

Preventivi 2014

Advanced VIRGO experiment

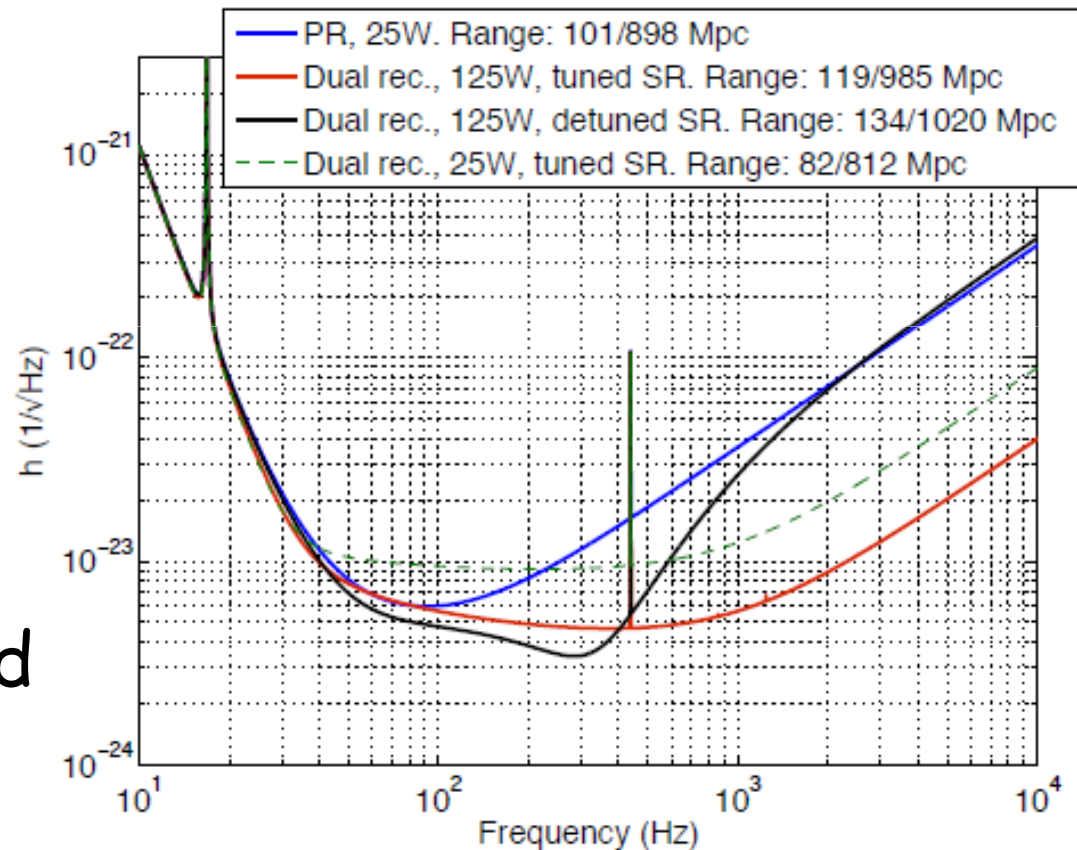
Sezione INFN Pisa – July 2, 2013

VIRGO Group

Towards Advanced VIRGO

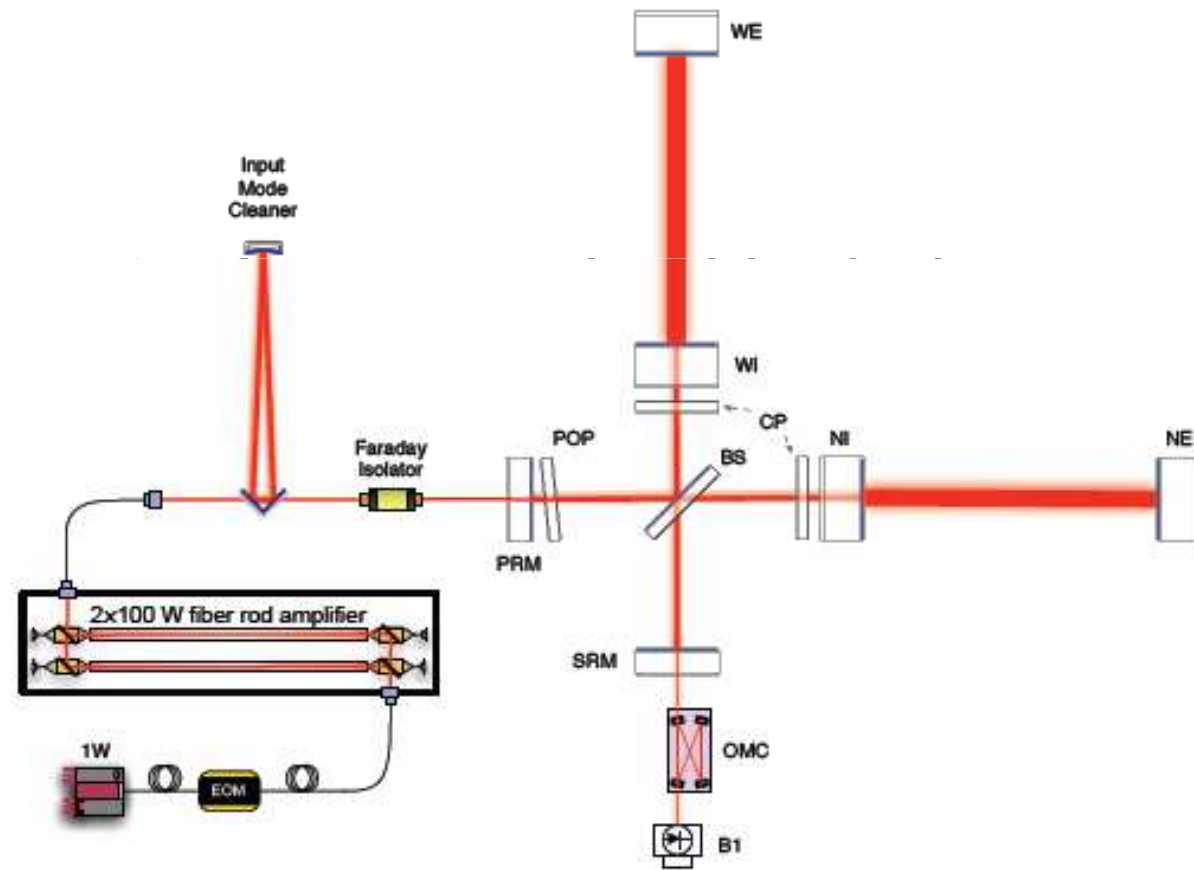
Goals:

- Sensitivity improved by **10** (optimized for BNS horizon @ 134 Mpc)
- Start the data taking by the end of **2015**



The Advanced VIRGO Project

- Advanced VIRGO is the project to upgrade the VIRGO instrument of university
- The international Marginal



Data Analysis: stochastic background

Search for gravitational waves that can be modeled only as a stochastic process.

Joint use of VIRGO & LIGO data is mandatory in this case (correlation).

Cosmological backgrounds

- Upper limits for early universe evolution models

- Detection, study of anisotropies

- This is the main field of activity.

Interesting upper limits available.

LSC/VIRGO collaboration. An upper limit on the stochastic gravitational-wave background of cosmological origin.

Nature 460, 990-994 (20 August 2009)

Astrophysical backgrounds

- Star formation history

- Population statistic

Pisa group:

- S5/VSR1 LIGO/VIRGO joint analysis

- *LSC/VIRGO collaboration. An upper limit on a stochastic gravitational wave background using LIGO and Virgo interferometers at 600-1000 Hz. Phys. Rev. D85, 122001 (2012)*

- Porting of LIGO data analysis pipeline on GRID (in progress)

- Analysis on GRID (VIRGO pipeline)

- Analysis of S6/VSR2 data (under review)

Software & hardware injections analysis

- Study of constraints on extended gravitation theories

Specialistic thesis in progress (F. Di Renzo)

- Study of backgrounds from cosmic strings populations

Specialistic thesis ended last month (M. Pieroni). A paper on the results will be submitted to CQG before fall

Other phenomenological studies planned.

Data Analysis: continuous waves

Search for monochromatic gravitational waves.

Not really monochromatic:

- Doppler shift induced by detector's motion
- Spin down (or spin up)

Several strategies:

- Blind search (heavy computational effort, not pursued in Pisa)
- Semi-targeted search (source position known, frequency unknown)
- Targeted search (source position and frequency known)

Pisa group:

- Application of a Doppler demodulation algorithm developed inside the Group
S. Braccini, G. Cella, I. Ferrante, D. Passuello, O. Torre. Resampling technique to correct for the Doppler effect in a search for gravitational waves. Phys. Rev. D83, 044033 (2011)

- Semitargeted search to the RX J0852.0-4622 supernova remnant

Final results foreseen for this year

One dedicated Ph.D. Candidate (O. Torre)

- Mock data challenge (several injections with known and unknown parameters)

Future (next year):

- Starting project (with FERMI-LAT): unveiling the physics of compact objects with joint observations of GW and electromagnetic radiation (FIRB).

Activity for AdV and beyond

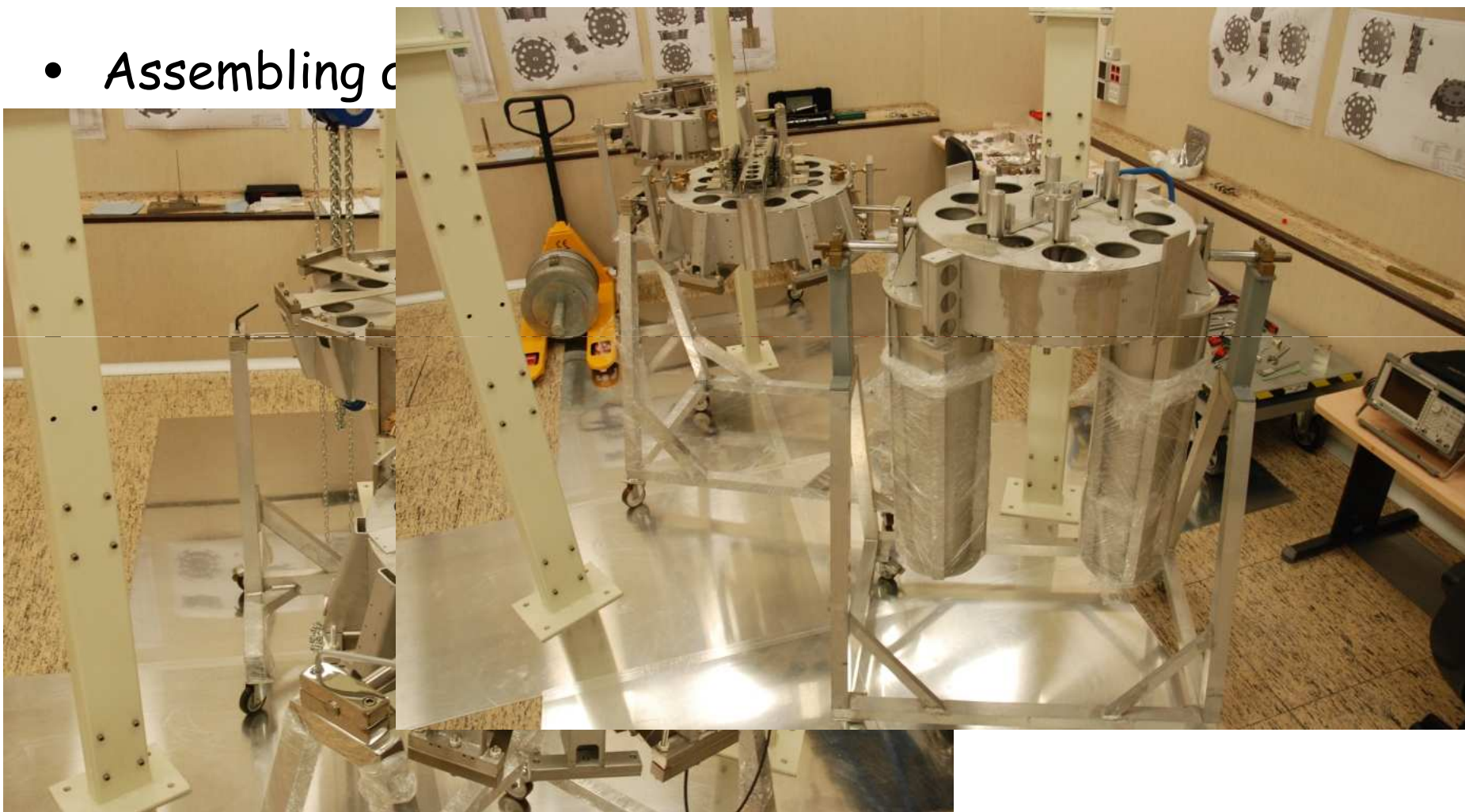
- Important changes have been introduced in the AdV project with respect to the baseline → impact on SA
- Scattered light mitigation:
 - use of large baffles;
 - all science-mode photodiodes in vacuum and seismically isolated.
- Laser: from solid state to rod technology.
- More complex Thermal Compensation System.
- Payloads: new mechanical design, no recoil mass, actuation cage connected to F7.

Hardware for AdV

- With **MSRC** optical scheme for AdV the Pisa Group activity is focused on:
 - F7 re-design for new geometry of the payloads(**7 filters + monitoring systems**);
 - SA up-grades for tilt control (**6 new IP** and **30 PZT actuators**);
 - new SA for SR mirror (a complete suspension: **IP + 6 filters + Safety Structure**);
 - seismic isolation to be improved on short SA with an additional mechanical filter (**3 filters**);
 - design of the new **SIB** (mechanics);
 - design of **large baffles** on all payloads (... and not only);
 - new Control Electronics for SA.

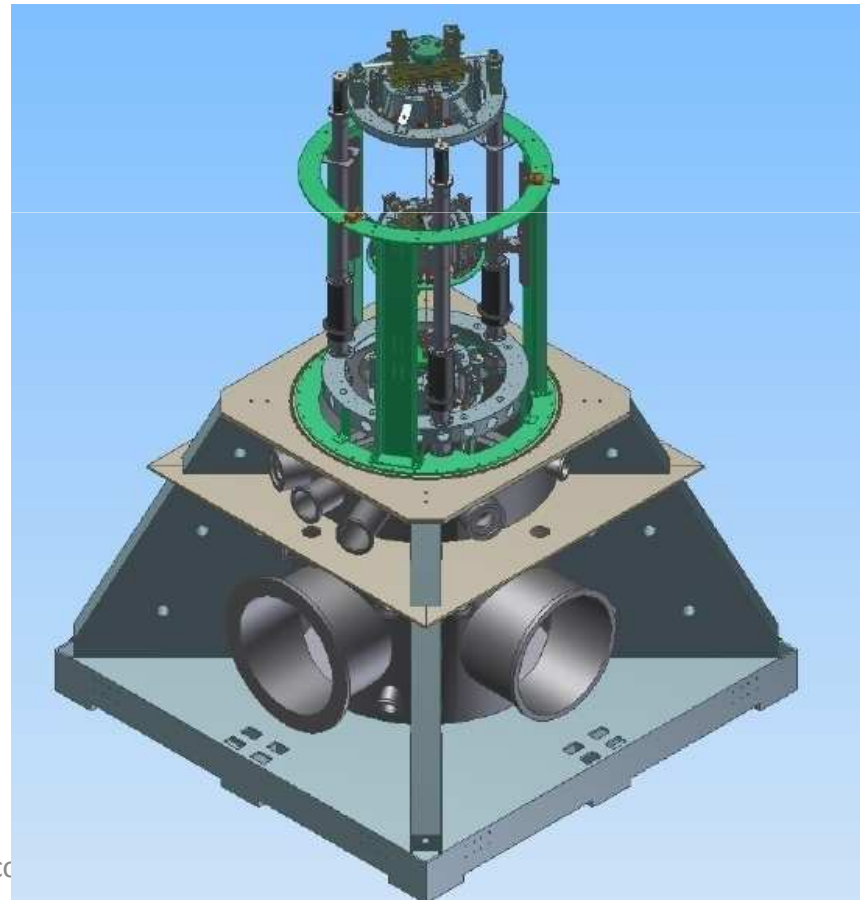
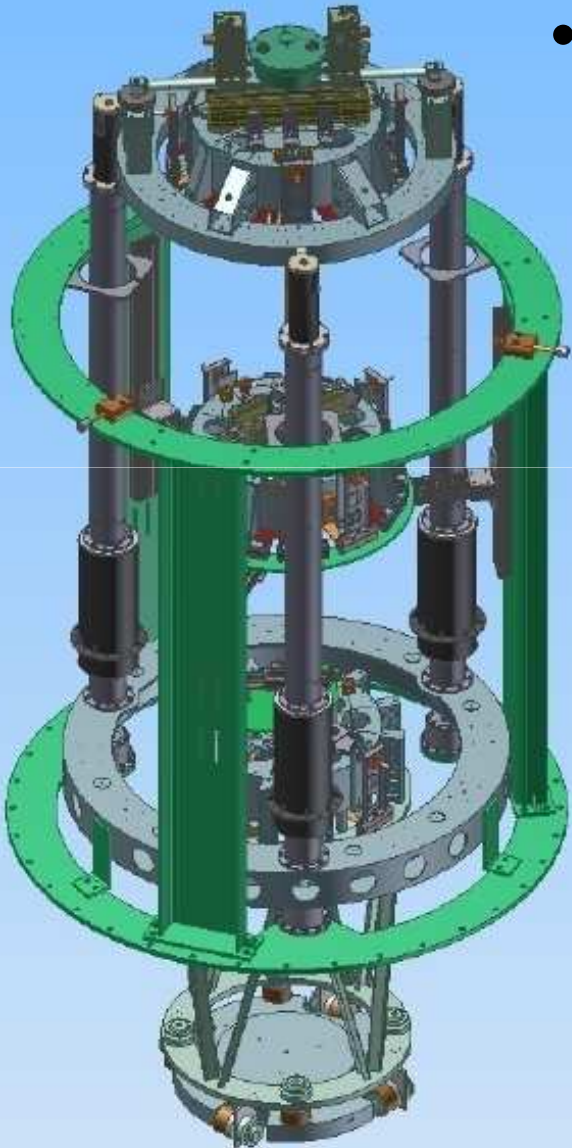
Activity on Seismic Filters

- Assembling c

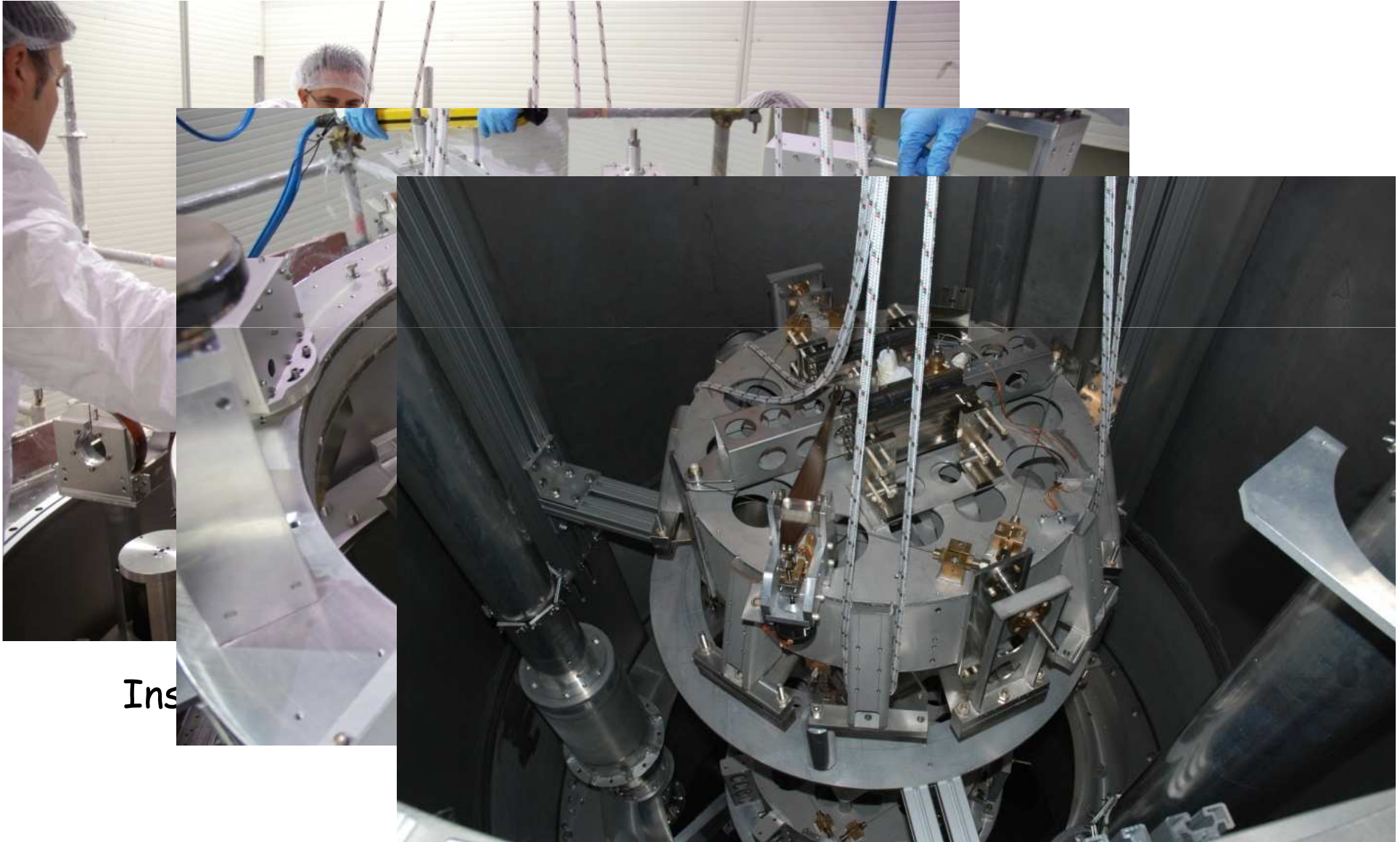


Working in progress: AdV Short SA

- Seismic isolation improvement adding a Mechanical Filter on MC, INJ and DET suspensions

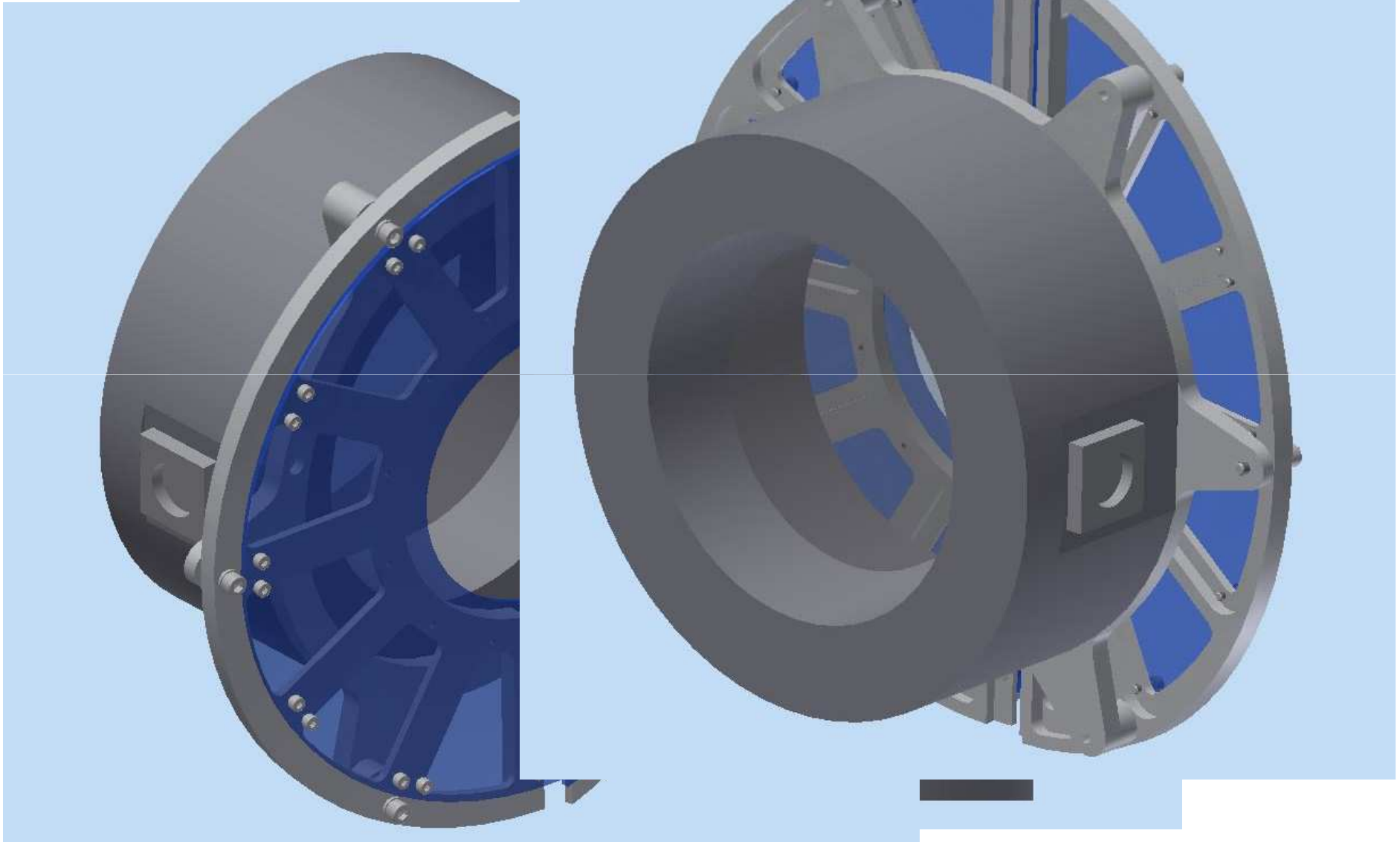


Up-grades installation



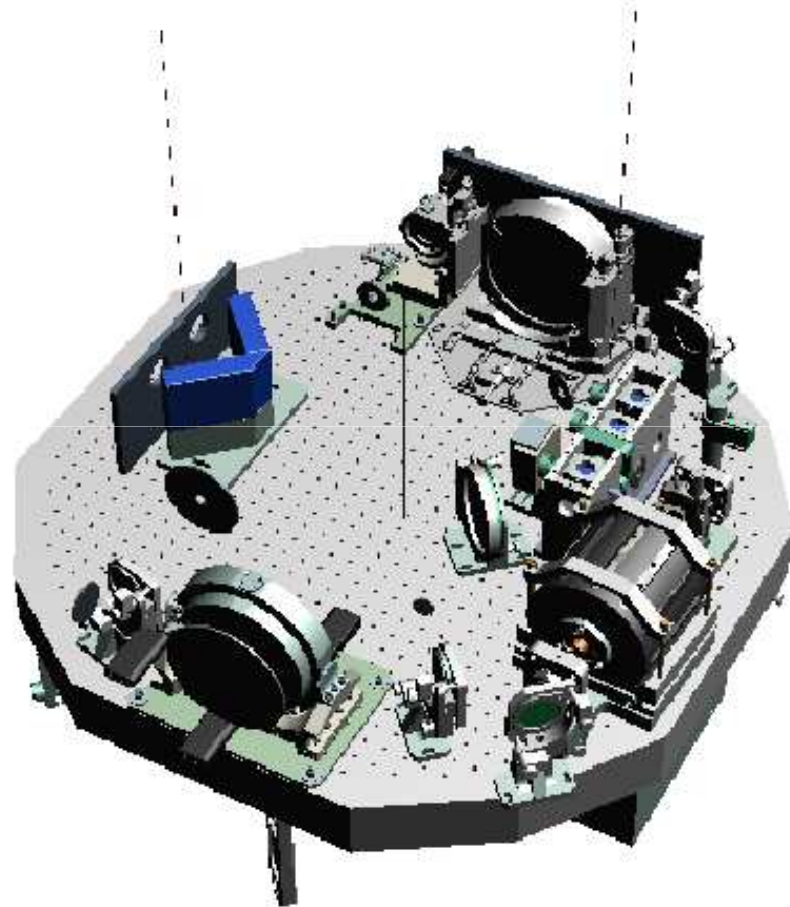
Ins

A Baffle



Suspended Injection Bench

- A multi-holes optical bench for the Injection system has been developed. It will be suspended from a short suspension chain (SIB).



Activities on Long SA for AdV

- Re-design and prototype construction of **Filter7** in accordance with the new Payloads geometry (different payloads geometry = different Filter7);
- **Filter7** and Payload prototypes construction for BS is finished. They have been installed on NE Suspension (May 16, 2013) for a long period test;
- Different **spatial distribution** of the mechanical filters along the suspension chain (optimization of seismic noise filtering in accordance with a new geometry of the Intermediate Vacuum Chamber);
- Re-tuning of some mechanical filters in accordance with the load to be supported (new Payloads in the Fabry-Perot cavities).

Working in progress: AdV Long SA



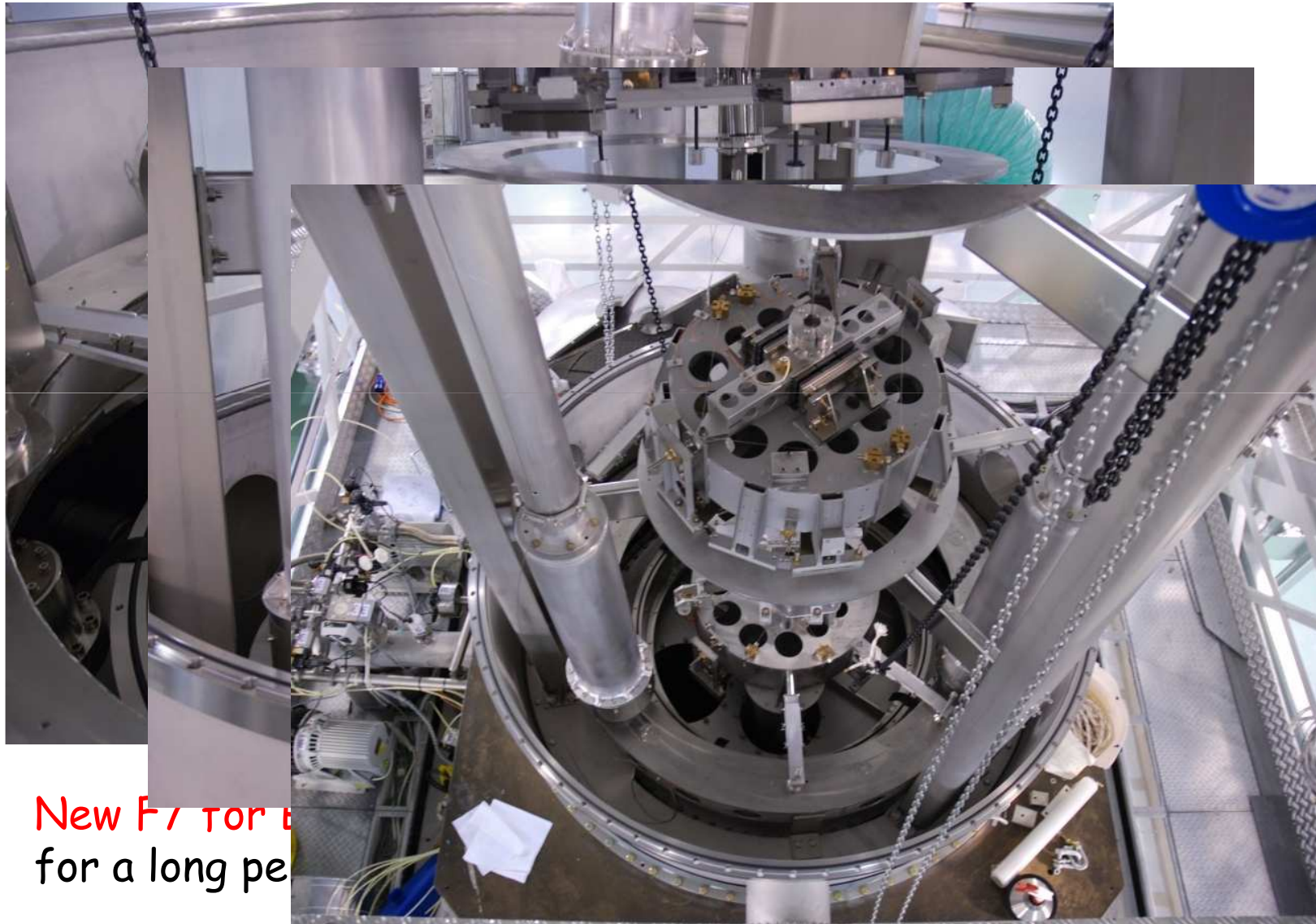
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Prototypes Installation



New F7 for
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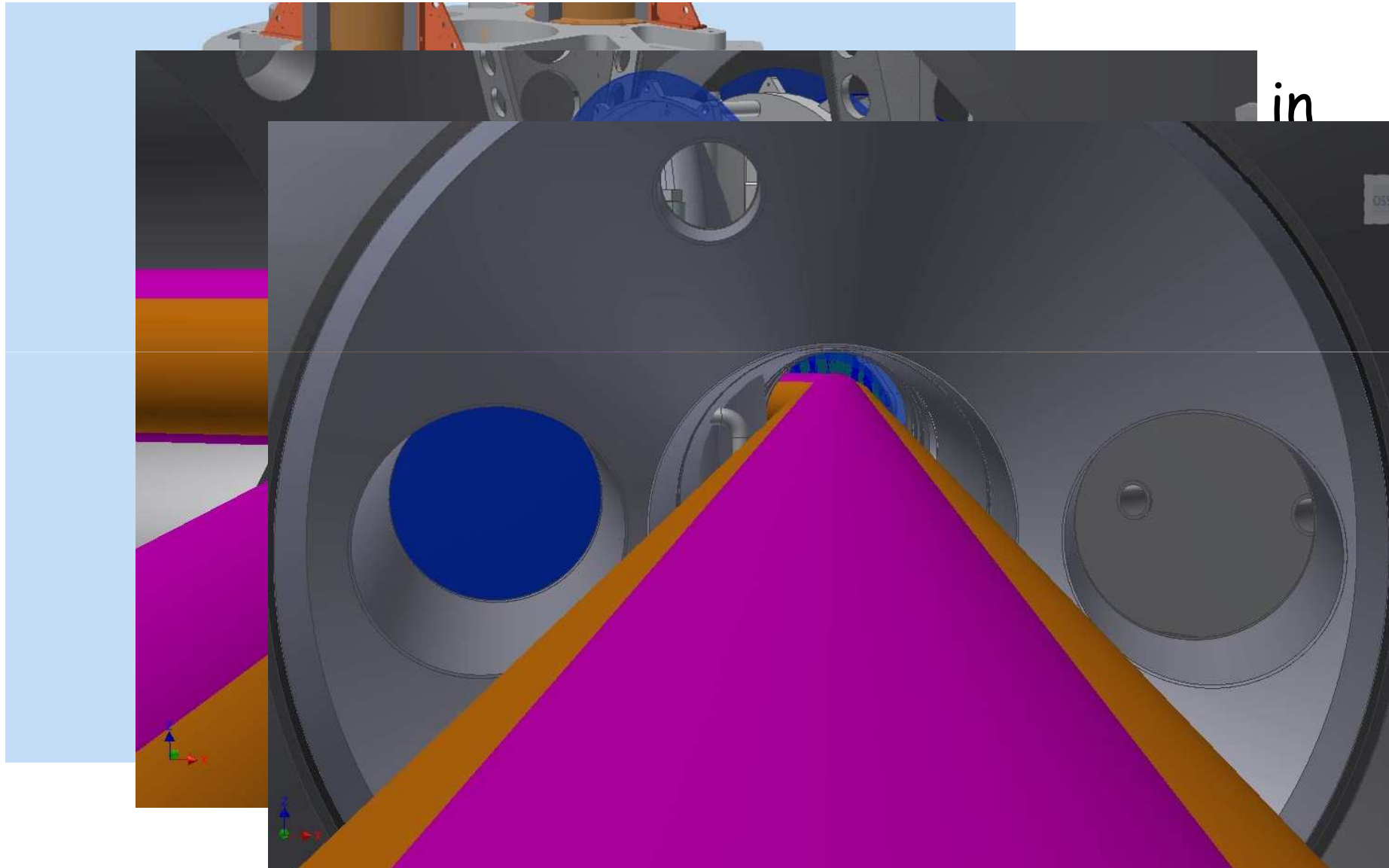
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BS Payload Prototype

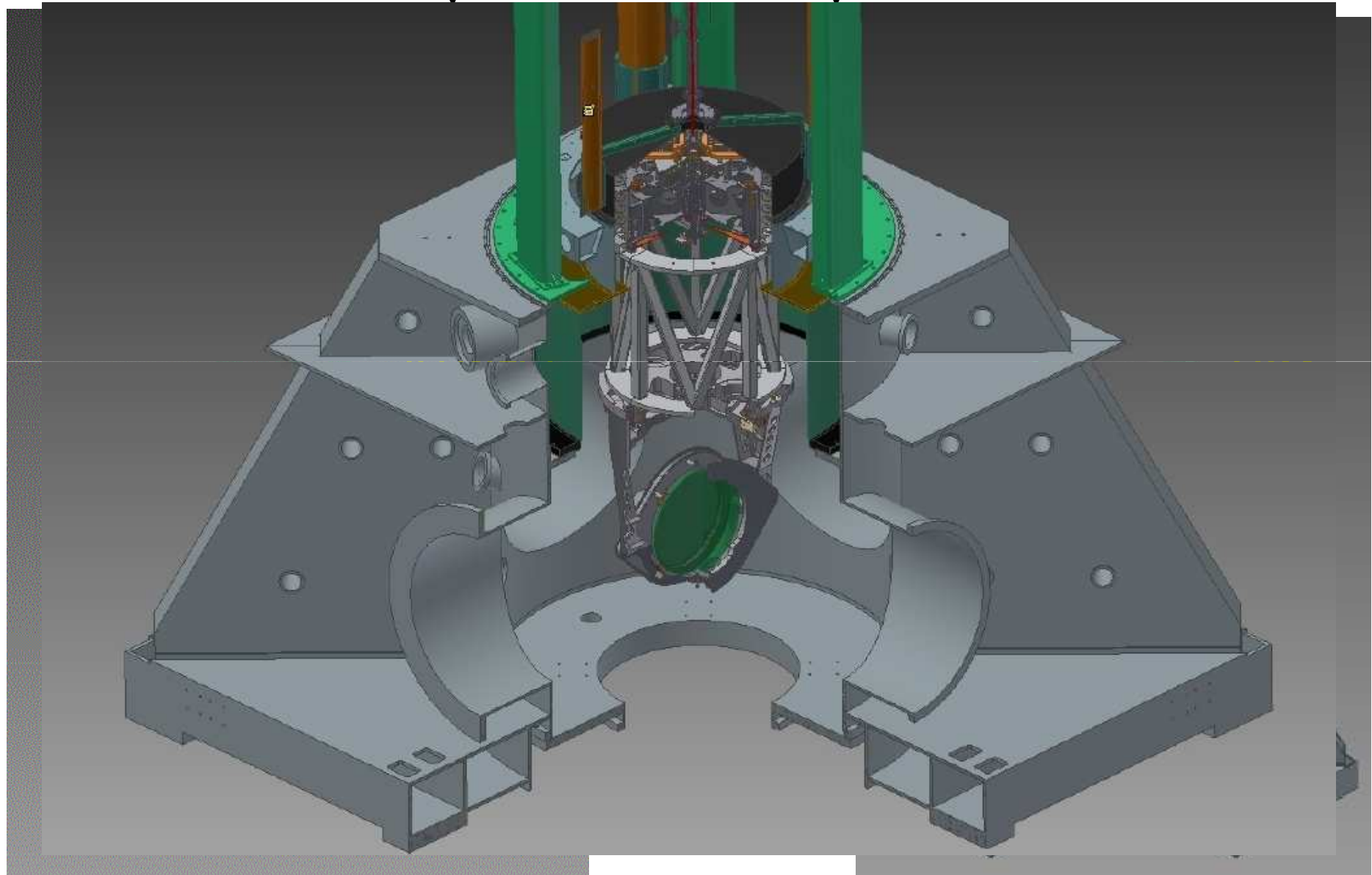


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A large baffle for BS Payload



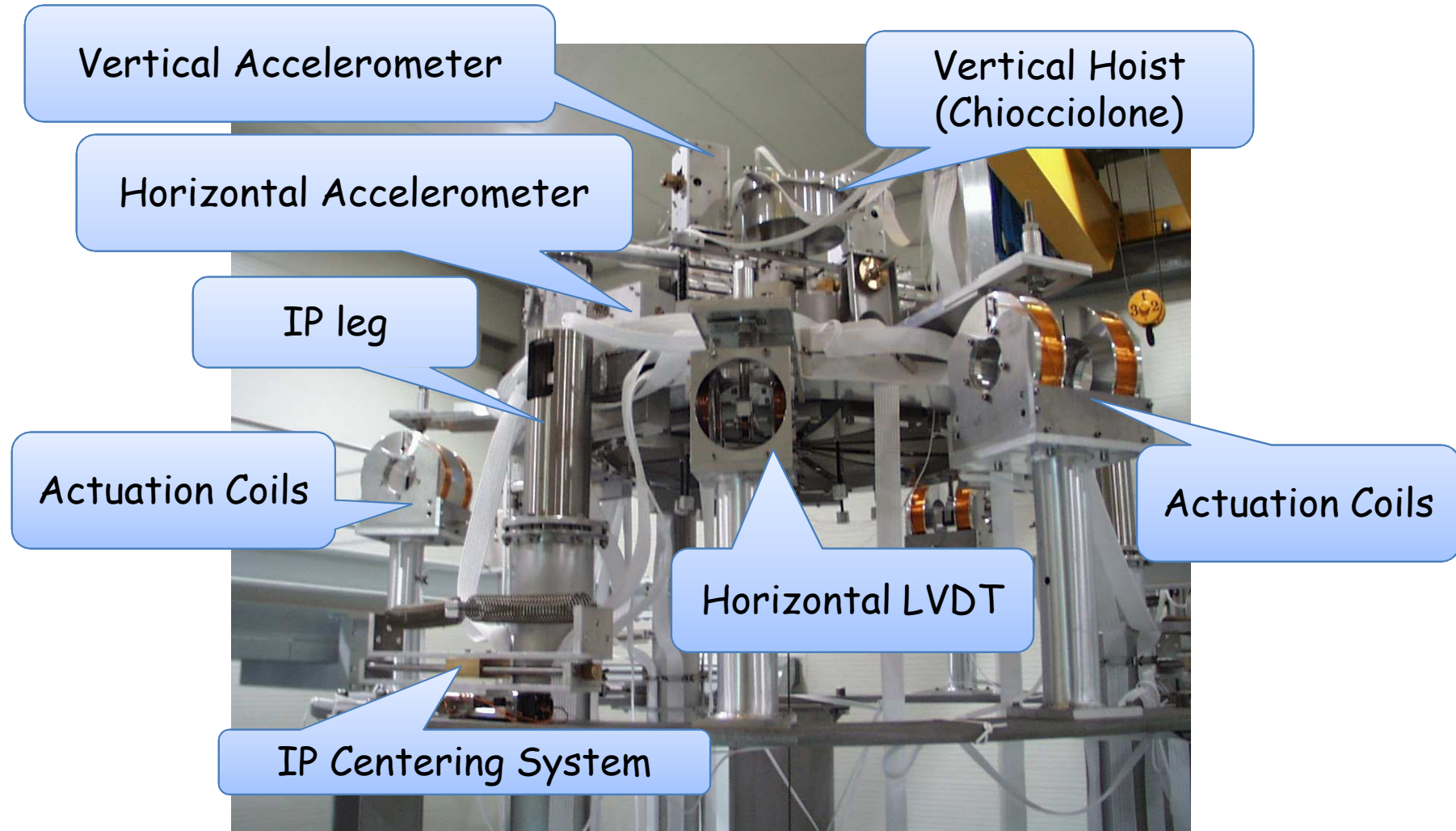
Suspensions Comparison



New Control Electronic

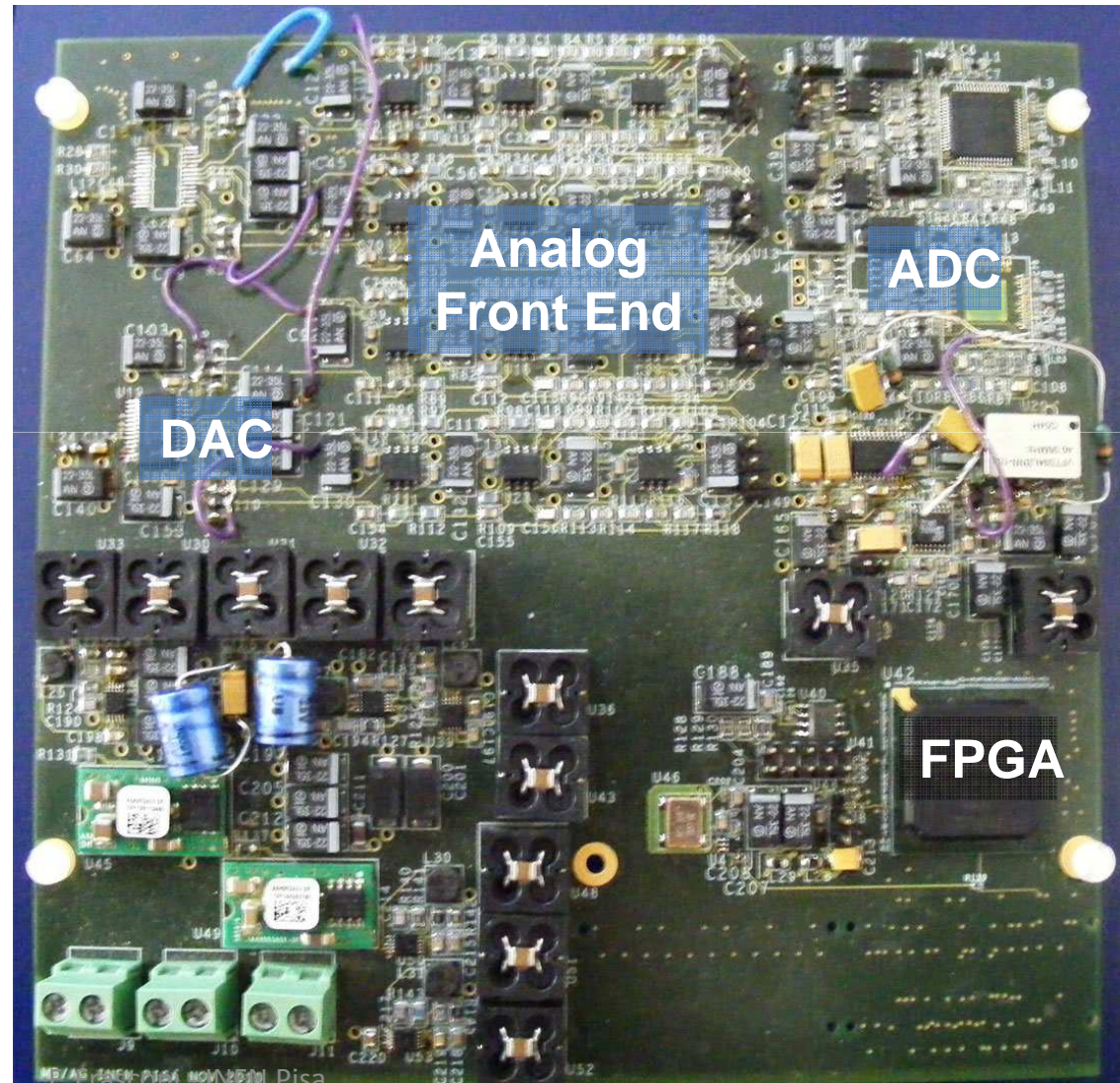
- The **control electronic** of the Superattenuator has been re-designed thanks to the acquired experience operating the VIRGO interferometer;
- It has a crucial role in the Superattenuator **hierarchical control** extending the AdV detection band in the low frequency region (below 5 Hz).

The IP Top Stage: feed-back control



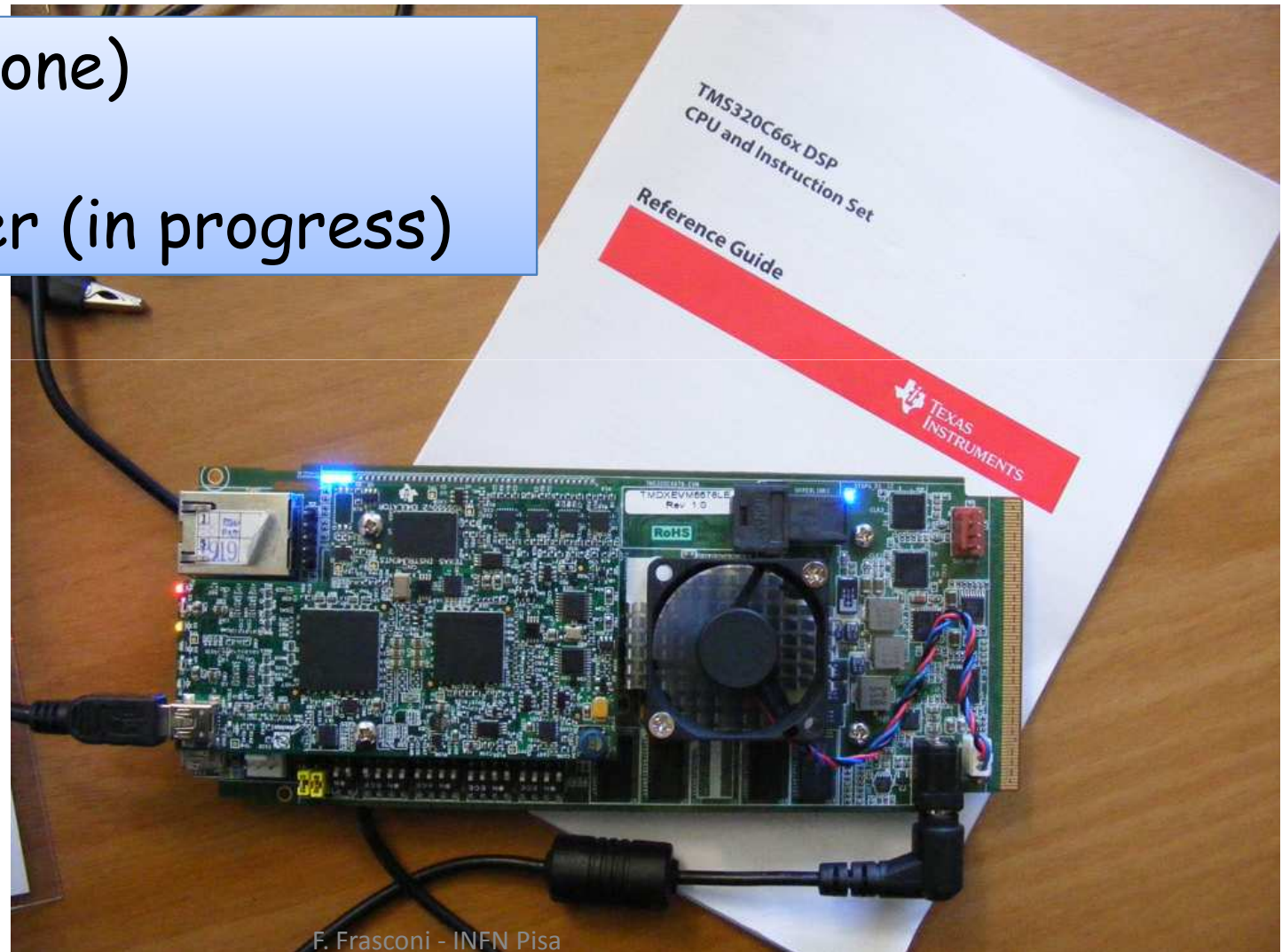
New Control Electronic

- Due to the obsolescence of the components the control electronic of the Superattenuator has been completely re-designed (the previous project was 15 years old !!);
- Analog and digital parts have been embedded in a single board.

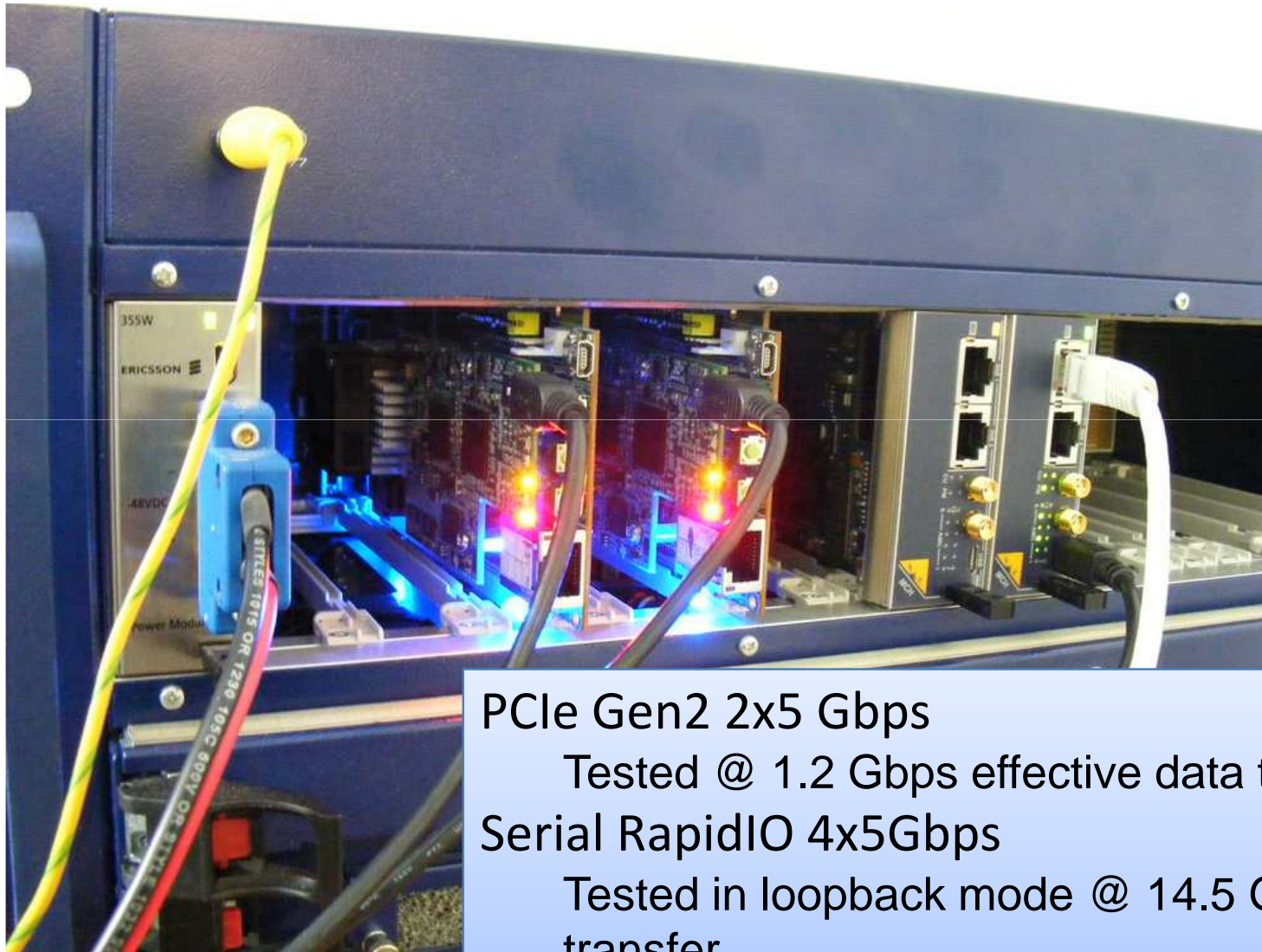


DSP Prototyping and Test

- DSP Boot (done)
- DSP Compiler (in progress)



DSP Communication Testing



PCIe Gen2 2x5 Gbps

Tested @ 1.2 Gbps effective data transfer.

Serial RapidIO 4x5Gbps

Tested in loopback mode @ 14.5 Gbps effective data transfer

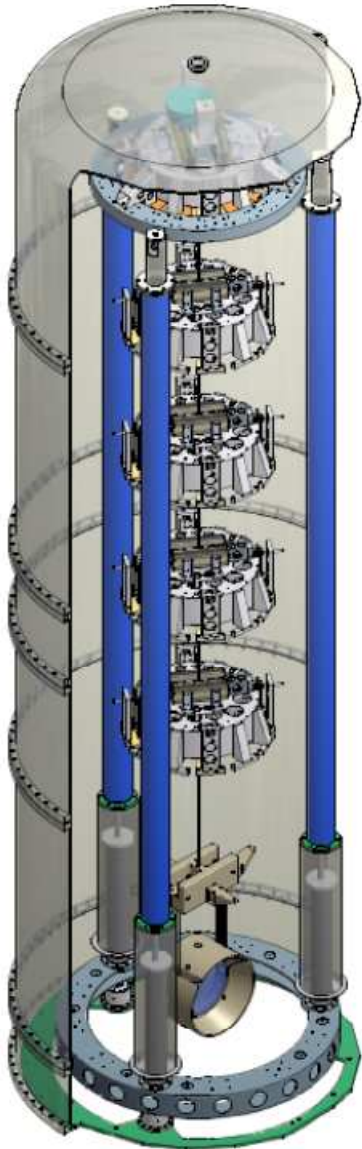
Board to board test in progress

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Complementary activity: SAFE

- The **SAFE Project** is based on the upgrades devoted to improve the feed-back control performance of the SA;
- A long VIRGO SA (with minor differences) to be used as a test bench has been assembled (filters not yet installed) on **EGO** site with:
 - more rigid pre-isolator stage (new IP with monolithic legs)
 - new Top Stage platform (no spurious resonances)
 - 3 PZT actuators (under the IP feet) for tilt control and vertical ID improvements;
- **Facility to be used during AdV Commissioning.**

SAFE: a suspension for Squeezed Light



- The vacuum volume is large enough to install a multi-stage pendulum with 4 standard filters and a suspended bench;
- The suspended bench will be used as a platform for a small interferometer as squeezed light source;
- The bench will be equipped with cantilever blades to improve seismic noise isolation performance on vertical d.o.f.;
- Its mechanical structure will be similar to that one designed for the Injection System (SIB) of AdV.



ISAV



Unione europea
Fondo sociale europeo



- Isolatori Sismici per Advanced VIRGO programma di formazione per giovani laureati della Regione Toscana & Comunita' Europea (POR CREO FSE 2007-2013)
- 3 *"Borse per innovazione e trasferimento tecnologico alle imprese con finanziamento della Regione Toscana"*
- Partnership con: Scienza Machinale S.r.l.
- Conclusione attivita': 31 Ottobre 2013 (- 3 FTE in 2014)

Support from INFN Pisa branch

- **Fully involved:** F. Frasconi, R. Passaquieti, D. Passuello, A. Gennai, V. Boschi;
- **Partially involved:** F. Fidecaro, C. Bradaschia, A. Giazotto;
- **Desiderata 2013-14:**
 - **mechanics:** A. Basti (0.7), A. Moggi (0.5);
 - **"alte technologie":** G. Balestri (0.8) + one technician (for filter assembling and installation team on EGO site);
 - **electronics:** C. Magazzu' (1) + Electronic Engineer
 - **electronic engineer (A. Kutynia arrived July 4, 2012):** contract extended up to the end of 2013 (Warsaw University, for 1.5 year);
 - **FAI request to extend his involvement up to June 30, 2014.**

Group Composition

Name	FTE	Author	Student	Activity
Allocca Annalisa	100%	Yes	Yes	Interferometer Sensitivity and Control
Basti Andrea	70%	Yes	No	SA Mechanics
Boschi Valerio	100%	Yes	No	SA Controls
Bradaschia Carlo	40%	Yes	No	Outreach coordinator, Vacuum AdV
Cella Giancarlo	100%	Yes	No	DA, Stochastic background & Continuous Waves
Di Lieto Alberto	40%	Yes	No	R&D on Optics
Di Virgilio Angela (?)	30%	Yes	No	Gyrolaser, DA on Noise studies
Ferrante Isidoro	70%	Yes	No	Data analysis and Noise studies
Fidecaro Francesco	100%	Yes	No	Noise Studies, AdV SA
Frasconi Franco	100%	Yes	No	AdV SA , R&D on Suspensions ,Cryogenics
Gennai Alberto	100%	Yes	No	AdV Control Electronics
Giazotto Adalberto	40%	Yes	No	Future itfs, VIR-LIGO Liason, Tiltmeters, AdV SA
Kutynia Adam	100%	Yes	No	SA Electronics
Moggi Andrea	50%	Yes	No	SA Mechanics
Passaquieti Roberto	100%	Yes	No	AdV SA
Passuello Diego	100%	Yes	No	AdV Control Electronics
Paoletti Federico *	100%	Yes	No	AdV Electronics
Poggiani Rosa	40%	Yes	No	R&D on Cryogenic, DA on Pulsar
Razzano Massimiliano	30%	Yes	No	DA, Electromagnetic follow-up
Tonelli Mauro	40%	Yes	No	R&D on Optics

~ 13 FTE

Financial Request (very preliminary)

- **Missioni Interne: 62 kEuro** (2013: 49 kEuro su 69 kEuro richiesti);
- **Missioni Estere: 27 kEuro** (2013: 22 kEuro su 34 kEuro richiesti);
- **Consumi: 17 kEuro** (2013: 15 kEuro su 18 kEuro richiesti)
 - 6 kEuro electronic lab maintenance
 - 6 kEuro SAFE & Suspension Labs maintenance
 - 3 kEuro cryogenic lab maintenance
 - 2 kEuro material for clean room
- **Inventario: -- kEuro** (2013: 32 kEuro per Analizzatore di Spettri)

Financial Request (very preliminary) (cont.)

- **Costruzione apparati: 20 kEuro** (2013: 22 kEuro su 22 kEuro richiesti)
 - 8 kEuro large baffle prototyping
 - 6 kEuro suspended bench with blades for SAFE
 - 6 kEuro thermal blankets for SAFE vacuum tank
- **TOTALE: 126 kEuro** (2013: 108 kEuro su 175 kEuro richiesti)

Final Considerations

- AdV detector introduced different changes with respect to the original project with **important impact** on the SA:
 - **New design of F7**
 - **Re-tuning of all seismic filters**
 - **New IP structures**
 - **Construction of a complete suspension for SR mirror** to be compliant with new payload geometry, new mirrors and **large baffles** for diffused light mitigation;
- Up-grade process on short SA in progress;
- **New control electronics for SA;**
- **SAFE** as test facility for AdV commissioning to be used also in **PRIN on squeezed light** for future interferometers;
- Interferometer re-start delayed of about 9 months.