Some Perspectives on the Evolution of our Understanding of Sagittarius A*

Mark Morris, UCLA

Sagittarius A*

1969-71: a gleam in the mind's eye of Lynden-Bell & Rees
1974: moment of conception -- it becomes a reality
but what is it?
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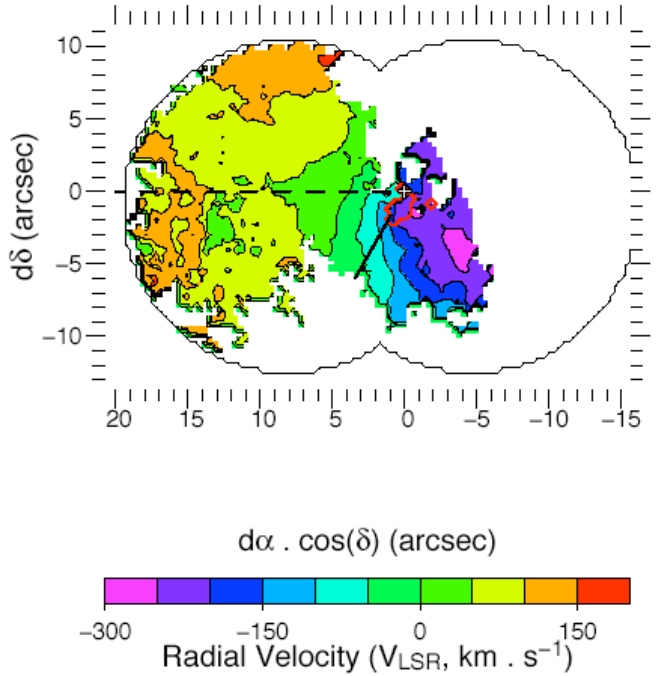
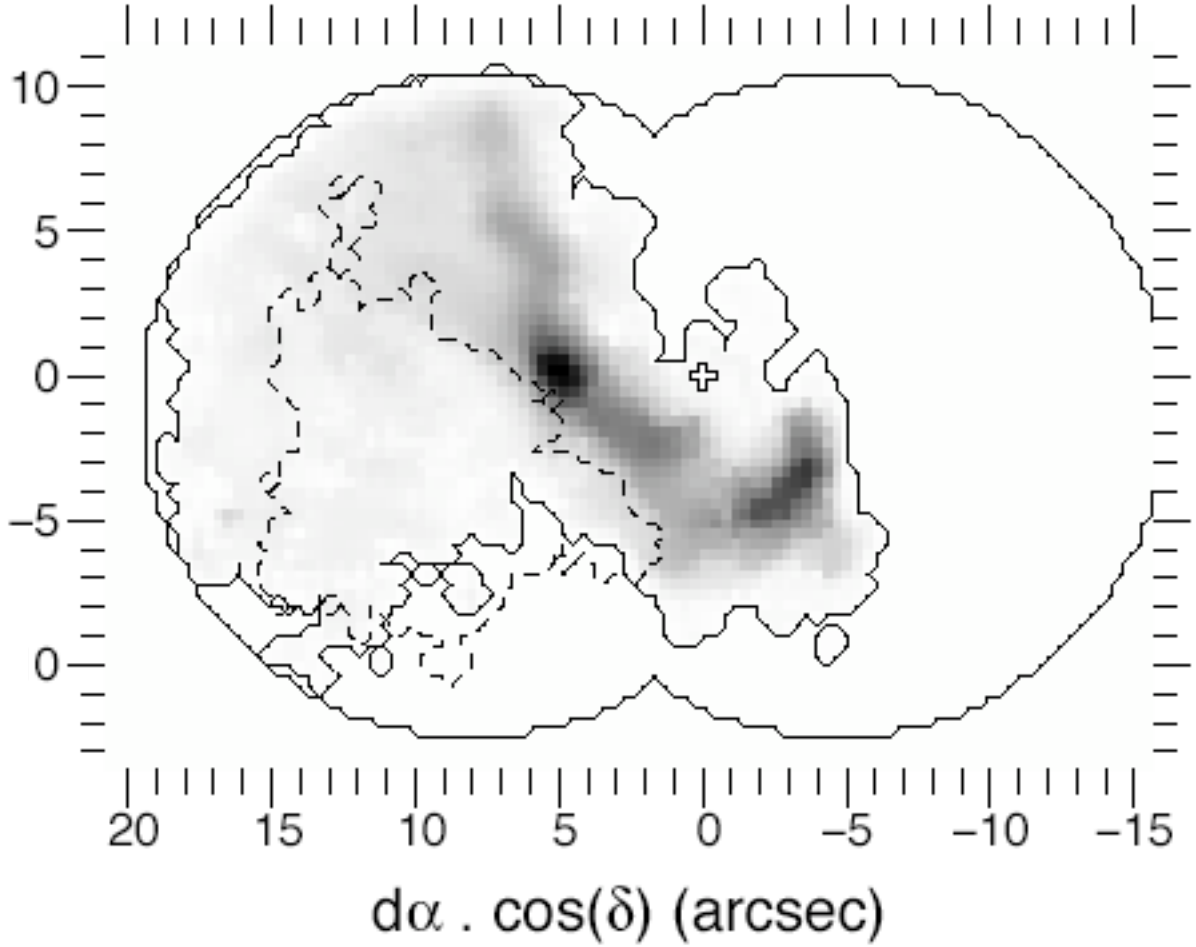
The Northern Arm

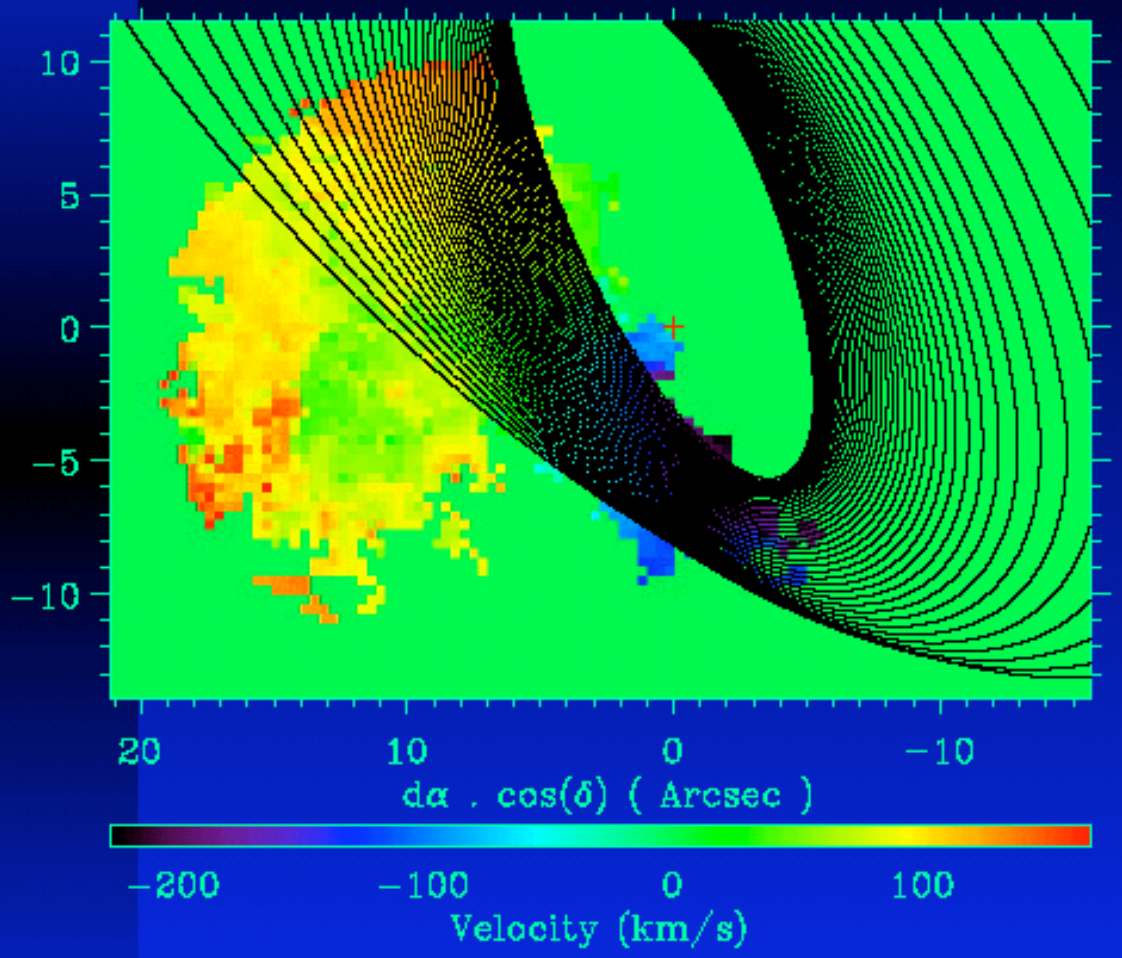
(Paumard et al. 2004)

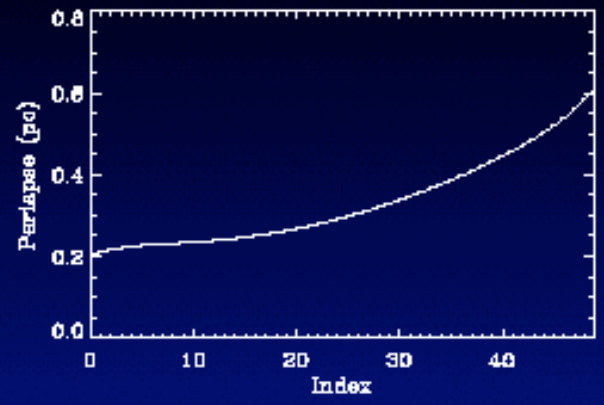


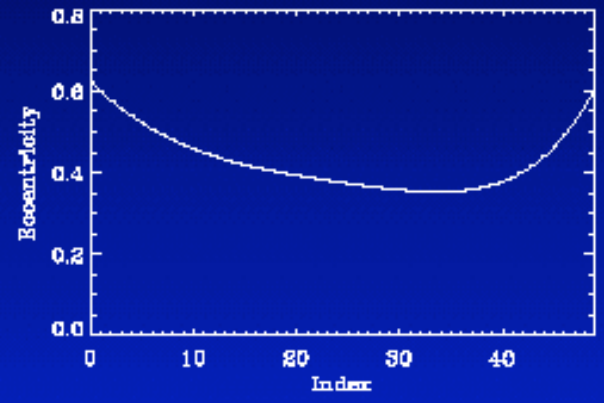


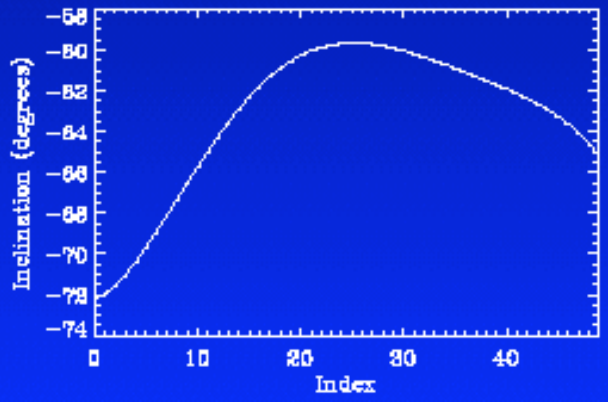
(a) Northern Arm flux map. The outline of the Eastern Bridge is given (dashed line), showing that ture is superimposed on a weak region of the Northern Arm (Sect. 4.4).

Orbit bundle fitted on the Northern Arm

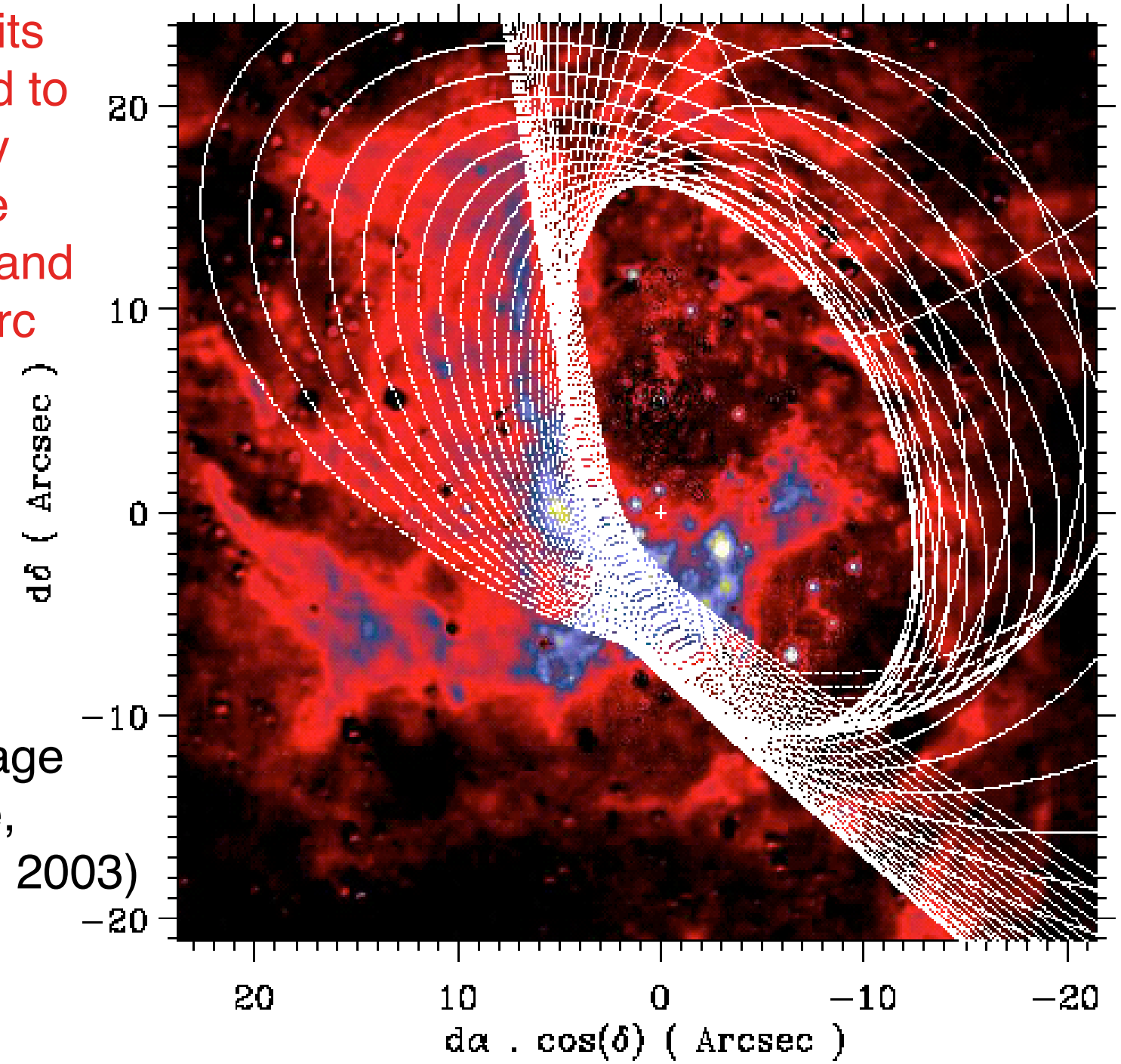








This set of orbits was configured to simultaneously account for the Northern Arm and the Western Arc



Paschen-β NICMOS image from Scoville, Stolovy et al. 2003)

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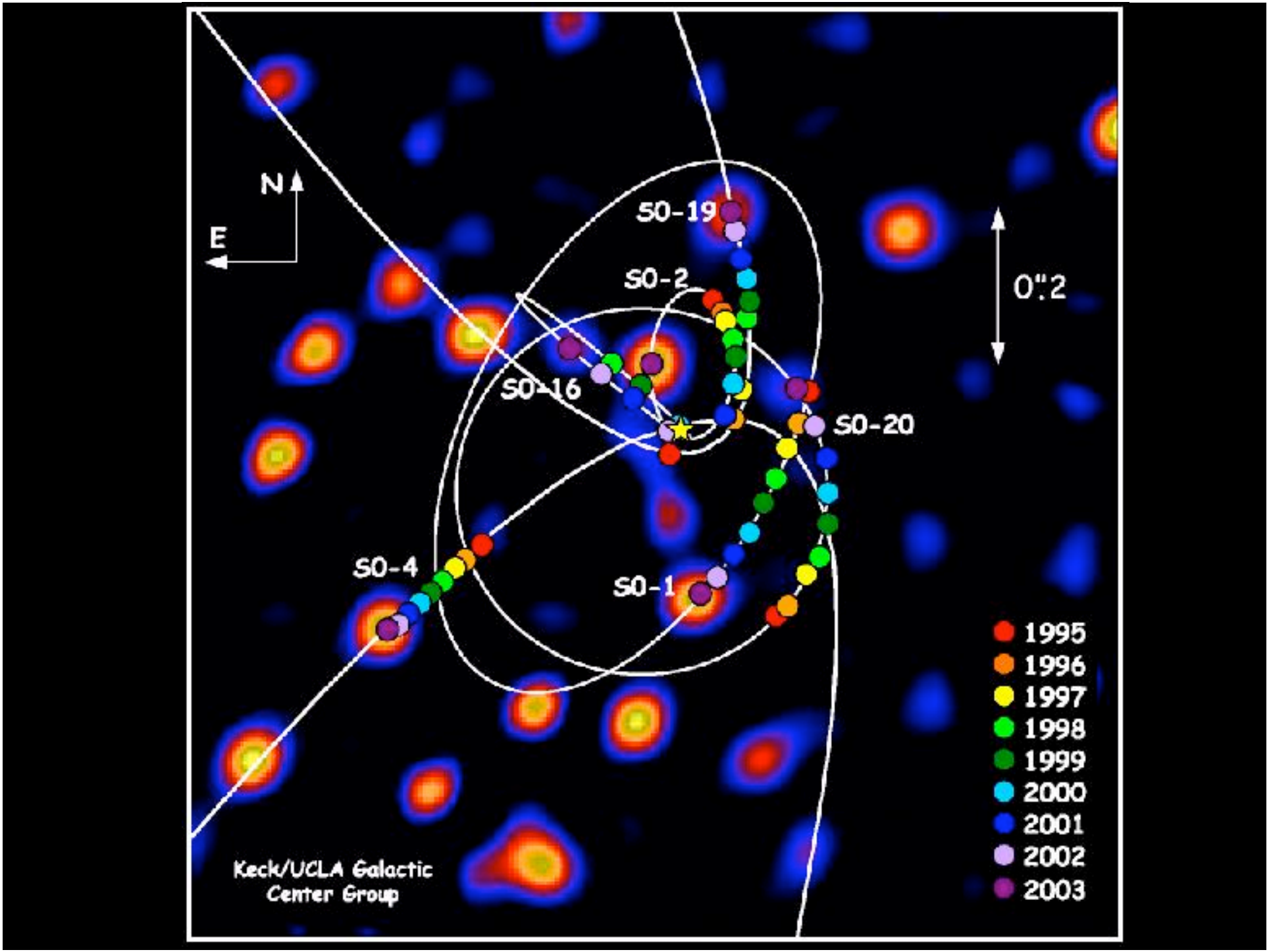
N
E
S0-19
S0-2
S0-16
S0-20
S0-4
S0-1
0".2
1995
1996
1997
1998
1999
2000
2001
2002
2003
Keck/UCLA Galactic
Center Group

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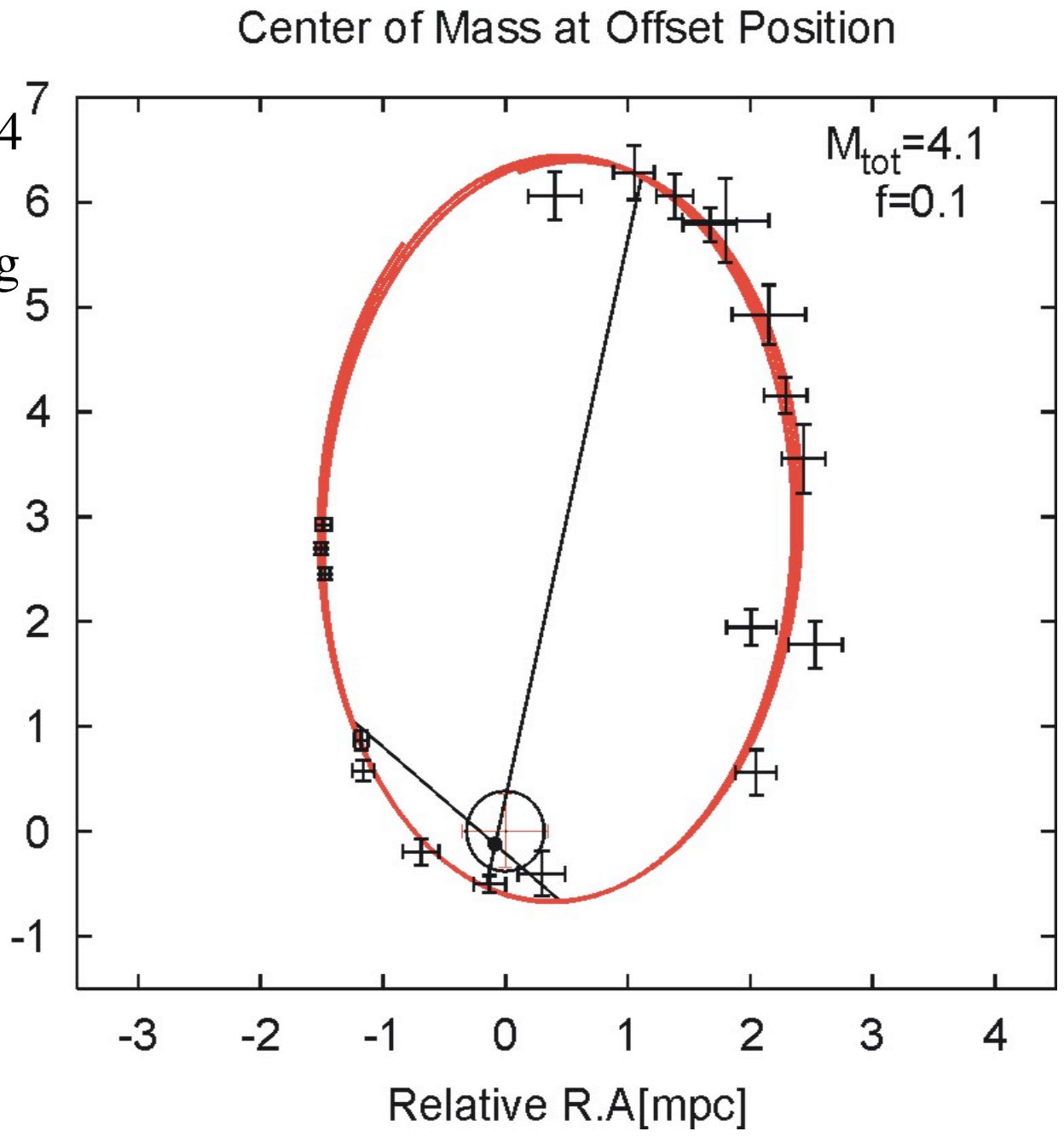
Mouawad et al. 2004

→toward identifying a dark entourage.



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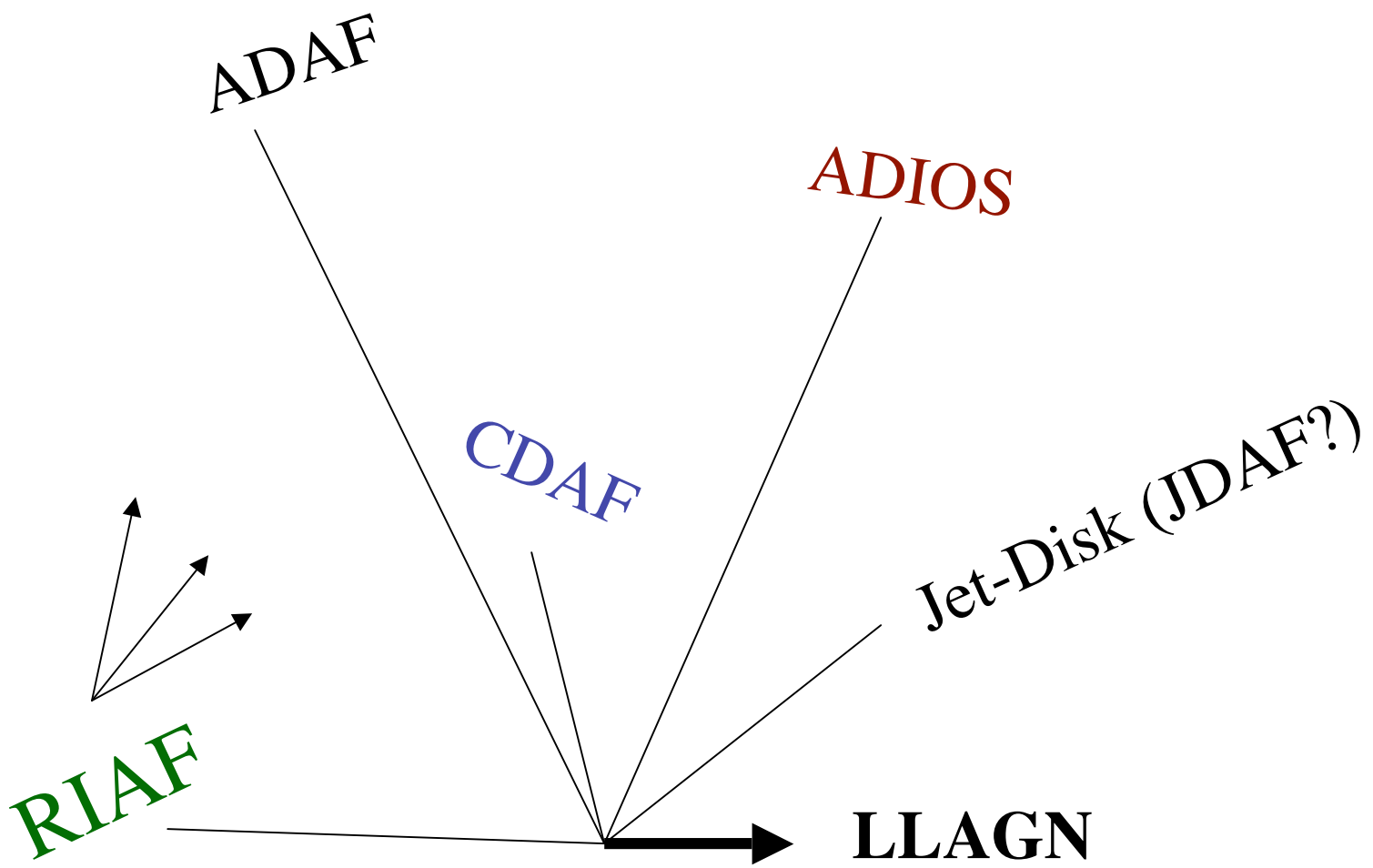

LLAGN

vastly sub-Eddington

combine winds/jets with energy advection

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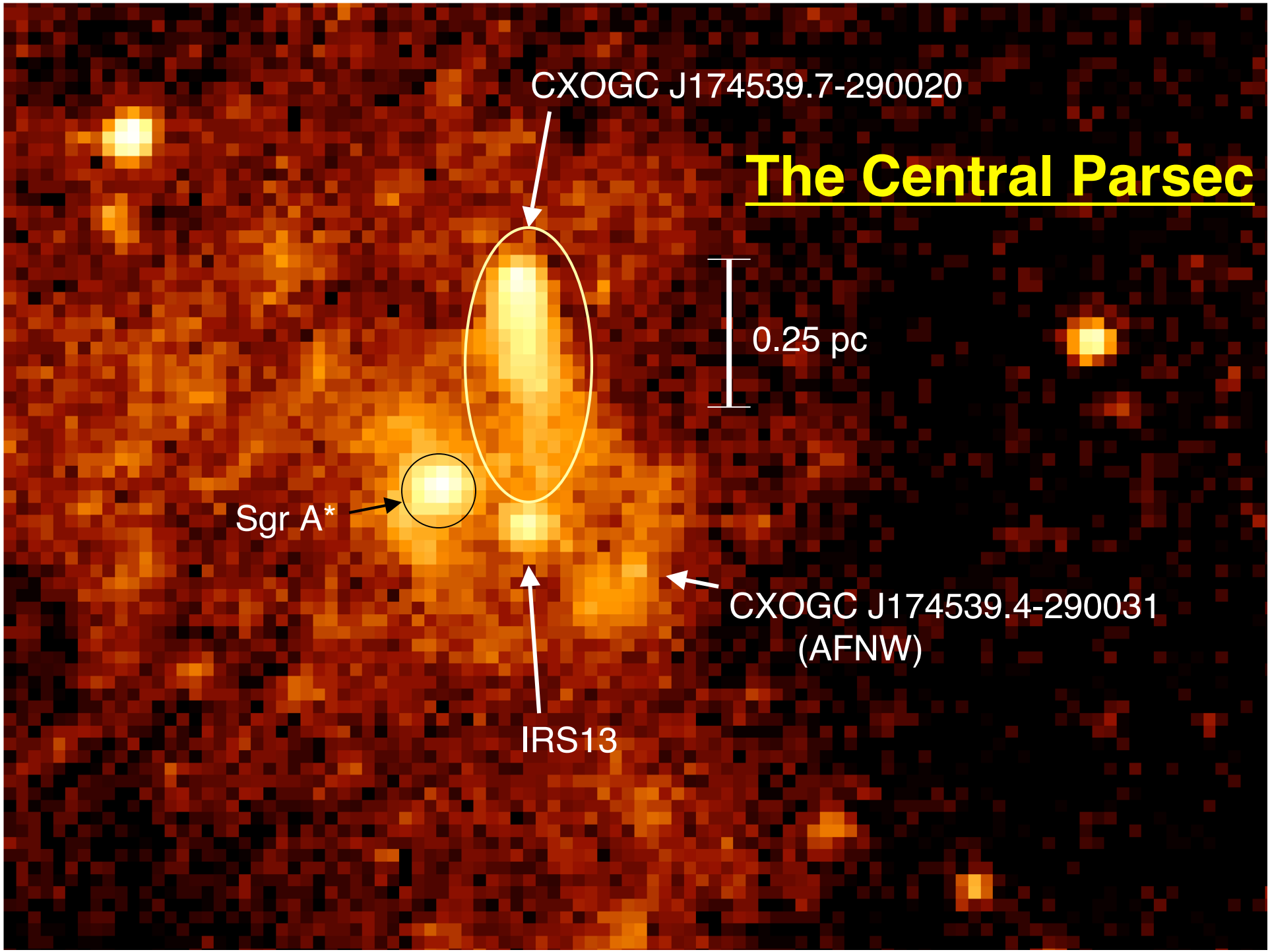
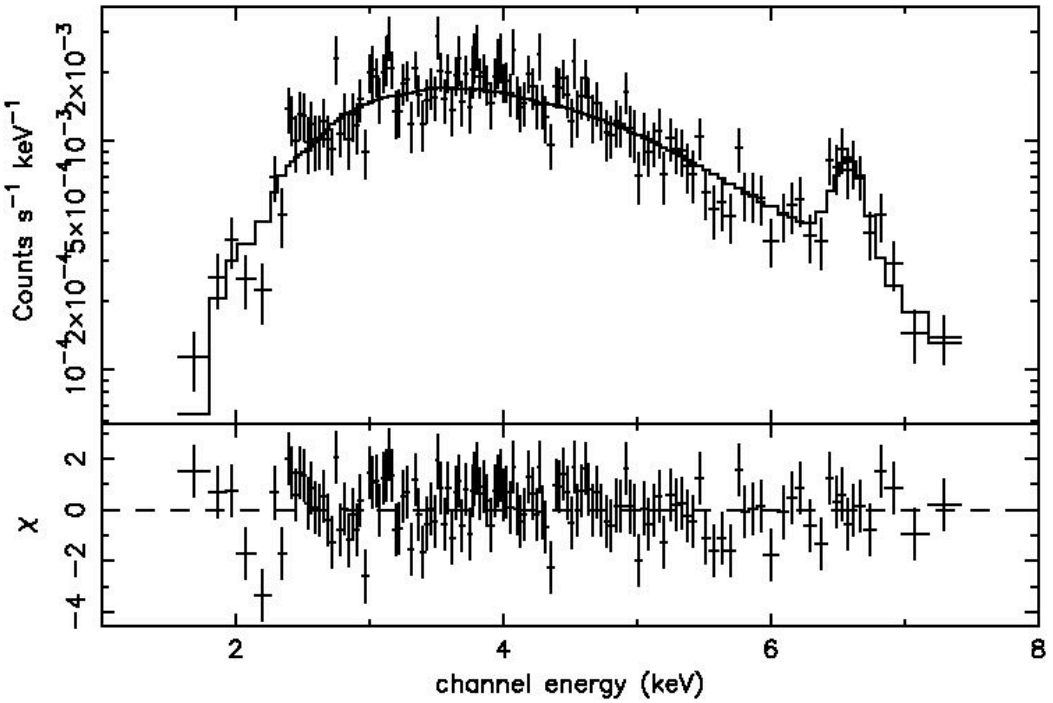

CXOGC J174539.7-290020
The Central Parsec
0.25 pc
Sgr A*
CXOGC J174539.4-290031
(AFNW)
IRS13

Integrated Sgr A* Quiescent X-ray Spectrum

Absorbed Power-law Model – Dust Corrected



Gamma = 2.4
N_H = 5.9 x 10^{22} cm^{-2}
E = 6.59 (6.54-6.64) keV
Line is narrow
F_X = 1.8 x 10^{-13} erg cm^{-2} s^{-1}
L_X = 1.4 x 10^{33} erg s^{-1}
D = 8 kpc

$\langle L_F \rangle / \langle L_Q \rangle$ = 14.0

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2000 on: linear polarization at mm wavelengths
(Aitken et al., Bower et al.)
2001: Periodicities: 100 days, 250 days (?) (Zhao et al.)
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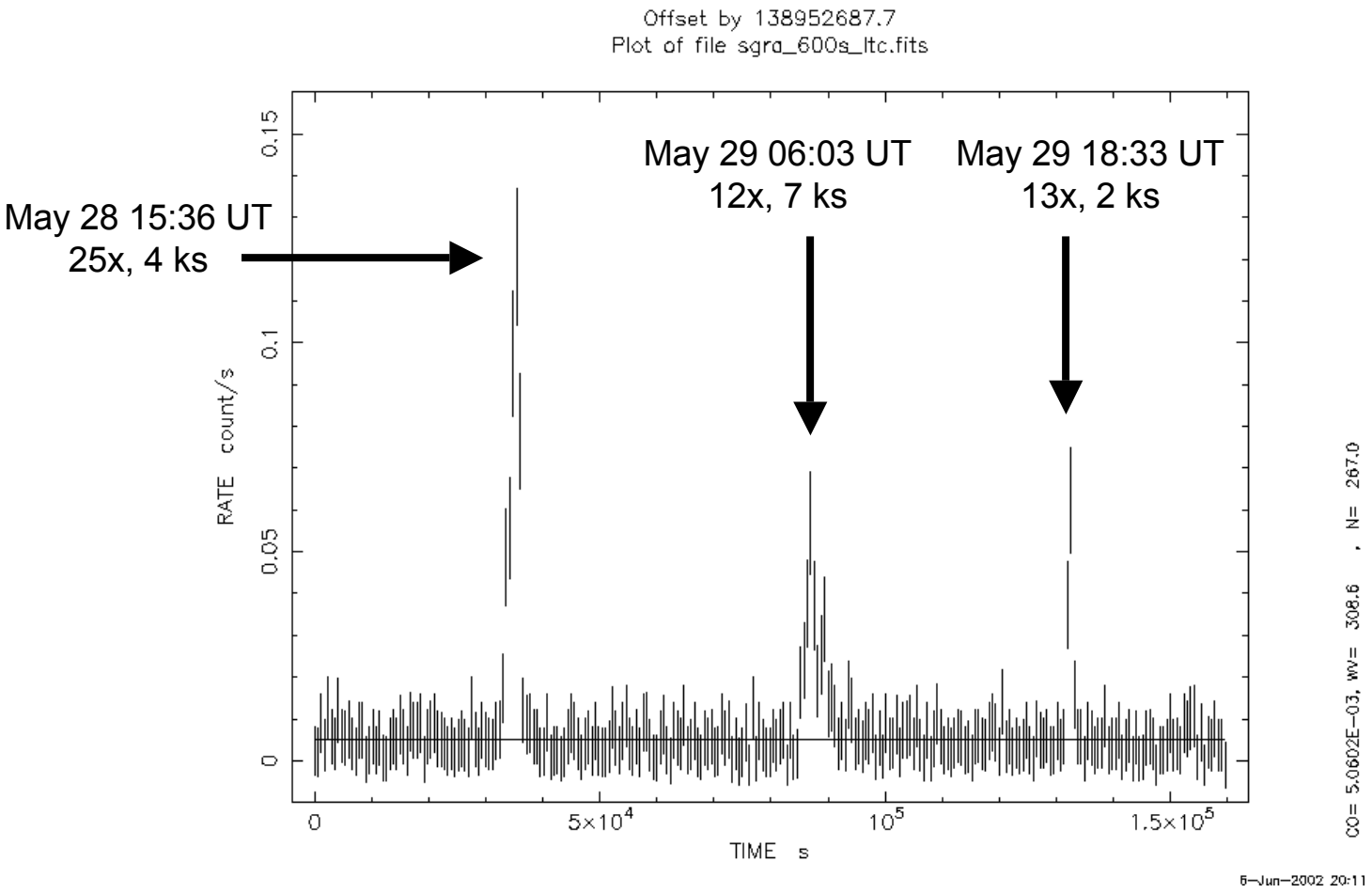
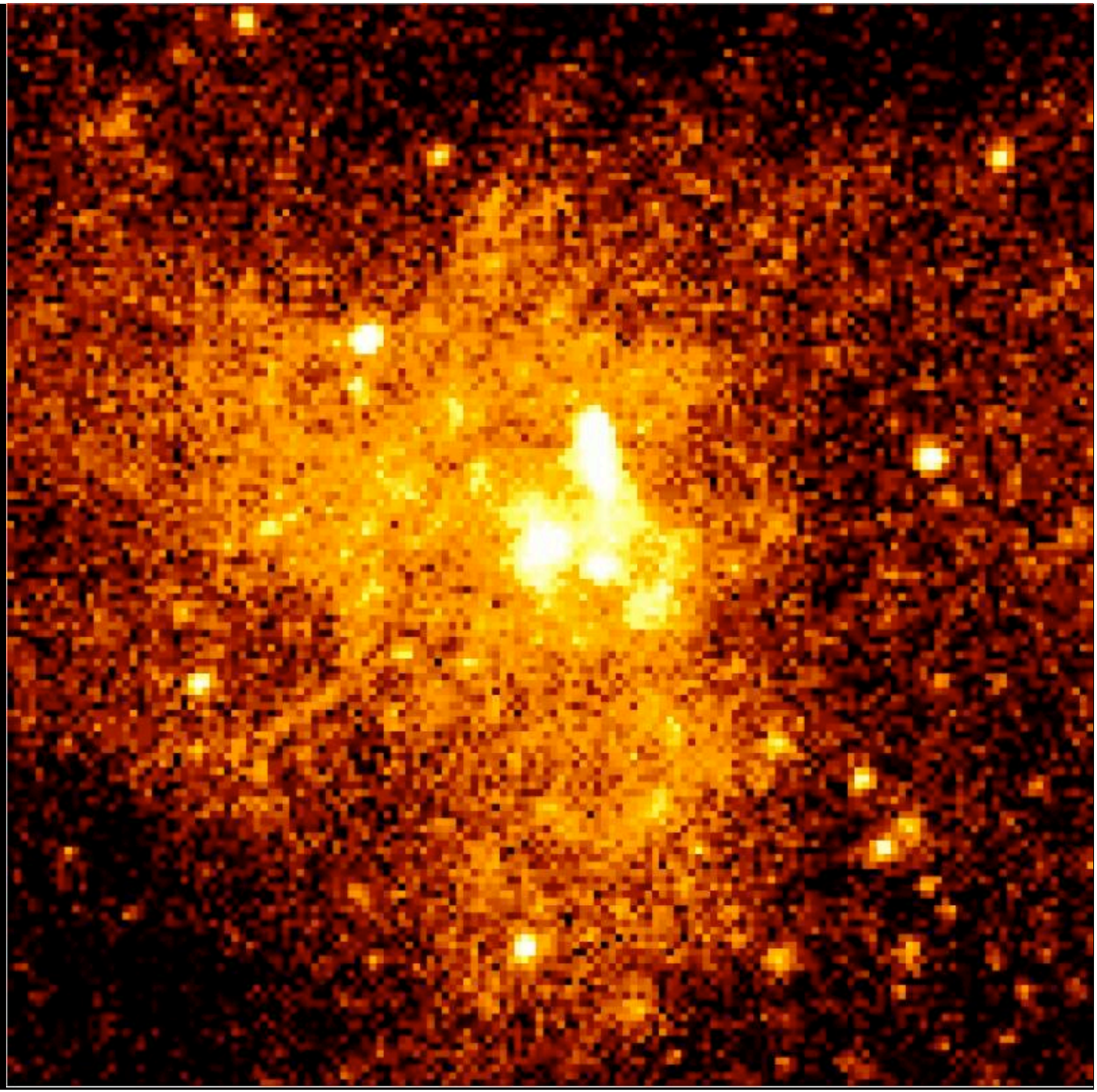
2002 jet? Historical activity: bipolar lobes.

2002 – 23-30 May Orbit 3

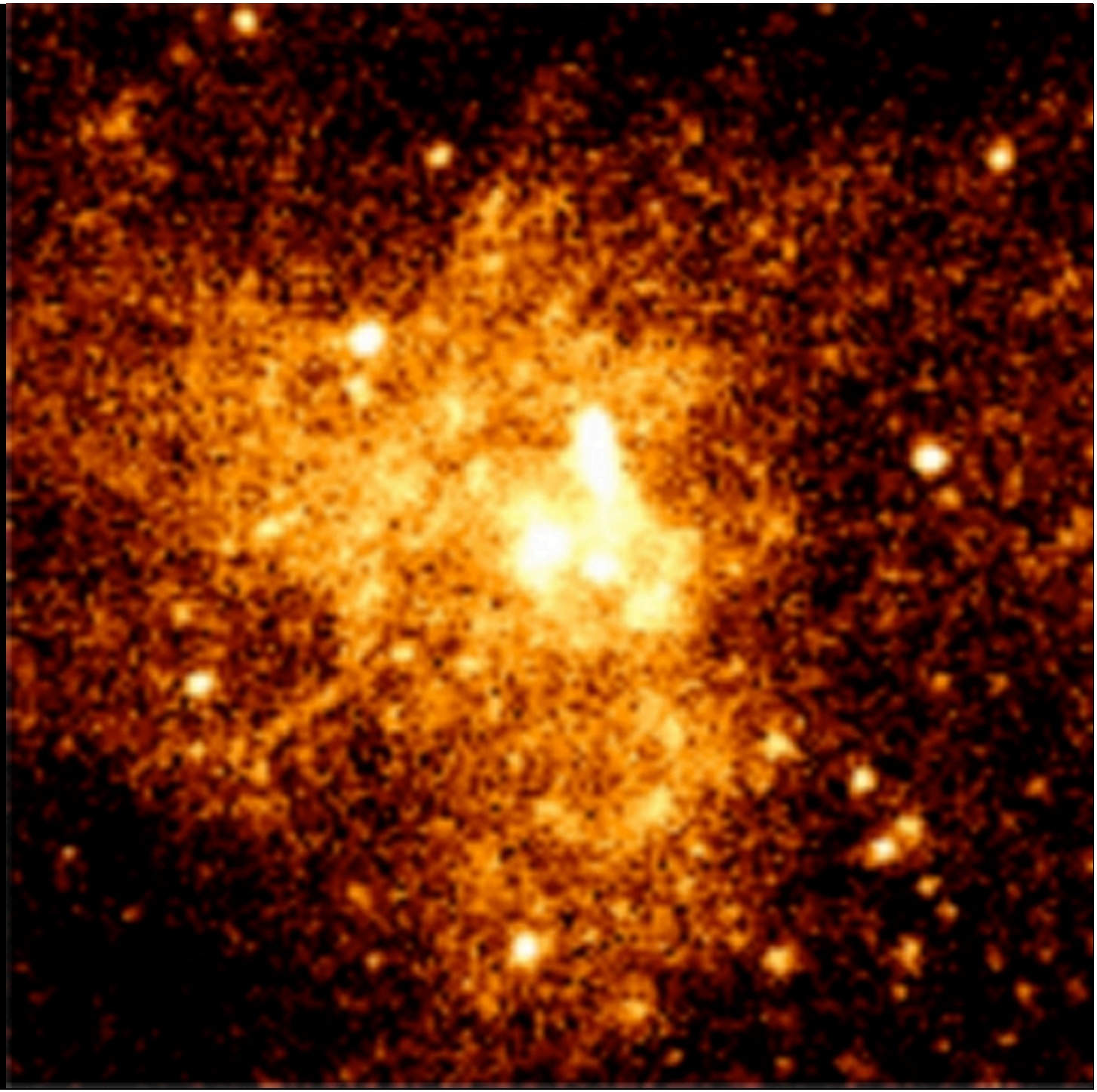


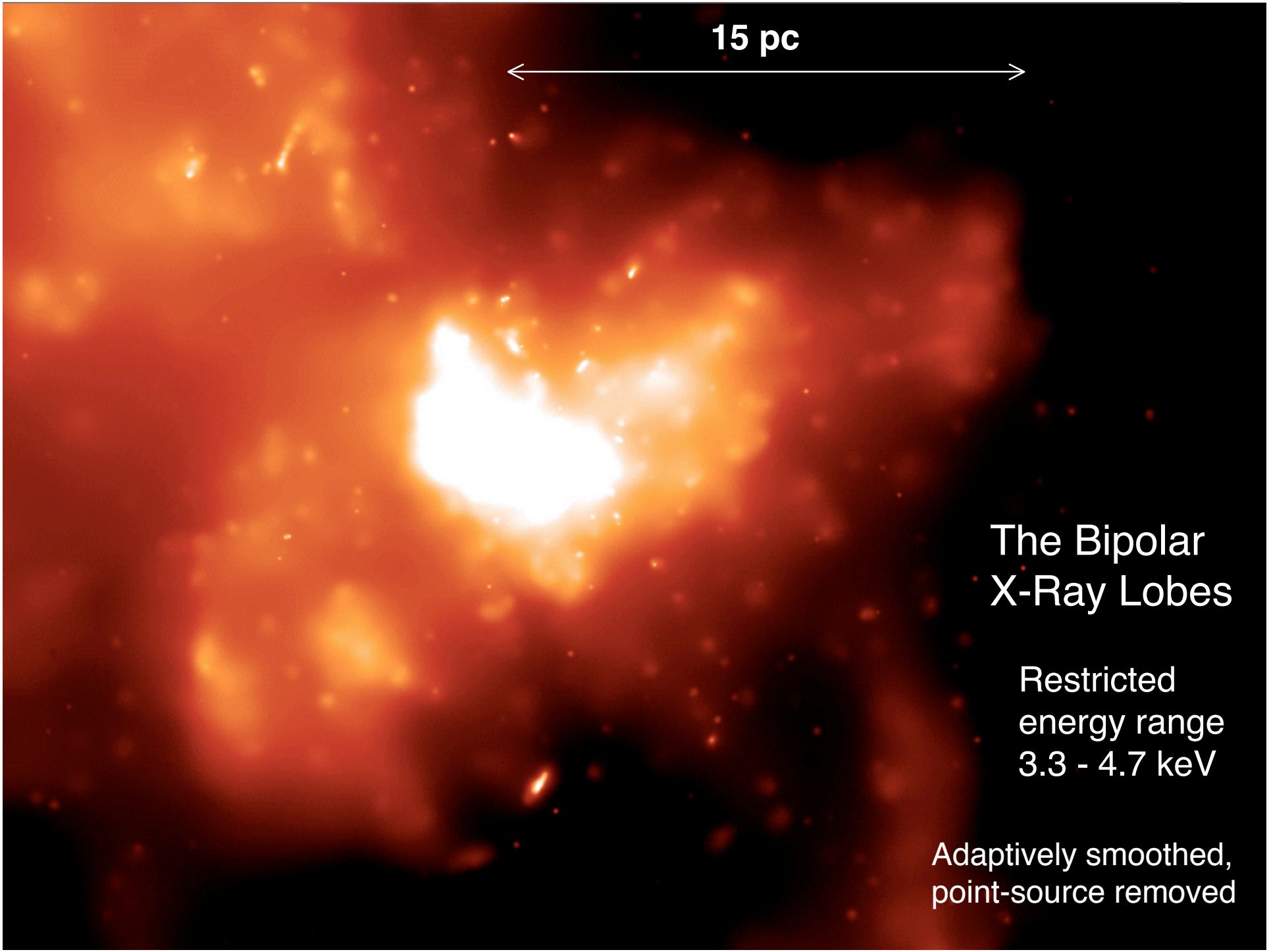
The Sgr A* Jet

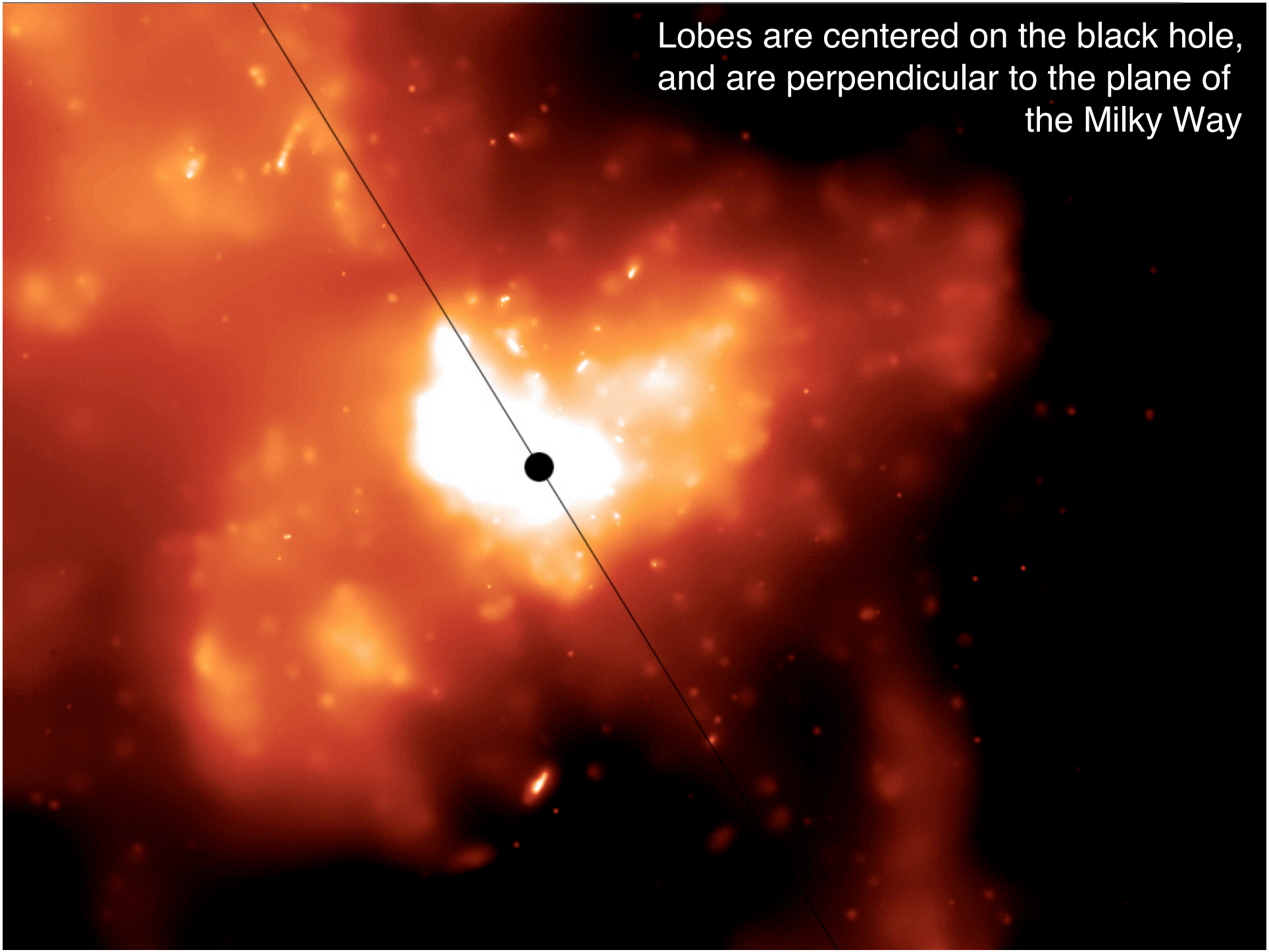


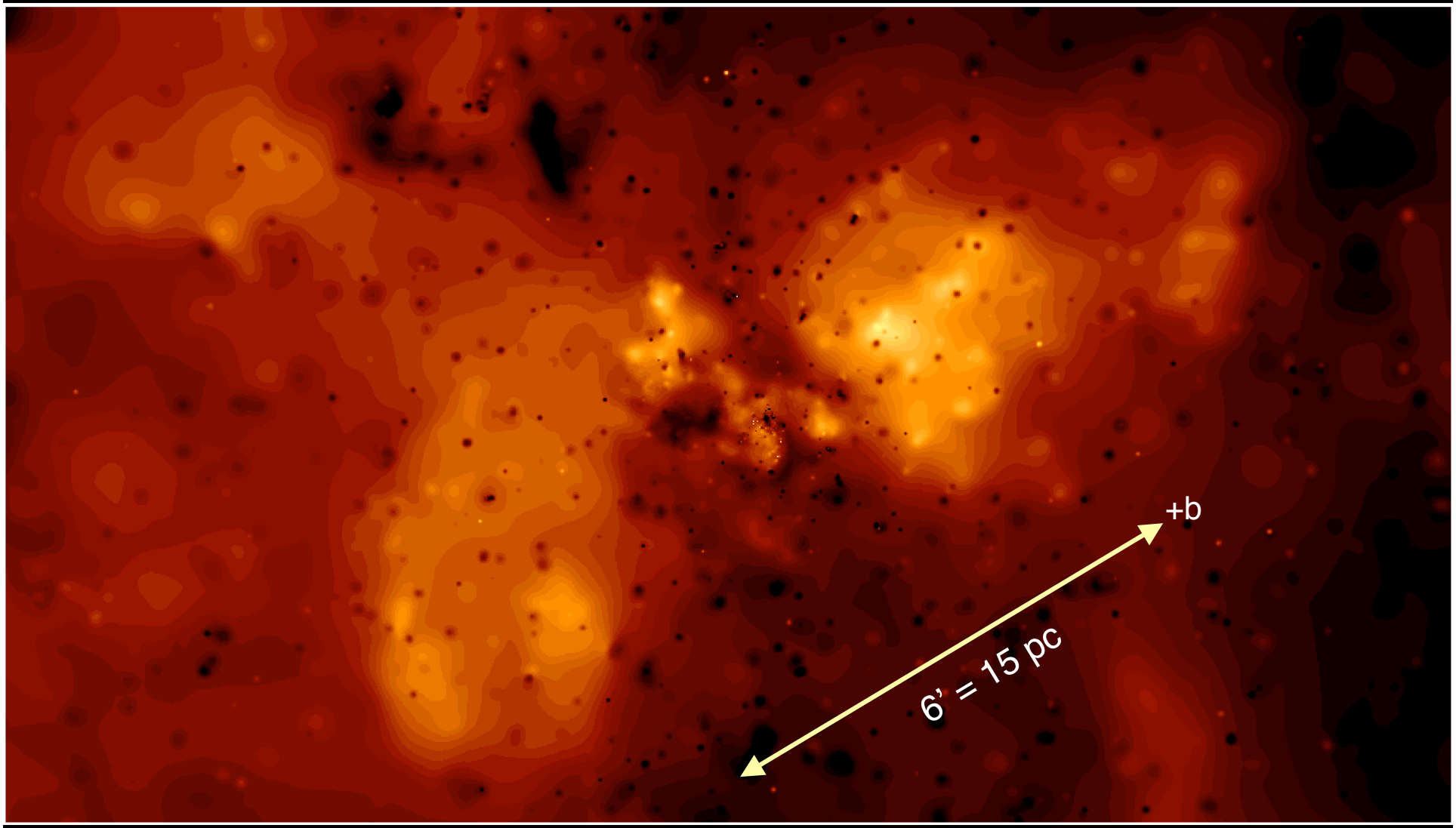
Scale ~ 1 pc

Slightly smoothed version …..




15 pc
The Bipolar
X-Ray Lobes
Restricted
energy range
3.3 - 4.7 keV
Adaptively smoothed,
point-source removed

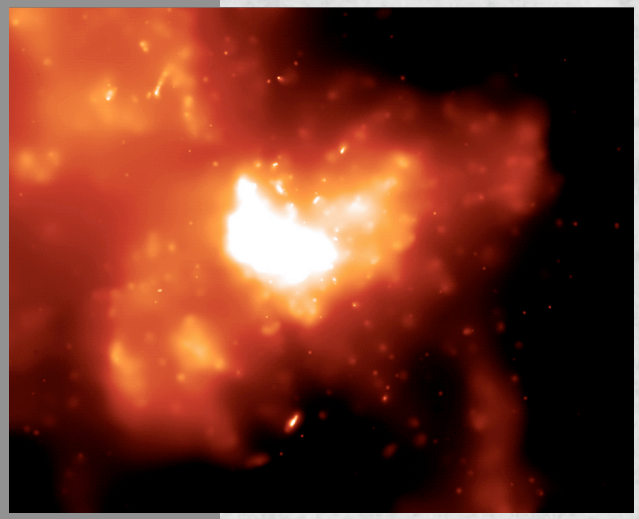

Lobes are centered on the black hole,
and are perpendicular to the plane of
the Milky Way



softness ratio: soft (2 – 4.7 keV) / hard (4.7 – 8 keV)
(most point sources removed)

330 MHz VLA image

Nord et al. 2003



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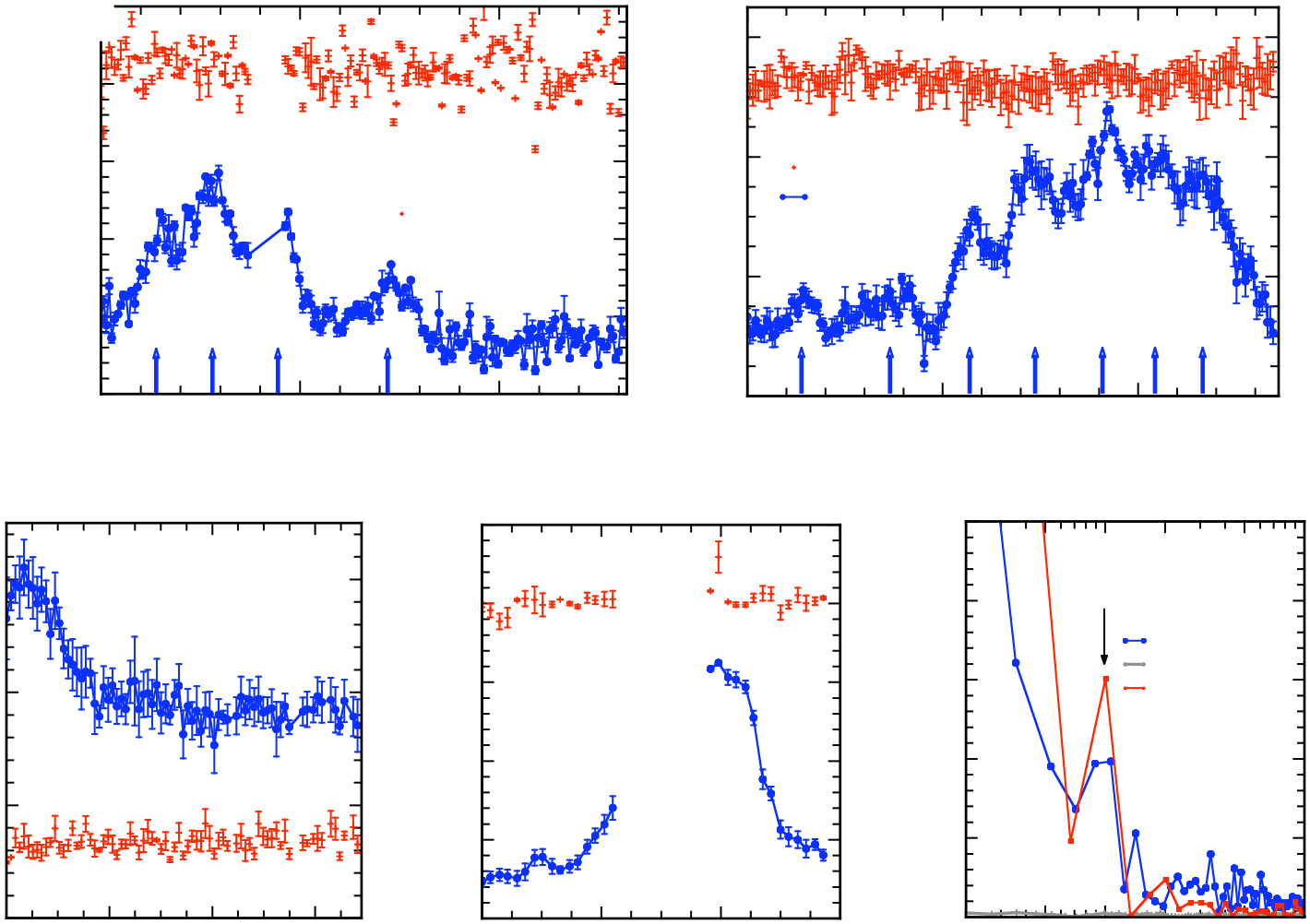
2003: IR detection, IR flares, simultaneous X/IR

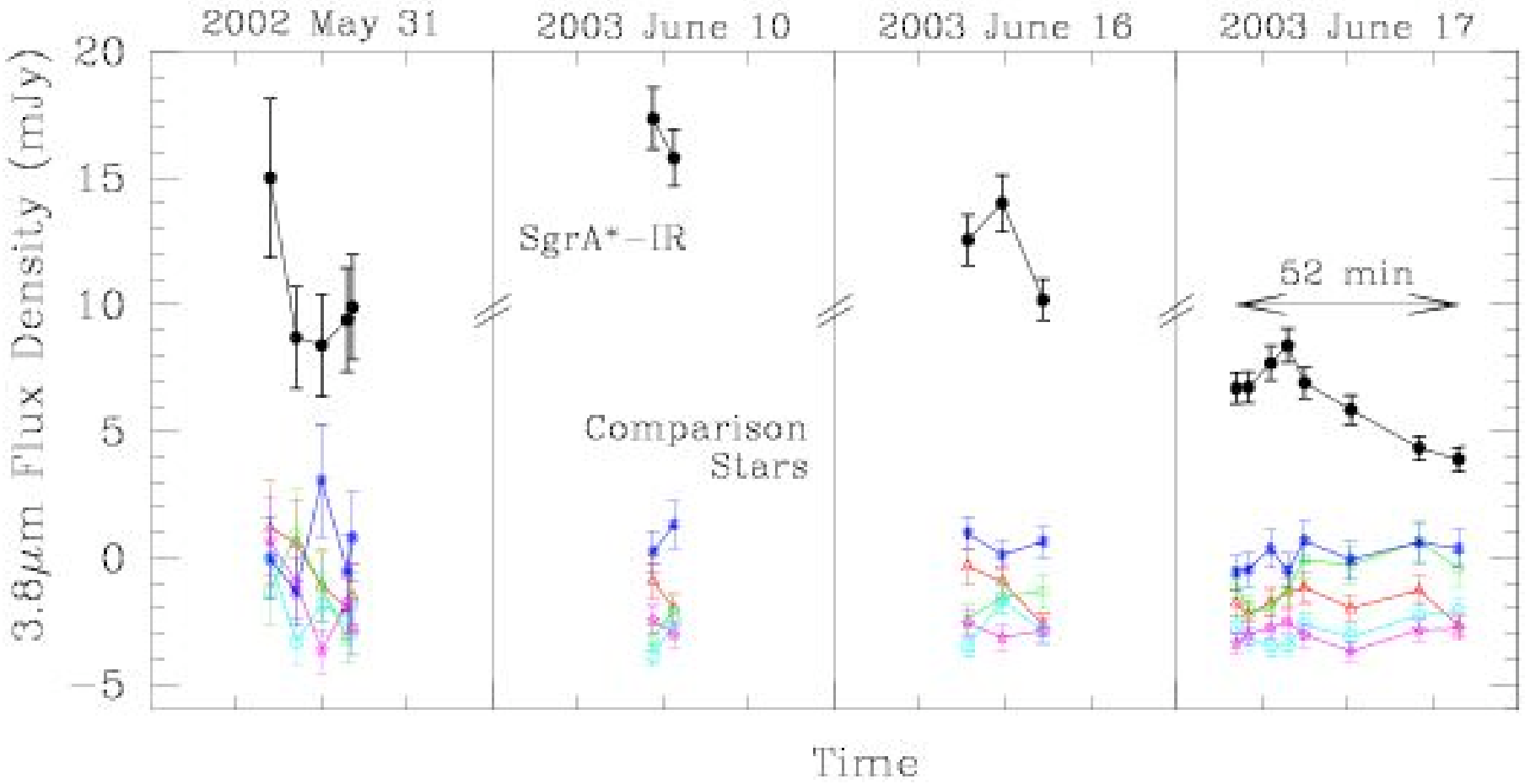
IR flares & quiescent emission from SgrA*



Genzel et al. 2003, Nature

[Schödel]

$R_{SgrA^*\text{-}flares} < 3$ *mas*
(350 R_s*)*



Ghez et al. 2003

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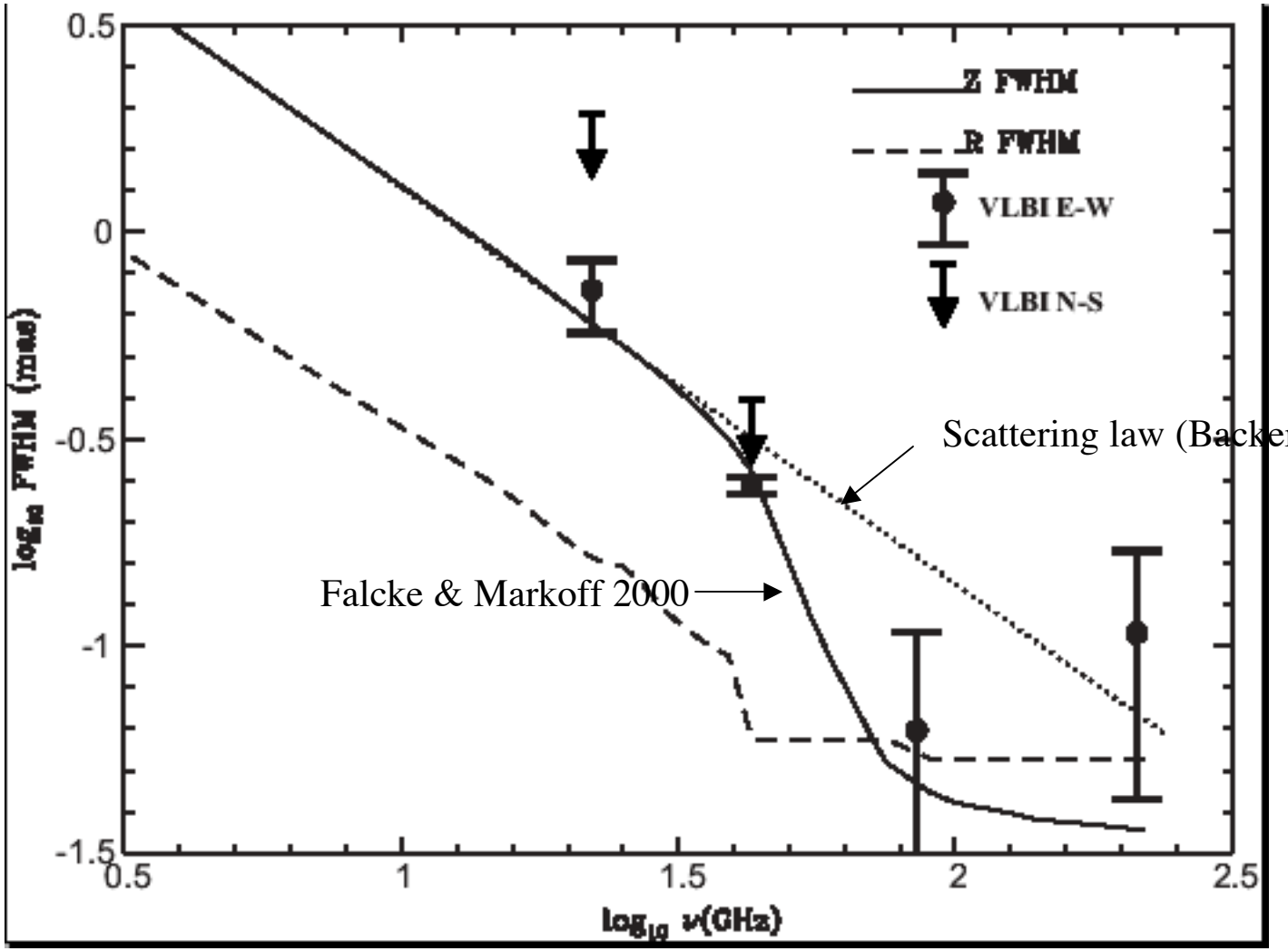

Bower et al. 2004 Science

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2003-2004 resolved radio source
2003-2005 Short-term time variations of radio (Zhao et al)
Etc, etc....

The pace is accelerating!!

Magnetic Fields

Important Open Questions

✳ Will the 17-minute IR flare variability hold up?
(is there an X-ray counterpart to that?)

✳ SgrA* spectrum: jet or disk?

✳ Is there a quiescent infrared state?

✳ IR variations: flares or stochastic variations?

✳ What role is played by the magnetic field?

✳ Interaction between accretion and star formation?

✳ Fossil evidence for stellar disruption (t ~ few 10^4 yrs)?

✳ What will it take to image the "event horizon" (tonight)

Sgr A* is fast becoming as familiar and as venerable as many of us who have been studying it !

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Congratulations to the supremely venerable
Bruce Balick
Bob Brown