

*Millimeter and  
sub-millimeter team*

# Millimeter-wave Array at Room Temperature for Instruments in Leo Altitude Radio Astronomy

Gabriel Santamaría Botello<sup>1</sup>, Luis Enrique García Muñoz<sup>1</sup>.

<sup>1</sup>University Charles III of Madrid, Madrid, Spain.

[legarcia@ing.uc3m.es](mailto:legarcia@ing.uc3m.es)

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MARTINLARA



### research activities

One of the main research lines of GREMA is focused on the development of millimeter and sub-millimeter technologies, specially increasing the sensibility in the detectors, for applications such as radioastronomy instrumentation, weather prediction, imaging and so on.

The design and characterization of novel structures and antenna geometries, and the design and development of ultra wideband antennas in array configuration for obtaining optimum radiation parameters are other important research lines of GREMA.

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de Madrid

## GREMA

RADIOFREQUENCY, ELECTROMAGNETICS,  
MICROWAVES & ANTENNAS



<http://grema.webs.tsc.uc3m.es>



@e\_\_mc\_2



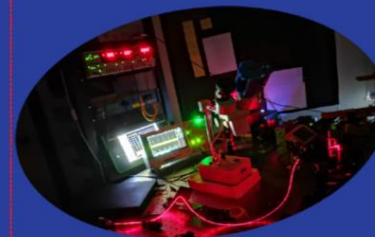
@grema.uc3m



### CONTACT

Luis Enrique García Muñoz  
[legarcia@ing.uc3m.es](mailto:legarcia@ing.uc3m.es)

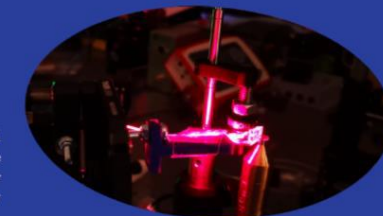
### mm and sub-mm laboratory



### mm and submm-wave device characterization

The group has a 4-port AGILENT PNA-X network analyser up to 70 GHz with the extension heads (WR10 and WR08) for measurements in the mm-wave frequency range up to 350 GHz.

The group has all the facilities for characterizing devices, antennas, emitters, receivers and complete systems from kHz-MHz range up to 2 THz, covering the complete range in GHz.

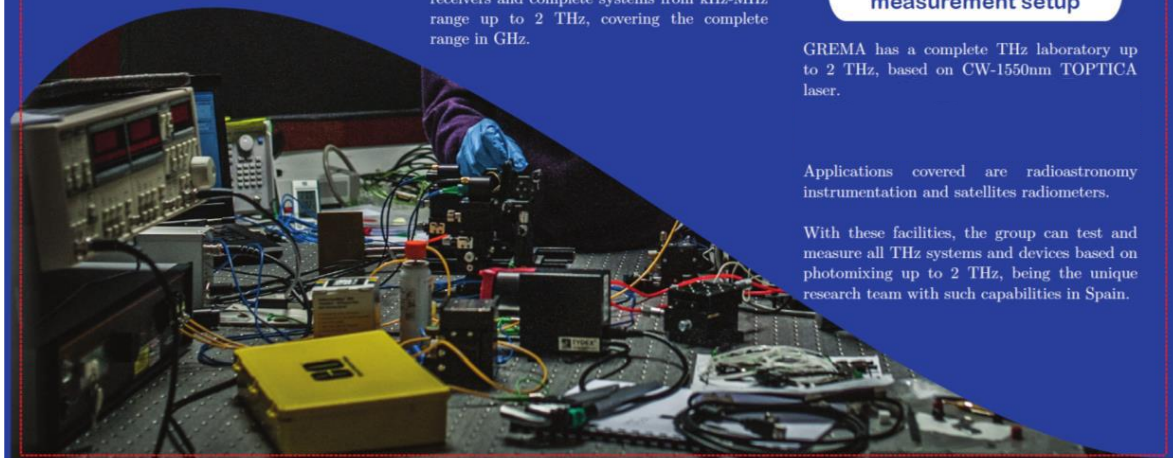


### 1550 nm complete measurement setup

GREMA has a complete THz laboratory up to 2 THz, based on CW-1550nm TOPTICA laser.

Applications covered are radioastronomy instrumentation and satellites radiometers.

With these facilities, the group can test and measure all THz systems and devices based on photomixing up to 2 THz, being the unique research team with such capabilities in Spain.





## Telescopio de 40m de Yebes

Receptores de 2 GHz a 120 GHz



## APEX y SOFIA

Receptores de 100 GHz a 2,7 THz



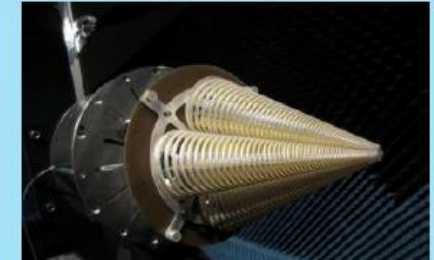
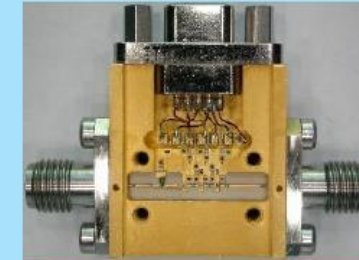
## Square Kilometer Array SKA

Receptores de 300 MHz a 1 GHz



## VLBI - VGOS

Receptores de 2 GHz a 14 GHz





## Telescopio de 40m de Yebes

Receptores de 2 GHz a 120 GHz



## APEX and SOFIA

Frequency bands from 100 GHz up to 2.7 THz



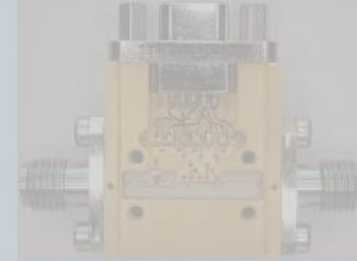
## Square Kilometer Array SKA

Frequency band from 300 MHz up to 1 GHz



## VLBI - VGOS

Frequency bands from 2 GHz up to 14 GHz



# Radiotelescopio 40m de Yebes



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## Objetivos

High-frequency branch:

30,45, 80 y 100 GHz, Redshift, Multibeam 3 mm.

Low-frequency branch:

S band VLBI, X band VLBI, 22 GHz

## Líneas

Bocinas, lentes, reflectores, GO-PO-GTD, Quasi-óptica

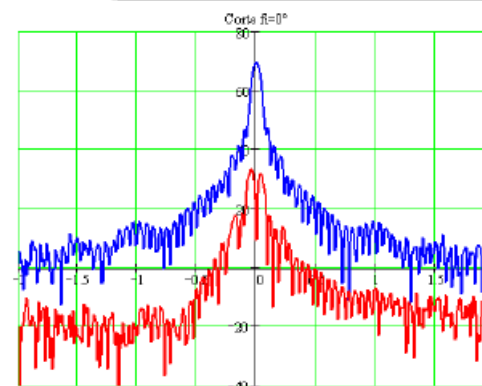
## Resultados

Revistas JCR: 9 (7 Q1)

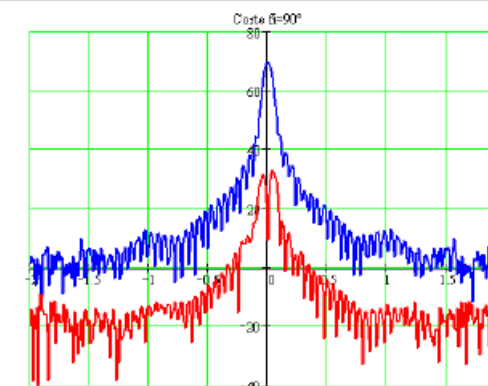
Congresos: 13

Estancias: Telecom Paris (FR, 2000)

Proyectos: 6 art. 83



— RHC  
— LHC



— RHC  
— LHC



## 40m radiotelescope Yebes

Frequency bands from 2 GHz up to 120 GHz



## APEX and SOFIA

Frequency bands from 100 GHz up to 2.7 THz



## Square Kilometer Array SKA

Receptores de 300 MHz a 1 GHz



## VLBI - VGOS

Frequency bands from 2 GHz up to 14 GHz



# Square Kilometer Array



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## Objetivos

Phased array, 300 MHz-1GHz  
Several beams  
Sub-tile and tiles, LNA's

## Líneas

Phased arrays, ultra wideband antennas, LNA's

## Resultados

Tesis: 2

Revistas JCR: 8 Q1

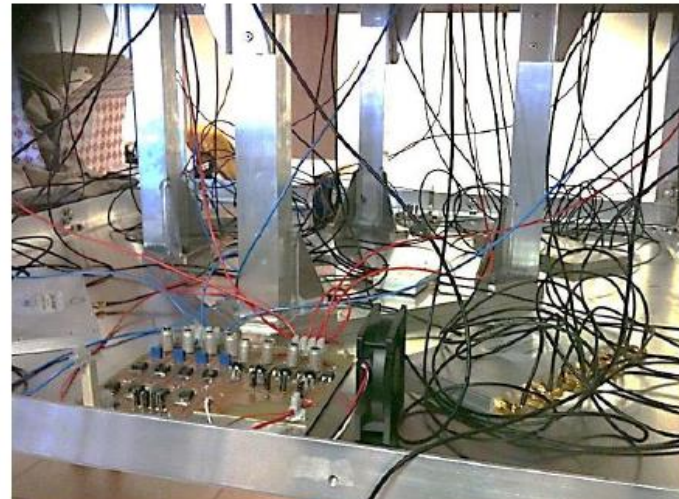
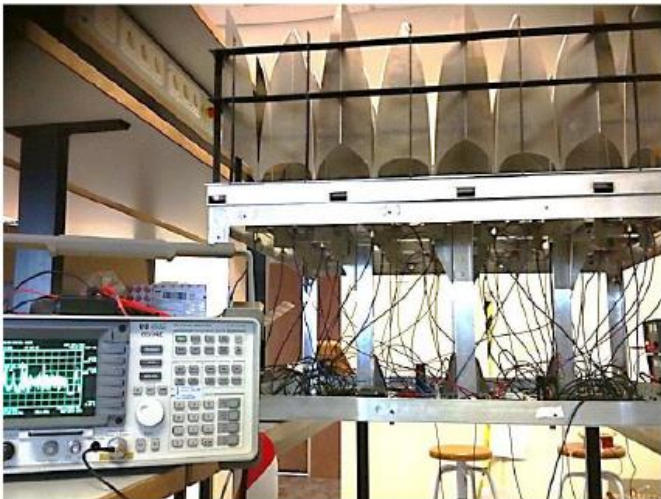
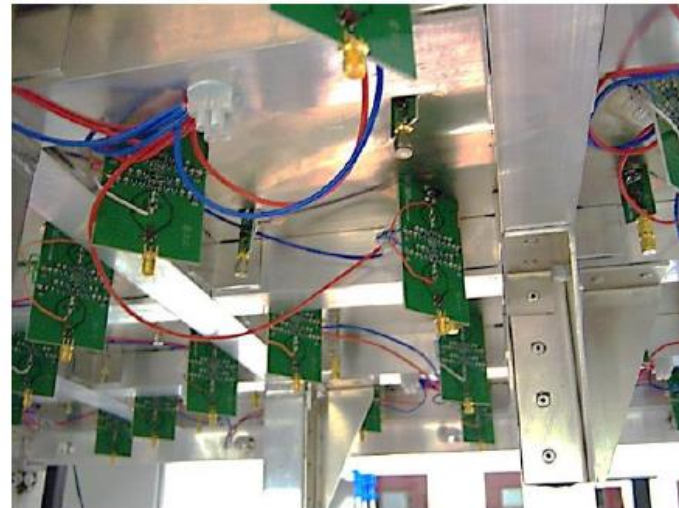
Congresos: 34

Estancias: 2, ASTRON (NL, 2007, 2008), 1 UCL (BE, 2008)

Invited talks: 2

Capítulo de libro: 1

Proyectos: 5 art. 83 (IP), 1 proy. EU (IP)





## 40m radiotelescope Yebes

Frequency bands from 2 GHz up to 120 GHz



## APEX and SOFIA

Receptores de 100 GHz a 2,7 THz



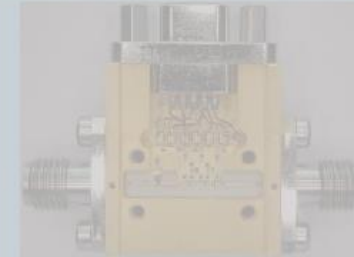
## Square Kilometer Array SKA

Frequency band from 300 MHz up to 1 GHz



## VLBI - VGOS

Frequency bands from 2 GHz up to 14 GHz





# Telescopios APEX y SOFIA



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## Objetivo

Generation of terahertz radiation by mixing two lasers frequencies in a photomixer. The THz Signal (LO signal) is mixed with the astronomical signal in an heterodyne receiver.  
Photonic LO working at **room temperature**.

## Líneas

THz, photomixers, reflectors, antennas

## Resultados

Tesis: 3 leídas y 1 en curso

Premios: 3 Mejores tesis categorías COIT (2013, 2014, 2014)

Revistas JCR: 19 Q1

Congresos: 42

Estancias: 1 UCSD, (USA, 2010), 3 MPIfR, (AL, 2009, 2010, 2014)

Invited talks: 9

Libro: 1

Proyectos: 3 PN I+D (2 IP), 1 Proy. EU IPHOS (Co-IP)



Channel	Frequencies (THz)	Lines of Interest
low-frequency L1 a,b	1.25-1.50 (single pixel)	[NII], CO series, OD, HCN, H <sub>2</sub> D <sup>+</sup>
low-frequency L2	1.81-1.91 (single pixel)	NH <sub>3</sub> , OH, CO(16-15), [CII]
mid-frequency M a,b	2.5 – 2.7 (single pixel)	OH( <sup>2</sup> π <sub>3/2</sub> ), HD
high-frequency H	4.7 (single pixel)	[OI]
upGREAT Low Frequency Array (LFA)	1.9 – 2.5 (14 pixels)	OH lines, [CII], CO series, [OI]
upGREAT High Frequency Array (HFA)	4.7 (7 pixels)	[OI]





## 40m radiotelescope Yebes

Frequency bands from 2 GHz up to 120 GHz



## APEX and SOFIA

Frequency bands from 100 GHz up to 2.7 THz



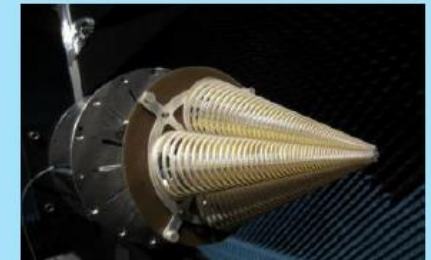
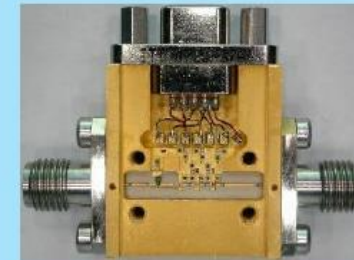
## Square Kilometer Array SKA

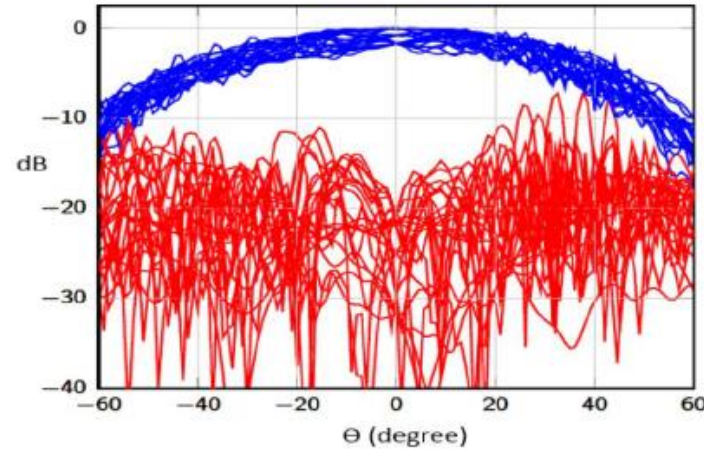
Frequency band from 300 MHz up to 1 GHz



## VLBI - VGOS

Receptores de 2 GHz a 14 GHz





## Objetivo

### Feed for VLBI2010 radiotelescope

- Operation band: 2 — 14 GHz
- Minimum gain: 11 dB  $\pm$  1 dB
- Reflector half flare feed angle: 65°
- 16-dB half beamwidth: 65°
- Polarization: double
- Maximum VSWR: 2:1
- RF connectors: female SMA
- 15K cooled option inside a cryostat.

## Líneas

Ultrawideband antennas, LNA's

## Resultados

Tesis: 2 en curso

Revistas JCR: 4 Q1

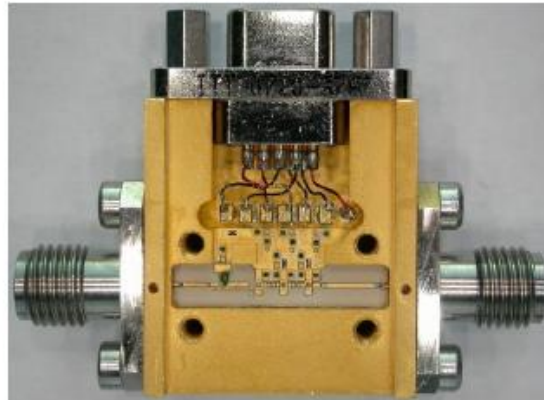
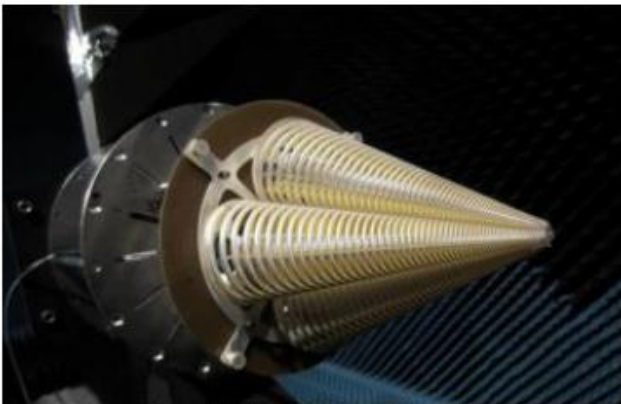
Congresos: 12

Estancias: 1 UST, (USA, 2018), 1 UoO, (NZ, 2017)

Invited talks: 3

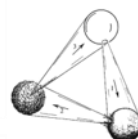
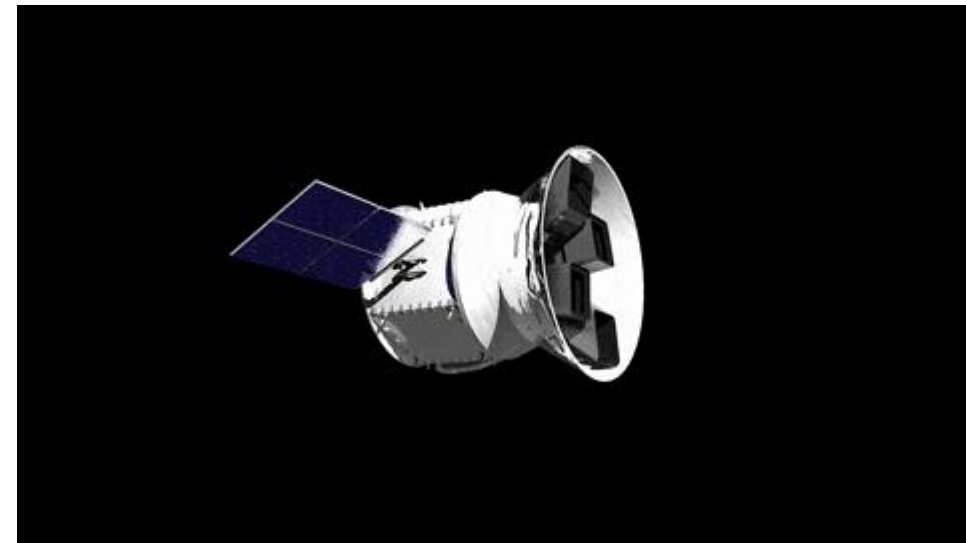
Libro: 1

Proyectos: 1 Macrogrupo CAM





**MARTINLARA** desarrolla una misión espacial de demostración en órbita integrando en un nanosatélite tecnologías de radiometría para observación de la Tierra, fotónica espacial, y propulsión espacial eléctrica.

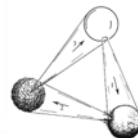




GRUPO	TIPO	RESPONSABLE	FUNCIÓN	ORGANISMO/CENTRO
GREMA	Beneficiario	GARCÍA MUÑOZ, LUIS ENRIQUE	Coordinador	Universidad Carlos III de Madrid / Escuela Politécnica Superior
AEGORA	Beneficiario	GOMEZ DE CASTRO, ANA INES	Responsable	Universidad Complutense de Madrid / Facultad de Ciencias Matemáticas
DIEMAG	Beneficiario	GONZALEZ POSADAS, VICENTE	Responsable	Universidad Politécnica de Madrid / E.T.S. Ingeniería y Sistemas de Telecomunicación
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GOTL	Beneficiario	CARPINTERO DEL BARRIO, GUILLERMO	Responsable	Universidad Carlos III de Madrid / Escuela Politécnica Superior
377	Laboratorio	RODRIGUEZ AMOR, JOSÉ ROBERTO	Responsable	Instituto Nacional de Técnica Aeroespacial Esteban Terradas / Instituto Nacional de Técnica Aeroespacial Esteban Terradas



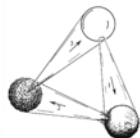
Universidad Carlos III de Madrid



**Teconología espacial debe superar  
validacion en misión de demostración**

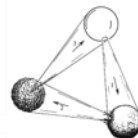
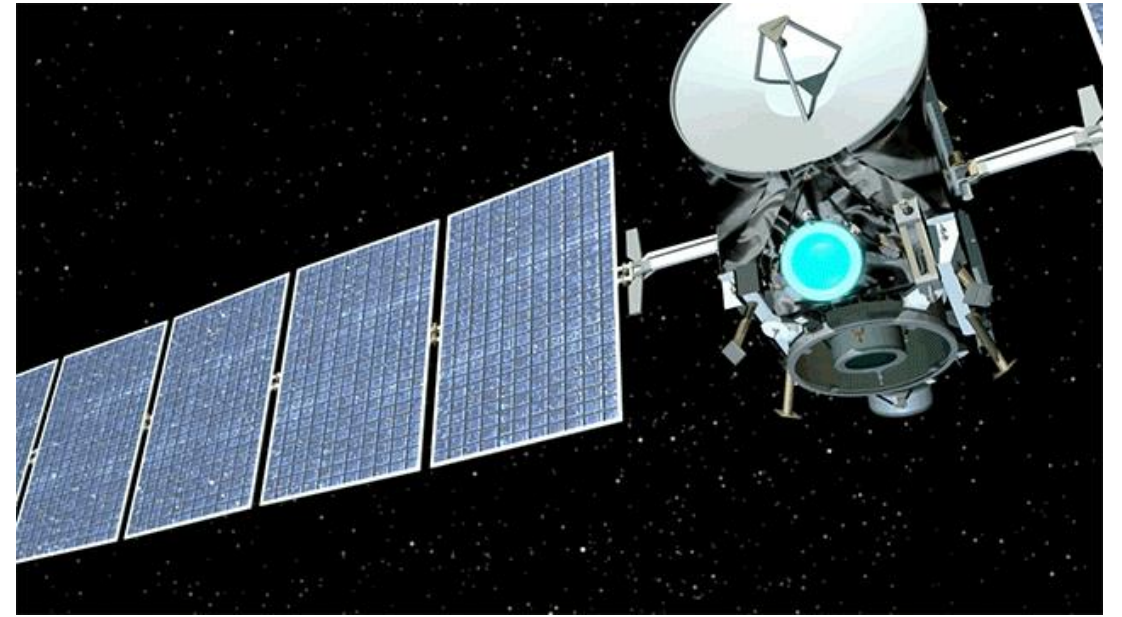
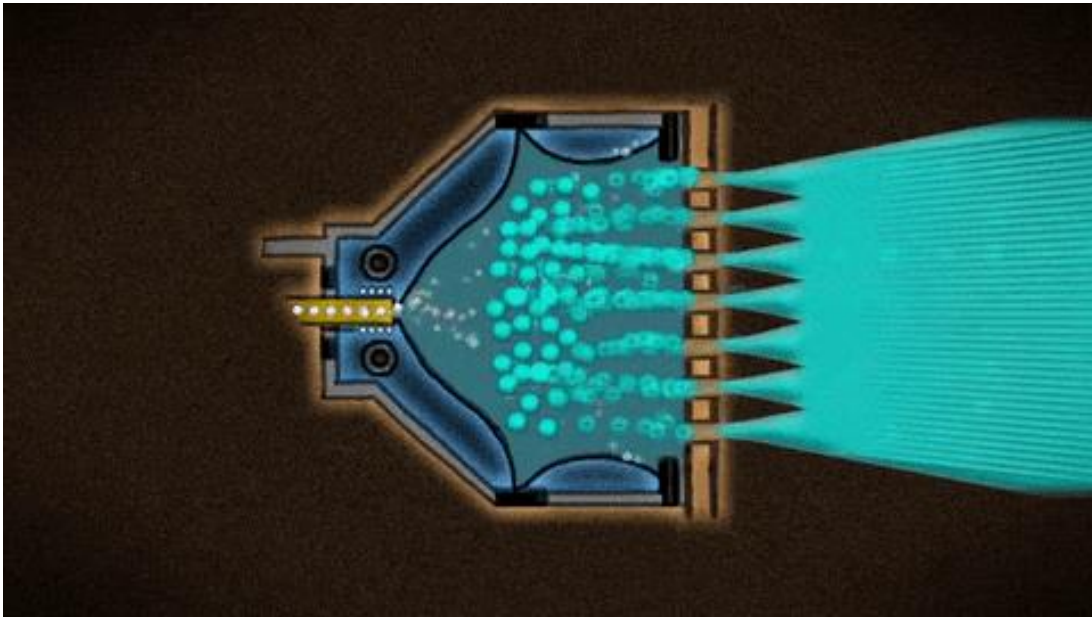
**Objetivos aeronáuticos**

**Objetivos científico-  
tecnológicos**



# Motivación: objetivos aeronáuticos

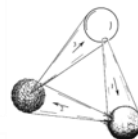
Un sistema eléctrico de retropropulsión espacial usa energía eléctrica para cambiar la velocidad de una nave espacial. La mayoría de estos sistemas de retropropulsión espacial utilizan campos electromagnéticos para expulsar propelente (masa de reacción) a alta rapidez.



**Teconología espacial debe superar  
validacion en misión de demostración**

**Objetivos aeronáuticos**

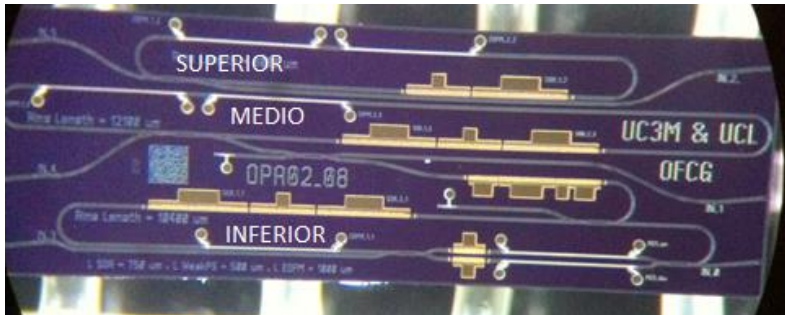
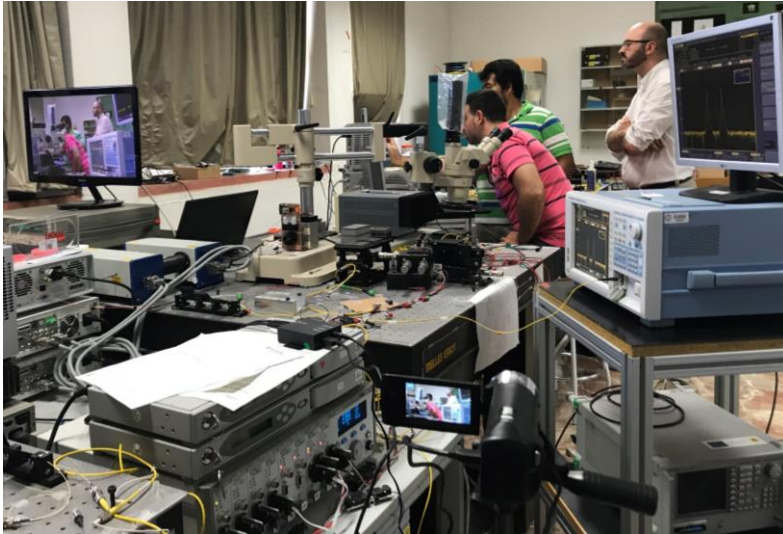
**Objetivos científico-  
tecnológicos**





# Motivación: objetivos científico-tecnológicos

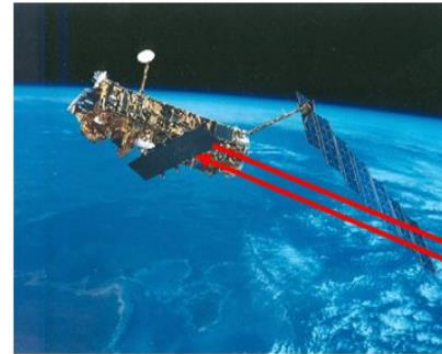
## Tecnologías fotónicas en espacio



GOTL

15/05/2019

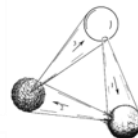
## Retroreflectores para SLR



- SLR significa Satellite Laser Ranging (Mediciones Láser a Satélites)
- Con esta técnica se mide distancias a satélites a través de pulsos de luz láser
- Una red de 35 estaciones SLR distribuidos por todo el mundo mide las órbitas de 25 satélites diferentes
- La alta precisión de estos datos (milímetros) sirve para un un gran espectro de aplicaciones científicas



GEOSIGN



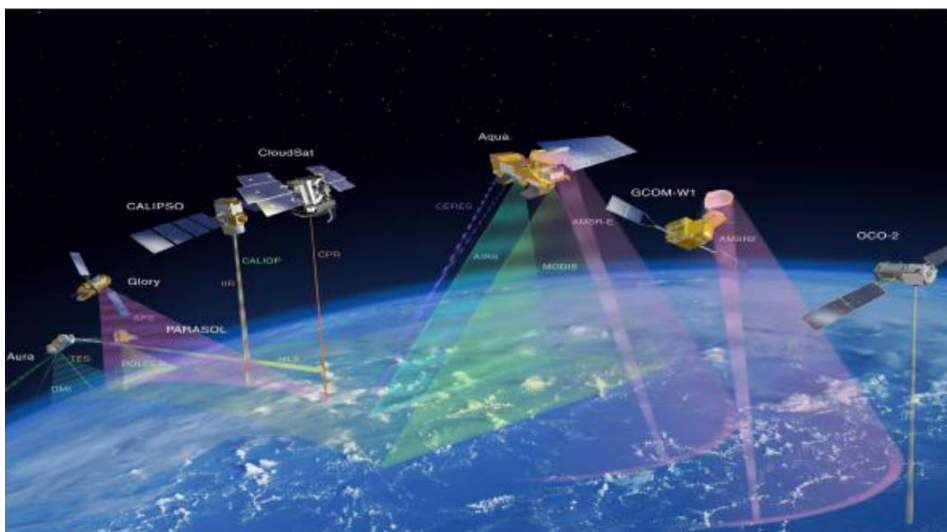
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# Motivación: objetivos científico-tecnológicos

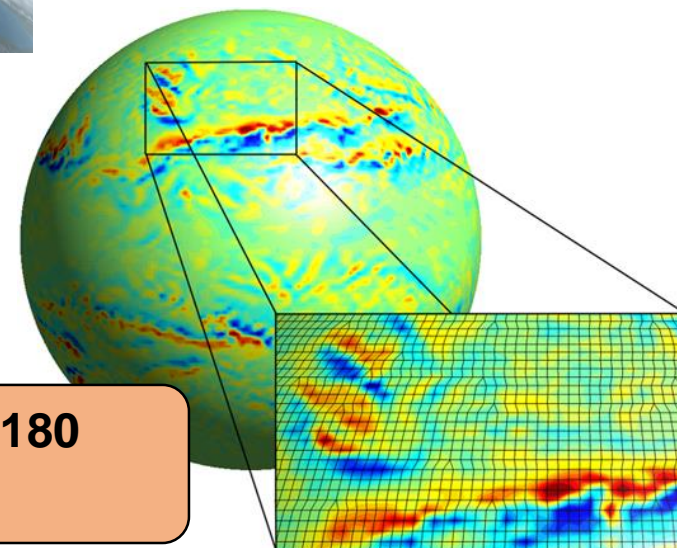
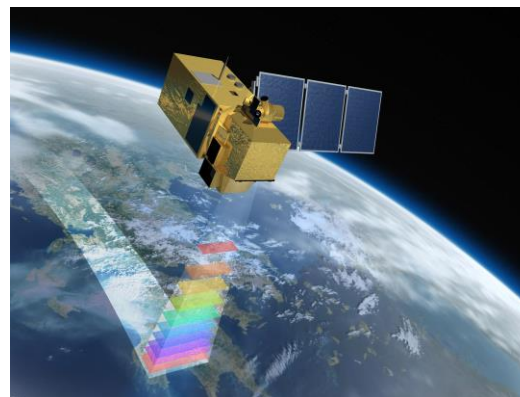
## Instrumentación fotónica “ultra-low noise”

Potencial para aplicaciones en radioastronomía, observación de la Tierra, misiones planetarias,...

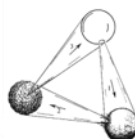
GREMA / GOTL



“Numerical Weather Prediction”



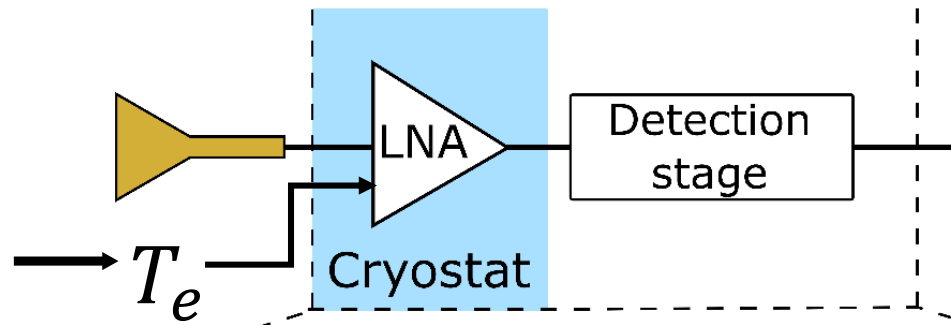
Vapor de agua a 180 GHz



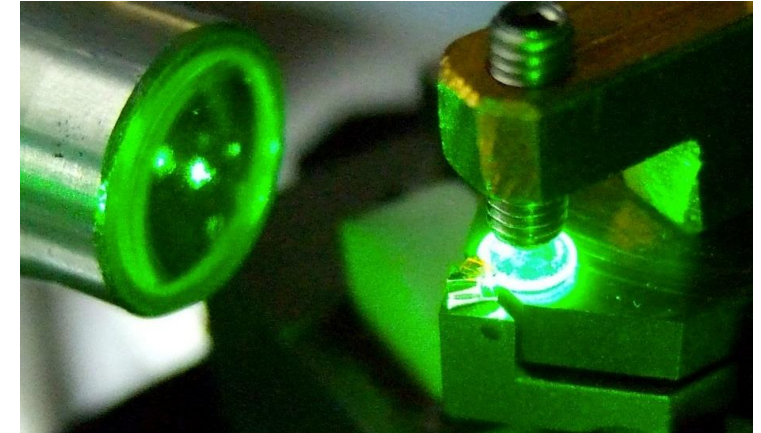
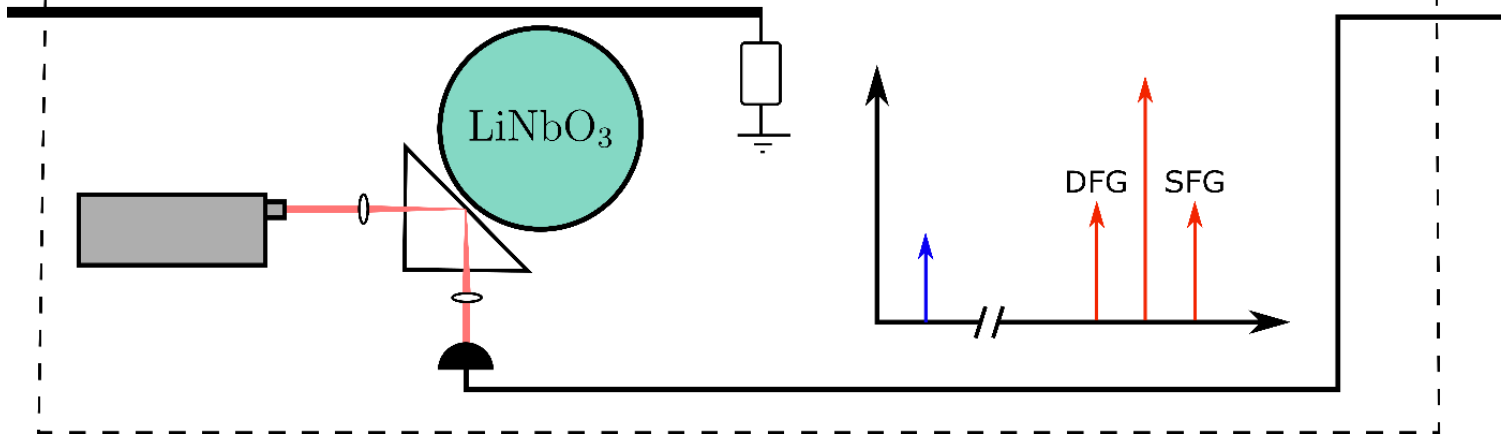
# Instrumentación fotónica de bajo ruido



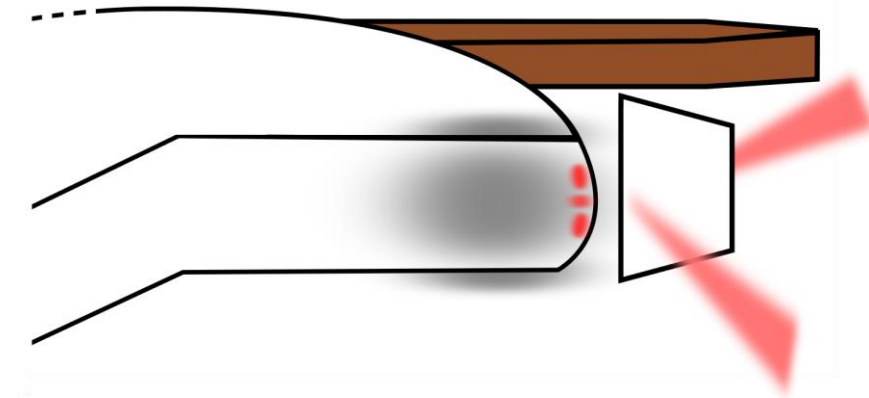
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Electro-optic modulator



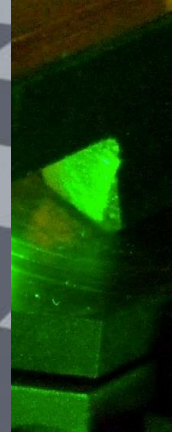
Dr. Harald G. L. Schwefel's group <http://www.wgmr.eu>



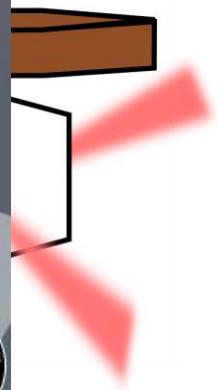
# Instrumentación fotónica de bajo ruido



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[www.wgmr.eu](http://www.wgmr.eu)



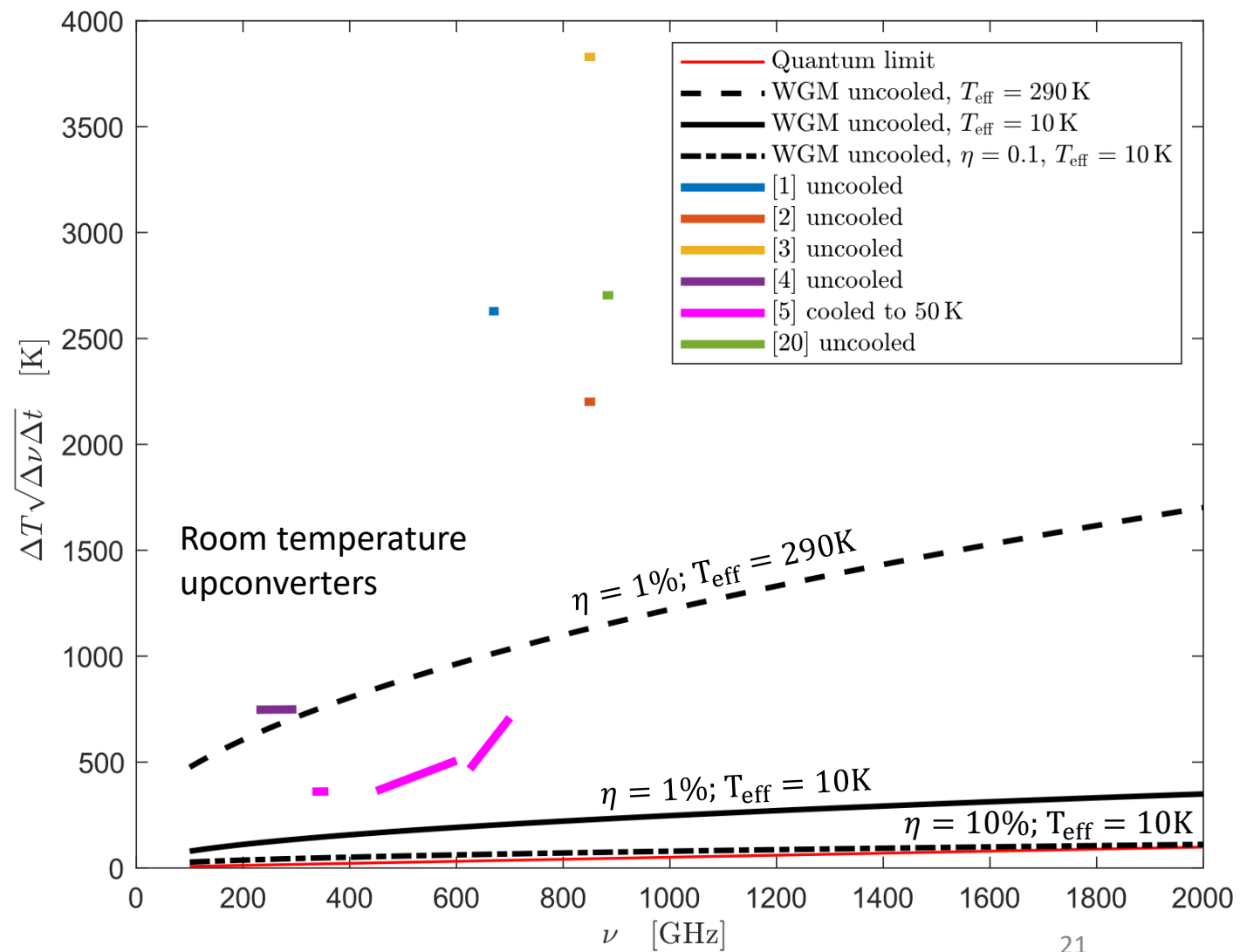
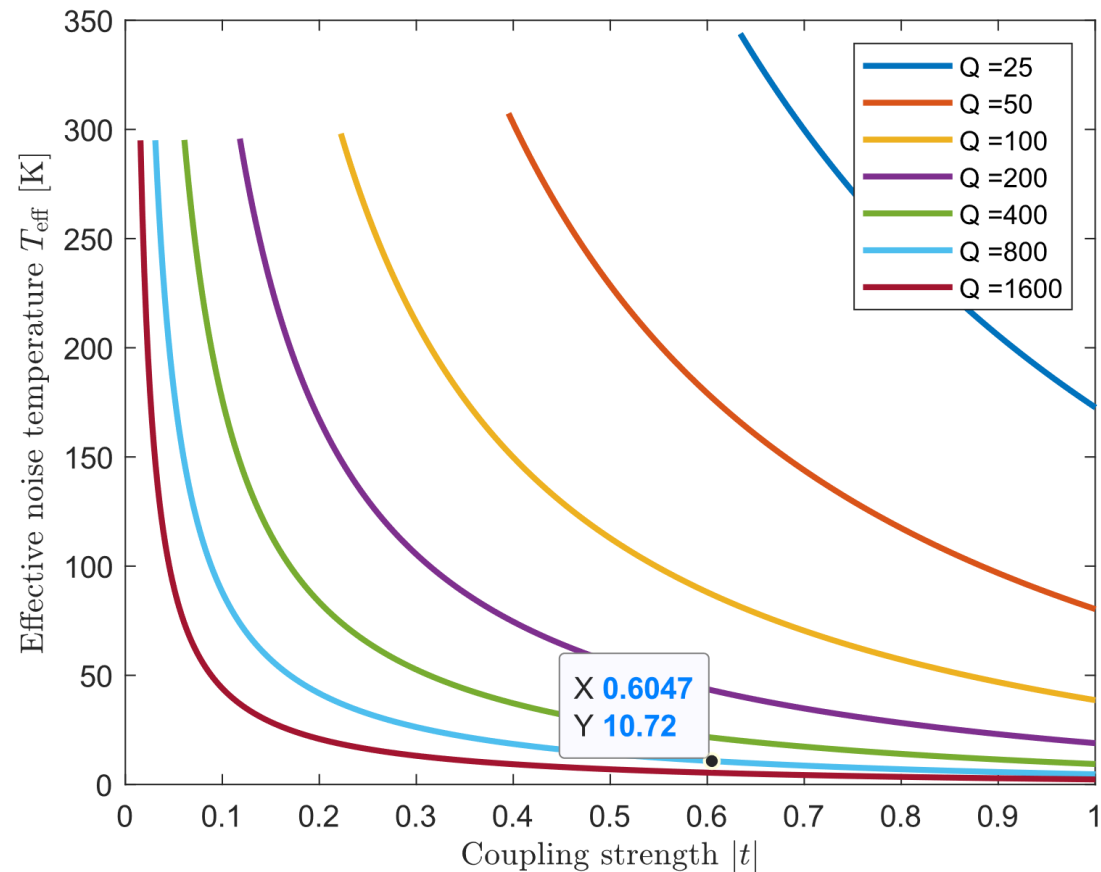
**GREMA**  
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MICROWAVES & ANTENNAS



# Instrumentación fotónica de bajo ruido



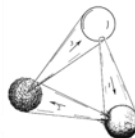
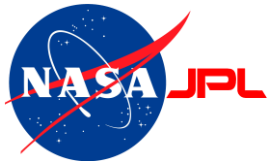
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# Conclusiones: agradecimientos al equipo de trabajo



University of Colorado  
Boulder



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