NEWS

H2020-MSCA-RISE-2016 – Grant Agreement N° 734303

Gravitational waves detectors

Helios Vocca and Enrico Calloni

WP-3 Co-Leaders

WP3: Gravitational wave detectors (Research, Training, Transfer of Knowledge)

Lead: UNIPG

Participant: INFN, UNIPI, UNINA, UNIPG, Impex, EGO, CNRS, CALTECH, NAOJ

Objectives

O3.1: Test the frequency dependent squeezing on a fullscale prototype, before using this technique in the Advanced detectors.

O3.2: Develop a subtraction scheme for non stationary gravity gradient noise.

O3.3: Study of silicon and sapphire materials for third generation monolithic suspensions.

O3.4: Study of payload and seismic suspension systems for cryogenic facilities

O3.5: Implementation of advanced control techniques for second and third generation gravitational wave detectors

WP Status

All the items are proceeding more or less on time (even if the number of secondments done is still below the expected).

There is an intense work on the three detectors (LIGO, Virgo and Kagra) for the foreseen upgrades and for the run activity, but the number of secondments in increasing faster that the first period...

Planned secondments (as the original GA)

Staff member ID	Staff member profile	Sending Organization	Seconded to Organization	Starting month	Duration (month)
47	ER	UNIPG	NINS-NAOJ	9	1
47	ER	UNIPG	ICRR	21	1
47	ER	UNIPG	ICRR	33	1
49	ER	UNIPG	ICRR	5	1
49	ER	UNIPG	ICRR	17	1
49	ER	UNIPG	ICRR	29	1
49	ER	UNIPG	ICRR	35	1
49	ER	UNIPG	IMPEX	38	1
50	Technical Staff	UNIPG	ICRR	7	1
50	Technical Staff	UNIPG	ICRR	19	1
50	Technical Staff	UNIPG	CALTECH	31	1
50	Technical Staff	UNIPG	CALTECH	43	1
51	Technical Staff	UNIPG	NINS-NAOJ	4	1
51	Technical Staff	UNIPG	ICRR	22	1
51	Technical Staff	UNIPG	CALTECH	40	1
82	ER	INFN	NINS-NAOJ	21	1
82	ER	INFN	NINS-NAOJ	33	1
82	ER	INFN	NINS-NAOJ	45	1
85	ER	UNINA	NINS-NAOJ	4	1
85	ER	UNINA	NINS-NAOJ	28	1
86	ER	EGO	ICRR	5	1
87	ER	EGO	CALTECH	18	1
88	ER	EGO	CALTECH	32	1
89	ER	EGO	CALTECH	40	1
91	ER	INFN	CALTECH	42	1
92	ER	INFN	CALTECH	32	1
94	ER	UNIRO	NINS-NAOJ	25	1
95	ER	UNIRO	NINS-NAOJ	13	1
100	ESR	CNRS	NINS-NAOJ	28	1
100	ESR	CNRS	NINS-NAOJ	40	1
102	ER	CNRS	CALTECH	10	1
104	ER	UNIPI	CALTECH	14	1
105	ER	INFN	CALTECH	10	1
106	ER	INFN	CALTECH	14	1
107	ER	INFN	CALTECH	18	1
108	ER	INFN	ICRR	22	1
109	ESR	INFN	ICRR	14	1
110	ER	INFN	CALTECH	9	1
111	ER	INFN	CALTECH	12	1
113	ER	IMPEX	INFN	20	1
151	ER	INFN	ICRR	12	1
151	ER	INFN	ICRR	18	1
151	ER	INFN	ICRR	30	1

Secondments status

Staff member	Staff member profile	Sending Organization	Seconded to Organization	Duration (month)
Helios Vocca	ER	UNIPG	NINS-NAOJ	2.17
Helios Vocca	ER	UNIPG	ICRR	3.47
Helios Vocca	ER	UNIPG	CALTECH	0.23
Antonfranco Piluso	Technical Staff	UNIPG	NINS-NAOJ	1.03
Antonfranco Piluso	Technical Staff	UNIPG	ICRR	2.07
Damiano Aisa	Technical Staff	UNIPG	ICRR	2.07
Flavio Travasso	ER	UNIPG	ICRR	3.47
Flavio Travasso	ER	UNIPG	IMPEX	0.23
Matewsz Bawaj	ER	UNIPG	ICRR	0.3
Fabio Garufi	ER	UNINA	CALTECH	0.23
Michele Punturo	ER	INFN	CALTECH	0.2
Annalisa Allocca	ER	INFN	CALTECH	1.03
Ettore Majorana	ER	INFN	ICRR	0.87
Matteo Bischi	ESR	INFN	CALTECH	1.2
Francesca Badaracco	ESR	INFN	ICRR	0.53
Massimiliano Razzano	ER	UNIPI	CALTECH	0.47
Franco Carbognani	ER	EGO	CALTECH	0.3
Irene Fiori	ER	EGO	ICRR	1.43
Federico Paoletti	Technical Staff	EGO	ICRR	1.37
Camilla De Rossi	ER	EGO	ICRR	1.1
Marc Eisenmann	ESR	CNRS	NINS-NAOJ	1.73
Marc Eisenmann	ESR	CNRS	ICRR	0.87
Pierre Prat	ER	CNRS	NINS-NAOJ	2.1
Matteo Barsuglia	ER	CNRS	NINS-NAOJ	0.47
Raffaele Flaminio	ER	CNRS	NINS-NAOJ	0.6
Sibilla Di Pace	ER	UNIRM	MIT	0.63

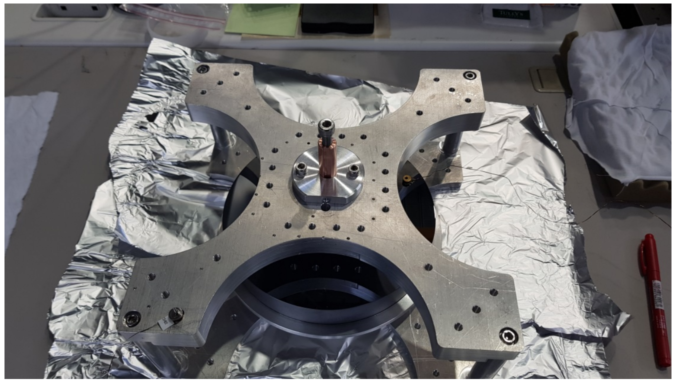
Secondments status per sending organization ~ 30

Sending Organization	Seconded to Organization	Duration (month)
UNIPG	NINS-NAOJ	3.2
UNIPG	ICRR	11.38
UNIPG	CALTECH	0.23
UNIPG	IMPEX	0.23
UNINA	CALTECH	0.23
INFN	CALTECH	2.43
INFN	ICRR	1.4
UNIPI	CALTECH	0.47
EGO	CALTECH	0.3
EGO	ICRR	3.9
CNRS	NINS-NAOJ	4.9
CNRS	ICRR	0.87
UNIRM	MIT	0.63

Last secondments topic (UNIPG to ICRR)

UNIPG continued its secondments to **ICRR** (Japan) on the realisation of a first prototype of a silicon cryogenic suspension for the 3rd generation detectors.

The barrel of the silicon mirror was polished to reduced the surface losses. Moreover, two lateral flats were machined with a polishing of λ/10 to allow the gluing of the lateral supports, essential step for realizing the monolithic suspension.

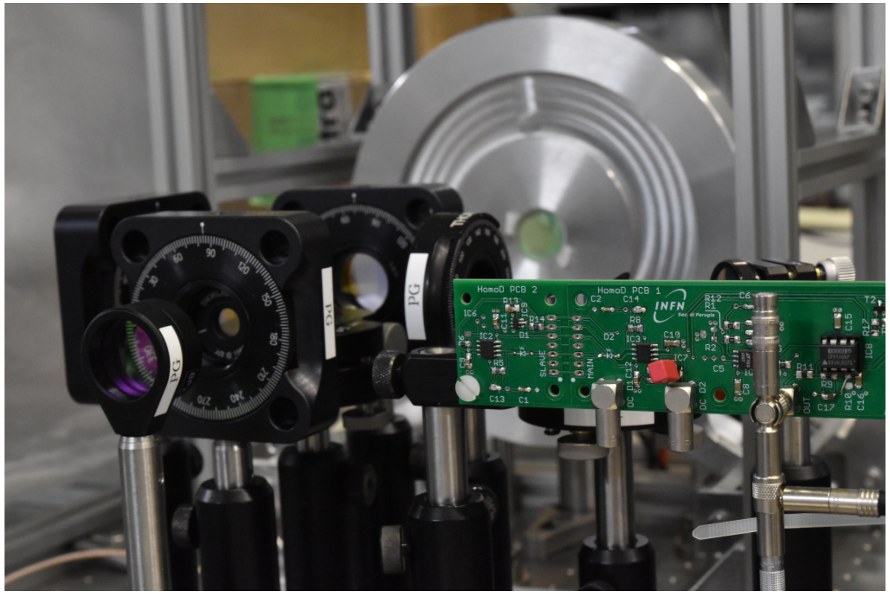


Last secondments topic (UNIPG to ICRR)

A homodyne system was developed to measure the motion of a dummy suspended (with steel wires) substrate:

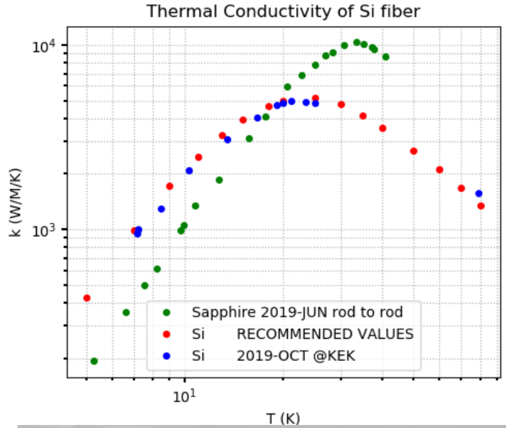
- Q measurements
- control strategy

Due to the recoil losses, it is fundamental to have a cryostat with a very rigid mechanical link to the floor: thanks to the efforts of KAGRA CRYO-Group, the ICRR system perfectly fits this purpose

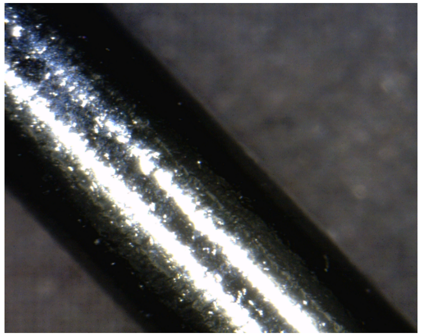


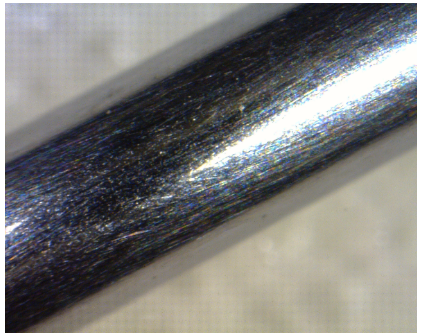
Last secondments topic (UNIPG to ICRR)

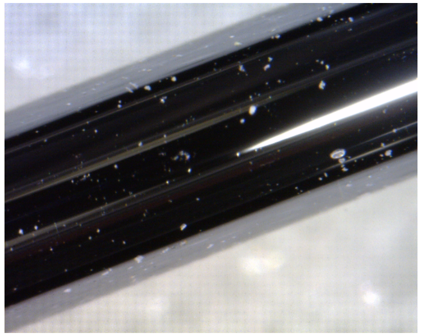
The thermal conductivity of silicon fibers produced with technique and different doping was measured

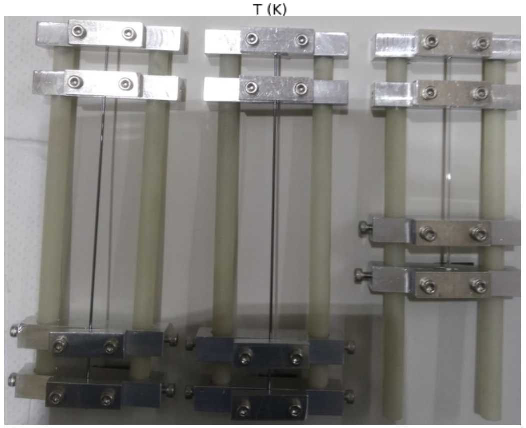


New silicon fibers with improved surface quality were already produced. Their thermal conductivity will be measured next summer.

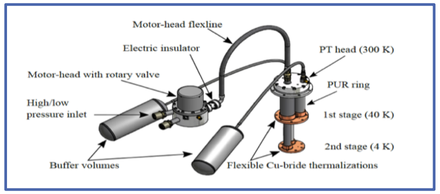








3G cryogenics technical noise



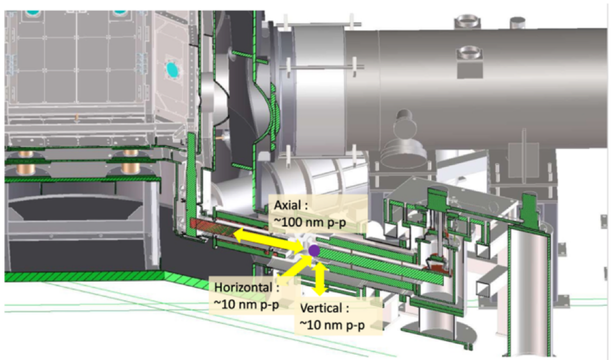
- Mechanical modelling of cryostat VS thermal-duct coupling
- Optimization of soft heat links (KEK)
- Design and test of an auxiliary heat link vertical isolation system (HLVIS), successfully integrated in the cryostats

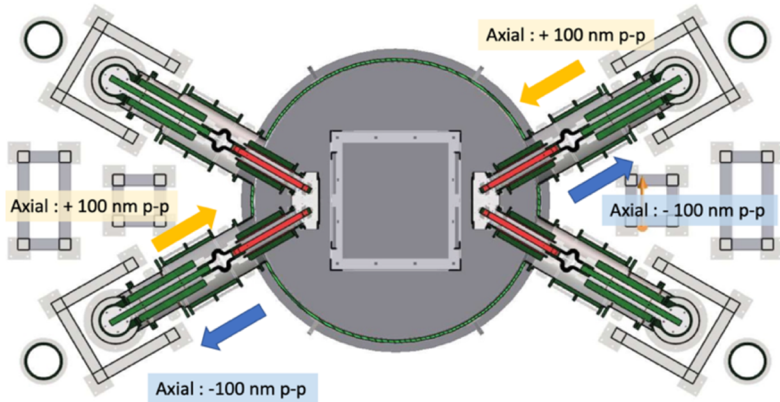
- A tiny effect related to Pulse Tube (PT) technical noise sources should still appear at LF (outside th e detection bandwidth) at full sensitivity.
- Massive use of PT technology for larger detector installations, as for instance for Einstein Telescope,

3G detectors will certainly exploit KAGRA know-how of cryogenics with no cryo-liquids.

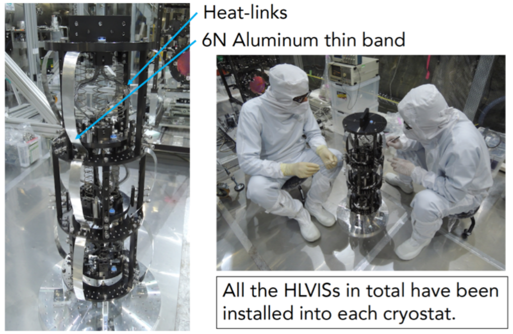
PT vibrations are mainly due to:

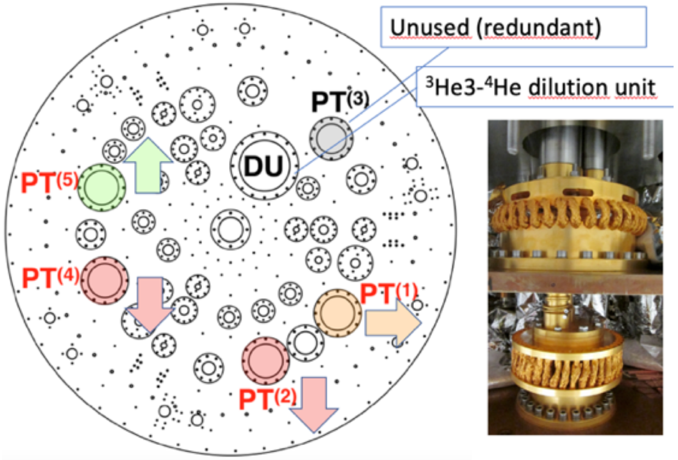
- Rotary valve through a stepper motor
- Gas pulsation through the connecting pipe to the head
- Pressure waves at the level of the head and through the tubes, reaching the two stages





- We started to focus 3G cryostats in 2019 (fall) in collaboration with KAGRA
- In this context, following the work done under NEWS support about heat link vibration rejection at the site, we envisaged further vibration reduction potential: **active vibration compensation**





In the CUORE experiment, $0\nu\beta\beta$ search bolometric detection requires excellent cryogenic performance, but also demanding vibration attenuation, and PT head flange was designed according to a quite asymmetric geometry taking care uniquely of cryogenics efficiency. Then a smart compensation controlling PT compressor relative phases was developed later on.

Lett: overall layout of the phases

$PT^{(5)}$ Reference

Phase $PT^{(4)}$ - Phase $PT^{(5)} = \pi$

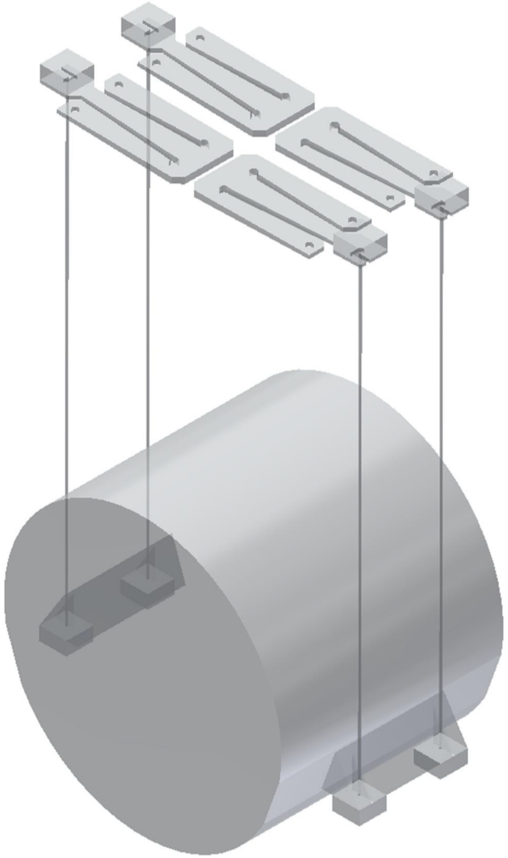
Phase $PT^{(2)}$ - Phase $PT^{(5)} = \pi$

Phase $PT^{(1)}$ - Phase $PT^{(2)} = \pi/2$

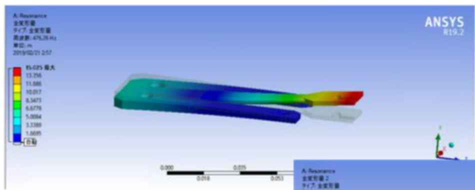
- We planned an activity funded through ICRR Inter University programme (also supported by INFN) also exploiting NEWS support

- The activity started in Italy (demonstration milestone using Sumitomo cryocooler). In June-July 2020 we plan to
- perform tests at Kamioka

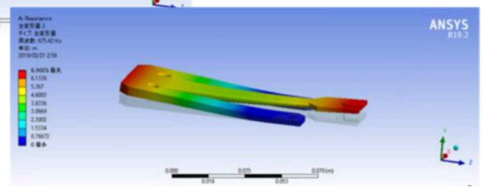
Not only 3G Silicon suspension developments in NEWS (in the context of ICRR Inter Univ. programme)



- Homologous exchange programmes (NEWS/JSPS) allowed to develop a collaboration framework dedicated to sapphire suspension for present detectors



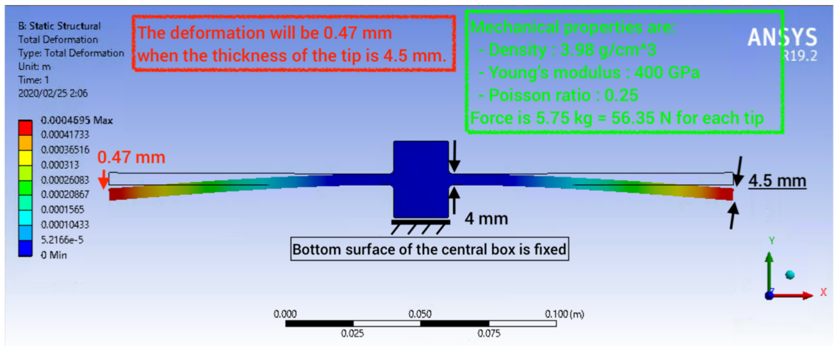
1st mode: 476 Hz



2nd mode: 675 Hz

In 2019 we performed

- measurements
- Design of new solutions
- Results are thought for KAGRA at the moment
- But they are directly interesting also for 3G detectors



Actual blade suspension for sapphire wires used for the mirror

UNIPG at Kagra site - Starting of the observation run