



People

Paris-Orléans-Nançay

• Permanent:

(Paris)

Stas Babak (APC), Marc Besançon, Antoine Petiteau (CEA)
+ Chiara Caprini (APC), Daniele Steer (LPENS), Marta Volonteri (IAP),
Analysis methods, populations of sources, memory effect, LISA link, cosmology

(Orléans)

Aurélien Chalumeau, Ismaël Cognard, Jean-Mathias Griessmeier,
Lucas Guillemot, Gilles Theureau

(backend development, observations, timing pipeline, ... NRT, LOFAR-FR606, NenuFAR)

+ Cherry Ng-Guiheneuf (FRBs, pulsar search, SKA pipelines)

• Post-doc: Prerna Rana (from Feb. 2026, 2 years)

Francesco Iraci (From Feb 2026, 2 years)

+ Fabian Jankowski (FRB's, single pulse studies, pulsar SED)

• PhD: Sara Manzini (eccentric binaries wave forms, both individual and full population signatures)

Clara Blanchard (BW timing, population and eclipse characterization, third bodies)

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Hippolyte Quelquejay (PTA signal vs SMBHB population simulations, targeted search of CW)

Pauline Noé (DM & scattering noise structure using LOFAR/NenuFAR/EPTA data vs ISM)

Adrien Cogez (Data Analysis and Fundamental Physics with PTA and LISA)

+ Pranav Limaye (MSPs in Galactic Center, MeerKAT and Fermi-LAT)

NRT

2nd semester 2025:

hydraulic maintenance + new anti-corrosion operation happened in early June (3 spans and 2 pylons).

Paris-Orléans-Nançay

EPTA 813 hrs
Fermi follow-up 308 hrs
TRAPUM follow-up 11 hrs
binary pulsar timing 513 hrs
GC pulsar search. 12 hrs

1657 hrs (~75% of scientific time) + ~200 hrs dir. time (proposal 2026A submitted Oct 26th)

NenuFAR

near-complete deployment

96/104 MA / Core (92/96 MA) / Remote (4/8 MA)

12 LT programs → pulsars = 762 hrs for semester 2026A

4 PI programs

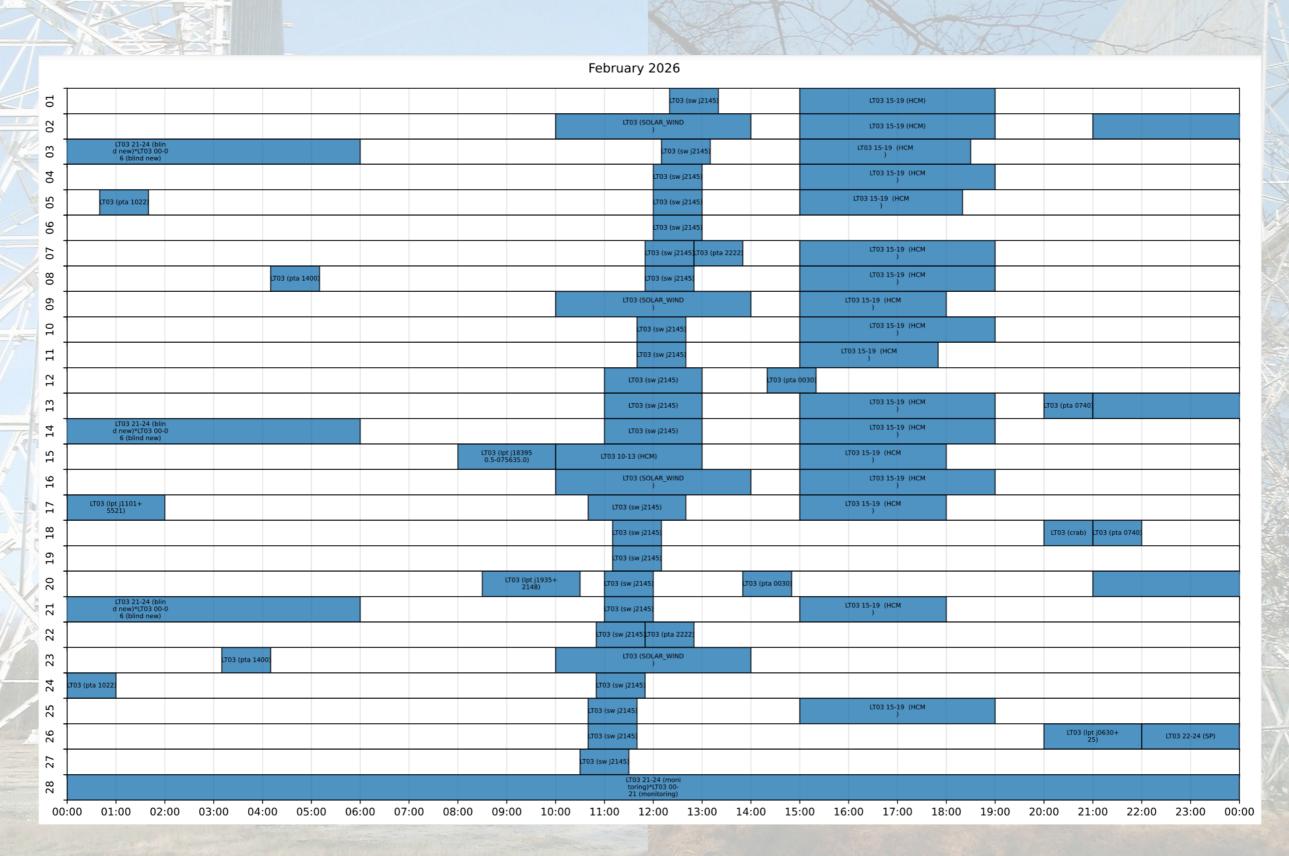
blind survey (150 hrs), census of known pulsars,

bright sources (144 hrs) + 6 MSPs (150 hrs) monitoring

single pulse multi-telescopes studies (6 hrs), LPT (60 hrs)...



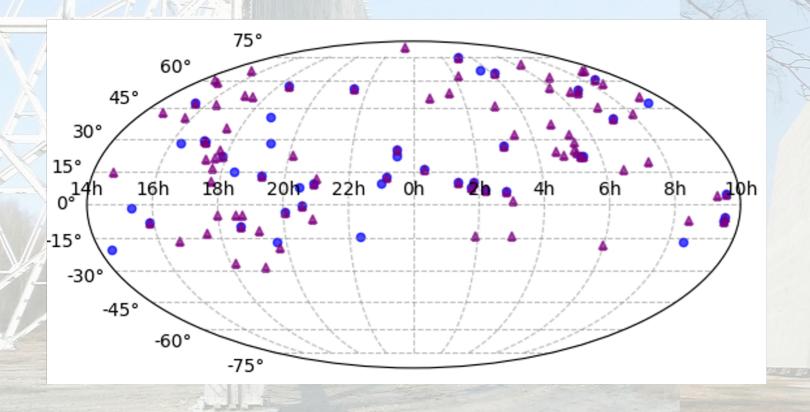
NenuFAR contribution (excerpt from 2026A schedule)

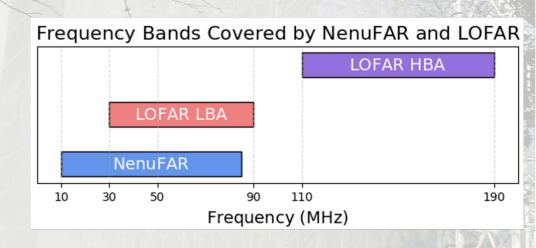




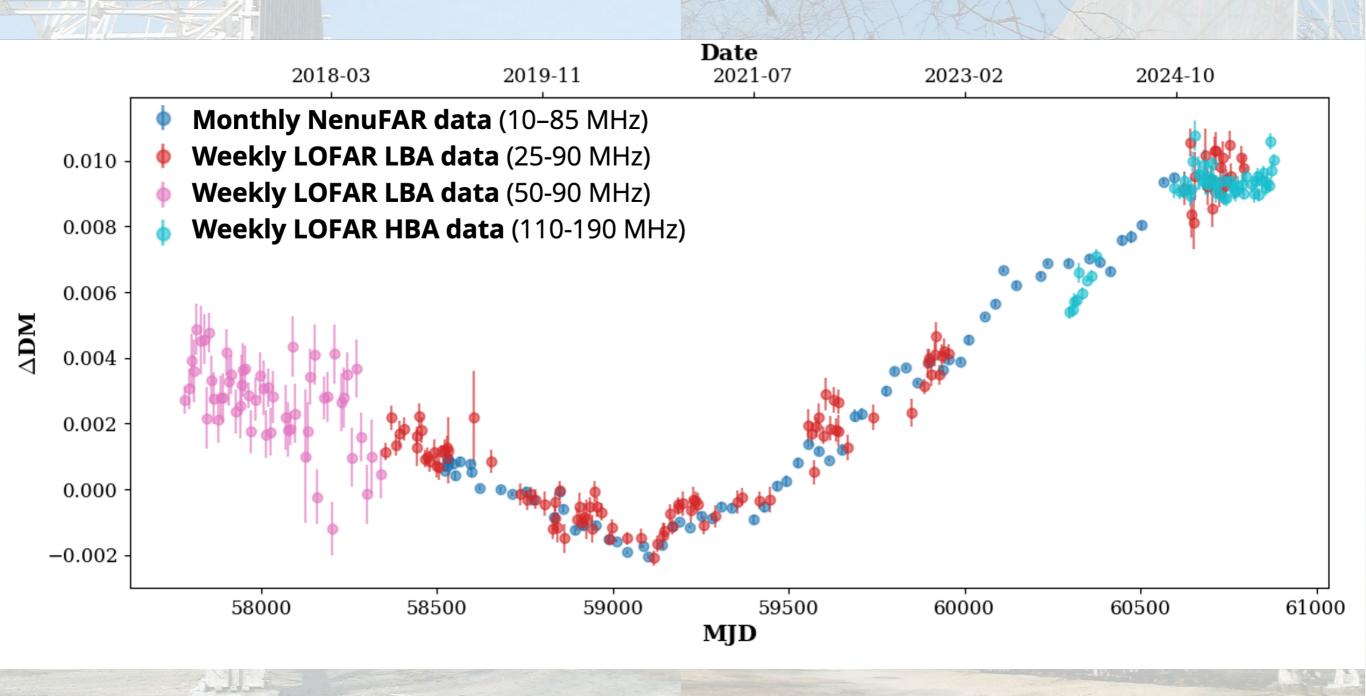
DATASETS

- NenuFAR (10–85 MHz): Monthly observations over 5 years of ~ 40 normal pulsars + few ms pulsars + currently conducting dense monitoring 1day->1month
- LOFAR LBA (30-90 MHz) and HBA (110–190 MHz): weekly time series acquired over 10 years, for 100 pulsars

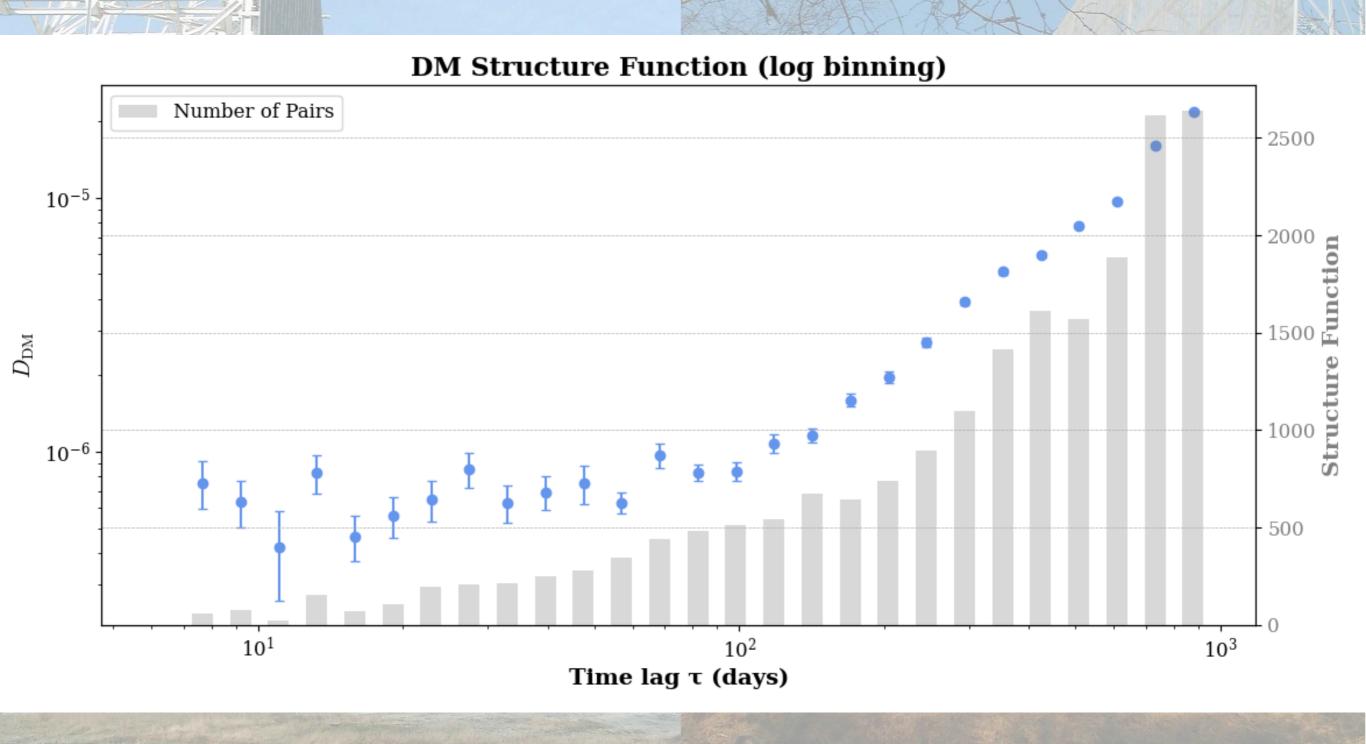




J1840+5640



J1840+5640

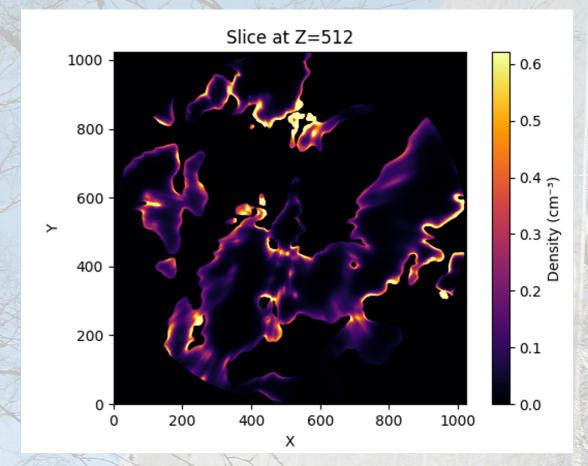


Next step:

Compare with other ISM probes

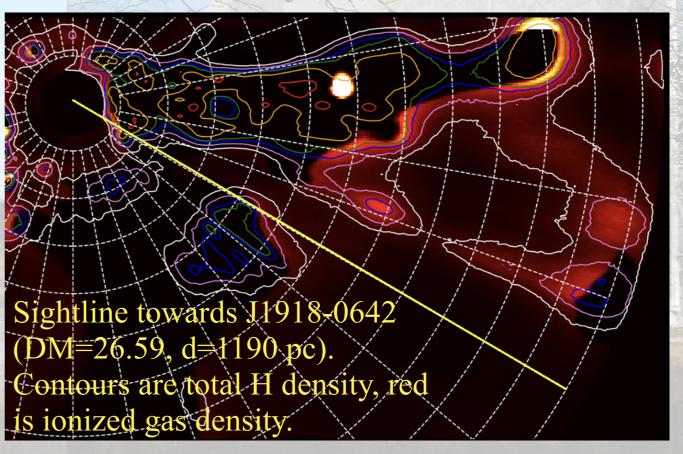
McCallum+25a,b

→spatial distribution of ionized gas out to ~1.25 kpc from the Sun.



Their models are built by using:

- the known 3D distribution of O stars (as ionizing sources),
- the known 3D distribution of dust (as absorbers of ionizing photons),
- a constant gas-to-dust ratio throughout the volume,
- + performing full 3D radiative transfer of Lyman continuum photons



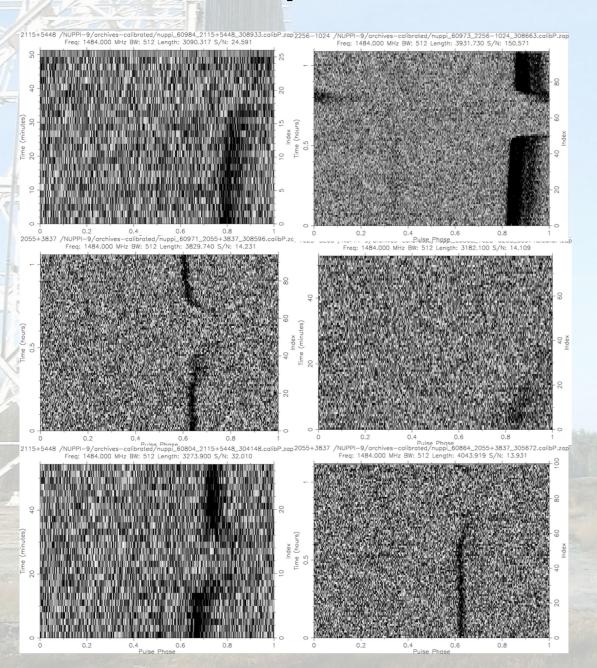
BW timing analysis and population studies (Blanchard et al 2025)



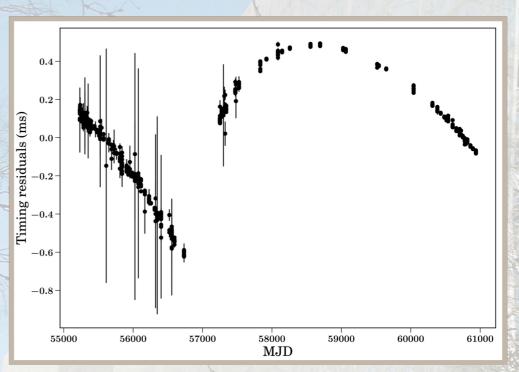
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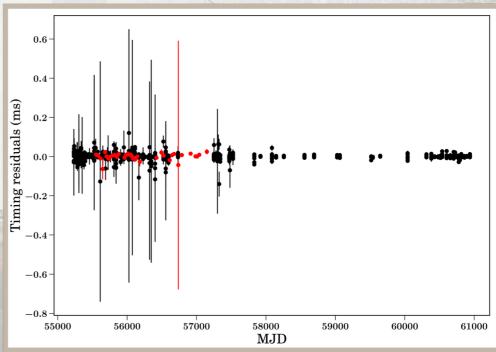
19 spiders, > 6500 obs. or 30 000 ToAs

Eclipses



Planet orbit's (here J1745+1017)





PTA vs SMBHB population (Quelquejay-Leclere et al 2025)

The multimessenger view of Pulsar Timing Array black holes with the Horizon-AGN simulation

Hippolyte Quelquejay Leclere¹, Kunyang Li², Marta Volonteri², Stanislav Babak¹, Ricarda S. Beckmann⁵, Yohan Dubois², Clotilde Laigle², and Natalie A. Webb³

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October 17, 2025

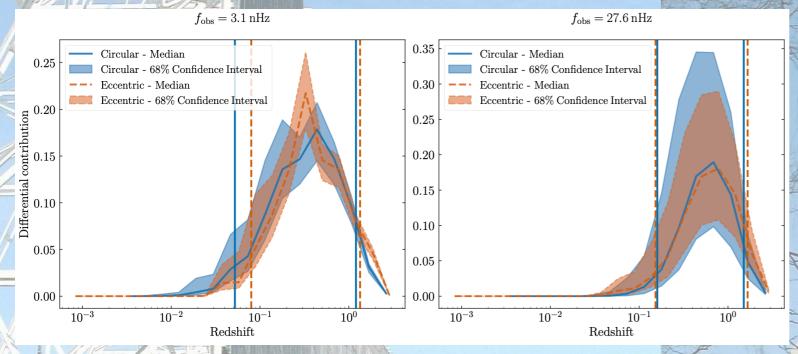
arXiv:2510.14613

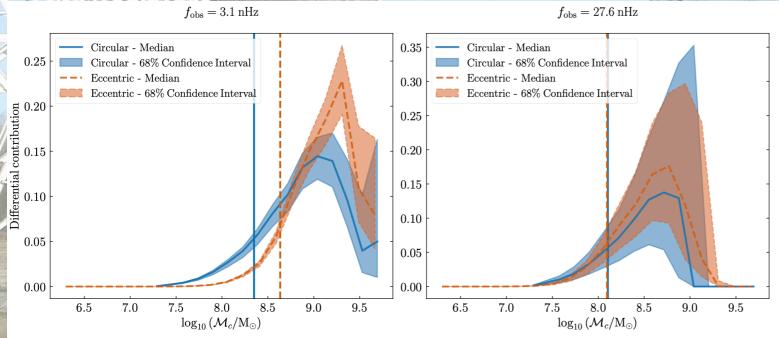
ABSTRACT

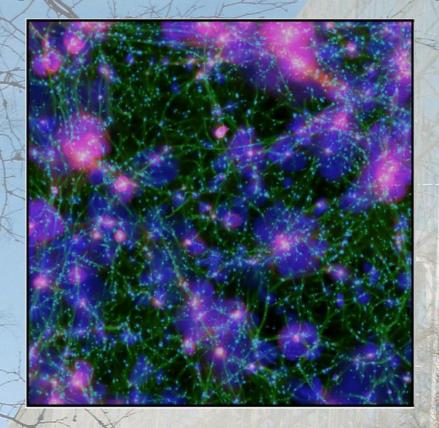
We use the Horizon-AGN cosmological simulation to study the properties of supermassive black hole binaries (MBHBs) contributing most to the gravitational wave background (GWB) signal expected in the pulsar timing array (PTA) band. We develop a pipeline to generate realistic populations of MBHBs, allowing us to estimate both the characteristic strain and GWB time series observable by PTA experiments. We identify potential continuous wave (CW) candidates standing above the background noise, using toy PTA sensitivities representing the current EPTA and future SKA. We estimate the probability of detecting at least one CW with signal-tonoise ratio > 3 to be 4% (20%) for EPTA (SKA)-like sensitivities, assuming a 10-year baseline. We find the GWB to be dominated by hundreds to thousands of binaries at redshifts in the range 0.05-1, with chirp masses of $10^{8.5}-10^{9.5}~\rm M_{\odot}$, hosted mainly in quiescent massive galaxies residing in halos of mass $\sim 10^{13}~\rm M_{\odot}$. CW candidates have larger masses, lower redshifts and are found in even more massive halos, typical of galaxy groups and clusters. The majority of these systems would appear as AGN rather than quasars, because of their low Eddington ratios. Nevertheless, CW candidates with $f_{\rm Edd} > 10^{-3}$ can still outshine their hosts, particularly in radio and X-ray bands, suggesting them as the most promising route for identification. Our findings imply that optical and near-infrared searches based on light curve variability are challenging and biased toward more luminous systems. Finally, we highlight important caveats in the common method used to compare PTA observations with theoretical models. We find that GWB spectral inferences used by PTAs could be biased toward shallower slopes and higher amplitudes at $f = 1/\rm yr$, thereby reducing the apparent tension between astrophysical expectations and PTA observations.

Key words. Gravitational waves – Galaxies: supermassive black holes – Methods: numerical

PTA vs SMBHB population (Quelquejay-Leclere et al 2025)

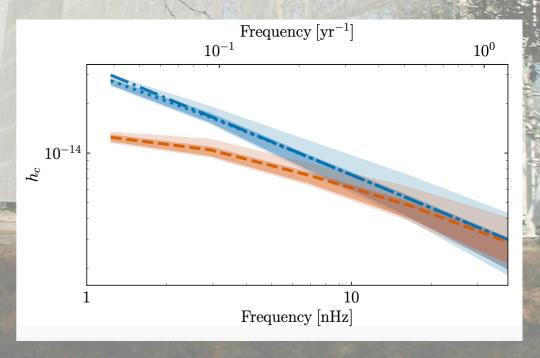






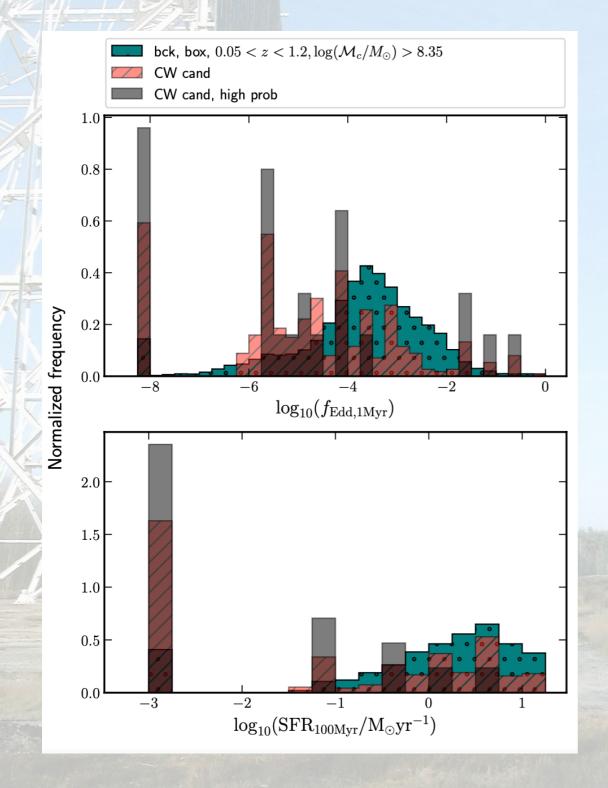
Extraction of SMBH Mergers

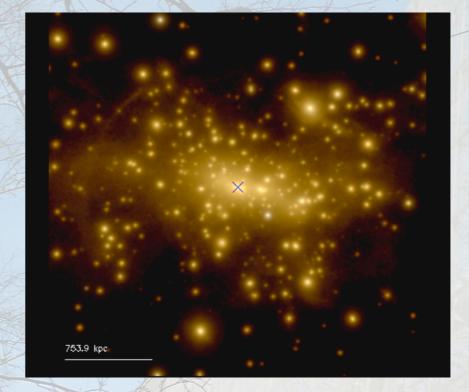
➤ From simulation: Numerical merger once two SMBHs reach 4 kpc separation
➤ Delayed mergers: sub-grid delays computed in post-processing (dynamical friction, viscous drag, stellar hardening, GW driven phase)

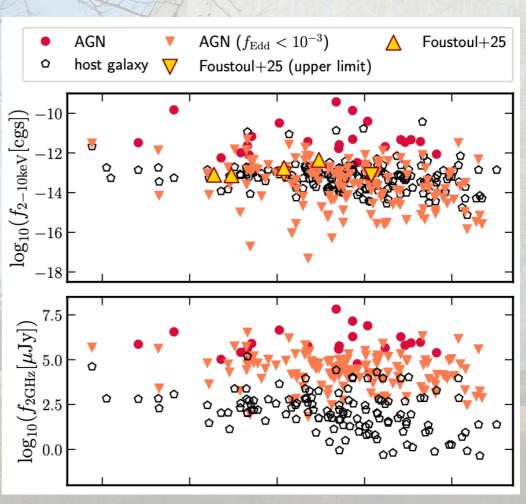


PTA vs SMBHB population (Quelquejay-Leclere et al 2025)

identify and study the SMBHBs that contribute most to the GW signal in the PTA band,







Gravitational waveform model for eccentric binaries (Sara Manzini - to be submitted shortly)



Effective-one-body modelling of eccentric supermassive black hole binaries for Pulsar Timing Array.

Sara Manzini* and Stanislav Babak[†]
Université Paris Cité, CNRS, Astroparticule et Cosmologie, F-75013 Paris, France
(Dated: November 10, 2025)

Pulsar Timing Arrays (PTAs) observations will detect gravitational waves (GWs) from the early inspiral phase of supermassive black hole binaries (SMBHBs) with orbital periods of weeks to years. Current PTA analyses generally assume circular binaries; however, dynamical interactions with the surrounding environment can prevent complete circularisation, allowing SMBHBs to retain appreciable eccentricities. In this work, we present a gravitational waveform model for eccentric binaries based on the Effective-One-Body (EOB) formalism, designed for continuous GW searches in PTA data. The model is accurate up to the second post-Newtonian (2PN) order for the conservative dynamics and up to post-leading order for the radiation-reaction terms. We provide both a numerically precise and a computationally efficient approximate implementation and evaluate the latter's accuracy against the full model over a broad range of eccentricities and initial orbital frequencies. Our results show that a substantial region of the parameter space exhibits pronounced orbital evolution, much stronger than in the circular case. We demonstrate the rich harmonic structure of timing residuals induced by eccentric GWs. Properly characterising eccentric binaries is an essential step toward detecting GWs in PTA data and interpreting the results, ultimately improving our understanding of the supermassive black hole population in the local Universe.

I. INTRODUCTION

Another mechanism involves perturbations from a third SMBH introduced during a subsequent galactic merger. Such a perturber can trigger Kozai-Lidov oscillations

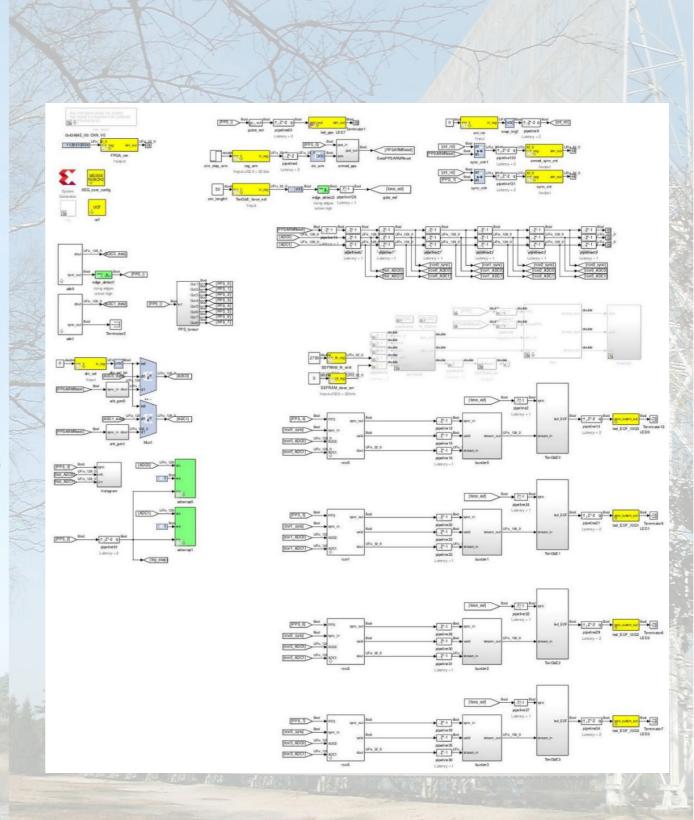
NEXT NRT INSTRUMENTATION

- currently ROACH2 based, before upgrade to RFSoC within a 1-2 year(s)
- A/D conversion right after the receiver

bw 0-1.8GHz for BF

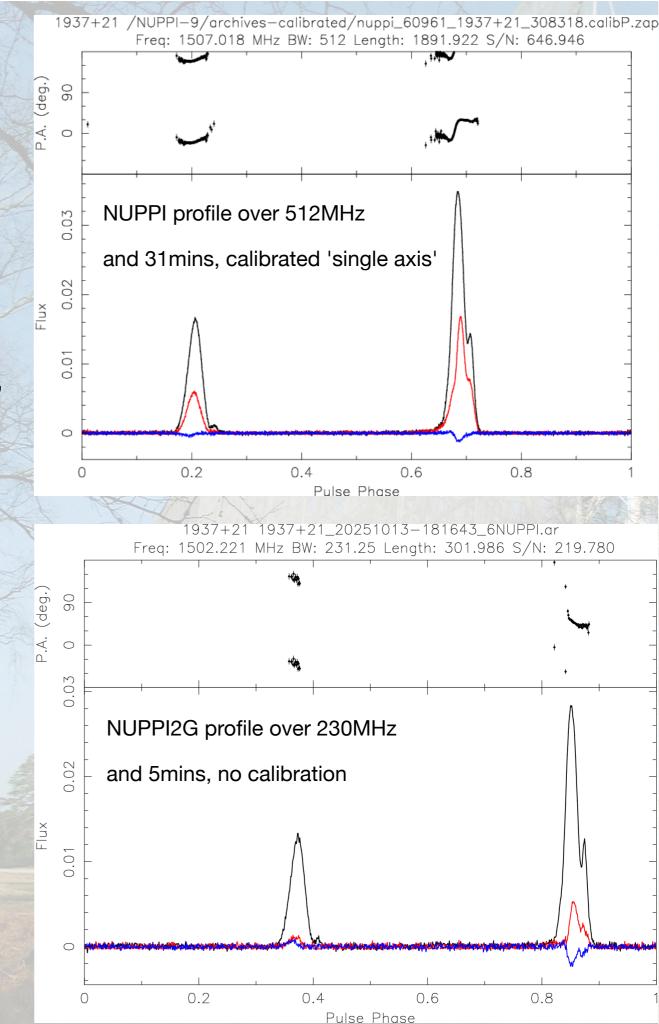
bw 1.8-3.6GHz for HF (in second Nyquist zone)

- wave forms output 'galactic/extragalatic' 1-4x28/112MHz channels
- wave forms output 'pulsar' 1024x 1.8MHz channels (over 8x 10Gbe fiber links)



OCTOBER 2025: FIRST PULSAR TESTs on SKY

- PSRDADA wave forms put on disk over 128ch, simultaneously to NUPPI observations
- 'dspsr' dedispersion/folding with NUPPI polycos, no calibration

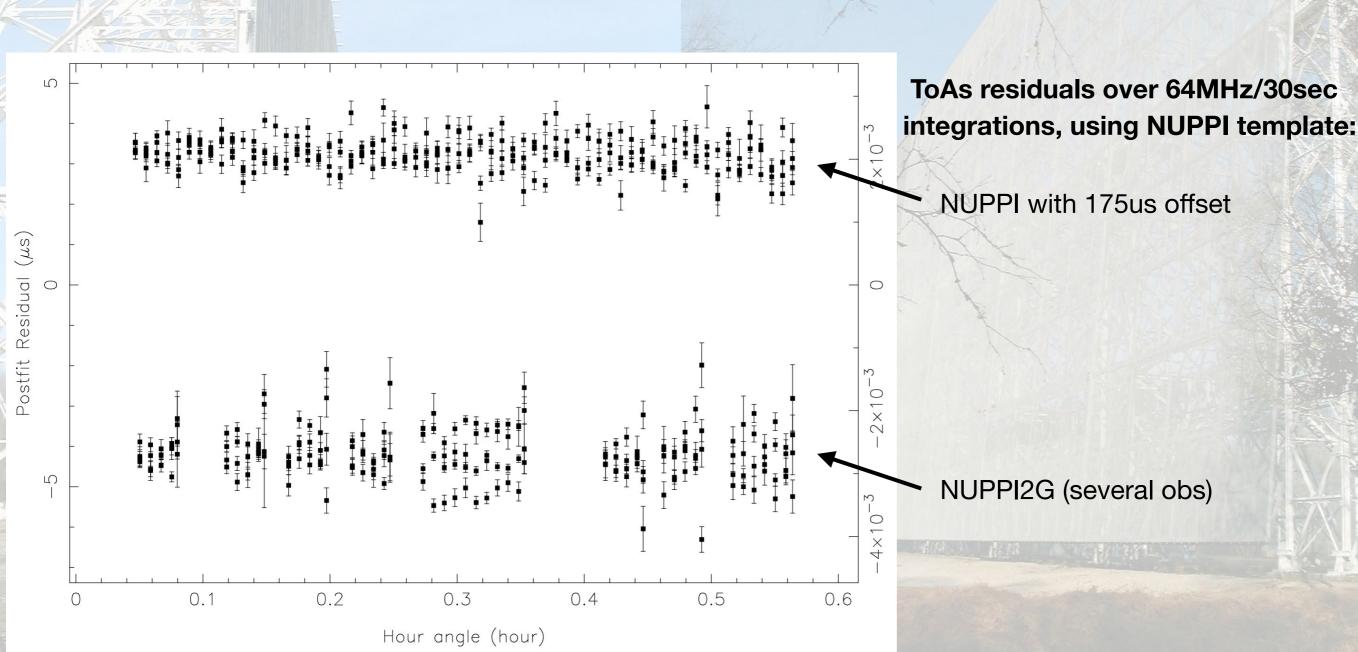


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- ToAs extraction and analysis — (pam, pat and tempo2)

very similar ToAs residuals with same BW/T_{int}

1pps signal well managed for building start times



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NEXT STEP

 PSRDADA wave forms on galactic/extragalactic streams (—> LEAP alike mode)

 code NUPPI Nvidia/CUDA to be ported to Nvidia/Holoscan to send data directly from 10Gbe interfaces to GPU memory

