



20<sup>th</sup> Rencontres du Vietnam



# Astrophysics in Vietnam: present and perspectives

**Pham Ngoc Diep**  
**Department of Astrophysics (DAP)**  
**Vietnam National Space Center (VNESC)**

Particles, String and Cosmology (PASCOS)

7-13 July 2024, ICISE, Quy Nhon, Vietnam

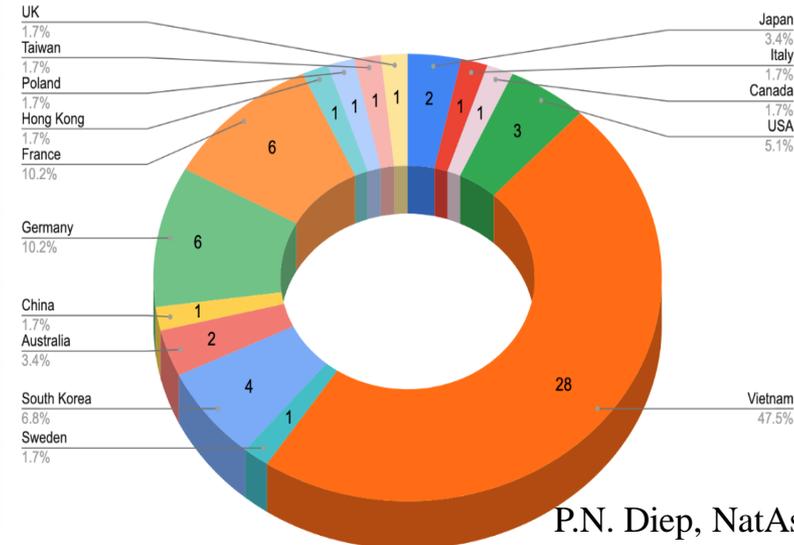
# ASTROPHYSICS RESEARCH IN VIETNAM

*Essentially limited to:* Pr. Phan Bao Ngoc (IU, HCM city), Pr. Dinh Van Trung (IOP, Hanoi), Pr. Dao Tien Khoa (INST/Vinatom, Hanoi), Dr. Do Quoc Tuan (Phenikaa Uni., Hanoi), VNSC/VAST Department of Astrophysics (7 PhD+1 PhD student, Hanoi).

Most of us are working on radio astronomy: brown dwarf (Ngoc), molecular complexity around evolved stars (Trung), high-redshift galaxies and stellar physics (DAP), nuclear astrophysics (Khoa), and cosmology (Tuan).

Data obtained from large installations/telescopes through collaborations or using archival data.

IAU members	
Vietnam	14 Member status (Suspended)
Thai Lan	51
Malaysia	21
Indonesia	19
Phillipinnes	5



**HỘI THIÊN VĂN VŨ TRỤ VIỆT NAM - Vietnamese Astronomical Society - VAS**

2.7K likes • 2.9K followers



P.N. Diep, NatAst (2021)

In 2017, Vietnam joined the East Asian Observatory (EAO) as an observer. Vietnamese astronomers can use EAO's facilities.

We actively join the activities of the Observatory: proposing observing time, taking shift, serving on the TAC, participating in the EAO's meetings and workshops.



The JCMT is the largest single-dish telescope in the world dedicated to detecting submillimetre radiation.

# Vietnam Astrophysics Research Network (VARNET), since November 2020

<https://sites.google.com/view/sf2-varnet/>

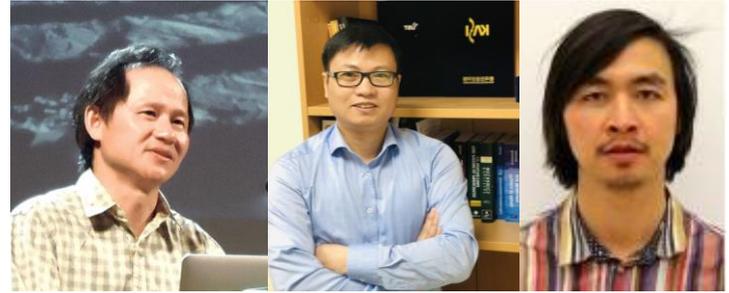


- ▶ Organize 3 international workshops
- ▶ >15 publications on Q1 journals

6 students were fully funded to follow the graduate programs in Korea, France, USA, and UK

Aim: to study the roles of magnetic fields and dust physics in star formation and stellar feedback processes; to train young researchers;

# SAGI's Mission



*SAGI endeavors to facilitate astrophysics research collaboration between domestic and international researchers*

- Training young researchers in astrophysics, and engaging in the science education for the public in the region.
- Meeting point for domestic and overseas Viet researchers.

SAGI  
Simons Astrophysics Group at ICISE

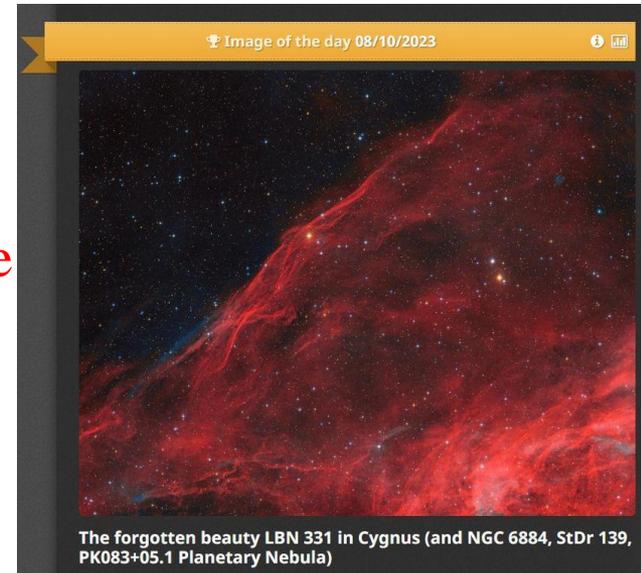
Quy Nhơn, July 25, 2022

# OUTREACH

Several amateur astronomer clubs

Planetariums and similar initiatives at various places,  
Hoa Lac, Quy Nhon, Nha Trang,...

Good introduction to astronomy/astrophysics  
given to students at pedagogic universities and space  
science students at University of Science and  
Technology of Hanoi (USTH).



## Two science exploration centres in Quy Nhon and Hanoi



Quy Nhon completed in  
2018

Hanoi (Hoa Lac Hi-Tech Park)  
to be completed in 2024



## Completion of Nha Trang and Hoa Lac Observatories in 2018

VNSC is heading the Vietnam Space Center project. The headquarter is being built in Hoa Lac High-Tech Park (30 km, west of Hanoi).

It includes two observatories equipped with **two planetariums** (60 and 100 seats) and **two 0.5 m optical telescopes**, aimed at fostering interest on astronomy in the country and at helping with the training of students.



## 60-seat planetarium at Nha Trang Observatory



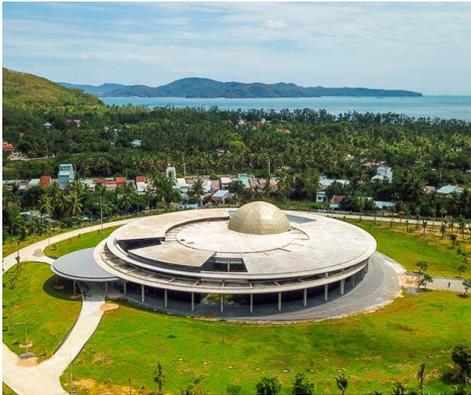
# 0.5 m optical telescope at Nha Trang Observatory



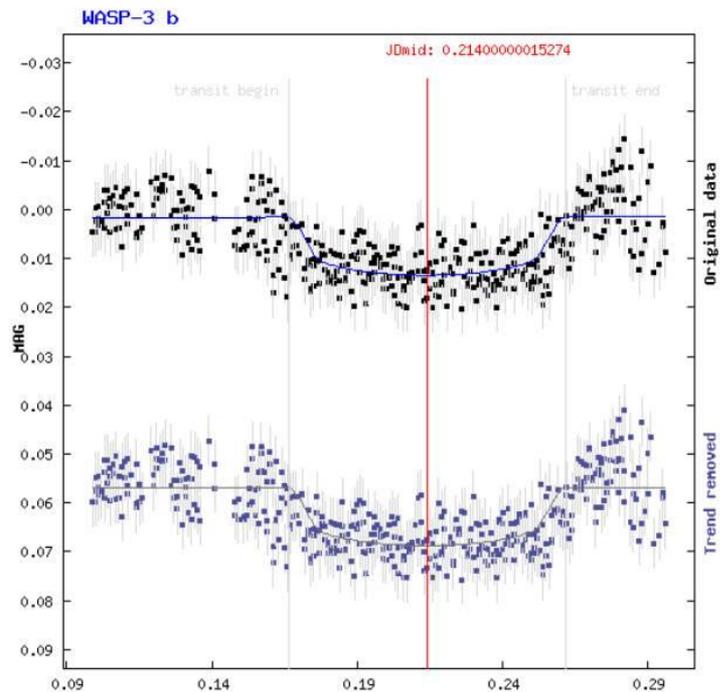
# International Center for Interdisciplinary Science and Education (ICISE)

The founder of the center is Prof. Jean Tran Thanh Van. *ICISE organises each year >10 conferences and schools, out of that about ~1/3 on astronomy/astrophysics.*

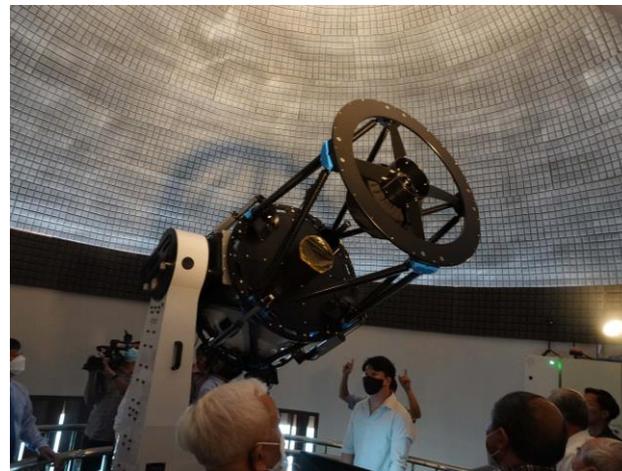
ICISE supported Quy Nhon city to build a **science exploration center (ExploraScience)** for public outreach and education where there are three exhibition rooms, a planetarium, and an observatory.



# Quy Nhon Observatory (QNO) ExploraScience

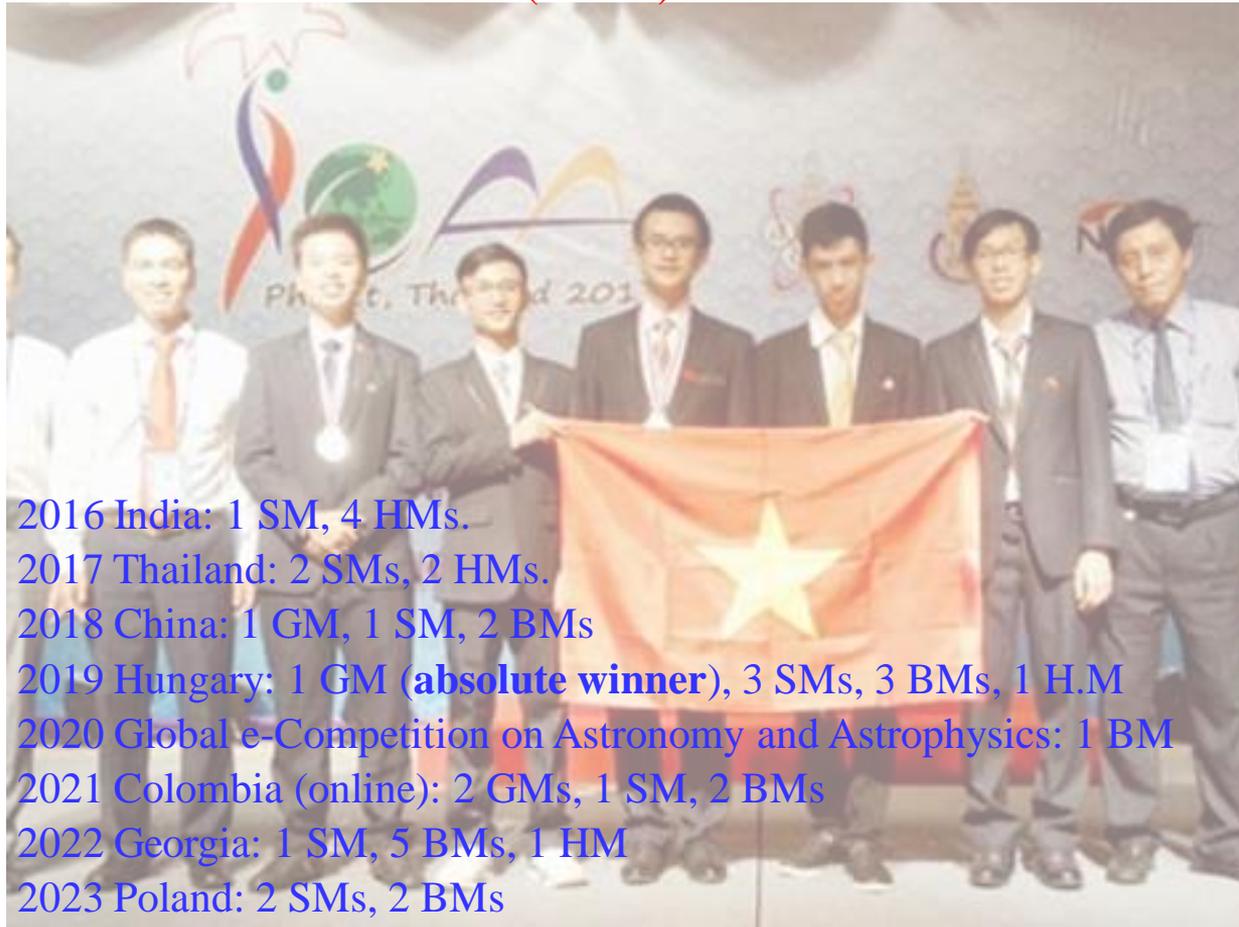


CDK600



M51

## Vietnam team in the International Olympiad on Astronomy & Astrophysics (IOAA)



2016 India: 1 SM, 4 HMs.

2017 Thailand: 2 SMs, 2 HMs.

2018 China: 1 GM, 1 SM, 2 BMs

2019 Hungary: 1 GM (**absolute winner**), 3 SMs, 3 BMs, 1 H.M

2020 Global e-Competition on Astronomy and Astrophysics: 1 BM

2021 Colombia (online): 2 GMs, 1 SM, 2 BMs

2022 Georgia: 1 SM, 5 BMs, 1 HM

2023 Poland: 2 SMs, 2 BMs

# Department of Astrophysics (DAP/VNSC)

P.N. Diep, P.T. Nhung, P.Tuan-Anh, D.T. Hoai, N.T. Phuong, T.T. Thai, N.B. Ngoc, P. Darriulat

For some ten years, the main interest of the team was the study of very high energy extragalactic cosmic rays in collaboration with the Pierre Auger Observatory in Argentina.

We also developed and operated detectors of our own at home, with which we measured the flux and asymmetry of atmospheric cosmic neutrinos on the geomagnetic equator [Nuclear Physics B, 627(2002)29, 661(2003)302 and 678(2004)3].



Pierre Darriulat in 1980  
Spokesperson of UA2  
CERN Research Director  
(1987-1994)



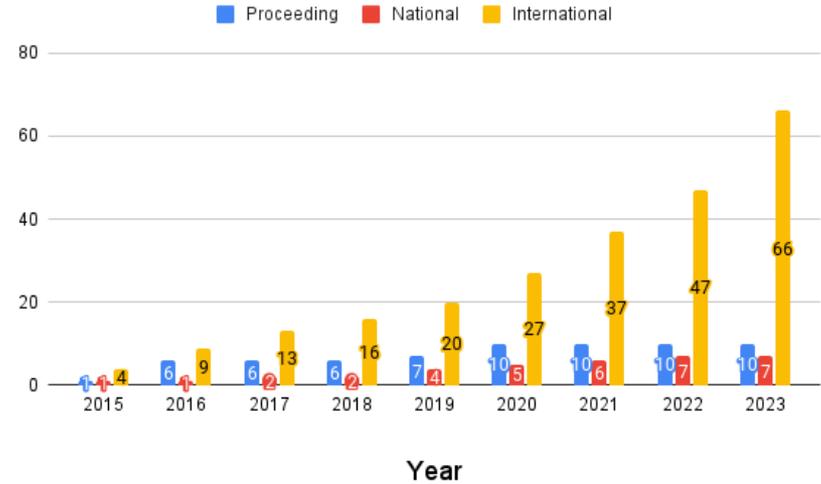
## Current research

Evolved stars, protostars, high-z galaxies, and reionization are studied using high resolution continuum and line emissions from dust and molecules (ALMA, NOEMA, MUSE/VLT, HST).

Magnetic fields and dust physics using polarization data (HERSCHEL, PLANCK, JCMT, SOFIA).

# Science and Training at DAP

Between **2015 and 2023** we have published 66 articles in international refereed journals.



## Training

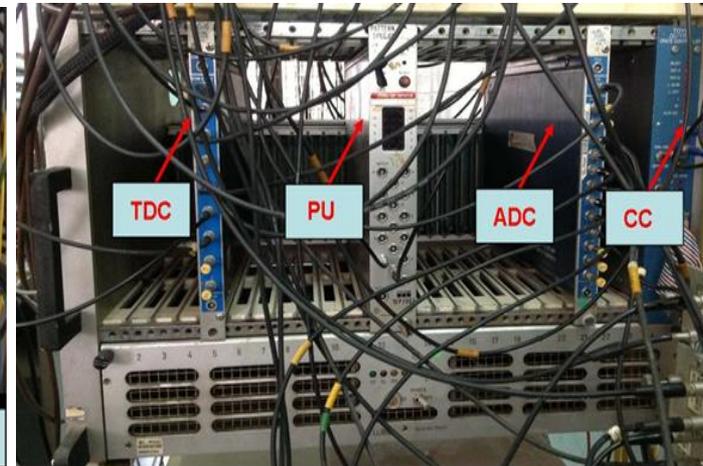
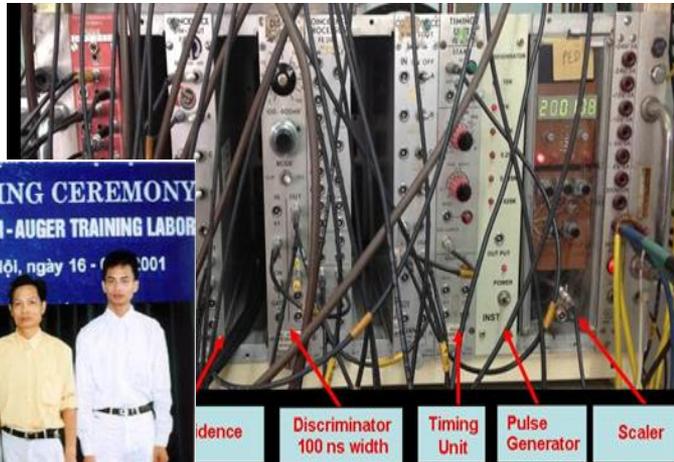
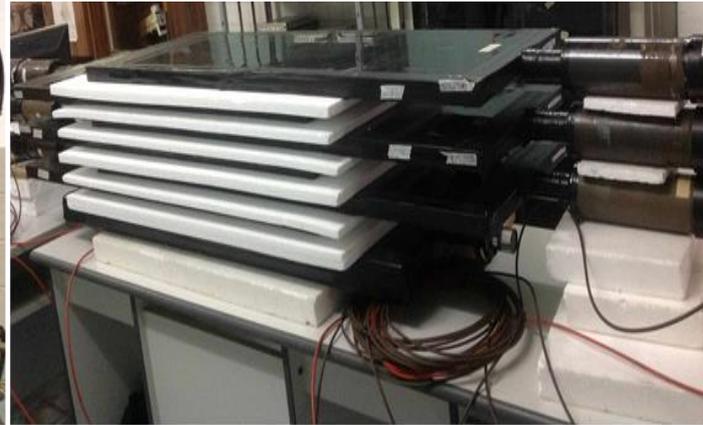
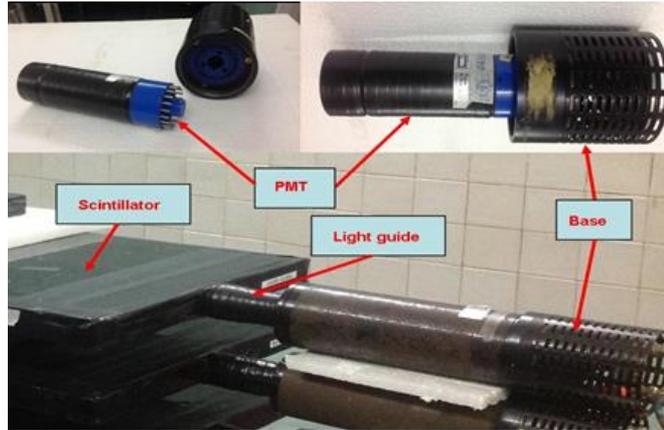
Undergraduate dissertations (17)

Master theses (12)

PhD Theses (9)

Interns (from Vietnam and abroad)

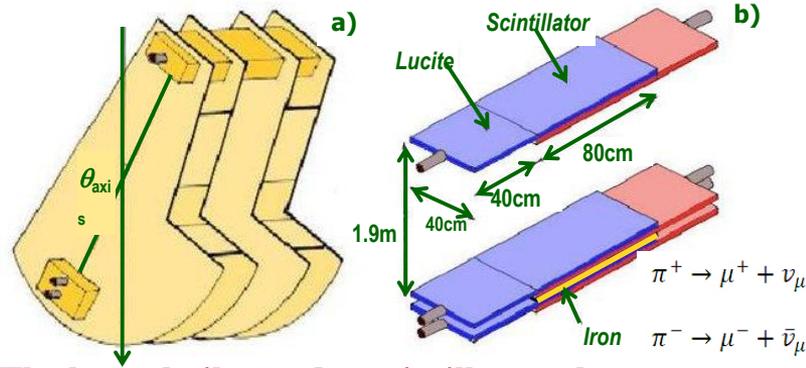
Our team was established in 2001 by Prof. Pierre Darriulat when he came to Vietnam with detectors.



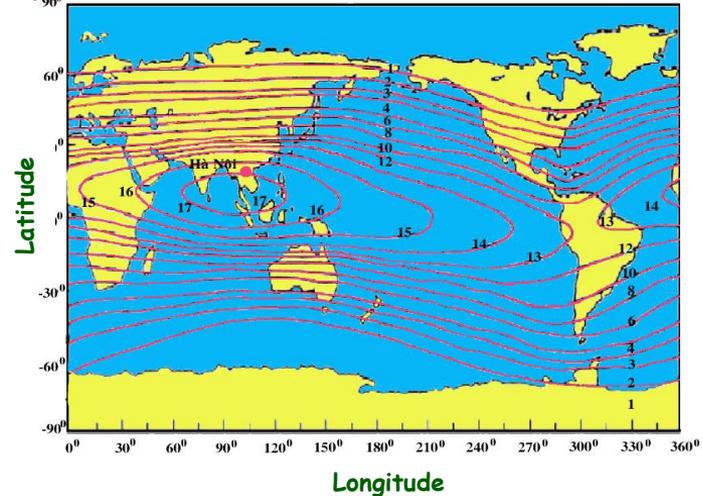
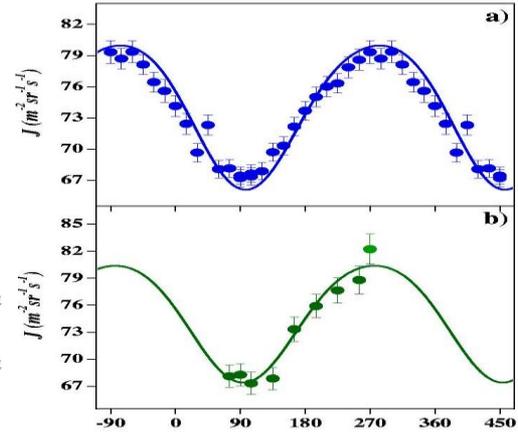
# Instrumentation

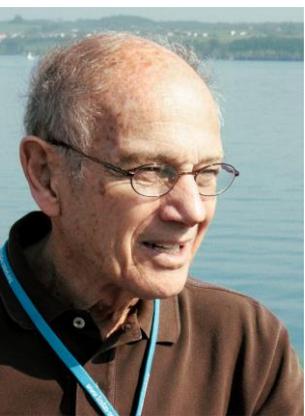


# Measurement of cosmic muon flux in Hanoi



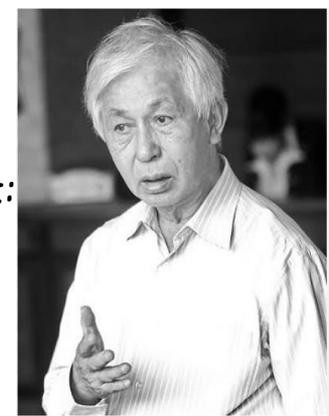
The home built wooden scintillator telescope measured the muon fluxes with a precision of 1%





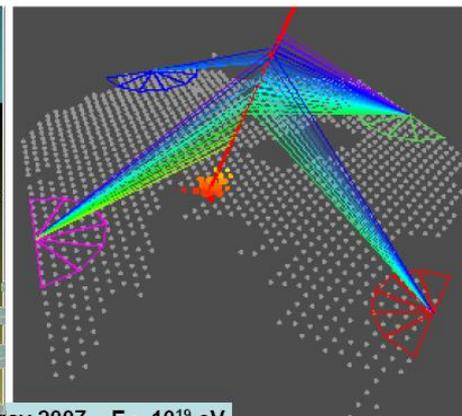
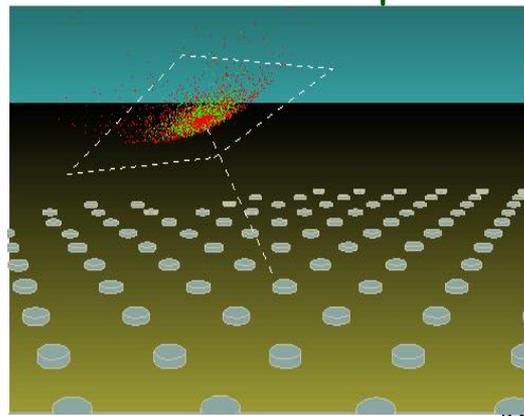
# We immediately joined the **Pierre Auger Observatory**

*The Auger Observatory is the first large hybrid detector ever built:  
it combines the strengths of*  
**Surface Detector Array & Air Fluorescence Detectors**



## THE PHYSICS OF ULTRA HIGH ENERGY COSMIC RAYS

- Accurate measurement of the high end of the energy spectrum
  - Identification of possible sources
    - Nature of the primaries



U may 2007 E ~ 10<sup>19</sup> eV

# Science

AAAS

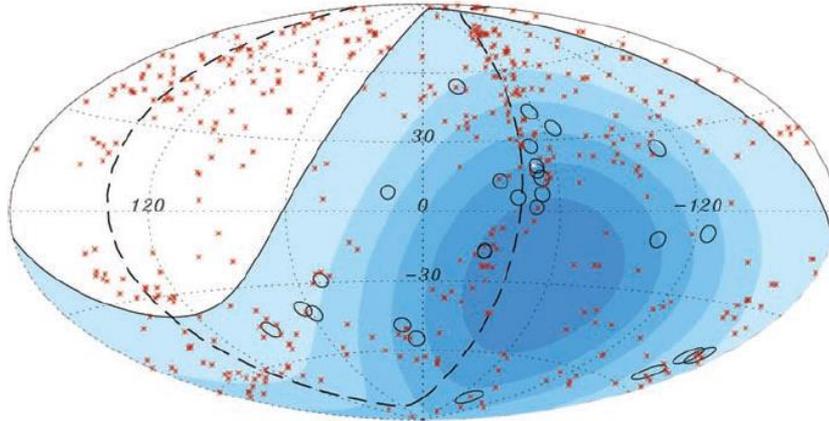
## Correlation of the Highest-Energy Cosmic Rays with Nearby Extragalactic Objects

The Pierre Auger Collaboration, *et al.*

*Science* **318**, 938 (2007);

DOI: 10.1126/science.1151124

Top ten physics  
event of APS



Three of us have made our  
PhD theses in this field. We  
made significant contributions  
to the very successful  
achievements of this program.

TRANG NHẬT

Thời sự - Xã hội

Kinh tế

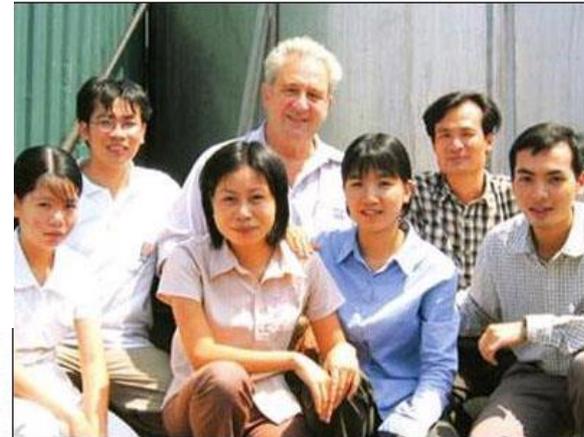
Thanh niên-Thời đại

KHOA HỌC-CÔNG NGHỆ

Thứ Sáu, 09/11/2007, 06:26

Nhóm Vật lý Việt Nam là đồng tác giả trong phát hiện về tia vũ trụ

P - Các nhà khoa học vừa kết luận: Các trung tâm thiên hà AGN ồ ạt đến siêu nặng đang hoạt động mạnh là nguồn phát khả dĩ nhất của tia vũ trụ năng lượng cao đến trái đất. Đáng chú ý, phát minh này có đóng góp của các nhà vật lý trẻ VN.



Các nhà vật lý trẻ thuộc phòng thí nghiệm VATLY và GS Pierre Darriulat - Cố vấn khoa học của Dự án

Sau lũy tre làng

Phóng sự

Bạn đọc & Tiên phong

RSS

TRỰC TUYẾN

THÔNG TIN CẦN BIẾT

Thời tiết

Phát hiện này nằm trong dự án thí nghiệm Pierre Auger và được đăng trên tạp chí *Science* số ra hôm nay, 9/11.

## High energy cosmic rays

Collaboration with the Pierre Auger  
Observatory in Argentina



## Radio astronomy

Collaboration with French institutes  
Using 2.6 m radio telescope at home



Radio astronomy is at the forefront of current research; observations made from major international observatories; availability of archival ALMA observations 1 year after they were taken.

For training students at home, it is much better adapted to the Vietnamese tropical sky than optical astronomy, for which observations are rarely possible.

**We now work exclusively in radio astronomy.**

We use observations made with **radio interferometers**:  
Plateau de Bure (6 antennas) and ALMA (66 antennas).



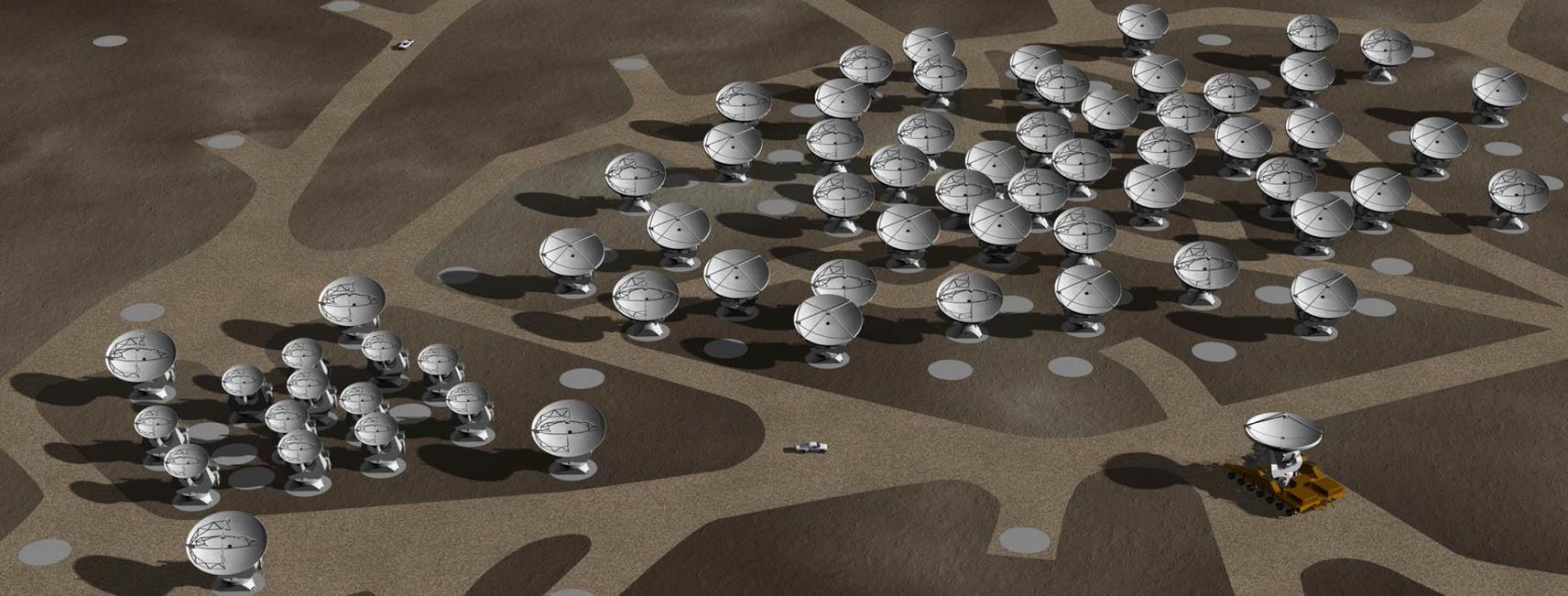
**Data**

Plateau de Bure (PdBI)



NOEMA (NOrthern Extended Millimeter Array)

# Atacama Large Mm/sub-mm Array (ALMA)

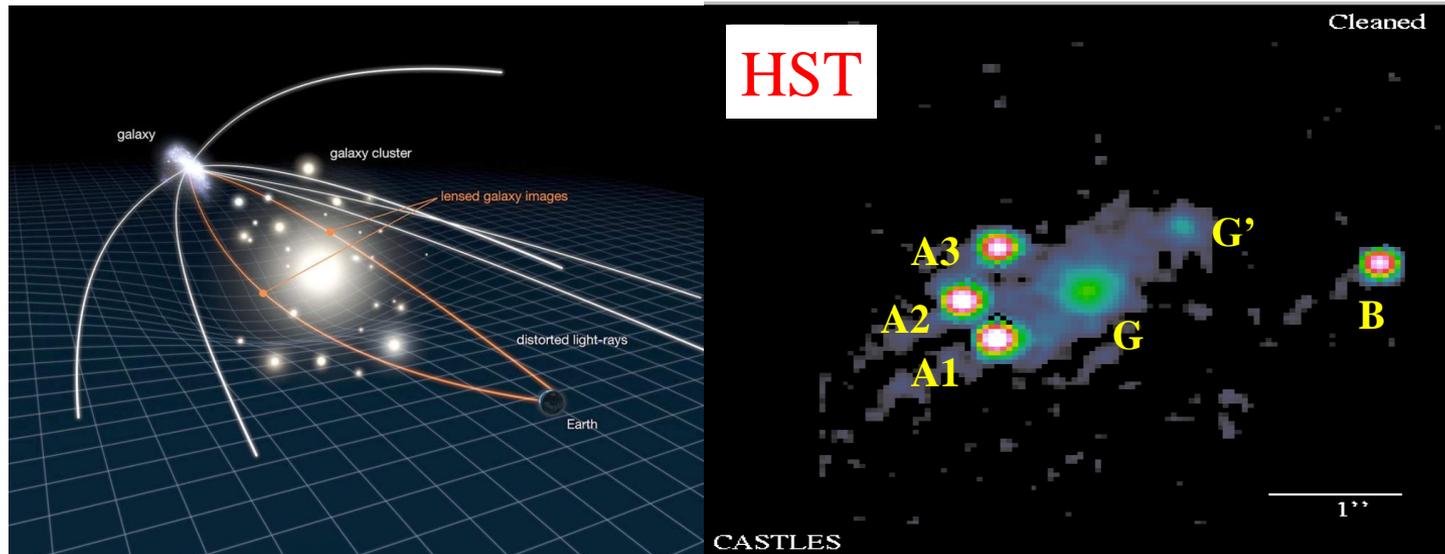


ALMA (66 antennas, alt. 5059 m, 0.3-3.6 mm), detector temperature 4 K, surface precision 20  $\mu\text{m}$ , no significant rainfall between 1570 and 1971.

Since Cycle 8 (1/10/2021), ALMA adds the full-polarization capability.

# High redshift galaxies: a typical example, RX J0911

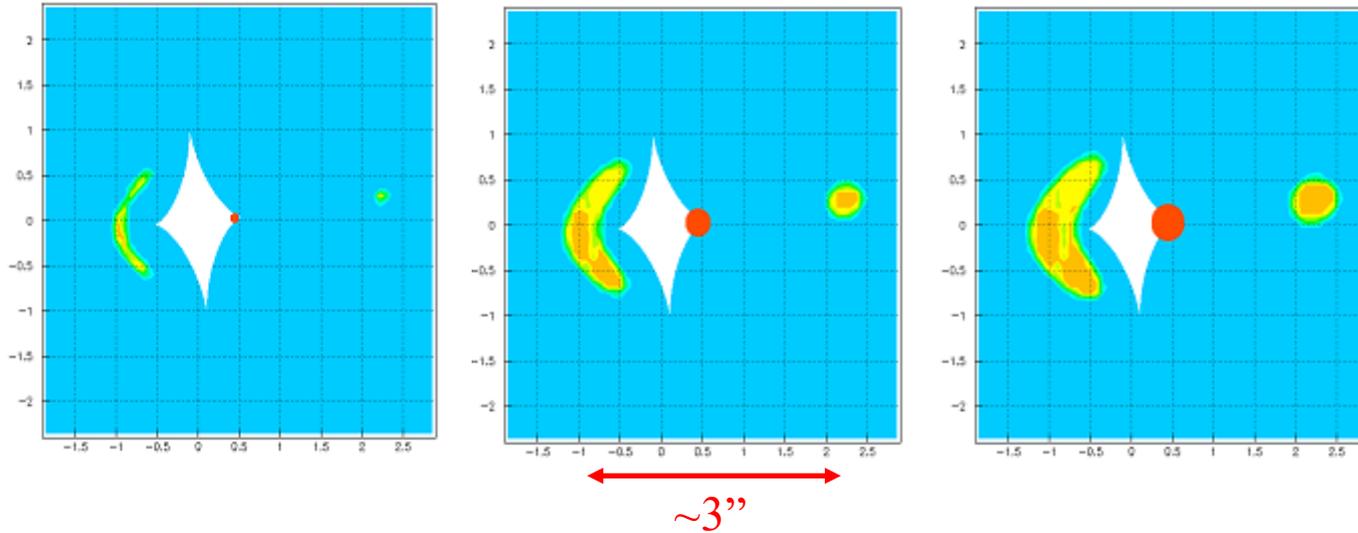
RX J0911: the host galaxy of a gravitationally lensed high redshift quasar ( $z \sim 2.8$ , look back 11.3 Gyr). Detection of the CO(7-6) line by Plateau de Bure measures its gas content; and of the continuum underneath by ALMA, its dust content.



**Gravitational lensing effect**

**RX J0911**

Lensing is complicated by the fact that the extended source overlaps the lens caustic. We studied this peculiar situation in detail.

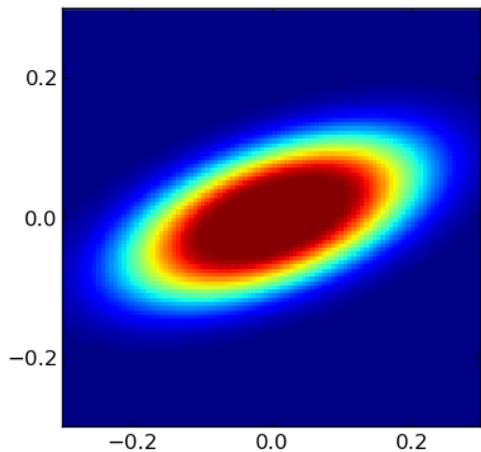


## RX J0911: Gas properties

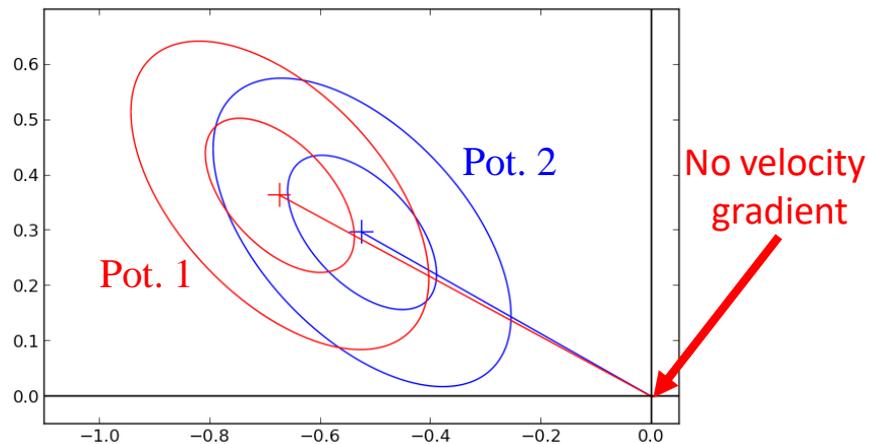
The gas source has a **radius of  $850 \pm 120$  pc** on the line ( $\sim 7$  s.d.) and provide evidence for **ellipticity** and for a significant **velocity gradient** (molecular outflow and/or rotation).

Ellipticity: 3.3 s.d.  
away from circular

Evidence for velocity gradient  
at 4.5 s.d.

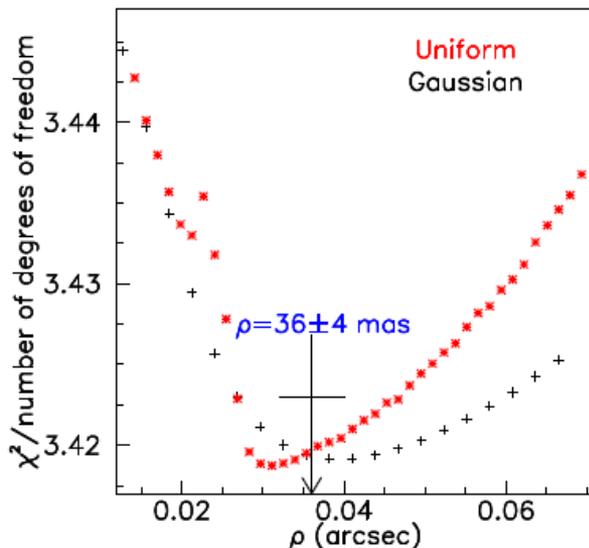


arcsec



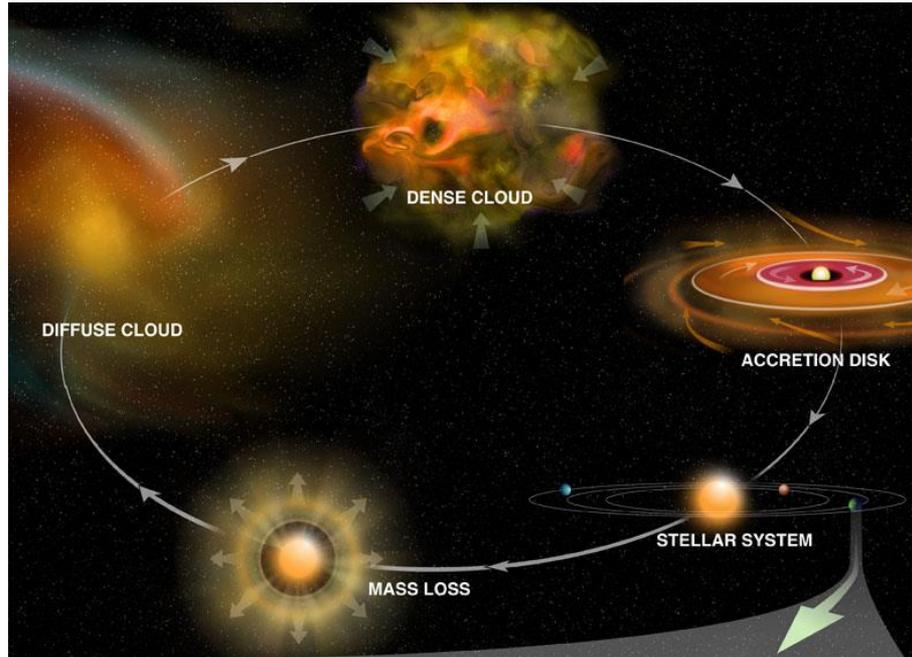
## RX J0911: Dust component

The dust component is found much more compact than the gas component,  $\sim 3.4 \pm 0.4$  times less extended and too small to allow for an ellipticity measurement.



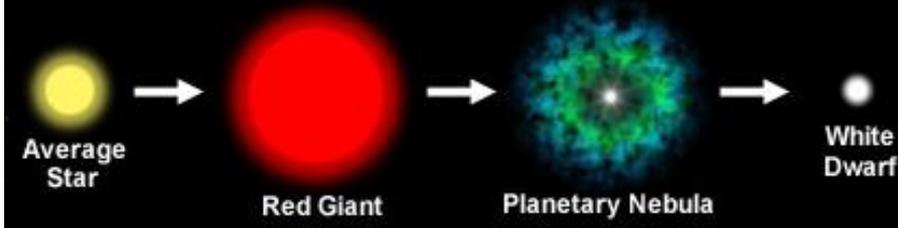
**This measurement makes RX J0911 one of the few high- $z$  galaxies for which the dust and gas are resolved with dimensions being measured.**

# Stellar Physics



**Star  
formation**

**Evolved  
star**



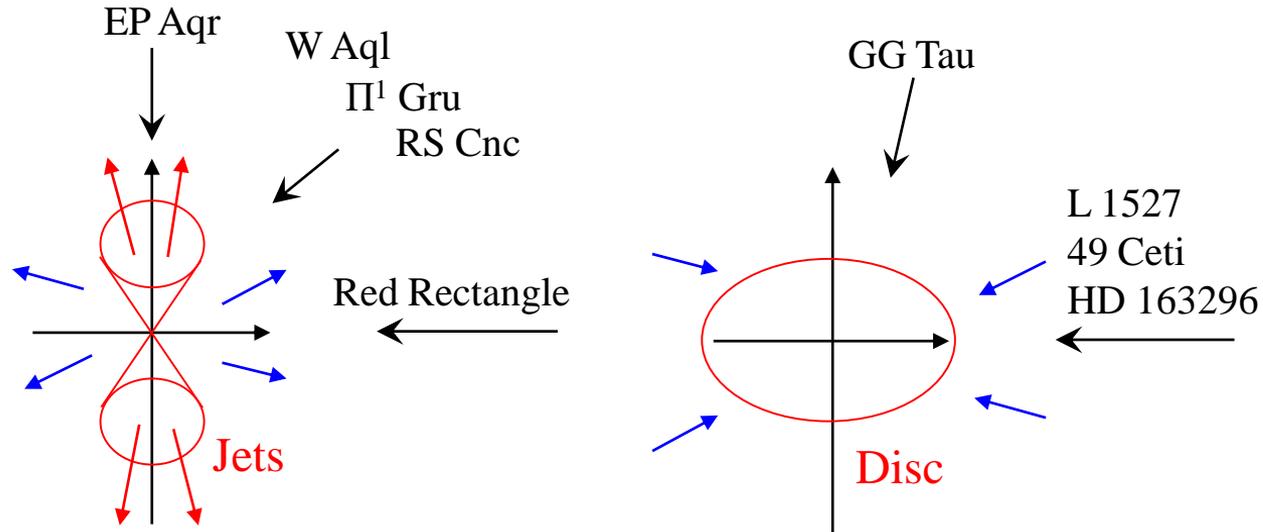
What are the symmetry breaking mechanism?



A Hubble Space Telescope sampler of planetary nebulae (NASA/ESA)

Evolved stars and protostars are studied using high resolution continuum and line emissions from dust and molecules. The former often feature a **bipolar molecular outflow**, the latter the formation of a **disc**.

Mira Ceti, R Dor, L2 Pup, O Ceti, W Hya, R Leo

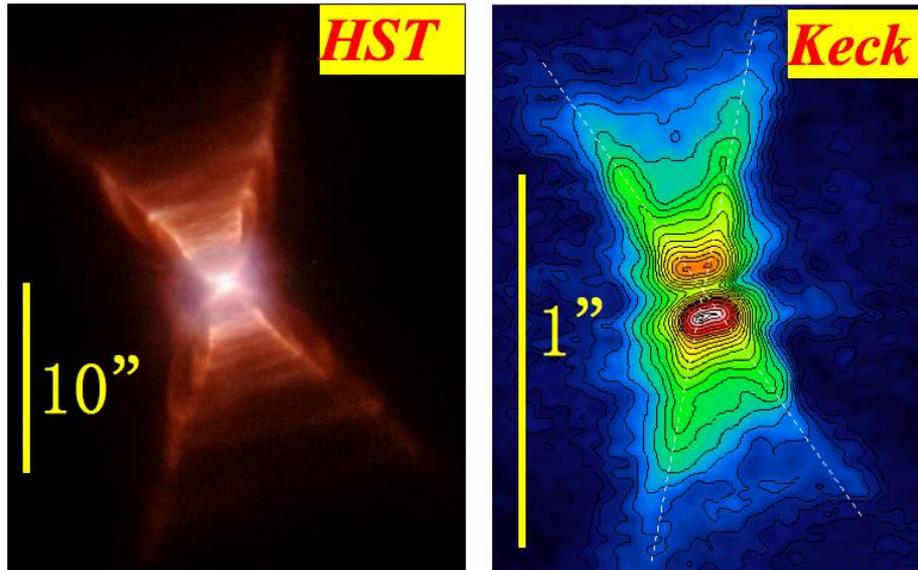


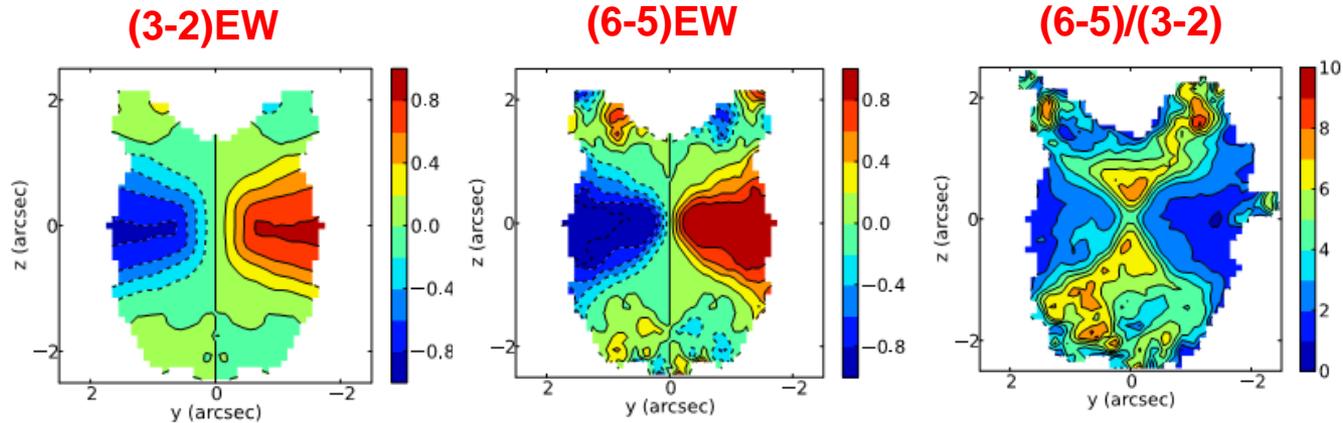
**Space reconstruction:** P.N. Diep et al., MNRAS, 461, 4276 (2016)  
P.T. Nhung et al., MNRAS, 480, 3324 (2018).

## An evolved star, the Red Rectangle

The Red Rectangle is a Post-AGB source, having its axis perpendicular to the line of sight.

We studied CO(6-5) and (3-2) emissions measured by ALMA (archival data of unprecedented quality).





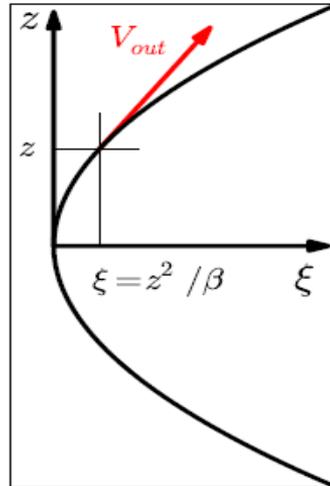
East-West Doppler velocity asymmetry reveals a very clear **rotation of the equatorial region** about the star axis.

CO(6-5)/CO(3-2) intensity map provides evidence for a **temperature distribution** dominated by the biconical structure down to low distances from the star.

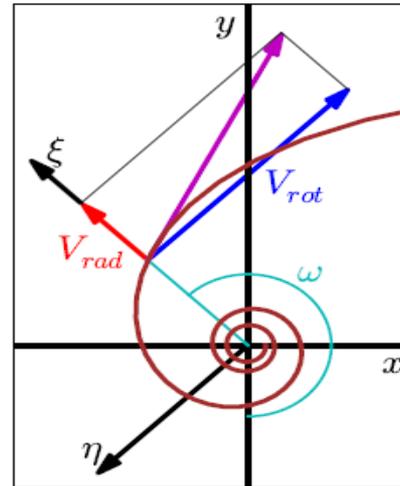
## Gas kinematics

**Polar regions:** parabolic meridian trajectories joining smoothly between the equatorial torus and the star axis with a constant wind velocity.

**Equator region:** spiraling trajectories with rotation and expansion.



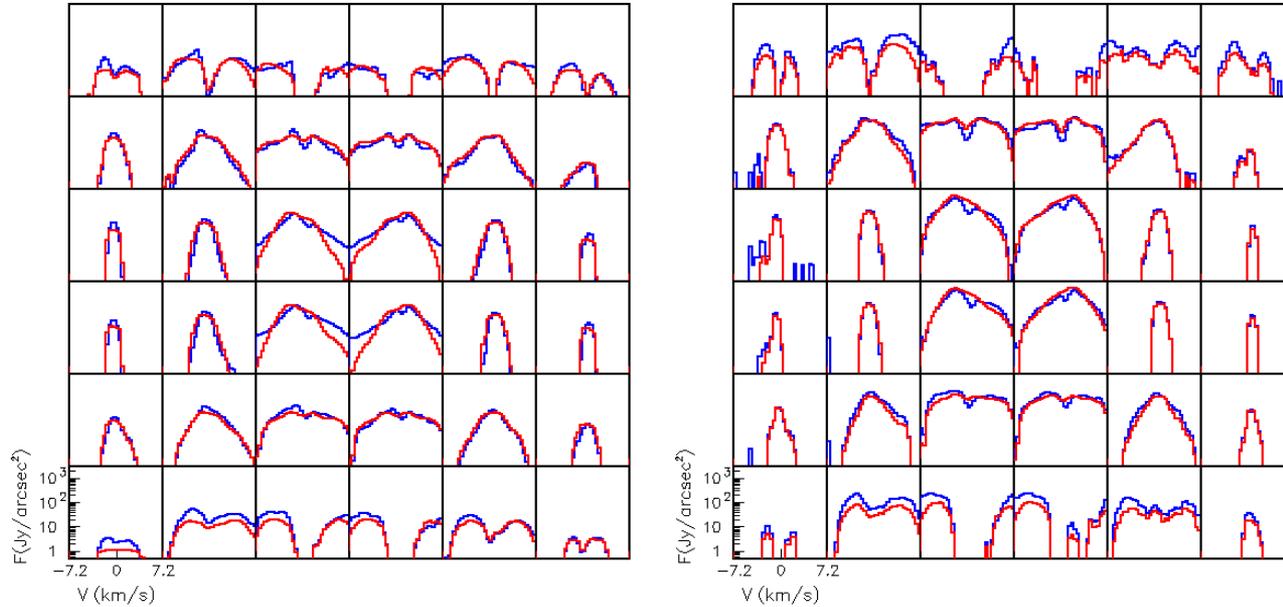
**Polar region**



**Equatorial region**

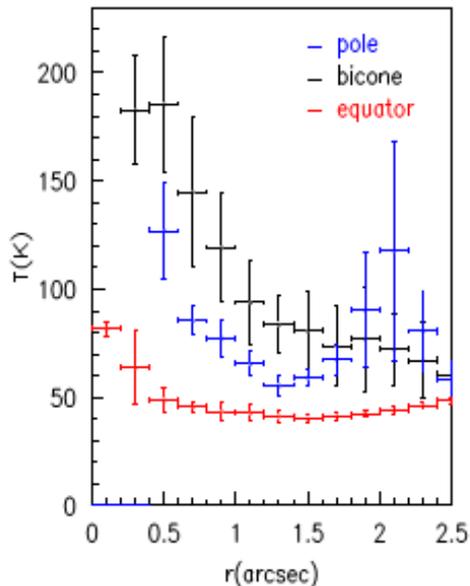
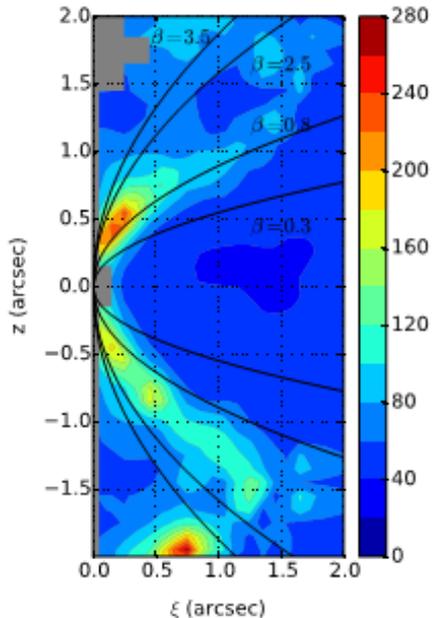
## Results

We find  $V_{rot} \sim 1.0$  km/s,  $V_{rad} \sim 1.6$  km/s

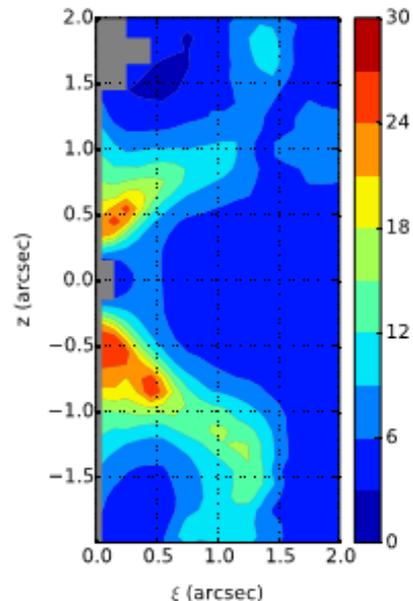


**The fit is surprisingly good in view of the crudeness of the model.**

## Temperature



## Density $\times r^2$



The gas morphology is reconstructed in space (here shown in the meridian plane): sharp separation between the equatorial and polar regions.

## A protostar: GG Tau

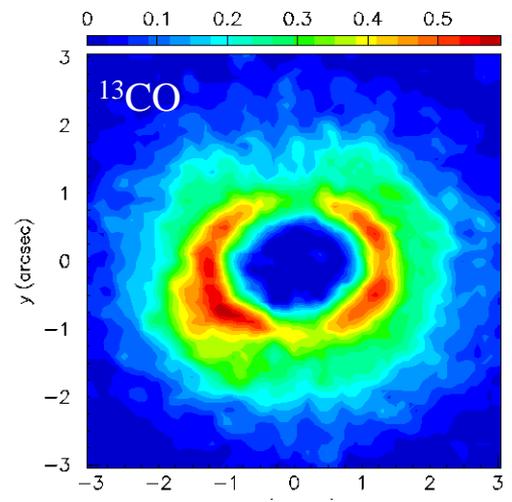
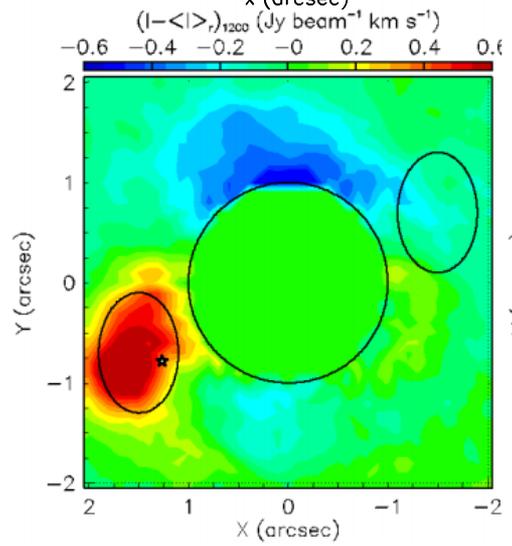
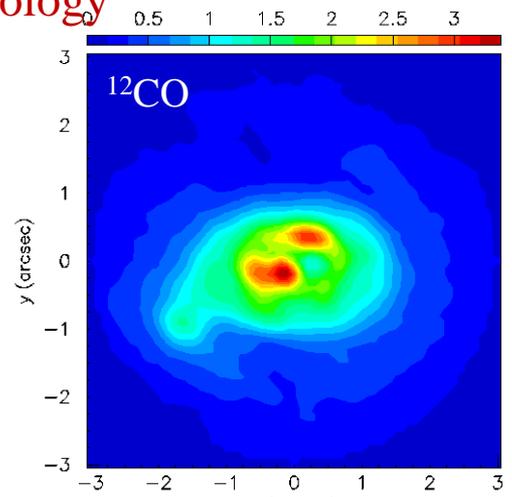
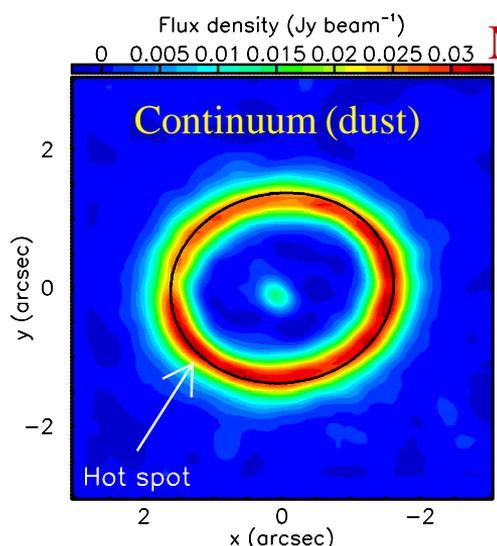
GG Tau is a triple star, with respective separations of 35 au and 4.5 au. It is located at 140 pc in the Taurus molecular cloud. Surrounded by a circumbinary envelope of gas and dust with a **ring spanning from ~190 to 280 au** and an **outer disc extending up to ~800 au** from the protostar with a total mass ~0.15 solar masses.



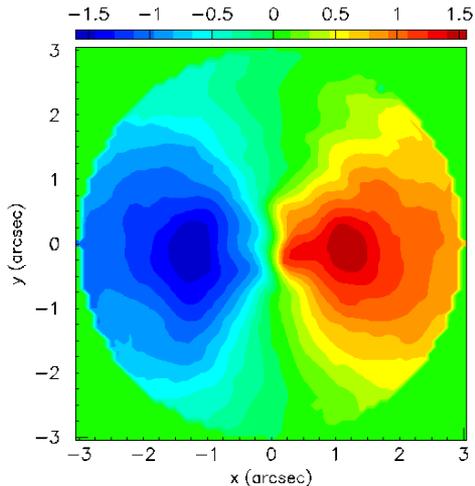
Artist view

Main questions address the morphology and kinematics of the surrounding gas and dust, the complex chemistry at stake (strongly influenced by dust grains) and the possible formation of planets.

# Morphology

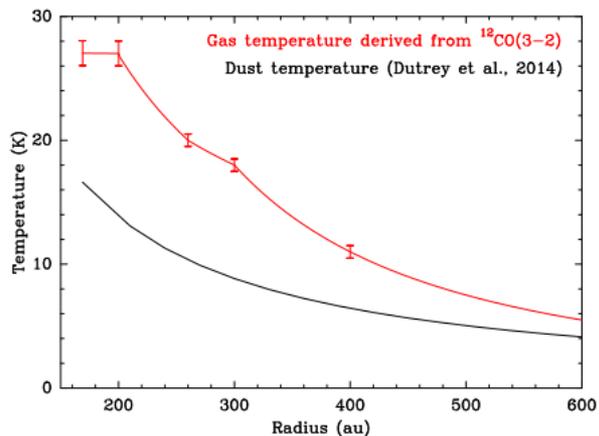
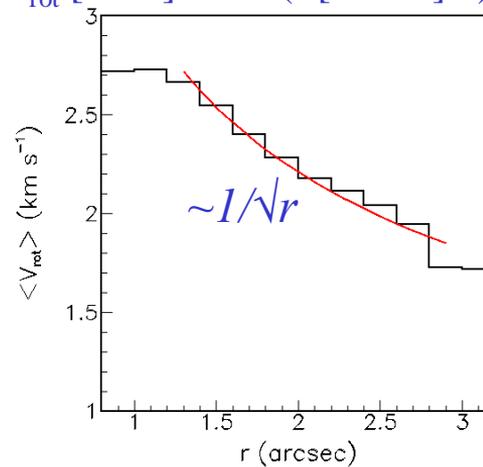


# Kinematics and Physical Condition



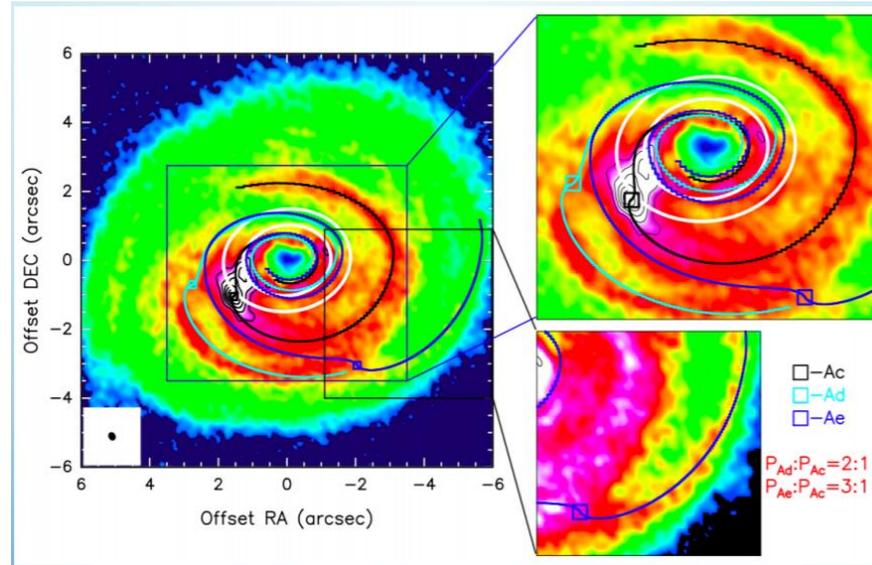
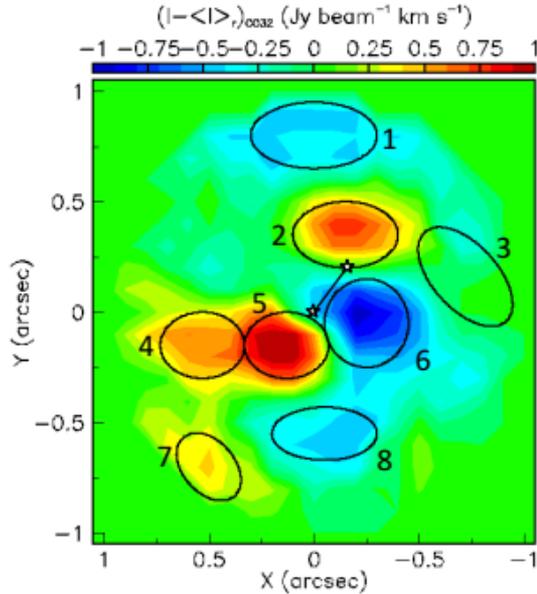
Upper limit of  
infall  
Measure the  
thickness of the  
disk

The ring is in Keplerian rotation:  
 $V_{\text{rot}} [\text{km/s}] = 2.21(r [\text{arcsec}]/2)^{-0.48}$



# Cavity and Chemistry

See the talk by Nguyen Thi Phuong this afternoon



A&A 616, L5 (2018)

Letter to the Editor

## First detection of H<sub>2</sub>S in a protoplanetary disk

The dense GG Tauri A ring

N. T. Phuong<sup>1,2,3</sup>, E. Chapillon<sup>1,4</sup>, L. Majumdar<sup>5</sup>, A. Dutrey<sup>1</sup>, S. Guilloteau<sup>1</sup>, V. Piétu<sup>4</sup>, V. Wakelam<sup>1</sup>, P. N. Diep<sup>2,3</sup>, Y.-W. Tang<sup>6</sup>, T. Beck<sup>7</sup> and J. Bary<sup>8</sup>

N. T. Phuong, P.N. Diep, A. Dutrey, (2018, 2020a, 2020b).

A&A 653, L5 (2021)  
<https://doi.org/10.1051/0004-6361/202141881>  
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**Astronomy  
&  
Astrophysics**

LETTER TO THE EDITOR

## An unbiased NOEMA 2.6 to 4 mm survey of the GG Tau ring: First detection of CCS in a protoplanetary disk

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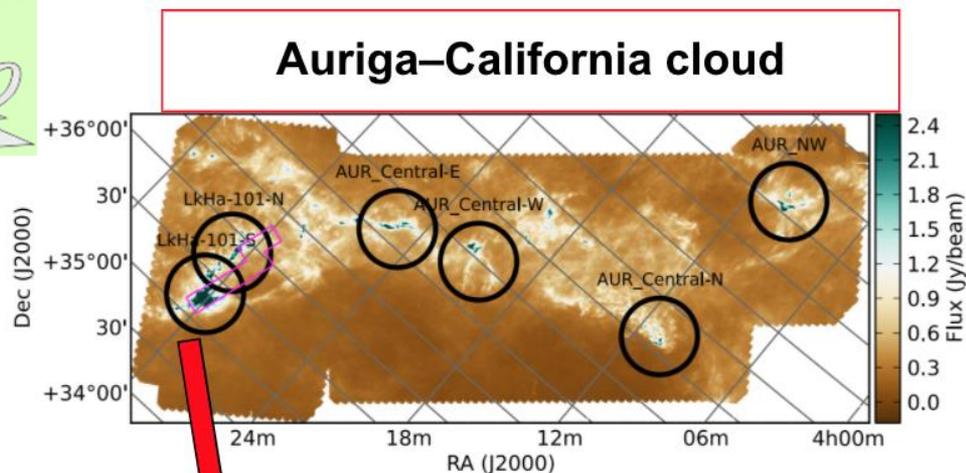
Magnetic fields in star forming regions;  
Polarization and Dust physics

# LkH $\alpha$ 101 Region

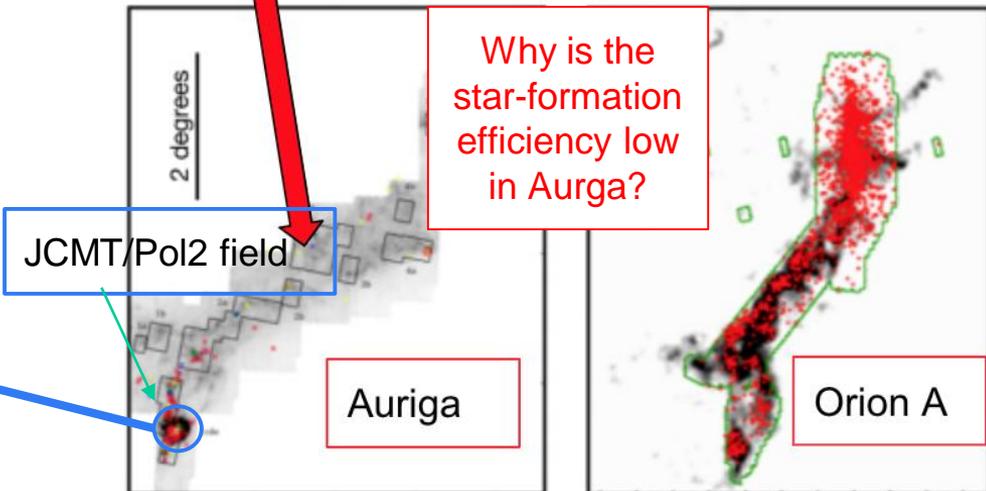
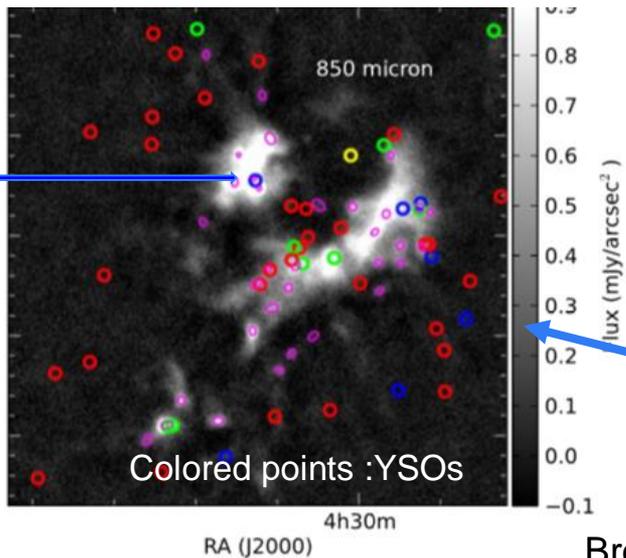


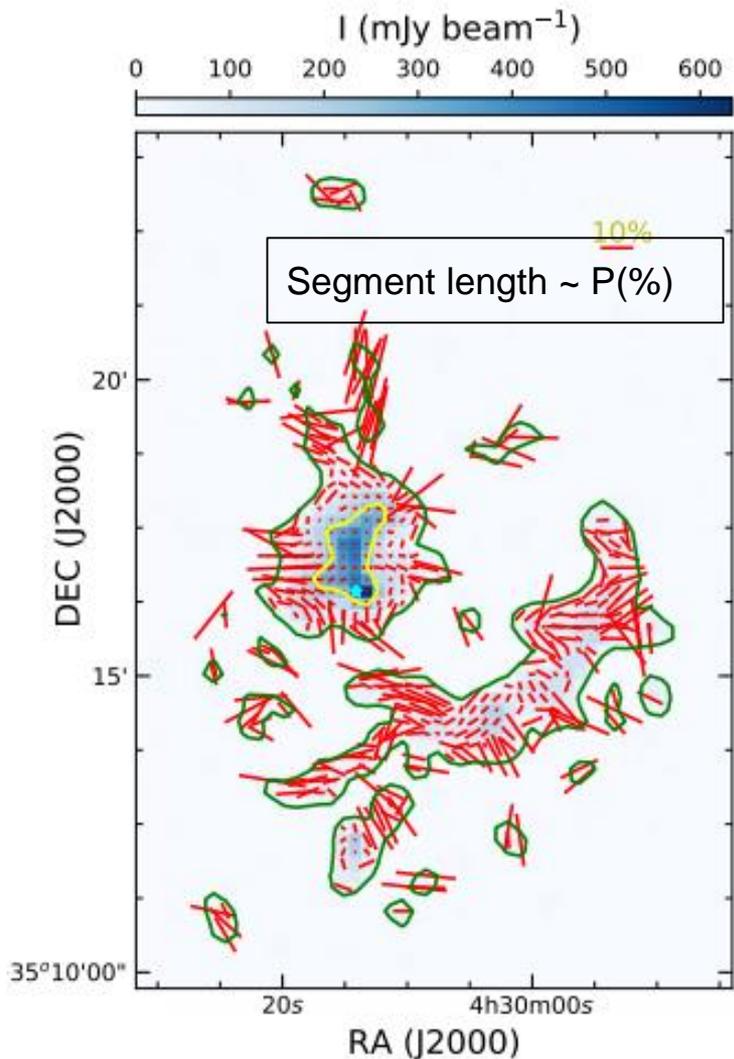
Highest star-formation efficiency in Auriga-California cloud

33 candidate protostars with **only one early-B star (LkH $\alpha$  101)**



LkH $\alpha$  101





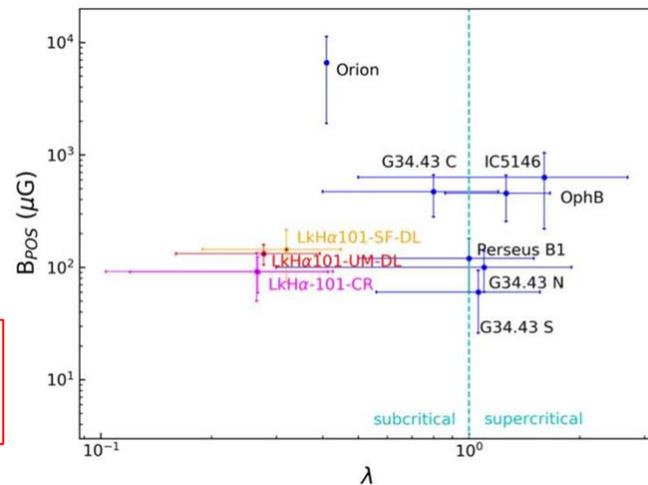
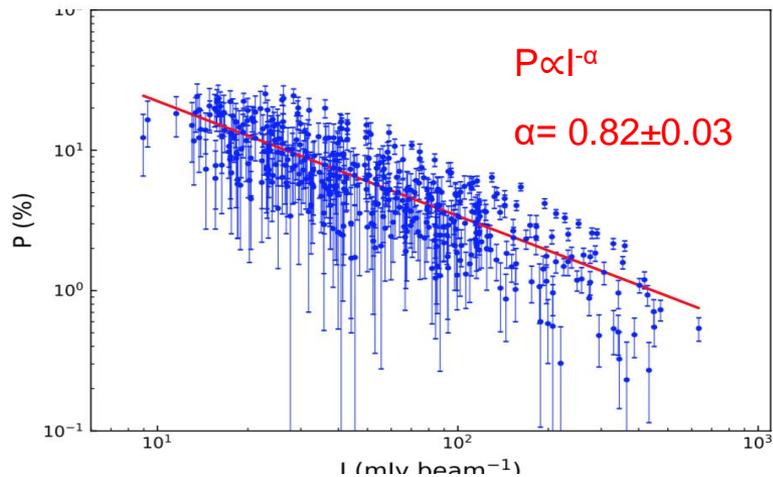
### Causes

disorganized B-field lines smeared out in the synthesized beam (field tangling)

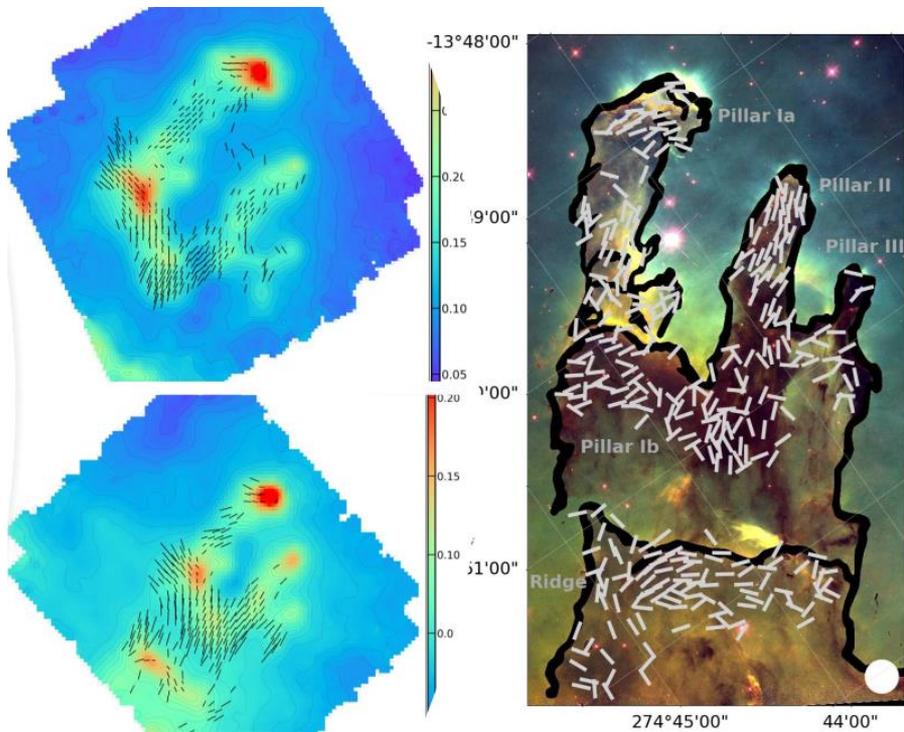
lack of irradiation, RAT disruption, and/or changes in dust grain characteristics toward high column density regions

Ngoc et al., ApJ, 2021 for BISTRO Collaboration

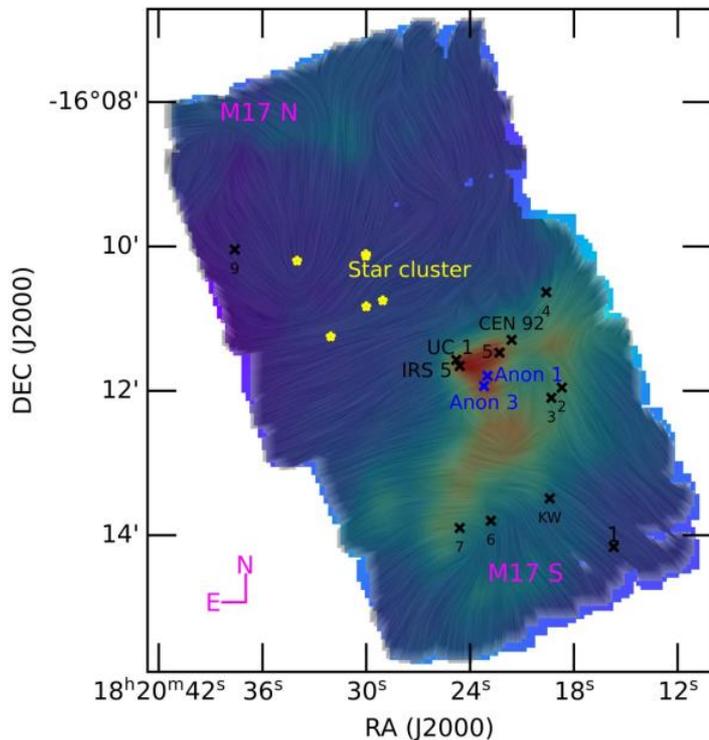
### Polarization hole



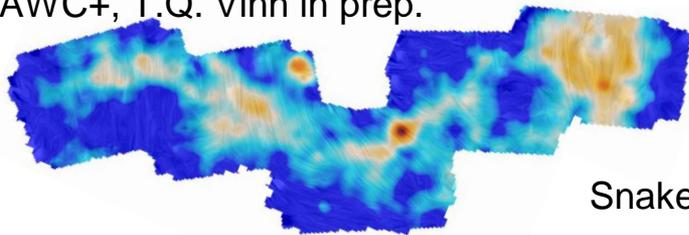
# M16, M17, and the Snake filament: morphology, strength, relative role, grain alignment and properties



M16, SOFIA/HAWC+, T.Q. Vinh in prep.

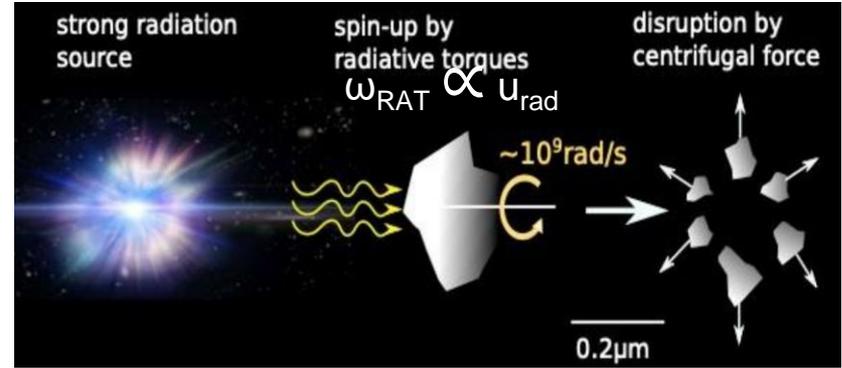
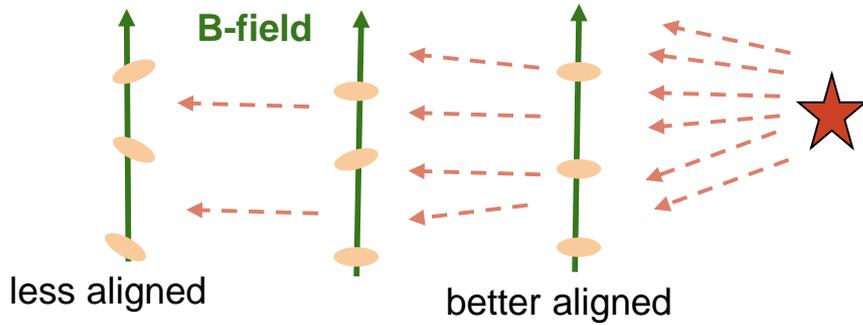


M17, SOFIA/HAWC+, H.D. Thuong+ (2022)



Snake filament, N.B. Ngoc+ (2023)

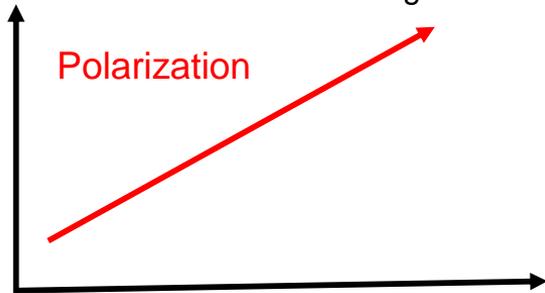
# Test the predictions of RAdiative Torque (RAT) theory



## RATA prediction:

$P$  (%) increases with increasing  $T_{\text{dust}}$

E.g. Lazarian & Hoang 2007

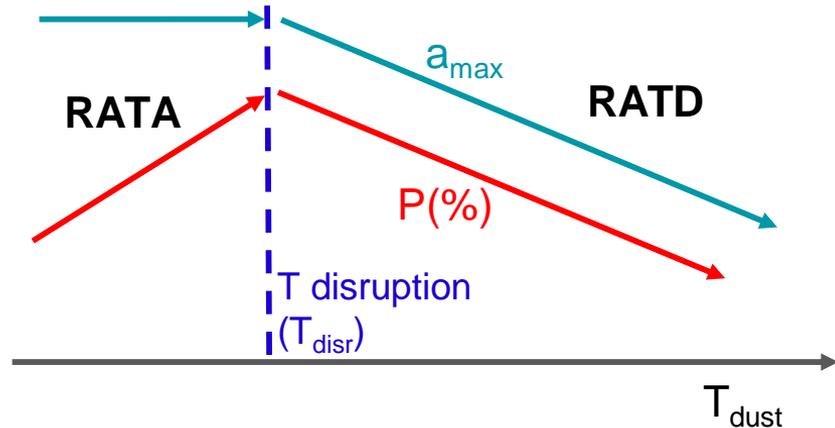


Radiation strength  $\sim$  Dust temperature ( $T_{\text{dust}}$ )

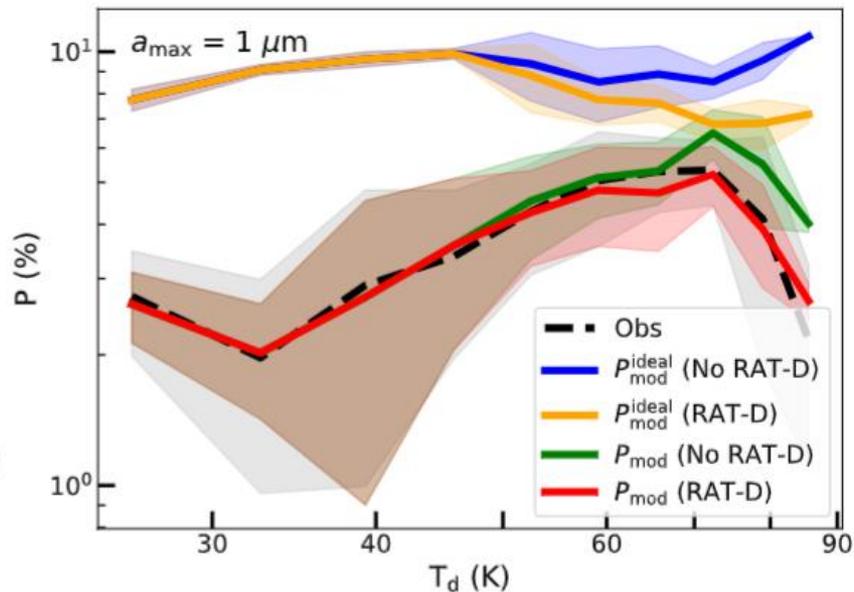
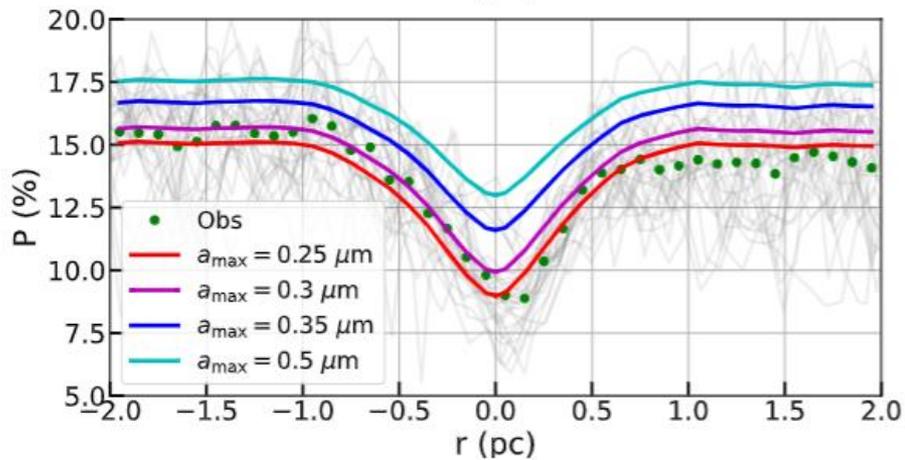
## RATD prediction:

Hoang, Tram + 2019

$P$  (%) increases and then decreases with increasing  $T_{\text{dust}}$



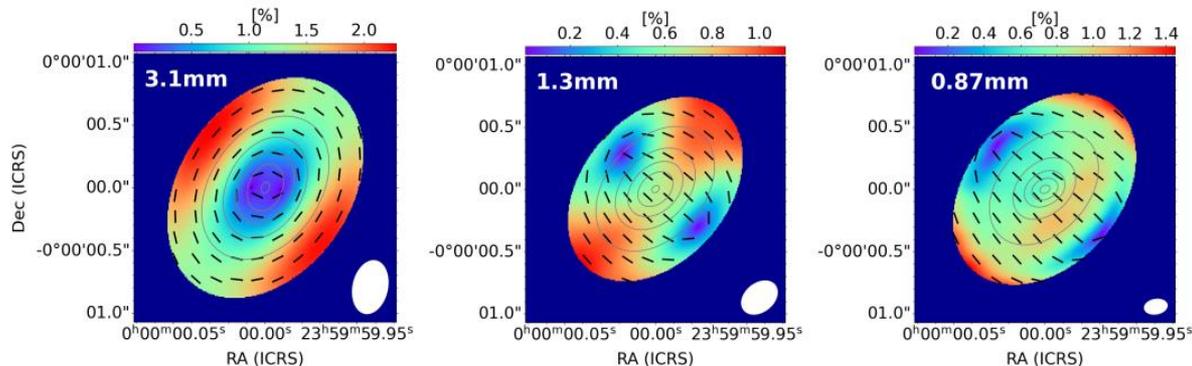
# Testing RAT predictions for Musca and Orion filamentary molecular clouds



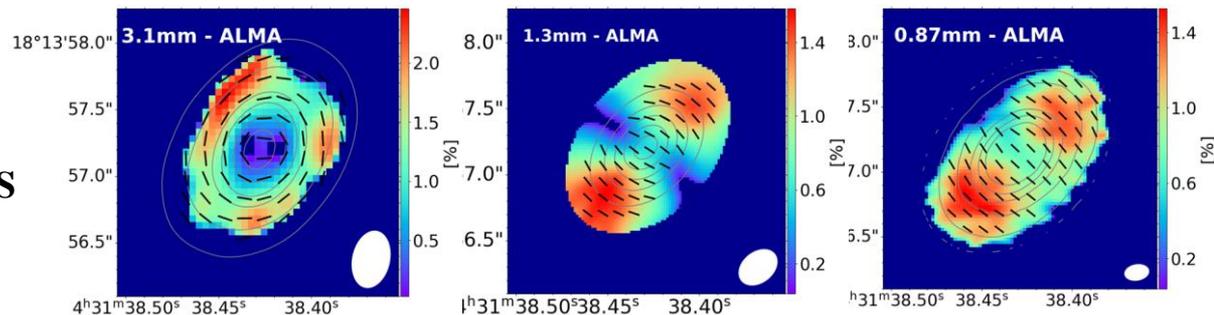
Ngoc et al. (2024) under review

# Mixture Of MRAT Grain Alignment And Self-Scattering Models: HL Tau

**OUR  
RESULTS**



**ALMA  
OBSERVATIONS**



- Reproduce observations
- Constrained results :

- Grain size :  $a_{\max} \sim 130, 80, 60 \mu\text{m}$  at  $\lambda = 3.1, 1.3, 0.87 \text{ mm}$
- Grain magnetic property :  $N_{\text{cl}} \sim 10^3, Q_{\text{X,low-J}} \sim -0.4$

Nguyen Tat Thang et al. (accepted)

# Summary

Astronomy and astrophysics (A&A) in Vietnam are still in their infancy. We are making efforts to stimulate interest in the general public, to foster the teaching of basic knowledge, and to develop research on frontline topics.

Astrophysics, one of the most dynamic branches of modern physics, matches well our needs. Open access data allow astronomers from developing countries to do frontier research. We are immensely indebted and grateful to this generous policy of the astronomical community, in particular the ALMA partnership.

**Perspectives:** Efforts to develop astrophysics research from different groups (Hanoi, HCM, Quy Nhon; inside/oversea; professional/amateur), great interest from the public and youngsters (VSOA), increasing interest from universities and government (A&A and cosmology are included in the Master Plan for space science and technology until 2030 and beyond and in VAST's priority research domains), good economy development in the country.

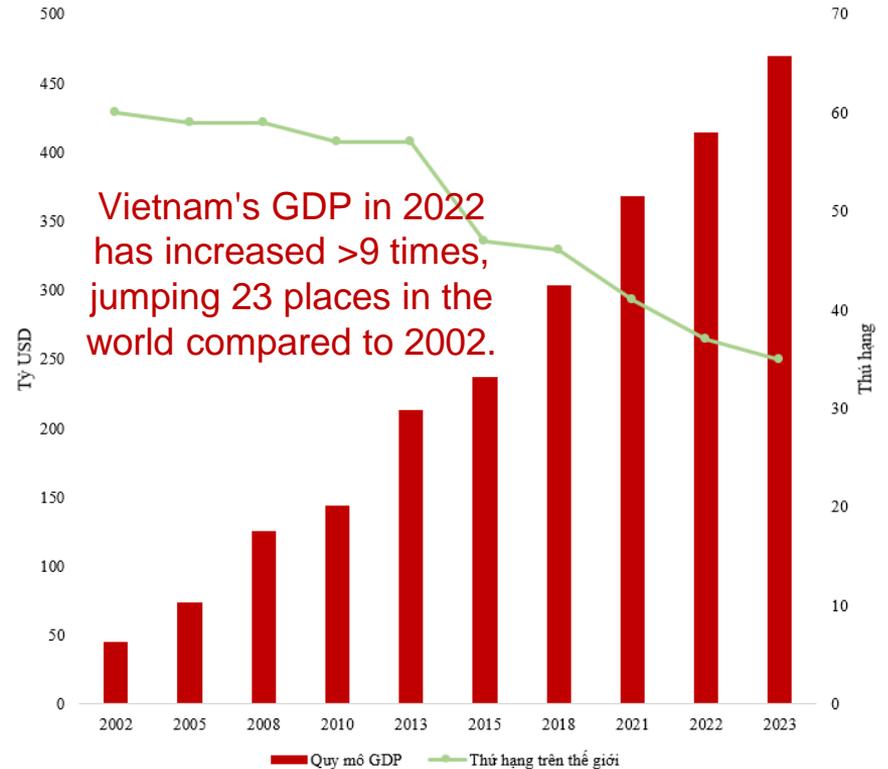
We have been receiving **constant support** from abroad which is vital for our progress.

# Thank you for your attention!



Credit: Tran Ha

Quy mô GDP Việt Nam giai đoạn 2002-2021  
và dự báo 2022-2023



Scale of Vietnam's GDP in the period 2002-2022 and forecast for 2022-2023. Source: IMF