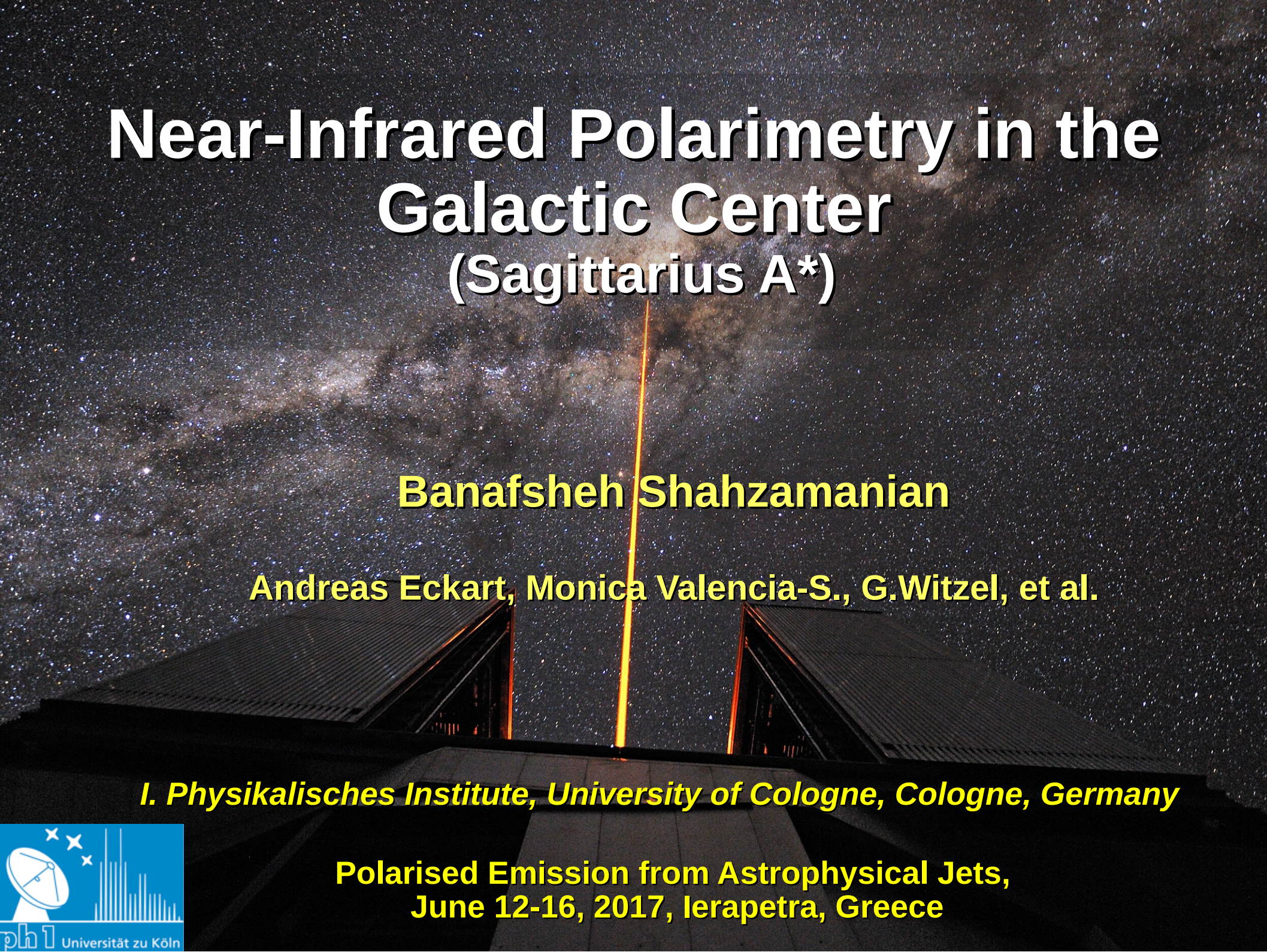
Near-Infrared Polarimetry in the Galactic Center (Sagittarius A*)



Banafsheh Shahzamanian

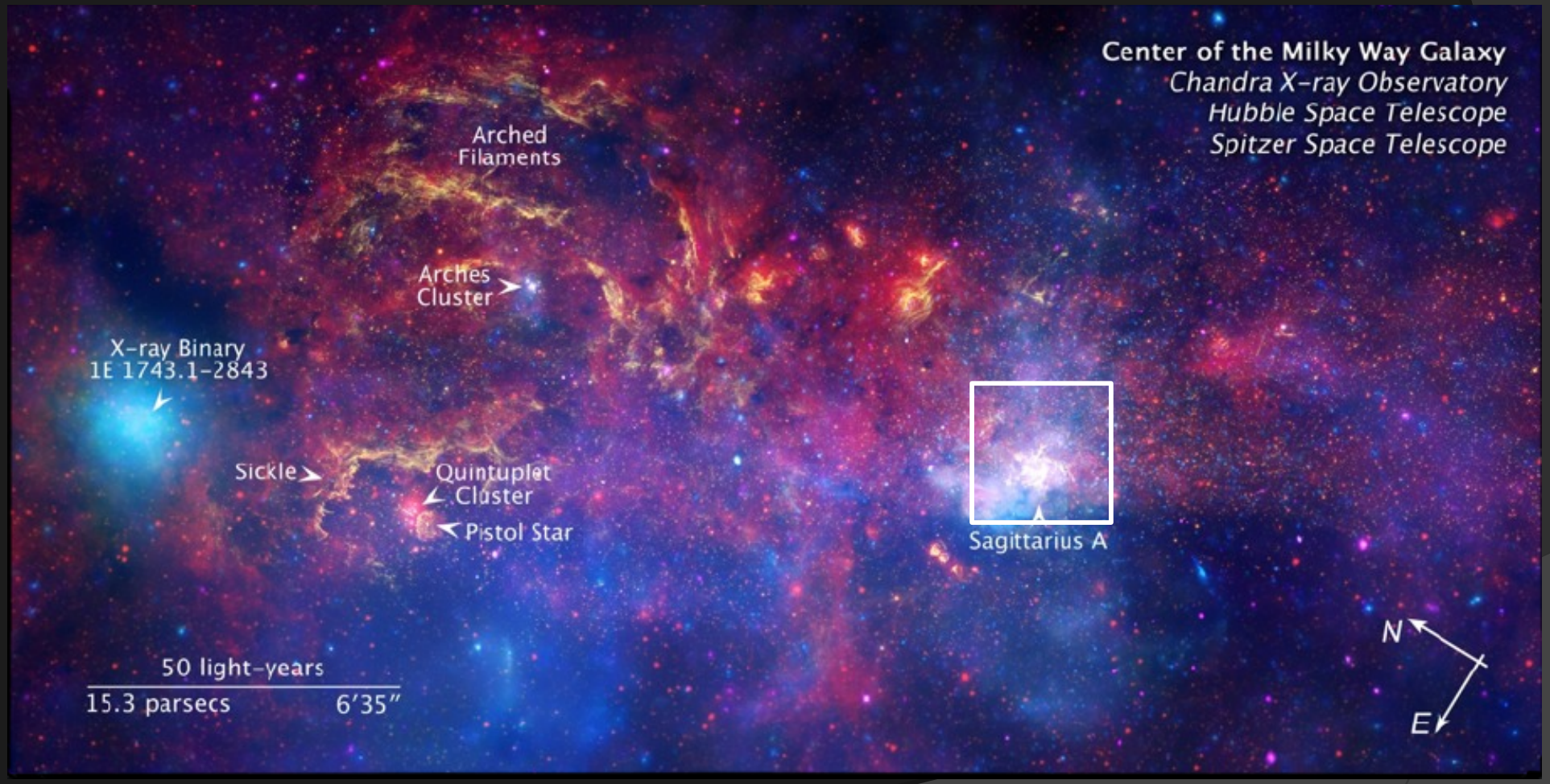
Andreas Eckart, Monica Valencia-S., G.Witzel, et al.

I. Physikalisches Institute, University of Cologne, Cologne, Germany

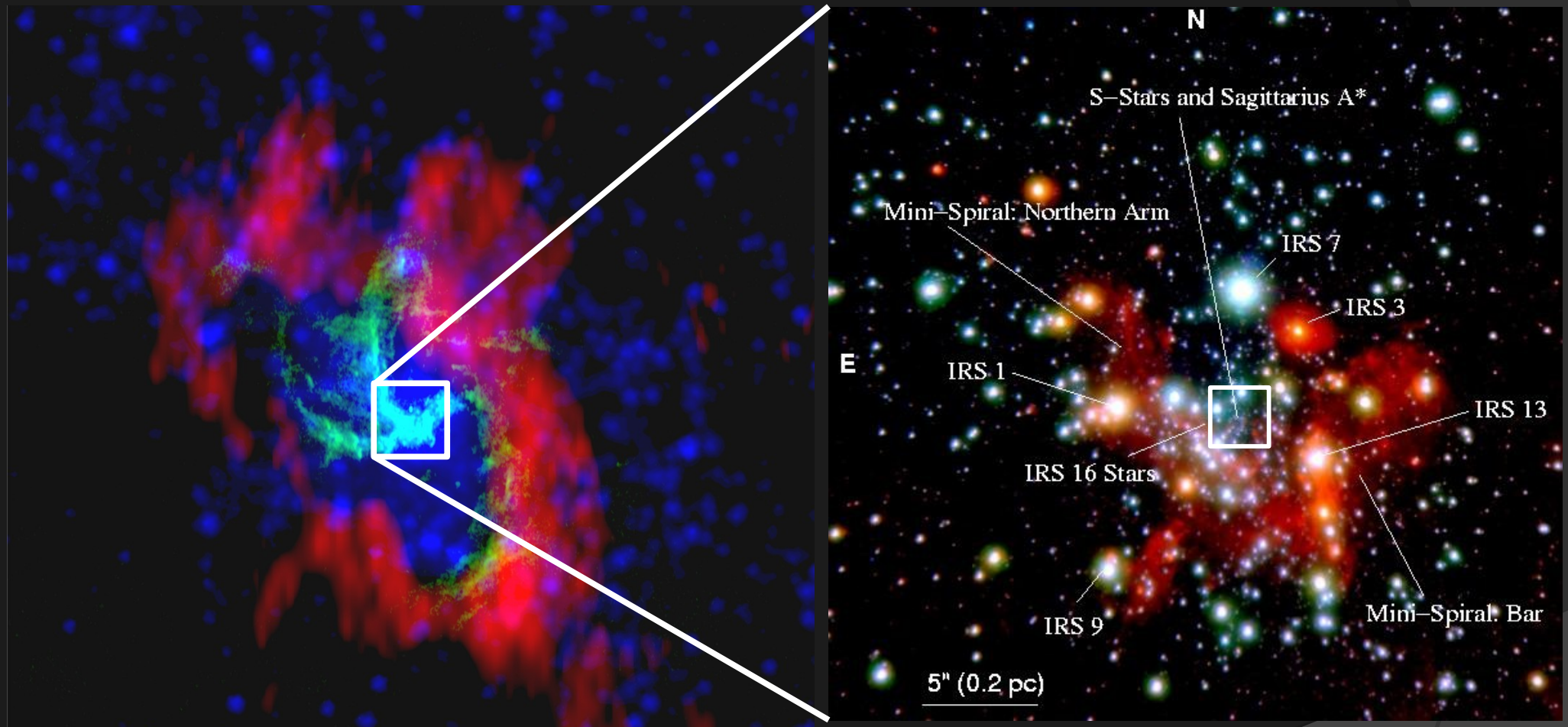
Polarised Emission from Astrophysical Jets,
June 12-16, 2017, Ierapetra, Greece

The Galactic Center

The Galactic Center



The Galactic Center

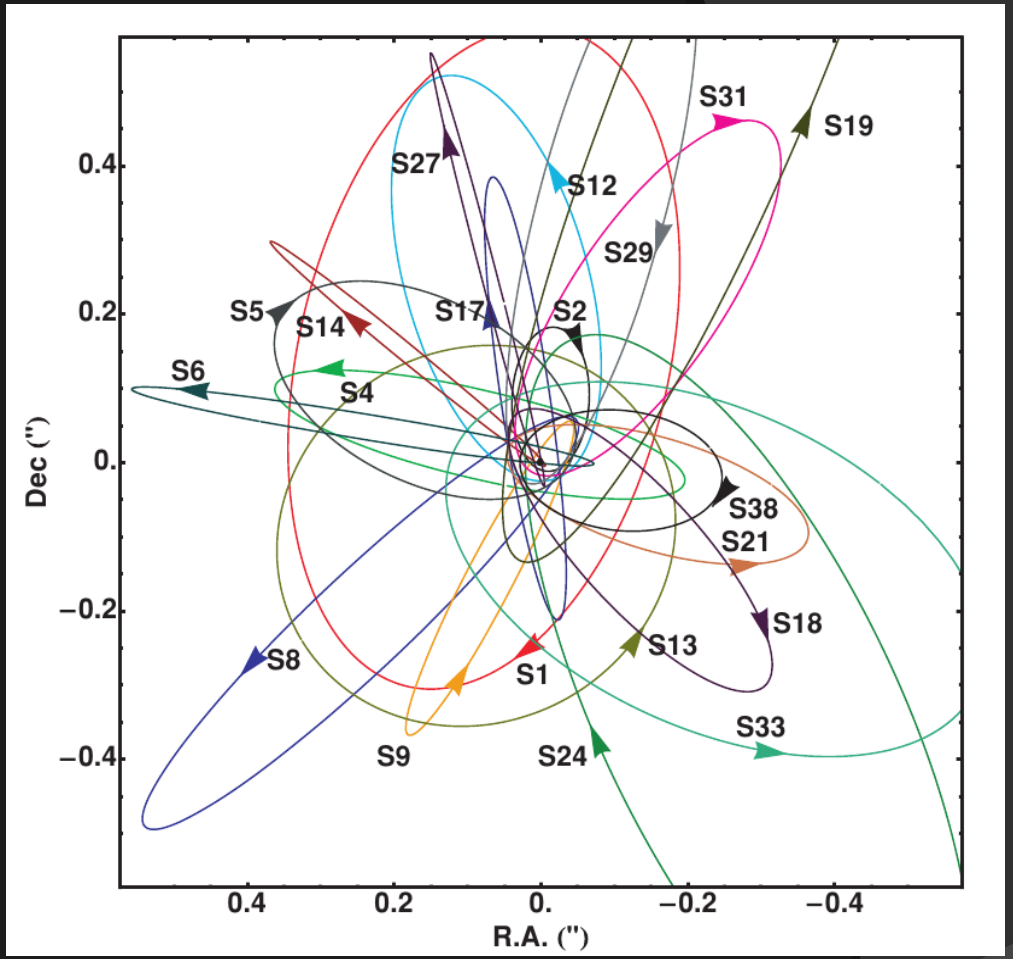


Sagittarius A*

- Compact Radio, Infrared and X-ray source at the GC

- The nearest SMBH (8 kpc / ~4x10^6 M_{sun})

- Sgr A* is under luminous (10 $^{-9...-10}$ L_Edd)



Gillessen et al. 2009

Eckart & Genzel 1996/1997 (first proper motions)

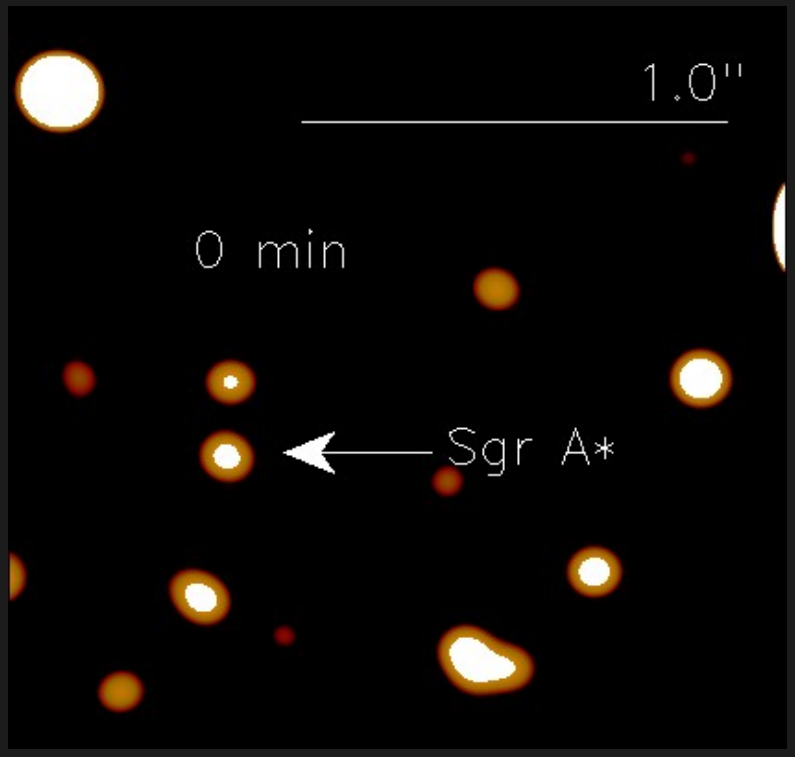
Eckart et al. 2002 (S2 is bound; first elements)

Schoedel et al. 2002, 2003 (first detailed elements)

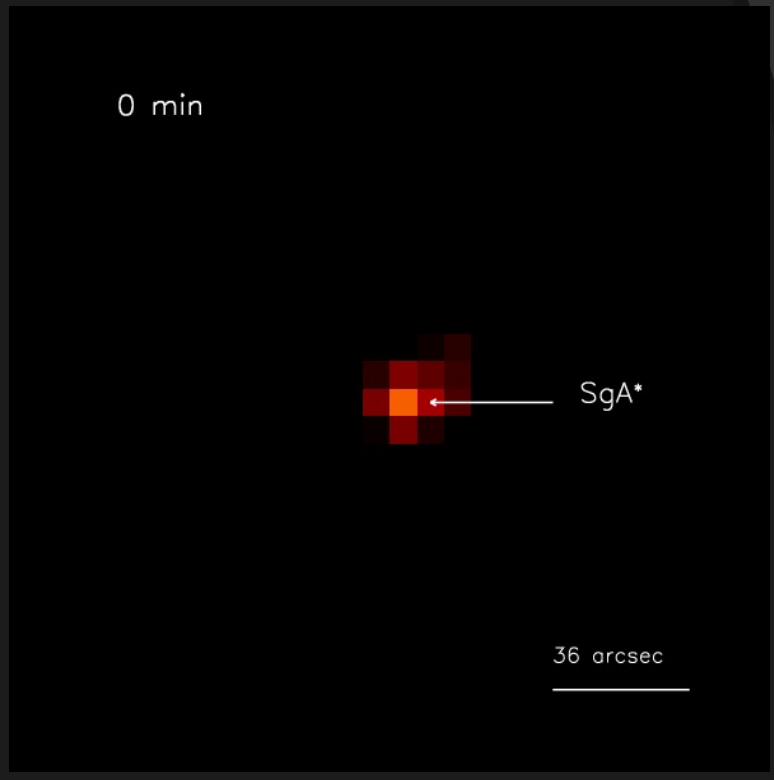
Ghez et al. 2003 (detailed elements)

Eisenhauer 2005, Gillessen et al. 2009 (improved elements on more stars and distance)

Variability of Sgr A*

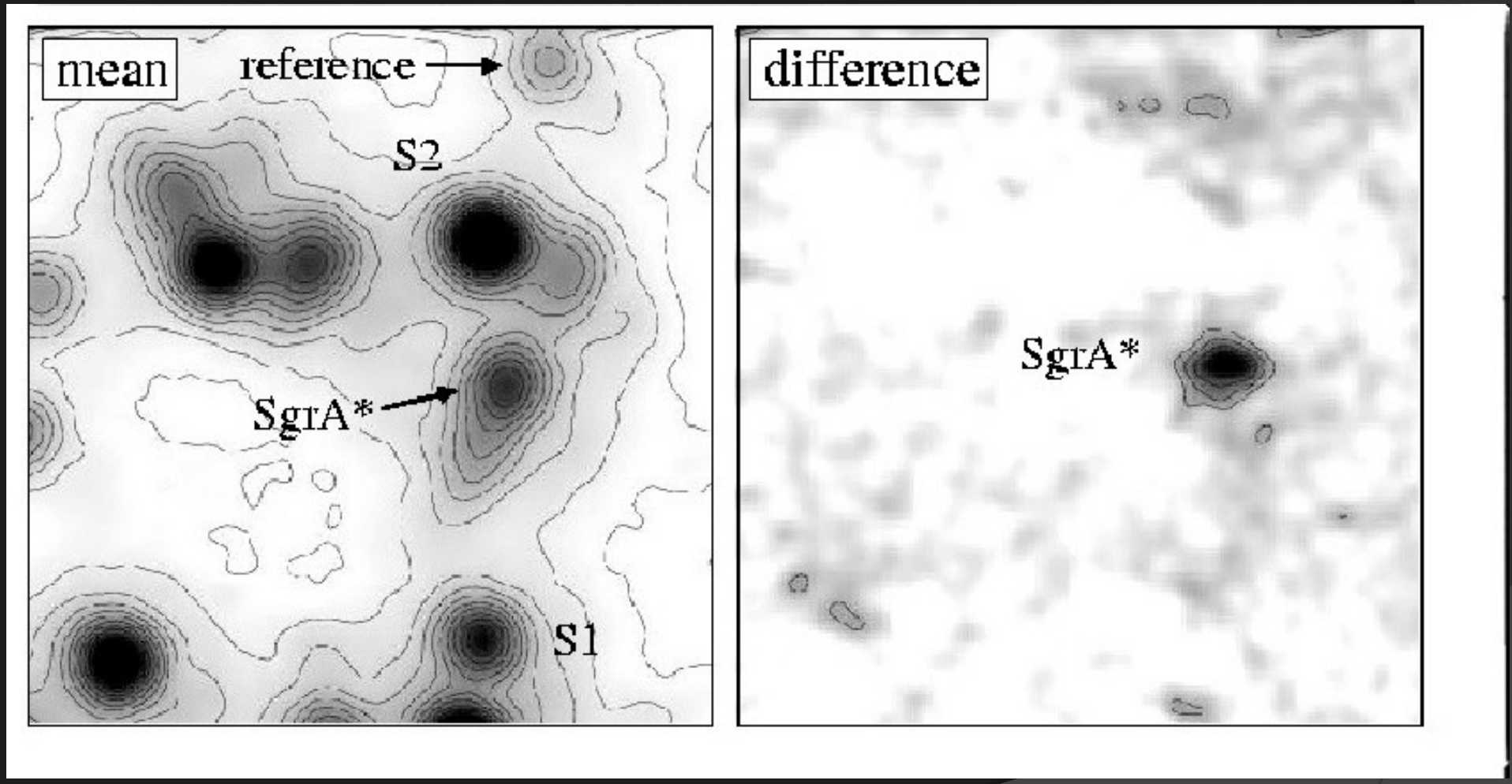


NIR L'-band (3.8 micrometer)
VLT UT4



Radio (1.3mm)
APEX

Polarization of Sgr A*



Eckart et al. 2006

Polarization studies of Sgr A*

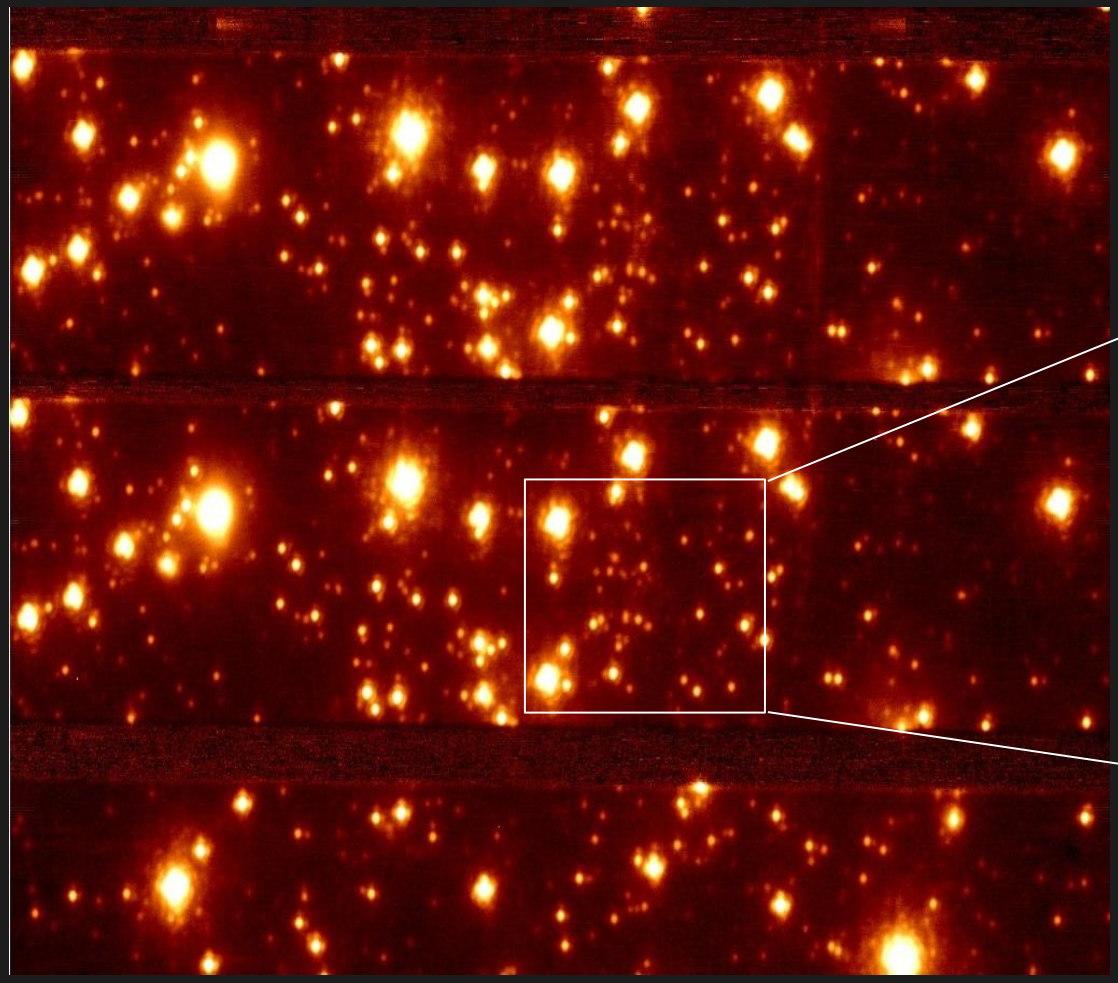
NIR observations

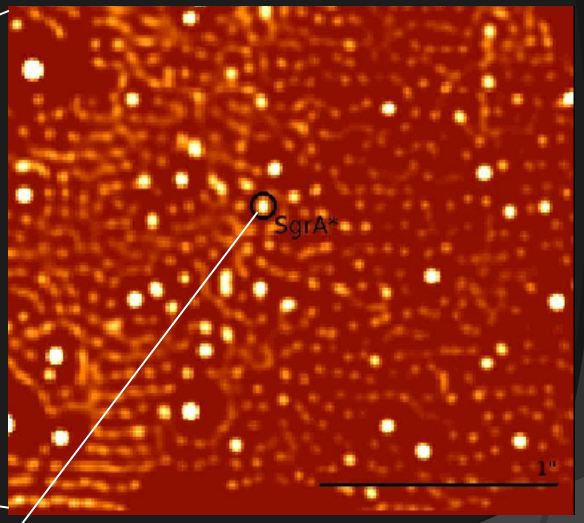
NACO at Very Large Telescope

Image courtesy: ESO

Polarimatric imaging with NACO

17.05.2012 Ks-band (2.2 μm) Infrared/Wollaston prism

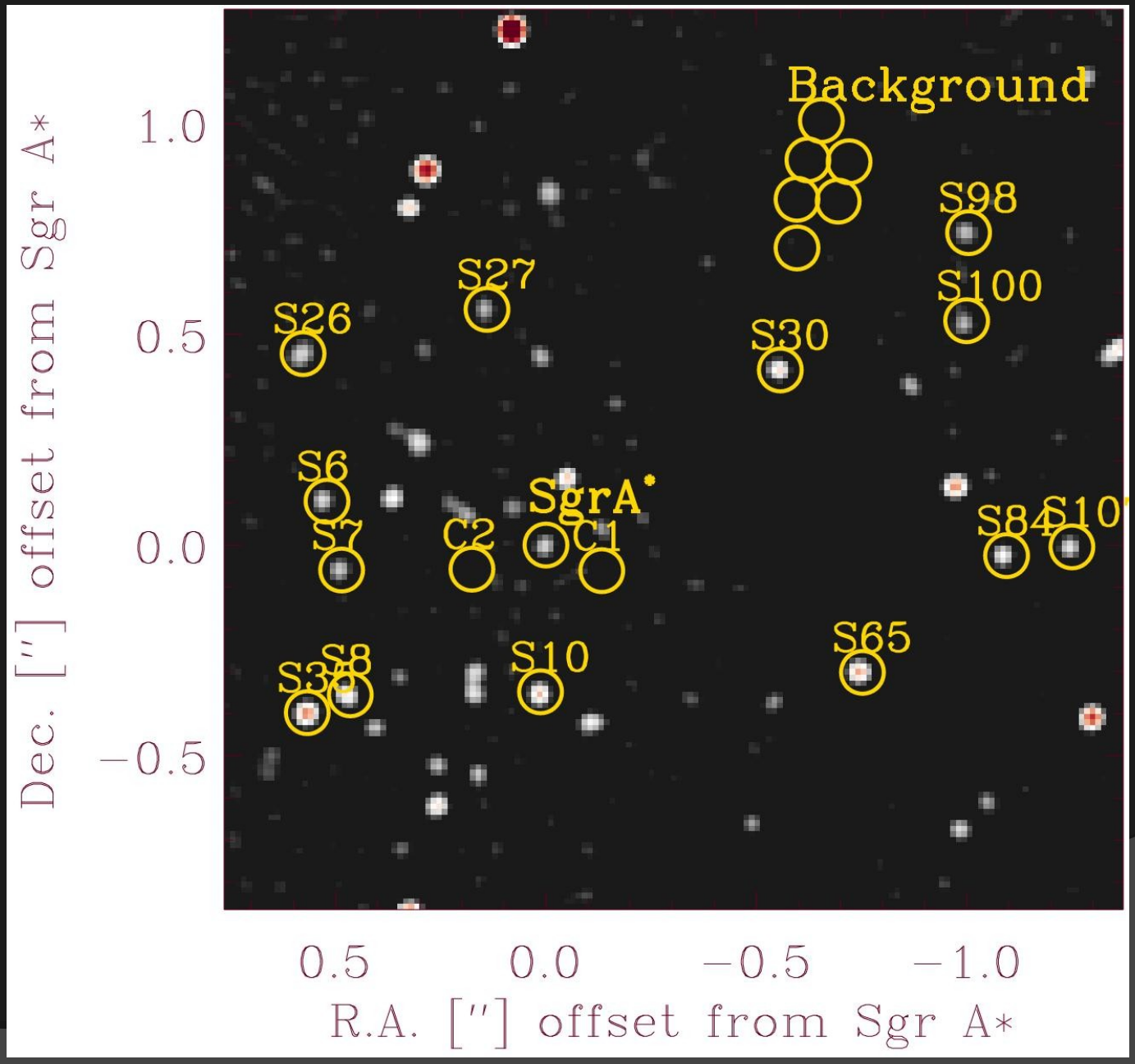




Deconvolved image

Sgr A* position

Aperture photometry



Light curve and polarization measurement

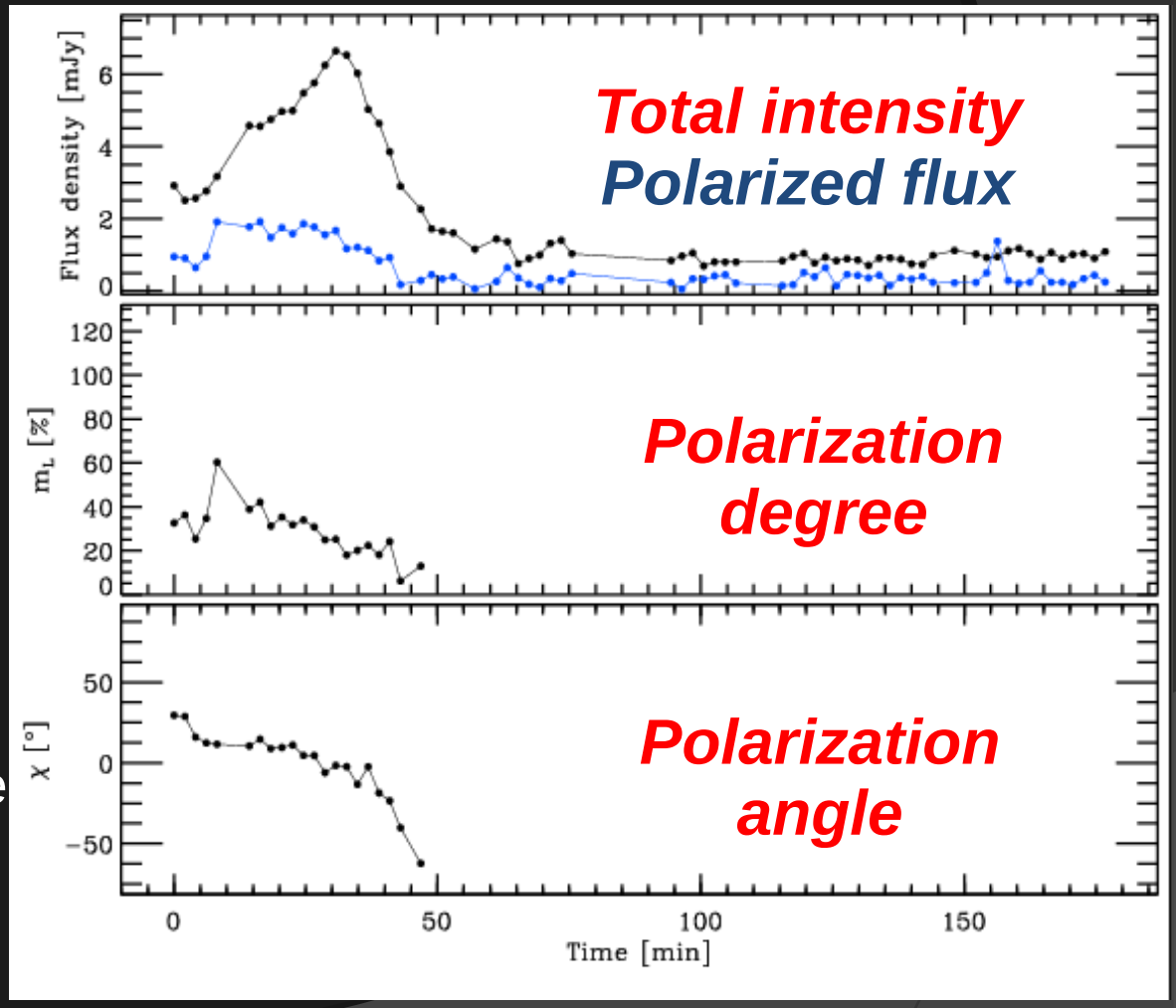
$$S = \begin{pmatrix} I_{\rm tot} = 1 \\ Q \\ U \\ V \end{pmatrix}$$

$$Q = \frac{I(0^\circ) - I(90^\circ)}{I(0^\circ) + I(90^\circ)}$$

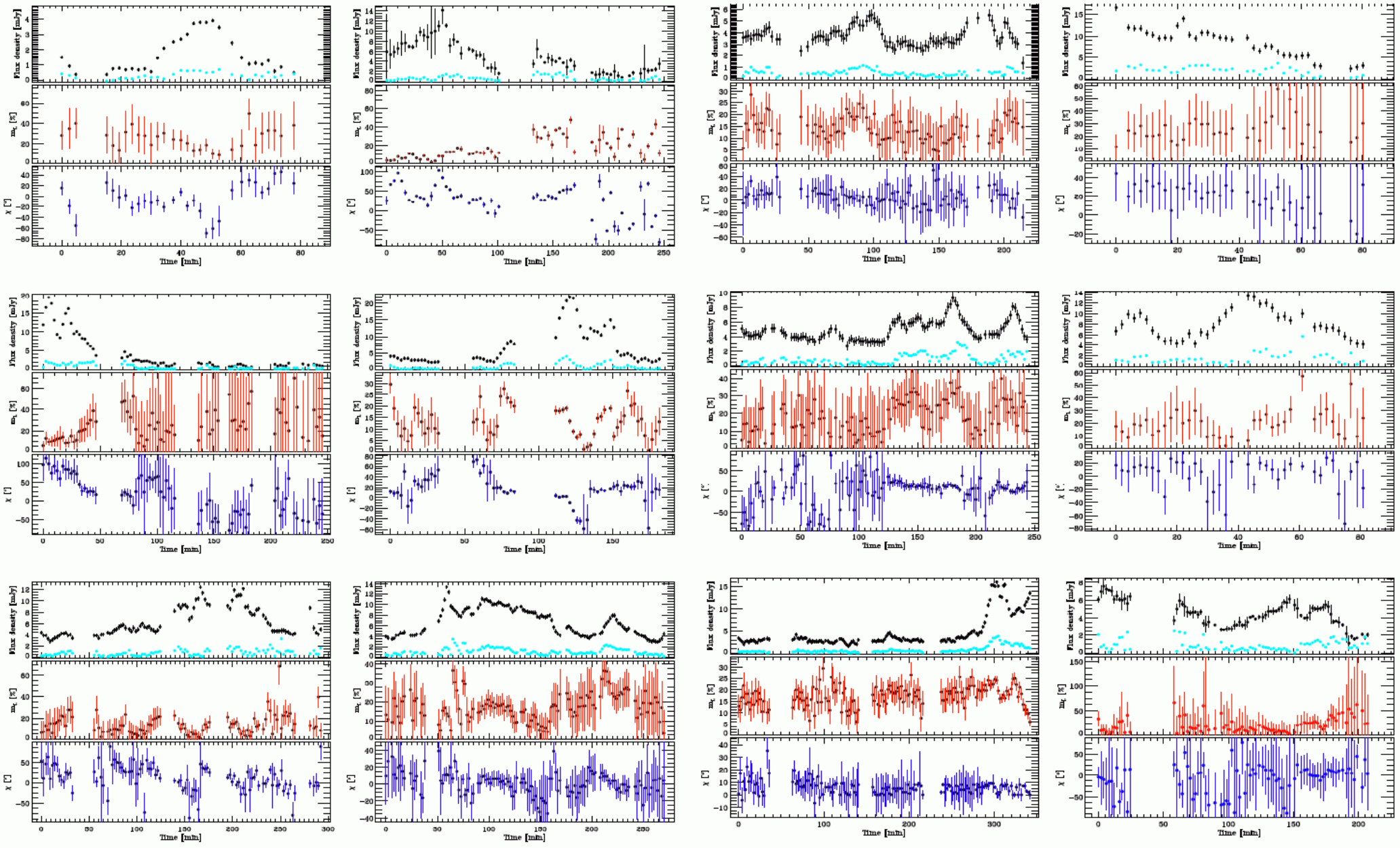
$$U = \frac{I(135^\circ) - I(45^\circ)}{I(135^\circ) + I(45^\circ)}$$

$$P = \sqrt{Q^2 + U^2}$$ Polarization degree

$$\phi = \frac{1}{2} \arctan\left(\frac{U}{Q}\right)$$ Polarization angle



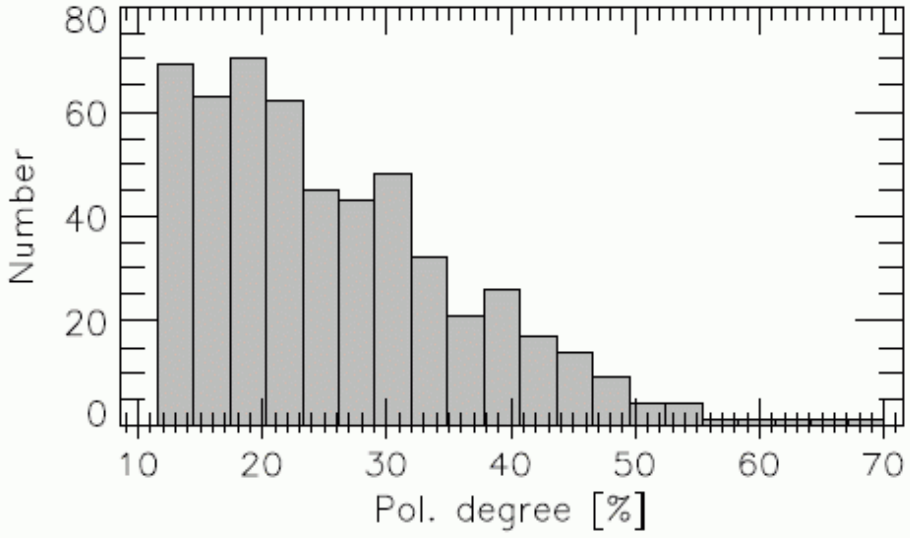
Light curves and polarization measurements (2004 to 2012)



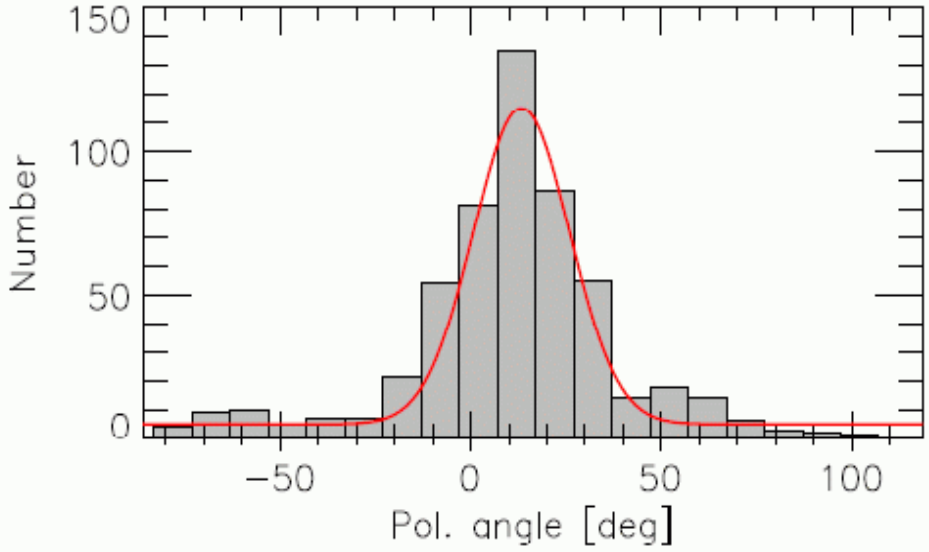
Data Analysis - statistical Approach

Polarization measurements statistics

Pol. degree distribution



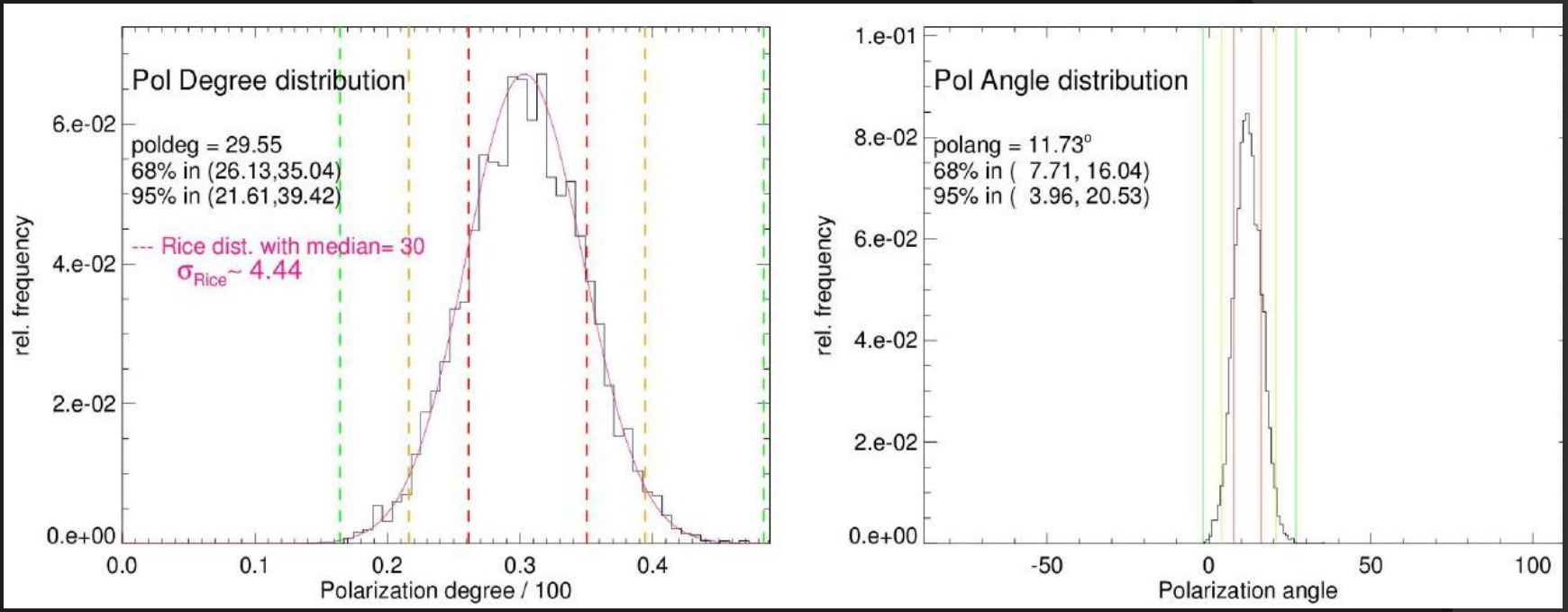
Pol. angle distribution



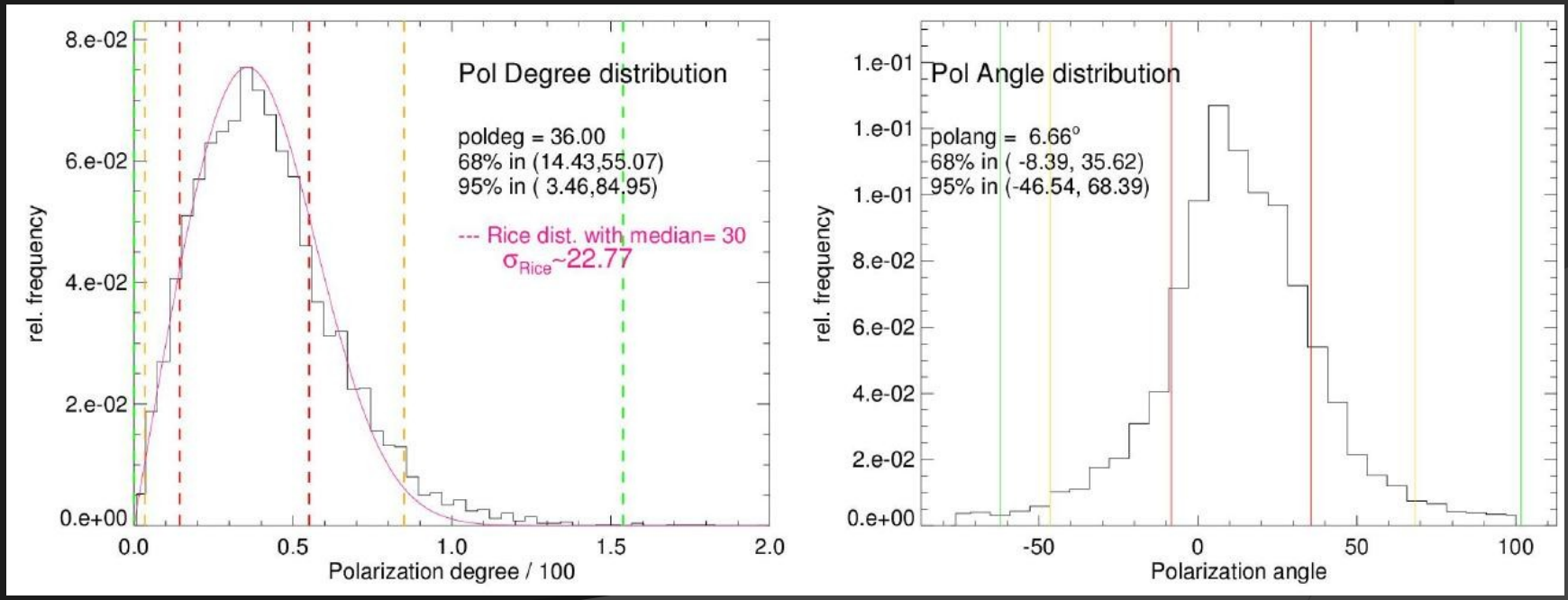
All the values are the significant measurements

How do we determine the significant polarization values and also the polarization measurement uncertainty ?

or high S/N

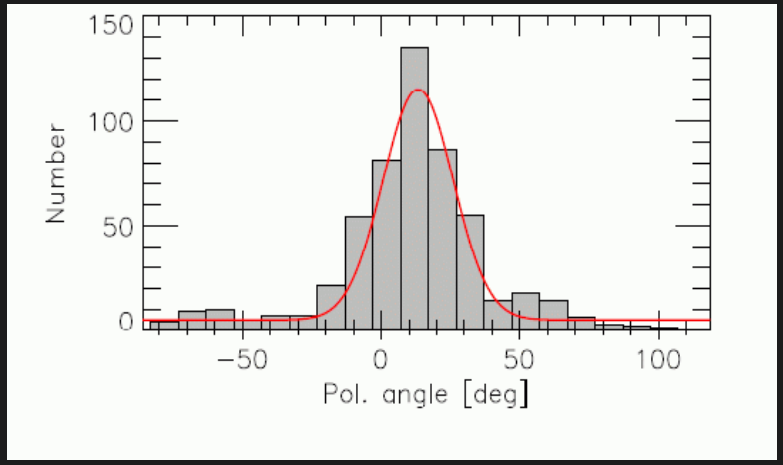


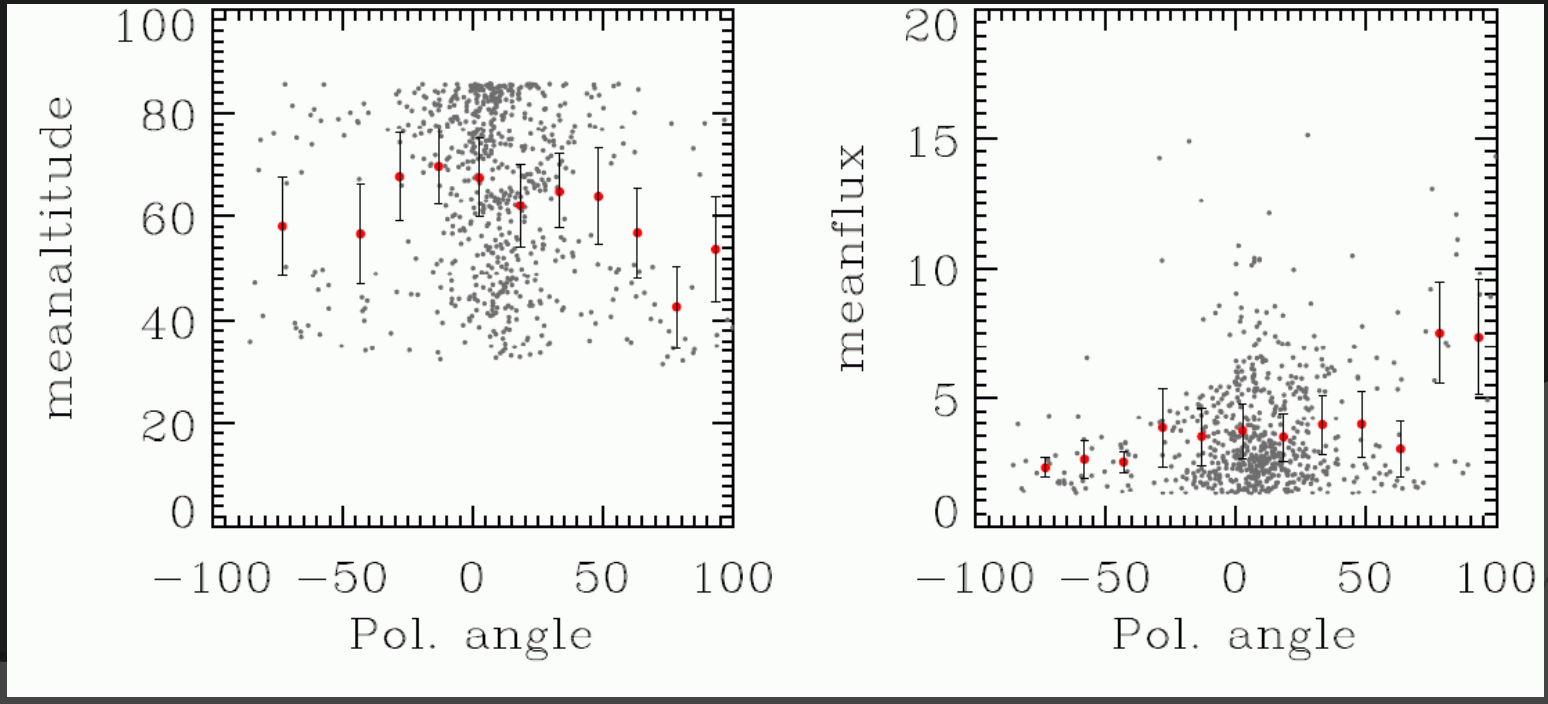
For low S/N



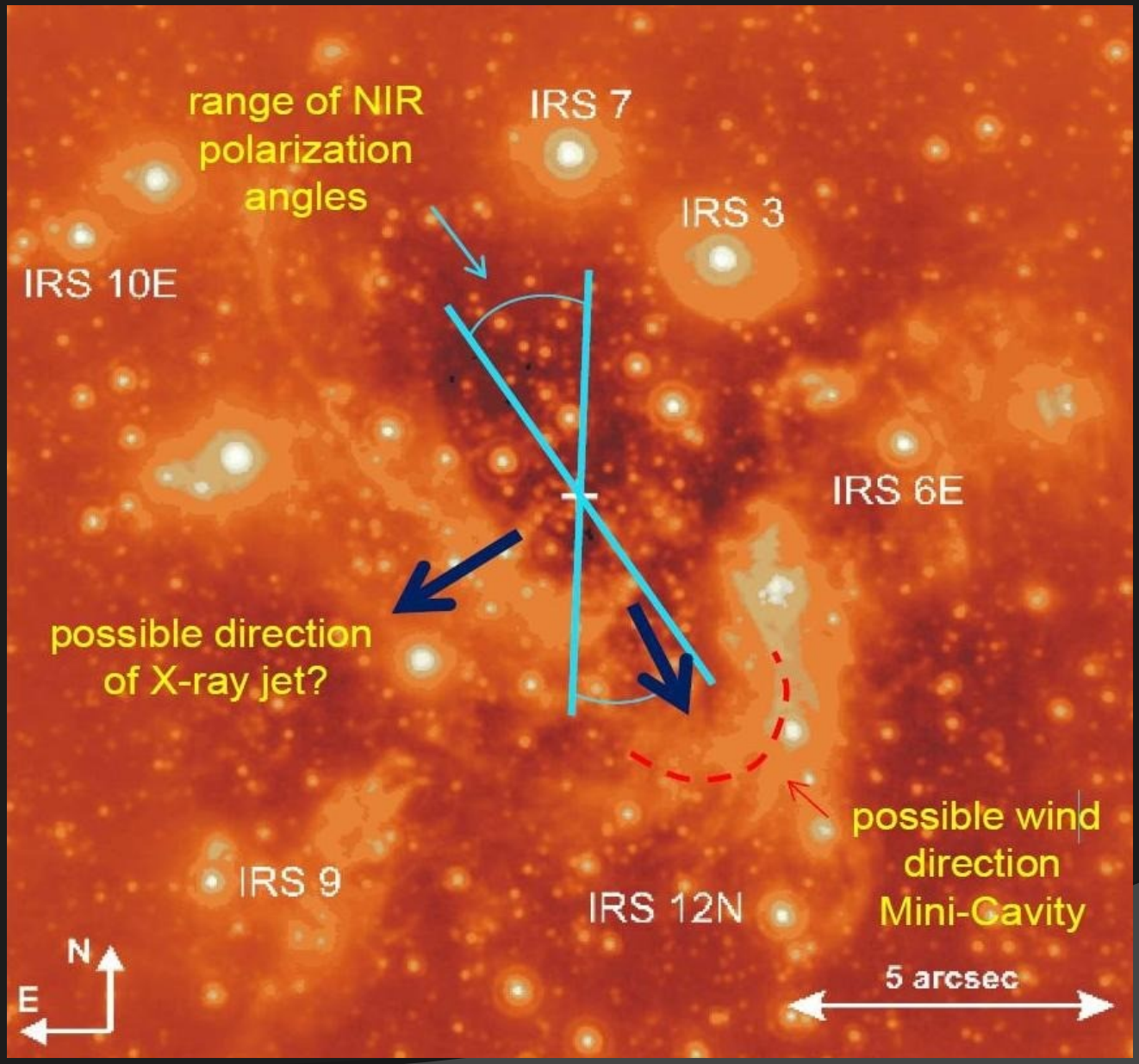
Shahzamanian et al. 2015b

How reliable is the polarization angle?





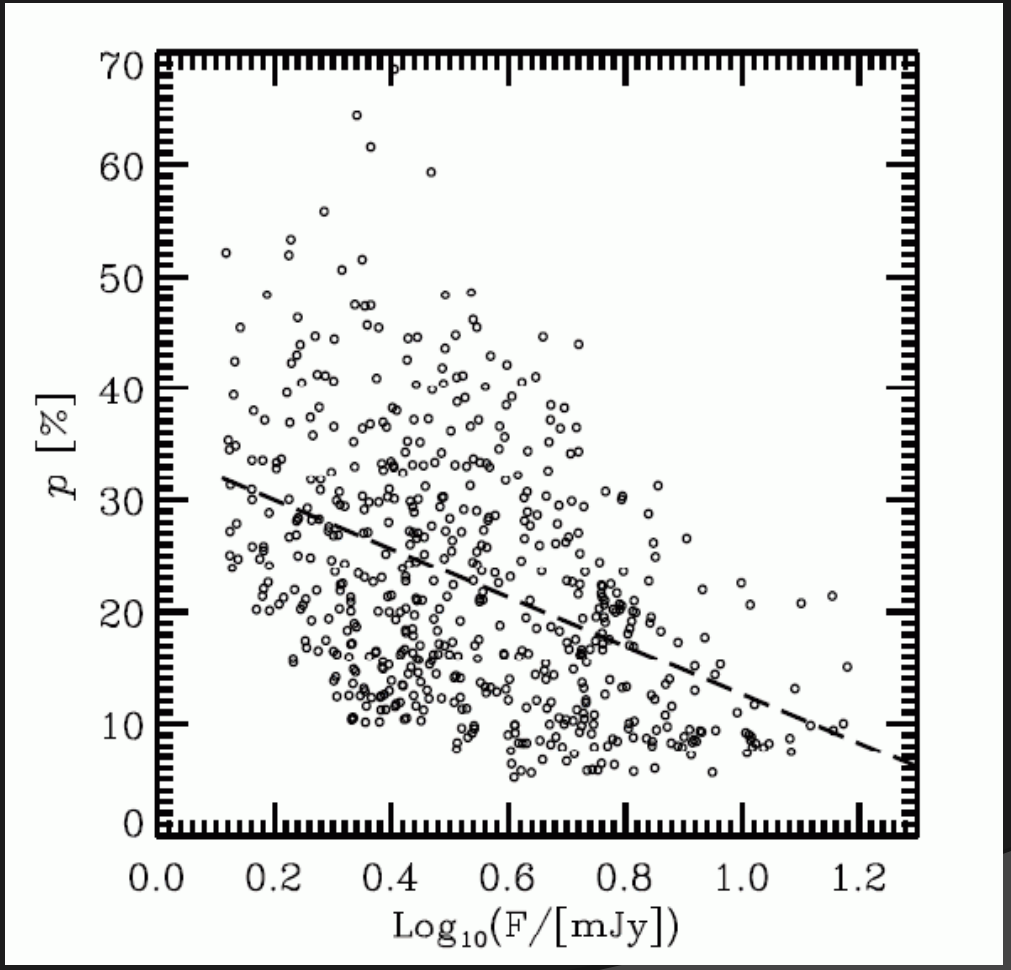
Stable geometry



Shahzamanian et al. ESO Messenger 2015

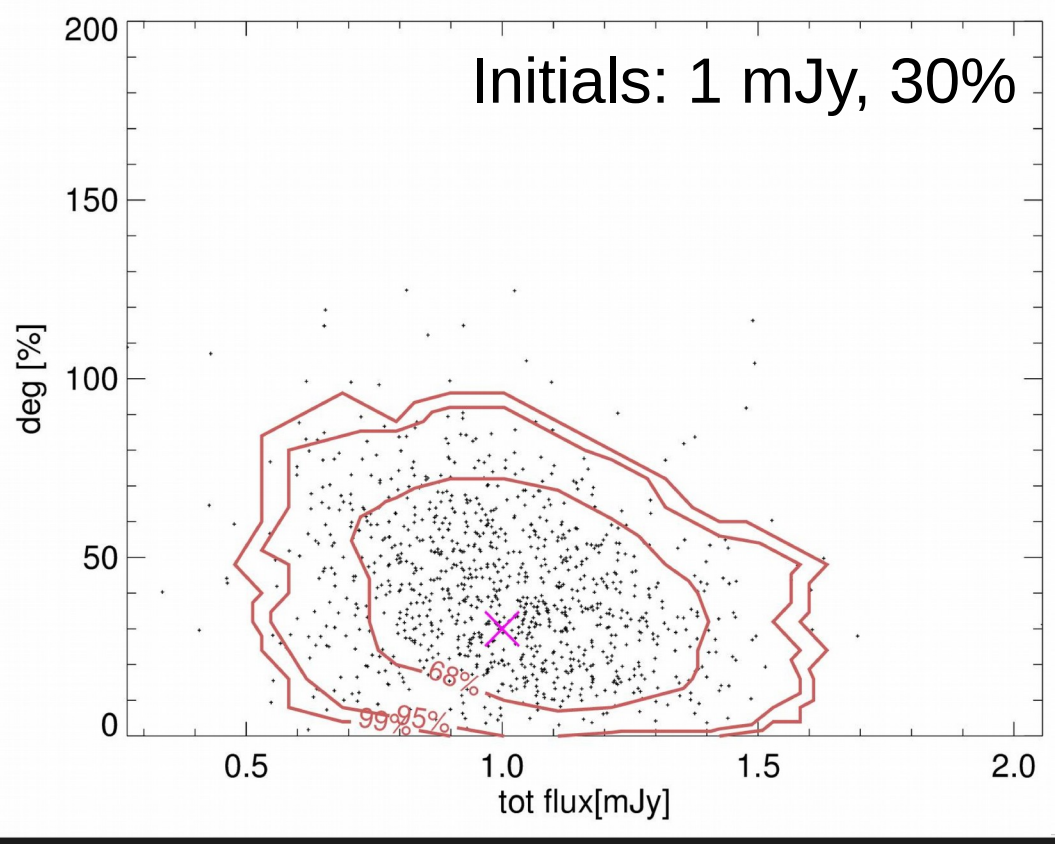
Polarization degree & flux dependency

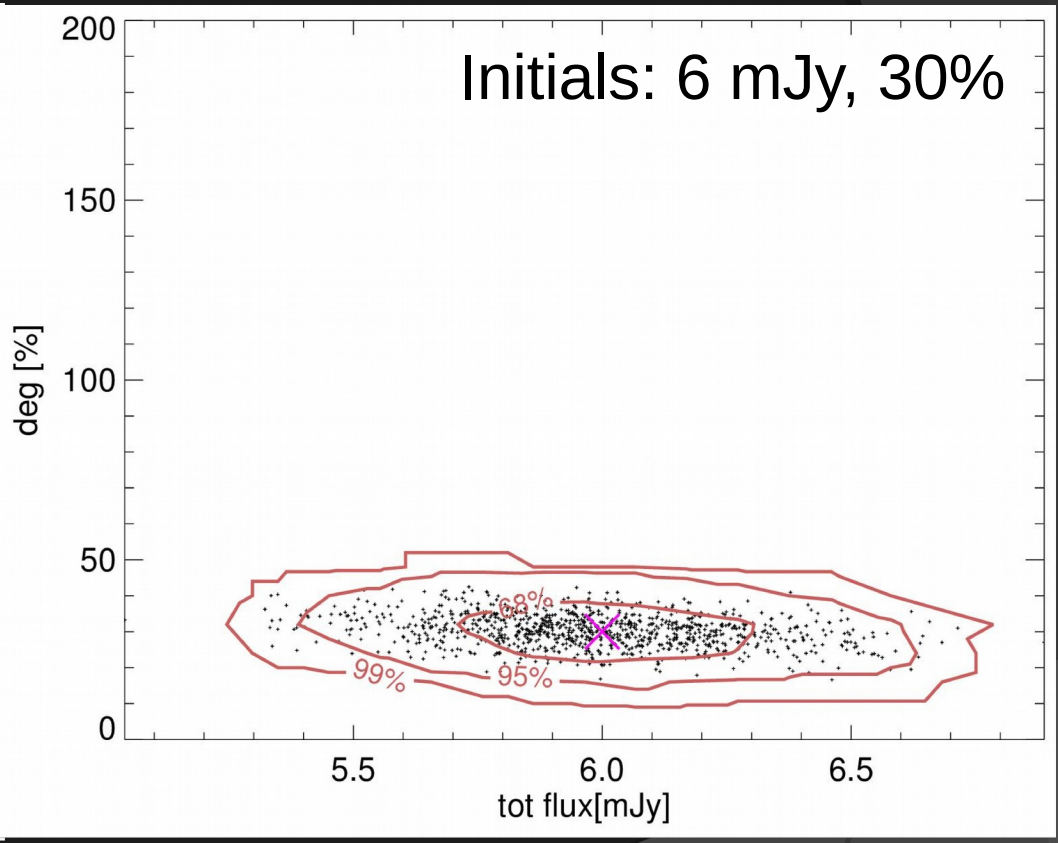
Degree-Flux correlation



Shahzamanian et al. 2015b

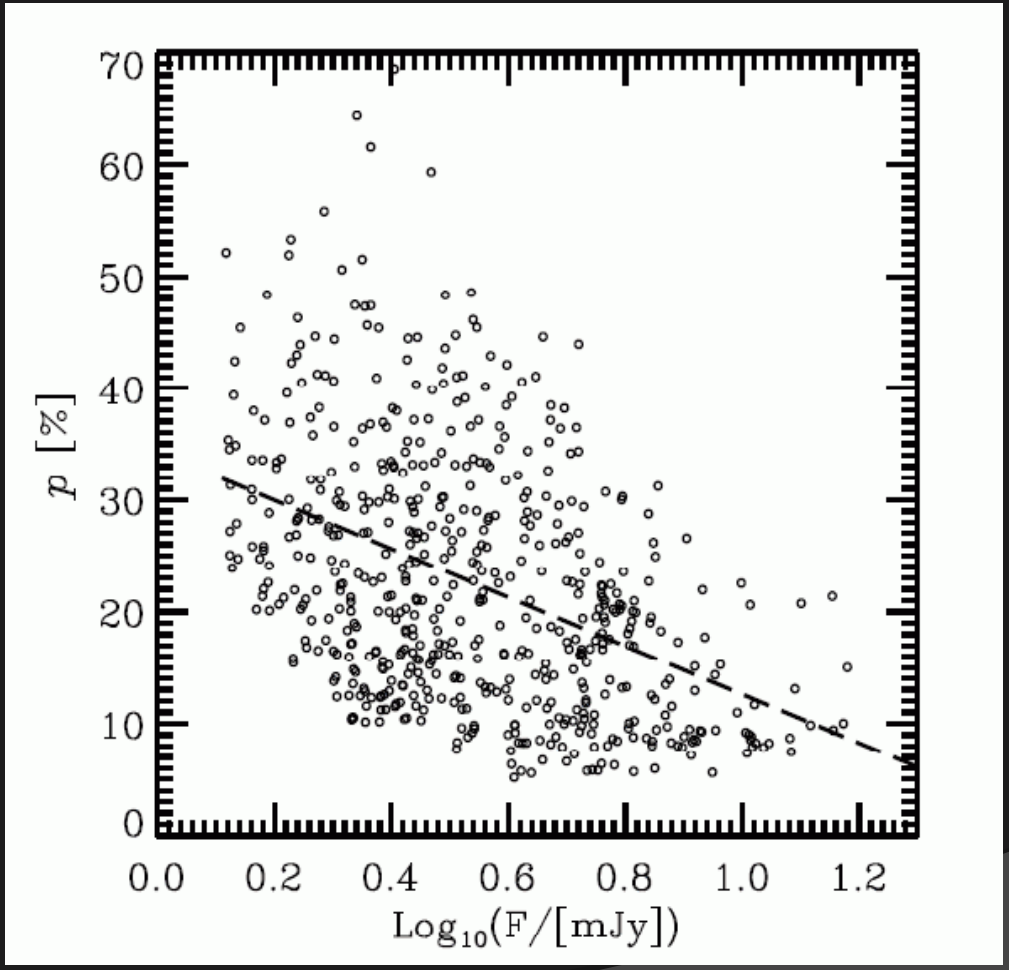
Influence of noise on flux-degree relation





Polarization degree & flux dependency

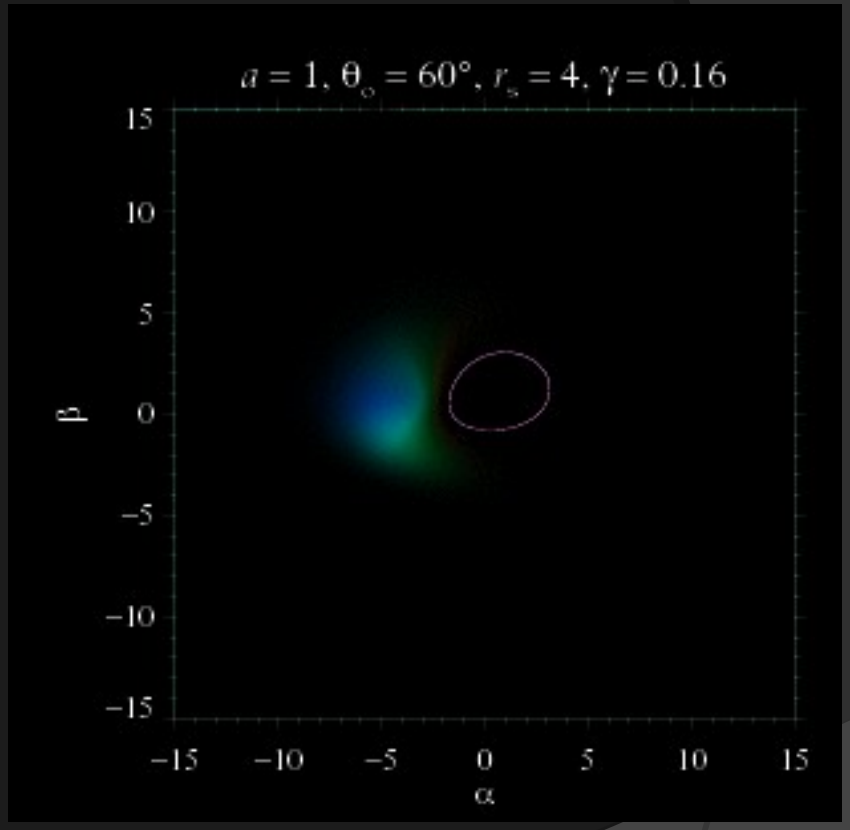
Degree-Flux correlation



Shahzamanian et al. 2015b

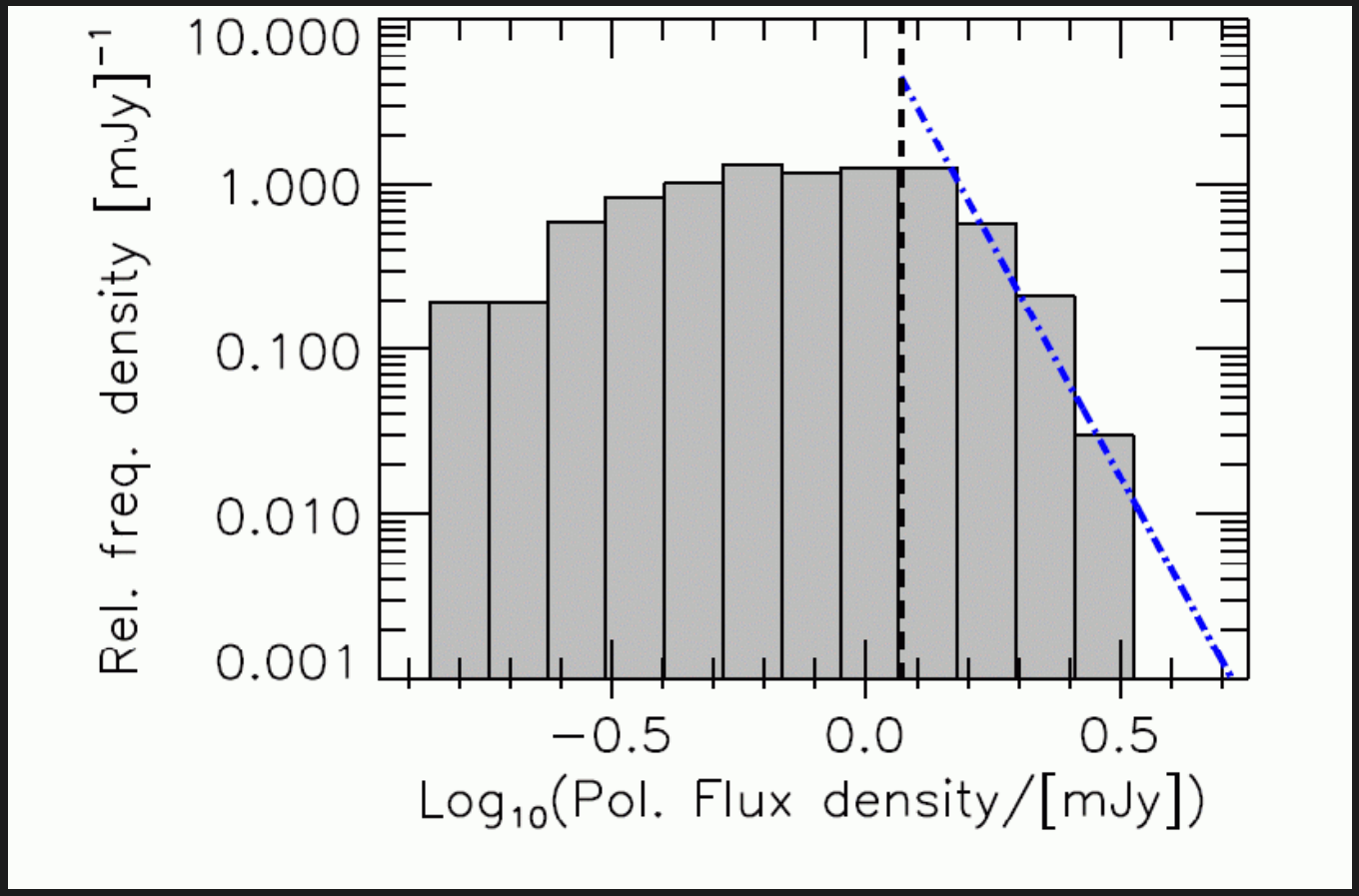
Depolarization in higher fluxes

Mild relativistic boosting and the formation of a partial Einstein ring during the approach of an orbiting source component can lead to bright geometrically depolarized emission during a flare event.



Dovciak, Karas & Yaqoob 2004
Dovciak et al. 2006
Eckart et al. 2006
Broderick & Loeb 2006ab

Polarized flux distribution

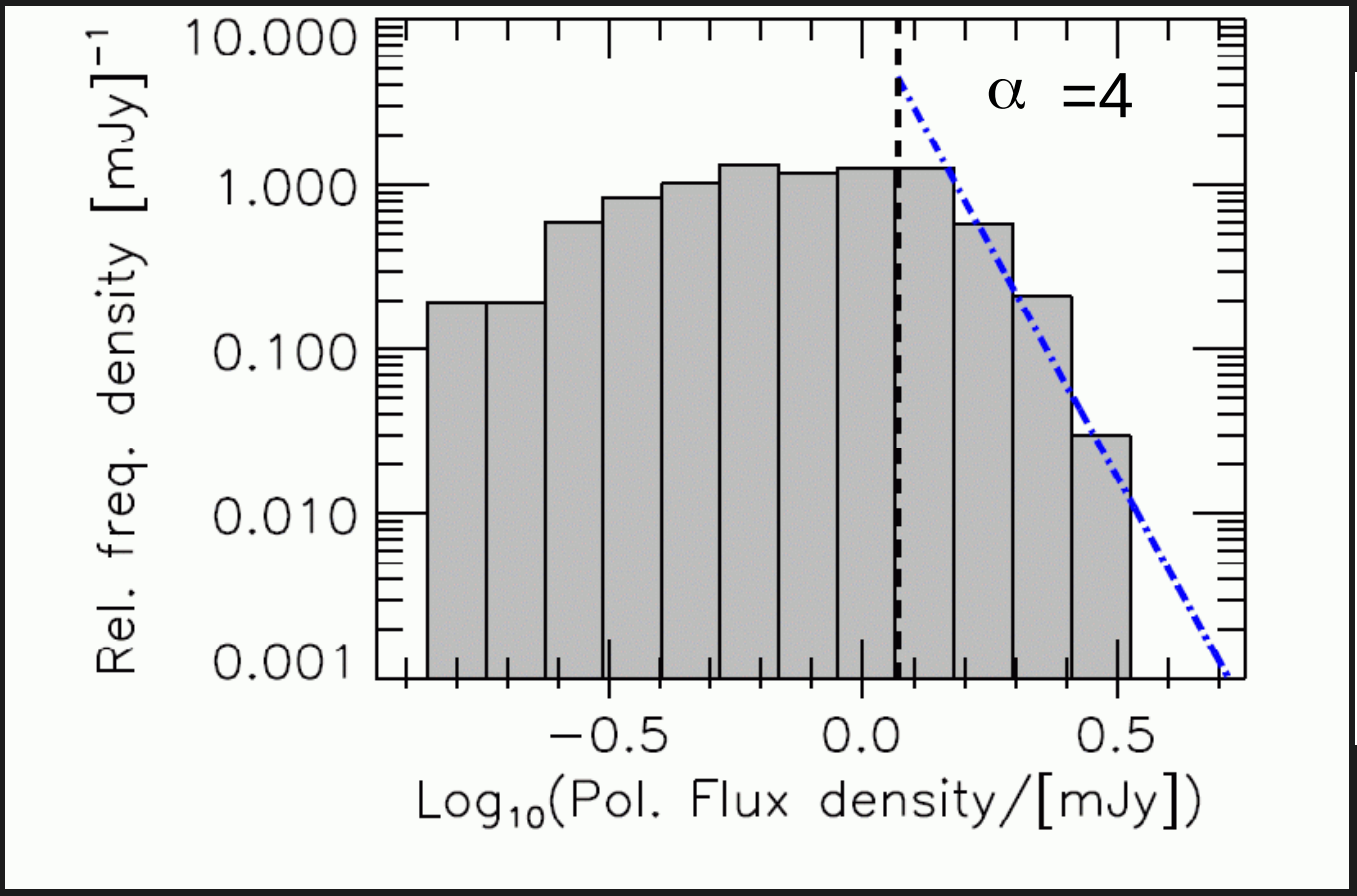


$$p(x) = \begin{cases} 0 & : \quad x \leq x_{\min} + x_0 \\ \frac{\alpha-1}{x_{\min}} \cdot \left(\frac{x-x_0}{x_{\min}} \right)^{-\alpha} & : \quad x > x_{\min} + x_0 \end{cases}$$

α estimation: maximum-likelihood statistics

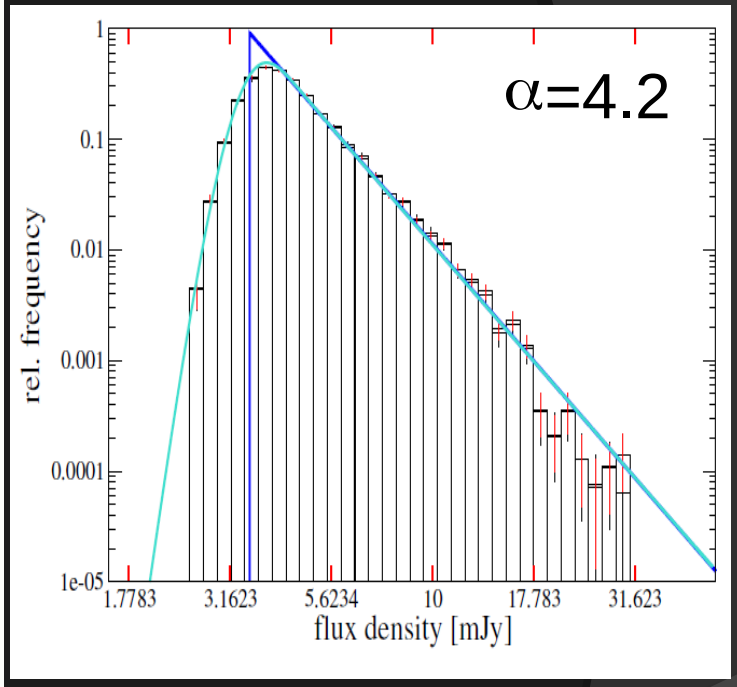
xmin, x0 estimation: Kolmogorov-Smirnov statistics

Polarized flux distribution



Shahzamanian et al. 2015b

Total flux distribution



Witzel et al. 2012

It also indicates a stable accretion mechanism

Conclusion

Sgr A* :

- For high flare fluxes there is a range of polarization degrees of 10-30%.

- For polarized flux density distribution, we find a power-law slope of about 4 which is very close to the slope in the total flux density distribution, indicating that there is a preferred range of intrinsic polarization degrees.

- We conclude that 13deg of polarization angle is a source intrinsic property. The angle may be linked to Jet/wind directions or the corresponding orientation of a temporary accretion disk.

Thank you for your attention!