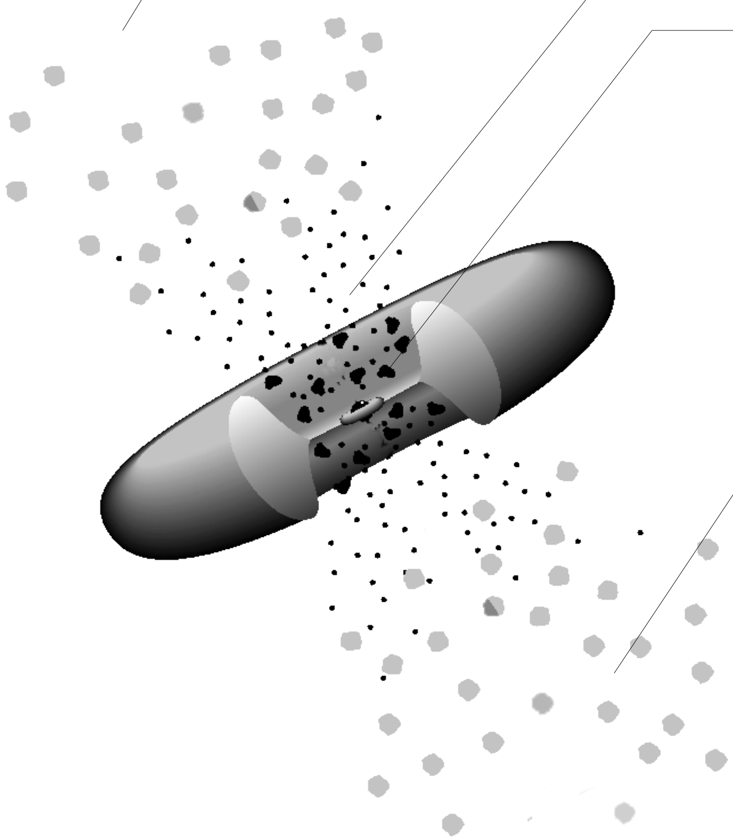
From the theoretical Unified Model to NGC 1068 : new UV/optical constraints on the AGN reprocessing regions



Frédéric Marin

René W. Goosmann
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Michal Dovciak

Brussels - 2012

Observatoire astronomique de Strasbourg

cnrs dépasser les frontières

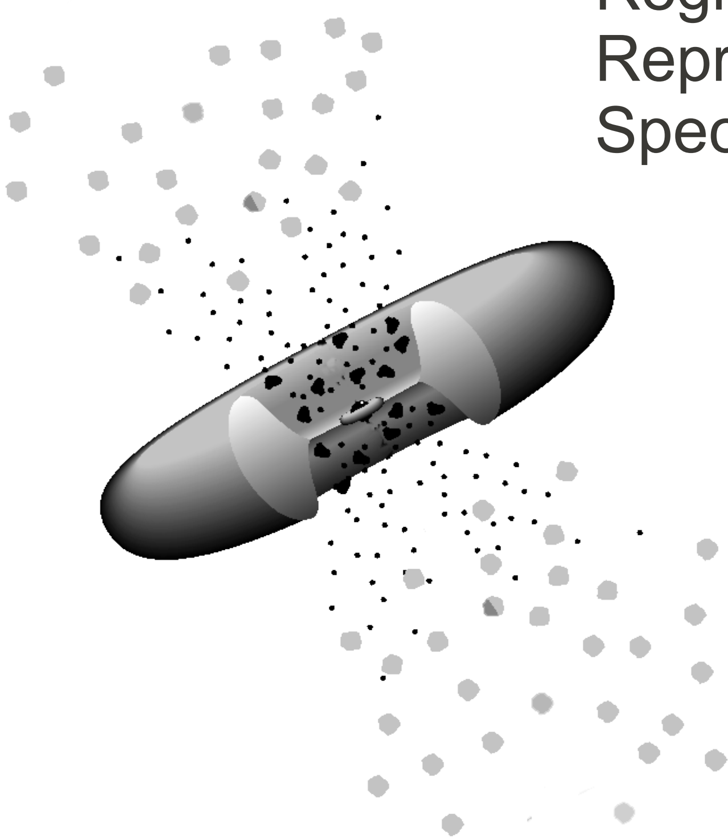
UNIVERSITÉ DE STRASBOURG

AGENCE NATIONALE DE LA RECHERCHE ANR

Goals

AGNs : several emission and reprocessing regions
→ radiative coupling

Regions spatially unresolved
Reprocessing and scattering polarize
Spectropolarimetry as a diagnostic tool



● : to obtain a coherent model of the polarization resulting from the radiative coupling

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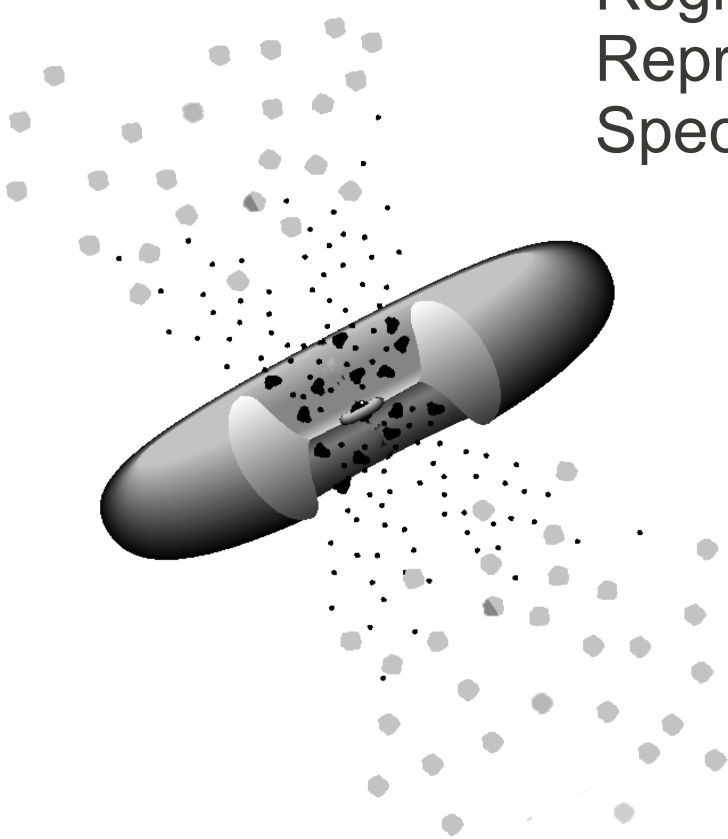

- : to obtain a coherent model of the polarization resulting from the radiative coupling
- : to derive new constraints on the geometry and composition from the observations

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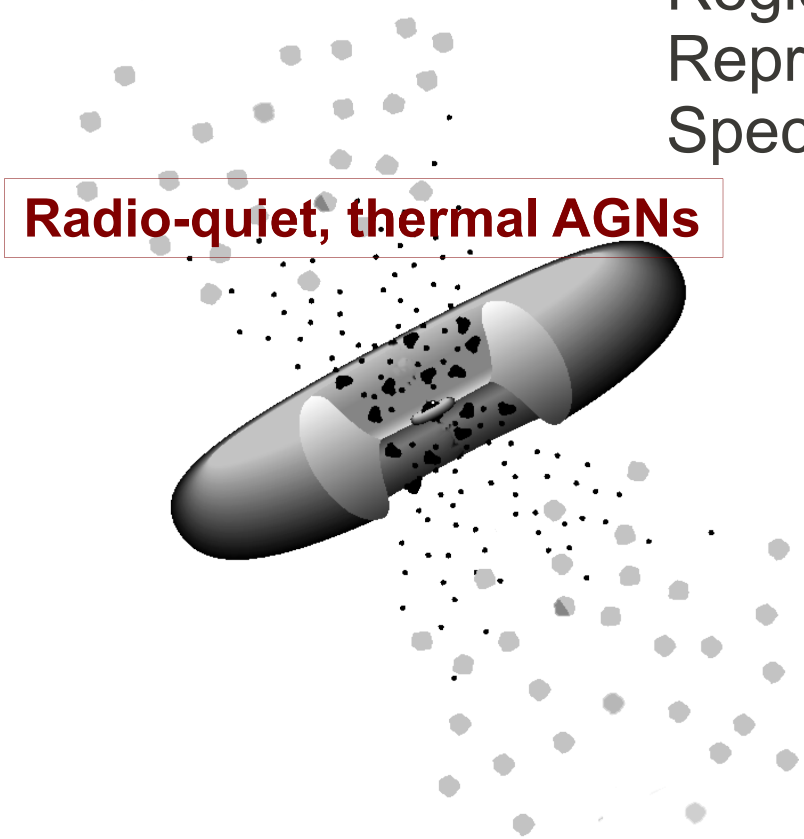
Reprocessing and scattering polarize
Spectropolarimetry as a diagnostic tool



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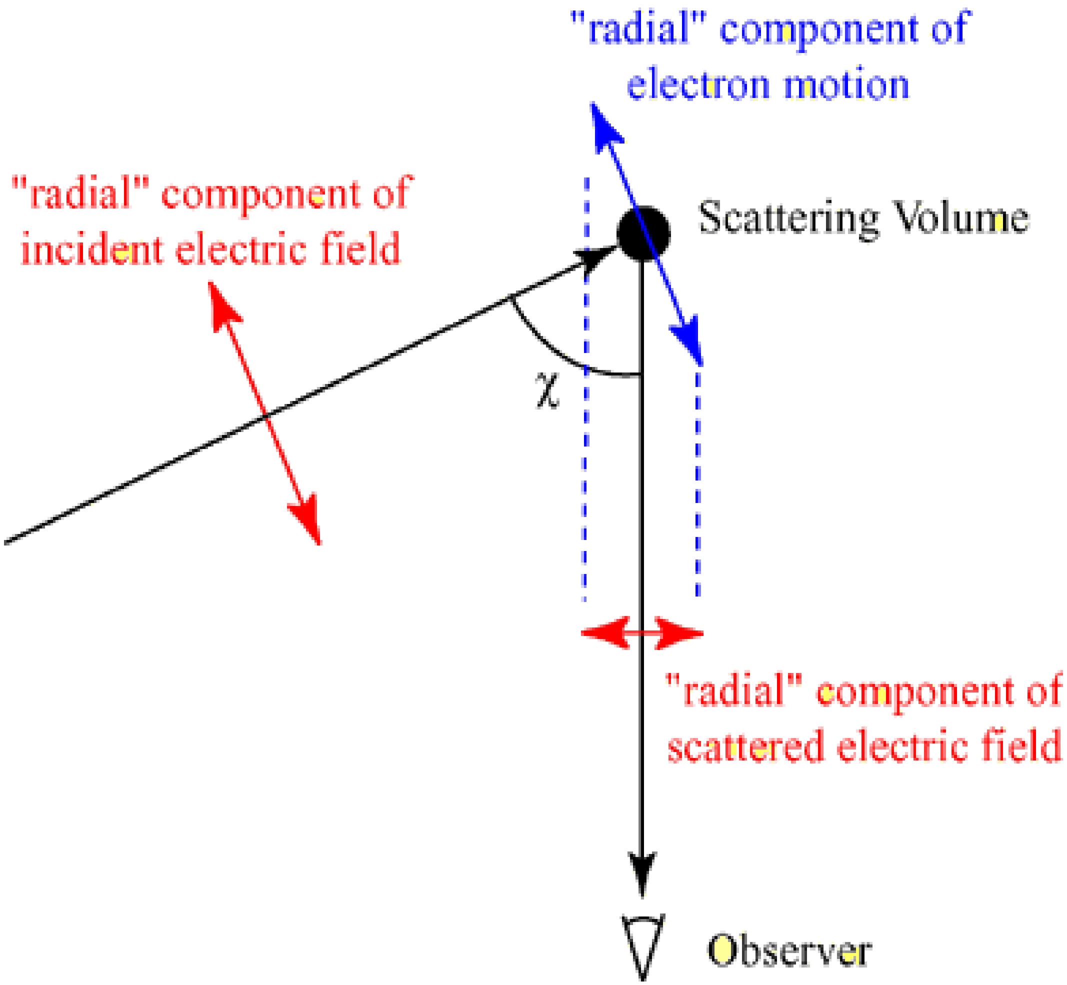
Linear polarization

UV and optical scattering
- electron (Thomson) scattering



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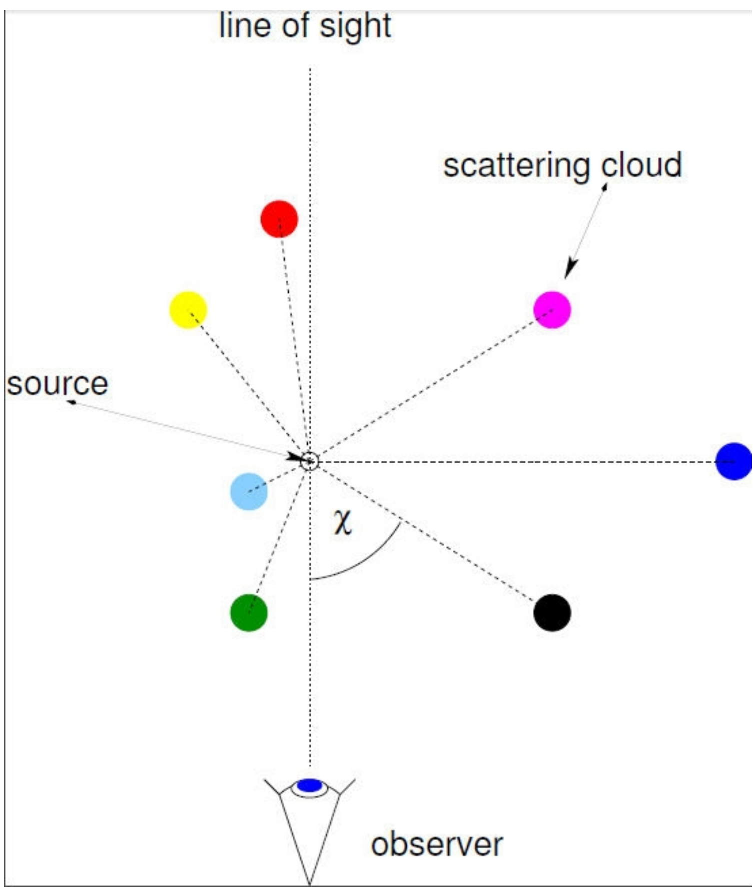
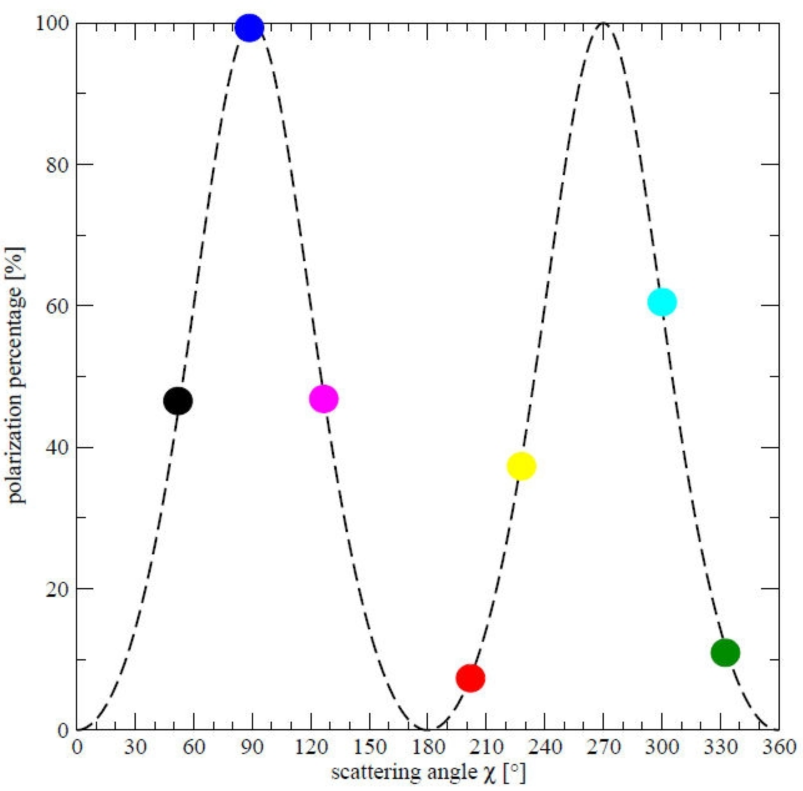




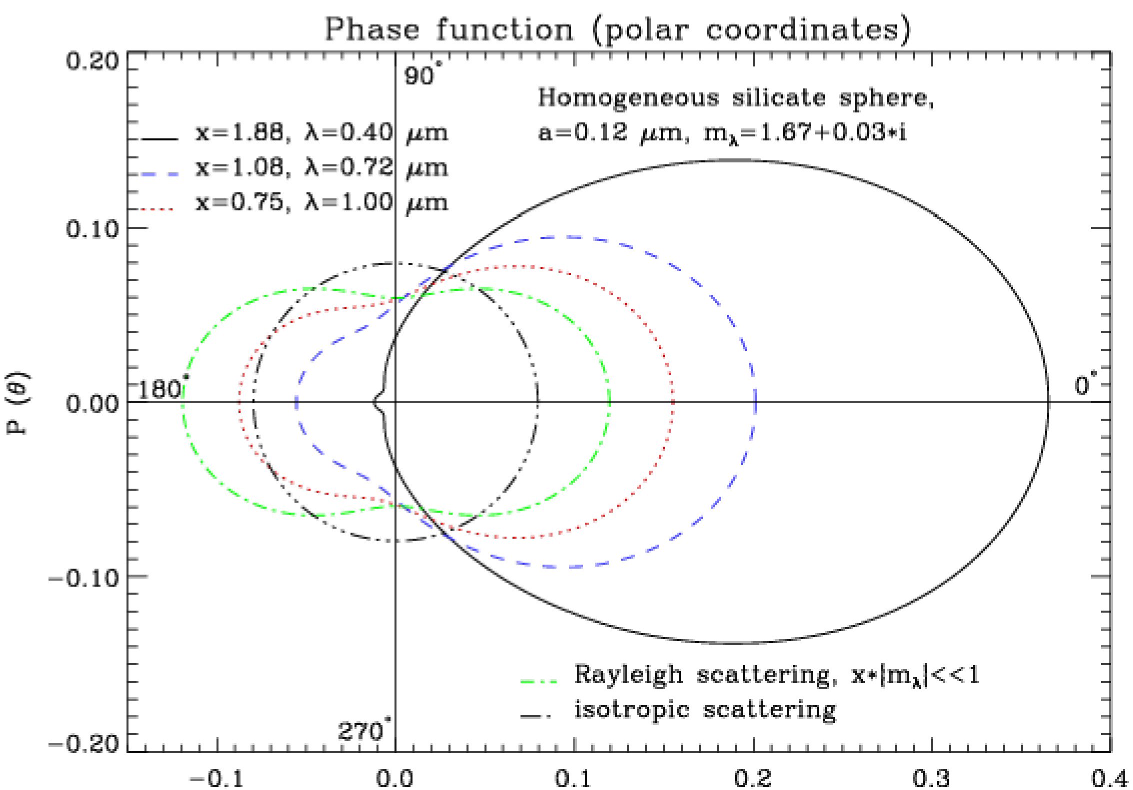
Thomson scattering phase function

Linear and circular polarization

UV and optical scattering

- electron (Thomson) scattering
- dust (Mie) scattering

Linear polarization

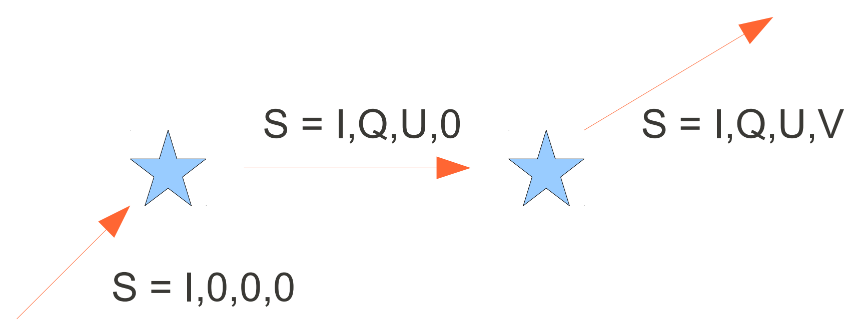


Steinacker et al. (2002)

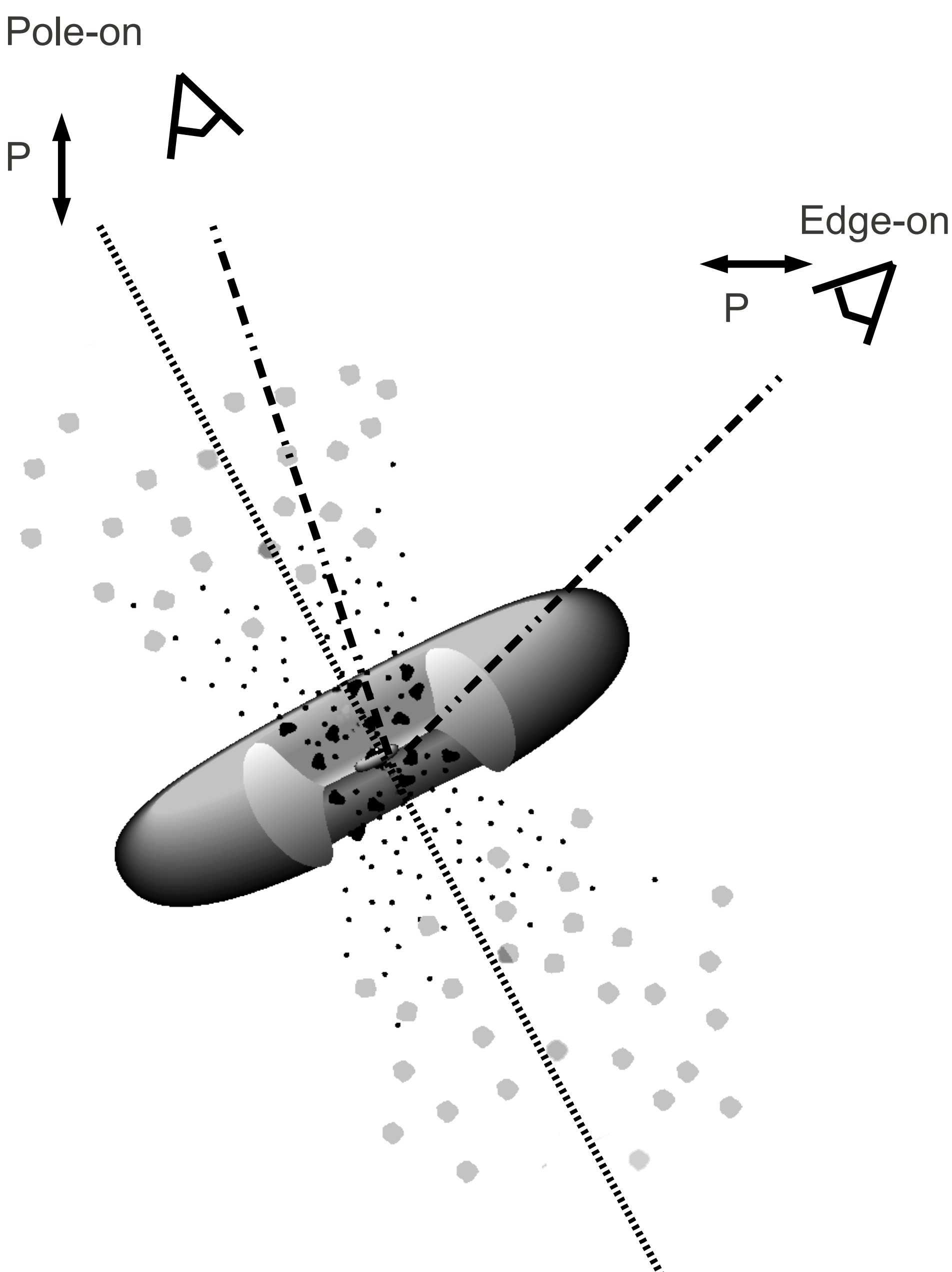
Circular polarization

and Martin (1973). Essentially the light is linearly polarized at the first scattering, and then a second scattering introduces ellipticity, provided the electric vector is not perpendicular or parallel to the scattering plane. This works for spherical or randomly aligned particles as long as their size is comparable to the wavelength.

Angel et al. (1976)



Polarization dichotomy



Observed dichotomy
- pole-on
  parallel* polarization
  negative P

- edge-on
  perpend. polarization
  positive P

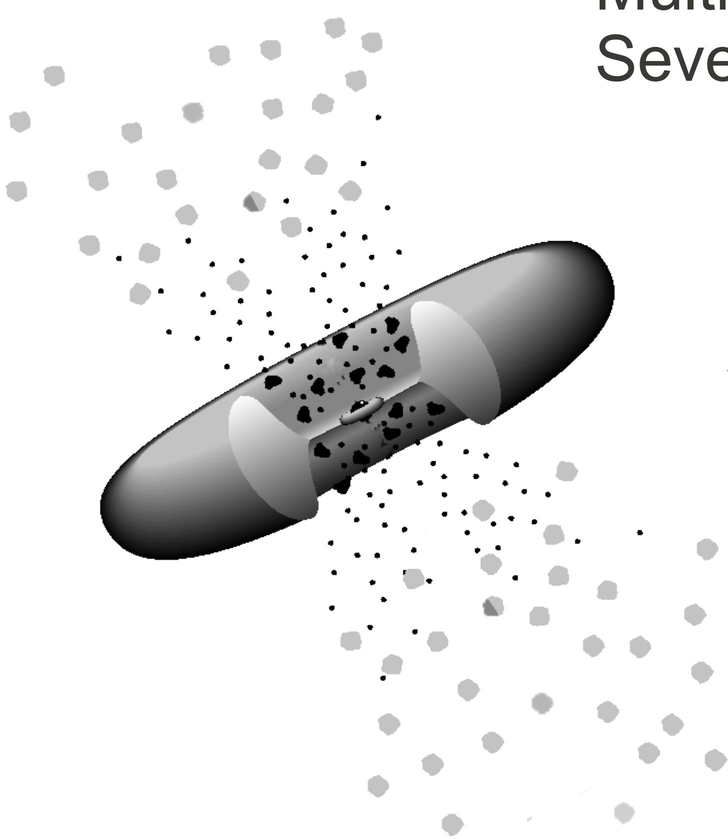
*** Parallel / perpendicular polarization : E-vector aligned / orthogonal with the small scale radio structure**

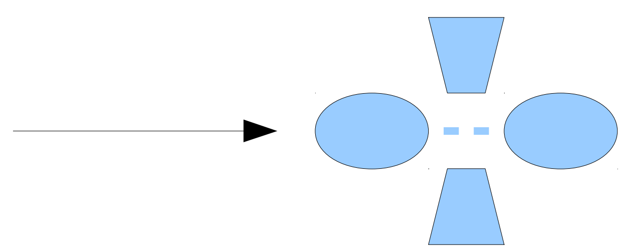
Modeling with STOKES

STOKES : Monte Carlo radiative transfer code

Spectropolarimetry & polarization mapping
Multiple scattering
Several scattering regions

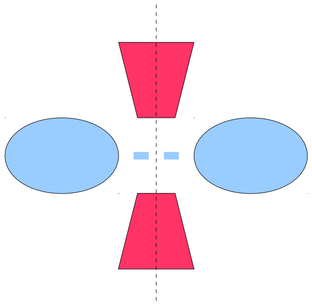
Goosmann & Gaskell (2007)
Marin et al. (2012)



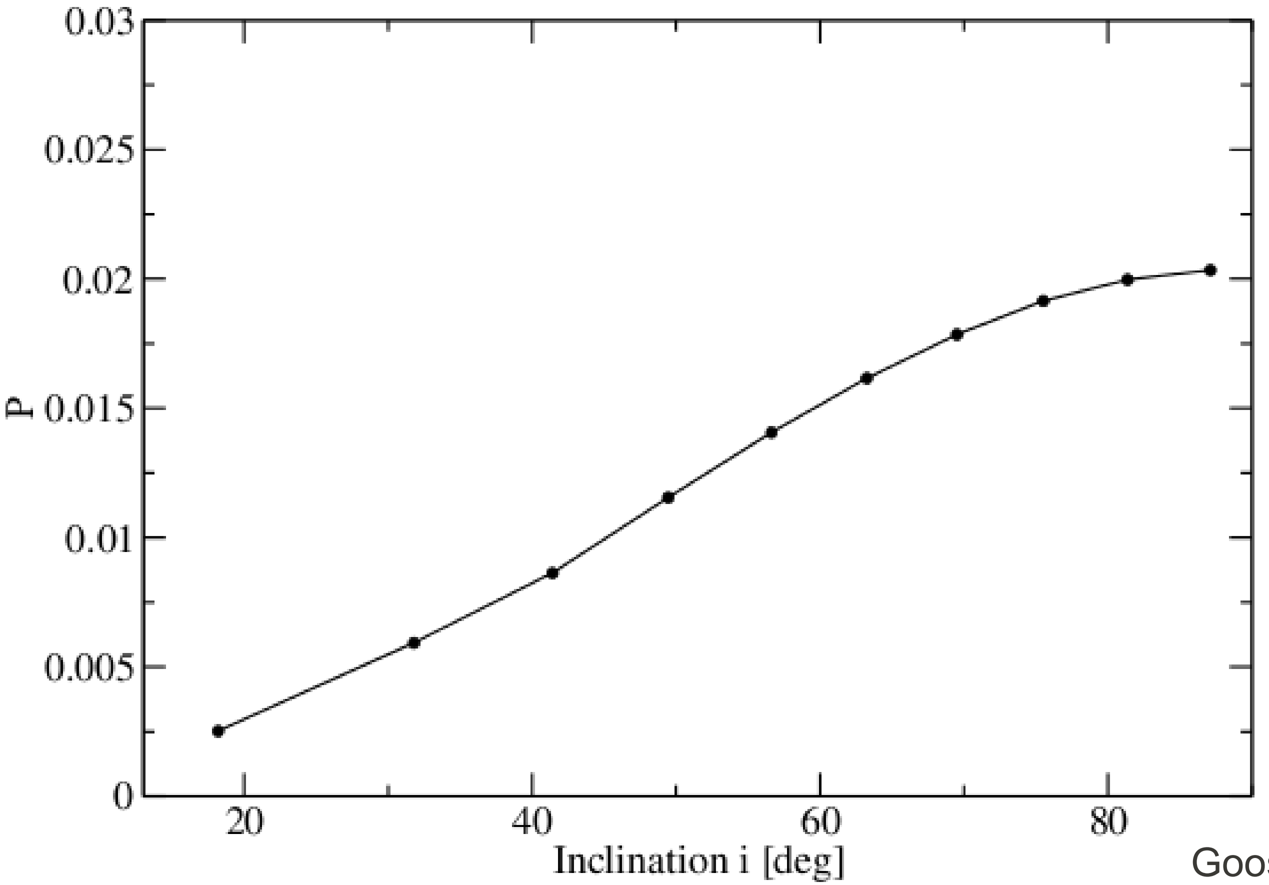


From isolated, reprocessing regions to a complex, three-component AGN model

Isolated region : polar winds



Ionized polar winds
$\tau \sim 0.3 \quad \theta \sim 30°$

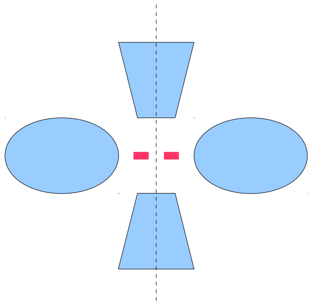


Thomson scattering
→ λ-independent

Perpendicular
(positive) P

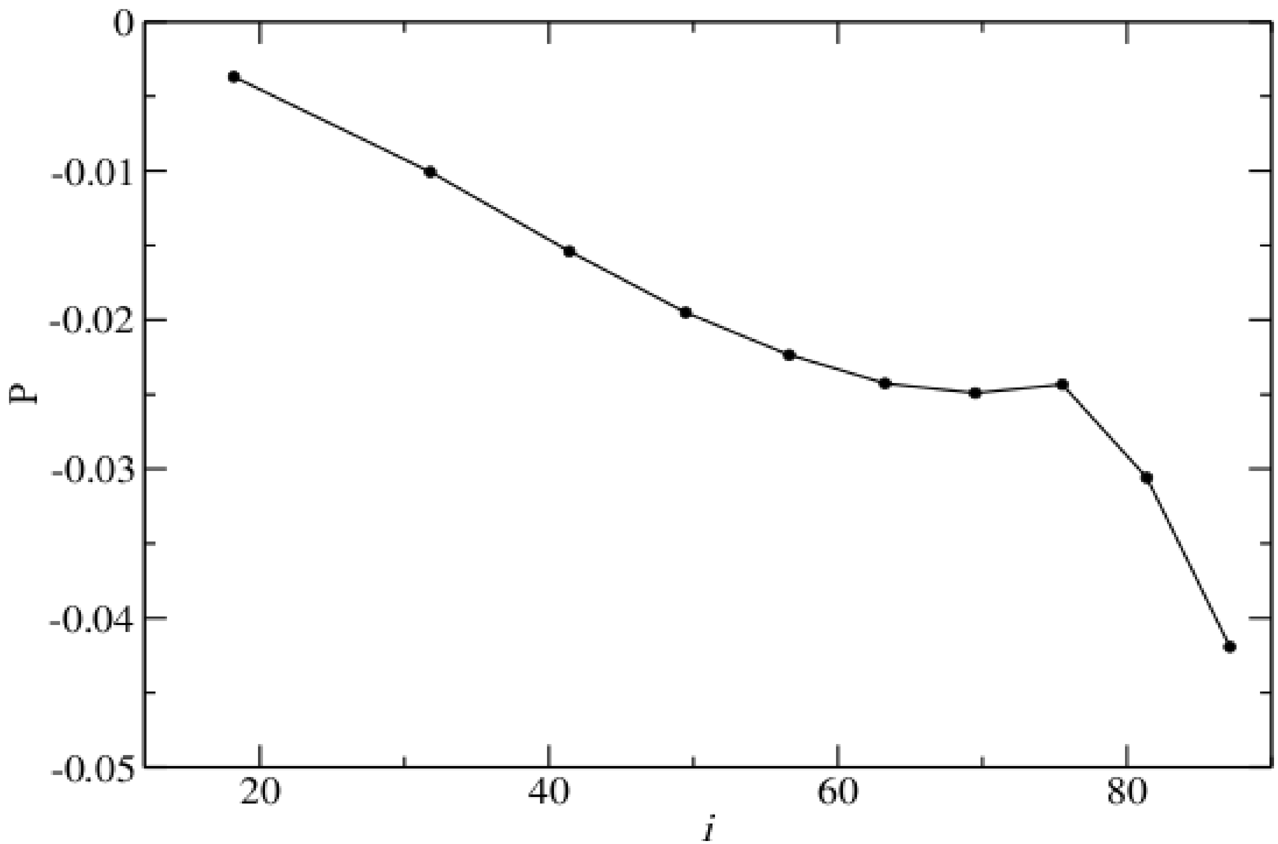
Goosmann & Gaskell (2007)
Marin et al. (2012)

Isolated region : equatorial inflow



Radiation supported disc

$\tau \sim 1 \quad \theta \sim 10°$

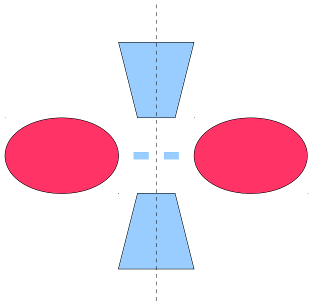


Thomson scattering
→ λ-independent

Parallel (negative) P

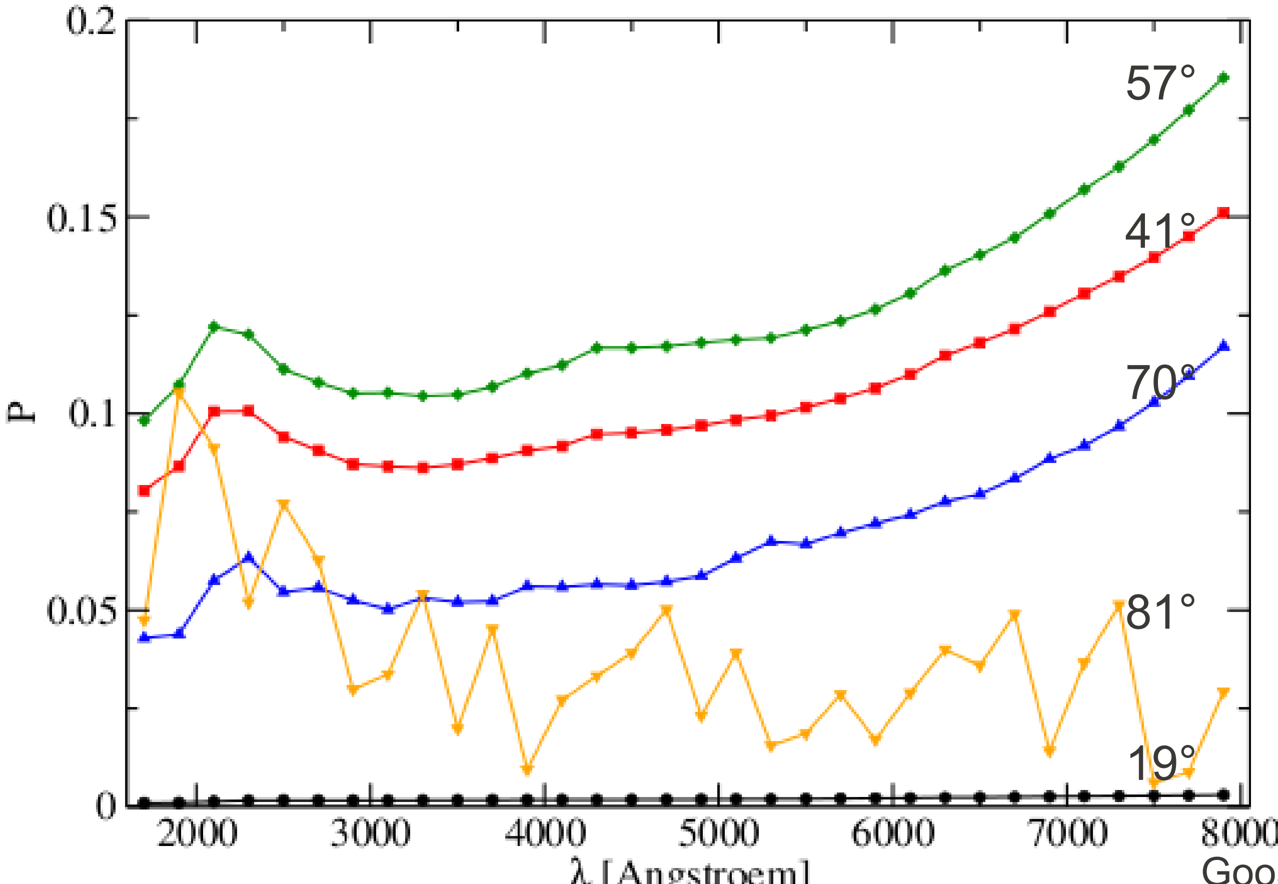
Antonucci (1984)
Smith et al. (2004)
Goosmann & Gaskell (2007)
Marin et al. (2012)

Isolated region : dusty torus



Circumnuclear dust region

$\tau \sim 750 \quad \theta \sim 30°$



Mie scattering

→ λ-dependent

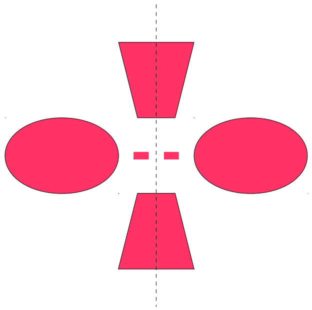
Perpendicular P

Graphite feature (2175 Å)

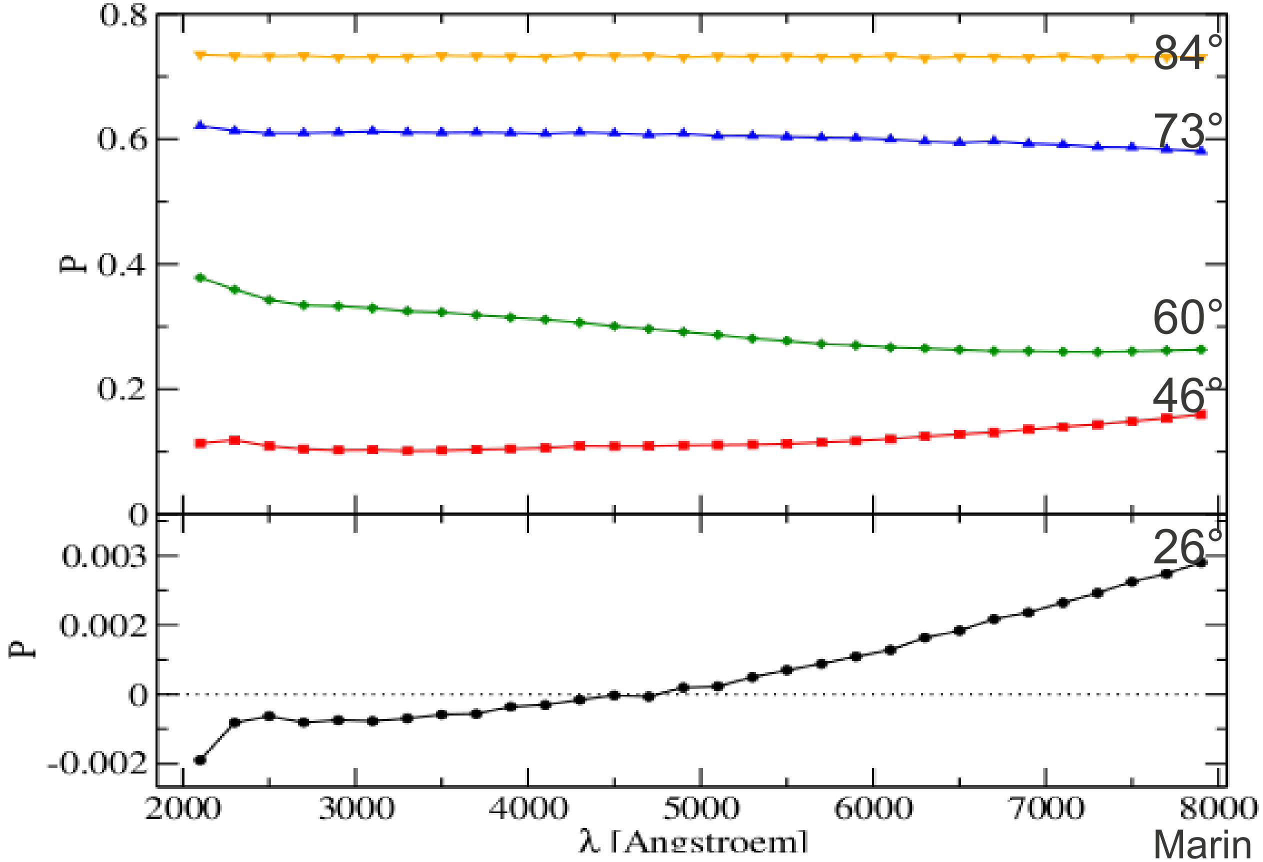
Goosmann & Gaskell (2007)

Marin et al. (2012)

Coupled region : AGN model



3-component AGN

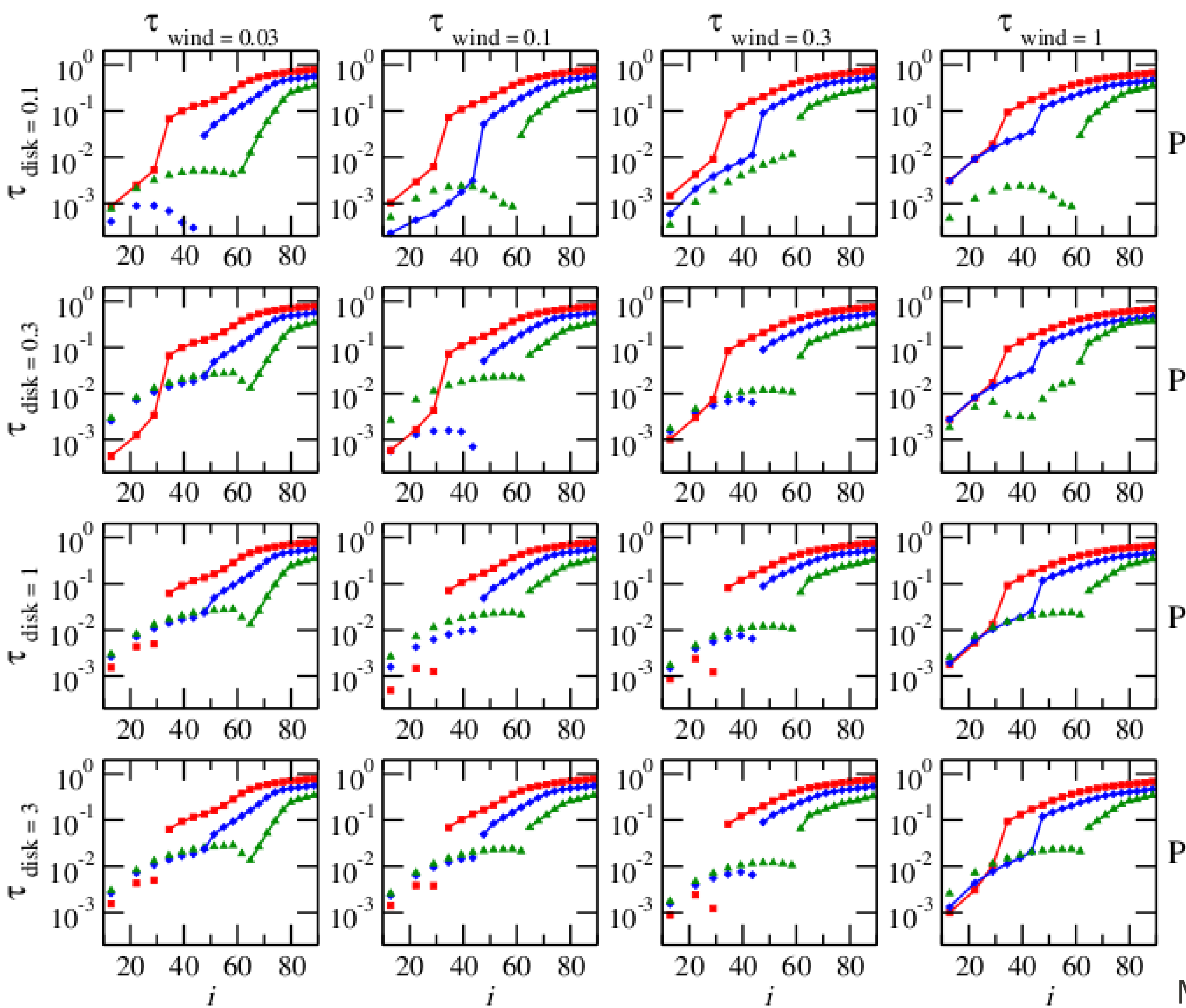


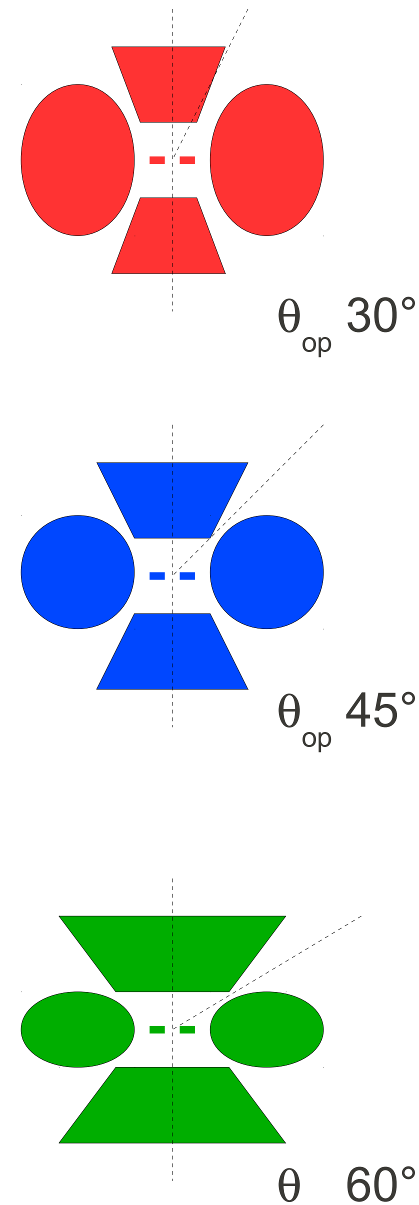
Pole-on : para/perp polarization

Edge-on : max P λ-independent

Marin & Goosmann (2011)
Marin et al. (2012)

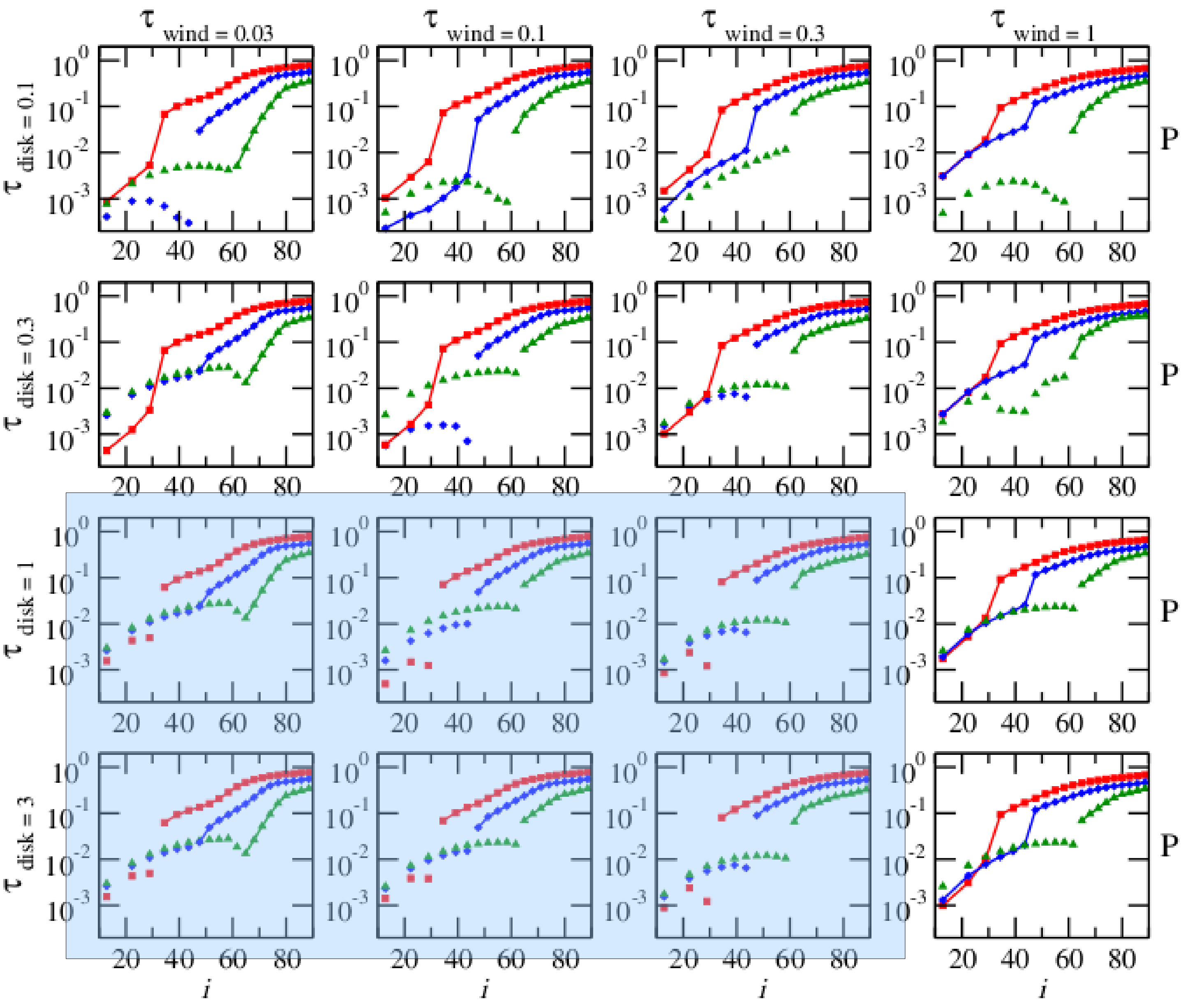
Impact of morphology and composition





Marin et al. (2012)

Impact of morphology and composition

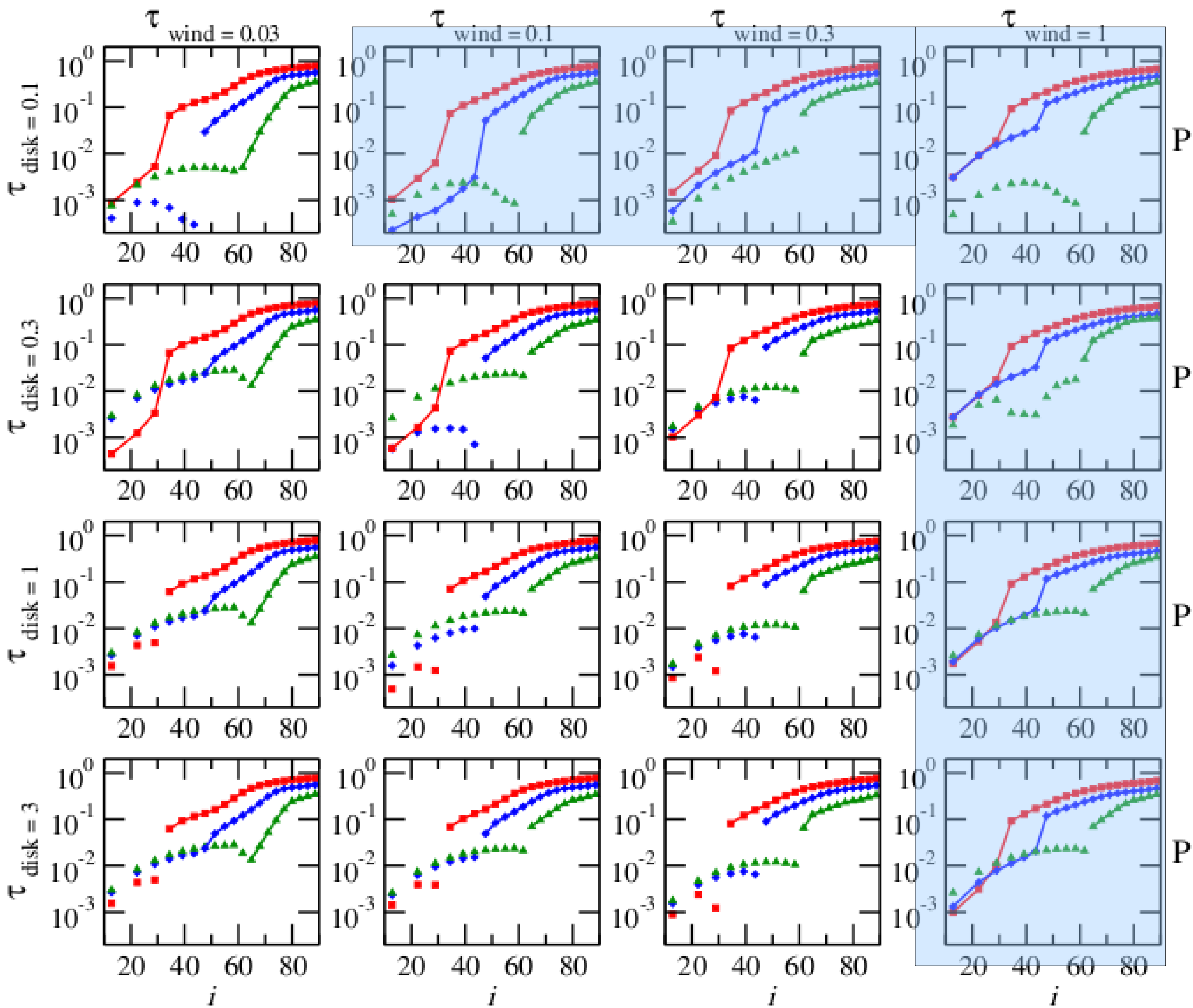


Inflow between torus and BLR

- geometrically thin
- optically thick
  (1 < τ < 3)
- < 1% P

Marin et al. (2012)
Smith et al. (2002)

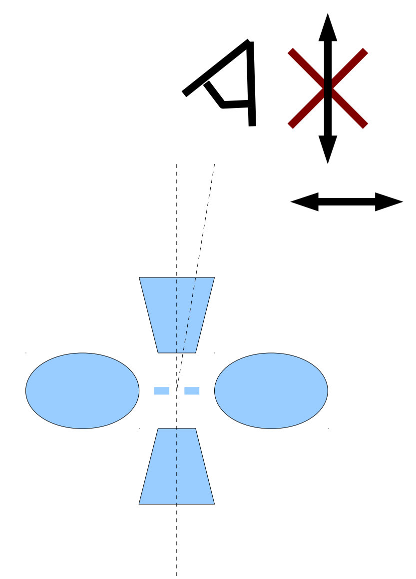
Impact of morphology and composition



Polar scattering dominated AGN

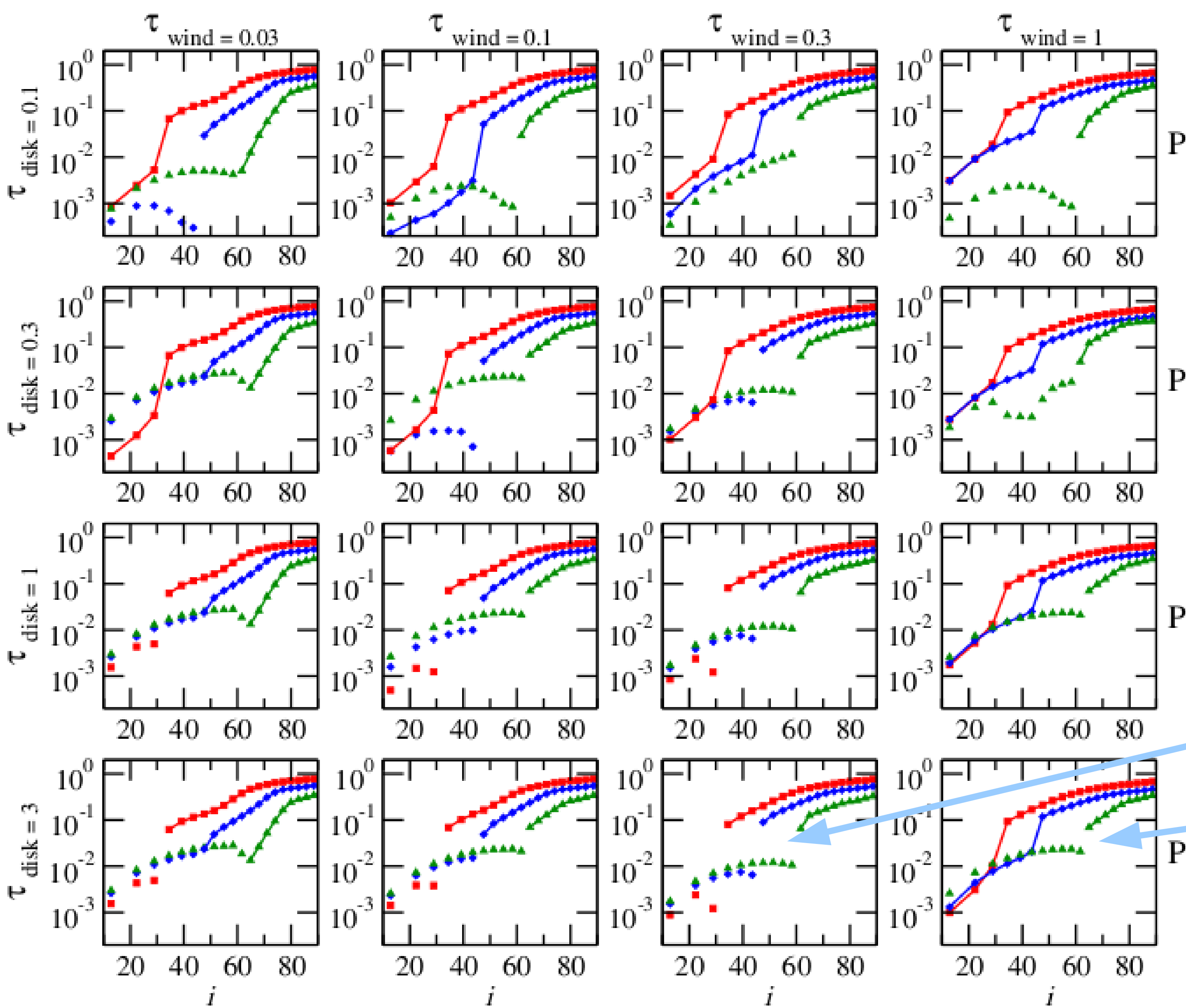
Smith et al. (2002/2004)

- torus 30° < θ_{op} < 45°
- optically thick winds
- optically thin inflow



Marin et al. (2012)

Impact of morphology and composition



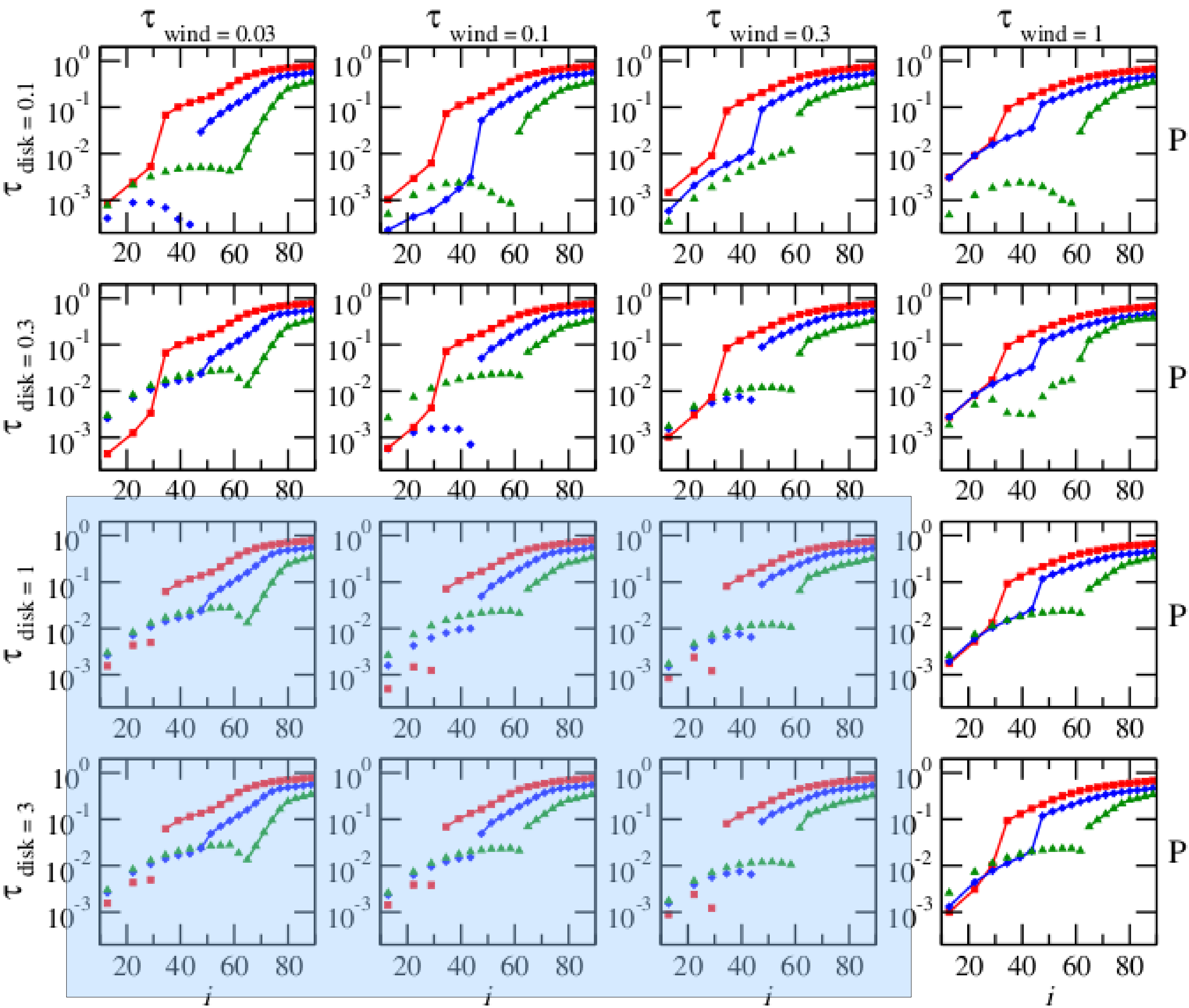
Torus geometry

- $\theta_{op} > 60°$
- optically thick
- high P   Kay (1994)
- clumpy structure

Hönig & Kishimoto (2010)
Nenkova et al. (2003/2008)

Marin et al. (2012)

Impact of morphology and composition

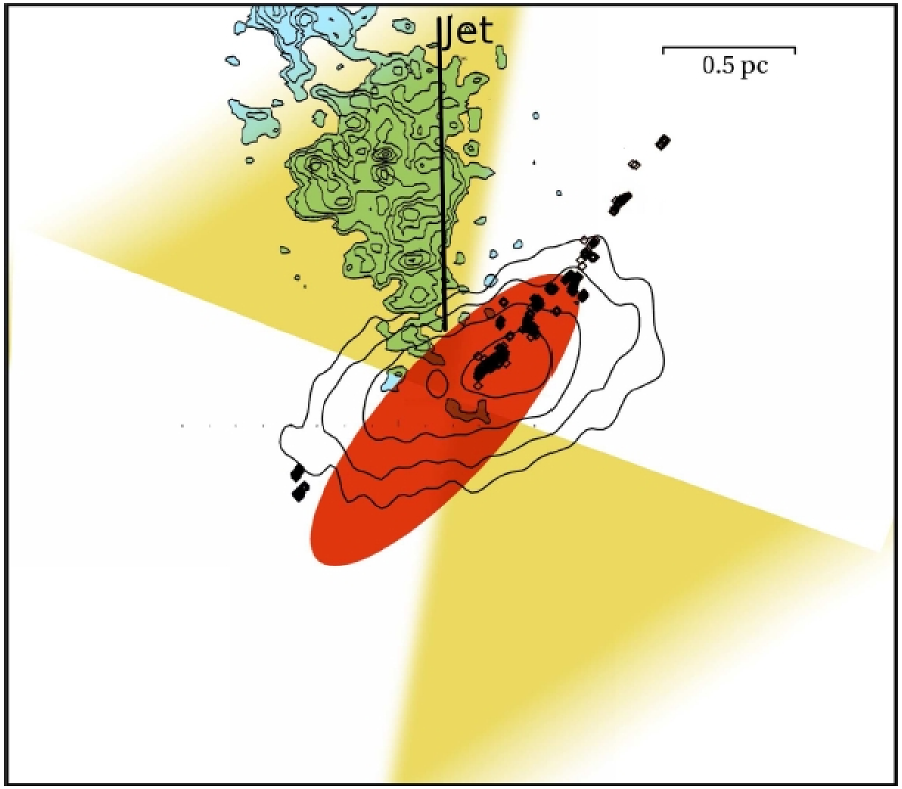


Torus-collimated outflows

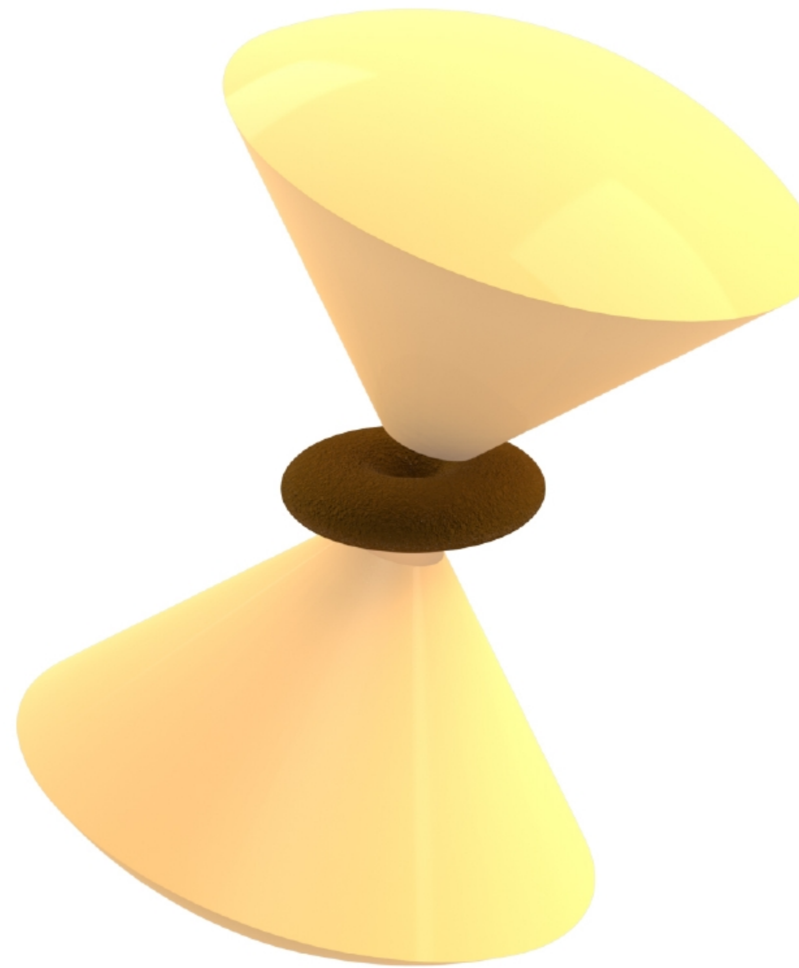
- optically thin $\tau < 1$
- high P Kay (1994)
- clumpy structure
- are they really collimated ?

Marin et al. (2012)
Ogle et al. (2003)

The case of non-collimated winds : NGC 1068



Raban et al. (2009)

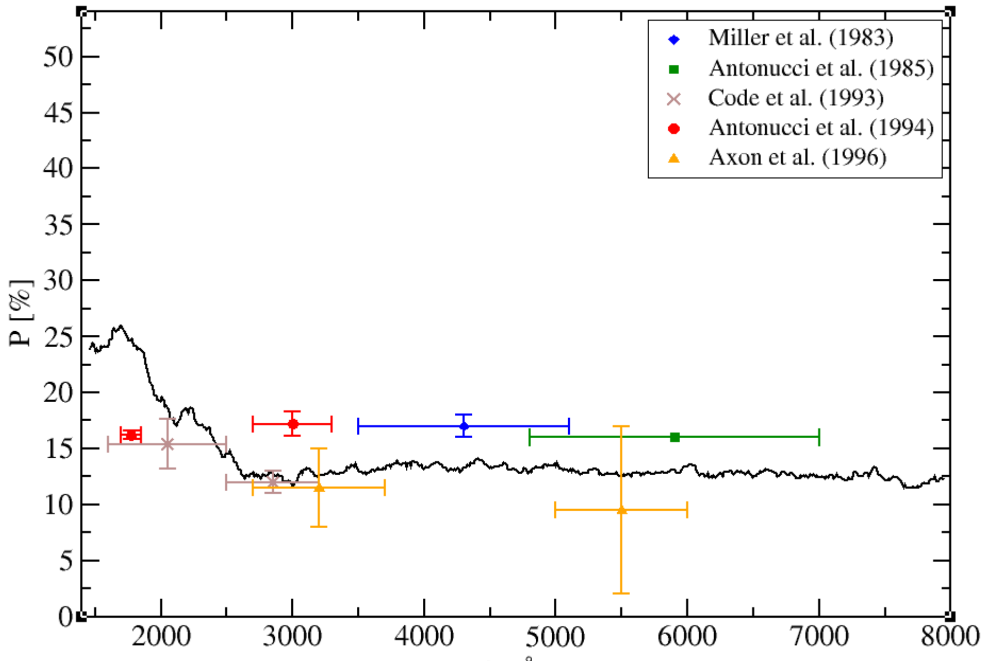


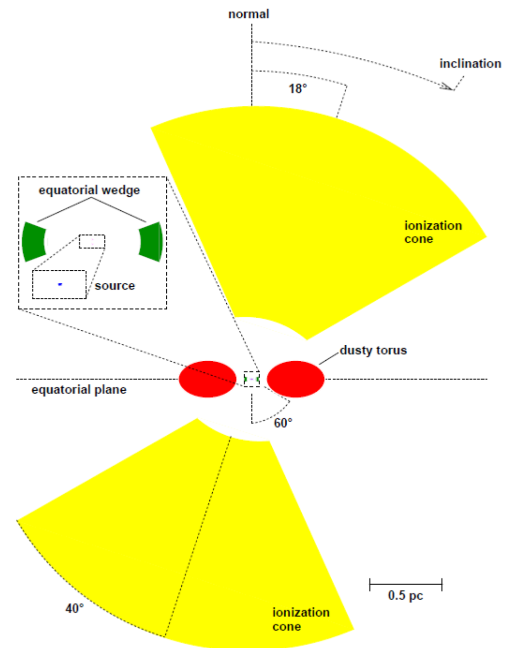
Credits : Alix Videlier

Outflows out of the plane-of-the-sky
Investigating the broken symmetry

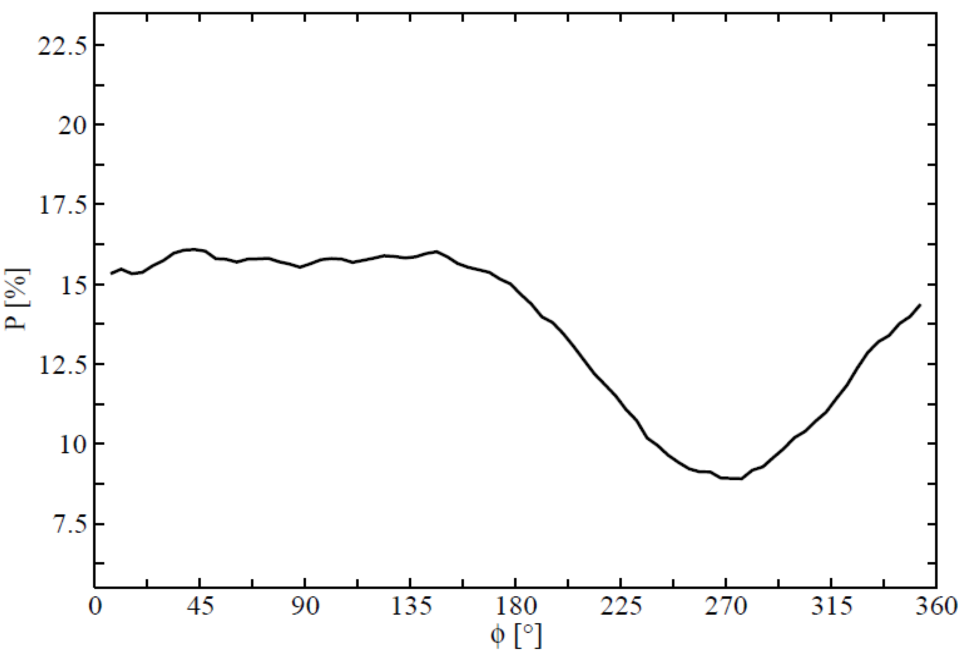
Marin, Goosmann & Dovciak (2012)
Marin et al. (in prep.)

The case of non-collimated winds : NGC 1068





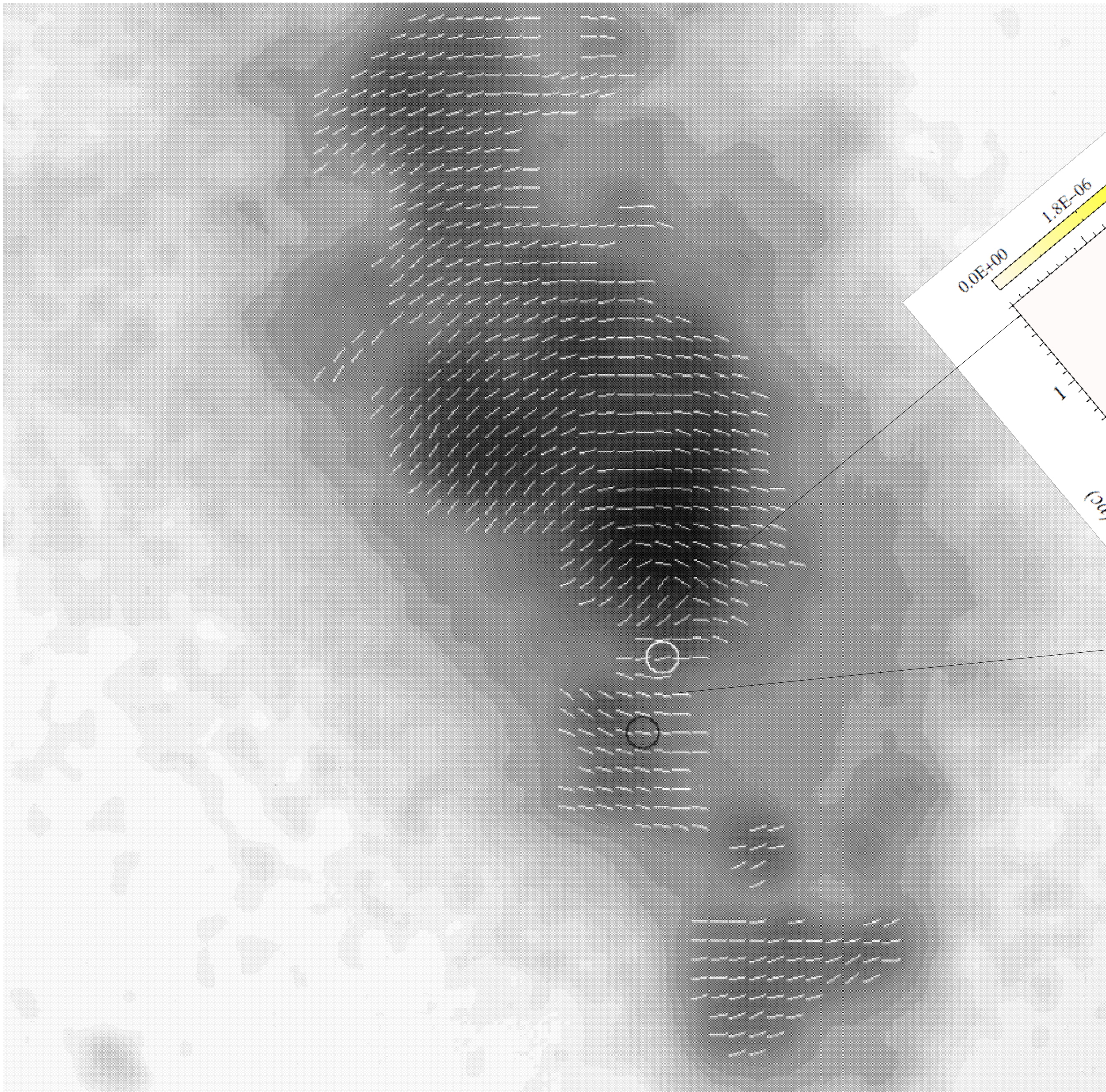
Goosmann & Matt (2011)

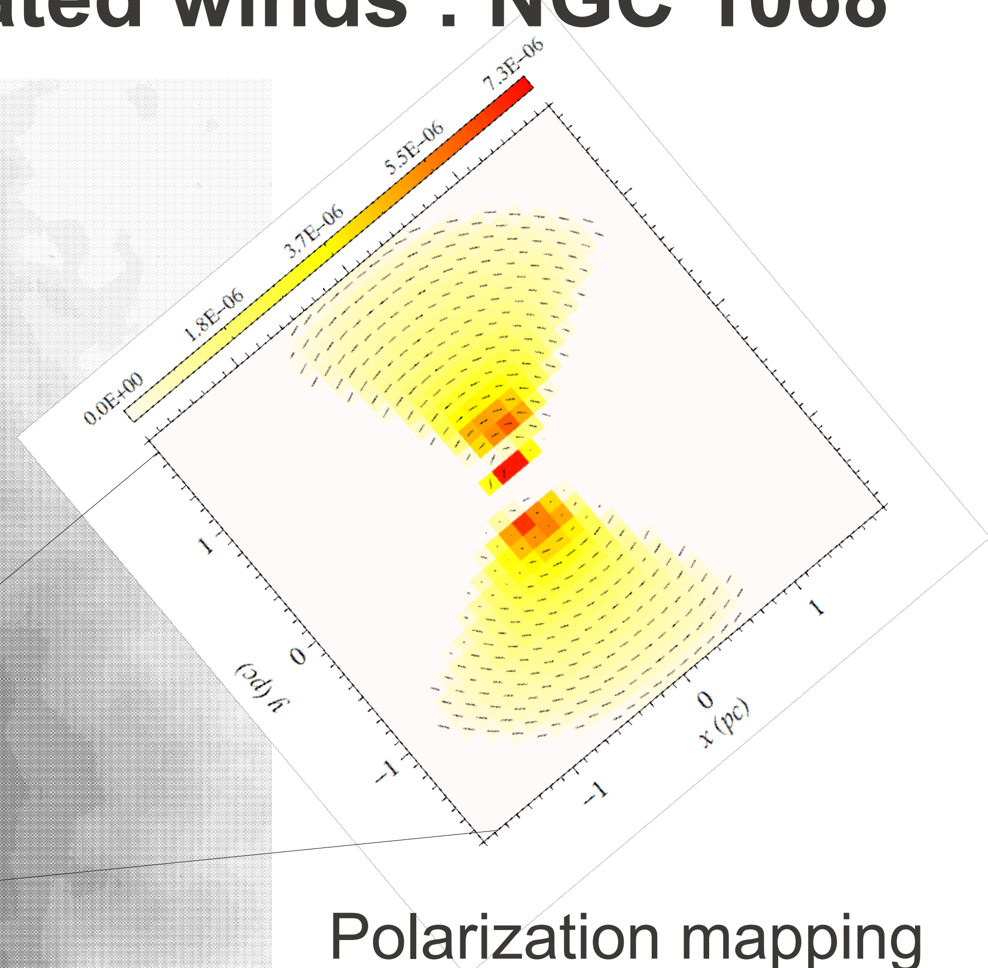


Fine-tuning of the polar and azimuthal tilting angle needed

Marin et al. (in prep.)

The case of non-collimated winds : NGC 1068

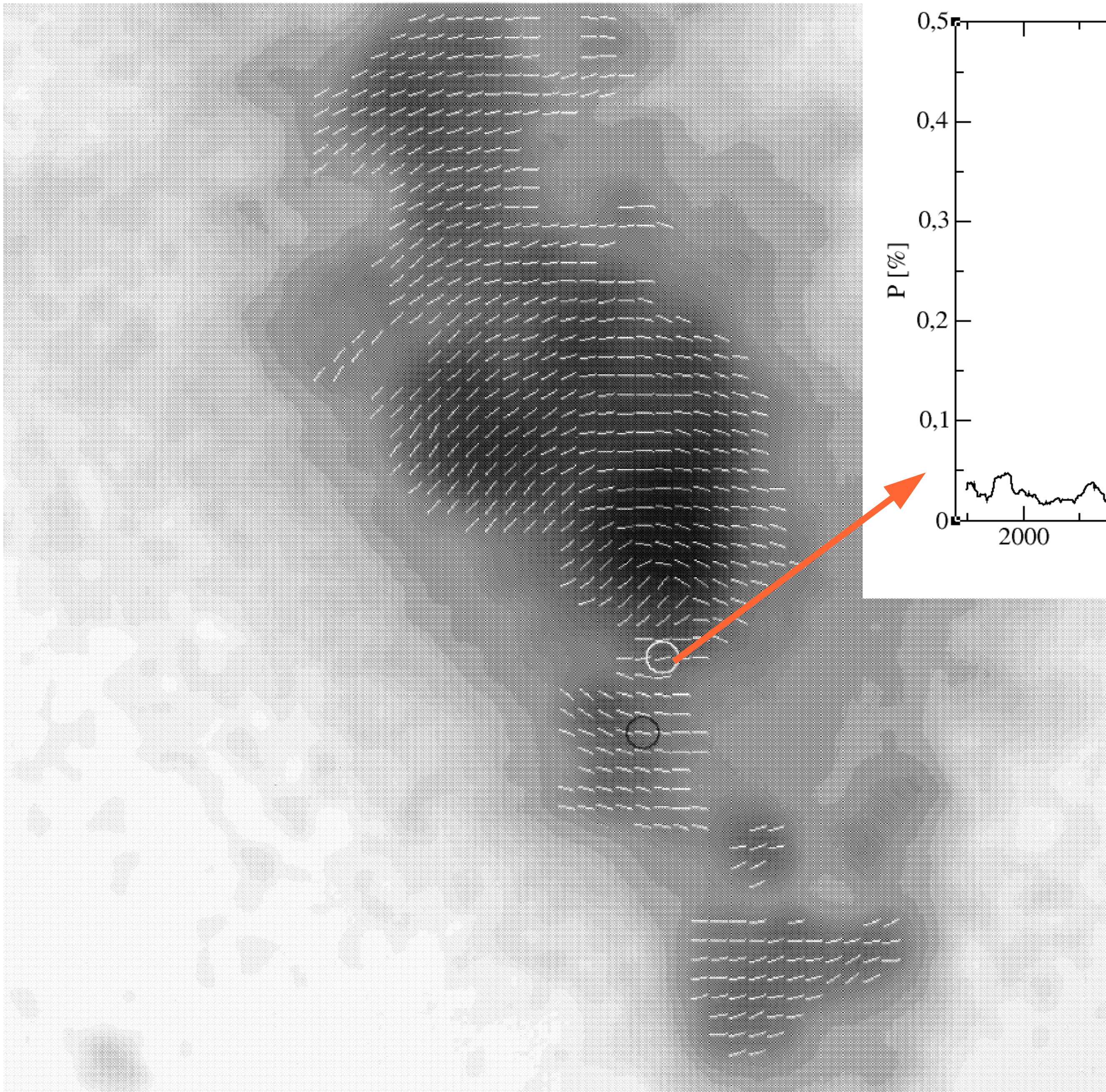


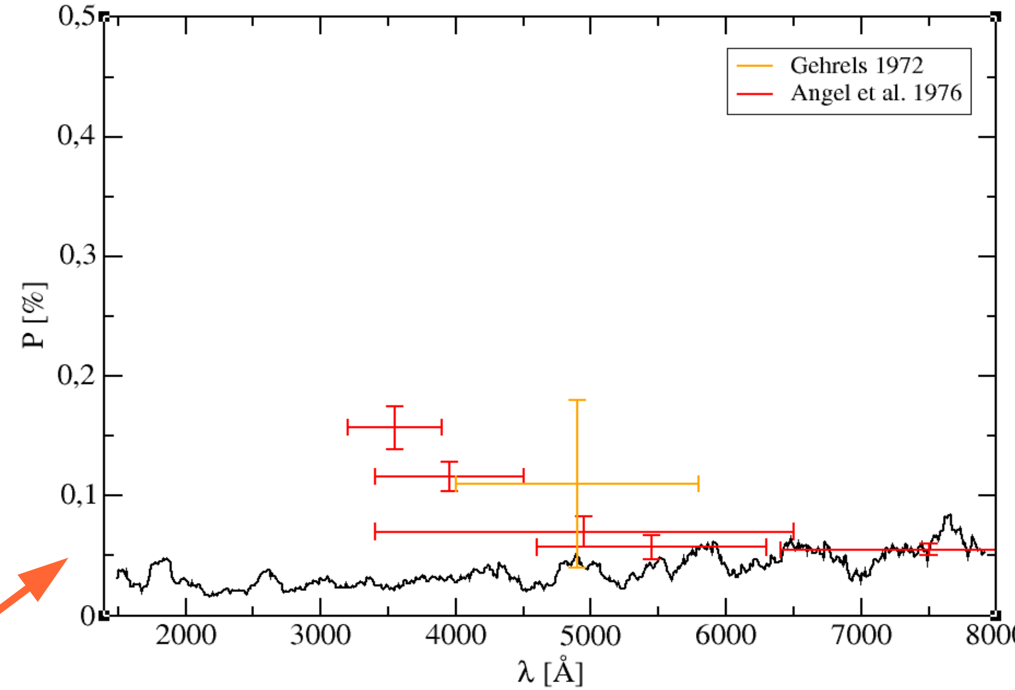


Polarization mapping

Capetti et al. (1995)
Kishimoto (1999)
Marin, Goosmann & Dovciak (2012)
Marin et al. (in prep.)

The case of non-collimated winds : NGC 1068





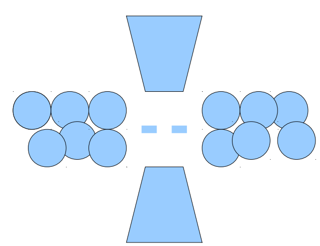
Circular polarization
(Milky Way dust model)

Marin et al. (in prep.)

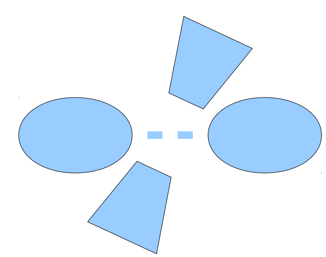
Summary and perspectives

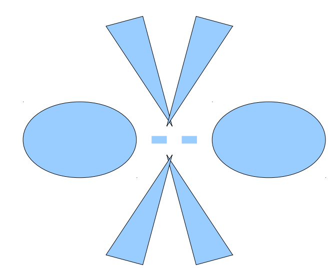
Unified model new constraints :
- geometrically thin, 1< τ < 3 inflowing medium between the BLR and the torus
- with torus-collimated outflows → τ < 1
- torus more likely to have a θ_{op} > 60°
- polar scattering dominated AGN → torus 30° < θ_{op} < 45°

To be further explored :
- fragmented media
  - torus
  - winds



- non-axisymmetric winds (NGC 1068)
  - hollow winds ?





Das et al. (2006)
Kartje & Königl (1994)