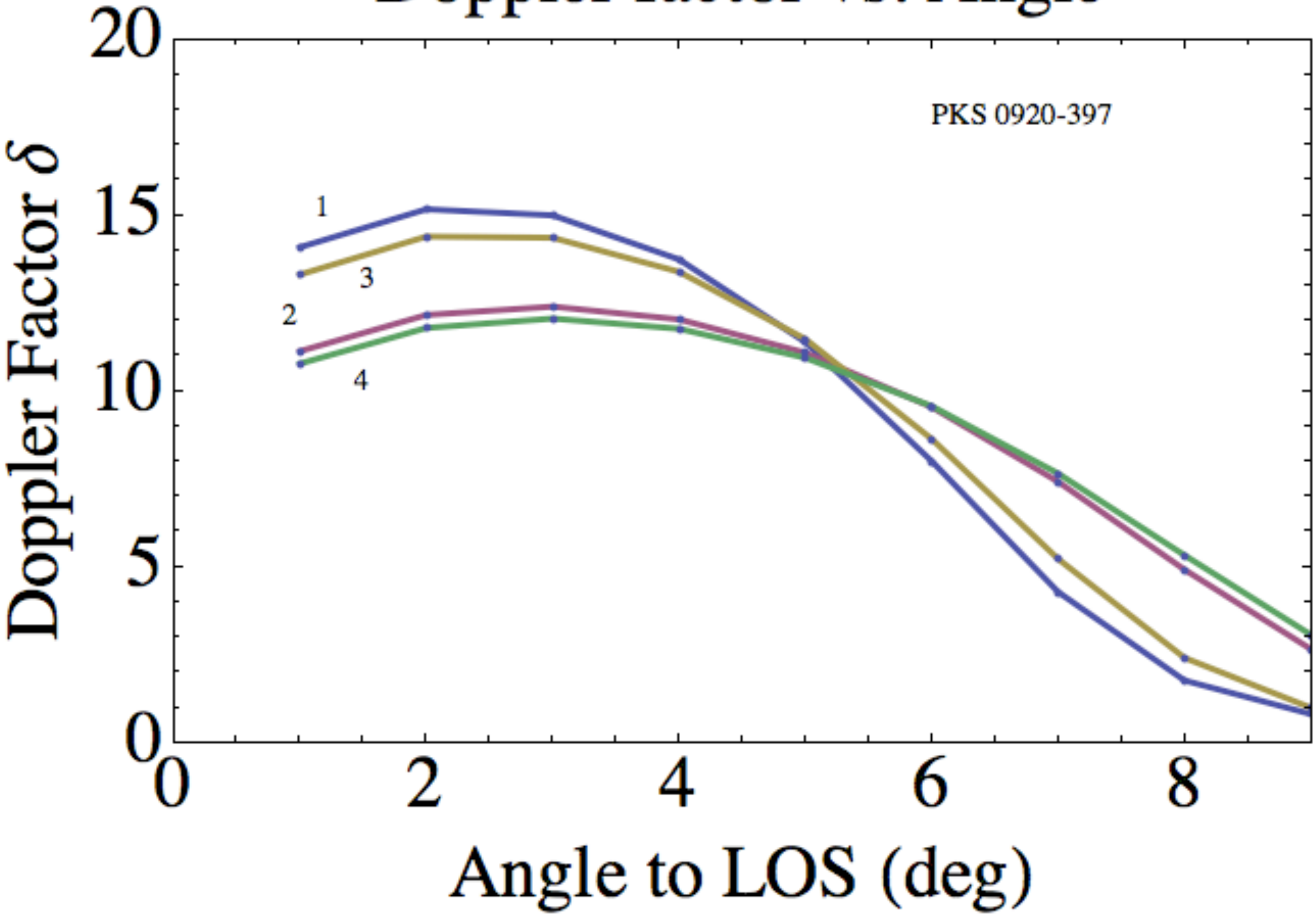
$$\mathbf{H_{min}} \propto \left(\frac{\mathbf{f_\nu} \left(\frac{1}{\delta}\right)^{2+\alpha} \mathbf{Sin}[\theta]}{\theta_1 \, \theta_r^2} \right)^{\frac{1}{3+\alpha}}$$

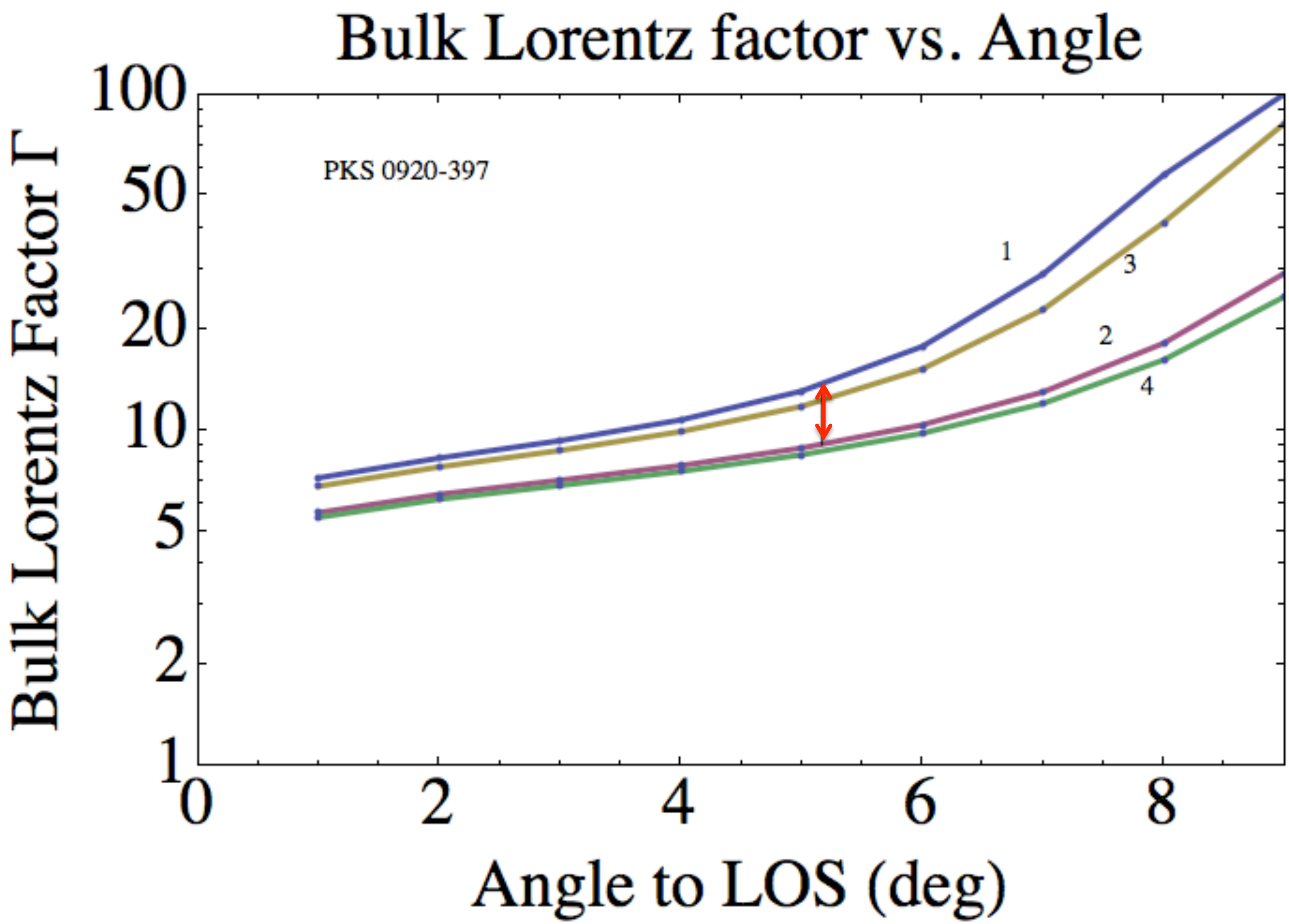
$$H_{cmb} = \Gamma \, H_{FM}$$

$$H_{cmb} = H_{min}$$

$$\delta = 1/(\Gamma(1-\beta \cos\theta))$$

Doppler factor vs. Angle




Bulk Lorentz factor vs. Angle
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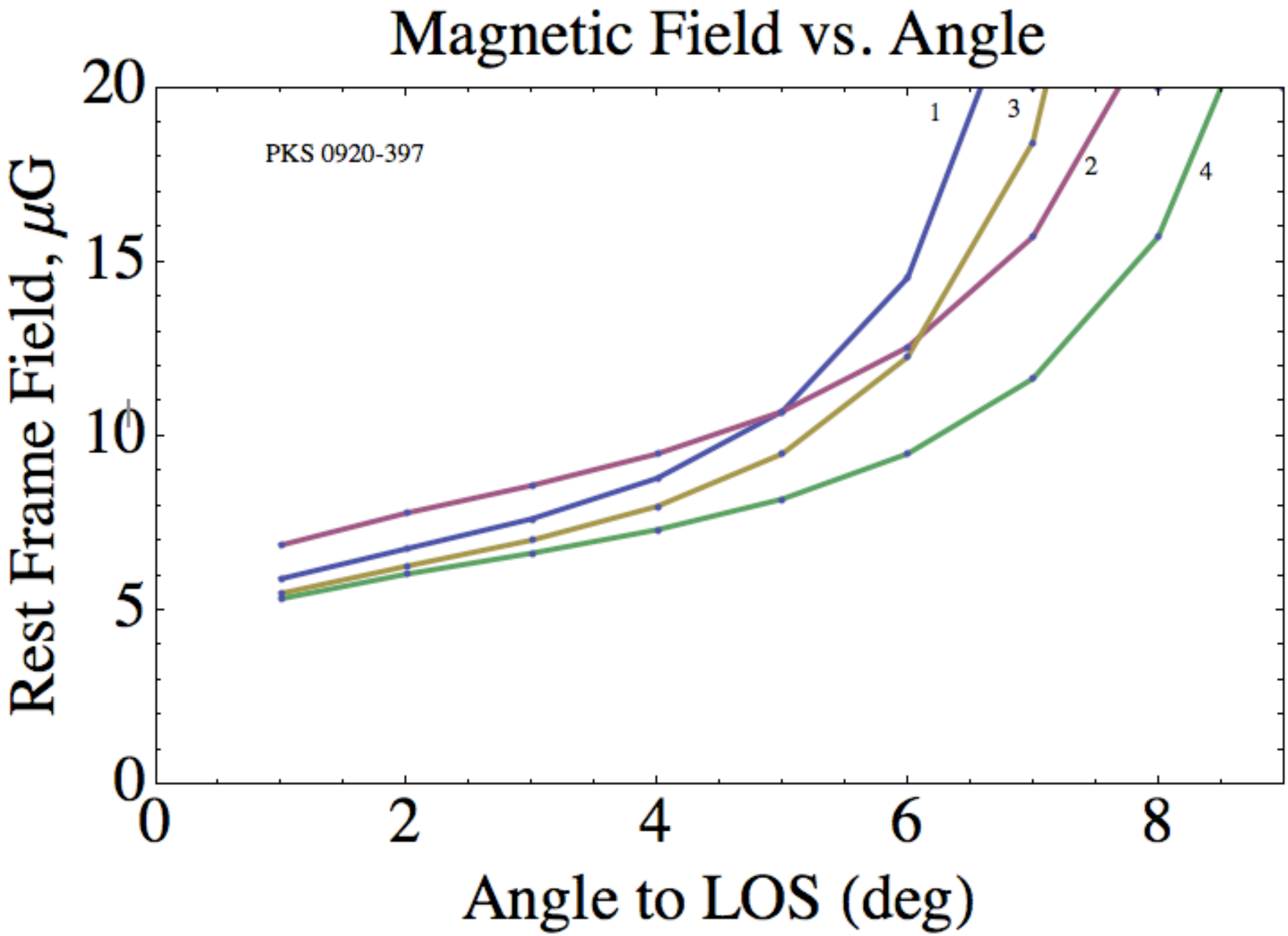
Bulk Lorentz Factor Γ
100
50
20
10
5
2
1
0
2
4
6
8
Angle to LOS (deg)
1
3
2
4


Magnetic Field vs. Angle
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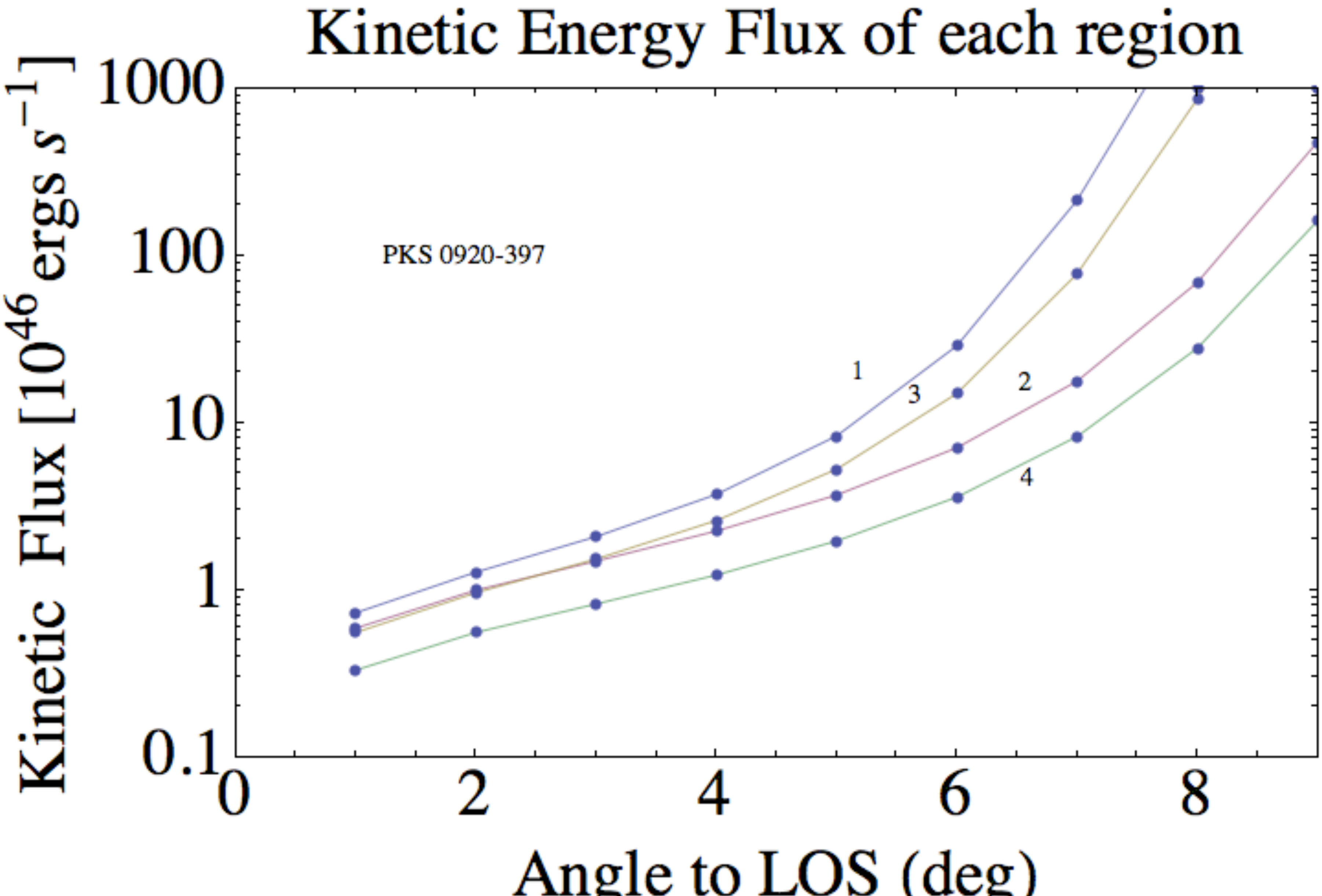
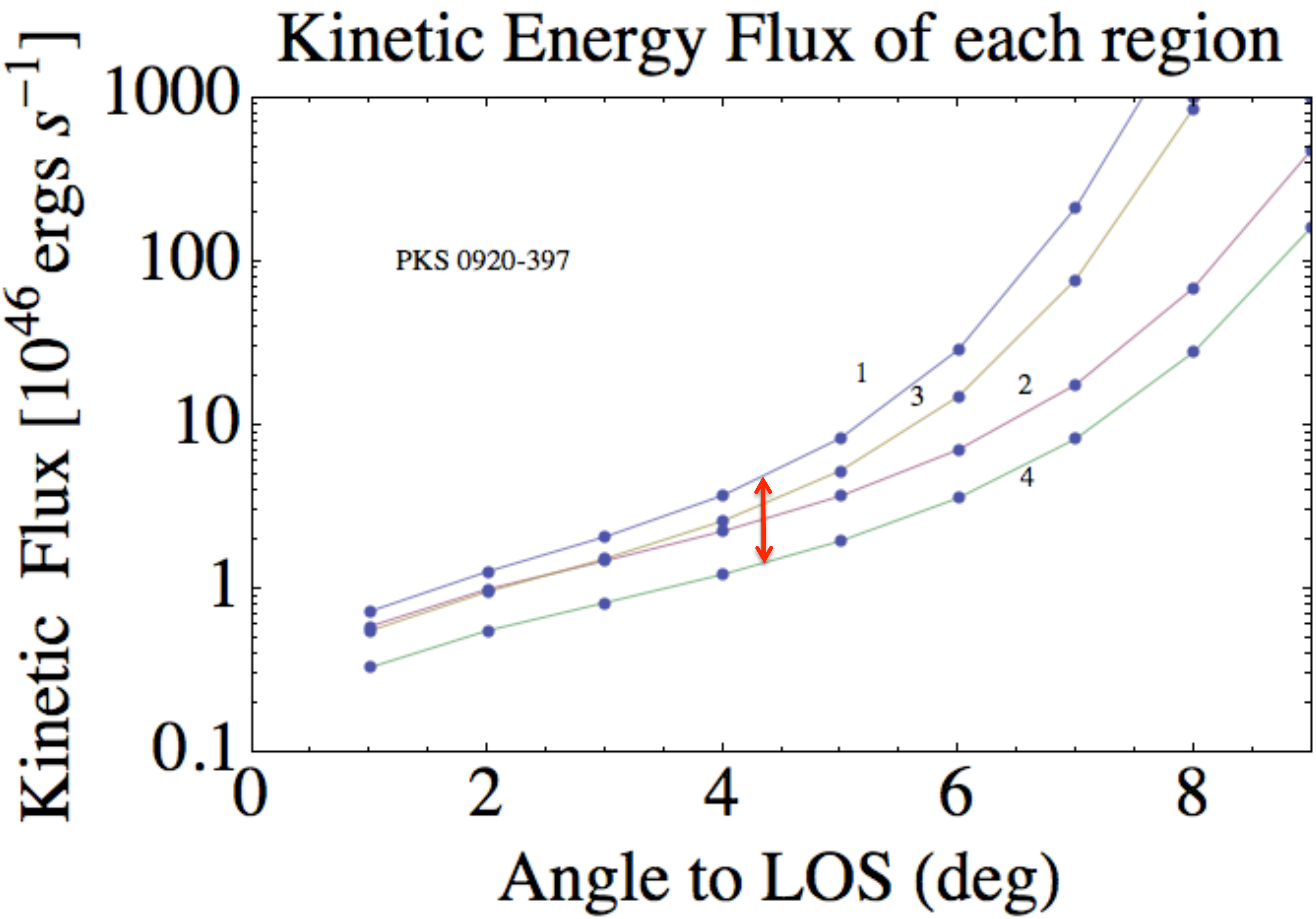
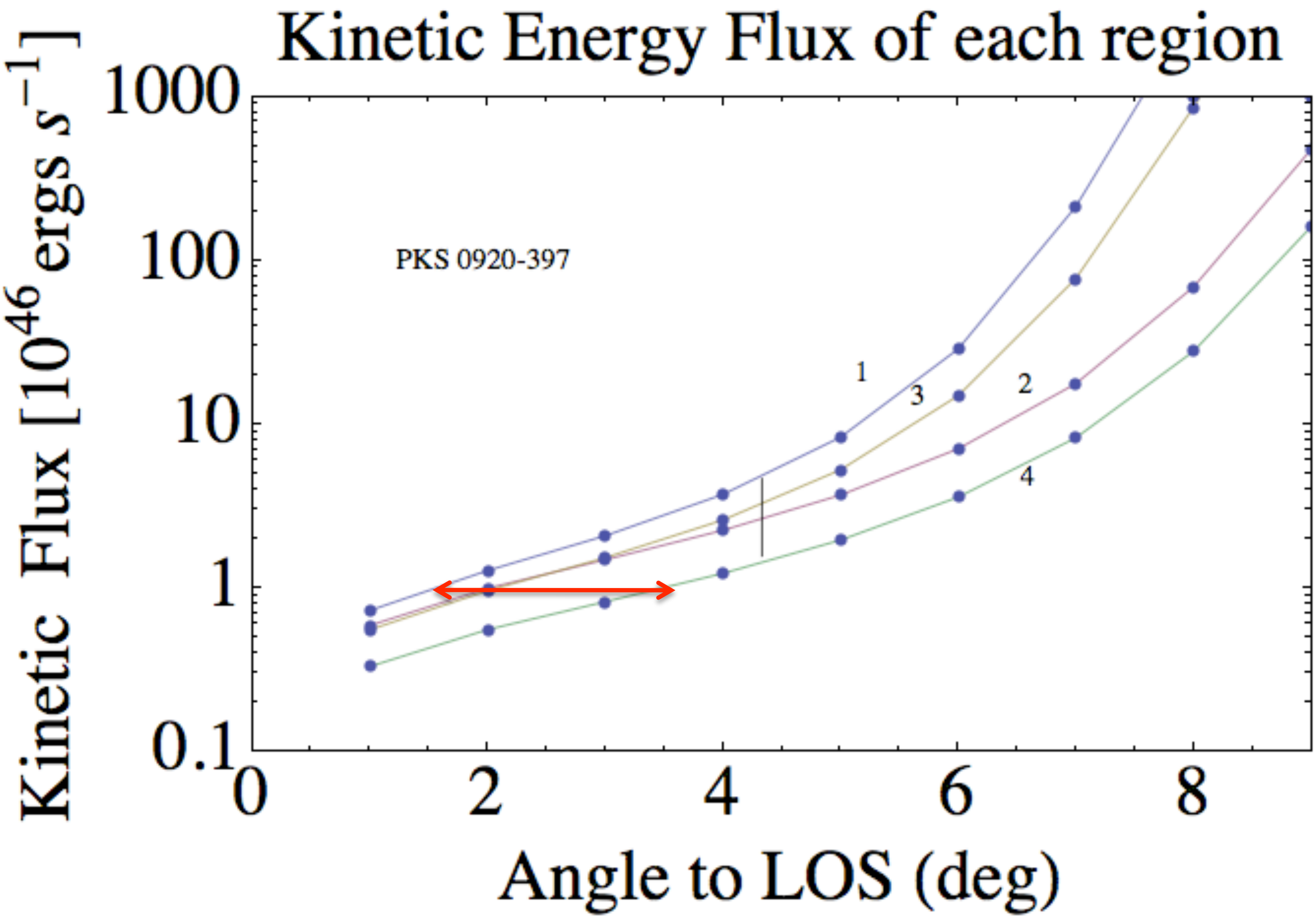
Rest Frame Field, μG
Angle to LOS (deg)
1
3
2
4
0
5
10
15
20
0
2
4
6
8

Kinetic Energy Flux of each region

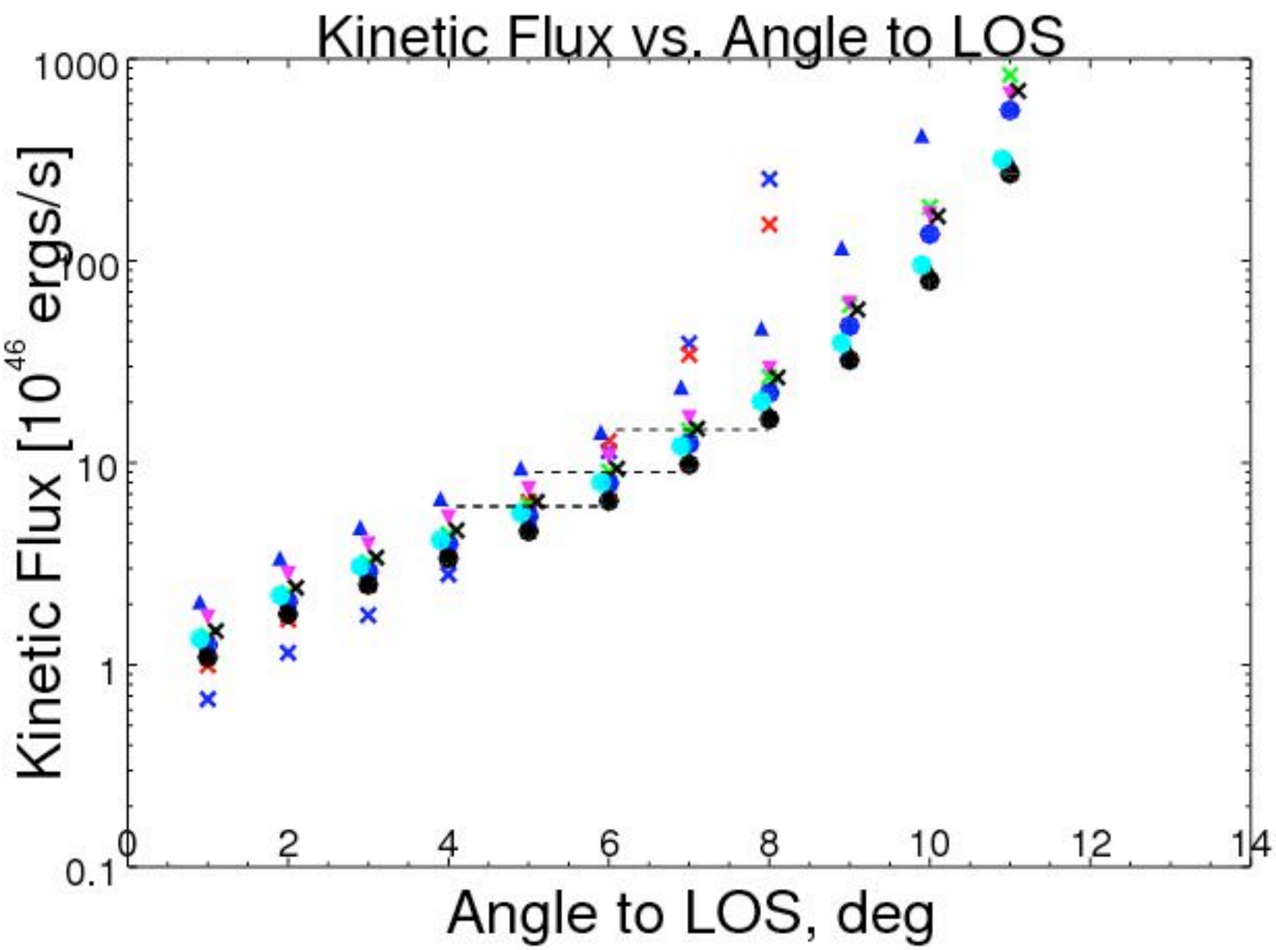



Kinetic Energy Flux of each region
Kinetic Flux [10^{46} ergs s^{-1}]
1000
100
10
1
0.1
PKS 0920-397
1
3
2
4
0
2
4
6
8
Angle to LOS (deg)



Mean angle, 2° to 4°. Angle deviation δθ ≈ ±1°. Kinetic Flux ≈ 1 to 3 E46 erg/s

Kinetic Flux: PKS 1354+195



Mean angle, 5° to 7°. Angle deviation δθ ≈ ±1°. Kinetic Flux = $9x10^{46}$

- PKS 0920-397 X-ray jet likely arises from IC/CMB
  - SED
  - Correlation of X-ray and Radio profiles
- Determination of Γ, δ, θ crucial for structure and dynamics of jets.
- Γ= δ Cannot be correct. Try:
  - Assumption of roughly constant Kinetic Flux, and/or
  - Minimum LOS angular fluctuation
  - Either are applicable, in view of statistical or systematic errors.
- Removing Γ= δ allows Γ and KE flux to be smaller, at "penalty" of requiring a smaller angle to the line of sight.