

Gravitational waves

Carlos Delgado
on behalf of GW group

Brief Description of the goals of the line

Employing GW for inference on cosmological model parameters.

Searching for Sub Solar Mass compact objects (PBH).

Exploring search methodologies for events beyond CBC (i.e. Burst, SN,...)

Developing analysis techniques in Virgo to improve the detector performance (as a pathway to ET)

Developing the capabilities to contribute to the instrumentation and computing of advance interferometers, identifying high impact niches in instrumentation development in ET where we could participate.

Personnel

Scientific Personnel

Staff: M. Cárdenas, C. Delgado, P. García Abia, S. Mangano

Students: D. Beltrán

Mechanics

Staff Engineer: C. Díaz

Temporal engineer: M. Polo (on leave)

Electronics

Computing

Staff: F.J. Calonge

Staff: G. Merino (PIC)

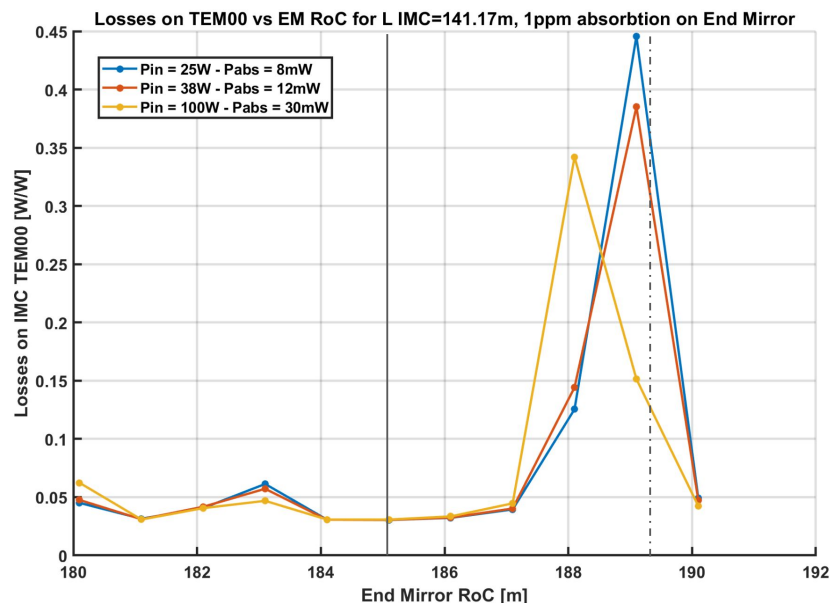
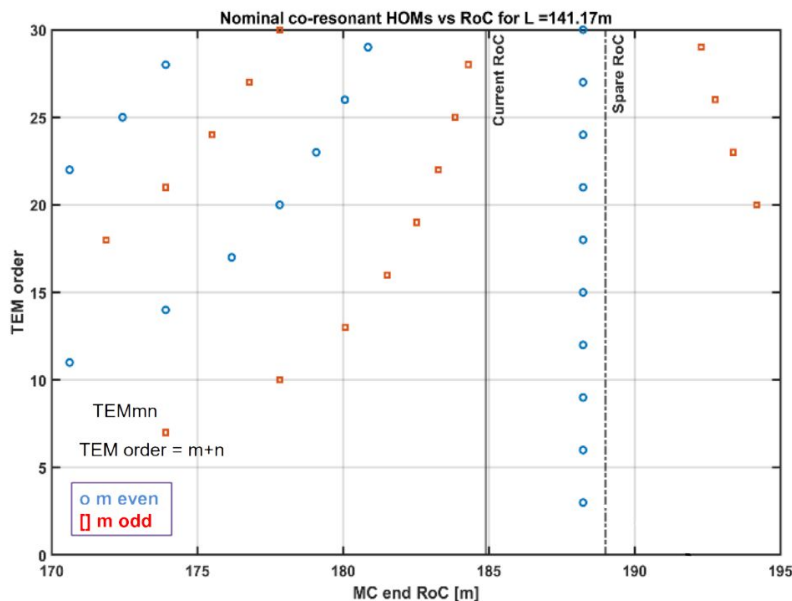
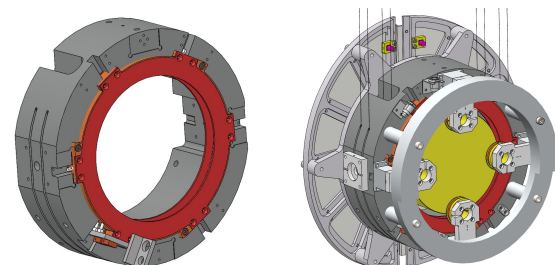
Administration

Highlights in the mid2023-mid2025 period

- CIEMAT enters in Virgo collaboration as group in probation period in 2022, became full member by beginning 2025.
- The only offsite low-latency cluster, at the time, for Virgo online data analysis was successfully deployed and entered in operation in 2024.
- The IMC upgrade project for Virgo O5 run led by CIEMAT-FP passes the first Critical Design Review.

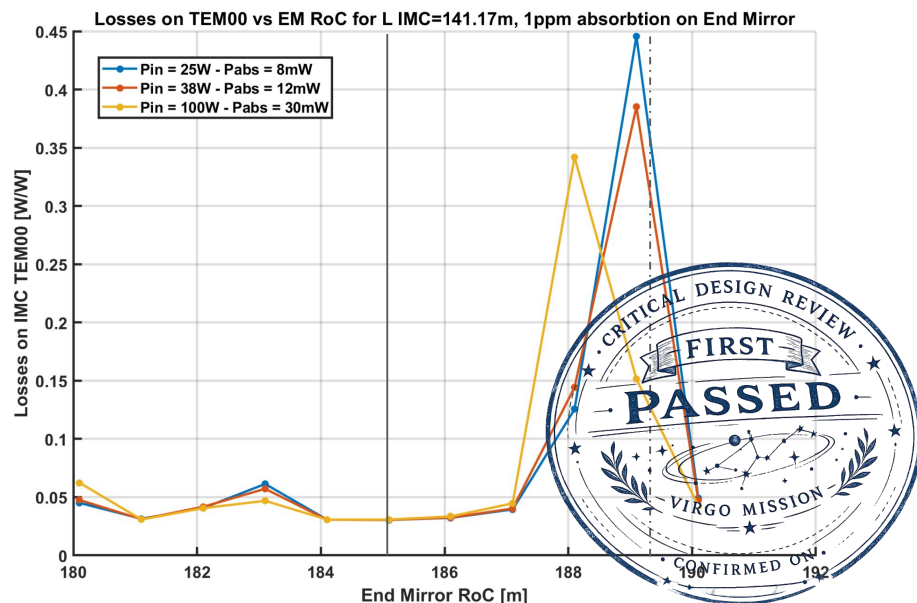
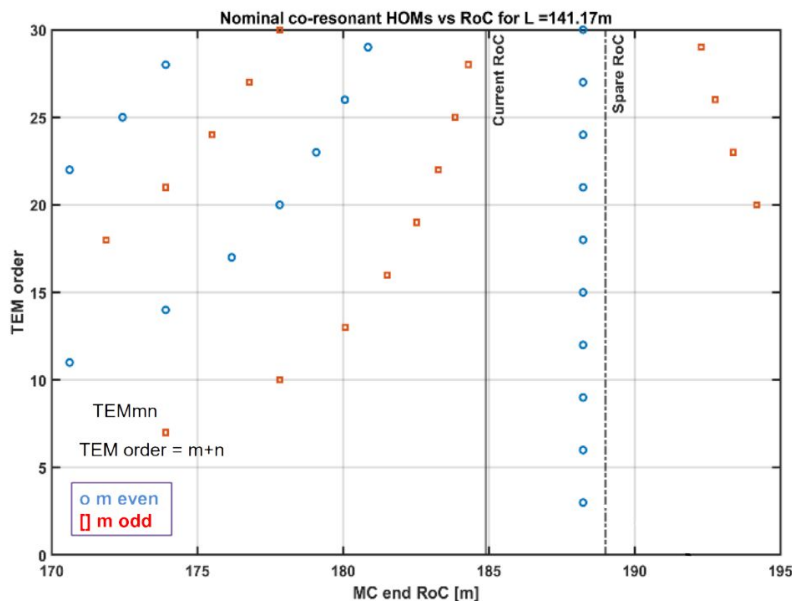
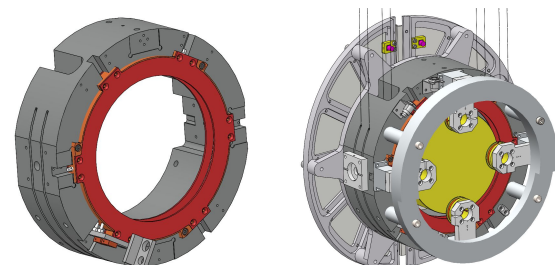
Instrumentation: Upgrade of Virgo's Input Mode Cleaner

Adding a ring heater to adjust the mirror radius of curvature in the payload of the IMC

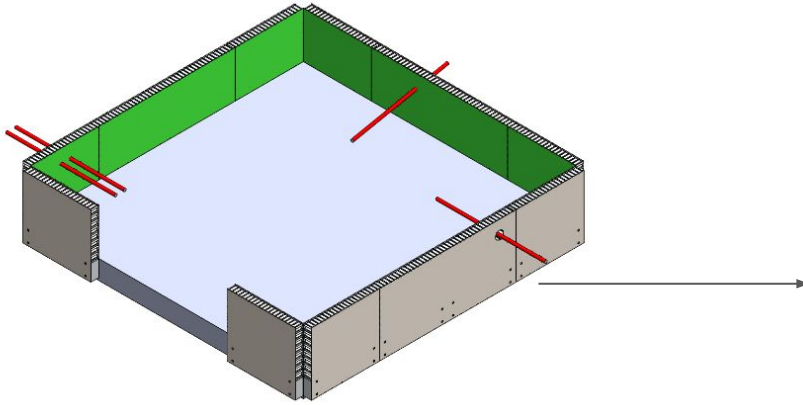


Instrumentation: Upgrade of Virgo's Input Mode Cleaner

Adding a ring heater to adjust the mirror radius of curvature in the payload of the IMC



Instrumentation: Baffles for stray light control



Passive baffles for stray light mitigation for the new Virgo's suspended injection and detection benches for O5.

Demanding in weight, stiffness, vacuum compatibility, and reflectivity.

First production test performed: some issues identified.

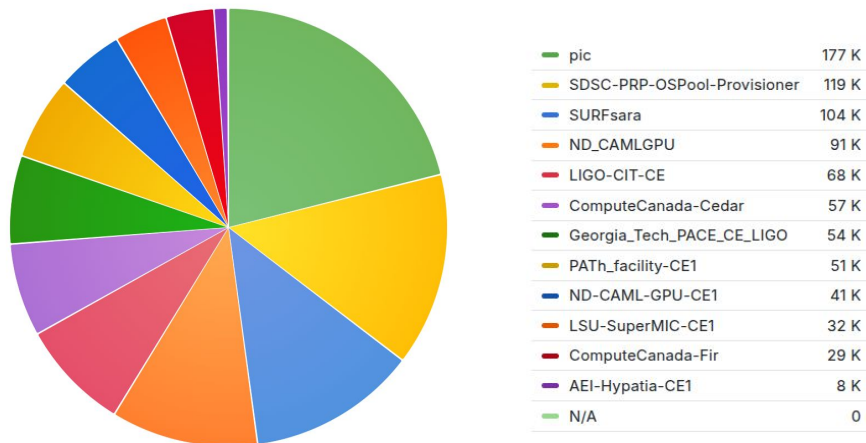
Pending on finalization of beam positions in the suspended benches design.

Computing Activities.

Contributing to LVK computing Grid since 2019, through the PIC data center in Barcelona (Collaboration CIEMAT-IFAE)

- Effective contribution from day 1 thanks to common technologies with the WLCG.
- PIC is currently the largest GPU provider of the LVK grid (>20%), and provides 5% of CPU contribution, despite of being only opportunistic due to lack of funds

GPU Wall Hours by Facility (LIGO, last year)



Computing Activities.

Hosting of a low latency cluster for LKV at CIEMAT headquarters, running since 2023.

- Role under discussion: will likely become a LVG grid node.

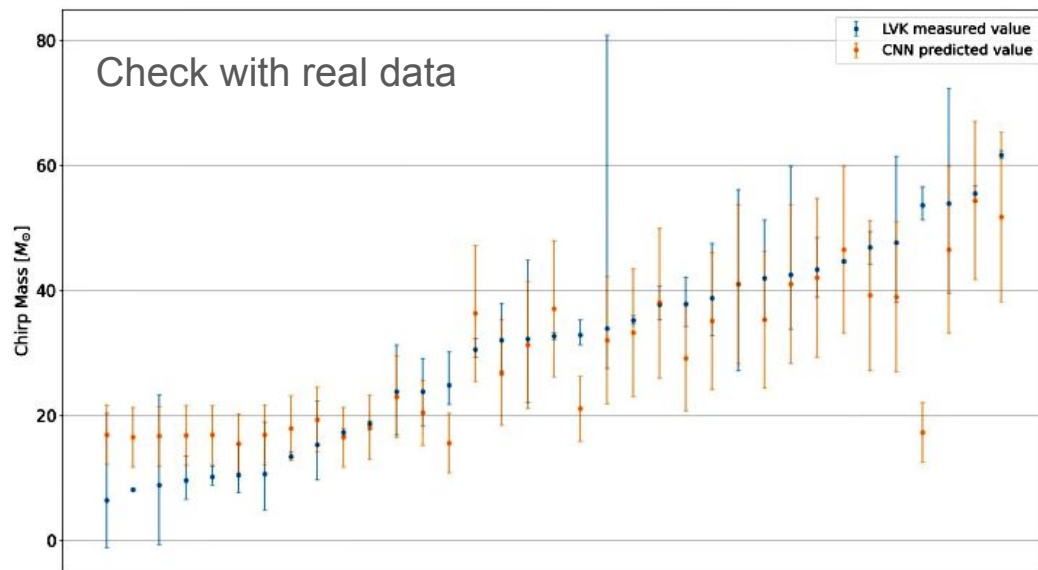
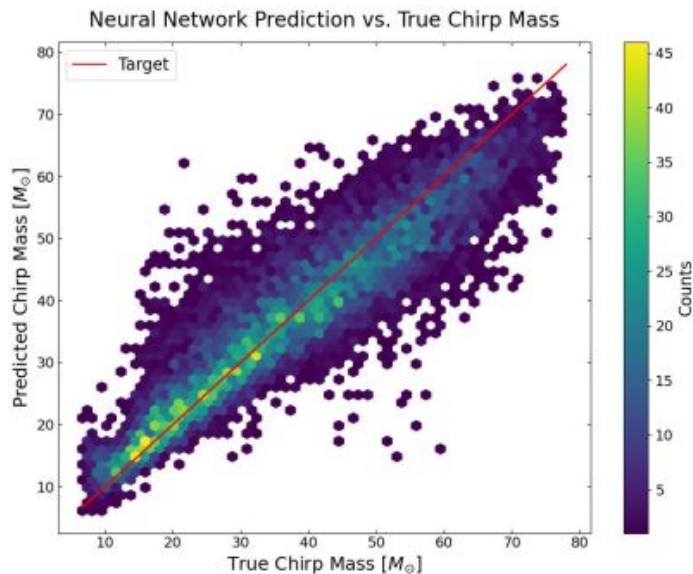
Contributing in the development of the ET Computing Model, coordinated with WP8 of ET Preparatory Phase

- provide a running estimate of the computing resources needed.
- define the overall architecture of the e-Infrastructure.
- define a process to evaluate computing needs.

AI tools for GW: parameter estimation

(6) Parameter estimation using CNN with (frequentist) error estimates using Mondrian Conformal estimates.

Training and testing

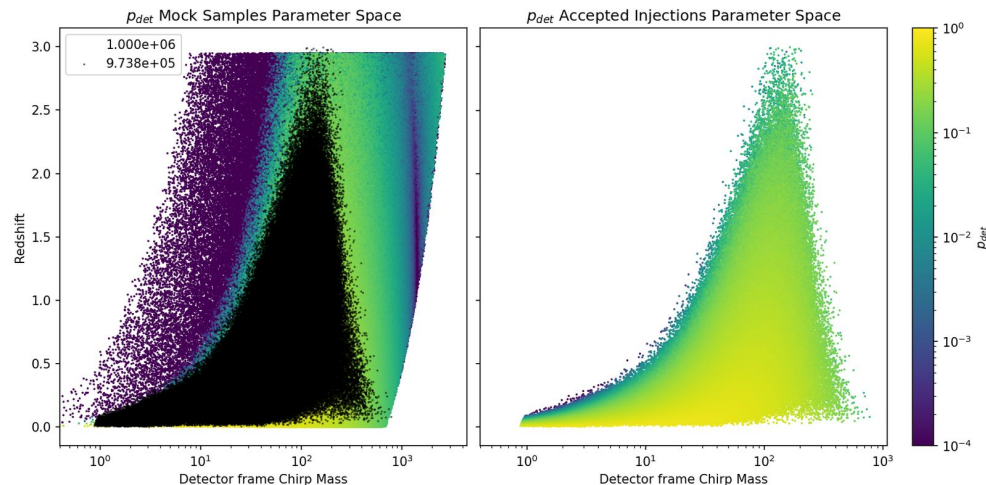
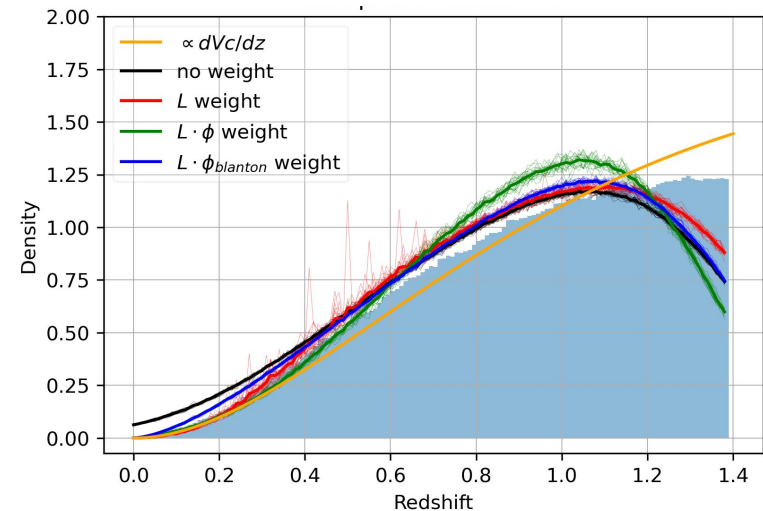


And first test on foundation models for parameter estimation.

Analysis

Evaluate the impact of uncertainties associated with galaxy catalog when inferring cosmological parameters

Developing an estimator for the injection recovery probability, to go deeper and reduce the variance in such regions.



And detector characterisation, SSM sensitivity estimates, parametric modeling of BBH poblations & rank-statistic based signal detection.

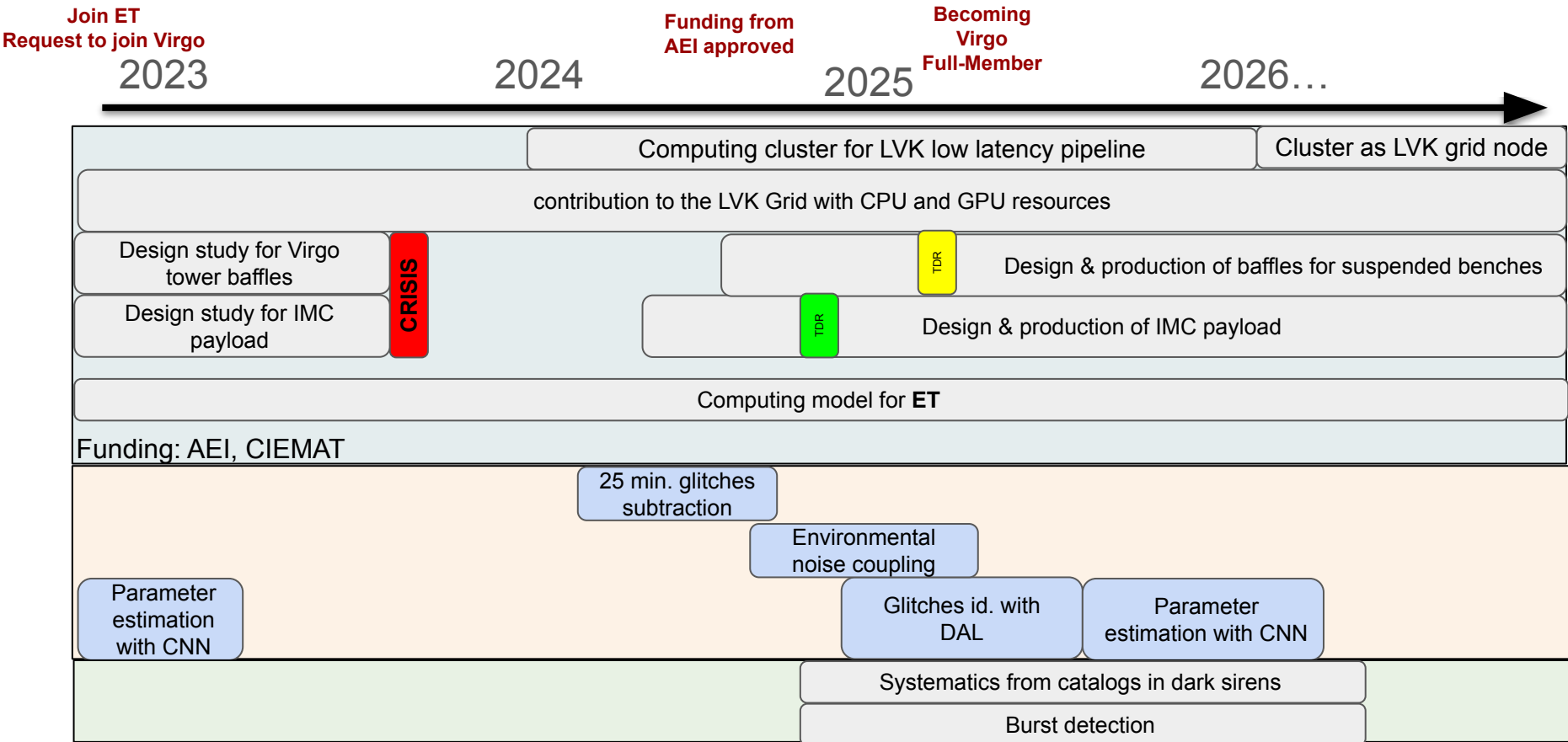
Major responsibilities

- C. Delgado: INJ.04 and SLC.04 deliverables coordinator.
- C. Diaz: engineering leading roles
 - Design, production and installation of the mechanics of the of the IMC payload.
 - Design, production and installation of SLC Baffles for injection and detection suspended benches.
- P. García Abia: maintenance and operation of offsite low latency cluster.
- G. Merino: coordinator of task force to
 - estimate of the computing resources needed.
 - define a process to evaluate computing needs.
 - define the overall architecture of the e-Infrastructure.

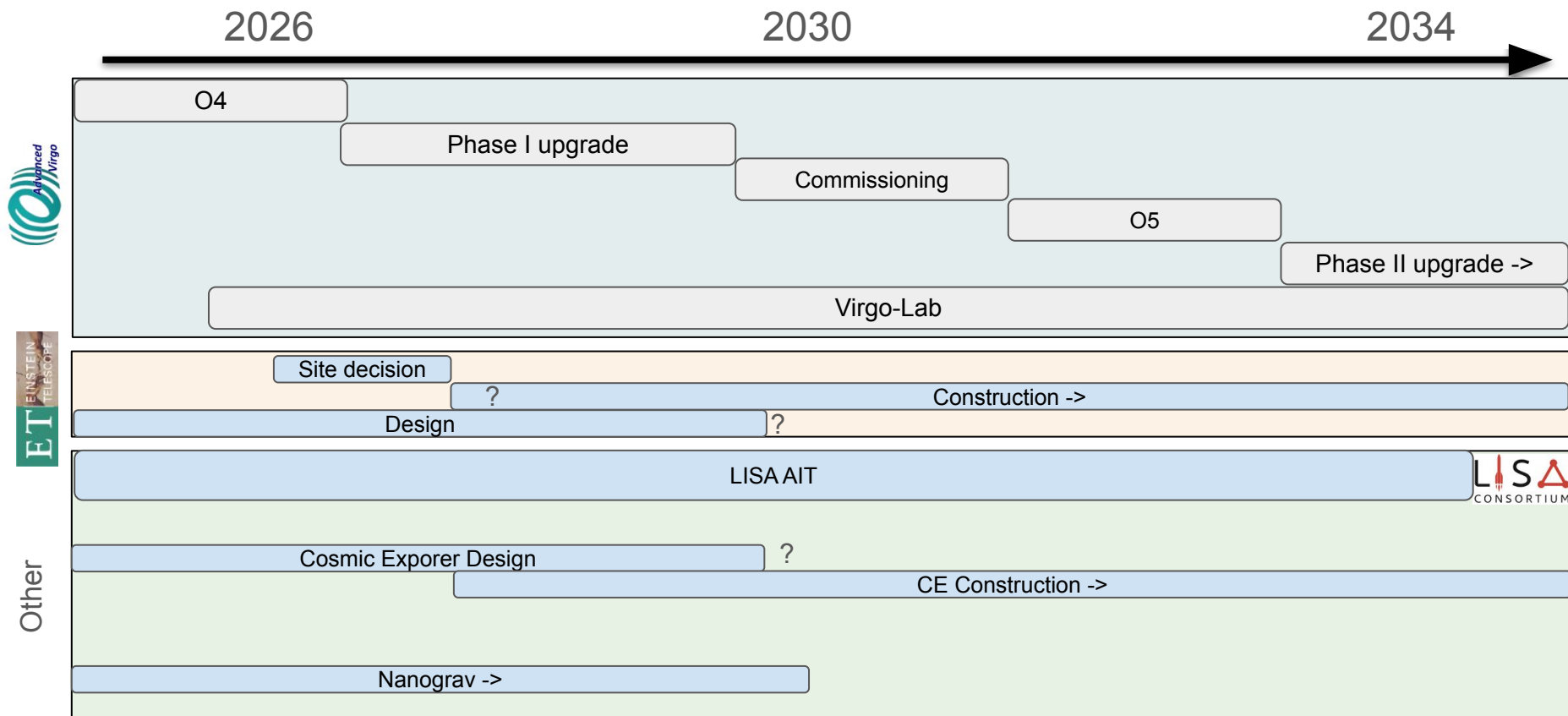
Funding

- Until second half of 2024, only marginal funding from CIEMAT available
- Since Sept. 2024 until end 2027 with an AEI competitive project with 101.900€ for direct costs
 - Mostly to produce the hardware we are committed to
 - No allowance for personnel
- 1 Phd. student from CIEMAT program

Some thoughts about the future of the research line



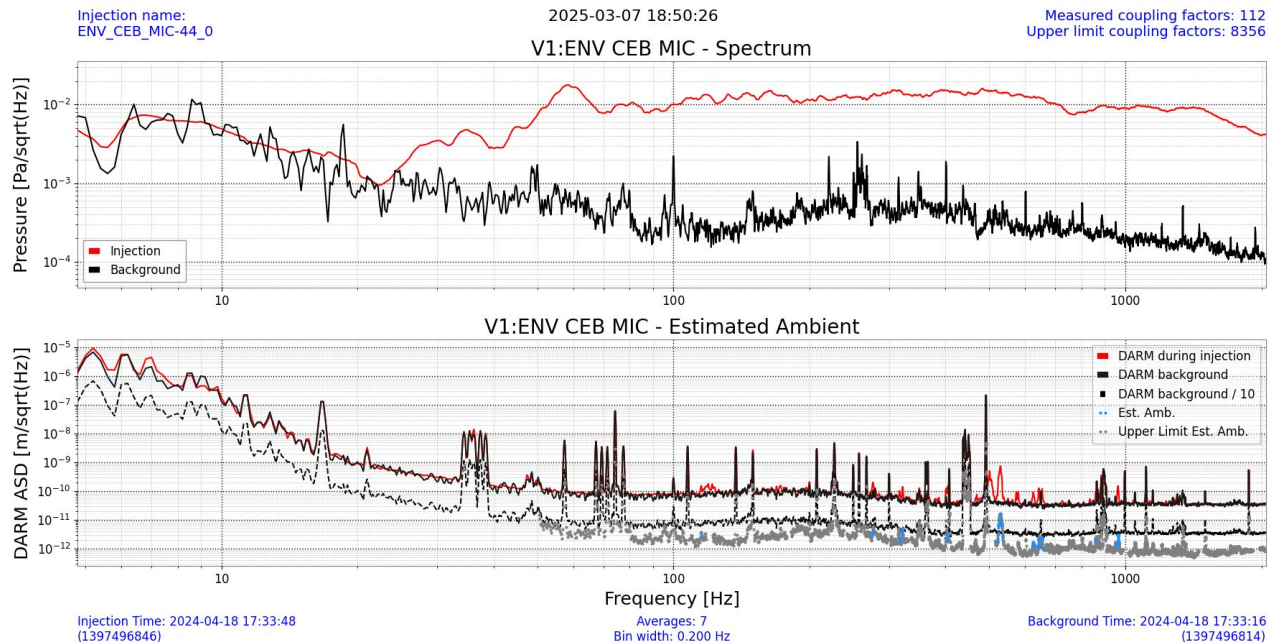
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The End

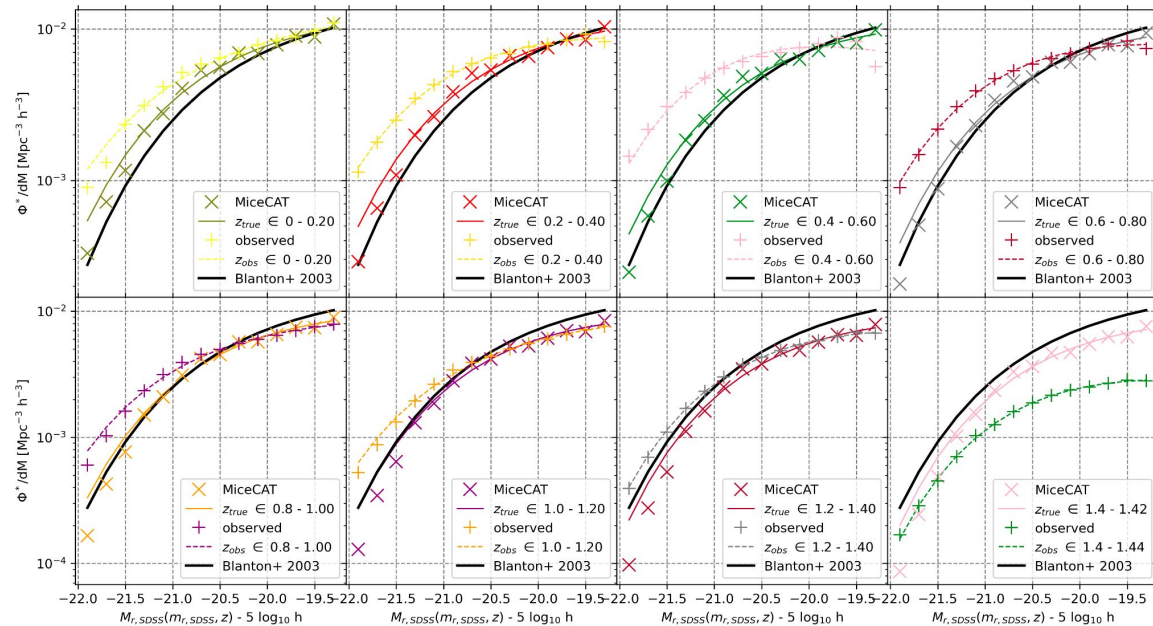
Detector characterization

Study the response of the detector (DARM) to environmental perturbation, through the computation of coupling functions with controlled noise injections.



Systematics from catalogs

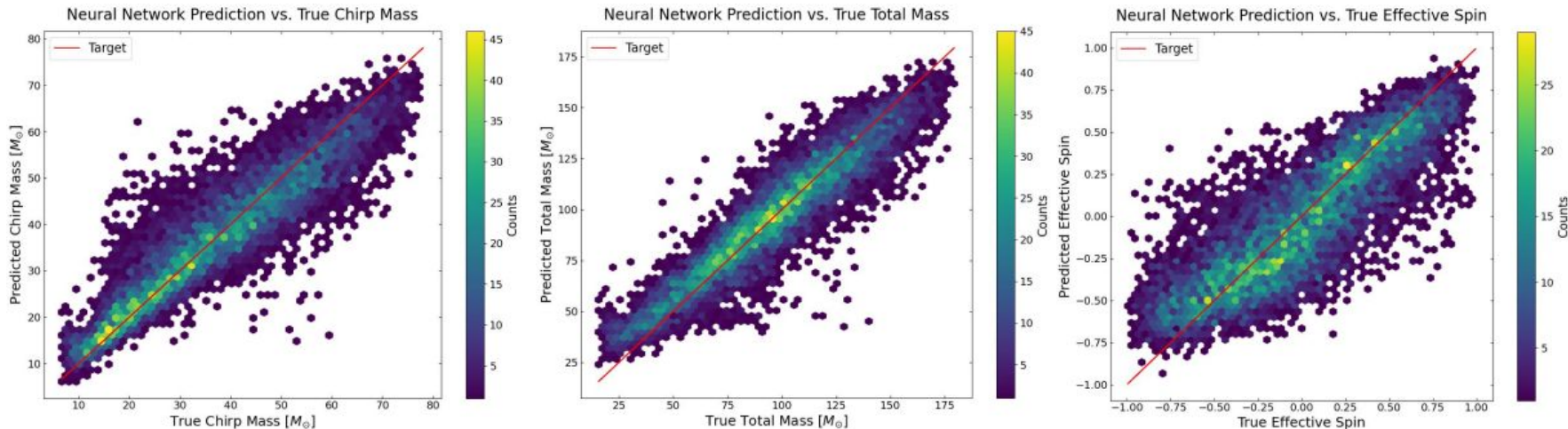
Studying how the luminosity function parameters evolve with redshift and how this uncertainties in the evolution may impact GW cosmological inference.



AI tools for GW: parameter estimation

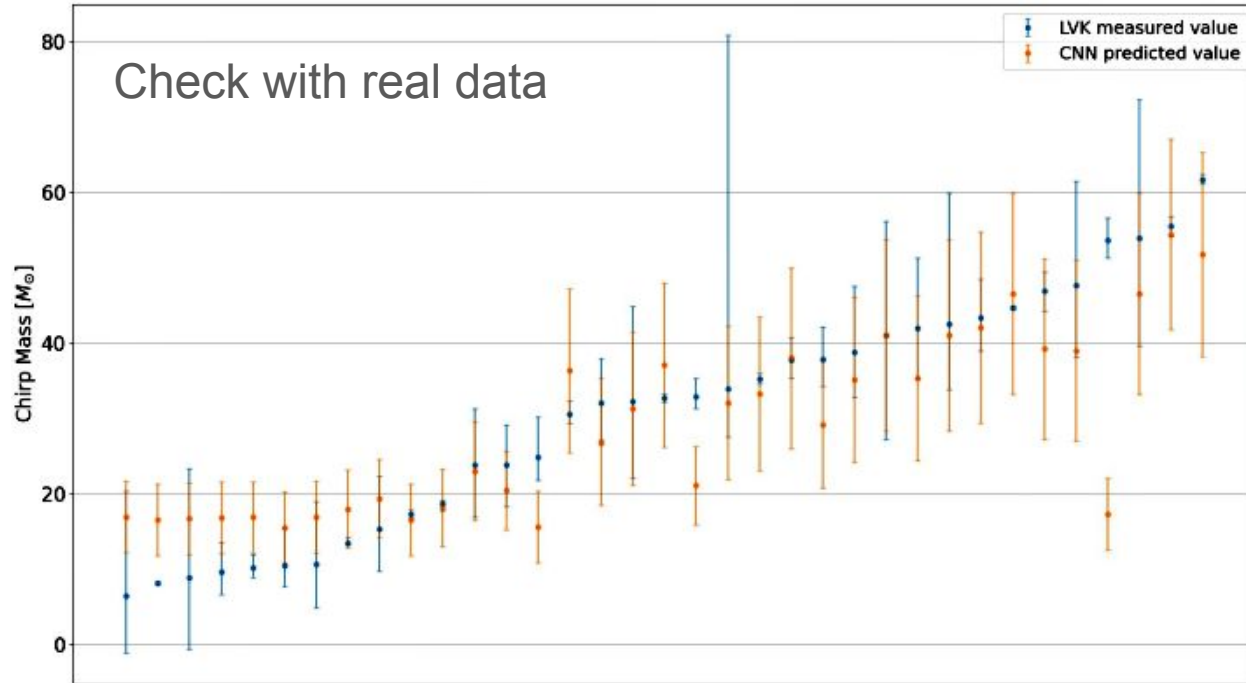
(6) Parameter estimation using CNN with (frequentist) error estimates using Mondrian Conformal estimates.

Training and testing simulated samples



AI tools for GW: parameter estimation

(6) Parameter estimation using CNN with (frequentist) error estimates using Mondrian Conformal estimation.



Historial Context

Line created by beginning 2023, funded since mid-2024, with the goal of contributing to the ET project and training future physicists and engineers for its exploitation.

Founded by members from other lines who volunteered, motivated by the high potential physics returns (currently limited by observation time) and CIEMAT's patrons interest in entering the field.

Full membership in Virgo obtained after a two years probationary period, delayed due to CIEMAT internal matters.

Participation in Virgo (and in LIGO, KAGRA) identified as the first step toward integration into the GW experimental community, with contributions focused on hardware and computing.