# IEEE 802.15.4 transceiver for the 868/915 MHz band using Software Defined Radio

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# Outlines

1. Background of IEEE 802.15.4 PHY specifications

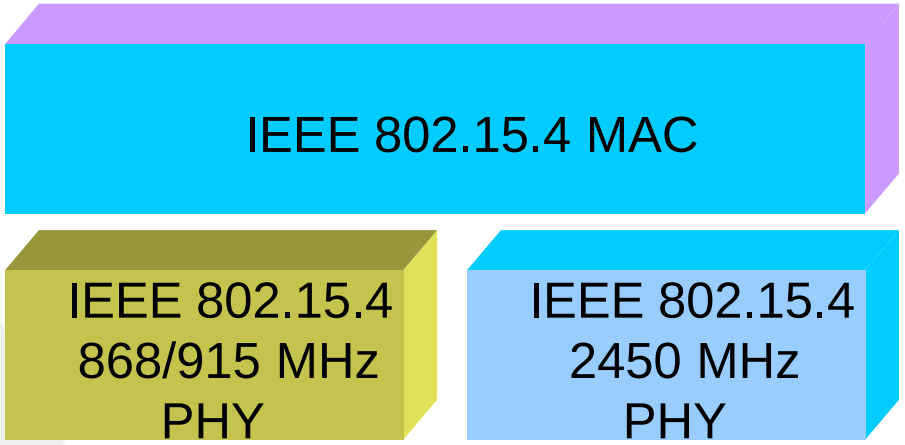
2. Software Implementation on GNU Radio

- Software architecture
- Transmitter
- Receiver

3. Experimental approaches and results

4. Conclusions and perspectives

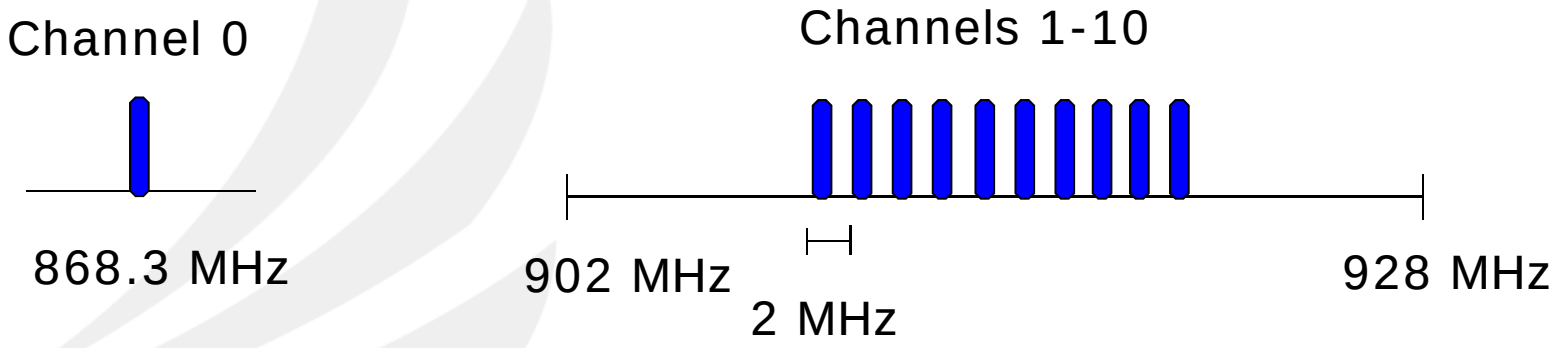
# IEEE 802.15.4 PHY specifications




- Low Rate WPAN (LR-WPAN)
- Simple
- Low cost
- Low power consumption E.g. Sensor networks
- Data rates: 20-40 kbps (868/915 MHz) 250 kbps (2450 MHz)

# IEEE 802.15.4 PHY specifications

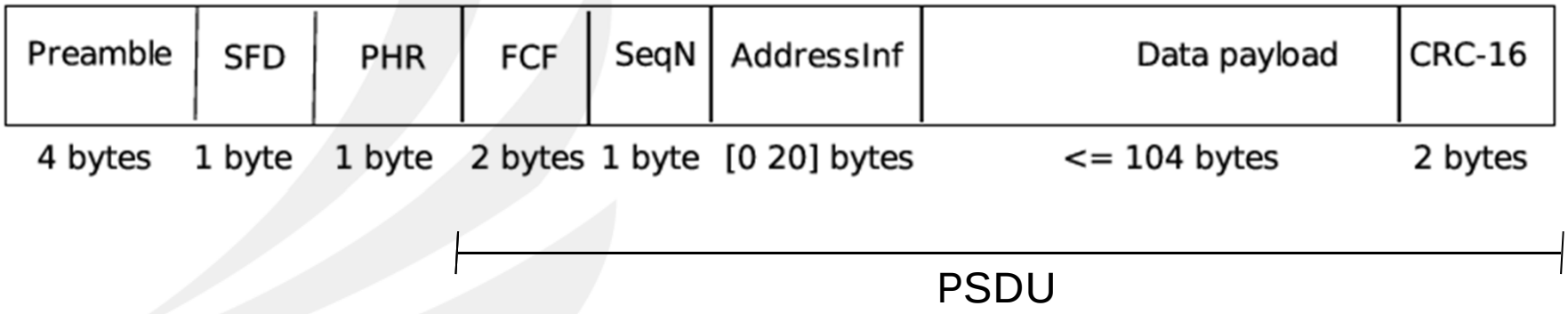
| PHY (MHz) | Frequency band (MHz) | Spreading parameters | | Data parameters | | |
|---|---|---|---|---|---|---|
| | | Chip rate (kchip/s) | Modulation | Bit rate | Symbol rate (ksymbol/s) | Symbols |
| **868/915** | **868-868.6** | **300** | **BPSK** | **20** | **20** | **Binary** |
| | **902-928** | **600** | **BPSK** | **40** | **40** | **Binary** |
| 2450 | 2400-2483.5 | 2000 | O-QPSK | 250 | 62.5 | 16-ary Orthogonal |



# IEEE 802.15.4 PHY specifications

**PHY packet structure :**

- Synchronisation → Preamble sequence ( 4 Bytes)
- Start of Frame Delimiter → ( 1 Byte)
- PHR or PHY Header → PSDU length (1 Byte)
- PSDU = FCF+SeqN+ AddressInf+ Data payload+CRC-16



# Software Implementation on GNU Radio

How do i change the transcrive parameters to adapt it to my requirements


Software implementation of my transceiver gives me the flexibility to change these parameters

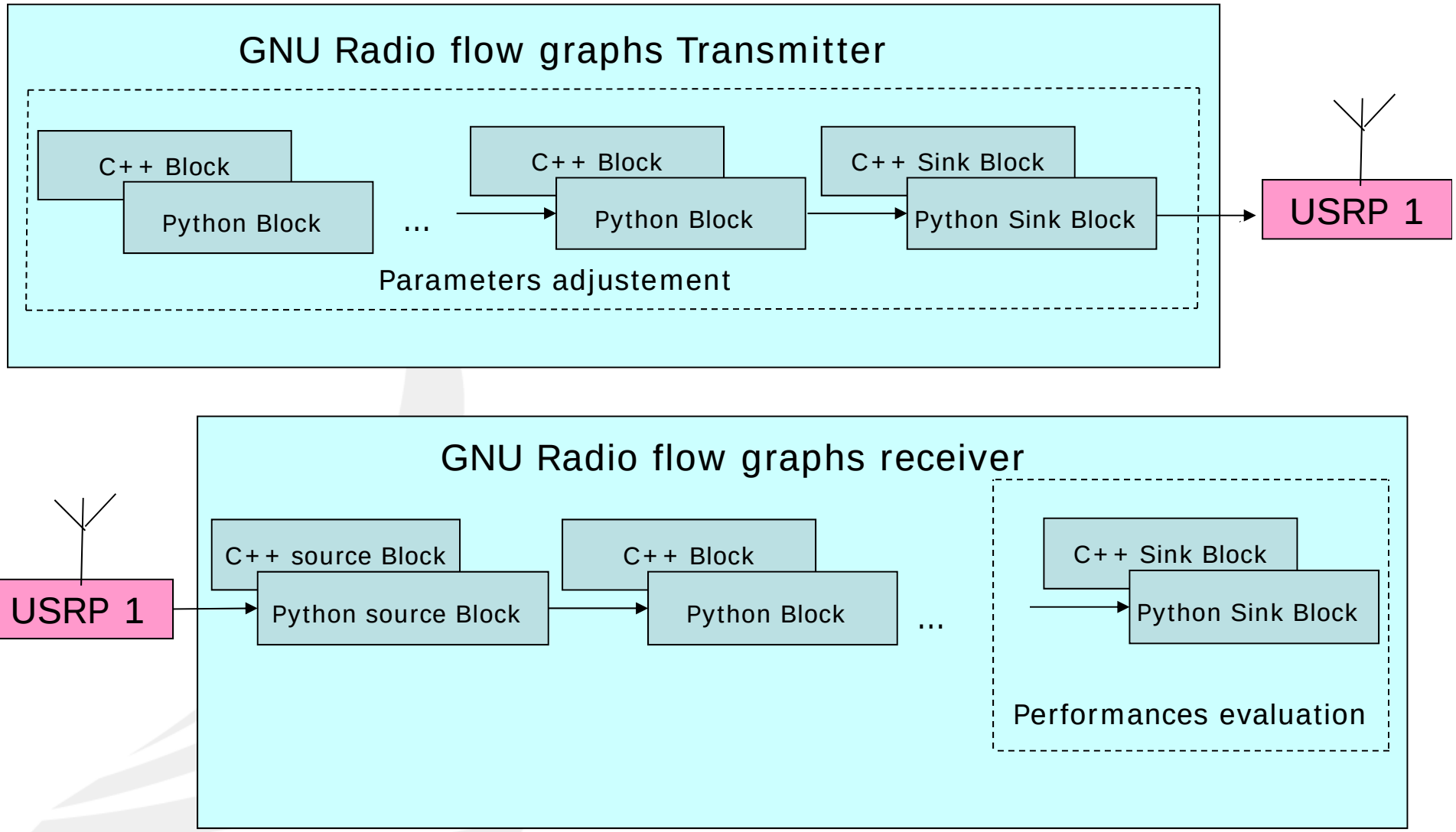
# Software Implementation on GNU Radio

Why software implementation ?

- Perfect command of GNU Radio toolbox
- Hardware implementation of IEEE 802.15.4 transceiver for 868/915 MHz band was been done only on ASICs or FPGA
- Need to control the standard specifications by the flexibility and the ability of the software definition
- Performances evaluation of the transmissions by changing the physical parameters
- IEEE 802.15.4 transceiver in 868/915 MHz presents wider range than that of the 2450 MHz band for a given link budget
- Possibility to adapt software transceiver for cognitive radio purposes

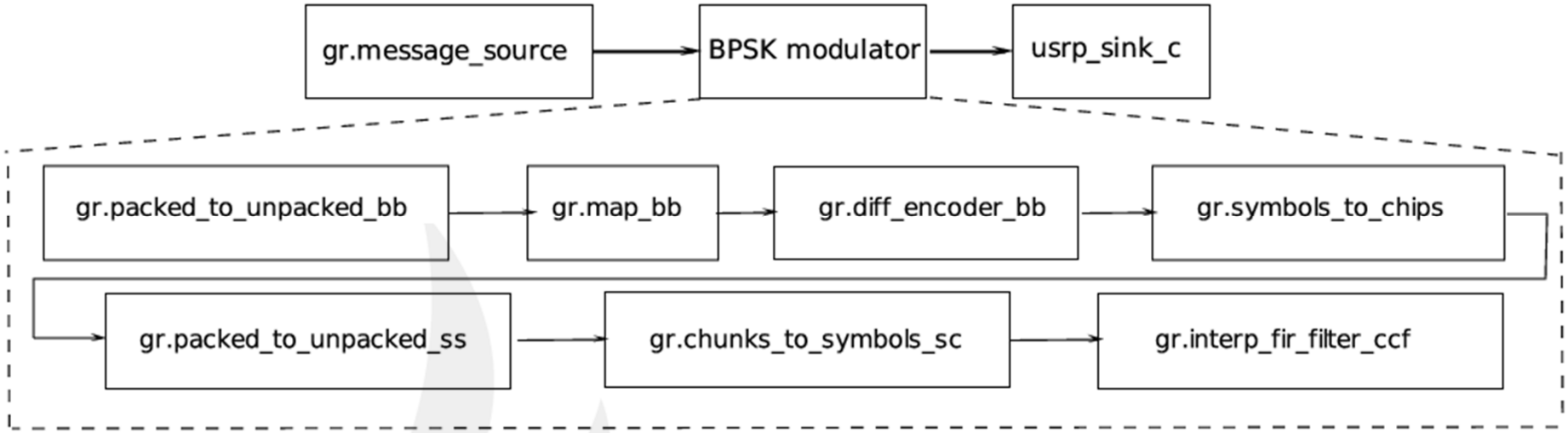
# Software Implementation on GNU Radio

**Software Architecture :**



# Software Implementation on GNU Radio

**Transmitter :**



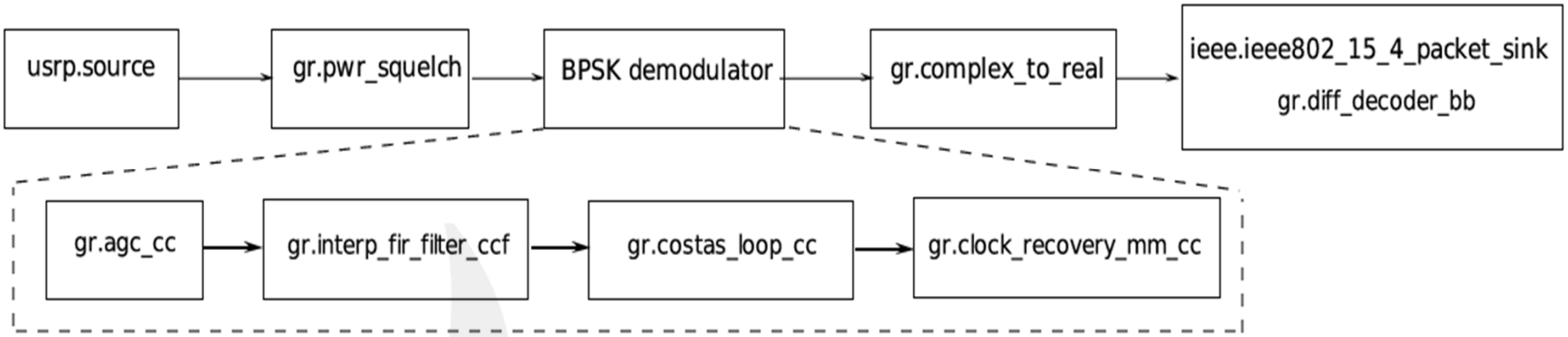

A new block gr.symbols_to_chips is add to GNU Radio.

Symbol spreading is the Direct Sequence Spread Spectrum (DSSS)

| **Input bits** | **Chip values** (c0 c1 . . . c14) |
|---|---|
| 0 | 1 1 1 1 0 1 0 1 1 0 0 1 0 0 0 |
| 1 | 0 0 0 0 1 0 1 0 0 1 1 0 1 1 1 |

# Software Implementation on GNU Radio

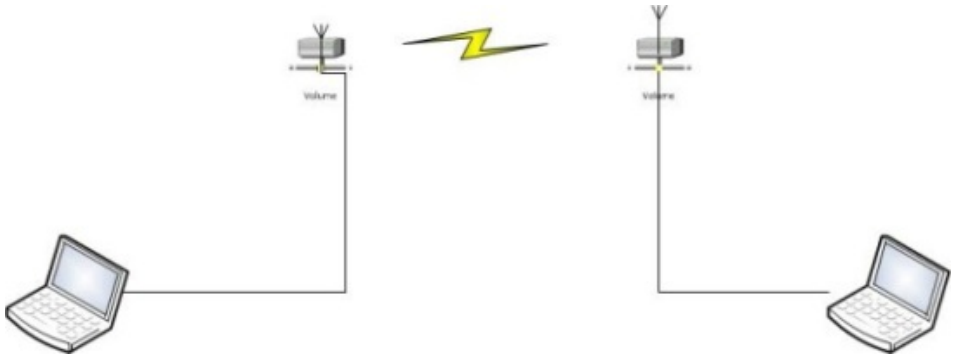
**Receiver :**




- A new block ieee.ieee802_15_4_packet_sink coombined with gr.diff_decoder_bb is add to GNU Radio.

- Packet queue is observed by an external python thread

# Experimental approaches and results



- Indoor environment
- 2 USRP 1 with RFX 900 Daughterboards
- Host computer with one Core 2 Duo CPU running at 2.4GHz and 2 GB of RAM.
- Distance between the two USRP1 boxes was bigger than 2 meters.
- Decimation D and Interpolation I of respectively USRP receiver and USRP transmitter are :

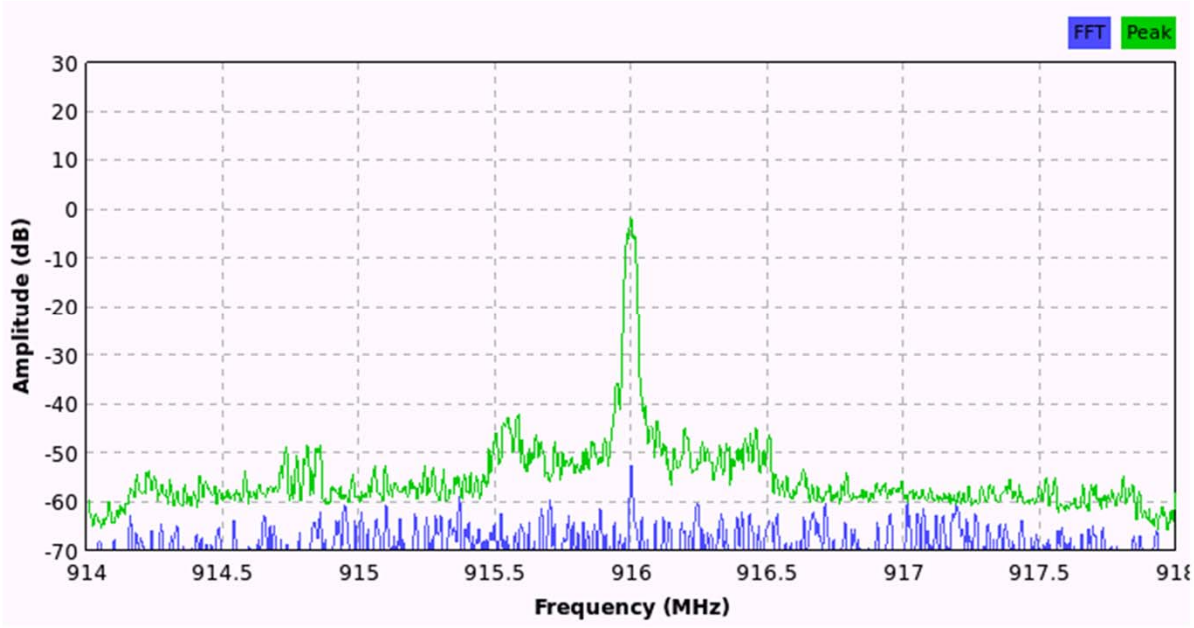
$$I = \frac{DAC\_s}{r.sps}, \quad D = \frac{ADC\_s}{r.sps}$$

$$DAC\_s = 128MSPS$$
$$I \in [16,20,24,...,508,512]$$
$$ADC\_s = 64MSPS$$
$$D \in [8,10,12,...,254,256]$$

# Experimental approaches and results

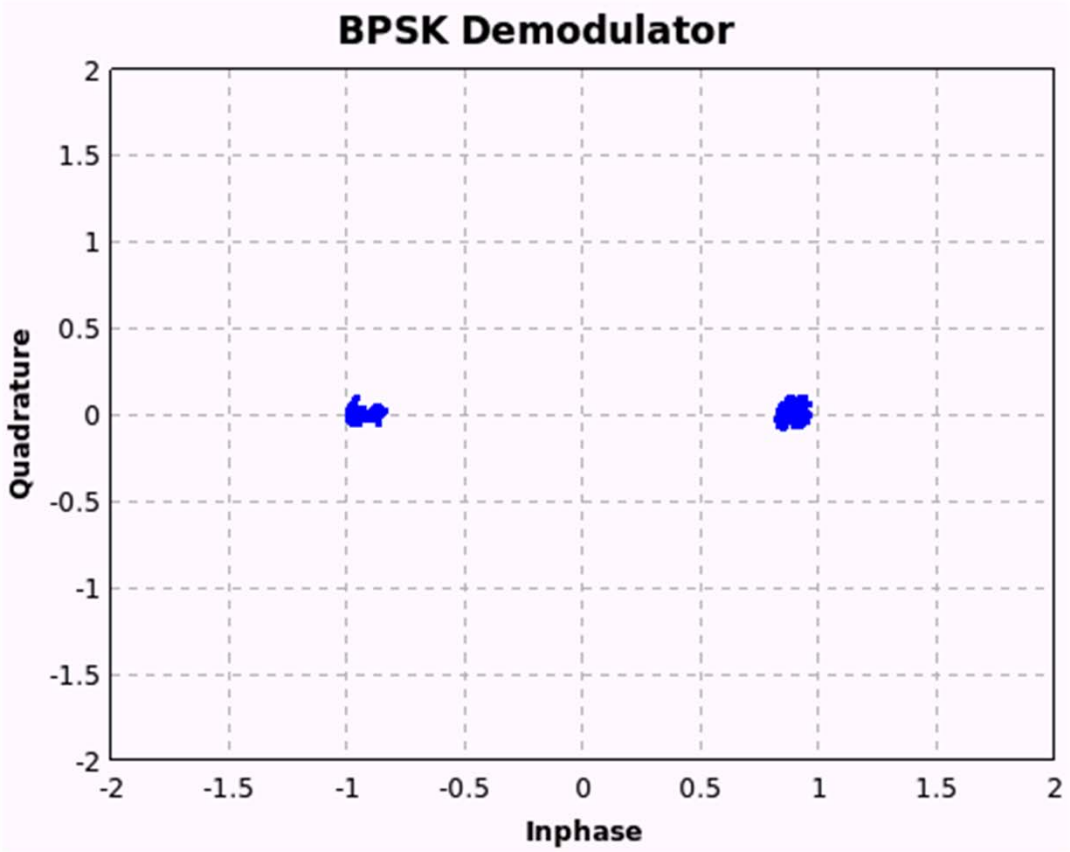
| | Bit rate | Sampling | Decimation D | Interpolation |
|---|---|---|---|---|
| 868.3 MHz | 20 kbps | 16 sps | 200 | 400 |
| 916 MHz | 40 kbps | 8 sps | 200 | 400 |

Power spectrum of our software transceiver recorded with the USRP



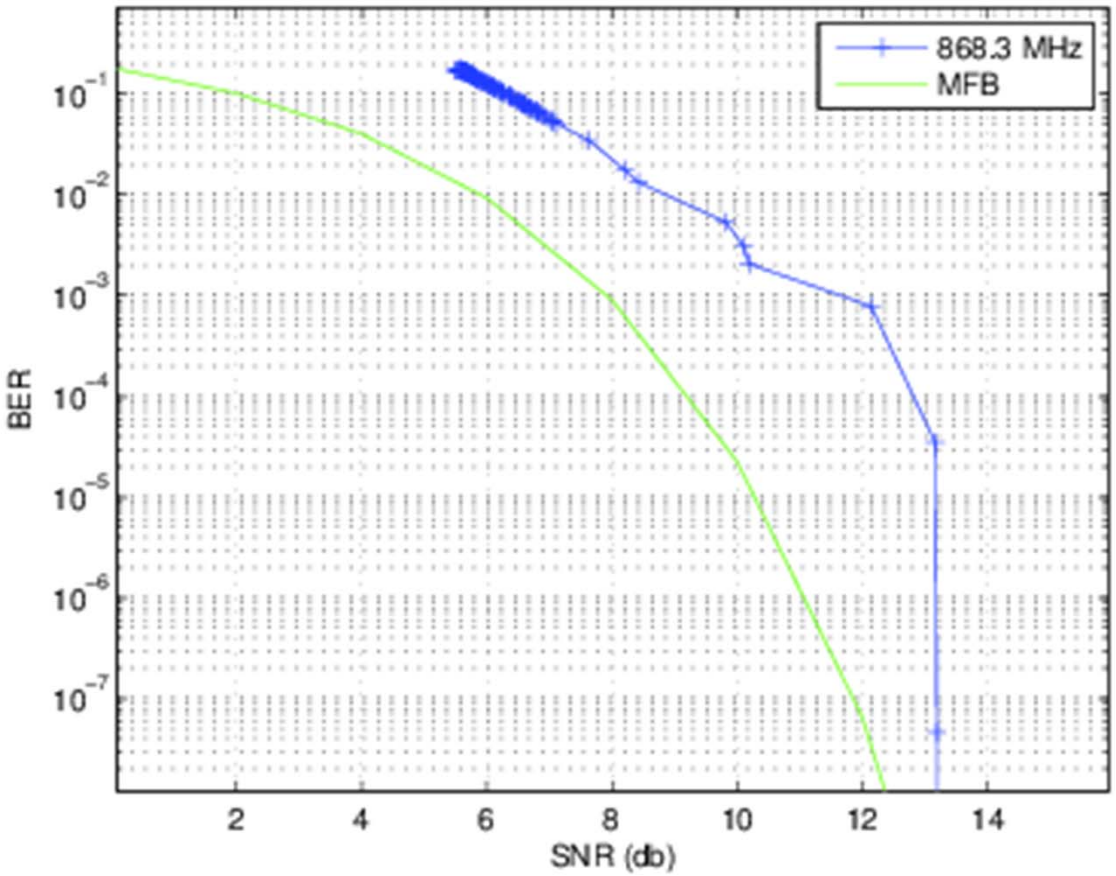
# Experimental approaches and results

Receiver symbol constellation



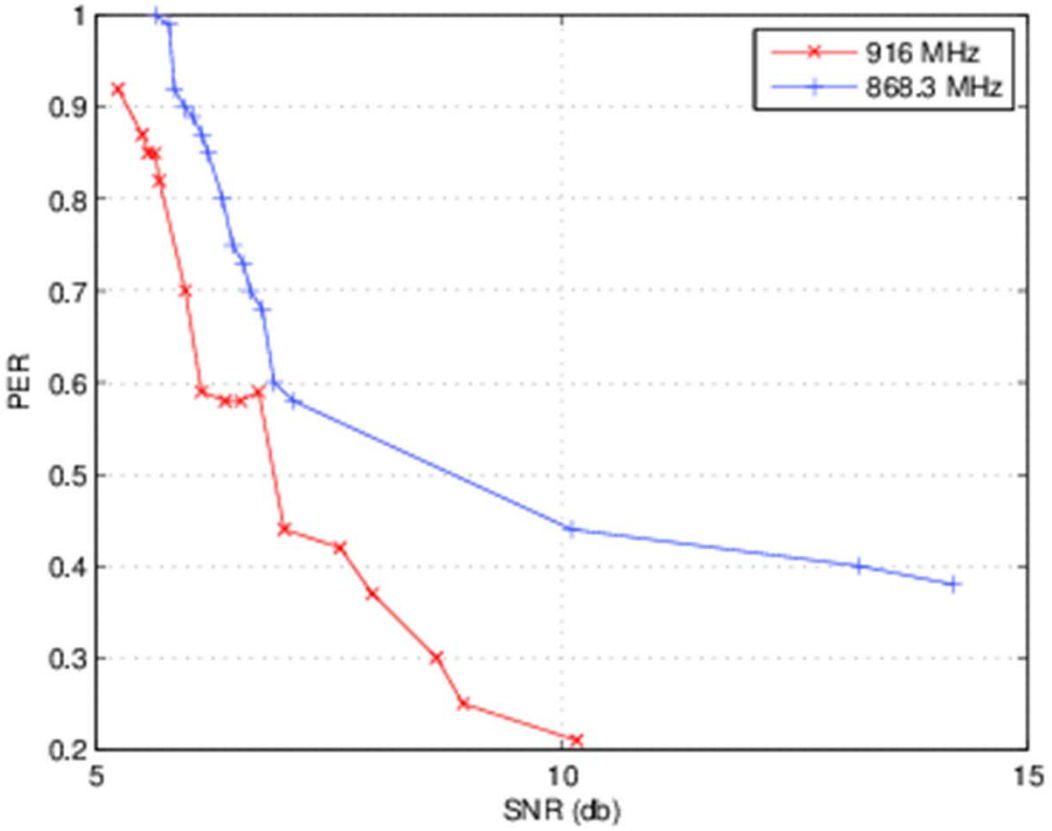
# Experimental approaches and results

The BER versus received SNR for central frequency 868.3 MHz and for the MFB



# Experimental approach and results

The PER over received SNR using two central frequencies 916 MHz and 868 MHz



# Conclusions and perspectives

- Here we present the implementation of the IEEE 802.15.4 standard on a SDR transceiver for the 915/868 MHz band with two additional blocks at the GNU Radio Platform

- The BER and the PER, calculated in an indoor environment, become lower than the expected theoretical bound

- The software transceivers for 868/915 MHz and 2450 MHz can be combined (cognitive radio) to increase the transmission performances

Thank you for your attention

Questions