NGC 1275
Then and Now

K. I. Kellermann, J. Romney, W. Alef, R. C. Walker
M. Lister, Y. Kovalev, M. Aller, H. Aller, T. Hovatta
and the MOJAVE Team
Why study 3C 84

• **Strong at short wavelengths**
  – Good angular resolution with good sensitivity

• **Close: z = 0.147**
  – Good linear resolution
    • 1 mas = 0.35 pc
    • 1 mas/yr = 1.2c

• **Big**
  – 2D
  – Lots of independent pixels in image (~200)

• **Well defined blobs (not hot spots)**

• **Two sided**
  – Study both approaching and receding components
NGC 1275 – aka 3C 84

- Perseus A
  - Sydney: Mills, 1952
  - Jodrell Bank: Handbury-Brown & Hazzard, 1952
  - Cambridge, Ryle et al. 1954 (RSE 03.02)
- NGC 1275: Baade & Minkowski (1954)
- Seyfert Galaxy: Carl Seyfert (1943)
  - Not typical Seyfert: P~10^{26} W/Hz
  - AGN not SF
- 2C 296 (1955)
- 3C 84: 3C Catalogue (1959)
  - 1970 to 1975: NUG imaging
  - 1976, Pauliny-Toth et al. Core-jet
- 2.8 cm kinematics: Alef et al (1977-1995)
  - NUG+EFF
- VLBA: Double Source: 4 cm, 1994, Romney, Walker, Benson
- 2 cm kinematics: MOJAVE (2000-2010)

Taylor & Vermeulen, 1996

1.3 GHz

0.1asec

Pedlar et al. 1990

15 GHz

ΔS = 2Jy/yr

Walker et al., 2000

FFA

UMRAO

$3C\ 84$

$t_0 \sim 1958$

$\triangle = 4.8\ GHz \quad \square = 8.0\ GHz \quad \times = 14.5\ GHz$
Pauliny-Toth et al. 1976*

- First mas image of 3C84
- Grid-fit algorithm
- Amplitude only
- No phase closure
- Got it almost right

*Pauliny-Toth, Preuss, Witzel, Kellermann, Shaffer, Purcell, Grove, Jones, Cohen, Moffet, Romney, Schilizzi, Rinehart, Nature 259, 17
$\mu_a = 0.22 \text{ mas/yr}$

$v/c = 0.25$
$\mu = 0.27 \pm 0.05 \text{ mas/yr}; \quad \beta_a = \frac{v}{c} = 0.31 \pm 0.06$

$t_o = 1950 \pm 6$

$\mu = 0.07 \pm 0.02 \text{ mas/yr}; \quad \beta = \frac{v}{c} = 0.08 \pm 0.03$
\[ \beta_a = \beta \sin \theta / (1 - \beta \cos \theta) \]

\[ \beta_r = \beta \sin \theta / (1 + \beta \cos \theta) \]

\[ \frac{D_a}{D_r} = \frac{(1 + \beta \cos \theta)/(1 - \beta \cos \theta)} \]

\[ \frac{P_a}{P_r} = \left[\frac{(1 + \beta \cos \theta)/(1 - \beta \cos \theta)}\right]^n \quad n = p + \alpha \]
• **If ejection is symmetric**
  — If both components are ejected at same speed
  — If both components move in opposite directions
  — If both components move through same environment
  — If the pattern velocity = bulk flow velocity
  — If each component has the same intrinsic luminosity
• **The kinematics is completely constrained by the observations**
$\beta = 0.51$

$\theta = 16\ deg$

$\gamma = 1.15$

$\delta_a = 1.7$

$\delta_r = 0.60$
\[
S_s/S_n = [(1 + \beta \cos \theta)/(1 - \beta \cos \theta)]^n
\]

\[n = \alpha + \rho\]
\[S_s/S_n = 3.6\]
\[n = 1.9\]
\[\alpha \sim -0.3\]
\[\rho \sim 2.2\]

\[\theta = 16\ \text{deg}\]
\[L = 120\ \text{ly}\]
\[24\ \text{ly}\]
Fermi light curve

Flux ($10^{-9}$ ph/cm$^2$/s)

Time (years)

0316+413

EGRET

6/22/2010

Fermi Meets Jansky
Summary

• 3C 84 is powerful AGN: $P = 10^{26}$ W/Hz
• 3C 84 is only mildly relativistic
  – $\beta \sim 0.5$
  – $\delta \sim 1.7$
• Motion is close to the line of sight (16 deg)
• Not a mis-oriented BL Lac jet
• 3C 84 is a small moderately strong $\gamma$-ray source
  – Location of gamma-ray emission near base of jet?
• Is it a Blazar?