

Single Dish Radio Observation

Observing sequence and data reduction

Hyeong-Sik Yun

Observing astronomical object

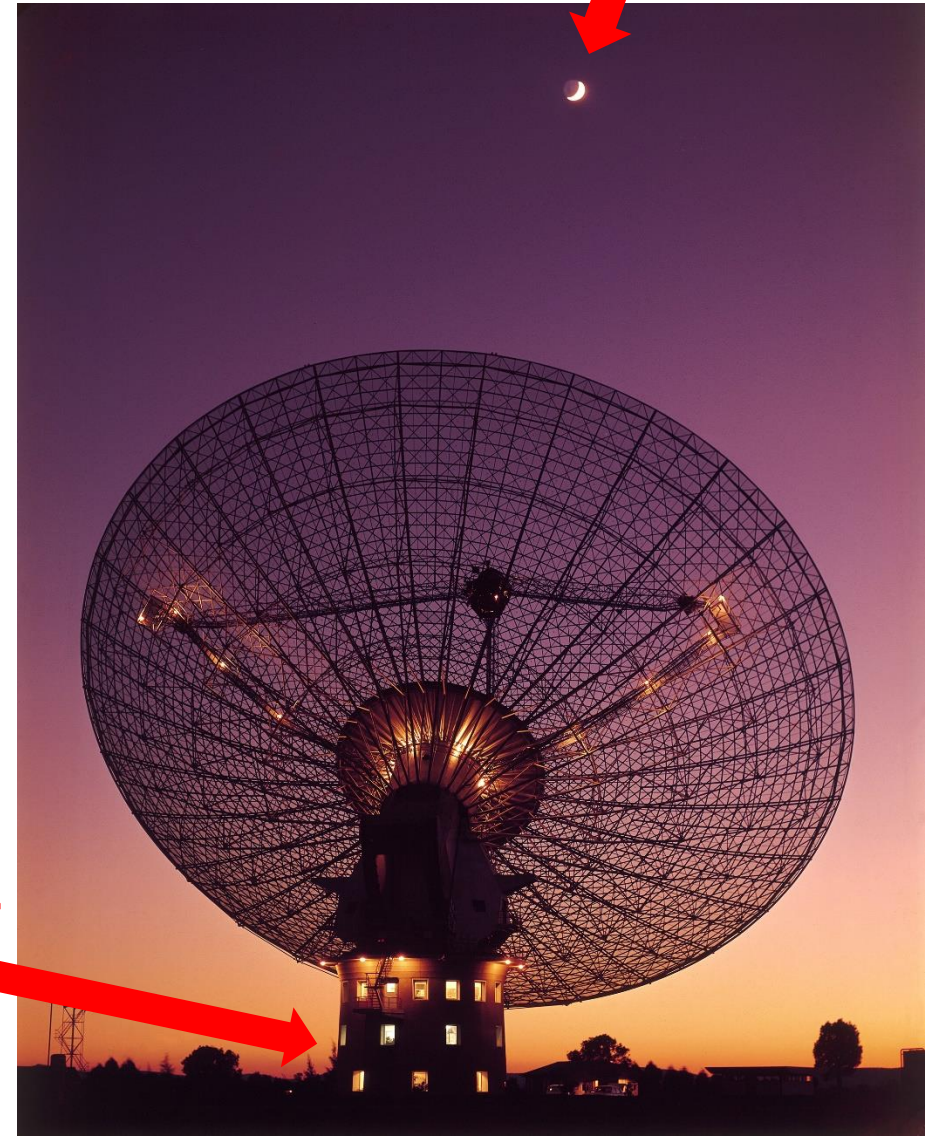
- During the observation, we **investigate various data** to obtain the spectrum, which is solely originated from observing target (Calibration).

The things that we should consider during the observation.

1. Focus and pointing of the telescope
2. Error signal from the system
3. Atmosphere

Observer

Target source



Sky changes depending on the observing frequency

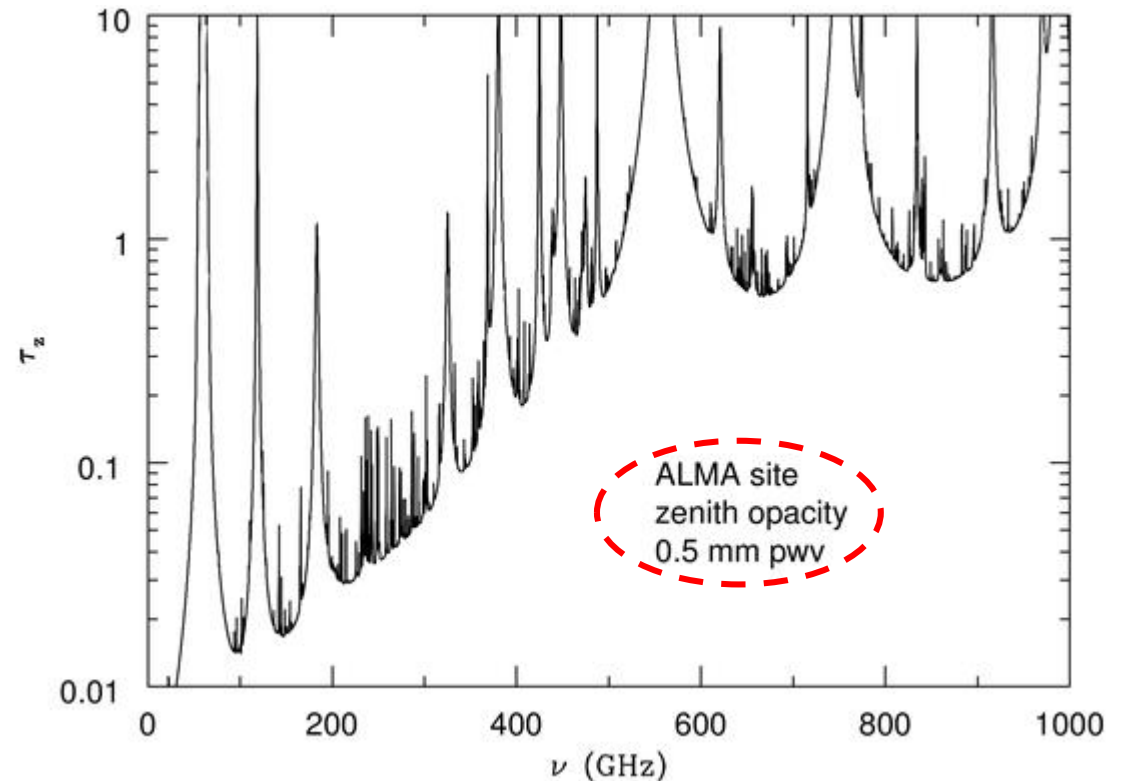
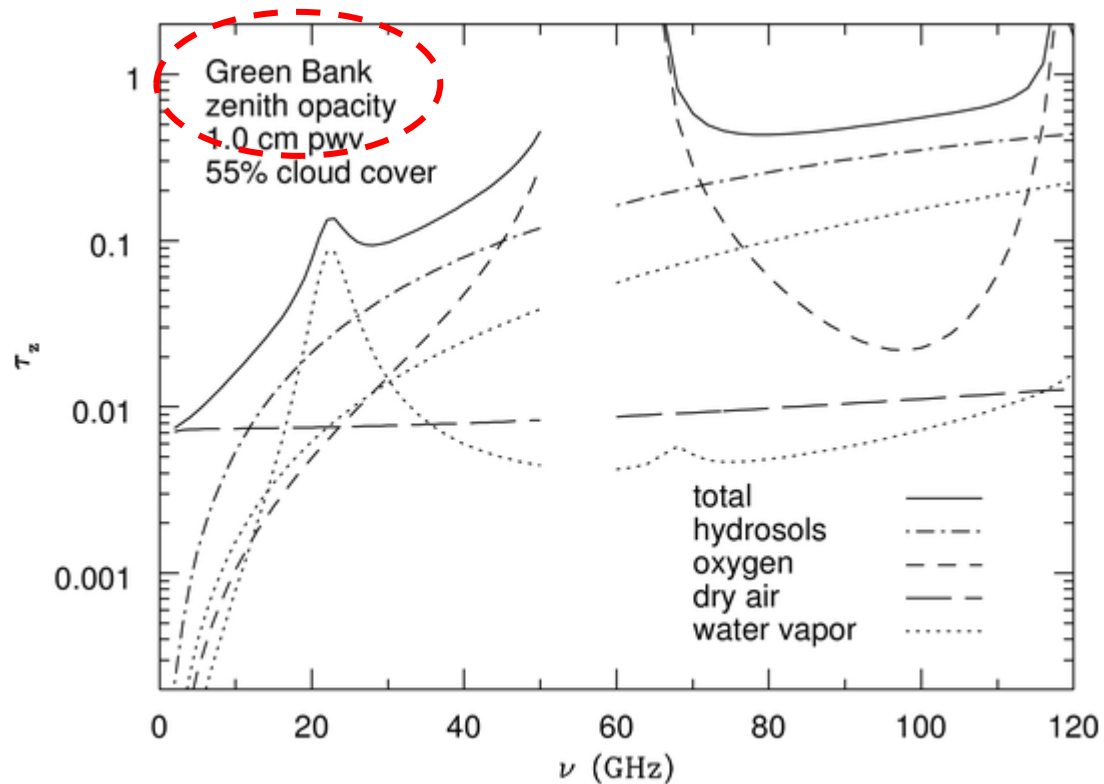
- Opacity: the measure of impenetrability to radiation.



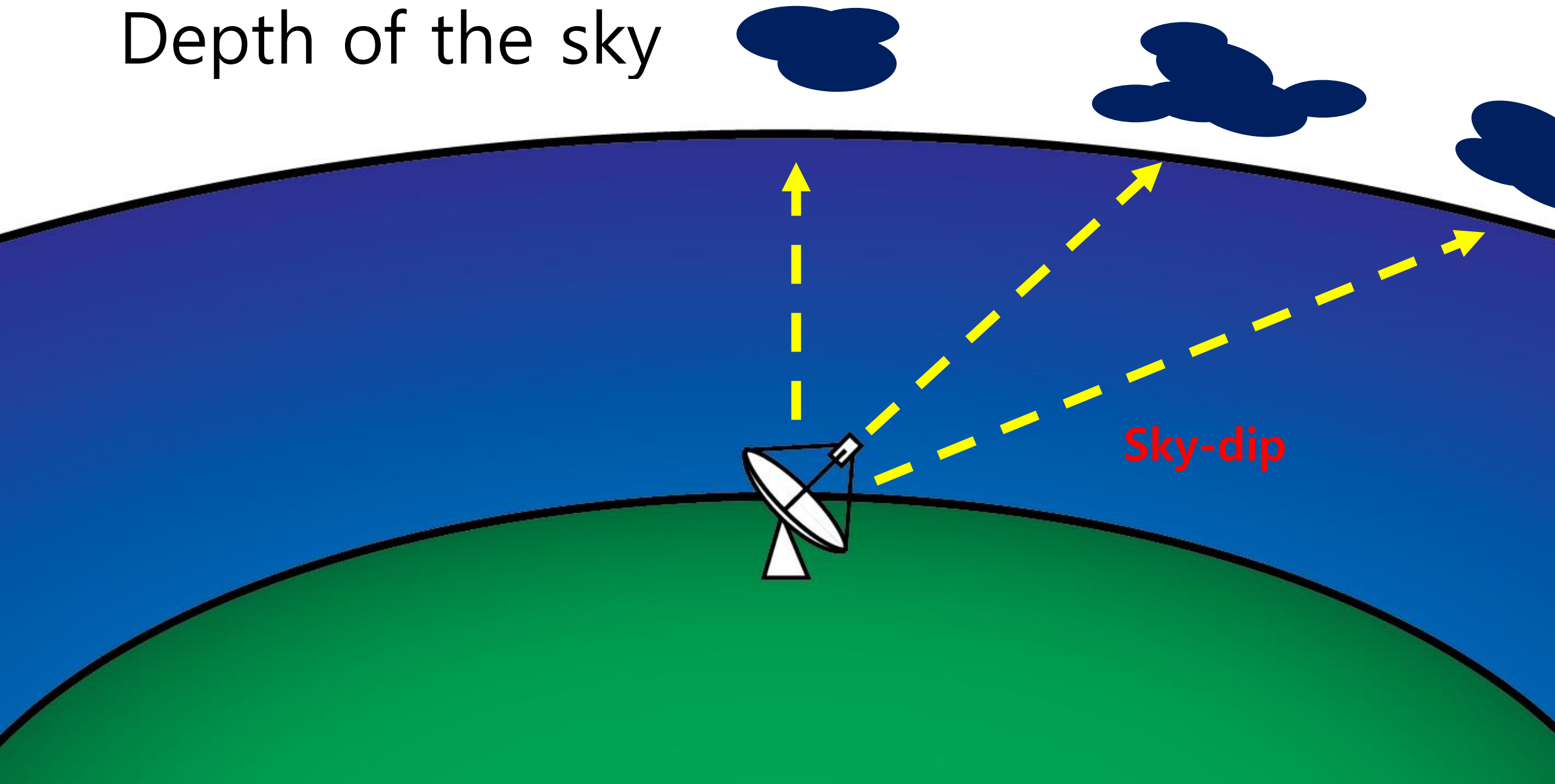
- Opacity of the atmosphere depending on the frequency.
 - Longer wavelength (higher frequency) -> less opaque
 - The frequency that its energy is consistent to the energy gap of a certain molecule.

Sky changes depending on the observing frequency

- Opacity: the measure of impenetrability to radiation.



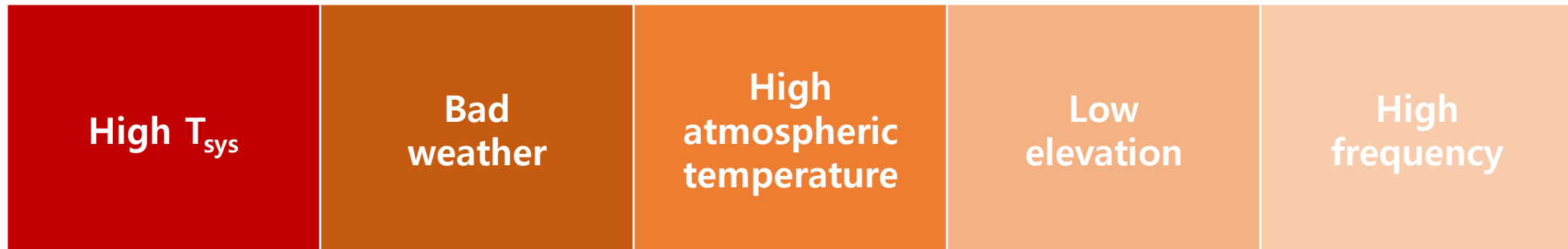
Depth of the sky



The system temperature (T_{sys})

- Total noise power: the sum of many contributors to the antenna temperature.

ex) CMB, background emission, radiation from ground, and
noise generated by the telescope itself.



❖ How to measure T_{sys} ?

- Chopper wheel **calibration** method

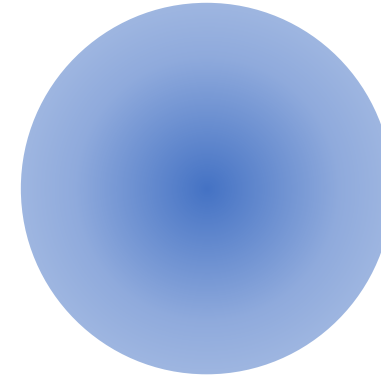
Related reference: [Atmospheric phase correction at the IRAM instruments Radiometer Workshop at the Universität BW, Neubiberg July 26, 2005](#)

Focus and Pointing

- **Five-point** observation.



Well-known
point-like radio
source

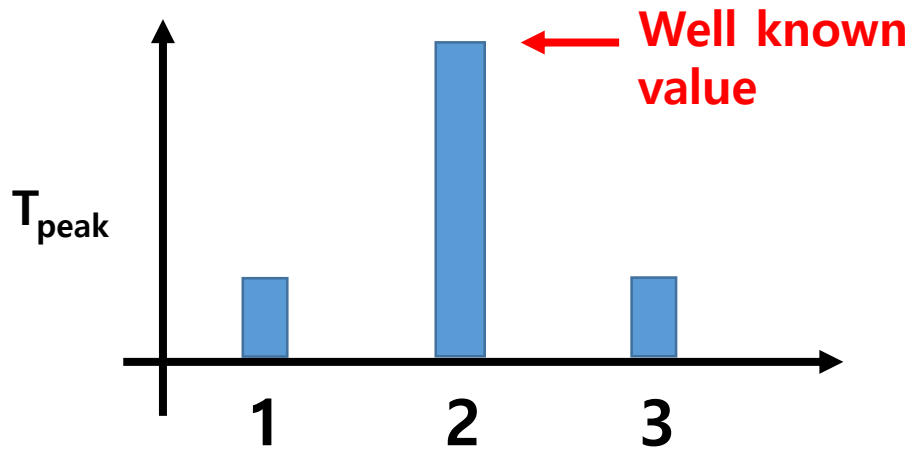


Main beam
projected on
the sky plane

- The best focus
the smallest beam size
- Not on the best focus
the beam size becomes larger

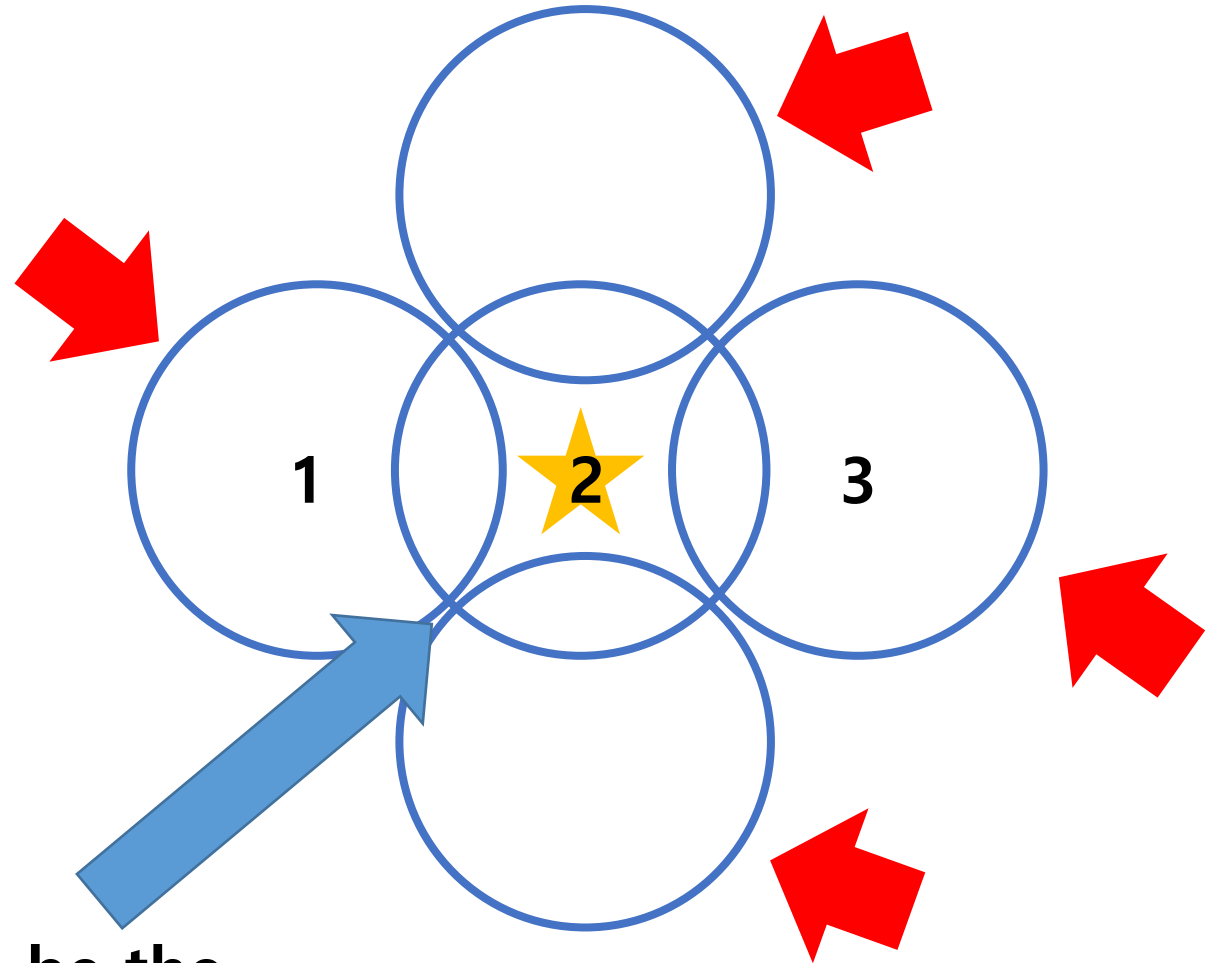
Focus and Pointing

- **Five-point** observation with the best focus and the best pointing



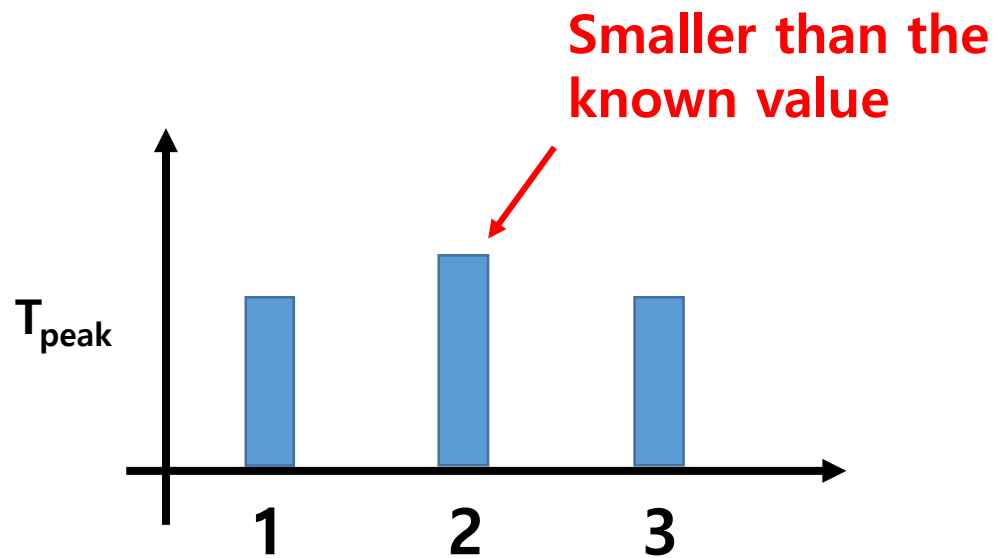
The line would be the strongest in the center

The other pixels would detect smaller and similar line emissions.

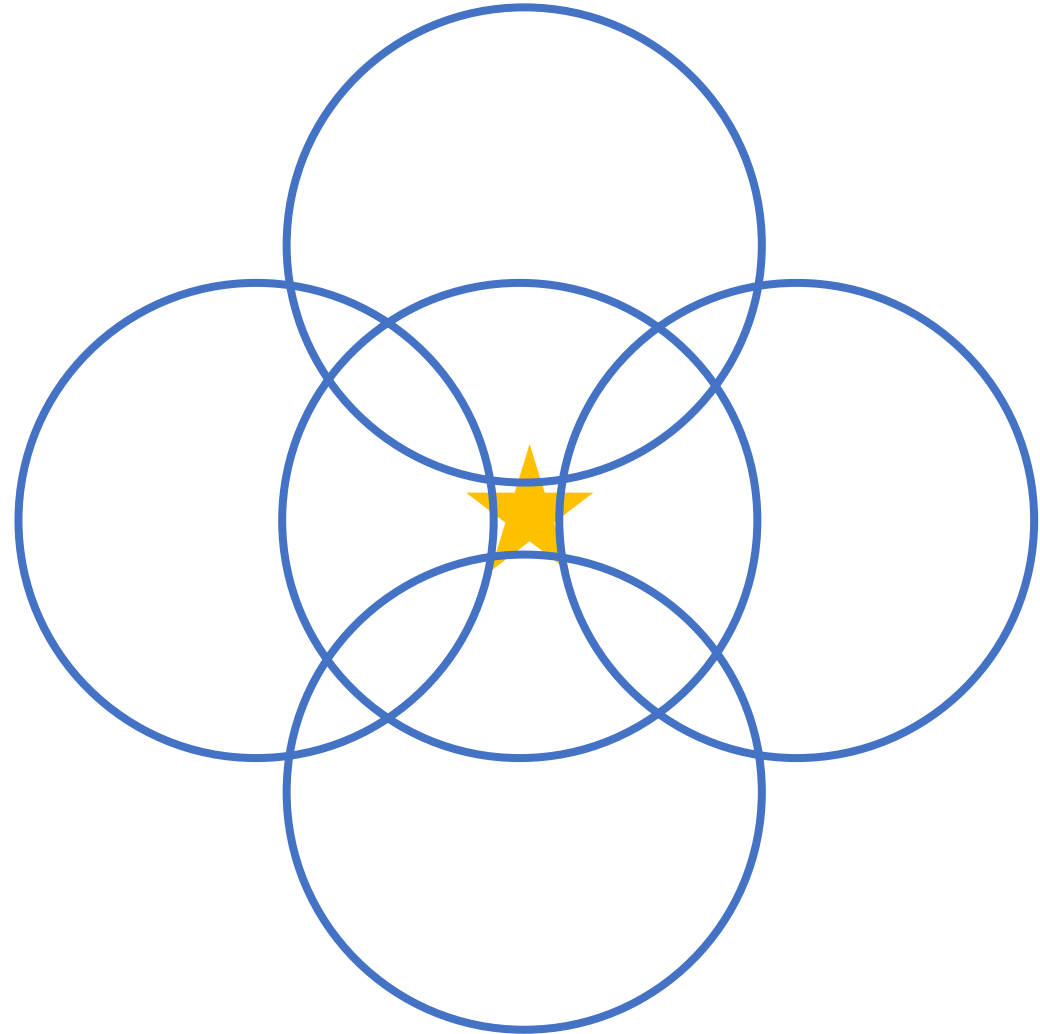


Focus and Pointing

- **Five-point** observation without the best focus

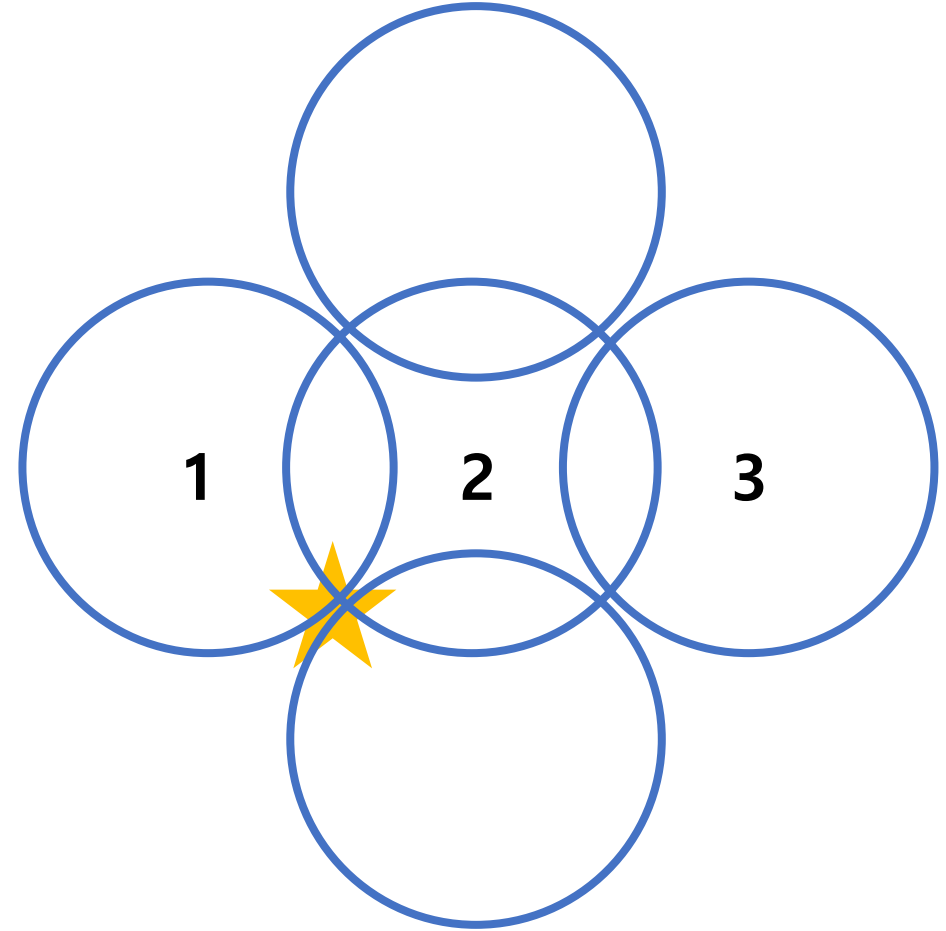
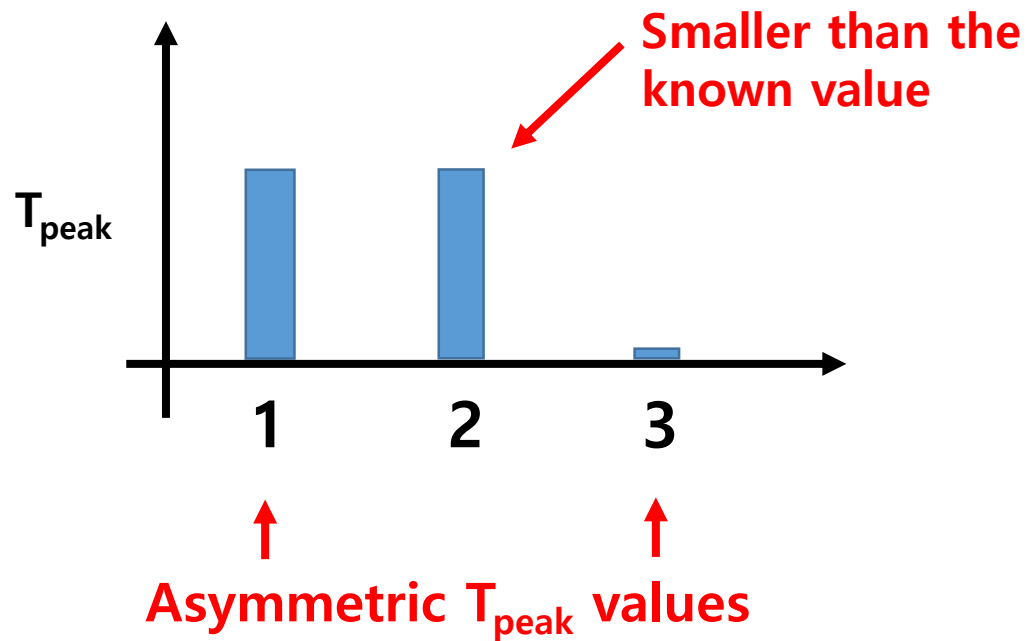


The peak temperature is not concentrated to the center



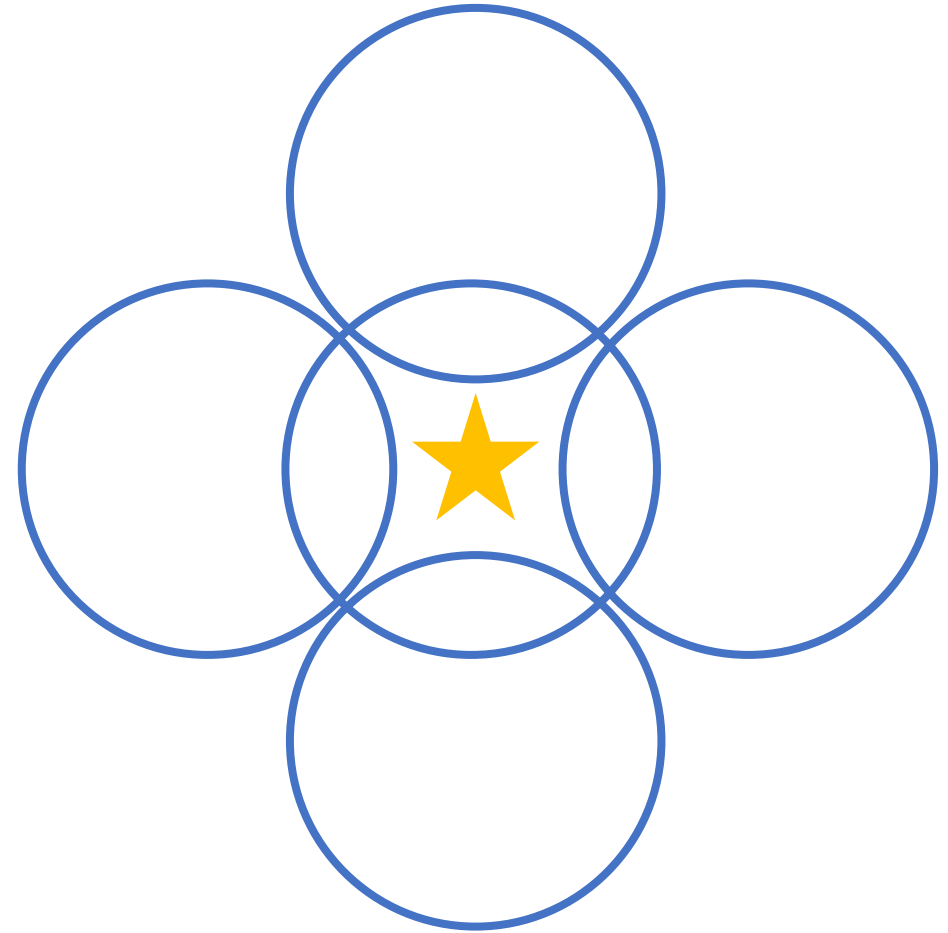
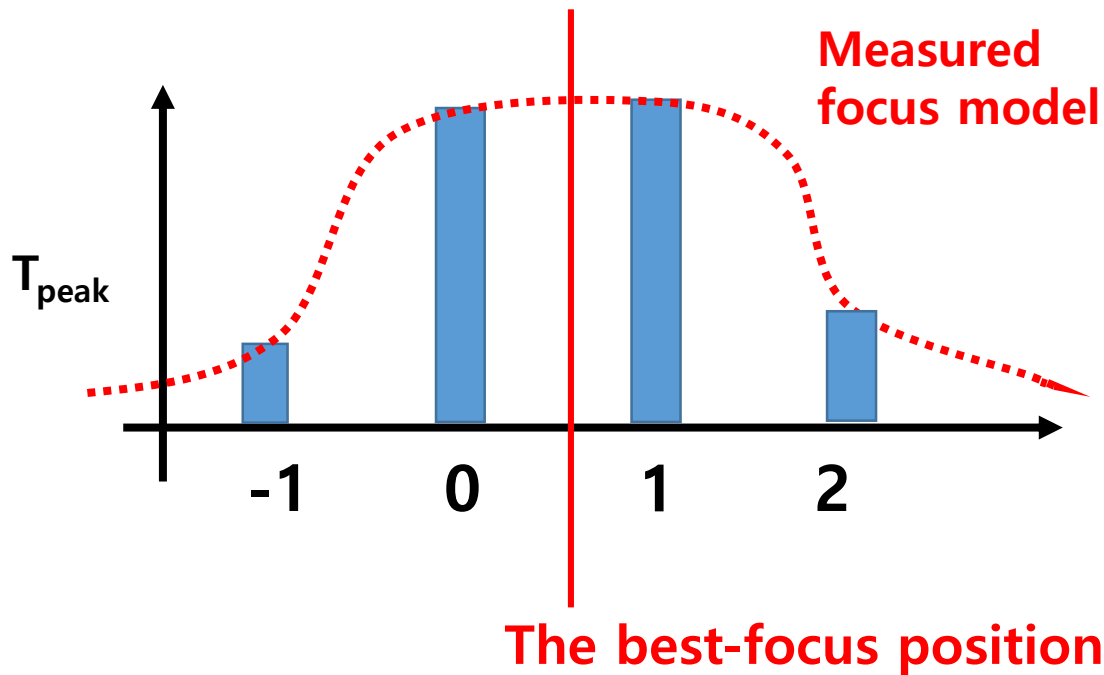
Focus and Pointing

- **Five-point** observation with an wrong pointing



Focus and Pointing

- Repeat following processes
 1. Move sub-reflector
 2. Find pointing
 3. Measure Focus



The best-focus position



Find pointing



Start observation

The typical observation sequence

1. Tuning (change frequency; for pointing)
2. Calibration
3. Sky-dip (measure sky opacity; for pointing)
4. Calibration
5. 5-point observation (Find focus & pointing)
6. Calibration
7. Tuning (change frequency; for observation)
8. Calibration
9. Sky-dip (measure sky opacity; for observation)
10. Calibration
11. Observation start!!

Observing log

TRAO 14M Radio Telescope

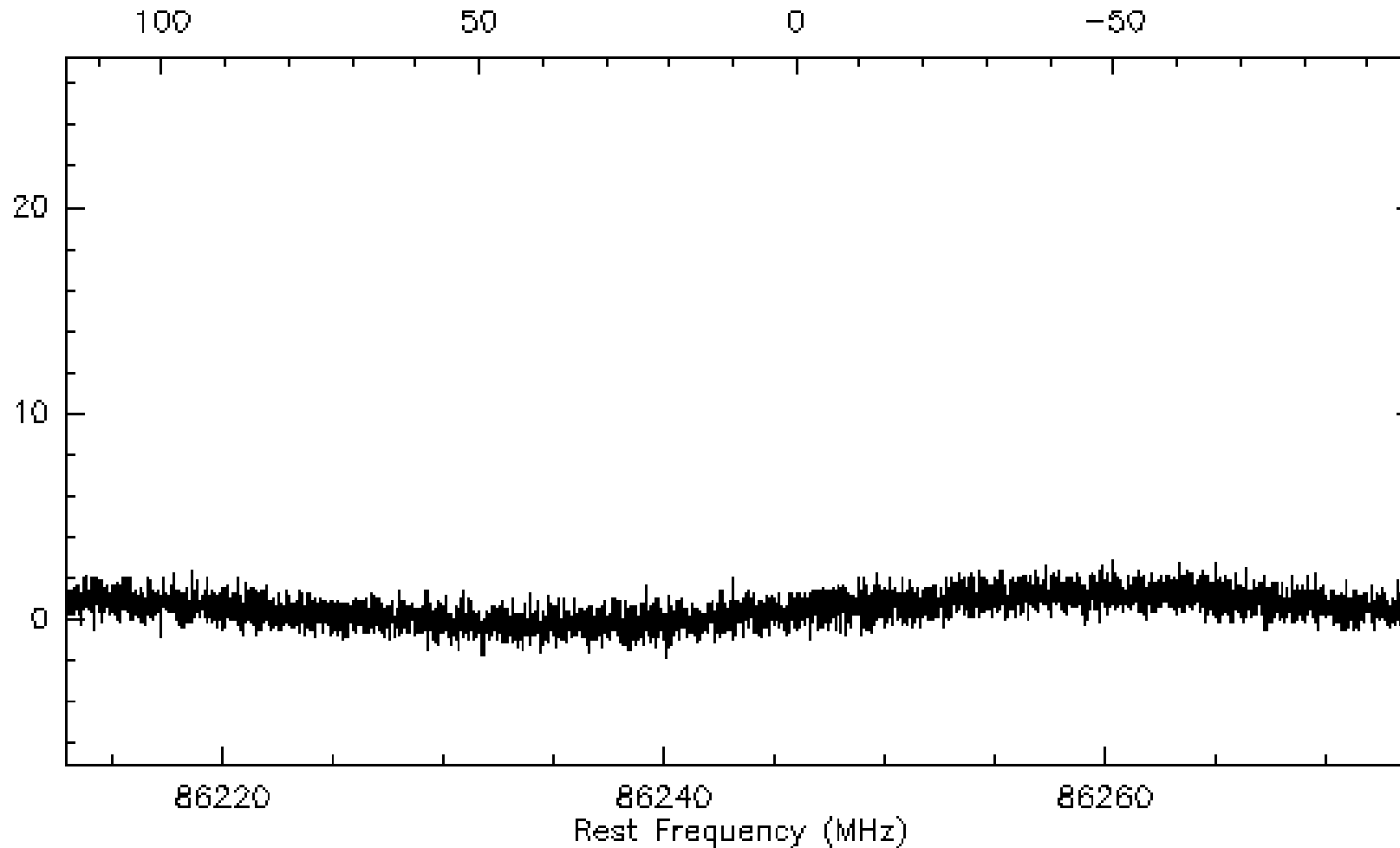
Object TPMC Date 2017/04/16 Observer(s) Hyang-Sik Yun Page 1
 Freq 1 Focus Δ AZ Δ EL Tolerance 7.2
 Freq 2 SSB 1 Weather T_{amb} WVP

Scan#	LST	Source	$\alpha(2000)/L$	$\delta(2000)/B$	$\Delta\alpha/\Delta L$	$\Delta\delta/\Delta B$	AZ	EL	VLSR	T_{sys}	Mode	RPT	T_{int}	Etc
24199	13:14	whya		SiO/HCO ⁺				24.5	42	286/254				pointing/Focus
		tau: 0.150/0.144					baseline problem.		restart.					
24200	13:20	whya		SiO/HCO ⁺				24.7	42	285/251				pointing/Focus
~24225	~13:41								A ₂ PC: 0.0003	ELPC: 0.0006				BF: -0.09
24226	13:57	Ophiuchus-center		HCN/HCO ⁺				19.49	5	305/271				PS
		tau: 0.156/0.152					T _{peak} : 3.9/2.5 K							
24227	14:02	Oph-S+O2+O2-DEC		HCN/HCO ⁺				20.3	5	296/264				OTF-DEC
~24264	~15:14	with Ref1												
24265	15:15	Ophiuchus-center		HCN/HCO ⁺				26.7	5	240/225				PS
							T _{peak} : 3.2/2.9 K							
24266	15:19	Oph-S-O1+O2-RA		HCN/HCO ⁺				27.5	5	238/223				OTF-RA
~24303	~16:29	with Ref1												
24304	16:29	Ophiuchus-center		HCN/HCO ⁺				28.9	5	231/220				PS
							T _{peak} : 3/2.6 K							
24305	16:43	Oph-S-O1+O2-DEC		HCN/HCO ⁺				29.3	5	231/220				OTF-DEC
~24342	~18:44	with Ref1												
24343	17:45	Ophiuchus-center		HCN/HCO ⁺				26.2	5	251/232				PS
							T _{peak} : 3.1/2.6 K							

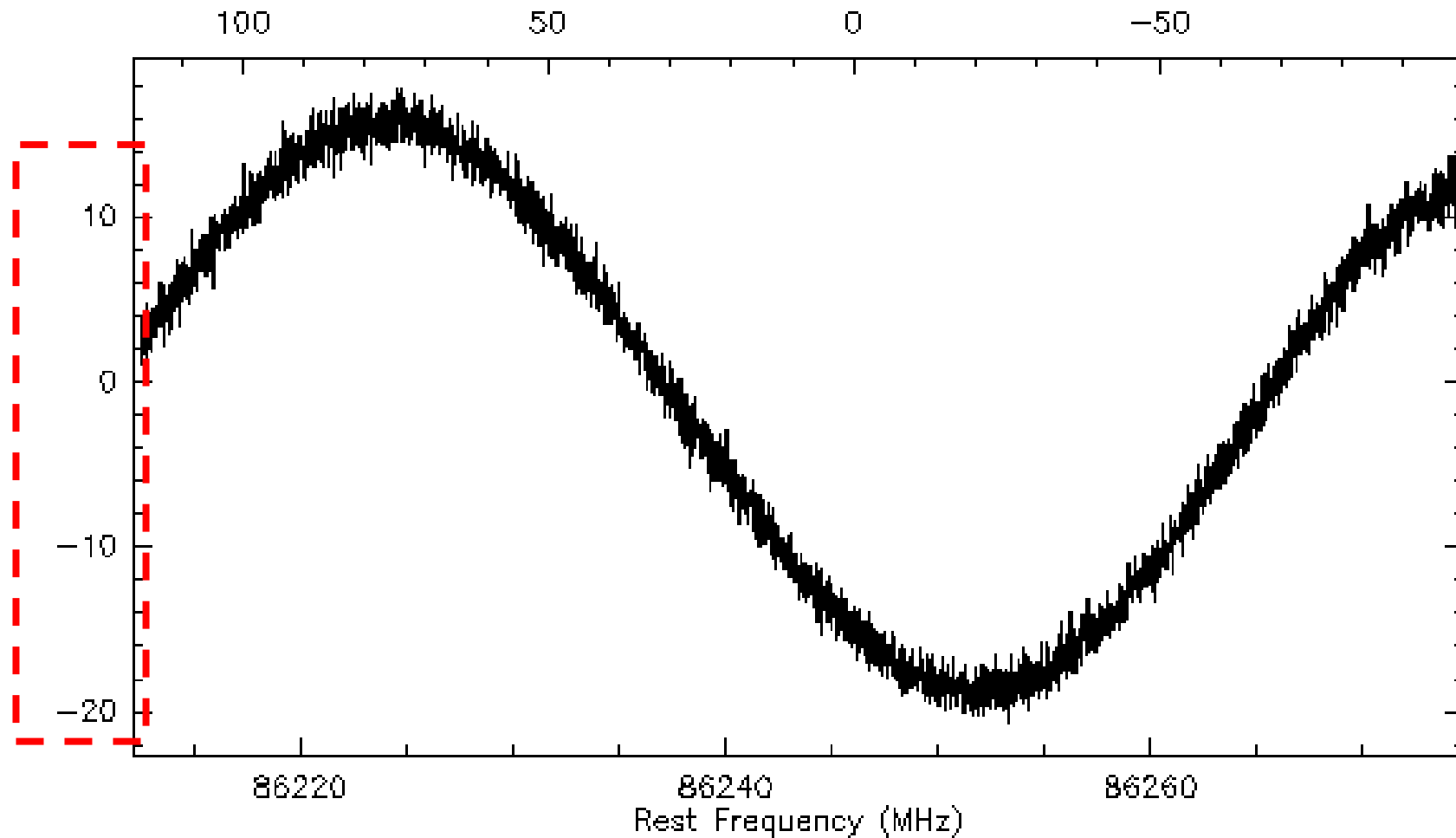
Baseline problem.

	24.9
baseline	problem

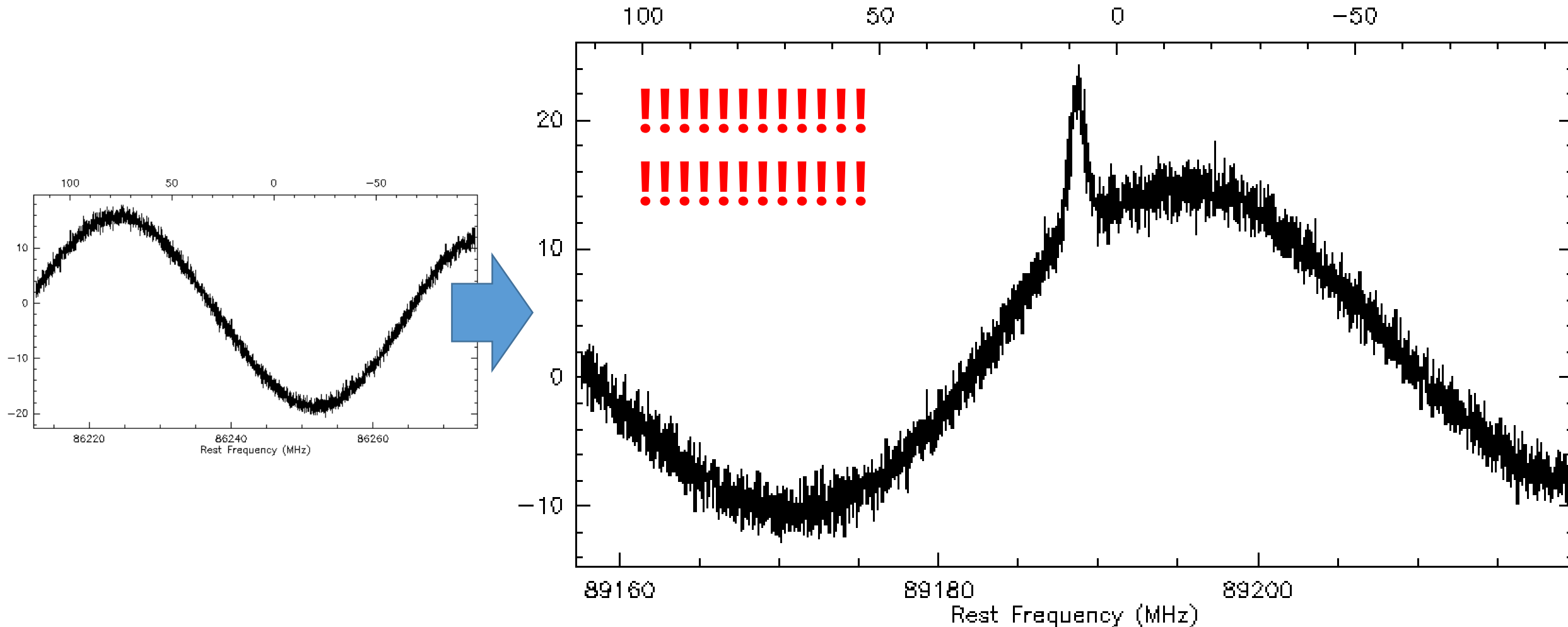
Example: Baseline fluctuation (example1)



Example: Baseline fluctuation (example2)

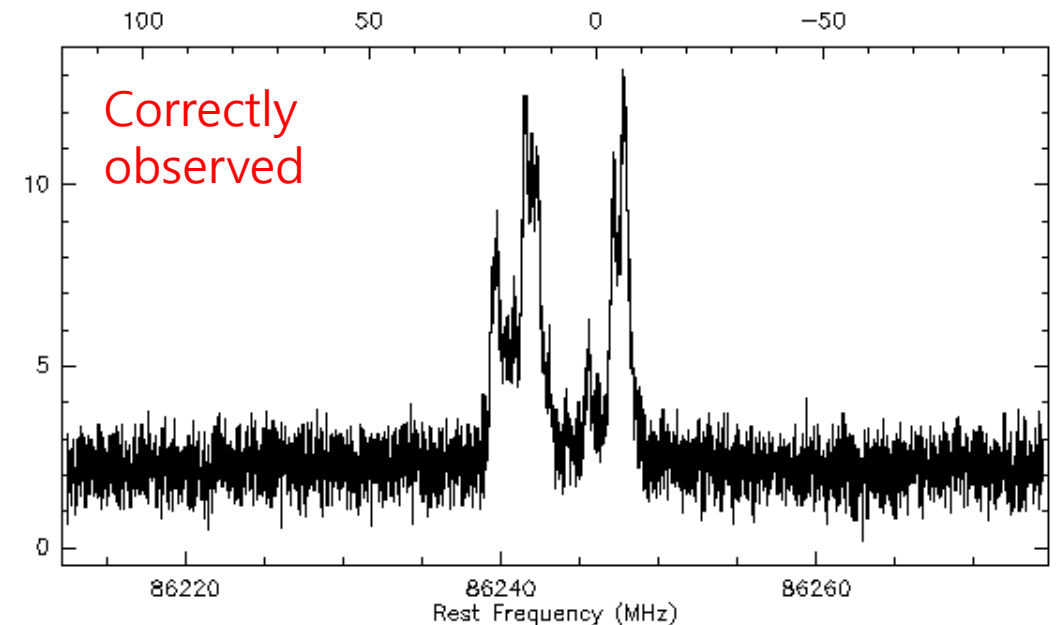
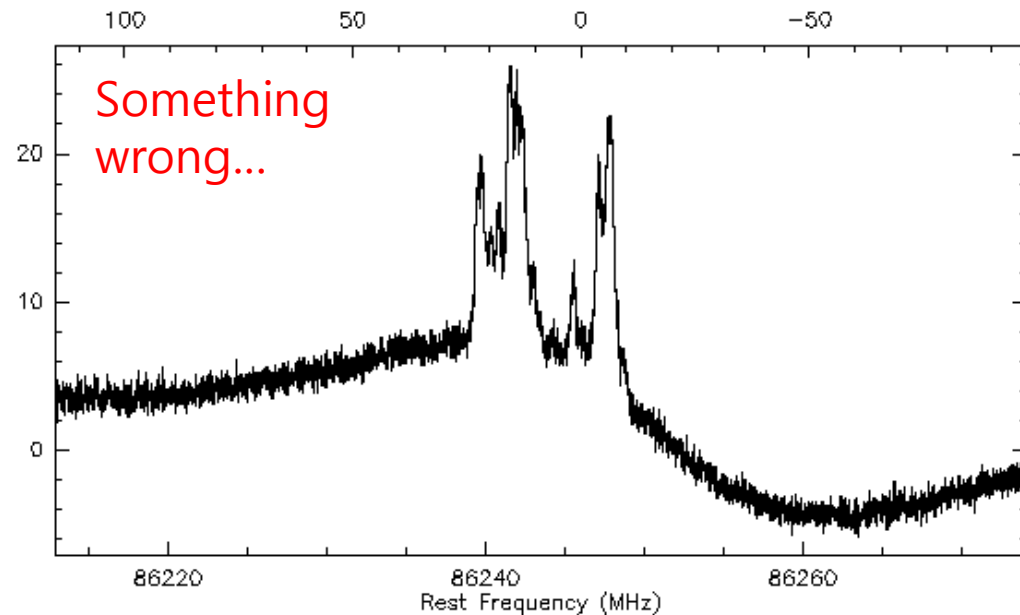


Example: Baseline fluctuation with line



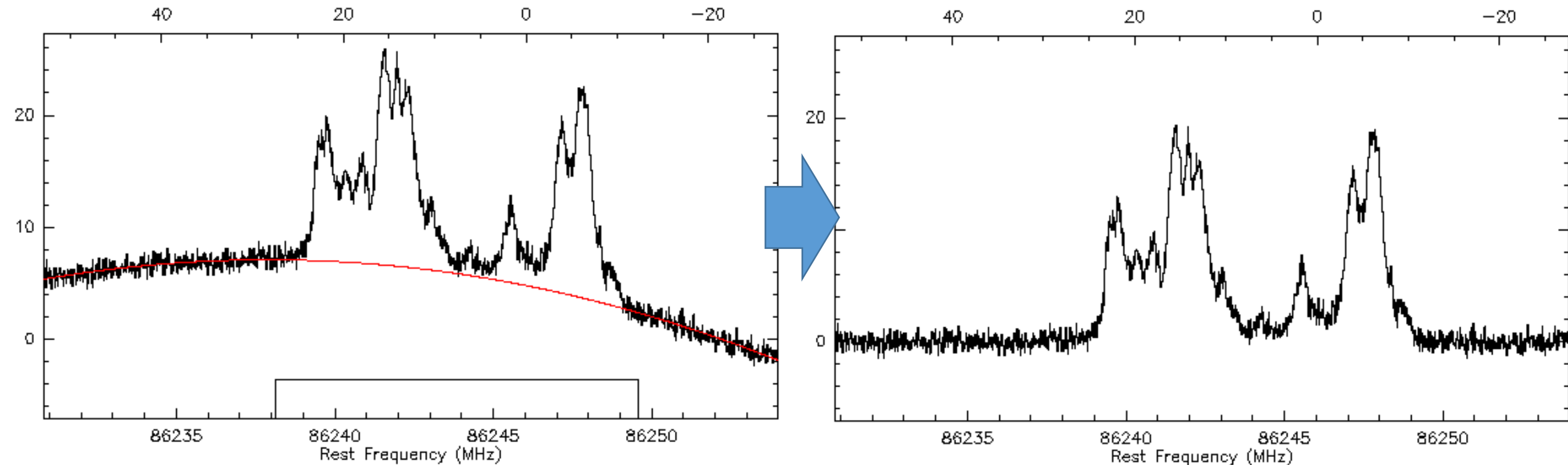
Baseline

- Reference point for the measured intensity
- The baseline can be artificially changed.
- To estimate the true intensity of emission lines, the baseline should be removed.



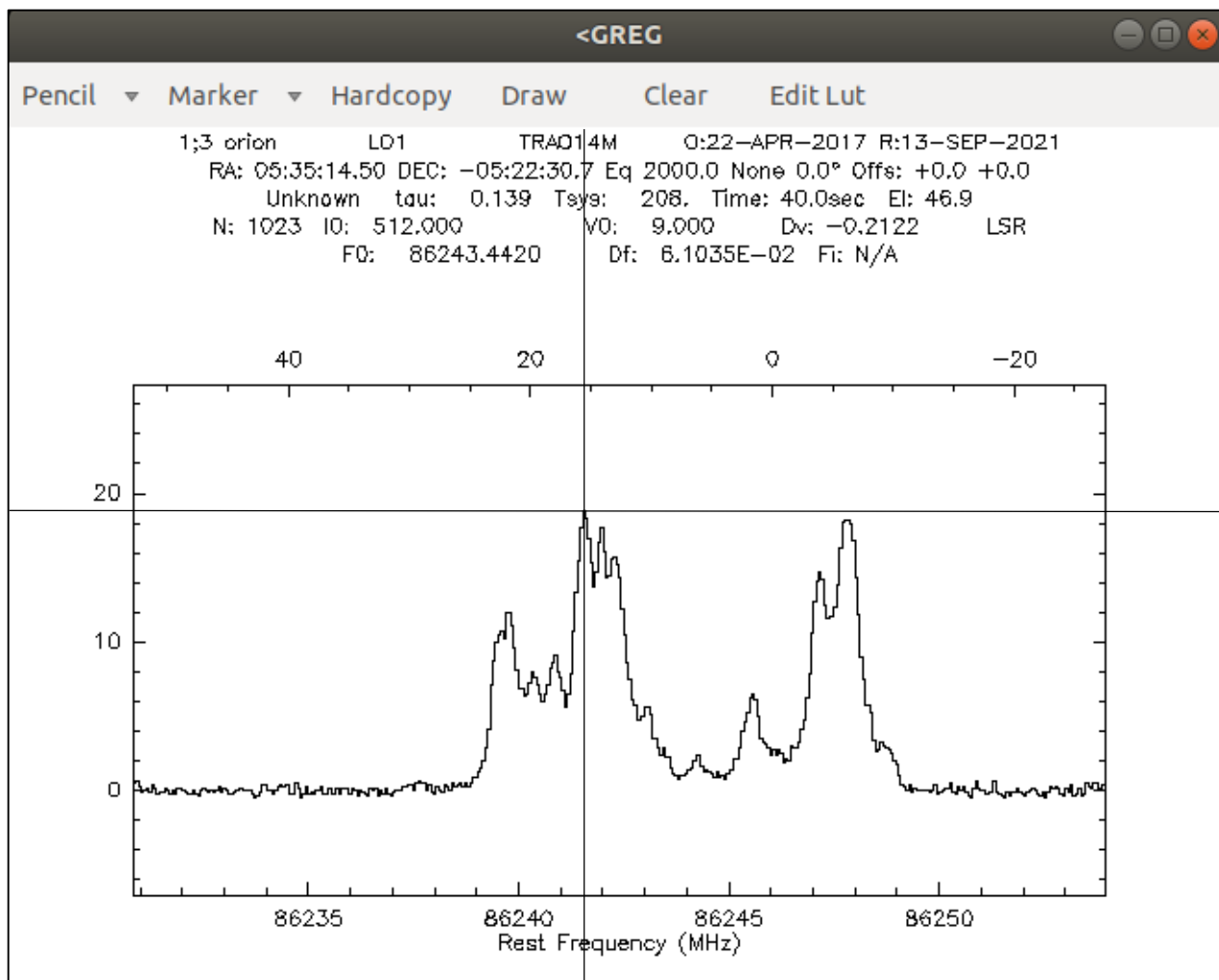
Baseline

- Baseline can be removed by fitting a polynomial to the baseline spectrum in the data.



Peak temperature

- The maximum temperature of the observed line.



- Smooth the spectrum
- Measure the peak temperature
- Output:

```
LAS> draw
Channel number      : 481.56
Velocity            : 15.459 km/s
Rest Frequency      : 86241.5842768 MHz
Image Frequency     : N/A
Offset Frequency    : -1.8577 MHz
Antenna Temperature : 18.817 K
LAS> █
```

Practice!

- Access the Github repository
[HyeongSikYun/Singledish_class2 \(github.com\)](https://github.com/HyeongSikYun/Singledish_class2)
- bad_baseline_#.class : the spectra with a fluctuating baseline
- good_baseline_#.class: the spectra with a stable baseline
- GILDAS_advance_useage_of_Class.txt: Guideline to use the Class program
- Final goal:
Try to measure the peak temperature of the line from 'bad_baseline_#.class', and compare it with that from the 'good_baseline_#.class'.

How to export the spectrum?