Studying AGNs with GRAVITY

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The AGN central engine
Open questions

- How does **accretion** work on parsec scale?
  - How is the inflowing gas distributed?
- Is **AGN feedback** relevant?

- What geometry does the **Broad Line Region** have?
  - Is it in a rotating (thin) disk? Or an outflowing wind?
  - Is it aligned with the obscuring structure?
- Are reverberation-based **Black Hole masses** biased?

The central engines of AGNs are ideally suited for optical/IR interferometric studies due to their compact sizes and very high surface brightnesses

A simple BLR model

max v ~ 5000 km/s
delta v ~ 70 km/s
i=25°
beam 10 μarcsec

100 μas

produced with DYSMAL
(see Davies+ 2011)

Photocenter displacement

Photocenter displacement
(of order ~ 10-100 µas)

kinematic axis
of BLR

Θ

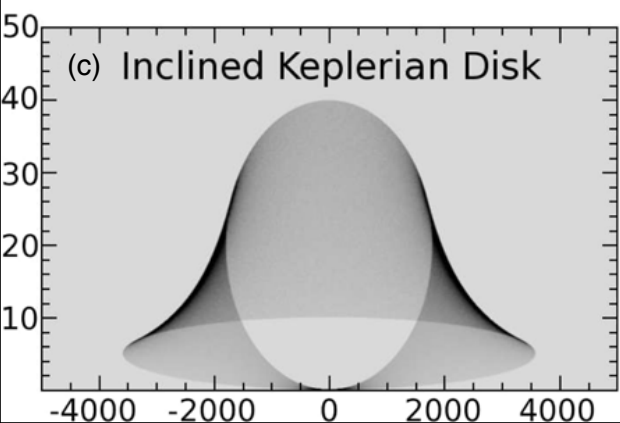VLTI baseline
Position Angle

VLTI beam: 4 mas

Br-γ or Pa-α

z < 0.1

$v_{\mathrm{BLR}} = f \cdot \mathrm{FWHM}$

Visibility

λ

Angular offset [micro-arcseconds]

(Phase)

Θ = 0°, 30°, 60°, 70°, 80°, 90°

Inclination of BLR: i = 36 deg

Δφ_max

Velocity offset [km/s]
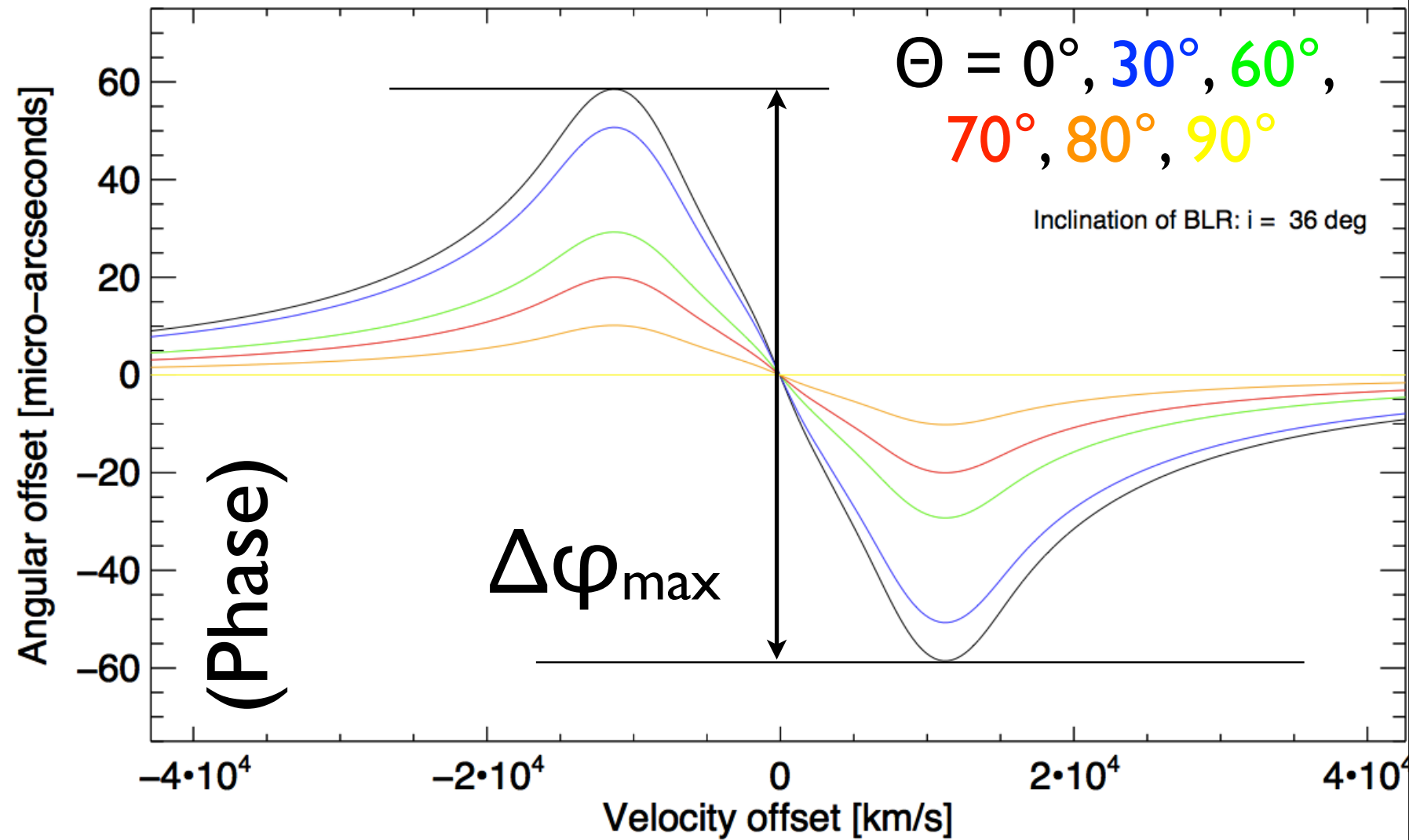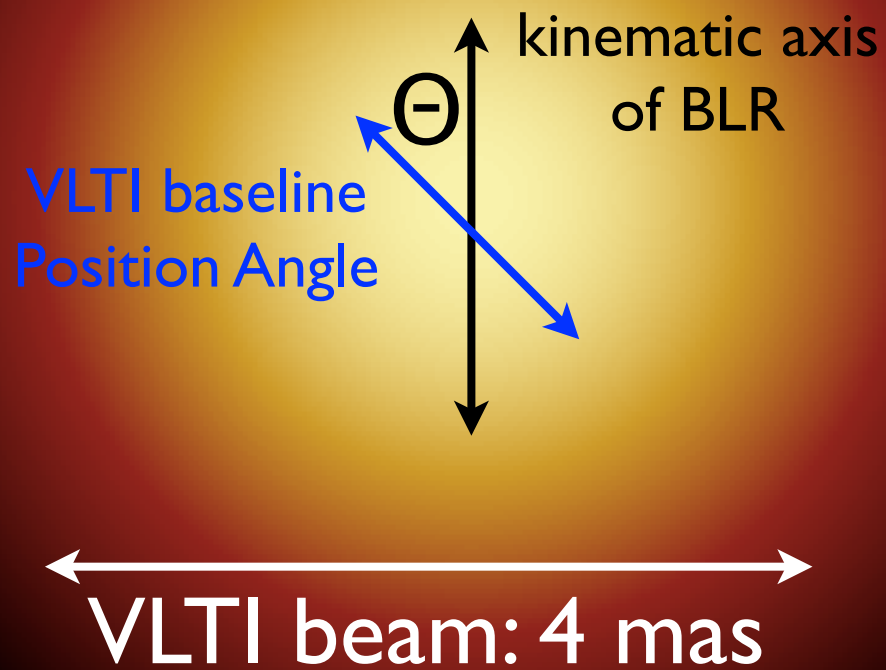
(Wavelength)

$R_{\mathrm{BLR}} \propto \Delta\phi$
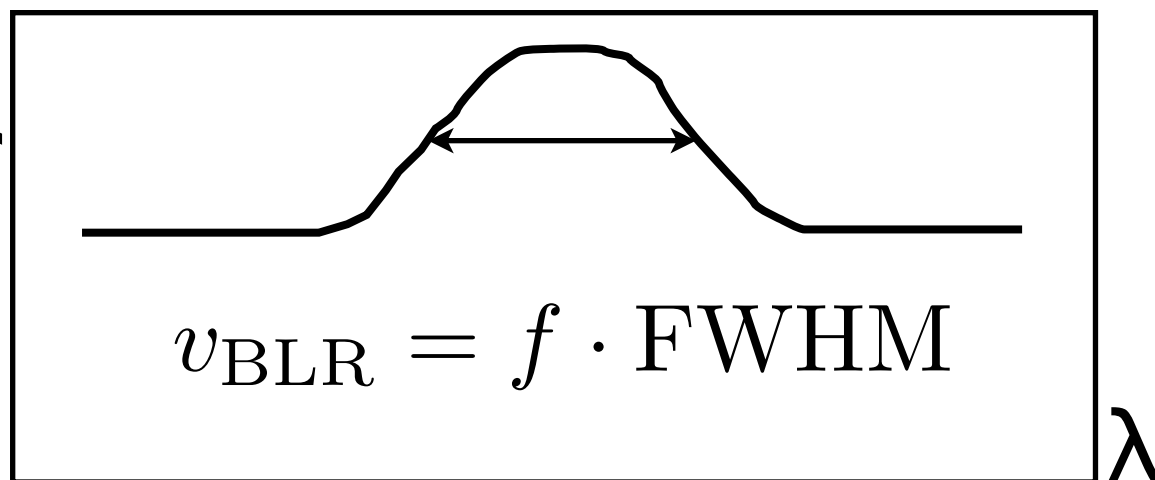
Broad line region studies

"velocity-resolved delay maps" show how the broad line region reacts to continuum variations
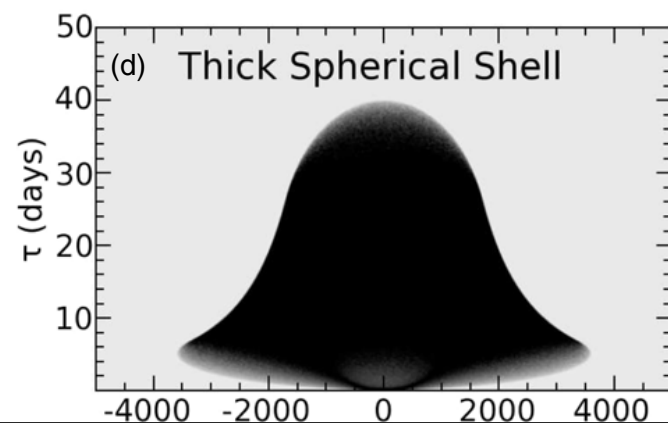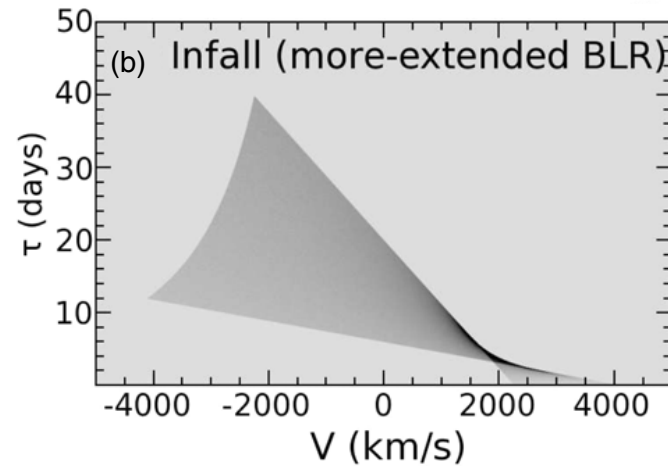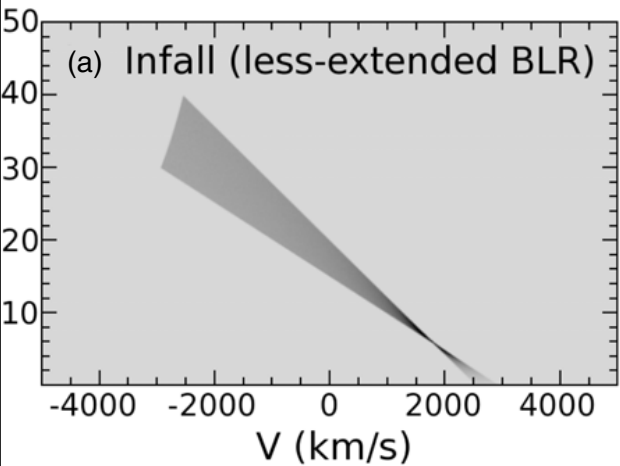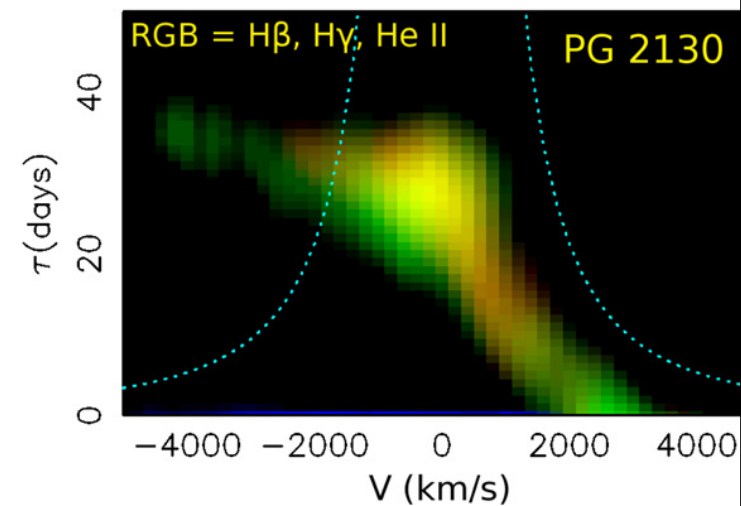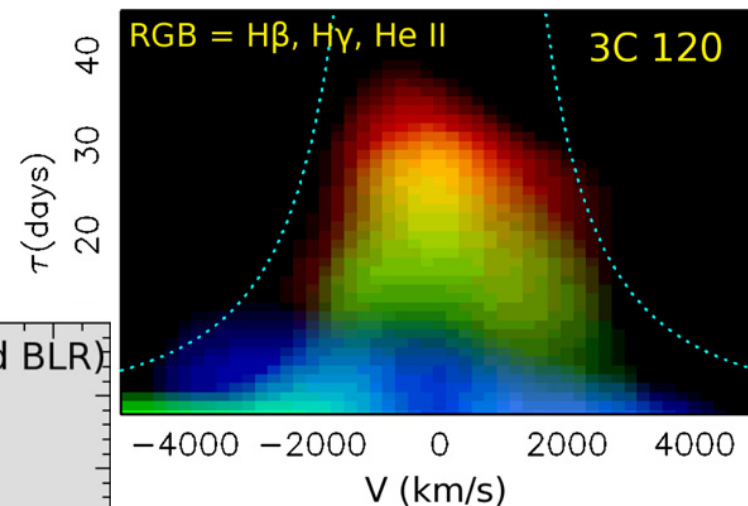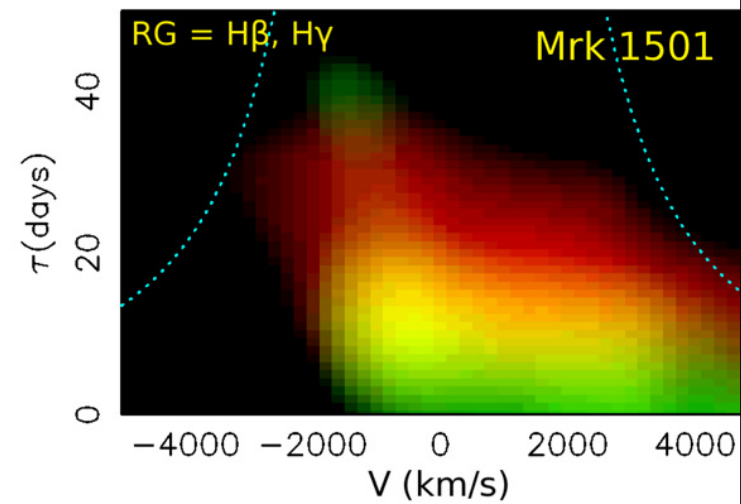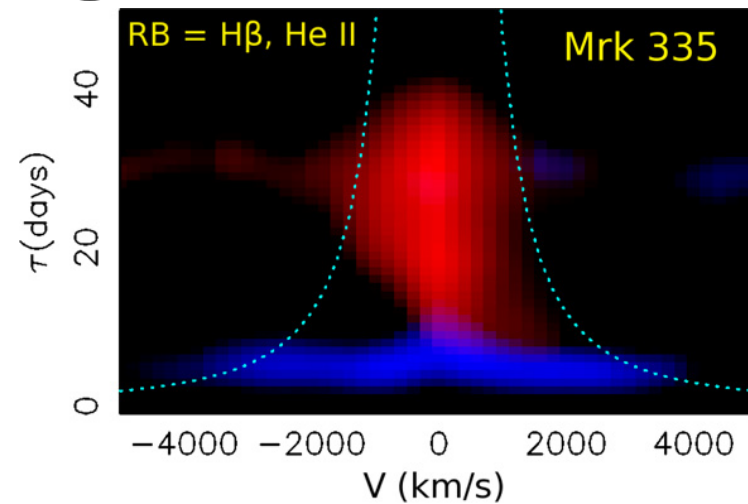
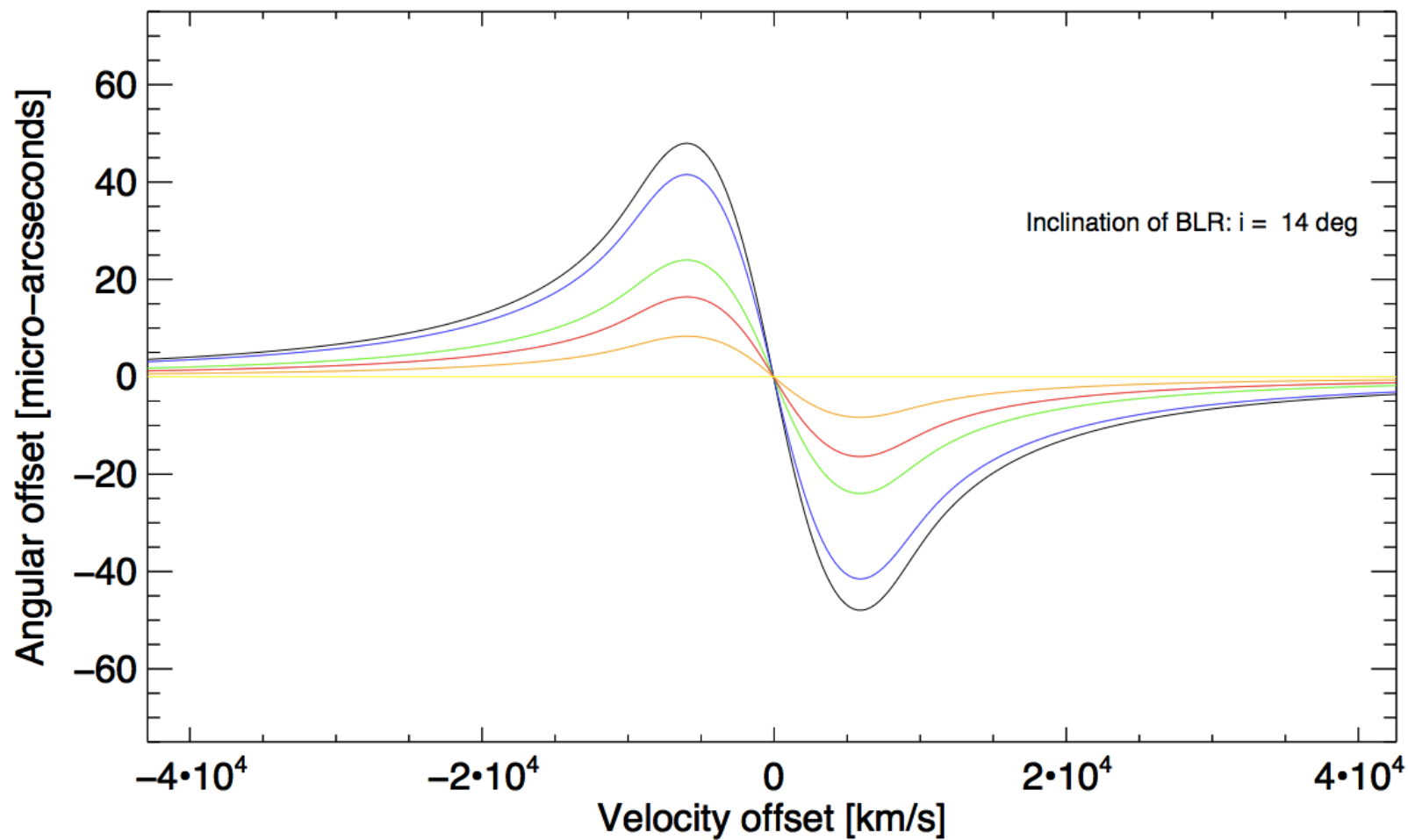Grier+ 2013

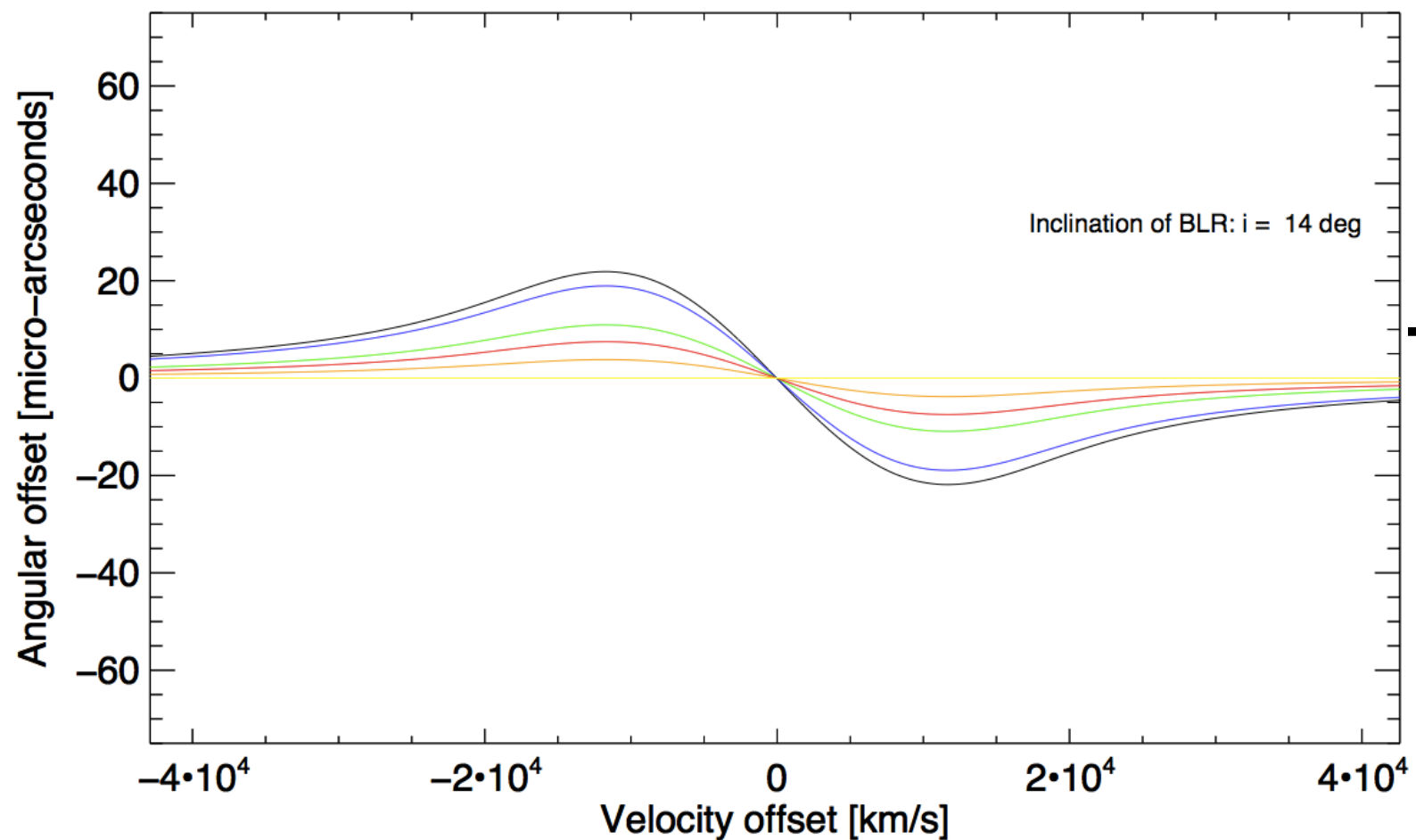recent observations indicate a variety of geometries from infall to disks

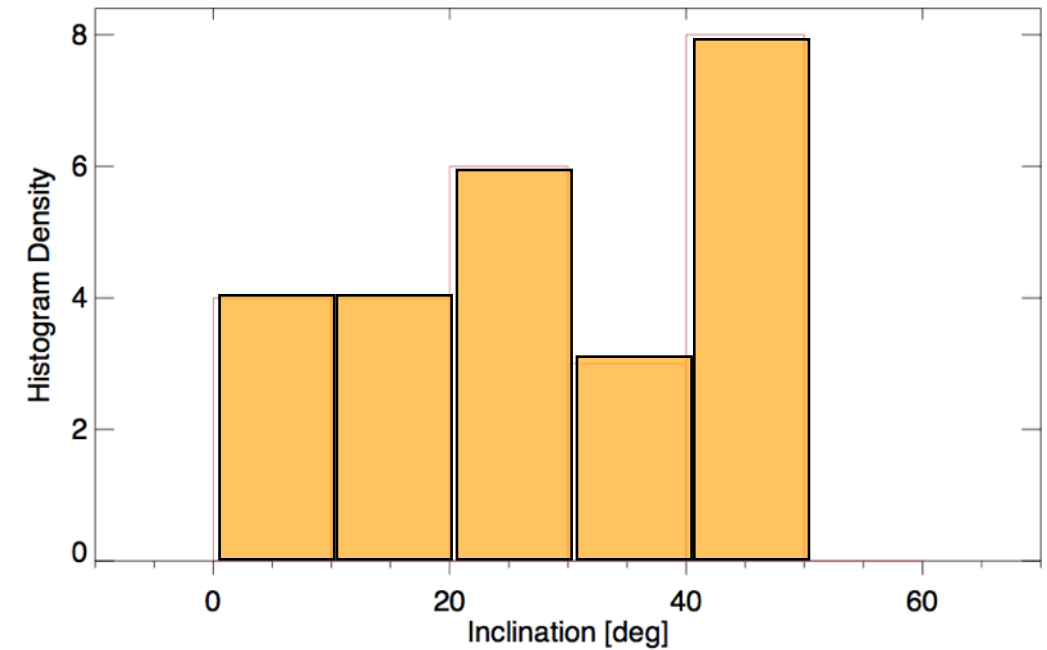$$v_{\mathrm{BLR}} = f \cdot \mathrm{FWHM}$$

f ~ 0.7 - 5

Thin disk (H/R < 0.1)
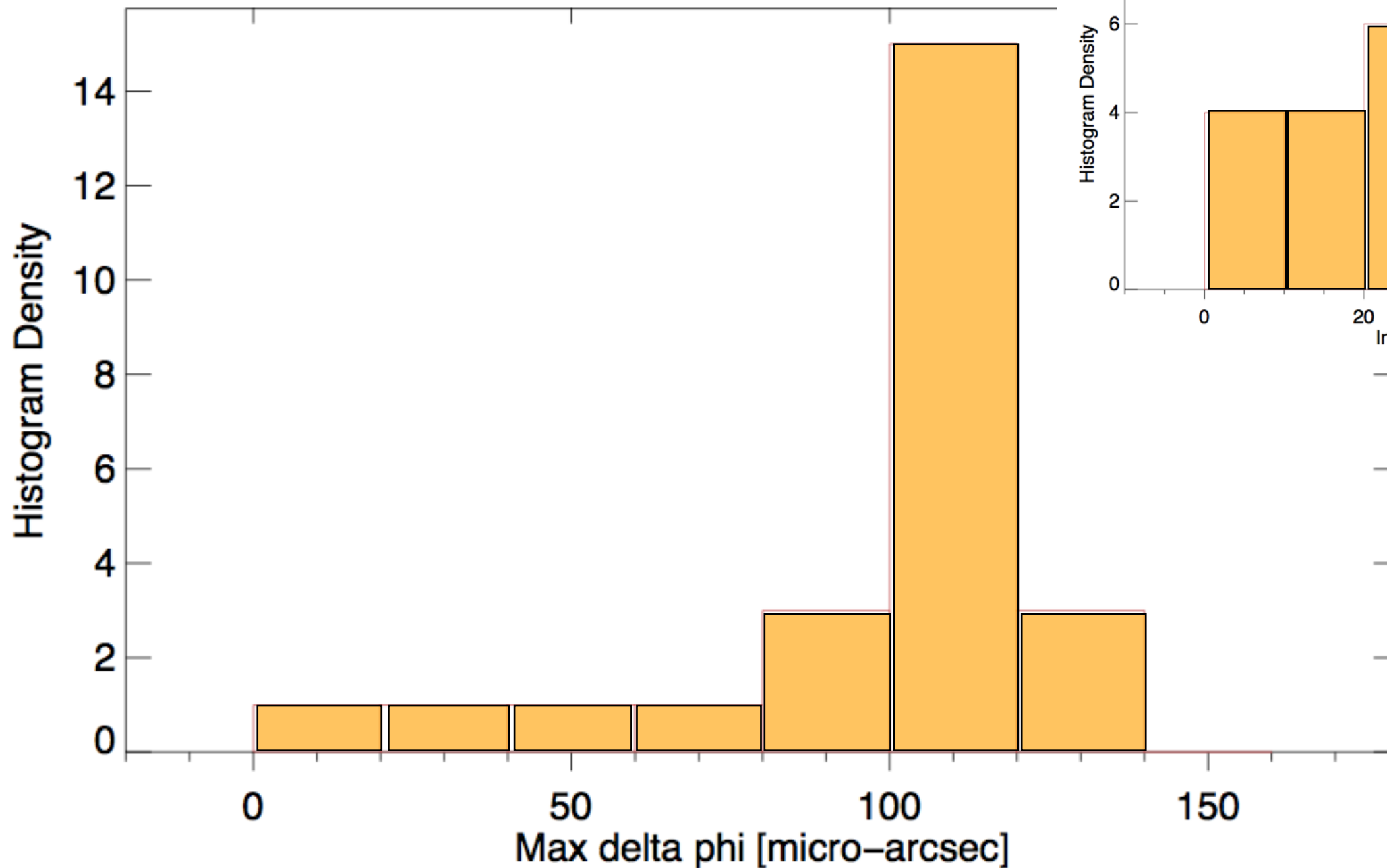
Inclination = 14°
(almost face-on)

Thick disk (H/R = 1/3)

Thin disk sample

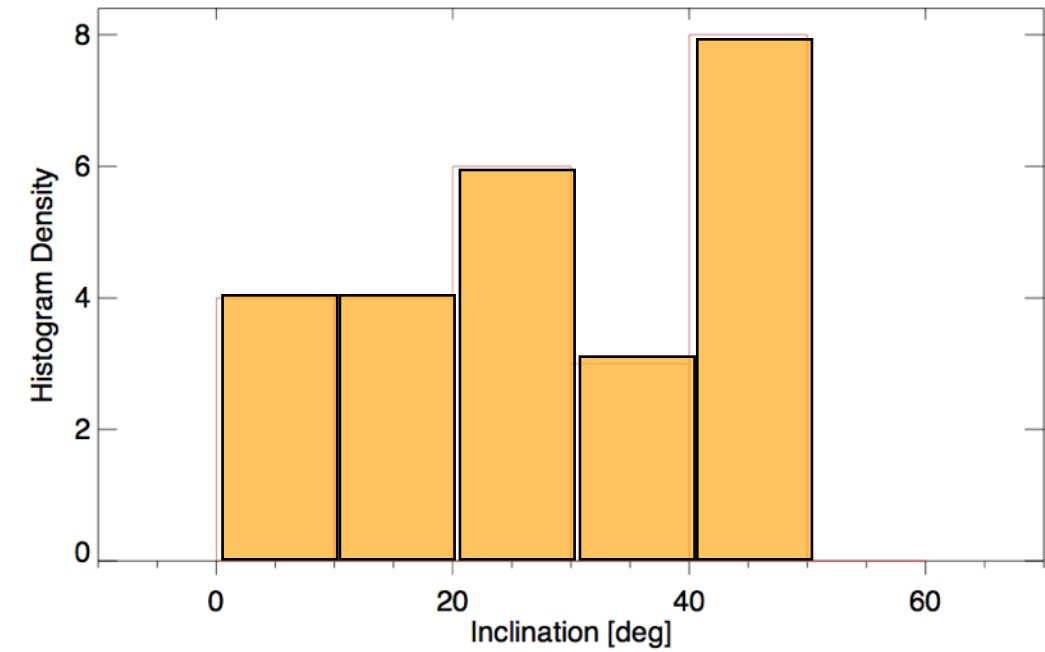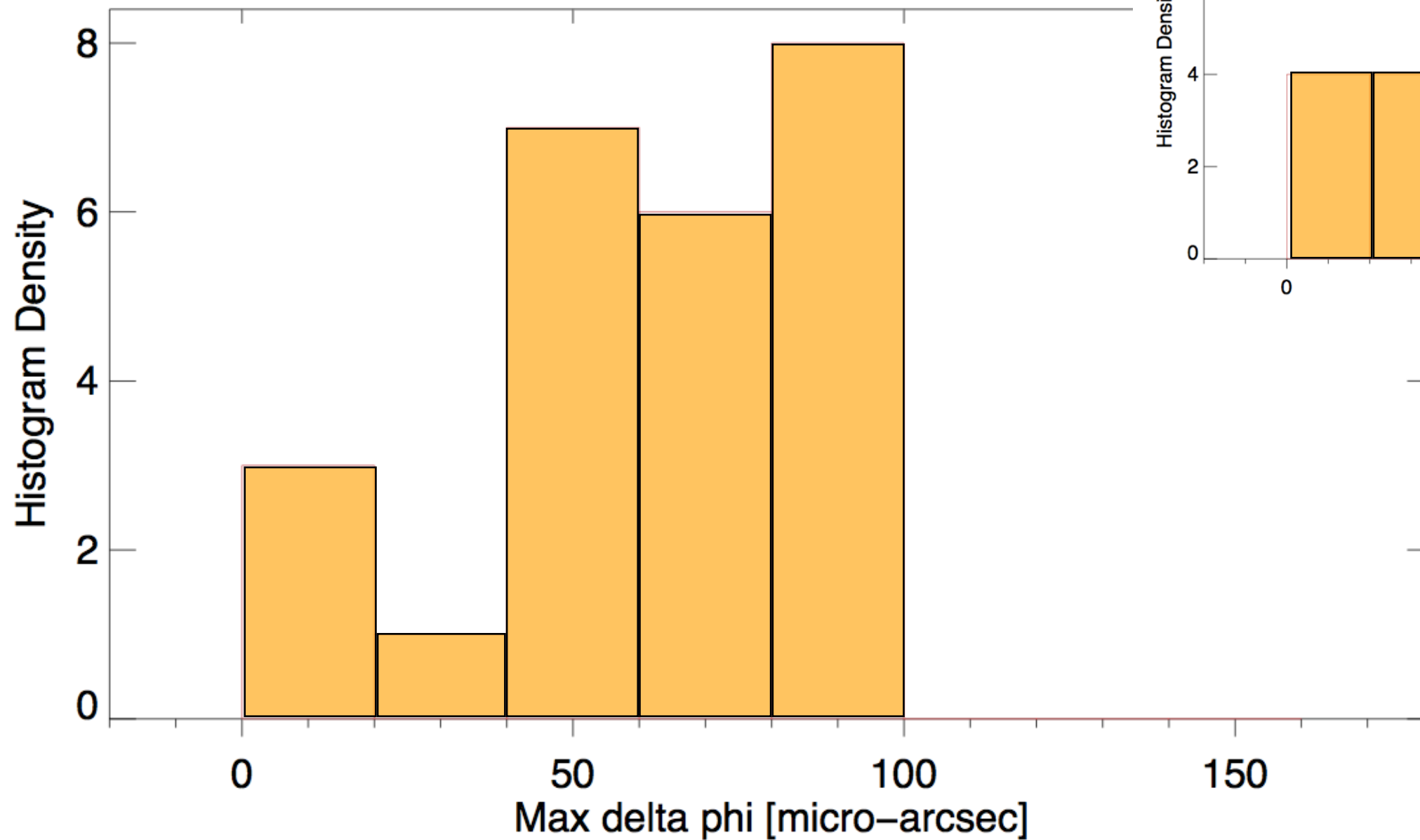

Thick disk sample
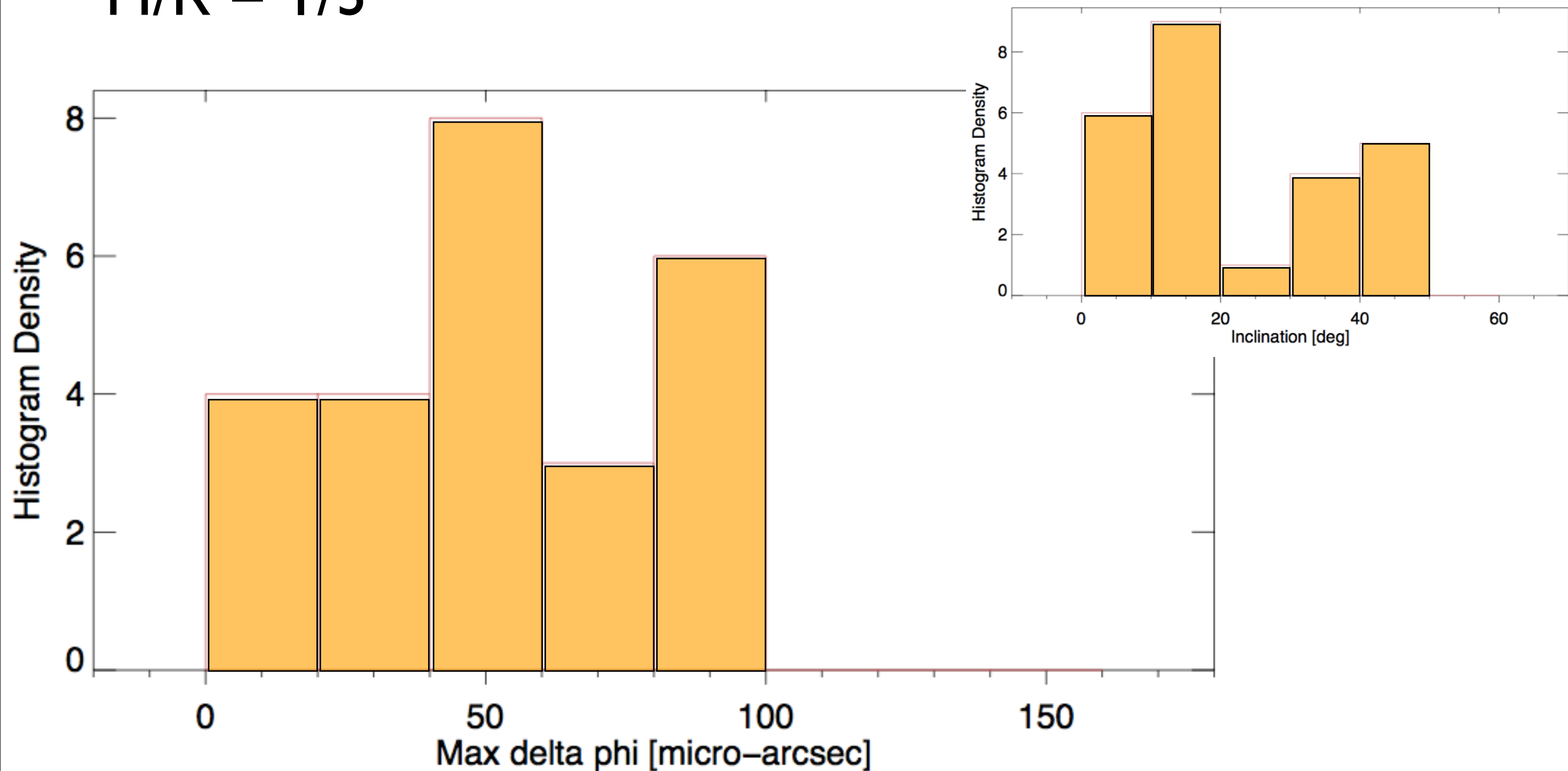
with **same** inclination distribution as before

Another thick disk sample
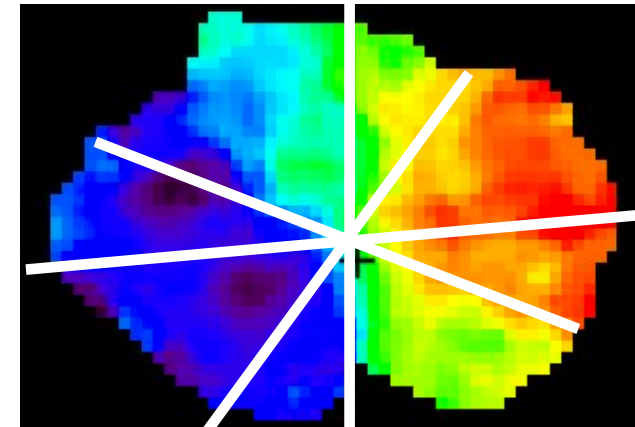
with **different** inclination distribution

H/R = 1/3

Broad line region studies

open questions accessible with GRAVITY

$$v_{\mathrm{BLR}} = f \cdot \mathrm{FWHM}$$

$$M_{\mathrm{BH}} \sim \frac{R_{\mathrm{BLR}} \cdot v_{\mathrm{BLR}}^2}{G}$$

- How reliable are rev. based BH masses? This is currently the only method to access SMBH masses at all redshifts!

- measure R_{BLR} along multiple position angles to determine the **geometry of the BLR** in a statistical study of many objects

- if BLRs are actually disk-like: **derive inclination** and **calibrate reverberation mapping** „fudge factor'

McConnell+2013
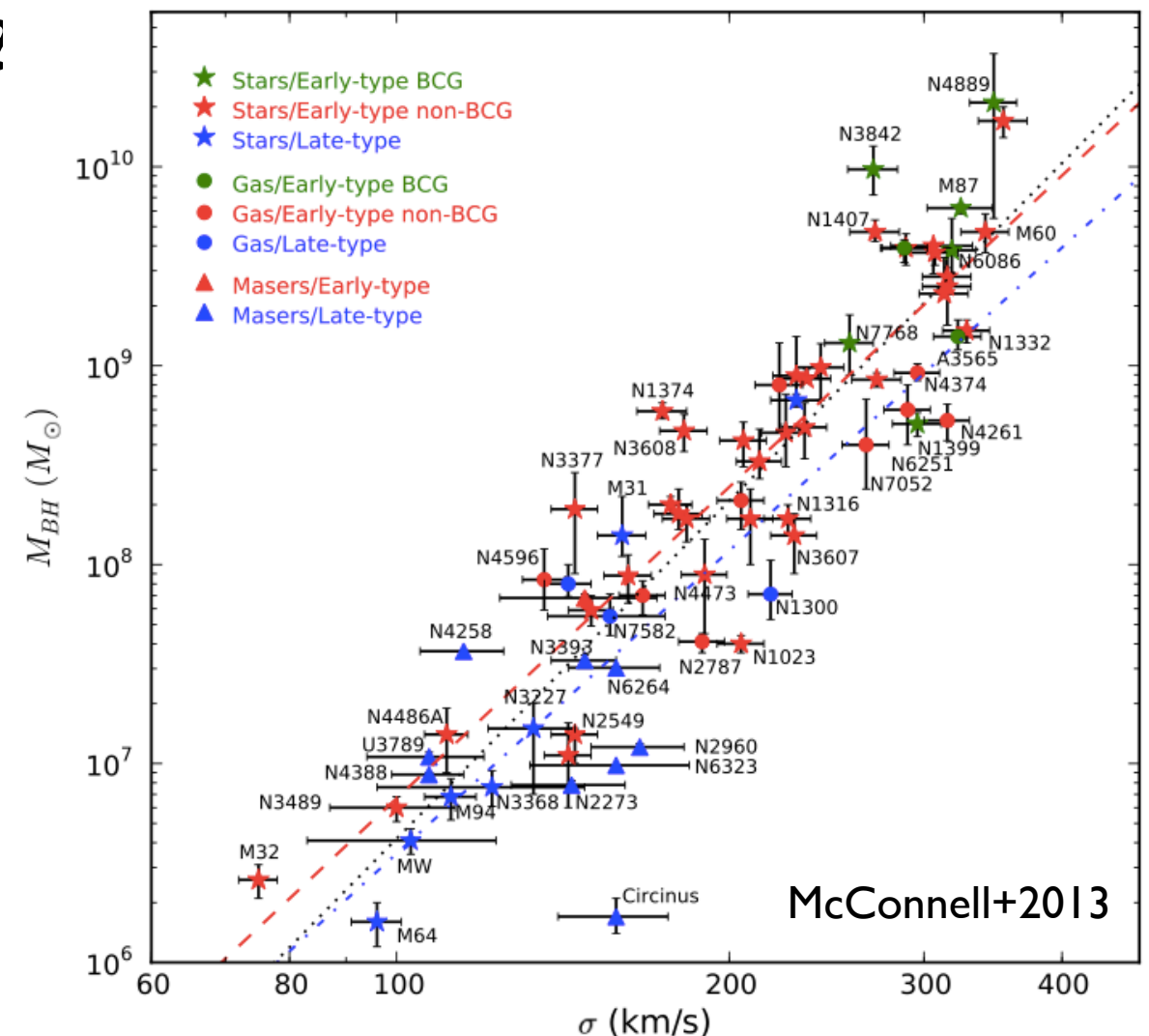
How many sources?

on-axis

AGN
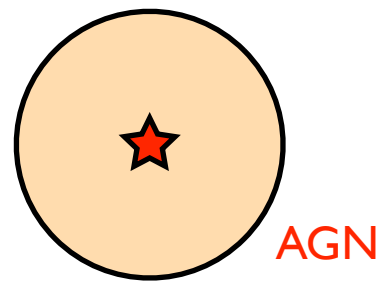
2"
VLTI field of view

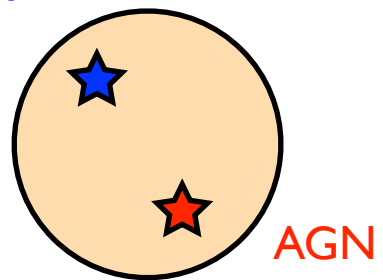| Veron-Cetty & Veron 2010
167566 AGNs + QSOs | X | 2MASS PSC
K < 10.5, dist < 2", DEC < +30, Sy 1 |

= 24 candidates to be checked with high-res imaging

off-axis

star

AGN

2"
VLTI field of view

| Fraction of sky accessible for fringe tracking
K < 10.5, dist < 2" | = | 4.5e-5
→ a few candidates |