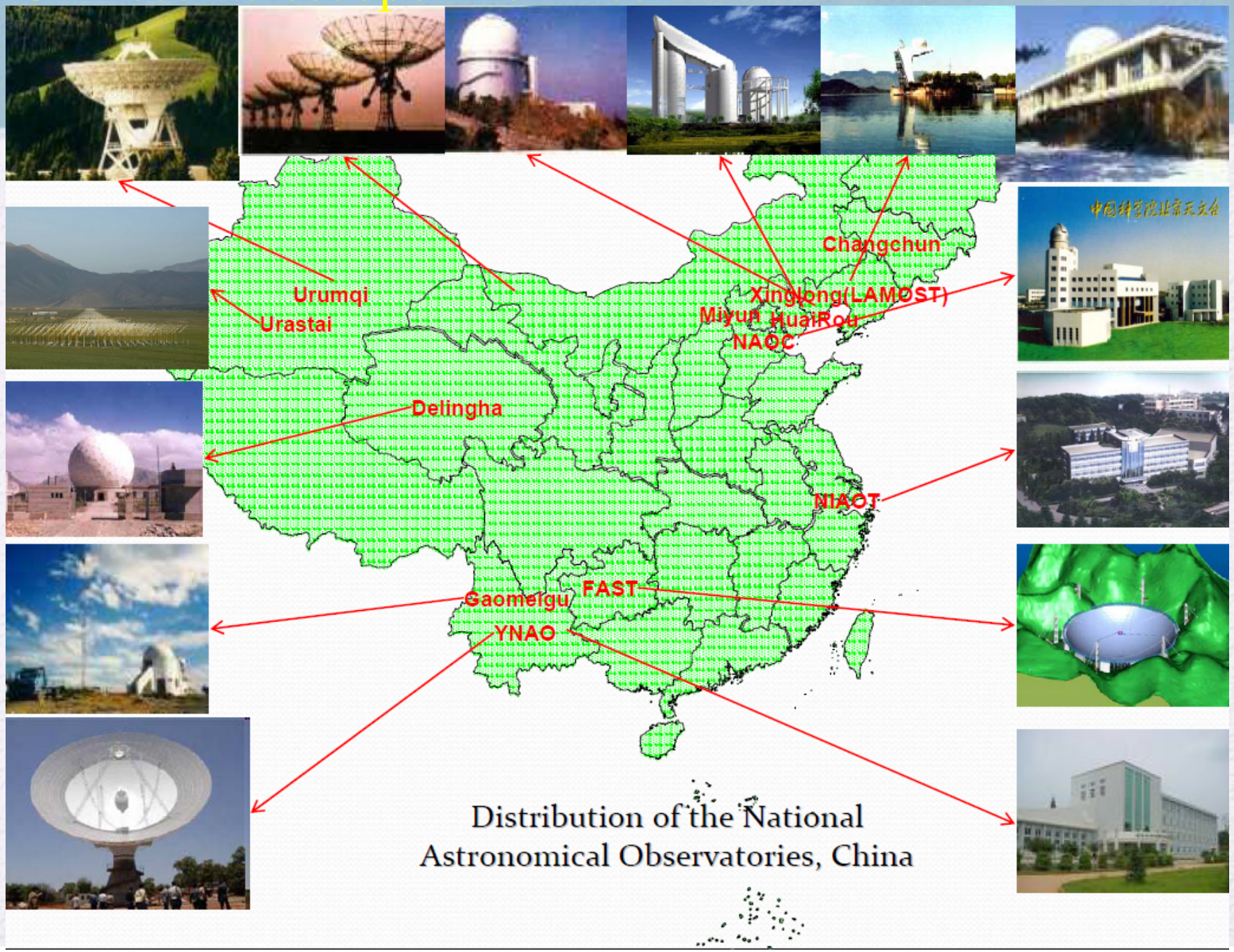
China Lijiang IFU

CHILI

Lei Hao, Shanghai Astronomy Observatory

Chinese Telescope Facilities

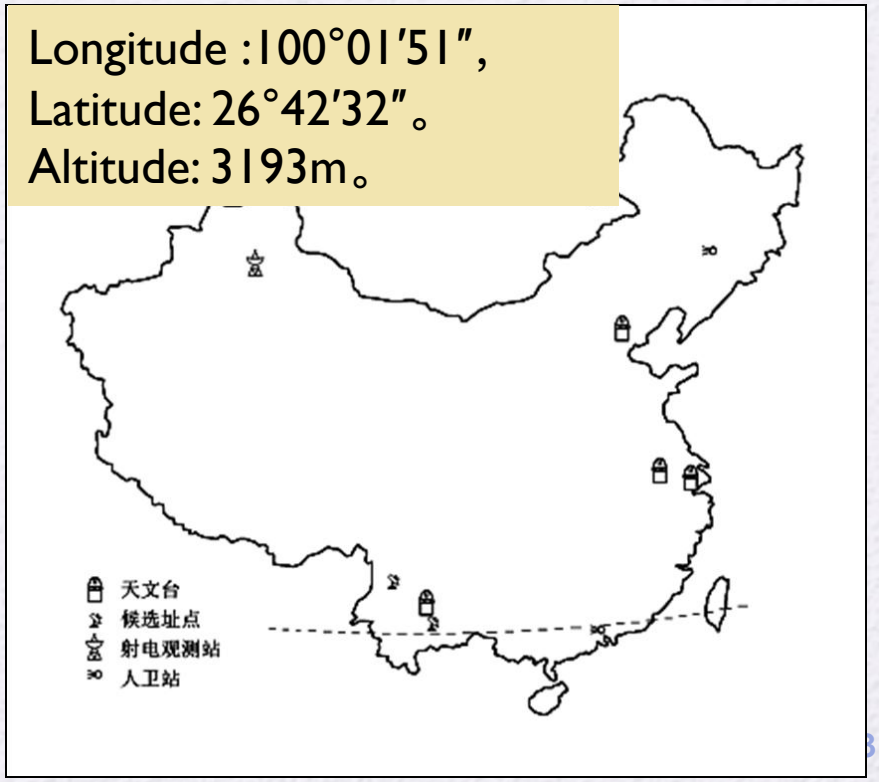
Credit: Prof. Jinming Bai



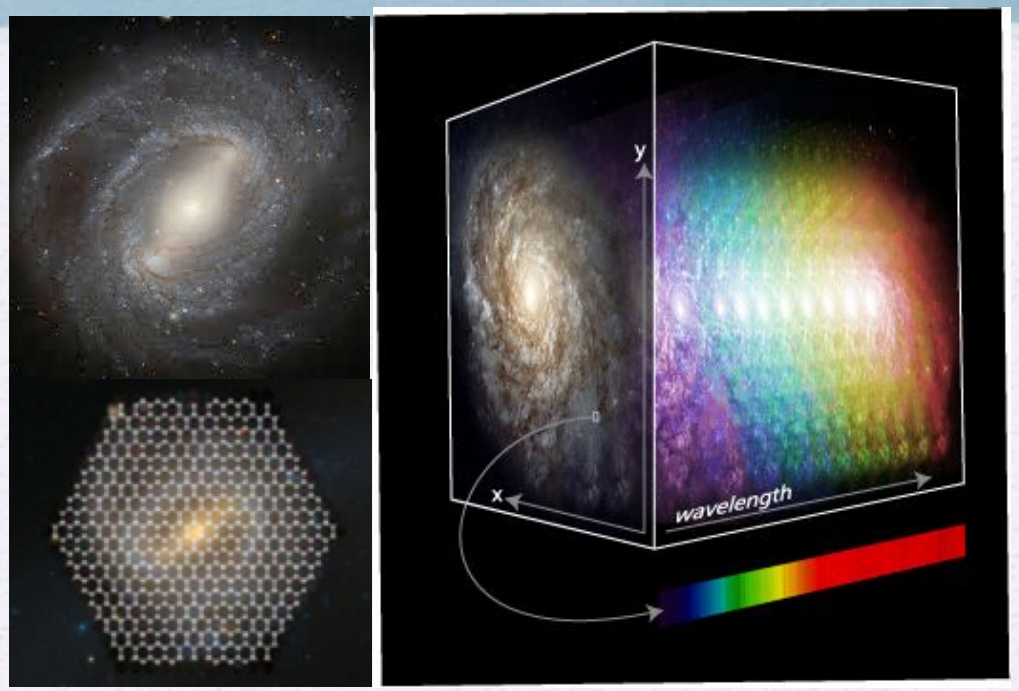
Background

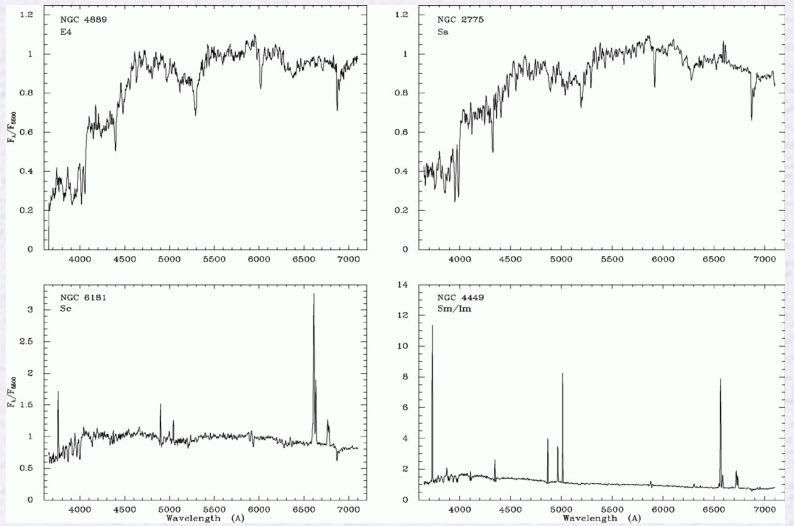
- Optical facilities in China
  - LAMOST
  - Lijiang 2.4m, 2.16m in Xinglong

Longitude :100°01′51″,
Latitude: 26°42′32″。
Altitude: 3193m。



Background





- 2D spectroscopy: obtain the spectra of multiple regions simultaneously
- IFU： many science possibilities, on telescopes with different apertures
- Structures and maps of properties, such as the Starformation, mass, metallicity, AGN feeding and feedback, kinematics, etc.

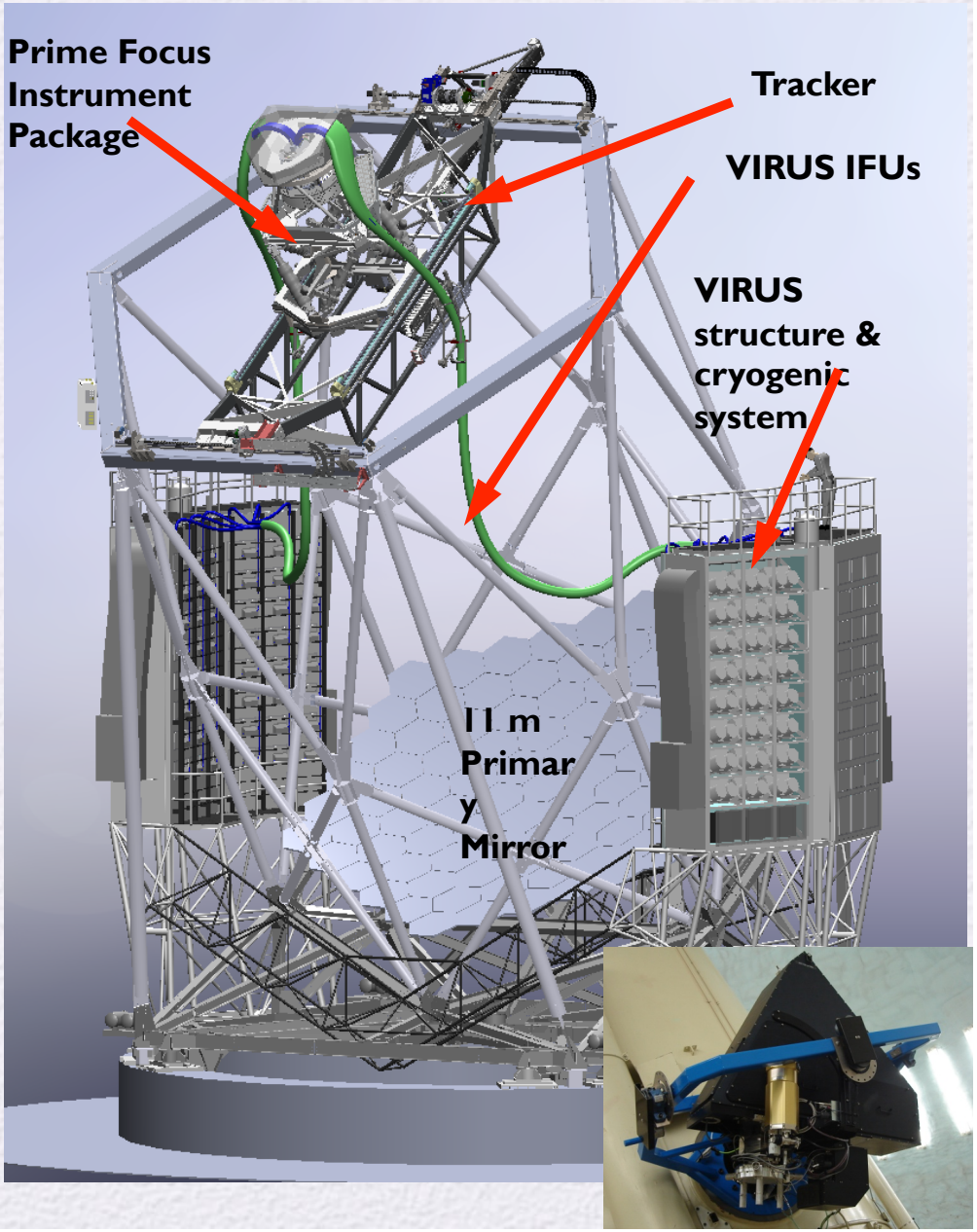
Background

- HETDEX collaboration, copy of a VIRUS unit, ~2xVIRUS-P

2.4m telescope in Lijiang

HETDEX: Hobby Eberly Telescope Dark Energy Experiment

- HETDEX is:
  - Upgrade of HET to have a new wide 22' field of view
  - Deployment of the hugely replicated spectrograph, VIRUS, putting >33,000 fibers on sky, per exposure
  - 3-5 year blind spectroscopic survey
- HETDEX will:
  - map a million LAEs ($1.9 < z < 3.5$) and a million [OII] emitters ($z < 0.5$)
  - measure expansion history to 1% precision at z~2.5
    - determine if dark energy evolves, looking back 11 billion years
    - measure curvature of the universe to 0.1% (better than Planck)
- HETDEX is a unique blind spectroscopic survey with many other applications



CHILI

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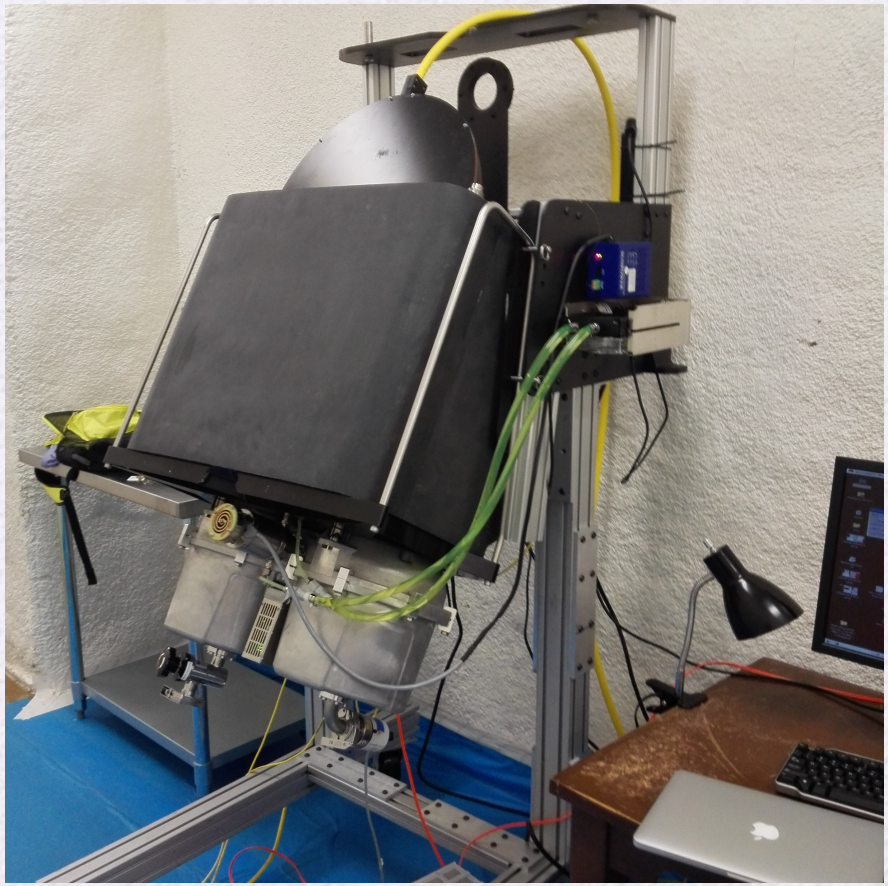

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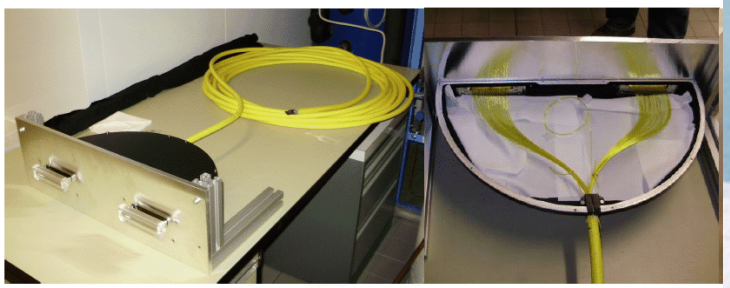
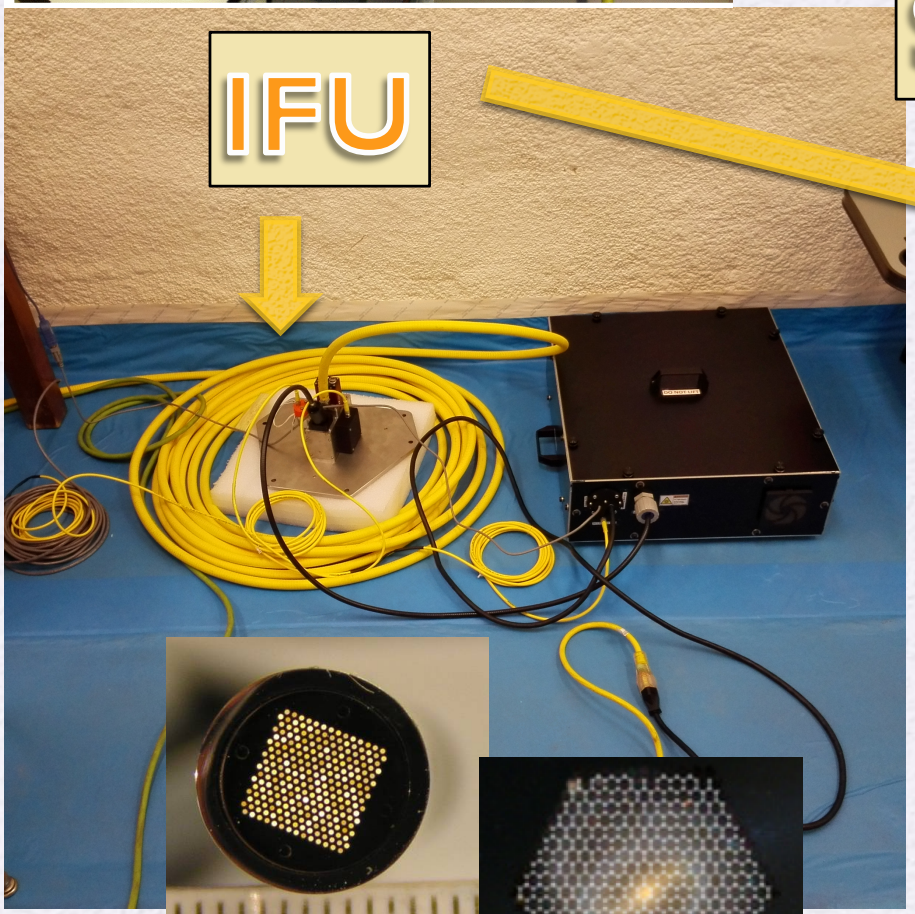


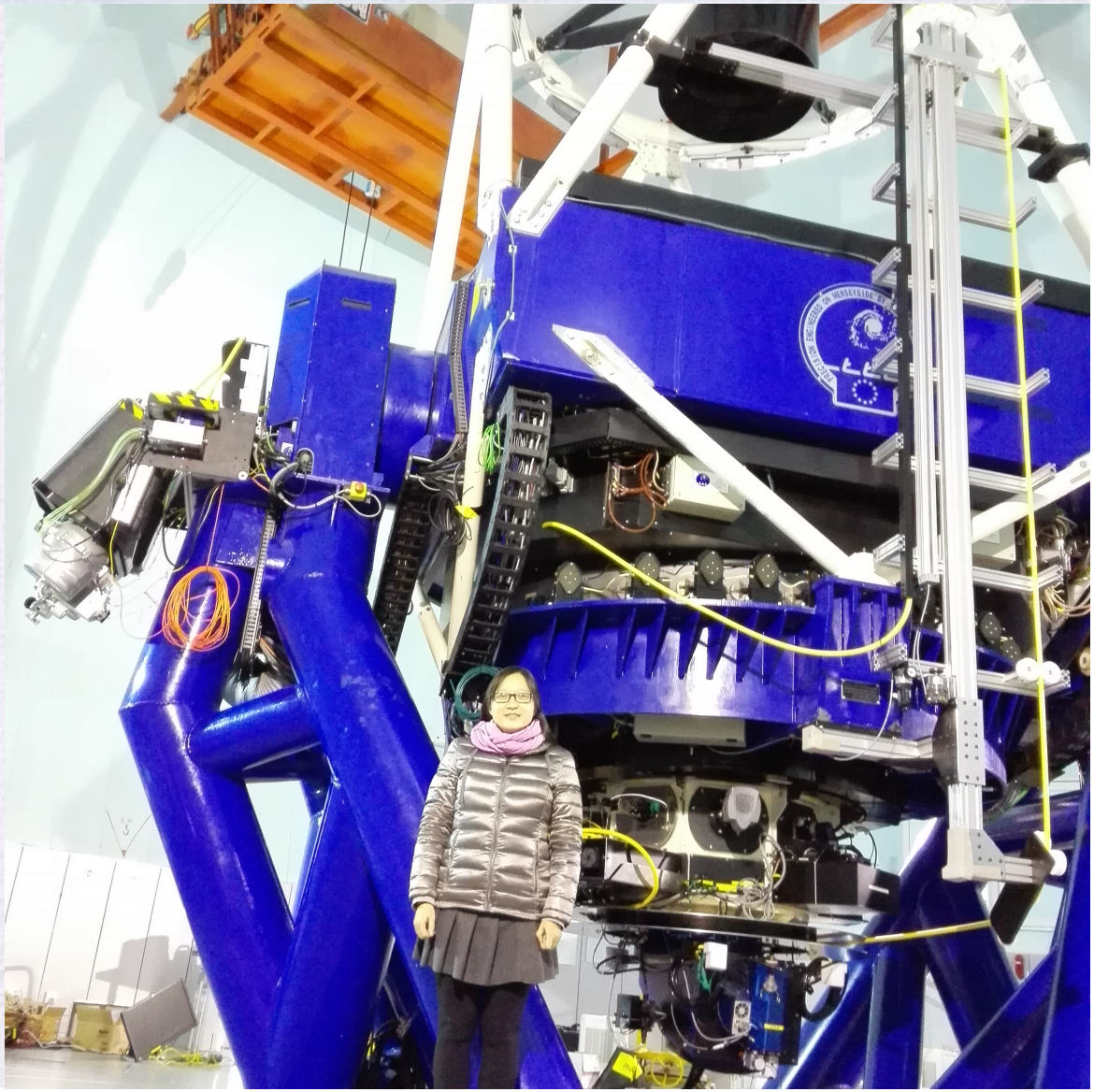
IFU

SPECTRAGRAPH



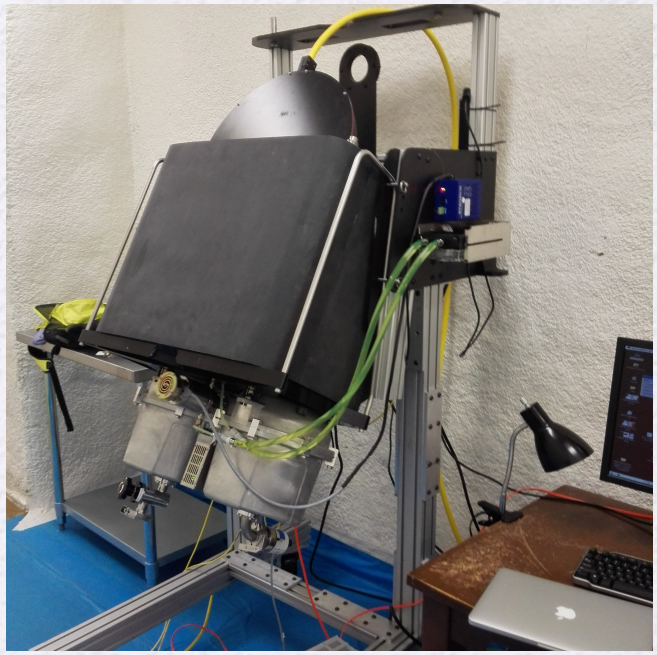
CHILI

- CHILI on the telescope



CHILI

- HETDEX collaboration, copy of a VIRUS unit, ~2xVIRUS-P
- 494 fibers, each fiber 3.2 arcsec
  - VIRUS-P: 246 fibers, each 4.2”
  - MaNGA: 17x19-127 fibers, each 2”
- The total field of view is 71”x65”
  - Almost 100% filling factor
    - VIRUS-P: 100”x100”, at 1/3 filling
    - MaNGA: <32”, at 60% filling
- R=900 (~VIRUS-P) and R~2000 (~MaNGA),
- Spectral coverage: 360-720nm
  - ~VIRUS-P, not as broad as MaNGA
- Red and blue are not observed simultaneously
  - ~VIRUS-P, Different from MaNGA

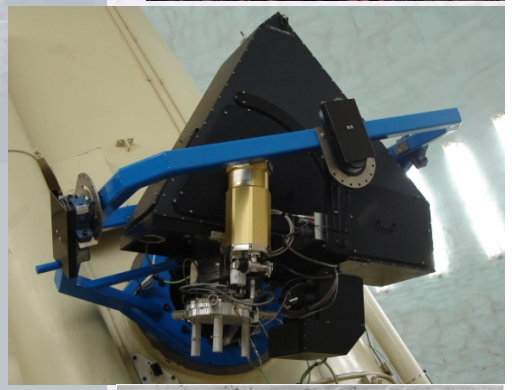


VENGA and MaNGA

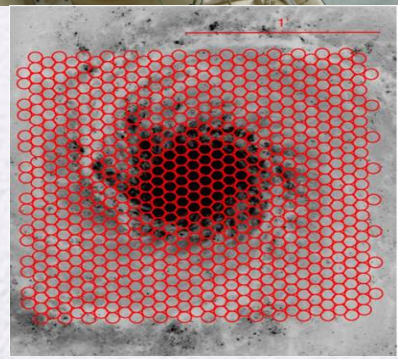
- **VENGA**
  - VIRUS-P Exploration of Nearby Galaxies
  - 30 disk galaxies
  - Deep integration, wide FOV: 1.7'x1.7'
- **MaNGA**
  - IFU observations of ~10,000 galaxies, part of SDSS-IV
  - FOV: <32"

2.7 m
Harlan J. Smith
Telescope

VIRUS-P



246 fibers
in one pointing
of VIRUS-P



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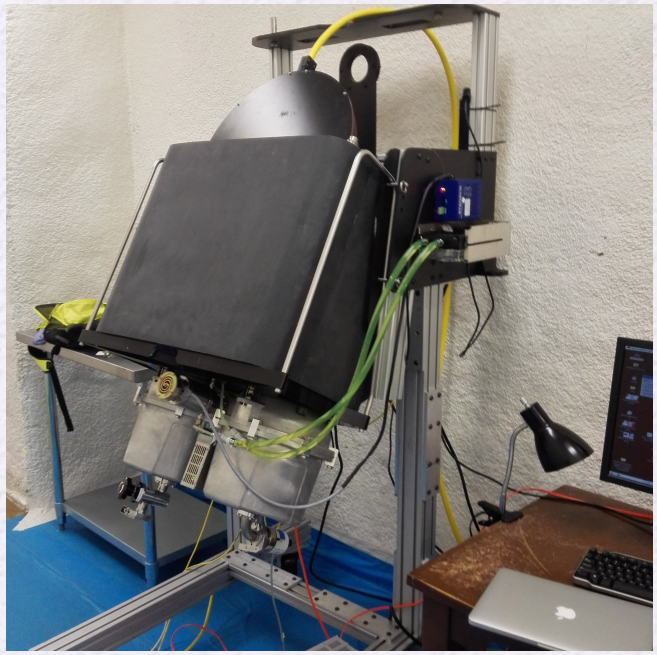

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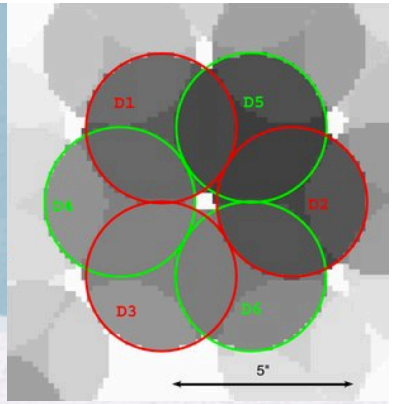
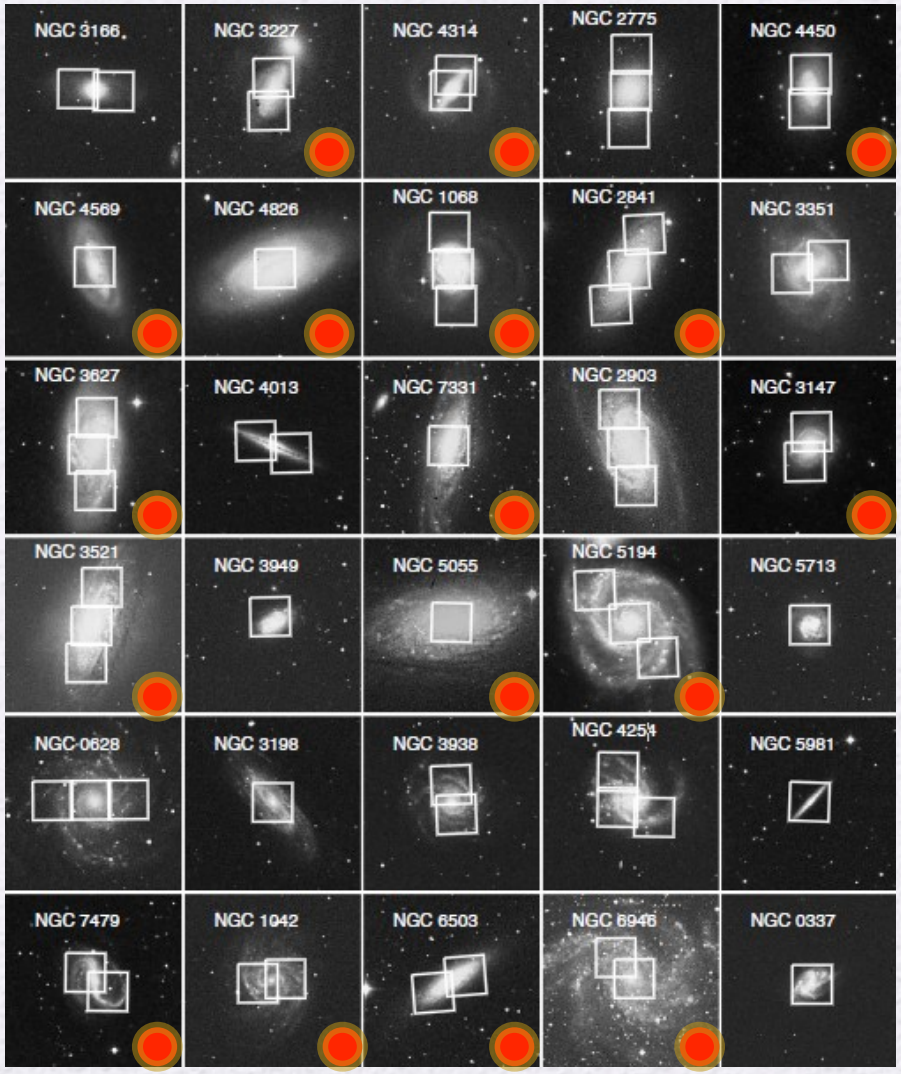


- Big Field of View
  - microlense （~100% filling） ： 71”x65”
    - SAURON: 33”x44”， WiFeS: 38”x25”
  - 3 observations： >VIRUS-P by 33%
- Light bucket：
  - 100% filling+fat fibers: f = Σ•A
  - Avoid Dither
  - Deep exposure

CHILI

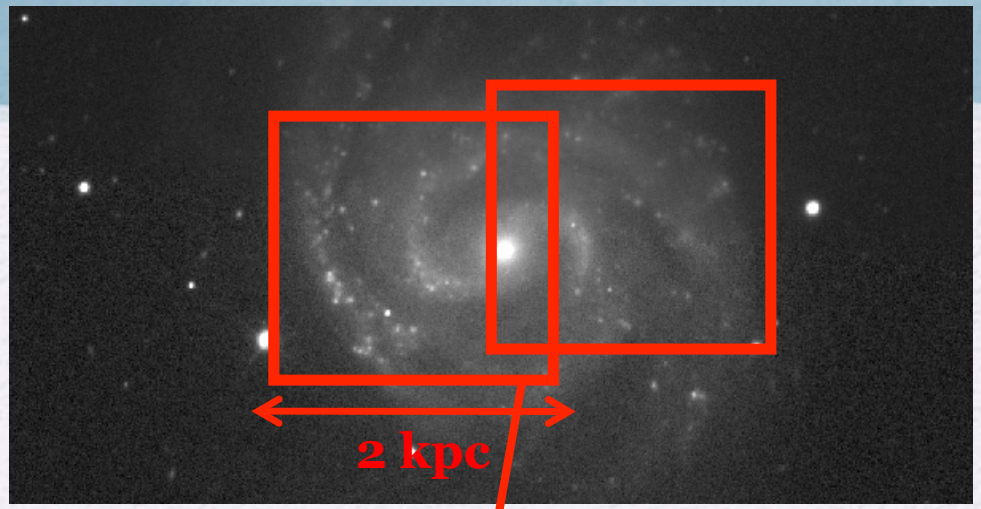
- FOV: 71x65 arcsec
  - 3 pointings:
    - 115 x 115 arcsec
    - ~ 3 x 1 arcmin^2
  - 9 pointings:
    - 3 x 3 arcmin^2
  - Galaxies with plenty multiwavelength data
    - X-ray, UV, Infrared, submm, radio, for example, **MALATANG**
    - Probe gas and stars at different state



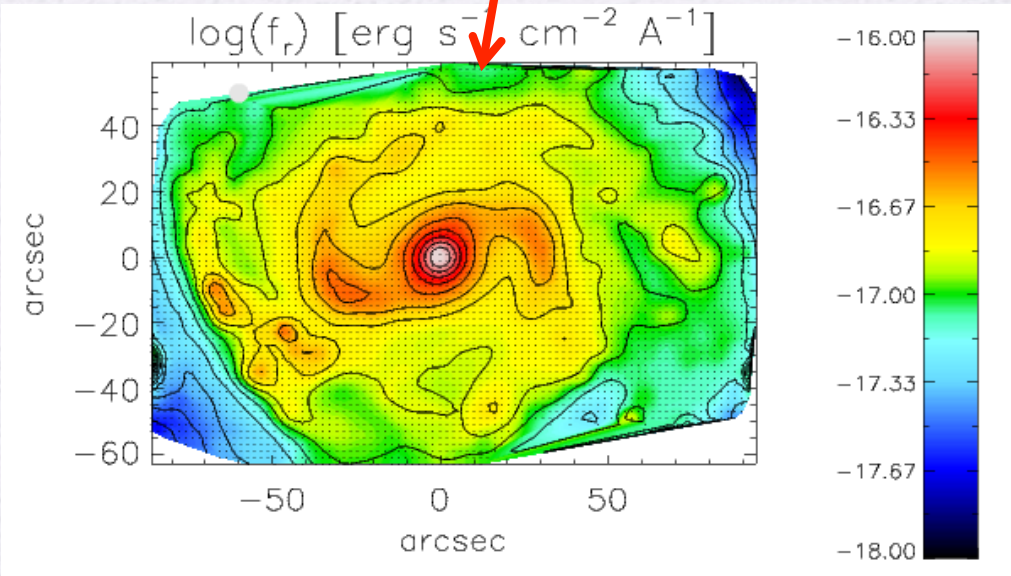
NGC1042

- 1500 spectra in two pointings of VIRUS-P
  (3.6 kpc ×2.2 kpc)
- Effective PSF FWHM:
  5.6" (spatial resolution 112 pc)
- Total exposure time:
  26.72 (hours)
- Median seeing: 2.20 "

Luo, Hao, et al., 2016, ApJ



SDSS r-band image of NGC 1042



Reconstructed map of r-band flux

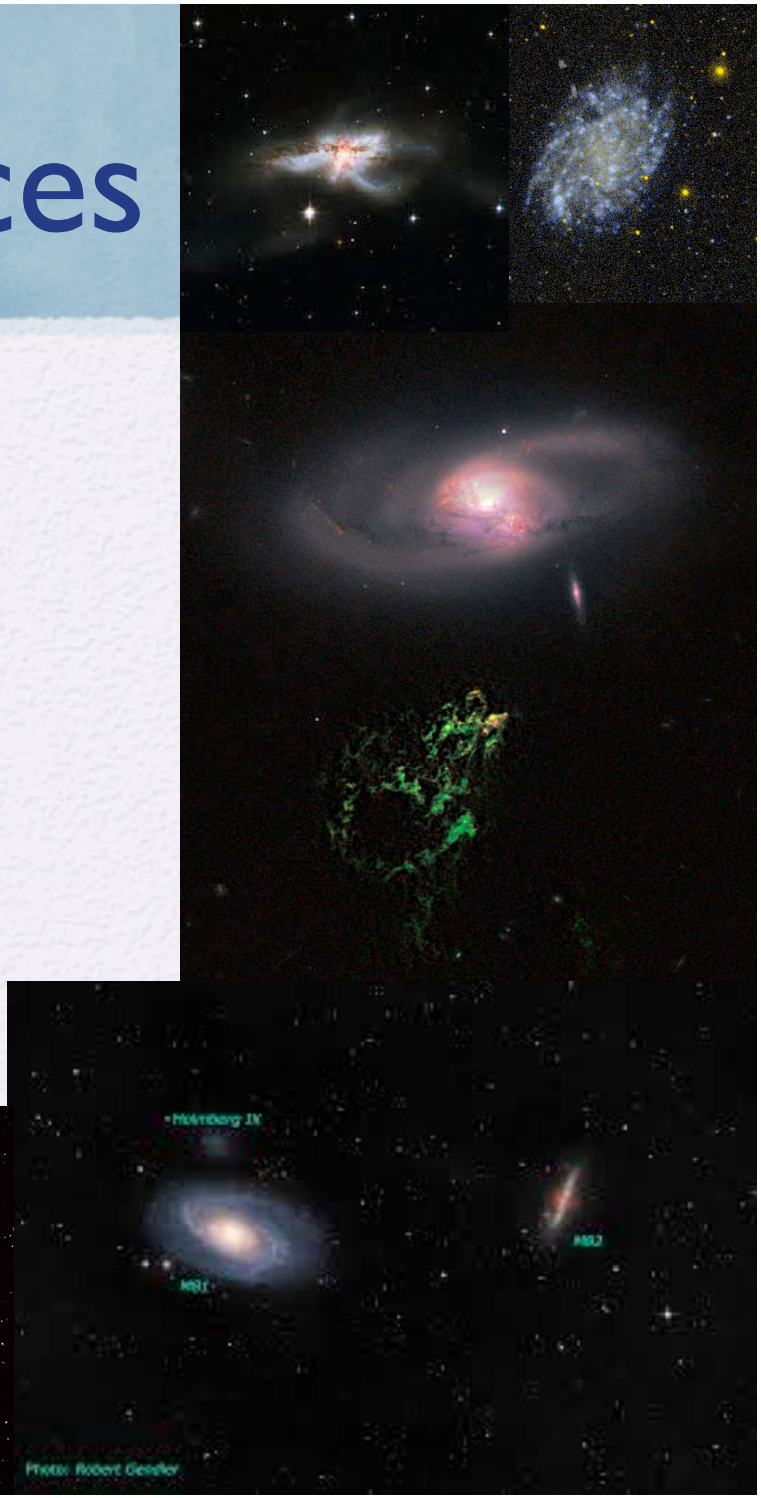
Table 2. Summary of VENGA Observations of NGC 1042

Pointing	Equatorial Coord.		Setup	Dither	Exposure Time	N	⟨Seeing⟩	⟨Transparency⟩
	α	δ			hours		$''$	
P1	2:40:26.28	-8:26:07.70	red	D1	2.00	4	2.20	0.87
			red	D2	3.5	7	2.29	0.87
			red	D3	4	8	2.25	0.89
			blue	D1	0.83	2	2.00	0.71
			blue	D2	2.08	5	2.00	0.64
			blue	D3	1.67	4	2.00	0.73
P2	2:40:21.34	-8:25:56.10	red	D1	2.06	6	2.20	0.65
			red	D2	2.50	5	2.52	0.67
			red	D3	3.50	7	1.90	0.68
			blue	D1	2.08	5	2.58	0.68
			blue	D2	1.25	3	2.93	0.69
			blue	D3	1.25	3	1.63	0.65

Overall we spent 27 hours of exposure time on the 59 good frames of this galaxy. As a result, the spectra have high S/N ratios per spectral resolution element, with a median value at ~ 100 in the continuum. In the central parts (500 pc $\times$ 500 pc) of the galaxy we typically have S/N > 200, while the spectra in the most outer regions (from 2.0 kpc to 2.5 kpc) have a median S/N ~ 55. We only have 20 out of 4789 spaxels (0.42%) with S/N less than 10.

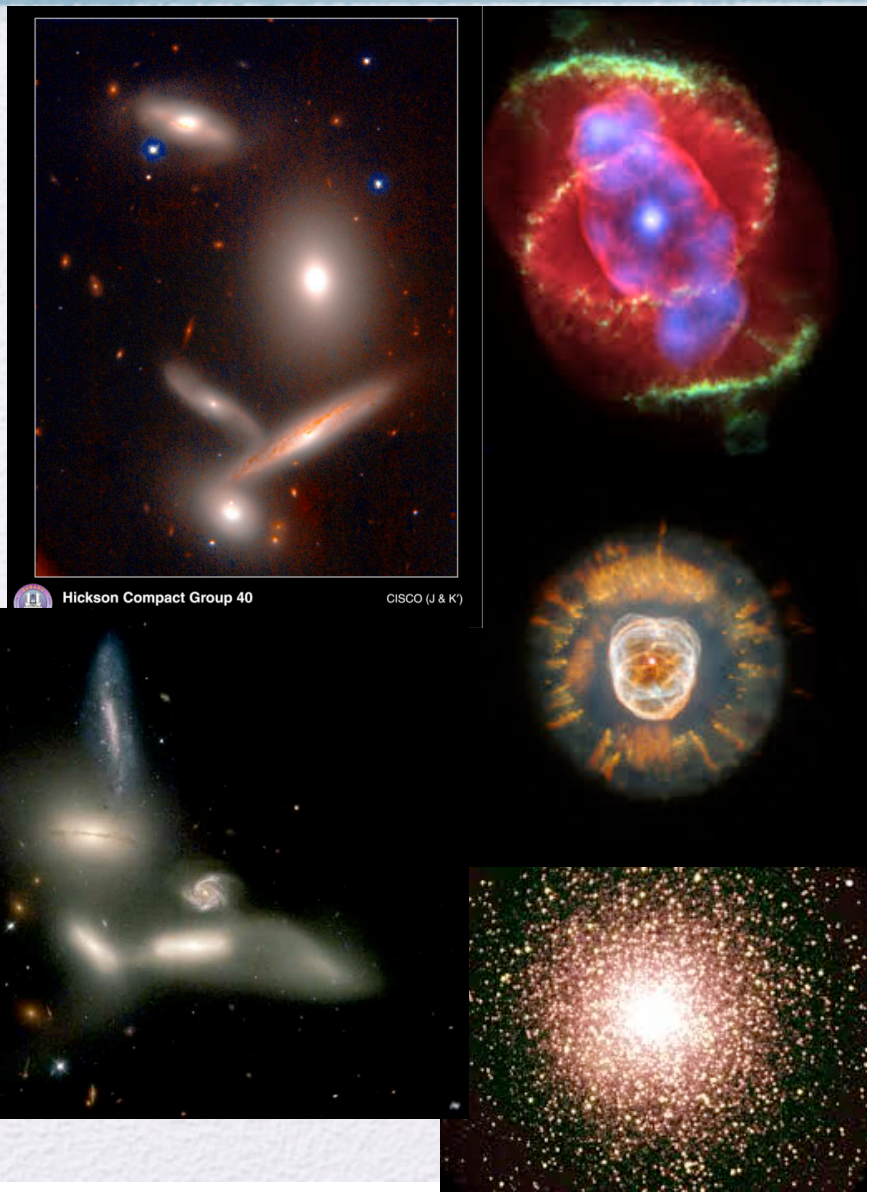
CHILI Sciences

- Galaxies
  - Not a survey
  - Individual nearby galaxies, extensive studies
  - Deep observations on some galaxies
  - Maybe a good compliment to existing IFU surveys



CHILI Sciences

- Galaxy groups
- PNe
- Globular Clusters
- SN hosts
- ……

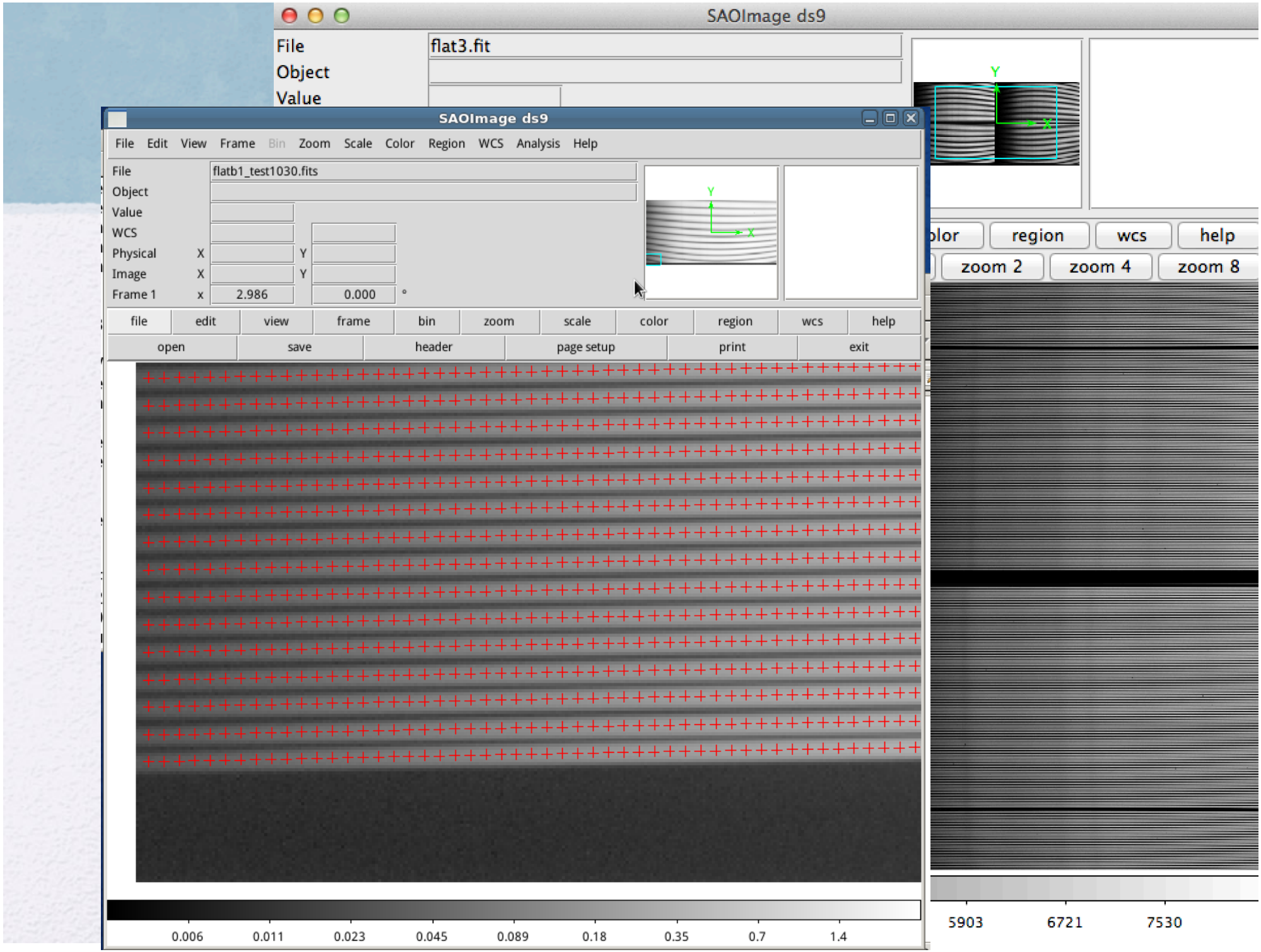


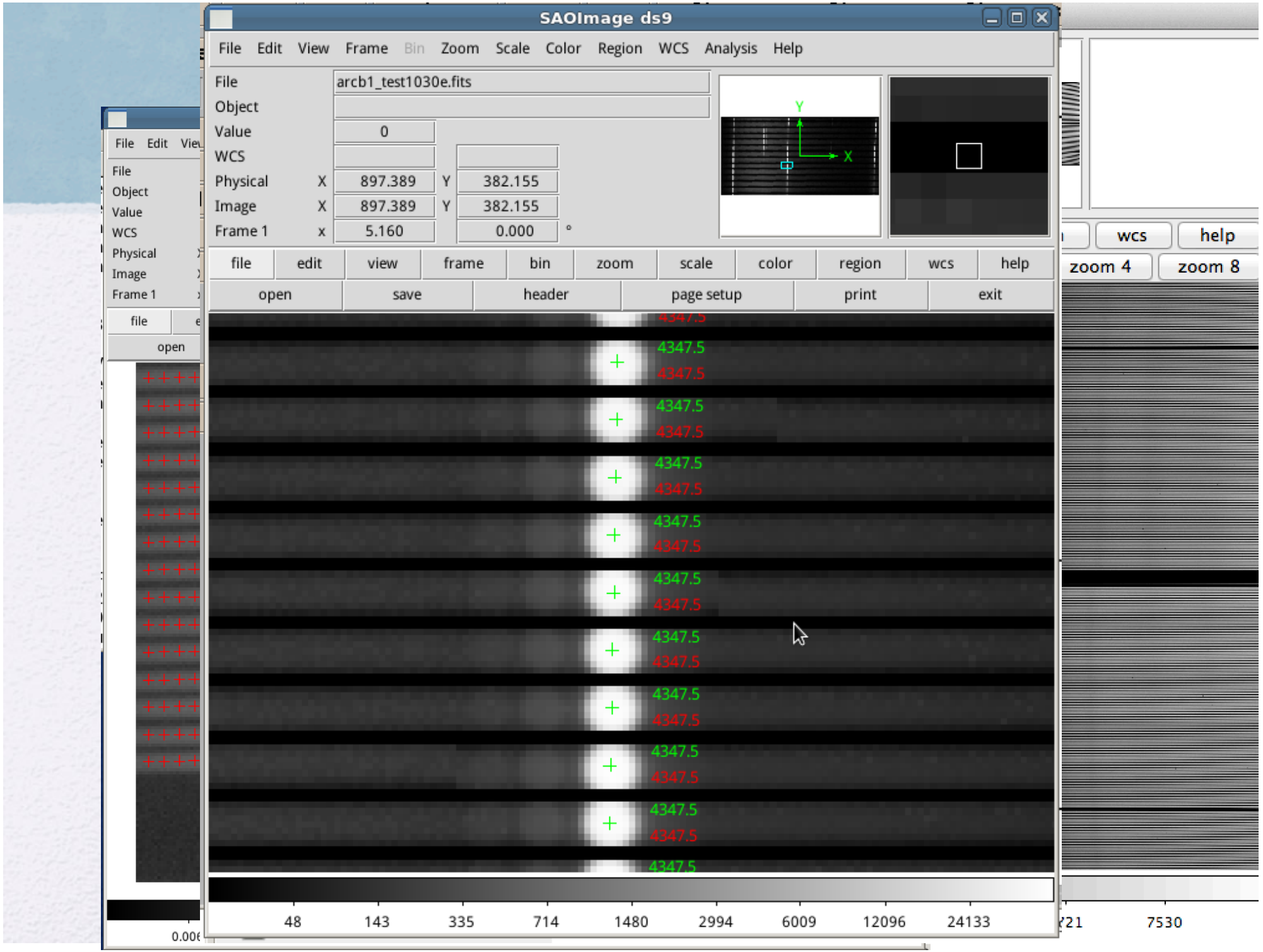
CHILI

- Timeline:
  - 2014, funded
  - Dec, 2014, contract finally signed
  - Dec, 2015, CHILI spectrograph installed, IFU not ready
  - Aug, 2016, CHILI IFU installed, preliminary test fine
  - Sep, 2016, Telescope recoating, has to take it down
  - Nov, 2016-Feb, 2017, test running, test observing
  - Feb, 2017-, telescope pointing error test, suspend

CHILI Pipeline

- Has VIRUSP observation pipeline to start with
  - CHIP: developed from VACCINE, data extraction
  - DATA CUBE building
  - Guider images, may help with the absolute flux calibration, testing.


SAOImage ds9
File
flat3.fit
Object
Value
SAOImage ds9
File Edit View Frame Bin Zoom Scale Color Region WCS Analysis Help
File
flatb1_test1030.fits
Object
Value
WCS
Physical X Y
Image X Y
Frame 1 x 2.986 0.000 °
file edit view frame bin zoom scale color region wcs help
open save header page setup print exit
region
wcs
help
zoom 2
zoom 4
zoom 8
0.006 0.011 0.023 0.045 0.089 0.18 0.35 0.7 1.4
5903 6721 7530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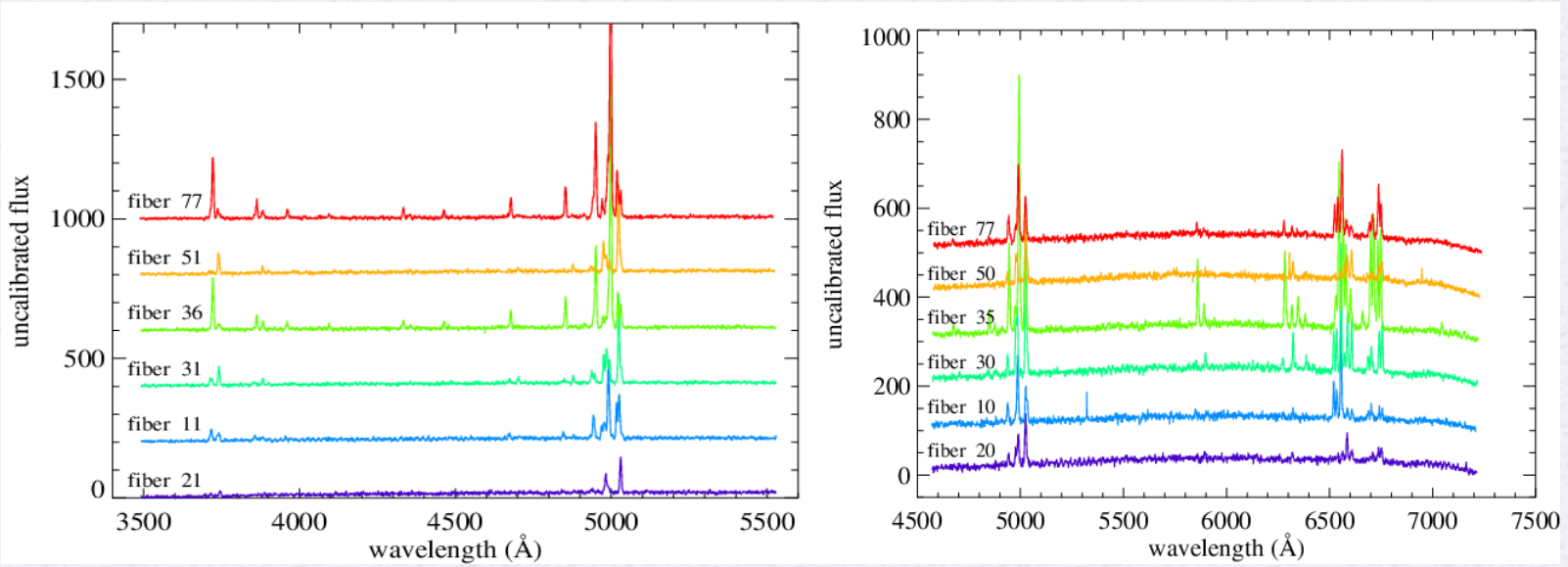
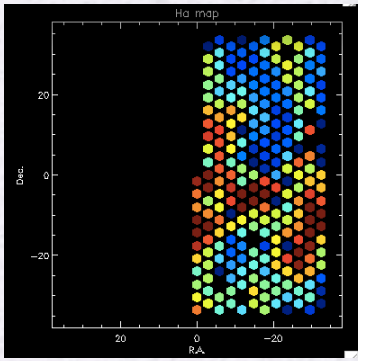
File arcb1_test1030e.fits
Object
Value 0
WCS
Physical X 897.389 Y 382.155
Image X 897.389 Y 382.155
Frame 1 x 5.160 0.000 °
file edit view frame bin zoom scale color region wcs help
open save header page setup print exit
4347.5
48 143 335 714 1480 2994 6009 12096 24133
wcs help
zoom 4 zoom 8
7530

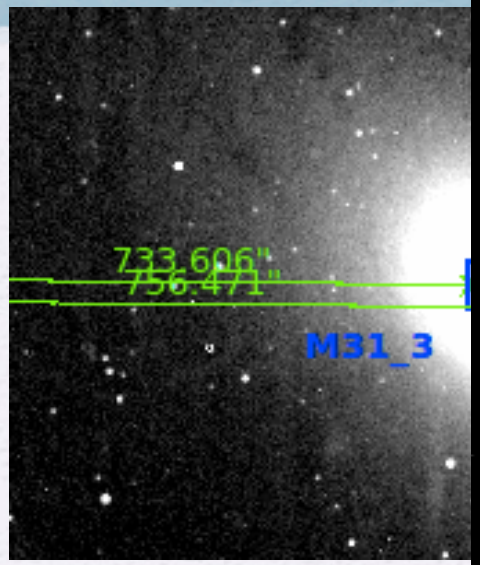
CHILI



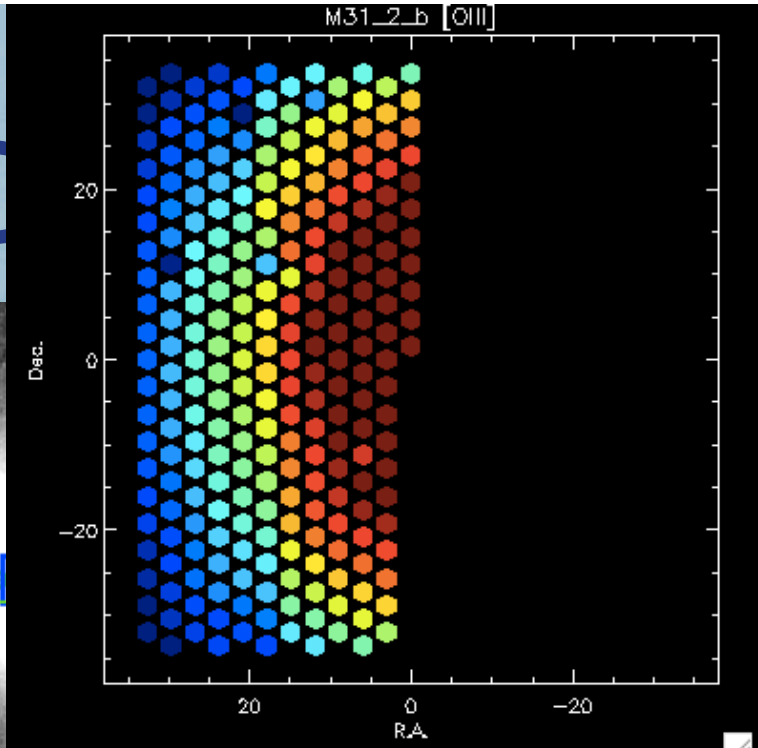


Hα map

20mins on Crab Nebular


733.606"
756.471"
M31_3

M31


M31_2_b [OIII]
Dec.
RA
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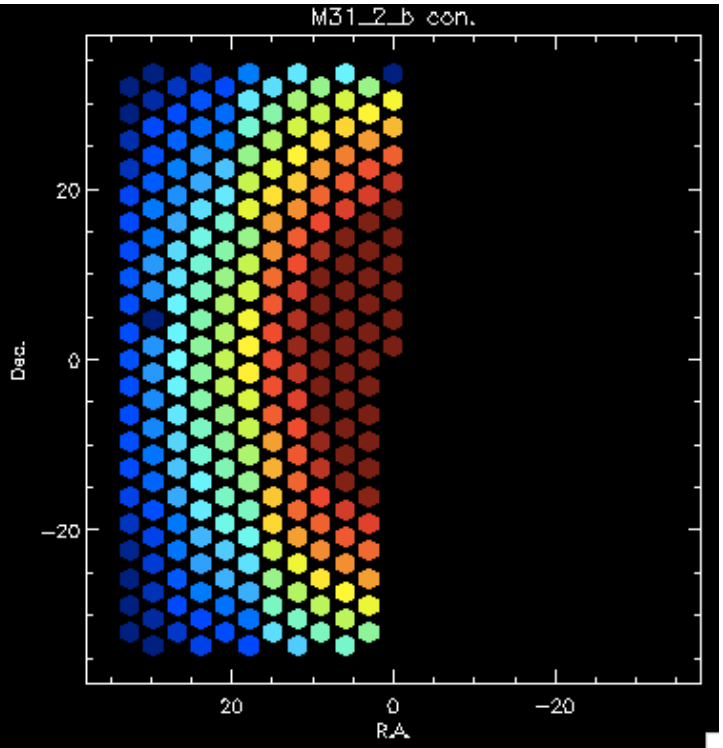
0
−20


M31_2_b con.
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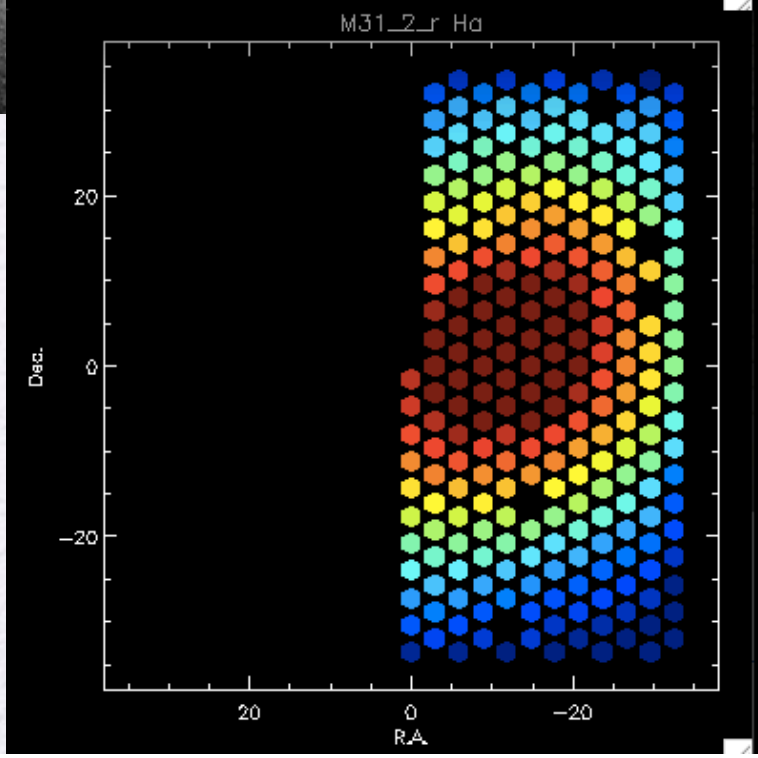
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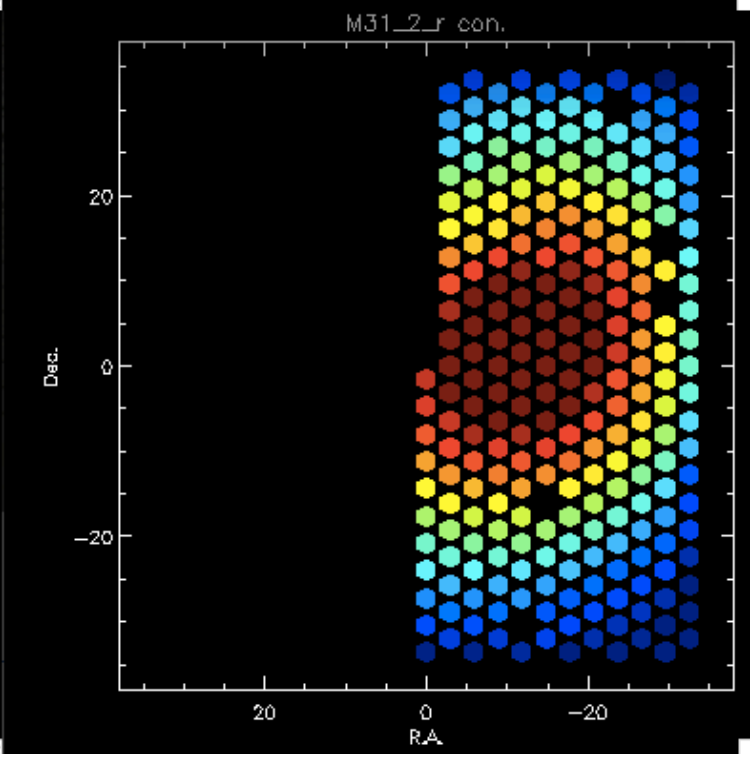
M31_2_r con.
Dec.
RA
20
0
−20

CHILI

- Difficulties :
  - Team building turns out to be the hardest part of the project
  - Some progresses but not ideal
  - Observing time

CHILI Team

- CHILI Groups:
  - Scientific Working Group: >50 peo
  - Instrumentation: ~10 people
  - Software Development Team: ~15 people
- Activities:
  - 2014.11.15: Science cook-off meeting
  - 2015.1.16-19: Instrumentation kick-off meeting
  - 2015.1.23-30: Software kick-off meeting
  - Website & Wiki
  - 2015.12.7-15: CHILI installation
  - 2016.2.27-28: 2nd Science meeting