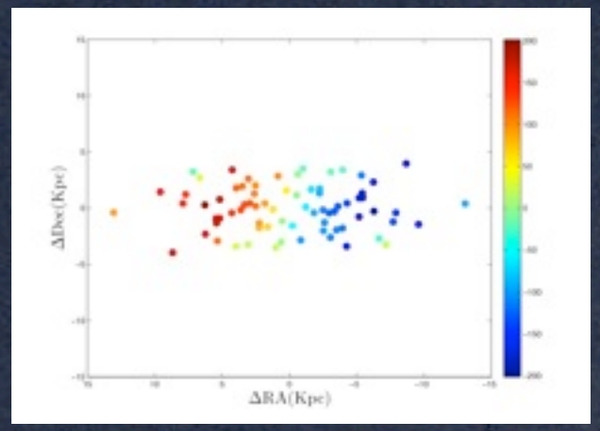
Dynamics of Nearby (early-type) Galaxies with SITELLE



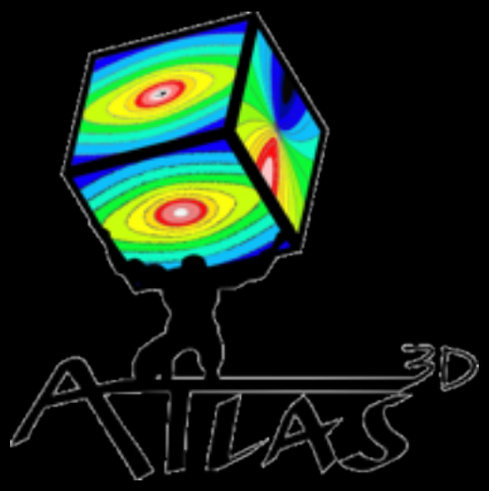
Eric Peng
Peking University
Kavli Institute for Astronomy and Astrophysics

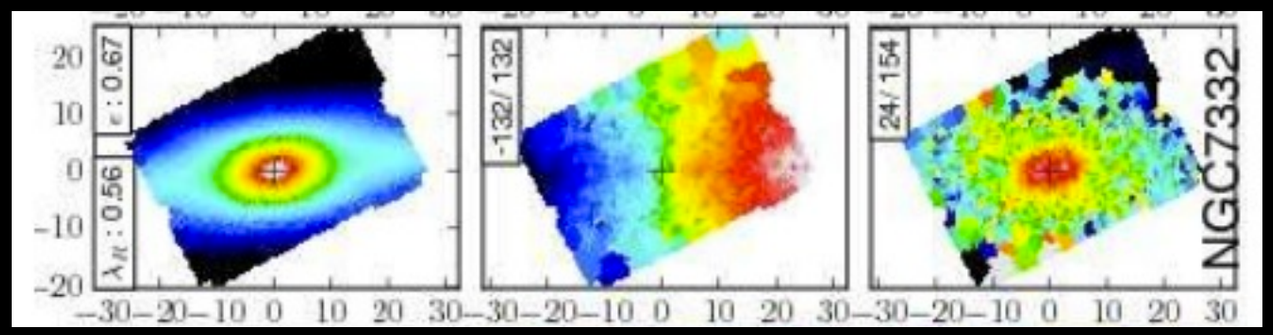
Stellar Dynamics in Early-type Galaxies

Science Drivers

- Dark matter content and profile (ETGs have little gas at large radii)
- Assembly history through kinematics (V/sigma, angular momentum, velocity ellipsoid, substructures)

IFU surveys of galaxies (SAURON/ATLAS3D, CALIFA, MaNGA)





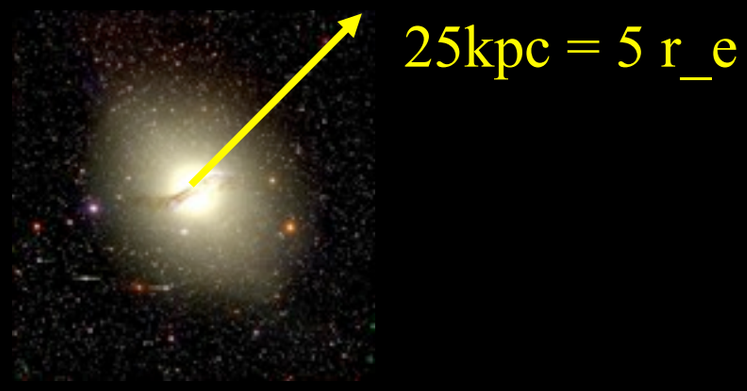
Stellar Dynamics in Early-type Galaxies

<u>Pushing to Large Radius: The Dynamics of Stellar Halos</u>

- Outer regions have high M/L
- Long dynamical times preserve signatures of evolution (mergers, accretion)

Integrated light techniques have a very hard time beyond 3-4 R_e

- Surface brightness falls off rapidly (well below sky level)
- Areal coverage becomes too big for traditional IFUs



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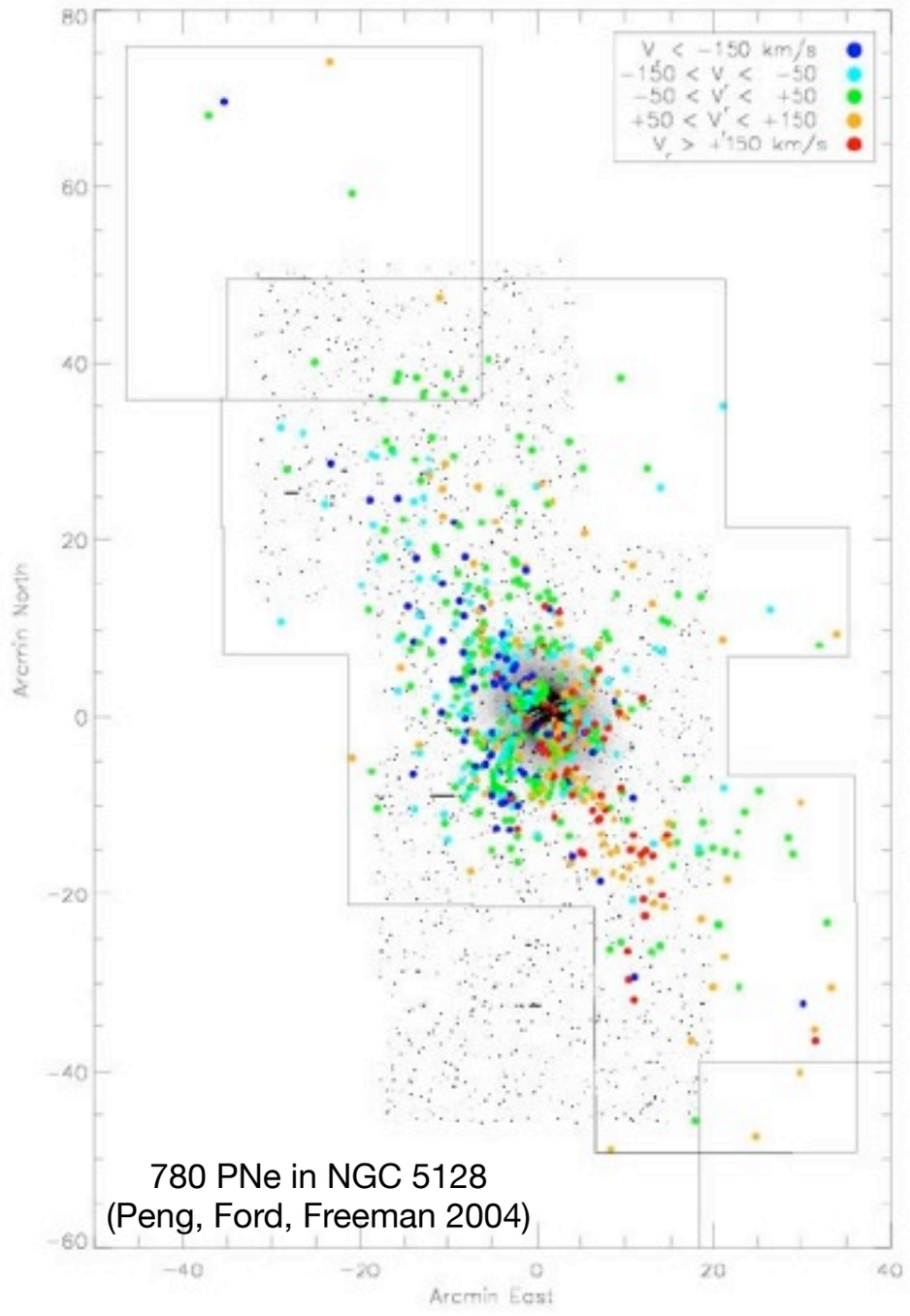
25kpc = 5 r_e

100 kpc = 18 r_e

Planetary Nebulae and Globular Clusters



780 PNe in NGC 5128
(Peng, Ford, Freeman 2004)

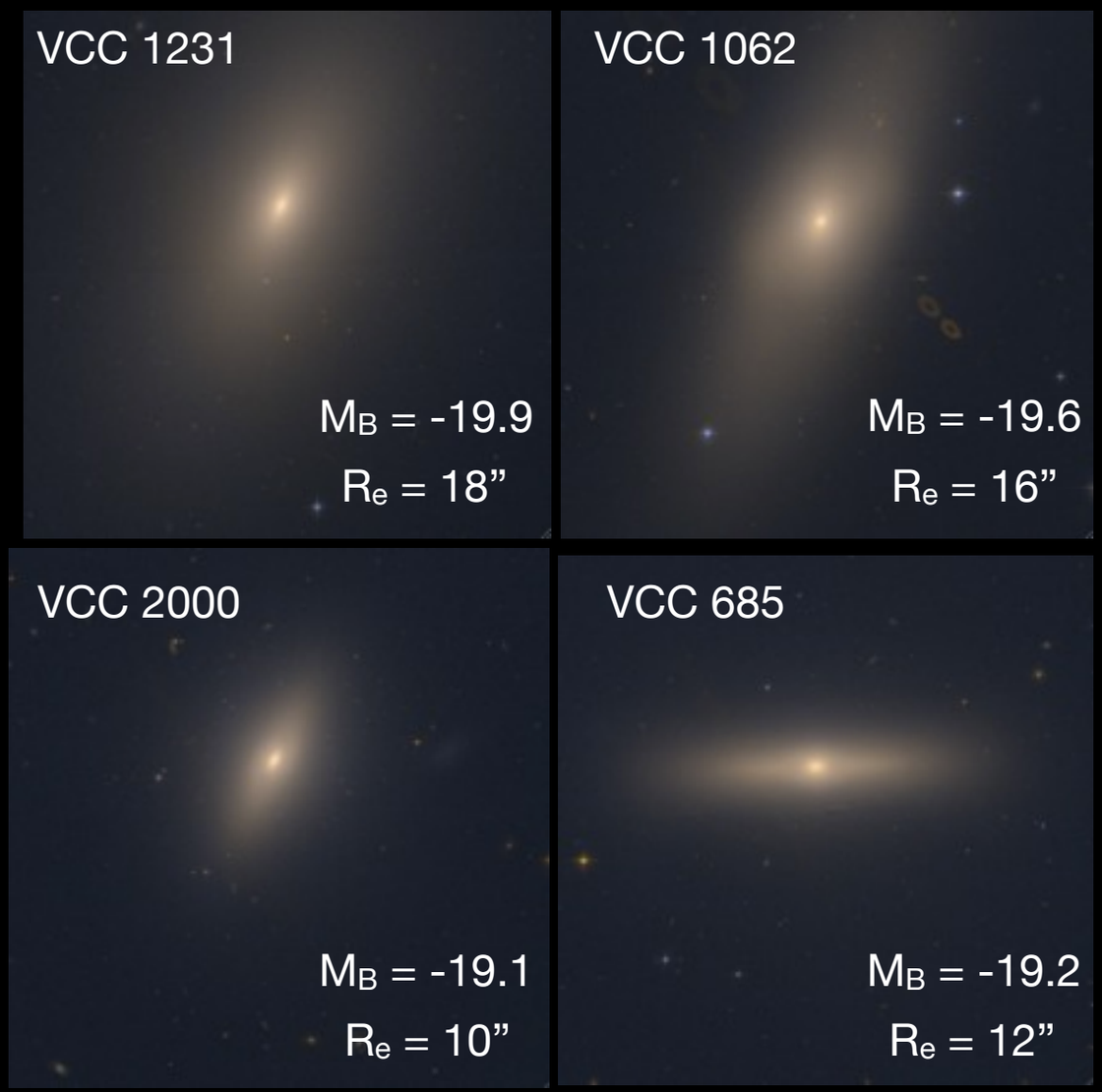
563 GCs in NGC 5128 (Woodley+10)

- emission lines
- ~5 km/s velocity resolution
- they are stars
- no confusion with foreground

- stellar population information
- probe of **different** formation conditions, accretion history
- Only “standard” imaging necessary

Roughly equal numbers of PNe and GCs accessible in each galaxy with similar aperture telescopes. Obviously, do both.

A Gemini/GMOS study of GCs in four intermediate luminosity early-type galaxies



Li, Peng+ in prep

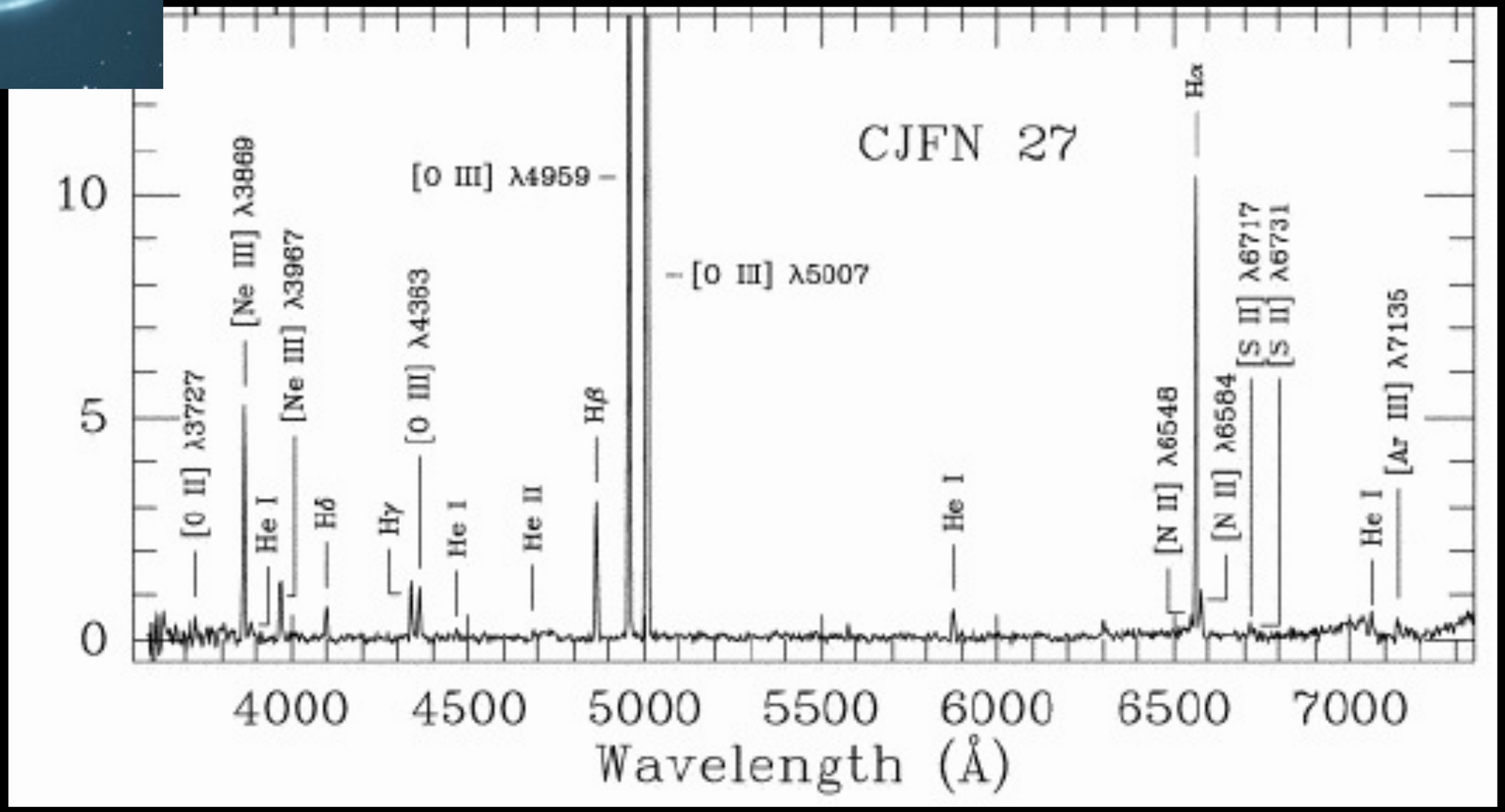
- Galaxy sample sub-L*
- Based on excellent GC selection from ACS Virgo Cluster Survey
- 3 masks per galaxy to overcome slit crowding (except for VCC 685)
  - ★ VCC 1231 / N4473: 52 GCs
  - ★ VCC 1062 / N4442: 36 GCs
  - ★ VCC 2000 / N4660: 44 GCs
  - ★ VCC 685 / N4350: 17 GCs (1 mask)
- Goals: GC kinematics, dark matter

Biao Li (PKU), Andrés Jordán, Gelys Trancho, Dean McLaughlin, Marianne Takamiya, Patrick Coté, Laura Ferrarese, Thomas Puzia, et al.

Biao Li (PKU)

Galaxy Dynamics with SITELLE: Planetary Nebulae

~15% of flux is in [OIII]5007 emission line.

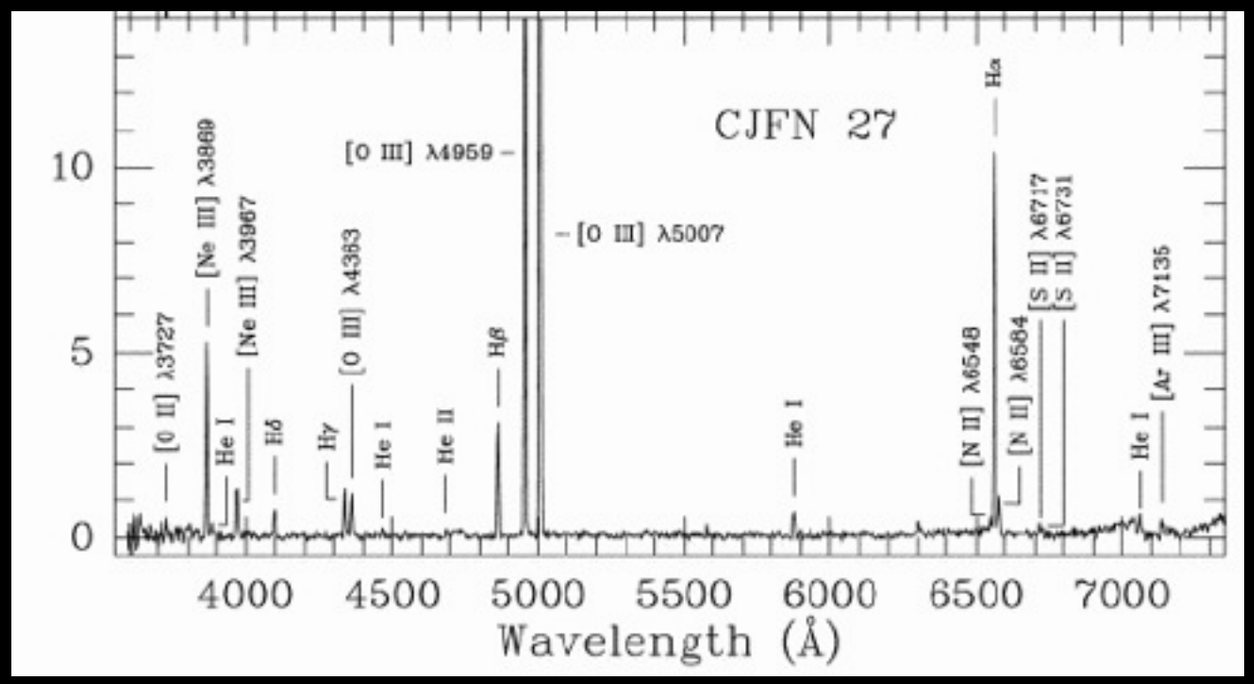


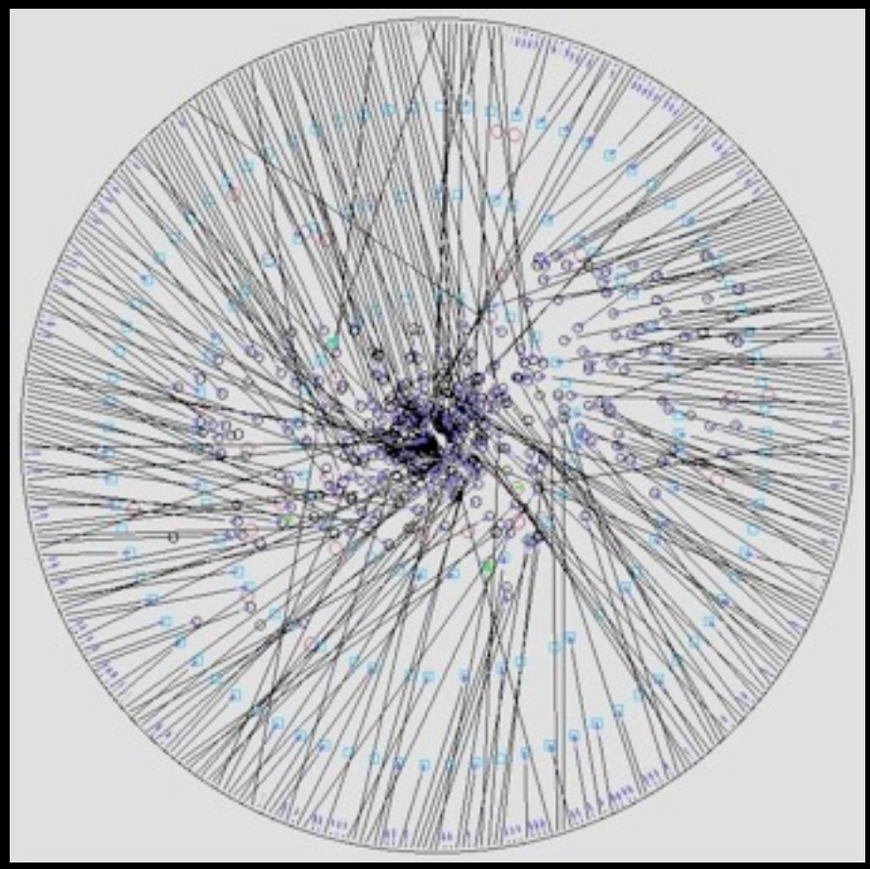
~10^4 L_{sun} in a single emission line with 0.5A FWHM!
Typical fluxes in nearby galaxies of 10^{-17} erg/s/cm^2

Galaxy Dynamics with SITELLE: Planetary Nebulae

Traditonally, doing PNe kinematics is a two-step process:

narrowband imaging + multi-object spectroscopy





Time-consuming and logistically problematic

SITELLE enables detection and velocity measurement in single observation

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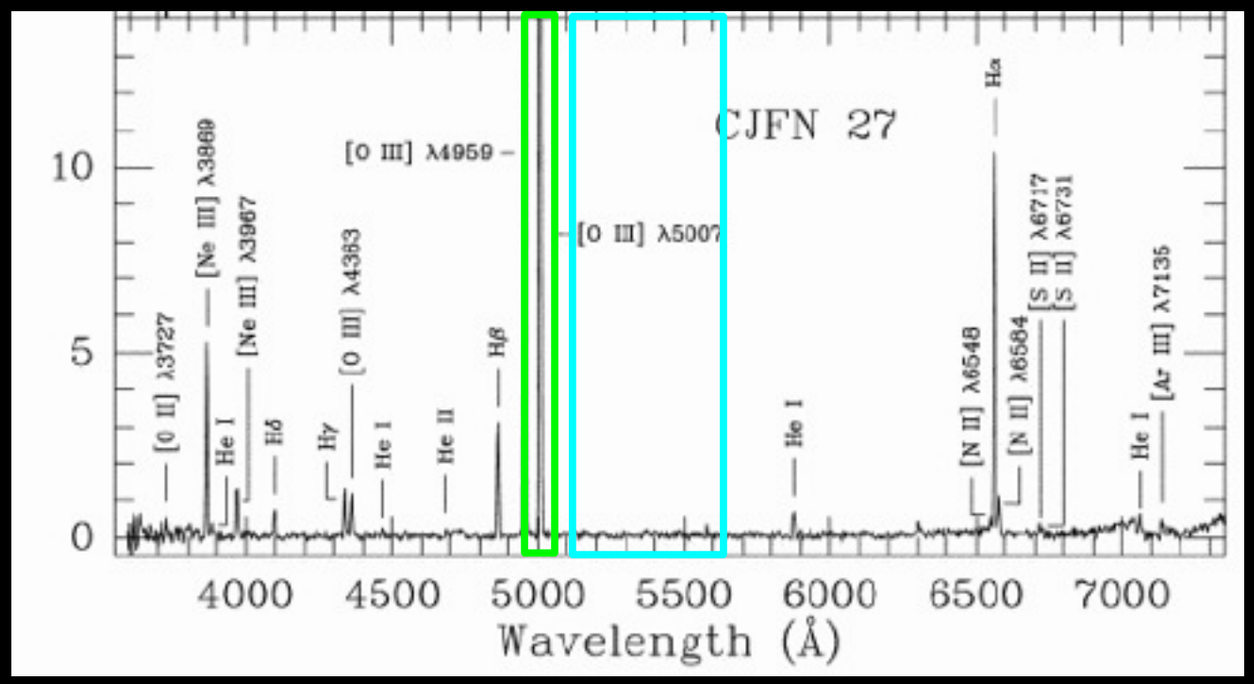

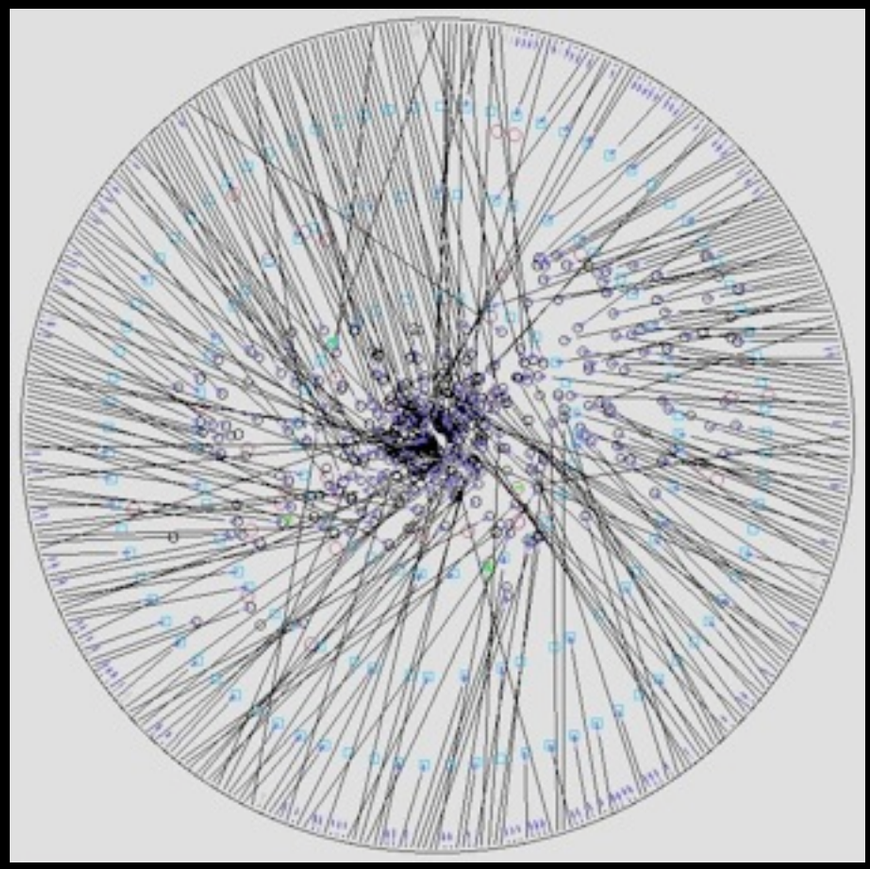

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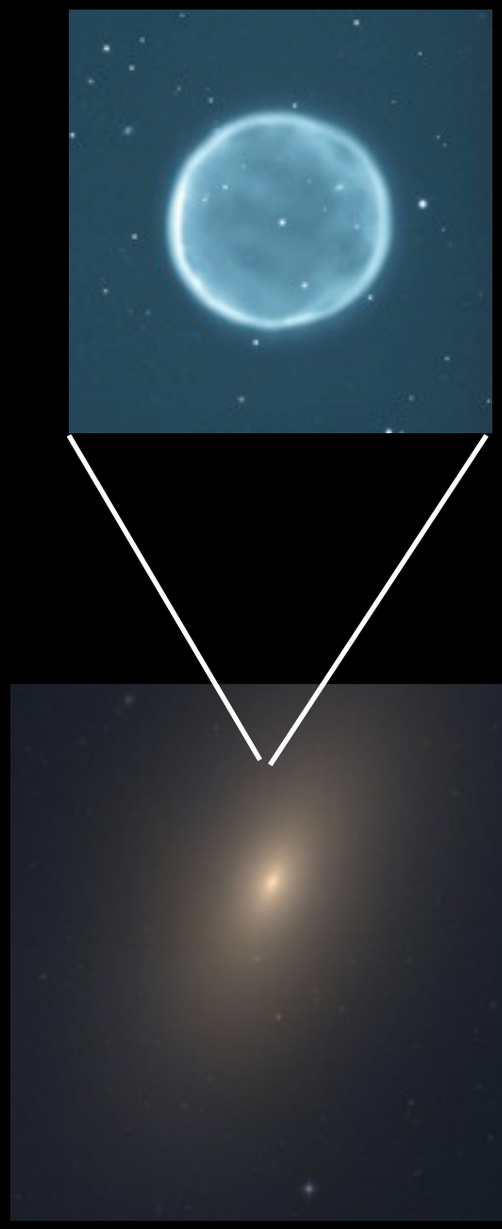


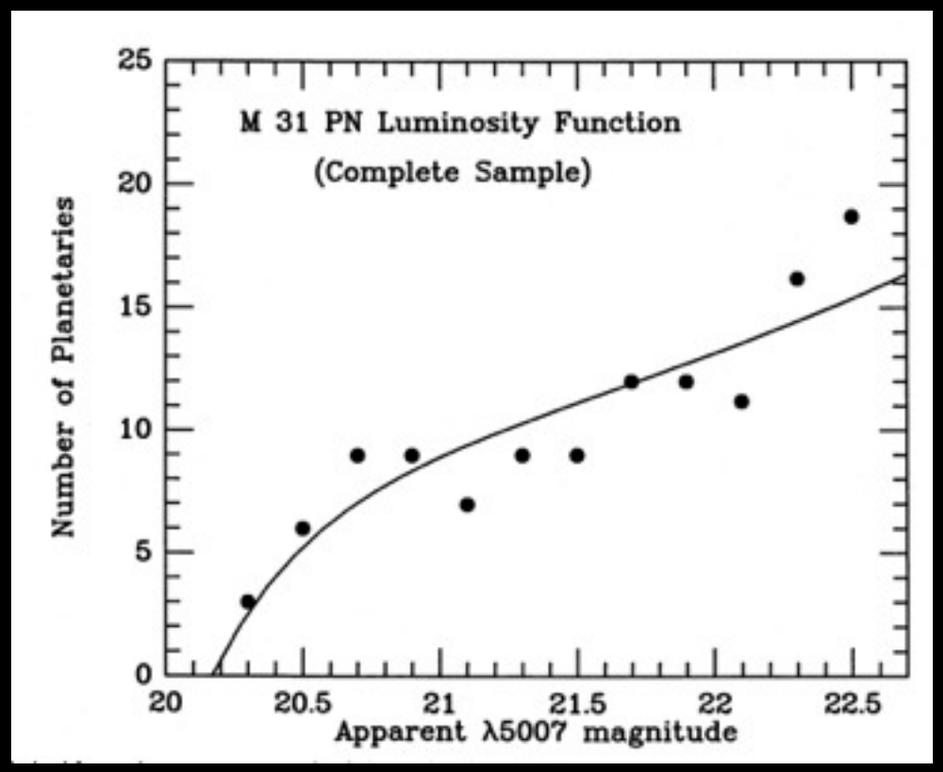
- PNe have expansion velocities of 20-30 km/s
- With R~10,000, can obtain velocities accurate to ~3 km/s, an order of mag better than most previous surveys
- Expansion velocities - AGB phase
- Single bright emission line - fairly narrow bandpass filter (~30-70A) to eliminate sky
- Hundreds of PNe over the 11’ FOV, which is well-suited to nearby galaxies

Main contamination: Lyman-alpha galaxies at z~3

R ~10,000 with adequate S/N easily resolves the Ly-a line (100-200 km/s)

Galaxy Dynamics with SITELLE: Planetary Nebulae

- m(5007) = -2.5*log(F(5007))-13.74
- M* = -4.51 (bright end cutoff of PNLF)
- $F(5007)_{M31,+2.5} \sim 3x10^{-15}$ erg/s/cm^2
- $F(5007)_{Virgo,+2.5} \sim 7x10^{-18}$ erg/s/cm^2
- $F(5007)_{Coma,+2.5} \sim 2x10^{-19}$ erg/s/cm^2



Ciardullo et al.

At Virgo distance:

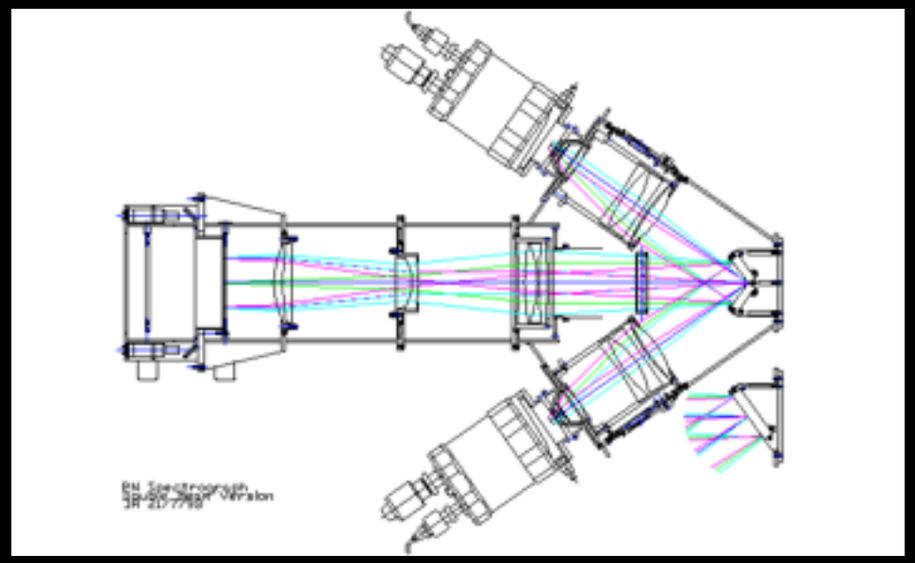
11 photons/minute at CFHT

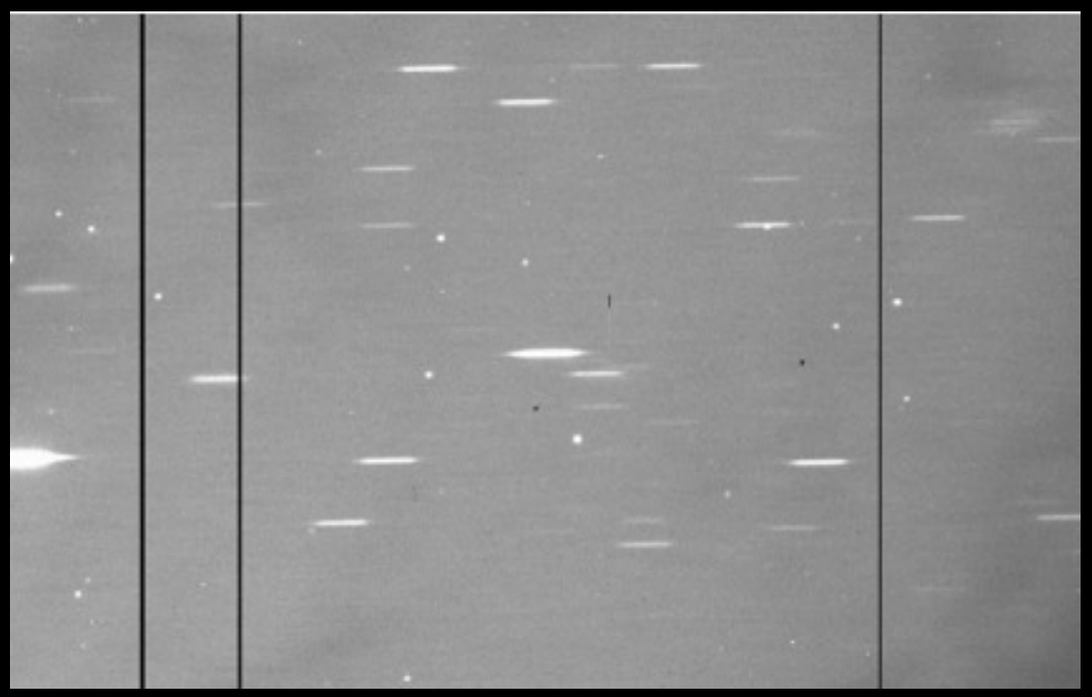
We will probably not detect PNe in single steps of a scan...

The Competition: VLT/FLAMES

- Multifiber spectrograph (130 fibers)
- FOV ~ 25’ diameter
- R~25,000
- Still requires prior imaging for targets
- SITELLE’s advantages: image quality, throughput, single observing detection
- CFHT/SITELLE could be competitive with VLT/FLAMES

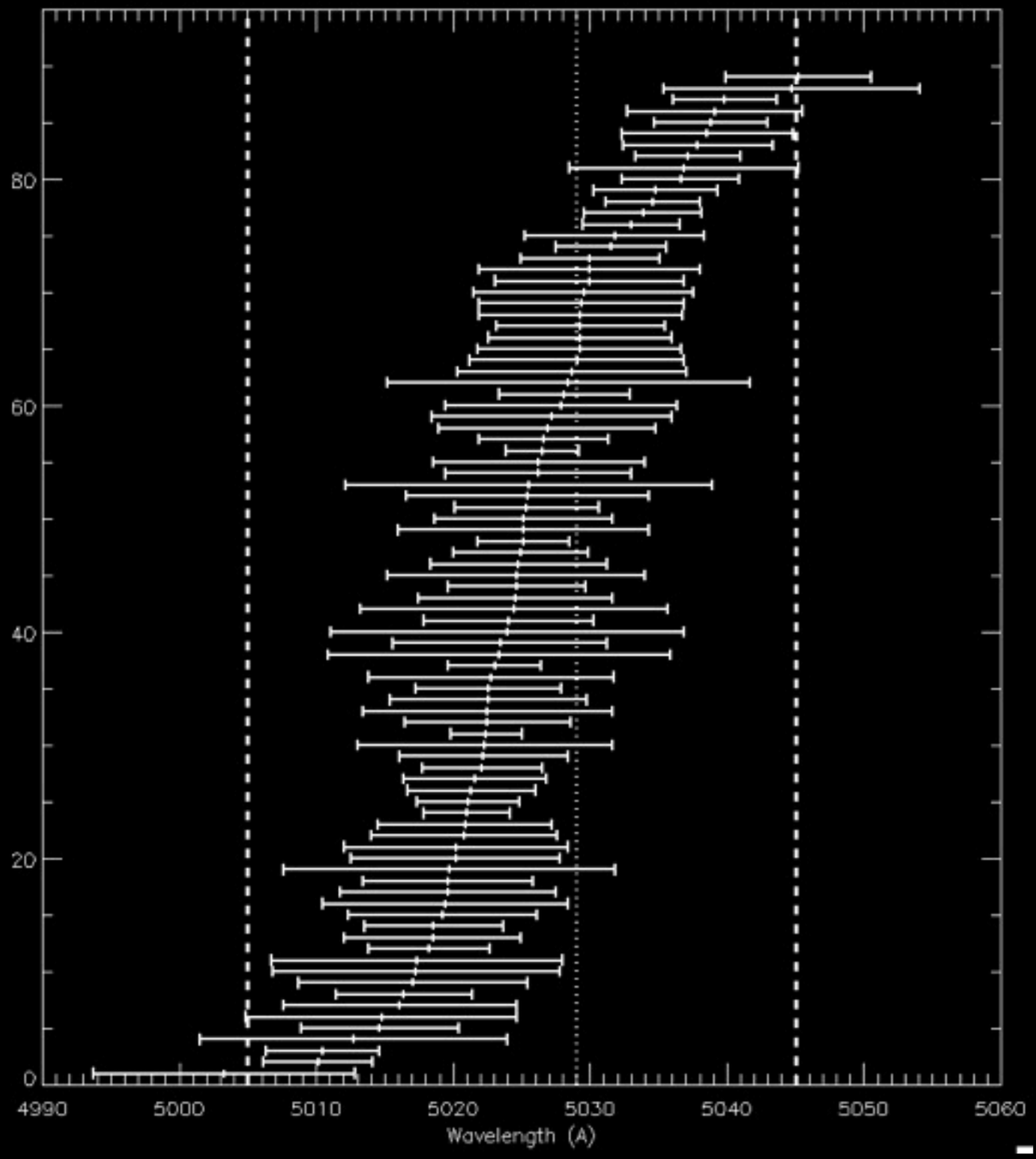
The Competition: The PN Spectrograph





- Counter-dispersed imaging, 11’ FOV
- Slitless spectroscopy also enables identification and velocity in one observation
- Already surveyed ~30 galaxies at WHT 4.2m
- SITELLE’s advantages: image quality at CFHT (0.7” vs 1.8”), throughput, spectral resolution

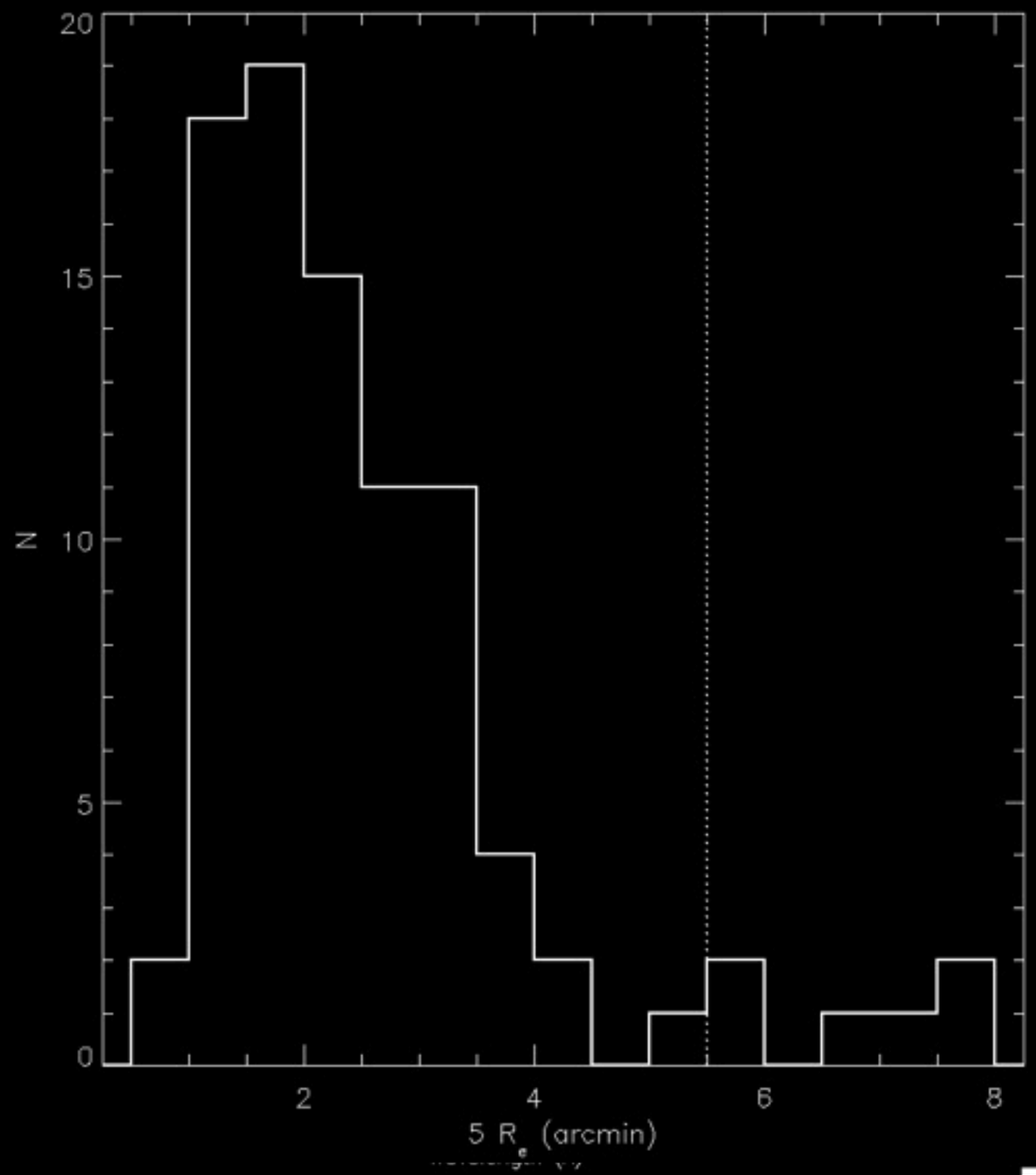
Galaxy Dynamics with SITELLE: Planetary Nebulae



<u>Filter considerations</u>

- 89 ATLAS3D early-type galaxies within 20 Mpc
- SITELLE bandpass filter: narrow as possible while including as many galaxies as possible
- ~5005A-5045A (40A) enables observations of most galaxies within 20 Mpc
- SITELLE FOV well-matched

Galaxy Dynamics with SITELLE: Planetary Nebulae



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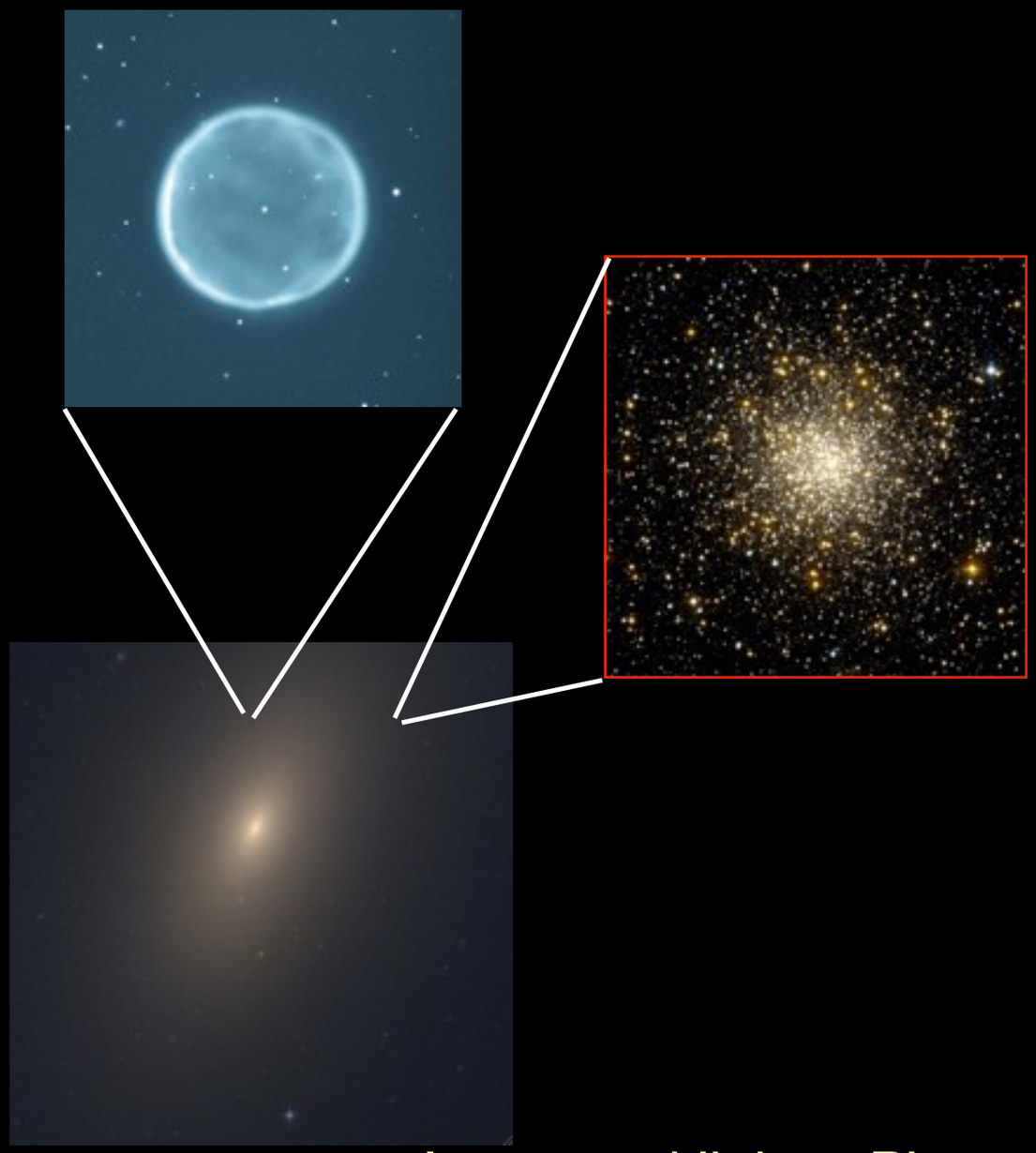
Galaxy Dynamics with SITELLE: The Dream

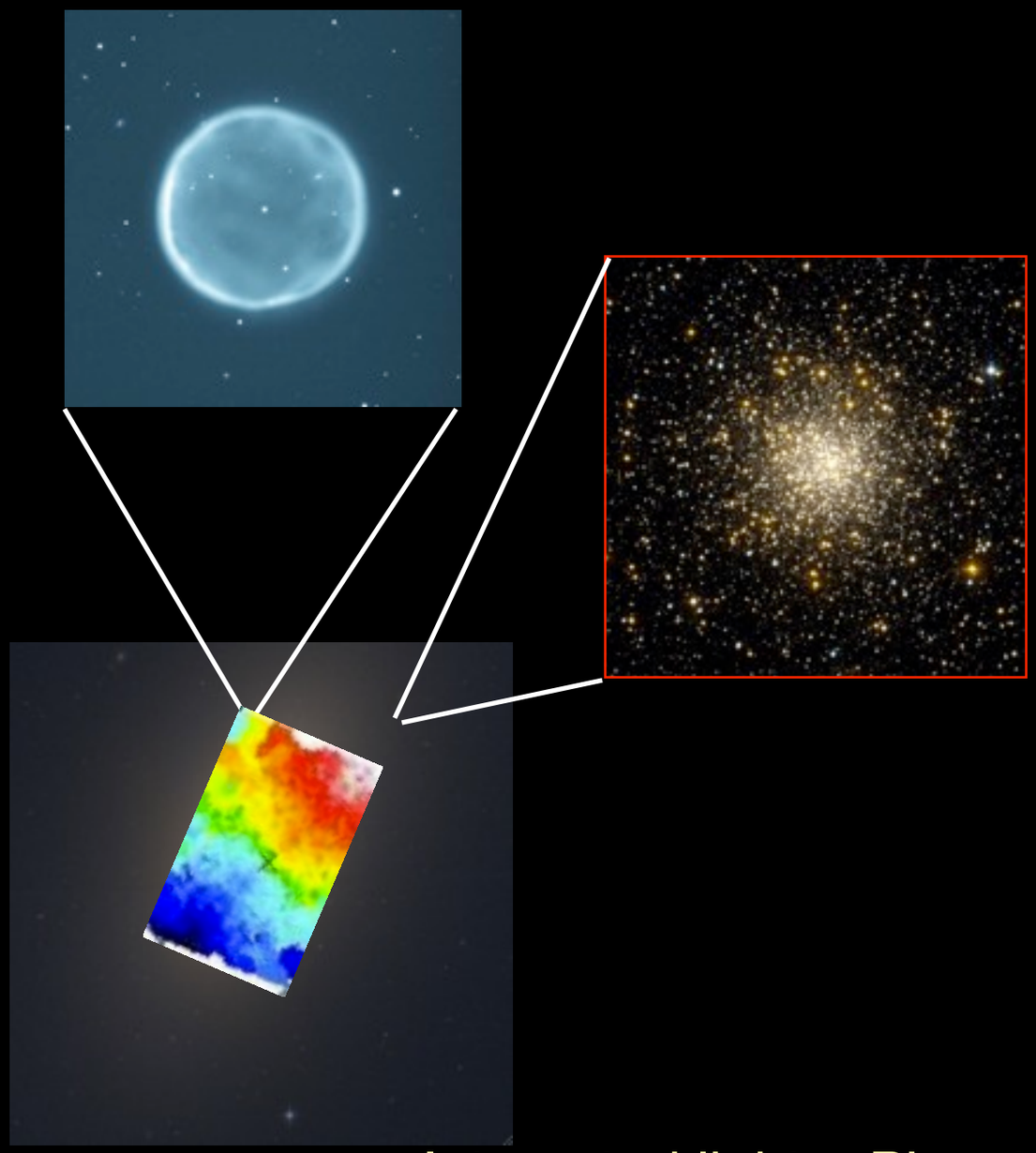


- GCs are complementary tracers
- Which wavelength region?
- H-beta, Mgb, H-alpha, CaT
- At Virgo distance 19<V<24

- Integrated light kinematics
- Which wavelength region?
- H-beta, Mgb, H-alpha, CaT
- How to measure LOSVD?

Integrated light + Planetary Nebulae + Globular Clusters =
The most comprehensive and homogeneous survey of early-type galaxy kinematics
(see talks by Martin Bureau and Pat Côté)

Galaxy Dynamics with SITELLE: The Dream



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