Crowded Field 3D Spectroscopy: Resolved Stellar Populations in Nearby Galaxies Observed with MUSE

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& MUSE Team

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Estallidos VIII
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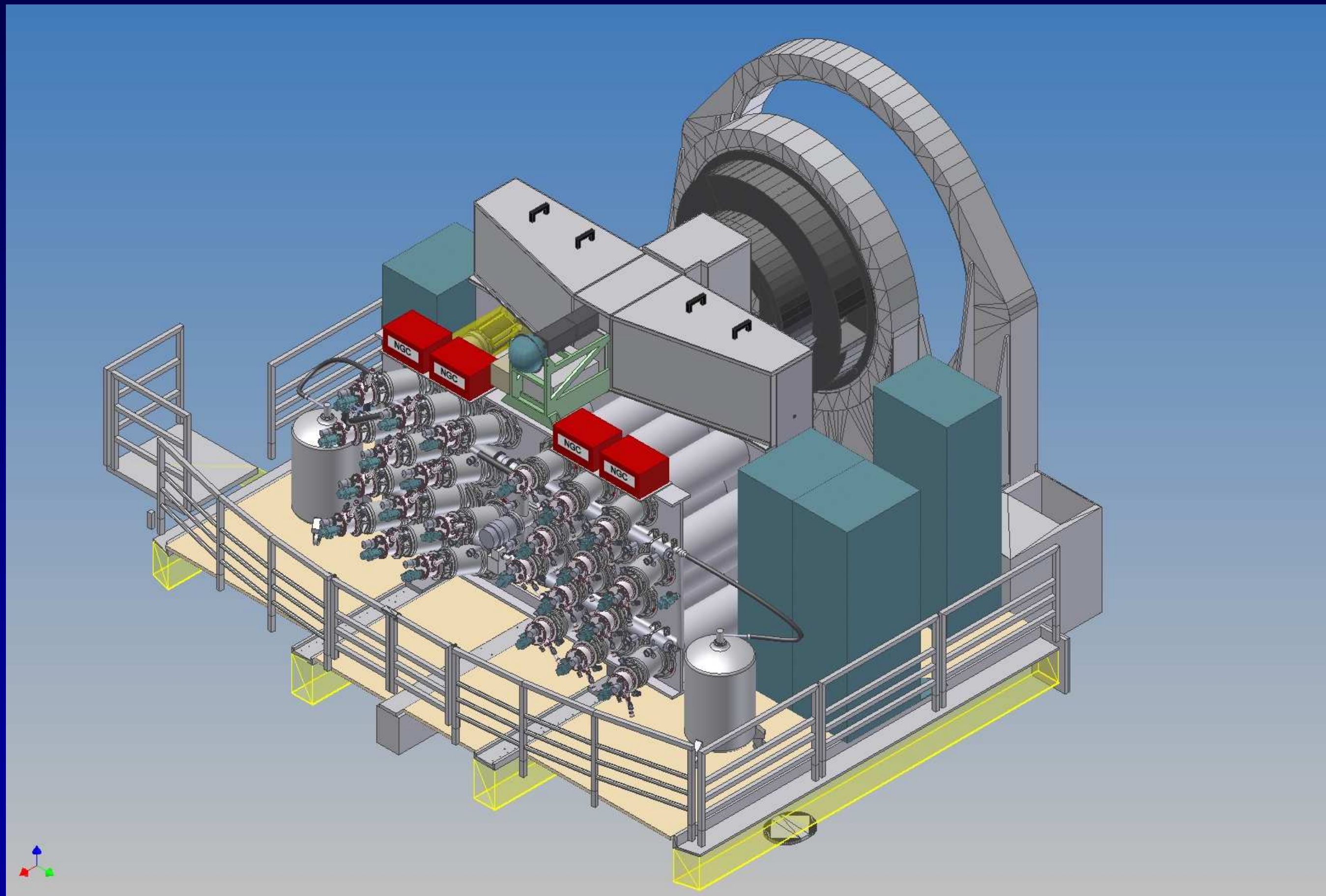
I. Status of MUSE

II. Crowded Field 3D Spectroscopy

III. MUSE GTO planning

IV. Conclusions

I. MUSE Status (as of March 2010)



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	1x1 arcmin ^{2}
Spatial sampling	0.2x0.2 arcsec ^{2}
Spatial resolution (FWHM)	0.3-0.4 arcsec
Gain in ensquared energy within one pixel with respect to seeing	2
Condition of operation with AO	70%-ile
Sky coverage with AO	70% at Galactic Pole
Limiting magnitude in 80h	I_{AB} = 25.0 (R=3500)
	I_{AB} = 26.7 (R=180)
Limiting Flux in 80h	3.9 10^{-19} erg.s $^{-1}$.cm $^{-2}$

4096 pixels

370 x 10^6 pixels

90,000 spaxels

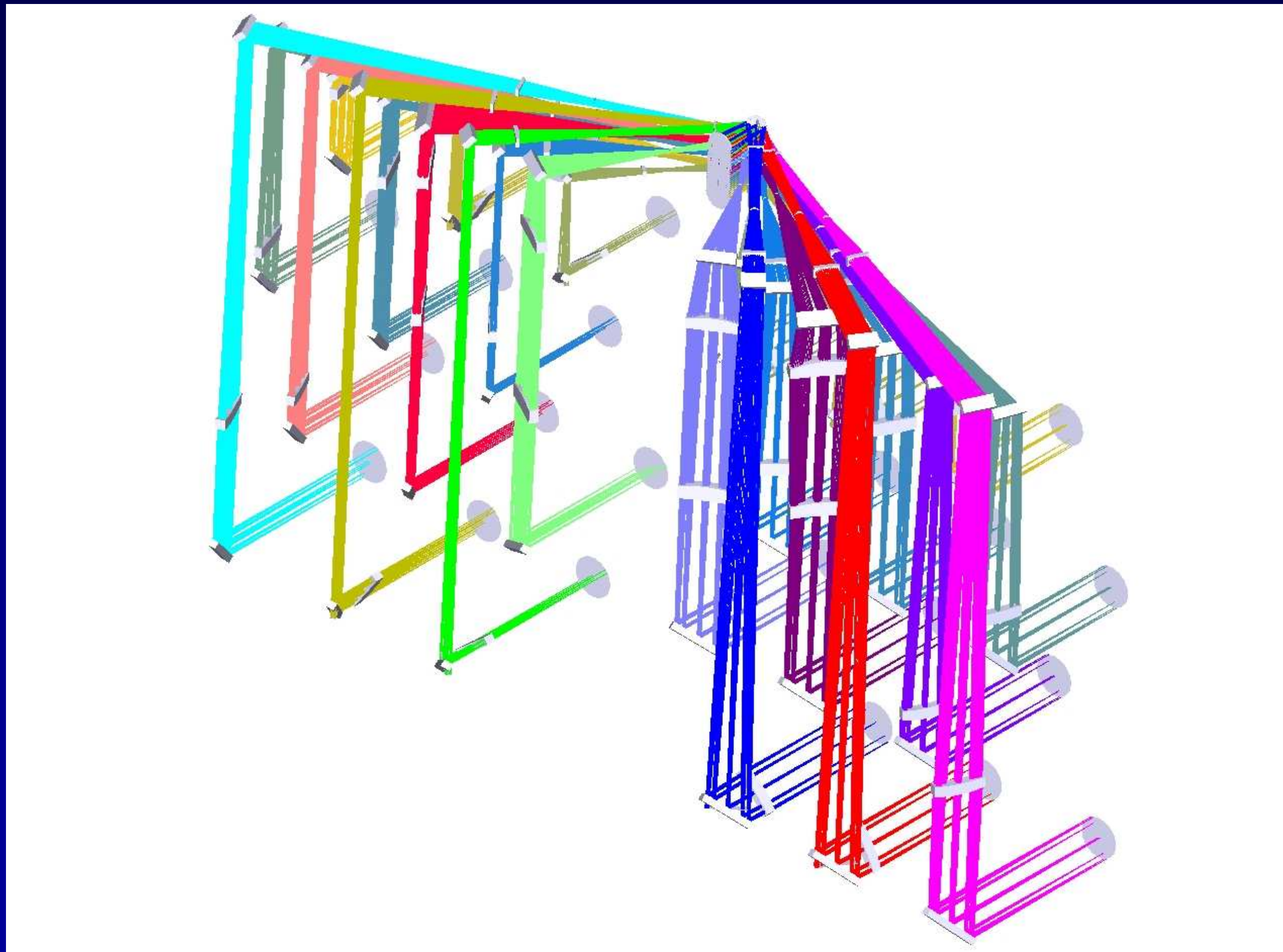
AO

Laser guide stars

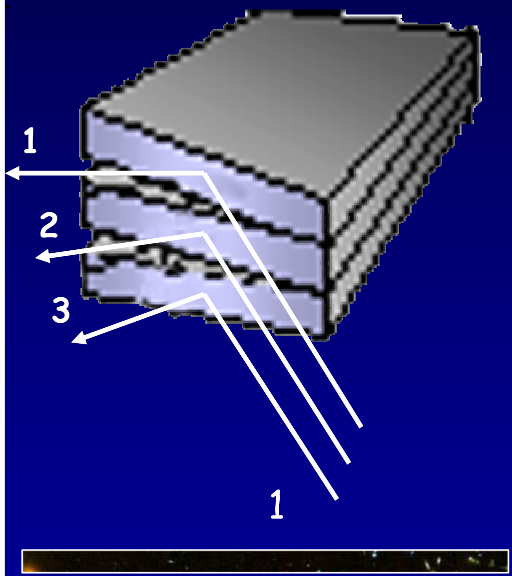
High throughput

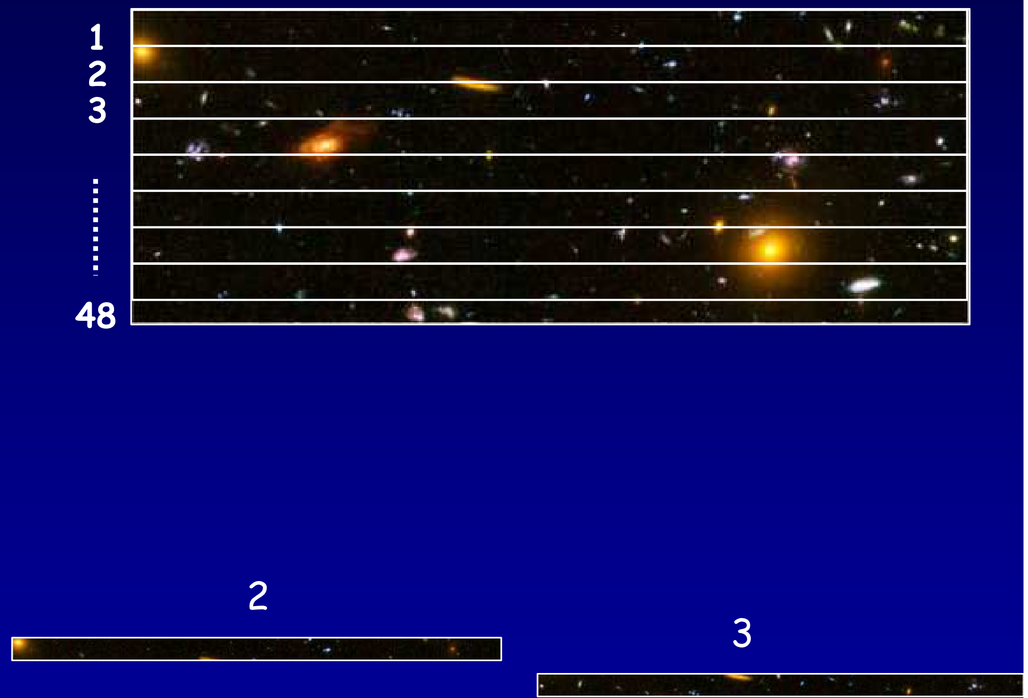
Stability

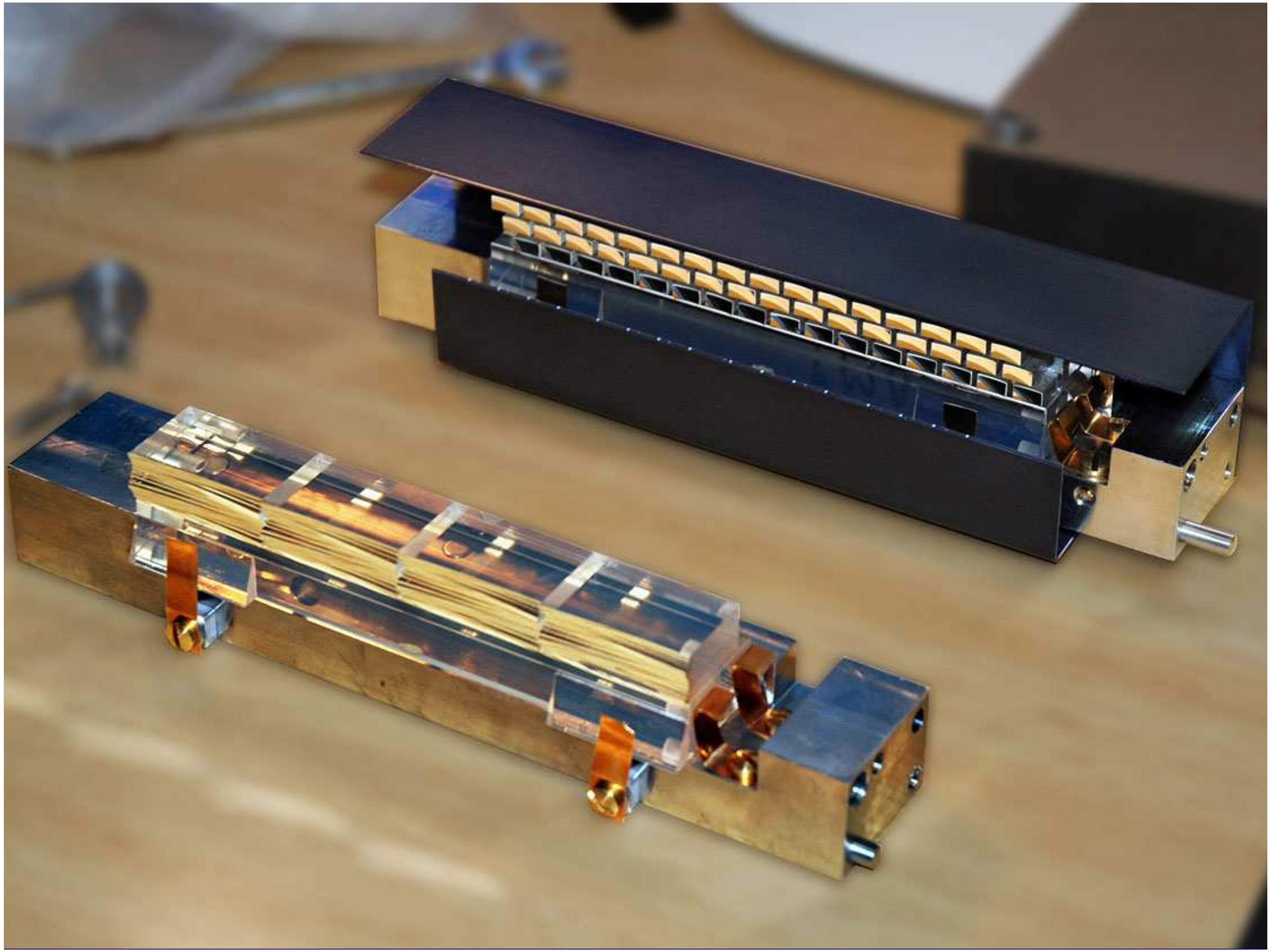
Field Splitter and Separator

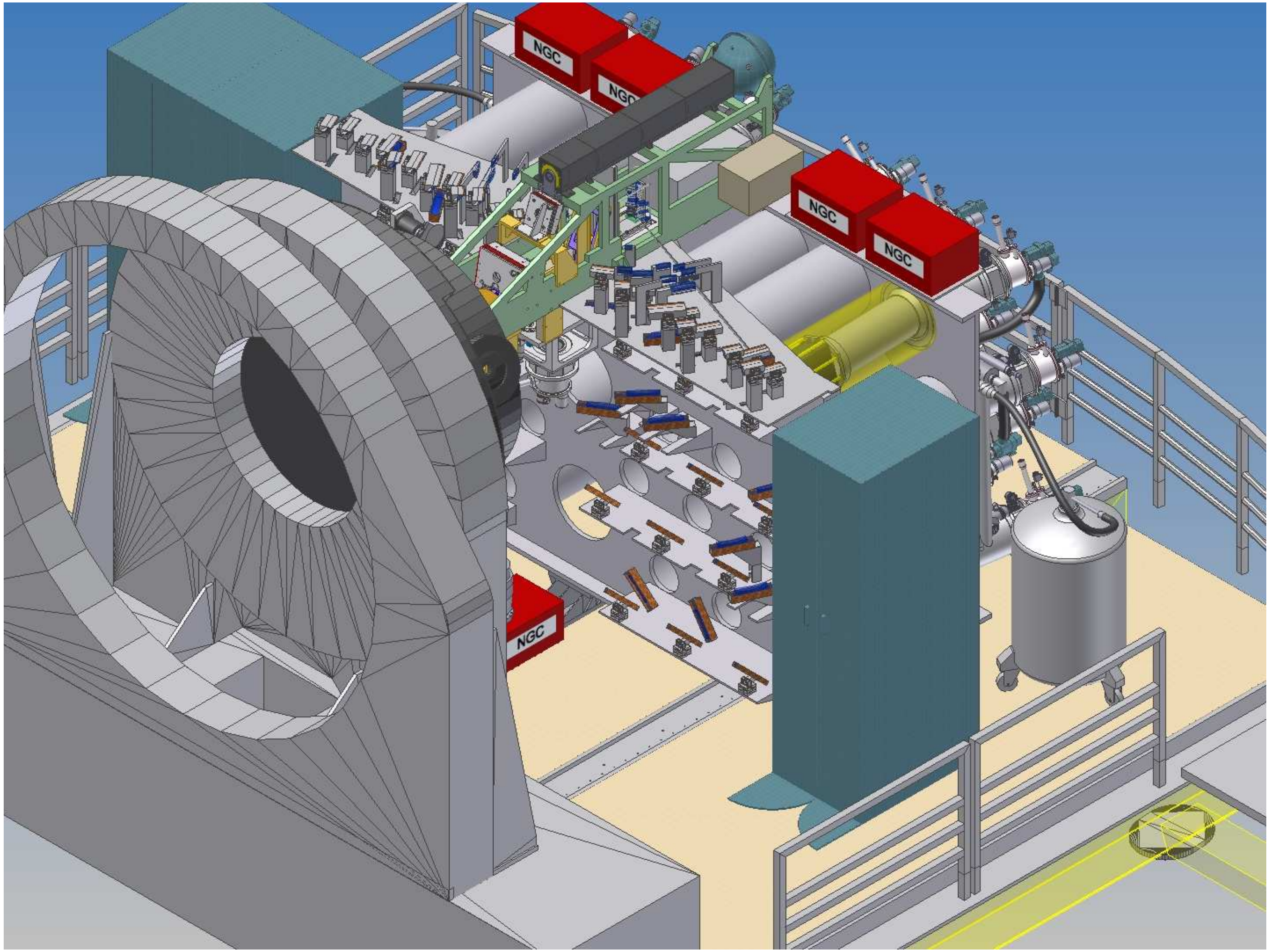


Slicer IFU :

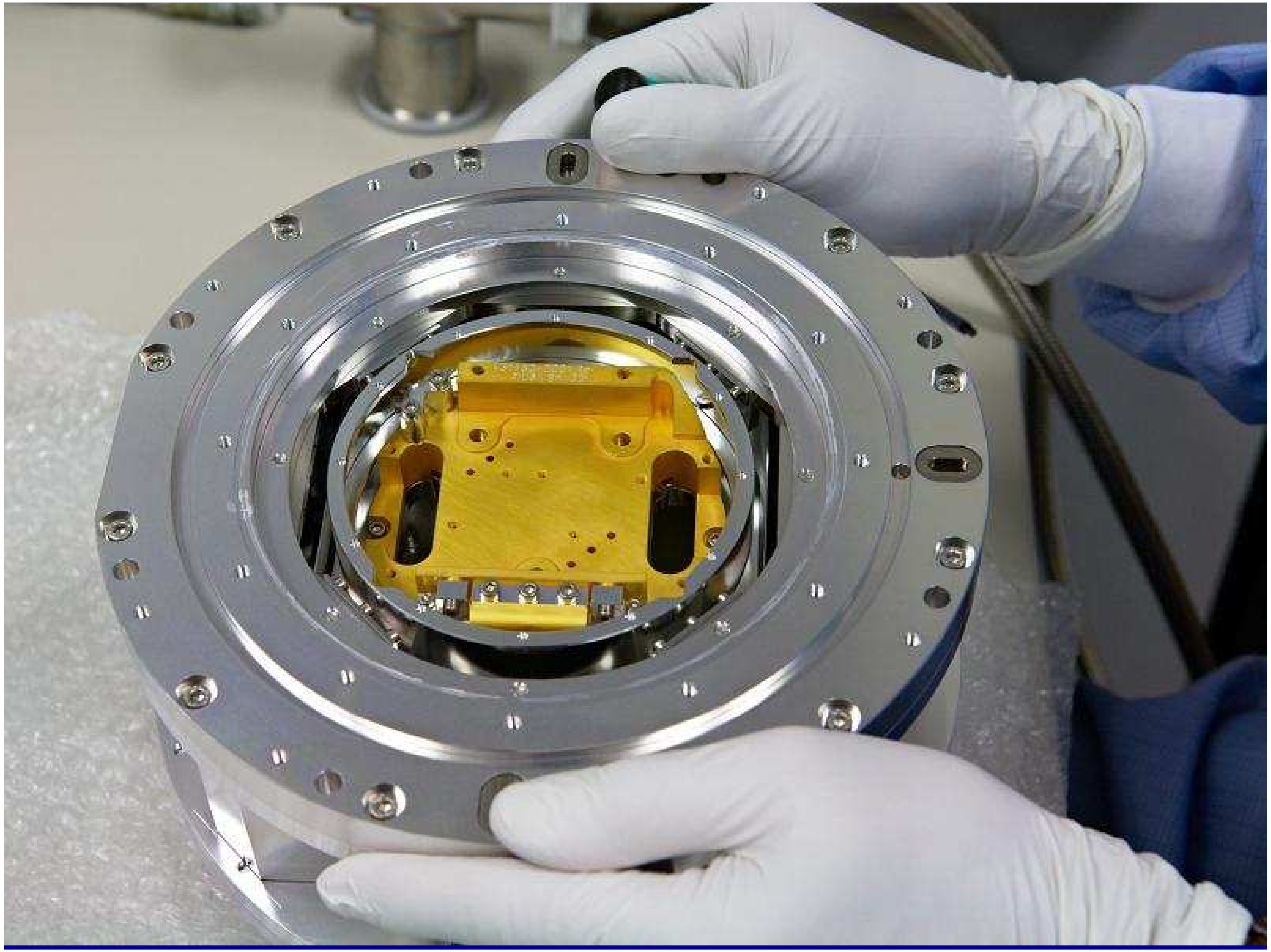


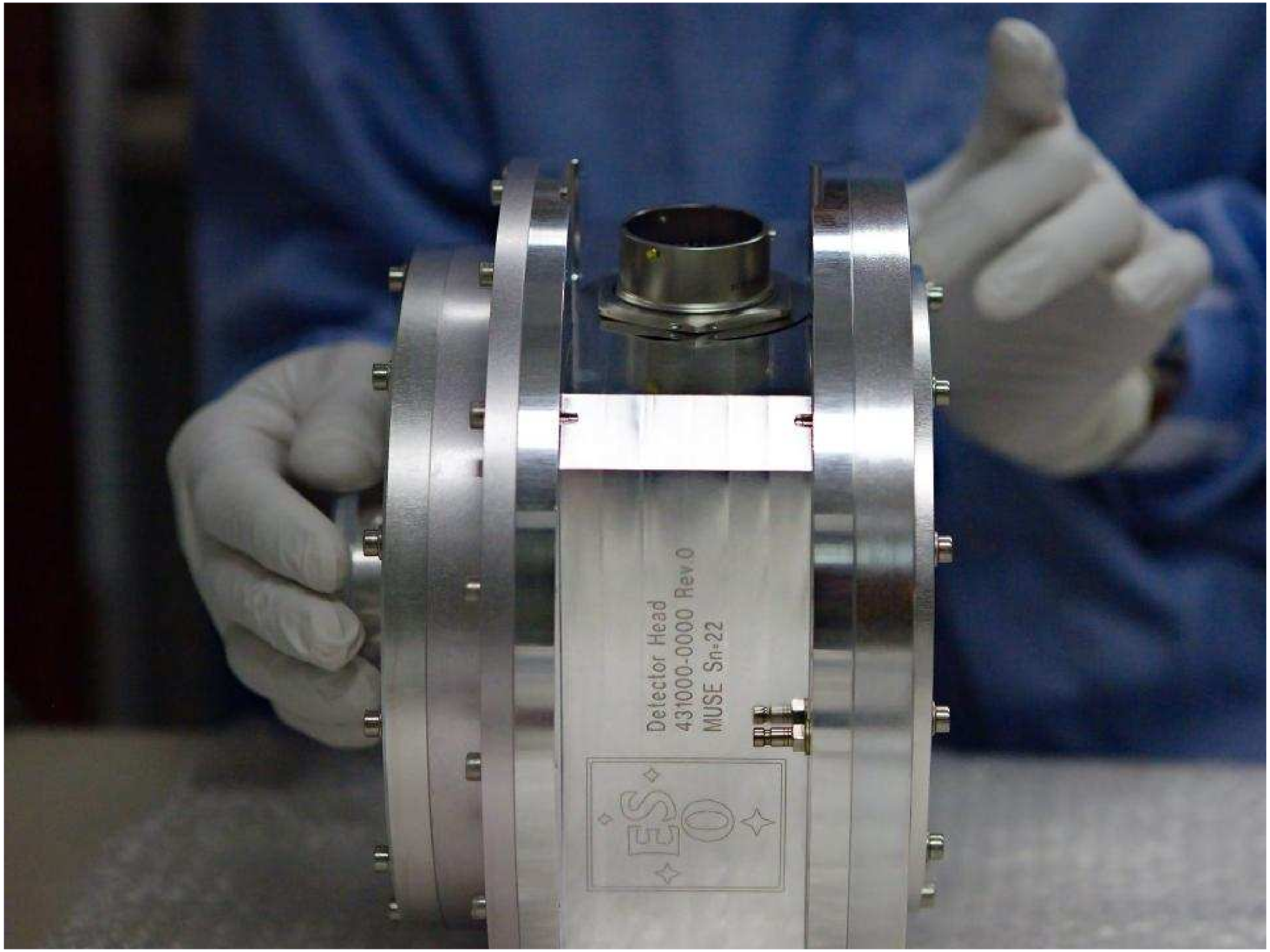


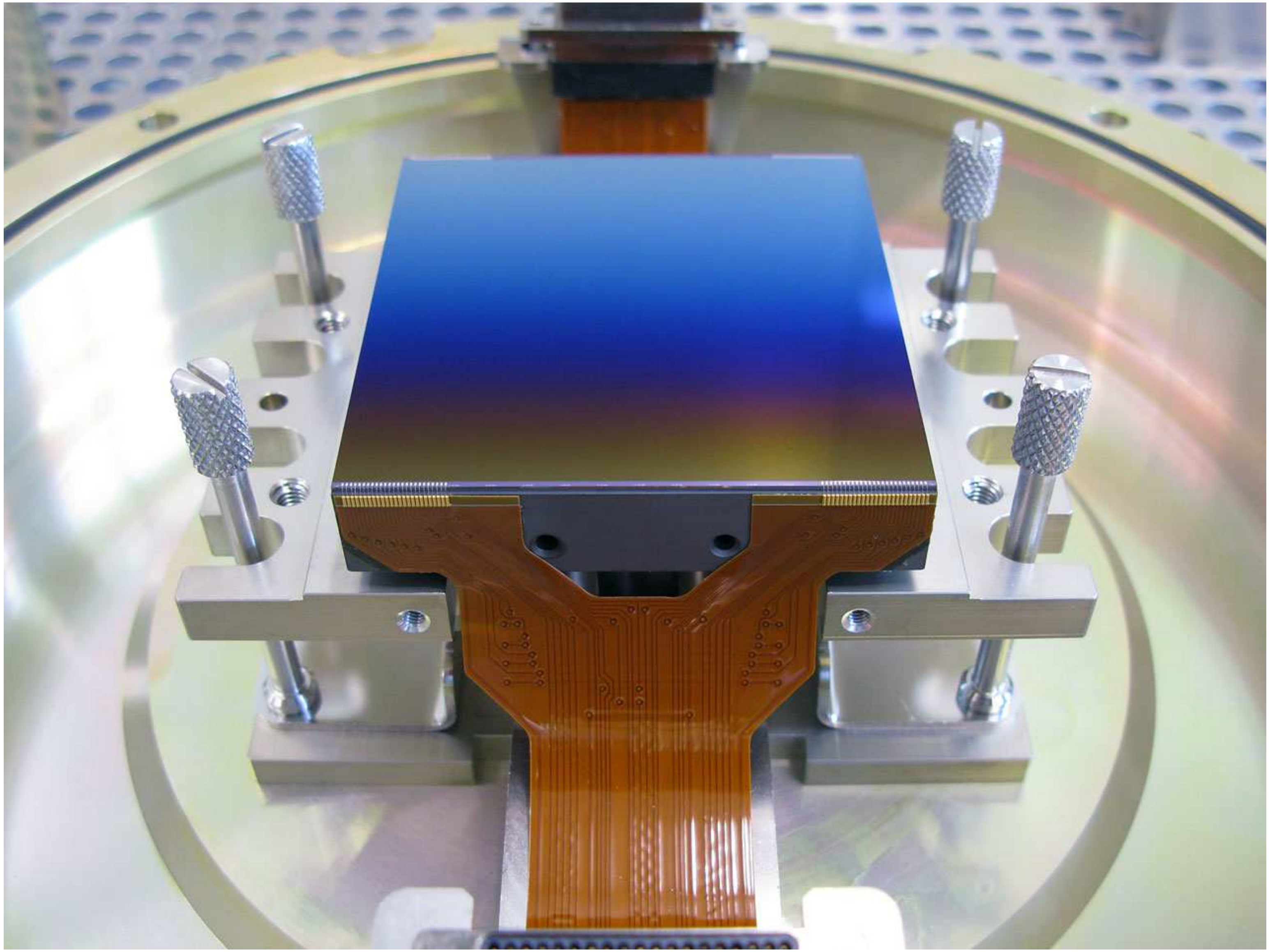


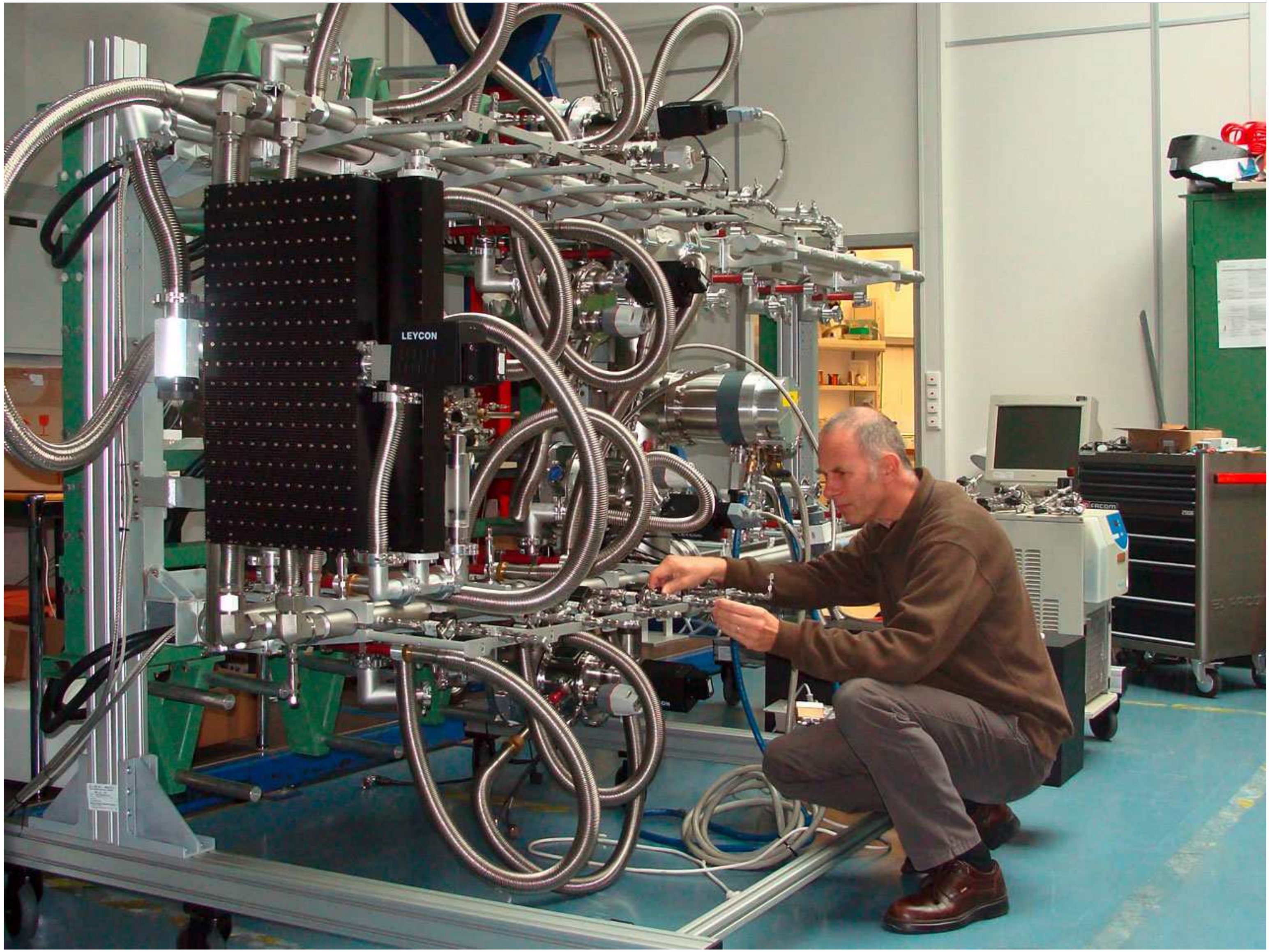

NGC


Newport

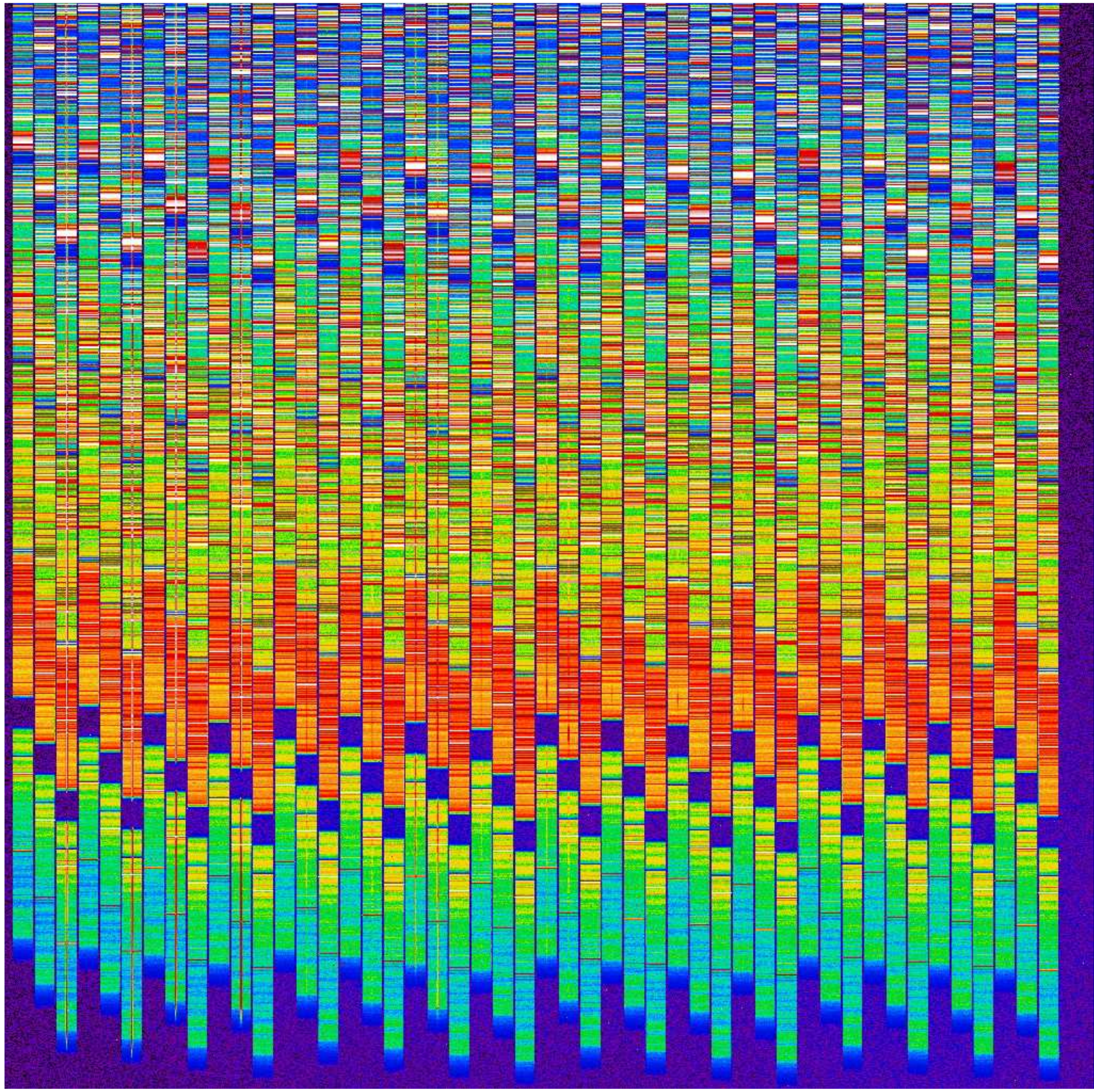



Detector Head
431000-0000 Rev.0
MUSE Sn-22



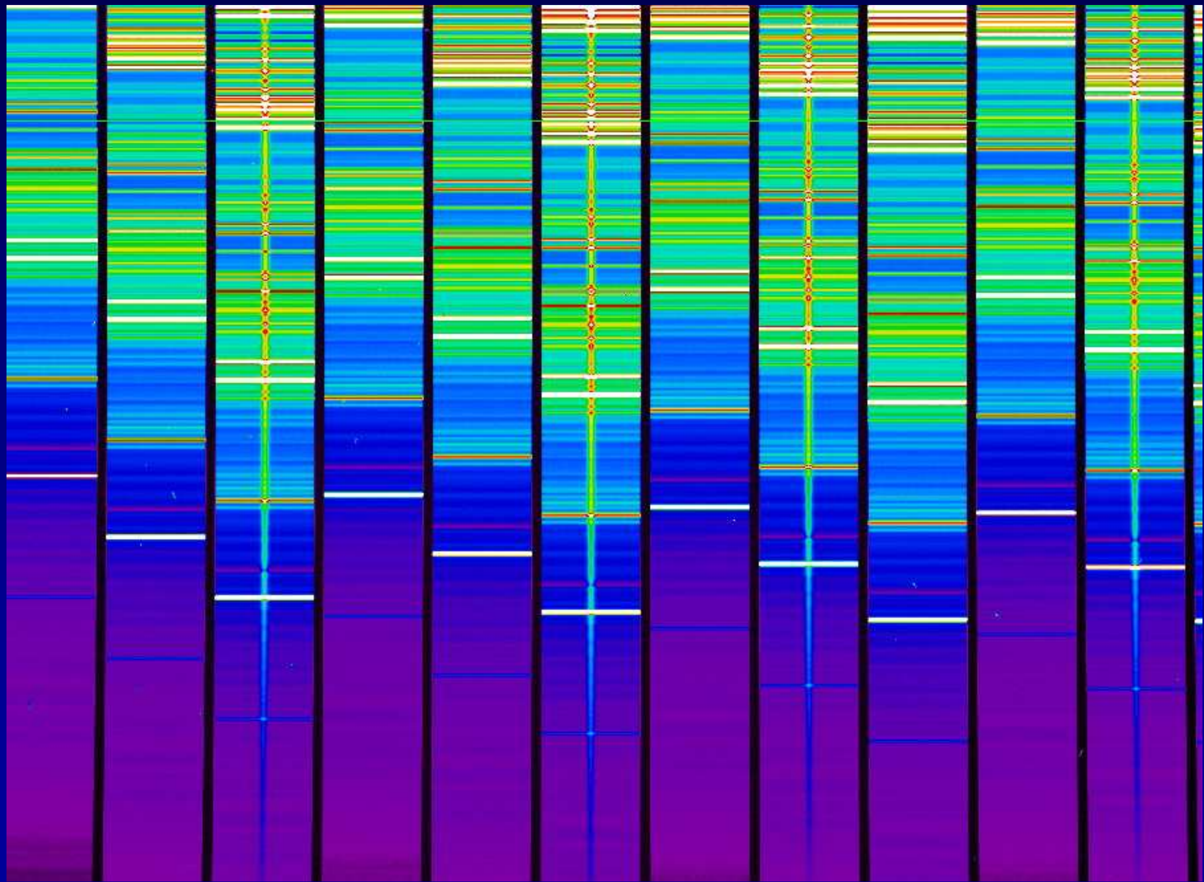

LEYCON

MUSE



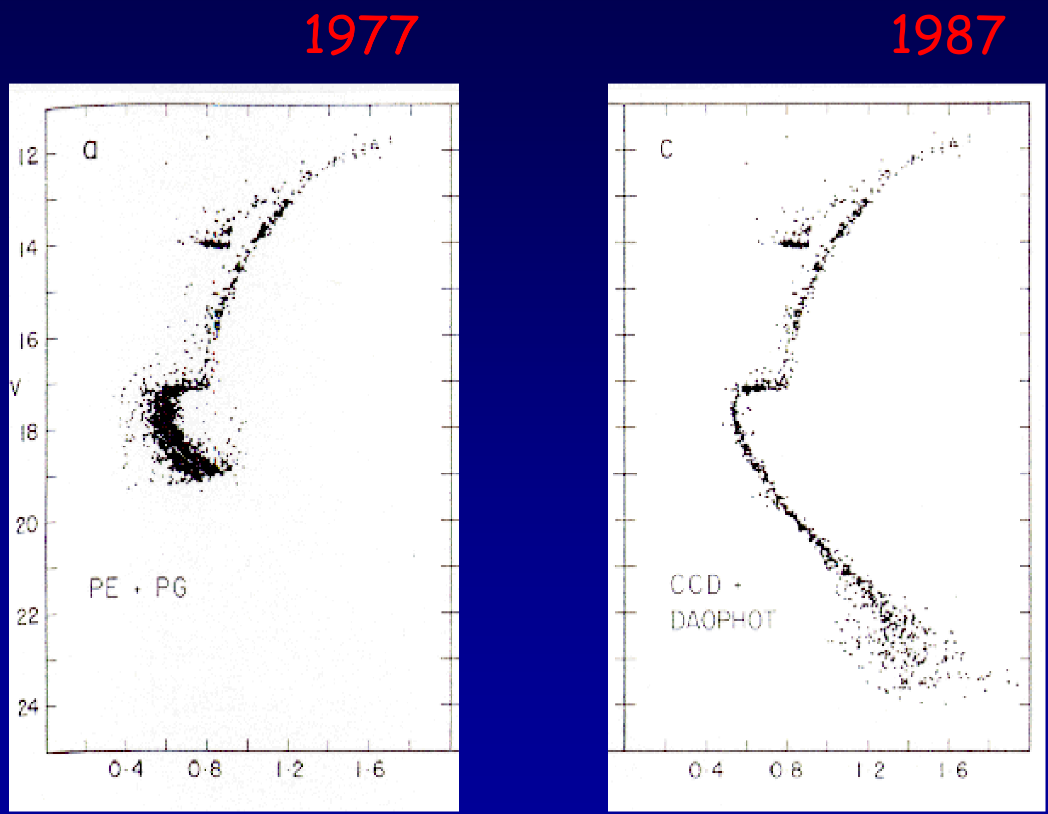
raw science frame :

2400s, 158 cosmic ray hits



II. Crowded Field 3D Spectroscopy

47 Tuc



Hesser et al. 1987

„Imaging the Universe in Three Dimensions“
Walnut Creek, March 1999

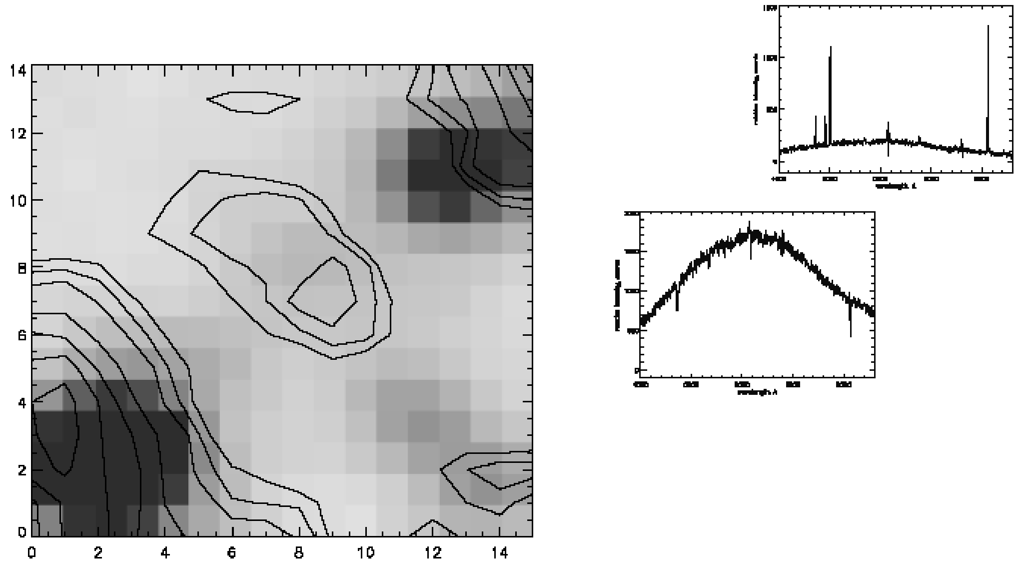
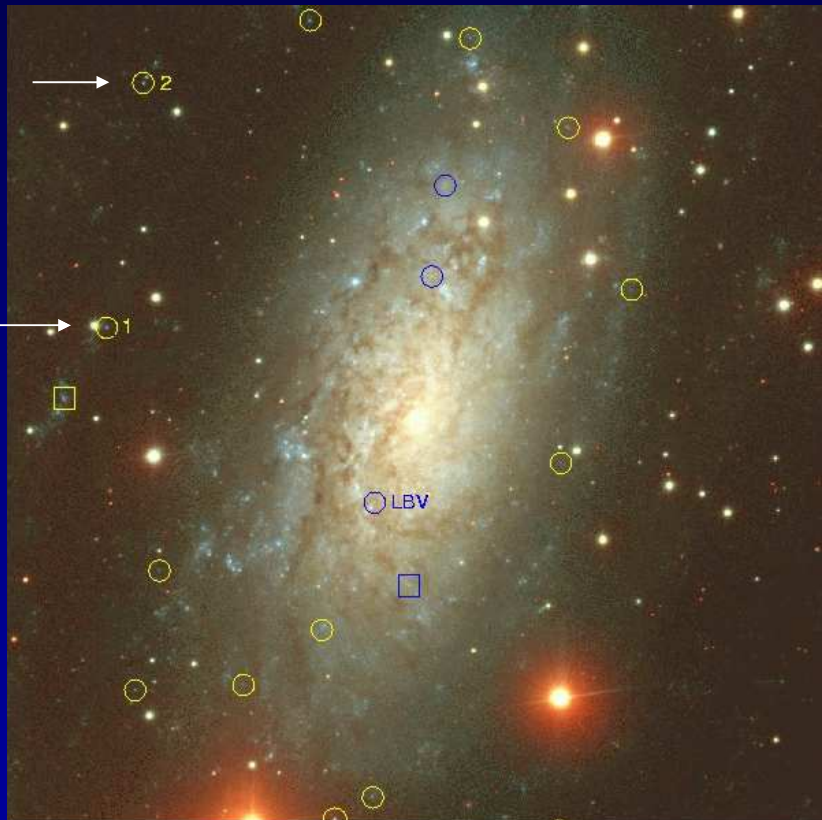


Figure 1. Crowded field 2D spectroscopy of a star forming region in M33. The greyscale image represents the continuum, contours indicating the emission line surface brightness in H_α. Integrated spectra of the star to the upper right ($m_v \approx 18$) and a nearby H II region are plotted on the right. The example demonstrates how the subtraction of the nebular emission would have been underestimated from slit spectroscopy, taking e.g. background values from above and below the star with a vertically oriented slit. MPFS data kindly provided by S. Fabrika, V. Afanasiev, S. Dodonov (SAO).

Blue Supergiants in local Volume Galaxies

Star 1: V = 20.41

Star 2: V = 20.43

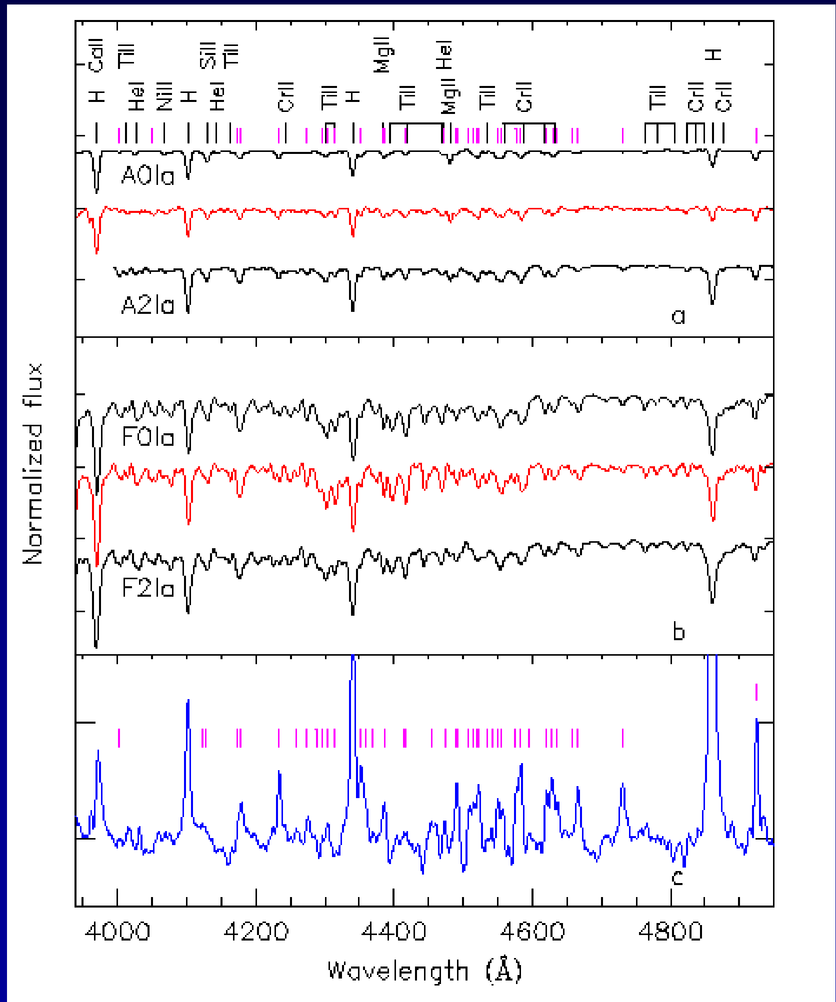


NGC3621
d = 6.7 Mpc

Bresolin et al. 2001, ApJ 548, L159

Star 1: V = 20.41 →

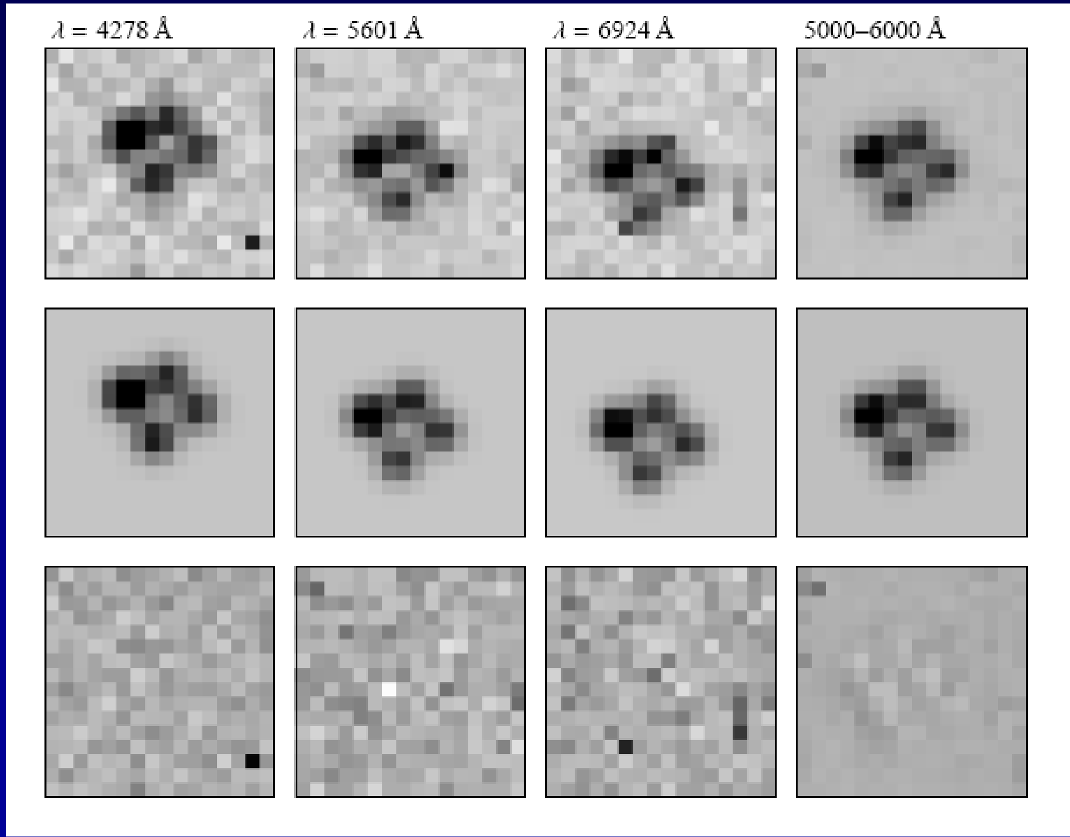
Star 2: V = 20.43 →



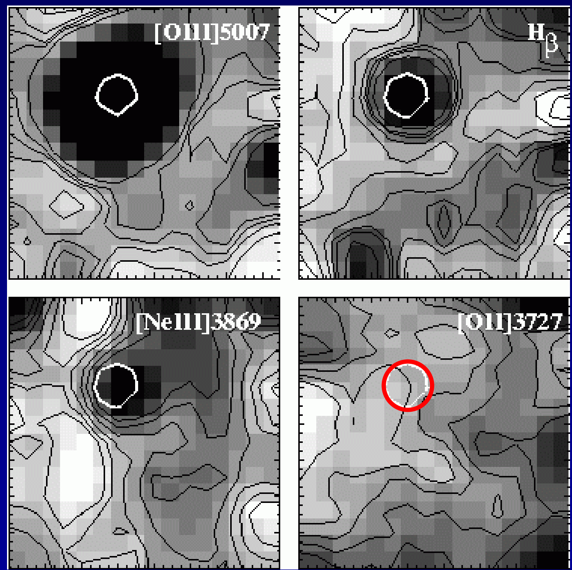
Bresolin et al. 2001, ApJ 548, L159

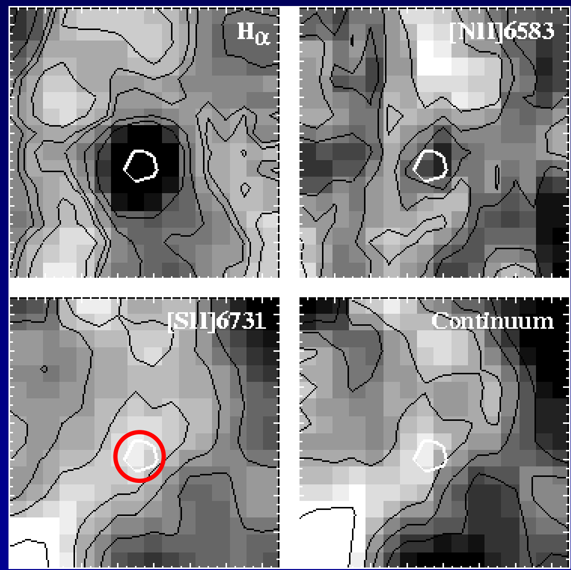
lensed QSO HE 0435-1223

Wisotzki et al. (2003)

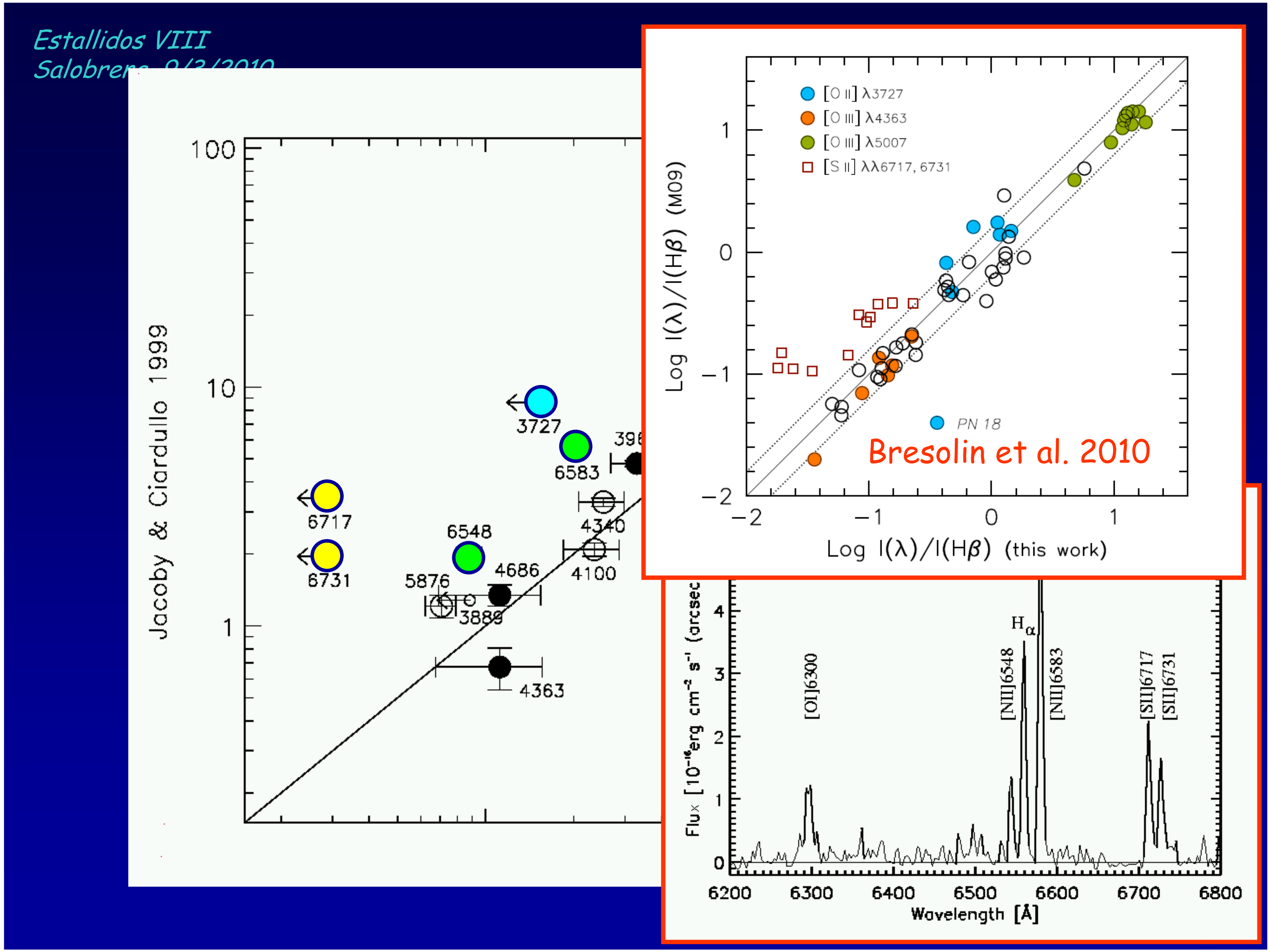


Planetary Nebulae in M31





Roth et al. (2005)



Estallidos VIII
Jacoby & Ciardullo 1999
100
10
1
3727
6583
6717
6731
6548
5876
4686
3889
4363
4340
4100
[O II] λ3727
[O III] λ4363
[O III] λ5007
[S II] λλ6717, 6731
PN 18
Bresolin et al. 2010
Log I(λ)/I(Hβ) (M09)
Log I(λ)/I(Hβ) (this work)
[OI]6300
[NII]6548
Hα
[NII]6583
[SII]6717
[SII]6731
Wavelength [Å]
6200 6300 6400 6500 6600 6700 6800

III. Proposed MUSE GTO Project:

Resolved Stellar Populations in the MW and in Nearby Galaxies

MUSE Science Team Working Group
"Resolved Stellar Populations"

Stefan Dreizler
Tim-Oliver Husser
Roelof de Jong
Sebastian Kamann
Carolina Kehrig
Martin M. Roth
Olivier Schnurr
Matthias Steinmetz
Ole Streicher
Peter Weilbacher
Lutz Wisotzki

Resolved Stellar Populations

Four Science Cases under Discussion:

- Milky Way Bulge
- Globular Clusters
- Young Open Clusters
- Local Volume Galaxies

1. Milky Way Bulge

Major Science Drivers:

1) Is the bulge mainly formed by early accretion/merging or the result of secular evolution through bar dynamics?

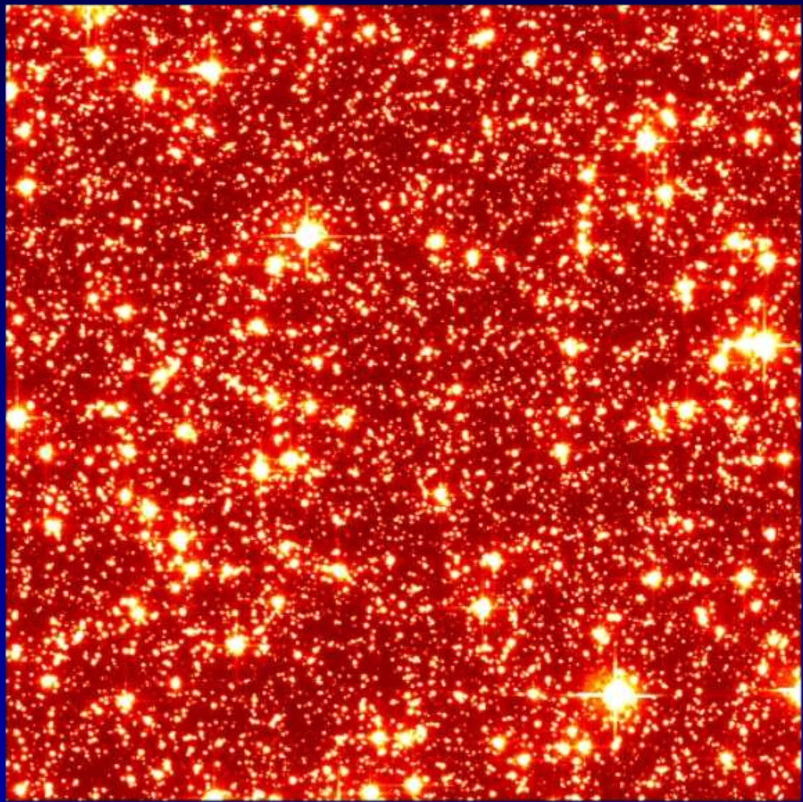
2) What is the chemistry and dynamics of the MW bar?

3) What is the binary fraction for old, high metallicity, low mass stars?

4) Are there Population III candidate stars in the bulge? (speculative)

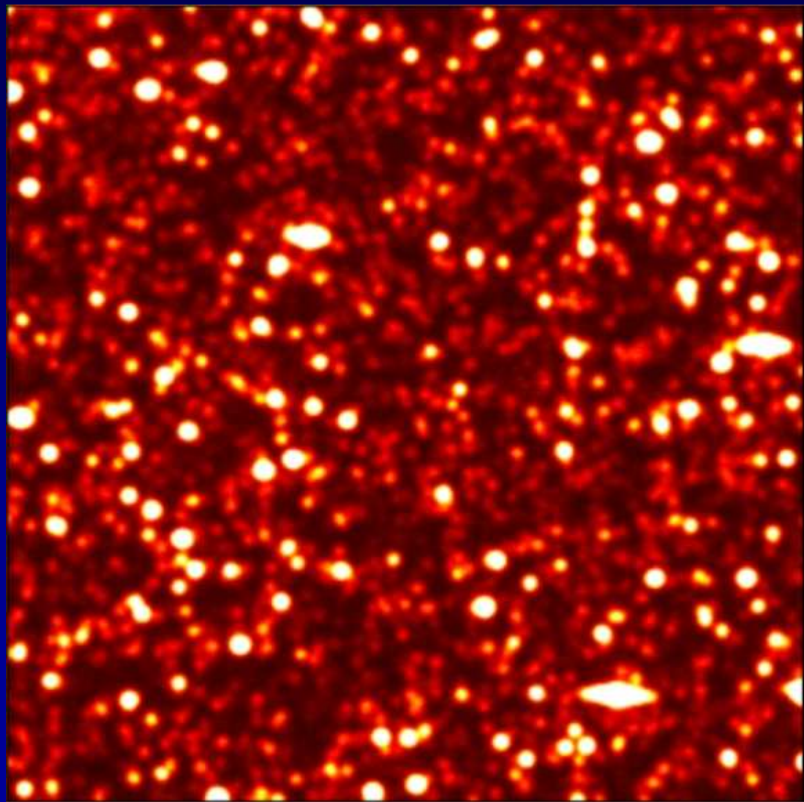
1. Milky Way Bulge

HST:



1. Milky Way Bulge

MUSE:



(Simulations by Sebastian Kamann, AIP)

2. Globular Clusters

2. Globular Clusters

Major Science Drivers:

1) search for binary stars
   . binary star fraction
   . orbit/mass determination where possible
   . comparision of populations of binary and single stars
   . check dynamical models

2) mass limits for intermediate mass black holes:
   radial distribution of sigma

3) search for fast stars being thrown out of the cluster

2. Globular Clusters

Additional **Science**:

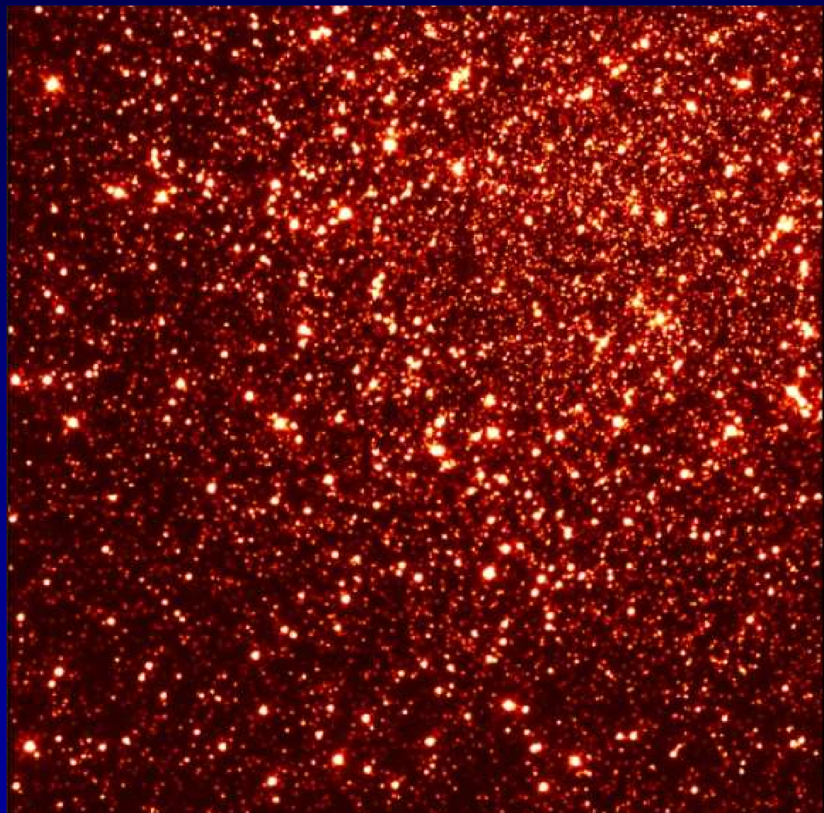
- age and metallicity ([Fe/H]) distributions, down to main sequence

-possibly determine alpha/Fe for a fraction of the observed stars

- search for planetary nebulae

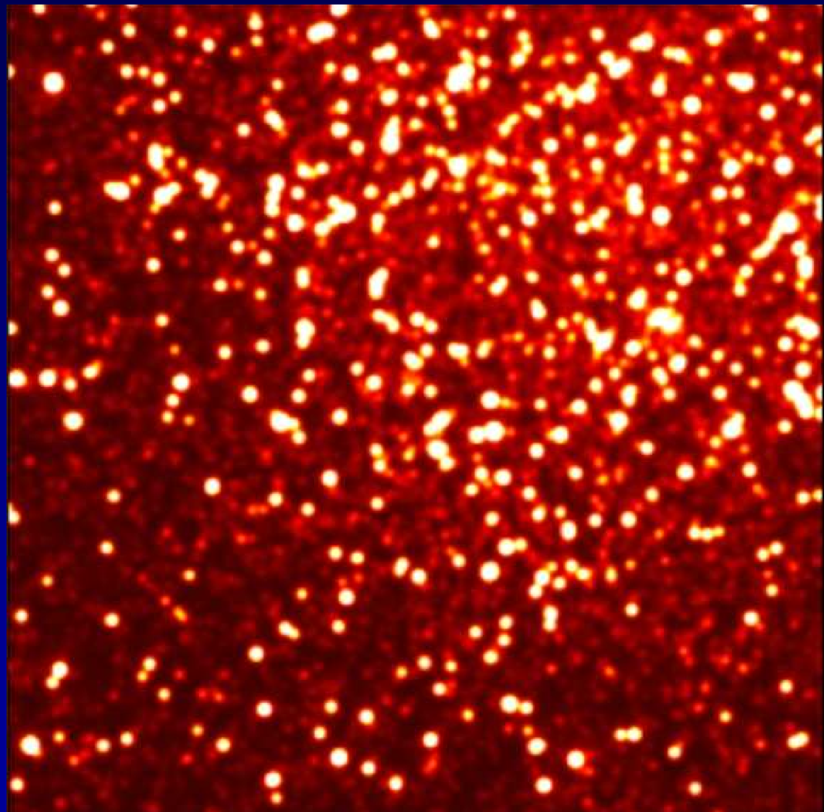
2. Globular Clusters

HST:



2. Globular Clusters

MUSE:



(Simulations by Sebastian Kamann, AIP)

3. Young Open Clusters

R136 (LMC)

- ionizing cluster of the Tarantula Nebula
- most massive starburst in Local Group
- very young (<2 Myr), but multi-burst population

Image: WFC3, 2.6' x 2.6'

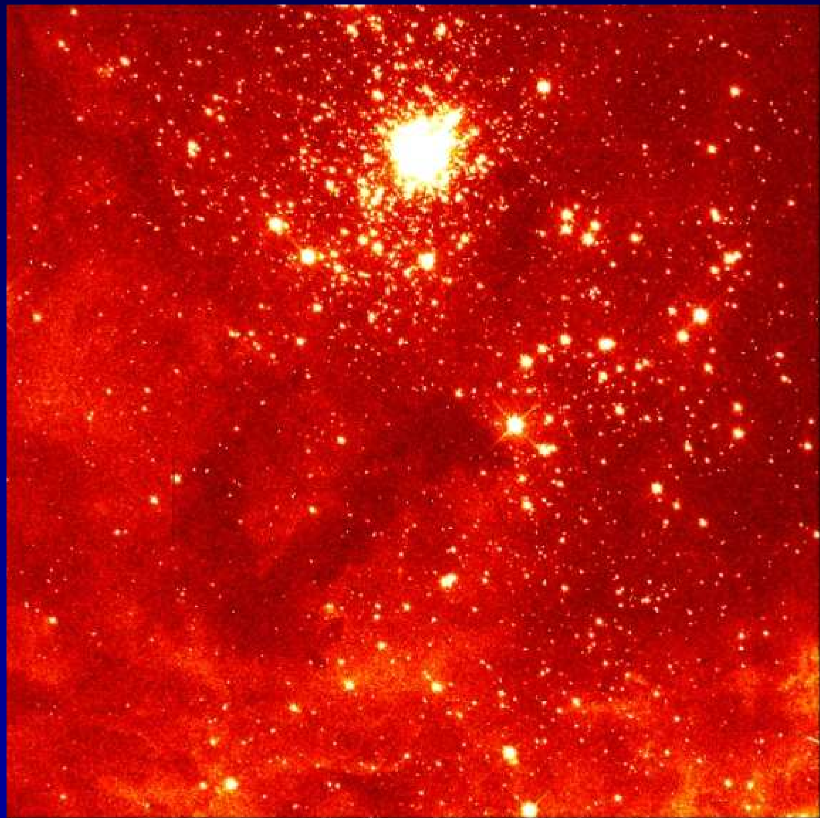
3. Young Open Clusters

Major Science Drivers:

1) Stellar parameter from individual stars
2) Combine with analysis of surrounding gas
3) Abundances, kinematics, ionization...
4) Binary fraction and properties
5) Eclipsing binaries are in-situ calibrators for models
6) constrain star-formation physics, pairing function, N-body simulations, cluster dynamics
7) Provide reliable calibrators for extragalactic SFR indicators
8) Use as in-situ calibrator for narrow-band imaging

3. Young Open Clusters

HST:



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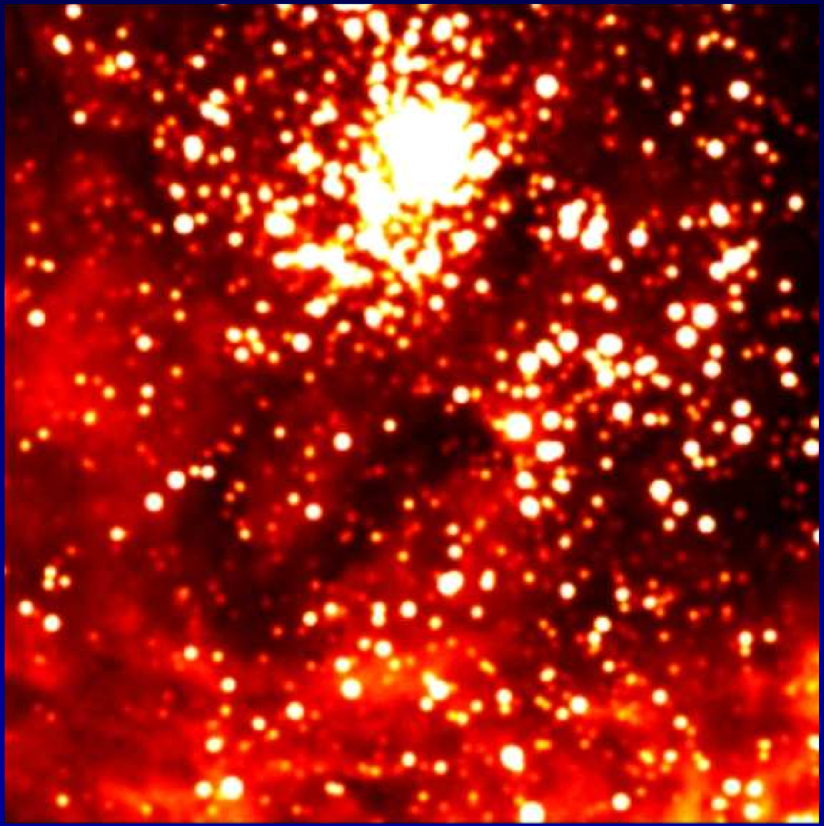

(Simulations by Sebastian Kamann, AIP)

3. Young Open Clusters

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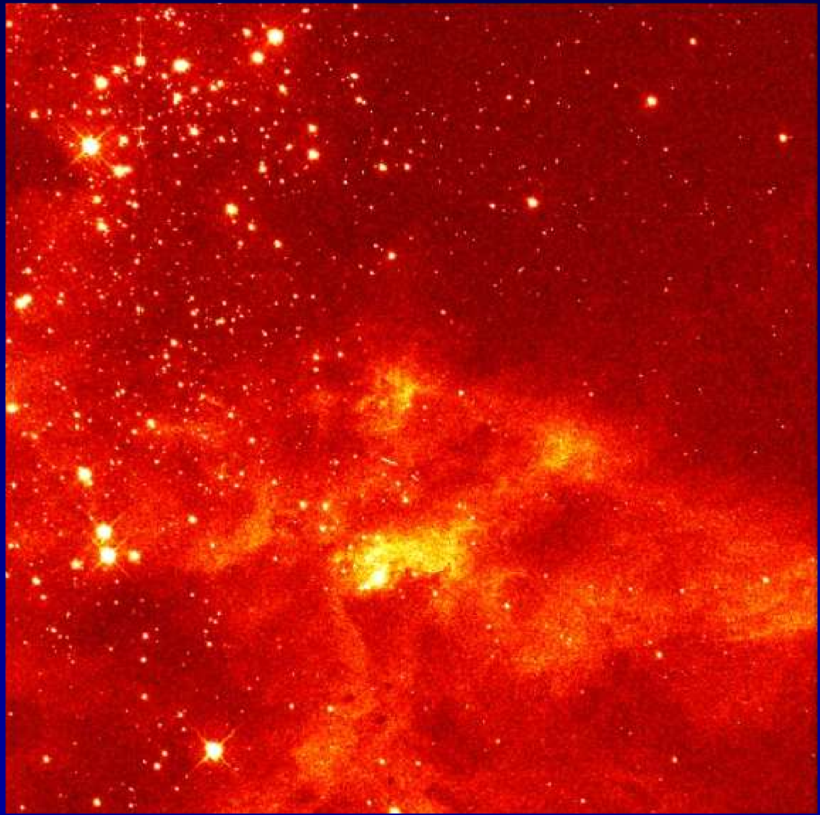
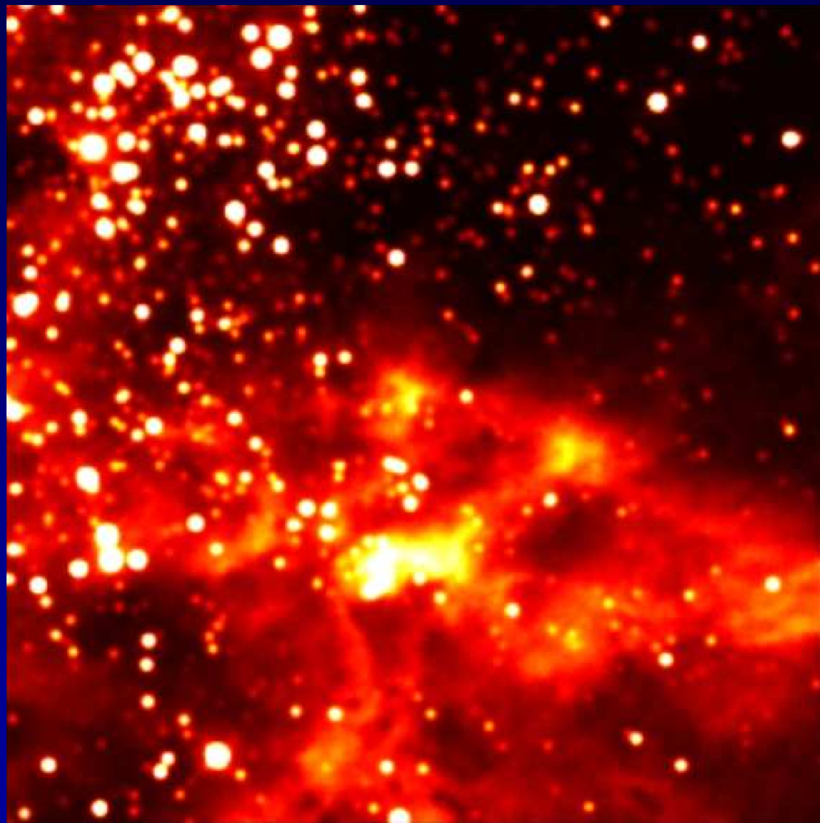


3. Young Open Clusters

MUSE:



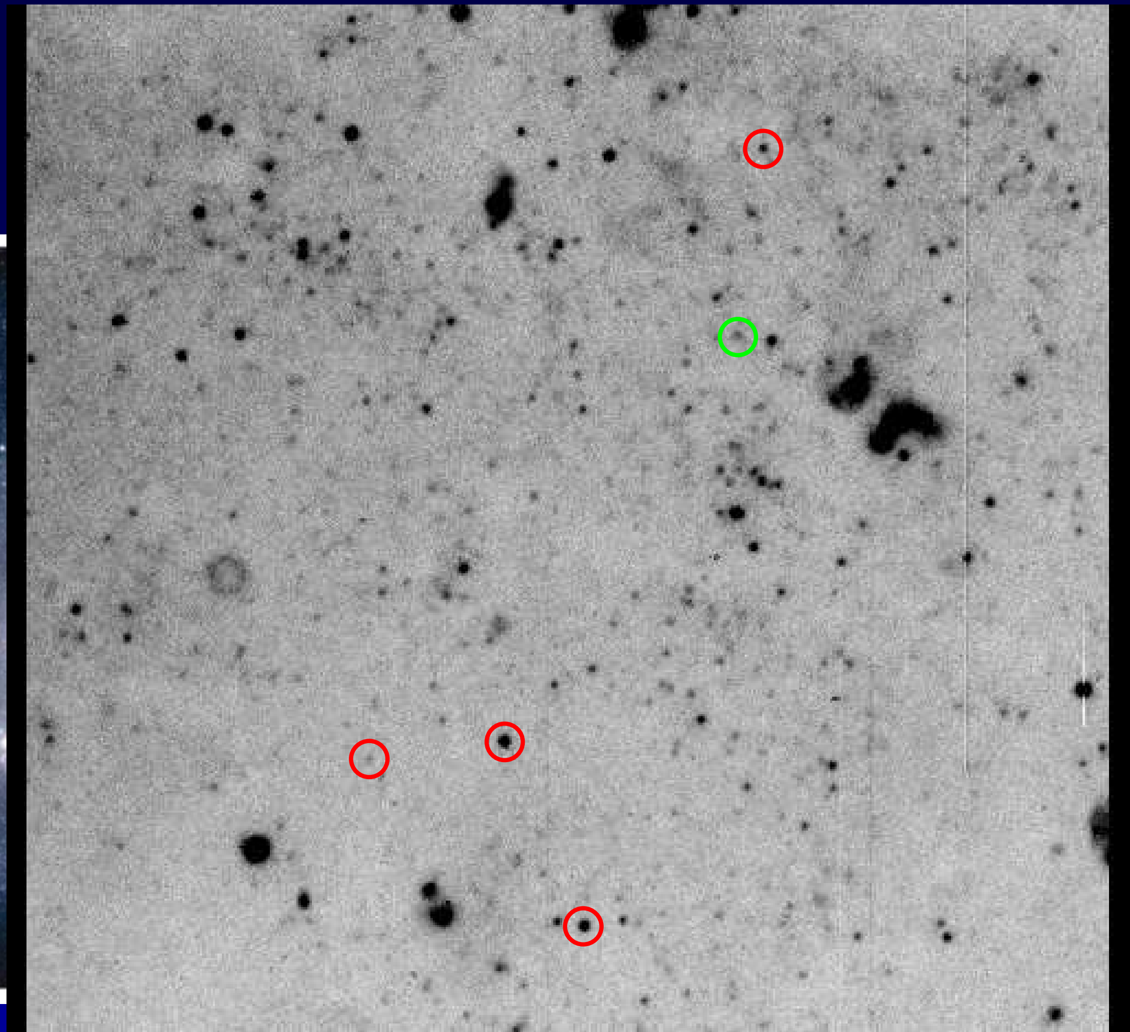
(Simulations by Sebastian Kamann, AIP)

4. Local Volume Galaxies

Major Science Drivers:

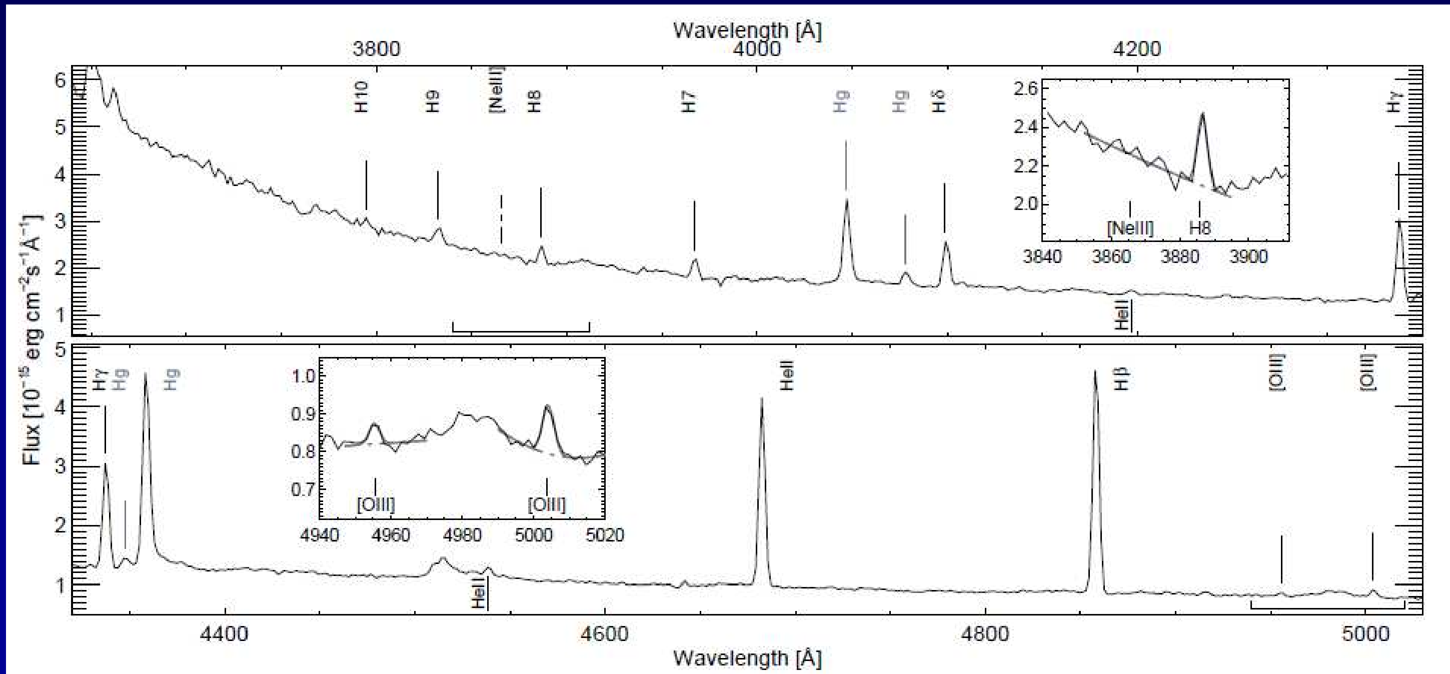
1) Comprehensive inventory of massive stars, planetary nebulae, H II regions, SNRs, SSX sources, and other emission line objects, in particular unusual objects, down to faint limits
2) Quantitative spectroscopy of massive stars and the physical properties of the surrounding gas (ne, Te, extinction, metallicity, kinematics)
3) Evolution of massive stars: the evolutionary connections between the different types of massive stars (i.e. WR, LBV, Ofpe/WNL, etc.)
4) Search for the nebular HeII4686 emission line objects and ionization source
5) Feedback from massive stars and chemical enrichment in the ISM
6) Compare the metallicity derived from stellar spectra to the metallicity obtained from the gas

Estallidos VIII
Salobrena, 9/3/2010



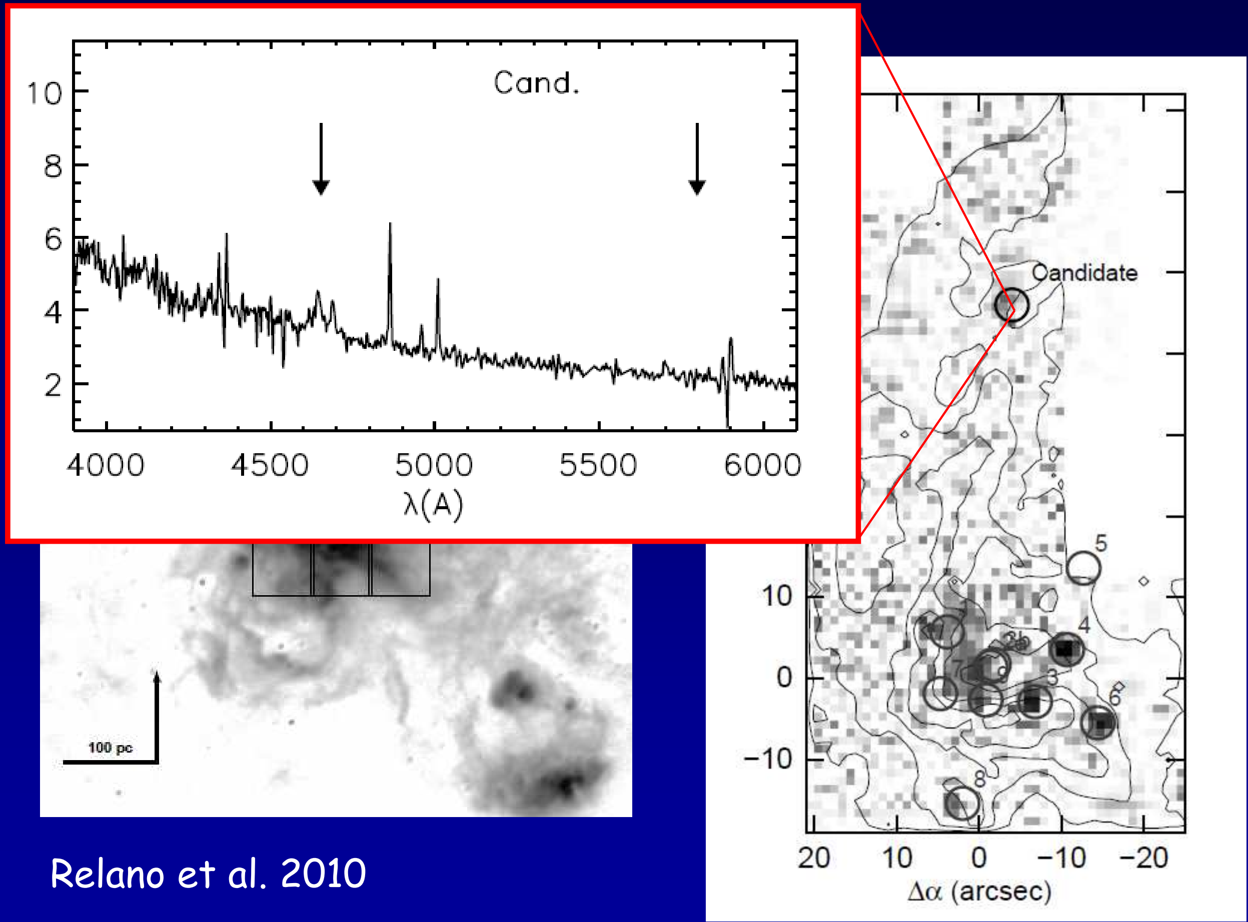
4. Local Volume Galaxies

PNG135.9+55.9 (SBS 1150+599A)



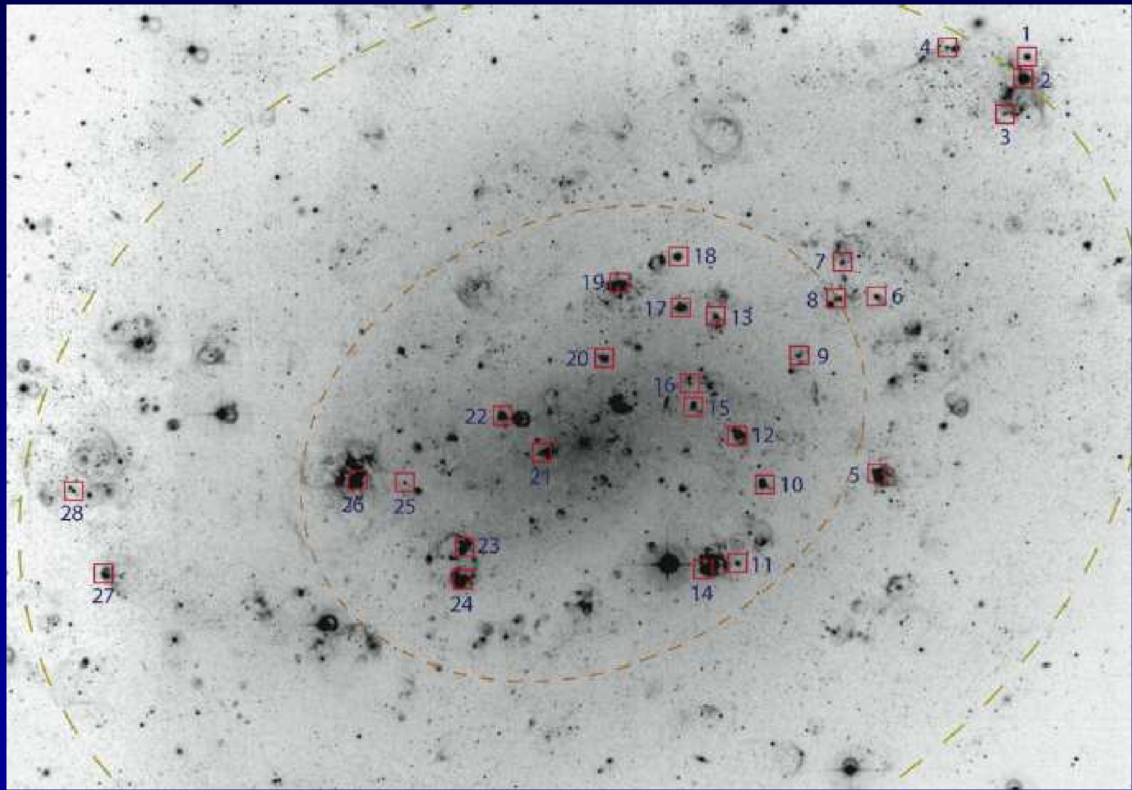
Sandin et al. 2009, arXiv:0912.5430v1

4. Local Volume Galaxies



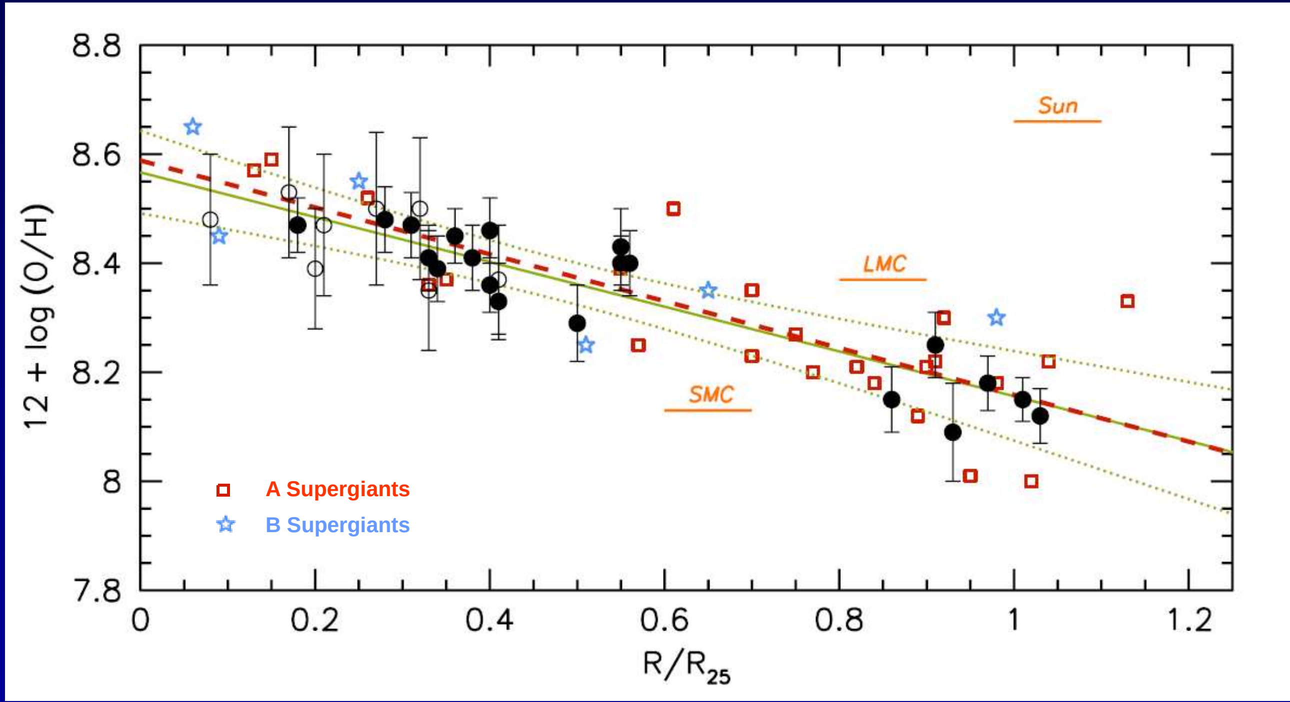
Relano et al. 2010

4. Local Volume Galaxies



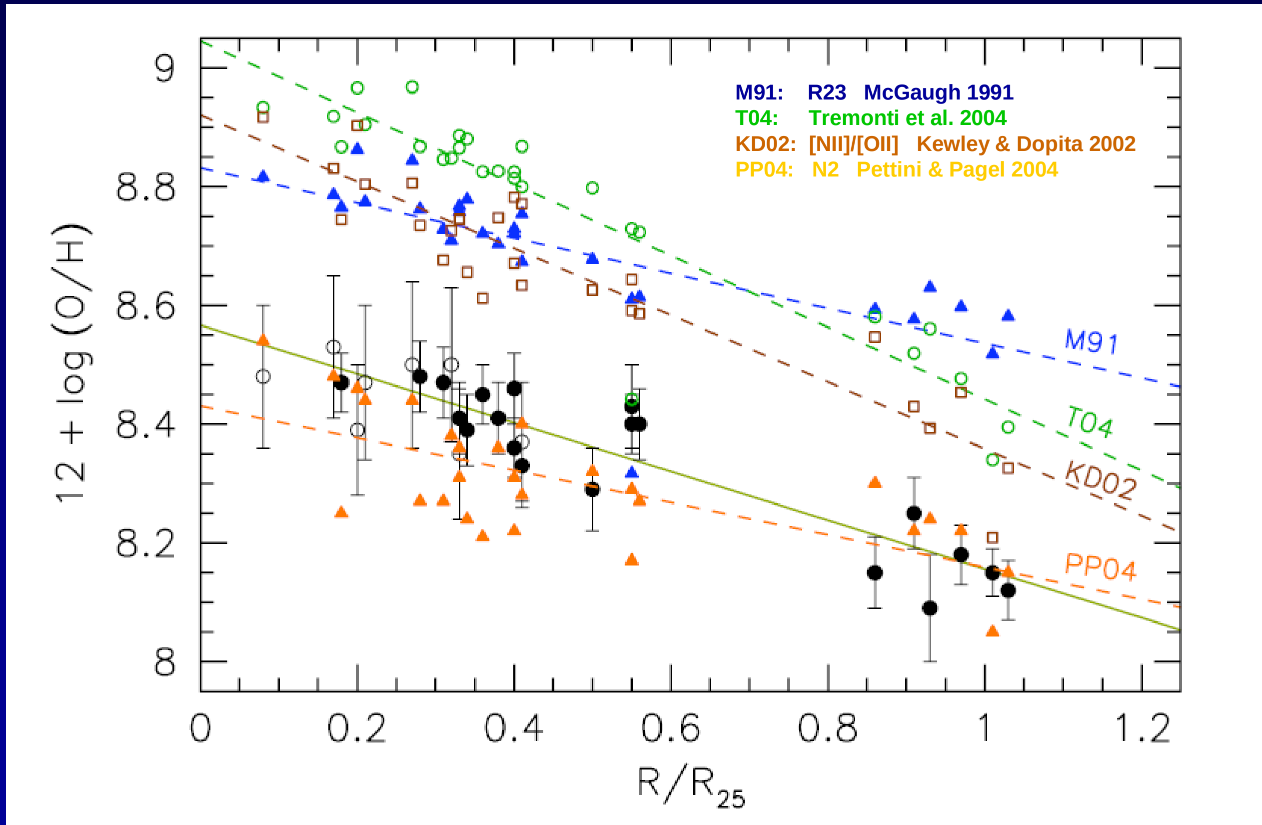
Bresolin et al. 2009

4. Local Volume Galaxies



Bresolin et al. 2009, Kudritzki et al. 2008

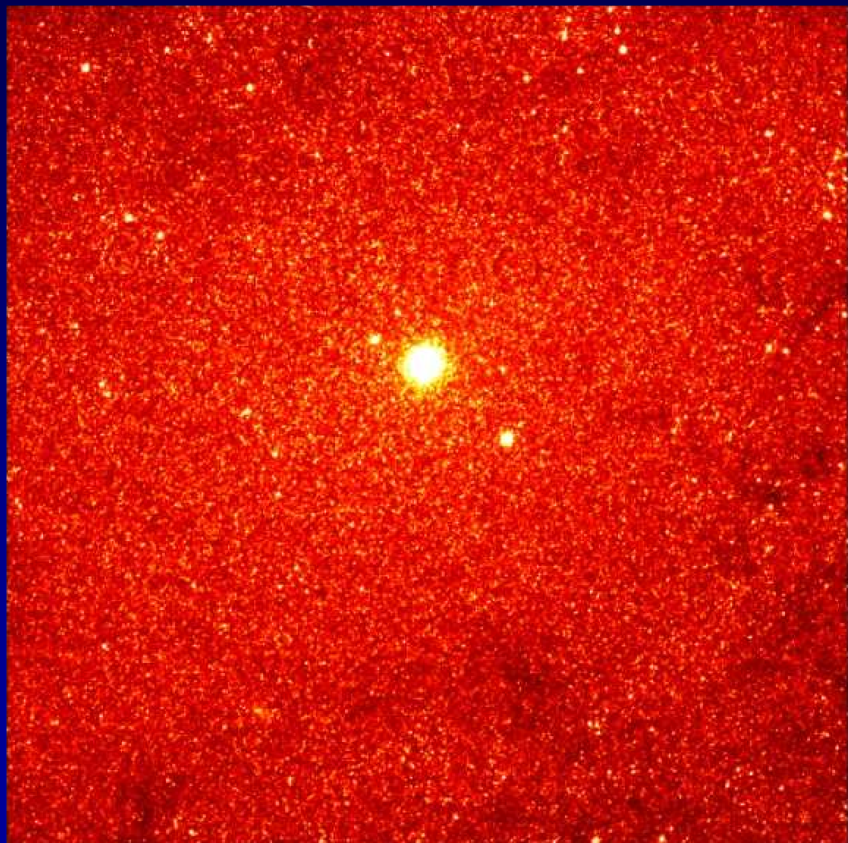
4. Local Volume Galaxies



Bresolin et al. 2009

4. Local Volume Galaxies

HST:



(Simulations by Sebastian Kamann, AIP)

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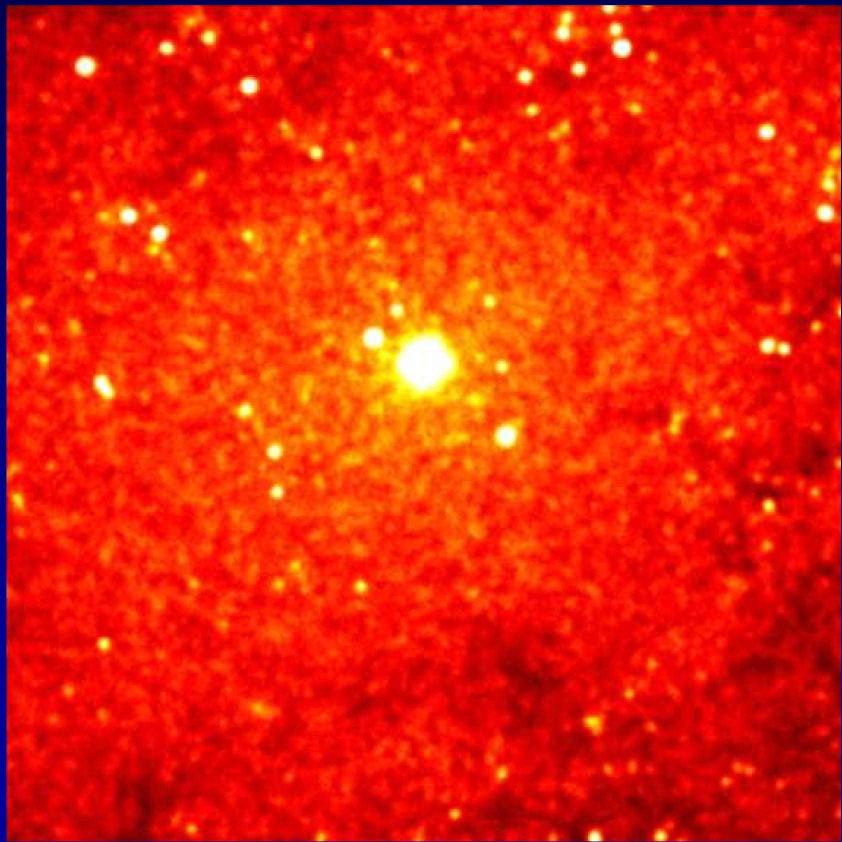

(Simulations by Sebastian Kamann, AIP)

Outlook & Conclusions

- Crowded-Field 3D Spectroscopy still in its infancy
- Powerful future route for study of resolved stellar populations
- Exciting prospects for ELTs
- Analysis tools needed (PSF fitting techniques)
- Simulations & development of algorithms now underway in Potsdam and Göttingen

▶ Interest in the ESTALLIDOS community ?