

Design of Microwave Reflectometry for Helimak

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7th International Conference Frontiers in Diagnostics Technologies
INFN – Laboratori Nazionali di Frascati, Frascati (Rome), Italy
October 21nd-23th, 2024

Background

- HELIMAK
- Microwave reflectometry

Design

Implementation

Preliminary test

Summary

Background

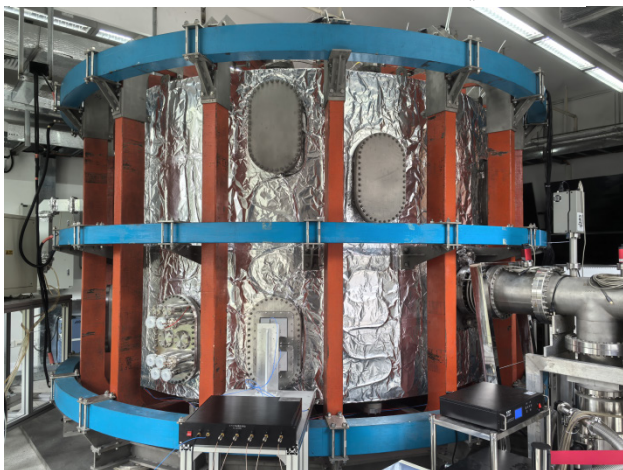
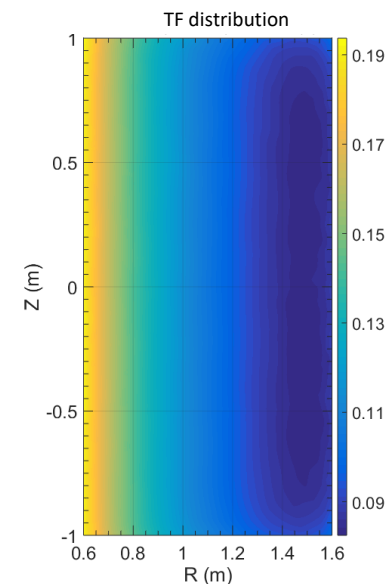
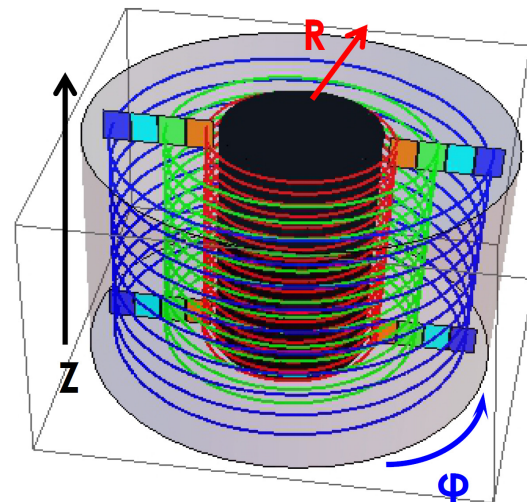
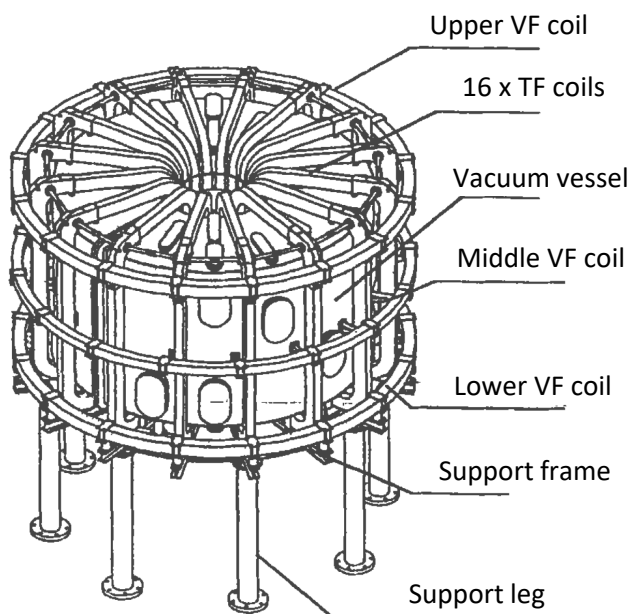
- HELIMAK
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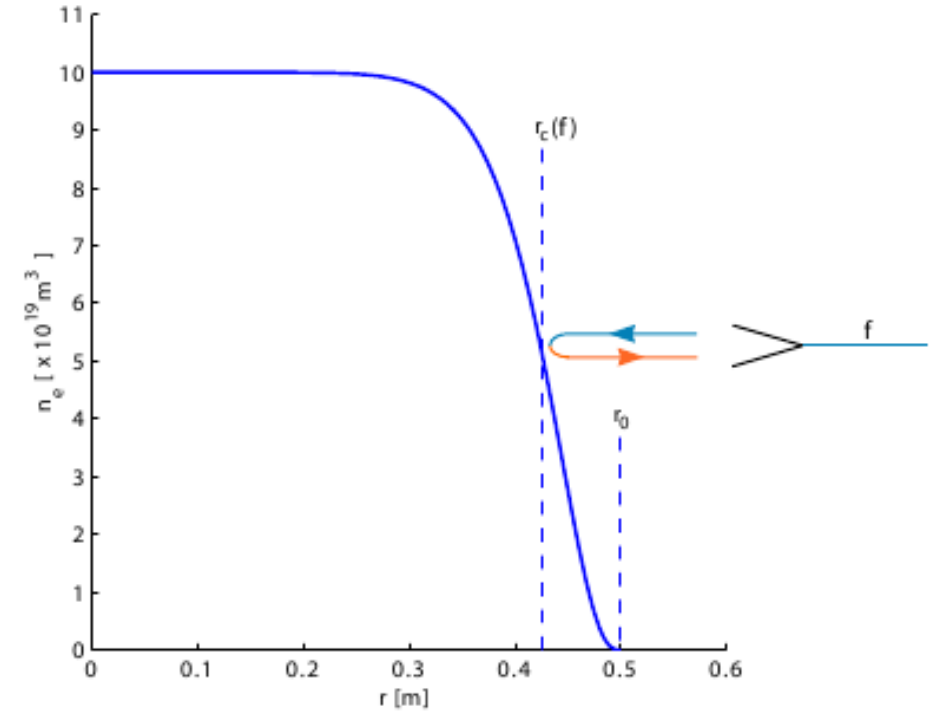
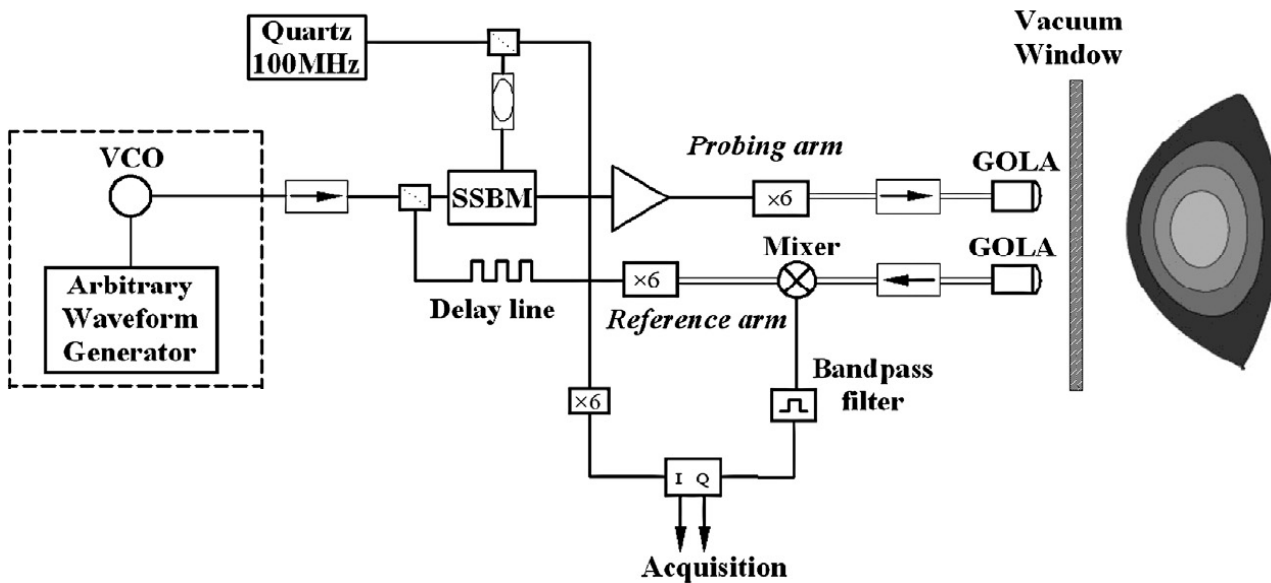
Summary



Gas	Helium	Argon
T_e (eV)	15	10
n (m^{-3})	$\leq 5 \times 10^{16}$	$\leq 1 \times 10^{17}$
B_ϕ (T)	0.05 to 0.13	0.05 to 0.13
$\langle R \rangle$ (m)	1.1	1.1
$L_n = n/(dn/dr)$ (m)	0.1	0.1
c_s (m/s)	2×10^4	5×10^3
ρ_s (mm)	8	20
v_{de} (m/s)	10^3	10^3
β	3×10^{-5}	4×10^{-5}
ν_{ee} (s^{-1})	$\leq 10^5$	$\leq 2 \times 10^5$
Connection length $L_{ }$ (m)	$500 \geq L_{ } \geq 12$	$500 \geq L_{ } \geq 12$
Neutral pressure (Torr)	$\geq 10^{-5}$	$\geq 10^{-5}$
ν_{en} (s^{-1})	$\geq 4 \times 10^5$	$\geq 4 \times 10^5$

Density profiles measurements:

- ❑ Microwave can be reflected when the cut-off layer reached
- ❑ Fast sweep microwave source to freeze the density fluctuations
- ❑ Time delay of the microwave used to extract density profile



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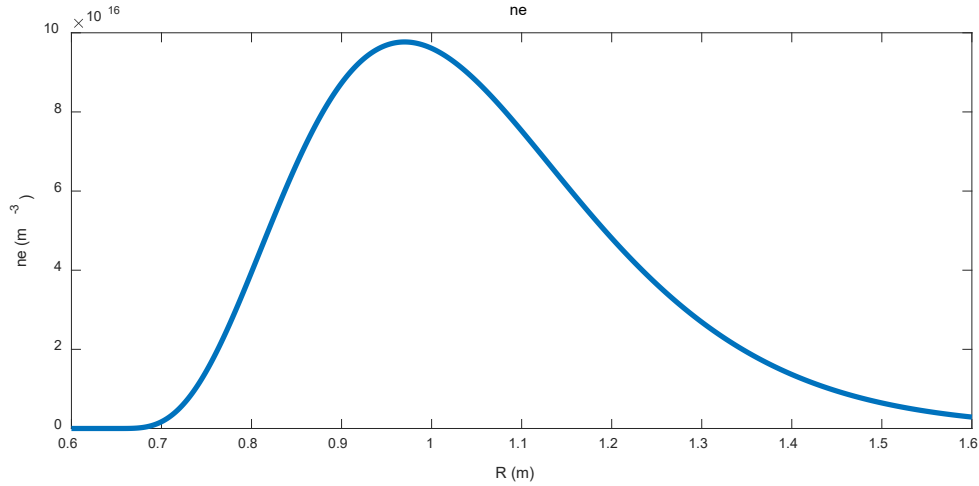
Summary

□ Purpose

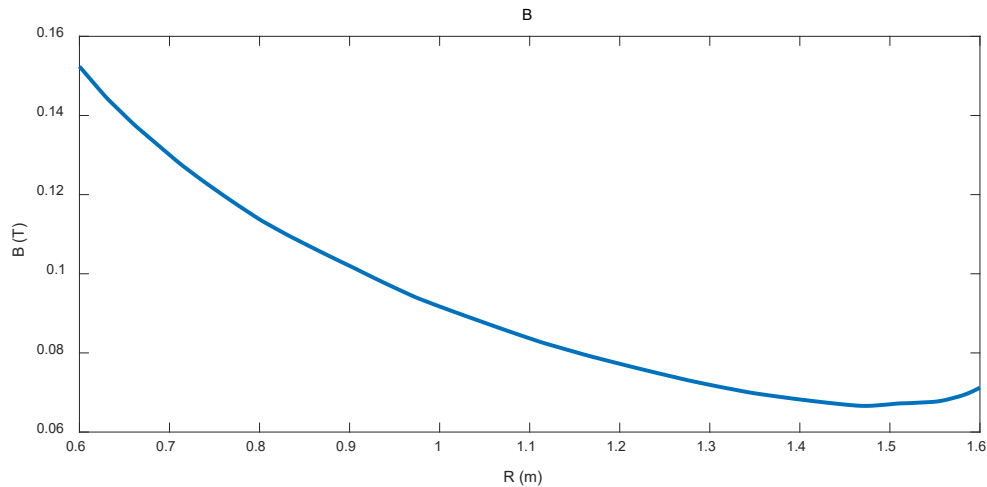
- To measure density profile for experimental research
- To provide opportunities to learn about microwave diagnostics for students in plasma physics

□ Requirements

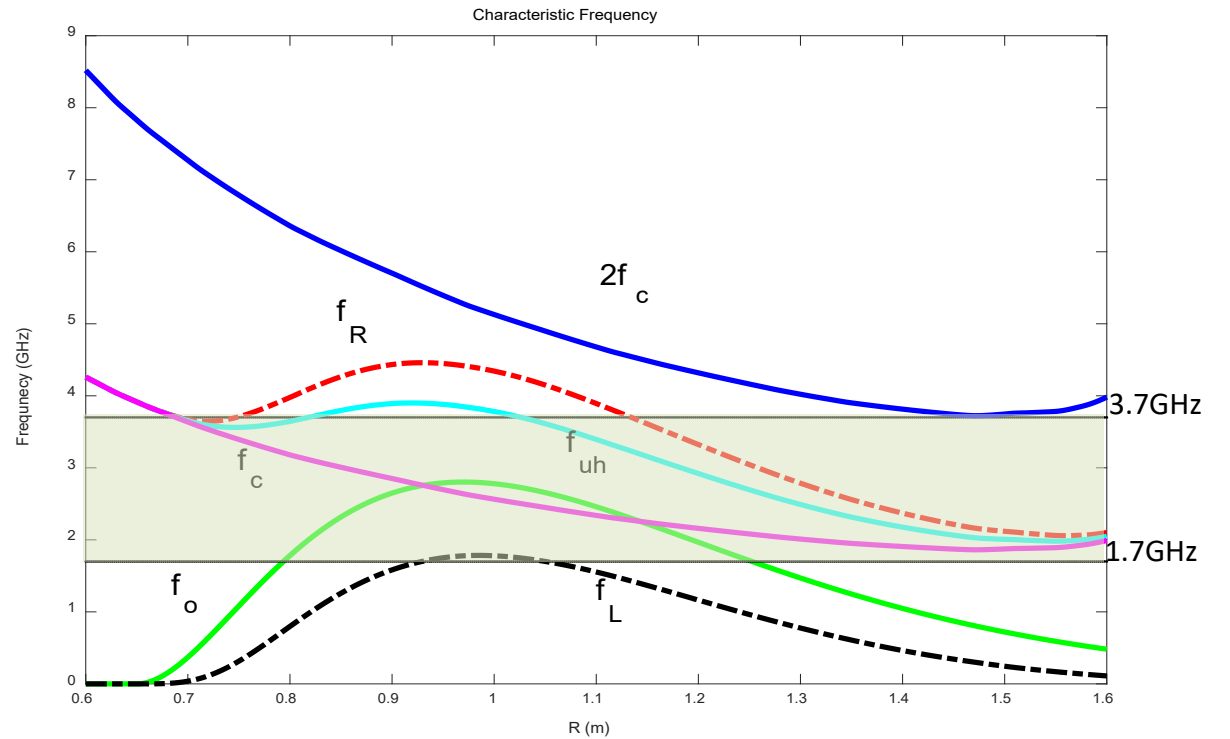
- Good adaptability to Helimak plasma
- Spatial resolution: 10cm
- Temporal resolution: 50us
- Remote control
- High reliability
- High maintainability
- Upgradability to accommodate future increases in plasma density
- Simple structure and easy to understand
- Low cost



a) Density profile

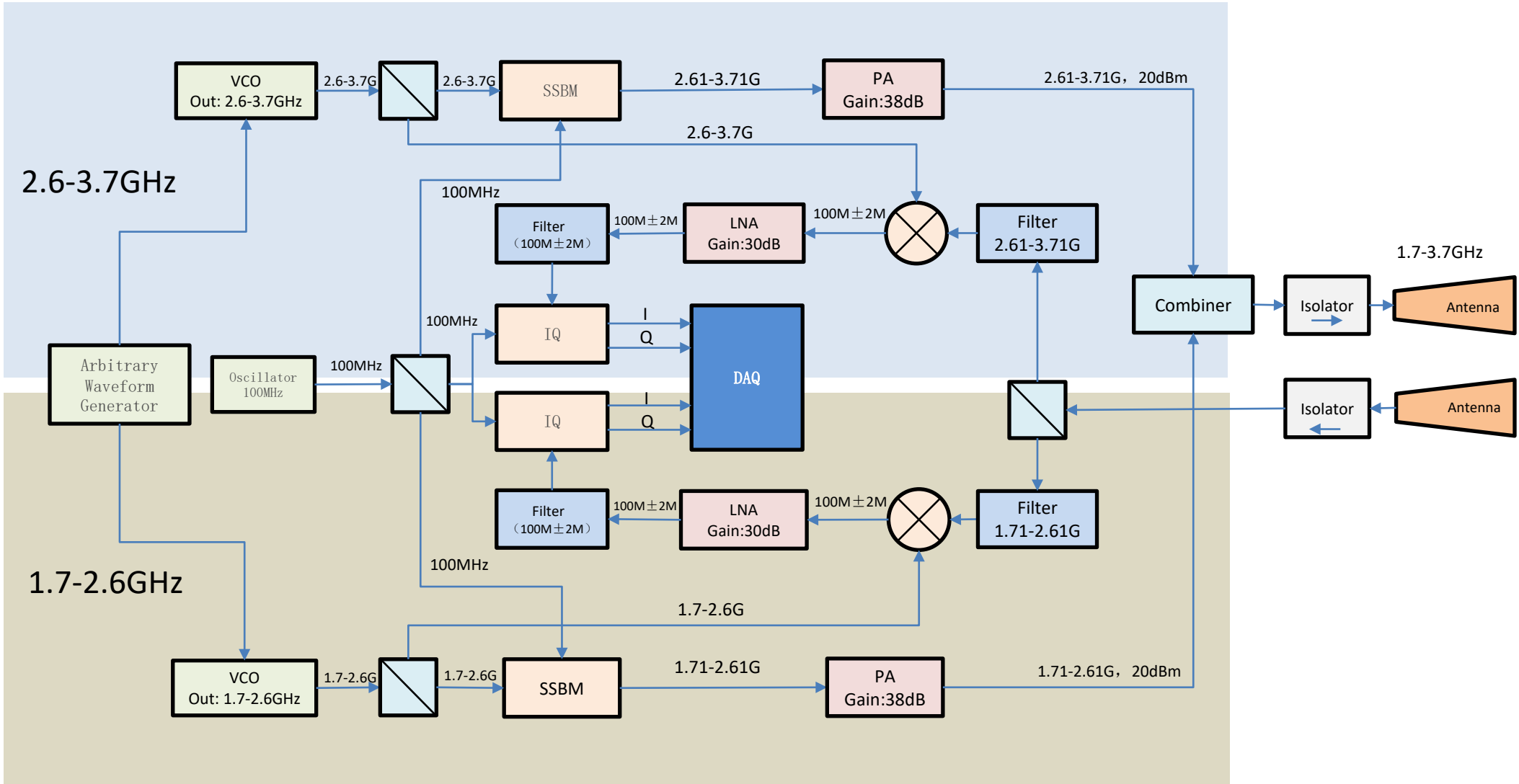


b) Magnetic field profile



c) Characteristic frequency

Design: Microwave Circuit



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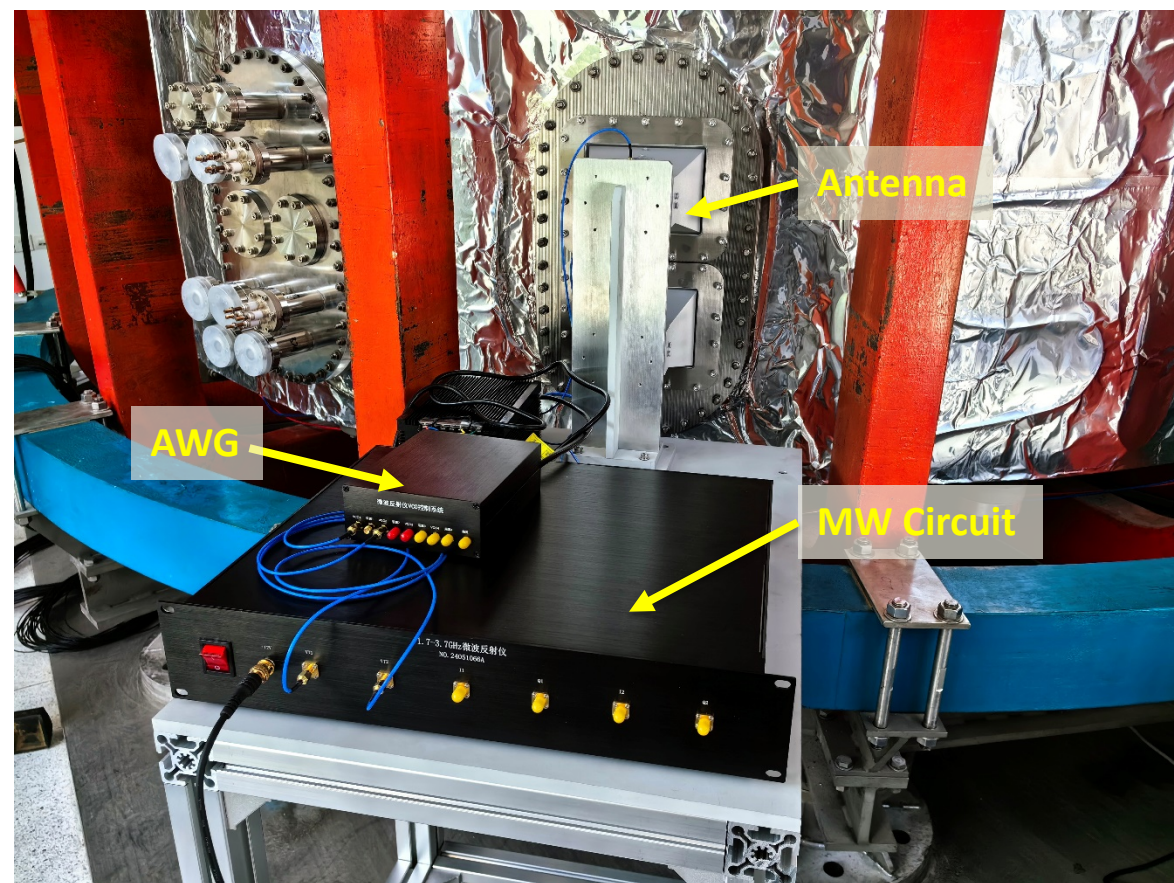
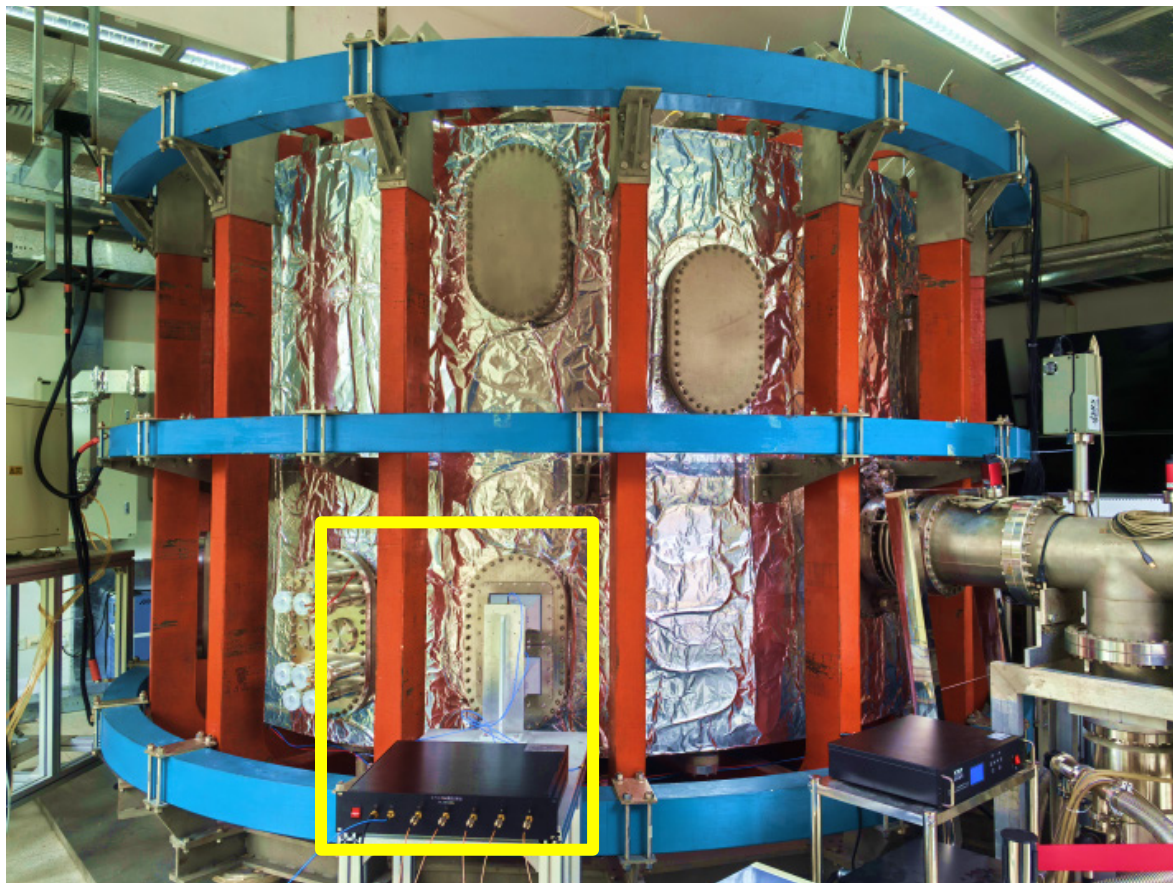
System Design

Implementation

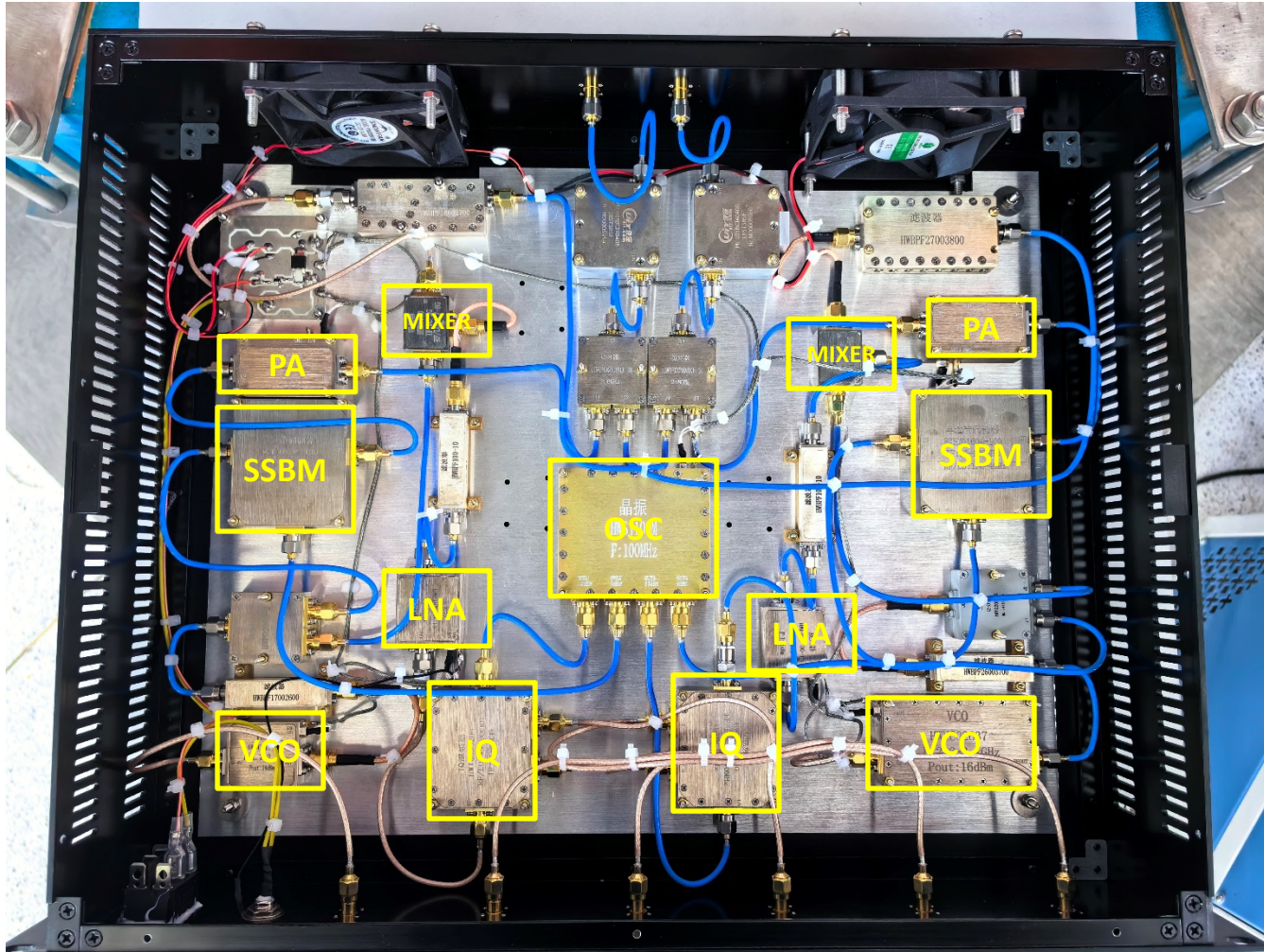
Preliminary test

Summary

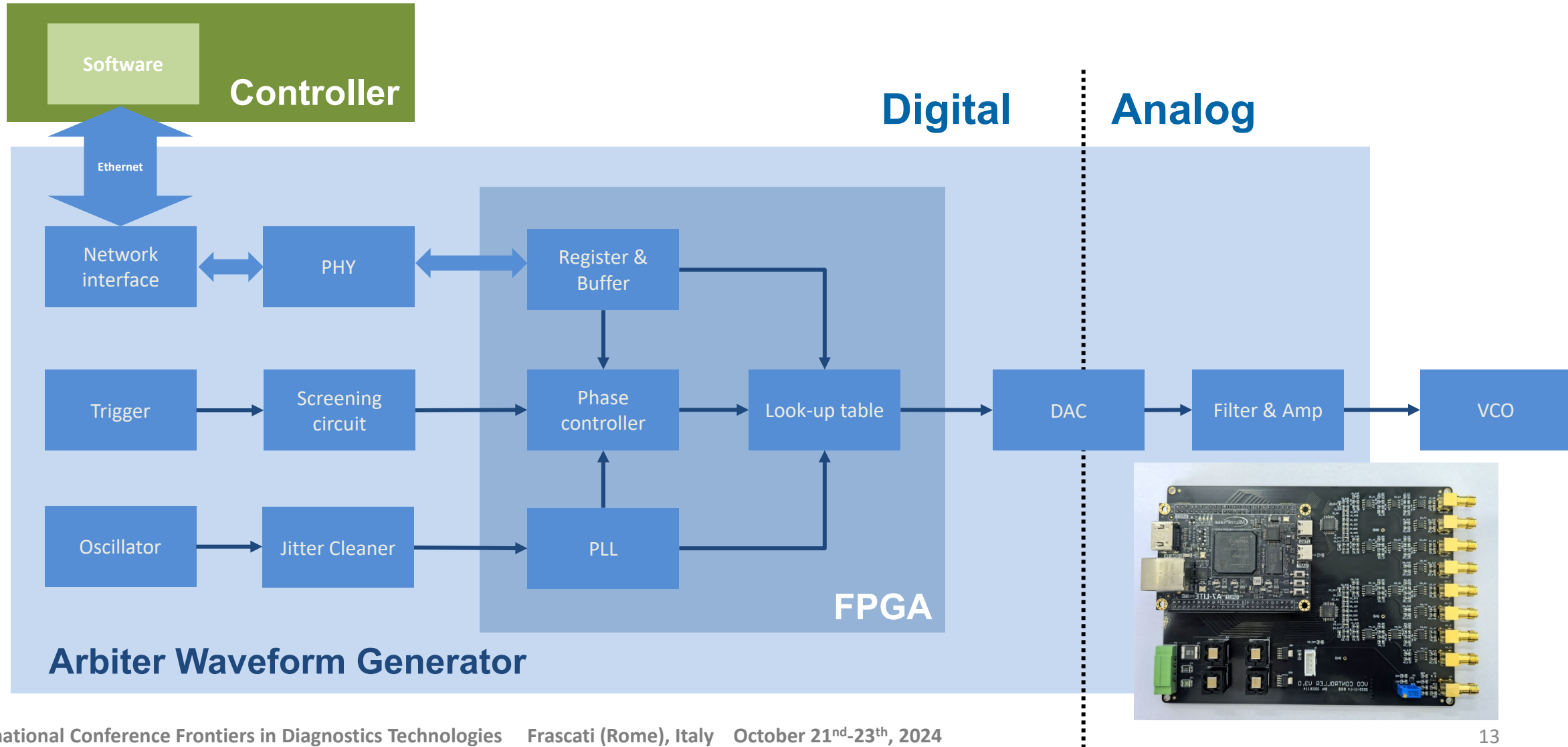
Implementation: Installation



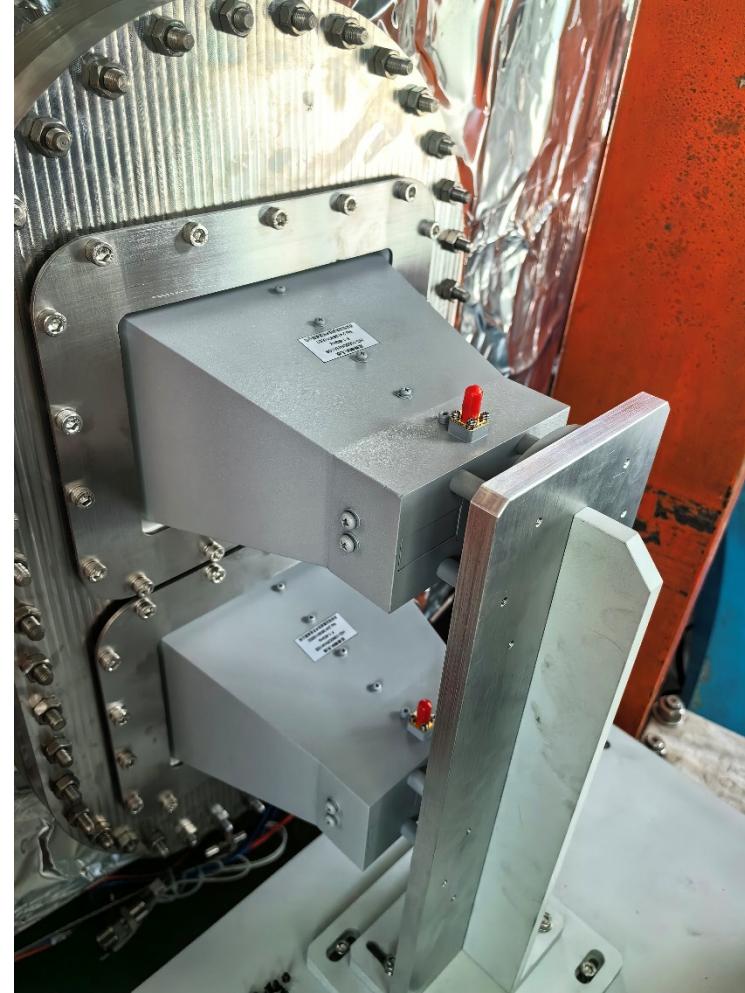
Implementation: Microwave Circuit



- **PA:** Power Amplifier
- **SSBM:** Single Side-Band Modulator
- **LNA:** Low-Noise Amplifier
- **VCO:** Voltage Controlled Oscillator
- **OSC:** Oscillator
- **IQ:** In-phase and Quadrature Detector



Implementation: Antenna



Double ridge wide-band antenna (1-6GHz)

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System Design

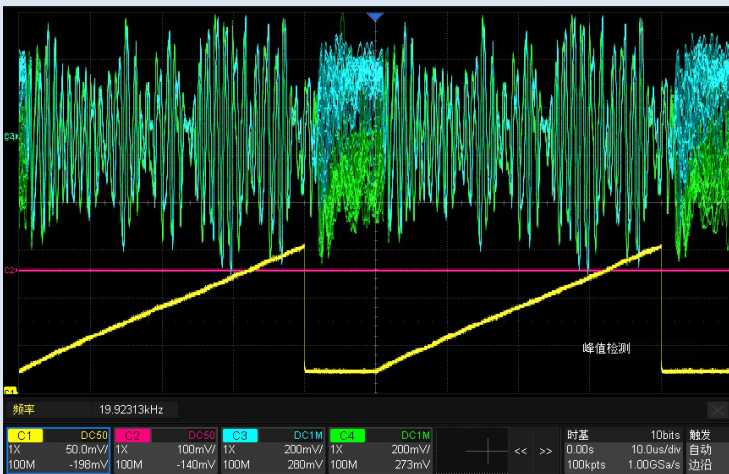
Implementation

Preliminary test

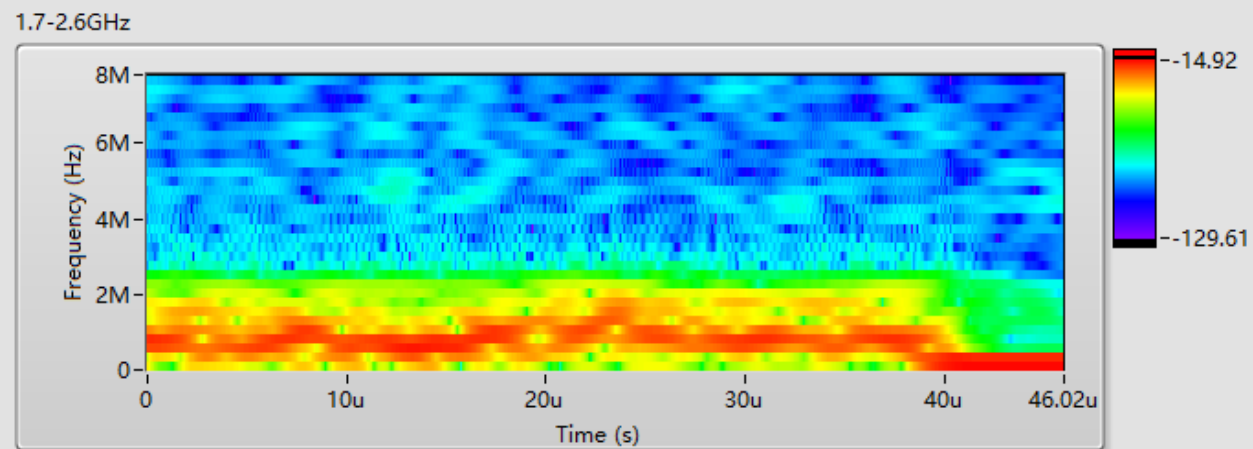
Summary

2.6-3.7GHz

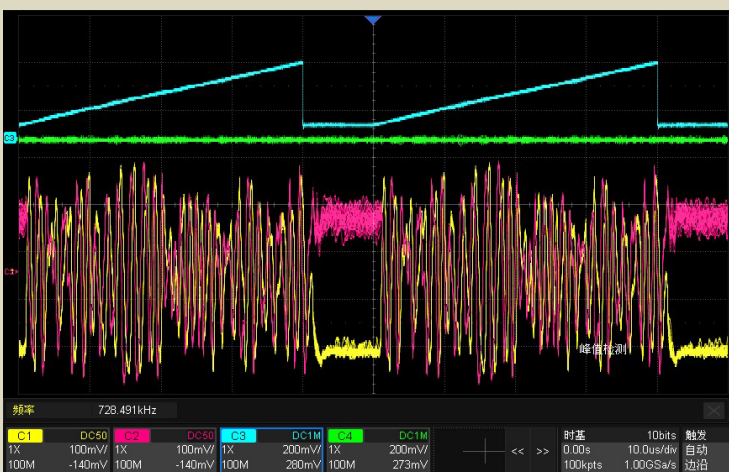
IQ signal and frequency sweep control signal



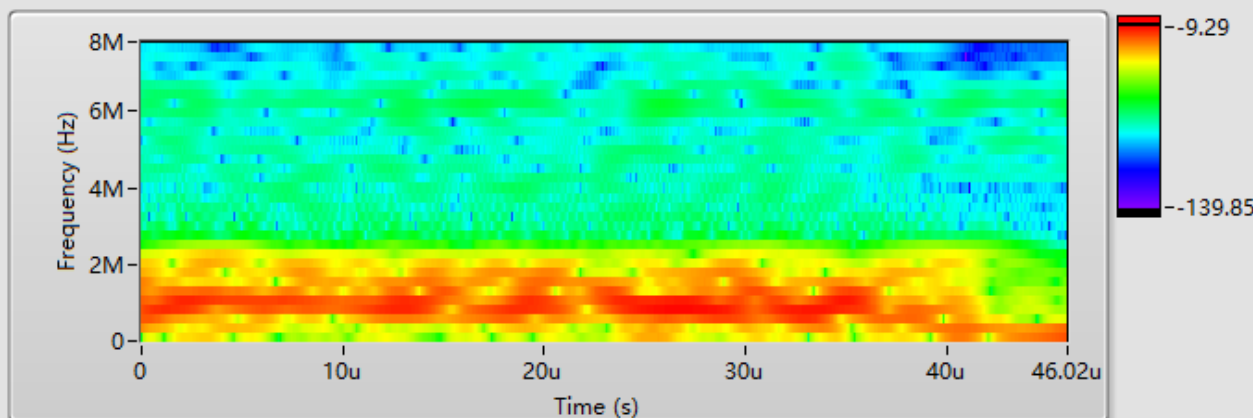
Time frequency spectrum calculated from IQ signal



1.7-2.6GHz



2.6-3.7GHz



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□ Background

- HELIMAK is a experimental device for plasma wall cleaning technology now.
- The microwave reflectometry is proposed to measure density profile as supplement to the probe.

□ Design, implementation and test

- A X-mode microwave reflectometer working at 1.7-3.7GHz has been installed on the Helimak.
- Preliminary test shows that the system is working properly.

□ Next step

- The test with plasma needs to be done in the near future.
- Digital sources (Direct Digital Synthesis) and digital receivers (direct intermediate frequency sampling) will be added to the system in the upgrade plan.

Thank you for your attention!

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