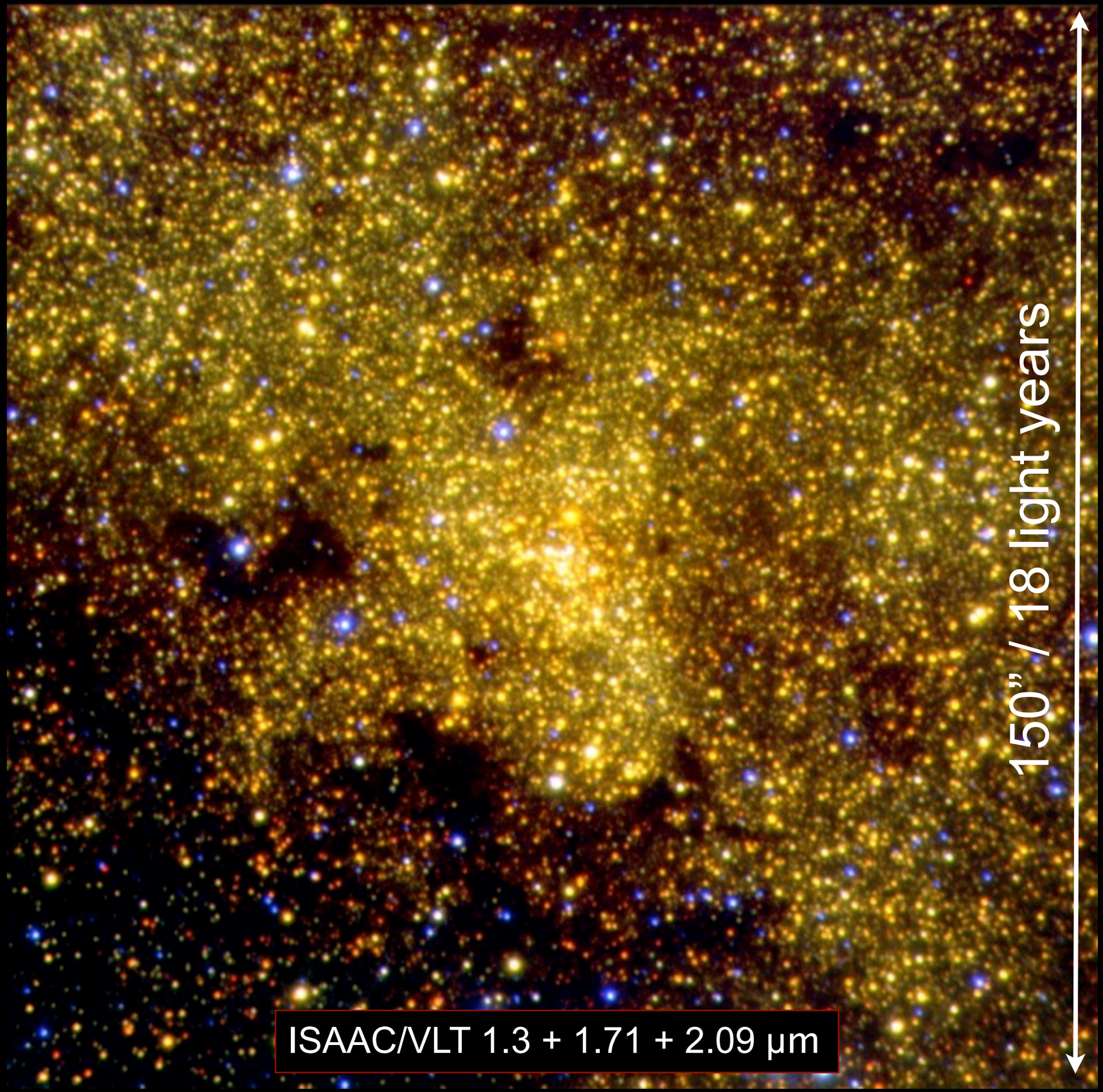
The Nucleus of the Milky Way


150” / 18 light years
ISAAC/VLT 1.3 + 1.71 + 2.09 µm

blue: stars (near-infrared)

green: ionizaded gas (radio - cm)

red: molecular gas (radio - mm)

Circum Nuclear Ring

mini-spiral
(Sagittarius A West)

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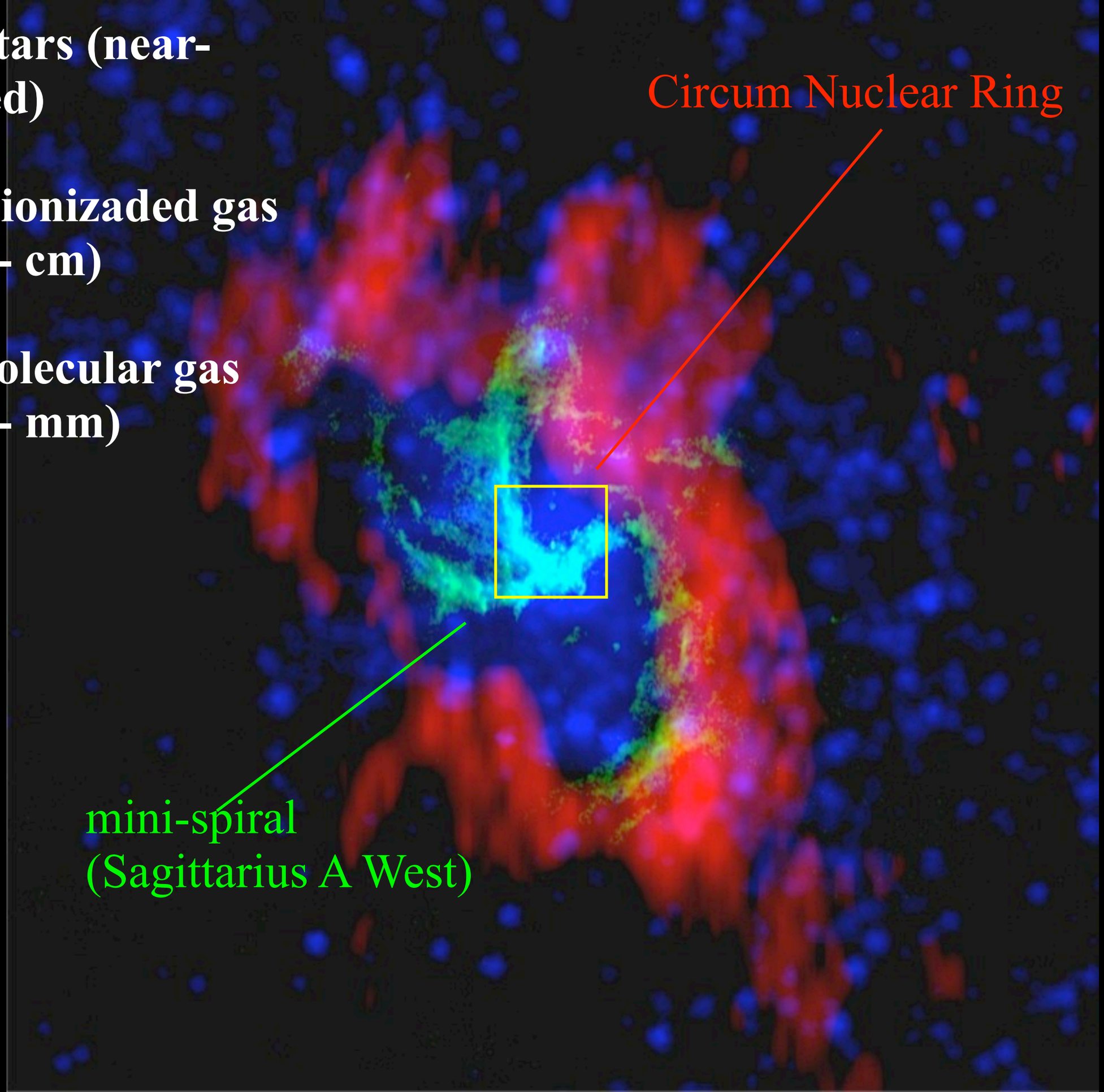
green: ionizaded gas (radio - cm)

red: molecular gas (radio - mm)



blue: stars (near-infrared)

green: ioniz
(radio - cm

red: molecu
(radio - mn

ng

Sagittarius A*
(Balick & Brown, 1974)

2"
0.08pc

VLA at 13 mm: Zhao & Goss 1998

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(radio - cm

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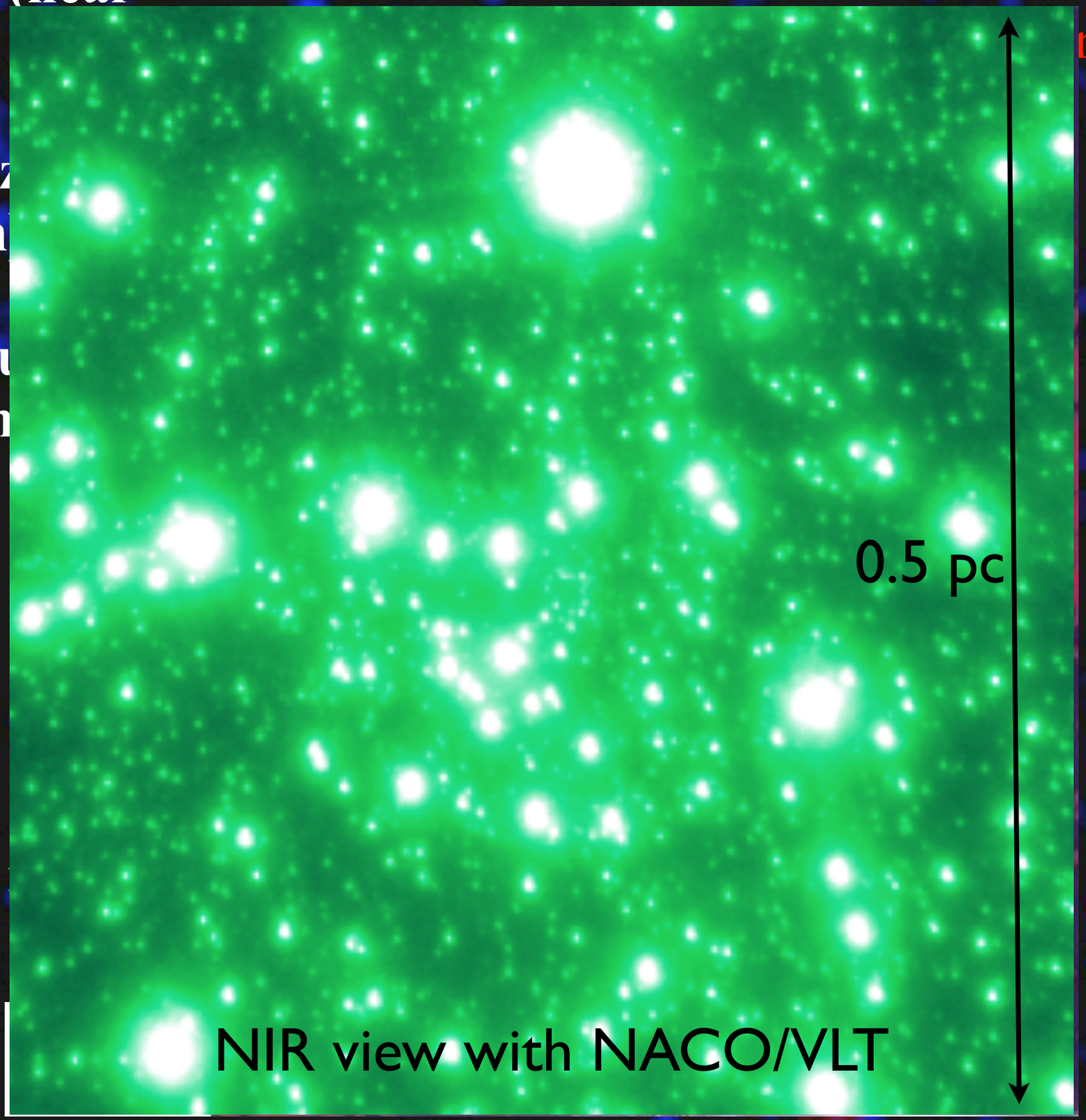
(radio - mn



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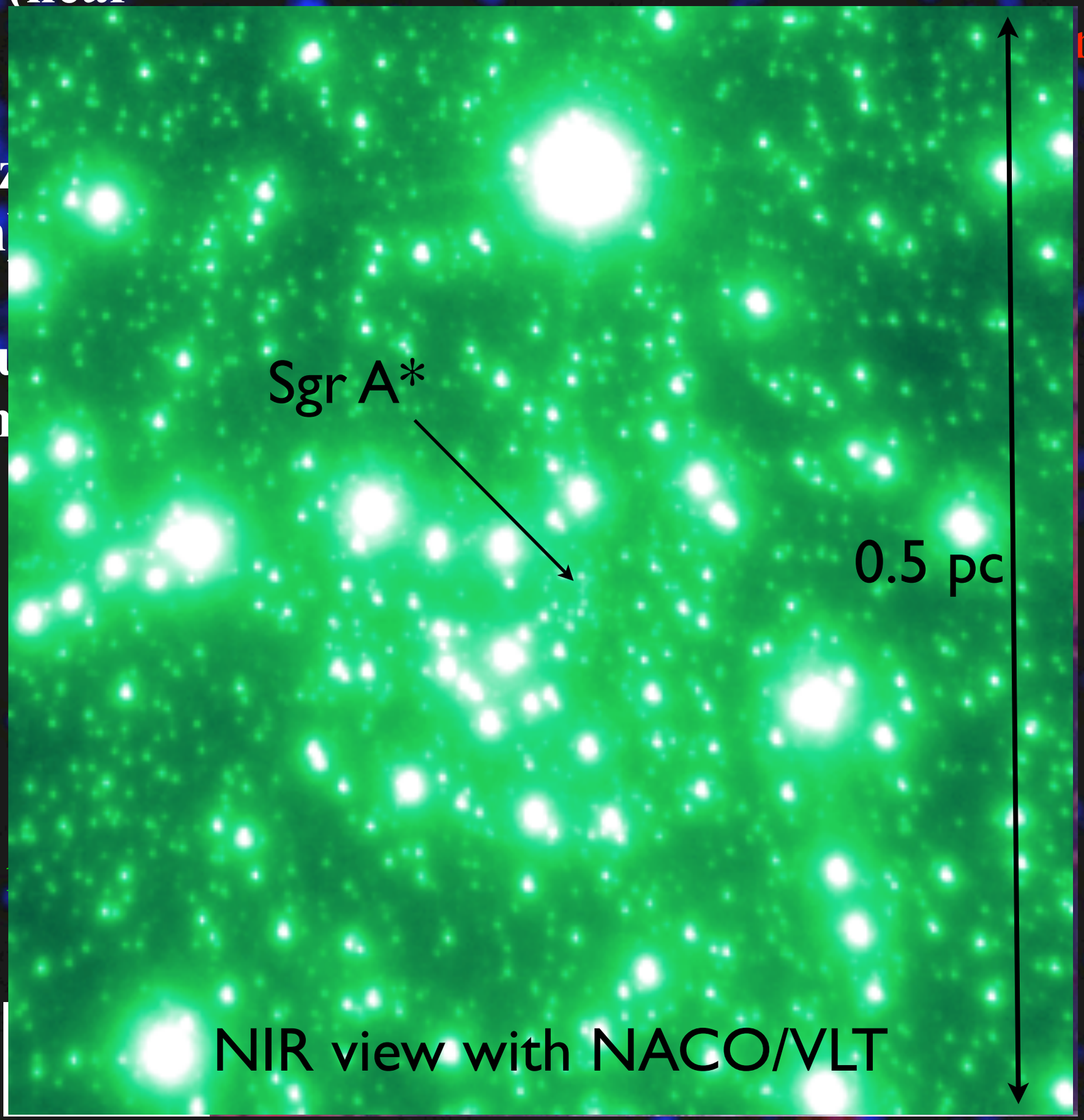

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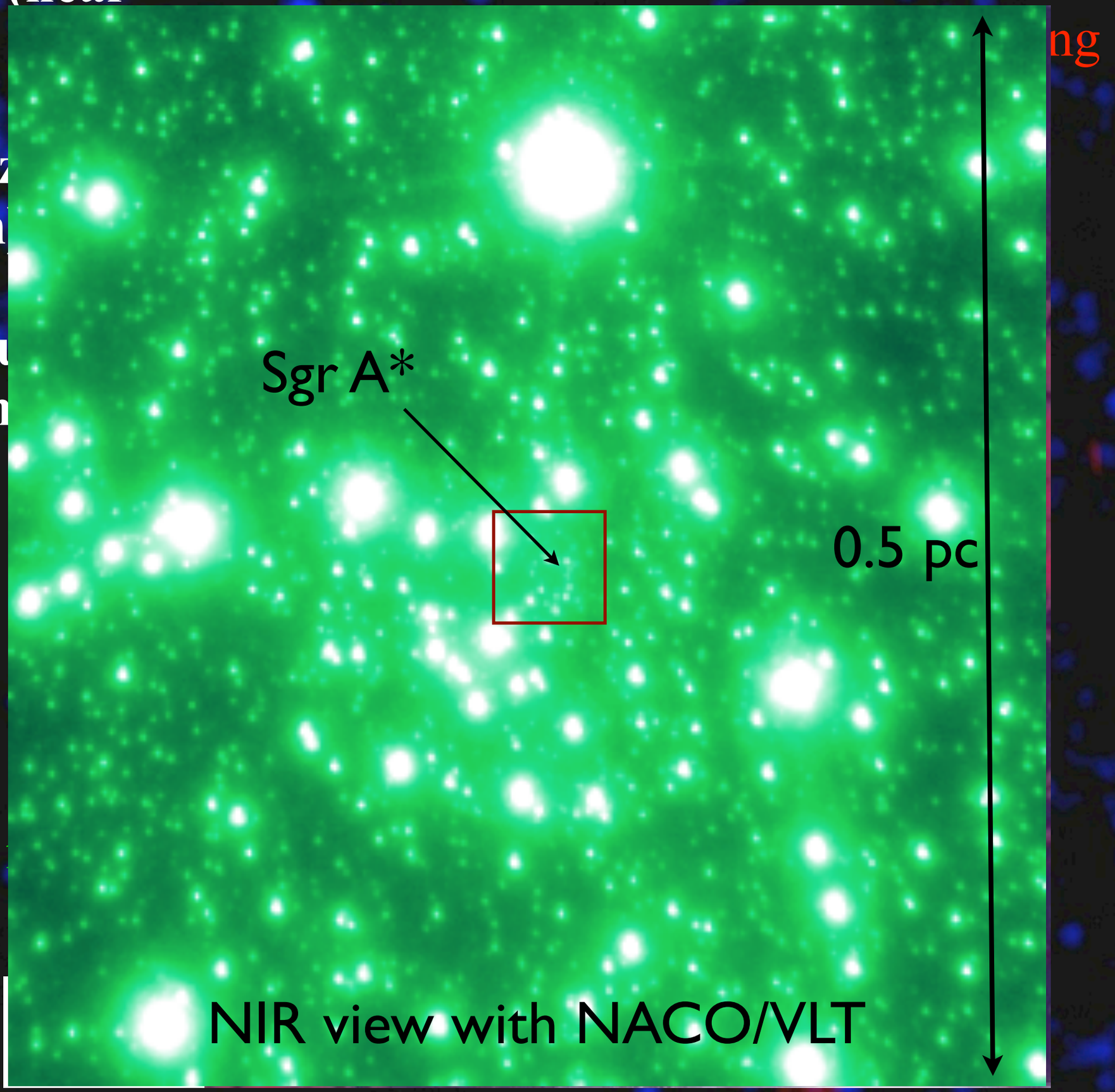

50 light days

14 light days

MPE/ESO

UCLA/Keck

e.g. Eckart & Genzel (1996); Ghez et al. (1998, 2003,2008); Genzel et al. (2000); Eckart et al. (2002); Schödel et al. (2002, 2003); Reid et al. (2004); Eisenhauer et al. (2003, 2005); Gillessen et al. (2009); Yelda et al. (2010)

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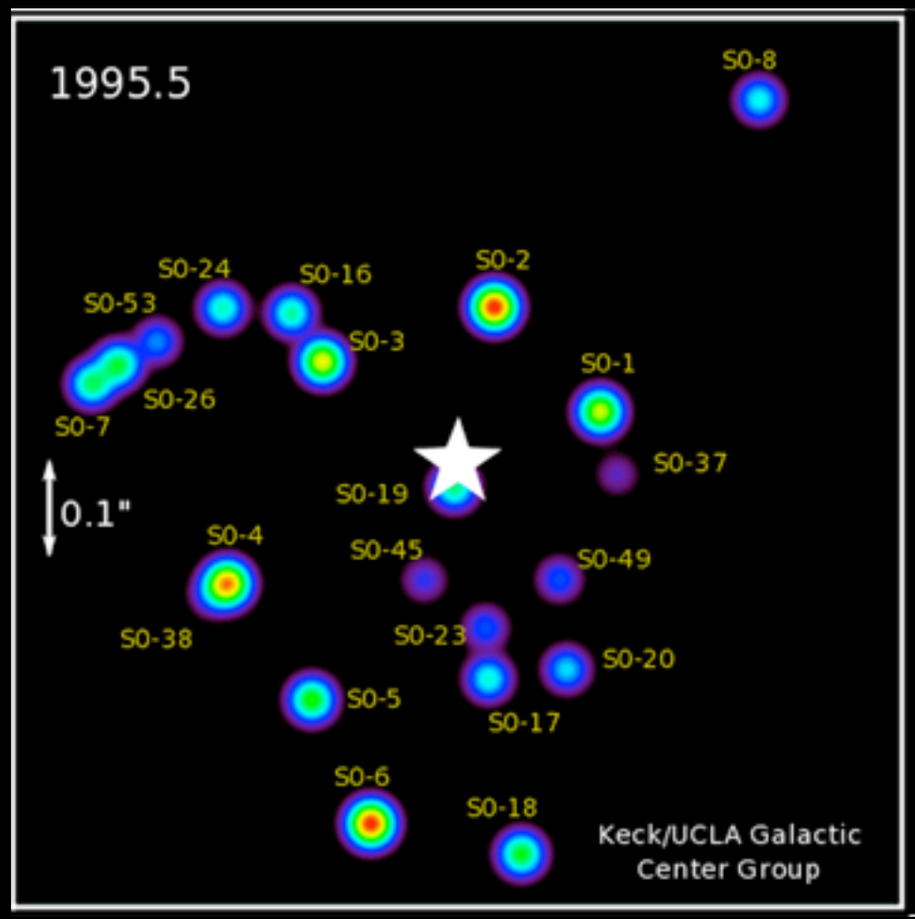

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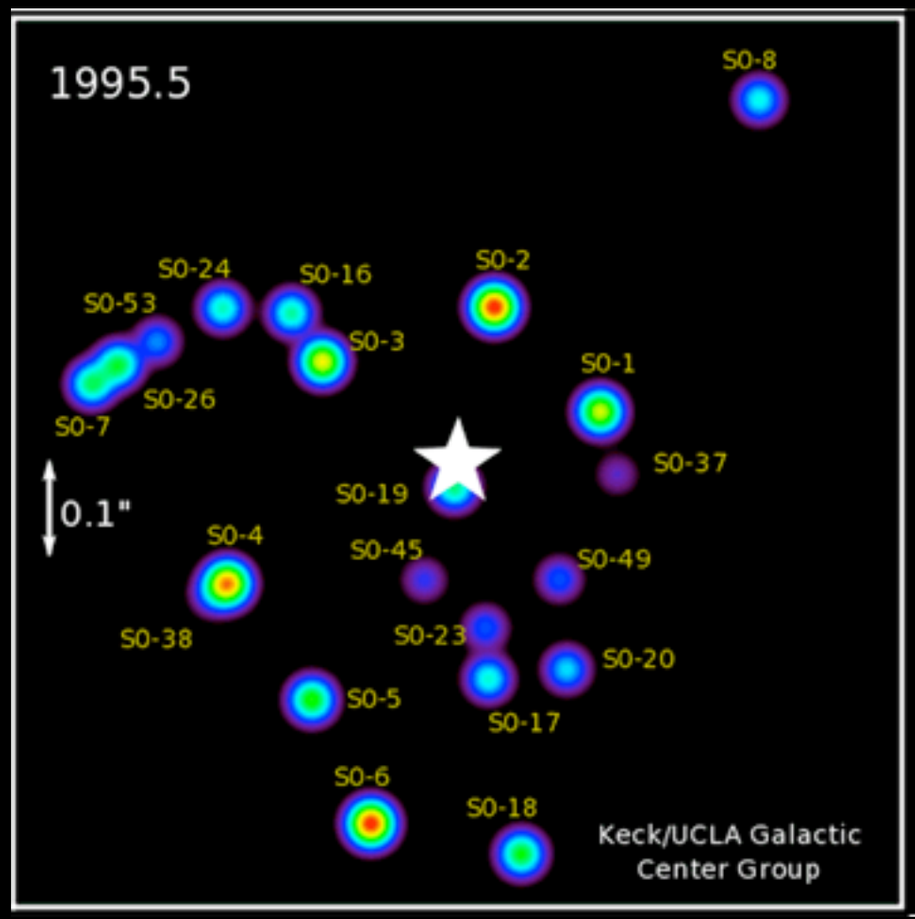

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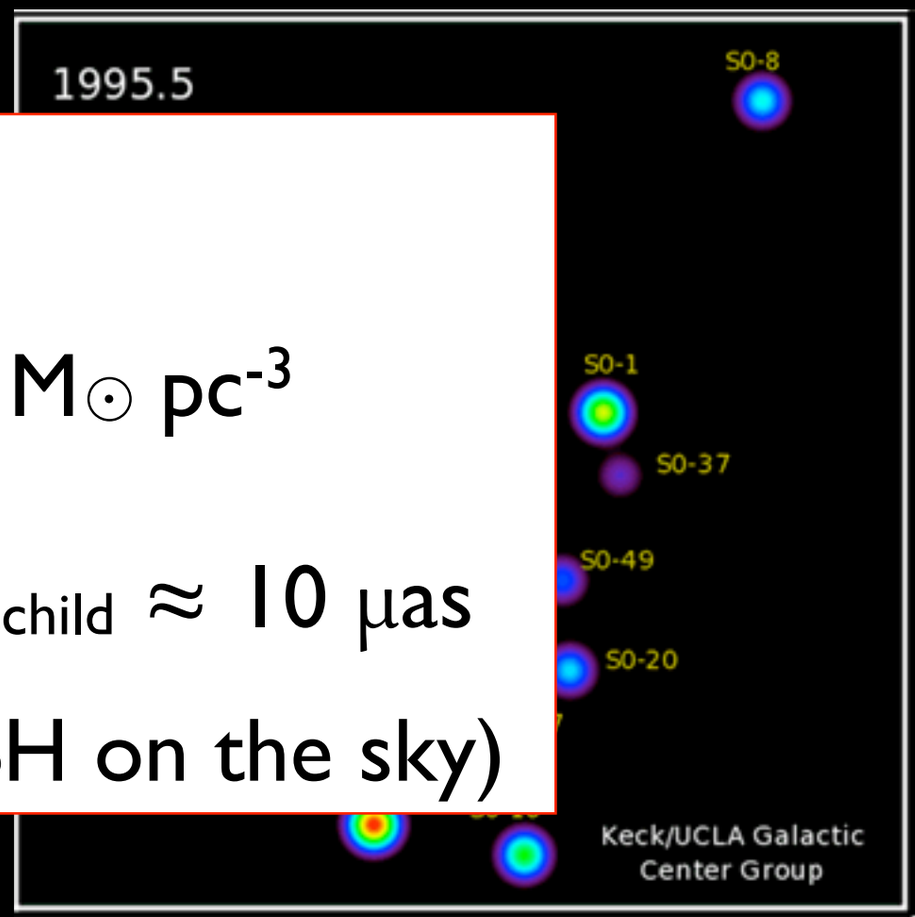

- Distance: 8.1 - 8.3 kpc
- Mass: 4.1 -4.3 $\times 10^6$ $M_\odot$
- Mass density: $> 5 \times 10^{15}$ $M_\odot$ pc^{-3}

$\Rightarrow$ angular size of $R_{Schwarzschild} \approx 10$ μas

(along with M87 largest BH on the sky)

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UCLA/Keck

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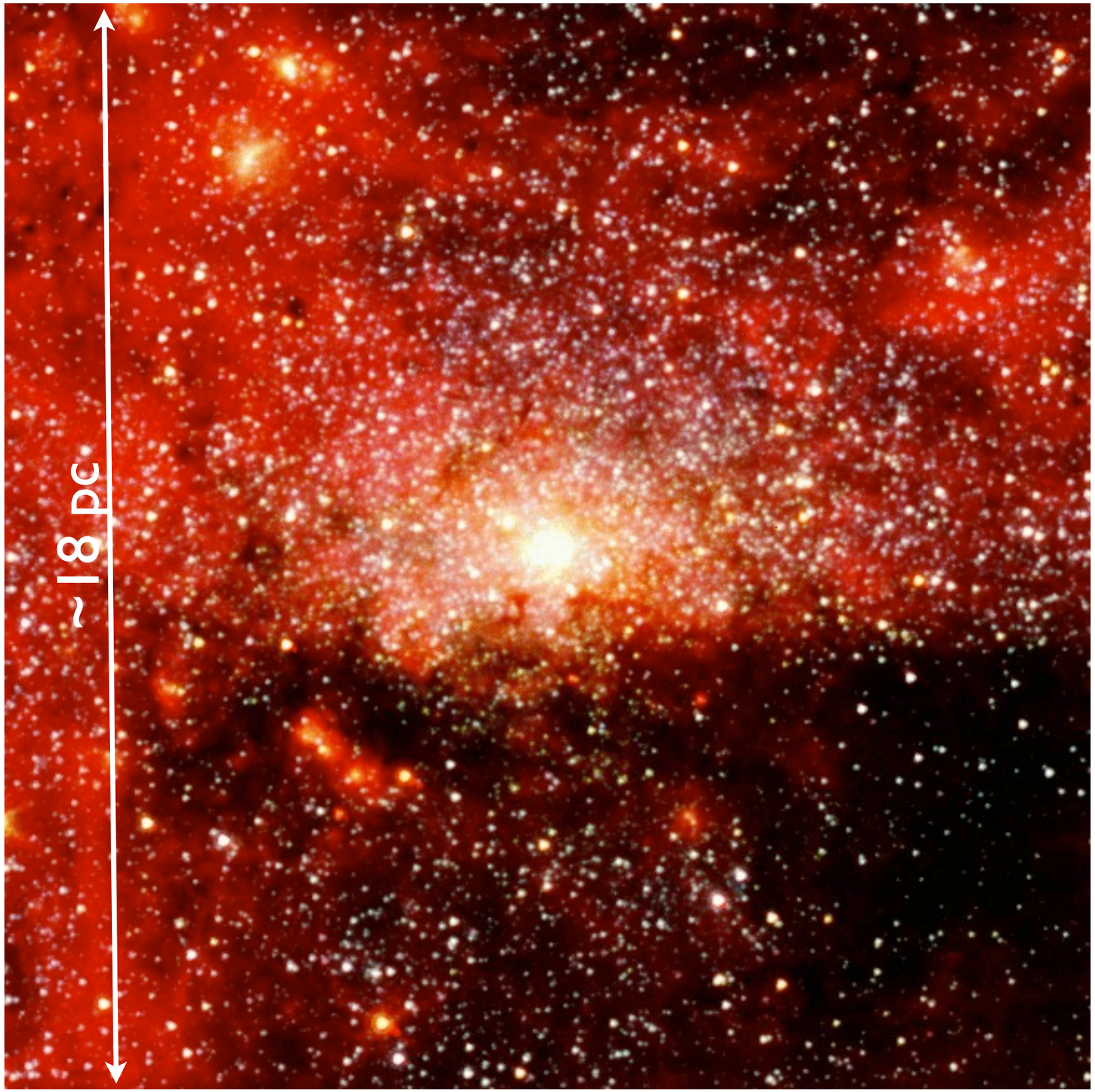
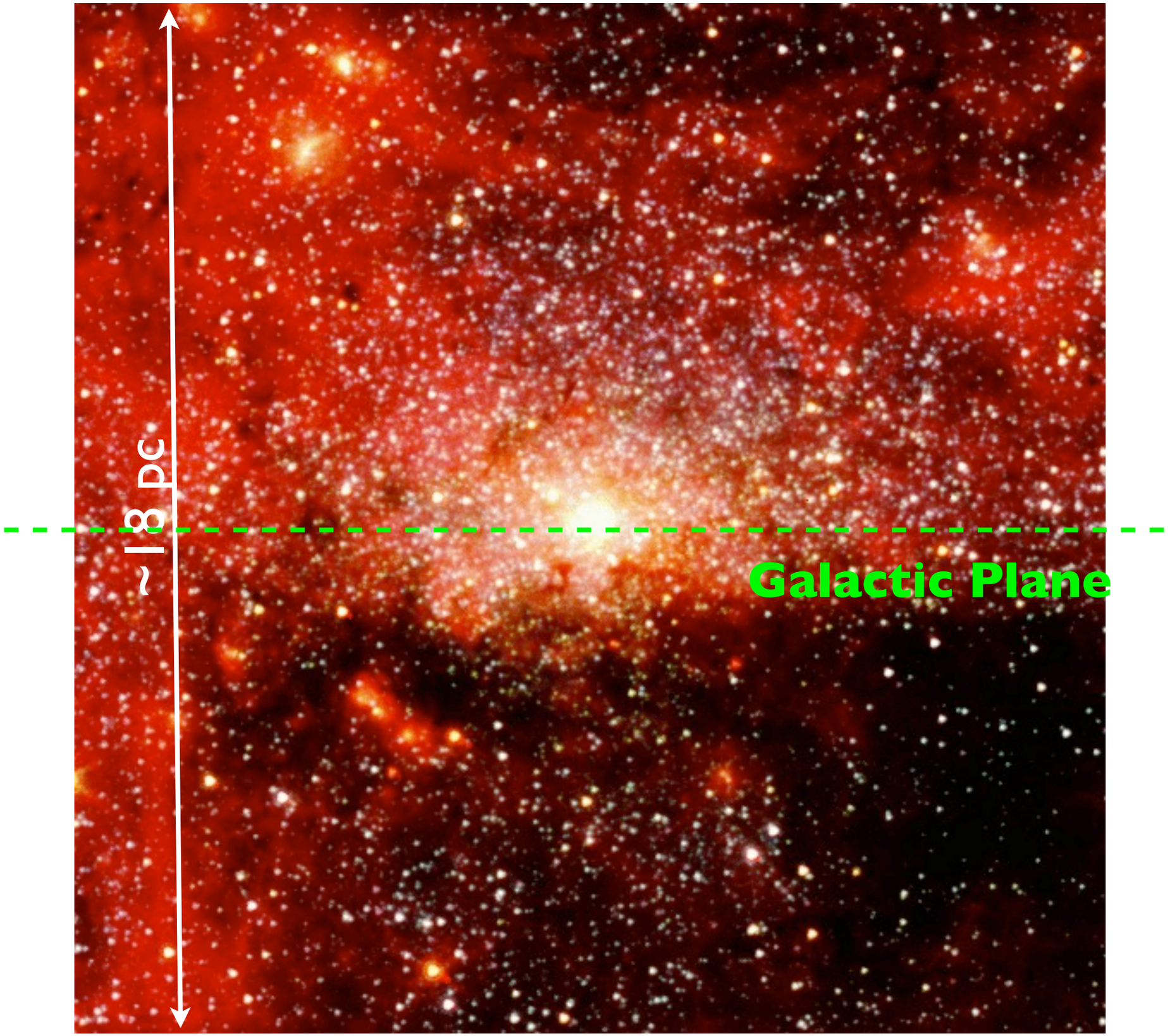


NASA/JPL-Caltech/S. Stolovy (Spitzer Science Center/Caltech)

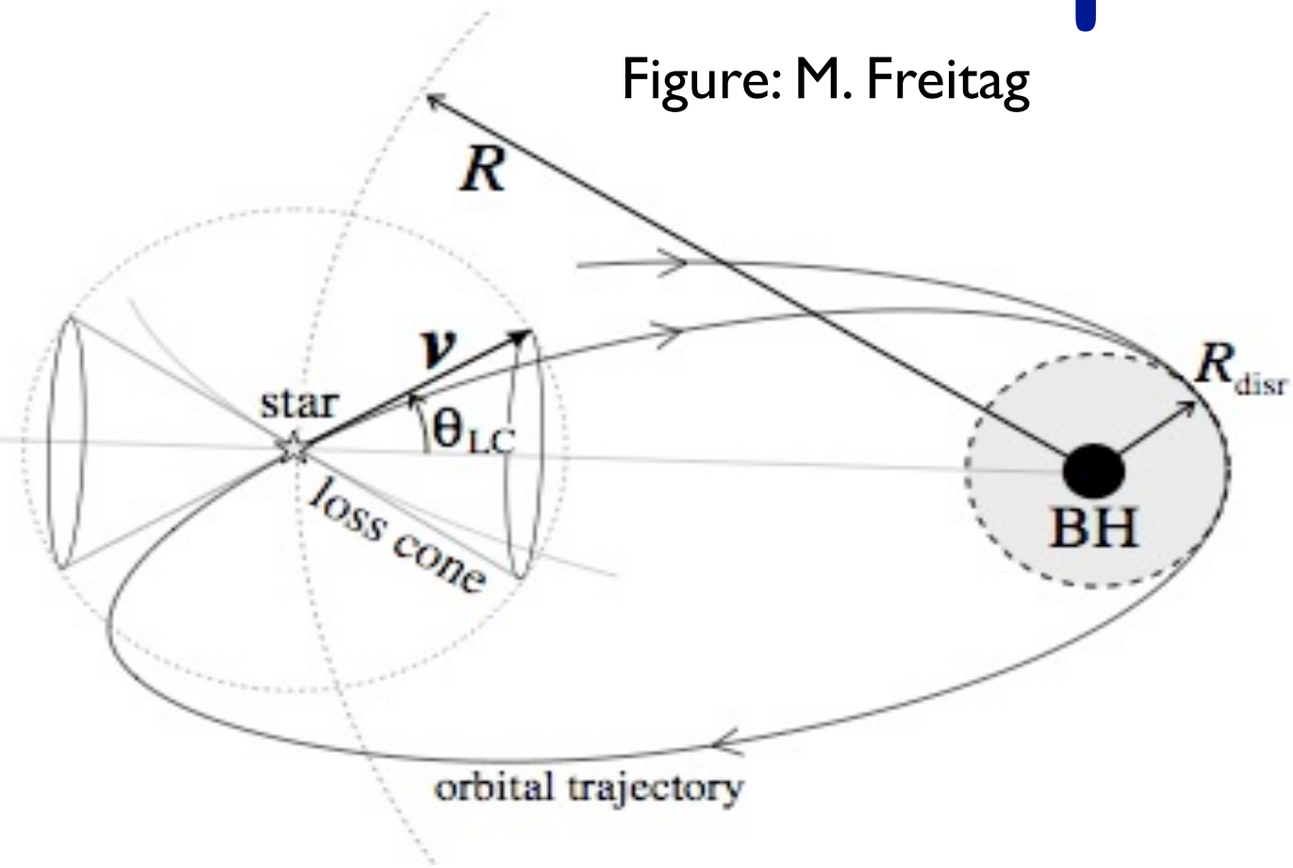


NASA/JPL-Caltech/S. Stolovy (Spitzer Science Center/Caltech)

NSC + central BH: Is there a stellar cusp?

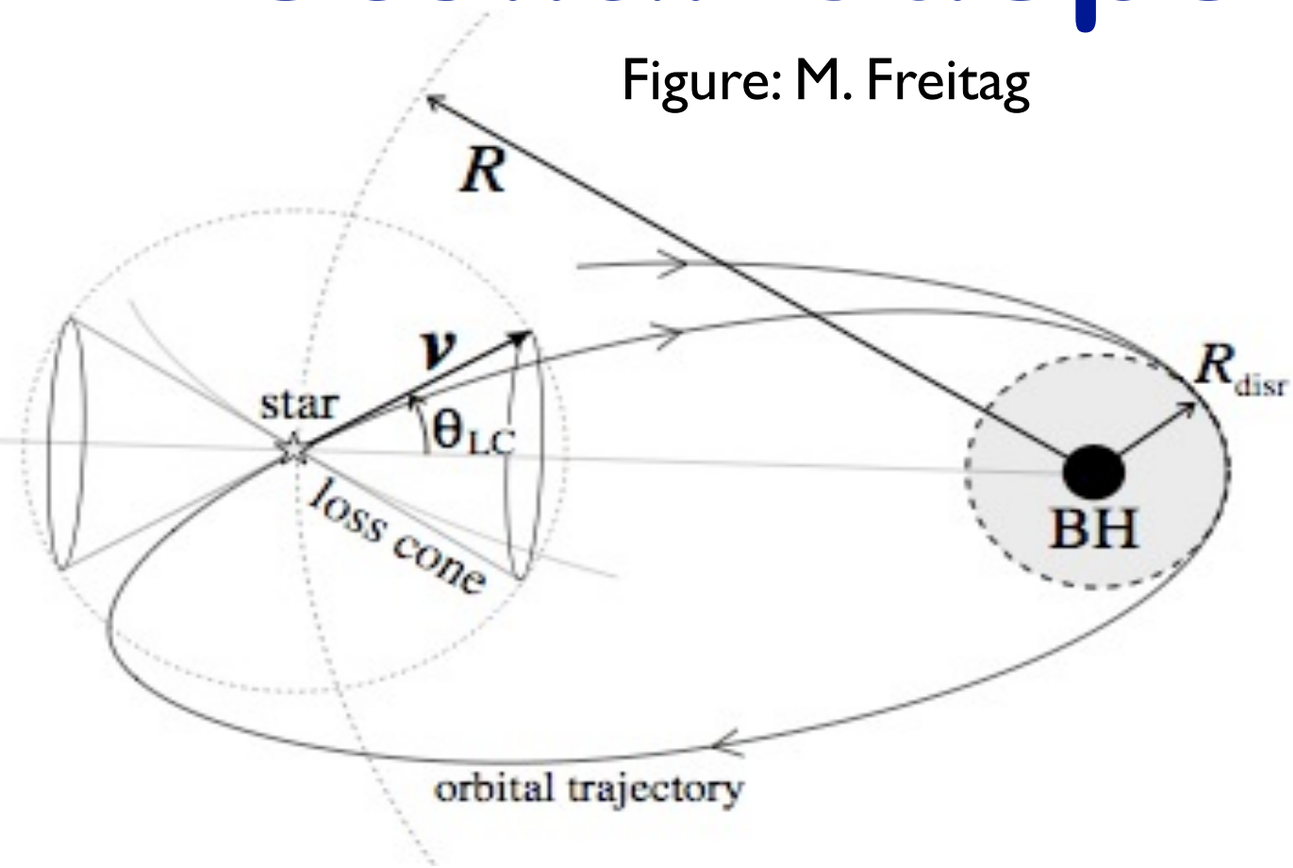
Stellar cusps around MBHs

Figure: M. Freitag



Stellar cusps around MBHs

Figure: M. Freitag

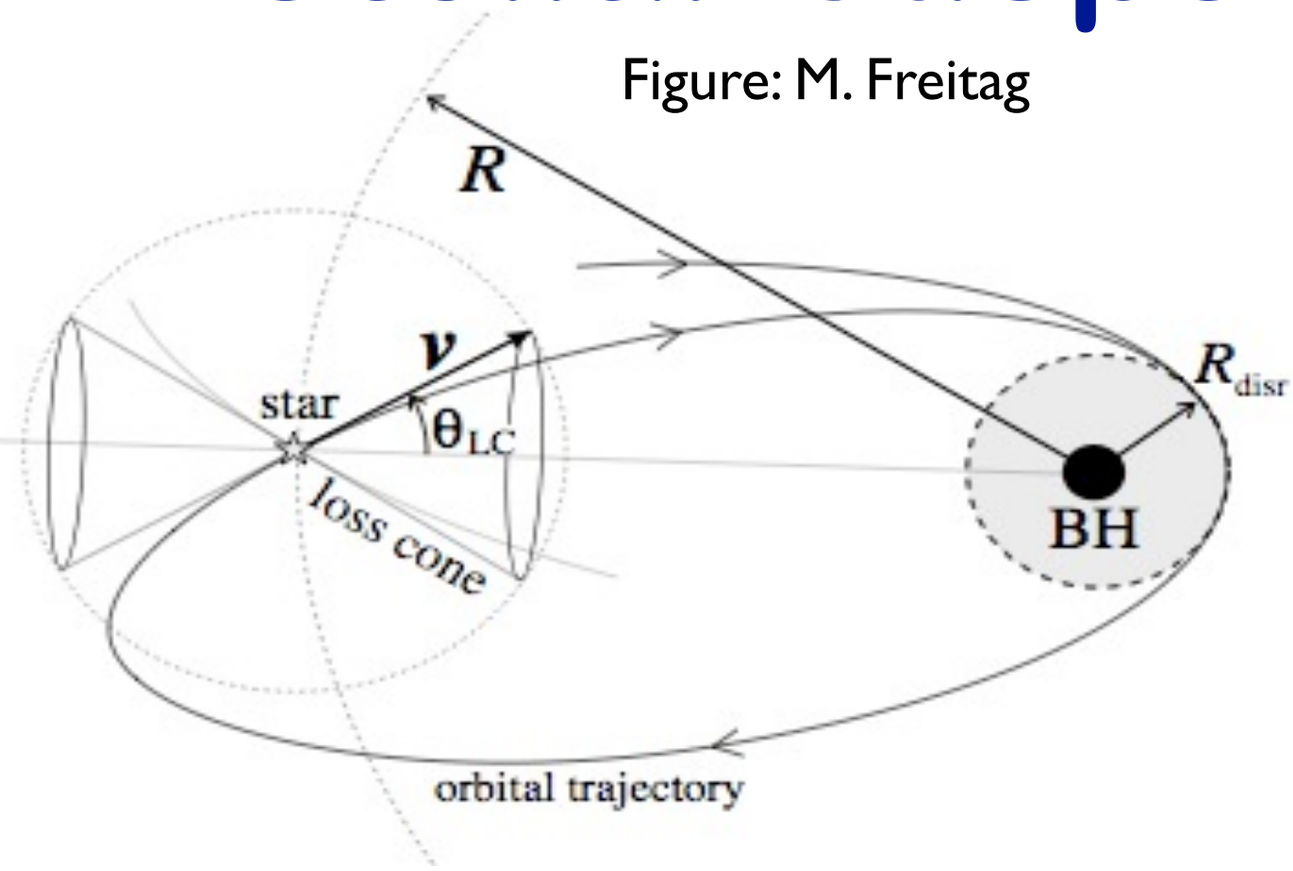


2-body relaxed cluster around massive black hole should display a *cusp* with

$\rho \propto r^{-1.5 \ldots -1.75}$

Stellar cusps around MBHs

Figure: M. Freitag



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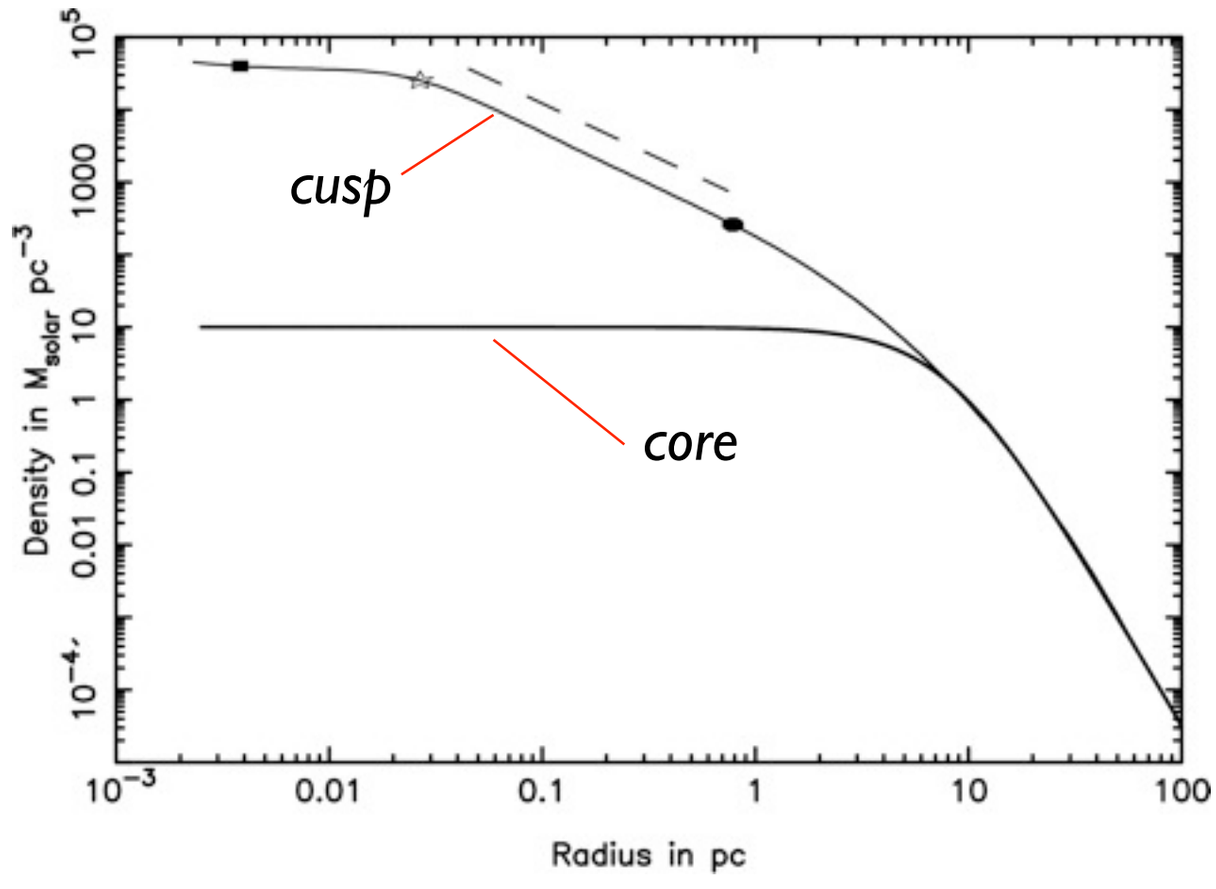

Stellar cusps around MBHs

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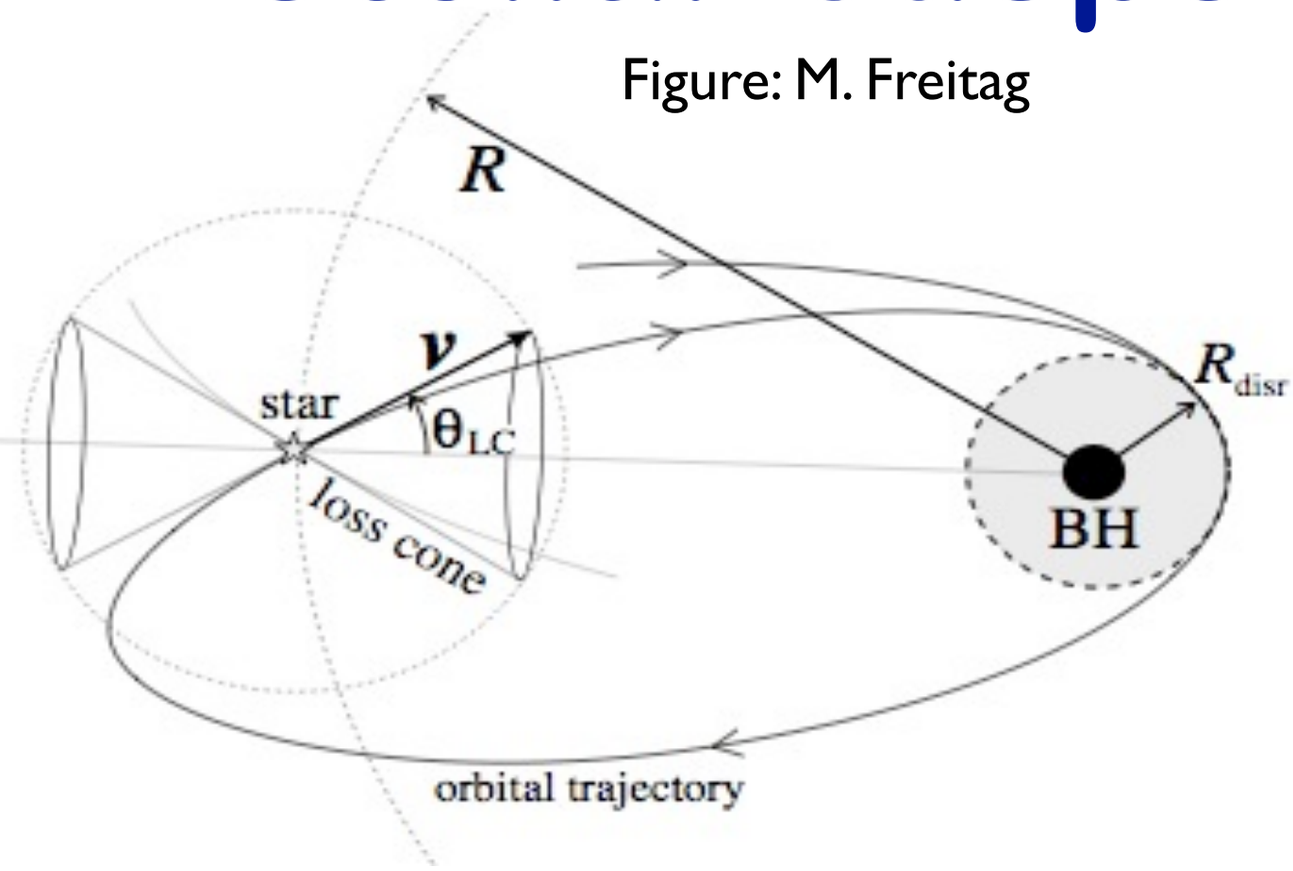

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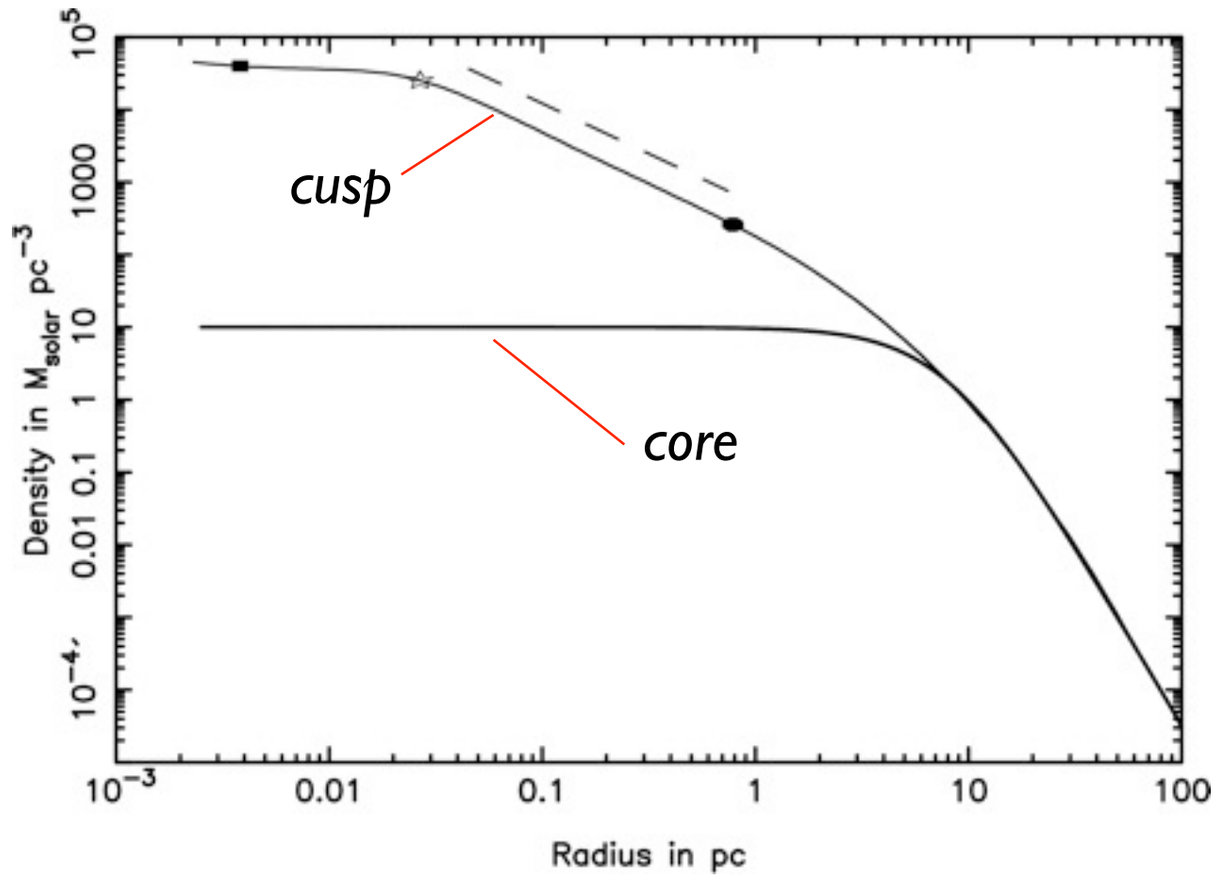
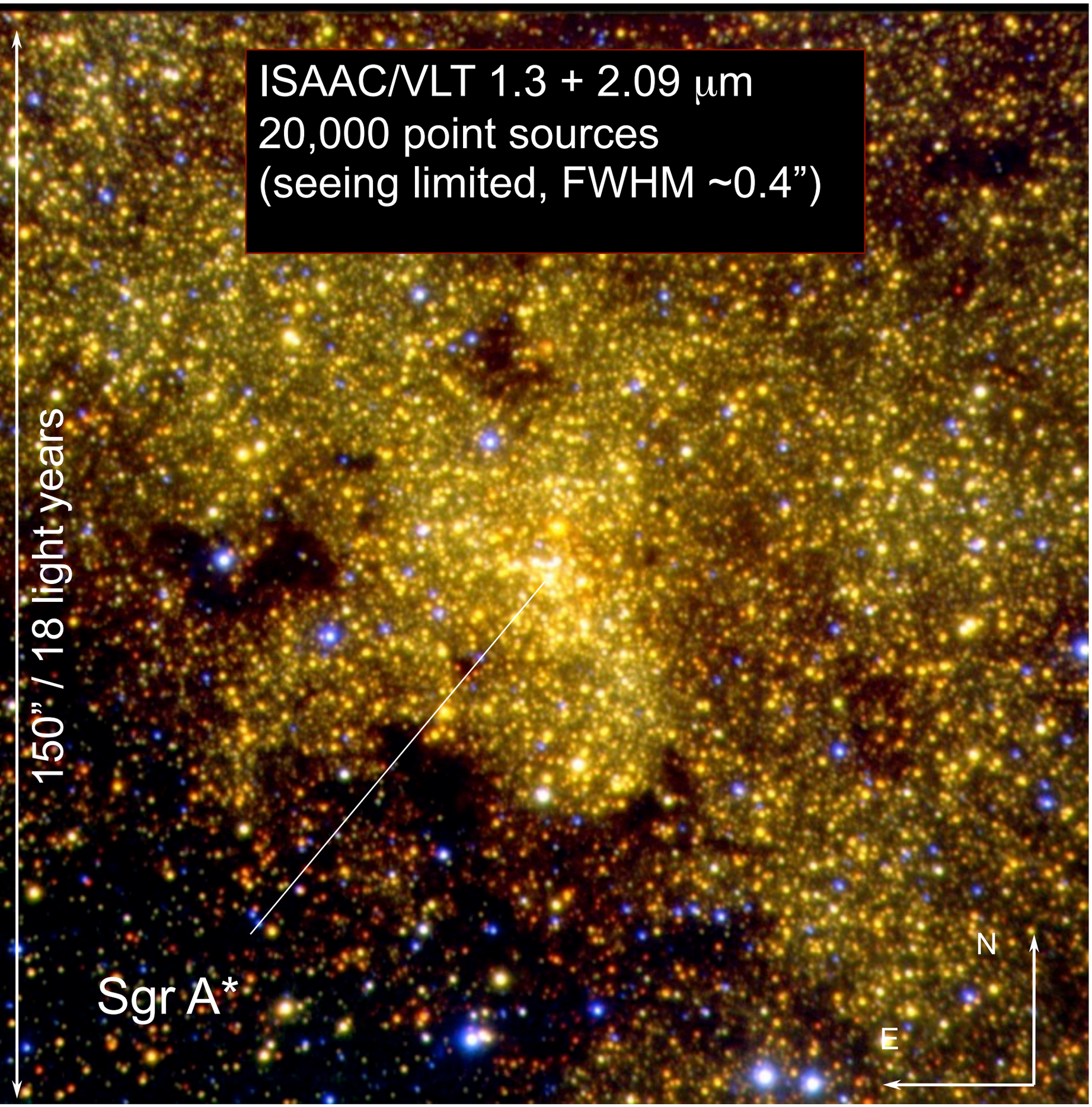
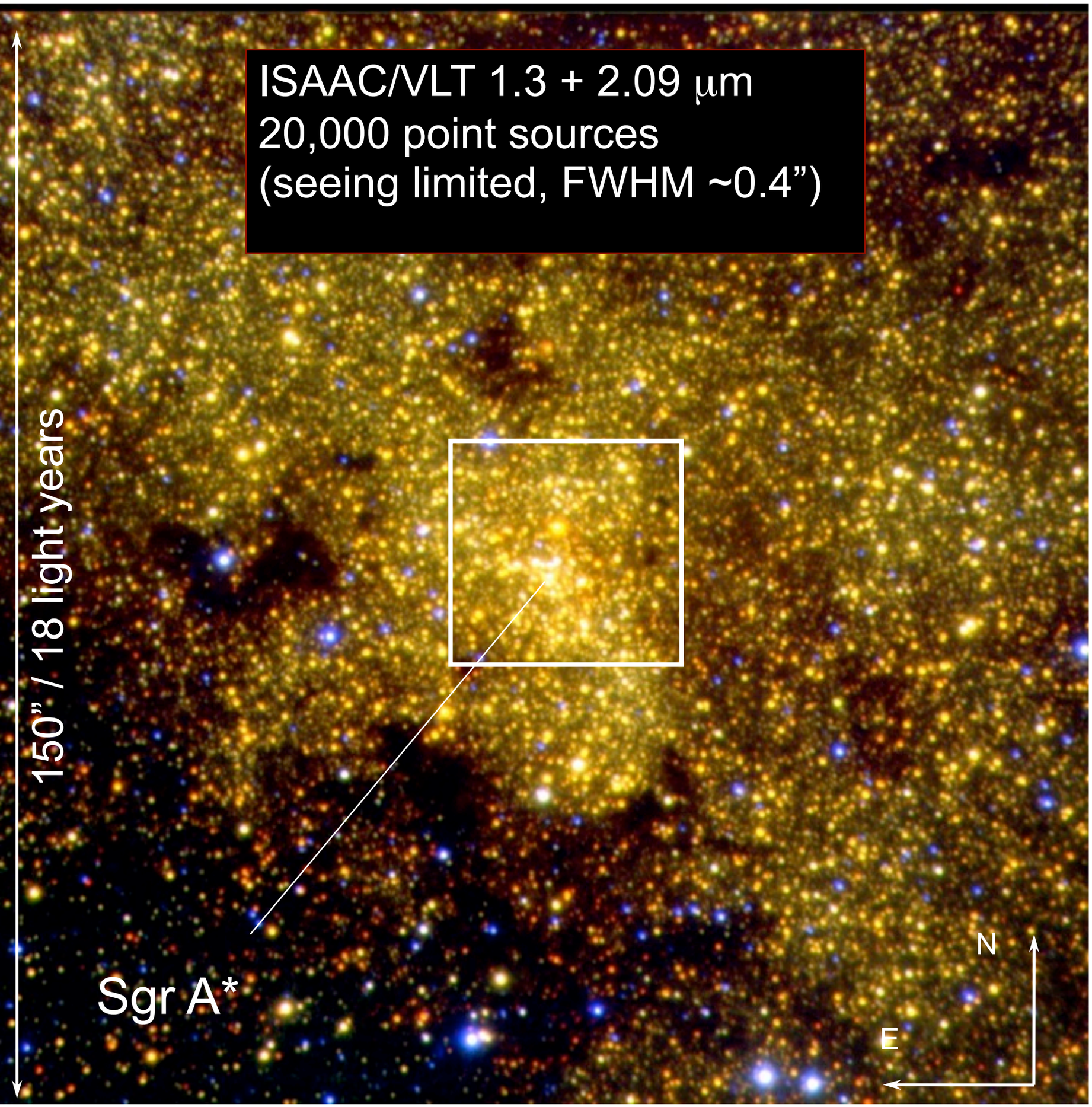


Cusp formation is a **robust** prediction of theoretical stellar dynamics

(e.g., *Lightman&Shapiro, 1977; Bahcall & Wolf 1976, 1977; Freitag+ 2006; Hopman & Alexander 2006)*.


ISAAC/VLT 1.3 + 2.09 μm
20,000 point sources
(seeing limited, FWHM ~0.4”)
150” / 18 light years
Sgr A*
N
E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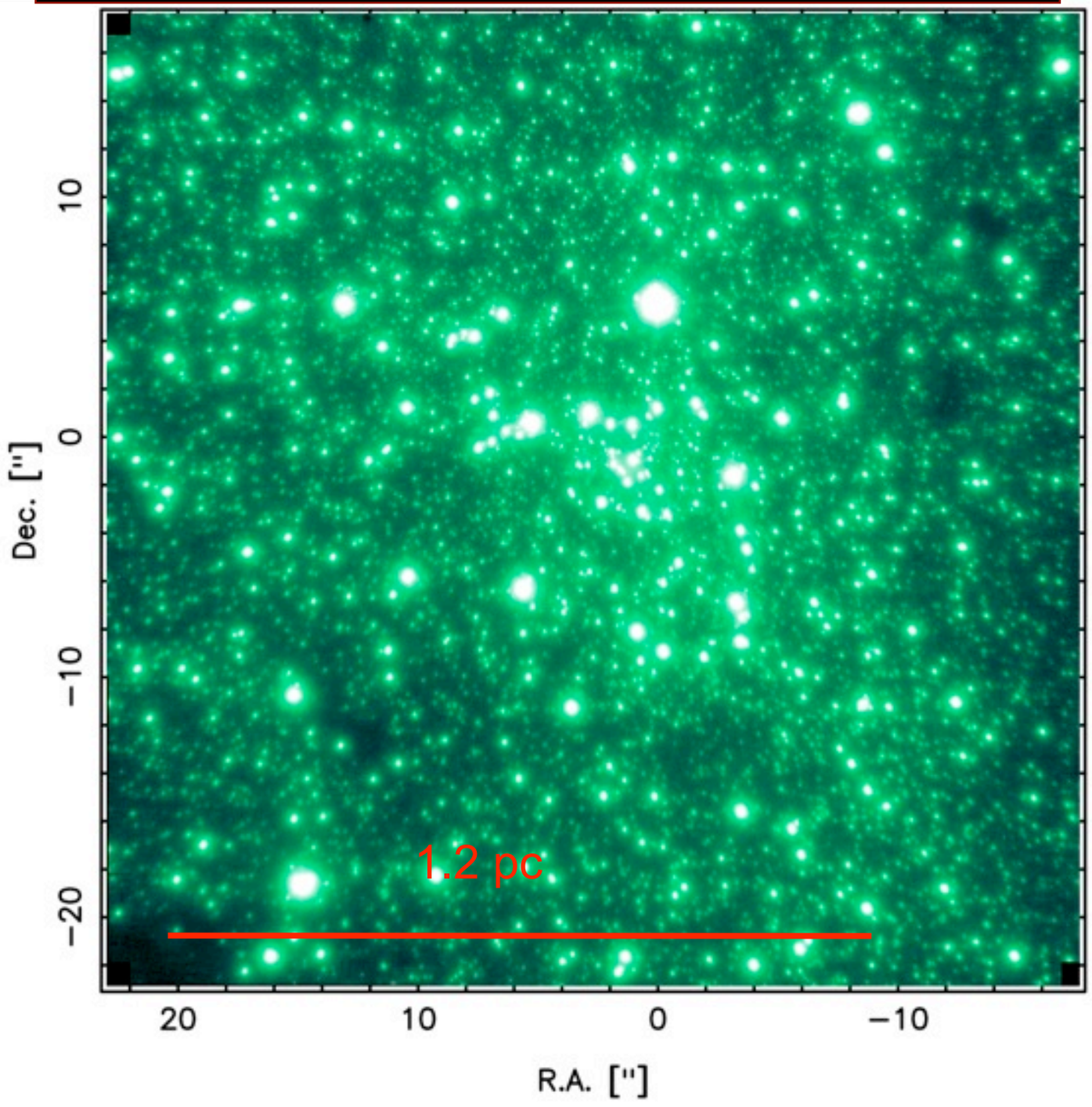
N
E

ISAAC/VLT 1.3 + 2.09 μ
20,000 point sources
(seeing limited, FWHM

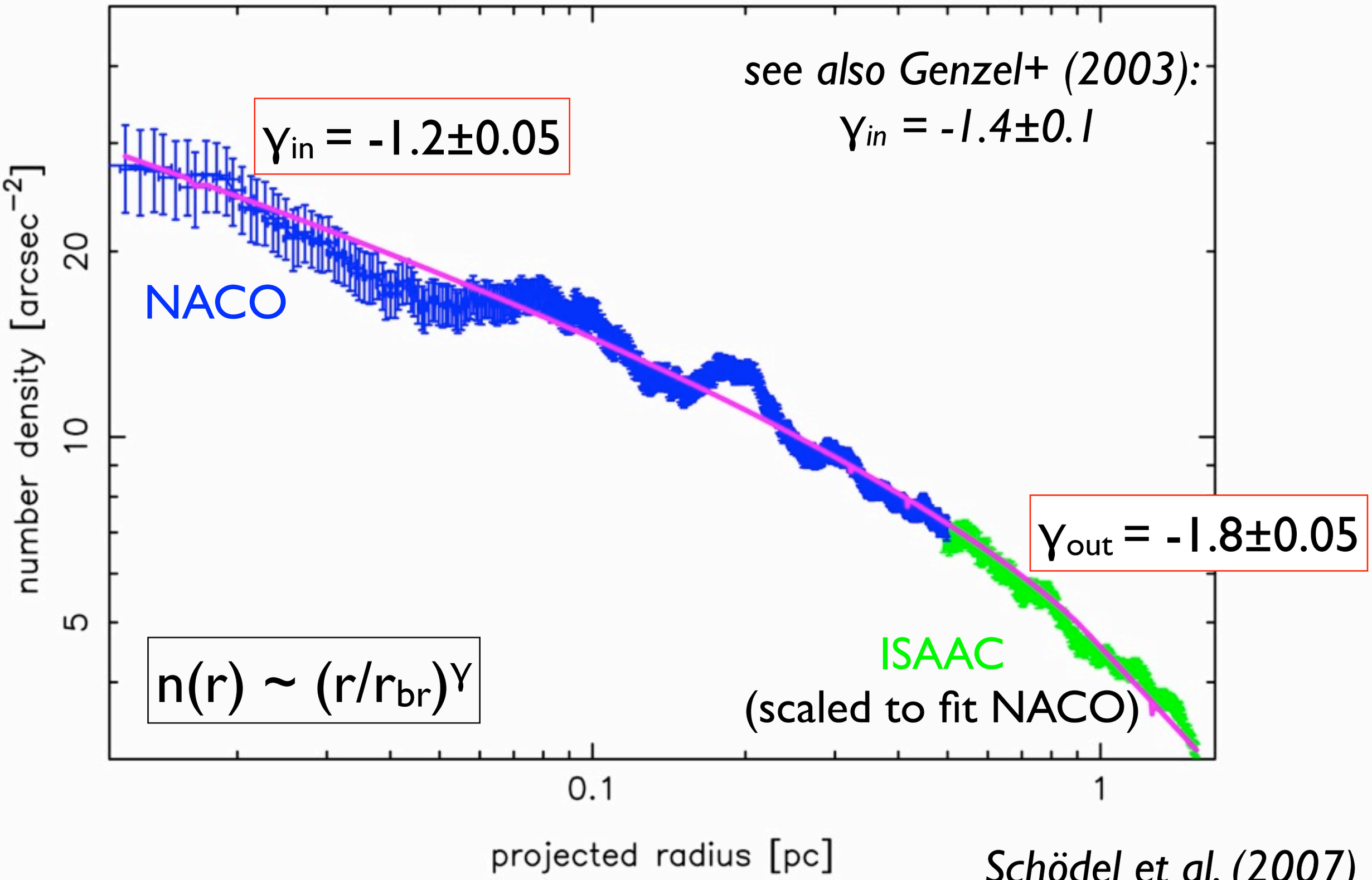
NACO/VLT, 2.2 μm
adaptive optics, ~0.06” FWHM
10,000 point sources ($mag_K \leq 17.5$)

150” / 18 light years

Sgr A*



Stellar surface number density



Schödel et al. (2007)

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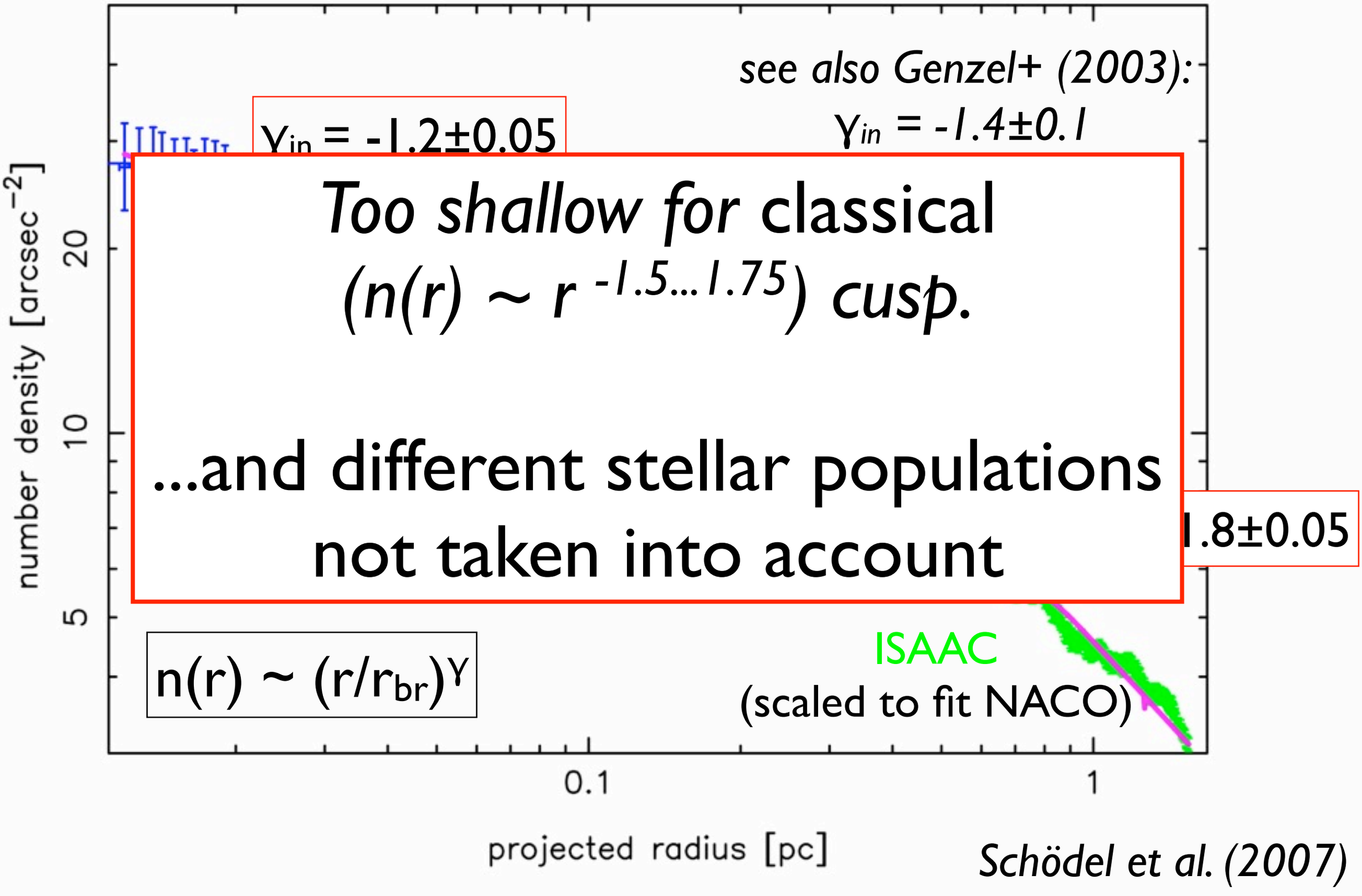

Schödel et al. (2007)

Classifying stars at the GC

...is painful business.

- high ($A_V \approx 40, A_K \approx 3$) and variable (scales of arcsec) extinction
- only H,K,L observations (narrow range of stellar colors)
- crowded field: ~10 sources/arsec^2
- FOV of spectroscopy very small
- photometric precision limited by crowding and PSF variability

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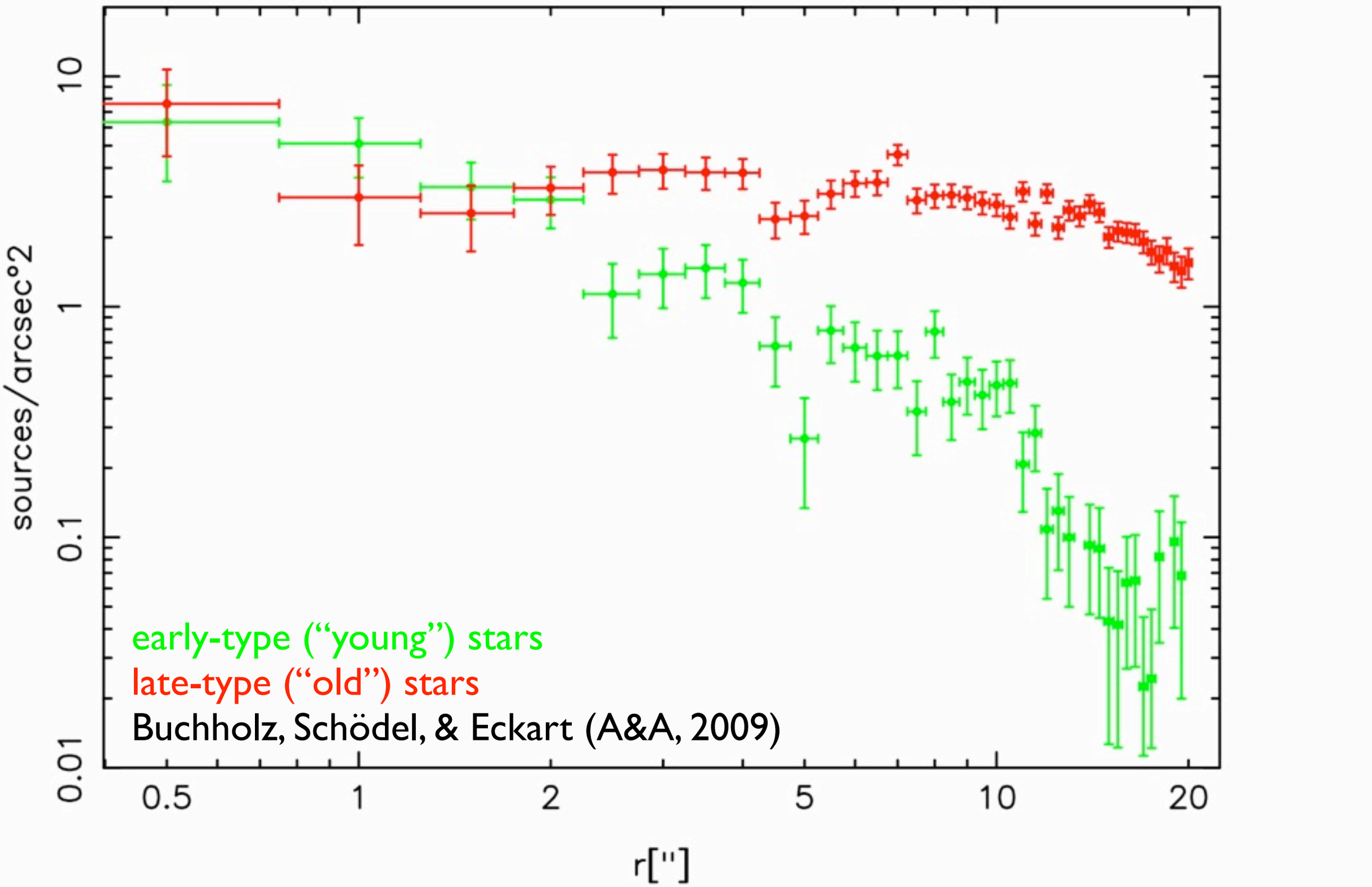
... but it can be done

- reasonably accurately with IFS for hundreds of stars *(e.g. Eisenhauer+ 2005; Maness+ 2007; Do+ 2009; Bartko+ 2010)*, using dozens of hours of observing time
- more dirtily (~90% accuracy) but efficiently via narrow band imaging for 1000s of stars in the central pc *(Buchholz + 2009)*

n(r) of old stars ≠ n(r) of young stars



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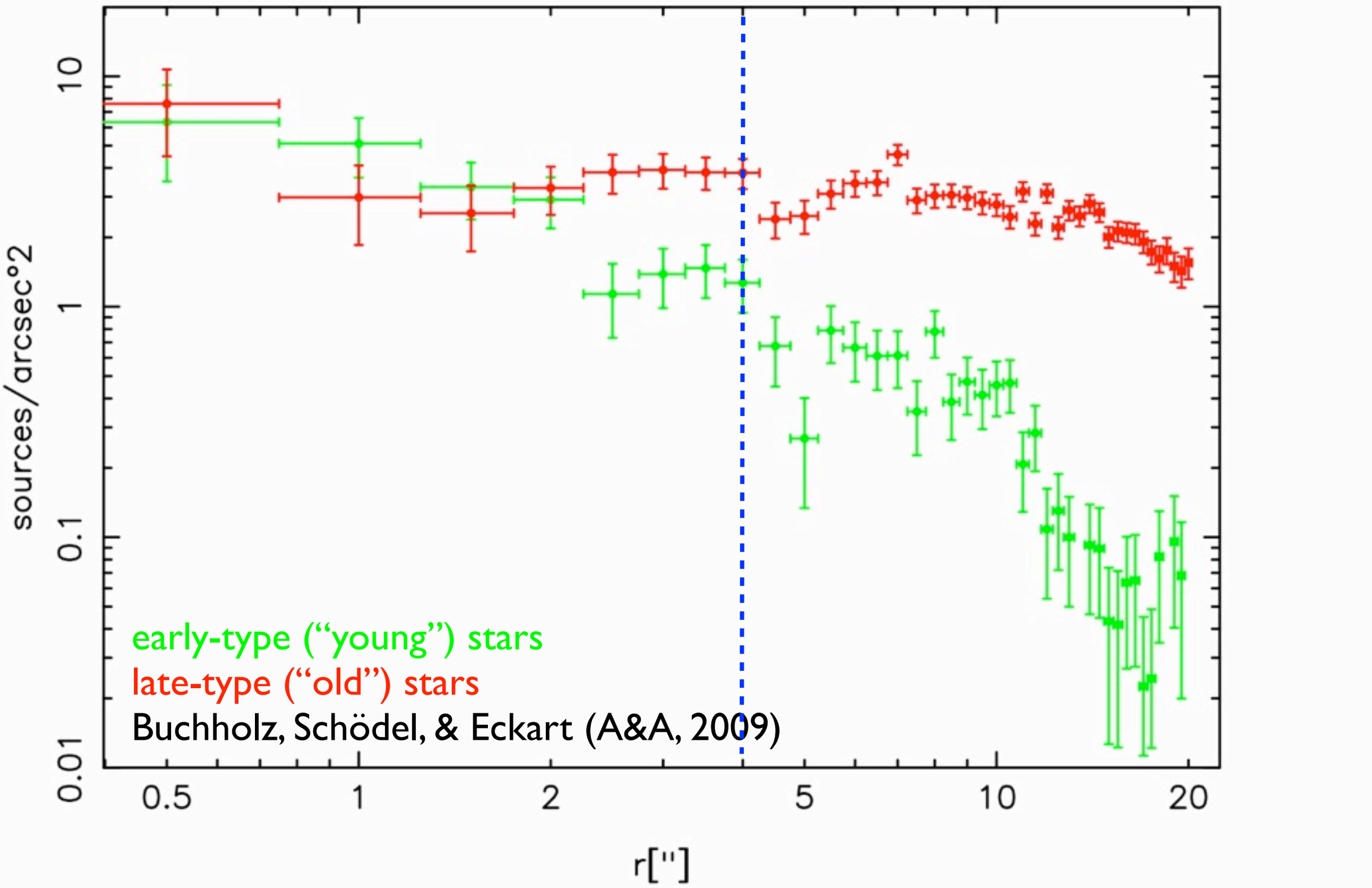
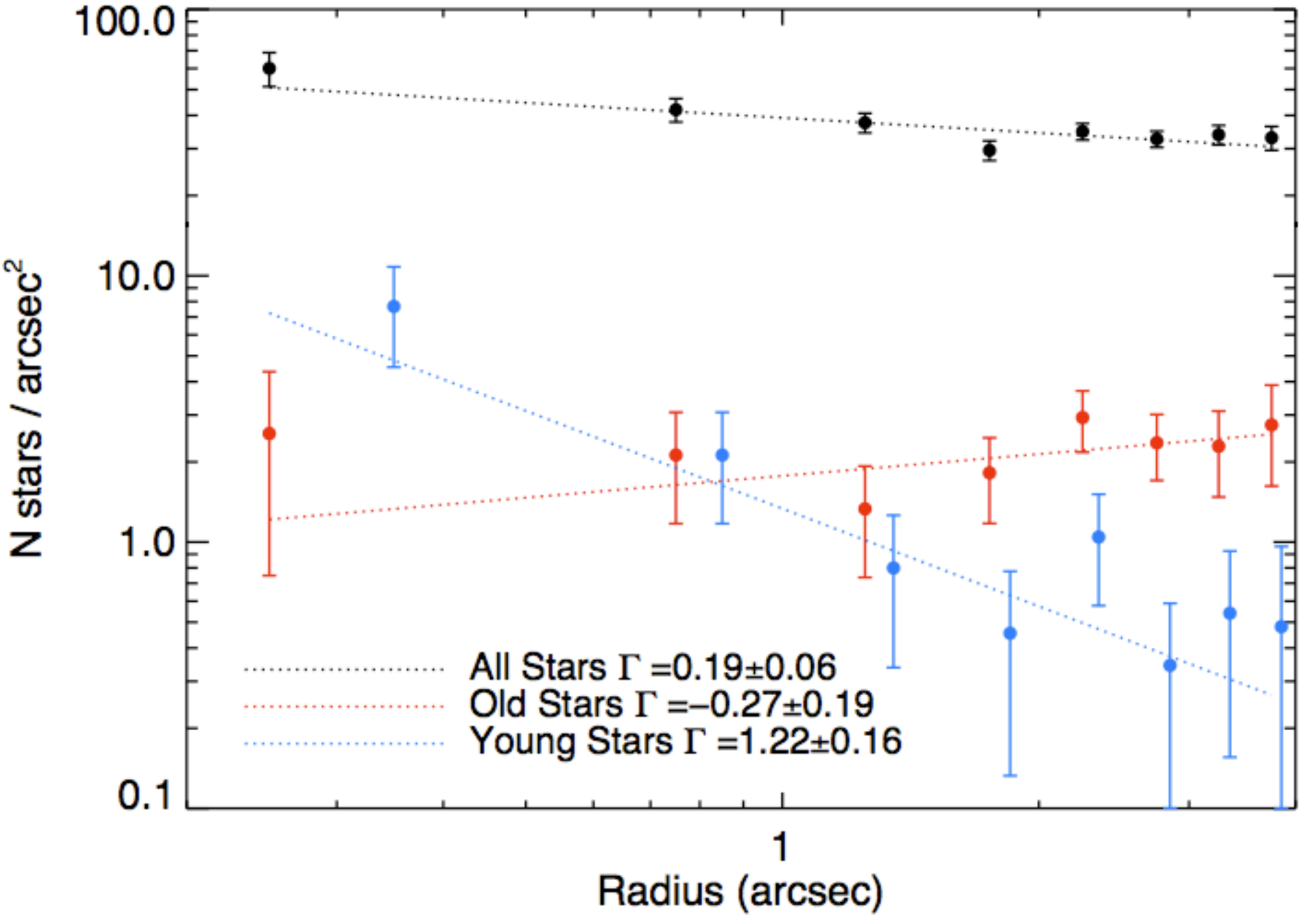


Stellar classification with AO-assisted integral field spectroscopy

(OSIRIS/Keck Do et al., 2009; see also SINFONI//VLT : Bartko et al. 2010)



Stellar classification with AO-assisted integral field spectroscopy

(OSIRIS/Keck Do et al., 2009; see also SINFONI//VLT : Bartko et al. 2010)

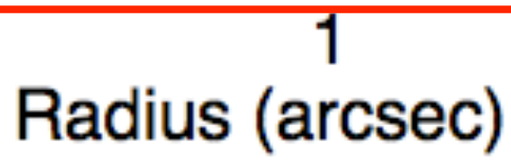
Decreasing density of old stars toward Sgr A*.

➔ $\gamma < 1.0$ with >99% probability *(Do et al., 2009)*

➔ There is no observable cusp, maybe even a deficit of old stars around Sgr A*

Known for the brightest (K<13) giants since the 1990s. The new measurements show that there is also a deficit of the lower mass RC giants near Sgr A*.

(Sellgren+ 1990; Genzel+ 1996; Haller+1996; first indication for RC stars given in Genzel+ 2003)



Where is the stellar cusp at the GC?

- Destroyed:
  e.g., by infall of IMBH up to a few 10^9 yr ago *(see Merritt &Szell 2006)*

- Not yet formed:
  necessary time scale may be longer than ~10^{10} yr *(Merritt 2009)*

- Invisible:
  giants could be destroyed by collisions with MS stars and BHs in dense cluster center; however, mechanism probably not effective enough *(e.g. Dale+ 2009)*

- Are our assumptions correct?
  Continuous star formation, cluster not old enough?, cluster structure on large scales, relation to nuclear stellar disk, fraction of disrupted stars accreted onto BH?, etc.

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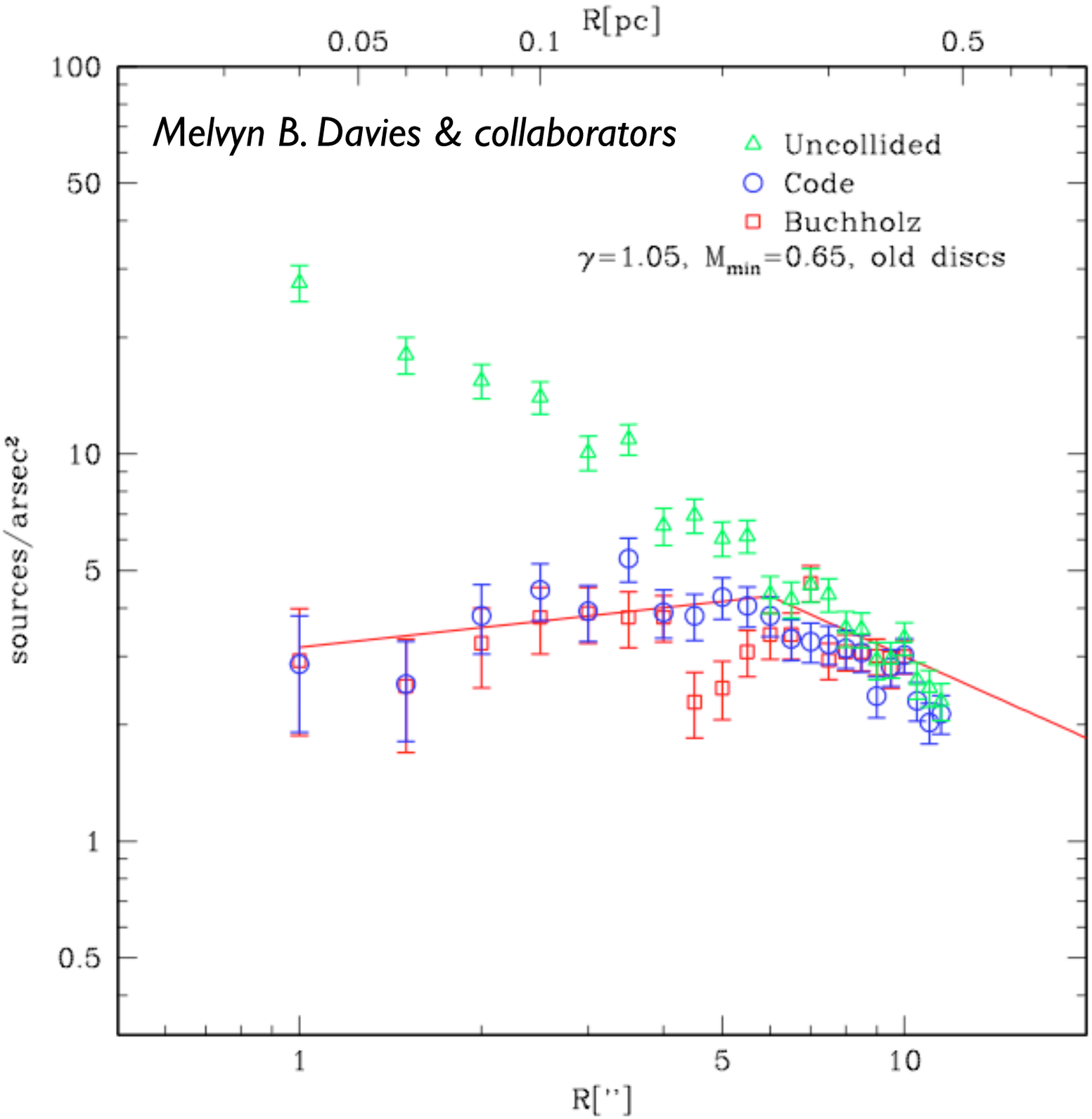

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What do we observe at the GC?

50% completeness limit in central parsec: $K \approx 18$ (MS stars of $\sim 2 M_\odot$)

Main tracers are HB/RC stars.

What do we observe at the GC?

Source:Wikipedia
Created by Uwe Kils (iceberg) and User:Wiska Bodo (sky).

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Main tracers are HB/RC stars.