Polarimetry of AGN: the present and the future

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COST meeting Future of Polarimetry

Royal Library, Brussels, Belgium

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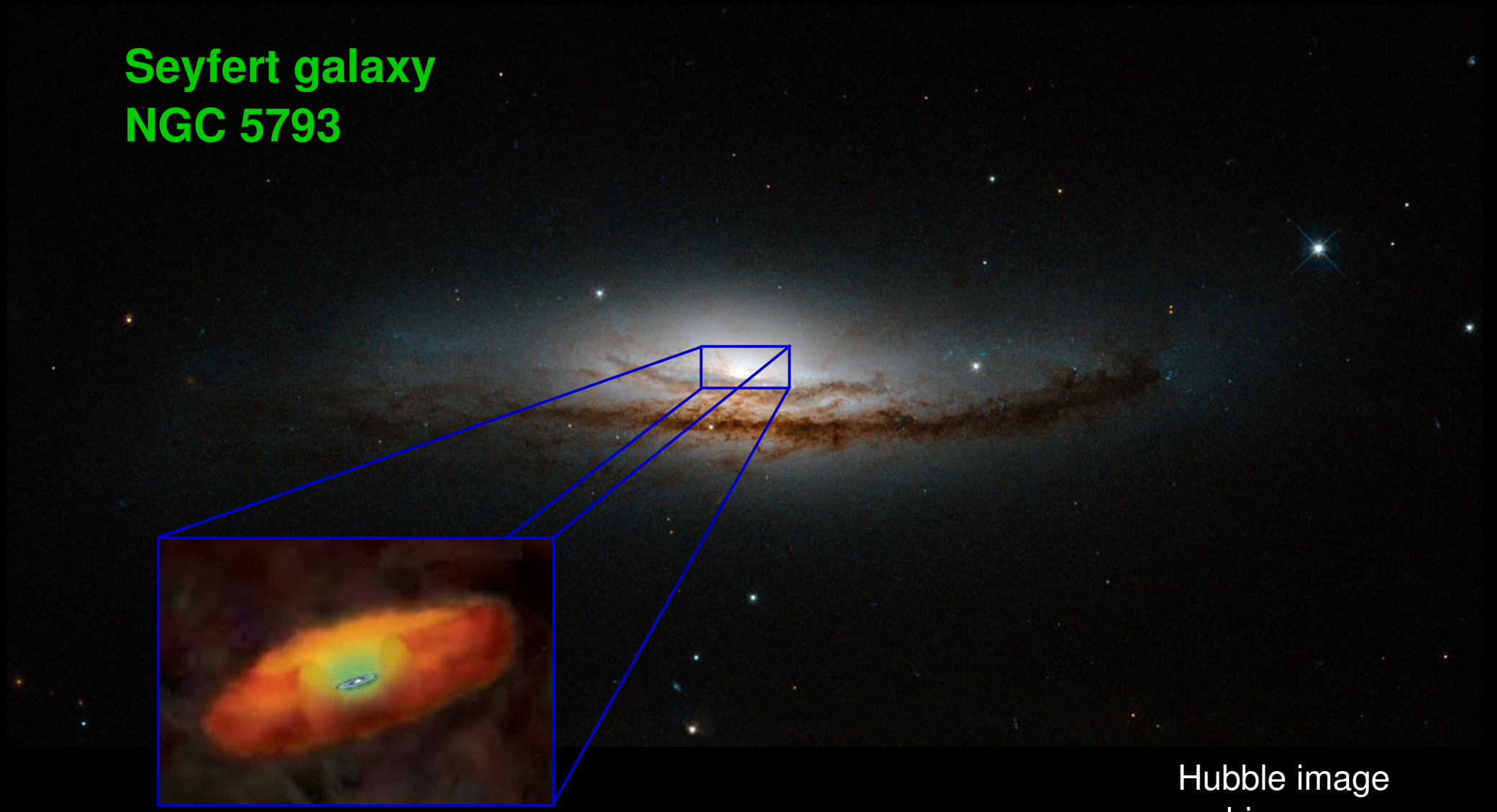
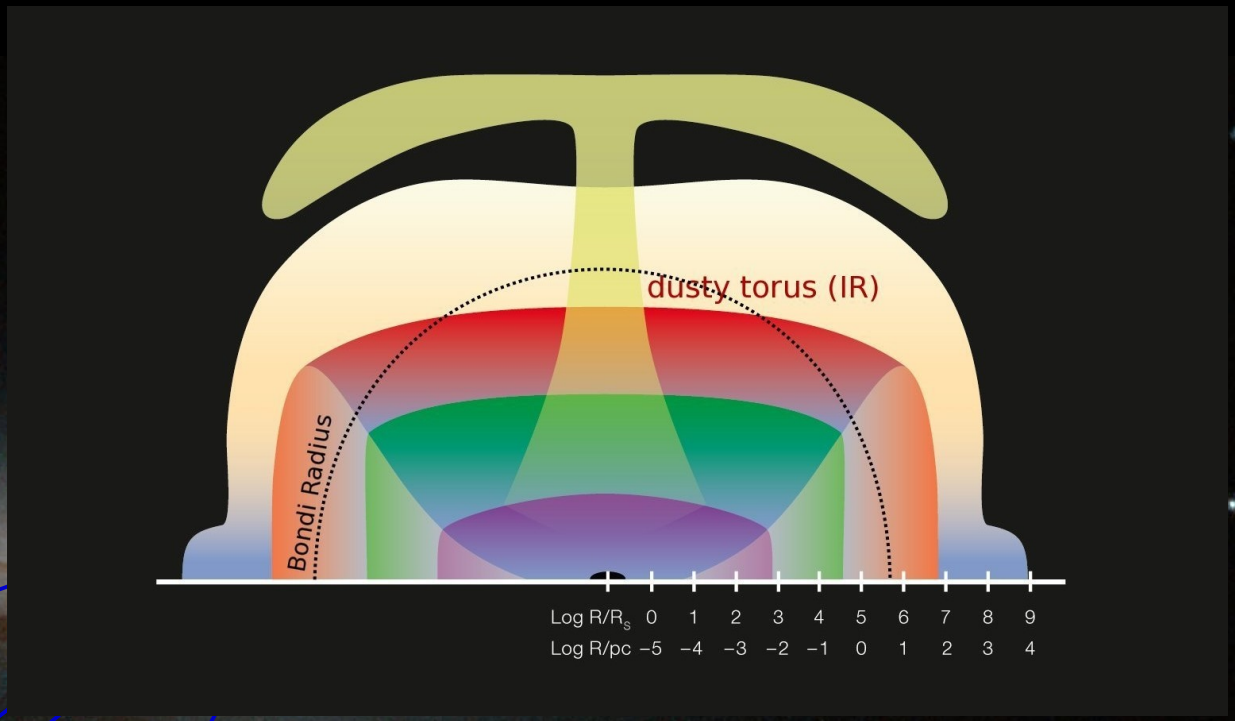
How to resolve the unresolvable?



How to resolve the unresolvable?

Seyfert galaxy NGC 5793



THE ULTIMATE GOAL

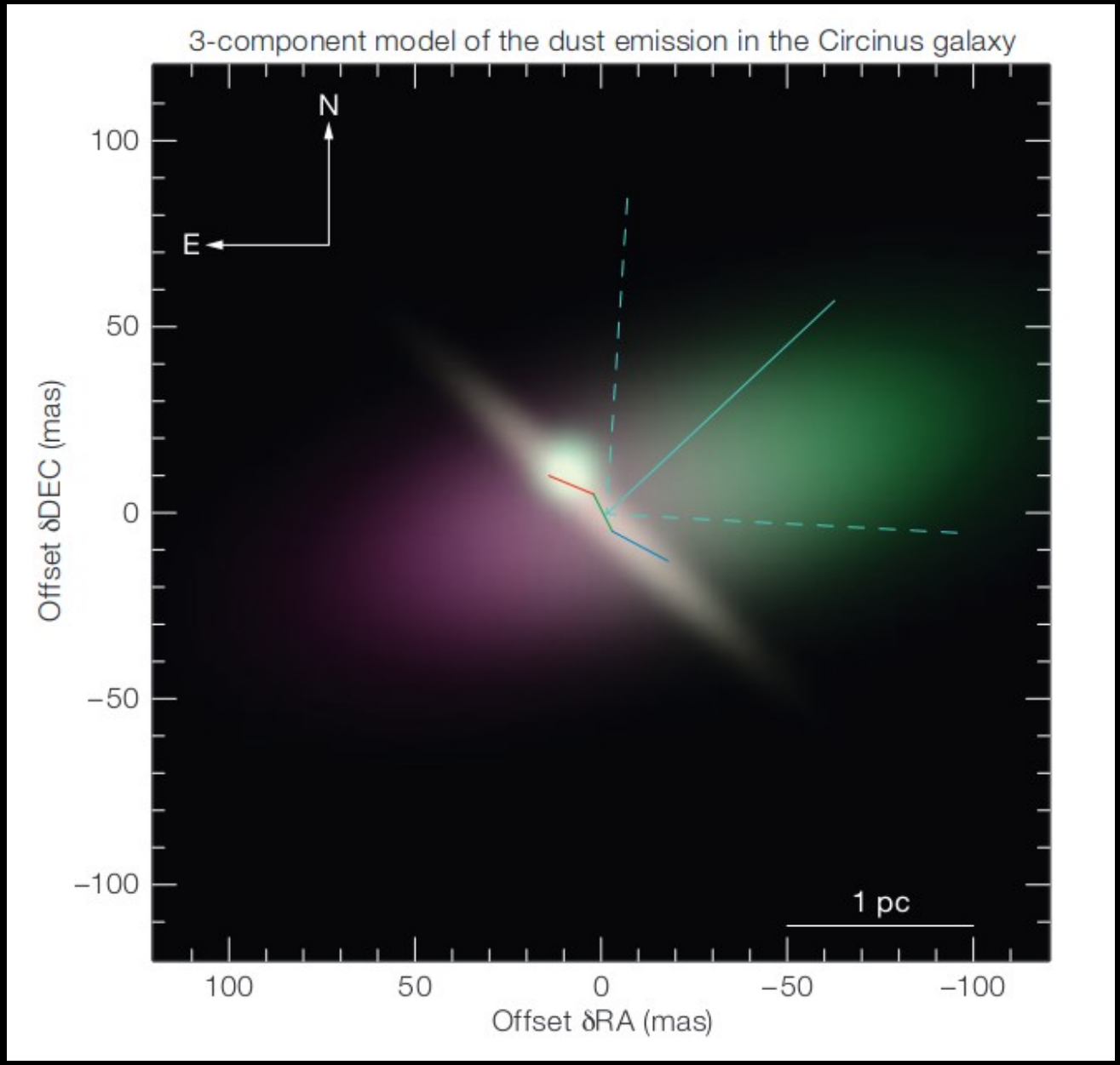
Constrain the unresolved geometry and dynamics of AGN by using broad-band polarimetry as a complement to spectroscopy, imaging and timing...

Starting to resolve circumnuclear dust

VLTI reveals circumnuclear dust in the infrared band

e.g.
Glass et al. (2004),
Jaffe et al. (2004),
Burtscher & Tristram (2013)

Important result:
The dusty “torus” is a compact structure with an extension < 10 pc for nearby Seyfert galaxies.

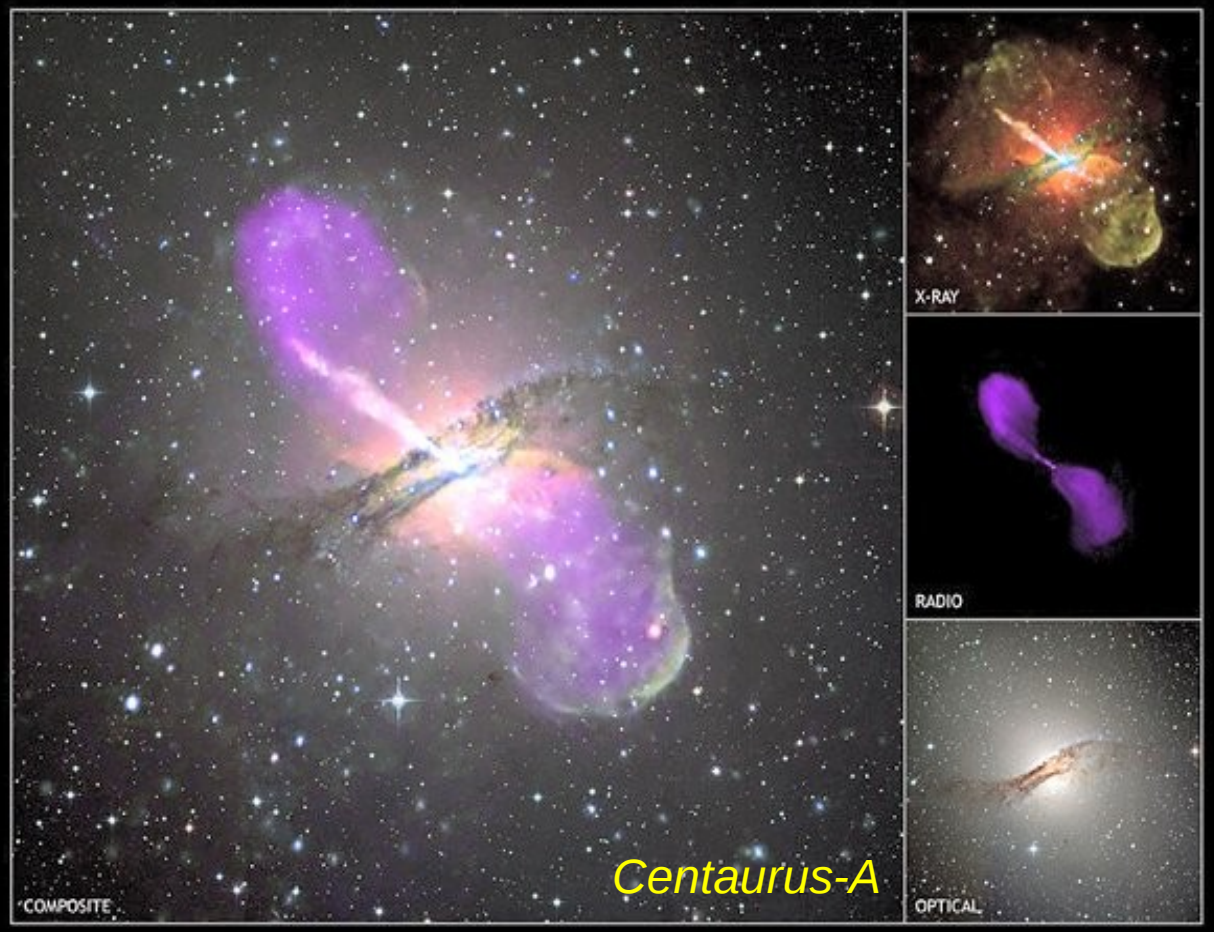


Polarization of radio-loud AGN

• broad-band polarization in radio-lobes or -jets due to synchrotron mechanism (Angel & Stockman 1980)

• in the inner regions of radio galaxies other mechanisms (electron scattering, dichroic absorption, etc.) are possible but less likely (Capetti et al. 2007)

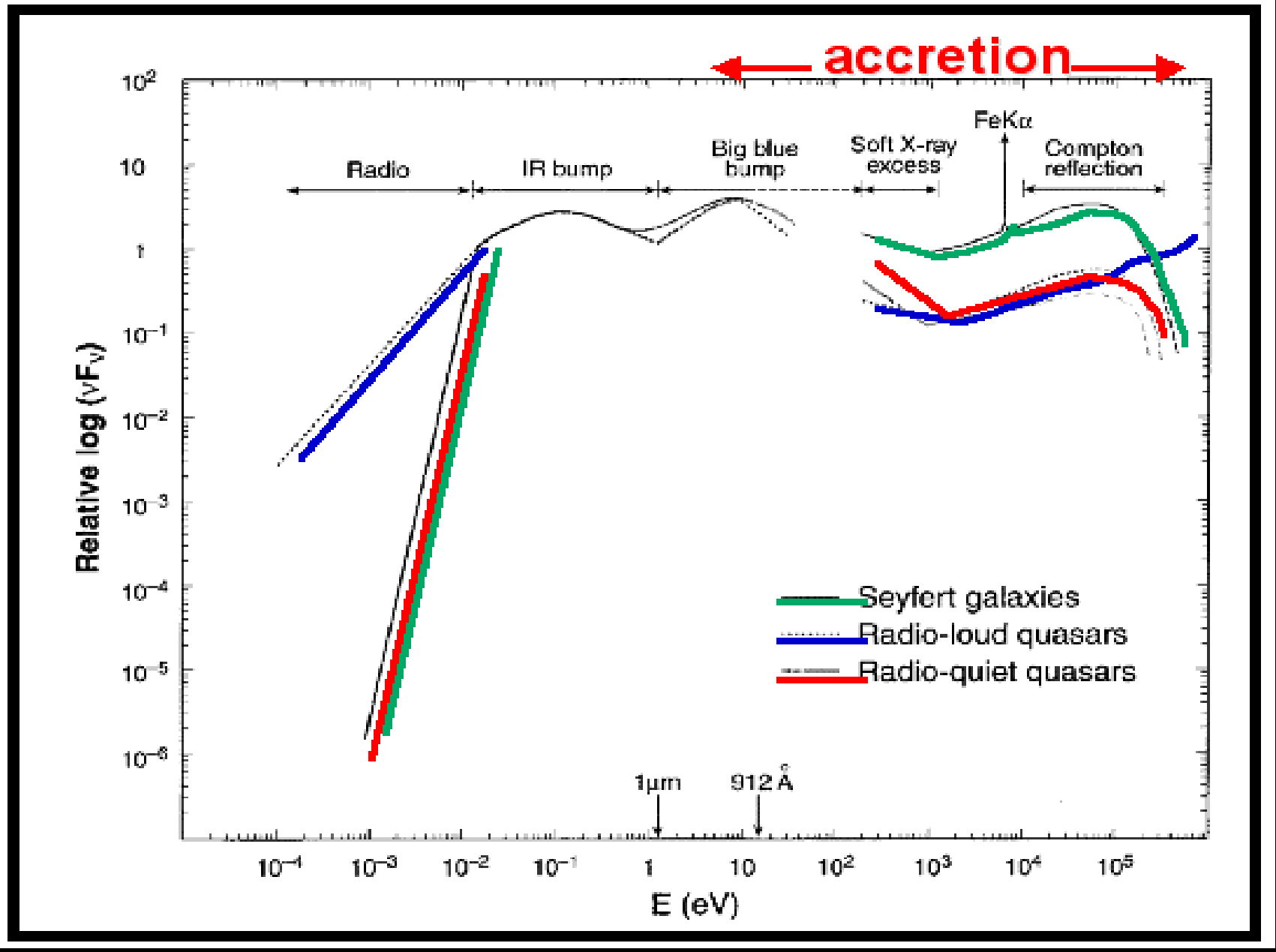
• synchrotron polarization can be highly variable (~4h) clearly indicating a jet origin (Villforth et al. 2008)



Kraft et al. (CfA)

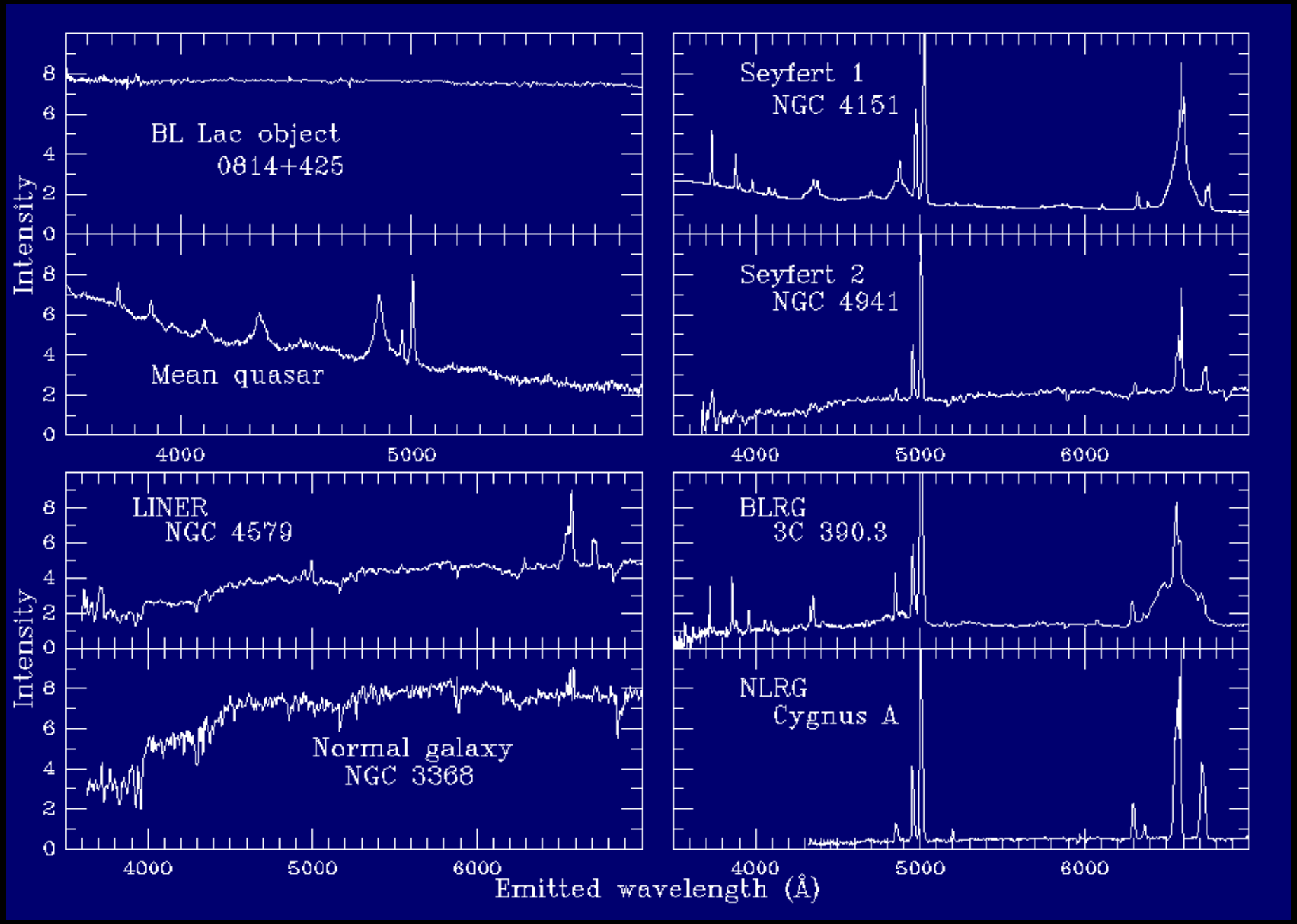
For more, see Monday's talk by Talvikki Hovatta !

The broad spectrum of AGN



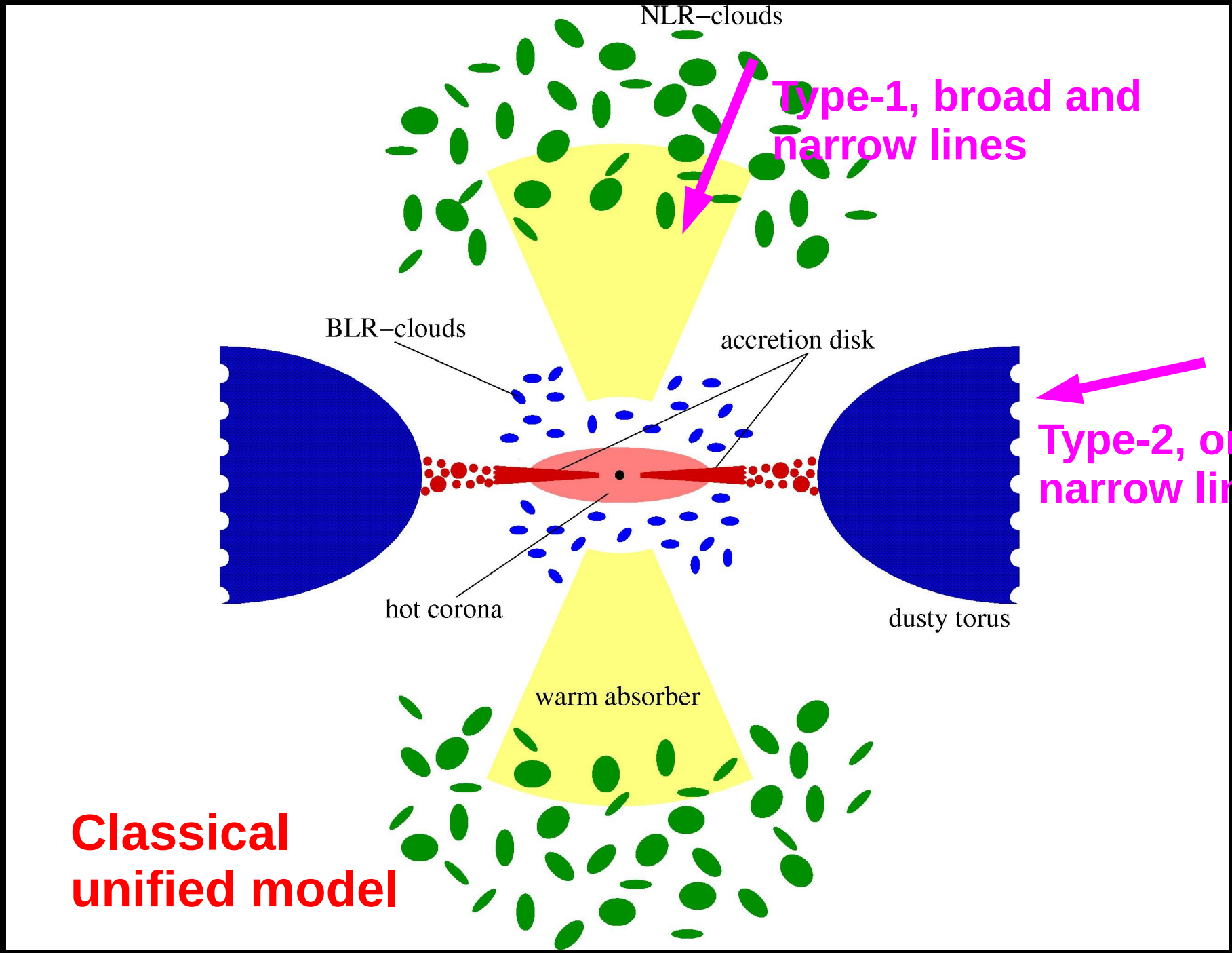
Collin (2001), Sanders et al. 1989

The AGN zoo : optical properties of different sub-types



(Bill Keel)

Unifying broad and narrow line objects



Classical unified model

Optical fact sheet for the unified model of AGN

- Strong energy release in a very limited spatial region due to accretion onto a central supermassive black hole (10^6—10^9 solar masses).
- In radio-quiet objects, the bulk continuum emission comes from an accretion disk.
- In radio-loud objects (~10% of all AGN), strong continuum emission also comes from the ballistic jets.
- Around the accretion disk, high velocity clouds reprocess the continuum producing broad emission lines.
- The broad lines are seen at lines of sight not going through the equatorial dust lanes (type-1 AGN).
- At viewing angles blocked by the dust, only narrow lines are seen (type-2 AGN).

Infrared polarimetry of the type-2 AGN IC 5063

Data taken at the AAT using the IR polarimeter built at the University of Hertfordshire.

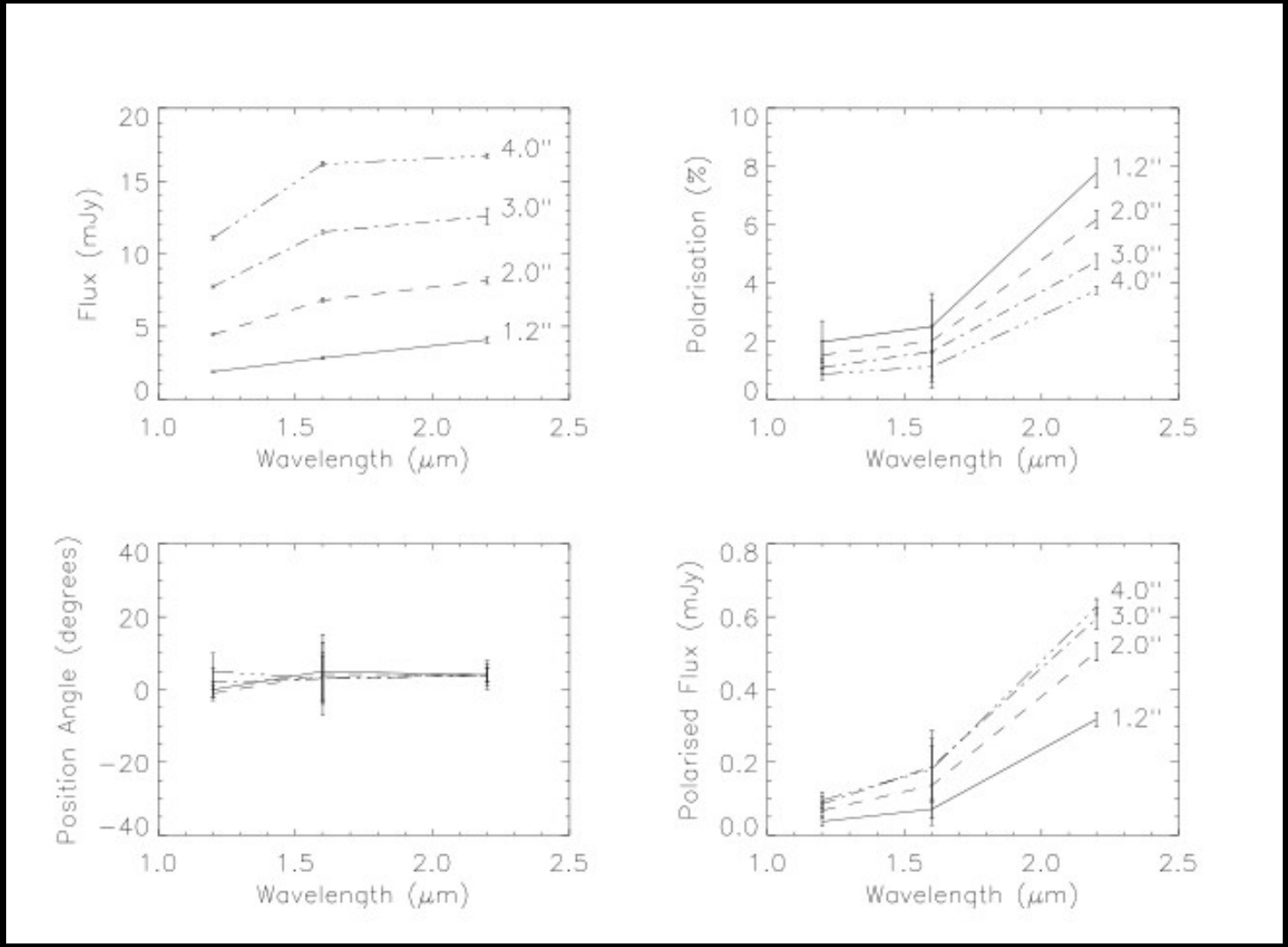
IR polarization fraction rises towards the mid-IR

IR polarization angle is wavelength-independent

Synchrotron origin is unlikely (sub-mm?)

Scattering and dichroic absorption invoked to explain the polarization

Estimation of the B-field possible : 12 – 128 mG

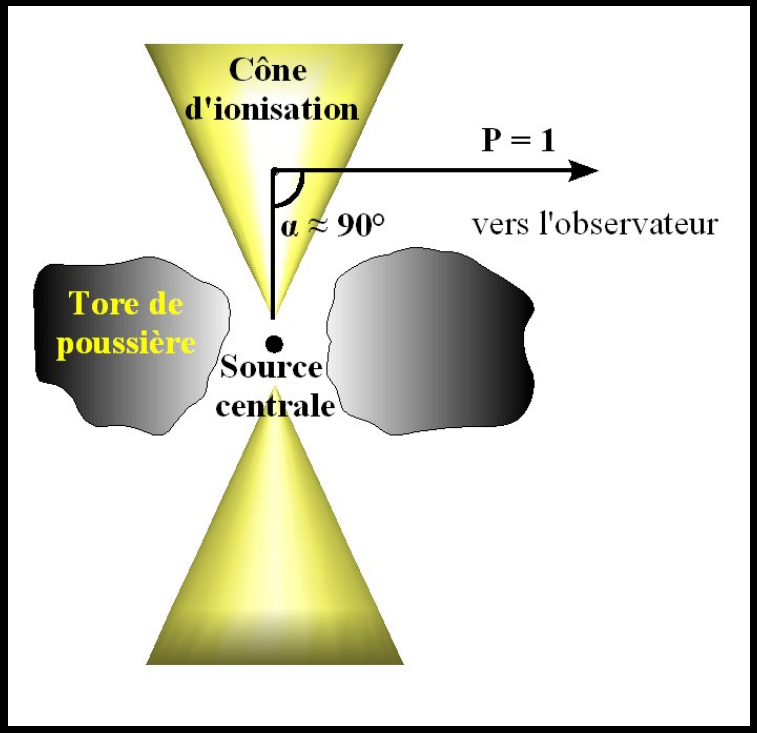


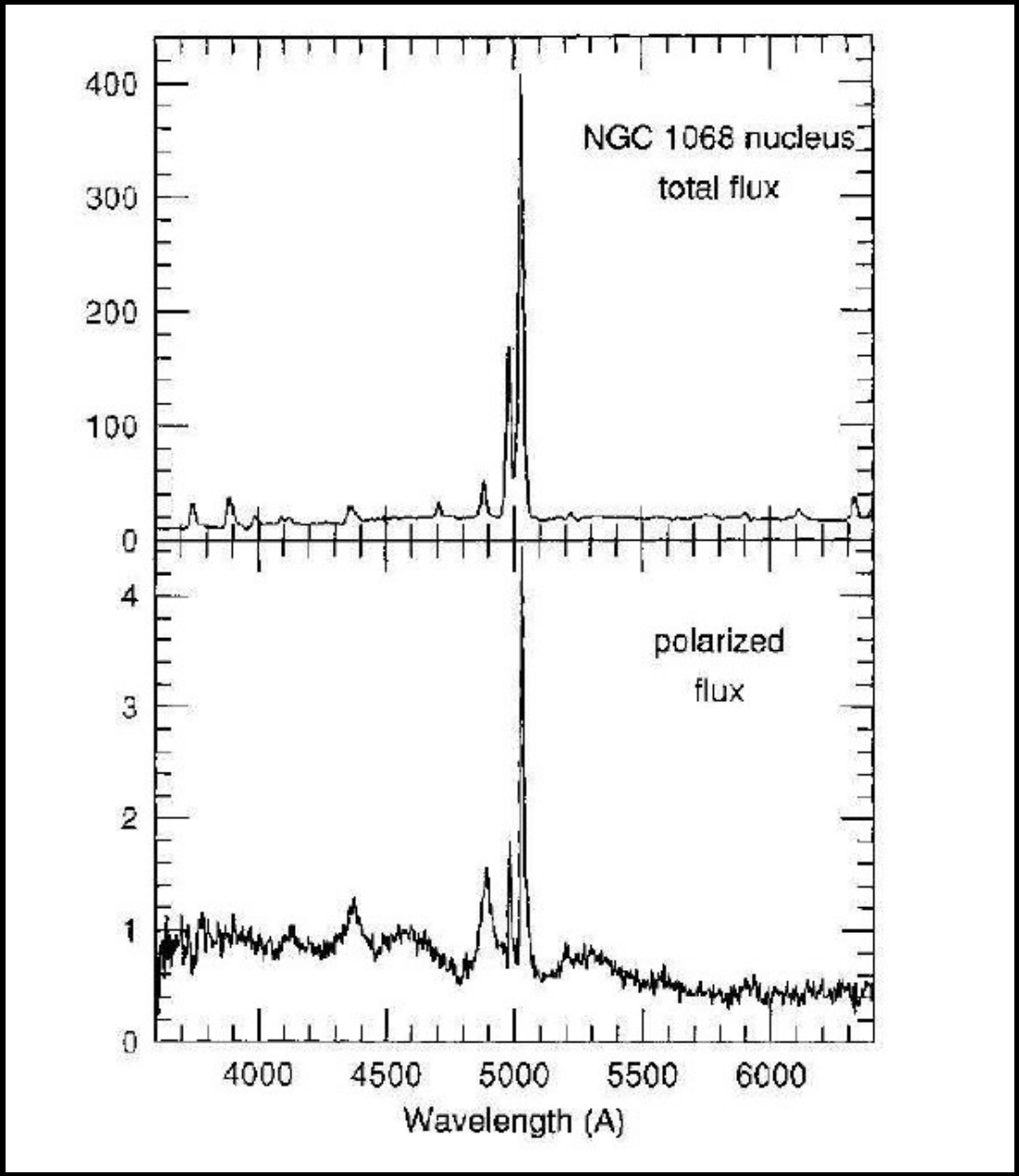
Lopez-Rodriguez et al. 2013

Radio-quiet objects Hidden type-1 AGN

A major break-through for the unified model for NGC 1068 (Antonucci & Miller 1985)

→ **periscope view of AGN in polarized flux**

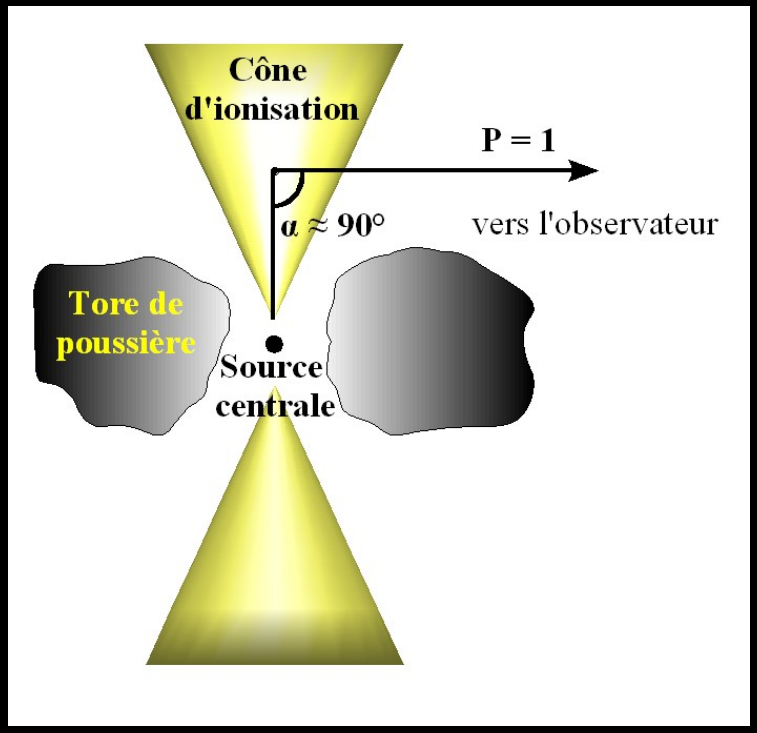


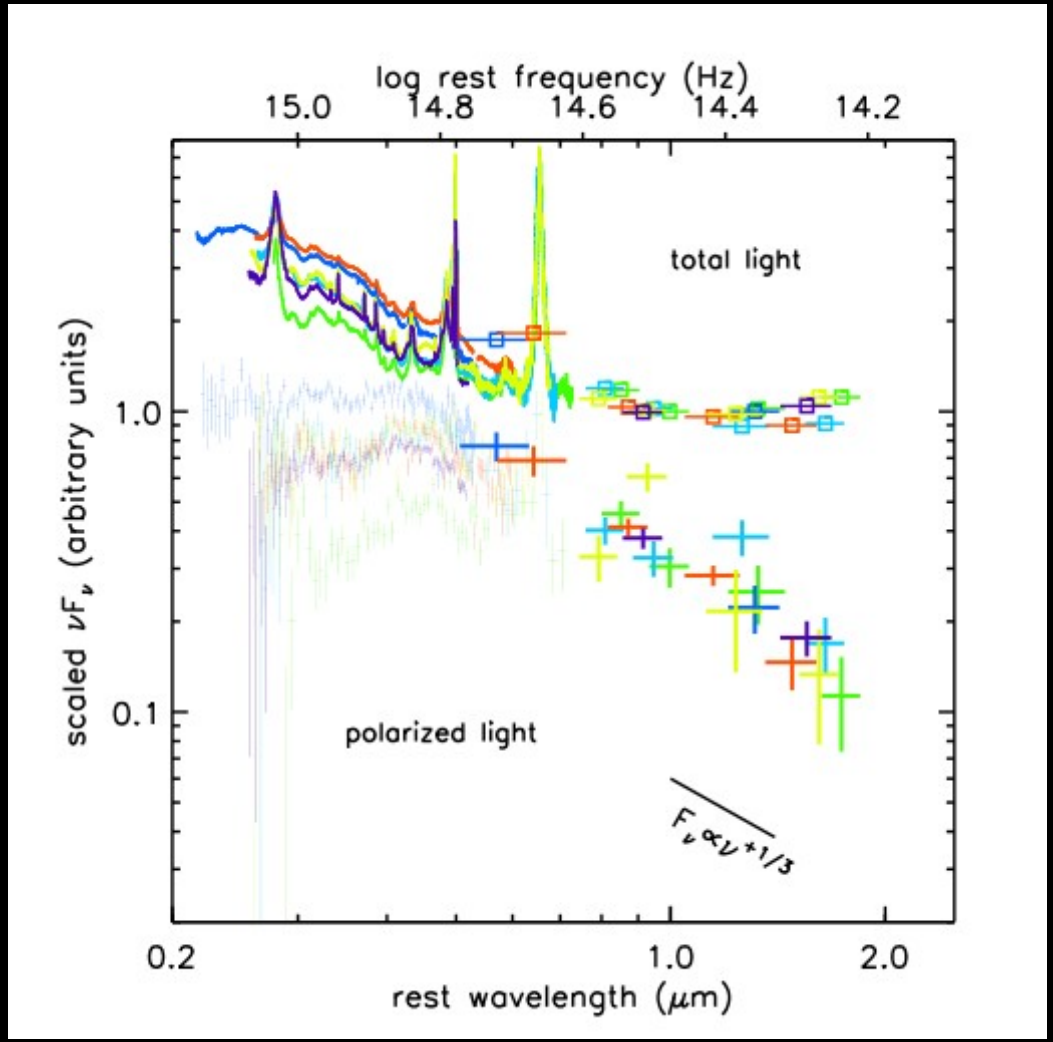


Recovering the hidden accretion disk spectrum

Looking through the periscope, the continuum spectrum of the disk can be recovered.

A multiple-blackbody shape with power-law slope of $n^{-1/3}$

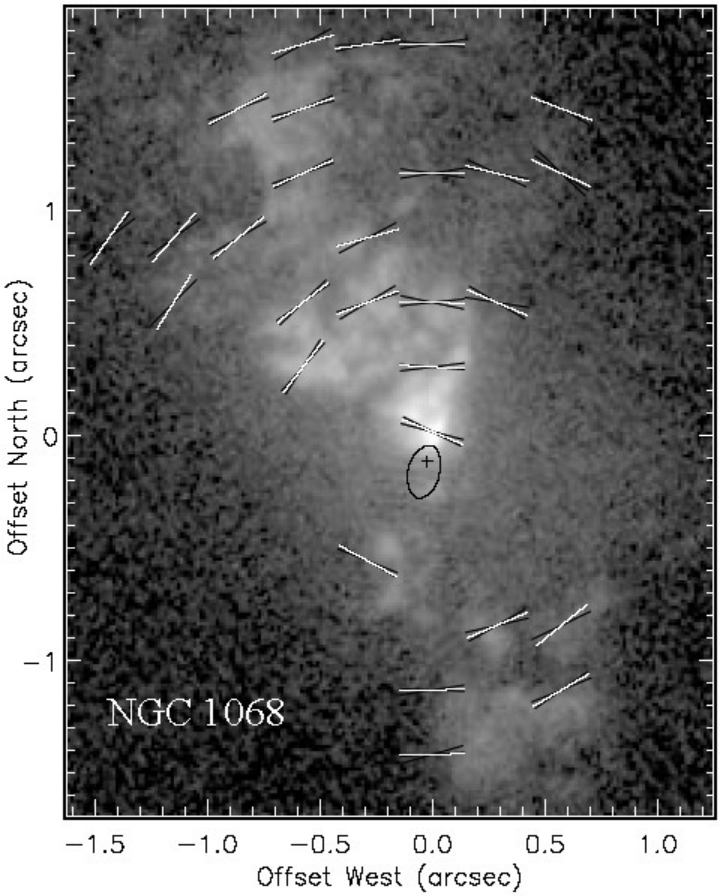


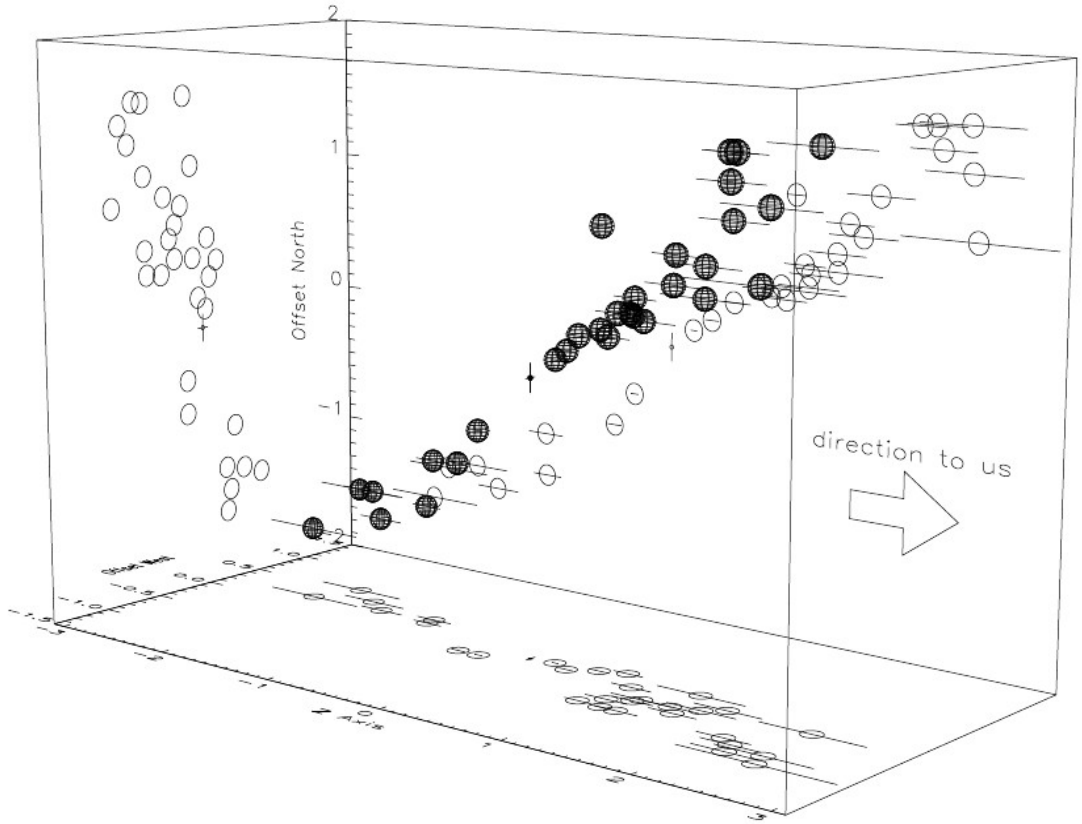


Kishimoto et al. 2008

Polarimetry with the E-ELT would open this study to many more type-2 AGN (see this morning's talk by Frans Snik) !

A 3D image of the scattering clouds in NGC 1068





Capetti et al. 1995

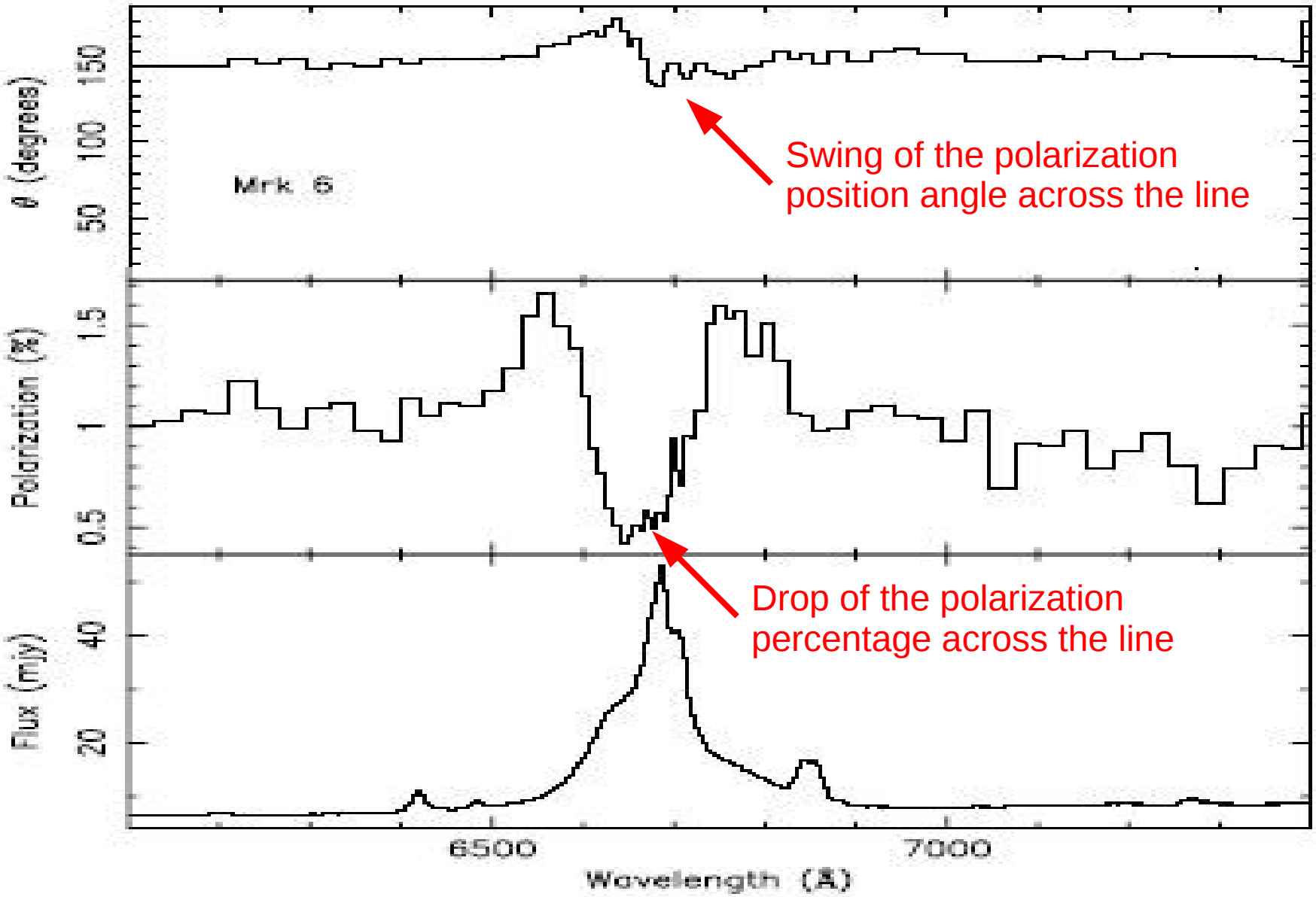
Kishimoto et al. 1999

Phase function of Thomson scattering
Spatial distribution of polarized flux → 3D image of the scattering clouds
Assuming optically thin matter

See Monday's talk by Frédéric Marin for more modeling of clumpy AGN.

Spectropolarimetry of broad lines

Smith et al. (2002)



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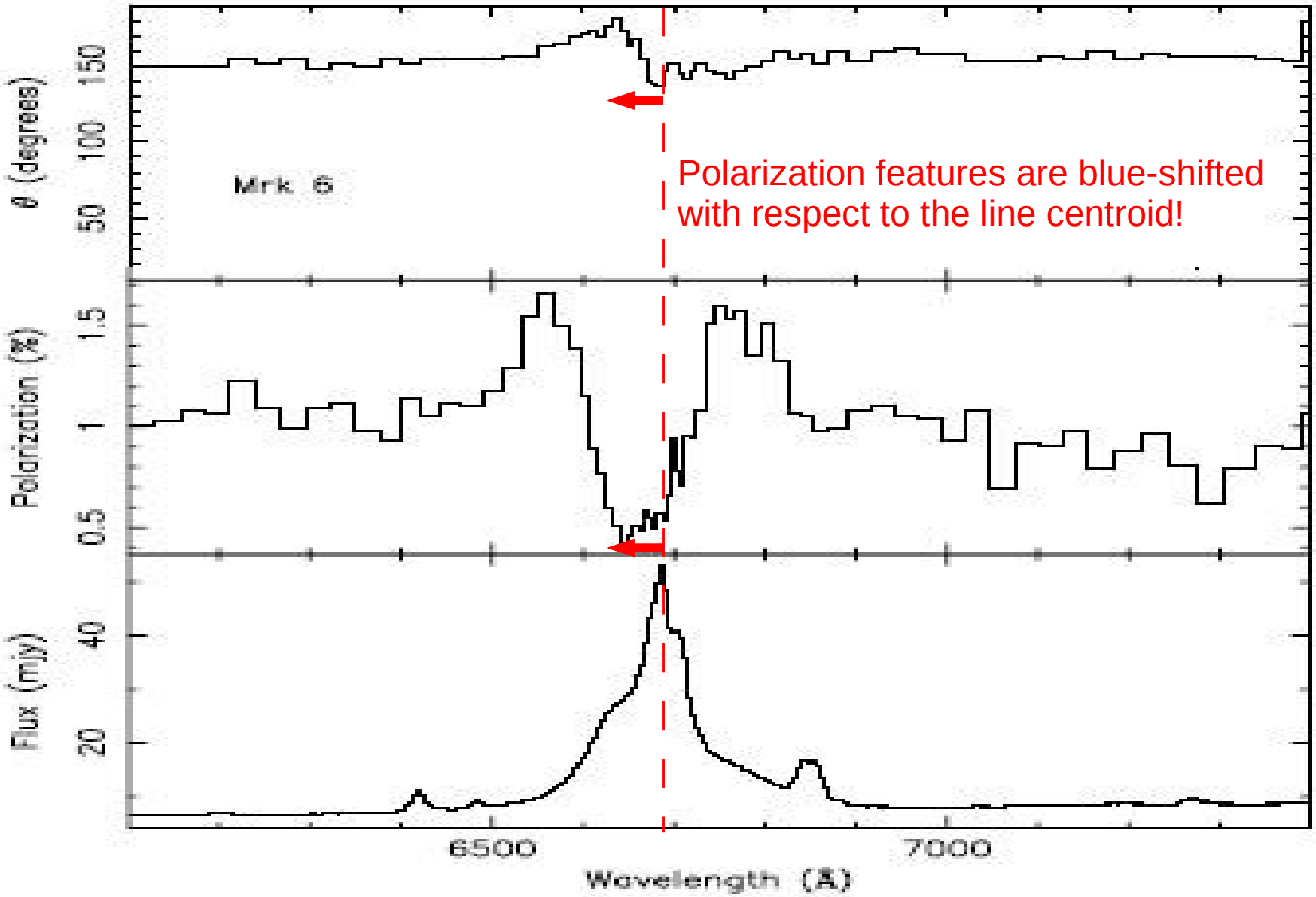
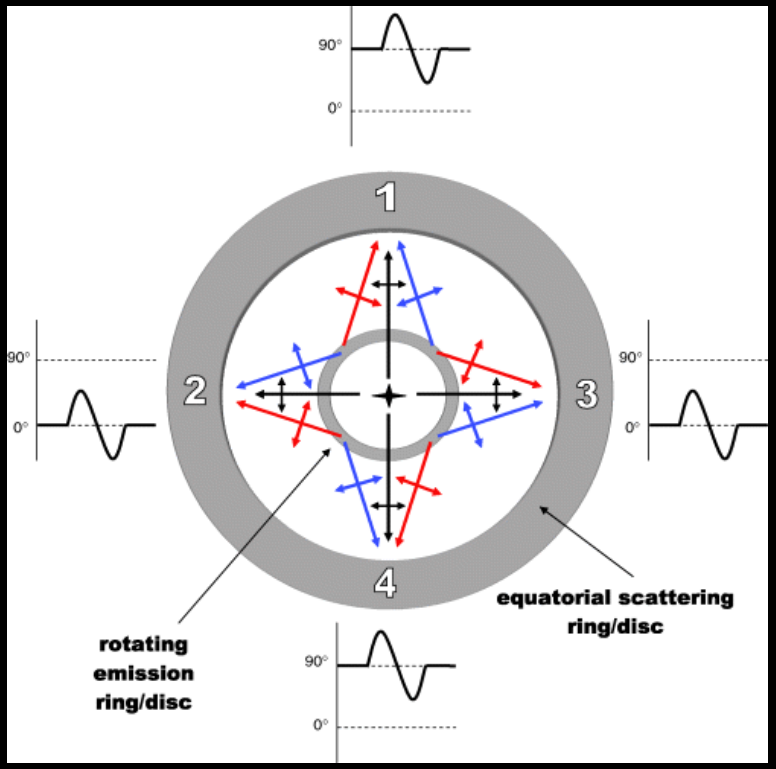
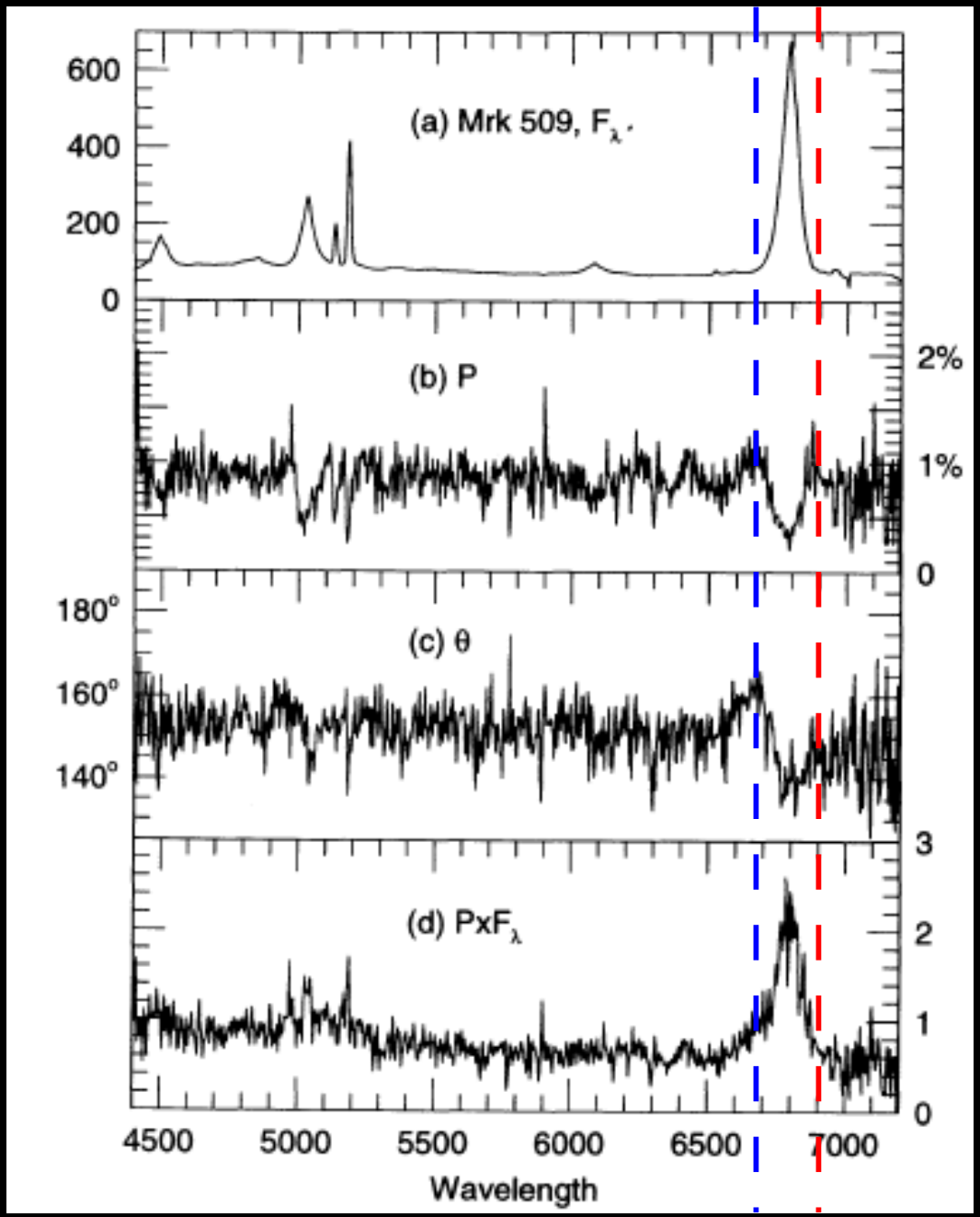


Rotation of polarization angle across emission line

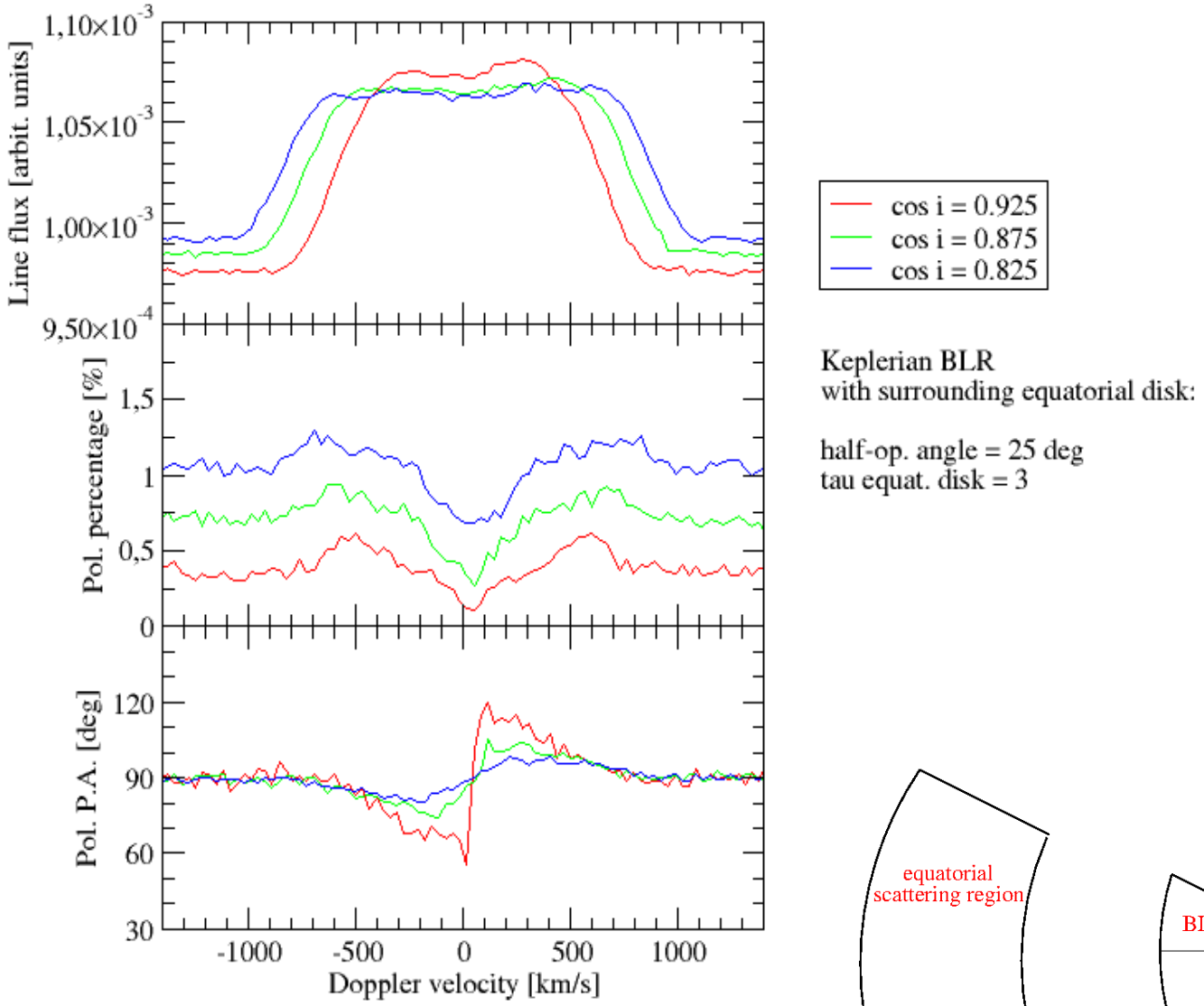


Interpretation and modeling
by Smith et al. (2005)



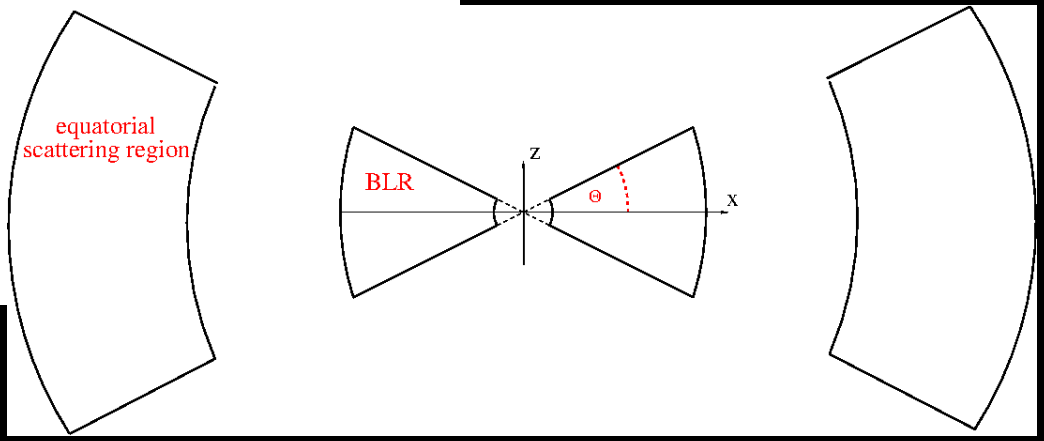
Spectropolarimetric data for Mrk 509
from Goodrich & Miller (1994)

Reproducing the Smith model with STOKES



We confirm the Smith et al. model with STOKES while introducing a larger half-opening of the equatorial structures than prescribed in Smith et al. (2005).

Work in progress... and funded by this COST action!

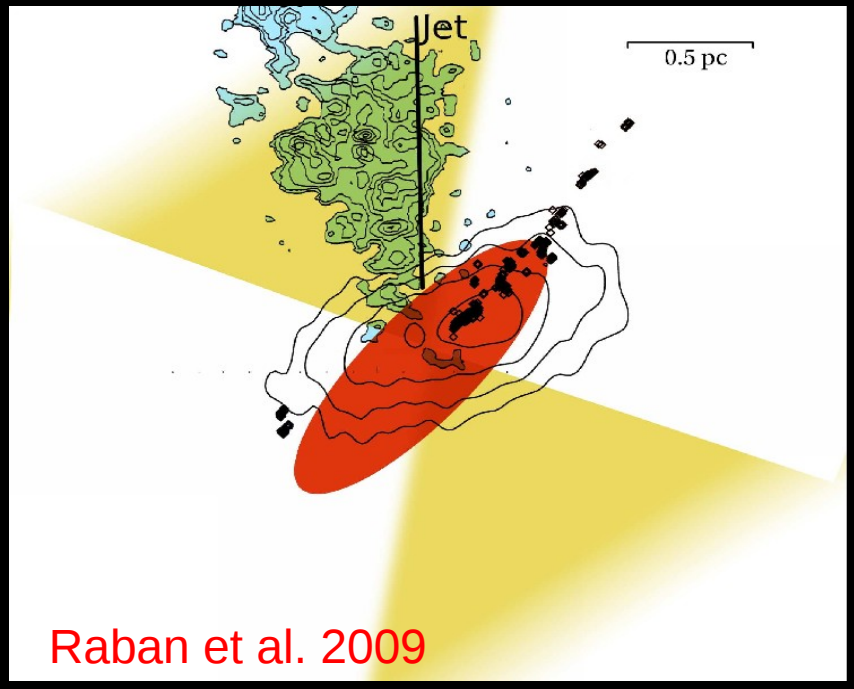


X-ray polarization modeling of NGC 1068

Modeling of an irradiated accretion disk, a dusty torus with Θ=60°, and inclined outflows as suggested by Raban et al. (2009).

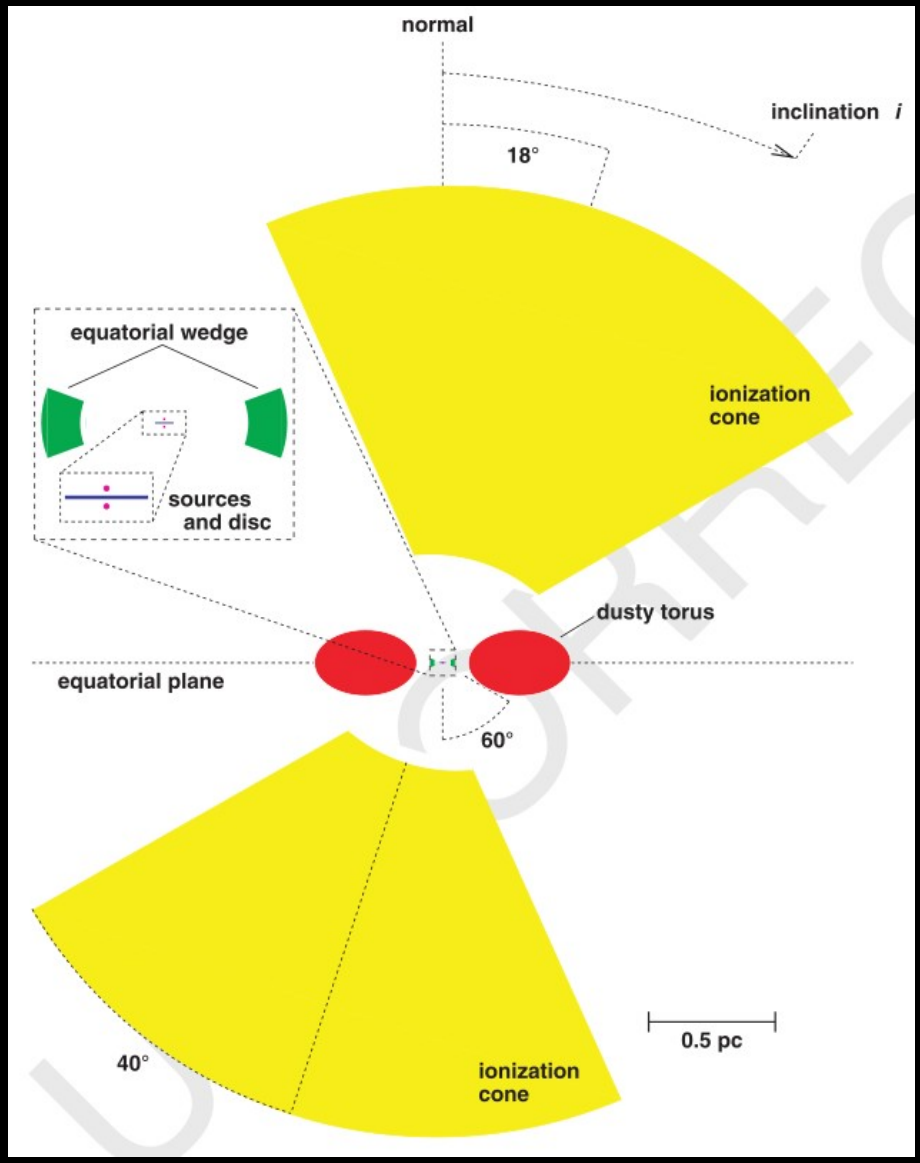
Goosmann & Matt 2011

Marin, Goosmann & Dovciak (2012)



Raban et al. 2009

Possibility to constrain the relative angle between torus and outflows by broad-band polarimetry!



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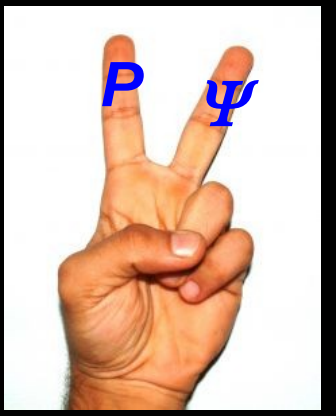
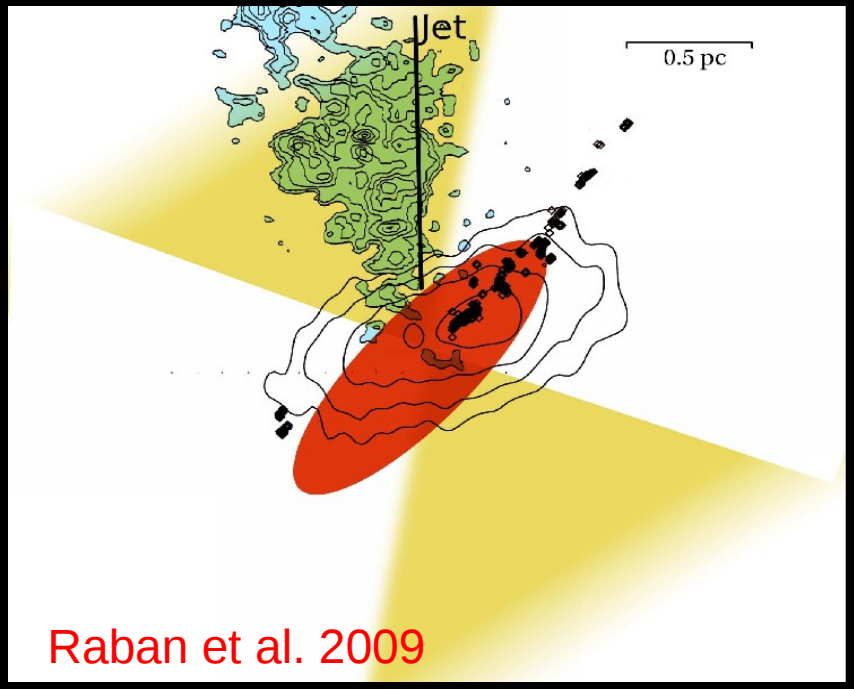
Goosmann & Matt 2011; Marin, Goosmann & Dovciak (2012)





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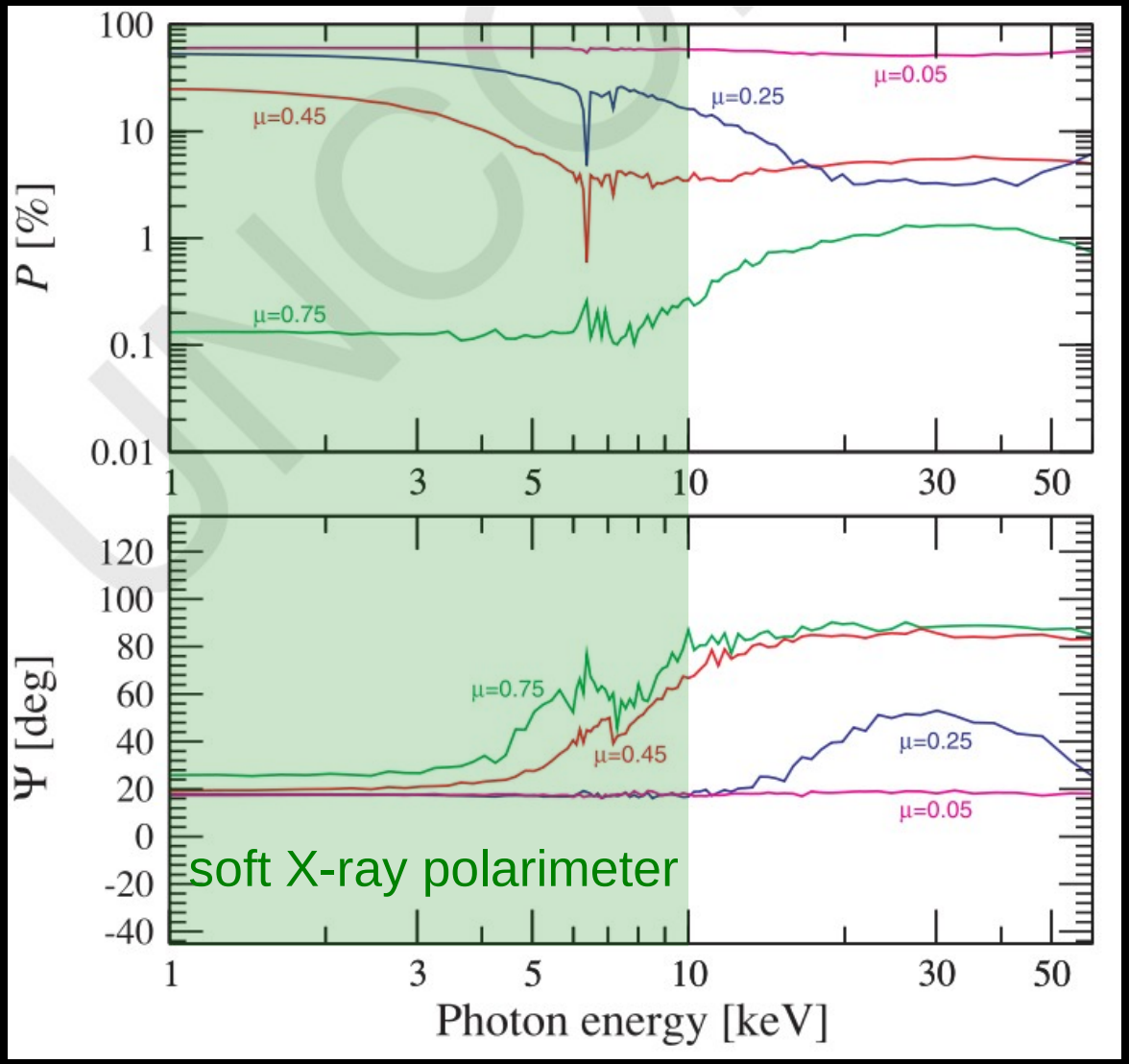
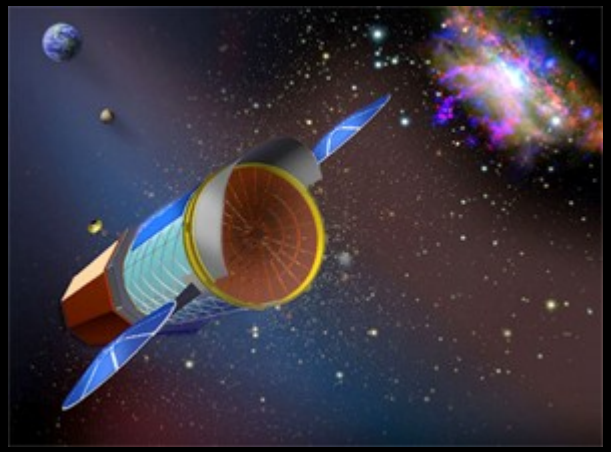
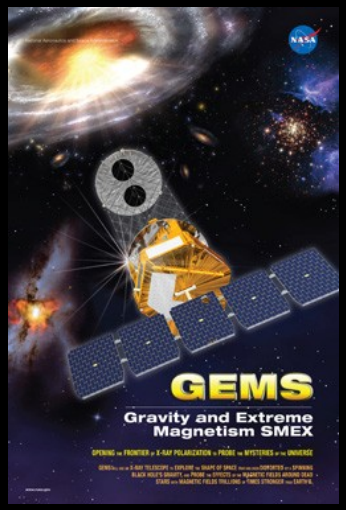


Our dilemma : the so-far missing observational perspective

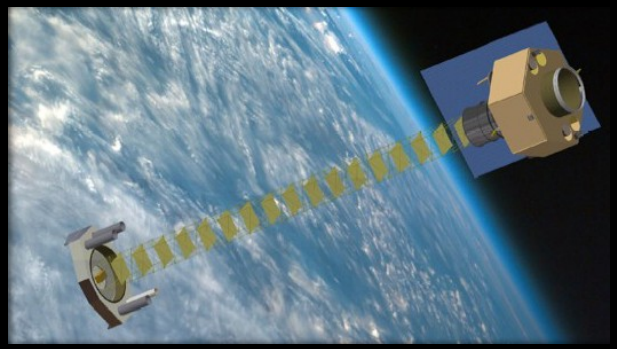


IXO+XPOL (†2011)

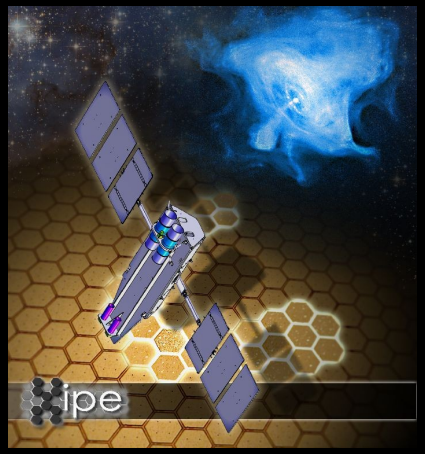


GEM SMEX (†2012)

?



NHXM (†2012)

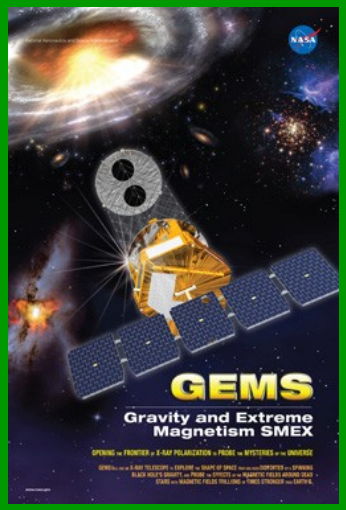


XIPE (†2012)

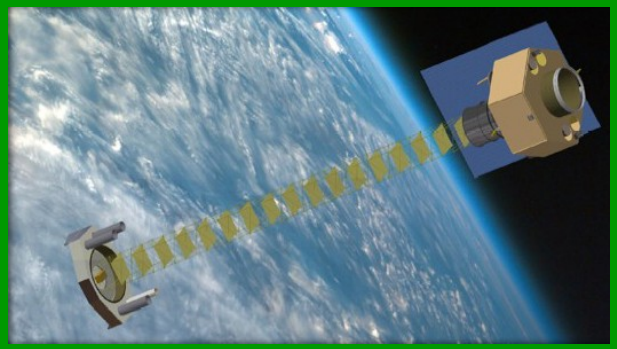
However, the landscape is changing!

See Tuesday's talk by Enrico Costa !

IXO+XPOL (†2011)



GEMS (†2012)



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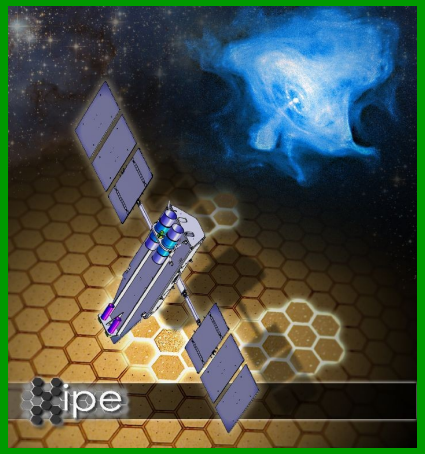
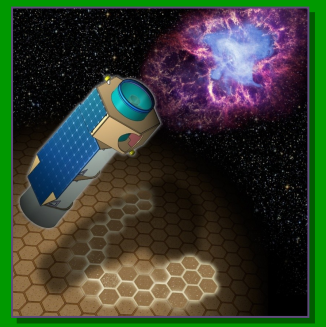


(former) XIPE (†2012)

- 3 X-ray polarimetry mission projects in NASA's SMEX competition
- Selection of the (new) XIPE to be studied for ESA's M4



A FEW CONCLUSIONS...

• Scattering-induced polarization as a function of wavelength and/or position reveals details of the interaction between radiation and matter in AGN. It thereby constraints geometry and dynamics.

• Clumpy models of accretion and ejections flows are on the rise.

• We are currently making important progress in probing the detailed geometry and dynamics off scattered BLR radiation.

• X-ray polarization may set important constraints on the outflow geometry in AGN.

• Polarimetry must be an option on the next generation of giant telescopes such as the E-ELT.
•
• More on this can be found in our book, chapter on AGN co-authored by Chris Packham and René Goosmann.

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September 23rd 2015, Brussels, Belgium