SDR-Empfang – quer durchs Sonnensystem

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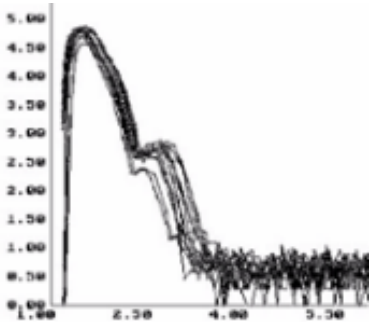
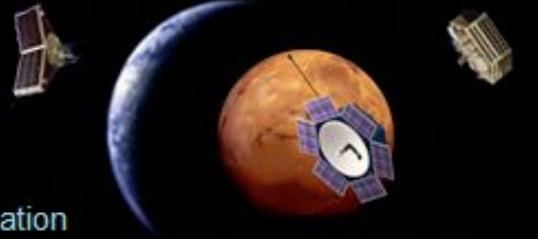




Outline

- Motivation: Kommunikation über Distanzen
- Ziel: Die STEREO-Sonden der NASA
- Grundlagen von SDRs
- Vorstellung von PothosWare
- Live-Demo
- Zusammenfassung

Ich bin Funkamateur...

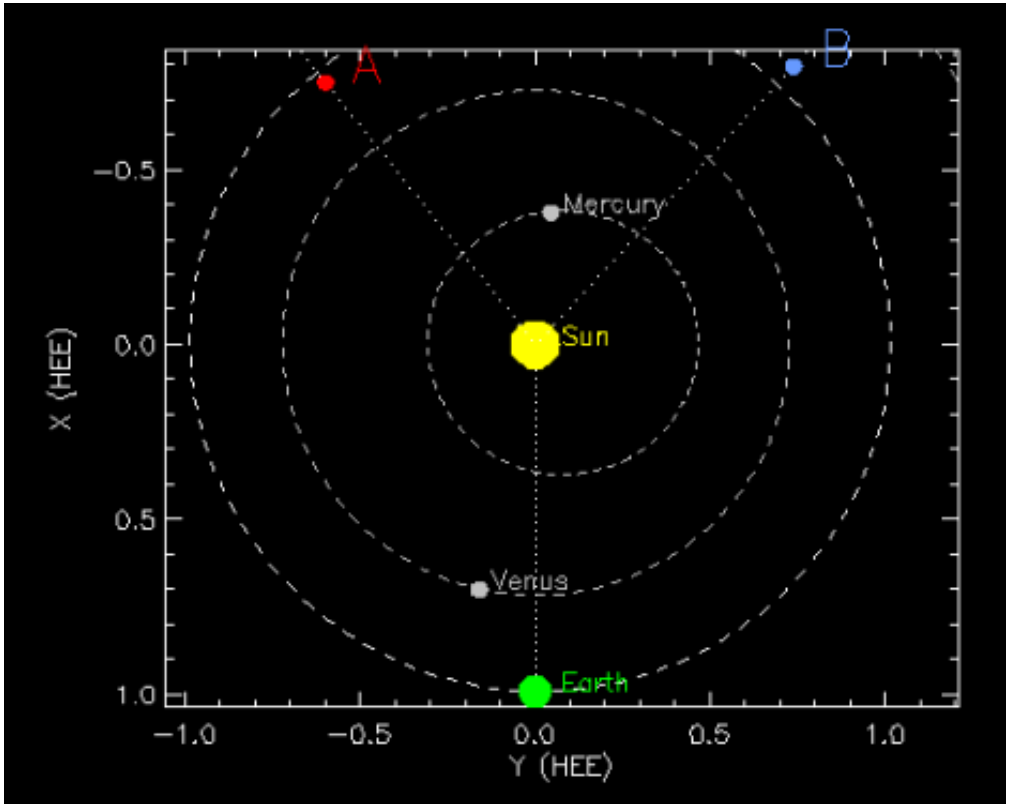
und möchte daher ~~große~~ größere Distanzen überbrücken

Größenordnungen

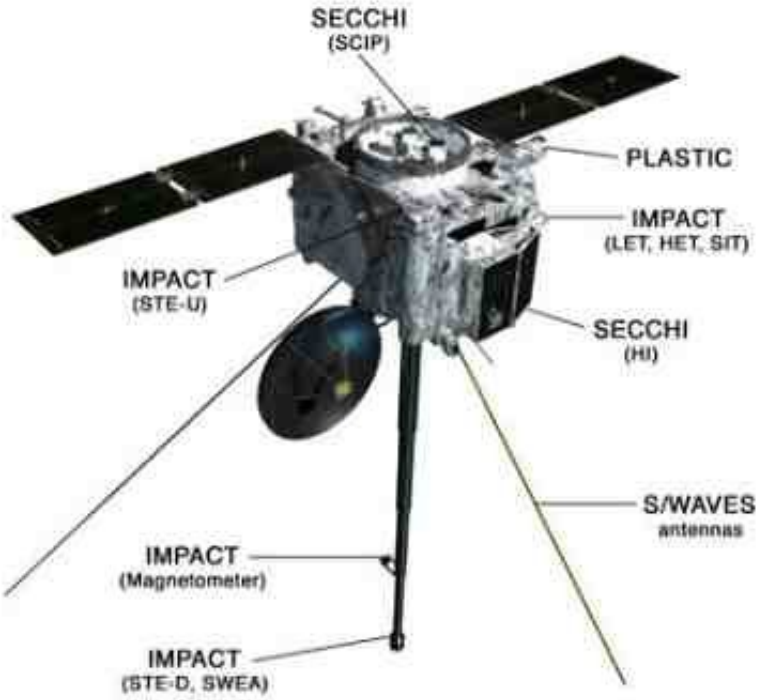
1m	Meter	Meter	Bluetooth
1 000m	1000 Meter	1 Kilometer (km)	WLAN Outdoor
1 000 000m	1000 Kilometer	1 Megameter (Mm)	Kurzwelle/Kontinent
1 000 000 000m	1 Mio Kilometer	1 Gigameter (Gm)	Weltraum

1 AE = 149.6 Gm

Die Ziele: STEREO-A/B

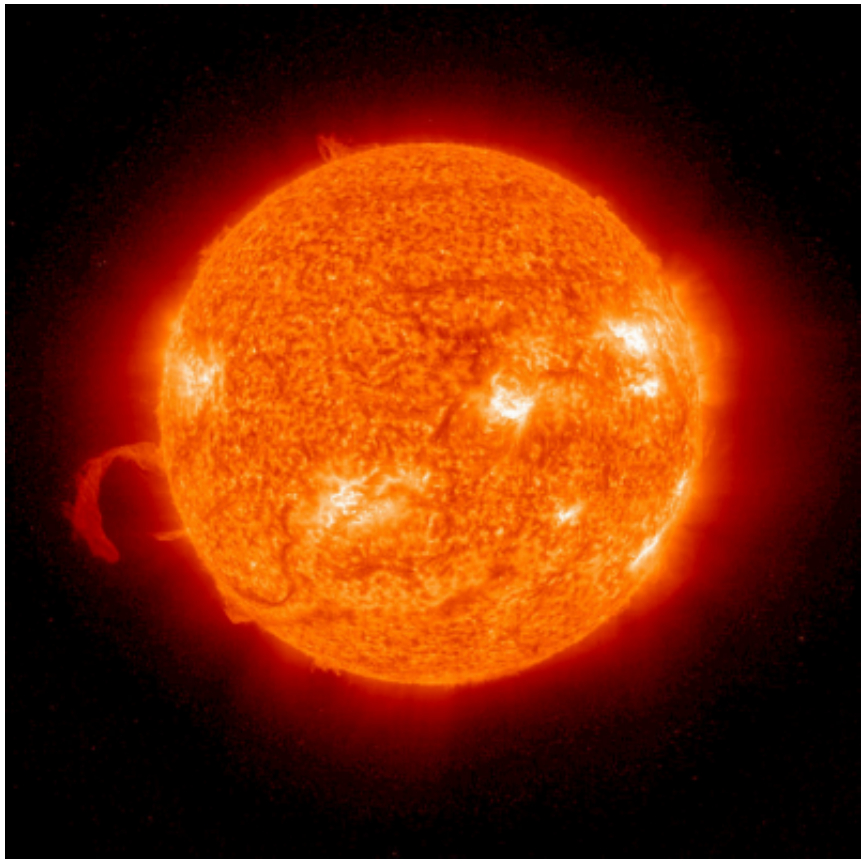


Position STEREO A/B 04.03.2017
https://stereo-ssc.nascom.nasa.gov/where.shtml

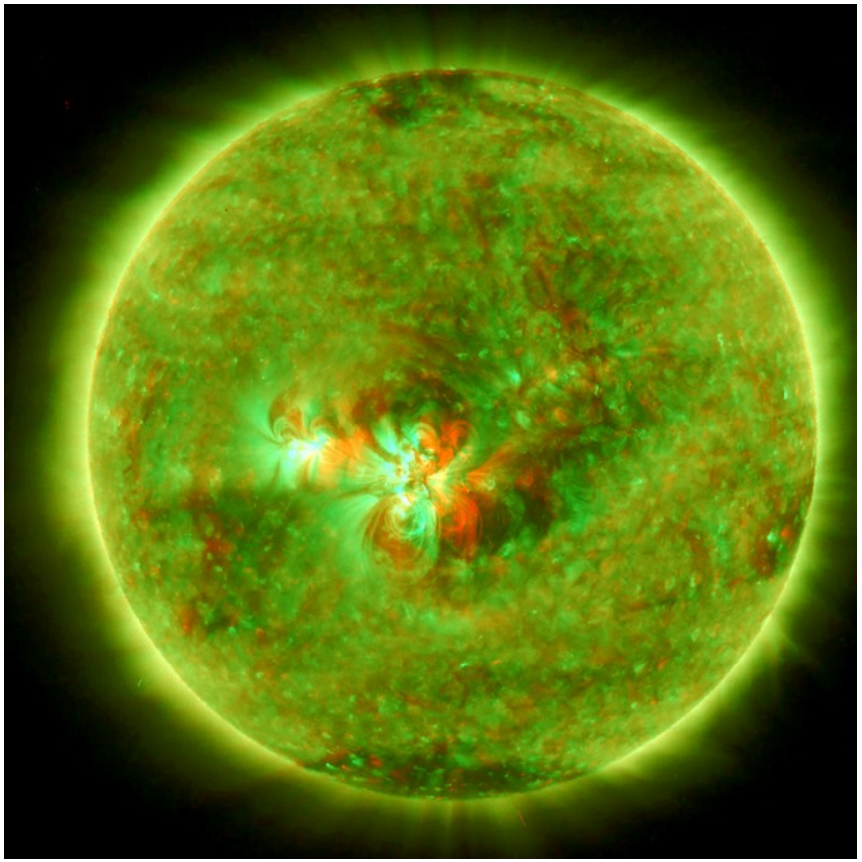


Modell STEREO (Quelle: NASA)

Was macht STEREO ?



Prominence (Quelle: NASA)



Die Sonne – in 3D (Quelle: NASA)

Warum STEREO ?

Kapazität[bit/s] → $C = B \log_2\left(1 + \frac{S}{N}\right)$

Bandbreite[Hz]

Signal/Rausch-Verhältnis

Größere Antenne → Besseres S/N
Sendedatenrate ≈ Kapazität (70m Spiegel: 720 kbit/s)

Kleinere Antenne → Sendedatenrate > Kapazität → Keine fehlerfreie Kommunikation

Aber: 633 b/s “Space Weather Mode”, wenn DSN nicht aktiv

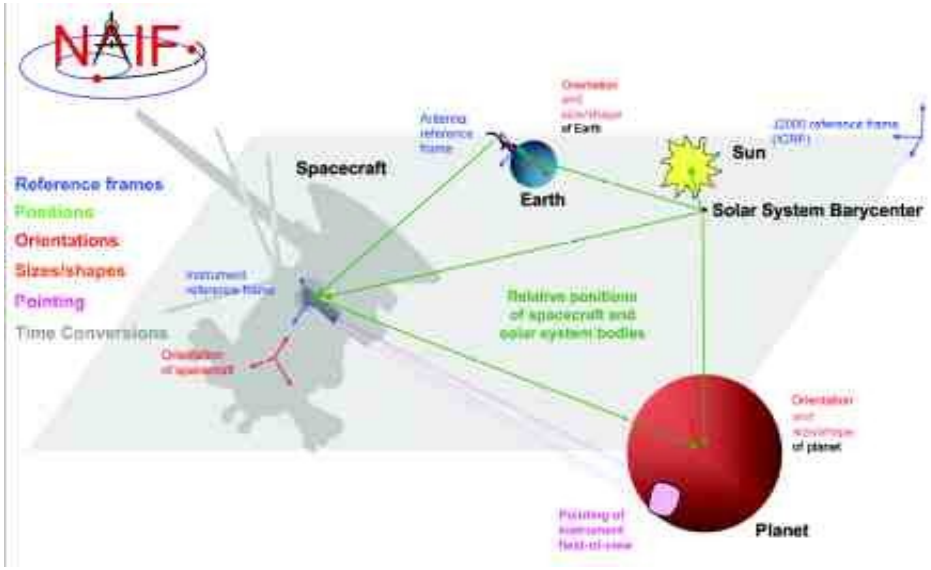
Was braucht man zum Empfang? (1)

70m-DSN-Antenne Madrid (Quelle: NASA)

20m Antenne Sternwarte Bochum / AMSAT-DL

Was braucht man zum Empfang? (2)

NASA Open Source Software zur Berechnung von Antennenausrichtung und Dopplerverschiebung

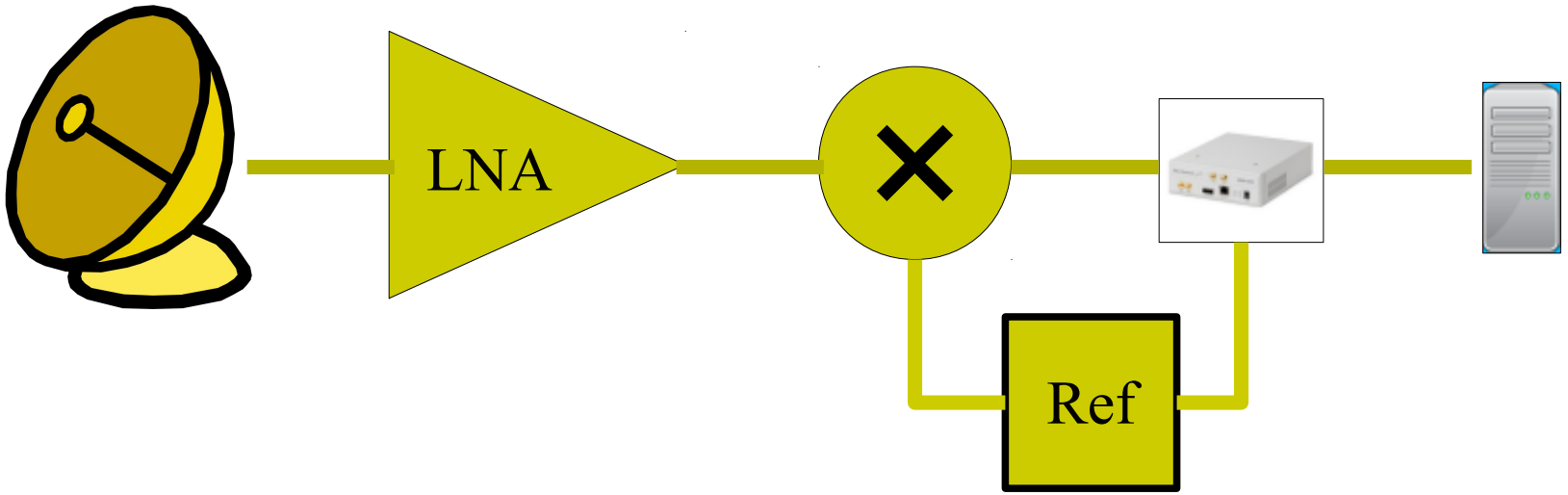


https://naif.jpl.nasa.gov

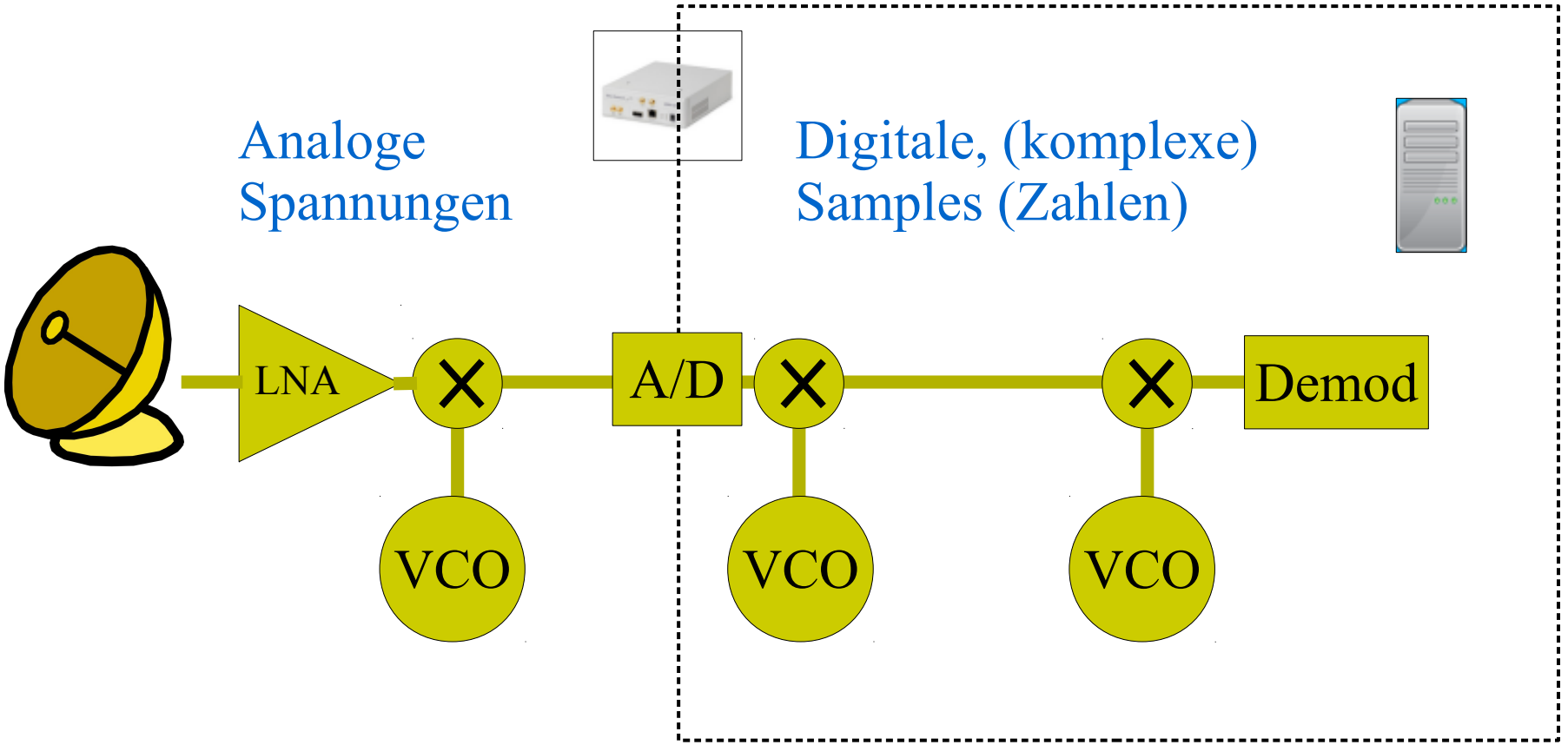
http://gmatcentral.org

Was braucht man zum Empfang? (3)

- Einen geeigneten Empfänger!



Radiobasteln für größere Kinder



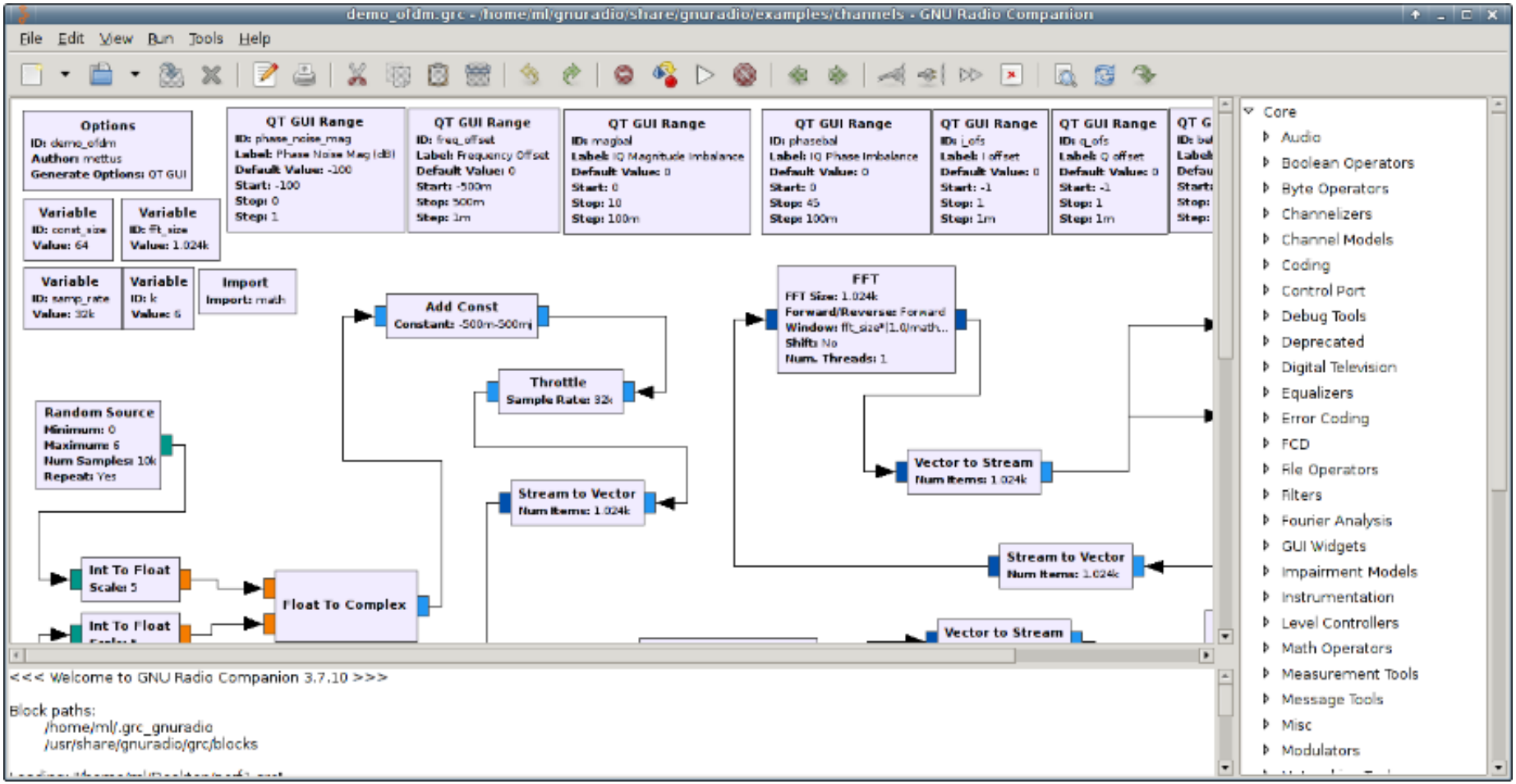
Anforderungen an SDR-Frameworks

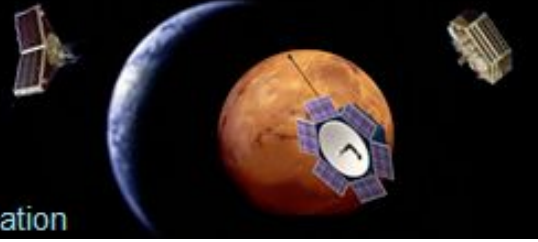
- Geeignete Lizenz
- Dokumentation

- Datenfluss-Framework
- Diagnosemöglichkeiten
  - Zeit-,
  - Frequenz-,
  - Symbolebene

- Umfangreiche Algorithmensammlung
- Grafische Oberfläche
- Geringer Programmieroverhead

Der Platzhirsch: GNU Radio





Alternativen

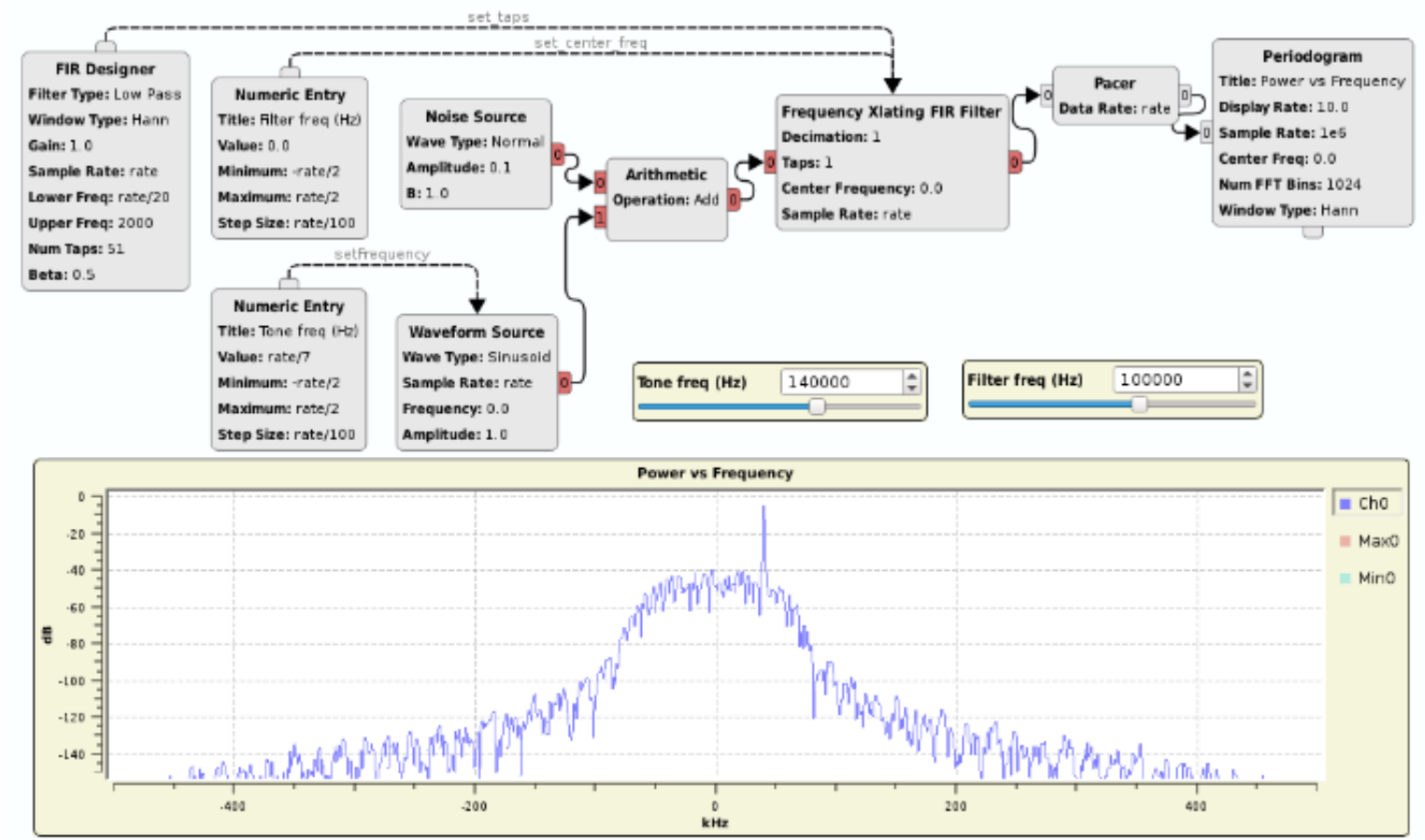
- Matlab/Simulink
- NI Labview

- gqrx/cubesdr/...

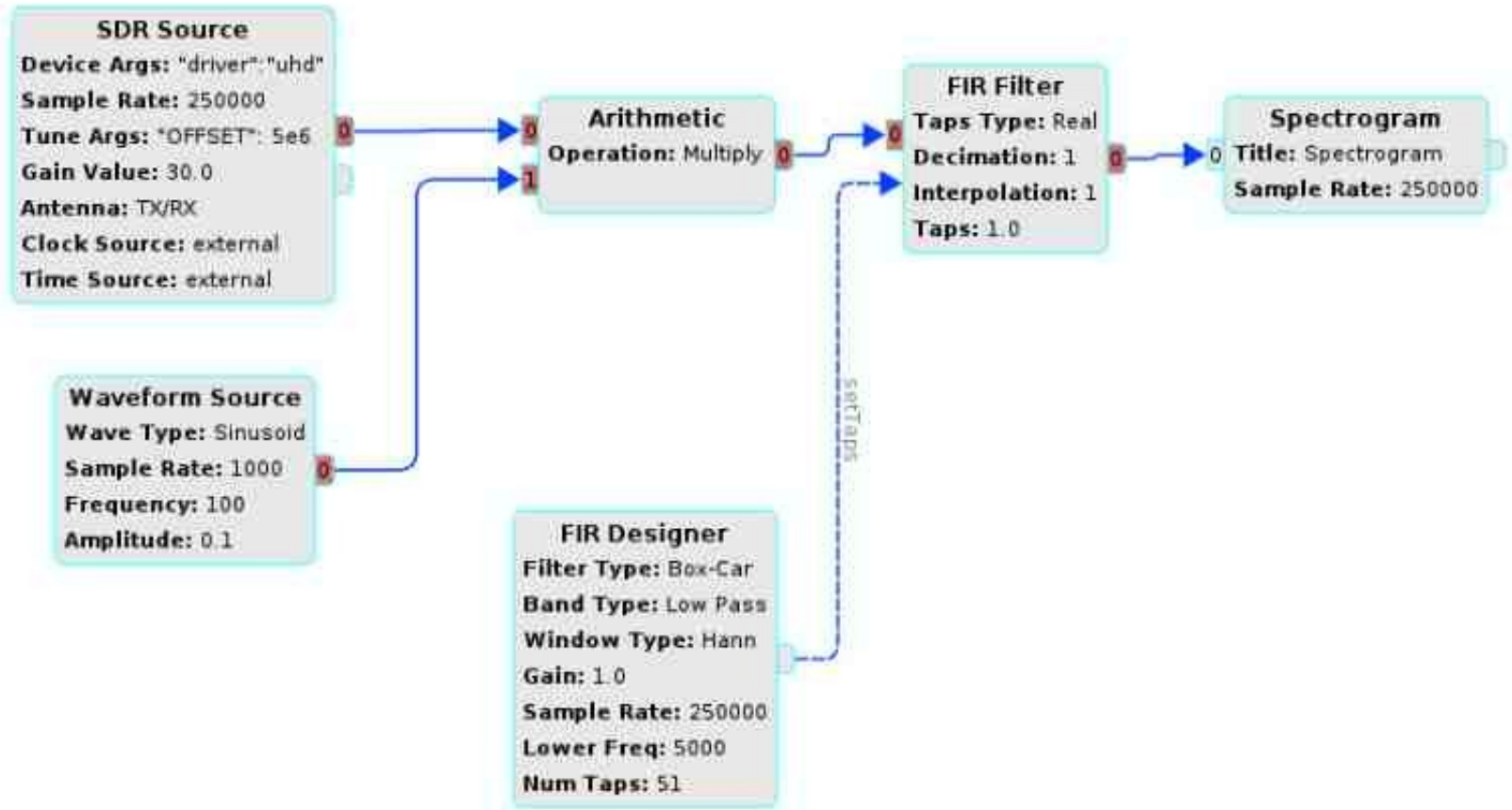
- liquid-dsp: http://liquidsdr.org

- LuaRadio: http://luaradio.io

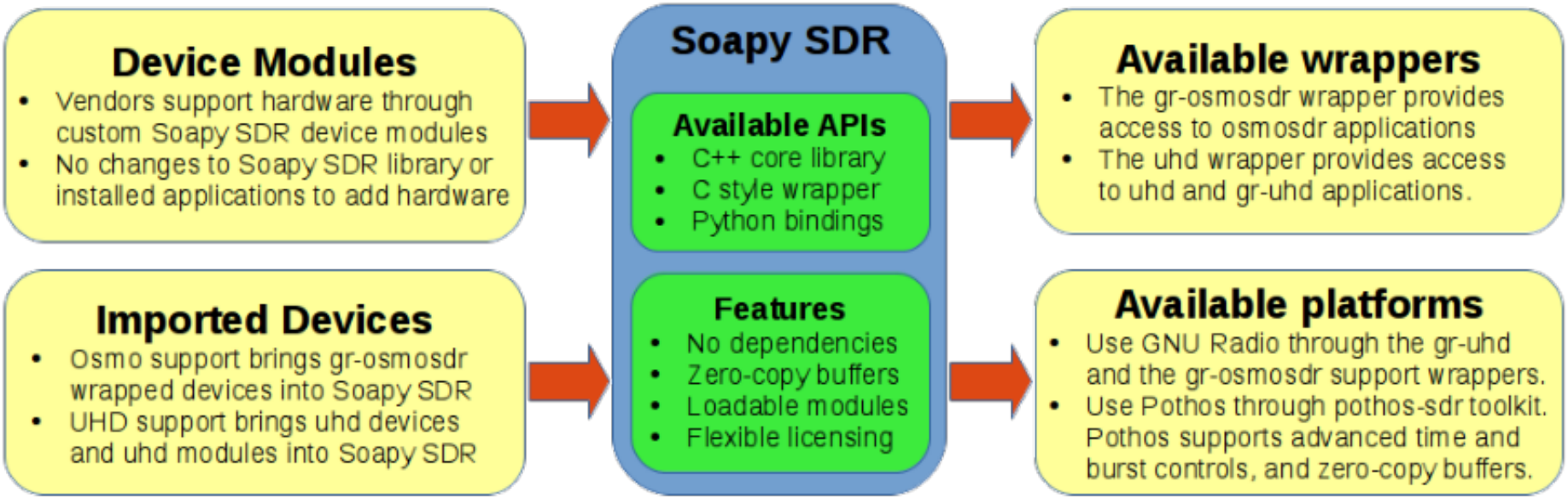
Pothosware


set_taps
set_center_freq
FIR Designer
Filter Type: Low Pass
Window Type: Hann
Gain: 1.0
Sample Rate: rate
Lower Freq: rate/20
Upper Freq: 2000
Num Taps: 51
Beta: 0.5
Numeric Entry
Title: Filter freq (Hz)
Value: 0.0
Minimum: -rate/2
Maximum: rate/2
Step Size: rate/100
Noise Source
Wave Type: Normal
Amplitude: 0.1
B: 1.0
Arithmetic
Operation: Add
Frequency Xlating FIR Filter
Decimation: 1
Taps: 1
Center Frequency: 0.0
Sample Rate: rate
Pacer
Data Rate: rate
Periodogram
Title: Power vs Frequency
Display Rate: 10.0
Sample Rate: 1e6
Center Freq: 0.0
Num FFT Bins: 1024
Window Type: Hann
setFrequency
Numeric Entry
Title: Tone freq (Hz)
Value: rate/7
Minimum: -rate/2
Maximum: rate/2
Step Size: rate/100
Waveform Source
Wave Type: Sinusoid
Sample Rate: rate
Frequency: 0.0
Amplitude: 1.0
Tone freq (Hz)
140000
Filter freq (Hz)
100000
Power vs Frequency
Ch0
Max0
Min0
dB
0
-20
-40
-60
-80
-100
-120
-140
-400
-200
0
200
400
kHz

Quellen, Blöcke, Senken

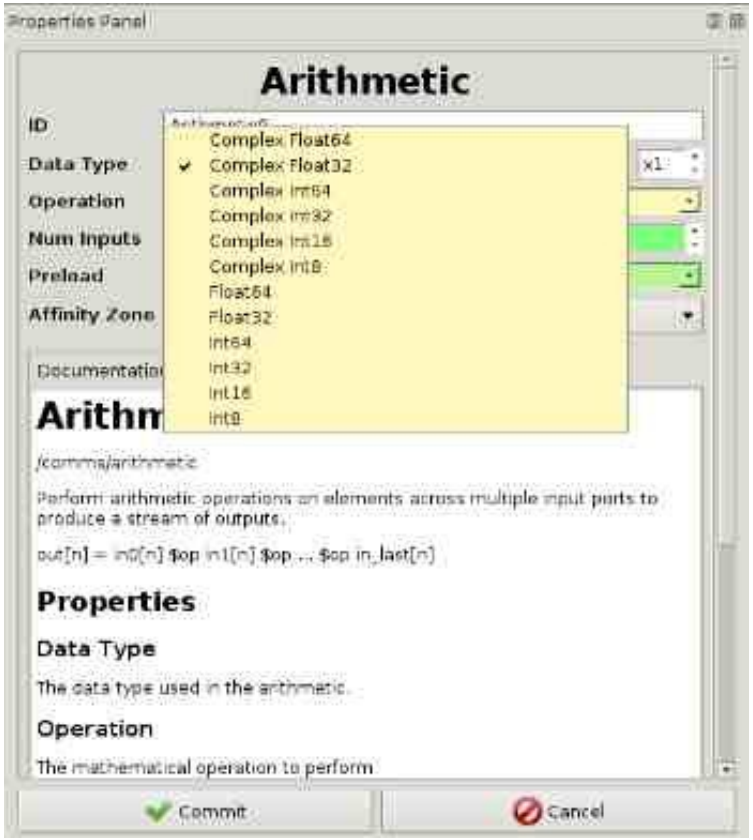


SDR Source/Sink – SoapySDR

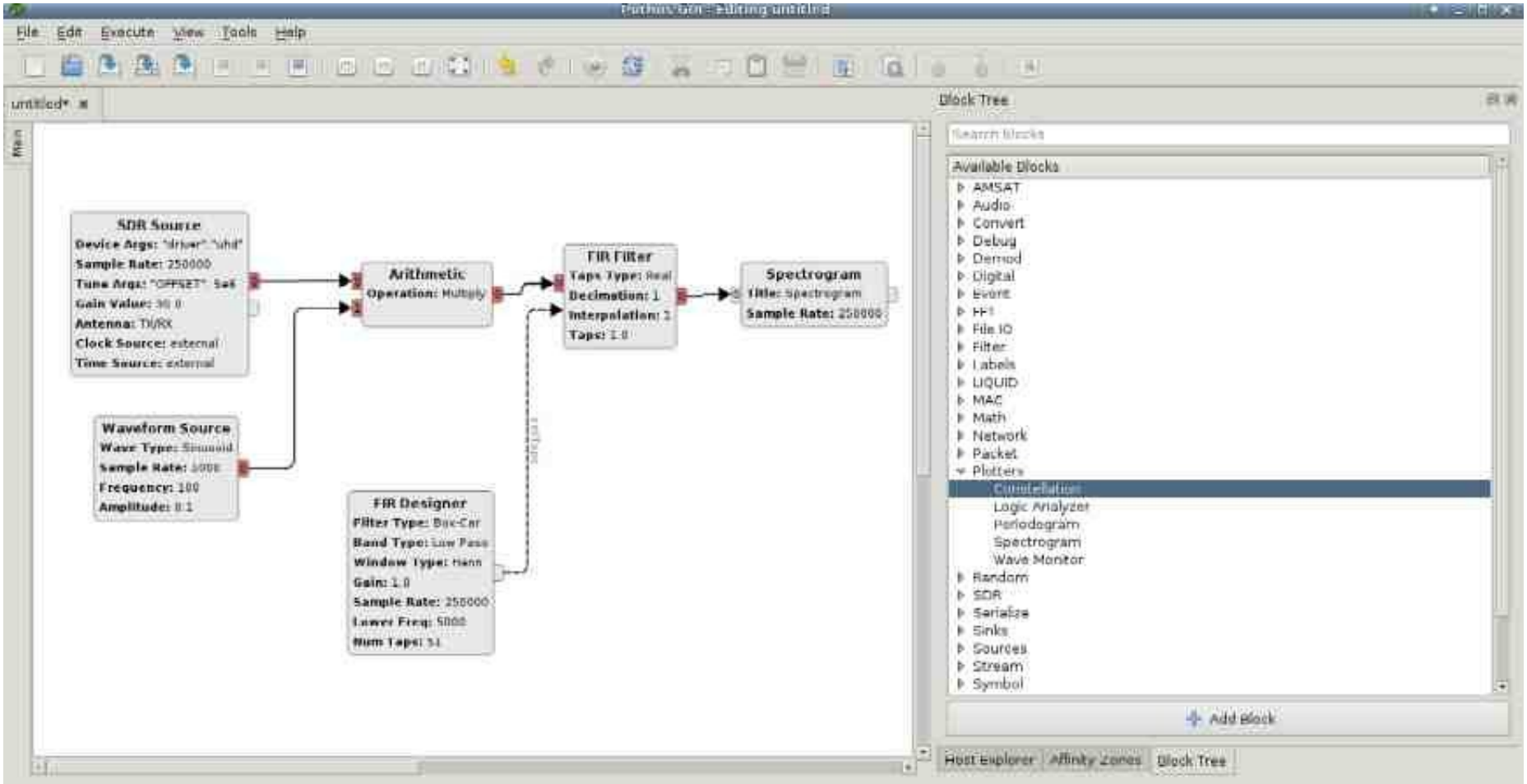


Quelle: https://github.com/pothosware/SoapySDR/wiki

Synchrones Streaming: Datentypen



Blöcke


File Edit Execute View Tools Help
untitled*
SDR Source
Device Args: "driver" "uhd"
Sample Rate: 250000
Tune Args: "OFFSET" 5e6
Gain Value: 30.0
Antenna: TX/RX
Clock Source: external
Time Source: external
Arithmetic
Operation: Multiply
FIR Filter
Taps Type: Real
Decimation: 1
Interpolation: 1
Taps: 1.0
Spectrogram
Title: Spectrogram
Sample Rate: 250000
Waveform Source
Wave Type: Sinusoid
Sample Rate: 1000
Frequency: 100
Amplitude: 0.1
FIR Designer
Filter Type: Box-Car
Band Type: Low Pass
Window Type: Hann
Gain: 1.0
Sample Rate: 250000
Lower Freq: 5000
Num Taps: 51
Block Tree
Search Blocks
Available Blocks
AMSAT
Audio
Convert
Debug
Demod
Digital
Event
FFT
File IO
Filter
Labels
LIQUID
MAC
Math
Network
Packet
Plotters
Constellation
Logic Analyzer
Periodogram
Spectrogram
Wave Monitor
Random
SDR
Serialize
Sinks
Sources
Stream
Symbol
Add Block
Host Explorer
Affinity Zones
Block Tree

… oder selbst schreiben

```
#include <Pothos/Framework.hpp>
#include <iostream>
/***********************************************************
 * |PothosDoc My Block
 *
 * Example Block....
 *
 * |category /AMSAT/Category
 * |keywords TEST Block
 *
 * |factory /DL5MLO/MyBlock()
 **********************************************************/
```

… oder selbst schreiben

```
class MyBlock : public Pothos::Block
{
public:
    MyBlock() {
        // Set up Ports
        this→setupInput(0, typeid(std::complex<float>));
        this->setupOutput(0, typeid(std::complex<float>));
    }

    static Block *make() {
        //factory function: create an instance of MyBlock
        return new MyBlock();
    }
```

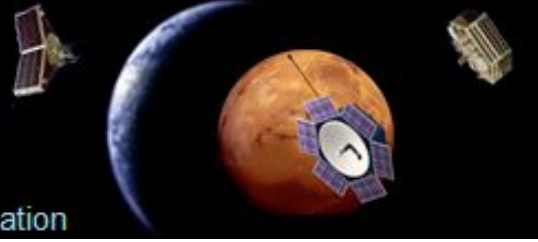
… oder selbst schreiben

```
    void work(void) {
        // Prepare input and output ports
        auto inPort = this->input(0);
        auto in=inPort->buffer().as<std::complex<float>*>();

        auto outPort = this->output(0);
        auto out=outPort->buffer().as<std::complex<float>*>();

        // Determine number of elements
        const size_t numElements =
            this->workInfo().minElements;

        for (size_t i = 0; i < numElements; i++) {
            // report the handled elements
            out[i] = in[i];
        }

        outPort->produce(numElements);
        inPort->consume(numElements);
    }
};
```

… oder selbst schreiben

```
//register MyBlock into the block registry
static Pothos::BlockRegistry registerMyBlock(
    "/DL5MLO/MyBlock", &MyBlock::make);
```

- Live-Demo….



Zusammenfassung

- STEREO-Sonden der NASA
- SDR-Empfänger mit PothosWare
- Programmierung von Blöcken
- Live-Demonstration

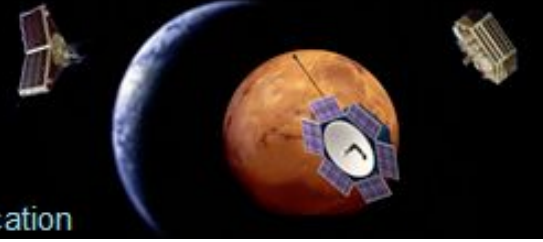
Selber machen...

- https://github.com/pothosware/pothos/wiki/GettingStarted

- Source
- Binaries für Ubuntu, Suse, Windows, OSX, FreeBSD (wip)

- Hardware:
  - USRP (http://www.ettus.com)
  - RTL SDR (diverse)
  - AirSpy (http://www.airspy.com)
  - LimeSDR http://www.crowdsupply.com/lime-micro/limesdr

- Antenne: Bei mir melden



Vielen Dank für Ihre Aufmerksamkeit!

Fragen?

Email: dl5mlo@amsat-dl.org

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und Energie

aufgrund eines Beschlusses
des Deutschen Bundestages

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