

# FMCW Surveillance Radar

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# Sections

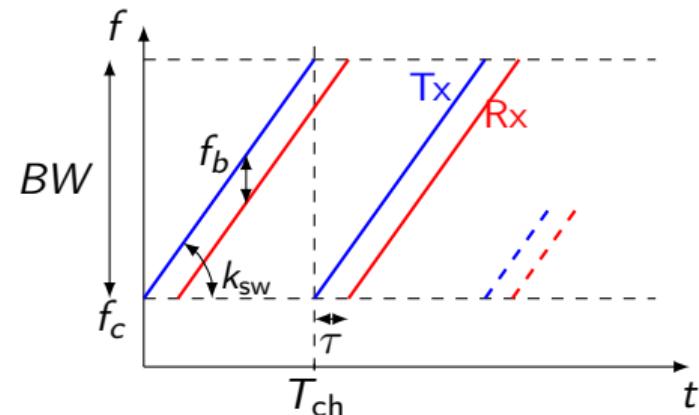
- 1** Surveillance FMCW Radar
- 2** SiRad Easy
- 3** Rotary Platform
- 4** Desktop Application
- 5** Conclusion

## Surveillance Radar

- Localization of target in plane or 3D space
- 2 basic approaches
  - Electronic beamsteering: MIMO systems, complex processing, preferred for demanding applications
  - Mechanically steered beam: simpler, easier processing, cheaper, less reliable
- Generally based on pulsed radars

# FMCW Radar

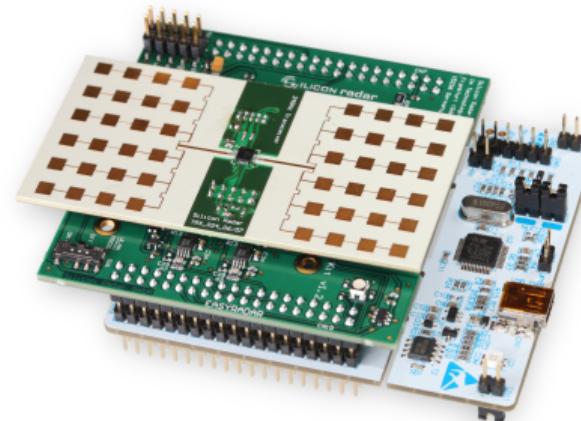
- Broadcasts frequency modulated signal
- Low power consumption with great ranger resolution
- Range of target: proportional to beat frequency
- Speed of target: causes phase shift across many chirps



FMCW TX and RX Signal

## SiRad Easy

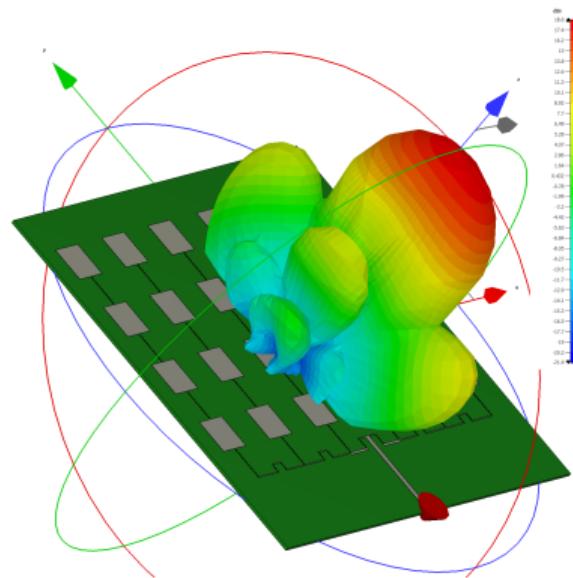
- Evaluation kit from Indie Semiconductors
- 24 GHz and 122 GHz transceivers modules
- Provides raw data from ADC converters over serial
- Slow update rate (at best around 20 ms)
  - Max target speed below 1 ms/s
  - Rotation speed limited to low RPM



SiRad Easy 24 GHz Configuration

## SiRad Easy: 24 GHz Module

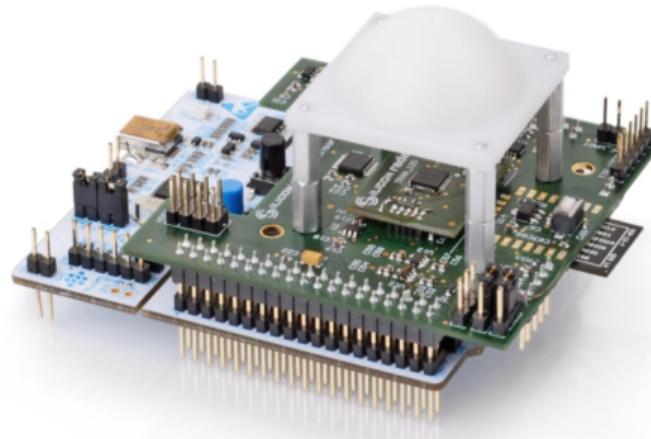
- Radiation characteristics simulated in CST studio
- 16 degrees in azimuth, 30 degrees in elevation
- Long range applications (300 m)



Radiation Pattern of 24 GHz Header

## SiRad Easy: 122 GHz Module

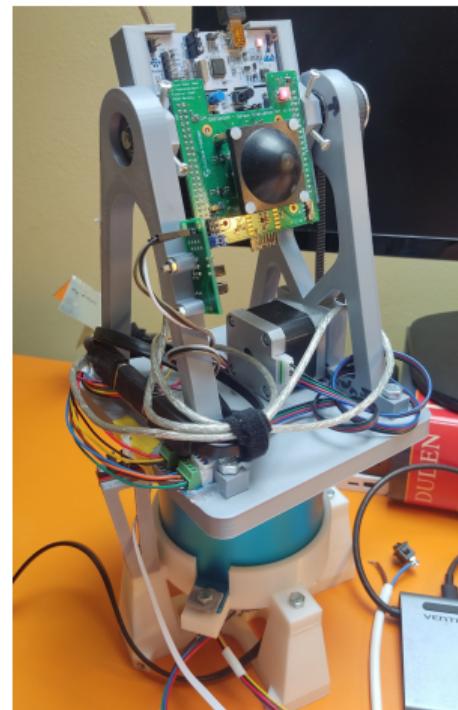
- Tight radar beam  $\pm 4^\circ$  in both directions
- Measured maximal range of 30 m
- Ideal for close range, high resolution (5 cm) applications



SiRad Easy 122 GHz Configuration

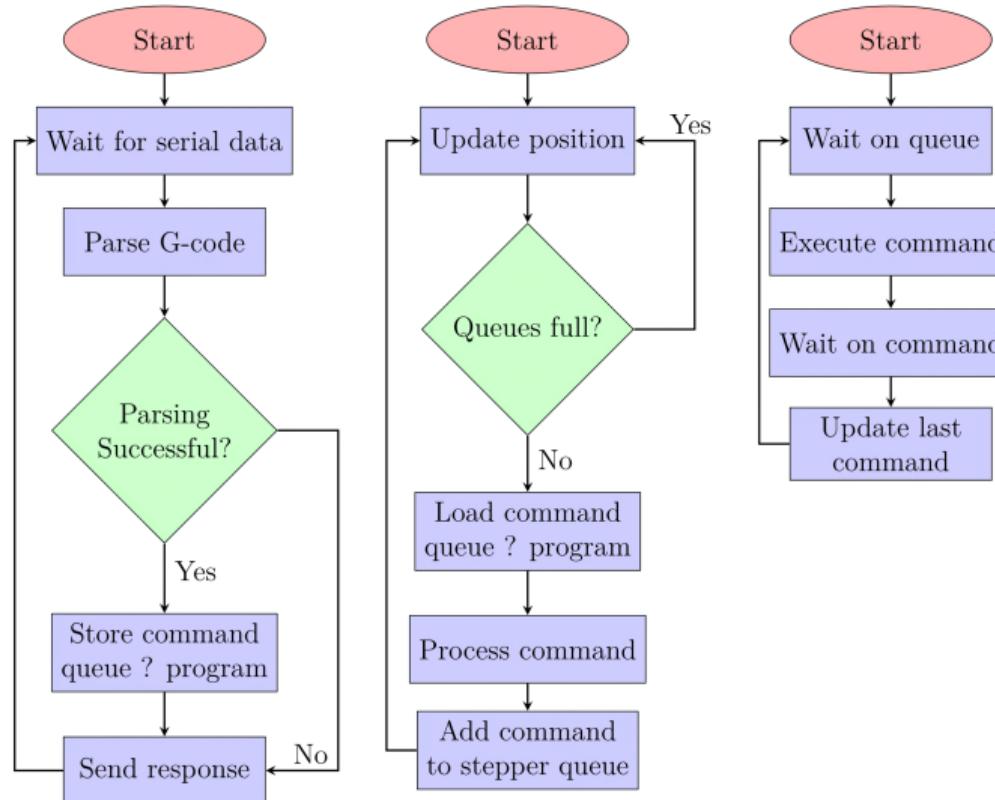
## Rotary Platform

- Two axis of movement, at low RPM
- Continuos rotation in azimuth
- ESP32C6 microcontroller
- G-Code-like API over serial
- Supports: automatic homing,  
relative/absolute positioning,  
spindle, preprogramming movement  
sequences



Platform with 122 GHz Module

## Platform Firmware Flow

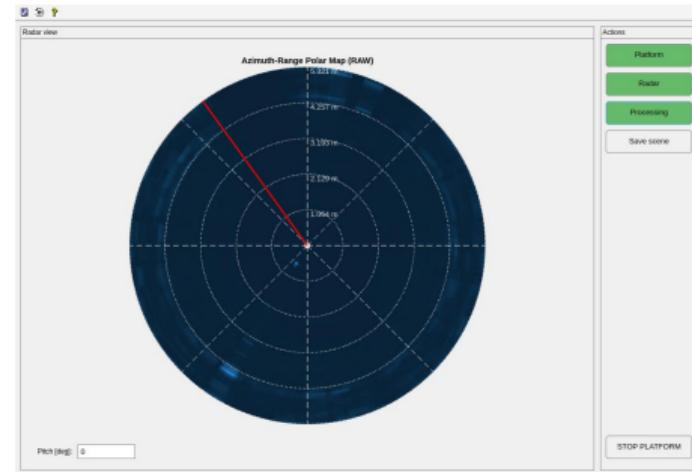


## Platform Program Example

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

## Desktop Application

- Control app written in MATLAB
- Integrates radar and platform data
- Offers wide degree of customization



Main App Window

## Preferences: Radar

### RADAR CONFIG

Radar frequency [GHz]: 24  122

Radar bandwidth [MHz]:

Trigger period [ms]:

Radar gain [dB]:  ▾

Chirp samples:  ▾

Max speed limit [m/s]: 0.0245732

ADC ClkDiv [MS/s]:  ▾

Chirp time [ms]: 1.14783

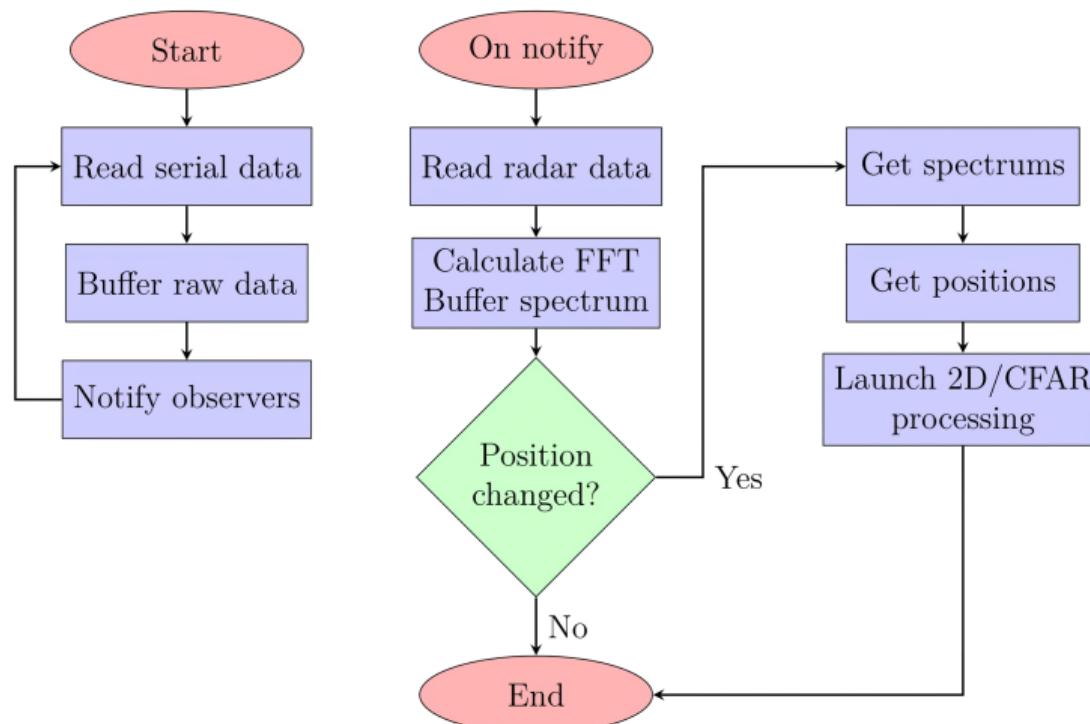
Ramp coherent avg:  ▾

## Preferences: Processing

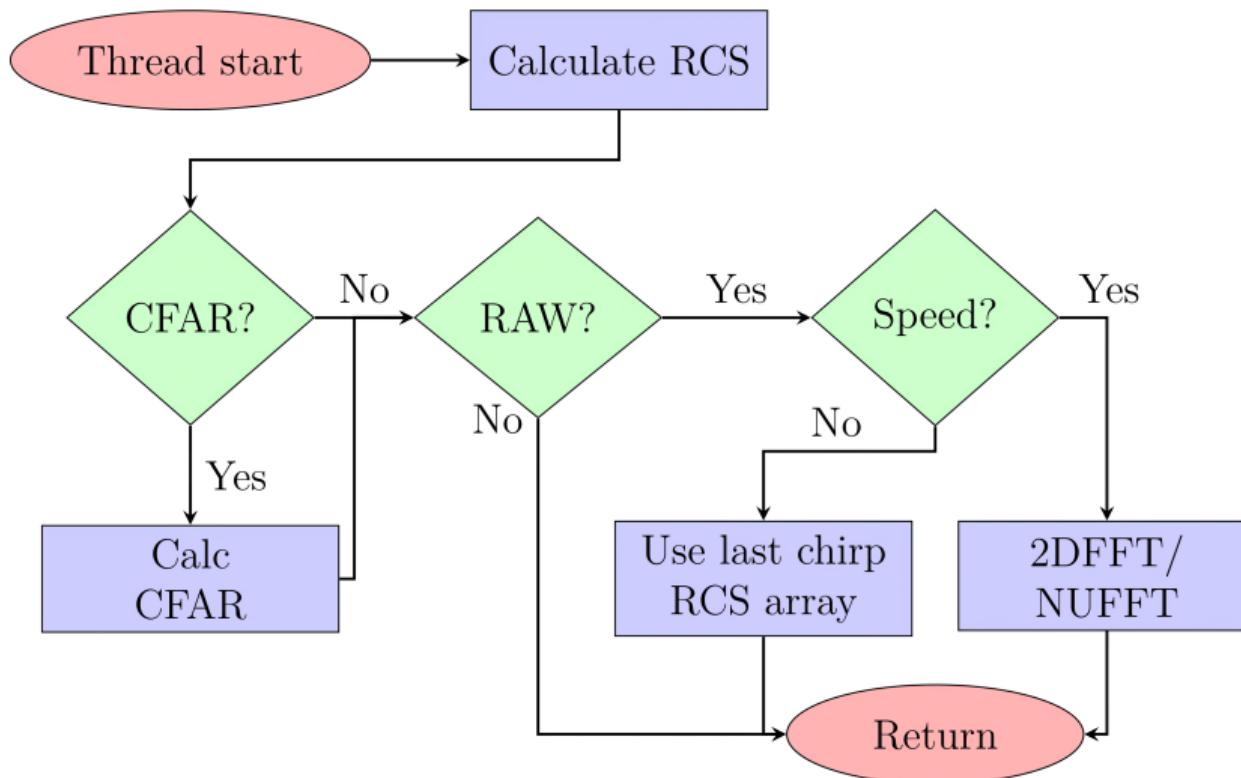
### PROCESSING CONFIG

Visualization:	Range-Azimuth ▾	Calc speed:	On <input checked="" type="checkbox"/> Off
Speed NFFT:	8 ▾	Range bin width [m]:	0.0498873
Range NFFT:	128 ▾	Speed bin width [m/s]:	0.00614329
Reset yaw:	0	Calc raw cube:	On <input checked="" type="checkbox"/> Off
CFAR training:	10	Calc CFAR:	On <input checked="" type="checkbox"/> Off
CFAR guard:	2	Require pos change:	On <input checked="" type="checkbox"/> Off
Spread in yaw [deg]:	3	Cube decay:	Decay <input checked="" type="checkbox"/> Reset
Spread in pitch [deg]:	7	Use spread pattern:	On <input checked="" type="checkbox"/> Off
Update batch size:	3	Enable DBSCAN:	On <input checked="" type="checkbox"/> Off
DBSCAN epsilon:	3		
DBSCAN min count:	6		
Max display value:	8e+06		

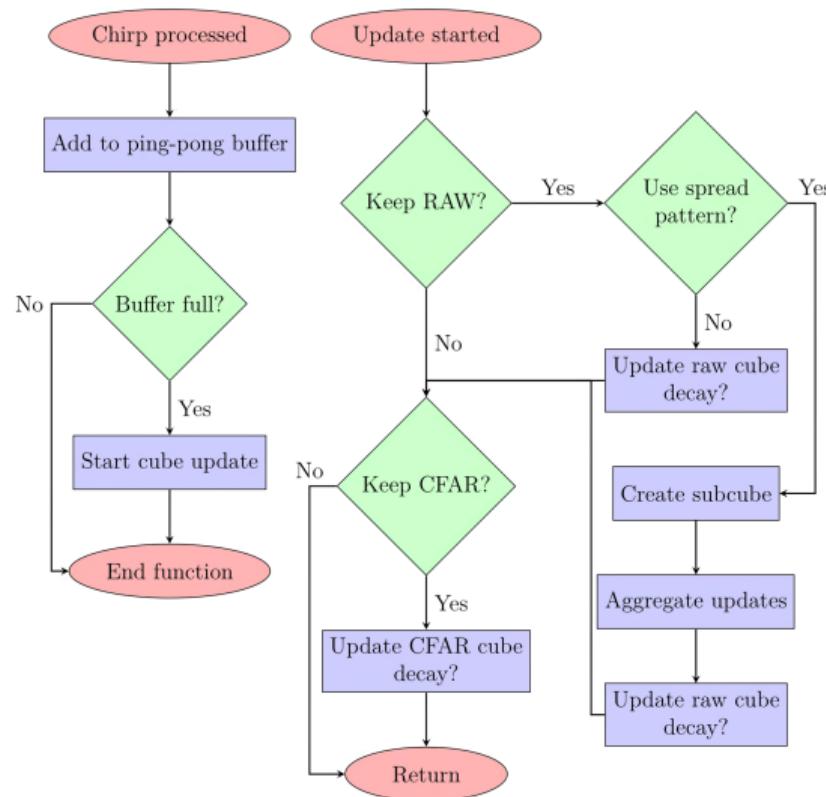
## Data Aquisition



## Data Processing



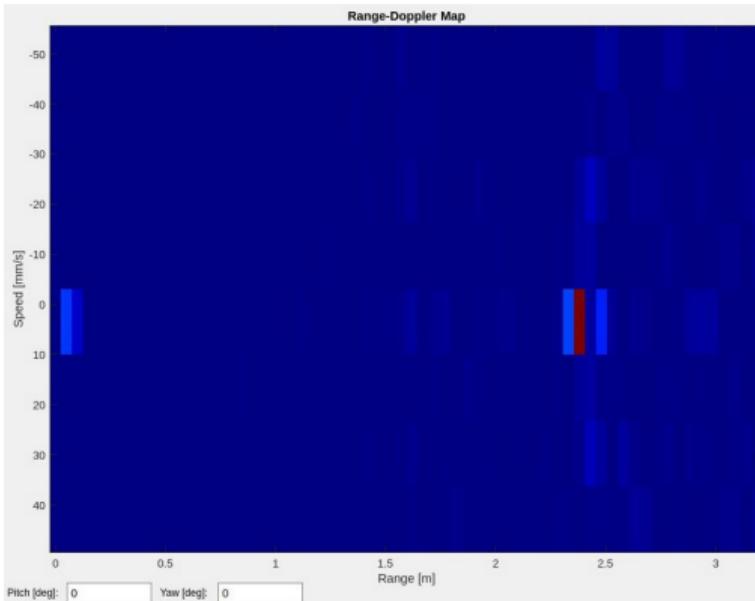
# Data Storing



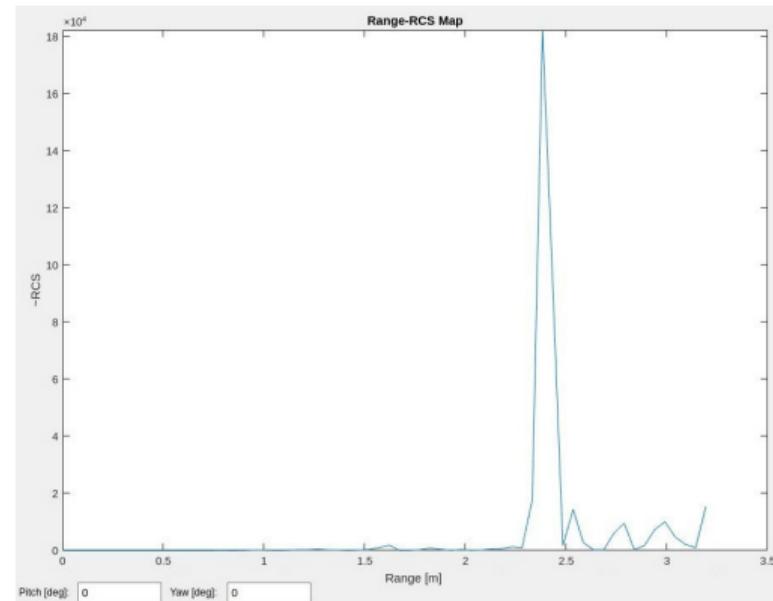
# Visualization

- Data are only provided in a graphic way to the user
- Three visualization styles
  - Range-RCS or Range-Doppler (fixed azimuth and elevation)
  - Range-Azimuth (fixed elevation)
  - 3D

# Visualization: Range-RCS/Doppler

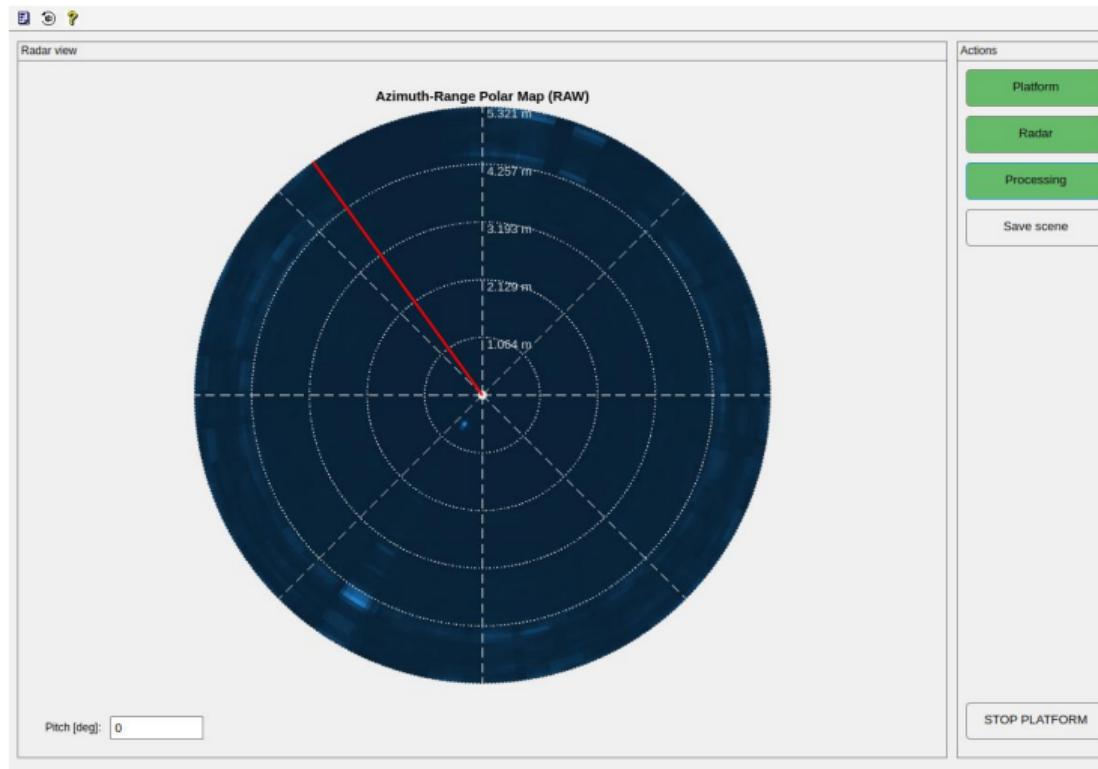


Range-Doppler



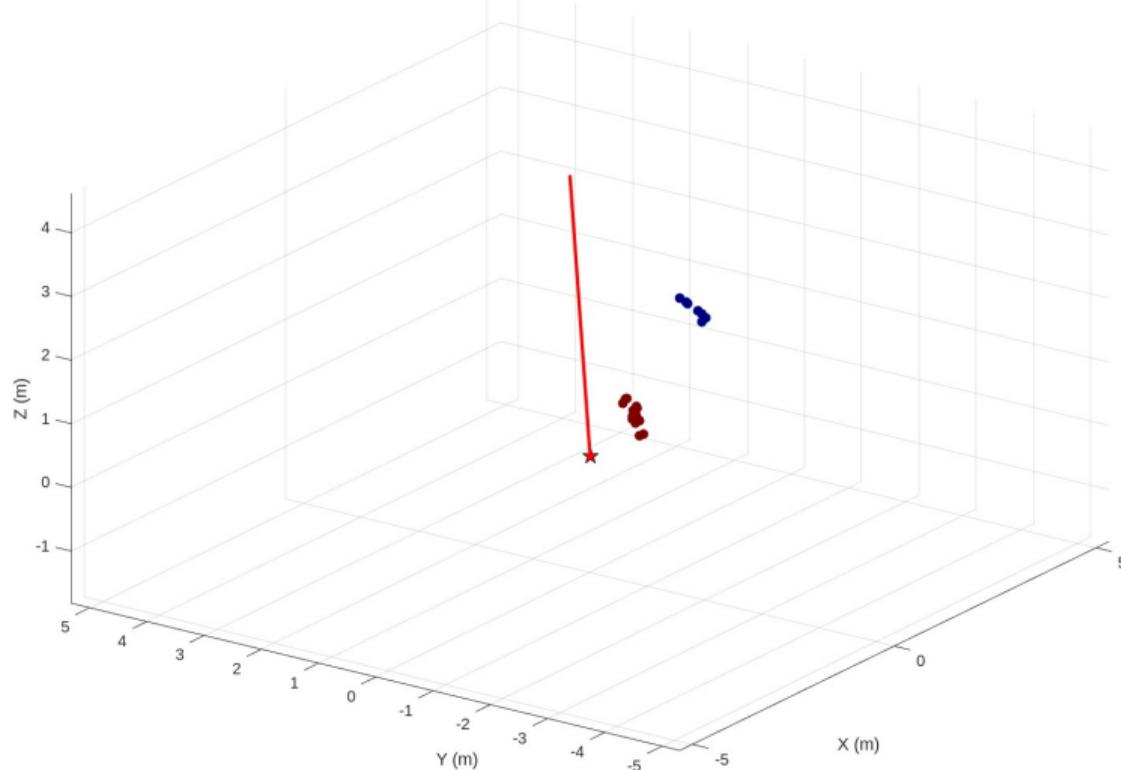
Ranger-RCS

# Visualization: Range-Azimuth



# Visualization: 3D

3D Target Visualization (DBSCAN)



# Conclusion

- SiRad Easy
  - Sufficient for monitoring static scenes
  - Speed estimation is limited – tracking application isn't a possibility
- Rotary platform
  - Matches design requirements
  - Underpowered azimuth motor and low belt tension
- Desktop application
  - Great degree of configuration
  - Pipeline performant, except for final visualization under Linux

## Q1: Experimental Data

- Large number of parameters: header, bandwidth, gain, target, CFAR setting – requires fine tuning
- Rotary movement + inconsistent radar timing complicate reproducibility
- Author couldn't establish correct, reproducible, validation methodology to give measured data any validity
- No testing in a controlled environment was done
- When static, the radar capabilities generally match advertised
  - 122 GHz header – Tight beam ⇒ very sensitive to target orientation