Fermi Gamma-ray Space Telescope

Fermi LAT Discovery of Gamma-rays from the Giant Radio Lobes of Centaurus A

C.C. Teddy Cheung (NRC/NRL)
Lukasz Stawarz (ISAS/JAXA)
Yasushi Fukazawa (Hiroshima)
Jürgen Knödlseder (CESR)
on behalf of the
Fermi-LAT Collaboration

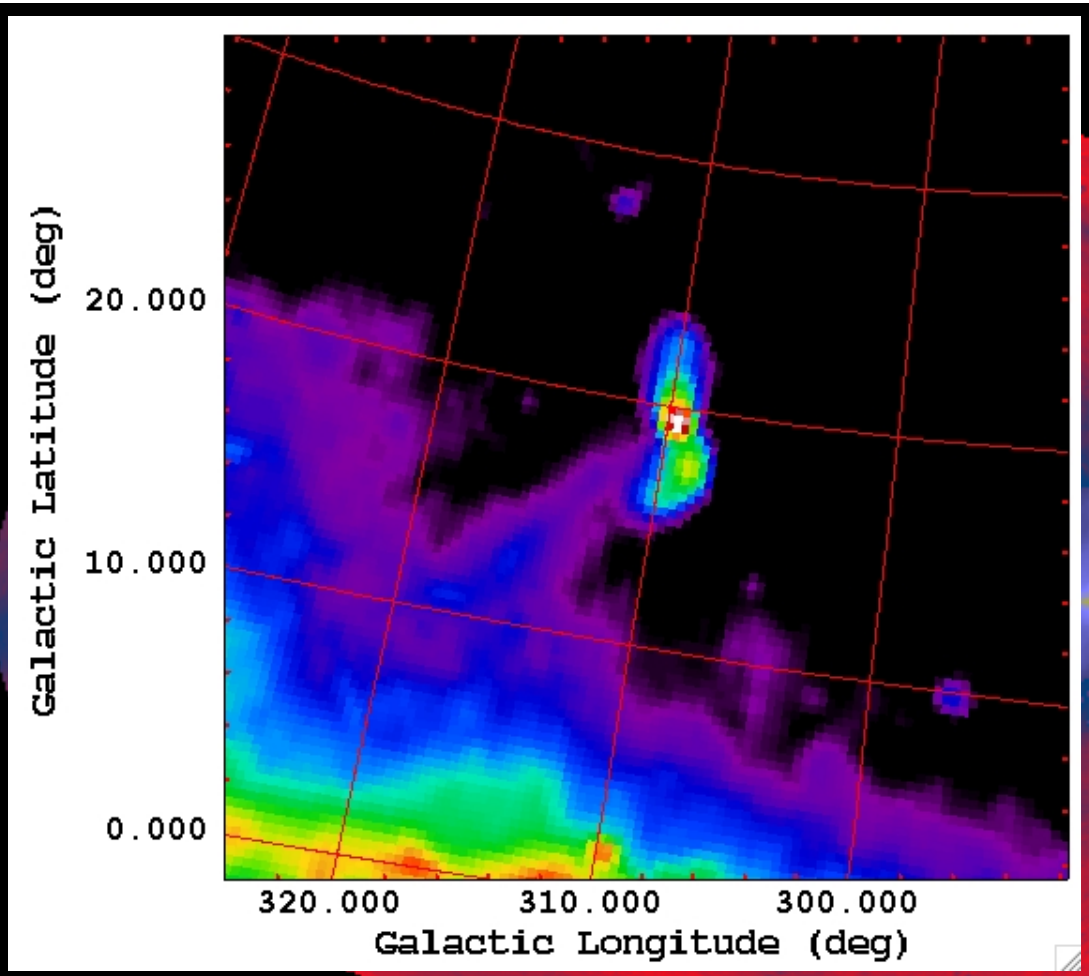
Gamma-ray Imaging of a Radio Galaxy

Over ½ of the total >100 MeV observed LAT flux in the lobes

- Pre-launch expectation that lobes can produce **γ-rays via inverse Compton process**
- Cen A is (uniquely) large enough to directly image with LAT -- derive physical conditions
- What does this mean for LAT radio galaxies (& blazars) in general?

Feain et al. (2010)

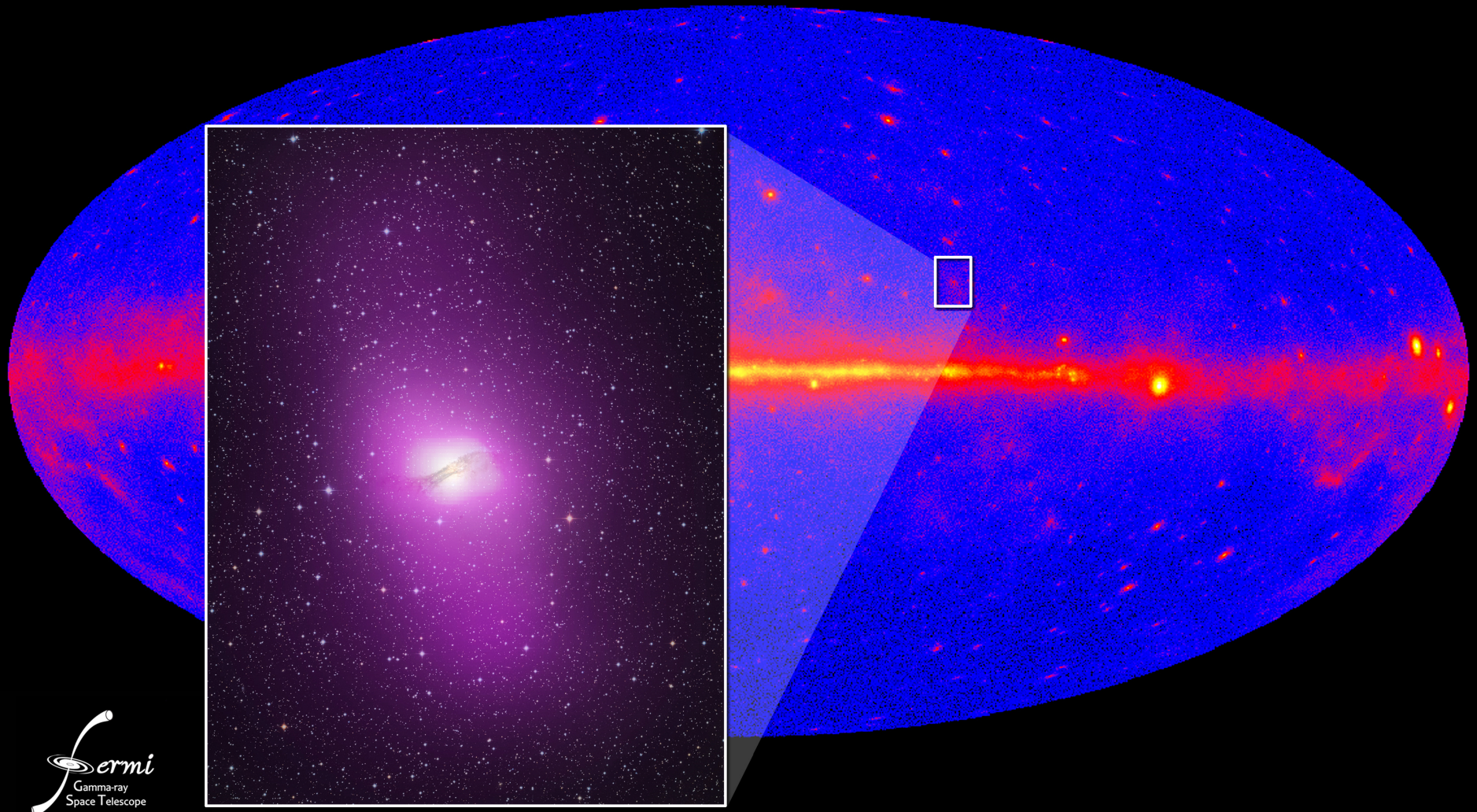
Cen A the Radio Galaxy



- Nearest Radio-loud AGN
- Radio source extent: ***L***~10^{o}
- At D=3.7 Mpc, ***L***=600 kpc

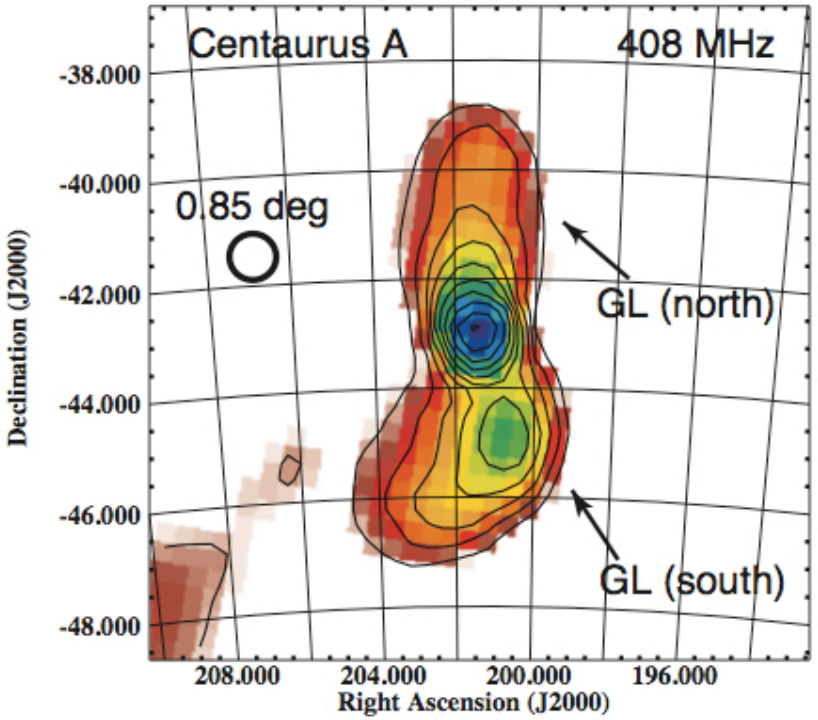
Cen A the Radio Galaxy

NASA's Fermi telescope resolves radio galaxy Centaurus A

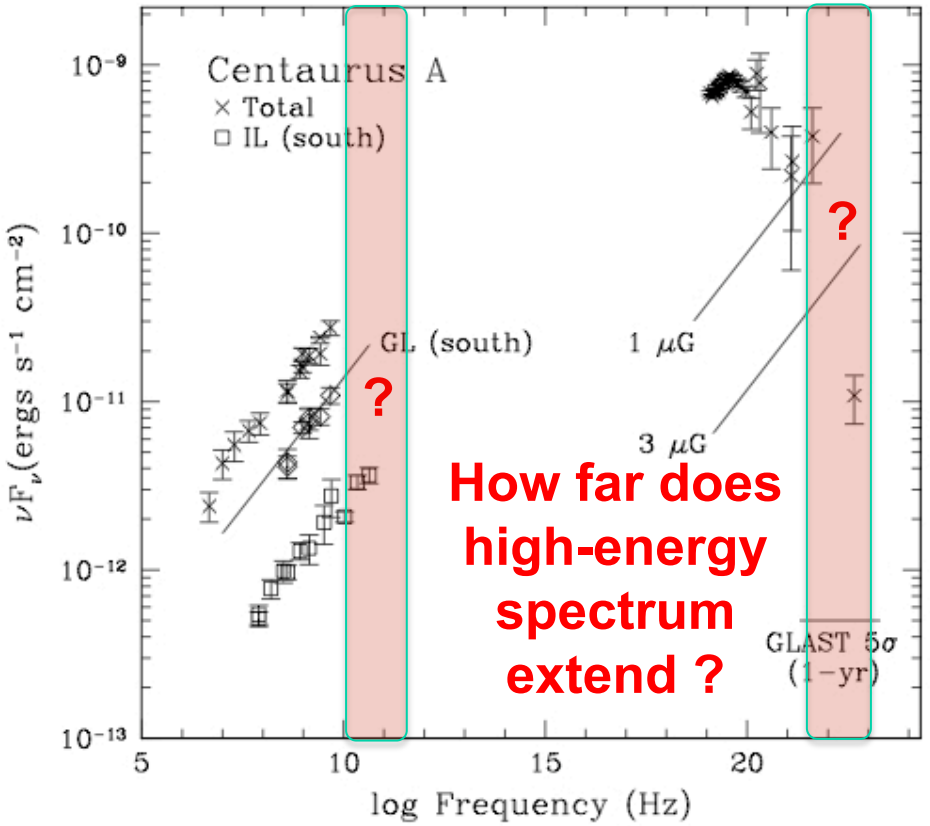


Not a Complete Surprise

☑ LAT resolution = 0.8° at 1GeV
so can *image* the radio structure



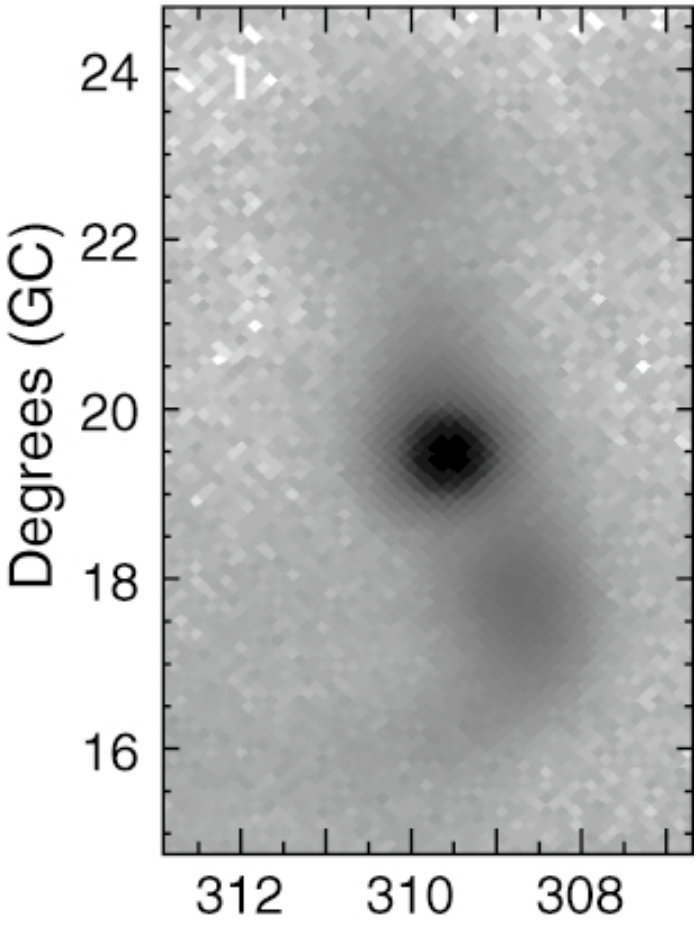
☑ IC/CMB γ-ray lobes?
Expect $L_\gamma / L_S \sim U_{CMB}/U_B \sim$ 1-10



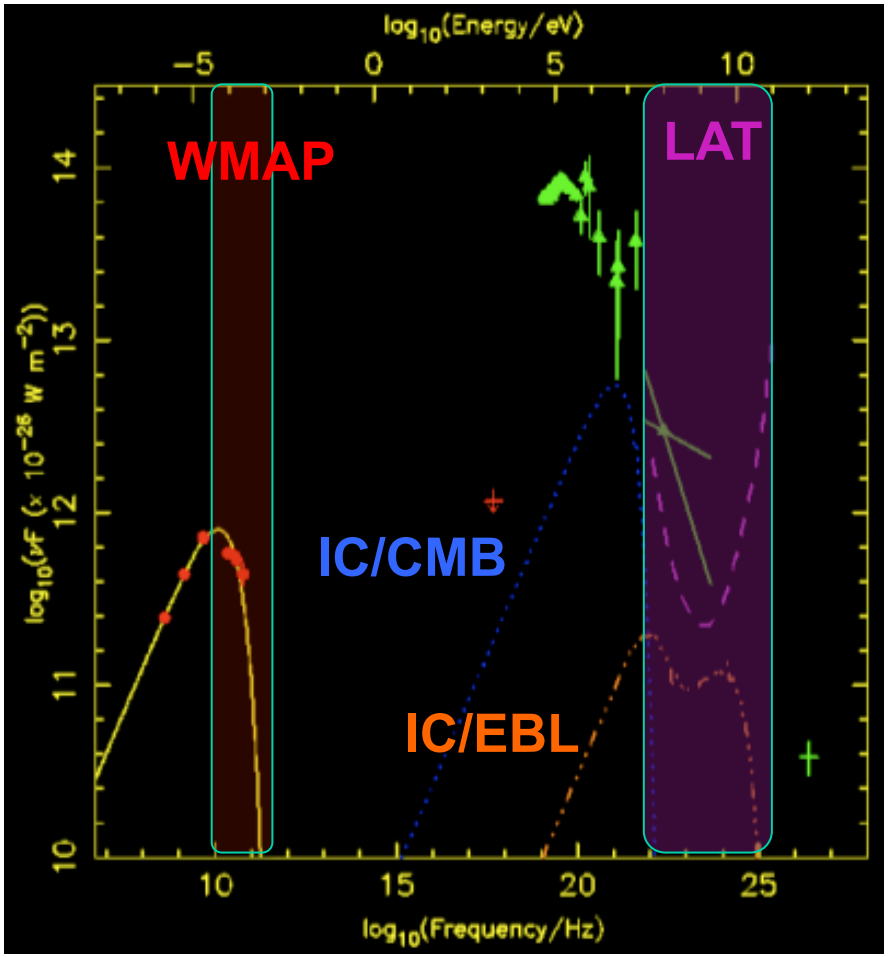
Cheung 2007 (1st GLAST symp)

Expectations for Fermi LAT

Lobes detected by WMAP at 20-60 GHz

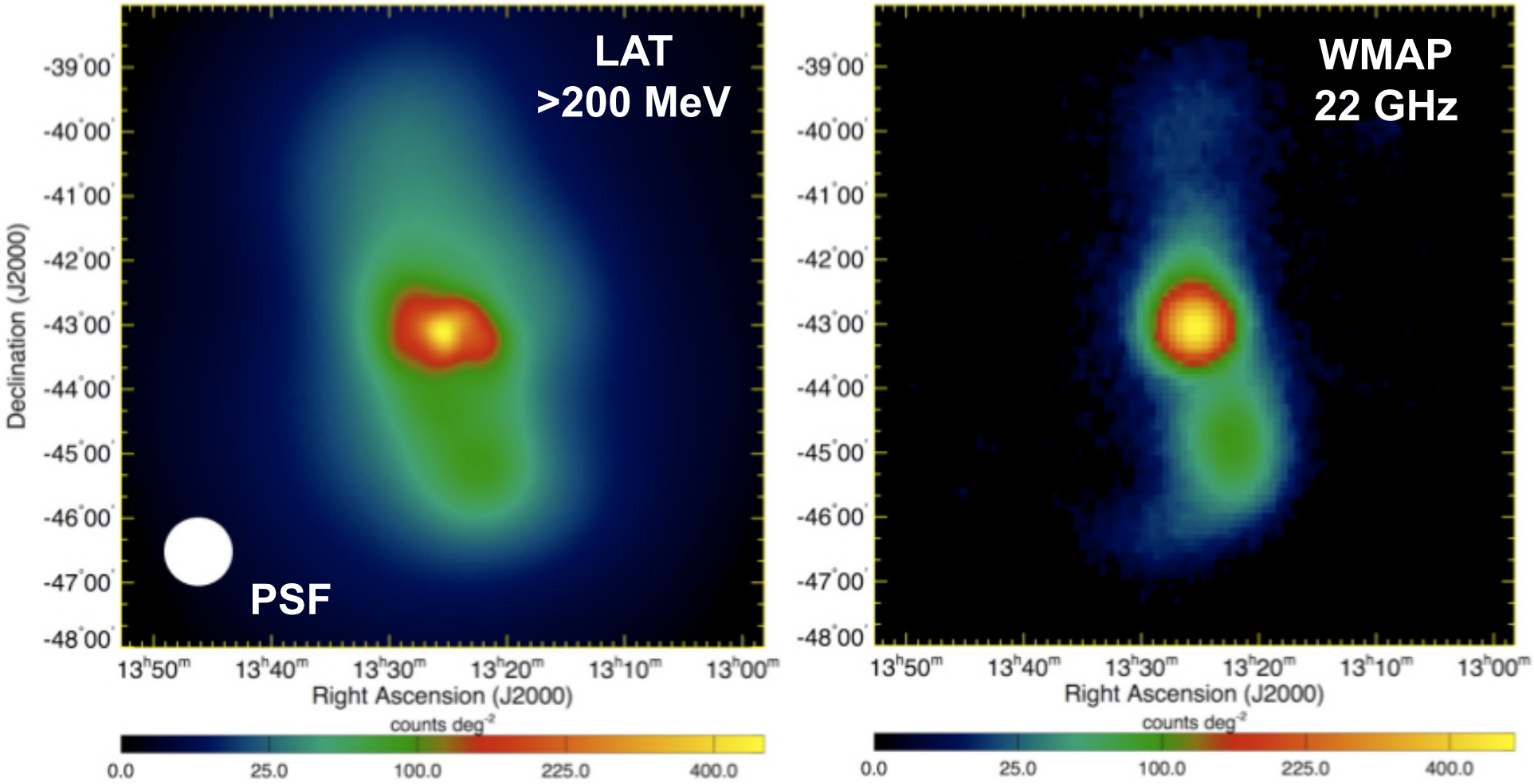


Page et al. 2007



LAT predictions for Cen A: Hardcastle, et al. 2009

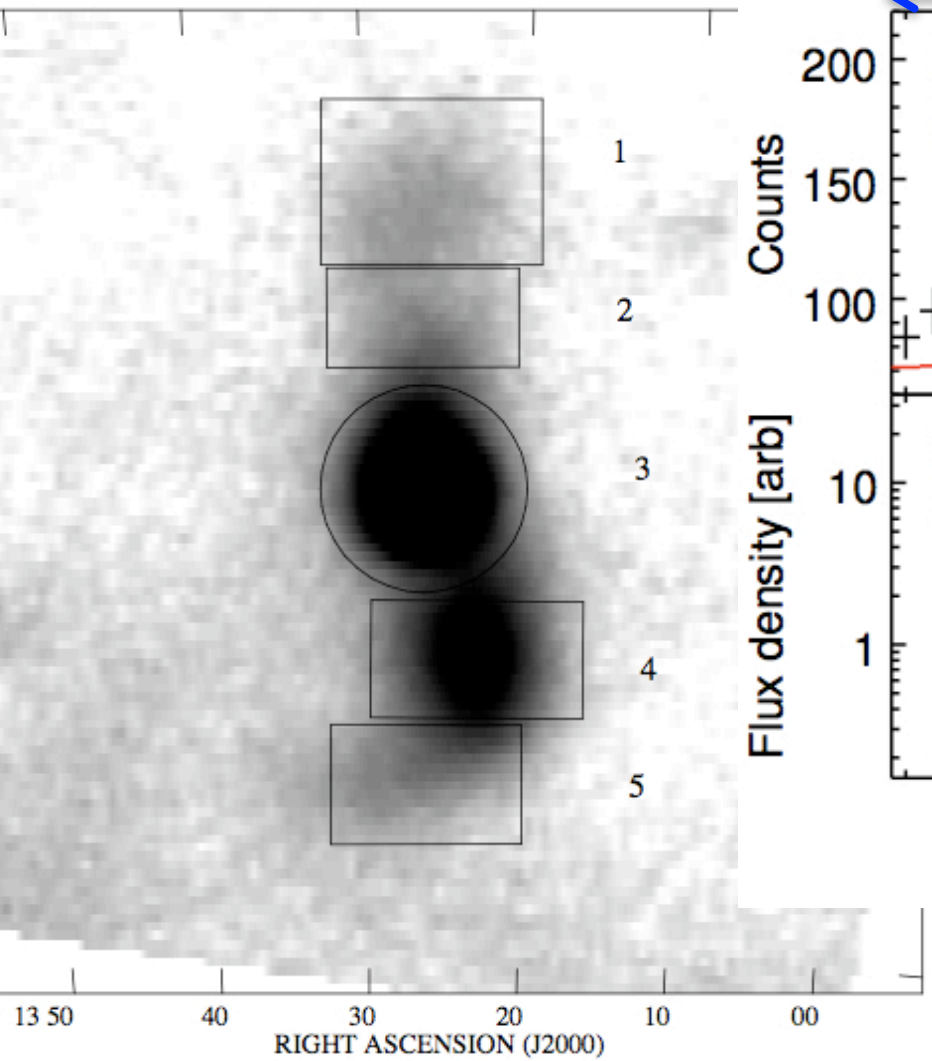
Here's what LAT sees in γ-rays

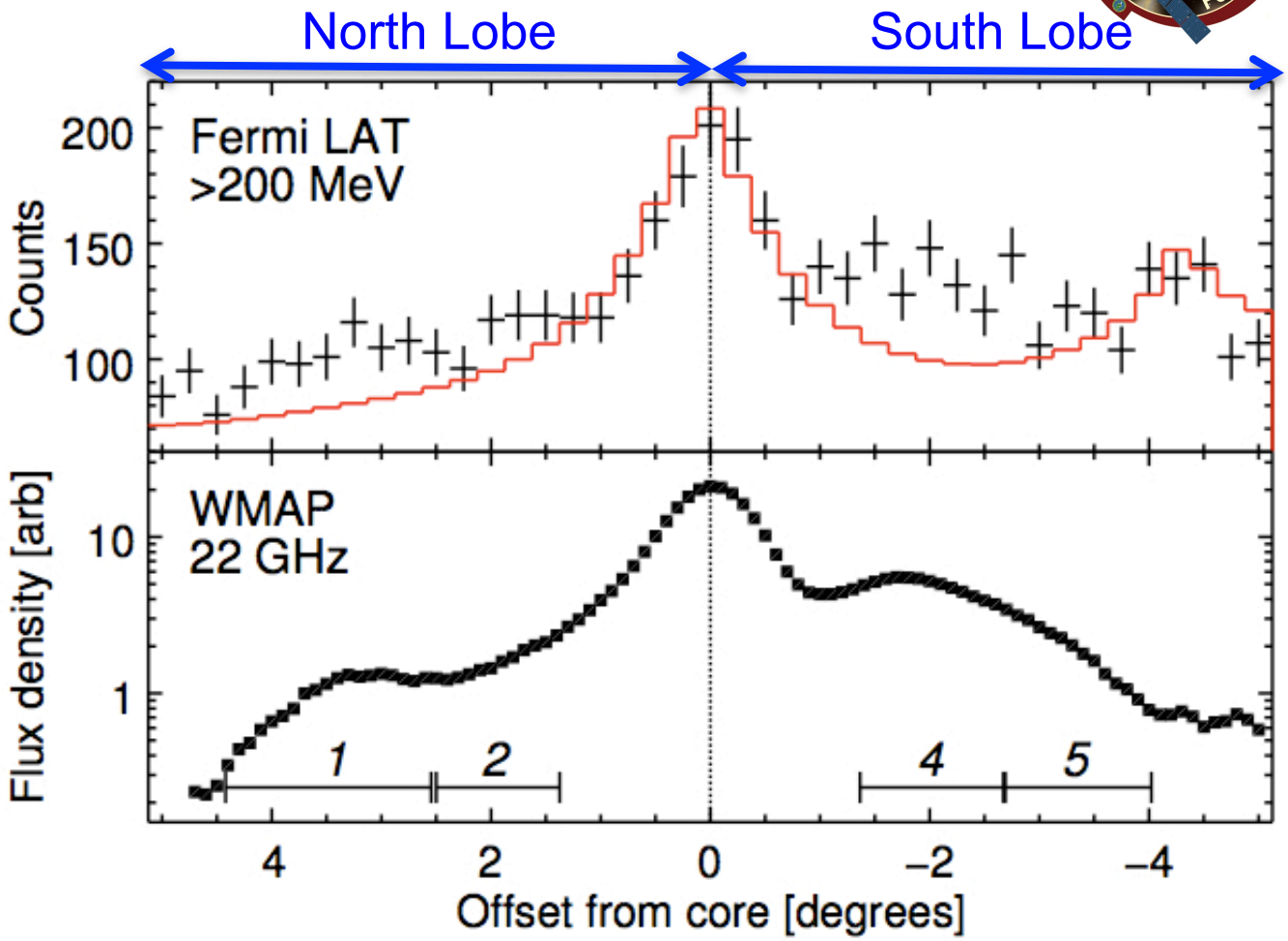


Background (isotropic and diffuse) and field point sources subtracted

WMAP images provided by Nils Odegard (GSFC)

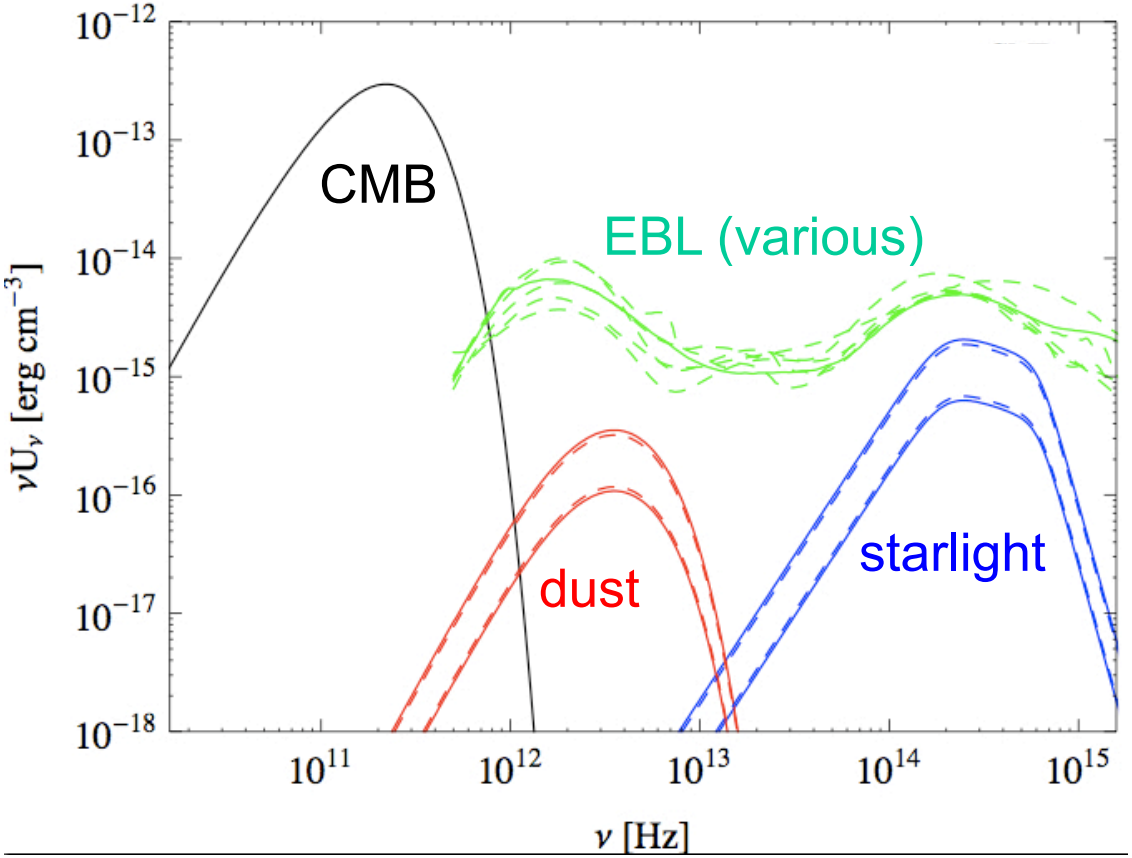
Gamma-ray and Radio Counts Profiles





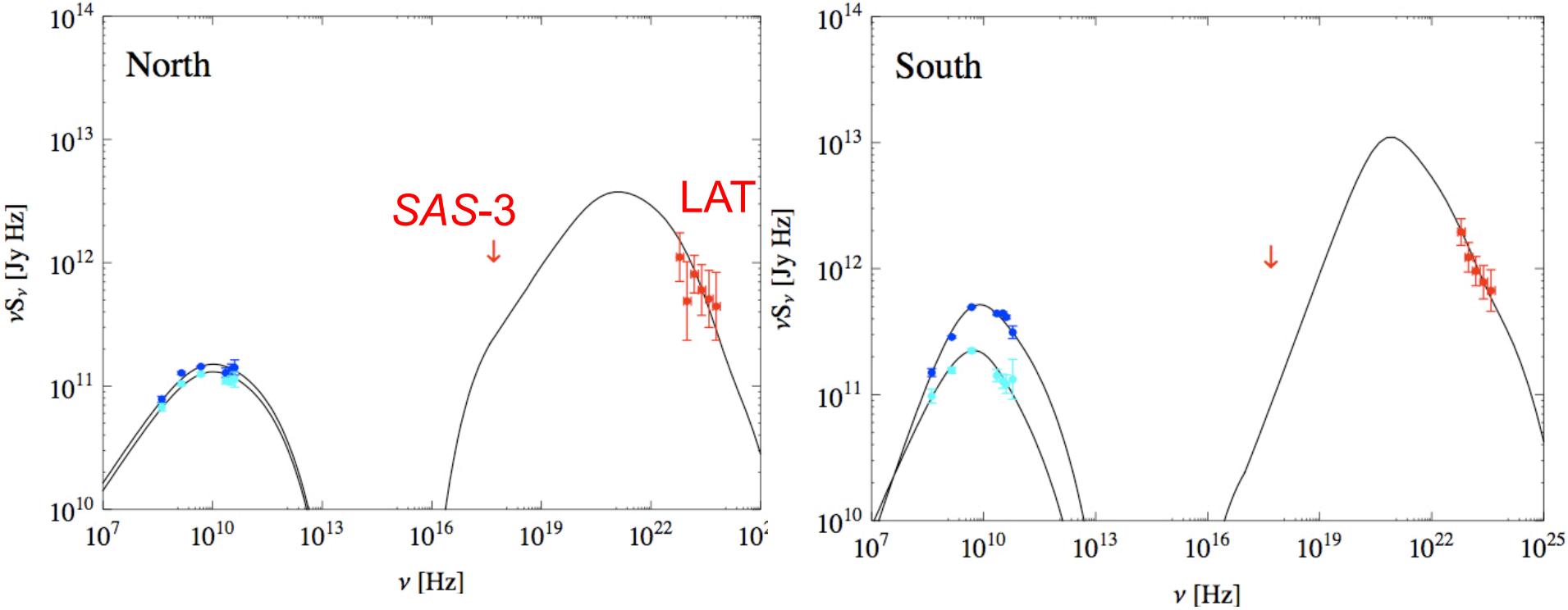
Regions 1 & 2 (north) and 4 & 5 (south) as defined in Hardcastle et al. 2009

Relevant Photon Fields



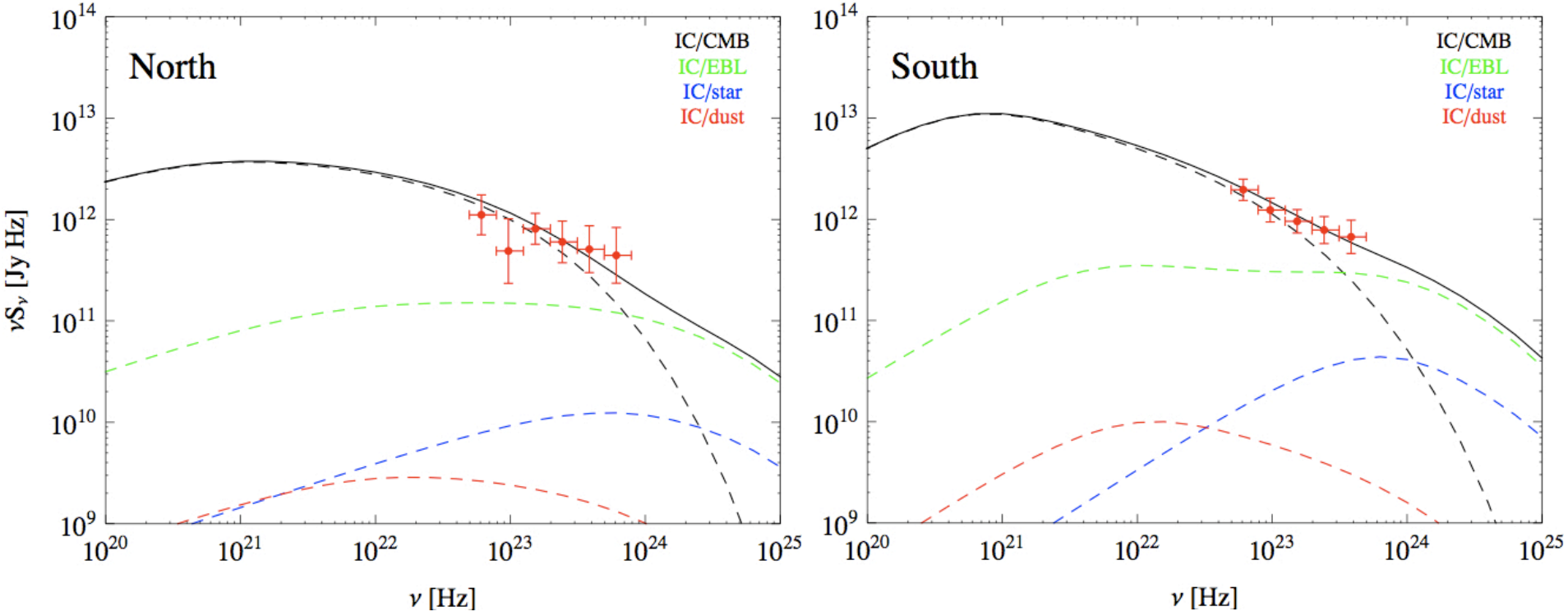
- Dominant photon fields are CMB and IR +optical extragalactic background light (EBL)

Inverse Compton Emission



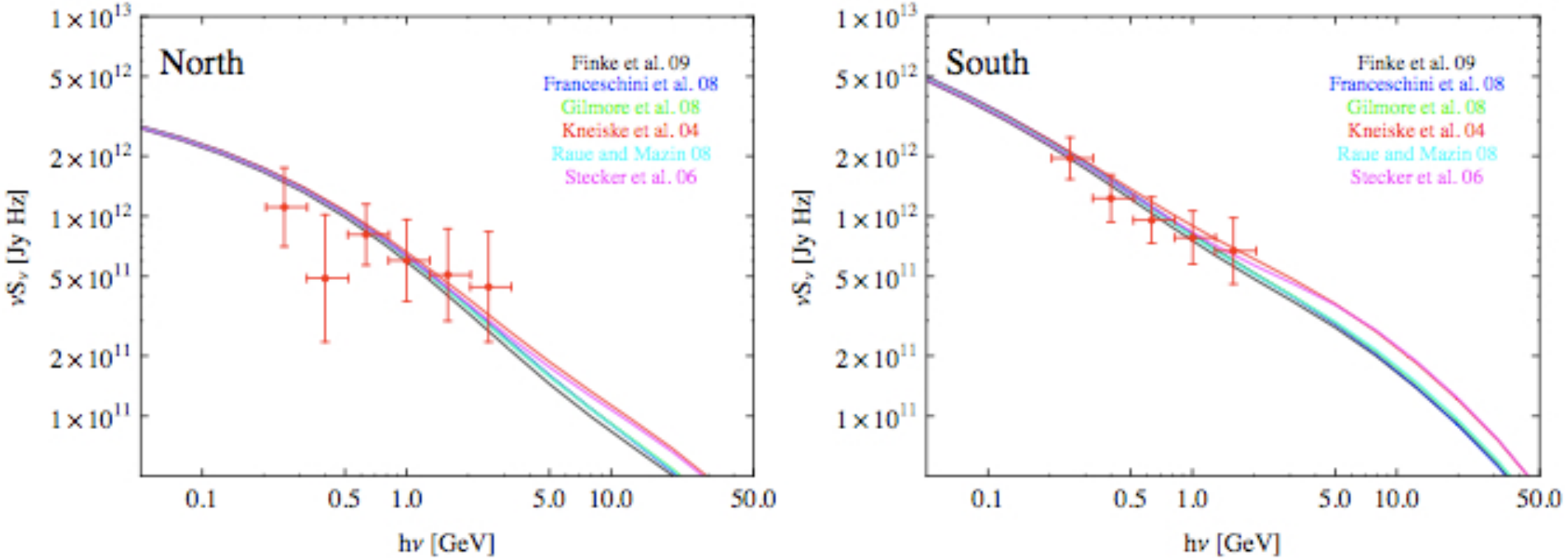
- **First inverse Compton (IC) lobe measurements in γ-rays!**
- Good fits of LAT spectra with **B ~ 1 μG** in both lobes
- Approximate energy equipartition, i.e., U_e/U_B ~ 1 to 4
- IC/CMB X-rays in radio lobes: U_e/U_B ~1-10

Inverse Compton Emission: Close-up



- Detected LAT emission dominated by IC/CMB component for the modeled electron energy spectra
- EBL component dominating at highest-energies (>GeV)

Gamma-ray probe of the EBL?



- Different EBL models/compilations give (only) slight differences in predicted inverse Compton gamma-ray spectrum

Inferred Physical Parameters

- LAT detected γ-ray emission requires 0.1-1 TeV electrons in 100's kpc-scale lobes that are probably accelerated in-situ

- Non-thermal plasma / ambient gas in approximate pressure balance

- Jet Calorimetry:
  - E_{tot} = 10^{58} erg radiated in both lobes over 30 Myrs
  - Jet power ~7 x 10^{42} erg s^{-1} (~10^{-5} L_{edd}) sub-Eddington, typical for low power radio galaxies

- LAT γ-ray image requires a very extended source (***L***~10^{o} in this case) – other examples?