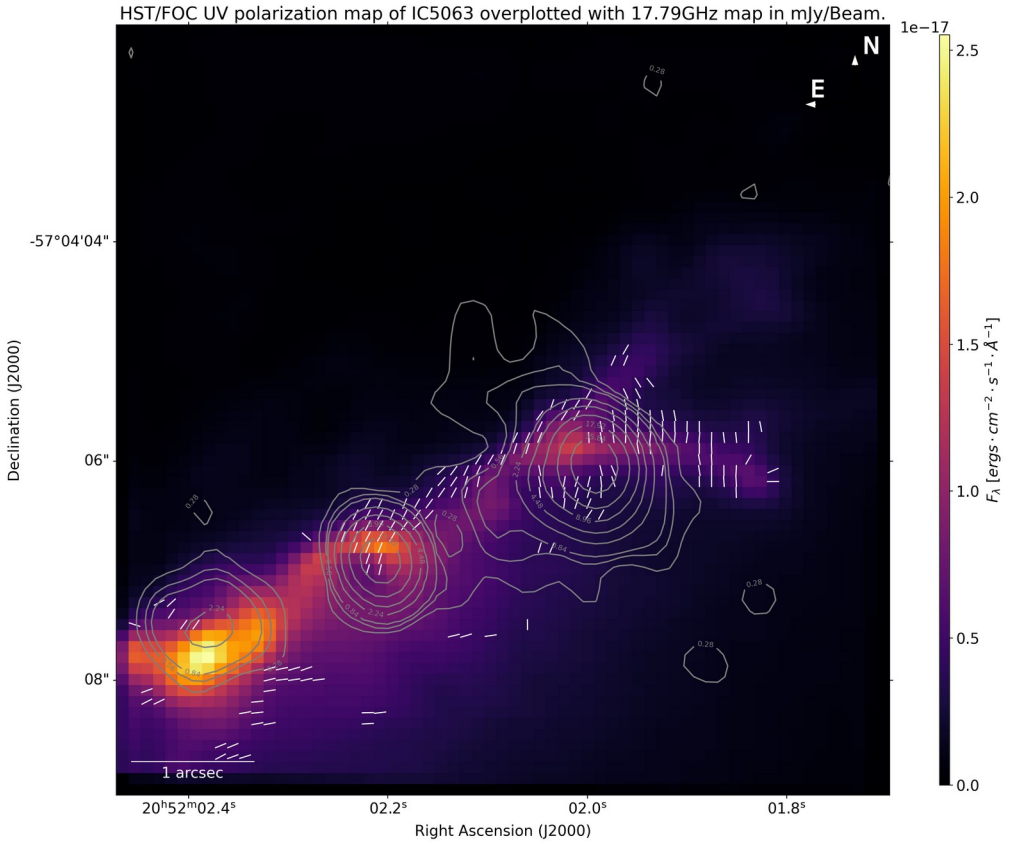
The dusty environment of IC~5063 seen under the (polarized) magnifying glass of the HST/FOC



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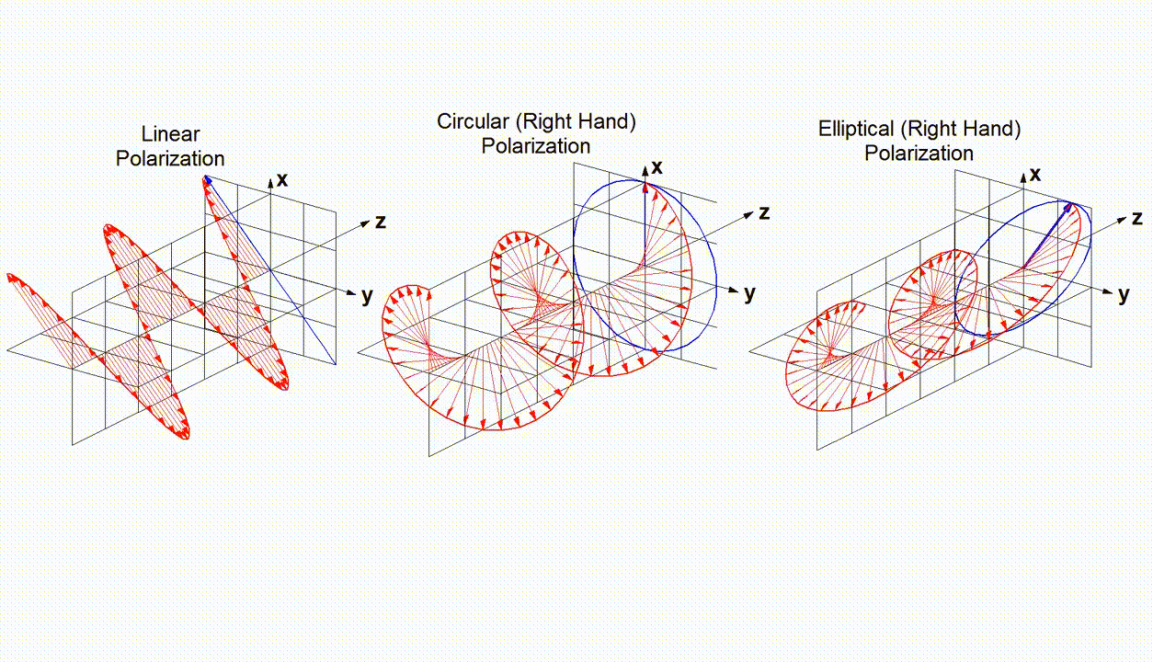
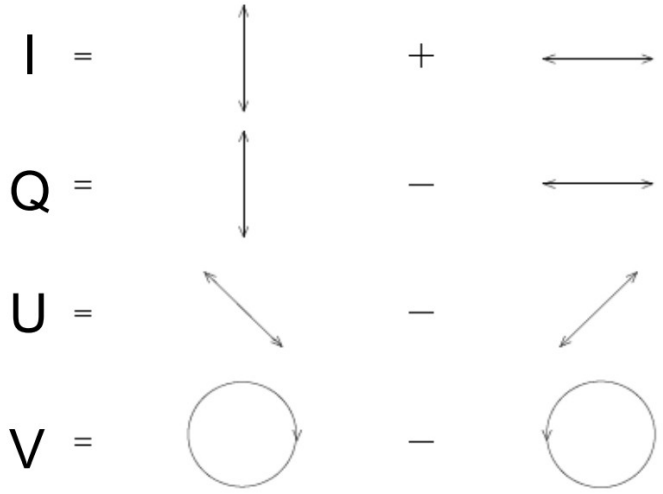
Observatoire astronomique de Strasbourg | ObAS

Polarization



Polarization of an electromagnetic wave



Stokes parameters describing the polarization state

Polarization from aligned dust grains

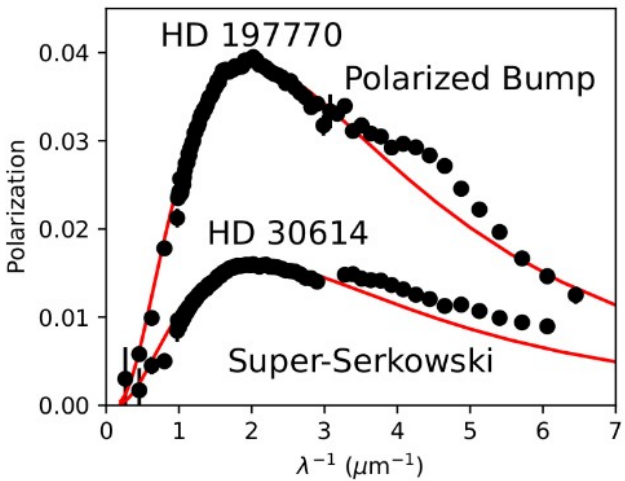
Interstellar continuum polarization over the UV-to-microwave range is due to dichroic extinction (or emission) by asymmetric, aligned dust grains.

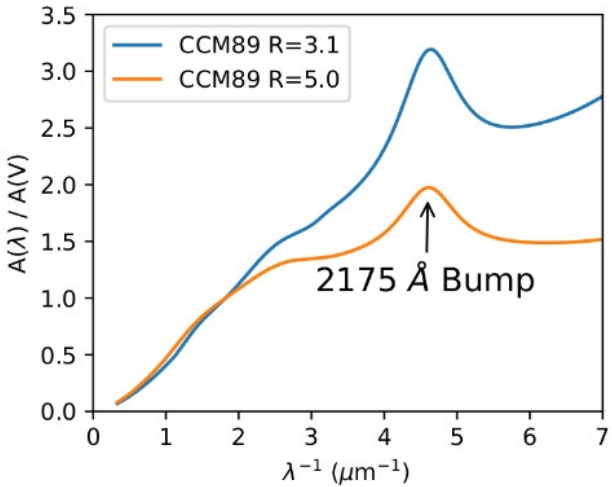
→ the wavelength dependence of the polarization, generally, traces the size of the aligned grains and the magnetic field topology (Hough et al. 1989; Hildebrand et al. 2000; Hildebrand 2002; Aiken et al. 2002)

Ultraviolet polarimetry provides the best probe of the smallest dust grains (diameter< 0.09μm), their mineralogy and interaction with the environment such as λ < 2*a

(λ = wavelength, a = effective grain radius)

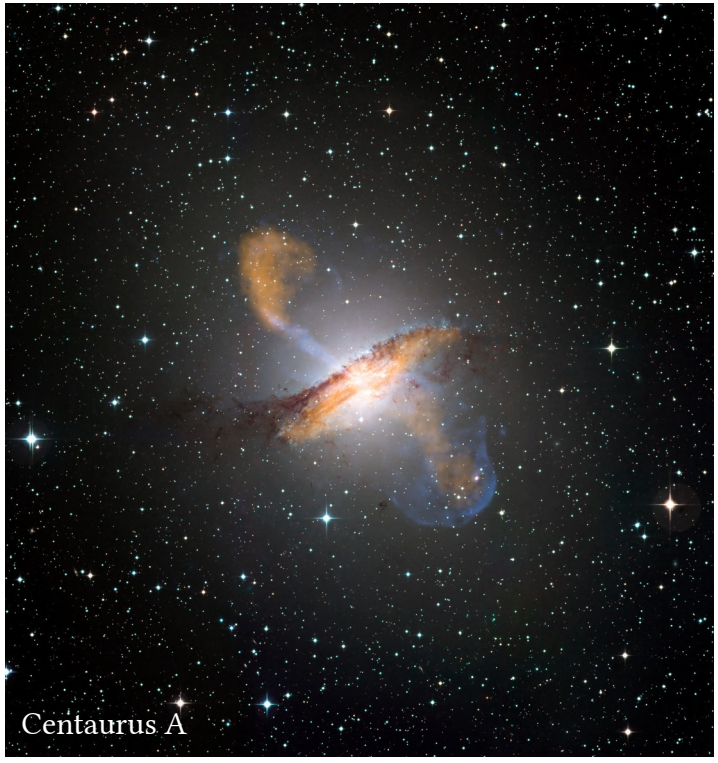
(formula from Radiative Alignment Torque Theory, Dolginov & Mytrophanov 1976)



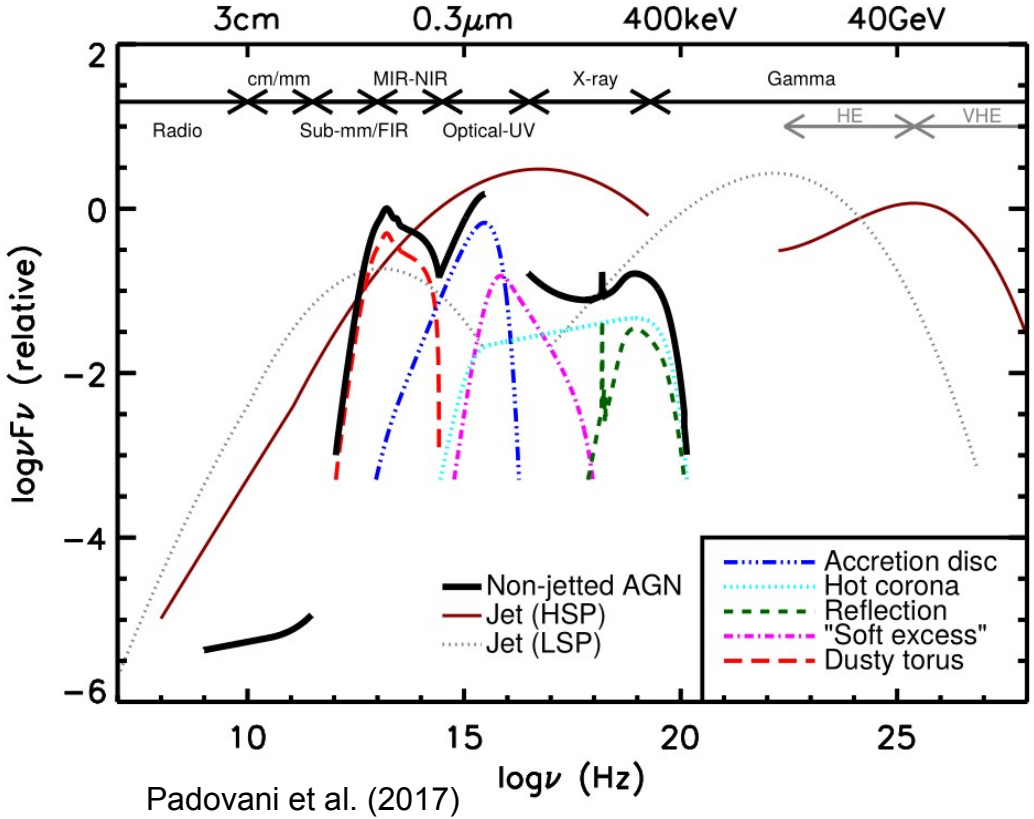


Andersson et al (2021)

Active Galactic Nuclei (AGN)

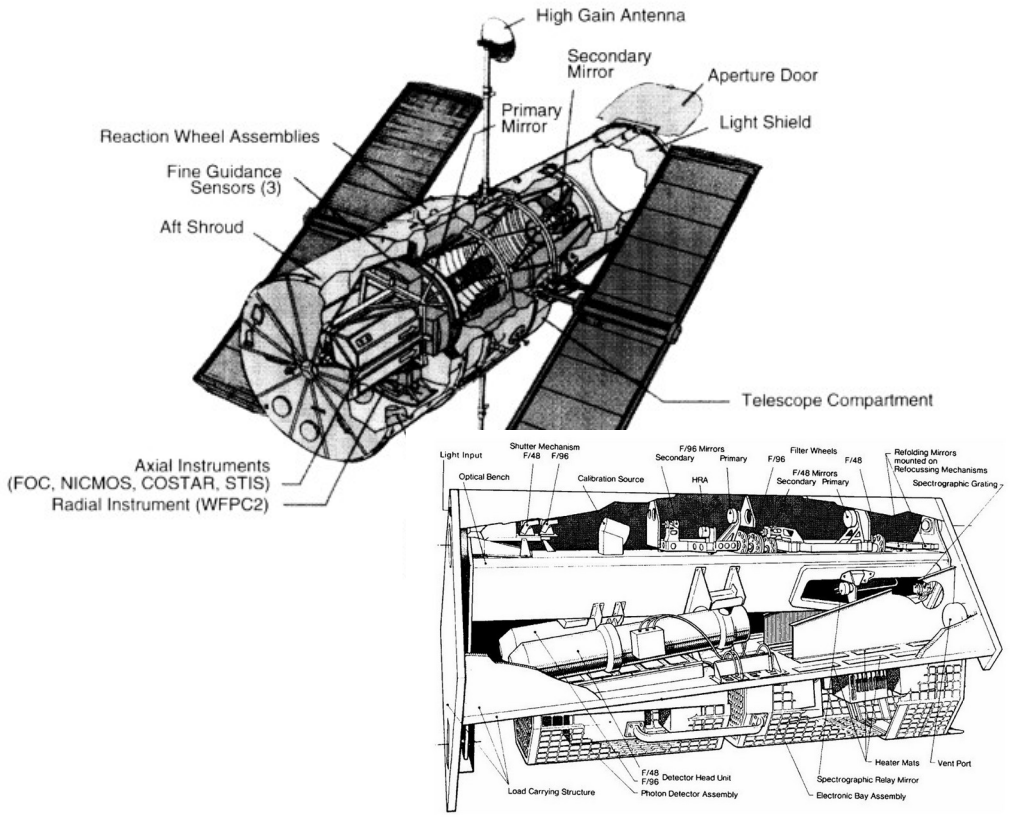


ESO/WFI (Optical); MPIfR/ESO/APEX/A.Weiss et al. (Submillimetre); NASA/CXC/CfA/R.Kraft et al. (X-ray)



Padovani et al. (2017)

HST : Faint Object Camera



Characteristics of the FOC :

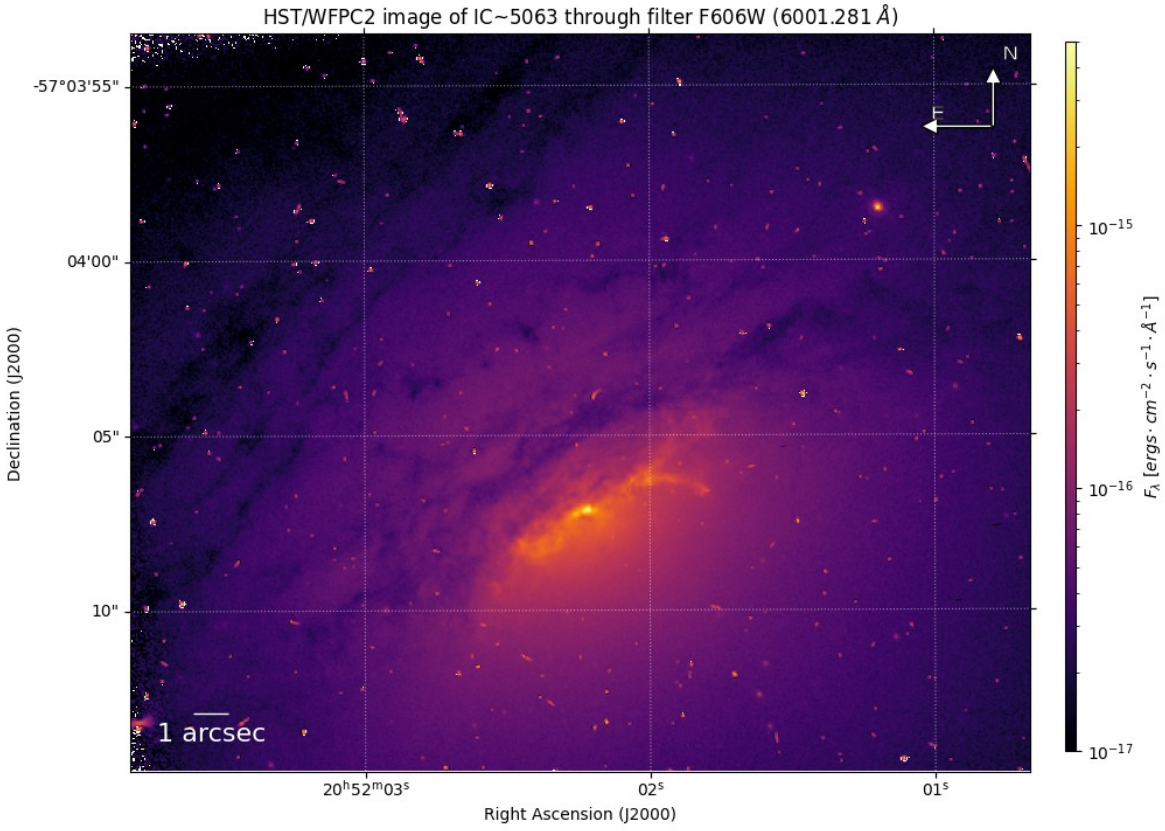
- Photon-counting imager
- Long focal ratio
- Wavelength range : 1150 – 6500 Å
- Field-of-view : 7” x 7”
- Pixel-size : 0.014” x 0.014”
- 3 polarizer filters : 0°, 60°, 120°

Archives of the HST/FOC :

615 datasets : 27 quasars

→ 15% of the whole sample has no associated paper

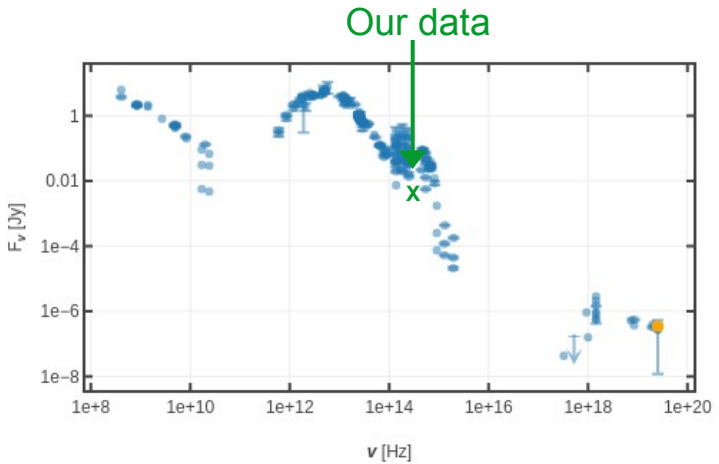
IC~5063



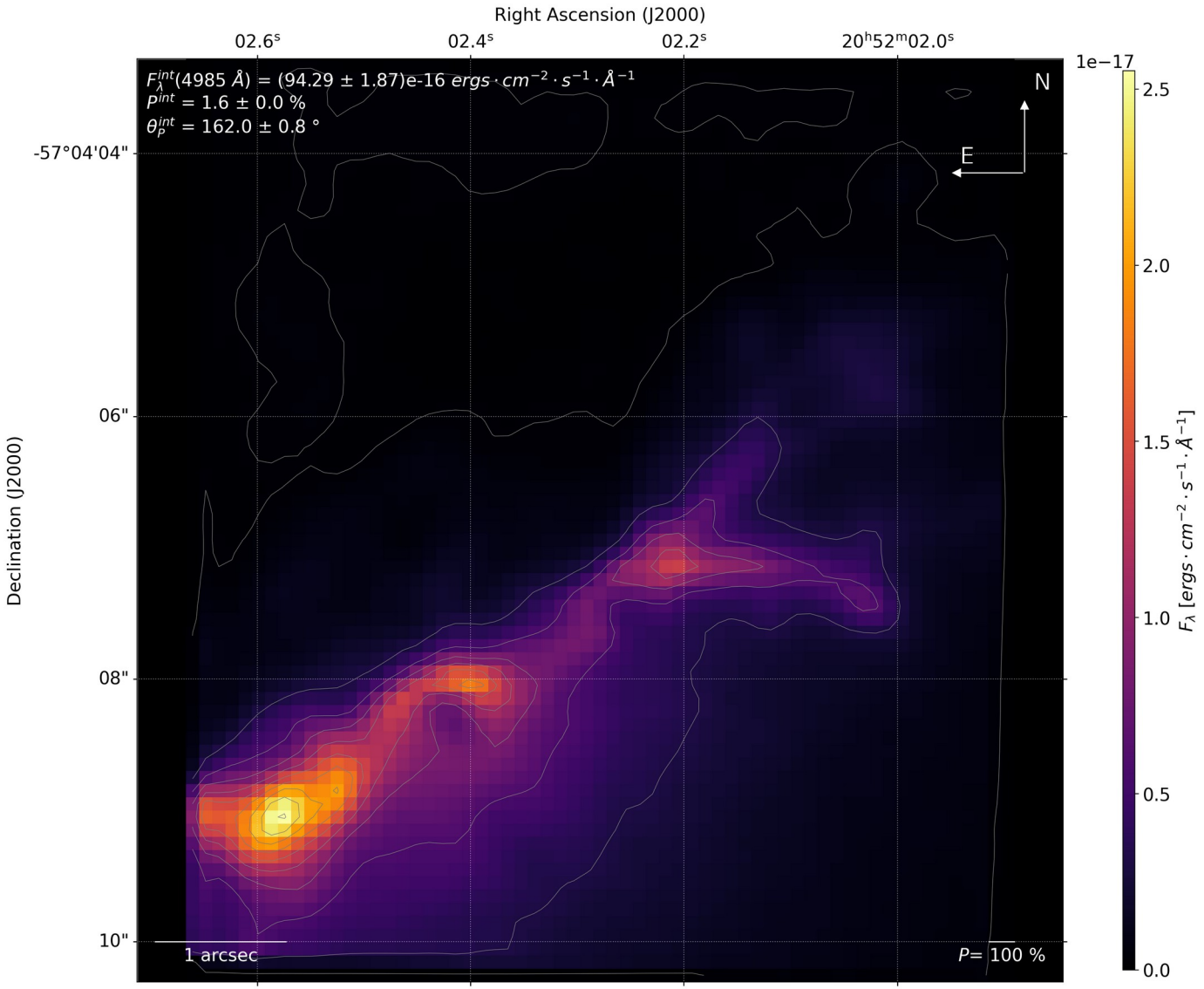
Maksym (2020) : composite image WFC3/ACS (HST)

IC~5063: total flux UV

Total flux: 94.29e-16 ergs/cm²/s/A
Core : 8.04e-16 ergs/cm²/s/A
SE lobe : 17.12e-16 ergs/cm²/s/A
NW lobe : 7.03e-16 ergs/cm²/s/A

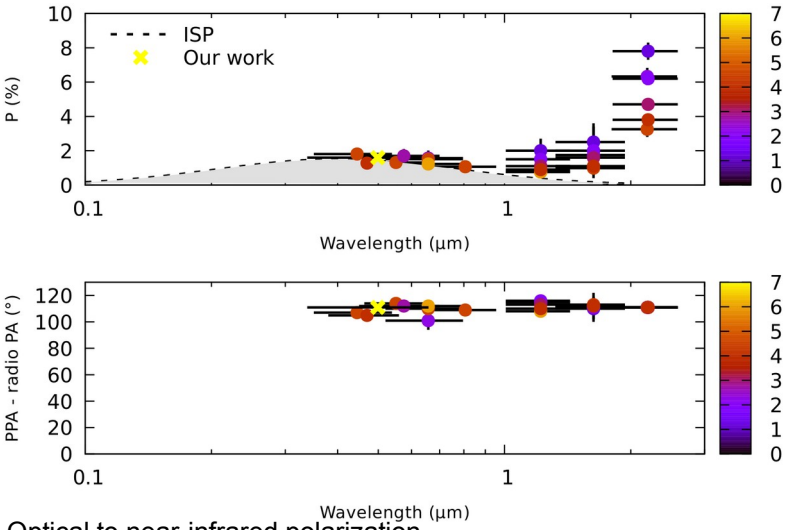


Spectral Energy Distribution of IC~5063 (NED)

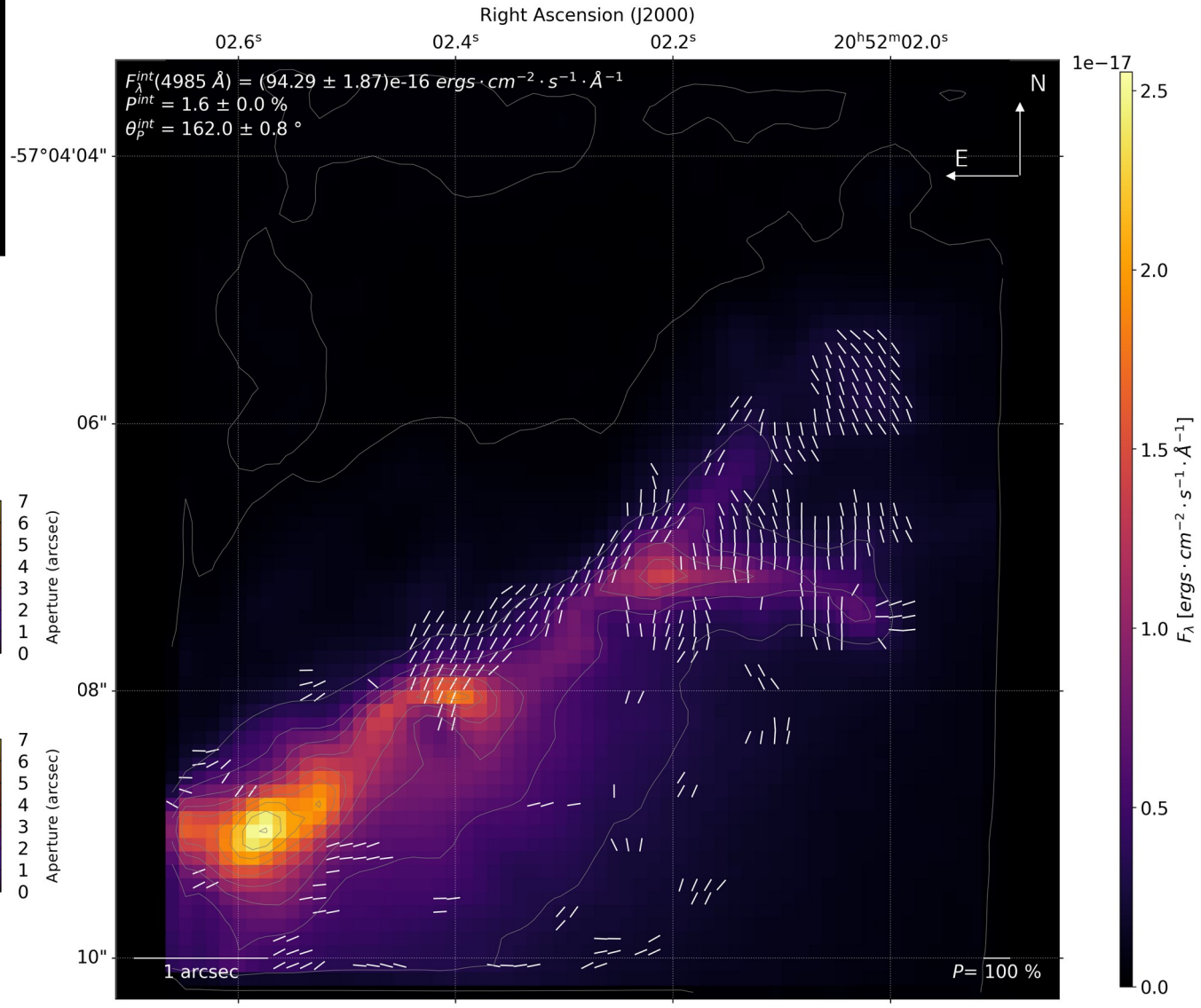


IC~5063: polarization map

Polarization degree: 1.6%
Polarization angle: 162°
Aperture: 7”
Dominated by dichroic transmission



Optical to near-infrared polarization

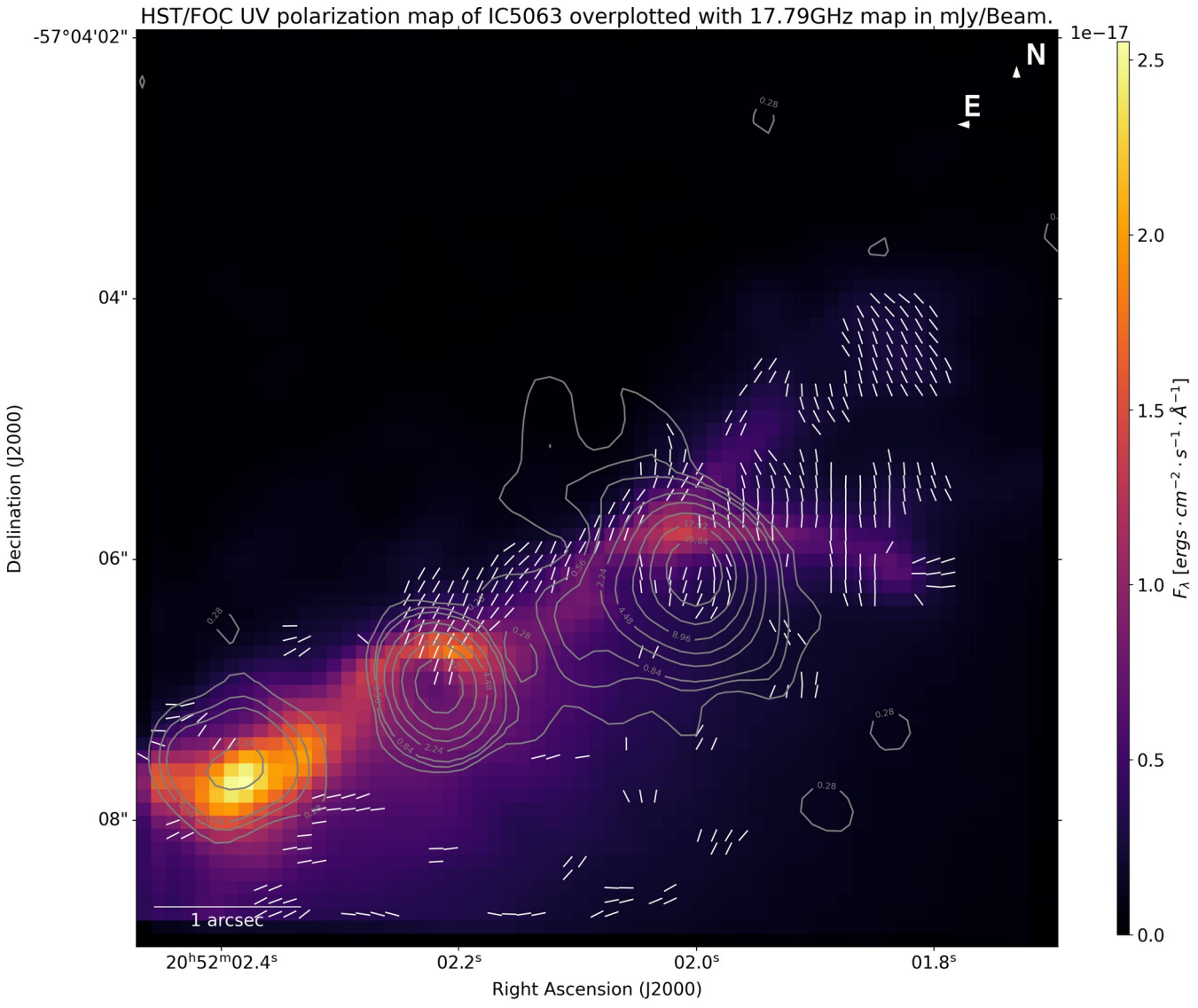


IC~5063: radio (18GHz)

Radio:
- NW lobe 16 times brighter than SE lobe
- NW approaching jet, SE counter-jet

UV:
- SE lobe 2.5 times brigther than NW lobe

Depolarized flux in radio jets regions
- Displaced medium
- Matter has been pushed away by the jets



IC~5063: radio (18GHz)

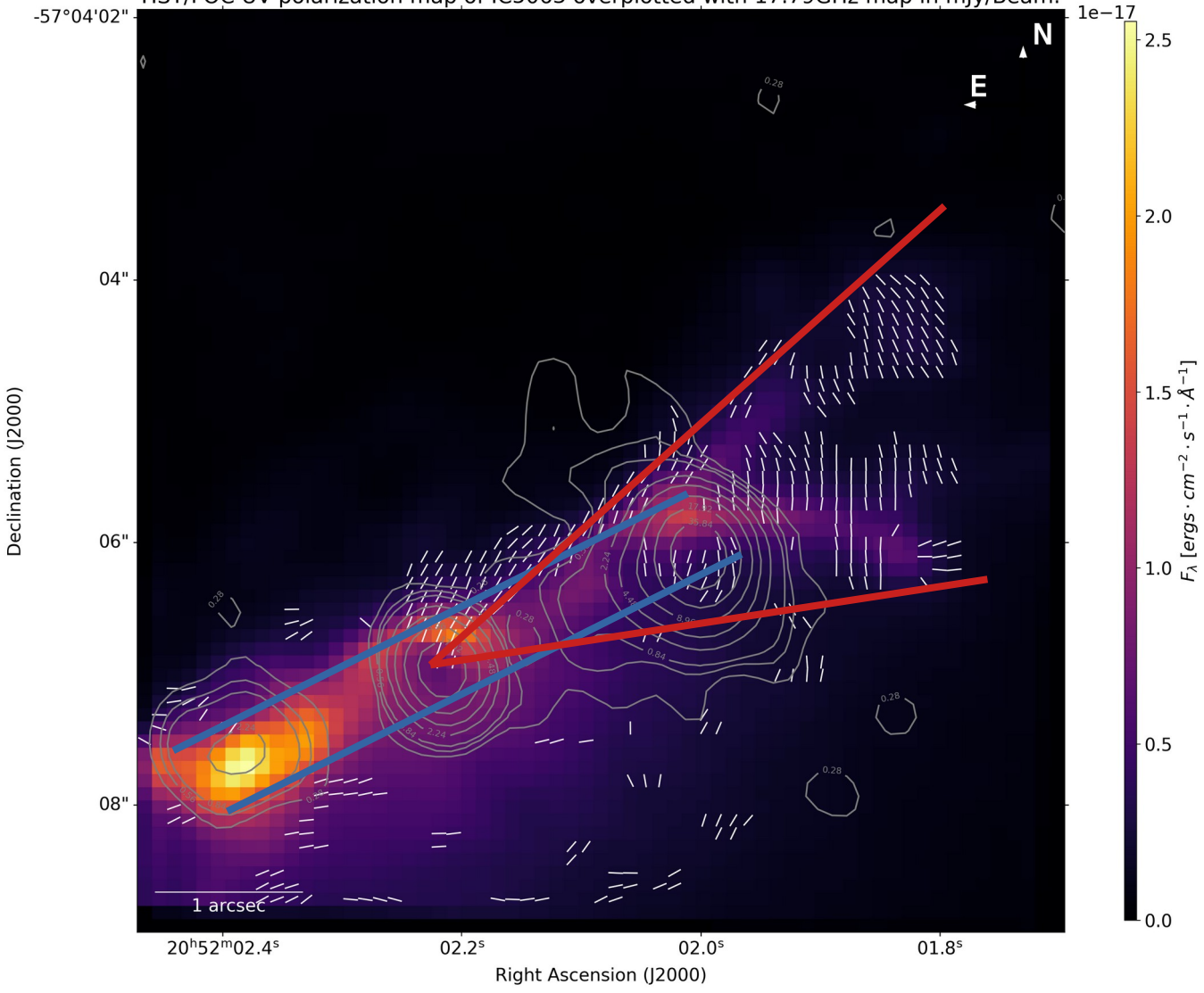
Blue: matter-free region (jet swipping)

Red: AGN ionization cone

Polarization pattern characteristic of scattering on AGN winds where the jets didn't penetrate the medium yet

Flux: 11.9e-16 ergs/cm²/s/A
Polarization degree: 5.7%
Polarization angle: 11.6°

We can probe perturbed (post-jet) and non-perturbed (pre-jet) media



IC~5063: infrared

Polarization pattern along the dust lane

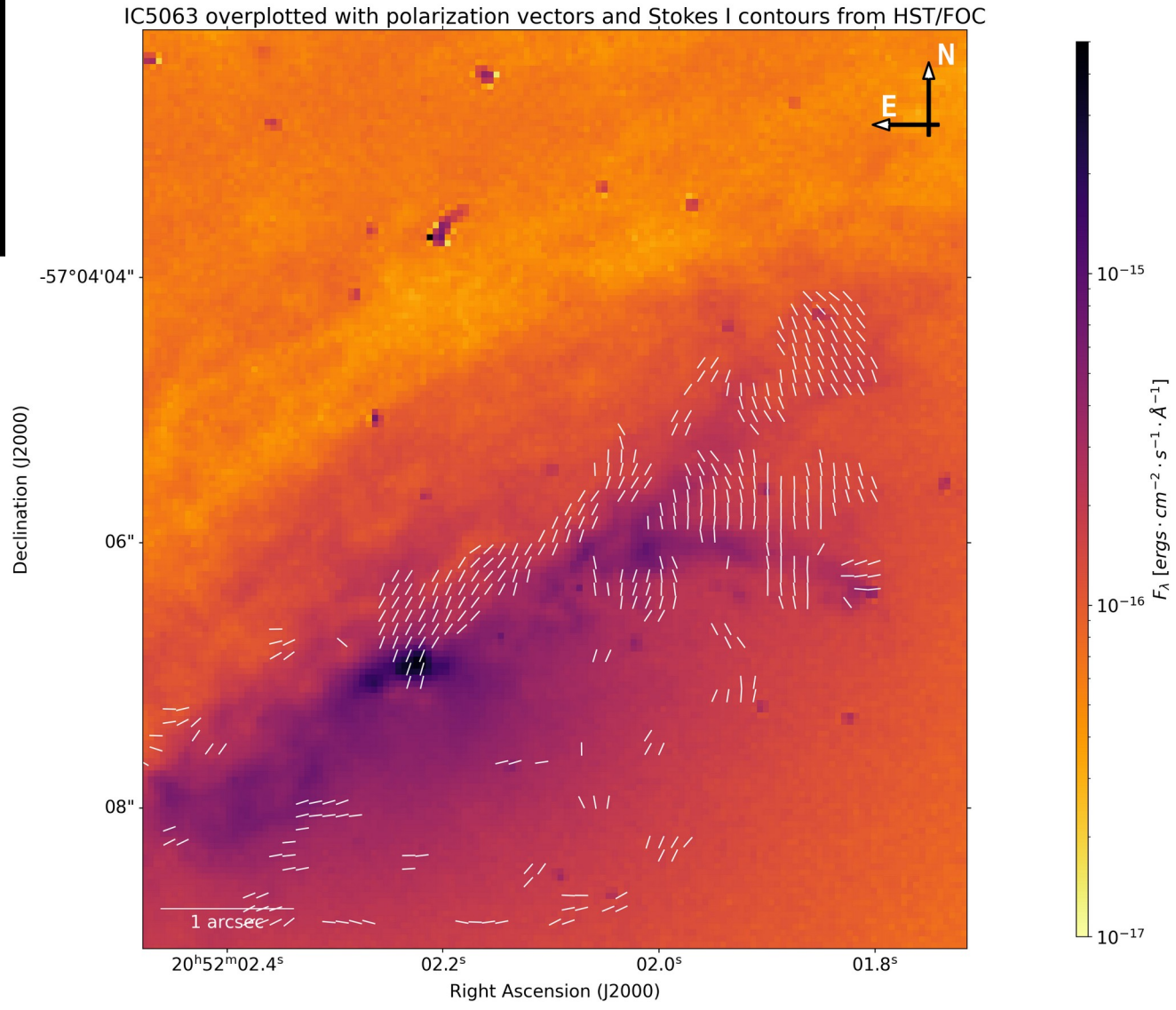
Flux: 2.62e-16 ergs/cm²/s/A
Polarization degree: 7.6%
Polarization angle: 154°

Dichroic transmission through foreground dustlane (forward scattering)

Question: how distant is the dust lane from the AGN ?

→ rather close according to the polarization vectors

→ jet pushed some of the dust lane material away



IC~5063: infrared

We quantify the wavelength dependent nature of the dust extinction, the extinction curve, using relation:

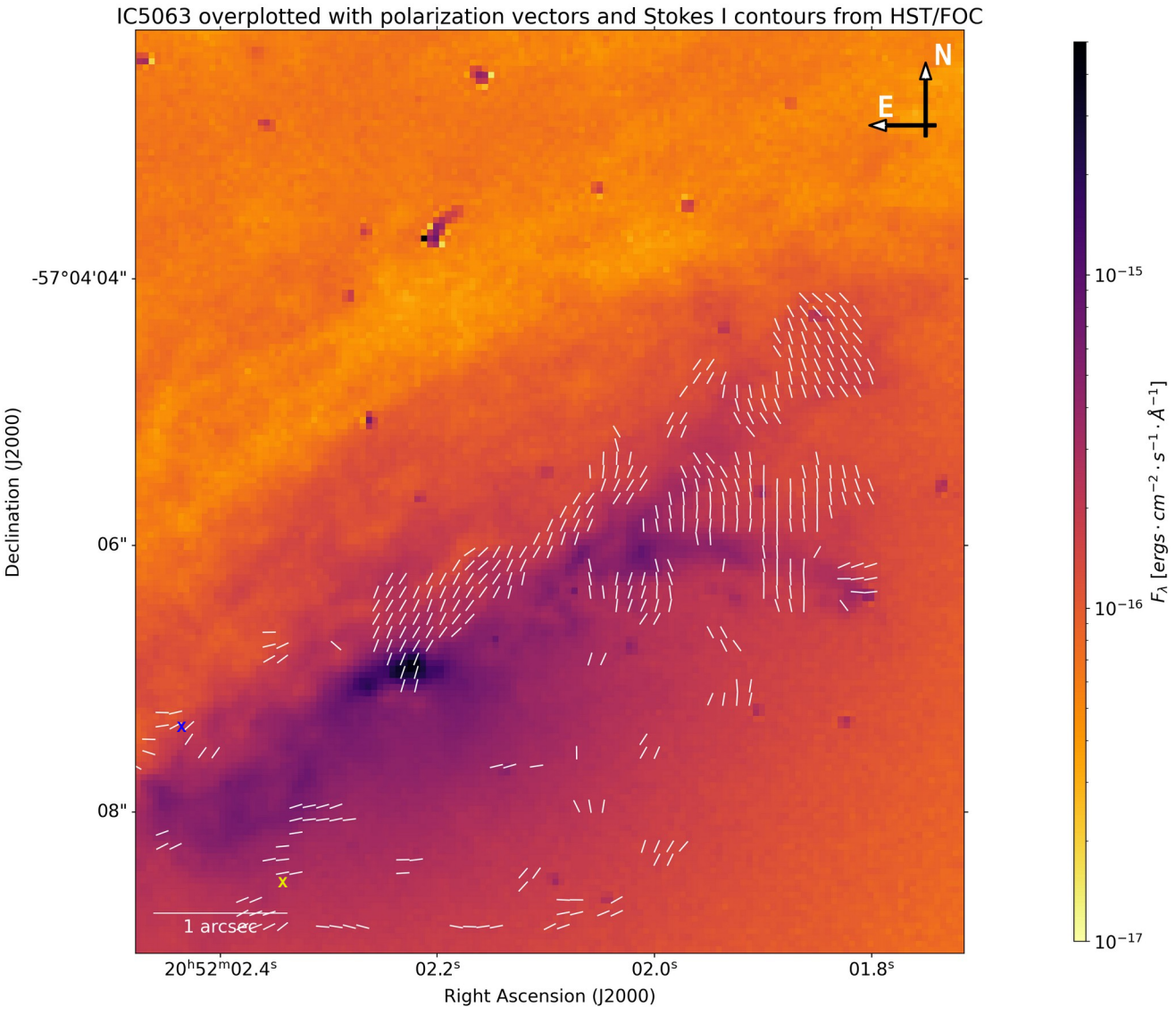
$$A_\lambda = -2.5 \log \left(\frac{I_{\lambda,obs}}{I_{\lambda,model}} \right)$$

where, A_λ gives the amount of total extinction in a particular pass band (B,V,R,I) measured in magnitude scale, while $I_{\lambda,obs}$ (x) and $I_{\lambda,model}$ (x) represent the observed (attenuated) and un-attenuated light intensities in a given pass band, respectively.

$I_{\lambda,obs}$ = 87.95e-19 ergs/cm²/s/A
$I_{\lambda,model}$ = 99.66e-19 ergs/cm²/s/A

A_λ = 0.312 mag

Colina et al. (1991) : Av = 0.3 mag in the dust lane



IC~5063: infrared

For a normal gas-to-dust ratio:
$A(V) = N_H / 1.8e21\ mag \cdot cm^{-2}$

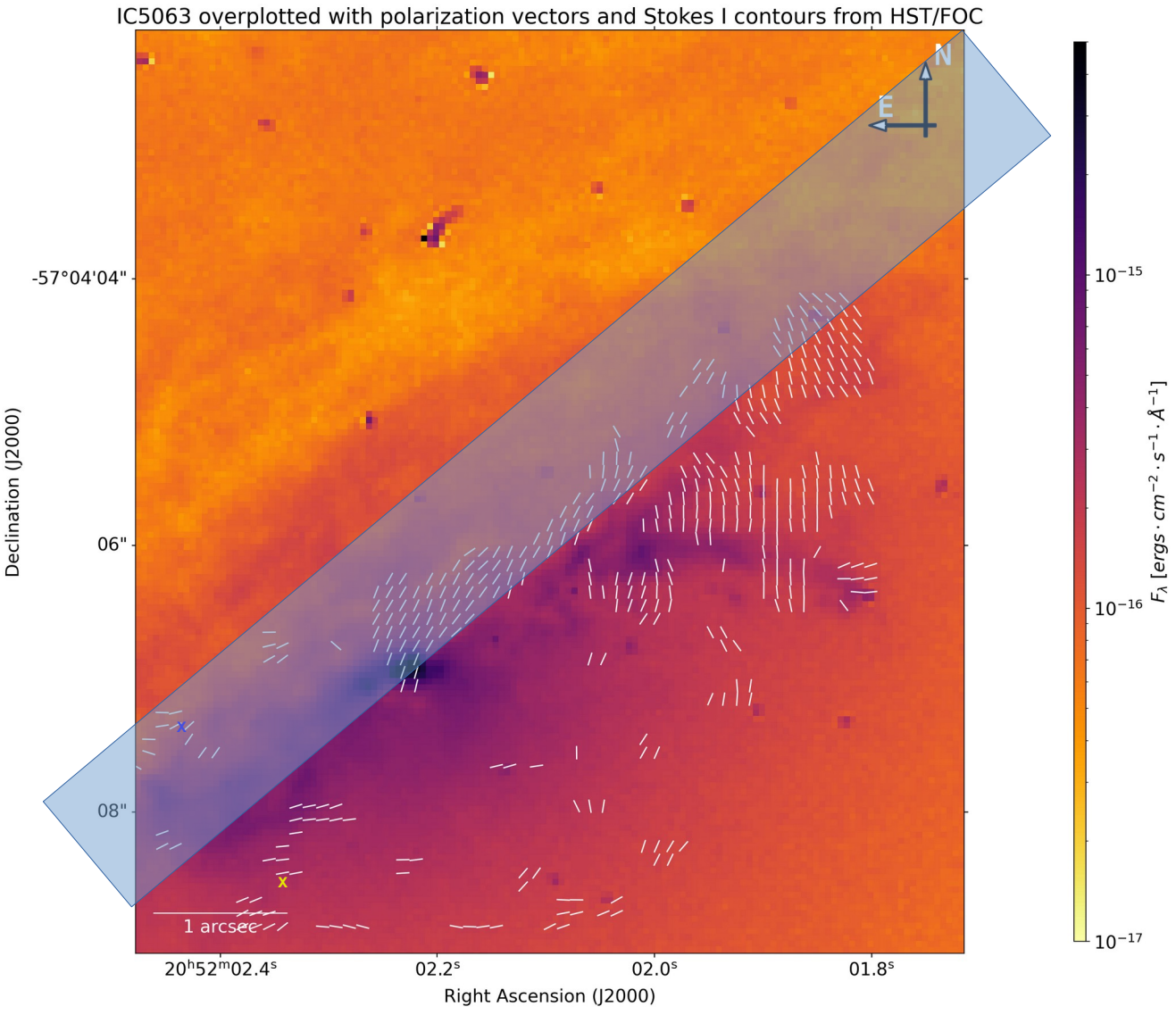
this corresponds to a column density of associated hydrogen of ~4e20 $atoms^{-1} \cdot cm^{-2}$

Estimation of the total gas surface density

→ rectangle of 1.07”x9” (257.47pc x 2165.67pc) coincident with polarized detection of dichroic transmission

→ surface density : 0.4 solar mass / pc² (Zhu et al. 2017)

Consistent with Oosterloo et al. (2002) findings, where dust lanes in elliptical galaxies are in the range 0.3 – 1
→ too low for large scale star-formation



IC~5063: AGN interacting with host dust

What is the mechanism that aligns the grains in the dust lane ?
- large scale magnetic field
- aligned by the jet (parallel to the jet)

We don't have spectropolarimetry of the dust lane or the central AGN region so we cannot push forward the analysis
→ this makes the case for UV spectropolarimetry to study dust in AGNs
→ POLLUX instrument aboard LUVOIR ?

Maybe this is the way to finally detect the extinction bump around 2175 angstroms that has never been found in AGN

Why AGN dust so different from Milky Way dust?