The Chirp Transform Spectrometer (CTS) is the only heterodyne real-time spectrometer backend that was successfully flown on a deep space mission so far. A version with 180 MHz bandwidth and 4096 channels was operated in space without any problems between the Rosetta launch in 2004 and the end of the mission in 2016 as part of the MIRO (Microwave Instrument of the Rosetta Orbiter) instrument. A new version with 1 GHz bandwidth and 100000 spectral channels in under development for the JUICE-SWI (Jupiter Icy moons Explorer – Submillimeter Wave Instrument) instrument. It is based on the same basic principles, however, is using a higher degree of digital technologies which results in higher flexibility (e.g. programmable input bandwidth, center frequency, spectral resolution etc.), more than 6 times lower mass and about 2.5 times lower power consumption than the MIRO version. The first full representative model of the SWI-CTS is available since of end of July 2019. The shape of this model and all components will be already flight-like. From August to November 2019 the functional performance of the CTS will be tested and environmental tests will be performed. This presentation will illustrate the development progress.

**CTS Functional Principle**
- While the MIRO-CTS was placed into two tops of 305x20x cm³ volume, the SWI-CTS fits into one tray with a volume of 75x12x4.4 cm³. The main components integrated into the tray are:
  - (i) Radio frequency (RF) processing board. Its purpose is to amplify, filter, multiply and combine the time signal to be Fourier transformed, the premultiplying chirps and the signal representing the result of the analogous Fourier transform.
  - (ii) SAR filter (square delay line, DDL) mounting. The analog Fourier transform is performed by the DDLs in convolving the product of input signal and chirp.
  - (iii) ASIC board including chirp generator and digital preprocessor. See SWI CTS block diagram.
  - (iv) DDL temperature control electronics: the DDLs are based on the piezoelectric substrate LiNbO₃. The speed of the surface acoustic wave on this substrate is temperature dependent. While in the MIRO-CTS the use of DDLs for chirp generation has some compensating effect, using a digital chirp generator requires a very stable temperature environment for the convolving DDLs. The DDLs are required to be stable within 0.1 K over the operational temperature range.

**MIRO CTS Block Diagram**

**SWI CTS Block Diagram**

**Explanation of CTS Functional Principle**
- Applies linear FM pulse to matched filter
- Matched filter is a dispersive delay line based on SAW principle
- The pulse response of the matched filter to the linear FM pulse (chirp) is a band limited delta function. The power spectrum of delta function and chirp are identical, just the phase spectrum differs.
- Adding a mixer between chirp and DDL offers the function of shifting the chirp in frequency. Due to the linear frequency-time relationship this leads to a shift of the delta function in time.
- This is expressed by the chirp transform algorithm (see CTS Functional Principle), which is equivalent to the Fourier transform.
- The spectrum at the output of the DDL is complex. It is split in real and imaginary components by a 90°-deg. power divider.
- Power of phase spectrum are then calculated by $R_e = |R_e|^2$ respectively $\tilde{R}_e = |\tilde{R}_e|^2$ respectively.
- In practice either a lookup-table or a digital multiplier/divider is applied.

**CTP tray side with RF-processing board**

**DDL mounting & ASIC board including CG and PP**

**Including DDL temperature control electronics**

**References**