MIS-PLASMAS Team

Nathan Maindon

HH 46/47, NIRCAM - Crédits: NASA, ESA, CSA -Joseph DePasquale, Anton M. Koekemoer

LUX Starting Day

Presentation of my research topic

Feedback of protostellar ejections on planetary formation

Supervisors : Sylvie CABRIT, Guillaume PINEAU DES FORÊTS

Context of star formation

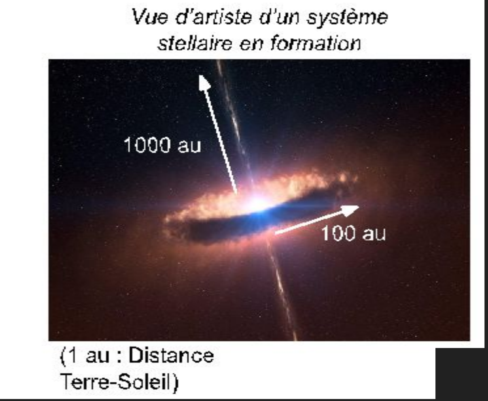
- Collapse of the gas cloud
- Formation of a gas/dust disk
- Accretion on central object

Atomic jets :
10 000 K, 100 km/s
Origin < 0.1 AU

$$\dot{M} \approx 0.1\dot{M}_{accretion}$$

Molecular flows (CO):
30 K, 10 km/s
Origin 1-30 AU

$$\dot{M} \approx \dot{M}_{accretion}$$



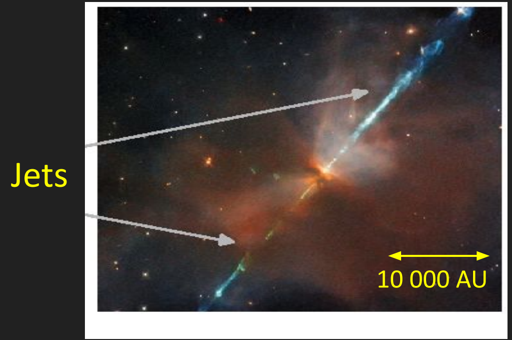


Image de HH111, HST/Nisini+2021

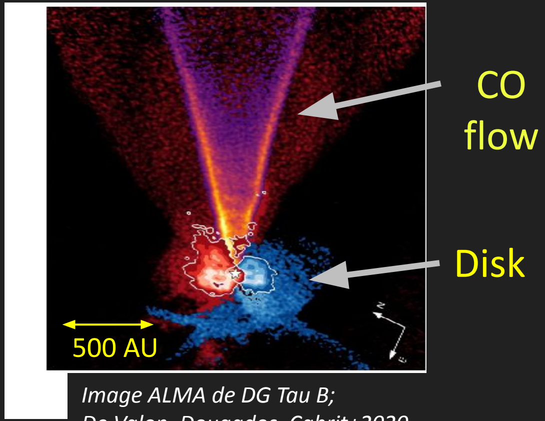


Image ALMA de DG Tau B;
De Valon, Dougados, Cabrit+2020

Questions : What is the **origin** of the **observed molecular flows**?
What **impact** do these outflows have **on planetary formation**?

Questions : What is the **origin** of the **observed molecular flows**?
What **impact** do these outflows have **on planetary formation**?

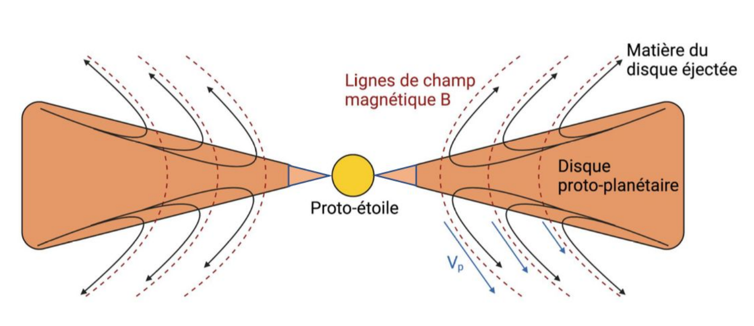
TWO COMPETING MODELS

1) MHD magneto-centrifugal disk-wind ?

Recently privileged thanks to ALMA observations:
- **Coherent** rotation rates, mass fluxes & velocities of ejection
- **Magnetic braking** could **explain accretion** on star

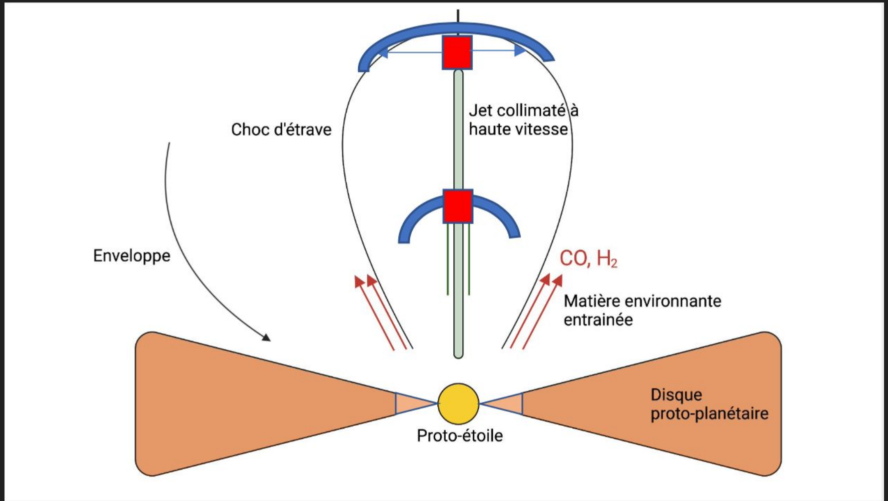
Major MHD effects on planetary formation and migration?

Problem: thinness of the CO cavity (r << R_{disk}), + not detected in every accreting disk



2) Matter dragged by jet bow-shocks ?

Alternative scenario & aim of this research
Variable jet: produces bow shocks on envelope & disk
Would explain **thinness** of CO cavity + **rarity** of the phenomenon



Promising recent models: ***Rabenanahary, et al. 2022***

First simulations of a variable jet in a stratified environment up to 10 ^{4} years (with Z. Meliani)

Code : AMR-VAC ; parallelized on MESO-PSL

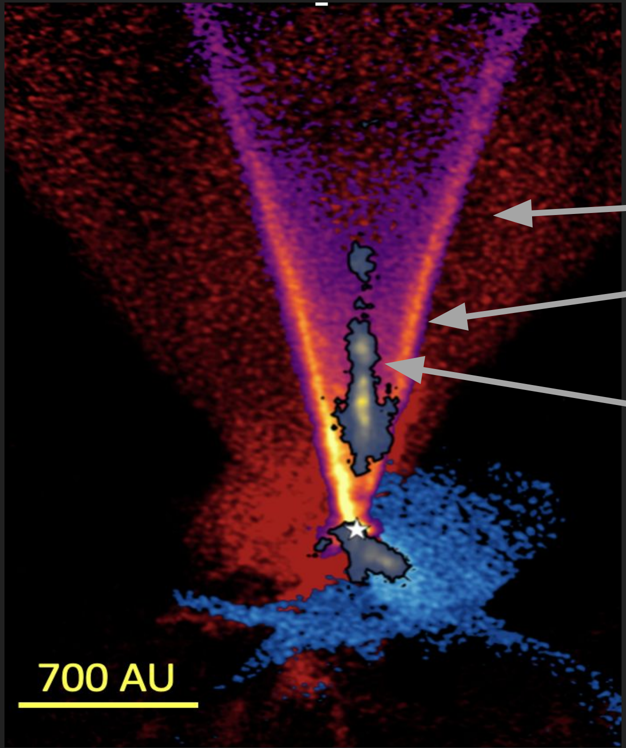
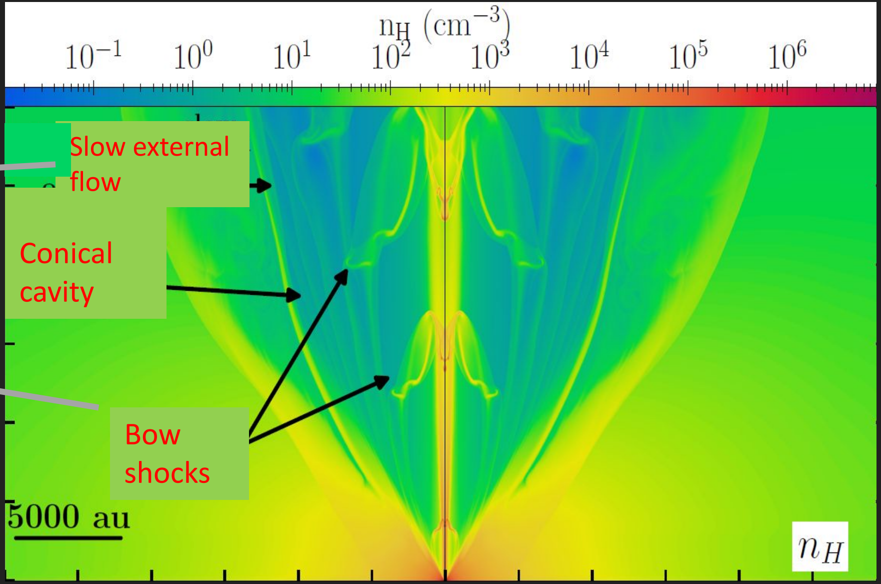


Image ALMA de DG Tau B;
De Valon, Dougados, Cabrit+2020



Yet too many hypothesis were done:

- -Statical environment (no rotation)
- -No chemistry
- -No disk
- -Scales >> 1000 AU

What I did – and will do:

1) Develop first simulations of the jet/disk interaction < 1000 au

- add rotation and hydrostatic disk (Nelson et al., 2013) ✅
- add grains-gas interaction & corrected radiative cooling (almost ✅ !!)
- Run the first big simulations 🔜
- Basic out-of-equilibrium chemistry (H^+, H, H_2, CO)
  + associated radiative transfer (later ⏳)

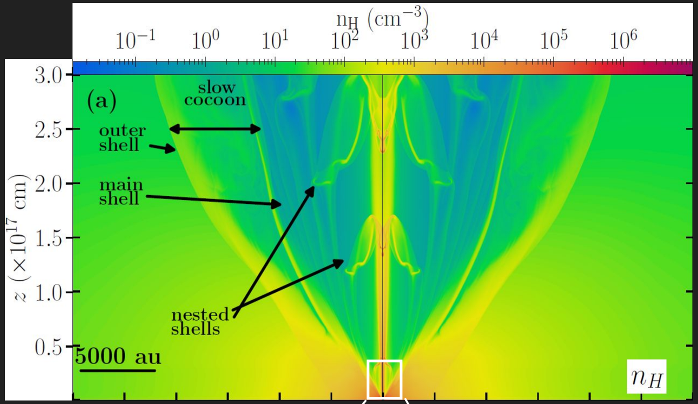
2) Comparison to the observations (later ⏳)

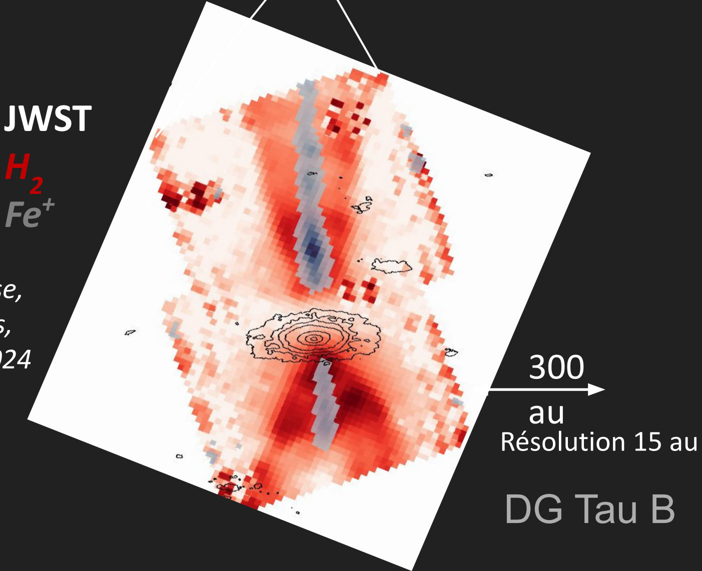
- JWST : H_2 (2000 K): Shock tracers
- ALMA: Cold CO: Rotation, outflowing mass flux

=> Discrimination *versus* MHD disk-wind (later ⏳)

3) Impact on planetary formation (later ⏳)

- Shocks on the disk : quantify depletion of matter?
- Negligibility of MHD effects ?



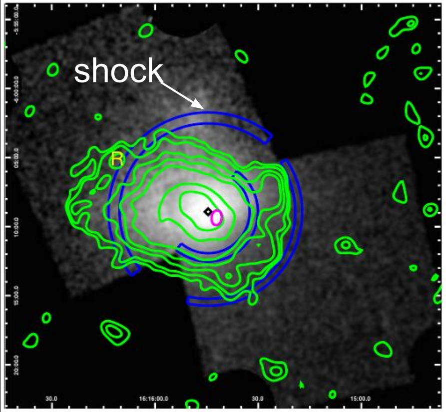


Simulations and Experiments of Shocks in Weakly Collisional Plasmas

LUX starting day

Thershi Seebaruth, LUX, LPP & LULI

Supervisors:
Andrea Ciardi (LUX)
Anna Grassi (LULI)
Roch Smets (LPP)



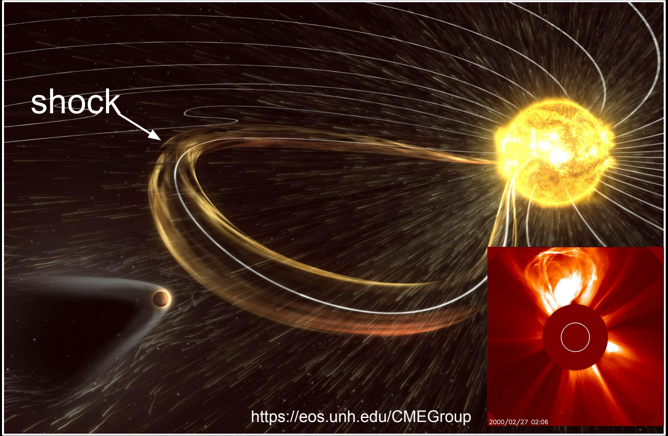
S. Thölken et al 2021 Discovery of large scale shock fronts in the A2163 galaxy cluster

Galaxy clusters

Size ~ 10^{24} cm

T ~ 10^{8} K

n ~ 0.001 cm^{-3}

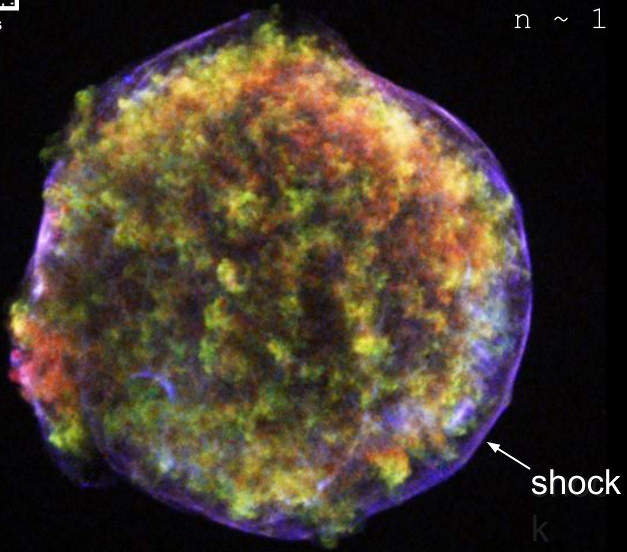


Coronal mass ejections

Size ~ 10^{13} cm

T ~ 10^{5} K

n ~ 1 cm^{-3}



NASA/CXC/Rutgers/J.Warren & J.Hughes et al.

SN remnants

Size ~ 10^{17} cm

T ~ 10^{4} K

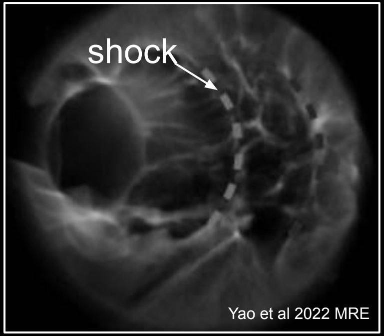
n ~ 100 cm^{-3}

Laboratory plasmas

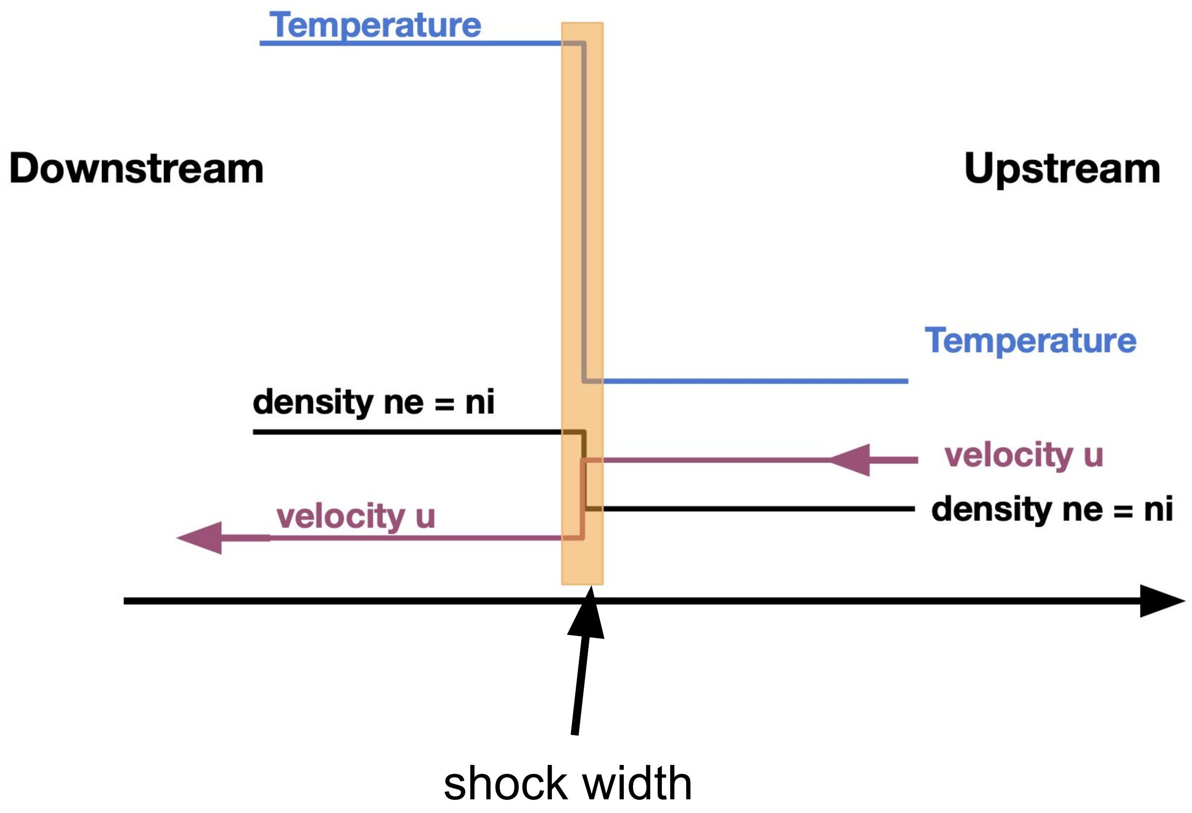
Size ~ 1 cm

T ~ 10^{6} K

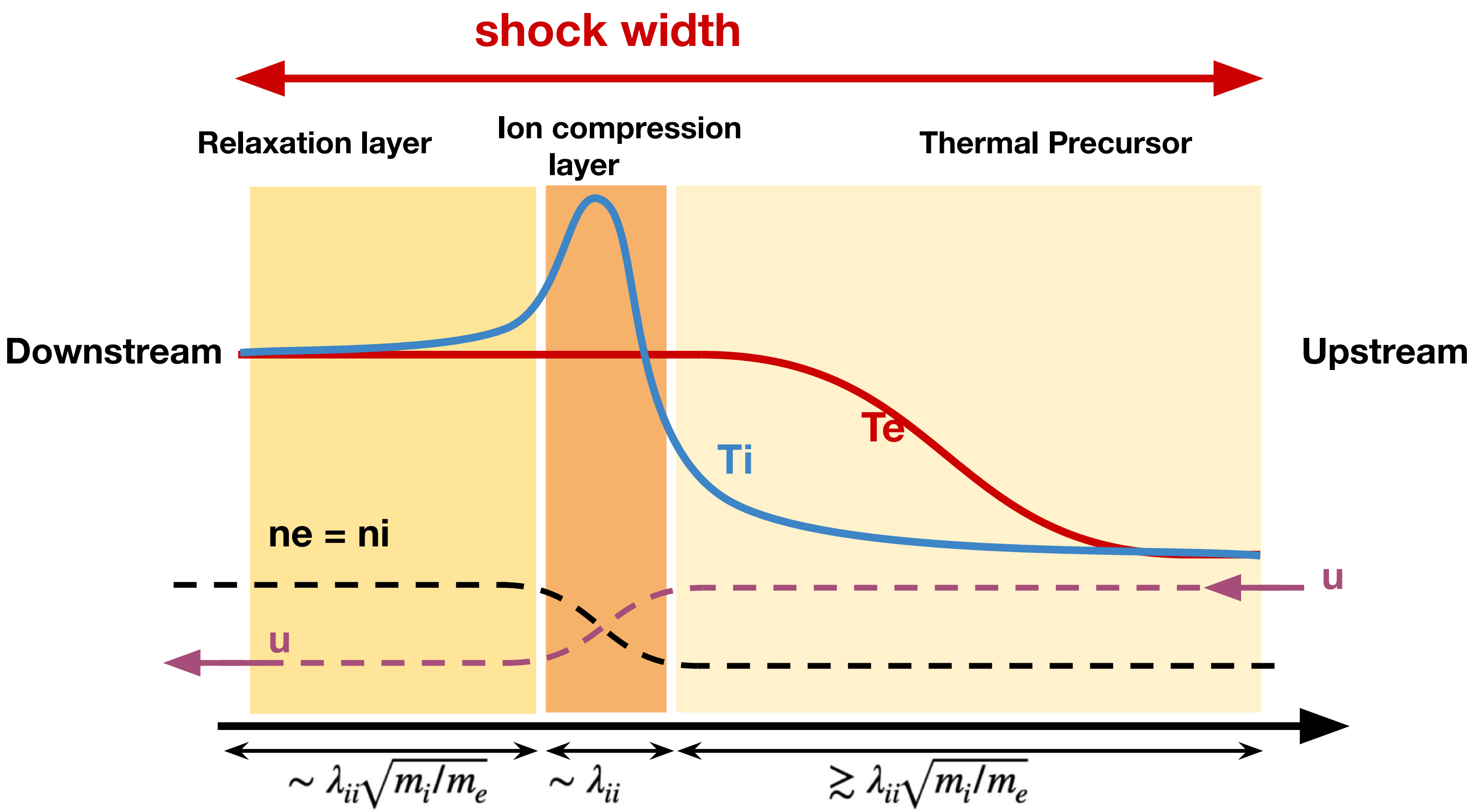
n ~ 10^{18} cm^{-3}



Shock as a discontinuity

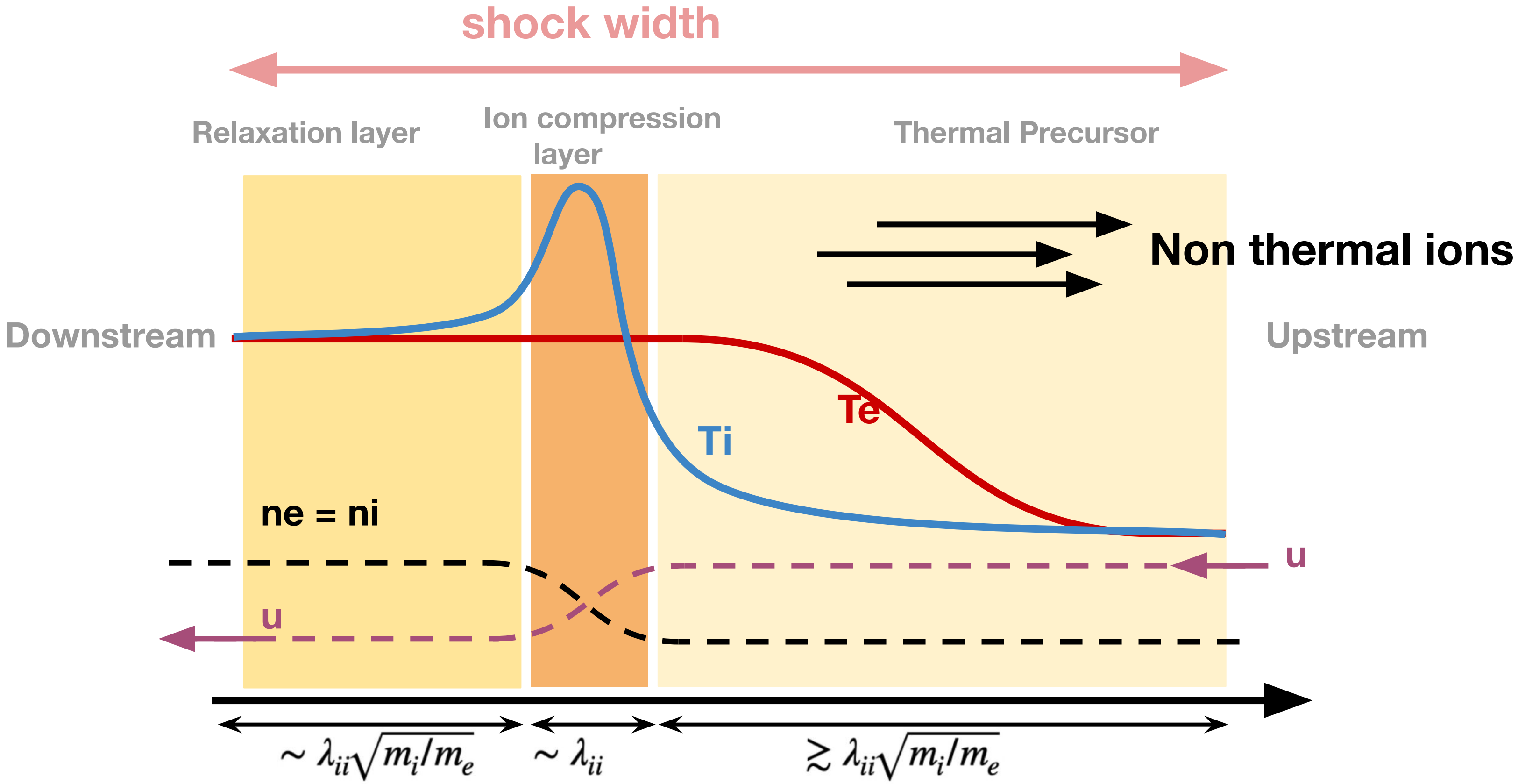


Shocks in plasma: decoupling of ion and electron dynamics



Jaffrin & Probstein 1964, Shafranov 1957, Vidal+ 1993, …

Shocks in plasma: decoupling of ion and electron dynamics

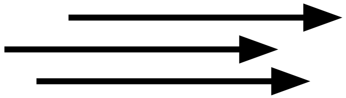


Jaffrin & Probstein 1964, Shafranov 1957, Vidal+ 1993, …

Shocks in plasma: kinetic effects

- More evident in stronger shocks (higher Mach number)

- Will propagate longer in weakly collisional plasmas



Non thermal ions

Jaffrin & Probstein 1964, Shafranov 1957, Vidal+ 1993, …

Shocks in plasma: kinetic effects

- More evident in stronger shocks (higher Mach number)
- Will propagate longer in weakly collisional plasmas

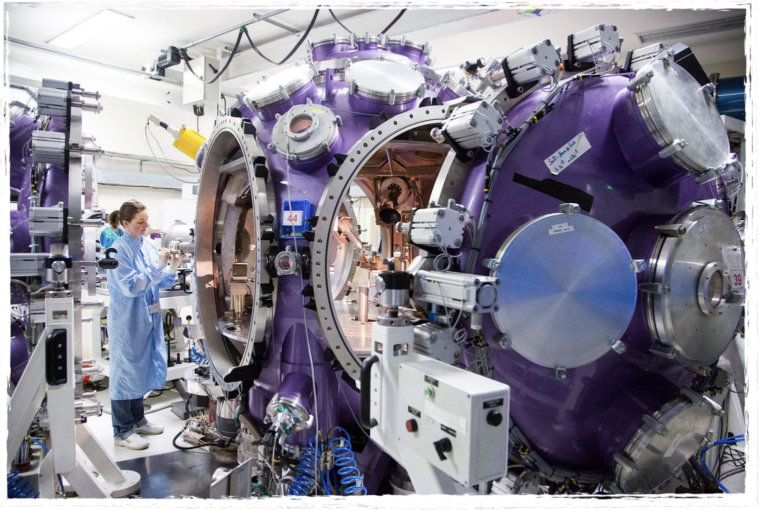
Non thermal ions

Explore the shock structure and non thermal effects under different conditions

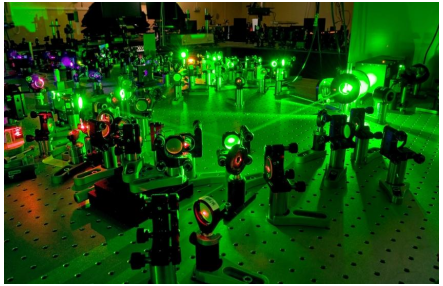
Jaffrin & Probstein 1964, Shafranov 1957, Vidal+ 1993, …

Laboratory experiments and Simulations

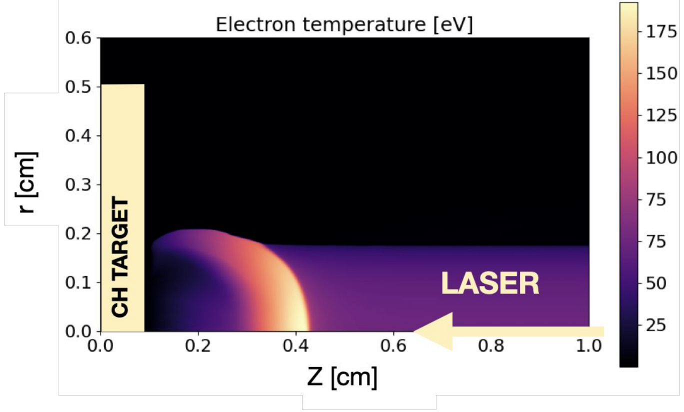
Large laser facility experiments



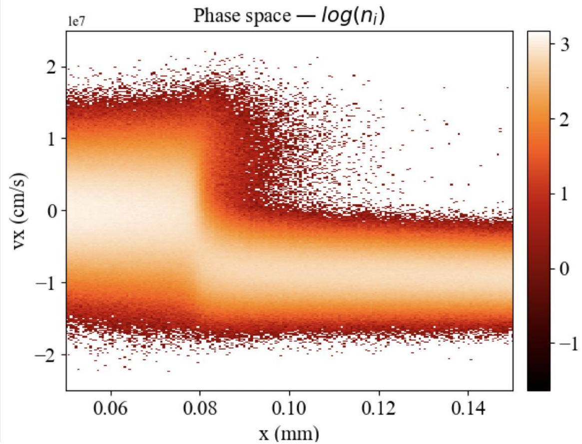
LULI2000 laser facility – Ecole Polytechnique



MHD simulations – FLASH



Fully kinetic PIC simulation – Smilei



Thank you

Measurement of ozone cross section around 308 nm for remote sensing

LUX launch day

14 mars 2025

Short presentation

Team : MIS-PLASMAS

Supervisors

- Christof JANSSEN
- Thomas ZANON

Presented by Coline MAHOB - PhD Student

Observatoire de Paris | PSL · MONARIS · CNRS · Sciences Sorbonne Université · LP2N Laboratoire Photonique Numérique & Nanosciences · GSMA · Université de Reims Champagne-Ardenne · UVSQ université Paris-Saclay · LPL Laboratoire de Physique des Lasers · Université Sorbonne Paris Nord · anr · lefe

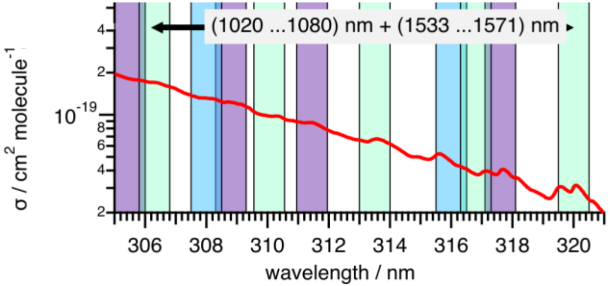
Reasons of the need of highly accurate measurement of ozone cross section :

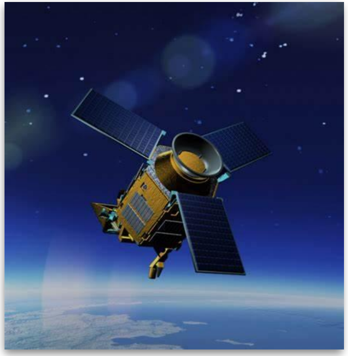
- Assessment of atmospheric ozone
- Understand the evolution of the climate and pollution in the atmosphere
- Uncertainties in the actual values

Alpha-O3 project members

Observatoire de Paris | PSL | MONARIS | cnrs | Sciences Sorbonne Université | LP2N Laboratoire Photonique Numérique & Nanosciences

GSMA | Université de Reims Champagne-Ardenne | UVSQ université Paris-Saclay | LPL Laboratoire de Physique des Lasers | Université Sorbonne Paris Nord | anr | lefe





TROPOMI

Brewer

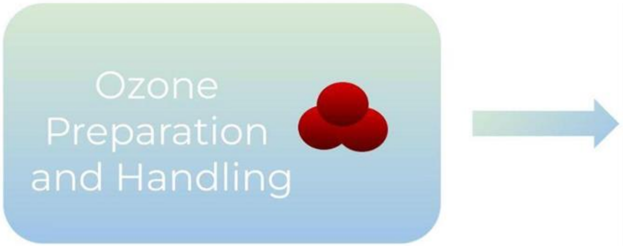
Dobson

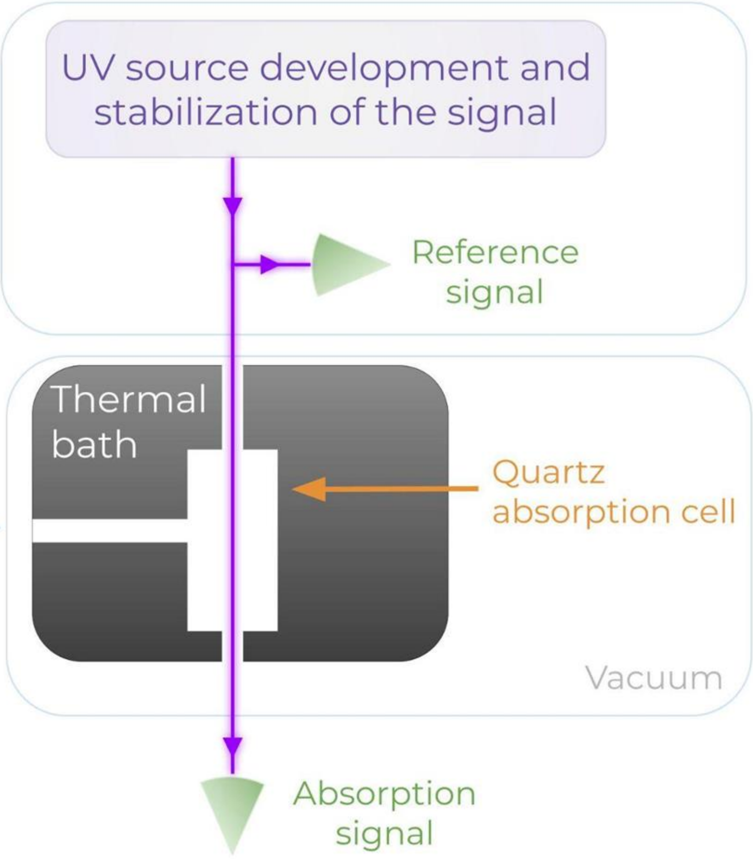
LIDAR

Goal: Measurement of ozone cross section

Technique : Absorption measurement in UV

Key composants:
- UV Source
- Quartz Cell : Contains ozone produce in laboratory, temperature controled environnement

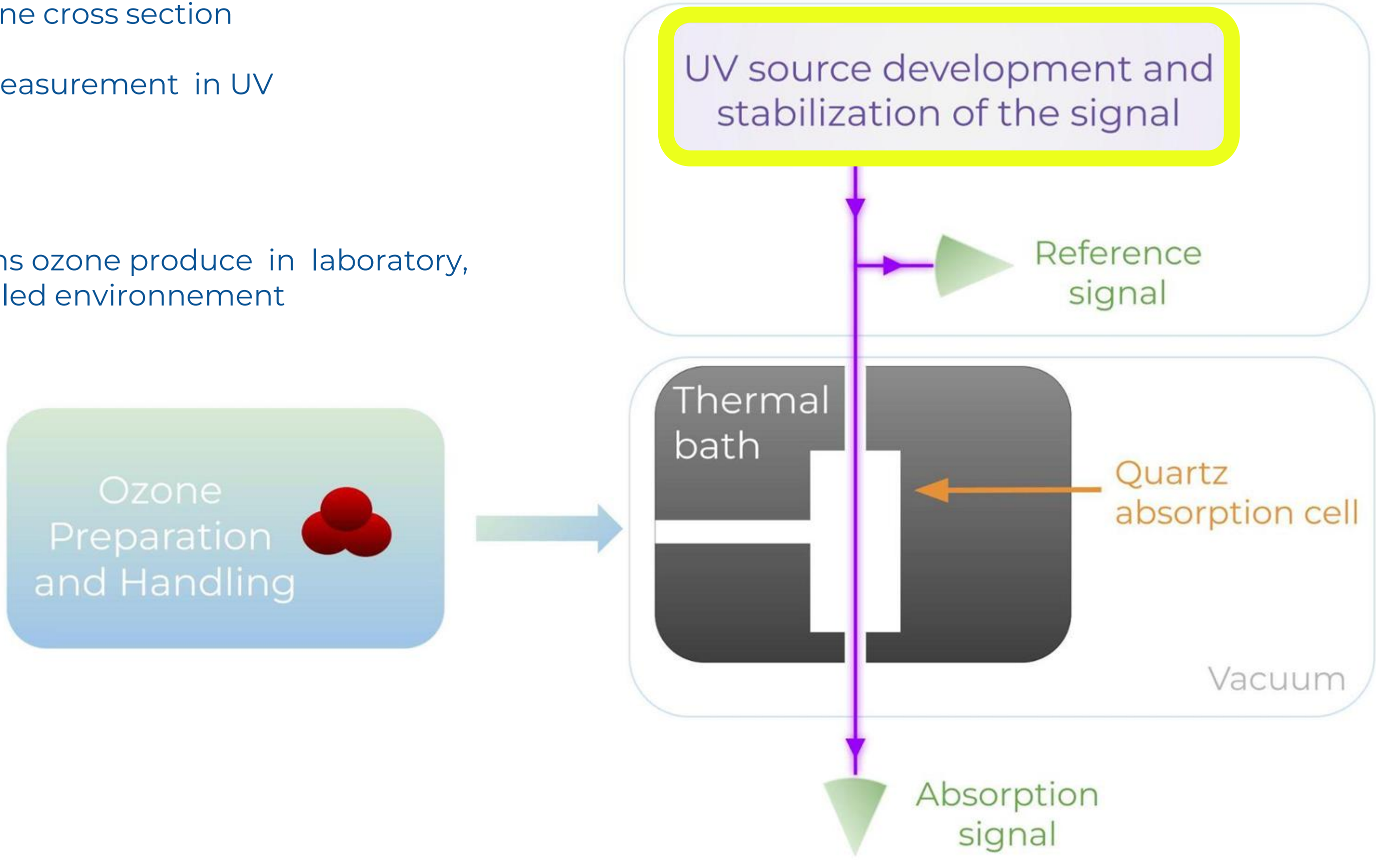




Goal: Measurement of ozone cross section

Technique : Absorption measurement in UV

Key composants:
- UV Source
- Quartz Cell : Contains ozone produce in laboratory, temperature controled environnement



UV source development and signal stabilization

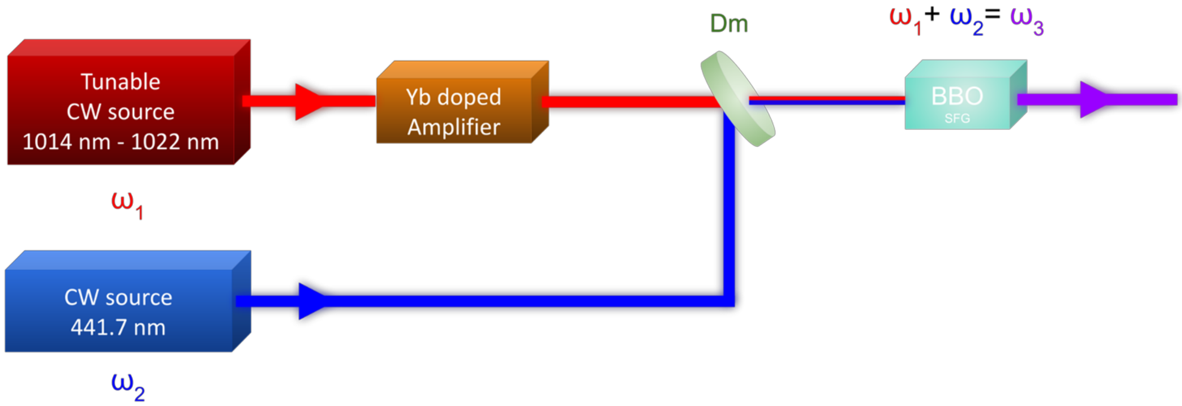
System 1 : for stratospheric LIDAR
➔ range : 307.8 to 308.2 nm

System 2 : for wider measurement
➔ range : 308 to 318 nm

UV source development and signal stabilization

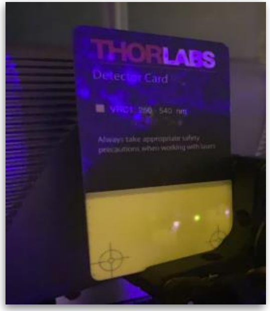
System 1 : for stratospheric LIDAR
➔ range : 307.8 to 308.2 nm

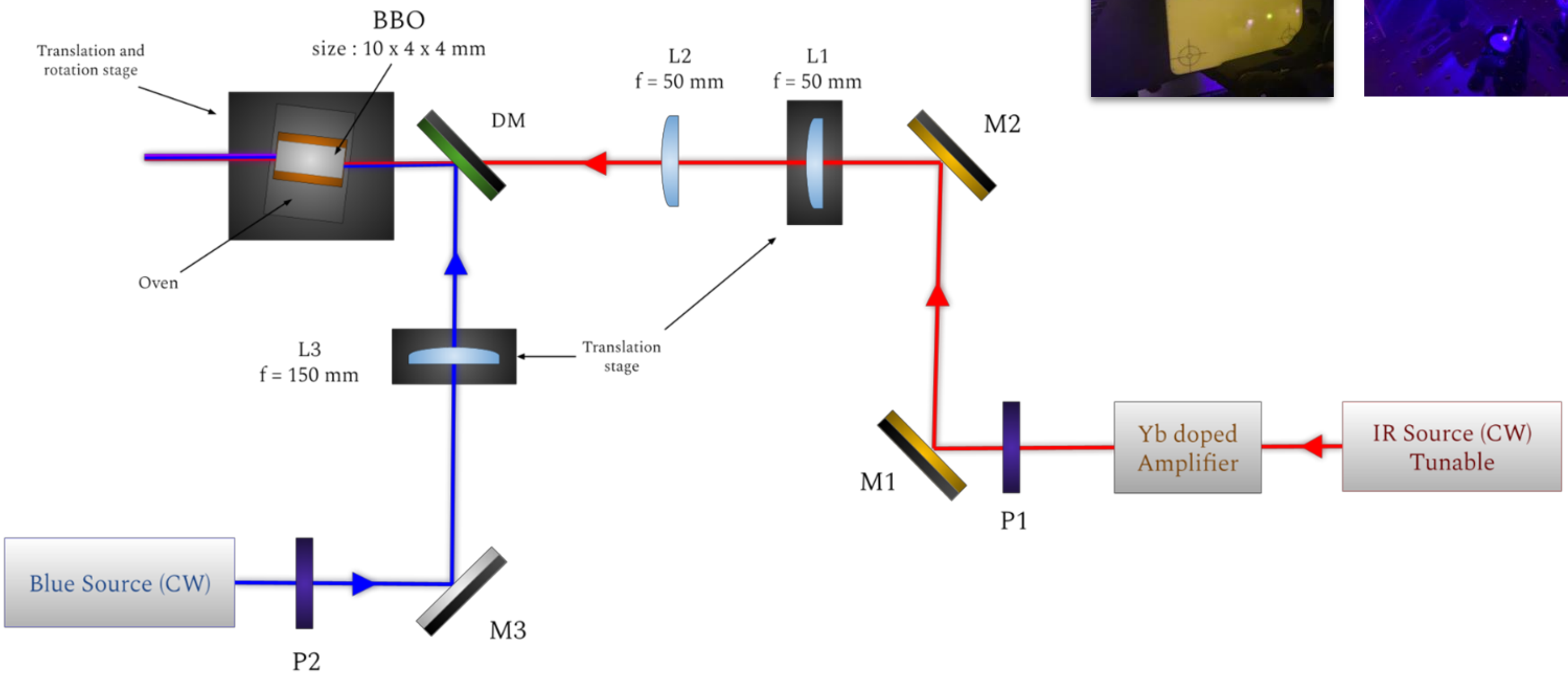
System 2 : for wider measurement
➔ range : 308 to 318 nm



Set up for UV generation with non linear optics :

➔ SHG in a BBO

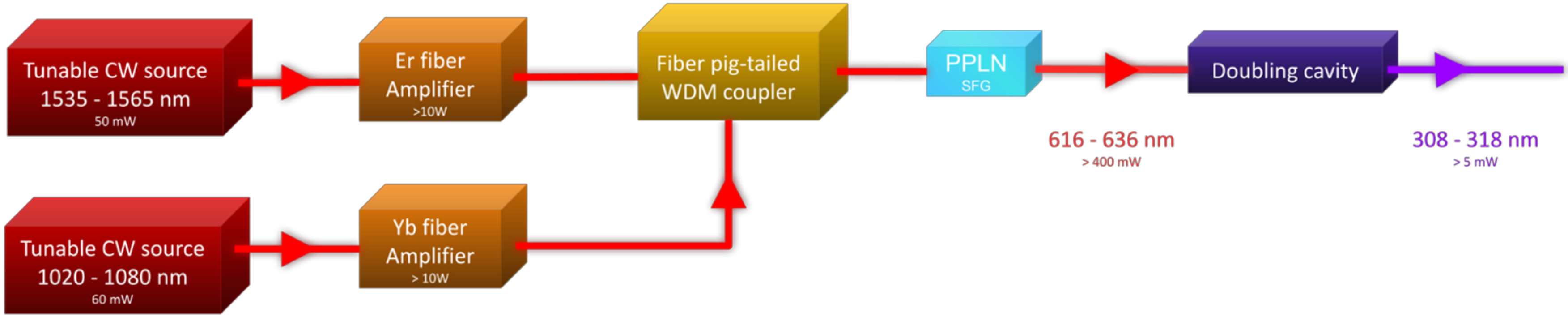




UV source development and signal stabilization

System 1 : for stratospheric LIDAR
➔ range : 307.8 to 308.2 nm

System 2 : for wider measurement
➔ range : 308 to 318 nm



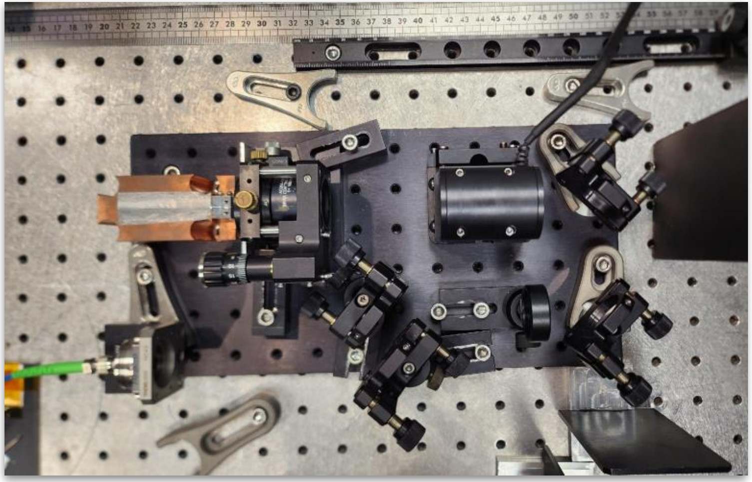
LP2N Laboratoire Photonique Numérique & Nanosciences

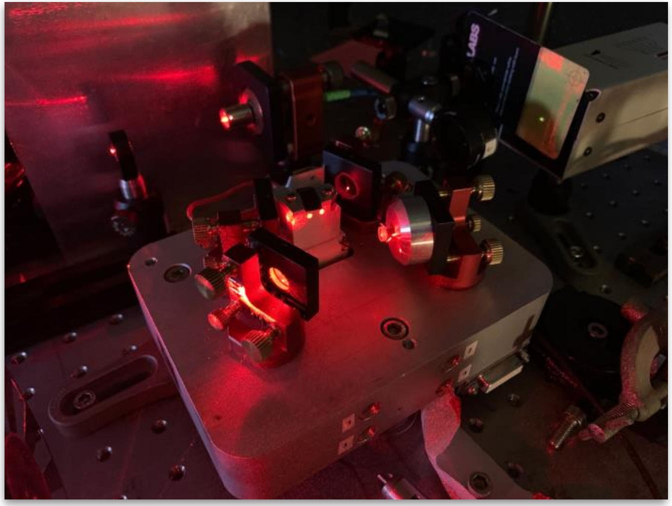
LPL Laboratoire de Physique des Lasers

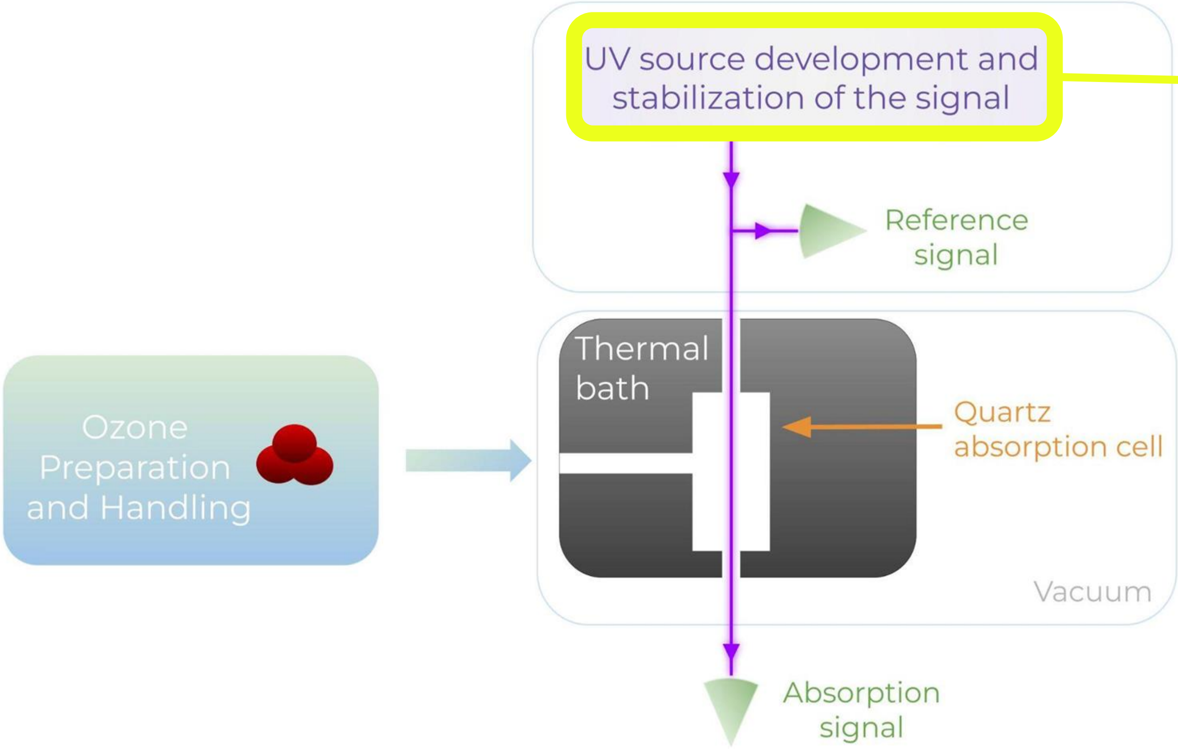
Laboratoire Kastler Brossel

Set up for UV generation with non linear optics :

IR → Red → UV

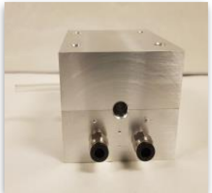






Stabilization and optimisation

Development in progress



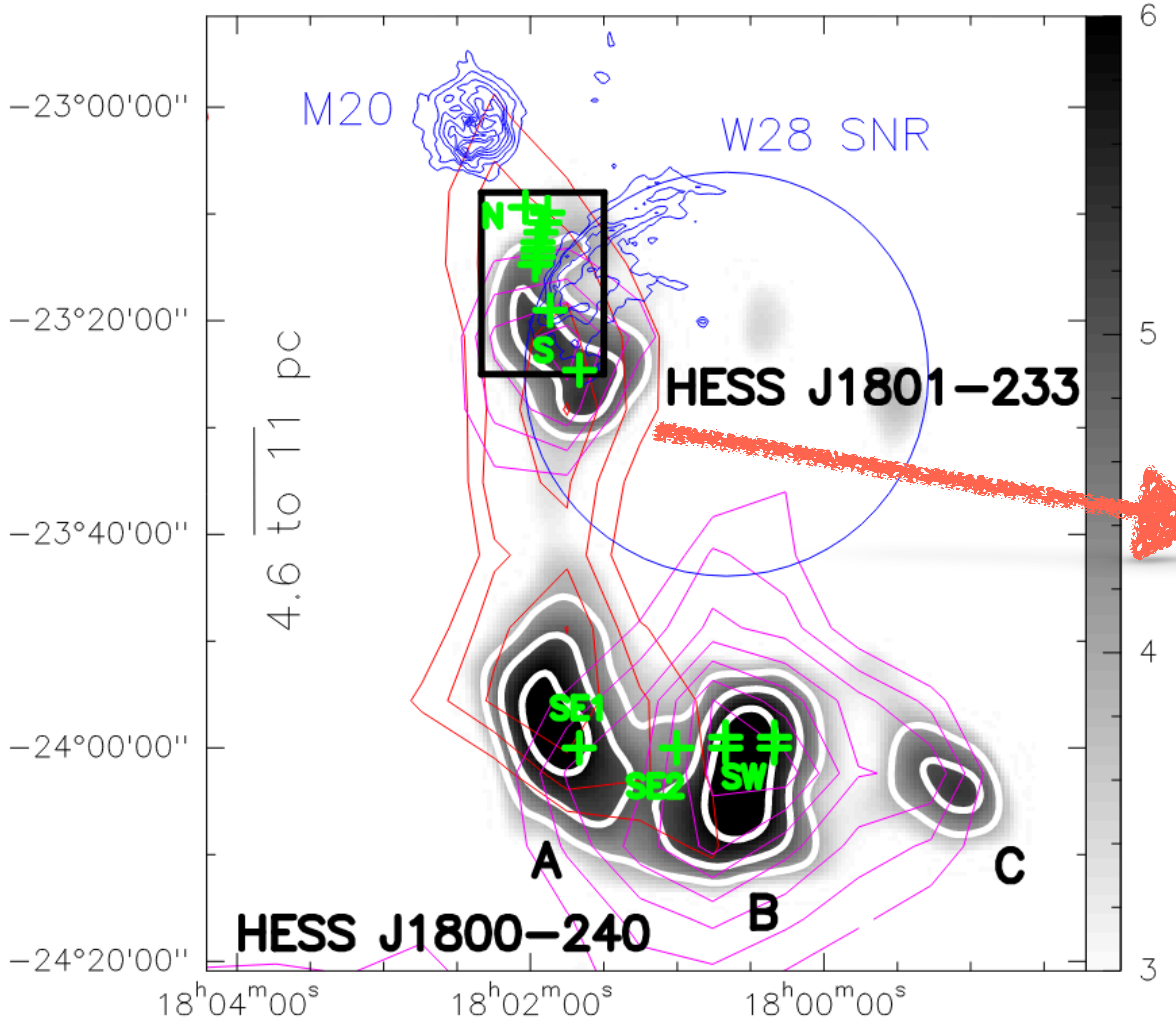
Thank you for your attention

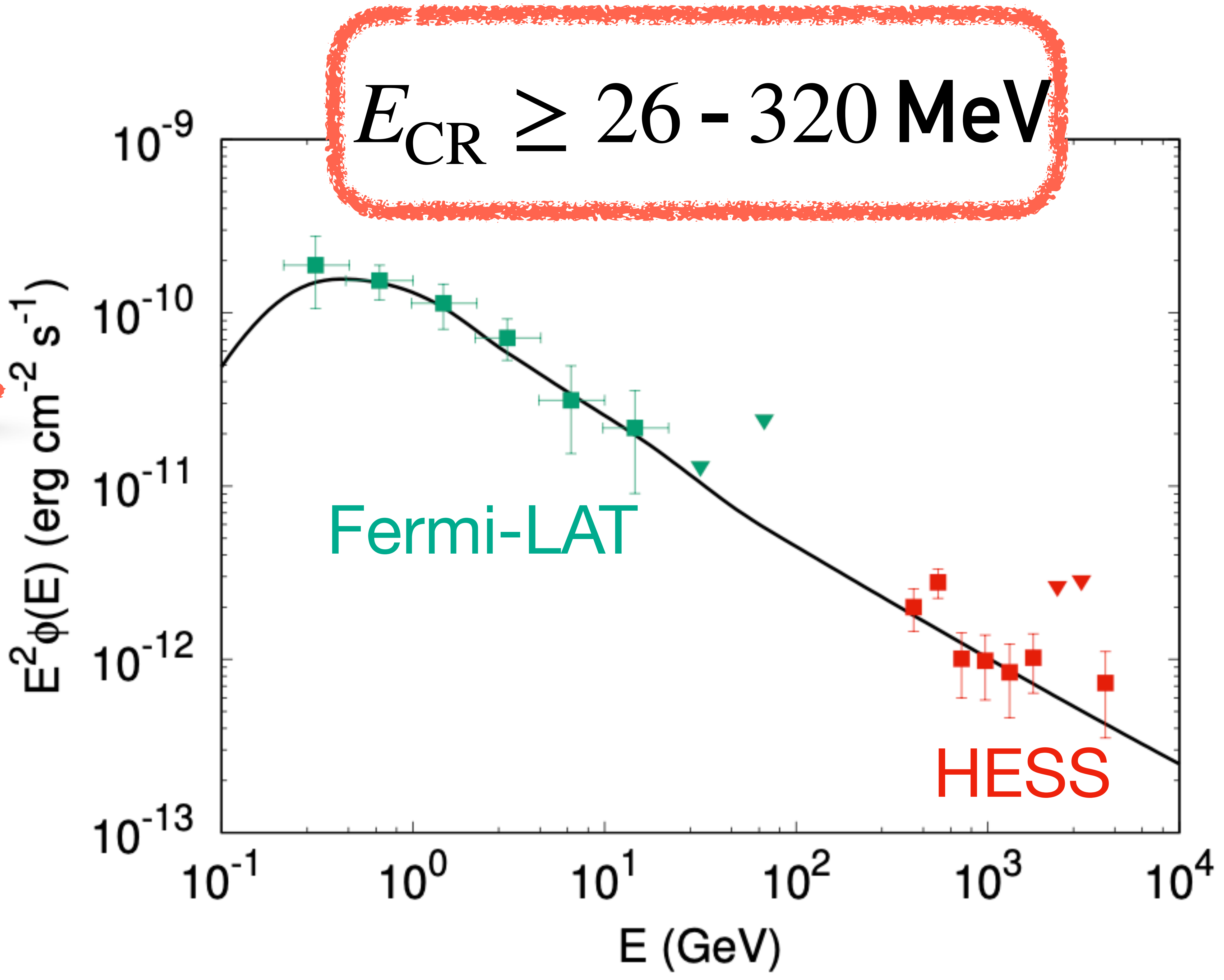
From cosmic-ray transport to physics of the interstellar medium

Vo Hong Minh Phan
LUX, Observatoire de Paris and Sorbonne University
MIS-PLASMAS and ASTRE

With help of Andra Ciardi, Pierre Cristofari, Stefano Gabici, Philipp Mertsch, Giovanni Morlino, Sarah Recchia, Regis Terrier, Jacco Vink, Weipeng Yao, Arno Vanthieghem and many others.

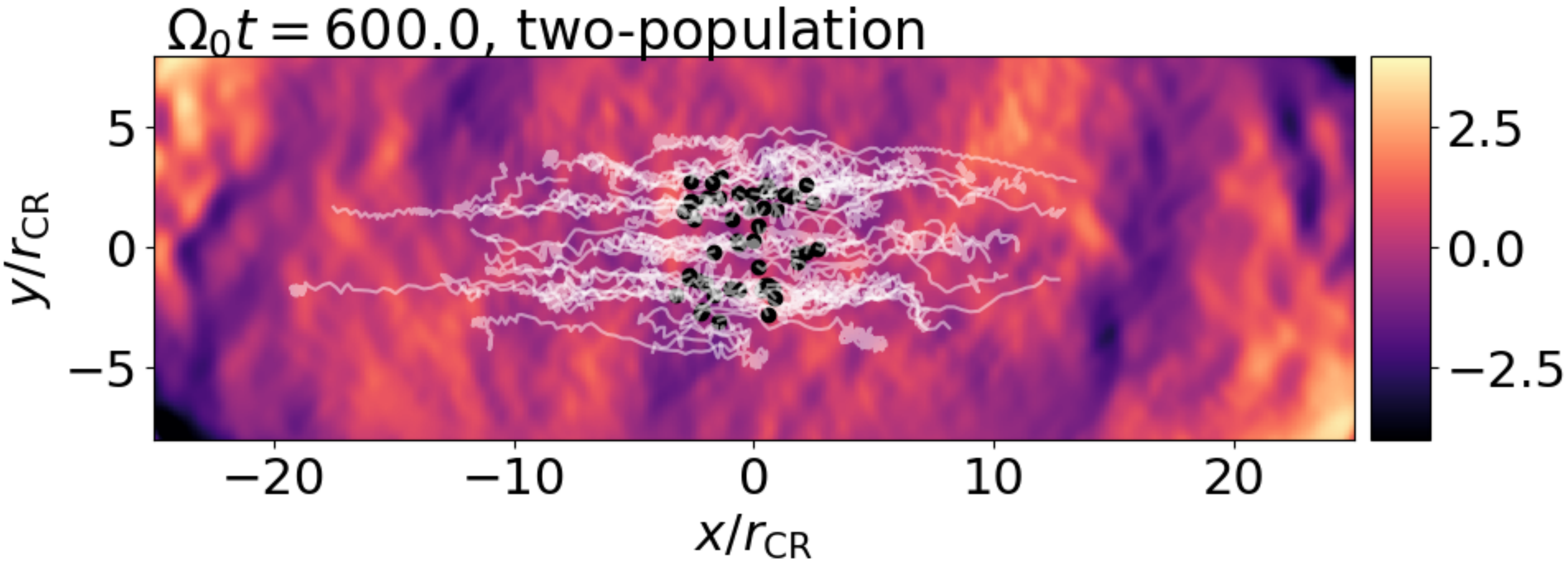
Non-thermal emissions from supernova remnants





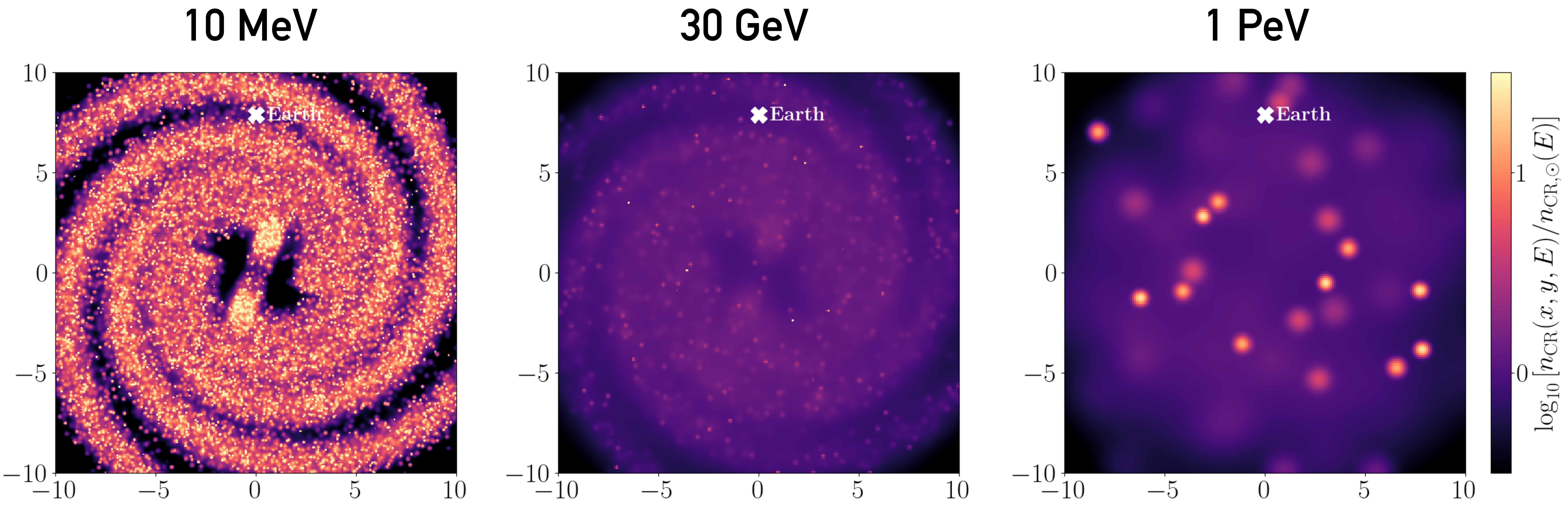
Phan et al., A&A 2020

Cosmic-ray escape with MHD PIC simulations



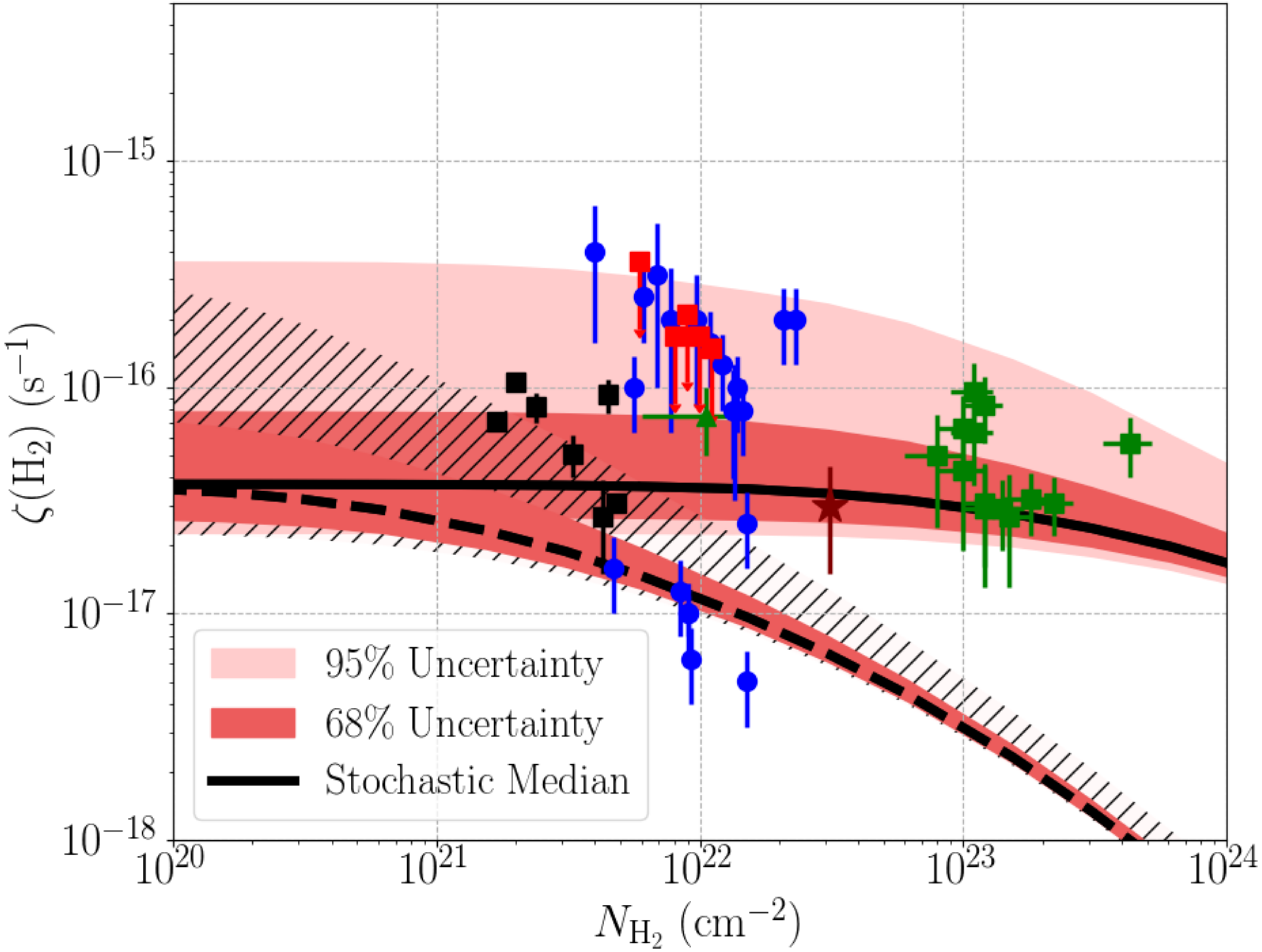
Phan et al. (with Weipeng Yao, Arno Vanthieghem and Andrea Ciardi), in progress

Galactic distribution of cosmic rays



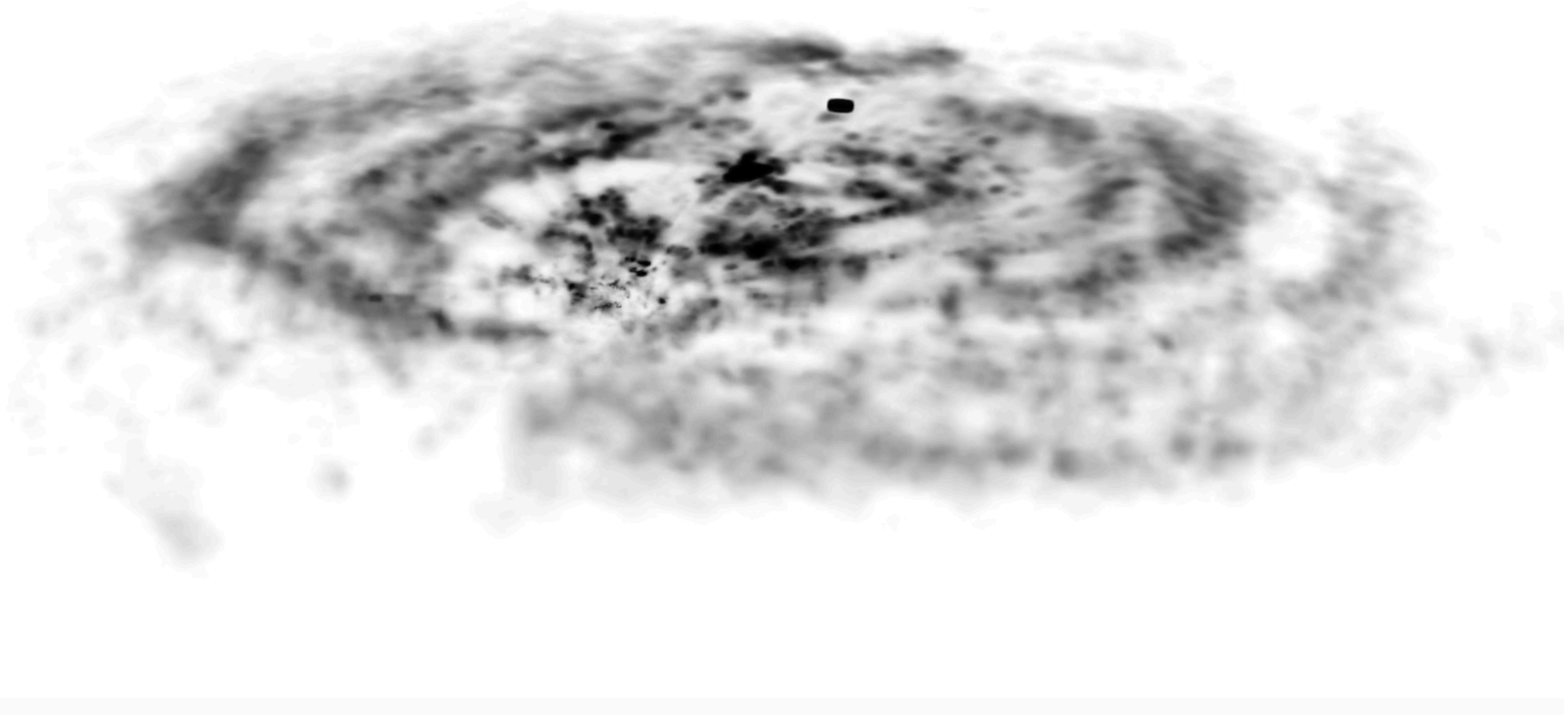
Phan et al., Physical Review Letters 2021, **Phan** et al., Physical Review D 2023

Cosmic-ray ionization rates



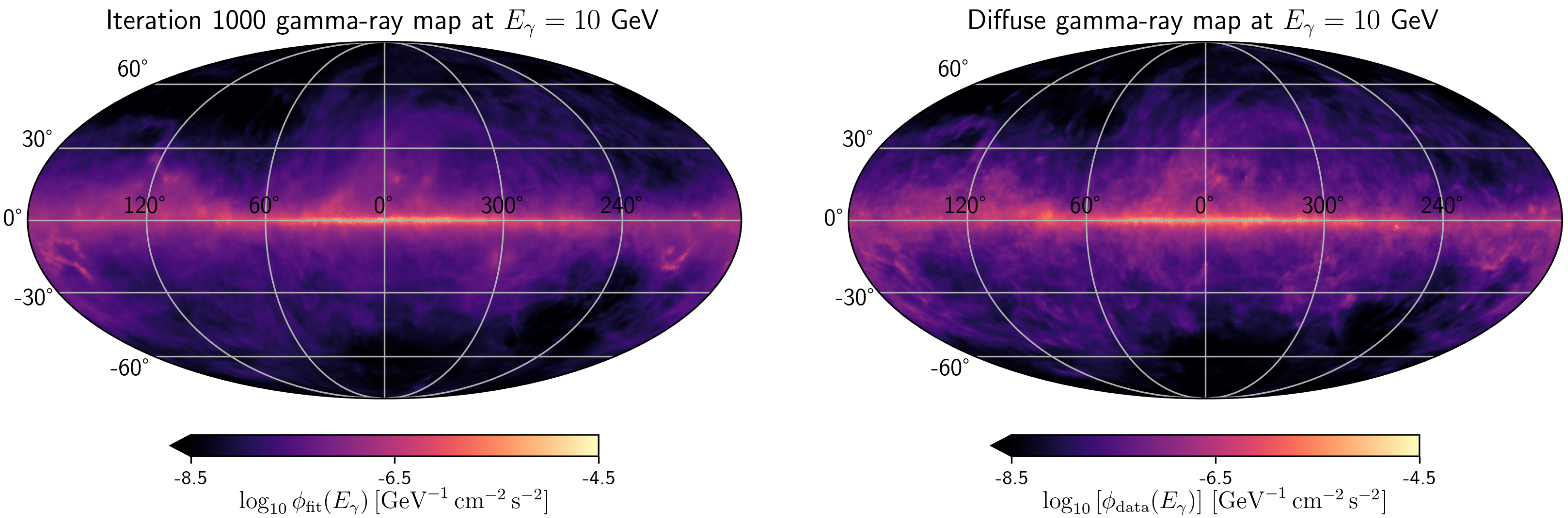
Phan et al. in progress, **Phan** et al., Physical Review Letters 2021, **Phan** et al., Physical Review D 2023

3D reconstructed gas maps



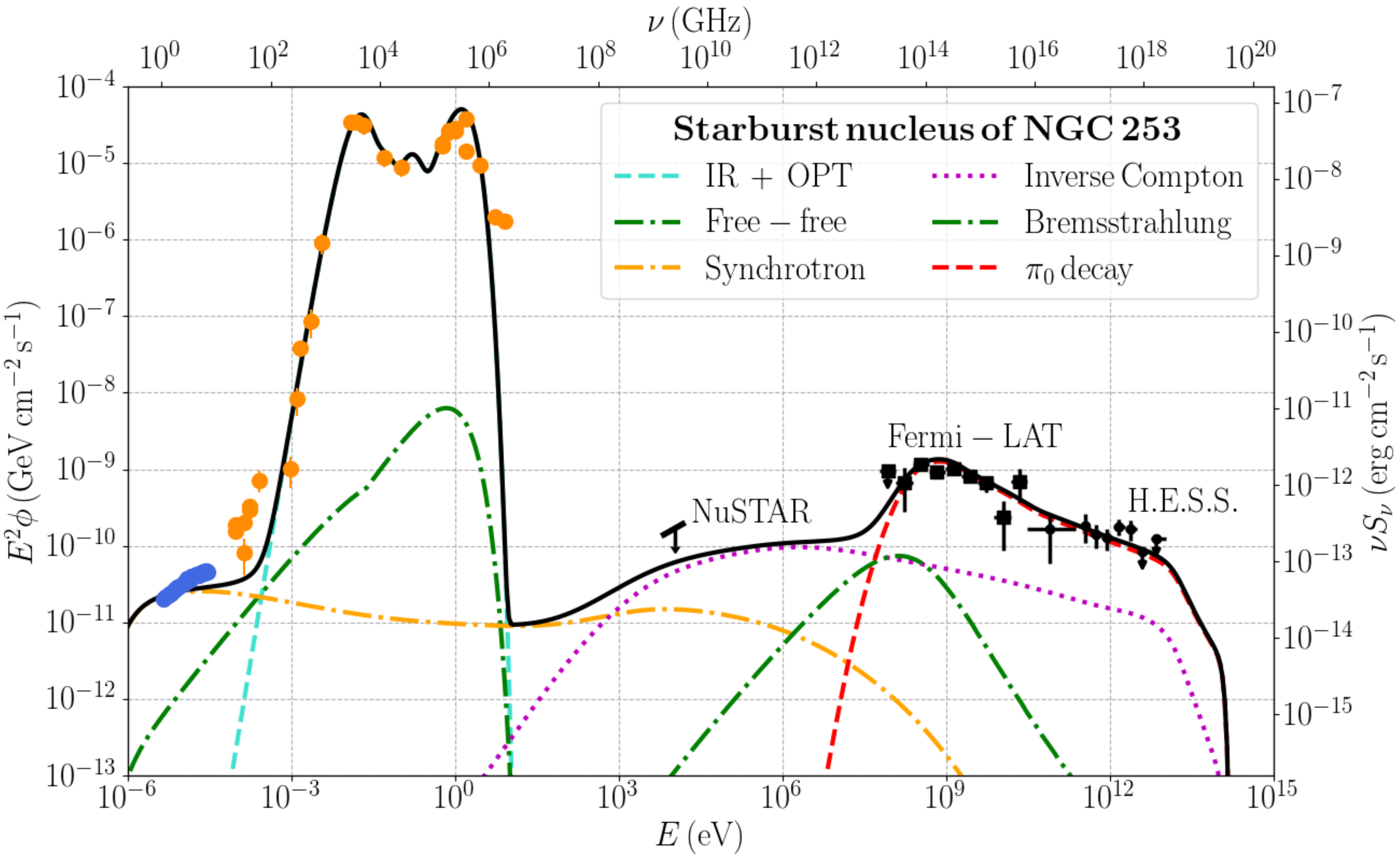
Mertsch & **Phan**, A&A, 2023, Söding (with **Phan**) et al., A&A, 2024, https://zenodo.org/records/12578443
Credit: animation made by Laurin Söding

Galactic diffuse gamma-ray emissions



Phan et al., in progress

Non-thermal emissions from starburst galaxies



Phan and Peretti et al. (with Pierre Cristofari), MNRAS 2024

Modelling pulsars in Mixed Morphology Supernova Remnants

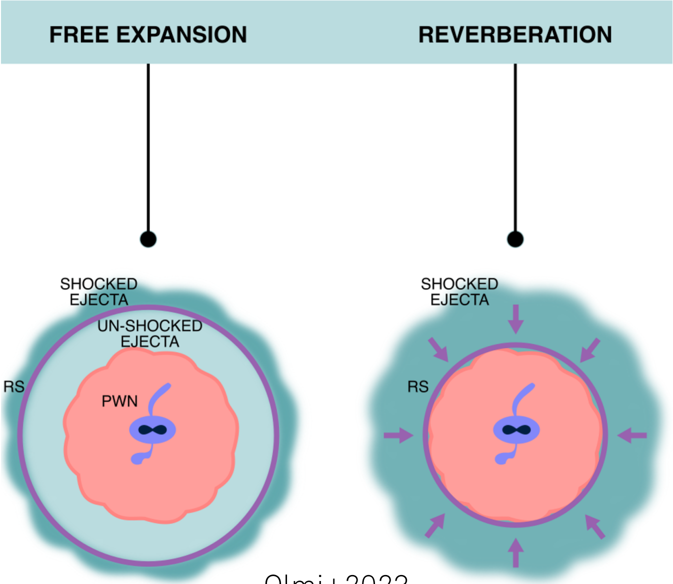
Gauri Patti (Observatoire de Paris, Université PSL)

Advisors: Dr. Zakaria Meliani (LUX), Dr. Dominique M.-A. Meyer (Institute of Space Sciences, Barcelona)

14 March, 2025

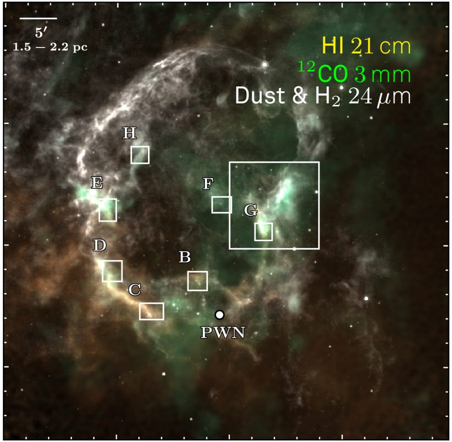
Observatoire de Paris | PSL

Evolution of Supernova Remnants



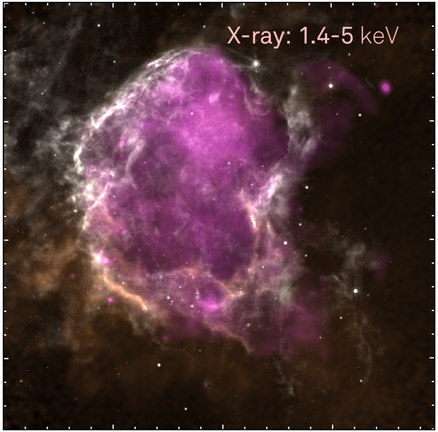
Olmi+2023

Mixed Morphology Supernova Remnants



IC443; Lee+2008,2012

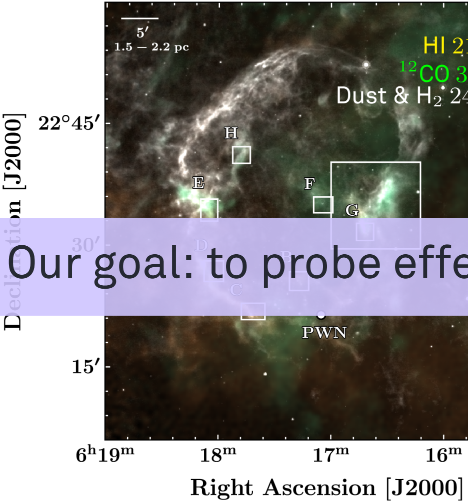
Radio like shell



Greco+2018

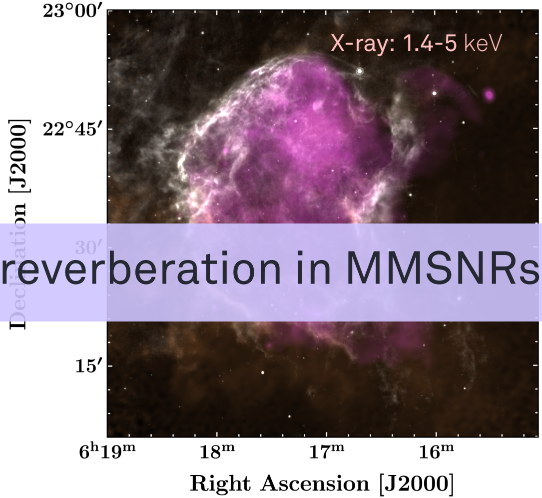
X-ray bright cavity

Mixed Morphology Supernova Remnants



IC443; Lee+2008,2012

Radio like shell

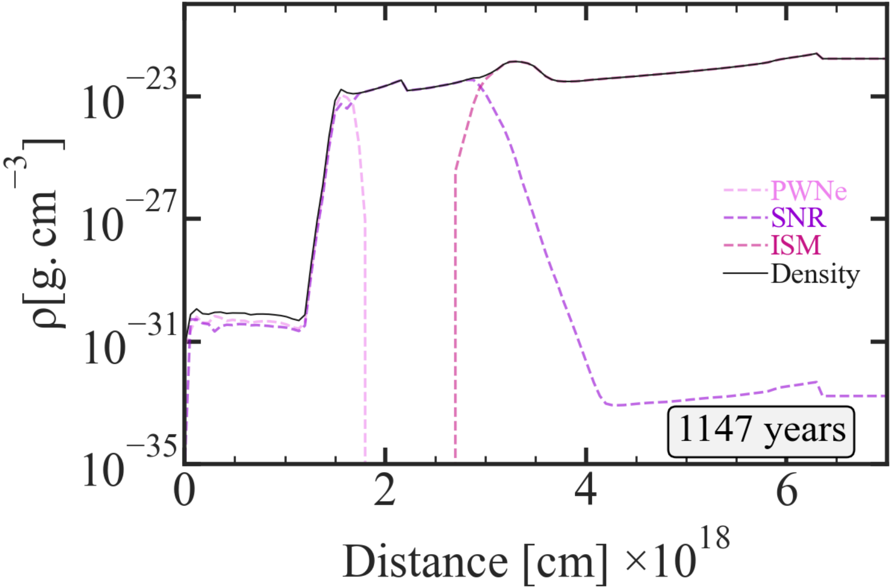


Greco+2018

X-ray bright cavity

Our goal: to probe effects of reverberation in MMSNRs

1D model: PW, SNR & ISM TOGETHER!



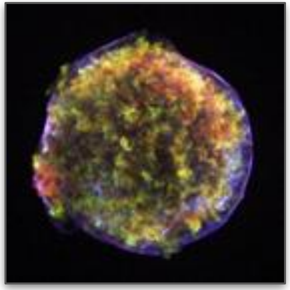
Thank you!
Questions?

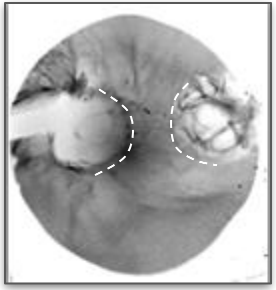
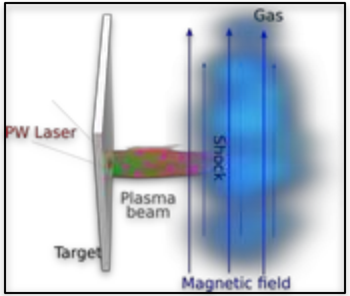
Particle stochastic acceleration in laser-driven magnetized Rayleigh-Taylor instability

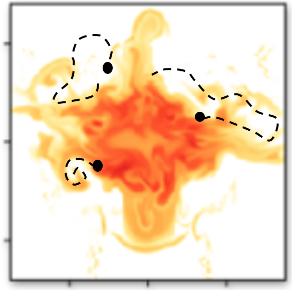
Weipeng Yao, Thershi Seebaruth, Arno Vanthieghem, Andrea Ciardi

LUX starting day

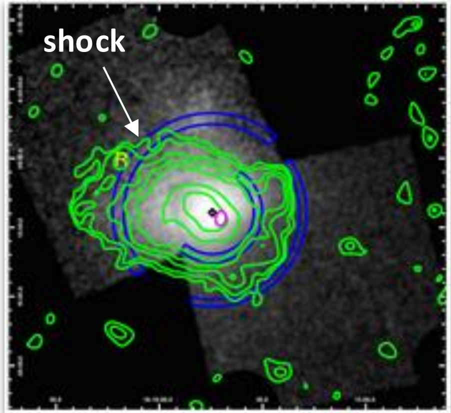
March 14, 2025





Shocks in the Universe & Laboratory



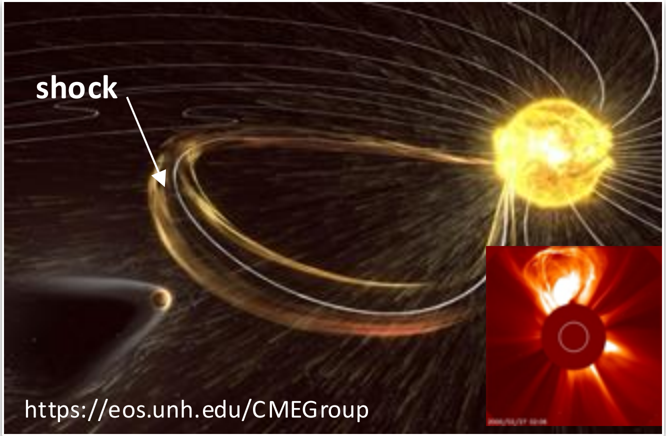
S. Thölken et al 2021 Discovery of large-scale shock fronts in the A2163 galaxy cluster

Galaxy clusters

Size ~ 10^{19} km

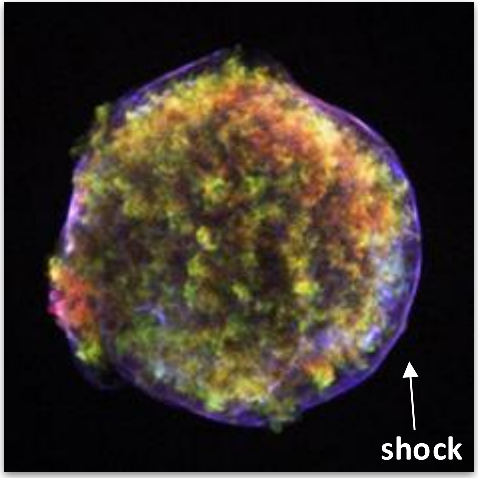
Coronal mass ejections

Size ~ 10^{8} km



Supernova remnants

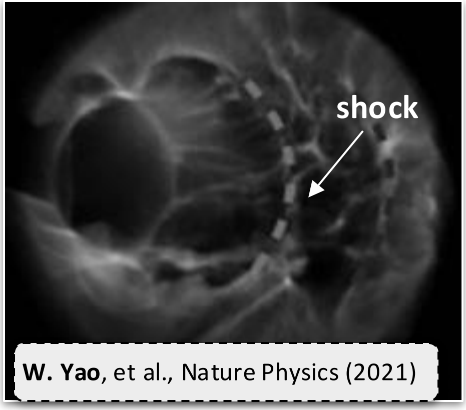
Size ~ 10^{13} km



NASA/CXC/Rutgers/J.Warren & J.Hughes et al.

ns-Laser driven plasmas

Size ~ 10^{-5} km ~ 1 cm



Credit: Andrea Ciardi

Laboratory Astrophysics on high-energy lasers

High-energy & Long-pulse lasers: kilo to Mega joule of energy within ns pulses ($10^{12\text{-}14}$ W)

VULCAN

NIF

LULI2000

LMJ

OMEGA(-EP)

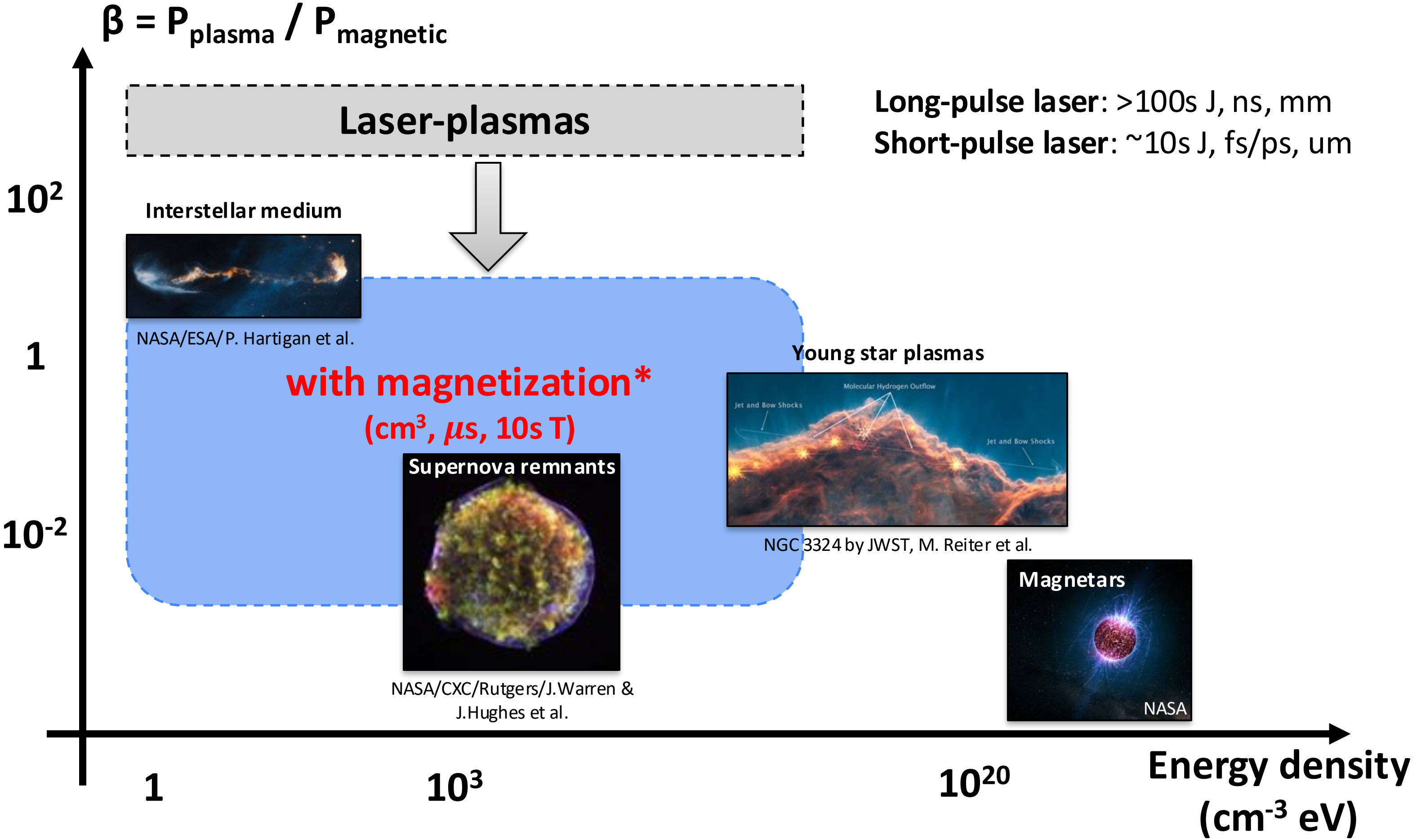
CAEP

GEKKO

- ❑ Fusion energy
- ❑ Material science
- ❑ Basic plasma physics
- ❑ **Laboratory astrophysics *(~ 40% of total beam time*)***
- ❑ …

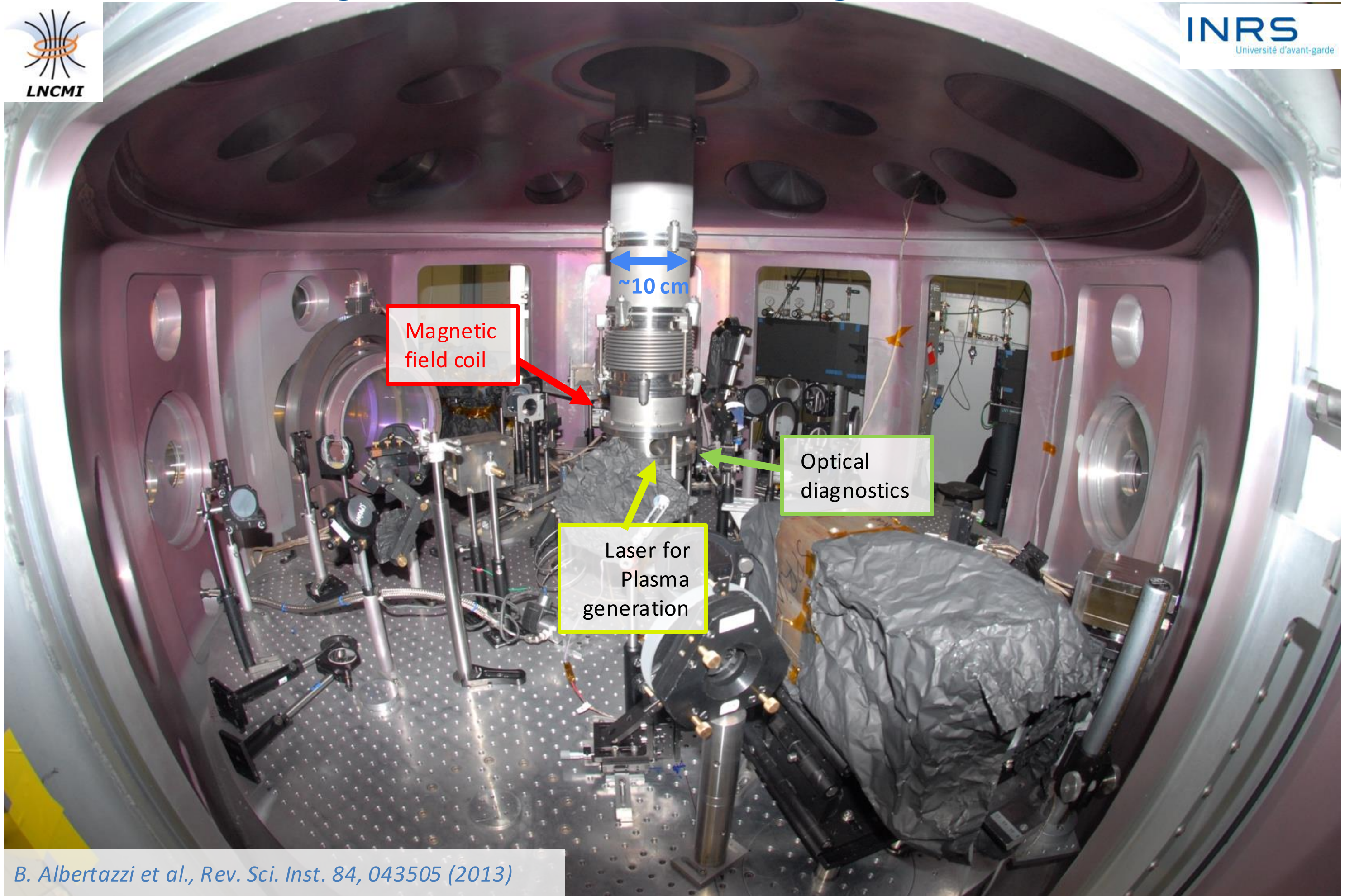
**B. A. Remington, "Exploring the universe through Discovery Science on NIF", 2021 IEEE International Conference on Plasma Science (ICOPS)*

Plasmas at extreme conditions via laser & magnetic fields



B. Albertazzi et al., Rev. Sci. Inst. 84, 043505 (2013)

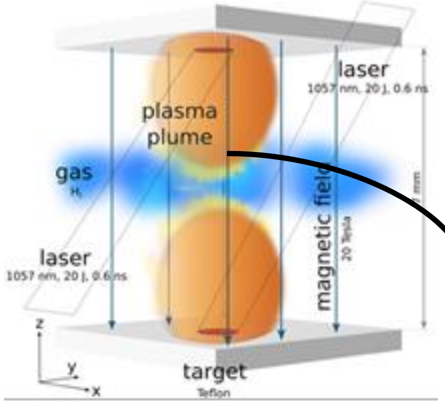
Our solution for large-scale external magnetization



B. Albertazzi et al., Rev. Sci. Inst. 84, 043505 (2013)

Particle acceleration in magnetized Rayleigh-Taylor instability

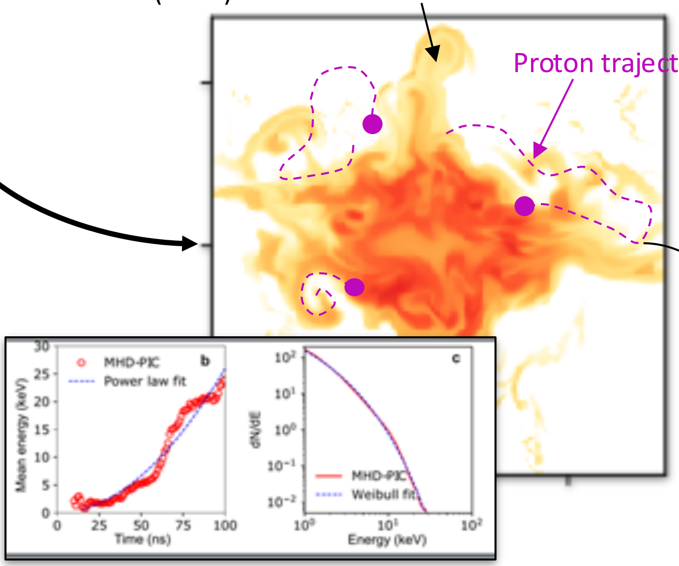
Experimental setup



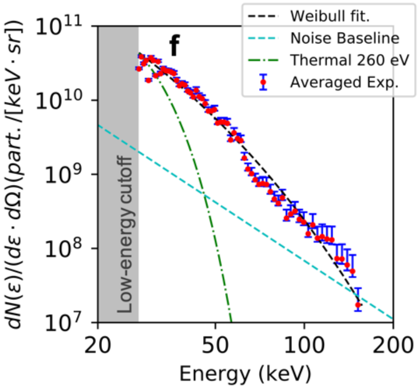
3D MHD-PIC simulations

GORGON

(MHD)



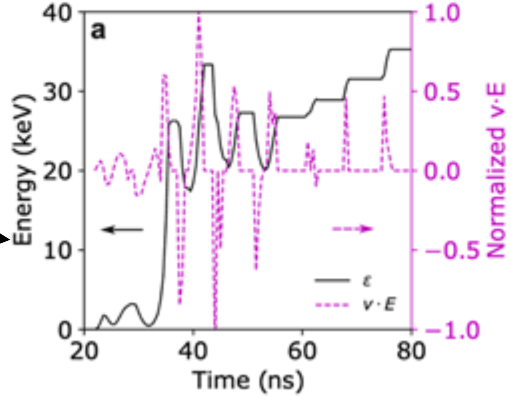
Experimental measurements



$$N(E) = A(E/E_\tau)^{\beta-1}e^{-(E/E_\tau)^\beta}$$

Pallocchia+2017

Stochastic acceleration mechanism



$$\mathbf{E} = -\mathbf{u} \times \mathbf{B} + \eta \mathbf{j} + \ldots ?$$

W. Yao, et al., to be submitted

Question time

ASTRE Team

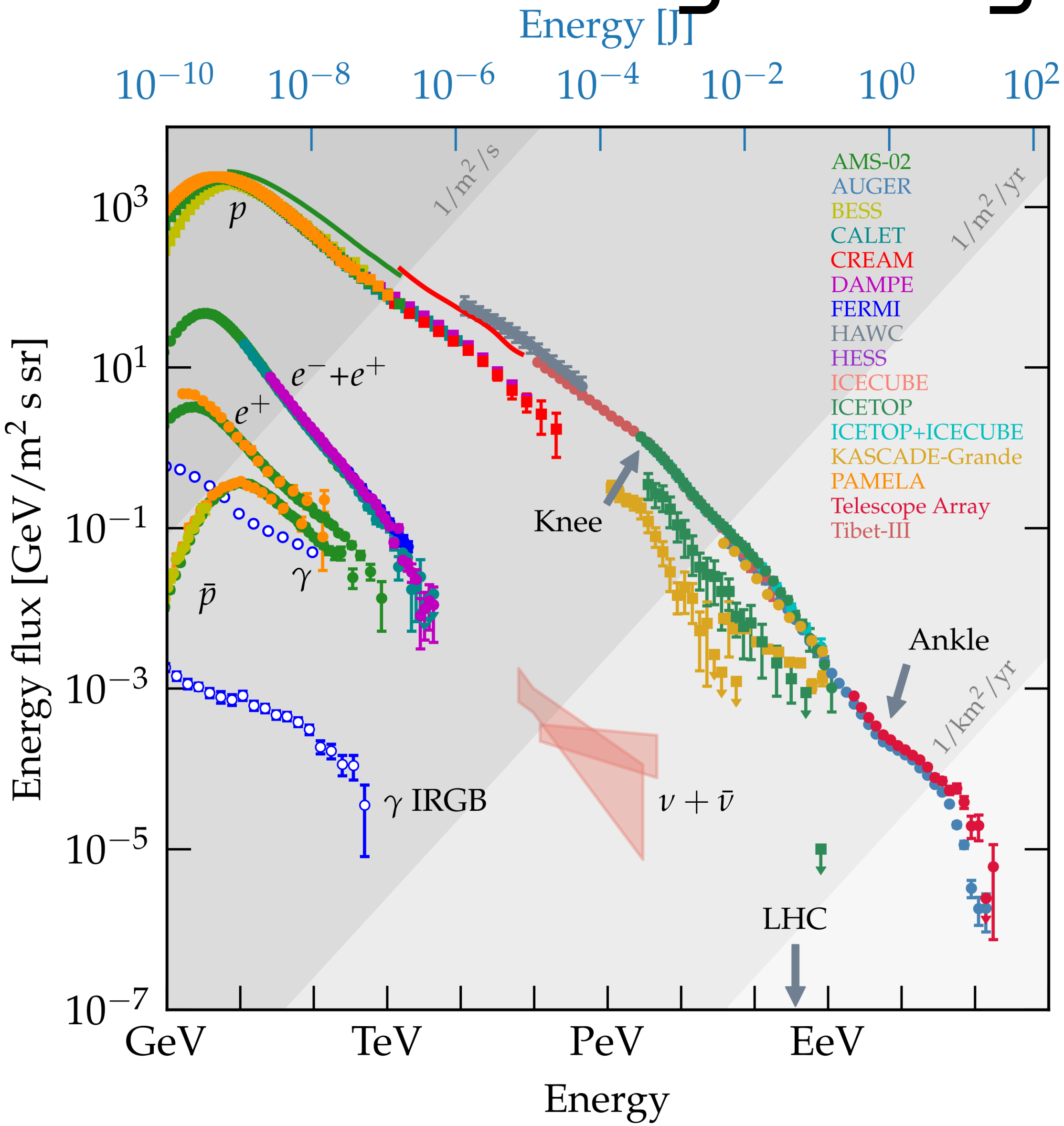
Particle acceleration at Ultra-fast Outflows (UFO) and relativistic jets of AGNi

Team : ASTRE

Baptiste Le Nagat Neher
With Pierre Cristofari et Andreas Zech

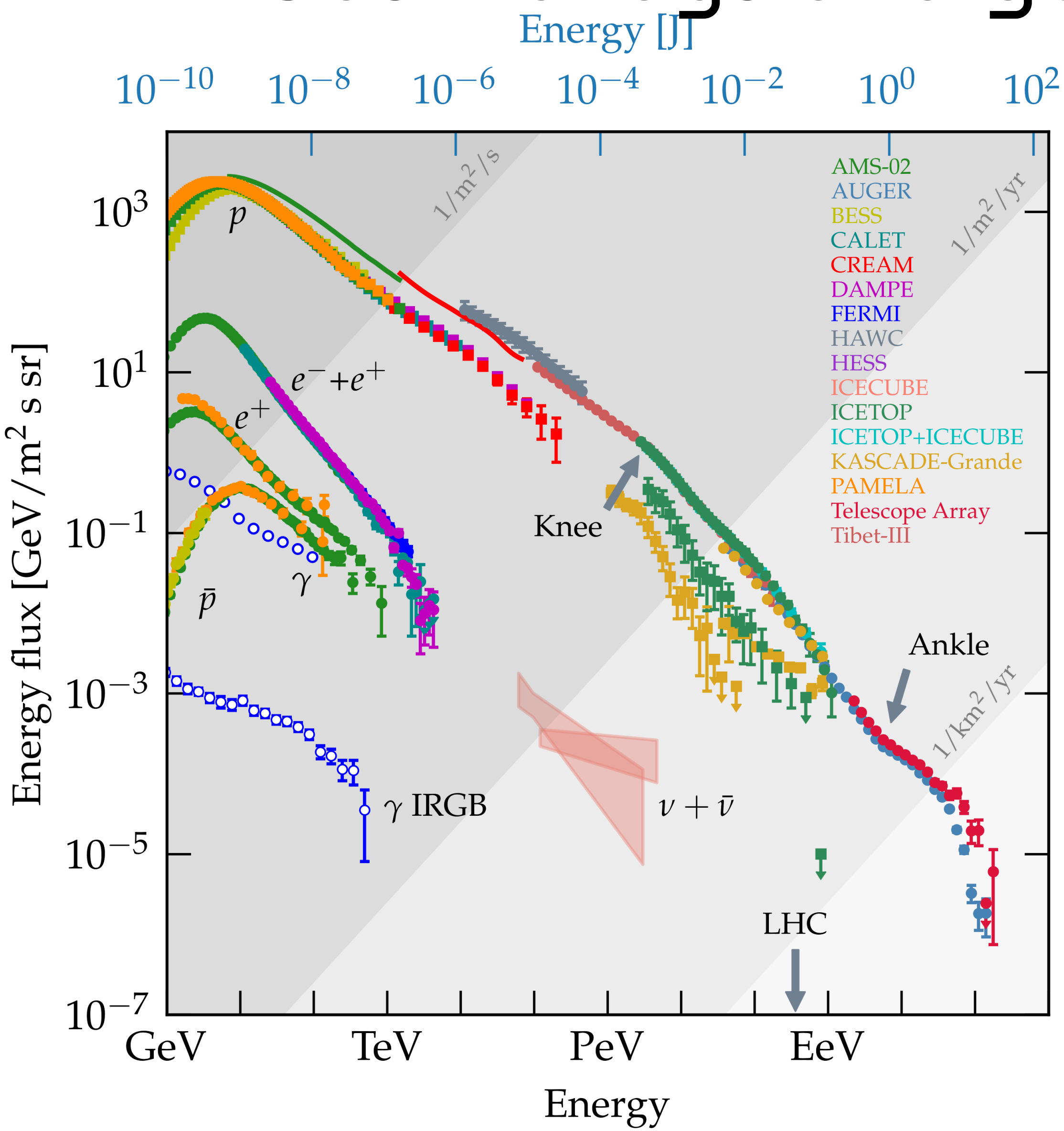
π Day 2025

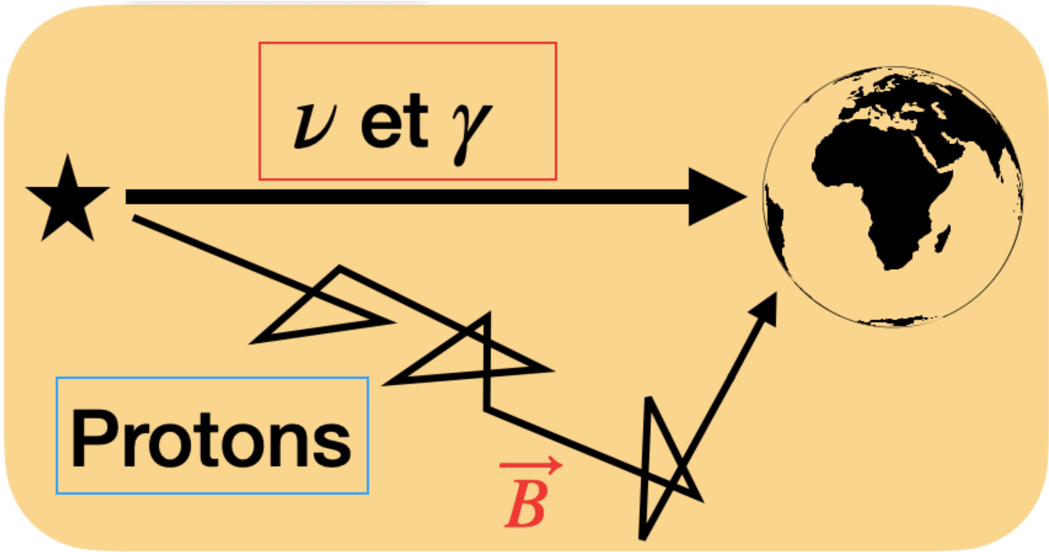
Cosmic rays and gamma ray astronomy



[Evoli 2021]

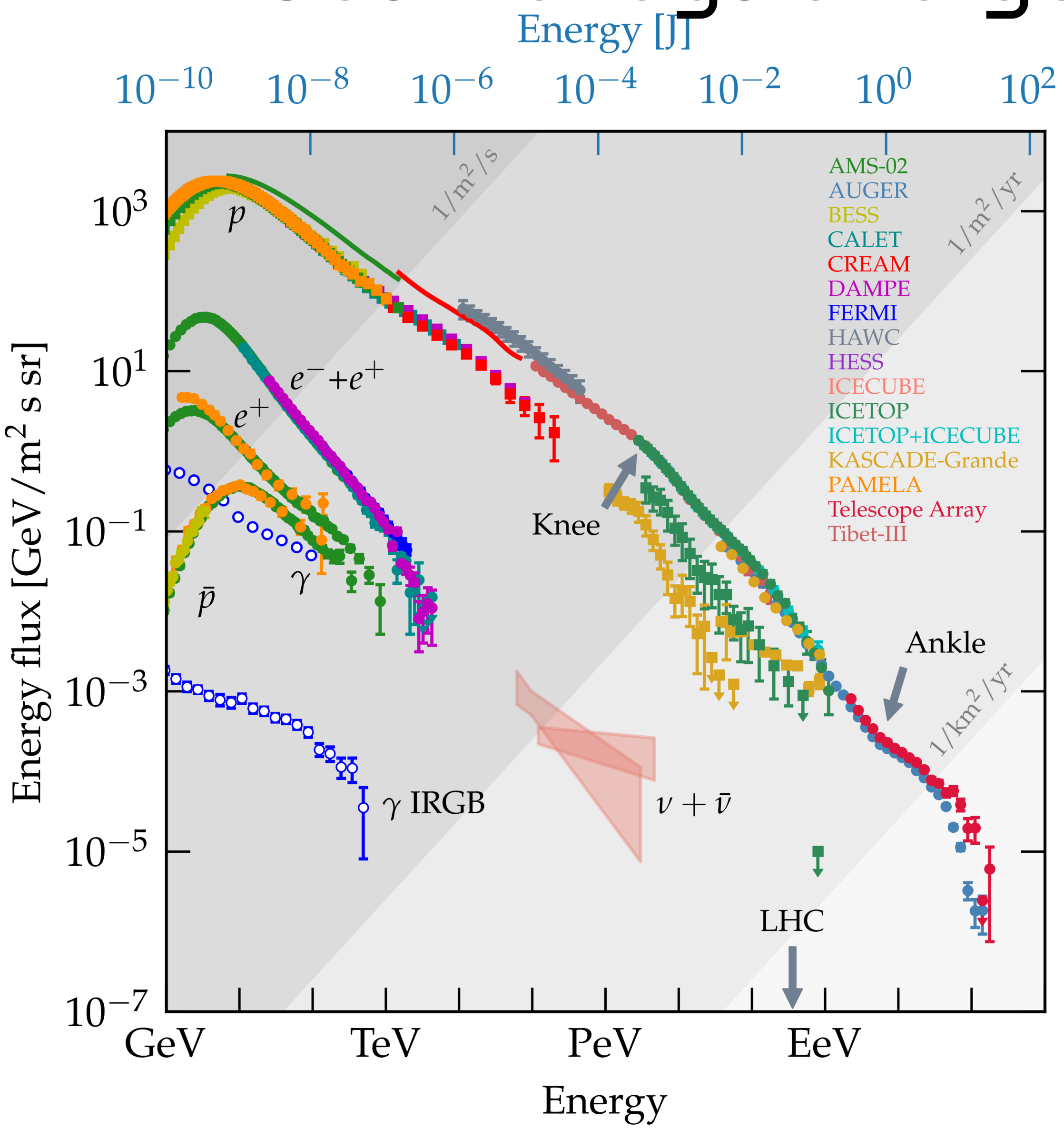
Cosmic rays and gamma ray astronomy

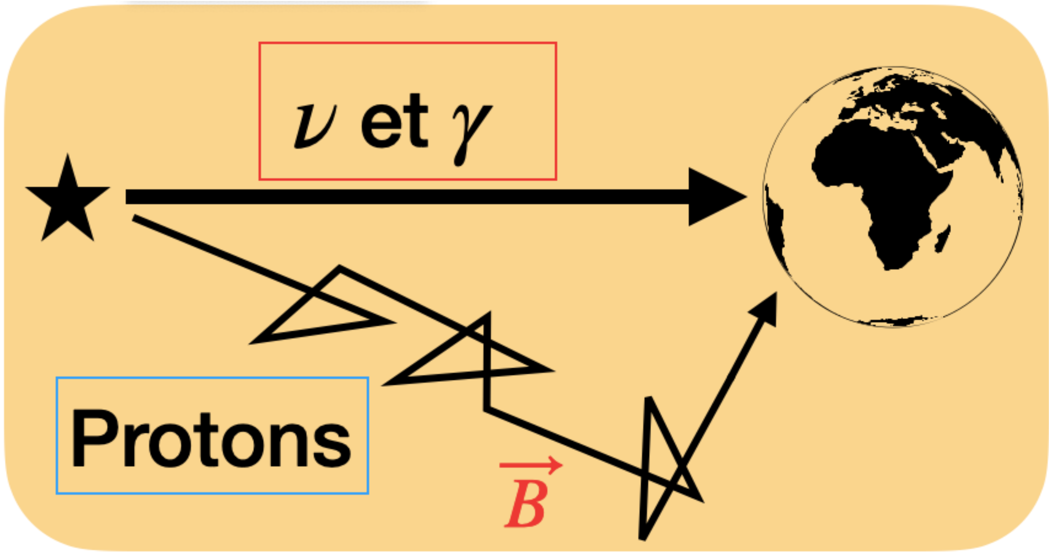




[Evoli 2021]

Cosmic rays and gamma ray astronomy

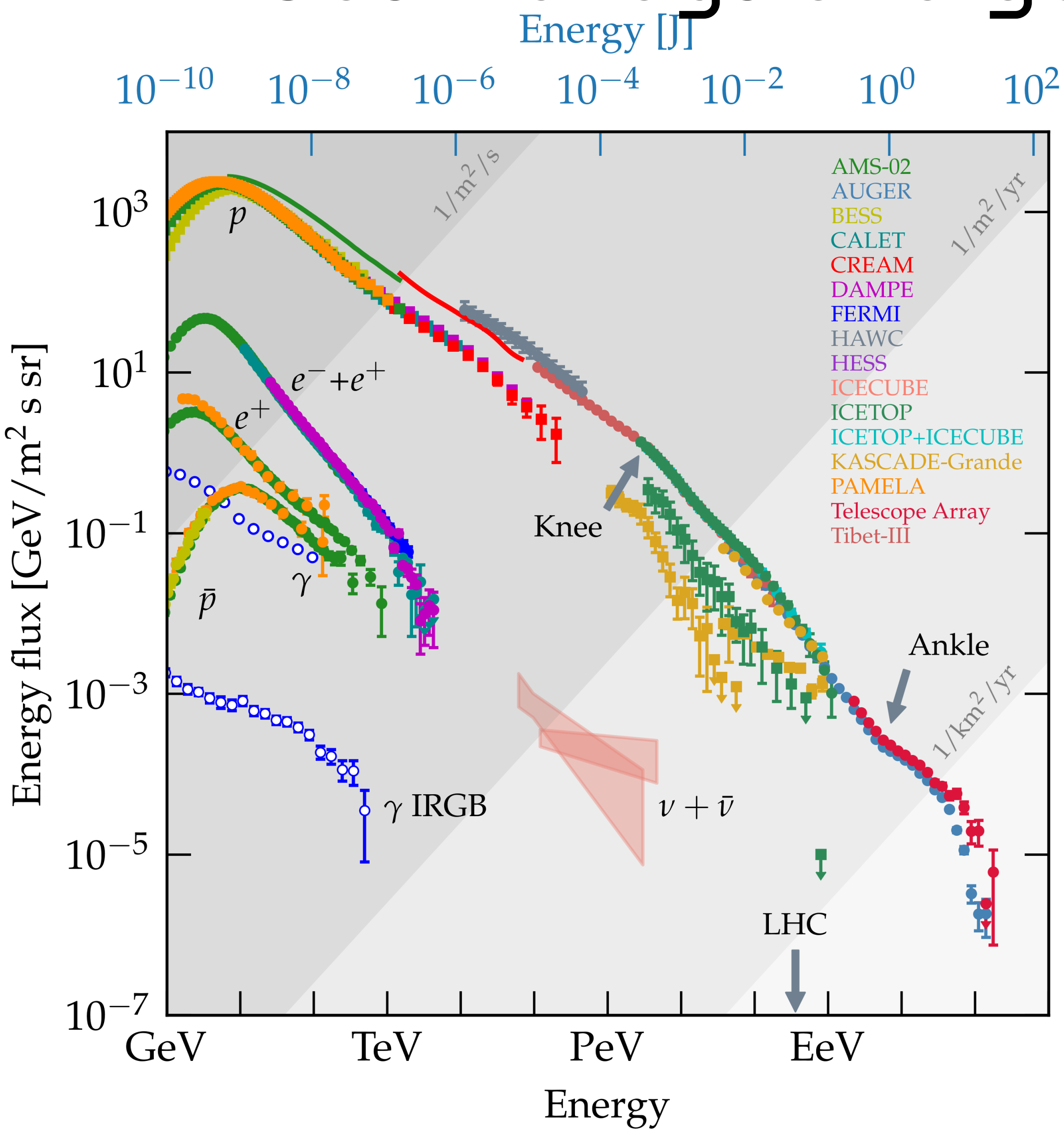




Where are cosmic rays produced ?

[Evoli 2021]

Cosmic rays and gamma ray astronomy

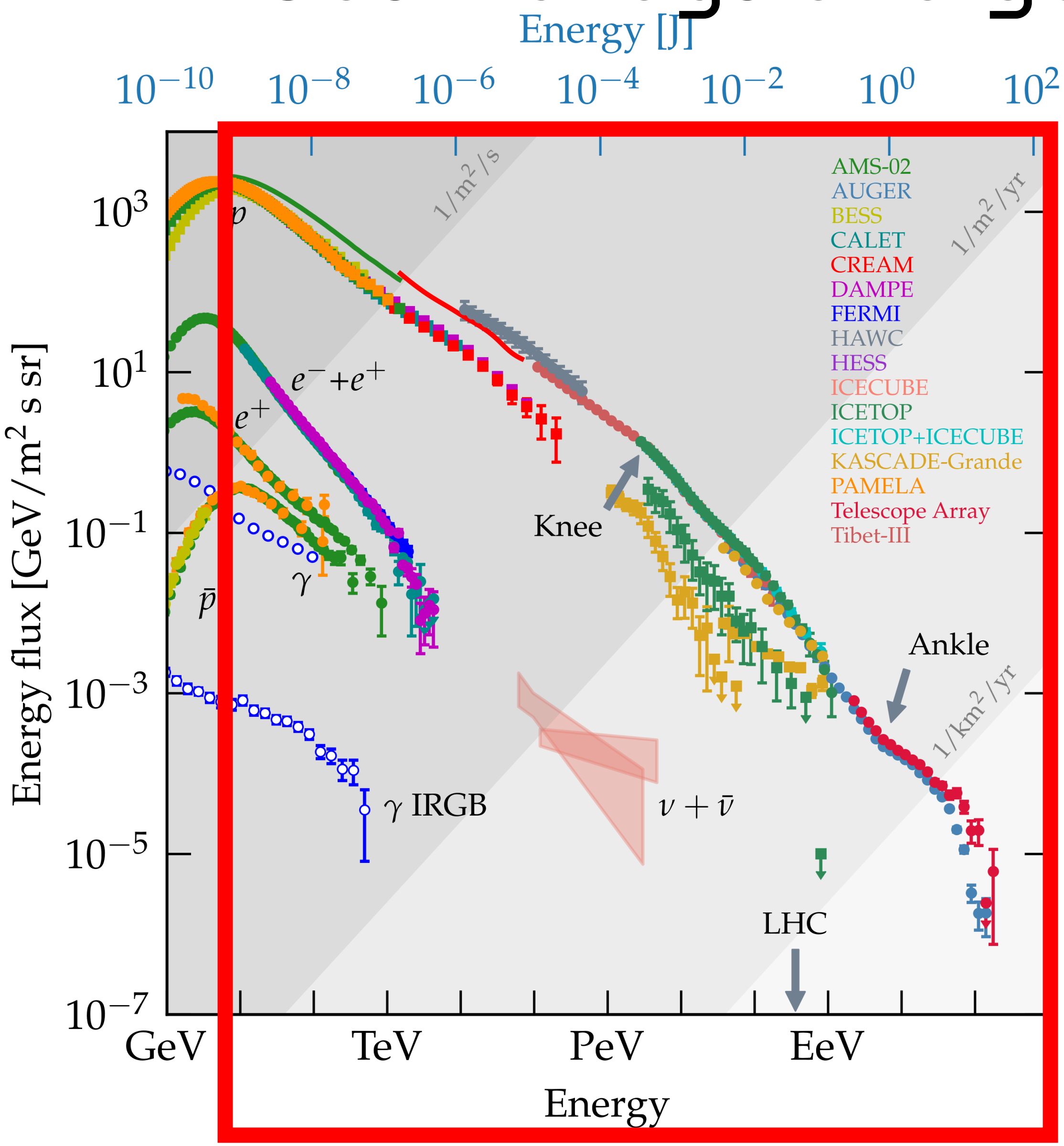


$$p + p \rightarrow \pi^0 \rightarrow \gamma$$

CR ISM

[Evoli 2021]

Cosmic rays and gamma ray astronomy



$$p + p \rightarrow \pi^0 \rightarrow \gamma$$

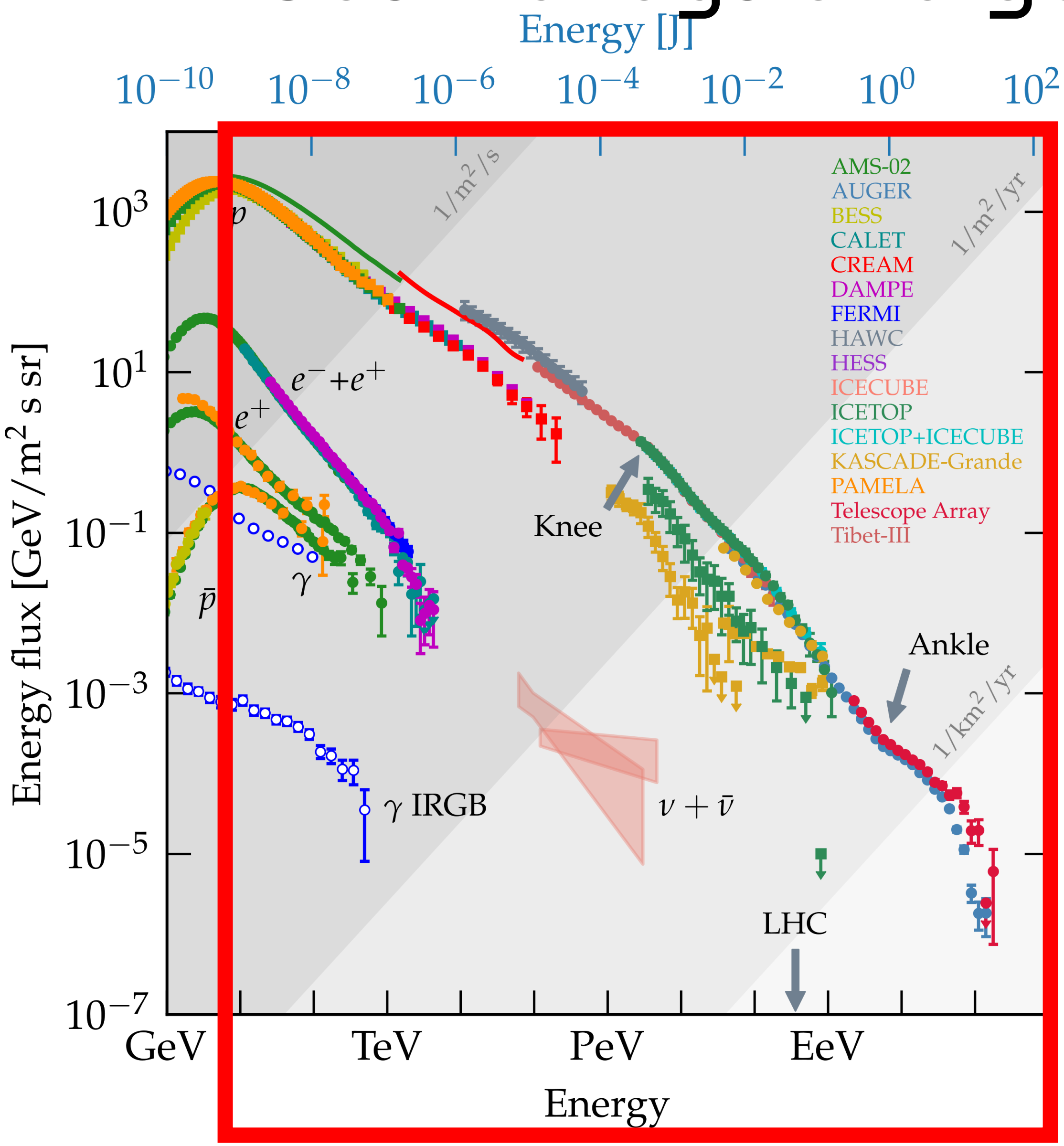
CR ISM

$$E_\gamma \approx \frac{E_p}{10}$$

Gamma ray astronomy

[Evoli 2021]

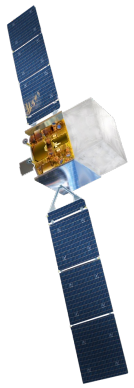
Cosmic rays and gamma ray astronomy

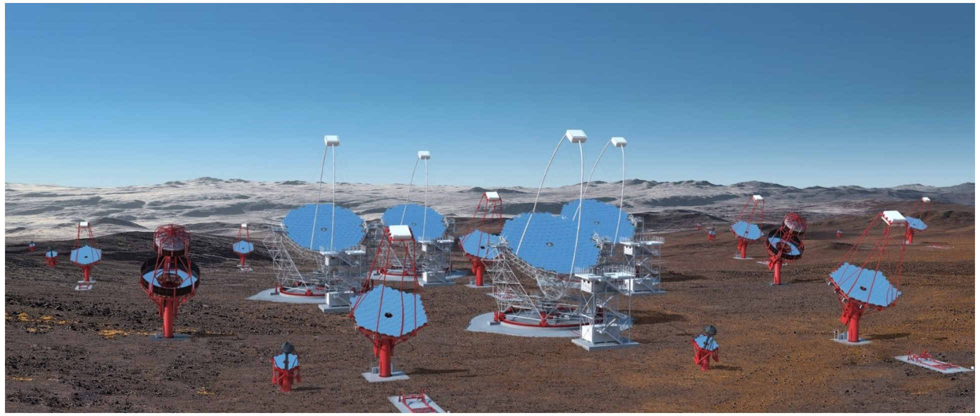


$$p + p \rightarrow \pi^0 \rightarrow \gamma$$

CR ISM

$$E_\gamma \approx \frac{E_p}{10}$$

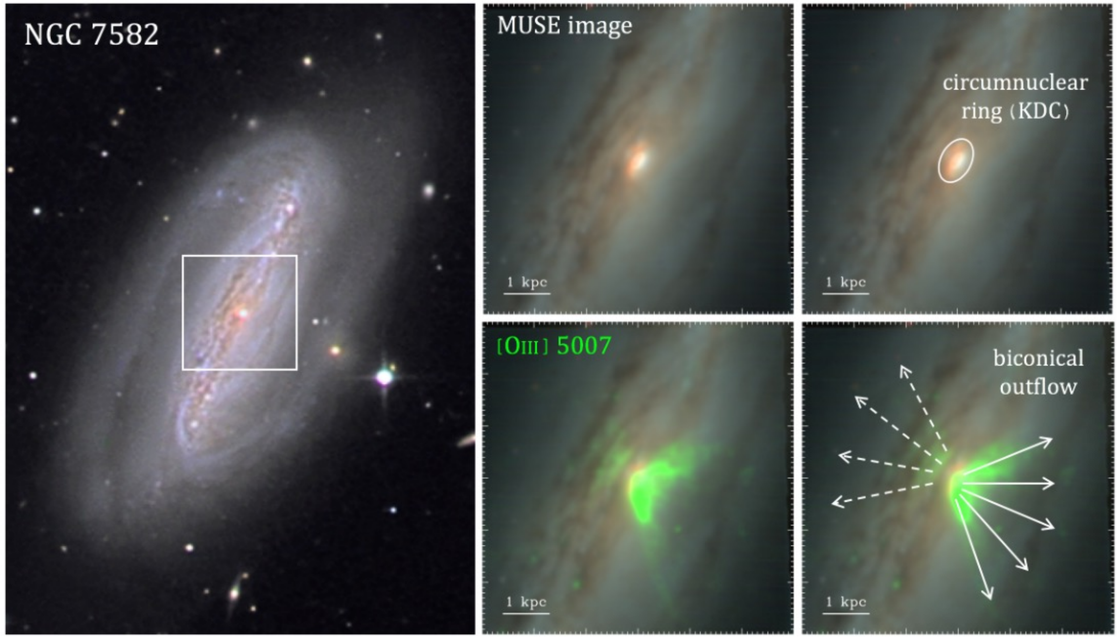




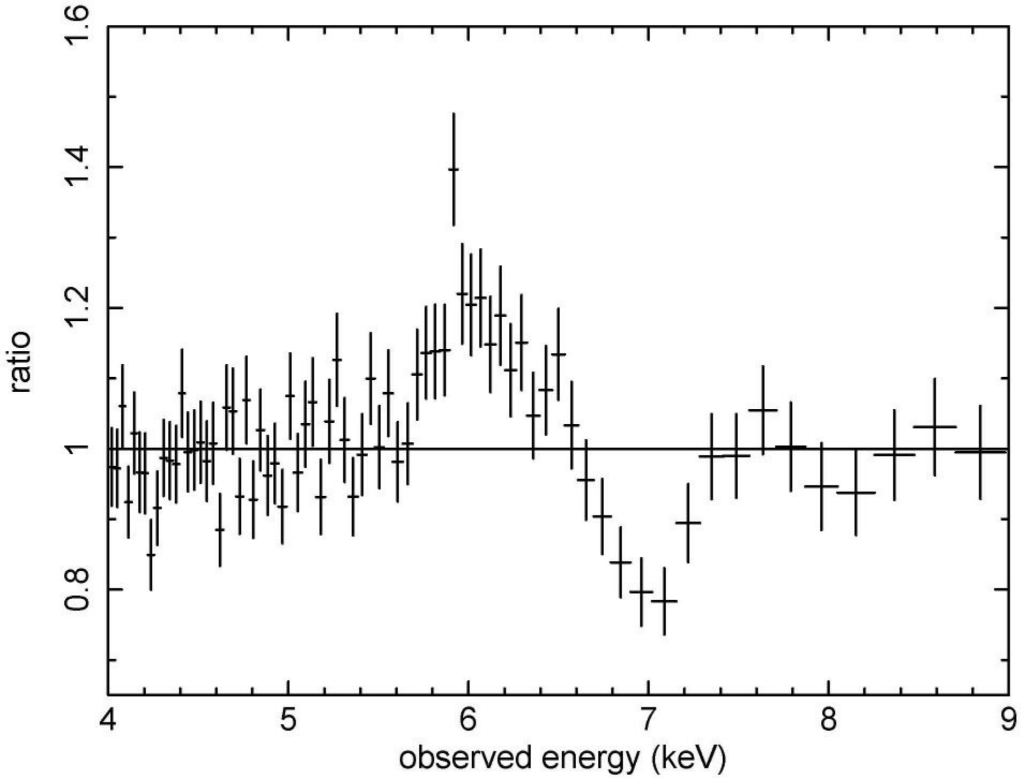
Gamma ray astronomy

[Evoli 2021]

Ultra Fast Outflows



[Juneau et al. 2022]

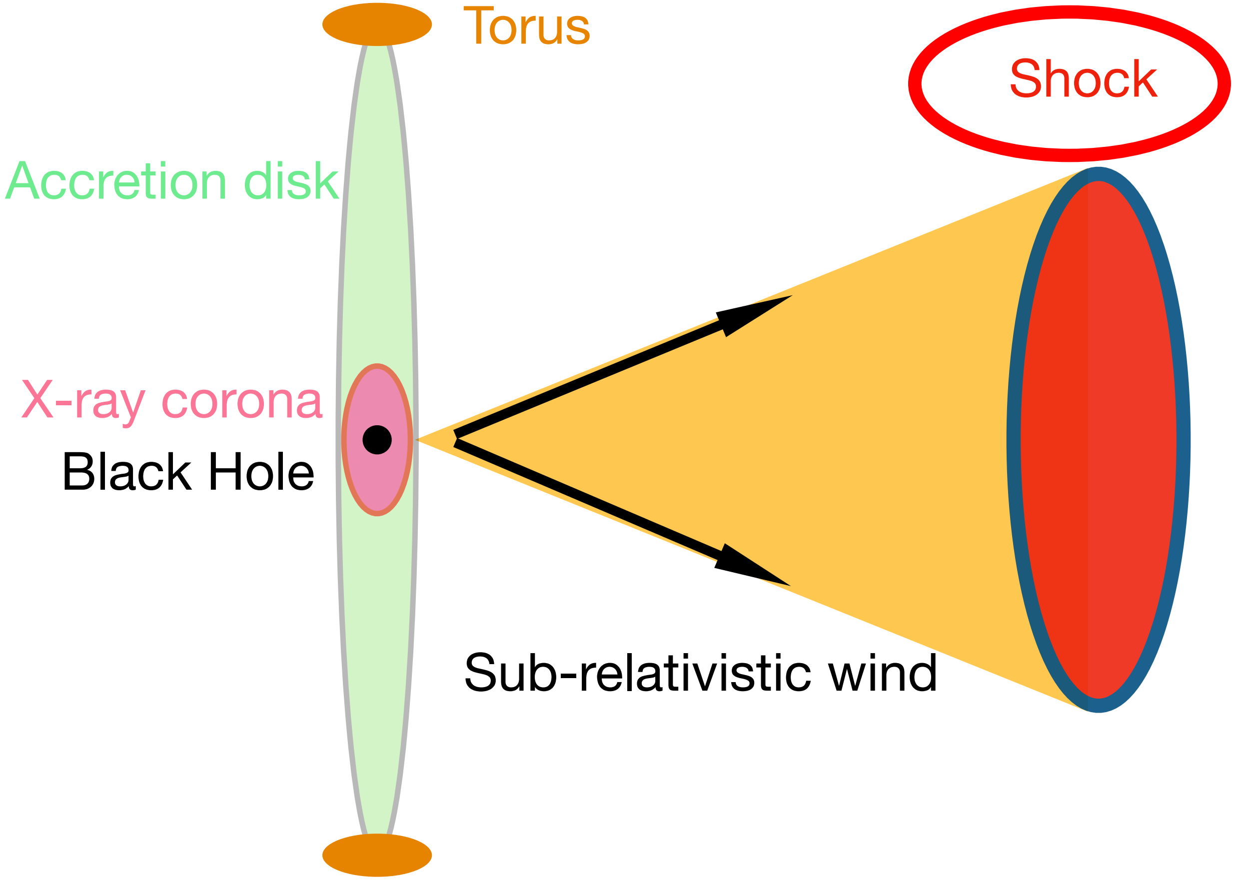


Blueshifted FE XXV absorption lines in X-rays

[Pounds et al. 2009]

Particle acceleration in UFO

Blueshifted absorption lines in X-rays



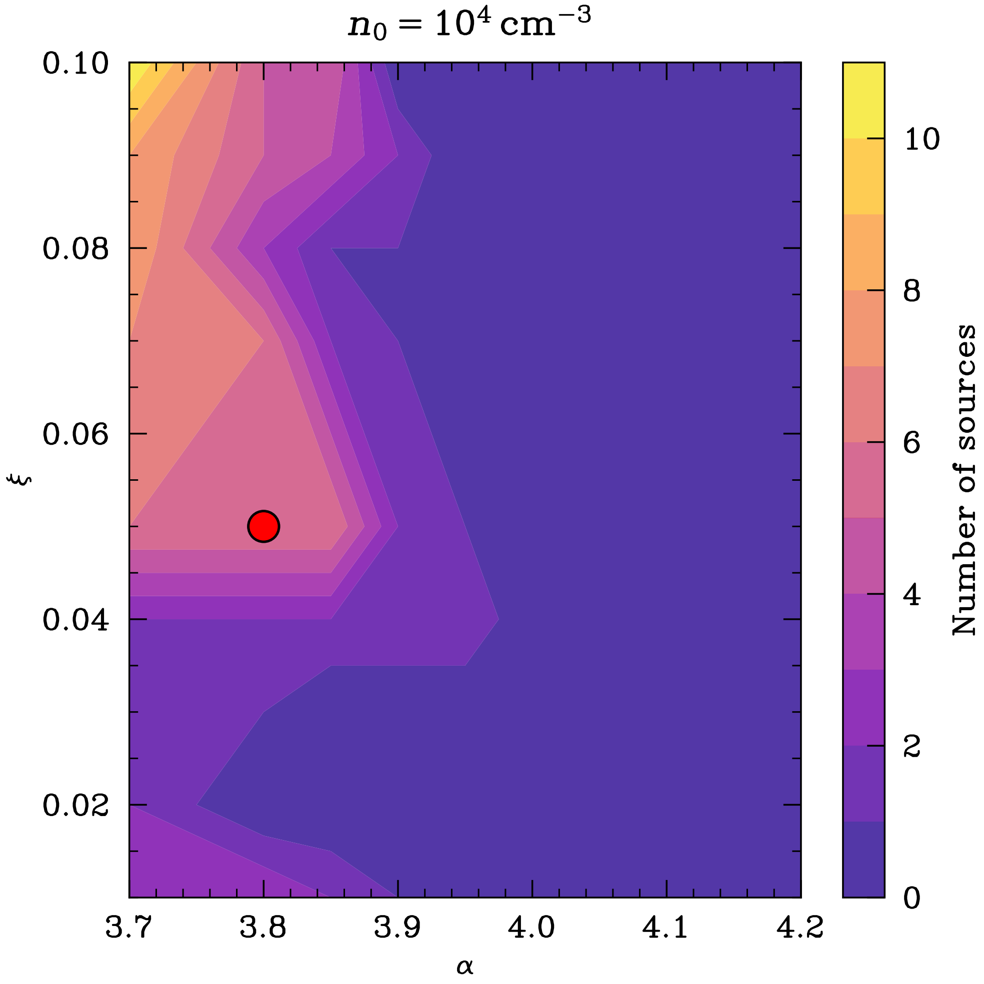
$$0.1 \lesssim \frac{u_{sh}}{c} \lesssim 0.5$$

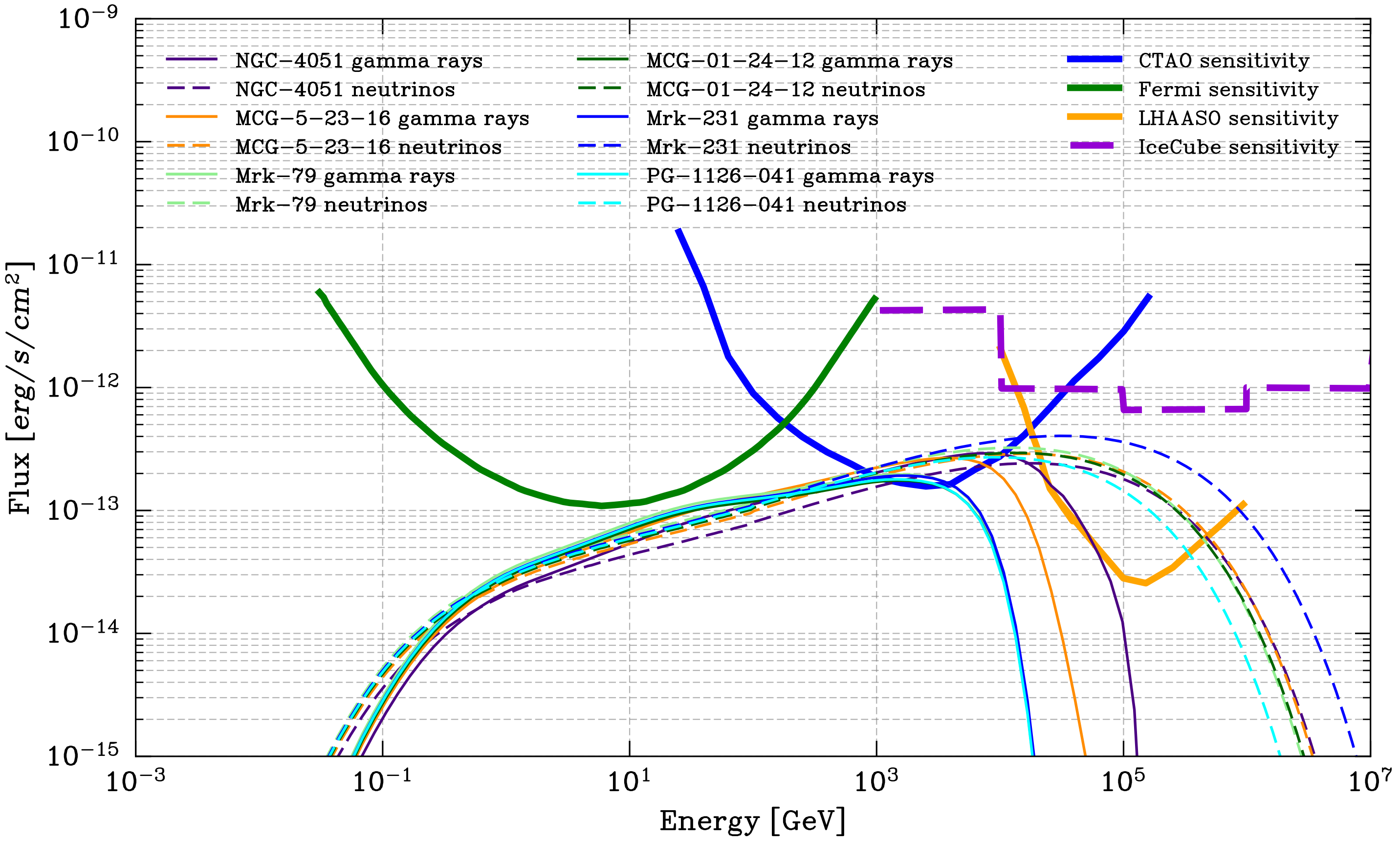
$$\mathcal{M} \gg 1$$

$$n_0 = 10^2 - 10^5 \mathrm{cm}^{-3}$$

Diffusive Shock Acceleration
Fermi I

Multimessenger emissions from UFO





Gamma-ray bursts as multi-messenger probes

Sofia Bisero

Supervisor: Susanna Vergani

ASTRE

École Doctorale d'Astronomie & Astrophysique d'Île-de-France

Electromagnetic follow-up of gravitational wave events

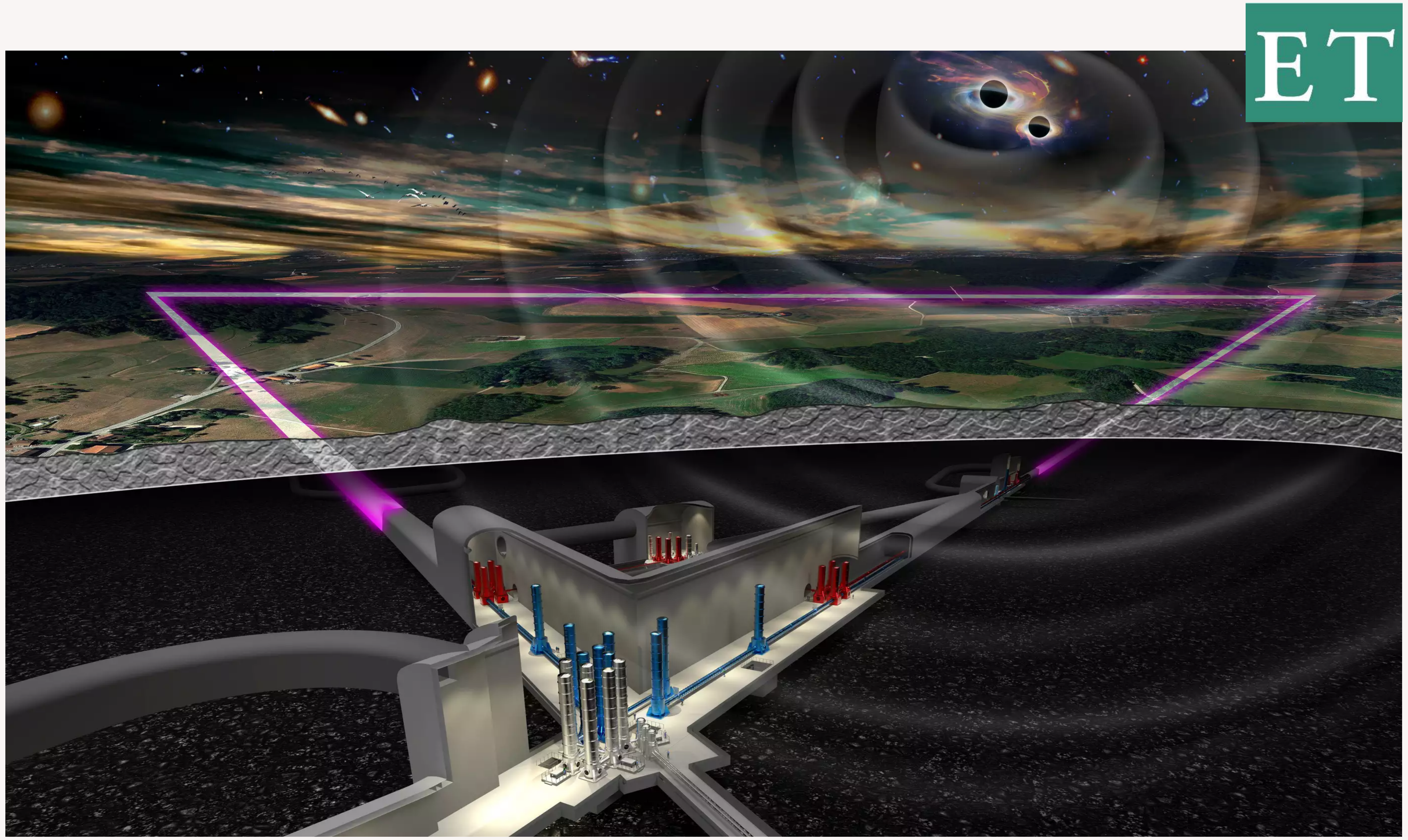
Performing simulations to prepare observations of EM counterparts of GW detections from next generation interferometers

In collaboration with the scientific team at the
Gran Sasso Science Institute (GSSI)

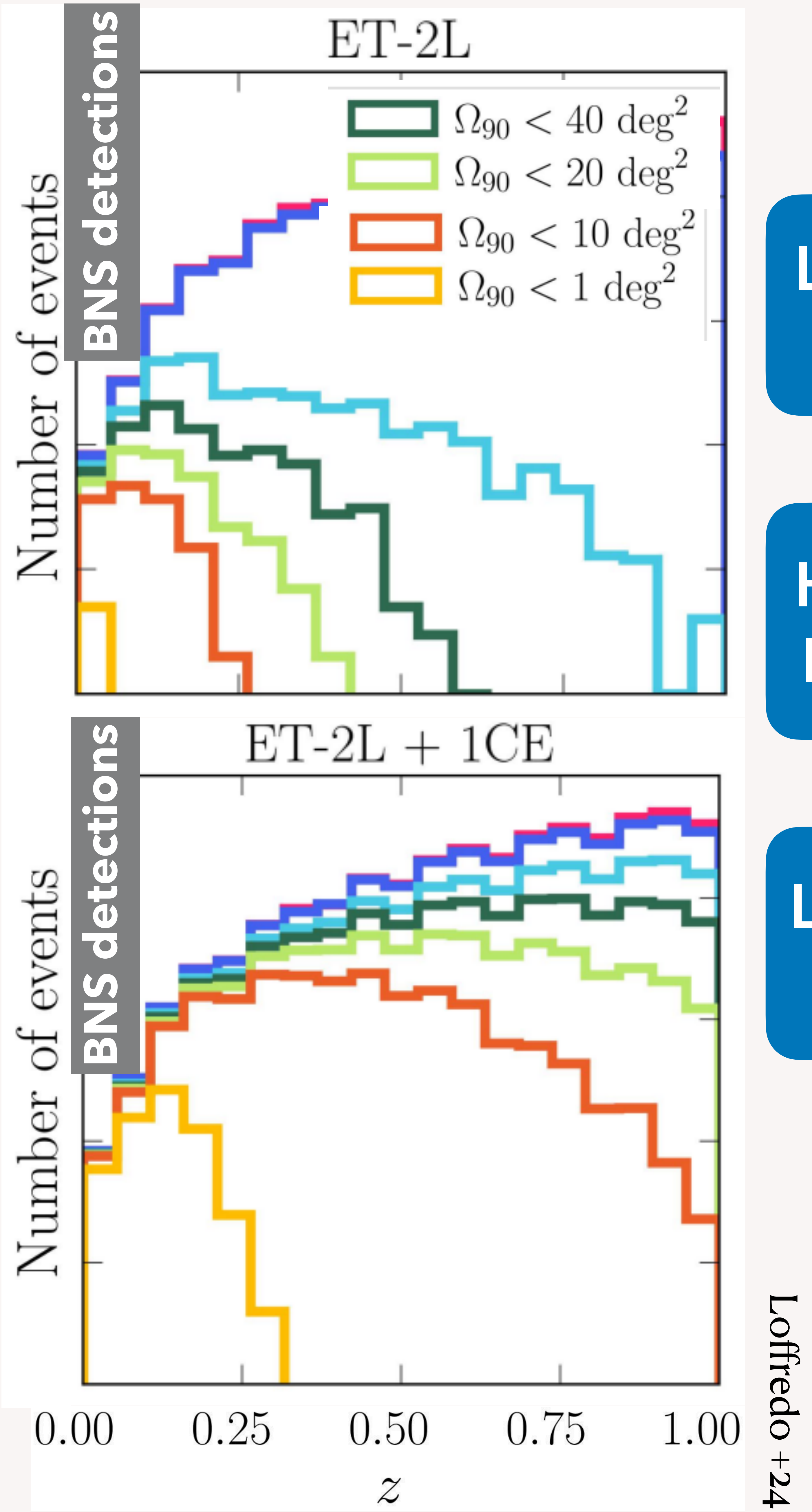
Journée du LUX

Next generation gravitational wave interferometers

The Einstein Telescope



In the ESFRI road map, to be realised in the late 2030s



Large volume of the Universe

Huge number of BNS detections

Large GW signal error regions

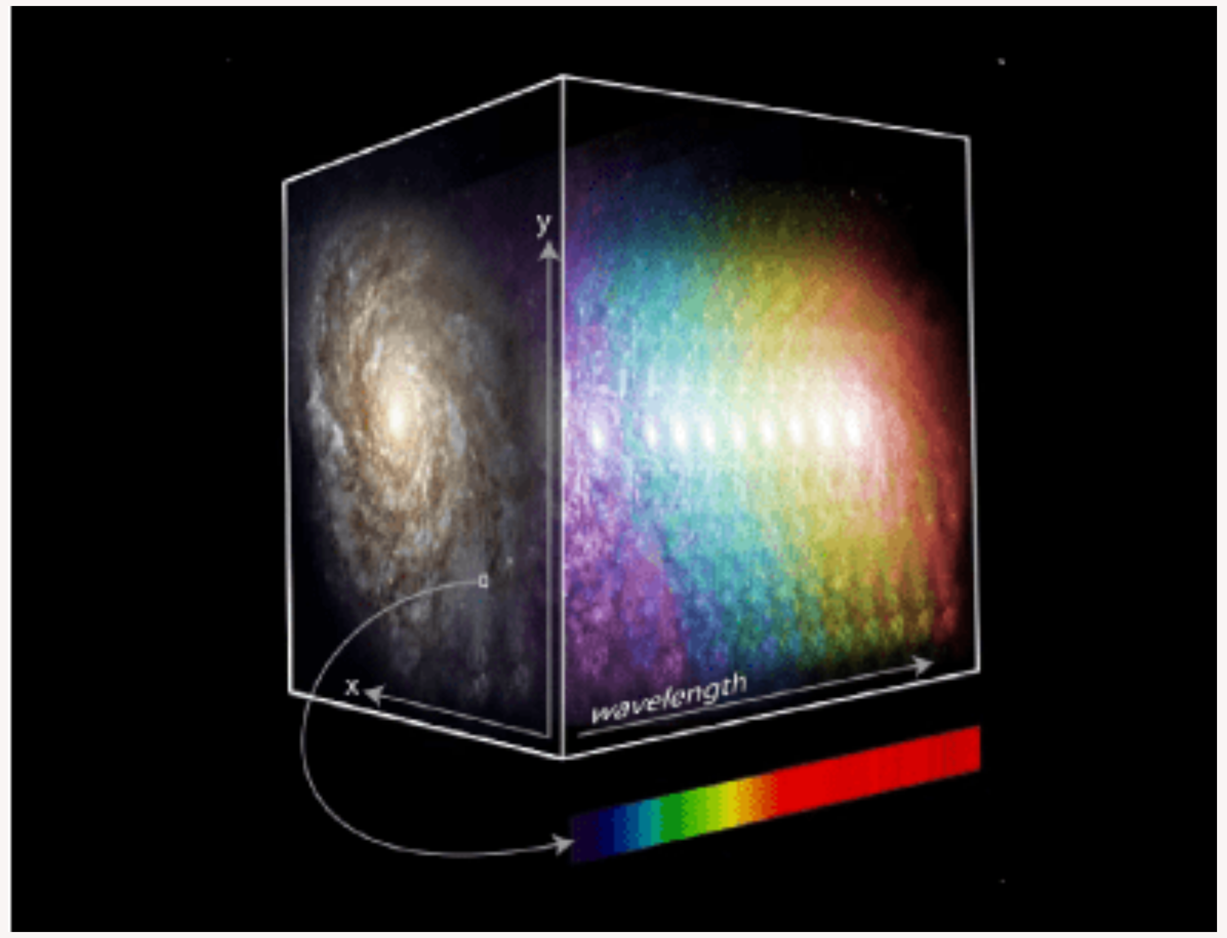
Challenges of electromagnetic counterparts research

Faint optical-NIR EM counterparts to be found within large error regionsamong a huge number of contaminants

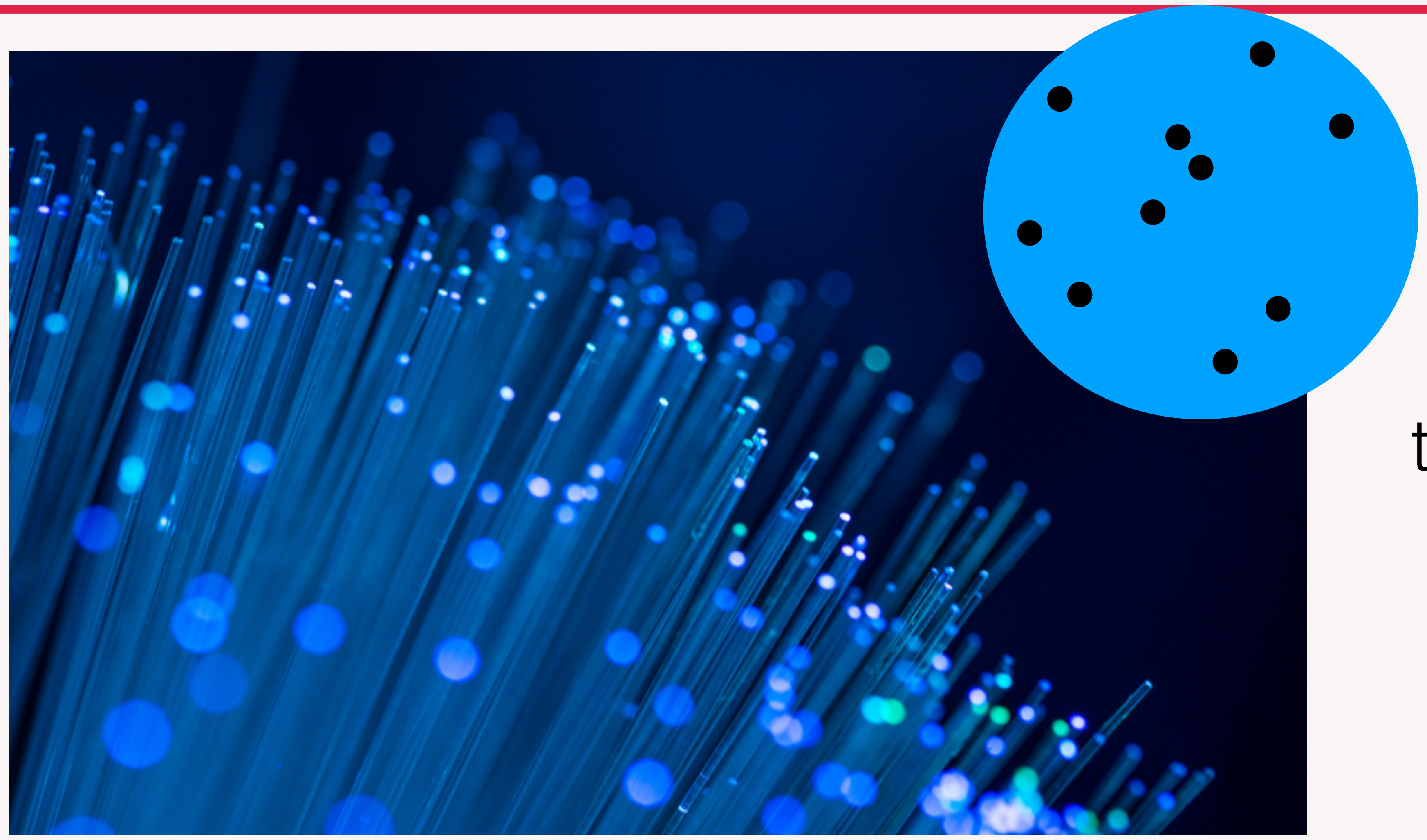
Photometric observations with facilities like the Vera C. Rubin Observatory,will provide a lot of **counterpart candidates**

Spectroscopy: the **bottleneck** of this research, as it allows counterparts identification and characterisation

With Integral Field and Multi-Object Spectroscopy (**IFS** and **MOS**) it will be possible to acquire **multiple spectra at once**

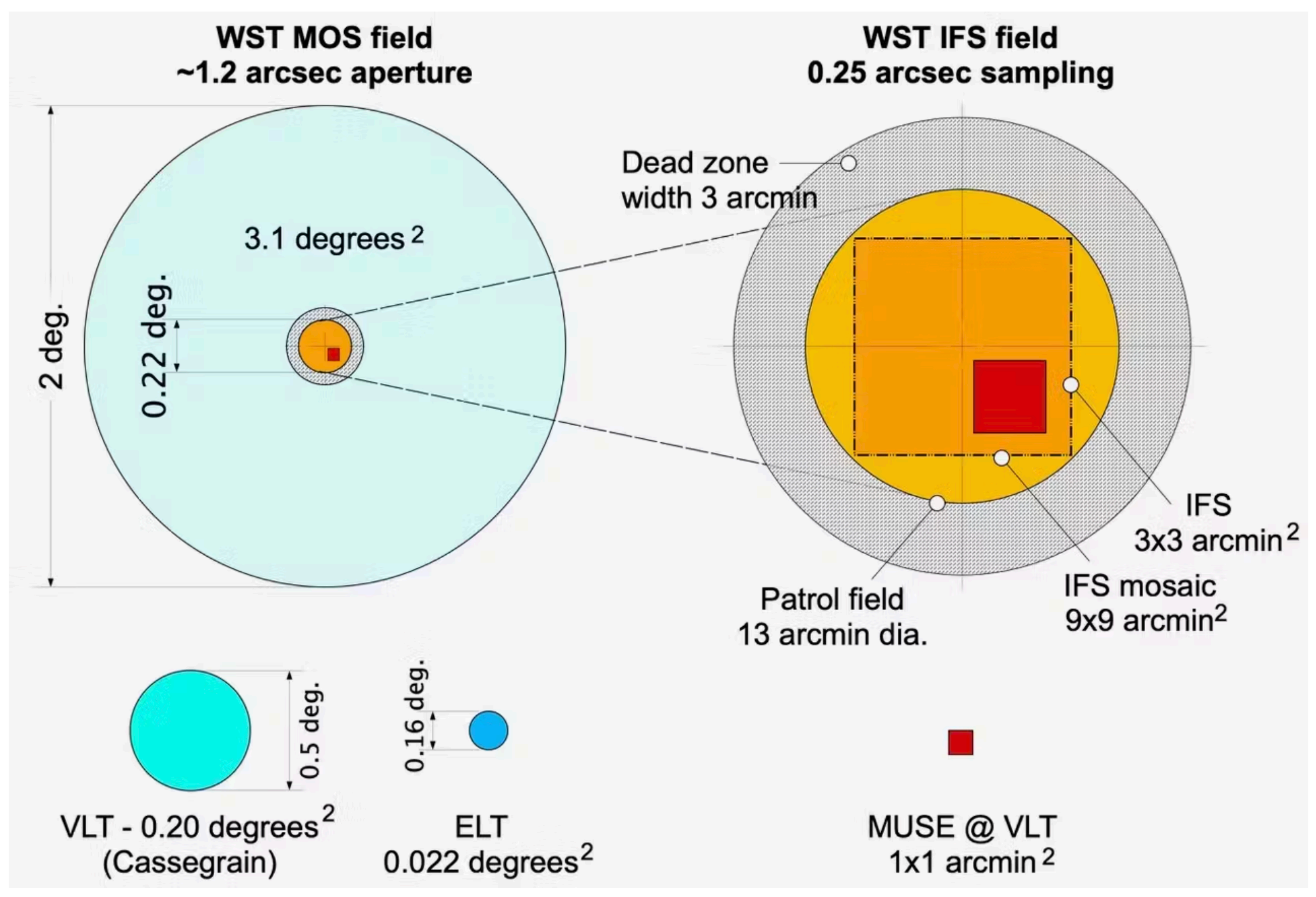


A spectrum for each pixel of the 2D field image



Fibers positioned on the localisation of the sources of interest

IFS and MOS with the Wide-field Spectroscopic Telescope



Preparing an observing strategy

Science case
“**WST - ET synergies for BNS multi-messenger observations**”
within the WST Time Domain Working Group

and the **Division 4** of the **ET OSB: Multimessenger Observations**

Bisero et al. 2025 in prep

GRB afterglows

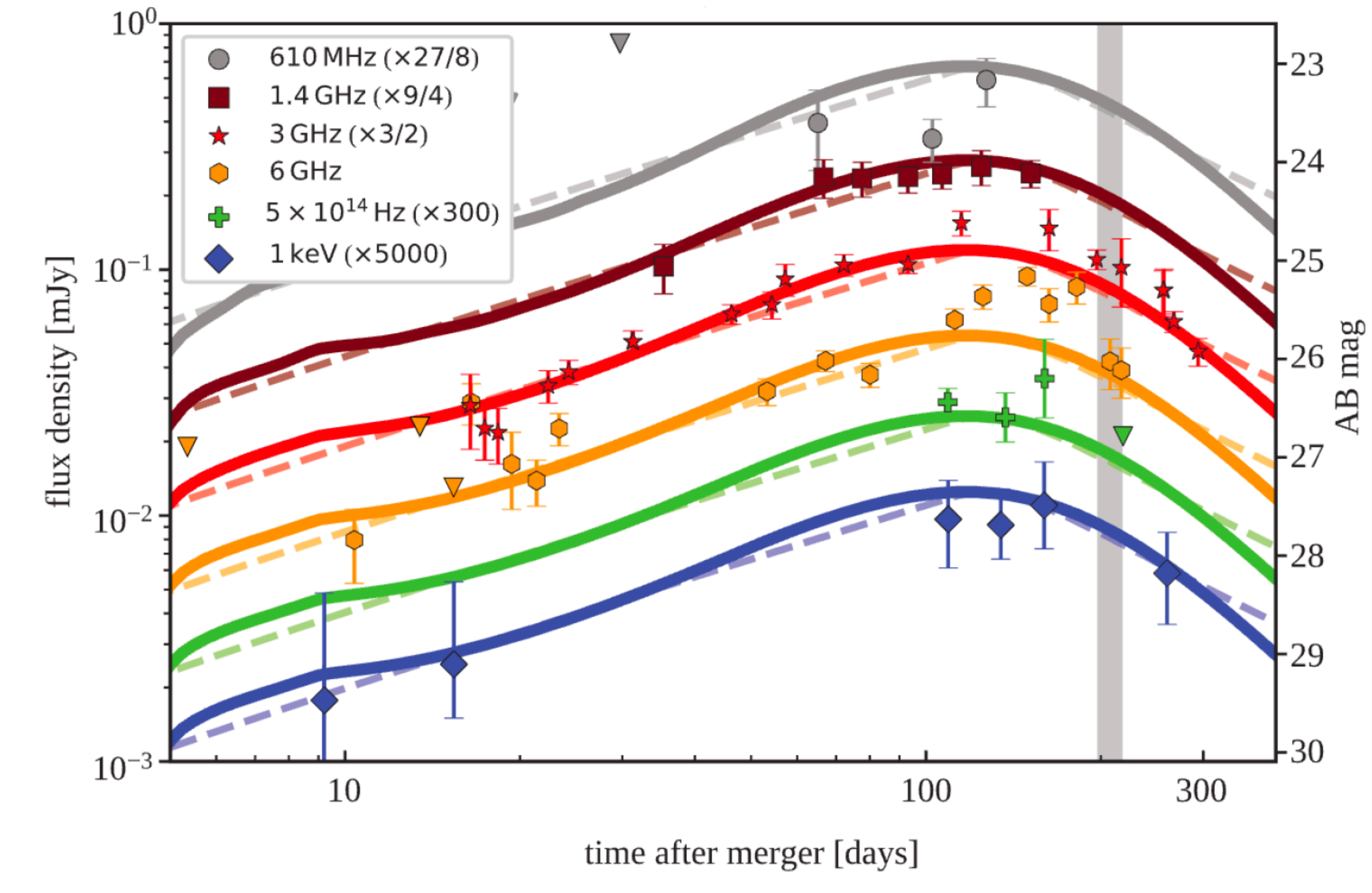
Investigating the <u>plateau phase</u> of GRB afterglows and its possible link with the <u>jet structure</u>

In collaboration with Frederic Daigne and Clement Pellouin
Institut d’Astrophysique de Paris (IAP)

Journée du LUX

GRB afterglows

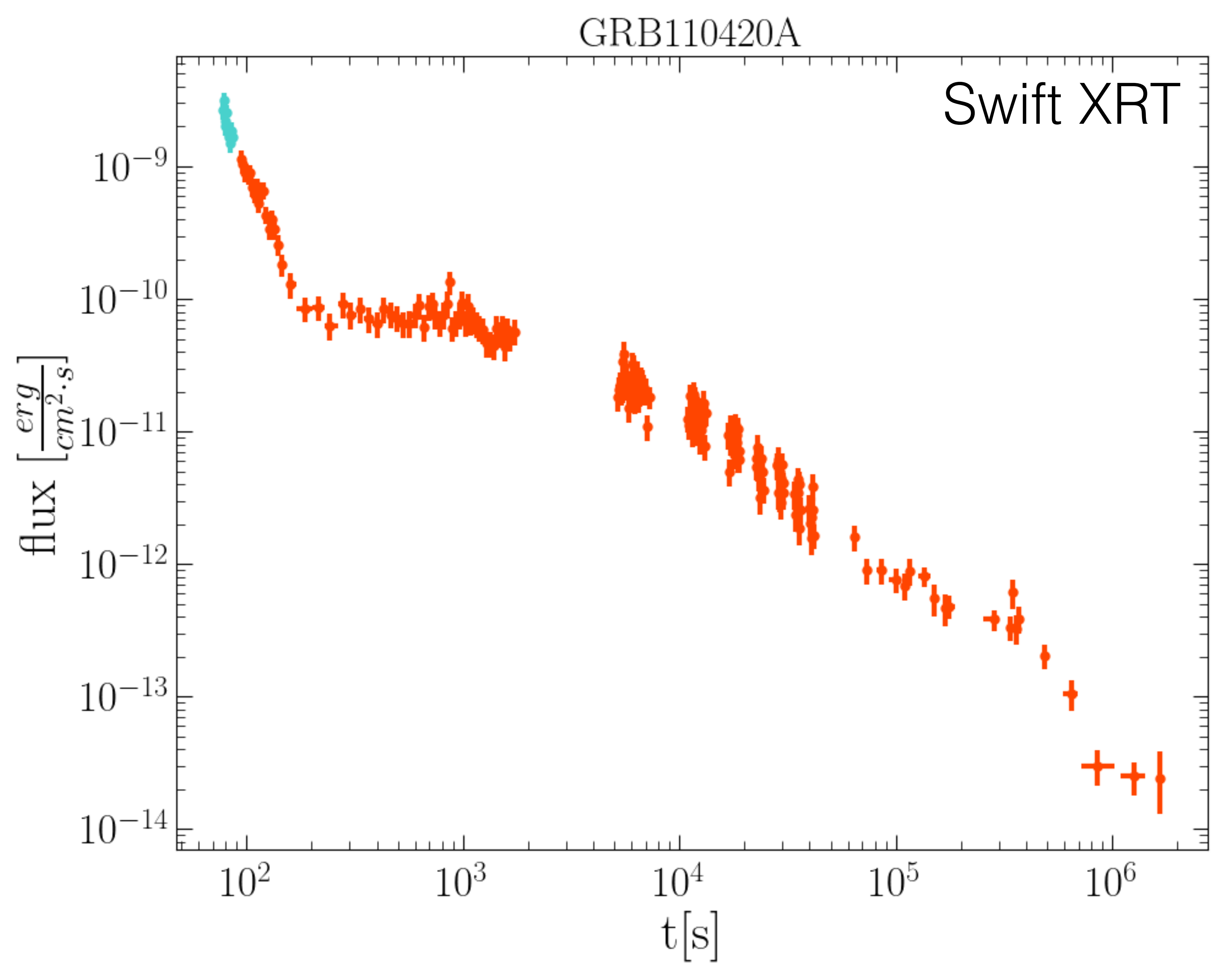
SGRB170817A afterglow



Ghirlanda+19

The first monitoring of a GRB afterglow **off-axis**

Showed that the jet of that GRB was structured



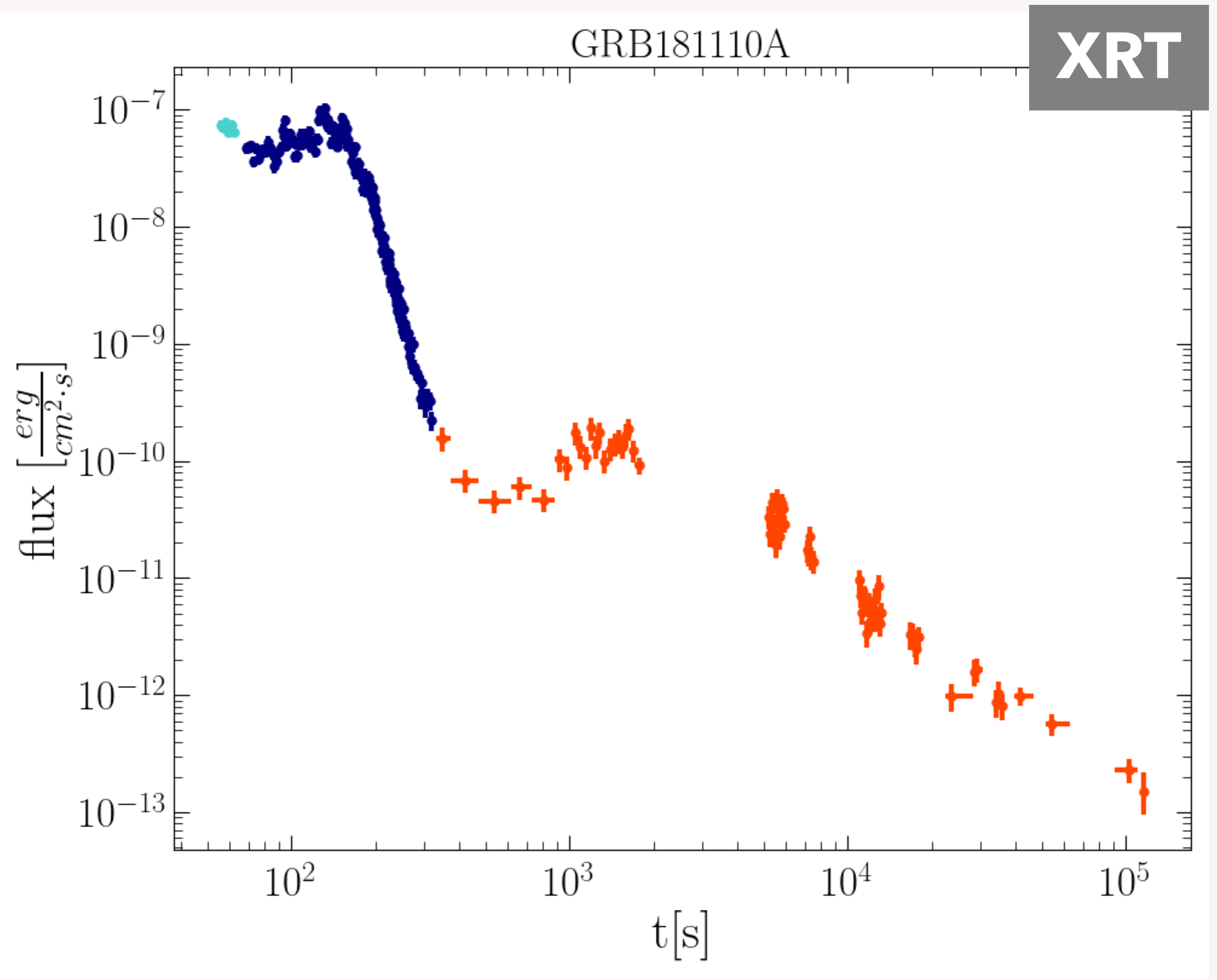
Some GRB light curves show a plateau phase that can be explained by a near-core line of sight

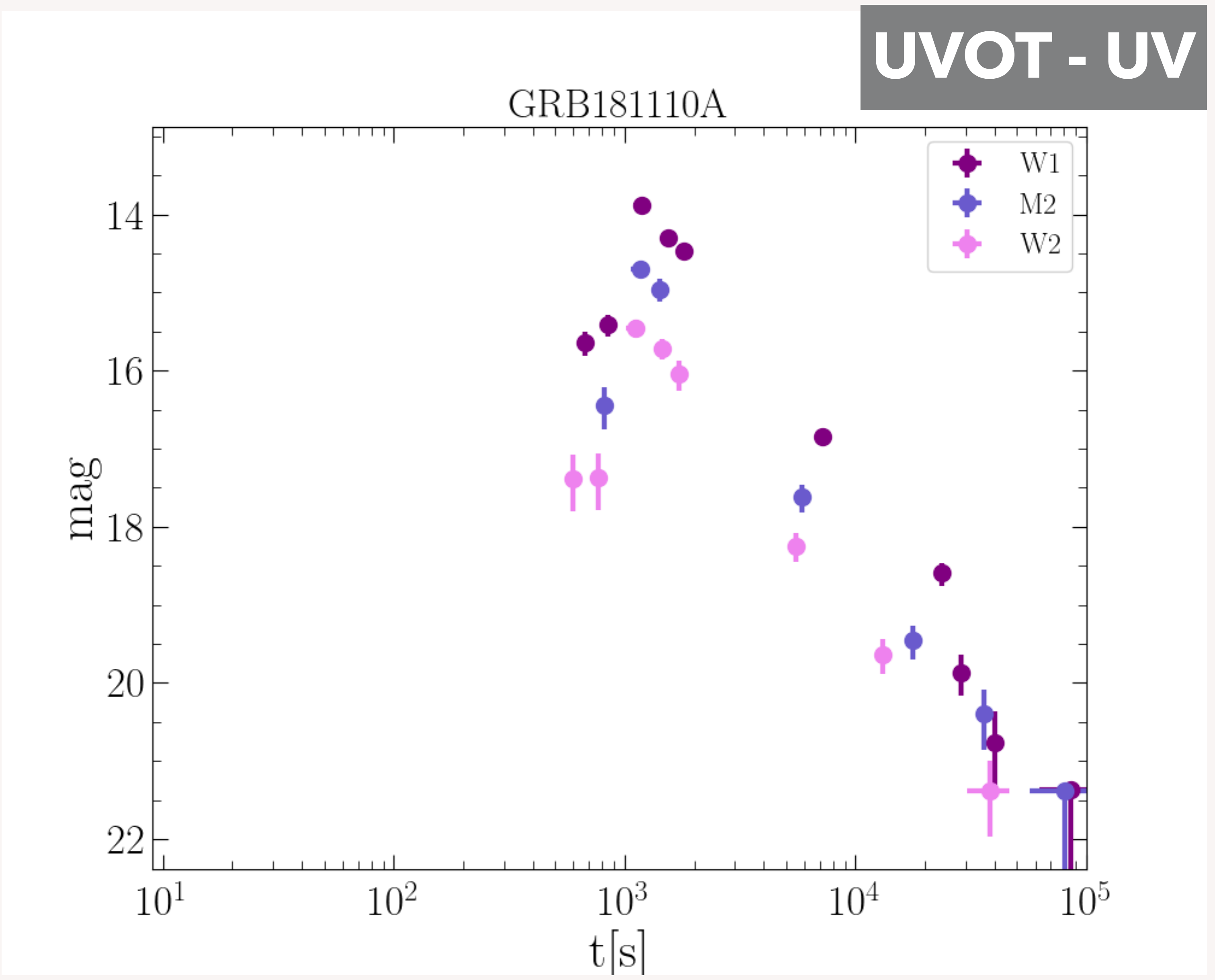
Investigating the nature of the plateau phase:

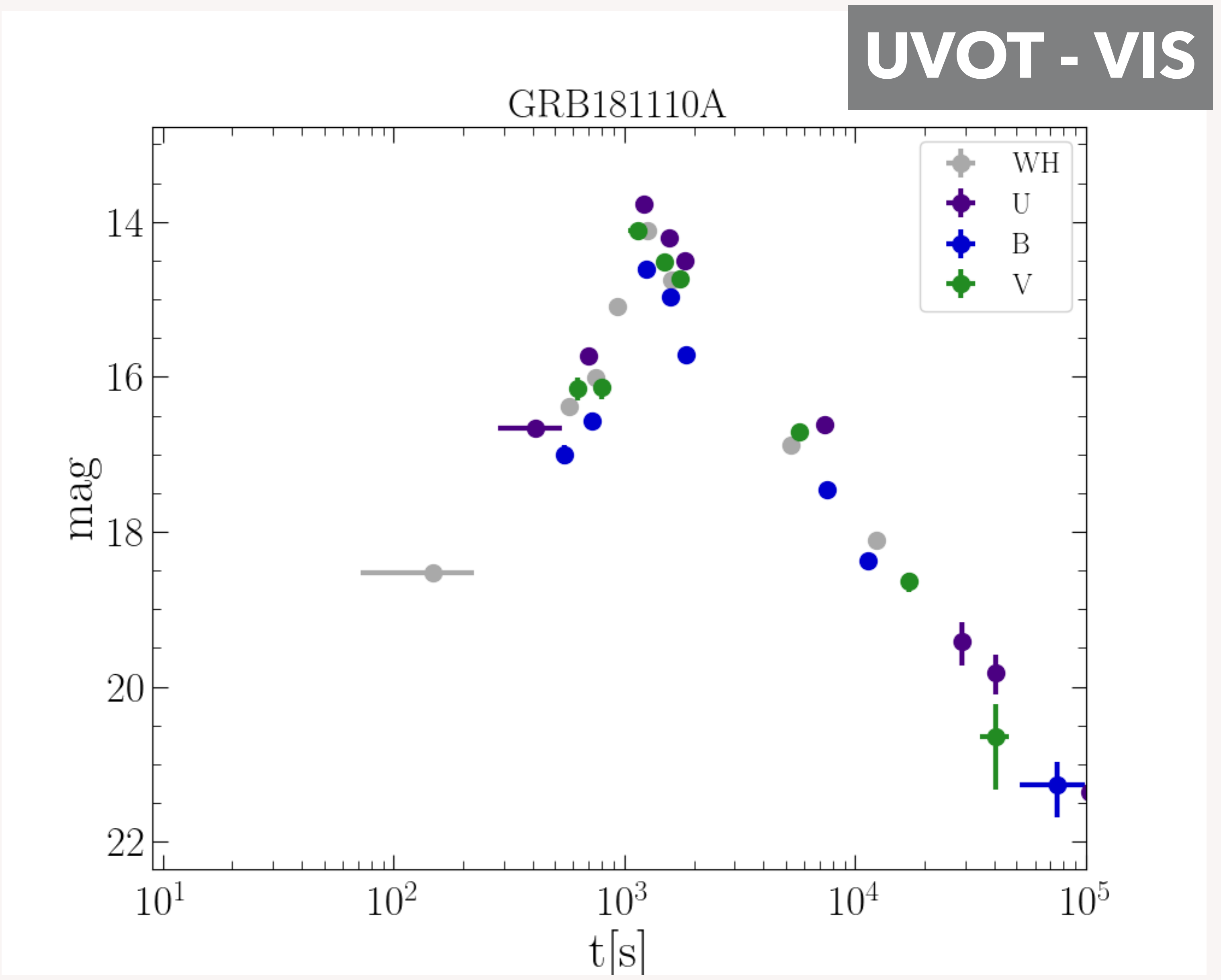
Is it due to the GRB jet structure in a (slightly) off-axis scenario?

GRB afterglows: investigating the plateau phase

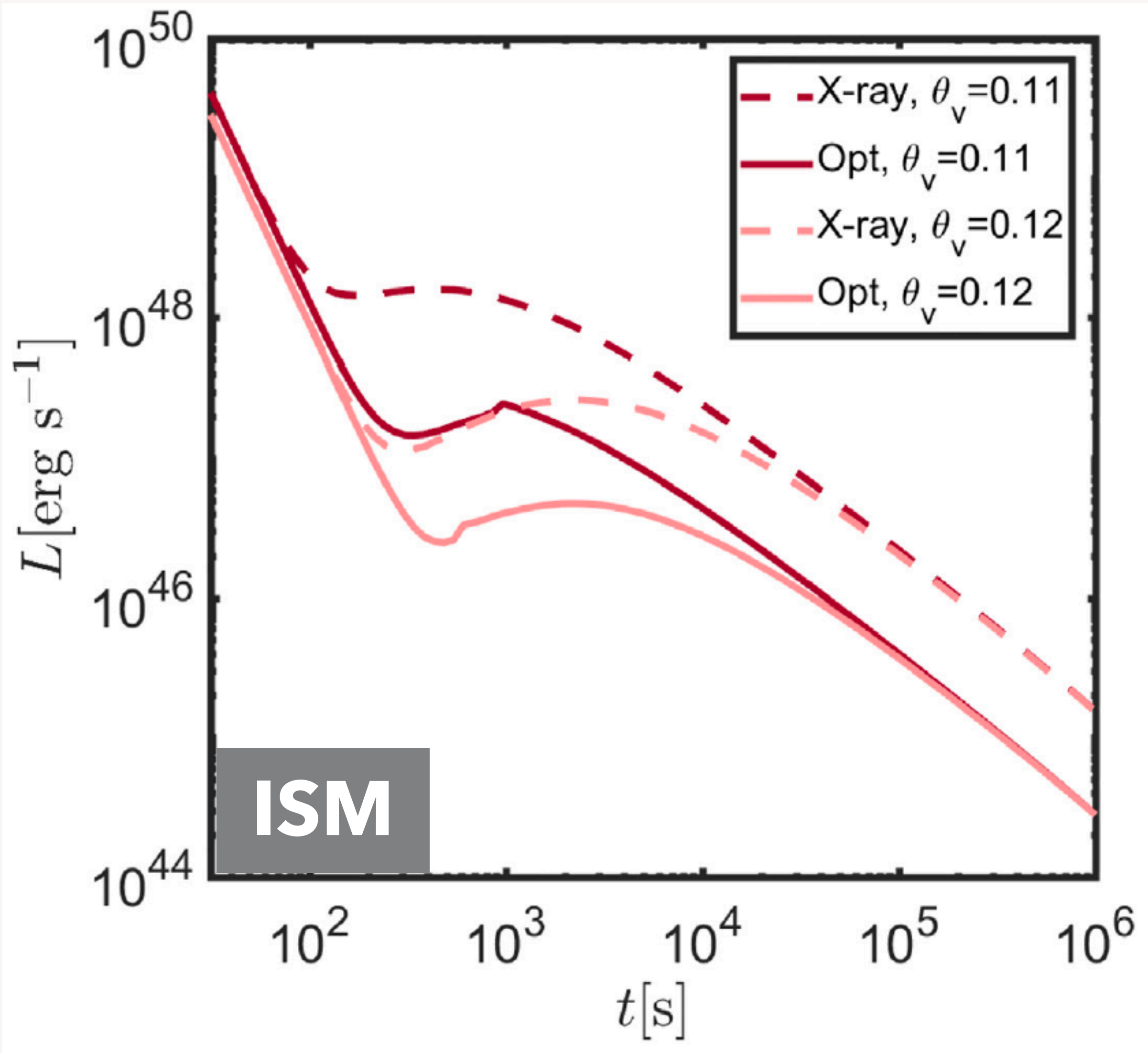
- Unbiased database of Swift optical and x-ray light curves

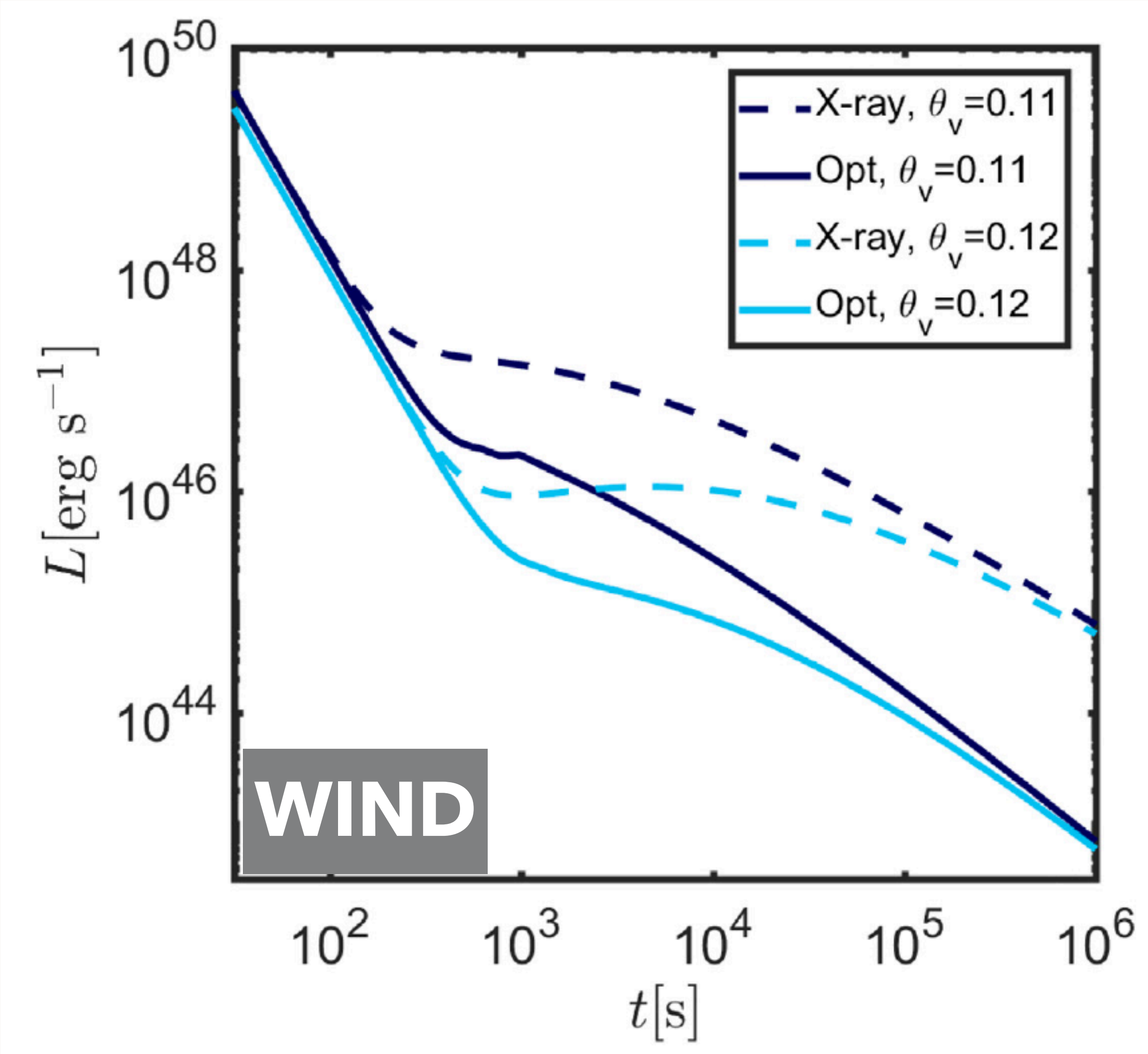






- Comparing data with models
(Model details in Pellouin et al 2024)





Beniamini+20

Thank you for your attention!

Galaxies: the study of multiple components through cosmic time

Spectroscopic studies of GRB afterglows and host galaxies.

Valentina Abril-Melgarejo
Observatoire de Paris – LUX

Supervisor: Susanna Vergani

Observatoire de Paris

valentina.abril-melgarejo@stsci.edu

ACADEMIC AND CULTURAL JOURNEY..

- **BSc Physics**
  Universidad de los Andes (Colombia)
- **MSc Astrophysics**
  Universidad Nacional Autónoma de México–IA
- **PhD Astrophysics**
  Aix-Marseille Université – LAM
- **Postdoctoral Fellow** Space Telescope Science Institute
- **Postdoctoral Researcher** Observatoire de Paris

Universidad de los Andes

instituto de astronomía
unam

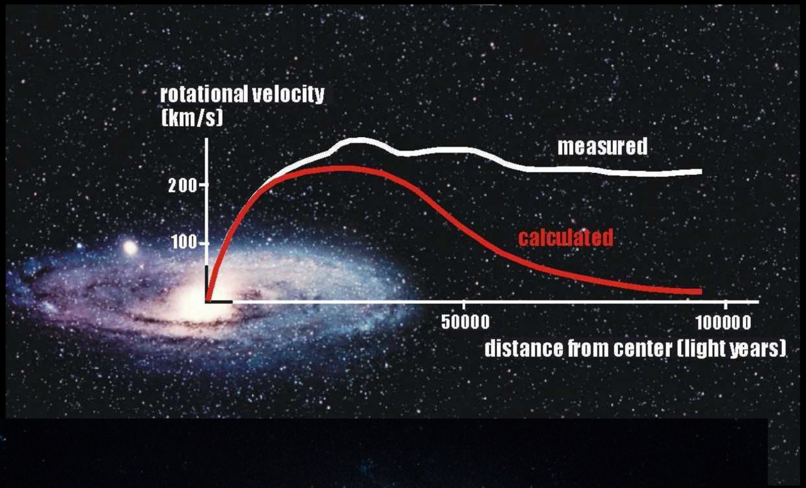
LAM
LABORATOIRE D'ASTROPHYSIQUE DE MARSEILLE
Aix*Marseille université

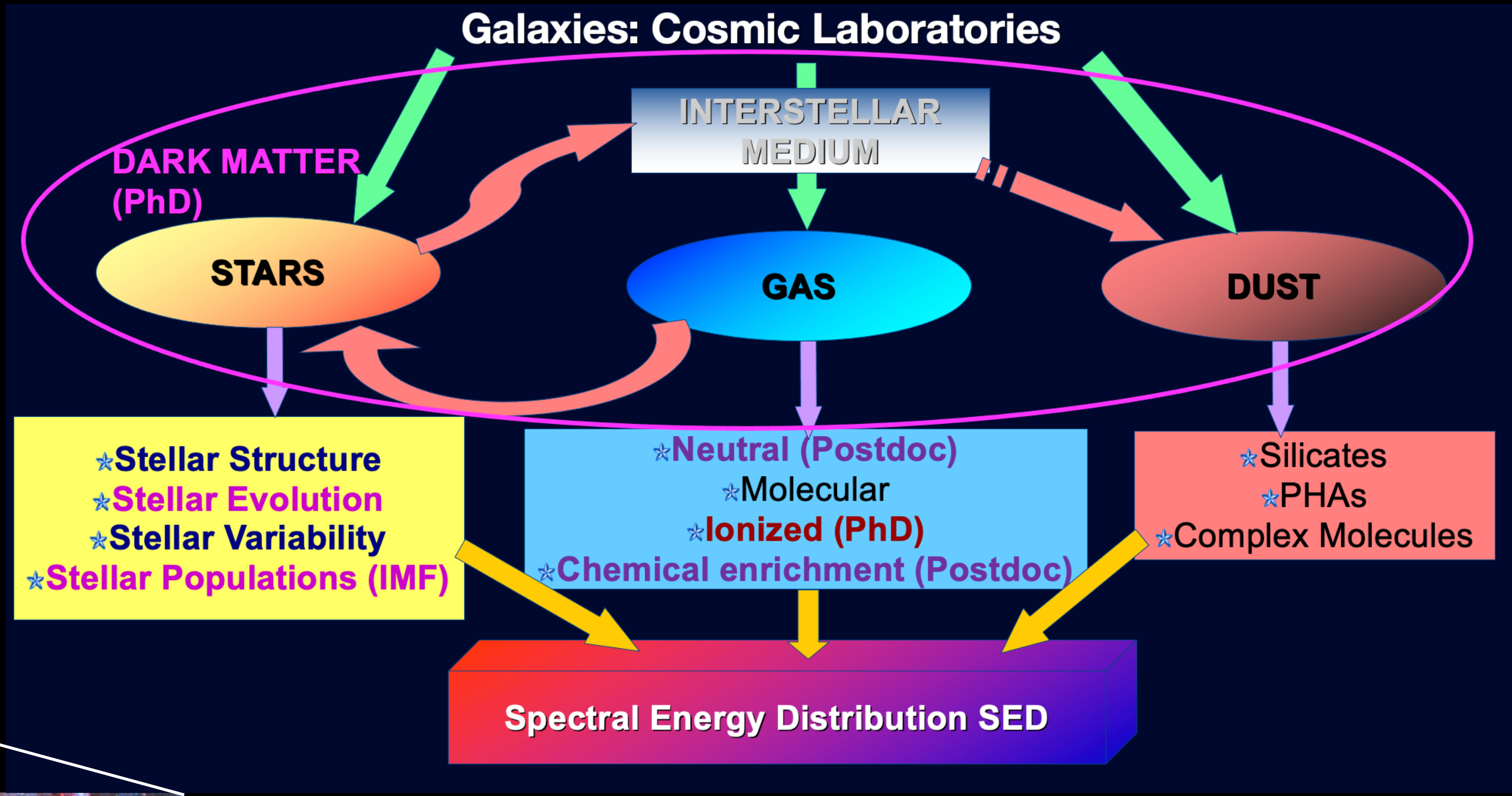
STScI | SPACE TELESCOPE SCIENCE INSTITUTE

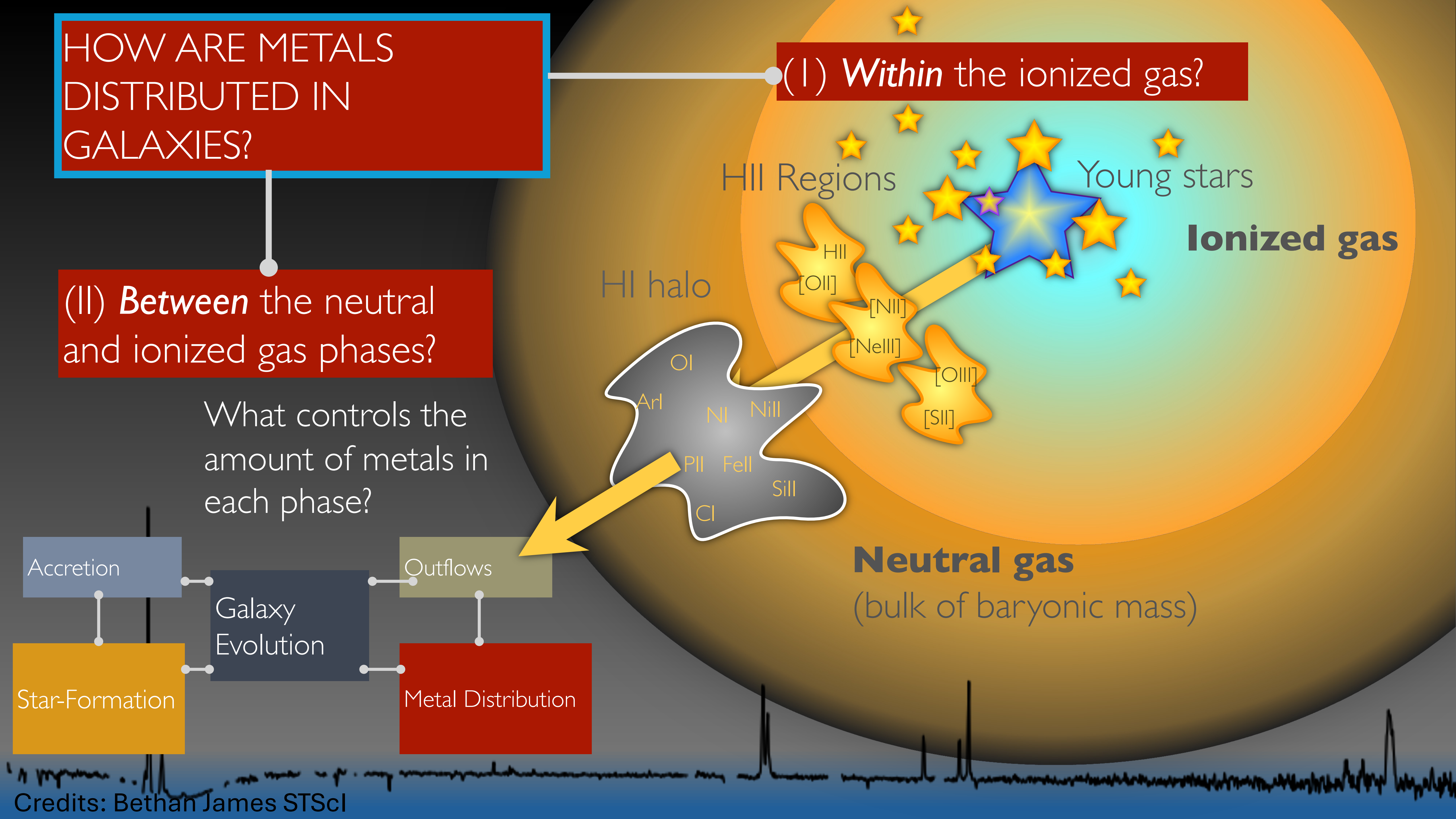
Observatoire de Paris

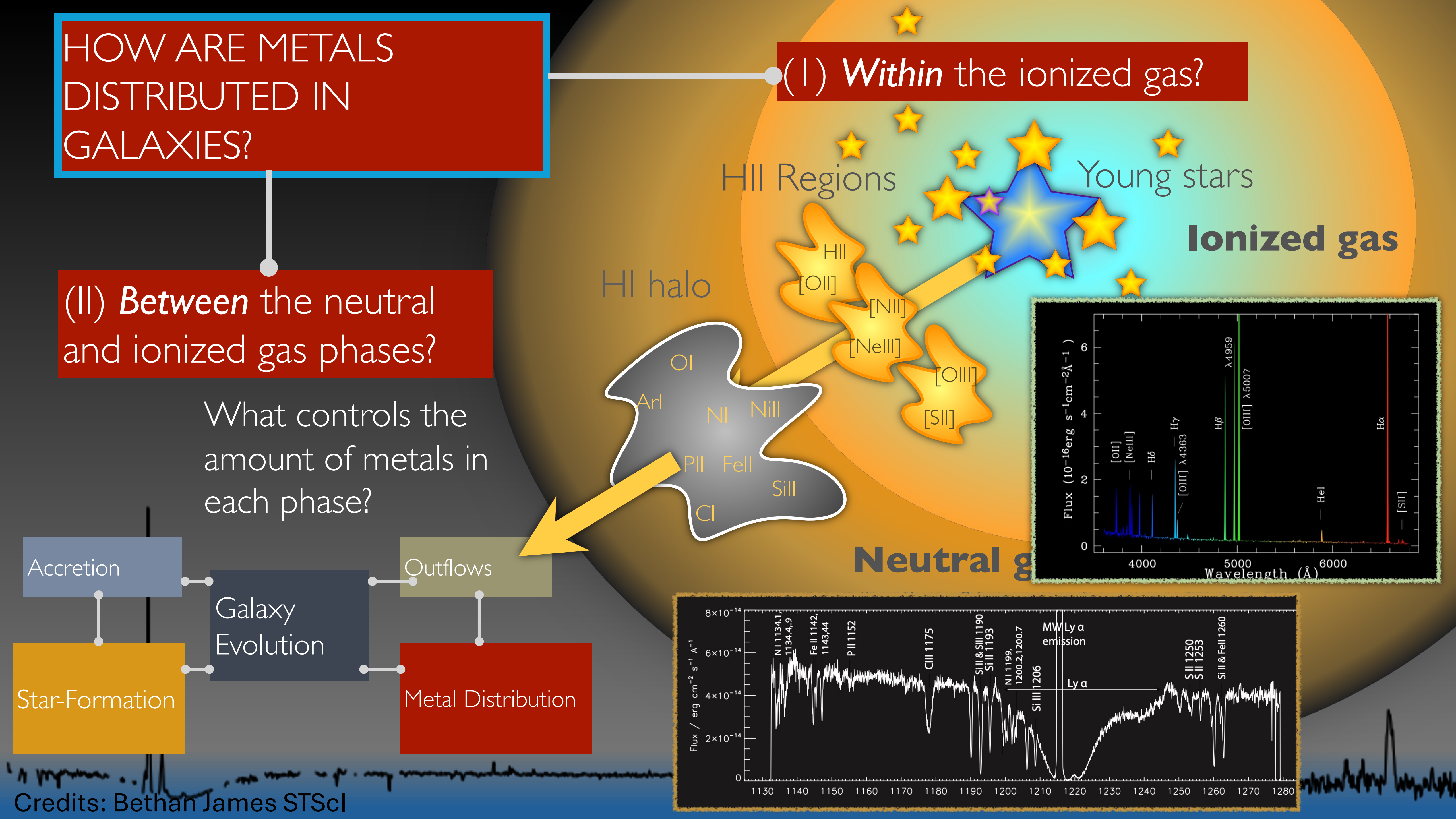
Valentina Abril-Melgarejo vabrilmelgarejo@stsci.edu

Galaxies are complex systems






HOW ARE METALS DISTRIBUTED IN GALAXIES?
(I) Within the ionized gas?
(II) Between the neutral and ionized gas phases?
What controls the amount of metals in each phase?
HII Regions
Young stars
Ionized gas
HI halo
HII
[OII]
[NII]
[NeIII]
[OIII]
[SII]
OI
ArI
NI
NiII
PII
FeII
SiII
CI
Neutral gas
(bulk of baryonic mass)
Accretion
Galaxy Evolution
Outflows
Star-Formation
Metal Distribution
Credits: Bethan James STScI



HOW ARE METALS DISTRIBUTED IN GALAXIES?
(I) Within the ionized gas?
(II) Between the neutral and ionized gas phases?
What controls the amount of metals in each phase?
HII Regions
Young stars
Ionized gas
HI halo
HII
[OII]
[NII]
[NeIII]
[OIII]
[SII]
OI
ArI
NI
NiII
PII
FeII
SiII
CI
Neutral g
Accretion
Galaxy Evolution
Outflows
Star-Formation
Metal Distribution
Flux (10⁻¹⁶erg s⁻¹cm⁻²Å⁻¹)
Wavelength (Å)
[OII]
[NeIII]
Hδ
[OIII] λ4363
Hγ
Hβ
λ4959
[OIII] λ5007
HeI
Hα
[SII]
4000
5000
6000
Flux / erg cm⁻² s⁻¹ Å⁻¹
N I 1134.1, 1134.4,.9
Fe II 1142, 1143,44
P II 1152
CIII 1175
Si II & SIII 1190
Si II 1193
N I 1199, 1200.2,1200.7
Si III 1206
MW Ly α emission
Ly α
S II 1250
S II 1253
Si II & FeII 1260
1130
1140
1150
1160
1170
1180
1190
1200
1210
1220
1230
1240
1250
1260
1270
1280
Credits: Bethan James STScI

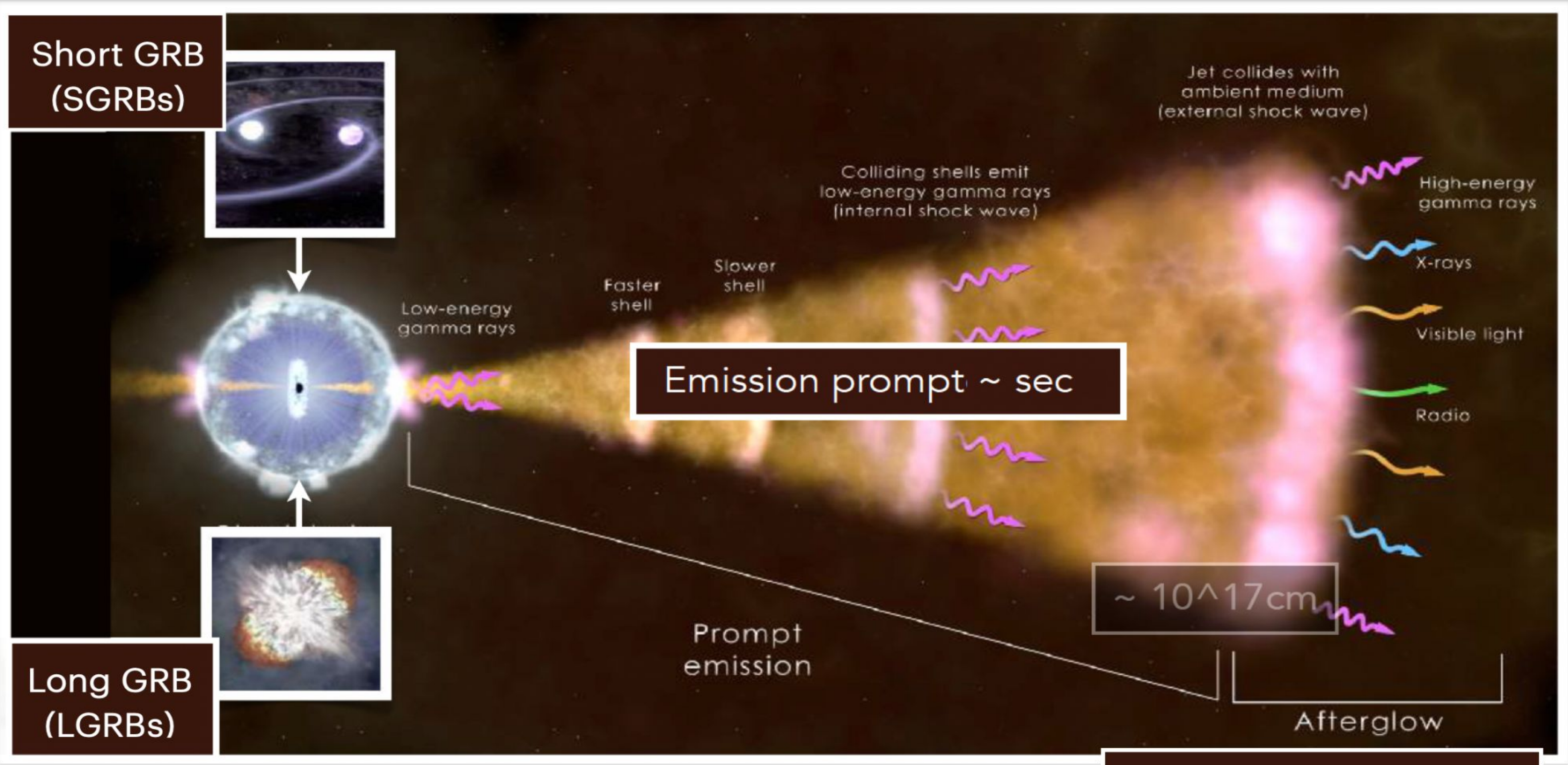
Gamma Ray Bursts detected by SVOM

Unique tools to explore galaxies and stellar evolution

Marine Garnichey

Supervision: Susanna Vergani
Team: ASTRE

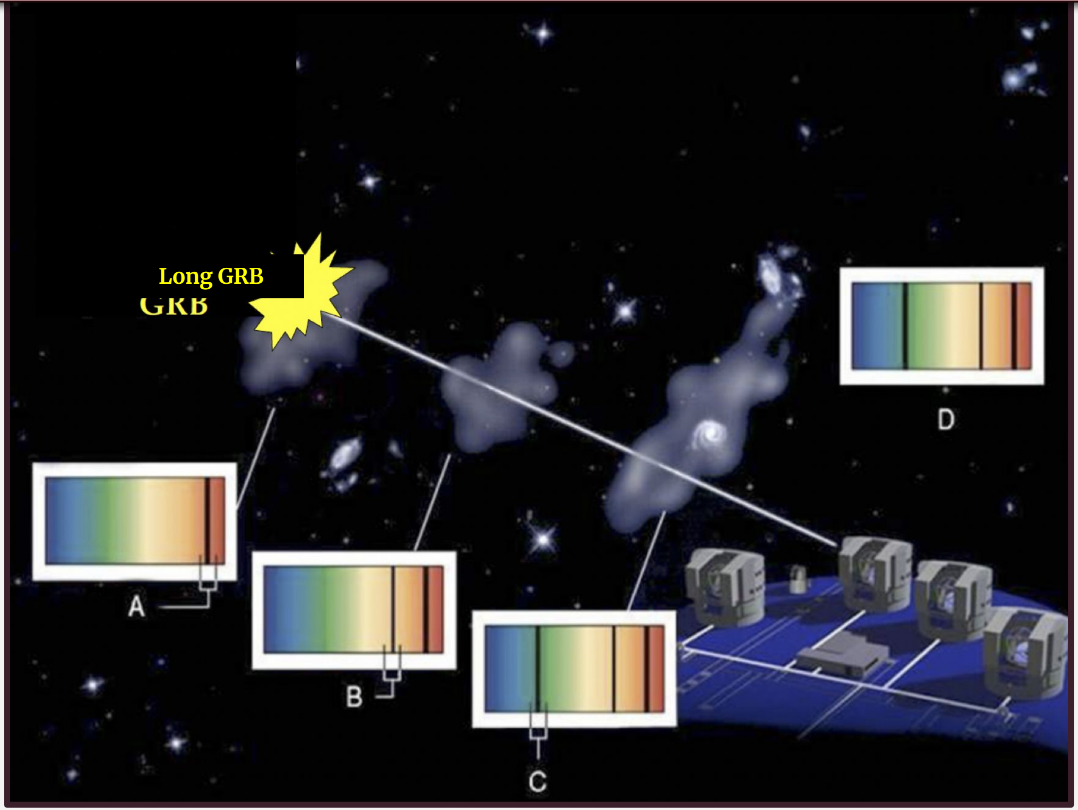
Gamma Ray Bursts detected by SVOM



Credits:NASA

Afterglow emission
a few hours --> years
(depending on
the frequency range)

Gamma Ray Bursts detected by SVOM



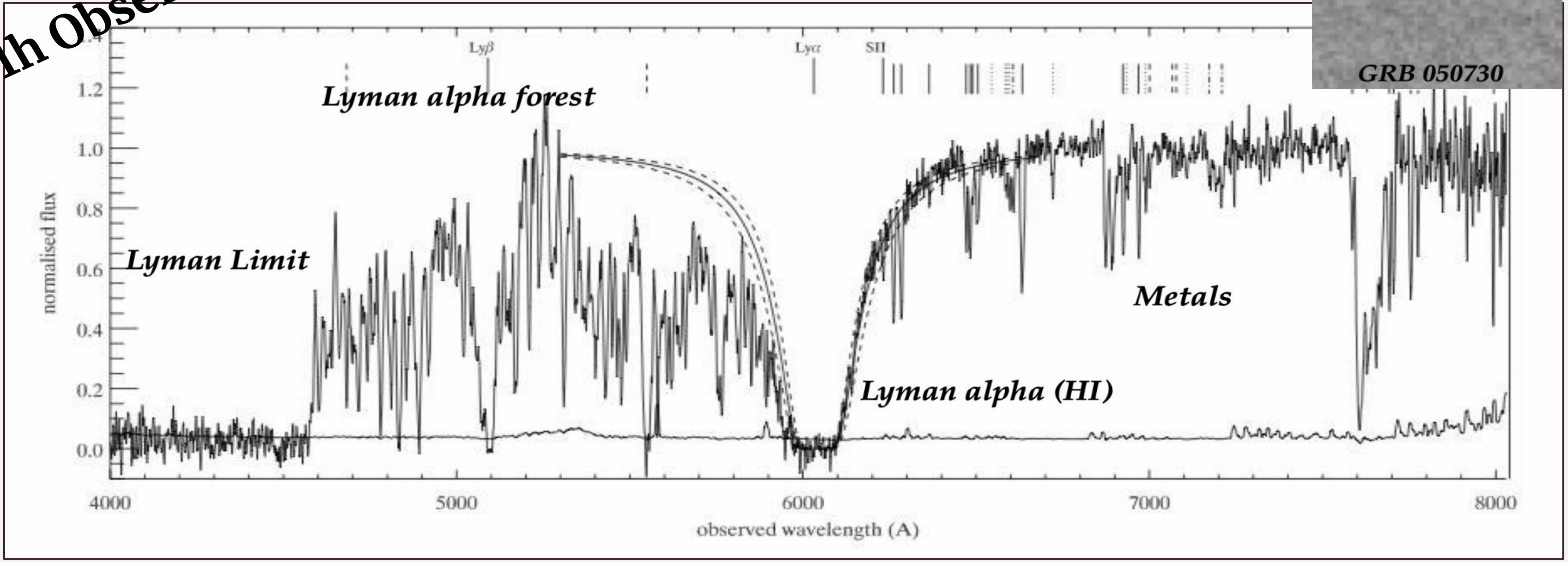
Observation of the afterglow on the line of sight

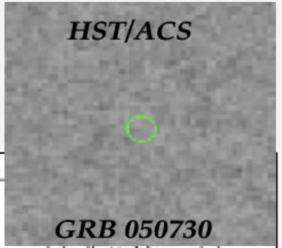
Credits: Adapted from ESO PR0813a

Combining absorption spectra of afterglows and host galaxy's spectra/imaging

~1h Observation

GRB 050730 z=3.968

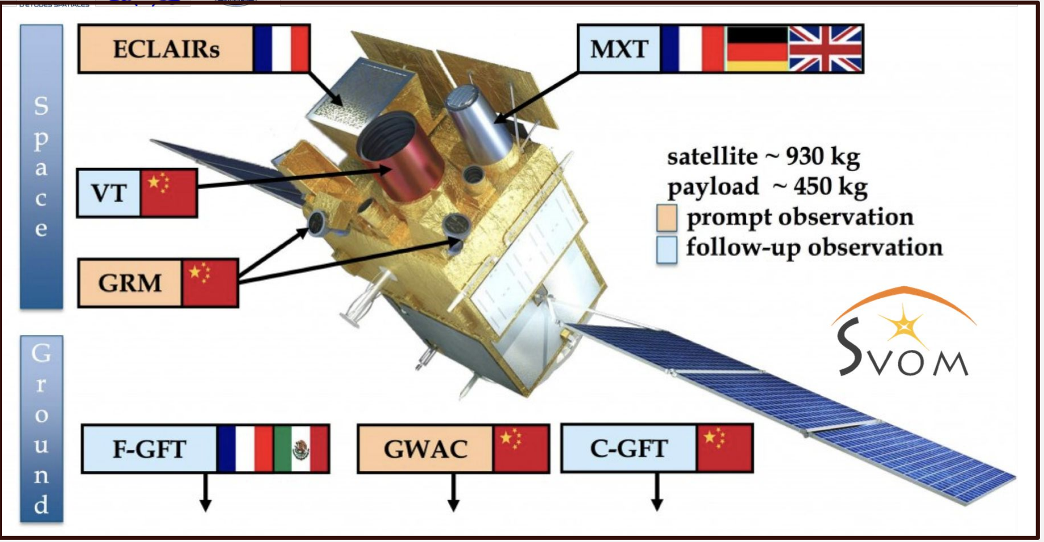




r > 28.5

Spectra of the afterglow emission on the line of sight
Starling et al. 2005

Burst Advocate



Presentation of the SVOM satellite with it’s instruments
Credits: SVOM

Stargate

Crédits: ESO

SOXS

Crédits: ESO/SOXS

Yannis Canton
Research Engineer
ASTRE, LUX

HOW TO EXTRACT GRB CANDIDATES WITH SVOM'S VISIBLE TELESCOPE … WITHOUT IMAGES … AND IN ~10 MINUTES ?

Detection

Detection of an event by ECLAIRs !!!

Slewing of the satellite

Observations with the Visible Telescope (VT) in the visible range

4 sequences of observation in the nominal case

(Pre)processing Steps

Retrieve the signal on the ground → Reconstruct data from the signal → Perform astronomical data processing → Extract a list of sources observed by the VT

Information stored in the list

- Position of the sources
- Magnitude (brightness)
- Shape

VTAC Pipeline (my work !)

List of sources →

- Source brightness changed over time ?
- Source already referenced in a catalog ?
  - ↓ Difference in brightness between observation and reference ?

→ Combination of criteria → List of GRB candidates

Objectives

- Extract a precise estimate of the position of a GRB
- Enable worldwide instruments to perform precise follow-up observations

Gravitational waveform modeling in general relativity and alternative theories of gravity

---

Eve Dones - 3rd year PhD student

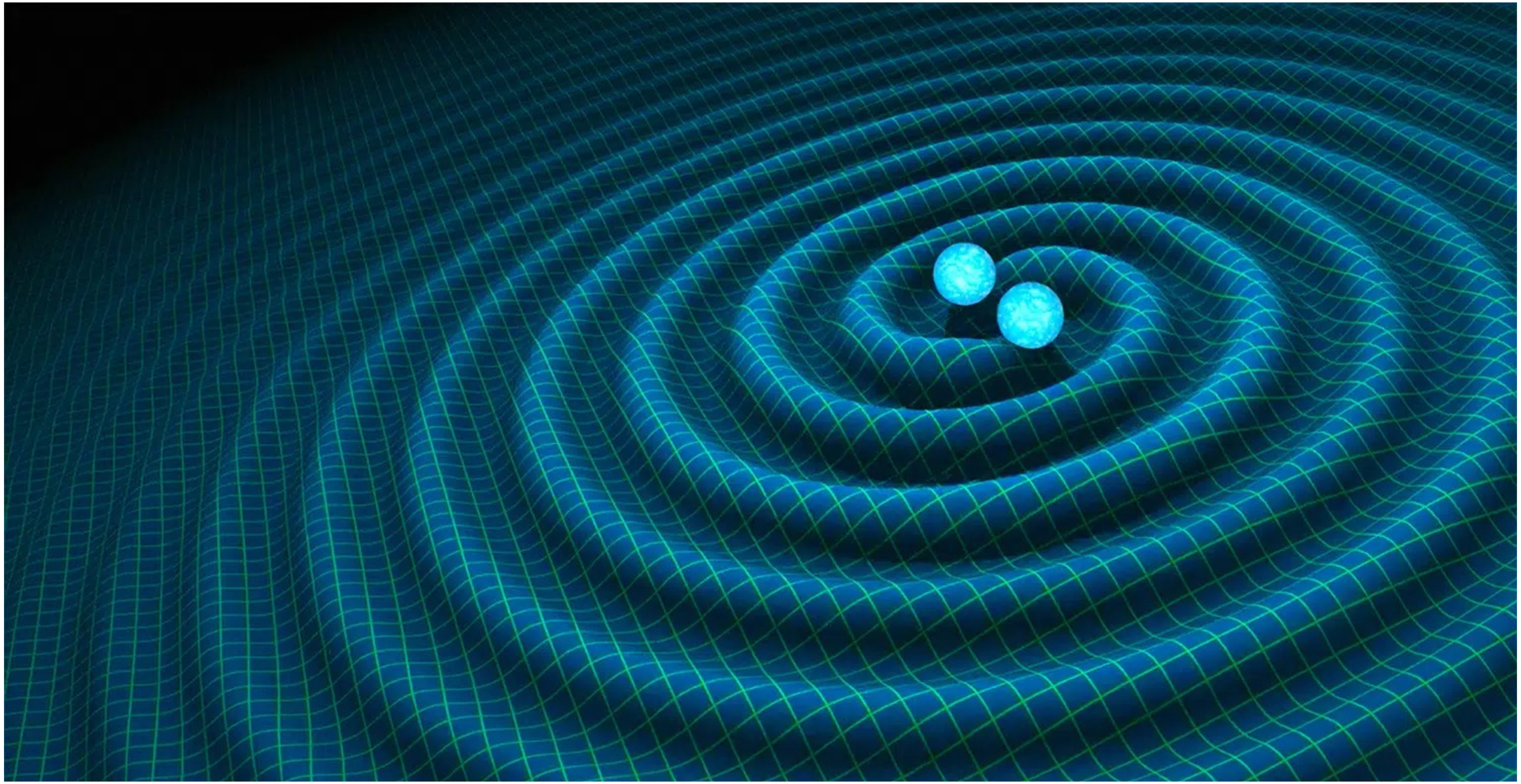
Scientific Team : ASTRE - Relativistic Astrophysics

Supervisor : Laura Bernard

LUX Inaugural Day

March 14, 2025

Gravitational waves

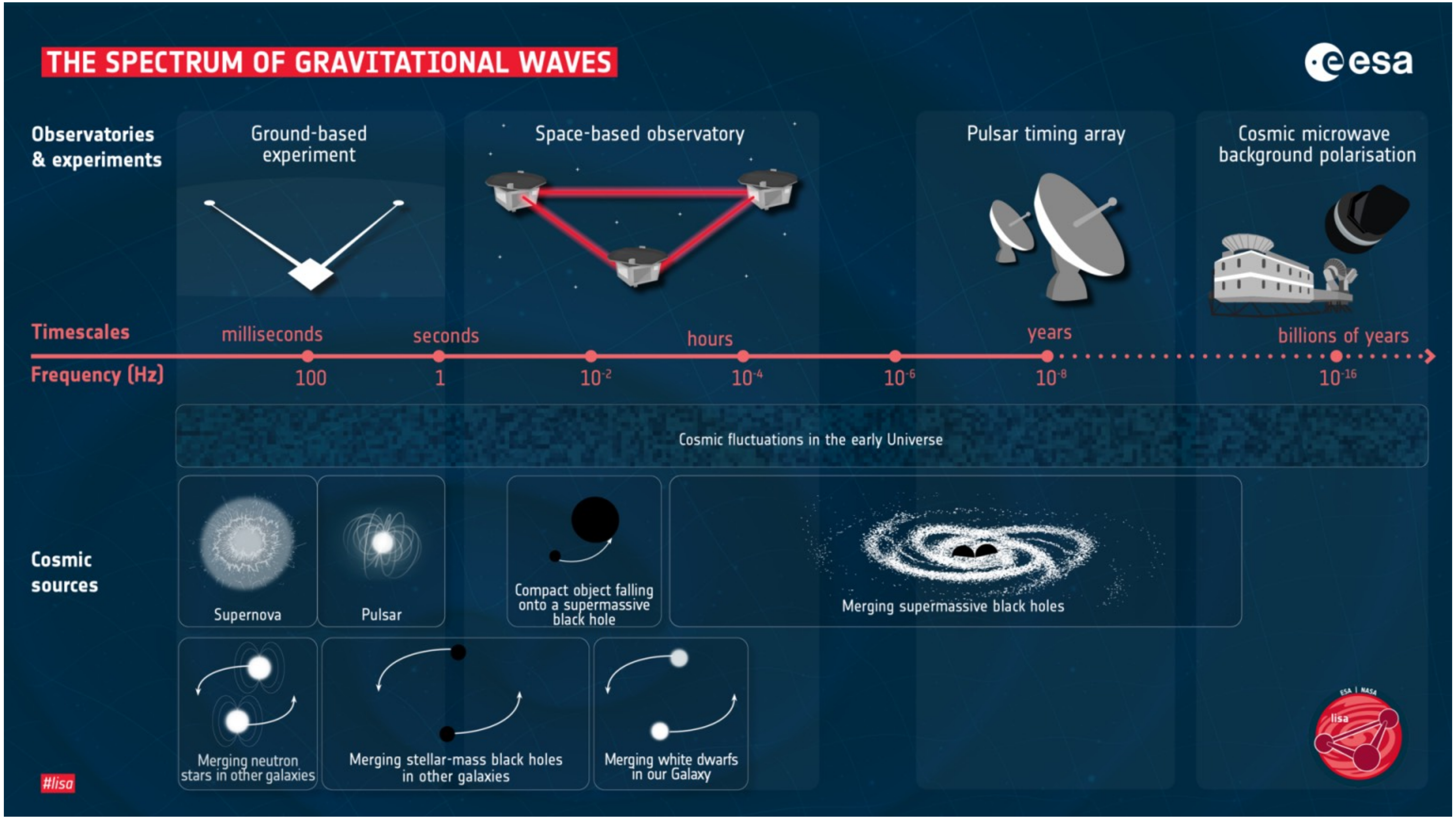


The GW Universe: Present & Future

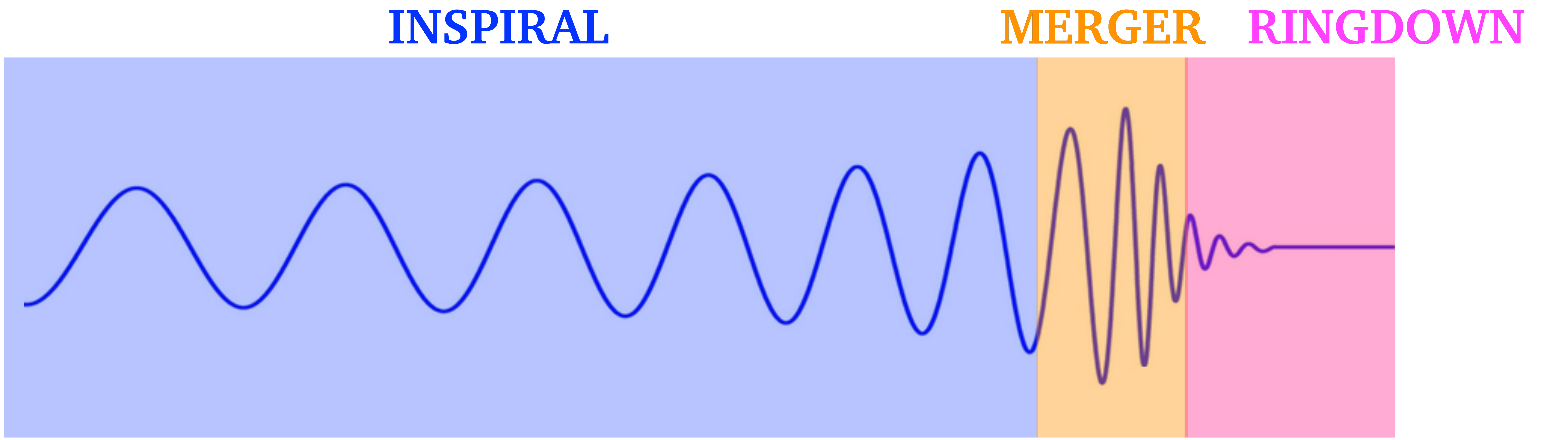
Ground-based & space-based observatories

will detect many more signals in different frequency bands

From various cosmic sources

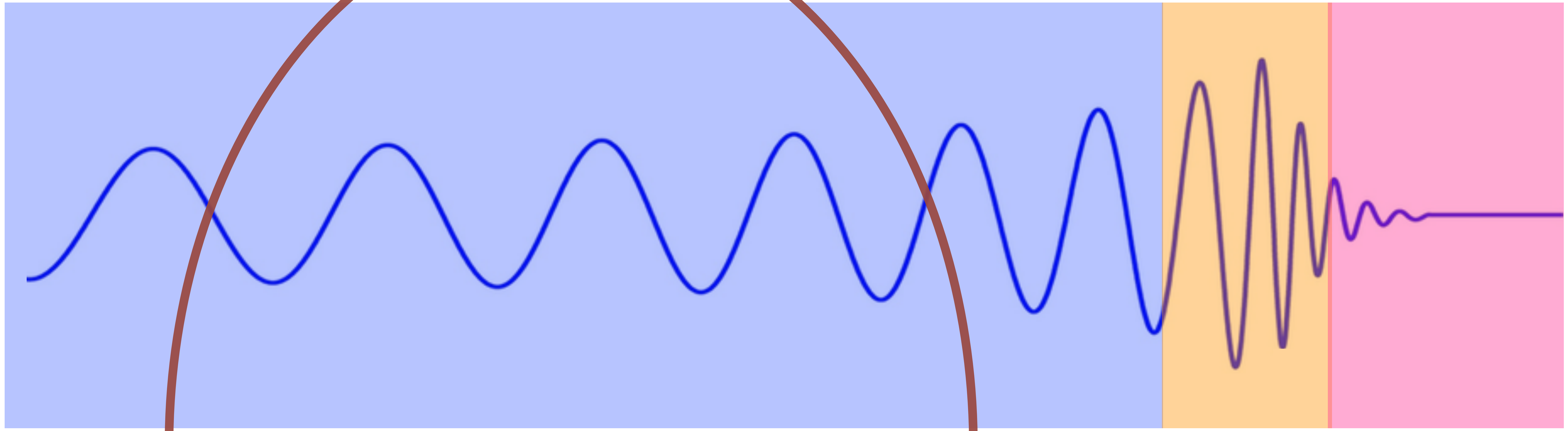


Approaches to computing the waveform



	Inspiral	Merger	Ringdown
3 Phases			
Different Formalisms	Post-Newtonian Theory	Numerical Relativity	Perturbation Theory
Solutions	Analytical & Approximative	Numerical & Exact	Analytical & Approximative

Approaches to computing the waveform

	Inspiral	Merger	Ringdown
3 Phases			
Different formalisms	Post-Newtonian theory	Numerical relativity	Perturbation theory
Solutions	Analytical & approximative	Numerical & exact	Analytical & approximative

My thesis

Framework : Post-Newtonian Theory

Compute the dynamics and waveform (phase + amplitude)

→ key observables for data analysis

Goals

- Compute waveform templates in alternative theories

→ to test alternative theories with GW observations

- Model the impact of neutron star matter on the GW

→ to probe the inner structure of neutron stars

Dynamics and gravitational waves' emission of spinning compact binary systems in general relativity and beyond

Tom Colin
First-year PhD Student

ASTRE Team
Supervisors: Laura Bernard, Sashwat Tanay

LUX Day

Gravitational Wave Modeling from Compact Binaries

- Develop accurate **gravitational wave templates** for advanced detectors (LISA, ET).
- Gravitational waves depend on **CB trajectories**.
- Incorporate **non-aligned spins** and **arbitrary eccentricity** during inspiral phase.

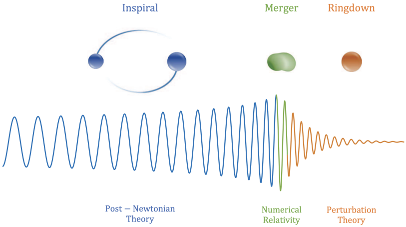
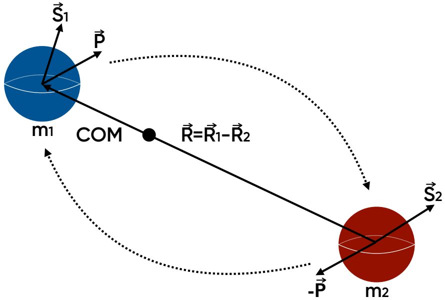


Image credit: https://arxiv.org/pdf/1610.03567

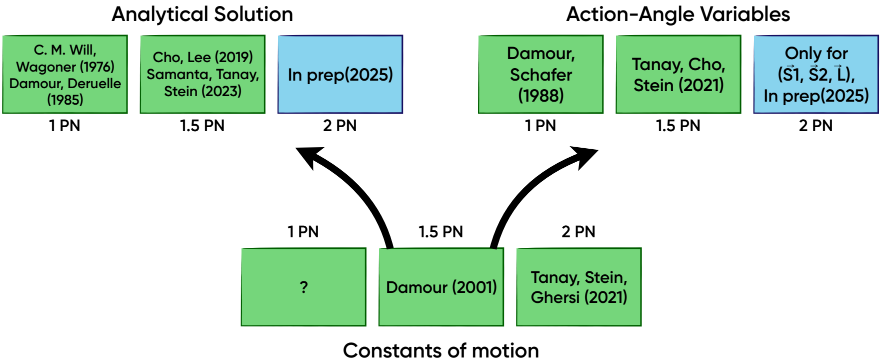
Hamiltonian Framework for BBH Dynamics

- **Post-Newtonian expansion** : valid for inspiral phase.
- Hamiltonian formulation with **action-angle variables**.
- Accounts for **spin-orbit** and **spin-spin** interactions.
- **Phase-Space** : $\vec{R}, \vec{P}, \vec{S}_1, \vec{S}_2$

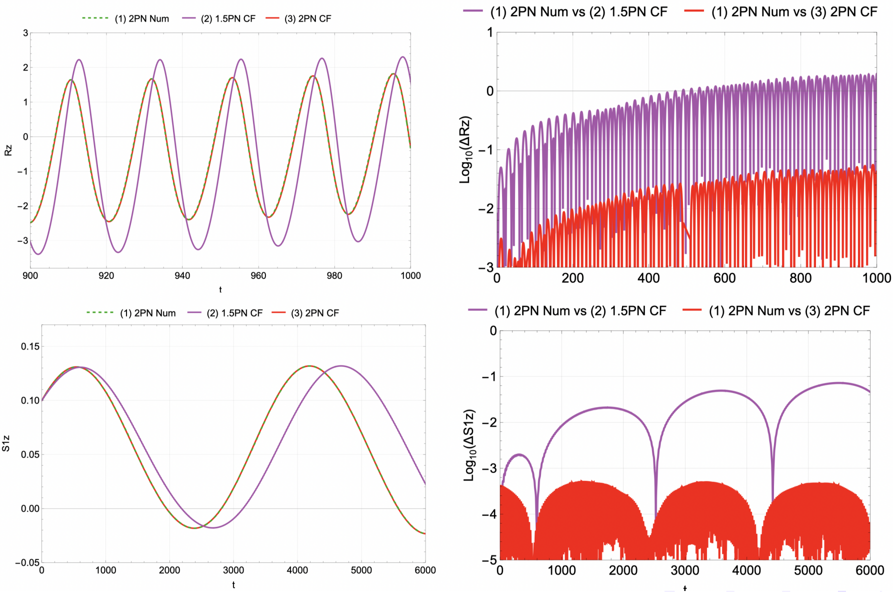


Previous and Ongoing Work

- C. M. Will, Wagoner (1976): Early analytical solutions.
- Damour, Deruelle (1985): 1PN solutions.
- Cho, Lee (2019): 1.5PN contributions.
- Tanay, Stein, Ghersi (2021): 2PN advancements.
- Ongoing work (2025): Further 2PN developments.



2PN Analytical Solution for R_z and S_{1z}



Next Work

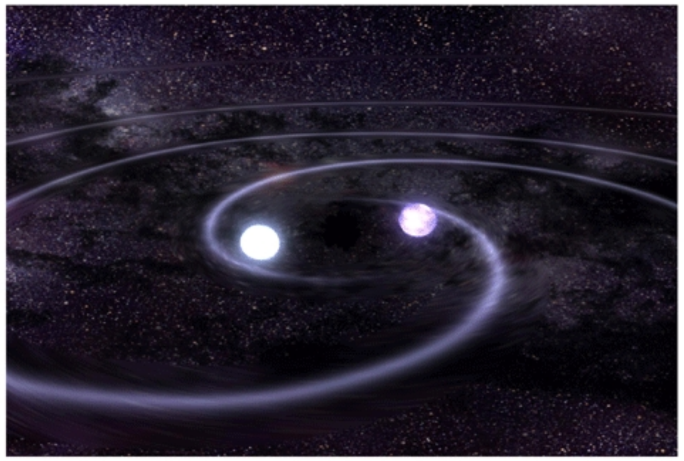
- Extend to order **2.5PN in GR**, including radiation-reaction and gravitational wave emission.
- Compute the first non-trivial contribution both for **spin-orbit** and **spin-spin** interactions in **modified theories of gravity**

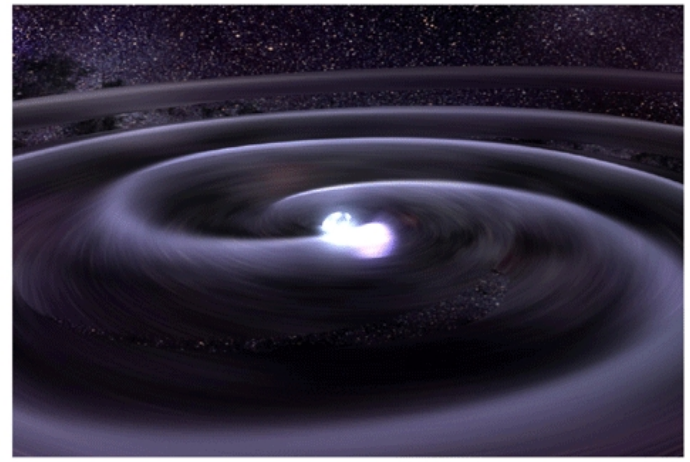
QFT-based methods for classical gravity

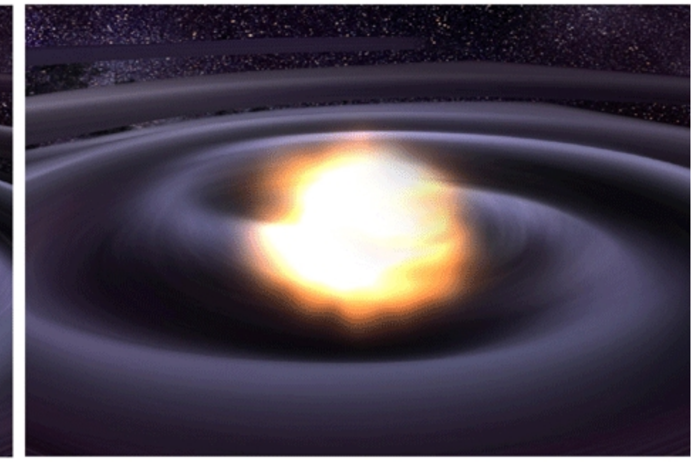
Laboratoire d'étude de l'Univers et des phénomènes eXtrêmes

Stavros Mougiakakos

PI: **Laura Bernard**







Inspiral

Analytic treatment

Merger

Numerical Relativity

Ringdown

BHPT

Gravitational Wave

GW detection

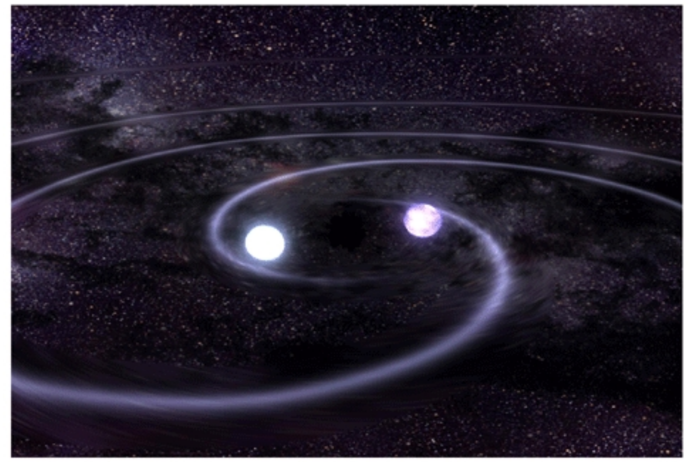
=

Matched Filtering

~

GW templates

GW Observatories



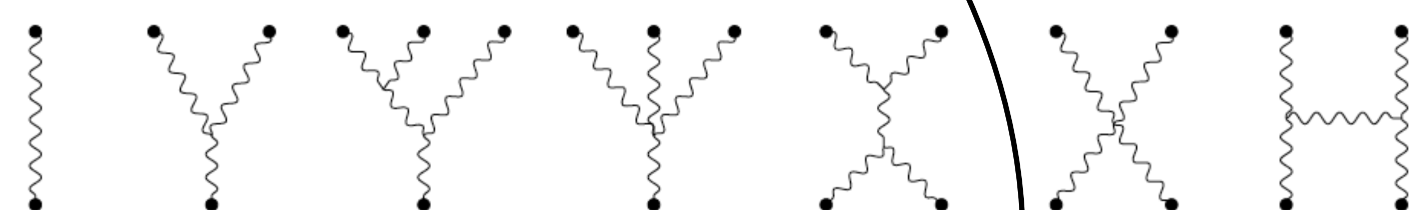
Inspiral

Analytic/Perturbative treatment

$$G_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}$$

$$\mathscr{L}_{eff} = \mathscr{L}_{EH} + \mathscr{L}_{matter}$$

Treat GR+matter as QFT
+Scattering Amplitudes
+Feynman integrals



(a) (b) (c) (d) (e) (f) (g)

Traditional

QFT-based

BLACK HOLES IN MODIFIED GRAVITY

Hugo CANDAN – 1st year PhD student

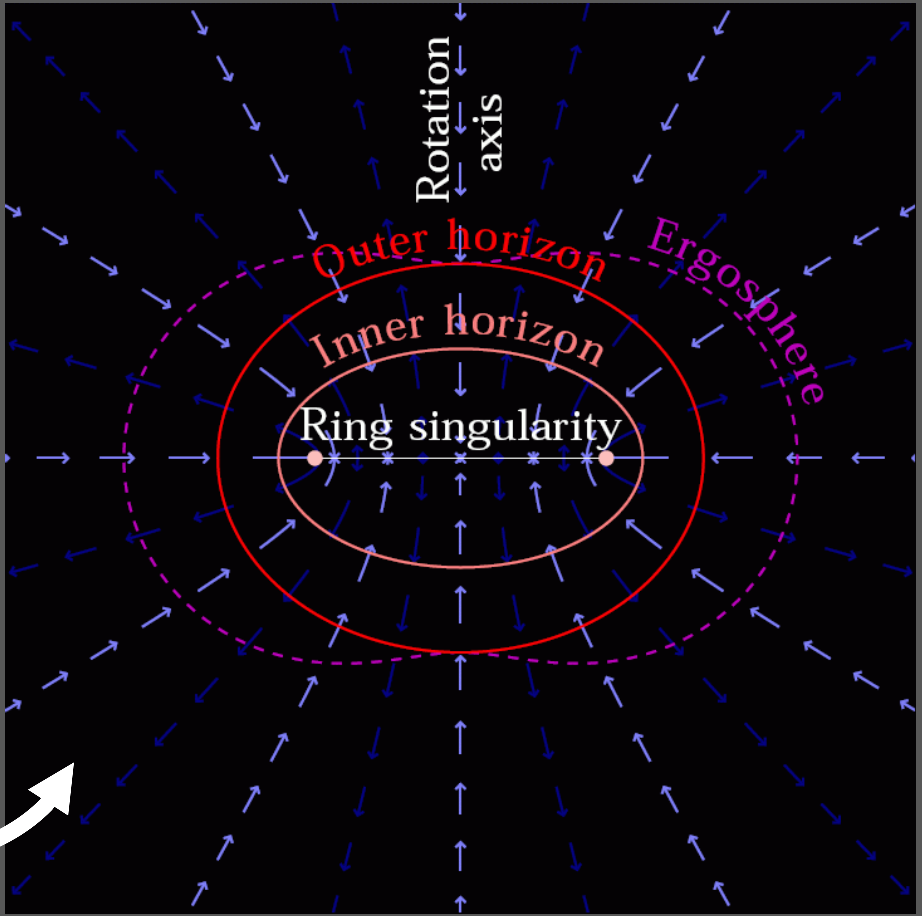
With Philippe Grandclément in ASTRE team

In Einstein's theory of gravity

→ Black Hole uniqueness theorem

Only vacuum solution of Einstein's equation is the Kerr metric

Fully characterised by its mass M and angular momentum J



Only possible Black Hole according to Einstein's theory

What about alternative theories of gravity ?

→ new Black Holes are possible
can be characterised by new parameters

Can we detect the difference ?

First need to find the expression of the gravitational field (metric) of those Black Holes

$$ds^2 = -c^2 d\tau^2 = -\left(1 - \frac{r_s}{r}\right) c^2 dt^2 + \frac{dr^2}{1 - \frac{r_s}{r}} + r^2 \left(d\theta^2 + \sin^2\theta \, d\varphi^2\right)$$

← Black Hole metric in Einstein's theory

Need to solve very difficult coupled non-linear partial differential equations

Einstein's equation :

$$R_{\mu\nu} - \frac{1}{2} R g_{\mu\nu} = 8\pi T_{\mu\nu}$$

Alternative theories :

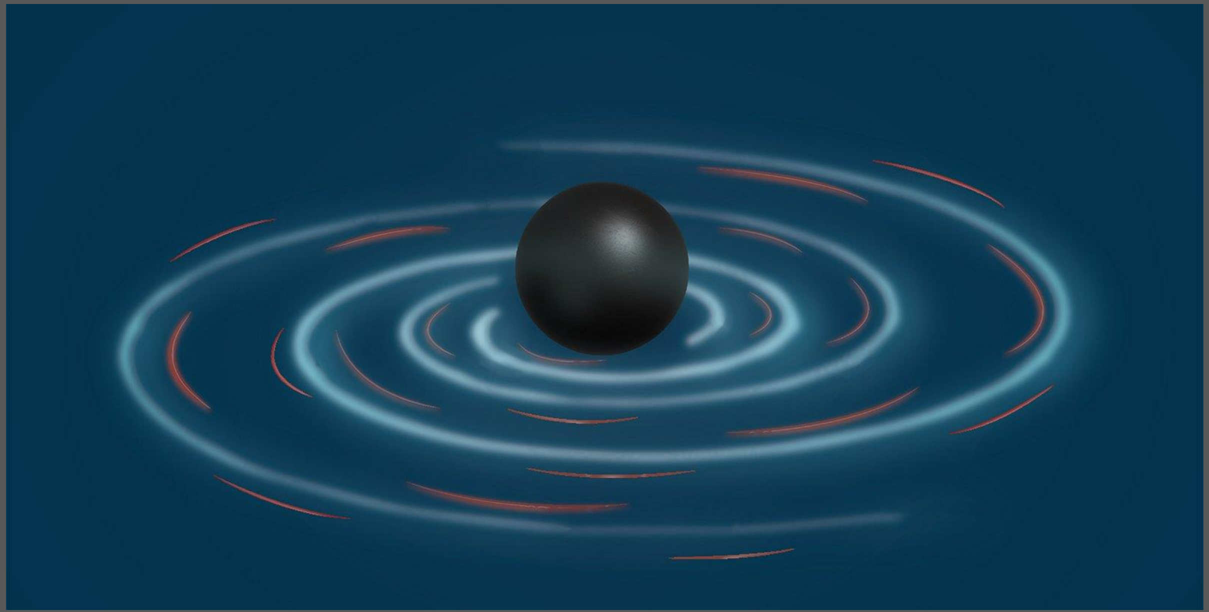
$$\begin{aligned}
&G_4(X)\left(R_{\mu\nu} - \frac{1}{2} R\, g_{\mu\nu}\right) + G_4'(X)\Big(-\frac{1}{2} R\, \phi_\mu \phi_\nu - \Box\phi\, \phi_{\mu\nu} + R_{\mu\alpha}\phi^\alpha \phi_\nu + R_{\alpha\nu}\phi^\alpha \phi_\mu \\
&+ \phi_{\mu\alpha}\phi^\alpha{}_\nu + \frac{1}{2}\Box\phi^2 g_{\mu\nu} - R_{\alpha\beta}\phi^\alpha\phi^\beta g_{\mu\nu} + R_{\mu\alpha\nu\beta}\phi^\alpha\phi^\beta - \frac{1}{2}\phi_{\alpha\beta}\phi^{\alpha\beta} g_{\mu\nu}\Big) \\
&+ G_4''(X)\Big(-\frac{1}{2}\Box\phi^2 \phi_\mu\phi_\nu + \Box\phi\, \phi^\alpha \phi_{\alpha\mu}\phi_\nu + \Box\phi\, \phi^\alpha\phi_{\alpha\nu}\phi_\mu - \phi^\alpha\phi^\beta\phi_{\alpha\mu}\phi_{\beta\nu} + \phi^\alpha\phi^\beta\phi_{\alpha\beta}\phi_{\mu\nu} \\
&- \phi^\alpha \phi_\alpha{}^\beta \phi_{\beta\mu}\phi_\nu - \phi^\alpha\phi_\alpha{}^\beta\phi_{\beta\nu}\phi_\mu + \frac{1}{2}\phi_{\alpha\beta}\phi^{\alpha\beta}\phi_\mu\phi_\nu - \Box\phi\, \phi_{\alpha\beta}\phi^\alpha\phi^\beta g_{\mu\nu} + \phi_{\alpha\beta}\phi^\beta{}_\gamma \phi^\alpha\phi^\gamma g_{\mu\nu}\Big) \\
&- \frac{1}{2} G_2(X) g_{\mu\nu} - \frac{1}{2} G_2'(X)\phi_\mu\phi_\nu = 0
\end{aligned}$$

Some analytical solutions for static black holes are known

BUT : not astrophysically relevant, Black Holes do rotate !

GOAL : use numerical tools to solve the equations and find rotating Black Holes solutions

→ Find Gravitational Waves frequencies (Quasi-Normal modes)



Thank you !

Question time

COSGAL Team

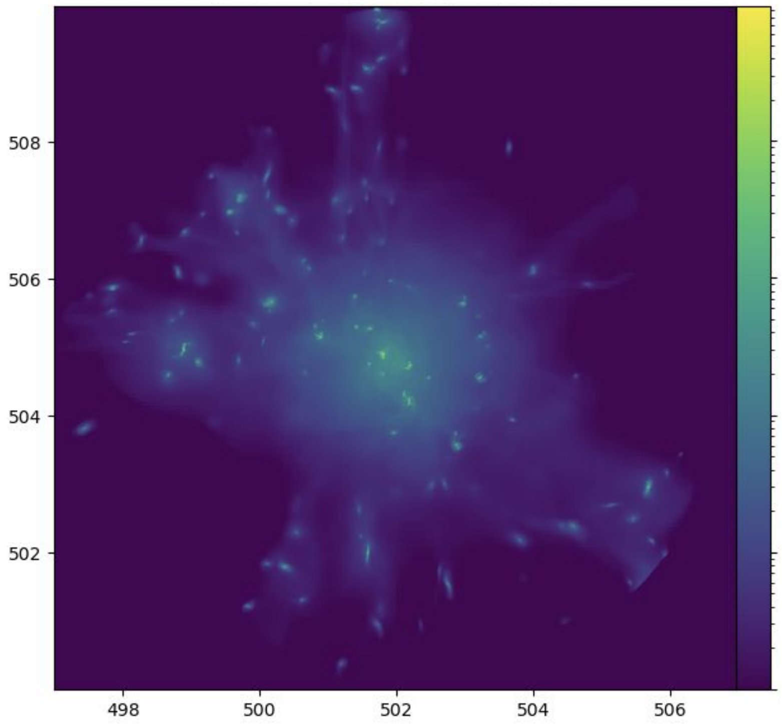
Félix TORNATORE - 1st year Phd Student in COSGAL

With Amandine LE BRUN
And Pier Stefano CORASANITI

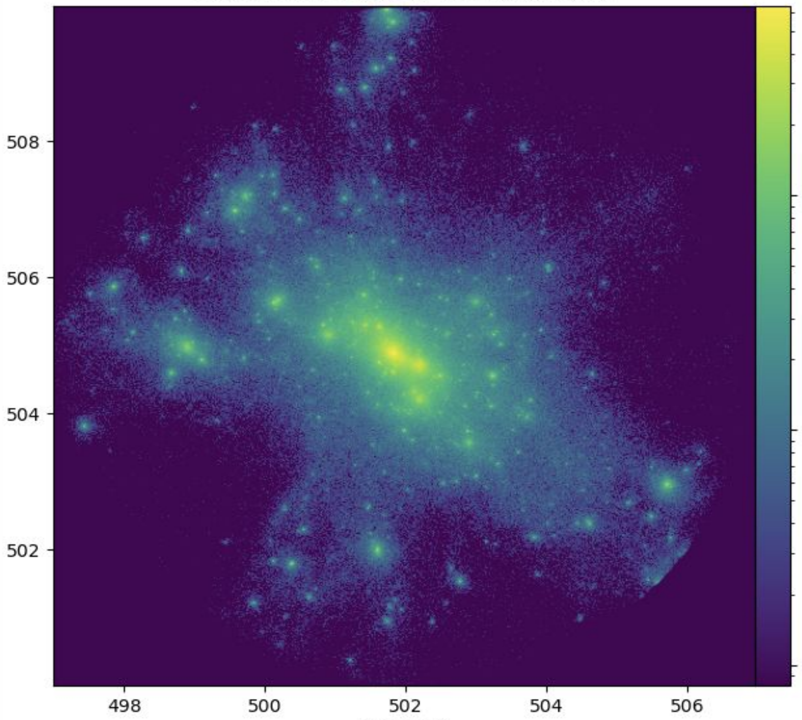
Simulations of Galaxy Clusters in Non Standard Cosmological scenarios

Lux starting Day 12/03/2025

Cosmological simulation of Galaxy Clusters …

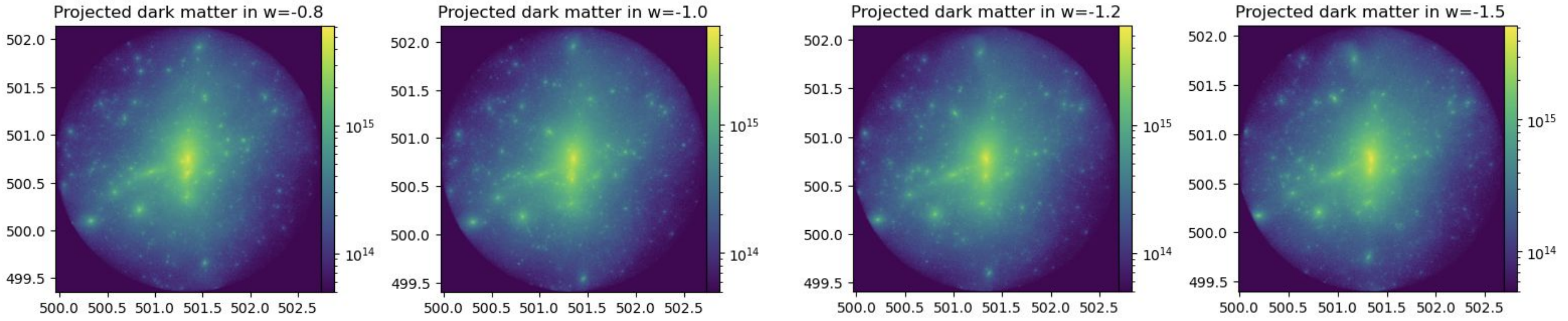


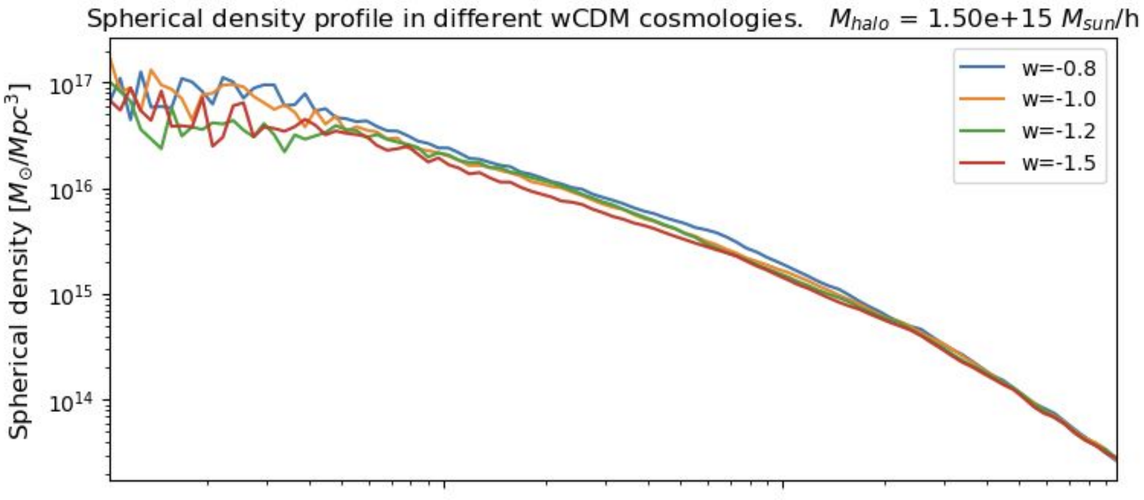
Gas density



Dark matter density

… in non standard dark energy models:





Same dark matter halo in 4 wCDM cosmologies with corresponding **mass density profiles**

Work in Progress for galaxy clusters !!

Goal:

Study the joint effect of a modification of the dark energy model and the baryonic physics at work in galaxy clusters

- Star formation
- Supernovae feedback
- AGN feeback

THANK YOU !

ACCURATE THEORETICAL PREDICTIONS FOR THE GALAXY CLUSTER NUMBER COUNTS / CLUSTERING DARK ENERGY

2nd year PhD student : Théo Gayoux

Supervisors:
Pier-Stefano Corasaniti (LUX - COSGAL)
Linda Blot (Kavli IPMU (WPI), UTIAS, The University of Tokyo)

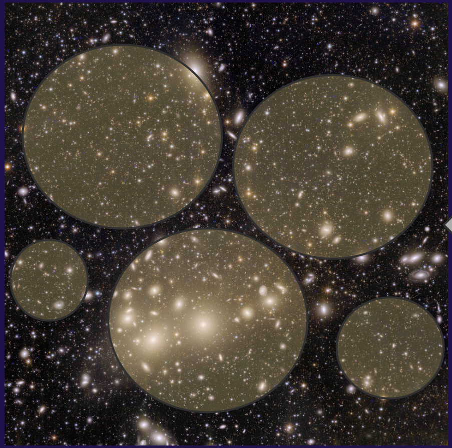
Team : COSGAL

LUX starting day

GALAXY CLUSTER NUMBER COUNTS

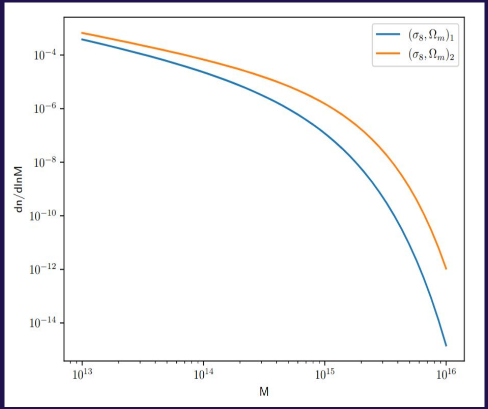
→ Largest structures gravitationally bound in the Universe
→ Abundance very sensitive to cosmological parameters (e.g. σ_8, Ω_m)

Observational side

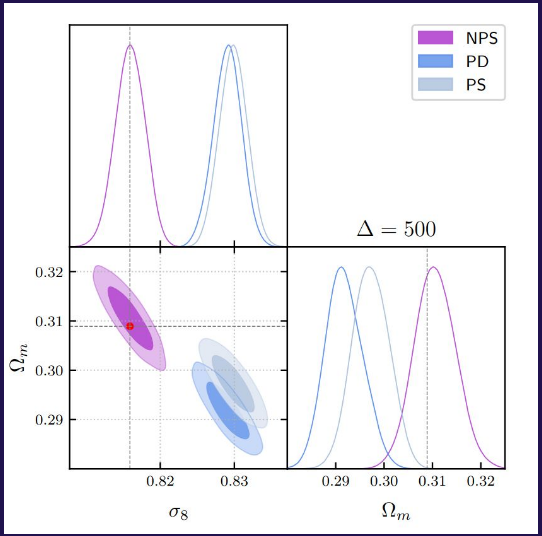


Our universe (true cosmology)

Theoretical prediction



Halo mass function (cosmology dependent)

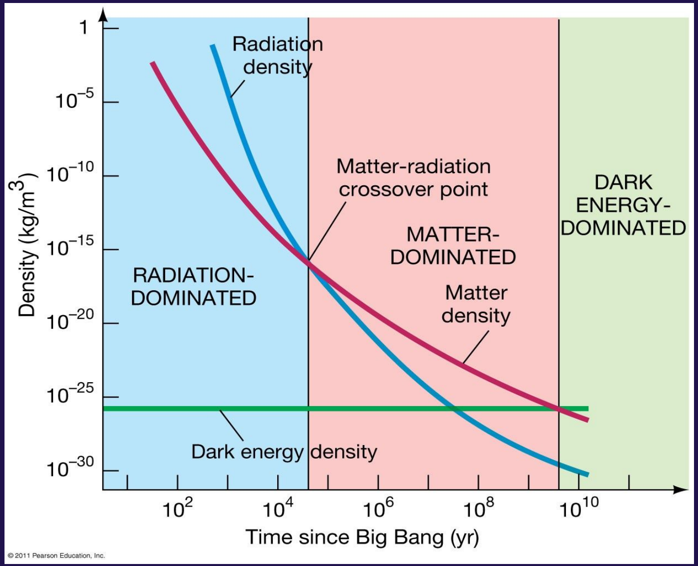


3 theoretical models → Bias

CLUSTERING DARK ENERGY

→ What is **Dark Energy** ?

Today : accelerated phase of the expansion
Existence of an exotic component : ***Dark Energy*** *(DE)*



→ *Standard cosmological model :*

$$\Lambda CDM$$

DE: constant in space and time

Cold Dark Matter

$$P = \omega \bar{\rho} < 0$$
$$\omega = -1$$

Equation of state

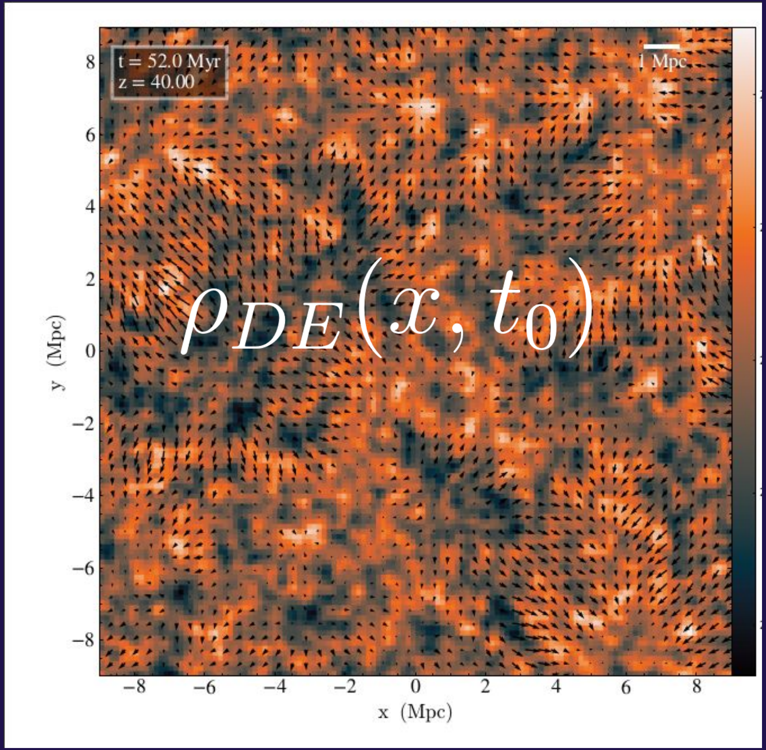
Clustering Dark Energy:

$$P_{de}(x,t) = \bar{\rho}_{de}(t)\omega c^2 + \bar{\rho}_{de}(t) c_s^2 \delta_{de}(x,t)$$

Time and space dependence

NEFERTITI
CLUSTERING DARK ENERGY

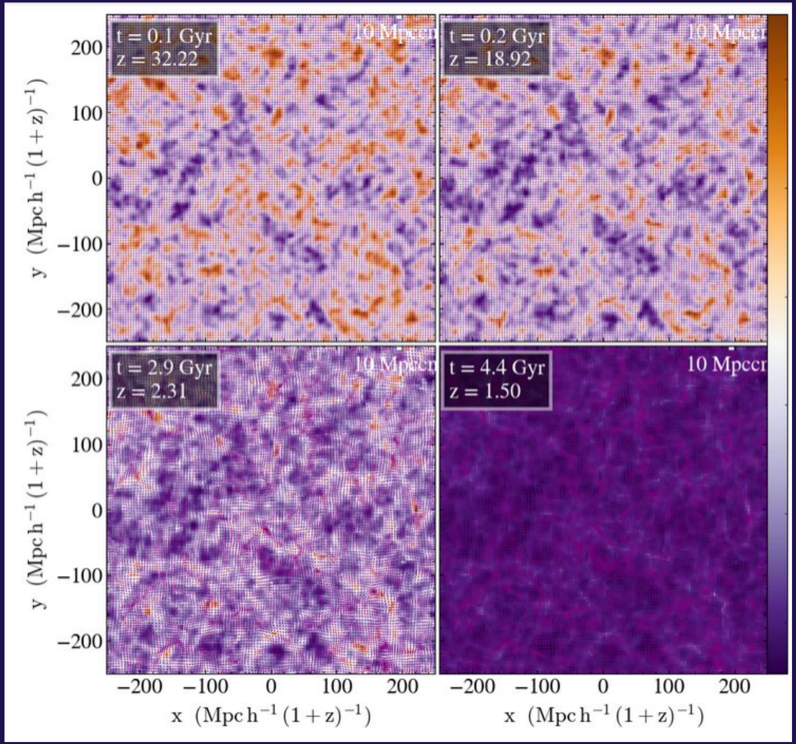
Initial conditions



$\rho_{DE}(x, t_0)$

Fluid equations

Nefertiti



THANK YOU FOR YOUR ATTENTION :)

Predictions of the impact of relativistic effects on the large-scale structures of the universe

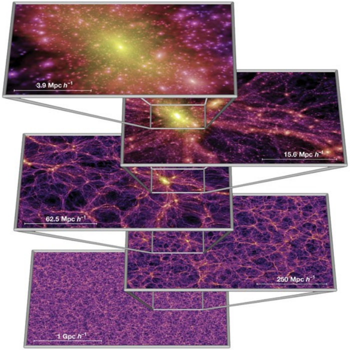
Marta Corioni

LUX/Paris Observatory

14/03/2025

State of the art

- Λ**CDM model** well tested but still not fully explained.
- Different observations have revealed some **tensions**, prompting considerations beyond the ΛCDM model
- Multiple **modified gravity** theories.



Constraining a Theory of Gravity

Cosmological parameters

↓

Generate initial conditions

↓

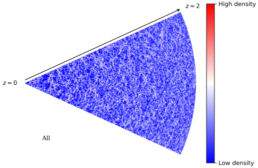
N-body simulation

↓

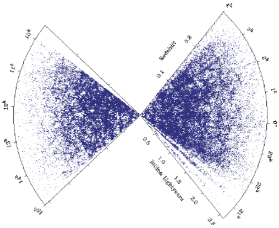
Ray-tracing techniques

↓

Observables

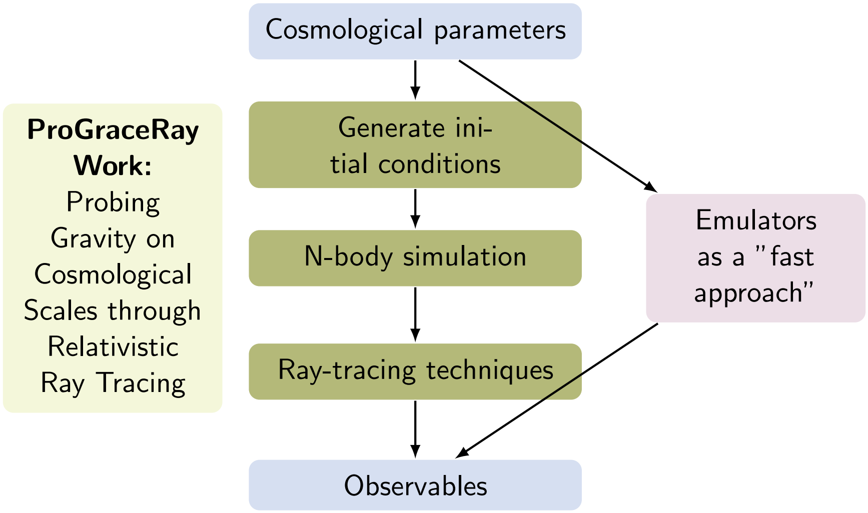


(a) 2D density field from RayGal simulation.



(b) 2dF redshift survey.

Constraining a Theory of Gravity



Emulator: advanced interpolator

Small detail:
we need to
run multiple
simulations first,
to explore the
dark energy
parameter space

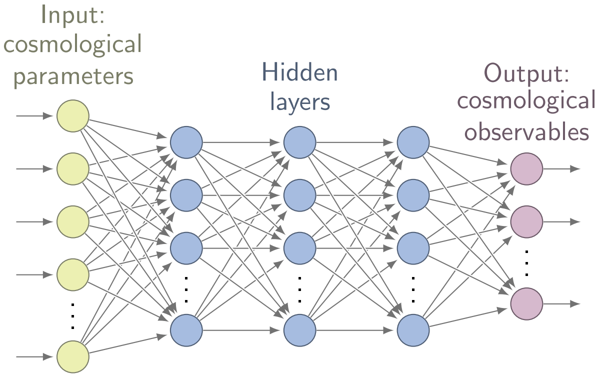


Figure: Emulator in practice

Exploring relativistic effects

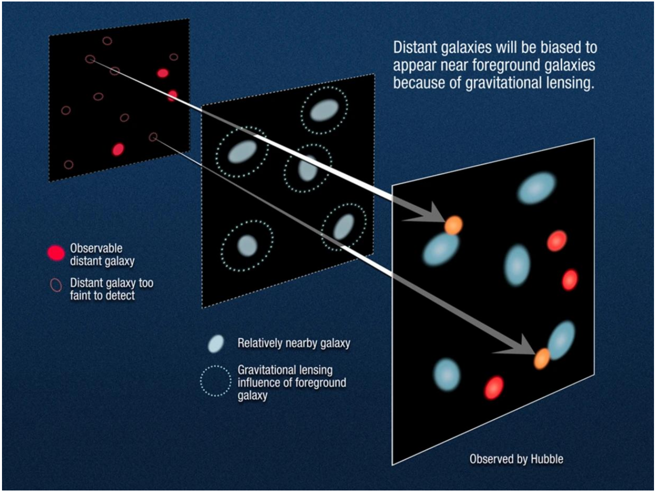


Figure: Representation of Magnification bias, *A. Feild / STScI / NASA / ESA*

Conclusion

Relativistic Effects:
Essential for Constraining Dark Energy

Ongoing Development: Emulator to Assess
the Impact of Relativistic Effects

Himanish Ganjoo

Postdoc

With Yann Rasera in the ProGraceRay Project, at LUX Meudon

COSGAL Group

Himanish Ganjoo

Postdoc

With Yann Rasera in the ProGraceRay Project, at LUX Meudon

COSGAL Group

From Delhi, India

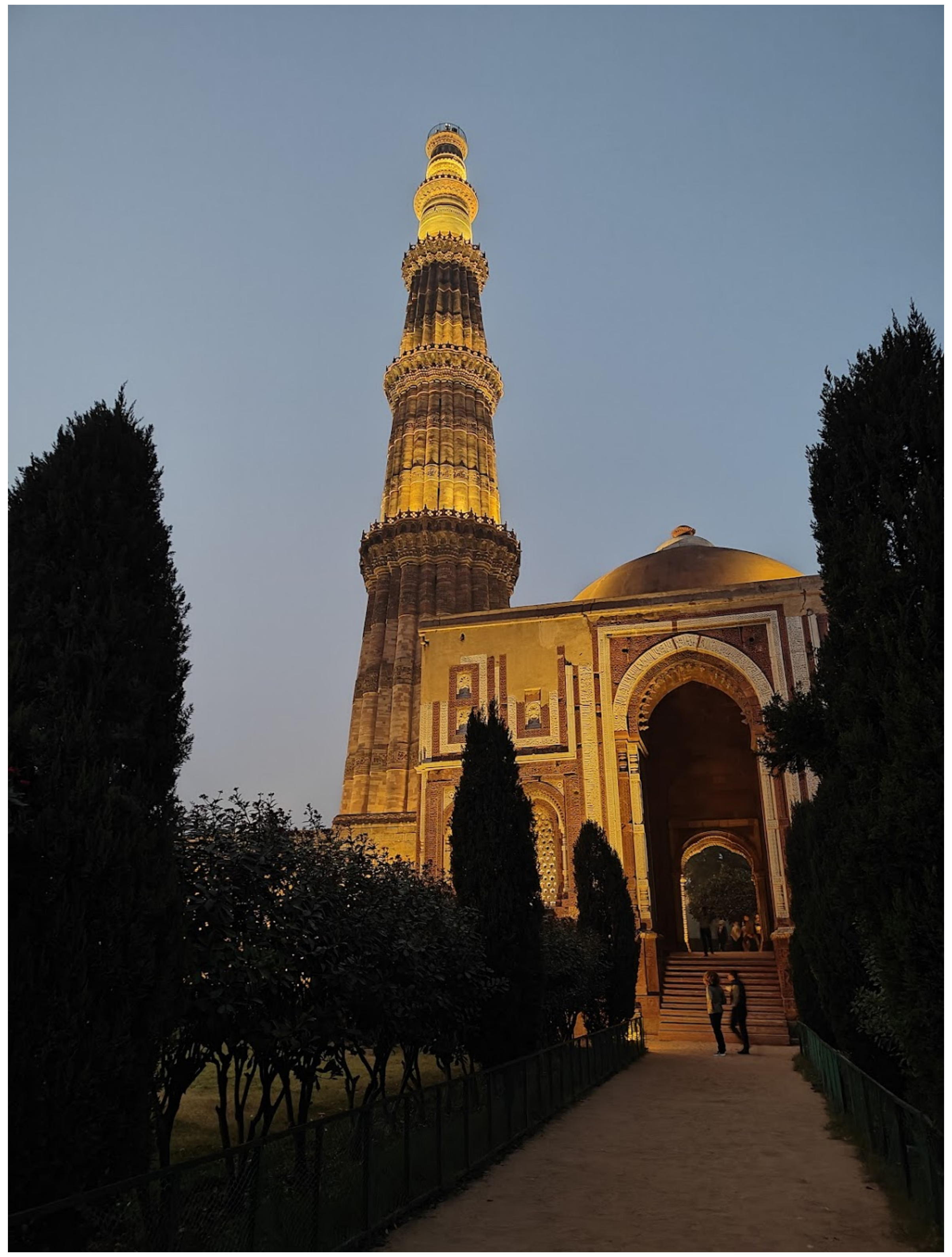
Himanish Ganjoo

Postdoc

With Yann Rasera in the ProGraceRay Project, at LUX Meudon

COSGAL Group

From Delhi, India



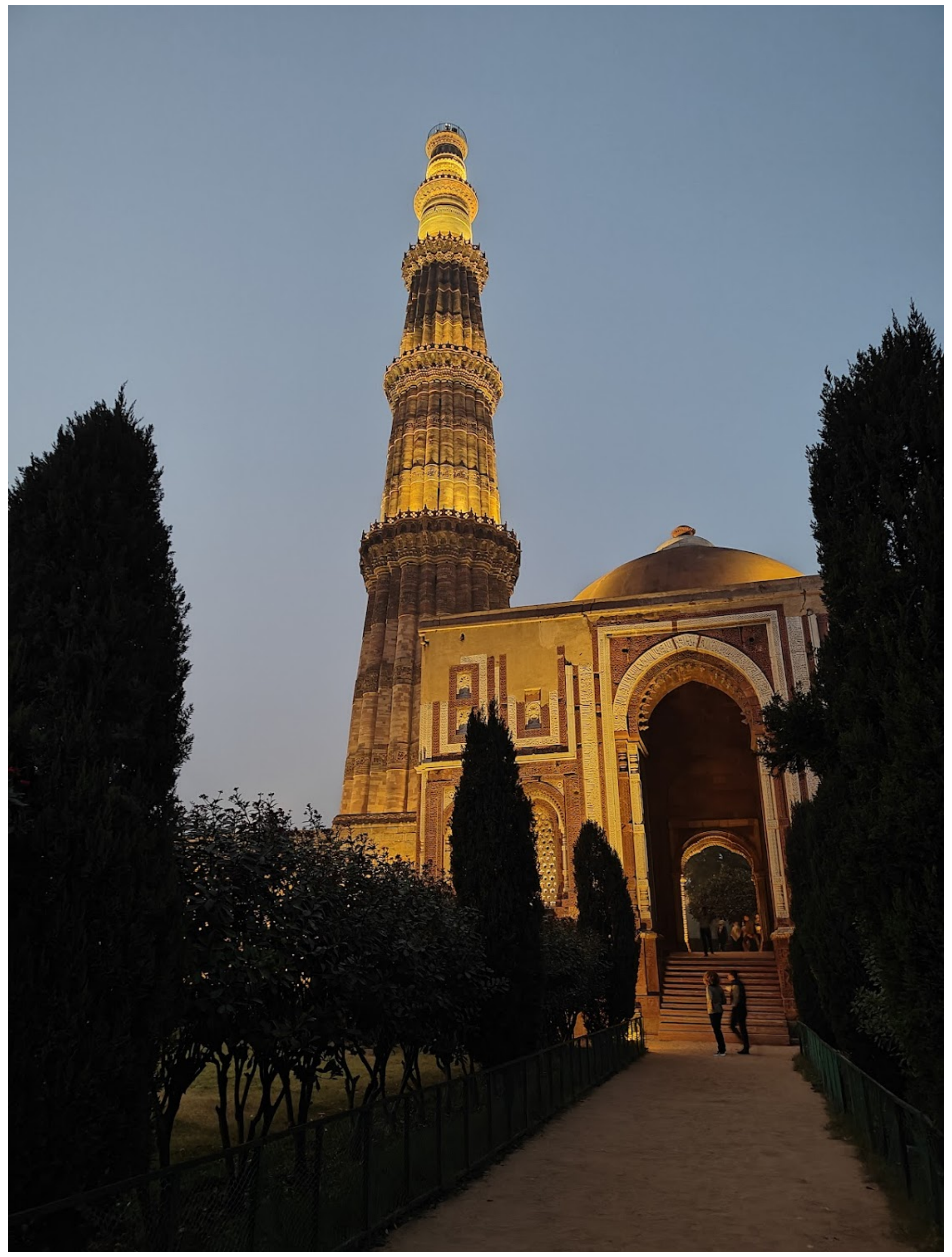
Himanish Ganjoo

Postdoc

With Yann Rasera in the ProGraceRay Project, at LUX Meudon

COSGAL Group

From Delhi, India



PhD at Perimeter Institute
With Katie Mack, on Early
Matter Dominated Eras
and simulating extremely
small-scale structure
formation

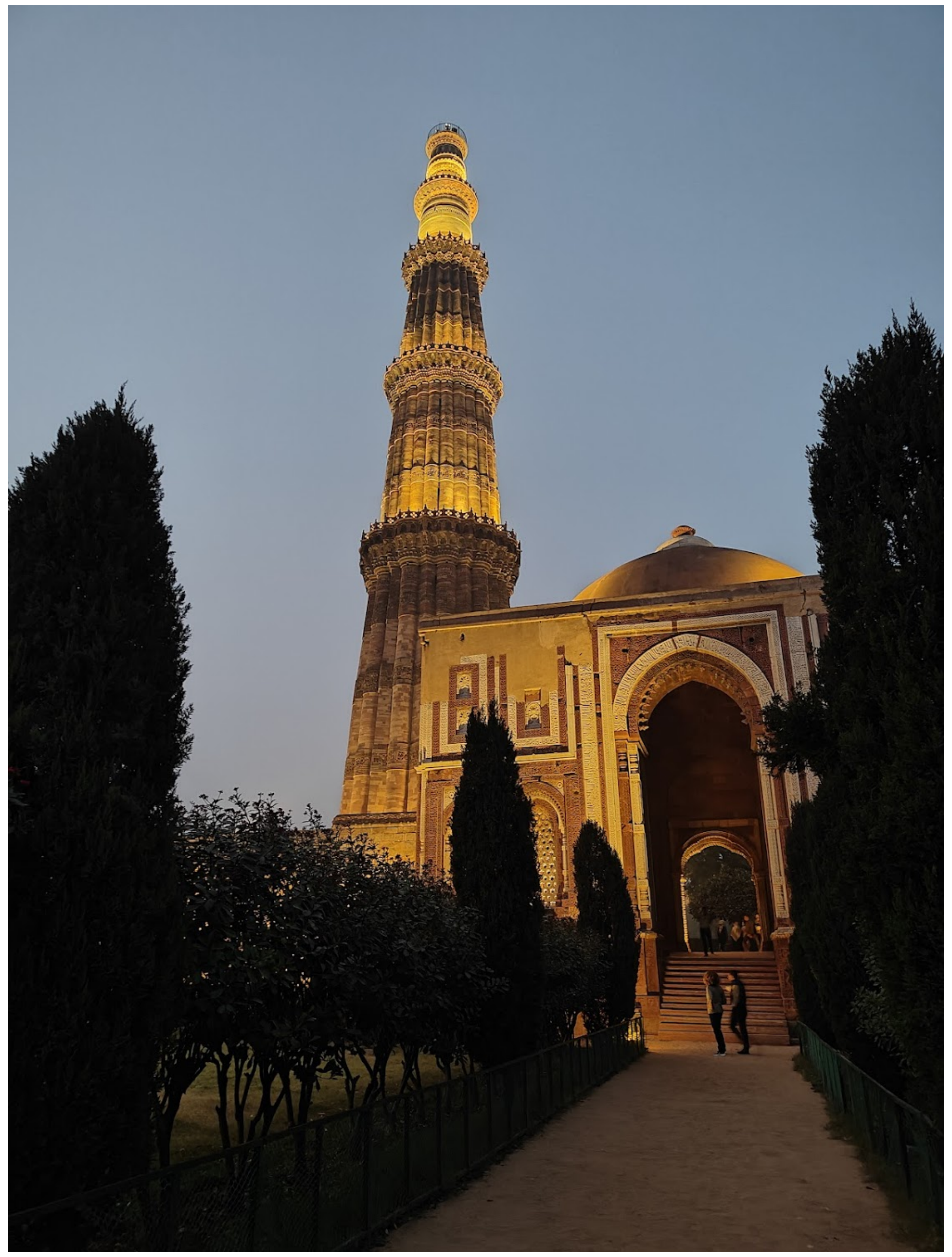
Himanish Ganjoo

Postdoc

With Yann Rasera in the ProGraceRay Project, at LUX Meudon

COSGAL Group

From Delhi, India



PhD at Perimeter Institute
With Katie Mack, on Early Matter Dominated Eras and simulating extremely small-scale structure formation

Other Interests:
Cricket (was analyst of the World Cup winning Indian team)
Cooking
Music
Singing

ProGraceRay

ProGraceRay

Questions:

What is the nature of gravity on the largest scales?

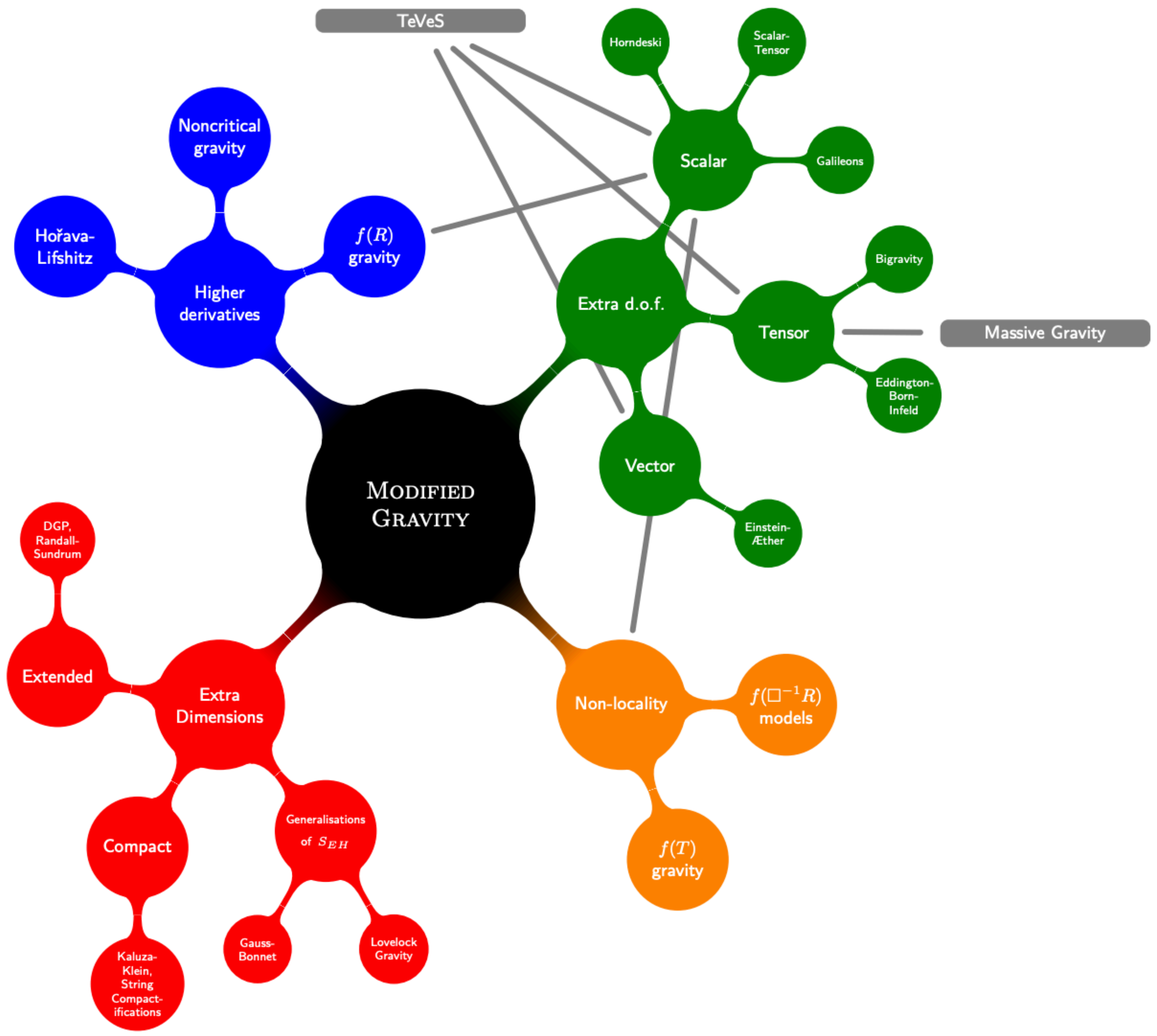
What drives the accelerated expansion of the universe?

ProGraceRay

Questions:

What is the nature of gravity on the largest scales?

What drives the accelerated expansion of the universe?

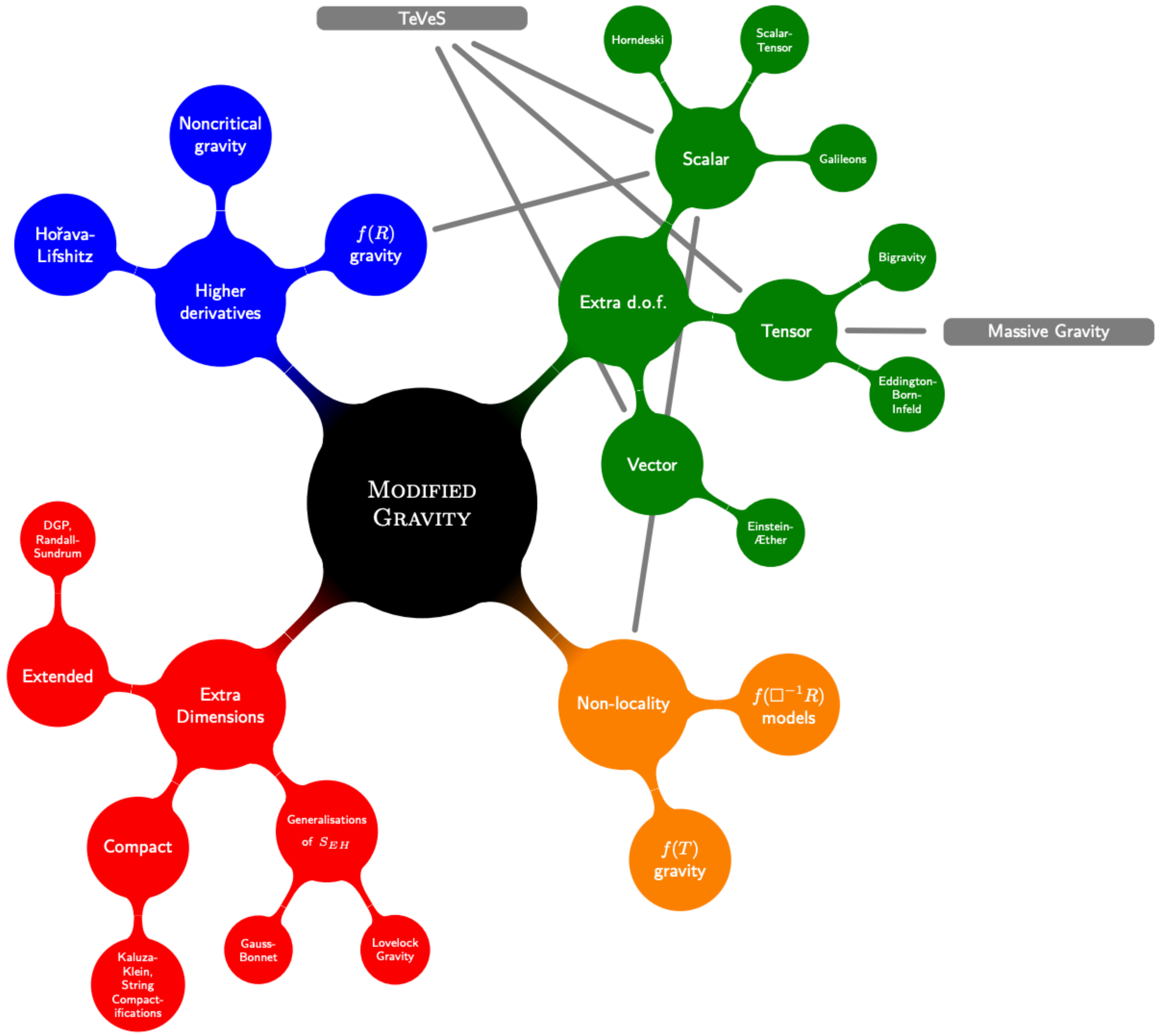


ProGraceRay

Questions:

What is the nature of gravity on the largest scales?

What drives the accelerated expansion of the universe?



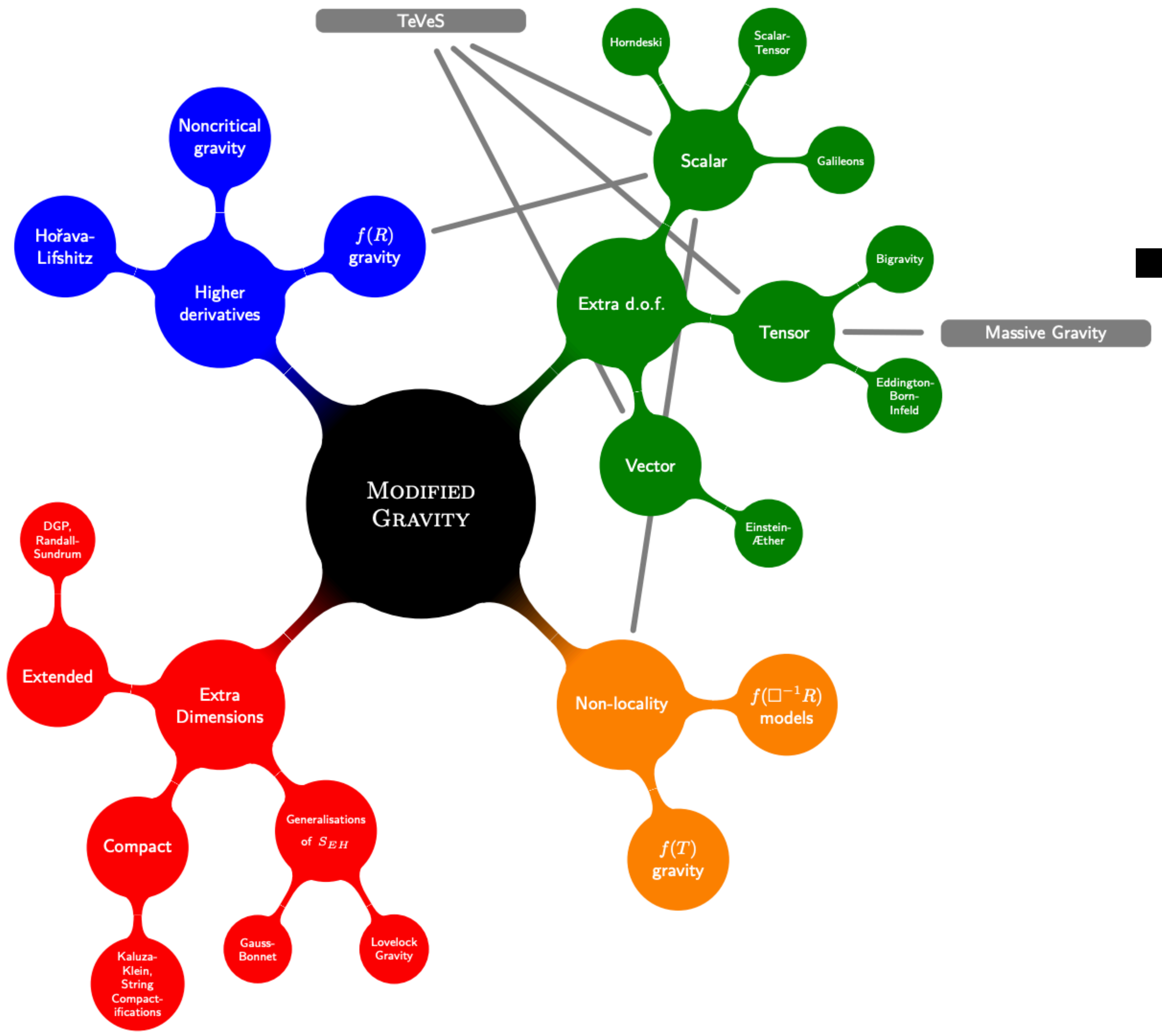
Need accurate predictions for both

ProGraceRay

Questions:

What is the nature of gravity on the largest scales?

What drives the accelerated expansion of the universe?



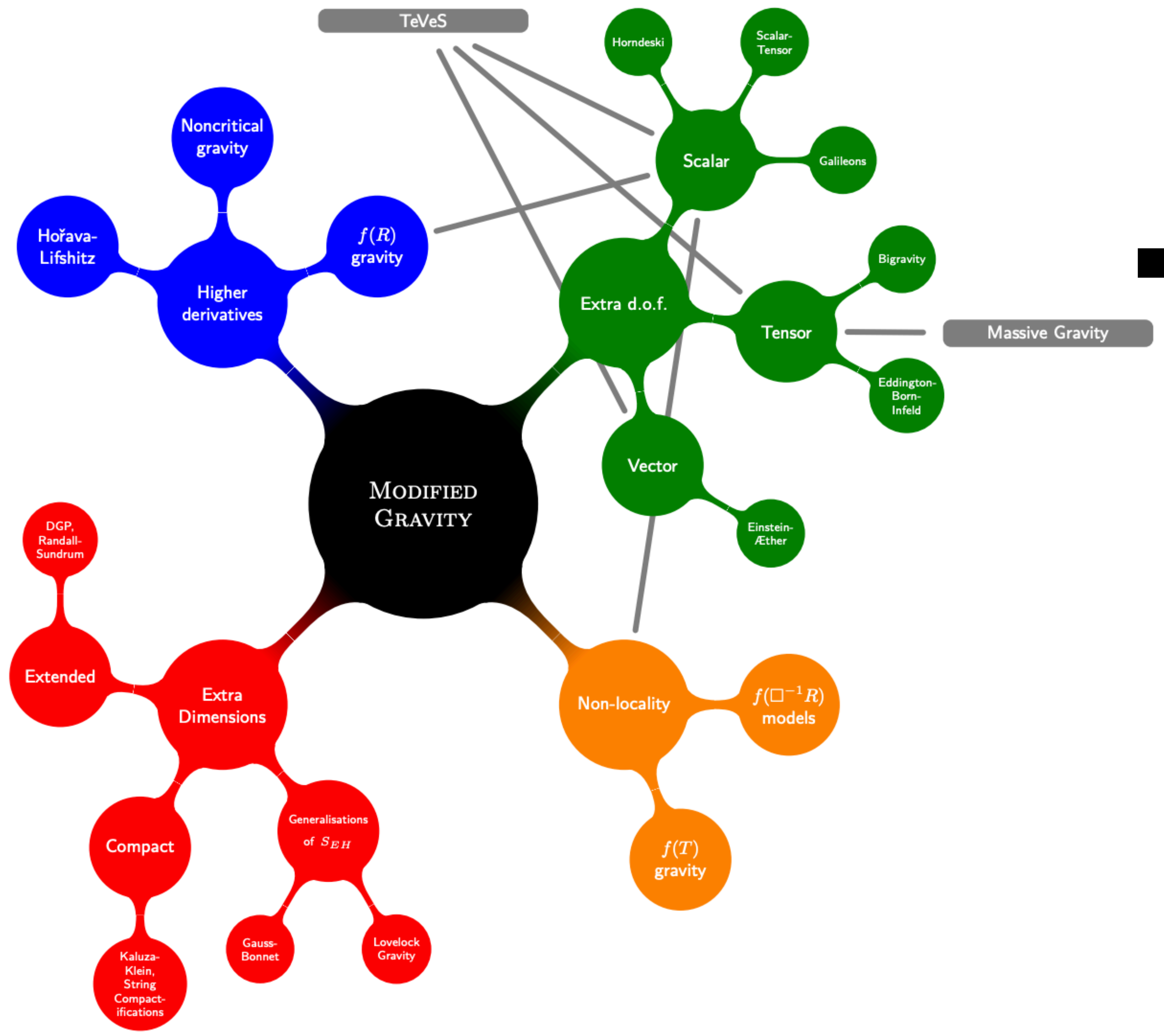
→ Need accurate predictions for both

ProGraceRay

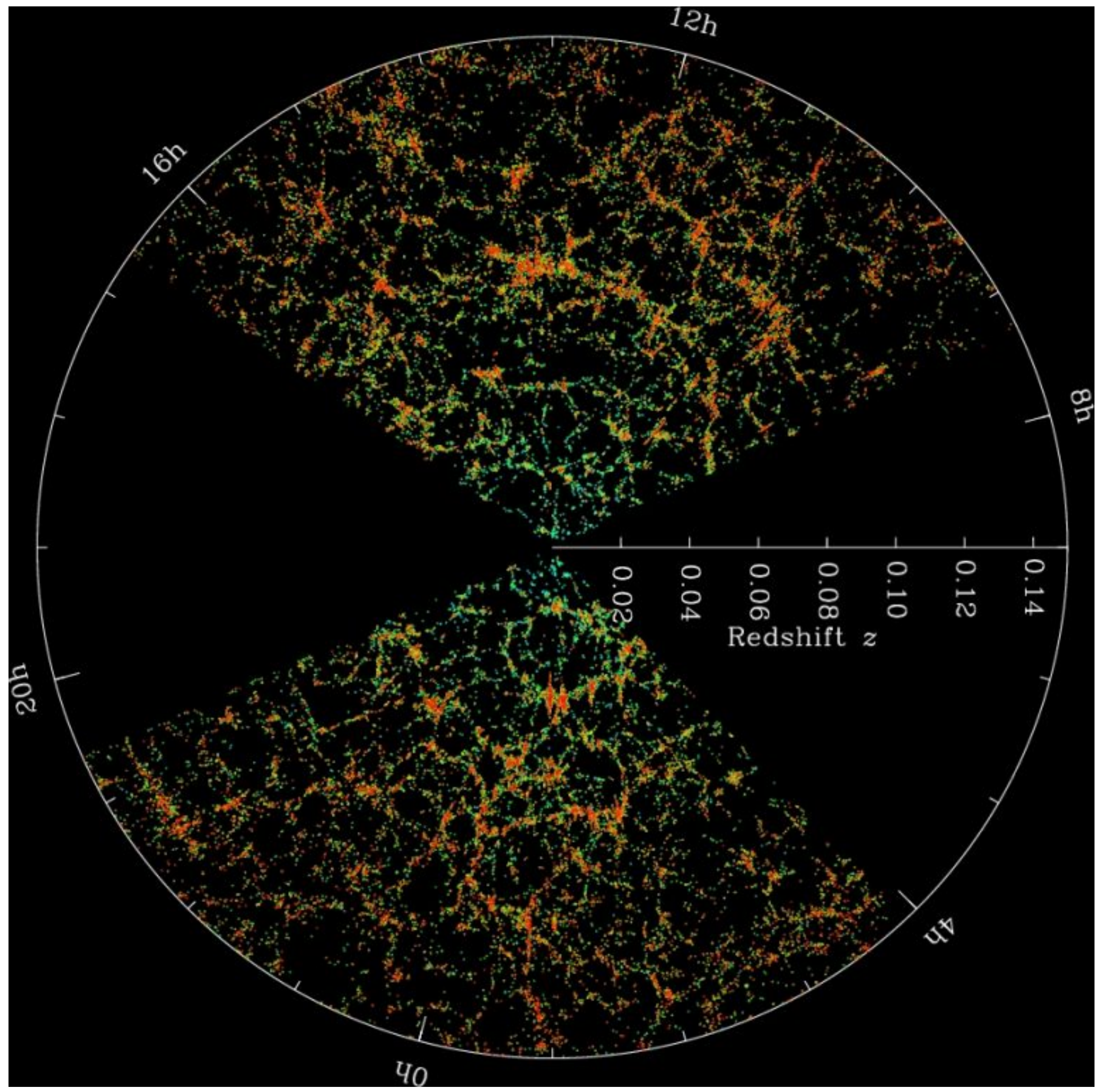
Questions:

What is the nature of gravity on the largest scales?

What drives the accelerated expansion of the universe?



Need accurate predictions for both



Large-Scale Structure

+

Lensing Maps

ProGraceRay

ProGraceRay

Aim

Accurate predictions of structure formation and lensing
in various modified gravity scenarios

ProGraceRay

Aim

Accurate predictions of structure formation and lensing in various modified gravity scenarios

Approach

ProGraceRay

Aim

Accurate predictions of structure formation and lensing in various modified gravity scenarios

Approach

Modify the AMR N-body code RAMSES (Teyssier 2002) to include an additional scalar field.

ProGraceRay

Aim

Accurate predictions of structure formation and lensing in various modified gravity scenarios

Approach

Modify the AMR N-body code RAMSES (Teyssier 2002) to include an additional scalar field.

The scalar field leads to a “slip” between the two potentials Φ and Ψ.

ProGraceRay

Aim

Accurate predictions of structure formation and lensing in various modified gravity scenarios

Approach

Modify the AMR N-body code RAMSES (Teyssier 2002) to include an additional scalar field.

The scalar field leads to a “slip” between the two potentials Φ and Ψ.

Structure: sensitive to Φ

ProGraceRay

Aim

Accurate predictions of structure formation and lensing in various modified gravity scenarios

Approach

Modify the AMR N-body code RAMSES (Teyssier 2002) to include an additional scalar field.

The scalar field leads to a "slip" between the two potentials Φ and Ψ.

Structure: sensitive to Φ

Lensing: sensitive to $\Phi + \Psi$

ProGraceRay

Aim

Accurate predictions of structure formation and lensing in various modified gravity scenarios

Approach

Modify the AMR N-body code RAMSES (Teyssier 2002) to include an additional scalar field.

The scalar field leads to a "slip" between the two potentials Φ and Ψ.

Structure: sensitive to Φ

Lensing: sensitive to $\Phi + \Psi$

With accurate maps of the universe at large scales, obtained via N-body simulations, we can constrain many modified gravity theories.

PROGRACERAY

PROGRACERAY

Model

Effective Field Theory of Dark Energy

PROGRACERAY

Model

Effective Field Theory of Dark Energy

Advantages

PROGRACERAY

Model

Effective Field Theory of Dark Energy

Advantages

- EFT unifies dark energy and modified gravity models in one framework.

PROGRACERAY

Model

Effective Field Theory of Dark Energy

Advantages

- EFT unifies dark energy and modified gravity models in one framework.
- Expresses a wide variety of models using a few parameters.

PROGRACERAY

Model

Effective Field Theory of Dark Energy

Advantages

- EFT unifies dark energy and modified gravity models in one framework.
- Expresses a wide variety of models using a few parameters.
- Provides a model-independent method of probing these theories.

ProGraceRay

Methods

ProGraceRay

Methods

- Rewrite the Lagrangian to include the additional scalar field.

ProGraceRay

Methods

- Rewrite the Lagrangian to include the additional scalar field.

ProGraceRay

Methods

- Rewrite the Lagrangian to include the additional scalar field.

- Parametrize the Lagrangian in terms of a few α parameters - these describe the deviation of the theory from GR.

ProGraceRay

Methods

- Rewrite the Lagrangian to include the additional scalar field.

- Parametrize the Lagrangian in terms of a few α parameters - these describe the deviation of the theory from GR.

ProGraceRay

Methods

- Rewrite the Lagrangian to include the additional scalar field.

- Parametrize the Lagrangian in terms of a few α parameters - these describe the deviation of the theory from GR.

- Write the equations for the three fields and implement methods to solve them numerically on the grid inside an N-body simulation using **multigrid methods.**

Kevin Luke, Phd student(1st year) LUX, Obs. Paris-Meudon, PSL

Advance sky subtraction algorithms and blind detection of Lyman alpha emitters in MOONS GTO data

Under supervision of Dr. Mathieu Puech (LUX) and Dr. Myriam Rodrigues (UNIDIA)

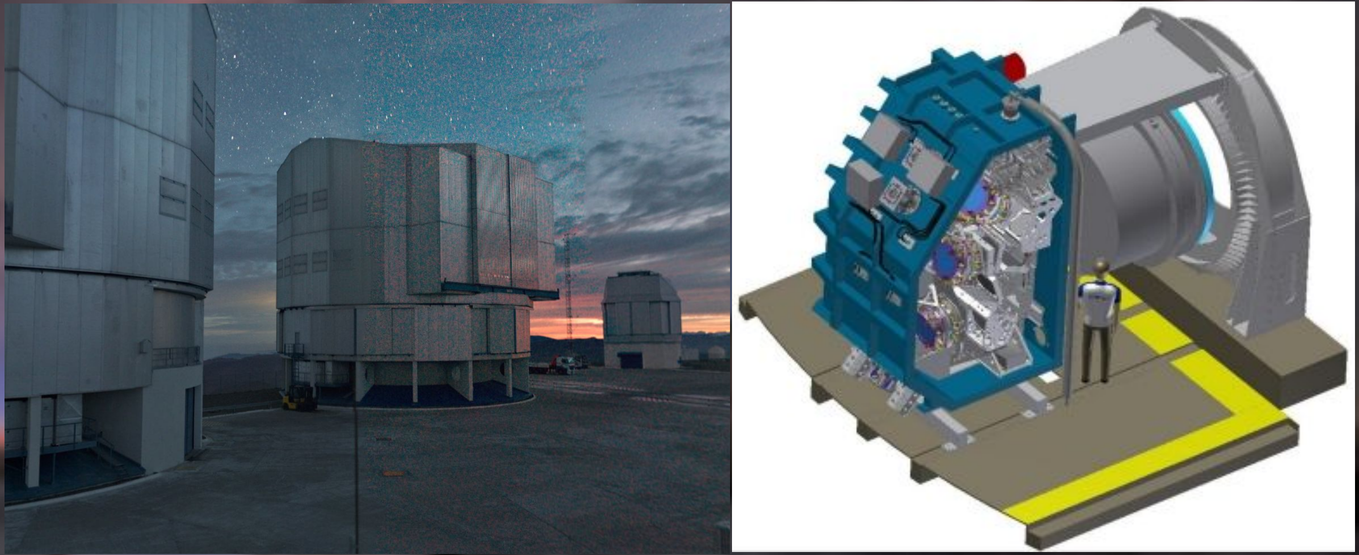


Fig 1: One of the Very Large Telescopes (VLT) and the Multi Object Optical and Near Infrared Spectrograph (MOONS) which is a fiber fed spectrograph at VLT. Credits: ESO

MOONS1D

Science simulator for VLT/MOONS.
I am redesigning it to:

1) have high fidelity with actual instrument
2) generate spectra for sky subtraction strategies

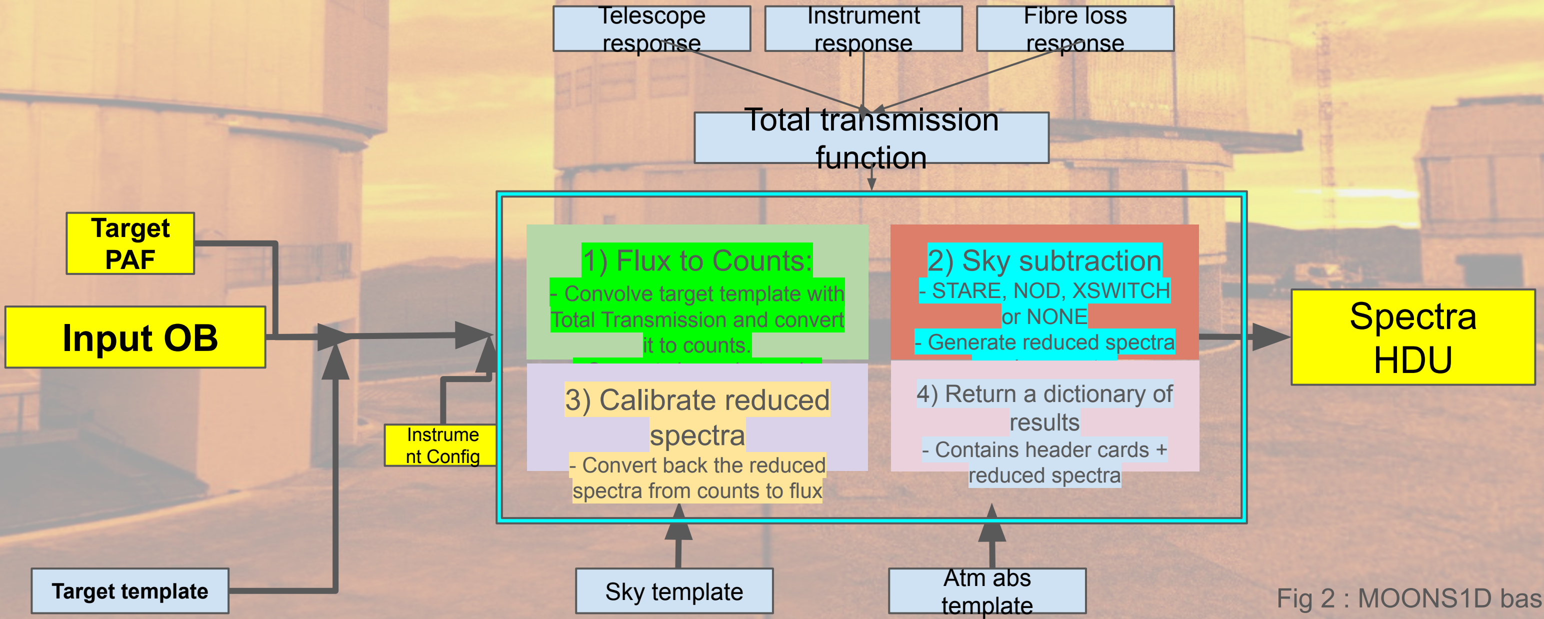


Fig 2 : MOONS1D basic workflow

ADVANCED SKY SUBTRACTION STRATEGIES FOR MOONS

Simulated Spectra from MOONS 1D

Possible collab with Dr. David Cornu, LUX

Neural Network:

- **Train** on blank sky spectra
- **Apply** models on science spectra
- Model **generate** blank sky spectra for science spectra and subtraction can be done

Principal Component Analysis/Non Negative Matrix Factorisation:

- **Apply PCA/NNMF** on localised sky spectra
- **Model local** background spectra from PCA/NNMF
- **Subtract local** models from science spectra

Possible collab with Dr. Vivienne Wild, St. Andrews, UK

Comparison/Testing:

Compare these models with classical methods and test them with MOONS **commissioning** data

Detection and Study of Lyman Alpha Emitters

LAEs?

-High redshift, low mass and high star formation galaxies

- Reionization made universe transparent and Ly A emitted

- Redshifted to optical region and shrouded by atmospheric emission

Studying Them?

Study their properties and **evolution** over redshift and their **contribution** to reionization

MOONS Guaranteed Time Observation (GTO):

Detect them without **selection bias** with our sky subtraction in GTO program.

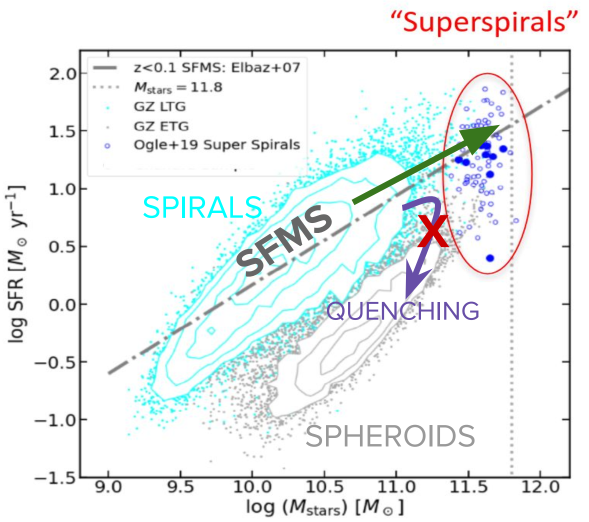
Colab with Dr. Roser Pello, LAM, Marseille.

Fig 3: Artistic impression of a LAE. Credits: Chandra Photo Album

What are Super Spiral galaxies?

Extreme objects, **84** catalogued by P. Ogle from SDSS (z<0.3)

1. Failed quenching :



Crédit: U. Lisenfeld adapted from Ogle+19b

Mapping molecular gas in Super Spiral galaxies

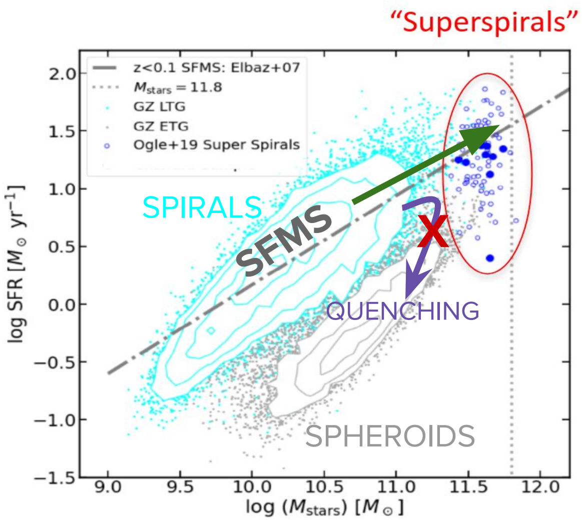
Investigating star formation in unquenched massive galaxies

supervised by :
P. Salomé (LUX)
D. Le Borgne (IAP)

What are Super Spiral galaxies?

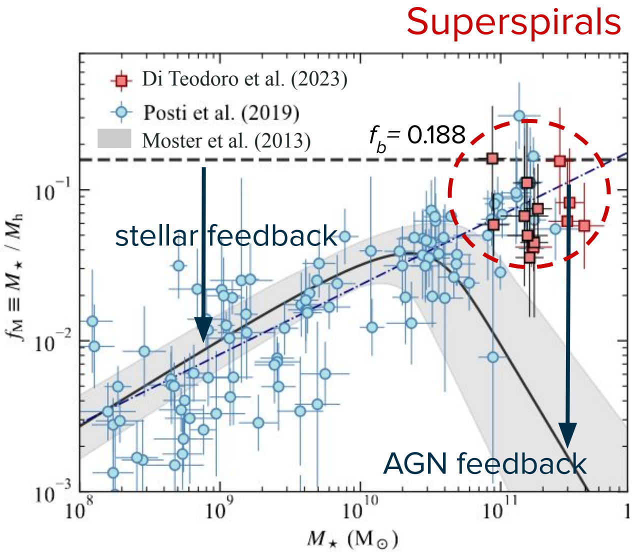
Extreme objects, **84** catalogued by P. Ogle from SDSS (z<0.3)

1. Failed quenching :



Crédit: U. Lisenfeld adapted from Ogle+19b

2. High baryonic fraction :



Credits: adapted from Di Teodoro+23

Mapping molecular gas in Super Spiral galaxies

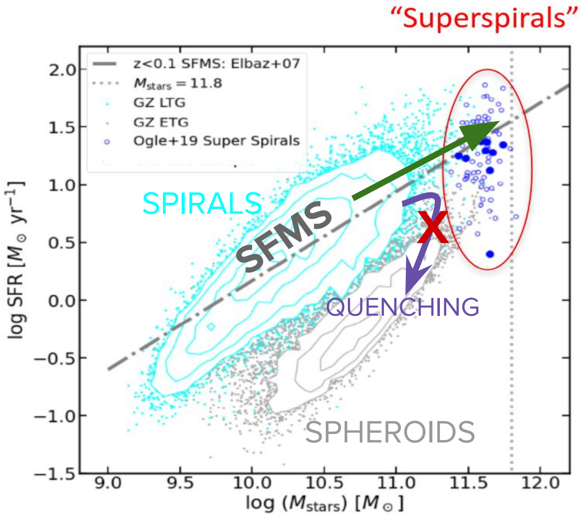
Investigating star formation in unquenched massive galaxies

supervised by :
P. Salomé (LUX)
D. Le Borgne (IAP)

What are Super Spiral galaxies?

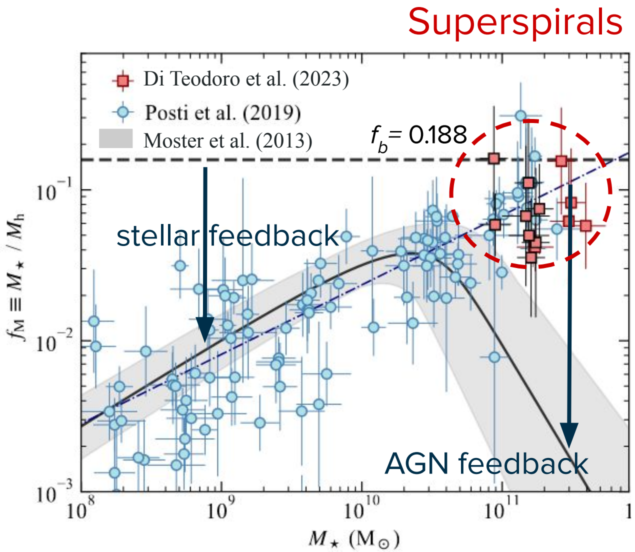
Extreme objects, **84** catalogued by P. Ogle from SDSS (z<0.3)

1. Failed quenching :



Crédit: U. Lisenfeld adapted from Ogle+19b

2. High baryonic fraction :



Credits: adapted from Di Teodoro+23

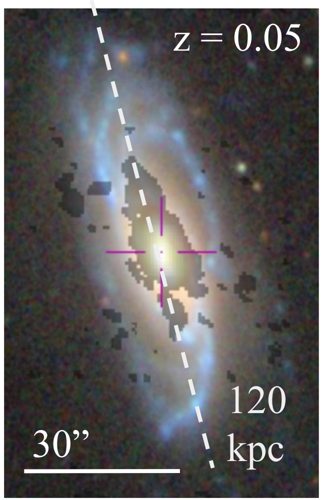
Main properties :

- Large isophotal diameters **50-140 kpc**
- SFR: 1 - 100 $M_\odot$ / yr
- ***On the SFMS***
- $M_\star > 2 \times 10^{11} M_\odot$
- **z < 0.3**

Where is the stellar formation taking place ?

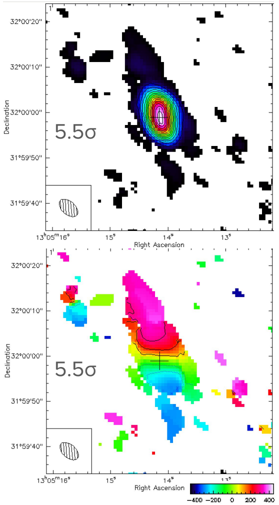
- Molecular gas reservoir

First resolved maps of CO (1-0)
15 SSGs with IRAM NOEMA interferometer (3” resolution)
2 redhift bins, z ≃ 0.15 and z ≃ 0.02



UGC 8179
DESI Legacy Surveys

CO (1-0) moment maps



Mapping molecular gas in Super Spiral galaxies
Investigating star formation in unquenched massive galaxies

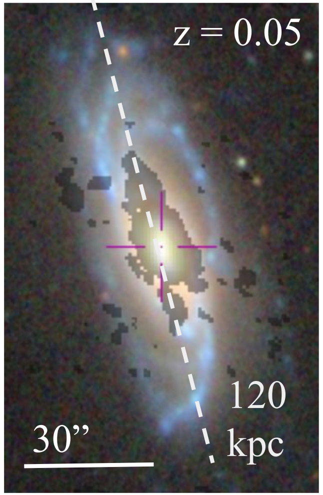
supervised by :
P. Salomé (LUX)
D. Le Borgne (IAP)

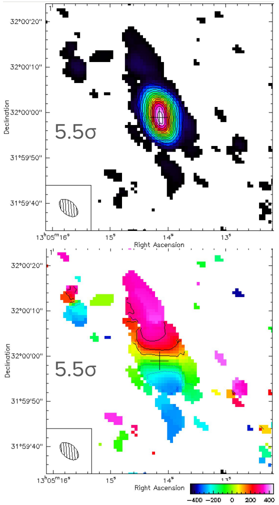
Where is the stellar formation taking place ?

- Molecular gas reservoir

First resolved maps of CO (1-0)
15 SSGs with IRAM NOEMA interferometer (3” resolution)
2 redhift bins, z ≃ 0.15 and z ≃ 0.02

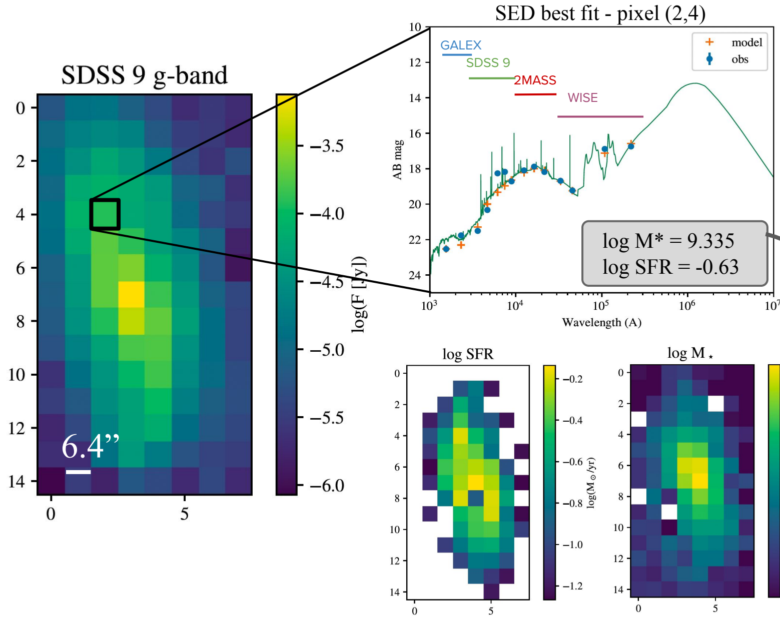
CO (1-0) moment maps





UGC 8179
DESI Legacy Surveys

- Resolved star forming properties through SED fitting



With CO data
➔ SFE
➔ f_{gas}

Internship subject: Study of gas accretion observations by supermassive black holes and their feedback

Supervised by Anaëlle Hallé and Françoise Combes
COSGAL team

Estelle Salibur

LUX starting day

M1 internship : Gas accretion by a supermassive black hole in a nearby Seyfert galaxy

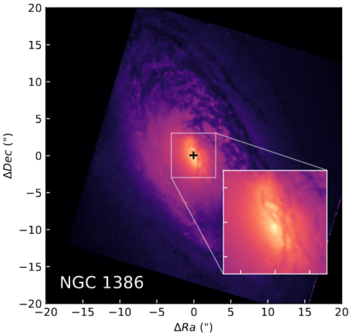


Figure 1 – HST observation of NGC 1386 and zoom into the central region.

Methods : Kinematics modeling of molecular gas with 3D-BAROLO on ALMA datacube.

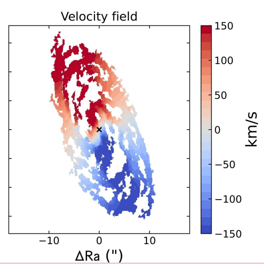
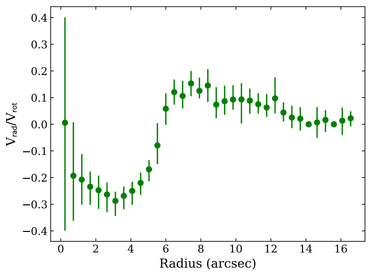


Figure 2 – Moment 1 map : rotation velocity modeled in the disk

Current internship : Study of gas accretion observations by supermassive black holes and their feedback

Preliminary work



- Differentiating inflow and outflow considering projection effects.

Research topics :

- Accretion by AGNs and feedback on galaxies using ALMA and JWST observations.
- Circumnuclear gas dynamics and scaling relationships.

Thank you !

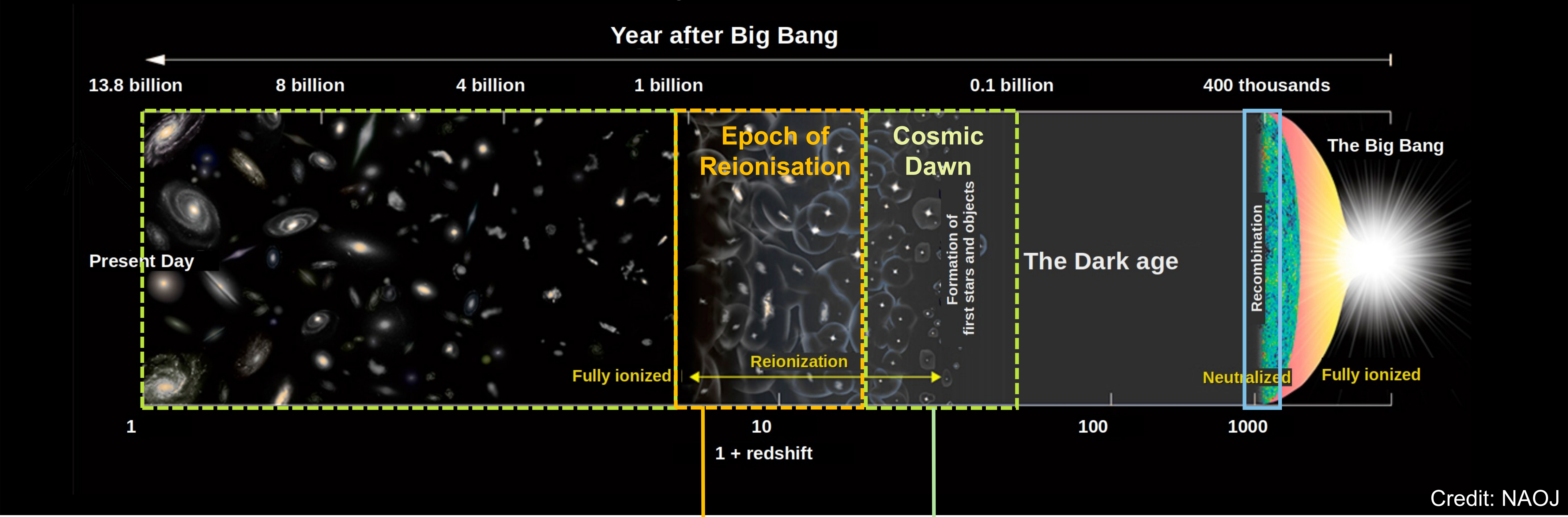
Unveiling the Physics of Cosmic Dawn and Reionization with NenuFAR and LOFAR

Mertens Florent (LUX, COSGAL)

And the NenuFAR Cosmic Dawn / LOFAR-EoR teams

Observatoire de Paris | PSL

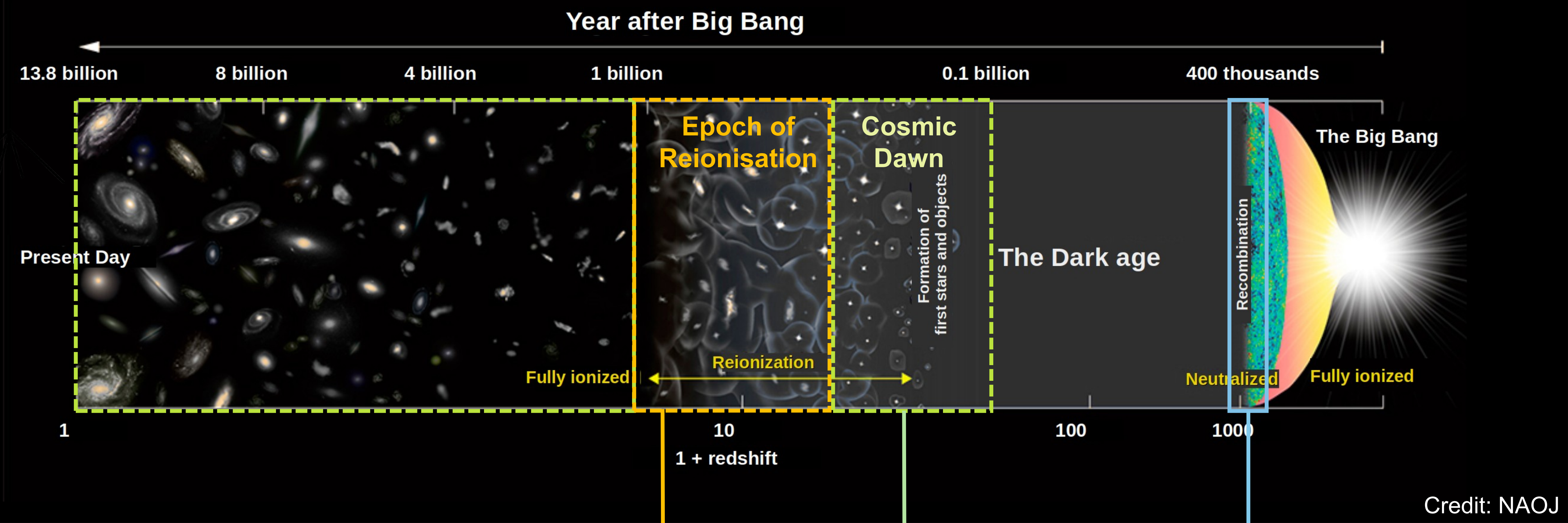
The history of the Universe



Epoch of Reionisation
Reionisation by early galaxies

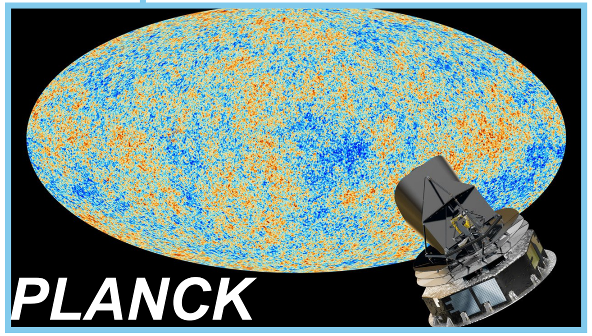
Cosmic Dawn
First stars/galaxies

The history of the Universe

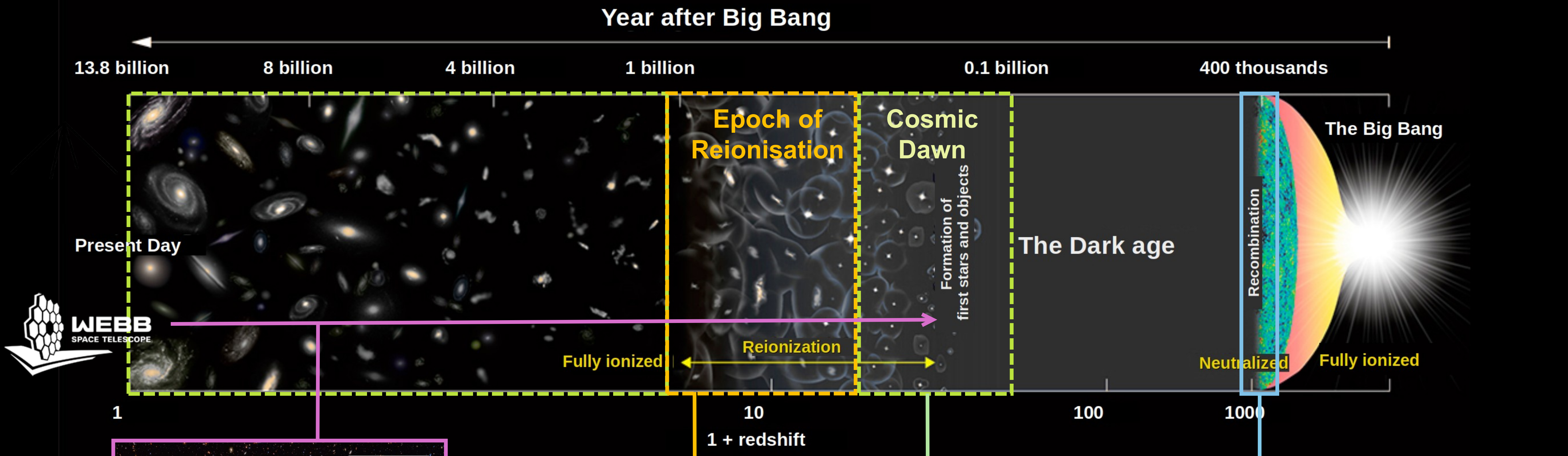


Epoch of Reionisation
Reionisation by early galaxies

Cosmic Dawn
First stars/galaxies



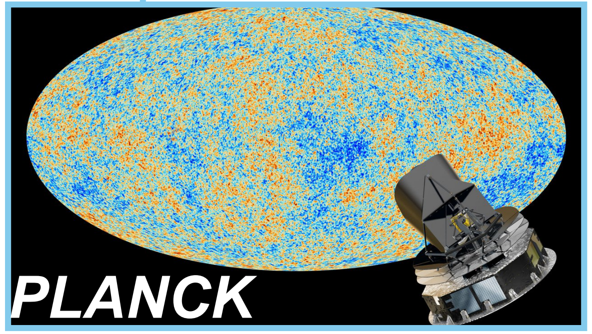
The history of the Universe



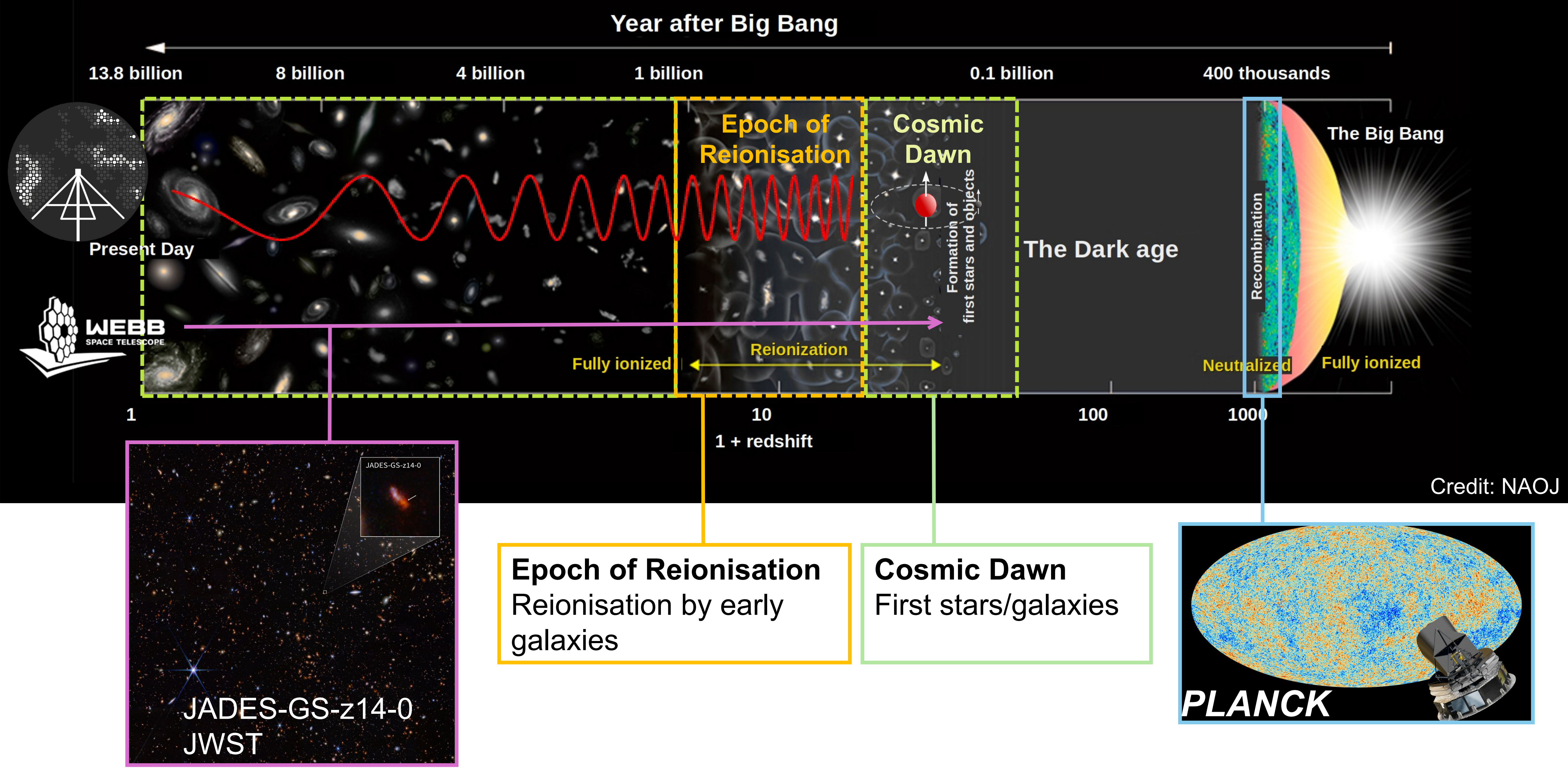
Credit: NAOJ

Epoch of Reionisation
Reionisation by early galaxies

Cosmic Dawn
First stars/galaxies



The history of the Universe



The EoR / CD 21-cm experiments

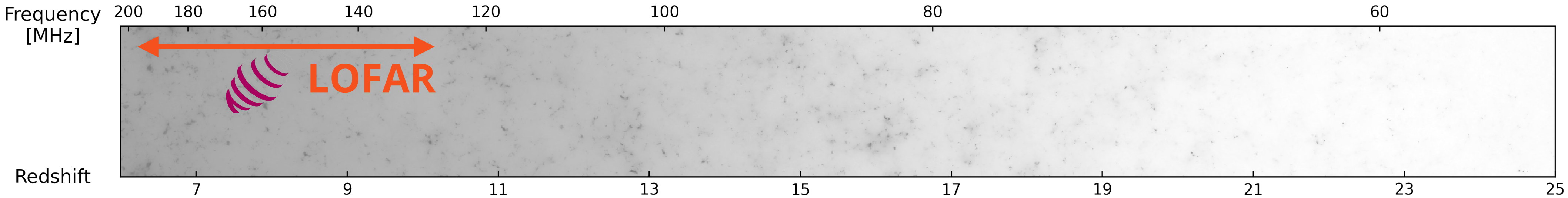
The largest radio-telescope on earth looking for the faint 21-cm signal

LOFAR-EoR

Observation started in 2012

➔ Properties of the IGM and ionising sources.

➔ History of reionization.



The EoR / CD 21-cm experiments

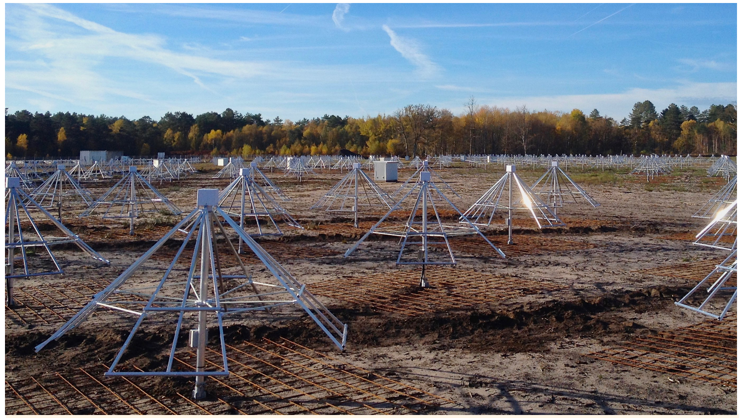
The largest radio-telescope on earth looking for the faint 21-cm signal

LOFAR-EoR

Observation started in 2012

➔ Properties of the IGM and ionising sources.

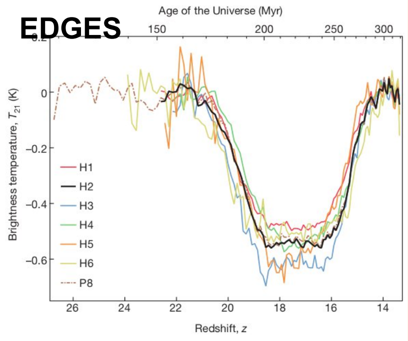
➔ History of reionization.

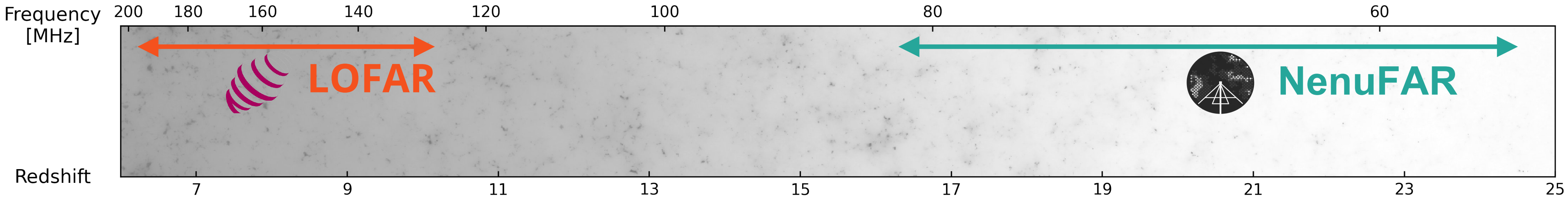


NenuFAR Cosmic Dawn

Observation started in 2019

➔ Testing of non-standard models.





The EoR / CD 21-cm experiments

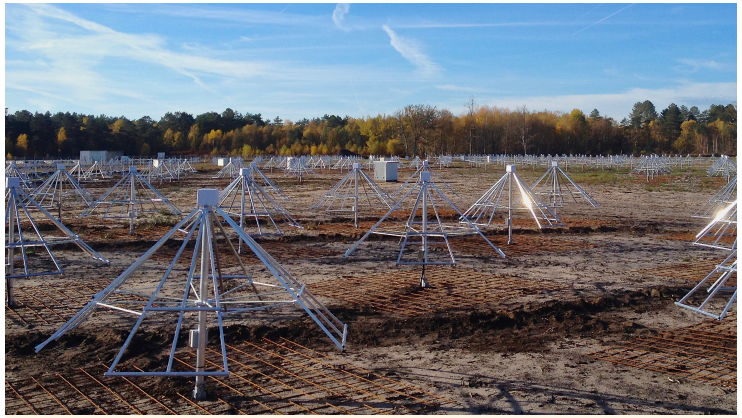
The largest radio-telescope on earth looking for the faint 21-cm signal

LOFAR-EoR

Observation started in 2012

➔ Properties of the IGM and ionising sources.

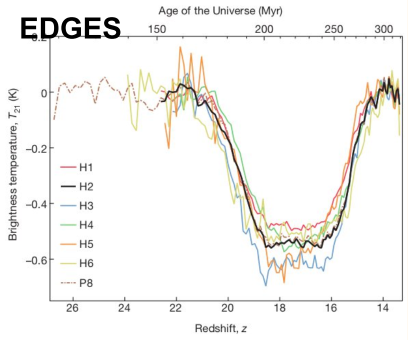
➔ History of reionization.

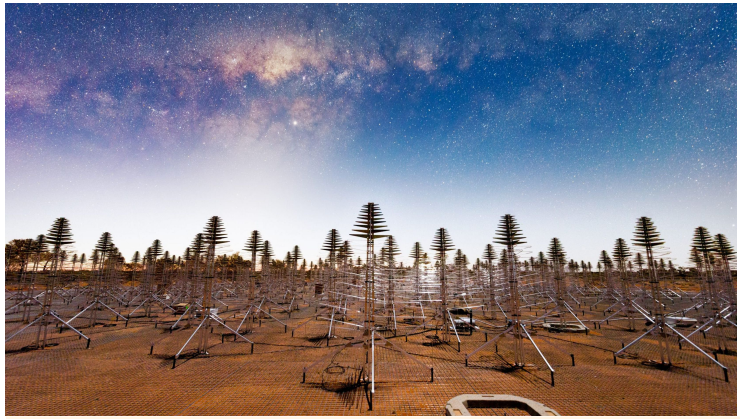


NenuFAR Cosmic Dawn

Observation started in 2019

➔ Testing of non-standard models.

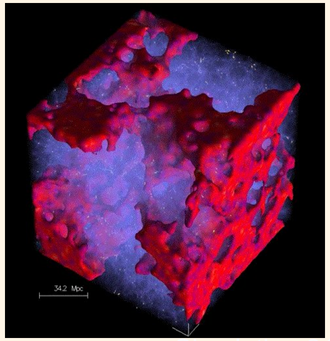




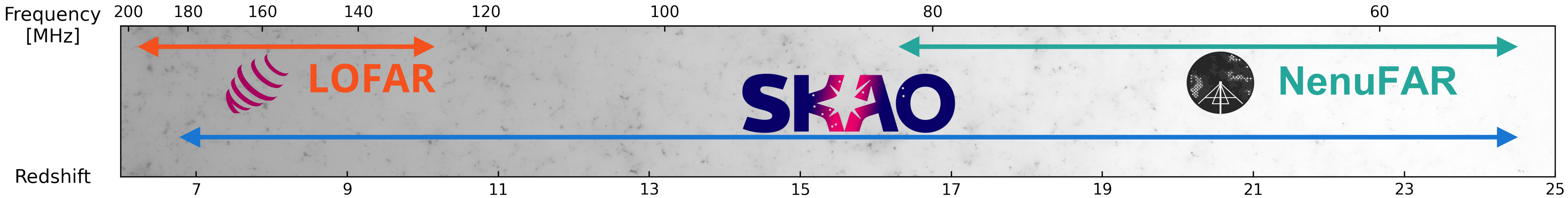
SKA CD/EoR

2030+

➔ Tomographic images of the EoR

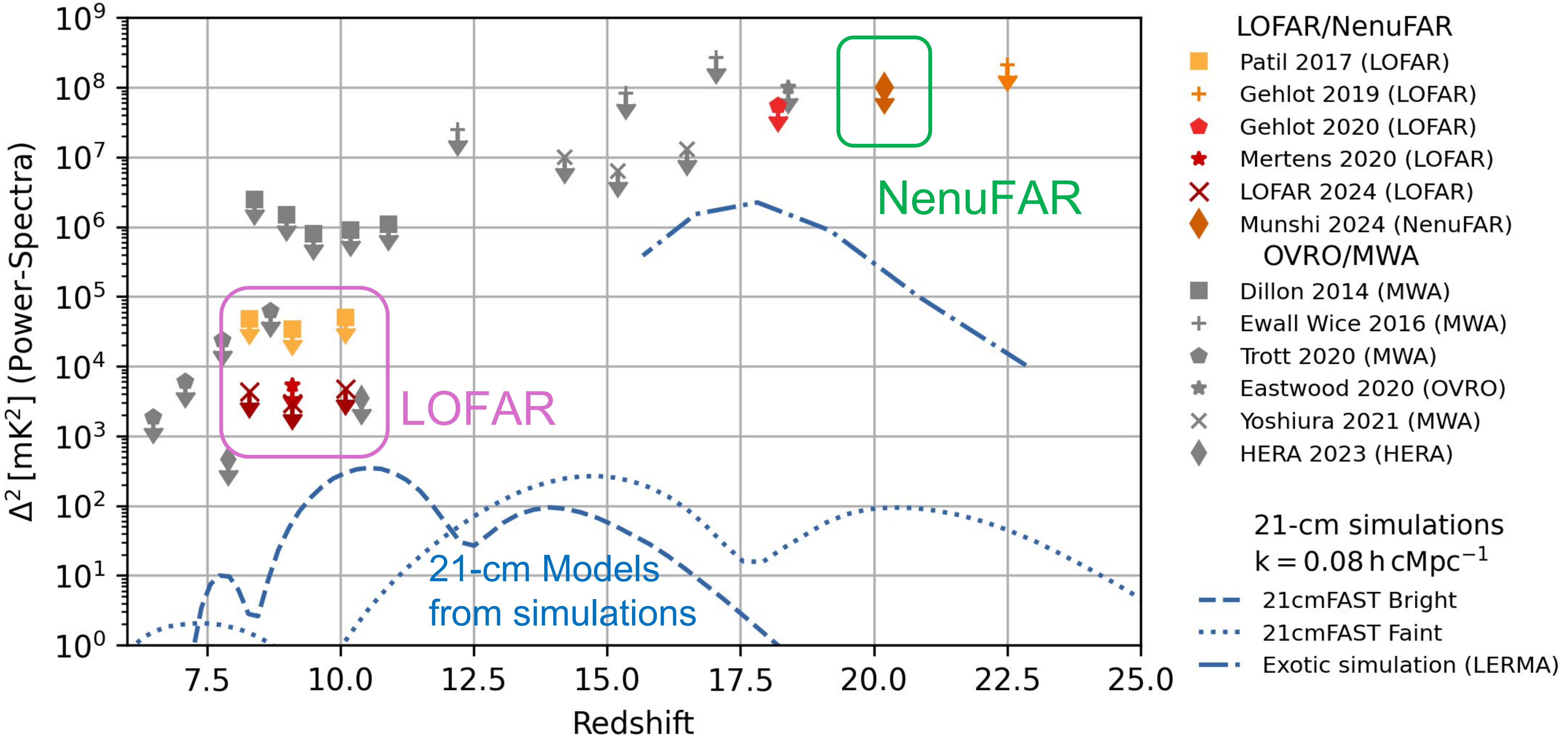


Simulation 21-cm du LERMA



Current 21-cm Power Spectrum Constraints

No detection yet, but increasingly tighter constraints over time



florian.dedieu@obspm.fr
office 801 bis
come say hello :)

Florian Dedieu
Master intern

Galaxy and Cosmology group - Supervised by Dr. Anaëlle Hallé and Pr. Françoise Combes

NGC 1512 - credit: NASA

ENS Paris-Saclay

(bachelor and M1)

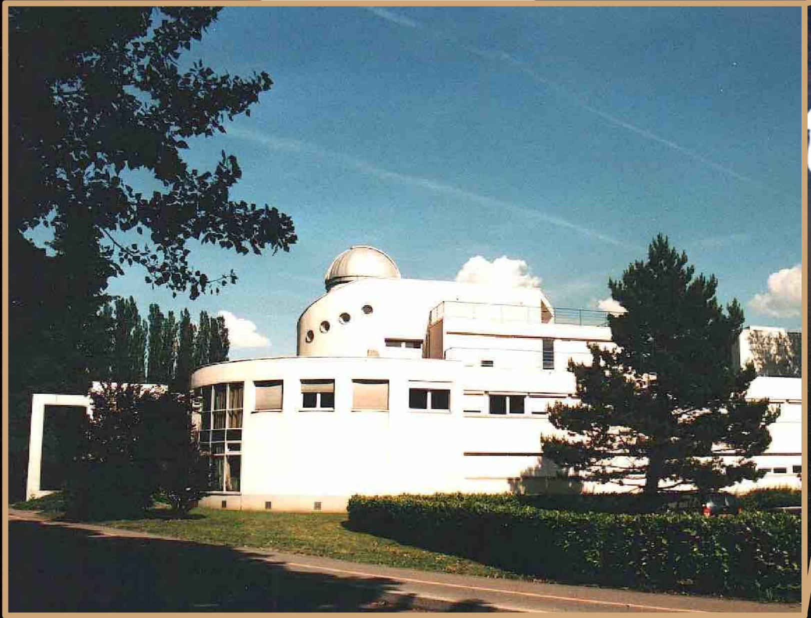
Kavli IPMU, Tokyo, Japan (M1 internship)

Supervised by Asst. Prof. Khee-Gan Lee

MPIA, Heidelberg, Germany

(Research Year)

Supervised by Dr. Annalisa Pillepich



IPAG, Grenoble, France

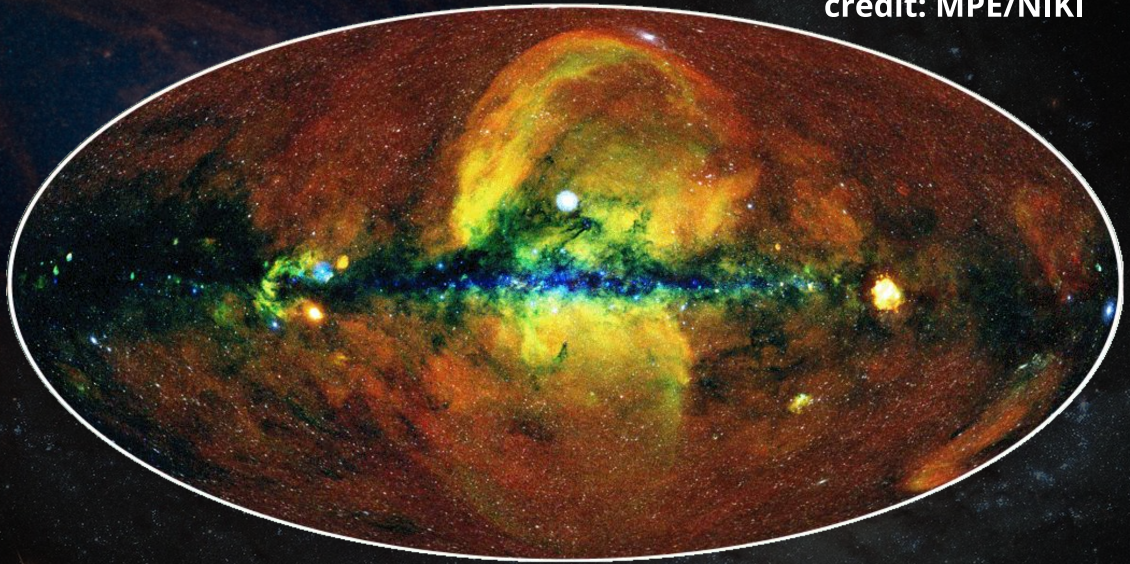
(M2 - master)

Last year: 9-month research internship in galaxy physics

MPIA - Galaxy and Cosmology Theory Group led by **Dr. Annalisa Pillepich**

Project: Study of the physical origin of eROSITA-like bubbles in the cosmological galaxy formation simulation TNG50

All-sky survey of eROSITA - credit: MPE/NIKI



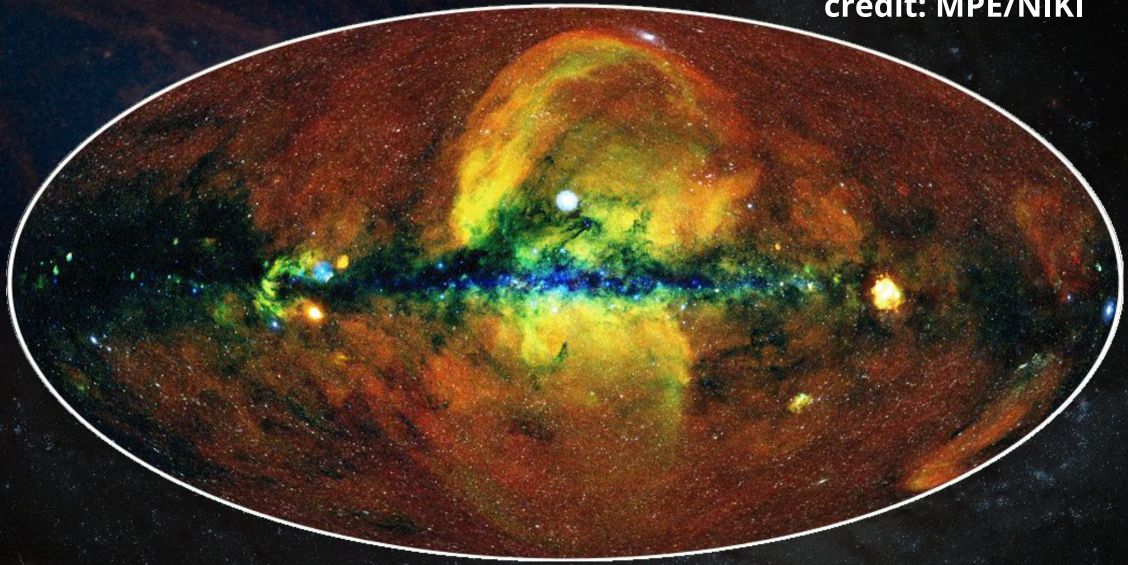
Last year: 9-month research internship in galaxy physics

MPIA - Galaxy and Cosmology Theory Group led by **Dr. Annalisa Pillepich**

Project: Study of the physical origin of eROSITA-like bubbles in the cosmological galaxy formation simulation TNG50

- Created by AGN or stellar feedback?
- Connection between the inclination with respect to the galactic plane and their origin?
- Are the real eROSITA bubbles inclined?

All-sky survey of eROSITA - credit: MPE/NIKI

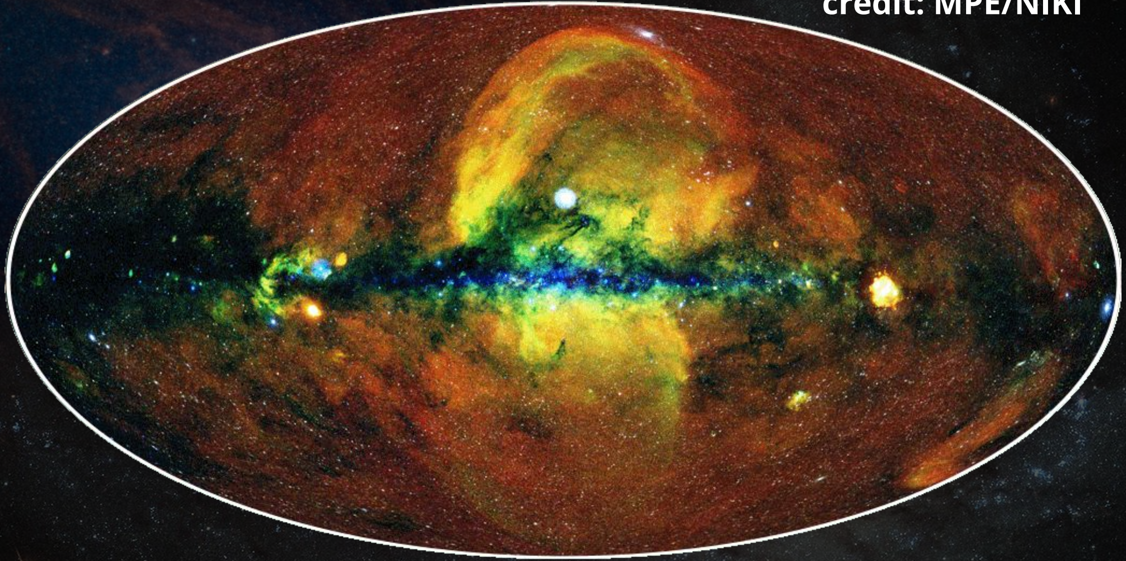


Last year: 9-month research internship in galaxy physics

MPIA - Galaxy and Cosmology Theory Group led by **Dr. Annalisa Pillepich**

Project: Study of the physical origin of eROSITA-like bubbles in the cosmological galaxy formation simulation TNG50

All-sky survey of eROSITA - credit: MPE/NIKI



- Created by AGN or stellar feedback?
- Connection between the inclination with respect to the galactic plane and their origin?
- Are the real eROSITA bubbles inclined?

Work presented in the Session SS15 of the 2024 EAS Congress in Padova, Italy

Last year: 9-month research internship in galaxy physics

MPIA - Galaxy and Cosmology Theory Group led by **Dr. Annalisa Pillepich**

Project: Study of the physical origin of eROSITA-like bubbles in the cosmological galaxy formation simulation TNG50

- Created by AGN or stellar feedback?
- Connection between the inclination with respect to the galactic plane and their origin?
- Are the real eROSITA bubbles inclined?

All-sky survey of eROSITA - credit: MPE/NIKI

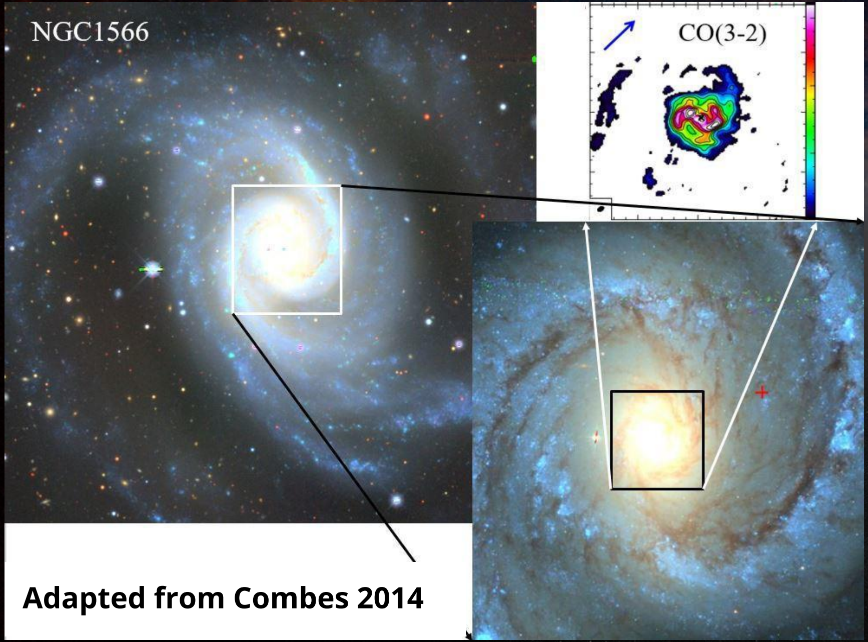
See my poster!

Work presented in the Session SS15 of the 2024 EAS Congress in Padova, Italy

My master's project:

LUX - Supervised by Dr. Anaëlle Hallé and Pr. Françoise Combes

Project: Numerical study of the gas accretion mechanisms in the centers of disk galaxies via the hydrodynamical code RAMSES

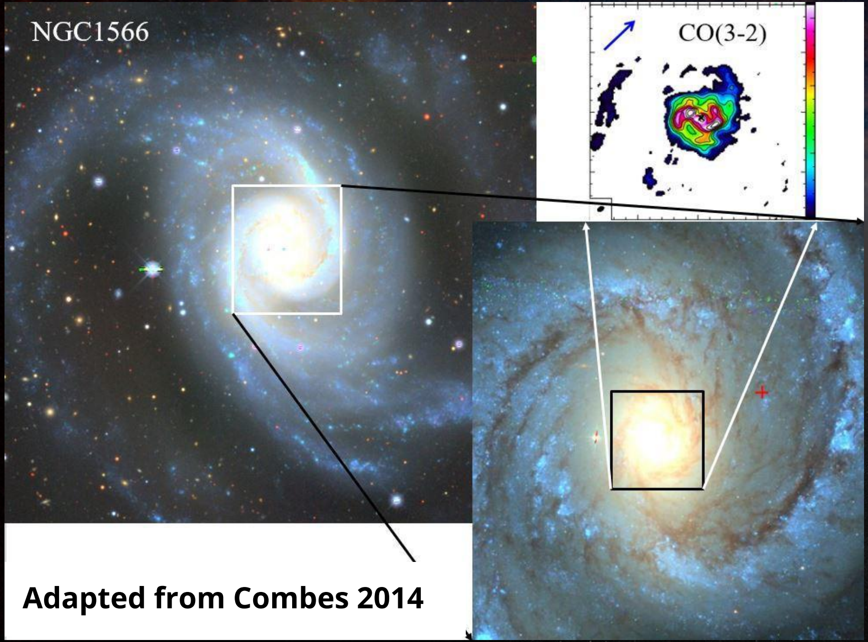


Adapted from Combes 2014

My master's project:

LUX - Supervised by Dr. Anaëlle Hallé and Pr. Françoise Combes

Project: Numerical study of the gas accretion mechanisms in the centers of disk galaxies via the hydrodynamical code RAMSES



Adapted from Combes 2014

- How does the gas lose its angular momentum and fall onto the Supermassive black hole?
- Formation and role of nuclear gaseous spirals? Impact of bars and other resonances?

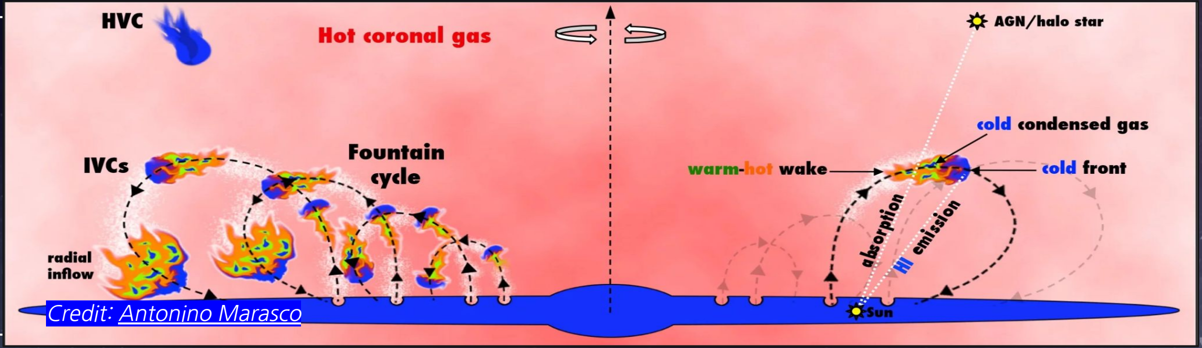
Method: zoom-in high-resolution realistic simulations of disk galaxies with RAMSES

Galactic Fountains Effects in M101

Aashiya Anitha Shaji COSGAL

Anne-Laure Melchior, Françoise Combes & Anaëlle Hallé

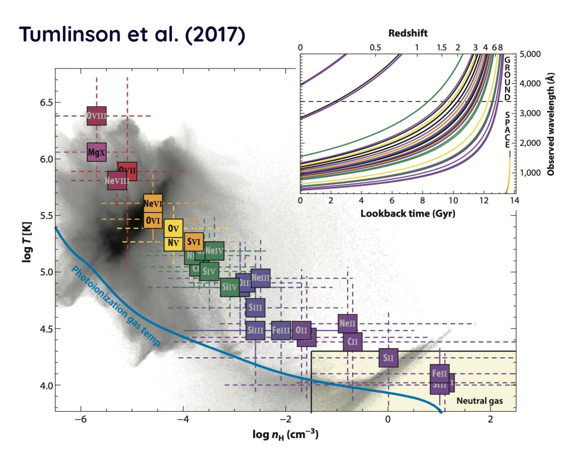
Galactic Fountains

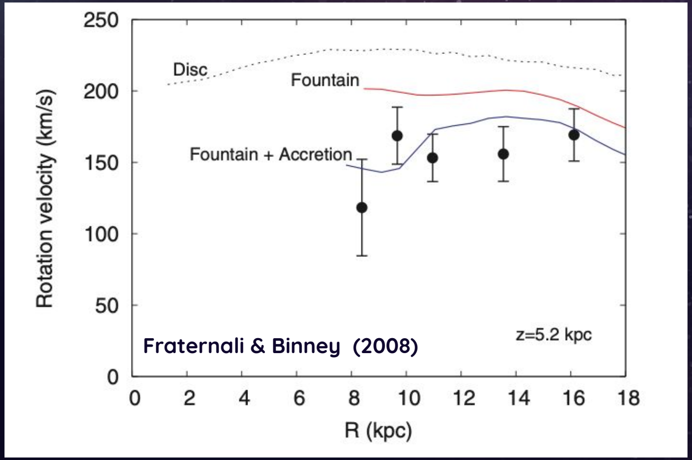


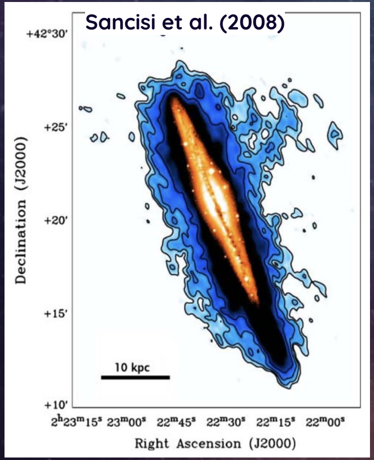
Metal Enrichment of Circumgalactic Medium

Sustaining Star Formation through gas recycling

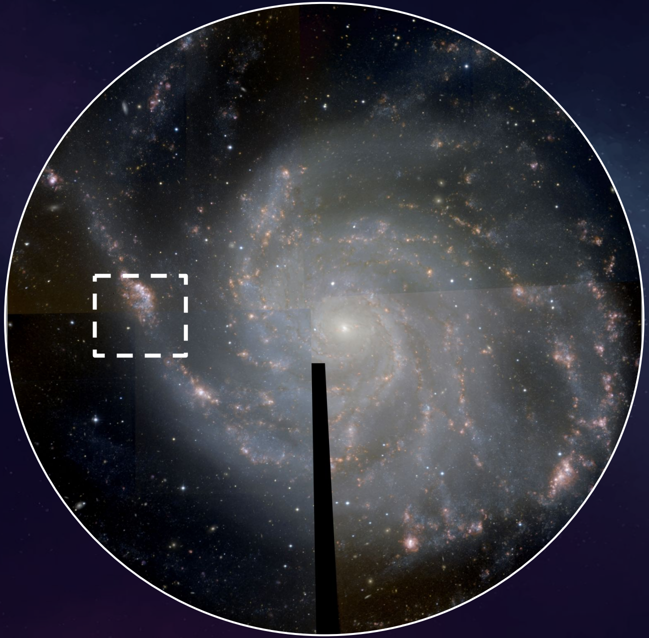
Origin of Thick Disks & Anomalous Gas







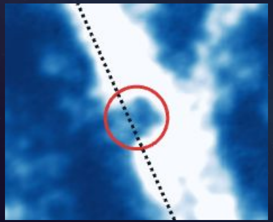
Credits: Laurent Drissen

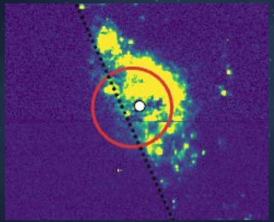


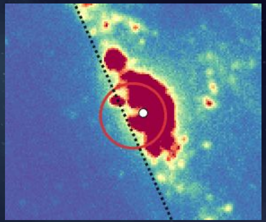
RGB Image of the Pinwheel Galaxy using SN1, SN2 and SN3 filters of CFHT-SITELLE

NGC 5457 (M101)

THINGS	SITELLE	GALEX
Neutral Gas (HI)	*Ionised Gas (Hα)*	*OB Stars (FUV)*





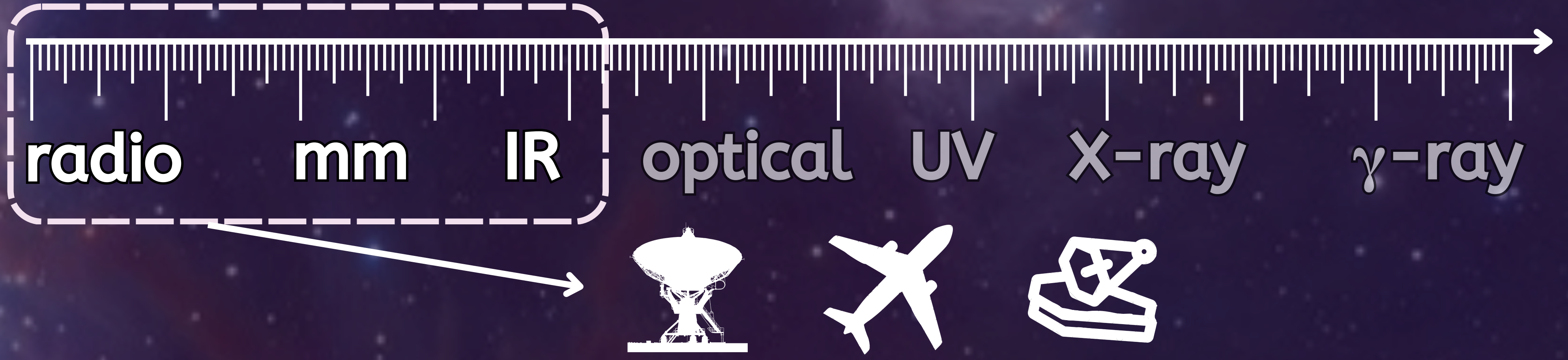


slidesgo

Ivana Bešlić

CNES postoctoral researcher
Group of Philippe Salomé

Observations

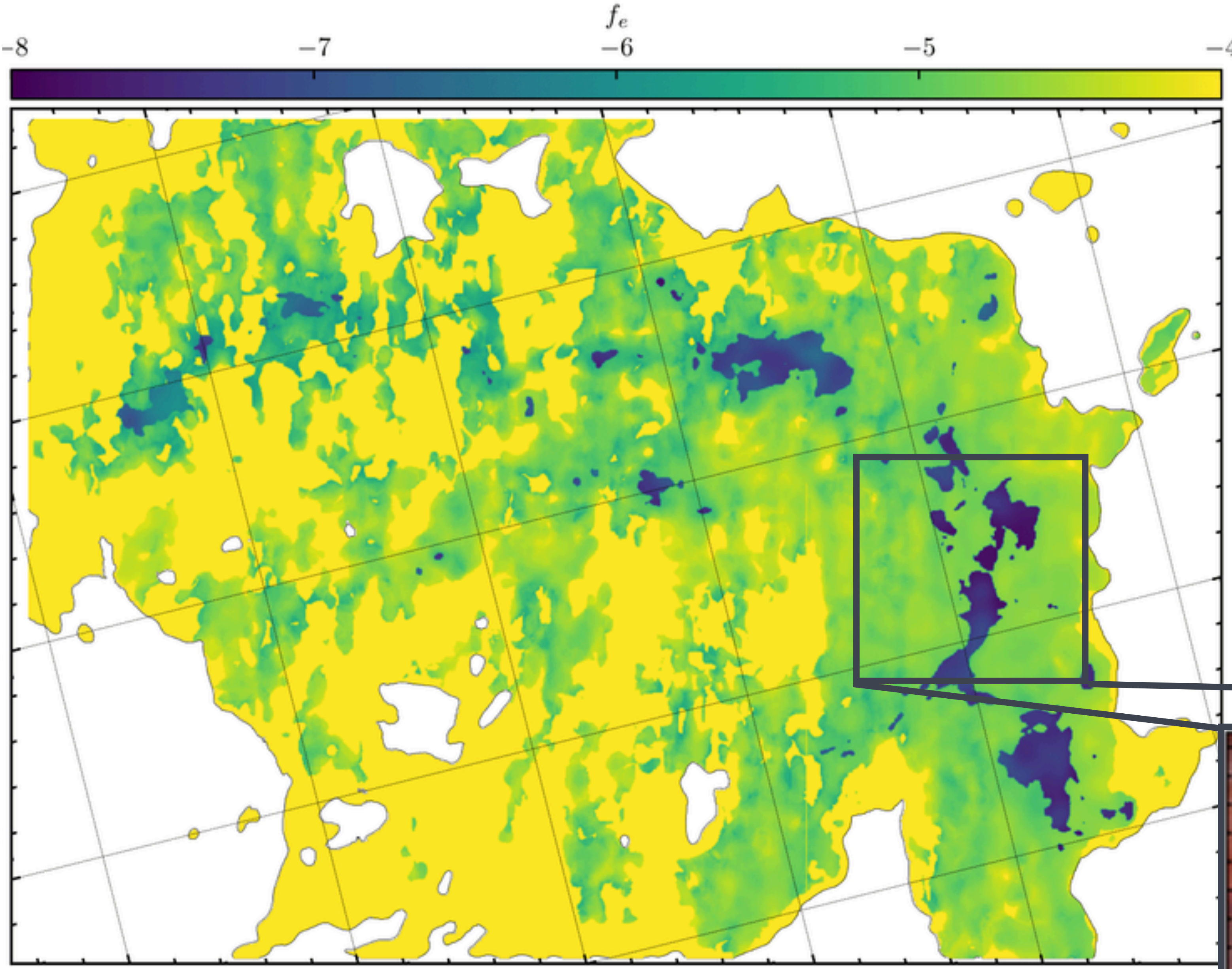


Interests

- Molecular gas properties in galaxies.
- Star formation.
- Turbulence, stellar feedback, and magnetic fields.

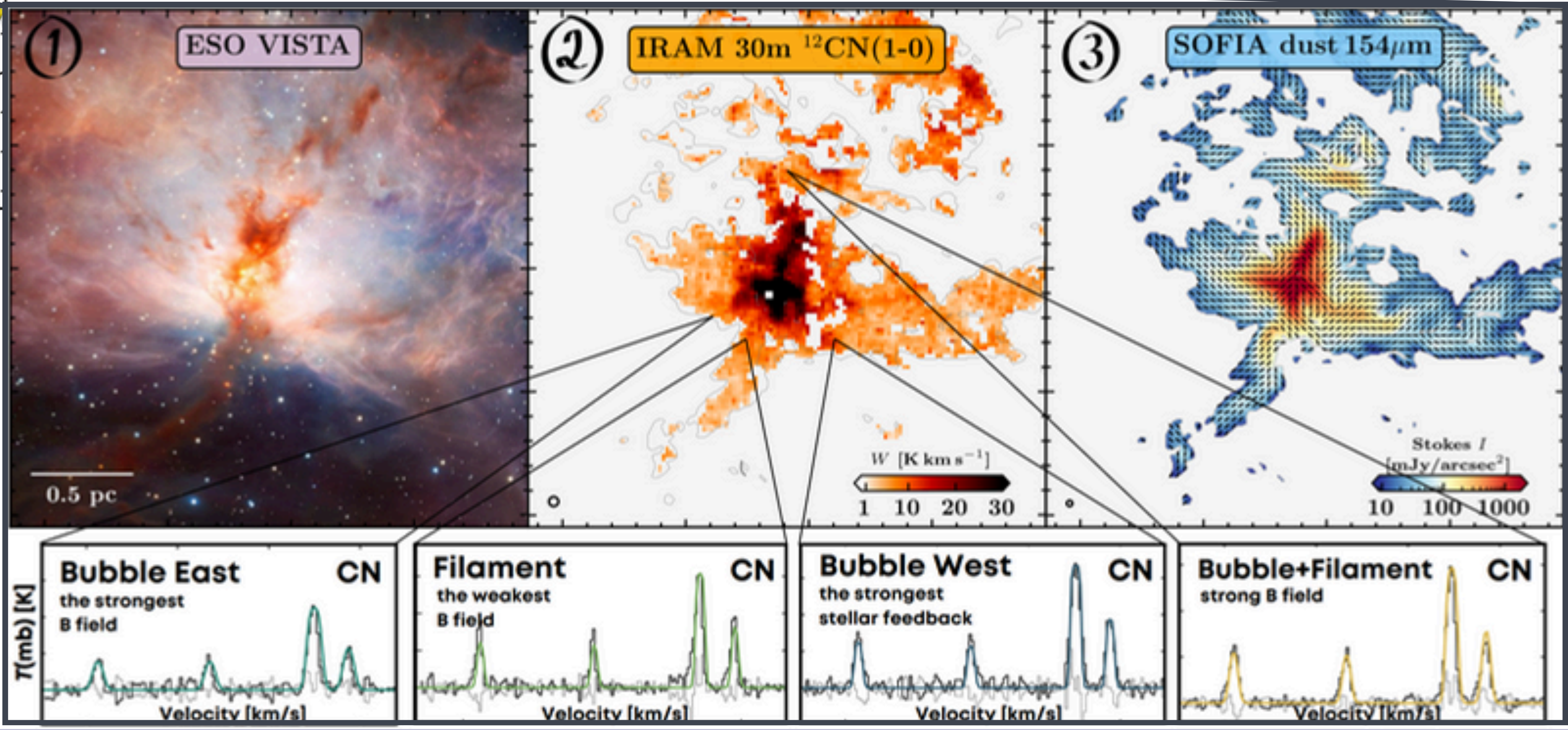
ivana.beslic@obspm.fr

1. IONIZATION FRACTION AND MAGNETIC FIELDS



ORION B IRAM 30-m Large program
PI: M. Gerin, J. Pety

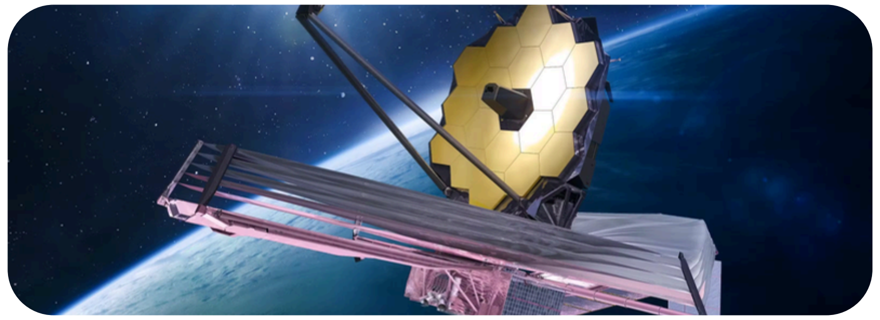
Goals: Orion B giant molecular cloud as a template for extragalactic clouds



Ivana Bešlić
ivana.beslic@obspm.fr

2. HOW TO FEED A BLACK HOLE?

Molecular and Ionized gas, dust
JWST - Program 5018, 20 hours



Sample of 7 BCGs
PI: (P. Salomé, M. Donahue)

Image credit: Hubble

Image credit: VLA

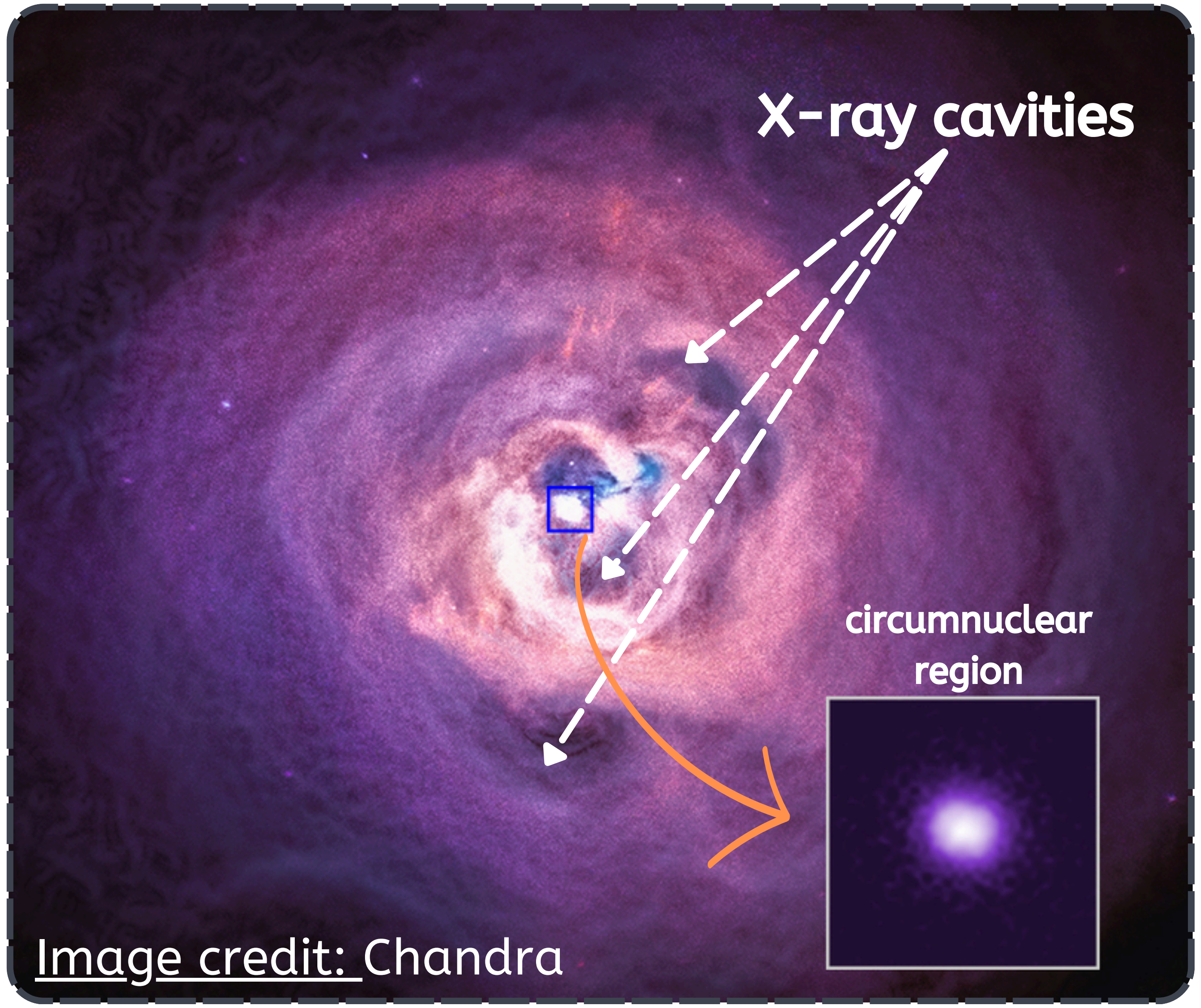


Image credit: Chandra

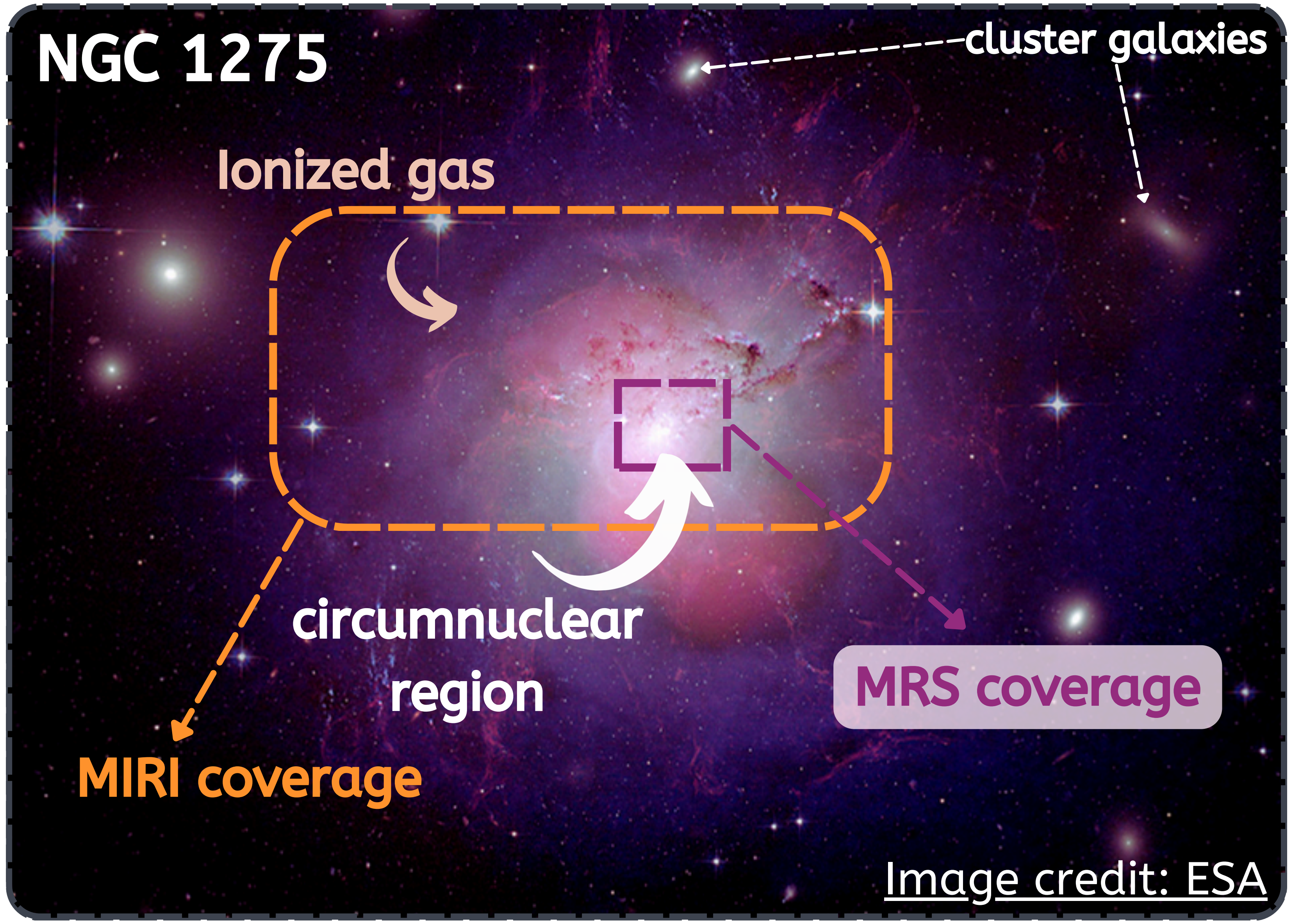


Image credit: ESA

Ivana Bešlić
ivana.beslic@obspm.fr

Question time