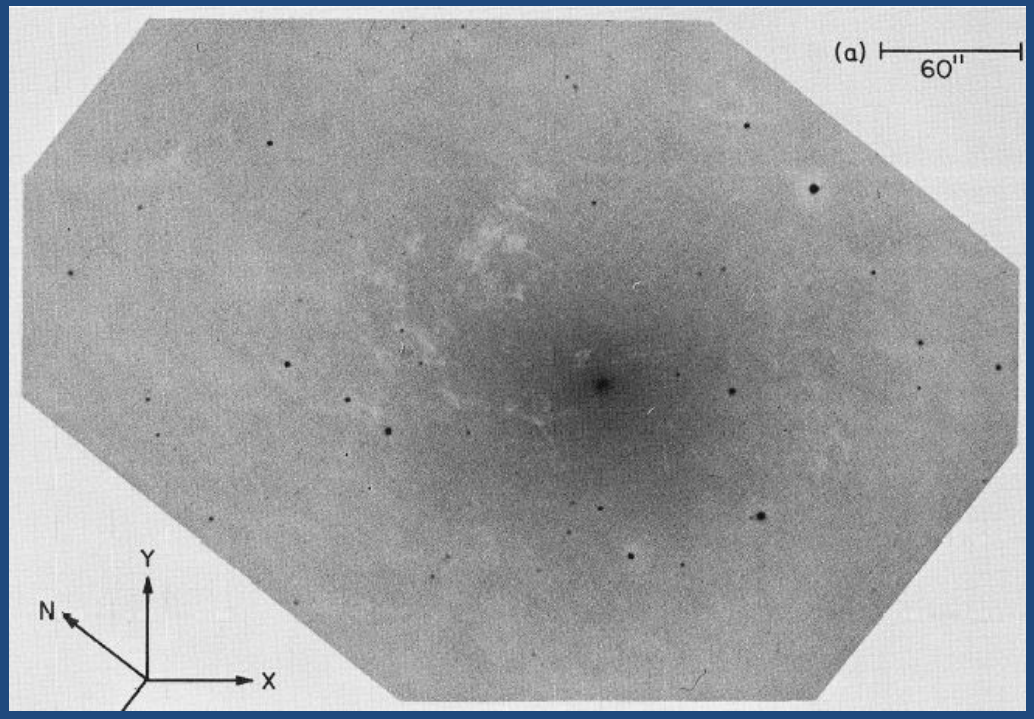
Ionized gas around the nucleus of M31

First mentions of ionized gas in the center of M31

- Lallemand, Duchesne and Walker (1960)
- Munch (1960)
- Rubin and Ford (1971)

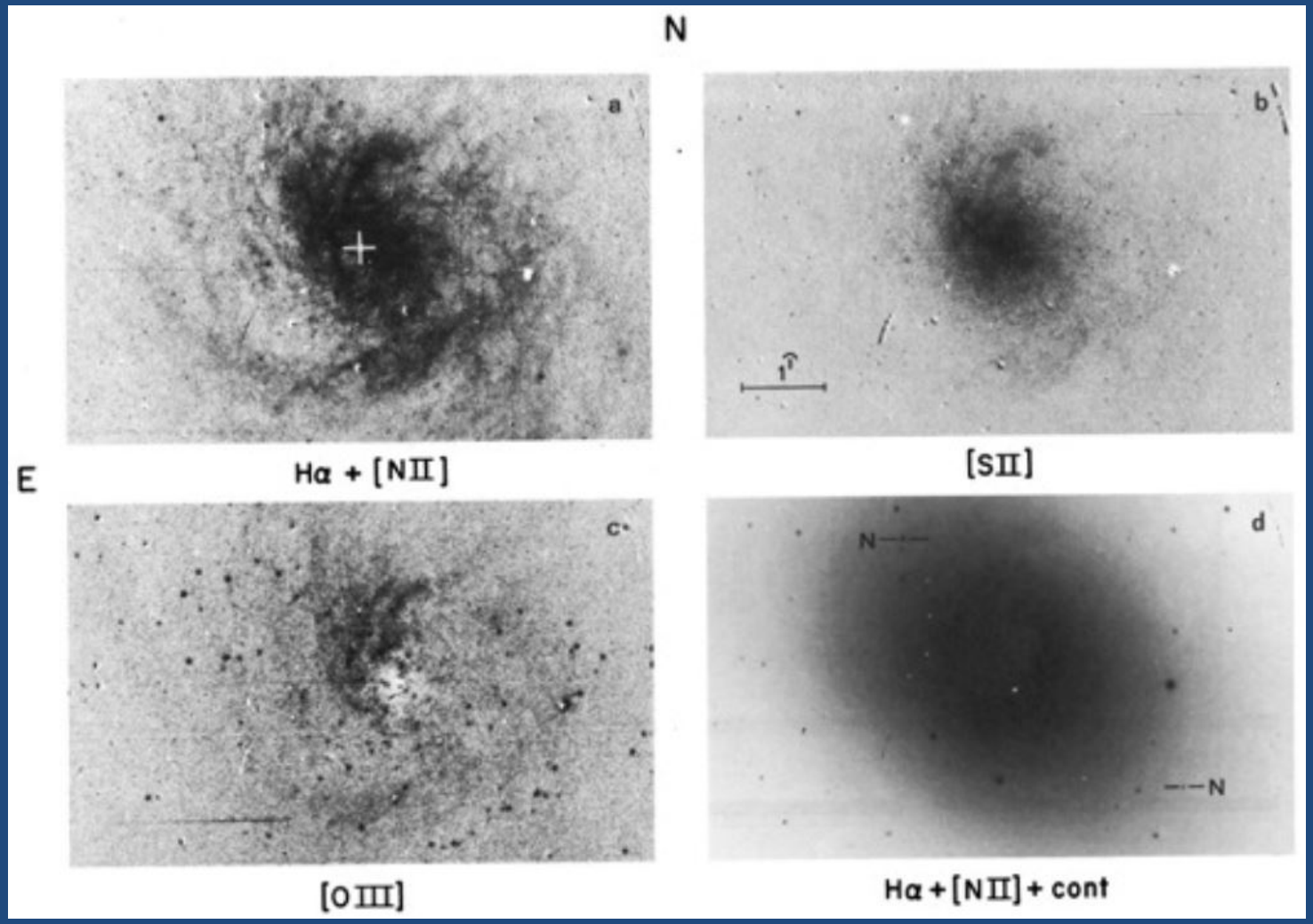
All of them observed emission lines close to the center of M31, while making spectra for kinematical investigations.



Detection of dust lanes close to the nucleus of M31
Johnson & Hanna (1972)

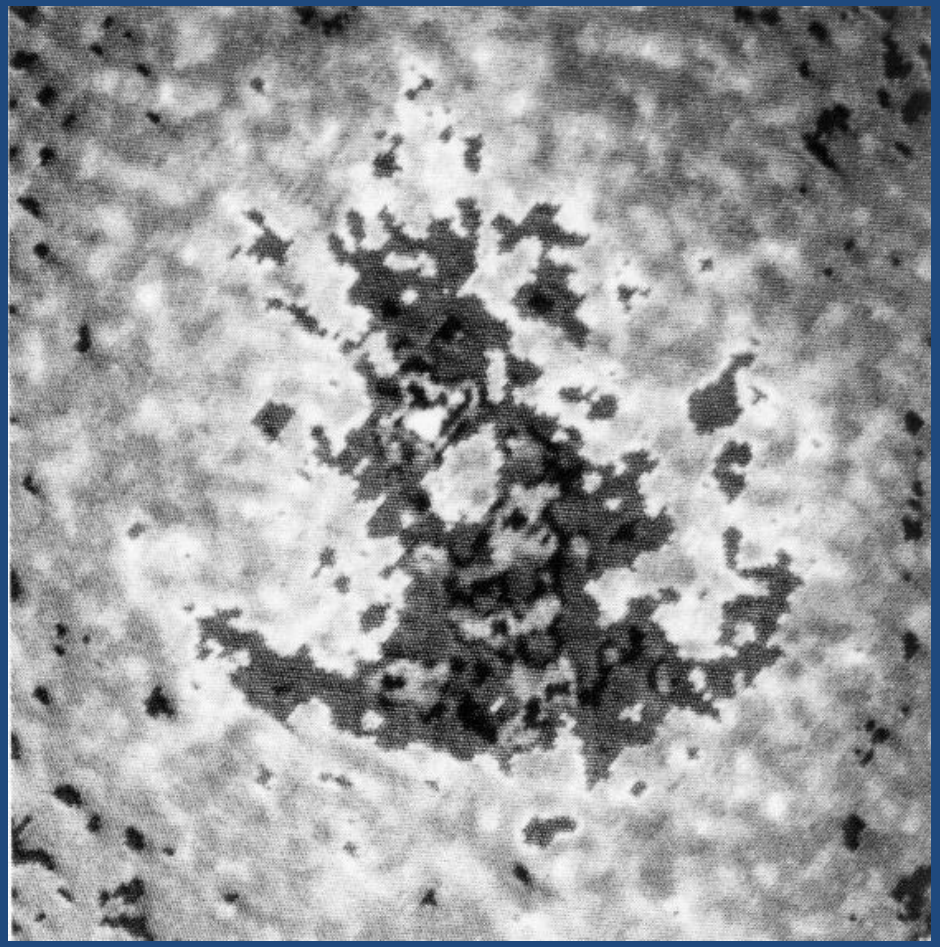
This image suggests that ionized gas could be found there…

First detailed images of the ionized gas in the center of M31



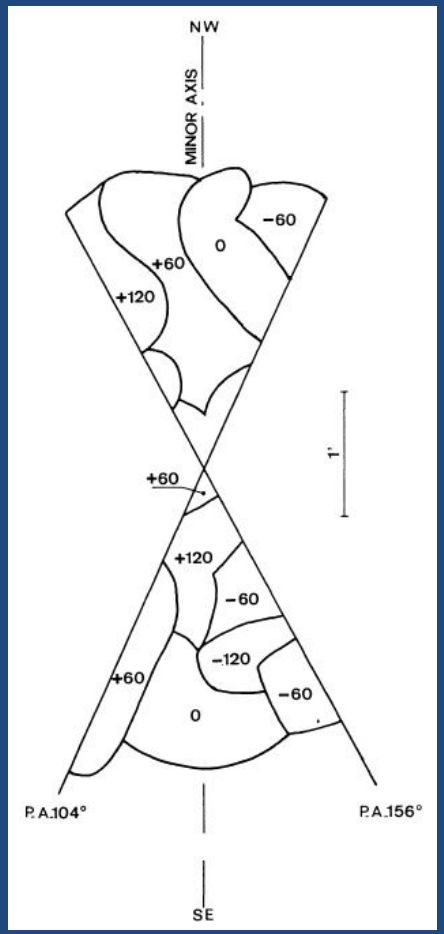
Jacoby et al. 1985

First 2D map of the velocities of the ionized gas
(Boulesteix et al. 1987)



[NII] line image

(FOV : 6 arcmin x 6 arcmin)

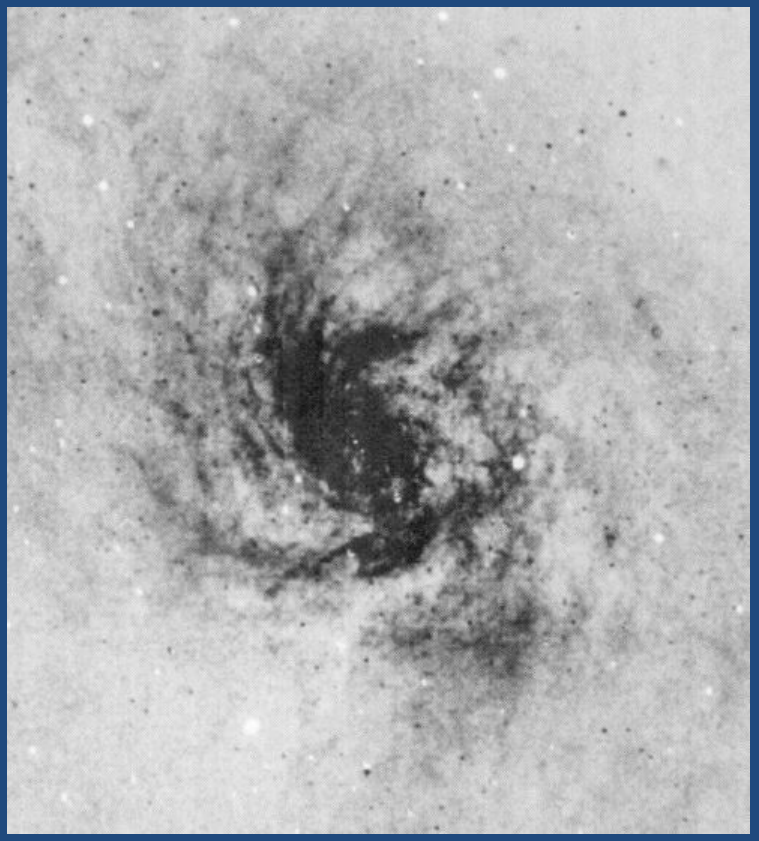


Radial velocities along the minor axis

P.A. = 130°

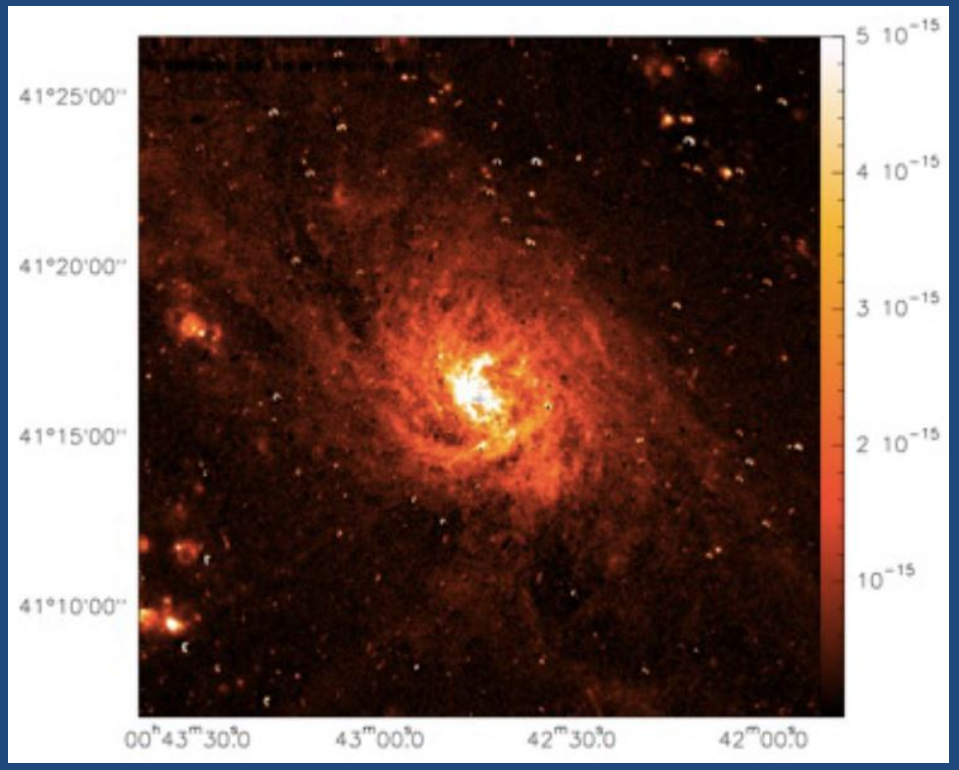
(showing expansion motions)

Other images of the ionized gas in M31



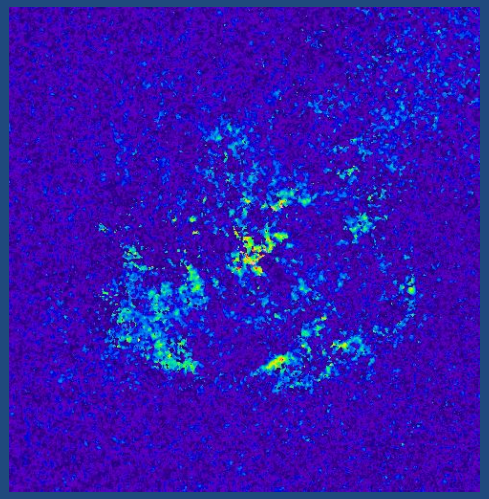
Hα + [NII]
Ciardullo et al. 1988

Gas collected from stars in the bulge has collapsed in a disk whose plane is tipped relative to that of the stellar disk.

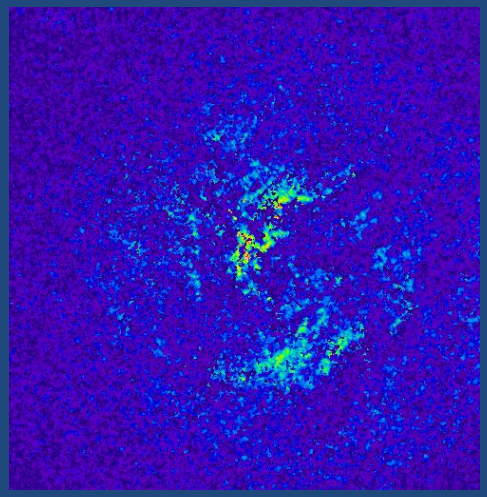


Hα + [NII]
Devereux et al. 1994

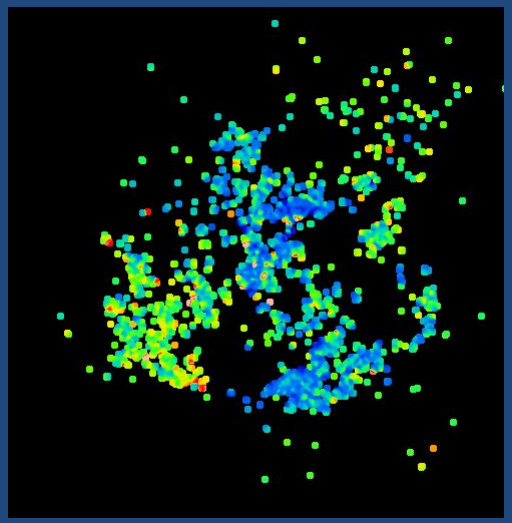
Recent Fabry-Perot observations (2016) at Mont Mégantic (Québec)



[NII]



Hα

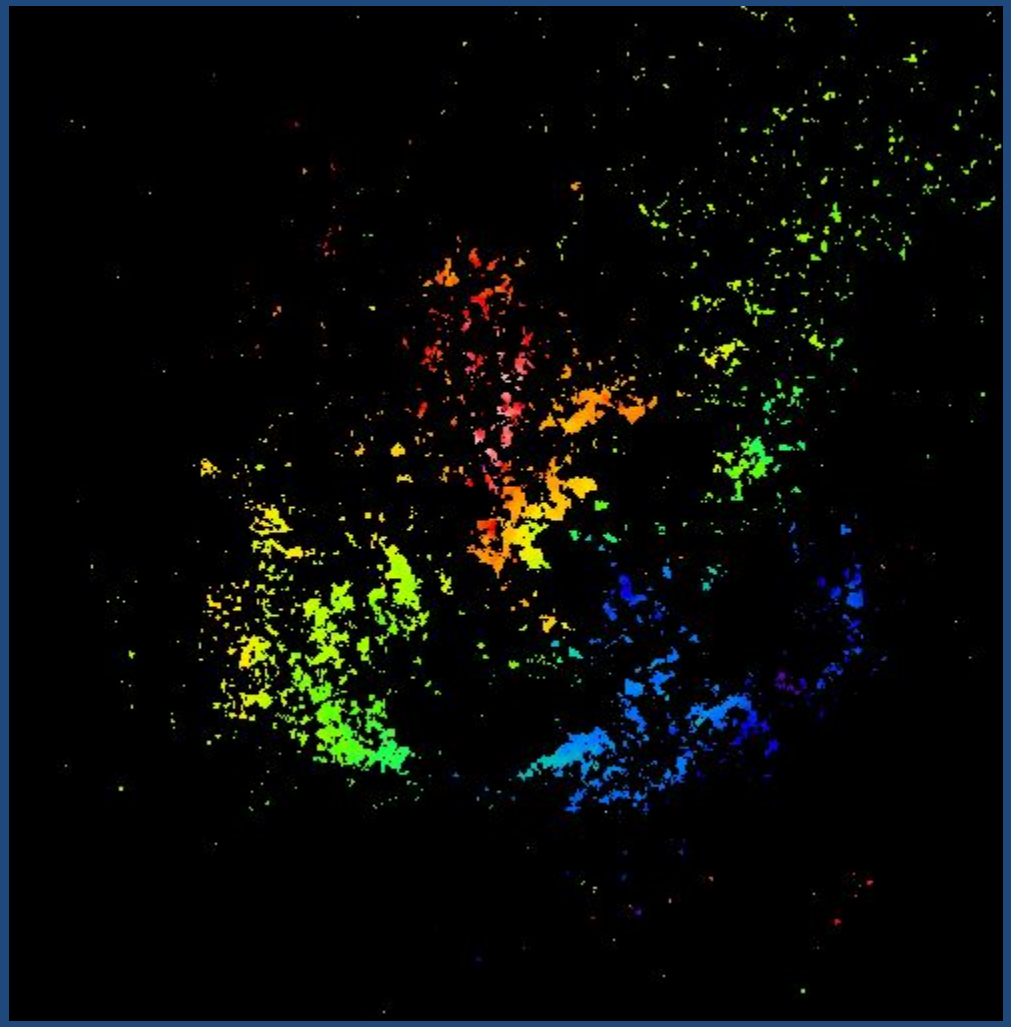


[NII]/Hα

Blue ~ 1 to 2
Green ~ 3

This ratio is typically 0.3 in normal HII regions and often higher than 1 in the nuclei of galaxies (Keel 1983, Rubin & Ford 1986)

[NII] velocity field



The results obtained at Mont Mégantic have been useful for obtaining observing time with SITELLE at CFHT

(SITELLE = optical imaging Fourier transform spectrometer)

Observations with SITELLE at CFHT

P.I. of the proposal : A.-L. Melchior[1]

L. Drissen[2], Ph. Amram[3], F. Combes[1], Z. Kam[4], M. Marcelin[3], R. P. Martin[5],
T. B. Martin[2], Ch. Morisset[6], C. Robert[2], L. Rousseau-Nepton[2], I. Katkov[7], A. Moiseev[8]

1 LERMA, UMR8112, Observatoire de Paris, France
2 Universite Laval (Departement de physique, genie physique et optique), Canada
3 Laboratoire d'Astrophysique de Marseille, France
4 University of Ouagadougou, Burkina Faso
5 University of Hawaii at Hilo (Physics & Astronomy), USA
6 Instituto de Astronomia UNAM, Mexico
7 Sternberg Astronomical Institute, Lomonosov Moscow State University, Russia
8 Special Astrophysical Observatory, Russian Academy of Sciences , Russia

Goal of the proposal : Study the ionization state of the gas surrounding the centre.
Understand its origin (inflow or outflow ?).

High spectral resolution needed (R > 5000) to disentangle the multiple components.
High spatial resolution is needed in order to distinguish the Planetary Nebulae.

We asked for 16h. French TAC gave 0… but Canadian TAC gave 8h !
Result :
SN3 data cube obtained on 25th August 2016 with Hα, [NII] and [SII] emission lines

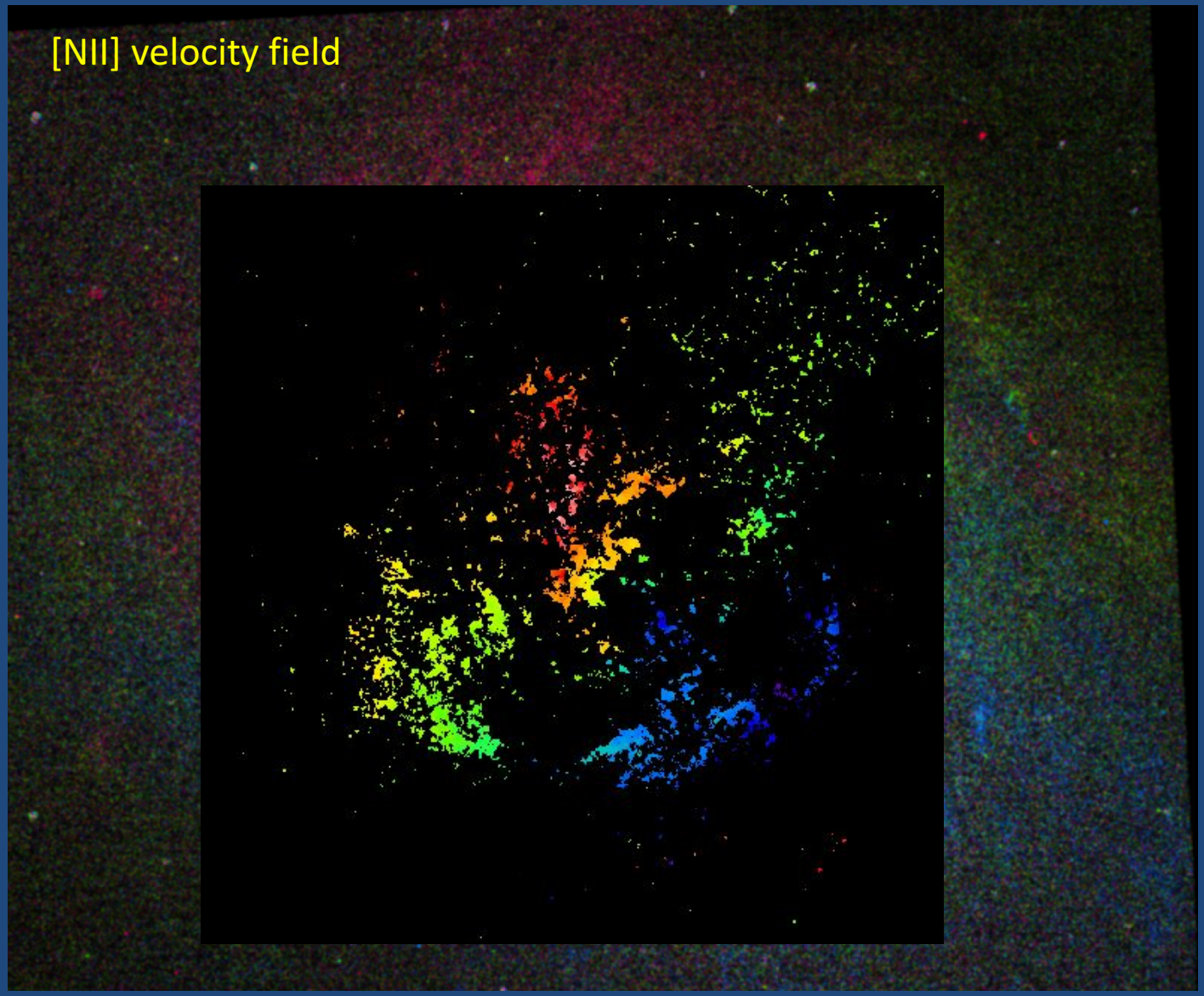
First results obtained with SITELLE

We have detected :

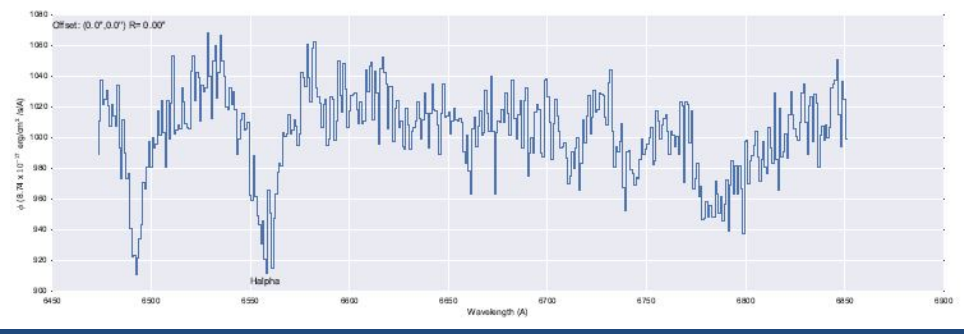
- About 400 planetary nebulae, with their velocity *(it will enable to investigate, in the central part, the stellar stream scenario proposed by Merrett et al. 2006).*
- A Galactic gas component (all over the FOV).
- The rotation of the gas down to the black hole.
- Double components along the minor axis as predicted on the basis of CO observations.

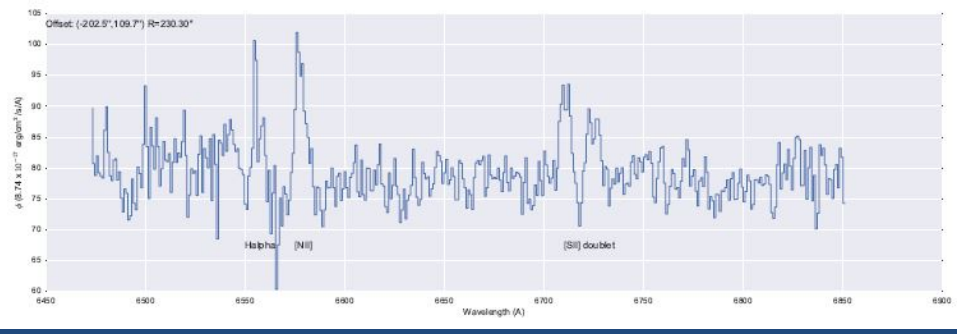
We have shown that, despite the strong stellar continuum, we are able to detect gas components 10 times weaker.

CFHT observations with SITELLE



Examples of spectra obtained with SITELLE

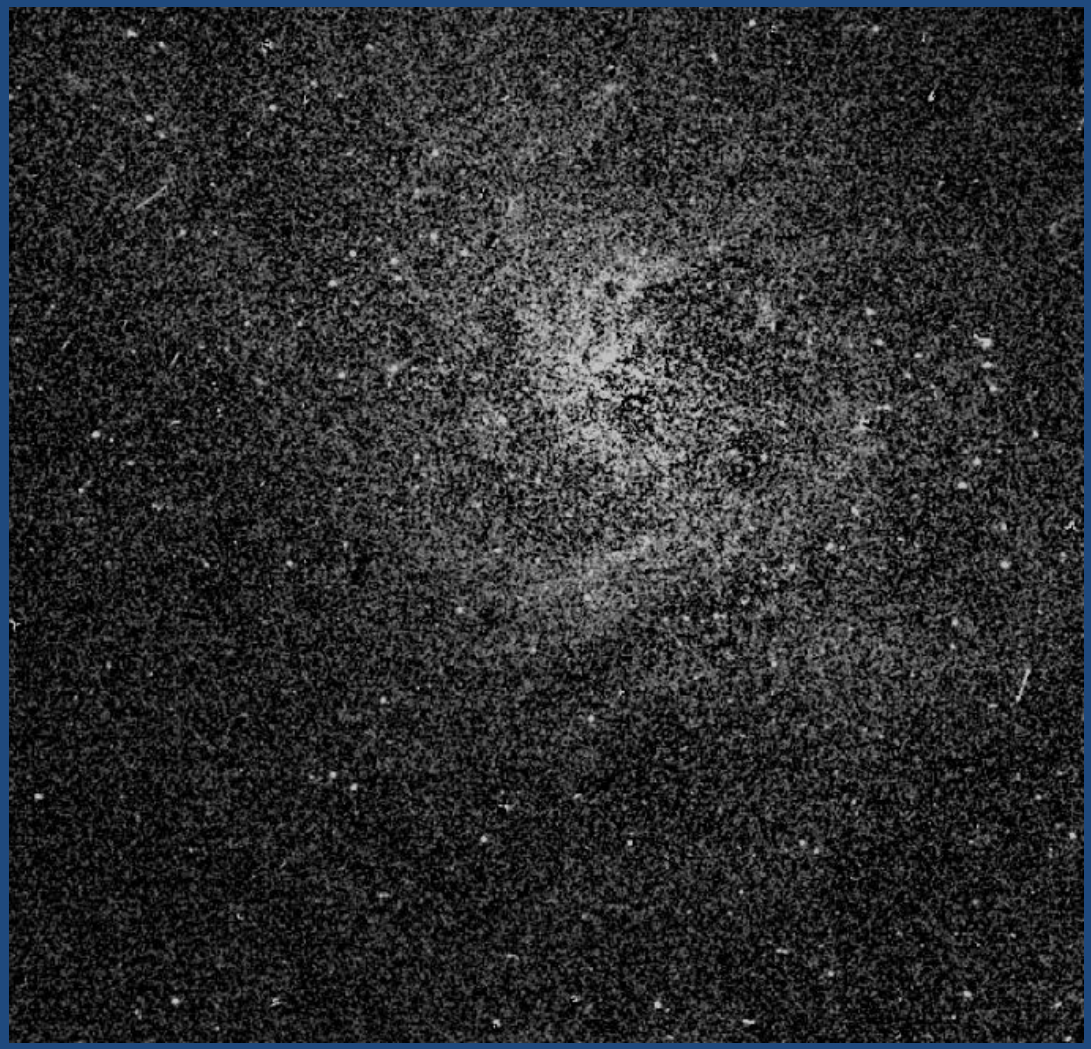




The left panel displays a strong absorption of the stellar continuum and a weak double emission line in Hα (integrated within a radius of 2.6") corresponding to the gas rotating in the sphere of influence of the black hole (which has a radius of 2").

On the right panel, a SITELLE spectra has been extracted at a position where CO has been detected (at 1mm wavelength) at the offset (-202.5",109.7") from the center with a 12" FWHM. A double peak is detected in Hα, [NII] and in the [SII] doublet.

[OIII] image obtained with SITELLE during the commissionning
(1h exposure at R=400)



The dots are Planetary Nebulae

Discretionary Time has been asked for observing at higher resolution, [OIII] and Hβ


STAY TUNED