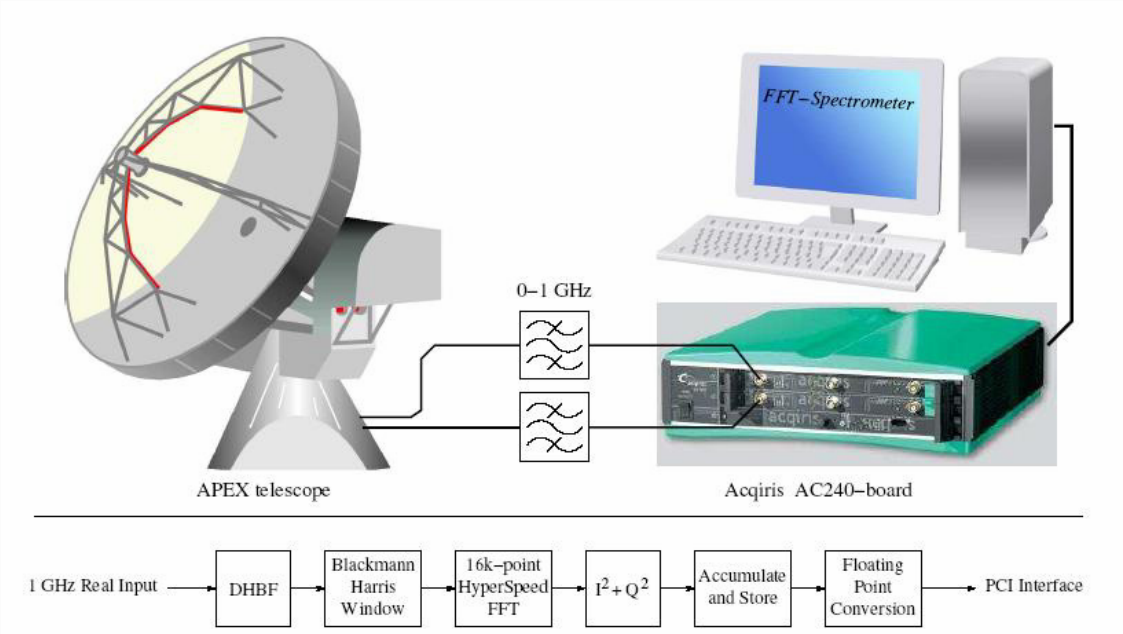
Fast Fourier Transform Spectrometer (FFTS)

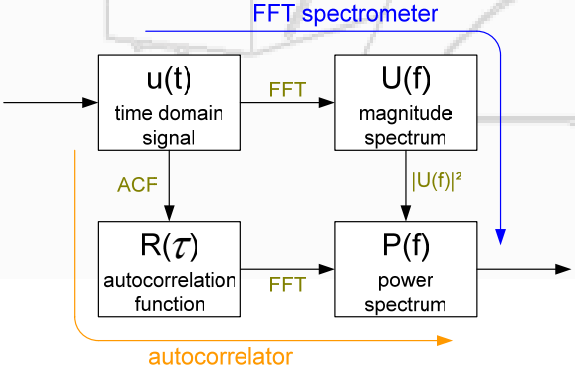
Today spectrometers offer useable bandwidth from a few kHz to 2GHz, with a few thousand spectral channels capable of resolving narrow spectral lines of masers and the thermal line emission of gaseous clouds. In the radio regime we can roughly identify three basic types of spectrometers: autocorrelators, acousto-optical spectrometers and filterbanks.



The APEX broadband FFTS is able to cover a frequency-bandwidth of up to 2x1 GHz using two commercially available ADC boards. - The lower flow illustrated the FPGA signal processing pipeline.

Spectrometer Technology

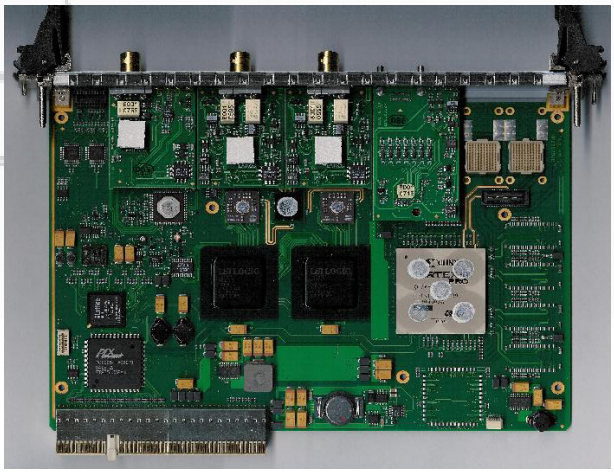
The rapid increase in the sampling rate of commercially available analog-to-digital converters (ADCs) and the increasing power of field programmable gate arrays (FPGAs) chips has led to the technical possibility to directly digitize the down-converted intermediate frequency (IF) signals of coherent radio-receivers, and to transform the digital signal into a spectrum in real-time.



"Wiener-Khinchin-Theorem": FFT spectrometer implement an alternative approach for obtaining the power spectrum of a given time signal.

With continuous bandwidths of the order of 500MHz-1GHz and very high spectral resolution (e.g. 16384 frequency-channels), the FFT spectrometers have big advantages in comparison to traditional radio-spectrometers.

The currently most powerful card commercially available is from ACQIRIS; it employs two 1 GigaSample/sec ADCs, which feed a XILINX Virtex 2 Pro 70 FPGA chip.



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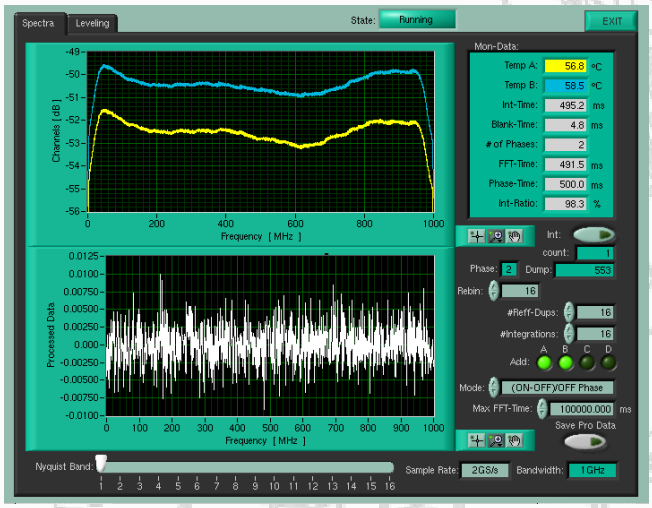
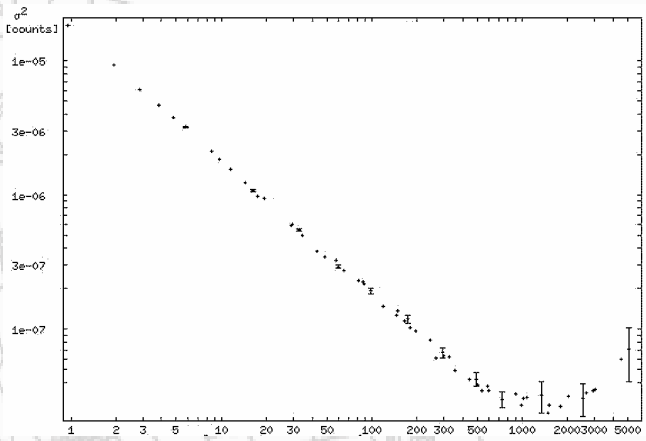
Advantages of digital FPGA based FFT Spectrometers

- high monolithic bandwidth (currently, up to 1 GHz)
- full signal sampling of 8 bit or more
- up to 2^{15} frequency channels (current) FPGA chips
- no additional calibration through implicit power measurements
- higher sensitivity and stability cf. autocorrelator
- modular design and simple reproducibility
- low space and power requirements – thus safe to use at high altitude (e.g. APEX)
- decreasing costs per GHz due to commercial digital design

→ **Future perspective**:
Increasing bandwidth with decreasing costs.



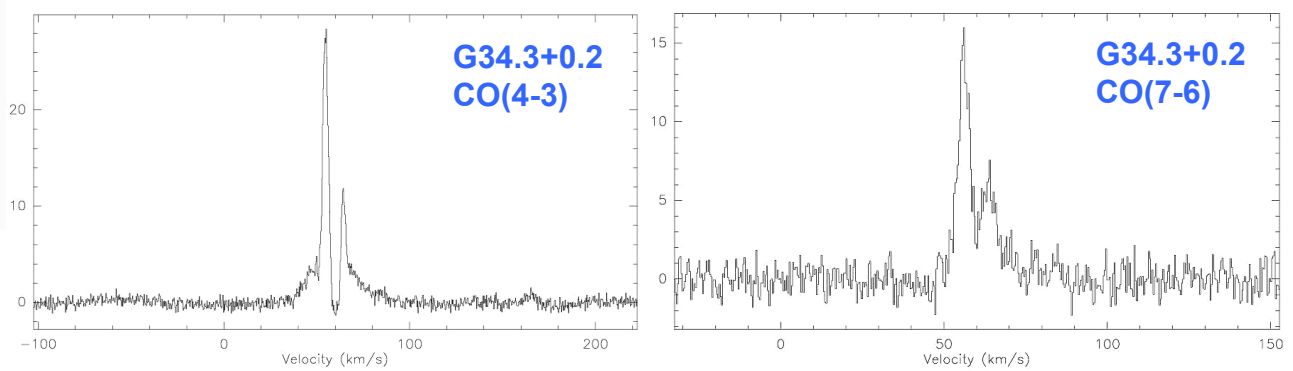
Allan Variance Plot of the APEX FFTS stability



The measured Allan Variance of APEX FFTS shows extremely high stability resulting in possible integration times of more then 1000 seconds.

Screenshot of the user-friendly LabView-Interface to the APEX FFTS. This interface can be used for online data quality control as well as system debugging during installation phases of various receivers. – In the upper panel the two receiver-bandpasses are shown. In the lower panel a sky integration is displayed.

Scientific application of APEX FFTS



First sample spectra on G34.3+0.2 in the CO(4-3) and CO(7-6) obtained with the APEX FFTS in combination with the FLASH receiver in the 460 and 810 GHz atmospheric windows (see dedicated flyer)