

# TEAM 42



UNIVERSITÉ  
LAVAL



Presentation of two different  
student built and designed antennas

*Extended Abstract - Antennas design*

Laval University Aerospace Group (GAUL), Quebec City

Vincent Rocheleau  
Undergraduate Student in Electrical  
Engineering (2014-2018)

May 25, 2018

# Presentation

## Presentation plan

Introduction

Yagi-Uda

Inset-fed patch

Special thanks

Questions

## Presentation plan

- Introduction
- Yagi-Uda ground station antenna
- Inset-fed patch rocket antenna
- Questions



# Presentation

Presentation plan

Introduction

Yagi-Uda

Inset-fed patch

Special thanks

Questions

## Introduction

- Our team uses 2 RFD900+ to transmit our telemetry from our rocket to the ground station.
- Operating frequencies: 902-928 MHz.
- Central frequency: 915 MHz.

Our simple network architecture:

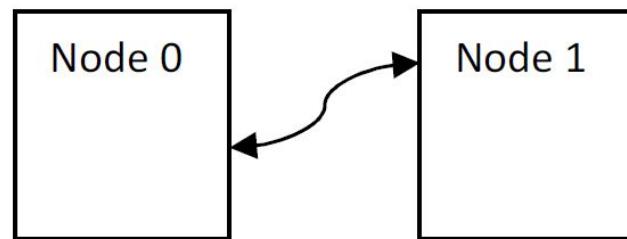


Figure 10.1: Two-node Network Setup



# Presentation

Presentation plan

Introduction

Yagi-Uda

Inset-fed patch

Special thanks

Questions

## Introduction

- Two different antennas built:
  - Yagi-Uda ground station antenna
  - Inset-fed patch rocket antenna
  
- A Yagi-Uda is well suited for a ground station antenna. You can point it directly to the rocket during its flight.
  
- An inset-fed patch antenna is slim so it can fit the curve of the rocket and has a directivity that allow to point toward the sides of the rocket.



# Presentation

Presentation plan

Introduction

Yagi-Uda

Inset-fed patch

Special thanks

Questions

## Yagi-Uda ground station antenna

- The design of such antennas is very difficult and empiric solutions are already given to obtain desired performances.
- The impedance matching is an important criteria. Since no stub were planned to be added to the Yagi-Uda antenna to simplify its construction, it is important to use a solution near 50 ohms of impedance.
- Reason: our coaxial cables have a 50 ohms characteristic impedance.



# Presentation

Presentation plan

Introduction

Yagi-Uda

Inset-fed patch

Special thanks

Questions

## Yagi-Uda ground station antenna

### Yagi-Uda sizing table

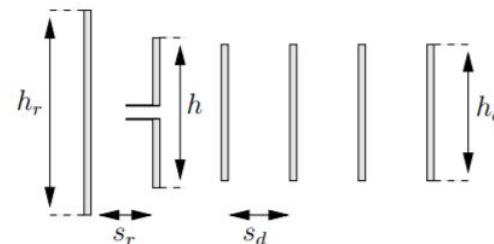


FIGURE 5.20 – Géométrie d'une antenne Yagi-Uda à plusieurs éléments.

$N$	$S_d, S_r$ ( $\lambda$ )	$h_r$ ( $\lambda$ )	$h$ ( $\lambda$ )	$h_d$ ( $\lambda$ )	$G$ (dB)	$FBR$ (dB)	$\bar{Z}_a$ ( $\Omega$ )	$\Theta_{H_{HPBW}}$ (°)	$\Theta_{E_{HPBW}}$ (°)
3	0.25	0.479	0.453	0.451	9.4	5.6	$22.3+j15.0$	84	66
4	0.15	0.486	0.459	0.453	9.7	8.2	$36.7+j9.6$	84	66
4	0.20	0.503	0.474	0.463	9.3	7.5	$5.6+j20.7$	64	54
4	0.25	0.486	0.463	0.456	10.4	6.0	$10.3+j23.5$	60	52
4	0.30	0.475	0.453	0.446	10.7	5.2	$25.8+j23.2$	64	56
5	0.15	0.505	0.476	0.456	10.0	13.1	$9.6+j13.0$	76	62
5	0.20	0.486	0.462	0.449	11.0	9.4	$18.4+j17.6$	68	58
5	0.25	0.477	0.451	0.442	11.0	7.4	$53.3+j6.2$	66	58
5	0.30	0.482	0.459	0.451	9.4	2.9	$19.3+j39.4$	42	40
6	0.20	0.482	0.456	0.437	11.2	9.2	$51.3+j1.9$	68	58
6	0.25	0.484	0.459	0.446	11.9	9.4	$23.2+j21.0$	56	50
6	0.30	0.472	0.449	0.437	11.6	6.7	$61.2+j7.7$	56	52
7	0.20	0.489	0.463	0.444	11.8	12.6	$20.6+j16.8$	58	52
7	0.25	0.477	0.454	0.434	12.0	8.7	$57.2+j1.9$	58	52
7	0.30	0.475	0.455	0.439	12.7	8.7	$35.9+j21.7$	50	46

TABLE 5.2 – Caractéristiques obtenues selon le nombre et l'espacement des éléments d'une antenne Yagi-Uda ( $a_o = 0.005\lambda$ ). 

Near 50 ohms  
of impedance  
for the real part.  
Imaginary part  
is near 0 ohms,  
which is what  
we want.



# Presentation

Presentation plan

Introduction

Yagi-Uda

Inset-fed patch

Special thanks

Questions

## Yagi-Uda ground station antenna

- Construction:
  - First iteration didn't work since the ratio distance between elements and diameter of the rods was too important (need to be equal or less than 0.5% as noted previously).



# Presentation

Presentation plan

Introduction

Yagi-Uda

Inset-fed patch

Special thanks

Questions

## Yagi-Uda ground station antenna

- Construction:
  - Second and last iteration worked well with this criteria respected. The given performances are approximately met.



# Presentation

Presentation plan

Introduction

Yagi-Uda

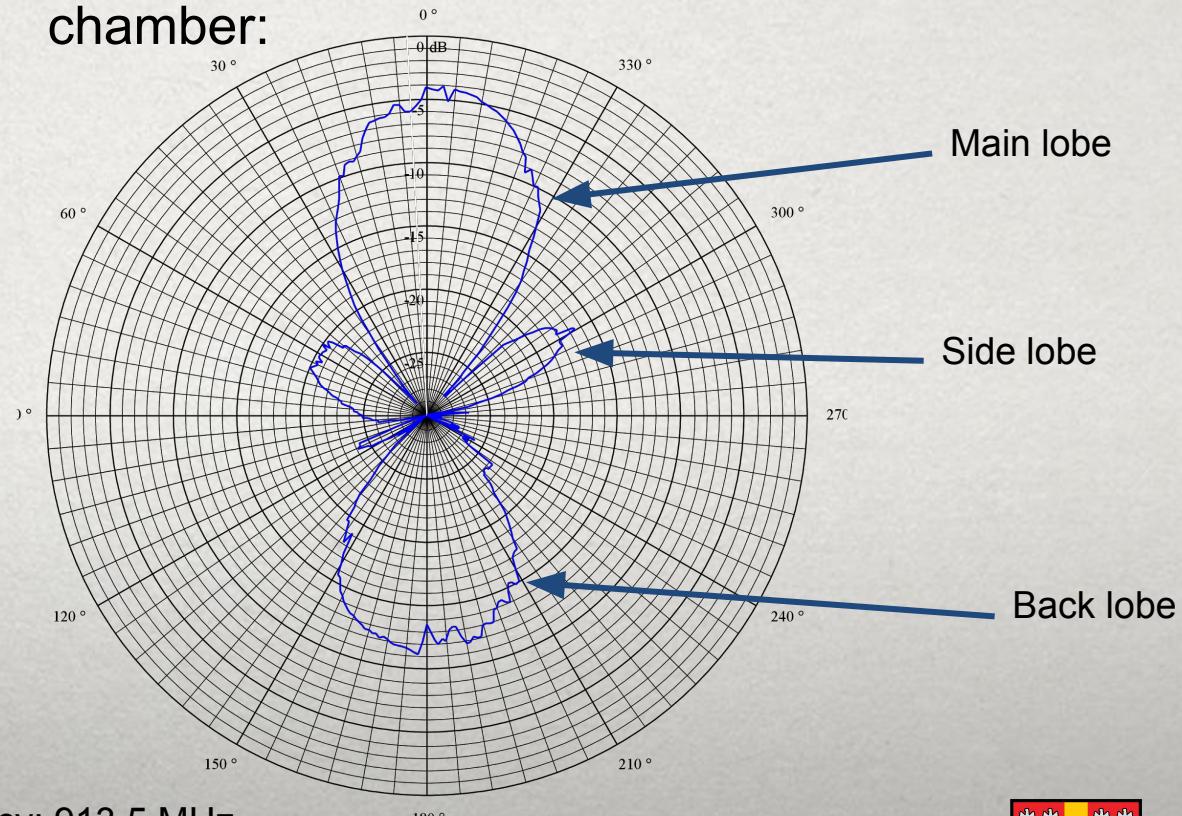
Inset-fed patch

Special thanks

Questions

## Yagi-Uda ground station antenna

- Directivity measurements in anechoic Lab-Volt chamber:



Plan d'antenne	Atténuation (dB)	Signal maximal		Ouverture à mi-puissance (°)
		Niveau (dB)	Position (°)	
Document7.ant			Type d'antenne: Doublet (Lambda)	
Plan E	0	-3.96	357	30.22
Plan H	0	-30.0	0	0



# Presentation

Presentation plan

Introduction

Yagi-Uda

Inset-fed patch

Special thanks

Questions

## Inset-fed patch rocket antenna

- The design of such antennas is easier and many softwares exists to calculate the sizing of the antenna relatively to the frequency operation.
- The central frequency is the main parameter that drives the design of the antenna.
- The impedance matching is also ALWAYS an important criteria.
- In our case, the Antenna Toolbox from our sponsor Matlab was used.



# Presentation

Presentation plan

Introduction

Yagi-Uda

Inset-fed patch

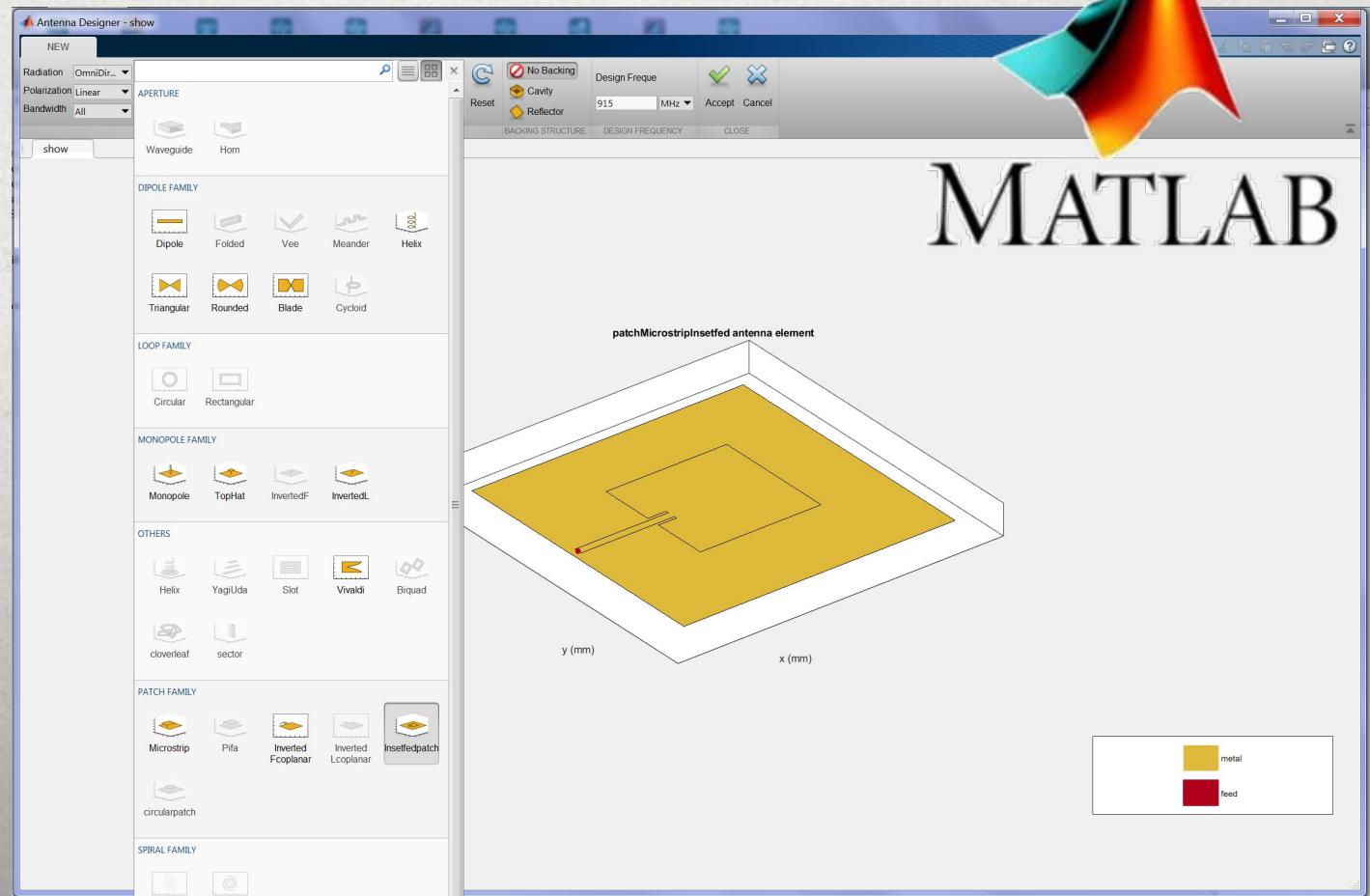
Special thanks

Questions

## Inset-fed patch rocket antenna

- Design of the antenna using the Antenna Toolbox of Matlab

Toolbox of Matlab:



# Presentation

Presentation plan

Introduction

Yagi-Uda

Inset-fed patch

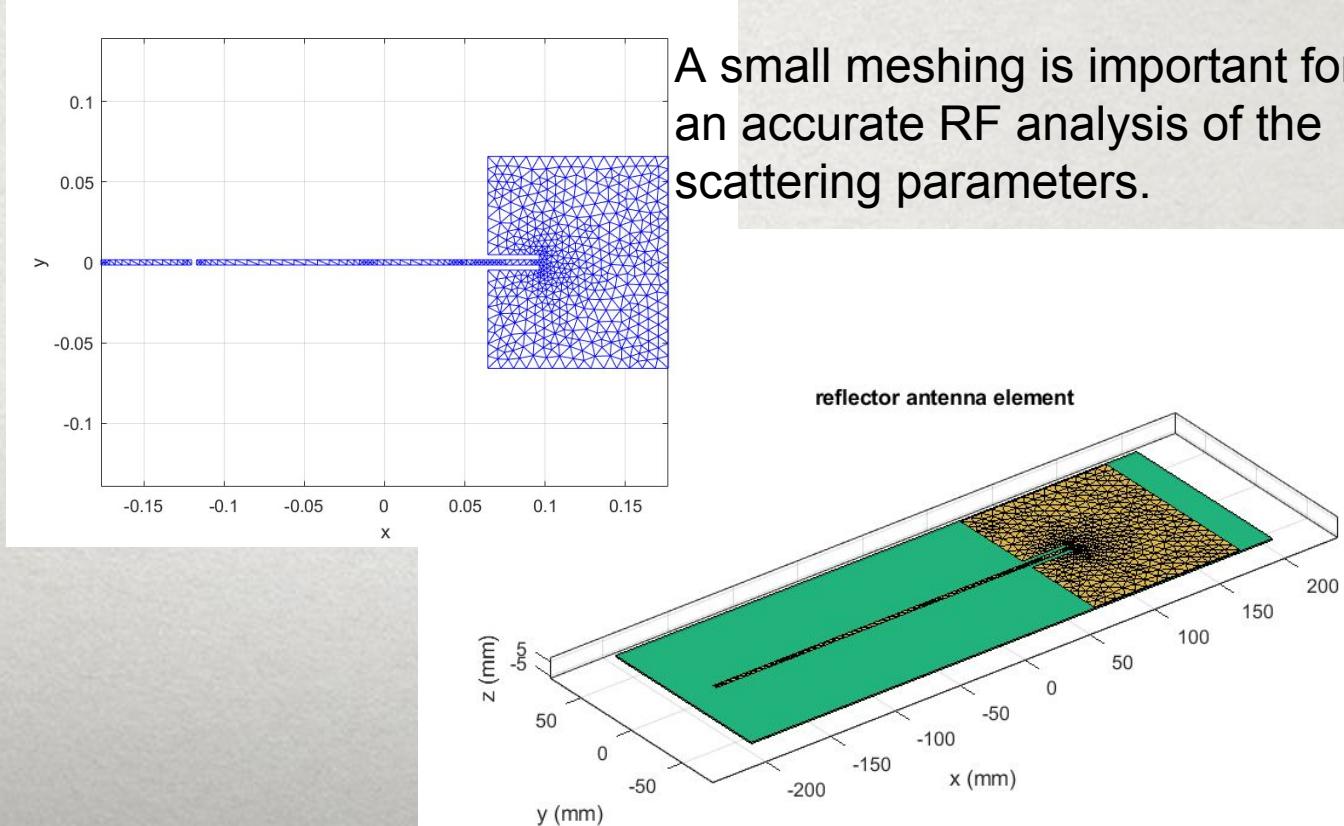
Special thanks

Questions

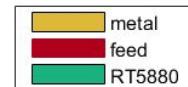
## Inset-fed patch rocket antenna

- Meshing and materials:

A small meshing is important for an accurate RF analysis of the scattering parameters.



Note: A good equivalent of Duroid RT5880 in terms of dielectric constant is Teflon.



# Presentation

Presentation plan

Introduction

Yagi-Uda

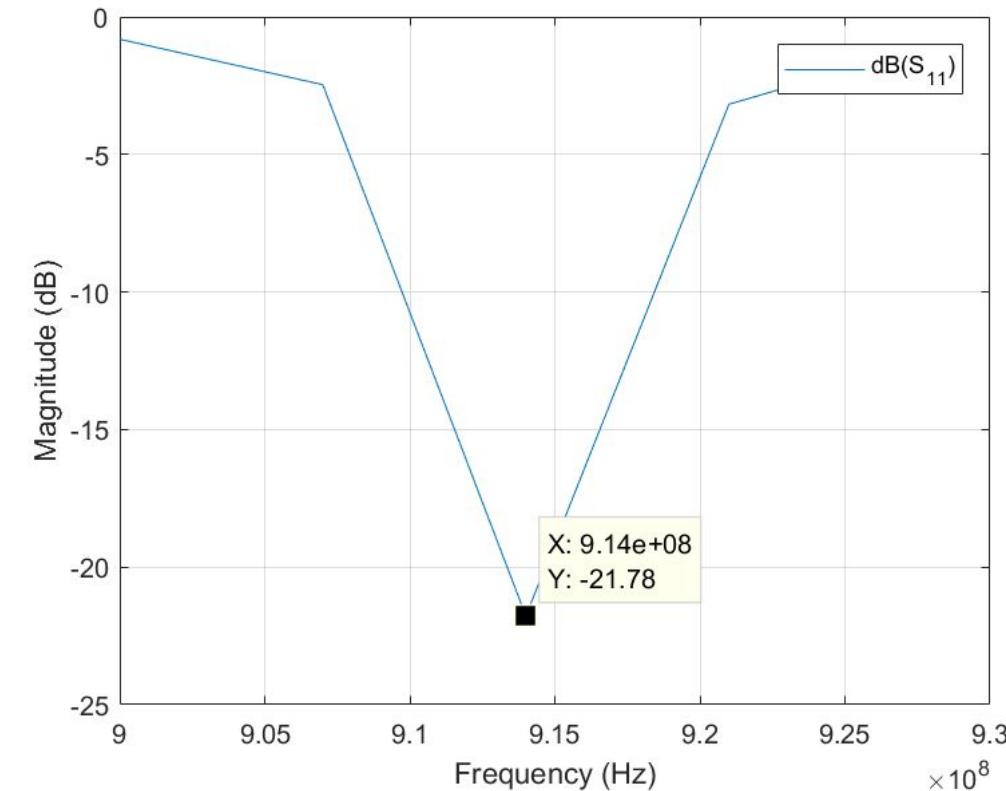
Inset-fed patch

Special thanks

Questions

## Inset-fed patch rocket antenna

- Theoric S-parameter performances for the inset-fed patch:



# Presentation

Presentation plan

Introduction

Yagi-Uda

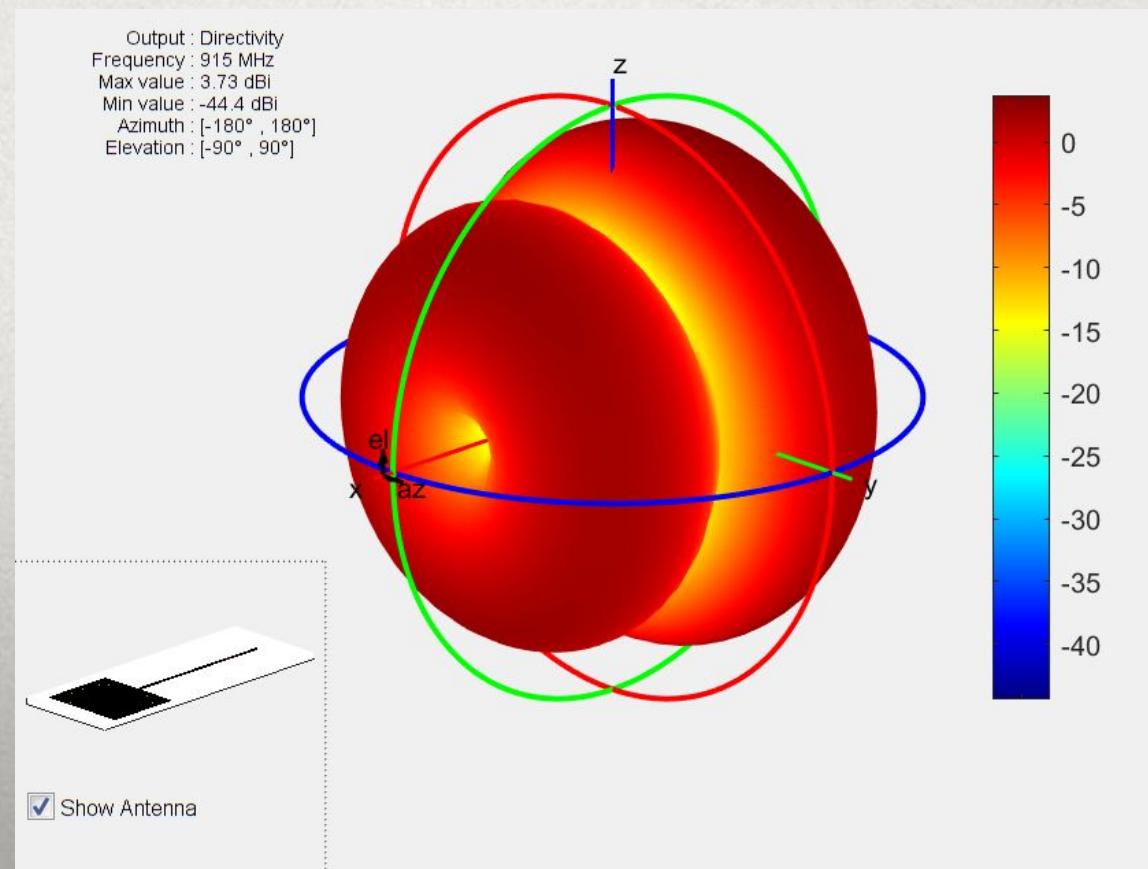
Inset-fed patch

Special thanks

Questions

## Inset-fed patch rocket antenna

- Theoric directivity performance for the inset-fed patch:



# Presentation

Presentation plan

Introduction

Yagi-Uda

Inset-fed patch

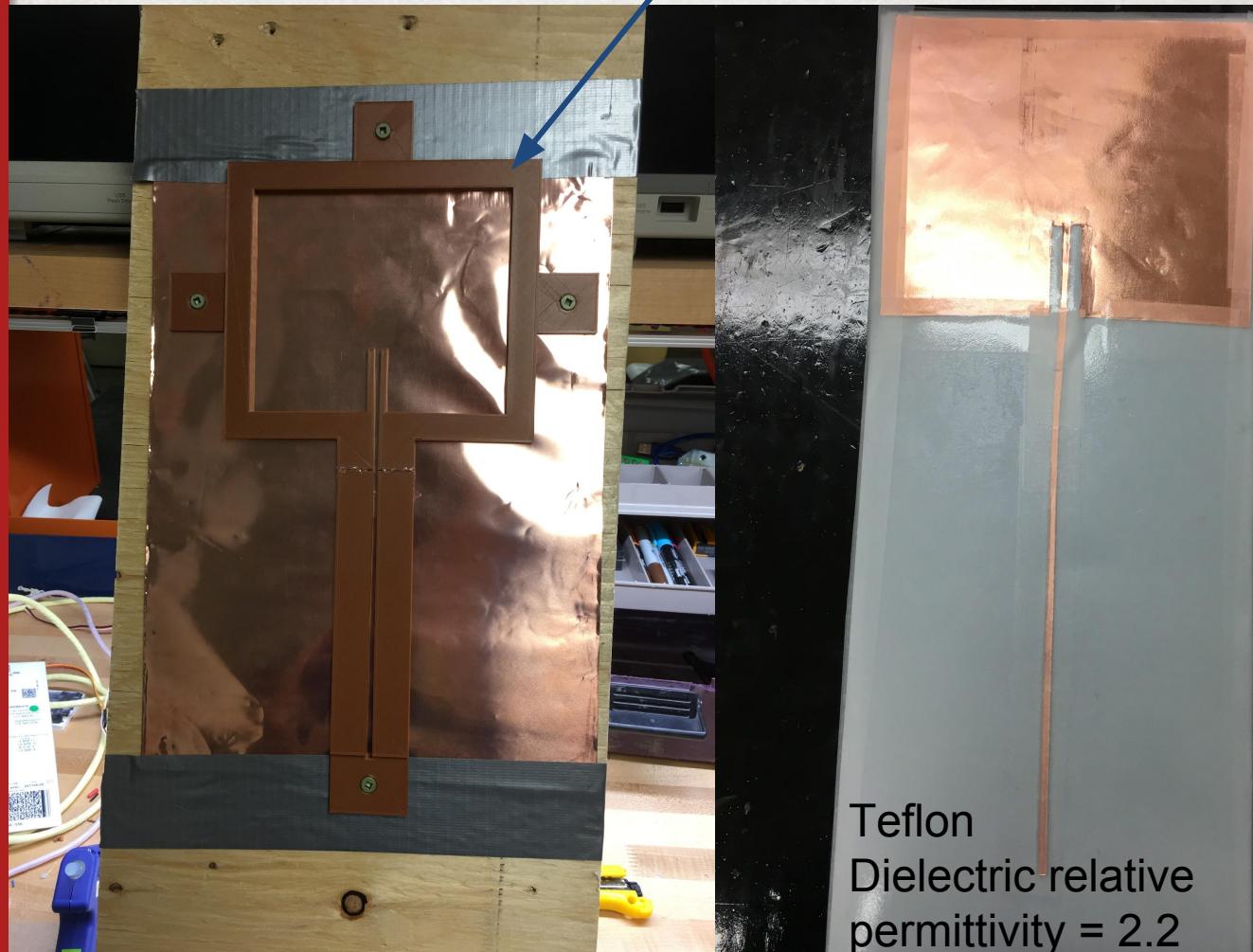
Special thanks

Questions

## Inset-fed patch rocket antenna

- Construction:

3D printed template



# Presentation

Presentation plan

Introduction

Yagi-Uda

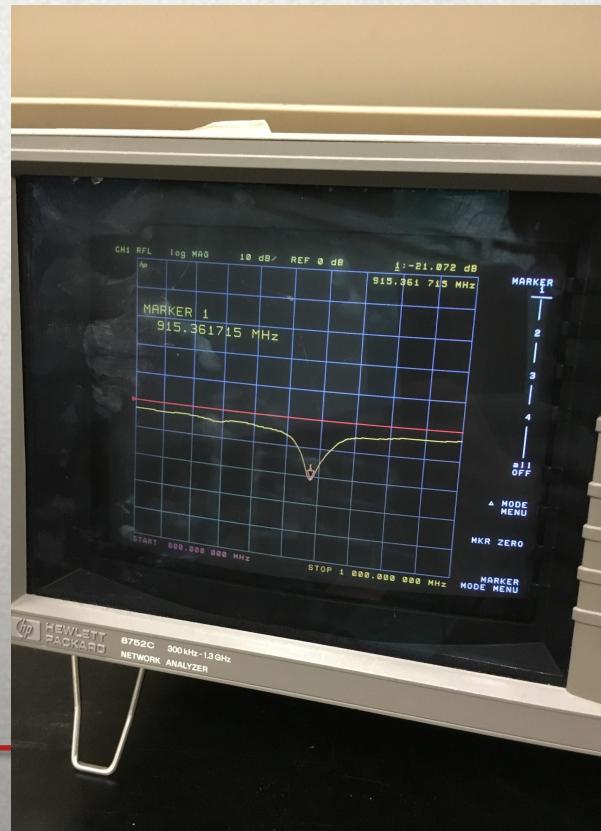
Inset-fed patch

Special thanks

Questions

## Inset-fed patch rocket antenna

- Antenna performances measured at the lab:
- Return loss ( $S_{11}$ ) = -21 dB at approx. 915 MHz.
- Approximately 90% of the power is transmitted at this central frequency. Confirms the theory.



# Presentation

Presentation plan

Introduction

Yagi-Uda

Inset-fed patch

Special thanks

Questions

## Special thanks

To **Dominic Grenier**, professor of the Electrical Engineering department at Laval University.

### Antennes et Propagation radio

GEL-4202/GEL-7019



Dominic Grenier

Département de génie électrique et de génie informatique  
Université Laval  
Québec, Canada G1V 0A6

Hiver 2019



# Presentation

Presentation plan

Introduction

Yagi-Uda

Inset-fed patch

Special thanks

Questions

## Questions

- Any questions?

