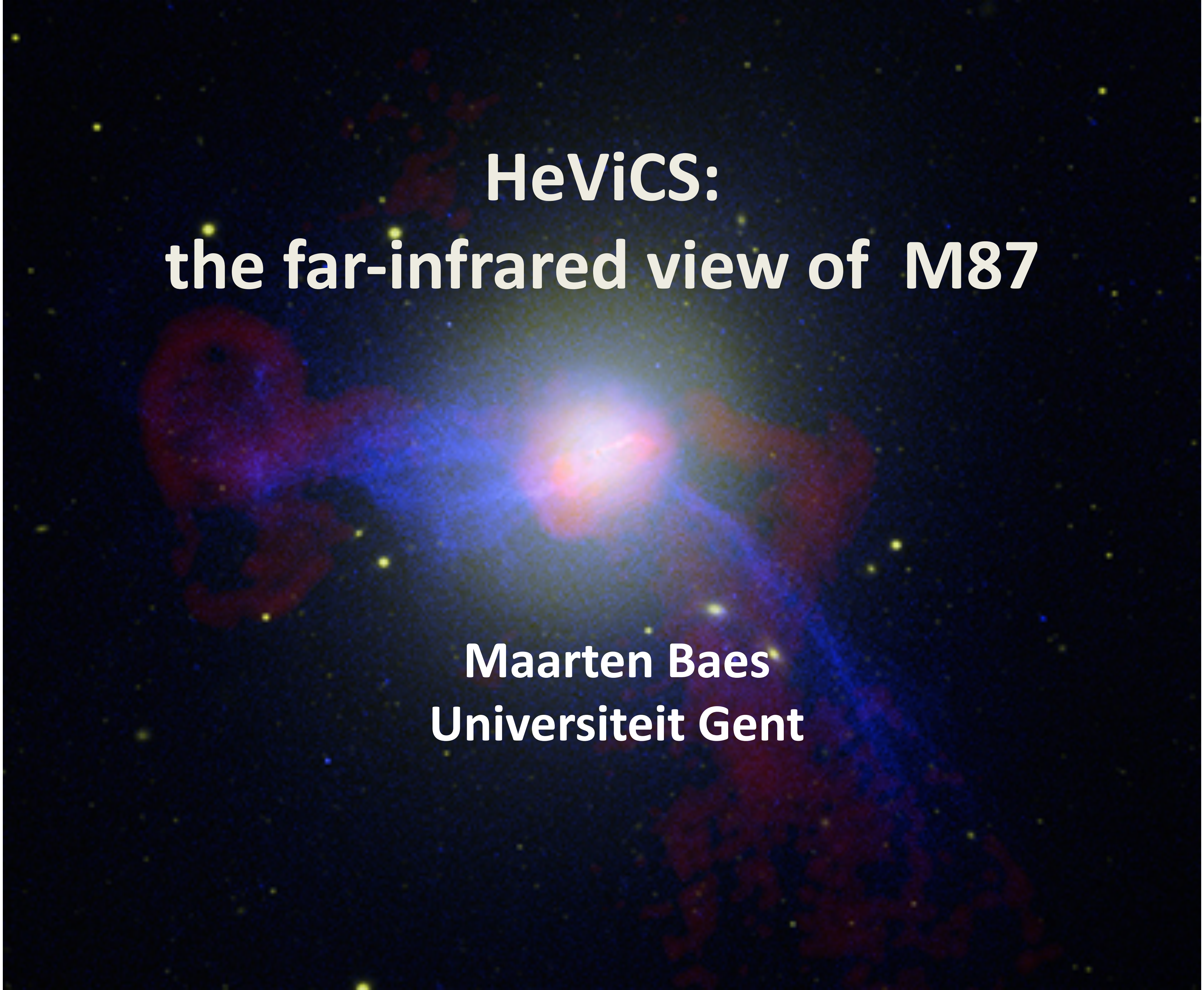
HeViCS: the far-infrared view of M87



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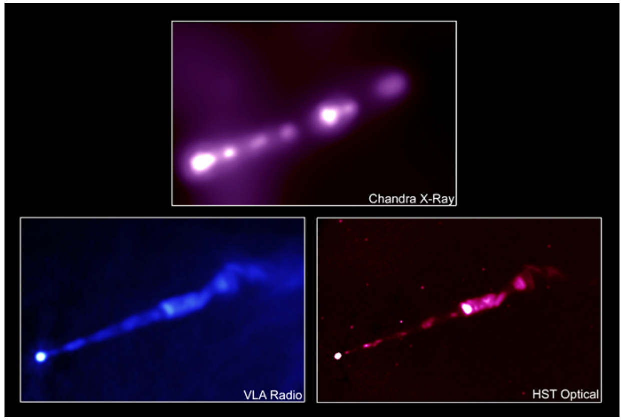
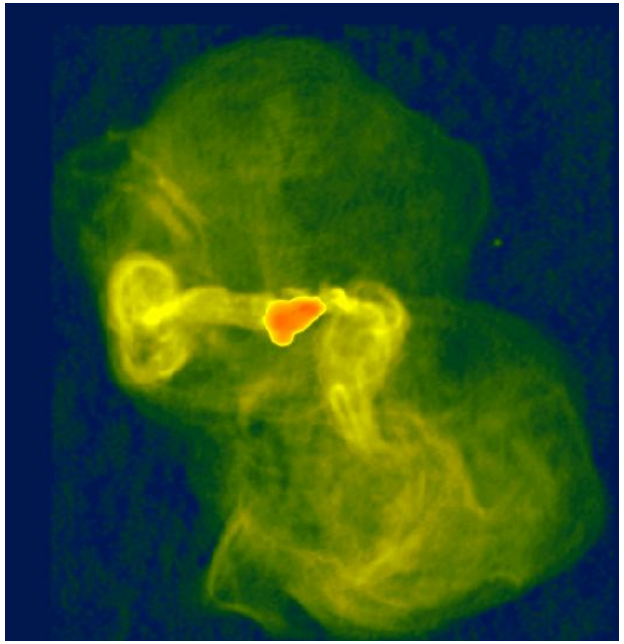
M87



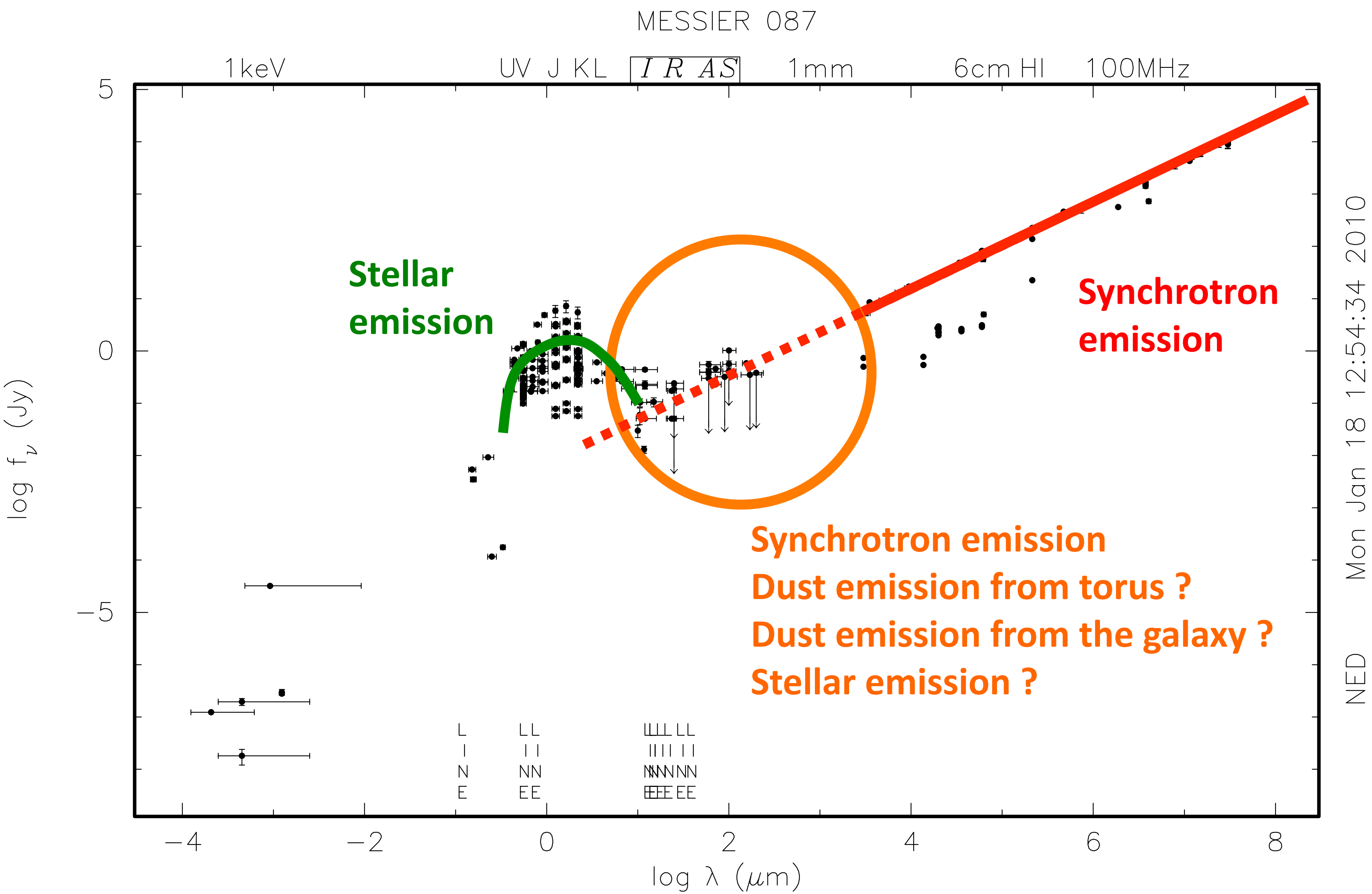


Dominant elliptical galaxy in the Virgo Cluster (distance 16.7 Mpc)

Observed at every possible wavelength from TeV gamma-rays to decametric radio waves (5484 references in ADS)

Among its many interesting features

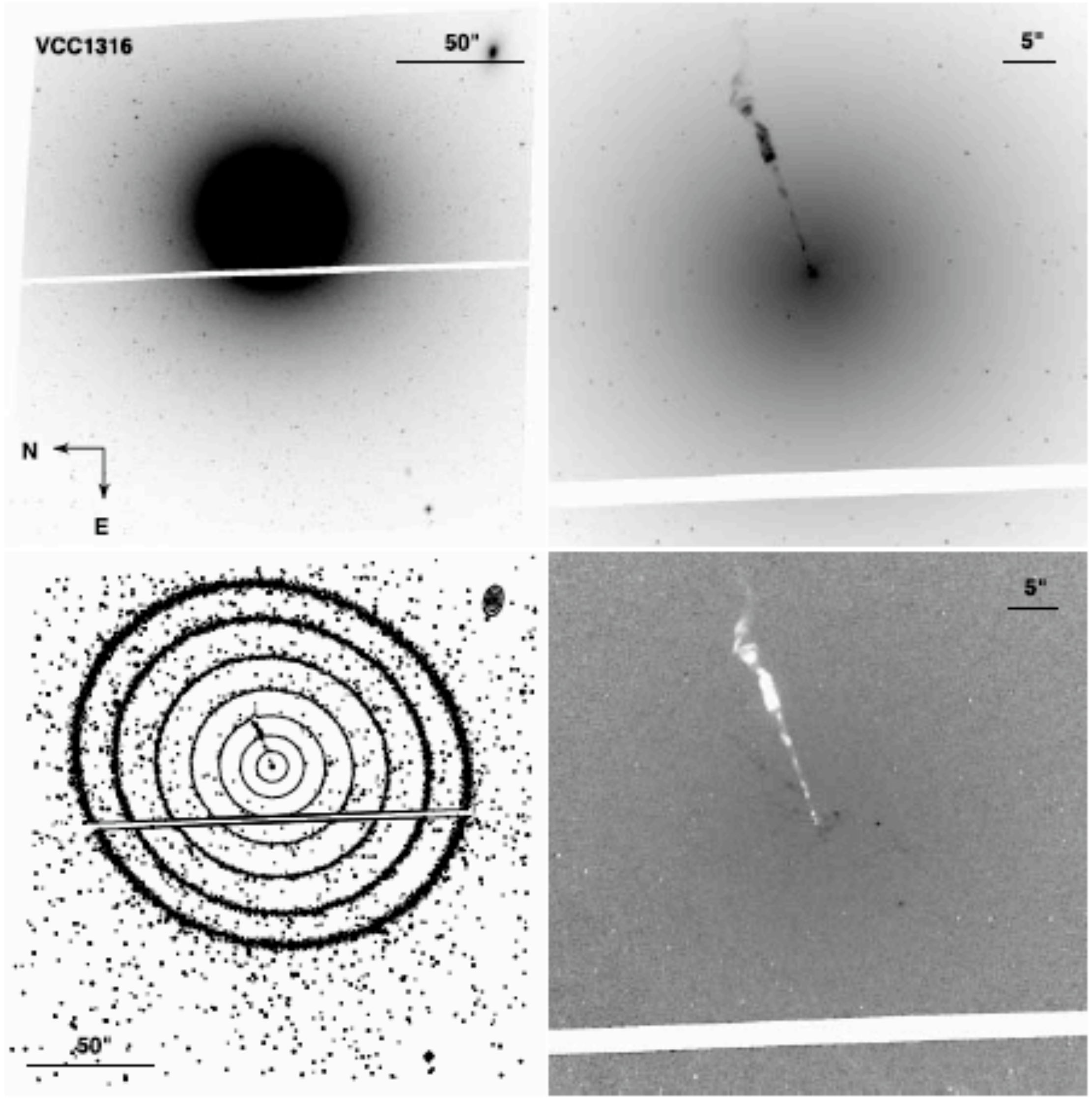
- jet, visible from X-ray to radio
- several billion solar mass black hole
- rich PN population
- complex extended radio structure


MESSIER 087
1keV
UV J KL
IRAS
1mm
6cm HI
100MHz
Stellar
emission
Synchrotron
emission
Synchrotron emission
Dust emission from torus ?
Dust emission from the galaxy ?
Stellar emission ?
log f_ν (Jy)
log λ (μm)
Mon Jan 18 12:54:34 2010
NED

Dust in M87 – the optical view

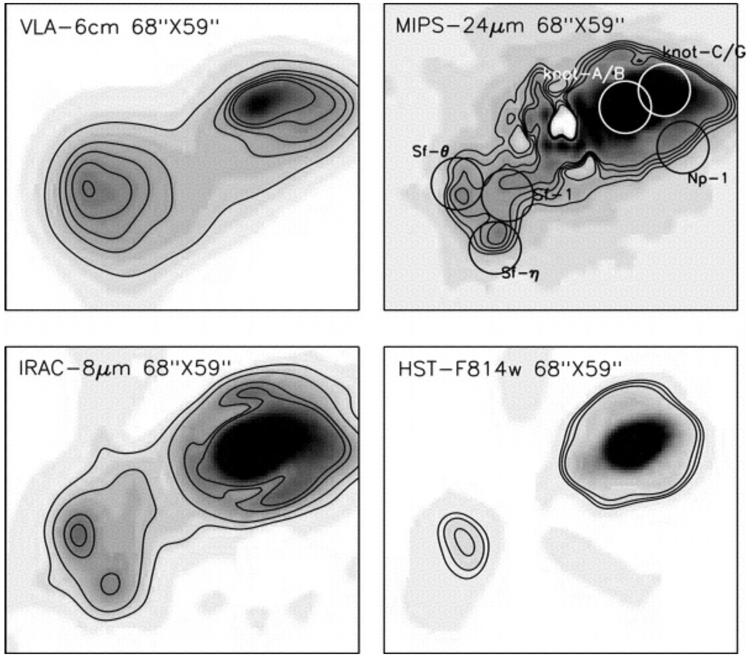
Dust is seen in absorption in optical images.

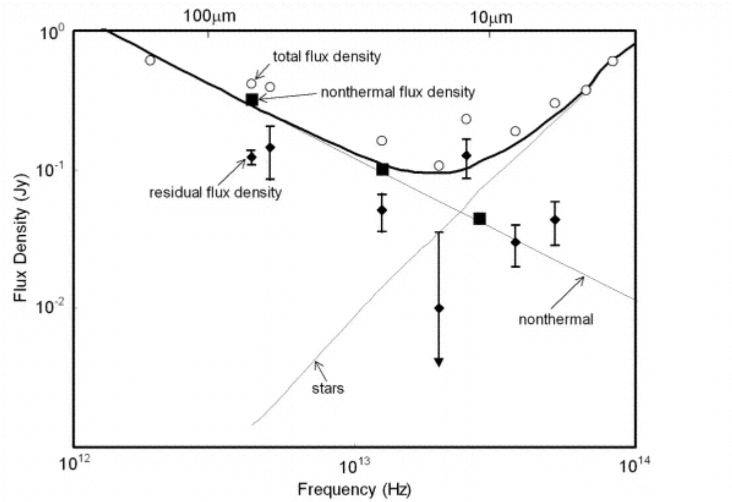
Most accurate study to date (ACS VCS, Ferrarese et al. 2006): Dust filaments radiate from the center outward, extending out to 13” from the nucleus.



Dust in M87 – the FIR view (1)

Shi et al. 2007: Analysis of Spitzer + radio maps and the SED



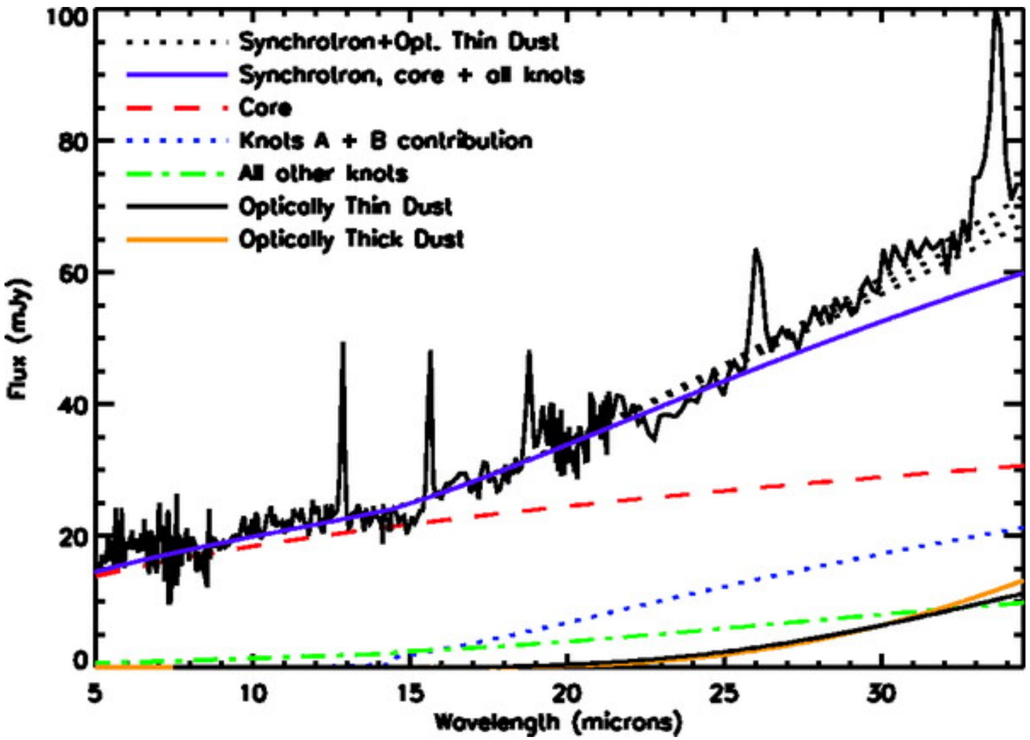


FIR excess over simple synchrotron power-law (radio-MIR-optical).

Most likely due to warm dust in the galaxy itself (similar to the FIR emission of normal giant elliptical galaxies).

Dust in M87 – the FIR view (2)

Perlman et al. 2007: Analysis of IRS spectrum and Subaru spectrum of nuclear region



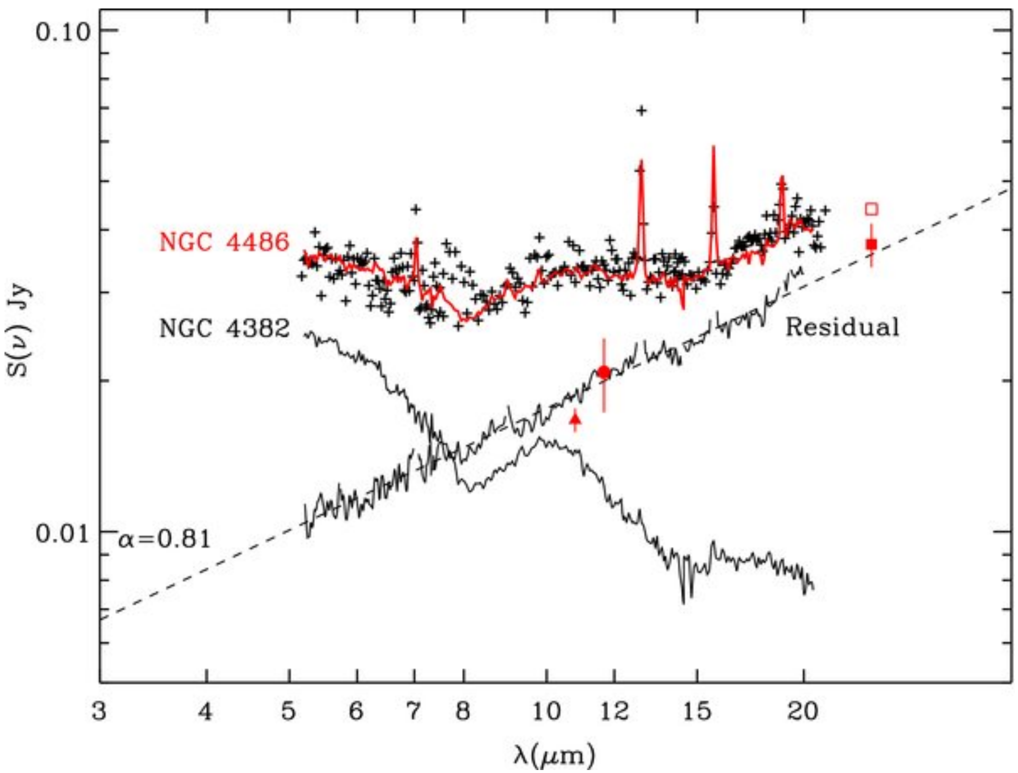
A clear excess in the nuclear spectrum at wavelengths longer than 25 μm.

Can be modelled as thermal emission from cool dust at a characteristic temperature of 55 ± 10 K

But: spectral index required to fit MIR spectrum: α ≈ 0.41 !

Dust in M87 – the FIR view (3)

Buson et al. 2009: Analysis of (higher SNR) nuclear IRS spectrum



Nuclear IRS spectrum 5-20 μm can be modelled as the sum of stellar contribution and synchrotron emission ($\alpha \approx 0.8$).

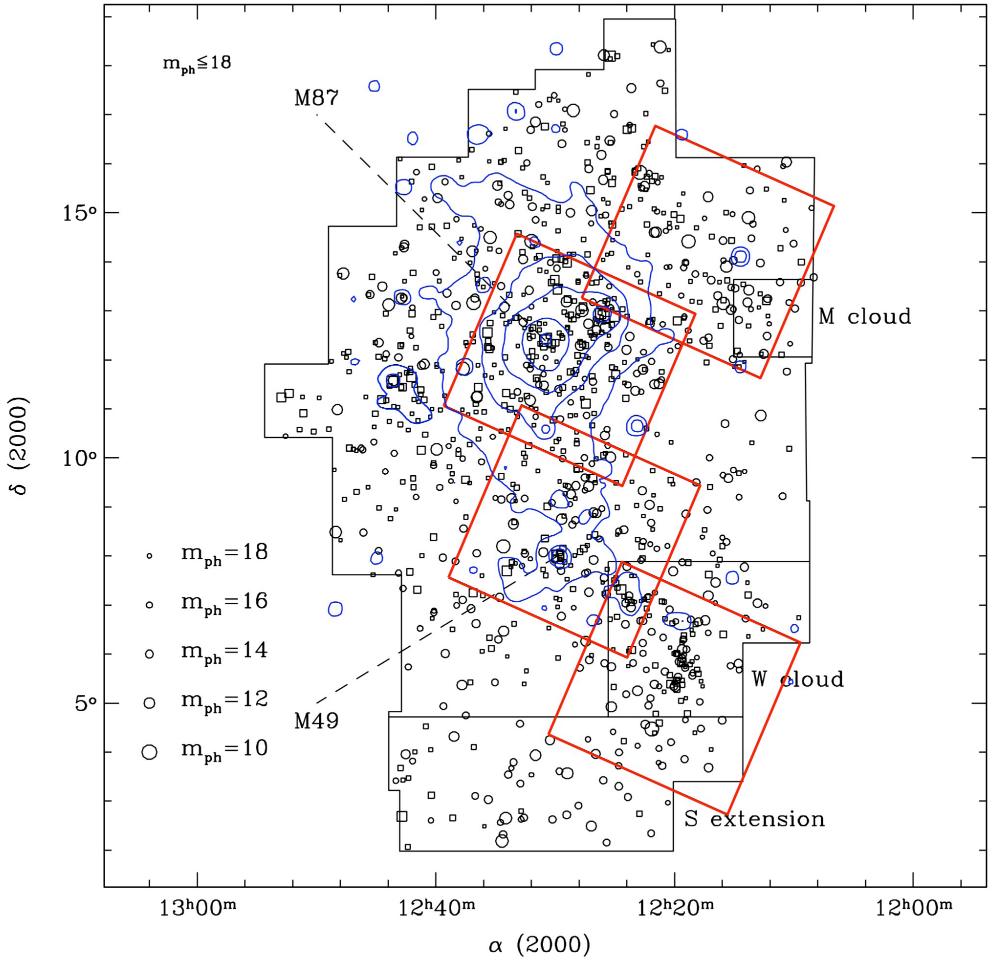
Little room for torus emission.

Herschel Virgo Cluster Survey (HeViCS)

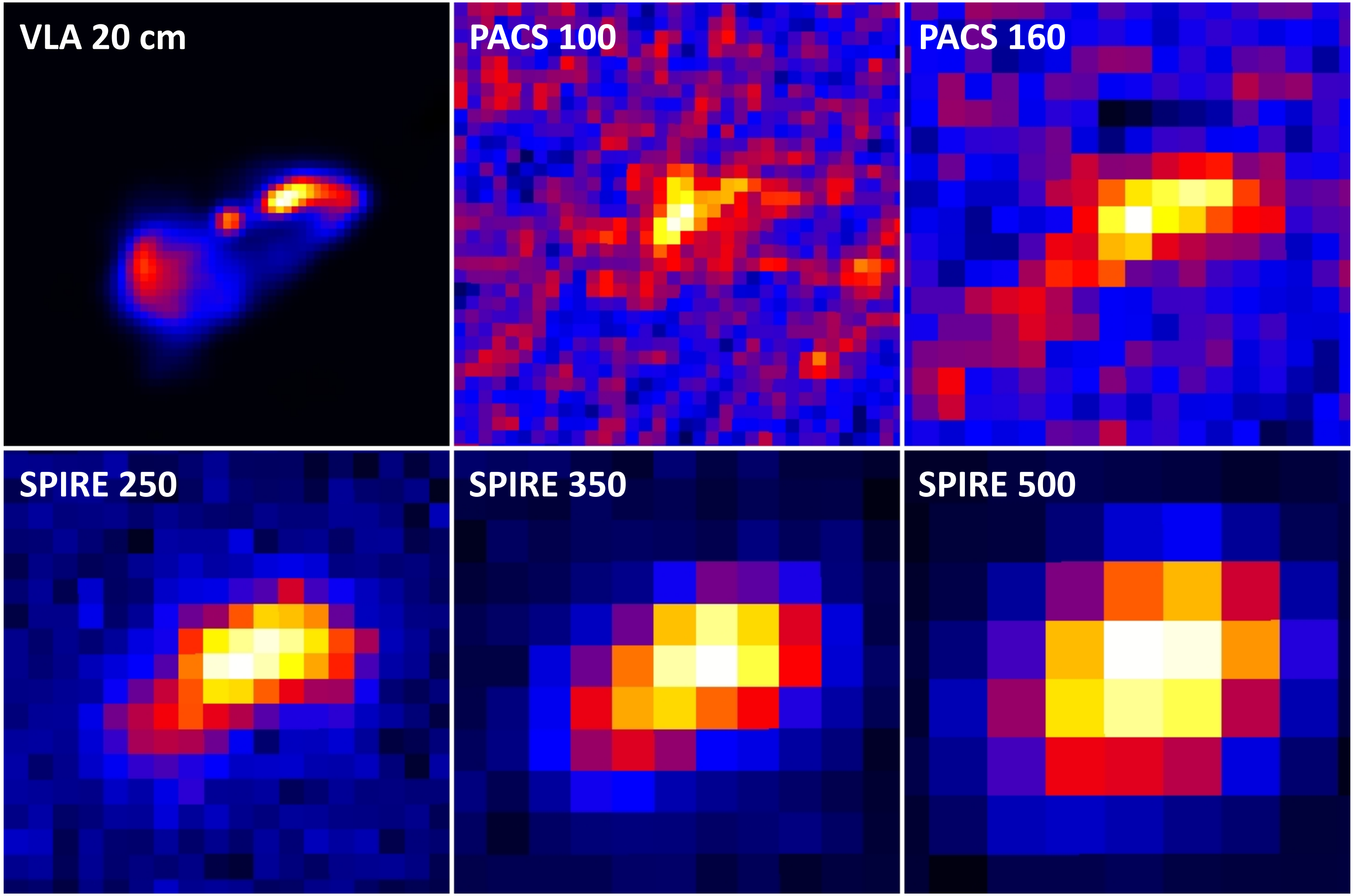
Survey of 60 deg^2 in the Virgo Cluster.
PACS + SPIRE imaging in parallel mode.

286h Open Time KP

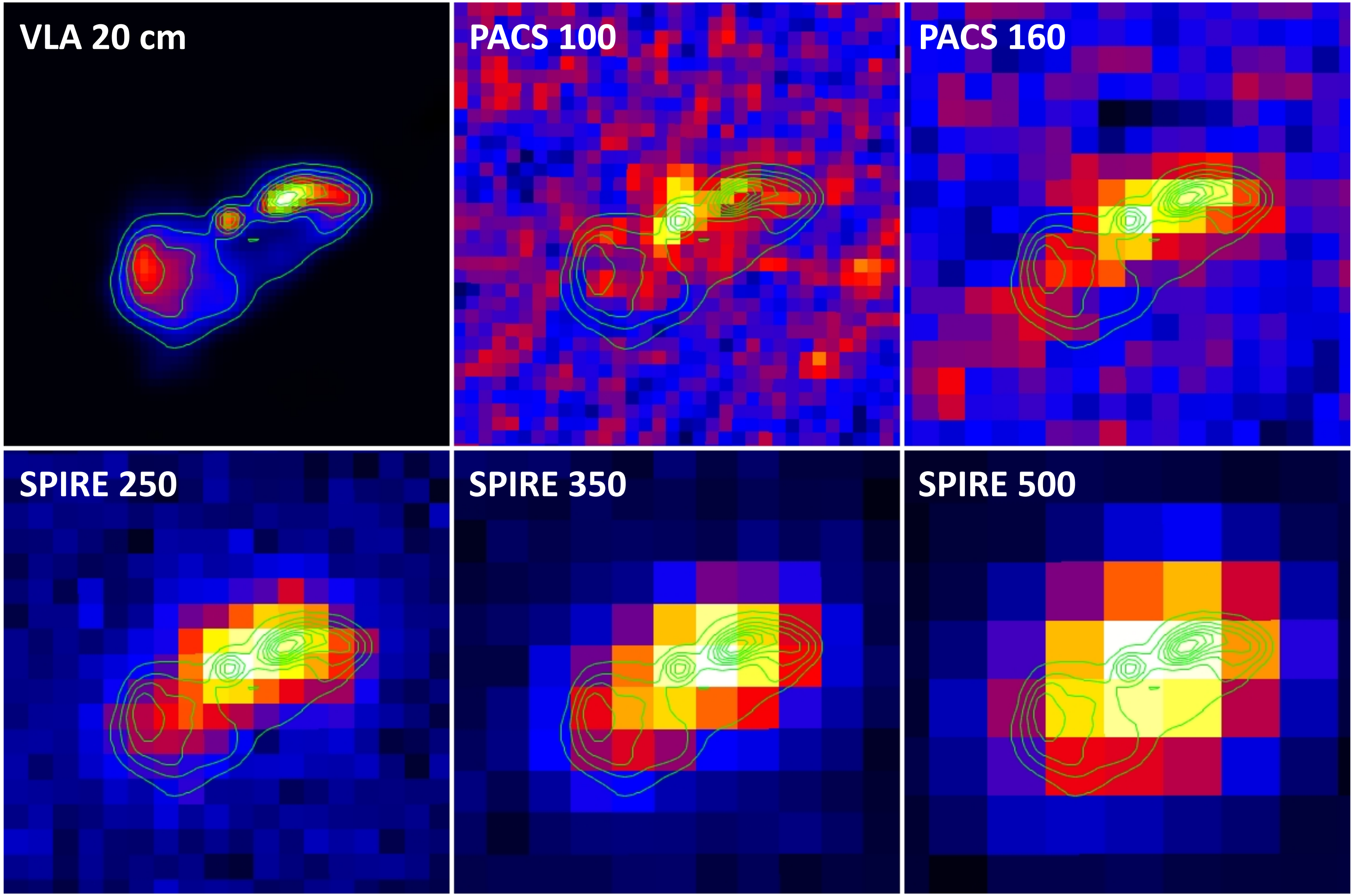
SDP observations: single cross-scan of central field (16 deg^2).
Centered on M87…



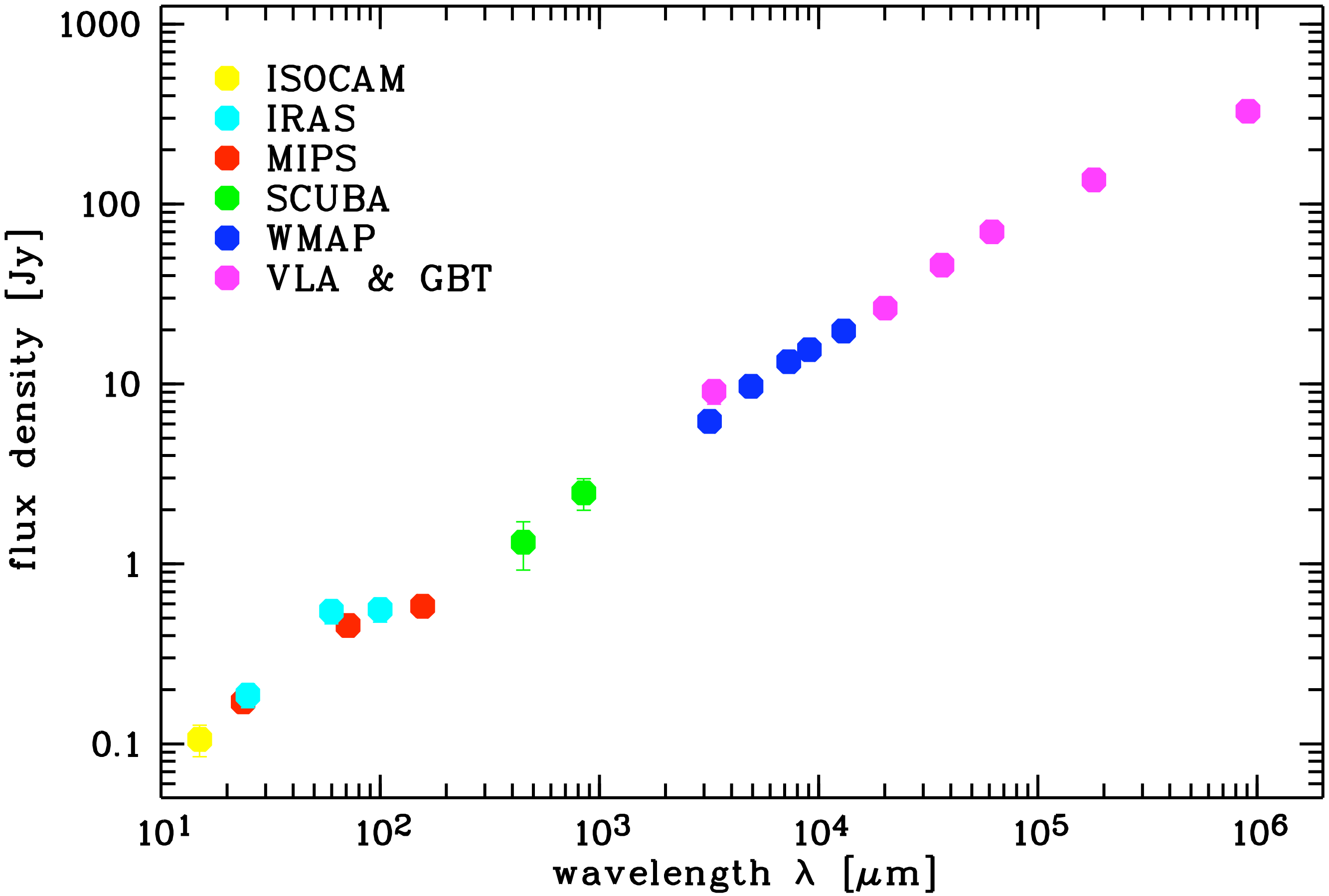
Herschel observations of M87



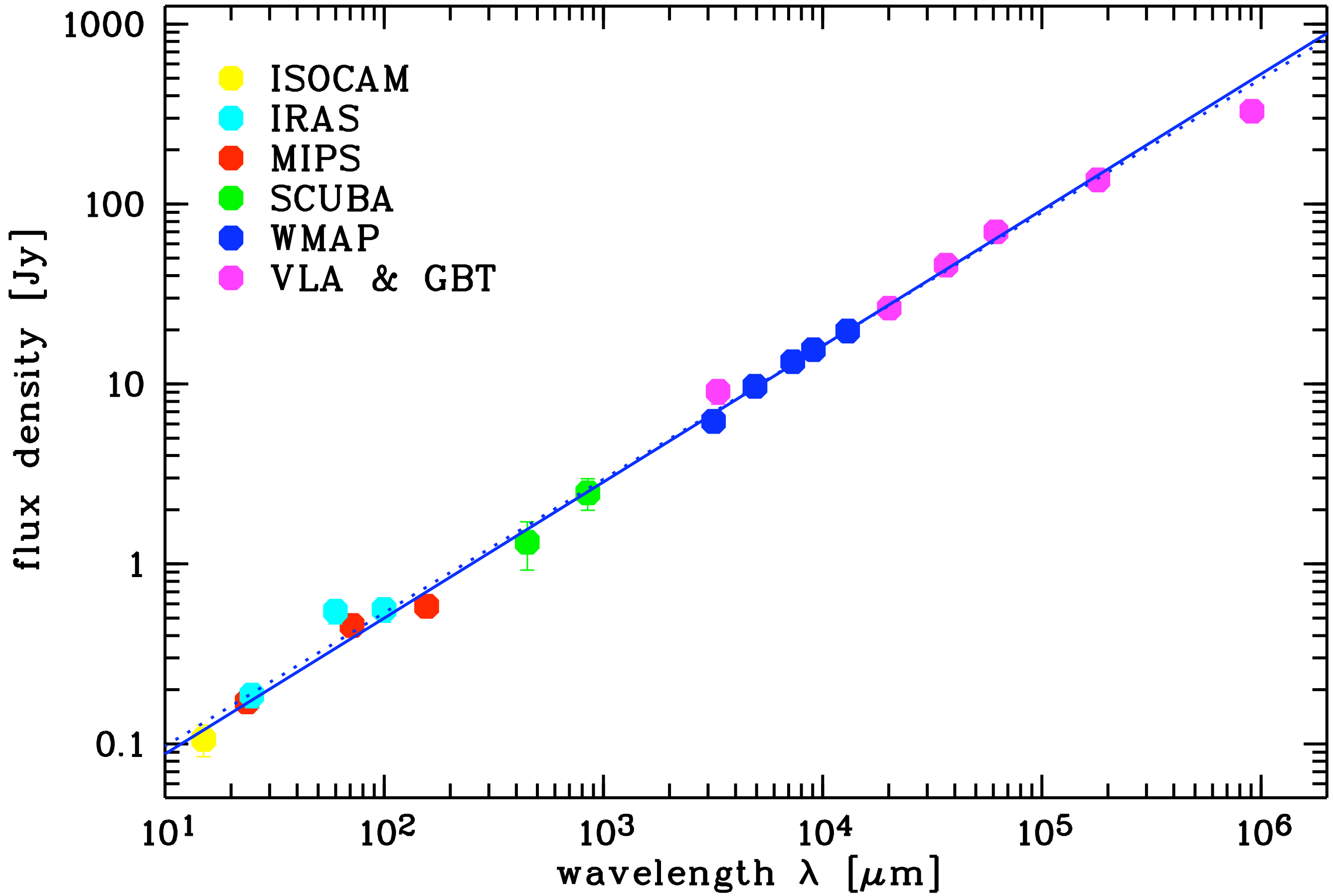
Herschel observations of M87



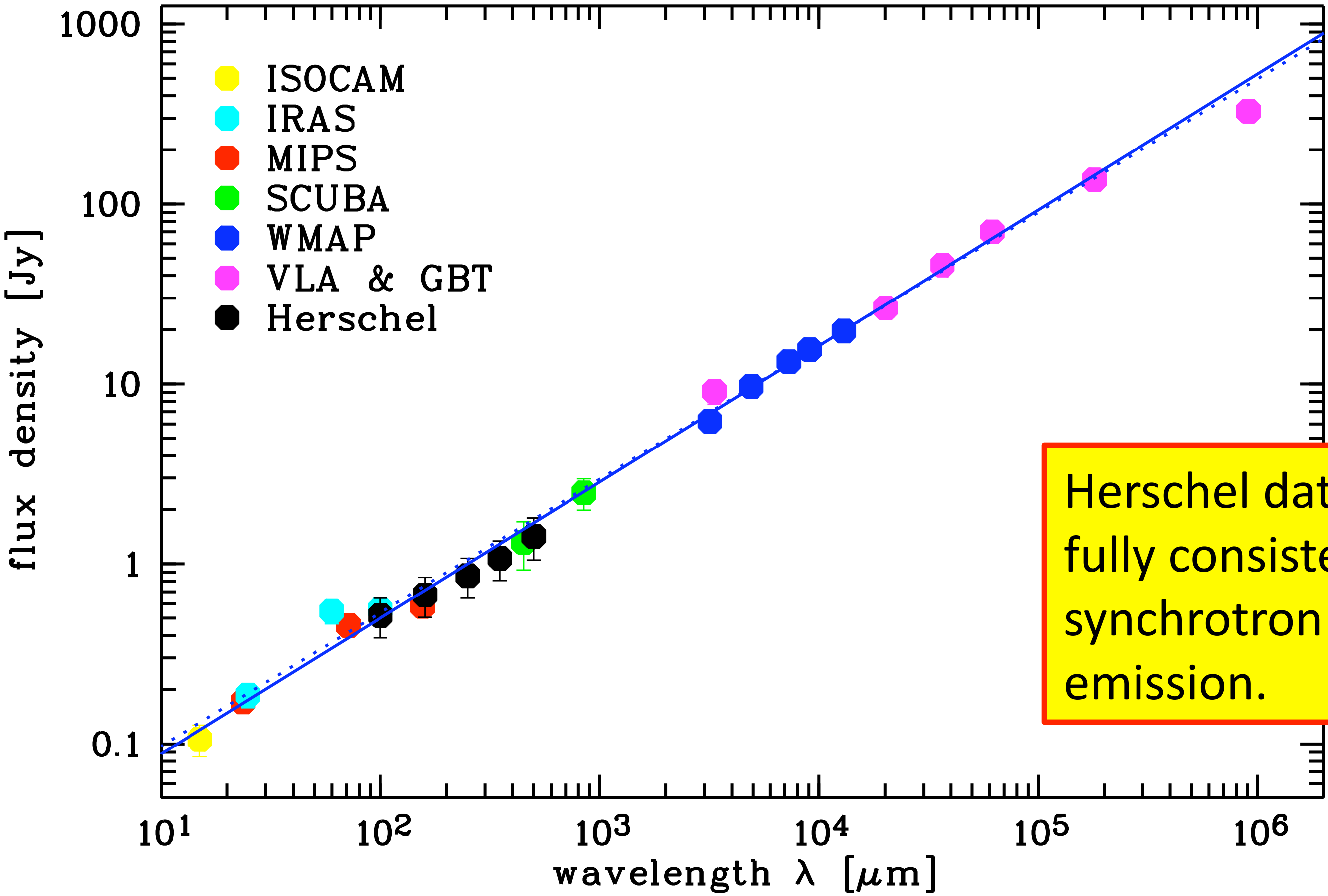
Spectral energy distribution



Spectral energy distribution



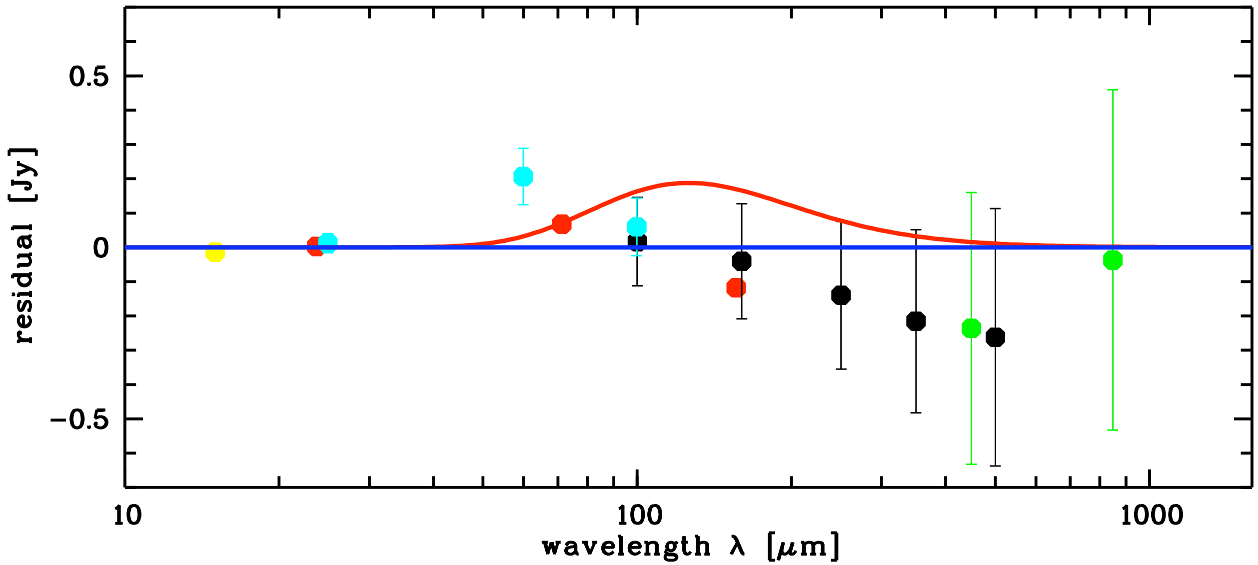
Spectral energy distribution



Herschel data are fully consistent with synchrotron emission.

Spectral energy distribution

Is there room for a contribution from thermal dust emission ?
SKIRT radiative transfer simulations
-> mean dust temperature in M87 around 23 K

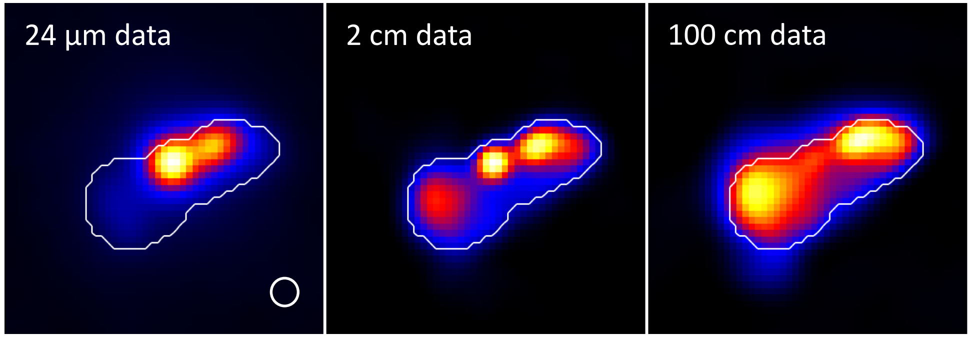


Greybody fits to the 1σ upper limits of residuals:
upper limit to the dust mass of 7 x 10^4 $M_\odot$

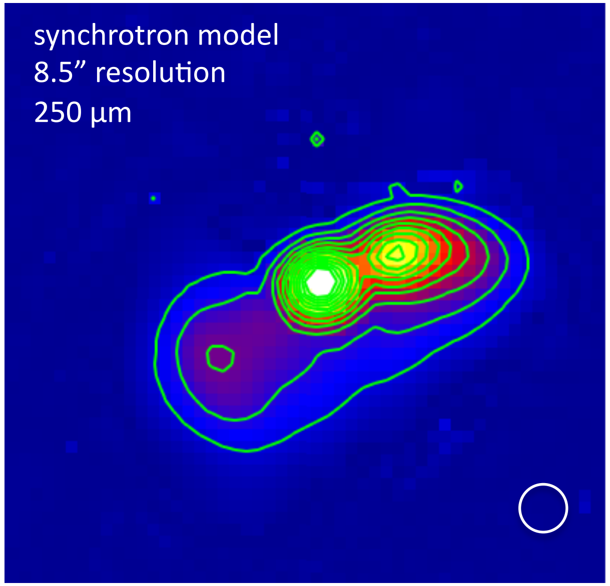
Spatially resolved analysis

Construction of synchrotron model for M87

- based on available data with sufficient resolution
  VLA (0.3, 1.6 4.9, 8.2 and 15 GHz), GBT (90 GHz), MIPS (24 μm) image
  (resolution: 8.5" FWHM, pixel scale 2")
- second order polynomial fitted to each pixel in data cube



A synchrotron model for M87



250 µm model image: three peaks
- nucleus (strongest)
- jet + NW lobes
- SE lobes.

After convolution to SPIRE 250 µm resolution (18.1” FWHM): elongated singly peaked emission

Good agreement in both flux levels and morphology between synchrotron model and observations

Conclusion

Synchrotron emission is a adequate explanation for the FIR emission in M87

- integrated SED
- 250, 350 and 500 μm maps
  (for 100 and 160 μm wait for better S/N maps)

No detection of a FIR excess emission

No need to invoke the presence of a substantial diffuse dust component

For T = 23 K (mean equilibrium temperature) $M_{dust} < 7 \times 10^4 M_{\odot}$

These results are in agreement with

- analysis of the nuclear emission (Buson et al. 2009)
- upper limit to dust grain lifetime of 46 x 10^6 years in passive ETGs
  (Clemens et al. 2010)
- non-detection of cool molecular gas
  (Salomé & Combes 2008, Tan et al. 2008)
- no significant intrinsic absorption in X-ray spectra
  (Böhringer et al. 2002)

Summary of the conclusion

Seen from the FIR point of view, M87 is a passive object with a central radio source emitting synchrotron emission, without a substantial diffuse dust component.

Thank you for your attention.
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