

Chirped Pulse Fourier Transform Microwave Spectrometer



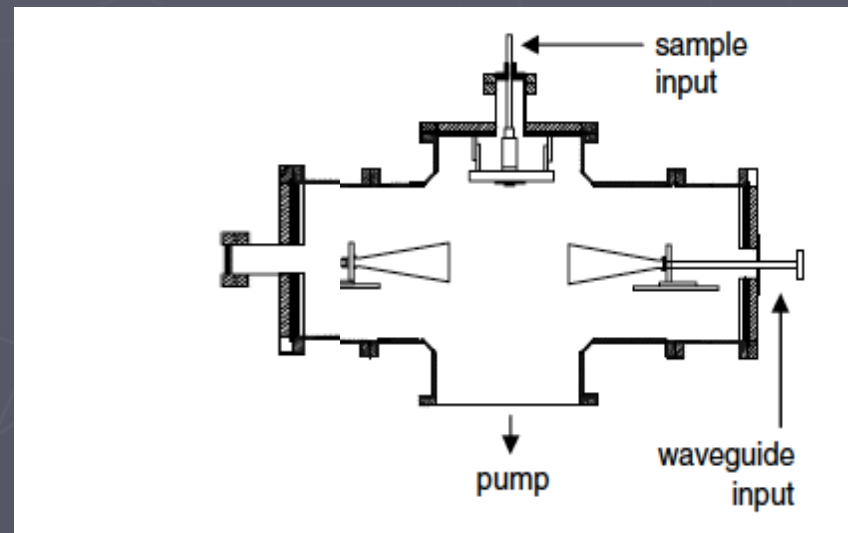
Principles of a Fourier Transform Microwave Spectrometer

- ▶ pulsed molecular expansion into chamber
- ▶ microwave excitation pulse
- ▶ pulse terminated, spontaneous coherent emission
- ▶ signal detection, signal digitized in o-scope, FT to have frequency domain spectrum

Principles

- ▶ pulsed molecular beam perpendicular to the MW pulse propagation
- ▶ amplified chirped pulse MW pulse excite mol.
- ▶ MW stops, rotational FID occurs
- ▶ emission collected by digitizer in O-scope, fast F.T.

side view of the molecular beam chamber



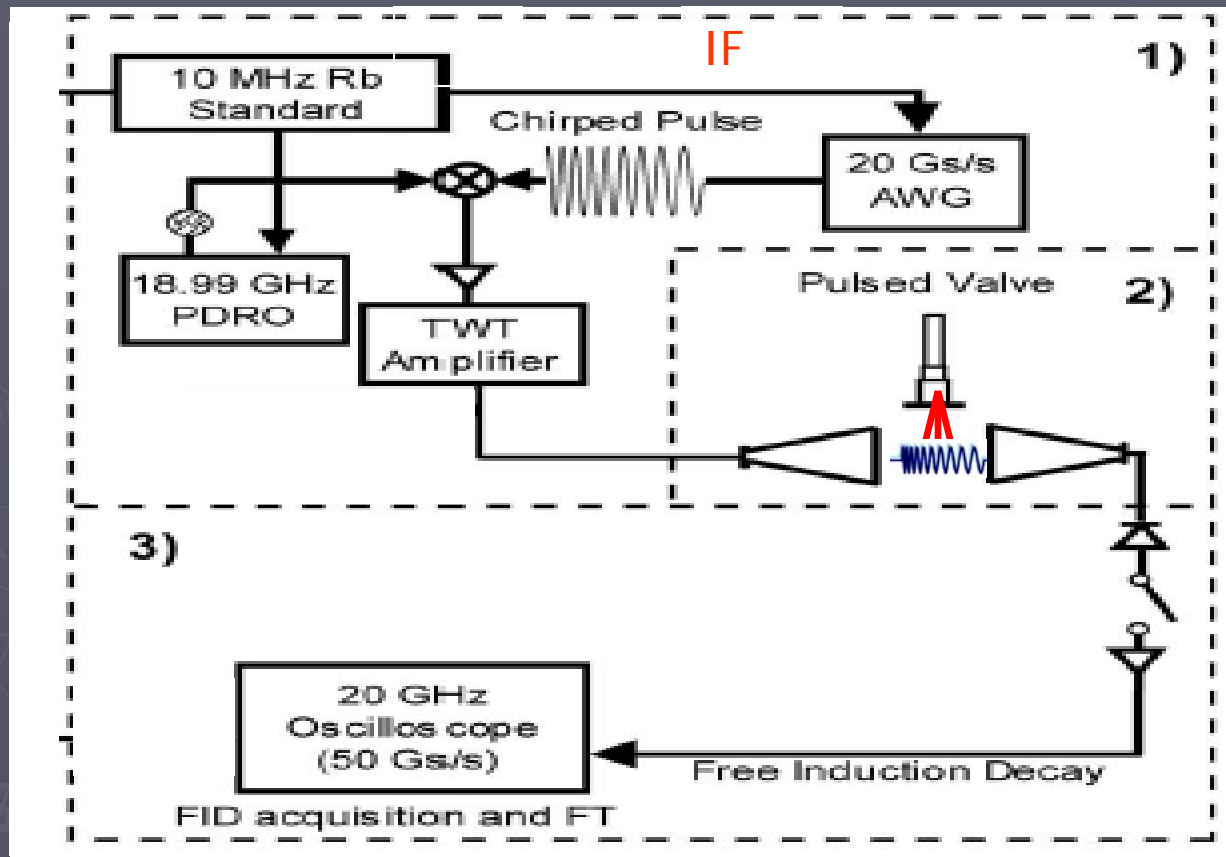
- ▶ reference to G.G. Brown et al. *Journal of Molecular Spectroscopy* 238 (2006) 200-212
- ▶ Jaeger group research *Fourier Transform Spectroscopy*

Chirped pulse FTMW spectrometer

► components:

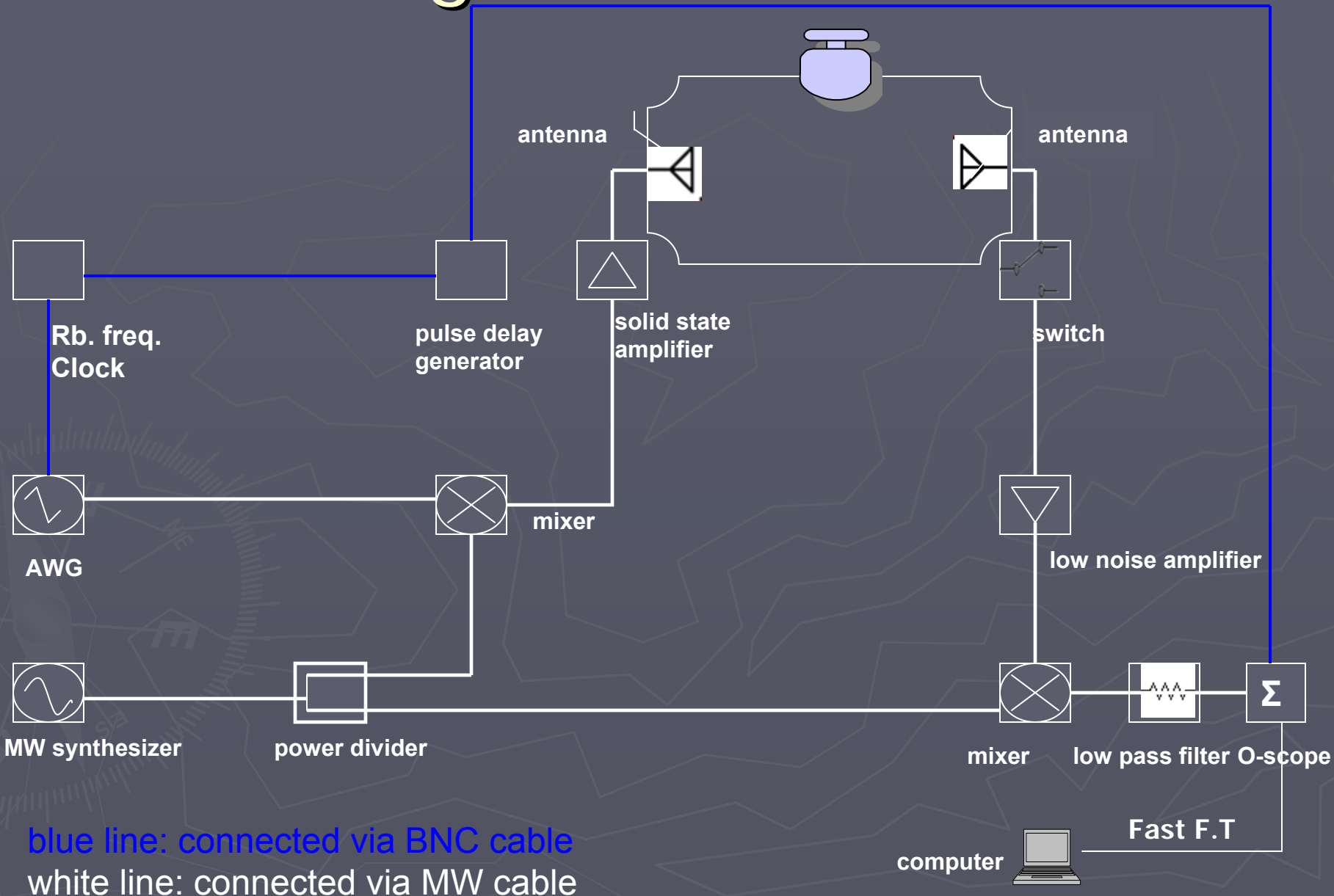
- i. chirped microwave pulse generation
a linear frequency sweep 7.5 to 18.5 GHz
- ii. MW excitation pulse and molecular beam
sample interaction region
- iii. detection of molecular emission

Simplified Schematic Diagram of CP-FTMW Spectrometer



- ▶ 1. chirped pulse generation
- ▶ 2. sample interaction region
- ▶ 3. FID detection

Circuit Diagram for CP-FTMW



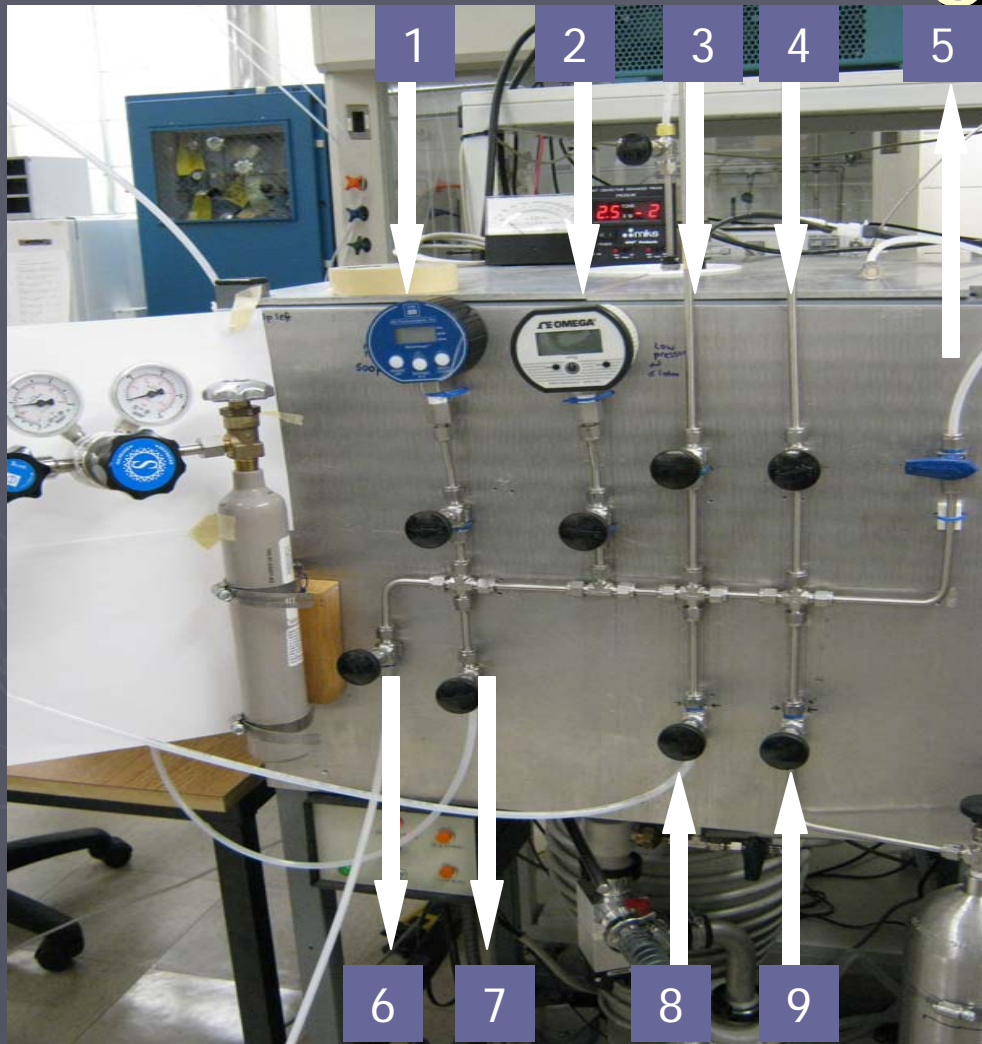
Chirped Pulse Generation

- ▶ AWG a chirped pulse with linear freq sweep from 250 MHz to 1.85 GHz. The chirped pulse is mixed up with a fixed frequency from a microwave synthesizer (ν)
- ▶ mixing -> a "split" chirp lower band $\nu-2100$ MHz to $\nu-250$ MHz, and upper band $\nu+250$ to $\nu+2100$ MHz
- ▶ then amplified to a power of 5W with solid state amplifier
- ▶ chirped pulse radiated onto molecular sample by means of a broadband, high gain horn antenna
- ▶ molecular sample is prepared using a pulsed nozzle
- ▶ FID is collected by a high gain horn antenna, then protected amplification (consist of power limiter, and low noise amplifier)
- ▶ signal down converted with a mixer and signal ν from MW synthesizer
- ▶ resulting down-converted molecular signal 250-2100 Mhz, is digitized and fast Fourier transformed on a broadband o-scope.

linear sweep pulse

- ▶ sweep range for the pulse is linearly related to the pulse duration (t_{pulse})
- ▶ CP provides a separation of the bandwidth and the pulse duration: allow to control frequency and amplitude of field delivered to sample
- ▶ efficient at polarizing the sample: the maximum amount of pulse energy, limited by T_2 , can be delivered to the sample for any excitation bandwidth
- ▶ CP is favored for large bandwidth measurements compared to transform limited pulse shapes.

Gas Handling System



- ▶ 1. Pressure gauge (high P)
- ▶ 2. Pressure gauge (low P)
- ▶ 3. Sample inlet (He)
- ▶ 4. Sample inlet (Neon)
- ▶ 5. Mixture to nozzle
- ▶ 6. To pump
- ▶ 7. Ventilation to fumehood
- ▶ 8. Sample inlet (e.g. OCS)
- ▶ 9. Sample cylinder

What can be achieved by it?

- ▶ fast, short spectrum acquisition times
7.5-18.5 GHz in one acquisition vs.
22000 measurements with a cavity FTMW
spectrometer (bandwidth ~500 kHz).
- ▶ gives accurate relative intensities
- ▶ sensitivity

References

- ▶ Brian C. Dian, et al. *Science* **320**, 924(2008) Measuring Picosecond Isomerization Kinetics via broadband Microwave spectroscopy
- ▶ Garry S. Grubbs II, et al. *Review of Scientific Instruments* 78,(2007) A Search Accelerated Correct Intensity Fourier Transform Microwave Spectrometer with Pulse Laser Ablation Source
- ▶ Picture of chamber retrieved from http://www.pcgg.de/abstract_image/abs_hansmann.jpg on June 3rd 2010
- ▶ nozzle expansion http://www.buchi.com/Spray_Drying_Processes.681.0.html retrieved on June 3rd 2010