Intermediate-Mass Black Holes

in Globular Clusters

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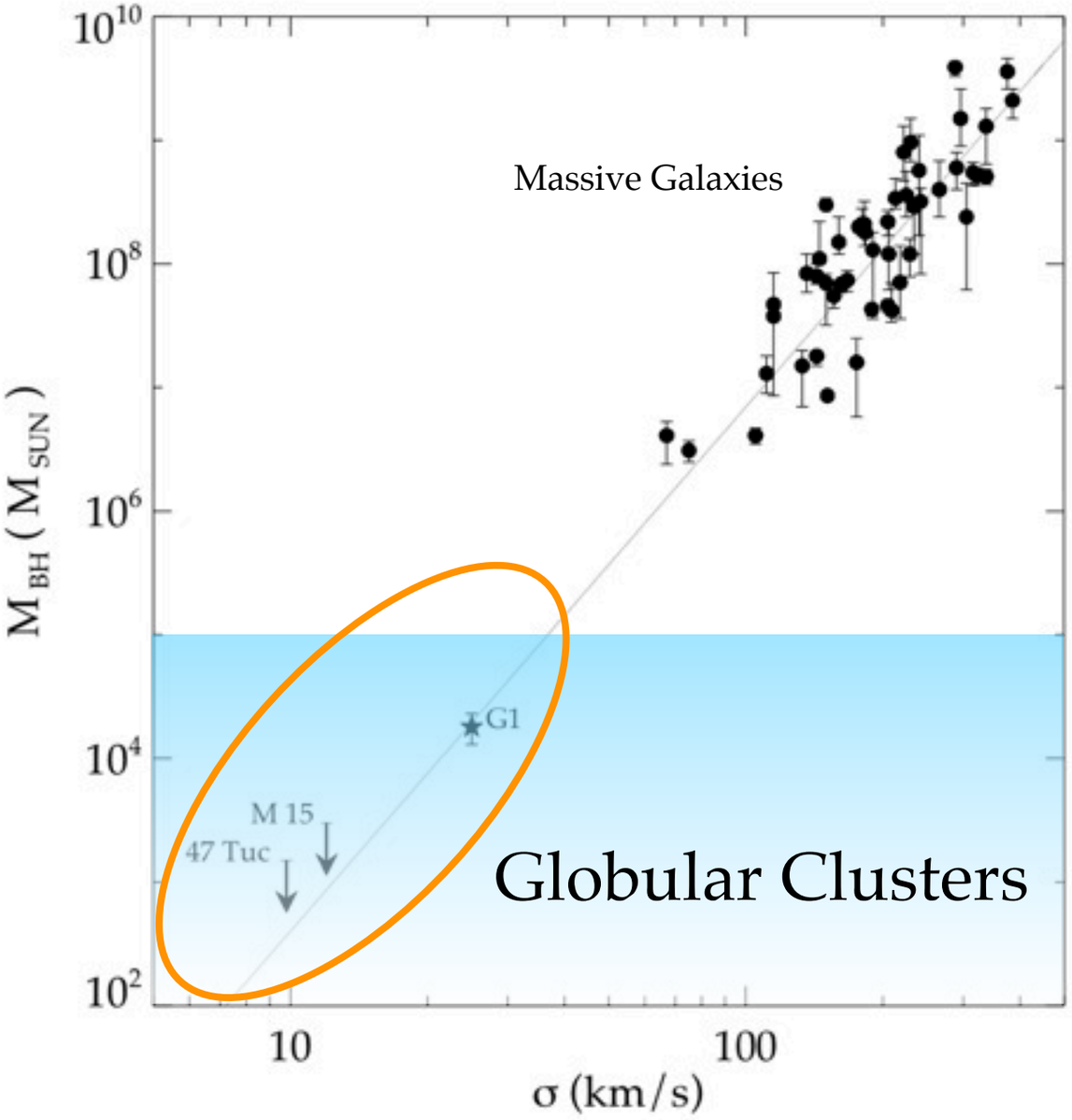
Why are we looking for them?

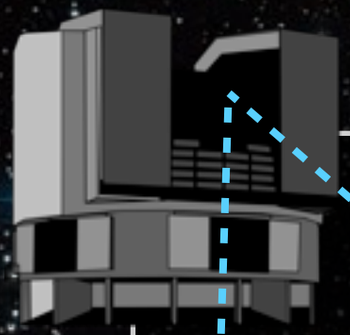


1. Relation at lower Masses?

2. Growth of Supermassive Black Holes?

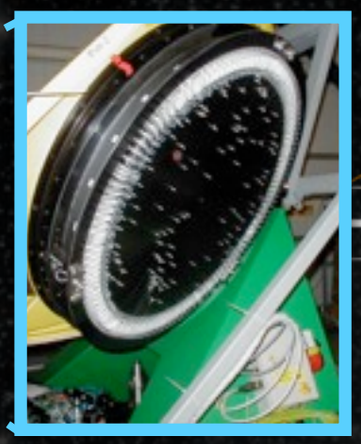
➡ Seeds: IMBHs

Observing - Spectroscopy

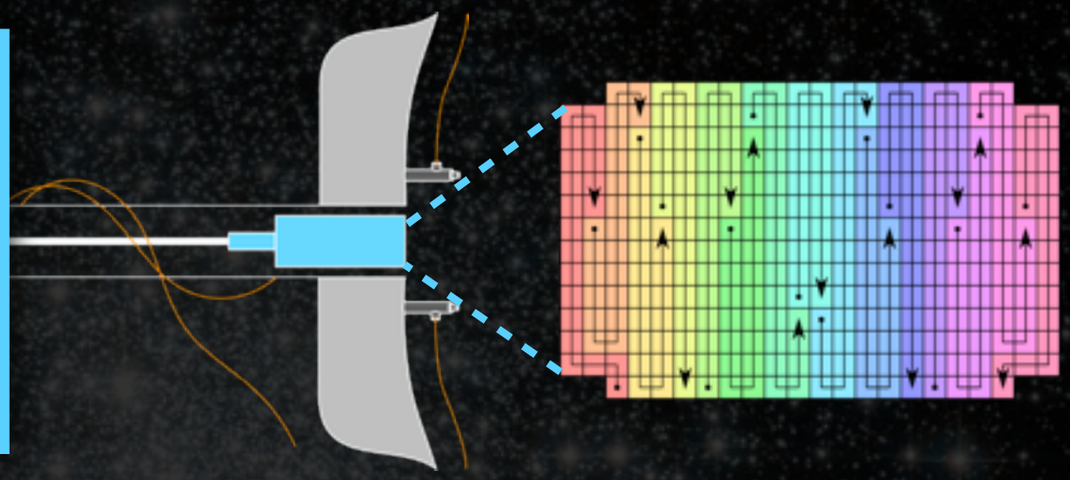


FLAMES

OZPOZ

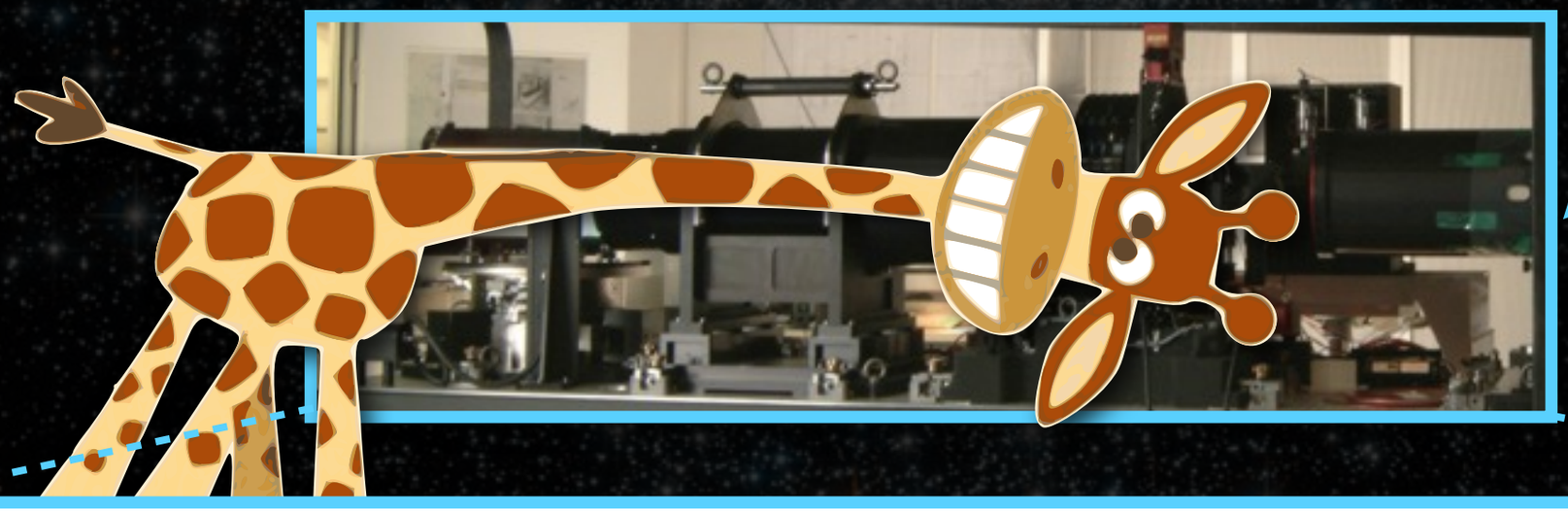


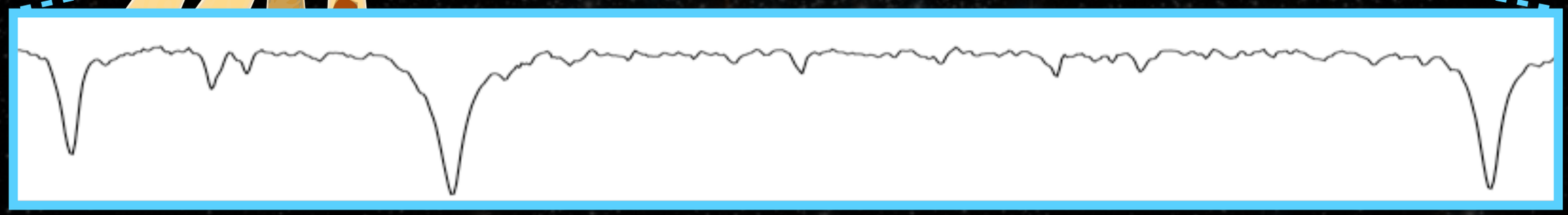
ARGUS



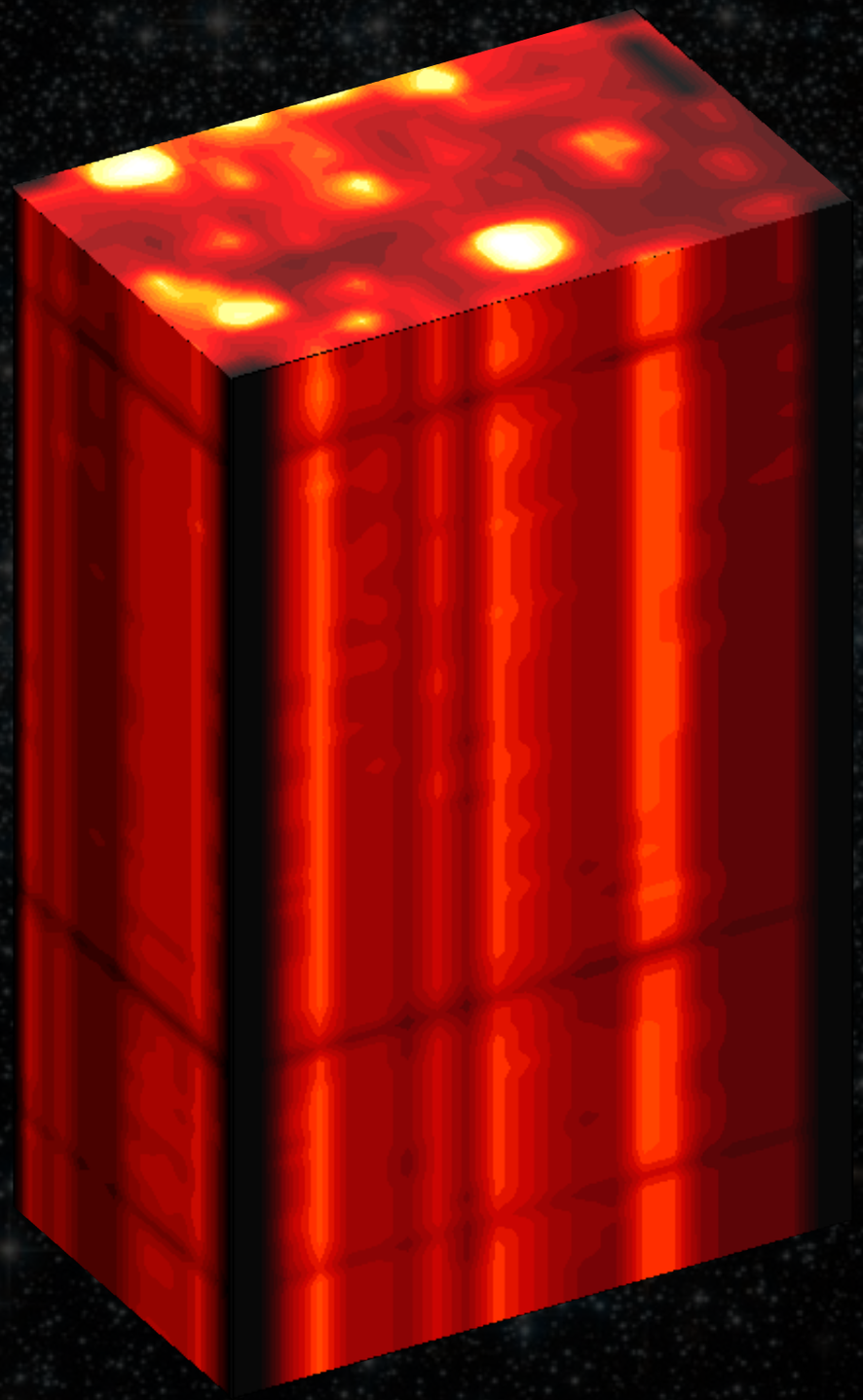
SLIT

GIRAFFE





Observing - Spectroscopy

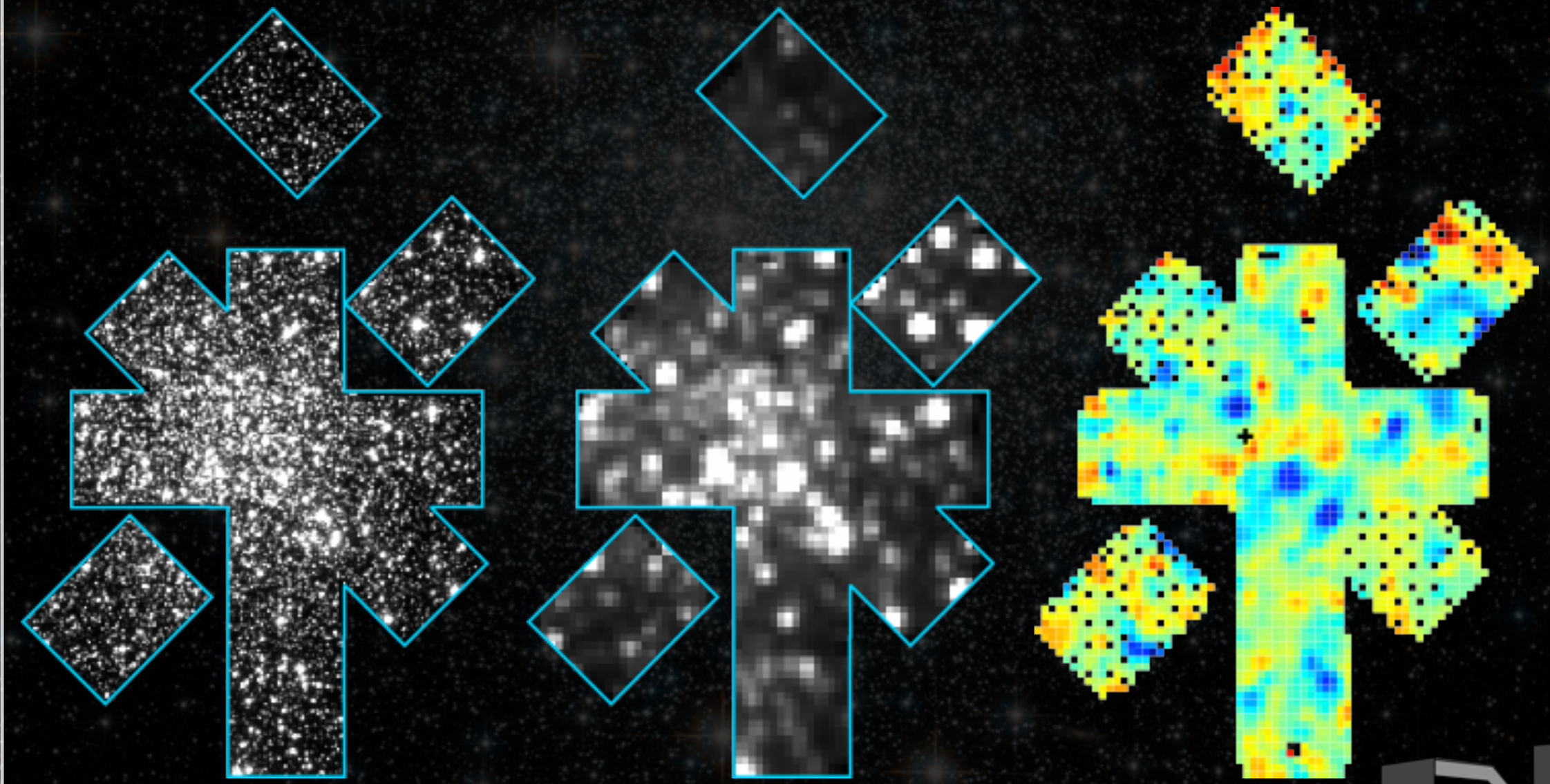


Observing - Spectroscopy

HST

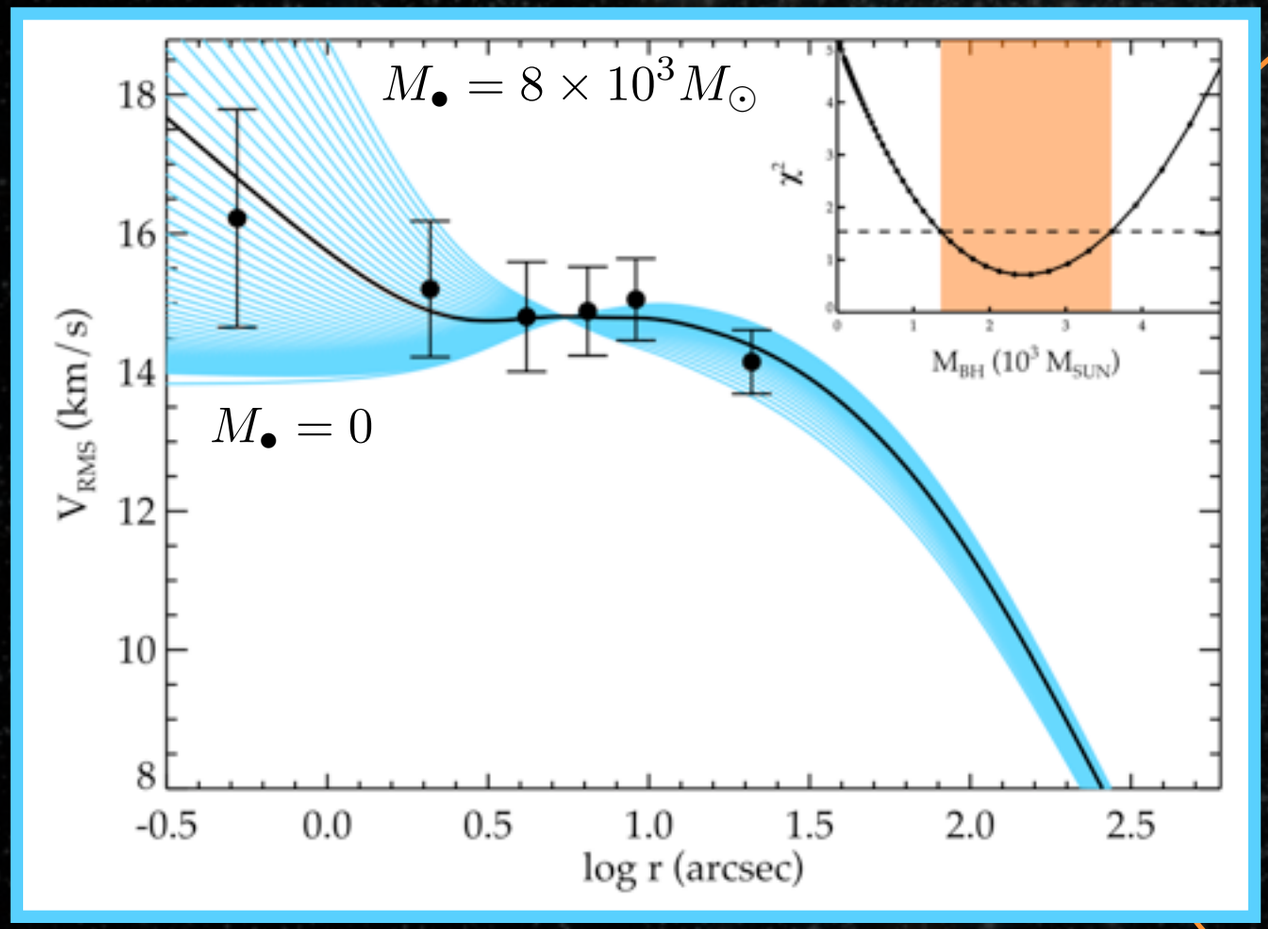
VLT/ARGUS

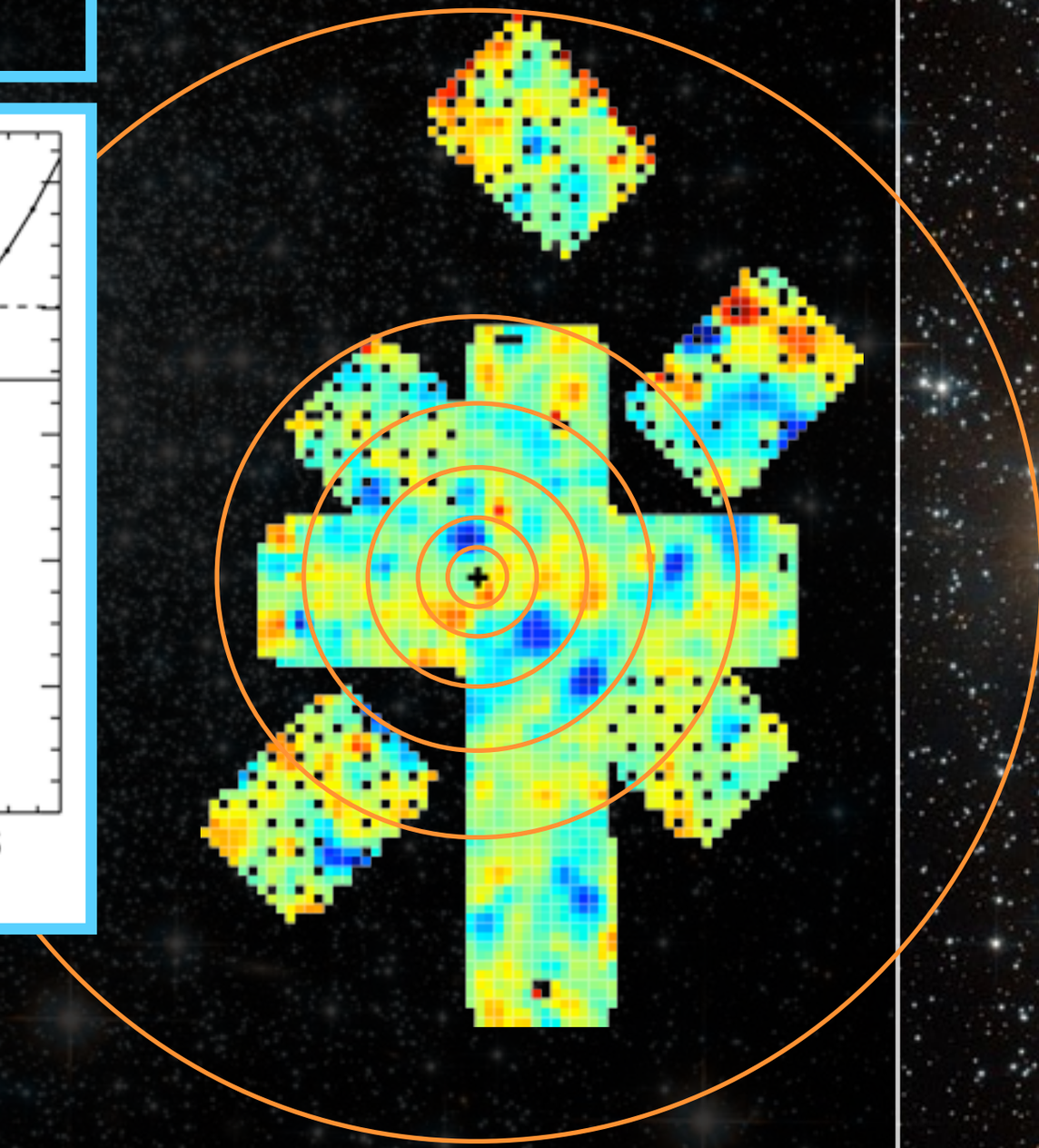
VELOCITY



Dynamical Models

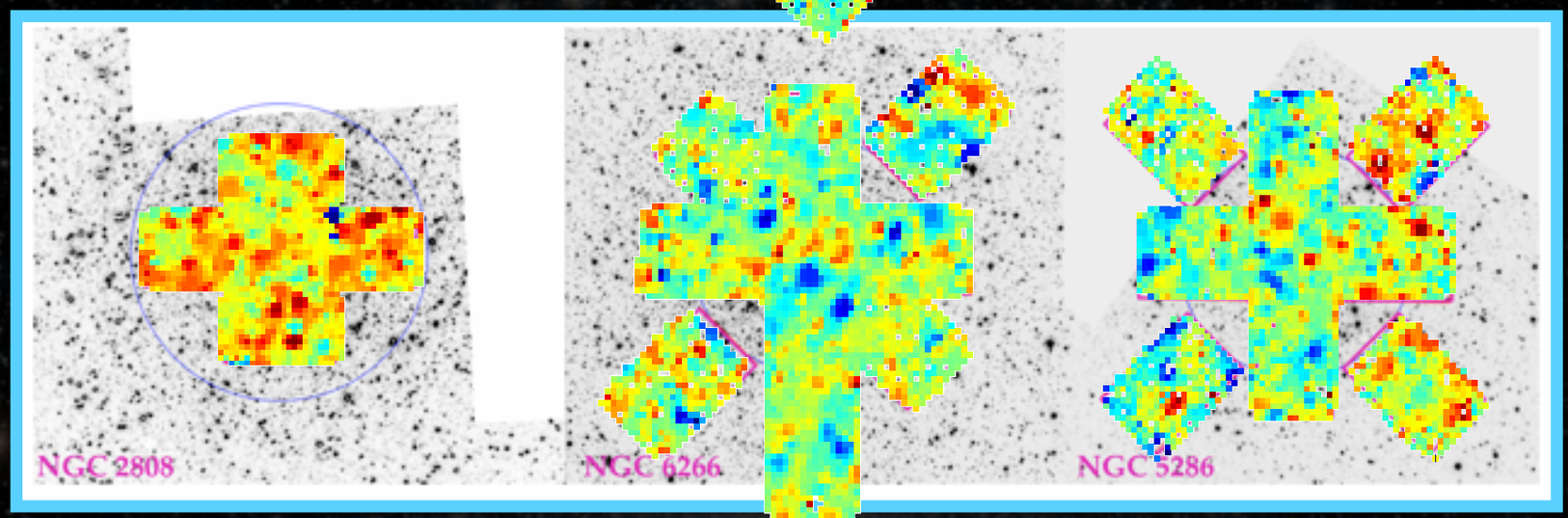
$$M_\bullet = (3 \pm 2) \times 10^3 M_\odot$$





NGC 6266, Lützgendorf et al., 2012, submitted

Our Sample


NGC 2808
NGC 6266
NGC 5286
NGC 5824
NGC 5694
NGC 1851
M 80
NGC 6388
M 79

N - Body Simulations

FACTS

- NBODY6 (Aarseth 1999) on GPUs
- N = 32k - 128k

✓ Stellar Evolution

✓ External Tidal Field

We vary:

- Black-Hole Retention Fraction
- Intermediate-Mass Black Hole
- Primordial Binary Fraction

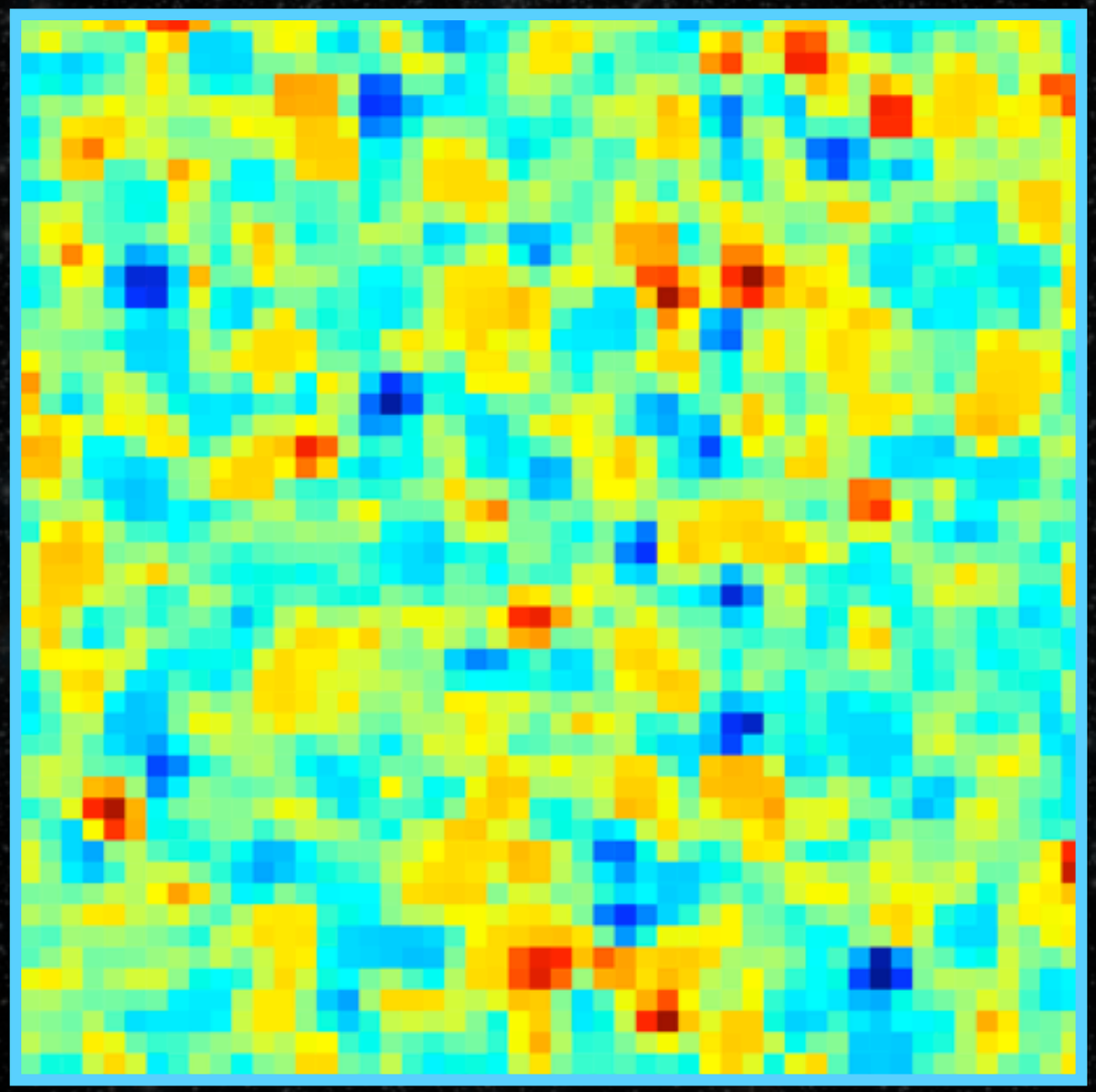
Goals:

1. Reproduce Observations
2. Test Analysis
3. Deeper Understanding

Test Analysis

PHOTOMETRY

- CMD
- Completeness
- Center
- SB-Profile

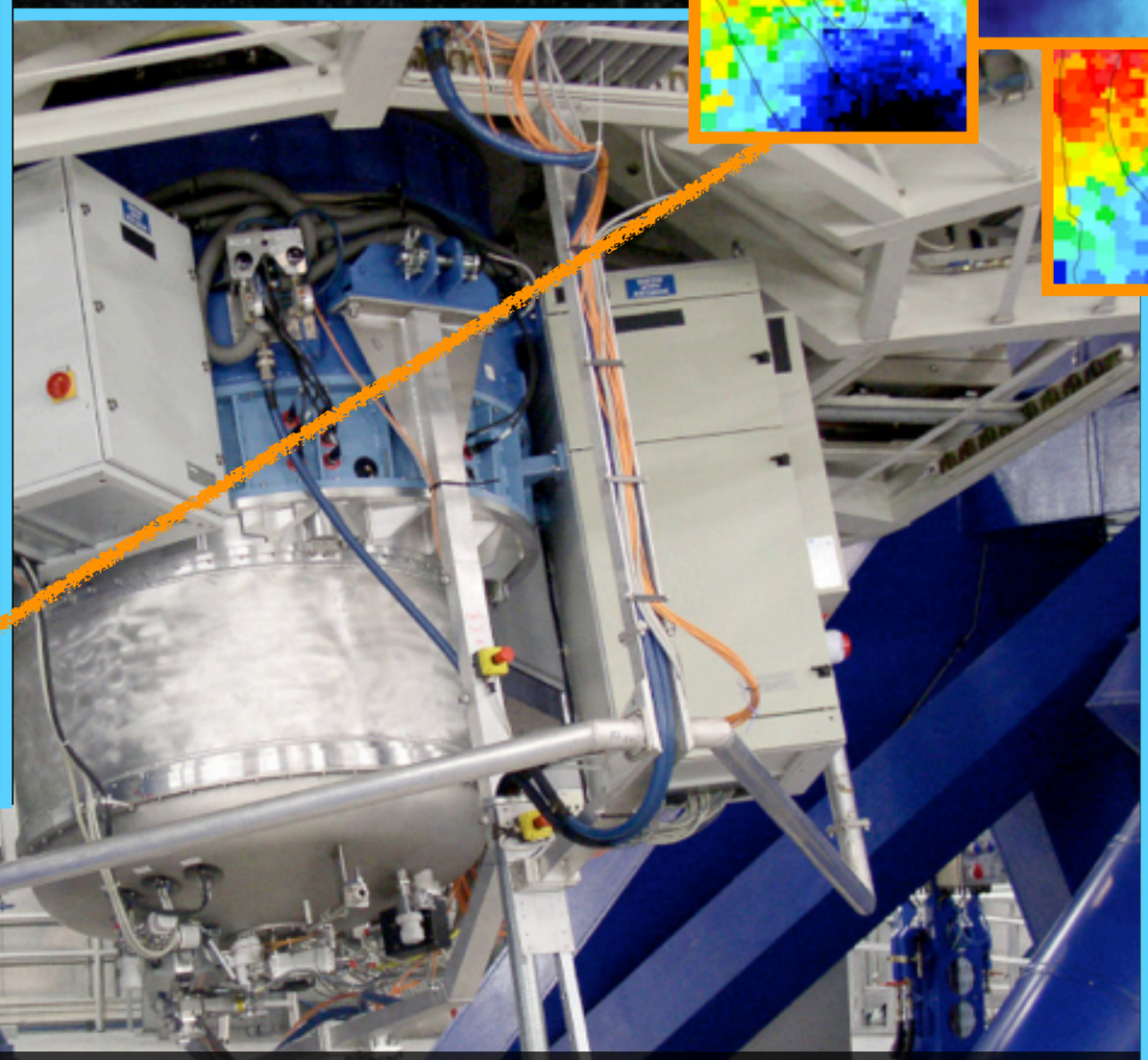


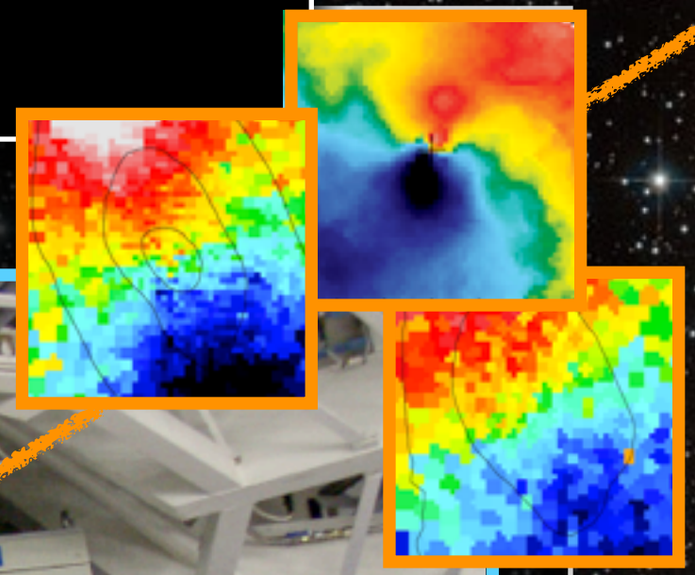
SPECTROSCOPY

- Velocity Map
- Templates
- Shotnoise
- σ - Profile

Whats next? - SINFONI

Extragalactic, d=50 kpc

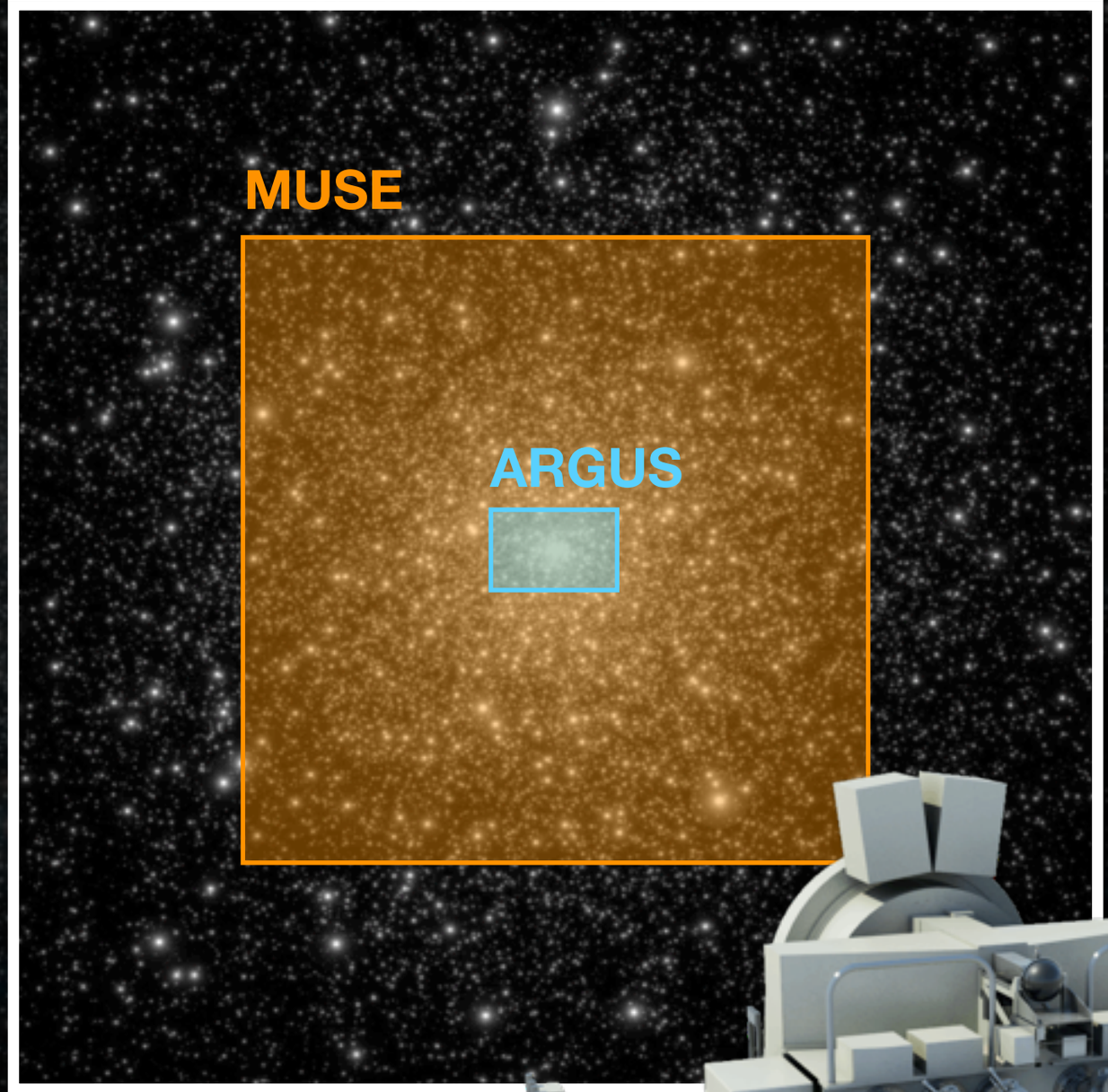


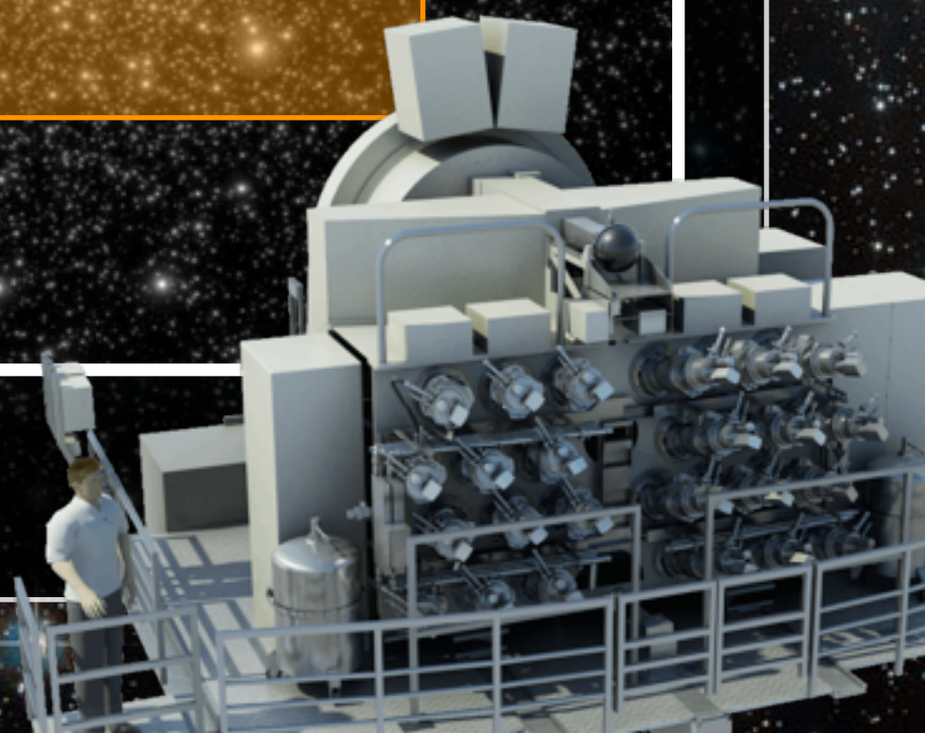


$$R = \lambda/\Delta\lambda = 4000$$ ☹

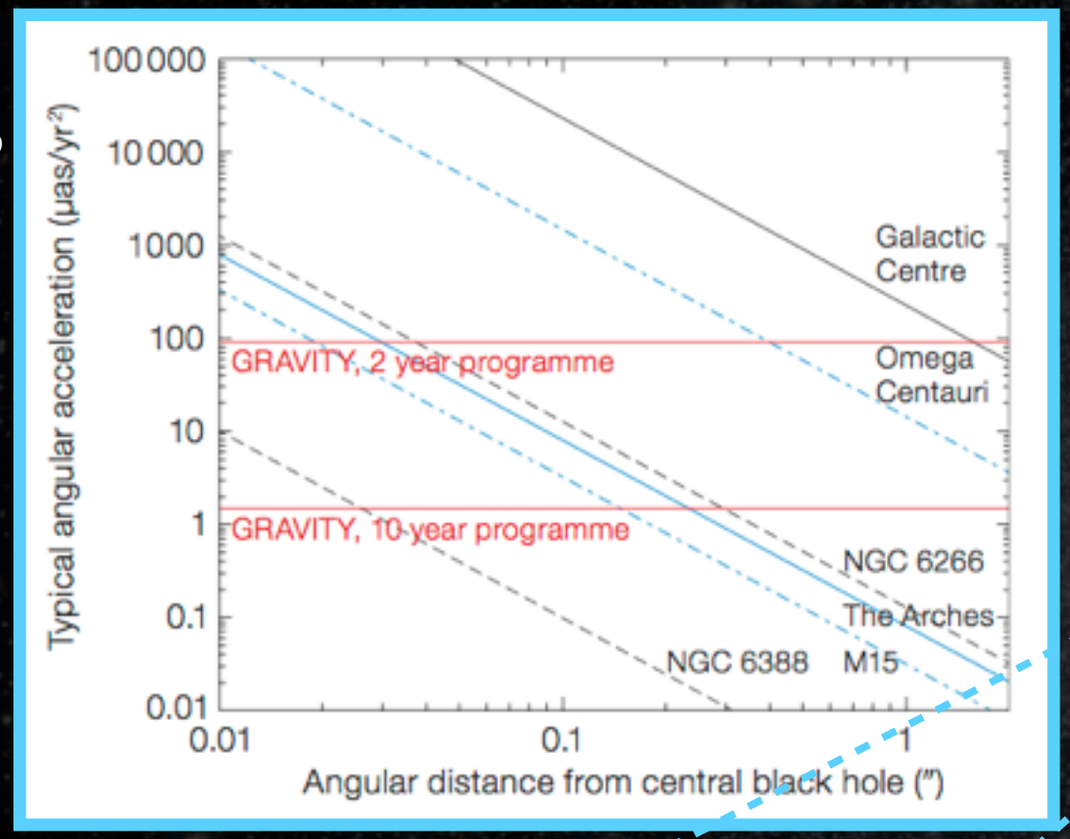
Whats next? - MUSE

OBSERVATIONAL PARAMETERS	
Spectral Range (simultaneous)	0.465 – 0.93 μm
Resolving Power	2000@0.46 μm 4000@0.93 μm
WIDE FIELD MODE (WFM)	
Field of View	1 × 1 arcmin^2
Spatial Sampling	0.2 × 0.2 arcsec^2
Spatial Resolution (FWHM)	0.3 – 0.4 arcsec^2
NARROW FIELD MODE (NFM)	
Field of View	7.5 × 7.5 arcsec^2
Spatial Sampling	0.025 × 0.025 arcsec^2
Spatial Resolution (FWHM)	0.030 – 0.050 arcsec^2

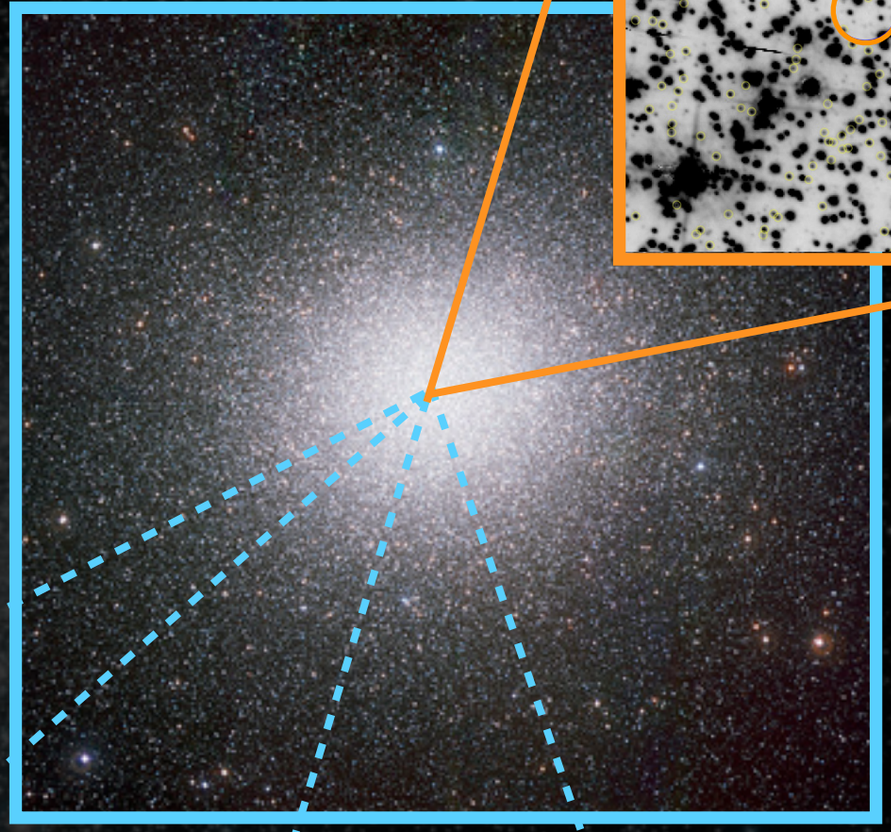


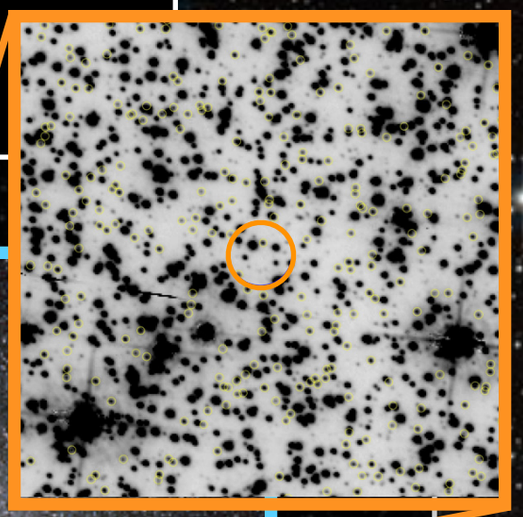


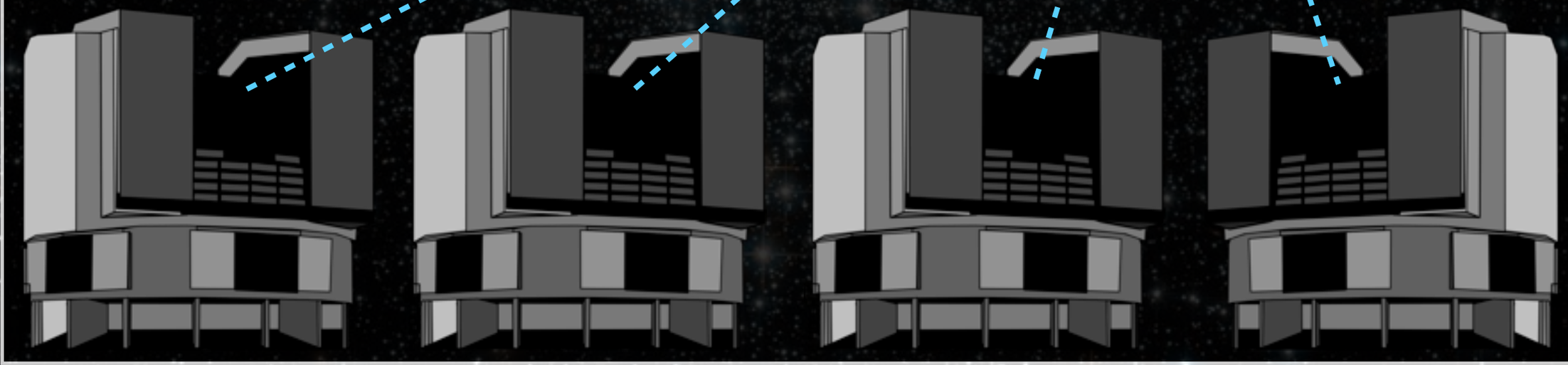
Whats next? - GRAVITY



F. Eisenhauer et al., 2011, Messenger

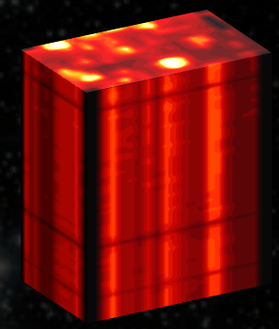


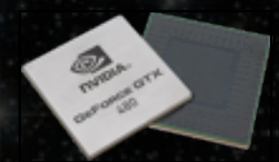


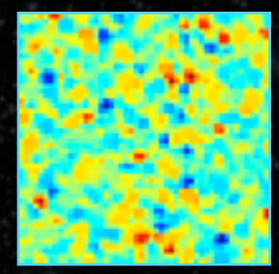


Conclusions

- **IFU - KINEMATICS FROM CROWDED FIELDS**
  - Black Hole Hunting in Globular Clusters
  - Sample of 10 Globular Clusters
- **N - BODY SIMULATIONS:**
  1. Reproduce Observations
  2. Test Analysis
  3. Deeper Understanding
- **FUTURE OBSERVATIONS:**
  - SINFONI
  - MUSE
  - GRAVITY







THANK YOU!