APEX Observing Strategies

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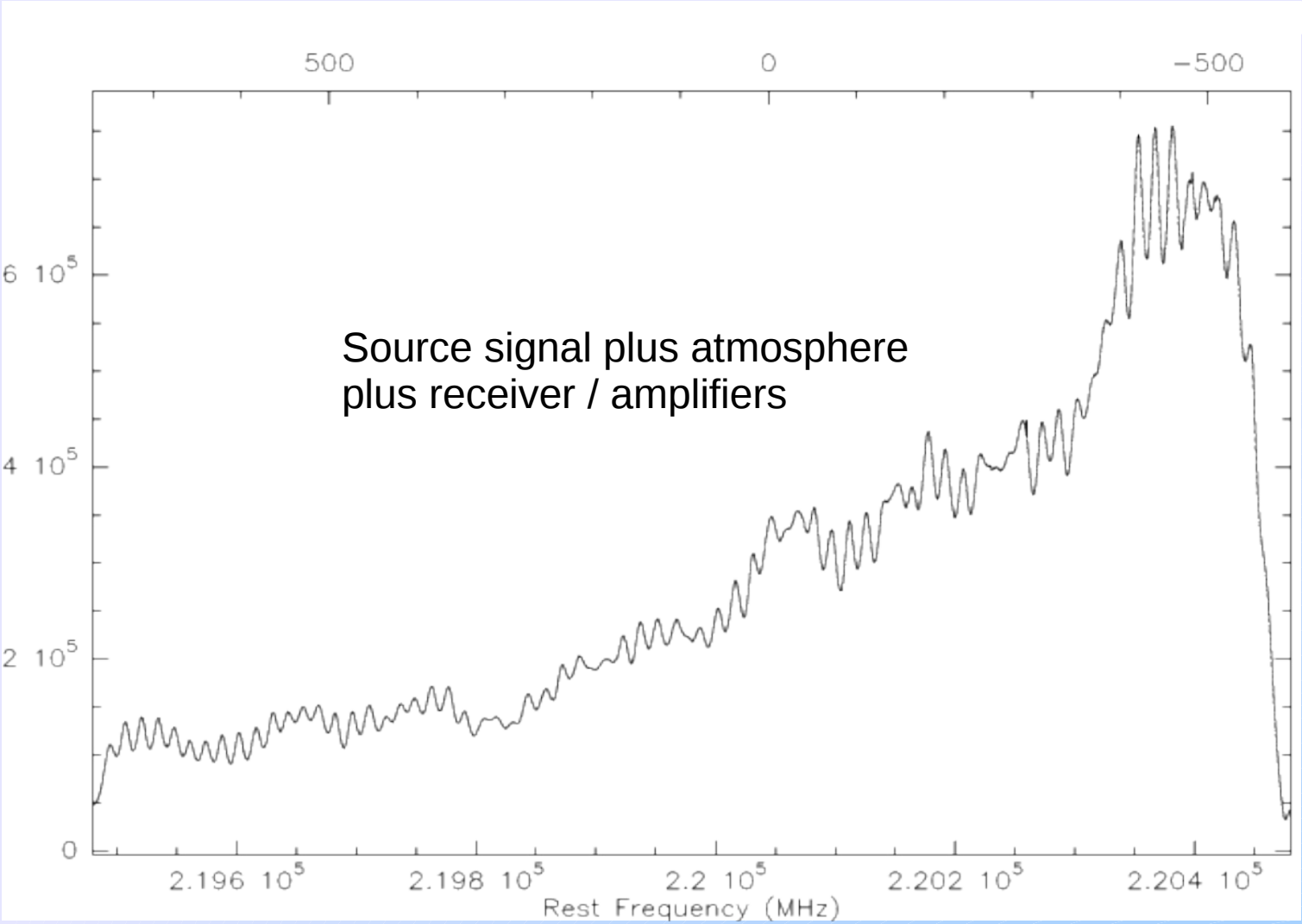
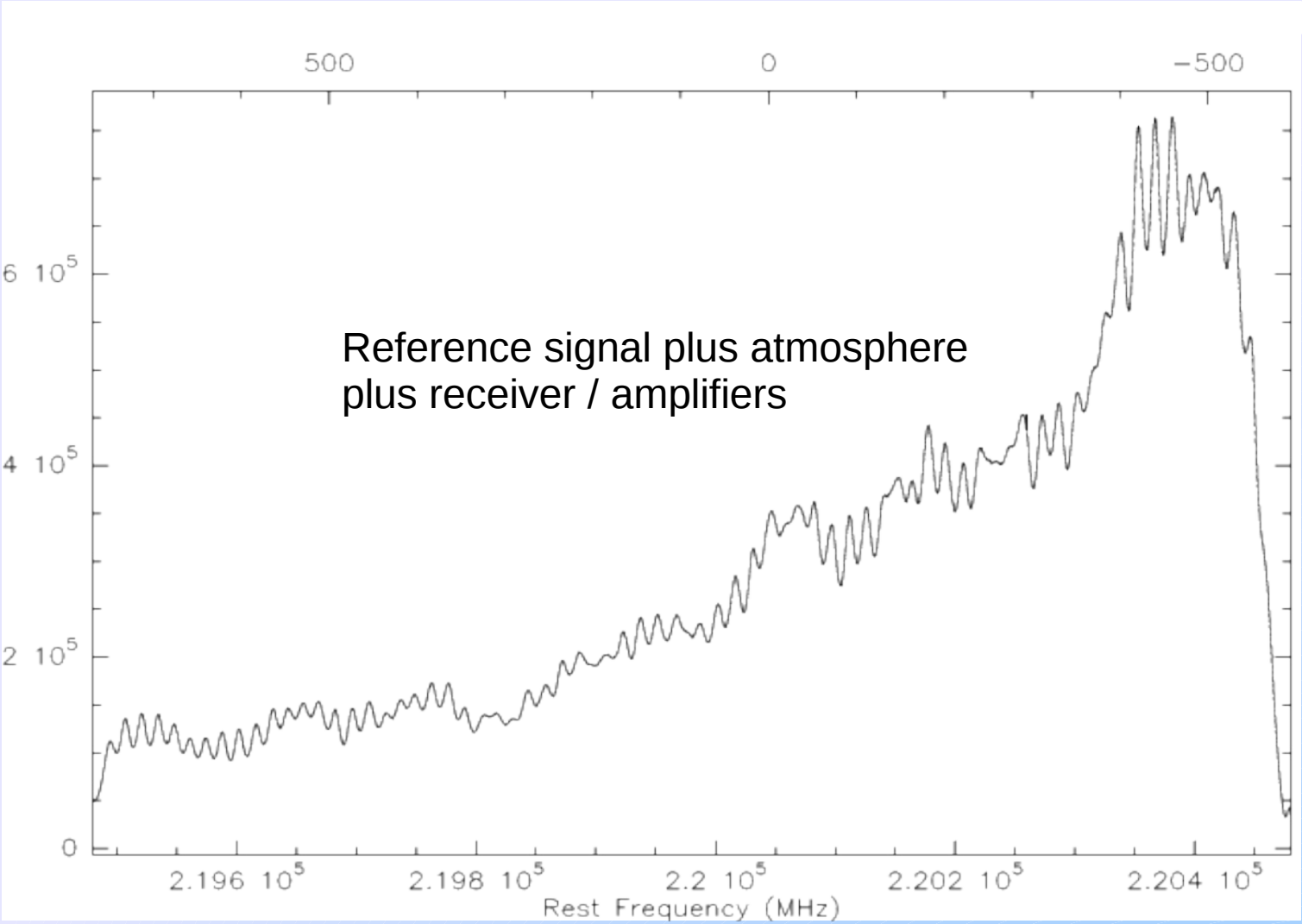
Instruments

- Observing setup depends on instrument type
- Bolometers
  - Wide bandwidth (several 10 GHz)
  - Continuum data, i.e. single number per sky position and pixel
  - Sky emission removed via correlated noise removal → need maps
- Heterodyne receivers
  - Narrow bandwidth (though nowadays 8-16 GHz per pixel)
  - Spectral data (32-64k channels per sub-band)
  - Sky emission removed via On-Off method → reference position

On-Off Method



On-Off Method



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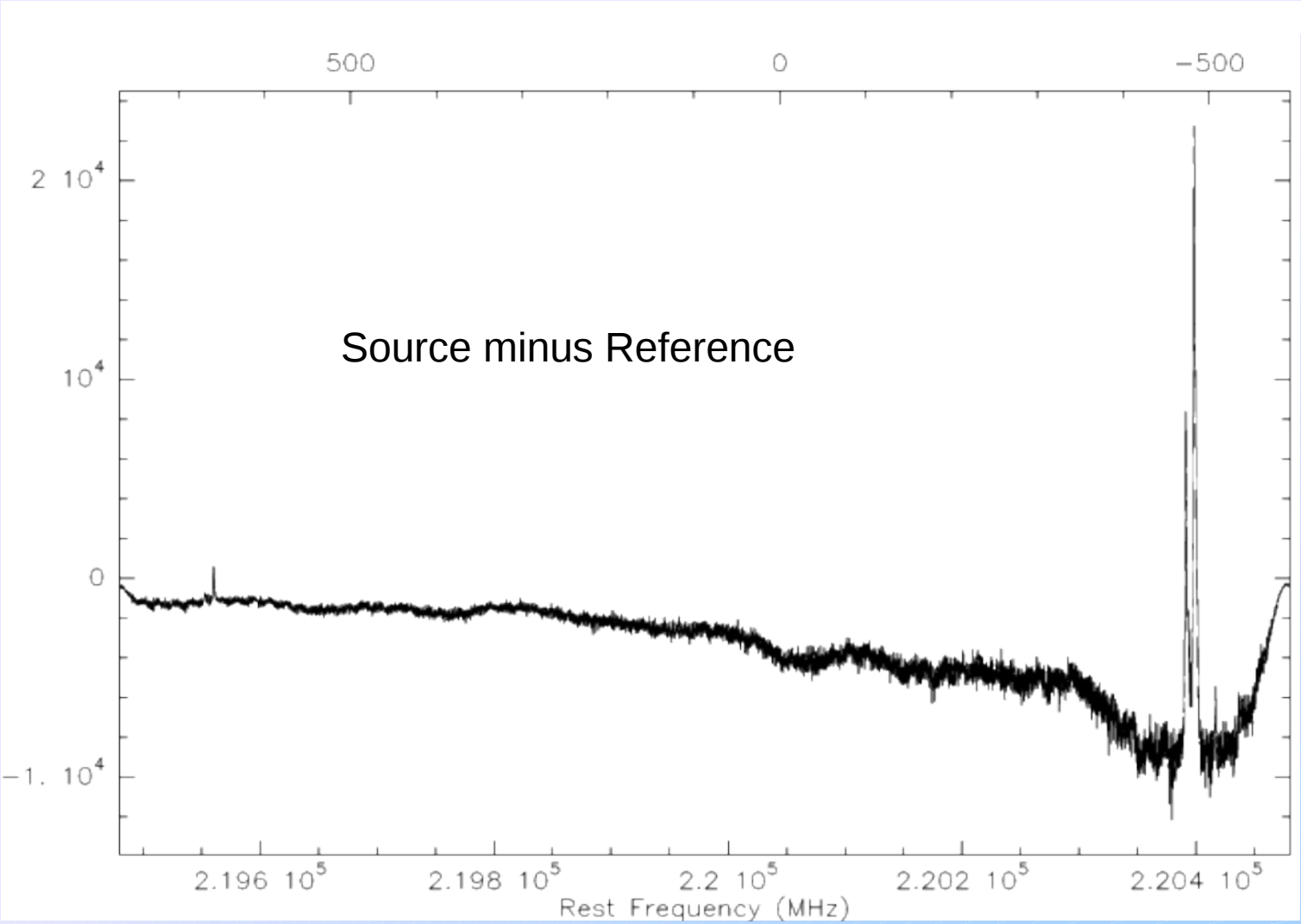
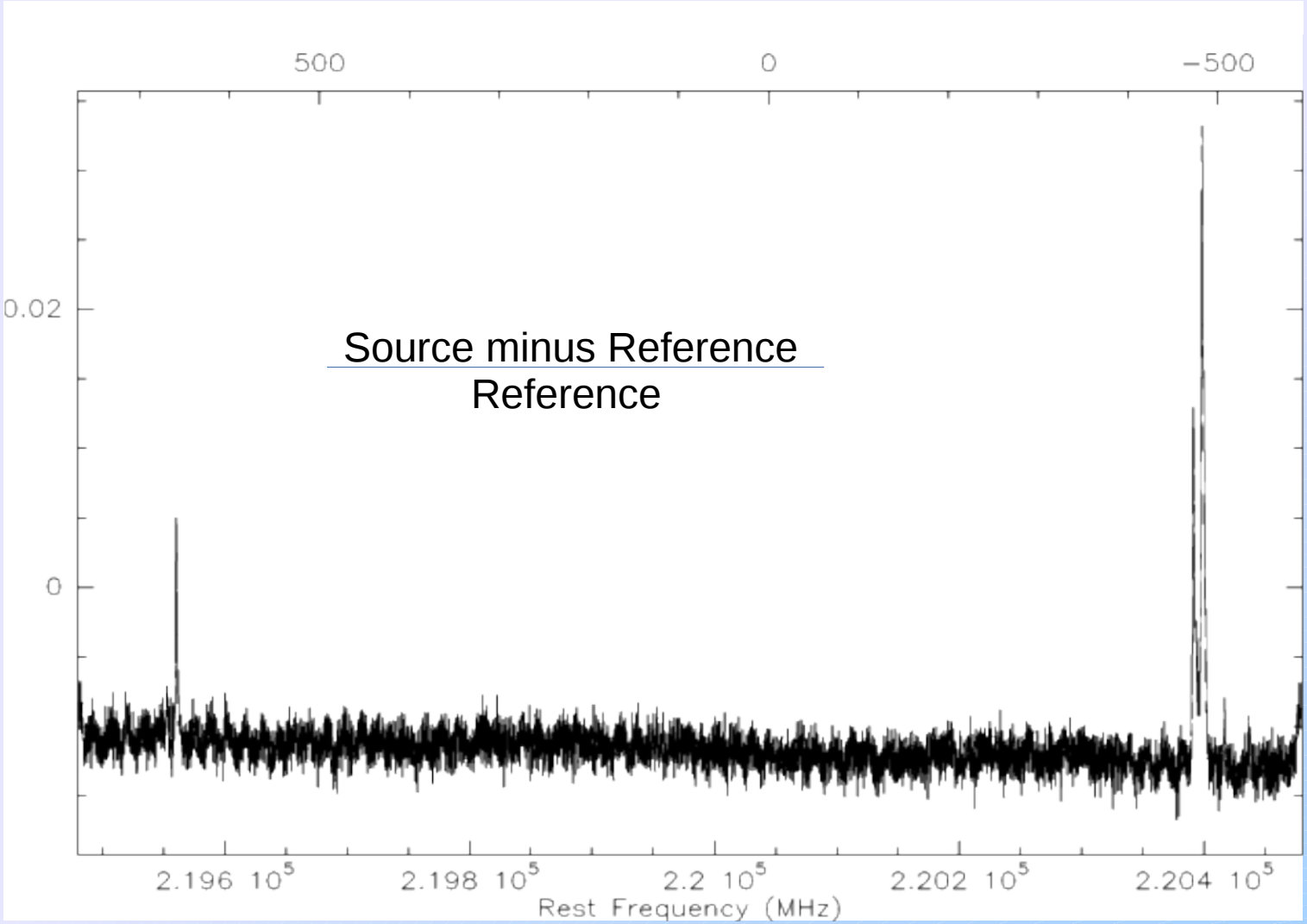
On-Off Method

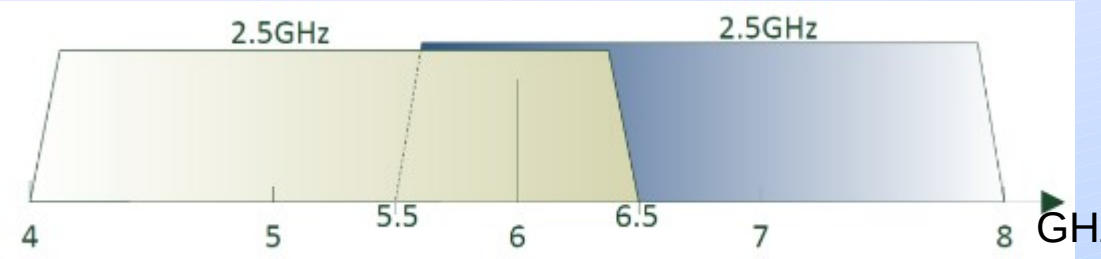


On-Off Method



Instrument Setups in APECS

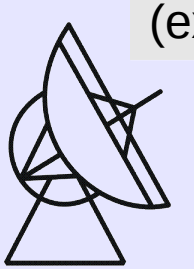
- “frontends” and “<frontend name>.backends” commands define the instrument chains
- Typically the heterodyne sideband bandwidth is larger than the backend bandwidth → need spectral stitching



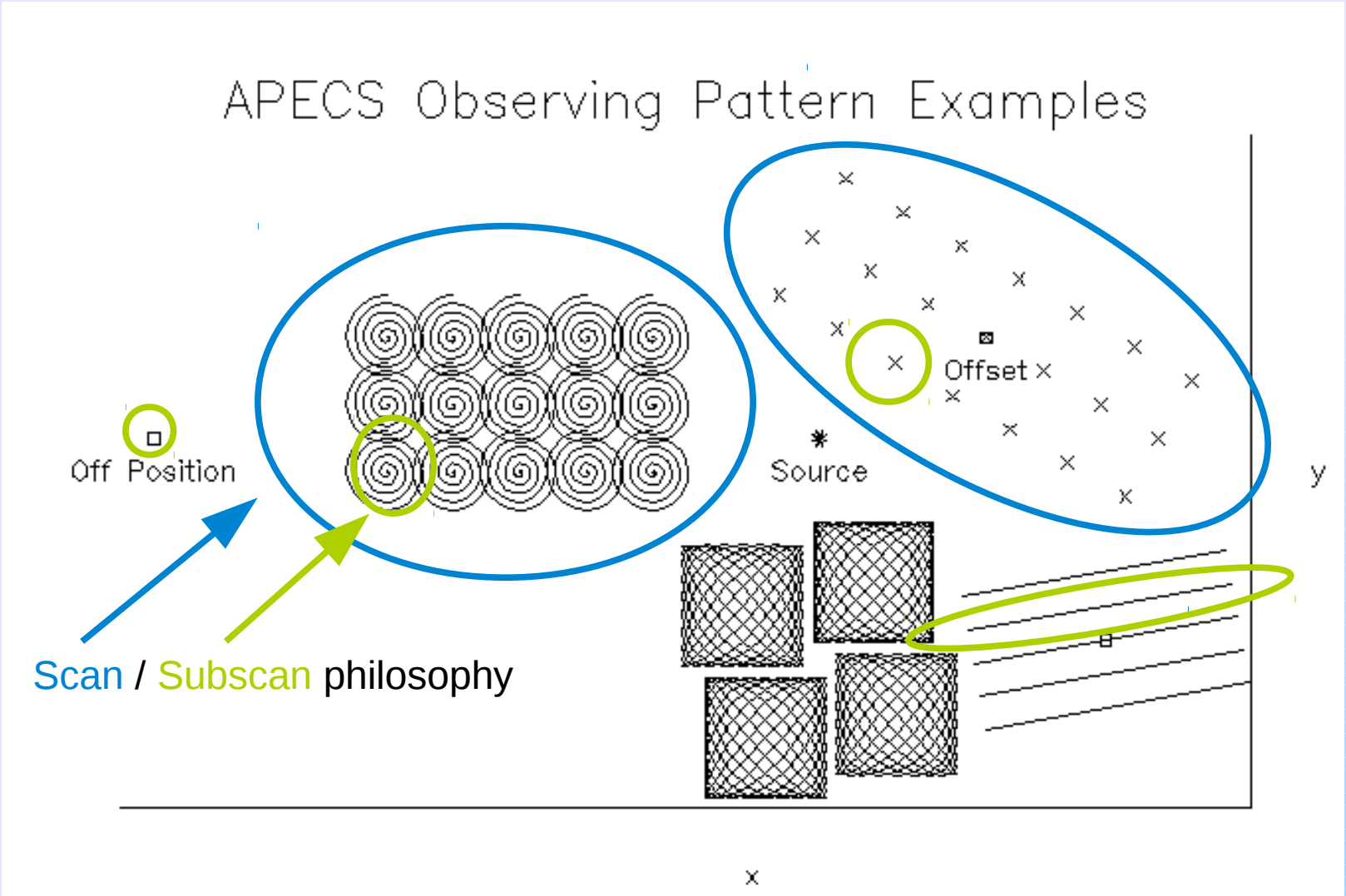
- Stitching via sky frequency offsets
- Complex details of LSB/USB, SSB/2SB setups coded in “setup_<frontend name>” commands

Observing Patterns

Pattern	Usage	Bolometer	Heterodyne
Single Point	Compact / Point sources Detection experiments		✓
Raster Maps	Rectangular; Dwell at given offset points; Small source extent		✓
On-The-Fly Maps	Move continuously across source while writing data; Large source extent	✓	✓
Spiral Raster Maps	Small to medium size with spirals per offset point	✓	
Hexagonal Raster (CHAMP)	Raster map with hexagonal offset pattern		✓
Lissajous Figures (experimental)	Allows for continuous long pattern in confined region	✓	



Patterns / Scan / Subscan



Observing Patterns

- More exotic options:
  - List of arbitrary offset positions as “on” subscans → surveys
  - “jiggle”: randomizes “on” subscan sequence
- Remember Nyquist sampling theorem by choosing at least half beam point spacing
- Avoid beam smearing in OTF setups ($\Delta \ll$ beam)
- All mapping patterns can be set up with a rotation angle to align them to the source morphology

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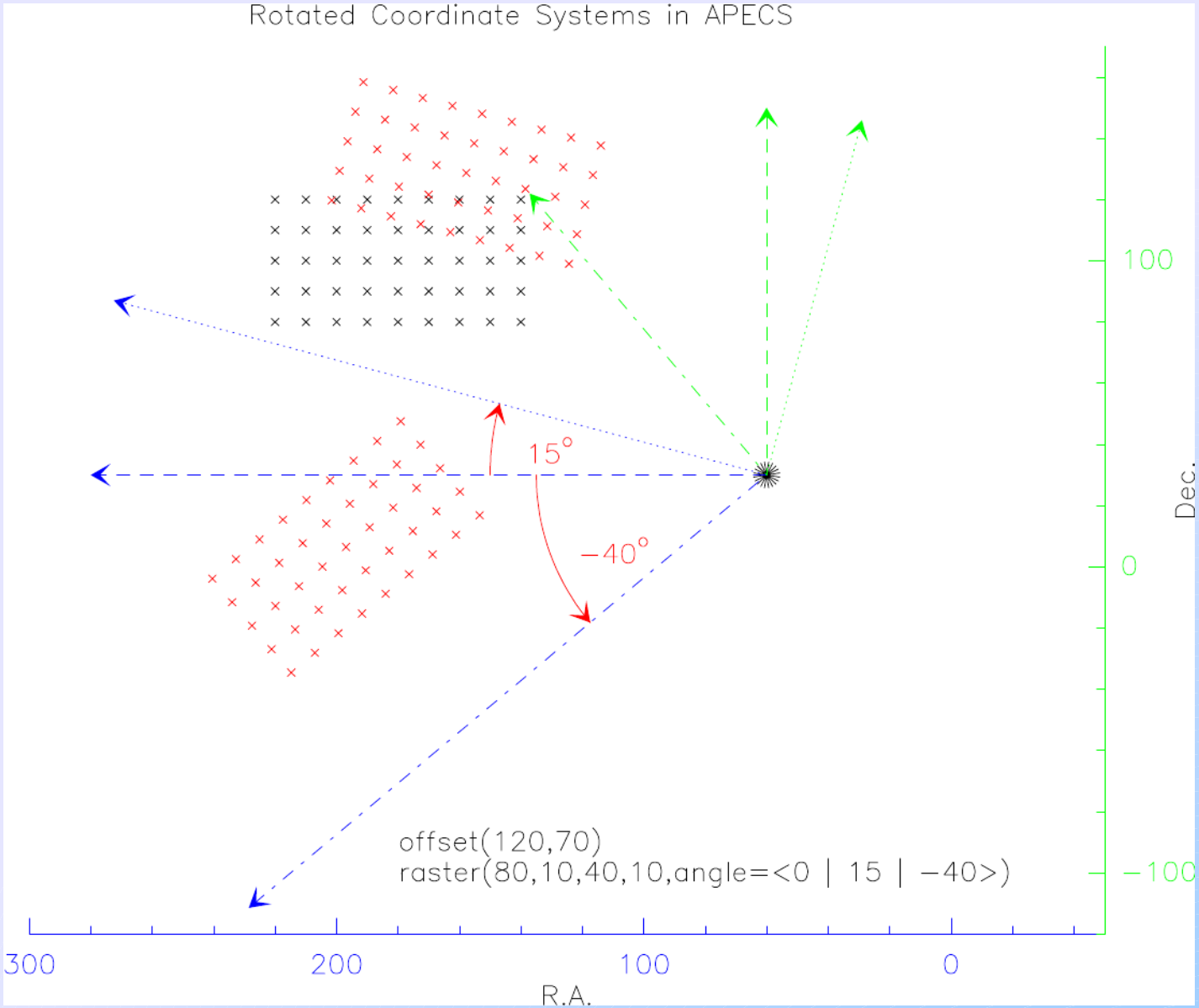
Rotated Patterns



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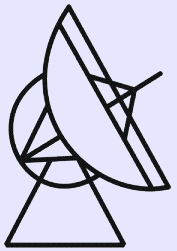
Typical Project Start Sequence

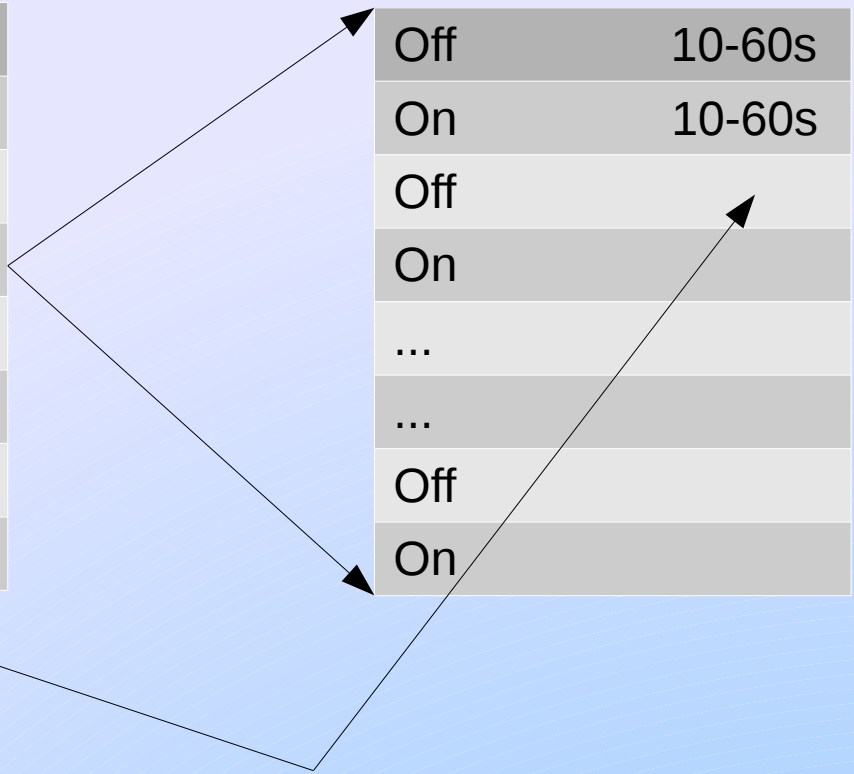
- For heterodyne: Sky-Hot-Cold calibration after tuning (*important: this sets the IF levels right*)
- In general:
  - Pointing; Focus & Pointing if at sun rise/set
  - Reference source (sky-hot-cold / skydip + on/off / spiral raster)
  - Science target (sky-hot-cold / skydip + patterns; pointing every 1-2 hours)



Science Target Observations

Sky-Hot-Cold / Skydip	
Pattern(s)	10-20 min
Sky-Hot-Cold	
Pattern(s)	10-20 min
...	
...	
Sky-Hot-Cold / Skydip	
Pattern(s)	10-20 min

Off	10-60s
On	10-60s
Off	
On	
...	
...	
Off	
On	



Times depend on weather and sky frequency

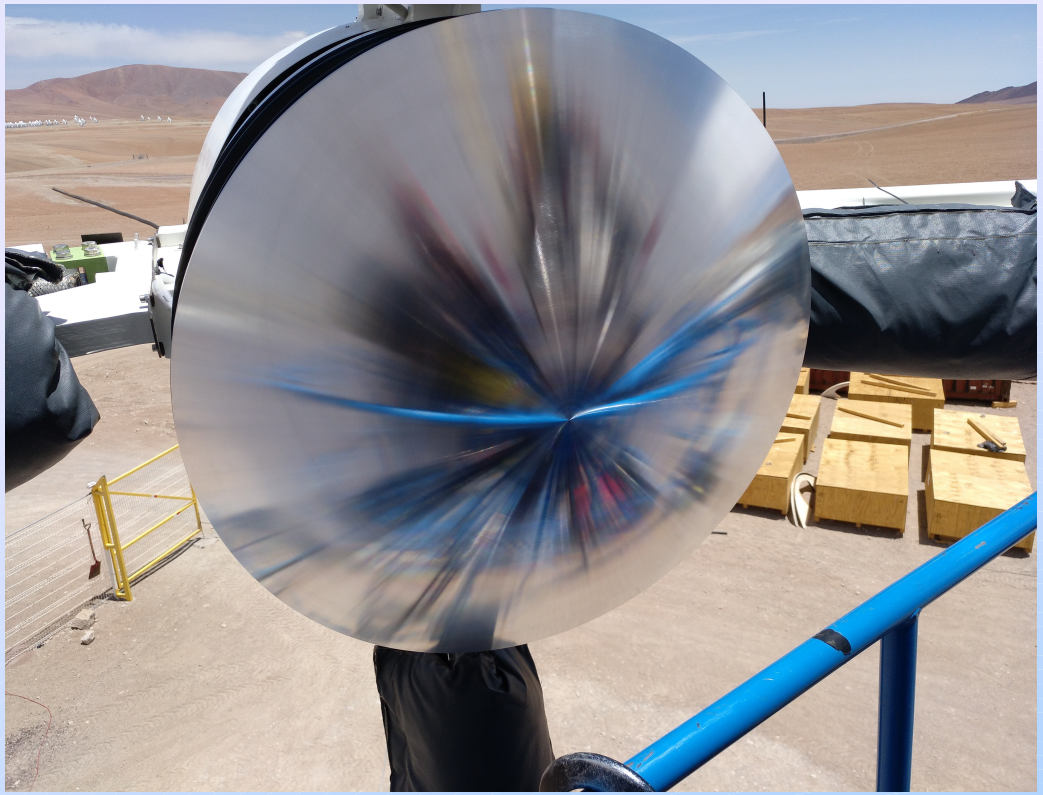
Caveat: very short subscan times (<10s) are very inefficient.

Embedded Calibrations

- Under very good observing conditions one can extend the time between two “off” subscans using the “on2off” parameter
- Longer scans (better time efficiency) can be set up with embedded sky-hot-cold calibration subscans via the “on2cal” parameter

Wobbler Switching

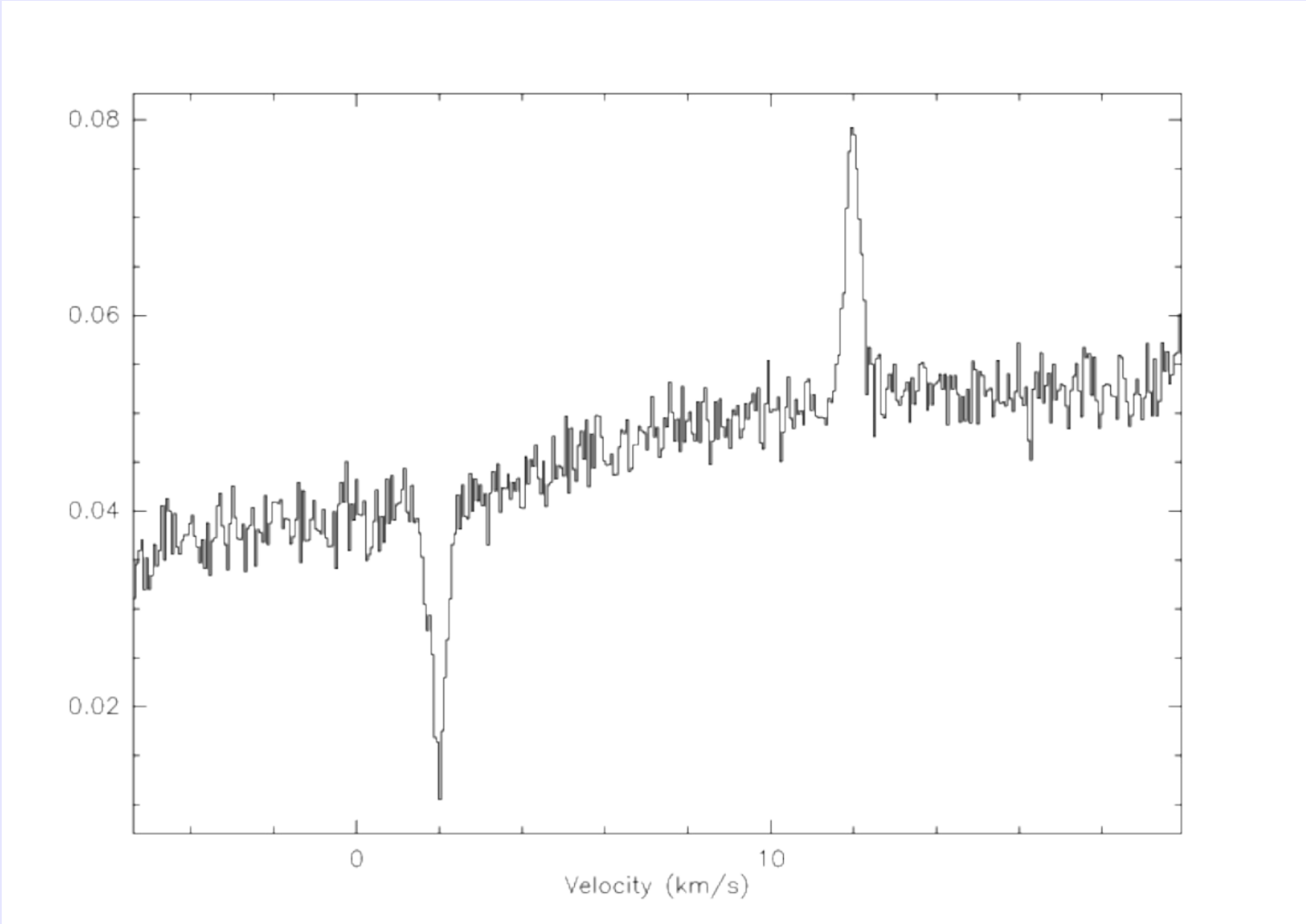
- A wobbler allows for very short switching times (at APEX down to 0.25 s) since only the M2 is moved, not the telescope
- There is a limited throw range (+/-300” for APEX-II), so the region has to be relatively compact
- Given the asymmetric illumination of the M2, one needs to combine two subscans with the source in the left and right beams



Frequency switching

- Another switching mode is to use two slightly (few 10 MHz) different tuning frequencies as the “On” and “Off” phases.

Frequency Switching



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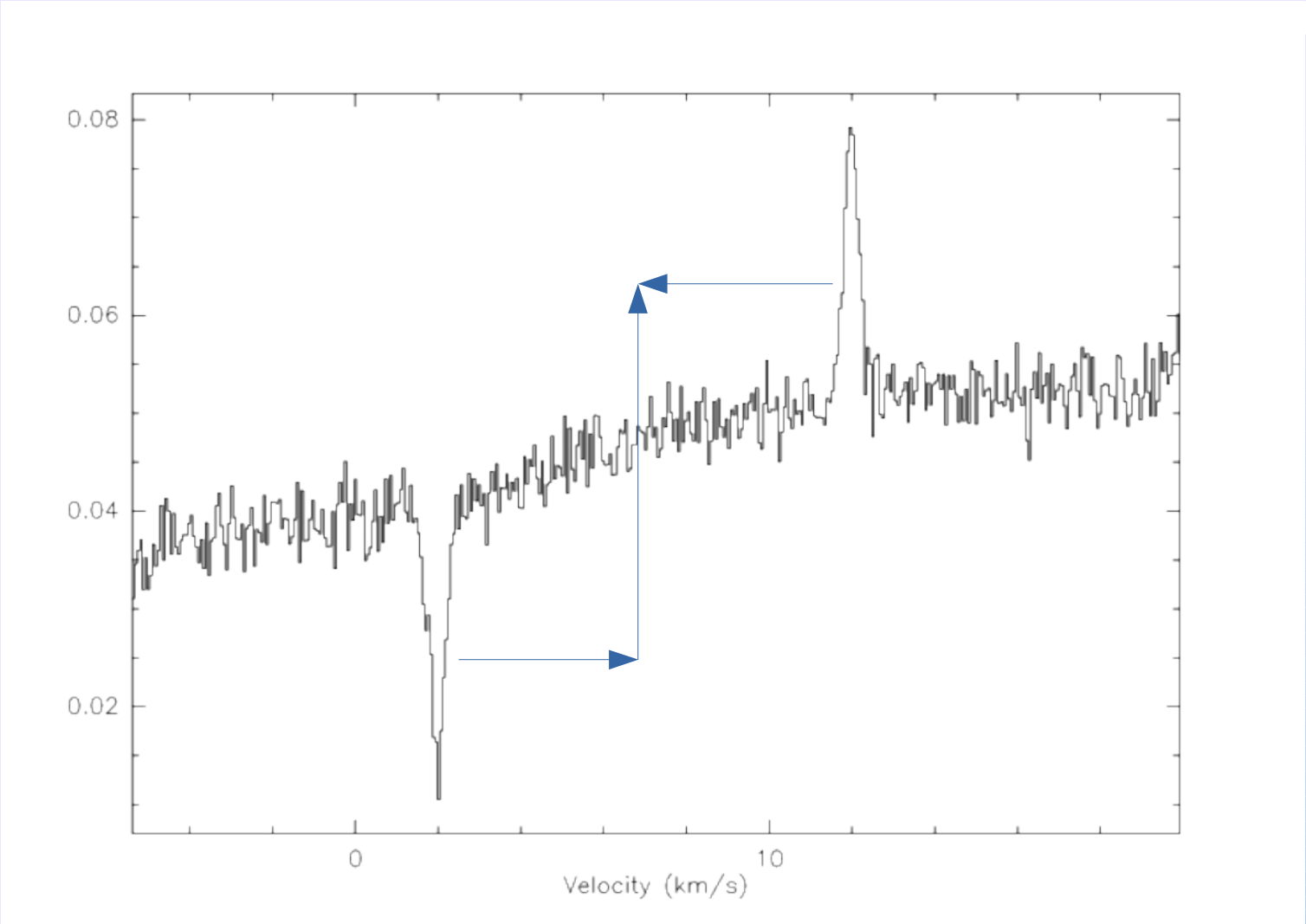
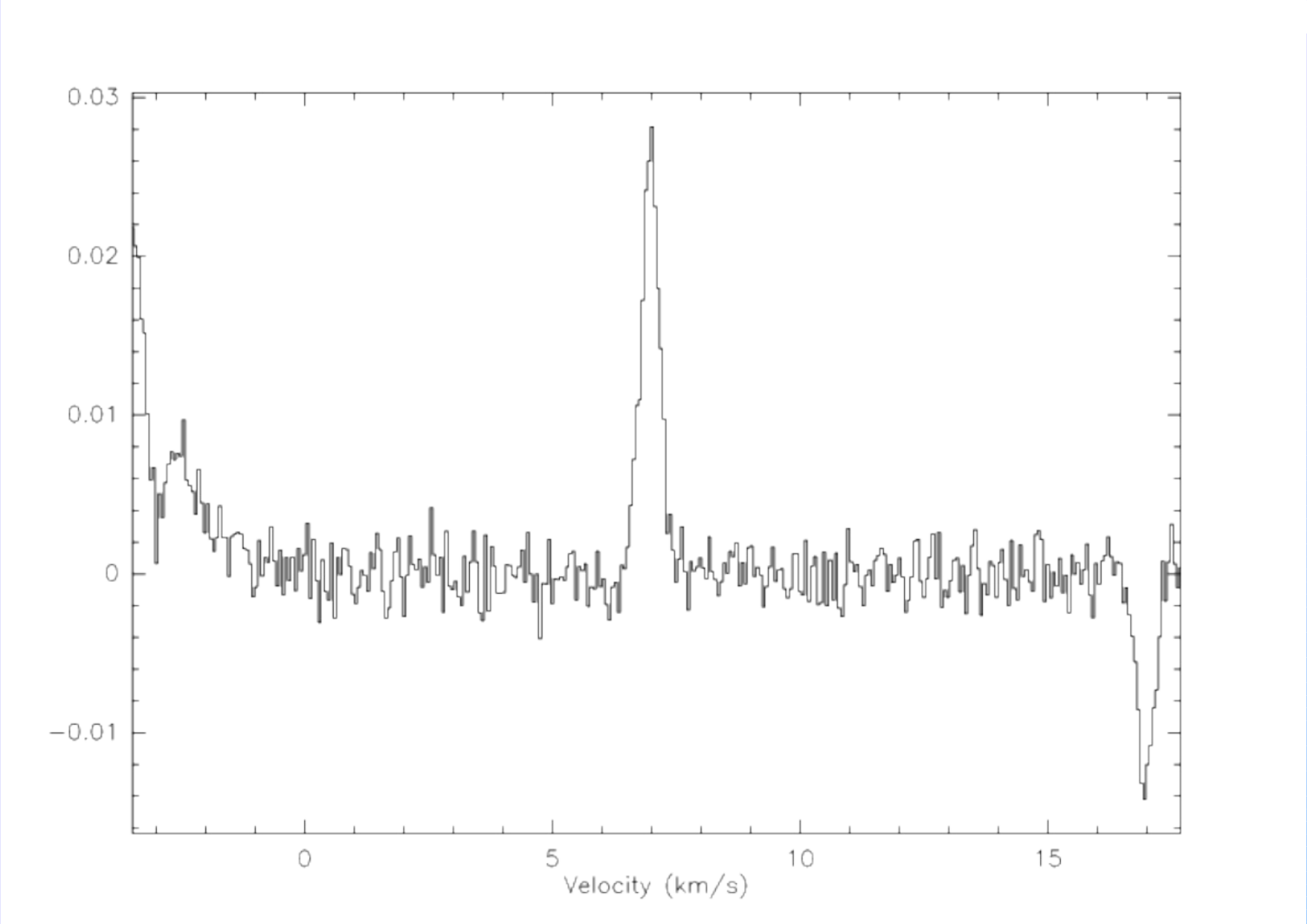
Frequency Switching

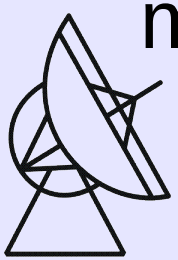


Frequency Switching



Frequency switching

- In principle one gains a factor 2 in observing time since the telescope is always on source.
- At APEX we found that the resulting spectral baselines have a significant structure making the spectra usable only for very narrow lines.
- To remedy this one would need to subtract a reference spectrum, thus canceling the time advantage. Still limits for line width. Thus the mode is not offered at APEX.



Data Products

- APEX data products are
  - Raw data (MBFITS)
  - Calibrated data (CLASS; T_A^*)
  - Observing logs
- The CLASS spectra's TELESCOPE variable is used to code instrument details as

  "AP-<2-char frontend abbrev.><2-digit pixel number>-<2-char backend abbrev.><2-digit section number>"

  Example: AP-F301-XF02 (FLASH345-XFFTS)

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References

- Guide to APEX observations from proposals to data reduction, APECS observing manual and observing time estimators can be found at

  www.apex-telescope.org/observing