Observations of the Galactic center with Subaru/GLAO

Shogo Nishiyama
(NAOJ)

Introduction
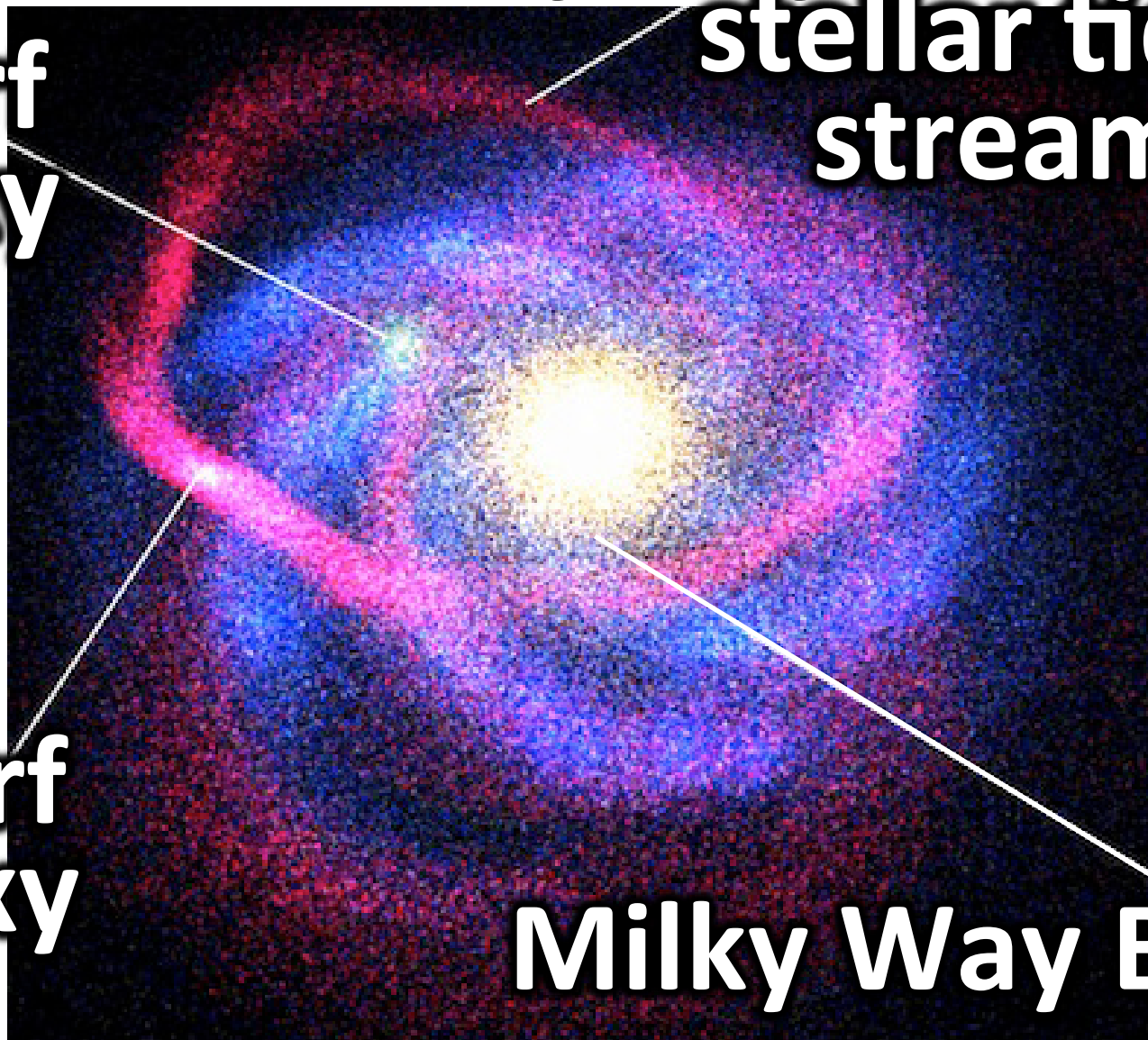

Milky Way

dwarf galaxy

stellar tidal stream
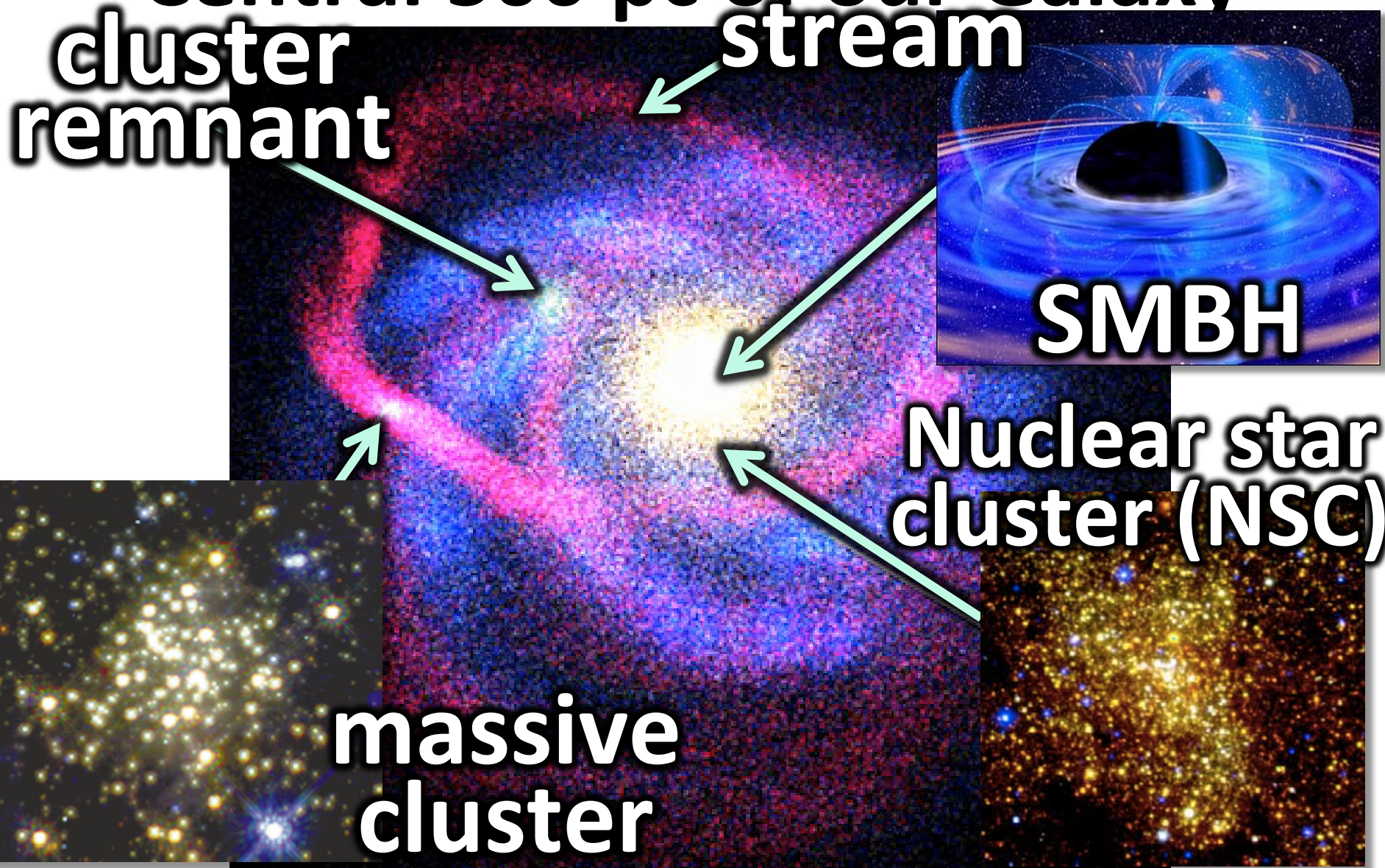
dwarf galaxy

Milky Way Bulge

©Strasbourg Observatory

Introduction

Central 500 pc of our Galaxy

cluster remnant

stream

SMBH

Nuclear star cluster (NSC)

massive cluster

Introduction

What I want to understand
1. How the NSC and SMBH are related
2. How the NSC evolved

Why GLAO+Subaru?
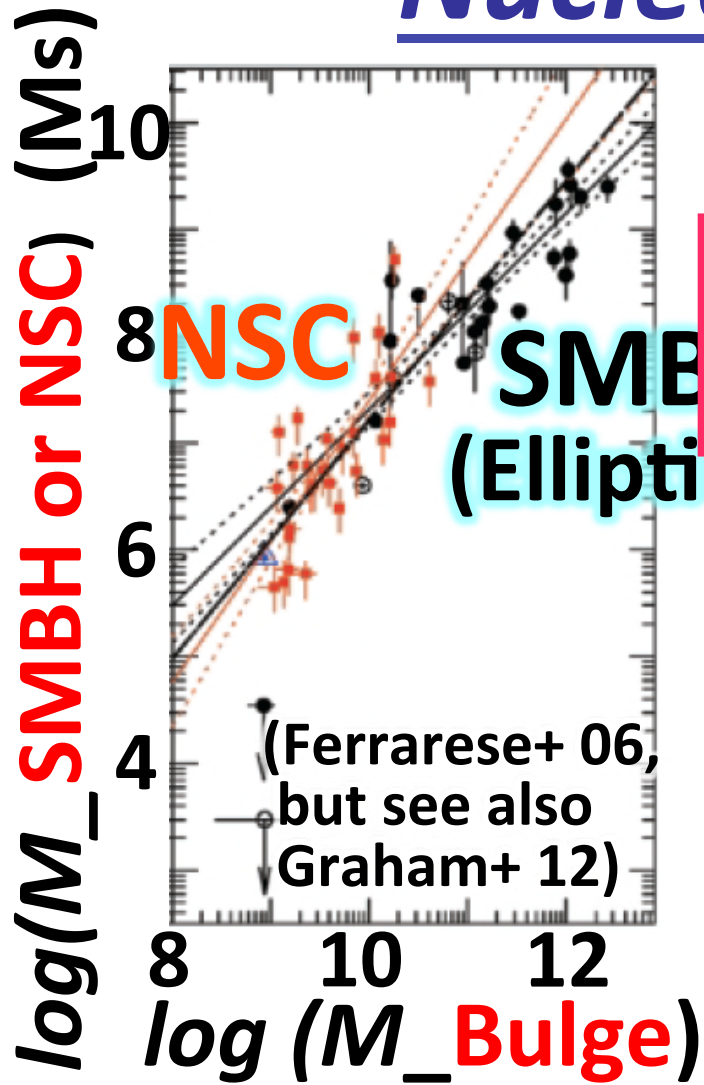Strong Extinction and Confusion

What I want to do
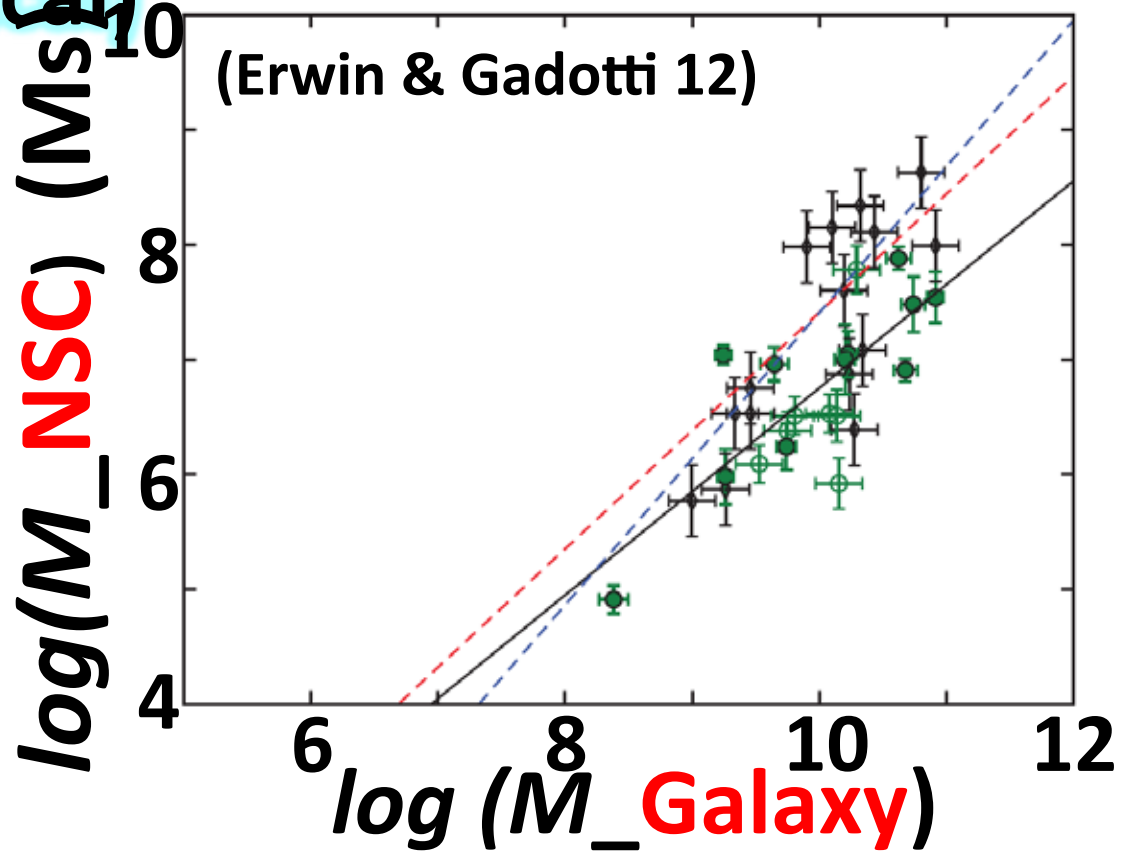Search for young/intermediate age stars

How to find them
(1) Astrometry
(2) Narrow-band Photometry

Nuclear Star Clusters
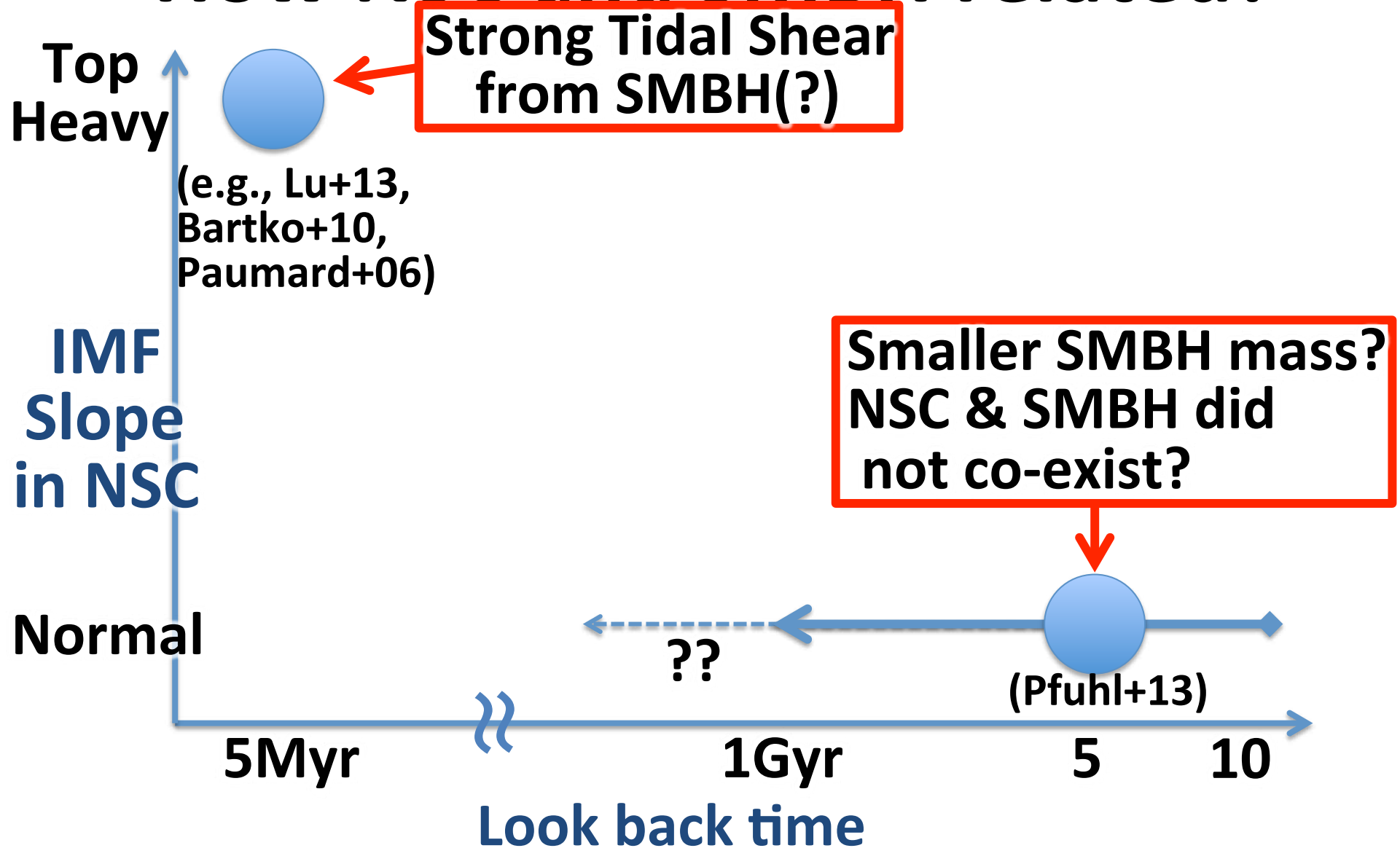

SMBH or NSC ↔ Bulge

SMBH ↔ Bulge
NSC ↔ (whole) Galaxy

NSC

SMB
(Elliptical)

(Ferrarese+ 06,
but see also
Graham+ 12)

$log(M\_SMBH\ or\ NSC)$ (Ms)

$log\ (M\_Bulge)$

(Erwin & Gadotti 12)

$log(M\_NSC)$ (Ms)

$log\ (M\_Galaxy)$

The Galactic NSC

How NSC and SMBH related?

Top Heavy

Strong Tidal Shear from SMBH(?)

(e.g., Lu+13, Bartko+10, Paumard+06)

IMF Slope in NSC

Smaller SMBH mass? NSC & SMBH did not co-exist?

Normal

??

(Pfuhl+13)

5Myr   **1Gyr**   **5**   **10**

Look back time

The Galactic NSC

How NSC and

Top Heavy

(e.g., Lu+13, Bartko+10, Paumard+06)

IMF Slope in NSC

Normal

5Myr   **1Gyr**   **5**   **10**

Look back time

(Pfuhl+13)

Strong Tidal from SM ??

??

??

??

??

HRD for (part of) NSC

50Myr   **1Gyr**

-6

Mbol

+2

w/o AO shallow but large FoV

GLAO target

w/ AO deep but small FoV

5000   *T*eff[K]   **2500**
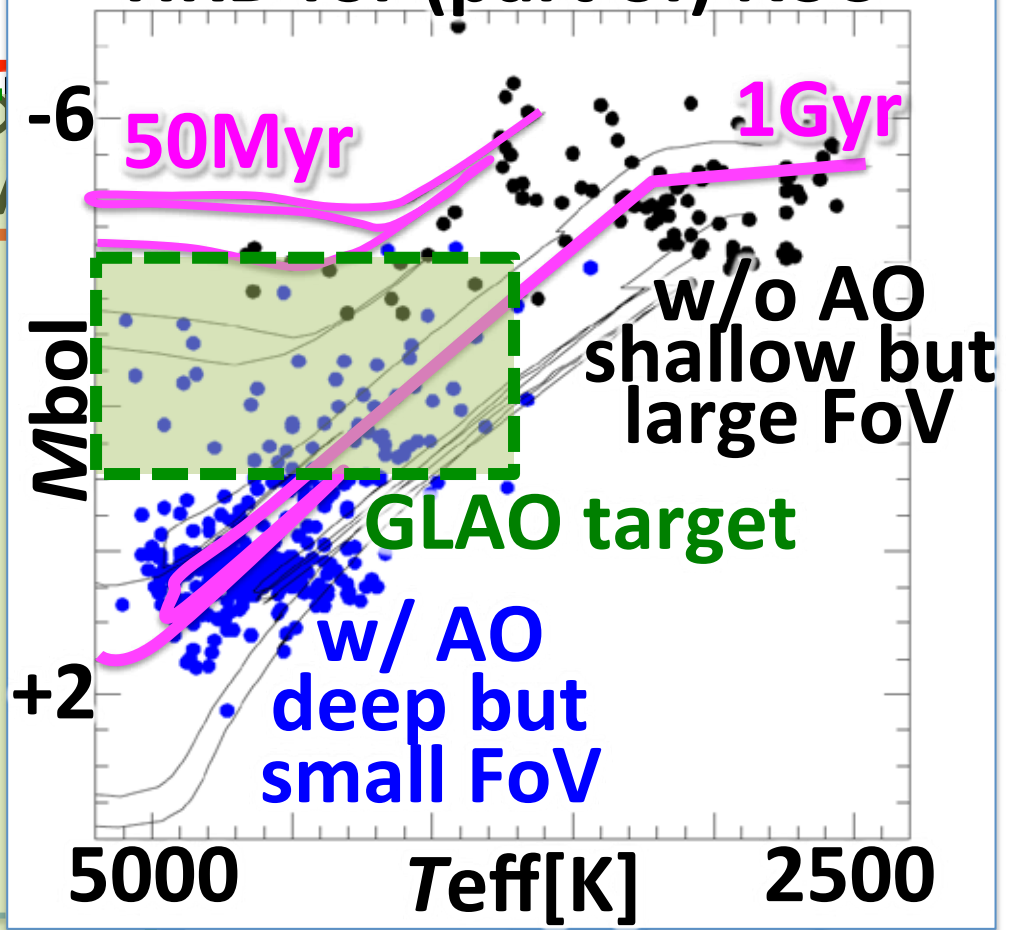
The Galactic NSC

How NSC evolved?

(Matsunaga+ 11)

Fujii+ 08

$T = 0.473$ Myr
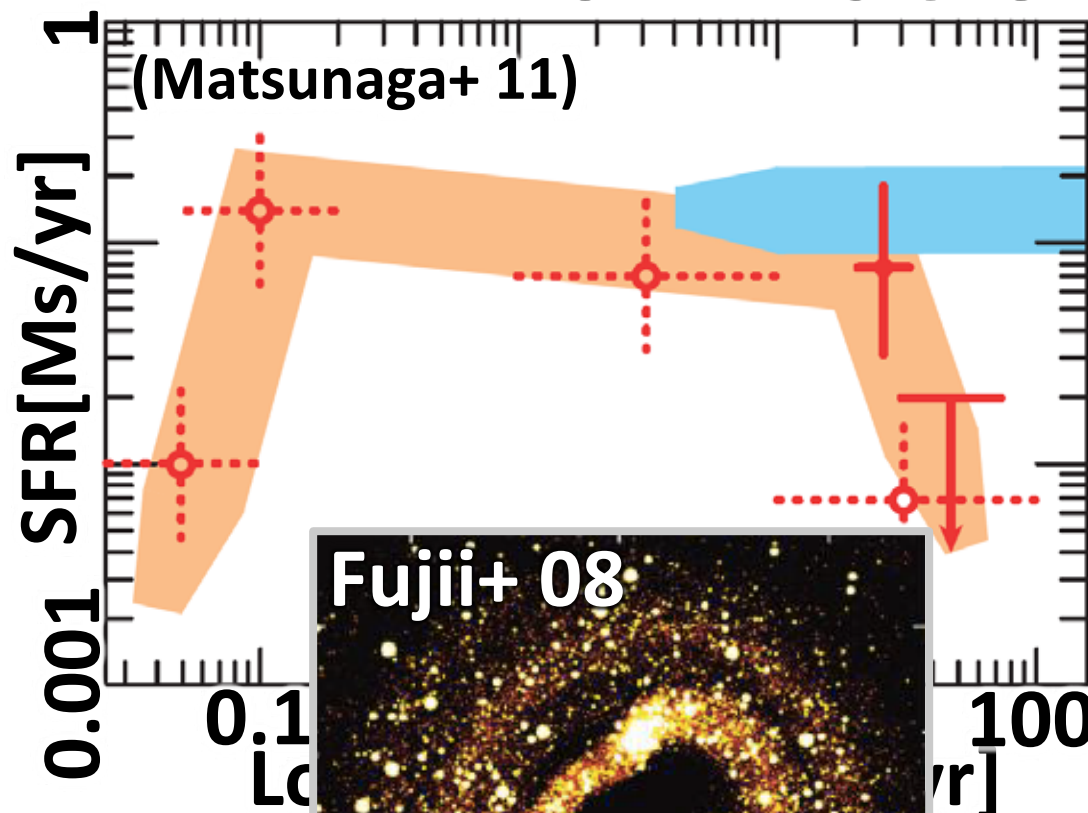
Star formation rate ~ 0.075 Msun/yr @central 400 pc
(Yusef-Zadeh+ 09, Matsunaga+ 11)

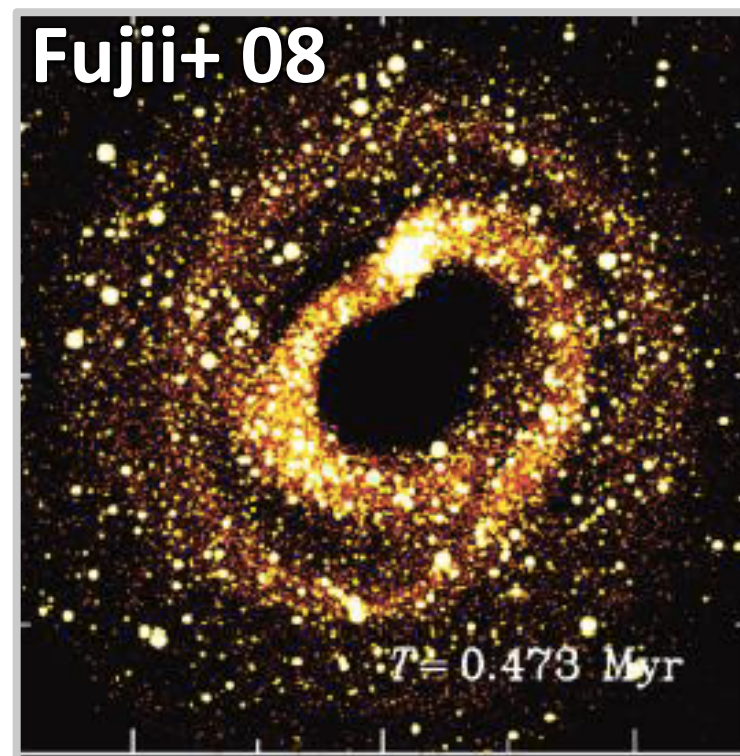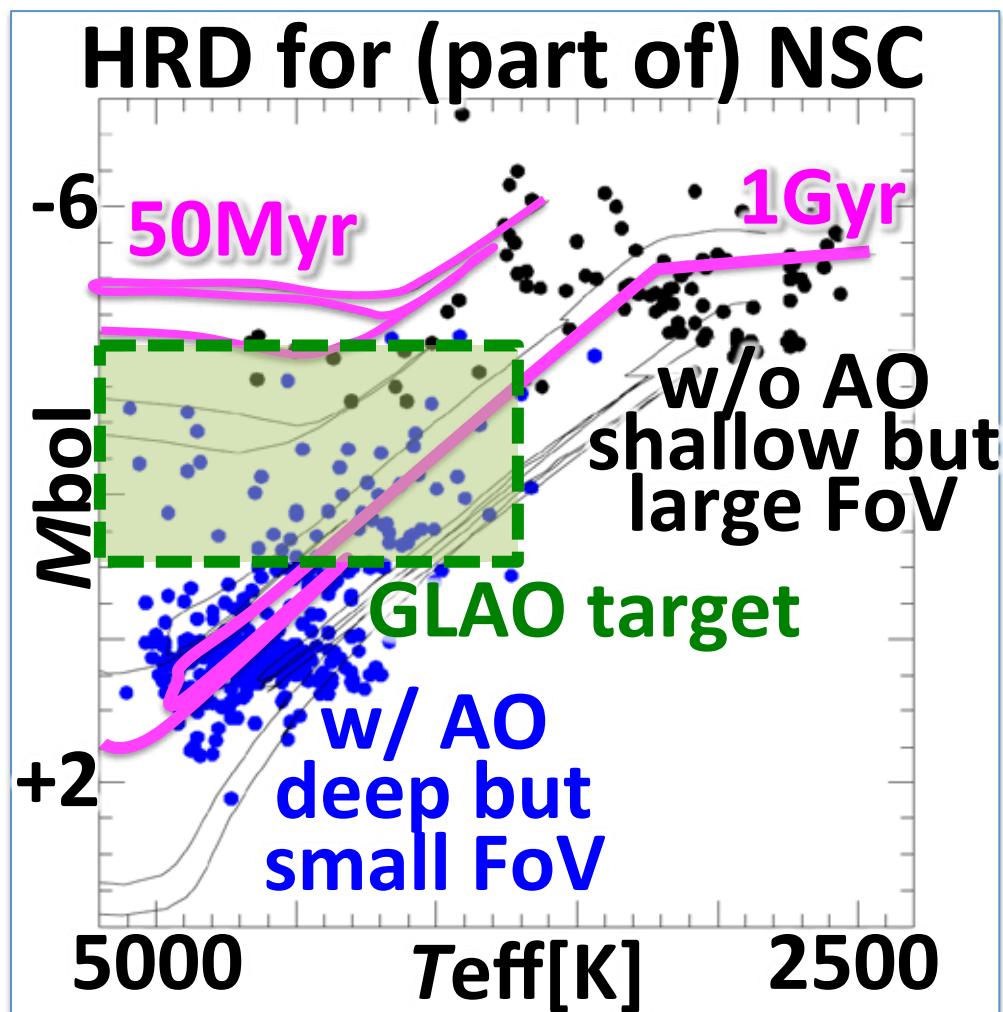**→ dozens clusters (several % of M$_{NSC}$) but**

2 clusters known → as yet unknown cluster remnants & tidal streams
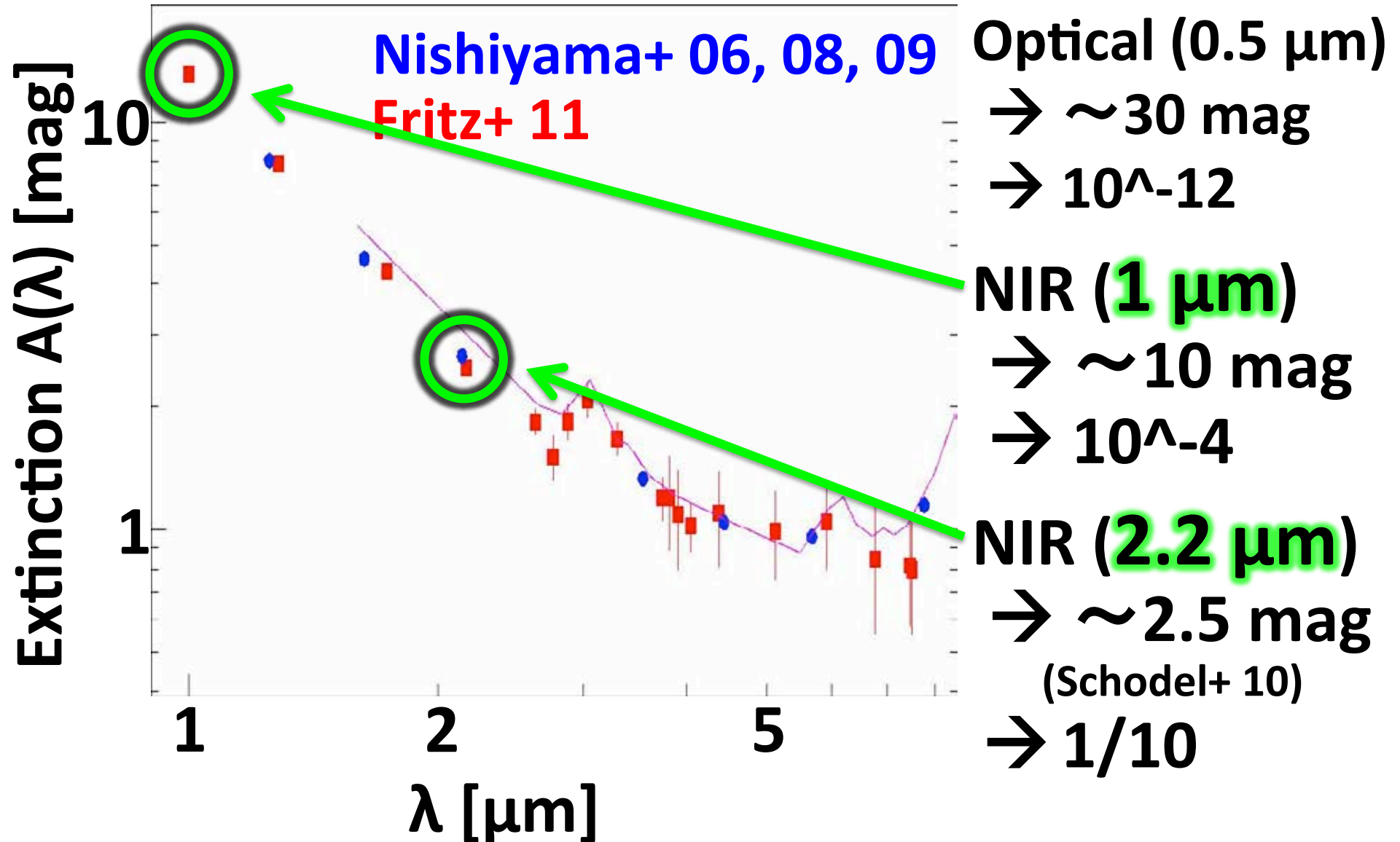
The Galactic NSC

What I want to do

Search for young/intermediate age population (a few Myr - ～1 Gyr)

HRD for (part of) NSC
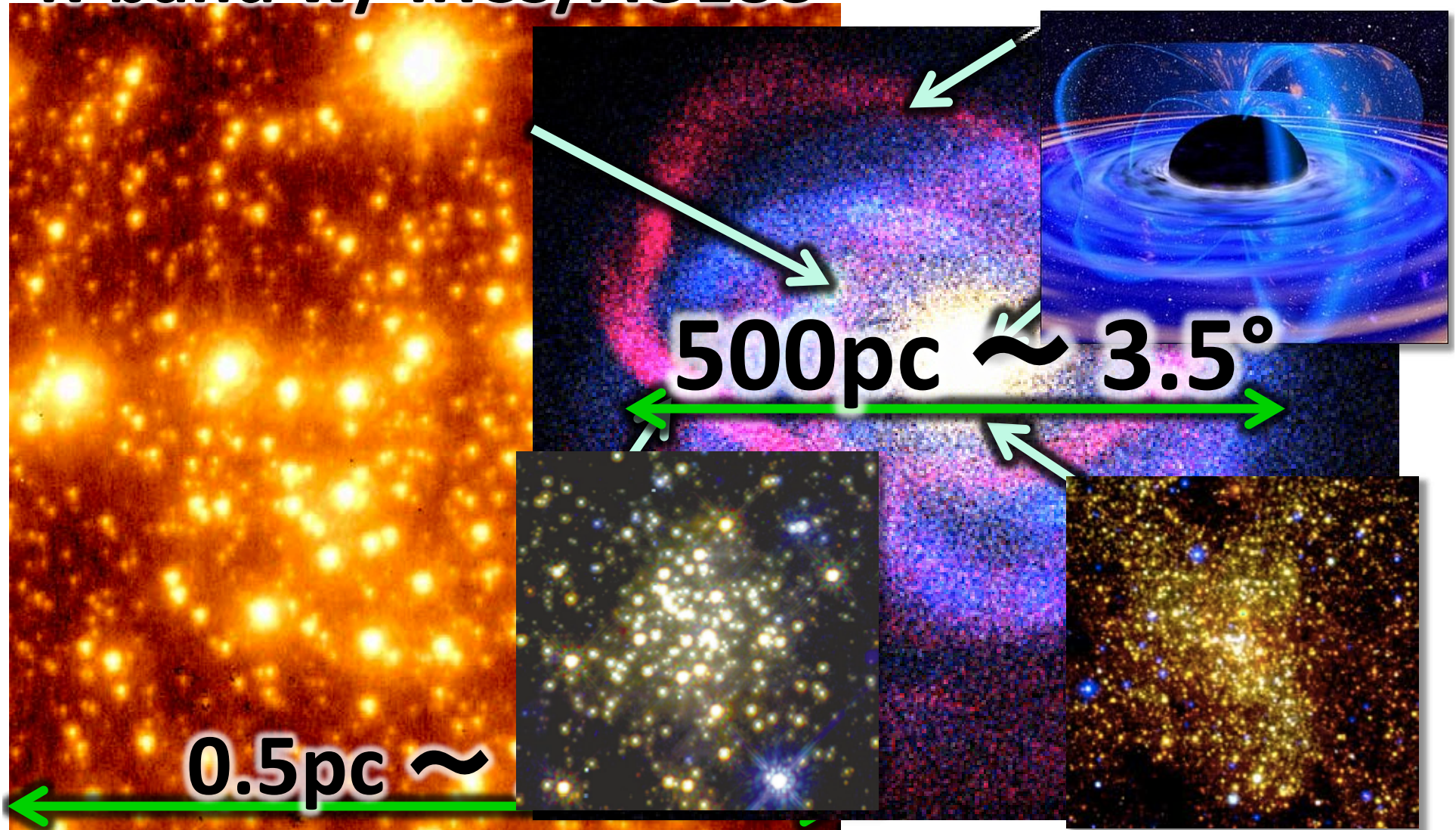
-6 **50Myr**   **1Gyr**

Mbol

w/o AO
shallow but
large FoV

GLAO target

+2

**w/ AO
deep but
small FoV**

5000   *T*eff[K]   2500

Fujii+ 08

T = 0.473 Myr

Observations of the GC

Why GLAO? Interstellar Extinction

Nishiyama+ 06, 08, 09
Fritz+ 11

Optical (0.5 μm)
→ ~30 mag
→ 10^-12

NIR (1 μm)
→ ~10 mag
→ 10^-4

NIR (2.2 μm)
→ ~2.5 mag
(Schodel+ 10)
→ 1/10

Extinction A(λ) [mag]

λ [μm]

Observations of the GC

Why GLAO? Confusion

K-band w/ IRCS/AO188

500pc ~ 3.5°

0.5pc ~

Observations

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(a few Myr - ～1 Gyr)

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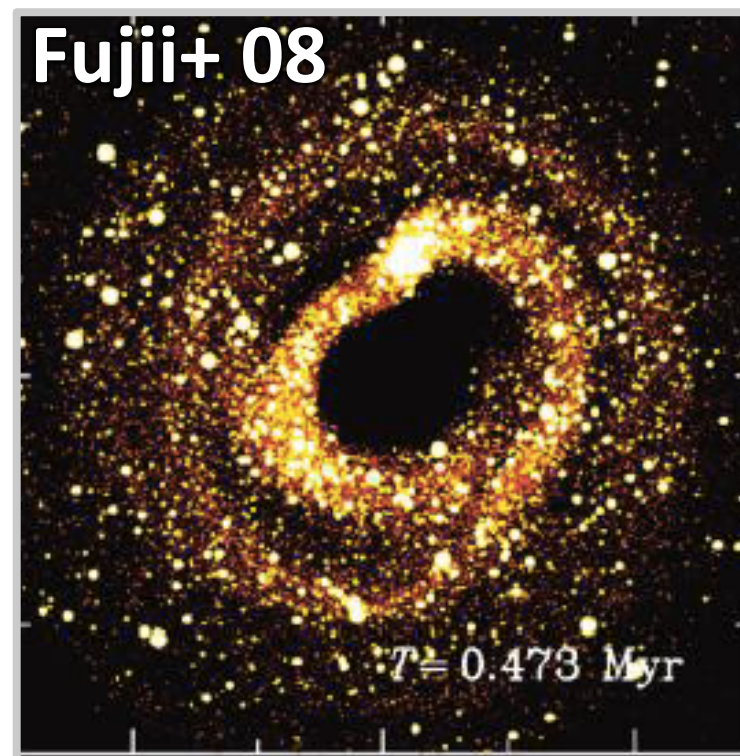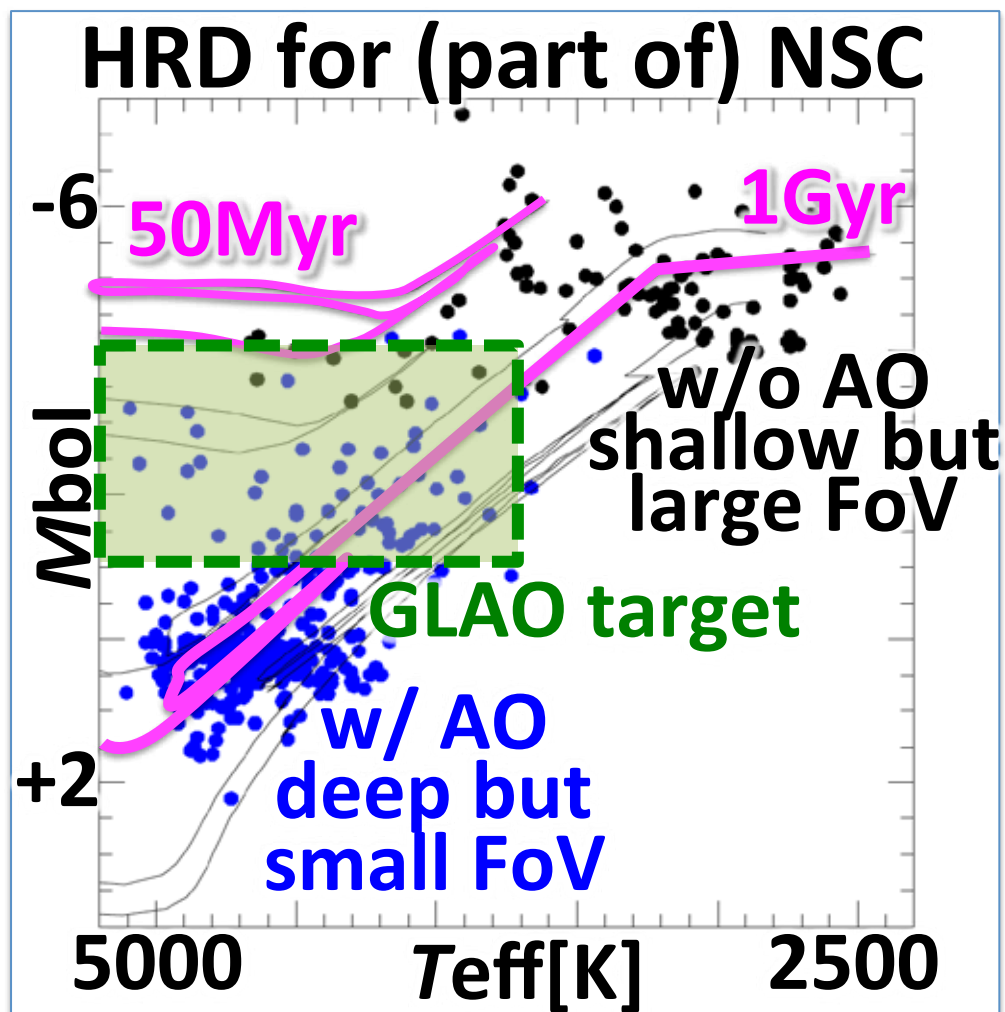
How to find them? (1) Narrow-band phot.

● **20 candidates**

B0 dwarf

K4.5 giant

CO

NB225

NB23

Buchholz+ 09

5 pc
2.5'

1pc

Magnitude

14.0

15.0

14.0

15.0

Wavelength [μm]

2.0   2.2

(Nishiyama & Schödel 13)
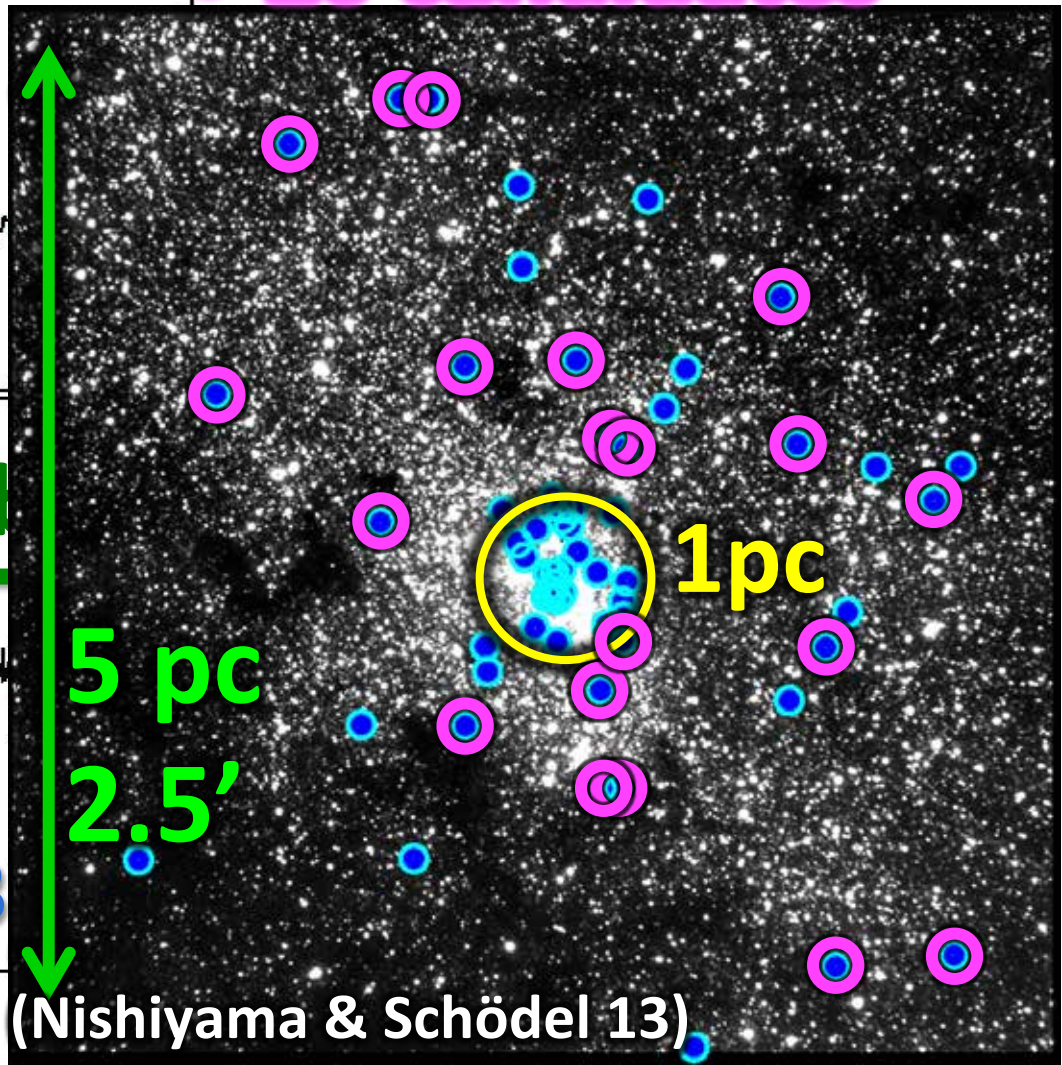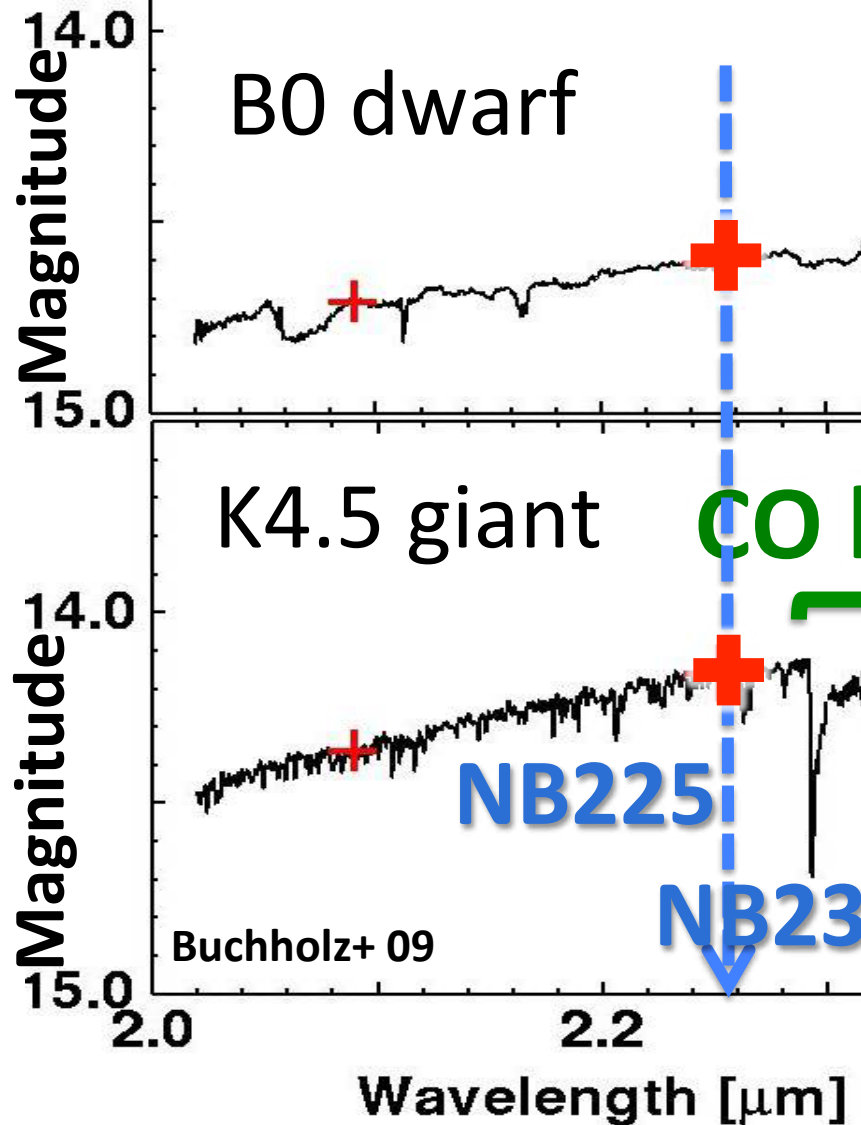
Observations: Narrow-band

How to find them? (1) Narrow-band phot.

80%(16/20): < 1Gyr ● **20 candidates**
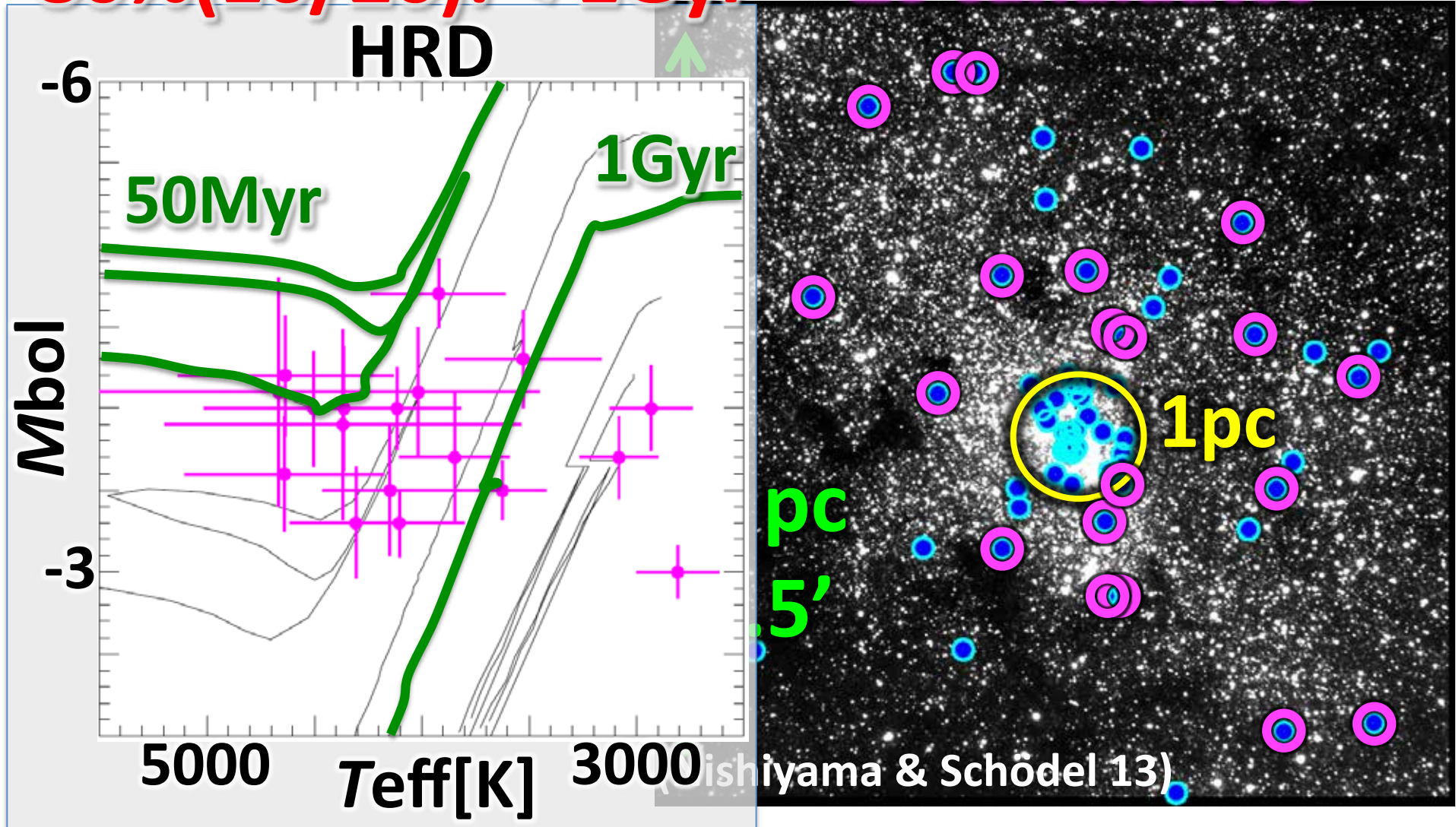
HRD

-6

50Myr 1Gyr

Mbol

-3

5000 Teff[K] 3000

pc
5'

1pc

(Nishiyama & Schödel 13)

Observations: Narrow-band

How to find them? (1) Narrow-band phot.

80%(16/20): < 1Gyr

HRD

50Myr

1Gyr

Mbol

Teff[K]

CMD for (part of) NSC
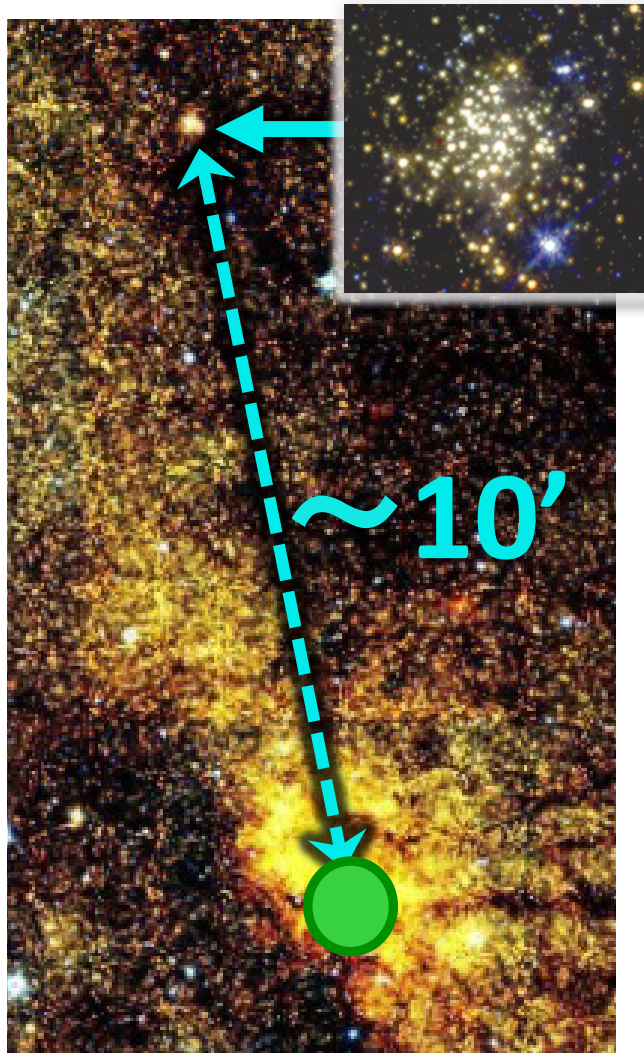
w/o AO

GLAO target

w/ AO

Mbol

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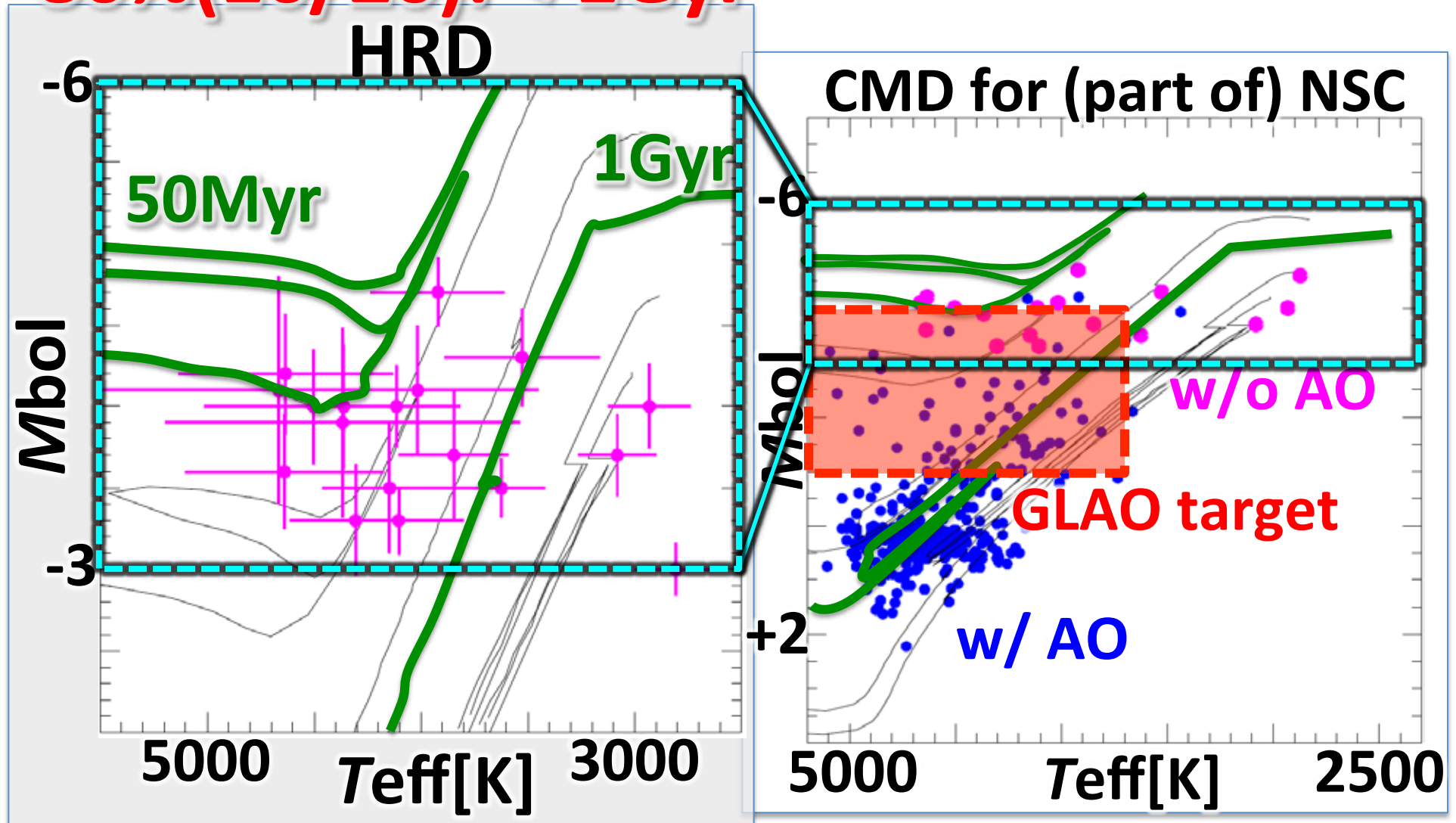
Observations: Astrometry

How to find them? (2) Astrometry

Relaxation timescale > 1 - 10Gyr (Alexander 05)

<1Gyr stars ← not dyn. relaxed

Stellar Proper motion

↔ 4 mas/yr

· cluster members
△ field stars

Cluster member (2 Myr)

~5 *mas/yr*

Field stars

~10'

(Stolte+ 08)
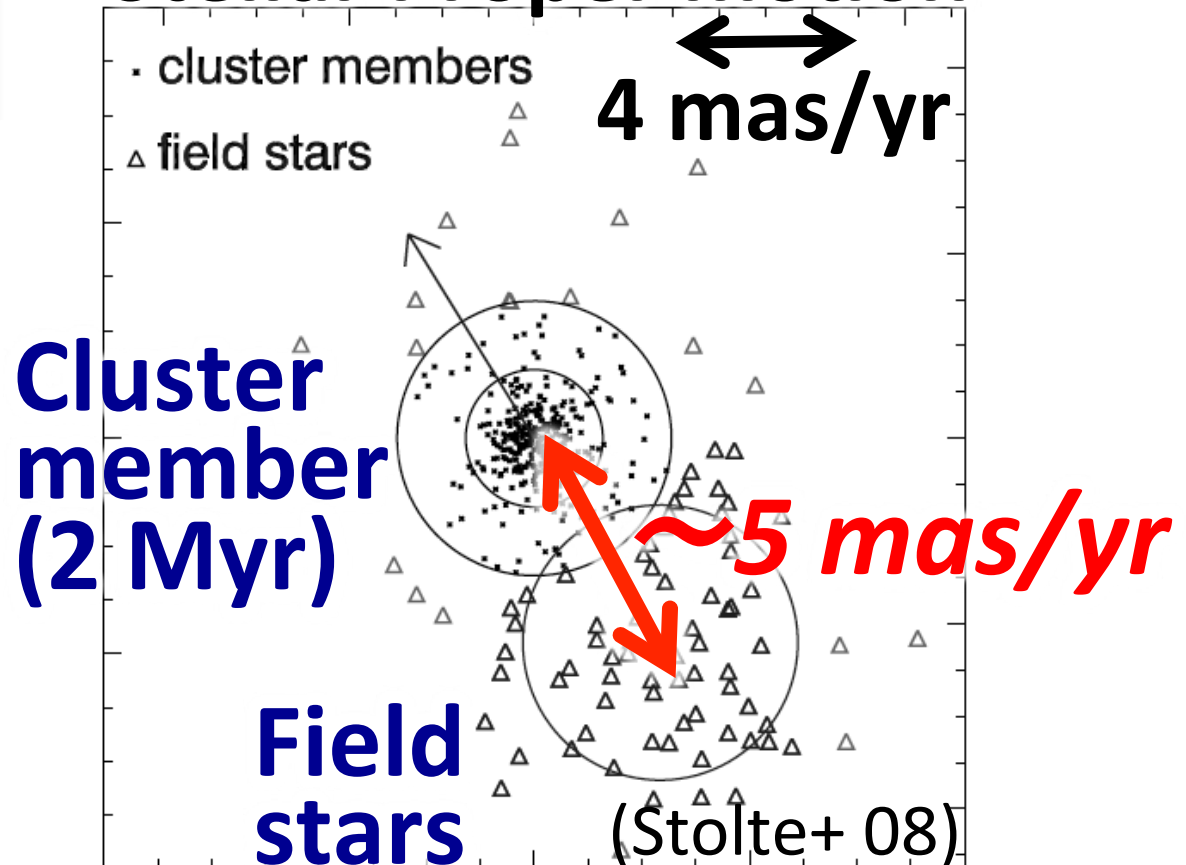
Observations: Astrometry

How to find

Relaxation tim

Fujii+ 08

$T = 0.473$ Myr

Cluster orbits viewed from **above** Galactic plane
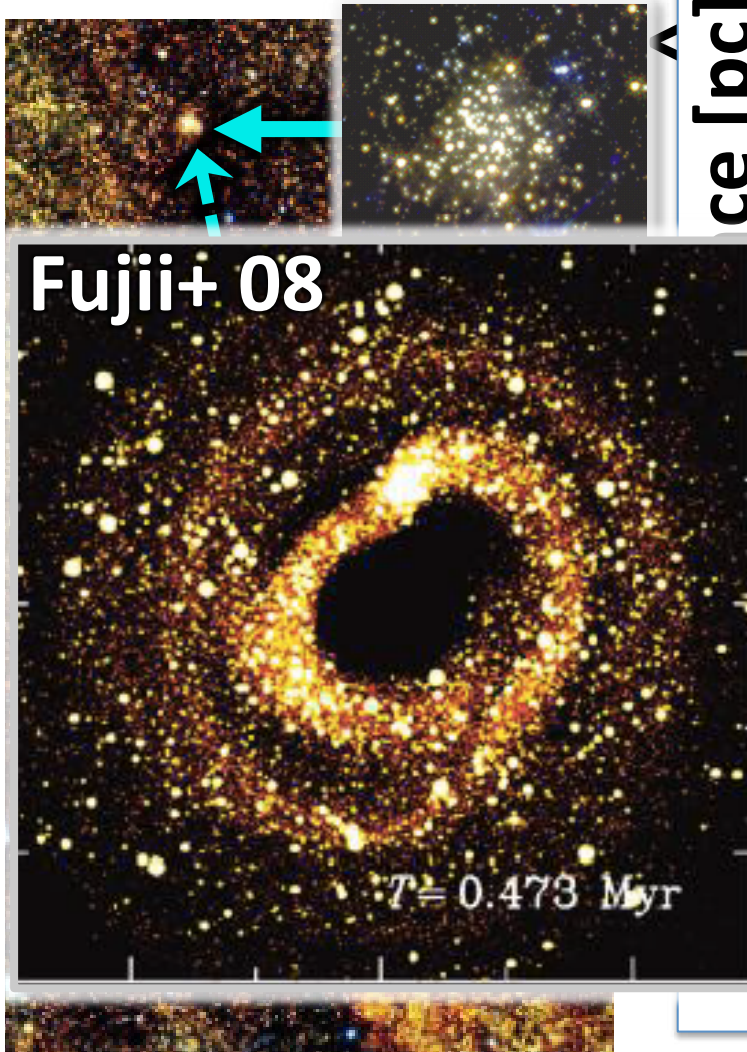
+200

ce [pc]

+100

0

-100

-200

Future Orbit

SMBH

Past Orbit

Birth location

Present location

-200 -100 0 +100 +200
Galactic plane position [pc]

400 pc ~ 3deg

Observations: Astrometry

How to find them? (2) Astrometry

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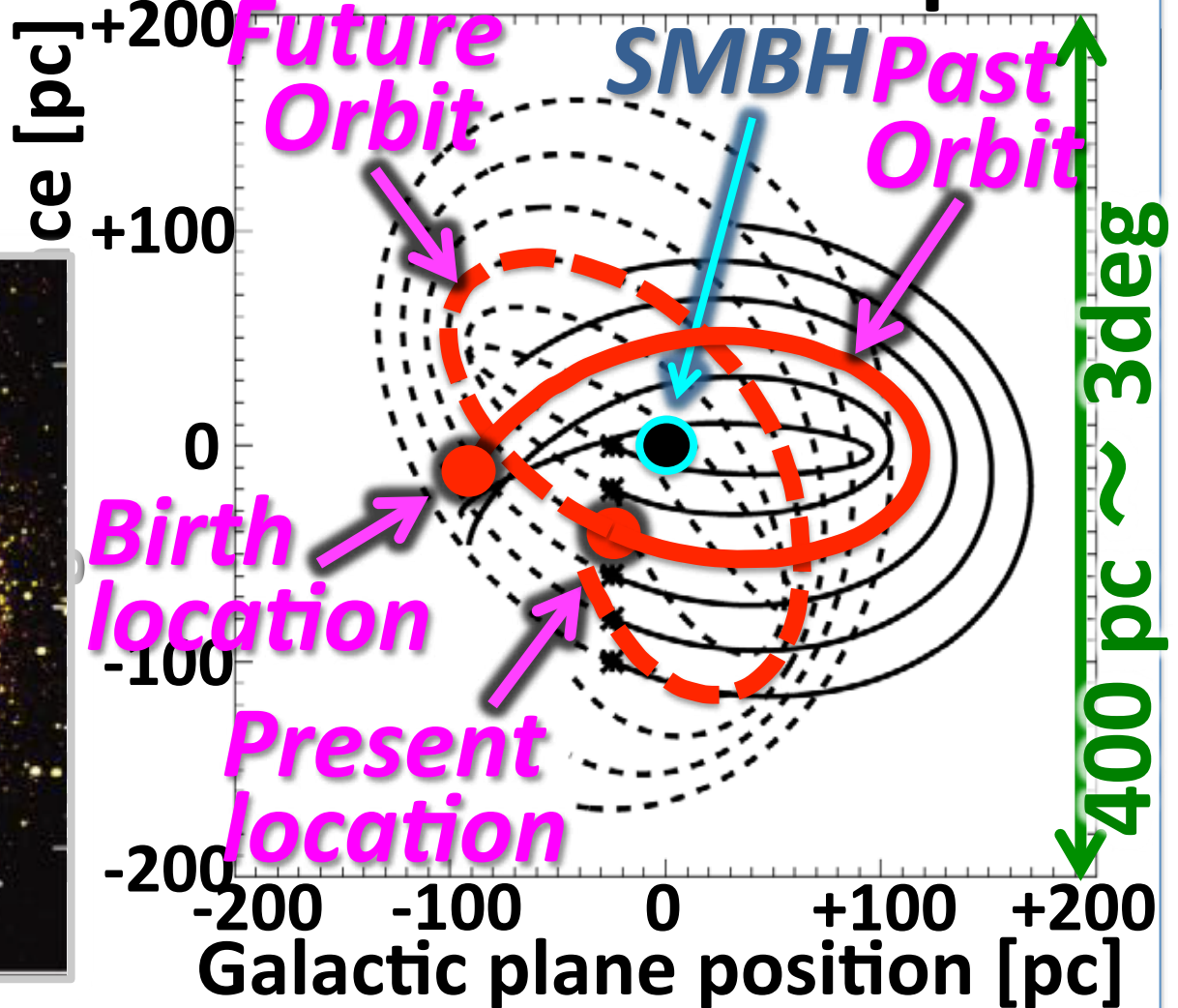
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HST/NICMOS/NB
(Dong+ 11)
FWHM:
〜**200mas@1.9µm**
SN=20: 〜16 mag
δp 〜40 mas
100 observations
(accracy∝√N)
→ 〜**4 mas**
> 5σ for 4 yrs

Stellar Proper motion
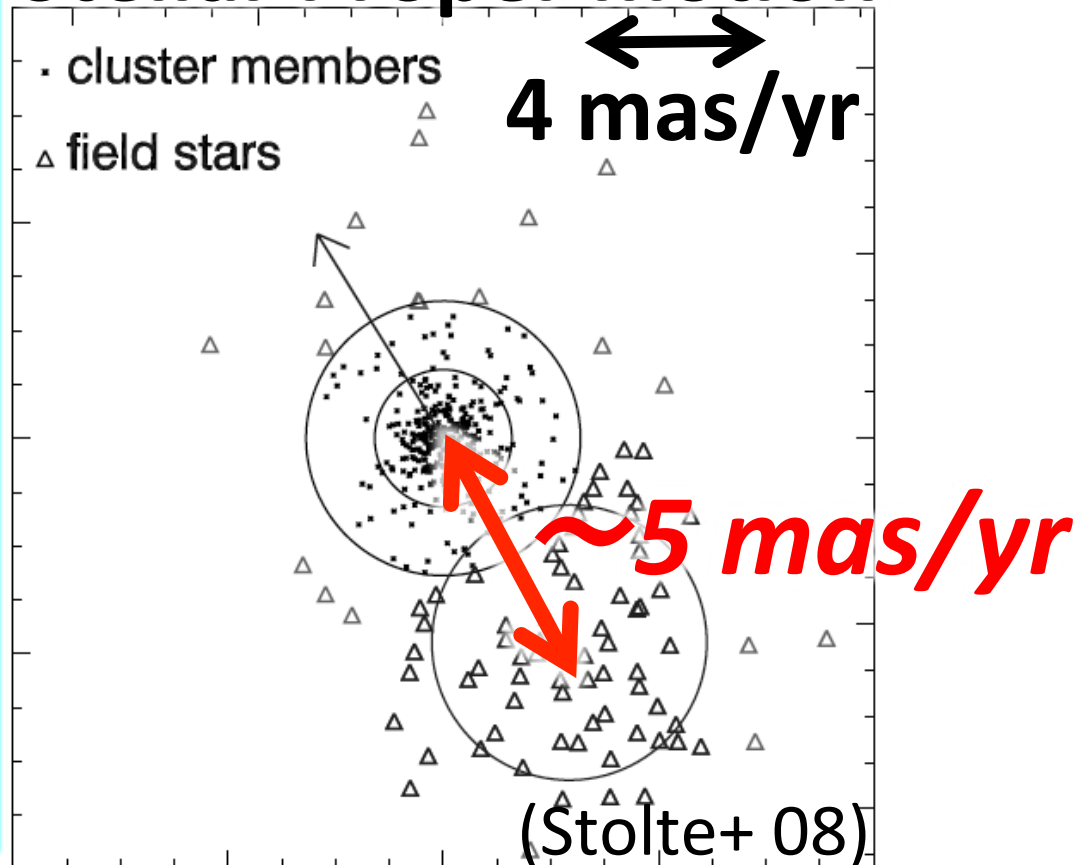
- cluster members
△ field stars

4 mas/yr

〜*5 mas/yr*

(Stolte+ 08)

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> 5σ for 4 yrs

100 x 100 pc (40')

1-min × 100obs

× 3×3 FoV = 15h

→ 8 (-half) nights/yr

(50% efficiency)

Summary 1/2

Q1. Wide-field imager + Narrow-band filters
   + fast readout mode may be helpful for astrometry

Q2. Optimized (finer than 0.1"/pix) plate scale preferred,
   but our object is GC... → TAO!

Q3, Q6. TMT targets:
   1. groups of Young/intermediate (Y/I) age population
      ← hidden cluster remnants
   2. other Y/I-age populations
      ← tidal stream? isolated star formation?

Q4. JWST: small FoV
   Euclid: no K-band, large pixel scale
   WISH: FWHM may be better? must be stable
      but long (> 6yr) operation will be required

Q5. ～8(-half) nights/yr for astrometry
   ～2 - 3 nights for narrow-band photometry

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