Image: central ~20pc of NGC205

Nearby Nuclear Star Clusters

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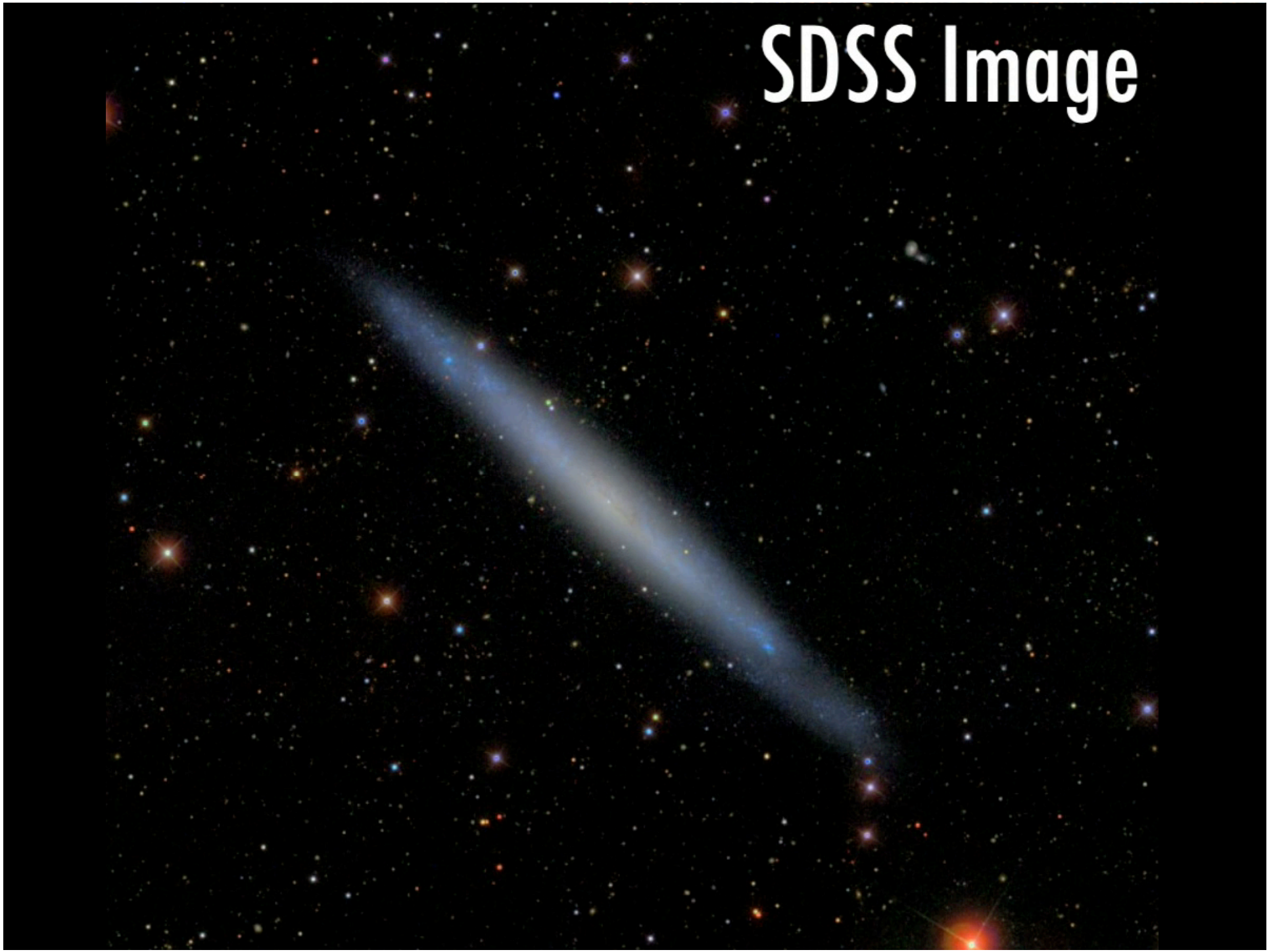
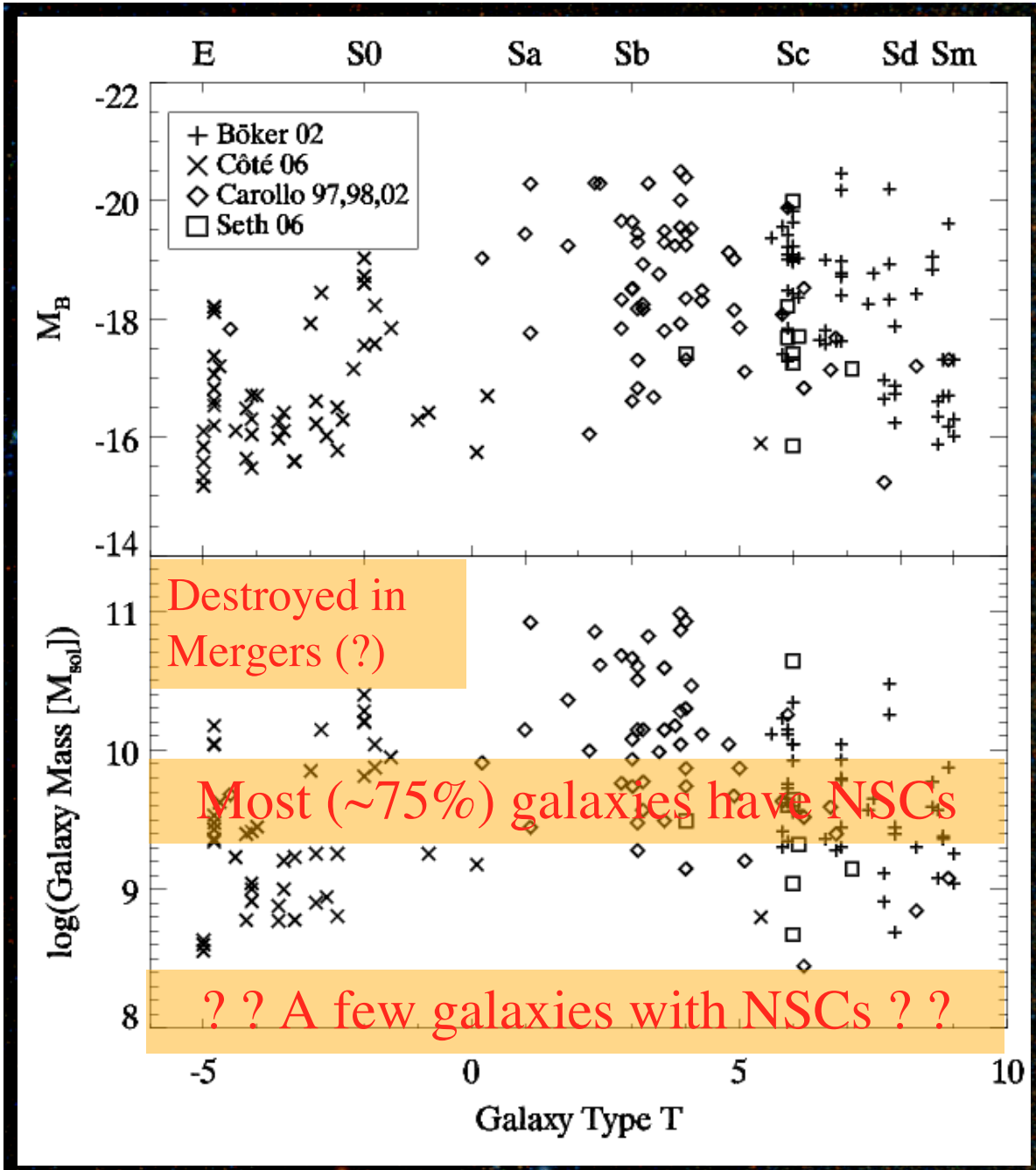
Initial results in:

Seth et al, 2008, ApJ 687, 997

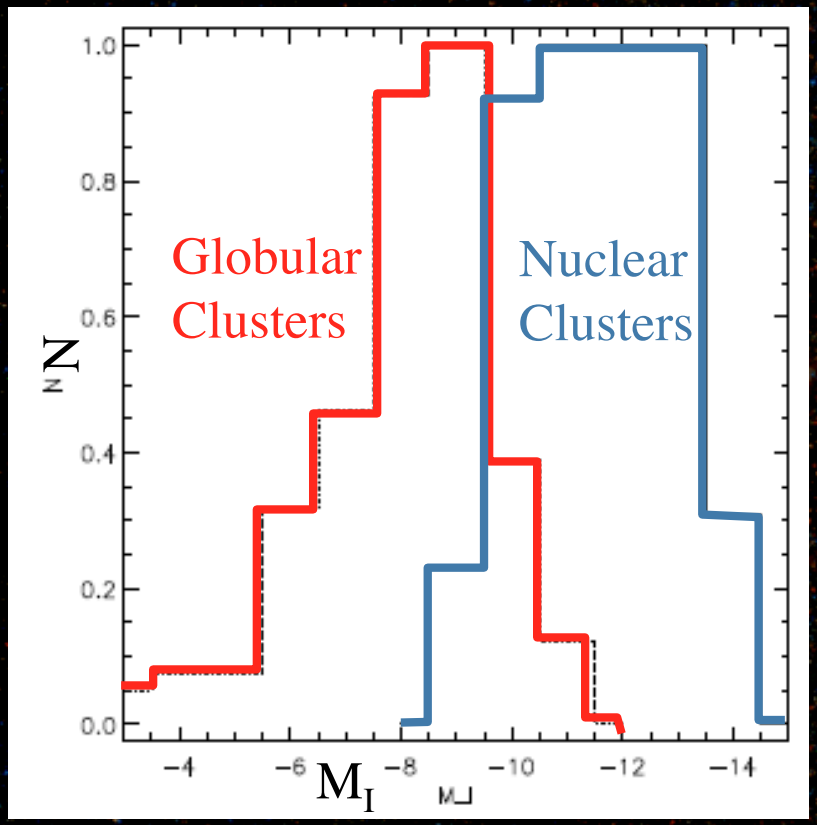

SDSS Image

Where Nuclear Star Clusters (NSCs) Live



Seth et al 2008a

Nuclear Star Cluster Properties

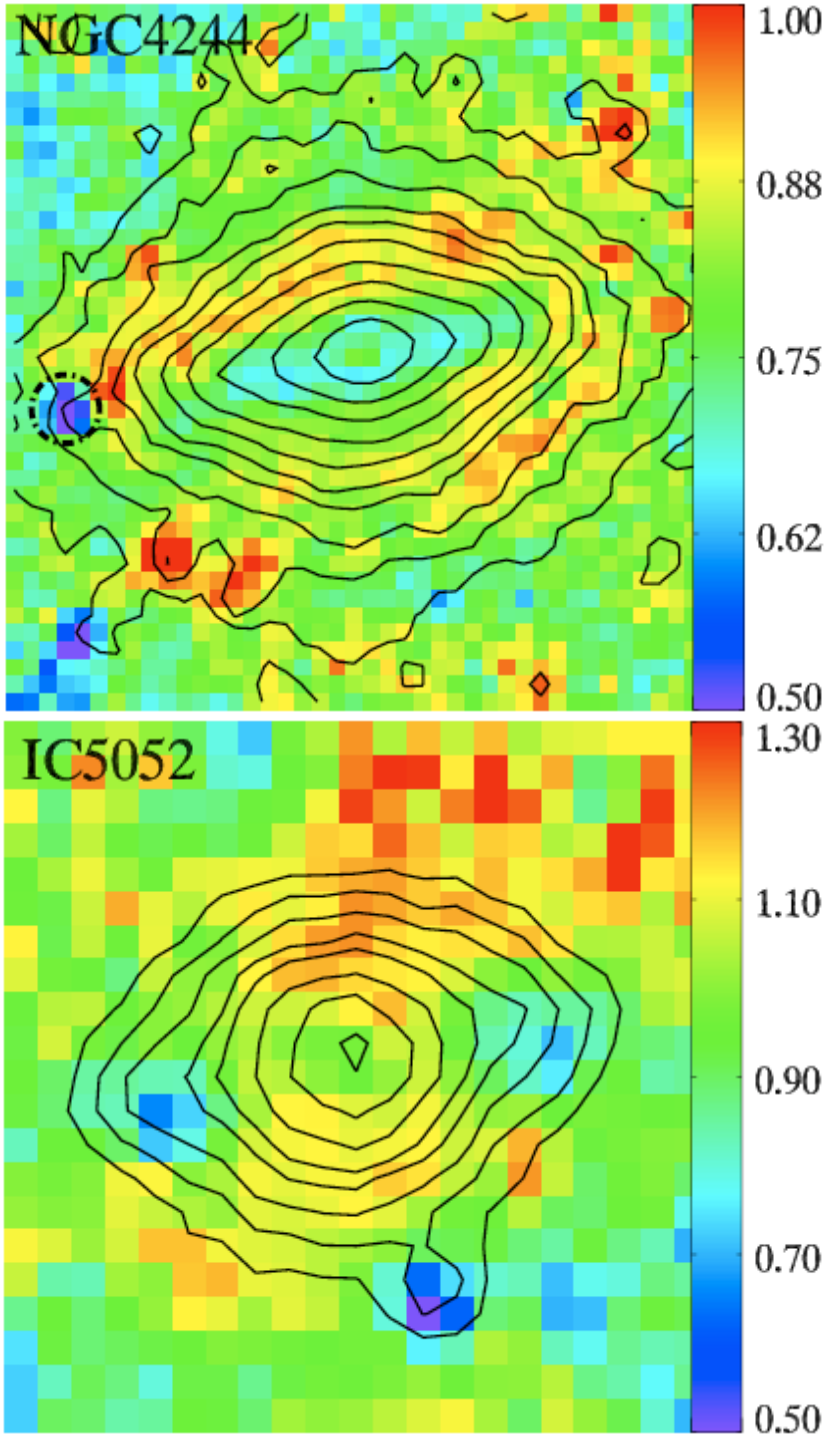


M_I histogram from Boeker, 2004

Compared to Globular Clusters:

- **Similar size** (r_{eff} ~ 5 pc)
- **Brighter** (M_I ~ -12)
- **More massive** (~10^7 M_{sol})

(Walcher et al 2005)



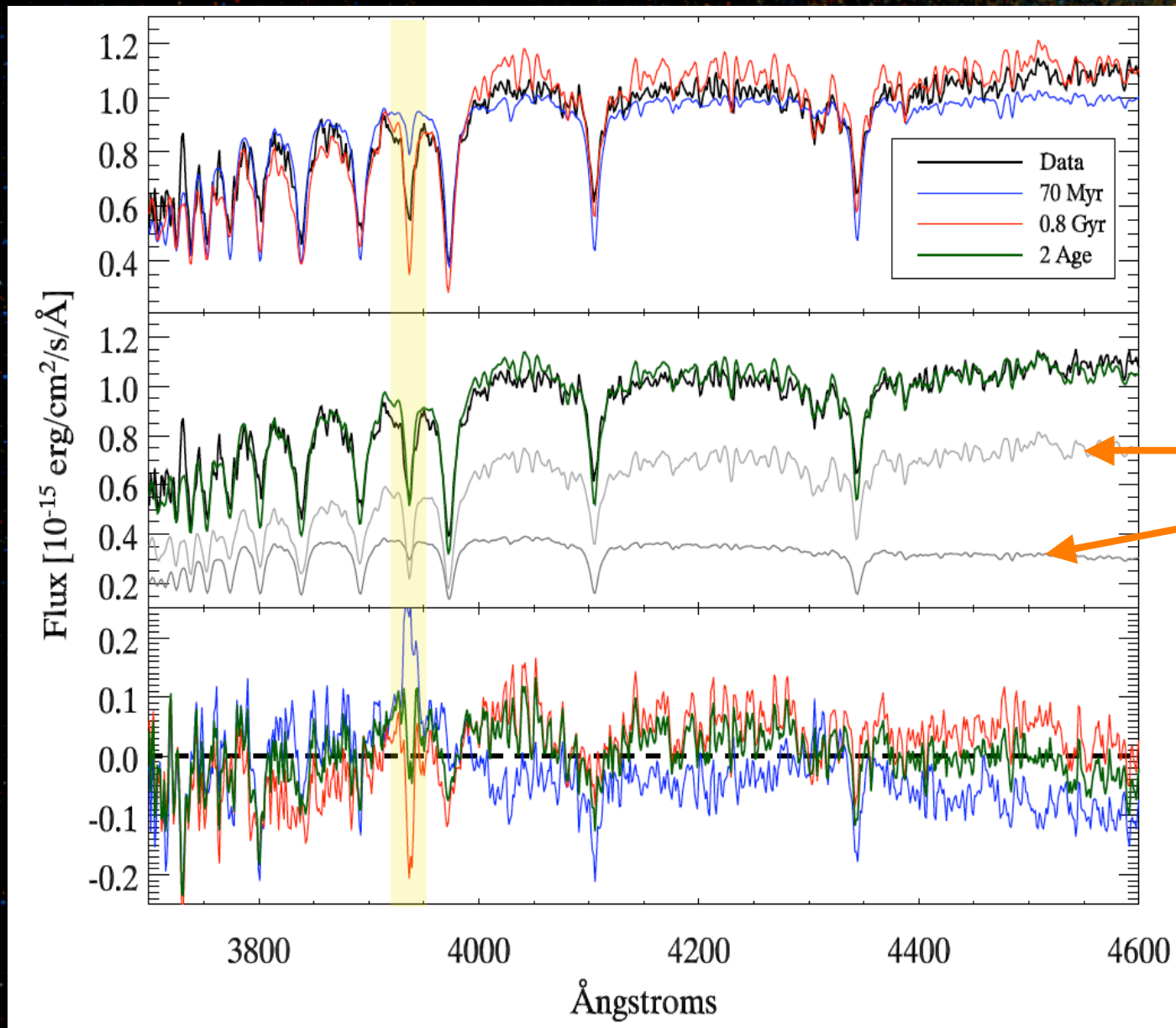
Complex Morphology

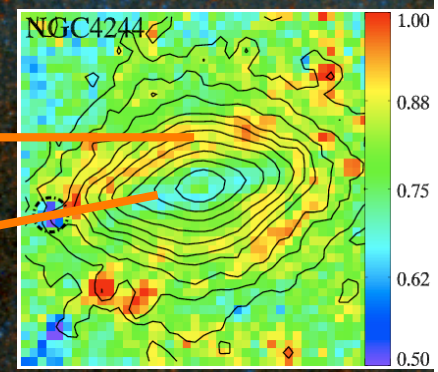
In edge-on spirals:

- Bluer disks/rings *aligned with galaxy disks*
- Redder more spheroidal components.

Seth et al 2006

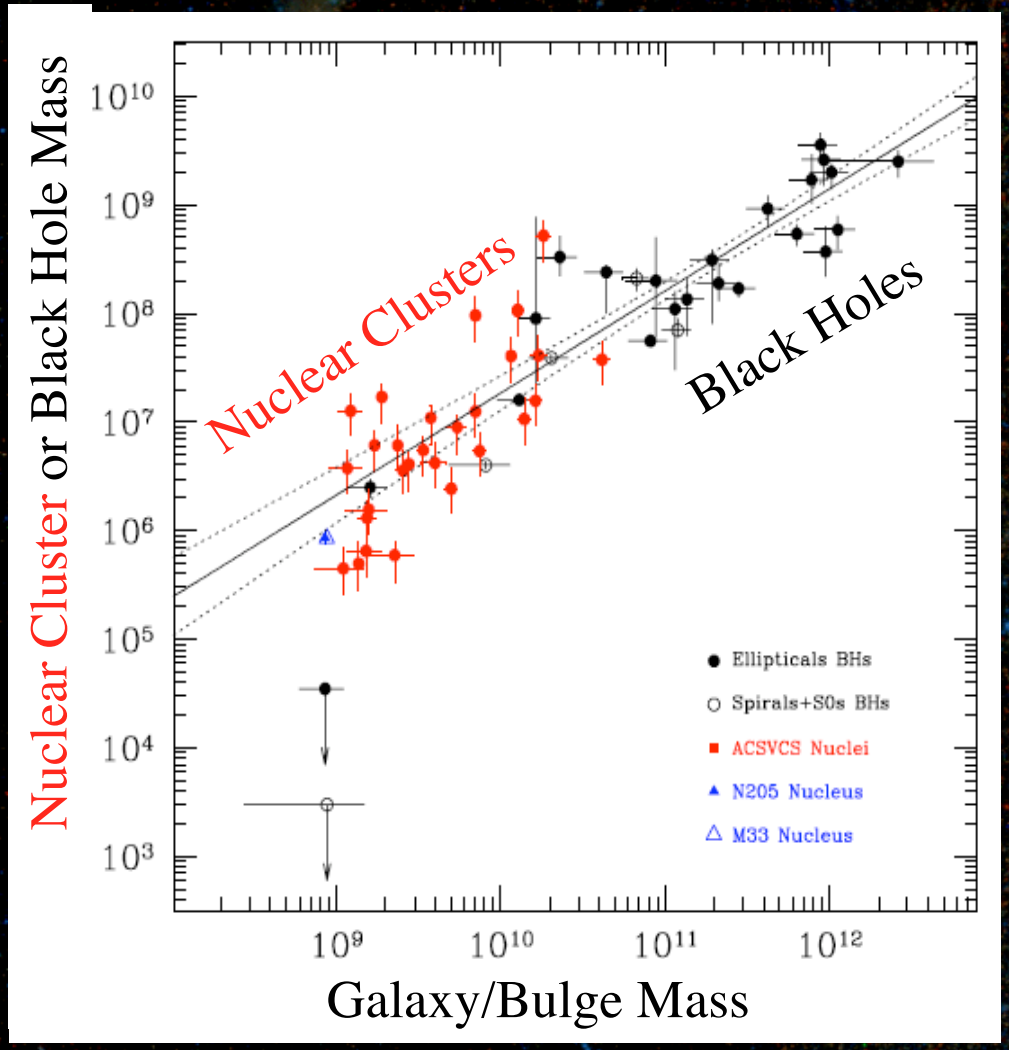
Multiple stellar pops





Seth et al 2006, Walcher et al 2006, Rossa et al 2006

Nuclear Star Clusters & Black Holes



Ferrarese et al 2006

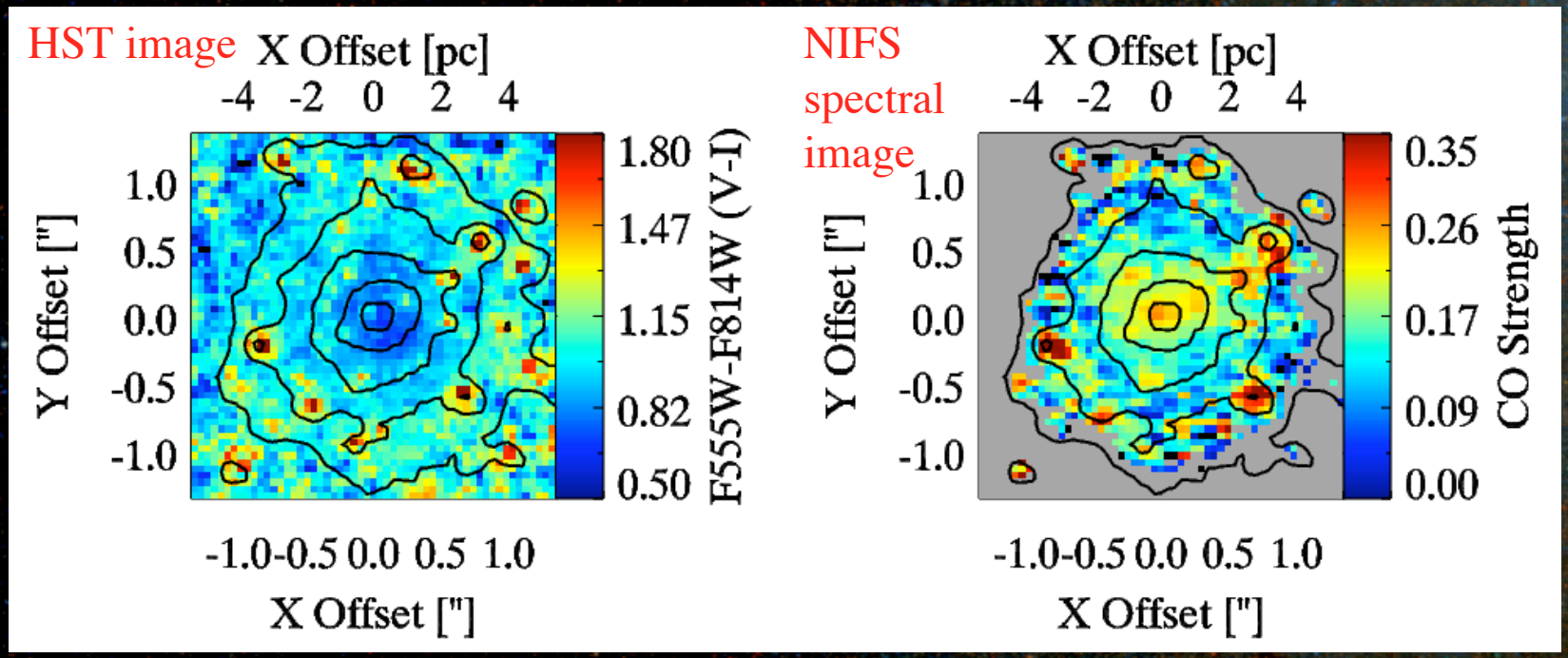
- Nuclear cluster masses correlated with galaxy masses and bulge velocity dispersions. (Wehner & Harris 2006, Rossa et al 2006, Ferrarese et al 2006, Graham & Driver, 2007)

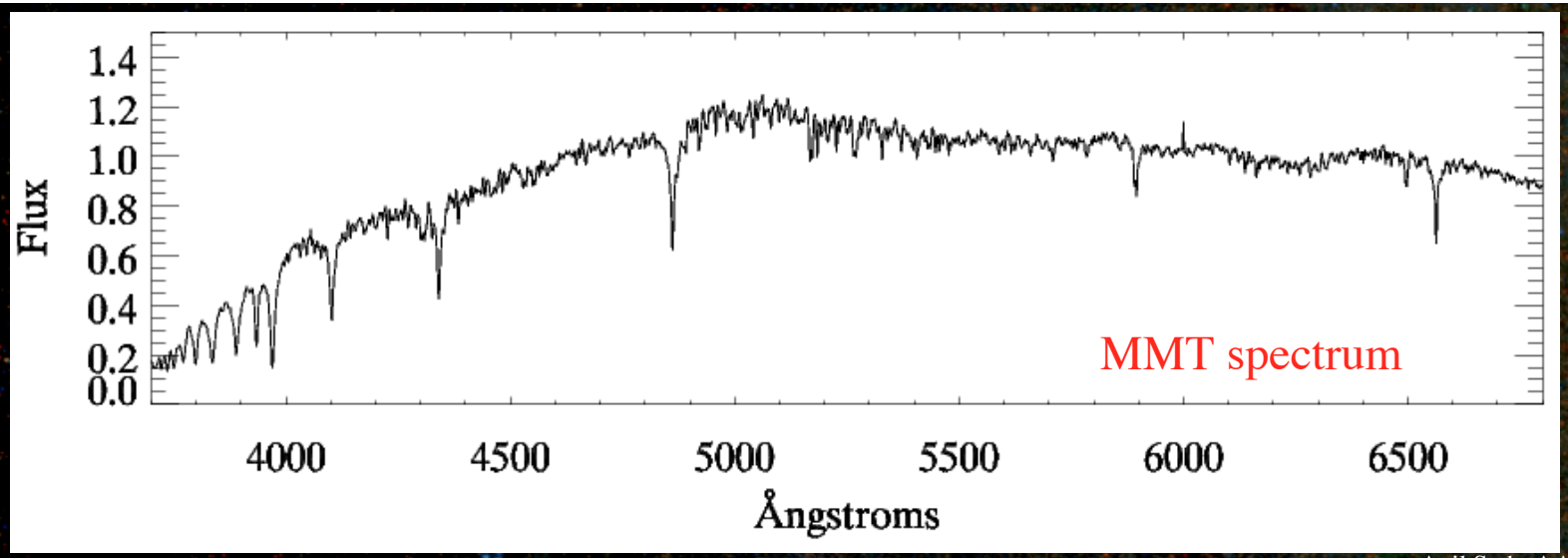
- Sometimes coexist (e.g. Milky Way, also Seth et al 2008a, Filippenko & Ho 2003, Satyapal et al 2007)

The Nearest Nuclear Star Clusters w/ Adaptive Optics

- Study nuclear star clusters within 5 Mpc in detail.
  1. Resolve stellar populations and kinematics --> formation / mass accretion history.
  2. Measure masses for the nuclear star clusters (and black holes?) --> scaling relations.
- 14 nuclear star clusters with D < 5 Mpc, Gemini/NIFS observations of 4 so far.

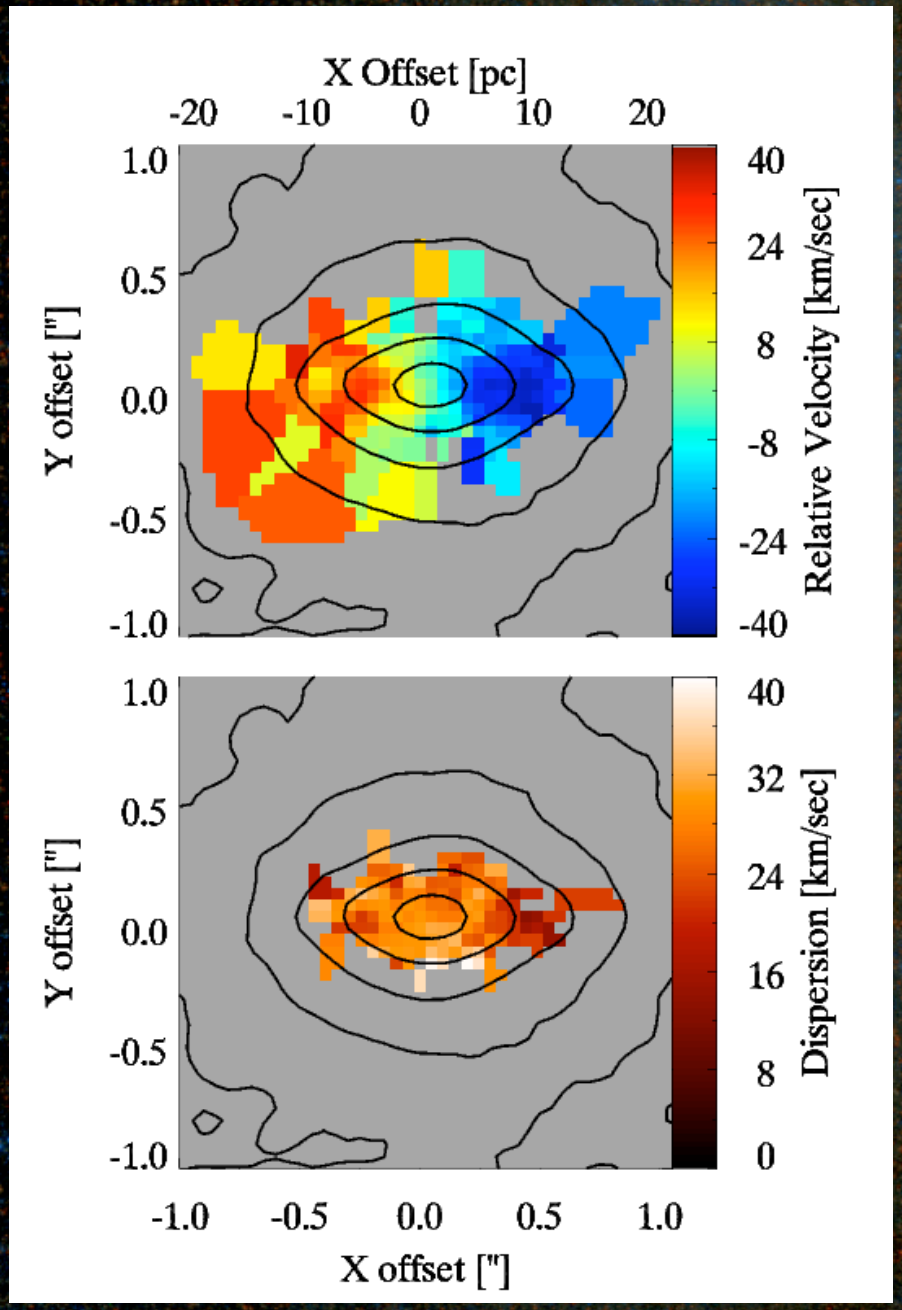
Stellar populations



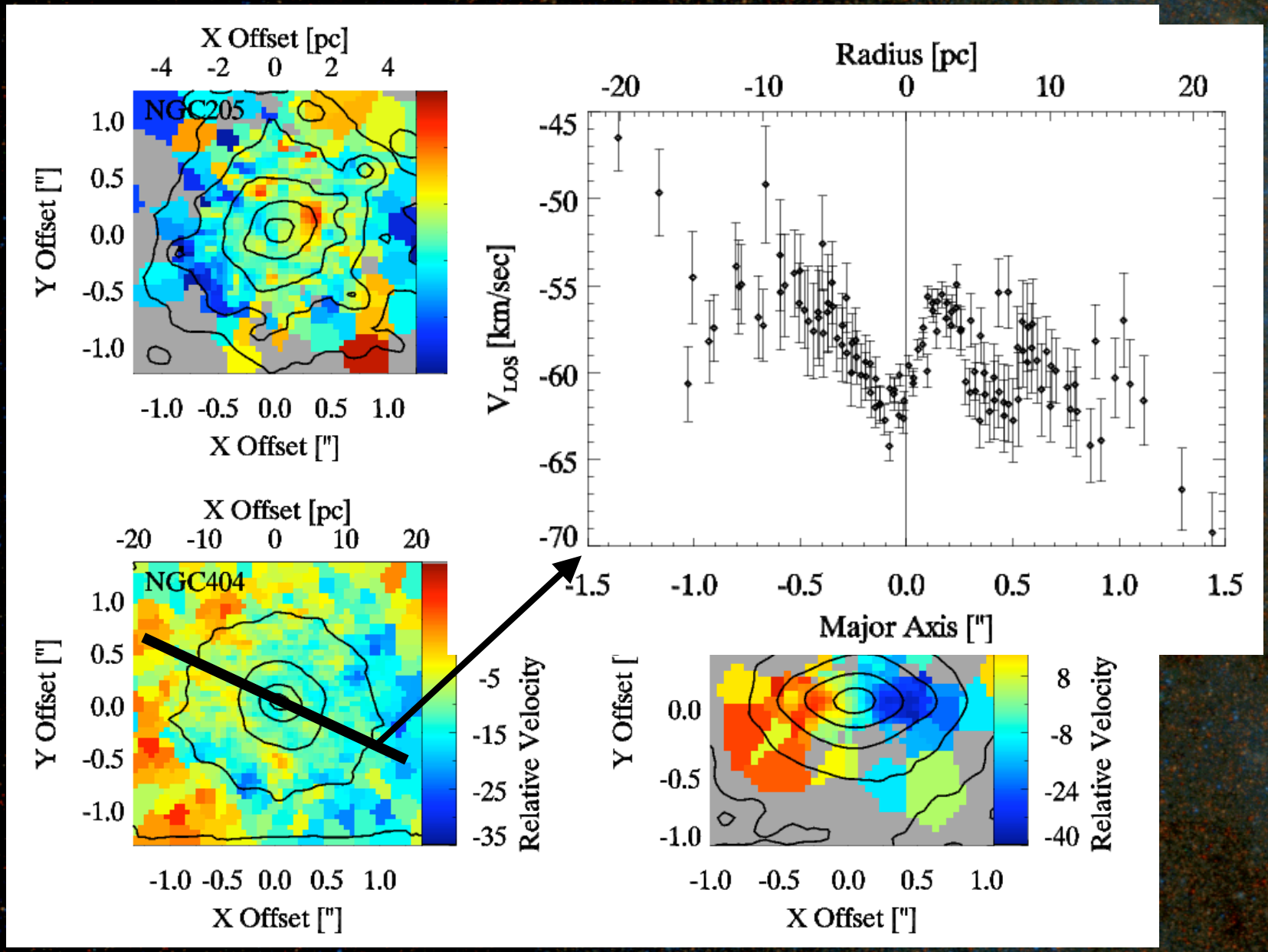


Resolving nuclear cluster kinematics

- Use Gemini/NIFS to achieve resolution of ~0.08”
- Kinematics from CO 2.3μm Bandhead
- NGC4244, whole cluster is rotating

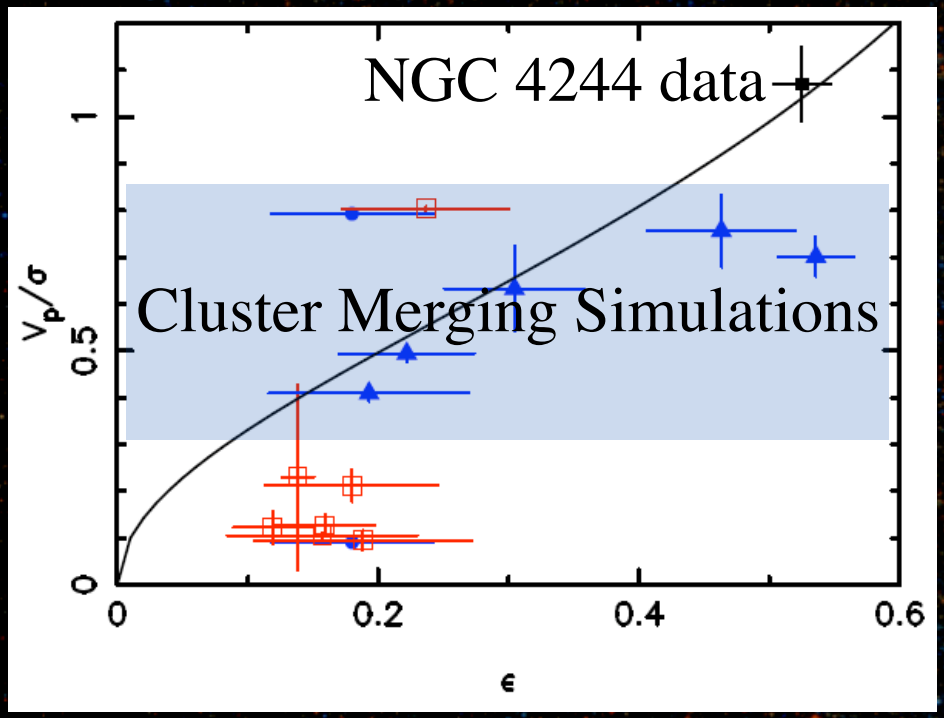


Seth et al 2008b



Lots of rotation; also Milky Way, G1, M54

Scenarios for nuclear star cluster formation



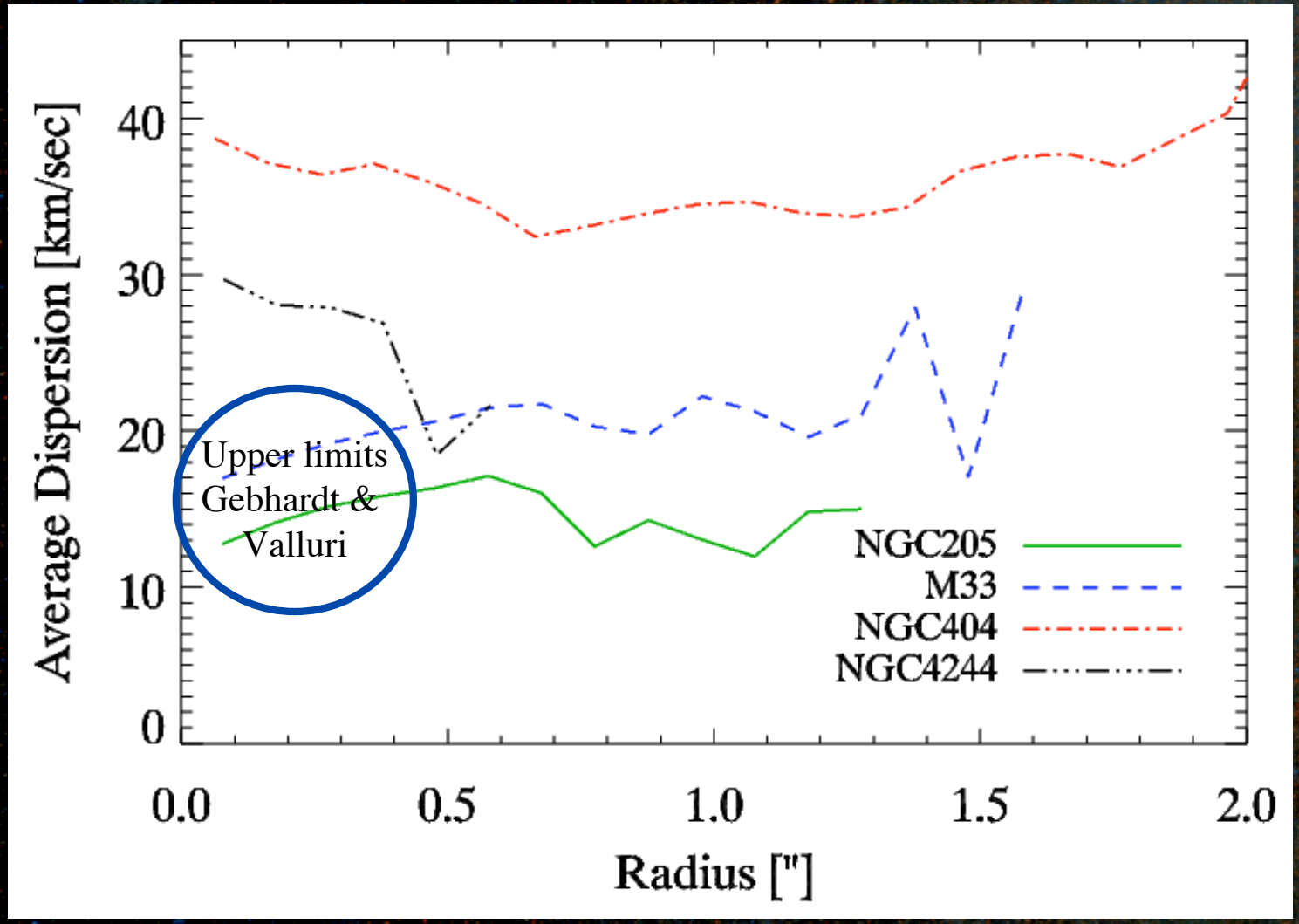
Hartmann et al, *in prep*

a) Dynamical friction makes globular clusters sink to center. Tremaine et al 1975, Lotz et al 2001

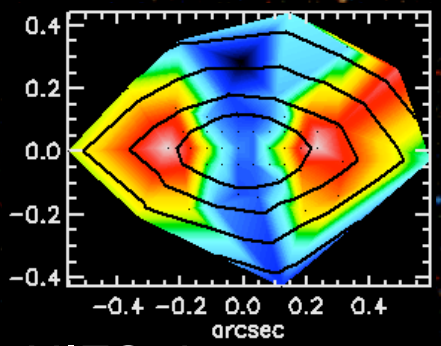
b) Formed *in situ* from gas transported to the center. Milosavljevic 2004, Bekki et al 2006

c) Young star clusters form in inner disk and sink to the center.

Mass modeling: nuclear star cluster masses & BH mass limits



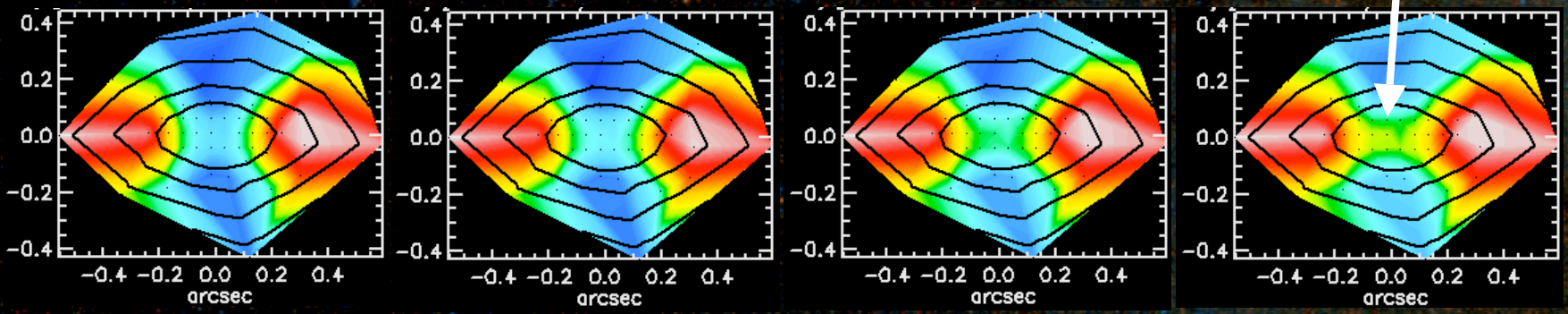
NGC4244:
Nuclear Cluster & Black Hole mass



NIFS data
NGC4244
$V_{RMS}=(V^2+\sigma^2)^{1/2}$

- Model with JAM Cappellari 2008
- Cluster mass ~1e7 $M_\odot$
- Fit for BH with fixed anisotropy
- BH < 1e5 $M_\odot$

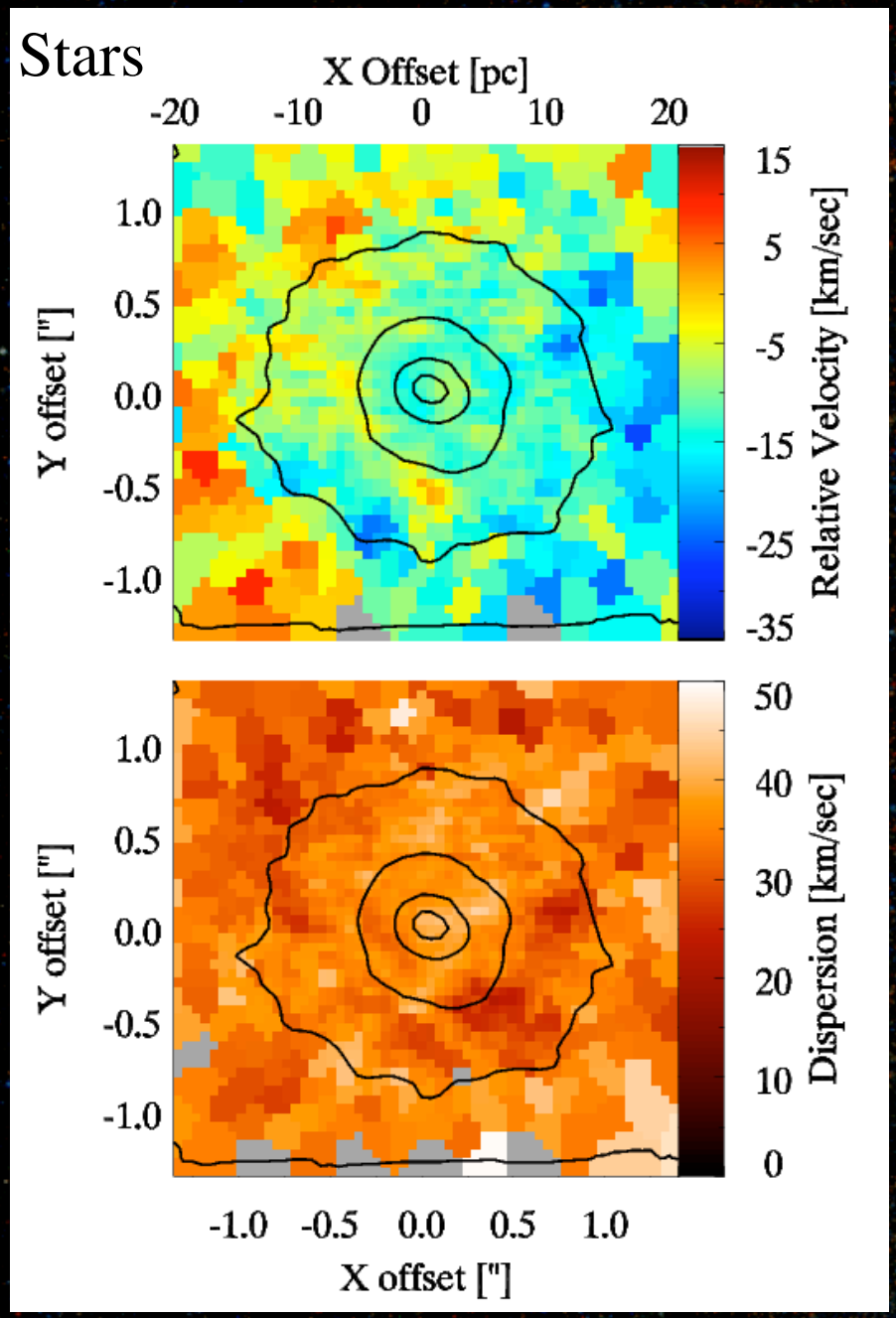
Note bridge



BH=0 | 8e4 | 1.5e5 | 2.3e5 Msun

NGC404: The Nearest LINER (D~3 Mpc)

- LINER spectrum
  (Ho et al 1997)
- Soft X-ray source
  (Eracleous et al 2002)
- MIR lines
  (Satyapal et al 2004)
- UV Variable
  (Maoz et al 2005)


Stars
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-10
0
10
20
Y offset ["]
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0.5
0.0
-0.5
-1.0
15
5
-5
-15
-25
-35
Relative Velocity [km/sec]
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40
30
20
10
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Dispersion [km/sec]
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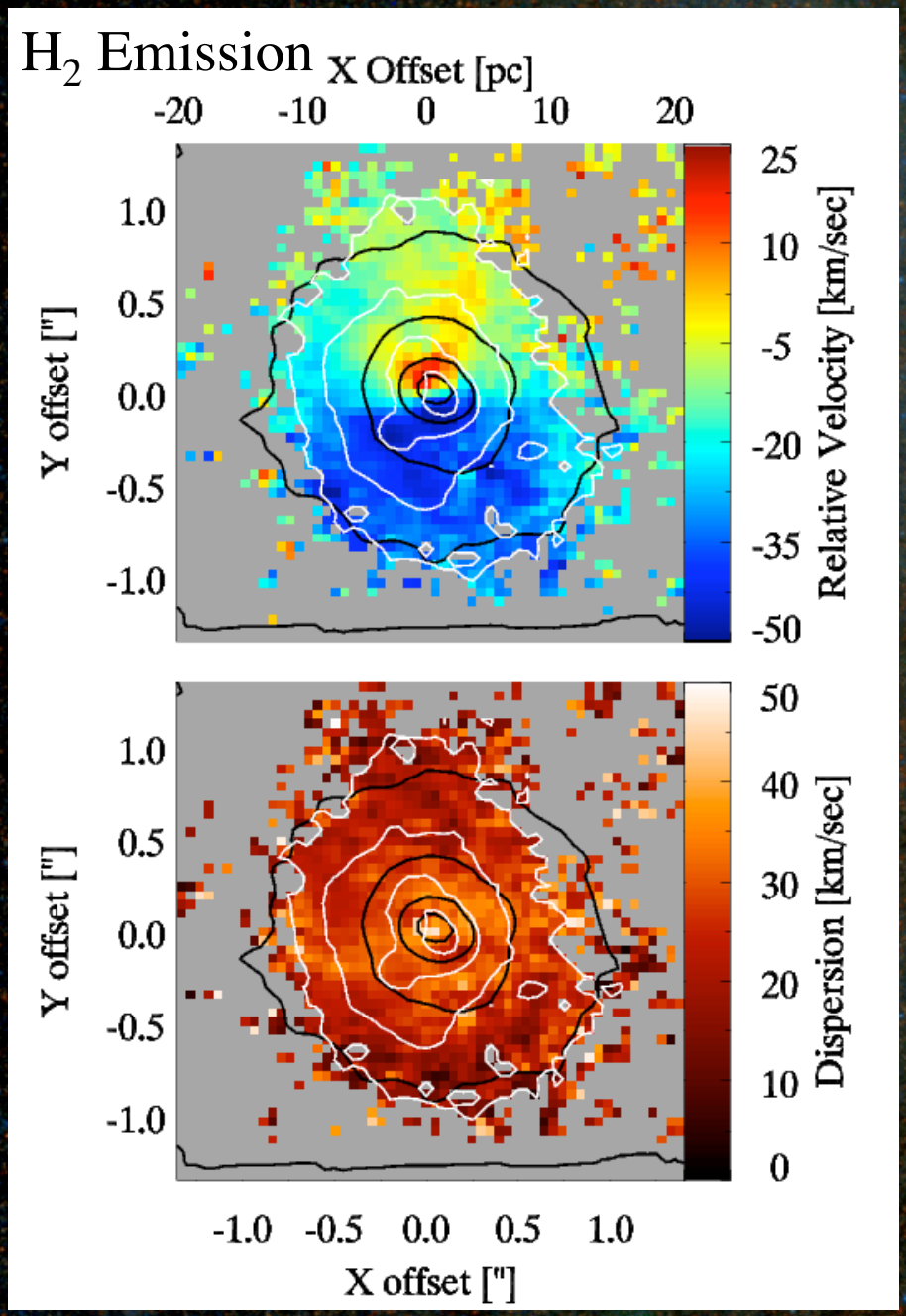
X offset ["]


H_2 Emission
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0
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20
Y offset ["]
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Relative Velocity [km/sec]
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40
30
20
10
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Dispersion [km/sec]
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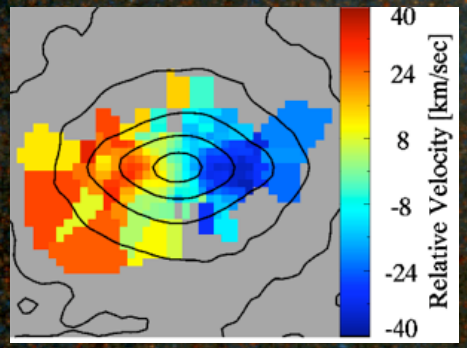
Conclusions

- Nuclear star clusters are common and interesting!

- Kinematics, populations and morphology suggest regular gas accretion into galaxy centers.



- May host detectable IMBHs