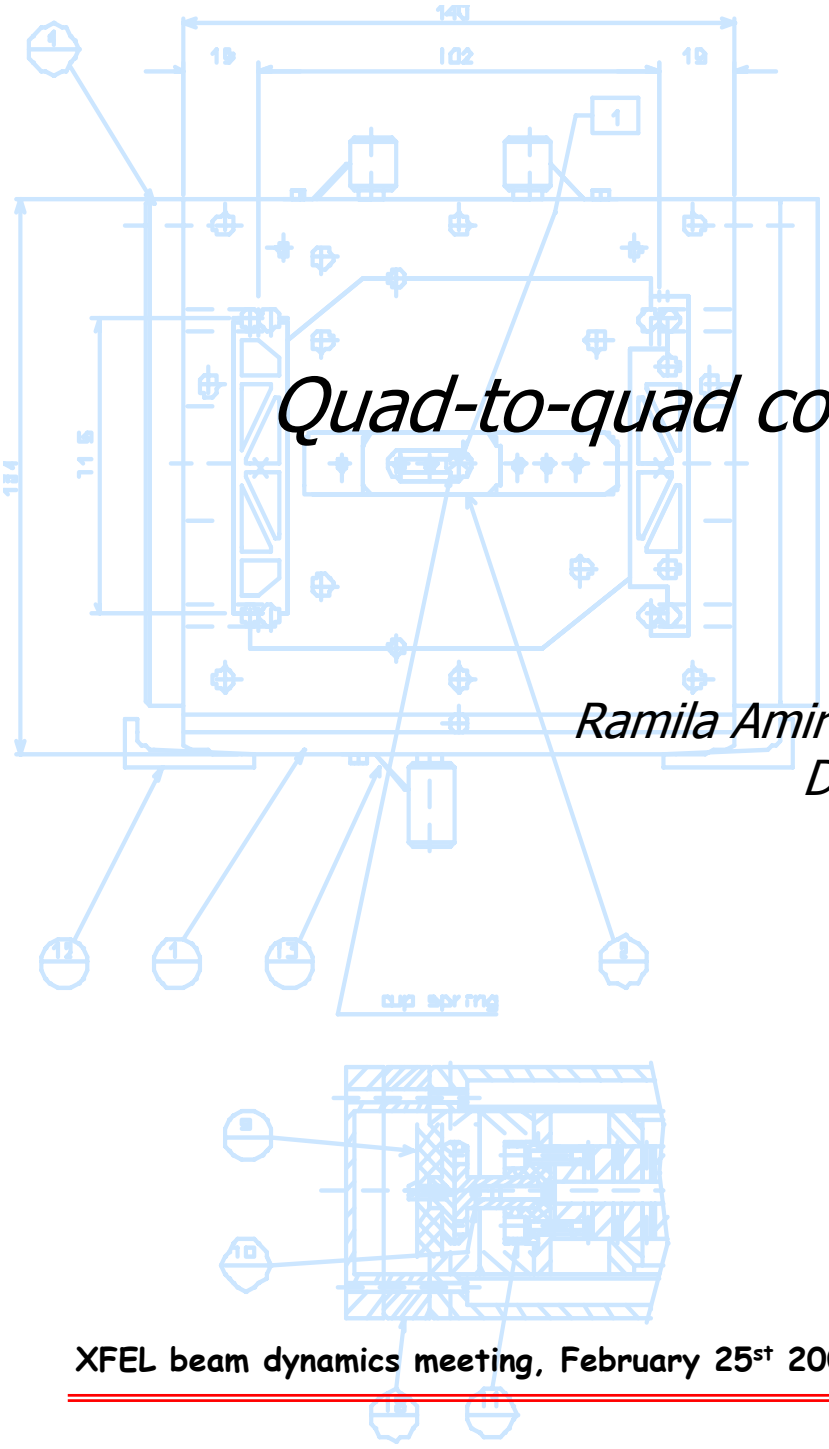
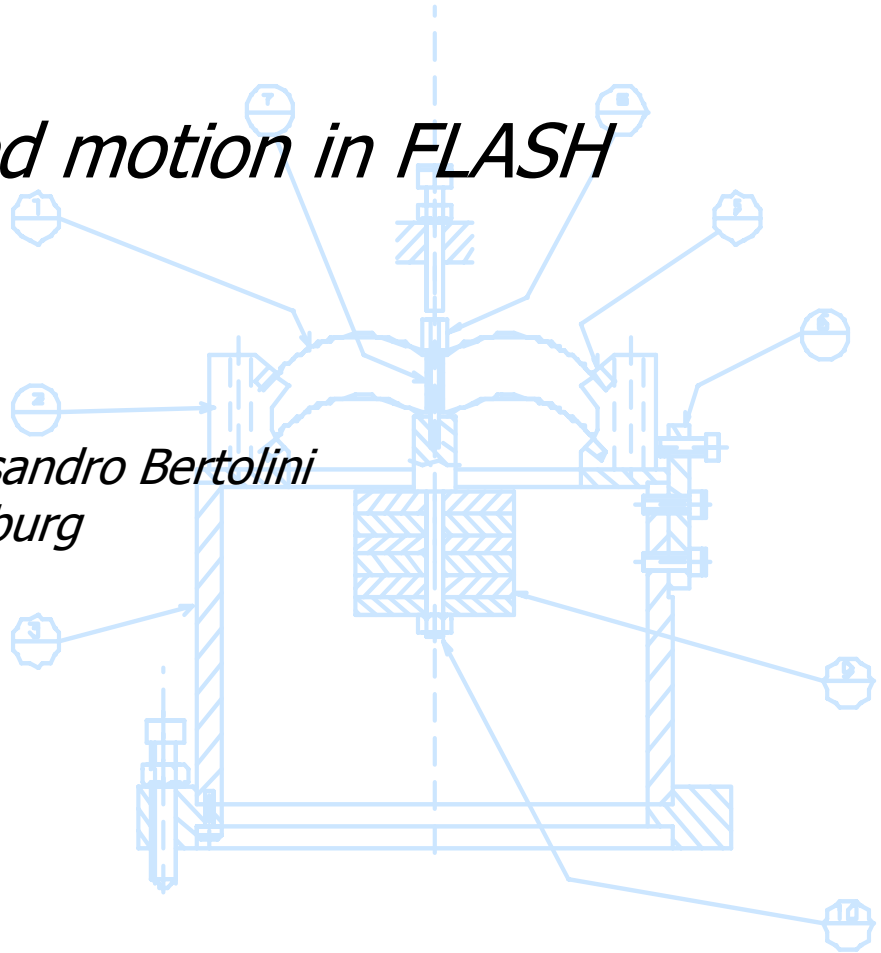


Quad-to-quad correlated motion in FLASH

Ramila Amirikas, Alessandro Bertolini
DESY Hamburg



The experiment - continuous monitoring of vibrations in the string of three Type III cryomodules + ACC3 during normal machine operation.

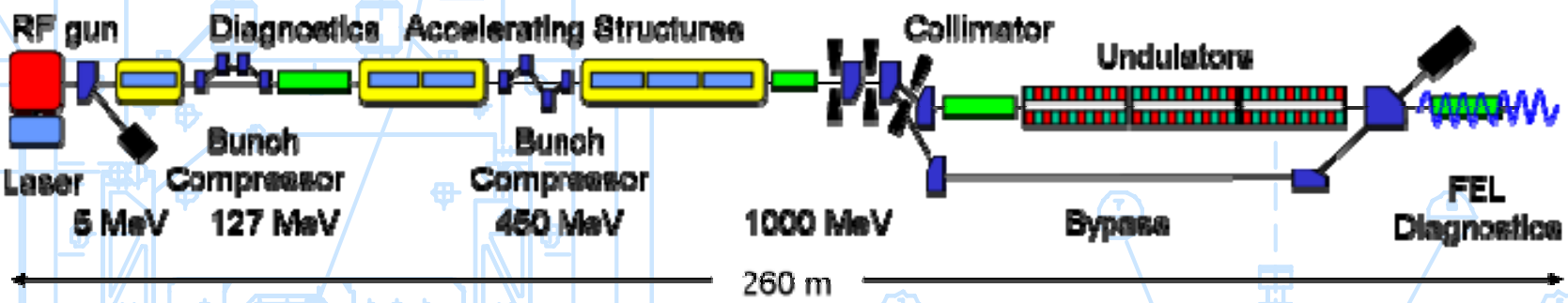
Goals

- evaluate the impact of the cryogenic plant on the mechanical dynamic stability of the linac, and compare it to the other sources of vibrations (ground motion, insulation vacuum system, etc.)

- study possible vibrations induced on quadrupoles (and cavities) by the 4.5K and 70K shields

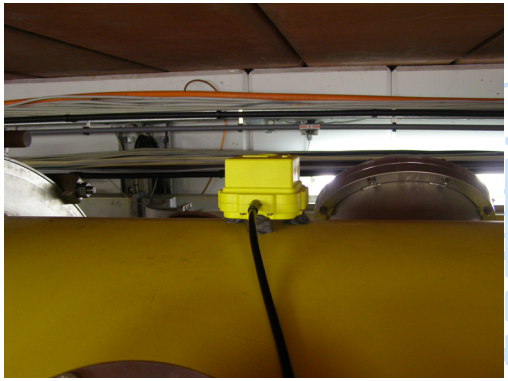
- quantitative measurement/ correlation of high level `microphonics` on the stability of the cavities

- quantitative measurement of the correlated motion between adjacent quadrupoles at both XFEL and ILC-like quad distance, for beam dynamics studies

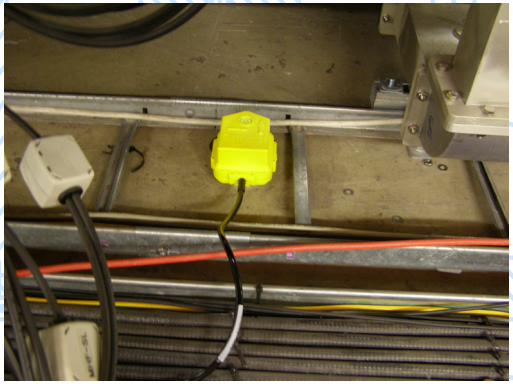


*The string of three Type III cryomodules (ACC4,5,6) has been instrumented with inertial velocity sensors (geophones). Each quadrupole is equipped with a single axis vertical sensor (even horizontal but they are not working, replacement from Sensor BV tested successfully); a triaxial geophone is placed on top of the main vessel (quad side) of each cryomodule. A further triaxial sensor is placed, as a reference, on the tunnel floor underneath ACC5.

Geophones on the quad He vessel

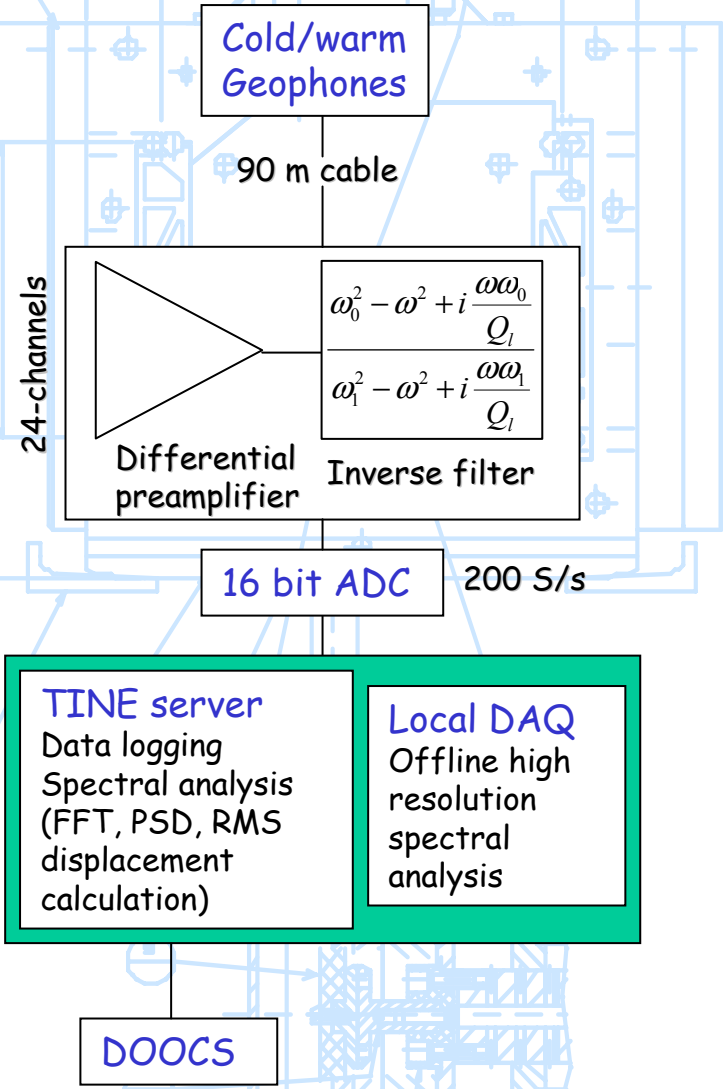


Triaxial sensor on vessel top



Reference sensor on tunnel floor

*ACC3 (Type II) is also similarly instrumented for correlated motion studies at ILC-like quad distance.



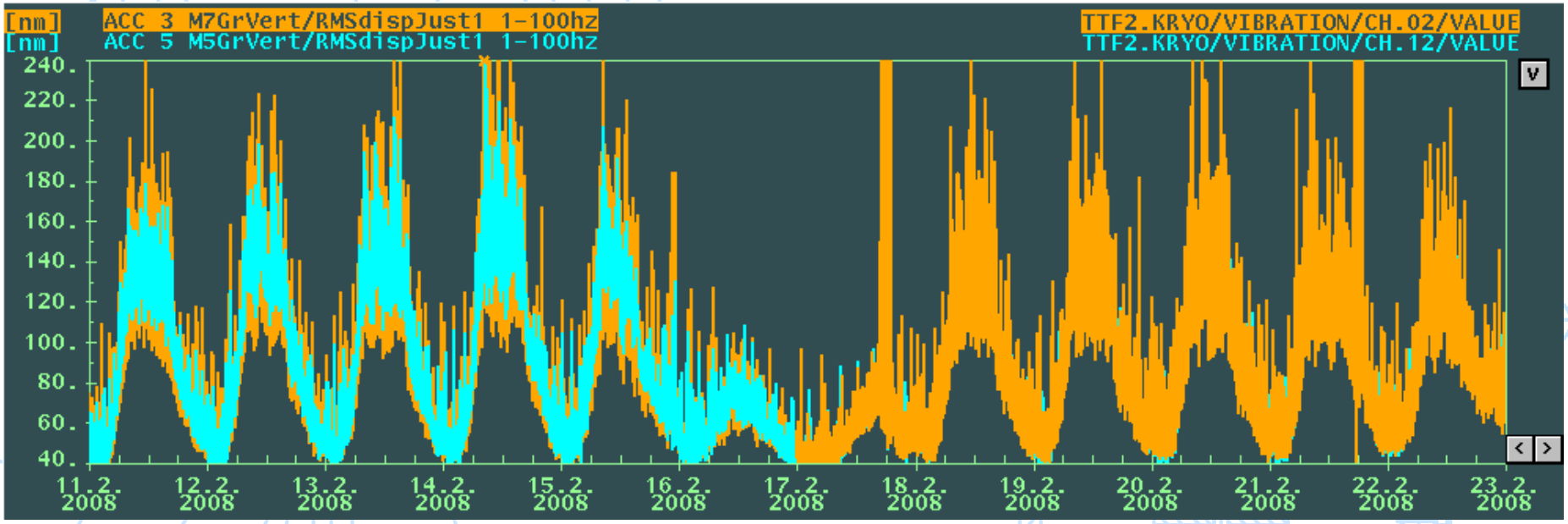
Some definitions

$x(t)$, $y(t)$	velocity time series of length T, N points each
$X(\nu_i)$, $Y(\nu_i)$	FFT
$\frac{XX^*}{(2\pi\nu_i)^2}$, $\frac{YY^*}{(2\pi\nu_i)^2}$	displacement power spectral density
$\sqrt{\frac{1}{T}\sum_{i=k}^{m} XX^*/(2\pi\nu_i)^2}$	RMS displacement in the frequency band (ν_k, ν_m)
$\frac{Re\{<XY^*>\}}{\sqrt{<XX^*><YY^*>}}$	correlation

What you see in the DOOCS display

the RMS displacement, integrated over the 1-100 Hz and 20-40 Hz frequency bands, measured during the last 20.5 sec, updated every ~1 second

*Vertical ground motion history (ACC3 and ACC5)



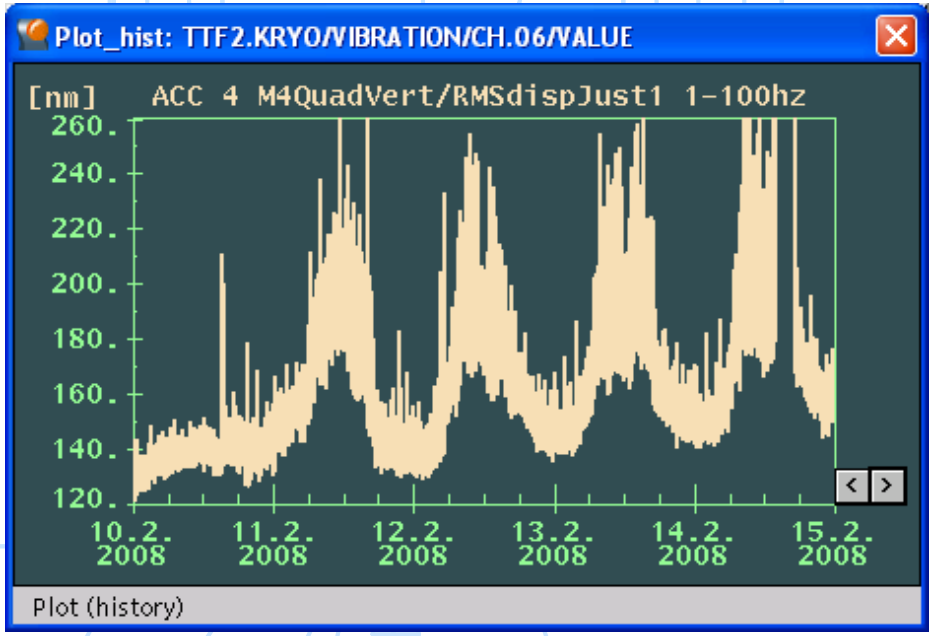
-Lowest vibration amplitude `thinkable`for the quadrupoles in the FLASH linac

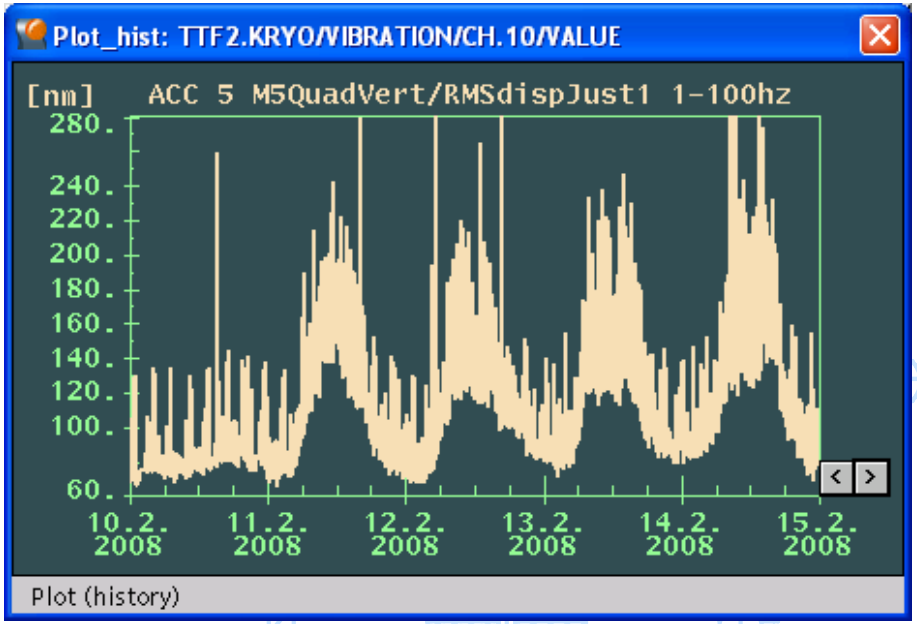
-'cultural noise' dominated with clear day/night and weekend variations

-range from 50 to 140 nm RMS (most part in the 1-7 Hz frequency band)

*displacement PSD integrated in the 1-100 Hz band

Vertical quad motion history (ACC4 and ACC5)

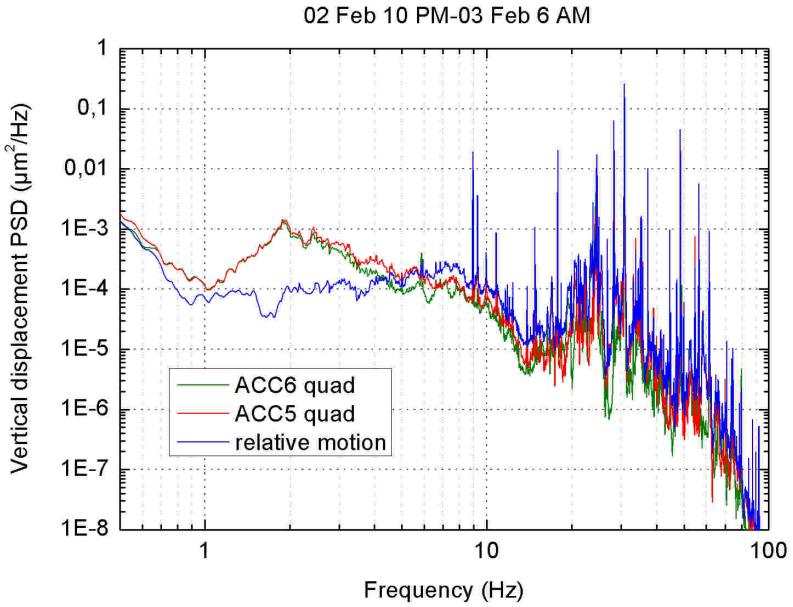


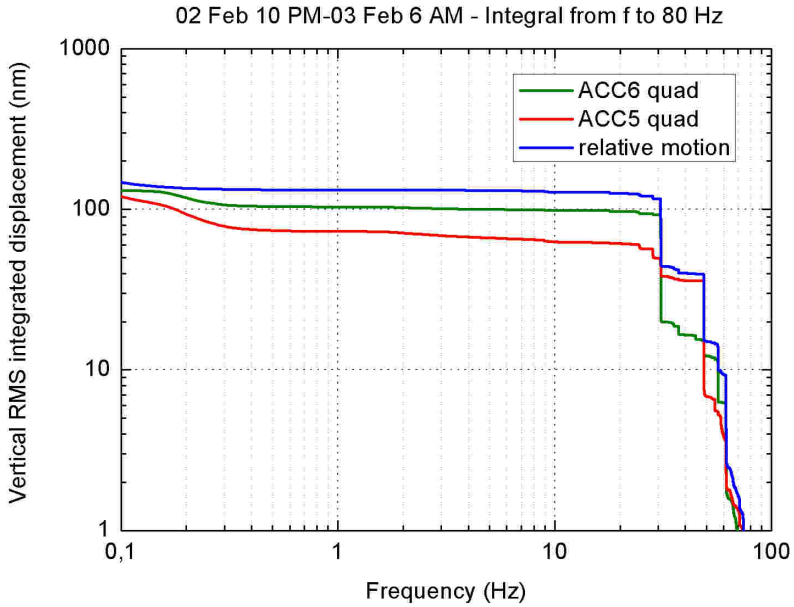


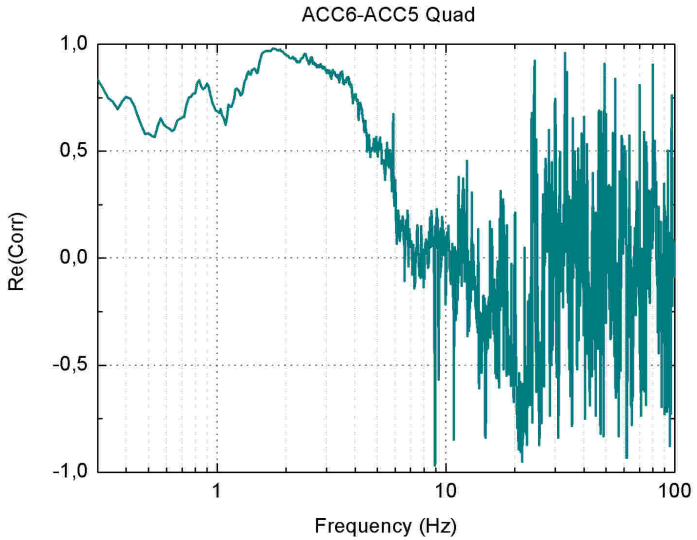
-'cultural noise' effect still present but on top of a much larger background due to the contribution of technical noise sources (isovac pumps, compressors, etc.) in the 20-50 Hz band

-as expected ACC5 is quietest of the string of three Type III modules (no isovac directly connected)

-range (ACC5) from 80 to 160 nm RMS (+70-100% expected in the horizontal transverse direction from our experience on CMs at room temperature, due to rocking modes of the vacuum vessel on the support system)



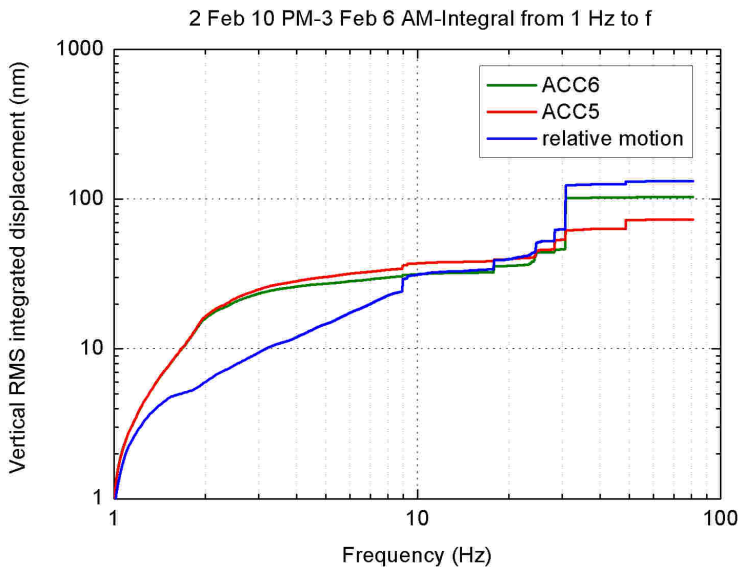




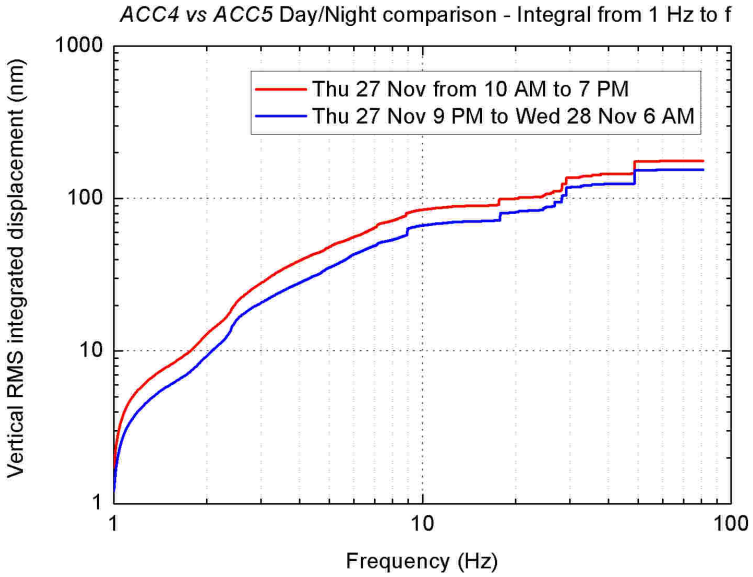
-Substantial suppression of the common mode up to ~6 Hz where the correlation function goes to zero

-differential motion dominated by technical noise sources

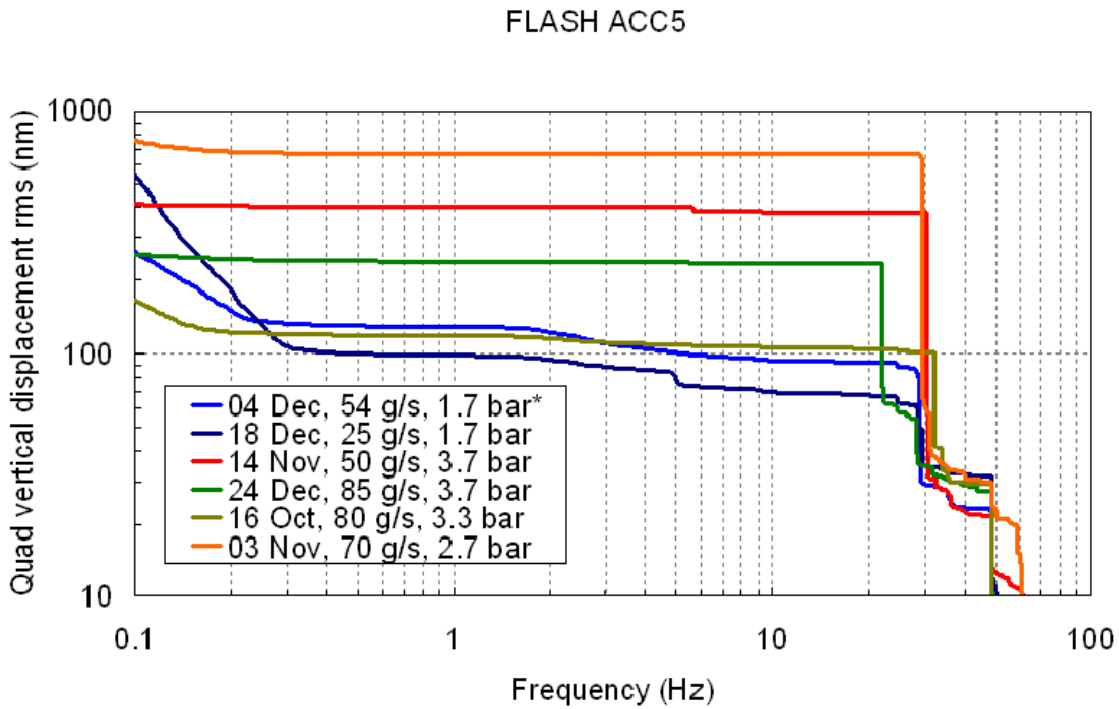
A different view…



Day/night relative motion



Now the linac is relatively quiet but much worse conditions have been observed in the last months…



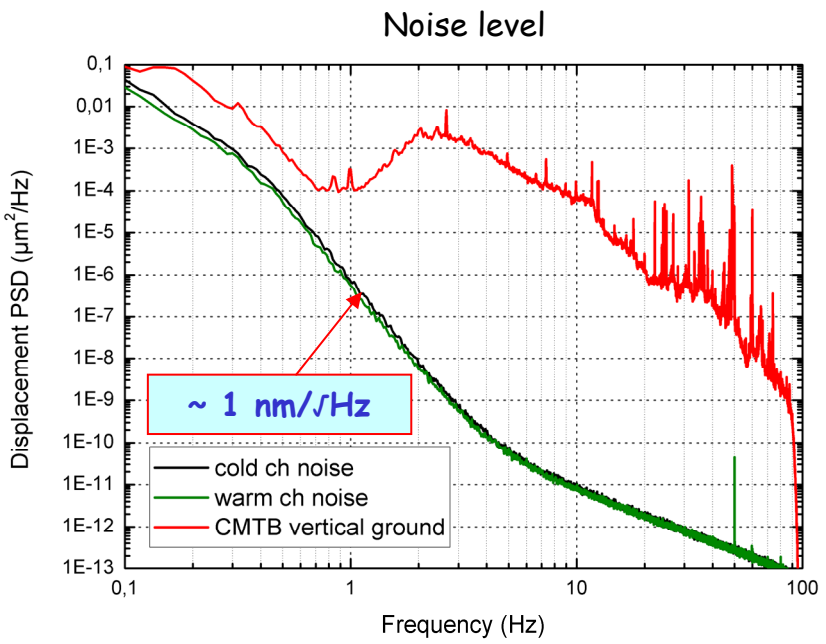
General comments

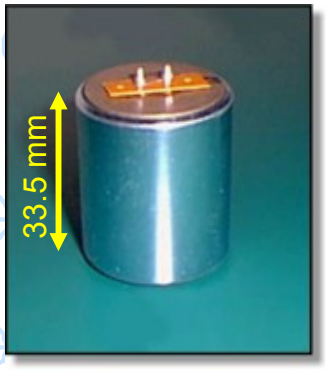
Three typical behaviour observed as a function of the pressure:
- Low pressure (1.5-1.7 bar) -> low noise
- Intermediate pressure (2.7-3.3 bar) -> appearance of a strong line around 30 Hz
- High pressure (3.7 bar) -> ~30 Hz line plus a low frequency line around 6 Hz

No systematic dependence on the flow.

Disturbances have the same frequencies along the whole linac.

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 !!