FMCW surveillance radar

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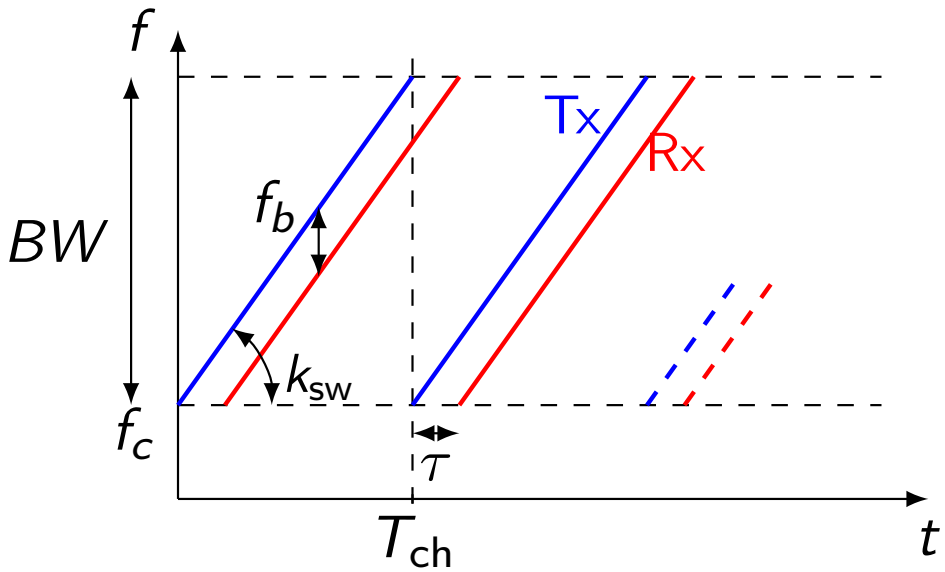
Sections

Surveillance radar

- Detection of target in 2D/3D space
- 2 basic approaches
  - MIMO systems - electronic beamsteering, complex processing, preferred for demanding applications
  - Mechanical scanning - simpler, easier processing, cheaper, mechanical components
- Generally based on pulsed radars – ideal for long range applications, require high broadcast power for good resolution

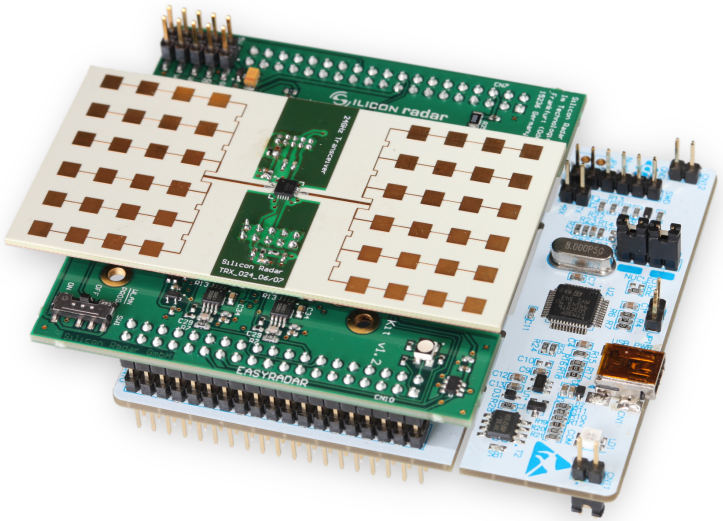
FMCW radar



Ideal relation of frequency on time for received and sent signal

- Broadcasts frequency modulated signal
- Low power consumption with great ranger resolution
- Range of target: $R = \frac{c_0 f_b T_{ch}}{2BW}$, $\Delta R = \frac{c_0 N_{samples}}{2BW \cdot NFFT}$
- Speed of target: causes phase shift across many chirps

SiRad Easy



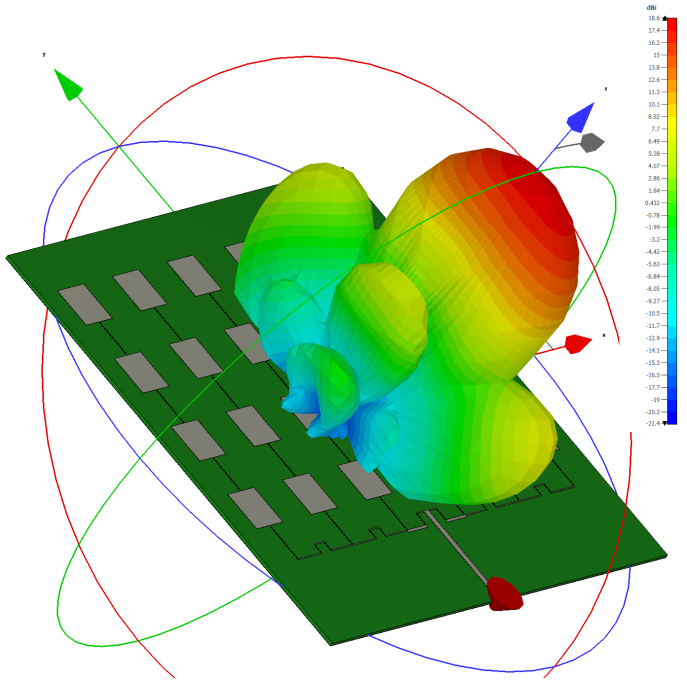
SiRad Easy 24 GHz configuration

- Evaluation kit from Indie Semiconductors
- Supports 24 GHz and 122 GHz transceivers
- Primarily designed to supply already processed data

SiRad Easy

- Slow sample rate (at best around 20 ms)
  - Maximal detectable speed bellow 1 ms/s
  - Rotation speed limited to low RPM
- 122 GHz header
  - Tight radar beam $\pm 4^\circ$ in both directions
  - Maximal advertised ranged of 40 m, measured one closed to 30 m
  - Ideal for close range, high resolution applications

SiRad Easy



Radiation pattern of 24 GHz header – 3D view

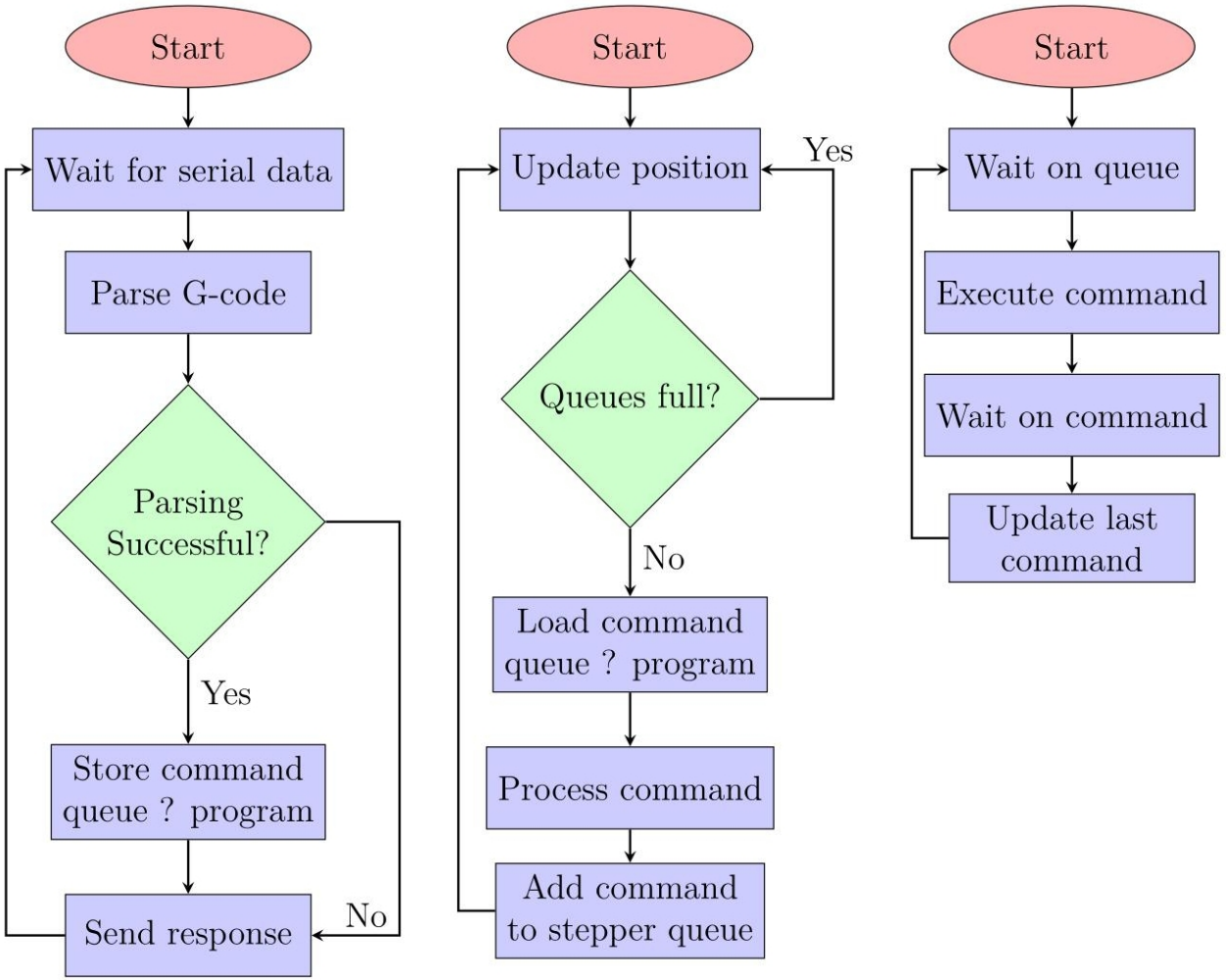
- 24 GHz header
  - Radiation characteristics simulated in CST studio
  - 16 degrees in azimuth, 30 degrees in elevation
  - Long range applications

Rotary Platform

- Two axis of movement
- Continuos rotation with aid of a slipring
- Powered by ESP32C6 microcontroller
- G-Code-like API
- Supports: automatic homing, relative/absolute positioning, spindle, preprogramming movement sequence

Platform

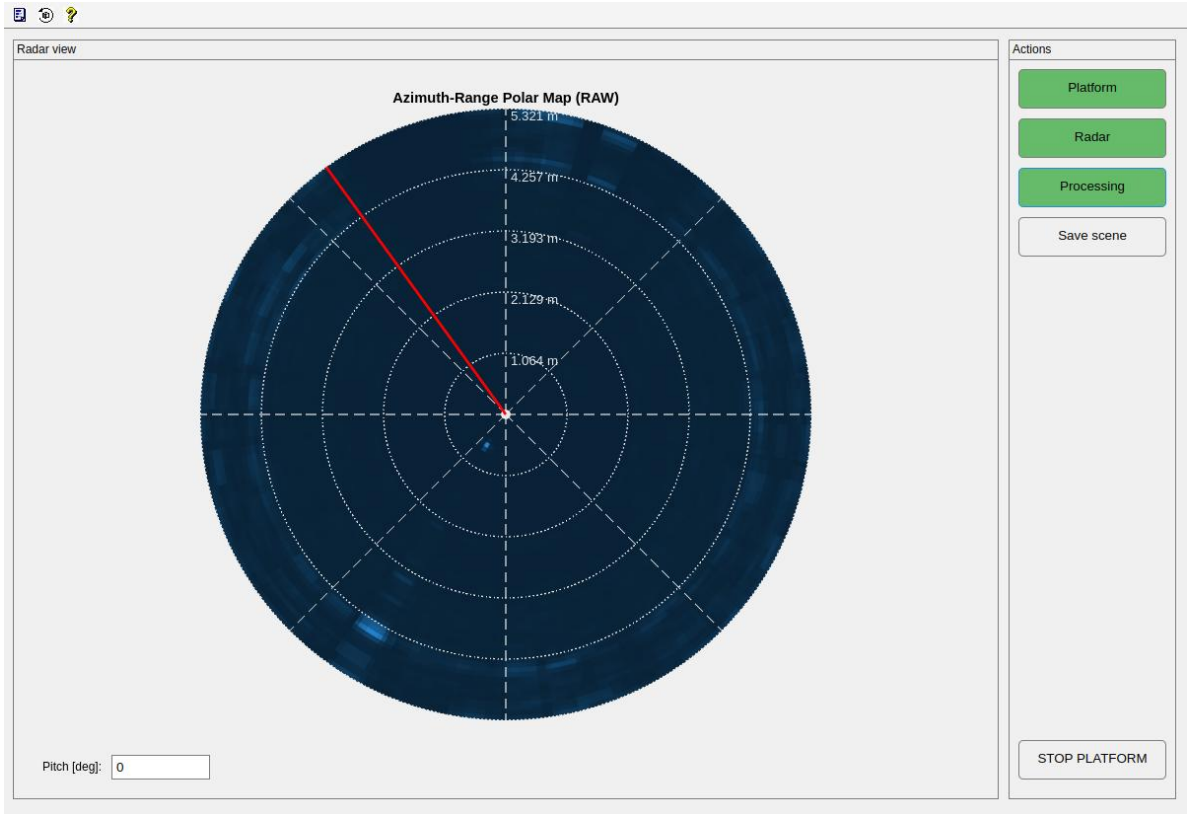
Platform Firmware Flow



Platform Program Example

Command	Mode	Purpose
`P90 rotTilt`	Header	Initialize program rotTilt
`G91`	Header	Set relative positioning
`G21`	Header	Set units to steps
`G28`	Header	Start auto home routine
`G0 P-50 S6`	Header	Move pitch 50 steps
`W3 T5000`	Header	Wait five second
`P92`	Header	Set current position as home
`P29`	Header	Enable infinite looping
`M03 SY6 Y+`	Header	Start Yaw spindle (6 RPM)
`P92`	Header	Finalize header declaration
`G0 S5 P40`	Body	Pitch movement
`G0 S5 P-40`	Body	Return pitch
`P92`	Body	Finalize program

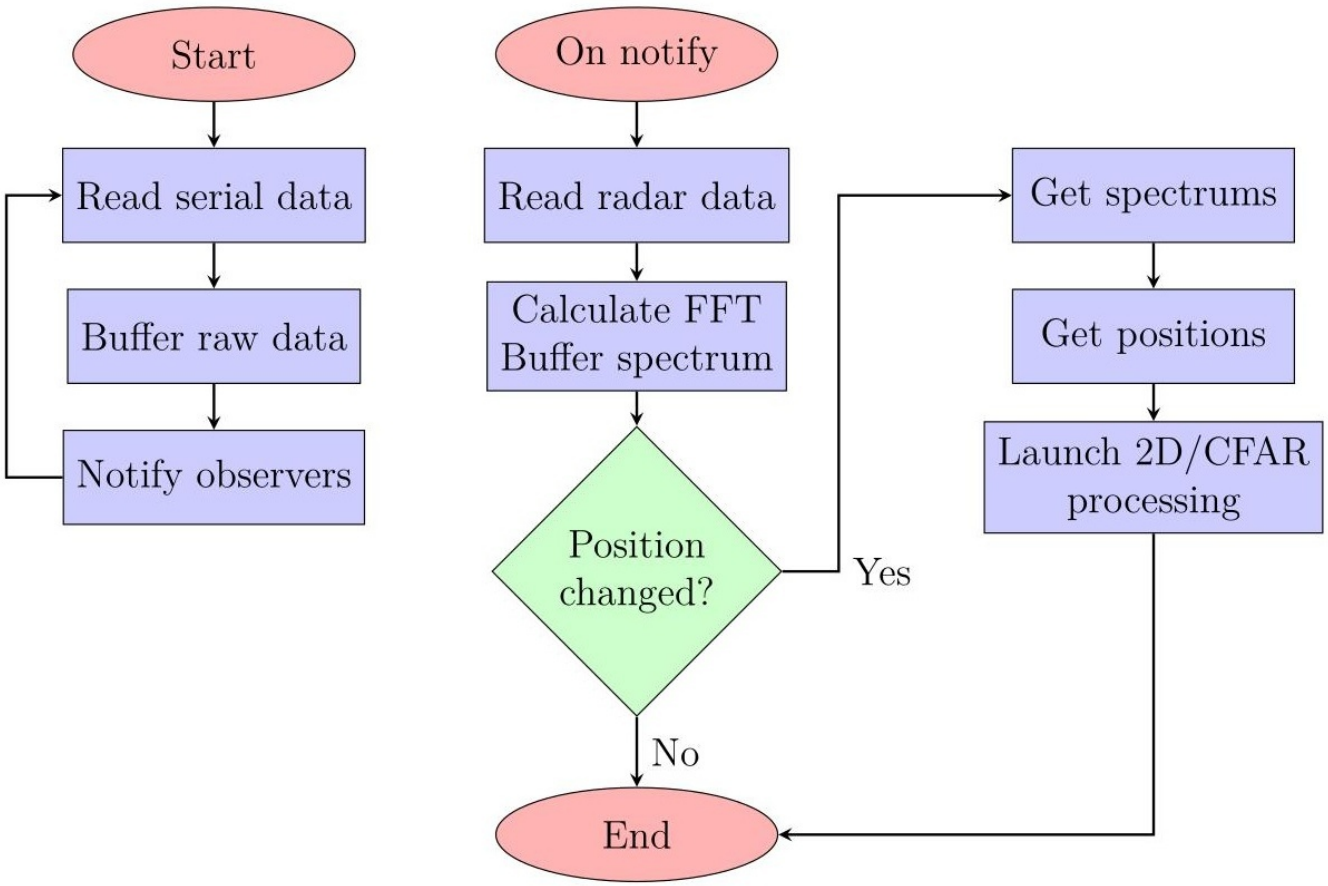
Data Processing



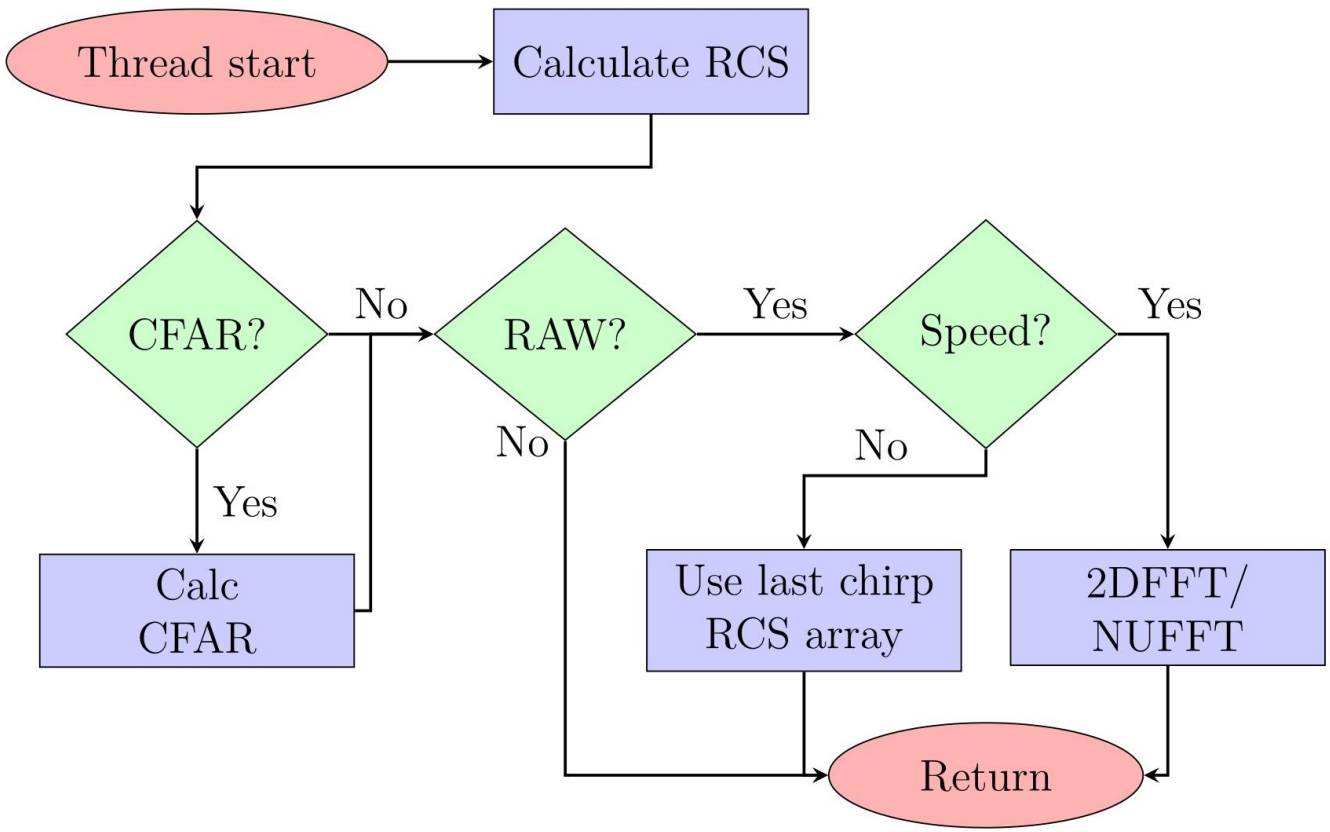
Range-Azimuth visualization

- Control app written in MATLAB
- Integrates radar and platform data
- Processing pipeline features extensive configurability

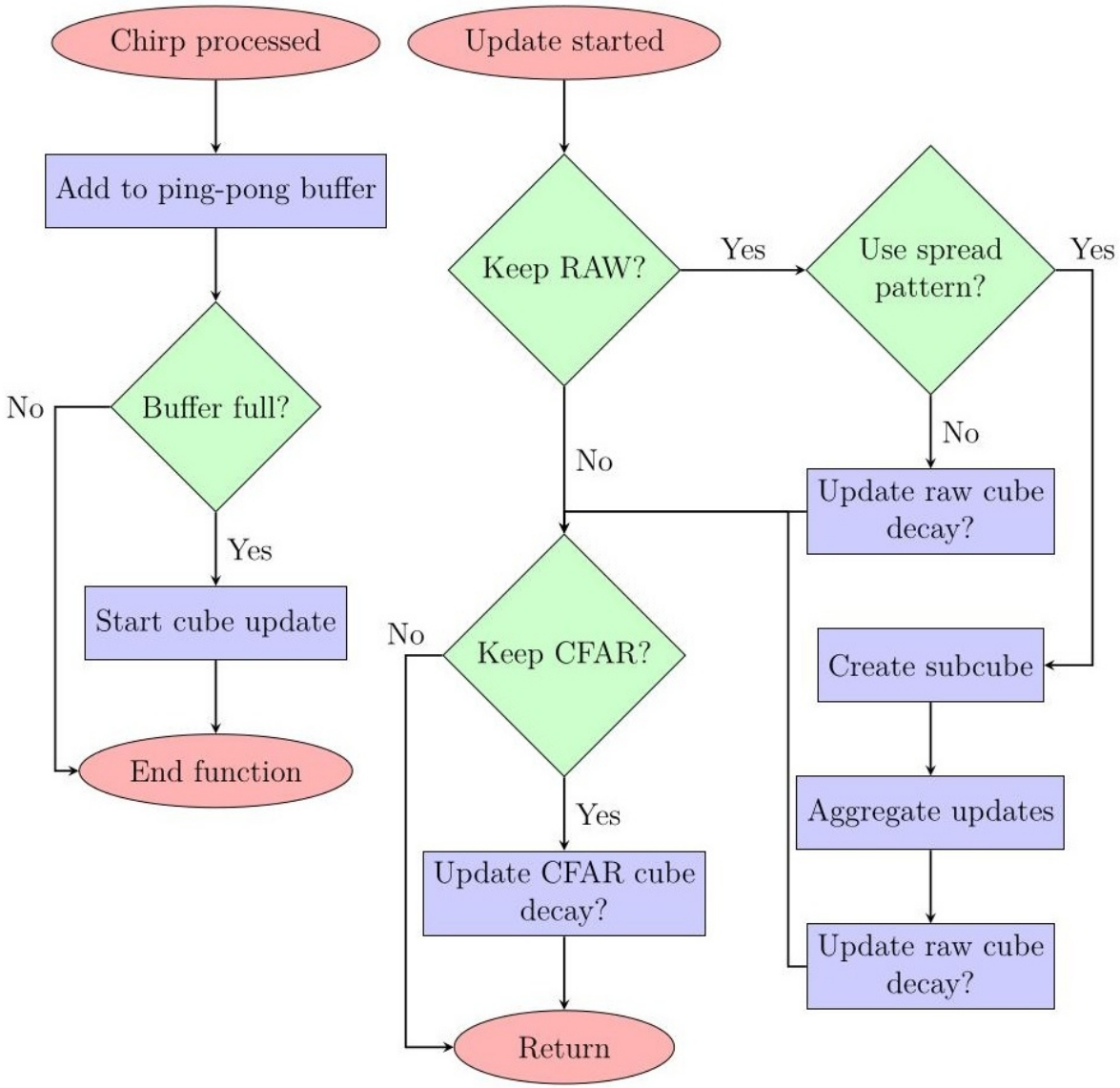
Data aquisition



Data processing



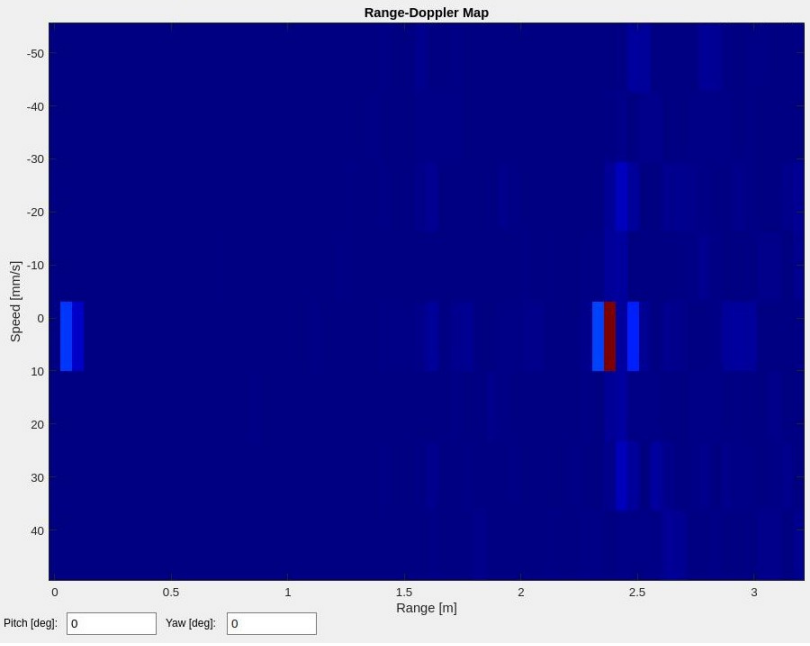
Data storing



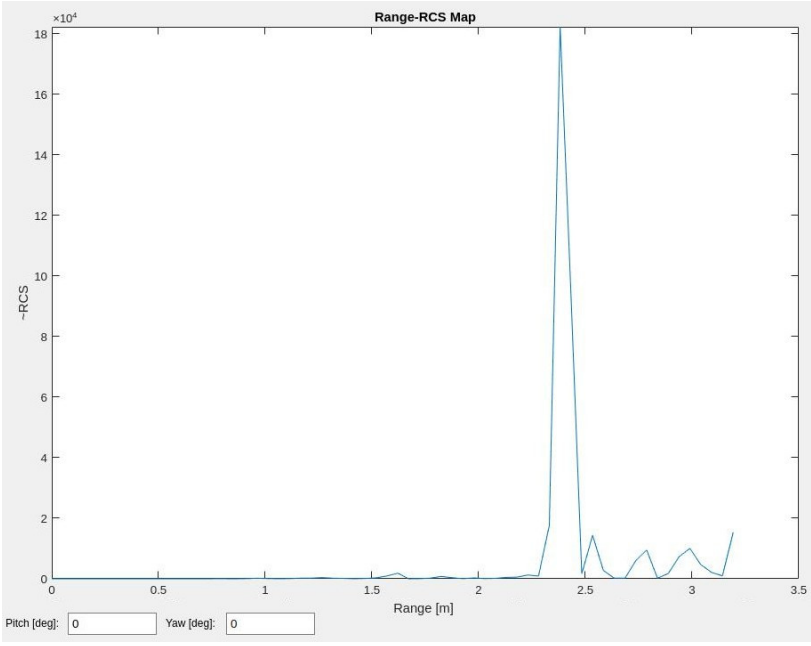
Visualization

- Data are only provided in graphic way to the user
- Simple storage method allows for easy integration of other visualizations
- Three visualization styles
  - Range-RCS or Range-Doppler
  - Range-Azimuth
  - 3D

Visualization – Range-RCS/Doppler

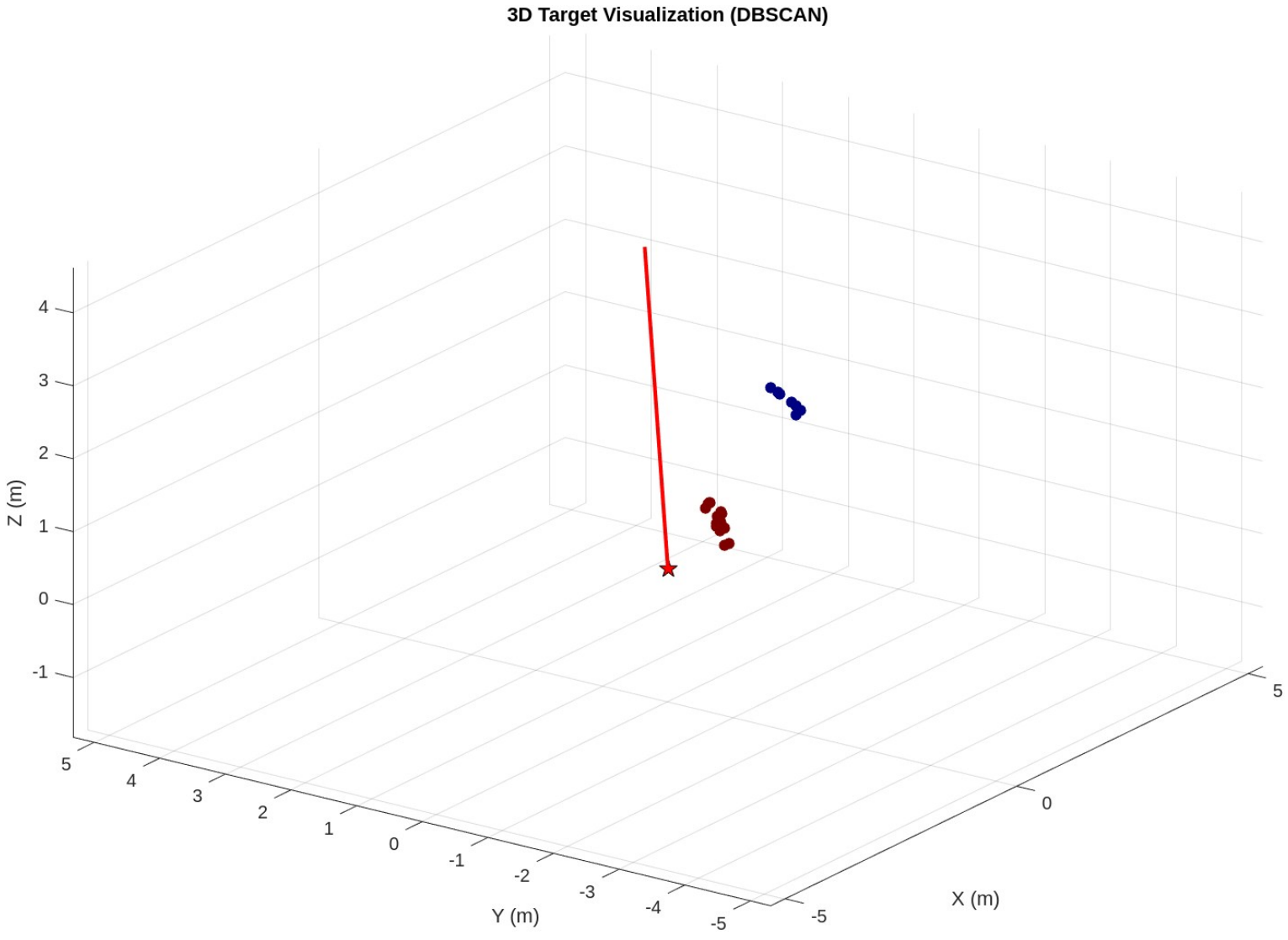


Range-Doppler



Ranger-RCS

Visualization – 3D



Conclusion

- SiRad Easy
  - Sufficient for monitoring static scenes
  - Speed estimation is limited – tracking application isn't a possibility
- Rotary platform
  - Matches design requirements, offers unique capabilities not found in other G-Code interpreters
  - Underpowered azimuth motor and low belt tension
- Processing
  - Large degree of configuration
  - Pipeline performant, except final visualization under Linux

Q1: Exprimental Data

- Large number of parameters: header, bandwidth, gain, target, CFAR setting – requires fine tuning
- Proper Hardware in the Loop testing is complex
- Author couldn't establish correct, reproducible, validation methodology to give measured data any validity
- No testing in controlled environment was done
- When static the radar capabilities generally match advertised
  - 122 GHz header – Tight beam $\Rightarrow$ very sensitive to target orientation