

Radioastronomía en Colombia Instrumentación y Observaciones

Germán Chaparro Molano, PhD
Universidad de Antioquia



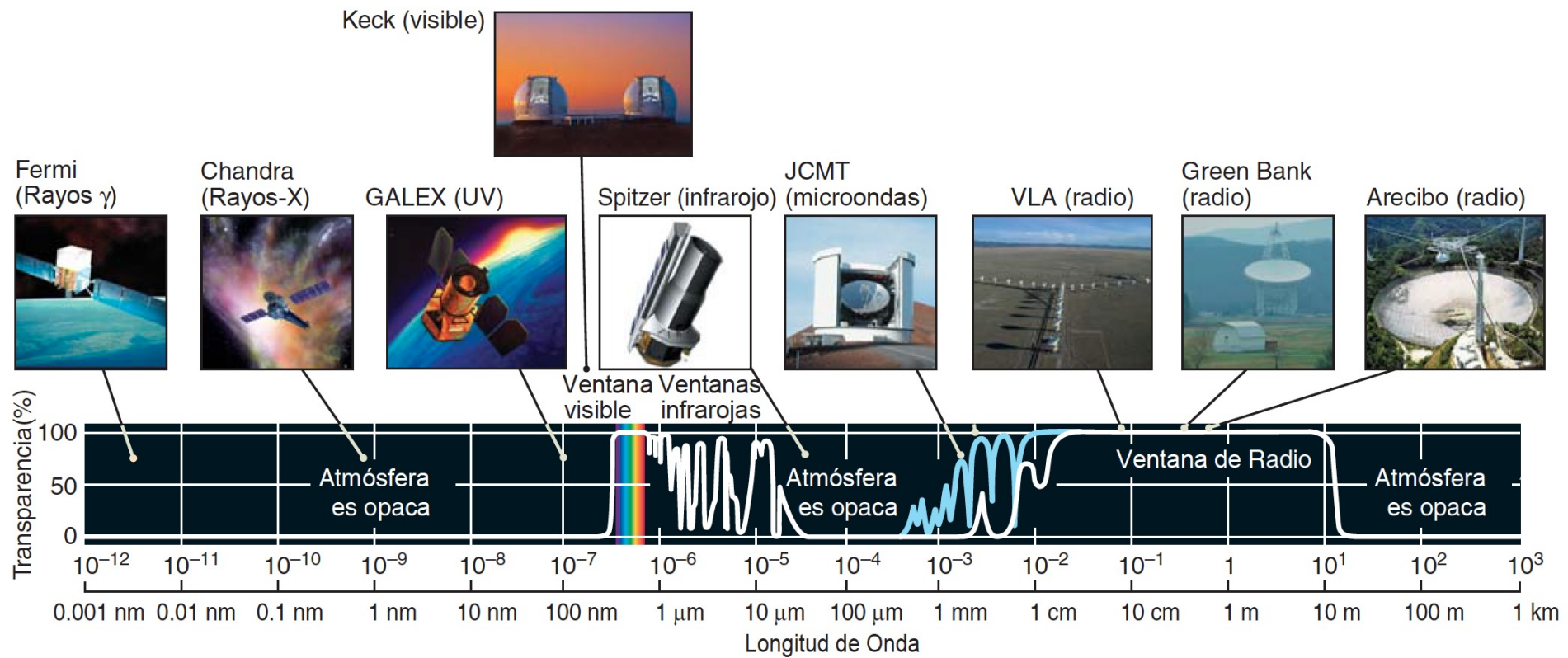
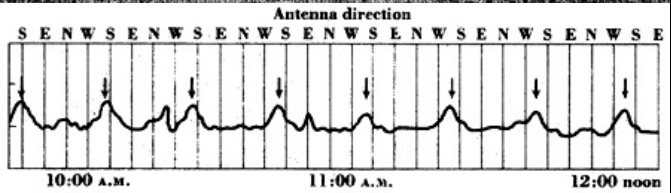
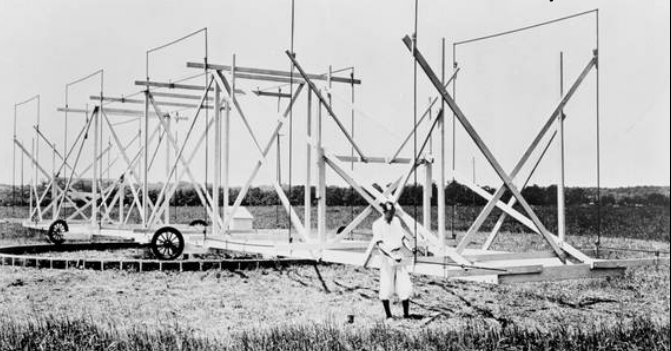


Imagen: Kay, Palen, Smith, Blumenthal 2013

Radioemisión de la Vía Láctea: Jansky 1932



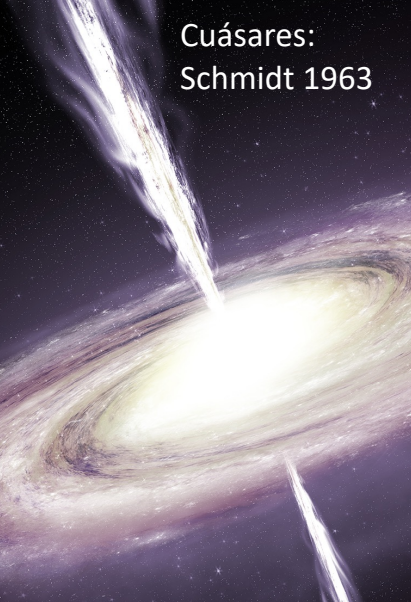
Radio Galaxias:
Reber 1940s



HI a 21 cm: Ewen & Purcell 1951



Cuásares:
Schmidt 1963

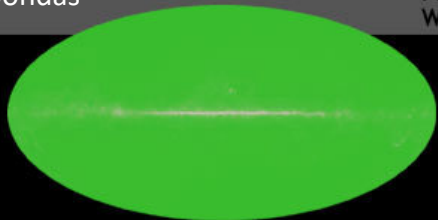


Síntesis de Apertura: Ryle 1964

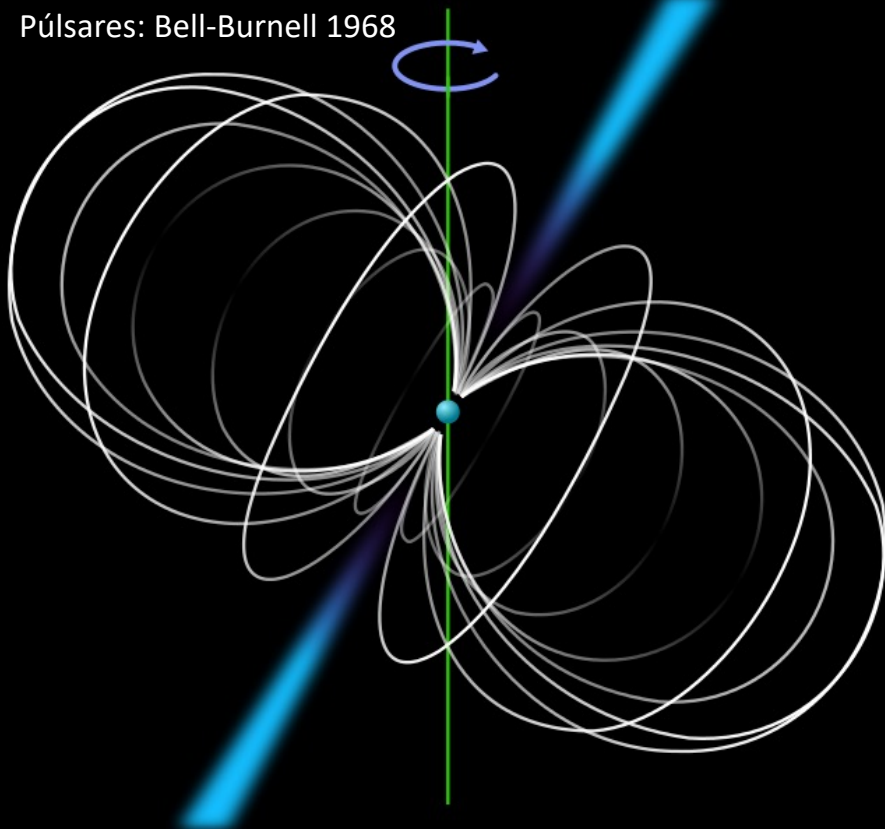


1965 Fondo Cósmico de Microondas

Penzias and Wilson



Púlsares: Bell-Burnell 1968

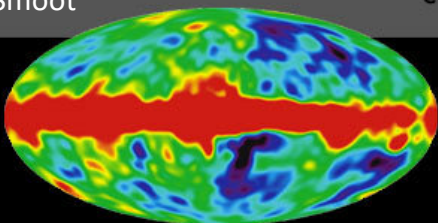


Exoplanetas:
Wolszczan 1992



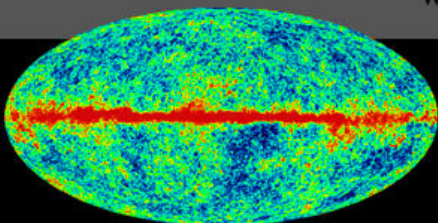
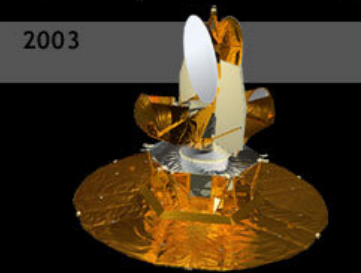
1992 Anisotropías: Mather & Smoot

COBE



2003

WMAP



Ondas Gravitacionales:
Hulse & Taylor 1993



M87*

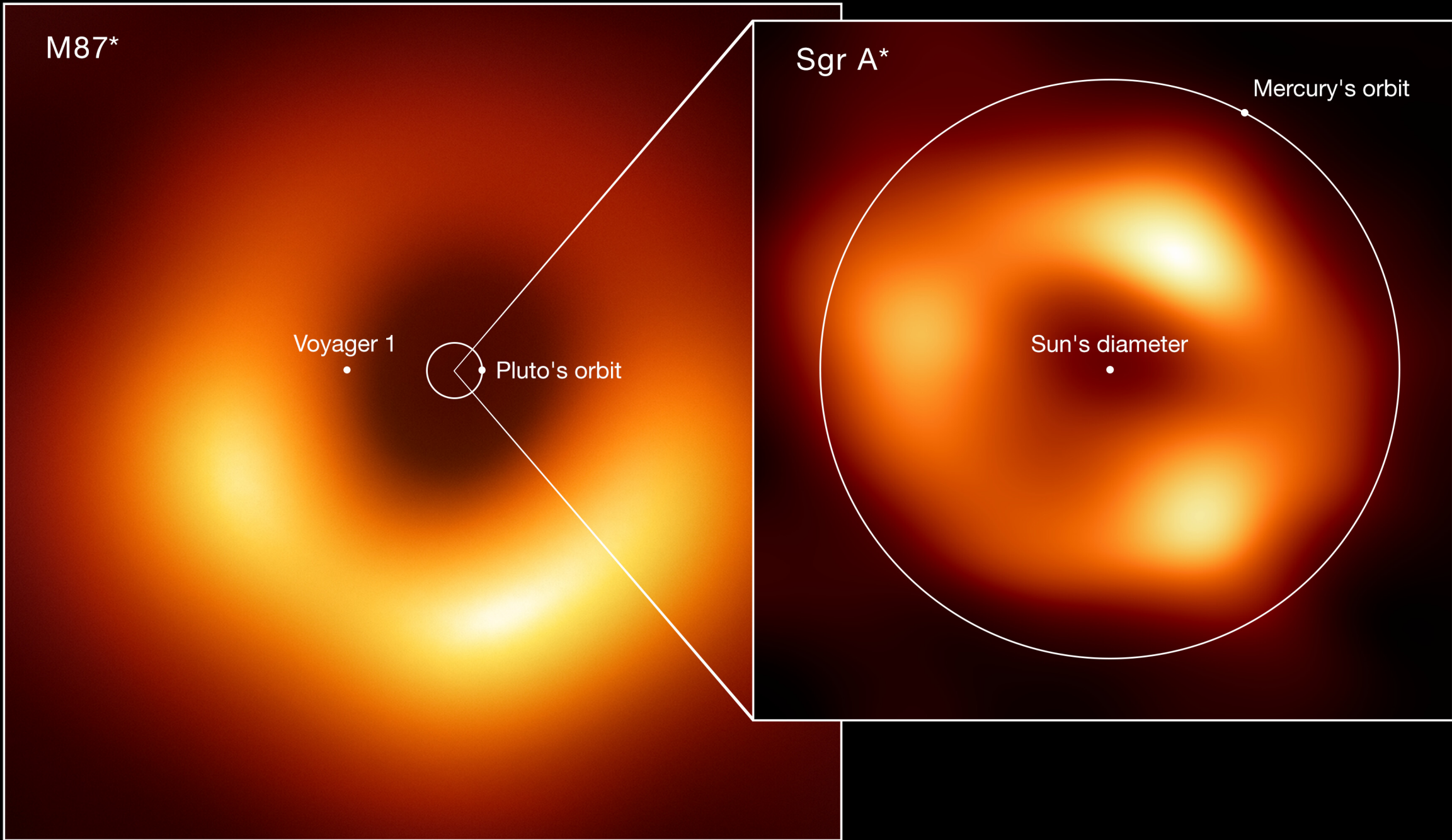
Voyager 1

Pluto's orbit

Sgr A*

Mercury's orbit

Sun's diameter



Radioastronomía en Colombia

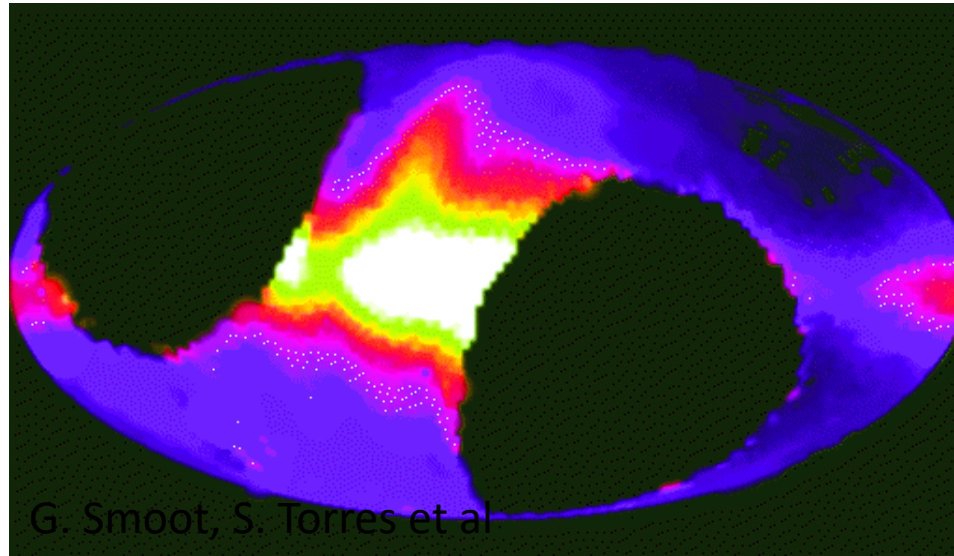
Instrumentación

Universidad Distrital

- Radio JOVE - Emisión de radio Joviana
- Observaciones radioastronómicas de cometas
- Modelos didácticos de la radioastronomía
- **Profesor Pedro Deaza**



Galactic Emission Mapping (GEM) 1990s



Sergio Torres
George Smoot



Radioastronomía Solar - Ionósfera



SE INVITA A QUE LA COMUNIDAD ASTRONOMICA A QUE HAGA PARTE DE UNA RED DE RADIOTELESCOPIOS Y REALICE MONTAJES COMO EL QUE APARECE A CONTINUACION

Radioastronomía en la Universidad de los Andes
Radio Astronomy at the Universidad de los Andes

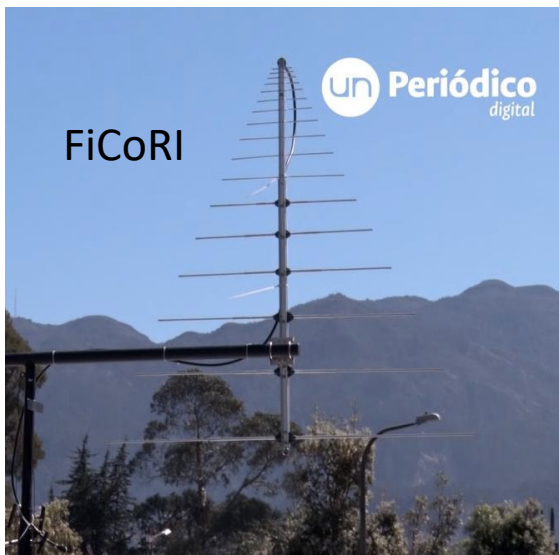
Mauricio Vinasco Téllez



30-200 MHz

M. Vinasco

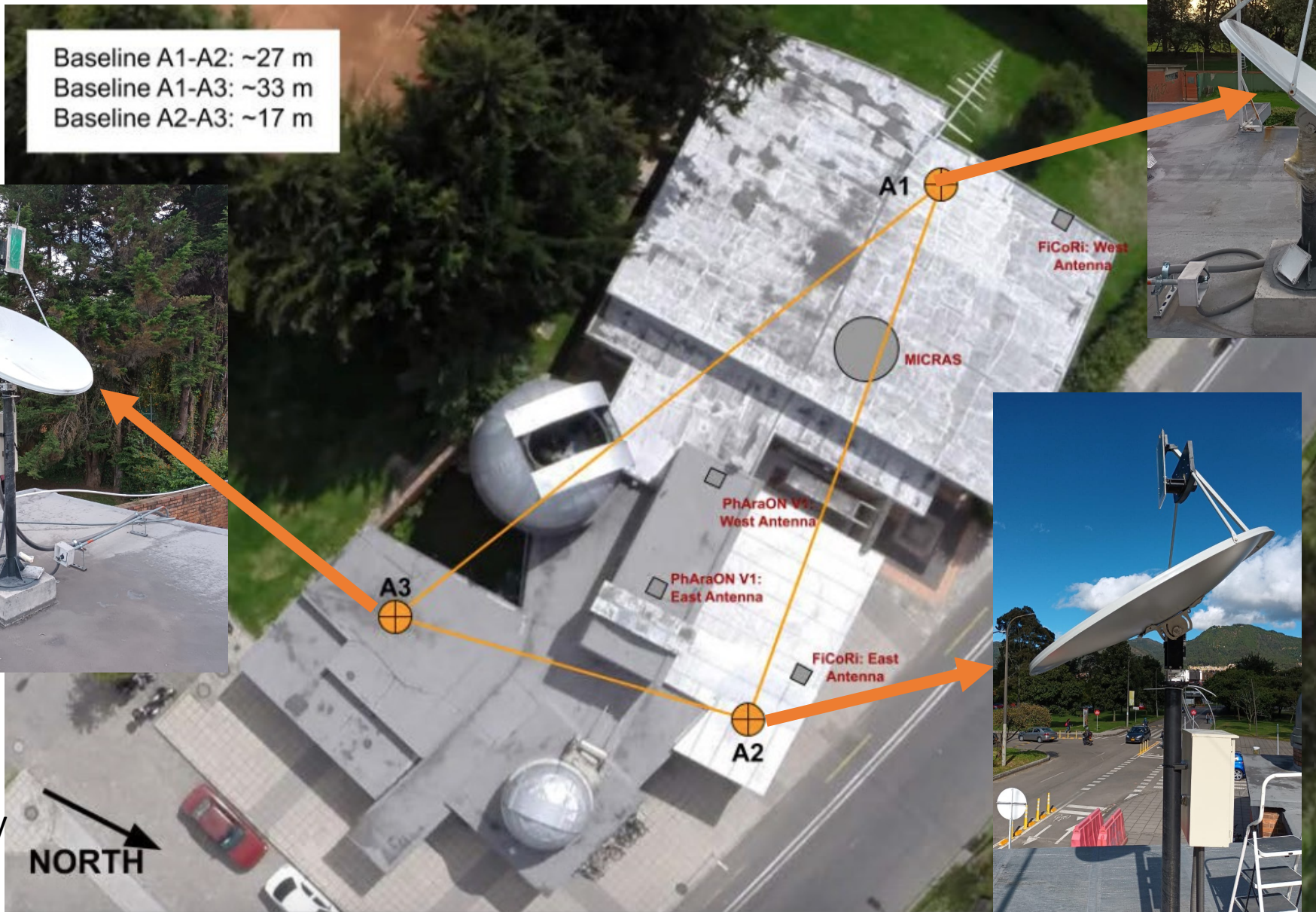
Universidad Nacional de Colombia



JC Guevara, S. Vanegas
Con C. Buitrago y JC Martínez (UC Berkeley)

Universidad Nacional de Colombia – PHARAON (1420 MHz)

Baseline A1-A2: ~27 m
Baseline A1-A3: ~33 m
Baseline A2-A3: ~17 m



JS Hincapié
con inv. UC Berkeley

UECCI

Prof. O. Restrepo



- Radio JOVE (2013)
- Conversión de Antena de 4 m @ 1.4 GHz (21 cm) - 2018
- 2 Becas doctorales para el RAIG, Universidad de Chile
- 7 Trabajos de pregrado en

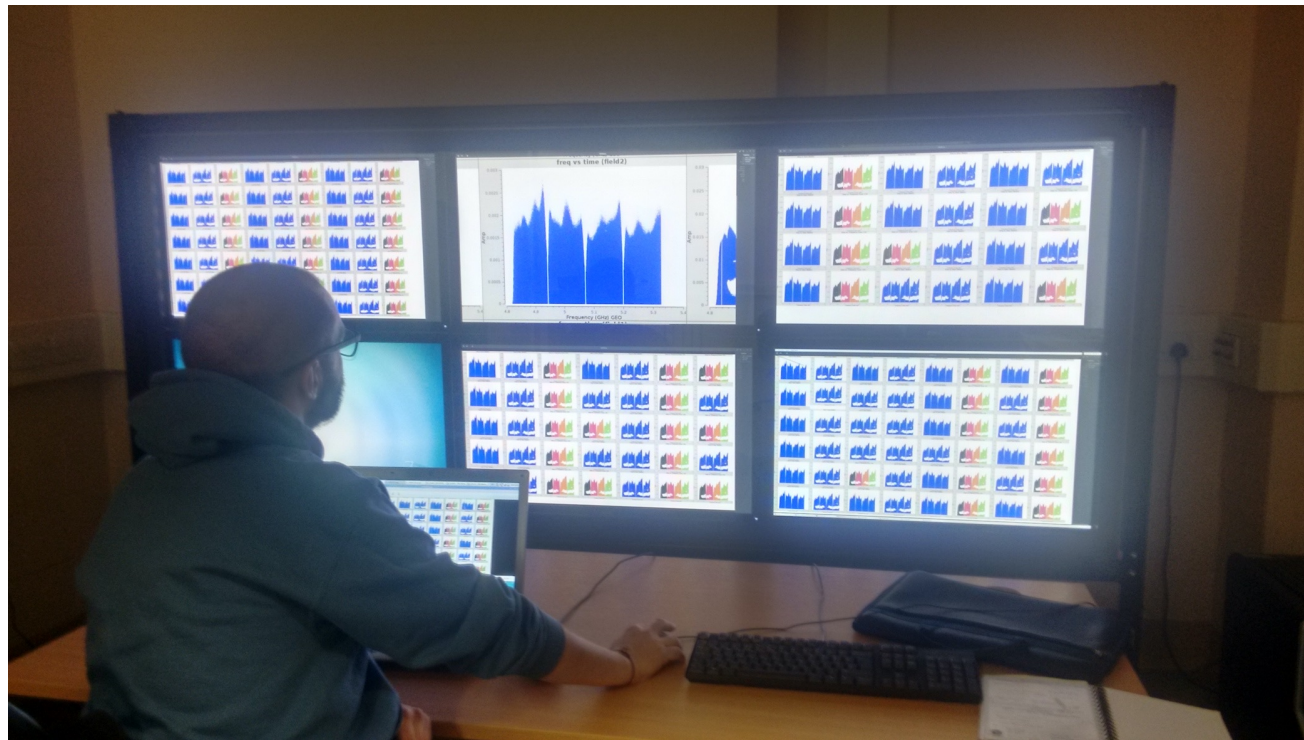
ingeniería: instrumentación radioastronómica, antenas para nanosatélites

- Actualmente: Site testing en VHF, Optimización de antenas para industria, colaboración con U. Sergio Arboleda/IAC



Use of power-wall displays for interactive RFI removal

- Felipe P. Mosquera, MPhil ULeeds
- Newton Fund - RADA Scholarship (2019)
- FUDARTA - Fundación para el Desarrollo de la Radioastronomía y Tecnologías Aplicadas



Low Dimensional Embedding of Climate Data for Radio Astronomical Site Testing in the Colombian Andes

Germán Chaparro Molano¹, Oscar Leonardo Ramírez Suárez¹, Oscar Alberto Restrepo Gaitán^{1,2}, and Alexander Marcial Martínez Mercado^{1,3,4,5}

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² Radio Astronomy Instrumentation Group, Universidad de Chile, Santiago de Chile, Chile; orestrepog@ecc.edu.co

³ Instituto de Hidrología, Meteorología y Estudios Ambientales, Bogotá, Colombia

⁴ Grupo de Simulación del Sistema Climático Terrestre, Universidad Nacional de Colombia, Bogotá, Colombia

⁵ Departamento de Ciencias Básicas, Universidad ECCI, Bogotá, Colombia

Received 2017 May 25; accepted 2017 July 31; published 2017 September 1

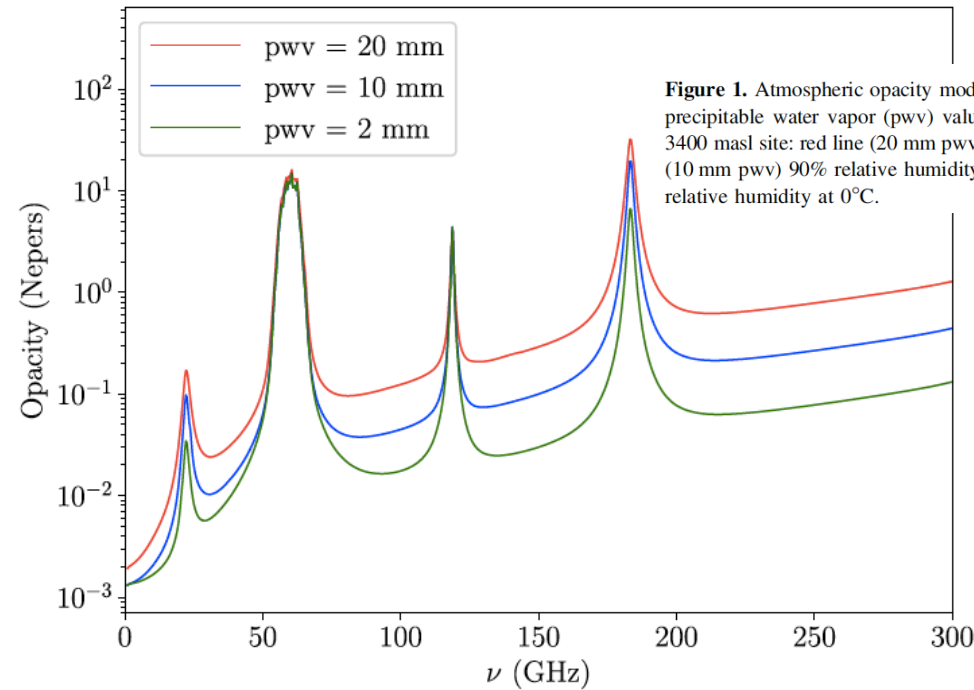
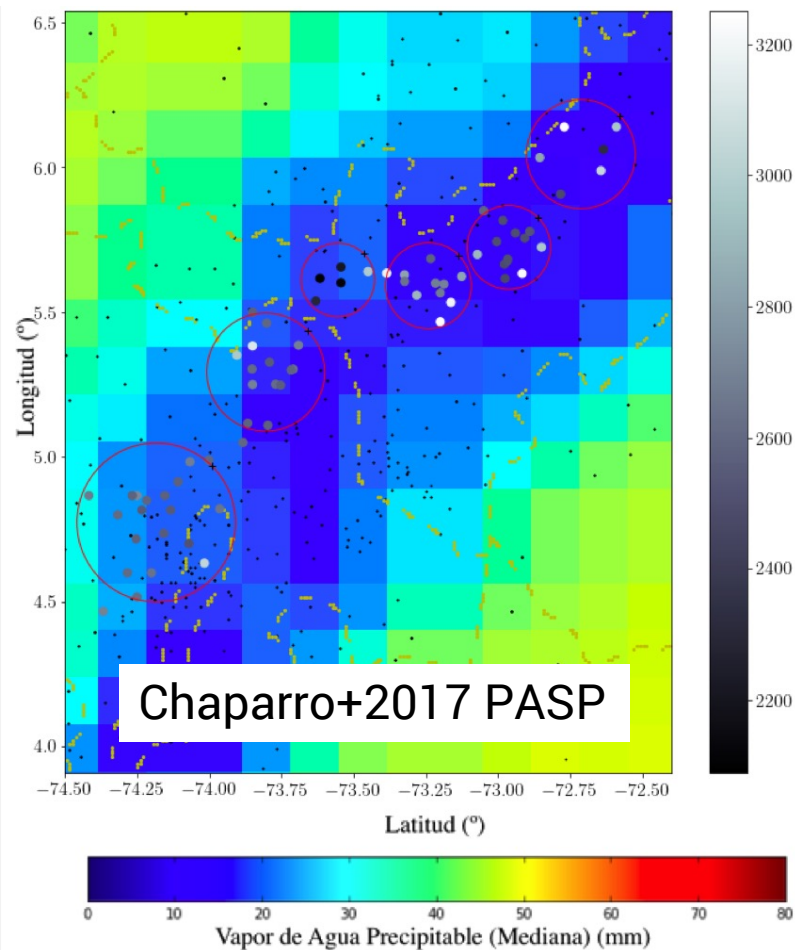
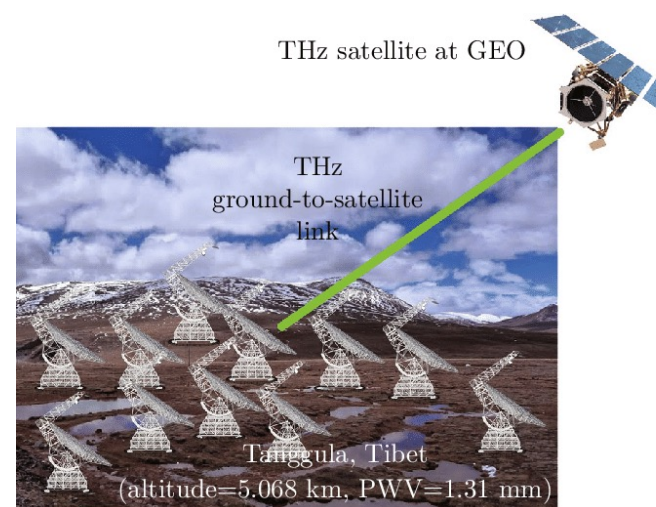


Figure 1. Atmospheric opacity models for the Colombian Andes for different precipitable water vapor (pwv) values corresponding to three scenarios for a 3400 masl site: red line (20 mm pwv) 90% relative humidity at 15°C, blue line (10 mm pwv) 90% relative humidity at 0°C, and green line (2 mm pwv) 30% relative humidity at 0°C.

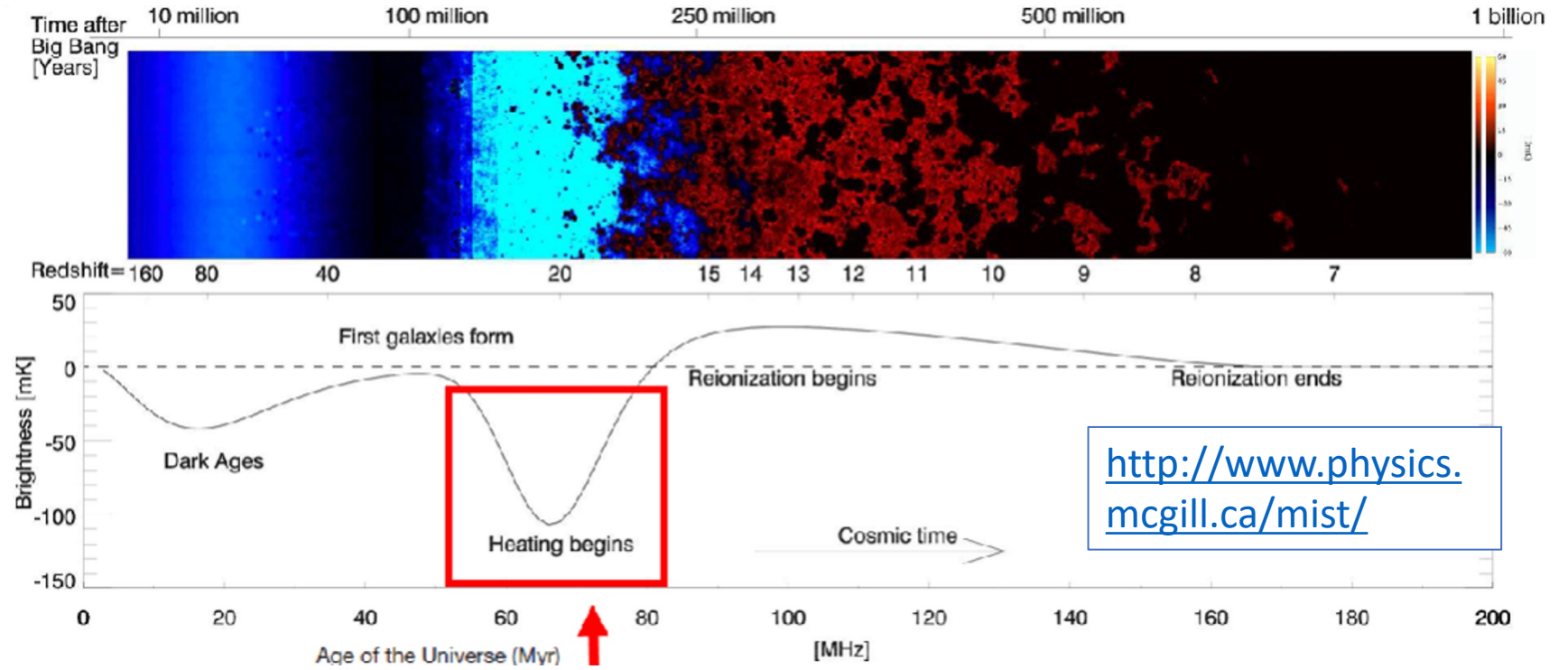
<https://iopscience.iop.org/article/10.1088/1538-3873/aa83fe>



https://www.researchgate.net/publication/323191278_Link_Budget_Analysis_for_Massive-Antenna-Array-Enabled_Terahertz_Satellite_Communications

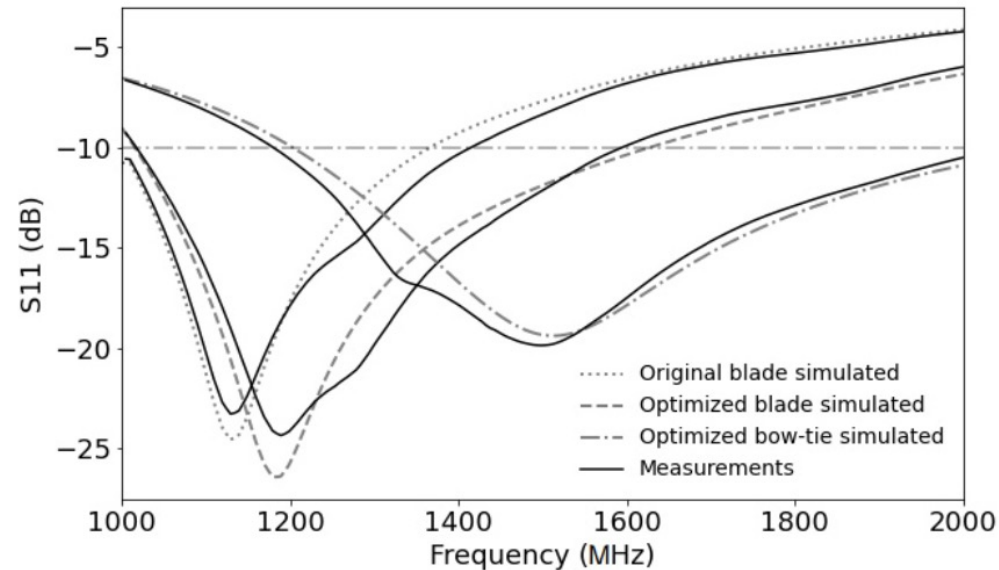
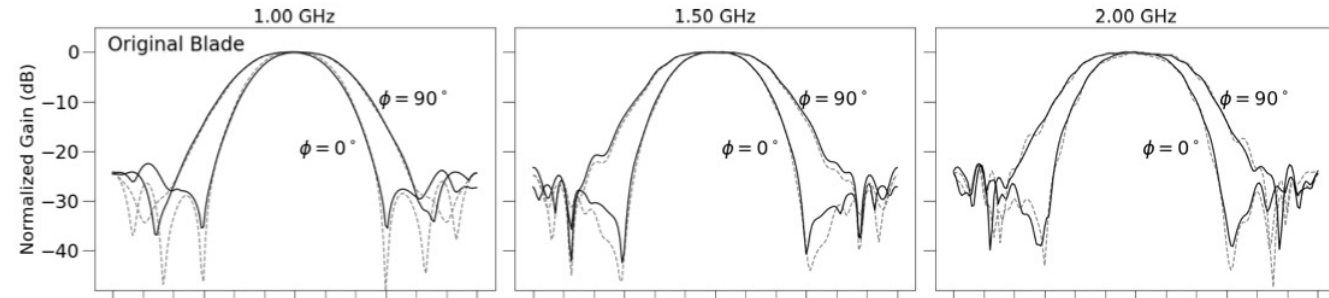
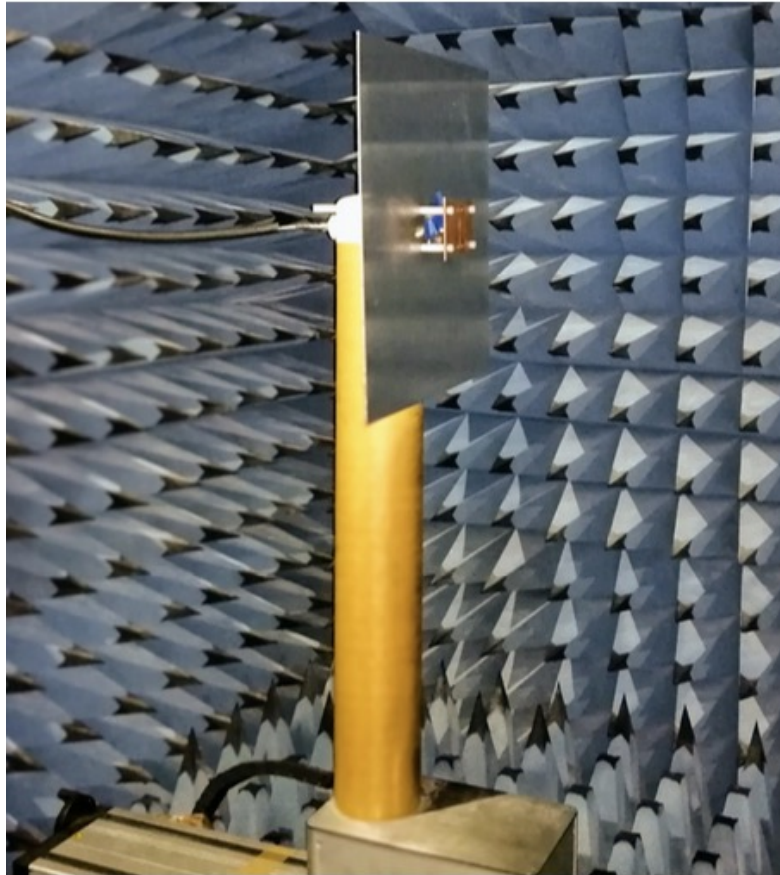


MIST - Mapper of the IGM Spin Temperature Cosmological 21 cm experiment, PI: Ricardo Bustos (UCSC - Chile), Co-PI: Raúl Monsalve - Berkeley



- Monsalve 2024 a,b (MNRAS, ApJ), coautor: O. Restrepo

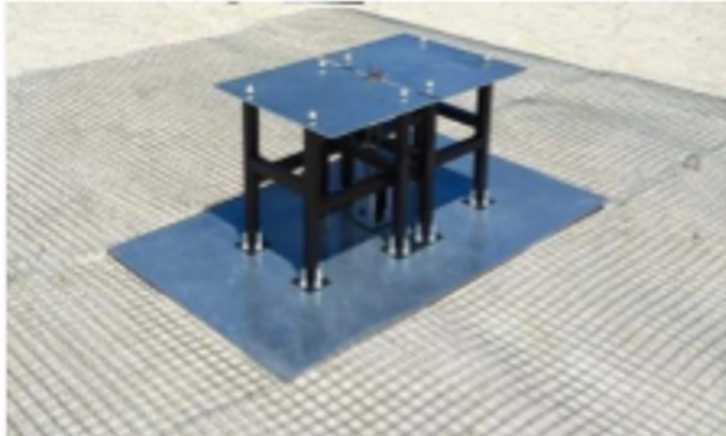
Optimization of Antenna Performance for Global 21 cm Observations and Verification Using Scaled Copies



PSO-aided antenna geometry: optimized bowtie design outperforms both original and optimized rectangular design (EDGES, Bowman+2018)

Restrepo, Lucero, Chaparro+ 2023 JAI

21 cm Cosmology @ Colombia

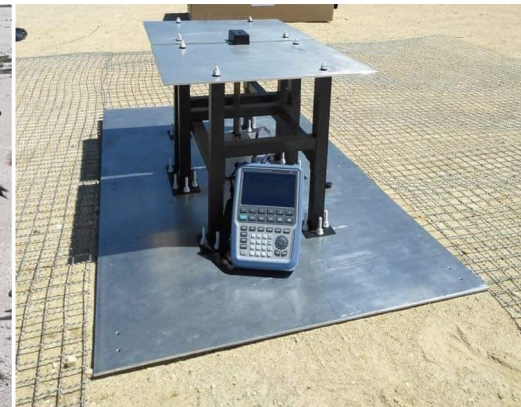


CASIRI (UIS + FUDARTA + ANE) 🇨🇴



Mosquera+ Poster in
IEEE AP-S/URSI 2022

Oscar Restrepo (UECCI)
Julián Rodríguez (UIS)
Felipe Mosquera (FUDARTA)
Germán Chaparro (UdeA)
+ R. Bustos (UCSC - Chile)



Programa Radioastronómico
Antártico Colombiano PRAC
IX, X, XI ECA

PI: **Julián Rodríguez UIS**

XI ECA con est. Meng UIS
Elián Calderón
David González

Programa Radioastronómico Antártico Colombiano (PRAC)

Dr. Julián RODRÍGUEZ-FERREIRA*

Investigador Principal

Contacto: jgrodrif@uis.edu.co

- **Co-investigadores:** Felipe P Mosquera¹, Carlos Jaime Barrios¹, Óscar M. Reyes¹, Homero Ortega¹, German Chaparro², Óscar Restrepo³, Ricardo Jaimes¹, Efrén Acevedo¹

- **Estudiantes Doctorado:** Hans García¹ (ahora prof UIS)

- **Estudiantes Maestría:** Leandro Rojas¹, Jherson Cáceres¹, Jhon Deivy Martínez¹, David González¹, Elián Calderón¹

- **Ingenieros de desarrollo y soporte:** Luis Miguel Díaz¹, Douglas Amaranto¹, Andrés Camilo Pitta¹, Tania Santos¹, Carlos Mario Martínez¹, Erika Cruz¹, Maira Camila Paba¹, Laura Zúñiga¹, Milena Alarcón¹

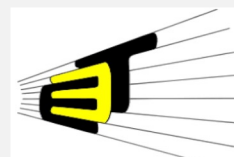
(1) *Universidad Industrial de Santander*

(2) *Universidad de Antioquia*

(3) *Universidad ECCI (Antes: U. de Chile)*

(4) *Dept. de Astronomía, Universidad de Concepcion, Chile*

(5) *Universidad Católica de la Santísima Concepción, Chile*



Escuela de Ingenierías
Eléctrica, Electrónica
y de Telecomunicaciones

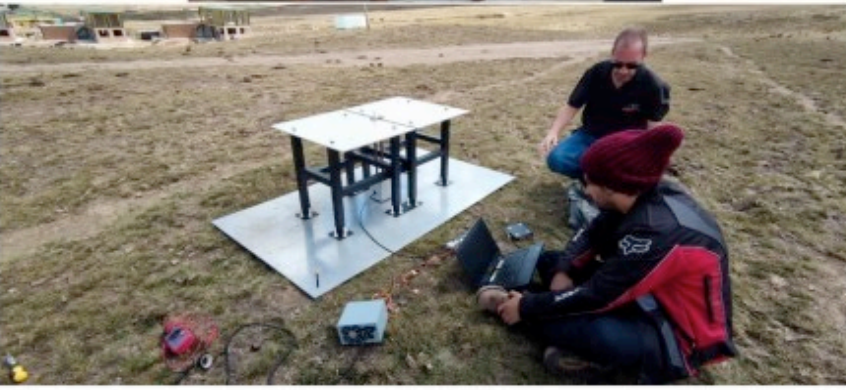


CPS

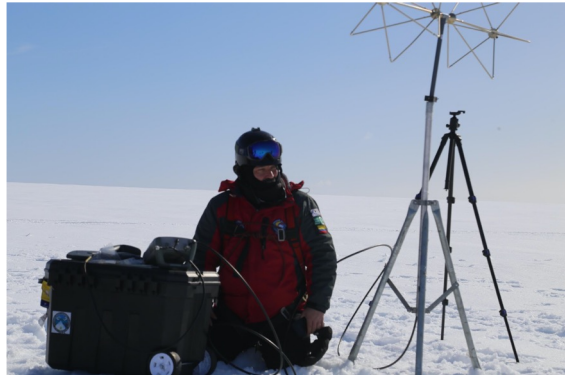


RADIOGIS®

Preparación para 9a Expedición Antártica Colombiana



9ª y 10ª Expedición Antártica Colombiana



11ª Expedición:

Desarrollo de sistema preamplificación para antena blade, diseño estructural: **David González**
Est. MEng UIS-CEMOS



Observatorio de Radioastronomía UIS



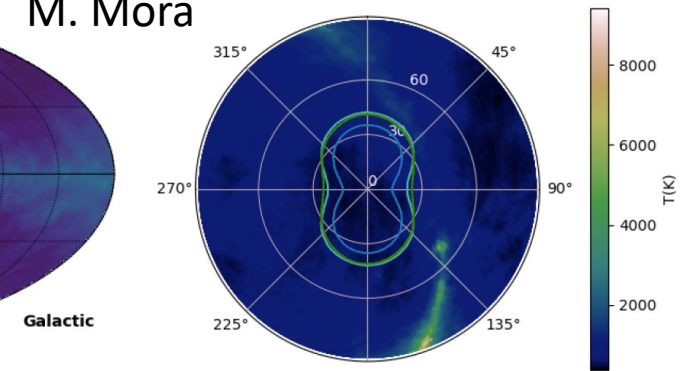
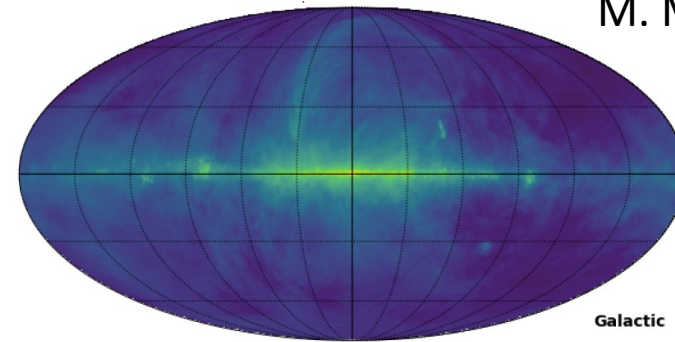
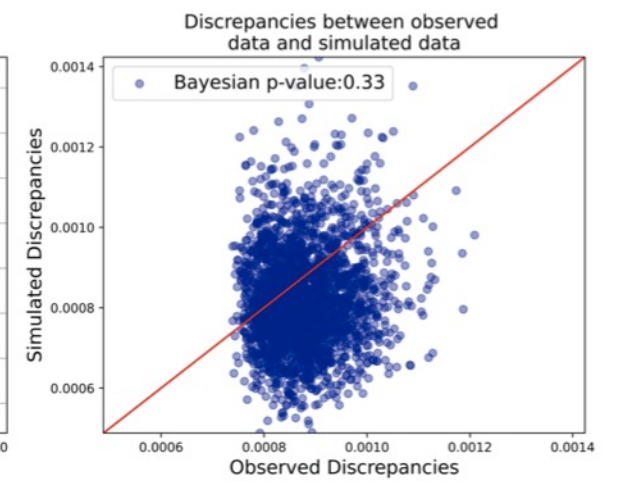
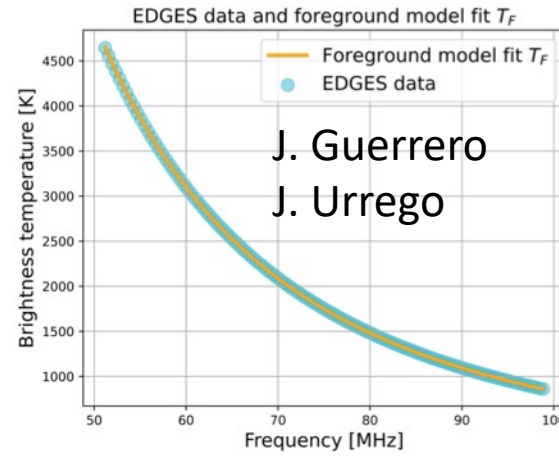
Minciencias 890 + FUDARTA
Interferómetro de 3 elementos
Enfocado en línea de 21cm (1420 MHz)
D = 4.5m x2 & 2m x1
Elián Calderón (est. Meng UIS-CEMOS)



UdeA: 21 cm cosmology, instrumentation

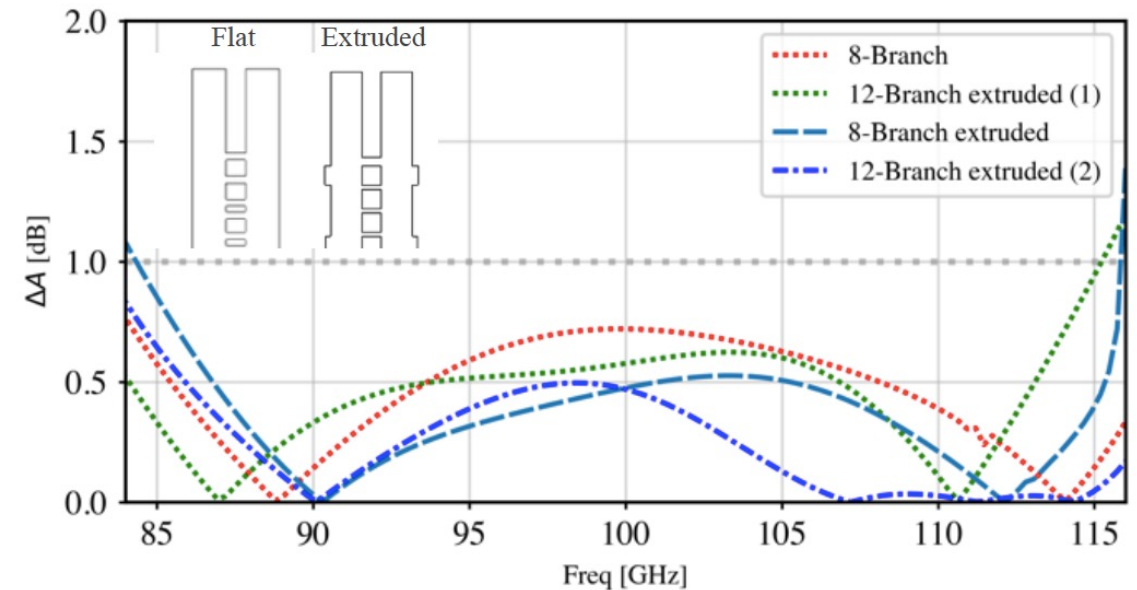
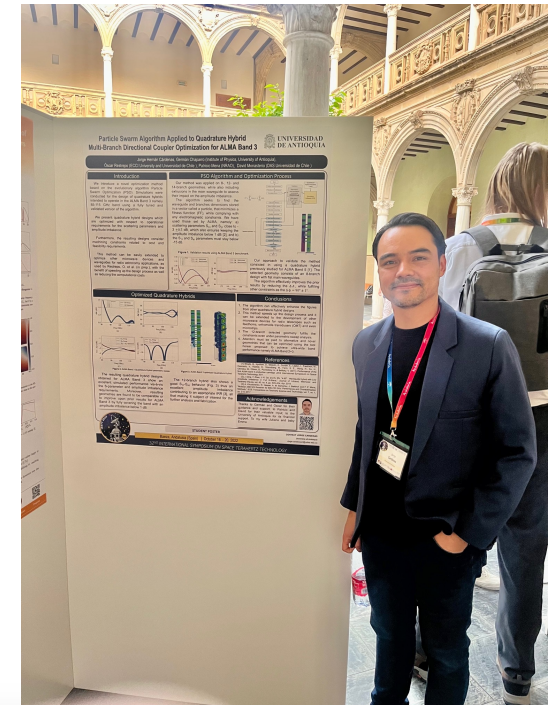
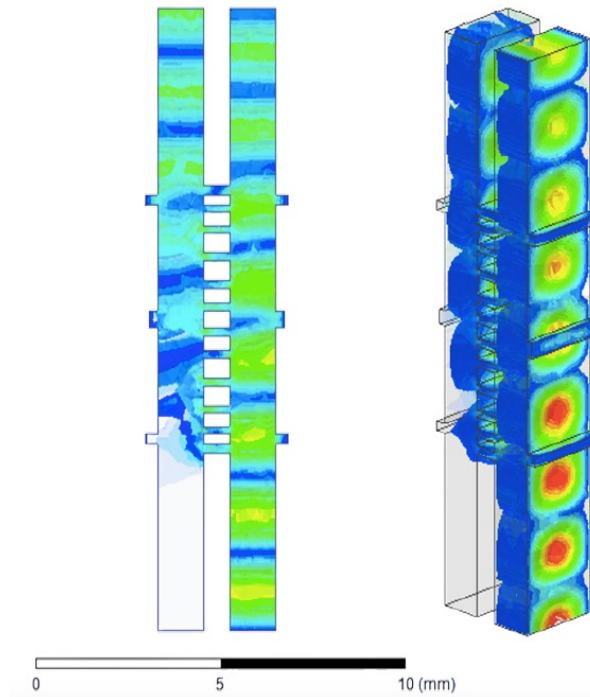
- Radio sky + ionosphere foregrounds simulations, statistical validation of EDGES signal (M. Mora, J. Guerrero, J. Urrego, in prep)

- Iris: Radio Telescope for galactic 21 cm line + other student projects (C. Londoño, **J. Giraldo - poster**)



UdeA: PSO-assisted W-band and ALMA Band 3 quadrature hybrid design (Jorge Cárdenas w. O. Restrepo)

- MSc research project – Poster presented in 32nd IEEE International Symposium on Space Terahertz Technology (2022)
- Software package: PERSEO
- BSc project: Fish School Optimization algorithm implementation (B. Pérez)

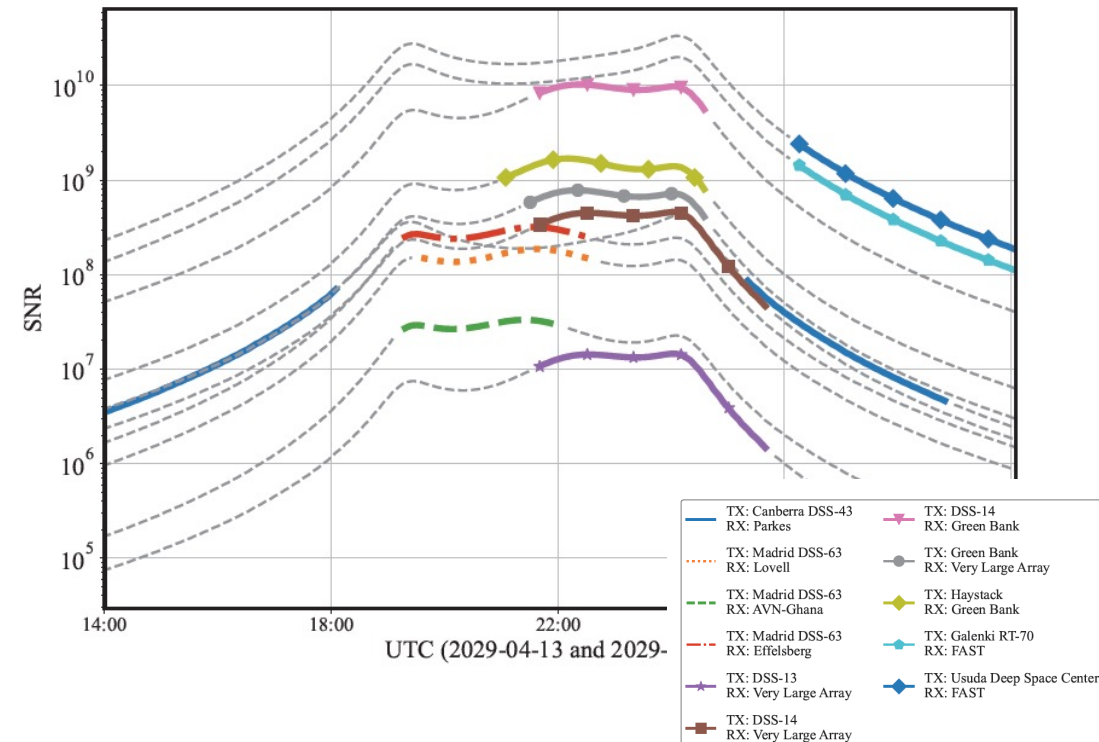
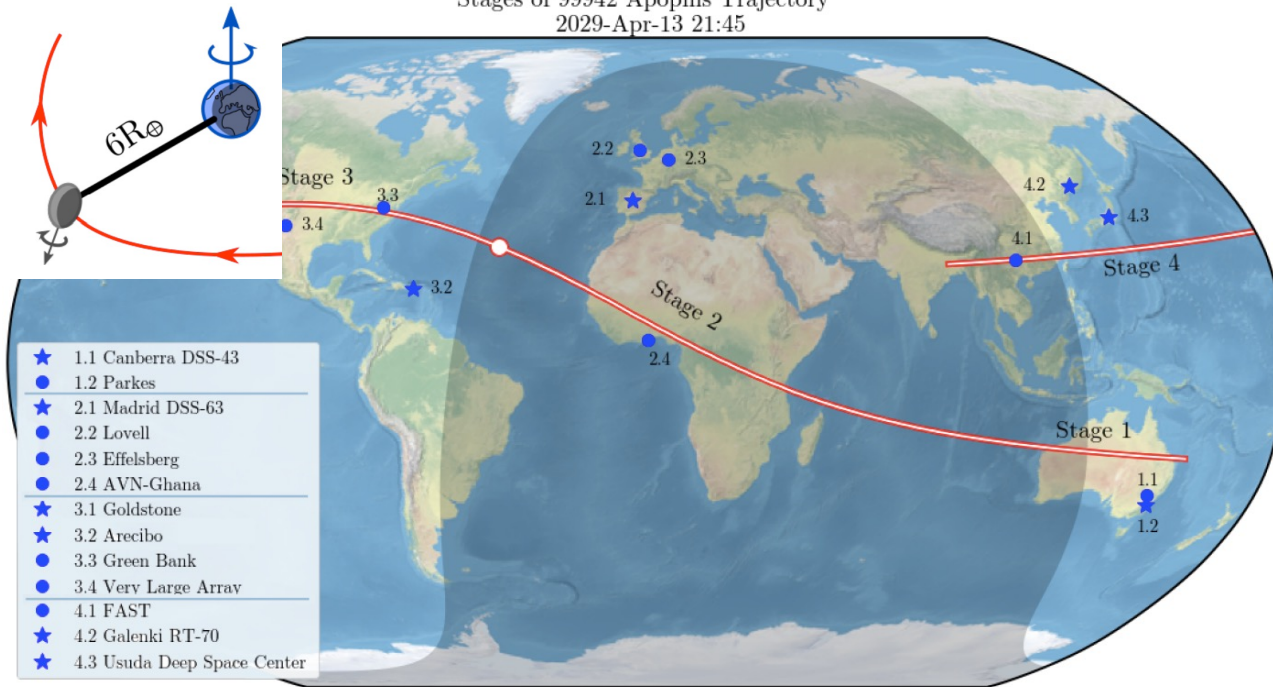


UdeA: Conditions for high-resolution bistatic radar observations of Apophis in 2029

Exact orbit computation, radar parameter computation (SNR, sky rotation, max. resolution), visual observation parameters.

Vallejo, Chaparro, Zuluaga 2023 MNRAS

Stages of 99942 Apophis Trajectory
2029-Apr-13 21:45





Radio Observatorio de Sicaya, Perú



México

Agencia Espacial tendrá radio telescopio en Valle de Tulancingo



IVIA
Iniciativa VLBI
Iberoamericana



Chocontá, Colombia

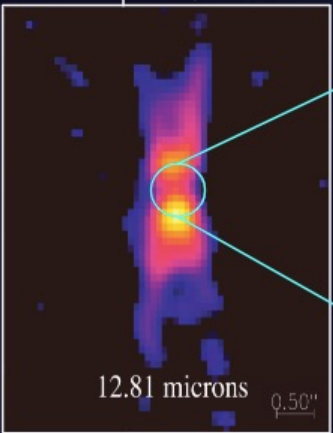
Alianza Telefonica-FUDARTA
¿AstroCO?

Radioastronomía en Colombia

Observaciones

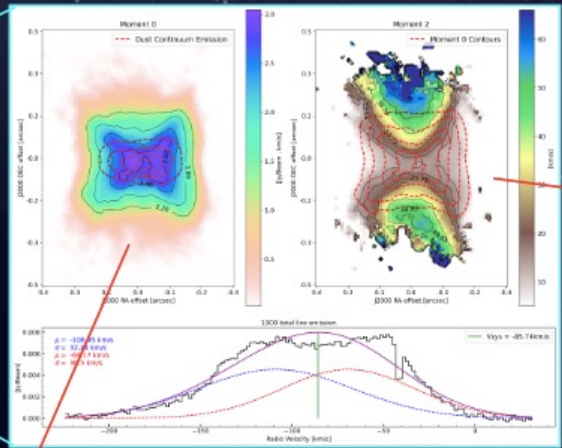
Distribución de polvo y gas molecular en la envoltura circunestelar de IRAS 15445-5449.

Observaciones de la región cercana a la estrella central



Lagadec et al. 2011

^{13}CO (3-2)

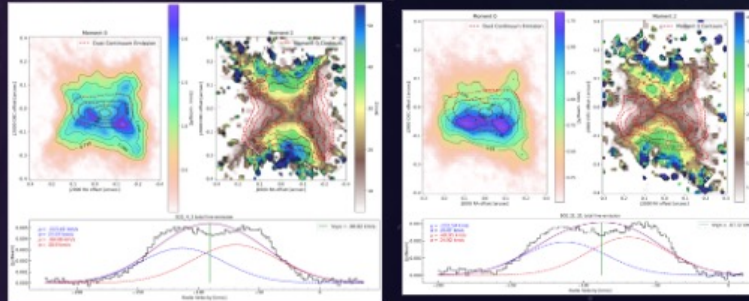


Momento 0:
Distribución espacial

La formación de estas moléculas se explica a partir de choques entre partículas a altas velocidades

SO_2 (4-3)

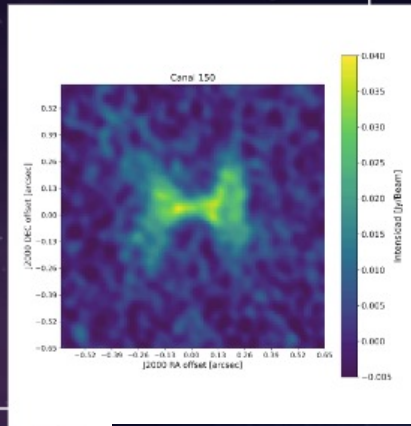
SO_2 (21-21)



Momento 2:
Campo de velocidades

Observaciones de ALMA

Crédito: ESO



Marcela Echeverri Gallego ¹

Andrés F. Pérez Sánchez ²

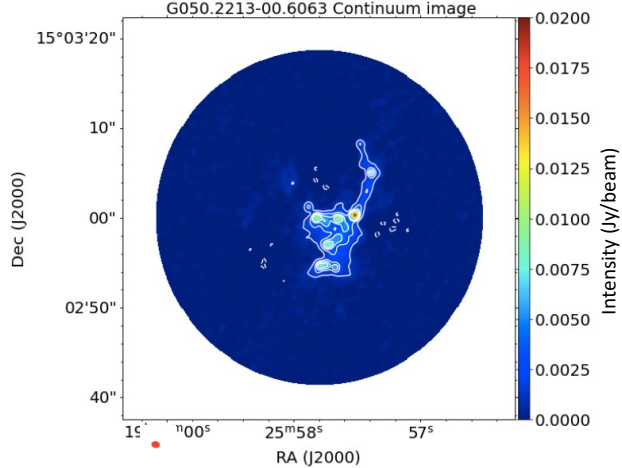
Esteban Silva Villa ¹

Pattern Finding in mm-Wave Spectra of Massive Young Stellar Objects

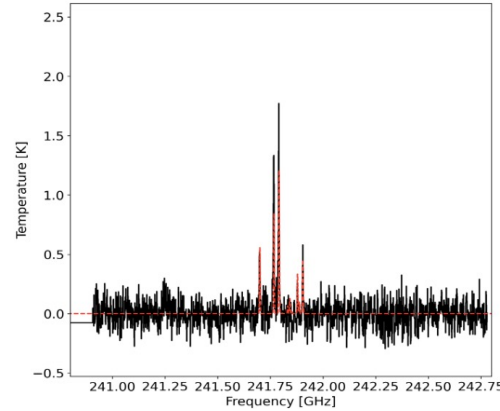
43 MYSOs from RMS (Lumsden 2013) and SDC (Peretto & Fuller 2009) catalogues

ALMA Band 6 continuum

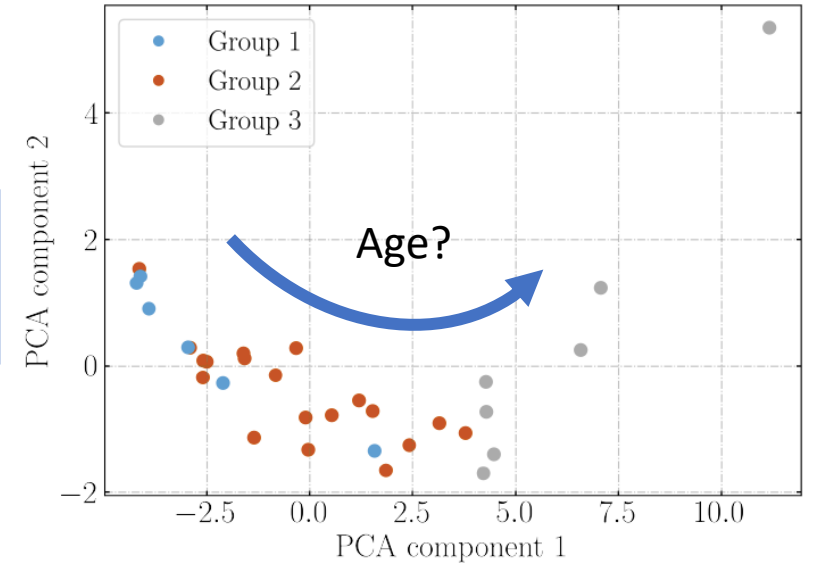
G050.2213-00.6063 Continuum image



ALMA Band 6 spectrum



PCA reduced spectra compared vs. LLE yields
1 → 2 → 3 MYSO groups



Avison et al 2023

Detections: Methanol, methyl acetylene, and methyl cyanide

Unsupervised classification (LLE+GMM) of MYSOs based on their molecular T_{rot} , N_{col} from rotational diagrams

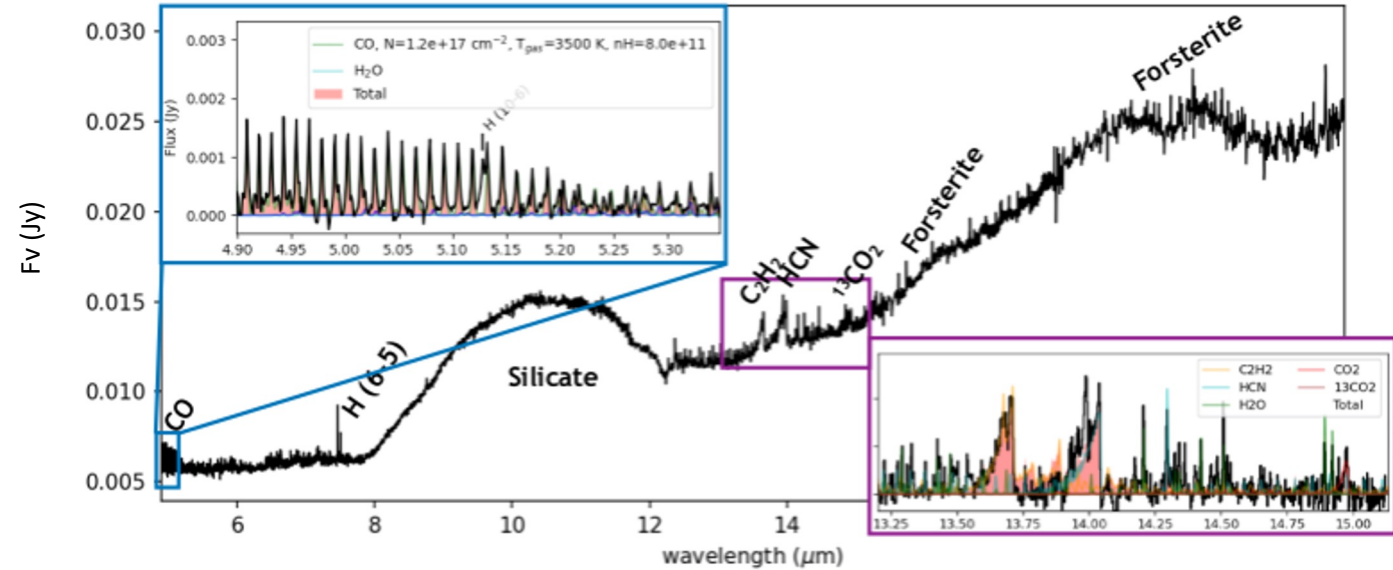
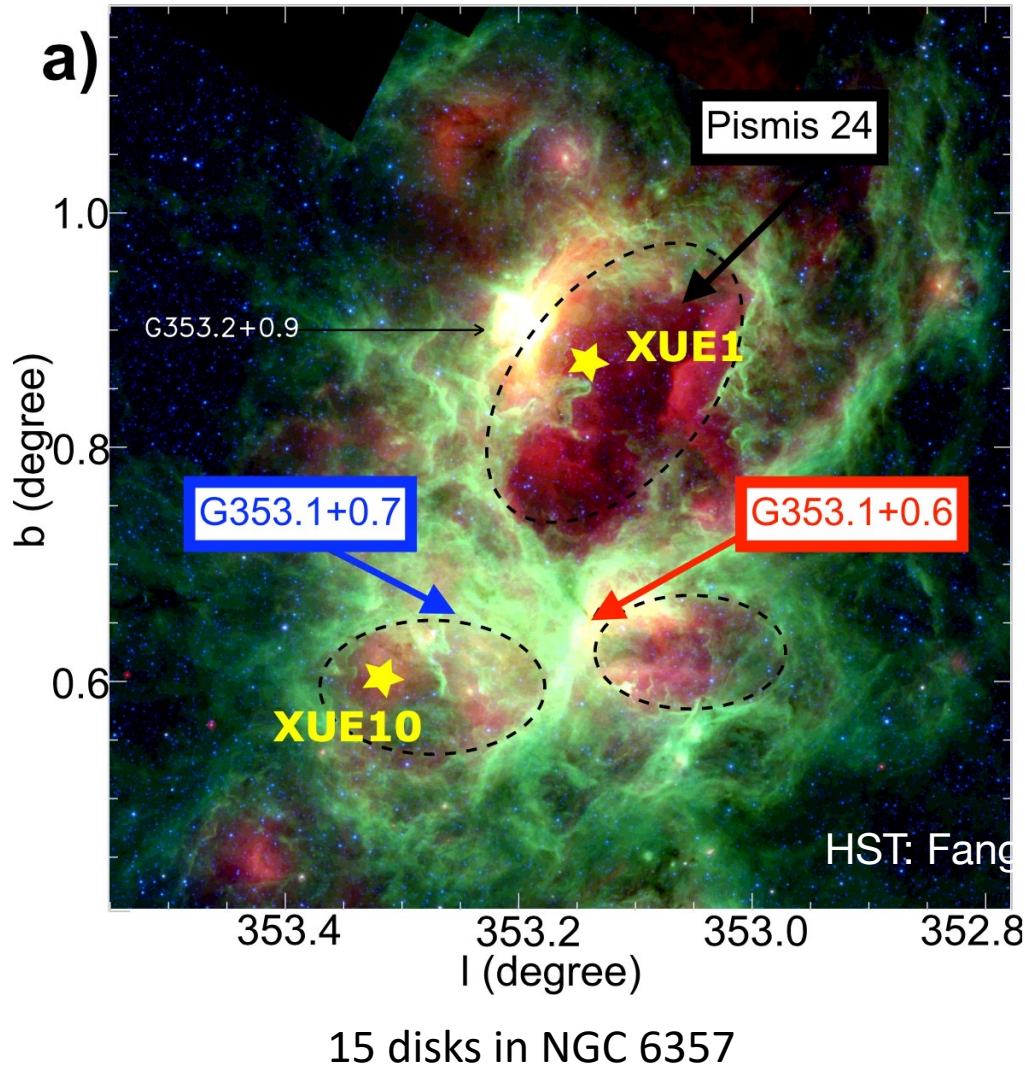
(1) GMM group	(2) T (K)	(3) M_{gas} (M_{\odot})	(4) N_{gas} (10^{24} cm^{-2})	(5) $T_{\text{CH}_3\text{OH}}$ (K)	(6) $N_{\text{CH}_3\text{OH}}$ (10^{16} cm^{-2})	(7) $T_{\text{CH}_3\text{CCH}}$ (K)	(8) $N_{\text{CH}_3\text{CCH}}$ (10^{16} cm^{-2})	(9) $T_{\text{CH}_3\text{CN}}$ (K)	(10) $N_{\text{CH}_3\text{CN}}$ (10^{16} cm^{-2})
1	20^{+18}_{-6}	34^{+12}_{-6}	$8.4^{+12.6}_{-3.4}$	20^{+10}_{-6}	$0.13^{+0.34}_{-0.06}$	30^{+2}_{-16}	$0.55^{+0.73}_{-0.31}$	30^{+16}_{-16}	$0.004^{+0.033}_{-0.002}$
2	220^{+130}_{-20}	$7.8^{+10.2}_{-3.3}$	$1.9^{+1.7}_{-0.8}$	220^{+34}_{-34}	25^{+76}_{-19}	60^{+20}_{-11}	$0.65^{+0.36}_{-0.31}$	220^{+130}_{-20}	$0.5^{+1.5}_{-0.4}$
3	300^{+200}_{-40}	26^{+18}_{-14}	$5.6^{+1.4}_{-3.2}$	250^{+4}_{-20}	300^{+220}_{-51}	75^{+15}_{-25}	$1.6^{+0.7}_{-0.8}$	300^{+200}_{-40}	$6.6^{+3.4}_{-3.6}$

Validation: A simple Random Forest classifier can deduce the evolutionary stage directly from dim. reduced spectra (F1, Prec., Rec. ~80%)

PCA components of spectra can be used to **directly classify MYSOs** without the need for individual line extraction (rot. diag.)

XUE (eXtreme UV Environments) collaboration

PI: Macla Ramírez Tannus   & Arjan Bik



MIRI - JWST observations of XUE1 (Ramírez-Tannus et al 2023)

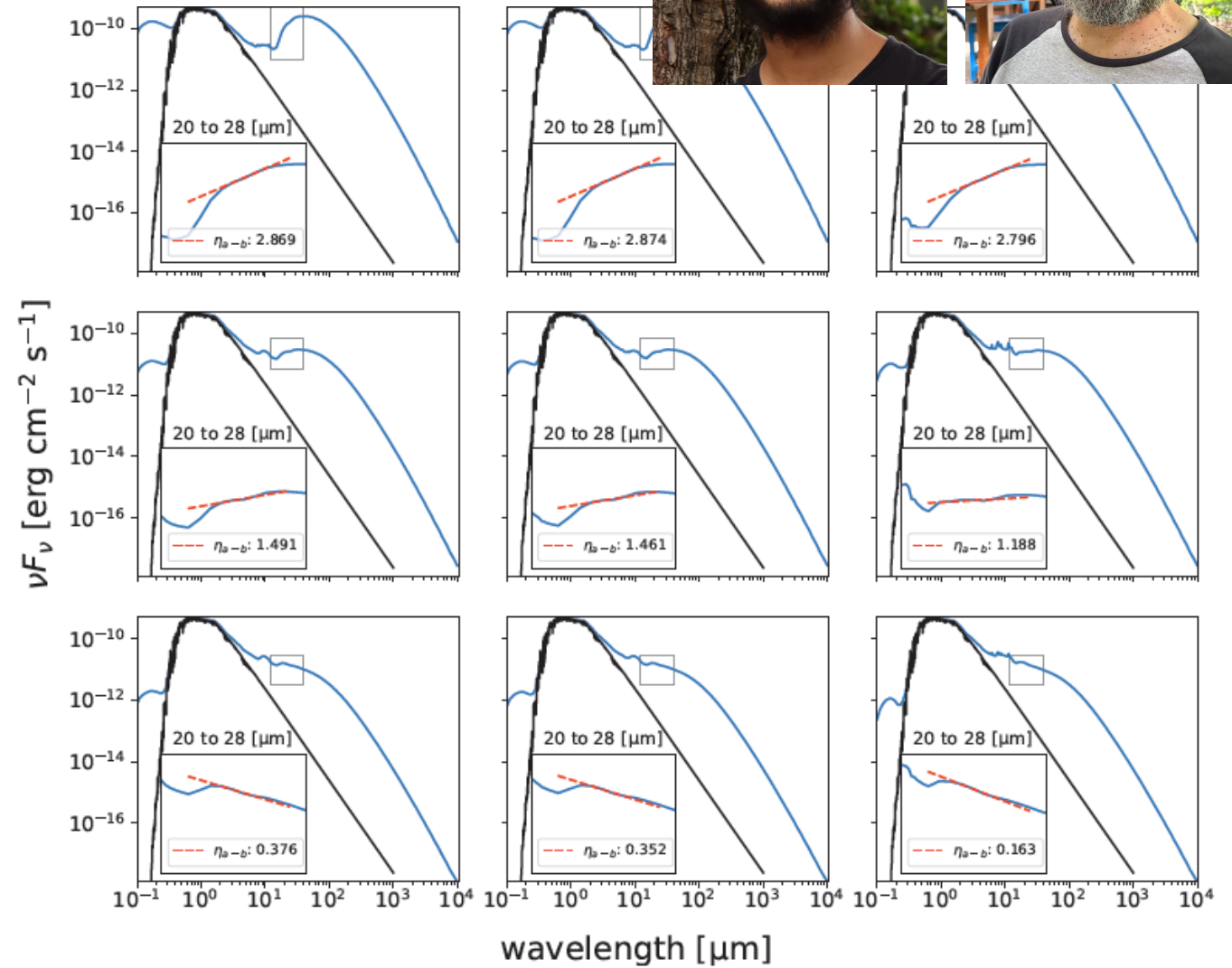
- Disk survival in highly irradiated environments
- Possible terrestrial planet formation
- Likely PAH depletion and disk truncation in XUE1
- Need to measure disk masses (ALMA) to break degeneracy
- Full radiative thermo-chemical disk models

Molecular Tracers of Disk Truncation and PAH Abundance in Highly Irradiated Environments



- ProDiMo (Woitke, Kamp, Thi 2009) model grid (2 x 4 x 4) covering:
 - External UV field strength ($1G_0$, 10^5G_0)
 - Disk truncation radius (Full, 30, 15, 5 au)
 - PAH fraction (1e-1, 1e-2, 1e-3, 1e-4 wrt ISM)
- Make synthetic spectra for ALMA, JWST etc.
 - **1-mm flux (disk mass) + sub-mm gas tracers**

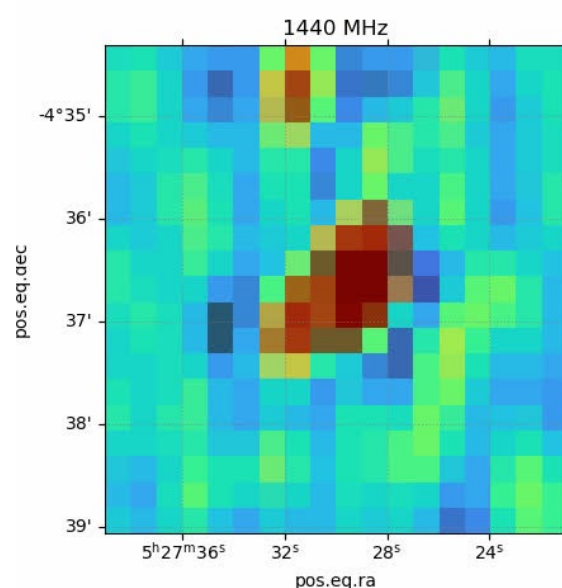
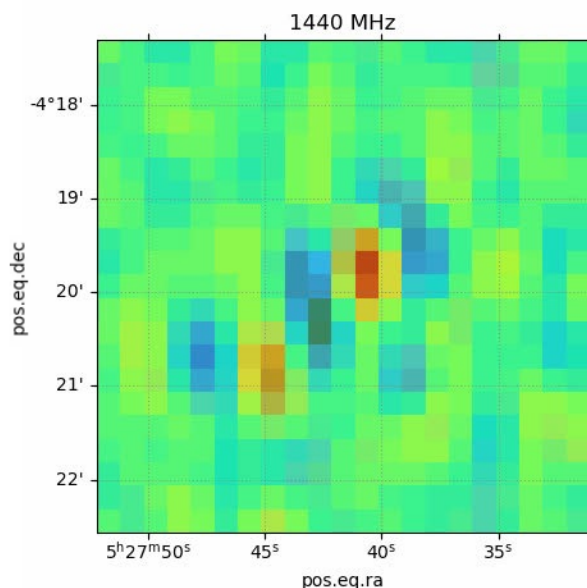
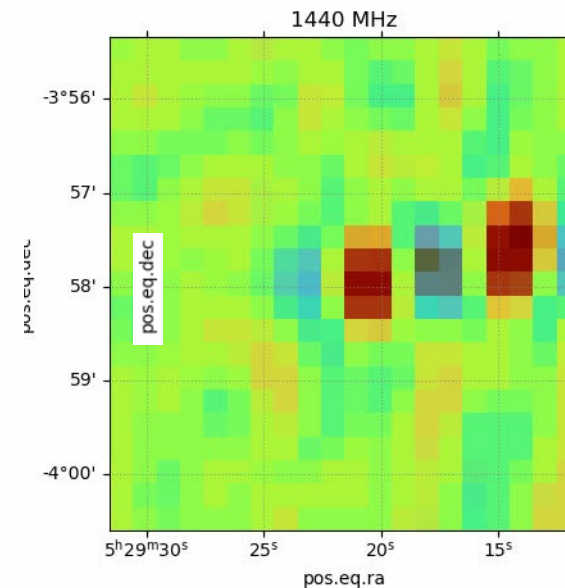
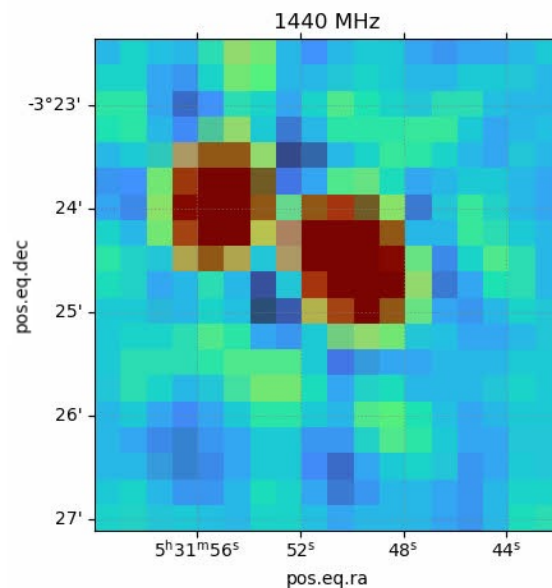
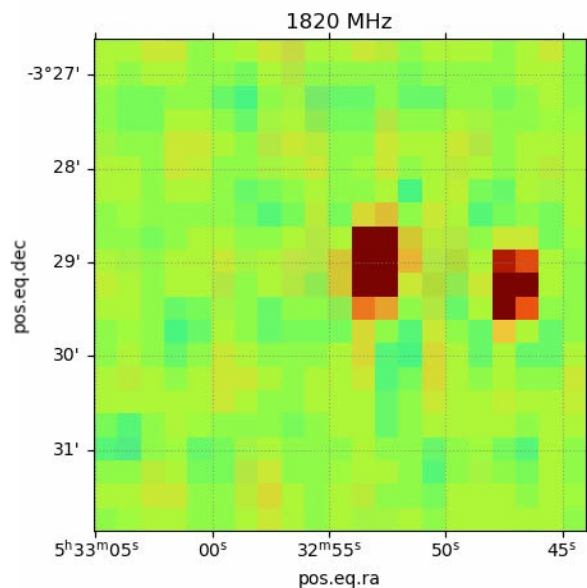
Truncation radius ↑



More PAH →

Characterization of Continuum Radio Sources near M42 with VLA data (J. Urrego,

J. Giraldo – talk 10:30 am w/ Juan Diego Soler, INAF 🇪🇸 🇮🇹)



- ODIN HI survey (1.2-1.9 GHz)
- 78 radiofuentes en total
- 45 no catalogadas (~57.7%)
- 5 posibles radiogalaxias

Searching for evidence of accretion to massive protostars beyond the classical feedback limit: Continuum + spectral VLA data, w/ Viviana Rosero @NRAO, now Caltech 🇨🇴 🇺🇸



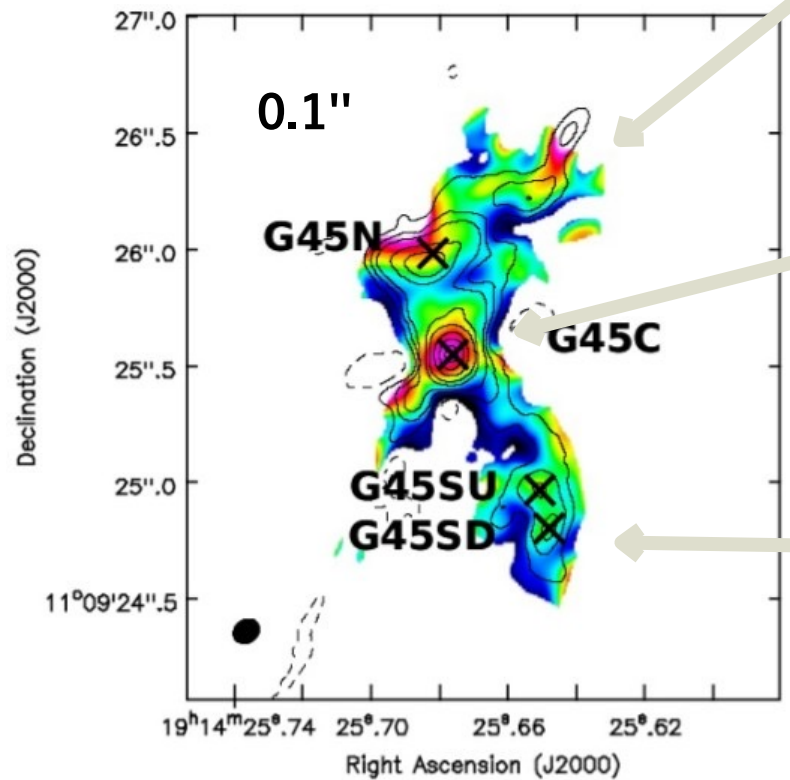
Spectral Index α : mapping

Ana Sofía Marulanda - talk

RECA Internship, now MSc work

Pixel-by-pixel map
Ku Band - KKaQ Image

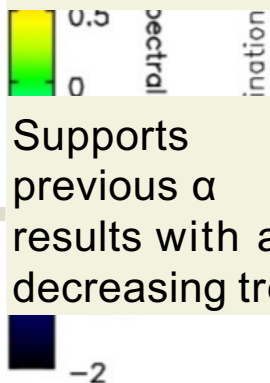
12-50 GHz 0.048 mJy beam⁻¹



Steep values to the north

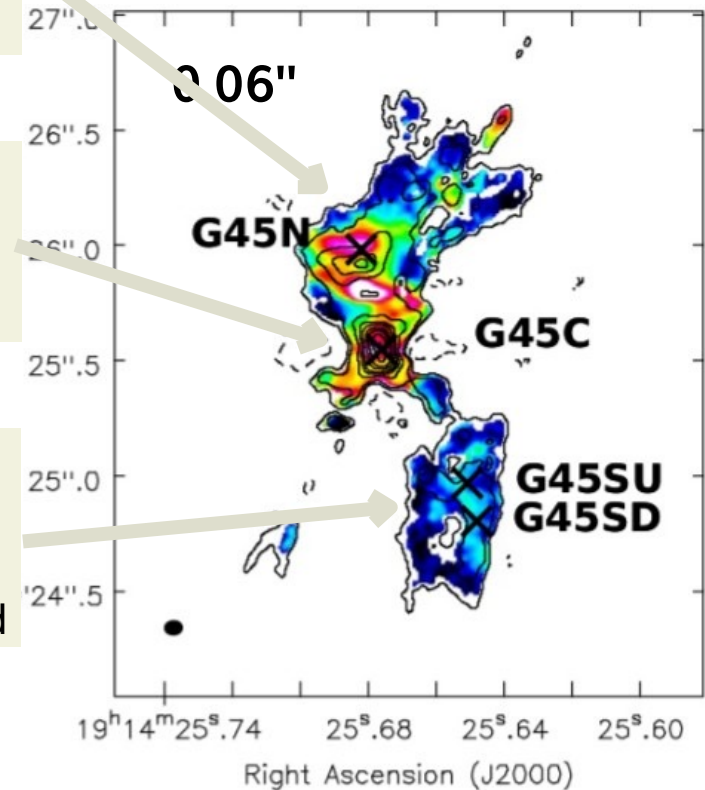
Agreement with initial characterization

Supports previous α results with a decreasing trend

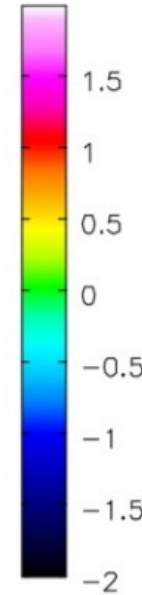


In-band wideband map
CKuKKaQ Bands

4-50 GHz 0.022 mJy beam⁻¹



Spectral Index



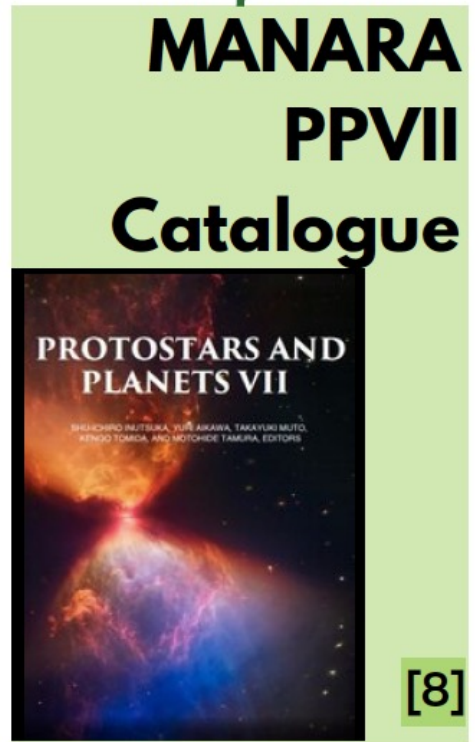
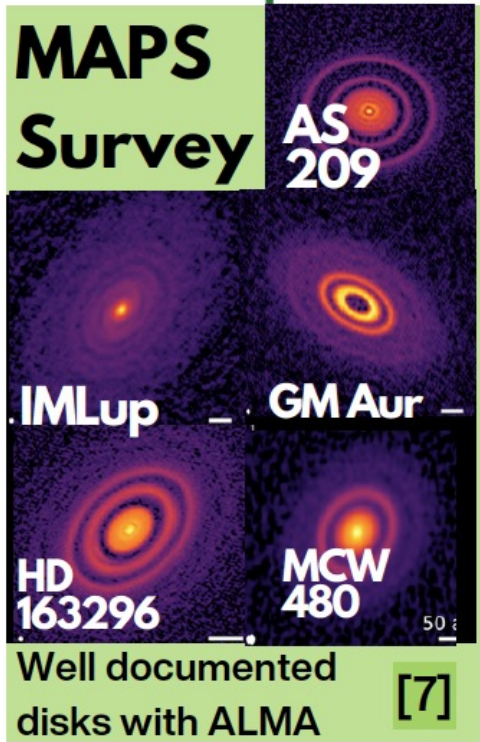
SiO Gas Emission as a Window into Low- & High-Mass Protoplanetary Disk Evolution

Ana Sofía Marulanda – poster
MSc work



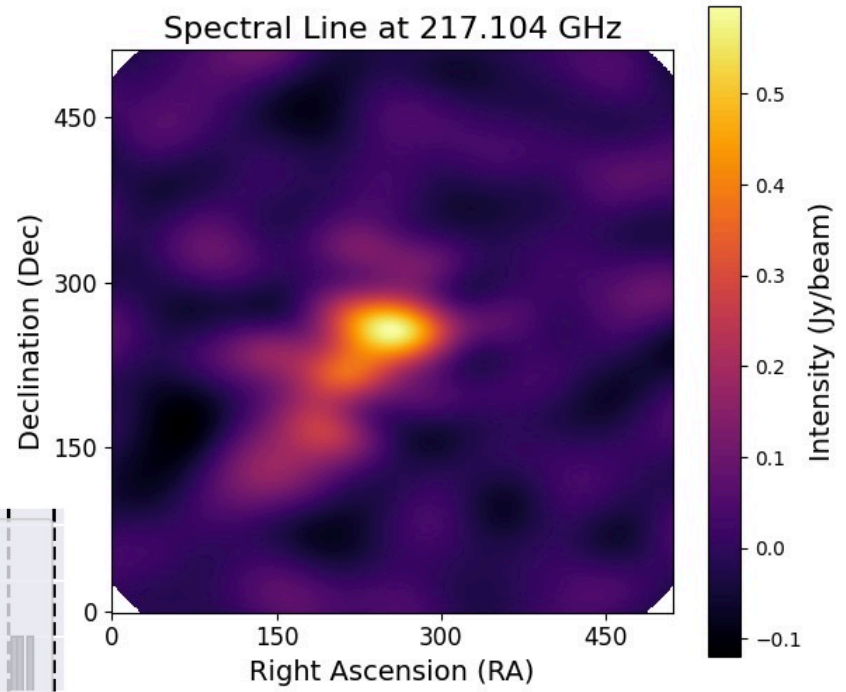
High mass
G17.64+0.16
1.3M [5]
137 pc

Low mass
Ser-emb 15
25M [6]
436 pc

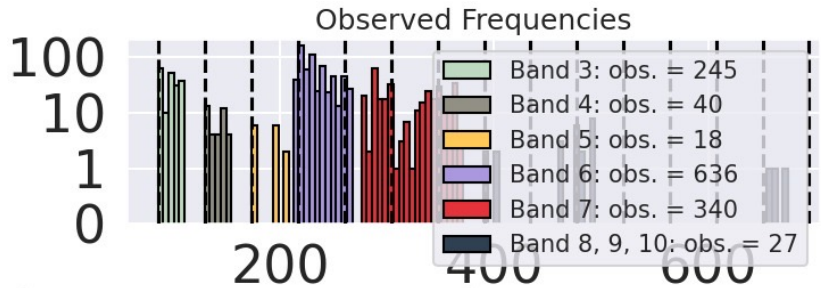


The observations

From SiO (2-1) 86.84 GHz
to SiO (11-10) 477.50 GHz
Manara Catalogue PPVII bandwidth coverage



High mass	Low mass
Outflows Jets	Not detected in disks yet

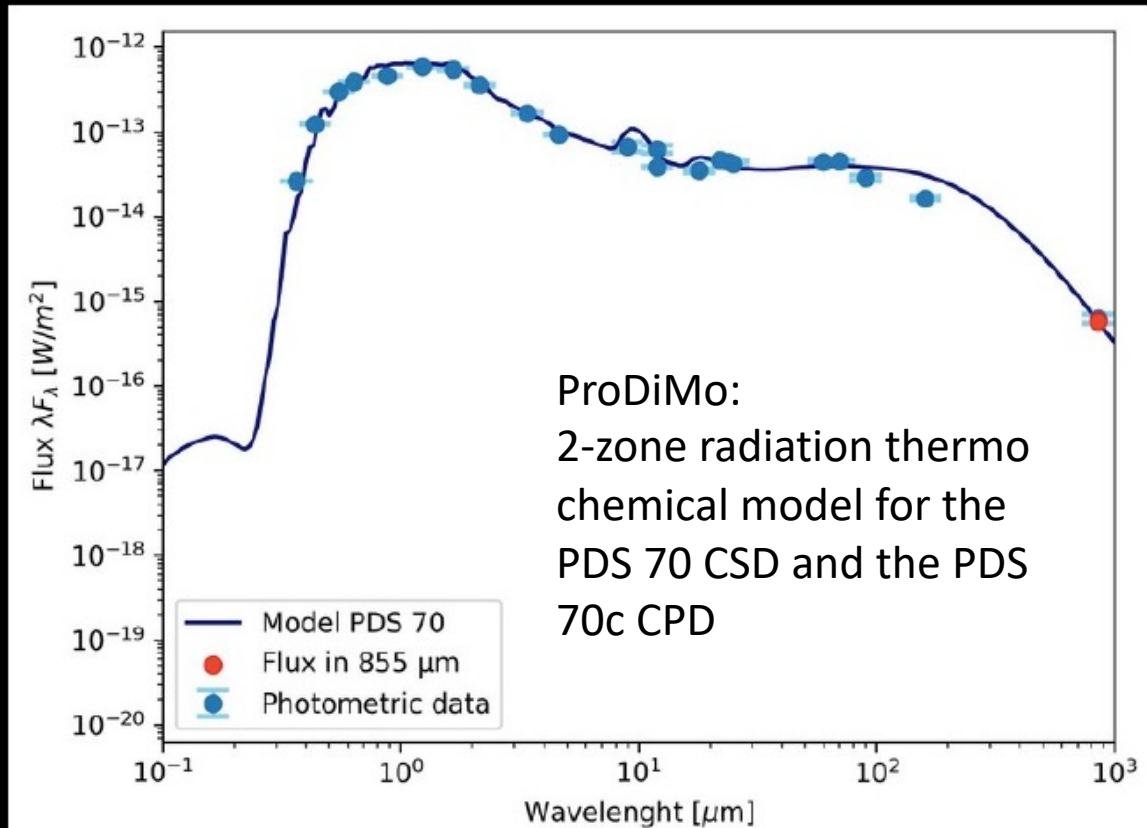
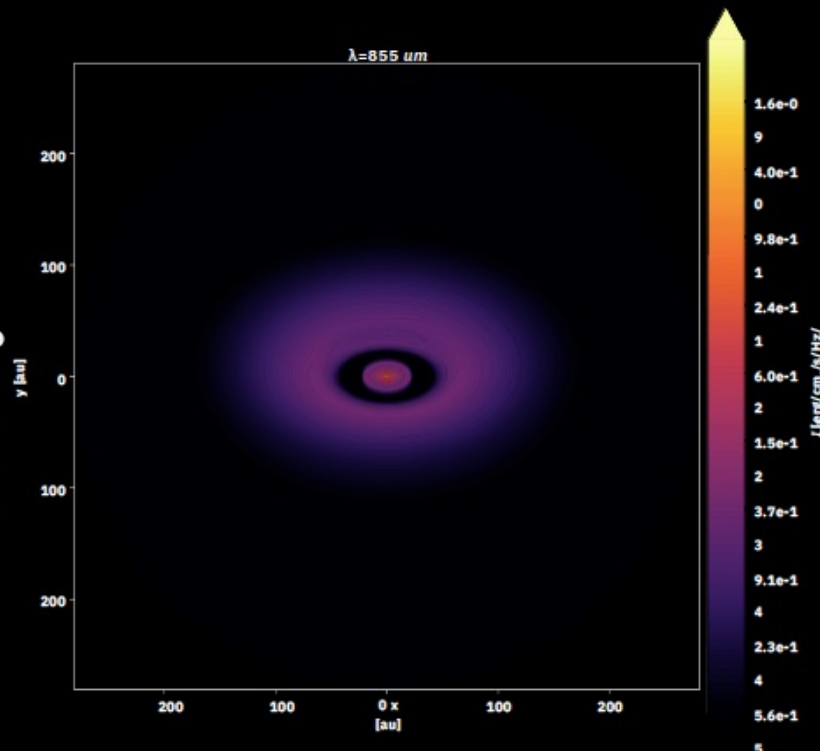


SPECTRAL SIGNATURES OF THE CIRCUMPLANETARY DISK IN PDS 70 c

Silvia Melo - talk
MSc work



08 SPECTRAL ENERGY DISTRIBUTION (SED) FOR PDS 70 III



$$\frac{1}{\rho(\vec{r})} \frac{\partial I_\nu(\vec{r}, \hat{k})}{\partial s} = -\kappa_\nu^{\text{ext}} I_\nu(\vec{r}, \hat{k}) + \kappa_\nu^{\text{abs}} B_\nu(T(\vec{r})) + \kappa_\nu^{\text{sca}} J_\nu(\vec{r}).$$

FACOM

¡Gracias!

Twitter: @germanchou



UNIVERSIDAD
DE ANTIOQUIA
1955



Universiteit
Leiden
The Netherlands

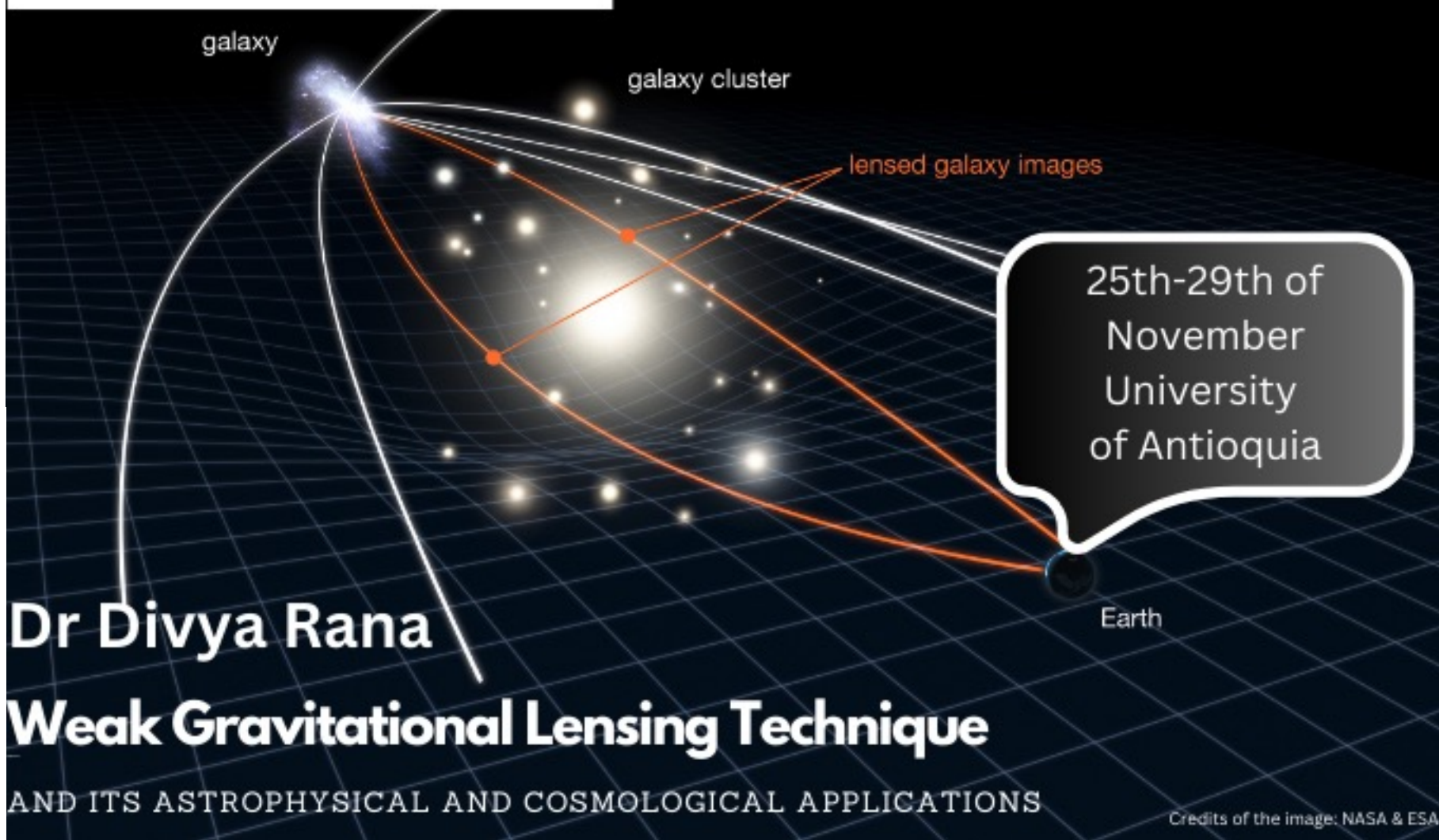
AstroTwinCoLO

Astronomy Twinning Program

University of Antioquia (Colombia)

University of Leiden (The Netherlands)

<https://sites.google.com/site/astrotwincolo/home>





Adriana Araujo



Pablo Cuartas



German Chaparro



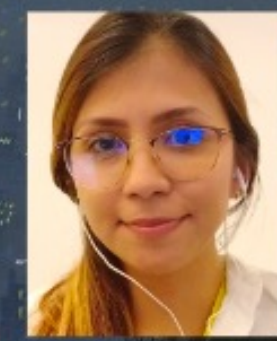
Juan C. Muñoz



Esteban Silva



Jorge I. Zuluaga



Lauren Flor

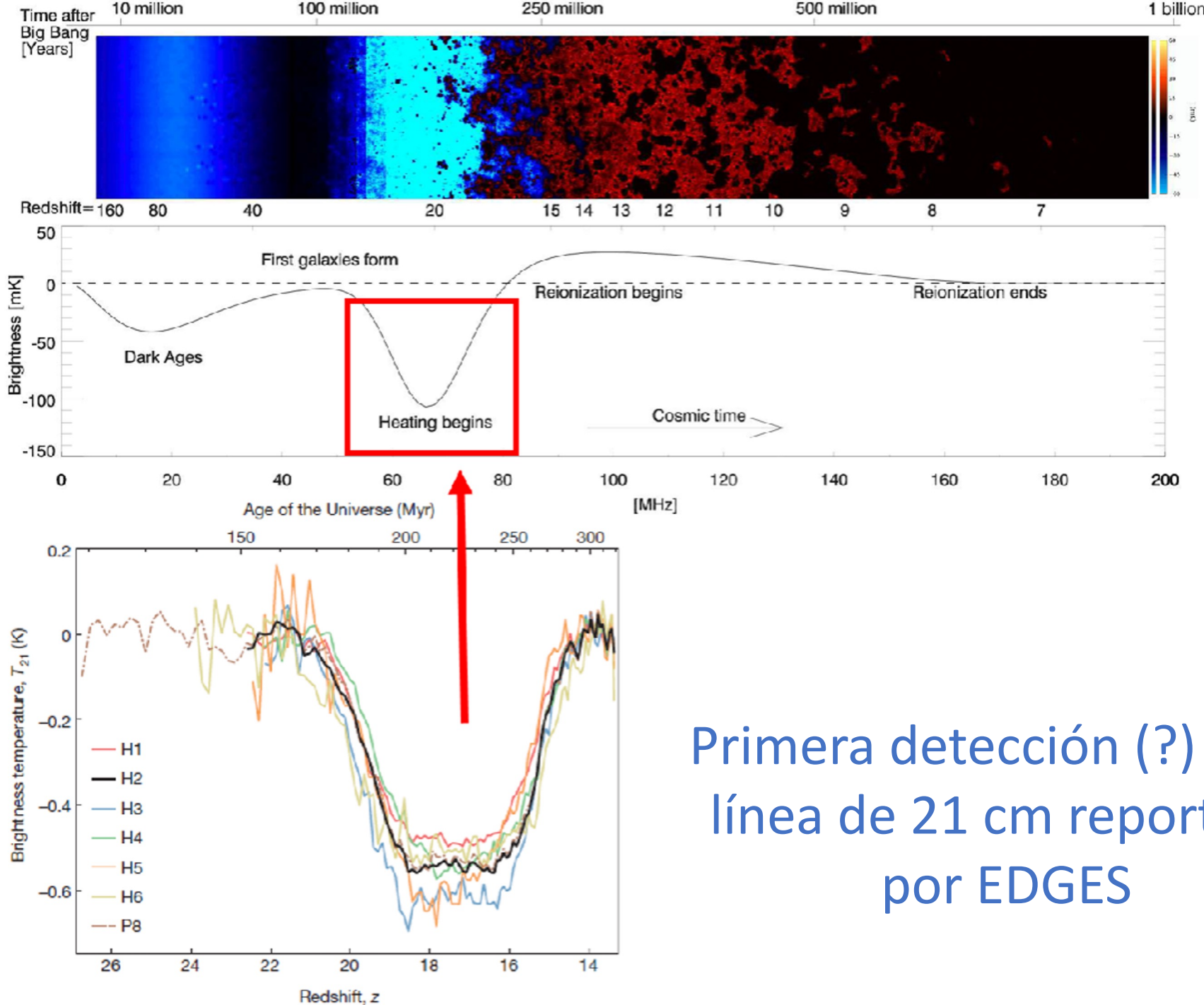


<https://anchor.fm/astromonia-udea>



Desde el Observatorio

El podcast del Universo



Primera detección (?) de la línea de 21 cm reportada por EDGES

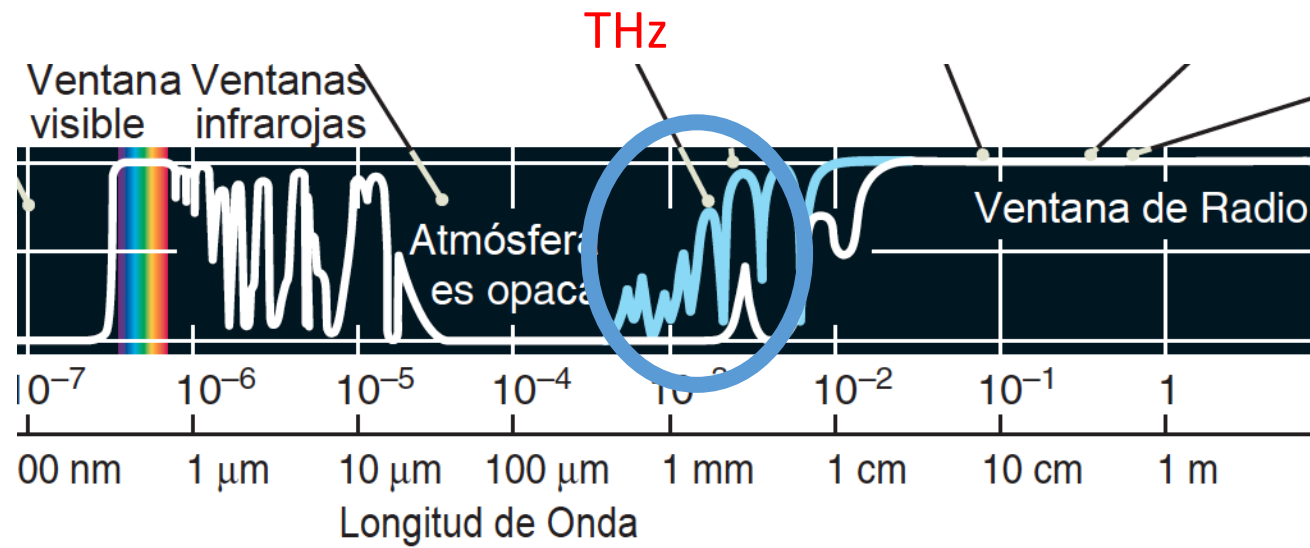


Imagen: Kay, Palen, Smith, Blumenthal 2013

IRAM 30 m



NOEMA



LMT



ALMA

