Laboratoire d'Annecy-le-Vieux de Physique des Particules

Ground Motion spectra status

A.Jeremie on behalf of the DESY EUROTeV group which ceased to exist mid-2008 :

R.Amirikas, A.Bertolini and W.Bialowons (et al)

CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE

IN2P3 Institut National de Physique Nucléaire et de Physique des Particules

UNIVERSITE SAVOIE CHAMBERY ANNECY

WP7 Deliverables:

- 1 Prototype mechanical stabilisation system.
- 2 Prototype laser-based stabilisation system
- 3 3 and 5 car prototypes of laser-based RTRS system.
- 4 Database (with public web interface) of catalogued and characterised ground vibration spectra.

Relevant EUROTeV reports

- 1) EUROTeV-Report-2005-007, Ground Vibration Measurements at the Proposed ALBA Site in Barcelona, W. Bialowons, H. Ehrlichmann
- 2) EUROTeV-Report-2005-023, Ground Motion and Comparison of Various Sites, R. Amirikas, A. Bertolini, W. Bialowons, H. Ehrlichmann
- 3) EUROTeV-Report-2006-033, Measurement of Ground Motion in Various Sites, Wilhelm Bialowons, Ramila Amirikas, Alessandro Bertolini, Dirk Krücker
- 4) EUROTeV-Report-2007-011, Measurement of Ground Motion in Various Sites, Wilhelm Bialowons, Ramila Amirikas, Alessandro Bertolini, and Dirk Krücker
- 5) EUROTeV-Report-2007-024, Introducing a Homepage for Information Retrieval and Backup of Ground Vibration Measurements and Mechanical Vibrations of Superconducting Modules at DESY, R. Amirikas, M. Kubczigk

DESY Ground Vibrations Database, a Snapshot

Overview of Measured Sites - Microsoft Internet Explorer

http://vibration.desy.de/overview/index_eng.html

vibration.desy.de

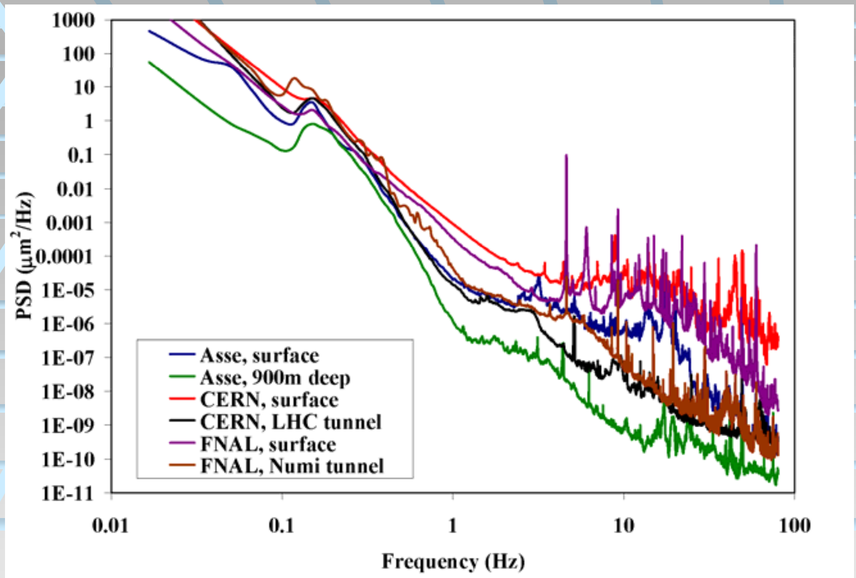
Overview of Measured Sites

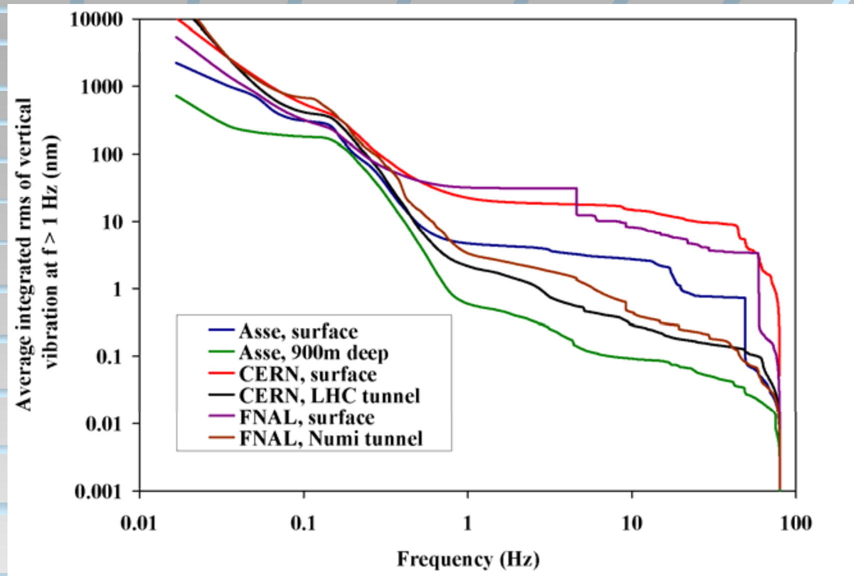
Overview of Measured Sites (Vertical Direction)

Site location	Average rms (nm)	σ (nm)	Day rms (nm)	Night rms (nm)	Pk-Pk (nm)	FWHM (nm)
ALBA, Barcelona, Spain	18.8	9.5	42.0	9.1	88.6	122.0
APS, Argonne, U.S.A.	10.7	1.0	11.0	9.8	68.5	57.7
Asse, Germany (salt mine)	0.6	0.1	0.7	0.5	13.1	35.4
BESSY, Berlin, Germany	75.0	28.1	140.7	53.1	249.3	158.4
BNL, Upton, U.S.A.	89.6	30.2	135.3	29.1	383.6	558.2
CERN LHC, Geneva, Switzerland	1.9	0.8	2.8	0.9	21.6	54.1
DESY HERA, Hamburg, Germany	53.3	18.9	77.0	34.8	178.4	204.3
DESY XFEL, Osdorf, Germany	29.1	11.9	48.4	19.5	147.9	196.9
DESY XFEL, Schenefeld, Germany	41.1	16.6	70.0	35.1	179.6	245.3
DESY, Zeuthen, Germany	64.4	40.4	75.6	66.5	115.3	240.0
Ellerhoop, Germany (TESLA IP)	18.2	8.4	35.9	9.3	102.0	162.4
ESRF, Grenoble, France	74.0	34.9	137.2	40.2	163.3	179.8
FNAL, Batavia, U.S.A.	3.0	0.9	4.0	2.2	24.4	49.1
IHEP, Beijing, China	8.5	0.5	9.0	8.1	49.5	18.6
KEK, Tsukuba, Japan	80.5	36.0	125.1	38.0	228.4	277.0
LAPP, Annecy, France	3.6	1.6	7.0	1.9	35.7	66.3
Moxa, Germany (seismic station)	0.6	0.1	0.9	0.5	7.9	16.8
SLAC, Menlo Park, U.S.A.	4.9	1.2	7.4	4.1	61.4	117.9
Spring-8, Harima, Japan	2.0	0.4	2.5	1.8	22.4	40.3
SSRF, Shanghai, China *	292.0	164.0	444.0	102.0	550.0	1000.0

* this site was under construction during the measurements

Examples: Variation vs. Tunnel Depth





rms @ f > 1 Hz (surface)
Asse: 5 nm
CERN: 22 nm
FNAL: 32 nm

rms @ f > 1 Hz (depth)
Asse (900 m underground): 0.5 nm
CERN (LHC tunnel): 2 nm
FNAL (Numi tunnel): 3 nm

Our Homepage:
http://vibration.desy.de

Our homepage is a venue for communication, retrieval & backup of our database. It uses AFS volumes to store our database:

- Raw data, FFT data
- Minute by minute PSDs & averages (15 minutes)
- PSD & rms spectra, variation vs. Time for each site, spectra of noisiest and quietest times of the day for each site and their corresponding rms
- A program to display spectra
- Documents
- Everything is downloadable.

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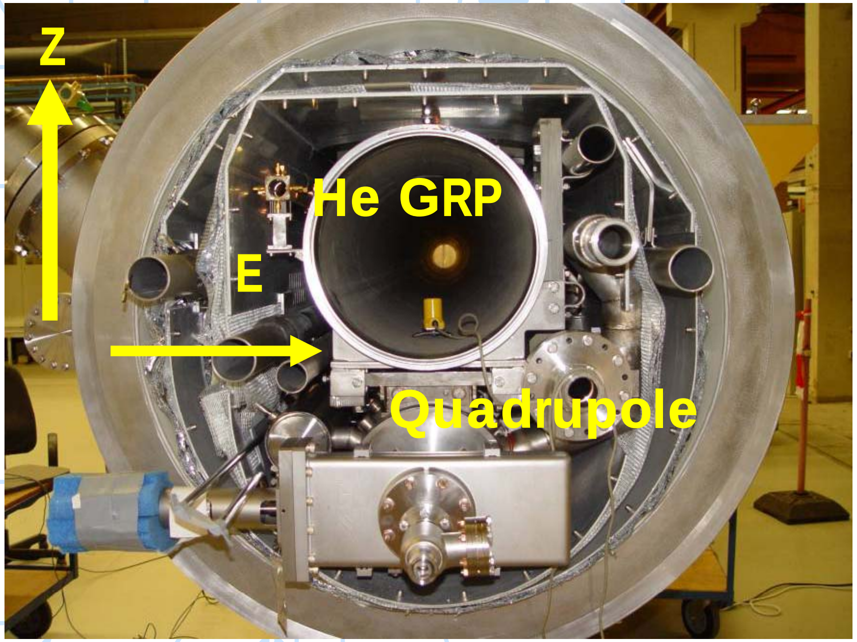
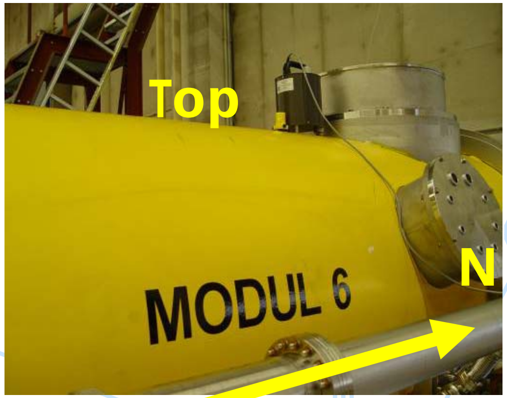
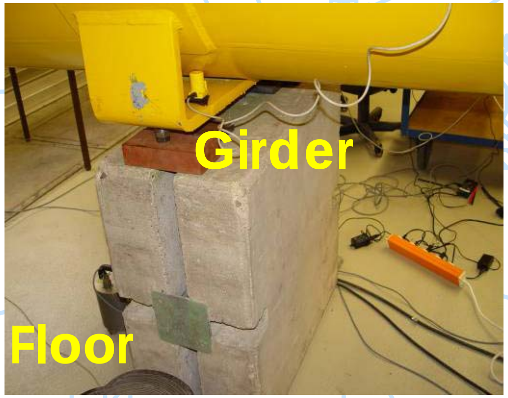
After that, we expanded our activities in the following directions:

- 1) Effects of cryogenic operation parameters on the mechanical stability of the linac modules during beam operation in FLASH. This was published in the recent EPAC'08: http://cape.elettra.eu/E08Papers/WEPP075.PDF
- 2) XFEL mock-up tunnel vibration measurements
- 3) Module 8, a type III+ vibration tests, including test of its new 4.5 K cryogenic shield design. An abstract at FEL'08 August 24-29 2008 in Korea (TUPPH078).
- 4) Recommendations for vibration measurements during module 8 transport to/from Saclay.

=>most results presented at EUROTeV Workshops and published







Some definition

x(t), y(t)	time series of length T, N points each
$X(\nu_i)$, $Y(\nu_i)$	FFT
<XX*>, <YY*>	Estimated displacement power spectral density (PSD)
$\frac{\lvert\langle XY^*\rangle\rvert^2}{\langle XX^*\rangle\langle YY^*\rangle}$	Coherence
$\sqrt{\frac{\lvert\langle XY^*\rangle\rvert}{\langle XX^*\rangle}}$	Transfer function amplitude
$\sqrt{\frac{1}{T}\sum_{i=k}^{N/2}\langle XX^*\rangle(\nu_i)}$	Integrated RMS amplitude at frequency ν_k

Sensors

	CMG-6TD	geophone
n.axis	triaxial	single axis
frequency range	0.033-80 Hz	1.7-350 Hz
accuracy	0.5%	3%
rms noise >1Hz	<0.02 nm	2 nm

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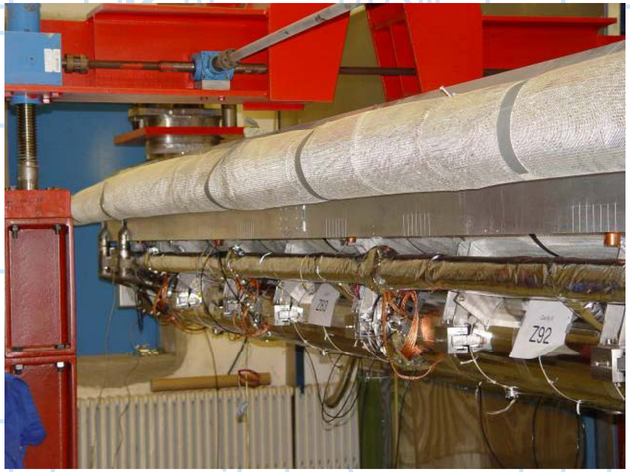
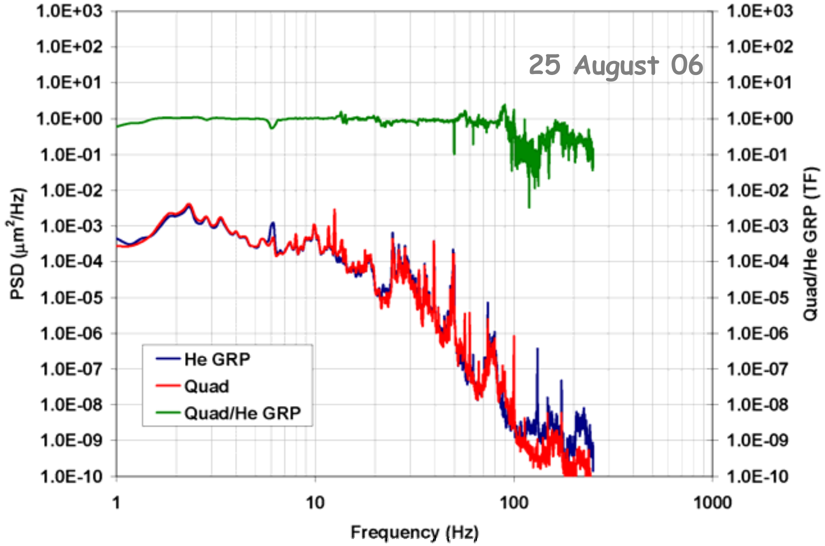
Type III design very stiff as expected with no internal resonances up to 100 Hz both in horizontal and in vertical.

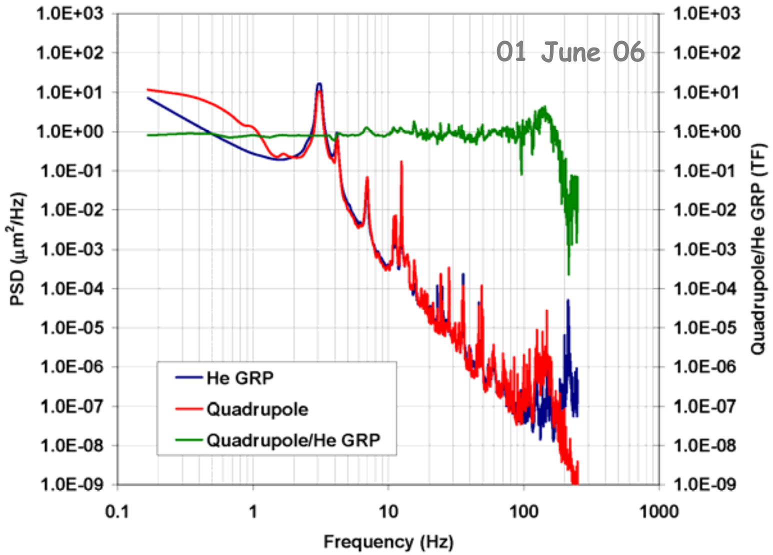


Module 6 cold mass on the assembly stand in DESY Hall III

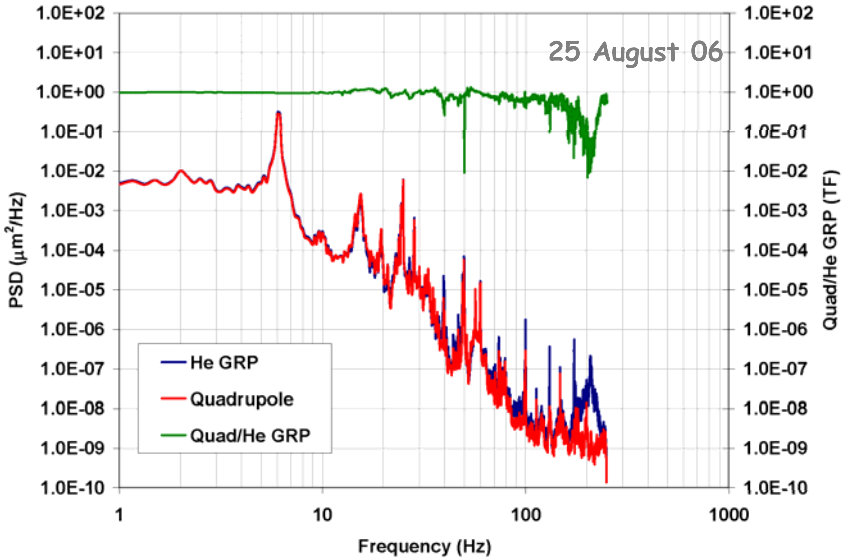
Vertical / Module 6 on CMTB



Horizontal transverse / CM assembly stand



Horizontal transverse / Module 6 on CMTB



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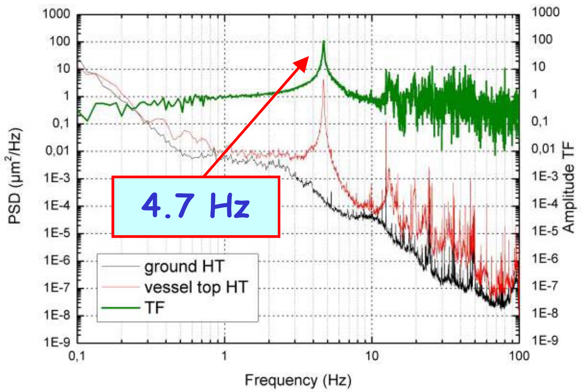
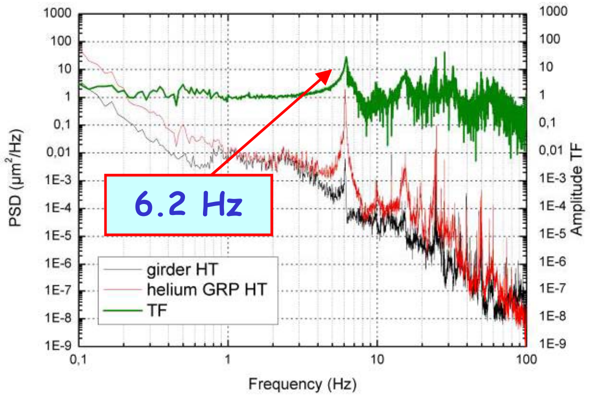
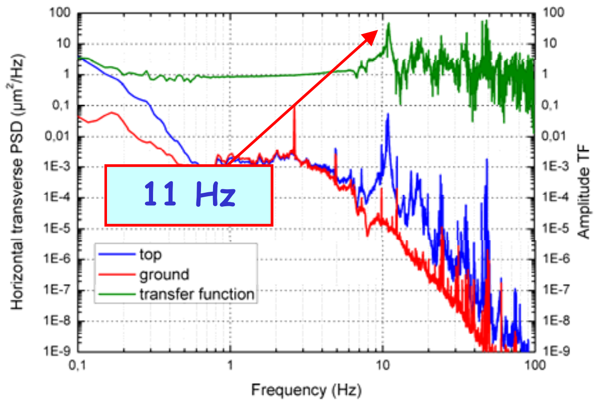
Hall III

CMTB-installation

CMTB-with endcaps







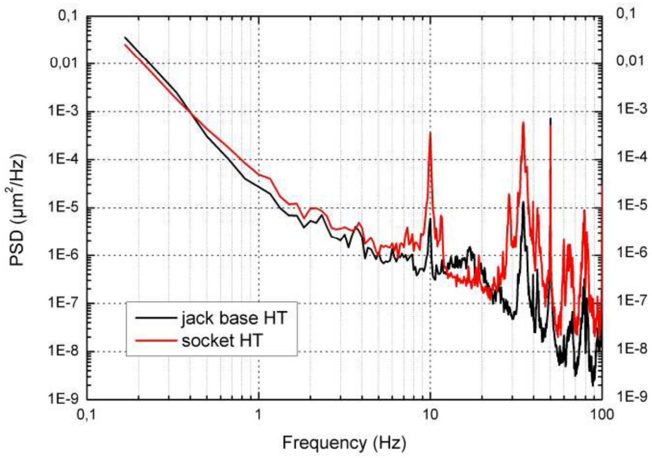
Effect of the support configuration+boundary conditions (pipe weldings+bellows) on the lowest frequency horizontal transverse mode with the clear stiffening after pipe weldings and closing the bellows

The cryostat on its support system behaves like a compound pendulum with normal modes (rocking+translational) at low frequencies that dominates the RMS amplitude together with technical noise sources. At present the support design looks the most relevant engineering issue to ensure dynamic stability to the cryomodule.

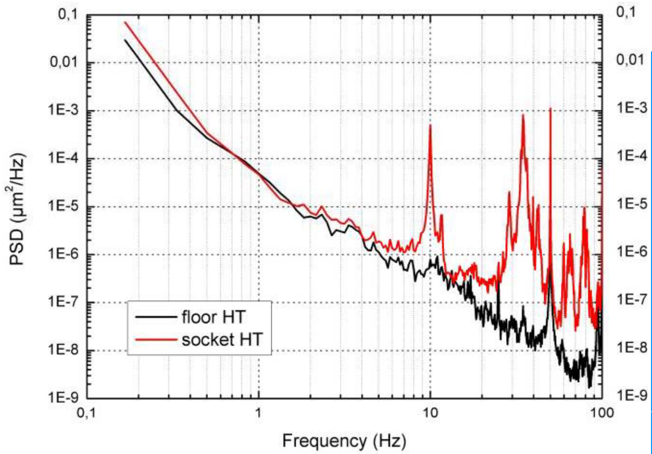
LHC Low ß Quadrupole

Effect of the support foundation

Vessel socket vs jack base



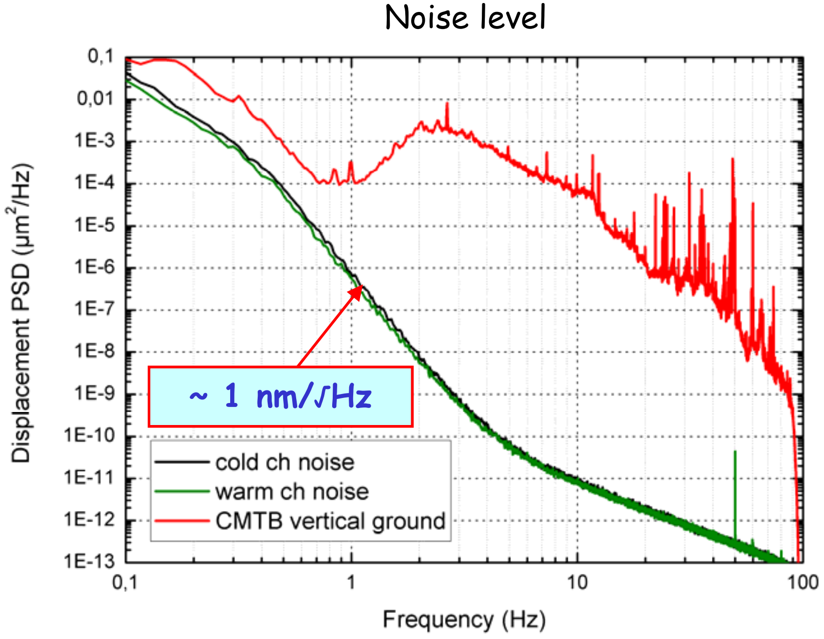
Vessel socket vs floor

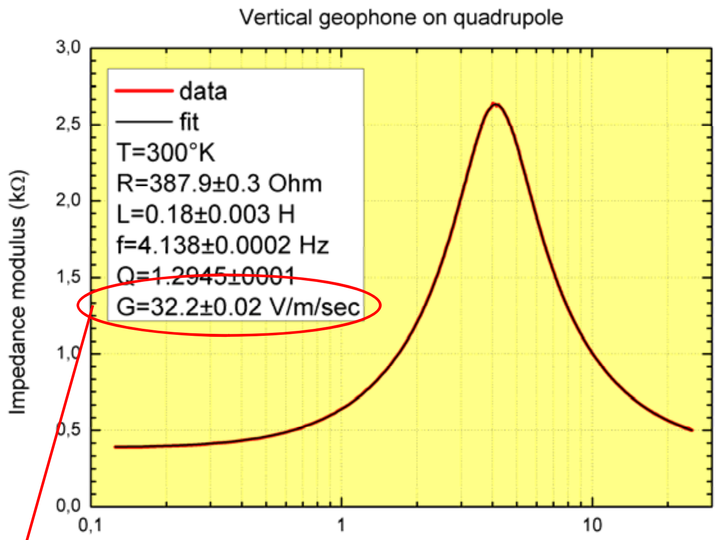


- **the transverse mode structure already visible at the interface between the jack and the concrete pad, but not in the floor**
- **the enlarged contact surface produces significant benefits on the dynamic stability of the module**

the results of the measurements on this short quadrupole cryostat look promising for the use of the alignment jacks for the ILC linacs, after suitable modifications

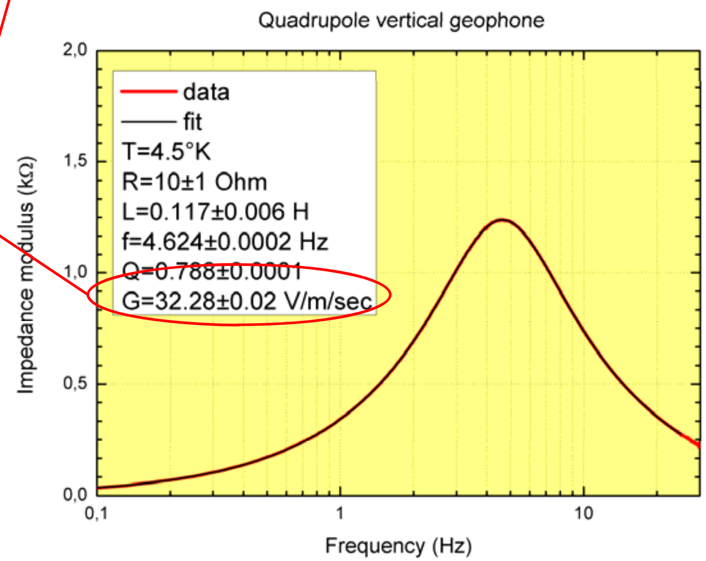
Commercial geophones have shown nanometer level resolution from 1 Hz even at liquid He temperatures and remote calibration capability

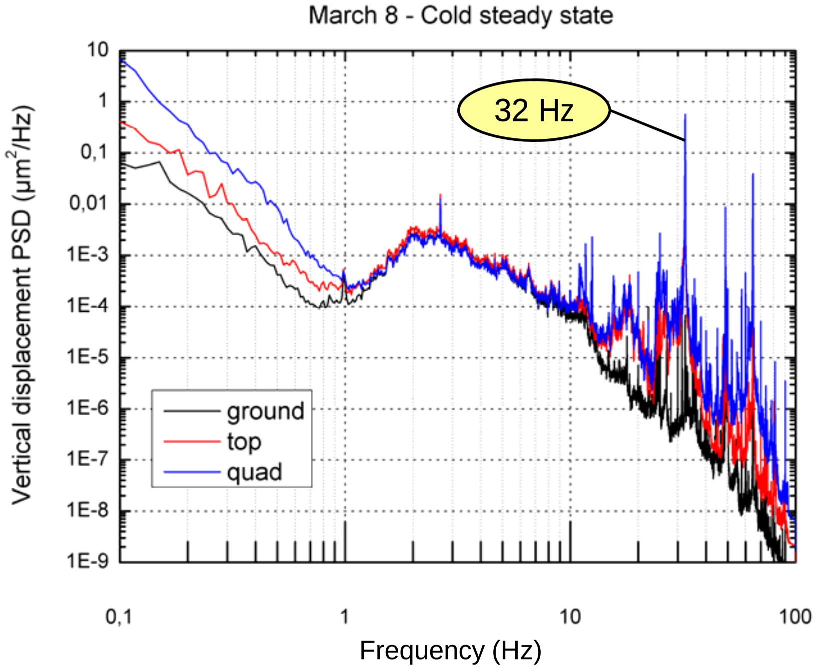


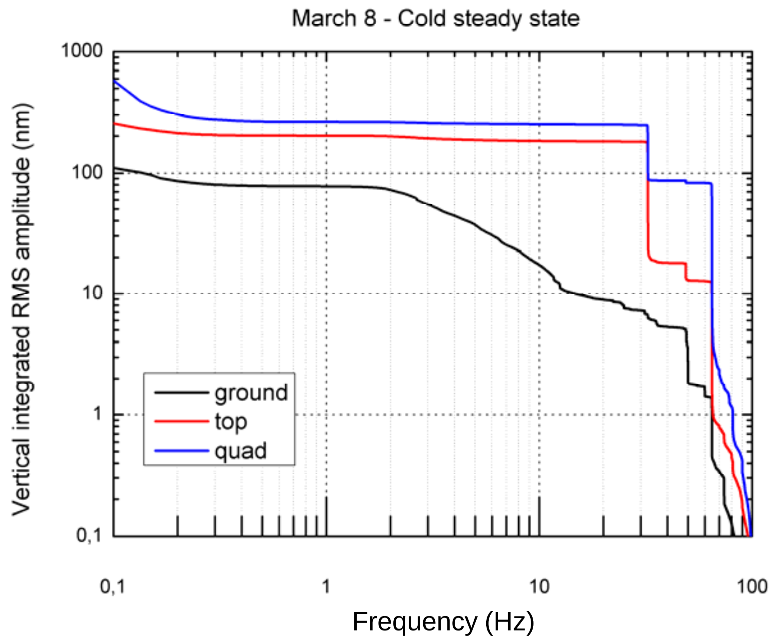


Oyo Geospace GS11D

No loss of sensitivity at liquid helium temperature !!



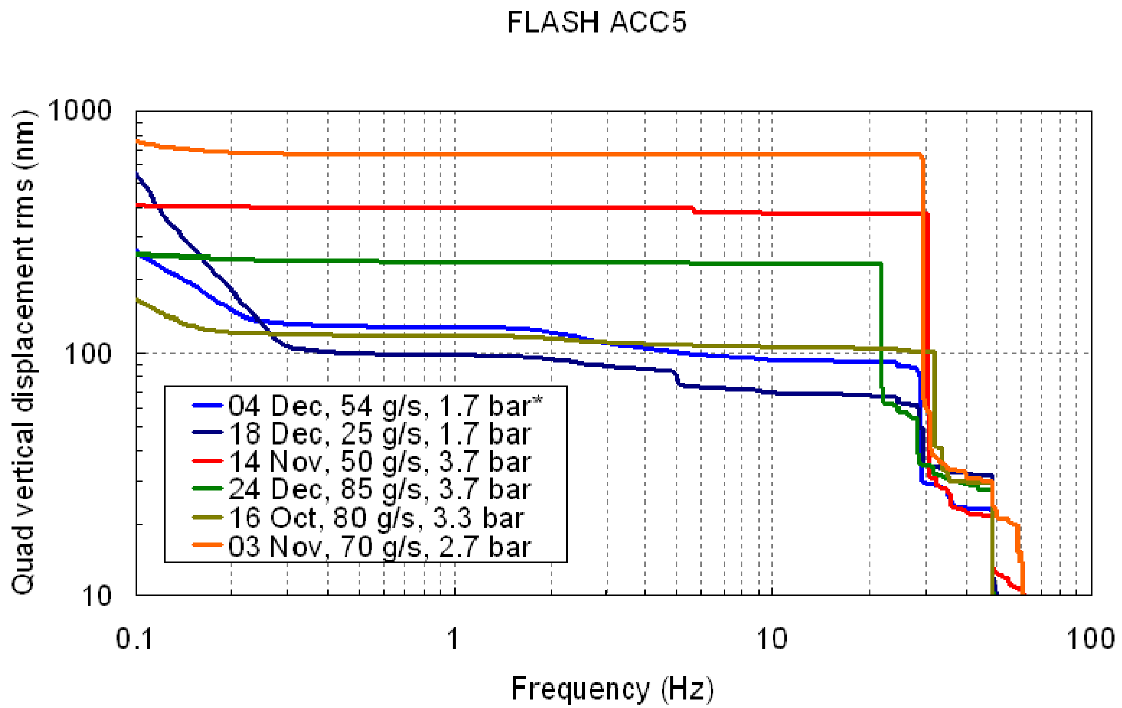




- low frequency (1-100 Hz) quadrupole vertical stability not affected by high gradient RF operation

- quadrupole vertical stability not affected by the refrigeration system at frequencies up to 30 Hz; results not conclusive at higher frequency because of the onset of a thermal acoustic oscillation in a diagnostic pipe upward of the 4.5K LHe forward line.

- high level of vibrations (up to 600 nm RMS) correlated with the parameters of the 4.5K line



General comments

Three typical behaviour observed as a function of the pressure:

- **Low pressure (1.5-1.7 bar) -> low noise**
- **Intermediate pressure (2.7-3.3 bar) -> appearance of a strong line around 30 Hz**
- **High pressure (3.7 bar) -> ~30 Hz line plus a low frequency line around 6 Hz**

No systematic dependence on the flow.

Disturbances have the same frequencies along the whole linac.

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