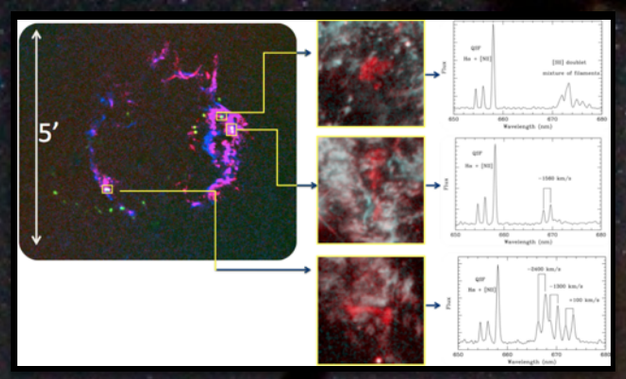
Large Binocular Telescope Observatory

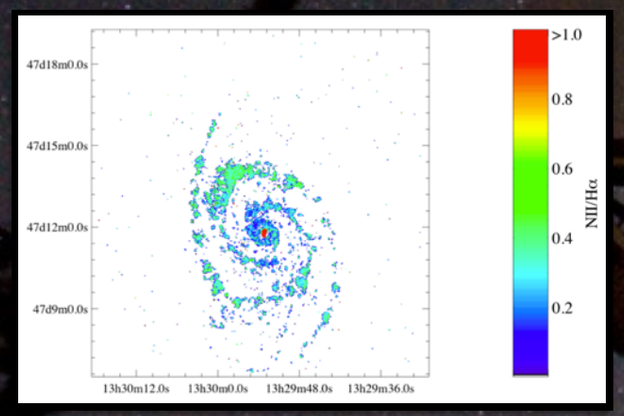
Imaging Fourier Transform Spectrometer for LBTO

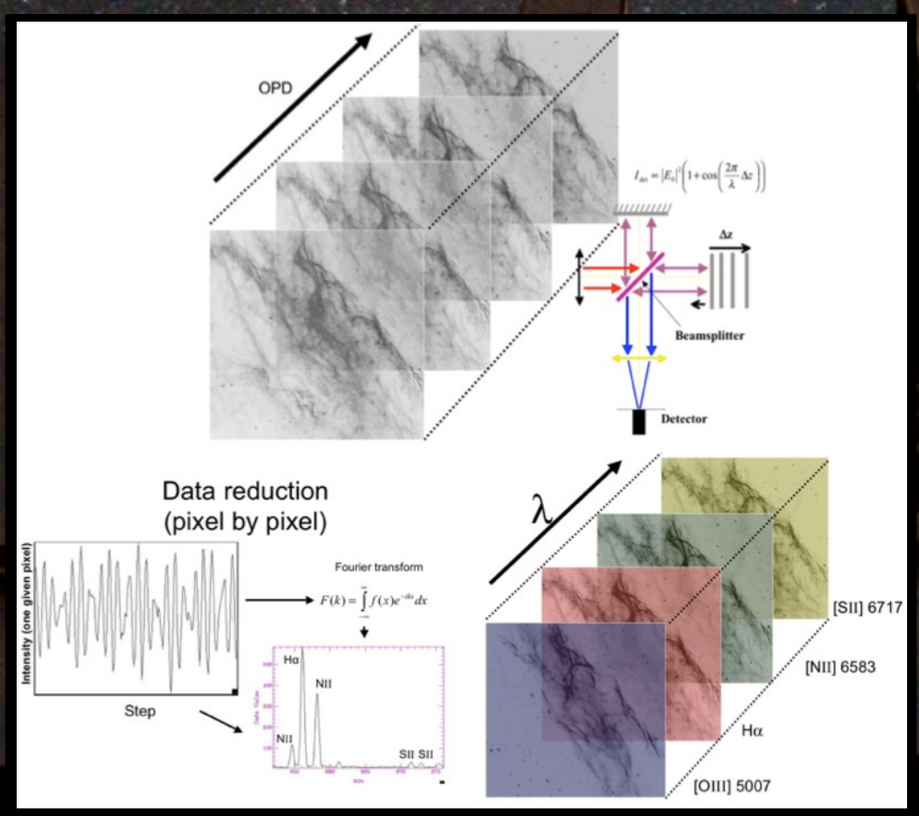
1st Users' Meeting

Glenn Morrison
University of Hawaii & CFHT

March 22-25, 2014







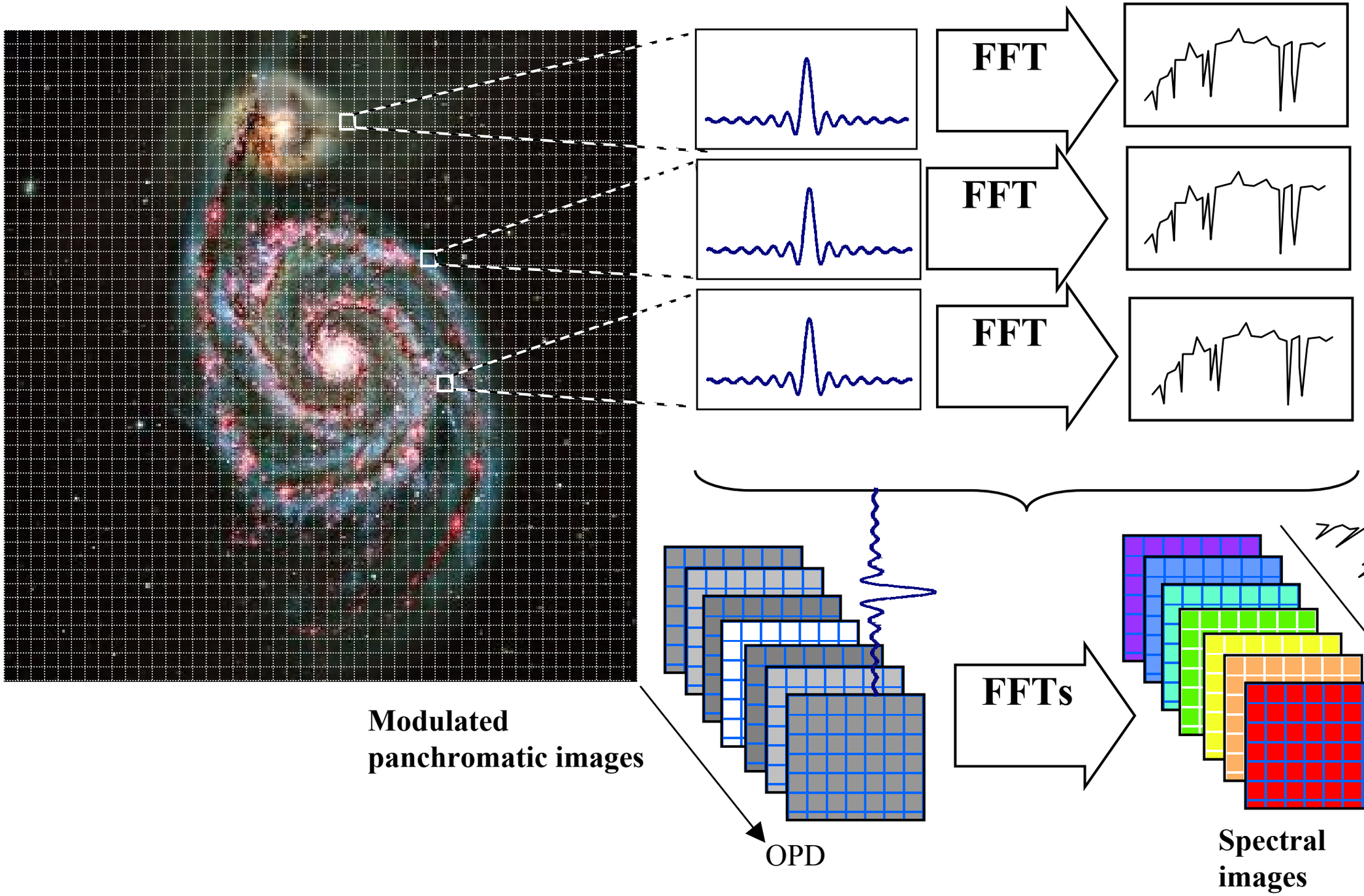
Contributors

- Frédéric Grandmont (ABB) - Contact
- Laurent Drissen (U. Laval) — PI SITELLE
- Rogier Windhorst (ASU)
- Mark Wagner (LBTO)
- John Hill (LBTO)

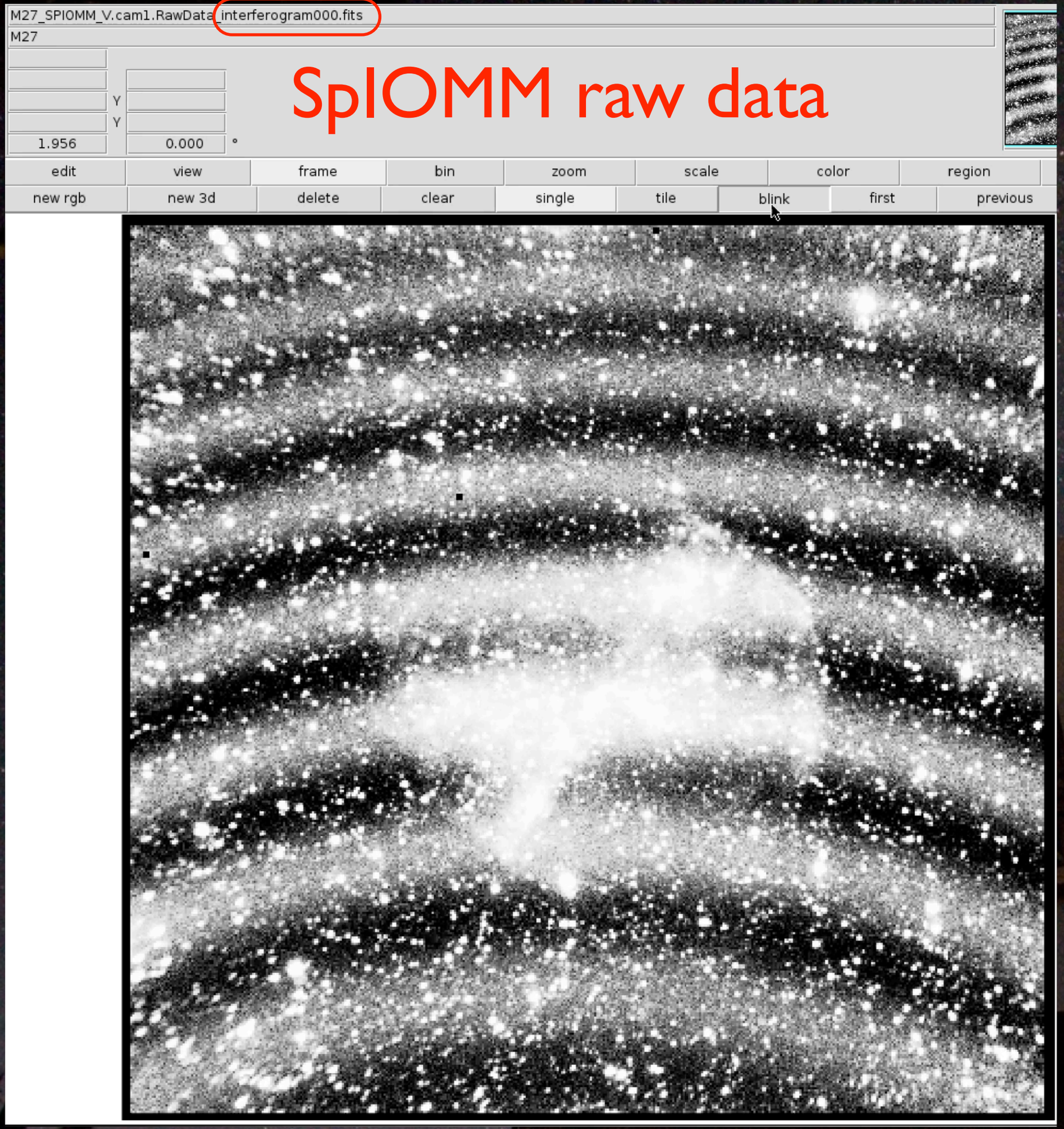
IFTS is for:

- Wide field (10'-28') with a
  - Spectrum at every pixel
  - Contiguous area spectroscopy
    - Extended objects
    - Emission line sources
- Narrow — medium bandwidth filters
- Shot noise uniformly distributed

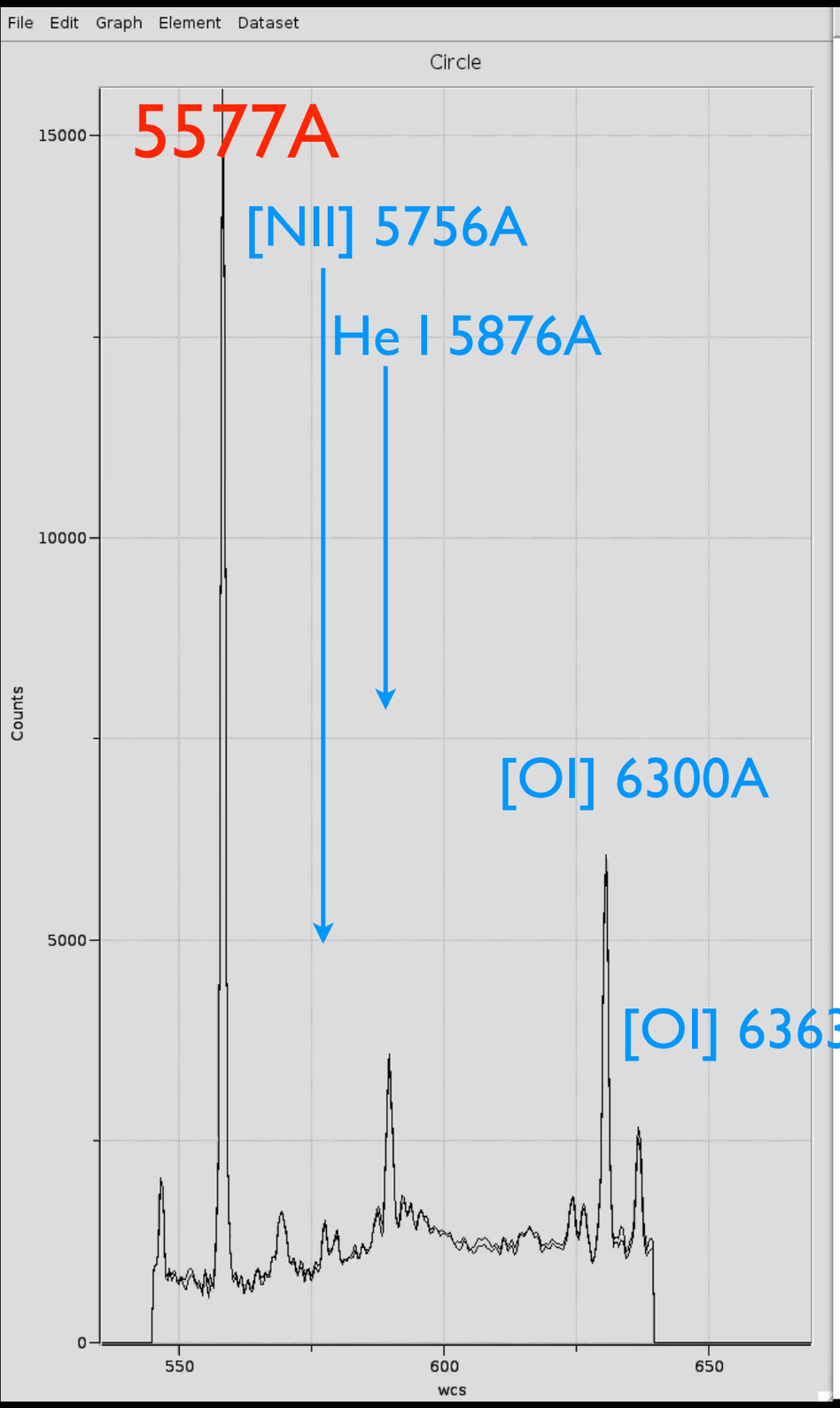
IFTS Concept

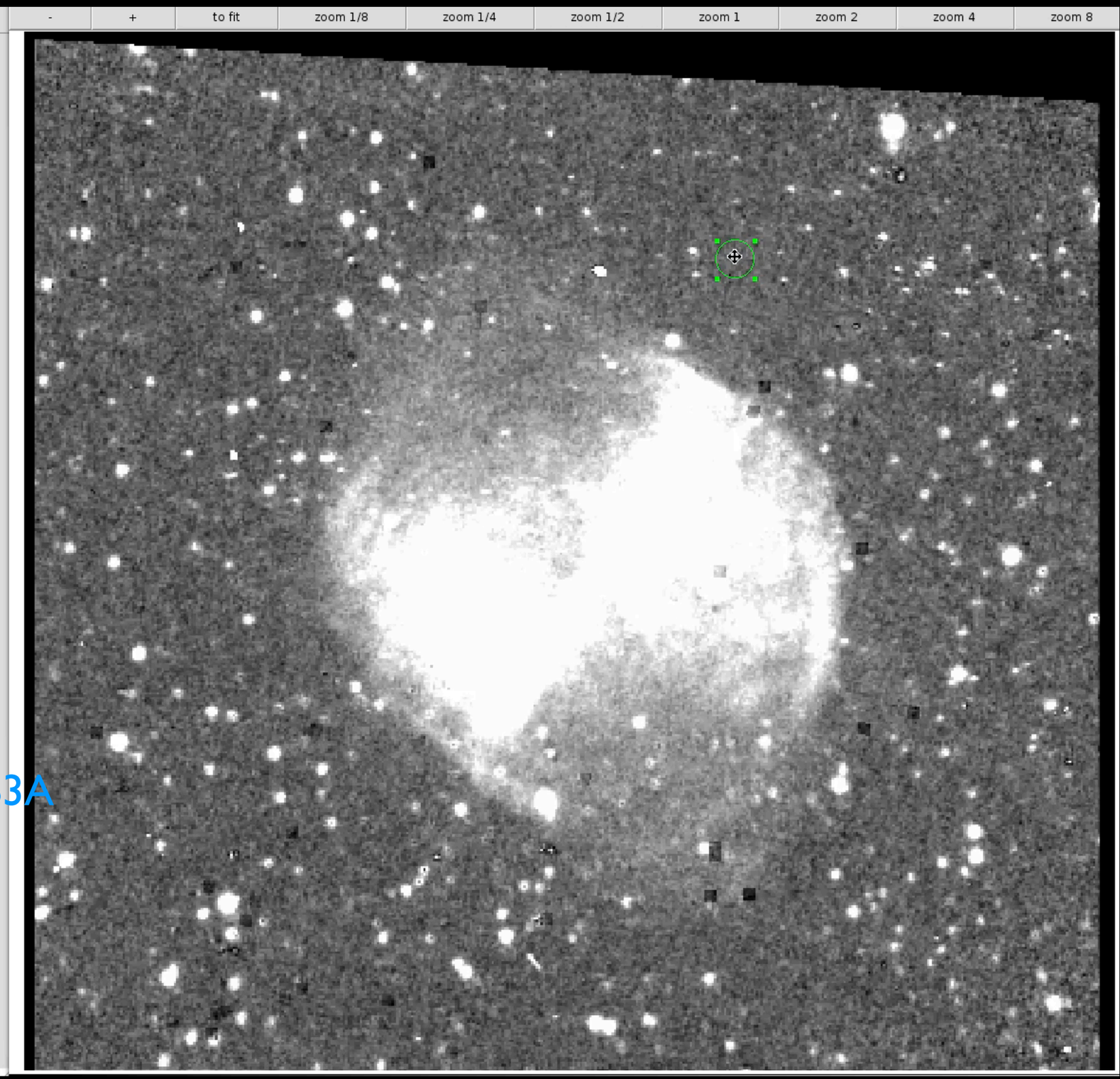


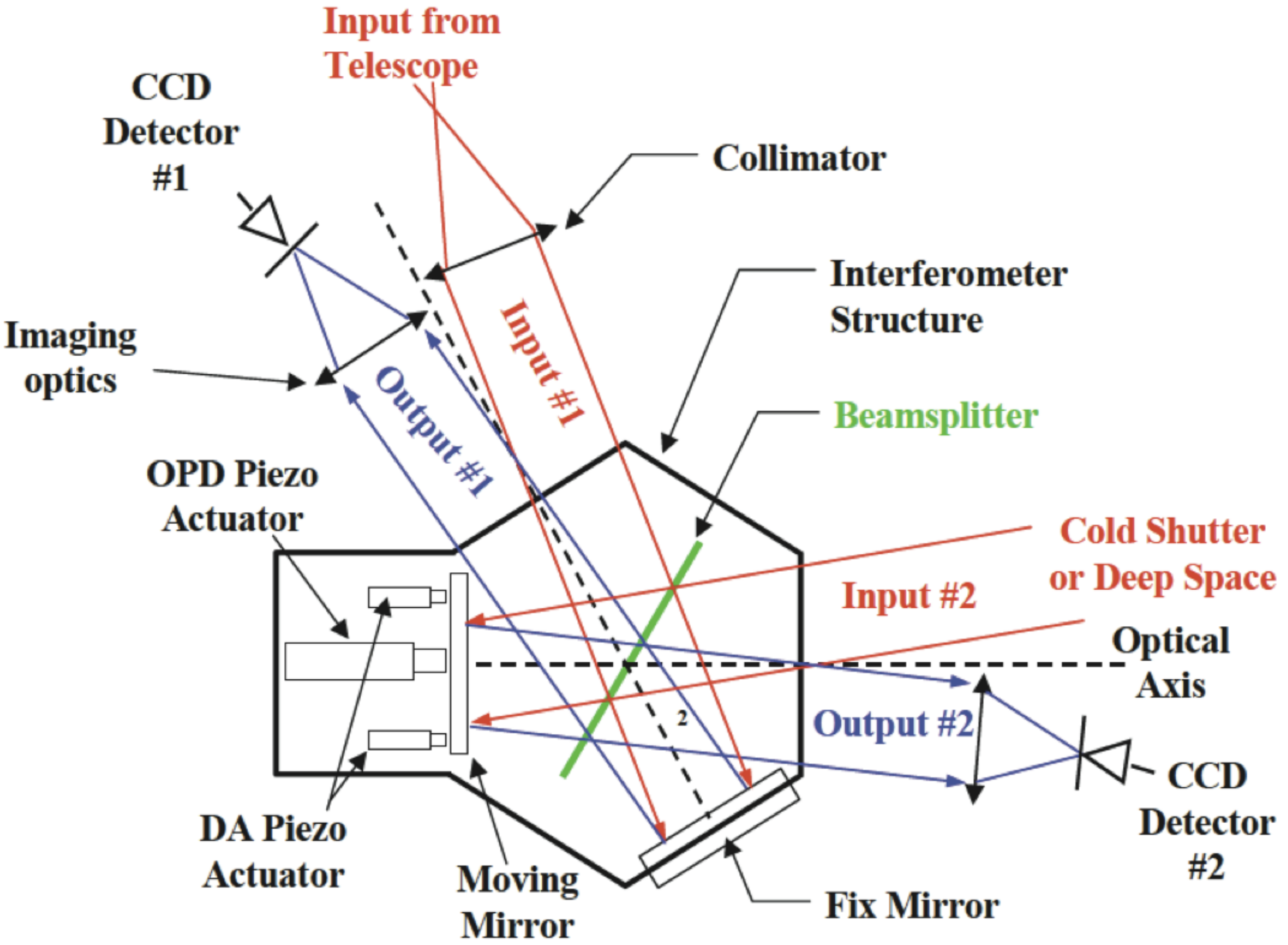
SpIOMM raw data



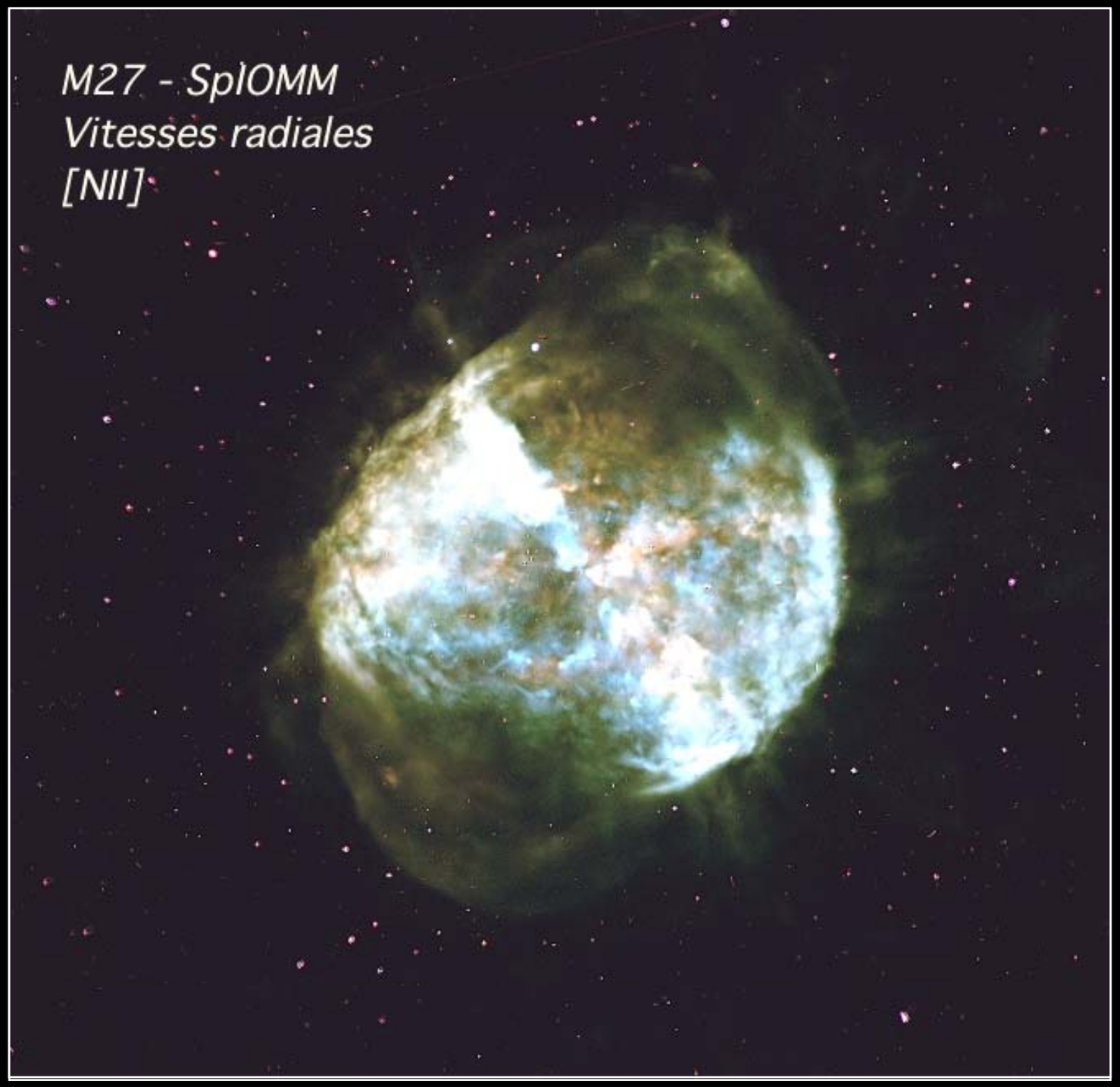
SpIOMM reduced data

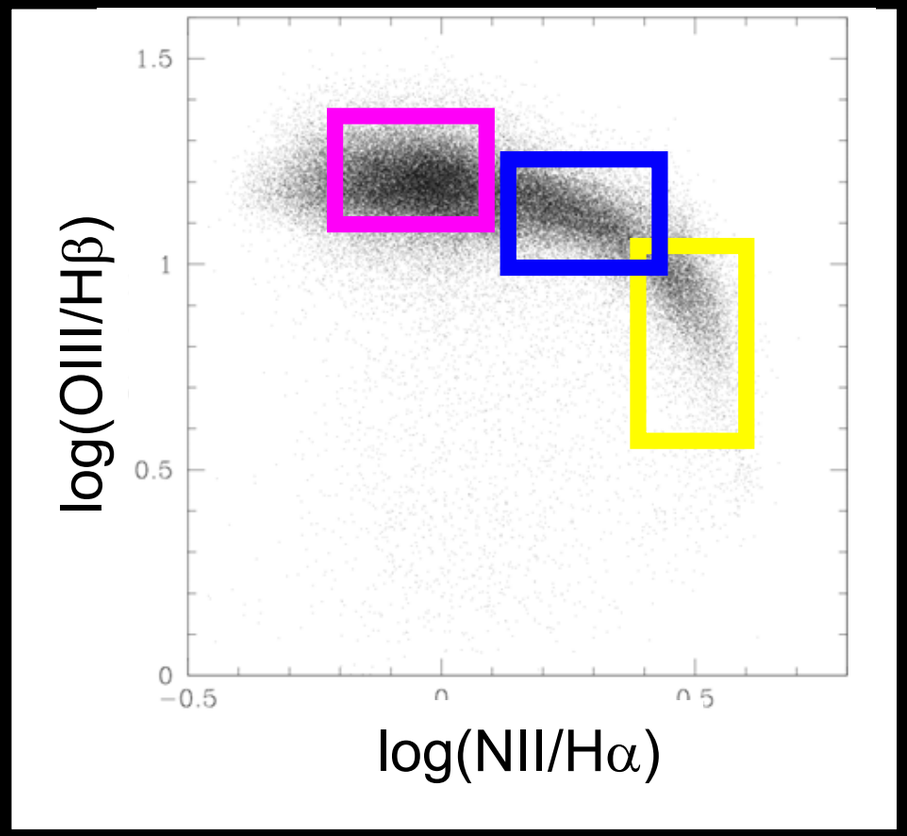


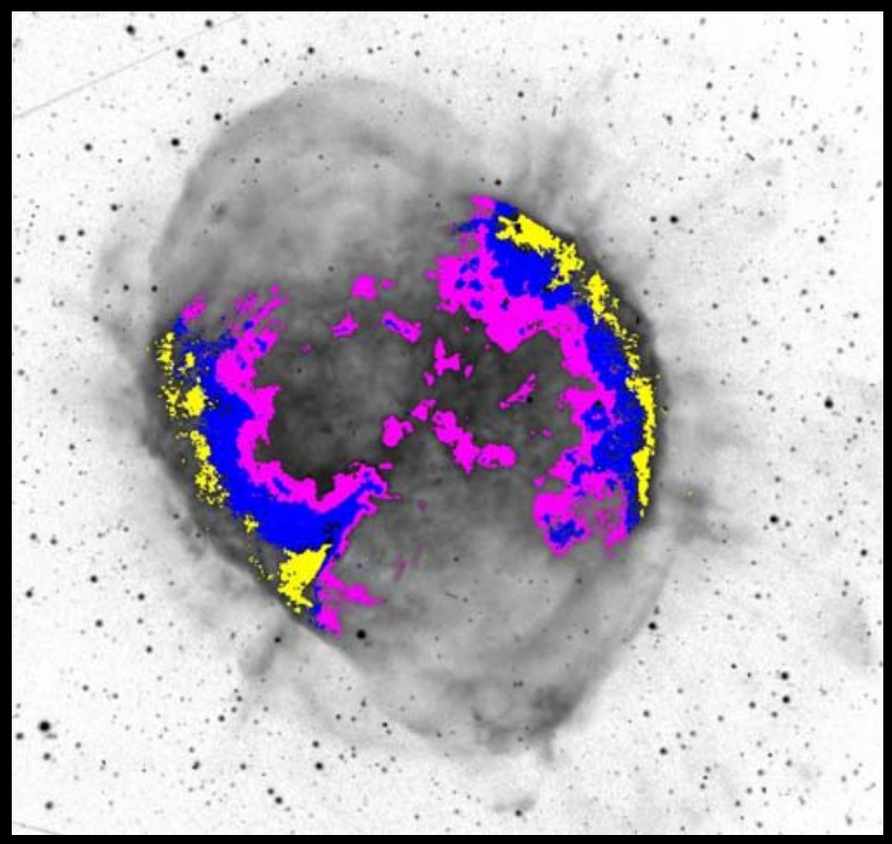



Input from Telescope
CCD Detector #1
Collimator
Interferometer Structure
Imaging optics
Input #1
Output #1
Beamsplitter
OPD Piezo Actuator
Cold Shutter or Deep Space
Input #2
Optical Axis
2
Output #2
CCD Detector #2
DA Piezo Actuator
Moving Mirror
Fix Mirror

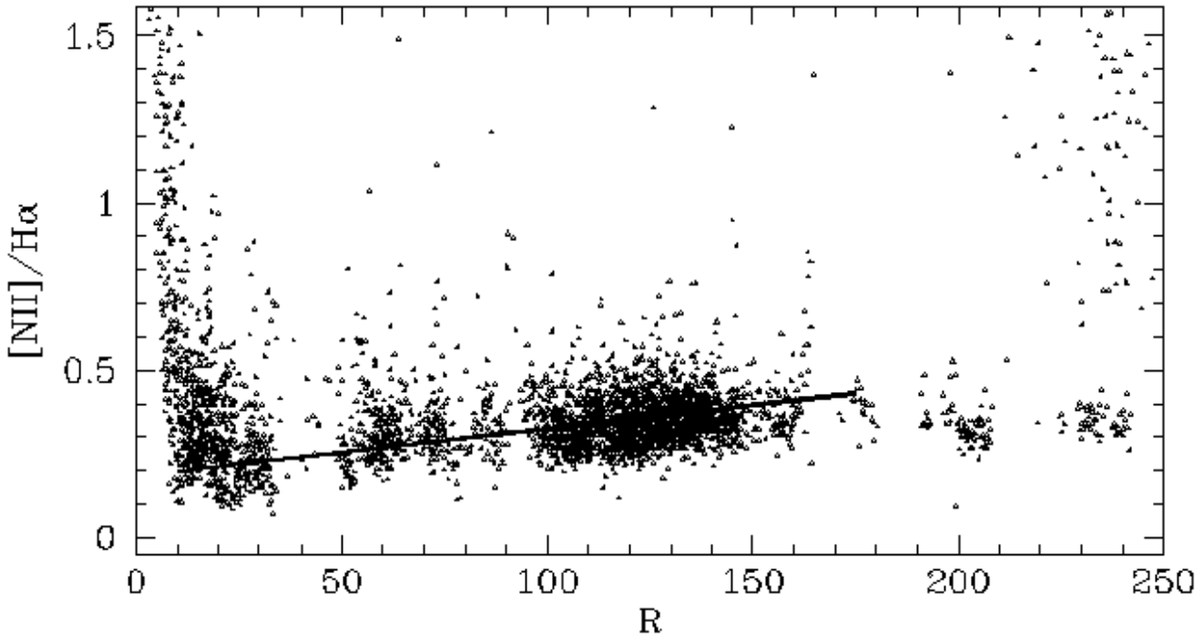
Diagnostic diagrams





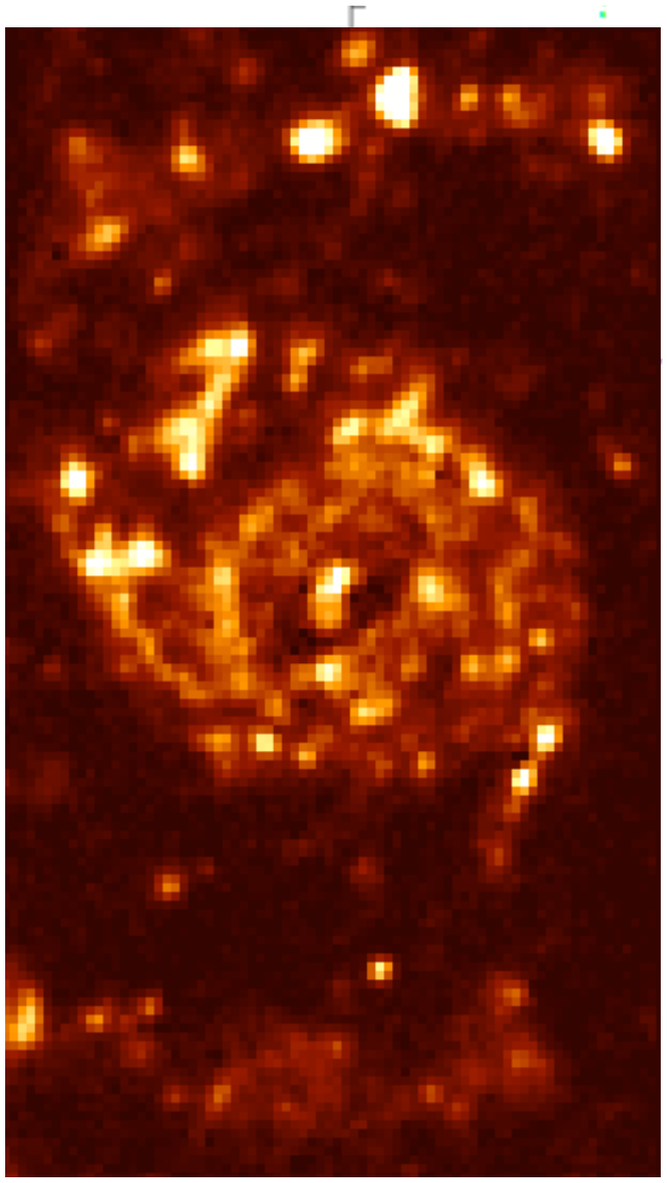


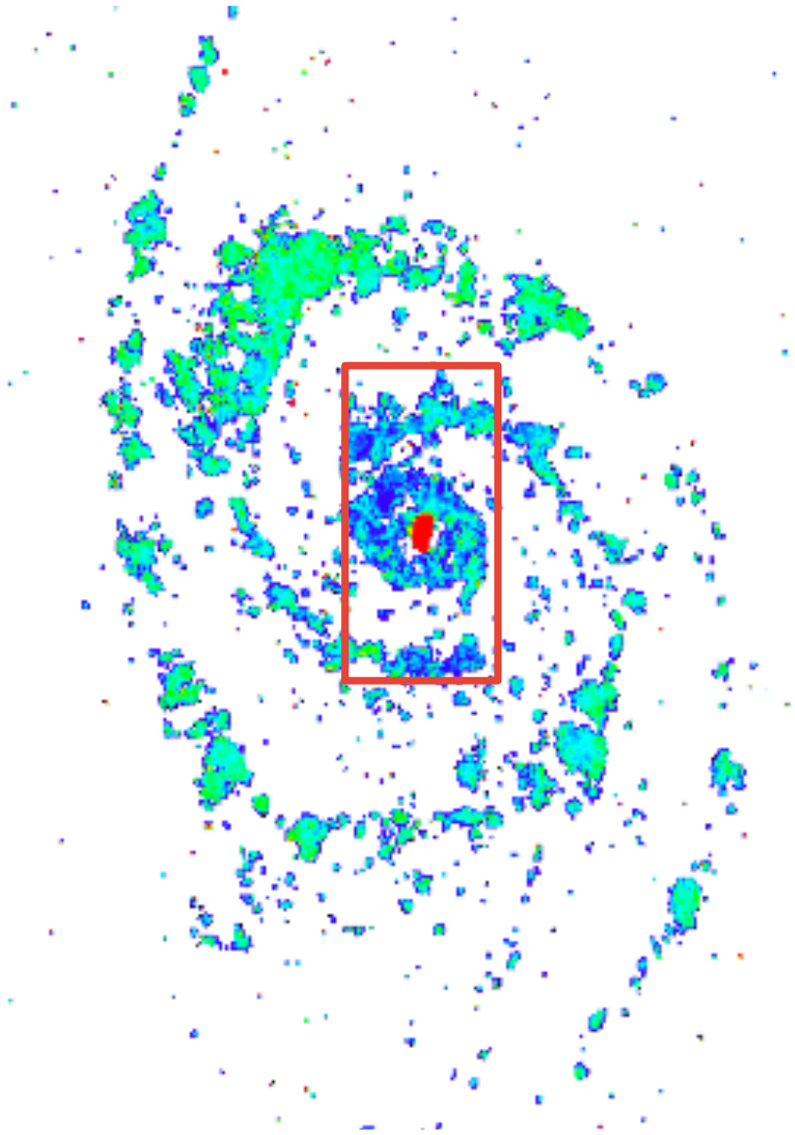
Drissen et al. 2010

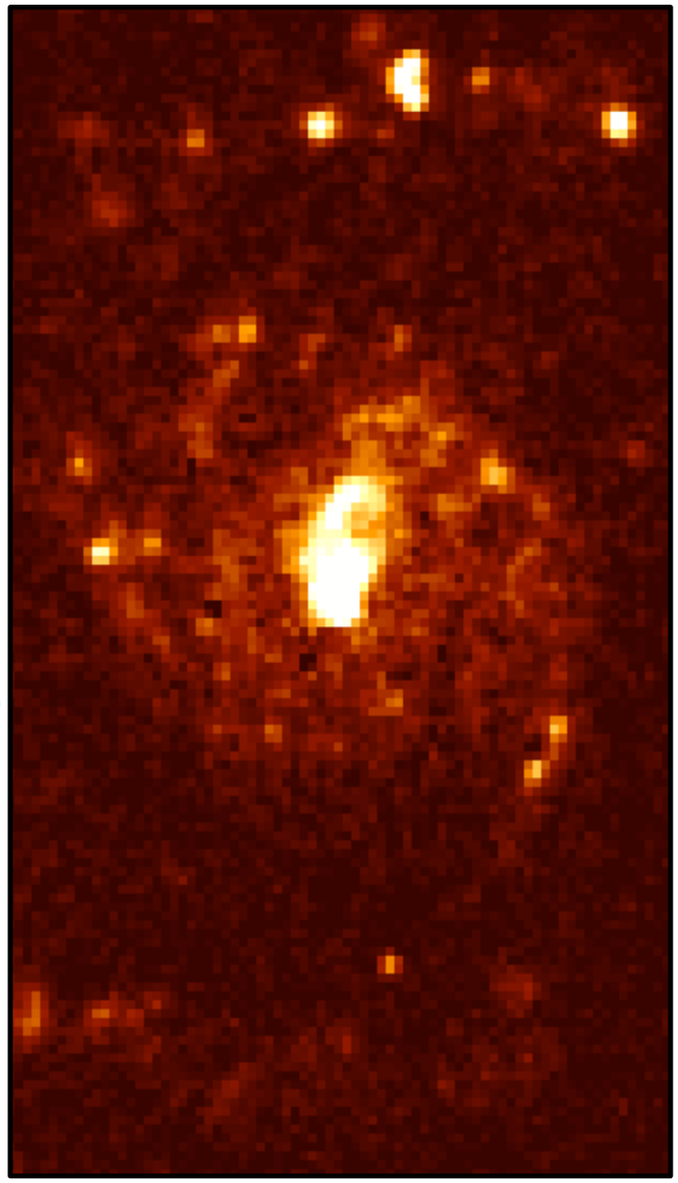


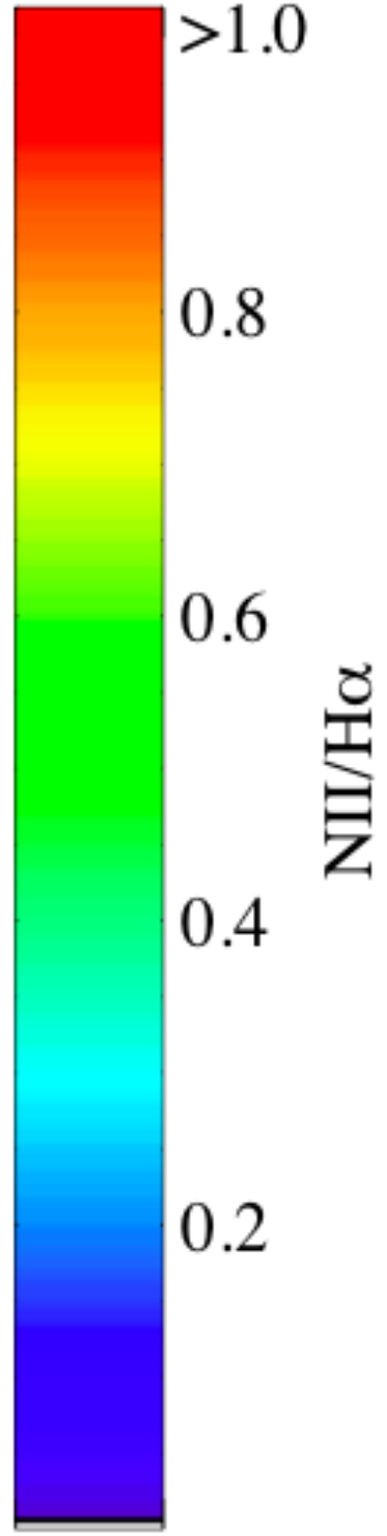
Hα

[NII]







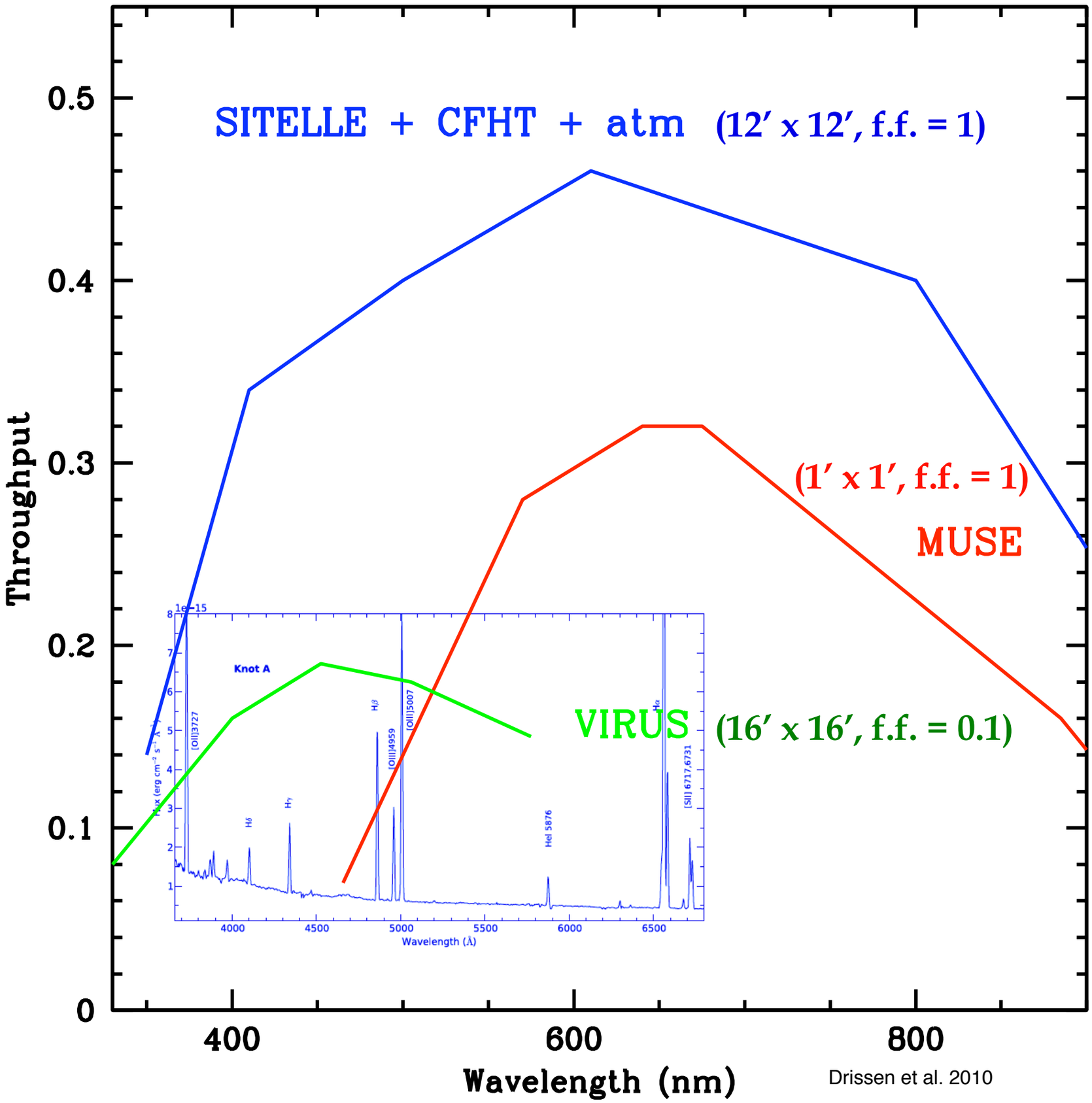


Drissen et a. 2010

SITELLE + CFHT

- 20x sensitive than SpIOMM
- Automated calibration
- Queue Ready
- Completed data reduction pipeline

SITELLE field of view compared to IFUs

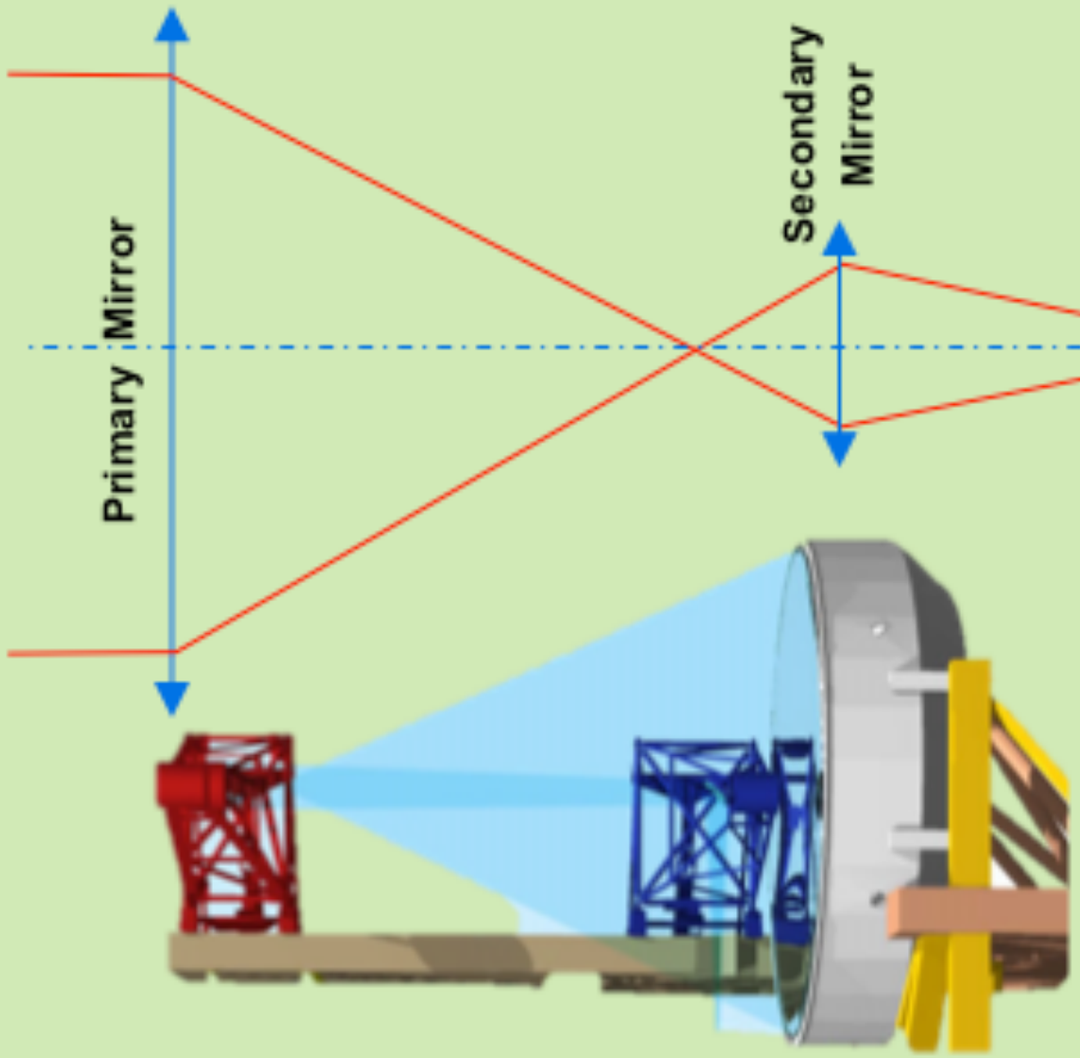


Drissen et al. 2010

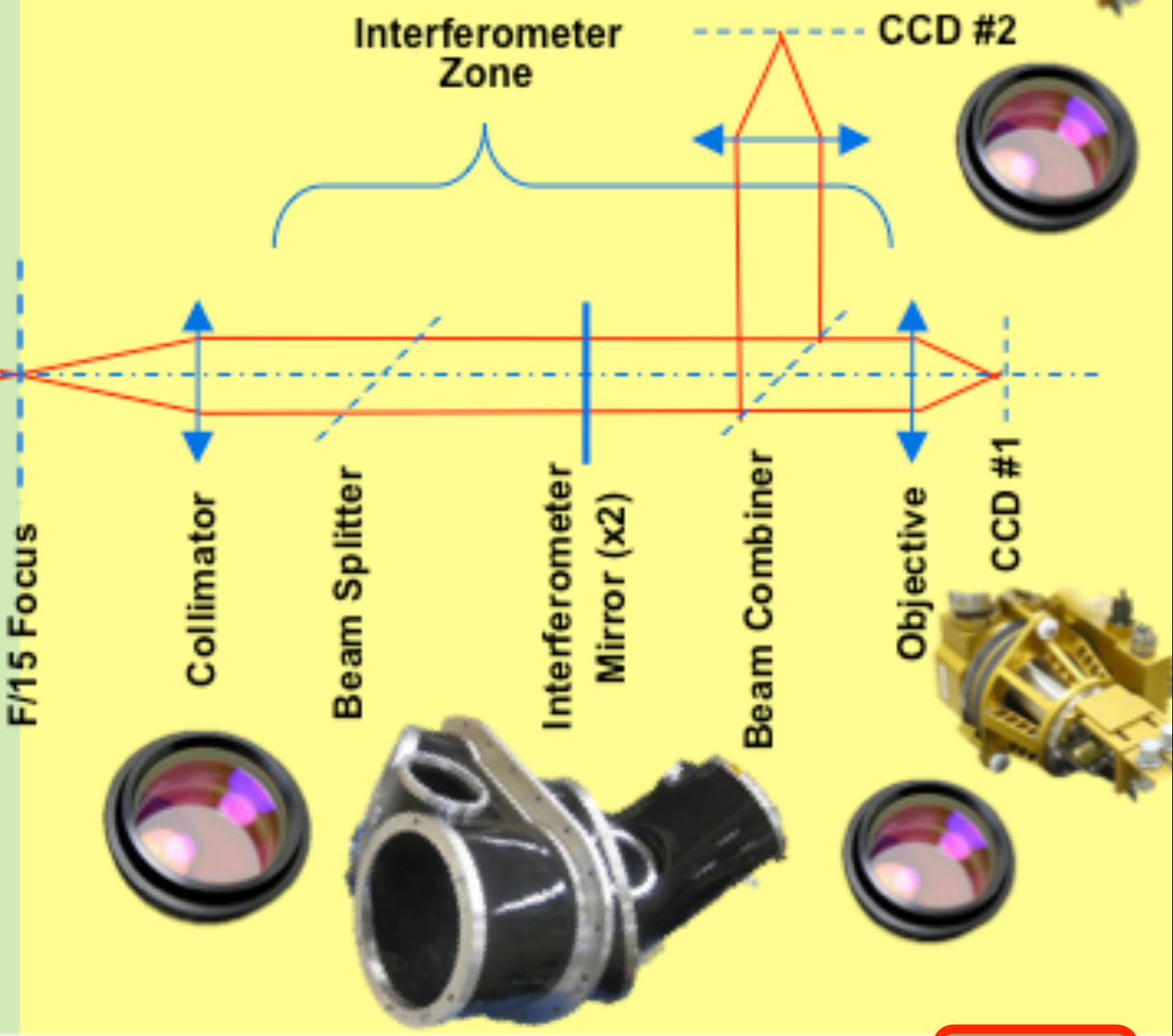
Imaging FTS Paraxial Ray Trace
Unfolded Representation

ABB Design

Telescope



Instrument



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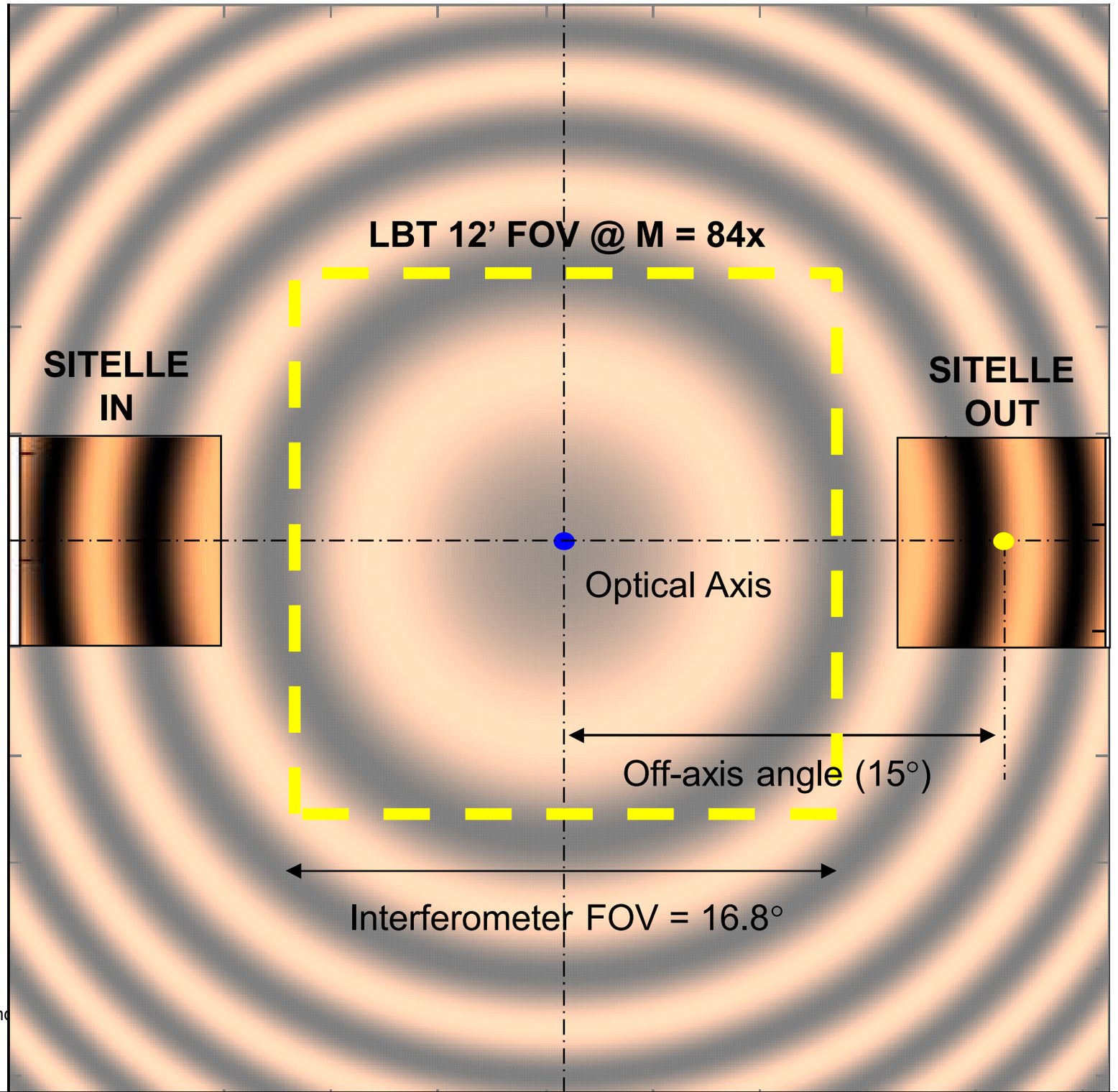
Mapping CCD FOV onto Interferometer Fringe Pattern
Centering FOV allows fitting more throughput.



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Configurations Trade-offs

- Assumptions:
  - Maximise FOV (10 – 24 arc min)
  - Limit instrument size (interferometer beam: 100 – 150 mm)
  - Maintain high spectral resolution of R > 10 000 in the visible
    Maximum OPD sets spectral resolution: MOPD > 5 mm

	SITELLE	LBTO					
Case #		1	2	3	4	5	6
Primary [mm]	3600	8400	8400	8400	8400	8400	8400
FOV [arcmin]	11	12	12	18	24	12	12
Array Size	2048	2048	4096	4096	4096	4096	2048
Pixel FOV [arc sec]	0.32	0.35	0.18	0.26	0.35	0.18	0.35
Pupil [mm]	90	100	100	100	140	70	120

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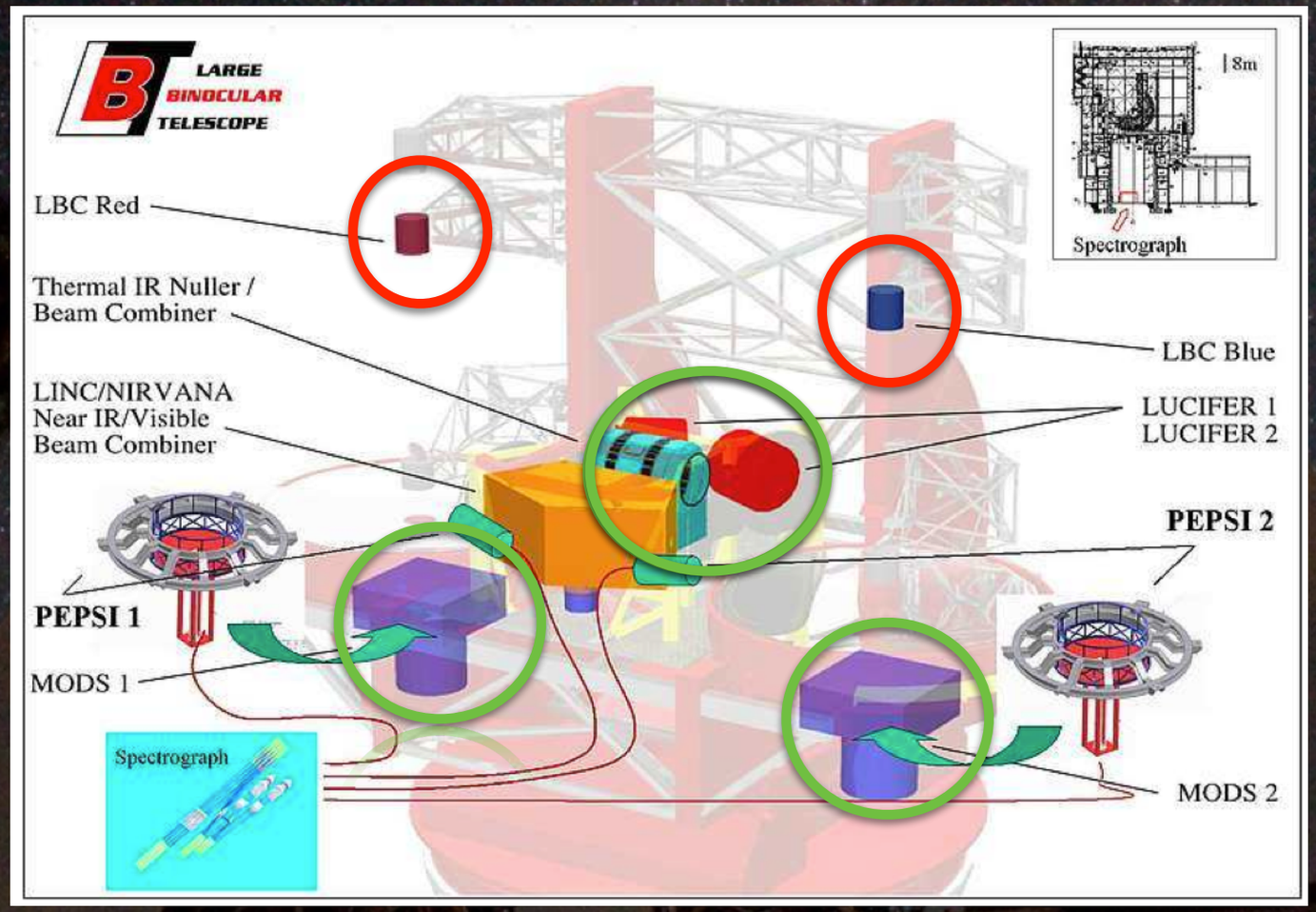
LBT Focal Stations

- Direct F/1.4
- F/15 Direct: FoV <11’
- F/15 Bent: FoV <11’
- F/15 GLAO: 4’x4’
- Cass foci: FoV 40’



Wagner 2012

Design Challenge to be Validated

- Most technical challenge were demonstrated in SITELLE.
- Redesign still imply new verifications:
  1. Can imaging quality be matched to pixel size for selected configuration and bandpass (350-950 nm)
  2. Validate that instrument size, mass and torque are compatible with LBT limits.
  3. Design an instrument structure that can maintain instrument flexures to a few pixels during long integration (few hours)
  4. Validate LBT operational vibration to be compatible with SITELLE interferometer metrology and scan mechanism.

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COST Evaluation

Cryotigers

- Cost driver:
  - New detector development vs past design reuse ? (SITELLE required custom vibration damped dewar design due to imposed cooling method)
  - Number, size & complexity of lens included in collimator and camera objective (2x)
  - 4-port interferometer approach using spatial separation doubles the number of optics (4 mirrors + 2 beamsplitter substrate)
  - Although more numerous interferometer optics are of similar complexity to those of SITELLE.
- Based on these considerations the cost of an LBT wide-field IFTS would be in the 5-6 M$ range.

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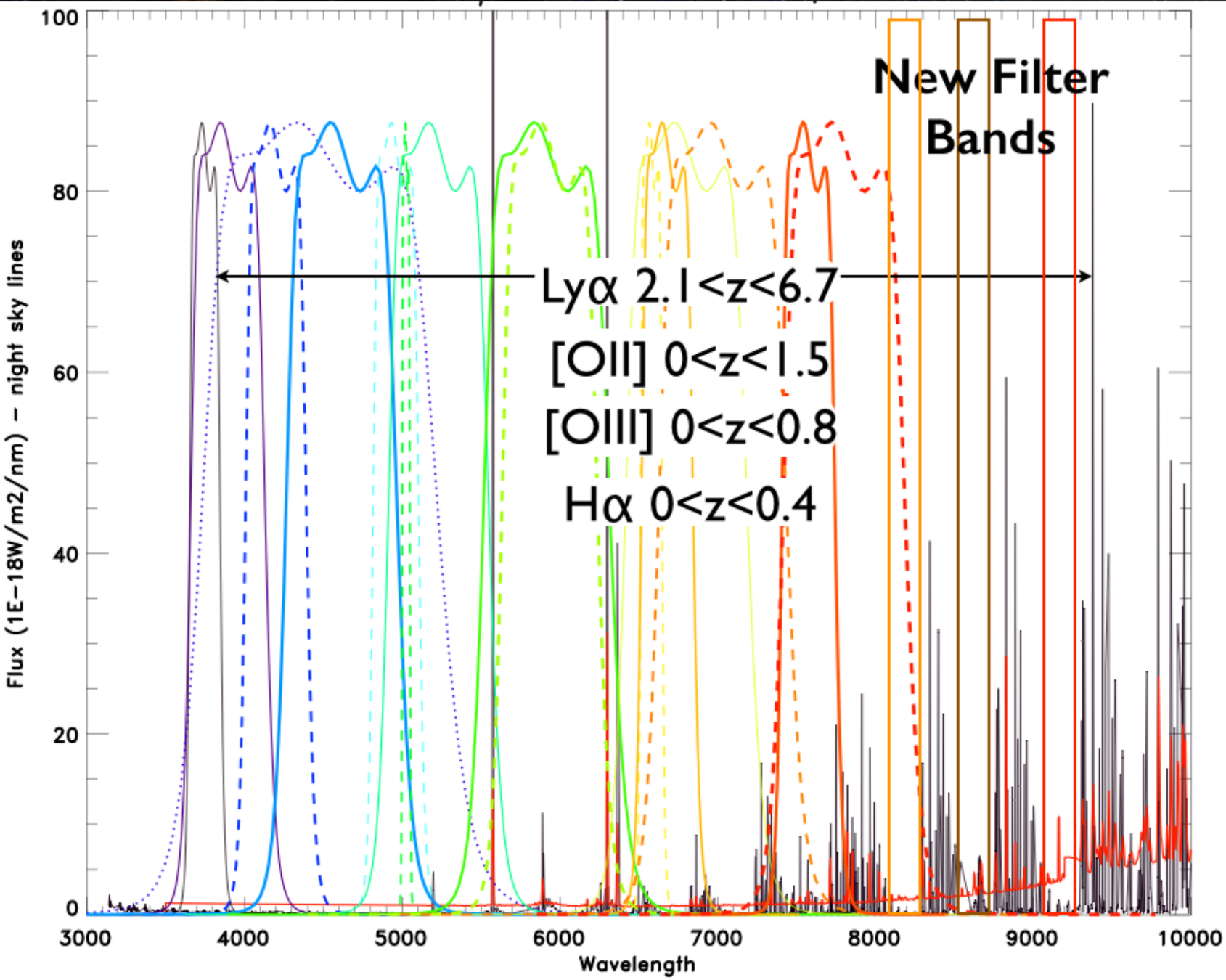
LBTO+IFTS

- Emission *and absorption* line studies
  - flux > ~1E-17 erg/s/cm^2 in 4hr (5-sigma)
- LBTO+IFTS 4-5x more sensitive than CFHT+SITELLE
- Filter selection - *community input*

- Science Projects
  - Solar system - *non-sidereal tracking - comets*
  - Galactic — HII regions, stars, SNR, planetary nebula
  - Extragalactic — nearby galaxies, hi-z galaxies, Lyman-alpha emitters, etc.

LBTO+IFTS: Science

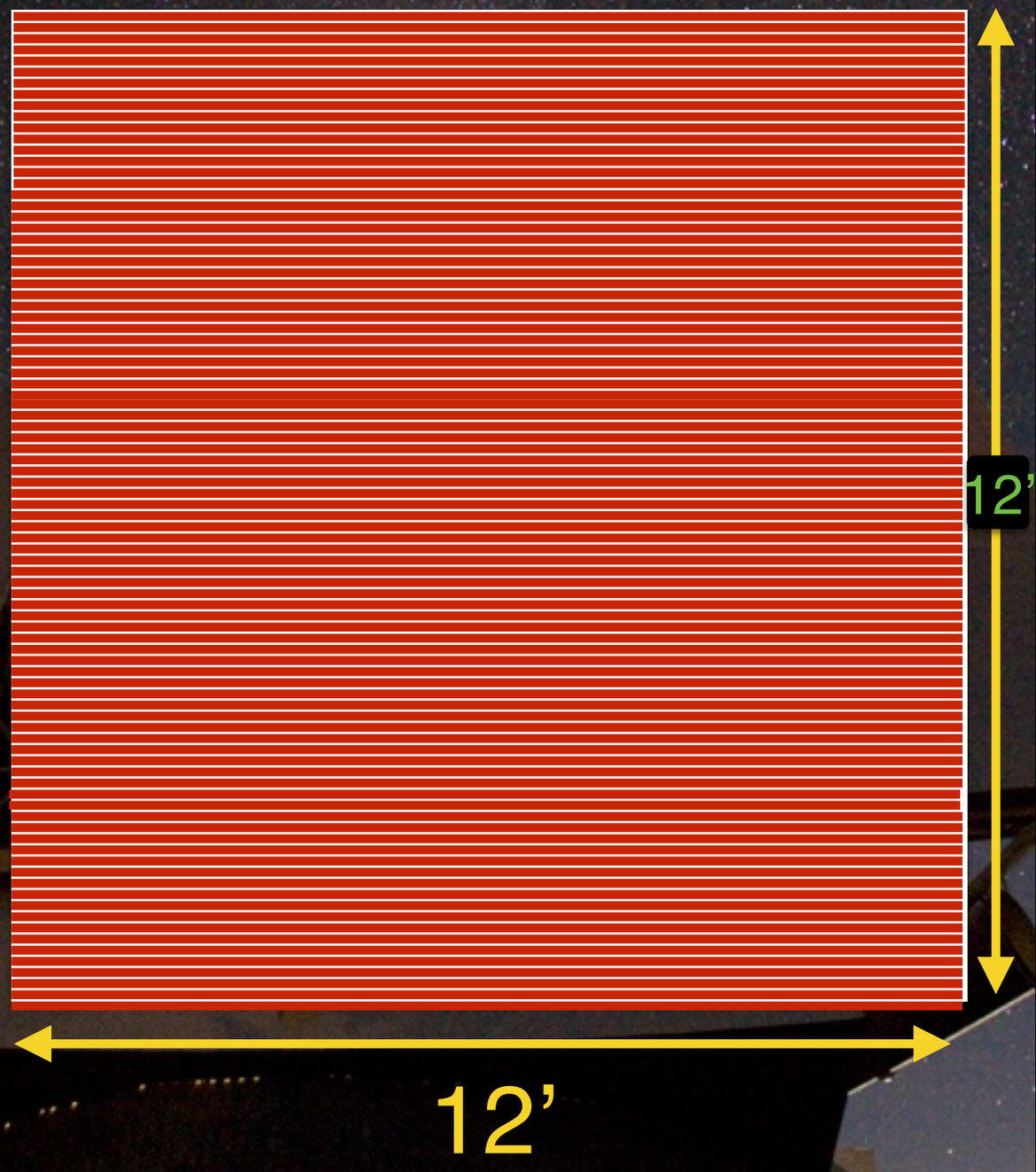


IFTS Software

- IFTS Simulator
  - Setup IFTS observations
    - Complete data reduction pipeline
      - Flux calibrated
      - Phase correction
      - Reduced data cube (α,δ, λ) are stackable

Summary

- SITELLE first light in fall 2014
- LBTO-IFTS 4-5x more sensitive than SITELLE
- Wider FOV than existing IFUs
- Science case that take advantage of wide-FoV and sources that are extended

Compare Dispersive Spectroscopy to IFTS

- M27 2hr IFTS observations filter BW=100nm; 1.6m telescope
- Dispersive=> 1” slit & BW=500nm
- 12’ =>720” or 720 slits
- 2hr or 7200s/720=10s per slit; SNR will be low