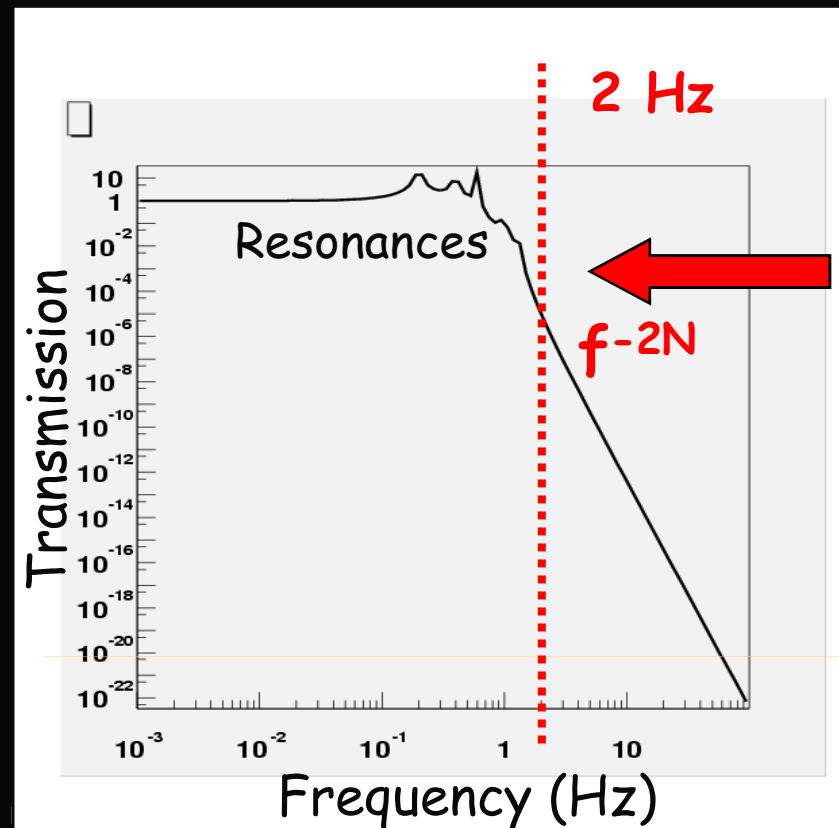
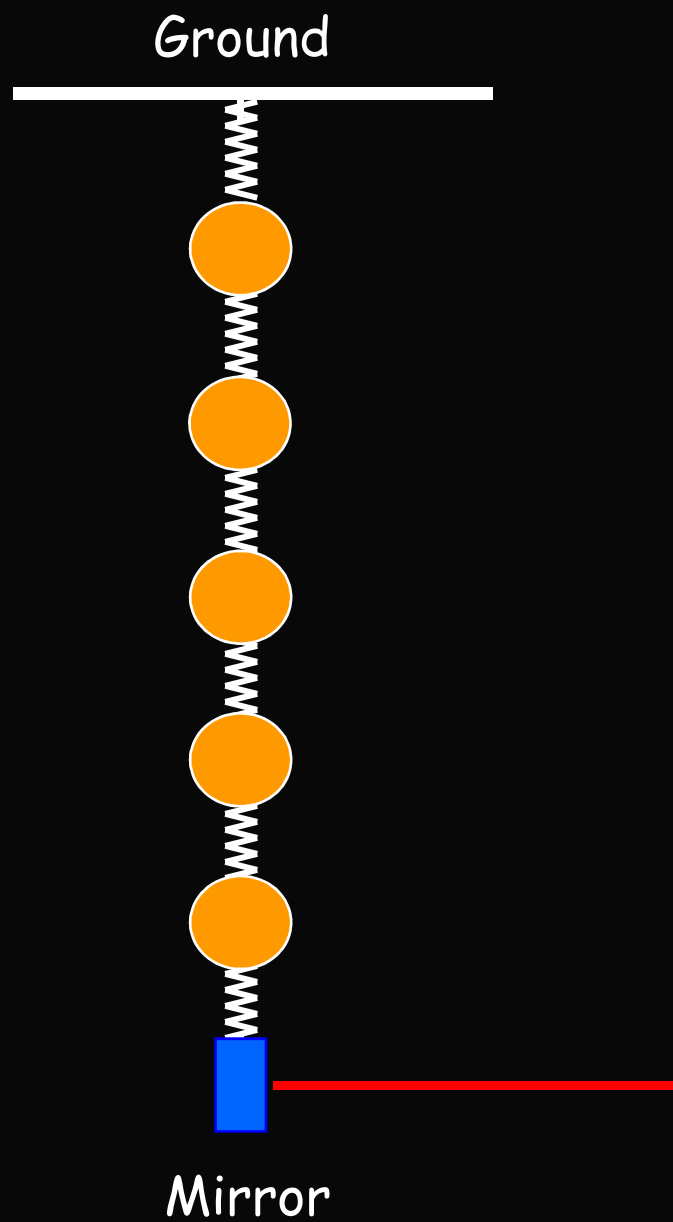


**Present Superattenuator performance  
vs.  
ET Requirements**

*S. Braccini - VIRGO  
for WG2 group*

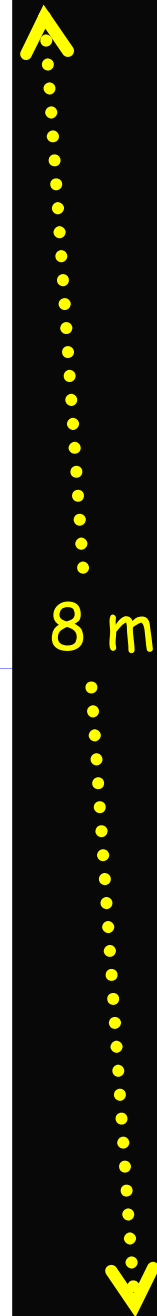
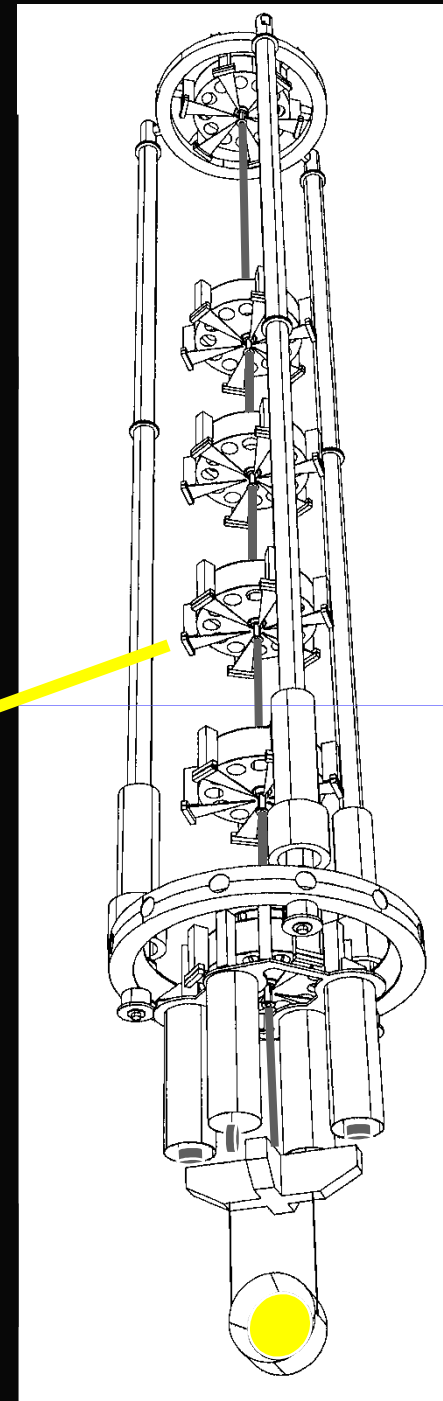
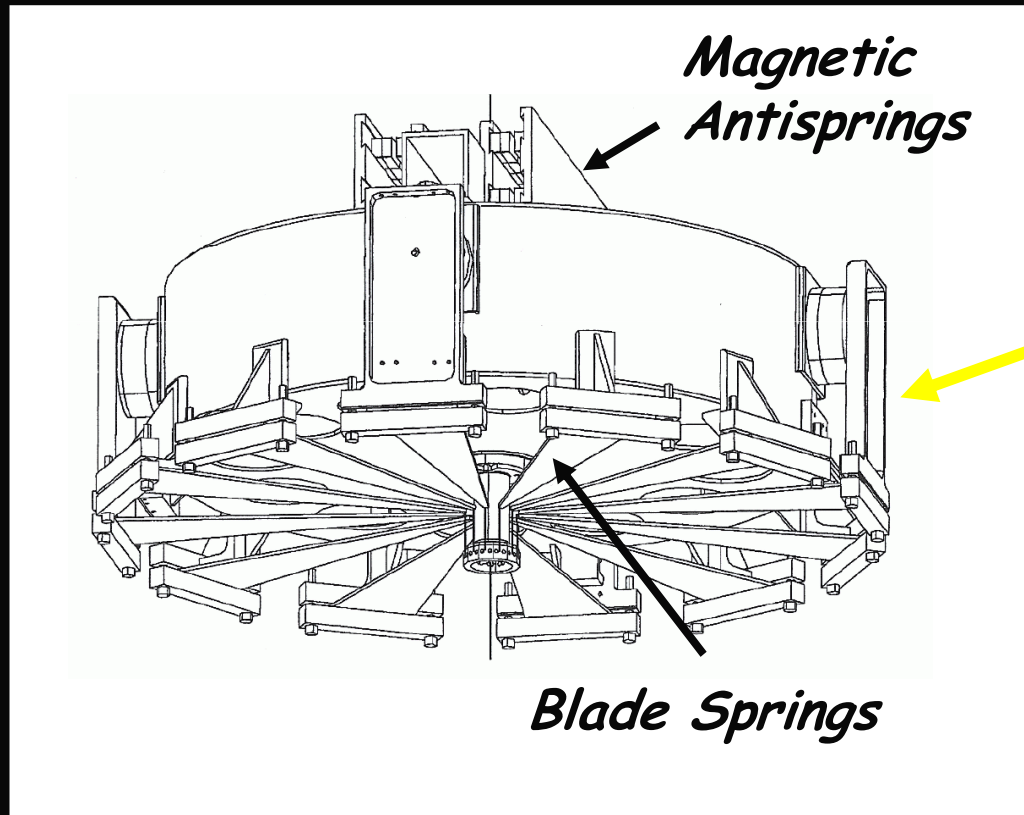
**1) Seismic Noise Attenuation**

**2) Control Noise Reduction**

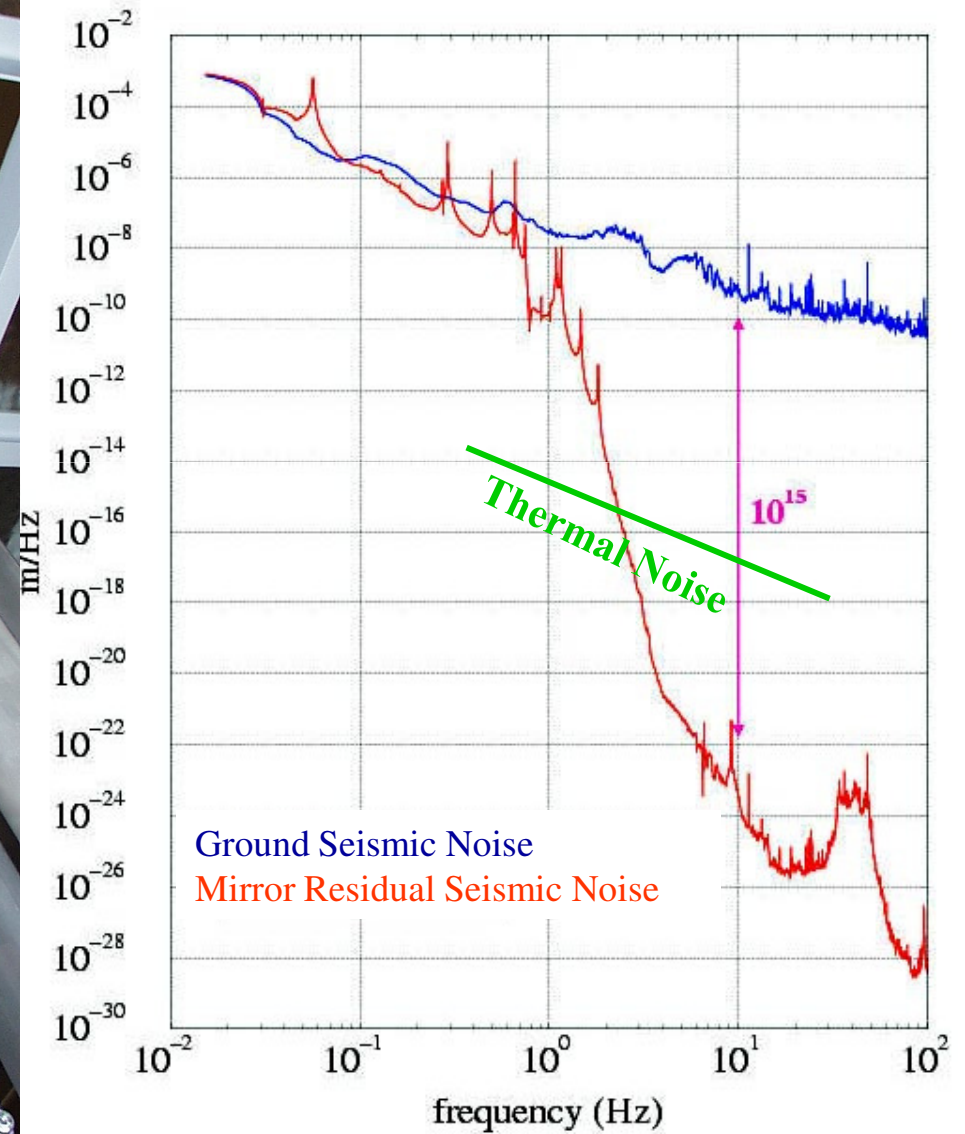
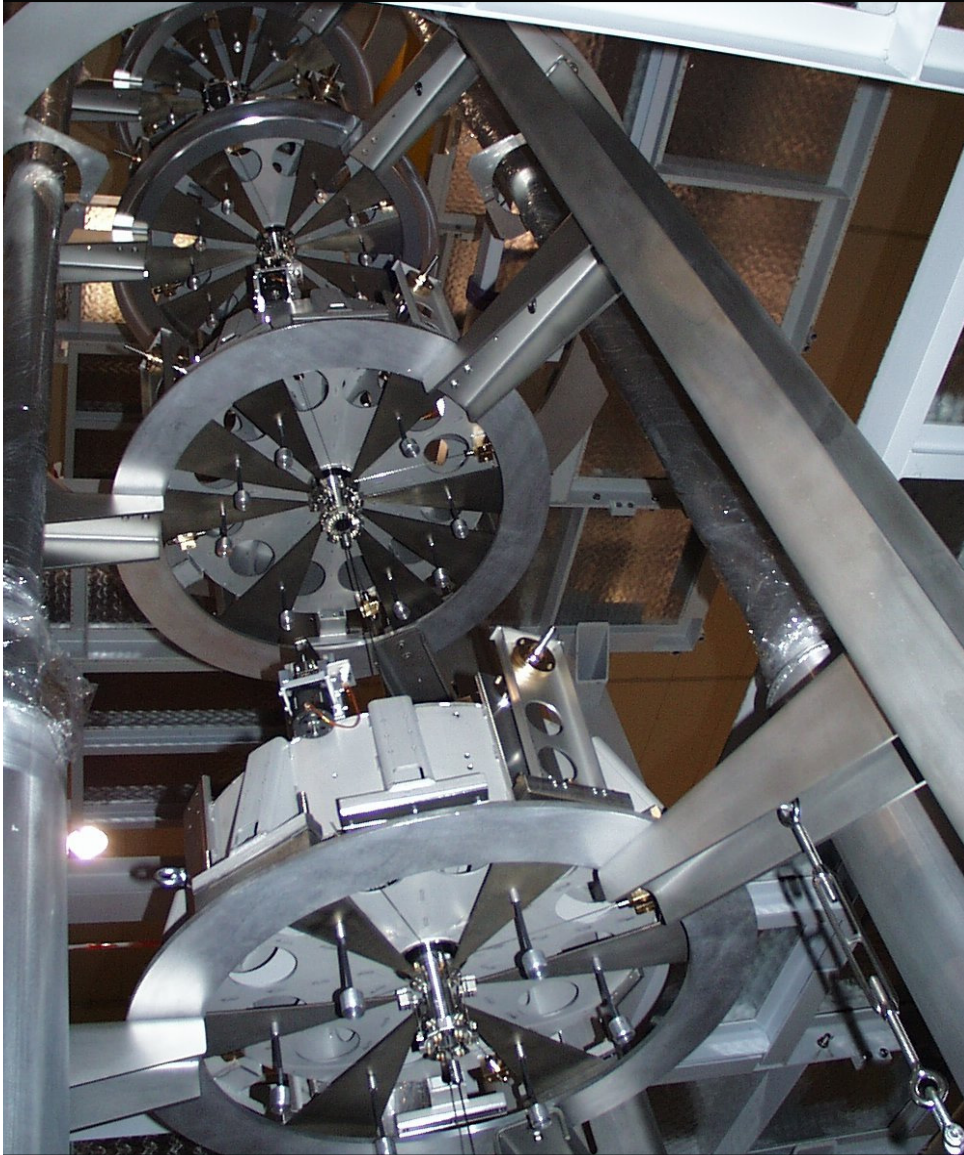


*Long Pendula*  
*Soft Springs*

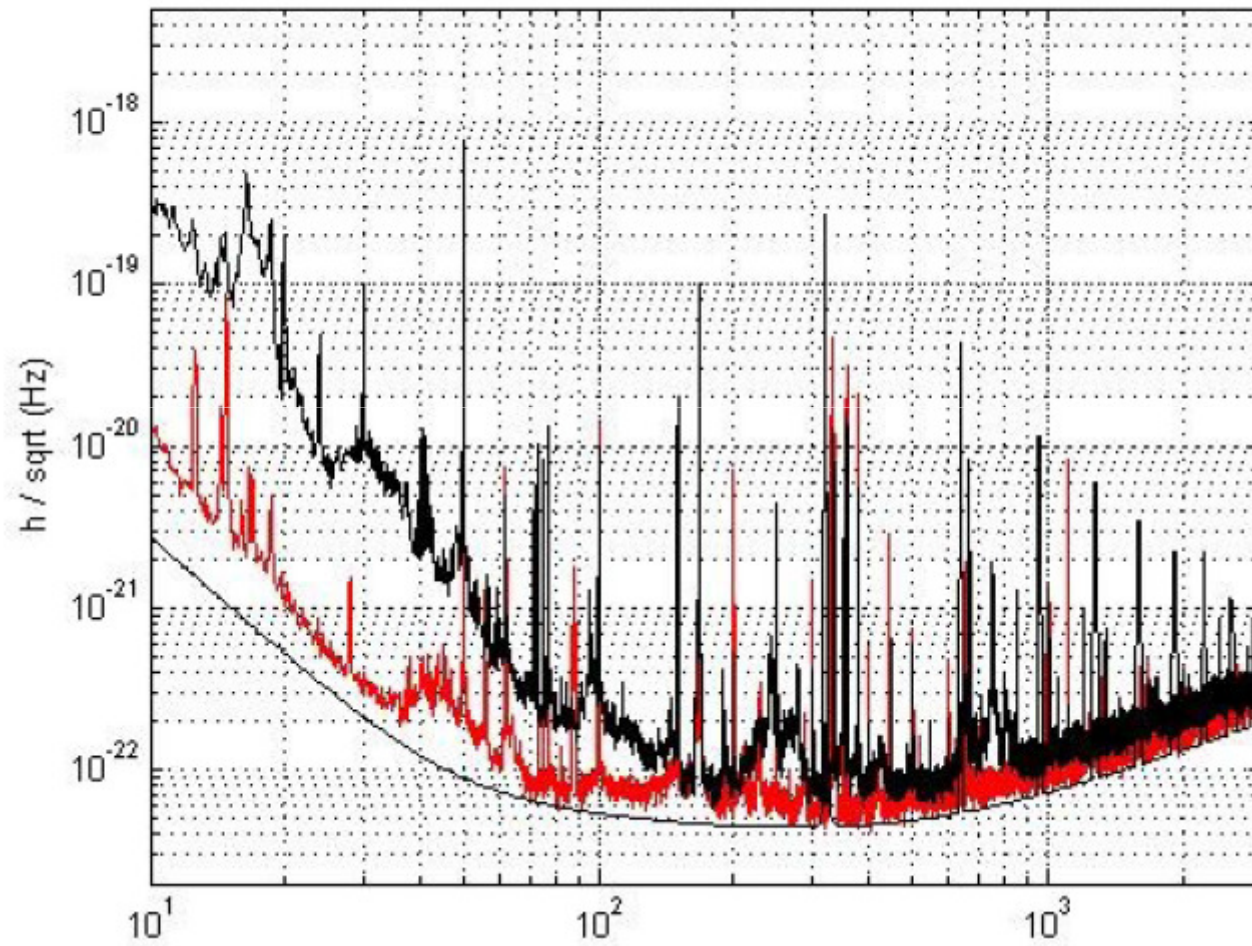
# *Superattenuator*



# Transfer Function Indirect Measurement

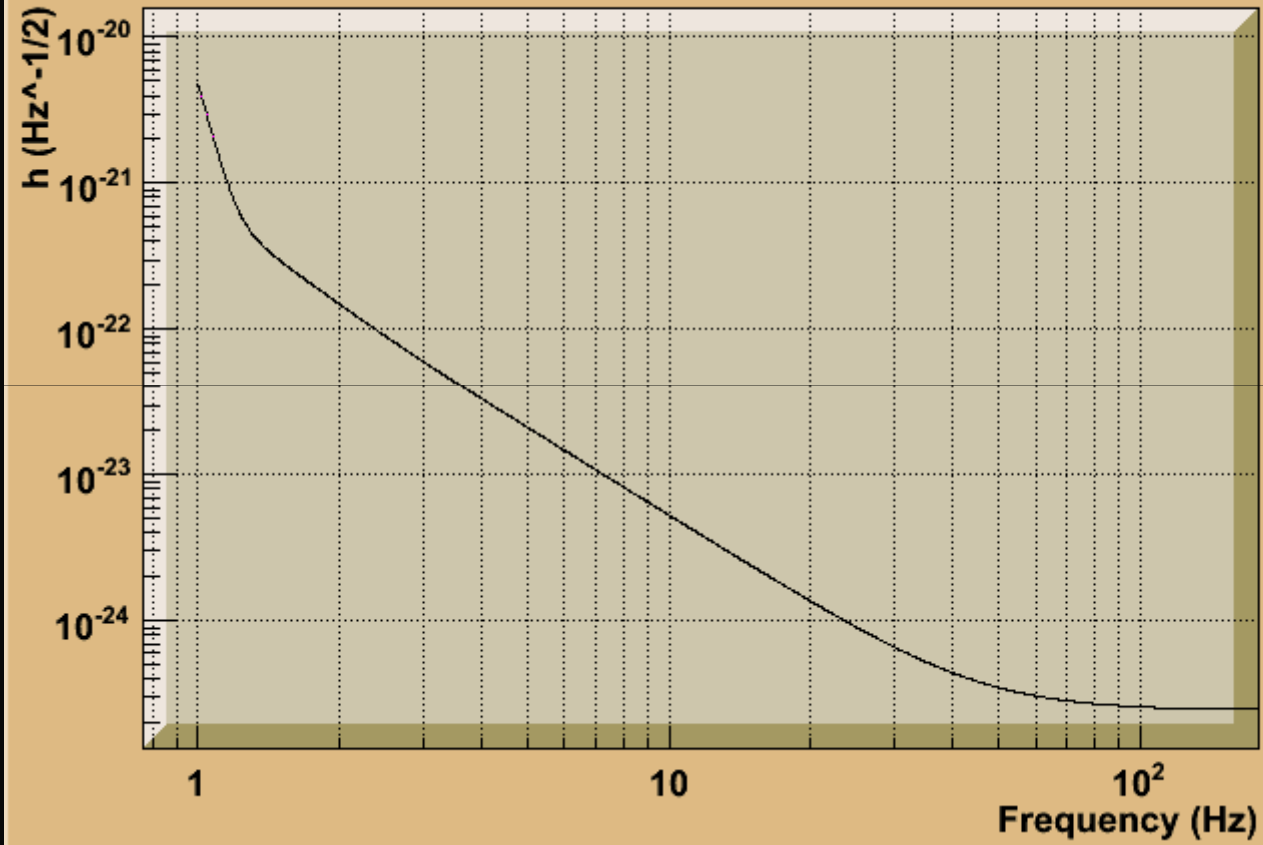


# Scientific Run 1 → Scientific Run 2



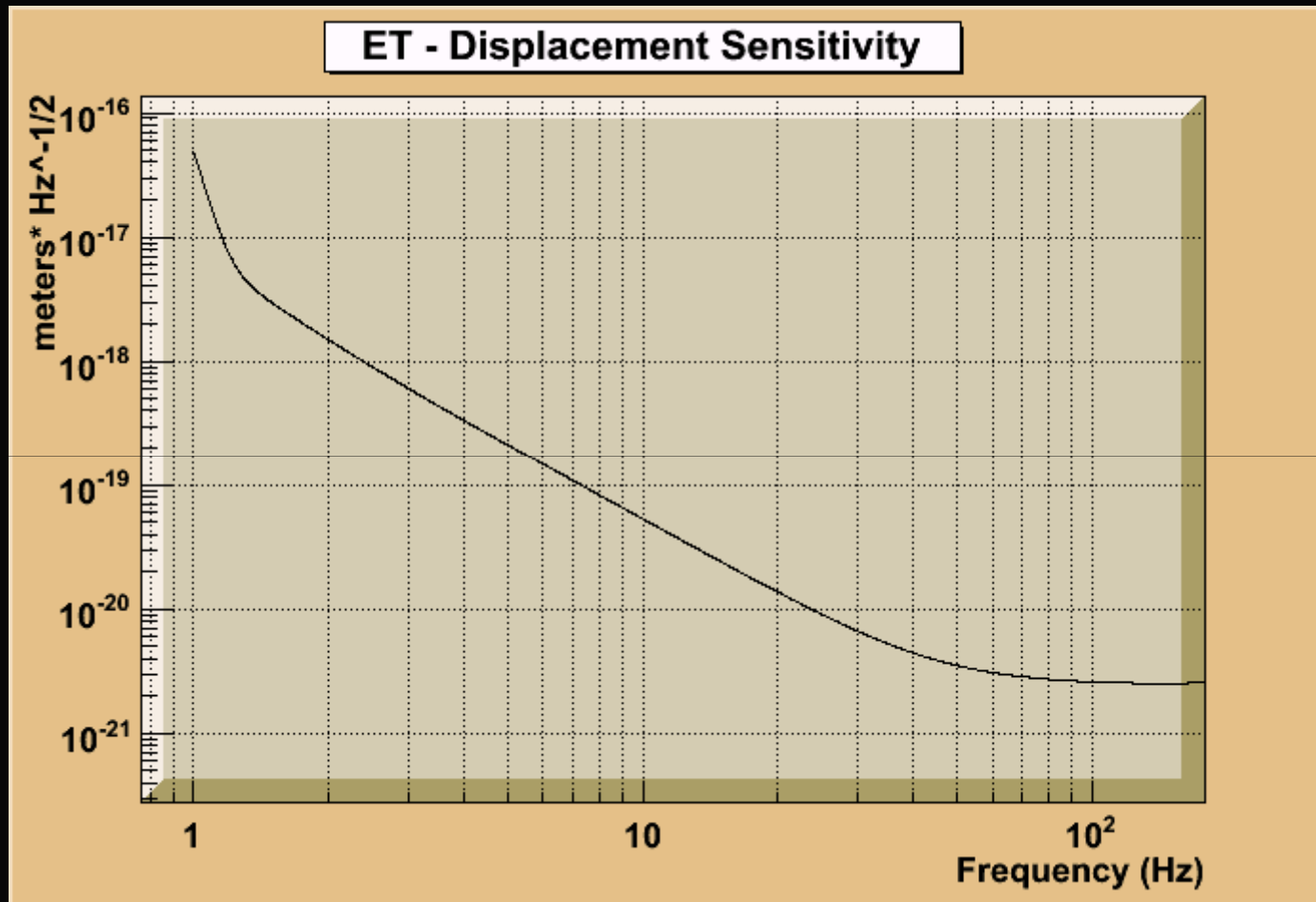
**What are seismic isolation requirements in ET?**

### ET - Sensitivity

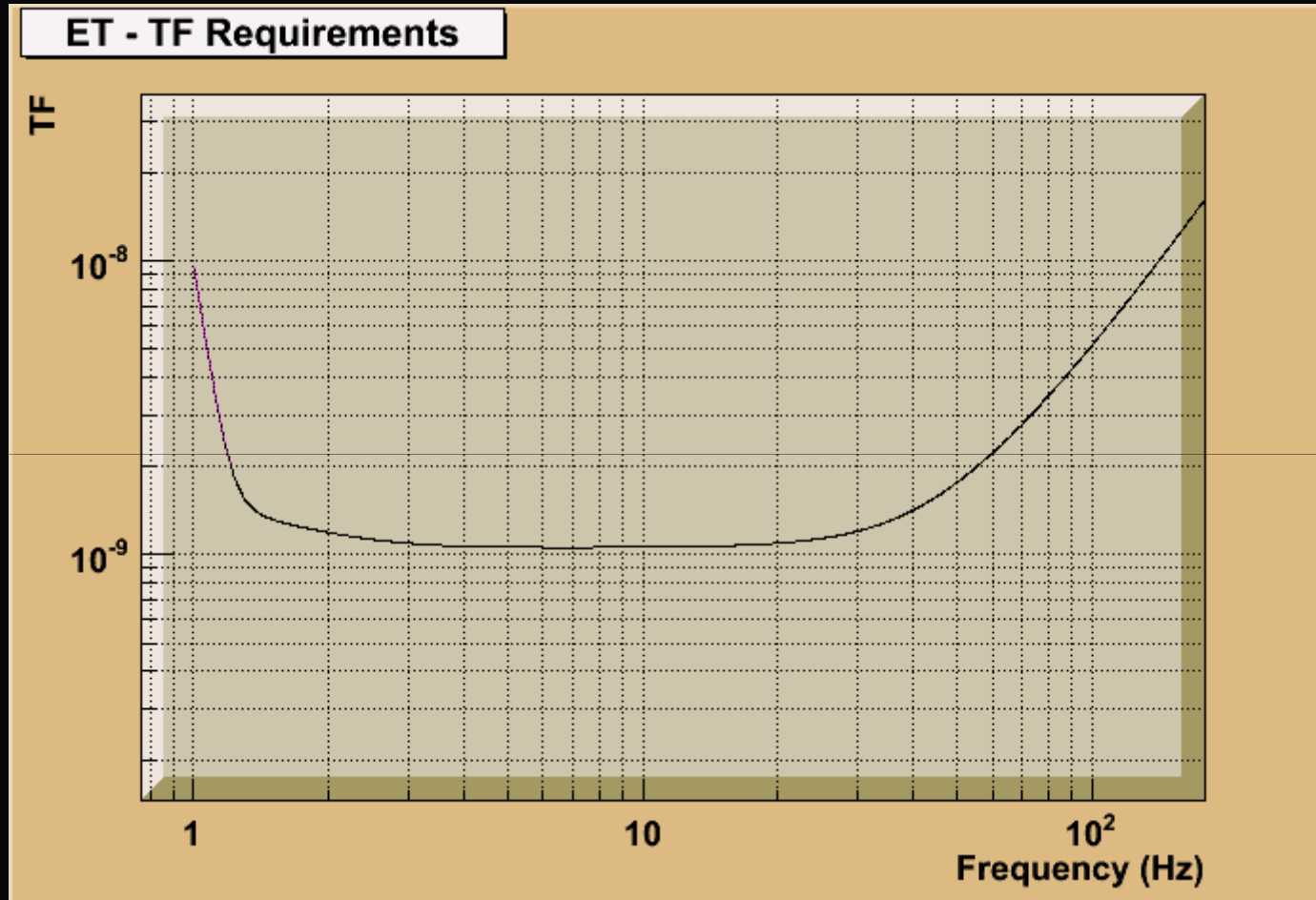




$$\Delta L(f) = h(f) \times 10000$$

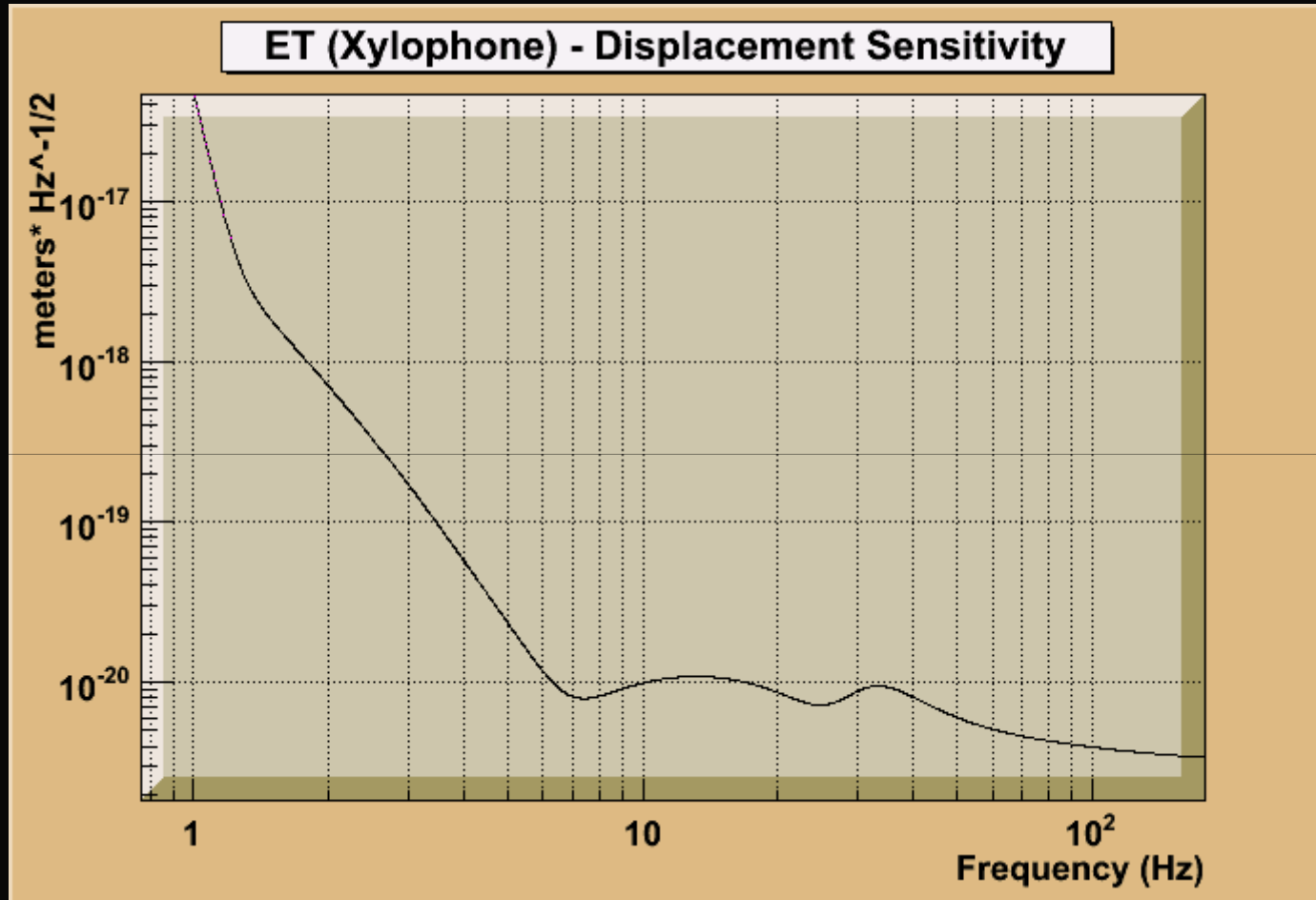


$$TF_{\max} = \Delta L(f) / (\text{LSD Underground Seismic Noise})$$

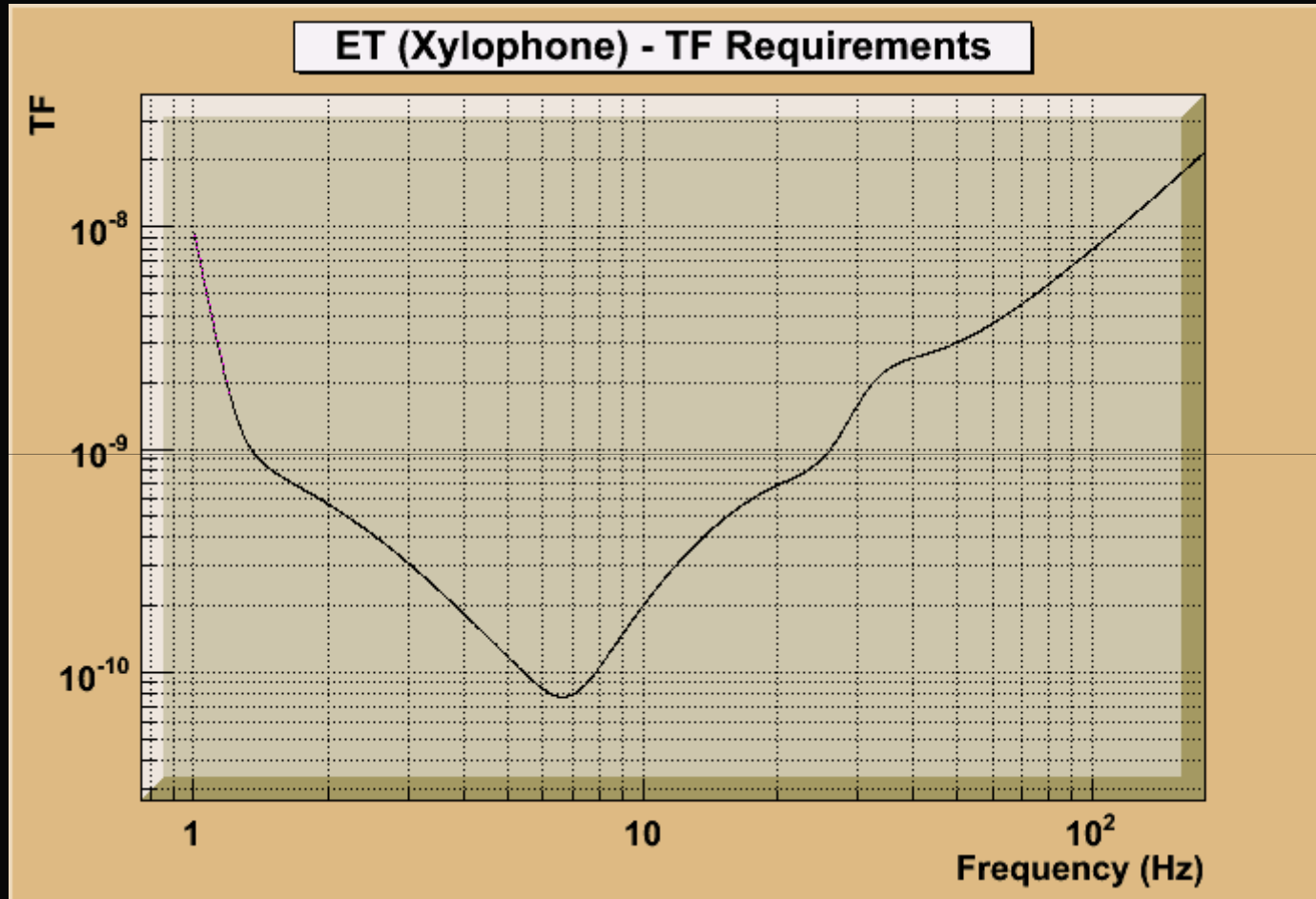


*LSD Ground Seismic Noise (Kamioka) -  $5 \times 10^{-9} / f^2$   
(Dusel Mine better)*

## *Same Exercise for ET-Xylophone sensitivity*

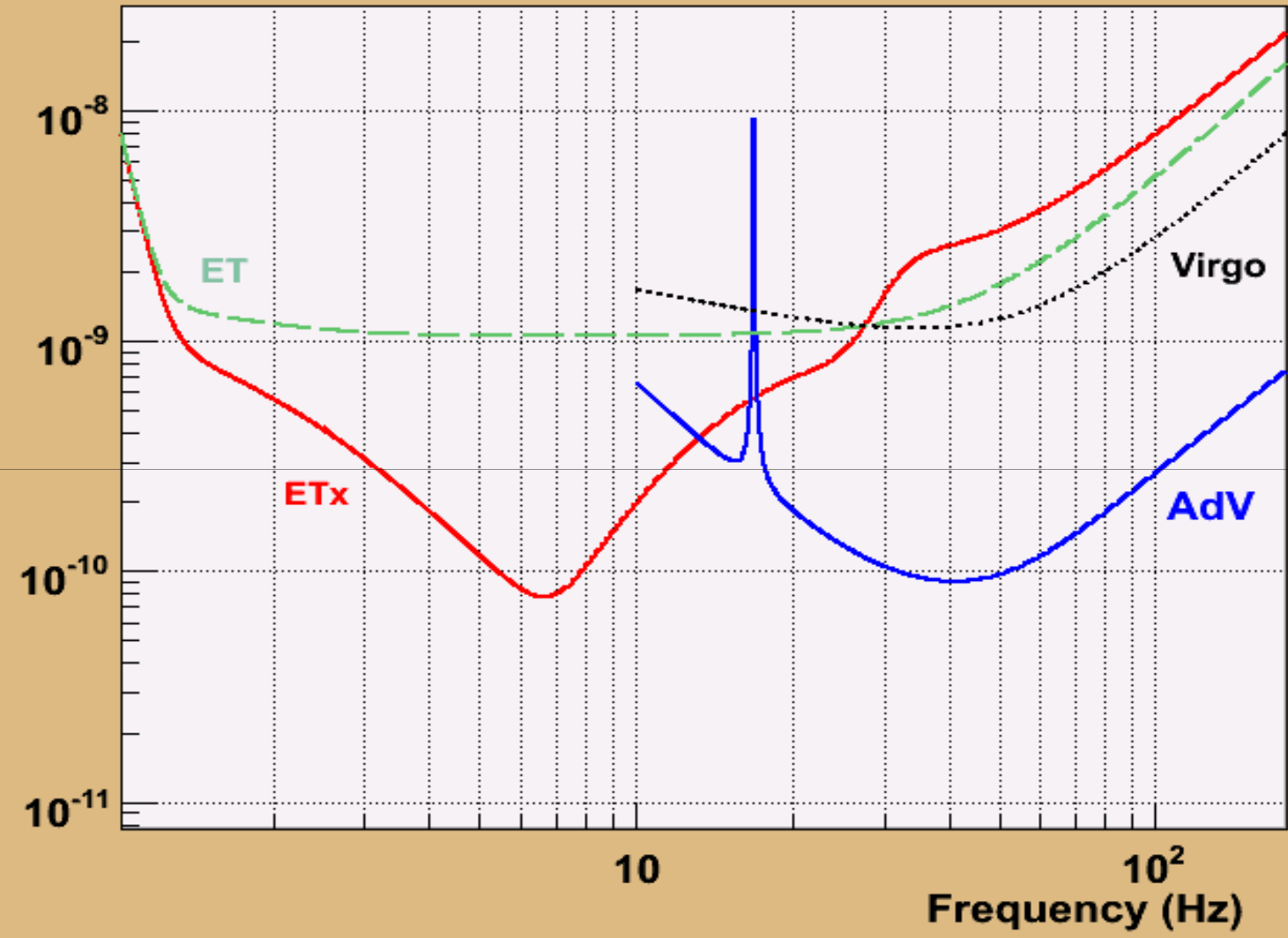


$$TF_{\max} = \Delta L(f) / (\text{LSD Ground Seismic Noise})$$

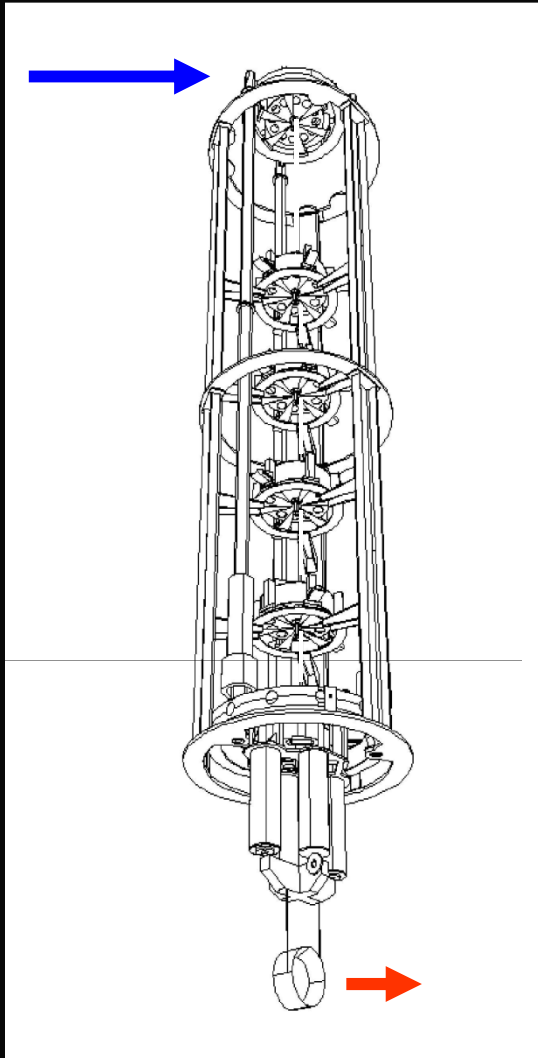


*LSD Ground Seismic Noise (Kamioka) -  $5 \times 10^{-9} / f^2$*

# TF Amplitude

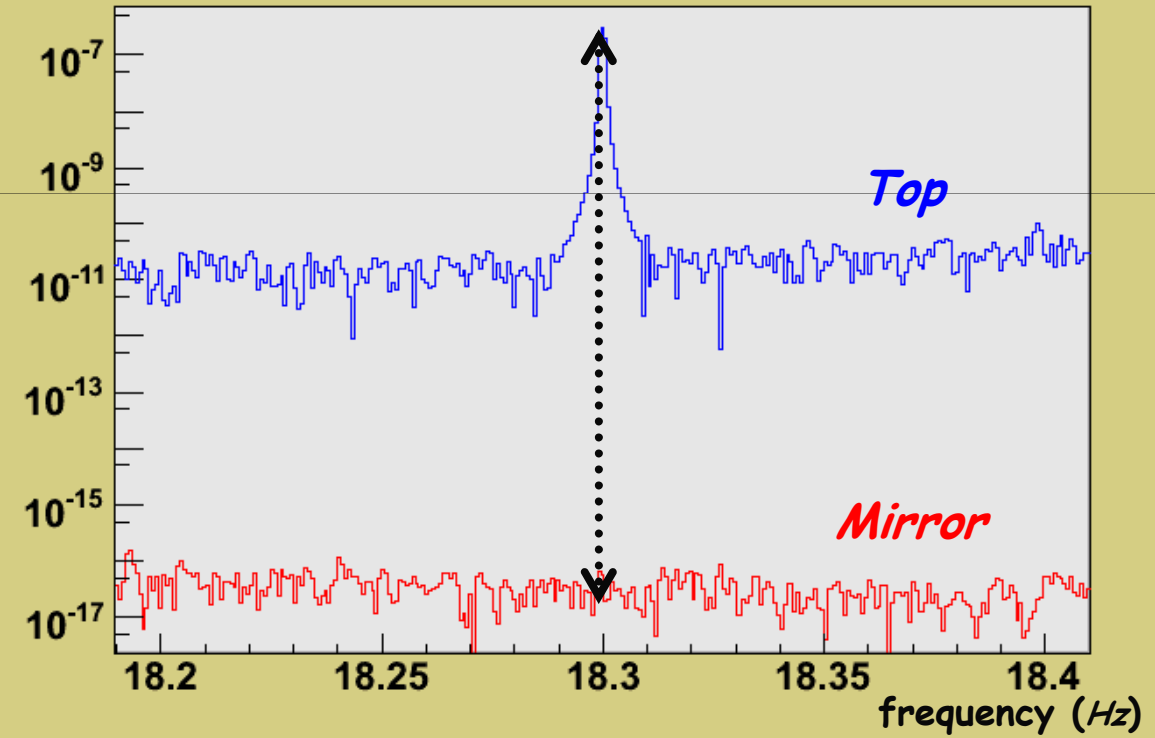


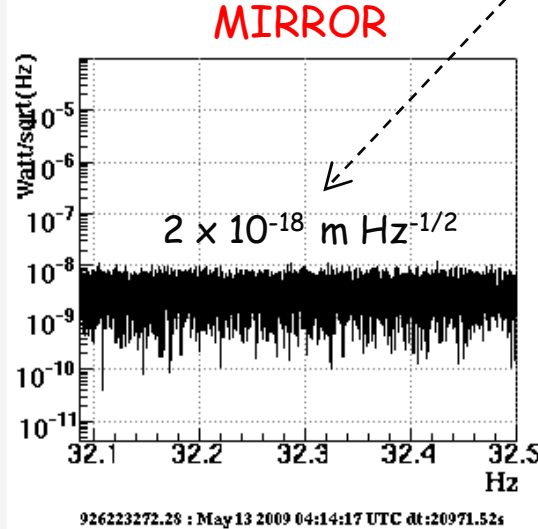
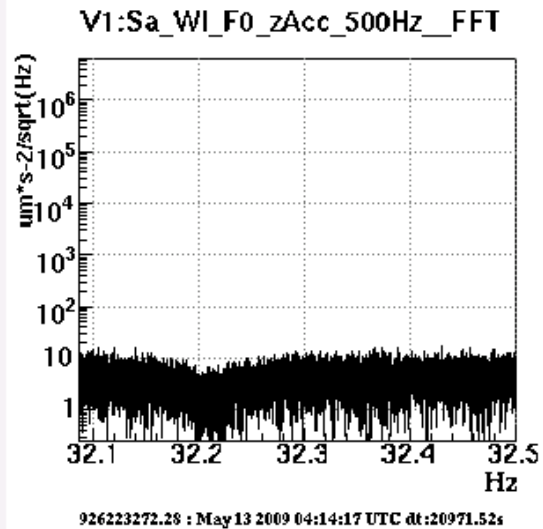
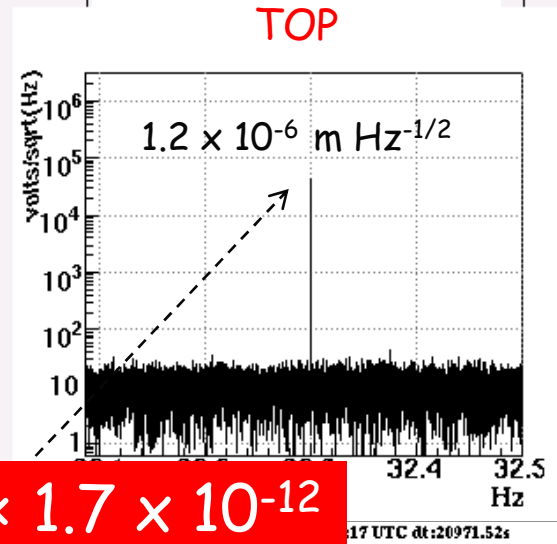
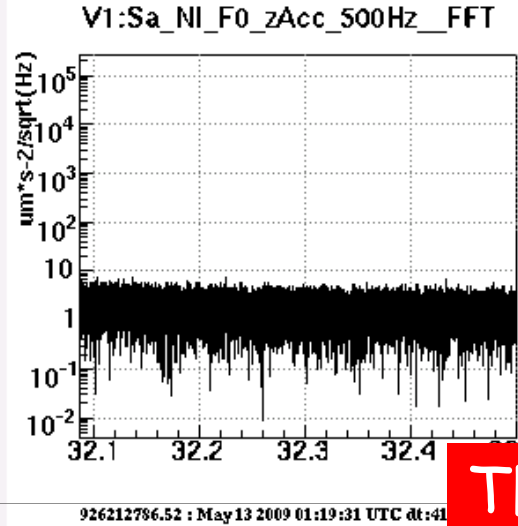
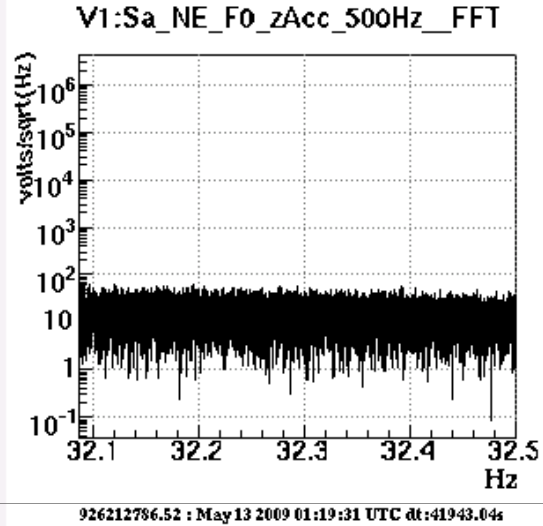
*TRANSFER FUNCTION REQUIREMENTS*



Transfer Function  $< 10^{-10}$

Displacement ( $m \cdot Hz^{-1/2}$ )

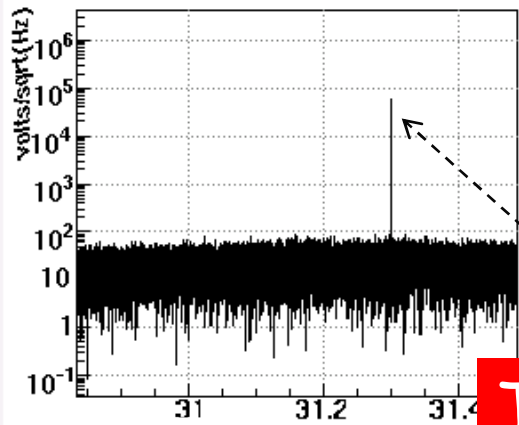




Stressed  
Measurement

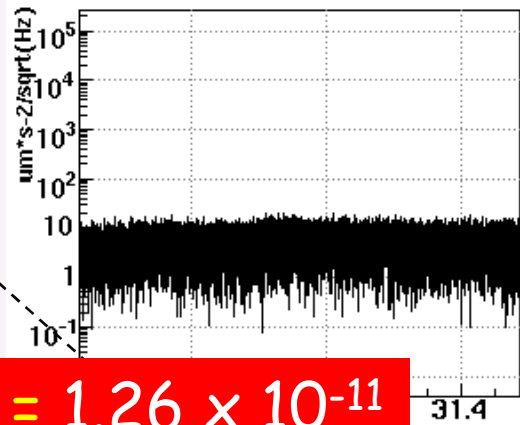
$T = 41943 \text{ s}$   
High Sens Range

V1:Sa\_NE\_F0\_zAcc\_500Hz\_FFT



926212786.52 : May 13 2009 01:19:31 UTC dt:41943.04s

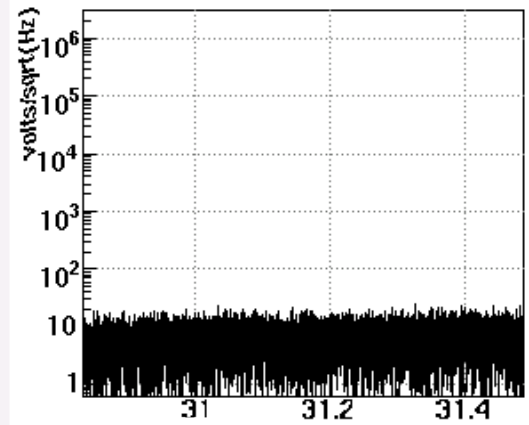
V1:Sa\_NI\_F0\_zAcc\_500Hz\_FFT



926212786.52 : May 13 2009 01:19:31 UTC dt:41943.04s

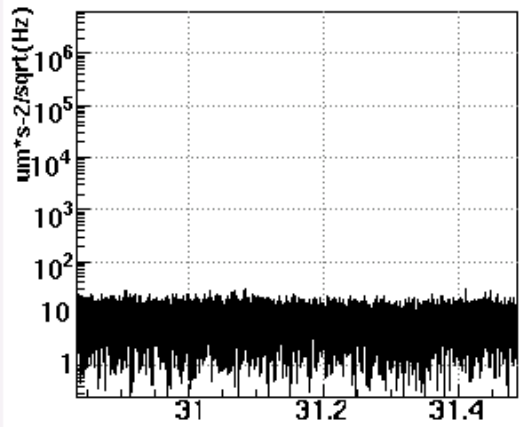
**TF = 1.26 × 10<sup>-11</sup>**

V1:Sa\_WE\_F0\_zAcc\_500Hz\_FFT



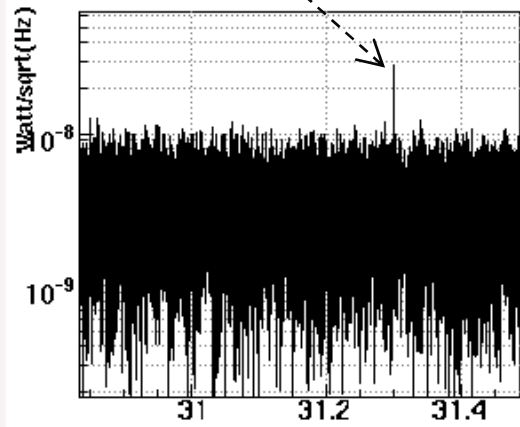
926223272.28 : May 13 2009 04:14:17 UTC dt:20971.52s

V1:Sa\_WI\_F0\_zAcc\_500Hz\_FFT



926223272.28 : May 13 2009 04:14:17 UTC dt:20971.52s

V1:Pr\_B1\_ACp\_FFT

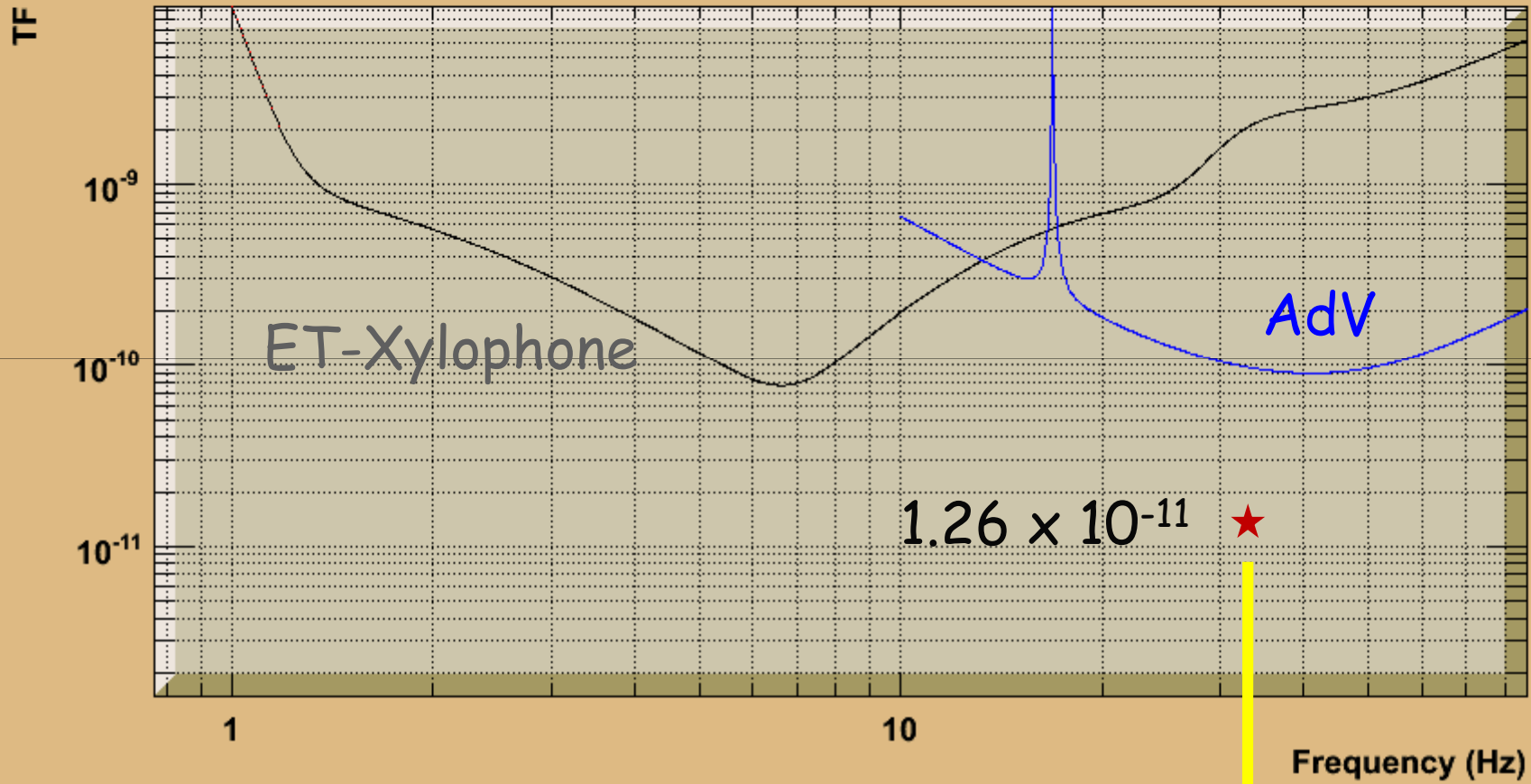


926223272.28 : May 13 2009 04:14:17 UTC dt:20971.52s

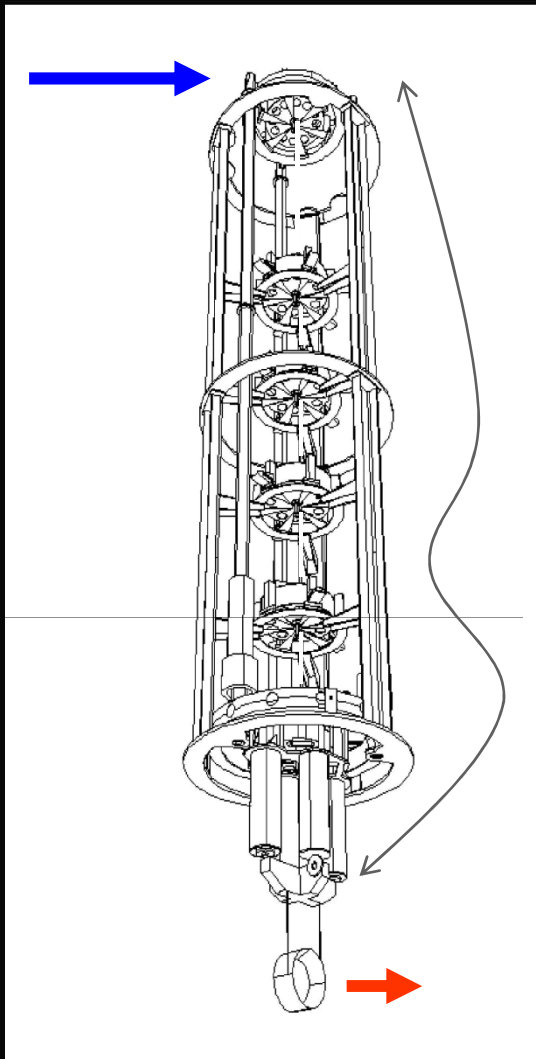




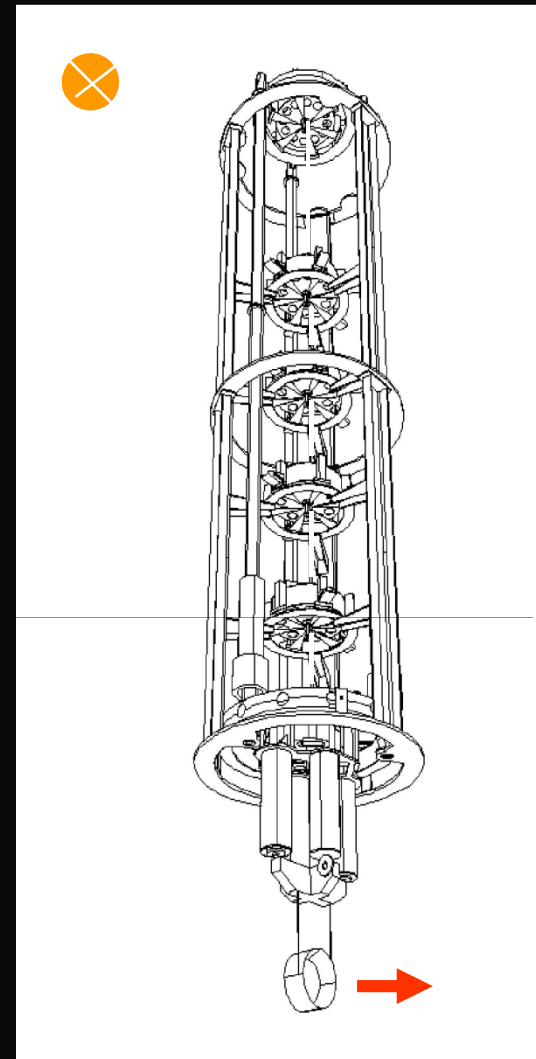
### Various TF Requirements



+ Pre-Isolator



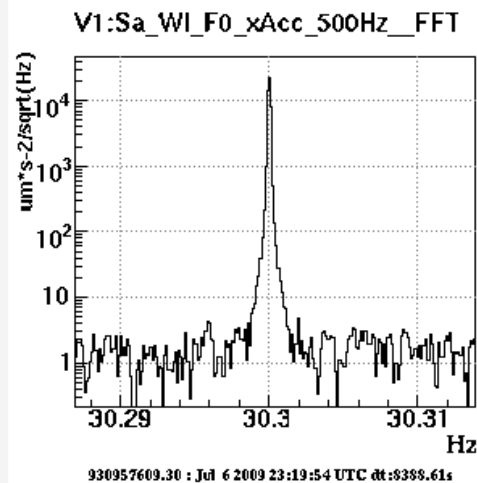
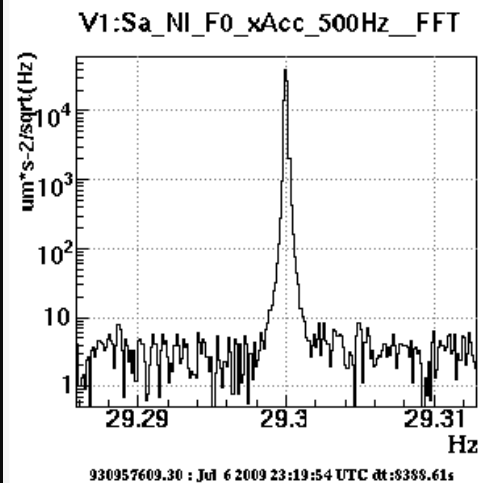
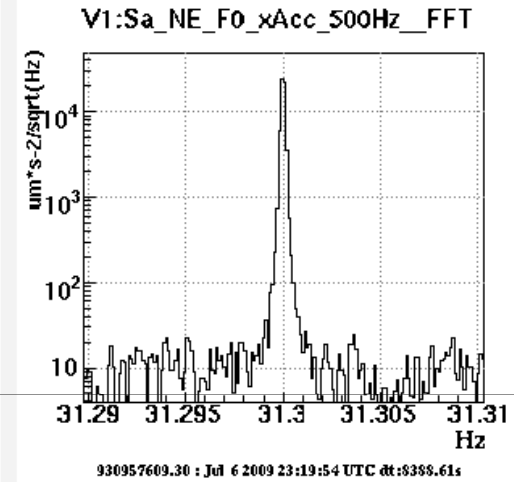
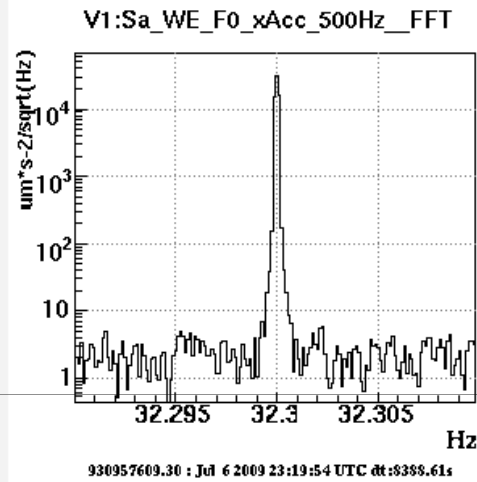
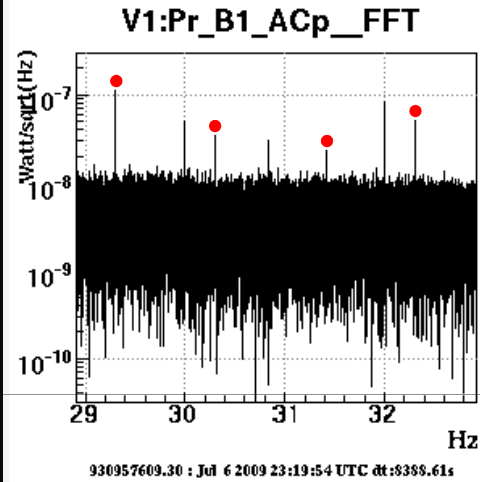
Possible Bypass



X-Excitation  
Experiment

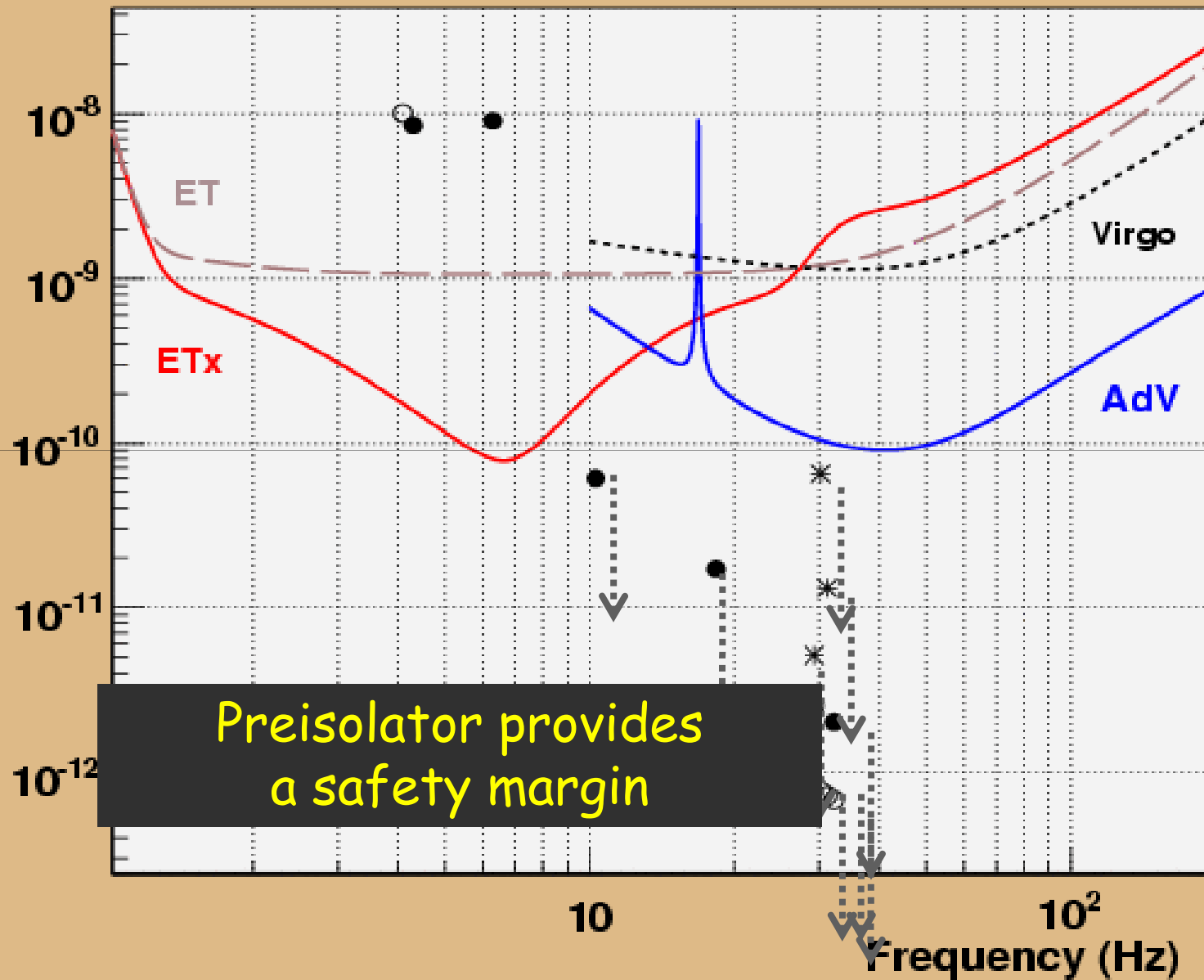
# X - Excitation Results

dataDisplay v9r12p7 : started by virgorun on Jul 8 2009 16:46:31 UTC



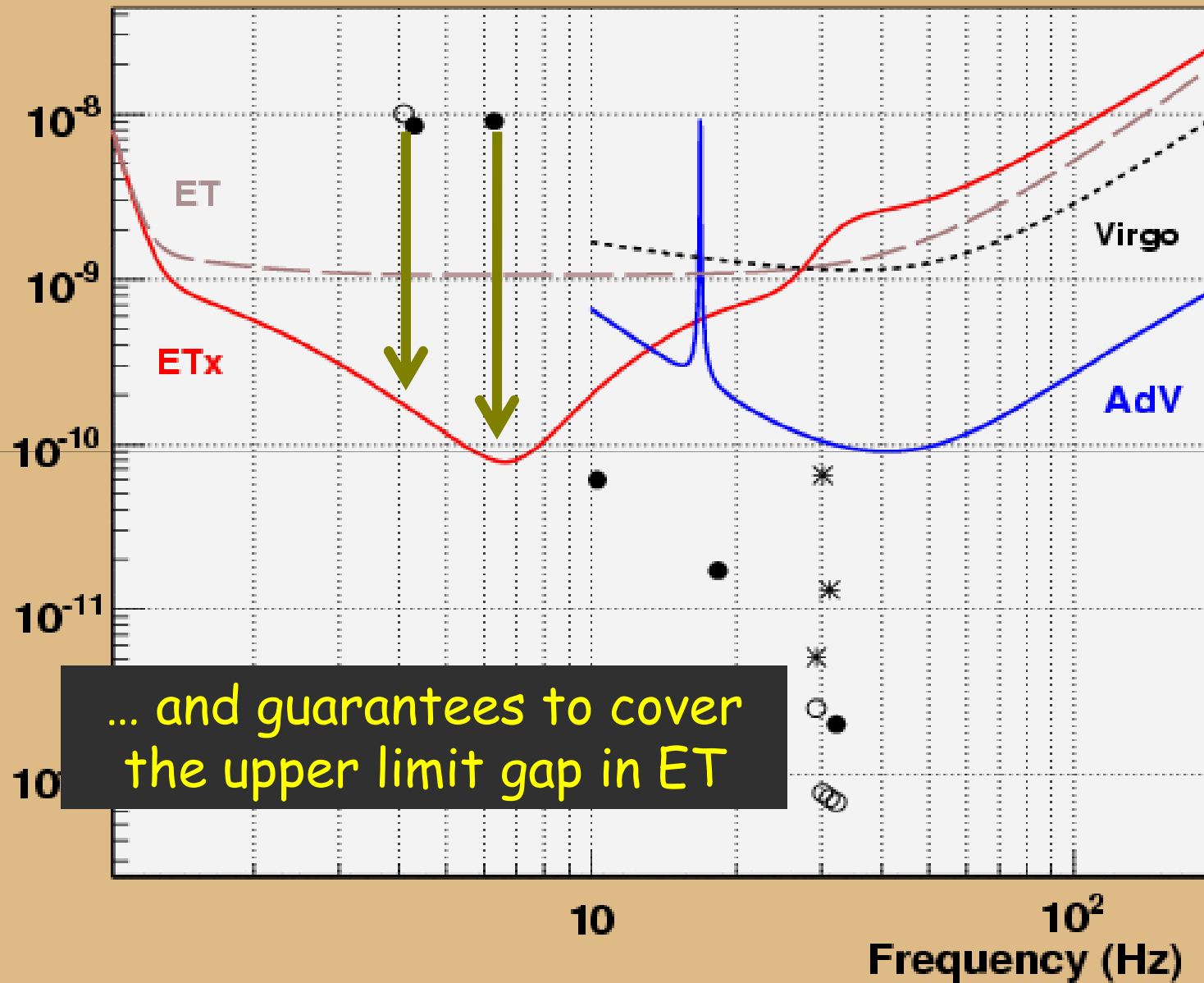
Bypass  
Indication ?

# TF Amplitude

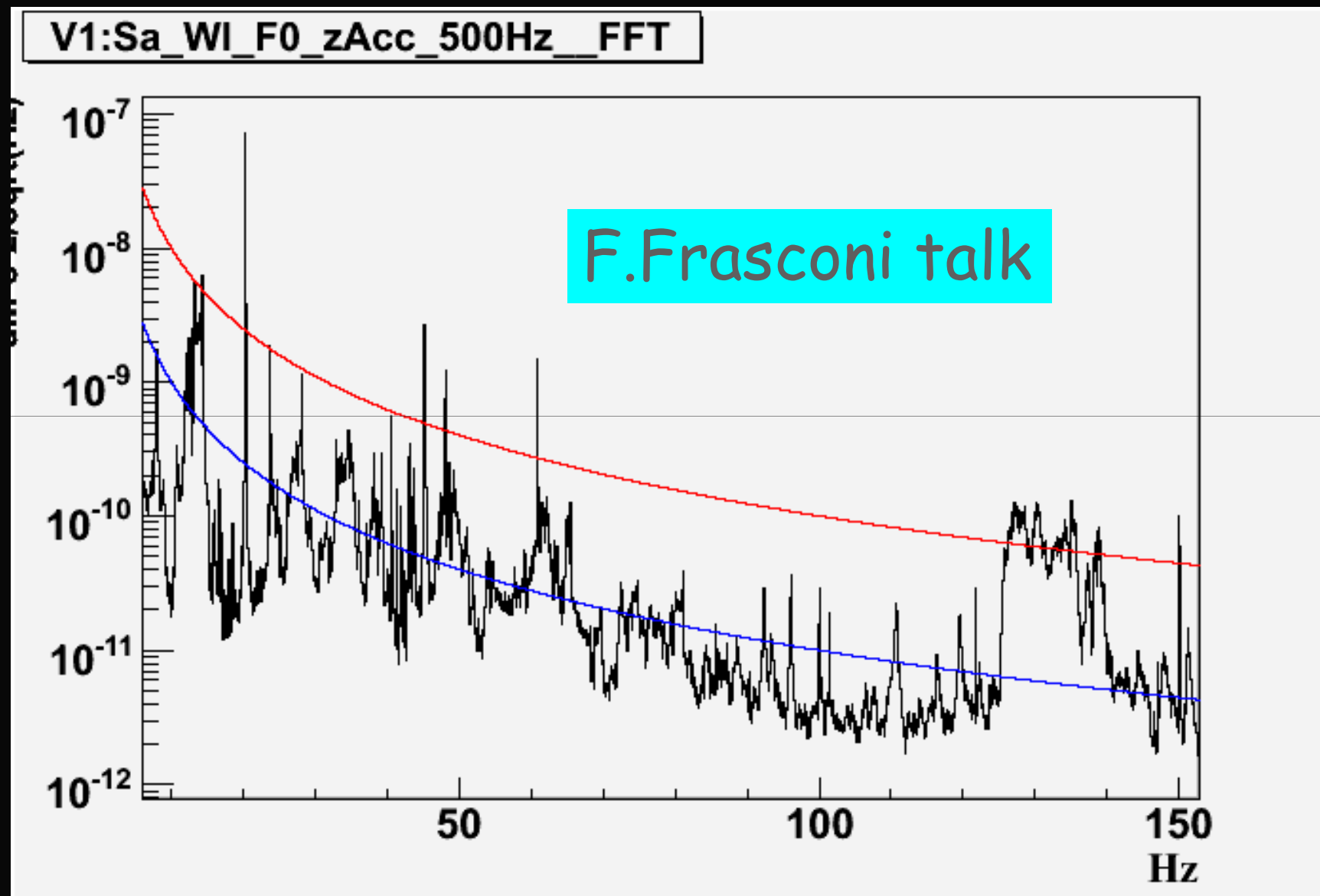


Preisolator provides a safety margin

# TF Amplitude

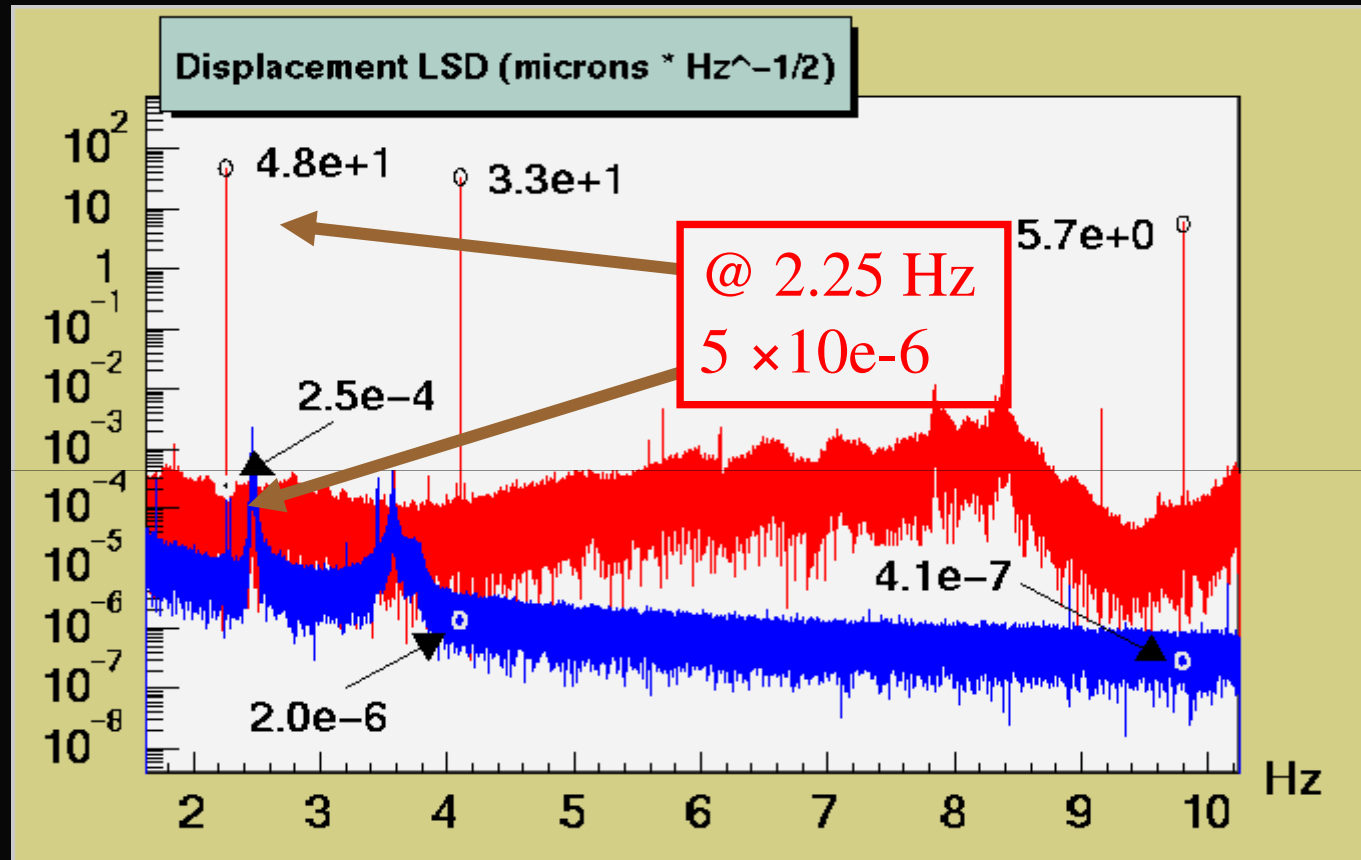


## Pay attention to top stage resonances



Where is the cross-over ?

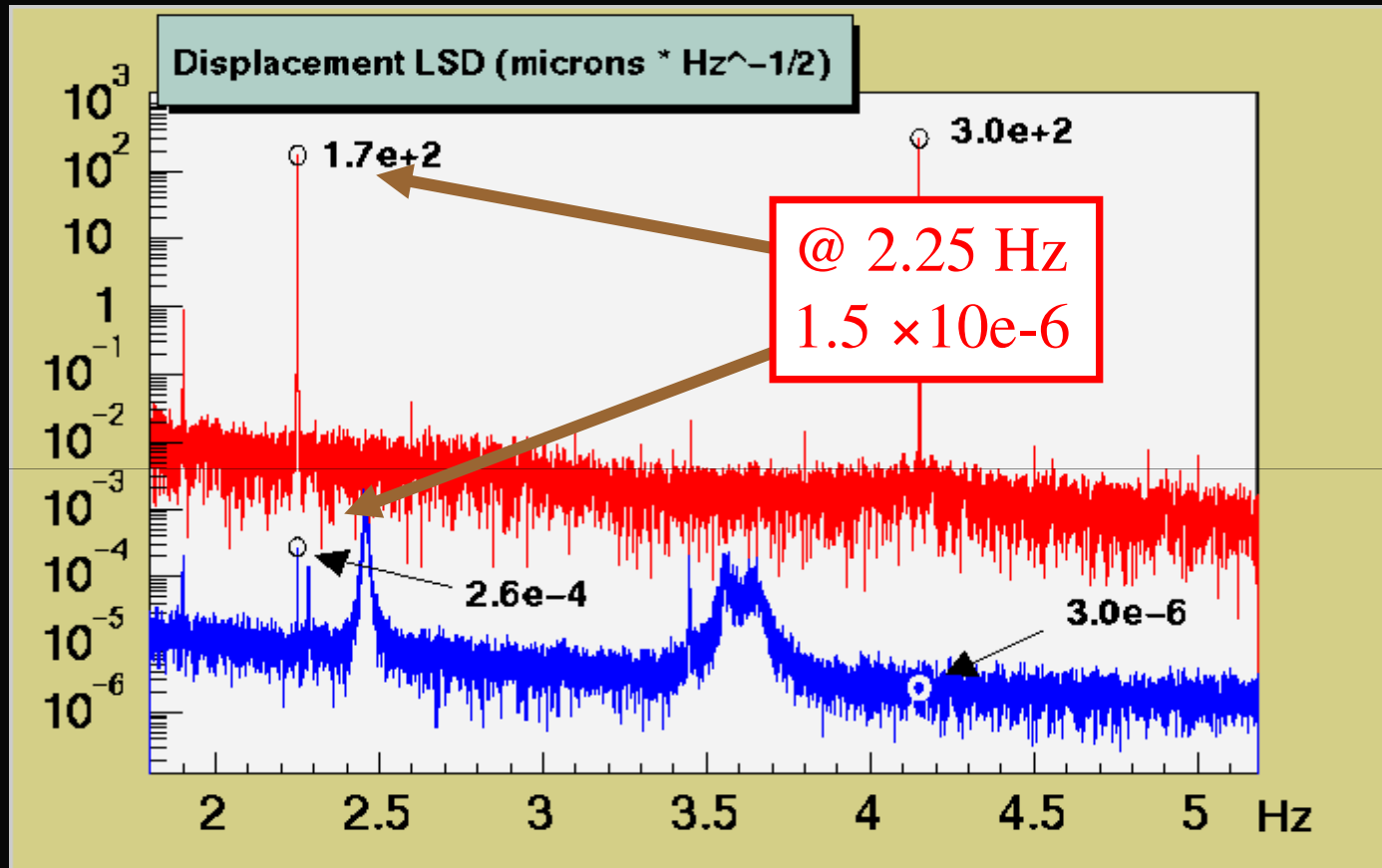
# HORIZONTAL



Remarkable Attenuation also at 2.25 Hz  
(but likely not enough)



# VERTICAL



Remarkable Attenuation also at 2.25 Hz  
(but likely not enough)

# Stage by Stage Measurement (and Model)



# PART 1 - Conclusions

SA attenuation compliant with Adv

.....enough also for ET but only above 3 Hz

(ET Note 25-09)

F.Frasconi

```
graph TD; A[F.Frasconi] --> B[UPGRADES]; A --> C[DESIGN STUDY];
```

UPGRADES

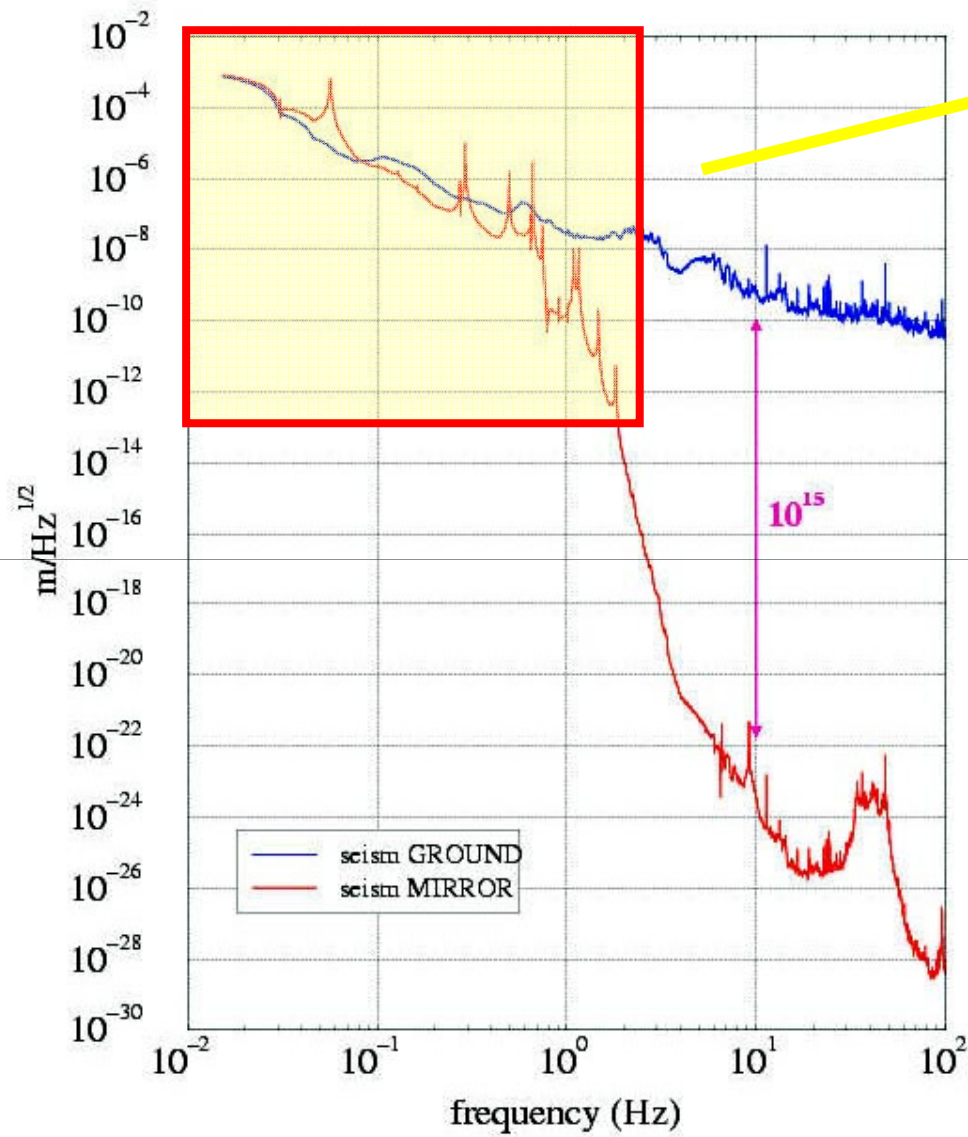
Top Stage Resonances

DESIGN STUDY

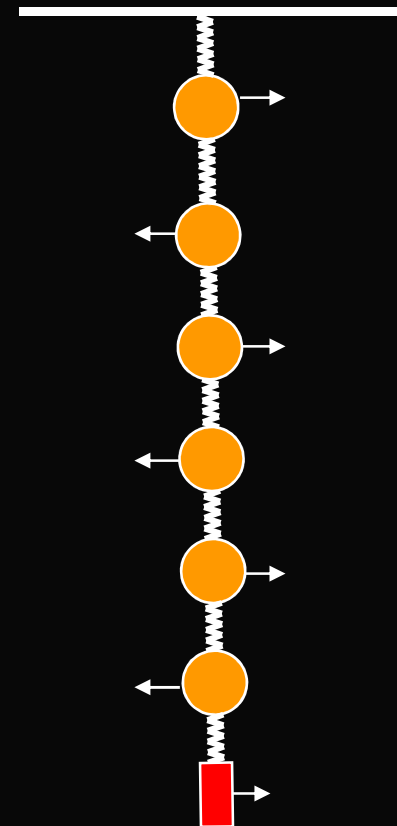
Cross-Over Reduction

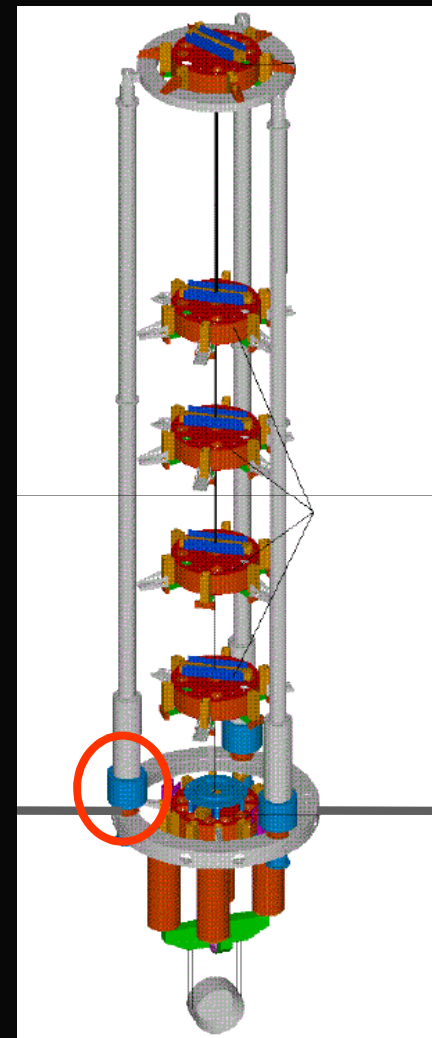
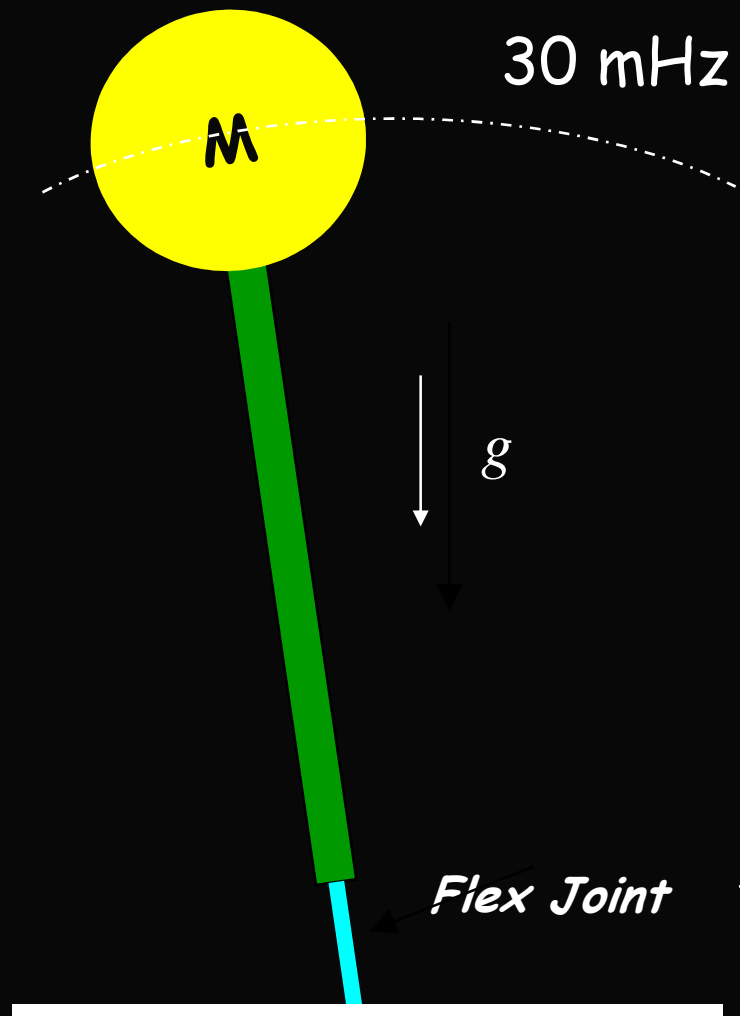
1) Seismic Noise Attenuation

2) Control Noise Reduction

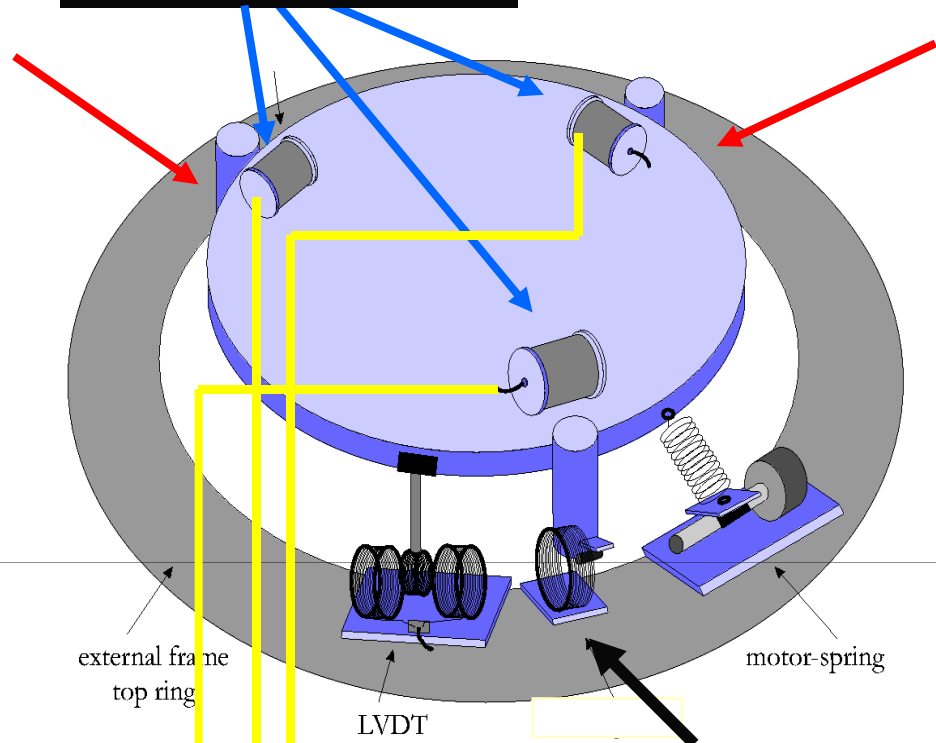


several microns swing

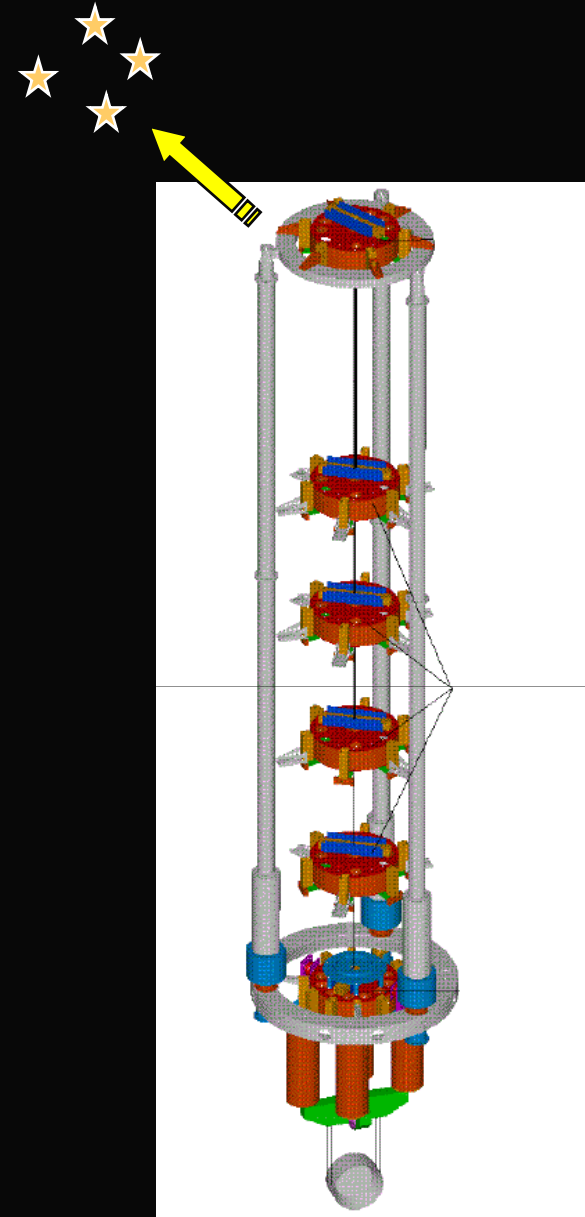
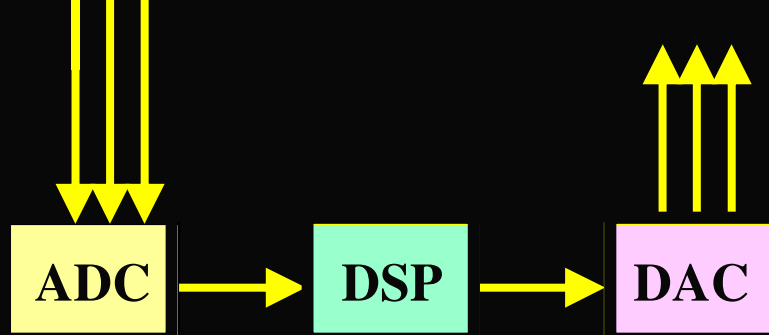




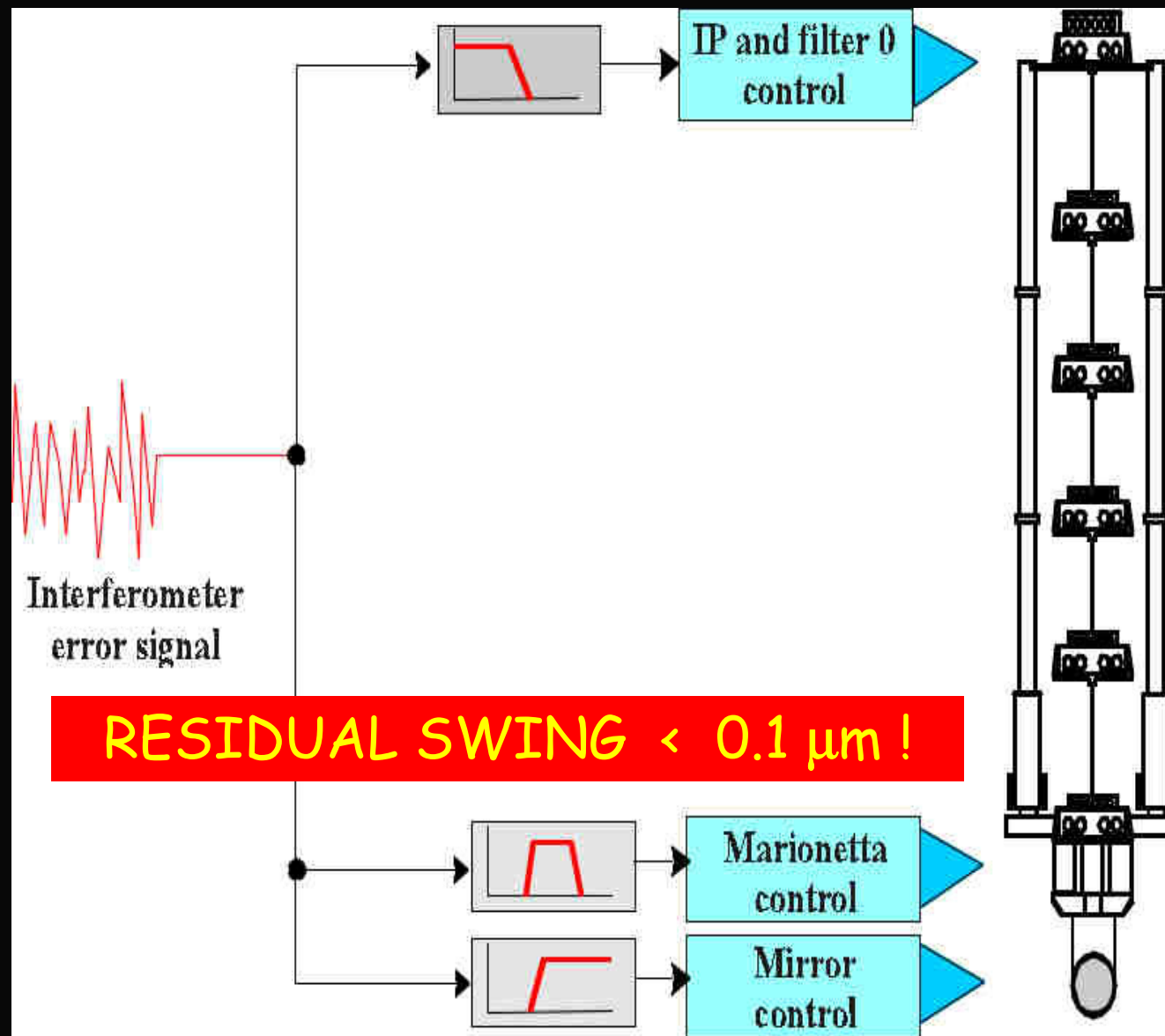
# Accelerometers



# Actuators

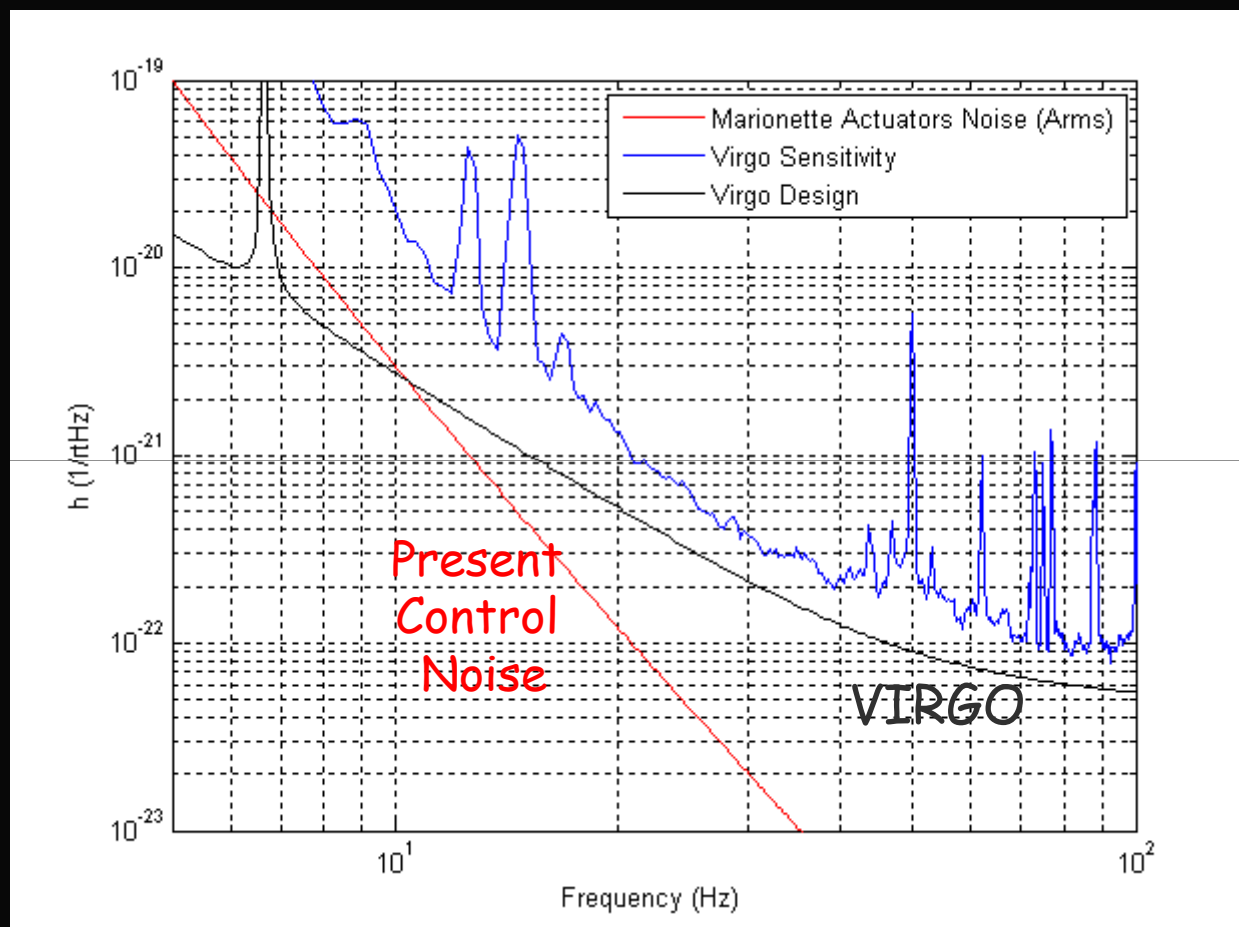


# Hierarchical Control



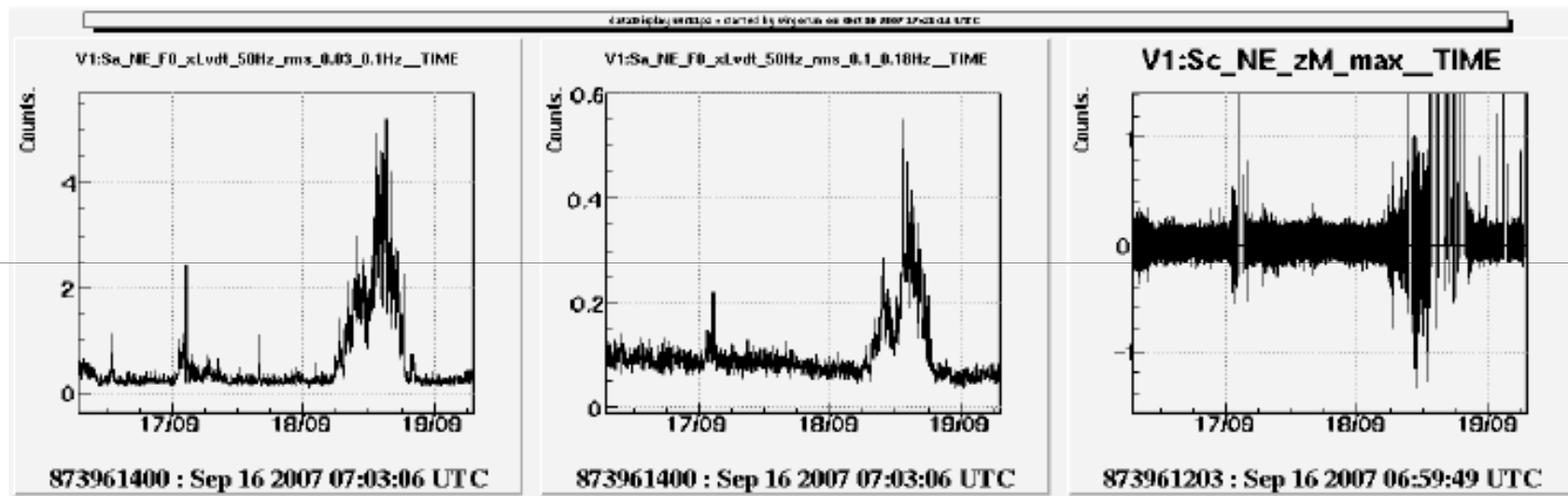


## Direct Measurement on the ITF !



*A. Gennai (VIR 029-A09)*

# The tilt problem

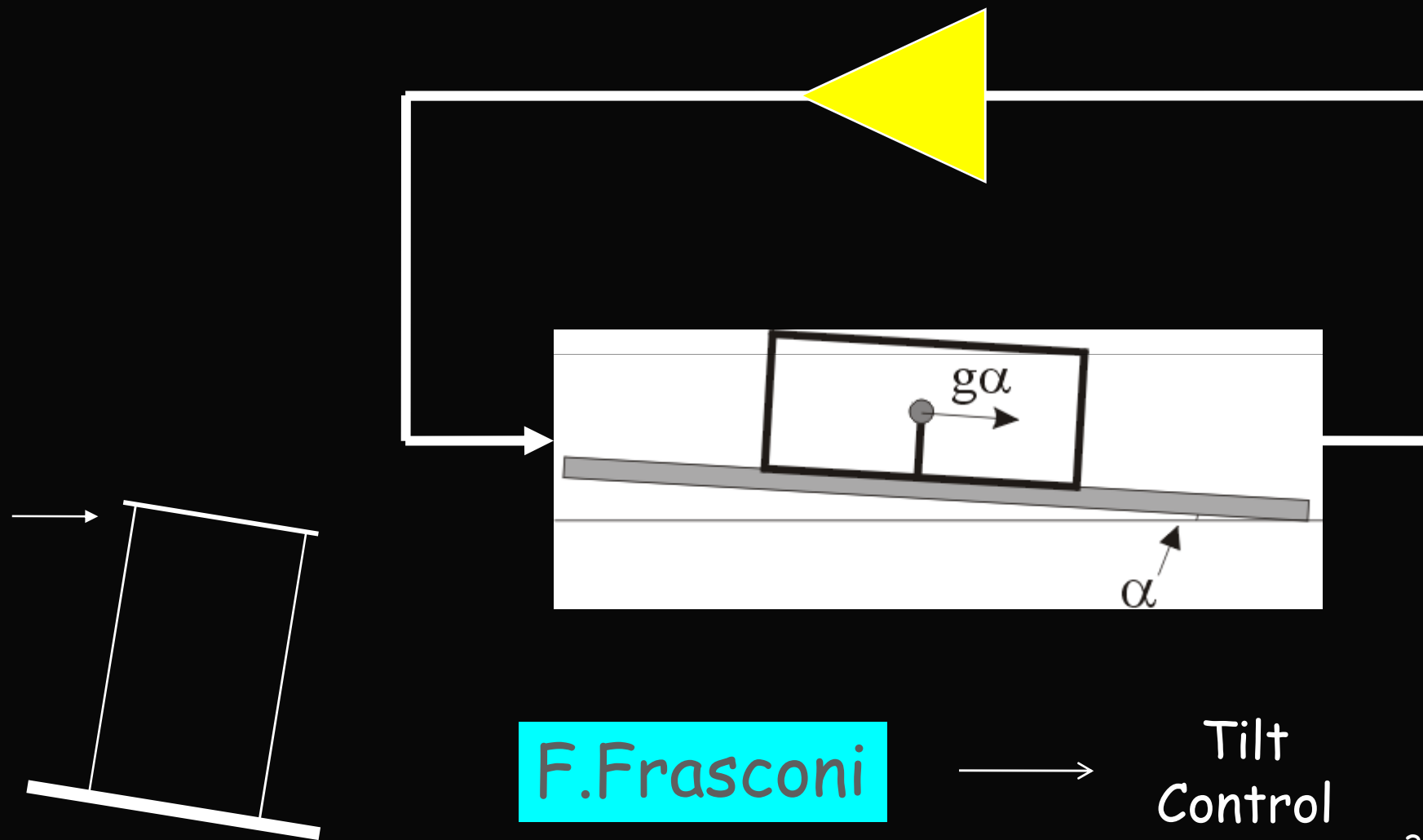


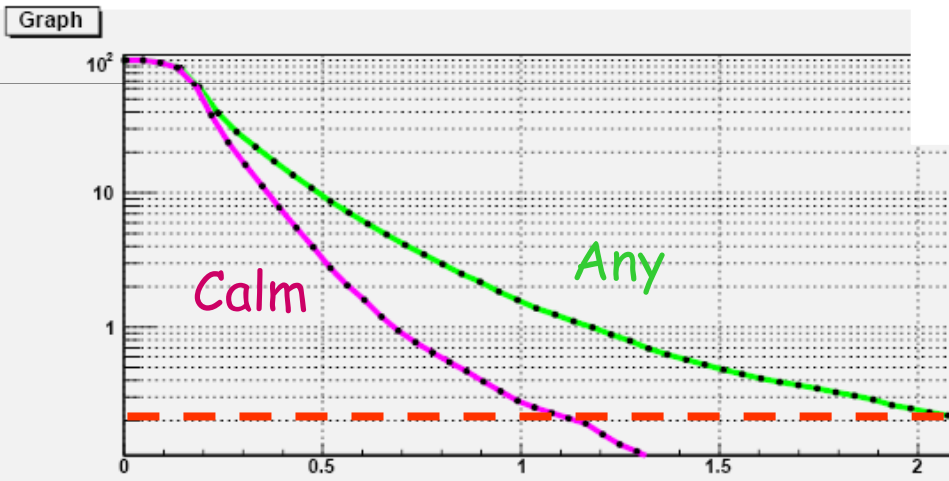
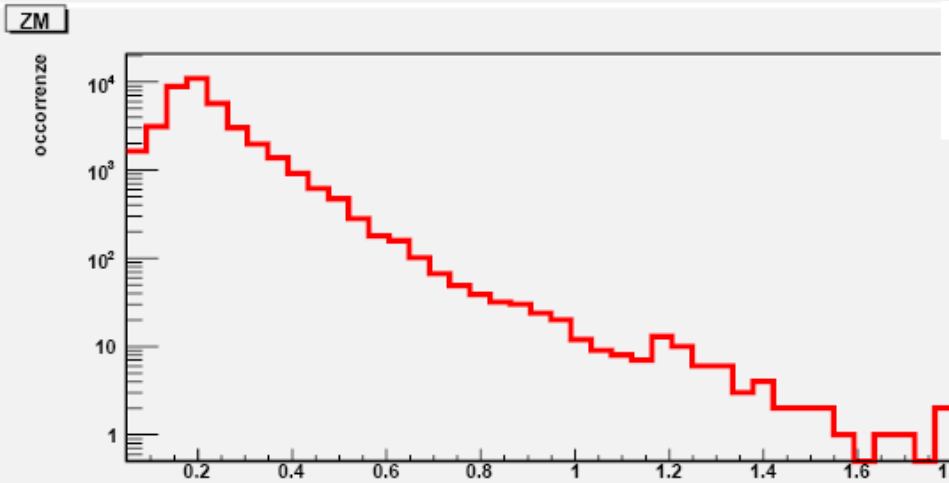
WIND

SEA

MIRROR  
ACTUATION

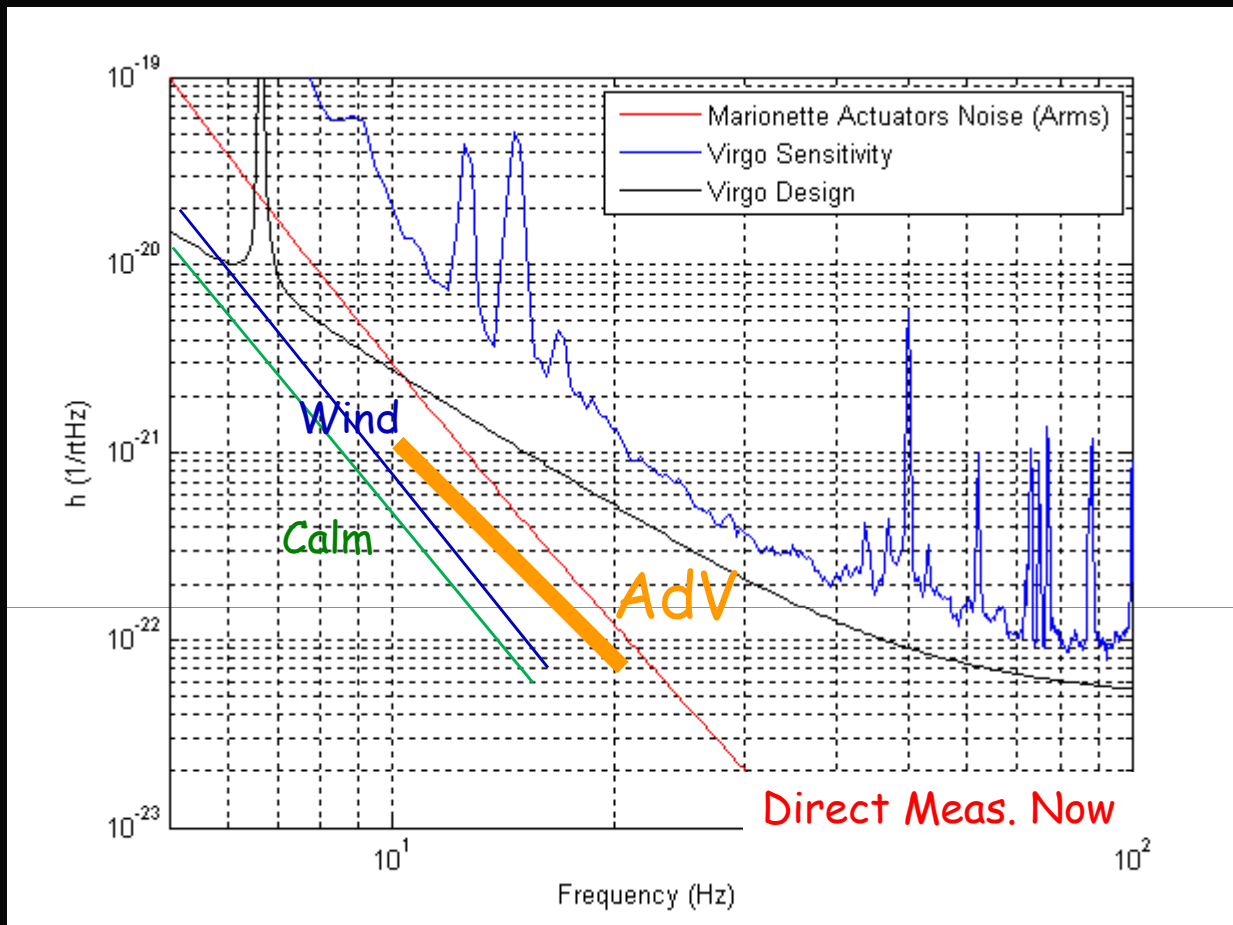
# The tilt problem





Noise Reduction  
 by a factor  
 4-5 (Wind)  
 7-8 (Calm)  
 Available

WE ARE USING ONLY  
 A PART OF THE DAC RANGE !



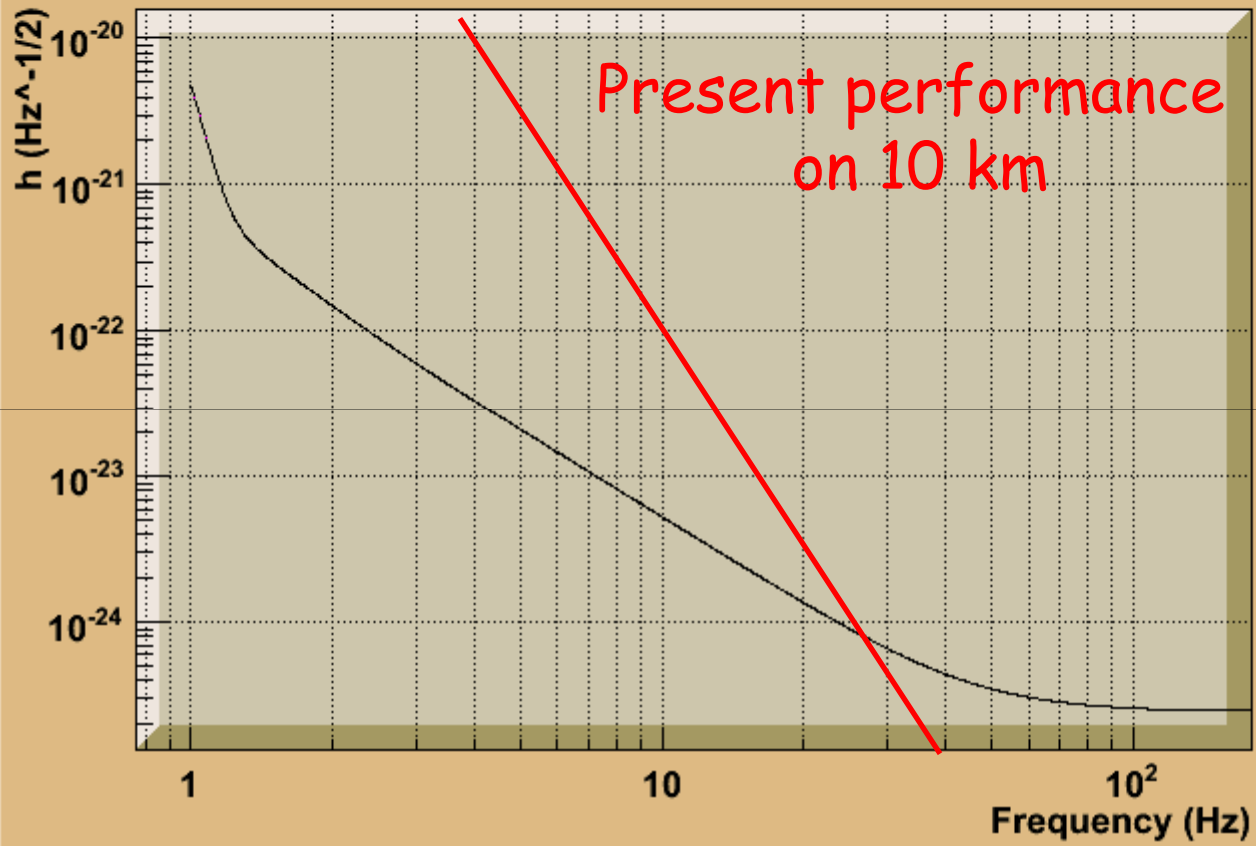
Reduction factor

4-5 Wind (5%)

7-8 Calm (95%)

Compliant for AdV but noisy for ET!

### ET - Sensitivity



## *What can we do ?*

- 1) New DAC board (factor 5-10)
- 2) Additional Hierarchical control
- 3) More mirror actions
- 4) Filter Enhancements

.....

## PART 2 - Conclusions

Payload swing chilled to "minimal values"

The frontier is to operate a silent payload control



# General Remarks

- 1) Attenuation OK above 3 Hz → **Cross-over reduction**
- 2) Payload swing close to minimum (Damping + Hierarchical)
- 3) Actuation noise OK for Adv but dominant in ET

**Short-Term upgrade (SAFE): New Pre-Isolators + Tilt control**

**Control Noise Reduction Strategy: DAC, ...hierarchy, ...**