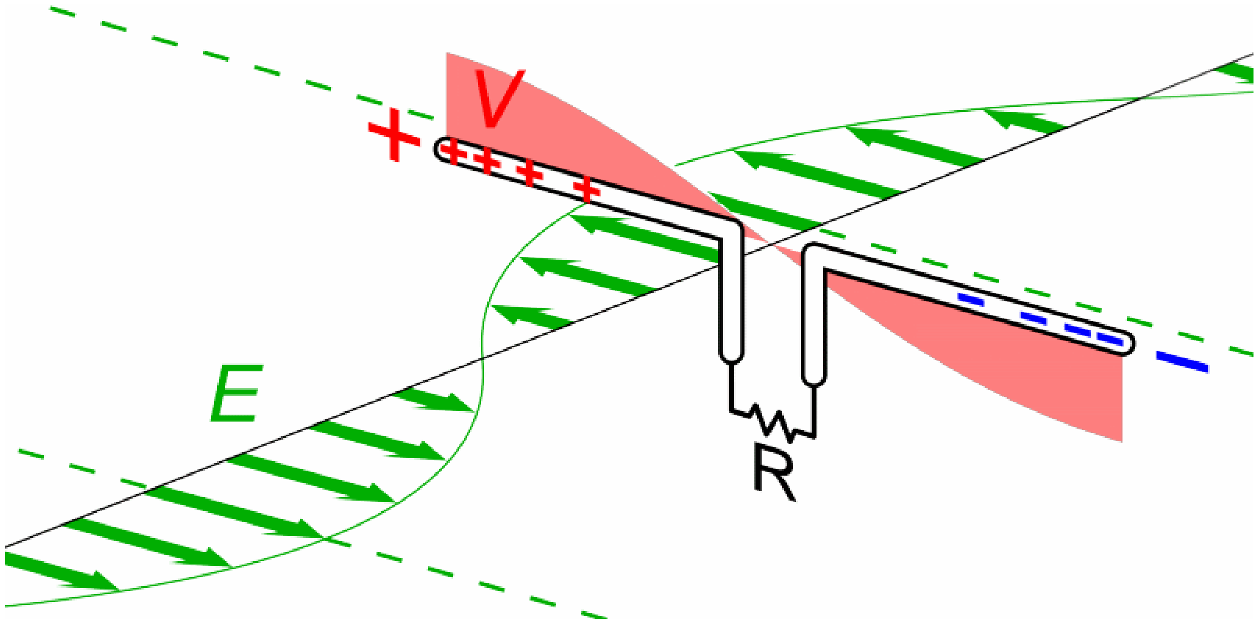
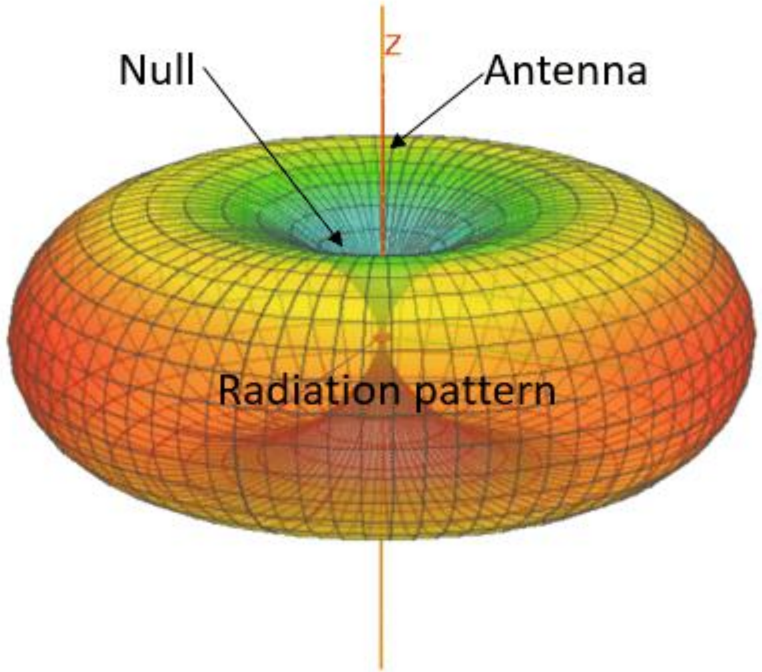
Single Dish Radio Observation

Observation using single dish radio antenna and its output

Hyeong-Sik Yun

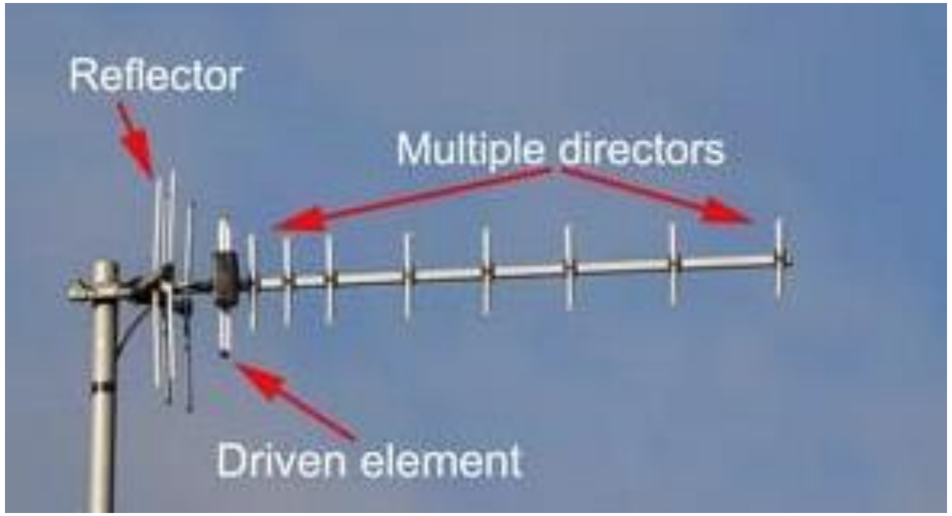
Antenna and Beam pattern

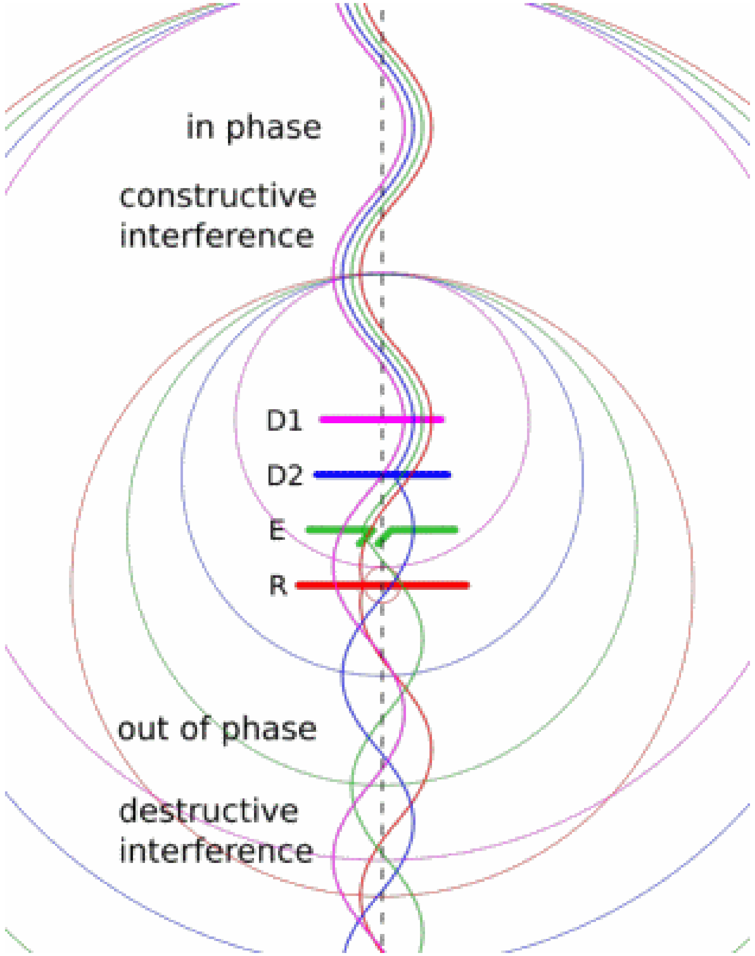




Dipole and monopole antenna

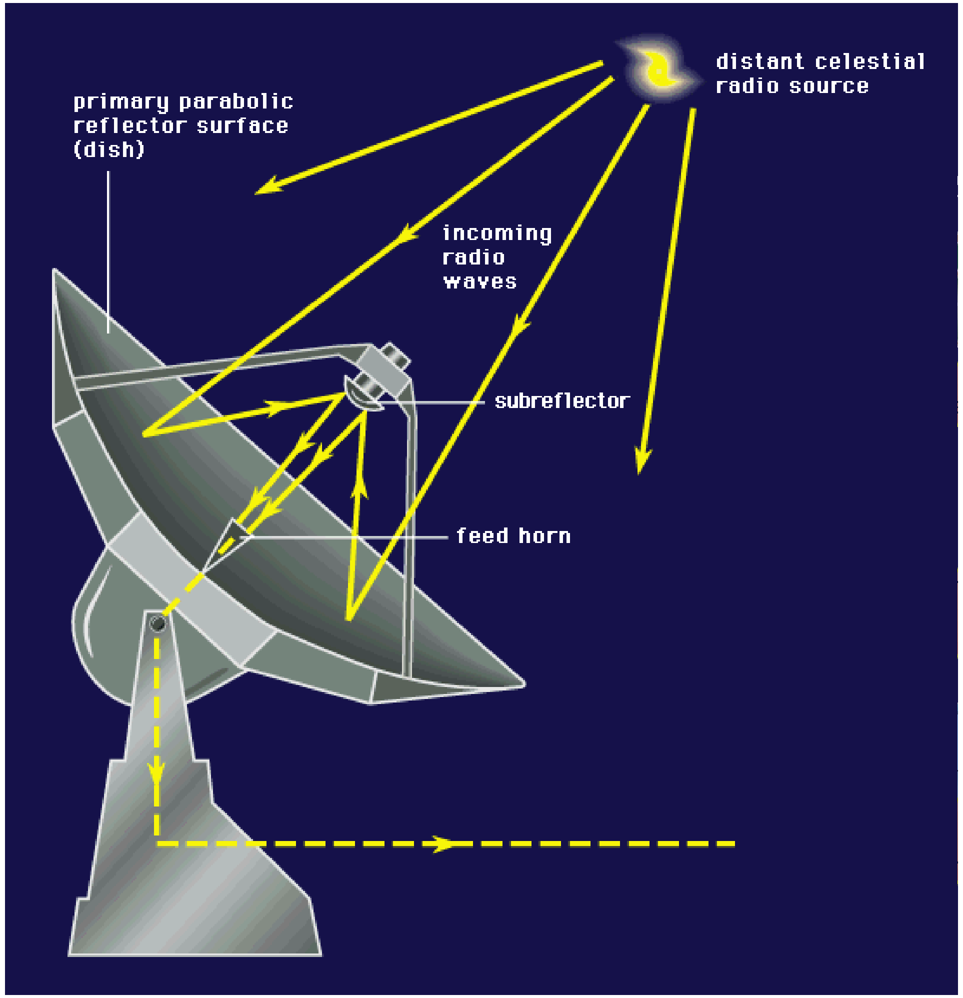
Antenna and Beam pattern

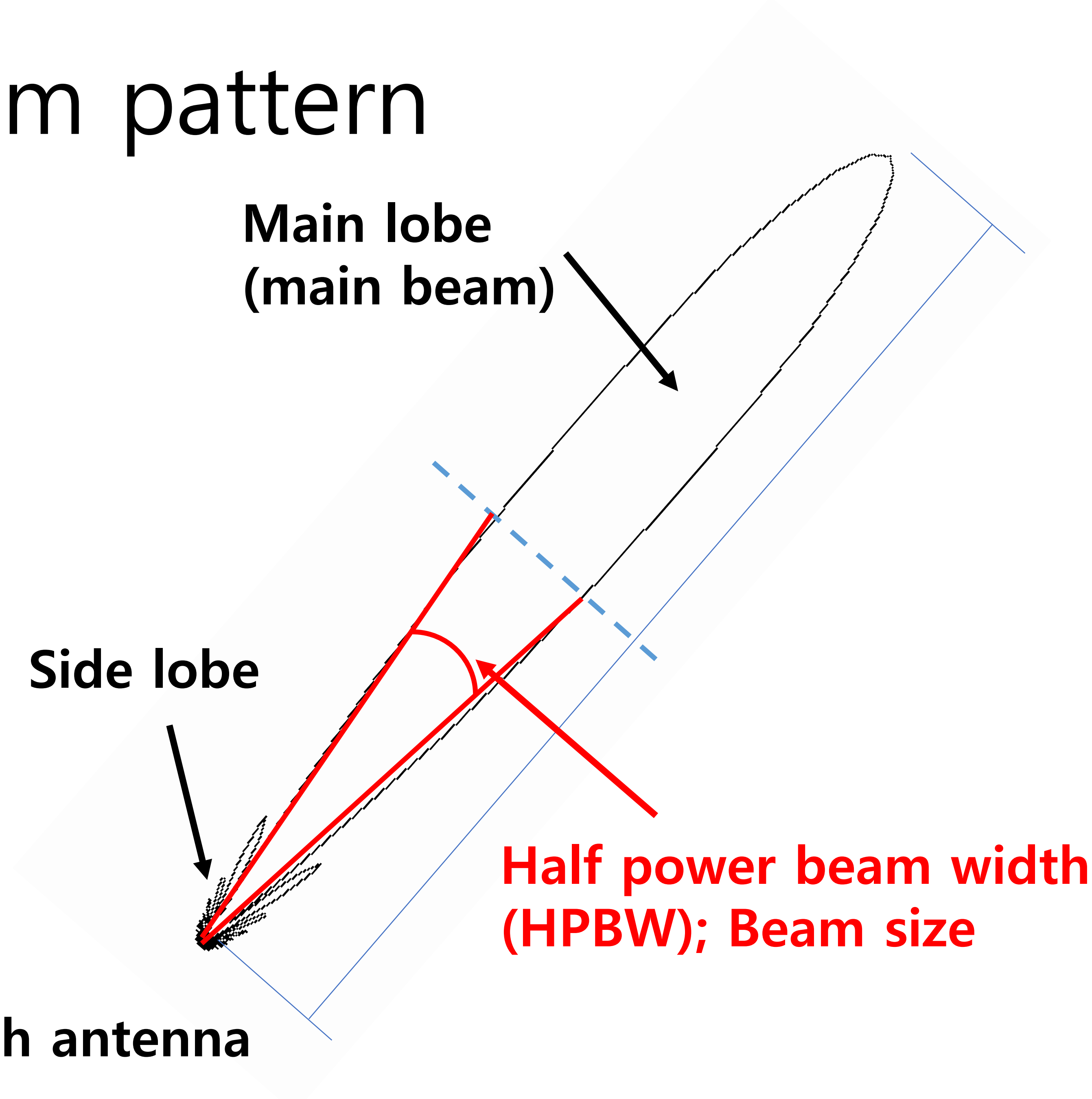




Yagi-Uda antenna

Antenna and Beam pattern





Dish radio antennae

Taeduk Radio Astronomy Observatory (TRAO)

Korean VLBI Network (KVN)

Single dish observation

- Observation of radio waves using a dish antenna.
- The radio signals received through the beam pattern are measured at the same time
  - Large beam size -> Low spatial resolution
  - Observed data contains the average signal within the main beam.

- Basically, single dish observation can investigate **a single-point data**.

Investigate multi-point data (Maps)

- **Grid mapping**
- Multi-beam receiver
- On-The-Fly (OTF) mapping

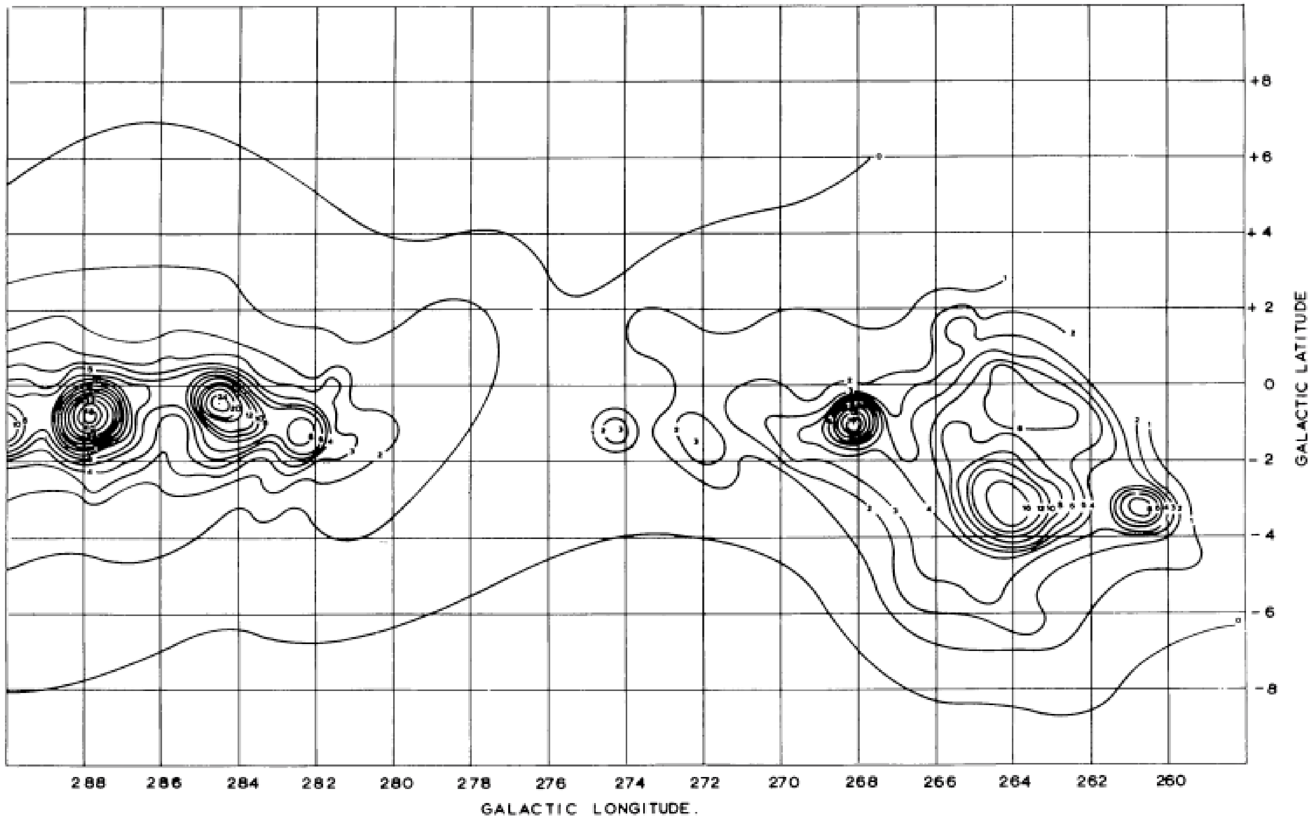
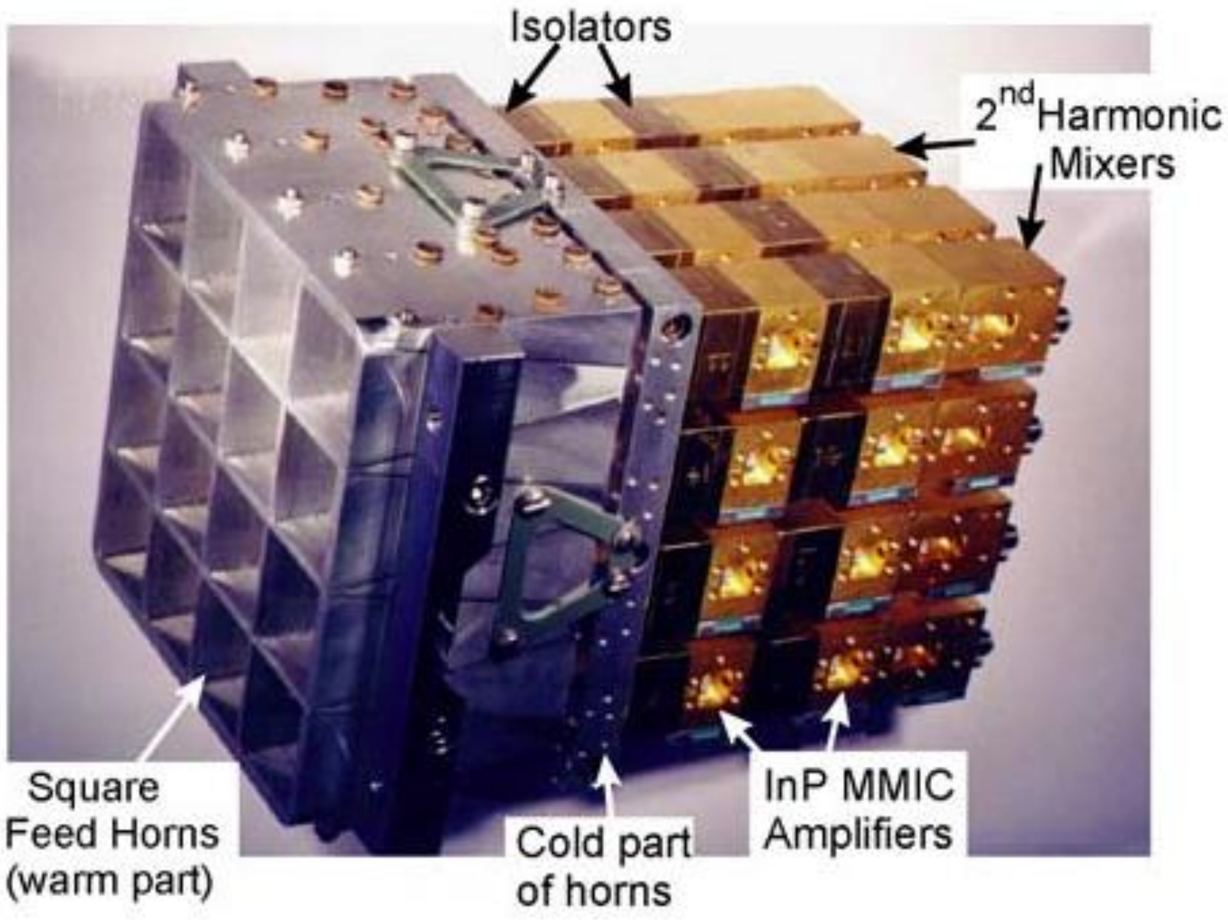


FIG. 2.—Galactic radiation at 960 Mc/s; $l = 260°–290°$.

Nicolson (1965); the first radio astronomy paper

Investigate multi-point data (Maps)

- Grid mapping
- **Multi-beam receiver**
- On-The-Fly (OTF) mapping



SEQUOIA-TRAO receiver system (TRAO)

Investigate multi-point data (Maps)

- Multi-beam receiver
- Grid mapping
- **On-The-Fly (OTF) mapping**

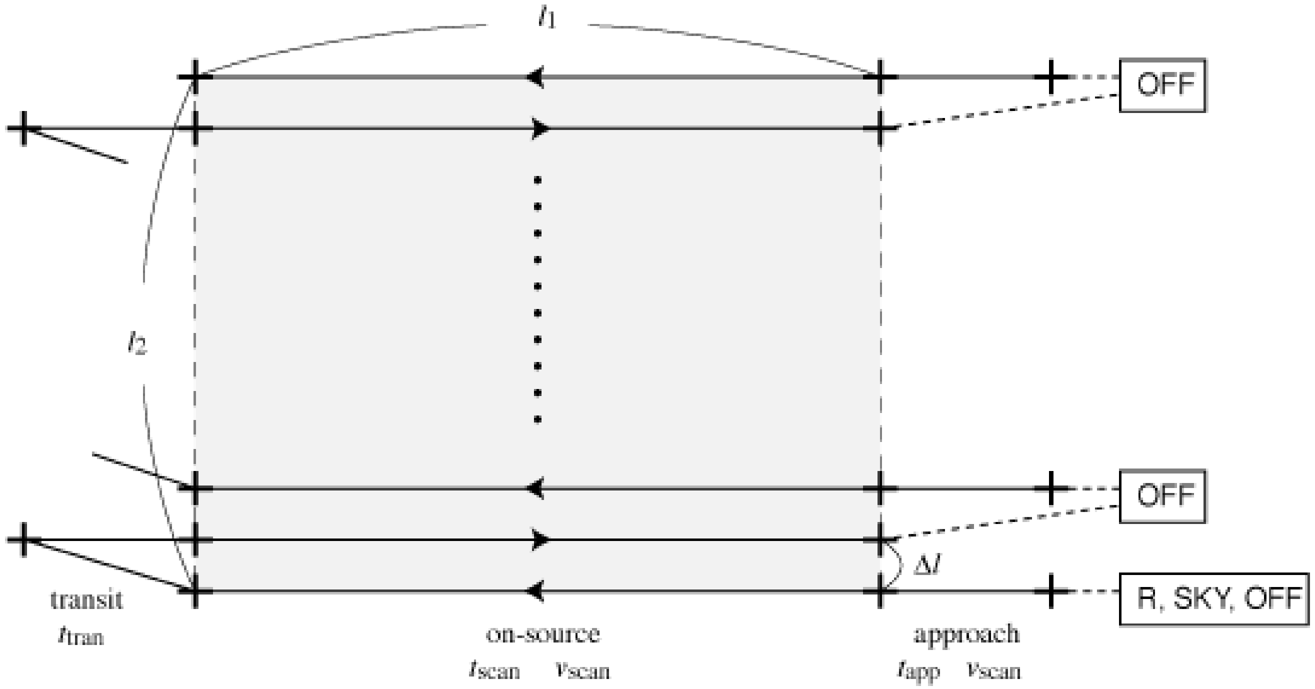


Figure. Schematic illustration of an OTF scan pattern (NRO)

Investigate multi-point data (Maps)

- Multi-beam receiver
- Grid mapping
- **On-The-Fly (OTF) mapping**

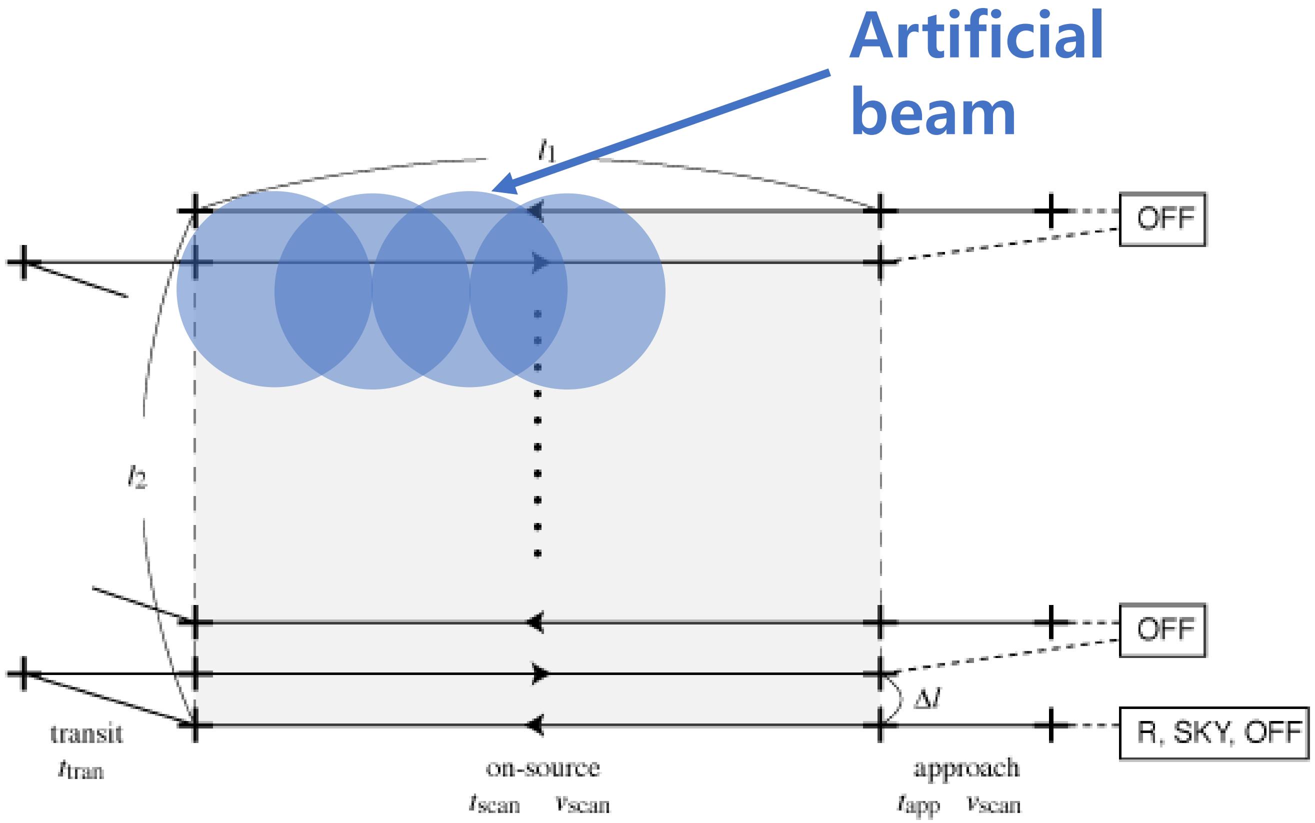


Figure. Schematic illustration of an OTF scan pattern (NRO)

Investigate multi-point data (Maps)

- Multi-beam receiver
- Grid mapping
- **On-The-Fly (OTF) mapping**

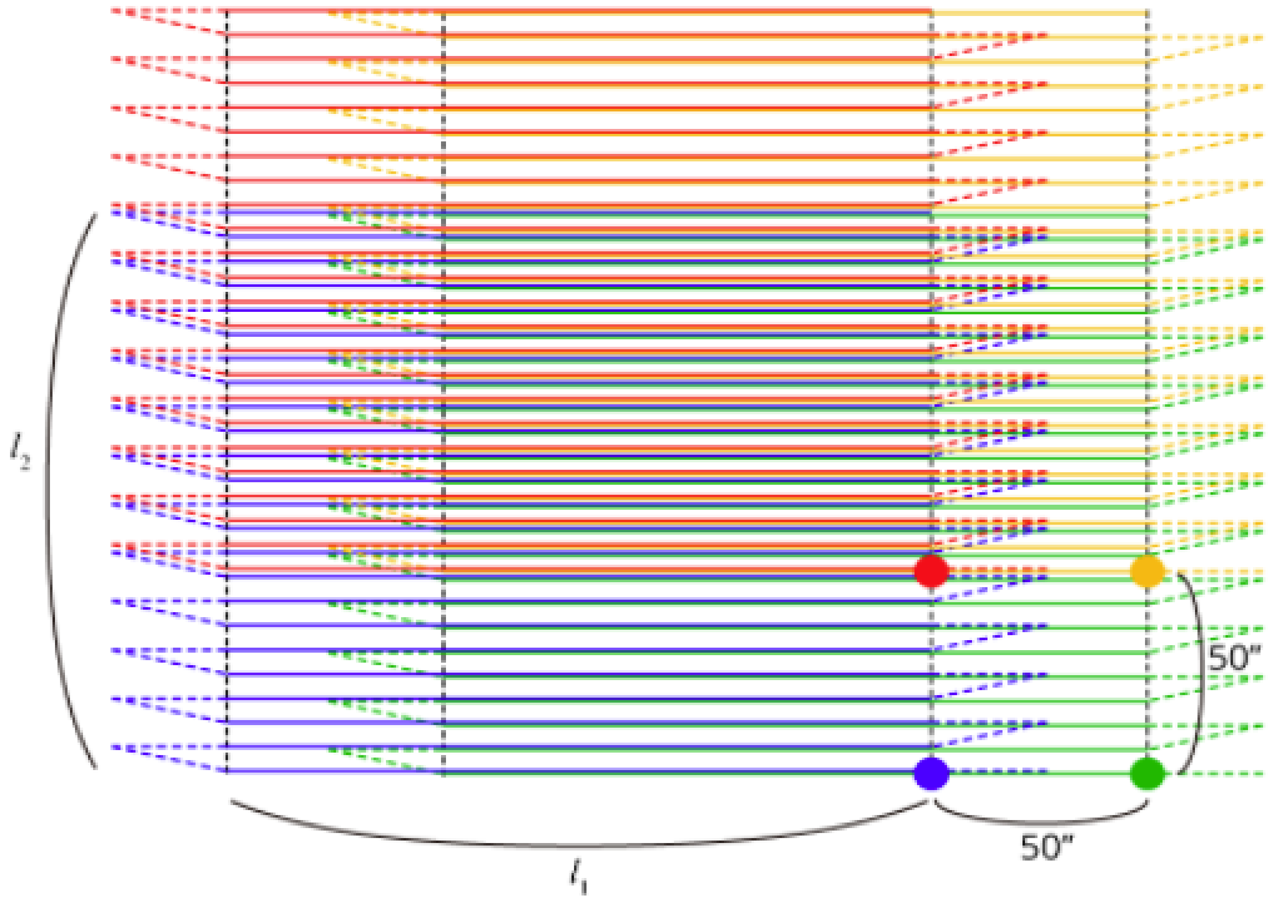


Figure. Schematic illustration of an OTF scan pattern with FOREST 4-beams receiver (NRO)

Investigate multi-point data (Maps)

- Multi-beam receiver
- Grid mapping
- **On-The-Fly (OTF) mapping**

High sensitivity can be achieved

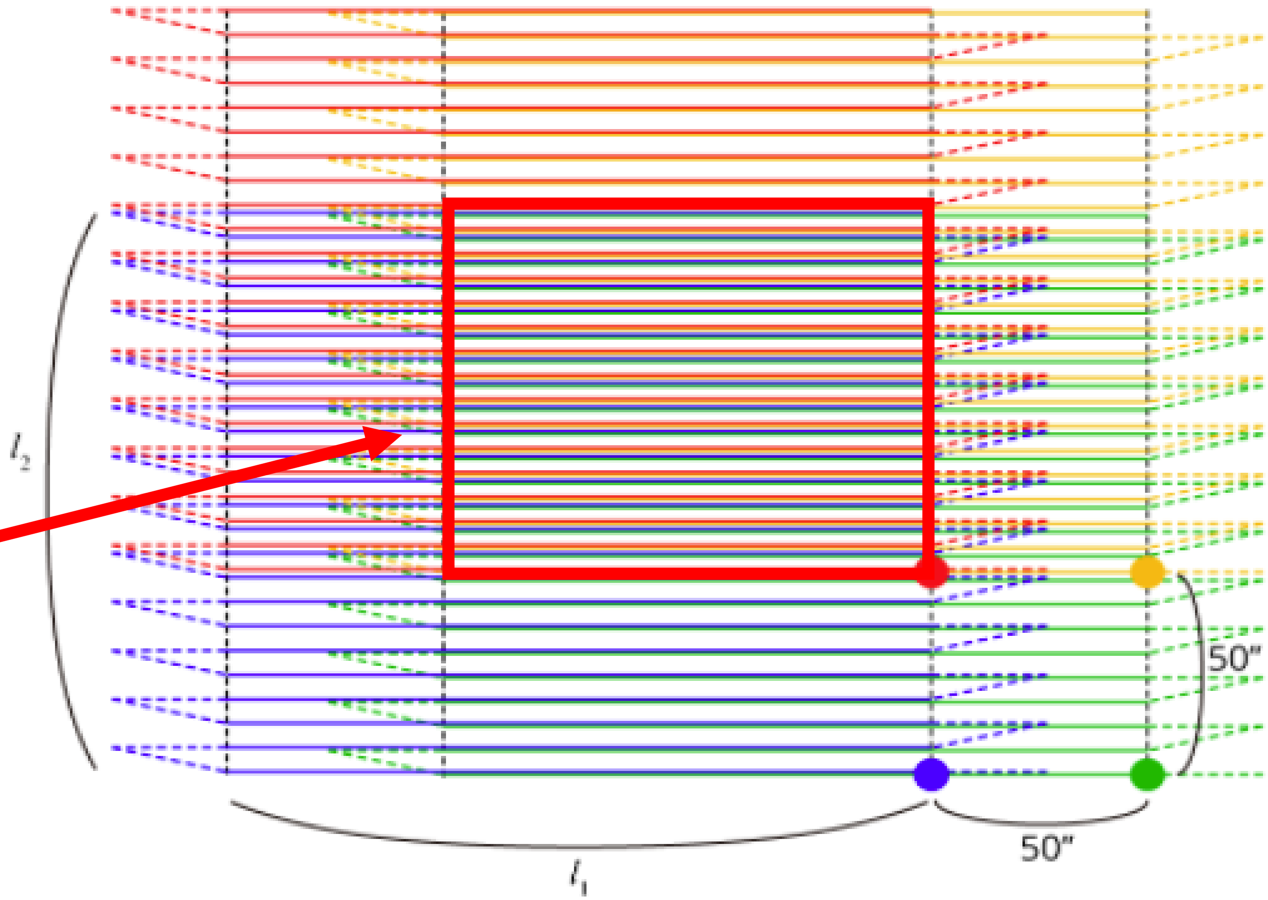
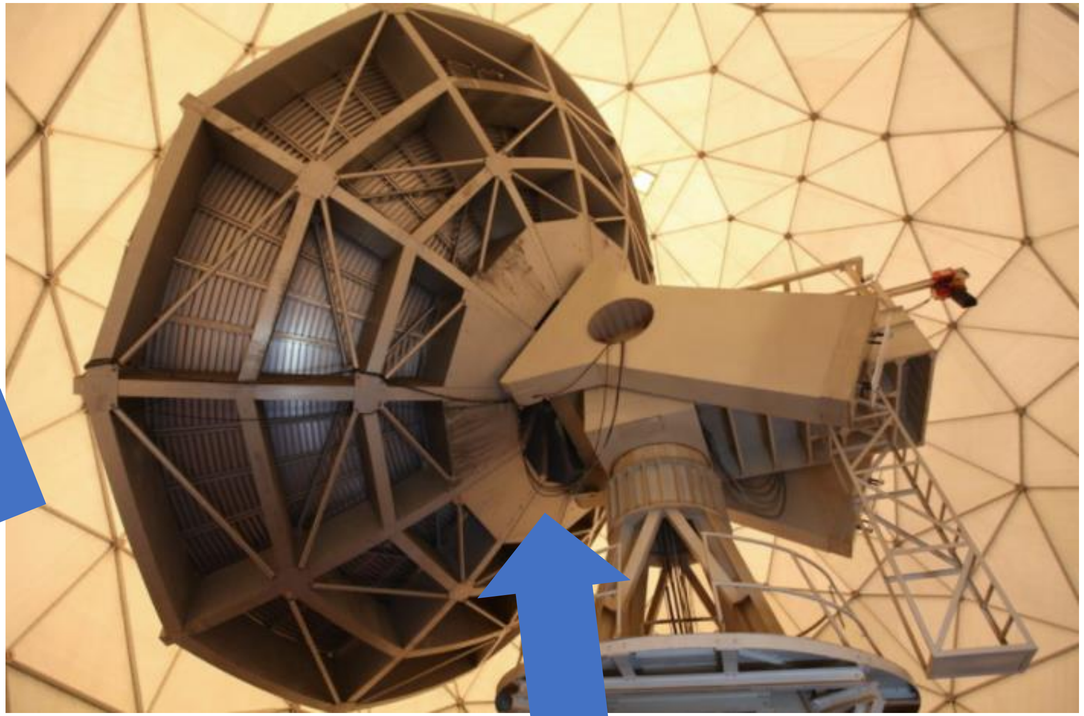
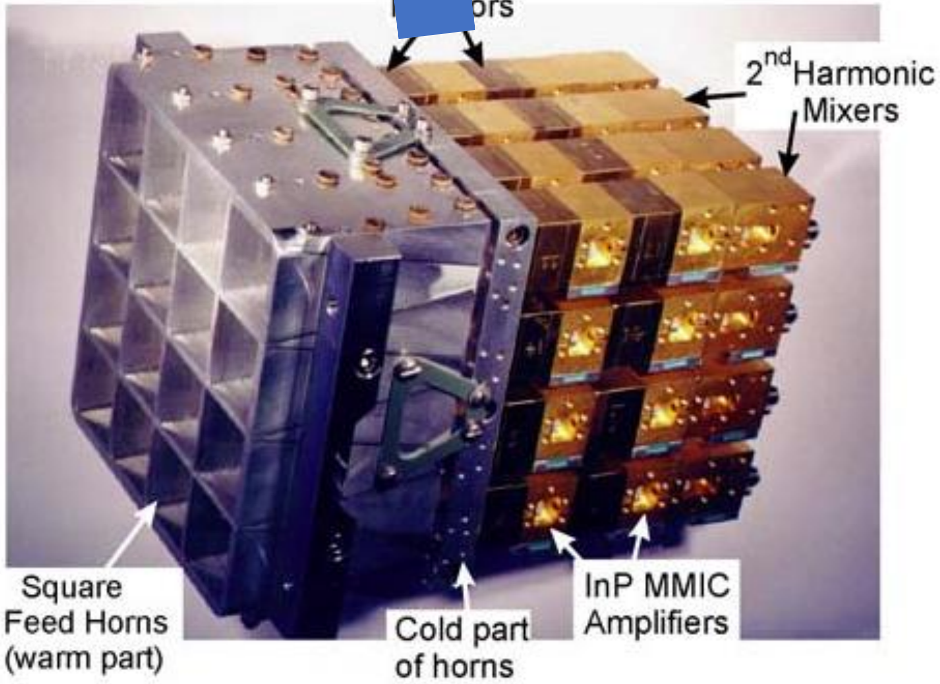


Figure. Schematic illustration of an OTF scan pattern (NRO)

TRAO 14-m telescope





4x4 pixels receiver

TRAO 14-m telescope

- Receiver with **16 pixels** arranged 4x4 array
- **OTF** observing mode
- Simultaneous observation of **two lines**

➡ **Very efficient to map the large area in multiple lines.**

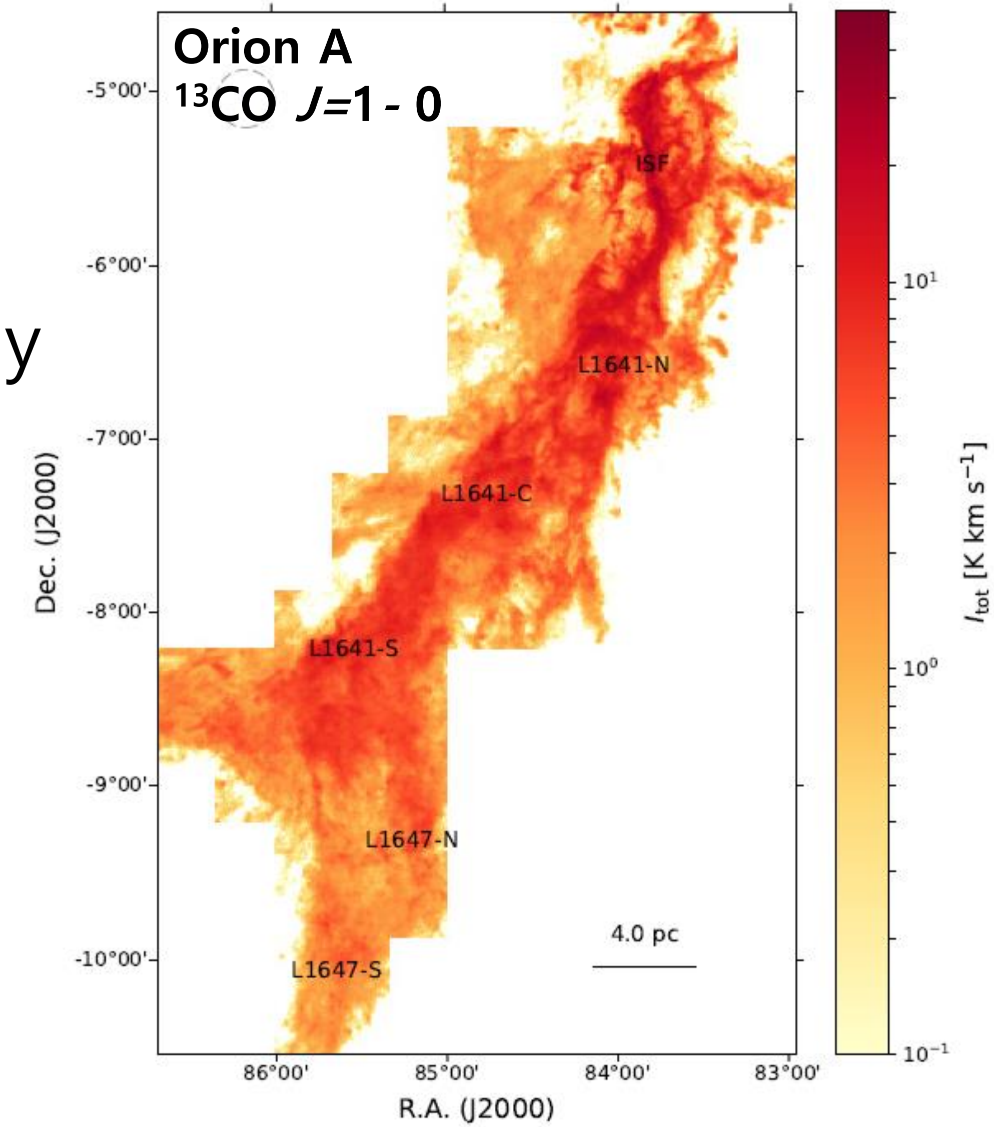
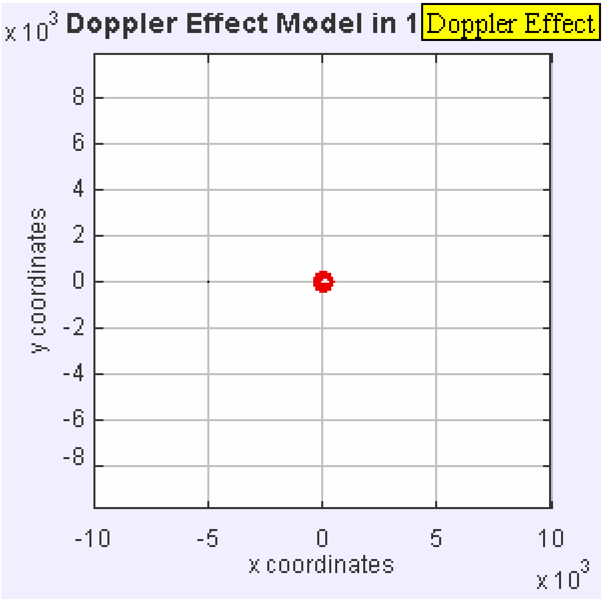


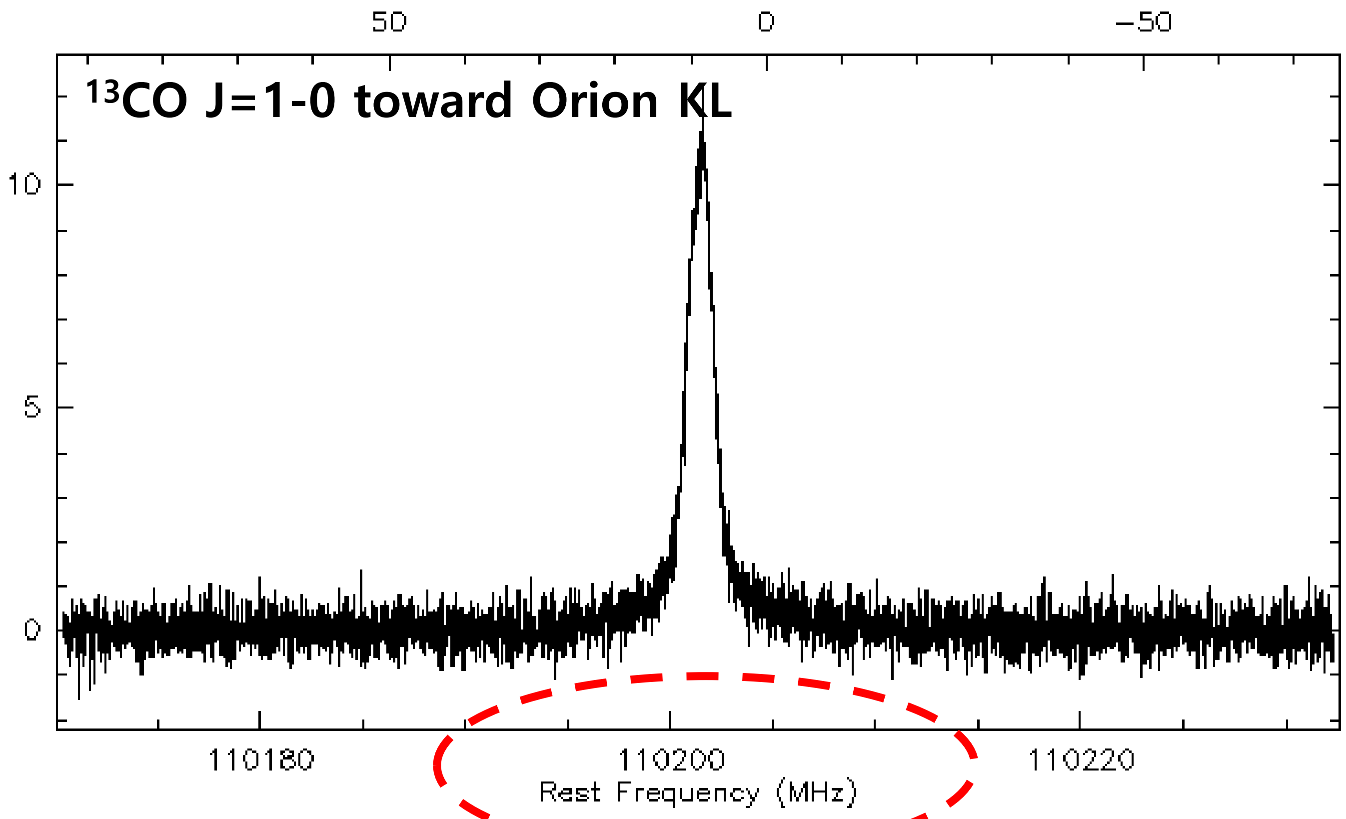
Figure. The integrated intensity map of the Orion A cloud obtained using TRAO (Yun et al. in press).

Spectroscopic observation

- Spectrum: Intensity on the wavelength (or **frequency**) space
- Spectral mapping: the maps in various frequencies

- Doppler effect

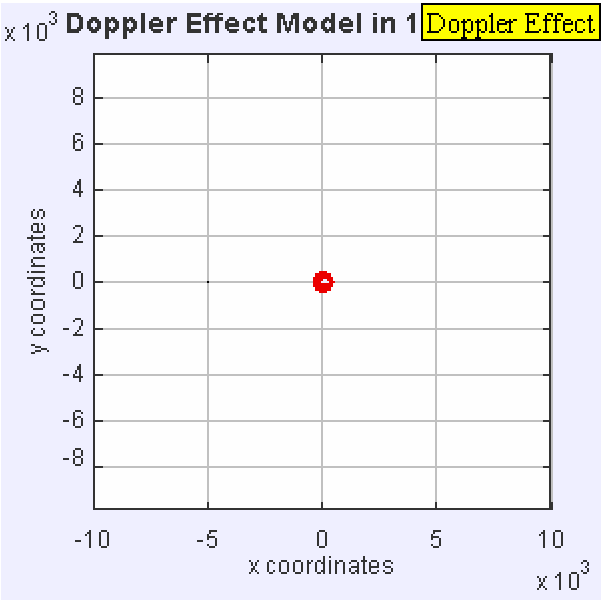


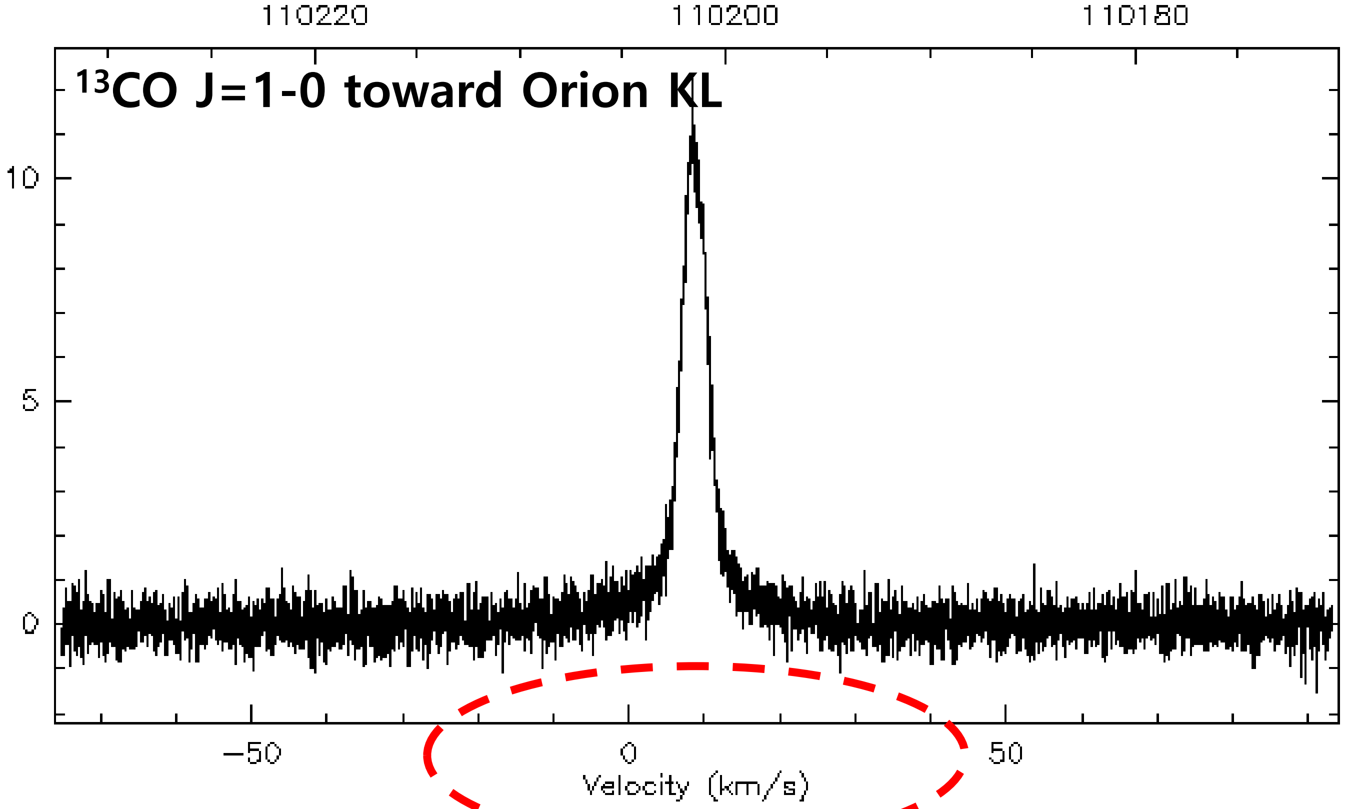


Spectroscopic observation

- Spectrum: Intensity on the wavelength (or **frequency**) space
- Spectral mapping: the maps in various frequencies

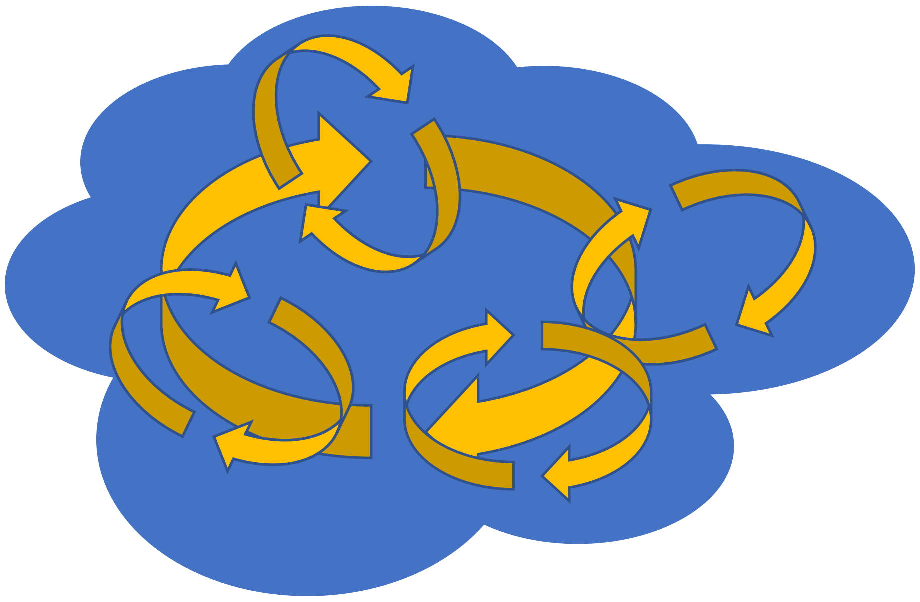
- Doppler effect





Turbulent star-forming molecular cloud

- All molecular clouds are turbulent.



- High velocity turbulent motions in large-scales

➡ **Produce high-density regions via shocks**

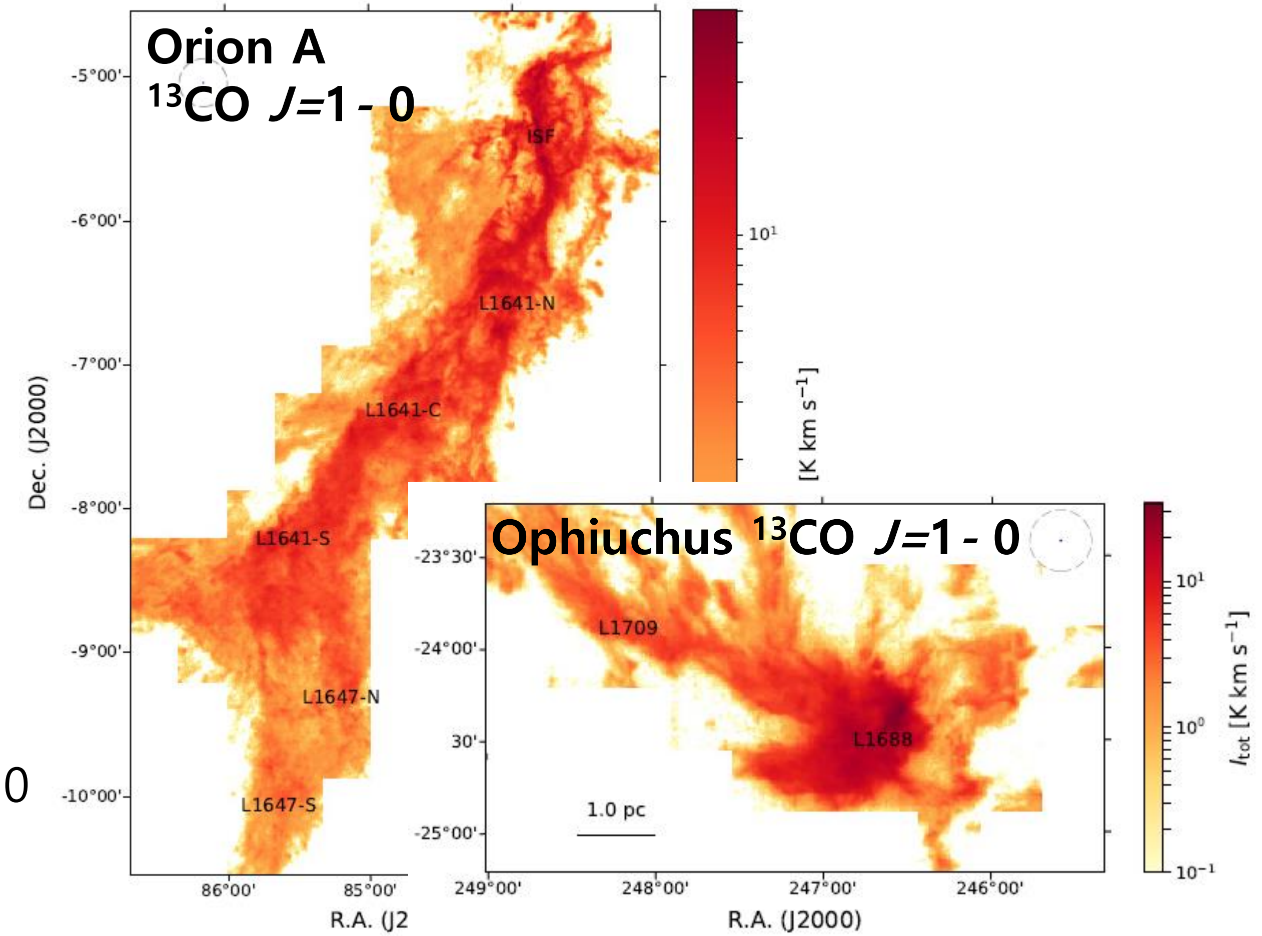
- Low velocity turbulent motions in small-scales

➡ **Produce non-thermal pressure**
Act against the gravity

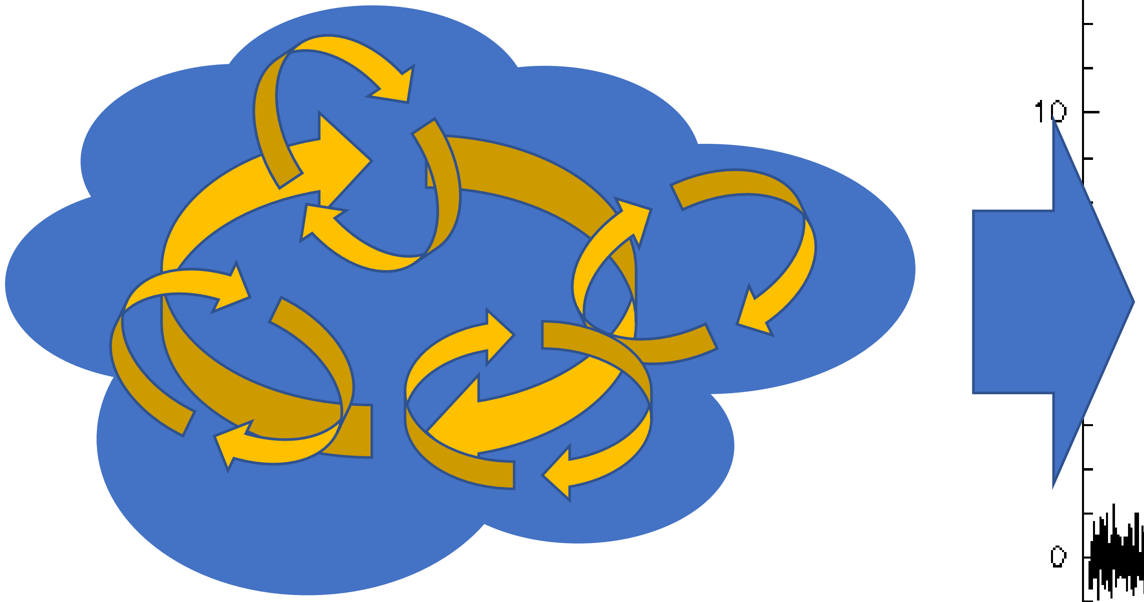
TRAO-KSP: **TIMES**

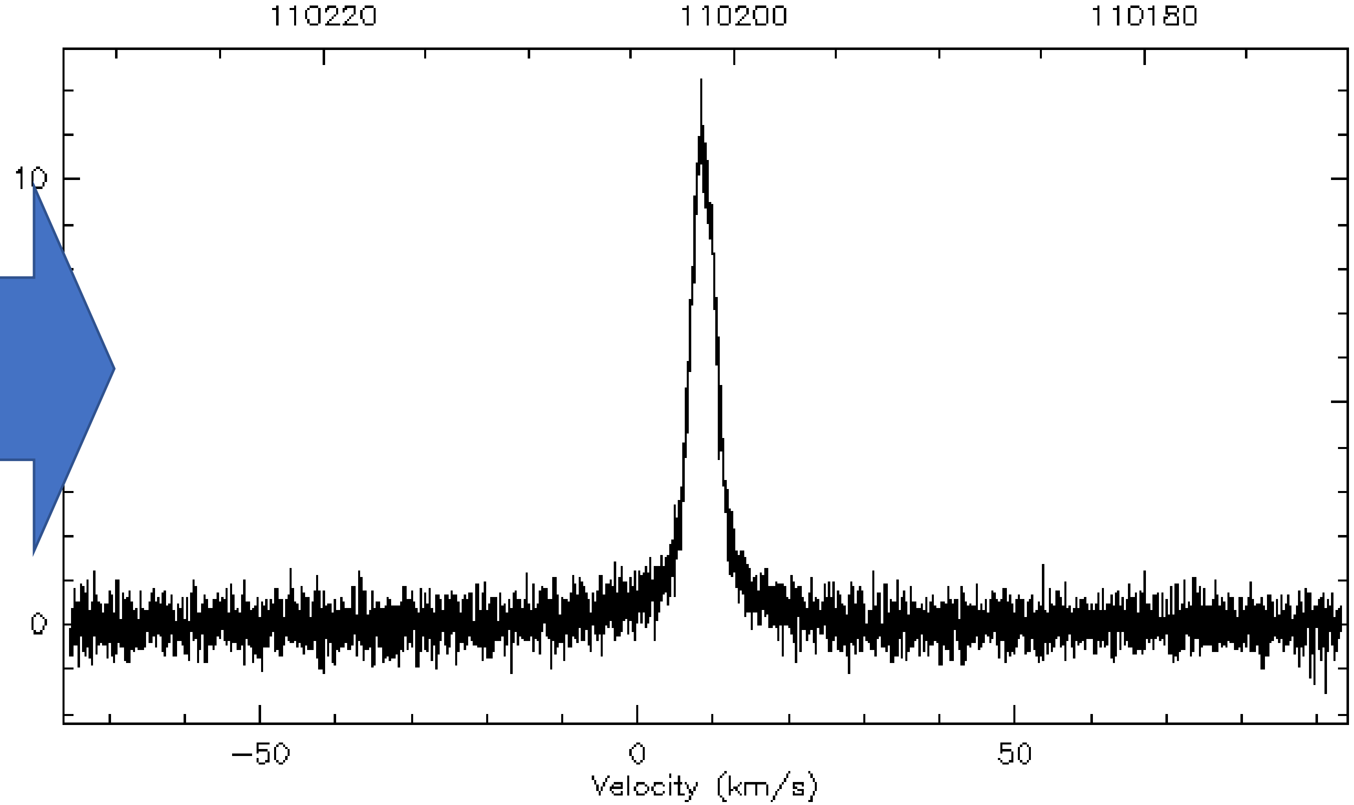
"mapping **T**urbulent properties **I**n star-forming **M**ol**E**cular clouds down to the **S**onic scale" (**TIMES**)

- Target clouds: Orion A (8.7 deg^2) and Ophiuchus (3.9 deg^2)
- Lines: ^{13}CO J=1 - 0, $C^{18}O$ J=1 - 0, HCN J=1 - 0, HCO^+ J=1 - 0, N_2H^+ J=1 - 0, CS J=2 - 1
- Observed time: 2016/01 –2019/04 (1673 hours)
    - ❖ Integrated intensity maps for ^{13}CO J=1 - 0 (Yun et al. in press)



Turbulence from the observed spectra

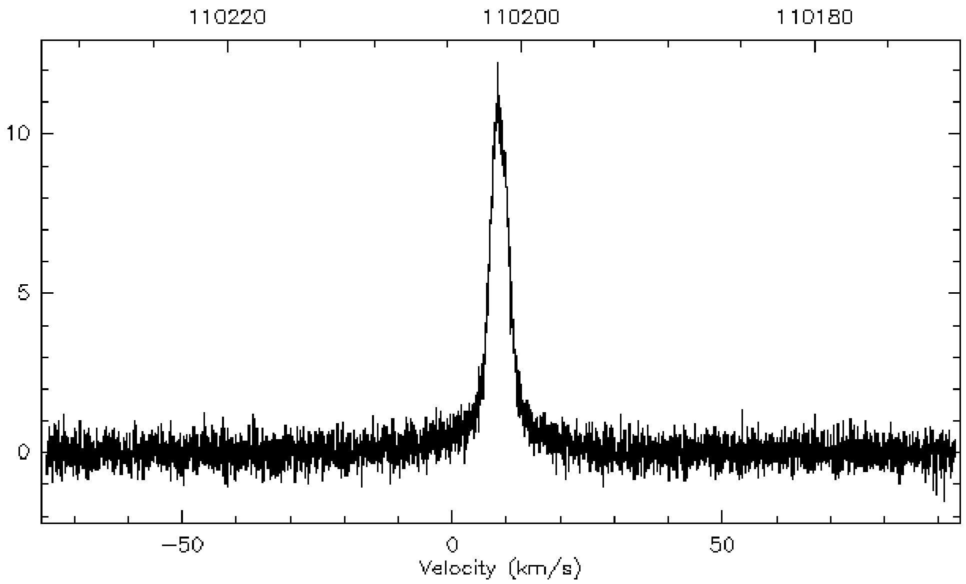




- How can we obtain the motion of turbulence from the observed spectrum?

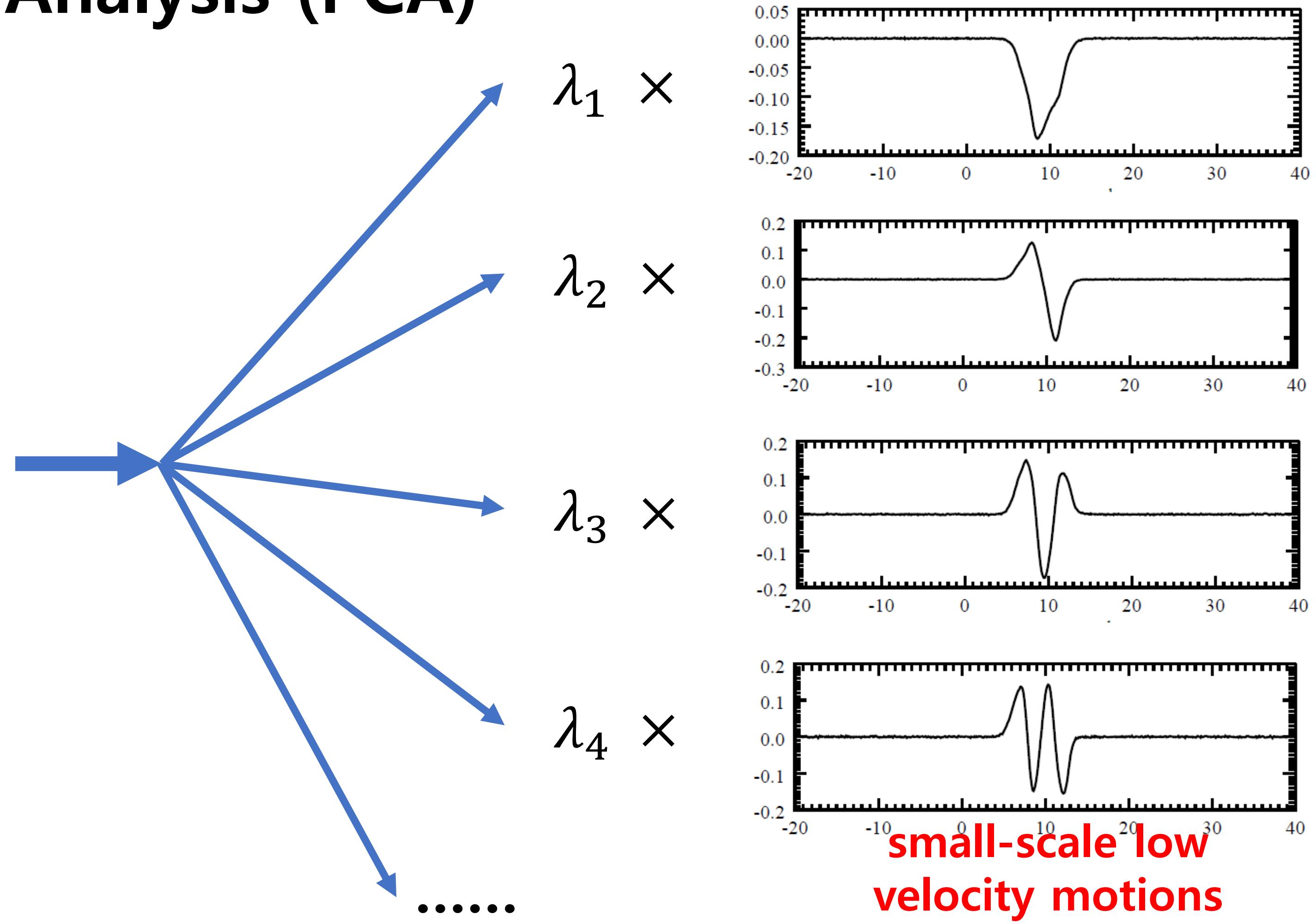
Turbulence from the observed spectra

- **The Principal Component Analysis (PCA)**



Decompose the obtained spectrum!

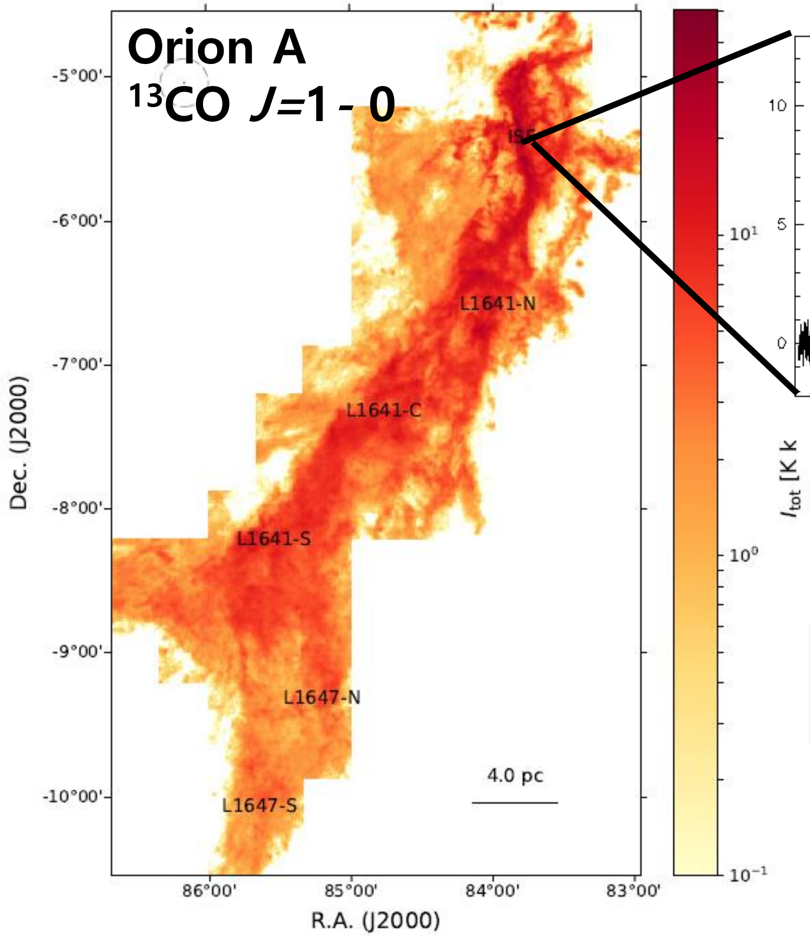
Large-scale high velocity motions

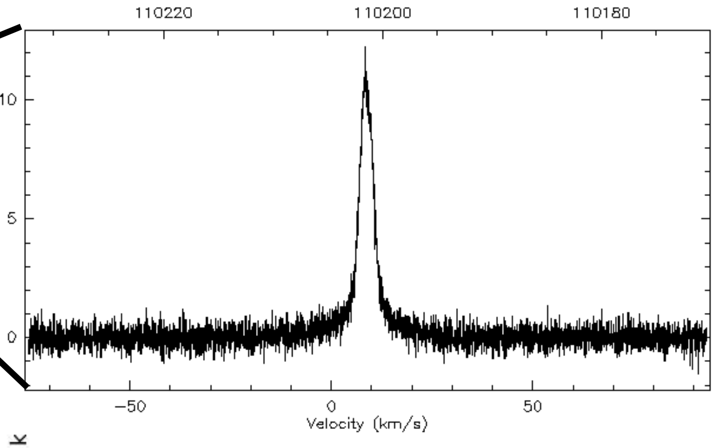


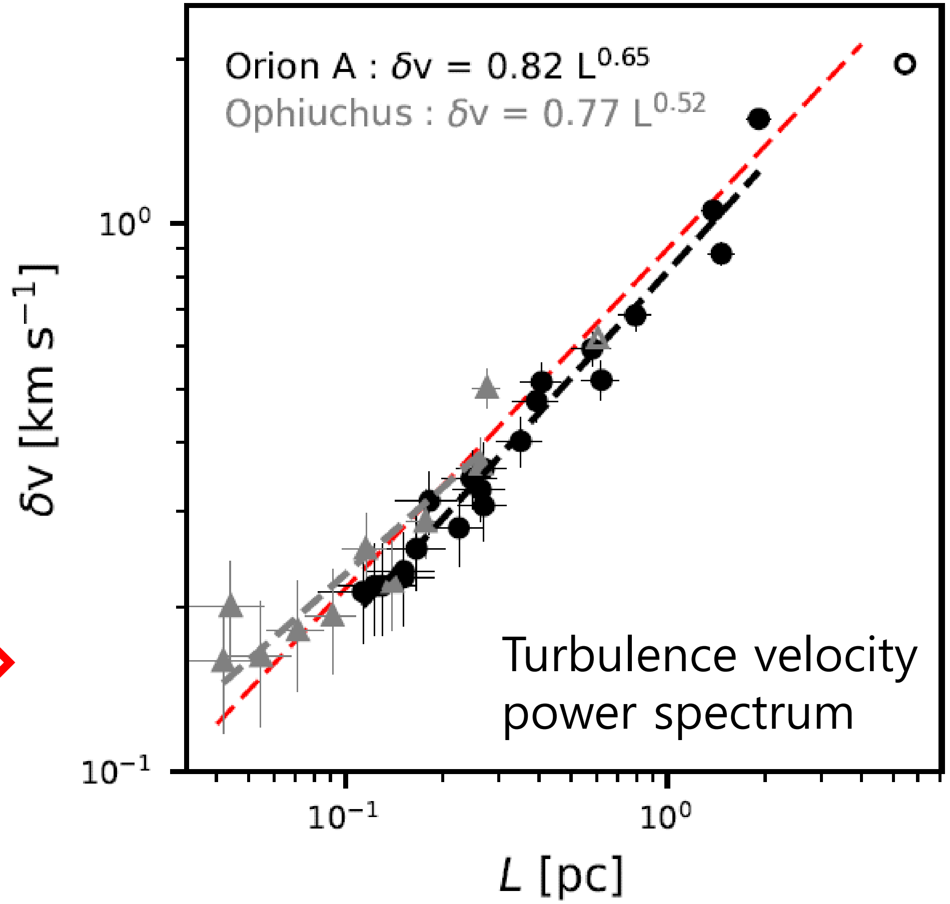
small-scale low velocity motions

Turbulence from the observed spectra

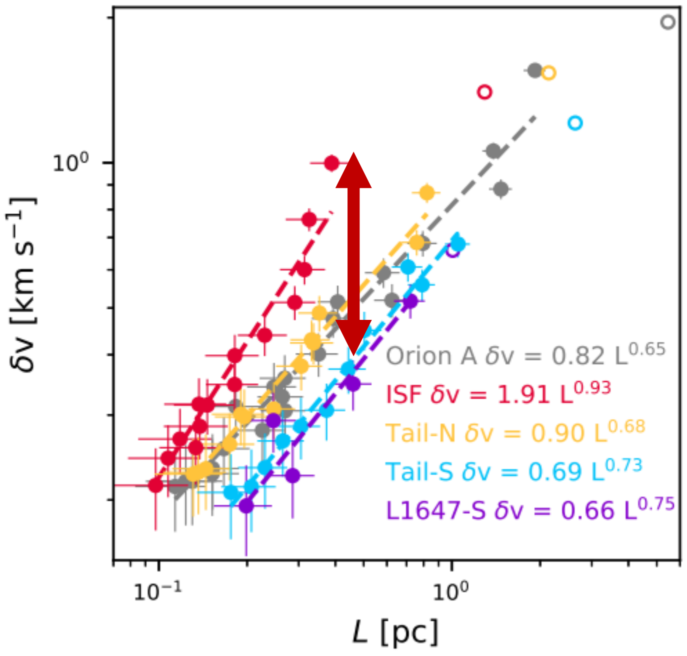
- **The Principal Component Analysis (PCA)**

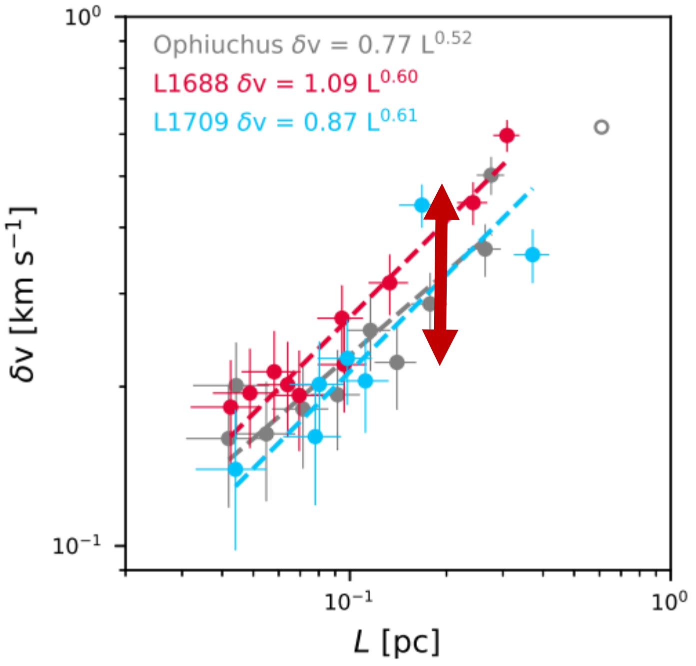


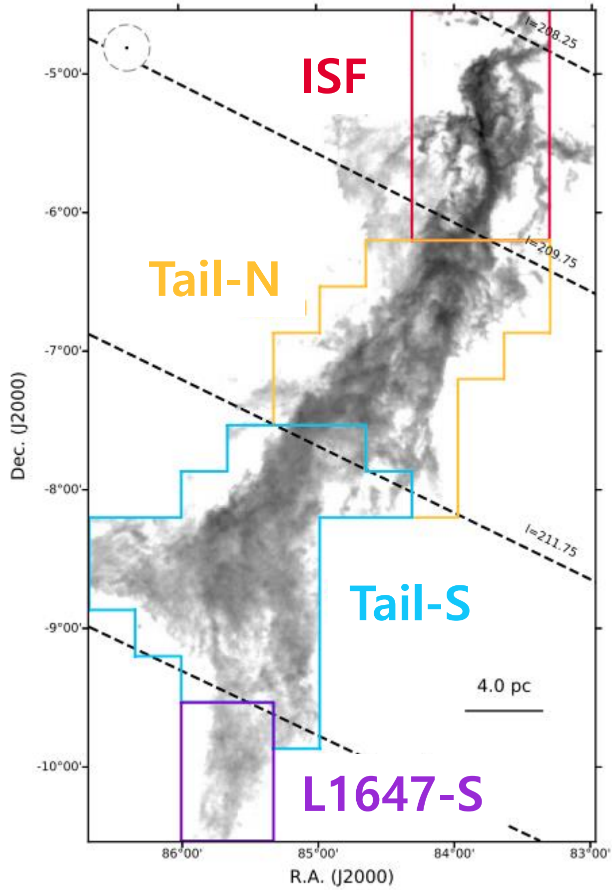


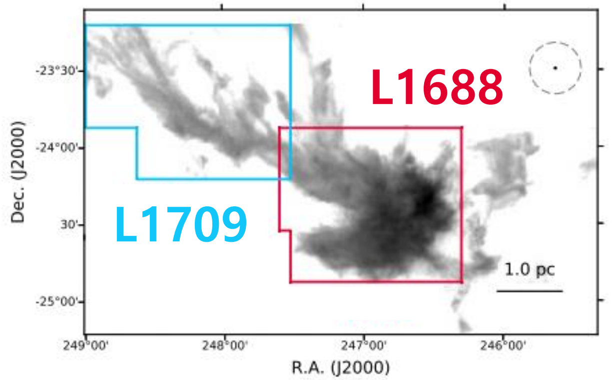


Turbulence in different sub-regions





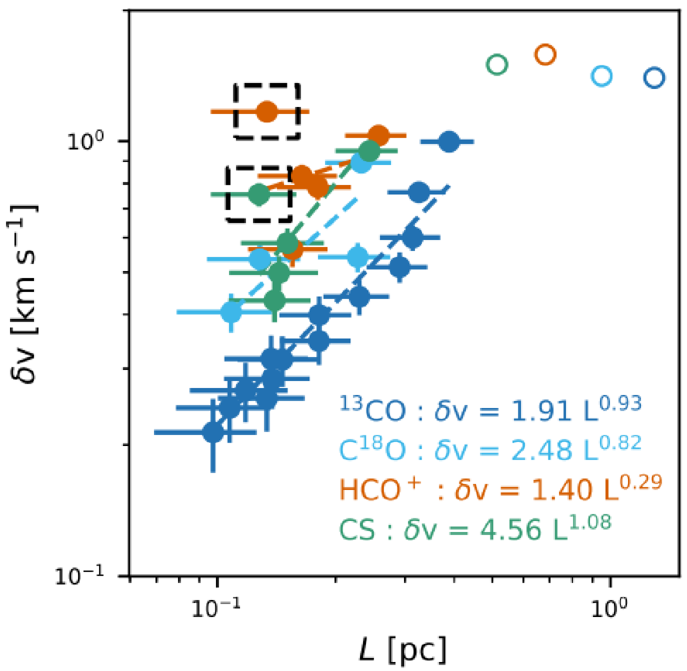


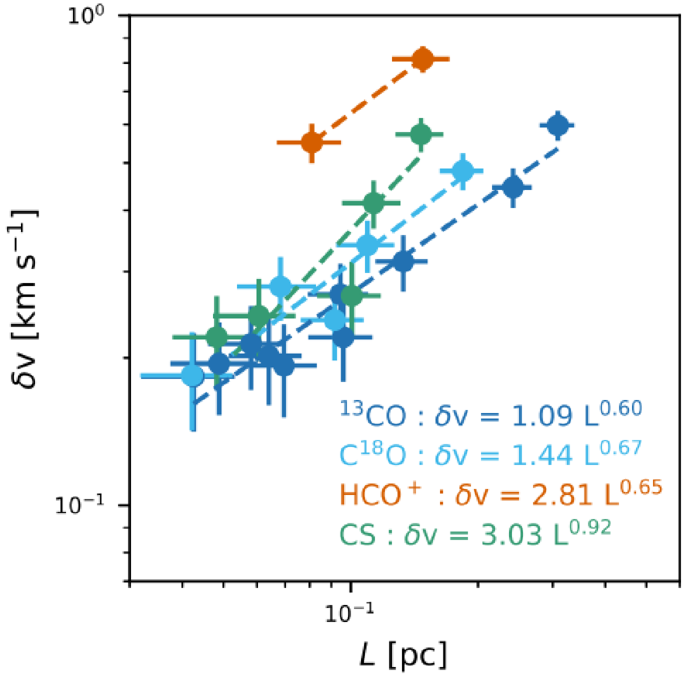


- The velocity dispersion (δv) for a given spatial size (L) is generally **higher in sub-regions that are more actively star-forming** (Furlan et al. 2016; Megeath et al. 2012; Dunham et al., 2015).

Yun et al. (in press)

Turbulence in different density environments





Lines:

^{13}CO *J*=1 - 0

C^{18}O *J*=1 - 0

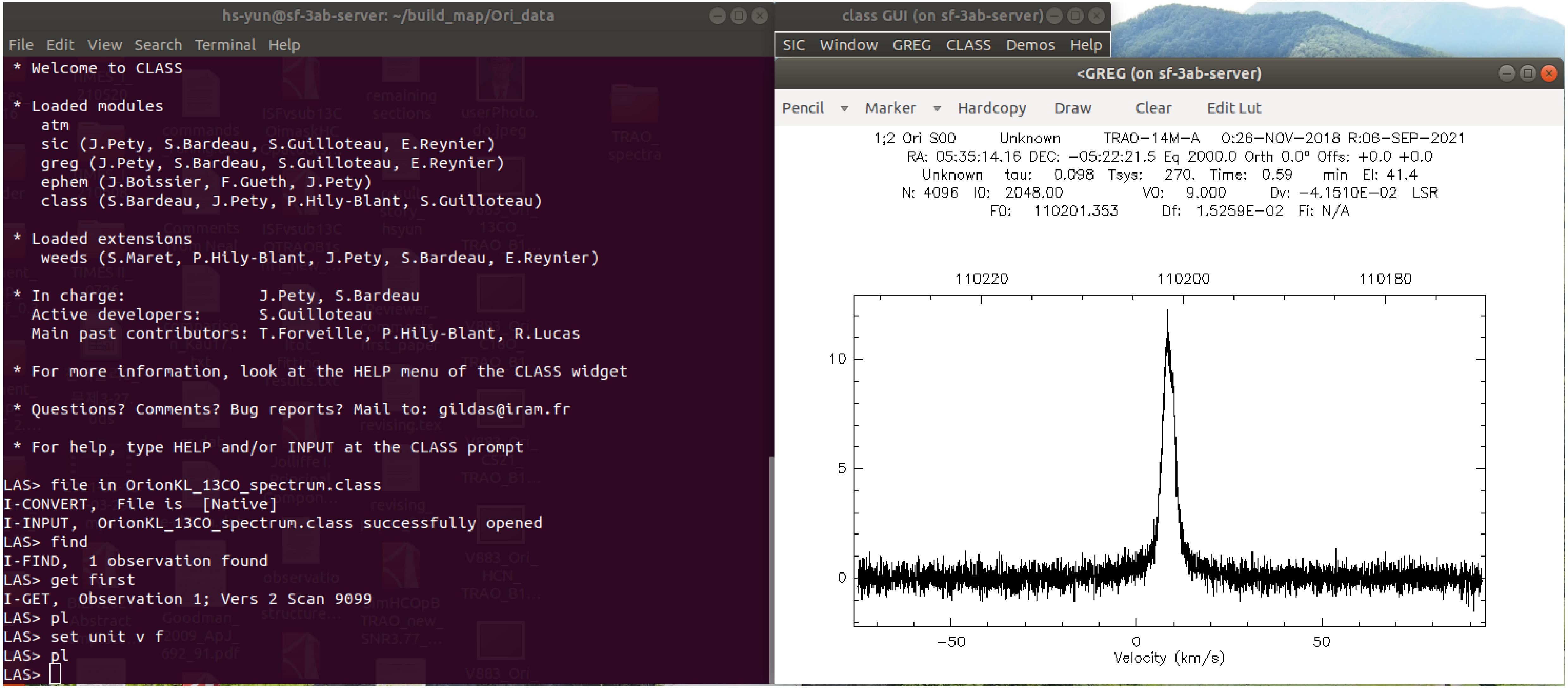
HCO$^+$ *J*=1 - 0

CS *J*=2 - 1

Yun et al. (in press)

- In the ISF and L1688, the δv of C^{18}O, HCO$^+$, and CS are generally higher than that of ^{13}CO.
- **The dense gas is more turbulent** than the diffuse gas in these regions.

Useful program: GILDAS/CLASS



Installation guide (the GILDAS package)

- Search 'GILDAS IRAM' on Google.
- Go to webpage (https://www.iram.fr/IRAMFR/GILDAS/)
- Move to 'Download – download area'

- See 'gildas.README'

- We will try to install 'the GILDAS package' and run 'CLASS'

https://github.com/HyeongSikYun/Singledish_class1