Passive Radar at home

Electrosmog made useful – Signal analysis magic with received radio signals and their reflections

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http://www.olifantasia.com

European USRP reseller | Open BTS kit
SDR Development | Consultancy

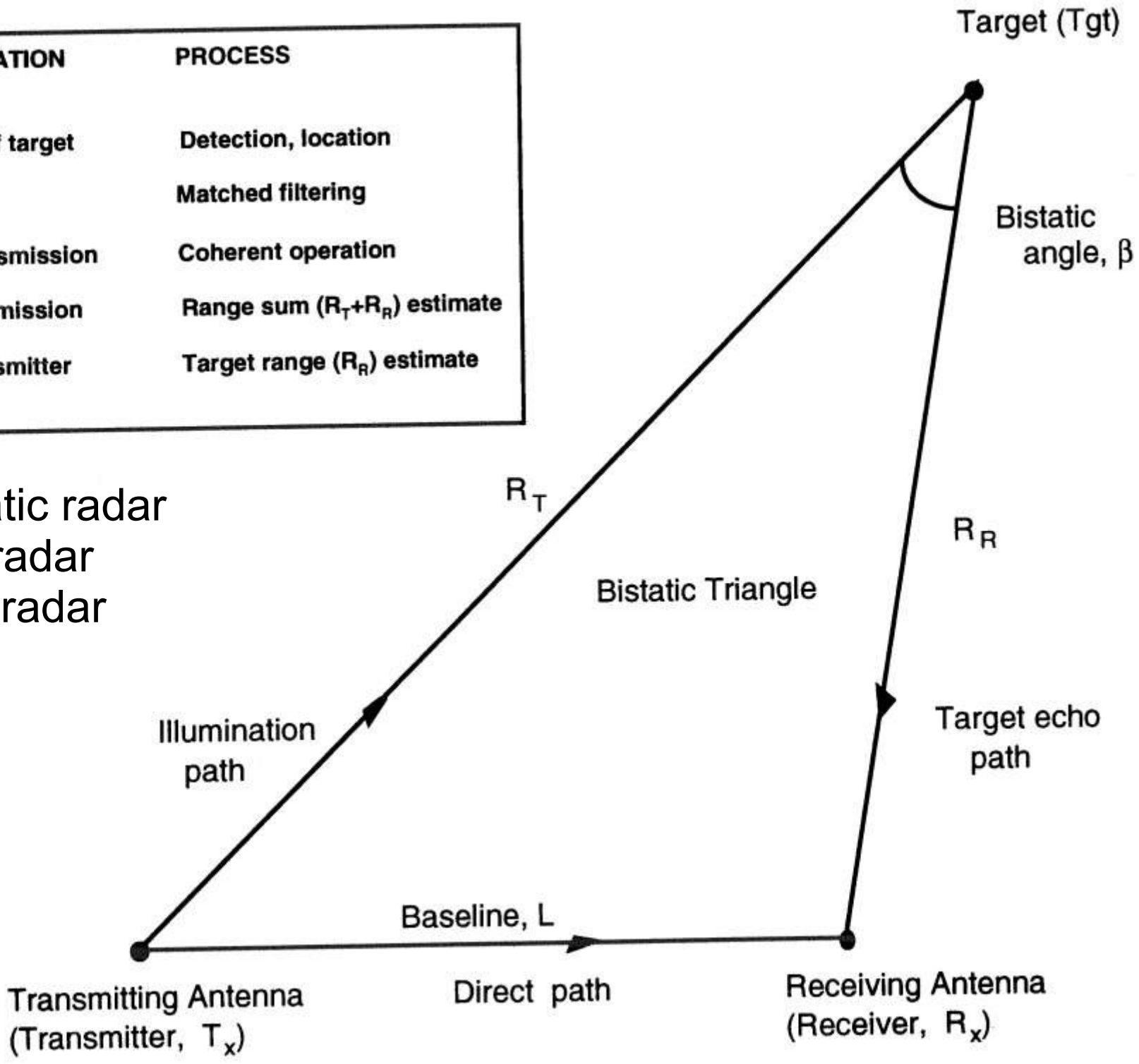
Radio Detection and Ranging

- Investigate reflections to determine:
  - Distance, direction => position
  - Speed
  - Type (classification)

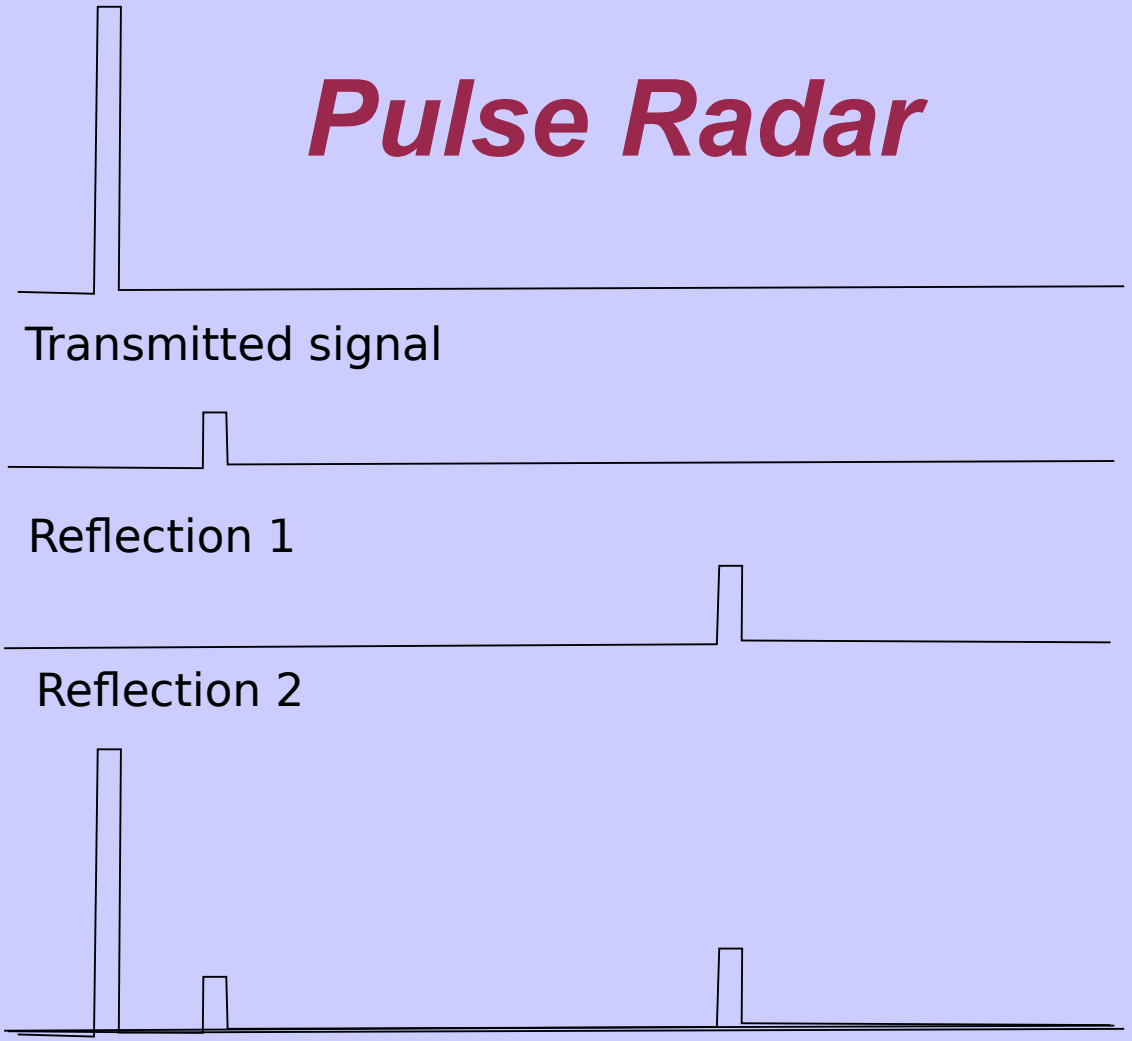
- My goals:
- Have fun with radiowaves
- Automatic maps of:
  - landscape
  - buildings
  - traffic
  - airplanes
  - weather / atmosphere / ionosphere

DATA / OPERATION	PROCESS
Illumination of target	Detection, location
Waveform	Matched filtering
Phase of transmission	Coherent operation
Time of transmission	Range sum (R_T+R_R) estimate
Relative transmitter position	Target range (R_R) estimate

- Monostatic radar
- Bistatic radar
- Passive radar



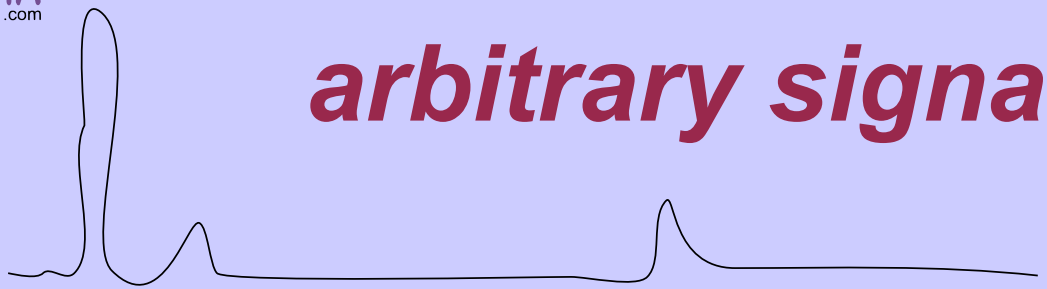
Pulse Radar



Source and two reflections

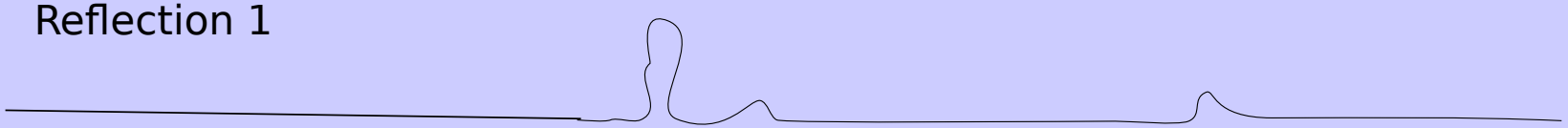
PULSE RADAR

arbitrary signal

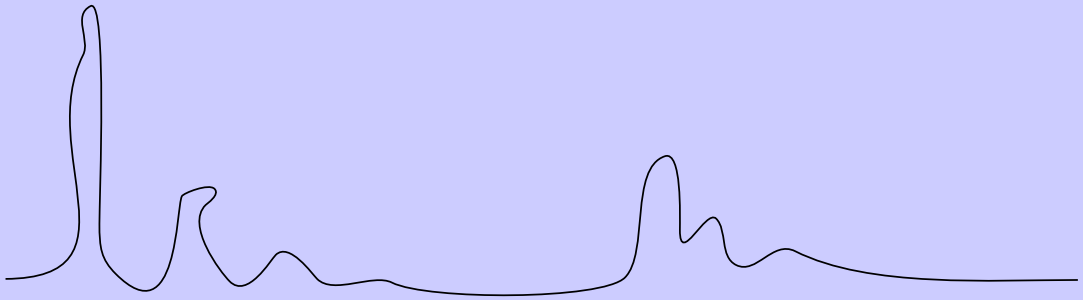


Transmitted signal

Reflection 1



Reflection 2



Received signal

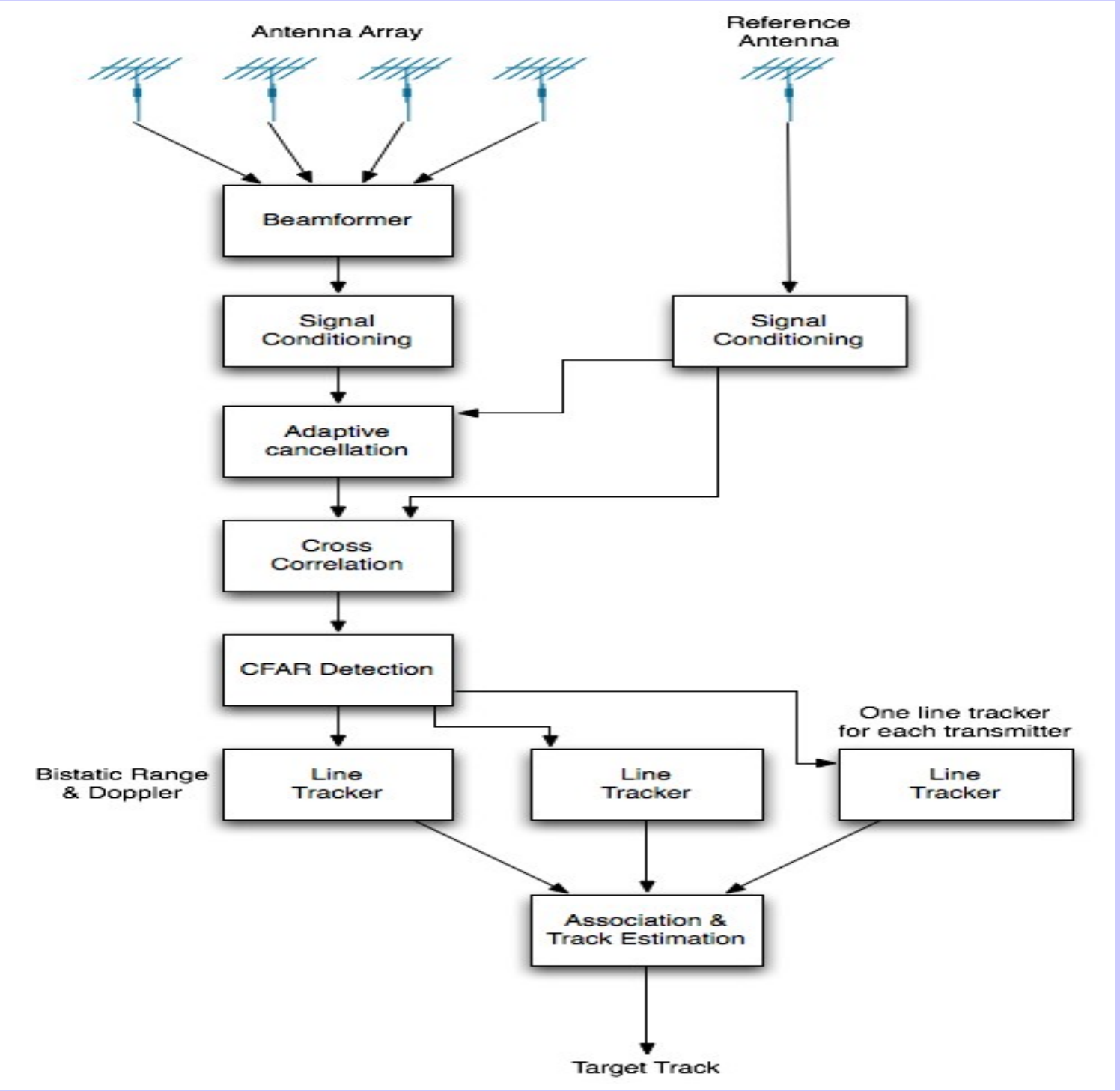
How many reflections are this ?

Arbitrary signal with large autocorrelation

cross-correlate

$$(f \star g)[n] \stackrel{\text{def}}{=} \sum_{m=-\infty}^{\infty} f^*[m]\ g[m+n].$$

- crosscorrelation = pattern recognision


Antenna Array
Reference Antenna
Beamformer
Signal Conditioning
Signal Conditioning
Adaptive cancellation
Cross Correlation
CFAR Detection
One line tracker for each transmitter
Bistatic Range & Doppler
Line Tracker
Line Tracker
Line Tracker
Association & Track Estimation
Target Track

Wat do I need ?

- Hardware
  - multichannel RF capture hardware
- Software
  - capture
  - preprocess
    - stream 1: only reflections, no direct path
    - stream 2: noise & reflection free direct path ref. signal
  - cross-correlate
  - combine/enhance

Wat do I need ?

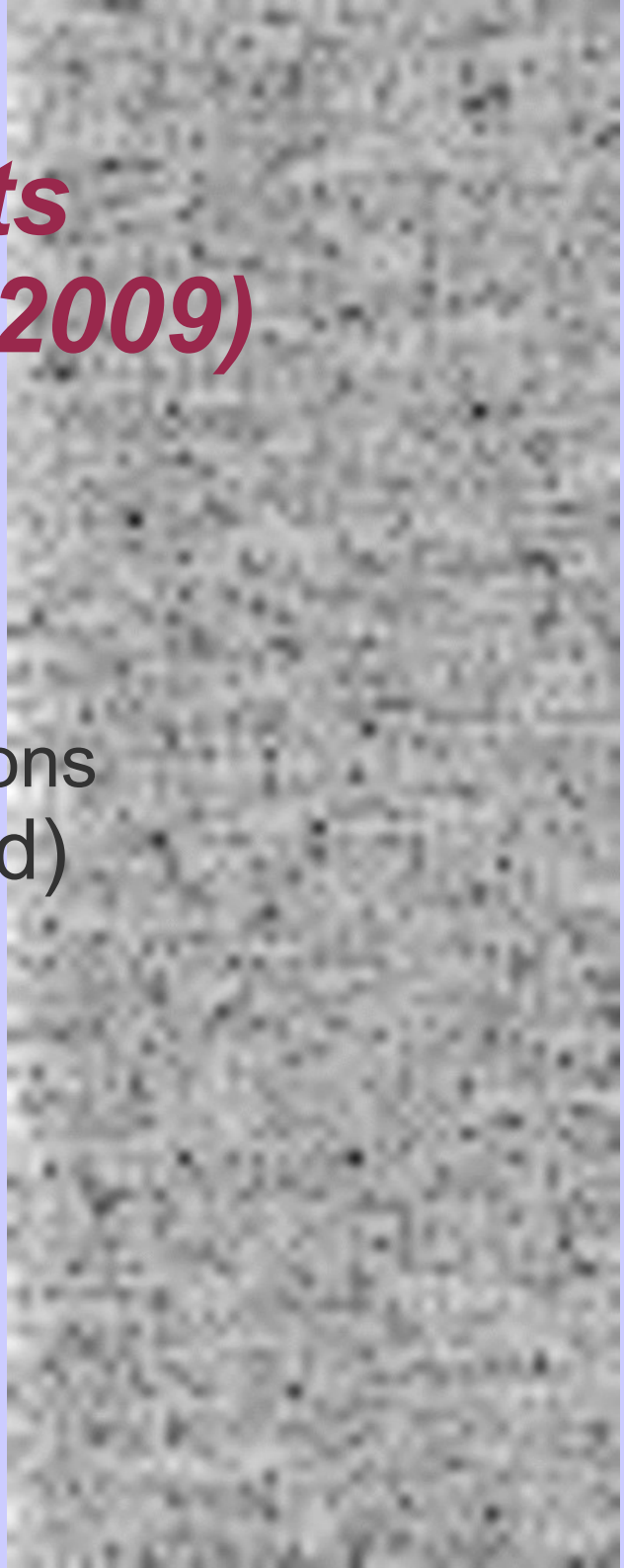
- Hardware
  - USRP B210 (with case)
    - dual channel, USB3,
    - 12 bit 61.44 MSPS A/D & D/A
    - 70 – 6000 Mhz
    - antennas

- Software
  - Frameworks/tools:
    - Ettus UHD driver
    - GNU Radio SDR framework
    - Gnuradio companion (block diagrams)
    - gnss-sdr
    - octave (math)
  - write my own Olifantasia code:
    - gr-passive-radar-standalone
    - + my gnss-sdr mods
    - + my octave and other code and scripts

signal processing solutions
OLIFANTASIA
.com

First experiments FM-radio (2005 & 2009)

- dual channel USRP 1
- 2 antenne phase-array
- CMA algorithme
  - Seperate direct path and reflections
- Wiener matched filter (modified)



Does my software work?

- Simulate FM transmitter & radar reflections
- Run analysis software

Need cleaner cross-correlation

- reflections are weak (pathloss 80 – 300 dB)
- need long integration time
- autocorrelation in ref. => fake reflections
- noise in reference signal => noise in output
- regenerate reference signal
  - demodulate noisy (digital) signal
  - quantize
  - remodulate noisefree signal

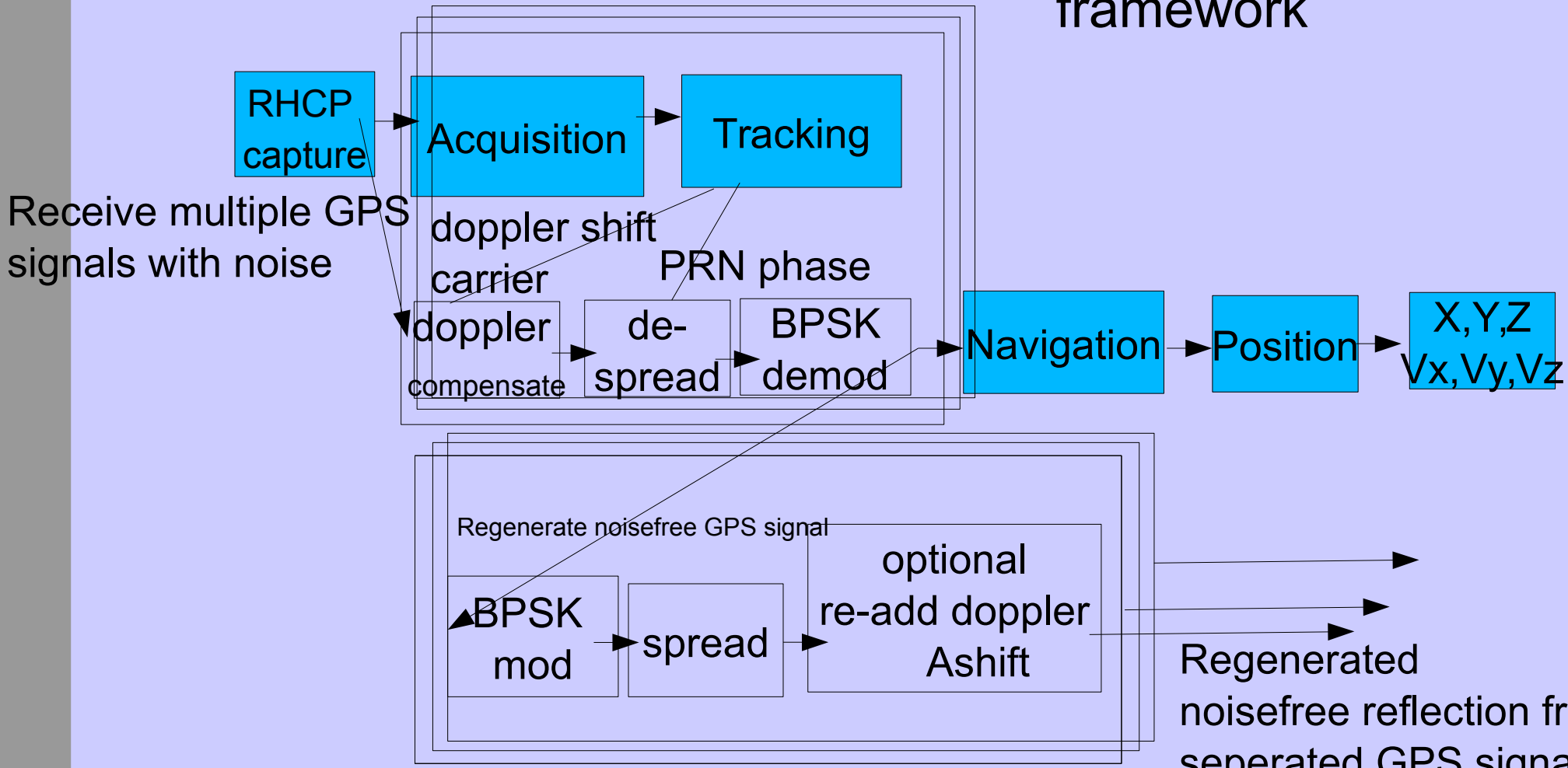
GPS

- Good:
  - digital spreadspectrum pseudorandom code
    - low autocorrelation (apart from t=0)
  - known positions and speeds
  - illuminate from all directions
  - one freq => one capture => all GPS satelites
  - RHCP righthanded circular polarisation
    - reflections LHCP
  - available worldwide
- Bad:
  - low power and high path loss
  - public signal not very wideband (1 MHz)

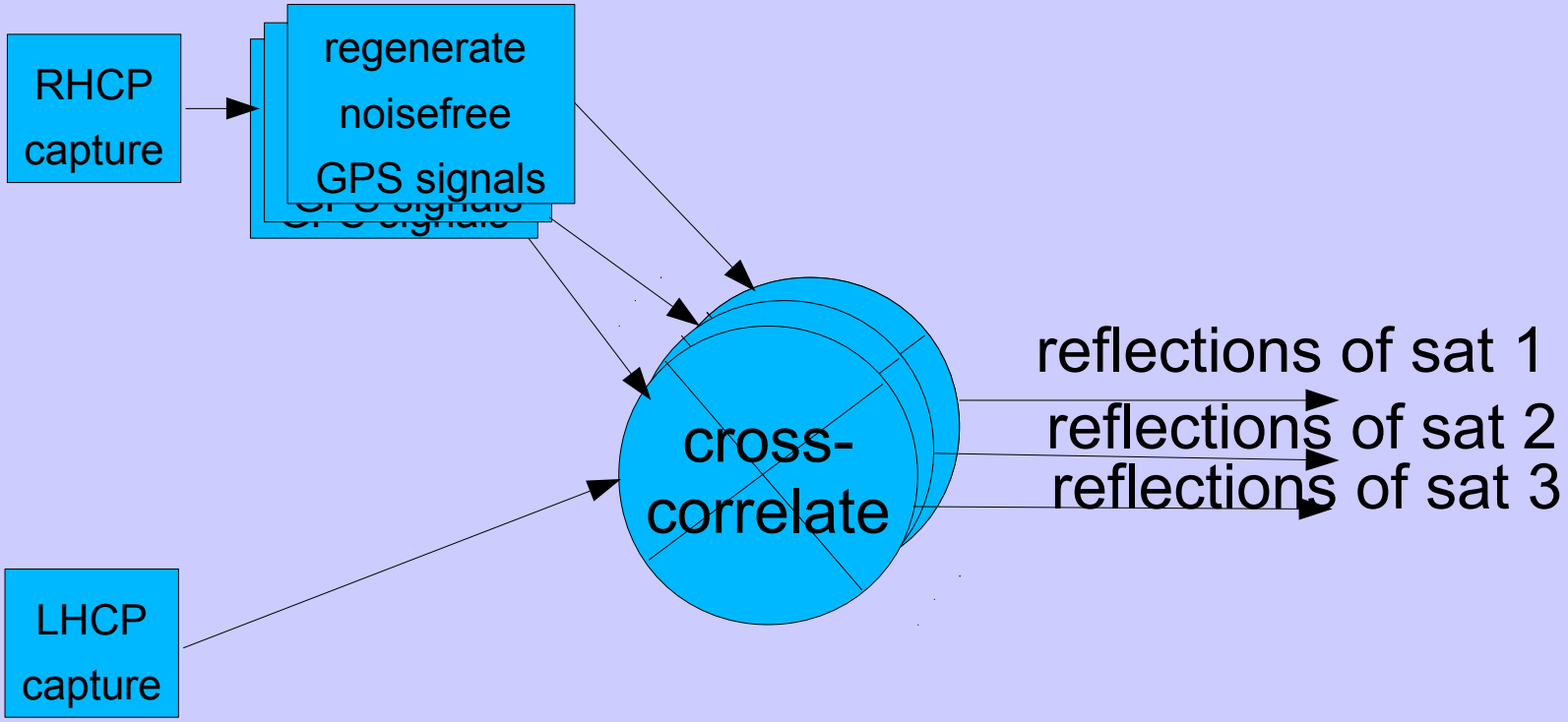
Regenerate noisefree GPS signal

Block is repeated for every PRN / GPS satellite

Uses GNSS-SDR framework

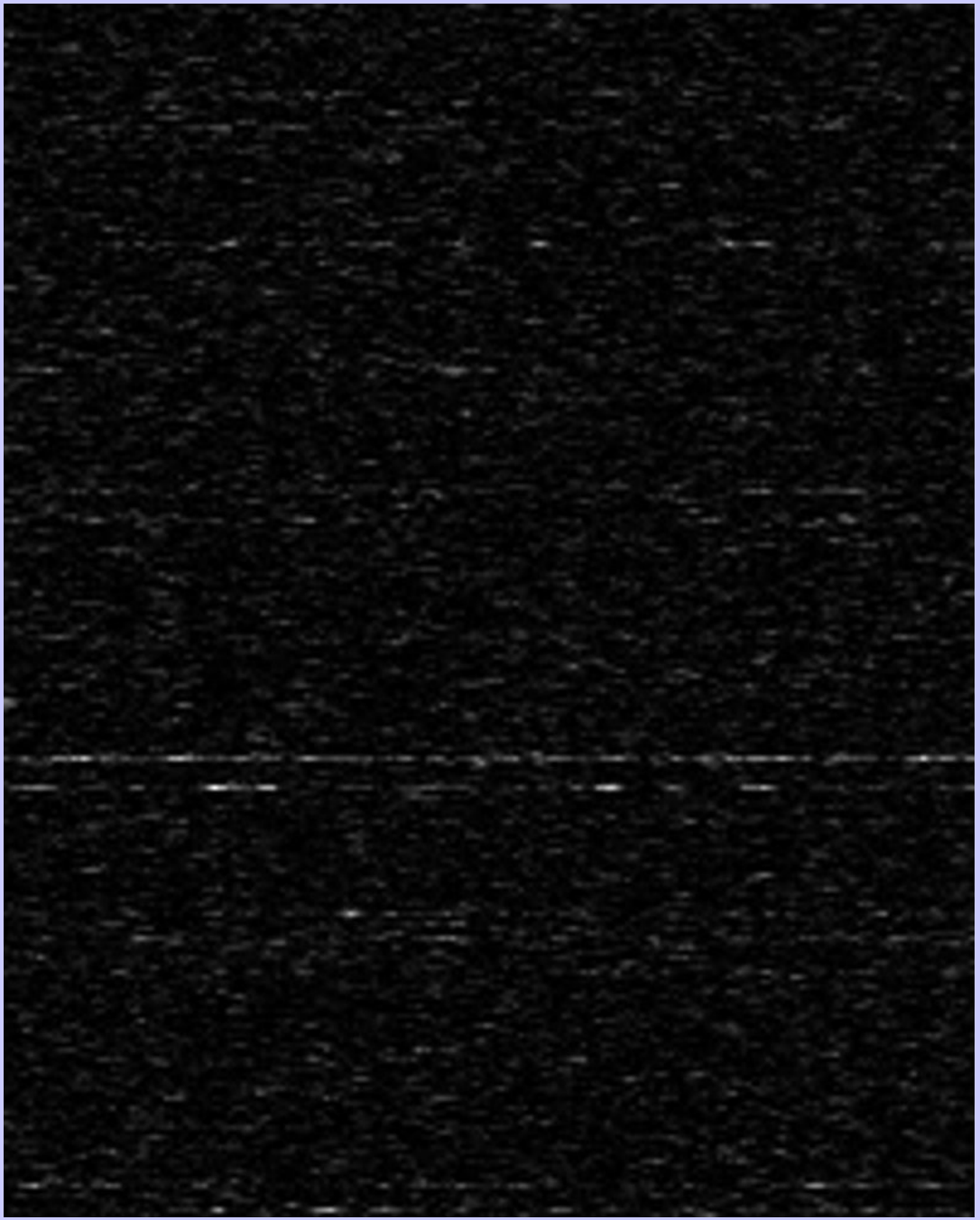


cross-correlate



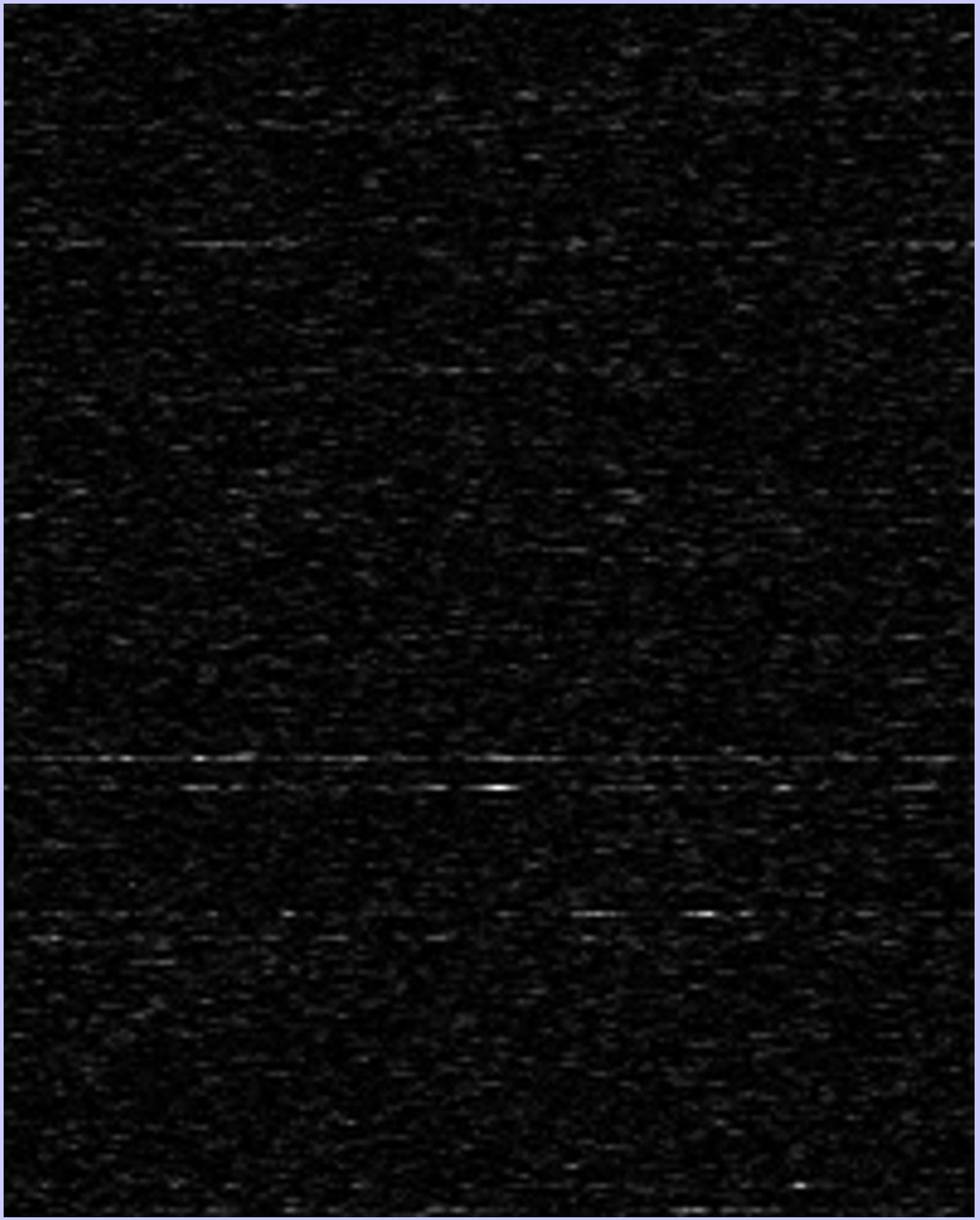
first GPS results

Sat 0



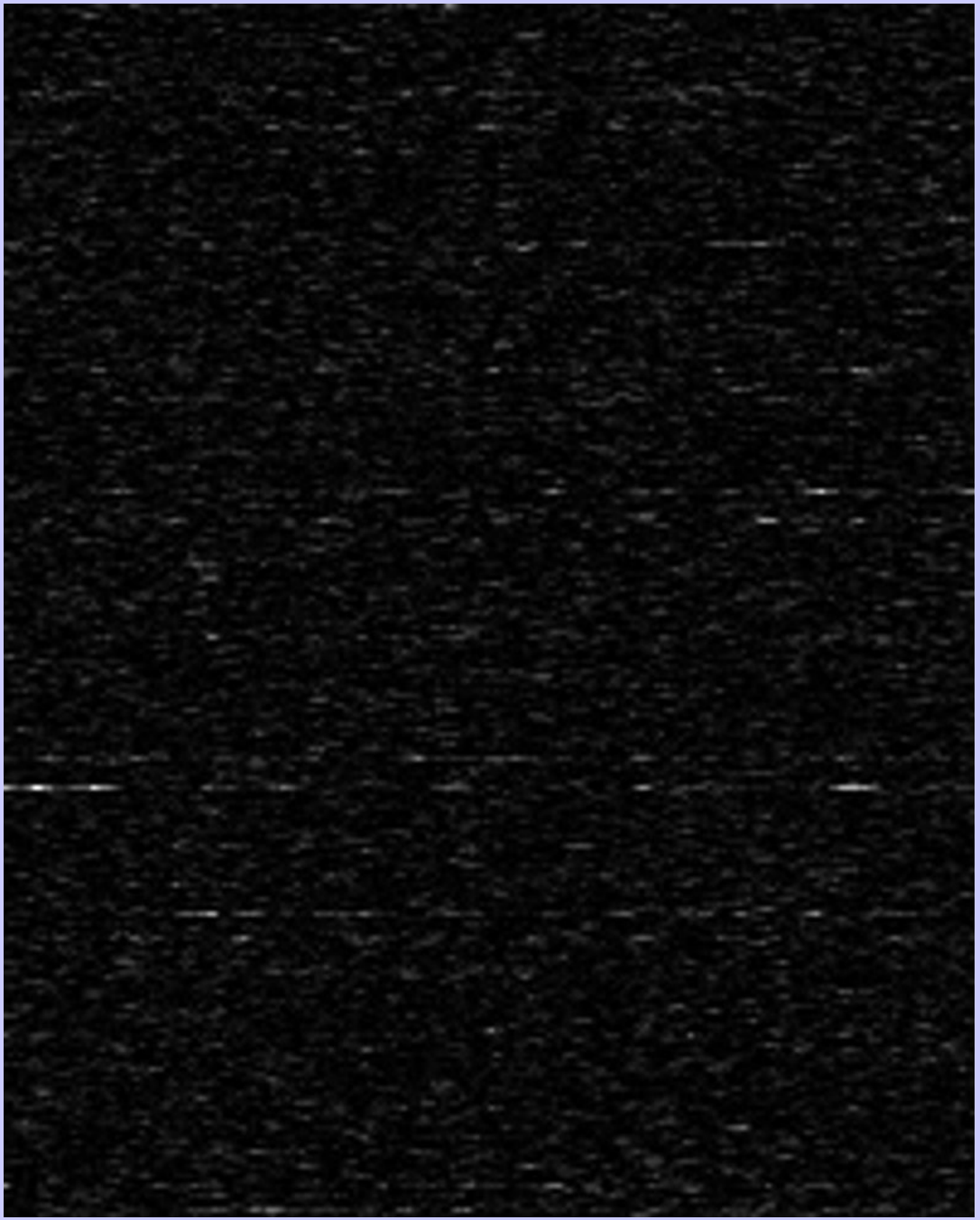
first results

Sat 1



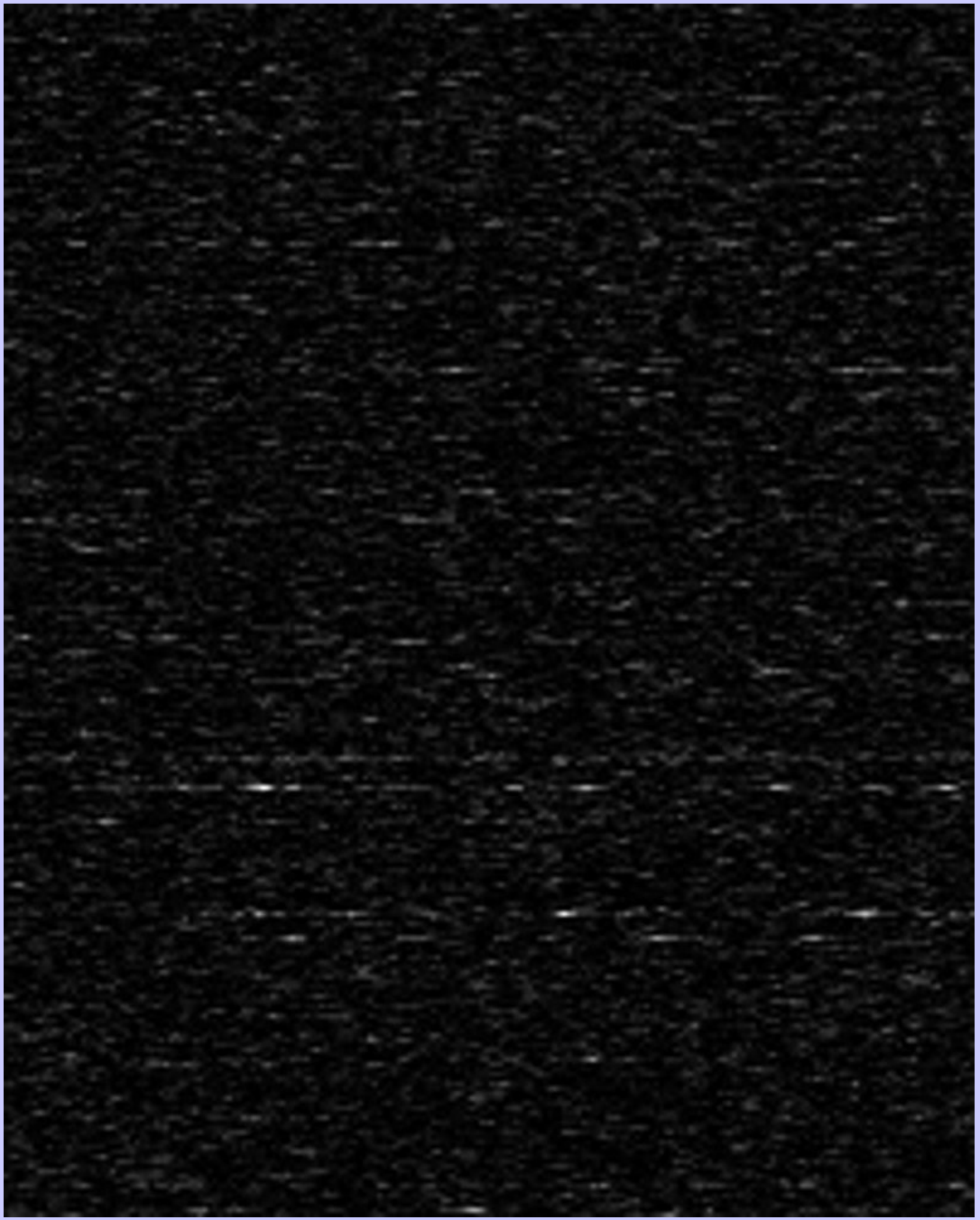
first GPS results

Sat 2



first GPS results

Sat 3



first GPS results

combined

Combine smart, get 3D position

- multiliteration
  - (kind of) GPS fix of reflections
  - each satellite has different pos. and speed
  - crosscorr peaks at different time and doppler
  - determine possible locations of objects. (intersect ellipsoids of reflection pseudoranges)
- eliminate false positives
- combine into single 3D radar image

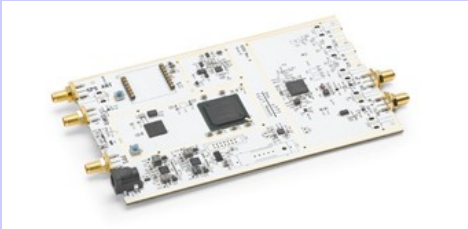
next steps...

- Goal: landscape, buildings and traffic
  - sub-meter resolution
- multiple receiver locations
  - Radar at home community
- real-time application with GUI
- multiple transmitter types
  - digital terrestrial TV signals, ~50 m resolution
  - broadband satellite TV, sub meter resolution
- Target tracking (multiple targets)

meetup ?

P Ost (1?3?)
extra small campsite for mobil homes, caravans and tents
right at the east exit of the messe (next to A7)

Resources / Contact



- http://www.olifantasia.com
  - contact form
- email: PA1SDR@olifantasia.com

- Hardware
  - USRP B200, B210 with metal case
  - coupon code: **HAMRADIO2015B2**
- Software
  - gnuradio.org, olifantasia.com & GNU octave
  - Contact me for my latest passive-radar-gps code
  - google "gr-passive-radar-standalone",
    (=older version in private branch nldudok1 on gnuradio server.)