

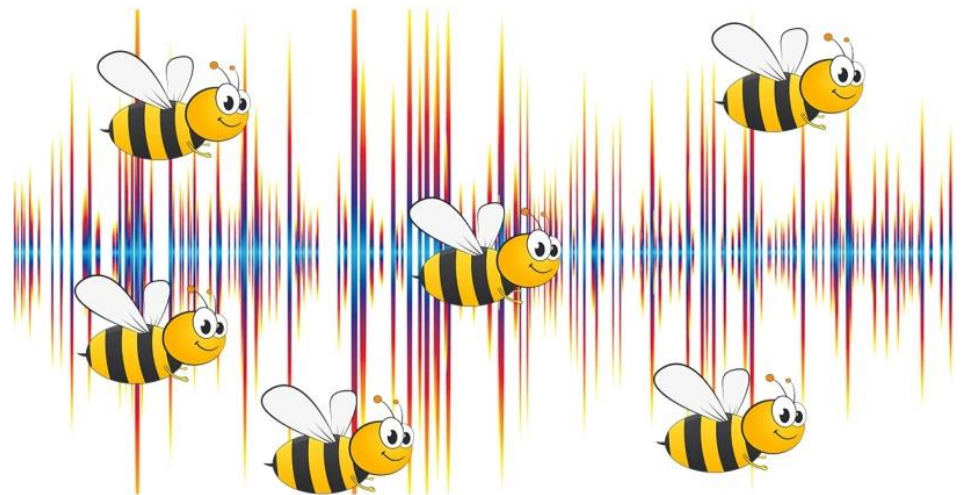


BEEP

Audio analysis and BEEP

Wouter Brok / BEEP meetup / 26012019

- Elements of sound
- History / commercial / academic
- Within the context of BEEP
- Tests done so far
- Outlook



Elements of sound



- Background sound vs. communication signals
- Airborne sound vs. substrate vibrations

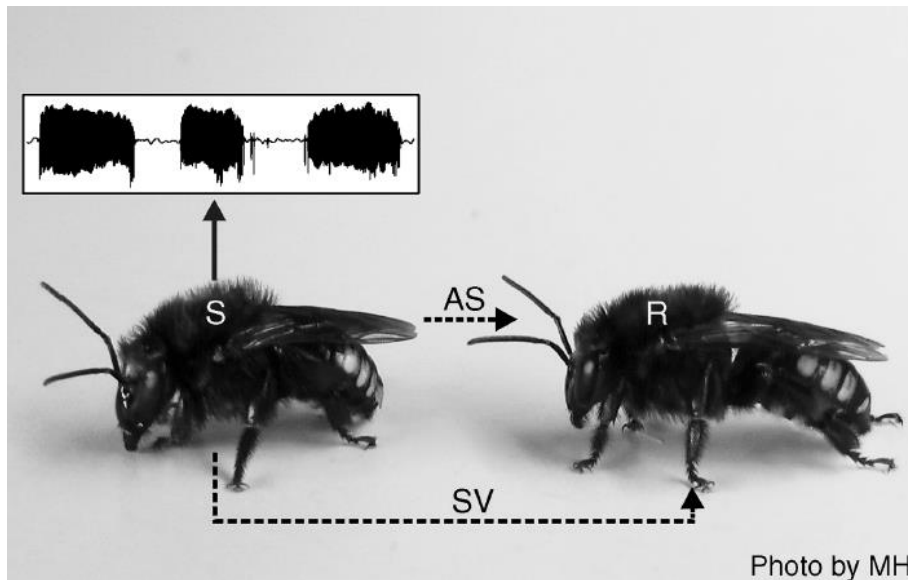
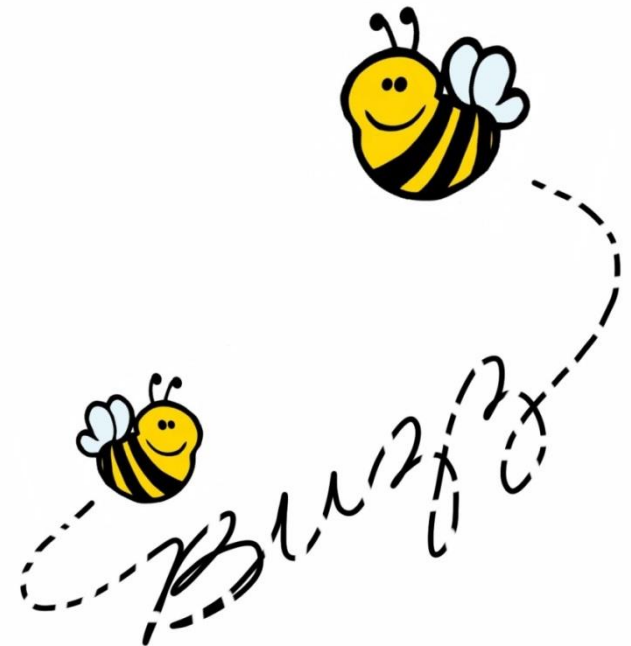


Photo by MH

cf. Insect Sounds and Communication: Physiology, Behaviour, Ecology, and Evolution. edited by Sakis Drosopoulos, Michael F. Claridge, CRC Press, 2005. [url](#).



Audio analysis in history



- Virgil – Georgics IV (BC)
- E.K. Eskov (1970s)

... and many more to follow



ЗВУКОВОЙ ФОН ПЧЕЛИНОЙ СЕМЬИ

Е. К. ЕСЬКОВ

*Научно-исследовательский институт пчеловодства
(г. Рыбное Рязанской области)*

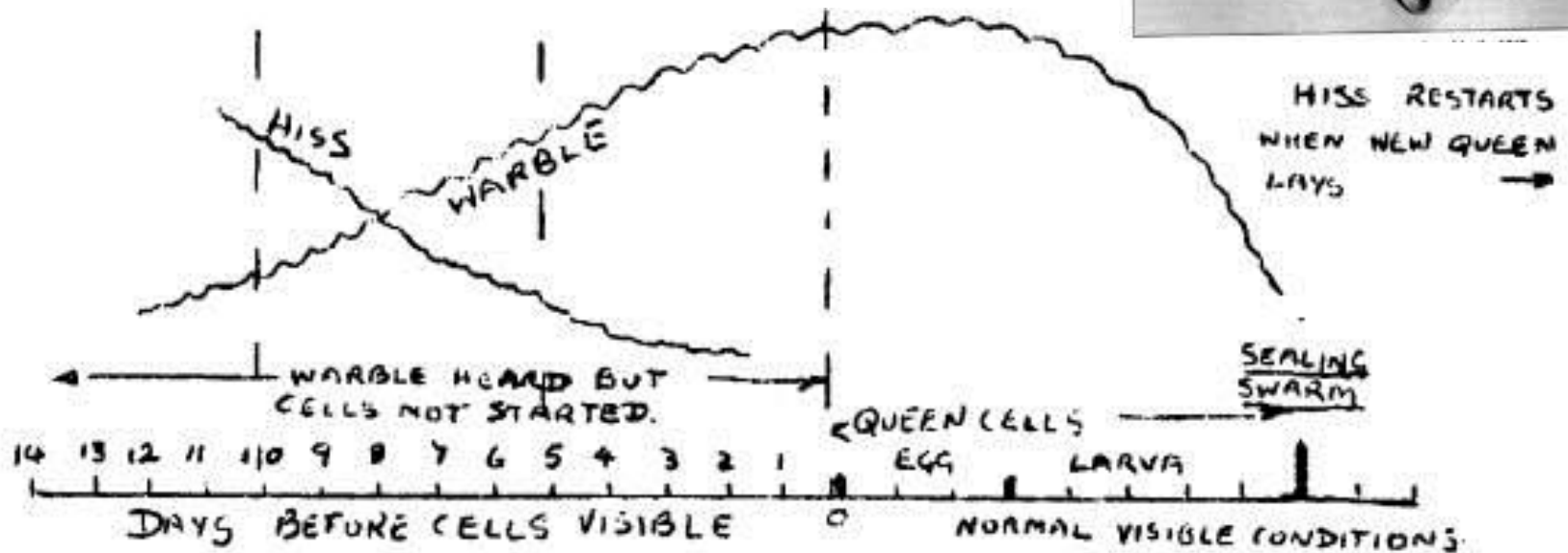
Звуковой фон семьи, находящейся в нормальном состоянии, лежит в диапазоне частот от 20 до 12 000 гц (динамический диапазон интенсивностей 40-86). Стабильные частотные составляющие лежат в диапазоне от 60 до 500 гц. Спектральные показатели звукового фона имеют четко выраженную сезонную цикличность. Соотношение интенсивностей частотных компонентов в стабильной зоне спектра закономерно изменяется в связи с изменением биологического состояния пчелиной семьи, что может быть использовано практическим пчеловодством. Некоторые звуки, из которых складывается звуковой фон улья, могут иметь для его обитателей сигнальное значение.

Audio analysis in history



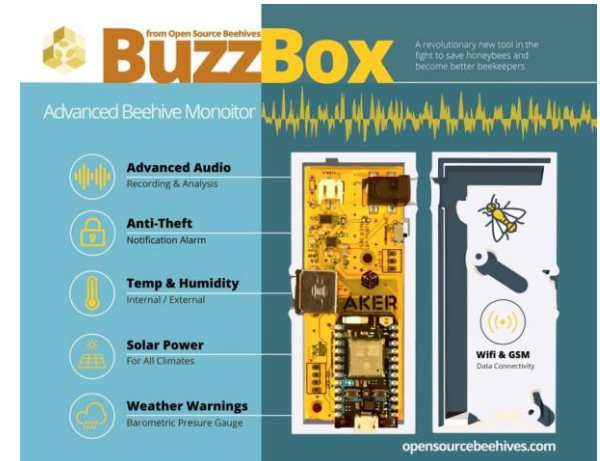
- Virgil – Georgics IV (BC)
- E.K. Eskov (1970s)
- **E.F. Woods – Apidictor (1950s)**

... and many more to follow



Modern Apidictors

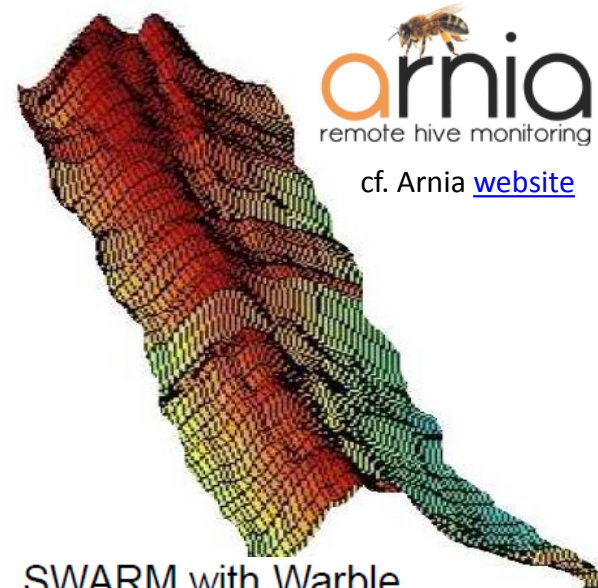
- OSBeeHives (US)
- Arnia (UK)
- Apivox Auditor (RU)
- ... others



cf. OSBeeHives [website](#)



cf. Apivox Auditor [website](#)



cf. Arnia [website](#)

Literature



- There is lots of scientific literature available
- Mostly on communication (tooting, piping, etc.) and on identifying swarming events
- List of papers found so far is available in case you are interested
- 100 – 600 Hz is a very interesting frequency window !!

(see next slide)

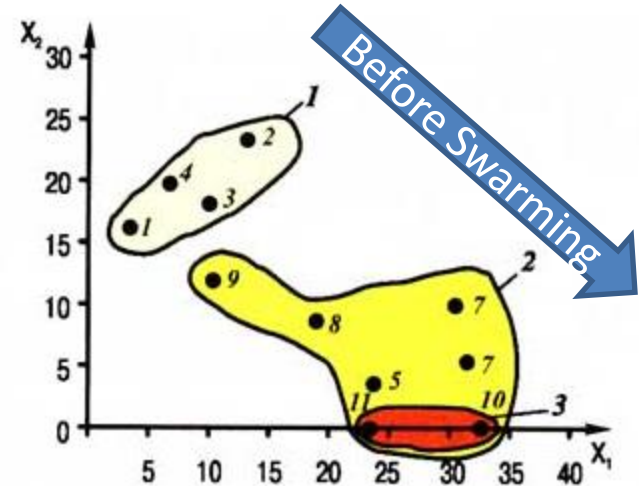


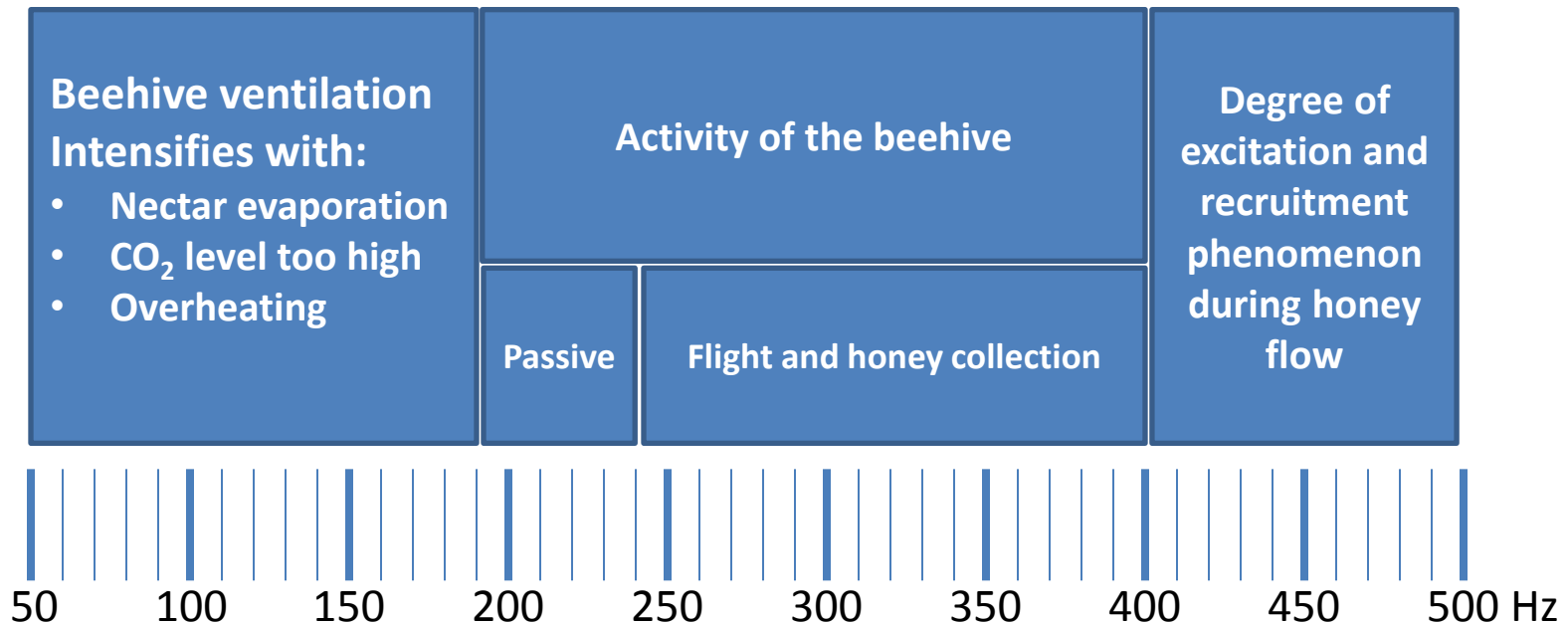
Рис. 1. Состояние семей: 1 — рабочие; 2 — подготовка к роению; 3 — выход роя

See for example: [hyperlink](#)

Sound map



During summer



**Higher frequency indicates higher intensity / excitement.
Greater amplitude indicates that more bees are involved in this work.**

cf. Apivox Auditor [website](#)

Within the context of BEEP

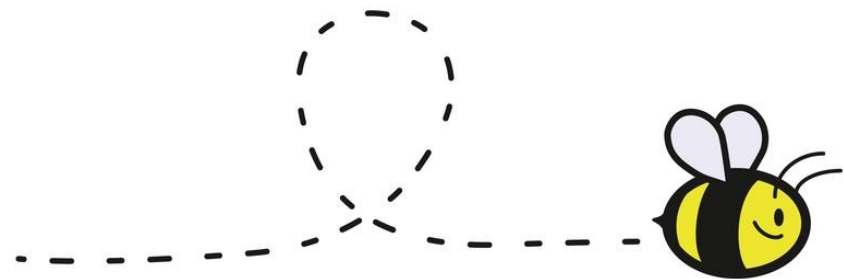


- Sensor system requirements:
 - Accessible and affordable: low bill of materials
 - Deployable in “remote” places: low power, high range radio
- You can only have two out of three characteristics: long distance, high bandwidth, and/or low power
- Low power wide area (LPWA) networks have limited bandwidth, but enable low power and high range.
- LoRaWAN (anno 2015) satisfies these requirement.
- Bandwidth worst case: 14 packages of 51 bytes per day.

Challenges



- How to extract and recognize relevant features related to the status of the hive
 - How to encode such that relevant information is maintained but the data is shrunk in order to be wirelessly transmitted and stored.
- How much processing needs to be done in the sensor node ??



So ... Let's try it



The Hiveeyes Community

Using the Adafruit Feather M0 LoRa (RFM95) and TTN

Entwicklung / Development

Funkinfrastruktur / Wireless infrastructure

ttn, lorawan, lora



clemens

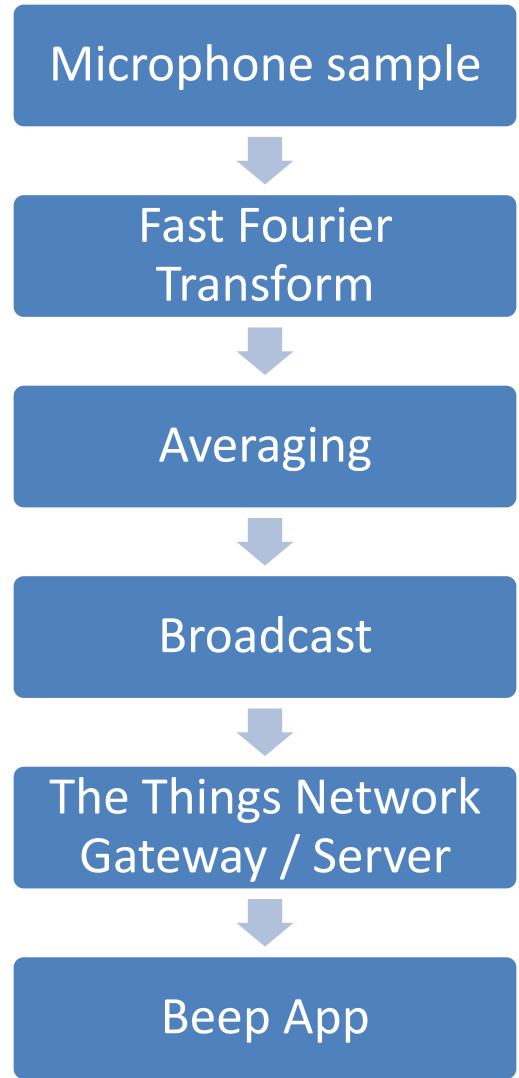
9 Oct '17

For a first LoRaWAN-Test I used the [Adafruit Feather M0 with RFM95 LoRa](#) ⁶⁵ as Hardware to send test data to [The Things Network](#) ¹³.

There are some tutorials out for the Feather LoRa. Be aware that you get this device in two flavors: The “**32u4**” with an ATmega32u4 as processor and the “**M0**” with ATSAMD21G18 ARM Cortex M0.

For memory reasons and for the option [recording sound via the I2S interface](#) ¹⁰ I would **recommend the M0!**

Implementation

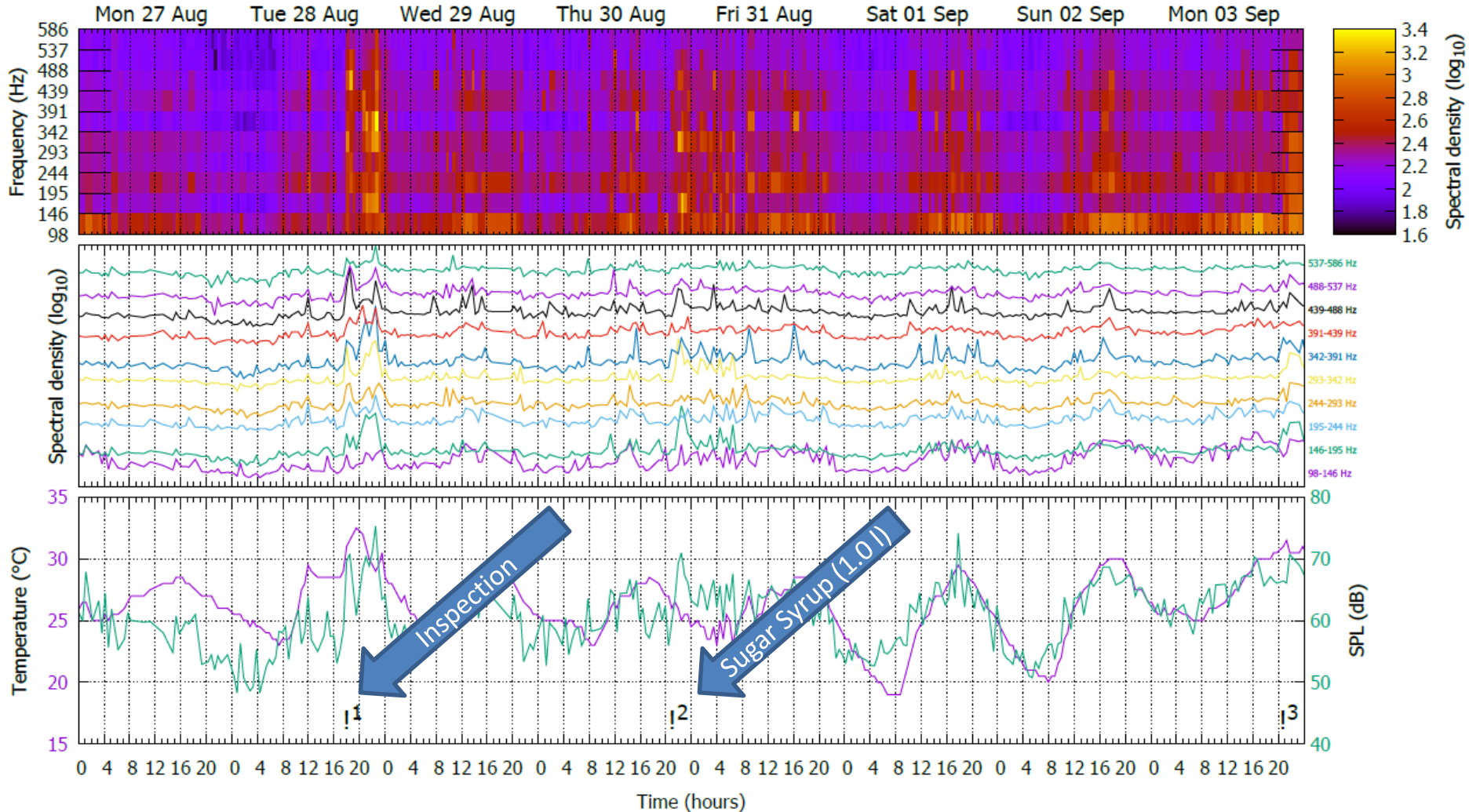


Data



BEEP

Feather M0 LoRa data / Wouter Brok / 27 Aug - 03 Sep 2018

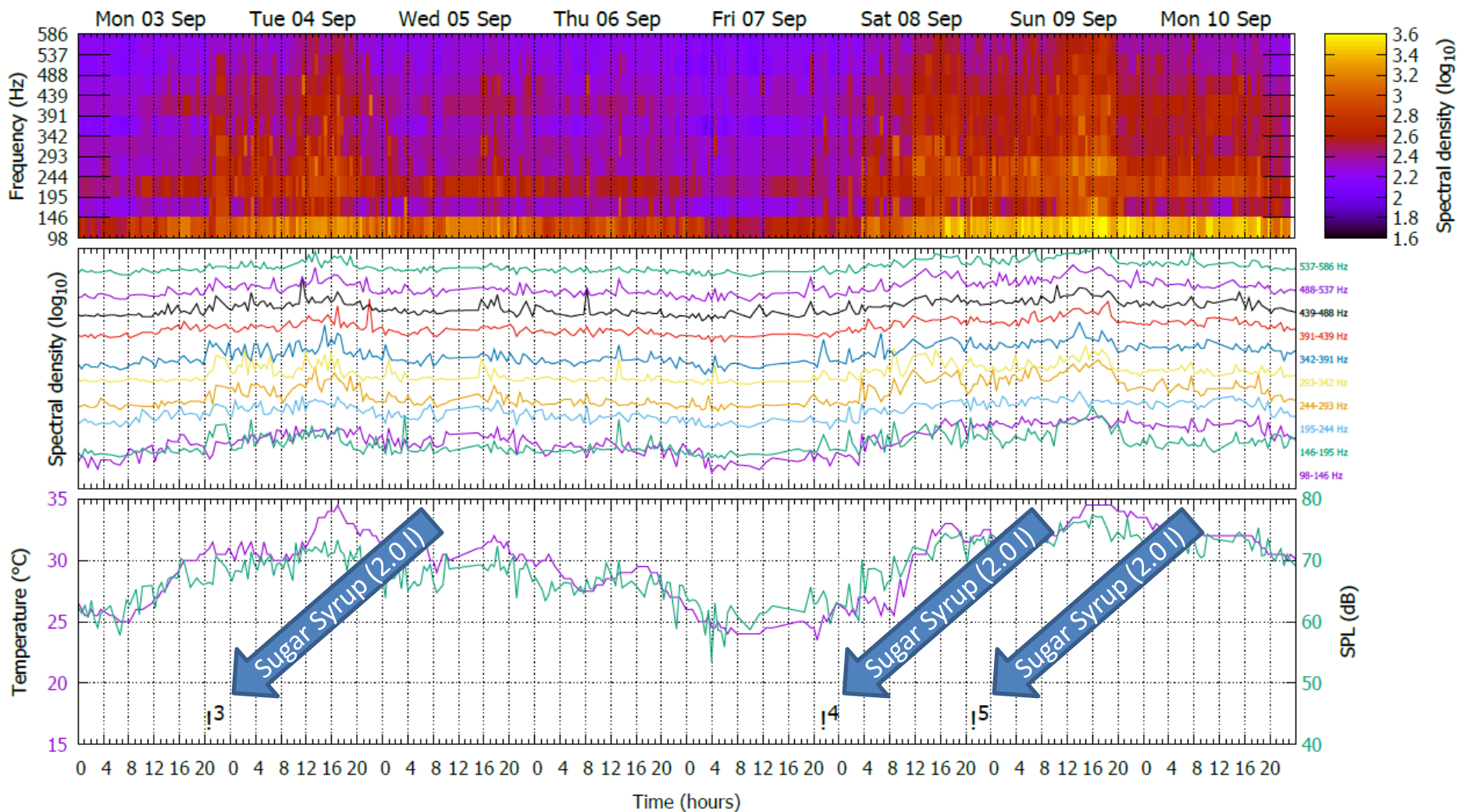


Data



BEEP

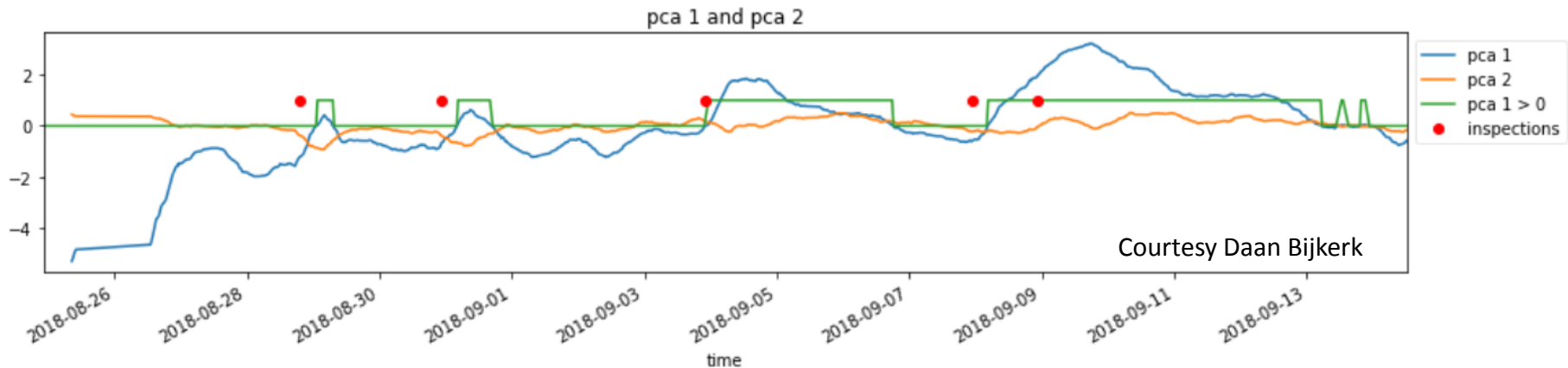
Feather M0 LoRa data / Wouter Brok / 03 - 10 Sep 2018



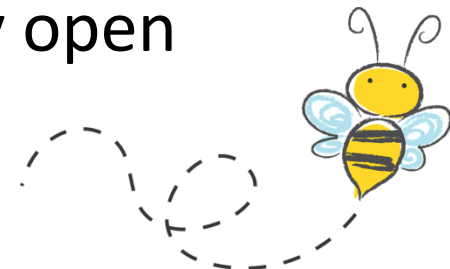
Further analysis



- Principle component analysis showed sensitivity to certain events



- Amount of data is too limited to be conclusive
- How/where to process data is completely open



Conclusion / Outlook



- Looking at sparse FFT data already gives interesting information: e.g. when the feeder is empty.
- Key question: how much processing in the sensor node and which data to make available for further processing?
- Much to do in terms of hardware choice, algorithms on the sensor node, server-side data processing, data labelling, etc.

