ICREA

IFAE Institut de Física d'Altes Energies

EXCELENCIA SEVERO OCHOA

bist

ET activities at IFAE & future plans

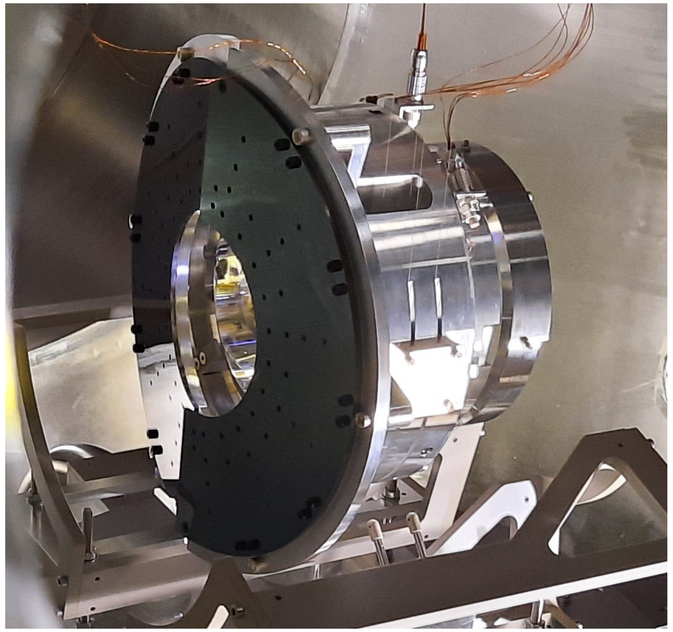
M. Martínez

ET-Spain Meeting, Barcelona, Nov 2026

Outline

- Composition of the IFAE group
  - Information from ET-DB
- Contributions to LVK
- Hardware Development
  - Virgo as R&D for ET
  - Involvement in ET-pathfinder
  - ET Stray Light Simulations
- Governance & EU Projects
- Physics Preparation
- Notes on Computing (see Gonzalo’s talk)





Contribution to Virgo hardware for more than 0.5M€ (core)

Group composition (2026)

IFAE @ LVK since 2018



Not listing IFAE Technical Division / Computing staff



Michele Maggiore



Eugenio Coccia



Andrew Lundgren



Mario Martínez



Lluïsa Mir

Headhunting for a junior leader (experimentalist)

Three PhD theses in 2023
(Then industry + research positions)
(A. Romero now staff in Annecy)

M. Maggiore visiting IFAE in 2024 — 2026

Part of IFAE's technical staff @ EGO in 2021



POSTDOC RESEARCHERS



Machiel Kolstein



Jam Sadiq



Kanchan Soni



Avani Vikrambhai Patel



Marc Andres



Giada Caneva



Catalina Miritescu

PHD STUDENTS



Saqlain Afroz



Dounia Nanadoumgar Lacroze



Sakshi Satish Madekar



Leonardo Toti

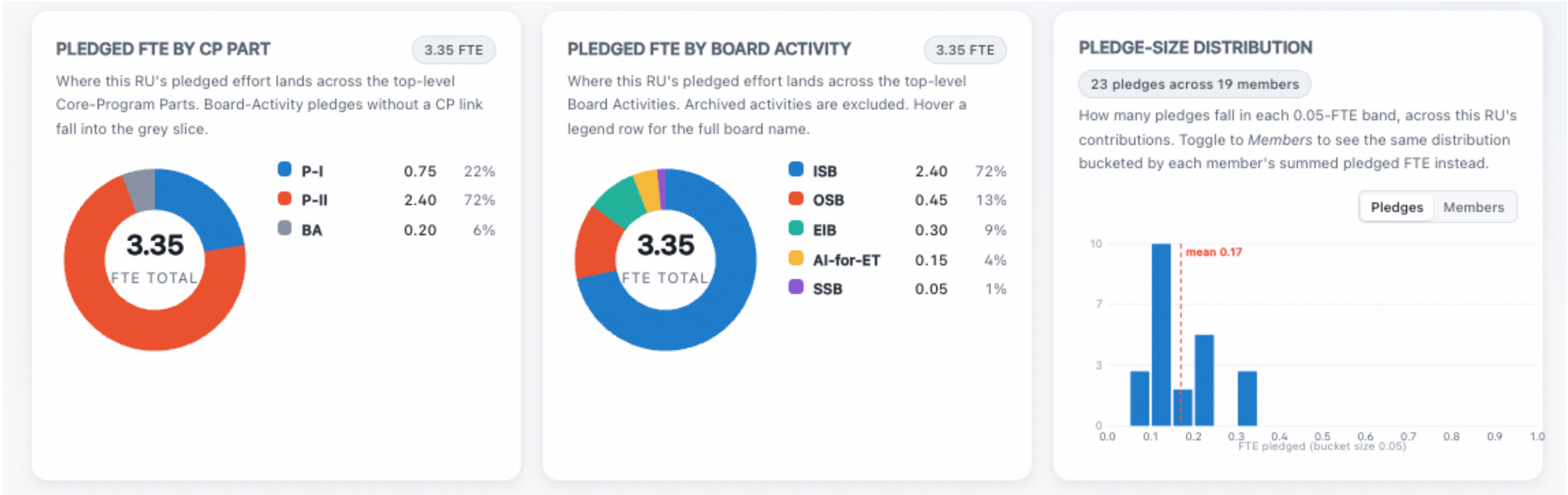


Elisabet Vallejo Pagès

Five PhD students

Three PhD theses in 2025/6
Now MIT, Niels Bohr Inst., Brussels U

ET DB



20+1 pesons listed — **3.35 + 0.2 = 3.55**
J. Jiménez (Research Engineer — Optics — fixing his DB entry — adds 0.2)

As today strongly dominated by ISR detector activities
More OSB physics -driven activities in the future

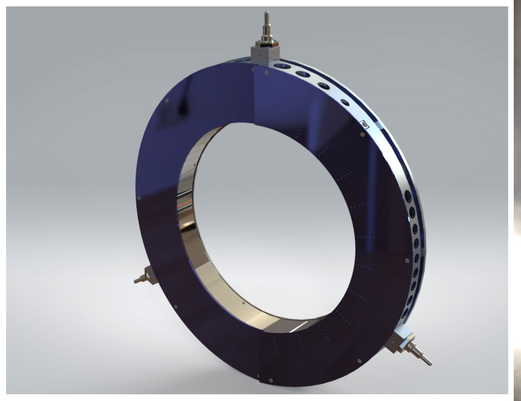
We foresee to increase by 1-2 FTEs in the following year
—> hiring a system engineer fully devoted to ET soon
—> headhunting of junior scientists on GW detector tech in the near horizon

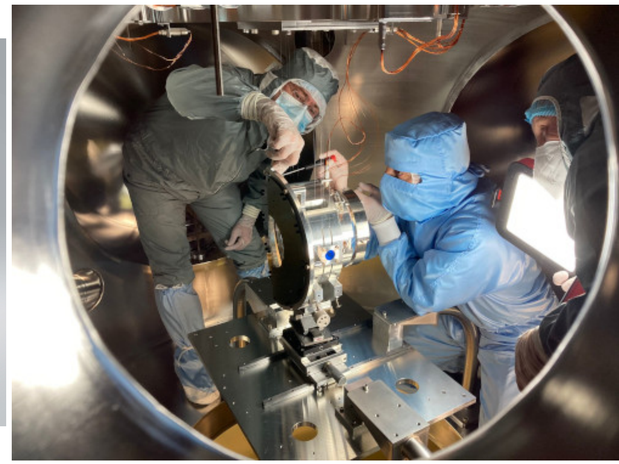
Contributions to LVK

- Contributions to commissioning, calibration & DetChar
- Responsibility of SLC subsystem coordination
- Development of instrumented baffles
- Delivery of non-instrumented baffles for FDS and SR mirror
- Significant (opportunistic) computing contributions to LVK

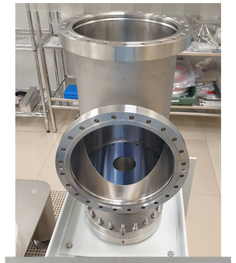
- Physics Exploitation
- Contributions to Virgo Governance & IGWN
- Organization of 2024 LVK meeting in BCN



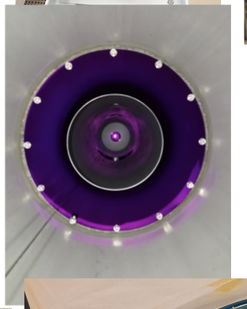


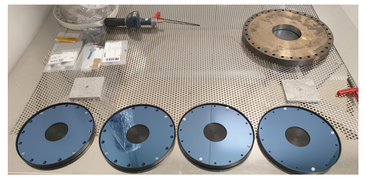






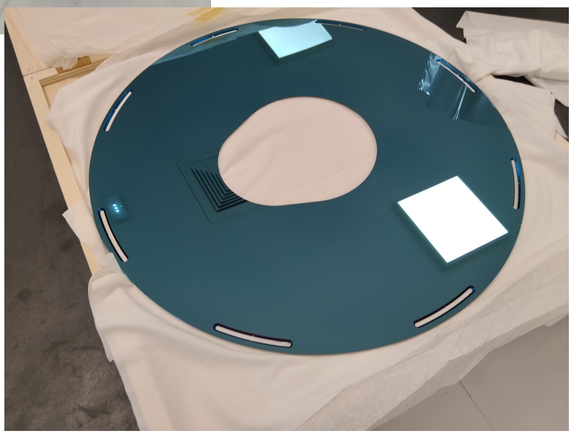












LVK operations and commissioning

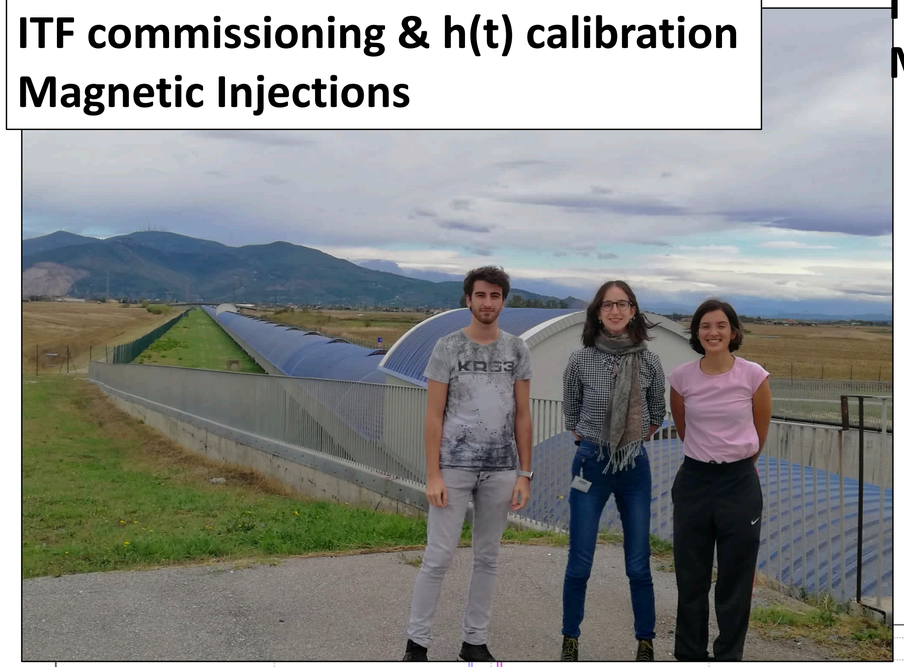
IFAE took an energetic approach for the involvement in VIRGO operations since 2019

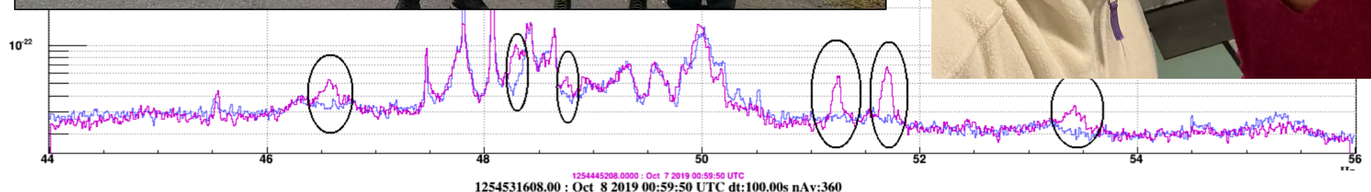
2019 Results Published

A Cirone *et al* 2019 *Class. Quantum Grav.* 36 225004

I. Fiori et al., *Galaxies* 2020, *8*(4), 82

2021 + 2023 → 3+1 people @ EGO
IMC baffle operations
ITF commissioning & h(t) calibration
Magnetic Injections

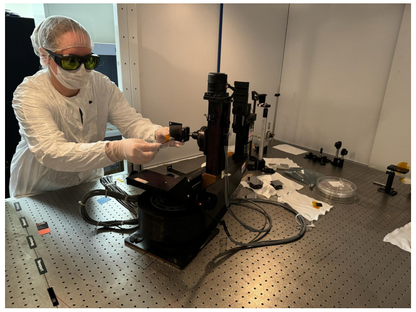




2024 —> 2 +1 people @ EGO
IMC baffle operations
ITF commissioning & h(t) calibration
Magnetic Injections





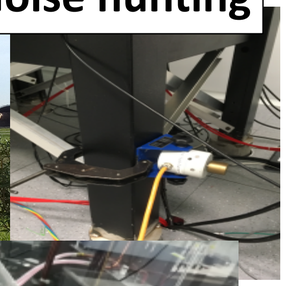


2025 —> 1 person @ EGO
Work on Auxiliary Optics and interferometer alignment in collaboration with EGO Optics Department



2019. → 3 people based @ EGO
IFT noise commissioning/Noise hunting







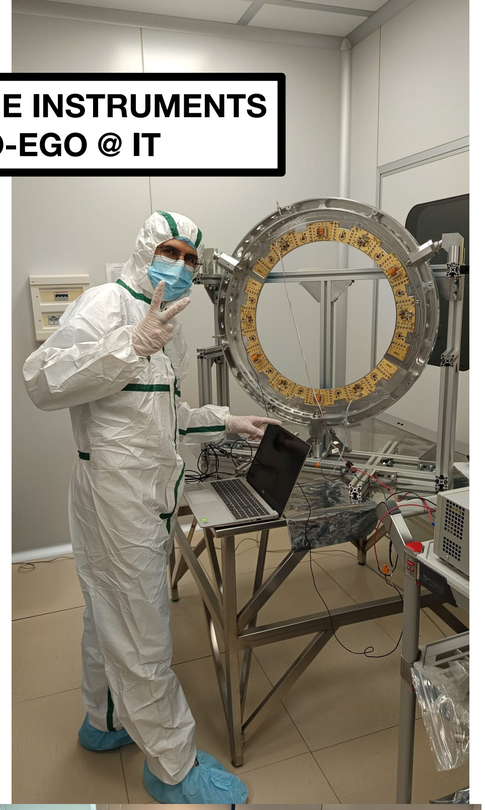
IFAE's R&D for Einstein Telescope



2021 FIRST INSTRUMENTED BAFFLE AT VIRGO-EGO @ IT

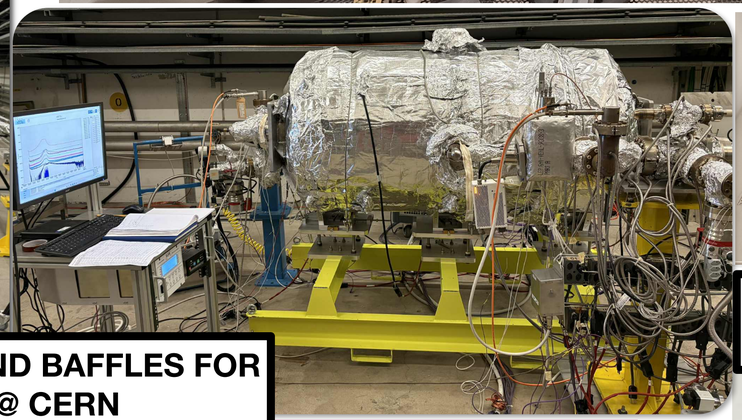


2026 TWO LARGE INSTRUMENTS AT VIRGO-EGO @ IT



2022/5 IFAE Staff - EGO @ IT



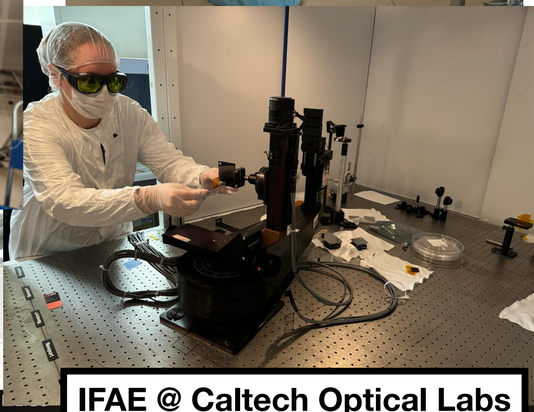


2024/6 DESIGN STUDIES AND BAFFLES FOR ET VACUUM PIPE @ CERN



2024 CRYOSHIELDING ET PATHFINDER @ NL





IFAE @ Caltech Optical Labs

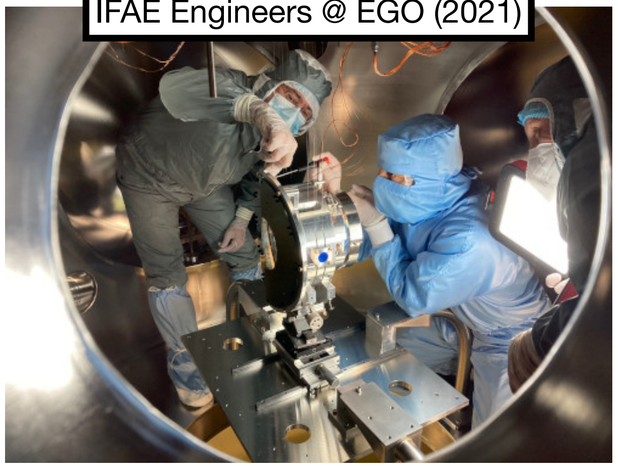


IFAE has made novel contributions to GW hardware since 2019
MoA with CERN for the Design of the ET Vacuum System
Active participation in the flagship R&D platform @ Maastricht
Close collaboration with USA in common ET/CE strategies
Participating in a number of EU initiatives for EC fundings

R&D synergies with other centers

- **Close collaboration with EGO/Virgo INFN & CNRS scientists (Overlaps with ET)**
  - Noise hunting and noise injection campaigns (IFAE people @ EGO)
  - Virgo Calibration and Commissioning (IFAE people @ EGO)
  - Vacuum tests @ EGO
  - Stray Light Control (includes hardware and simulations)
  - ITF simulations
- **Caltech & MIT**
  - Well established by now collaboration on simulations and baffle materials
  - Genuine interest in Caltech on the concept of instrumented baffles
  - Existing ET - CE collaboration on stray light simulations
  - Exchange of visiting actions @ Caltech since 2020 [extremely successful]
  - Exchange of visiting actions with MIT in 2024 (exporting instrumented baffle tech.)
- **CERN vacuum pilot sector for ET**
  - Major contributions on stray light simulations determining tube diameter and apertures in the main arms
  - Construction of baffles for pilot sectors and outgassing tests with different materials/polishing
- **ET-patfhfinder @ Maastricht**
  - Assisting in the design & production of the cryo-shieldings and LN2 vessels
  - Exploring the feasibility of pre-alignment system based on the concept of instrumented baffles (1550 nm sensors)
- **LMA (Lyon)**
  - Initiated discussions on mirror maps, stray light calculations, simulations and FP cavities @ Lab

IFAE Engineers @ EGO (2021)

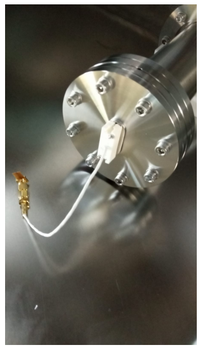


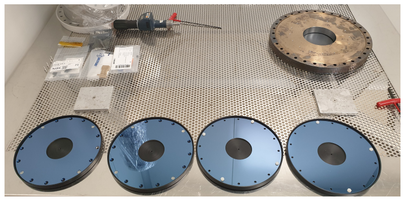
C. Miritescu @ Caltech Optical Lab (2024)

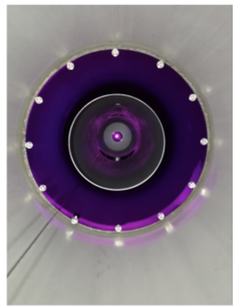


IFAE Engineers @ EGO (2022-2025)



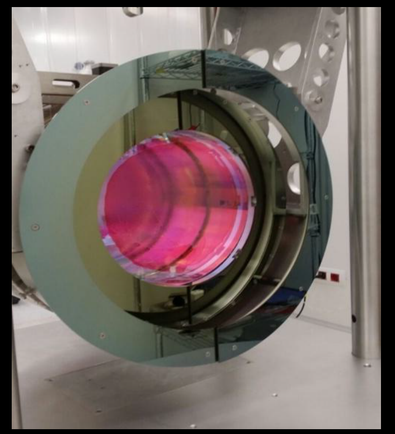


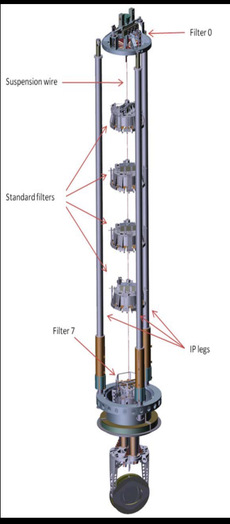


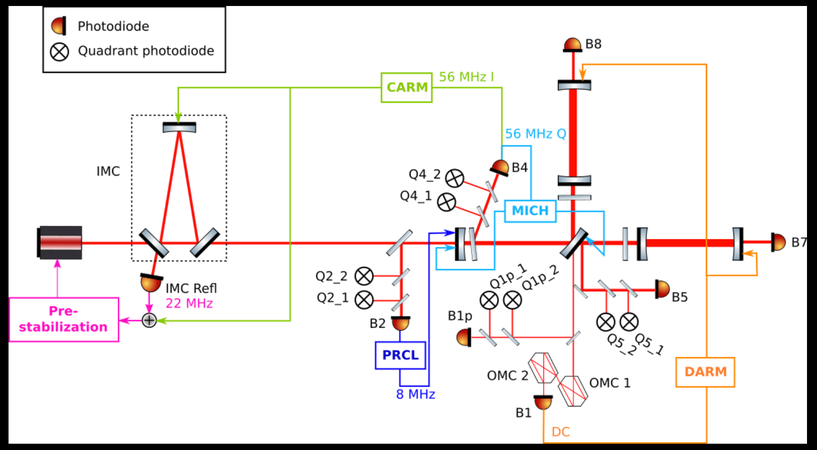


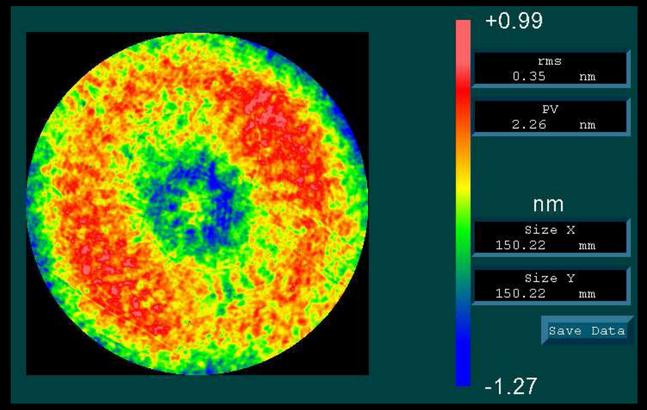
Case for instrumented baffle

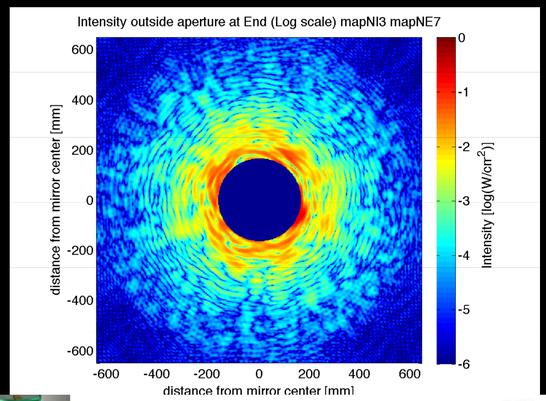
- Efficient pre-alignment of ITF
- Dynamic mapping of mirror surfaces, point defects, thermal deformations
- Monitoring of developing laser high modes
- Correlate with ITF glitches due to interaction with dust, overcorrections, etc



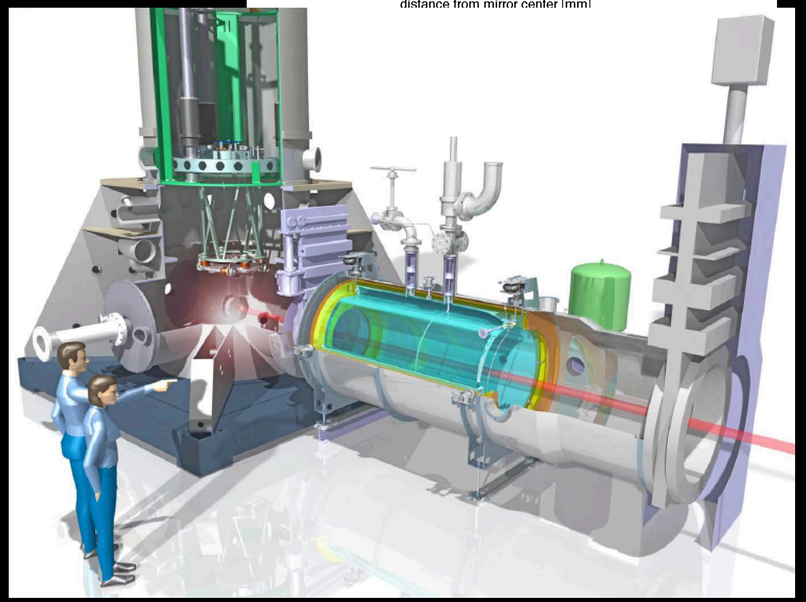




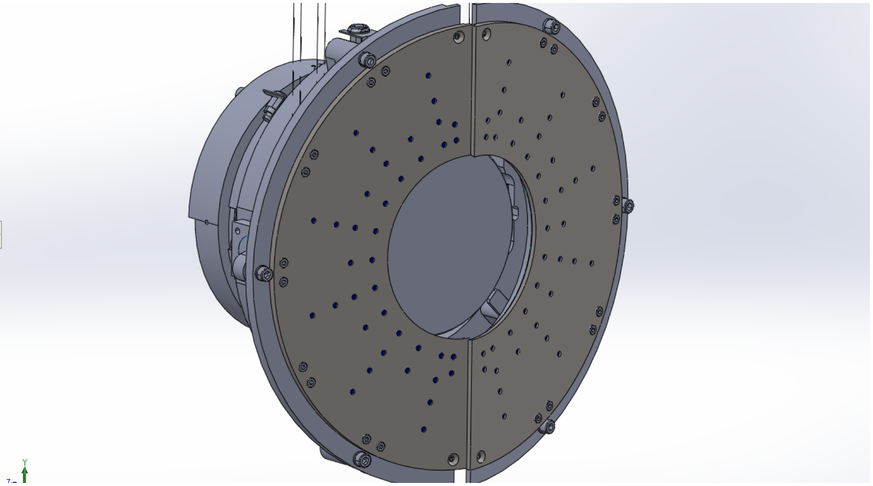


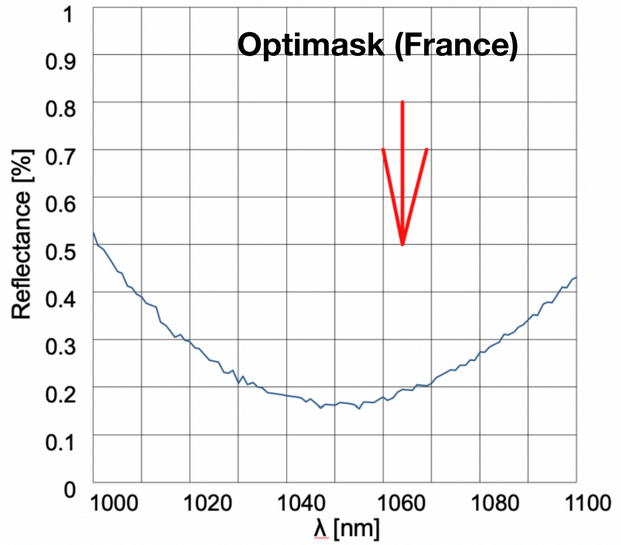


- Sensors on 1064 nm (IR)
- UHV (10^{-9} mbar)
- No active cooling possible
- Solid against baked out (100 C)
- Reflectivity less than 0.5%
- Total scattering under control
- Limited RO cabling —> explore wireless RO
- Negligible induced EM noise near mirrors
- ……



Instrumented baffle technology





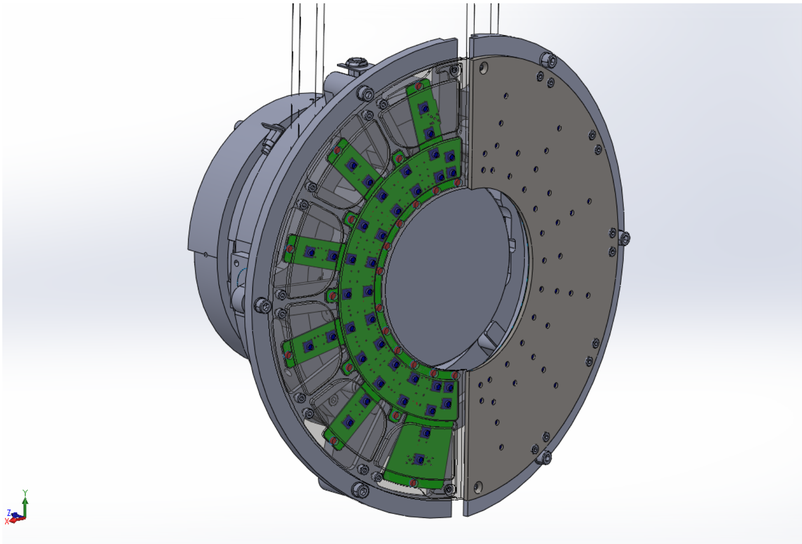
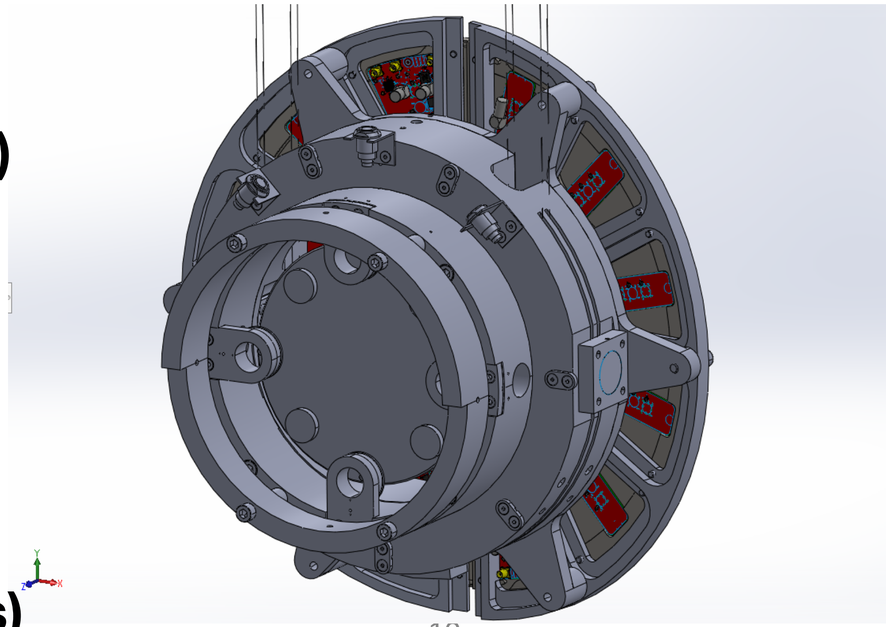


Photo-sensors located behind plate

- Super #8 polished SSL 304L + AR coating (< 0.5% reflectance)
- Number of sensors 76 (38 in each 1/2 baffle)
- Sensors mounted in large PCBs
- Sensors active area 0.49 cm2
- Light reaches sensors through conical (12º) holes of 4 mm of diameter (in the polished side)

> Avoid scattering in edges and hide PCB from light

> Knife like edges in holes and inner aperture (RoC of 10 microns)

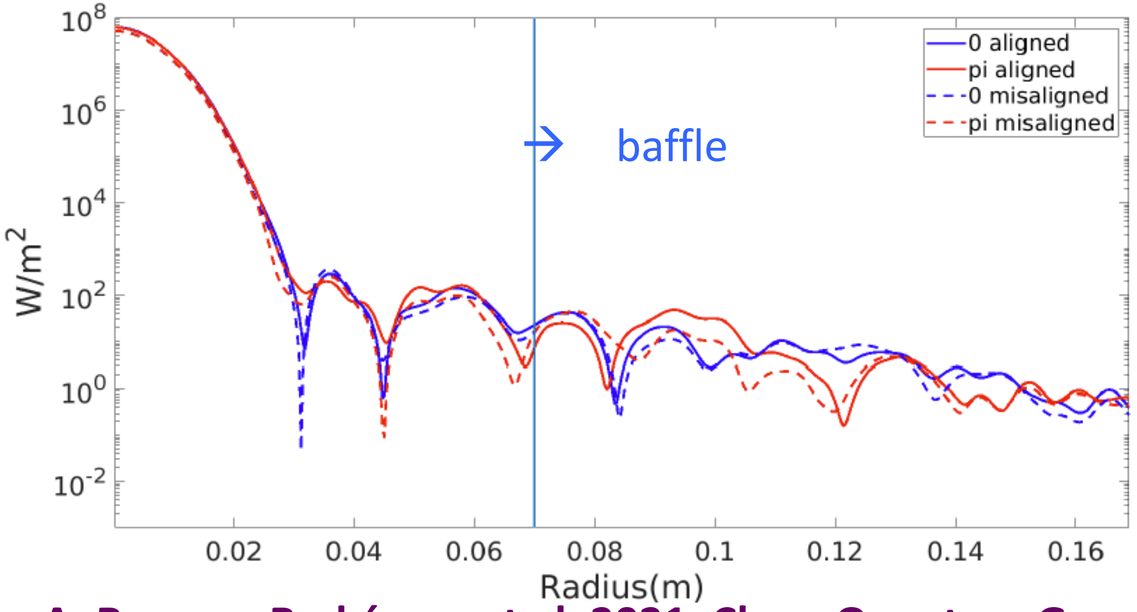


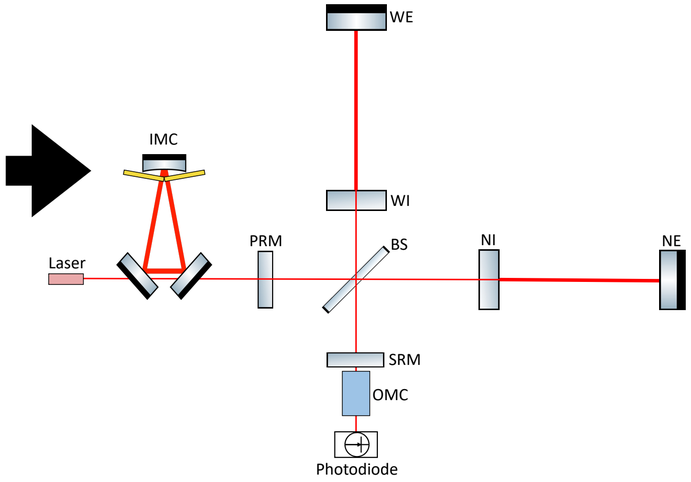
SLC Simulations @ IMC end mirror

Simulations were used to optimize the sensor layout and determine the level of light power to be exposed to

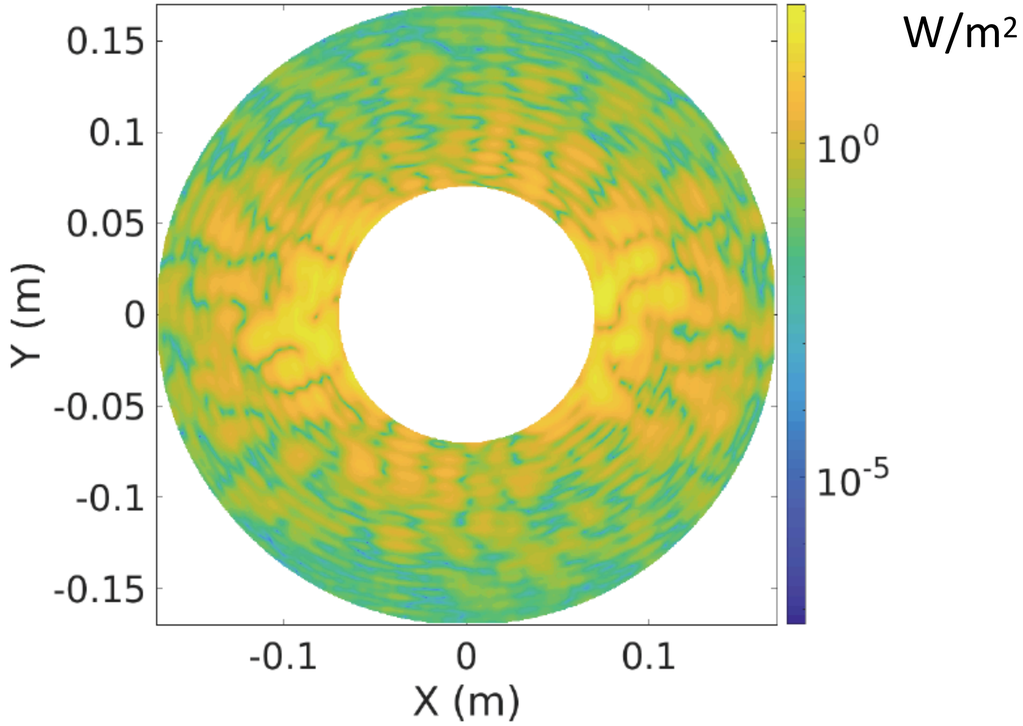
We performed also studies on miss-aligned cavities

Scenarios	Mirror + baffle	Baffle	Photodiode
Resonance	1.35 x 10^4 W	0.20 W	3.2 x 10^{-3} W
Misaligned (10 μrad)	1.19x 10^4 W	0.17 W	3.0 x 10^{-3} W
Extremely misaligned	-	-	2.1x 10^{-2} W
Mechanical drift	390 W	-	130 (for 10 ms)



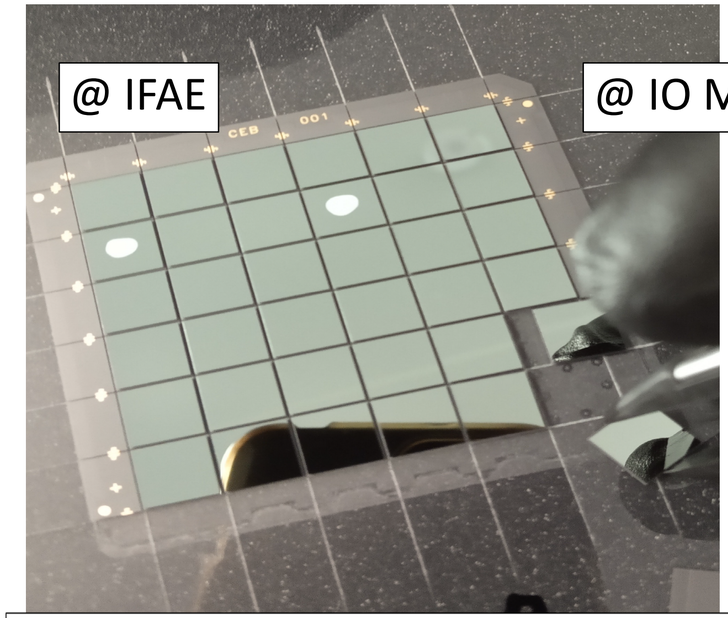


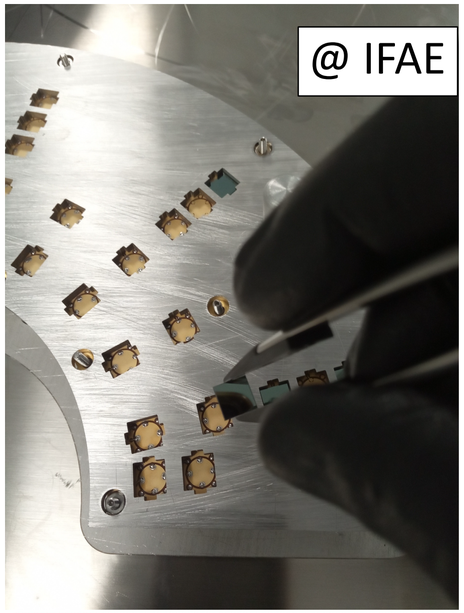
In close collaboration with Caltech and EGO/Pisa Scientists



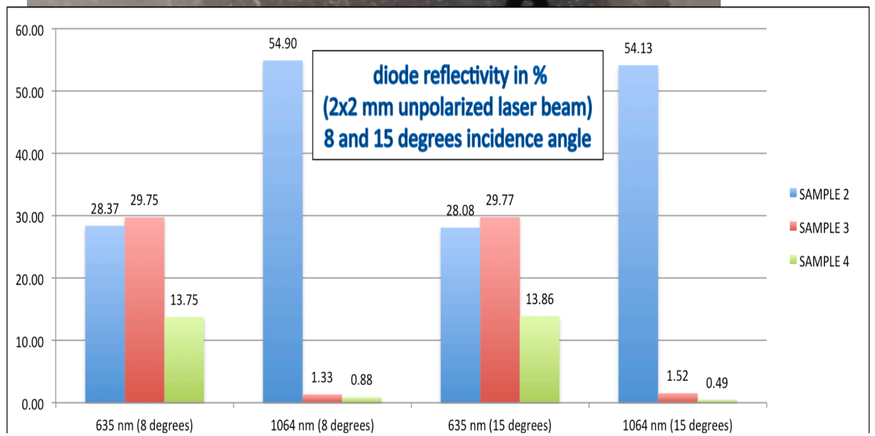
A. Romero-Rodríguez et al, 2021, Class. Quantum Grav. 38 045002

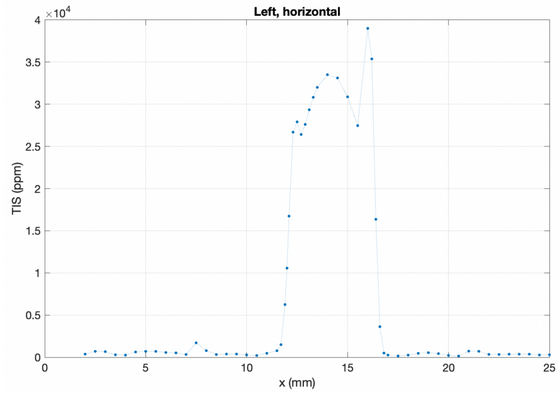
New AR-coated Hamamatsu Sensors

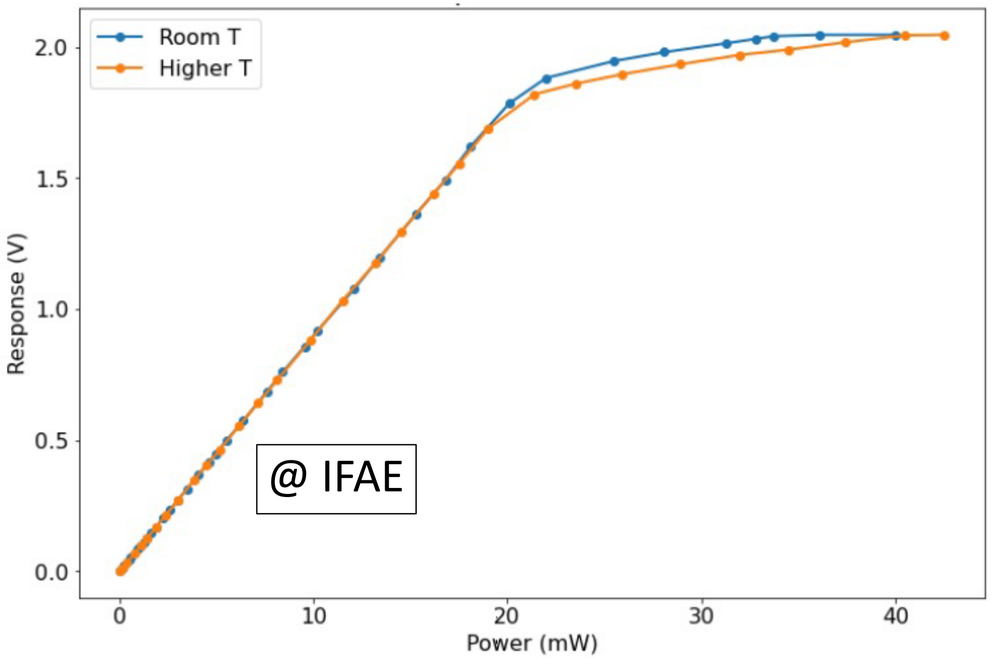




Dimensions	7.37 x 7.37 mm^2
Sensitive area	6.97 x 6.97 mm^2
Operation temperature	-40 to 100 °C
Power dissipation	50 mW
Optical coating	Anti-reflective (1.8%)
Photosensitivity	600 mA/W







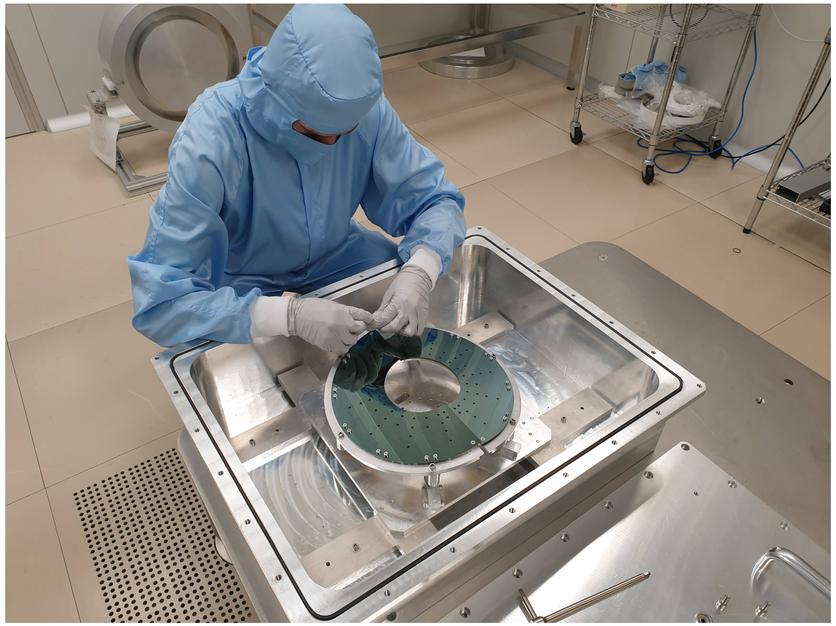
Thanks to 2-years long R&D with Hamamatsu we developed Si-based sensors
UHV compatible and with a reflectivity of about 1.2% - 1.8% reflectivity (v3 sensors)

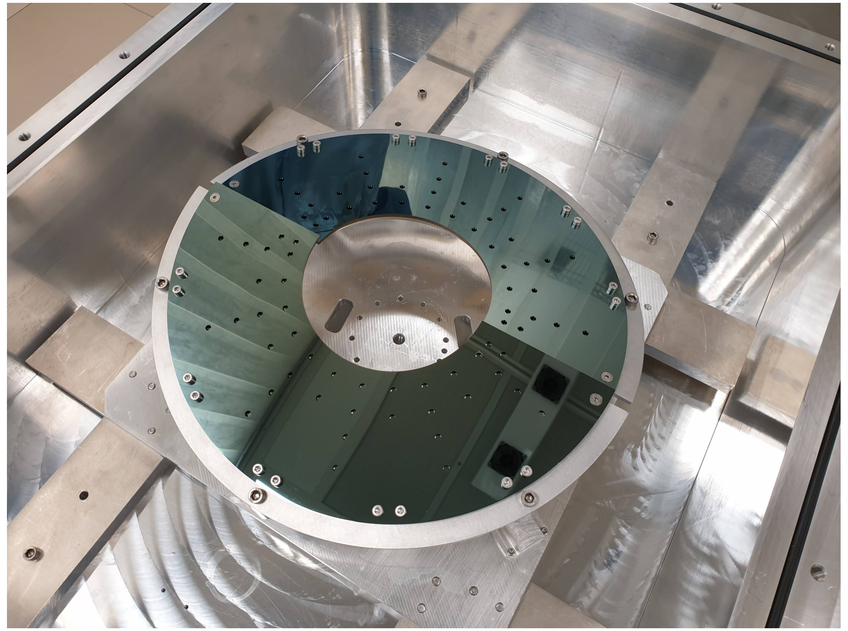
→ First attempts to reduce to < 1 % led to non-linearity and slower sensors (v4 sensors) —> could be used but we selected v3

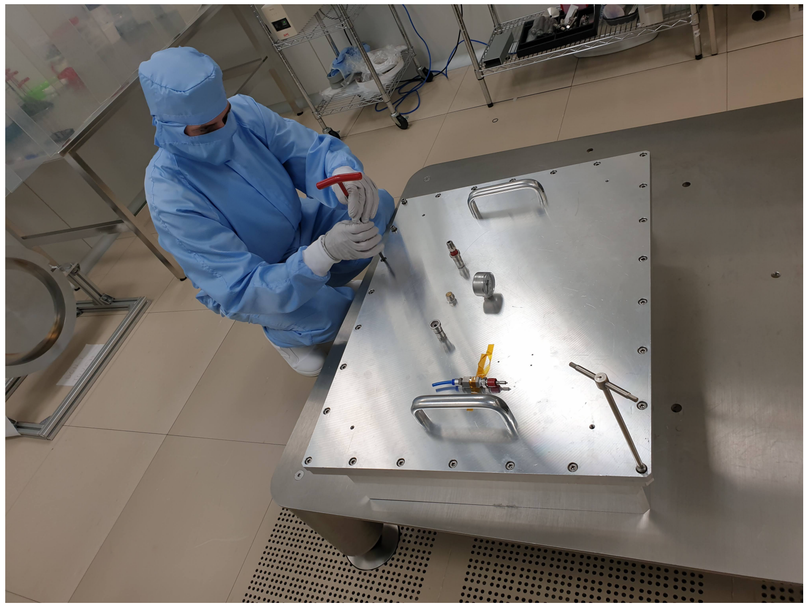
→ Attempt for v5 sensors with reduced TIS and special treatment of packaging ceramics did not converge……**for the future !!**

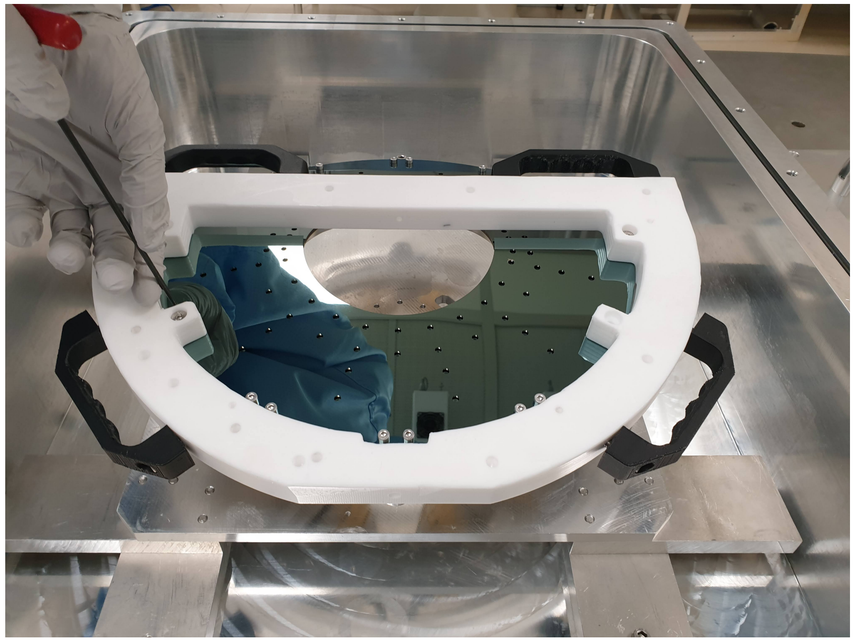
Installation @ IMC end mirror (April 2021)

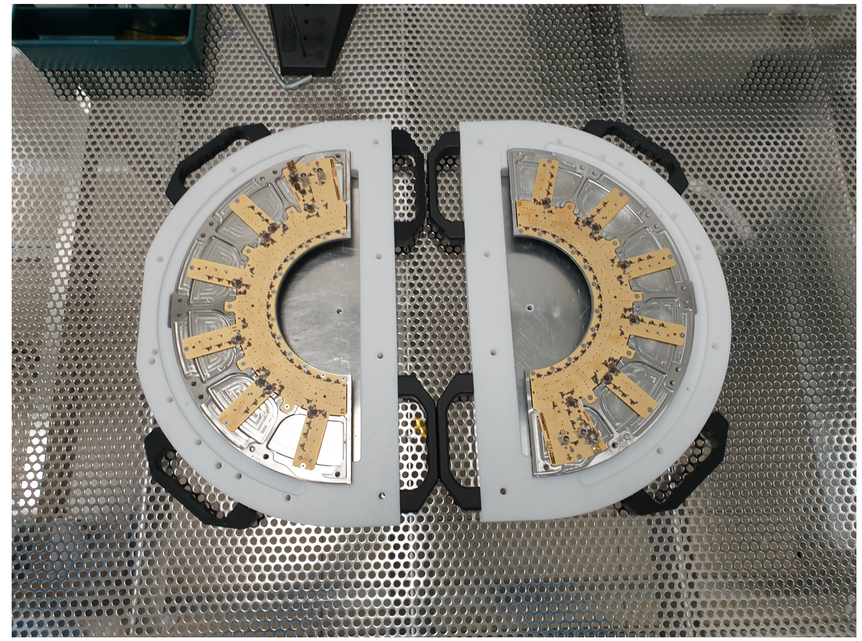








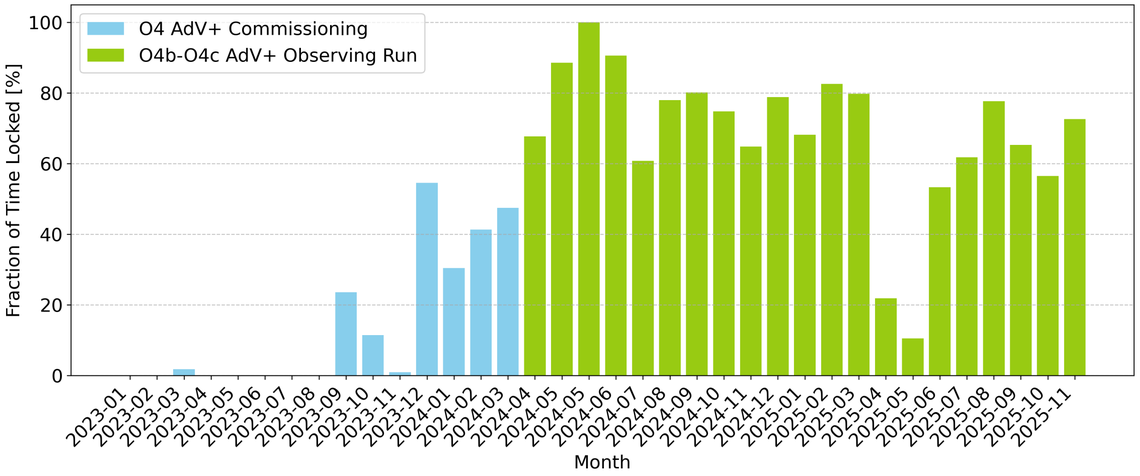


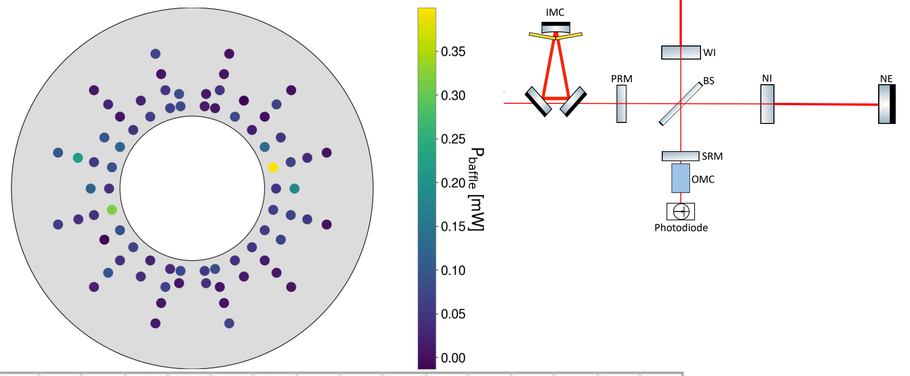


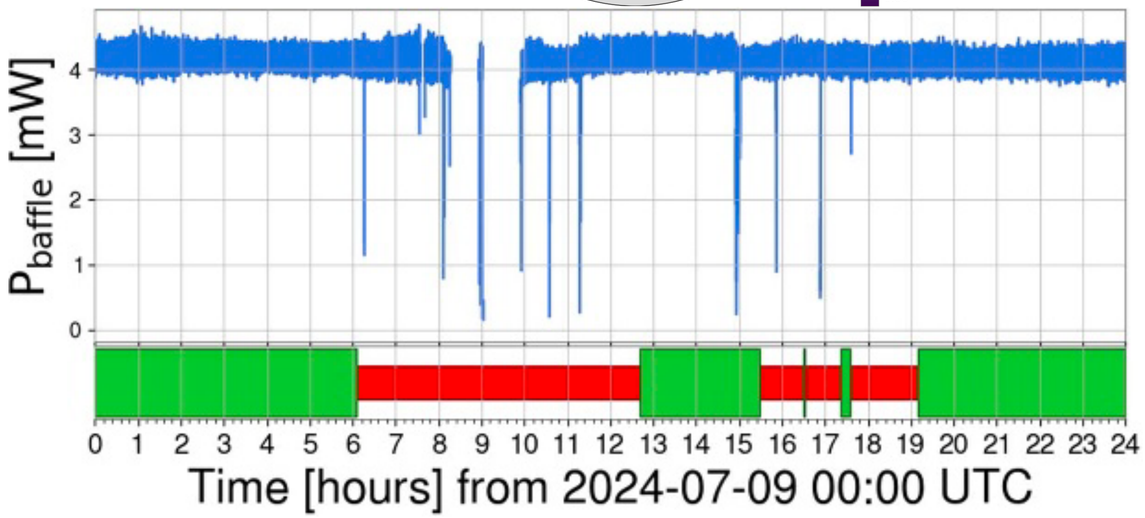
IMC long term experience

Class. Quantum Grav. 43 (2026) 215009

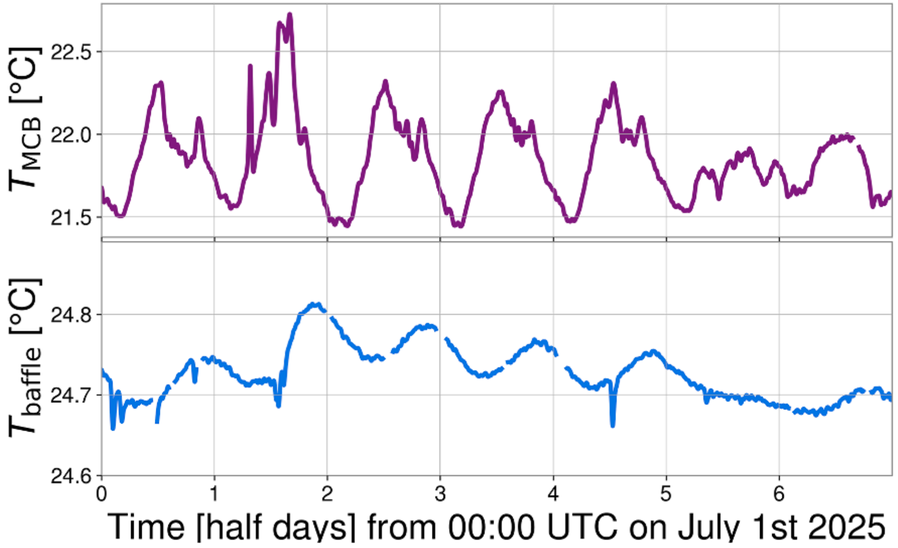
After > 5 years of continuous operations







It includes periods of commissioning with changing IMC cavity conditions as well as stable physics mode operations

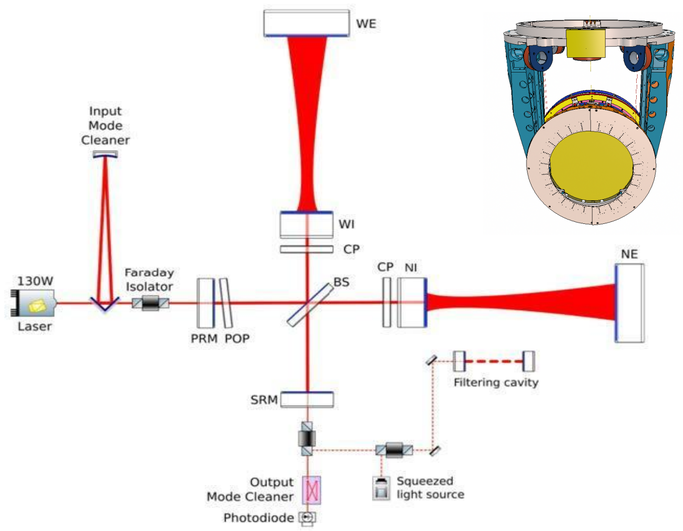


As expected baffle is very sensitive to unlocks of the cavity
Temperature of the baffle (dominated by electronics) very stable over time — no overheating

Interferometer performance parameters transparent to the presence of the baffle in the run

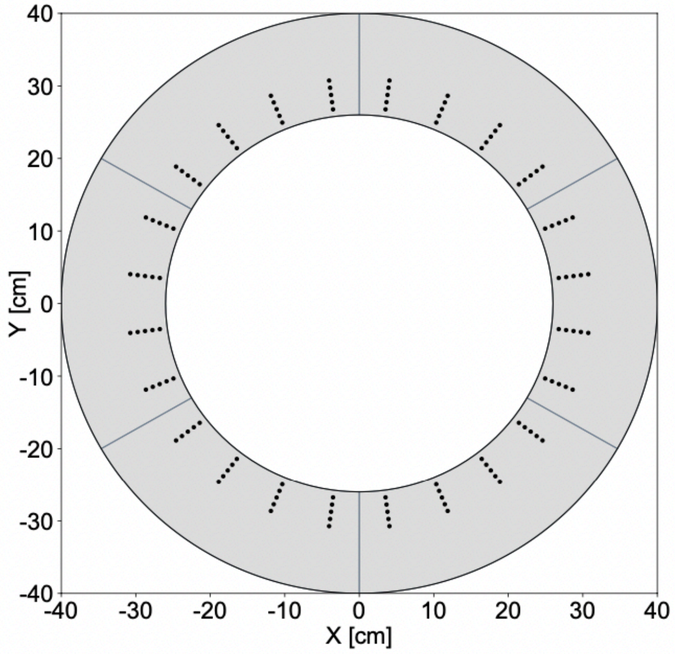
No effect in the operations of the interferometer

2G baffle simulations

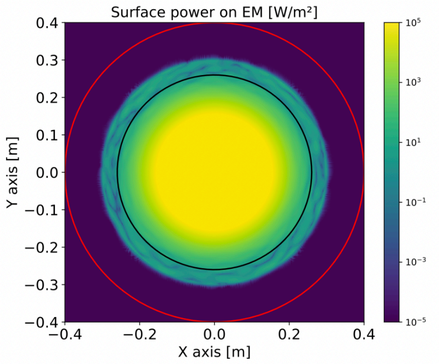


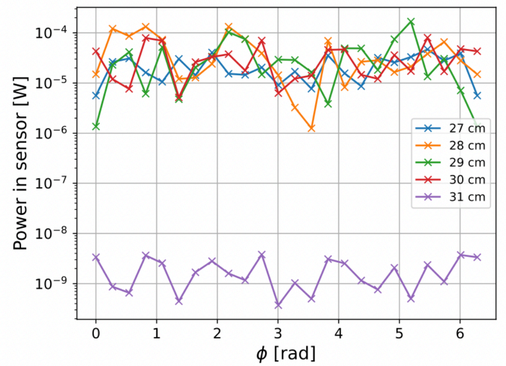
Much bigger than IMC

(35 cm → 80 cm)

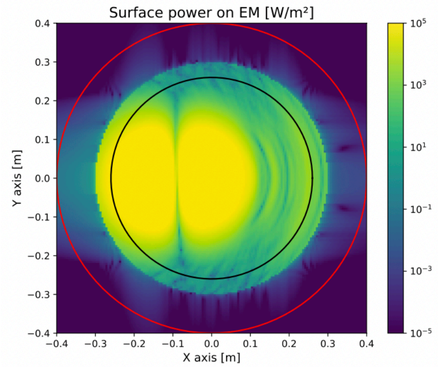


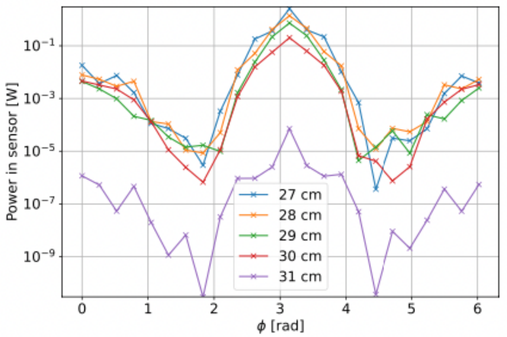
Nominal configuration



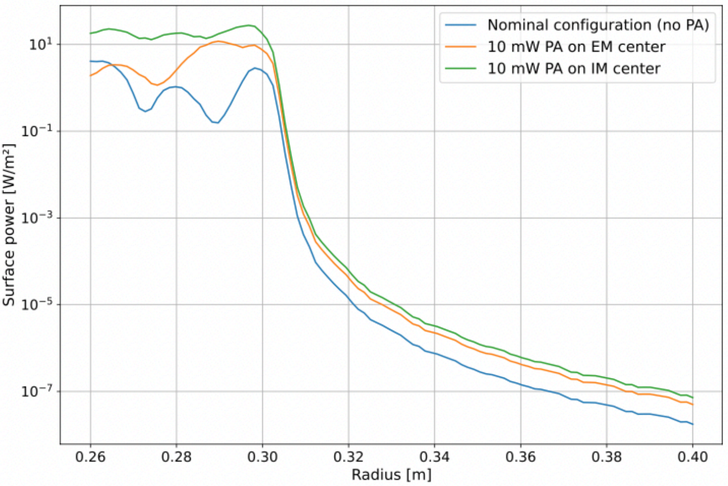


Mis-aligned configuration (0.8 micro rad)





Mirrors with point absorbers



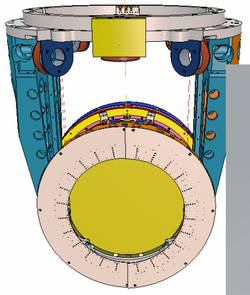
Using SIS simulations we showed the potential of instrumenting baffles

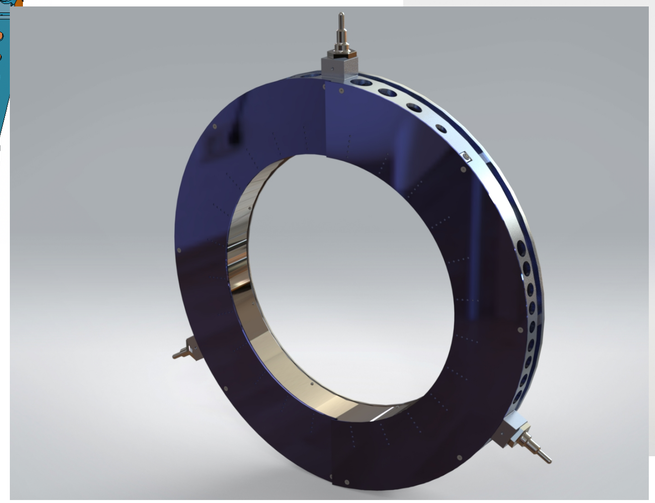
- Pre-alignment of the optical cavity
- Detection of point defects & absorbers in the mirrors
- Large sensitivity to mirror optical characteristics (scattering, surface roughness)
- **Correlation with glitches —> 1kHz readout + adapted DAQ gains / ring**

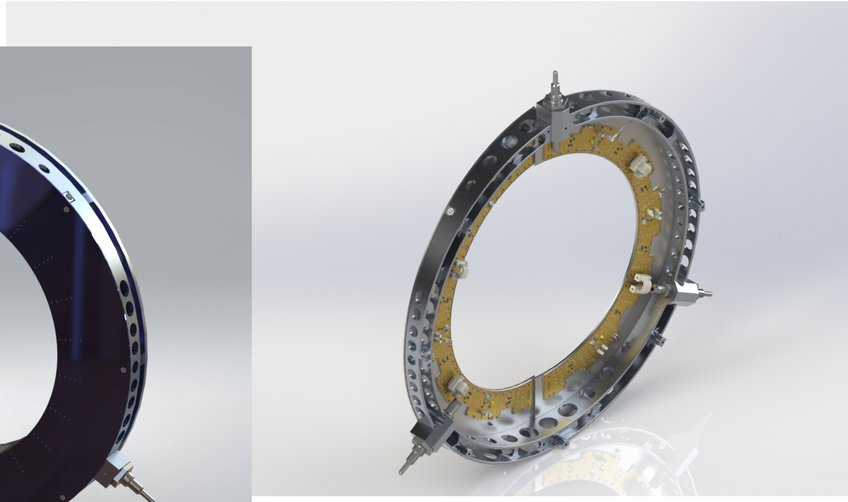
A. Macquet et al., Class. Quantum Grav. 40, 077001 (2023)

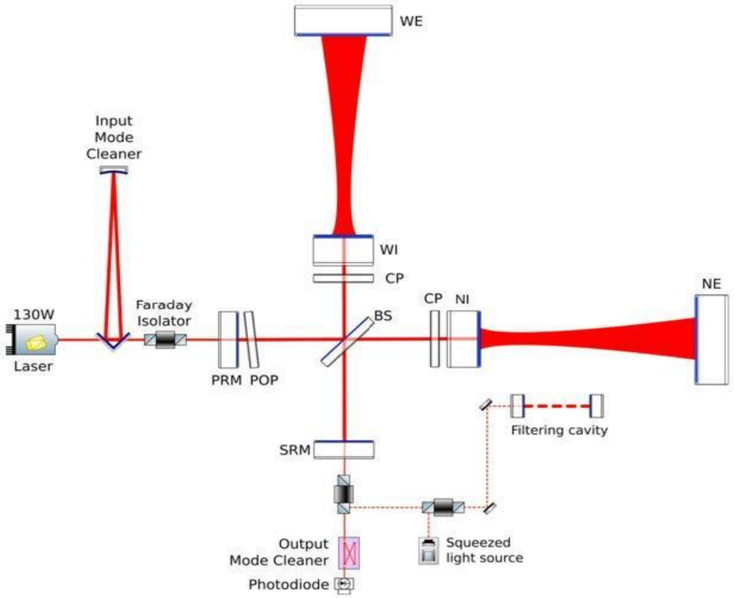
In close collaboration with H. Yamamoto (Caltech)

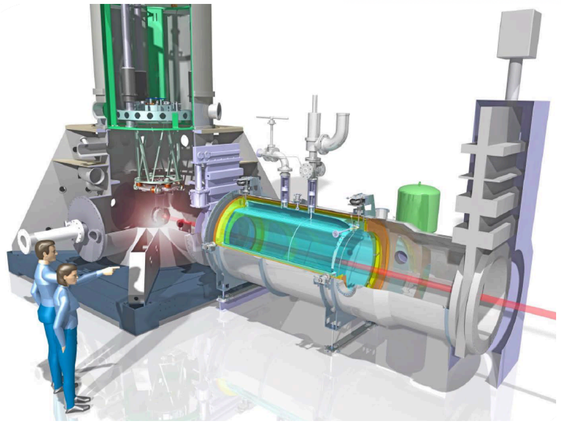
Baffles in main arms









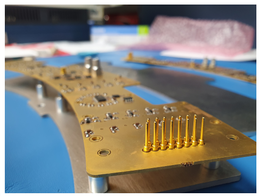


Finally installed @ entrance of ITM tower

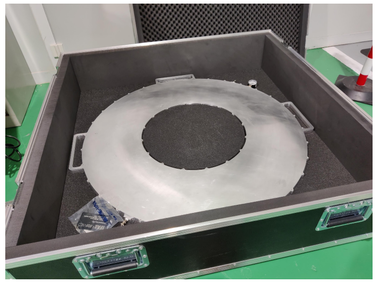
- **1.4 m away from mirror**
- **Additional coated baffle in the backside**
- **New integration mechanics inside the tube**
- **Modification of an existing baffle at entrance**

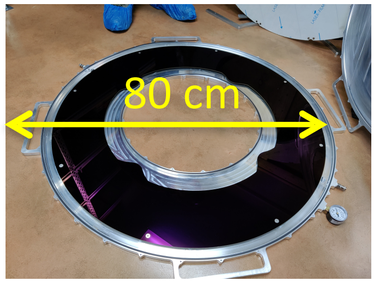
- **Same optical performance**
- **Reduced risk — farther away from the mirror**
- **Noise due to vibrations under control**

- **Originally designed and planned to be suspended around the new mirrors**
- **Large mirrors then became a post-O5 plan**
- **New instrumented baffles include**
  - 120 sensors distributed in 5 rings
  - New DAQ at 1kHz / serial + wireless readout
  - Further Improvements on material (starting from 316L perfect #10 polished)
  - Encapsulation of the FE electronics [no line of view between FE and mirror]
  - Further steps adopted in cleaning process (in house and also in industry)
  - Non-instrumented backside baffles produced and stored in coffins with N2 @ EGO already



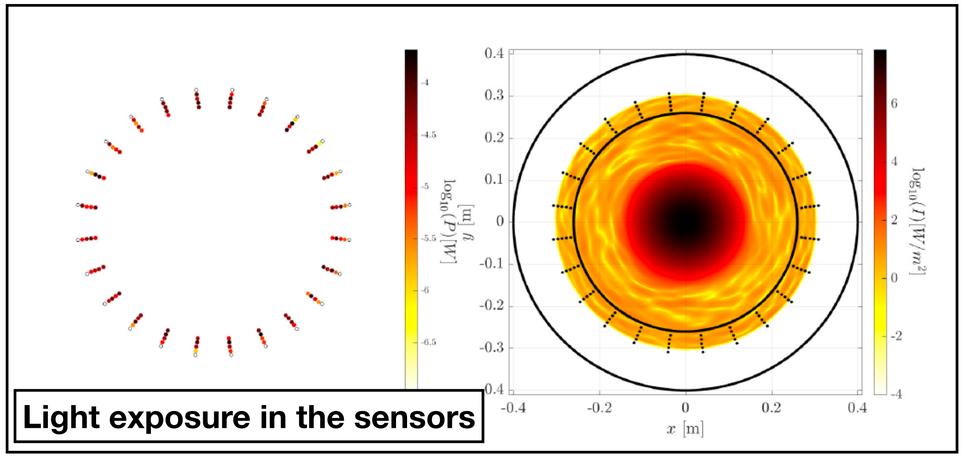






2G baffles — new simulations

M. Andres et al., Phys.Rev.D 111 (2025) 4, 042001



We performed new simulations to make sure the performance of the baffle remains untouched

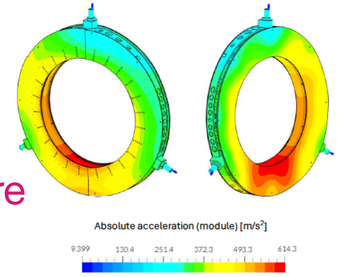
—>Triggered a change of DAQ gains in the FE electronics to further improve resolution

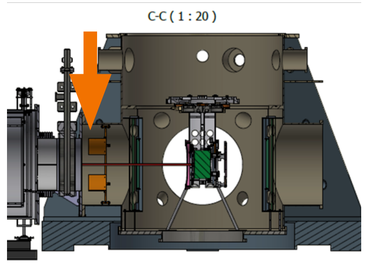
—> Triggered detailed mechanical resonance studies

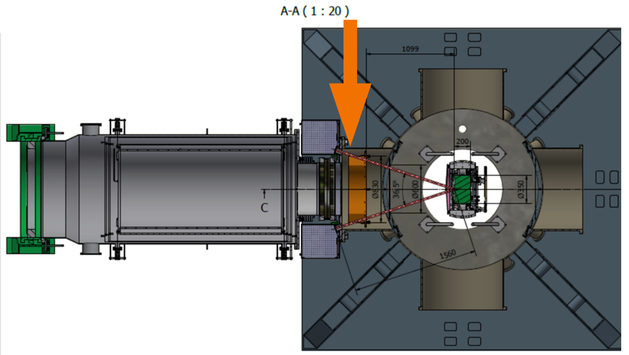
It will not introduce noise to Virgo at low frequency —Can be installed

—> Not suspended anymore in the payload

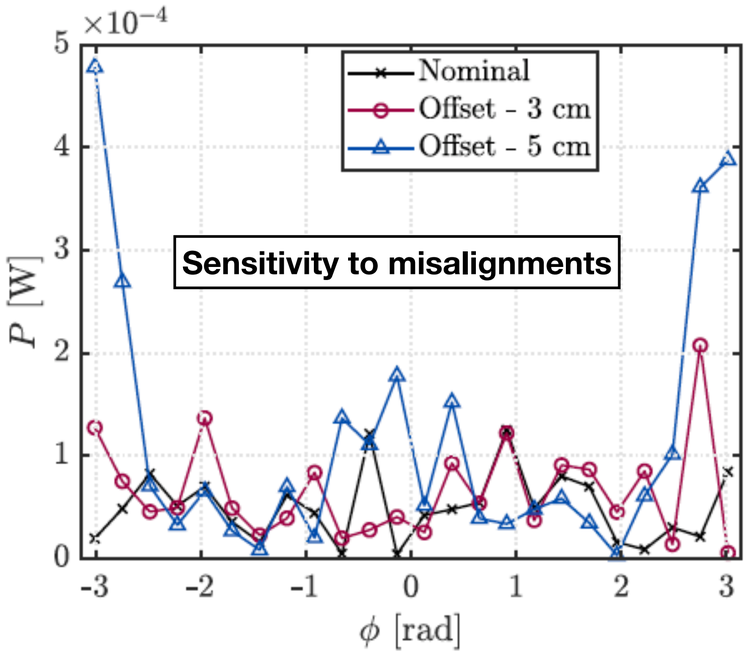
—> Vibrations require a particular attention

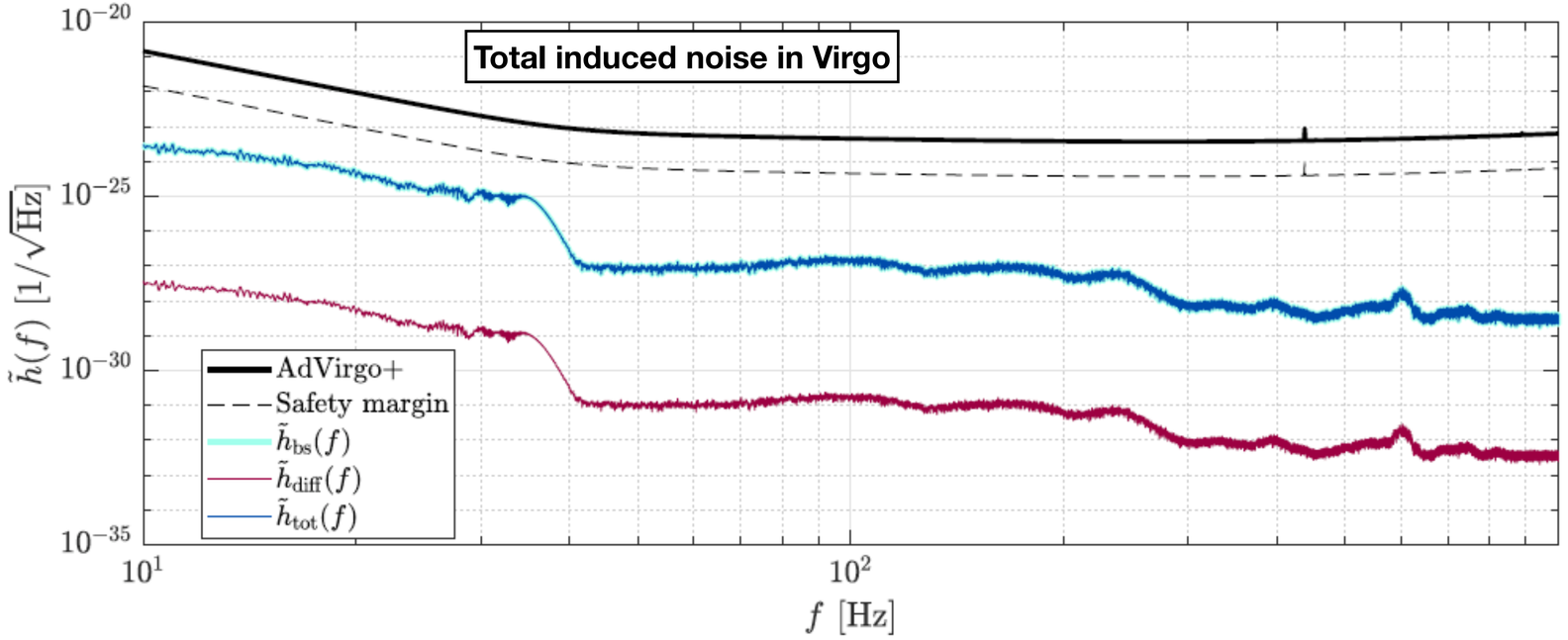




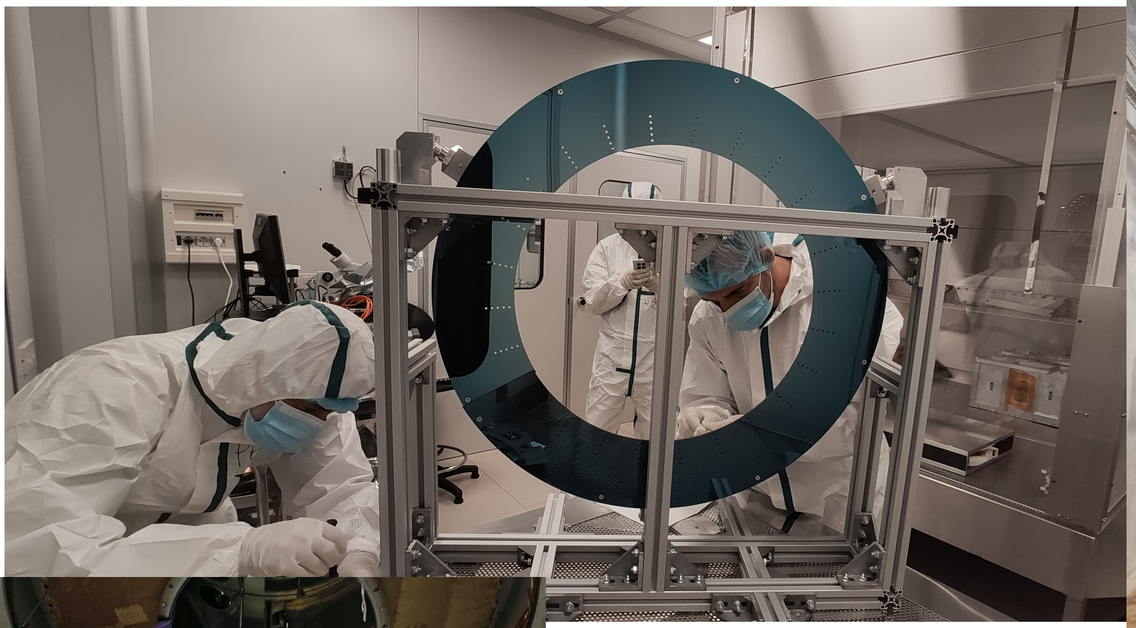


A modification of an existing baffle was implemented at the entrance of the tower (We built a new (better) one)





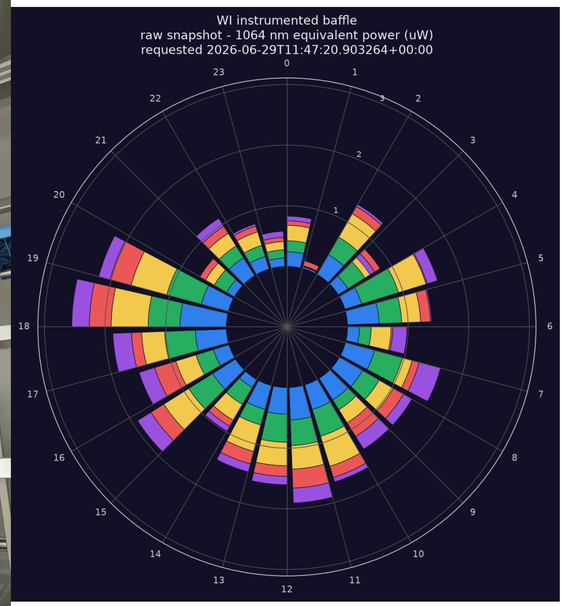
Baffle Installation (June 2026)

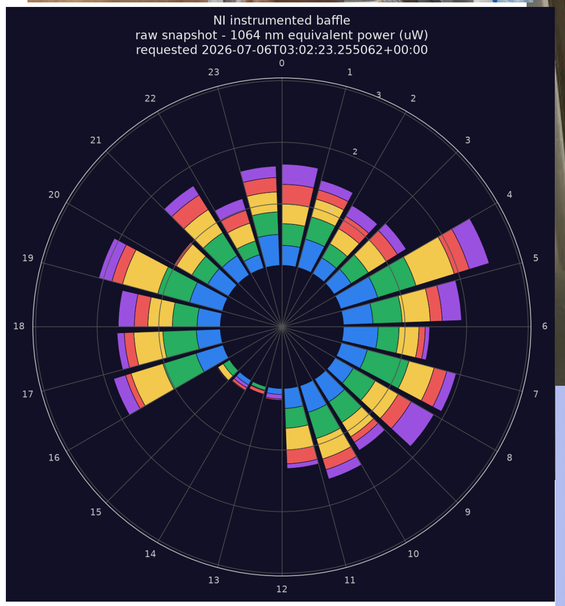




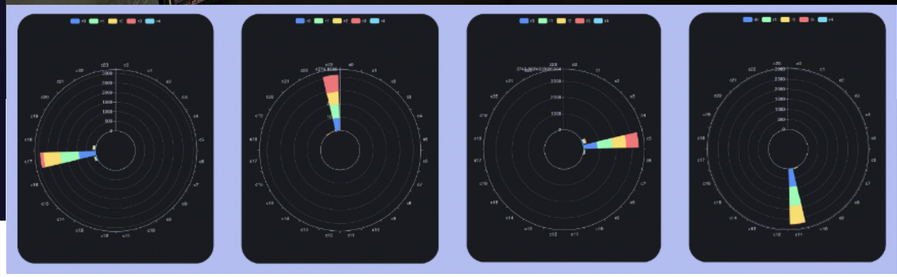








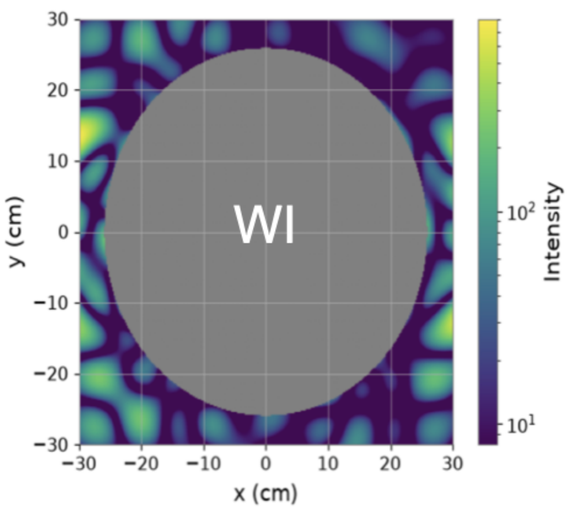
Cavity pre-alignment is straightforward

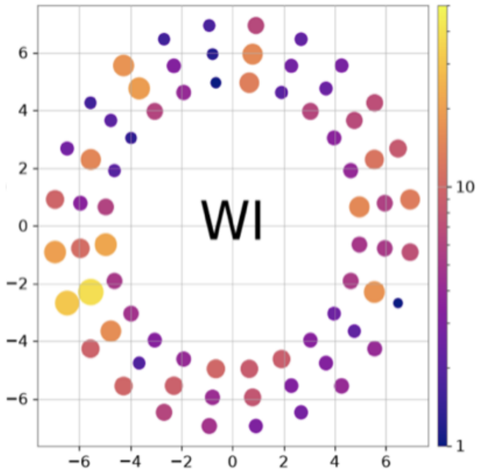


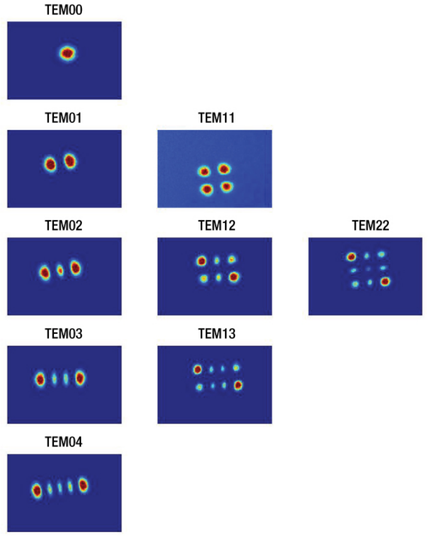
Mean Intensity (Units microWatts)

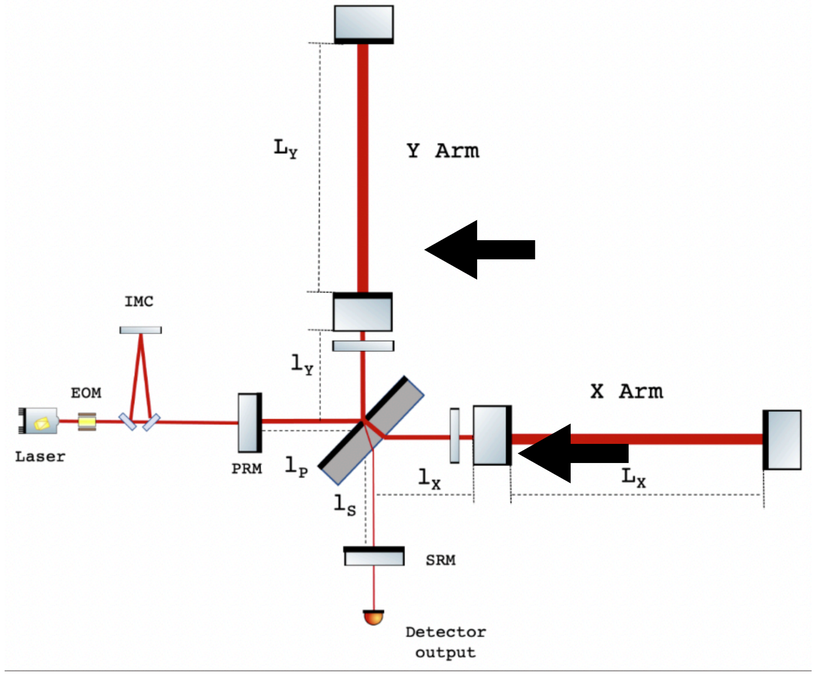
1 W/m^2 = 12.5 uW (PD opening 4 mm diameter)

(14,14) modes with c00 = 0.0001

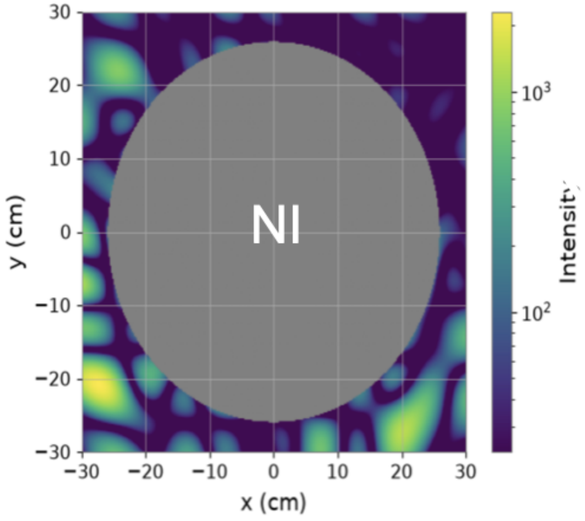


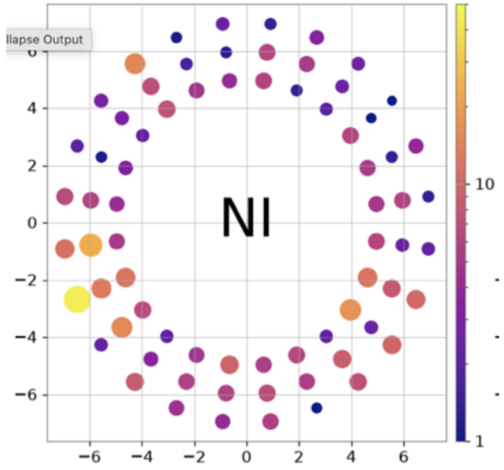






(12,12) modes with c00 = 1

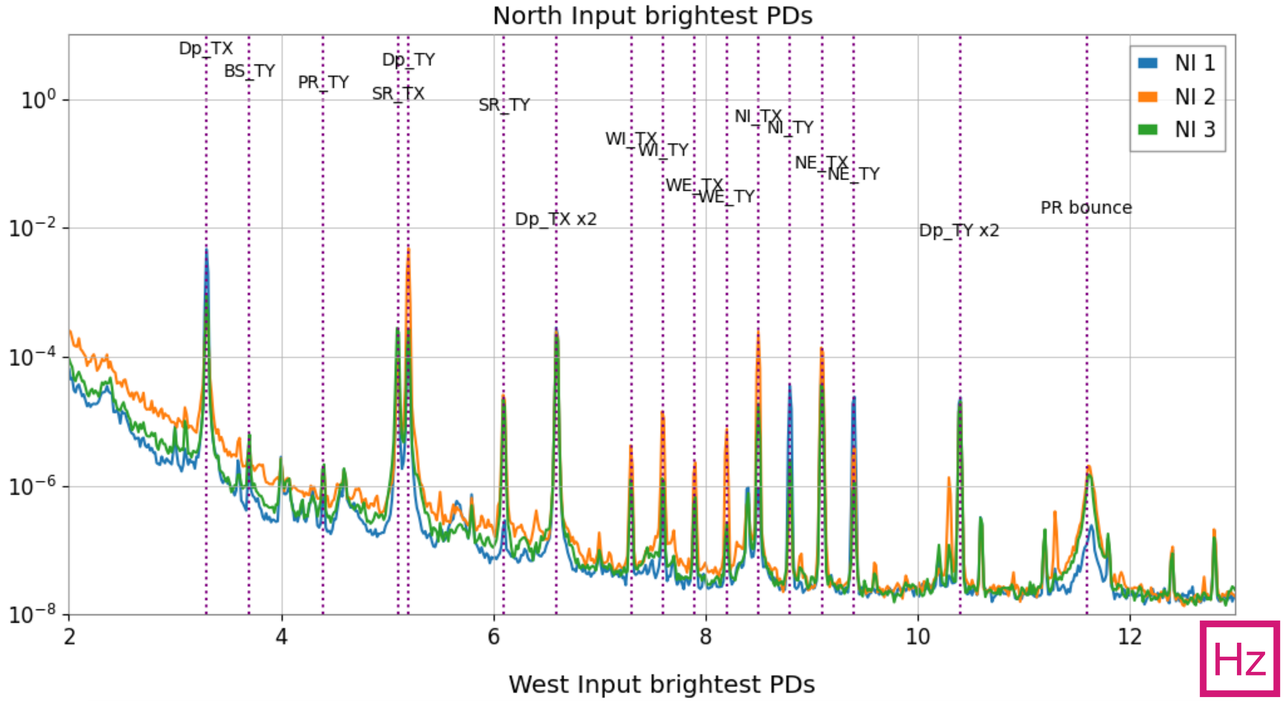


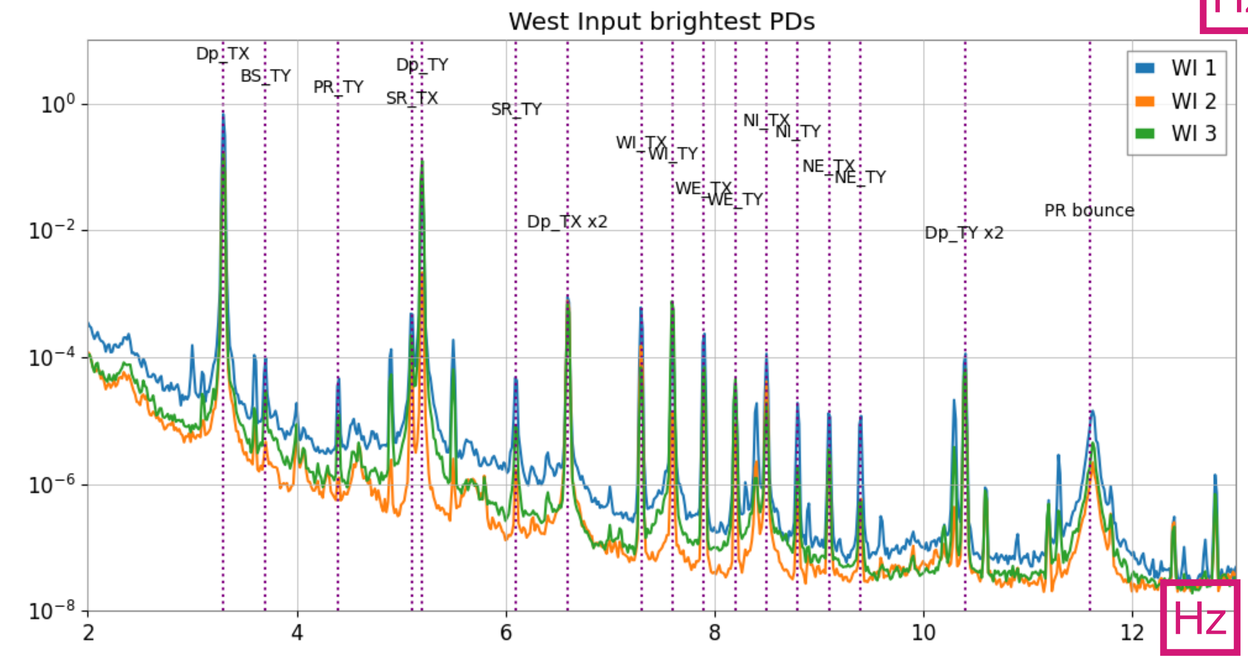


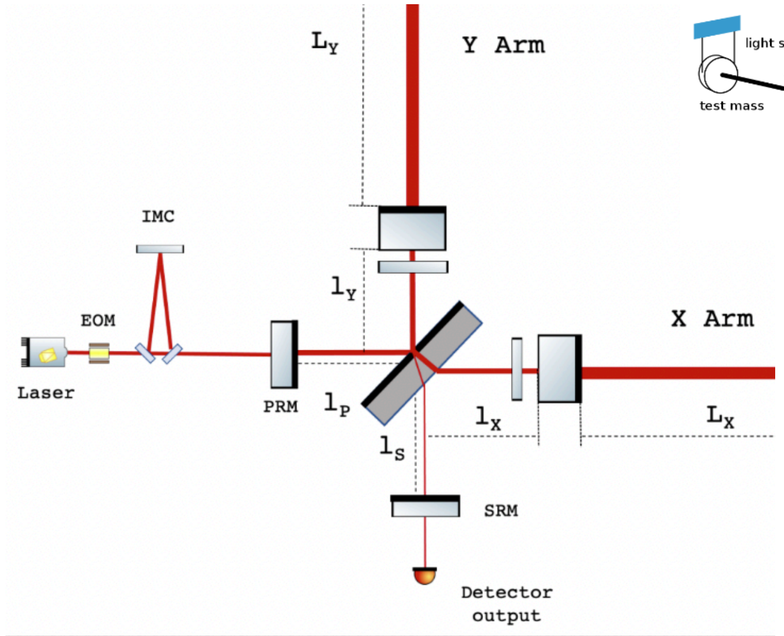
Baffles can identify
HOMs resonating in the cavity

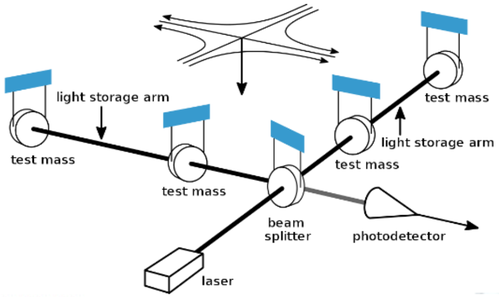
—> They appear if the FP cavity is not well aligned
—> They appear if there are distortions in the mirrors

Baffle Witnesses Nearly All Angular Dithers







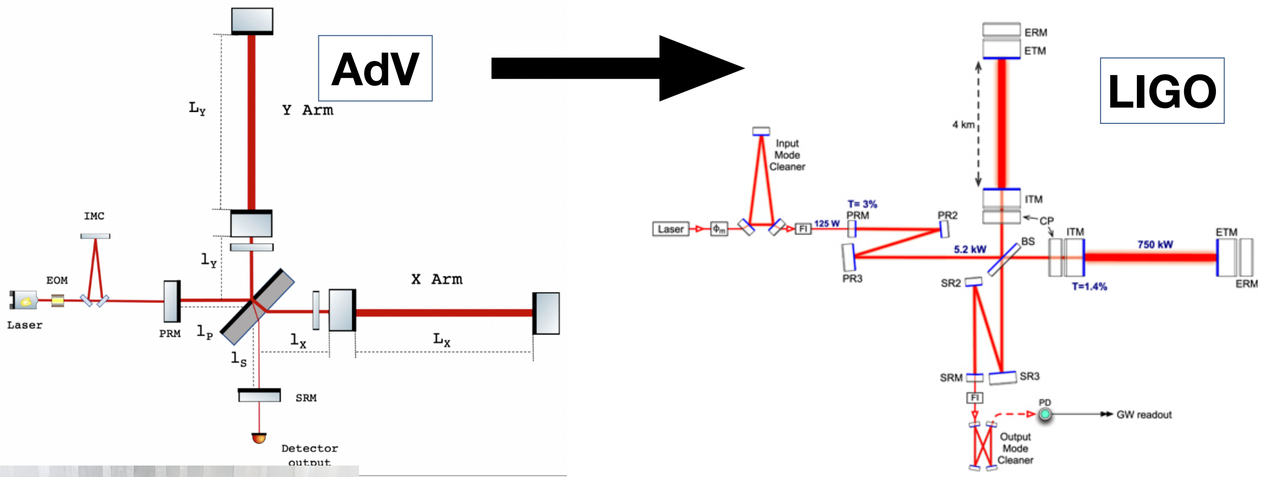


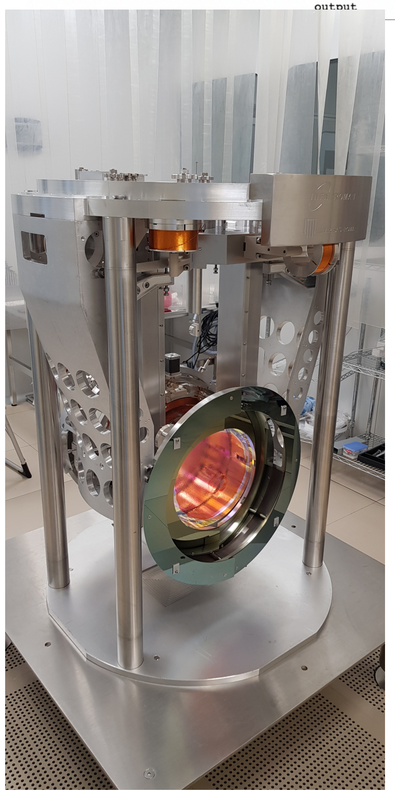
Running at 1kHz we can see photons affected by variations in the different suspension systems with well identified violin resonances

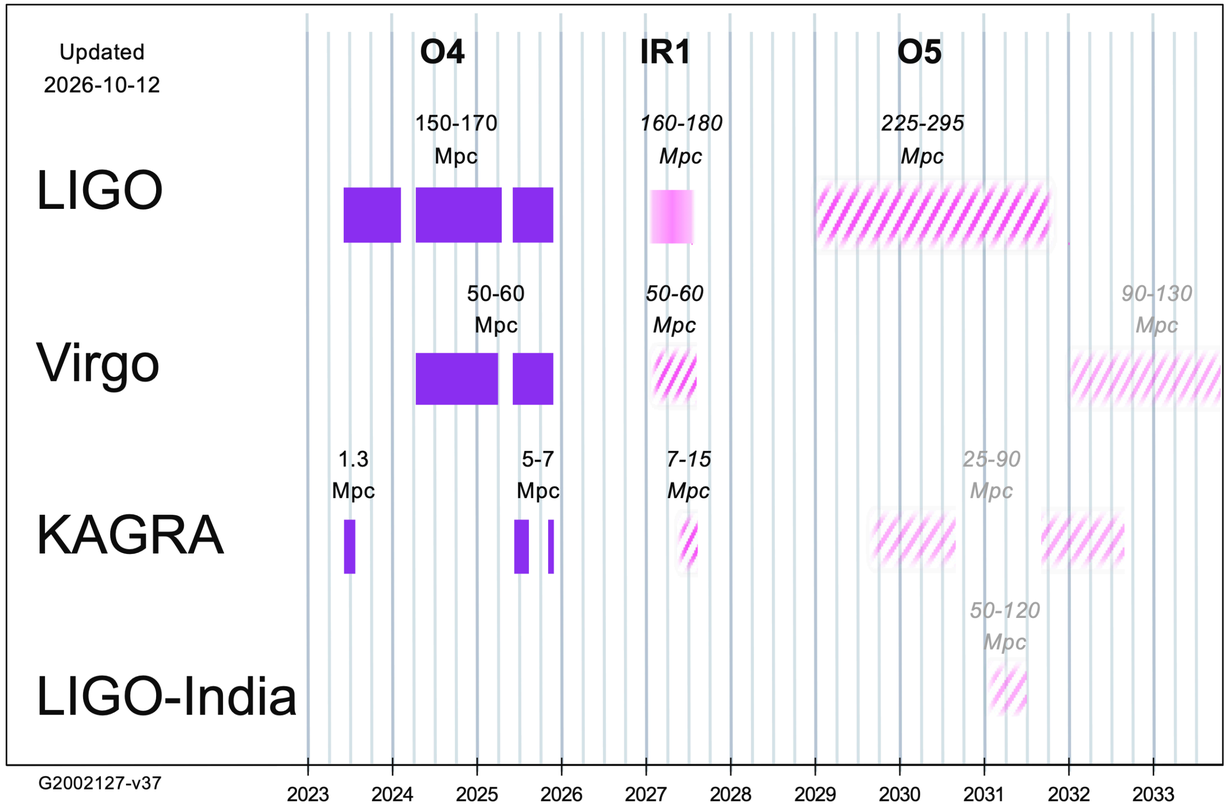
Plans

- Determine spatial distribution at each dither frequency
- Track evolution of dither couplings over time; there are minute-scale variations
- Track stability of light distribution across locks (features seem very stable)
- Use PCA to find which features evolve together
- Decompose into HG, LG, or other modal basis

New Prospects (preparing for ET)



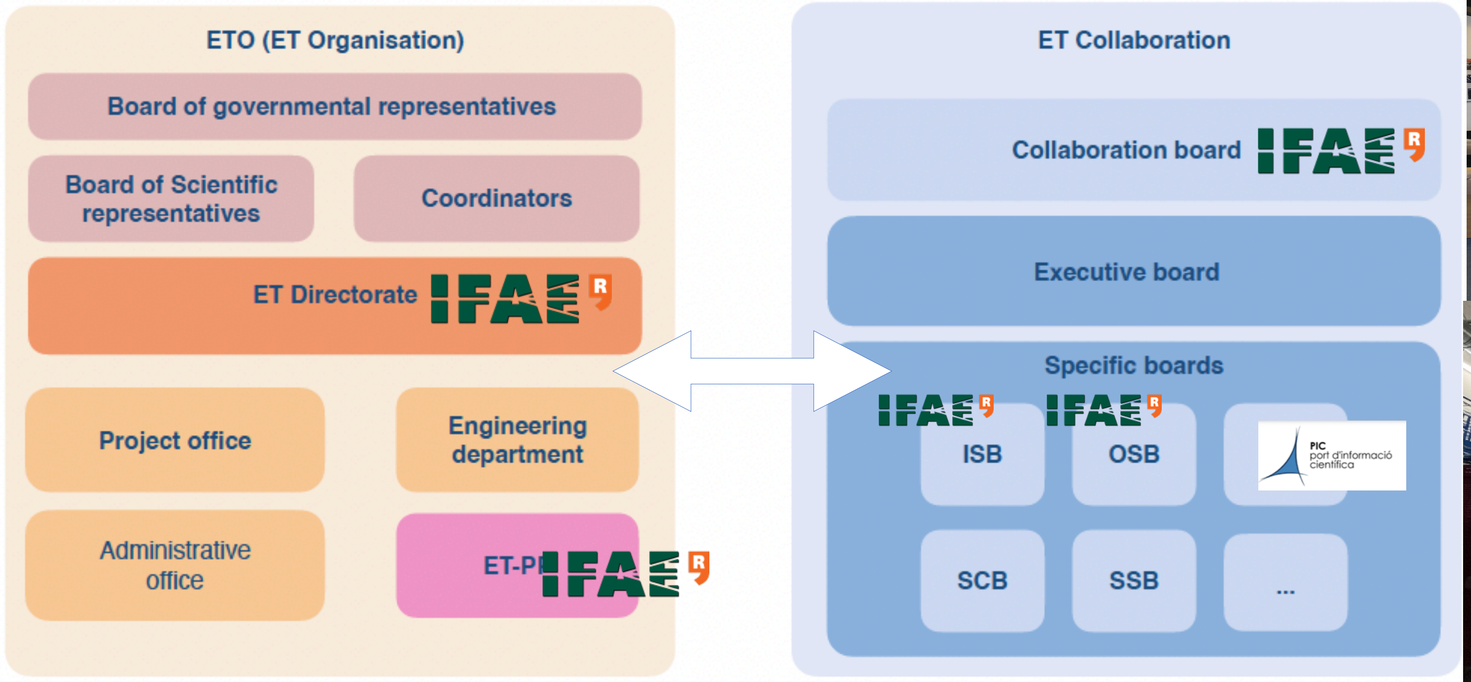




IR1 Operations of the instrumented baffles will consolidate the technology
—> Already adopted in the baseline design of both ET and CE
—> Still aiming to export the technology in time for A#
—> AI tools in the analysis of the LVK data / correlations with other detector channels

IFAE will now extent its competences towards payloads and suspensions
—> IFAE committed now to construct two large payloads for Virgo
—> Mechanics, opto-mechanics, control loops

IFAE @ ET Organization



IFAE is central in ET Governance

- Part of ETO Directorate and Coordinator of ET-PP EU project
- Chair of the ET Collaboration board (until end 2025)
- Convener of Virgo - SLC WG
- Co-convener of ET-SLC WG (until 2021 — fall 2025)
- Co-chair of the IGWN design committee

IFAE is member of the ETO funders group & ET-COMPASS

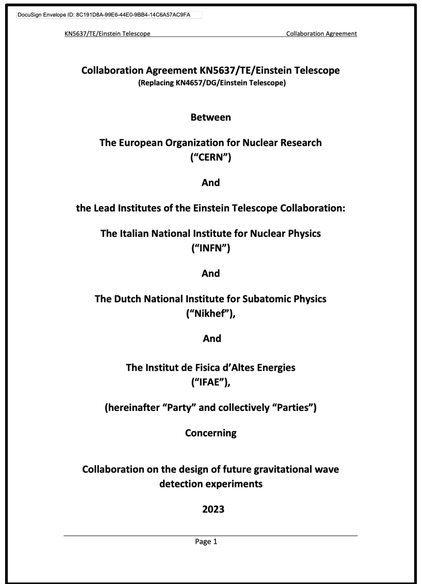
IFAE — CERN MoUs on Vacuum and Civil Engineering work










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KN5637/TE/Einstein Telescope Collaboration Agreement

Collaboration Agreement KN5637/TE/Einstein Telescope
(Replacing KN4657/DG/Einstein Telescope)

Between

The European Organization for Nuclear Research
("CERN")

And

the Lead Institutes of the Einstein Telescope Collaboration:

The Italian National Institute for Nuclear Physics
("INFN")

And

The Dutch National Institute for Subatomic Physics
("Nikhef"),

And

The Institut de Fisica d'Altes Energies
("IFAE"),

(hereinafter "Party" and collectively "Parties")

Concerning

Collaboration on the design of future gravitational wave detection experiments

2023

Page 1





Einstein Telescope as ESFRI

European Commission | Funding & tender opportunities
Single Electronic Data Interchange Area (SEDIA)

SEARCH FUNDING & TENDERS | HOW TO PARTICIPATE | PROJECTS & RESULTS | WORK AS AN EXPERT

Preparatory phase of new ESFRI research infrastructure projects

TOPIC ID: HORIZON-INFRA-2021-DEV-02-01

Grant

General | Topic de | Destinati | Conditio | Partner s | Submiss | Topic rel | Get supp

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Type of I... HORIZO... Based [H...

Deadline... 20 Janua...

single-stage | 30 September 2021

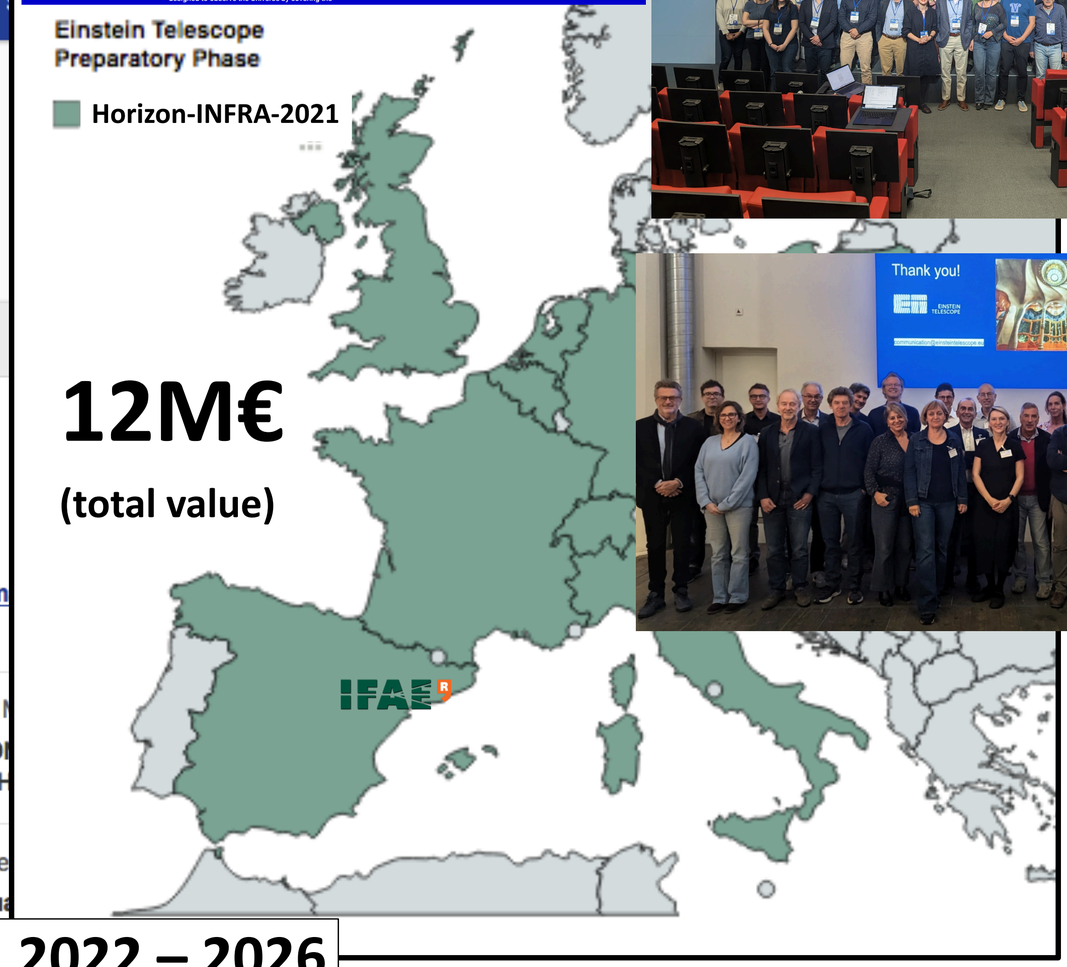
Goals for ET Preparatory Phase

- Governance
- Financial architecture/plan/framework
- Industrial Returns and KTT
- ET legal entity
- Final ET design and cost evaluation
- Site or sites selection
- Construction funding
- User services
- Computing model
- Sustainability

3.45M€











Einstein Telescope Preparatory Phase (ET-PP) in 2022 – 2026
HORIZON-INFRA-DEV EU Project coordinated by IFAE

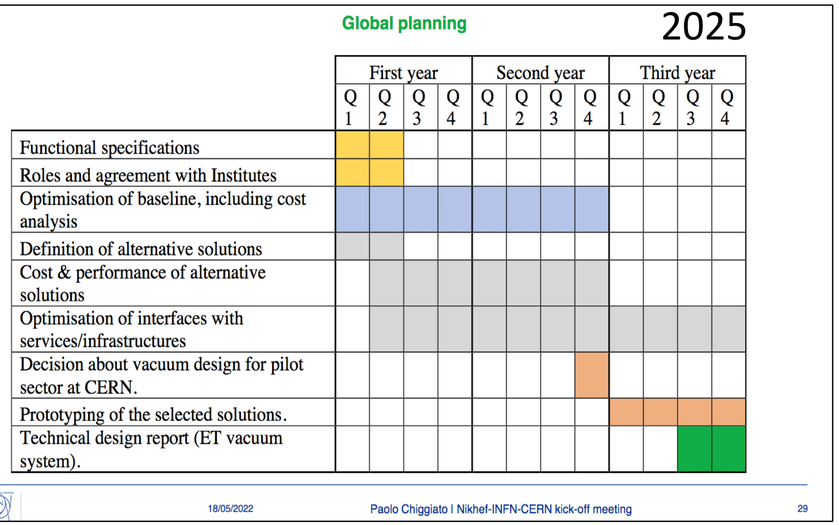
→ https://etpp.ifae.es —> 25 days more + closeout

This is an intense activity with large international visibility
— **5th annual meeting in BCN this week**

ET & CE vacuum pipe design

MoU signed with CERN

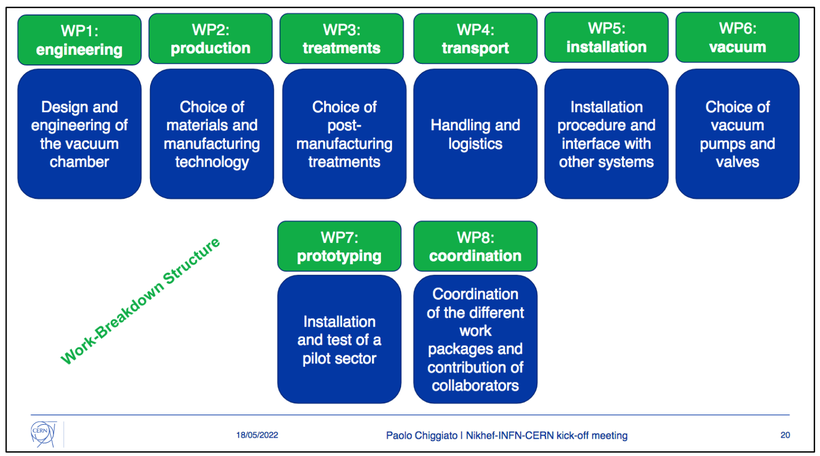
IFAE strategically placed in areas with huge industrial returns close contacts with Ministry and CDTI

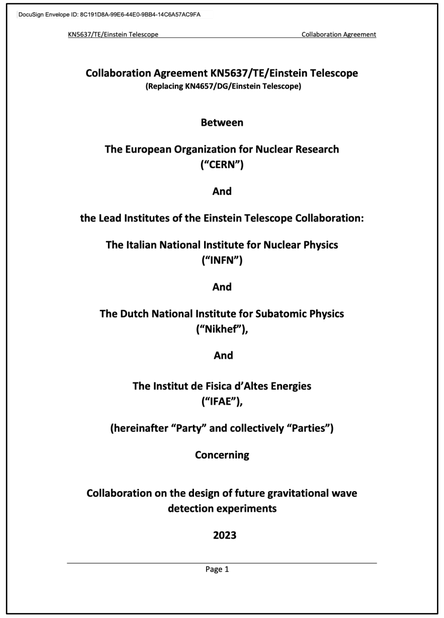


Global planning 2025

	First year				Second year				Third year			
	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4
Functional specifications												
Roles and agreement with Institutes												
Optimisation of baseline, including cost analysis												
Definition of alternative solutions												
Cost & performance of alternative solutions												
Optimisation of interfaces with services/infrastructures												
Decision about vacuum design for pilot sector at CERN.												
Prototyping of the selected solutions.												
Technical design report (ET vacuum system).												

18/05/2022 Paolo Chiggiato I Nikhef-INFN-CERN kick-off meeting 29





DocuSign Envelope ID: 8C191D8A-99E6-44E0-9BB4-14C6A57AC9FA

KN5637/TE/Einstein Telescope Collaboration Agreement

Collaboration Agreement KN5637/TE/Einstein Telescope
(Replacing KN4657/DG/Einstein Telescope)

Between

The European Organization for Nuclear Research ("CERN")

And

the Lead Institutes of the Einstein Telescope Collaboration:

The Italian National Institute for Nuclear Physics ("INFN")

And

The Dutch National Institute for Subatomic Physics ("Nikhef"),

And

The Institut de Fisica d'Altes Energies ("IFAE"),

(hereinafter "Party" and collectively "Parties")

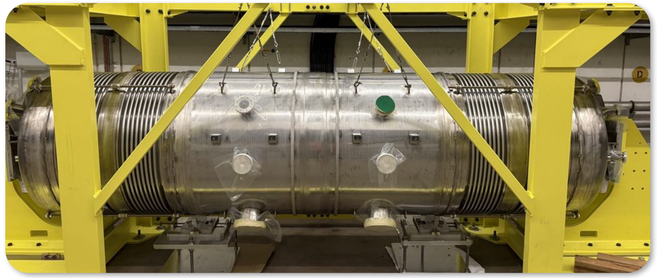
Concerning

Collaboration on the design of future gravitational wave detection experiments

2023

Page 1





Led by CERN :

design of ET vacuum pipe (1/3 ET core cost)

—> Prototypes 40 m long + UHV tests

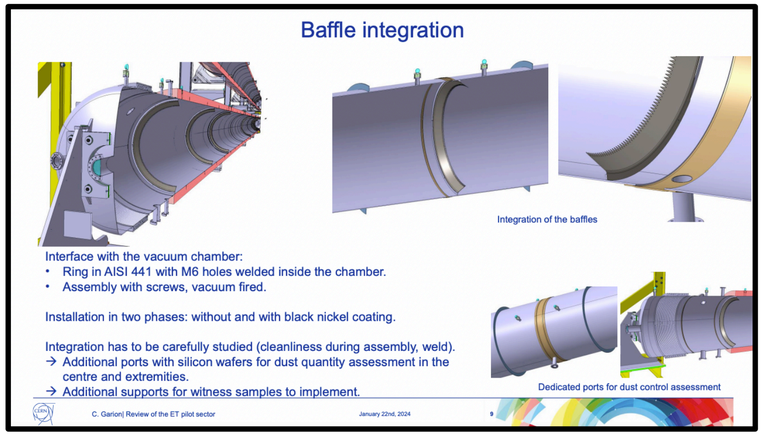
—> TDR by 2025 as main deliverable

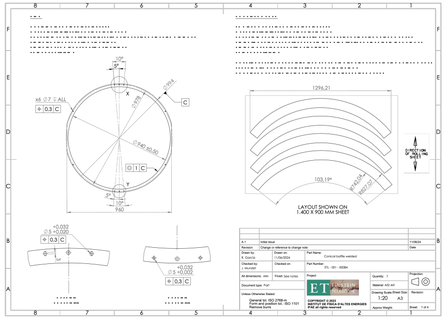
—> [extending action to 2027]

—> IFAE running stray light simulations

—> IFAE in-kind contribution - O(14) baffles (w/wo special optical coatings)

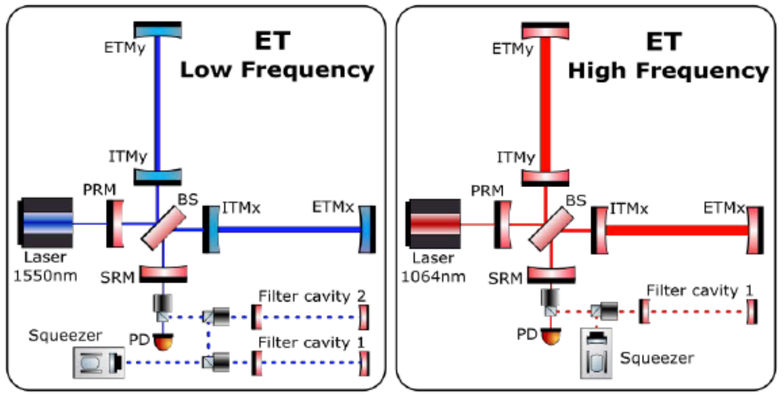
—> Synergy with LIGO and Cosmic Explorer

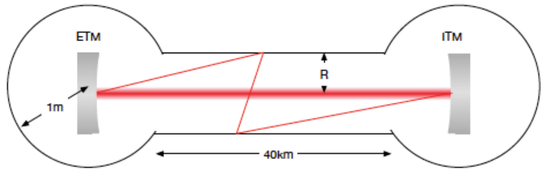


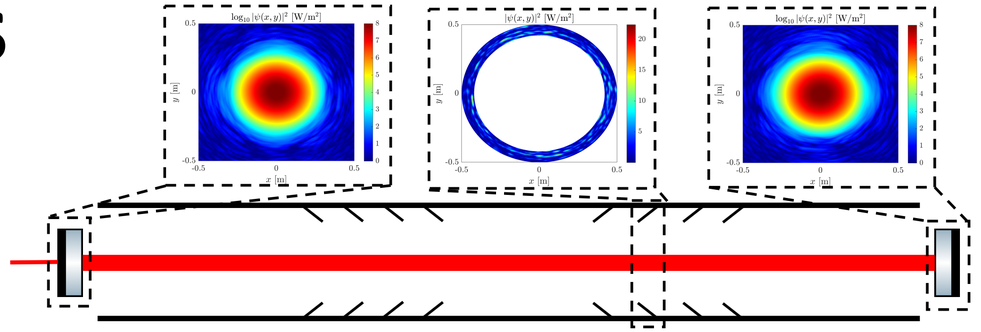


First 7 baffles already arrived to CERN

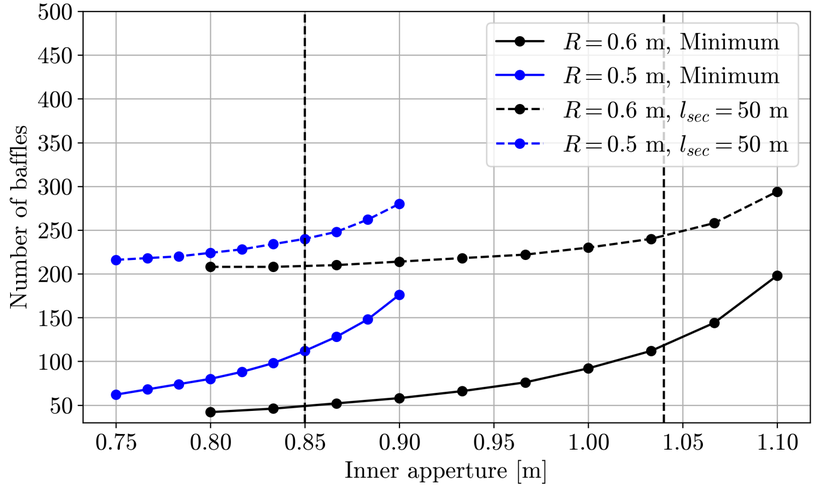
ET stray light simulations







IFO	λ	mode	mirror ⌀	R_C	w_0	z_0	w	$g-$factor
ET-HF	1064 nm	TEM_{00}	62 cm	5070 m	1.42 cm	5000 m	12.0 cm	0.95
ET-LF	1550 nm	TEM_{00}	45 cm	5580 m	2.9 cm	5000 m	9.0 cm	0.63



Detailed simulations of the light propagation in the optical cavities

—> Crucial input to determine tune diameter [huge impact on cost]

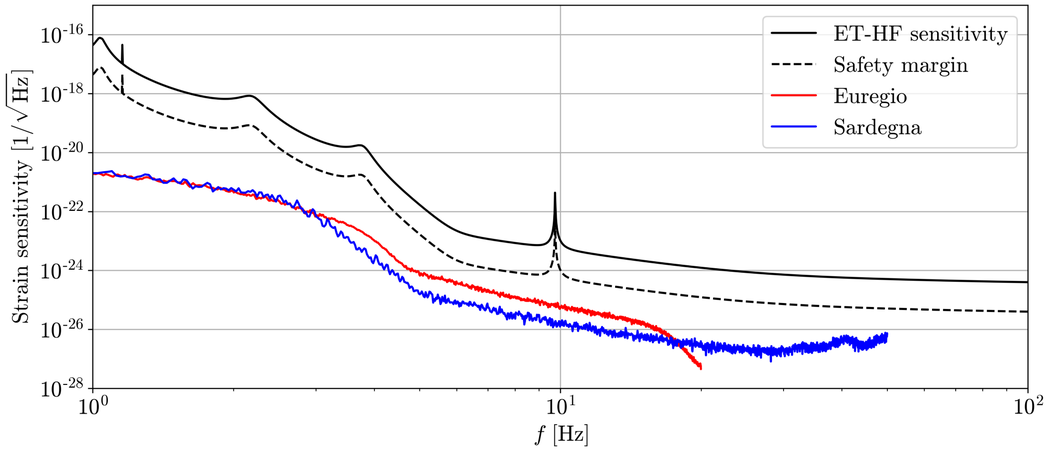
—> Determines the mitigation strategy for reducing stray light noise

—> Determines the baffle requirements (dimensions and optical specs)

—> Determines the distribution of baffles in the 10km and 15km arms

—> Possible thanks to close relation with Caltech - LIGO since 2020

—> Running common ET/Cosmic Explorer meetings on Stray Light Control



IFAE recognised now as the reference inside ET for these aspects

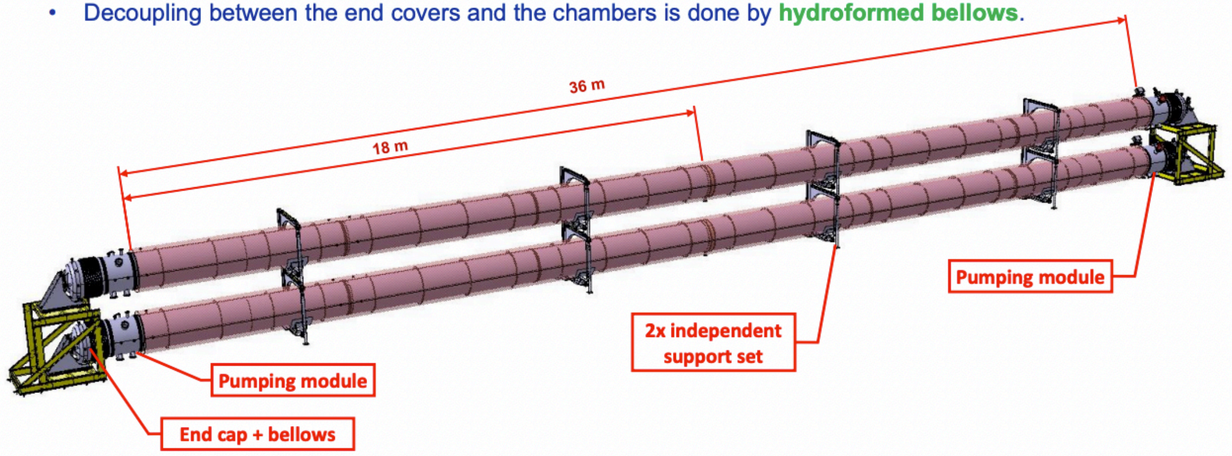
M. Andrés-Carcasona et al., Phys. Rev. D 108, 102001 (2023)

Feedback to suspension vs stray light

Resulted into a modified suspension for the ET vacuum tubes

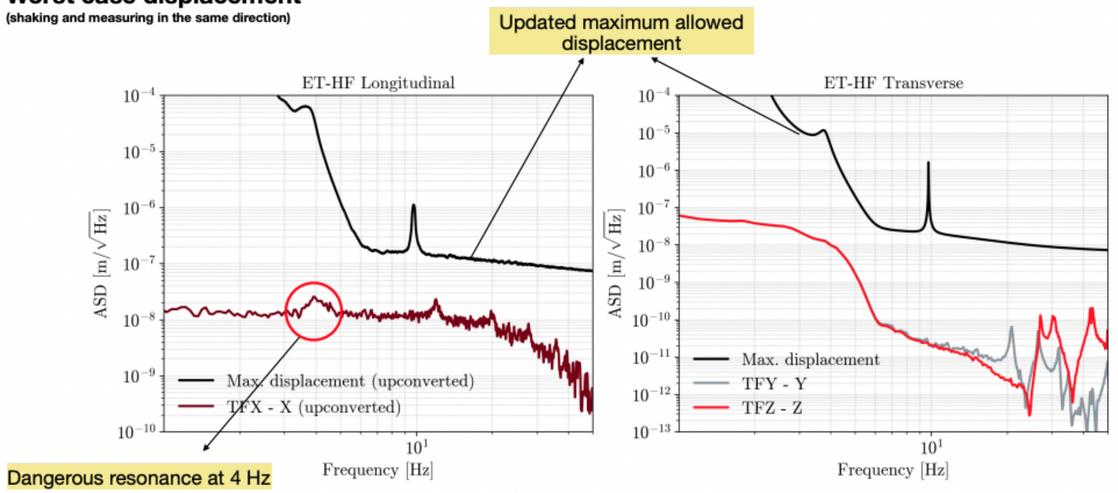
Mechanical layout of the ET pilot sector at CERN

- **Two independent vacuum chambers** of around 18m will be transported and installed individually.
- Each pipe is **suspended** on independent supports and can be aligned vertically and laterally.
- Each **endcap** can be aligned laterally, vertically and longitudinally.
- Decoupling between the end covers and the chambers is done by **hydroformed bellows**.

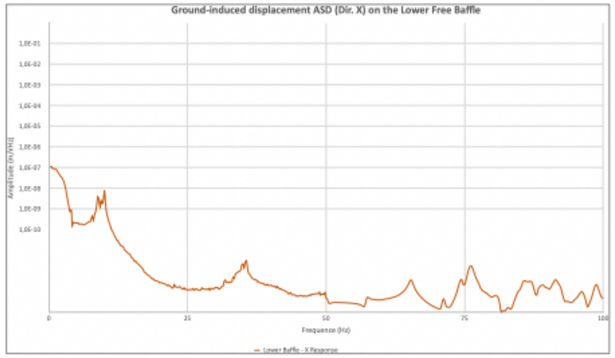


Top Tube ET-HF Updated ASD Curves

Worst case displacement
(shaking and measuring in the same direction)



Dangerous resonance at 4 Hz



We received from CERN the spectra of
movement of the baffles inside the prototype

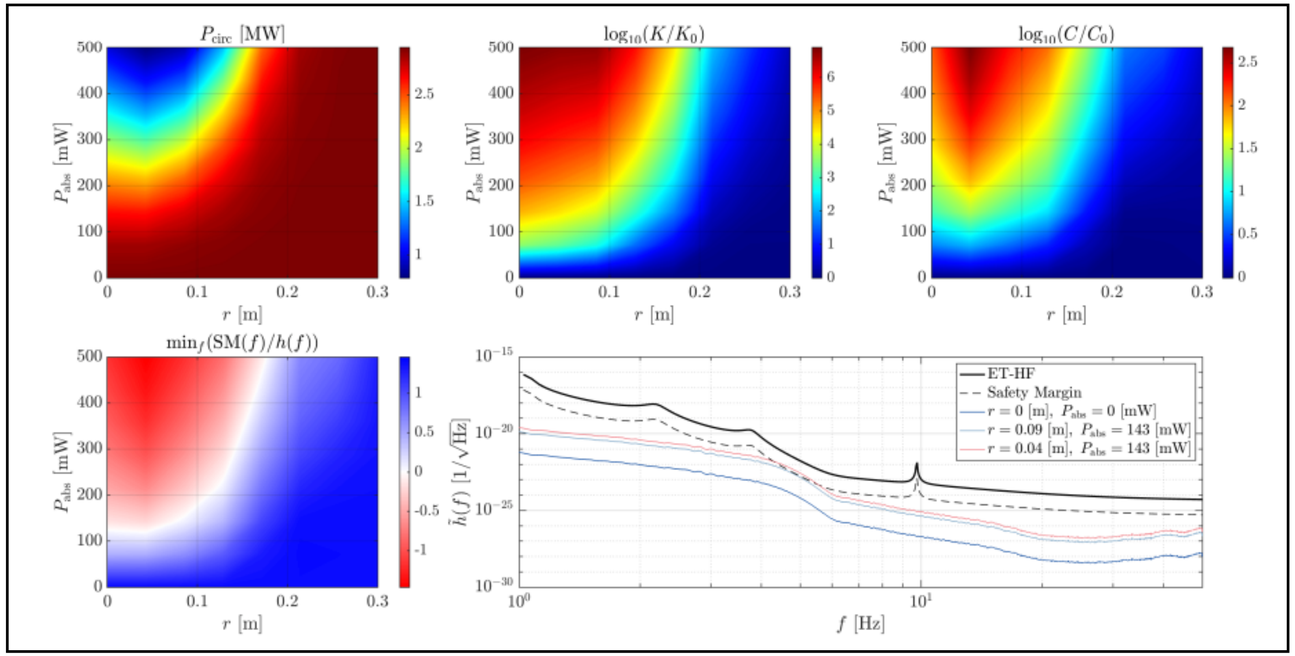
When translated into stray light noise it triggered a change
the way the tube is supported to avoid potentially dangerous resonances at low frequency

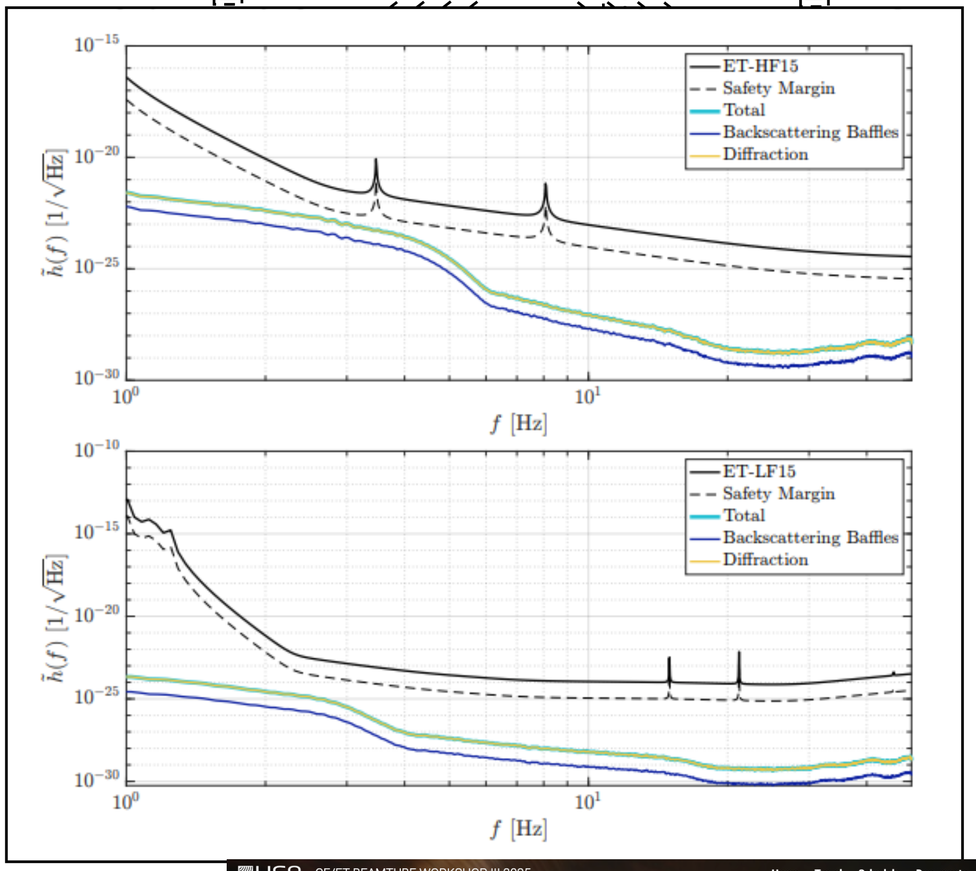
—> Direct impact on the design of the ET vacuum pipe design

New results with improved modelling

Andrés-Carcasona et al 2025 Class. Quantum Grav. 42 215021

- Revisited studies using improved simulations
- Considering both 10 km and 15 km arm length
- Effect of mis-alignments and mirror defects on performance





Existing collaboration with CERN and Cosmic Explorer on the design of the ET and CE vacuum tube — dictated by stray light

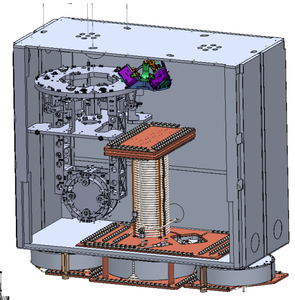
Co-charing the Stray Light WG in the incoming workshop in USA

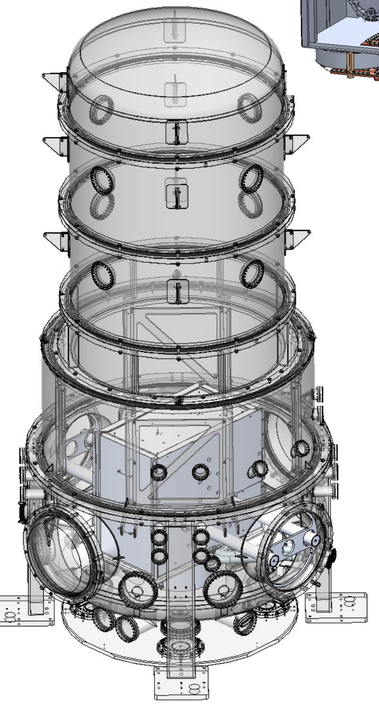


ETpathfinder(s)

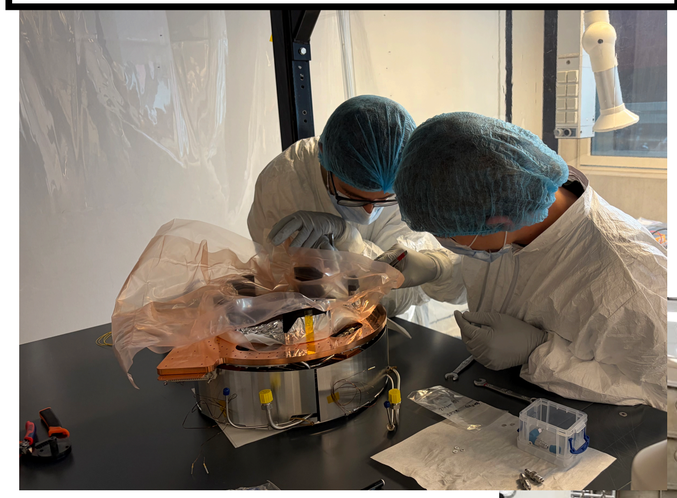
A collaboration established with Etpathfinder @ Maastricht

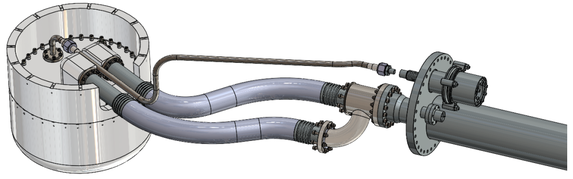
- **IFAE redesigned the cryo-shielding & LN2 vessel**
- **IFAE contributes to the installations in 2026**
- **Pre-alignment & monitoring of the mirror at 80 - 290 K (instrumented baffle with sensors for λ = 1550 nm)**
- **Initiating new R&D with Hamamatsu based on InGaAs**

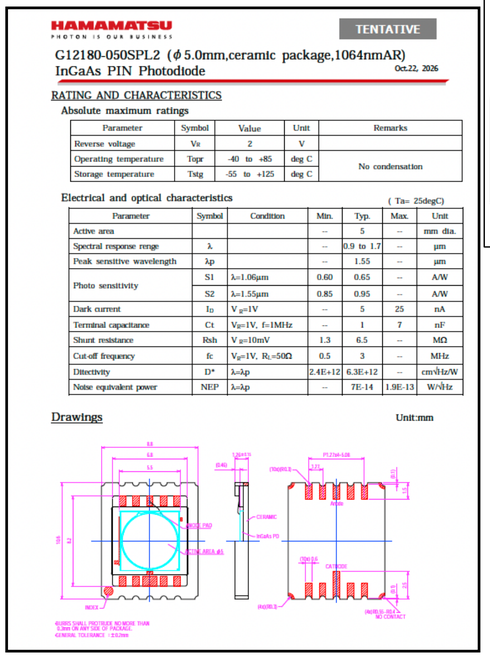




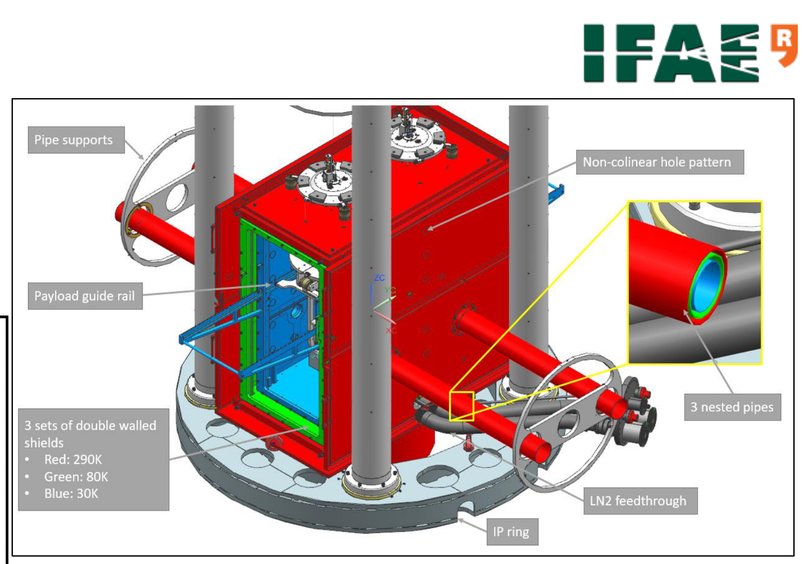
OCT 2026 — IFAE Staff - ET-PATHFINDER











IFAE @ ET pathfinder news



ETpathfinder workshop in February 2024. Photo: ETpathfinder / UM

Staying on the cutting edge

One of the contributors at the workshop was Rafael Garcia from the Spanish institute for high energy physics IFAE. He recalls how his group was asked to help finish the ETpathfinder thermal shields, which in four stages help thermally isolate the mirrors in the innermost part ETpathfinder. Garcia: "These shields protect the mirrors from heat radiation coming from the environment. The design has

speaking, it's a privilege for me having the opportunity to work for such a research facility. It allows me to stay on the cutting edge!"

New competences in advanced optics — close collaboration with the UPC Applied Optics Engineering Dept.

ETO Engineering & CERN

Civil Engineering activity for ET in Phase 1 – MOU CERN

	Workpackages	Date
WP1	Cost Estimation Classification	Q3 2024
WP2	Shared tool for modelling	Q2 2025
WP3	Design of the underground civil infrastructure (ED)	Q4 2024
WP4	Coordination of local team activity	Q4 2026
WP5	Preliminary CE TDR	Q6 2026

MOU established with CERN 2024-2026

- *support ETO on the preliminary TDR for the civil engineering infrastructure.*
- *review the activity plans and the documents from the local teams (TETI and EMR)*

ETO Civil Engineering meeting with Local Teams (EMR and TETI)
Meeting date: 29-30 April 2024
Meeting location: CERN

ADDENDUM NO. 1
KR5754/SCE
TO
FRAMEWORK COLLABORATION AGREEMENT
KN 5637/TE

BETWEEN: THE EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH ("CERN"), an Intergovernmental Organization having its seat at Geneva, Switzerland,

AND: THE NATIONAL INSTITUTE FOR NUCLEAR PHYSICS ("INFN"), established in Rome, Italy,

AND: THE DUTCH NATIONAL INSTITUTE FOR SUBATOMIC PHYSICS ("Nikhef"), established in Amsterdam, The Netherlands,

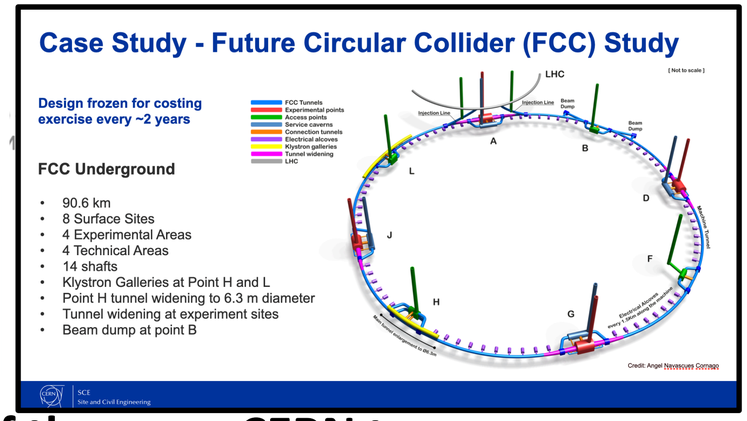
AND: THE INSTITUT DE FISICA D'ALTES ENERGIES ("IFAE"), established in Barcelona, Spain,

Hereinafter each individually referred to as a "Party" and collectively as the "Parties",

IFAE strategically placed in areas with huge industrial returns close contacts with Ministry and CDTI [being part of ET-PP]

SCE-SAM-Future Studies Section





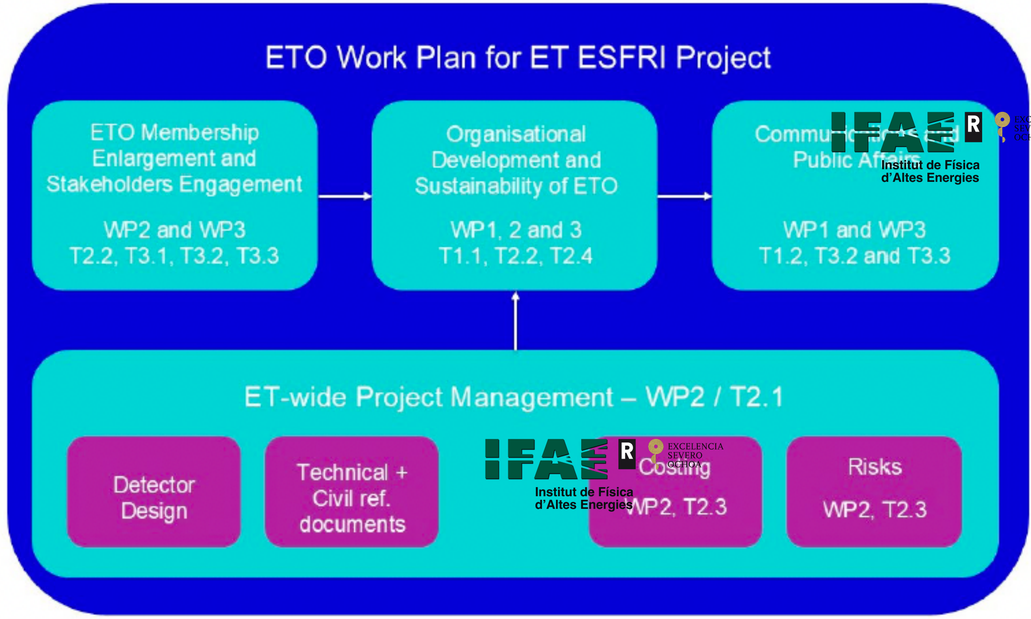


ET will count with the supervision of the same CERN team behind the recent FCC studies —> will guarantee the quality

ET-COMPASS

COordination, Management, Planning And Strategic Support for the ET Project — Continuation of ET-PP

- IFAE already participates in its continuation — ET-COMPASS (2026 - 2028) — led by INFN
  - ET-COMPASS will fund ET Organisation activities for 2 years
  - IFAE took the part of the Lion with significant responsibilities on determining the cost and associated risks of the ET infrastructure + global coordination/ communication
- Part for Spanish funds directly injected at IFAE will be used to reinforce IFAE role in the ET Governance



Ref. Ares(2026)1292710 - 05/02/2026

EUROPEAN RESEARCH EXECUTIVE AGENCY (REA)

REA.C – Future Society
C.4 – Reforming European R&I and Research Infrastructures

Subject: Horizon Europe (HORIZON)
Call: HORIZON-INFRA-2025-01
Project: 101292376 — ET-COMPASS
GAP invitation letter

1.5M€ (2 years)

Dear Applicant,

I am writing in connection with your proposal for the above-mentioned call.

Having completed the evaluation, we are pleased to inform you that your proposal has passed this phase and that we would now like to start grant preparation.

Please find enclosed the evaluation summary report (ESR) for your proposal.

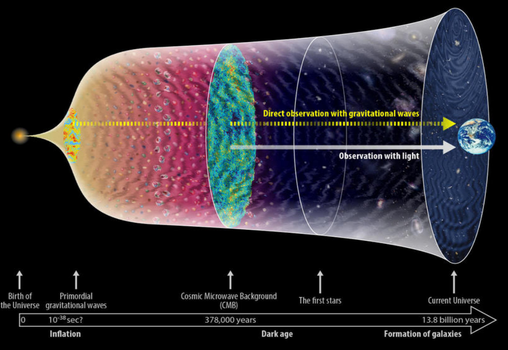
Invitation to grant preparation

Grant preparation will be based on the following:

1. **Project:**

   Project number and name: 101292376 — ET-COMPASS

   Topic: HORIZON-INFRA-2025-01-DEV-02 — Early phase implementation of ESFRI Projects that entered the ESFRI Roadmap in 2021



Physics Program

It happened in O3

Also happening for O4+O5

- → Use Deep Learning Techniques in the search for signals
- → Subsolar events and primordial Black holes as DM candidates
- → Determination of H_0 using binaries and Cosmology/tests of GR
- → Stochastic GW signals as window to the early universe

- → Search for light boson clouds and pBHs leading to GW signals
- → Test of GR using PN waveforms, tests for LIV ….
- → BH Spectroscopy using ringdown
- → Astrophysics & Multi-messenger & CBC population studies

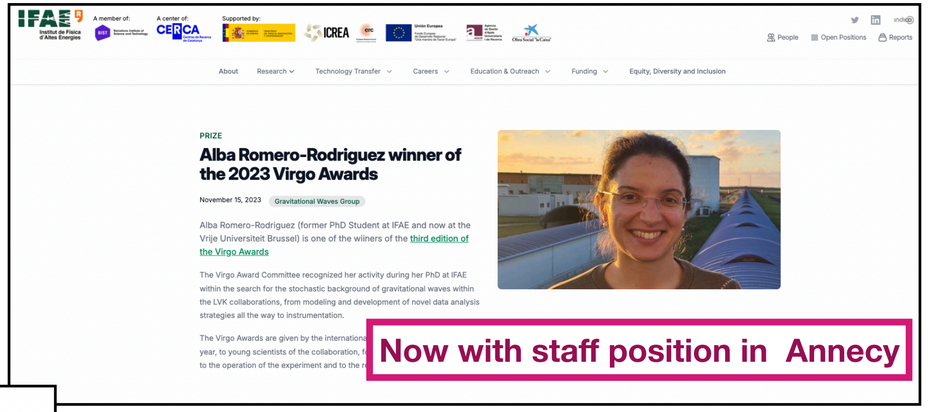
IFAE Physics Analysis @ LVK & ET papers

- **A rich physics program using LVK data including a number of short-author list Q1 paper** [not listing here LVK papers with many authors]
  - **Stochastic GWs**
    - A. Romero et al., Phys. Rev. Lett. 126, 151301 (2021)
    - A. Romero et al., Phys. Rev. Lett., vol. 128, 051301 (2022)
  - **Test of GR & Cosmology using GWs**
    - G. Caneva et al., Phys. Rev. Lett. 132, 251401 (2024)
    - S. Mastrogiovanni et al., Annalen Phys. 536 (2024) 2, 2200180
    - R. Gray et al., JCAP 12 (2023) 023.
    - S. Mastrogiovanni et al., Phys.Rev.D 108 (2023) 4, 042002
  - **Search for CBC events using AI**
    - A. Menendez et al., CQG 41 135018 (2024)
    - M. Andres-Carcasona et al., Mon. Not. Roy. Astron.Soc. 527 (2023) 2, 2887-2894
    - A. Menéndez-Vázquez, et al., Phys. Rev. D 103, 062004 (2021).
  - **Search for Dark Matter and PBHs**
    - M. Andres-Carcasona et al., Phys.Rev.D 107 (2023) 8, 082003
    - M. Andrés-Carcasona et al., Phys. Rev. D 110, 023040 (2024)
    - G. Morras et al., Phys.Dark Univ. 42 (2023) 101285
- **Also a number for. Hardware and Simulations for both Virgo and ET**
  - M. Andres-Carcasona et al., Phys.Rev.D 107 (2023) 6, 062001
  - M. Andres-Carcasona et al., Phys.Rev.D 108 (2023) 10, 102001
  - A. Macquet et al., Class.Quant.Grav. 40 (2023) 7, 077001
  - O. Ballester et al., CQG 39 (2022) 115011
  - A. Romero-Rodríguez et al, 2021, Class. Quantum Grav. 38 045002
  - A. Romero-Rodríguez et al., Galaxies 10, 86 (2022)

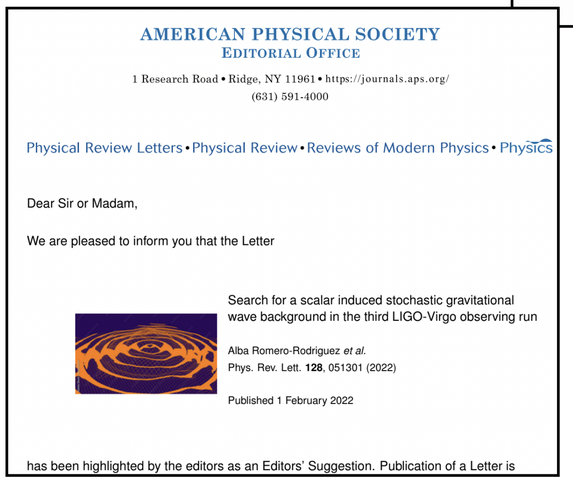
IFAE members also playing important roles in some of the O3 and O4 LVK analyses
- Main contacts in Stochastic GWs in O3
- Main contacts in pyRing (ringdown analysis) & beyond GR analyses
- Main contacts in a number of Continuous GW searches
- Main contacts in Cosmology (measure of H0) O3 analysis + H2 weights for O4

GW team very visible in numerous int. conferences and workshops across the years

Not updated list ….



Now with staff position in Annecy


AMERICAN PHYSICAL SOCIETY
EDITORIAL OFFICE
1 Research Road • Ridge, NY 11961 • https://journals.aps.org/
(631) 591-4000

Physical Review Letters • Physical Review • Reviews of Modern Physics • Physics

Dear Sir or Madam,

We are pleased to inform you that the Letter

Search for a scalar induced stochastic gravitational wave background in the third LIGO-Virgo observing run

Alba Romero-Rodriguez *et al.*
Phys. Rev. Lett. **128**, 051301 (2022)

Published 1 February 2022

has been highlighted by the editors as an Editors' Suggestion. Publication of a Letter is

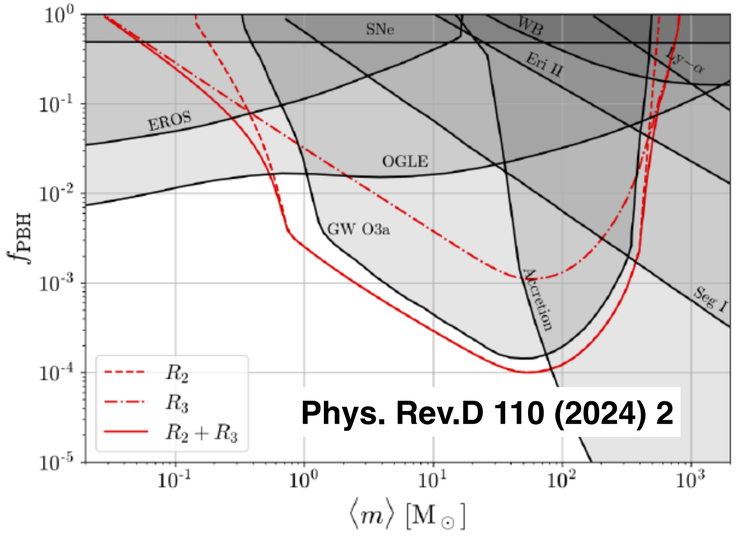
IFAE papers as PRL and PRD editors suggestions



Highlights of Physics Results (i)

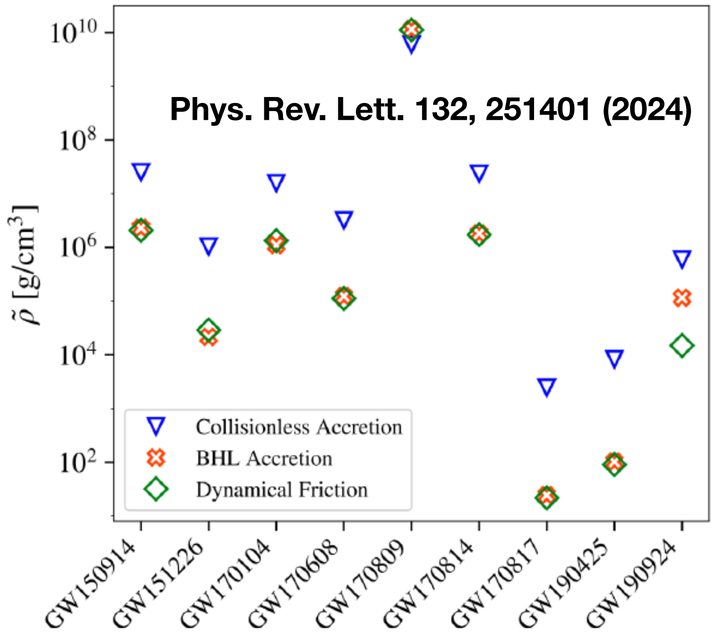
With IFAE scientists at the front

Primordial BHs



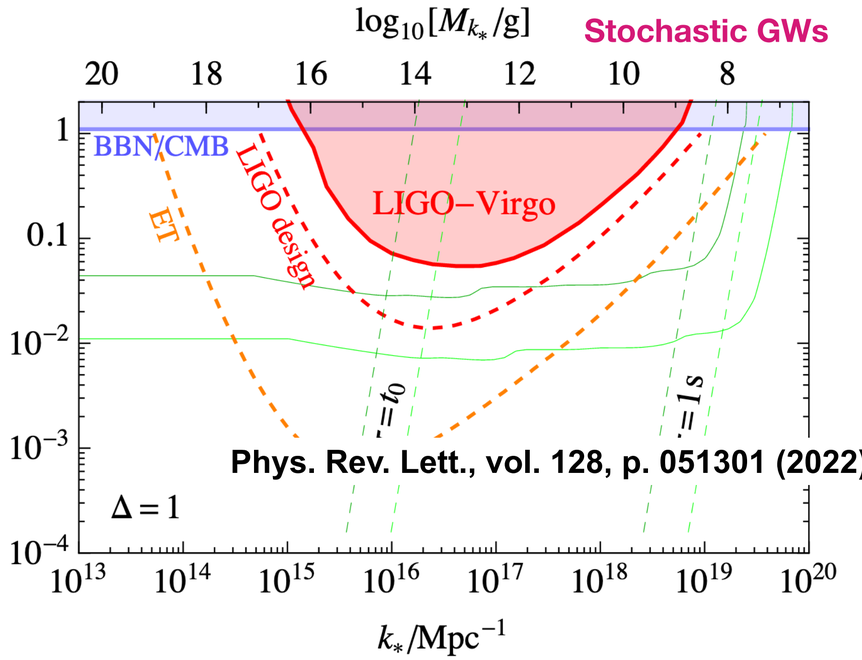
Phys. Rev.D 110 (2024) 2

Tests of GR and environmental effects



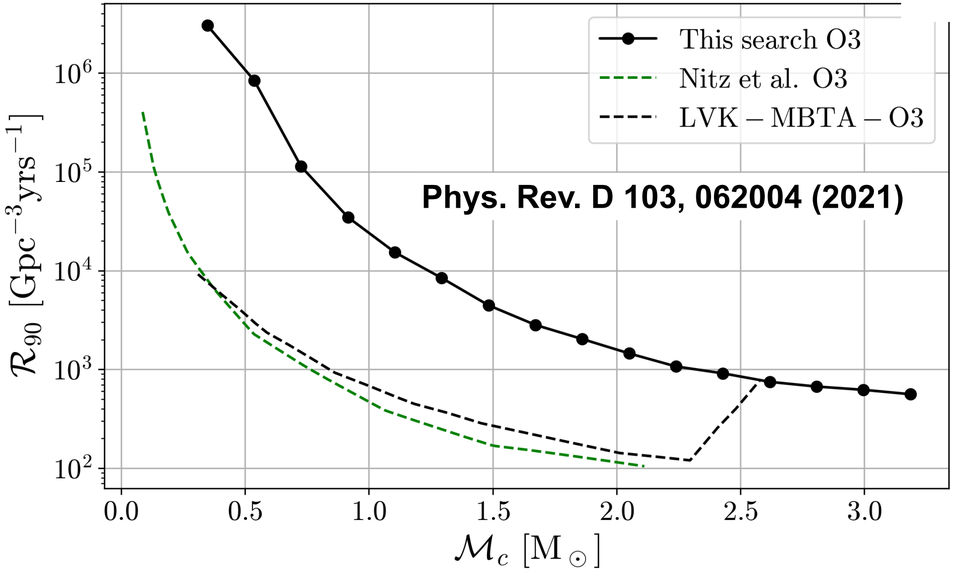
Phys. Rev. Lett. 132, 251401 (2024)

Stochastic GWs

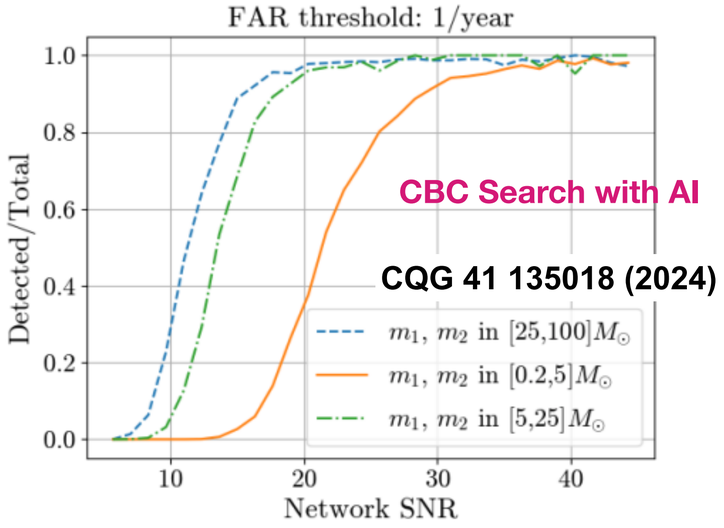


Phys. Rev. Lett., vol. 128, p. 051301 (2022)

Primordial BHs **Search with AI**



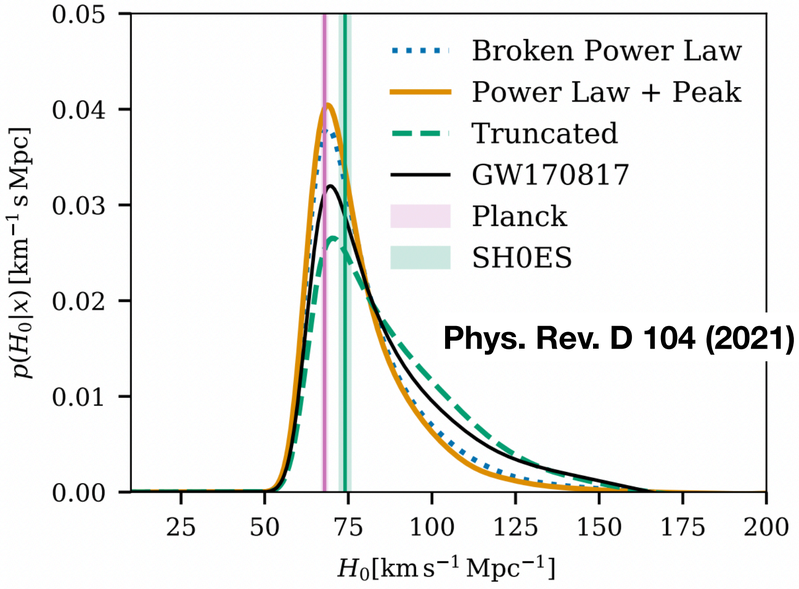
Phys. Rev. D 103, 062004 (2021)



CBC Search with AI

CQG 41 135018 (2024)

Cosmology



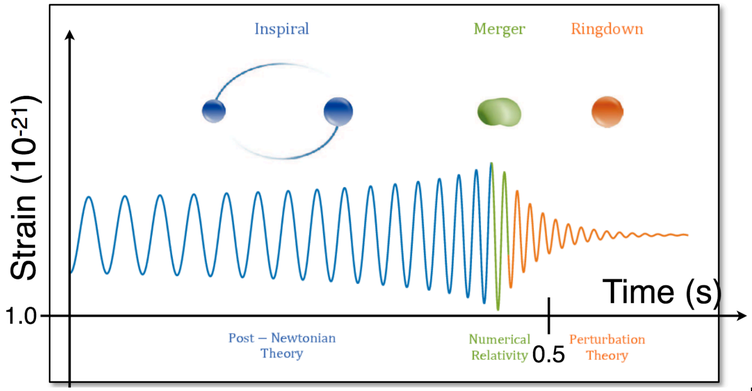
Phys. Rev. D 104 (2021)

Highlights (ii) (Test GR at LVK)

With leadership by IFAE (G. Caneva et al.)

Focused on the ring-down part

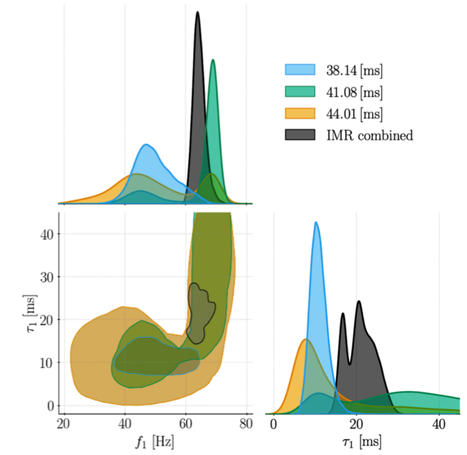
First hints for BH Quasinormal modes

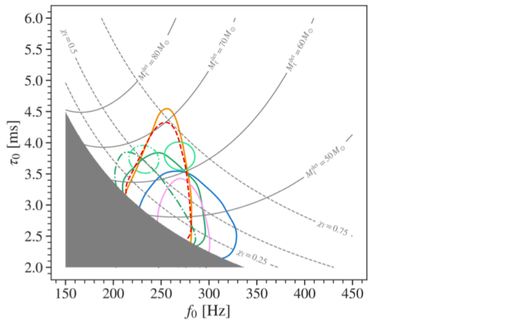


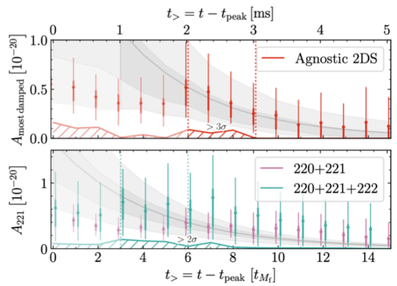
Ringdown analysis in LVK

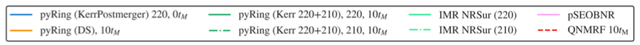
pyRing

- Special Events Contributions
  - GW231123 [2507.08219]
  - GW230814 [2509.07348]
  - GW250114 [PRL 135, 111403, 2509.08099]
- Testing General Relativity Ringdown Catalog [Coming soon]









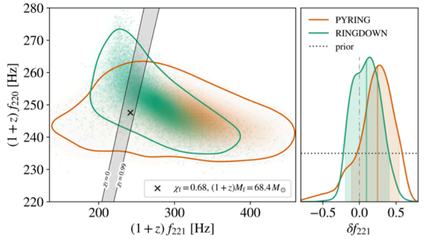
BH Spectroscopy & test of GR using ringdown will remain a major item in our physics program

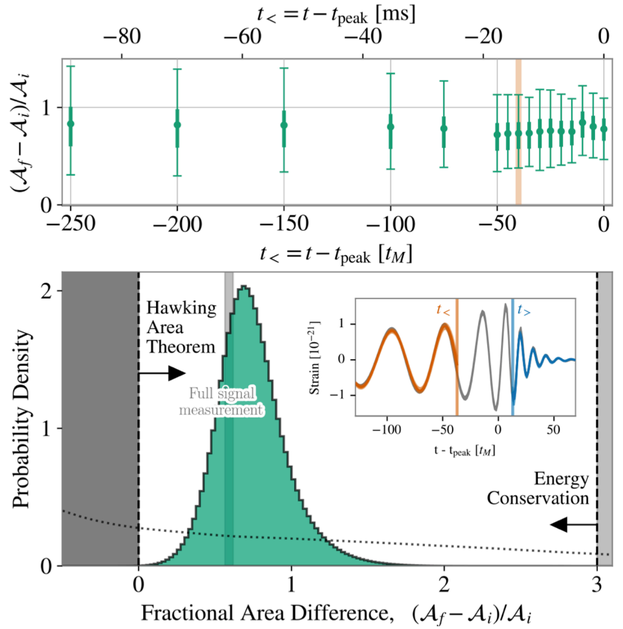
Testing Hawking's Area Law with GW250114

pyRing

PRL 135, 111403

First **high-confidence observational confirmation** of the black hole area law.





Phys. Rev. Lett. 135, 111403 (2025)

Highlight (iii) (Cosmology using dark sirens)

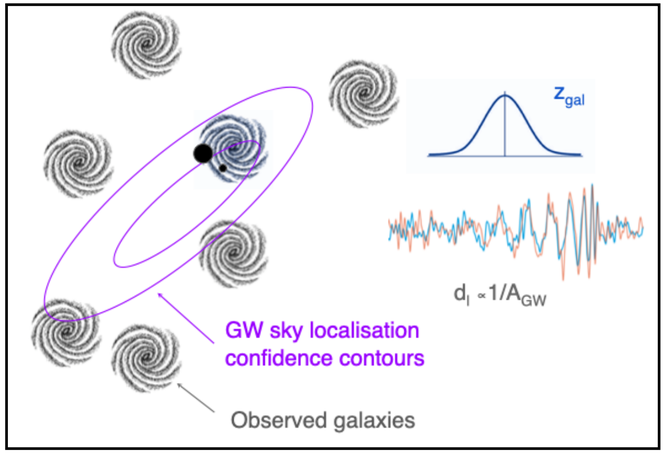
With leadership by IFAE (D. Dounia Nanadoumgar et al.)

- The lack of more Binary NS events with EM counterparts and the increasing statistics of Binary BH events has triggered interest in using BHs as dark sirens in combination with galaxy catalogs to extract Cosmological parameters

- Incomplete catalogs at large redshift becomes a limitation

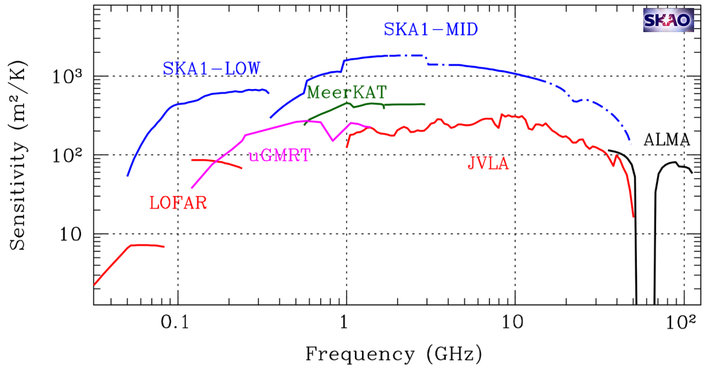
- Using HI density maps is a promising venue to complement the information from galaxies

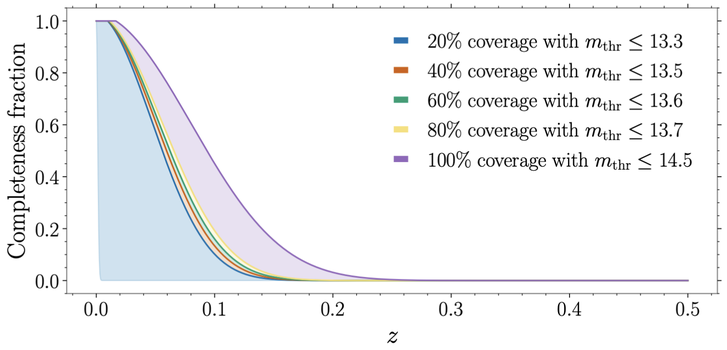
  - Implemented in LVK pipelines

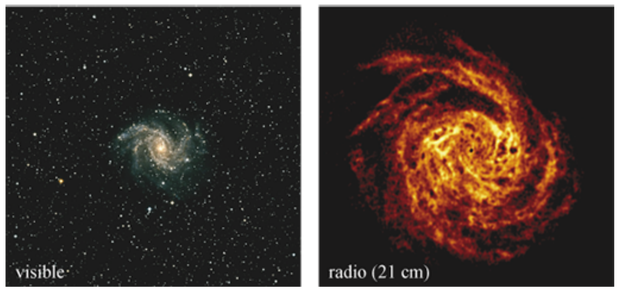


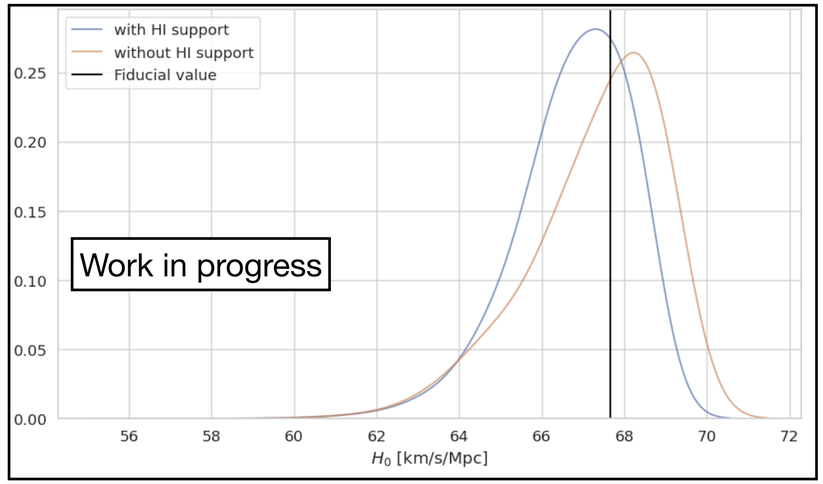


MeerKAT
10,000 sq. deg.
0.4 < z < 1.4 *









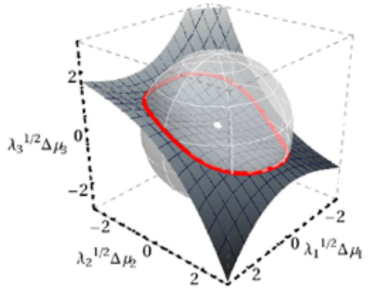
IFAE Plans in Physics / Data Analysis @ ET

- Under AI for ET:
  - Use of LLMs in searching and interpreting logbooks / instrument documentation
  - LLMs for aiding optical and control system simulation and design
  - Simulation-based inference for fast and efficient parameter estimation
- In compact binary searches:
  - Develop efficient template bank placement methods
  - Develop and profile large-scale CBC searches
  - Investigate methods to increase efficiency like hierarchical methods
- Robust search and PE methods for non-stationary and non-Gaussian data

Using LVK data to prepare for ET

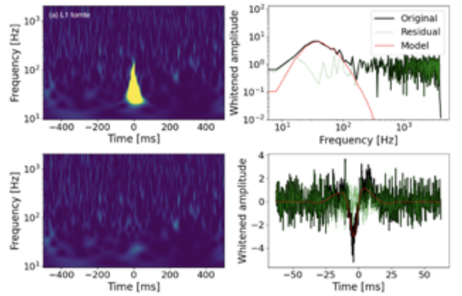
R&D on methodologies for improving PE

Glitch modeling



Under AI for ET:

- Use of LLMs in searching and interpreting logbooks / instrument documentation
- LLMs for aiding optical and control system simulation and design
- Simulation-based inference for fast and efficient parameter estimation



In compact binary searches:

- Develop efficient template bank placement methods
- Develop and profile large-scale CBC searches
- Investigate methods to increase efficiency like hierarchical methods

Methods for Search and PE Robustness

- Glitch modeling and removal
- Non-stationary spectra

Future vision (ambition)

- **Increasing the competences in preparation for ET would require an R&D platform in the BCN area**
  - Upgraded Optical Lab
  - Dedicated Optical Cavities
  - Metrology at 1064 and 1550 nm
  - UHV mechanics
  - Cryogenics
- Technical personnel
- New generation scientific personnel for ET
- We have further strengthen collaborations with industry and with other institutions in the BCN area
  - ALBA, CNM, UPC, BSC-CNS, ICMAB…
  - Explore new collaboration with UB, ICFO, ….

New Lab space
Extending clean rooms

A **strengthen and upgraded Tech Division infrastructure**

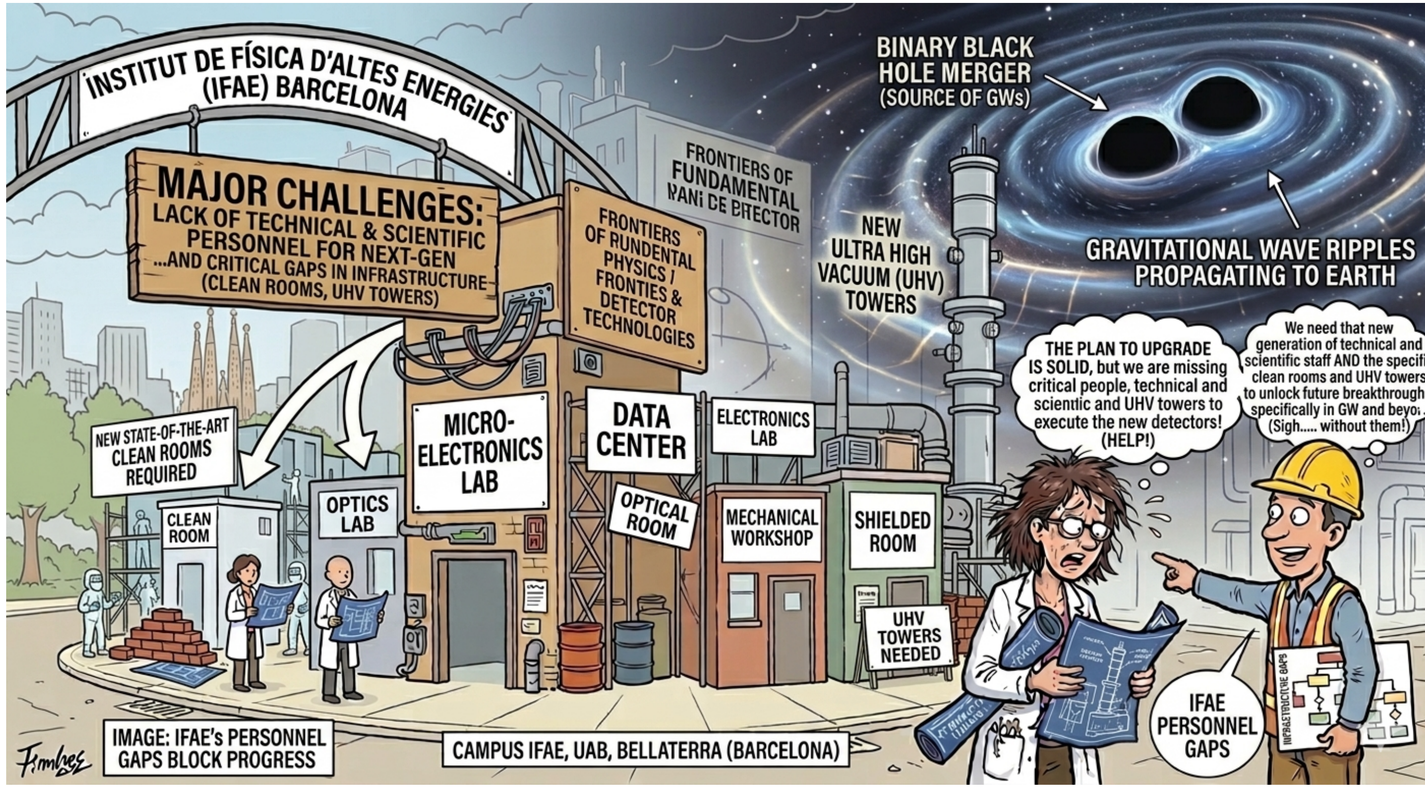
IFAE headhunting a new Technical Coordinator

hiring **junior faculties** fully devoted to the ET project









Computing resources for VIRGO/LIGO at PIC

Joined the LIGO/VIRGO Grid in Summer 2019.

Effective site integration from day 1 thanks to common sw stack with other supported experiments: LHC, DUNE, CTA

CPU and GPU access through HTCondor. Transparent & efficient access to sw and data through CVMFS (recently moved to Pelican)

Overall contribution to IGWN Grid since Jan'24 (data from GRACC)

- **6% of the CPU**
- **14% of the GPU**

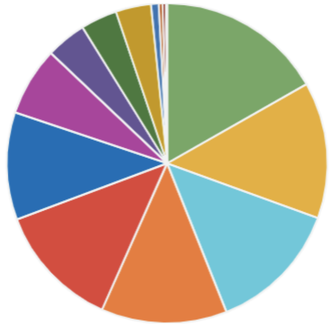
Opportunistic resources only

Gonzalo will give you the 2026 #s



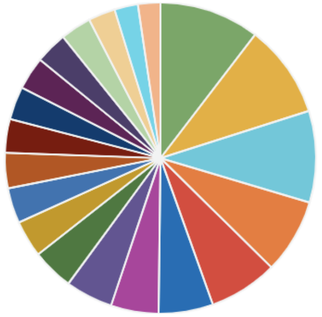


GPU Wall Hours by Facility



	total
ND_CAMLGPU	173 K
pic	142 K
SDSC-PRP-OSPool-Provisioner	138 K
SURFsara	131 K
ComputeCanada-Cedar	130 K
LIGO-CIT-CE	112 K
Georgia_Tech_PACE_CE_LIGO	71 K
LSU-SuperMIC-CE1	42 K

Core Hours by Facility



	total
Albert Einstein Institute	12 Mil
NIKHEF-ELPROD	12 Mil
CHTC	11 Mil
INFN-T1	9 Mil
SURFsara	9 Mil
PIC	7 Mil
ComputeCanada - Cedar	6 Mil
USdC	6 Mil

PIC high-quality contributed to LIGO/Virgo Grid since 2019
—> Repeating efforts to translate this into recognised in-kind
—> Recently hired a Comp Scientists at PIC working for LVK support